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Experiments with Mesons at Energies below 1 BeV: A Bibliography

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Compiled by

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EXPERIMENTS WITH MESONS AT ENERGIES BELOW 1 BEV: A BIBLIOGRAPHY

INTRODUCTION

The abstracts contained in this bibliography were taken from NUCLEAR SCIENCE ABSTRACTS only. Volumes for the year 1959 through 1966 were searched. Though the subject is restricted to experiments, abstracts of largely theoretical works are included when it is indicated that experiments are performed to validate the theory or when it is not clear from the abstract whether the paper is theoretical or experimental.

Abstracts 0 through 785 p. 3 - 129

are abstracts of journal articles, conference papers, reports and theses and are arranged alphabetically by first author, second author, etc., and then by title if there is more than one by the same authors.

Abstracts 786 through 823 p. 129 - 133

are abstracts of full conference proceedings and are arranged chronologically by year.

Abstracts 824 through 829 p. 133 - 134

are abstracts of bibliographies.

Abstracts 830 through 853 p. 134 - 138

are abstracts of progress reports and are arranged alphabetically by the corporate author.

Following the abstracts on page 139 is a KWIC-index of the titles appearing in the abstracts. A few titles were edited to make them more easily indexed, particularly those of the full conference proceedings and the bibliographies. The progress reports are indexed only once under the term "Progress Reports". In the Index when there are many entries listed under one word such as pion, the entries are arranged numerically by the abstract number. The list of words prevented from indexing was

taken from that of CHEMICAL TITLES, January 31, 1966, but altered to exclude the words gamma, negative and positive. The following arbitrary symbols were used for punctuation marks not available to the machines used to prepare the Index:

Symbol:	Replaced by:
" (quotes)	,, (two commas)
: (colon)	.* (period, asterisk)
' (apostrophe)	/ (slash)
? (question mark)	$. (dollar sign, period)

The permuted Index was produced by the Data Processing Group of the Los Alamos Scientific Laboratory's Accounting Department.

ABSTRACTS

0

15679 INTERACTIONS OF π^--MESONS OF KINETIC ENERGY 915 MeV WITH CARBON NUCLEI. N. Abbattista (Università, Bari, Italy), M. Biasco, S. Mongelli, A. Romano, P. Waloschek, and E. Perez-Ferreira. Nuovo cimento (10), 23: 1-12(Jan. 1, 1962). (In English)

Interactions of π^- mesons with carbon nuclei were studied using a propane bubble chamber. The total cross-section on carbon was (383 ± 20) mb of which (89 ± 12) mb corresponded to elastic scattering. A description of the events with re-emission of a π^- is made. The diffraction scattering angular distribution and the total cross section obtained were described by an optical model using an imaginary gaussian potential; the rms radius of this potential obtained was 3.0×10^{-13} cm, which is considerably greater than the corresponding radius obtained for the electric charge distribution. (auth)

1

40395 A FEASIBILITY STUDY OF THE THERAPEUTIC POSSIBILITIES OF π^- MESONS. *Aceto, Henry Jr.* Austin, Tex., Univ. of Texas, 1964. 123p.

The feasibility of extending the arsenal of heavy particles available in radiotherapy to include mesons (π^-) produced in the Berkeley 184-inch synchrocyclotron was investigated by employing several dosimetric techniques. On the basis of the data obtained, a preliminary assessment of the use of mesons (π^-) is discussed. The results are indicative of many possible advantages, both in improving radiotherapeutic techniques and in offering new areas for basic radiobiologic investigation. (Dissertation Abstr.)

2

3329 DEPOLARIZATION OF μ^- MESONS IN NIKFI EMULSIONS PLACED IN A MAGNETIC FIELD OF 10^4 Oe. Ileana Adreescu, Tatiana Angelescu, Calin Besliu, Virginia Coditã, Nicolae Martalogu, Victoria Pîrvu, and Nicolae Gheordănescu (Universitatea, Bucharest). Compt. rend. 251, 1496-8(1960) Oct. 10. (In French)

The depolarization coefficients of the μ^- meson was measured with the aid of two nuclear emulsions under the effect of two magnetic fields. One field of 150 Oe is capable of negating the parasitic effects, and the other of 10^4 Oe is intended to break one of the magnetic couplings and to revive partially the polarization of the μ^- meson. Therefore, the angular distribution of electrons from the disintegration $\mu^- \rightarrow e^- + \nu + \tilde{\nu}$ in nuclear emulsions was studied. The comparison of the values obtained with those previously reported led to the conclusion that in the absence of magnetic fields the depolarization of μ^- mesons is almost complete. In a magnetic field of 10^4 Oe a residual polarization of 38% is found which indicates the destruction of one of the magnetic couplings. (J.S.R.)

3

12617 THE $O^{16}(\pi,\pi')\,4\alpha$ REACTION FOR 80 Mev π^+ MESONS. B. P. Afanasev, V. E. Kosmach, and V. I. Ostroumov (Leningrad Polytechnic Inst.). Zh. Eksperim. i Teor. Fiz., 47: 1687-92(Nov. 1964). (In Russian)

Disintegration of ^{16}O nuclei into four α particles as a result of inelastic scattering of 80-Mev mesons (π^+) on the nuclei was investigated with aid of photographic emulsions. The cross section for the reaction was found to be 7.3 ± 1.7 mb. A kinematic analysis of the stars revealed that in more than half of the reactions direct emission of the α particles occurs with formation of an intermediate ^{12}C nucleus with an excitation energy of 9.6 and 13 Mev. (auth)

4

21279 CROSS SECTIONS FOR CERTAIN REACTIONS IN WHICH FAST π^+ MESONS ARE ABSORBED BY LIGHT NUCLEI. B. P. Afanasev and V. I. Ostroumov (Leningrad Polytechnic Inst.). Dokl. Akad Nauk SSSR, 159: 1255-6 (Dec. 21, 1964). (In Russian)

Photoemulsion stars formed during meson (π^+) absorption by C, N, and O nuclei were examined in a fine grain emulsion irradiated in a synchrocyclotron by 80 ± 6 Mev meson (π^+) beams. Seven hundred and eighty nine events of spallation with one or two gray tracks belonging to <20-Mev protons and 2 to 4 tracks of heavy particles (probably α particles) were observed in the 1.32 cm^3 emulsion. An analysis was made of the possible reactions in the selected events: $\pi + {}^{14}N \rightarrow 2p + 3\alpha$, $\pi + {}^{14}N \rightarrow p + d + 2\alpha + {}^3He$, $\pi + {}^{14}N \rightarrow \pi' + d + 3\alpha$, $\pi + {}^{16}O \rightarrow 2p + 2\alpha + {}^6Li$, $\pi + {}^{16}O \rightarrow p + {}^3He + 3\alpha$, and $\pi + {}^{12}C \rightarrow p + {}^3He + 2\alpha$. The energy of

gray track particles was determined by the method of least squares using 4 conservation equations, the energy of other particles was estimated by their paths in the nuclear emulsion. Cross sections of examined reactions were determined using the known bombarding meson (π) flux with consideration for meson (μ) admixtures in it and by the number of observed spallation events. The content of C, N, and O in the emulsion was 0.277, 0.087, and 0.283 g/cm^3, respectively. (R.V.J.)

5

33385 THE $N^{14}(\pi,2p)\,3\alpha$ REACTION WITH 80 Mev π^+-MESONS Afanasev, B. P.; Ostroumov, V. I. Yadern. Fiz., 1: 647-51(Apr. 1965). (In Russian)

The reaction $^{14}N(\pi,2p)3\alpha$ was investigated for 80 Mev π^+-mesons using the nuclear emulsion method. The effective cross section is found to be equal to 27.4 ± 7.2 mb. It follows from the proton angular and energy distributions that the mechanism of the meson absorption is quasideuteron and is realized mostly on p-shell nucleons. Possible energy states of three and two α-particles are investigated. The probability of the excitation of the ^{12}C nucleus to the energy 13 Mev is found to be quite considerable. (auth)

6

25831 INVESTIGATION OF FLUCTUATION AND IONIZATION IN PROPORTIONAL LOW-PRESSURE DETECTORS. E. O. Agasyan and G. A. Marikyan. Izv. Akad. Nauk Arm. SSR, Ser. Fiz.-Mat. Nauk, 16: 125-30 (1963). (In Russian)

The spread of ionization fluctuations was studied as a function of filling gas mixture in proportional counters. Correlations of experimental and theoretical ionization curves resulted in more exact criteria for selecting layer thicknesses for cascade measurements. A G-M telescope with two proportional counters and radiometric apparatus was installed for measuring μ meson trajectories. A series of five coincidence and one anticoincidence G-M counters with 1350 g/cm^2 and 283 g/cm^2 absorbers between them were used for measuring two groups of μ mesons with momenta ($3 \leq p/\mu \leq 7$) and ($p/\mu > 7$). Argon (25%) and methane (75%) at 40 cm Hg pressure was used. The experimental curve spread was wider than the theoretical; half widths 48 ± 2.5 and 31%, respectively. The curve spread for μ mesons with $p/\mu \geq 7$ was 0.53%. Differential ionization fluctuation curves for μ mesons (3 to 7) p/μ in propane-filled counters had relative widths of (42 ± 3), (49 ± 2.5), and (65 ± 5)%. (R.V.J.)

7

31008 (LA-3171) EXPERIMENTS ON THE REACTION $\pi + N \rightarrow \pi + \pi + N$ AT THE PROPOSED LOS ALAMOS MESON PHYSICS FACILITY. Lewis Agnew (Los Alamos Scientific Lab., Univ. of California, N. Mex.). Sept. 1, 1964. Contract W-7405-eng-36. 27p. Dep.; $2.00(cy), 1(mn) CFSTI.

A survey of experimental work on the $\pi + N \rightarrow \pi + \pi + N$ reaction at incident pion energies below 1 Bev is reported. The feasibility of using a bubble chamber to study this reaction at LAMPF is discussed, including the experimental layout, the composition of the target, beam, and bubble chamber, data collection and analysis, and necessary quantity and precision of data. Possible experiments using electronic counters are considered in comparison with a previously performed analogous experiment; cross sections and analyzing powers for measuring the distribution and polarization of the recoil proton are discussed. (M.J.T.)

8

12886

SCATTERING OF μ-MESONS IN LEAD. A. I. Alikhanyan (Alikhanian) and F. R. Arutyunyan (Arutyunian) (Physical Inst., Academy of Sciences, Erevan, Armenian S.S.R.). Nuclear Phys. 10, 244-55(1959) Mar.

Scattering of μ-mesons with momenta between 1.0 and 1.8×10^9 ev/c was studied in 7 mm lead plates. The experimental angular distribution is compared with the theoretical curve for multiple scattering which takes into account the finite dimensions of the nucleus. It is shown that after introduction of all relevant corrections the experimental data satisfactorily agree with the calculations. (auth)

9

14322

SINGLE SCATTERING OF 10-30 MeV μ^--MESONS ON CARBON. A. I. Alikhanyan, V. G. Kirillov-Ugryumov, L. P. Kotenko, E. P. Kuznetsov, and A. V. Samoilov. Zhur. Eksptl'. i Teoret. Fiz. 38, 387-93(1960) Feb. (In Russian)

Single scattering of μ^--mesons in a propane bubble chamber was measured for μ^--mesons possessing energies between 10 and 30 Mev. The differential angular distribution was found to be satisfactorily described by a Mott scattering curve if the finite size of the nucleus was taken into account. The experiment showed that the cross section for anomalous scattering (if it exists) through an angle of >45° cannot exceed 1.25×10^{-28} cm^2 per nucleon for the energies under consideration and does not exceed 0.7×10^{-28} cm^2 per nucleon for scattering through an angle >90°. Not one case of μ^--decay of the $\mu^- \rightarrow e^+ + e^- + e^-$ type was detected in the 60000 stoppage events. (auth)

10

33722 NEW EXPERIMENTAL DATA ON μ-MESONS. A. I. Alikhanian and A. O. Waisenberg. Izv. Akad. Nauk SSSR, Ser. Fiz., 26: 698-701(June 1962). (In Russian)

The accumulated experimental data on μ-mesons was examined. The electromagnetic interactions of muons are discussed. The cross sections for the production of $\mu^+\mu^-$ pairs from high energy photons were found to agree, within experimental errors, with the predicted values. From the scattering of muons on nuclei the characteristic length, that enters into the muon formfactor, was found to be approximately 0.5 fermis. The gyromagnetic factor for the

muon agrees to within 2% of the theoretical value. The weak interactions of μ-mesons were also considered. The experimental mean lifetime of the muon agreed with the calculated value and thus supported the existence of a universal weak interaction. The polarization of the muon at the time of $\pi \rightarrow \mu$ decay also agreed with that calculated from theory. The helicity of particles emitted in the decay, $\mu \rightarrow e + \nu + \bar{\nu}$, is also described. (TTT)

11

10817 (NP-11301) DAL'NEISHIE POISKI $\mu \rightarrow e + \gamma$ RASPADA. (Further Search for the Decay $\mu \rightarrow e + \gamma$). A. N. Alikhanov, A. I. Babaev, M. Ya. Balats, V. S. Kaftanov, L. G. Landsberg, V. A. Lyubimov, and Yu. V. Obukhov (Akademiya Nauk S.S.S.R. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1961. 7p. (ITEP-30-61)

A search for $\mu \rightarrow e + \gamma$ decay was made by correlating spark chambers with fast electronics. The scheme of the installation is given. A beam of 70 Mev π^+ mesons produced by a 680-Mev proton synchrotron was separated by monitor coincidences 1, 2, and 0. The beam intensity corresponded to 2300 π^+ stops per second. The coincidence count 0A (4, 5, 6 + 7, 8, 9 + 1, 2, 3 + 10, 11, 12) corresponded to the number of $\mu \rightarrow e + \nu + \bar{\nu}$ decays. The measurements show the upper boundary of $\mu \rightarrow e + \gamma$ decay is $\rho_{exp} < 1.5 \times 10^{-7}$ (with 50% accuracy) and $\rho_{exp} < 5 \times 10^{-7}$ (with 90% accuracy). (R.V.J.)

11a

17056 FURTHER SEARCHES FOR THE DECAY $\mu \rightarrow e + \gamma$. A. I. Alikhanov, A. I. Babaev, M. Ya. Balats, V. S. Kaftanov, L. G. Landsberg, V. A. Lyubimov, and Yu. V. Obukhov (Inst. for Experimental and Theoretical Physics, USSR). Zhur. Eksptl'. i Teoret. Fiz., 42: 630-1(Feb. 1962). (In Russian)

The decay of a muon into an electron and a gamma ray was investigated with the aid of a spark chamber and fast electronics. The muons were created by a beam of 70-Mev π^+ mesons; the beam intensity was 2300 mesons per second. The efficiency for the registration of 53-Mev electrons, resulting from the sought decay mode, was 40%. The efficiency for the detection of gamma quanta of 53 Mev was 15%. The over-all efficiency of the experimental set-up for the detection of $\mu \rightarrow e + \gamma$ occurrences, bearing in mind the applicable criteria, was 0.8%. During 66 hr of running time 5.5×10^8 π^+ mesons were registered. In that time six electron–gamma occurrences were obtained with angles between the e and γ quanta ranging from 174 to 144° in the first projection (the direction perpendicular to the beam) and from 180 to 140° in the second projection (the depth camera). From the measurements it is concluded that the ratio of the decay sought for to that of the ordinary muon decay is 5×10^{-7}. (TTT)

12

32688 THE INTERACTIONS OF π^--MESONS WITH COMPLEX NUCLEI IN THE ENERGY RANGE (100-800) MEV. II. THE INTERACTION LENGTHS AND ELASTIC SCATTERING OF 750 MEV π^--MESONS IN G5 EMULSION. J. E. Allen, A. J. Apostolakis, Y. J. Lee, J. V. Major, and E. Perez Ferreira (Univ. of Durham, Eng.). Phil. Mag. (8), 6: 833-8(July 1961).

A total of 100.5 m of track was scanned in a block of emulsion exposed to the 750 Mev π^--meson beam of the Brookhaven cosmotron. Allowing for the beam contamination of 7%, the interaction lengths for the production of inelastic events and for elastic scattering with projected angles of $2 \leq \phi < 10°$ are (43.6 ± 2.9) cm and (66.8 ± 5.6) cm respectively. The geometrical interaction length is 29.3 cm. A comparison with the optical model of the nucleus gives a value for the absorption coefficient $K = (1.5 \pm 0.2)\ 10^{12}\ cm^{-1}$ and for the change in wave number $k_1 = (1.84 \pm 0.06)\ 10^{12}\ cm^{-1}$. The absorption coefficient corresponds to a mean free path in nuclear matter $\lambda_n = (6.7 \pm 0.9)\ 10^{-13}$ cm, to an imaginary component of potential $V_i = (15 \pm 2)$ Mev and with the value of the change in wave number to a real potential $V_r = (36 \pm 1)$ Mev. (auth)

13

31013 (UCID-1165(Rev.)) DATA ANALYSIS FOR ASSOCIATED PRODUCTION EXPERIMENT. M. Alston and H. Monteros (Lawrence Radiation Lab., Univ. of California, Berkeley). Mar. 29, 1960, Revised May 1, 1961. Contract [W-7405-eng-48]. 29p. Dep.(mn); $2.00(cy), 1(mn) CFSTI.

An experiment is planned to investigate the production and subsequent interactions of the particles produced in the $\pi^- + p$ reaction; production reactions considered are $\pi^- + p \rightarrow K^0 + \Lambda$, $K^0 + \Sigma^0$, $K^+ + \Sigma^-$, and $\pi^- + \pi^0 + p$. Pion beam momenta of 800 to 1600 Mev/c will be used. Possible interactions of the strange particles produced in the above reactions are considered, and criteria for their identification and analysis are discussed, including kinematics of production and decays and sketching of various event types. (M.J.T.)

14

28364 EXPERIMENTAL TEST OF A DISPERSION RELATION IN THE Gev REGION. B. Amblard (CEN, Saclay, France), P. Borgeaud, Y. Ducros, et al. Phys. Letters, 10: 138-41(May 15, 1964).

The measurement of the π-N charge exchange scattering at zero degrees provides a test of the dispersion relations for forward scattering amplitudes. Calculated values of the real part of the scattering amplitude are compared with experimental values derived from the forward charge exchange differential cross sections and total cross sections for π^+-p interactions at 760 to 1655 Mev. (C.E.S.)

15

17611 MEASUREMENT OF THE RATE $\mu^- + C^{12} \rightarrow B^{12} + \nu$. E. J. Amier, B. L. Bloch, R. M. Edelstein, and R. T. Siegel (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters, 6: 417-19(Apr. 15, 1961).

The μ^- meson absorption reaction $C^{12}(\mu^-,\nu)B^{12}$ is studied. A pulsed 45 Mev μ^- beam is absorbed in a plastic scintillant. Counters are arranged so the electrons produced in μ^- decay and in B^{12} β decay can be measured separately. The ratio of the total number of decay particles observed from the two decay processes, combined with the μ^- decay rate in C, yields the reaction rate. The presence of a weak magnetic effect in the interaction is discussed. (T.F.H.)

16

38064 RADIATIVE PION ABSORPTION IN COMPLEX NUCLEI. Anderson, D. K.; Eisenberg, J. M. (Univ. of Virginia, Charlottesville). Phys. Lett., 22: 164-6(Aug. 1, 1966). (ORO 3915-60).

It is shown that radiative absorption of pions may be used to study spin-isospin modes of excitation in nuclei. (auth)

17

9389 COMPARISON OF THE LIFETIMES OF POSITIVE AND NEGATIVE MUONS IN LIQUID HYDROGEN. E. W. Anderson, E. Bleser, S. Meyer, J. Rosen, J. Rothberg, and I. T. Wang (Columbia Univ., New York). p.417-18 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

Measurement of μ^+ and μ^- lifetimes in very pure hydrogen gave a result of $\tau^+/\tau^- = 1.000$ with an uncertainty of 0.2%. (A.G.W.)

18

16943 (NP-11592(Vol.I)(p.141)) THE CAPTURE RATE FOR MUONS IN HELIUM. H. L. Anderson, E. P. Hinks, C. S. Johnson, C. Rey, and A. M. Segar (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies).

Measurements are reported on the relative number of capture neutrons and decay electrons observed from muons stopping in liquid He. A capture rate of 1.3×10^3 sec^{-1} is reported. (J.R.D.)

19

7769 ENERGY SPECTRA OF NEUTRONS EMITTED FOLLOWING π^- CAPTURE IN C, Al, Cd, Pb, AND U. H. L. Anderson, E. P. Hincks, C. S. Johnson, C. Rey, and A. M. Segar (Univ. of Chicago). Phys. Rev., 133: B392-403 (Jan. 27, 1964).

The neutron emission from the capture of stopped mesons(π^-) in C, Al, Cd, Pb, and U was studied using a time-of-flight detector. The energy spectra are characterized by a low-energy evaporation part, and a high-energy component due to the direct neutron emission. The general features of the direct neutron emission are similar for all the substances studied, with approximately 2 neutrons per π^- capture. In contrast, the relative yield of the low-energy component increases markedly in the heavier nuclei. The neutron multiplicities in energy range from about 1.8 to 150 Mev were 2.8 ± 0.3, 3.2 ± 0.3, 3.6 ± 0.4, 3.5 ± 0.4, and 5.0 ± 0.5, for C, Al, Cd, Pb, and U, respectively. The total kinetic energy in neutron emission was about 68, 74, 80, 69, and 100 Mev for C, Al, Cd, Pb, and U, respectively. In the case of Cd the data are sufficiently complete to give a good account of the energy balance. (auth)

20

9784 EXPERIMENTAL DATA FOR DETERMINING THE PION-PION CROSS SECTION. J. A. Anderson, P. G. Burke, D. D. Carmony, and N. Schmitz (University of California, Berkeley). p.58-61 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The reaction $\pi^- + p \rightarrow \pi^- + p + \pi^0$ was studied. For each event the proton momentum and angle were measured. Experimental distributions $F(p^2, \omega^2)$ are given as functions of p^2, where p is the difference in proton momentum before and after the interaction and ω is the total energy of the two resulting pions. A method for extracting pion-pion cross section from these functions by an extrapolation procedure is discussed. The values obtained for the cross section depend on the kind of expression used for $F(p^2, \omega^2)$. (M.C.G.)

21

45274 (NEVIS-136) ASYMMETRY IN ANGULAR DISTRIBUTION OF NEUTRONS FROM MUON CAPTURE IN SPIN 0 NUCLEI (thesis). Anderson, E. Walter (Nevis Labs., Columbia Univ., Irvington-on-Hudson, N. Y.). May 1965. Contract Nonr-266(72). 80p. (CU-242; R-505).

When muons are captured by protons in the process $\mu^- + p \rightarrow n + \nu$, there exists a correlation between the momentum of the neutron and the spin of the muon. With a polarized muon beam, this correlation establishes a spatial asymmetry in the direction of emission of the neutron relative to the direction of muon polarization. An experiment designed to measure this asymmetry was performed at the Nevis Laboratory of Columbia University. A pure muon beam from the Nevis synchrocyclotron was stopped in ^{40}Ca and ^{12}C targets located in a uniform transverse magnetic field. The resulting uniform precession of the muon spin transforms the spatial asymmetry to a time interval distribution as recorded by a fixed detector. The time interval distributions were measured both with a digital time analyzer and with photographs of an oscilloscope trace. The muon polarization was determined from measurements on the muon-electron decay asymmetry, and neutron-gamma ray discrimination was performed by a pulse shape analysis technique. Measurements were made at several neutron energy threshold levels, with the expectation that at high neutron

energies, the complications due to nuclear physics effects would be less significant. The results for ^{40}Ca at high neutron energies give a value of the asymmetry which is significantly larger than the theoretical value calculated for a V-A, G and T invariant form of the interaction. The results for ^{12}C suggest a similar behavior but because of a lower statistical level, the results are consistent with zero asymmetry. (auth)

22

31891 (CERN-64-30(p.221-7)) A PAIR SPECTROMETER USING ACOUSTIC SPARK CHAMBERS AND OTHER EXPERIMENTS IN PREPARATION. P. T. Andrews, P. G. Butler, N. Cohen, A. N. James, B. G. Lowe, and J. P. Nicholson (Liverpool. Univ.).

The microphones and electronics for use in spark chamber studies of photon energies from $\pi^- + D \rightarrow N + N$, γ and in quasielastic scattering of 400-Mev protons by nuclei are described. (R.E.U.)

23

37665 THE K — 3 π DECAY AND π-MESON LOW ENERGY INTERACTIONS. Anisovich, V. V. pp 375-89 of Voprosy Fiziki Elementarnykh Chastits. Erevan, Publishing House of Academy of Sciences, 1964. (In Russian)

The theoretical determination of the meson (π) scattering length from the K-3π decay data is reviewed. The theoretical results agree with experimental data if either one assumes that a_0 and $a_1 < 1$ (a_1 – scattering length of mesons(π) with isospin I) and then $a_0 a_2 = -0.2 \pm 0.2$; or one assumes that a_0 is large ($a_0 = 1 - 3$) and then the agreement is good for $a_0 \sim 1$. At present, due to the large errors in experimental data one can not deduce more accurate conclusions about the meson (π) scattering length. (CFSTI)

24

24474 THE PROBLEM OF DETERMINING THE NATURE OF THE LOW-ENERGY INTERACTION OF π MESONS ON THE BASIS OF THE $p + d \rightarrow {}^3He + 2\pi$ AND $\pi + N + 2\pi$ REACTIONS. V. V. Anisovich and L. G. Dakhno (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksperim. i Teor. Fiz., 46: 1152-5(Mar. 1964). (In Russian)

Data on low-energy interactions of π mesons were found to lead to contradictory conclusions. Study of the energy spectrum of ^3He in the $p + d \rightarrow {}^3He + 2\pi$ reaction revealed an energy distribution maximum, which was attributed to the large scattering length of the π mesons. Indications of a strong interaction at low energies were found in the $\gamma + p \rightarrow p + 2\pi$ and the $p + \bar{p} \rightarrow 6\pi$ reactions; however in the $\pi + N \rightarrow N + 2\pi$ reactions no resonance interaction of the π-mesons was observed. The study revealed that the divergence in the energy distribution as a function of $\sqrt{s}$, where $\sqrt{s}$ is the total energy of the π mesons formed in their center-of-mass system, at $\sqrt{s} = \sim 2$ in the $p + d \rightarrow {}^3He + 2\pi$ and $\pi + N \rightarrow N + 2\pi$ reactions may be due to logarithmic singularities at the amplitudes of their generation. In the latter reaction the logarithmic singularity was close to the physical region of an incident meson energy from 300 to 600 Mev. The logarithmic singularity could be used to explain the increase in the generation of π mesons at $s \cong 4$ in the $p + d \rightarrow {}^3He + 2\pi$ reaction. (TTT)

25

10854 (LNF-63/47(p.1-35)) RELAZIONE RIASSUNTIVA DEI RECENTI RISULTATI SPERIMENTALI OTTENUTI CON L'ELETTROSINCROTRONE DI FRASCATI. (Report Summarizing Recent Experimental Results Obtained with the Frascati Electrosynchrotron), P. Argan and G. Diambrini-Palazzi.

An attempt is made to present a panoramic view of the laboratory experiments carried out with the Frascati electrosynchrotron. In the study of new resonances two experiments were carried out: photoproduction of the η particle and study of its decay and photoproduction of the ABC particle. In the area of electrodynamics, the photoproduction of μ pairs and the annihilation in flight of 800-Mev positrons were studied. The results of experiments on coherent bremsstrahlung were also included. Studies on the photoproduction of neutral and singly charged pions on hydrogen, of K mesons on hydrogen, of π^0 in the Coulomb field of the nucleus, and of singly and multiply charged pions on complex nuclei are described. In conclusion, the absorption of π^- on copper, lead, and tin is considered. The experimental apparatus used and the results obtained in all the studies are discussed. (J.S.R.)

26

17254

ABSORPTION OF μ^- MESONS IN C^{12}. H. V. Argo, F. B. Harrison, H. W. Kruse, and A. D. McGuire (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. 114, 626-33(1959) Apr. 15.

It is known that there is a strong similarity between the electron-nucleon and electron-muon weak interactions. This paper is a report on an experimental investigation of the third leg of the triangle, the muon-nucleon interaction. The absorption of negative cosmic-ray muons stopped in C^{12} was studied, and the probability per second of absorption resulting in the formation of B^{12} in the ground state was measured and found to be 9050 ± 950 sec^{-1}. This is compared to the known rate of β decay of B^{12} to the ground state of C^{12}, 33.2 ± 0.65 sec^{-1}. The ratio of the rates is 273 ± 29. In the allowed approximation, the nuclear matrix elements for the two processes are the same, and the ratio of the rates can be calculated in terms of the ratio of the coupling constants without assuming a nuclear model. The short wavelength of the neutrino emitted in μ absorption (13 fermis) causes forbidden matrix elements to make an important contribution to the μ-absorption rate, so that the theoretical prediction is dependent on the nuclear model. Within the uncertainties of the calculation, the

electron-nucleon and muon-nucleon axial vector coupling constants are the same. (auth)

27

14748
SCATTERING AND RESIDUAL RANGE DETERMINATIONS OF THE MASSES OF CHARGED PARTICLES IN MULTIPLATE CLOUD CHAMBERS. F. R. Arutyunyan (Inst. of Physics, Academy of Sciences, Armenian SSR). Zhur. Eksptl'. i Teoret. Fiz. 36, 985-91(1959) Apr. (In Russian)

The method of determining the mass of a charged particle from its scattering and residual range in multiplate cloud chambers is experimentally checked by using it for determining the masses of protons and μ and π mesons identified independently (from momentum—range data). The proton and μ- and π-meson masses derived from the corresponding multiple Coulomb scattering curves are in good agreement with the correct values. (auth)

28

9758 PRODUCTION OF NUCLEAR FRAGMENTS IN NUCLEAR EMULSIONS BY 80 MEV π^+-MESONS. A. S. Assovskaya and N. S. Ivanova (Radium Inst., Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz., 39: 1511-16(Dec. 1960). (In Russian)

The production of multi-charged particles by comparatively low energy (80 Mev) π^+ mesons was investigated with nuclear emulsions. An analysis of the charge, energy, and angular distributions of the fragments and a comparison of the experimental data with the results of calculations indicated that for such incident meson energies the fragments are produced only by fast protons formed within the nucleus as a result of absorption of the π^+ meson by a nucleon pair (n,p). The experimental data did not contradict the possibility that the fragments are ejected by these protons. (auth)

29

38131 MUON CAPTURE IN OXYGEN. A. Astbury, L. B. Auerbach, D. Cutts, R. J. Esterling, D. A. Jenkins, N. H. Lipman, and R. L. Shafer (Univ. of California, Berkeley). Nuovo Cimento (10), 33: 1020-4(Aug. 16, 1964). (UCRL-11299)

Muon capture in oxygen was studied at the 184-inch cyclotron. Muons were identified by a time-of-flight system and brought to rest in a water-cell, where some of them were captured by the ^{16}O nucleus. In the present state of the theory, the only firm conclusion is that the pseudoscalar coupling constant is positive. (auth)

30

21426 THE ANGULAR DISTRIBUTION OF THE NEUTRONS ARISING FROM THE NUCLEAR CAPTURE OF POLARIZED MUONS. A. Astbury, J. H. Bartley, I. M. Blair, M. A. R. Kemp, H. Muirhead, and T. Woodhead (Univ. of Liverpool). Proc. Phys. Soc. (London), 79: 1011-16 (May 1, 1962).

An experiment designed to measure the angular asymmetry of the neutrons emitted when polarized muons are captured by nuclei is described. The element used is S. After correcting for the depolarization of the muon beam, a value of -0.22 ± 0.07 is obtained for the asymmetry parameter. The non-zero result confirms the violation of parity conservation in the muon capture process, and the magnitude of the effect suggests the presence of an effective pseudoscalar term in the transition amplitude for the fundamental process $\mu^- + p \rightarrow n + \nu$. (auth)

31

3947
ANGULAR DISTRIBUTION OF NEUTRONS FOLLOWING THE NUCLEAR CAPTURE OF POLARIZED MUONS. A. Astbury, I. M. Blair, M. Hussain, M. A. R. Kemp, H. Muirhead, and R. G. P. Voss (Univ. of Liverpool). Phys. Rev. Letters 3, 476-8(1959) Nov. 15.

The angular distribution of neutrons following the nuclear capture of polarized mesons (μ^-) in S^{32} was determined for the process: $\mu^- + p \rightarrow n + \nu$. The ($\mu^-$) lifetime in S^{32} was determined to be 0.40 ± 0.05 μsec. (C.J.G.)

32

8230 THE DEPOLARIZATION OF NEGATIVE MUONS IN LIGHT ELEMENTS. A. Astbury, P. M. Hattersley, M. Hussain, M. A. R. Kemp, H. Muirhead, and T. Woodhead (Univ. of Liverpool). Proc. Phys. Soc. (London), 78: 1144-8(Dec. 1, 1961).

A measurement of the polarization retained by μ^- in light elements is described. For elements with spin 0 the μ^- retains about 17% of its initial polarization. (auth)

33

9889 A DETERMINATION OF THE LIFETIME OF THE μ^+ MESON. A. Astbury, P. M. Hattersley, M. Hussain, A. Kemp, and H. Muirhead (Univ. of Liverpool, England). p.542-4 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The lifetime of μ^+ mesons was measured by stopping positive pions in a sulfur target and detecting the electrons from the decay sequence $\pi^+ \rightarrow \mu^+ \rightarrow e$. A value of 2.225 ± 0.006 μsec was obtained for the lifetime. (M.C.G.)

34

28342 (NP-10305) CONTRIBUTION A L'ÉTUDE DE LA DIFFUSION (π^+p) A 120 MeV, PAR L'EXPLOITATION DES CLICHES DE CHAMBRE A BULLES (THESE). (Contribution to the Study of (π^+p) Scattering at 120 Mev by Utilization of Photographic Plates in Bubble Chambers (thesis)). B. Aubert (Grenoble, France. Universite). June 18, 1960. 86p.

The results of an investigation of (π^+,p) scattering made on 20000 photographs of a propane bubble chamber are reported. Before giving a report of the experimental results, the theoretical bases are reviewed, and the apparatus used is described. Results obtained previously relative to the α_3 phase are not in agreement with theoretical predictions. The aim of the present investigation was to study the scattering with good precision. The bubble chamber permitted the materialization of (π^+,p) collisions by visible tracks forming a star with three branches. After the determination of the proton branch, the angular distribution in the center-of-mass system was studied, and the dephasing was deduced. (J.S.R.)

35

31529 MEASUREMENT OF THE μ^- CAPTURE RATE IN He^3. Leonard B. Auerbach, Robert J. Esterling, Roger E. Hill, David A. Jenkins, Joseph T. Lach, and Norman H. Lipman (Univ. of California, Berkeley). Phys. Rev. Letters, 10: 23-6(July 1, 1963). (UCRL-10836)

The rate was measured to an accuracy of a few percent, using high-pressure He^3 gas both as a target and as a scintillation detector for the recoil triton. The measured rate (average value, 1520 ± 50 sec^{-1}) agrees quite well with the 1450 sec^{-1} obtained on the basis of the universal Fermi interaction. (D.C.W.)

36

19198 MEASUREMENTS OF THE MUON-CAPTURE RATE IN He^3 AND He^4. Leonard B. Auerbach, Robert J. Esterling, Roger E. Hill, David A. Jenkins, Joseph T. Lach, and Norman H. Lipman (Univ. of California, Berkeley). Phys. Rev., 138: B127-44(Apr. 12, 1965). (UCRL-11004 (Rev.))

In order to test the universality of the V–A Fermi interaction and the presence of the induced pseudoscalar term in the hamiltonian, the rate of the reaction $\mu^- + {}^3He \rightarrow {}^3H + \nu_\mu$ was measured. This reaction is closely analogous to the fundamental muon-capture interaction $\mu^- + p \rightarrow n + \nu_\mu$. The total muon-capture rates in ^{3}Hc and ^{4}He; the rates for the reactions $\mu^- + {}^3He \rightarrow$ all final states and $\mu^- + {}^4He \rightarrow$ all final states, were measured. Negative muons were brought to rest in a high-pressure helium-gas target. The capture processes all yield a charged particle, whose energy was measured by observation of scintillation in the helium gas. Captures into the ^{3}H channel were recognized by the unique energy (1.9 Mev) of the triton recoil. The total capture rates obtained were: $\Lambda(^3He) = 2170$ sec^{-1}, and $\Lambda(^4He) = 375$ sec^{-1}. The partial capture rate to the triton ground state was measured as $\Lambda(^3He \rightarrow {}^0H) = 1505 \pm 46$ sec^{-1}. These results are in good agreement with theoretical predictions based on a universal Fermi interaction, and on a conserved vector current. They also indicate that the induced-pseudoscalar-coupling coefficient is positive. Interpretation of these results in terms of the fundamental muon-capture process is somewhat ambiguous because of the uncertainty in the structure of the helium nucleus. (auth)

37

773 (LAL-1114) TRACES ET PARCOURS D'ÉLECTRONS, MUONS ET PIONS DANS UNE CHAMBRE À ÉTINCELLES A PLAQUES ÉPAISSES. (Tracks and Course of Electrons, Muons, and Pions in a Spark Chamber With Thick Plates). J. E. Augustin, P. Marin, and F. Rumpf (Paris. Université, Orsay. Ecole Normale Supérieure. Laboratoire de l'Accélérateur Linéaire). Sept. 1964. 40p. Dep.(mn).

An experimental apparatus to be used for e^+e^- collision studies up to 600 Mev at the Orsay linac is described. A spark chamber with thick plates is used for the detection of electrons, muons, and pions. Particle tracks and ranges in the chamber are discussed. (R.E.U.)

38

36291 πp PHENOMENOLOGY, (300 TO 1300) MEV. P. Auvil and C. Lovelace (Imperial Coll. of Science and Tech., London). Nuovo Cimento (10), 33: 473-519(July 16, 1964).

Elastic scattering experiments from 300 to 1300 Mev are analyzed by various techniques. The usual D_{13} and F_{15} assignments for the second and third resonances are supported. The fourth resonance is found to be F_{37}, and the 500-Mev π^+-p shoulder to be D_{35} inelastic. There are also indications of four more inelastic shoulders: in P_{11}(~400 Mev), S_{11}(~600 Mev), D_{15}(~700 Mev), and G_{17}(~1200 Mev). Both S waves increase steadily with energy, indicating a strong repulsive core. The background at the fourth resonance is strongly spin-dependent, in contradiction to the usual diffraction model. The imaginary parts of the partial amplitudes are obtained quantitatively over much of this region. The most powerful new condition is the requirement that the elasticities of the resonances, as determined from total cross-sections and forward dispersion relations, be compatible with the differential cross-sections there. (auth)

39

40307 PION-NUCLEON PHASE SHIFTS AND RESONANCES. P. Auvil (Imperial Coll. of Science and Tech., London), C. Lovelace, A. Donnachie, and A. T. Lea. Phys. Letters, 12: 76-80(Sept. 1, 1964).

A phase shift analysis of π-p scattering at 300 to 700 Mev was performed. A phase set in excellent agreement with practically all the experiments and with predictions from partial-wave dispersion relations was obtained. The D_{13} resonance appeared at 620 Mev, but with a width of only 90 Mev. The Ball-Frazer mechanism in S_{11} was confirmed, and peculiarities were noted in the P_{11} resonance. (D.C.W.)

40

16217 REALIZATION OF VARIED TARGETS INCORPORATED IN NUCLEAR EMULSIONS. Madeleine Avan (Faculte des Sciences, Clermont-Ferrand, France). Inds. atomiques, 4: Nos. 11/12, 61-9(1960). (In French)

The practical realization of targets incorporated in nuclear emulsions requires the elimination of various difficulties: pseudophotographic actions of metals, local distortions in the vicinity of the targets, slight generalized deformations of the sensitive layer, and study of a method of appropriate development. The methods of incorporation of wires or powders are described. The first results obtained with the scattering of mesons by a silver wire incorporated in the emulsion are given to illustrate the method. (J.S.R.)

41

27908 (NP-11634) POISKI $\mu^+ \rightarrow e^+ + e^+ + e^-$. (A Search for the Decay $\mu^+ \rightarrow e^+ + e^+ + e^-$). A. I. Babaev, M. Ya. Balatz, V. S. Kaftanov, L. G. Landsberg, V. A. Lyubimov, and Yu. V. Obukhov (Akademiya Nauk S.S.S.R. Institut Teoreticheskoĭ i Eksperimental'noĭ Fiziki). 1962. 11p.

A search was made for the $\mu \rightarrow 3e$ process using an installation previously used by A. I. Alikhanov, et al. (Z. Eksp. i Teoret. Fiz. v. 42, No. 6, 630, 1962). The installation for recording $\mu^+ \rightarrow e^+ + e^+ + e^-$ consisted of a six-layer cylindrical spark chamber, a single-layer plane spark chamber, a camera, a mirror, and series of scintillation counters. The Dalitz diagram was used for determining the recording efficiency. After 70 hours, 6.98×10^6 meson stops were recorded, however, none could be considered $\mu^- \rightarrow 3e$ according to formulated criteria. The anticipated number of $\mu \rightarrow 3e$ decays was $M = \rho N_\mu \epsilon f$ (where ρ is the probability of $\mu \rightarrow 3e$ decay in relation to ordinary decay, $N_\mu = 6.98 \times 10^6$, ϵ is the efficiency of the installation = 0.0185, f is a correction factor = 0.76. Calculations made with the Poisson formula show $\rho_{\mu \rightarrow 3e} < 2.6 \times 10^{-7}$ (with 90% accuracy), considering matrix elements constant; with corrections for efficiency, $\rho_{\mu \rightarrow 3e} < 2.0 \times 10^{-7}$. (R.V.J.)

42

9283 FURTHER STUDIES ON THE $\mu^+ \rightarrow e^+ + e^+ + e^-$ DECAY. A. I. Babaev, M. Ya. Balats, V. S. Kaftanov, L. G. Landsberg, V. A. Lyubimov, and Yu. V. Obukhov. Zh. Eksperim. i Teoret. Fiz., 43: 1984(Nov. 1962). (In Russian)

In a previous work on this subject (Zhur. Eksper. i Teoret. Fiz. 42, 1685 (1962)) a spark chamber with a fast electronic system was used for studying the $\mu^+ \rightarrow e^+ + e^+ + e^-$ decay reaction. The experimental arrangement was improved because in the first study not a single case of the $\mu \rightarrow 3e$ decay could be established. The statistics of the system was doubled, corresponding to 1.38×10^9 incidences of μ-mesons on the target. The ability of the system for recording these events was further improved by means of additional calibrations and by making use of new computational techniques. In order to be recorded as a $\mu \rightarrow 3e$ decay, the event has to satisfy all the previously established criteria. During the 150 hours of the experiment, not a single such event was recorded. (TTT)

43

41171 (N64-33402) DANGER CAUSED BY RADIATION IN THE BEAMS AND BEAM ZONES OF THE SYNCHROCYCLOTRON. Baarli, J. Translation of Dangers dus aux Radiations dans les Faisceaux et les Zones de Faisceaux au Synchrocyclotron, from a report of the MSC (Synchrocyclotron Machine) Meeting, June 21, 1963. 6p. (NASA-TT-F-9136). CFSTI, $1.00 fs, $0.50 mn.

The danger caused by synchrocyclotron radiations varies with the nature of the beams, their intensities, particle energies, and the extent of scattering. The biological effects and damage due to radiations are discussed, and dose limits are defined. The maximum permissible particle flux is given for various regions in the proton and neutron rooms for 600-Mev protons, 400-Mev neutrons, 50-Mev π^--mesons, and μ mesons. (CFSTI)

44

41275 DETECTION OF TWO PARTICLES IN SPARK CHAMBER. A. I. Babaev and V. S. Kaftanov. Pribory i Tekhn. Eksperim., No. 4, 181-2(July-Aug. 1963). (In Russian)

The efficiency of a six-layer cylindrical spark chamber for detection of two particles in the decay $\mu \rightarrow e + \gamma$ and $\mu \rightarrow 3$ e was investigated. The outside diameter of the chamber is 203 mm and its electrodes were constructed of duraluminum with a gap of 7 mm. The chamber was filled with neon at a pressure of 1.1 atm. An exponential pulse with an amplitude of 11 kv was supplied to the electrodes. The efficiency of the chamber is dependent on the delay time of the voltage impulse. (C.E.S.)

45

35149 MEASUREMENT OF PION BETA-DECAY BRANCHING RATIO. Bacastow, Robert B. (Univ. of California, Berkeley); Chesquiere, Claude; Wiegand, Clyde E.; Larsen, Rudolf R. Phys. Rev., 139: B407-18(July 26, 1965).

The branching ratio for pion beta decay, $R = (\pi^+ \rightarrow \pi^0 + e^+ + \nu)/(\pi^+ \rightarrow \mu^+ + \nu)$, was measured. Arrays of lead sheets, scintillators, and spark chambers were used to measure the angular distribution of the γ rays in delayed coincidence with stopping pions. Thirty-eight events remained after subtraction of a background of eight, leading to a branching ratio of $(1.07 \pm 0.21) \times 10^{-8}$. This result is in good agreement with conserved vector-current theory and with the results of other experiments. (auth)

46

9386 EXPERIMENTAL EVIDENCE FOR PION β DECAY. R. B. Bacastow, T. Elioff, R. R. Larsen, C. Wiegand, and T. Ypsilantis (Univ. of California, Berkeley). p.409-10 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

An attempt to measure experimentally the pion β-decay branching ratio is described. The basic plan of the experiment is the detection of all the decay products except the neutrino. Preliminary analysis of the data indicates a branching ratio consistent with 10^{-8} (the value previously estimated and predicted by theory). (A.G.W.)

47

9252 MEASUREMENT OF THE BRANCHING RATIO FOR PION BETA DECAY. Robert Bacastow, Tom Elioff, Rudolph Larsen, Clyde Weigand, and Thomas Ypsilantis (Univ. of California, Berkeley). Phys. Rev. Letters, 9: 400-2(Nov. 1, 1962). (UCRL-10486)

Positive pions at 175 Mev/c were used to investigate the decay process $\pi^+ \rightarrow \pi^0 + e^+ + \nu$. The experiment was designed to detect the two π^0 gamma rays, the positron, and the positron annihilation radiation. Ten events were identified as the desired process and analyzed. The braching ratio was determined to be $2.0 \pm 0.6 \times 10^{-8}$, which is comparable with the prediction of the conserved vector current hypothesis. (H.D.R.)

48

2246 (UCRL-10429) ATOMIC CAPTURE OF μ^- MESONS IN CHEMICAL COMPOUNDS AND THE "FERMI-TELLER Z LAW" (*thesis*). Jagdish S. Baijal (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 20, 1962. Contract W-7405-eng-48. 76p.

Experimental studies of the relative atomic μ^--meson capture probabilities in the constituents of chemical compounds are described. Fermi and Teller had predicted that the atomic-capture probability is proportional to the nuclear charge of the atomic species weighted by its atomic concentration. This is sometimes referred to as the "Fermi-Teller Z law." Previous experiments indicated no clear systematics to this capture process, and there are conflicts between the results of several measurements made with the same or similar compounds. In these experiments the capturing atom was identified by detection of either mesic x rays or decay electrons from μ^- mesons bound in the mesic K shell in the atomic species. In these experiments oxides and sulfides of some medium- and high-Z elements as well as two metallic solutions were used, and a nuclear capture product (neutron) rather than the decay electrons was detected. Results show that among the substances examined, namely CuO, Sb_2O_3, PbO, CuS, Sb_2S_3, PbS, AgLi, and CuAu, the "Z law" behavior is not indicated either in insulators or in metals, although in all cases there is a preference for capturing in the atom of higher Z. If the atomic-capture probability is proportional to Z^n (n being any positive or negative number), then it is found that the experimental results fall approximately in the range $n = \frac{2}{3}$ to $n = 1.4$, where $n = 1$ would define the prediction by Fermi and Teller. The measured atomic-capture ratios are: Cu/O = 6.14 ± 0.85; Sb/O = 1.86 ± 0.096; Pb/O = 4.56 ± 0.53; Cu/S = 1.89 ± 0.18; Sb/S = 1.64 ± 0.10; Pb/S = 2.87 ± 0.35; Ag/Li = 11.66 ± 3.39; Au/Cu = 0.34 ± 0.032. In connection with this experiment it was also necessary to measure the μ^--meson lifetimes in a number of elements (including Au, which was not reported before). The measured lifetimes are (in nsec): S = 498 ± 17; Cu = 162.6 ± 1.9; Ag = 84.4 ± 1.0; Sb = 91.3 ± 1.4; Au = 68.6 ± 1.3; Pb = 74.1 ± 1.0. (auth)

49

9109 ATOMIC CAPTURE OF μ^--MESONS IN CHEMICAL COMPOUNDS. J. S. Baijal, J. A. Diaz, S. N. Kaplan, and R. V. Pyle (Univ. of California, Berkeley). Nuovo Cimento (10), 30: 711-26(Nov. 1, 1963). (UCRL-10671)

Experimental studies (NSA 17: 2246) of the relative μ^--meson atomic-capture probabilities in the compounds CuO, Sb_2O_3, PbO, CuS, Sb_2S_3, and PbS and in the metallic solutions $Ag_{0.58}Li$ and $CuAu_{0.18}$ were made to test the predictions of the "Fermi-Teller Z-law." In the experiment the capturing atom was identified by decomposing a compound lifetime curve obtained by detecting neutrons from μ^--capture. The measured atomic-capture ratios are:

Cu/O = 6.14 ± 0.85,	Sb/S = 1.64 ± 0.10,
Sb/O = 1.86 ± 0.096,	Pb/S = 2.87 ± 0.35,
Pb/O = 4.56 ± 0.53,	Ag/Li = 11.66 ± 3.39,
Cu/S = 1.89 ± 0.18,	Au/Cu = 0.34 ± 0.032.

Assuming the Z-dependence of the atomic-capture probability can be expressed as proportional to Z^n (n being any positive or negative number), it is found that the experimental results fall approximately in the range $n = \frac{1}{2}$ to $\frac{3}{2}$, where n = 1 corresponds to the theoretical prediction of Fermi and Teller. (auth)

50

32467 MUONIUM AND POSITRONIUM PHYSICS. J. M. Bailey and V. W. Hughes (Yale Univ., New Haven). p.839-46 of "Atomic Collision Processes." Amsterdam, North-Holland Publishing Co., 1964.

Experiments on muonium and positronium give the most unambiguous and precise values of the fundamental constant α, and also give valuable information about many atomic collision processes. (auth)

51

20553
NEUTRON ASYMMETRY FROM Mu CAPTURE IN MAGNESIUM. W. F. Baker and C. Rubbia (Columbia Univ., New York). Phys. Rev. Letters 3, 179-81(1959) Aug. 15.

It has previously been pointed out that a measurement of the angular distribution of neutrons emitted after the capture of polarized μ^- mesons by complex nuclei may give information on the nature of the coupling constants in the process $\mu^- + p \rightarrow n + \nu$. A spatial asymmetry with respect to the μ spin direction would also be evidence for parity nonconservation in the reaction. The neutron asymmetry was measured by processing the negative muons stopped in a magnesium target through 90° by a constant magnetic field which was reversed every 30 min. (W.D.M.)

52

38081 (JINR-P-1286) ISSLEDOVANIE POGLOSHCHENIYA π^+ I π^--MEZONOV PRI ENERGII 40-70 Mev V YADRAKH UGLERODA S POMOSHCH'YU PROPANOVOI PUZYR'KOVOI KAMERY. (Investigation of Pion Absorption by Carbon Nuclei at 40-70 Mev by Means of a Propane Bubble Chamber). M. P. Balandin, O. I. Ivanov, V. A. Moiseenko, and G. L. Sokolov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1963. 25p.

The absorption of meson ($\pi^\pm$) of equal energy by C nuclei was studied. The total cross sections for π^+ and π^- absorption and charge exchange were found to be 98×10^{-27} and 99×10^{-27} cm^2, respectively. The angular distribution of charged particles with respect to the incident meson direction proved to be isotropic in meson (π^-) absorption and anisotropic in meson (π^+) absorption. The distributions of absorption events indicate that absorption occurs only in nucleon pairs. The parameter η that determines the probability of $\pi^\pm$ absorption in neutron-proton pairs was found to be 0.65 ± 0.10. (auth)

53

10356

INVESTIGATION OF $\pi^+ - \mu^+ - e^+$ DECAY WITH HELP OF A PROPANE BUBBLE CHAMBER AND SCINTILLATION COUNTERS. M. P. Balandin, V. A. Moiseenko, A. I. Mukhin, and S. Z. Otvinovskii (Joint Inst. of Nuclear Research, Dubna, U.S.S.R.). Zhur. Eksptl'. i Teoret. Fiz. 36, 424-32(1959) Feb. (In Russian)

It was found that the angular distribution of the μ^+ mesons is isotropic, whereas the positron angular distribution, if described by the expression $(1/4\pi)(1 - a \cos\theta)$, is characterized by the quantity $a = 0.116 \pm 0.035$. This value for a is much smaller than the values obtained in other works in which propane bubble chambers were employed. Scintillation counter experiments carried out with the purpose of ascertaining the cause of this discrepancy showed that the magnitude of the anisotropy significantly depends on the degree of purification of the commercial propane which is sometimes employed in bubble chambers. A simultaneous analysis of the data obtained with propane of a given composition with aid of a bubble chamber and scintillation counters showed that the quantity $\lambda(1 - W_C)$ is equal to 0.78 ± 0.26 where W_C is the probability for depolarization of μ^+ mesons in graphite and λ is a fundamental parameter in neutrino theory. (auth)

54

15196 (JINR-P-1530) REZONANSNII MEKHANIZM ISPUSKANIYA NEITRONOV PRI ZAKHVATE μ^--MEZONOV KISLORODOM. (A Resonance Mechanism of Neutron Emission in Muon Capture by Oxygen). V. V. Balashov, V. B. Belyaev, N. M. Kabachnik, and R. A. Eramzhyan (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1964. 7p.

A resonance mechanism of neutron emission in the processes of muon capture by light nuclei is investigated. Detailed calculations are given for the reaction $\mu^- + O^{16} \rightarrow N^{15} + n + \nu$. It is shown that up to $E_n = 10$ Mev the resonance capture mechanism plays the main role in producing the neutron spectrum. (auth)

55

18560

ENERGY OF NEUTRONS FROM CAPTURE OF NEGATIVE μ-MESONS IN LEAD NUCLEI. W. Ball and K. H. Lauterjung (Max-Planck-Institut fur Kernphysik, Heidelberg, Ger.). Z. Naturforsch. 14a, 581-2(1959) May-June. (In German)

Experiments are described in which neutrons produced by μ^- capture in Pb were detected by paraffin recoil protons causing fluorescence in ZnS(Ag). The experimental set-up is described. The data show that most of the neutrons have energies below 3 Mev. Since the neutrons, according to their point of origin, have traveled great distances in the μ-meson absorber and have been left as lower-energy neutrons on the basis of their energy loss through inelastic scattering in the Pb, the total intensity of recoil protons is very small, though 25 captures/minute were recorded. An even larger recoil-proton count rate would be expected if neutrons with energies greater than 25 Mev were selected. (T.R.H.)

56

12903 (JINR-P-1490) VZAIMODEISTVIYA MEZONOV. (Interactions Between Mesons). V. S. Barashenkov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1963. 56p.

A review is given of the experimental and theoretical data on π-π, K-π, and K-K interactions. (auth)

57

13345 (JINR-P-1132) SECHENIYA ROZHDENIYA ANTINUKLONOV. (Cross Sections for Antinucleon Production). V. S. Barashenkov and I. Patera (Joint Inst. for

Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1962. 14p.

The available experimental data on the cross sections for antinucleon production in N–N, $\bar{N}$–N, and π–N interactions are discussed. Graphs and tables of data are included. 46 references. (auth)

58

4756

460 Mev NEGATIVE PION SCATTERING FROM NEUTRONS IN A PROPANE BUBBLE CHAMBER. J. Ballam and J. Hang (Michigan State Univ., East Lansing) and J. H. Scandrett and W. D. Walker (Univ. of Wisconsin, Madison). Nuovo cimento (10) 14, 240-4(1959) Oct. 1. (In English)

π^- scattering at 460 Mev by neutrons bound in a carbon nucleus in a propane bubble chamber was examined. The total and differential cross sections were determined. The angular distribution was determined and compared with the angular distribution obtained from (π^+,p) scattering. (C.J.G.)

59

24747 MOTT SCATTERING OF POLARIZED MUONS. Marcel Bardon, Paolo Franzini, and Juliet Lee (Columbia Univ., New York). Phys. Rev., 126: 1826-35(June 1, 1962).

An experimental determination was made of the helicity of muons from π^- decays and the cross sections for scattering from lead by Mott scattering. With $(2.0 \pm 0.3) \times 10^8$ muons incident on the scatterers, a left-right asymmetry of -0.090 ± 0.031 was measured for 1163 ± 60 scattering events. Checks indicated negligible systematic asymmetries. The sign of the asymmetry shows a positive helicity for the negative muon in pion decay in agreement with V-A theory. Agreement of the magnitude of the asymmetry and of the number of events with the ones predicted for the experimental arrangement (0.081 ± 0.001 and 1210 ± 220, respectively) confirms the results of experiments indicating a purely electromagnetic behavior for muon scattering. The average momentum transfer was 110 Mev/c. Mott scattering of transversely polarized fermions was measured. (auth)

60

15373 RECOIL PROTON POLARIZATION MEASUREMENTS IN PION-NUCLEON ELASTIC SCATTERING. Bareyre, P. (C.E.N., Saclay, France). Proc. Roy. Soc. (London), Ser. A, 289: 463-70(Jan. 25, 1966).

The angular distributions of the recoil proton polarization in π^+p elastic scattering were measured at 410 and 492 Mev incident pion kinetic energy by using a carbon plate spark chamber. (C.E.S.)

61

35164 MEASUREMENT OF THE RECOIL PROTON POLARIZATION IN ELASTIC π^-p SCATTERING AT T_π = 410 AND 492 Mev. Bareyre, P. (Centre d'Etudes Nucleaires, Saclay, France); Bricman, C.; Longo, M. J. (and others). Phys. Rev. Letters, 14: 878-80(May 24, 1965).

The results for the recoil proton polarization in negative pion-proton elastic scattering as measured with a carbon plate spark chamber are given. Also shown are the preliminary results of a calibration run made to verify the values adopted for the analyzing power of the chamber. (J.F.P.)

62

16617 MEASUREMENT OF THE RECOIL PROTON POLARIZATION IN ELASTIC π^+p SCATTERING AT $T\pi$ EQUALS 410 AND 492 Mev. P. Bareyre, C. Bricman, M. J. Longo, et al. (Centre d'Etudes Nucleaires, Saclay, France). Phys. Rev. Letters, 14: 198-201(Feb. 8, 1965).

The angular distribution of the recoil proton polarization in elastic π^+-p scattering at 410 and 492 Mev was measured. (D.C.W.)

63

16618 PHASE-SHIFT ANALYSIS IN π^+ SCATTERING AT $T\pi$ LAB EQUALS 410 AND 492 Mev. P. Bareyre, C. Bricman, J. Sequinot, and G. Villet (Centre d'Etudes Nucleaires, Saclay, France). Phys. Rev. Letters, 14: 201-5 (Feb. 8, 1965).

The results of phase shift analyses of π^+-p scattering at 410 and 492 Mev are presented and are compared with experimental data and theoretical predictions using partial-wave dispersion relations. SPD and SPDF analyses were made for both 410 and 492 Mev, and an SPDFG analysis was also made for 492 Mev. (D.C.W.)

64

45100 PION-NUCLEON PHASE SHIFT ANALYSIS BELOW 1 Gev. Bareyre, P.; Brickman, C.; Stirling, A. V.; Villet, G. (CEN, Saclay, France). Phys. Letters, 18: 342-5(Sept. 1, 1965).

A new analysis was made at 310 Mev of the meson (π)-nucleon phase shift using the π^-p polarization data previously obtained. For all other energies no selection was made in the experimental data except for slightly increasing the errors in π^0N differential cross sections also given previously. For each energy, starting from a random set of phase shift and varying it in order to minimize the total chi square of the various experimental data, a set of phase shifts corresponding to a relative minimum of the chi square; this operation was repeated many times. (J.F.P.)

65

35165 PION-PROTON PHASE-SHIFT ANALYSIS AT T_π = 410 AND 492 Mev. Bareyre, P.; Bricman, C.; Villet, G. (Centre d'Etudes Nucleaires, Saclay, France). Phys. Rev. Letters, 14: 881-4(May 24, 1965).

A recent phase-shift analysis of the π^+p scattering at T_π = 410 and 492 Mev and the recoil proton polarization for π^--proton scattering results permit the achievement of a complete phase-shift analysis for the I = 3/2 and I = 1/2 isospin states. With those polarization measurements, the total cross sections, elastic differential cross sections, forward elastic cross sections, and total inelastic cross sections were used. The search program minimizes the total χ^2 of these quantities, for π^+p and π^-p data, using a gradient method. (J.F.P.)

66

9203 (UCRL-10470) A STUDY OF THE REACTION $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ AT 310 AND 377 Mev (thesis). Barry C. Barish (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 20, 1962. Contract W-7405-eng-48. 65p.

Proton distributions for the reaction $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ are measured at incident-pion energies of 310 and 377 Mev. The protons from this reaction are identified in a scintillation counter telescope by a combination of dE/dx, range, and time-of-flight methods. At 310 Mev, selected proton energy intervals are taken at laboratory-system angles of 15 and 22.5 deg. At 377 Mev, distributions in energy from 60.5 to 163.5 Mev at angles from 10 deg to the kinematic limit are measured. The total cross sections obtained are: 0.14 ± 0.07 mb at 310 Mev, and 0.37 ± 0.03 mb at 377 Mev. These values are in good agreement with the theoretical predictions of a $\pi\pi$ interaction model by Schnitzer in which his parameters are chosen to fit the total cross section and the π^+ angular distribution in the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$. (32 references.) (auth)

67

14994 PION PRODUCTION BY NEGATIVE PIONS. Barry C. Barish, Richard J. Kurz, Paul G. McManigal, Victor Perez-Mendez, and Julius Solomon (Univ. of California, Berkeley). Phys. Rev. Letters, 6: No. 6, 297-300(Mar. 15, 1961).

The reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ is studied for incident T_{π^-} = 365 and 432 Mev. The energy spectra of the emergent π^+ mesons are measured at various angles with respect to the incident π^- beam. The differential cross sections are analyzed in terms of pion-pion interactions and pion-nucleon resonances. (T.F.H.)

68

30580 INELASTIC π^-–p INTERACTIONS IN THE ENERGY REGION OF 310 TO 454 Mev. Barry C. Barish, Richard J. Kurz, Victor Perez-Mendez, and Julius Solomon (Univ. of California, Berkeley). Phys. Rev., 135: B416-31 (July 27, 1964). (UCRL-11257)

The differential cross sections for positive pions, protons, and neutrons from inelastic π^-–p interactions at 310 to 454 Mev were measured. The data were obtained with electronic counter systems, which measured the energy distribution of the final-state particle of interest at a series of fixed angles. The results were interpreted in terms of the final states $\pi^+\pi^-n$, $\pi^0\pi^0n$, and $\pi^-\pi^0p$. The total cross sections for these three modes as a function of incident pion energy are in qualitative agreement with the predictions by Schnitzer. A preference is shown for his set of $\pi-\pi$ scattering lengths: a_0 = 0.65, a_1 = 0.07, and a_2 = 0.14 μ^{-1}. The observed neutron distributions correspond to a strong preference for low center of mass system neutron energies in both the $\pi^+\pi^-n$ and $\pi^0\pi^0n$ final states. The effect is not present in the observed proton distributions from the $\pi^-\pi^0p$ reaction, which suggests that it is due to a I = 0, $\pi\pi$ interaction. The π^+ data show the formation of the (3,3) isobar combination of the π^-–n system in the $\pi^+\pi^-n$ final state. Analysis in terms of an isobar model indicates the predominance of I = 1/2 incident state. (auth)

69

3029 (UCRL-11518) RANGE DIFFERENCES BETWEEN POSITIVE AND NEGATIVE PIONS IN EMULSION. Walter H. Barkas, W. Z. Osborne, William G. Simon, and F. M. Smith (California. Univ., Berkeley. Lawrence Radiation Lab.). June 1964. Contract W-7405-eng-48. 9p. (CONF-787-2). Dep.(mn); $1.00(cy), 1(mn) OTS.

From 5th International Conference on Nuclear Photography, Geneva, Sept. 1964.

The velocity dependence of the range difference, which should start at zero and approach a plateau at some moderate velocity, was measured for a pion range of about 100 μ. (auth)

70

15128 PION-PROTON SCATTERING AT 600 Mev. R. Barloutaud, L. Cardin, A. Derem, C. Gensollen, A. Levêque, C. Louedec, J. Meyer, and D. Tycho (Centre d'Etudes Nucleaire, Saclay, France). Nuovo Cimento (10), 26: 1409-11(Dec. 16, 1962). (In English)

A π^+-p scattering experiment was performed at 600 Mev incident pion kinetic energy with the 35 cm hydrogen bubble chamber. The total elastic and inelastic cross sections were determined by comparing the number of elastic and inelastic events and using a value for the total cross section. (C.E.S.)

71

19090 EVIDENCE FOR GIANT RESONANCE EXCITATION INDUCED BY THE CAPTURE OF MUONS IN O^{16}. J. Barlow (CERN, Geneva), J. C. Sens, P. J. Duke, and M. A. R. Kemp. Phys. Letters, 9: 84-8(Mar. 15, 1964).

A measurement of the total rate of capture of mesons (μ^-) in ^{16}O is reported. The result is in strong disagreement with the predictions based on an independent particle shell model. An alternative interpretation is discussed in terms of a collective excitation of the giant dipole resonance in ^{16}N. The interpretation appears to be in agreement with experiment. (C.E.S.)

72

11021

PION-PROTON SCATTERING BELOW 150 MEV. [PART] I. S. W. Barnes, B. Rose, G. Giacomelli, J. Ring, K. Miyake, and K. Kinsey (Univ. of Rochester, N. Y.). Phys. Rev. 117, 226-37(1960) Jan. 1.

Positive-pion proton differential cross sections were measured at 41.5 Mev for six angles. The angles in the center-of-mass system are 53°, 69.1°, 100.4°, 128°, 141.7°, and 163.5° and the corresponding cross sections in mb/sterad in the center-of-mass system are 0.252 ± 0.020, 0.354 ± 0.025, 0.777 ± 0.038, 1.145 ± 0.067, 1.495 ± 0.084, and 1.750 ± 0.110. Negative pion elastic cross sections were measured for the first five of the above angles and are, respectively, in mb/sterad in the c.m. system: 0.338 ± 0.047, 0.281 ± 0.038, 0.148 ± 0.029, 0.112 ± 0.042, and 0.085 ± 0.25. Phase-shift analyses of these data and those of other authors lead to the following expressions for the low-energy behavior of the $T = 3/2$ phases: $\alpha_{31}^N = -(0.0418 \pm 0.004)\eta^3$, $\alpha_3^N = -(0.1145 \pm 0.0026)\eta$, and $\cot\alpha_{33}^N = 4/3\eta^3 (0.0877 \pm 0.0014)/[\omega^*(1-\omega^*/2.17)]$. (auth)

73

11022

PION-PROTON SCATTERING BELOW 150 MEV. [PART] II. S. W. Barnes, H. Winick, K. Miyake, and K. Kinsey (Univ. of Rochester, N. Y.). Phys. Rev. 117, 238-42 (1960) Jan. 1.

Values found for 30-Mev scattering at the two center-of-mass angles 116.8° and 155° are, respectively, for positive pions 0.849 ± 0.048 and 1.098 ± 0.075 mb sterad^{-1}, and for negative pions of the same energy 0.187 ± 0.020 and 0.165 ± 0.022 mb sterad^{-1}. Phase-shift analyses are made of recent published π^- distributions in the above energy range and serve to furnish prescriptions for the low-energy behavior of the $T = 1/2$ phases. Calculations of σ^{--}, σ^{-0}, and σ_{total}^- at various energies agree with measurements found in the literature. An essential agreement is found between $\pi^- + p$ forward scattering amplitudes and a dispersion equation over this energy region. (auth)

74

37930 (CERN-63-27) INTERACTIONS OF POSITIVE PIONS WITH PROTONS NEAR THRESHOLD FOR SINGLE PION PRODUCTION. V. E. Barnes (Cambridge Univ., England. Cavendish Lab.); I. Derado (European Organization for Nuclear Research, Geneva); R. Carrara, et al. (Padua. Universita. Istituto di Fisica; and Italy. Istituto Nazionale di Fisica Nucleare, Padua). July 22, 1963. 15p.

The π^+-p interaction in the 300 Mev kinetic energy region was studied in a hydrogen bubble chamber. Three types of events were considered: elastic scattering, single pion production and single photon production. In the elastic scattering the phase shifts of the Fermi I solution are substantially compatible with previous results. Cross sections are determined for the in elastic processes and, although statistics are very low, the results are compared with calculations based on the peripheral and the isobaric models. (auth)

75

10341

CAPTURE AND DECAY OF μ-MESONS IN Fe. W. A. Barrett, F. E. Holmstrom, and J. W. Keuffel (Univ. of Utah, Salt Lake City). Phys. Rev. 113, 661-5(1959) Jan. 15.

The mean life of μ^- mesons in Fe was measured using an improved cosmic-ray apparatus. A positive identification of the stopped muon was made using Cherenkov velocity selectors in the incident telescope. The 2.2-μsec background from positive muons was reduced by a factor of 3 with a 3-layer sandwich of Fe and thin plastic scintillators, so arranged that electrons emitted in the target were mostly detected as such by the scintillators. The mean life is 196 ± 8 mμsec. By comparing this result with the electron-counting results of Lederman and Weinrich, the ratio of the decay rate of μ^- bound in Fe to the free μ^+-decay rate is found to be 1.15 ± 0.06. (auth)

76

33311 EXCITATION OF $\Delta T_z = 2$ ANALOG STATES BY DOUBLE CHARGE EXCHANGE SCATTERING OF PIONS. S. Barshay (Rutgers State Univ., New Brunswick, N. J.) and G. E. Brown. Phys. Letters, 16: 165-7(May 15, 1965).

Detailed calculations and angular distributions for reactions leading to the analog state in double charge exchange scattering of pions from nuclei are reported. The process of collective excitation by a high-energy pion of the member of a high-isotopic-spin nuclear multiplet with z-component, $T_z + 2$, starting from the lower-energy member with z-component, T_z, is analyzed. Calculations were carried out for ^{48}Ca, the two neutrons in the $j = f_{7/2}$ shell transforming into protons, for incident mesons of 210 Mev laboratory kinetic energy, and the results are shown. (I.B.S.)

77

3086 MEASUREMENTS OF THE RATES OF THE DECAY $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ AND OF π^- CAPTURE IN LiH, CH_2, AND CH. D. Bartlett, S. Devons, S. L. Meyer, and J. L. Rosen (Columbia Univ., New York). Phys. Rev., 136: B1452-63(Dec. 7, 1964).

The branching ratio for $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ was measured using the near anticollinearity of the two γ rays from the subsequent decay of the meson (π^0). On the basis of 39 events, of which 3 are attributed to background, and an independent calibration of the overall efficiency of the apparatus, the branching ratio was determined to be $(0.97 \pm 0.020) \times 10^{-8}$, in agreement with previous measurements and the prediction of the conserved-vector-current hypothesis. Using the same apparatus, W, the fraction of stopped

mesons (π^-) captured by hydrogen nuclei bound in chemical compounds was measured with the following results: $W_{LiH} = 40 \pm 4 \times 10^{-3}$, $W_{CH_4} = 17.9 \pm 1.9 \times 10^{-3}$; and $W_{CH} = 5.5 \pm 0.7 \times 10^{-3}$. Meson ($\pi^-$) capture in H_2-N_2 and H_2-He gas mixtures was also briefly studied. (auth)

78

14312 (CU-233) THE BRANCHING RATIO FOR PION BETA DECAY (thesis). David Bartlett (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). Nov. 1964. Contract Nonr-266(72). 107p. (NEVIS-127; R-468).

The conserved vector current theory predicts that the branching ratio for the decay of a charged pion into a neutral pion is $(1.05 \pm 0.02) \times 10^{-8}$, if the coupling constant is derived from muon decay, or $(1.00 \pm 0.02) \times 10^{-8}$, if the coupling constant is derived from nuclear beta decay. Using spark chambers to distinguish the nearly anticollinear gamma rays from π^+ beta decay from a background of other gamma rays, 36 events are found and the branching ratio is measured to be $(0.97 \pm 0.20) \times 10^{-8}$, in agreement with the theoretical prediction and previous measurements. The method of background subtraction ($\lesssim 10\%$) depends only on knowing that the background is isotropic for gamma rays having opening angles between 160 and 180°. (auth)

79

10889 SEARCH FOR THE DECAY MODE: $\mu \rightarrow e + \gamma$. D. Bartlett, S. Devons, and A. M. Sachs (Columbia Univ., New York). Phys. Rev. Letters, 8: 120-3(Feb. 1, 1962).

A search for the decay mode $\mu \rightarrow e + \gamma$ using spark chamber techniques is reported. Limits for the rate are less than 6×10^{-8} of the normal decay rate. (L.N.N.)

80

4966 A SEARCH FOR NEUTRINOLESS DECAY MODES OF THE NEGATIVE MUON. J. H. Bartley, H. Davies, H. Muirhead, and T. Woodhead (Univ. of Liverpool). Phys. Letters, 13: 258-9(Dec. 1, 1964).

An experiment was performed to search for the processes $\mu^- + Cu \rightarrow Cu + e^-$ and $\mu^- + Cu \rightarrow Cu + e^- + \gamma$. No event satisfying the criteria for either reaction was found. From the number of mesons (μ^-) stopped, the overall detection efficiencies, and the absence of events branching ratios of less than 2.2×10^{-7} and 7.8×10^{-7}, respectively, each with 90% confidence, are determined. The results are interpreted as an absence of neutral currents in strangeness-conserving weak interactions. (C.E.S.)

81

32989 A SEARCH FOR THE PROCESS $\mu \rightarrow e + \gamma + \gamma$. Bartley, J. H.; Davies, H.; Muirhead, H.; Woodhead, T. (Univ. of Liverpool, Eng.). Phys. Letters, 16: 187(May 15, 1965).

Positive pions were stopped in a plastic scintillator and the process $\mu \rightarrow e + \gamma + \gamma$ was sought during the time interval 100 ns to 5 μs following the arrival of the pion. No events were recorded in the NaI crystals and the scintillation telescope. An upper limit of 2.4×10^{-6} was deduced for the branching ratio of $\mu \rightarrow e + \gamma + \gamma$ relative to $\mu \rightarrow e + \nu + \bar{\nu}$. (L.B.S.)

82

7734 RATE OF TRANSFER OF MUONS FROM pμ ATOMS TO THE NUCLEI OF OTHER ELEMENTS. Basiladze, S. G.; Ermolov, P. F.; Oganesyan, K. O. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 49: 1042-8(Oct. 1965). (In Russian).

The rate of transfer on a negative muon from a pμ atom to the nuclei of carbon, argon, and xenon is measured with a gas target arrangement filled with hydrogen up to 45 atm. The transfer rates obtained (referred to the density of normal liquid hydrogen) are $\lambda_C = (5.1 \pm 1.0) \times 10^{10}$ sec^{-1}; $\lambda_A = (12.0 \pm 1.9) \times 10^{10}$ sec^{-1} and $\lambda_{Xe} = (44.6 \pm 3.6) \times 10^{10}$ sec^{-1} can be satisfactorily approximated by the dependence $\lambda_Z \sim Z$. (auth)

83

35384 (JINR-P-2153) IZMERENIE SKOROSTI PEREKHODA MYUONA OT pμ-ATOMA K YADRAM DRUGIKH ELEMENTOV. (A Measurement of the Muon Transition Rate From a pμ-Atom to the Nuclei of Other Elements). Basiladze, S. G.; Ermolov, P. F.; Oganesyan, K. O. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 16p. Dep.(mn).

The rates of transfer of a negative muon from a pμ atom to nuclei of C, Ar, and Xe were measured, using an arrangement with a gaseous target, filled with H to 45-atm pressure, and scintillation counters. The values obtained for the rates are well fitted by $\lambda_i \sim z$. (auth)

84

16930 (NP-11592(Vol.I)(p.27-35)) PION PRODUCTION BY POSITIVE PIONS AT 820 AND 900 Mev. R. Barloutaud, C. Choquet, C. Gensollen, J. Heughebaert, A. Leveque, J. Meyer, and G. Viale ([France. Commissariat à l'Energie Atomique. Centre d'Études Nucléaires, Saclay]).

An analysis of scattering events concerning 800- to 900-Mev incident pions observed in a 35-cm hydrogen bubble chamber is presented. Results indicate but do not confirm the existence of T = 2 pion-pion interaction. (J.R.D.)

85

26120 π^+-P ELASTIC SCATTERING AT 820, 900 AND 1050 Mev. R. Barloutaud, C. Choquet-Louedec, A. Derem, J. Heughebaert, A. Leveque, and J. Meyer (Centre d'Études Nucléaires, Saclay, France). Phys. Letters, 1: 207-8 (June 15, 1962). (In English)

Elastic and inelastic cross sections were measured, and angular distributions in elastic interactions were determined at 820, 900, and 1050 Mev. The experiment was performed using a 35-cm hydrogen bubble chamber producing a 14700-gauss magnetic field. Calculations and data are presented in graphical and tabular forms. (L.N.N.)

86

10828 TWO-PION RESONANT STATE AT 575 Mev. Roland Barloutaud, Jacques Heughebaert, Antione Lévêque, Joao Meyer, and Roland Omnès (Centre d'Etudes Nucleaires, Saclay, France). Compt. rend., 254: 252-4(Jan. 8, 1962). (In French)

Evidence is found for the existence of a dipion (mass 575 ± 20 Mev, isobaric spin 1) by studying the inelastic π^+-p interaction at π^+ energies of 820, 900, and 1050 Mev. (tr-auth)

87

33062 THE $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ REACTION NEAR THE THRESHOLD. I. TOTAL CROSS-SECTIONS AND ANGULAR DISTRIBUTIONS OF SECONDARY PARTICLES. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 1: 526-32(Mar. 1965). (In Russian)

Total cross sections for six energy values and angular distributions of secondary particles from the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$, in the energy region 200–300 Mev, were measured. (auth)

88

903

THE CROSS SECTION OF π MESON RECHARGE BY π-MESON IN THE REACTION ANALYSIS $\pi^- + p \rightarrow \pi^- + \pi^+ + N$ AT THE ENERGY OF 290 Mev. Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz. 39, 506-9(1960) Aug. (In Russian)

Data on π-π interaction cross sections are tabulated and reactions $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ in the photoemulsion (200 events) are studied. The emulsions were irradiated by a π^- meson beam from a cyclotron; the mean energy of the primary π mesons, considering bremsstrahlung in the emulsion, was 290 ± 15 Mev. The data on π-π scattering S-wave lengths (in $\hbar/\mu_\pi$ c units) are tabulated and correlated with published data. Owing to discrepancies between the obtained data and various published data, new experiments are planned at 240 to 250 Mev. (R.V.J.)

89

47298 (AD-613934) NATURE OF THE RESONANCE IN THE STATIC PION-NUCLEON SCATTERING IN ONE-MESON APPROXIMATION. Barut, A. O.; Ruei, K. H. (Syracuse Univ., N. Y.). 1961. Contract AF49(638)-801. 12p. (AFOSR-880). CFSTI $1.00 cy, $0.50 mn.

Solution of the Chew-Low integral equation for the static p-wave meson-nucleon scattering was studied as a function of the coupling constant to deduce the nature of the 33-resonance. It is shown that a dynamical resonance must occur in association with either a bound state or with at least one more p-wave resonance. The possibility of a kinematical resonance is also discussed and the effective range formula was derived directly from the dispersion relation. (auth)

90

47357 ANALYSIS OF EXPERIMENTAL DATA CONCERNED WITH PION-PION SCATTERING. Baton, J. P.; Regnier, J. (CEN, Saclay, France). Nuovo Cimento (10), 36: 1149-63(Apr. 16, 1965). (In French).

Experimental information concerning the $\pi^-\pi^0$ and $\pi^-\pi^+$ elastic scatterings are analyzed with the goal of making precise the phase shifts of the first partial waves and in particular that of the I = 1, l = 1 state. It is shown that the results depend critically on the hypothesis made as to the connections between the actual $\pi\pi$ scattering and the observed phenomenon. As an example, two series of phase shifts are given, one corresponding to the approximation said to be of the physical region, the other corresponding to the assumption that the ρ is a resonance in the I = 1, l = 1 state. (tr-auth)

91

26211

FORMATION OF CHARGE-CARRYING MESONS BY 290-Mev NEGATIVE PIONS ON HYDROGEN. Yu. A. Batusov, N. P. Bogachev, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). Doklady Akad. Nauk S.S.S.R. 133, 52-5(1960) July 1. (In Russian)

The angular and energy characteristics of secondary particles from $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ at a primary π energy of 290 Mev were studied. The obtained distributions were correlated with those predicted by the Fermi statistical theory and the Lindenbaum and Sternheimer isobar model; good agreement was obtained for the energy distributions. However, the angular distributions do not agree. (R.V.J.)

92

2893

FORMATION OF π MESONS BY POSITIVE 280 Mev PIONS ON NUCLEI IN PHOTOEMULSION. Yu. A. Batusov, N. P. Bogachev, V. M. Sidorov, and I. Chulli. Doklady Akad. Nauk S.S.S.R. 128, 491-4(1959) Sept. 21. (In Russian)

Reactions $\pi^+ + \rho \rightarrow \pi^+ + \pi^+ + N$ and $\pi^+ + N \rightarrow \pi^+ + \pi^- + \rho$ in fast π^+ interactions with nuclei in photoemulsions were investigated. The $\pi^+ + N \rightarrow \pi^+ + \pi^- + \rho$ reaction cross section estimated using data on π^- meson production and considering the meson absorption in nuclei is equal to (0.3 ± 0.2)mb. The $\pi^- + \rho \rightarrow \pi^- + \pi^+ + N$ reaction cross section with the incoming π meson of 280 Mev energy is equal to 0.1 mb. Three events of $\pi^+ + \rho \rightarrow \pi^+ + \pi^+ + N$ and two events of $\pi^+ + \rho \rightarrow \pi^+ + \rho$ were observed in 106 spallations containing at least one π^+ meson. The cross section of the processes at 280 Mev is nearly 10^{-25} cm^2. (R.V.J.)

93

38012 (JINR-P-2806) DVOINAYA PEREZARYADKA π^--MEZONOV S ENERGIEI 50-176 Mev V FOTOEMUL'SII. (Double Charge Exchange of 50- to 176-Mev π^- Mesons in Photo Emulsion). Batusov, Yu. A.; Bunyatov, S. A.;

Ionitse, G.; Loznyanu, E.; Mikhul, V.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 5p. Dep. mn.

Total cross section measurements were made for double charge exchange of 50 to 176 Mev π^- mesons in photo emulsions. (tr-auth)

94

9790 **DETERMINATION OF THE CHARGE-EXCHANGE CROSS SECTION OF π-MESONS INTO π-MESONS FROM** THE ANALYSIS OF THE REACTION $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ AT 290 MeV. Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). p.79-82 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester. The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ was studied in order to test the validity of some of the theories about the amplitude and cross section of the charge exchange process. Data on π-π interaction cross sections and s-wave scattering lengths are given. (M.C.G.)

95

43273 (JINR-P-2238) DVOINAYA PEREZARYADKA π-MEZONOV NA YADRAKH Bi, C, Al, I Pb. (Double Charge Exchange of Pions on Be, C, Al, and Pb Nuclei). Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 8p. Dep. mn.

The total cross sections of double 80 Mev π^+ meson charge exchange on Be, Al and Pb nuclei and 140 Mev π^- mesons on Be, C and Pb nuclei were measured. (auth)

96

10243 (JINR-P-1837) DVOINAYA PEREZARYADKA π^--MEZONOV. (Double Charge of π^- Mesons). Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 5p. Dep.(mn).

A double charge exchange of mesons (π^+) at 30 to 80 Mev with 0.5×10^{-27} cm^2 nuclear cross section was used in investigations of double meson (π) charge exchange in various nuclei. It is shown that the probability of double charge exchange of mesons (π^+) increased with an increase of primary meson energy. All recorded events were related to the primary 40 to 87 Mev mesons with a meson (π^-) double charge exchange cross section of $(0.09 \pm 0.03) \times 10^{-27}$ cm^2, which is smaller than the cross section for meson (π^+) double charge exchange cross sections at identical energies. Stars with a small number of prongs are characteristic of nuclear spallations produced in meson(π^-) double charge exchange. Most of such stars (85%) have only secondary π^+ meson tracks. The mean number of charged particles per one star (not counting mesons (π) and electrons) is 0.18. A corresponding number of stars in double charge exchange of mesons (π^+) is 1.65. A picture of typical events of π^+ and π^- double charge exchange in nuclear emulsions is included. (R.V.J.)

97

40071 (JINR-E-2774) ^{8}He PRODUCTION IN NEGATIVE PION CAPTURE BY CARBON AND OXYGEN NUCLEI. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 8p. Dep. mn.

The events of ^{8}He production and decay in negative pion capture by carbon and oxygen nuclei were detected in photoemulsion. The probability of ^{8}He production is $(2-3)\ 10^{-6}$. The mass of ^{8}He was measured to $M_{He^8} = (7481.3 \pm 0.9)$ Mev. (auth)

98

44770 ^{8}He PRODUCTION IN NEGATIVE PION CAPTURE BY CARBON AND OXYGEN NUCLEI. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 22: 487-9(Sept. 1, 1966).

The events of ^{8}He production and decay in negative pion capture by carbon and oxygen were detected in photoemulsion. The probability of ^{8}He production is $(2-3) \times 10^{-6}$. The mass of ^{8}He was measured to be 7481.3 ± 0.9 Mev. (auth)

99

10016 (JINR-P-1823) REAKTSIYA $\pi^-p \rightarrow \pi^+\pi^-n$ VBLIZI POROGA. 1. POLNYE SECHENIYA, UGLOVYE RASPREDELENIYA VTORICHNYKH CHASTITS. (The Reaction $\pi^-p \rightarrow \pi^+\pi^-n$ Near the Threshold. I. The Total Cross Sections, Angular Distributions of Secondaries). Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 11p. Dep.(mn)

The total cross sections have been measured for six values of energy, in addition to measurements of the angular distributions of secondaries, from the reaction $\pi^-p \rightarrow \pi^+\pi^-n$ in the energy range of 200 to 300 Mev. (auth)

100

8138 (JINR-P-1838) REAKTSIYA $\pi^-p \rightarrow \pi^+\pi^-n$ VBLIZI POROGA II SPEKTRY EFFEKTIVNYKH MASS $\pi^+\pi^-$ I $\pi^\pm$n-SISTEM. OPREDELENIE DLIN π-π-RASSEYANIYA V. S-SOSTOYANII. (The Reaction $\pi^-p \rightarrow \pi^+\pi^-n$ Near the Threshold. II. The Effective Mass Spectra for $\pi^+\pi^-$ and π^+n-Systems. A Determination of $\pi\pi$ Scattering Lengths in the S-State). Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 10p. Dep.(mn).

The mass spectra of $(\pi^+\pi^-)$ and (π^+n) systems from the reaction $\pi^-p \rightarrow \pi^+\pi^-n$ in the 280 to 350 Mev energy range are investigated. The analysis of the energy and angular distributions of secondary particles with an accuracy up to the linear terms in relative momenta shows that the difference between the $(\pi\pi)$ scattering lengths is equal to $+(0.25 \pm 0.05)\ \hbar/\mu c$. (auth)

101

33070 THE $\pi^- p \rightarrow \pi^+ \pi^- n$ REACTION NEAR THE THRESHOLD AND $\pi\pi$-INTERACTION. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 1: 687-92(Apr. 1965). (In Russian)

The $\pi^+\pi^-$ and $\pi^+ n$-systems mass spectra from the reaction $\pi^- p \rightarrow \pi^+ \pi^- n$ were investigated. The energy and angular distributions of secondary particles were analyzed with accuracy up to linear terms in the relative momenta, and the difference of the lengths $a_0 - a_2$ for $\pi\pi$-scattering was found to be $+(0.25 \pm 0.05)\hbar/\mu c$. (auth)

102

9284 THE $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ REACTION AT AN ENERGY 240 Mev, AND $\pi\pi$-INTERACTION. Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 43: 2015-18(Dec. 1962). (In Russian)

The mass spectrum of a $\pi^+\pi^-$ system is investigated in the 280 to 350 Mev energy range. The spectrum is shifted with respect to phase volume towards large mass values, but no peculiarities of a resonance nature have been observed. Some arguments are presented to prove that the cause of the spectrum shift is $\pi\pi$ interaction in the final state. Possible causes of appearance of the anomaly in π-meson formation in the $p + d \rightarrow He^3 + \pi + \pi$ reaction are discussed. (auth)

103

9788 PRODUCTION OF CHARGED MESONS BY 245 MeV π^- MESONS ON HYDROGEN. Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). p.74-5 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25-September 1, 1960."

Preliminary results of a study of the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ at a primary meson energy of 245 ± 15 Mev are given. Momentum and angular distributions were compared with data obtained at 290 Mev. (M.C.G.)

104

9789 PRODUCTION OF CHARGED MESONS BY 290 MeV π^--MESONS ON HYDROGEN. Yu. A. Batusov, S. A. Bunyatov, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). p.76-8 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25-September 1, 1960."

Momentum spectra and angular distributions were determined for the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ at 290 ± 15 Mev. Results were compared to calculations made according to the statistical theory and the isobar model. (M.C.G.)

105

6038 INVESTIGATION OF LOW ENERGY $\pi^+\pi^-$ INTERACTION BY THE CHEW AND LOW METHOD. Yu. A. Batusov, S. A. Bunyatov, Ying-seb To, V. M. Sidorov, and V. A. Yarba (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 45: 913-20(Oct. 1963). (In Russian)

The $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ reaction in the 210- to 310-Mev range is analyzed. For events involving small momentum transfer to nucleons, the experimental data are linearly extrapolated to the nonphysical region by the Chew and Low method. The $\pi^+ + \pi^- \rightarrow \pi^+ + \pi^-$ elastic scattering cross section, for $\omega^2 = 4-7$ obtained by linear extrapolation is 34 ± 9 mb. (auth)

106

22435 (NP-12730) ON THE ELASTIC SCATTERING OF PROTONS AND PIONS ON NUCLEONS WITH LARGE MOMENTUM TRANSFERS. Yu. Bayukov, N. G. Birger, G. A. Leksin, and D. A. Suchkov (Akademiya Nauk S.S.S.R. (Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1962. 12p.

Momentum transfer as a function of energy was studied for pion-nucleon, nucleon-nucleon, and antiproton-proton scattering. An expression for the four-momentum transfer function was obtained from a cross section expression. Cross sections for the above interactions were studied as a function of incident energy; values obtained were used to evaluate the momentum function in a few intervals of four-momentum transfer. Results are graphically displayed. (D.C.W.)

107

30875 SPARK CHAMBER WITH SMALL NUMBER OF OBSTACLES ALONG PARTICLE TRAJECTORY. Yu. D. Bayukov, G. A. Leksin, D. A. Suchkov, and V. V. Telenkov. Pribory i Tekhn. Eksperim., No. 2, 45-7(Mar.-Apr. 1963). (In Russian)

A spark chamber and its high-voltage supply system are described. The chamber is part of an arrangement for the detection of secondary mesons in the reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$. The main feature of the chamber is the small number of obstacles along the particle trajectory. The chamber electrodes were made of aluminum foil of 7 μ thickness and formed four spark gaps. The chamber works well with meson (π) beams. (tr-auth)

108

21323 POLARIZATION IN π^--p SCATTERING BETWEEN 500 AND 940 Mev. E. F. Beall (Univ. of California, Berkeley), B. Cork, P. G. Murphy, W. A. Wenzel, C. M. P. Johnson, and L. J. Koester, Jr. Phys. Rev., 126: 1554-60(May 15, 1962).

A graphite-plate spark chamber has been used to analyze

the polarization of protons recoiling from π^--p scattering. The observations were made at 90° (cm system) pion scattering angle for seven incident pion energies between 500 and 940 Mev, at 120° or 135° for five energies in this interval, and also at 75° for 500 Mev only. The results are compared with predictions of several models used to explain the maxima in the π^--p scattering cross section. Qualitative arguments show that the energy intervals between these maxima are not completely dominated by neighboring single-state resonances. Phase shifts found to be large in scattering also seem to be large in polarization. (auth)

109

26555 (ORNL-3582(p.130)) WAVE FUNCTIONS FOR MUON CAPTURE IN THE HYDROGEN Mu-MOLECULAR ION. R. L. Becker (Oak Ridge National Lab., Tenn.).

In order to determine the coupling constants for the muon capture interaction from experimental capture rates in liquid hydrogen, an accurate muon wave function in the $p \rightarrow \mu - p$ molecule is needed. A calculation is described. (auth)

110

23704 ELECTRON AND π^0 MEASUREMENTS IN A HEAVY LIQUID BUBBLE CHAMBER. L. Behr and P. Mittner (Ecole Polytechnique, Paris). Nucl. Instr. Methods, 20: 446-7(Jan. 1963). (In English)

A method is described for determining the energy of electrons by curvature, based on simple trajectory parameters, the total length and the sagitta (measured at the middle point). The effect of bremsstrahlung on sagitta measurement is analyzed. Measurement of the momentum and mass of a π^0 is discussed briefly. (A.G.W.)

111

16242
ON THE APPLICABILITY OF FERMI-TELLER "Z LAW" TO URANIUM CONTAINING PHOTOEMULSION. G. E. Belovetskiĭ (Lebedev Inst. of Physics, Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz. 38, 658-60 (1960) Feb. (In Russian)

Experimental studies were made of uranium fission by slow π mesons in order to verify the previously obtained P_f value of 0.18 to 0.5. Evaluations of P_f with various assumptions show that π-meson capture by various atoms in emulsions containing uranium has a tendency to follow the Fermi-Teller law. 200-μ NIKF-B photoplates filled with uranyl acetate were used in the experiments. The number of uranium nuclei was determined by α emission. The admixture of μ^- mesons was equal to 20%. The P_f of uranium nuclei by μ^- mesons did not exceed 3% and was incorporated in the final results. The results show that the probability of π-meson capture has a tendency of following the "Z law" in proportion to the number of atoms. The data hold also for other mesons as atomic shell capture of mesons does not depend on the properties of the mesons. Consequently, the data obtained correlated with published data indicate that the probability of meson capture by various atoms in heterogeneous media depends on the structure of the medium. (R.V.J.)

112

39211 (JINR-P-2842) IDENTIFIKATSIYA ZARYAZHENNYKH CHASTITS PO IONIZATSII I δ-ELEKTRONAM V PROPANOVOI PUZYR'KOVOI KAMERE. (Identification of Charged Particles by Ionization and δ-Electrons in a Propane Bubble Chamber). Bem, Ya.; Grishin, V. G.; Kriventsova, A. G.; Muminov, M. M.; Trka, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1966. 13p. Dep. mn.

The results of ionization measurements of positive particles in a 24-liter propane chamber are given. It is found that for the particles with $pc \leq 1$ Bev, by this method it is possible to distinguish between protons and π^+ mesons. A computer program is worked out and the method of the identification of the particles with $pc \geq 1$ Bev by δ electrons is tested. The ranges of electrons and positrons with $E \leq 8$ Mev in propane are calculated. (auth)

113

16223
SEARCH FOR AN ELECTRIC DIPOLE MOMENT STRUCTURE OF THE MUON. David Berley and George Gidal (Columbia Univ., New York). Phys. Rev. 118, 1086-91 (1960) May 15.

A search was made for an electric dipole moment in the muon with a sensitivity of 0.1% of a muon Compton wavelength times the electronic charge. The motivation for this investigation is provided by the interest in finding some property of the muon which would indicate a structure different from that of the electron, even though such a structure would violate both parity conservation and time reversal invariance. The muons pass through the fringe field of the cyclotron and an additional system of magnets producing an electric field in their rest frame. Any electric dipole moment would precess about this field producing a vertical plane component of spin transverse to the momentum. This is detected by measuring the electron asymmetry in the plane perpendicular to the momentum. The absence of such a component within the stated sensitivity gives an upper limit to the electric dipole moment of the muons as 2×10^{-16} cm × the charge of the electron. (auth)

114

39780 π^--p INTERACTIONS AT 775 Mev. Bertanza, L.; Bigi, A.; Carrara, R.; Casali, R. (Univ., Pisa, Italy. Istituto Nazionale de Fisica Nucleare, Pisa, Italy). Nuovo Cimento (10), 44A: 712-25(Aug. 1, 1966).

The interactions of 775 Mev (kinetic energy) π^- mesons

in a hydrogen bubble chamber were studied. Total and partial cross sections were determined with the following results: σ (total) = (39.0 ± 1.6) mb, σ (elastic) = (14.8 ± 0.7) mb, σ ($\pi^- + p \rightarrow$ all neutrals) = (9.0 ± 0.5) mb, σ ($\pi^- + p = \pi^- + \pi^+ + n$) = (9.8 ± 0.5) mb, and σ ($\pi^- + p = \pi^- + p + \pi^0$) = (4.8 ± 0.3) mb. The elastic-scattering angular distribution was fitted with a Legendre polynomial series terminated at the fifth order. Various angular and effective-mass distributions of single-π production are presented and discussed in terms of the Olsson-Yodh and O.P.E. models. (auth)

115

15592 Λ^0-K^0 PRODUCTION BY PIONS ON PROTONS. L. Bertanza, P. L. Connolly, B. B. Culwick, F. R. Eisler, T. Morris, R. Palmer, A. Prodell, and N. P. Samios (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Letters, 8: 332-5(Apr. 15, 1962).

In the Brookhaven 20-in. hydrogen bubble chamber, $p-\pi^-$ interactions at 775, 791, 829, 871 Mev were observed in the form $\pi^- + p \rightarrow \Lambda^0 + K^0$, in which $\Lambda^0 \rightarrow \pi^- + p$ and $K^0 \rightarrow \pi^- + \pi^+$. Cross sections, angular distributions, and polarizations of Λ^0 as a function of energy were determined. Results agreed with previous data. The partial-wave amplitudes exhibit an energy behavior such that the d-wave amplitude became finite and significant at 829 Mev but was consistent with zero at 871 Mev. A ΛK resonance with mass ≈1650 Mev was suggested. (L.N.N.)

116

25504 THE INDUCED PSEUDOSCALAR AND TENSOR COUPLINGS IN THE PROCESS $\mu^- + {}^3He \rightarrow {}^3H + \nu$. A. Bietti (California Inst. of Tech., Pasadena). Nuovo Cimento (10), 37: 337-41(May 1, 1965).

The induced pseudoscalar and tensor coupling constants in the process $\mu^- + {}^3He \rightarrow {}^3H + \nu$ are calculated and compared with the Goldberger-Treiman relations. The calculations take into account the Gaussian and Irving wave functions. (C.E.S.)

117

39368 (NP-15089) ETUDE DES EFFETS QUADRUPOLAIRES SUR LES NIVEAUX D'ENERGIE DANS UN ATOME DE MANGANESE μ-MESIQUE (these). (Study of the Quadrupolar Effects on the Energy Levels in a μ-Mesic Manganese Atom (thesis)). Berthier, Louis (Lyon Univ. (France)). June 1965. 36p. Dep.(mn).

The energy levels of the μ-mesic atom caused by the monopolar potential are calculated for the case of a manganese atom that has captured a negative μ meson. It is shown that the existence of a quadrupolar potential causes a modification of these calculated energy levels. This perturbation is a method that can be used to define the size of the quadrupole moment of the nucleus. (J.S.R.)

118

9391 DETERMINATION OF THE μ^- TOTAL CAPTURE RATE IN LIQUID HYDROGEN. E. Bertolini, A. Citron, G. Gialanella, S. Focardi, A. Mukhin, C. Rubbia, and S. Saporetti (Istituto Nazionale di Fisica Nucleare, Rome and Bologna and CERN, Geneva). p.421-3 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

The total μ^- capture rate in liquid hydrogen was measured in a hydrogen bubble chamber. The result was R_{H_2} = 420 ± 75 sec^{-1}. (A.G.W.)

119

31012 (TID-21806) A MEASUREMENT OF THE BRANCHING RATIO FOR PION-BETA DECAY: R = $(\pi^+ \rightarrow \pi^0 + e^+ + \nu_e)/(\pi^+ \rightarrow \mu^+ + \nu_\mu)$ (thesis). William Keith Bertram (Michigan Univ., Ann Arbor). [1964]. Contract AT(11-1)-1112. 57p. Dep.(mn); $3.00(cy), 2(mn) CFSTI.

The pion beam is discussed, including beam optics and determination of electron and muon contamination. The detection system is described in detail, considering the scintillator-spark chamber gamma detectors, the beam counter telescope and spark chamber to record the stopping pion, the optical system for viewing and photographing the spark chambers, and the fast electronics and oscilloscope with camera to record the timing between the stopping pion and the gamma pulses from the π^0 decay. About 40,000 pictures were taken during two experimental runs. The processes used for data scanning and reconstruction, correcting for detection efficiency, gate efficiency, effective number of stopping pions, and scanning efficiency, and background subtraction are described. The branching ratio, calculated using 35 ± 3 events, was found to be (1.10 ± 0.26) × 10^{-8}, in agreement with the CVC and Cabibbo predictions and with other experimental results. (M.J.T.)

120

15042 (NYO-2243) MEASUREMENT OF THE "ISOTOPE EFFECT" IN THE NUCLEAR CAPTURE OF NEGATIVE MUONS BY CHLORINE AND INVESTIGATION OF THE VALIDITY OF THE FERMI-TELLER "Z-LAW" IN AgCl. (thesis). Walter J. Bertram, Jr. (Carnegie Inst. of Tech., Pittsburgh). Sept. 1960. Contract AT(30-1)-882. 55p.

Negative muons were used to study some of the interactions of these particles in various materials. Information on the interactions was obtained by analysis of the time distribution of the electrons resulting from the decay of muons brought to rest in the material. The isotope effect in the nuclear capture of negative muons was studied in separated isotopes of chlorine. The ratio of the capture rates in the two stable isotopes was determined to be $\lambda_c(Cl^{37})/\lambda_c(Cl^{35})$ = 0.694 ± 0.034. This effect is larger than that of the ratio of 0.782 predicted by the general theory of Primakoff. Studies were also made of the validity of the Fermi-Teller Z-law, which predicts the probability of a negative meson becoming bound to a particular atomic species when the mesons are brought to rest in a chemical compound. These studies indicate that in AgCl, the muons are captured in equal numbers by the Ag and Cl atoms and not in the proportions predicted by the Z-law. The lifetimes of negative muons were measured in Ag, Cl, and F

and found to be 91.5 ± 2.3 nsec, 0.437 ± 0.022 μsec, and 1.217 ± 0.080 μsec, respectively. (D.L.C.)

121

20836
OBSERVATION OF THE "ISOTOPE EFFECT" IN THE NUCLEAR CAPTURE OF NEGATIVE MUONS BY CHLORINE. W. J. Bertram, Jr., R. A. Reiter, T. A. Romanowski, and R. B. Sutton (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters 5, 61-2(1960) July 15.

The isotope effect in meson (μ^-) capture by chlorine isotopes was determined with the following experimental arrangement: a 43-Mev μ^- beam from the CIT synchrocyclotron was passed through an aperture into Helmholtz coils containing enriched AgCl targets. Mesons (μ^-) and electrons stopped in the target were indicated by a setup of coincidence-anticoincidence counters. The data were analyzed on an IBM-650 computer, giving disappearance rates of $22.54 \pm 0.52 \times 10^5$ and $17.03 \pm 0.49 \times 10^5$ sec^{-1} and capture rates of $18.02 \pm 0.49 \times 10^6$ and $12.51 \pm 0.52 \times 10^5$ sec^{-1} for mesons (μ^-) in Cl^{35} and Cl^{37}, respectively. This gives a ratio of capture rates of 0.694 ± 0.034, confirming the theoretical expectation of a strong isotope effect in meson (μ) capture. (D.L.C.)

122

40280 DO NEUTRINOS INTERACT BETWEEN THEMSELVES? Z. Bialynicka-Birula (Inst. of Physics, Warsaw). Nuovo Cimento (10), 33: 1484-7(Sept. 1, 1964).

The question of whether present experimental data allow for the existence of interactions between neutrinos much stronger than their weak interactions. It is found that such interactions even if they were 10^6 times stronger than weak interactions could not be detected with the present experimental accuracy. The existence of Fermi-type interactions between various neutrinos is assumed. The influence of such an interaction on the properties of several processes is investigated. The meson (μ) decay, meson ($\pi^\pm$) and ($K^\pm$) decay into a meson (μ) and three neutrinos, and the production of electrons by meson (μ)-associated neutrinos on nucleons are considered. The comparison of the theoretical calculations with experimental results gives the upper limit for the coupling constant in the assumed neutrino interaction. (C.E.S.)

123

34915 SPECTRUM OF SMALL BURSTS CREATED BY μ-MESONS AT THE DEPTH OF 200m w.e. UNDERGROUND. Bibilashvili, M. F.; Barnaveli, T. T.; Grubelashvili, G. A.; Muradova, N. A. (Inst. of Physics, Academy of Sciences, Tbilissi, USSR). Phys. Letters, 17: 175-6(July 1, 1965).

A spark calorimeter was found to be advantageous in the detection of small bursts created by mesons (μ). Such a calorimeter containing five rows of spark chambers separated with lead filters was placed underground at a depth of 200 mwe. Each chamber was filled with neon of high purity at a pressure of one atmosphere. The obtained integral spectrum of bursts can be described by an exponential law with the exponent $\gamma = -2.3^{+0.4}_{-0.3}$. (J.F.P.)

124

12433 (NEVIS-102) THE SCATTERING OF 6-24 MEV NEGATIVE PIONS BY HYDROGEN. Enid Bierman (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Cyclotron Labs.). Feb. 1962. Contract AT(30-1)-1932. 29p.

The scattering of negative pions at laboratory energies between 6 and 24 Mev was observed in a liquid H bubble chamber. The energy of each scattering was deduced from the ranges and angles of the scattered pion and recoil proton. Flux was measured by direct count of tracks of stopped pions. A maximum likelihood analysis was performed treating the strength of the small P-wave contribution as known. Based on 246 scattering events at a median energy of 13 Mev, the S-wave scattering length $a = (2\alpha_1 + \alpha_3)/3\eta$ is found to be 0.090 ± 0.005 when the large Coulomb contribution is assumed to be the non-relativistic amplitude for pure Coulomb scattering. Results are also presented with further Coulomb corrections. Values of α_1 are computed from the combination of this experimental result with experiments on $\pi^+ - p$ scattering. (auth)

125

26561 ABSORPTION TIME OF NEGATIVE PIONS IN LIQUID HYDROGEN. E. Bierman, S. Taylor, E. L. Koller, P. Stamer, and T. Huetter (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Letters, 4: 351-3(May 15, 1963). (In English)

Measurements of mesons (π^-) stopping in liquid hydrogen are reported. The mean time for the meson (π^-) to go from v/c = 0.006 to nuclear capture is found to be $(2.0 \pm 0.6) \times 10^{-12}$ sec. The depth of the decay point, the meson (μ) range, and the decay angle, together with their errors, are calculated. (C.E.S.)

126

19338 ASYMMETRY PARAMETER OF NEUTRONS AND TRITONS FROM THE CAPTURE OF POLARISED μ^- IN ^{4}He. A. Bietti (Università, Rome and Instituto Nazionale di Fisica Nucleare, Rome). Phys. Letters, 4: 63-4(Mar. 1, 1963). (In English)

The asymmetry parameters of the recoil nuclei and the emitted neutrons were measured for polarized mesons(μ) capture by spin zero nuclei, in $\mu^- + He^4 \rightarrow H^3 + n + \nu$. The triton and neutron spectra give information about the coupling constants of the process, the pseudoscalar term, and the weak magnetism term. (C.E.S.)

127

6533 DIFFERENTIAL CROSS-SECTION OF THE $\pi^- + p \rightarrow \pi^0 + n$ PROCESS AT 930 Mev. A. Bigi, R. Carrara, and D. Zanello (Università, Pisa, Italy; Istituto Nazionale de Fisica Nucleare, Pisa, Italy; and Scuola Normale Superiore, Pisa, Italy). Nuovo Cimento (10), 34: 878-82 (Nov. 16, 1964).

A bubble chamber study of π-p charge-exchange scattering at 930 Mev is reported. The forward differential cross-section is derived and compared with the result obtained on the basis of dispersion relations and the charge-independence hypothesis. Satisfactory agreement is obtained. (auth)

128

19104 MEASUREMENT OF g/m FOR MUONS. G. McD. Bingham (Univ. of California, Berkeley). Nuovo Cimento (10), 27: 1352-8(Mar. 16, 1963). (UCRL-10346) (In English)

A free-running "muon stroboscope" was used to measure the ratio of the precession frequencies of muons (f) and protons (f_p) in water for the same magnetic field. The stroboscope frequency was 200 Mc. The results obtained were: positive muons stopping in bromoform $(f/f_p)^+ = 3.18336 \pm 0.00007$, and negative muons stopping in water $(f/f_p)^-_{H_2O} = 3.1808 \pm 0.0004$. The first ratio was assumed to be also that of the free particles, and led to the following values for $(g/m)^+$ and m^+: $(g/m)^+ = (9.6840 \pm 0.0002) \times 10^{-3}\ m_e^{-1}$, $m^+ = (206.766 \pm 0.005)\ m_e$ where m_e = the electron mass. A diamagnetic correction was applied to the second ratio and an equivalent value $(g/m)^-_{H_2O}$ was obtained for negative muons stopping in water: $(g/m)^-_{H_2O} = (9.6760 \pm 0.0013) \times 10^{-3}\ m_e^{-1}$. Assuming equal masses for positive and negative muons, $(g^-(H_2O) - g^+)/g^+ = -(8.3 \pm 1.4) \times 10^{-4}$. Analyzing and correcting the experimental results, $m^+ = (206.765 \pm 0.002)\ m_e$ and $(g^-(H_2O) - g^+)/g^+ = -(8.9 \pm 0.8) \times 10^{-4}$. (auth)

129

28654 SCATTERING OF COSMIC RAY MUONS BY LEAD AT A MOMENTUM BETWEEN 200 AND 1500 Mev/c. G. Bizard, J. Duchon, J. Milliard, J. P. Patry, M. Scherer, and J. Sequinot (Faculte des Sciences, Caen, France). Nucl. Phys., 56: 385-93(Aug. 1964). (In French)

Results on muon scattering in lead are given for cosmic rays in the momentum interval 200 to 1500 Mev/c. Two Wilson chambers were used, one with magnetic field, the other with lead screens. Results are in better accord with Olbert's theory than with Molière's. (auth)

130

42715 EXPERIMENTAL DETERMINATION OF THE TOTAL CAPTURE RATE OF NEGATIVE MUONS IN ^{4}He. R. Bizzarri, E. Di Capua, U. Dore, G. Gialanella, P. Guidoni, and I. Laakso (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). Nuovo Cimento (10), 33: 1497-1508(Sept. 16, 1964).

The total rate for nuclear capture of negative muons in ^{4}He was measured in the liquid-helium bubble chamber. A rate of $(336 \pm 75)\ s^{-1}$ is obtained in agreement with the theoretical predictions. The nuclear recoil spectrum from 930 captures of negative pions is also given. (auth)

131

9579 A MEASUREMENT OF μ^- TOTAL CAPTURE RATE IN He^4. R. Bizzarri, E. Di Capua, U. Dore, G. C. Gialanella, P. Guidoni, and I. Laakso (Università, Rome and Instituto Nazionale di Fisica Nucleare, Rome). Phys. Letters, 3: 151-2(Dec. 15, 1962). (In English)

The total capture rate of μ^- mesons in He^4 has been measured with a slow, high-purity muon beam and a helium bubble chamber. The range spectrum of nuclear recoils is given for the events and compared to recoils from π^- stars. When corrected for π^- contamination, the number of muon captures in the events was determined. The capture rate obtained is $950 \pm 90\ sec^{-1}$, in good agreement with theory. (H.D.R.)

132

1661 A MEASUREMENT OF μ^- TOTAL CAPTURE RATE IN He^4. R. Bizzarri, E. di Capua, U. Dore, G. Gialanella, P. Guidoni, and I. Laakso (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). p.21-3 of "Proceedings of the Sienna International Conference on Elementary Particles. Vol. I." Bologna, Societa Italiana di Fisica, 1963.

The total capture rate of μ^- mesons in ^{4}He was measured by exposing the Rome University liquid He bubble chamber to the CERN slow μ^- beam. Scanning of the pictures gave 123,000 decays and 304 non-decaying stopping tracks. After subtraction of π^- background, a capture rate of $340 \pm 65\ s^{-1}$ was obtained. Studies of proton background still in progress may result in a small correction. (A.G.W.)

133

42732 ISOTOPIC EFFECTS IN THE X-RAY SPECTRUM OF MUONIC ATOMS OF Ca^{40} AND Ca^{44}. J. A. Bjorkland (Argonne National Lab., Ill.), S. Raboy, C. C. Trail, R. D. Ehrlich, and R. J. Powers. Phys. Rev., 136: B341-6(Oct. 26, 1964).

The 2p — 1s transitions in muonic atoms of ^{44}Ca and ^{40}Ca were compared by use of a NaI(Tl) scintillation spectrometer with an anticoincidence annulus of NaI(Tl). It was found that the energy of the 2p — 1s transition in ^{40}Ca is 0.9 ± 0.3 kev greater than that in ^{44}Ca. (auth)

134

34552 RESULTS OF A SEARCH FOR π^+-π^- RESONANCE IN THE DIPION MASS REGION 280-350 Mev. I. M. Blair, G. Conforto, C. Rubbia, G. Torelli, and E. Zavattini (CERN, Geneva). Phys. Letters, 11: 79-

82(July 1, 1964).

An experiment is described for investigating the effects of the π-π final-state interaction in $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ at 285 Mev. The ($^3/_2$, $^3/_2$) meson (π)-nucleon resonance was eliminated by event selection. Triggered spark chamber photographs were used in the analysis. The existence of the ω_{ABC} (O^{++}) resonance is included. (R.E.U.)

135

775 A MEASUREMENT OF THE CAPTURE RATE OF NEGATIVE MUONS IN VARIOUS ELEMENTS. I. M. Blair, H. Muirhead, and T. Woodhead (Univ. of Liverpool). Proc. Phys. Soc. (London), 80: 945-6(Oct. 1, 1962).

A measurement of the lifetime and capture rate of negative muons in various elements is reported. The timing system was calibrated in terms of the accurately known positive muon lifetime. The values obtained are in reasonable agreement with previous experimental data, and have a comparable accuracy. (auth)

136

774 THE EFFECT OF ATOMIC BINDING ON THE DECAY RATE OF NEGATIVE MUONS. I. M. Blair, H. Muirhead, T. Woodhead, and J. N. Woulds (Univ. of Liverpool). Proc. Phys. Soc. (London), 80: 938-44(Oct. 1, 1962).

A measurement of the decay rate of bound negative muons in several elements ranging from vanadium to lead is reported. The results are given as a fraction of the free decay rate. They contradict the anomalously high values previously obtained in the iron region by other workers, and are also in better agreement with recent theoretical predictions for the heavy elements. (auth)

137

39779 SEARCH FOR A RESONANT π-π INTERACTION IN THE PROCESS $\pi^-p \rightarrow \pi^+\pi^-n$ NEAR THRESHOLD. Blair, I. M.; Torelli, G.; Zavattini, E. (CERN, Geneva). Nuovo Cimento (10), 44A: 071-97(Aug. 1, 1966).

The π-π interaction in the final state of the process $\pi^-p \rightarrow \pi^+\pi^-n$ was investigated at an incoming kinetic energy of 276 Mev. No resonant behavior was found in the invariant-mass range examined ((280 to 350) Mev). The π-π mass distribution is discussed and compared with other experimental and theoretical results. (auth)

138

15583 MUON CAPTURE IN LIQUID HYDROGEN. E. Bleser, L. Lederman, J. Rosen, J. Rothberg, and E. Zavattini (Columbia Univ., New York). Phys. Rev. Letters, 8: 288-90(Apr. 1, 1962).

The reaction $\mu^- + p \rightarrow n + \nu$ was studied; μ^- were stopped in liquid H, and the 5.2 Mev neutrons were detected in liquid scintillation proton recoil counters. Results agree with the bubble chamber capture rate (R.H. Hildebrand, Phys. Rev. Letters, 8: 34(1962)). The $(p\mu p)^+$ molecular ion state was dominant over the μp atom in the 1s state. (L.N.N.)

139

10892 μ-MESONIC MOLECULES IN LIQUID HYDROGEN. E. Bleser, L. Lederman, J. Rosen, J. Rothberg, and E. Zavattini (Columbia Univ., New York). Phys. Rev. Letters, 8: 128-31(Feb. 1, 1962).

Muon catalysis of the reaction $p + d \rightarrow He^3 + Q$ (5.4 Mev) is studied in order to obtain information on the reaction $\mu^- + p \rightarrow n + \nu$ in liquid hydrogen. Observation of the molecular systems pμp and pμd and measurement of the fusion rate initiated in an s state are thus facilitated. The yield of fusion γ from pure hydrogen is measured as a function of time relative to μ stopping at six D concentrations. (L.N.N.)

140

13666 (NYO-9280) EXPERIMENTS ON THE ABSORPTION OF POLARIZED NEGATIVE MU MESONS BY C^{12}. Bernard L. Bloch (Carnegie Inst. of Tech., Pittsburgh). Nov. 1960. Contract AT(30-1)-882. 90p.

Experiments performed in an effort to supply evidence for the universality of the V-A theory in weak interactions and for the law of conservation of leptons are described. In the first part, the production rate of B^{12} by the absorption of negative μ mesons in carbon was measured. From the amplitudes of the muon decay curve and the boron decay curve, the rate was calculated to be $(5.8 \pm 1.3) \times 10^3$ sec^{-1}, in agreement with the hypothesis of a universal V-A theory. In the second part, an attempt was made to measure the helicity of negative μ mesons by stopping longitudinally polarized muons in a carbon target and observing the electron asymmetry in the β-decay of the spin-1 B^{12}. The results of this part were inconclusive, a consequence attributed to a short boron thermal relaxation time. (auth)

141

1662 EXPERIMENTAL CAPTURE RATE FOR MUONS IN He^4. M. M. Block (Northwestern Univ., Evanston, Ill.). T. Kikuchi, D. Joetke, M. Schneeberger, C. R. Sun, R. Walker, G. Culligan, V. L. Telegdi, and R. Winston. p.26-9 of "Proceedings of the Sienna International Conference on Elementary Particles. Vol. I." Bologna, Societa Italiana di Fisica, 1963.

A muon beam obtained by converting the internal 400-Mev proton beam of the Chicago cyclotron to π^- in a Be target was directed into a liquid He bubble chamber. Scanning of the film showed 136×10^3 μ^- decays and 108 captures in the ^{4}He. The capture rate obtained was 364 ± 46 sec^{-1}. This result is consistent with other experiments within quoted errors. (A.G.W.)

142

26524 (BNL-837(p.309-13)) EXPERIMENTAL CAPTURE RATE FOR MUONS IN He^4. M. M. Block, T. Kikuchi, D. Koetke, M. Schneeberger, C. R. Sun, R. Walker (Northwestern Univ., Evanston, Ill.); G. Culligan, V. L. Telegdi, and R. Winston (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies).

The branching ratio of nuclear capture to decay of negative muons stopping in a liquid helium bubble chamber was measured. The capture rate is found to be 368 ± 46 sec^{-1}. (M.J.T.)

143

43356 MODERATION AND CASCADE TIMES OF NEGATIVE PIONS AND NEGATIVE KAONS IN LIQUID HELIUM. Block, M. M.; Kopelman, J. B.; Sun, C. R. (Northwestern Univ., Evanston, Ill.). Phys. Rev., 140: B143-52(Oct. 11, 1965).

Measurements were made of the mean moderation times $T_{\pi}^{He}(v_A)$ and $T_K^{He}(v_A)$, spent by π^- and K^-, respectively, in atomic orbits before nuclear capture in the Northwestern helium bubble chamber. It was necessary to resolve the velocities of π^- (or K^-) down to $v \approx 0.02c$. The resolution was obtained in the pion case by measuring the μ^- range from $\pi^- \to \mu^- \to e^-$ decays and in the kaon case by the kinematic analysis of the τ-decay mode. The following results are obtained: $T_{\pi}^{He}(0.02c) = (3.19 \pm 0.23) \times 10^{-10}$ sec, and $T_K^{He}(0.02c) = (2.4 \pm 0.4) \times 10^{-10}$ sec. These measured times are two orders of magnitude longer than that predicted by Day assuming dominant Stark effect and thus S-state capture. A recent calculation by Russell reduces the rate of Stark effect yet predicts cascade times still five times shorter than our experimental values. Thus the angular-momentum states of K^- capture in liquid helium, whose determination was the motivation for the present experiments, are still unknown without a detailed understanding of the de-excitation mechanism of the K-mesonic atom. (auth)

144

901 MODERATION TIME FOR NUCLEAR CAPTURE OF NEGATIVE PIONS IN LIQUID He^4. M. M. Block (Northwestern Univ., Evanston, Ill.), T. Kikuchi, D. Koetke, J. Kopelman, C. R. Sun, R. Walker, G. Culligan, V. L. Telegdi, and R. Winston. Phys. Rev. Letters, 11: 301-3 (Sept. 15, 1963).

A beam of slow mesons(π^-) was introduced into a He^4 bubble chamber to measure the mean time spent by a meson(π^-) in going from an initial velocity to nuclear capture and to obtain an accurate range spectrum of the prong produced in the nuclear capture of a meson(π^-) by He^4. (C.E.S.)

145

2682 (JINR-P-2320) ANALIZ REAKTSII $\pi^- + p \to \pi^- + \pi^+ + n$ I $\pi^- + p \to \pi^- + \pi^0 + p$ PRI KINETICHESKOI ENERGII π^--MEZONOV 338 Mev. (Analysis of $\pi^- + p \to \pi^- + \pi^+ + n$ AND $\pi^- + p \to \pi^- + \pi^0 + p$ REACTIONS AT THE π^- Kinetic Energy of 338 Mev). Blokhintseva, T. D.; Grebinnik, V. G.; Zhukov, V. A.; Libman, G.; Nemenov, L. L.; Selivanov, G. I.; Yuang Rung-fang (Joint Inst. for Nuclear Research, Dubna (USSR), Lab. of Nuclear Problems). 1965. 12p. Dep. mn.

The differences in the cross sections of the isobar channels for the $\pi^- + p \to \pi^-\pi^+ + n$(I) and $\pi^- + p \to \pi^-\pi^0 + p$(II) reactions are determined at the π^- meson kinetic energy of 338 Mev. If the isobar transitions occur in $T = 1/2$ state the total cross section for (II) within the experimental error is equal to the sum of the cross sections of the isobar channels. Under this assumption the total cross section for (I) is not described by the sum of the cross sections of the corresponding isobaric channels. The effect of $\pi\pi$ interaction manifests itself in the $\pi^+\pi^-$ effective mass spectrum but not in the $\pi^-\pi^0$ mass spectrum. The presence of the $(3/2,3/2)$ isobar affects the angular distributions of secondary particles from (I). (auth)

146

43044 (JINR-P-2255) ISSLEDOVANIE REAKTSII $\pi^- + p \to \pi^- + \gamma + p$ PRI ENERGII 338 Mev. (An Investigation of the Reaction $\pi^- + p \to \pi^- + \gamma + p$ at 338 Mev). Blokhintseva, T. D.; Grebinnik, V. G.; Libman, G.; Zhukov, V. A.; Nemenov, L. L.; Selivanov, G. I.; Yuang Rung-Fang (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 21p. Dep. mn.

From the analysis of the reaction $\pi^- + p \to \pi^- + \gamma + p$ the constant of the process $\gamma + \pi \to \pi + \pi$ was determined. (auth)

147

25859 ANALYSIS OF THE REACTIONS $\pi^- + p \to \pi^- + \pi^+ + n$ AND $\pi^- + p \to \pi^- + \pi^0 + p$ WITH 338-Mev π^- MESONS. Blokhintseva, T. D.; Grebinnik, V. G.; Zhukov, V. A.; Libman, G.; Nemenov, L. L.; Selivanov, G. I.; Yuan, Jung-fang (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 3: 687-92(Apr. 1966). (In Russian).

The differences of the cross section in the $\pi^- + p \to \pi^- + \pi^+ + n$ (I) and $\pi^- + p \to \pi^- + \pi^0 + p$ (II) reactions were determined for the kinetic energy of the π^--mesons 338 Mev. Under the assumption that the isobar transitions occur in the $T = 1/2$ state, the total cross section of the reaction (II) is equal to the sum of the isobar channel cross sections within the experimental errors. Under the same assumption the total cross section of the reaction (I) is not described by the sum of the corresponding isobar channel cross sections. The influence of the $\pi\pi$-interaction shows up in the effective mass spectrum of the $\pi^+\pi^-$-system, but not of the $\pi^-\pi^0$ one. The $3/2$ $3/2$ isobar influences the angular distribution of secondary particles from reaction (I). (auth)

148

37607 DETERMINATION OF THE CONTRIBUTION OF THE (3/2, 3/2) ISOBAR TO THE INELASTIC $\pi^- p$ INTERACTION PROCESSES AT 344 Mev MESON KINETIC ENERGY. Blokhintseva, T. D.; Grebinnik, V. G.; Zhukov, V. A.; Kravtsov, V. A.; Libman, G.; Nemenov, L. L.; Selivanov, G. I.; Yuan, Jung-fang (Joint Inst. for Nuclear Research, Dubna, USSR). Soviet J. Nucl. Phys. (English Transl.), 1: No. 1, 71-7(July 1965).

Translated from Yadern. Fiz., 1: 103-12(Jan. 1965).

By analyzing the difference of the distributions of the

number of interactions $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ with respect to the total center of mass energy for $\pi^- - n$ and $\pi^+ - n$ interactions, the contribution of the $(3/2, 3/2)$ isobar to the cross section of the interaction is determined at an initial meson (π^-) energy of 344 Mev. An analogous analysis is performed for data obtained at 290 and 360 Mev. It is shown that the difference of the cross section is related to the transition $D_{3/2} \rightarrow SP_{3/2}$. The possibility of determining $\pi - \pi$ scattering lengths from an analysis of this transition is indicated. (auth)

149

3024 (JINR-P-1746) OPREDELENIE VKLADA IZOBARY 3/2,3/2 V PROTSESSY π^--p-VZAIMODEISTVIYA PRI KINETICHESKOI ENERGII π-MEZONOV 344 Mev. (A Determination of the 3/2, 3/2 Isobar Contribution to the Inelastic π^--p Interaction Processes at the Kinetic Energy of Negative Pions of 344 Mev). T. D. Blokhintseva, V. G. Grebinnik, V. A. Zhukov, A. V. Kravtsov, G. Libman, L. L. Nemenov, G. I. Selivanov, and Jung-fang Yuan (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 19p. Dep.(mn).

By analyzing the difference between the π^-n and π^+n effective mass distributions of the reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$, the contribution of the N^*_{33} isobar to the cross section of the reaction was determined. The energy of primary negative pions was 344 Mev. A similar analysis was made for the data obtained at negative pion energies of 290 and 360 Mev. The difference of the cross sections for the isobar channels shown to correspond to the transition $D_{3/2} - sp_{1/2}$ was found. A possibility of determining the $\pi\pi$-scattering lengths from the analysis of this transition is indicated. (auth)

150

27884 EVALUATION OF CROSS SECTIONS OF ELECTROMAGNETIC PROCESSES $\pi^- + p \rightarrow \pi^+ + \pi^- + \gamma + n$, $\pi^- + p \rightarrow e^+ + e^- + n$, $\pi^- + p \rightarrow \pi^- + p + e^+ + e^-$ AT π^- MESON KINETIC ENERGY OF 340 Mev. **Blokhintseva, T. D.; Grebinnik, V. G.; Zhukov, V. A.; Kravtsov, A. V.; Libman, G.; Nemenov, L. L.; Selivanov, G. I.; Yuan, Jung-fang** (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 3: 779-81(Apr. 1966). (In Russian).

The interactions were studied by scanning 250,000 photographs obtained on a hydrogen bubble chamber exposed to a 340-Mev pion beam. Upper bounds are found for the differential cross sections of the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + \gamma + n$, assuming there is a single event of this type in the region with $M^2 > 1020$ Mev$^2/c^4$, where M is the neutral mass in events with the formation of a π^+ meson, and of the reaction $\pi^- + p \rightarrow e^+ + e^- + n$, for the ratio of the e^-e^+-pair invariant mass to the pion mass greater than one. A cross section of 1.6×10^{-30} cm^2 was found for the reaction $\pi^- + p \rightarrow \pi^- + p + e^+ + e^-$ from the analysis of three events. (M.J.T.)

151

2165 (JINR-P-1056) VZAIMODEISTVIE π^--MEZONOV S VODORODOM PRI ENERGII 340 Mev. (Interactions of π^- Mesons with Hydrogen at 340 Mev). T. D. Blokhintseva, V. G. Grebinnik, V. A. Zhukov, G. Libman, L. Nemenov, G. I. Selevanov, and Jung-fang Yün (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 28p.

A 25-cm liquid hydrogen bubble chamber placed in a magnetic field was used in studies of $\pi^- + p \rightarrow \pi^- + \pi^+ + n^+ + n$, $\pi^- + p \rightarrow \pi^- + \pi^0 + p$, and $\pi^- + p \rightarrow \pi^- + \gamma + p$ reactions at a π^- energy of 340 ± 15 Mev. Measurements of the total cross sections showed that π meson interactions at scattering length T = 0 is considerably stronger than at T = 2. The angular distributions of secondary particles and the distributions at total center-of-mass energy for π^+ n, π^- n, and $\pi^+ \pi^-$ were found. (tr-auth)

152

25853 INVESTIGATION OF THE REACTION $\pi^- + p \rightarrow \pi^- + \gamma + p$ AT 338 Mev. **Blokhintseva, T. D.; Grebinnik, V. G.; Zhukov, V. A.; Libman, G.; Nemenov, L. L.; Selivanov, G. I.; Yuan, Jung-fang** (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 3: 511-20(Mar. 1966). (In Russian).

An analysis of 84 events indicates the constant for photon production in $\pi^- + p$ interactions is 0.5 ± 0.3. (J.F.P.)

153

18402 MEASUREMENTS OF TOTAL $\pi^- - p$ REACTION CROSS SECTION FOR 340-Mev π^- MESONS. T. D. Blokhintseva, V. G. Grebinnik, V. A. Zhukov, G. Libman, L. L. Nemenov, G. I. Selivanov, and Jung-fang Yuan (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 42: 912-13(Mar. 1962). (In Russian).

The reactions $\pi^- + p \rightarrow \pi^- + \pi^+ + n$, $\pi^- + p \rightarrow \pi^- + \pi^0 + p$, and $\pi^- + p \rightarrow \pi^- + \gamma + p$ at a π^- energy of 340 ± 15 Mev were measured with a 25-cm liquid-hydrogen chamber placed in a magnetic field of 12000 gauss. The total cross sections were found to be $\sigma_1 = 1.24 \pm 0.14$ mb, $\sigma_2 = 0.13^{+0.06}_{-0.04}$ mb, $\sigma_3 = 0.09^{+0.03}_{-0.06}$ mb, respectively. (R.V.J.)

154

19171 TOTAL CROSS SECTIONS FOR THE π^-p-REACTIONS AT 276 Mev. T. D. Blokhintseva, V. G. Grebinnik, V. A. Zhukov, G. Libman, L. L. Nemenov, G. I. Selivanov, and Yung-fang Yuan (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 498-9(Feb. 1963). (In Russian)

The total cross sections for the $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ and $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ reactions at (276 + 10) Mev are measured with a liquid by hydrogen bubble chamber in a magnetic field. The experimental data are compared with theoretical predictions. (auth)

155

10948 MEASUREMENT BY BREMSSTRAHLUNG TRANSMISSION OF THE POLARIZATION OF e^+ FROM $\mu^+ \rightarrow e^+ + \nu_e + \nu^-\mu$. S. Bloom, L. A. Dick, L. Feuvrais,

G. R. Henry, P. C. Macq, and M. Spighel (CERN, Geneva). Phys. Letters, 8: 87-9(Jan. 1, 1964).

The polarization of the positron was measured by observing the transmission through magnetized iron of circularly polarized bremsstrahlung from the positron. The positrons were found to be right-handed with a polarization of 94 ± 38%, in agreement with the prediction of the V-A theory. (D.C.W.)

156

15141 TWO NEUTRINOS OR ONE? S. A. Bludman (Univ. of Pennsylvania, Philadelphia). Nuovo Cimento (10), 27: 751-60(Feb. 1, 1963). (UCRL-10449) (In English)

The value is discussed, in the light of "two-neutrino" experiments, of giving meaning to the neutrino charge or lepton number independent of helicity (i.e., of giving up the two-component neutrino theory and reverting to a single four-component neutrino, whose left- and right-helicity states are coupled to e^- and μ^+ respectively). It is shown that, in fact, only by such experiments, involving muons and electrons or their neutrinos, can a nontrivial meaning be given to lepton conservation. This Dirac neutrino theory is compared with the conventional theory of two two-component neutrinos from the conceptual and experimental points of view. Remarks are made about the possibility of explaining the $\mu-e$ mass difference. (auth)

157

40096 SOME REGULARITIES IN THE ANGULAR DISTRIBUTION OF NEUTRONS EMITTED IN POLARIZED μ-MESON CAPTURE BY NUCLEI. Bobodzhanov, I. B.; Kashkarov, L. L. Dokl. Akad. Nauk Tadzh. SSR, 7: No. 4, 12-15(1964). (In Russian).

The reaction $\mu^- + (A,Z) \rightarrow (A-1;\ Z-1) + n + \nu$ with polarized mesons (μ^-) on Cu, Fe, and Pb was investigated using cosmic radiation. The coefficient of asymmetry $a_n = b\ (1 - C)/(1 + C)$, where b accounts for the experimental geometry and C is the ratio of neutrons emitted in the same direction and the opposite direction as the mesons (μ^-), was -0.062 ± 0.054, -0.066 ± 0.81, and -0.079 ± 0.010, for Cu, Fe, and Pb, respectively. The coefficients a_n are approximately the same as the values of the coefficient of e asymmetry in the ($\mu^- - e^-$) decay. (D.C.W.)

158

37433 APPLICATION OF THRESHOLD CHERENKOV DETECTOR FOR SEPARATION OF π AND μ MESONS IN MESON BEAMS. V. D. Bobrov, V. G. Varlamov, Yu. M. Grashin, B. A. Dolgoshein, V. G. Kirillov-Ugryumov, V. S. Roganov, and A. V. Samoilov. Pribory i Tekhn. Eksperim., No. 3, 55-7(May-June 1963). (In Russian)

A Cherenkov detector with aqueous radiator and diffusion deflector is used for the separation of slow π and μ mesons. The detector has an efficiency of nearly 100% for μ mesons and not less than 70% for π mesons. It is possible to reduce the content of π mesons in a μ meson beam by a factor of 10. (tr-auth)

159

37896 CAPTURE OF NEGATIVE MUONS BY ATOMS IN CHEMICAL COMPOUNDS. Bobrov, V. D.; Varlamov, V. G.; Grashin, Yu. M.; Dolgoshein, B. A.; Kirillov-Ugryumov, V. G.; Roganov, V. S.; Samoilov, A. V.; Somov, S. V. (Inst of Physics and Engineering, Moscow). Zh. Eksperim. i Teor. Fiz., 48: 1197-9(Apr. 1965). (In Russian)

The relative probabilities of meson (μ^-) capture by atoms in several chemical compounds were measured with the aim of extracting information necessary for the interpretation of other experiments with muons. The results show that for the compounds investigated (LiCl, CsCl, ZnO, ZnS, and AlCu) the Fermi-Teller Z-law does not describe the experiment satisfactorily. An analysis of the available data shows that compared with the prediction of the Z-law, mesic atoms of the elements which have relatively large electron-affinity energy are produced with some preference. The results show that in most cases the tendency to preferred formation of the mesic atoms of the element with the larger electron affinity is violated only in five of 31 cases. Four out of the five violations are in compounds of carbon, and this is apparently connected with very complicated spatial configuration of these molecules. (ATD)

160

37897 CAPTURE OF NEGATIVE MUONS BY PURE CHROMIUM AND NICKEL ISOTOPES. Bobrov, V. D.; Varlamov, V. G.; Grashin, Yu. M.; Dolgoshein, B. A.; Kirillov-Ugryumov, V. G.; Roganov, V. S.; Samoilov, A. V.; Somov, S. V. (Inst. of Physics and Engineering, Moscow). Zh. Eksperim. i Teor. Fiz., 48: 1199(Apr. 1965). (In Russian)

Since data on muon capture by nuclei can be used as a tool for the study of the structure of the nucleus, muon capture by nuclei with closed neutron or proton subshells, in the form of isotopes of Cr with mass numbers 50, 52, 53, and 54 (^{52}Cr has a closed neutron subshell) and Ni isotopes with mass numbers 58, 60, and 62 (which have a closed proton subshell) was investigated. The isotope enrichment runs from 78.5 to 99.5%. The muon beam from the OIYaI synchrocyclotron was used for the experiments. The total muon capture probability was determined by measuring the lifetimes of the muons on the K orbit of the corresponding atom. (ATD)

161

32104 RADIATIVE DECAY OF THE MU MESON. Bogart, Elliot; DiCapua, Enrico; Strelzoff, Alan; Nemethy, Peter (Columbia Univ., New York). 41p. (CONF-651015-15). ORAU. Gmelin, AED-CONF-65-312-38.

From American Physical Society, Chicago.

The radiative decay $\mu^+ \rightarrow e^+ + \gamma + \nu_e + \bar{\nu}_\mu$ was investigated. The decay products e^+ and γ were observed at relative angles near 180° using scintillation counters and two 9 in. × 10 in. NaI crystals, which permitted the simultaneous measurement of the positron and gamma energies. The two-dimensional energy spectrum was obtained for approximately 900 events after subtraction of the background. This spectrum and the measured rate were compared with the prediction of a pure V-A theory; good agreement was obtained within the statistical errors. (D.C.W.)

162

7288 DISINTEGRATION OF THE C^{12} NUCLEUS INTO THREE α-PARTICLES AS A RESULT OF INELASTIC SCATTERING OF 80 Mev π^+-MESONS. V. I. Bogatin, Z. Novak, and V. I. Ostroumov (Leningrad Polytechnic Inst.). Zh. Eksperim. i Teor. Fiz., 43: 1582-91(Nov. 1962). (In Russian)

The disintegration of the C^{12} nucleus into three α particles as a result of inelastic scattering of 80-Mev π^+ mesons is studied by the photographic emulsion technique. Excitation of C^{12} nuclei to the 9.63-Mev level is found to contribute considerably to the cross section of the reaction (~20%). From the observed angular correlation of the decay products it is concluded that the spin of this level exceeds 1. The experimental data on the energy distribution of the α particles can be explained by assuming simultaneous breakup of the C^{12} nucleus into three α particles with resonance interaction between the particles in the final state. (auth)

163

18507 (BNL-10009) COMPARATIVE THERAPEUTIC EFFICACY OF HIGH-VERSUS LOW-LET RADIATIONS. Bond, V. P.; Robinson, C. V.; Fairchild, R.; Tisljar-Lentulis, G. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 37p. (CONF-651143-1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Conference on Radiobiology and Radiotherapy, Colorado Springs.

Possible approaches in radiotherapy using high-LET radiations are discussed. Included are neutron capture therapy; accelerator beams, particularly protons and negative Pi mesons; fast neutrons; and the influence of changes in cell survival curves on possible efficacy of high-LET radiations. An effort was made to present objectively the advantages and difficulties of the various approaches. It is possible, in principle, that these approaches may provide effective modalities for therapy, and in particular, that high-LET radiation may aid in overcoming the problem of relative protection of tumor cells located in hypoxic areas within neoplasms. In all approaches, it is necessary to consider carefully the concomitant changes in shape of dose-cell survival curves that accompany the change from low- to high-LET radiation. It is clear that while all proposed approaches have intriguing features, each requires considerably more work before it can be shown to be a useful adjunct in radiotherapy. (auth)

164

28363 FORWARD π^-p CHARGE EXCHANGE SCATTERING BETWEEN 0.8 AND 1.9 Gev. P. Borgeaud (CEN, Saclay, France), C. Bruneton, Y. Ducros, et al. Phys. Letters, 10: 134-7(May 15, 1964).

A study of the π^--p charge exchange scattering in the forward direction by a spark chamber technique is discussed. A dispersion relation was investigated in a region where the imaginary part of the forward scattering amplitude is expected to go twice through zero. The $\pi^- + p \rightarrow \pi^0 + n$ events were detected through the observation of the showers produced by the two decay photons of π^0 in a spark chamber. Measurements were carried out at 15 energies between 0.8 and 1.9 Bev. (C.E.S.)

165

28115 PRODUCTION OF ^3H IN THE ABSORPTION OF π^- IN ^4He. M. V. Bortolani, L. Lendinara, and L. Monari (Università, Bologna and Istituto di Fisica Nucleare, Bologna). Nuovo cimento (10), 25: 603-10(Aug. 1, 1962). (In English)

Experimental results are given on the absorption of π^- mesons in He^4. Using a model in which pions are absorbed on two nucleons, the results of this experiment indicate that absorption takes place essentially on a proton-neutron pair. (auth)

166

4433 (UCRL-10977) LOW-ENERGY NEGATIVE PION INTERACTIONS IN DEUTERIUM. William C. Bowman (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 5, 1963. Contract W-7405-eng-48. 82p.

An attempt is made to resolve the discrepancy between the measured deuterium ratio, $S = [\omega(\pi^- + d \rightarrow n + n)/\omega(\pi^- + d \rightarrow n + n + \gamma)]$, and values predicted from the s-wave pion relations and the theoretically calculated ratio $T = [\omega(\pi^- + d \rightarrow n + n + \gamma)/\omega(\pi^- + p \rightarrow n + \gamma)]$. The cross sections $\sigma(\pi^- + d \rightarrow n + n + \gamma) = (3.78 \pm 0.79) \times 10^{-20}$ cm^2/steradian, $\sigma(\pi^- + d \rightarrow n + n) = (3.67 \pm 0.45) \times 10^{-28}$ cm^2/sr, and $\sigma(\pi^- + d \rightarrow \pi^0 + n + n) = (7.84 \pm 0.57) \times 10^{-28}$ cm^2/sr were measured at 90° in the center-of-mass system for 51-Mev incident pion energy. The radiative absorption cross section and the s-wave pion relations indicate the value of $T = 0.91 \pm 0.19$, in agreement with theoretical calculations. The calculation of $S = 1.51 \pm 0.40$ from the cross section measurements and the value $S = 1.92 \pm 0.33$ measured by direction detection of both reactions is in agreement with the value $S = 1.74 \pm 0.26$ calculated from the s-wave pion relations. An indirect measurement comparing radiative captures in hydrogen and deuterium gave a value of $S = 3.37 \pm 0.46$, in relative agreement with other indirect measurements. This discrepancy appears to be due to difficulty in monitoring the number of pions captured in hydrogen and deuterium. A total-absorption plastic scintillation counter was used for all measurements. 49 references. (auth)

167

10111 LOW-ENERGY NEGATIVE PION INTERACTIONS IN DEUTERIUM. William Charles Bowman. Thesis, Berkeley, Calif., Univ. of California, 1964. 82p.

An attempt is made to resolve the discrepancy between the measured deuterium ratio, $S = [\omega(\pi^- + d \rightarrow n + n)/\omega(\pi^- + d \rightarrow n + n + \gamma)]$, and values predicated from the s-wave pion relations and the theoretically calculated ratio $T = [\omega(\pi^- +$

$d \rightarrow n + n + \gamma)/\omega(\pi^- + p \rightarrow n + \gamma)]$. The cross sections $\sigma(\pi^- + d \rightarrow n + n + \gamma) = (3.78 \pm 0.79) \times 10^{-29}$ cm²/sterad, $\sigma(\pi^- + d \rightarrow n + n) = (3.67 \pm 0.45) \times 10^{-28}$ cm²/sterad, and $\sigma(\pi^- + d \rightarrow \pi^0 + n + n) = (7.84 \pm 0.57) \times 10^{-28}$ cm²/sterad were measured at 90° in the center-of-mass system for 51-Mev incident pion energy. The radiative absorption cross section and the s-wave pion relations indicate the value of $T = 0.91 \pm 0.19$, in agreement with theoretical calculations. The calculation of $S = 1.51 \pm 0.40$ from the cross section measurements and the value $S = 1.92 \pm 0.33$ measured by direction detection of both reactions is in agreement with the value $S = 1.74 \pm 0.26$ calculated from the s-wave pion relations. An indirect measurement comparing radiative captures in hydrogen and deuterium gave a value of $S = 3.37 \pm 0.46$, in relative agreement with other indirect measurements. This discrepancy appears to be due to difficulty in monitoring the number of pions captured in hydrogen and deuterium. A total-absorption plastic scintillation counter was used for all measurements. (Dissertation Abstr., 25: No. 3, Sept. 1964)

168

41442 PION-NUCLEON SCATTERING AMPLITUDES IN THE RANGE 300-700 Mev. Bransden, B. H. (Durham Univ., Eng.); O'Donnell, P. J.; Moorhouse, R. G. Phys. Rev., 139: B1566-84(Sept. 20, 1965). (NIRL-R-79).

The cross section for the scattering of π^+ and π^- by nucleons in the energy range 300 to 700 Mev was analyzed in terms of energy-independent parameters. The parameterization is based on a dispersion relation satisfied by the partial-wave amplitudes, by replacing the left cut by a superposition of poles and the inelasticity function $R_l = \sigma_l(\text{tot})/\sigma_l(\text{el})$ by a ratio of polynomials in the momentum. Detailed results are presented for the real and imaginary parts of the phase shifts with $l \leq 3$. The structure of the second resonance is more complicated than has heretofore been thought, p_{11}, s_{11}, and d_{13} waves all playing an important part. The width of the d_{13} resonance is found to be considerably smaller than previous values from total cross-section measurements. The role of the (possibly resonant) amplitudes p_{11} and s_{11} is discussed. (auth)

169

37920 PION-NUCLEON SCATTERING IN THE RANGE 300-700 Mev AND THE POSSIBLE P_{11} RESONANCE. B. H. Bransden (Univ. of Durham, Eng.), P. J. O'Donnell, and R. G. Moorhouse. Phys. Letters, 11: 339-41(Aug. 15, 1964).

The results of an energy-dependent phase shift analysis of $\pi^{\pm}$-p scattering at 300 to 700 Mev are presented. The results indicate that the p_{11} resonance is around 600 Mev, not 430 Mev, if it exists. (D.C.W.)

170

37957 DISPERSION THEORY METHODS FOR PION-DEUTERON ELASTIC SCATTERING. John Joseph Brehm, Jr. Thesis, College Park, Md., Univ. of Maryland, 1963. 180p.

The problem of low-energy pion-deuteron elastic scattering is undertaken using the methods of dispersion theory. Complex singularities do not occur if the momentum transfer is used as the variable in a dispersion relation with the energy taken to be fixed and real. Anomalous discontinuities are developed by analytic continuation in the deuteron mass. Subsequent analytic continuation in the energy provides the representation of the physical amplitude. A sample calculation is made, ignoring spin. The contributions of pion-nucleon scattering are estimated by assuming the dominance of the $T = 3/2$ resonance in the energy channel and of the ABC resonance in the momentum transfer channel. The angular distribution is computed at 85 Mev and some agreement with experimental data is obtained. (Dissertation Abstr., 24: No. 12, Pt. I (June 1964))

171

4767

MEASUREMENTS ON THE $\pi^{\pm}$-p TOTAL SCATTERING CROSS SECTIONS IN THE ENERGY RANGE OF 0.4 TO 1.5 Bev. J. C. Brisson, J. Detoef, P. Falk-Vairant, L. van Rossum, G. Valladas, and Luke C. L. Yuan (Centre d'Etudes Nucléaires, Saclay, France). Phys. Rev. Letters 3, 561-3(1959) Dec. 15.

Total scattering cross sections are given for the (π^+,p) and (π^-,p) reactions at 0.373 to 1.150 Bev in hydrogen. (C.J.G.)

172

14973 MEASUREMENT OF THE TOTAL CROSS SECTION FOR π^+-p AND π^--p AT 400 Mev TO 1.5 Gev. J. C. Brisson, J. F. Detoeuf, P. Falk-Vairant, L. Van Rossum, and G. Valladas (Centre d'Études Nucléaires, Saclay, France). Nuovo cimento (10), 19: 210-33(Jan. 16, 1961). (In Italian)

The total cross sections were measured for π^+-p and π^--p interactions by attenuation in liquid hydrogen of a beam whose energy is known to ±1% and with a total $\Delta P/P$ of ±1.8%. The energies and values for the cross sections at the maxima are: π^-: $T\pi = (605 \pm 6)$ Mev, $\sigma_{tot} = (45.8 \pm 1.8)$ mb, $T\pi_{lab} = (890 \pm 9)$ Mev, $\sigma_{tot} = (58.0 \pm 1.8)$ mb, π^+: $T\pi_{lab} = (1330 \pm 30)$ Mev, $\sigma_{tot} = (38.0 \pm 2.0)$ mb. Results are compiled concerning the elastic and inelastic cross sections obtained by other experimental techniques in the neighborhood of the second and third resonances of π^-. The second and third resonances are discussed. (auth)

173

16932 (NP-11592(Vol.I)(p.45-55)) MESURE DE LA SECTION EFFICACE TOTALE DES PROCESSUS NEUTRES DANS L'INTERACTION π^--p DE 300 A 1600 MeV ET DETERMINATION DU RAPPORT ENTRE LA PRODUCTION DE π^0 ET L ECHANGE DE CHARGE JUSQU'A 1112 Mev. (Measurement of the Total Cross Section for Neutral Processes in the π^--p Interaction from 300 to 1600 Mev and Determination of the Relation Between π^0 Production and

Charge Exchange up to 1112 Mev). J. C. Brisson, P. Falk-Vairant, J. P. Merlo, P. Sonderegger, R. Turlay, and G. Valladas (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay).

174

9810 MEASUREMENT OF THE TOTAL CROSS SECTION FOR π^--p CHARGE EXCHANGE FROM T_π = 0.4 GeV TO T_π = 1.5 GeV. J. C. Brisson, P. Falk-Vairant, J. P. Merlo, P. Sonderegger, R. Turlay, and G. Valladas (Centre d'Études Nucléaires, Saclay, France). p.191-3 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The total cross section for charge exchange of mesons (π^-) on hydrogen ($\pi^- + p \rightarrow \pi^0 + n$) was determined. This was done by measuring the number of mesons (π^-) which interacted in a liquid hydrogen target without triggering a 4π-scintillation counter surrounding the target. The total cross section for neutral events showed maxima at energies close to the resonances in the π^--p total cross section. (M.C.G.)

175

19705 ENERGY MEASUREMENTS OF THE 2p–1s TRANSITIONS IN μ-MESONIC ATOMS. P. Brix (Technische Hochschule, Darmstadt, Ger.), R. Engfer, U. Hegel, D. Quitmann, G. Backenstoss, K. Goebel, and B. Stadler. Phys. Letters, 1: 56-8(Apr. 15, 1962).

Measurements of μ-mesonic x-ray energies for selected elements from S to Bi were performed. Special attention for Z < 30, where data indicated radii considerably smaller than obtained by electron scattering, was given. Results using muons were compared with those using electrons as probes for nuclear electromagnetic properties. Efforts were concentrated on comparison of μ-mesonic x rays with nearby γ lines of radioisotopes and determination of precise energy differences for mesonic x rays of similar energies. (L.N.N.)

176

31817 (CERN-66-16) PRECISION SERVO: N.M.R. FIELD MEASURING EQUIPMENT FOR THE CERN MUON STORAGE RING. Brown, R. Armstrong (European Organization for Nuclear Research, Geneva (Switzerland)). Mar. 28, 1966. 30p. Dep. mn.

Nuclear magnetic resonance equipment for measuring the muon magnetic moment in the CERN muon storage ring is described. Schematic drawings are included. (M.O.W.)

177

2612 PION-DEUTERON SCATTERING AT 330 Mev. G. Brunhart, G. S. Faughn, and V. P. Kenney (Univ. of Kentucky, Lexington). Nuovo Cimento (10), 29: 1162-8 (Sept. 1, 1963).

Pion-deuteron scattering at 330 Mev was studied in a hydrogen bubble chamber. The total cross section was measured to be (55.5 ± 2.97) mb, of which (13.3 ± 1.17) mb is charged elastic, (33.9 ± 2.60) mb is charged inelastic, and (8.3 ± 0.85) mb is scattering into an all-neutral final state. The differential cross section for elastic scattering is appreciably smaller than values obtained by straightforward application of the impulse approximation, suggesting that higher-order multiple scattering effects are important at this energy. (auth)

178

953 EXCITATION OF THE He^4 NUCLEUS BY 150 Mev π^--MESONS. Yu. A. Budagov, P. F. Ermolov, E. A. Kushnirenko, and V. I. Moskalev (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 40: 1615-17(June 1961). (In Russian)

An upper limit of 3.8 mb is obtained for the He^4 excitation cross section in reactions $\pi^- + He^4 \rightarrow \pi^- + He^3 + n(1)$ and $\pi^- + He^4 \rightarrow \pi^- + T + p$ (2), at a π^- energy of 150 Mev in a diffusion cloud chamber. The total cross section, the inelastic cross section, and the cross sections for reactions (1) and (2) are presented. (auth)

179

22944 INTERACTION BETWEEN 153-Mev NEGATIVE π-MESONS AND HELIUM. Yu. A. Budagov, P. F. Yermolov, E. A. Kushnirenko, and V. I. Moskalev (Joint Inst. of Nuclear Research, Dubna, U.S.S.R.). Zhur. Eksptl'. i Teoret. Fiz., 42: 1191-1208(May 1962). (In Russian)

The interaction between 153 Mev π^- mesons and He^4 nuclei is investigated with a high pressure diffusion cloud chamber operating in a magnetic field. The total π-He^4 interaction cross section, elastic scattering cross section, and cross sections for a number of inelastic processes are determined by measuring the total π^- track length. The angular distribution of elastic π-He^4 scattering is of a diffractional nature with a distinct minimum (80°) and a secondary maximum (100°). Optical model calculations assuming a square well complex potential $V = V_R + iV_i$ show that best agreement with the experimental data can be obtained for $V_R = -(18 \pm 7)$ Mev and $V_i = -(63 \pm 6)$ Mev, $r_0 = 1.5 \times 10^{-13}$ cm. These values are in good agreement with those computed by Frank, Gammel and Watson from the relation between the optical potential and forward scattering amplitude for free π-p scattering. The angular distribution of quasielastic π^- scattering on bound nucleons is compared with the calculations of Watson and Zemach. The probability of multiple π^- scattering in the nucleus and the charge exchange scattering cross section are estimated. (auth)

180

24682 (JINR-P-868) VZAIMODEISTVIE OTRITSATEL'NYKH π-MEZONOV S GELIEM PRI ENERGII 153 Mev. (Interaction of Negative π-Mesons with Helium at an Energy of 153 Mev). Yu. A. Budagov, P. F. Ermolov, E. A. Kushnirenko, and V. I. Moskalev (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 32p.

The 153-Mev π^- interaction with He^4 nuclei was investigated using the high pressure diffusion cloud chamber operated in the magnetic field. The total cross section for π^--He interaction, elastic scattering cross section, and cross section for a number of inelastic processes were determined by measuring the total length of the π^- meson tracks in the chamber. The angular distribution of elastic π^--He scattering has a diffraction character, the first minimum being 80° and the second maximum 100°. The optical model calculations of elastic scattering with the square well complex potential $V = V_R + iV_I$ have shown that the best agreement with the experimental data can be obtained for the values of the parameters $V_R = -(18 \pm 7)$ Mev, $V_I = -(63 \pm 6)$ Mev, and $r_0 = 1.5 \times 10^{-13}$ cm. These values are consistent with those calculated by Frank, Gammel, and Watson from the relation connecting the optical potential with the forward scattering amplitude for free π-p scattering. The angular distribution of the quasi-elastic π^- meson scattering on the bound nucleons is compared with Watson's and Zemach's calculations. The probabilities of the multiple π^- meson scattering in a nucleus as well as the charge exchange scattering cross section are estimated. (auth)

181

15263

ELASTIC SCATTERING OF 128 AND 162 Mev π^--MESONS BY PROTONS. Yu. A. Budagov, S. Viktor, V. P. Dzhelepov, P. F. Ermolov, and V. I. Moskalev. Zhur. Eksptl'. i Teoret. Fiz. 38, 734-46(1960) Mar. **(In Russian)**

A hydrogen-filled diffusion cloud chamber in a magnetic field was used to measure the angular distribution of 128 and 162 Mev π^--mesons elastically scattered on protons. The total elastic scattering cross sections for these energies are respectively $(12.8 \pm 1.0) \times 10^{-27}$ cm^2 and $(21.4 \pm 1.2) \cdot 10^{-27}$ cm^2. The angular distribution has the form $a + b \cos\theta + c \cos^2\theta$ with the coefficients given. At the indicated energies the real parts of the forward scattering amplitudes in $\hbar/m_\pi c$ units are respectively 0.261 ± 0.031 and 0.216 ± 0.033. These values agree with those computed from the dispersion relations with coupling constant $f^2 = 0.08$. (auth)

182

6851 NP-8277

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems.

ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT ENERGIES 128 AND 162 Mev. Yu. A. Budagov, S. Wiktor, V. P. Dzhelepov, P. F. Yermolov, and V. I. Moskalev. 1959. 27p. (P-402).

The elastic scattering angular distribution of negative pions by protons was measured by means of a hydrogen-filled diffusion cloud chamber in a magnetic field. 344 and 941 elastic scattering events were recorded at the angles $\delta\theta > 10°$ cm. The total cross sections for elastic scattering at 128 Mev = $(12.8 \pm 1.0) \times 10^{-27}$ cm^2 and at 162 Mev = $(21.4 \pm 1.2) \times 10^{-27}$ cm^2 were determined by calculating the total length of negative pion tracks in the chamber. (auth)

183

39578 (JINR-P-2807) ISSLEDOVANIE STRUKTURY K-SERII ARGONA PRI ATOMNOM ZAKHVATE OTRITSATEL'NYKH MYUONOV V CHISTOM GAZE I V SMESI S VODORODOM. (Investigation of the Structure of Argon K-Series During an Atomic Capture of Negative Muons in Pure Gas and in a Mixture With Hydrogen). Budyashov, Yu. G.; Ermolov, P. F.; Zinov, V. G.; Konin, A. D.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 7p. Dep. mn.

The experiments showed that during the argon interception of the negative muon in $(p-\mu)$ nucleus, the intensity of the hard lines in argon k-series is sharply increased in comparison to the case of direct muon capture by argon. (M.O.W.)

184

37741 (JINR-P-2788) ZAKHVAT MYUONOV V SMESYAKH GAZOV. (Muon Capture in Mixed Gases). Budyashov, Yu. G.; Zinov, V. G.; Konin, A. D.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 9p. Dep. mn.

The probability of nuclear capture of muons in mixed single atom (helium and neon) and multi-atom (nitrogen and carbon oxide) gases in relation to argon was measured using $\mu - x$ radiation recordings. The study did not exhibit any systematical relation between the probability of capture and nuclear charge which is another indication of the influence of molecular size on nuclear capture. (tr-auth)

185

9160 A MEASUREMENT OF THE e^+ POLARISATION IN MUON DECAY: THE e^+ ANNIHILATION METHOD. A. Buhler, N. Cabibbo, M. Fidecaro, T. Massam, Th. Muller, M. Schneegans, and A. Zichichi (CERN, Geneva). Phys. Letters, 7: 368-71(Dec. 15, 1963).

The experimental design for measuring the e^+ polarization in μ^+ decay by e^+ annihilation in magnetized iron foil is described. From measurements based on two foil orientations, a value of $P_{(e^+)} = (105 \pm 30)\%$ was obtained, which is consistent with predictions of the (V-A) theory of weak interactions. (L.B.S.)

186

3097 TOTAL CROSS SECTIONS AND ANGULAR DISTRIBUTIONS FOR π^- p CHARGE EXCHANGE IN THE SECOND AND THIRD RESONANCE REGIONS. F. Bulos (Brown Univ., Providence), R. E. Lanou, A. E. Pifer, et al. Phys. Rev. Letters, 13: 558-62(Nov. 2, 1964). (MIT-2098-59p.)

Data for nine different incident meson (π) energies were analyzed to study the cross sections and angular distributions in the reaction $\pi^- + p \rightarrow \pi^0 + n$. The energies span the region of the second (600 Mev) and third (900 Mev) meson (π)-nucleon resonances. The angular distributions indicate very little structure in the 600-Mev region, but in the 900-Mev region give strong evidence for a $D_{\frac{3}{2}} - F_{\frac{5}{2}}$ interference in the $T = \frac{1}{2}$ state. (C.E.S.)

187

14809 (JINR-P-1494) PIONNYE REZONANSY. (Pion Resonances). S. A. Bunyatov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 39p.

The experimental data on pion resonances are discussed, and the main properties of these resonances are tabulated. 132 references. (auth)

188

23222 SHAPING OF A HIGH-ENERGY μ-MESON BEAM. N. A. Burgov and A. G. Beda (Inst. of Theoretical and Experimental Physics, Moscow). Pribory i Tekhn. Eksperim., No. 1, 20-4(Jan.-Feb. 1965). (In Russian)

The method of shaping high energy meson (μ) beams ($P \sim 1$ Bev/c) was investigated with the help of iron-free systems consisting of some parallel conductors, by which the current goes at high energy in one direction. It was shown that the systems delay, in the immediate proximity, a large part of the μ mesons formed by the decomposition of π mesons. The competence of the proposed method was confirmed by experiments on electron models. Thermal and dynamic analyses, confirming the possibility of the design of efficient installations, led to specially prepared isolated dodecametric sections for the proposed system. (tr-auth)

189

30524 (TID-20750) π^--p INTERACTIONS AT 683 Mev/c. Technical Report No. 346. R. A. Burnstein, G. Charlton, T. B. Day, G. Quareni, A. Quareni-Vignudelli, and G. B. Yodh (Maryland. Univ., College Park). Jan. 1964. Contract AT(40-1)-2504. 36p.

Interactions of 683-Mev/c mesons (π^-) with protons were investigated using a 14-in. hydrogen bubble chamber in a 17-kilogauss field. Two thousand elastic scatterings were analyzed yielding a cross section of 18.91 ± 1.01 mb. No evidence for powers of cos θ higher than two was observed in the elastic angular distribution. The angular distribution obtained was $(d\sigma/dw) = (0.384 \pm 0.026) + (1.70 \pm 0.06) \cos\theta + (3.36 \pm 0.11) \cos^2\theta$(mb/sterad). The single meson (π) production reactions $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ and $\pi^- + p \rightarrow \pi^- + \pi^+ +$ n were studied in detail. A total of 441 π^0 productions and 833 π^+ productions were analyzed giving a cross section of 3.99 ± 0.21 and 7.50 ± 0.40 mb, respectively. The differential distributions for these inelastic processes are presented and compared with the predictions of the model of Olsson and Yodh. The distribution of events on the Dalitz plots for π^0 production is accounted for by the model. However, for the π^+ reaction, the model (so far developed) does not describe adequately the distribution of events on the Dalitz plot. The center-of-mass angular distributions for π^0 and π^+ production reactions are presented and compared with the model. (auth)

190

8097

PION-PROTON RESONANCE SCATTERING NEAR 900 Mev. H. C. Burrowes, D. O. Caldwell, D. H. Frisch, D. A. Hill, D. M. Ritson, R. A. Schluter, and M. A. Wahlig (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Letters 3, 110-21(1960) Feb. 1.

The scattering of negative and positive pions by hydrogen in the laboratory energy range 470 to 1200 Mev was investigated in order to clarify the broad resonance occurring near 900 Mev. The target was five feet of liquid hydrogen. The experimental setup is described, and results are given. (W.D.M.)

191

44428 (CERN-65-4(Vol.II), pp IX9-13) EMULSION GRAIN DENSITY IN THE EXTREME RELATIVISTIC REGION. Buskirk, F. R.; Dyer, J. N.; Hanson, H. D.; Seng, R.; Weidman, R. H.

Nuclear emulsion measurements of the blob density of meson (π) and electron tracks in the range $\gamma = 2$ to 4000 ($\gamma = 1/\sqrt{1-\beta^2}$) are reported. Data were gathered from four pellicles of 600 μ Ilford K-5 emulsion. The experimental procedure is given. (M.O.W.)

192

10945 (AD-260039) MEAN LIFE OF THE NEGATIVE MUON IN CARBON (thesis). Robert Albert Butterfield (Utah. Univ., Salt Lake City). June 1961. 34p.

Positive and negative muons are stopped and their decay observed. The composite mean life of these muons is calculated and the negative mean life in carbon is computed from the composite data. Results of calculations show a composite mean life in carbon of $(2.087 \pm 0.037) \times 10^{-6}$ sec, and the negative muon mean life in carbon is $(1.94 \pm 0.09) \times 10^{-6}$ sec. (J.R.D.)

193

18347 UCRL-9048

California. Univ., Berkeley. Lawrence Radiation Lab. CHARGE-EXCHANGE SCATTERING OF NEGATIVE PIONS

BY HYDROGEN AT 230, 260, 290, 317, and 371 MEV (thesis). John C. Caris. Mar. 18, 1960. 105p. Contract W-7405-eng-48. OTS.

The differential cross section for charge-exchange scattering of π^- by H was observed at 230, 260, 290, 317, and 371 Mev. The reaction was observed by detecting one gamma ray from the π^0 decay with a scintillation-counter telescope. A least-squares analysis indicates that d-wave scattering is not established in this energy range. (auth)

194

4601 (UCRL-9278) TOTAL CROSS SECTIONS FOR NEGATIVE PIONS ON PROTONS AT 230, 290, 370, 427, AND 460 MEV. John C. Caris, Lester K. Goodwin, Robert W. Kenney, Victor Perez-Mendez, and Walton A. Perkins, III (California. Univ., Berkeley. Lawrence Radiation Lab.). June 15, 1960. 19p. Contract W-7405-eng-48. OTS.

Total cross sections for negative pion interactions with protons were measured at laboratory-system energies of 230, 290, 370, 427, and 460 Mev. The total cross sections agree within statistical error with other measured values, and with values calculated from sums of elastic, inelastic, and charge-exchange measurements. (auth)

195

32689 TOTAL CROSS SECTIONS FOR NEGATIVE PIONS ON PROTONS AT 230, 290, 370, 427, AND 460 Mev. John C. Caris, Lester K. Goodwin, Robert W. Kenney, Victor Perez-Mendez, and Walton A. Perkins, III (Univ. of California, Berkeley). Phys. Rev., 122: 262-4(Apr. 1, 1961). (UCRL-9463)

Total cross sections for negative pions on protons were measured at laboratory energies of 230, 290, 370, 427, and 460 Mev. The measurements were made in the same pion beams as and at energies identical with those of our π^--p differential scattering experiments. Comparisons of the total and differential scattering can be made with the dispersion theory at a given energy without introducing the systematic errors that would normally enter due to uncertainties in the parameters of more than one pion beam. The measured total cross sections are found to agree within statistics with other measured values, and with the sums of elastic, inelastic, and charge-exchange cross sections measured at this laboratory. (auth)

196

9715 CHARGE-EXCHANGE SCATTERING OF NEGATIVE PIONS BY HYDROGEN AT 230, 260, 290, 317, AND 371 Mev. John C. Caris, Robert W. Kenney, Victor Perez-Mendez, and Walton A. Perkins, III (Univ. of California, Berkeley). Phys. Rev., 121: 893-904(Feb. 1, 1961).

The differential cross section for charge-exchange scattering of negative pions by hydrogen was observed at 230, 260, 290, 317, and 371 Mev. The reaction was observed by detecting one γ ray from the π^0 decay with a scintillation-counter telescope. A least squares analysis was performed to fit the observations to the function

$$(d\sigma/d\omega) = \sum_{l=1}^{5} a_l P_{l-1}(\cos\theta)$$

in the c.m. frame. The best fit to the experimental measurements required only s- and p-wave scattering. The least squares analysis indicated that d-wave scattering was not established in this energy range. (auth)

197

18502 POSITIVE-PION CROSS SECTIONS ON COMPLEX NUCLEI. John C. Caris, Edward A. Knapp, Victor Perez-Mendez, and Walton A. Perkins (Univ. of California, Berkeley). Phys. Rev., 126: 295-302(Apr. 1, 1962). (UCRL-6366)

Absorption and diffraction cross sections were measured for positive pions at 442 Mev. The target elements used were C, Al, Cu, and Cd. The absorption and diffraction cross sections were determined by fitting the experimental data (taken at six angles) to the shape given by the optical-model theory. The nuclear radius and the falloff parameter were taken to be approximately those determined from nuclear charge distribution measurements. The experimental data were compared with the results of the optical-model theory. Experimental values for the imaginary part of the potential were in agreement with the theoretical value. However, the experimental values for the real potential increased with increasing atomic number, becoming far larger than the theoretical value. (auth)

198

16929 (NP-11592(Vol.I)(p.25-6)) PION PRODUCTION BY POSITIVE PIONS ON PROTONS AT 308 Mev KE. R. Carrara, M. Cresti, A. Grigoletto, A. Loria, L. Peruzzo, R. Santangelo, and D. Venchiarutti (Padua. Università. Instituto di Fisica).

An analysis is presented concerning measurements on pictures taken in conjunction with exposure of the CERN 32-cm hydrogen bubble chamber to a positive pion beam at about 310 Mev from a synchrocyclotron. A sample of 5000 events was studied, and a total inelastic cross section of $0.40^{+0.23}_{-0.18}$ mb at 308 Mev KE found. (J.R.D.)

199

7475 (TID-19854) RADIATIVE PION-NUCLEON SCATTERING. P. Carruthers (Cornell Univ., Ithaca, N. Y. Lab. of Nuclear Studies and Cornell Univ., Ithaca, N. Y. Lab. of Atomic and Solid State Physics). Nov. 1963. Contracts AT(30-1)-2179 and NONR 401-51. 19p.

The cross section for bremsstrahlung in π-N interactions is calculated from the results of the static nucleon theory. The result agrees well with a recent measurement of the reaction $\pi^+ + p \rightarrow \pi^+ + p + \gamma$ at an average pion laboratory

kinetic energy of about 300 Mev. The theoretical result is 0.25 mb, compared to the experimental value 0.22 ± 0.05 mb. The energy distribution of the final pion is computed at laboratory energies of 200, 300, and 400 Mev. The 3-3 isobar shows up clearly at the latter two energies, in agreement with experiment. Experiments are suggested whereby the bremsstrahlung can be used as a probe to obtain information about the higher resonances in π-N scattering. (auth)

200

19481 π-N PHASE SHIFTS FROM 300 TO 700 Mev. Cence, J. (Univ. of Hawaii, Honolulu). Contract AT(04-3)-511. Phys. Lett., 20: 306-8(Feb. 15, 1966).

A phase shift analysis for π-N scattering was carried out from 300 to 700 Mev. The $T = 3/2$ phase shifts are in qualitative agreement with previous results. However, it is found that the $T = 1/2$ phase shifts lie within ±45 deg up to 700 Mev. (auth)

201

37963 RECENT ELASTIC-SCATTERING AND POLARIZATION STUDIES OF THE π-N INTERACTION IN THE HIGHER RESONANCE REGION. Robert J. Cence (Univ. of California, Berkeley). p.131-41 of "Nucleon Structure." Stanford, Calif., Stanford University Press, 1964.

The resonances (peaks) at 600 and 900 Mev in the π^--p total cross section and at 1350 Mev in the π^+-p total cross section were studied by measuring the $\pi^\pm$-p differential cross sections and the recoil proton polarization at energies near the resonances. Phase-shift analyses of the data were performed. The data are consistent with a $D_{3/2}$, $T = 1/2$; $F_{5/2}$, $T = 1/2$; and $F_{7/2}$, $T = 3/2$ resonances at 600, 900, and 1311 Mev, respectively. (D.C.W.)

202

13409 A MEASUREMENT OF THE FORWARD CHARGE-EXCHANGE CROSS SECTIONS OF 170 Mev NEGATIVE PIONS IN HYDROGEN. C. Cernigoi (Università, Trieste, Italy and Istituto Nazionale di Fisica Nucleare, Trieste, Italy), I. Gabrielli, G. Iernetti, and C. Villi. Phys. Letters, 3: 18-21(Nov. 15, 1962). (In English)

The measurement of the forward charge-exchange cross section $\sigma_0(0^0,\omega)$ for the process $\pi^- + p \rightarrow \pi^0 + n$ was carried out at a π^- energy of 170 ± 3 Mev. The final result is $\sigma_0(0^0 + 8^0) = 5.023 + 0.26$ mb/sterad. The meson-nucleon coupling constant f^2 was determined using all available data on $\sigma_0(0^0,\omega)$ from 95 to 290 Mev and is presented as a χ^2 fit. (H.D.R.)

203

16026 CONSIDERATION OF "SPHERICAL HOT SPOTS" ARISING FROM PION CAPTURE IN EXPLOSIVES USING THERMAL INITIATION THEORY. Joseph Cerny and J. V. Richard Kaufman (Picatinny Arsenal, Dover, N. J.). J. Chem. Phys., 40: 1736-44(Mar. 15, 1964).

The process whereby relatively high energy density, spherical zones of radiation heating may arise from slow π^--meson irradiations is described, and the effects of such microscale hot spots on six explosives (lead azide, lead styphnate, mercury fulminate, RDX, TNT, and PETN) was investigated. No explosions or signs of thermal decomposition were observed with any of the explosives. Analysis of these results by the hot-spot model of explosive initiation and thermal growth was attempted. The conclusions were: that this model can not explain the experimental results observed for RDX, in that it predicts initiation, and that the previous experiments attempting explosive initiation by the microscale thermal effects of ionizing radiation have not investigated those explosives most susceptible to initiation by this mechanism. (auth)

204

29543 DETERMINATION OF THE REACTION RATE $\pi^-_{\text{at rest}} + p \rightarrow \pi^0 + n$ IN HYDROGENOUS MATERIALS. M. Chabre, P. Depommier, J. Heintze, and V. Soergel (CERN, Geneva). Phys. Letters, 5: 67-9(June 1, 1963). (In English)

The fraction of mesons(π^-) stopped in hydrogenous materials that interacts with hydrogen nuclei by the process $\pi^- + p \rightarrow \pi^0 + n$ was determined for LiH, CH, and CH_2 by detecting coincidences between the π^- and the two γ rays from π^0 decay. Measurements were also made with Li and C targets so the background could be subtracted. The values obtained are about three times as large as those obtained in other experiments. A value obtained for H_2 agrees well with expectations. (D.C.W.)

205

866 (UCRL-10949) PION SCATTERING FROM A POLARIZED TARGET. Owen Chamberlain, Carson D. Jeffries, Claude H. Schultz, Gilbert Shapiro, and Ludwig Van Rossum (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 7, 1963. Contract W-7405-eng-48. 17p. (CONF-46-106)

From American Physical Society 1963 Spring Meeting, Washington, D. C., Apr. 1963.

The parameter P, equivalent to that determined by analyzing the recoil proton polarization in scattering from an unpolarized target, was measured to an unprecedented accuracy at an energy and angles inconvenient for double-scattering techniques by detecting pion-proton coincidences in 246-Mev meson (π^+) scattering by a target containing polarized protons. (D.C.W.)

206

31331 ELECTROMAGNETIC CORRECTION EFFECTS ON THE $\pi^+ \rightarrow \pi^0 e^+ \nu$ DECAY. Ngee-Pong Chang (Columbia Univ., New York). Phys. Rev., 131: 1272-5(Aug. 1, 1963).

Recently experiments have been done on the rare decay of the π^+ into the $\pi^0 e^+ \nu$ mode as a third and independent test of the conserved vector current hypothesis. This note reports briefly on a simple perturbation calculation of the radiative corrections. With a cutoff of around a nuclear mass, the radiative correction shortens the lifetime by $\sim -1.1\%$. (auth)

207

31034 THE ANOMALOUS MAGNETIC MOMENT OF THE MUON. G. Charpak, F. J. M. Farley, R. L. Garwin, T. Muller, J. C. Sens, and A. Zichichi (CERN, Geneva). Nuovo Cimento (10), 37: 1241-1363(June 16, 1965).

The anomalous part of the gyromagnetic ratio, $a \equiv \frac{1}{2}(g-2)$ of the muon was measured by determining the precession $\theta = a\omega_0 \overline{B}t$ for 100-Mev/c muons as a function of storage time t in a known static magnetic field of the form $B = B_0(1 + ay + by^2 + cy^3 + dy^4)$. The result is $a_{exp} = (1162 \pm 5) \times 10^{-6}$ compared with the theoretical value $a_{th} = \alpha/2\pi + 0.76\ \alpha^2/\pi^2 = 1165 \times 10^{-6}$. This agreement shows that the muon obeys standard quantum electrodynamics down to distances ~0.1 fermi. Details are given of the methods used to store muons for $\sim 10^3$ turns in the field, and of measuring techniques and precautions necessary to achieve the final accuracy. Some of the methods of orbit analysis, magnet construction shimming and measurement, polarization analysis, and digital timing electronics may be of more general interest. (auth)

208

5892 QUENCHING OF MUON DEPOLARIZATION BY WEAK MAGNETIC FIELDS. G. Charpak, F. J. M. Farley, R. L. Garwin, T. Muller, J. C. Sens, V. L. Telegdi, C. M. York, and Z. Zichichi (CERN, Geneva). Nuovo cimento (10), 22: 199-202(Oct. 1, 1961). (In English)

If muons are stopped in an electrically conducting material they suffer very little depolarization. In insulators the results are variable, some materials giving no depolarization (bromoform, methylene iodide), while in others (sulfur, NaCl) the depolarization is almost complete. Depolarization in the case of a plastic scintillator target was measured. Re-establishment of polarization at low fields was detected. At ~150 gauss, the asymmetry reached about 50% of its full value. Results are represented in graphical form. (L.N.N.)

209

25513 STUDY OF TWO-HOLE STATES IN LIGHT NUCLEI BY MEANS OF $(\pi^+, 2p)$ REACTIONS. G. Charpak (CERN, Geneva), G. Gregoire, L. Massonnet, J. Saudinos, J. Favier, M. Gusakow, and M. Jean. Phys. Letters, 16: 54-6(May 1, 1965).

Targets of ^{6}Li, ^{7}Li, CD_2, CH_2, and liquid nitrogen were bombarded with a beam of 106-Mev pions from the CERN synchrocyclotron, and the summed energy spectra of the two protons were measured for the $(\pi^+, 2p)$ reaction on ^{6}Li, ^{7}Li, ^{12}C, and ^{14}N. The structure expected from the two-hole interpretation of the final nuclear states was clearly displayed for the $^6\text{Li}(\pi^+, 2p)^4\text{He}$ reaction; the absence of the structure in the spectra of the other reactions is attributed to poor energy resolution and the natural widths of the hole states. (L.B.S.)

210

3970

THE ANGULAR DISPERSION OF PARTICLE BEAMS PASSING THROUGH NUCLEAR EMULSIONS. Brigitte Chemel and Tsai-Chü. Compt. rend. 249, 1494-6(1959) Oct. 19. (In French)

The measurement of the angular dispersion of a 6-Bev proton beam and a 300-Mev π meson beam has permitted the determination of the vector of deformation and the multiple scattering constant. The scattering constant approaches an upper limit for particles of high velocity. (tr-auth)

211

3315 (UCRL-9028) POSSIBLE MANIFESTATIONS OF A PION-PION INTERACTION. Geoffrey F. Chew. California. Univ., Berkeley. Lawrence Radiation Lab. Jan. 6, 1960. 10p. Contract W-7405-eng-48. OTS.

Various experiments to verify the existence of a P-wave resonance in the π-π system are proposed. Topics discussed in some detail include nucleon electromagnetic structure, electromagnetic π-π production, a three-pion resonance or bound state, and peripheral collisions. (W.D.M.)

212

8122

SCATTERING OF μ MESONS FROM LEAD NUCLEI. B. Chidley, P. Goldstein, G. Hinman, R. Summers, and R. Adler (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. 116, 1015-21(1959) Nov. 15.

The angular distribution of 23-Mev μ^- mesons scattered by lead nuclei was measured by using a counter arrangement and also by using a propane bubble chamber. The results agree, to the accuracy of the experiments, with the distribution predicted by the ordinary Coulomb interaction of the μ meson and the lead nucleus. (auth)

213

25502 NUCLEAR DE-EXCITATION FOLLOWING MUON CAPTURE AND THE BOUND MUON DECAY ANOMALY. Frank Chilton (Univ. of Washington, Seattle). Phys. Rev. Letters, 7: 31-4(July 1, 1961).

The rate of the μ^- meson decay reaction $\mu^- \rightarrow e^- + \nu + \overline{\nu}$ in the Coulomb field of a nucleus is studied. It is suggested

that discrepancies between the observed and theoretical rates may be caused by the unwanted detection of the μ^- capture reaction $\mu^- + p \rightarrow n + \nu$. The neutron from this reaction can produce gamma radiation by various processes, and the gamma radiation can produce electrons either by pair production or by the Compton effect. Experimental methods for testing the existence of this mechanism are proposed. (T.F.H.)

214

37951 RADIATIVE CORRECTIONS FOR WEAK INTERACTION PROCESSES. Cheng-jui Ching (Peking Univ.). Sci. Sinica (Peking), 13: 1323-5(Aug. 1964). (In Russian)

Radiative corrections for photons and neutrinos in meson(μ) and neutron decay are discussed. (C.E.S.)

215

13458 (UCRL-16209) PION-PROTON CHARGE-EXCHANGE SCATTERING, 500 TO 1300 Mev [Thesis]. Chiu, Charles Bin (Lawrence Radiation Lab., Univ. of California, Berkeley). Nov. 2, 1965. Contract W-7405-eng-48. 162p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Differential cross sections for the reaction $\pi^-p \rightarrow \pi^0n$ were measured at nine incident-pion kinetic energies in the interval from 500 to 1300 Mev. The negative pion beam, obtained from the bevatron, was focused on a liquid hydrogen target surrounded by a cubic array of six steel-plate spark chambers. The spark chambers were triggered on events with neutral final states. Charge-exchange events were identified from the one-shower and two-shower events in the spark chamber pictures. By the Monte Carlo technique, the π^0 distributions were calculated from the bisector distributions of the two-shower π^0 events together with the observed gamma-ray distributions of the one-shower π^0 events. These π^0 distributions were fitted with both Legendre polynomial expansions and power-series expansions by the method of least squares. The extrapolated forward differential cross sections are in good agreement with the dispersion calculations. The Legendre coefficients for the differential cross sections in a pure $I = \frac{1}{2}$ isospin state, and for the differential cross sections due to the interference of $I = \frac{3}{2}$ and $I = \frac{1}{2}$ amplitudes, were obtained by combining our results with the available data on π^+p elastic scattering, in the light of the existing phase-shift solutions, the behavior of these coefficients is discussed. The well-known D_5F_5 interference term that peaks near 900 Mev is verified to be predominantly in a pure $I = \frac{1}{2}$ state. (auth)

216

29574 (NYO-10562) OBSERVATION OF RADIATIVE CAPTURE OF MUONS IN COPPER. William T. Chu (Carnegie Inst. of Tech., Pittsburgh). Jan. 1963. Contract AT(30-1)-882. 124p.

The radiative capture of negative muons by a complex nucleus, μ^- + Nucleus $\rightarrow$ Nucleus' + neutrino + photon, was observed for muons stopping in Cu. Events were identified visually using a spark chamber with copper plates to detect the stopping muons and a spark chamber with lead plates to detect the pair resulting from conversion of the associated photon. The energy of the photon was deduced from the pulse produced by the pair in a large NaI crystal. Counter pulses displayed on a fast oscilloscope gave information on the time distribution of events. For approximately 3×10^8 μ-stops, 100 good events were observed. Extraction of the branching ratio R of radiative capture to the ordinary capture depends upon detailed assumptions about the internal excitation of the final nucleus following the muon capture. However, the dependence is not very strong and the overall average branching ratio is $R = (5.5 \pm 1.8) \times 10^{-4}$. The result is larger than would be expected theoretically for a pure V−A coupling and is consistent with an estimate that includes an additional pseudoscalar interaction in the four Fermion coupling of muon and neutrino to proton and neutron. 39 references. (auth)

217

10339 RADIATIVE μ^- CAPTURE IN COPPER. William T. Chu, Irving Nadelhaft, and Julius Ashkin (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 137: B352-66(Jan. 25, 1965).

The radiative capture of negative muons in copper (μ^- + Cu $\rightarrow$ Ni + ν + γ) was measured. The muons were captured in the copper plates of one spark chamber and the gamma rays converted in the lead plates of a second spark chamber. A large (8 in. × 8 in.) NaI crystal was used to measure the gamma energy. The apparatus was sensitive to gamma rays of energy larger than 50 Mev. The observed gamma spectrum is compared to a theoretical spectrum based on a Fermi-gas model of the nucleus. The comparison gives branching ratios for radiative muon capture relative to ordinary muon capture of $R = (4.6 \pm 0.7) \times 10^{-4}$ for $M^* = M_p$ and $R = (5.2 \pm 0.8) \times 10^{-4}$ for $M^* = M_p/2$, where M^* is the effective nucleon mass used in the model and M_p is the mass of the proton. An attempt is made to extrapolate the observations in copper to the case of a free proton. (auth)

218

22935 RESONANCE INTERACTIONS OF PI MESONS WITH STRANGE PARTICLES (EXPERIMENTAL DATA). I. V. Chuvilo. Uspekhi Fiz. Nauk, 76: 329-50(Feb. 1962). (In Russian)

Experimental results are given which show that $\pi\Sigma$, $\pi\Lambda^0$, and πK interactions in the region from 100 to 300 Mev possess a resonance character. The masses are given as: $\pi\Lambda^0$-system (Y_1^*-particle) = 1385 Mev, half-width 20 Mev; $\pi\Lambda^0$-system (Y_0^*-particle) = 1405 Mev, half-width 20 Mev; πK-system (K^*-particle) = 835 Mev, half-width 16 Mev. The half-widths mean that the lifetimes of these particles are of the order of $4 \cdot 10^{-23}$ sec, longer than the well-known π-nucleon $(\frac{3}{2}, \frac{3}{2})$ resonance, but still of the same magnitude as the duration of strong interaction processes. The isotopic spin of Y_1^* is 1, of Y_0^* is 0, and of K^* is $\frac{1}{2}$. It is further noted that the Y_1^* particle is in an $S_{\frac{1}{2}}$-state, although $P_{\frac{1}{2}}$ cannot be excluded. There is no definitive evidence concerning the spin and parity of the $\pi\Sigma$-interaction, whereas the spin of the K^*-particle is either 0 or 1. In particular, it is pointed out, that the spin and

parity determination of the Y_1^*-particle is of great significance to the "global symmetry" hypothesis of Gell-Mann. (TTT)

219

27222 PION-NUCLEON COUPLING CONSTANT FROM n-p DIFFERENTIAL CROSS-SECTIONS OVER AN ENERGY RANGE. R. Cirelli (Universita, Milan and Istituto Nazionale di Fisica Nucleare, Milan) and G. Stabilini. Nuovo Cimento (10), 37: 1165-9(June 1, 1965).

The pion-nucleon coupling constant is determined by extrapolation to the backward one-pion-exchange pole over a large energy range. Data on the neutron-proton differential cross section ranging from 62.5 to 550 Mev are used in the treatment. The values of g^2 obtained by this global determination turn out to be rather good. (auth)

220

33878 SCATTERING OF μ MESONS BY CARBON. A. Citron, C. Delorme, D. Fries, L. Goldzahl, J. Heintze, E. G. Michaelis, C. Richard, and H. Oeverås (CERN, Geneva). Phys. Letters, 1: 175-8(June 1, 1962).

The scattering of 180- and 240-Mev/c μ^- mesons by C is measured at angles up to 72.5°. Four-momentum transfers up to 250 Mev/c ($|q|^2 = 1.5$ fermi^{-2}) are thus achieved. Within the limits of experimental error, no deviation (other than that arising from the mass difference) is found between the μ^- and electron scattering cross sections on C. Further, if it is assumed that the μ^- meson has a structure with an rms charge radius r_0, an upper limit of $r_0 = 0.68$ fermi can be set with 95% confidence. (T.F.H.)

221

10373 CAPTURE OF MUONS IN HELIUM-3. Douglas Roger Clay. Thesis, Salt Lake City, Univ. of Utah, 1964. 129p.

An experiment using negative muons from the synchrocyclotron of the Carnegie Institute of Technology was carried out to measure the rate of the interaction $\mu^- + {}^3\text{He} \rightarrow {}^3\text{H} + \nu_\mu$ where the produced ^{3}H nucleus is in the ground state. Both the stopping muons and the subsequent 1.9-Mev recoil tritons were measured in a ^{3}He gas scintillation counter operated at 360 psi. A 10% admixture of Xe greatly enhanced the scintillation efficiency and reduced the fraction of tritons leaving the target. Use of a CsI(Tl) crystal above the photomultiplier window and a pulse-shape discriminator circuit precluded the counting of muons stopped in the glass. The gas was contained in a thin-walled Ag box surrounded by a Xe scintillation counter that detected μ-decay electrons. A two-dimensional time and pulse-height analysis was performed on the tritons. Simultaneously, the electrons were time-analyzed with the same apparatus. In a separate run, the Xe concentration in the target counter was increased so that electrons could be counted efficiently in it. An energy resolution of 15% was achieved for recoil tritons, making possible a precise background subtraction. The experimental result, based on about 6800 tritons, is 1470 ± 67 sec^{-1} and is to be compared with 1505 ± 120 sec^{-1}, the rate expected on the basis of muon-electron universality, conserved vector current hypothesis, and the calculated value of induced pseudoscalar coupling constants. (Dissertation Abstr., 25: No. 3, Sept. 1964)

222

47350 A POSSIBLE MODEL FOR A STRONG INTERACTION IN THE P_{11} PION-NUCLEON STATE. Clegg, A. B. (Oxford Univ.). Nuovo Cimento (10), 36: 1052-4 (Apr. 1, 1965).

An explanation for the observed rapid rise in the P_{11} phase in pion-nucleon scattering near 500-Mev pion energy is offered. A conceivable model for a strong interaction of two pions with the nucleon at the same time is discussed. It is proposed that both pions may each spend an appreciable part of the time in the $(I, J) = (3/2, 3/2)$ state with respect to the nucleon. It is shown that it is possible to find a wave function for an $(I, J) = (1/2, 1/2)$ state of the N$\pi\pi$ system in which both pions have a large probability of being in an $(I, J) = (3/2, 3/2)$ state with respect to the nucleon at the same time. (M.J.T.)

223

34960 μ CAPTURE IN OXYGEN. R. C. Cohen, S. Devons, and A. D. Kanaris (Columbia Univ., New York). Phys. Rev. Letters, 11: 134-7(Aug. 1, 1963).

The capture rates of μ^- mesons by O^{16}, leading to the first four bound states of N^{16}, are measured. The ratio of capture to the 0^- and 1^- states of N^{16} is measured as: ratio $(0^-/1^-) = 0.38 \pm 0.07$. This result is consistent with an induced pseudoscalar coupling constant/induced axial vector coupling constant ratio of about 15 in the basic reaction $\mu^- + p \rightarrow n + \nu_\mu$. (T.F.H.)

224

6273 (AD-617398). MU CAPTURE IN OXYGEN [Thesis]. Cohen, R. C. (Nevis Labs., Columbia Univ., Irvington-on-Hudson, N. Y.). Apr. 1965. Contract Nonr26672. 80p. (CU-236; NEVIS-130). CFSTI $3.00 cy, $0.75 mn.

By measuring the μ induced ^{16}N beta radioactivity and the low energy gamma transitions in this nucleus, estimates were obtained of the absolute capture rates for μ^- stopping in oxygen and producing ^{16}N in three of the lowest lying states. The results are: $\mu^- + {}^{16}\text{O}$ (O+) to ^{16}N (2(–), ground state) + ν = 6,300 ± 700/sec to ^{16*}N (O(–), 120 kev) + ν = 1,100 ± 200/sec to ^{16*}N (1(–), 392 kev) + ν 1,730 ± 100/sec. Within the limits noted in the text, the rate to the O(–) state indicates the value for the pseudoscalar coupling constant lies between $10g_A$ and $26g_A$. (auth)

225

35460 SEARCH FOR THE TETRANEUTRON VIA THE REACTION $\pi^- + {}^7\text{Li} \rightarrow {}^4\text{n} + {}^3\text{He}$. Cohen, R. C. (Columbia Univ., New York); Kanaris, A. D.; Margulies, S.; Rosen, J. L. Phys. Letters, 16: 292-3(June 1, 1965).

Presented is an investigation of two-body breakups following π^- absorption at rest in lithium. Measurements were sensitive to four neutron final-state interactions and particle-unstable tetraneutrons, as well as to particle-stable ones. (M.O.W.)

226

19177 TWO-BODY BREAKUPS FOLLOWING π^- ABSORPTION IN LITHIUM: EVIDENCE FOR THE PRODUCTION OF H^4. R. C. Cohen, A. D. Kanaris, S. Margulies, and J. L. Rosen (Columbia Univ., New York). Phys. Letters, 14: 242-5(Feb. 1, 1965).

An experiment is described, which yields evidence for the $\pi^- + {}^6Li \rightarrow {}^3H + {}^3H$, $\pi^- + {}^6Li \rightarrow {}^2H + {}^4H$, and $\pi^- + {}^7Li \rightarrow {}^3H + {}^4H$ reactions. Collinear particle pairs following pion absorption were detected in two counter telescopes, and two-body reaction products were identified from their unique ranges by varying the thickness of an aluminum absorber in one telescope. Differential range curves are presented. It is concluded that the observed reactions occurring with probabilities of one in a few thousand indicate that capture yielding nucleon clusters is appreciable enough to be measured accurately, and evidence is provided for the existence of a ^4H state which is unstable against decay into $^3H + n$. Results for the $\pi^- + {}^7Li \rightarrow {}^2H + {}^5H$ reaction were inconclusive. (L.B.S.)

227

38114 THE LIFETIME OF THE NEGATIVE MUON IN ^{239}Pu. Cojocaru, V. (Inst. of Atomic Physics, Bucharest); Marinescu, L.; Mihai, I.; Petrascu, M.; Voiculescu, Gh.; Ignatenco, I.; Omelianenco, M. Rev. Roum. Phys., 11: 207-12(1966).

The time distribution of fission due to the nuclear capture of negative muons in plutonium was measured and the value 76 ± 9 ns for the muon lifetime was obtained. There is a good agreement, within the experimental errors, between the experimental value and that calculated with the theoretical formula given by Primacoff. (auth)

228

17028 EXPERIMENTAL STUDY OF DOUBLE-CHARGED PION PRODUCTION IN (π^-,p) COLLISIONS AT 900 Mev. Derek C. Colley and Joseph T. Ratau (Columbia Univ., New York). Phys. Rev., 130: 357-61 (Apr. 1, 1963).

Eight hundred and forty events of the kind $\pi^- + p \rightarrow \pi^- + p + \pi^- + \pi^+$ produced in the 20-in. BNL hydrogen bubble chamber by 900-Mev pions were unambiguously identified using spatial reconstruction and kinematic fitting programs as well as ionization density estimates. The π^+,π^- and π^-,π^- combined mass distributions can be fitted by smooth curves with no deviation beyond statistical fluctuations; no indication was found of any prominent pion-pion resonance in this interaction, which covers a mass range up to 610 Mev. The π^+,p combined mass distribution differs markedly from the four-body phase-space curve, but can be well fitted by weighing the π^+,p total cross section curve at each point according to the amount of phase space available for production of an isobar of corresponding mass. Assuming that the interaction proceeds exclusively via formation of the (π^+,p) isobar, one can get a good fit to the π^-,π^- mass spectrum. This isobar model is also consistent with all of the observed angle and momentum distributions for both pions and protons. The momentum distributions show no indication of any pion-pion-proton resonance in the range up to 1550 Mev, or of any three-pion resonance in the range up to 750 Mev. The cross section for the events studied was measured and found to be (0.33 ± 0.04) mb. (auth)

229

19089 ON THE ABSORPTION OF NEGATIVE PIONS BY LIQUID HELIUM. G. T. Condo (Univ. of Tennessee, Knoxville and Oak Ridge National Lab., Tenn.). Phys. Letters, 9: 65-6(Mar. 15, 1964).

A de-excitation mechanism is proposed for the absorption of mesons (π^-) in liquid helium. It is shown that an alternate cascade scheme exists that is in accord with experiment and that does not require the absence of the molecular Stark effect. (C.E.S.)

230

24582 (AD-439331) ABSORPTION OF NEGATIVE PI MESONS IN LIGHT NUCLEI. Technical Report No. 46. G. T. Condo and R. D. Hill (Illinois. Univ., Urbana). Mar. 1964. Contract NONR-1834(05). 10p.

Meson (π^-) stars observed in normal Ilford G-5 emulsion and in water-soaked G-5 emulsion were examined. It was found that 57.5% of all meson (π^-) stars in the normal emulsion were caused by absorption in heavy nuclei, while such absorption accounted for only 43% of all meson (π^-) stars in the water-soaked emulsion. Events in the light nuclei were separated into captures in C, N, and O on the basis of the number of prongs and the distinction between proton and alpha prongs. Specific results are given, together with the results of other determinations for normal emulsions. (D.C.W.)

231

26142 OBSERVATION OF RADIATIVE CAPTURE OF NEGATIVE MUONS IN IRON. G. Conforto, M. Conversi, and L. di Lella (CERN, Geneva). Phys. Rev. Letters, 9: 22(July 1, 1962).

The reaction $\mu^- + N \rightarrow N^1 + \nu + \gamma$ was detected; rates of occurrence under given conditions were measured. Feasibility of experiments on the coupling constants, the circular polarization, and the γ asymmetry of gamma emission from radiative capture of polarized muons by spinless nuclei was estimated. Evidence for occurrence of the process in Fe with a branching ratio of about 10^{-4} was found. (L.N.N.)

232

9394 ON RADIATIVE MUON CAPTURE. G. Conforto, M. Conversi, and L. Di Lella (CERN, Geneva). p.427-30 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

In a search for the hitherto unobserved process $\mu^- + N \rightarrow N + \nu + \gamma$, 90-Mev μ^- were stopped in the steel plates of a spark chamber, and γ rays with energy >60 Mev were recorded. The conditions considered as identifying the process searched for were met by 9.5 ± 3.8 events. From this the branching ratio relative to ordinary μ^- capture was found to be $\sim 10^{-4}$. (A.G.W.)

233

5377 SEARCH FOR NEUTRINOLESS COHERENT NUCLEAR CAPTURE OF μ^--MESONS. G. Conforto, M. Conversi, L. Di Lella, G. Penso, C. Rubbia, and M. Toller (Università, Rome; INFN, Rome; and CERN, Geneva). Nuovo cimento (10), 26: 261-82(Oct. 16, 1962). (In English)

A high sensitivity experiment to search for the neutrinoless conversion of a muon into an electron ($\mu^- + N = N + e^-$, where N is a Cu nucleus) has been carried out at the CERN Synchrocyclotron. The space correlation between the muon and the electron was seen in a spark chamber operated as a target in the muon beam. The time correlation was observed on an oscilloscope trace which also contained the pulse from a large NaI(Tl) crystal, used to measure the energy of the electron (103.8 Mev in the case of the above mentioned process occurring coherently in the Cu plates of the chamber). Nearly 2.4 billion μ^--mesons were stopped during the main run. From the scanning of the film of the chamber (two 90° stereo-views) and of the corresponding oscilloscope pictures obtained in this run, four events were found fulfilling all requirements of time correlation, space correlation, and correct energy release in the NaI counter. It is shown, however, that ~5 ± 2 is the expected number of events of spurious nature. Hence, if the neutrinoless coherent nuclear capture of a meson exists at all, its branching ratio to the ordinary capture is concluded to be less than 2.2×10^{-7} with 90% confidence level. This negative result fits into the recent discovery of two kinds of neutrinos. (auth)

234

9921 ELASTIC SCATTERING OF μ^+ IN NUCLEAR EMULSION. P. Connolly, J. G. McEwen, and J. Orear (Cornell Univ., Ithaca, N. Y.). p.796 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The cross sections were measured for the elastic scattering of mesons (μ^+) on AgBr in nuclear emulsions for momentum transfers of up to 160 Mev/C. Data indicated that the μ^+ meson behaves the same as a position, but with a mass 207 times larger. (M.C.G.)

235

21470 ELASTIC SCATTERING OF MUONS IN NUCLEAR EMULSION. P. L. Connolly, J. G. McEwen, and J. Orear (Cornell Univ., Ithaca, N. Y.). Phys. Rev. Letters, 6: 554-6(May 15, 1961).

Mesons μ^+ and μ^-, at maximum energies of 43 and 60 Mev respectively, are elastically scattered by emulsion nuclei. For the μ^+ scattering, only 14 to 40 Mev muons that are scattered between 80 and 180° are considered. The calculated and observed number of μ^+ events having a momentum transfer greater than q, and the average differential scattering cross sections for Ag and Br, are given as functions of q. Only preliminary results are given for μ^- scattering. No indication of an anomalous μ-nucleus interaction is found. (T.F.H.)

236

27365 USE OF A SPARK CHAMBER IN A SEARCH FOR NEUTRINO-LESS CONVERSION OF MUONS INTO ELECTRONS. M. Conversi (Univ. of Rome). p.140-1 of "Proceedings of the Symposium on Nuclear Instruments." New York, Academic Press Inc., 1962.

A search for the reaction $\mu^- + N \rightarrow N + e$ was made. Apparatus design and performance are described. (L.N.N.)

237

26525 (BNL-837(p.315-23)) RADIATIVE MUON CAPTURE IN Ca^{40} AND THE INDUCED PSEUDOSCALAR COUPLING CONSTANT. M. Conversi, R. Diebold, and L. di Lella (European Organization for Nuclear Research, Geneva).

A preliminary account is given of an experiment on the muon radiative capture process $\mu^- + p \rightarrow n + \nu_\mu + \gamma$, where p is a proton on a Ca^{40} nucleus. The induced pseudoscalar coupling constant, g_p, is determined from measurement of the reaction rate. (M.J.T.)

238

18668 EXPERIMENT ON THE PROCESS $\mu^- + N = e^- + N$. M. Conversi, L. di Lella, A. Egidi, C. Rubbia, and M. Toller (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). Nuovo cimento (10), 19: 999-1009(Mar. 1, 1961). (In Italian)

An experiment is performed on the process $\mu^- + N \rightarrow N + e^-$ making use of a low energy high intensity μ^- beam. If, as expected on theoretical ground, coherent neutrinoless capture of muons in copper is at least 6 times more probable than the corresponding incoherent process, the branching ratio relative to ordinary muon capture turns out to be less than 5.9×10^{-6}, with 90% confidence level. (auth)

239

25922 (NP-11977(p.49-52)) MISURA DELLA POLARIZZAZIONE DEI NEUTRONI DA CATTURA DI MESONI μ^-. (Measurement of the Polarization of Neutrons from the Capture of μ^- Mesons). M. Conversi, L. di Lella, A. Egidi, C. Rubbia, and M. Toller (Italy. Istituto Nazionale di

Fisica Nucleare, Rome).

The experimental setup being designed for the measurement of neutron polarization by μ^- capture is described. It is planned to use a target of calcium for the μ^- beam at CERN. (J.S.R.)

240

18667 ON THE NUCLEAR CAPTURE OF NEGATIVE MUONS WITH ELECTRON EMISSION. M. Conversi, L. di Lella, A. Egidi, C. Rubbia, and M. Toller (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). Nuovo cimento (10), 19: 987-98(Mar. 1, 1961). (In Italian)

An experimental search is described for the neutrinoless μ^- capture reaction $\mu^- + N \rightarrow N + e^-$. μ^- mesons at 600 Mev stop in a copper target. The upper limit for the branching ratio of the process searched for, relative to ordinary muon capture, is improved by a factor of more than 20 with respect to previous measurements. (auth)

241

16342 ON THE NUCLEAR CAPTURE OF MUONS WITH ELECTRON EMISSION. M. Conversi, L. Di Lella, A. Egidi, C. Rubbia, and M. Toller (Università, Rome). Phys. Rev., 122: 687-95(Apr. 15, 1961).

Two experiments carried out to search for the process of muon capture with electron emission are reported. The second of the two experiments is nearly 200 times more sensitive than earlier attempts to find this capture mode, but no indication is obtained in favor of the latter. In both experiments negative muons are made to stop in copper, where coherent capture is predominant, so that the "capture electrons" should be emitted with an energy spectrum sharply peaked around 100 Mev. For the branching ratio of the process searched for, relative to ordinary muon capture, upper limits of about 5×10^{-5} and 5×10^{-6} are established through the first and second experiment, respectively. (auth)

242

11978 SEARCH FOR ELECTRONS FROM MUON CAPTURE. M. Conversi, L. di Lella, A. Egidi, C. Rubbia, and M. Toller (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). Nuovo cimento (10), 18: 1283-6(Dec. 16, 1960). (In English)

Experiments were performed to show the existence of the processes $\mu^- + p \rightarrow p + e^-$ or $\mu^- + n \rightarrow n + e^-$ if the branching ratio (R = rate of $\mu^+ + Cu \rightarrow Cu + e^-$/rate of $\mu^- + Cu \rightarrow Ni + \nu$) was larger than a few times 10^{-6}. The 60-Mev muon beam at CERN was used with 12 plastic scintillators in an electron telescope which had a detection efficiency of 0.14 for 8-fold coincidences. A value of $R < 5.9 \times 10^{-6}$ with 90% confidence level was found, in agreement with that found by Sard et al., using a different technique. (T.R.H.)

243

10891 SEARCH FOR CONVERSION OF MUONS INTO ELECTRONS. M. Conversi (Università, Rome), L. di Lella, G. Penso, M. Toller, and C. Rubbia. Phys. Rev. Letters, 8: 125-7(Feb. 1, 1962).

An investigation of the possible existence of the process $\mu^- + N = N + e^-$ is conducted from both the theoretical and the experimental point of view. Experimental equipment includes a monitoring telescope for the incoming μ^-, a spark chamber where the μ^- are brought to rest, and a telescope for the outgoing electrons. Electron energies are measured. Branching ratios are evaluated at 90 to 110 Mev, and over-all efficiencies are measured. If the process $\mu^- + N \rightarrow N + e^-$ exists at all, its branching ratio cannot exceed 2.4×10^{-7}. (L.N.N.)

244

25923 (NP-11977(p.53-4)) RICERCA DELLA CATTURA RADIATIVA DEL MESONE MU. (Research on the Radiative Capture of Mu Mesons). M. Conversi, L. di Lolla, C. Rubbia, and M. Toller (Italy. Istituto Nazionale di Fisica Nucleare, Rome).

An experimental method for the measurement of the radiative capture of muons is described. The method consists in the measurement of the gamma emitted by a copper target irradiated with a pure intense beam of muons. The gamma rays are measured with a NaI scintillator, preceded by a plastic scintillator in anticoincidence, by a lead converter, and by a plastic scintillator telescope in coincidence. The factors that can reduce the background to improve the measurement accuracy are briefly discussed. (J.S.R.)

245

14525 (BNL-6767) PERSONNEL DOSIMETRY OF VERY HIGH ENERGY RADIATIONS. Frederick P. Cowan (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 9p.

Two basic methods of dosimetry applicable to high energy radiation areas are briefly reviewed, and the problem of μ-meson dosimetry is examined theoretically. Experimental results indicate that standard methods of film badge interpretation may be used for rem dose determinations in μ-meson areas. Preliminary measurements on dosimetry of proton beams indicate a need for more research and careful control of exposures. (D.C.W.)

246

21399 MUON CAPTURE RATES FOR ^{44}Ca AND ^{40}Ca: OBSERVATION OF THE ISOTOPE EFFECT. W. A. Cramer, V. L. Telegdi, and R. Winston (Univ. of Chicago) and R. A. Lundy. Nuovo cimento (10), 24: 546-8(May 1, 1962). (In English)

Time distribution of capture products was used for

determining μ disappearance; results are presented in graphical form. A diagram and a description of the apparatus are given. Observed and predicted values for the isotope effect are compared, and fair agreement is obtained. (L.N.N.)

247

8098

π^--p SCATTERING BELOW 1 Bev. R. R. Crittenden, J. H. Scandrett, W. D. Shephard, and W. D. Walker (Brookhaven National Lab., Upton, N. Y.) and J. Ballam (Michigan State Univ., East Lansing, and Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Letters 2, 121-4(1959) Feb. 1.

Measurements of π^--p total and differential elastic cross sections in the energy range 400 to 800 Mev were carried out. This work was done by exposing a propane bubble chamber in a pion beam at the Brookhaven Cosmotron. Results are shown for a total of 60,000 pictures. (W.D.M.)

248

12529 STUDY OF π-NUCLEI SCATTERING BELOW 500 AND 1300 Mev. M. Crozon, Ph. Chavanon, A. Courau, Th. Leray, J. L. Narjoux, and J. Tocqueville (Collège de France, Paris). Nucl. Phys., 64: 567-84(Apr. 1965). (In French)

The total elastic (σ_{el}) and inelastic (σ_a) cross sections for reactions of π-mesons with Be, C, and Al nuclei at various energies around 1 Bev were measured. The counter experiment, made with the help of Saclay's proton synchrotron, was a poor and rich geometry one. The extrapolation to zero angle of the attenuation of the beam measurements at different angles was made with the use of the optical model. It is assumed that the shape of the nuclei is the one determined by electron scattering experiments, and that the inelastic products have an approximately constant distribution. From this use of the optical model one can get not only σ_a and σ_{el}, but also a value of the mean forward scattering amplitude $\overline{f(0)}$ of the π-nucleon system for linked nucleons. This value has to be compared to the mean π-free nucleon amplitude at the same energy of the pion, in order to check the usual approximations used in the optical model. The order of magnitude of the two amplitudes is the same and, in particular, the real parts are not significantly different, as could be deduced from other experiments. To get a fair agreement between the imaginary parts, one has to take account of the Fermi momenta of nucleons and of second order corrections using correlation functions of nucleons inside nuclei. (auth)

249

41915 ANGULAR DISTRIBUTION OF π^- MESONS AT 960 Mev/c SCATTERED ON NUCLEI. M. Crozon, T. Leray, and J. Tocqueville (Faculté de Sciences, Paris). Nuovo Cimento (10), 29: 655-69(Aug. 1, 1963). (In French)

Differential cross-sections were measured for negative pion scattering on nuclei at 960 Mev/c. The target elements used were C, Al, and Cu. An attempt was made to separate elastic and quasi-elastic scattering from true-inelastic processes. The results show a good agreement with the predictions of the optical model. The nuclear radius and the fall-off parameter were taken to be approximately those determined from nuclear charge distribution measurements. Some discrepancies between experimental and predicted values of σ are discussed. (auth)

250

9223

LONGITUDINAL POLARIZATION OF THE ELECTRONS FROM THE DECAY OF UNPOLARIZED POSITIVE AND NEGATIVE MUONS. G. Culligan, S. G. F. Frank, and J. R. Holt (Univ. of Liverpool). Proc. Phys. Soc. (London) 73, 169-77(1959) Feb.

The polarization of electrons from the decay of unpolarized positive and negative muons was detected by the method of transmission of bremsstrahlung through magnetized iron. It is shown that the positrons have positive helicity and the negatrons negative helicity, thus providing a clear demonstration of violation of invariance under charge conjugation. It follows on the basis of the two component neutrino theory that the neutrino associated with the decay of the pion has negative helicity and the anti-neutrino positive helicity. The agreement of this with recent results for the neutrino in β decay lends support to this theory and confirms the law of conservation of leptons. (auth)

251

21458 THE DECAY OF NEGATIVE π-MESONS STOPPED IN LIGHT ELEMENTS AND INSULATORS. G. Culligan, D. Harting, N. H. Lipman, L. Madansky, and G. Tibell (CERN, Geneva). Nuovo cimento (10), 20: 351-8(Apr. 16, 1961). (In English)

Beams of 170 Mev/c π^+ or π^- mesons, from which the π mesons are selected, by time-of-flight methods, are stopped in Be, B_4C, Teflon, and Al targets. The ratio of the numbers of electrons produced by the negative and positive beams by π-μ-e decay is determined for each of these materials. Assuming that no π^- decay occurs in the Al target, an upper limit of one per cent is found for the decay probability of π^- mesons stopped in either Be, B_4C, or Teflon. (auth)

252

6975 EXPERIMENTAL PROOF OF THE SPIN DEPENDENCE OF THE MUON CAPTURE INTERACTION, AND EVIDENCE FOR ITS (F-GT) CHARACTER. G. Culligan (Univ. of Chicago), J. F. Lathrop, V. L. Telegdi, R. Winston, and R. A. Lundy. Phys. Rev. Letters, 7: 458-60(Dec. 15, 1961).

Observations to determine whether the "universal V-A" interaction, as yet unproved in the case of μ capture, are made qualitatively. The time dependence of the rates at

which neutral products (neutrons and/or nuclear photons) are emitted in the capture of muons by F^{19} was measured to determine the spin dependence. A LiF target was used, since lithium has a negligible capture rate. Selection of either γ- or n-induced pulses could be made. Results are presented in tabular form, and comparisons between observed and theoretical parameters are made. Using the precession rate, decay asymmetry parameters of μ^- bound to F^{19} (UF_6 target) and to C^{12} (graphite) are compared. It is concluded that, in general, μ^- capture is spin dependent; for F^{19}, $\Lambda^- > \Lambda^+$ ($A' > 0$); its magnitude is near the maximum possible, i.e., that predicted for an (F' × GT) interaction with $x \simeq -1$; both the absolute rates and their spin dependence agree with the "universal V-A" prediction, and exclude a (V + A) interaction; and there is a fast $F^+ \rightarrow F^-$ conversion process of the predicted rate. (L.N.N.)

253

21315 INTERNALLY PRODUCED ELECTRON PAIRS FROM π^--MESONS CAPTURED IN HYDROGEN. D. C. Cundy, R. A. Donald, W. H. Evans, D. W. Hadley, W. Hart, P. Mason, R. W. Newport, D. E. Plane, J. R. Smith, and J. G. Thomas (Univ. of Liverpool). Phil. Mag. (8), 7: 121-6(Jan. 1962).

Internal pairs produced by π^--mesons captured in hydrogen were studied with a hydrogen bubble chamber. The probability that a stopped meson produces a pair was found to be 0.0093 ± 0.0006. This probability, which is very insensitive to the Panofsky ratio, serves to check the theoretically predicted values of the conversion coefficients of Joseph. (auth)

254

21043 THE S-WAVE SCATTERING LENGTHS FOR THE PION-PROTON INTERACTION. D. C. Cundy, R. A. Donald, W. H. Evans, W. Hart, P. Mason, D. E. Plane, J. R. Smith, and J. G. Thomas (Univ. of Liverpool). Proc. Phys. Soc. (London), 85: 257-65(Feb. 1965).

From an analysis of charge exchange and elastic scattering of 35 Mev negative pions using a liquid hydrogen bubble chamber, the charge-exchange total cross section is found to be 5.61 ± 0.40 mb and the s-wave scattering lengths $a_1 = +0.187 \pm 0.009$ and $a_3 = -0.082 \pm 0.011$ in units of $\hbar = c = m_\pi = 1$. The quantity $a_1 - a_3$ is found by a method free from systematic error and independent of Coulomb corrections. It is compared with that of the analysis of pion–proton scattering data, using dispersion relations, by Hamilton and Woolcock. The agreement is reasonable. (auth)

255

16487 INELASTIC COLLISIONS FOR SMALL MOMENTUM TRANSFERS. J. Cunningham (University Coll. of North Wales, Bangor, U. K.). Australian J. Phys., 17: 553-5(Dec. 1964).

Inelastic meson(π)-nucleon collisions with small momentum transfers are considered. The analytic properties of the amplitudes are examined as a function of the energy variables. (C.E.S.)

256

16884 EXPERIMENTAL INVESTIGATION OF μ^--MESIC ATOM PROCESSES IN GASEOUS HYDROGEN. V. P. Dzhelepov, P. F. Ermolov, E. A. Kushnirenko, V. I. Moskalev, and S. S. Gershtein (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 42: 439-49 (Feb. 1962). (In Russian)

A diffusion cloud chamber in a magnetic field was employed to study a number of μ-mesic atom processes in hydrogen. The following quantitative data have been obtained: cross section for elastic scattering of $p\mu$ mesic atoms on protons, $\sigma_{p\mu} = (1.7^{+0.4}_{-0.5}) \times 10^{-19}$ cm^2; the rates of the μ-meson transfer from a proton to deuterons and complex nuclei (C and O) recalculated for density of liquid hydrogen, $\lambda_d = (0.95^{+0.34}_{-0.21}) \times 10^{10}$ sec^{-1} and $\lambda_Z = (1.2^{+0.8}_{-0.5}) \times 10^{10}$ sec^{-1}; the rate of the formation of $pp\mu$ mesic molecules in liquid hydrogen, $\lambda_{pp\mu} = (0.6^{+0.8}_{-0.5}) \times 10^6$ sec^{-1}. The experimental values of λ_d, $\lambda_{pp\mu}$, and λ_Z satisfactorily agree with the theoretical values. This confirms the correctness of the mechanisms of the processes proposed in the theory. The cross section $\sigma_{p\mu}$ was found to be close to the theoretical value computed without taking into account the hyperfine structure of the $p\mu$ mesic atom. However, it is not excluded that fast transitions to the lower state with a total mesic atom spin F = 0 may occur. The absolute value of λ_d determined opens the possibility of finding the absolute probabilities of a large number of μ mesic molecular processes by employing it as a scale. (auth)

257

25361 THE WEAK INTERACTIONS OF THE MUON. R. H. Dalitz (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 285: 229-47(Apr. 20, 1965).

A survey on meson (μ) decay, meson (μ^-) capture by hydrogen and complex nuclei, and leptonic decays of strange particles is presented. The accuracy and detail with which the weak interactions of the electron and the meson (μ) are identical in form are emphasized. Only the hypothesis that these leptons participate in weak interactions only through the charged current vectors and its Hermitian conjugate is considered. (D.C.W.)

258

26972 (JINR-P-1985) UVELICHENIE DLITEL'NOSTI IMPUL'SOV PUCHKOV CHASTITS SINKHROTSIKLOTRONA OIYAI NA 680 Mev. (The Increase of the Pulse Duration of Particle Beams at a 680-Mev Synchrocyclotron of the Joint Institute for Nuclear Research). V. I. Danilov, I. B. Enchevich, B. I. Zamolodchikov, E. A. Polferov, E. I. Rozanov, V. I. Smirnov, and V. G. Testov (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 12p. Dep.(mn).

A method of increasing the duty cycle of the particle beams is described. It was tested at the JINR synchrocyclotron. The method is based on an excitation of the forced radial oscillations of the beam by the local inhomogeneity of the magnetic field variable in time. The magnetic field perturbation is produced by a pair of coils supplied by the current pulses with a half-conduction angle

of 90° and located at a radius of 265 cm. The pulse duration of the meson beam was increased 5–6 times and is about 2500 μsec at the level of intensity 0.5. (auth)

259

1406 RELATIVE BIOLOGICAL EFFICIENCY OF NEGATIVE μ-MESONS AND COBALT-60 γ-RAYS. D. R. Davies, A. H. Sparrow, R. G. Woodley, and A. Maschke (Brookhaven National Lab., Upton, N. Y.). Nature, 200: 277-8(Oct. 19, 1963). (BNL-7324)

The relative biological effectiveness of mesons (μ^-) and Co^{60} gamma rays in inducting somatic mutation in staminal hair cells of a diploid clone (02) derived from a variety of Tradescantia occidentalis was investigated. Eight fluorescences were exposed in air in the muon beam for each of the periods of time—2, 4, 6, 8, and 10 hr. As a standard for the muon treatments, influorescences were exposed in air at a dose rate of 7.5 rads/hr to four doses of Co^{60} gamma rays: 30, 48.7, 71.2, and 120 rads. Mutations were scored in the staminal hairs of flowers emerging on four successive days and the data relating yield per flower, to dose in rads, fitted to linear, $y = k + \alpha D$, and quadratic, $y = k + \alpha D + \beta D^2$, regressions. In all instances linear regressions better fitted the data. The RBE of muons : γ is given by the ratio of the α coefficients, and has a mean value for all days of 0.79. (P.C.H.)

260

15794 HIGH ENERGY γ RAYS FROM PION CAPTURE. Davies, H.; Muirhead, H.; Woulds, J. N. (Univ. of Liverpool). Nucl. Phys., 78: 673-80(1966).

The yields and energy spectra of the high energy γ radiation arising from meson(π) capture in complex nuclei were measured by means of a sodium iodide crystal. The γ-rays appear to peak strongly in the region of 100–115 Mev for a range of nuclei from ^6Li to natural copper; the yield is about 2% per meson(π) capture and falls slowly with increasing atomic weight. Possible reaction mechanisms are discussed. (auth)

261

41770 THE POLARIZATION OF PROTONS RECOILING FROM π^+ + p COLLISIONS AT 265 Mev. D. G. Davis, A. Ghani, R. C. Hanna, F. F. Heymann, G. Heymann, and A. L. Read (CERN, Geneva). Nuovo Cimento (10), 29: 507-14(July 16, 1963).

The polarization of protons recoiling at 23° in the laboratory from π^+ + p elastic collisions at 265 Mev was measured using carbon as an analyzer, together with a system of large directional counters. The polarization was found to be -0.11 ± 0.007. The inclusion of these data with existing information on differential and total cross sections at this energy strengthens the case for the inclusion of D-waves in a phase-shift analysis at this energy. (auth)

262

18340 NP-8693

Maryland. Univ., College Park.

ABSORPTION MECHANISMS OF NEGATIVE K MESONS AND PIONS IN LIQUID HYDROGEN. Thomas B. Day. Apr. 1960. 19p. Contract AF49(638)-24. ([AFOSR]-TN-60-501).

Slowing down and capture of negative mesons by the atoms and molecules in liquid hydrogen are treated. The results of an experiment on following 80,000 pion tracks stopping in a liquid hydrogen bubble chamber are discussed. The question of from which atomic state the meson is absorbed is considered. (W.D.M.)

263

6847 AFOSR-TN-59-1295

Maryland. Univ., College Park.

HIGH ORBITAL S-STATE CAPTURE OF π^--MESONS BY PROTONS. Physics Dept. Technical Report No. 159. T. B. Day, G. A. Snow, and J. Sucher. Dec. 1959. 9p. Contracts AF49(638)-24 and AT(40-1)-2504. OTS.

The time which elapses between that point in the slowing down of a π^--meson in liquid H_2 when it has a velocity $v \simeq 0.05c$ and the moment of capture by a proton was recently measured to be $\simeq 3.5 \times 10^{-12}$ sec. The result is considered from the Stark effect and capture process previously proposed for the K^-,p) atom. It is concluded that the number is so restrictive that the Stark effect process cannot explain the capture rates of pions in hydrogen. (W.D.M.)

264

6966 π^- p INTERACTIONS AT 224 MEV. J. Deahl, M. Derrick, J. Fetkovich, T. Fields, and G. B. Yodh (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 124: 1987-94(Dec. 15, 1961).

Interactions of 224-Mev negative pions with protons were investigated using a 15-cm hydrogen bubble chamber in a 13-kgauss field. Seventeen hundred elastic scatterings were analyzed yielding a cross section of 16.0 ± 0.8 mb for this process. No evidence for powers of $\cos\theta$ higher than two was observed in the angular distribution. The charge-exchange cross section, based on 1200 events was 34.4 ± 1.9 mb. The results of a random-search phase-shift analysis, using these data in conjunction with earlier π^+-p elastic scattering results and recoil proton polarization measurements (π^--p), are reported. A search for pion production yielded three events of the type $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ corresponding to a cross section of ~30 μb. No events of the type $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ were observed. (auth)

265

9808 π^--p INTERACTIONS AT 225 MeV. J. Deahl, M. Derrick, J. Fetkovich, T. Fields, and G. B. Yodh

(Carnegie Inst. of Tech., Pittsburgh, Penna). p.185-7 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

Meson (π^-) interactions with protons at 225 Mev were studied in order to obtain scattering data of higher accuracy than that previously available and to observe meson (π) production. Total and elastic differential cross sections were determined. An s,p phase-shift analysis was made on the data. (M.C.G.)

266

6530 π^+-PROTON INTERACTIONS AT 500 Mev INCIDENT ENERGY. J. Debaisieux, F. Grard, J. Heughebaert, R. Servranckx, and R. T. Van de Walle (Institut Interuniversitaire des Sciences Nucleaires, Brussels). Nucl. Phys., 63: 273-85(Mar. 1965).

Results are presented on π^+-p interactions at 500 Mev from an experiment performed with the Saclay 35-cm hydrogen bubble chamber. A total of 1840 events was observed. The branching ratio for elastic events is equal to 0.883 ± 0.008. Eight events are unambiguously attributed to the $\pi^+p \rightarrow \pi^+p\gamma$. Cross sections for the various interactions are given. The elastic angular distribution was determined up to $\cos\theta = +0.975$ and shows evidence for S, P, D waves, in good agreement with the results obtained in other experiments. For the one-pion production reactions, the ratio of π^0 production to π^+ production is found to be equal to 4.1 ± 0.8. This result and the corresponding distributions for momentum and angle of the secondaries are compared with the predictions of the isobaric models. (auth)

267

36302 EXPERIMENTAL STUDY OF THE $\pi^+ + d \rightarrow p + p$ REACTION BETWEEN 0.65 AND 1.95 Gev/c. D. Dekkers, (CERN, Geneva), B. Jordan, R. Mermod, C. C. Ting, G. Weber, T. R. Willitts, K. Winter, X. De Bouard, and M. Vivargent. Phys. Letters, 11: 161-4(July 15, 1964).

The differential and total cross sections of the $\pi^+ + d \rightarrow p + p$ reaction were investigated for energies between 0.65 and 1.95 Bev/c. (C.E.S.)

268

27501 STARS PRODUCED BY π^- MESONS AT REST: NATURE OF UNIT CHARGE BRANCHES. M. Dellagi (Faculte des Sciences, Tunis). J. Phys. (Paris), 26: 59-62(Feb. 1965). (In French)

The results are reported of multiple scattering measurements made on 209 tracks of length $\geq 1\ 100\ \mu$ at the end of their range in nuclear emulsion (constant sagitta method, Dilworth series of residual range). The chosen parameter is D, the arithmetic mean of the second differences relative to 4 times the length of the basic cell. The D distribution may be looked upon as one made up to two Gaussian distributions only, arising from the proton and deuteron contribution. The proton ratio is 1.1 ± 0.2. It is shown that the gap length distribution is different for tracks at very large or very small D; these tracks belong to distinct groups of particles. (auth)

269

34746 THE EFFECT OF A PION PRODUCTION ON THE LOW ENERGY PION-NUCLEON SCATTERING. A. Deloff. Bull. Acad. Polon. Sci., Ser. Sci., Math., Astron. Phys., 11: 323-6(1963). (In English)

The meson (π) production cross section in meson (π)-nucleon scattering above the 170-Mev threshold is investigated to determine the effect of the meson (π) production process. (C.E.S.)

270

5992 (NP-13347) ETUDE DES EFFETS DE STRUCTURE HYPERFINE DANS LA CAPTURE DES MESONS-MU. APPLICATION AU CAS DU LITHIUM-6 (thesis). (Study of the Effects of Hyperfine Structure in the Capture of μ Mesons. Application to the Case of Lithium-6 (thesis)). Jean Delorme (Lyon. Université). [1962]. 72p.

The effect of hyperfine structure in the capture of μ mesons is studied and extended to transitions leading to a particular final state. The hyperfine difference $\Delta\lambda$ between states is calculated, and the matrix elements of the hyperfine structure operators in the shell model are derived. The results are then applied to the transition $Li^6 + \mu^- \rightarrow He^6 + \nu$. It is shown that this reaction has as great a hyperfine structure as μ^- capture by hydrogen. The effect is essentially due to the conservation of the angular momentum and to the predominance of orbital moment configurations totaling zero in Li^6 and He^6. (J.S.R.)

271

26365 ELASTIC π^- MESON SCATTERING ON CARBON AT 5 TO 15 Mev. V. S. Demidov, V. G. Kirillov-Uzryumov, A. K. Ponosov, V. P. Protasov, and F. M. Sergeev (Moscow Inst. of Engineering Physics). Zhur. Eksptl'. i Teoret. Fiz., 42: 1687-8(June 1962). (In Russian)

Previous studies of elastic π^- scattering on C at less than 22 Mev indicated the presence of an effective repulsion potential. An analysis of π^- scattering at identical energies was made in order to determine the π-nucleus potential by the difference in the interference of electromagnetic and nuclear interactions. A $370 \times 140 \times 100$ mm propane bubble chamber irradiated by a 5 to 15 Mev π^- beam was used in the experiment. The tabulated results, compared with the data for π^+, revealed a region (20 to 120° angle) where the π^- scattering is much weaker than the π^+. Further studies showed that in the weaker region the contributons of interfering Coulomb and nuclear interactions are highly pronounced. The divergence in the angular distributions of π^- and π^+ permit a direct determination of the π-carbon nucleus potential that corresponds to β-state repulsion. The obtained data were used for evaluating the phase shifts in π^- scattering on C and, in turn, the β-state repulsion. The data are in close agreement with those of N. Byers (Phys. Rev 107: 843(1957)). (R.V.J.)

272

24475 ABSORPTION OF SLOWED DOWN π^- MESONS IN PROPANE. V. S. Demidov, V. S. Verebryusov, V. G. Kirillov-Ugryumov, A. K. Ponosov, and F. N. Sergeev. (Inst. of Engineering Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 46: 1220-5(Apr. 1964). (In Russian)

The energy spectra of secondary singly charged particles produced as a result of absorption of slowed down mesons (π^-) by carbon and also the angular distribution between the prongs in meson (π) stars are obtained with a 4 liter propane bubble chamber. Estimations performed on basis of the energy spectra show that the maximum contribution of the process of meson (π) absorption by a complex consisting of several nucleons (≥ 4) does not exceed 20%. An analysis of over 200 interactions carried out on an electronic computer by the Monte Carlo method shows that the experimental data are in agreement with the two-nucleon mechanism and, in accordance with preliminary results, the probability for meson (π) absorption by a pair of different nucleons (np) is two or three times greater than that for absorption by a pair of identical (pp) nucleons. (auth)

273

9229 DETERMINATION OF THE $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ DECAY RATE. P. Depommier, J. Heintze, A. Mukhin, C. Rubbia, V. Soergel, and K. Winter (CERN, Geneva). Phys. Letters, 2: 23-6(Aug. 1, 1962). (In English)

Events of the type $\pi^+ \rightarrow \pi^0 + e^+ + \nu$; $\pi^0 \rightarrow 2\gamma$, have been observed and analyzed. A detailed analysis of the experimental arrangement and the evaluation of events is presented. The e^+ spectrum has the allowed shape with an end point at $E_{\beta max} = 4.0$ Mev. The experimental branching ratio obtained, $(1.7 \pm 0.5) \times 10^{-8}$, is compatible within 1.3 standard deviations with the conserved vector current value. (H.D.R.)

274

9387 EXPERIMENTAL EVIDENCE FOR STRUCTURE EFFECTS IN THE $\pi^+ \rightarrow e^+ + \nu + \gamma$ DECAY PROCESS. P. Depommier, J. Heintze, A. Mukhin, C. Rubbia, V. Soergel, and K. Winter (CERN, Geneva). p.414-16 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

An experiment intended to detect high-energy electron-γ pairs emitted in opposite directions from the $\pi^+ \rightarrow e^+ + \nu + \gamma$ decay process was performed. It is shown that the number of such events recorded (8 ± 2) indicates the presence of a structure in the radiative π^+ decay. (A.G.W.)

275

29541 FURTHER MEASUREMENTS OF THE $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ DECAY RATE. P. Depommier, J. Heintze, C. Rubbia, and V. Soergel (CERN, Geneva). Phys. Letters, 5: 61-3(June 1, 1963). (In English)

Calculations based on 38 ± 2 additional events give a value for the branching ratio $R = \pi^+ \rightarrow \pi^0 + e^+ + \nu / \pi^+ \rightarrow \mu^+ + \nu$ of the process $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ of $R_{exp} = (1.08 \pm 0.21) \times R_{cvc}$, where R_{cvc} is the value predicted by the conserved vector current theory. Good agreement between experimental and theoretical coupling constants and weak anomalous magnetic moments supports the validity of the conserved vector current theory. (D.C.W.)

276

15411 SINGLE PION PRODUCTION IN π^-p INTERACTIONS BETWEEN 600 AND 900 Mev. Derado, I. (Univ. of Notre Dame, Ind.); Kenney, V. P.; Lamsa, J. W.; Poirier, J. A.; Shephard, W. D.; Stautberg, J. L.; Vittitoe, C. N. pp 244-50 of Resonant Particles. Athens, Ohio, Fazl-i-Umar Research Inst., 1965.

The results of a study of single pion production in π^-p interactions at incident pion kinetic energies of 604, 790, 830, and 870 Mev are prescribed. The analysis of these data in terms of the formation of the $N^*_{3,3}(1238)$ isobar is also discussed. (G.O.Y.)

277

20788 NYO-2241

Carnegie Inst. of Tech., Pittsburgh.

INTERNAL PAIRS FOLLOWING π^- CAPTURE IN HYDROGEN. M. Derrick, J. G. Fetkovich, T. H. Fields, and J. Deahl. June 1960. 26p. Contract AT(30-1)-882. OTS.

Internal electron pairs from the two reactions (1) $\pi^- + p \rightarrow n + \pi^0 \rightarrow n + \gamma + e^+ + e^-$ and (2) $\pi^- + p \rightarrow n + e + e^-$ were studied in a hydrogen bubble chamber. 2184 cases were seen. A geometrical cut off selected 1523 of these as suitable for momentum measurement. By an analysis of the momentum spectrum the Panofsky ratio was measured to be 1.51 ± 0.10. The total intensity, momentum partition within the pairs, and distribution in virtual photon mass are in essential agreement with the theoretical predictions of Kroll and Wada as recently extended by Joseph. (auth)

278

24819 BOUND MUON DECAY IN IRON AND ZINC. Lewis Gail Despain (Univ. of Utah, Salt Lake City). Dissertation Abstr., 22: 4378-9(June 1962).

An improved cosmic ray counter consisting of a sandwich array of Čerenkov and scintillation detectors is used to obtain a composite time distribution of decay electrons from positive and negative muons stopping in aluminum, iron, and zinc. The decay electron is detected in an improved toluene scintillation counter capable of absorbing a considerable fraction of the disintegration energy available to the decay electron. The decay time of each muon was measured and electronically converted to a pulse height and then tabulated in the proper time channel by

means of a pulse height analyzer. Least squares analysis of the decay data and subsequent manipulation yields the ratio of λ_d, the decay rate for negative muons bound to the target nuclei, to λ_0, the decay rate for free muons. Measurements showed the λ_d/λ_0 ratio to be 1.08 ± 0.07 for iron and 1.01 ± 0.08 for zinc. This experiment offers evidence in support of the anomalous behavior of the λ_d/λ_0 ratio in the region near Z = 26. The ratio of the number of stopping μ^+ to the number of stopping μ^-, was found to be ρ = 1.17 ± 0.12. This value agrees very well with other reported values.

279

15211

MEASUREMENT OF THE TOTAL CROSS SECTION FOR THE INTERACTION OF CHARGED π MESONS WITH PROTONS. J. phys. radium 21, 15S-16S(1960) Feb. (In French)

The experimental arrangement for measuring the attenuation of a beam of π mesons in liquid hydrogen is described. The energy of the beam was measured directly by curves of differential path of protons at 800 Mev/c, by curve of differential path of $\pi^\pm$ at 400 Mev/c, and by time-of-flight of the protons. The corrections for the contamination of the beam with μ mesons and electrons were determined to be 0.07 ± 0.03 at 1 Bev and 0.30 ± 0.03 at 400 Mev, respectively. (J.S.R.)

280

25835 ANGULAR DISTRIBUTION OF THE π^0 IN THE REACTION $\pi^+ + p \rightarrow \pi^+ + p + \pi^0$ UP TO 1070 Mev. Detoeuf, J. F.; Ducros, Y.; Merlo, J. P.; Stirling, A. V.; Thevenet, B.; van Rossum, L.; Zsembery, J. (Centre d'Etudes Nucleaires, Saclay, France). Phys. Rev. Lett., 16: 860-3 (May 9, 1966).

A description is presented on the experimental arrangement and the principle of analysis of the results in a previous investigation concerning the total cross section of the process $\pi^+ + p \rightarrow \pi^+ + p\,\pi^0$. The experimental results of cross sections up to the third order fit and π^0 angular distributions are presented for incident pion energies of 420 to 1070 Mev. (B.G.D.)

281

14889 MEASUREMENTS OF THE $\pi^+p \rightarrow \pi^+p\pi^0$ CROSS SECTION FROM 0.5 TO 1.5 Gev/c. J. F. Detoeuf, Y. Ducros, J. P. Merlo, A. Stirling, B. Thevenet, L. van Rossum, and J. Zsembery (CEN, Saclay, France). Phys. Rev., 134: B228-35(Apr. 13, 1964).

The cross section for $\pi^+p \rightarrow \pi^+\pi^0p$ was measured for meson (π^-) energies from 0.5 to 1.5 Bev/c. This cross section increases rapidly between 600 and 900 Mev/c to reach 10 mb. Using the results, the $\pi^+p \rightarrow \pi^+\pi^+n$ cross section was calculated. (auth)

282

28185 ELASTIC SCATTERING OF CHARGED PIONS BY DEUTERONS AT 300 Mev. V. Devanathan (Univ. of Madras, India). Nucl. Phys., 43: 684-6(June 1963). (In English)

Numerical calculations on the elastic scattering of charged pions by deuterons at 300 Mev are presented, and the agreement with experimental results is satisfactory. (auth)

283

34172 INFLUENCE OF PION-NUCLEON RESONANCE ON ELASTIC SCATTERING OF CHARGED PIONS BY DEUTERONS. Devanathan, V. (Univ. of Madras). pp 109-11 of Matscience Symposia on Theoretical Physics. Vol. 1. Ramakrishnan, Alladi (ed.). New York, Plenum Press, 1966.

The cross section for the elastic scattering of charged pions by deuterons at 300 Mev was calculated. The results of the calculation for various laboratory angles are compared with previous experimental and theoretical results. The importance of these experiments for testing the validity of the impulse approximation is briefly discussed. (G.O.Y.)

284

18658 (UCRL-9548) $\pi^\pm$-p TOTAL CROSS SECTIONS IN THE RANGE 450 Mev TO 1650 Mev (thesis). Thomas J. Devlin (California. Univ., Berkeley. Lawrence Radiation Lab.). Mar. 6, 1961. Contract W-7405-eng-48. 59p.

The total scattering cross sections for positive and negative pions on hydrogen was measured at intervals from 450 to 1650 Mev. Six scintillation counters measured the transmission of pions at various solid angles, and the results were extrapolated to zero solid angle. Two peaks previously discovered in the π^--p cross section were measured and found centered at 600 ± 15 and 900 ± 15 Mev. A broad maximum was observed in the π^+-p cross section at approx 1350 Mev. A "shoulder" at approximately 800 Mev, in a region where the π^+-p cross section is rapidly rising, gives some support to speculation that there is a resonant state at this energy. (auth)

285

13184

$\pi^\pm$-p TOTAL CROSS SECTIONS IN THE RANGE 450 Mev TO 1650 Mev. Thomas J. Devlin, Barry C. Barish, Wilmot N. Hess, Victor Perez-Mendez, and Julius Solomon (Univ. of California, Berkeley). Phys. Rev. Letters 4, 242-4(1960) Mar. 1.

The total cross section at 450 to 1650 Mev for $\pi^\pm$ mesons on protons was measured. Peaks in the π^- cross section were observed at 600 ± 15 and 900 ± 15 Mev and in the π^+ cross section at 1350 Mev. (C.J.G.)

286

9382 $\pi^{\pm}$-p TOTAL CROSS SECTIONS IN THE RANGE 450 TO 1650 Mev. Thomas J. Devlin, Burton J. Moyer, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev., 125: 690-700(Jan. 15, 1962). (UCRL-9548 (Rev.))

The total cross sections for positive and negative pions on hydrogen were measured at frequent intervals in the energy range from 450 to 1650 Mev. Six scintillation counters measured the transmission of pions at solid angles, and results were extrapolated to zero solid angle. The two peaks previously discovered in the π^--p cross section are centered at 600 ± 15 Mev and 900 ± 15 Mev. A broad maximum was observed in the π^+-p cross section at approximately 1350 Mev. A "shoulder" at approximately 800 Mev, in a region where the π^+-p cross section is rapidly rising, supports speculation that there is a resonant state at this energy. (auth)

287

33031 PION-PROTON TOTAL CROSS SECTIONS: 400 TO 2000 Mev. Devlin, Thomas J.; Solomon, Julius; Bertsch, George (Princeton Univ. and Princeton-Pennsylvania Accelerator, Princeton, N. J.). Phys. Rev. Letters, 14: 1031-5(June 21, 1965). (PPAD-2137-537)

The total cross section for the scattering of positive and negative pions on protons in the energy range of 400 to 2000 Mev with a statistical uncertainty of about 1% (0.3 to 0.5 mb) is measured. Results are compared with previous data. (M.O.W.)

288

12950 STUDY OF THE DECAY $\pi \rightarrow e + \nu$. E. Di Capua, R. Garland, L. Pondrom, and A. Strelzoff (Columbia Univ., New York). Phys. Rev., 133: B1333-40(Mar. 9, 1964).

A large NaI(Tl) crystal was used to measure the $\pi \rightarrow e/\pi \rightarrow \mu$ branching ratio. From a sample of 10,800 $\pi \rightarrow e$ decay electrons the branching ratio was found to be $R = (1.247 \pm 0.028) \times 10^{-4}$ in agreement with a universal theory for ($e\nu$) and ($\mu\nu$) weak couplings. (auth)

289

4610 MEASUREMENT OF THE POLARIZATION OF POSITRONS EMITTED IN THE DISINTEGRATION OF Na^{22}, B^8, AND μ^+. L. Dick, L. Feuvrais, and M. Spighel (CERN, Geneva). Phys. Letters, 7: 150-3(Nov. 1, 1963). (In French)

Asymmetries and polarizations in the positron emission in beta decay of B^8, Na^{22}, and μ^+ mesons are measured. (T.F.H.)

290

10021 (UCRL-11690) RECOIL-PROTON POLARIZATION IN π^--p ELASTIC SCATTERING AT 365 Mev (thesis). Dale Flint Dickinson (California. Univ., Berkeley. Lawrence Radiation Lab.). Nov. 11, 1964. Contract W-7405-eng-48. 56p. Dep.(mn); $3.00(cy), 2(mn) OTS.

The polarization of the recoil nucleon in π^-p elastic scattering at an incident-pion energy of 365 Mev was measured. The polarization was measured by rescattering the proton from a carbon analyzer placed between two thin-plate aluminum spark chambers, which recorded the directions of the incident and scattered protons. These spark chambers were triggered by scintillation counters, which tagged the protons as being elastic scatters undergoing interaction in the carbon plate. The spark tracks were viewed by a camera, which automatically digitized the spark coordinates and stored the information on magnetic tape for ready processing by computer. Of the 400,000 recorded events, 22,000 showed scatters; of these, 4000 were useful in the final polarization analysis. The average computer time required to process an event was approximately 30 msec. The resulting values of polarization are given. (auth)

291

19495 RECOIL-PROTON POLARIZATION IN π^--p ELASTIC SCATTERING AT 365 Mev. Dickinson, D. F.; Helland, J. A.; Perez-Mendez, V. (Univ. of California, Berkeley). Phys. Lett., 20: 549-51(Mar. 15, 1966). (UCRL-11690(Rev.)).

The polarization of the recoil proton at this energy depends on the interference of the P_{33} phase shift with the P_{11} and S_{11} phase shifts. The measured values indicate the existence of a large P_{11} phase shift. The polarization was measured by scattering from carbon blocks in spark chambers using a Vidicon scanner to record the data. (auth)

292

35490 π^- CAPTURE BY ^{3}He AND THE TWO-NUCLEON CAPTURE MODEL. Divakaran, P. P. (Oxford Univ. and Univ. of Chicago). Phys. Rev., 139: B387-400(July 26, 1965).

The rates of capture of π^- mesons by ^{3}He leading to the final states d + n and p + n + n are calculated using a phenomenological two-nucleon hamiltonian for the capture interaction $\pi NN \rightarrow NN$, obtained previously by Eckstein from an analysis of the experimental data on the inverse process of one-pion production in nucleon-nucleon collisions. Both S- and P-orbit captures are considered and it is shown that P-orbit capture does not compete with the $P \rightarrow S$ radiative transition. The radiative capture rate W_γ (for final state $^3H + \gamma$) is computed in terms of the photoproduction amplitude of Chew, Goldberger, Low, and Nambu and is used to deduce the nucleonic absorption rate $W_{abs} = W_d + W_p$ from the ratio W_{abs}/W_γ measured experimentally. The agreement between calculation and experiment for W_{abs} is satisfactory. The conclusion is that the form of close pair correlations in nuclei is essentially the same as that for the free nucleon-nucleon interaction and is comparatively insensitive to the presence of other nucleons. (auth)

293

1070 MUON REACTIONS IN LIQUID HYDROGEN AND LIQUID DEUTERIUM. John H. Doede (Enrico Fermi Inst. for Nuclear Studies, Chicago and Univ. of Chicago). Phys. Rev., 132: 1782-99(Nov. 15, 1963).

The reactions of muons in liquid hydrogen containing a low concentration of deuterium, $p\mu + d \rightarrow d\mu + p \rightarrow (d\mu p)^+ \rightarrow He^3 + \mu^-$(a) or $(He^3\mu)^+ + \gamma$(b), and in liquid deuterium containing a low concentration of hydrogen, $d\mu + p \rightarrow (d\mu p)^+ \rightarrow He^3 + \mu^-$(c) or $(He^3\mu)^+ + \gamma$(d), and $d\mu + d \rightarrow (d\mu d)^+ \rightarrow He^3 + n + \mu^-$(e) or $p + t + \mu^-$(f), were investigated using the Chicago 9-in. bubble chamber. Using previously determined values for the formation and fusion rates of the $(d\mu p)^+$ ion in hydrogen in conjunction with a theoretical determination of the population of the various hyperfine levels in the $(d\mu p)^+$ ion, reaction (a) is found to occur in (15 ± 1.5)% of all $(d\mu p)^+$ fusion reactions. The formation rate of the $(d\mu d)^+$ ion in liquid deuterium is found to be $\lambda_{dd} = (3.6 \pm 1.3) \times 10^5$ sec^{-1}. The fusion rate of the $(d\mu d)^+$ is $\lambda_{df} = (2.5 \pm 0.04) \times 10^5$ sec^{-1}, and the fraction of muons which, having catalyzed reaction (e), are subsequently bound in a $(He^3\mu)^+$ muonic ion is (0.31 ± 0.0034). The rate of deexcitation to the lower hyperfine level of the $d\mu$ muonic atom via the reaction $d\mu(3/2) + d \rightarrow d + d\mu(1/2)$ was investigated and found to be $(7.9 \pm 2.8) \times 10^5$ $sec^{-1} < \lambda_{(3/2-1/2)} < (1.35 \pm 0.48) \times 10^6$ sec^{-1}. The interference of reactions (c), (d), (e), and (f) in the investigation of the spin-independent capture reaction $\mu^- + d \rightarrow n + n + \nu$ is discussed. (auth)

294

6691 MODERATION AND ABSORPTION TIMES FOR NEGATIVE PIONS IN LIQUID DEUTERIUM. J. H. Doede, R. H. Hildebrand, and M. H. Israel (Argonne National Lab., Ill. and Univ. of Chicago). Phys. Rev., 136: B1609-14 (Dec. 21, 1964).

The moderation and absorption times for negative pions stopping in liquid deuterium have been measured. In deuterium the mean time for a negative pion to go from an initial velocity $v_0 \leq 0.006c$ to nuclear capture was found to be $(2.1 \pm 0.5) \times 10^{-12}$ sec. The relationship of this capture time to that for liquid hydrogen, $(2.3 \pm 0.6) \times 10^{-12}$ sec, is discussed in detail. Results are also presented for the moderation times of pions with initial velocities between 0.05c and 0.006c. (auth)

295

17230 MODERATION AND ABSORPTION TIMES OF NEGATIVE PIONS IN LIQUID HYDROGEN. J. H. Doede (Argonne National Lab., Ill. and Univ. of Chicago), R. H. Hildebrand, M. H. Israel, and Manfred R. Pyka. Phys. Rev., 129: 2808-11(Mar. 15, 1963). (TID-17794)

Among 546,000 negative pions stopping in a liquid hydrogen bubble chamber, 21 events were found corresponding to pion-muon decay in the backward hemisphere from a velocity ≤0.006c. Analysis gives $(2.3 \pm 0.6) \times 10^{-12}$ sec as the mean time for a pion to go from this velocity to nuclear capture. Results are also presented for the moderation time of pions between velocities 0.1c and 0.006c. (auth)

296

19515 AN INCONSISTENCY IN LOW-ENERGY PION PHYSICS. Donald, R. A.; Evans, W. H.; Hart, W.; Mason, P.; Plane, D. E.; Read, E. J. C. (Univ. of Liverpool). Proc. Phys. Soc. (London), 87: 445-53(Feb. 1966).

Results are reported of measurements of charge-exchange scattering of negative pions by protons, and of elastic scattering of negative pions by protons, at a mean energy of 39 Mev. These results, combined with those obtained from an earlier experiment at 35 Mev, reveal an inconsistency between the hypothesis of charge independence and measured values of the s-wave scattering lengths obtained from elastic scattering and from charge-exchange scattering. (auth)

297

23411 VERY SHORT-RANGE INTERACTION IN PION-NUCLEON SCATTERING. A. Donnachie (London Univ.) and J. Hamilton. Phys. Rev., 138: B678-88(May 10, 1965).

The dispersion relations for $F_l(s) = f_l(s)/a^{2l}$, where $f_l(s)$ is the usual partial-wave amplitude, are required by unitarity to obey a high-energy boundary condition. It is shown that this gives rise to a unitary sum rule. This sum rule can be used to estimate the short-range parts of the pion-nucleon interaction, and that makes it possible to give accurate predictions of the nonresonant P-, D-, and F-wave π-N amplitudes up to around 650 Mev. The results are in good agreement with a recent analysis of the experimental data. (auth)

298

45073 THE INFLUENCE OF THE NEUTRON-NEUTRON FINAL-STATE INTERACTION ON THE CAPTURE OF MUONS BY DEUTERONS. Dosch, H. G. (CERN, Geneva). Nuovo Cimento (10), 39: 731-8(Sept. 16, 1965).

The influence of the neutron-neutron final-state interaction on the μ capture in deuterium is calculated. It is shown that this process allows from the theoretical point of view a determination of the neutron-neutron scattering length with an accuracy of about 5%. (auth)

299

26564 ELECTRODYNAMIC PROCESSES WITH NUCLEAR TARGETS. S. D. Drell and J. D. Walecka (Stanford Univ., Calif.). Ann. Phys. (N. Y.), 28: 18-33(June 5, 1964).

It is known that two general form factors depending on energy loss and momentum transfer characterize inelastic electron scattering from nuclei in the first Born approximation in $\alpha = 1/137$. The same two form factors appear in all electrodynamic processes connected by one-photon exchange with nuclei. This observation is used to compute cross sections and to discuss experiments which are aimed at probing electrodynamics by scattering or pair producing electrons or muons from nuclear targets. (auth)

300

20905 (JINR-P-1559) BETA-RASPAD PIONA. (Beta Decay of the Pion). A. F. Dunaitsev, V. I. Petrukhin, Yu. D. Prokoshkin, and V. I. Rykalin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 15p.

Forty-three $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ events were detected using Cherenkov spectrometers. A fast five-ray oscilloscope was used to identify events. The relative probability of beta decay was found to be $(1.1 \pm 0.2) \times 10^{-8}$, in agreement with the conserved vector current hypothesis. The positron spectrum was also consistent with that predicted by theory. (auth)

301

24689 (JINR-P-948) OBNARUZHENIE PEREZARYADKI OSTANOVIVSHIKHSYA π-MEZONOV NA YADRAKH SVYAZANNOGO VODORODA. (Detection of Charge Exchange in π-Mesons Stopped in Bound Hydrogen Nuclei). A. F. Dunaitsev, V. I. Petrukhin, Yu. D. Prokoshkin, and V. I. Rykalin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 5p.

Meson π^- charge exchange in polyethylene was evaluated with a high-frequency spectrometer monitoring a 75-Mev π^- beam (passing through a system of scintillation counters and bremsstrahlung filters). Cherenkov spectrometers insensitive to background radiation were used for measuring π^0 decay γ quanta produced by stopped π^-. The ratio of π^0 production in hydrogen and polyethylene was $W_{H_2}/W_{CH_2} = 290 \pm 40$. The statistical order of accuracy was over 5%. The magnitude W_{H_2}/W_{CH_2} in π^- charge exchange in polyethylene is characterized by intense π^- capture by hydrogen nuclei. (R.V.J.)

302

22049 DETECTOR OF DELAYED MESONS. A. F. Dunaitsev, V. I. Petrukhin, Yu. D. Prokoshkin, and V. I. Rykalin (Joint Inst. for Nuclear Research, Dubna, USSR). Pribory i Tekhn. Eksperim., No. 1, 159-61(Jan.-Feb. 1963). (In Russian)

Descriptions are given of a high-selectivity scintillation delay detector capable of recording up to $K \approx 50$ π^+ meson delays. The detector selectivity is based on the difference in ionization losses. The instrument was tested using 75-Mev π^+ beams passing through monitoring scintillation counters, delayed by polyethylene filters, and stopping in the last scintillator. The mesons were recorded by a fast coincidence scheme. (R.V.J.)

303

26273 (BNL-837(p.344-52)) THE INVESTIGATION OF PION BETA-DECAY. A. F. Dunaitsev, V. I. Petrukhin, Yu. D. Prokoshkin, and V. I. Rykalin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R.).

Investigations of the decay $\pi^+ \rightarrow \pi^0 + e^+ + \nu$, $\pi^0 \rightarrow 2\gamma$, are reported. The positron spectrum is presented. The branching ratio is found to be $\lambda = (1.30 \pm 0.35) \times 10^{-8}$. (M.J.T.)

304

36353 PION BETA DECAY. A. F. Dunaitsev, V. I. Petrukhin, Yu. D. Prokoshkin, and V. I. Rykalin (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 47: 84-91(July 1964). (In Russian)

Pion β-decay events were recorded with Cherenkov spectrometers. The relative probability for the decay is found to be $\lambda = (1.1 \pm 0.2) \cdot 10^{-3}$ which confirms the hypothesis of conservation of vector current. The values of the constants G and G_β characterizing pion and nucleon β decay are equal: $G = (1.03 \pm 0.11)G_\beta$. The energy spectrum of positrons produced in β decay of pions is in agreement with that calculated on basis of the hypothesis of conservations of vector current. (auth)

305

13130 MEASUREMENT OF THE ENERGY OF NEGATIVE π MESONS USING A STAR DETECTOR. A. F. Dunaitsev, Yu. D. Prokoshkin, and T'ang Hsiao-Wei (Joint Inst. for Nuclear Research, USSR). Pribory i Tekh. Ekspt., No. 5, 133(Sept.-Oct. 1960). (In Russian)

A star detector constructed with two scintillation coincidence counters is used for selective π^- meson recordings. The detector is capable of rapidly measuring (15 min at beam intensity of $\sim 10^3$ π^-/sec) the track and energy of π^- mesons. Track curves for π^- mesons at 160 Mev are plotted. The diagram shows that the star detector records the stars and not the stopped particles. The sensitivity of the detector to μ^- mesons is about 20 times weaker than to π^- mesons. (R.V.J.)

306

833 NP-7974

Joint Inst. of Nuclear Research Dubna, U.S.S.R. Lab. of Nuclear Problems.

STAR-DETECTOR FOR π^- MESONS. A. F. Dunaitzev, Yu. D. Prokoshkin, and Tang Syao-vay. 1959. 4p. (P-392).

In contrast to many other particles, stopping π^- mesons effectively produce stars with large energy release. These phenomena were utilized for selected detection of π meson. The star-detector of π mesons consists of a telescope of two scintillation counters set in coincidence. The first counter is an ordinary counter with 100% efficiency for passing particles. The second counter works at a comparatively low voltage supply, hence it detects the large light impulses only. A typical range curve for 160 Mev π^- mesons in carbon is given. (W.D.M.)

307

32947 MEASUREMENT OF THE PANOFSKY RATIO BY THE METHOD OF GAMMA-GAMMA COINCIDENCES. A. F. Dunaitsev, Yu. D. Prokoshkin, V. S. Pantuev, Syao-wei Tang, and M. N. Khachaturyan. Wu Li Hsueh Pao, 18:

218-20(Apr. 1962). (In Chinese)

The ratio of the probability of two capture processes of stopped negative pions in hydrogen was measured by the γ-γ coincidence method. The experimental result is equal to 1.40 ± 0.08. This value agrees with the data on photoproduction and scattering of pions. (auth)

308

34617 CATALYSIS OF THE d + d → He^3 + n FUSION REACTION BY NEGATIVE MUONS. V. P. Dzhelepov, P. F. Ermolov, Yu. V. Katyshev, V. I. Moskalev, V. V. Fil'chenkov, and M. Friml (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 46: 2042-5(June 1964). (In Russian)

Twenty cases of an hitherto unobserved reaction (2) $d\mu$ + d → ^3He + n + μ^- are recorded in a diffusion chamber filled with deuterium to a pressure of 7.2 atm. The yield of the reaction (2) relative to that of reaction (1) $d\mu$ + d → t + p + μ^- is 1.2 ± 0.37. Estimations of the relative yields of reactions (3) $d\mu$ + d → pμ + t and (4) $d\mu$ + d → $^3He\mu$ + n show that with a probability of 90% w(3)/w(1) < 0.13 and w(4)/w(2) < 0.13. The yield of reaction (1) agrees with data previously obtained. However in the experiments the yields of reactions (1) and (2) exceed by approximately an order of magnitude the values which should be expected on basis of the data on reaction (1) obtained in liquid deuterium. (auth)

309

45273 (JINR-P-2356) KATALIZ OTRITSATEL'NYMI MYUONAMI YADERNYKH REAKTSII d μ + p → ^3He + μ^- I d μ + d → p + t + μ^- I OBRAZOVANIE μ-MOLEKUL pd μ I dd μ V GAZOOBRAZNOM VODORODE. (Negative Muon Catalysis of the Fusion Reactions d μ + p → ^3He + μ^- and d μ + d → t + p + μ^- and pd μ and dd μ MU-Molecule Production in Gaseous Hydrogen). Dzhelepov, V. P.; Ermolov, P. F.; Moskalev, V. I.; Fil'chenkov, V. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 48p. Dep. nn.

The yields of nuclear reactions $d\mu$ + p → ^3He + μ^- and $d\mu$ + d → p + t + μ^- were measured with a diffusion cloud chamber filled with hydrogen and deuterium at 7 to 23 atm. The muon transfer rate from the $d\mu$-atom to carbon and oxygen was found from experimental $d\mu$-atom range distributions and Auger electron yields. The formation rates of the $pd\mu$ and $dd\mu$ molecules (reduced to the density of normal liquid hydrogen and deuterium) were found to be $\lambda_{pd\mu}$ = 1.8 + 0.6 × 10^6 sec^{-1} and $\lambda_{dd\mu}$ = 0.75 ± 0.11 × 10^6 sec^{-1}. The analysis of the experimental data on the reactions leads to the conclusion that the resonance mechanism of $dd\mu$-molecule formation and the nuclear reaction in-flight is most likely to be the reason for the large yield of the two deuteron fusion reactions under the conditions of the experiments. (auth)

310

7016 (JINR-D-812) AN EXPERIMENTAL INVESTIGATION OF μ-MESONIC ATOMIC PROCESSES IN GASEOUS HYDROGEN. V. P. Dzhelepov, P. F. Ermolov (Yermolov), E. (Ye.) A. Kushnirenko, V. I. Moskalev, and S. S. Gershtein (Gerstein) (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems and Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics). 1961. 21p.

Mesonic atom processes in hydrogen were studied experimentally by means of a diffusion cloud chamber in the magnetic field. The following quantitative data were obtained: the cross section for elastic scattering of pμ-mesonic atoms on protons $\sigma_{pp} = (1.7^{+0.6}_{-0.5})\,10^{-19}$ cm^2; the rates of the meson transfer from a proton to deuterons and complex nuclei (C and O) recalculated to the liquid hydrogen density $\lambda_d = (0.96^{+0.34}_{-0.27})\,10^{10}$ sec^{-1} and $\lambda_z = (1.2^{+0.6}_{-0.5})\,10^{10}$ sec^{-1}; and the rate of the formation of mesonic molecular ions ppμ in liquid hydrogen $\lambda_{pp\mu} = (0.6^{+0.8}_{-0.5})\,10^6$ sec^{-1}. The experimental values of λ_d, $\lambda_{pp\mu}$, and λ_z are in good agreement with the theoretical ones which confirms the validity of the mechanisms of the processes suggested theoretically The cross section σ_{pp} was found to be close to the theoretical value calculated without the hyperfine structure of the pμ mesonic atom being taken into account. However, the possibility of the fast transitions to the lower state with the total spin of a mesonic atom F = 0 is not excluded. The determination of the absolute value of λ_d carried out in this investigation allowed the absolute probabilities of a number of μ-mesonic molecular processes to be found by using it as a scale. (auth)

311

34109 NEGATIVE MUON CATALYSIS OF THE NUCLEAR REACTIONS dμ + p → ^3He + μ^- AND dμ + d → t + μ + μ^- AND pdμ AND ddμ MOLECULE FORMATION IN GASEOUS HYDROGEN. Dzhelepov, V. P.; Ermolov, P. F.; Moskalev, V. I.; Filchenkov, V. V. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 50: 1235-51(May 1966). (In Russian).

The yields of nuclear reactions (1) dμ + p → pdμ → ^3He + μ^- and (2) dμ + d → ddμ → p + t + μ^- were measured with a diffusion cloud chamber filled with hydrogen and deuterium at 7–23 atm. The muon transfer rate from the dμ-atom to carbon and oxygen was found from experimental dμ-atom range distributions and Auger electron yields. The formation rates of the pdμ and ddμ molecules (reduced to the density of liquid hydrogen and deuterium) were found to be $\lambda_{pd\mu} = (1.8 \pm 0.6) \cdot 10^6$ sec^{-1}, $\lambda_{dd\mu} = (0.75 \pm 0.11) \cdot 10^6$ sec^{-1}. The estimate of the relative yield of the reaction (3) dμ + d → ddμ → tμ + p provides that Y(3)/Y(2) < 0.14 with a 90% probability. The analysis of experimental data on reactions (1) and (2) allows a conclusion that the resonance mechanism of ddμ-molecule formation and the nuclear reaction inflight is likely to be the reason of the large yield of the two deuteron fusion reactions under the conditions of our experiments. (auth)

312

18636 (JINR-D-1551) NEGATIVE MUON CATALYSIS OF THE NUCLEAR FUSION REACTION d + d → He^3 + n. V. P. Dzhelepov, V. V. Filchenkov, M. Friml, Yu. V. Katyshev, V. I. Moskalev, and P. F. Yermolov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear

Problems). 1964. 7p.

Twenty occurrences of the previously unobserved reaction $d\mu + d \rightarrow (dd\mu)^+ \rightarrow He^3 + n + \mu^-$(2) were detected in a diffusion cloud chamber filled with deuterium up to 7.2 atm. The branching ratio (2) over $(dd\mu)^+ \rightarrow t + p + \mu^-$(1) is 1.20 ± 0.37. The estimates of the relative yields of the reactions $(dd\mu)^+ \rightarrow p\mu + t$(3) and $(dd\mu)^+ \rightarrow (He^3\mu)^+ + n$(4) indicate that w(3)/w(1) < 0.13 and w(4)/w(2) < 0.13 with a probability of 90%. The yield for (1) agrees with previous results, but the yields of 1 and 2 are an order higher than those expected on the basis of data for (1) in liquid deuterium. (auth)

313

9404 MESONIC ATOM PROCESSES IN HYDROGEN AND DEUTERIUM AND THE MUON CATALYSIS OF FUSION REACTIONS. V. P. Dzhelepov, M. Friml, S. S. Gershtejn, Yu. V. Katyshev, V. I. Moskalev, and P. F. Yermolov (Joint Inst. for Nuclear Research, Dubna, USSR). p.484-90 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

In experiments carried out with a high-pressure diffusion chamber, the following measurements were made: the rate of the muon transfer $p\mu + d \rightarrow d\mu + p$ from the proton to the deuteron; the rates of formation of the $pp\mu$, $pd\mu$, and $dd\mu$ ions; the cross section of elastic scattering of $p\mu$ mesonic atoms by protons; and the rates of the muon transfer from the proton and the deuteron to complex nuclei. The conditions of experiments and the results are tabulated. It is concluded that the majority of the quantitative properties of mesonic atom processes measured experimentally is in satisfactory agreement with theoretical predictions and confirms the correctness of the mechanism suggested theoretically. (A.G.W.)

314

24275 (UCRL-10629) POLARIZATION OF RECOIL PROTONS IN PION-PROTON ELASTIC SCATTERING AT 523, 572, AND 689 Mev (thesis). Richard D. Eandi (California. Univ., Berkeley. Lawrence Radiation Lab.). Mar. 18, 1963. Contract W-7405-eng-48. 80p.

Angular distributions of recoil-proton polarization for elastic scattering of positive and negative π mesons on protons were measured at 523, 572, and 689 Mev incident-pion kinetic energy. The pion source was an internal target of the Berkeley Bevatron. Polarization measurements were made by observing the azimuthal asymmetry of sample angular distributions of recoil protons that scatter in large carbon-plate spark chambers. The spark chambers proved to be very suitable polarization analyzer-detectors. The spark chambers were triggered by an array of scintillation and Čerenkov counters that identified the particles entering the chambers as recoil protons from elastic pion-proton scattering. Two plausible nonunique sets of phase shifts were obtained by employing: restrictive assumptions related to the higher resonances, available pion-proton total and differential cross sections measured at nearby energies, and the measurements of this experiment. One set is characterized by a $J = 3/2$, $T = 1/2$, D-wave resonance; the other set is characterized by a $J = 3/2$, $T = 1/2$, P-wave resonance at 600-Mev incident-pion energy. 38 references. (auth)

315

42440 POLARIZATION OF RECOIL PROTONS IN π^+p ELASTIC SCATTERING NEAR 600 Mev. Richard D. Eandi, Thomas J. Devlin, Robert W. Kenney, Paul G. McManigal, and Burton J. Moyer (Univ. of California, Berkeley). Phys. Rev., 136: B536-42(Oct. 26, 1964). (UCRL-10629(Rev.))

Angular distributions of recoil-proton polarization in elastic π^+p scattering were measured at 523-, 572-, and 689-Mev incident pion kinetic energy. Polarization measurements were made by observing the azimuthal asymmetry in the subsequent scattering of recoil protons in large carbon-plate spark chambers. Typical strong variation of the polarization with pion scattering angle near the πp diffraction minima was observed. Since existing opinion favors a D_{13} resonance at 600 Mev, a phase-shift analysis was attempted in order to confirm the existence and parity of this resonance. Available πp total and differential cross sections, these polarization data, and some possible restrictive assumptions related to the 600-Mev resonance were used in the analysis. Though the polarization results aided significantly in restricting the number of acceptable phase-shift sets, still, many plausible and qualitatively different sets were found. (auth)

316

3074 POLARIZATION OF RECOIL PROTONS IN π^+p ELASTIC SCATTERING AT 864, 981, AND 1301 Mev. Richard D. Eandi, Thomas J. Devlin, Robert W. Kenney, Paul G. McManigal, and Burton J. Moyer (Univ. of California, Berkeley). Phys. Rev., 136: B1187-9(Nov. 23, 1964).

The angular distributions of recoil-proton polarization in elastic π^+p scattering were measured at 864, 981, and 1301 Mev. Polarization measurements were made by observing the azimuthal asymmetry in the subsequent scattering of recoil protons in large carbon-plate spark chambers. The spark chambers proved to be very suitable polarization analyzer detectors. Strong variation of the polarization with backward pion scattering angle was observed. (auth)

317

5324 (NYO-9286) MEASUREMENTS OF NEGATIVE MUON LIFETIMES IN LIGHT ISOTOPES (thesis). Morton Eckhause (Carnegie Inst. of Tech., Pittsburgh). Feb. 1962. Contract AT(30-1)-882. 68p.

Negative muons from the Carnegie Tech synchrocyclotron were stopped in the following targets: separated isotopes of lithium (Li^6 and Li^7) and of boron (B^{10} and B^{11}), as well as natural beryllium, carbon, and oxygen. From an

analysis of the corresponding time spectrum of the decay electrons, the negative muon lifetime in each of these substances was obtained. From a separate measurement of the μ^+ lifetime (2.202 ± 0.004 μsec), the capture rates in the above elements were determined. They are (in units of 10^5/sec): $\lambda_c(Li^6) = 0.111 \pm 0.013$, $\lambda_c(Li^7) = 0.028 \pm 0.013$, $\lambda_c(Be) = 0.11 \pm 0.02$, $\lambda_c(B^{10}) = 0.273 \pm 0.015$, $\lambda_c(B^{11}) = 0.227 \pm 0.016$, $\lambda_c(C) = 0.394 \pm 0.011$, and $\lambda_c(O) = 0.97 \pm 0.03$. (auth)

318

40572 MEASUREMENTS OF NEGATIVE-MUON LIFETIMES IN LIGHT ISOTOPES. M. Eckhause, T. A. Filippas, R. B. Sutton, and R. E. Walsh (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 132: 422-5(Oct. 1, 1964).

Negative muons were stopped in the following targets: separated isotopes of lithium (^{6}Li and ^{7}Li) and boron (^{10}B and ^{11}B), and natural beryllium, carbon, nitrogen, and oxygen. From an analysis of the resulting time spectrum of the decay electrons, the negative-muon lifetime in each of these substances was obtained. From a separate measurement of the μ^+ lifetime, (2.202 ± 0.003) μsec, the capture rates in the above elements were determined. They are (in units of 10^5/sec): $\lambda_{cap}(^6Li) = 0.061 \pm 0.014$, $\lambda_{cap}(^7Li) = 0.018 \pm 0.014$, $\lambda_{cap}(^{10}B) = 0.265 \pm 0.015$, $\lambda_{cap}(^{11}B) = 0.218 \pm 0.016$, $\lambda_{cap}(Be) = 0.10 \pm 0.02$, $\lambda_{cap}(C) = 0.397 \pm 0.013$, $\lambda_{cap}(N) = 0.65 \pm 0.04$, and $\lambda_{cap}(O) = 0.98 \pm 0.03$. (auth)

319

28348 MUON CAPTURE RATES IN COMPLEX NUCLEI. Eckhause, M. (Coll. of William and Mary, Williamsburg, Va.); Siegel, R. T.; Welsh, R. E.; Filippas, T. A. Nucl. Phys., 81: 575-84(June 1966). (TID-22367).

Total disappearance rates of negative muons brought to rest in 30 elements were measured to 1–2% precision. The experimental procedure and the results obtained are presented. In addition, a compilation of all measurements of muon capture rates in complex nuclei as presently known is given, and several analytical fits to these rates are discussed. (auth)

320

16492 π^- SCATTERING FROM COMPLEX NUCLEI. R. M. Edelstein, W. F. Baker, and J. Rainwater (Columbia Univ., New York). Phys. Rev., 122: 252-61(Apr. 1, 1961). (NEVIS-88; CU-190; R-259)

Differential cross sections were measured for π^--carbon scattering at 69.5 and 87.5 Mev and π^--oxygen scattering at 87.5 Mev from 20° to 125° extending the technique of Baker, Rainwater, and Williams. The energy resolution was sufficient to measure pure elastic as well as 5- and 10-Mev inelastic cross sections. The modified Kisslinger optical-model equation was used to fit the elastic-cross-section data. A χ^2 analysis for the 69.5-Mev carbon data gave a nuclear radius parameter $r_0 = 1.05 \pm 0.02$ fermis and a fall-off parameter $t = 1.16 \pm 0.07$ fermis. These parameters give good fits to the other data as well. An energy dependence in the strength parameters for carbon is observed in qualitative agreement with prediction. (auth)

321

21160 (CONF-231-5) MEASUREMENT OF THE RATE FOR $\mu^- + He^3 \rightarrow H^3 + \nu$. R. M. Edelstein (Carnegie Inst. of Tech., Pittsburgh); D. Clay, J. W. Keuffel, and R. L. Wagner, Jr. (Utah. Univ., Salt Lake City). [1963]. Contracts AT(30-1)-1825 and AT(11-1)-82. 9p.

From the International Conference on Fundamental Aspects of Weak Interactions, Upton, N. Y., Sept. 1963.

The reaction rate for $\mu^- + {}^3He \rightarrow {}^3H + \nu$ was measured using a high-pressure, ^{3}He, gas scintillation counter as the target for stopping muons. A value of 1450 ± 75 sec^{-1} was obtained, in agreement with other experiments and with the prediction based on the universal Fermi interaction with conserved vector current. (D.C.W.)

322

17205

THE ELASTIC SCATTERING OF 98 Mev NEGATIVE PIONS BY HYDROGEN. D. N. Edwards, S. G. F. Frank, and J. R. Holt (Univ. of Liverpool). Proc. Phys. Soc. (London) 73, 856-68(1959) June.

The elastic scattering by hydrogen of negative pions with mean energy 98 Mev has been measured at 13 angles between 30 and 150° (lab). The pion beam was monitored with a calibrated ionization chamber and its muon and electron contamination determined by means of a Cherenkov counter. This counter was also used in the scattering telescope to separate out the electrons produced by charge exchange γ radiation. The results were corrected for Coulomb effects and a 3-parameter curve fitted to the nuclear parts. The curve is $d\sigma/d\Omega = (1 \pm 0.027)\,[0.385 \pm 0.008 + (0.276 \pm 0.015)\cos\theta + (0.282 \pm 0.031)\cos^2\theta]$. Thus the forward scattering intensity is 0.942 ± 0.043 mb·$sterad^{-1}$. In a separate transmission experiment the total nuclear cross section for scattering of 98-Mev negative pions by hydrogen was found to be 21.9 ± 0.7 mb. These two figures yield a value for the real part of the forward scattering amplitude $D_- = 0.195 \pm 0.006$ in units $\hbar/m_\pi c$. The corresponding value of f^2 from the dispersion relation is 0.073. (auth)

323

24278 (JINR-P-971) K VOPROSU OB ANOMALII PRI RASPADE μ^- MEZONOV V MEZOATOMAKH PEREKHODNYKH METALLOV GRUPPY ZHELEZA. (On the Anomalies in μ^- Meson Decay in Mesoatoms of Transitional Iron Group Metals). L. B. Egorov, A. E. Ignatenko, A. V. Kuptsov, and M. G. Petrashku (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 10p.

Relative measurements of the probabilities of the μ^-

meson decay in Fe, Zn, Ni, and Cu mesic atoms were made using scintillation counters. The gamma ray yields from the targets were found the same within experimental error. This indicates that the apparatus effect is not the reason for anomalies. (auth) -

324

6888 ON THE QUESTION OF ANOMALY IN THE DECAY OF μ^--MESONS IN MESIC ATOMS OF TRANSITION METALS OF THE IRON GROUP. L. B. Egorov, A. E. Ignatenko, A. V. Kuptsov, and M. G. Petrashku (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 43: 1149-53(Oct. 1962). (In Russian)

By the method of scintillation counters, relative measurements are made of the decay probabilities of μ^- mesons in mesic atoms of iron and zinc and also nickel and copper. The results of measurements indicate an absence of anomaly observed by a number of authors. Equality, within the limits of errors of the experiment, of the yield of γ rays from the above-mentioned targets indicates that the instrument effect is not the cause of the anomaly observed. (auth)

325

26080 (JINR-P-972) POISKI ANOMALII PRI RASPADE μ^- MEZONOV V PARAMAGNITNYKH METALLAKH. (Search for Anomalies in μ^- Meson Decay in Paramagnetic Metals). L. B. Egorov, A. E. Ignatenko, A. V. Kuptsov, and M. G. Petrashku (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 6p.

Relative electron yields from μ^- mesons in the mesic atoms of palladium, titanium, and their hydrides were measured with scintillation counters. The results indicate the absence of the effects due to uncoupled electrons of the atoms which lead to an increase in the μ meson decay probability in the mesic atoms of the transition metals of the iron group, as well as to the displacement of the levels of the x rays emitted in 2p-1s-transitions. (auth)

326

974 INVESTIGATION OF THE SPIN DEPENDENCE OF WEAK INTERACTION IN THE PROCESS $\mu^- + p \rightarrow n + \nu$. L. B. Egorov, G. V. Zhuravlev, A. E. Ignatenko, A. V. Kuptsov, Hsüang-ming Li, and M. G. Petrashku (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 684-91(Sept. 1961). (In Russian)

The asymmetry coefficients ($\bar{a}_0$) of $\mu - e$ decay electrons, averaged over two hyperfine structure states, are measured by means of scintillation counters in mesic atoms of silver and red and black phosphorus. The meson lifetimes $\bar{\tau}$ in the two phosphorus modifications are also measured. The magnitudes of $\bar{a}_0$ for red (insulator) and black (conductor) phosphorus indicate that the presence of conductivity electrons shortens the meson spin relaxation time in mesic atoms. The values of $\bar{a}_0$ and $\bar{\tau}$ in phosphorus are employed to determine the level population in states F = 1 and F = 0 and also the probabilities (λ_1 and λ_0) for meson capture by the nucleus in these states. It is found that $\lambda_1 \pm \lambda_0$ (weak interaction is spin dependent) and $\lambda_0 > \lambda_1$ (capture takes place more rapidly from the F = 0 state than from the F = 1 state). The lower limit obtained for the quantity is direct evidence that the interaction is of the type A − xV. (auth)

327

13498 DEPOLARIZATION OF POSITIVE MUONS IN SOLIDS. Eisenstein, B.; Prepost, R.; Sachs, A. M. (Columbia Univ., New York). Phys. Rev., 142: 217-27 (Feb. 1966).

When polarized positive mesons(μ) stop in a solid, they may be depolarized prior to their decay. The presence of a magnetic field along the direction of initial polarization will inhibit, or quench, some of this depolarization. Depolarization and quenching was studied in a variety of solids, including semiconductors, at temperatures as low as 4.2°K. No evidence was found that any meson(μ) depolarization is associated with the formation of a muonium atom which is bound for $>10^{-10}$ sec, even in samples at 4.2°K. For many samples and temperatures, the quenching of the observed depolarization is consistent with a model in which the meson(μ) captures and loses electrons repeatedly, forming a succession of briefly bound muonium atoms. In some of the semiconductors at low temperatures, as well as in other samples, a large fraction of the depolarization is quenched by a field of 100 G. This is seen as evidence for another depolarization mechanism. It is also found that the time during which depolarization occurs in boron carbide decreases with decreasing temperature. (auth)

328

12167 (NEVIS-124) MUON DEPOLARIZATION IN SOLIDS (thesis). Bob Einsenstein (Columbia., Irvington-on-Hudson, N. Y. Nevis Labs.). May 1964. Contract Nonr-266(72). 63p. (CU-230; AD-606475; R-427)

When polarized positive muons stop in a solid, they may be depolarized prior to their decay. The presence of a magnetic field along the direction of initial polarization will inhibit, or quench, some of this depolarization. Depolarization and quenching were studied in a variety of solids, including semiconductors, at temperatures as low as 4.2°K. No evidence was found that any muon depolarization is associated with the formation of a muonium atom which is bound for $> 10^{-10}$ sec, even in samples at 4.2°K For many samples and temperatures, the quenching of the observed depolarization is consistent with a model in which the muon captures and loses electrons repeatedly forming a succession of briefly bound muonium atoms. In some of the semiconductors at low temperatures, as well as in other samples, a large fraction of the depolarization is quenched by a field of 100 G. This is seen as evidence for another depolarization mechanism. (auth)

329

15232 CALCULATION OF THE ABSORPTION RATES OF π^- MESONS BY NUCLEI. Magda Ericson (Université, Lyon). Compt. Rend., 258: 1471-4(Feb. 3, 1964). (In French)

The probabilities for the absorption of π mesons in mesic

atoms was calculated by assuming an absorption by nucleon pairs and by using the production amplitudes of π mesons. The corresponding imaginary optical potential was constructed. Experimental results are in good agreement with the hypothesis of pair absorption. (tr-auth)

330

16952 (NP-11592(Vol.I)(p.203-7)) REACTION $\pi^- + p \rightarrow \Lambda^0 + K^0$ AUX SEUILS POUR LES REACTIONS $\pi^- + p \rightarrow \Sigma^{0-} + K^{0+}$ (CUSP). (Reaction $\pi^- + p \rightarrow \Lambda^0 + K^0$ at the Thresholds for $\pi^- + p \rightarrow \Sigma^{0-} + K^{0+}$ (Cusp) Reactions). F. Eisler (Brookhaven National Lab., Upton, N. Y.); J. M. Gaillard, J. Keren, M. Schwartz, and S. E. Wolf (Columbia Univ., New York).

The angular distributions from the reaction $\pi^- + p \rightarrow \Lambda^0 + K^0$ are measured at π^- energies of 890 to 914 Mev, i.e., near the threshold for $\Sigma^{0-} + K^{0+}$ production, in an attempt to determine the Λ-Σ relative parity. It is found, however, that the $\Lambda^0 + K^0$ production reaction is probably governed by complex D and F wave interactions, rather than by simple S and P waves. It is thus concluded that the relative Λ-Σ parity cannot be resolved by a study of this reaction. (T.F.H.)

331

36643 (CERN-63-28(p.47-72)) INTERACTIONS OF PIONS WITH COMPLEX NUCLEI. Torleif Ericson (European Organization for Nuclear Research, Geneva).

The suitability of very intense pion beams for studying nuclear properties is outlined, and the information that can be obtained by various types of experiments is discussed. Aspects of performing and interpreting certain experiments are also considered. (D.C.W.)

332

38175 PION CAPTURE AND NUCLEAR STRUCTURE. T. Ericson (CERN, Geneva). p.39-45 of "Direct Interactions and Nuclear Reaction Mechanisms." New York, Gordon and Breach, Science Publishers, 1963.

The meson (π^-)-capture process that leads to the emission of two nucleons is explained, and nuclear structure data that can be obtained from this process are discussed. (C.E.S.)

333

42718 A DETECTOR FOR THE INDUCED PSEUDOSCALAR COUPLING CONSTANT. T. Ericson (CERN, Geneva), J. C. Sens, and H. P. C. Rood. Nuovo Cimento (10), 34: 51-66(Oct. 1, 1964).

The detection of partial muon capture rates in ^{16}O forms a sensitive detector for the induced pseudoscalar coupling constant. The effects of nucleon velocity terms in the weak Hamiltonian and of realistic nuclear wave-functions are investigated. Their inclusion is essential for a correct treatment of the problem. In addition to the previously suggested detector level, it is found that capture into the ground state of ^{16}N permits an almost complete elimination of nuclear physics by comparison to the β-decay rate. (auth)

334

34152 (JINR-P-2711) GAZOVAYA MILTSEN DLYA EKSPERIMENTOV S MEDLENNYMI MEZONAMI. (Gas Target for Slow Meson Experiments). Ermolov, P. F.; Lepilov, V. I.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 5p. Dep. mn.

The gas target is described which is intended to operate with slow mesons at a gas pressure up to 100 atm. Two scintillation counters are placed inside the target. Thereby an effective selection of meson stoppings in gas is attained. The latter is equal to 70% from the total number of stoppings registered by the electronic equipment at a hydrogen pressure of 50 atm. (auth)

335

962 A SEARCH FOR BREMSSTRAHLUNG PRODUCED IN ELASTIC SCATTERING OF NEGATIVE π-MESONS BY PROTONS. P. F. Ermolov and V. I. Moskalev (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 322-6(Aug. 1961). (In Russian)

Not in one of 1500 events of elastic scattering of 128 and 162 Mev π^- mesons by protons in a hydrogen diffusion chamber was it found that the angle of emission of the recoil proton exceeded by more than 3° the angle computed on basis of conservation laws. On this basis the upper limit for the cross section for bremsstrahlung emitted by π^- mesons on nuclear forces is derived and found to be 5.10^{-29} cm^2. (auth)

336

34776 (UCRL-11004) MEASUREMENTS OF THE MUON-CAPTURE RATE IN He^3 AND He^4 (thesis). Robert John Esterling (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 9, 1964. Contract W-7405-eng-48. 169p.

A measurement was made of the total muon-capture rates in ^3He and ^4He and the partial capture rate into the channel $\mu^- + {}^3He \rightarrow {}^3H + \nu$. Negative muons were brought to rest in a high-pressure helium gas target. The capture processes all yield a charged particle whose energy was measured by observation of scintillation in the helium gas. Captures into the ^3H channel were recognized by the unique energy (1.9 Mev) of the triton recoil. The total capture rates obtained were: $\Lambda(^3He) = 2170$ sec^{-1} and $\Lambda(^4He) = 375$ sec^{-1}. The partial capture rate to the triton ground state was measured as $\Lambda(^3He \rightarrow {}^3H) = 1505 \pm 46$ sec^{-1}. The results are in good agreement with theoretical predictions that are based on the universal Fermi interaction. (auth)

337

15721 (JINR-E-2517) ANGULAR DISTRIBUTION OF HIGH-ENERGY NEUTRONS EMITTED IN ABSORBING POLARIZED μ^--MESONS IN CALCIUM. Evseev, V. S.; Chang, Run-hwa; Chernogorova, V. A.; Roganov, V. S.; Shimchak, M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 30p. Dep.mn.

The asymmetry coefficient B was measured in the angular distribution of neutrons from mesons (μ^-)-capture in Ca in the E_n energy range from 6.7 to 20.7 Mev. For higher thresholds ($E_n \geq 18$ Mev) the asymmetry coefficient reduced to the 100% residual polarization of mesons (μ^-) is close to −1, which contradicts calculations on the basis of the universal weak interaction theory. (auth)

338

15720 (JINR-E-2516) ASYMMETRY IN THE ANGULAR DISTRIBUTION OF THE HIGH-ENERGY NEUTRONS FROM MU$^-$ CAPTURE IN SULFUR. Evseev, V. S.; Chernogorova, V. A.; Kilbinger, F.; Roganov, V. S.; Shimchak, M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 10p. Dep. mn.

The asymmetry coefficient B in the angular distribution of high energy neutrons from meson (μ^-) capture in sulphur was measured. The value of the asymmetry coefficient reduced to 100% of meson (μ^-) residual polarization is close to −1, which contradicts calculations on the basis of the universal weak interaction theory. (auth)

339

31501 (JINR-P-759) ASIMMETRIYA V UGLOVOM RASPREDELENII NEITRONOV, ISPUSKAEMYKHPRI ZAKHVATE μ^--MESONOV V KAL' TSII. (Asymmetry in Angular Distribution of Neutrons Emitted in μ^-Meson Capture in Calcium). V. S. Evseev, V. I. Komarov, V. Z. Kush, V. S. Roganov, V. A. Chernogorova, and M. M. Shimachak (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1961. 27p.

The asymmetry in the angular distribution of neutrons emitted during nuclear capture of polarized μ^- mesons ($\mu^- + A \rightarrow A + n + \bar{\nu}$) was measured in order to analyze the non-conservation of parity in μ^- absorption by protons and to determine the constants of μ^- weak interactions with nucleons. (R.V.J.)

340

28607 ASYMMETRY IN ANGULAR DISTRIBUTION OF NEUTRONS EMITTED IN μ^- MESON CAPTURE IN CALCIUM. V. S. Evseev, V. I. Komarov, V. Z. Kush, V. S. Roganov, V. A. Chernogorova, and M. M. Shimchak (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 306-7(July 1961). (In Russian)

Measurements of $\tilde{a}$ asymmetry in μ^- absorption in calcium were made using 250 Mev/c pulsed μ^- mesons stopped in a 12 g/cm^2 calcium target in a magnetic field. The preliminary data show $\tilde{a}_{Ca} = -(0.93 \pm 0.33)$. The theoretical and measured magnitudes of $\tilde{a}$ indicate the presence of pseudoscalar interaction in the $\mu^- + A \rightarrow A' + n + \bar{\nu}$ process. The sign of the pseudoscalar and pseudovector constant in the ratio g_P/g_A is positive. The value of $\tilde{a}$ is considerably larger than the theoretical value $\tilde{a} = 0.41$ developed with $g_A/g_V = -1.25$, $g_P/g_A = 8$, and $g_T/g_V = 3.7$. (R.V.J.)

341

41935 ANGULAR DISTRIBUTION OF NEUTRONS DUE TO μ^--CAPTURE IN CALCIUM FOR VARIOUS ENERGY THRESHOLDS. V. S. Evseev, V. S. Roganov, V. A. Chernogorova, Run-hwa Chang, and M. Szymczak (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Letters, 6: 332-3 (Oct. 1, 1963).

Results are given on measurements of the asymmetry coefficient in the angular distribution of neutrons at various thresholds of E_n from 7 to 23 Mev. (R.E.U.)

342

28027 (JINR-D-988) MEASUREMENT OF THE $\mu^- + He^3 \rightarrow H^3 + \nu$ REACTION RATE. I. V. Falomkin, A. I. Filippov, M. M. Kulyukin, B. Pontecorvo, Yu. A. Scherbakov, R. M. Sulyaev, V. M. Tsupko-Sitnikov, and O. A. Zaimidoroga (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 8p.

The reaction $\mu^- + He^3 \rightarrow H^3 + \nu$ was investigated. A magnetic diffusion chamber filled with He^3 at 20 atm was placed in the 217 Mev/c beam of the Dubna 680 Mev synchrocyclotron. Since the tritium produced in the reaction has a definite energy, the problem of identifying events of the reactions consists of selecting a group of one-prong stars with the corresponding energy range from the background due to other processes. The reaction rate was determined to be $1.36 \pm 0.18 \times 10^3$ sec^{-1}. This agreed with the rate predicted by the universal theory within the accuracy of the experiment. (M.C.G.)

343

28126 MEASUREMENT OF THE $\mu^- + He^3 \rightarrow H^3 + \nu$ REACTION RATE. I. V. Falomkin, A. I. Filippov, M. M. Kulyukin, B. Pontecorvo, Yu. A. Scherbakov, R. M. Sulyaev, V. M. Tsupko-Sitnikov, and O. A. Zaimidoroga (Joint Inst. for Nuclear Research, Lab. of Nuclear Problems, Dubna, USSR). Phys. Letters, 1: 318-20(July 15, 1962). (In English)

The reaction $\mu^- + He^3 \rightarrow T + \nu$ was investigated using a statistical material giving results an order of magnitude better than those obtained previously (O. A. Zaimidoroga et al., J. Exptl. Theor. Phys., 41: 1804(1961)); previous experimental techniques were used. The rate of the reaction was measured to study muon-electron symmetry in interactions of these particles with nucleons; data agree with calculations within theoretical and experimental inaccuracies. Muon-electron symmetry in lepton capture by nucleons is implied. (L.N.N.)

344

13569 MEASUREMENT OF THE $\mu^- + He^3 \rightarrow H^3 + N$ REACTION RATE: FINAL RESULTS. I. V. Falomkin, A. I. Filippov, M. M. Kulyukin, B. Pontecorvo, Yu. A. Scherbakov, R. M. Sulyaev, V. M. Tsupko-Sitnikov, and O. A. Zaimidoroga (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Letters, 3: 229-31(Jan. 15, 1963). (In English)

The final results of an He^3 diffusion chamber experiment were given, based on 200 events of the reaction $\mu^- + He^3 \rightarrow H^3 + \nu$. (C.E.S.)

345

9308 THE PANOFSKY RATIO FOR He^3 AND THE ROOT-MEAN-SQUARE RADIUS OF THE TRANSITION $He^3 \rightarrow H^3$. I. V. Falomkin, A. I. Filippov, M. M. Kulyukin, Yu. A. Scherbakov, R. M. Sulya'ev, V. M. Tsupko-Sitnikov, and O. A. Zaimidoroga (Joint Inst. for Nuclear Research, Dubna, USSR). p.14-17 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

Six processes allowed by the conservation laws for capture of stopped negative pions in He^3 are listed. The processes were studied experimentally by stopping pions in a diffusion chamber filled with He^3 at 20 atm pressure. A table shows the number of events of each type found in 8500 photographs. From measurements of selected events it was found that the relative rates of the reactions $\pi^- + He^3 \rightarrow H^3 + \pi^0$ (3) and $\pi^- + He^3 \rightarrow H^3 + \gamma$ (4) were $W_3 = (13.5 \pm 0.9)\%$ and $W_4 = (6.2 \pm 0.7)\%$. The ratio of the rates of reactions (3) and (4), called the Panofsky ratio, was 2.16 ± 0.28. The root-mean-square radius of the transition from He^3 to H^3 was calculated to be $r = (1.24^{+0.30}_{-0.46}) \times 10^{-13}$ cm. (A.G.W.)

346

14914 ELECTROMAGNETIC PROPERTIES OF THE MUON. F. J. M. Farley (CERN, Geneva). Progr. Nucl. Phys., 9: 257-93(1964).

Properties considered include mass, spin, charge, magnetic moment, and electric dipole moment a low energy, and at high energy the form factors. Experiments used to determine the properties are discussed. 130 references. (R.E.U.)

347

37969 THE MUON AS A PROBE FOR NUCLEON STRUCTURE. F. J. M. Farley (CERN, Geneva). p.228-34 of "Nucleon Structure." Stanford, Calif., Stanford University Press, 1964.

The advantages of mesons(μ) over electrons for probing nucleon structure are summarized, and a meson(μ) storage ring under consideration at CERN for (g-2) measurements and studies of μ-p scattering with polarized mesons(μ) is described. (D.C.W.)

348

44207 ANOMALOUS MAGNETIC MOMENT OF THE NEGATIVE MUON. Farley, F. J. M.; Bailey, J.; Brown, R. C. A.; Giesch, M.; Joestlein, H.; van der Meer, S.; Picasso, E.; Tannenbaum, M. (CERN, Geneva). Nuovo Cimento (10), 45A: 281-6(Sept. 1, 1966).

An experiment is described using the magnetic storage ring in which a preliminary measurement of the anomalous magnetic moment of the negative muon yielded $(1165 + 3) \times 10^{-6}$. The new device offers the possibility of an order-of-magnitude improvement in accuracy. (L.B.S.)

349

9388 A MEASUREMENT OF THE μ^+ LIFETIME. F. J. M. Farley, T. Massam, T. Muller, and A. Zichichi (CERN, Geneva). p.415-17 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

The muon lifetime was measured by the standard technique of stopping π^+ in a carbon absorber and recording the time distribution of positrons from the $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ decay chain. The experiment was designed to eliminate systematic errors due to beam structure to a greater extent than in previous measurements. Preliminary results give a value of 2198 ± 1 nsec. (A.G.W.)

350

41744 (NYO-10561) A BUBBLE CHAMBER STUDY OF NEGATIVE MUON ABSORPTION IN CARBON. Leo M. Fatur (Carnegie Inst. of Tech., Pittsburgh). May 1963. Contract AT(30-1)-882. 75p.

Mesons(μ^-) from the synchro-cyclotron were stopped in a 6-in. propane bubble chamber, and the ratio of absorptions to decays was measured. The pion contamination of the beam was measured using three independent techniques to be (0.38 ± 0.08)%. Results from approximately 20,000 muon stops yield a ratio of absorptions to decays of $(8.90 \pm 0.24) \times 10^{-2}$. Assuming a muon lifetime against decay of (2.202 ± 0.004) μsec, a capture rate in carbon of $(0.404 \pm 0.011) \times 10^5$ sec^{-1} is obtained. Additional results were the prong energy distributions due to the absorptions in carbon of muons and pions respectively. (auth)

351

10893 THE PHYSICS OF MUONS AND MUON NEUTRINOS. Gerald Feinberg and Leon M. Lederman (Columbia Univ., New York). Ann. Rev. Nucl. Sci., 13: 431-504(1963).

The static properties of the muon are discussed. Electromagnetic and weak interactions of muons and muon neutrinos are reviewed. Muonic atoms and molecules and possible anomalous interactions are discussed. 230 references. (R.E.U.)

352

1369 PION-NUCLEON PHASE SHIFT ANALYSIS. B. T. Feld and D. L. Roper (Massachusetts Inst. of Tech., Cambridge). p.400 of "Proceedings of the Sienna International Conference on Elementary Particles. Vol. I." Bologna, Societa Italiana di Fisica, 1963.

An analysis was carried out of all available pion-nucleon interaction data at the pion kinetic energy of 310 Mev. Some of the fits previously obtained are markedly improved by inclusion of an ABC-pole with $l_{max} = 4$. Preliminary results of an energy-dependent analysis in the energy range 0-700 Mev show a marked preference for $D-\frac{3}{2}$ as the state responsible for the 600-Mev, T ½ resonance. The analysis also indicates a very strongly absorbing $P-\frac{1}{2}$, T ½ state, the real part of whose phase shift is already quite large and increasing at the end of this energy range. (A.G.W.)

353

15310

ABSORPTION OF NEGATIVE MUONS IN C^{12} LEADING TO PRODUCTION OF BOUND B^{12}. J. G. Fetkovich, T. H. Fields, and R. L. McIlwain (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. 118, 319-24(1960) Apr. 1.

A negative muon beam from the Carnegie Tech synchrocyclotron was stopped in a six-inch propane bubble chamber. Since the hydrogen does not form μ-mesonic atoms in the presence of carbon, the pictures yield information on the interaction of stopped muons with carbon. About 30,000 pictures of stopping muons were taken with the bubble chamber kept sensitive for ~20 msec after the beam pulse in order to observe the beta decay of any bound B^{12} nuclei resulting from μ absorption by carbon. The chamber was photographed right after the beam pulse to determine whether a given stopped muon decayed or was absorbed. Another photograph was taken about 15 msec later to determine if the absorption had led to a nucleus which had beta decayed. A count of μ-e decays in the same film allowed the determination of the probability per unit time of bound B^{12} formation. Forty-six boron decays were observed yielding $(7.6 \pm 1.2) \times 10^3$ sec^{-1} for the rate of bound B^{12} production. Possible interpretation of this result in terms of a universal V-A Fermi interaction is discussed. (auth)

354

17314

FORMATION OF μ-MESONIC MOLECULES IN H–D MIXTURES. J. G. Fetkovich, T. H. Fields, G. B. Yodh, and M. Derrick (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters 4, 570-2(1960) June 1.

Experimental data are reported which allow a determination of reaction rates involved in the catalysis of nuclear reactions by μ mesons. The chain of events believed to lead to catalysis at low deuterium concentrations is depicted. It was found that the number of regenerations per muon were nearly equal to that found by Alvarez et al. at saturation. There were found large discrepancies when the calculated and experimental values were compared. Analyses indicate that for H – (> 1%) D mixtures all absorption of μ by protons will be from a $(p\mu^-d)$ molecule, while for H–(< 1%) D, it is not at present possible to know the states from which muons are captured. The work presented is being extended for lesser hydrogen concentrations, which should allow more precise determinations. (B.O.G.)

355

898 EXPERIMENTAL STUDY OF THE CASCADE TIME OF NEGATIVE MESONS IN A LIQUID HELIUM BUBBLE CHAMBER. J. G. Fetkovich and E. G. Pewitt (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters, 11: 290-3(Sept. 15, 1963).

The cascade time of mesons (π^-) in liquid helium was measured. The results seem to rule out significant amounts of Stark effect and polarization capture in liquid helium. It appears that the measured cascade time is consistent with the assumption that radiation and external Auger effect are the primary cascade mechanisms. (C.E.S.)

356

24418 PRODUCTION OF TWO CHARGED PIONS IN 871 Mev π^--p INTERACTIONS. W. J. Fickinger, J. G. Mowat, and W. D. Shephard (Univ. of Kentucky, Lexington). Nuovo Cimento (10), 32: 18-24(Apr. 1, 1964).

Double pion production has been observed in 871 Mev π^--p interactions in a hydrogen bubble chamber. A total of 347 events were identified as $\pi^- + p \rightarrow \pi^- + p + \pi^- + \pi^+$ corresponding to a partial cross section of (0.30 ± 0.03) mb. The results are compared to a one-pion-exchange model and to a statistical model with (π^+p) isobar formation. The latter model seems to explain deviations from four-body phase space observed in the experimental distributions. (auth)

357

20839

CASCADE TIME OF π^- IN LIQUID HYDROGEN. T. H. Fields, G. B. Yodh, M. Derrick, and J. G. Fetkovich (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters 5, 69-70(1960) July 15.

The time required for π^- to go from a velocity of 0.01c to nuclear capture in liquid H_2 was measured by scanning H_2 bubble chamber photographs of a stopping π^- beam for $\pi^- \rightarrow \mu^- \rightarrow e^-$ decays (two-kinked tracks). From a total of 80,000 π^- coming to rest, two $\pi^- \rightarrow \mu^-$ decays were observed for which velocity < 0.01c, giving a mean time for π^- to go from 0.01c to nuclear capture of 1.2×10^{-12} sec, with a statistical error of $+1.2, -0.5 \times 10^{-12}$ sec. The results are in reasonable agreement with pion absorption from S states via Stark effect mixing. (D.L.C.)

358

31584 (JINR-D-768) OBSERVATION OF THE REACTION $\mu^- + He^3 \rightarrow H^3 + \nu$. A. I. Filippov, M. M. Kulyukin, B. Pontekorvo (Pontecorvo), Yu. A. Scherbakov, R. M. Sulyaev, V. M. Tsupko-Sitnikov, and O. A. Zaimidoroga (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1961. 9p.

An investigation was made of the reaction $\mu^- + He^3 \rightarrow H^3 + \nu$ in a diffusion chamber filled with He^3 at a pressure of 20 atm. About 6000 photographs of meson stopping were obtained and 14 events of muon capture in He^3 with emission of H^3 and a neutrino in the final state were observed. The mean range of tritium determined on the basis of 14 cases was 2.37 ± 0.02 mg/cm^2. The upper limit of the mass of the neutral particle emitted in the process of muon capture by nucleons was calculated to be less than 6 Mev with a probability of 99%. The probability of the reaction was calculated. (M.C.G.)

359

21406 THE INTERACTIONS OF π^--MESONS WITH COMPLEX NUCLEI IN THE ENERGY RANGE (100-800) Mev. III. THE INTERACTION LENGTHS AND ELASTIC SCATTERING OF 300 Mev π^--MESONS IN G5 EMULSION. P. J. Finney, J. V. Major, and P. G. J. T. Parkhouse (Univ. of Durham, Eng.). Phil. Mag. (8), 7: 237-45(Feb. 1962).

A stack of pellicles was exposed to the 300 Mev π^--meson beam of the 660 Mev proton synchrotron at CERN, Geneva. The interaction lengths for the production of inelastic interactions and elastic scatterings through projected angles greater than 5°, found by scanning along 140 m of track, are (37.9 ± 2.0) and (77.4 ± 5.8) cm, respectively, compared to the geometrical interaction length of 29.3 cm. By comparison with the optical model the absorption coefficient and change in wave number are $(1.53 \pm 0.15)\ 10^{12}$ and $\pm (1.35 \pm 0.12)\ 10^{12}$ cm^{-1}, corresponding to a nuclear potential with a real component of (25 ± 1) Mev (of which the sign is not known), an imaginary component, $-(14.1 \pm 1.4)$ Mev and a mean free path for interaction in nuclear matter of $(6.5 \pm 0.7)\ 10^{-13}$ cm. The differences from the expected values are consistent with a considerable reduction within the nucleus of the cross section for elastic scattering of π-mesons by nucleons. (auth)

360

20076 INTERACTION OF 560-Mev NEGATIVE π-MESONS WITH EMULSION NUCLEI. Å. Frisk, S. Nilsson, B. E. Ronne, and W. Schneider (Univ. of Uppsala). Arkiv Fysik, 19: 69-82(1961). (In English)

Interactions of 560 π^- with emulsion nuclei were investigated. 4454 stars were found by area scanning. These yield an interaction mean free path of processes including absorption, charge exchange scattering, and inelastic scattering of 28 ± 2 cm. 485 stars were analyzed in detail. The frequency of stars with charged pions is $33 \pm 4\%$ where those with no heavy prong were excluded. The average kinetic energy of pions from stars with one negative pion is 176 ± 20 Mev. A marked correlation exists between the pion energy and the angle of emission. Eight events with two charged pions and ten with one positive pion were found. A rough estimate gives a fraction of events with charged pion production of $7 \pm 4\%$. (auth)

361

42576 METHOD OF INVESTIGATING FAST CHEMICAL REACTIONS BASED ON μ^+-MESON DEPOLARIZATION. Firsov, V. G.; Byakov, V. M. (Inst. of Theoretical and Experimental Physics, Moscow). pp 537-45 of STI/PUB/91(Vol.II). (In Russian).

When a μ^+-meson is slowed down in a substance the hydrogenoid muonium atom formed enters into chemical reactions similar to the corresponding interactions of atomic hydrogen. The observed angular distribution effect of the meson decay is associated with the chemical state of the meson. The absolute constants of the rate of the chemical reactions are determined in relation to the known nuclear physical decay characteristics. The method is independent of the state of aggregation of the substance and can be applied at essentially any temperature. Quantitative identification of the classes of the substances obtained (radical and molecular products are determined separately) is possible, as is individual determination based on variations in the precession of the system of spins in the magnetic field using a number of diatomic molecules as an example. The possibility of studying the structural parameters of the radicals and molecules, and of estimating the lifetime of the short-lived intermediate compounds is considered. The elementary steps in fast chemical reactions were investigated. (auth)

362

30812 ELECTRON AND MUON SCATTERING FROM NUCLEAR CHARGE DISTRIBUTIONS AT INCIDENT MOMENTA BETWEEN 50 AND 183 Mev/c. C. R. Fischer (Adelphi Univ., Garden City, N. Y.) and G. H. Rawitscher. Phys. Rev., 135: B377-83(July 27, 1964).

The comparison of theoretical elastic-scattering cross sections of positrons and electrons from Woods-Saxon (WS) and "wine-bottle" (WB) charge distributions of the nucleus of Au, previously performed for 183 Mev, is extended to lower energies and repeated for muons of comparable incident momenta. It is found that, for momentum transfers of less than 1.5 F^{-1}, the percent change of the cross section corresponding to a change from the WS to the WB charge distribution is largest, of the order of 30% for incident momenta of ~100 Mev/c, particularly for positrons. At an electron energy of 50 Mev, the cross section depends mainly on the mean-square radius of the nucleus; and an accuracy better than 5% is needed in order to determine additional nuclear charge distribution parameters. The mean-square radii of the WS and WB charge distributions differ by 6.5%, while the corresponding electron cross sections at 50 Mev differ by a maximum of 15%. A comparison with experimental elastic positron and electron scattering cross sections for Pb measured by Miller and Robinson is carried out; and a systematic discrepancy with theory is found for both e^+ and e^- cross sections for the 50–70 Mev energy

range, while theory and experiment agree well at 87 Mev and higher energies. The calculation consists of a conventional numerical phase-shift analysis based on the Dirac equation, and the nuclei are assumed to be static, spherically symmetric, extended charge distributions. (auth)

363

6893

SCATTERING OF 3.7–25 MEV POSITIVE PIONS BY HYDROGEN. G. E. Fischer and E. W. Jenkins (Columbia Univ., New York). Phys. Rev. 116, 749-53(1959) Nov. 1.

The Columbia University hydrogen bubble chamber was used to investigate the π^+-p scattering cross section in a laboratory energy range from 3.7 to 25 Mev. A total of 950 events were measured, of which 338 were caused by incident pions that would have come to rest in the chamber. Treating the small p-wave and large Coulomb contributions as known, the s-wave phase shift is found to deviate from a linear dependence on momentum only by one and a half standard deviations. (auth)

364

45127 A CONTRIBUTION TO DISPERSION THEORY OF PION-PION SCATTERING. Fischer, Jan. Rozpravy Cesk. Akad. Ved, Rada Mat. Prirod. Ved, 74: No. 12, 1-59 (1964). (In Czech).

Elastic scattering of pions on pions in the low-energy region is studied on the basis of the unitary condition and the Mandelstam integral representation of the scattering amplitude A. A historical survey of the dispersion theory is presented. Fundamental relations following from the Mandelstam representation are obtained in general form. The derivation of a set of integral equations for A is given. This set is obtained from the Mandelstam representation and unitarity by expanding the angular dependence of A in powers of a special function w, which represents by itself a conformal mapping of the complex cosine plane. An approximative resonant solution of the set of equations is given and relations between resonance parameters are derived. In Appendix A, the isotopic structure of A is derived. In Appendix B, it is shown that from the Mandelstam representation the one-dimensional dispersion relations may be derived for an arbitrary straight line lying in the s, u, t plane. Two special cases thereof, the so-called fixed-momentum-transfer and fixed-cosine dispersion relations are frequently used in the literature. In Appendix C, properties of different conformal mappings of the complex cosine plane are summarized. (auth)

365

22817

MEASUREMENT OF μ^+ LIFETIME. J. Fischer, B. Leontic, A. Lundby, R. Meunier, and J. P. Stroot (CERN, Geneva). Phys. Rev. Letters 3, 349-50(1959) Oct. 1.

The remarkable agreement of the experimental with the theoretical value for the lifetime of the muon is the strongest indication that the vector current is conserved and the strengths of axial and polar vector currents are equal when strong interactions are not present. An experiment to remeasure the μ^+ lifetime is described. A value of 2.20 ± 0.015 μsec was obtained. (W.D.M.)

366

36584 (TID-19343) MULTIPLE PION PRODUCTION IN INTERACTIONS OF POSITIVE PIONS WITH PROTONS NEAR 1.0 Bev. Horst W. J. Foelsche and Henry L. Kraybill (Yale Univ., New Haven). 1963. Contract AT(30-1)-1349. 66p.

Multiple pion production in the reactions $\pi^+ - p \rightarrow p + \pi^+ + \pi^+ + \pi^-$ and $\pi^+ - p \rightarrow p + \pi^+ + \pi^+ + \pi^- + \pi^0$ at 910, 1090, and 1260 Mev was studied. Double pion production is found to be dominated by the production of the well known $(^3/_2,^3/_2)$-isobar and no other resonant states among the outgoing particles can be identified. Triple pion production is found to proceed almost exclusively by the formation of the meson(η) (mass 549.0 Mev) which subsequently decays into $(\pi^+ + \pi^- + \pi^0)$. The isotopic spin of the η is confirmed to be I = 0 and the spin J, parity P, and G-parity G are confirmed to be most likely $J^{PG} = 0^{-+}$. The relative decay rate $\rho = (\eta \rightarrow \pi^+ + \pi^- + \gamma)/(\eta \rightarrow \pi^+ + \pi^- + \pi^0)$ is found to be $\rho = 0.14 \pm 0.08$, and the decay ratio $R = (\eta \rightarrow 3\pi^0)/(\eta \rightarrow \pi^+ + \pi^- + \pi^0)$ is found to be $R \sim 2 \pm 1$. No η's were observed at 910 Mev. At 1090 and 1260 Mev the production angular distributions of the η are roughly isotropic. η-production appears to be associated with the production of the $(^3/_2,^3/_2)$-isobar in the (p,π^+) system. The energy 1090 Mev represents the threshold energy for production of η with isobar, and the η meson appears to emerge with angular momenta higher than $\ell = 0$. 30 references. (auth)

367

6681 MUON CAPTURE IN NUCLEI. L. L. Foldy and J. D. Walecka (CERN, Geneva). Nuovo Cimento (10), 34: 1026-61(Nov. 16, 1964).

The total meson (μ) capture rates for some light nuclei (^{40}Ca, ^{16}O, ^{12}C and ^{4}He) were calculated, taking into account the effect of the giant dipole resonances in the capture process. The results were compared with experimental observations. (D.C.W.)

368

47656 NUCLEAR CORRELATION FUNCTIONS AND MUON CAPTURE. Foldy, L. L.; Walecka, J. D. (CERN, Geneva). Nuovo Cimento (10), 36: 1257-66(Apr. 16, 1965).

Properties of certain nuclear correlation functions which enter into the theory of muon capture in complex nuclei in the closure approximation are examined. The reliability of certain suggested methods for evaluating these correlation functions involving the Fermi gas approximation, and refinements of it, are assessed both from the point of view of internal theoretical self-consistency and by comparison with pertinent empirical information available from photodisintegration data on nuclei. (auth)

369

4600 (UCRL-9191) SCATTERING OF POSITIVE PIONS ON PROTONS AT 310 Mev: RECOIL-NUCLEON POLARIZATION AND PHASE-SHIFT ANALYSIS (thesis). James Herbert Foote (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 16, 1960. 131p. Contract W-7405-eng-48. OTS.

The recoil-proton polarization in π^+-p elastic scattering at 310-Mev incident-pion laboratory kinetic energy was measured at four scattering angles with plastic scintillation counters. These polarization results were combined with accurate differential- and total-cross-section data at 310 Mev, and a comprehensive phase-shift analysis was performed. The D-wave phase shifts were definitely needed to attain an adequate fit to the data. A general search for phase-shift solutions was carried out by using S-, P-, and D-wave phase shifts. The solution that best fits the data is of the Fermi type. The calculated errors in the phase shifts varied from 0.4 to 0.6°. Because it was felt that these errors might be deceivingly restrictive, the effects of small nuclear F-wave phase shifts on the results of the analysis were investigated and were found to be large; not only are the uncertainties in the original Fermi type solution increased but also additional sets of phase shifts that fit the data well arise. One of the solutions is similar to the original Fermi set except that the magnitudes of the phase shifts in this new fit are, in general, larger than those in the initial solution, and the signs of the D-wave phase shifts are reversed. Inelastic-scattering processes were neglected during the phase-shift analysis. Extension of the phase-shift inquiries to include G waves was attempted, but it was observed that the available data and theory do not allow the G-wave interaction to be significantly incorporated into the analysis. The sign of the recoil-proton polarization is defined to be positive when a preponderance of the protons recoiling to the right side of the incident π-meson beam had their spin vectors pointing up. A beam of 1×10^6 pions/sec incident upon a 1.0 g/cm^2 thick liquid-hydrogen target produced the recoil protons, which were then scattered by a carbon target at a mean energy varying with recoil angle from 113 to 141 Mev. The polarization of the recoil protons was analyzed by measuring the asymmetry produced in the carbon scattering. (auth)

370

5808

π^+-p SCATTERING AND PHASE-SHIFT ANALYSIS AT 310 MEV. James H. Foote, Owen Chamberlain, Ernest H. Rogers, Herbert M. Steiner, Clyde Wiegand, and Tom Ypsilantis (Univ. of California, Berkeley). Phys. Rev. Letters 4, 30-3(1960) Jan. 1.

At the 184-inch synchrocyclotron in Berkeley, data were obtained on elastic π^+-p scattering at 310 Mev. Quantities measured were the differential cross section, the total cross section, and the polarization of the recoil protons as a function of center-of-mass angle. The data were analyzed in terms of S, P, and D waves and only one acceptable solution was obtained—the Fermi type phase shift. Errors on the small phase shift were reduced to less than 1°. (B.O.G.)

371

17510 π^+-p ELASTIC SCATTERING AT 310 Mev; PHASE-SHIFT ANALYSIS. James H. Foote, Owen Chamberlain, Ernest H. Rogers, and Herbert M. Steiner (Univ. of California, Berkeley). Phys. Rev., 122: 959-71(May 1, 1961). (UCRL-9481)

A comprehensive phase-shift analysis of π^+-p elastic-scattering data at 310-Mev incident-pion laboratory kinetic energy is performed. The experimental data utilized include measurements of the differential and total cross sections and of the recoil-proton polarization. The D-wave phase shifts were found to be definitely needed in order to attain an adequate fit to the data. A general search for phase-shift solutions was carried out, using S-, P-, and D-wave phase shifts. One solution—of the Fermi type—was found that fits the data significantly better than any of the other solutions obtained. The calculated errors in the phase shifts of this set vary from 0.4 to 0.6 deg. The effects of small nuclear F-wave phase shifts on the results of the analysis were investigated and were found to be large. The nuclear phase shifts in the original Fermi solution and their rms errors are (when F-wave phase shifts are allowed): $S_{3,1} = -17.2 \pm 2.6$ deg, $P_{3,1} = -2.9 \pm 4.0$ deg, $P_{3,3} = 135.0 \pm 0.6$ deg, $D_{3,3} = 3.1 \pm 2.6$ deg, $D_{3,5} = -4.9 \pm 2.1$ deg, $F_{3,5} = 0.5 \pm 0.6$ deg, $F_{3,7} = -0.6 \pm 1.4$ deg. The values given here for the first five phase shifts approximate the corresponding values obtained when the F-wave phase shifts were assumed negligible. However, all except $P_{3,3}$ fall outside the limits set by the small original errors. Inelastic-scattering processes were neglected during the phase-shift analysis. Extension of the phase-shift inquiries to include G waves was attempted, but it was observed that the available data and theory do not allow the G-wave interaction to be significantly incorporated into the analysis. (auth)

372

17509 π^+-p ELASTIC SCATTERING AT 310 Mev: RECOIL-NUCLEON POLARIZATION. James H. Foote, Owen Chamberlain, Ernest H. Rogers, Herbert M. Steiner, Clyde E. Wiegand, and Thomas Ypsilantis (Univ. of California, Berkeley). Phys. Rev., 122: 948-58(May 1, 1961).

Recoil-proton polarization in π^+-p elastic scattering at 310-Mev incident-pion laboratory kinetic energy is experimentally measured at four scattering angles with scintillation counters. Polarization values obtained, related rms experimental errors, and mean center-of-mass recoil angles are: $+0.044 \pm 0.062$ at 114.2 deg, -0.164 ± 0.057 at 124.5 deg, -0.155 ± 0.044 at 133.8 deg, and -0.162 ± 0.037 at 145.2 deg. The sign of the polarization is defined to be positive when a preponderance of the recoil protons had their spin vectors pointing in the direction of $p_i \times p_f$, where this quantity is the cross product of the initial and final

momentum vectors of the conjugate pions. A beam of 1×10^6 pions per sec incident upon a 1.0-g/cm^2-thick liquid-hydrogen target produced the recoil protons, which were then scattered by a carbon target at a mean energy varying with recoil angle from 113 to 141 Mev. The polarization of the recoil protons was analyzed by measuring the asymmetry produced in the carbon scattering. A proton beam of known polarization was used to determine the analyzing ability of the system at each recoil angle. Values obtained for the analyzing ability range from 0.41 to 0.57. (auth)

373

34065 1964 RUTHERFORD MEMORIAL LECTURE. π MESONS VERSUS CANCER. Fowler, P. H. (Wills Physics Lab., Bristol, Eng.). Proc. Phys. Soc. (London), 85; 1051-66(June 1965).

The case is made for the investigation of various beams of heavily ionizing radiations with a view to their eventual use in radiotherapy. Beams of heavy ions and stopping mesons (π^-) are considered, and the probable oxygen enhancement ratio and distribution of dose with depth are compared with ^{60}Co γ rays and other beams in current use. Beams of stopping mesons (π^-) give an excellent distribution of dose with depth, and a very favorable oxygen enhancement ratio. The feasibility of preliminary experiments with biological material is considered. (auth)

374

17026 SEARCH FOR $\mu^- \rightarrow e + e + e$. S. Frankel (Univ. of Pennsylvania, Philadelphia), W. Frati, J. Halpern, L. Holloway, W. Wales, F. W. Betz, and O. Chamberlain). Phys. Rev., 130: 351-4(Apr. 1, 1963).

A search was made for the neutrinoless decay mode $\mu^- \rightarrow e + e + e$. Positive pions from the Berkeley 184-in. synchrocyclotron were stopped in a lithium target. The detection of three decay particles not in coincidence with an incoming pion served to trigger two thin-plate spark chambers viewing the decays. The energy of the decay particles was measured with a combination of NaI counters and range telescopes. The spark chamber pictures were first scanned for events with three tracks meeting at a common point in the target. A requirement that no angle between any of the three tracks could be greater than 160° eliminated essentially all of the main source of background, namely, knock-on collisions of electrons passing through the target. Further requirements for the three tracks to be coplanar and for each particle to have at least 16 Mev eliminated all but one ambiguous event. For this event insufficient energy information was available. If we assume that one event to be $\mu^- \rightarrow e + e + e$, and with a calculated detection efficiency of 0.0083, an upper limit for the branching ratio for this mode can be set at 1.5×10^{-7} with a 90% confidence level. (auth)

375

19095 A SEARCH FOR THE DECAY $\mu^- \rightarrow e + \nu[\gamma]$. S. Frankel (Univ. of Pennsylvania, Philadelphia), W. Frati, J. Halpern, L. Holloway, W. Wales, and O. Chamberlain. Nuovo Cimento (10), 27: 894-912(Feb. 16, 1963). (In English)

A search for the decay $\mu^- \rightarrow e + \gamma$ is made using spark chambers and sodium iodide crystals. The spark chambers provide the means of measuring the angle between the electron and photon, while the sodium iodide crystals are used to measure the particle energies. A lithium target and thin (0.001 in.) aluminum foils in the spark chamber are used to minimize the scattering of the electron. An upper limit of $4.3 \cdot 10^{-8}$ (90% confidence) is found for the ratio of the rate of the $\mu^- \rightarrow e + \gamma$ decay to the normal muon decay rate. A search for the decay $\mu^- \rightarrow e + \gamma + \gamma$ is also made. (auth)

376

15238

FURTHER SEARCH FOR THE DECAY $\mu^+ \rightarrow e^+ + \gamma$. S. Frankel, V. Hagopian, J. Halpern, and A. L. Whetstone (Univ. of Pennsylvania, Philadelphia). Phys. Rev. 118, 589-90(1960) Apr. 15.

A new experiment for determining the upper limit for the branching ratio R of the process $\mu^+ \rightarrow e^+ + \gamma$ relative to the normal decay mode $\mu^+ \rightarrow e^+ + \nu + \bar{\nu}$ yields a value of R of less than 1.2×10^{-6} with a 90% confidence level. (auth)

377

10890 NEW LIMIT ON THE $e + \gamma$ DECAY MODE OF THE MUON. S. Frankel (Univ. of Pennsylvania, Philadelphia), J. Halpern, L. Holloway, W. Wales, M. Yearian, O. Chamberlain, A. Lemonick, and F. M. Pipkin. Phys. Rev. Letters, 8: 123-5(Feb. 1, 1962).

Limits for the decay mode $\mu^- \rightarrow e + \gamma$ are studied using spark chamber techniques. A rate of less than 1.9×10^{-7} of the normal decay rate is the upper limit. (L.N.N.)

378

28423 DETERMINATION OF THE μ-NEUTRINO HELICITY. P. Franzini (Università, Pisa, Italy and Istituto Nazionale di Fisica Nucleare, Pisa, Italy). p.248-53 of "Selected Topics on Elementary Particle Physics." New York, Academic Press, 1963.

An experiment was performed to measure the sign of the helicity of negative muons produced in the decay of negative pions. The result, that helicity of negative muons is positive, agrees with other experiments and with the predictions of the V-A theory. Thus, the μ neutino has the same helicity as the neutrino involved in β decay, and no information is obtained on the question of the identity of the two neutrinos. Agreement between expected and measured muon yield and asymmetry proves that the muon is a Dirac particle having only electromagnetic interaction. (M.J.T.)

379

28400 SCATTERING OF SLOW PARTICLES IN NUCLEAR EMULSIONS. E. Fridlender (Inst. of Nuclear Physics, Rumania). Rev. phys., Acad. rep. populaire Roumaine, 5: 355-65(1960). (In Russian)

Effective cross sections for low-energy π meson interactions were studied by analyzing the distribution of π orientations at the end of tracks. The total effect of Coulomb scattering, multiple scattering, and nuclear scattering is calculated. (R.V.J.)

380

47227 RESTUDY OF THE MUON CAPTURE IN HYDROGEN. Fujii, Akihiko (Jochi Univ., Japan). Genshikaku Kenkyu, 9: 726-31(Mar. 1965). (In Japanese).

The muon capture rate in hydrogen is reanalyzed with the newly published molecular parameters. The prediction is in good agreement with the experiment. (auth)

381

22909 MUON CAPTURE IN He^3. Akihiko Fujii and Yoshio Yamaguchi (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 31: 107-14(Jan. 1964).

The transition rate of the particular muon capture reaction between the ground states of ^3He and ^3H is calculated in a completely relativistic fashion, in which all the structure effects are reduced to form factors. The computed capture rate agrees well with the experimental data, provided that the induced pseudoscalar term has the same sign and nearly the same magnitude as Goldberger-Treiman's result for the nucleon in the dispersion theoretic approach. (auth)

382

10501

ELASTIC SCATTERING OF 150-Mev NEGATIVE PIONS BY NUCLEI. Tadao A. Fujii (Univ. of Chicago). Phys. Rev. 113, 695-709(1959) Jan. 15.

The elastic scattering of 150-Mev negative pions by complex nuclei was experimentally studied by the use of energy-sensitive Čerenkov detectors with a pulse-height analyzer. The elastic scattering could be distinguished from inelastic processes within the 10-Mev resolution width of these detectors. The differential cross sections of carbon, aluminum, copper, and lead were measured at angles between 18.5° and 43.6°. In addition, measurements on carbon and lead were extended to large angles between 45° and 139°. It was found that elastic scattering was confined predominantly to the forward angles less than 60°. Calculations based on the optical model with a square well were carried out to obtain the values of parameters which provided the best fit to the data. They are -30 Mev $\geq V_R \geq -40$ Mev, -65 Mev $\geq V_I \geq -75$ Mev, and 1.3×10^{-13} $A^{1/3}$ cm $\leq R \leq 1.4 \times 10^{-13}$ $A^{1/3}$ cm, where V_R and V_I are real and imaginary parts of the potential, R is the nuclear radius, and A is the nuclear mass. The corresponding values of the reaction mean free path were of the order of the pion Compton wavelength. These values are close to those predicted by Frank, Gammel, and Watson from the knowledge of the pion-nucleon interaction. (auth)

383

10327

"ANOMALOUS" SCATTERING OF μ MESONS. Shuji Fukui (Osaka Univ.) and Takashi Kitamura and Yuzuru Watase (Osaka City Univ.). Phys. Rev. 113, 315-24 (1959) Jan. 1.

A μ-meson scattering experiment in which the mesons are required to traverse a thick block of iron and stop and decay in a thin layer of carbon, is reported. Any uncertainty in the identity of the scattered particle has thus been eliminated, and further, the momentum of the particles is well defined. The observed angular distribution of the scattered μ mesons in the momentum range $(1^{+0.15}_{-0.2})$ Bev/c was found to be in good agreement with the distribution predicted from the Coulomb scattering theory for extended nuclei obtained by Cooper and Rainwater. There is thus no indication from the present experiment for any anomalous scattering of μ mesons near 1 Bev/c momentum. The angular distribution of scattering of those particles which traversed the iron absorber but did not necessarily stop and decay in the carbon layer was not in good agreement with the Cooper and Rainwater theory, there being more than the expected number of particles scattered through large angles. It is shown, however, that the predicted scattering distribution, at large angles (assuming no anomalous contribution) arises almost entirely from the scattering of particles in the 1–2 Bev/c region, and therefore is very sensitive to the assumed intensity in this region. It is concluded that the results from this part of the experiment cannot be accepted as evidence favoring the existence of anomalous scattering. The experimental results of other authors on the scattering of energetic μ mesons are summarized and discussed. It is concluded that the evidence for anomalous interactions is not strong. (auth)

384

3971

THE ELASTIC SCATTERING OF NEGATIVE PIONS OF 745 Mev/c ON HYDROGEN. Jean-Marc Gaillard, Pierre Lehmann, Antoine Lévêque, João Meyer, Daniel Revel, and Jean Sacton. Compt. rend. 249, 1497-9(1959) Oct. 19. (In French)

The $\pi^- - p$ differential cross section was measured on the second resonance (pions of 745 Mev/c). The total elastic cross section is 20 ± 3 mb. (tr-auth)

385

18315 INVESTIGATION OF FLUCTUATIONS IN MEASUREMENT OF PARTICLES IONIZATION POWER IN A SPARK CHAMBER. Yu. V. Galaktionov, F. A. Yech, and V. A. Lyubimov (Inst. for Theoretical and Experimental Physics, Moscow). Nucl. Instr. Methods, 33: 353-4(Mar. 1965).

It was previously found that at definite regimes of operating the large gap spark chamber, the luminosity of the spark breakdown depends on the ionization power of the particles passing normal to the electrodes of the chamber. The fluctuations in measurement of the ionization power of the particles in a spark chamber are investigated. Spark chambers with 15 cm gap were exposed to a beam of mesons (π) and protons at 600 Mev/c. With the aid of Cherenkov counters and absorbers mesons (π) of minimal ionization power and protons of ionization power 1.9, 2.7, and 3.4 J/J_{min} could be separated. (C.E.S.)

386

2931

CHARGE EXCHANGE SCATTERING OF 128-Mev NEGATIVE PIONS ON HYDROGEN. E. Garwin, W. Kernan, C. O. Kim, and C. M. York (Univ. of Chicago, Ill.). Phys. Rev. 115, 1295-9(1959) Sept. 1.

The charge exchange scattering of negative pions by liquid hydrogen was measured at 128 ± 2 Mev bombarding energy. A lead-glass Cerenkov counter was used to measure the energy spectrum of the gamma rays emitted in the decay of the neutral pions. The gamma rays were detected at four angles relative to the incident beam: 45, 80, 116, and 135°. The integrated cross section is $\sigma_{tot}(\pi^-,\pi^0) = 25.6 \pm 1.3$ mb, which is in good agreement with other work. (auth)

387

14721

PRECISE DETERMINATION OF THE MUON MAGNETIC MOMENT. R. L. Garwin, D. P. Hutchinson, S. Penman, and G. Shapiro (Columbia Univ., New York). Phys. Rev. Letters 2, 213-15(1959) Mar. 1.

A stroboscopic method was adopted for determining the muon magnetic moment, in which the muon is brought to rest with its spin perpendicular to a magnetic field. By use of a high precession frequency and by a different method of utilizing time information of the muon decay, the experiment described achieved a muon moment accuracy of 0.007%. (W.D.M.)

388

15222

ACCURATE DETERMINATION OF THE μ^+ MAGNETIC MOMENT. R. L. Garwin, D. P. Hutchinson, S. Penman, and G. Shapiro (Columbia Univ., New York). Phys. Rev. 118, 271-83(1960) Apr. 1.

Using a precession technique, the magnetic moment of the positive mu meson is determined to an accuracy of 0.007%. Muons are brought to rest in a bromoform target situated in a homogeneous magnetic field oriented at right angles to the initial muon spin direction. The precession of the spin about the field direction, together with the asymmetric decay of the muon, produces a periodic time variation in the probability distribution of electrons emitted in a fixed laboratory direction. The period of this variation is compared with that of a reference oscillator by means of phase measurements of the "beat note" between the two. The magnetic field at which the precession and reference frequencies coincide is measured with reference to a proton nuclear magnetic resonance magnetometer. The ratio of the muon precession frequency to that of the proton in the same magnetic field is thus determined to be 3.1834 ± 0.0002. Using a re-evaluated lower limit to the muon mass, this is shown to yield a lower limit on the muon g factor of 2(1.00122 ± 0.00008), in agreement with the predictions of quantum electrodynamics. (auth)

389

4686 (CERN-61-28) THE INVERSE PHOTOPRODUCTION REACTION $\pi^- + p \rightarrow \gamma + n$. G. Gatti, P. Hillman, W. C. Middelkoop, T. Yamagata, and E. Zavattini (European Organization for Nuclear Research, Geneva). Oct. 11, 1961. 35p.

A measurement has been made of the inverse photoproduction reaction $\pi^- + p \rightarrow \gamma + n$ with 72 Mev pions and at 90° c.m. The differential cross-section is $(70 \pm 7)\,10^{-30}$ cm^2 $ster^{-1}$. Detailed balance and published measurements on the reaction $\gamma + p \rightarrow \pi^+ + n$ gave a π^-/π^+ ratio of 1.34 ± 0.15 at a proton energy of 182 Mev (c.m.) and at a c.m. angle of 90°. The technique used was coincidence detection of both particles with time-of-flight measurement of the neutron energy to separate the reaction from the much more probable charge exchange reaction $\pi^- + p \rightarrow \pi^0 + n$. (auth)

390

22902 INVERSE PHOTOPRODUCTION REACTION $\pi^- + p \rightarrow \gamma + n$ IN FLIGHT. G. Gatti, P. Hillman, W. C. Middelkoop, T. Yamagata, and E. Zavattini (CERN, Geneva). Phys. Rev. Letters, 6: 706-8(June 15, 1961).

The absolute value of the cross section for the process $\pi^- + p \rightarrow \gamma + n$ from which the free-neutron photoproduction cross section is immediately calculable using the principle of detailed balance was measured. The experiment was performed at 90°C.M. angle and a pion energy of 72 Mev. The cross section was measured by detecting the neutrons in a plastic scintillation counter. The energy of the neutrons was measured by time of flight in order to discriminate against the charge-exchange reaction $\pi^- + p \rightarrow \pi^0 + n$. (P.C.H.)

391

11023

π^+-p ELASTIC SCATTERING AT 30 MEV. G. Giacomelli

(Univ. of Rochester, N. Y.). Phys. Rev. 117, 250-1(1960) Jan. 1.

Differential scattering cross sections in hydrogen for (30 ± 1.5)-Mev positive and negative pions were measured at the two center-of-mass angles of 82 and 99.9 degrees. The cross sections for positive pions in mb/sterad in the center-of-mass system are 0.435 ± 0.028 and 0.590 ± 0.030; for negative ones, 0.268 ± 0.028 and 0.239 ± 0.021, respectively. (auth)

392

25792 (UCRL-16282) DIFFERENTIAL DISTRIBUTIONS OF π^+ IN THE REACTION $\pi^-p \rightarrow \pi^+\pi^-n$ FROM 500 TO 700 Mev [Thesis]. Giancoli, Douglas Charles (Lawrence Radiation Lab., Univ. of California, Berkeley). Mar. 10, 1966. Contract W-7405-eng-48. 78p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The energy distributions of the π^+ in the reaction $\pi^-p \rightarrow \pi^+\pi^-n$ were measured at several π^+ angles for incident π^- beam energies of 516, 550, 599, 667, and 715 Mev. The negative-pion beam was obtained from the Berkeley Bevatron. The energies of the π^+ were measured with a magnetic spectrometer consisting of a C-magnet with thin-walled aluminum spark chambers to display the trajectory of the particle entering and leaving the magnet. An array of scintillation counters was used to detect the occurrence of an event. An electronic time-of-flight system was used to distinguish positive pions from protons, which also pass through the spectrometer. The distributions at each angle were integrated over energy to obtain the differential cross sections, $d\sigma/d\Omega^*$. The measured spectra cannot be adequately explained by the statistical model nor by an isobar model, although production of the N^*_{33} isobar is present. (auth)

393

43350 MUON CAPTURE IN ^{16}O. Gillet, Vincent; Jenkins, David A. (Univ. of California, Berkeley). Phys. Rev., 140: B32-41(Oct. 11, 1965). (UCRL-16029).

The muon capture rate in oxygen is used as a means for measuring the induced pseudoscalar coupling constant (C_P) of weak interactions. The capture rate between the $J^P = 0^+$ ground state of ^{16}O and the 0^-, 1^-, 2^-, and 3^- states of ^{16}N are calculated as a function of C_P with different nuclear models. C_P is then determined using the experimental values of the transition rates. It is found that the transition rate, and therefore C_P, depends strongly on the nuclear model. It is concluded that $5 < C_P/C_A < 20$. (auth)

394

3080 DOUBLE CHARGE EXCHANGE WITH NEGATIVE PIONS. SEARCH FOR TETRANEUTRON. Gilly, L.; Jean, M.; Meunier, R.; Spighel, M.; Stroot, J. P.; Duteil, P. (CERN, Geneva. Faculte des Sciences, Orsay, France). Phys. Lett., 19: 335-8(Nov. 1, 1965).

Eventual production of light nuclei such as tetraneutrons and hydrogen-7 was investigated in double charge exchange reactions with negative mesons (π). Since production of A(Z-2) in a two-body process would lead to a mono-energetic meson (π) emission, positive mesons (π) emitted forward were registered. The meson (π^+) detection equipment was the double spectrometer with DISC Cherenkov counters. A negative meson (π) beam over an energy range from 120 to 280 Mev was used. Data were taken at a fixed spectrometer velocity setting, the incident negative mesons (π) being varied in steps of 6 Mev. Liquid He, Li, Be, and C targets were investigated. In no case was a two-body reaction observed. Curves of the intensity distribution of about 180 Mev π^+ as a function of π^- energy are given. For each target nucleus a binding energy scale was drawn for an eventual two-body channel. Double charge exchange cross section for all final states available increases with the atomic number. (J.F.P.)

395

38141 DOUBLE CHARGE EXCHANGE WITH POSITIVE PIONS. L. Gilly, M. Jean, R. Meunier, M. Spighel, J. P. Stroot, P. Duteil, and A. Rode (CERN, Geneva and Laboratoire de Physique Nucleaire, Orsay, France). Phys. Letters, 11: 244-8(Aug. 1, 1964).

The differential cross sections for double charge exchange of mesons (π^+) on Be, Li, and Na at 195 Mev were determined by detecting the mesons (π^-) produced in the forward direction with a DISC spectrometer. (D.C.W.)

396

11377 YADERNAYA KHIMIYA. (Nuclear Chemistry). Goldanskii, V. I.; Lavrukhina, A. K. Moscow, Izdatel'stvo Nauka, 1965. 330p.

Seventeen articles are included on fast-proton reactions in meteorites, composition and origin of galactic cosmic rays, fragmentation by high-energy particles, production of tritium and more complex particles in high-energy proton reactions, secondary reactions of formation of At in high-energy bombardment of Bi and Pb, direct nuclear reactions at high energies, mechanism of heavy-ion induced nuclear reactions, origin of rare-earth isotopes in the solar system, chemistry of hot atoms in condensed organic systems, momentum distribution of annihilating electron-positron pairs from photon angular correlations, Hartree-Fock method in positron annihilation in condensed ionic media, Mössbauer effect in analytic chemistry and geochemistry, annihilation of positrons from polarized states in alkali-halide crystals, positron capture by defects in alkali-halide crystals, molecular neutron spectroscopy, physics and chemistry of muonium, and study of chemical reactions by depolarization of muons. (M.J.T.)

397

14939 INELASTIC EFFECTS IN PION-NUCLEON REACTIONS. H. Goldberg and E. L. Lomon (Massachusetts Inst. of Tech., Cambridge). Pt. II, p.75-6 of "Proceedings of the Eastern Theoretical Physics Conference." Chapel Hill, N. C., University of North Carolina, 1963.

It was shown previously that complicated structure in the $T = \frac{1}{2}$, $S_{\frac{1}{2}}$ state and the resonant $T = \frac{1}{2}$, $D_{\frac{3}{2}}$ state of pion-nucleon scattering can be understood in terms of coupling to other channels. By means of the boundary condi-

tion model of strong interactions the T = 0 dipion-nucleon channel was coupled to the S state and the ρ meson-nucleon channel to the D state. The results are in excellent agreement with data from 0 to 700 Mev as shown in accompanying graphs. (C.E.S.)

398

18500

A METHOD FOR STUDY OF THE ELECTROMAGNETIC PROPERTIES OF CHARGED π MESONS. Lazare Goldzahl, Bernard Jouvet, Maurice Mathieu, and Jacques Poyen (Collège de France, Paris). Compt. rend. 249, 88-90(1959) July 6. (In French)

The possibility of studying the electromagnetic structure of π mesons by observing the electrons projected by them is investigated. These experiments led to a new method of determining the spin of the π meson. (tr-auth)

399

18348 UCRL-9119

California. Univ., Berkeley. Lawrence Radiation Lab. THE ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 230, 290, 370, AND 427 MEV (thesis). Lester K. Goodwin. Apr. 7, 1960. 84p. Contract W-7405 eng-48. OTS.

The elastic differential cross section for the scattering of π^--mesons by hydrogen was measured at laboratory kinetic energies of 230, 290, 370, and 427 Mev. The elastically scattered pions were detected by a counter telescope which discriminated against recoil protons and inelastic pions on the basis of their shorter ranges. Nine differential-cross-section points obtained at each energy were fitted by a least-squares program to a Legendre polynomial series. At the three higher energies, D waves are required to give a satisfactory fit to the data. The real part of the forward-scattering amplitudes calculated from the data are in agreement with the predictions of dispersion theory. The results in conjunction with data from other $\pi-N$ scattering experiments support charge independence at these higher energies. (auth)

400

16506 ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 230, 290, 370, AND 427 Mev. Lester K. Goodwin, Robert W. Kenney, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev., 122: 666-64 (Apr. 15, 1961). (UCRL-9119-R).

The elastic differential cross section for the scattering of negative pions by hydrogen was measured at laboratory-system pion kinetic energies of 230, 290, 370, and 427 Mev. The elastically scattered pions were detected by a counter telescope which discriminated against recoil protons and inelastic pions on the basis of range. Differential cross sections were obtained at nine angles for each energy and were fitted by a least-squares program to a series of Legendre polynomials. At the three higher energies, D waves are required to give satisfactory fits to the data. The real parts of the forward-scattering amplitudes calculated from this experiment are in agreement with the predictions of dispersion theory. The results of this experiment, in conjunction with data from other pion-nucleon scattering experiments, support the hypothesis of charge independence at these higher energies. (auth)

401

9237 EXPERIMENTAL OBSERVATION OF SOME REGULARITIES IN μ^+ REPOLARIZATION. S. Gorodetzky (Institut de Recherches Nucleaires, Strasbourgh), Th. Muller, M. Port, and A. Zichichi. Phys. Letters, 2: 133-5(Sept. 1, 1962). (In English).

The μ^+ repolarization as a function of externally applied longitudinal magnetic fields was measured for carbon, sulphur, a plastic scintillator (NE-102), and water. All materials showed a low-field ($\leq$ 1 k gauss) repolarization, and a saturation effect in the repolarization at $\sim$4 k gauss upward. The carbon depolarization at zero field was $\sim$25% and was fully restored at $\sim$4 k gauss. The depolarization in the plastic scintillator was restored to 90% at 10^3 gauss, and fully polarized at $\sim$4 k gauss. In no material did the measurements agree with simple muonium formation theory. (H.D.R.)

402

16931 (NP-11592(Vol.I)(p.37-43)) PROTON SCATTERING IN THE ENERGY REGION 500–1100 Mev. F. Grard, G. R. Macleod, L. Montanet (European Organization for Nuclear Research, Geneva); M. Cresti (Padua. Universita. Istituto di Fisica); R. Barloutaud, C. Choquet, J. M. Gaillard, J. Heughebaert, A. Leveque, P. Lehmann, J. Meyer, and D. Revel (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay).

Results are presented on π^--p scattering at 516, 616, 710, 887, and 1085 Mev and preliminary results on π^+-p scattering at 820 and 900 Mev are included. A discussion is also included on the angular distributions of elastic scattering and the values for the total elastic and inelastic cross-sections for π^--p, π^+-p, and for the isotopic spin T = $\frac{1}{2}$ state. (J.R.D.)

403

5891 π^--PROTON SCATTERING AT 516, 616, 710, 887, AND 1085 MeV. F. Grard (CERN, Geneva), G. Macleod, L. Montanet, M. Cresti, R. Barloutaud, C. Choquet, J.-M. Gaillard, J. Heughebaert, A. Leveque, P. Lehmann, J. Meyer, and D. Revel. Nuovo cimento (10), 22: 193-8 (Oct. 1, 1961). (In English)

Results on π^--p scattering at kinetic energies of 516, 616, 710, 887, and 1085 Mev are presented in graphical and tabular form. Data were obtained by exposing a liquid-

hydrogen bubble chamber to a pion beam from the Saclay proton synchrotron. The chamber had a diameter of 20 cm and a depth of 10 cm. There was no magnetic field. At the highest energies under consideration, a peak appears in the forward direction. If this is interpreted as due only to shadow scattering, reasonable agreement with the angular distribution at 1085 Mev is obtained by taking for the optical radius a value of 1.08×10^{-13} cm, consistent with results at 1.2 to 1.3 Bev. (L.N.N.)

404

12251

ELASTIC SCATTERING OF 390 Mev π^+ MESONS BY PROTONS. E. L. Grigor'ev and N. A. Mitin (Joint Inst. for Nuclear Research. Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz. 37, 1583-6(1959) Dec. (In Russian)

The angular distribution of (390 ± 25) Mev π^+ mesons elastically scattered on hydrogen was measured with help of nuclear photographic emulsions. An expression for the differential scattering cross section is given. Phase shifts of the Fermi solution obtained by assuming that only S and P states participate in scattering are $\alpha_3 = -34°$, $\alpha_{33} = 151°$, and $\alpha_{31} = -16°$. (auth)

405

21400 UCRL-trans-486

POLARIZATION OF RECOIL PROTONS IN ELASTIC π^+-p-SCATTERING AT THE ENERGY OF 307 Mev. Ye. (E.) L. Grigor'ev and N. A. Mitin. Translated from a publication of the Joint Institute for Nuclear Research, Dubna, 1959. 19p. \$3.30(ph), $2.40(mf) JCL or LC.

An experiment on recoil proton polarization in π^+-p scattering at 307 Mev and an angle of 140 ± 8° in the center-of-inertia system is described. On the basis of the data on the value of left-right asymmetry, polarization equal to $P_1 = -0.19 \pm 0.17$ was determined. Phase-shift analysis of the differential cross sections is discussed. (W.D.M.)

406

22832

POLARIZATION OF RECOIL PROTONS PRODUCED IN ELASTIC π^+—p-SCATTERING AT 307 Mev ENERGY. E. L. Grigor'ev and N. A. Mitin (Joint Inst. of Nuclear Studies). Zhur. Eksptl'. i Teoret. Fiz. 37, 413-21 (1959) Aug. (In Russian)

Results are presented of investigation on the polarization of recoil protons appearing in elastic π^+–p scattering through an angle of 140 ± 8° in the cms at an energy of 307 ± 5 Mev. A polarization value $P_1 = -0.19 \pm 0.17$ was derived from the data on the magnitude of the left-right asymmetry in elastic scattering of recoil protons on nuclei of the photographic emulsion. Phase shifts satisfying the indicated polarization value and consistent with the differential cross section for elastic scattering of π^+-mesons by protons are given. Problems connected with the use of various phase shift sets for analysis of the experimental data are discussed. (auth)

407

20931 (JINR-P-1951) O VOZMOKHNOM SUSHCHESTVOYANII NOVYKH BOZONNYKH REZONANSOV, RASPADAYUSHCHIKHSYA S UCHASTIEM γ-KVANTOV. (On a Possible Existence of New Boson Resonance Decays Involving γ Quanta). V. G. Grishin (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1965. 7p. Dep.(mn).

The properties of the hypothetical mesons (L) are considered for which the decays into other particles via strong coupling are forbidden. It is shown that if L mesons have a mass in the range from 140 up to 560 Mev and S = 0, I = 1, $J \leq 1$, they decay mainly through the electromagnetic channel, γ quanta being involved. A similar situation takes place if the L meson masses are from 500 to 780 Mev and S = 1, I = 1, $J \leq 1$. Such decays are not yet studied experimentally. (auth)

408

15374 CHARGE EXCHANGE SCATTERING NEAR THE N*(1510) AND N*(1690) RESONANCES. Guerriero, L. (Univ. of Padua). Proc. Roy. Soc. (London), Ser. A, 289: 471-88(Jan. 25, 1966).

Preliminary results of an experiment to measure the total cross sections and the angular distributions in the charge exchange reaction $\pi^- + p \rightarrow \pi^0 + n$ at eleven energies between 500 and 1150 Mev are reported. (C.E.S.)

409

36309 ASYMMETRY OF THE $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ DECAY-ELECTRON ANGULAR DISTRIBUTION IN A LONGITUDINAL MAGNETIC FIELD OF 140,000 GAUSS. I. I. Gurevich (Kurchatov Atomic Energy Inst., Moscow), L. A. Makariyna, B. A. Nikol'skii, B. V. Sokolov, L. V. Surkova, S. Kh. Khakimov, V. D. Shestakov, Yu. P. Dobrotsov, and V. V. Akhmanov. Phys. Letters, 11: 185-8(July 15, 1964).

The angular distribution of $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ decay positrons was studied with a longitudinal magnetic field of 140,000 gauss. An emulsion stack inside a magnetic coil was exposed to a meson (π^+) beam. Asymmetry coefficients were determined. (C.E.S.)

410

20487

TRIPLE ELECTRON μ MESON DECAY. I. I. Gurevich, B. A. Nikol'skiĭ, and L. A. Surkova. Zhur. Eksptl'. i Teoret. Fiz. 37, 318-19(1959) July. (In Russian)

An event of triple relativistic electron emission at the μ-meson stopping point was observed during measurements of electron angular distribution asymmetry in $\pi \rightarrow \mu \rightarrow e$ decay. The microprojection of the μ meson triple-electron decay shows that all three electrons

have a large deflecting angle to the emulsion plane. The recorded electron tracks and the angles between the electrons are given. The observed event is interpreted as $\mu^+ \rightarrow e^+ + e^+ + e^- + \nu + \tilde{\nu}$; however, the interpretation does not qualify whether this is a case of virtual or real conversion of γ quantum into an electron-positron pair. One of the suggested explanations postulates that this represents the decay $\mu^+ \rightarrow e^+ + \nu + \tilde{\nu} + \gamma$ followed by γ quantum conversion into a pair. The event was observed among 50,000 μ meson decays; hence, the relative probability of the μ meson "triple-electron" decay should be estimated as $p(3e)/p(e) < 2 \times 10^{-5}$. Considering that there was only one event of "triple electron" decay, a possibility of accidental superposition of tracks is not excluded. (R.V.J.)

411

20995 MEASUREMENT OF THE NEUTRON-NEUTRON S-WAVE SCATTERING LENGTH FROM THE REACTION $\pi^- + d \rightarrow 2n + \gamma$. R. P. Haddock (Univ. of California, Los Angeles), R. M. Salter, Jr., M. Zeller, J. B. Czirr, and D. R. Nygren. Phys. Rev. Letters, 14: 318-23(Mar. 1, 1965).

Neutron time-of-flight spectra from the reaction $\pi^- + d \rightarrow 2n + \gamma$ were measured, using coincidence detection of all three final particles by scintillation counters. Results based on 2002 events at four angles from 0 to 17° are given in histograms. The data were fitted to theoretical hypotheses, and a preliminary value for the neutron-neutron S-wave scattering length of -16.4 ± 1.9 f was found. The result is compared with those of previous experiments. (M.J.T.)

412

3948

PION MASS MEASUREMENTS USING NEUTRON TIME-OF-FLIGHT TECHNIQUES. Roy P. Haddock, Alexander Abashian, Kenneth M. Crowe, and John B. Czirr (Univ. of California, Berkeley). Phys. Rev. Letters 3, 478-80(1959) Nov. 15.

Using neutron time-of-flight techniques, the π^- mass was determined to be 272.4 ± 1.1 and the mass difference of π^- and π^0 to be 8.991 ± 0.020 m_e. These values agree favorably with determinations by other groups. (C.J.G.)

413

39981 (UCRL-10516) NEUTRON ENERGY SPECTRA FROM NUCLEI EXCITED BY μ^--MESON CAPTURE (thesis). Donald E. Hagge (California. Univ., Berkeley. Lawrence Radiation Lab.). June 12, 1963. Contract W-7405-eng-48. 81p.

The neutron energy spectra from nuclear capture of μ^- mesons in Al, Ca, Fe, Ag, I, Au, and Pb were measured. Nuclear temperatures were deduced from the spectra according to the Weisskopf evaporation theory. Results were compared to other experimental measurements and consistency with compound nuclear theory was discussed. The direct neutron emission spectrum was calculated by using a degenerate Fermi gas model and momentum distributions of a Gaussian type. The neutron detector was a liquid scintillation counter in conjunction with a pulse-shape discrimination circuit used for γ-ray rejection. The recoil-proton pulse-height spectra were unfolded by a computer code to obtain the neutron energy spectra. Measurements of neutrons from deuterium-tritium and Be–Pu sources indicate good reproduction of spectra if single collisions with hydrogen are assumed. 47 references. (auth)

414

26356 RARE DECAYS OF THE μ MESON. Jules Halpern (Univ. of Pennsylvania, Philadelphia). Proc. Am. Phil. Soc., 107: 427-30(Oct. 15, 1963).

An angle and energy analysis of all the events observed when 10^{10} mesons (π^+) were stopped in Li showed that, with 50% confidence, the decay of a meson (μ) into an electron and a photon is less than 2 parts in 10^8 of normal decay. Apparently some new prohibition is in operation, probably the existence of a mu neutrino and an electron neutrino. (auth)

415

7472 (NP-13451) APPLICATIONS OF DISPERSION RELATIONS TO PION-NUCLEON AND PION-PION PHENOMENA. Lecture Given by J. Hamilton at Universitetets Institut for Teoretisk Fysik and NORDITA Copenhagen. (London. Univ. University Coll. and Nordisk Institut for Teoretisk Atomfysik, Copenhagen). 1963. 174p.

The use of forward and fixed momentum transfer dispersion relations to determine the main parameters of low energy π-N physics from the experimental data to predict low energy π-N phase shifts (primarily in terms of the known π-N resonances) is described. Some general problems that arise in this method are discussed. It is then shown that partial wave π-N dispersion relations can be used to derive information about the low energy π-π interactions, especially the $T = 0$ $J = 0$ π-π interaction. The analysis of s-wave and p-wave π-N scattering in terms of the several interactions that cause the scattering is given. Finally, various topics in the solution of partial wave dispersion relations are considered. The validity of the N/D method and the effect of high energy boundary conditions on N/D solutions are examined. Also, a variational method for the solution of partial wave dispersion relations is developed and applied in a semiphenomenological way to give solutions for the $(3/2, 3/2)$ π-N resonance and the $T = 1$ $J = 1$ π-π resonance (ρ). 68 references. (auth)

416

6521 (SLAC-25(Pt.II)(p.1-30)) INELASTIC ELECTRON-PROTON, POSITRON-PROTON, AND MUON-PROTON SCATTERING. L. Hand and R. Wilson (Cambridge Electron Accelerator, Mass.).

Theoretical and experimental results are reviewed on electron–proton, positron–proton, and muon–proton interactions. (T.F.H.)

417

18531 (CERN-63-3(p.325-37)) THE DETERMINATION OF THE LIFETIME OF THE π^0 MESON. H. Heckman (California. Univ., Berkeley. Lawrence Radiation Lab.).

Measurements and techniques for a nuclear emulsion experiment to determine the meson (π^0) lifetime are discussed. (C.E.S.)

418

3969 (UCRL-10378) DIFFERENTIAL CROSS SECTIONS FOR ELASTIC SCATTERING OF POSITIVE PI MESONS ON PROTONS IN THE ENERGY REGION 500 TO 1600 Mev (Thesis). Jerome A. Helland (California. Univ. Berkeley. Lawrence Radiation Lab.). Aug. 15, 1962. Contract W-7405-eng-48. 91p.

Differential cross sections for the elastic scattering of positive pi mesons on protons were measured at the Berkeley Bevatron at laboratory kinetic energies of the pion between 500 and 1600 Mev. Fifty scintillation counters and a matrix coincidence system were used to detect the recoil proton and the pion, both before the latter reached a liquid-hydrogen target and after scattering. Various corrections were applied to the data, and the results were fitted with a power series in the cosine of the scattering angle in the center-of-mass system. Total elastic cross sections were obtained by integrating under the fitted curves. The coefficients of the cosine series are shown plotted vs the laboratory kinetic energy of the pion. The most striking features of these curves are the large positive value of the coefficient of $\cos^6\theta^*$, and the large negative value of the coefficient of $\cos^4\theta^*$, both of which peaked in the vicinity of the 1350-Mev peak in the total cross section. These results indicate that the most predominant state contributing to the scattering at the 1350-Mev peak has total angular momentum $J = 1/2$, considering that the coefficients for terms above $\cos^6\theta^*$ are negligible at this energy. One possible explanation is that the 1350-Mev peak is the result of an $F_{1/2}$ resonance lying on the same Regge-pole trajectory as the famous (3,3) resonance near 195 Mev. (auth)

419

9304 ANGULAR DISTRIBUTION IN $\pi^{\pm}$-p ELASTIC SCATTERING IN THE RANGE 530 TO 1550 Mev. J. A. Helland, T. J. Devlin, D. E. Hagge, M. J. Longo, B. J. Moyer, and C. D. Wood (Univ. of California, Berkeley). p.3-6 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

Elastic scattering of pions with laboratory kinetic energies of 530, 580, 700, 870, and 990 Mev for π^+ and π^- and 1310 and 1550 Mev for π^+ from a liquid-hydrogen target was measured. The value of the differential cross section was measured simultaneously at 21 different angles ranging from 40° to 170° in the pion center-of-mass scattering angle. From the data total elastic cross sections were obtained. (A.G.W.)

420

24454 ELASTIC SCATTERING OF NEGATIVE PIONS ON PROTONS IN THE ENERGY RANGE 500-1000 Mev. Jerome A. Helland, Calvin D. Wood, Thomas J. Devlin, Donald E. Hagge, Michael J. Longo, Burton J. Moyer, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev., 134: B1079-86(June 8, 1964). (UCRL-10495)

Differential cross sections for the elastic scattering of negative pi mesons on protons ($\pi^- - p \rightarrow \pi^- - p$) were measured at the Berkeley Bevatron at five laboratory kinetic energies of the pion between 500 and 1000 Mev. The results were least squares fitted with a power series in the cosine of the center-of-mass scattering angle, and total elastic cross sections for ($\pi^- - p \rightarrow \pi^- - p$) were obtained by integrating under the fitted curves. The coefficients of the cosine series are shown plotted versus the incident pion laboratory kinetic energy. These curves display as a striking feature a large value of the coefficient of $\cos^5\theta^*$ peaking in the vicinity of the 900-Mev resonance. This implies that a superposition of $F_{5/2}$ and $D_{5/2}$ partial waves is prominent in the scattering at this energy, since the coefficients for terms above $\cos^5\theta^*$ are negligible. One possible explanation is that the $F_{5/2}$ enhancement comes from an elastic resonance in the isotopic spin $T = 1/2$ state, consistent with Regge-pole formalism, and the $D_{5/2}$ partial-wave state may be enhanced by inelastic processes. At 600 Mev, the values of the coefficients do not seem to demand the prominence of any single partial-wave state, although the results are compatible with an enhancement in the $J = 3/2$ amplitude. A table listing quantum numbers plausibly associated with the various peaks and "shoulders" seen in the $\pi^{\pm} - p$ total-cross-section curves is presented. (auth)

421

9267 ANGULAR DISTRIBUTIONS IN $\pi^{\pm}$-p ELASTIC SCATTERING IN THE RANGE 500 TO 1600 Mev. Jerome A. Helland, Thomas J. Dovlin, Donald E. Hagge, Michael J. Longo, Burton J. Moyer, and Calvin D. Wood (Univ. of California, Berkeley). Phys. Rev. Letters, 10: 27-9(Jan. 1, 1963). (UCRL-10478)

Angular distributions, differential cross sections, and total elastic cross sections are measured for the π^--p elastic interaction at incident kinetic energies of 533 to 990 Mev and for the π^+-p elastic interaction at 533 to 1555 Mev. The differential cross sections are least-squares fitted to a power series of the form $a_n\cos^n\theta$, where a_n is a constant, n is an integer ≥ 0, and θ is the cms scattering angle. (T.F.H.)

422

24453 ELASTIC SCATTERING OF POSITIVE PIONS BY PROTONS IN THE ENERGY RANGE 500-1600 Mev. Jerome A. Helland, Thomas J. Devlin, Donald E. Hagge, Michael J. Longo, Burton J. Moyer, and Calvin D. Wood (Univ. of California, Berkeley). Phys. Rev., 134: B1062-78(June 8, 1964). (UCRL-10378(Rev.1))

Differential cross sections for the elastic scattering of positive pi mesons by protons were measured at the Berkeley Bevatron at pion laboratory kinetic energies between 500 and 1600 Mev. Fifty scintillation counters and a matrix coincidence system were used to identify incoming pions and detect the recoil proton and pion companions. Results were fitted with a power series in the cosine of the center-of-mass scattering angle, and total elastic cross sections were obtained by integrating under the fitted curves. The coefficients of the cosine series are displayed, plotted versus the laboratory kinetic energy of the pion. The most striking features of these curves are the large positive value of the coefficient of $\cos^6\theta^*$, and the large negative value of the coefficient of $\cos^4\theta^*$, both of which maximize in the vicinity of the 1350-Mev peak in the total cross section. These results indicate that the most predominant state contributing to the scattering at the 1350-Mev peak has total angular momentum $J = {}^7/_2$, since the coefficients for terms above $\cos^6\theta^*$ are negligible at this energy. One possible explanation is that the 1350-Mev peak is the result of an $F_{7/2}$ resonance lying on the same Regge-pole trajectory as the $({}^5/_2, {}^3/_2)$ resonance near 195 Mev. (auth)

423

22668 (AD-417241) MUON CAPTURE IN CHEMICAL COMPOUNDS (thesis). Roy Eugene Herman (Utah. Univ., Salt Lake City). Aug. 1963. 29p.

The law governing the probability that a muon should come to rest on a particular atom in a chemical compound was investigated using SiO_2 and P_2O_5. The observed O/P and O/Si stopping ratios were in agreement with the stoichiometric ratios of the compounds. (auth)

424

9395 OBSERVATION OF μ^- CAPTURE IN LIQUID HYDROGEN. Roger H. Hildebrand (Argonne National Lab., Ill. and Univ. of Chicago). Phys. Rev. Letters, 8: 34-7 (Jan. 1, 1962).

A 99½% pure muon beam from the Chicago cyclotron is brought to rest in an 8-liter hydrogen bubble chamber. The incoming particles are identified as muons by their residual range versus curvature in the 20-kilogauss field of the chamber. The reaction $\mu^- + p \rightarrow n + \nu$ is identified by the absence of a decay electron and by the appearance of a recoil proton created by the neutron. Pion captures and μ captures in elements of $Z > 1$ are excluded in identification. Nondecaying meson tracks are not associated with recoil protons due to the general background of low-energy neutrons near the meson beam. The energy of a neutron emitted from the end of a meson track must be determined with adequate precision by measuring the range and direction of a recoil proton it is supposed to have caused. (L.N.N.)

425

9390 μ^- CAPTURE IN HYDROGEN. R. H. Hildebrand (Argonne National Lab., Ill. and Univ. of Chicago) and J. H. Doede. p.418-20 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

The rate of the basic μ^- capture process $\mu^- + p \rightarrow n + \nu$ in liquid hydrogen was measured in a hydrogen bubble chamber. The result was $\Lambda = 434 \pm 100\ \text{sec}^{-1}$. An upper limit to the capture rate obtained by identifying capture events simply by the non-decay of the μ's was $\Lambda \leqq 613 \pm 50\ \text{sec}^{-1}$. These results are compared with the "universal" V – A capture theory and the V + A variant of the theory. (A.G.W.)

426

28374 A NOTE ON THE CAPTURE OF NEGATIVE MESONS IN PHOTOGRAPHIC NUCLEAR EMULSIONS. R. D. Hill (University Coll., London). Nuovo cimento (10), 19: Suppl. No. 1, 83-90(1961). (In English)

The slowing down of extremely low energy negatively charged mesons is discussed and range-energy curves are obtained. Based on these curves, an evaluation is made of the relative capture rates of negative mesons in light and heavy nuclei of photographic emulsions. These rates appear to be in very good agreement with experimental observations on the capture of negative μ mesons in nuclear emulsions. (auth)

427

34512 (UCRL-11140) PION-NUCLEON SCATTERING AT 310 Mev: NEUTRON POLARIZATION IN $\pi^- + p \rightarrow \pi^0 + n$ AND PHASE-SHIFT ANALYSIS (thesis). Roger Eugene Hill (California. Univ., Berkeley. Lawrence Radiation Lab.). June 26. 1964. Contract W-7405-eng-48. 104p.

The recoil neutron polarization in π^--p charge-exchanger scattering at an incident pion kinetic energy (lab) of 310 Mev and at a pion center-of-mass scattering angle of 30 deg was measured. The polarization was obtained from measurements of the left-right asymmetries in the scattering of the neutrons from liquid helium at lab scattering angles of 125 and 75 deg. The measured polarization was $+0.24 \pm 0.07$, where the + sign indicates a direction parallel to $\vec{k}_{in} \times \vec{k}_{out}$. This is opposite in sign to the prediction of the only SPD phase-shift solution and of the "best" of the three SPDF phase-shift solutions arrived at by partial-wave analyses of all the previously available data at or near 310 Mev. The extension of the phase-shift analyses to include this new datum has yielded no SPD solution and only two likely SPDF solutions. Both these solutions have

positive $S_{1,1}$ and $P_{1,1}$ phase shifts, and both are of the Fermi type in the I = 3/2 set, though one of them (A) has $(D_{3,3} - D_{3,5}) > 0$, while the other solution (B) has $(D_{3,3} - D_{3,5}) < 0$. The errors on the individual phase shifts range between 0.3 and 1.5 degrees. The π^--p polarization data show a preference for solution A. Partial-wave amplitude dispersion relation calculations are in poor agreement with both A and B, though forward dispersion relation calculations for the real part of the forward non-spin-flip amplitudes show a preference for, and are in excellent agreement with, solution A. (auth)

428

6884
THE $\pi^- - \pi^0$ MASS DIFFERENCE. P. Hillman, W. C. Middelkoop, T. Yamagata, and E. Zavattini (European Council for Nuclear Research, Geneva). Nuovo cimento (10) 14, 887-94(1959) Nov. 16. (In English)

The time of flight of the neutron resulting from the reaction $\pi^- + p \rightarrow \pi^0 + n$ at rest was measured. From this a value for the $\pi^- - \pi^0$ mass difference of (9.01 ± 0.08) electron masses was obtained. (auth)

429

26352 POSSIBLE RESONANCE AT 829 Mev IN ΛK^0 PRODUCTION. G. T. Hoff (Univ. of Chicago). Phys. Rev. Letters, 12: 652-6(June 8, 1964).

Resonance effects in the interaction $\pi^- + p \rightarrow \Lambda + K^0$ at an incident pion energy of 829 Mev are studied. It is hypothesized that a ΛK resonance exists, with a cms energy of 1650 Mev and a spin-parity of $5/2^+$. A preliminary attempt is made to identify this resonance with the F_{5} resonance in pion-nucleon interactions. The resonance in question dies off rapidly both below and above 829 Mev pion energy. (T.F.H.)

430

3936
THE MULTIPLE SCATTERING OF PARTICLES OF OPPOSITE CHARGE. I. S. Hughes and D. Sinclair (Univ. of Glasgow). Phil. Mag. (8) 4, 1013-16(1959) Sept.

Earlier investigations by a number of workers revealed an apparent difference in the multiple scattering of positively and negatively charged particles which is much greater than that predicted by theory. Experiments were carried out in which the existence of such a difference was investigated for the multiple scattering of positive and negative μ mesons, π mesons, and electrons in nuclear emulsions. No significant difference was found. (auth)

431

2483 MUON RESONANCE. Vernon W. Hughes (Yale Univ., New Haven). p.382-96 of "Paramagnetic Resonance. Vol. I." New York, Academic Press, 1963.

The availability of polarized muons and the ability to detect the spin direction, which are provided by parity nonconservation in the decays of the pi meson and the muon, have made possible magnetic resonance experiments on the muon, on muonium, and on mu-mesic atoms. The study of muon magnetism has advanced our knowledge of the properties of the muon, of relativistic and other higher order effects in atomic magnetism including solid state effects, and of nuclear structure. (auth)

432

17019 ANGULAR DISTRIBUTION OF MUONS IN π-μ DECAY AT REST. H. Hulubei, J. S. Auslaender, E. M. Friedlaender, and Ş. Ţiţeica (Inst. of Atomic Physics, Bucharest). Phys. Rev., 129: 2789-2801(Mar. 15, 1963).

Evidence for a significant departure from isotropy of the muon angular distribution from π-μ decay at rest is presented, based on measurements of projected angles in two emulsion stacks, exposed to the Dubna and CERN synchrocyclotrons. Extensive control experiments concerning observational bias, distortion, and inhomogeneous detection efficiencies prove that the observed lack of isotropy cannot be reduced to such spurious effects. (auth)

433

26799 (NP-10301(p.130-44)) ON ANGULAR CORRELATIONS IN $\pi - \mu - e$ DECAY. H. Hulubei, J. Ausländer, S. Ţiţeica, and E. Friedländer [Academia R.P.R. Institutul de Fizca Atomica, Bucharest].

Angular correlations in the decay chain $\pi - \mu - e$ are studied in emulsion, using area and track scanning techniques. The π mesons have an initial energy of ~300 Mev. About 13,800 events are followed. (T.F.H.)

434

37584 PHASE-SHIFT ANALYSIS OF ELASTIC PION-NUCLEON SCATTERING. Hull, M. H. Jr.; Lin, F. C. (Yale Univ., New Haven). Phys. Rev., 139: B630-45(Aug. 9, 1965). (YALE-1807-24)

A many-energy analysis of π-N scattering data in the energy range from 20 to 340 Mev was carried out by fitting phase shifts in S, P, D, and F states in gradient searches. Semiphenomenological analyses, with F-wave phase shifts calculated from approximate evaluations of pion-nucleon dispersion relations and D-wave phase shifts similarly obtained for the lower energy range, were equally successful in fitting the data. Particular attention was paid to the possibility of obtaining a unique set from all possible sets allowed by data. Several sets of phase shifts have been found. One of these is preferred by data and by comparison with dispersion-theoretical calculations. Comparisons with other recent analyses are made. (auth)

435

37593 ISOTROPIC AND NONISOTROPIC π-μ DECAYS.

Hulubei, H. (Inst. of Atomic Physics, Bucharest); Friedlaender, E. M.; Nitu, R.; Visky, T.; Anghelescu, D.; Auslaender, J. S. Phys. Rev., 139: B729-32(Aug. 9 1965).

Nuclear emulsion experiments on π-μ decay at rest are described, and the muon angular distribution is compared with that obtained in previous experiments under radically different conditions. In the present experiment the pions were produced in a magnetic field of 10^4 gauss, the angle of emission was 180°, the kinetic energy was ~50 Mev and no filter was interposed between target and stack (flight path 765 cm), whereas in the previous experiment there was no field, the emission angle was 0°, the kinetic energy was ~300 Mev, and the beam traversed 685 cm, of which 17 cm were of Cu. The muon angular distribution in this experiment is isotropic and significantly different from that of the previous one. Thus, pion history seems to have an essential influence on the properties of part of the decaying particles. (auth)

436

9591 NEGATIVE MUON POLARIZATION IN PHOSPHORUS AND FLUORINE. D. P. Hutchison (Columbia Univ., New York), J. Menes, and G. Shapiro. Phys. Rev. Letters, 9: 516-18(Dec. 15, 1962).

The polarization of negative muons stopped in two substances of nuclear spin $\frac{1}{2}$(P^{31} and F^{19}) was measured by precessing the negative muon spins in a high field (2kG) and looking for oscillations in the time distribution of decay electrons emitted in a fixed laboratory direction. A test run was made using a sulfur target, and the decay-electron time distribution is shown. The frequency spectra of electron time distributions is shown for sulfur, red phosphorus, and lithium fluoride. The phosphorus showed no polarization. The lithium fluoride spectra shows an expected precession peak at 10 Mc/sec and an unexpected peak at 20 Mc/sec. (H.D.R.)

437

31341 MAGNETIC MOMENT OF NEGATIVE MUONS. D. P. Hutchinson (Columbia Univ., New York), J. Menes, G. Shapiro, and A. M. Patlach. Phys. Rev., 131: 1362-7 (Aug. 1, 1963).

The magnetic moment of negative muons bound in atoms of carbon, oxygen (in water), magnesium (metallic and in MgH_2), silicon, and sulfur has been measured with a precision ranging from 3×10^{-5} in carbon to 1.6×10^{-4} in sulfur. The measured moment is corrected for relativistic effects, diamagnetism, and nuclear polarization before being compared to the moment of the positive muon. The two moments are found to be equal to 3×10^{-4}, where the major uncertainty is due to Knight shift. The relativistic, diamagnetic, nuclear, and solid-state shifts are large enough compared to the statistical and systematic errors to make this technique usable for the investigation of these effects. (auth)

438

31340 MAGNETIC MOMENT OF THE POSITIVE MUON. David P. Hutchinson (Columbia Univ., New York), Jack Menes, G. Shapiro, and A. M. Patlach. Phys. Rev., 131: 1351-62(Aug. 1, 1963).

The magnetic moment of the positive muon has been redetermined in terms of proton moments using a precession technique. The sensitivity achieved yields an error of 13 parts per million. The muons are stopped in various targets in a homogeneous magnetic field. The anisotropic distribution of the decay electrons relative to the muon spin direction permits the measurement of the spin precession frequency. The proton spin resonance is measured in the same field, yielding $f_\mu/f_p = 3.18338 \pm 0.00004$. This result may be combined with that of other experiments, the muon g factor, and the ratio of electron cyclotron frequency to proton resonance, f_e/f_p, to obtain a more precise evaluation of the muon mass in terms of electron masses, m_μ/m_e equals 206.765 ± 0.005. (auth)

439

5576 (JINR-D-570) DEPOLARIZATION PROCESSES OF NEGATIVE MUONS. A. E. Ignatenko (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1960. 18p.

On the basis of measurements of the asymmetry of (μ-e)-decay electrons the depolarization processes of negative muons in different matters were studied with scintillation counters. It was found that most essential muon depolarization takes place after their slowing down in mesic atom production. It is shown that reasons causing muon depolarization in a mesic atom are the following: (a) spin-orbital interaction leading to the fine structure of energy levels, (b) interaction of muon and nuclear magnetic moments responsible for mesic atom hyperfine structure, (c) muon interaction with quadrupole nuclear distortion, and (d) interaction of muon magnetic moment with the magnetic field of the electron shell. The principal peculiarities of each depolarization process are described. (auth)

440

25382 (JINR-D-701) SPIN DEPENDENCE OF WEAK INTERACTION IN THE PROCESS $\mu^- + p \rightarrow n + \nu$. A. E. Ignatenko, A. B. Kuptsov, Suang-ming Li, M. G. Petrasku, L. B. Yegorov, and G. V. Zhuravlev (Joint Inst. for Nuclear Reaearch, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1961. 14p.

Using the scintillation counter method, measurements were made of the values, average with respect to two states of hyperfine structure, of the $\bar{a}_0$ assymetry coefficients of ($\mu \rightarrow$ e)-decay electrons in mesic atoms of silver and red and black phosphorus. The lifetimes τ of mesons in these modifications of phosphorus were also determined. The quantities of $\bar{a}_0$ for red and black phosphorus indicated that the time of the relaxation of meson spins in mesic atoms decreases owing to the presence of conductivity electrons. On the basis of $\bar{a}_0$ and τ, the n, and n_0 level populations in the states F = 1 and F = 0 in phosphorus as well as the λ_1 and λ_0 probabilities of the capture of mesons by the nucleus in these states were calculated. The values found indicated that $\lambda_0 > \lambda_1$. (auth)

441

13467 AN APPLICATION OF THE QUASIPOTENTIAL METHOD TO PION NUCLEON SCATTERING. Isaev, P. S.; Smith, J. (Joint Inst. for Nuclear Research, Dubna USSR). Acta Phys. Acad. Sci. Hung., 19: 259-62(1965).

The quasipotential method developed in Dubna Laboratory was applied to pion-nucleon scattering processes up to the energies 500 Mev, for obtaining the resonance behavior of the P_{33}-phase shift. Although numerical calculations are not completed, the existence of a resonance seems very probable. (auth)

442

7024 THE EFFECT OF $\pi\pi$-INTERACTION ON s- AND p-WAVES OF πN-SCATTERING. P. S. Isaev and V. A. Meshcheryakov (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 43: 1339-48 (Oct. 1962). (In Russian)

On the basis of the Mandelstam picture, account is taken of the effect of $\pi\pi$ interaction in s and p waves of πN scattering. Transition to partial waves is effected by means of combining dispersion relations for forward and backward scattering. The equations for s^- and p^- waves are compared with experimental data on the phases of πN scattering. Satisfactory agreement is obtained up to incident π-meson energies ~500 Mev in the laboratory coordinate system. It is shown that $\pi\pi$ interaction significantly affects the energy dependence of the s^- and p^- phase even at low energies, and up to ~400 Mev (in the laboratory system) produces but a slight effect on the behavior of the $p^-_{\frac{1}{2}}$ phase. (auth)

443

37975 PARTIAL πN SCATTERING WAVES WITH ACCOUNT OF $\pi\pi$ INTERACTION. P. S. Isayev, V. I. Lendel, V. A. Meshcheryakov (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 45: No. 2, 294-302(Aug. 1963). (In Russian)

The effect of π-π interaction in the T = J = 0 state on the partial π-N scattering waves is investigated by the dispersion relations technique. In the final expressions a transition is made to the static limit which is then compared with the experimental data. The most probable form of the π-π scattering phase shift δ_0^0 is discussed. Relations connecting the interaction contributions to the s and p scattering waves are derived. A number of investigations on π-N scattering are analyzed on the basis of these relations. The consequences of the relations for the static limit are considered. (auth)

444

4955 PHASE SHIFT ANALYSIS OF THE π^+p ELASTIC SCATTERING AT 240 Mev. I. M. Ivanchenko (Joint Inst. for Nuclear Research, Dubna, U.S.S.R.) and V. A. Schegelskii. Phys. Letters, 13: 174(Nov. 15, 1964).

Data on elastic π^+-p scattering at 240 Mev were analyzed under the assumptions that S, P, and D waves are involved or that only S and P waves are involved. The best fit was provided by an SPD solution. (D.C.W.)

445

15388 PHASE-SHIFT ANALYSIS OF ELASTIC πN SCATTERING AT 240 Mev. Ivanchenko, I. M.; Shchegelskii, V. A. (Ioffe Inst. of Physics and Tech., Leningrad). Yadern. Fiz., 3: 108-11(Jan. 1966). (In Russian).

The phase-shift analysis of $\pi \pm$ p-scattering at 240 Mev was performed, taking the data on recoil proton polarization in π^+ + p-scattering into account. The absence of experiments on the polarization in π^- p-scattering makes it impossible to obtain a unique set of phase-shifts. A comparison with analyses at other energies indicates that the most probable solution is that with the following nuclear phase-shifts (in degrees): $S_{31} = -15.7 \pm 1.3$; $P_{33} = 112.6 \pm 0.5$; $P_{31} = -3.4 \pm 2.3$; $D_{35} = -2.6 \pm 1.1$; $D_{33} = 2.1 \pm 1.3$; $S_{11} = 6.0 \pm 5.9$; $P_{13} = 0.16 \pm 2.4$; $P_{11} = 19.0 \pm 3.1$. The accuracy of the experiment is not sufficient to determine the D-phase-shift with the isospin $I = \frac{1}{2}$. (auth)

446

9757 INVESTIGATION OF μ^+-MESON DEPOLARIZATION IN A NUCLEAR EMULSION. Yu. M. Ivanov and A. I. Fesenko (Moscow Inst. of Engineering Physics). Zhur. Eksptl'. i Teoret. Fiz., 39: 1492-6(Dec. 1960). (In Russian)

The influence of the relative content of AgBr in a nuclear emulsion on the magnitude of the asymmetry coefficient for $\mu^+ - e^+$-decay was studied experimentally. Separate values were obtained for the μ^+ meson depolarization AgBr and the gelatin. (auth)

447

31046 DEPOLARIZATION OF THE μ-MESON IN AN ELECTRIC FIELD. Yu. M. Ivanov, B. A. Nikol'skii, B. N. Smirnov, and L. V. Surkova. Zhur. Eksptl'. i Teoret. Fiz., 43: 337-9(July 1962). (In Russian)

Additional depolarization of a μ^+ meson (from a $\pi^+ \rightarrow \mu^+$ decay) was observed in the presence of an electric field with a tension $E \sim 10^5$ V/cm. Hence, it was concluded that the μ^+ meson is captured by a gelatin molecule, since theoretical calculations show that a field of 10^5 V/cm cannot depolarize a μ-meson in the free state or in the state of a muon (the system μ^+e^-). The experiment was carried out by synchronizing the pulses of 85 Mev π^+ mesons with electrical impulses having an amplitude U = 5 kv, which were fed to plane electrodes between which a photoemulsion 200 to 400 μ thick was placed. The electrical field in the emulsion was 1.2 to 2.5×10^5 V/cm. All $\pi \rightarrow \mu \rightarrow$ e disintegrations in the emulsion took place in this strong electric field (the variation in electric field did not exceed 10%). Control experiments were also run in the absence of an electric field in order to exclude the effect of the external magnetic field on the depolarization of the μ-meson. The values of the asymmetry coefficient $\underline{a}$, which determines the angular distribution of electrons in a $\pi \rightarrow \mu \rightarrow$ e-disintegration in the equation $dN/d\theta \sim 1 - a \cos \theta$ were

found to be 0.14 with no electric field, 0.08 with an electric field of 1.2×10^5 V/cm, and 0.06 with an electric field of 2.4×10^5 V/cm. This effect can be qualitatively explained, if it is assumed that the μ-meson is captured by a gelatin molecule. (TTT)

448

3061

CROSS SECTIONS OF ELASTIC SCATTERING OF 195-Mev π^+ MESONS BY CARBON AND LITHIUM NUCLEI. V. G. Ivanov, V. T. Osipenkov, N. I. Petrov, and V. A. Rusakov (Joint Inst. of Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz. 37, 863-6(1959) Sept. (In Russian)

Some 410 events of elastic scattering were observed in carbon nuclei and 243 in lithium nuclei. Total cross sections of inelastic interactions were normalized with geometric cross section of nuclei with $R = 1.4\ A^{1/3} \times 10^{-13}$ cm. Correlations of data on carbon nuclei show that cross sections for positive and negative π meson elastic scattering at 195 and 230 Mev are equal within the limits of experimental error. The angular distribution of elastic scattering on carbon and lithium nuclei is plotted. (R.V.J.)

449

12253

PRODUCTION OF MULTI-CHARGED PARTICLES ON PHOTOGRAPHIC EMULSION NUCLEI BY 280 Mev π^+ MESONS. N. S. Ivanova, V. I. Ostroumov, and Yu. V. Pavlov (Radium Inst., Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz. 37, 1604-12(1959) Dec. (In Russian)

The production of fragments in nuclear disintegrations induced by 280 Mev π^+ mesons is studied by aid of photographic emulsions. The angular, charge, and energy distributions of the emitted fragments are measured. An analysis of the experimental data and comparison with the results of theoretical calculations show that in the case under consideration the particles responsible for formation of the fragments are protons produced in the absorption of π^+ mesons by quasi-deuteron pairs and also recoil nucleons produced in scattering of π mesons on separate nucleons of the nucleus. Some suggestions regarding the mechanism of formation of such fragments are made on the basis of an analysis of the energy spectra of fragments produced by particles of various energy. (auth)

450

29652 (NP-11950(Vol.I)(p.261-74)) ANALYSIS OF PION-NUCLEON INTERACTION FROM 500 TO 1500 Mev. Maurice Jacob (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay).

Data obtained on pion-nucleon interactions at 400 to 1500 Mev are discussed. Other experimental data needed are described. Photoproduction, π^--p scattering, and pion production are discussed. (M.C.G.)

451

18330 BRANCHING RATIO BETWEEN THE VARIOUS DECAY MODES OF THE Mu MESON. Alix Jacquemin and Paul Kessler (Collège de France, Paris). J. phys. radium, 22: 824-6(Dec. 1961). (In French)

Using the method of quasi-real processes, the branching ratios between the three observed decay modes of the mu meson were calculated: $\mu \rightarrow e + \nu + \bar{\nu}$, $\mu \rightarrow e + \nu + \bar{\nu} + \gamma$, and $\mu \rightarrow e + \nu + \bar{\nu} + e^- + e^+$. These branching ratios are functions of the threshold energy of the emitted photon or the pair created. The results are in rough agreement with the recent experimental measurements of Crittenden, Walker, and Ballam. (auth)

452

12290 WEAK INTERACTIONS. J. D. Jackson (Univ. of Illinois, Urbana). p.263-425 of "Elementary Particle Physics and Field Theory. Vol. 1." New York, W. A. Benjamin, Inc., 1963.

A survey of the theory of beta decay, meson (μ) decay and capture, meson (π) decay, and strange particle decays is presented, with consideration of the associated experimental observations. 280 references. (D.C.W.)

453

6194 ON RADIATIVE μ-CAPTURE IN NUCLEI. F. Janouch and M. Vinduska (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., 13: 710-15(1963). (In Russian)

The radiative μ-capture from the K-orbit of complex nuclei is investigated for an allowed transition. The probability and circular polarization degree are calculated. (auth)

454

27159 (LA-3126) PION-NUCLEON ELASTIC SCATTERING EXPERIMENTS WITH HIGH INTENSITY MESON BEAMS. Nelson Jarmie (Los Alamos Scientific Lab., Univ. of California, N. Mex.). Aug. 1964. Contract W-7405-eng-36. 29p. Dep.; $2.00(cy), 1(mn) CFSTI.

Pion-nucleon elastic scattering experiments that should be useful to do with a high-current proton linear accelerator ("Meson Factory") are studied in detail. Counting rate calculations are made for experiments to measure the pion-proton differential cross section, polarization, and rotation parameters at 300-Mev pion energy. Errors, backgrounds, duty cycles, corrections, and costs are studied in detail. An experiment to measure the pion-neutron interaction is briefly investigated. The results are compared with present research programs and indicate that experiments in elastic pion-nucleon scattering can be done with a high-intensity meson beam cleanly, quickly, economically, and with greatly improved precision. The small size of the beam of the high-intensity source combines with the high intensity to produce notable advantages. The contribution to the phenomenological understanding of the pion-nucleon interaction should be significant. (auth)

455

38176 INVESTIGATION OF CORRELATIONS IN LIGHT NUCLEI BY MEANS OF FAST PION NUCLEAR INTERACTIONS. M. Jean (Faculté des Sciences, Orsay, France). p.46-50 of "Direct Interactions and Nuclear Reaction Mechanisms." New York, Gordon and Breach, Science Publishers, 1963.

Reactions of the type (π^-,np), $(\pi^-,2n)$, $(\pi^+,2p)$, and (π^+,np) that give direct information on two-nucleon correlations are discussed. The $Li^6(\pi^+,2p)He^4$ reaction is used as an illustrative example. (C.E.S.)

456

45339 NUCLEAR STRUCTURE INVESTIGATION BY MEANS OF PION-NUCLEUS INTERACTION. Jean, M. (Universite de Paris, Orsay, France). Nuovo Cimento (1), 2: Suppl., 400-14(1964).

The information that can be learned from nuclear interactions with pions is sketched briefly. The discussion is limited to a consideration of energies less than 200 Mev. The absorption and then the scattering of pions by nuclei are considered. (J.S.R.)

457

47707 MUON CAPTURE IN OXYGEN (thesis). Jenkins, David Albert. Berkeley, Calif., Univ. of California, 1964. 72p.

The muon-capture rate in oxygen, $\mu^- + {}^{16}O - {}^{16*}N + \nu$, is used as a means for measuring the induced-pseudoscalar-coupling constant (C_P) of weak interactions. The capture rates between the $J^P = 0^+$ state of ^{16}O and the 0^- and 1^- states of ^{16}N are measured by the stopping of muons in water where some of these muons are captured by ^{16}O and form excited states of ^{16}N. Capture into the excited states of ^{16}N is identified by counting the gamma rays that are emitted in the nuclear transition to the ground state. A rate of $(1.6 \pm 0.2) \times 10^3$ sec^{-1} for the capture rate into the 0^- state was obtained and used to calculate C_P with different nuclear models for the ^{16}O wave functions. The transition rate, and therefore C_P, depends strongly on the nuclear model. It is concluded that $5 < C_P/C_A < 20$. (Dissertation Abstr.)

458

34851 ABSORPTION OF π^- MESONS AND THE CORRELATION OF NUCLEONS IN LIGHT NUCLEI. R. I. Jibuti and T. I. Kopaleishvili (Tbilisi State Univ., Georgian, USSR). Nucl. Phys., 55: 337-49(June 1964).

The absorption of stopped π^- mesons by light nuclei with the emission of two nucleons (detected by coincidence) is investigated in terms of the direct absorption of a meson by correlated pairs of nucleons. A study is made of the effect of the Pauli principle and interaction between the emitted nucleons in the final state, and pairing correlation of nucleons in a nucleus on the distribution of the emitted nucleons over their relative energies. The question of how the shell or cluster structure of a nucleus may show up in this distribution function is also discussed. The comparison of the theoretical value of the probability ratio $dW(\pi^- + np \rightarrow nn)/dW(\pi^- + pp \rightarrow np)$ with its experimental value for the ^{12}C nucleus warrants the conclusion that the proton-proton correlation in a nucleus must be weaker than the neutron-proton correlation. (auth)

459

41823 TRANSITION PATHS OF μ^- MESONS CAPTURED IN SOLID LITHIUM (thesis). Johnson, Coates Richard. Berkeley, Calif., Univ. of California, 1963. 105p.

An investigation was made on the cascade down to the ground state of meson (μ^-) captured by an atom of solid lithium. The cascade takes place predominately through three processes. These are radiation transitions, Auger transitions involving the K-shell electrons of the mesonic atom, and Auger transitions involving the band electrons of the solid. It is assumed that the meson is captured in a state of high principal quantum number ($n \sim 15$). It is found, independent of the number of K-shell electrons remaining in the mesonic atom that the principal decay paths follow, at least approximately, and if the meson is captured in a high l state, the route $\Delta n = \Delta l = -1$. For mesons captured in low l states there is a tendency for the main paths to pass through states of higher l than that given by $\Delta n = -1$, $\Delta l = -1$. Because of the presence of Auger transitions where $\Delta n = -1$, $\Delta l = 0$ and where $\Delta n = 0$, $\Delta l = -1$, the cascades contain a rather large dispersion away from the main paths and towards both large and small l. Reasons are given for expecting the same qualitative description of mesonic cascades to hold also for mesons (π^-) captured in lithium, and for both mesons (μ^-) and (π^-) captured in other light solids ($Z < 6$). (Dissertation Abstr.)

459a

1025 (UCRL-10965) TRANSITION PATHS OF μ^- MESONS CAPTURED IN SOLID LITHIUM. Coates R. Johnson (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1963. Contract W-7405-eng-48. 105p.

The cascade to the ground state of a μ^- meson captured by an atom of solid lithium is investigated. The cascade takes place predominately through three processes. These are radiation transitions, Auger transitions involving the K shell electrons of the mesonic atom, and Auger transitions involving the band electrons of the solid. It is assumed that the meson is captured in a state of high principal quantum number ($n \sim 15$). It is found, independent of the number of K shell electrons remaining in the mesonic atom, that the principal decay paths follow, at least approximately, and if the meson is captured in a high l state, the route $\Delta n = \Delta l = -1$. For mesons captured in low l states there is a tendency for the main paths to pass through states of higher l than that given by $\Delta n = -1$, $\Delta l = -1$. Because of the presence of Auger transitions where $\Delta n = -1$, $\Delta l = 0$ and where $\Delta n = 0$, $\Delta l = -1$, the cascades contain a rather large dispersion away from the main paths and towards both large and small l. Reasons are given for expecting the same qualitative description of mesonic cascades to hold also for π^- mesons captured in lithium, and for both μ^- and π^- mesons captured in other light solids ($Z < 6$). (auth)

460

20065 (TID-12762) THE SPIN OF THE MU-MESON. P. K. Kabir (Carnegie Inst. of Tech., Pittsburgh). 1961. 4p.

An extension is given of the Hughes study [Phys. Rev. Letters 5 63(1960)] of the formation and observation of muonium through its Larmor precession, which shows that the experiment provides a measurement of a spin of 1/2 for the μ^+ – mesons. (B.O.G.)

461

35509 CALCULATION MUON PENETRATION THROUGH SUBSTANCES TAKING INTO ACCOUNT FLUCTUATION LOSSES. Kalitkin, N. N.; Kuzmina, L. V.; Zatsepin, G. T. p.217-18 of International Conference on Cosmic Rays. Vol, 6. Bombay, Tata Institute of Fundamental Research, 1964.

The interaction constants of a meson (μ) with a substance can be determined by experiments on penetration of mesons (μ) through large thicknesses of substance. With a mathematically exact account of the fluctuation character of radiation and photonuclear losses of energy an accurate calculation of the meson (μ) passage can be made. In this calculation values are selected for agreement with experiment and the role of each type of loss is not separated. (J.F.P.)

462

37943 RADIATIVE CORRECTIONS TO $\pi \rightarrow \mu$ (OR e) + ν WITH FINITE NEUTRINO MASS. A. N. Kamal (Univ. of Alberta, Edmonton, Can.). Nuovo Cimento (10), 33: 1108-18 (Aug. 16, 1964).

The radiative corrections to the decay $\pi \rightarrow$ lepton + ν were calculated to order e^2 in the coupling constant and to order m_ν^2 in the neutrino mass. The possibility of setting upper limits on the neutrino mass by measuring the photon spectrum in the radiative decay of pion is investigated. The effect of the neutrino mass on the branching ratio $(\pi \rightarrow e)/(\pi \rightarrow \mu)$ is found to be small enough to elude experimental detection with the present experimental accuracies. (auth)

463

35454 THE ENERGY SPECTRUM OF PROTONS DISCOVERED IN STARS PRODUCED BY PI-MESONS IN EMULSIONS. Kane, G. (Manhattan Coll., New York); O'Friel, Z. Nuovo Cimento (10), 38: 680-3(July 1, 1965).

An analysis of stars produced in a stack of nuclear emulsions by stopped mesons (π^-) is presented. A statistical analysis is made of the measured star prongs using an evaporation model including the contribution made by the evaporation of protons, deuterons, tritons, and alpha particles from heavy nuclei. In analyzing the data, contributions of all particles except protons were subtracted out. (J.F.P.)

464

31366 MODIFIED PHASE SHIFT ANALYSIS OF PION-NUCLEON SCATTERING DATA. G. L. Kane and T. D. Spearman (Univ. of Illinois, Urbana). Phys. Rev. Letters, 10: 45-8(July 1, 1963).

A method is presented for analyzing π-N scattering data using phase shifts for the low partial waves and a closed term to represent the effect of all higher partial waves. The closed term is calculated on the basis of the analytic properties of the scattering amplitude in the complex cos θ plane. The method is applied to π^+-p angular distribution and polarization data at 310 Mev and removes ambiguous results obtained in a conventional phase shift analysis when f-wave phase shifts were included. Values for the T = $\frac{3}{2}$ π-N phase shifts at 310 Mev are obtained. (auth)

465

25469 (CAR-882-9) STUDY OF THE DEPOLARIZATION OF NEGATIVE MUONS IN LIQUID HELIUM. John Kane (Carnegie Inst. of Tech., Pittsburgh, Pa. Dept. of Physics). May 1964. Contract AT(30-1)-882. 79p. Dep. (mn); $3.00(cy), 2(mn) CFSTI.

The ground state polarization was determined for μ^--mesons stopping in nuclear spin zero targets of liquid helium, liquid argon, and carbon. A precessional technique was employed, allowing (μ – e) decay anisotropy to be observed in terms of the sinusoidally modulated decay distribution $N_0 e^{-\lambda T t} [1 + A \cos(\omega t - \bar{\varphi})] + B_0$. An analysis of the data over one or more precession cycles was made by means of a least-squares procedure, with the results being corrected for the finite geometry used. In contrast to carbon, which under different conditions yielded asymmetry coefficients of a = –0.052 ± 0.004 and a = –0.040 ± 0.010, both helium and argon demonstrated asymmetry values consistent with total depolarization. This indicates a deviation from the pattern of large asymmetry established in a number of other spin-zero nuclei. (auth)

466

4892 (JINR-P-1785) NUKLON-NUKLONNOE I PION-NUKLONNOE VZAIMODEISTVIYA V OBLASTI ENERGII DO 1 Gev. (Nucleon-Nucleon Interaction Below 1 Gev). Yu. M. Kazarinov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R.). 1964. 42p. (CONF-550-67). Dep.(mn).

From the International Conference on High-Energy Physics, Dubna, USSR, Aug. 1964.

A review is given of available data on processes in N-N and π-N interactions. Diagrams of the energy dependence of phase shifts in N-N scattering, parameter measurements in p-p scattering at 430 Mev with predictions for phase analysis, energy dependence of cross sections for π-meson production in p-p interactions, and energy dependence of the coefficient b in π-meson angular distribution $\cos^2 \vartheta$ were plotted, as well as cross section energy dependence for π-meson production in n-p interactions. Data on π-p scattering and correlations of Roper and Loveless phase analysis were also plotted. (R.V.J.)

467

13667 (NYO-9281) ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 226 MEV (thesis). Simon Kellman (Carnegie Inst. of Tech., Pittsburgh). Dec. 1960. Contract AT(30-1)-882. 101p.

The total and differential elastic cross sections of 226-Mev π^- scattered by protons were measured. For detection of elastically scattered π^- only, the proton recoiling from the π-p collision was detected in coincidence with the associated scattered meson. Pulse height analysis of the Cherenkov radiation produced by the scattered beam was used to differentiate between π^- and electrons in the scattered particles. A total cross section of 52.9 ± 1.4 mb was measured. Analysis of the differential cross section data gave $d\sigma/d\Omega = (1.000 \pm 0.012)\ [(0.66 \pm 0.02) + (0.41 \pm 0.05) \cos\theta + (2.16 \pm 0.08) \cos^2\theta]$, which supports the hypothesis that only S and P waves contribute appreciably to the scattering. Integration gave a total elastic cross section of 17.4 ± 0.3 mb, in agreement with other recent measurements. The absolute value of the real part of the forward scattering amplitude was determined to be −0.129, which agrees with that calculated with pion dispersion relations. (auth)

468

6977 ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 152 AND 226 Mev. S. Kellman, W. P. Kovacik, and T. A. Romanowski (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 129: 365-74(Jan. 1, 1963).

The differential elastic and total cross sections for the scattering of 152- and 226-Mev negative pions by protons have been measured with a liquid hydrogen target and scintillation counters. Analyses of the incident pion beams with a Cherenkov counter yielded higher electron contents than those deduced from range curves. Elastically scattered pions were distinguished from electrons among the scattered particles by use of a Cherenkov counter, or by demanding a coincidence between the scattered pion and recoil proton. The total cross sections measured were 63.7 ± 2.0 and 52.9 ± 1.4 mb at 152 and 226 Mev, respectively. With the present uncertainties, the real parts of the forward scattering amplitudes agree with the predictions of pion dispersion relations. (auth)

469

20382

VELOCITY DEPENDENCE OF THE BUBBLE DENSITY FOR CHARGED PARTICLE TRACKS IN LIQUID HYDROGEN. V. P. Kenney (Brookhaven National Lab., Upton, N. Y. and Univ. of Kentucky, Lexington). Phys. Rev. 119, 432-5(1960) July 1.

Bubble densities of tracks of 635-Mev/c protons and pions in a liquid hydrogen bubble chamber operated at 26.5°K, 62 psig were determined from measurements of the distribution in spacing of the individual bubbles. The velocity dependence of the bubble density was obtained by fitting the bubble densities observed to the expression $m = A/\beta^b$ by the least-squares method, yielding the values A = 8.64 bubbles/cm, and exponent b = 1.935 ± 0.077. The constant A is a function of the temperature of the liquid hydrogen, varying ~30% per 0.1°K. If the number of bubbles per unit track length observed is correlated with the rate of delta-ray formation, it would appear that an energy of the order of 400 ev is necessary for bubble nucleation in liquid hydrogen. (auth)

470

6954 MULTIPLE PION PRODUCTION BY PIONS AND THE ISOBAR MODEL. V. P. Kenney, J. G. Dardis, and G. Brunhart (Univ. of Kentucky, Lexington). Phys. Rev., 124: 1568-74(Dec. 1, 1961).

Multiple pion production by pions in hydrogen was studied in the interaction $\pi^- + p \rightarrow p + \pi^- + \pi^+ + \pi^-$ at 810, 970, and 1100 Mev. Total cross sections were measured as 0.26 ± 0.14 mb at 810, 0.32 ± 0.21 mb at 970, and 0.54 ± 0.32 mb at 1100 Mev. The kinematics of this pion production reaction at these energies appear to be reasonably well described by phase space dependence, but provide some support for an "isobar cascade" scheme in which the $T = \frac{1}{2}$ "second resonance" is excited and decays to the $T = J = \frac{3}{2}$ isobar, which decays in turn to a final state consisting of a nucleon, a recoil pion, and two decay pions. (auth)

471

14959 RESONANCE-LIKE EFFECTS IN PION-NUCLEON INTERACTIONS BELOW 1 Bev. V. P. Kenney and C. N. Vittitoe (Univ. of Kentucky, Lexington). p.246-58 of "Proceedings of the Athens Topical Conference on Recently Discovered Resonant Particles." Athens, Ohio, Ohio University, 1963.

Resonance-like effects that occur in pion-nucleon interactions from the pion production threshold up to the region where p-production is expected to dominate are discussed. Peaking in the total cross section, the pion-nucleon 3,3 state considered as a quasi-bound state or isobar, the nonresonant π-π interaction, and two-pion states are considered. (C.E.S.)

472

22325

CHARGE-EXCHANGE SCATTERING OF NEGATIVE PIONS AT 150 Mev. W. J. Kernan (Univ. of Chicago). Phys. Rev. 119, 1092-6(1960) Aug. 1.

The charge-exchange scattering of π^- by hydrogen was measured at a bombarding energy of 150 Mev. The energy distribution of gamma rays from the decay of π^0 was measured with a lead glass Cherenkov counter at laboratory angles of 45, 75, 105, and 135°. If the charge exchange differential scattering cross section in the center-of-mass system is expanded as a series of Legendre polynomials, the result is: $d\sigma/d\Omega = (1.00 \pm 0.03)[3.39 \pm 0.11 - (1.54 \pm 0.29)P_1(\cos\theta') + (3.57 \pm 0.56)P_2(\cos\theta')]$ mb-sr^{-1}. The total

cross section for charge exchange, obtained by integration, is then $\sigma_{tot}(\pi^- \rightarrow \pi^0) = 42.6 \pm 1.9$ mb. (auth)

473

45354 NEUTRON-NEUTRON SCATTERING LENGTH BY PION ABSORPTION IN ^{3}He. Khanna, F.; Bonner, B. E.; Duck, I. (Rice Univ., Houston, Tex.). Phys. Letters, 18: 318-19(Sept. 1, 1965). (TID-22101).

The final state interaction idea is used for the reaction $\pi^- + {}^3\text{He} \rightarrow p + n + n$. Assuming that the capture takes place from the Bohr 1s-orbit, the three nucleons are left in a state with the parity and spin of $\frac{1}{2}^-$. The enhancement in the proton spectrum is due to the strong s-wave correlation between the two neutrons since the p-wave to s-wave enhancement is less than 1% for small relative momenta between the two neutrons. The proton is in a p-wave relative to the center of mass of the two neutrons. With these assumptions the differential cross section is plotted as a function of s for several values of the scattering length, which is assumed negative. A careful examination on the proton spectrum near the maximum energy of protons will yield information on the neutron-neutron scattering length. (J.F.P.)

474

24712 THE RHO VALUE FOR THE BETA DECAY OF THE NEGATIVE MUON. Tadashi Kikuchi (Duke Univ., Durham, N. C.). Dissertation Abstr., 22: 4380(June 1962).

The decay spectrum of negative muons was investigated for the μ^- decays found in the Duke Helium Bubble Chamber, operated in a magnetic field of 14,000 gauss. About 50,000 pictures were scanned for μ^- decays, and 4300 of the decays observed were measured. An analysis of 2276 selected events yielded a value for the Michel parameter, ρ, of 0.751 ± 0.034. A statistical analysis of the momentum scale confirmed the accuracy of the experimental assumptions. The ρ value is in good agreement with the most recent results of the decay spectrum of positive muons and confirms the validity of the two component neutrino and universal V-A theories.

475

34604 AN ANALYSIS OF THE LOW ENERGY π-N SCATTERING. Masayoshi Kikugawa (Hiroshima Univ.). Progr. Theoret. Phys. (Kyoto), 31: 654-78(Apr. 1964).

The π-N scattering below 500 Mev is investigated. The contributions of the first and second resonances (N*) and (N**), a scalar meson with I = 0 and a vector meson with I = 1, are taken into account. From the analysis of both the I-spin flip and non-flip combinations of phase shifts up to the D($\frac{5}{2}$) state, the following results are obtained. For the explanation of the I-spin non-flip combination of phase shifts, a scalar meson with I = 0 is required. For the π-N interaction, PV-type coupling must coexist with PS-type. Two sets of coupling constants are found to fit the experiments. The contribution of a vector meson with I = 1 is favorable for the explanation of the I-spin flip combination of phase shifts, but the contribution shows opposite sign to that given by Bowcock. This discrepancy originates mainly from the effects of N** neglected in their analysis. (auth)

476

3357 MEASUREMENT OF THE GAMMA-RAY SPECTRUM FROM RADIATIVE MUON DECAY. C. O. Kim, W. J. Kernan, and C. M. York (Univ. of Chicago). Phys. Rev. 120, 983-7(1960) Nov. 1.

The energy spectrum of the γ rays emitted by inner bremsstrahlung in the muon decay process, $\mu^+ \rightarrow e^+ + \nu + \bar{\nu} + \gamma$, was measured by means of a large sodium iodide crystal. Only those γ rays which were time-coincident with the decay electrons were recorded. These decay electrons were detected in a scintillation counter telescope adjoining the crystal counter. The counter geometry permitted detection of events with angles between the electron and γ ray in the range from 0 to 26°. The muons were obtained by stopping a positive pion beam in a block of material. By measuring the γ-ray spectra from muons originating first in carbon and then aluminum, a correction could be made for bremsstrahlung externally produced by the decay electrons. The measured spectrum is in agreement with that predicted by the theory with an average ratio of 1.02 ± 0.10. (auth)

477

SCATTERING OF μ-MESONS WITH MOMENTA OF ABOUT 100 Mev/c IN COPPER AND IRON. V. G. Kirillov-Ugryumov, B. A. Dolgoshein, A. M. Moskvichov, and L. P. Morozova (Moscow Engineering-Physical Inst., U.S.S.R.). Nuclear Phys. 11, 357-67(1959) May (3).

Scattering of μ mesons was studied in 4mm copper plates (μ-meson momenta between 85 and 144 Mev/c) and iron plates (μ-meson momenta between 81.2 and 135 Mev/c). The μ-meson distribution derived from 2350 scattering events satisfactorily agrees with the distribution for a point nucleus. (auth)

477a

10355

SCATTERING OF μ-MESONS WITH MOMENTA OF ABOUT 100 Mev/c IN COPPER AND IRON. V. G. Kirillov-Ugryumov, B. A. Dolgoshein, A. M. Moskvichov, and L. P. Morozova (Moscow Inst. of Engineering Physics). Zhur. Eksptl'. i Teoret. Fiz. 36, 416-23 (1959) Feb. (In Russian)

Scattering of μ mesons was investigated in copper plates (in the μ-meson momentum interval from 85 to 144 Mev/c) and in iron plates (μ-meson momenta from 81.2 to 135 Mev/c). The μ-meson angular distribution plotted on the basis of 2350 scattering events satisfactorily agrees with the distribution for a point nucleus. (auth)

478

7007

ELASTIC SCATTERING OF 5 to 22 Mev π^+ MESONS ON CARBON. V. G. Kirillov-Ugryumov, L. P. Kotenko, E. P. Kuznetsov, F. M. Sergeev, and A. F. Grashin. Zhur. Eksptl'. i Teoret. Fiz. 37, 1273-80(1959) Nov. (In Russian)

Elastic scattering of 5 to 22 Mev π^+ mesons on carbon in a propane bubble chamber was investigated. A phase shift analysis of the argular distributions shows that a repulsive potential acts on the meson in the S state in the nucleus. (auth)

479

13527 THE REACTION $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ FROM 350 TO 800 Mev [Thesis]. Kirz, Janos. Berkeley, Calif., Univ. of California, 1963. 81p.

The reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ is studied in the Lawrence Radiation Laboratory 72-inch hydrogen bubble chamber. Events are located by scanning the pictures for π^+ tracks. Cross sections, Dalitz plots, angular distributions, and $\pi^+\pi^-$ and $\pi^+ n$ mass spectra are given at beam energies of 360, 430, 460, 480, 555, 605, 673, and 780 Mev. No clear evidence is found for $\pi^+\pi^-$ resonances between threshold and $M_{\pi\pi} = 680$ Mev. However, there is a strong preference for high $\pi^+\pi^-$ effective masses, especially at the lowest beam energies. Arguments are given to ascribe this anomaly to the I = 0 state of the π-π system. Production of the N^*_{33} (1238) isobar is observed in its negative charge state. (Dissertation Abstr.)

479a

26339 REACTION $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ FROM 360 TO 800 Mev. Janos Kirz, Joseph Schwartz, and Robert D. Tripp (Univ. of California, Berkeley). Phys. Rev., 130: 2481-4(June 15, 1963). (UCRL-10676)

The reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ is studied in the Lawrence Radiation Laboratory's 72-in. hydrogen bubble chamber. Events are located by scanning the pictures for π^+ tracks. Cross sections, Dalitz plots, and $\pi^+\pi^-$ and $\pi^+ n$ mass spectra are given at 360, 430, 460, 480, 555, 605, 673, and 780-Mev beam energies. No clear evidence is found for $\pi^+\pi^-$ resonances between threshold and 680 Mev. However, there is a strong preference for high $\pi^+\pi^-$ effective masses, especially at the lowest beam energies. Arguments are given to ascribe this anomaly to the I = 0 state of the $\pi-\pi$ system. The $N^*_{33}(1238)$ isobar is observed in its negative charge state. The angular distribution of its production is discussed. (auth)

480

5793

SEARCH FOR THE "ANOMALOUS" SCATTERING OF Mu-MESONS. (ON THE APPARATUS USING A DELAYED COINCIDENCE METHOD). Takashi Kitamura (Osaka City Univ.). J. Phys. Soc. Japan 14, 1654-63(1959) Dec.

A critical discussion is presented on experimental results and theories reported by other workers on μ-meson anomalous scattering. It is concluded that the apparatus used to obtain previously reported scattering results showed uncertainties in determining the identity and momenta of μ-mesons. An experimental apparatus is described which utilizes a Wilson cloud chamber, G. M. counters, and a delayed coincidence method to separate μ-mesons from other particles. The possibility of triggering this arrangement with particles other than μ-mesons was found to be quite negligible. (C.J.G.)

481

22523 ELASTIC SCATTERING AND PHASE SHIFT ANALYSIS OF $\pi^+ + P$ NEAR 30 Mev. David E. Knapp. Thesis, Rochester, N. Y., Univ. of Rochester, 1962. 128p.

To increase the angular range and accuracy of elastic pion proton scattering measurements, 5 measurements of $\pi^- + p$ differential cross sections and three measurements of $\pi^+ + p$ differential cross sections were made. The main achievement of the measurements is to reduce the uncertainty in the $T = \frac{1}{2}$ phase shifts to 10 to 15%. The results combined with previous measurements at 30 Mev, were used to find a 5-parameter phase-shift solution with only α_{33} fixed by data from other energies. The inability of the 30 Mev data to provide a solution for all 6 phase shifts is shown to be a characteristic of measurements at this energy. From the phase-shift solution, the quantity $a_1 - a_3 = 0.254 \pm 0.015$ was predicted, a value in statistical agreement with the prediction $a_1 - a_3 = 0.245 \pm 0.01$ for the same quantity from photoproduction measurements. The total cross sections $\sigma^{2+} = 6.15 \pm 0.12$ mb/sterad, $\sigma^{-0} = 7.02 \pm 0.32$, and $\sigma^{2-} = 1.847 \pm 0.080$ were also predicted. Finally, the nonresonant P-wave phase shifts follow the general trend indicated by recent theoretical predictions for the effect of a pion-pion resonance on these phase shifts at moderate energies. (M.P.G.)

482

31349 π^+-p ELASTIC SCATTERING AT 31.4 Mev. D. E. Knapp and K. F. Kinsey (Univ. of Rochester, N. Y.). Phys. Rev., 131: 1822-5(Aug. 15, 1963). (NYO-10257)

Five new measurements of $\pi^- + p$ and three of $\pi^+ + p$ elastic differential cross sections, extend the angular range and the accuracy of the data near 30 Mev. These data, combined with the previous measurements at this energy, provide a significant improvement in the accuracy of s- and nonresonant p-wave phase shifts. A phase-shift analysis yields four solutions, two of which are inconsistent with photoproduction measurements near threshold. One of the remaining two is preferred on the basis of a considerably more likely fit to recent charge-exchange measurements at the same energy. Assuming $f^2 = 0.0878$; $\alpha_1 = 0.087 \pm 0.009$; $\alpha_{11} = 0.051 \pm 0.008$, $\alpha_{13} = -0.043 \pm 0.004$; $\alpha_{31} = -0.008 \pm 0.002$; $\alpha_3 = -0.066 \pm 0.001$. (auth)

483

31302 CHARGE EXCHANGE NUCLEAR REACTIONS INDUCED BY A PION. Kohmura, Toshitake (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 33: 480-8(Mar. 1965).

The experimental situation for six types of charge-exchange nuclear reactions induced by a pion at low energy is discussed. A double charge exchange process without any change of the mass, which can never be attained by a nuclear reaction of a single nucleon, is shown to be more abundantly realized by the reaction (π^+,π^-) than by (π^-,π^+). The cross section for the reaction (π^+,π^-) turns out to be of the order of several ten μb, and the selection rule for the reaction is discussed. (auth)

484

38167 MU-MESIC ATOM FORMATION OF DEFORMED NUCLEUS. Toshitake Kohmura (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 31: 799-803(May 1964).

The suitability of mu-mesic atom formation for probing nuclear deformation is shown. The rate of direct 1s orbit trapping of the low-energy meson(μ) is calculated. The rate is highly enhanced for deformed nuclei. The anisotropy of the rate results from the nuclear deformation. (D.C.W.)

485

47679 NUCLEON PAIRS EMITTED BY NEGATIVE PION CAPTURE AND CHARGE-DEPENDENT NUCLEAR WAVE FUNCTIONS IN LIGHT NUCLEI. Kohmura, Toshitake (Tokyo Univ.). Progr. Theoret. Phys. (Kyoto), 34: 234-42(Aug. 1965).

The ratio of nn pair to pn pair emitted by π^- capture in light nuclei, $R = P(\pi^- + pn \rightarrow nn)/P(\pi^- + pp \rightarrow pn)$, is investigated, and it is shown that the ratio is seriously influenced by charge dependence of nuclear wave functions. From the experimental value of the ratio, it is concluded that the range of the wave function for a ^3S pair is shorter than that for a ^1S pair by about five percent. (auth)

486

21420 INFLUENCE OF INTERMEDIATE VECTOR BOSON ON MUON CAPTURE RATE. M. Koiv, J. Meitre, and L. Palgi. Tr. Inst. Fiz. i Astron., Akad. Nauk Est. SSR, No. 25: 63-9(1964). (In Russian)

Nonlocal corrections due to the intermediate charged vector boson to muon capture in He, H, and C are examined. The results are compared with experimental data. (auth)

487

19106 MEAN LIFE-TIME OF THE NEUTRAL PION. E. L. Koller, S. Taylor, and T. Huetter (Stevens Inst. of Tech., Hoboken, N. J.). Nuovo Cimento (10), 27: 1405-9 (Mar. 16, 1963). (In English)

The mean lifetime of the π^0 meson is measured. The decay distance of π^0 mesons produced by $K_{\pi 2}$ decay at rest $(K^+ \rightarrow \pi^+ + \pi^0)$ and subsequent decay by the Dalitz mode $(\pi^0 \rightarrow e^+ + e^- + \gamma)$ is measured. Using Ilford G-5 emulsions, exposed in a 300 Mev/c separated K^+ beam, 88 of the above events are found. The observed mean π^0 lifetime is $(2.8 \pm 0.9) \times 10^{-18}$ sec. (auth)

488

18456 DETERMINATION OF THE FREQUENCY OF SLOW MESON CAPTURE BY LIGHT AND HEAVY NUCLEI IN PHOTOEMULSION. D. A. Kopylova, Yu. B. Korolevich, N. I. Petukhova, and M. I. Podgoretskiĭ (Joint Inst. of Nuclear Research Dubna, U.S.S.R.). Zhur. Eksptl', i Teoret. Fiz. 36, 1955-6(1959) June. (In Russian)

Descriptions are given of a simple method for determining the percentage of interactions of light nuclei (C, N, and O) and heavy nuclei (Ag, Br, etc.) without special emulsions. Descriptions are confined to the nuclear capture of stopped π^-. If the meson produces Auger electrons, the capture is in a heavy nucleus. When the σ_π star contains particles with $\leq 50\ \mu$ tracks, the capture is in a light nucleus. 349 σ_π stars were tested. The method can also be used for determining the frequency of slow K-meson capture by light and heavy nuclei in emulsions. (R.V.J.)

489

41773 DOUBLE-CHARGE-EXCHANGE SCATTERING OF LOW-ENERGY PIONS BY NUCLEI. Koltun, D. S.; Reitan, A. (Univ. of Rochester, N. Y.). Phys. Rev., 139: B1372-4(Sept. 6, 1965). (UR-875-80).

The double-charge-exchange cross section for the scattering of low-energy pions by nuclei is calculated in second Born approximation, considering only s-wave scattering of the pions by individual nucleons. The differential cross section for pions of energy 20 to 40 Mev and a light target with two neutrons outside a closed shell is calculated to be $\sim 7\ \mu$b/sr, with considerable enhancement for targets with larger neutron excess. The scattering to the isobaric analog of the target ground state is strongly favored. (auth)

490

33247 (NP-15048) O MEKHANIZME (π^-,π^-n) REAKTSII. (Mechanism of the π^-,π^-n Reaction). Report No. 27. Kolybasov, V. M. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1964. 21p. Dep.(mn).

Total cross sections of the reaction $^{12}C(\pi^-,\pi^-n)^{11}C$ in the bombarding energy range from 40 to 600 Mev in the pole approximation were calculated. The calculated excitation function is in agreement with experimental data. The reduced vertex part (neutron width) of the virtual decay $^{12}C \rightarrow {}^{11}C + n$ was found from the absolute values of the cross sections. Its value turns out to be equal to that obtained from the pick-up reaction $^{12}C(p,d)^{11}C$. These facts confirm the hypothesis of the pole mechanism for the given reaction. (auth)

491

19702 NP-8711

Joint Inst. for Nuclear Research Dubna, U.S.S.R. Lab. of Nuclear Problems.

SEARCH FOR ρ^0-MESON AND TEST OF DISPERSION RELATIONS IN PION-NUCLEON SCATTERING. A. D. Konin, S. M. Korenchenko, B. Pontecorvo, and V. G. Zinov. 1959. 15p. (D-455).

Total π^-p cross sections (σ_t^-) were measured with an accuracy of 1.5 to 2% at pion energies ranging from 140 up to 380 Mev. In the energy dependence of σ_t^- there were found no anomalies which might give evidence on the existence of ρ^0-mesons with mass in the interval 270 to 410 Mev/c^2. The data are not compatible with the energy value $E_2 = 650$ Mev for the second maximum in $\sigma_t^-(E)$ discovered by Frish et al., but confirm the conclusion of Brisson et al., that such a maximum is found at a smaller energy ($E_2 = 610$ Mev). The data are in excellent agreement with dispersion relations for (π^-p) scattering. They definitely show that the "Puppi-Stanghellini problem," as such, does not exist any more and that it arose only owing to inexact knowledge of the total cross section of (π^-p) interaction. (auth)

492

39932 ABSORPTION OF γ QUANTA AND STOPPED π MESONS BY NUCLEI WITH TWO-NUCLEON EMISSION AND THE STRUCTURE OF LIGHT NUCLEI. Kopaleishvili, T. I. (Tbilissi State Univ., USSR). Yadern. Fiz., 1: 961-70(June 1965). (In Russian).

The absorption of high-energy (E > 100 Mev) gamma quanta and stopped mesons (π) by nuclei, accompanied by the emission of two nucleons, is investigated theoretically using the independent pair model. Expressions are obtained for the distribution of nucleons emitted in (π^-, nn) and (π^-, np) processes on ^{16}O and ^{12}C nuclei, with respect to their relative energy and also for the (γ,np) total cross section on the same nuclei as a function of the gamma quantum energy. The obtained quantities are used to investigate the role of the interaction between the emitted final-state nucleons and the correlated nucleon pair in the nucleus for these processes. Other light nuclei structure problems are also considered. The theoretical results are compared with existing experimental data. (auth)

493

5909 π^+-PROTON SCATTERING AT 990 Mev. J. K. Kopp (Brookhaven National Lab., Upton, N. Y.), A. M. Shapiro, and A. R. Erwin. Phys. Rev., 123: 301-7(July 1, 1961).

Positive-pion scattering at 990 ± 30 Mev was examined in a 6 × 3 × 2 in. hydrogen bubble chamber without a magnetic field. The cross sections for elastic and inelastic scattering were found to be 15.3 ± 1.5 mb and 12.6 ± 3.3 mb, respectively. The inelastic scattering cross section includes $0.19^{+0.09}_{-0.07}$ mb of $\Sigma^+ - K^+$ production and 0.78 ± 0.14 mb of $\pi^+\pi^+\pi^-p$ production. A simple pion-pion model which predicts the branching ratios for double pion production in $\pi^- - p$ collisions is found to be inconsistent with the double pion production observed in this experiment. The relation of the experiment to $\pi^- - p$ experiments in the region of the second and third resonances is discussed. (auth)

494

31585 (JINR-P-305) OB OPREDELENII CHASTOTY ZAKHVATA MEDLENNYKH MEZONOV LEGKIMI I TYAZHELYMI YADRAMI EMUL'SII. (On Determining the Frequency of Slow Meson Capture by Light and Heavy Emulsion Nuclei). D. K. Kopylova, Yu. B. Korolevich, N. I. Petukhova, and M. I. Podgoretskii (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of High Energy). 1959. 5p.

A simple method is suggested for determining the percentage of interactions taking place on light and heavy nuclei. The method is demonstrated with nuclear capture of stopped π mesons. It is shown that when stopped π mesons produce auger electrons the capture takes place in heavy nuclei. Capture in light nuclei forms σ_π stars containing particles with ≤50 μ tracks (sub-barrier particles). (R.V.J.)

495

10963 NP-8492

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems.

PHASE SHIFT ANALYSIS OF π-MESON SCATTERING ON HYDROGEN AT 240-333 Mev. S. M. Korenchenko, N. I. Polumordvinova, G. T. Tentiukova, and V. G. Zinov. 1959. 23p. (P-431).

The results of phase shift analysis of experimental data on pion-nucleon scattering at 240 to 330 Mev are given. The isotopic spin formalism based on the charge independence hypothesis was used. Comparison with the dispersion relations was satisfactory. (T.R.H.)

496

27434 (JINR-P-2063) ZAKHVAT μ^--MEZONOV LEGKIMI YADRAMI. (The Capture of μ^- Mesons by Light Nuclei). G. Ya. Korenman and R. A. Eramzhyan (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1965. 8p. Dep.(mn).

The probability of the μ^--meson capture from a definite state of the hyperfine structure of a mesic atom is investigated. It is shown that in the case of ^{19}C and ^{19}F, the probability of the capture from the lower state of the hyperfine structure depends only on G_β^2. (auth)

497

31383 ELASTIC SCATTERING OF NEGATIVE MUONS IN NUCLEAR EMULSION. David Kotelchuck. Thesis, New York, Cornell Univ., 1963. 49p.

An emulsion stack was exposed to a separated beam of ~2×10^7 μ^- particles of energy 52 ± 8 Mev at the CERN synchrocyclotron. Mesons(μ) with endings in a region near

the incoming edge of the plates were traced back to scatters, thus discriminating in favor of events with momentum transfers from 100–160 Mev/c. The 78 events found give evidence that the meson(μ) behaves merely as a heavy electron, in contradiction to the anomalous meson(μ)-nucleus scattering reported in several cosmic ray experiments. The data indicate, however, a possibility of a small amount of scattering in excess of that predicted, particularly for momentum transfers >130 Mev/c. This may be ascribed either to unresolvable inelastic scattering, to inaccuracies in the parameters of the nuclear charge distribution, or to the breakdown in the representation of the many-body nucleus by a smoothed-out potential. Of the 78 events, one was an elastic scatter by hydrogen, which is consistent with the Mott scattering formula. (auth)

498

6988 ELASTIC μ^- SCATTERING IN NUCLEAR EMULSION. D. Kotelchuck, J. G. McEwen, and J. Orear (Cornell Univ., Ithaca, N. Y.). Phys. Rev., 129: 876-9(Jan. 15, 1963).

An emulsion stack was exposed to a separated beam of $\sim 2 \times 10^7$ μ^- of energy 52 ± 8 Mev at the CERN synchrocyclotron. Muons with endings in a region near the incoming edge of the plates were traced back to scatters, thus discriminating in favor of events with momentum transfers from 100 to 160 Mev/c. The 78 events found give evidence that the muon behaves merely as a heavy electron, in contradiction to the anomalous muon-nucleus scattering reported in several cosmic-ray experiments. Our data indicate, however, a possibility of a small amount of scattering in excess of that predicted, particularly for momentum transfers >130 Mev/c. This may be ascribed either to unresolvable inelastic scattering, to inaccuracies in the parameters of the nuclear charge distribution, or to the breakdown in the representation of the many-body nucleus by a smoothed-out potential. Of the 78 events, one was an elastic scatter by hydrogen, which is consistent with the Mott scattering formula. (auth)

499

14944 (NYO-2242) ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 152 MEV (thesis). William P. Kovacik (Carnegie Inst. of Tech., Pittsburgh). July 1960. Contract AT(30-1)-882. 60p.

The differential elastic and total cross sections for 152-Mev negative pions on hydrogen were measured. An analysis of the incident pion beam from the synchrocyclotron was made with a Cerenkov counter, which yielded an (11 ± 1)% contamination of negative muons and electrons. In order to detect only elastically scattered pions, coincidences were demanded between the particles in the scattered beam and the recoil protons that are associated with elastically scattered pions. At the angles where the protons were not energetic enough to leave the target a Cerenkov counter was used to separate the pions from electrons. The scattered pion beam was found to be contaminated with up to 20% electrons at some angles. A total cross section of 63.7 ± 2.0 mb was measured. A least squares fit to the differential cross section indicates that only S and P partial waves are involved. Integration of the differential cross section yields a total elastic cross section of 20.1 ± 0.7 mb. The real part of the forward scattering amplitude, $|D_-^b|$, is determined to be $0.190^{+0.021}_{-0.021}$ $\hbar/m_\pi c$. Within the errors this value of $|D_-^b|$ agrees with the value calculated from the pion dispersion relations for the coupling constant $f^2 = 0.08$. (auth)

500

14438

INELASTIC INTERACTION OF π^+-MESONS WITH HELIUM NUCLEI AT AN ENERGY OF ABOUT 300 MeV. M. S. Kozodaev, M. M. Kulyukin, R. M. Sulyaev, A. I. Filippov, and Yu. A. Shcherbakov. Zhur. Eksptl'. i Teoret. Fiz. 38, 409-22(1960) Feb. (In Russian)

The interaction of positive and negative π-mesons with helium nuclei at energies of 273 and 330 Mev was studied using a diffusion cloud chamber. Quasifree scattering on neutrons and protons, multiple scattering, and absorption of the mesons were discriminated. The total inelastic interaction cross sections were $(145 \pm 15) \times 10^{-27}$ cm^2 for $E_\pi = 273$ Mev and $(103 \pm 10) \times 10^{-27}$ cm^2 for $E_\pi = 330$ Mev. The relative probabilities for quasifree scattering on neutrons and protons through angles >45° in the laboratory coordinate system were found to agree with the corresponding probabilities for scattering on free nucleons. The probabilities for multiple scattering processes were found to be 0.24 ± 0.06 for $E_\pi = 273$ Mev and 0.29 ± 0.05 for $E_\pi = 330$ Mev. The angular distribution of inelastically scattered π-mesons was compared with the Watson–Zemach calculations. (auth)

501

8121

SCATTERING OF NEGATIVE MESONS BY HYDROGEN AT 130 AND 152 Mev. U. E. Kruse and R. C. Arnold (Univ. of Chicago). Phys. Rev. 116, 1008-15(1959) Nov. 15.

The elastic scattering and total cross sections for negative π mesons on hydrogen were measured at 130 and 152 Mev. At both energies, the number of electrons arising from the charge exchange scattering were determined with a Cherenkov counter. At 152 Mev, recoil protons were counted, and were distinguished from π mesons by energy loss in a scintillator. The real part of the forward scattering amplitude was determined to be 0.243 ± 0.015 and 0.218 ± 0.016, in units of the meson Compton wavelength, at 130 and 152 Mev, respectively. These values agree within limits of statistical error with the predictions from dispersion relations. (auth)

502

12896
THE CAPTURE OF NEGATIVE PIONS IN HYDROGEN AND DEUTERIUM. I. HYDROGEN. J. A. Kuehner, A. W. Merrison, and S. Tornabene (Univ. of Liverpool). Proc. Phys. Soc. (London) 73, 545-50(1959) Apr.

A high-energy pair spectrometer was used to determine the ratio of the radiative to mesonic capture of pions stopped in liquid hydrogen. The measurement agrees well with the value expected from the charge-exchange scattering and photoproduction of pions. (auth)

503

12897
THE CAPTURE OF NEGATIVE PIONS IN HYDROGEN AND DEUTERIUM. II. DEUTERIUM. J. A. Kuehner, A. W. Merrison, and S. Tornabene (Univ. of Liverpool). Proc. Phys. Soc. (London) 73, 551-5(1959) Apr.

The same apparatus described in a companion paper on hydrogen was used to study the radiative capture of pions in liquid deuterium. The result agrees well with previous measurements and the value expected from the production of pions in nucleon–nucleon collisions. (auth)

504

12166
RECOIL PROTON POLARIZATION FROM 225-Mev π^-–p SCATTERING. J. F. Kunze, T. A. Romanowski, J. Ashkin, and A. Burger (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. 117, 859-68(1960) Feb. 1.

Mesons (π^-) of energy 225 Mev were scattered from liquid hydrogen. The polarization of the recoil proton has been measured at two angles. The computed polarizations are -0.13 ± 0.16 at a laboratory recoil angle of 15°, and $+0.36 \pm 0.29$ at 31°. The positive sign is for polarization in the direction of the vector cross product of the incident meson (π) momentum and the recoil proton momentum. A comparison of the data is made with various sets of scattering phase shifts which represent the differential cross-section data equally well. The results favor the Orear type of Fermi set in which the S-wave α_1 phase shift is positive. (auth)

505

9205 (UCRL-10564) DIFFERENTIAL DISTRIBUTIONS OF NEUTRONS IN INELASTIC π^-p INTERACTIONS AT 374, 417, AND 454 Mev (thesis). Richard J. Kurz (California. Univ., Berkeley. Lawrence Radiation Lab.). Nov. 15, 1962. Contract W-7405-eng-48. 142p.

The inelastic interactions of negative π mesons with protons at 374, 417, and 454 Mev incident π kinetic energy are studied by measuring the differential distributions of final-state neutrons. The π source is an internal target of the Berkeley 184-inch synchrocyclotron. A magnetic beam-transport system momentum-analyzes and focuses the π beam at a liquid hydrogen target located in an adjacent shielded experimental area. The time-of-flight distribution of neutral particles is measured at various laboratory-system angles between 10 and 65 deg. Neutral particles are detected by observing the charged products of their interactions in plastic scintillator. The time-of-flight information is determined electronically by time-to-height conversion and pulse-height analysis. The time resolution of the total system is 1.0 nsec. Detected neutral particles accompanied by charged particles are separated by the electronic system from those not accompanied by charged particles. Analysis presuming the principal inelastic reactions to be $\pi^-p \rightarrow \pi^+\pi^-n$ and $\pi^-p \rightarrow \pi^0\pi^0n$ separates the time-of-flight spectra into gamma rays, neutrons from the reaction $\pi^-p \rightarrow \pi^0n$, and inelastic neutrons. Calculated values of the neutron-detection efficiency are used in the conversion of the neutron time-of-flight distribution to neutron differential distributions as a function of energy. A description of the neutron efficiency calculation is included. A definite deviation from the behavior expected on the basis of a statistical distribution or a simple peripheral collision model is observed in the distributions of the inelastic neutrons. The inelastic neutron differential distributions showed a strong preference for neutrons of low cm momentum. By integrating the differential distributions, the total cross sections for the two inelastic reactions listed above were obtained. The cross section for the $\pi^+\pi^-n$ channel was a rapidly rising function of incident π energy, whereas the cross section for the $\pi^0\pi^0n$ channel was essentially constant as a function of energy. In addition, the total cross section for the processes $\pi^-p \rightarrow$ neutrals was obtained along with tentative data on the angular distribution of the reaction $\pi^-p \rightarrow \pi^0n$. (46 references) (auth)

506

37544 (UCRL-11548) ANGULAR DISTRIBUTIONS FOR $\pi^-p \rightarrow \pi^0n$ AT 315 AND 371 Mev. Kurz, Richard J.; Lind, Don L. (Lawrence Radiation Lab., Univ. of California, Berkeley). July 6, 1964. Contract W-7405-eng-48. 11p. Dep.(mn); $1.00(cy), 1(mn) CFSTI.

An analysis of the angular distribution of the reaction $\pi^-p \rightarrow \pi^0n$ incorporating four classes of data is reported. They are: (a) previously published γ-angular distributions at T_{π^-} = 317 and 371 Mev (T_{π^-} = incident π^- kinetic energy); (b) the neutron differential cross section at T_{π^-} = 374 Mev in the range $84 \leq \theta^*_n \leq 133$ deg^2 (θ^*_n = c.m.-system neutron angle = $\pi - \theta^*_{\pi^0}$, * denotes c.m.-system variable), (c) neutron differential cross sections at T_{π^-} = 313 and 371 Mev in the range $21 \leq \theta^*_n \leq 123$ deg^3; and (d) the differential cross section at θ^*_n = 0 deg calculated from the forward-direction, fixed-momentum-transfer dispersion relations for pion nucleon scattering. A least-squares analysis was performed to fit these data to the c.m.-system differential cross section in the form: $d\sigma/d\Omega^*(\cos\theta^*_{\pi^0}) = \Sigma_{l=0}^{N} a_l P_l(\cos\theta^*_{\pi^0})$. (M.O.W.)

507

4609 NUCLEAR CAPTURE OF MU MESONS. Włodzimierz Kusch (Inst. for Nuclear Research, Warsaw). Postepy Fiz. 11, 69-82(1960). (In Polish)

After a brief history of early discoveries and difficulties relating to π and μ mesons, this review article follows the theoretical and experimental developments of the interaction of negative μ mesons with nuclei. Twenty-six references to μ meson capture are listed. First, the basic interaction with a proton, the mechanism of the interaction, and the probability of capture of a negative μ meson as a function of Z are treated. Next, the side products (emission of nucleons) resulting from the capture of a μ meson by a proton in a nucleus and from the subsequent excitation of this nucleus are discussed. Measurements of emission probability of N neutrons (N = 0, 1, 2...) are compared with the predictions of 3 nuclear models. The last section deals with observations that have the capability of demonstrating nonconservation of parity, in particular, the measurements of angular distributions of neutrons emitted after the capture of polarized μ mesons by nuclei. (TTT)

508

3050

ABSORPTION OF π^+-MESONS WITH AN ENERGY OF APPROXIMATELY 50 MeV BY CARBON NUCLEI. J. V. Laberriggue-Frolova, M. P. Balandin, and S. Z. Otvinovskiĭ (Joint Inst. of Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz. 37, 634-8(1959) Sept. (In Russian)

A propane bubble chamber was employed to study stars produced in the absorption of 50 ± 20 Mev π^+ mesons in carbon nuclei. The cross section for production of such stars was found equal to 145 ± 36 mb. The star prong distribution is characterized by an average number of prongs equal to 2.6 ± 0.3. An appreciable anisotropy of the angular distribution of the prongs relative to the direction of motion of the π^+ meson was observed. The main cause of this anisotropy is apparently preabsorption scattering of π^+ mesons on separate nucleons in the nucleus. A distribution of two-prong stars with respect to the angle between the prongs is presented. (auth)

509

10982

ABSORPTION OF π^+ MESONS OF ENERGY IN THE VICINITY OF 50 Mev BY CARBON NUCLEI. Jeanne Laberrigue-Frolow (Laboratoire de Physique Nucléaire, Orsay, France) and M. P. Balandin (Balandine) and S. Z. Otvinovski (Joint Inst. of Nuclear Research, Dubna, USSR). J. phys. radium 21, 54-8(1960) Jan. (In French)

Stars caused by the absorption of π^+ mesons of energy 50 ± 20 Mev in carbon nuclei are studied by means of a propane bubble chamber. The cross section is found to be 145 ± 36 mb. The distribution of these stars as a function of the number of prongs indicates a mean number of prongs 2.6 ± 0.3. There is a noticeable anisotropy in the angular distribution of prongs relative to the direction of the incoming π^+. The fundamental reason of this assymetry is, probably, due to quasi-elastic scattering of the π^+ on nucleons inside the nucleus before its absorption. The distribution of two prongs stars as a function of the angle between the two prongs is given. (auth)

510

26827 (JINR-P-328). O POGLOSHCHENII π^+ MEZONOV S ENERGIEI OKOLO 50 MEV YADRAMI UGLERODA. (On the Absorption of π^+ Mesons of Nearly 50 Mev Energy by Carbon Nuclei). Zh. V. Laberrig, M. P. Balandin, and S. Z. Otvinovskii (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1959. 13p

The stars formed by 50 ± 20-Mev π meson absorption by carbon nuclei were studied using a propane bubble chamber. The cross sections of the stars were found to be 145 ± 36 mb. Star distributions were determined by the number of prongs (average = 2.6 ± 0.3). A considerable anisotropy was observed in the angular distribution of prongs in relation to the π^+ direction. It is postulated that prior to the absorption, scattering on separate nucleons in the nucleus must serve as a source of anisotropy. The distribution of two-prong stars was found in relation to the angle between the prongs. (tr-auth)

511

20410 USE OF SOLID-STATE DETECTORS AS ENERGY SPECTROMETERS FOR COSMIC HIGH-ENERGY PARTICLES. J. Labeyrie (CEN, Saclay, France). p.187-93 of "Cosmic Rays, Solar Particles and Space Research." New York, Academic Press, 1963.

Advantages of semiconductor- over gas-filled ionization chambers are enumerated. Measurements of proton and pion energy deposition at 0.5 to 1.5 Bev obtained with silicon filled detectors are given. (M.J.T.)

512

26215 HEAVY PARTICLES IN MEDICINE. John H. Lawrence and Cornelius A. Tobias (Univ. of California, Berkeley). p.127-46 of "Progress in Atomic Medicine. Vol. I." New York, Grune and Stratton, 1965.

The use of high-energy heavy-particle beams in therapy with or without the Bragg peak to deliver large amounts of energy to relatively localized areas of the body including the pituitary gland, brain, and soft tissues in the successful treatment of several metabolic, neoplastic, and neurologic diseases including acromegaly, Cushing's disease, diabetic retinopathy, and brain and soft-tissue tumors is discussed. The properties of the heavy particles, including their linear energy transfer, RBE, independence of oxygen concentration, and lack of tissue recovery are described. Particles such as pi mesons are also being studied to find how they might be used advantageously in radiotherapy. (P.C.H.)

513

9330 INVESTIGATION OF THE PION-PION INTERACTION AT LOW ENERGIES. L. Lapidus (Joint Inst. for Nuclear Research, Dubna, USSR). p.115-19 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

An emulsion chamber technique was used to study the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$; the mean energy of the primary π^- mesons was (240 ± 15) Mev. It was found that the experimental mass spectrum of the $\pi^+\pi^-$ system was shifted in the direction of greater mass values in comparison with the calculated phase space volume. The cause of this shift appears to be a π-π interaction in the final state. Another group studying the same reaction at 340 Mev with the 25-cm liquid hydrogen bubble chamber came to the same conclusions. (A.G.W.)

514

15139 INTERPRETATION OF PION-NUCLEON SCATTERING RESULTS IN THE RESONANCE REGION. W. M. Layson (CERN, Geneva). Nuovo Cimento (10), 27: 724-47 (Feb. 1, 1963). (In English)

Recognizing that information on pion-nucleon scattering in the range (300 to 1500) Mev is insufficient for a complete and unambigous analysis in terms of angular-momentum amplitudes, a study is made employing restrictive assumptions related to the higher resonances. The π^-p angular distribution data are found consistent with resonances of $(T,J) = (1/2,3/2^-)$ and $(1/2,5/2^+)$ at 600 and 900 Mev respectively. A plausible, but nonunique, set of amplitudes is determined, and the only significant departure from a simple behavior is in the amplitude for the $(1/2,1/2^+)$ state, which could contain a resonance at 900 Mev. The Λ^0K^0 production cross section shows features in agreement with such a resonance. A proposed phenomenological model based on the role of the $(3/2,3/2^+)$ pion-nucleon state predicts the existence of eight resonances below 1500 Mev. Experimental results are compared with the model and suggestions are made regarding possible tests. (auth)

515

39671 A LOW ENERGY π^+ DETECTION SYSTEM, FOR USE IN INTENSE ELECTRON AND γ-RAY BACKGROUND CONDITIONS. D. W. G. S. Leith, E. M. Lawson, R. Little, and G. M. Lewis (Glasgow Univ.). Nucl. Instr. Methods, 29: 341-4(Oct. 1964).

A scintillator counter technique was developed to detect low energy π^+ mesons, (~4–40 Mev), in an intense background of electrons and γ rays at forward angles. The identification of a π^+ meson required the observation of the characteristic decay ($\pi^+ \rightarrow \mu^+ + \nu$ in 2.55×10^{-8} sec) of the pion, together with the fulfillment of restrictions on the energy loss and total energy of the particle under examination. The system was used to investigate π^+ meson photoproduction cross sections at 30° laboratory angle in the γ ray energy region (155–190) Mev. (auth)

516

1328 MEASUREMENT OF THE TOTAL CROSS SECTION π-DEUTERIUM. T. Leray, A. Berthon, M. Crozon, and J. L. Narjoux (College de France, Paris). p.102-6 of "Proceedings of the Sienna International Conference on Elementary Particles. Vol. I." Bologna, Societa Italiana di Fisica, 1963. (In French)

The effective total cross sections for meson (π^-) scattering by deuterium were measured at several energies between 420 and 1360 Mev and were compared with the sum of the effective total cross sections for $\pi^\pm$-p interactions. Comparative measurements of the effective cross sections for meson ($\pi^\pm$) scattering by deuterium at 491 to 1063 Mev were made at several solid angles. No violation of the principle of charge symmetry was observed. (D.C.W.)

517

27259 ANGULAR DISTRIBUTION OF CHARGE EXCHANGE AND INELASTIC NEUTRONS IN π^--p INTERACTIONS AT 313 AND 371 Mev. Don L. Lind, Barry C. Barish, Richard J. Kurz, Philip M. Ogden, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev., 138: B1509-17(June 21, 1965). (UCRL-11435(Rev.))

Neutron angular distributions from the charge-exchange (π^0n) and inelastic modes ($\pi^0\pi^0$n, $\pi^+\pi^-$n) of the π^--p interaction were investigated at 313 and 371 Mev incident-pion kinetic energy. The data were obtained with an electronic counter system. Elastic and inelastic neutrons were separated in the all-neutral final states by time of flight. At both energies the charge-exchange differential cross section at the forward neutron angles differ from that determined by Caris et al. from measurements of the π^0-decay gamma distributions, but generally agrees with the phase-shift-analysis calculations of Roper. The distribution of inelastic neutrons from both modes shows a strong preference for low center-of-mass neutron energies. The distribution of these neutrons does not correspond to that expected from the I = 0, π-π interaction (ABC effect) suggested to account for the anomaly in p-d collisions observed by Abashian et al. Finally, all available charge-exchange differential-cross-section data from this and other experiments were combined by a least-squares fit to a Legendre expansion. (auth)

518

14257 NP-8597

Liverpool. Univ.

THE CAPTURE AND DECAY INTERACTIONS OF NEGATIVE MUONS STOPPED IN MATTER (thesis). Norman H. Lipman. Sept. 1959. 80p.

The muon capture process ($\mu^- + p \rightarrow n + \nu$) is discussed, and an experiment is described in which muon capture rates were measured to accuracies of a few per cent for various target nuclei. The main interest of the experiment was to make a comparison between measured capture rates and the theoretically predicted capture rates of Tolhoek and Luyten. The theory is sensitive to the type of coupling that prevails in the muon capture process, and Tolhoek and Luyten have derived two values for the capture rate in each element considered, one for a Fermi type of coupling

(pseudoscalar, scalar, and vector) and the other for Gamow-Teller coupling (axial vector and tensor). A comparison between experiment and theory over a range of selected elements should in principle detect whether the coupling is pure Fermi, pure Gamow-Teller, or a mixture of the two. The results, in fact, favor an excess of the Gamow-Teller over the Fermi type of coupling. The perturbation of the muon decay process ($\mu^- \rightarrow e^- + \nu + \bar{\nu}$) brought about by atomic binding is considered. A muon in orbit within a muonic atom may be expected to decay at a modified rate; this was investigated experimentally for negative muons stopped in aluminum and in copper. It is shown that there is no deviation from the free muon decay rate within the experimental standard deviation of 5%. (auth)

519

45351 MUON CAPTURE AND ELECTRIC DIPOLE EXCITATION FOR LITHIUM. Lodder, A.; Jonker, C. C. (Vrije Universiteit, Amsterdam). Phys. Letters, 18: 310-13(Sept. 1, 1965).

The total meson (μ) capture probabilities for lithium-6 and -7, which were measured previously, are calculated. The two capture probabilities are calculated in two ways, by means of the closure approximation, and by extracting the dipole part of the main meson (μ) capture-matrix elements from the cross section for the giant resonance gamma excitation. It is shown that a previous proposal for double magic nuclei can be extended to a greater class of nuclei. (J.F.P.)

520

33025 "ABNORMAL" QUANTUM NUMBERS AND DECAY CHANNELS: J^{PG} ASSIGNMENT FOR EPSILON; A NORMAL SCALAR OCTET. Loebbaka, David; Pati, Jogesh C. (Univ. of Maryland, College Park). Phys. Rev. Letters, 14: 929-32(May 31, 1965).

The recent indication of an enhancement at about 730 Mev in the recoil spectrum of the proton in $\pi^- + p$ reactions is considered. An investigation is presented assuming that a resonance, such as above, exists which does not decay with appreciable branching ratio to a two- or three-pion system, but shows up in a recoil spectrum, hence is produced with appreciable cross section. Also a study of the possible decay modes of the said resonance for different assignments of its quantum numbers J^{PG}, and an estimation of the order of magnitude of the corresponding partial widths, assuming the dominance of low-mass intermediate states, are included. (M.O.W.)

521

12967

OBSERVATION OF THE BREMSSTRAHLUNG OF π-MESONS INTERACTING WITH NUCLEI. M. F. Lomanov, A. G. Meshkovskii (Meshkovsky), Ya. Ya. Shalamov, V. A. Shebanov, and A. F. Grashin (Academy of Sciences, Moscow). Nuclear Phys. 10, 283-93(1959) Mar.

Nuclear force bremsstrahlung of π^+ mesons was observed in a freon bubble chamber in which 80 to 300 Mev π^+ mesons interacted with carbon, fluorine, and chlorine nuclei. In the indicated energy range the bremsstrahlung cross section for inelastically and elastically scattered π^+ mesons as derived from 20 scattering events was found to be $(4.5^{+1.2}_{-2.0}) \times 10^{-27}$ cm^2 per fluorine nucleus. Three cases of bremsstrahlung involved absorption of the π^+-mesons by the nucleus; in two cases of bremsstrahlung charge-exchange scattering of π^+-mesons on the nucleus occurred. The bremsstrahlung cross sections for these various types of nuclear processes were computed in the quasiclassical approximation. The values obtained from the formulas satisfactorily agree with the experimental results. (auth)

522

8120 THE SCATTERING OF POSITIVE 120 Mev PIONS ON PROTONS. A. Loria (Università, Padua and Istituto Nazionale di Fisica Nucleare, Padua), P. Mittner, R. Santangelo, et al. Nuovo cimento (10), 22: 820-43 (Nov. 16, 1961). (In English)

An investigation of the elastic scattering of 120-Mev π^+ by protons is described. The experiment was performed by exposing a liquid propane chamber to the CERN 600-Mev synchrotron. The results refer to 5405 selected events in which the contamination from scattering on carbon nuclei is shown to be negligible. The values obtained for the phase-shifts are: $\alpha_{31} = -2.60° \pm 0.69°$, $\alpha_3 = -11.05° \pm 1.32°$, $\alpha_{33} = 31.67° \pm 1.01°$. The value of α_3 differs significantly from that expected if the linear dependence of α_3 on the momentum, which was proposed, is assumed. The result is discussed in connection with theoretical developments. (auth)

523

22885 (CERN 61-11) THE SCATTERING OF POSITIVE 120 MEV PIONS ON PROTONS. PART I. A. Loria, P. Mittner, R. Santangelo, I. Scotoni, and G. Zago (Padua. Università. Istituto di Fisica and Italy. Istituto Nazionale di Fisica Nucleare, Padua). PART II. B. Aubert, A. Brenner, Y. Goldschmidt-Clermont, F. Grard, G. R. Macleod, A. Minguzzi-Ranzi, and L. Montanet (European Organization for Nuclear Research, Geneva). Apr. 11, 1961. 70p.

An investigation of the elastic scattering of 120 Mev positive pions by protons is described in which a liquid propane chamber was exposed to the CERN 600 Mev synchrocyclotron. The results refer to 5405 selected events in which the contamination from scattering on carbon nuclei is shown to be negligible. The values obtained for the phase shifts are: $\alpha_{31} = -2.60° \pm 0.69°$, $\alpha_3 = -11.05° \pm 1.32°$, $\alpha_{33} = +31.67° \pm 0.01°$. The value of α_3 differs significantly from that expected if the linear dependence of α_3 on the momentum, which has been proposed by some authors, is assumed. (auth)

524

42859 (UCRL-16246, pp 100-2) DIFFERENTIAL CYTOLOGIC EFFECTS OF NEGATIVE PION BEAMS IN PLATEAU AND "STAR" REGIONS. Preliminary Report. Loughman, William D.; Winchell, H. Saul; Aceto, Henry; Richman, Chaim; Raju, Mudundi R.; Lawrence, John H. (California Univ., Berkeley. Donner Lab. California Univ., Berkeley. Donner Pavilion).

LAF_1 mice carrying the Ly2 lymphoma as an ascites tumor were exposed to the negative pion beam of the 184-in. cyclotron (including its muon and electron contaminants). Mice exposed in the plateau region of the pion beam received 65 to 80 rads, with the beam estimated to contain about 64% pions. Mice exposed in the star region of the pion beam received 80 to 95 rads, with the beam estimated to contain less than 50% pions. Cytological examination of lymphoma cells aspirated from mice at various time intervals following pion irradiation was performed. Four characteristics were scored: mitotic index; frequency of polyploid metaphase cells; frequency of anaphase cells displaying bridges; and chromosome counts of metaphase cells. Results indicated a greater RBE for negative pions in star region than for those in the plateau region (H.G.D.)

525

15223

MUON DECAY IN NUCLEAR EMULSION AT 25,000 GAUSS. G. R. Lynch and J. Orear (Cornell Univ., Ithaca, N. Y.) and S. Rosendorff (Columbia Univ., New York). Phys. Rev. 118, 284-91(1960) Apr. 1.

Positive pions from the 90-Mev pion beam of the Nevis cyclotron were stopped in nuclear emulsion which was in a magnetic field of 25,000 gauss. The asymmetry parameter for the angular distribution of the positrons which came from the decay muons was measured. The result that $P\xi = -0.87 \pm 0.04$ implies that either the asymmetry parameter ξ is different from the value of -1 predicted by the V-A theory or that there is about 13% depolarization of positive muons in nuclear emulsion at 25,000 gauss. (auth)

526

47388 FIXED VARIABLE DISPERSION RELATIONS FOR THE PION-NUCLEON SYSTEM. Lyth, D. H. (NORDITA, Copenhagen). Rev. Mod. Phys., 37: 709-23 (Oct. 1965).

It is shown that an earlier study by Hamilton and Woolcock of fixed momentum-transfer dispersion relations may be complemented by a study of fixed energy dispersion relations. Two main results are obtained. First, by demanding that the two types of relation give the same value for the amplitude, nontrivial restrictions are obtained on the amplitude (the f_0-N-N coupling constants and the values of certain integrals over the high-energy πN amplitude are obtained). Secondly, the fixed energy relation enables one to discuss quantitatively the validity of the "CGLN" approximate method which Hamilton and Woolcock had used to calculate the partial-wave amplitudes at low energies from the fixed momentum-transfer dispersion relation alone. The terms neglected by this approximation are evaluated, and found to be large except at low energies. Even when these terms are included, undesirable cancellations occur, and the conclusion in fact is that fixed variable relations are not suitable for calculating the partial-wave amplitudes (except at low energies), but only for providing sum rules. (auth)

527

21400 OBSERVATION OF THE HYPERFINE EFFECT IN MUON CAPTURE BY $^{19}_{9}F$ via THE TIME-DEPENDENCE OF THE DECAY ELECTRON RATE. R. A. Lundy (Argonne National Lab., Ill.), W. A. Cramer, G. Culligan, V. L. Telegdi, and R. Winston. Nuovo cimento (10), 24: 549-53 (May 1, 1962). (In English)

The hyperfine effect in μ capture by F^{19} is confirmed. The rate at which neutrons are emitted following μ arrival in K shells is not affected by branching ratio effects. The decay symmetry parameter for μ^- bound to the $I = \frac{1}{2}$ nucleus F^{19} is -0.021 ± 0.007, about $\frac{1}{2}$ that of μ^- in C; μ^-'s in crystalline LiF, at least in a longitudinal field of ~100 gauss, are not subject to appreciable spin relaxation in the mesic K orbit. (L.N.N.)

528

43043 (JINR-P-2202) ZAVISIMOST NAKLONA DIFRAKTSIONNYKH KRIVYKH pp, $\bar{p}p$, K^+p, K^-p, π^+p, I.π^-p RASSEYANIYA OT ENERGII. (Energy Dependence of the Slope of the Diffraction Curves for pp, $\bar{p}p$, K^+p, K^-p, π^+p, and π^-p-Scattering). Lyubimov, A. L. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1965. 6p. Dep. mn.

It is shown that the energy dependence of the slope of the diffraction curves for elastic pp, $\bar{p}p$, π^+-p, and K^+-p-scattering can be described in a unique manner. This dependence demonstrates a shrinkage of the diffraction pattern with energy for all the mentioned scattering processes. It shows also that the total interaction cross sections affect the slope of the diffraction curve. (auth)

529

41796 MEASUREMENT OF PARTICLE IONIZATION POWER IN A SPARK CHAMBER. V. A. Lyubimov and F. A. Pavlovsky (Inst. of Theoretical and Experimental Physics, Moscow). Nucl. Instr. Methods, 27: 342-5(July 1964).

An attempt was made to measure the ionization power in a spark chamber with a large gap between the electrodes. The chambers were irradiated in a beam of positive 600-Mev particles. They were filled with Ne + 0.03% propane admixture under the pressure of 540-mm Hg and placed close to each other so that the particles initiating the master pulse passed through both chambers. The tracks from protons and mesons(π^+) were appreciably different. The spark discharges initiated by the particles with higher ionization density had a much higher number of bunches than the discharges from the particles with minimal ionization. The luminosity ratio of the proton and meson(π^+) tracks proved to be 3.0 ± 0.4, which is close to the ratio of the

particles ionization power. It was found that at definite conditions the spark discharge itself spreading in the direction of the particle motion contains information about the ionization power of the particle. (M.C.G.)

530

24473 MEASUREMENT OF THE IONIZING ABILITY OF PARTICLES IN THE SPARK CHAMBER. V. A. Lyubimov and F. A. Pavlovskii. Zh. Eksperim. i Teor. Fiz., 46: 1142-6(Mar. 1964). (In Russian)

The period of the memory cell of a spark chamber with a 30-cm-long gap between the electrodes was measured; it was found that when the chamber was filled with a pure inert gas, the period was relatively long, reaching several tens of microseconds but impurities such as air, propane, or alcohol shortened this time considerably. The high-voltage discharge in a chamber filled with He + 1% air was found to depend greatly on the time delay involved. It was assumed that there is a correlation between the structure of the discharge and the ionizing ability of the particles. Admixture of electronegative gases caused a decrease of the ionization density while addition of multiatomic gases resulted in the extinction of the photon discharge mechanism, slowing down the process. In order to verify the assumptions, the ionizing ability of the gases was measured, making use of protons and π mesons in chambers filled with Ne + 0.03% propane under a pressure of 540 mm of Hg. The ionizing ability of the particles could be derived on the basis of the varying brightness of the tracks. Previously J. W. Cronin (Nucl. Instr. and Meth. 20: 143(1963)) and C. T. Coffin (Ibid. 20: 156(1963)) made such observations, finding that proton tracks exhibited greater brightness than π-meson tracks, while studying the decay of λ particles in a multilayer spark chamber. (TTT)

531

7418 FLUCTUATIONS OF ENERGY LOSS BY HEAVY CHARGED PARTICLES IN SILICON DETECTORS: PRELIMINARY MEASUREMENTS. Maccabee, H. D.; Raju, M. R. (Univ. of California, Berkeley). Nucl. Instrum. Methods, 37: 176-8(Nov. 1965).

The probability distributions of energy losses of 730-Mev protons and 370-Mev pions in 0.48-g/cm^2 and 0.45-g/cm^2 Si detectors, respectively, are measured over the energy-loss range of 0.5 to 1.4 Mev. The results are compared with the Vavilov and Landau theories for the proton and pion energy losses, respectively. Explanations are proposed for the discrepancies noted. (T.F.H.)

532

40516 (UCRL-11243) NEUTRONS FROM NEGATIVE MU-MESON CAPTURE (thesis). Burns Macdonald (California. Univ., Berkeley. Lawrence Radiation Lab.). June 29, 1964. Contract W-7405-eng-48. 78p.

Average neutron emission and neutron multiplicity distributions from μ^--meson capture in Al, Si, Ca, Fe, Ag, I, Au, and Pb were measured. A high-efficiency cadmium-loaded liquid scintillator tank was used having an efficiency of 54.5% for detecting neutrons from fission. Fermi gas and Gaussian nuclear models are used to fit the experimental results. A reduced nucleon effective mass is employed to give the observed average neutron multiplicity, and values are obtained as a function of the width of the nucleon momentum distribution assumed. Use of the Gaussian momentum distribution obtained in experiments on quasi-elastic scattering gives effective masses ranging from ≈ 0.7 M_p in the lighter nuclei to ≈ 0.45 M_p in the heavier nuclei. An excited Fermi gas distribution gives larger effective masses for the lighter nuclei and smaller effective masses for the heavier nuclei than does the Gaussian model. With either of these models the distributions of neutron multiplicities cannot be explained without allowing for direct neutron emission and clustering on the nuclear surface. For ^{40}Ca a shell-model calculation with a simple harmonic oscillator potential gave good agreement with the observed average neutron multiplicity. For both the Fermi gas and Gaussian models, the average nuclear excitation energy varies linearly with average neutron multiplicity and is relatively insensitive to the model parameters. When the average neutrino momentum is expressed in units of the muon mass reduced by its K-shell binding energy the result (with the exception of doubly magic calcium) is constant, 0.82 ± 0.01, over the wide range of atomic numbers covered in the experiment. (auth)

533

31014 (UCRL-7942) DETERMINATION OF THE NUCLEON-NUCLEON ELASTIC SCATTERING MATRIX. II. PHASE-SHIFT ANALYSES OF EXPERIMENTS NEAR 50, 95, 142, 210, AND 310 Mev. Malcolm M. MacGregor, Richard A. Arndt, and David S. Bailey (Lawrence Radiation Lab., Univ. of California, Livermore). June 29, 1964. Contract W-7405-eng-48. 63p. Dep.(mn); $3.00(cy), 2(mn) CFSTI.

Phase shift analyses have been carried out for (p,p) and (n,p) experiments at energies near 50, 95, 210, and 310 Mev. Both (p,p) data analyses and combined (p,p) plus (n,p) data analyses were obtained at these energies. Attention was concentrated in all cases on the Stapp type 1 solution, with the objective being to obtain the best possible values for the phase shifts from the existing nucleon-nucleon data. Error matrices were calculated for all solutions, and determinations of the pion-nucleon coupling constant g^2 were carried out. It was found that reasonably consistent values for g^2 can be obtained if a suitable selection of the phenomenological phase shifts is made. The $T = 1$ phase shifts determined from (p,p) data only were found to be in good agreement with the $T = 1$ phase shifts obtained from combined (p,p) plus (n,p) data, thus verifying the gross features of charge independence. For completeness, phase shift values at 142 Mev are included. (auth)

534

46782 ELECTRON IDENTIFICATION IN LEAD PLATE SPARK CHAMBERS. McLeod, D. W.; Phelan, J. J.; Roberts, A.; Yurka, G. E. (Argonne National Lab., Ill.). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci.,

NS-12: No. 4, 28-30(Aug. 1965).

A spark chamber containing Pb, Al, and Cu plates is exposed to momentum-analyzed electron and pion beams at 80 to 340 Mev/c. It is found that the chamber can discriminate electrons from pions with 99 to 99.5% reliability. The chamber geometry and operation for this use are described. (T.F.H.)

535

32398 (NYO-9287) MEASUREMENT OF THE RATE OF THE REACTION $\mu^- + C^{12} \rightarrow B^{12} + \nu$ (thesis). Eugene J. R. Maier (Carnegie Inst. of Tech., Pittsburgh). May 1962. Contract AT(30-1)-882. 99p.

The rate of the reaction $\mu^- + C^{12} \rightarrow B^{12} + \nu$ was measured by stopping negative muons from the Carnegie Tech synchrocyclotron in a plastic (CH) target. The number of incident muons was monitored by observing the amplitude of their characteristic exponential decay, and the reaction product, B^{12}, was detected by observation of its beta decay with characteristic meanlife 29.3 msec. Separation of the partial capture rate to the ground state of B^{12} from the total capture rate was effected by direct observation of the emitted gamma ray in coincidence with the recoil of the B^{12} ion from the neutrino emission. The result, for capture to the ground state, is $\lambda_R^{gnd} = (6.75^{+0.30}_{-0.75}) \times 10^3$ sec^{-1} which is in agreement with several theoretical calculations. (auth)

536

43081 AN N/D CALCULATION OF THE J = 3/2, T = 3/2 π N PHASE-SHIFTS FROM THE POSITION AND WIDTH OF THE N* RESONANCE. Majumdar, Rabi (Univ. of Delhi). Nuovo Cimento (10), 39: 186-9(Sept. 1, 1965).

An N/D calculation of the J = 3/2, T = 3/2 pion-nucleon phase shifts is performed with the position and width of the J = 3/2, T = 3/2 N* resonance as the only input parameters. The correct phase shift at the resonance point is thereby guaranteed, and the distant phase shifts are determined as an extrapolation. The results are in good agreement with experiment in the energy region up to ~225 Mev of pion laboratory energy. (auth)

537

45085 THE LOW-ENERGY PION-KAON INTERACTION. Martin, A. D. (Univ. of Durham, Eng.); Vick, L. L. J. Nuovo Cimento (10), 39: 905-27(Oct. 1, 1965).

An attempt is made to find a self-consistent solution of the πK partial-wave and fixed-momentum-transfer dispersion relations. The existence of the K* resonance is assumed at the outset of the calculation. The solution is found to predict a reasonable value for the kaon form factor, to give a value of the $\rho K\bar{K}$ coupling constant comparable to that predicted by unitary symmetry, and to be in good agreement with an analysis of the data for K^-p inelastic scattering. Although an attractive I = 1/2 s-wave πK phase shift is found, no κ (725 Mev) resonance is generated in this channel. In particular it is found hard to determine the value of the isospin plus combination of the s-wave πK scattering lengths; the value most favored by this calculation is in disagreement with that predicted from an analysis of K^+p elastic scattering data. The forces that give rise to the πK interaction are given, and in particular it is found that short-range forces are extremely important in producing the K* resonance. (auth)

538

41508 A STUDY OF THE REACTION $\pi^- + P \rightarrow \pi^- + p + \pi^0$ AT 905 Mev (thesis). Massimo, Joseph Thomas. Providence, Brown Univ., 1964. 120p.

A study was made of the reaction $\pi^- + P \rightarrow \pi^- + P + \pi^0$ in a special bubble chamber containing an internal liquid hydrogen target. The laboratory kinetic energy of the incident pion was 905 Mev. A high-Z liquid mixture was used in the chamber to enhance the materilization of gamma rays from the decay of the π^0. Thus events are observed to which can be applied the constraints of hydrogen kinematics, and in which the gamma-ray directions are also measurable. Some of the advantages and disadvantages of this relatively new technique are discussed. The production of a neutral pion at 905 Mev was found to be in large part consistent with the description offered by the extended isobar model. This was particularly evident in the pion momentum distributions. However, the angular distribution of the proton strongly favored the backward direction of the center-of-mass system, suggesting that the interaction is essentially peripheral. Furthermore, the effective mass distribution of the two pions indicated that the influence of the ρ resonance, although strongly suppressed because of the available phase space, is probably not negligible. The statistics of the experiment did not permit a complete analysis of the relative influence of the different resonances, but it was concluded that in this energy region both the higher isobars and the ρ resonance compete with the 3-3 resonance in pion production. The total cross section for the above reaction was found to be 5.0 ± 0.7 mb. Rough estimates of other inelastic cross sections were made. (Dissertation Abstr.)

539

16978 STUDY OF SOME NUCLEAR REACTIONS PRODUCED BY THE ABSORPTION OF π^- MESONS BY LIGHT NUCLEI IN CORPUSCULAR PHOTOGRAPHIC EMULSION. J. P. Massue, H. Braun, G. Baumann, and P. Cueer (Centre de Recherches Nucléaires, Strasbourg). J. Phys. (Paris), 24: 841-4(Nov. 1963). (In French)

Some types of nuclear reactions produced by the absorption of stopping π^- mesons in ^{12}C, ^{14}N, and ^{16}O nuclei are analyzed. These reactions allow us to approach the mechanism of the primary absorption event, in order to study the decay of strongly excited nuclei with two holes and to determine the binding energy of pairs of nucleons. Among other data the energy and angular spectra of the pairs of nucleons issued by the primary event are given. (auth)

540

15368 EXPERIMENTAL STUDY OF π-π INTERACTION IN THE REACTION $\pi^- + p \rightarrow \pi^0 + \pi^0 + n$ AT INCIDENT π^- ENERGY OF 378 Mev. Maung, Tin; Crowe, Kenneth M.; Dairiki, Ned T. (Univ. of California, Berke-

ley). Phys. Rev. Lett., 16: 374-7(Feb. 28, 1966). (UCRL-16444).

The differential neutron time-of-flight distribution from the interaction $\pi^- + p \rightarrow n + \pi^0 + \pi^0$ at 378 Mev was measured. A lower limit for the magnitude of the I = 0, s-wave π-π scattering length was obtained. It was found that at low momentum transfers the data do not agree with a pure one-pion-exchange model. It was concluded that the π-π cross section is 60 mb or larger. (D.C.W.)

541

30076 MUON-NUCLEON INELASTIC INTERACTIONS [Thesis]. McNulty, Peter J. Buffalo, State Univ. of New York, 1965. 93p.

Previous experiments in which cosmic-ray muons were used for pion production indicated the existence of an anomalous non-electromagnetic interaction in addition to the Coulomb scattering. In the present experiment it is shown that the inelastic interactions can be explained in terms of pure electromagnetic interactions. This would imply that the muon would make an excellent probe for determining the nucleon structure. The muon would make an excellent replacement for the electron in scattering studies especially at high energies where bremsstrahlung effects make a monoenergetic electron beam much more difficult to obtain. Muons would, therefore, make an ideal probe in the search for a breakdown in electrodynamics at small distances. The virtual photon exchange in the electromagnetic interaction was analyzed. No evidence was found of interactions that could be attributed to longitudinally polarized virtual photons. Therefore, at this incident energy and at small angles, the cross section for the inelastic muon-nucleon interaction can be expressed solely in terms of the cross section for transversely polarized virtual photons, the limit of this latter cross section approaching the real photoproduction cross section as q^2 approaches zero. The semi-classical Williams-Weiszacker approach, therefore, is shown to be valid and its extensions in quantum electrodynamics to be in complete agreement with experiment. Further studies of muon scattering at higher incident energies will be necessary to search for the possible breakdown of electrodynamics at small distances. Such studies would provide additional information on pion production in electromagnetic interactions and would allow a more quantitative determination of any contribution from longitudinally polarized virtual photons. (Dissertation Abstr.)

542

13865 (NEVIS-101) MAGNETIC MOMENT OF NEGATIVE MUONS (thesis). J. Menes (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Cyclotron Labs.). Feb. 1962. Contract Nonr-266(72). 28p.

The magnetic moment of negative muons bound in atoms of carbon, oxygen (in water), magnesium, silicon, and sulfur is measured with a precision ranging from 3×10^{-5} in carbon to 1.6×10^{-4} in sulfur. The measured moment is corrected for relativistic effects, diamagnetism, nuclear polarization, and (in the case of carbon and magnesium) Knight shift, before being compared to the moment of the positive muon. The two moments are found to be equal to 3 parts in 10^4, where the major uncertainty is caused by the Knight shift. The relativistic, diamagnetic, nuclear, and solid state shifts are large enough compared to the statistical and systematic errors to make this technique usable for the investigation of these effects. (auth)

543

8133 COUNTER TECHNIQUES IN HIGH ENERGY NUCLEAR PHYSICS: RARE DECAYS OF π- AND μ-MESONS. A. W. Merrison. Proc. Phys. Soc. (London), 78: 1116-24 (Dec. 1, 1961).

It is shown, with particular reference to the decay $\mu^+ \rightarrow e^+ + \gamma$, how the study of rare decays of pions and muons, by means of counter techniques, contributes to understanding the weak interactions. (auth)

544

14317 (JINR-P-1896) MEKHANIZM ISPUSKANIYA ZHESTKIKH γ-KVANTOV V REATSTII $\pi + N \rightarrow \pi + \gamma + N$. (A Mechanism of Emission of Hard γ Quanta in the Reaction $\pi + N \rightarrow \pi + \gamma + N$). V. A. Meshcheryakov, L. L. Nemenov, L. D. Solovev, P. Strokach, and F. G. Tkebuchava (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics and Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 10p. Dep.(mn).

A mechanism of emission of hard photons in the pion-nucleon interaction is considered. The formulas obtained are compared with experimental data. The constant of the $\gamma + \pi \rightarrow \pi + \pi$ process is estimated. (auth)

545

5896

INELASTIC INTERACTIONS BETWEEN 80 to 300 Mev π^+ MESONS AND LIGHT NUCLEI. A. G. Meshkovskii and Ya. Ya. Shalamov. Zhur. Eksptl'. i Teoret. Fiz. 37, 978-82 (1959) Oct. (In Russian)

The cross sections for inelastic interaction between π^+ mesons and a mixture of C, F, and Cl nuclei were measured for 10 values of the π^+ meson energy in the region from 80 to 300 Mev. The results are compared with curves calculated on the basis of the optical model under the assumption of a uniform distribution of the nuclear charge and a Fermi type distribution. It is shown that the experimental results satisfy the second type of distribution. The cross sections for inelastic scattering of π^+ mesons are measured. (auth)

546

15212

ELASTIC SCATTERING OF π^- MESONS ON PROTONS AT THE FIRST RESONANCE $T = \frac{1}{2}$. M. J. Meyer (Centre d'Études Nucléaires, Saclay, France). J. phys. radium 21, 18S-19S(1960) Feb. (In French)

The first results obtained at Saclay with a hydrogen bubble chamber in the study on the angular distribution

of π^- mesons elastically scattered at 745 Mev/c are presented. The results are graphed and show a distribution slightly more backward and forward than previous experiments. (J.S.R.)

547

29497 (NEVIS-114) PRECISION LIFETIME MEASUREMENT ON POSITIVE AND NEGATIVE MUONS. S. L. Meyer, E. W. Anderson, E. J. Bleser, L. M. Lederman, J. L. Rosen, J. E. Rothberg, and I. T. Wang (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). May 1963. Contract Nonr-266(72) 20p. (R 366; Cu-2211)

An experiment to measure and compare the free decay rates of positive and negative muons is described. Muons from the Nevis Synchrocyclotron were stopped in a liquid hydrogen target containing less than 1 ppm D_2 and less than 1 part in 10^9 of other impurities. In this situation, the rate of μ^- capture in H_2 was the only significant correction to the free decay rate of μ^- and was measured in a separate experiment. The lifetimes were monitored by measuring the time intervals between muon stops and decay electrons using a transistorized digitron of 30 nsec channel width. Electronic circuitry of the "interference remover" type was employed to eliminate time-dependent background. μ^- and μ^+ lifetimes were measured with the same apparatus and under essentially the same conditions of rate and geometry. The ratio of the lifetimes is expected to be particularly insensitive to any systematic errors. The results are: $\tau_{\mu^-} = 2.198 \pm 0.002$ μsec (hydrogen correction made); $\tau_{\mu^+} = 2.197 \pm 0.002$ μsec; and $R = \tau_{\mu^-}/\tau_{\mu^+} = 1.000 \pm 0.001$. (auth)

548

41157 RELATIVE CYTOGENETIC EFFICIENCY OF MUONS AND π^- MESONS IN ZEA MAYS (L.). Alexander Micke, Harold H. Smith, Robert G. Woodley, and Alfred Mashke (Brookhaven National Lab., Upton, N. Y.). Proc. Natl. Acad. Sci. U. S., 52: 219-21(Aug. 1964). (BNL-7764)

Dormant seeds of a stock of Zea mays (L.), heterozygous for the yellow-green Yg_2/yg_2 alleles, were irradiated with beams of mesons (μ^-) and mesons (π^-). The efficiency of mesons (μ^-) in producing yellow-green sectors in the seedling leaves was ~0.8 compared to 250-kvp x rays, while the relative efficiency of mesons (π^-) was about 3.4. (auth)

549

5696 RELATIVE CYTOGENETIC EFFICIENCY OF MUONS AND π^- MESONS IN ZEA MAYS (L.) AND ITS MODIFICATION BY POSTIRRADIATION STORAGE. Alexander Micke, Harold H. Smith, Robert G. Woodley, and Alfred Maschke (Brookhaven National Lab., Upton, N. Y.). Radiation Res., 23: 537-50(Dec. 1964). (BNL-7959; BNL-7959-R)

Dormant seeds of a stock of Zea mays L. heterozygous for the yellow-green alleles Yg_2/yg_2 were irradiated with muons (μ^- particles) and negative π mesons (π^- particles) from the Alternating Gradient Synchrotron at Brookhaven National Laboratory. The efficiency of muons was 0.76, and that of π^- mesons was 3.23, compared with 250-kvp x rays. Postirradiation storage for ~18 weeks increased the efficiency of muons to 1.58, and that of π^- mesons to 4.14. The hight RBE of π^- mesons was found only for the tested chromosomal damage or alteration, not for biological parameters involving germination and growth. (auth)

550

24364 AN EXPERIMENT ON THE RADIATIVE CAPTURE IN FLIGHT OF PIONS IN HYDROGEN AND A MEASUREMENT OF THE $\pi^- - \pi^0$ MASS DIFFERENCE. W. C. Middelkoop. Thesis, Amsterdam, Universiteit Amsterdam, 1962. 78p.

Interest in and problems connected with the measurement of the cross section for the radiative capture in flight ($\pi^- + p \rightarrow \gamma + n$) are discussed, and equipment used in the detection of photons and neutrons is examined. The time-of-flight arrangement used to measure the differential cross section for 72 Mev π^- as 70 ± 7 μb/sr is explained, and methods for measuring the $\pi^- - \pi^0$ mass difference are reviewed. Another time-of-flight experiment yielded a value of (9.01 ± 0.08) electron masses for this difference. (D.C.W.)

551

19190 CHARGE EXCHANGE CROSS SECTION FOR SLOW MESONS (μ^-) ON HYDROGEN ATOM. V. D. Mikhailov. p.107-17 of "Nekotorye Voprosy Fiziki Elementarnykh Chastits i Atomnogo Yadra." Moscow, Gosatomizdat, 1962.

The cross section of charge exchange in hydrogen was studied as a first step toward estimating the cross section of electron capture by a μ^+ meson in an arbitrary substance. Calculations of scattering amplitudes and variable methods for calculating electron wave functions obtained for the total cross section $\sigma = \int d\sigma \cong 140\pi a_0^2$, indicating that the anticipated increase in capture probability was 100 fold higher than the orbital area. (R.V.J.)

552

15326

FISSION OF URANIUM-238 WITH μ^- MESONS. A. K. Mikhul and M. G. Petrashku (Joint Inst. for Nuclear Research, Dubna, USSR). Rev. phys. 4, 355-8(1959). (In Russian)

The interaction of μ^- mesons at 150 Mev with U^{238} was investigated using nuclear emulsions. The experimental set-up and the development of the emulsion are described. Some 26,975 cases of the stopping of the mesons in the emulsion were investigated, and 59 cases of fission were observed. The fission probability was considered on the basis of the Fermi-Teller principle and of its independence from Z. The results are compared with previous results. (J.S.R.)

553

34766 A $K\pi$ RESONANT STATE AT 726 Mev. D. H. Miller, G. Alexander, O. I. Dahl, L. Jacobs, G. R. Kalbfleisch, and G. A. Smith (Univ. of California, Berkeley). Phys. Letters, 5: 279-82(July 15, 1963). (UCRL-10797 (Rev.)) (In English)

The existence of an unstable meson with strangeness $S = +1$, mass 726 ± 3 Mev, and full width $\Gamma \lesssim 20$ Mev appears reasonably established from a study of the $K\pi$ effective-mass distributions observed in $\pi^- + p$ interactions. The simplest interpretation of these data suggests the isotopic-spin assignment $I = \frac{1}{2}$. No unambiguous evidence for a determination of the spin and parity was obtained. (R.E.U.)

554

11033
POSITIVE PION SCATTERING FROM HYDROGEN AT 24.8 MEV. Douglas Miller and James Ring (Univ. of Rochester, N. Y.). Phys. Rev. 117, 532-4(1960) Jan. 15.

An angular distribution for the process $\pi^+ + p \rightarrow \pi^+ + p$ was measured at 24.8 Mev by counter techniques. At this energy the S-wave interaction is larger than the P-wave. Differential cross sections at the three center-of-mass angles, 66, 92, and 163.5°, are (0.286 ± 0.028) mb/sterad, (0.458 ± 0.042) mb/sterad, and (0.993 ± 0.120) mb/sterad, respectively. Over 250 hydrogen interactions were observed at each angle. (auth)

555

8182 NOTE ON THE $\pi + N \rightarrow \eta + N$ REACTION NEAR THRESHOLD. S. Minami (Osaka City Univ.). Phys. Letters, 13: 353-4(Dec. 15, 1964).

Various possible explanations of the angular distribution for the $\pi + N \rightarrow \eta + N$ reaction near threshold are pointed out, and a method for experimentally determining a correct one among the possible explanations is suggested. ((C.E.S.)

556

39564 SPECULATIONS ON THE MESON-DEUTERON INTERACTION. Minami, Shigeo (Osaka City Univ.). Progr. Theoret. Phys. (Kyoto), 33: 759-60(Apr. 1965).

Since there is a discrepancy between the SU_6 prediction and a phase shift analysis of p-p scattering at 660 Mev, which shows a small D_2 phase shift, in the two-baryon system with $Y = 2$, it is suggested that the D_{12} should not be regarded as a resonance in the p-p system, but as a resonance in the π-d system. The $\bar{K}$-d, η-d, and K-d interactions are also discussed. (J.F.P.)

557

8053 (NP-11232(p.236-42)) τ-MESON DECAY—A REVIEW. A. N. Mitra (Aligarh Muslim Univ., Aligarh, India).

A brief survey is given of the progress made so far in understanding the main features of the problem of τ-decay, as they have emerged from an analysis of the experimental material accumulated over the years. The role of the pion-pion interaction is discussed in relation to this problem. It was concluded from the study that the picture of τ-decay with the pions going out in S states and interacting through the $T = 2$ state is more consistent with the experimental information than any other hypothesis. (P.C.H.)

558

9809 π^+-p ELASTIC SCATTERING AT 120 MeV. A. Loria (Istituto di Fisica dell'Università, Padua, Italy), P. Mittner, R. Santangelo, G. Zago, A. Brenner, F. Grard, and J. L. Montanet. p.188-9 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25—September 1, 1960."

An investigation was made of the elastic scattering of 120-Mev mesons (π^+) obtained by exposing a liquid propane bubble chamber to the CERN 600-Mev synchrocyclotron. Differential cross sections and angular distributions were determined. Results of a phase-shift analysis are given. (M.C.G.)

559

21505
MOLECULAR PROCESSES INDUCED BY μ^- MESONS IN HYDROGEN BUBBLE CHAMBER. II. MECHANISMS OF FORMATION OF μ^- MESONIC HYDROGEN MOLECULAR ION. Yukio Mizuno, Takeo Izuyama, and Mikio Shimizu (Univ. of Tokyo). Progr. Theoret. Phys. (Kyoto) 21, 479-80(1959) Mar.

A study of the mechanism of μ^--mesic molecular ion formation by the low energy collision of a mesonic proton or deuteron atom with a proton or deuteron bound in an ordinary hydrogen molecule in a bubble chamber is presented. (C.J.G.)

560

15300 ANALYSIS OF INELASTIC COLLISION π^- + C AT 915 Mev. S. Mongelli (Università, Bari), A. Romano, P. Waloschek, A. Gentile, and E. Perez-Ferreira. Nuovo Cimento (10), 26: 1368-75(Dec. 16, 1962). (In English)

A calculation of some predictions of the independent particle model is described and compared with the experimental results on inelastic events occurring in the collision of π^- mesons on carbon nuclei, at the kinetic energy of 915 Mev. The experimental data are well described by the independent particle model when the inelastic pion-nucleon cases are assumed to be dominated by the $\frac{3}{2}, \frac{3}{2}$ resonance and the possibility of a second interaction of the pion within the nucleus is taken into account. (auth)

561

47401 THE PRODUCTION OF η-MESONS IN PION-NUCLEON COLLISIONS (thesis). Moss, Thomas Alan. Baton Rouge, La., Louisiana State Univ., 1964. 48p.

The $\pi + N \rightarrow \eta + N$ reaction in the neighborhood of threshold is studied from a field-theoretical viewpoint. The effects of the second resonant state of the pion-nucleon system are taken into account, and a parameter study of the reaction is performed in which the variable parameters are the coupling constants involved in the reaction and the resonance width of the second resonant state. The angular distributions and excitation function for the reaction are calculated for various relative magnitudes of the coupling constants and two values of the width. A comparison between these calculated data and experimental angular distributions and excitation functions in the neighborhood threshold is suggested when experimental data in this energy range become available. This comparison may give an indication of the importance of the effect of the second resonant state on the $\eta-N$ interaction thus suggesting the possibility of strong d-wave $\eta-N$ interaction at low energy. (Dissertation Abstr.)

562

40255 (UCRL-11577) PION-NUCLEON SCATTERING IN THE $T = \frac{1}{2}$ STATE AS DEDUCED FROM RECENT EXPERIMENTS. Burton J. Moyer (California. Univ., Berkeley and California. Univ., Berkeley. Lawrence Radiation Lab.). July 1964. Contract W-7405-eng-48. 10p. (CONF-550-47)

From the International Conference on High-Energy Physics, Dubna, USSR, Aug. 1964.

A review is presented of recent experiments involving elastic $\pi^{\pm}-p$ scattering at 300 to 700 Mev, charge-exchange scattering at 500 to 1300 Mev, and polarization measurements at 500 to 1000 Mev. (R.E.U.)

563

32587 ANGULAR DISTRIBUTION OF CHARGE EXCHANGE OF π-NUCLEON BETWEEN 600 AND 900 Mev. A. Muller (CEN, Saclay, France), E. Pauli, R. Barloutaud, J. Meyer, M. Beneventano, G. Gialanella, and L. Paoluzi. Phys. Letters, 10: 349-51(June 15, 1964). (In French)

The reaction $\pi^+ + d \rightarrow \pi^0 + p + p$ was studied at pion energies of 600, 650, 750, 800, and 850 Mev. Effective differential cross sections were obtained by fitting measured angular distribution points with series expansions of $d\sigma/d\Omega = \Sigma\, a_n \cos^n\theta^*$ for the reaction $\pi^+ + n \rightarrow \pi^0 + p$, considering the less energetic scattered proton as a spectator. Measured total cross sections are compared with other experimental values. (M.J.T.)

564

17048 ON THE DECAY $\pi \rightarrow e + \nu + \gamma$. V. F. Mueller (Universität, Heidelberg). Z. Physik, 172: 224-30(1963). (In German)

The radiative decay of the charged π-meson $\pi^+ \rightarrow e + \nu + \gamma$ was calculated using dispersion relation techniques. It is assumed that the weak interaction producing the decay has a V-A structure. The decay through the vector variant was reinvestigated and found to be different from the result of Vaks and Ioffe. The theoretical prediction is in agreement with a preliminary experiment recently performed at CERN. (auth)

565

40533 THE EFFECT OF NEUTRINOS POSSESSING A NON-ZERO MASS ON THE DECAY CONSTANT OF BOUND μ MESONS. Tibor Nagy (Lorant Eötvös Univ., Budapest). Magy. Fiz. Folyóirat, 12: 133-50(1964). (In Hungarian)

The unstable mesons(μ) decay into an electron and 2 neutrinos at an average life of 2.2×10^{-6} sec. The positive muons can be experimentally studied but the negative muons are involved in a number of complex processes: they are captured in the Coulomb field of the nucleus and reach the ground state within 10^{-9} sec. In view of the competition of these two processes, the time distribution of the decay electrons is determined not only by the decay constant but by the sum of the decay and capture probabilities. The capture probability is a function of the order number of the capturing material. An attempt was made to reconcile the previously noted differences between theoretical predictions and experimental results, making use of a new assumption of the theory of elementary particles, according to which there are 2 different neutrinos, one of which possesses a mass which at rest is different from 0. From the examination of the available experimental data it was concluded that the abnormally large value of the decay probability of bound mesons(μ) in the vicinity of Fe cannot be explained on the basis of the currently accepted theories. It appears highly desirable to repeat the experiments before reevaluating the assumptions of the theory. Recent measurements seem to indicate that the decay probability does not have a maximum at Z = 26. (TTT)

566

47378 ON THE NATURE OF MUON. Nakamura, Seitaro (Tokyo Univ.; Nihon Univ., Tokyo); Itami, Kunio; Ugai, Hiroyuki. Progr. Theoret. Phys. (Kyoto), 34: 256-62(Aug. 1965).

By assuming that a neutral intermediate boson $W^{0'}$ with the particle number ± 2 interacts between muon and electron in the following channels: $(\mu^+)^c \rightarrow e^- + (W^{0'})^c$, $\mu^+ \rightarrow (e^-)^c + W^{0'}$, their effects on the anomalous magnetic moments of muon and electron are calculated. With regard to the μ-e decay and the anomalous magnetic moments, a consistent solution of the coupling constants is found for the theory in which the intermediate boson interacts with neutrino in the super-weak coupling and with the fermions (other than neutrino) in the meso-strong coupling. (auth)

567

20852 ASYMPTOTIC PROPERTIES AND ZEROS OF THE FORWARD SCATTERING AMPLITUDE. Józef

Namysłowski and Romuald Wit (Jagellonian Univ., Krakow). Acta Phys. Polon., 23: 197-203(Feb. 1963). (In English)

Starting from the well established agreement between the one subtracted ordinary dispersion relation and the experimental data, the diffraction picture for the pion-nucleon forward scattering amplitude at very high energy is presented. It is found that there are two or four zeros lying in the domain of analyticity of the pion-nucleon forward scattering amplitude. (auth)

568

27167 (UCRL-11333) A MEASUREMENT OF $d\sigma(0)/d\Omega$ FOR THE REACTION $\pi^- + p \rightarrow \pi^0 + n$ AT 900 Mev IN THE 72-INCH HYDROGEN BUBBLE CHAMBER. Alan Natapoff and Vo Xuan Bang (Lawrence Radiation Lab., Univ. of California, Berkeley). Mar. 13, 1964. Contract W-7405-eng-48. 17p. Dep.(mn); $1.00(cy), 1(mn) CFSTI.

A low-statistics measurement of $d\sigma(0)/d\Omega$ for the reaction $\pi^- + p \rightarrow \pi^0 + n$ at 1.03 Bev/c in the 72-inch hydrogen bubble chamber is described. The π^- beam comes from the Bevatron, and the secondary neutrons are detected when subsequent elastic scatters $n + p \rightarrow n + p$ yield visible stopping protons. The real events were separated from the spurious by a Boolean algebraic method that reduced the set of all events to a sum of a small number of physically significant sets. The residual background fraction was estimated at 10% by a computer simulation technique using the known beam distribution and a pure sample of background events. The bubble chamber, so used, detects about 5% of the secondary neutrons emitted in the charge-exchange reaction. There were 12 experimental events in three intervals lying in the range $0.84 \leq \cos\theta^{c.m.}_{\pi^0} \leq 0.96$. A zero-constraint, least-squares fit of the distribution yielded the estimate $d\sigma^{ce}(0)/d\Omega = (3.65 \pm 1.93)$mb/sr. This result is consistent with the predictions based on the dispersion relations. (auth)

568a

37542 (UCRL-11333(Rev.)) A MEASUREMENT OF $d\sigma(0)/d\Omega$ FOR THE REACTION $\pi^- + p \rightarrow \pi^0 + n$ AT 900 Mev IN THE 72-INCH HYDROGEN BUBBLE CHAMBER. Natapoff, Alan; Bang, Vo Xuan (Lawrence Radiation Lab., Univ. of California, Berkeley). May 1964. Contract W-7405-eng-48. 14p. Dep.(mn); $1.00(cy), 1(mn) CFSTI.

The pion-nucleon dispersion relations, based on the principle of microscopic causality, permit the calculation of the real parts of the forward amplitudes for π^--p and π^+-p scattering at a fixed energy, if the corresponding total cross sections are known as a function of energy. In addition, the forward differential cross section, $d\sigma^{ce}(0)/d\Omega$, for charge exchange ($\pi^- + p \rightarrow \pi^0 + n$) was calculated previously, assuming charge independence. Experimental values for the latter, therefore, can help to determine the validity of the principle of microscopic causality. A low-statistics measurement of $d\sigma^{ce}(0)/d\Omega$ at 1.03 Bev/c in the 72-inch hydrogen bubble chamber is described. The π^- beam came from the Bevatron, and the secondary neutrons were detected when subsequent elastic scatters $n + p \rightarrow n + p$ yielded visible stopping protons. The real events were separated from the spurious by a Boolean algebraic method that reduced the set of all events to a sum of a small number of physically significant sets. The residual background fraction was estimated at 10% by a computer simulation technique using the known beam distribution and a pure sample of background events. The bubble chamber, so used, detected about 5% of the secondary neutrons emitted in the charge-exchange reaction. There were 12 experimental events in three intervals lying in the range $0.84 \leq \cos\theta^{c.m.}_{\pi^0} \leq 0.96$. A zero-constraint, least-squares fit of the distribution yielded the estimate $d\sigma^{ce}(0)/d\Omega = (3.65 \pm 1.93)$ mb/sterad. This result is consistent with the predictions based on the dispersion relations. (auth)

569

47347 S-WAVE PION-PION SCATTERING IN THE STATE T = 0. Nath, Ravinder; Pande, L. K. (Univ. of Delhi). Nuovo Cimento (10), 36: 1035-8(Apr. 1, 1965).

An attempt is made to reproduce the correct scattering length for the possible S-wave, T = 0 $\pi\pi$ resonance, the σ meson, in a simple N/D method, using a knowledge of the forces due to the low-mass intermediate states in the crossing channel. One- and two-channel calculations are made for the $\pi\pi \rightarrow \pi\pi$ and $\pi\pi \rightarrow K\bar{K}$ scattering; it is not found possible to obtain the σ meson in this way. (M.J.T.)

570

31611 INTERACTIONS OF π^+ MESONS WITH HYDROGEN AND CARBON AT 78 MEV. D. V. Neagu and R. G. Salukvadze (Joint Inst. for Nuclear Research, Dubna, USSR and Tbilisi Inst. of Physics, Academy of Sciences, Georgian SSR). Acad. rep. populare Romîne, Inst. fiz., atomică şi Inst. fiz. Studii cercetări fiz., 12: No. 1, 39-54(1961). (In Rumanian)

Interactions of 78 ± 2.35 Mev π^+ mesons with hydrogen and carbon were studied by means of a propane bubble chamber. The elastic scattering cross section $\sigma(\pi^+, \rho) = (38.85 \pm 5.95)$ mb and the total scattering cross section $\sigma(\pi^+, C) = 166 \pm 13.6$ mb were determined. Angular distributions and the absorption cross section $\sigma_{abs}(\pi^+, C) = (180 \pm 20)$ mb were also determined. Star distribution by the number of prongs is described by $\bar{l} = 2.50 \pm 0.18$. The angular distribution of prongs in relation to the incident meson is anisotropic with a coefficient $(N\uparrow - N\downarrow / N\uparrow - N\downarrow) = 0.13 \pm 0.02$. Seventy percent of the absorption takes place through capture by nucleon pairs, while in the rest of the cases, a larger complex of nucleons participate in the capture. (R.V.J.)

571

4464 PHOTOPRODUCTION AND SCATTERING OF PI-MESONS. N. F. Nelipa, International Monographs on Advanced Mathematics and Physics Series. Translated from the Russian (Russian Tracts on Advanced Mathematics and Physics. Volume 7). New York, Gordon and Breach Science Publishers, 1963. 107p. $5.00.

Experimental data on the photoproduction and scattering of mesons (π) on nucleons are presented. The photoproduction differential cross section and the relation between the processes of scattering and photoproduction are discussed.

The decomposition of a plane photon wave is considered, and an expression for the polarization of neutrons is derived. Tables of Clebsch-Gordon, Racah, and Z-coefficients are included. (C.E.S.)

572

1193 ON THE ABSORPTION OF STOPPED π^--MESONS BY ^{12}C NUCLEI. Nguyen-Trung, C.; Cheon, Il-T. Sakamoto, Y. (Kyoto Univ.). Phys. Lett., 19: 232-4(Oct. 15, 1965).

The absorption of a stopped meson (π^-) by a nucleon pair with the emission of a high-energy nucleon was studied. The other nucleon is trapped by the nucleus and renders it highly excited. The excitation energy distribution of the ^{11}B nuclei was calculated. (D.C.W.)

573

41804 INTERACTION OF POSITIVE PIONS WITH HYDROGEN AT 600 Mev. Peter C. A. Newcomb (Univ. of California, Berkeley). Phys. Rev., 132: 1283-92(Nov. 1, 1963). (UCRL-10682)

A hydrogen bubble chamber was used to investigtae $\pi^+ - p$ interactions at 600 Mev. There were 1738 good events, of which 71.9 ± 0.8% were elastic. Partial waves up to at least $D_{3/2}$ are required to fit the elastic angular distribution. The inelastic evenis were almost entirely single-pion production. The ratio (p + 0)/(n++) was found to be 5.5 ± 0.8, which agrees well with 4.9 predicted by the $(3/2,3/2)$ pion-nucleon isobar model of Olsson and Yodh. It is also consistent with 6.5 predicted by Sternheimer and Lindenbaum. The pion momentum spectra and the $\pi - \pi$ Q-value distributions also support the Olsson and Yodh model. Thus the $(3/2,3/2)$ pion-nucleon isobar is apparently the principal mechanism for single-pion production at 600 Mev. Angular distributions for the single-pion-production data are presented. (auth)

574

28156 (UCRL-10563) π^+-p SCATTERING AT 600 Mev (thesis). Peter Cyrenius Adelbert Newcomb (California. Univ., Berkeley. Lawrence Radiation Lab.). Jan. 7, 1963. Contract W-7405-eng-48. 80p.

The Berkeley 15-inch hydrogen bubble chamber was used at the Bevatron to investigate π^+-p interactions at 600 Mev. Seventeen hundred and thirty-eight good events were found; 71.9 ± 0.8% of these were elastic. The inelastic interactions were almost entirely single pion production. The elastic angular distribution was fitted by a fourth order polynomial in cos $\theta_{c.m.}$. This implies that states with an orbital angular momentum of at least 2 $\hbar$ were present. It was also shown that the upper bound of the total angular momentum was at least (5/2) $\hbar$, where $\hbar$ is Plank's constant divided by 2 π. For the single pion production, the ratio of the number of interactions of the type $\pi^+ + p \rightarrow \pi^+ + p + \pi^0$ to those of the type $\pi^+ + p \rightarrow \pi^+ + n + \pi^+$ was found to be 5.5 ± 0.8. This result is in good qualitative agreement with the value 6.5 predicted by Sternheimer and Lindenbaum. The pion momentum spectra for the reaction $\pi^+ + p \rightarrow \pi^+ + p + \pi^0$ do not show the dip predicted by Bergia, Bonsignori, and Stanghellini. A peak was found in the $Q(\pi^+\pi^0)$ distribution; however, it is thought that this peak is more likely to be an effect of the $(3/2, 3/2)$ pion-nucleon isobar than that of a π-π resonance. Angular distributions are also given for the inelastic events. 21 references. (auth)

575

17297 DECAY OF BOUND MUONS IN TITANIUM, IRON, AND LEAD. Lloyd Carlisle Nielsen. Thesis, Salt Lake City, Univ. of Utah, 1962. 102p.

The bound muon decay rate λ_d was measured for Ti, Fe, and Pb by observing the composite time distribution of decay electrons from positive and negative cosmic-ray muons. The decay electrons were detected in a 12" deep carbon-tetrachloride Čerenkov counter which absorbed most of the electron energy. Aluminum reference targets were used to avoid the necessity for precise knowledge of the abundance ratio of positive to negative cosmic-ray muons. Particular care was taken to correct the data for contamination by muon-capture events, and for differences in decay-electron spectra. The ratio λ_d/λ_0 of bound to free decay rates was found to be 0.92 ± 0.06 for Ti, 1.05 ± 0.06 for Fe, and 0.88 ± 0.13 for Pb. The result for Pb is in agreement with recent theoretical predictions. The Ti and Fe results, taken by themselves, are in fair accord with theory. They are in good agreement, however, with the results of other measurements made at this laboratory; the combined results indicate an anomaly of about 8% near Z = 26. This discrepancy is smaller than has been previously reported. (Dissertation Abst., Vol. 23; No. 7)

576

19180 THE INTERACTION AND THE HYPOTHETICAL STRUCTURE OF MUONS. A. I. Nikishov and I. L. Rozental'. p.48-71 of "Nekotoryye Voprosy Fiziki Elementarnykh Chastits i Atomnogo Yadra." Moscow, Gosatomizdat, 1962.

Papers published since 1939 on the interaction of muons and on hypotheses as to muon structure are reviewed. Muons have spin 1/2. The first radiative correction to the magnetic moment is consistent with experimental data. Accelerator experiments showed no scattering anomalies greater than 10^{-29} cm^2 per nucleon in the transfer of momenta less than 400 Mev. Muons can be described by Dirac's equation. It is still unknown why muons and electrons have different masses. The production of muons at very high energies (~ 10^{16} ev) should be studied and the following experiments are recommended: more precise measurement of the magnetic moment, investigation into the production of muon pairs with transfer of large momenta, determination of the form factors of protons and muons from μp scattering, experiments with oppositely directed beams of electrons and positrons, scattering of muons from electrons with transfer of a large transverse momentum, investigation of secondary-particle interaction

ranges in nuclear collisions with $E_0 \gtrsim 10^{15}$ ev, search for anomalously scattered muons having an energy of more than 1 Bev and a cross section of 10^{-31} cm^2 per nucleon, and underground precision measurements of bursts in ionization chambers at great depths. (OTS)

577

9909 ANGULAR DISTRIBUTION OF THE $\mu^+ \rightarrow e^+$ DECAY ELECTRONS IN STRONG MAGNETIC FIELDS. B. A. Nikolsky and S. A. Ali-Zade (I. V. Kurchatov Inst. of Atomic Energy of the USSR Academy of Sciences, Moscow, U.S.S.R.). p.614-17 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

The asymmetry parameter a of the angular distribution of the $\pi \rightarrow \mu \rightarrow e$ decay electrons was studied in magnetic fields with intensities up to 35,000 gauss. Since the μ meson is depolarized in coming to rest, the angular distribution of decay electrons determines the value $a^* = Pa$, where P is the degree of residual polarization of the meson which is stopped in a given moderator. A value of $\frac{1}{3}$ was obtained for a^* at field intensities of 20,000 to 30,000 gauss. A slight increase in a^* was observed with increases in field intensity and with dilution of the emulsion. Results indicated that a depolarization mechanism in addition to muonium formation must exist. (M.C.G.)

578

21072 FUNDAMENTAL PARTICLES. K. Nishijima. Lecture Notes and Supplements in Physics. New York, W. A. Benjamin, Inc., 1964. 419p.

A historical survey of the discovery of muons and pions in cosmic rays is given. The study of invariance principles and their application to the determination of the pion transformation properties are discussed, with consideration of time reversal, parity, spin, and charge conjugation. Charge symmetry and charge independence in nuclear and pion physics are considered. Covariant perturbation theory and dispersion theory are introduced, and the dynamical properties of the pion-nucleon interaction are described in terms of dispersion relations, emphasizing the analysis of nucleon form factors leading to predictions on the presence of vector mesons. A discussion of strange particles and hyperfragments is presented. The violation of parity in weak interactions is discussed. (M.J.T.)

579

47582 (NEVIS–129) ISOTOPIC DIFFERENCES IN THE MU-MESIC K X-RAY ENERGIES OF ^{16}O–^{18}O, ^{40}Ca–^{44}Ca, ^{116}Sn–^{124}Sn, ^{155}Gd–^{160}Gd (thesis). Nissim-Sabat, Charles (Nevis Labs., Columbia Univ., Irvington-on-Hudson, N. Y.). Mar. 1965. Contract Nonr-266(72). 85p. (R–483; CU–235).

The isotopic differences in the μ-mesic K x-ray energies of $^{16}O-^{18}O$, $^{40}Ca-^{44}Ca$, $^{116}Sn-^{124}Sn$, and $^{155}Gd-^{160}Gd$ were measured in order to obtain information about the change in the radius of the nuclear proton distribution as the neutron number is increased. The essential feature of the experimental method is the simultaneous measurement of the spectra of the two isotopes by means of a conventional NaI(Tl) crystal γ-ray spectrometer. Great care was taken to aviod any bias or nonstatistical errors in measurements and analysis by treating the two isotope targets in an exactly similar fashion. Probable contributions to the isotopic shifts from nuclear polarization effects are examined and are found to be negligible. The relevance of isotope shift measurements to the understanding of general nuclear properties, such as compressibility, is also considered. A review is made of the theory of optical isotopic shift measurements in order to determine how they can best be complemented by future high accuracy μ-mesic x-ray measurements. (auth)

580

25277 DEPOLARIZATION OF μ^+ MESONS IN CONDENSED MEDIA. V. G. Nosov and I. V. Yakoleva (Kurchatov Atomic Energy Inst., Moscow). Nucl. Phys., 68: 609-31(July 1965).

A theory of μ^+ meson depolarization in condensed matter is developed. It is shown that the depolarization of a muonium electron in a medium is in general maintained, but is suppressed when the muonium enters into chemical reaction, which occurs long before its decay. Using experimental data on the depolarization of μ^+ mesons in an emulsion the parameters entering the formulas of the phenomenological theory are determined and the asymptotic polarization curve in strong magnetic fields is derived. Several possible mechanisms of the depolarization of a muonium electron as well as some problems of the chemistry of muonium are discussed. The case of substances with a large dielectric constant and its weakly pronounced frequency dispersion is considered. The theory is generalized for the case when the depolarization of a μ^+ meson is due to multiple charge exchange of muonium into μ^+ meson and vice versa. (auth)

581

41803 PION-NUCLEON SCATTERING AND THE J = 2, T = 0 PION-PION INTERACTION. G. C. Oades (Univ. of London). Phys. Rev., 132: 1277-82(Nov. 1, 1963).

The effect of the $J = 2$, $T = 0$ $\pi-\pi$ interaction on the $\pi-N$ invariant amplitude, $B^{(+)}$ is analyzed. It is found that the $\pi-N$ scattering data are inconsistent with a $J = 2$, $T = 0$ $\pi-\pi$ phase δ_2^0 that rises to above 13° around 650 Mev. The data are consistent with a δ-function contribution at 1200 Mev but it is impossible to say whether this corresponds to a resonant phase or only a sharp peak in the corresponding absorptive part of the amplitude. (auth)

582

12236 PI-p ELASTIC SCATTERING IN THE ENERGY RANGE 300-700 Mev. Philip M. Ogden, Donald E. Hagge, Jerome A. Helland, Marcel Banner, Jean-Francois Detoeuf, and Jacques Teiger (Univ. of California, Berkeley). Phys. Rev., 137: B1115-25(Feb. 22, 1965). (UCRL-11180 (Rev.))

Differential cross sections for elastic π-p scattering

were measured at eight energies for positive pions and seven energies for negative pions. Energies ranged from 310 to 650 Mev. These measurements were made at the 3-Bev proton synchrotron. A beam of pions from an internal BeO target was directed into a liquid-hydrogen target. Fifty-one scintillation counters and a matrix-coincidence system were used to measure simultaneously elastic events at 21 angles and charged inelastic events at 78 π-p angle pairs. Events were detected by coincidence of pulses indicating the presence of an incident pion, scattered pion, and recoil proton, and the results were stored in the memory of a pulse-height analyzer. Various corrections were applied to the data and a least-squares fit was made to the results at each energy. The form of the fitting function was a power series in the cosine of the center-of-mass angle of the scattered pion. Integration under the fitted curves gave values for the total elastic cross sections (without charge exchange). The importance of certain angular-momentum states is discussed. The π^--p data are consistent with a D_{13} resonant state at 600 Mev, but do not necessarily require such a resonant state. (auth)

583

17208

SEARCH FOR THE PROCESS $\mu^+ \rightarrow e^+ + \gamma$. T. W. O'Keeffe, M. Rigby, and J. R. Wormald (Univ. of Liverpool). Proc. Phys. Soc. (London) 73, 951-3(1959) June.

The spectrum of positrons emitted by positive muons decaying at rest, in coincidence with a γ-ray photon at 180°, was examined in search of the decay $\mu^+ \rightarrow e^+ + \gamma$. No evidence for the existence of this decay mode was found. An upper limit to the branching ratio ($\mu^+ \rightarrow e^+ + \gamma$ vs. $\mu^+ \rightarrow e^+ + \nu + \tilde{\nu}$) is 7.5×10^{-4}. (L.T.W.)

584

37520 (CAR-882-8) π^- + p INTERACTIONS AT 646 Mev. Oliver, John D. (Carnegie Inst. of Tech., Pittsburgh, Pa. Dept. of Physics). Jan. 1965. Contract AT-(30-1)-882. 134p. Dep.(mn); $4.00(cy), 3(mn) CFSTI.

A study of π^-p reactions at 646 Mev was made using a 14-inch liquid hydrogen bubble chamber. Approximately 6600 good events were analyzed and the following cross sections were obtained: $\sigma_{(elastic)} = 17.56 \pm 0.43$ mb, $\sigma(\pi^0\pi^-p) = 4.65 \pm 0.17$ mb, $\sigma(\pi^-\pi^+n) = 7.14 \pm 0.23$ mb, $\sigma_{neut.} = 11.78 \pm 0.43$ mb, $\sigma(\pi^-\pi^+\pi^0n) = 0.33 \pm 0.04$ mb, and $\sigma(\pi^-p\pi^-\pi^+) = 0.08 \pm 0.02$ mb. This gives a total cross section of 41.54 ± 0.82 mb. The elastic differential cross section was fitted to a 5th order polynomial in $\cos\theta^*$ with coefficients $a_0 = 0.27 \pm 0.02$, $a_1 = 1.48 \pm 0.11$, $a_2 = 3.86 \pm 0.22$, $a_3 = -0.29 \pm 0.53$, $a_4 = -0.65 \pm 0.28$, and $a_5 = 1.69 \pm 0.52$ (mb/ster). The fact that a 5th order curve was needed indicates that partial waves up to $F_{\frac{5}{2}}$ are present. The inelastic reactions are dominated by production of the N*(1238) isobar and were fitted to the model of Olsson and Yodh. The model failed to explain the angular distributions of the reaction products and also failed to explain the $M_{\pi^-\pi^+}$ plot. However, it was successful with the other two-body effective mass plots. (auth)

585

34203 π^- + p INTERACTIONS AT 646 Mev. Oliver, John D.; Nadelhaft, I. (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 147: 932-8(July 29, 1966).

A 14-in. liquid-hydrogen-filled bubble chamber in a 17.5-kG magnetic field was exposed to a beam of negative pions. About 26,000 pictures were taken and examined for the following final states: (1) elastic scattering (π^-p); (2) π^+ production ($\pi^-\pi^+$n); (3) π^0 production ($\pi^-\pi^0$p); (4) neutrals. Values for the cross sections for these processes were obtained. The elastic-scattering angular dependence in the cms was fitted by a power-series expansion in cosθ and the coefficients were evaluated. Cross sections for multiple-pion production were also measured as well as the total neutral cross section, the total charged-events cross section, and the total cross section. For single-pion production events, two-body mass distributions and angular distributions were compared with the predictions of the Olsson-Yodh isobar model. (auth)

586

41509 A FINAL STATE INTERACTION MODEL IN THE REACTION $\pi + N \rightarrow \pi_1 + \pi_2 + N'$ BELOW 1 Bev (thesis). Olsson, Martin Godfrey. College Park, Univ. of Maryland, 1964. 159p.

A phenomenological model for the single pion production process in pion-nucleon reactions is presented. It is the purpose of this model to identify those aspects of the experimental data which are determined by the effects of known final-state interactions, and hence, to calculate some of the gross properties of the primary mechanism and its relation to the elastic pion-nucleon channel. In $T = \frac{1}{2}$ production reactions both $P_{\frac{1}{2}}^+$ and $D_{\frac{3}{2}}^-$ states are large and attractive below 700 Mev. The latter has a phase angle which is rapidly increasing, passing through 90° near 500 Mev. From the relation of this phase angle to the elastic scattering phase shift, a connection to the well-known 600-Mev resonance is established. Below 700 Mev the $T = \frac{3}{2}$ production occurs strongly through an attractive $D_{\frac{3}{2}}^-$ state and a repulsive $P_{\frac{3}{2}}^+$ state. Energy and angle distributions as well as the energy dependence of the cross sections are accounted for in the five experimentally known production reactions. The prominent exception to the preceding statement is the appearance of an anomaly in the pion-pion mass spectra in the two reactions in which the two pions might be in a T = 0 state. The model assumes that only those amplitudes are important in which there exists an attractive interaction between two of the three particles in the final state. Attempts were also made to construct a model which is close enough to reality to be able to fit the experimental data, but yet make a minimum of assumptions about the nature of underlying dynamics. (Dissertation Abstr.)

587

22727 (NP-13860) PHYSIQUE DES MESONS π DE BASSE ENERGIE. (Physics of π Mesons at Low Energy). Roland Omnes (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay). [1961]. 128p.

The main characteristics of mesons (π) and the methods by which they were determined are summarized. Isotopic

spin and quantum field theory are then considered, and π-N scattering at low energies is analyzed. Theory for π-N scattering at low energies in the static model is reviewed, together with Mandelstam representation. (D.C.W.)

588

16989 (NP-11592(Vol.I)(p.467-83)) ANALYSIS OF PION-NUCLEON INTERACTIONS FROM 500 TO 1200 MeV. Roland Omnes and Georges Valladas (France. Commissariat à l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay).

Sets of data on pion-nucleon iteractions at 400 to 1500 Mev are analyzed in an effort to clarify reaction mechanisms. Conclusions concerning resonances and production momenta are listed and recommendations concerning future investigations are included. (J.R.D.)

589

26740 DEPOLARIZATION OF A BEAM MOVING IN A NONUNIFORM MAGNETIC FIELD. Yu. F. Orlov and S. A. Kheifets (Inst. of Physics, Academy of Sciences, Armenian SSR). Izvest. Akad. Nauk Armyan. S.S.R., Ser. Fiz.-Mat. Nauk, 13: 169-71(1960). (In Russian)

Change of the polarization of the particle rotating in a magnetic field may be used for measuring the magnetic moment of μ particles such as electrons or μ mesons. The number of rotations must be quite high (10^8) and for this reason the magnetic field must be focused, making it nonuniform, to prevent the escape of the particles during the experiment. Equations were derived for calculating the motion of particles with given charge, mass, and spin in an electromagnetic field, and solved for the case of magnetic field. (TTT)

590

16233

π^- CAPTURE IN COMPLEX NUCLEI AND NUCLEAR PAIR CORRELATIONS. S. Ozaki, R. Weinstein, G. Glass, E. Loh, L. Neimala, and A. Wattenberg (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. Letters 4, 533-5(1960) May 15.

Scintillation counters in coincidence were used as detectors of neutrons and protons produced in π^- capture by complex nuclei. By measuring neutrons, it was hoped to establish whether π^- capture in complex nuclei involves two nucleons, and if it does, to use the process to study the ratio of neutron-proton pairs to proton-proton pairs. The π^- mesons were stopped in Li, C, Al, S, Cu, and Pb targets. In order to test the spatial correlation of the ejected nucleons, measurements were made with the counters 90° and 180° from each other. The results obtained are given as coincidences as a function of angle. If corrections are made for relative probability of detecting neutrons and protons, the following ratios of n-n events (a) [$\pi^- + p + n \rightarrow n + n$] to n-p events (b) [$\pi^- + p + p \rightarrow n + p$] are obtained: carbon, a/b = 5.0 ± 1.5; aluminum, a/b = 3.9 ± 1.2. Due to background subtractions and secondary events contributing more to the proton coincidence runs, it is felt that these observed ratios are to be taken as lower limits on the ratio of reaction. (B.O.G.)

591

21378 γ-NEUTRINO CORRELATION IN FIRST FORBIDDEN NUCLEAR μ-MESON CAPTURE. Z. Oziewicz and N. P. Popov (Ioffe Inst. of Physics and Tech., Leningrad). Phys. Letters, 15: 273-5(Apr. 1, 1965).

The angular gamma-neutrino correlation in meson (μ) capture is investigated for the case of first-forbidden transitions. The reaction $\mu + {}^{12}C \rightarrow {}^{12}B^* + \nu_\mu$ is considered as an example. (D.C.W.)

592

9166 SEARCH FOR THE DECAY $\mu^+ \rightarrow e^+ + \gamma$. Sherwood Parker, Herbert L. Anderson, and Charles Rey (Univ. of Chicago). Phys. Rev., 133: B768-78(Feb. 10, 1964).

A search was conducted for the decay $\mu^+ \rightarrow e^+ + \gamma$ using spark chambers, scintillators, and fast oscilloscopes. The number of stopped pions, 7.39×10^9, and the detection efficiency of the apparatus for $\mu \rightarrow e + \gamma$ events, 3.9%, would predict the detection of 3 events for a branching ratio of 10^{-8}. No evidence for the existence of this decay was found. The distribution in range of the e^+ in graphite, and of the (e,γ) angle for the events found near 180° was consistent with that expected from $\mu^+ \rightarrow e^+ + \nu + \bar{\nu} + \gamma$. The probability of finding the observed distribution was calculated to be greatest for an assumed $\mu \rightarrow e + \gamma$ branching ratio of zero. This probability drops below 50% of this value if the branching ratio is 0.6×10^{-8}, and below 10% for 2.2×10^{-8}. (auth)

593

25529 DOUBLE-CHARGE-EXCHANGE SCATTERING OF PIONS FROM NUCLEI. R. G. Parsons (Stanford Univ., Calif.), J. S. Trefil, and S. D. Drell. Phys. Rev., 138: B847-50(May 24, 1965). (SLAC-PUB-63)

Pions offer a unique possibility as probes of nuclear structure since they can exchange two units of electrical charge unaccompanied by other quantum numbers. The double-charge-exchange cross section for the reaction $\pi^- + {}^3He \rightarrow \pi^+ + 3n$ was calculated in the impulse approximation using the Chew-Low model for the pion-nucleon interaction. Only the dominant 3-3 channel is retained. For incident pions in the energy region of several hundred Mev, values of the differential cross section of $d^2\sigma/d\Omega dE \approx 1\text{-}10\ \mu b/$ Mev are obtained for forward angles. Triple-scattering terms are also calculated and found to introduce corrections of < 10% in $d^2\sigma/d\Omega dE$. Similar results are obtained when the work is extended to the reaction $\pi^+ + {}^{18}O \rightarrow \pi^- + {}^{18}Ne$ using shell-model wave functions. (auth)

594

1326 $\pi^+ + D$ COLLISIONS AT 650, 750, 850 Mev. E. Pauli (CEN, Saclay, France), A. Muller, R. Barloutaud,

L. Carcin, J. Meyer, M. Beneventano, G. Gialanella, L. Paoluzi, and R. Finzi. p.92-8 of "Proceedings of the Sienna International Conference on Elementary Particles. Vol. I." Bologna, Societa Italiana di Fisica, 1963.

Preliminary results are reported on the analysis of pictures taken with the Saclay deuterium bubble chambers exposed at the synchrotron Saturne to π^+ beams of 650, 750, and 850 Mev. Figures show the following: spectator proton and neutron distribution compared to Hulthen distribution normalized between 120 and 250 Mev; differential cross sections for $\pi^+ + n \rightarrow \pi^+ + n$ and $\pi^+ + p \rightarrow \pi^+ + p$ at several intervals of π^+n and π^+p energies; squared mass distribution of missing neutrals in the reaction $\pi^+ + d \rightarrow p + (p_s) +$ neutrals; total cross sections for reactions $\pi^+ + n \rightarrow p + \eta^0$, $\pi^+ + n \rightarrow p + \pi^0$, and $\pi^+ + n \rightarrow p + \pi^0 + \pi^0$ as a function of the center-of-mass pion-nucleon energy; the angular distribution for η production; and differential cross sections of charge exchange reactions at several intervals of π^+n center-of-mass energy. (A.G.W.)

595

22527 AN INVESTIGATION OF PION-PION INTERACTIONS IN THE REGION OF THE SECOND AND THIRD PION-NUCLEON RESONANCES. Charles Clyde Peck. Thesis, Ann Arbor, Mich., Univ. of Michigan, 1962. 131p.

Using a homogeneous sodium-iodide luminescent chamber, the effective mass spectra of the two pions produced in the reaction $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ has been studied at incident pion energies of 871, 775, and 682 Mev. A comprehensive survey of similar experiments is included to provide perspective for the interpretation of the results. A peak in the effective mass spectra with incident pions of 871 Mev is found between 580 and 660 Mev with high momentum transfers to the proton dominating. The possible relationship of this phenomenon to the existence of a J meson is discussed. Additionally, the possibility of peaking structures near 540 Mev in both the 775 and 682 Mev data is considered, with considerable reservation because of possible large errors. Finally, a possible tendency for the accumulation of events in the 350 Mev region of the effective mass spectrum is seen in the data collected at 682 Mev. The possibility that large systematic errors negate this final result does exist. The importance of the fact that this experiment was run in the vicinity of the second and third pion-nucleon resonances is emphasized in interpreting the results and comparing it to similar experiments. (Dissertation Abstr.)

596

24748 EVIDENCE CONCERNING PION-PION INTERACTIONS BELOW THE 765-Mev PION-PION RESONANCE. C. Clyde Peck, Lawrence W. Jones, and Martin L. Perl (Univ. of Michigan, Ann Arbor). Phys. Rev., 126: 1836-44 (June 1, 1962).

A search was made for π-π resonances in the reaction $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ at 871 and 775 Mev, using a sodium-iodide luminescent chamber as a detector. The spectra of m*, the total energy of the 2 pions in their own barycentric system, are presented and compared with the spectra predicted by phase-space alone. The maximum m* is 695 Mev, and the recoil proton momenta are 400 to 700 Mev/c. The 871-Mev spectrum shows a deviation from the phase-space prediction in the form of an abrupt rise at an m* of 590 Mev. This rise is most prominent for the spectrum with recoil proton momenta above 550 Mev/c. The 775-Mev spectrum does not show any strong deviations from phase space. It is concluded that the peak above phase space in the m* spectrum range of 575 to 700 Mev is due to at least one other process besides the 765-Mev 2-π resonance particular. The possible existence of a new two-pion, T = 1 resonance with an m* of about 600 Mev is discussed. An evaluation of the performance of the luminescent chamber is made. (auth)

597

31351 PION-DEUTERON ELASTIC SCATTERING AT 142 Mev AND THE FORM-FACTOR APPROXIMATION. Hugh N. Pendleton (Brandeis Univ., Waltham, Mass.). Phys. Rev., 131: 1833-44(Aug. 15, 1963).

The differential cross section for charged pions with laboratory kinetic energy of 142 Mev to be scattered elastically by deuterons is calculated in a form-factor approximation which includes double scattering effects. The calculations also include effects produced by the D-state part of the deuteron wave function and the repulsive core in the neutron-proton interaction. A meson-theory derivation of an impulse-approximation series for the scattering amplitude using the Heitler-London method is described, as is an "optimal" procedure for obtaining a form-factor approximation to that series. The differences between the optimal form-factor approximation and other versions of the impulse approximation are discussed. The comparison of the calculations with experimental data indicates that pion-deuteron elastic scattering in the region of the first pion-nucleon resonance depends on off-energy-shell features of the pion-nucleon interaction which cannot be treated by a simple form-factor approximation. (auth)

598

18432

PION PRODUCTION BY PIONS. Walton A. Perkins, John C. Carls, Robert W. Kenney, Edward A. Knapp, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev. Letters 3, 56-7(1959) July 1.

In order to study the direct interaction of the incident pion with a virtual pion in the meson cloud surrounding a nucleon, the reaction $\pi + p \rightarrow \pi^+ + \pi^- + n$ was investigated in the energy range from 260 to 430 Mev. Negative pion beams impinged on a 4-in.-thick liquid hydrogen target. Measurements were taken for π^+ mesons emitted at 60, 90, 125, and 160° in the barycentric system for incident π^- kinetic energies of 317, 371, and 427 Mev. An integration was performed over the energy of the π^+ meson at each angle to obtain the angular differential cross section. (W.D.M.)

599

12915 (TID-7686(p.131-4)) EVIDENCE CONCERNING PION-PION INTERACTIONS BELOW THE 765-Mev RESONANCE. Martin L. Perl (Michigan, Univ., Ann Arbor).

The interaction π^--p $\rightarrow$ π^--π^0-p at incident pion energies of 775 and 871 Mev was investigated. The results support a two-pion resonance with T = 1 at 575-Mev. Observations on the 765-Mev resonance in this and other π^+-p interactions are also discussed. (D.C.W.)

600

42382 (UCRL-11576) NEUTRAL FINAL STATES IN π^-p INTERACTIONS FROM 500 TO 1300 Mev. Vincent Z. Peterson, Robert J. Cence, Victor J. Stenger (Hawaii. Univ., Honolulu), Charles B. Chiu, Richard D. Eandi, Robert W. Kenney, Burton J. Moyer, John A. Poirier, and W. Bruce Richards (California. Univ., Berkeley. Lawrence Radiation Lab.). July 1964. Contract W-7405-eng-48. 9p. (CONF-550-82)

From The International Conference on High-Energy Physics, Dubna, USSR, Aug. 1964.

Total cross sections and angular distributions were measured for π^--p interactions at 531 to 1308 Mev. Production of η^0 and single and multiple π^0 was studied. Measurements were made in a 4π spark chamber array. (R.E.U.)

601

18503

FISSION OF Th^{232} NUCLEI BY NEGATIVE μ- AND π-MESONS. M. G. Petrashku and A. K. Mikhul (Joint Inst. of Nuclear Research, Dubna, U.S.S.R.). Doklady Akad. Nauk S.S.S.R. 126, 752-4(1959) June 1. (In Russian)

Heavy nuclei fission by μ^- mesons is possible through nuclear excitation in the μ^- optic transition 2p–1s in a mesoatom. Fission occurs when the transition exceeds the photoproduction threshold and when mesons are absorbed by nucleons in reactions such as $\mu^- + p \rightarrow n + \nu$. The possibility of non-radiative excitation of nuclei according to the first type of event, with γ emission in the radiation transition followed by nuclear excitation, was observed previously. An attempt is made to obtain data on the non-radiative fission of thorium. In addition to studies of thorium fission by μ^-, studies are made of fission in π^- capture; in evaluating the probability of the first process it is imperative to know the effect of π^- capture, as the μ^- beam is not pure. Some 11,075 π^- capture events were observed, and the star distribution was compared with previously reported data. It was determined that the μ^- contribution was about 15%. Consequently, of the observed 11,075 captures 9400 are related to π^- mesons. In 17 fissions in the same area, ~0.5 events were related to μ^-. Hence, the probability $P(\pi^-)$ in which the π^- capture can initiate fission is equal to $(1.8 + 0.4) \times 10^{-3}$. Capture events totaling 11,270 were observed in plates irradiated by μ^- containing $0.2 \pm 0.1\%$ π^-. It was assumed that not more than 0.1% fissions result from π^- capture. The probability $P(\mu)$ with which μ^- induces fission is $(2.7 \pm 17) \times 10^{-4}$. The results confirm that there is slight probability of catalytic thorium fission by μ^- through non-radiative capture. The evaluation of the internal conversion probability showed one catalytic fission event requires nearly 300 μ^- captures. (R.V.J.)

602

5894

INELASTIC SCATTERING AND ABSORPTION OF 195 ± 15 Mev π^+ MESONS BY CARBON AND LITHIUM NUCLEI. N. I. Petrov, V. G. Ivanov, and V. A. Kusakov (Joint Inst. of Nuclear Studies USSR). Zhur. Eksptl'. i Teoret. Fiz. 37, 957-65(1959) Oct. (In Russian)

Inelastic scattering and absorption of (195 ± 15) Mev π^+ mesons by carbon and lithium ions were studied with a cloud chamber in a magnetic field. The total and differential inelastic scattering cross sections and also the total cross section for exchange scattering and absorption of π^+ mesons were determined. The experimental data obtained are compared with the results of calculation of a casçade in the carbon nucleus, and it is shown that inelastic scattering of mesons can be satisfactorily described on the basis of the pair collision hypothesis. It is shown that primarily only two nucleons of the nucleus participate in the act of absorption of a (195 ± 15) Mev π^+ meson. The probability for meson capture by n,p pairs is 2 to 3 times larger in this case than the probability for capture by pairs of identical nucleons. (auth)

603

7083 (JINR-P-1081) POGLOSHCHENIE π^- MESONOV V VODORODOSODERZHASHCHIKH VESHCHESTVAKH. (Absorption of π^- Mesons in Hydrogenous Substances). V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1962. 9p.

A detailed study was made of π^- capture in hydrogenous substances, and the probability of π^- capture by hydrogen nuclei was determined as a function of the nuclear charge Z chemically bonded with hydrogen. The scheme of the experiment, made using a 75-Mev π^- beam and a series of scintillation counters and Cherenkov spectrometers is included. (R.V.J.)

604

37934 (JINR-P-1309) IZMERENIE RAZNOSTI MASS ZARYAZHENNYKH I NEITRAL'NYKH PIONOV. (Measurement of Mass Difference of Charged and Neutral Pions). V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Prob-

lems). 1963. 11p.

The angular correlation of γ-quanta from the decay of neutral pions produced in the capture of negative pions by protons was measured. The magnitude of the pion mass difference was found to be (4.60 ± 0.02) Mev/c^2. The measurements were made by a method that is not affected by possible systematic inaccuracies due to the determination of the angular resolution and geometric corrections. (auth)

605

22600 PION ABSORPTION IN HYDROGENOUS SUBSTANCES. V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, USSR). Nuovo Cimento (10), 28: 99-106(Apr. 1, 1963). (In English)

The transfer process from hydrogen to other nuclei for negative pions stopped in hydrogenous substances is investigated. The probability of negative pion capture by the bound hydrogen nucleus reduces sharply with an increase of Z of the neighboring nucleus. (auth)

606

21281 ON Pi-MESIC ATOM PROCESSES IN HYDROGEN-CONTAINING SUBSTANCES. V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, USSR). Dokl. Akad. Nauk SSSR, 160: 71-2(Jan. 1, 1965). (In Russian)

An attempt was made to determine the mechanism of the transfer of pions from hydrogen atoms to heavier atoms in hydrogen-containing substances such as styrene. The negative pions passed through scintillation counters, were slowed down, and stopped in the target. The resultant gamma quanta were registered by Cherenkov total-absorption spectrometers. Various gases and solutions were used as the targets. The results showed that a probability of capture of pions by nuclei of bound hydrogen does not depend on the density of the material employed (ethane). Similar results were obtained also with solutions. It follows therefore that the transfer of pions in hydrogen-containing substances is a process which occurs with large intensity only when the distances between the hydrogen atoms and the heavy atoms are small. It is also concluded that the mechanism is more complicated than assumed previously by Panofsky et al. It is to be expected, in particular, that the intensity of the transfer depends essentially on the molecular structure of the substance. (ATD)

607

3237 (JINR-P-1767) O π-MEZOATOMIYKH PROTSESSAKH V VODORODOSODERZHASHCHIKH VESHCHESTVAKH. (On π^--Mesoatomic Processes in Hydrogenous Substances). V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 4p. Dep.(mn).

The capture of negative pions by protons in hydrogenous substances (gases and solutions) was investigated. It is shown that the pion transfer from hydrogen to heavier atoms has a local character. (auth)

608

19149 RADIATIVE CAPTURE OF STOPPED NEGATIVE PIONS BY NUCLEI. V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., 66: 669-72(May 1965).

Experiments aiming at the radiative capture of stopped π^- mesons by nuclei are described. The probability of the process detected is 2×10^{-2} and depends weakly upon nuclear charge and mass. The energy spectrum of γ quanta emitted in the capture turned out to be hard. The mean γ energy was about 80 Mev. (auth)

609

30721 (JINR-P-1663) RADIATSIONNII ZAKHVAT OSTANOVIVSHIKHSYA π^--MEZONOV YADRAMI. (Radiative Capture of Stopped π^- Mesons by Nuclei). V. I. Petrukhin and Yu. D. Prokoshkin (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1964. 7p.

The search experiments described were undertaken to detect a small-intensity radiative capture of π^- mesons by complex nuclei. The probability of the process is 2×10^{-2}; it does not depend significantly on the nucleus charge. The energy spectrum of γ-quanta measured with the help of the Cherenkov spectrometer turned out to be "hard," its average energy being about 80 Mev. (auth)

610

37740 (JINR-P-2780) PEREZARYADKA OSTANOVIVSHIKHSYA π-MEZONOV NA LEGKIKH YADRAKH. (Charge of π-Mesons Stopped on Light Nuclei). Petrukhin, V. I.; Prokoshkin, Yu. D.; Filippov, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 5p. Dep. mn.

Measurements were made of the charge exchange of π^- mesons stopped on ^{3}He nuclei. The charge exchange of the stopped π^- mesons on ^{10}B, ^{14}N, and ^{35}Cl was depressed by 10^4 folds. (tr-auth)

611

8101 (NYO-9283) INTERACTIONS OF 141 MEV NEGATIVE PIONS WITH DEUTERIUM. Edward G. Pewitt (Carnegie Inst. of Tech., Pittsburgh). May 1961. Contract AT(30-1)-882. 108p.

The interactions of 141-Mev π^- mesons with deuterium were studied using a bubble chamber. The elastic differential cross section was measured at Θ_π^{Lab} = 30 to 180° by examining the angular correlation, range of positive recoil, and coplanarity of those scatterings which resulted in two outgoing charged particles. The accuracy of the measurements in the backward hemisphere was of the order of 10 to 15 per cent. This elastic differential cross section was compared to the results of impulse approximation calculations and found to disagree for backward scattering. The differential cross section for the sum of elastic plus inelastic scattering ($\pi^- + d \rightarrow \pi^- + d$ or $\pi^- + d \rightarrow \pi^- + p + n$) was measured at Θ_π^{Lab} = 10 to 180°. The cross section for

elastic plus inelastic scattering was determined to be 137 ± 7 mb. The cross section for the three reactions giving neutral products ($\pi^- + d \rightarrow 2n$, $2n + \pi^0$, and $2n + \gamma$) was found to be 34.4 ± 2.6 mb. This gave a $\pi^- + d$ total cross section of 171 ± 7 mb. The results are compared with impulse approximation calculations. (auth)

612

31350 π^--D SCATTERING AT 142 Mev. E. G. Pewitt, T. H. Fields, G. B. Yodh, J. G. Fetkovich, and M. Derrick (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 131: 1826-32(Aug. 15, 1963).

The interactions of 142-Mev π^- mesons with deuterium have been studied using a 15-cm bubble chamber in a 12.7 kG field. The angular distributions for elastic and inelastic scattering were measured. The elastic differential cross section for scattering angles greater than 90° is not in agreement with theoretical calculations based on the impulse approximation. The total cross section for neutral products ($2\underline{n}$, $2\underline{n} + \gamma$, $2\underline{n} + \pi^0$) was measured to be 37.2 ± 2.8 mb. The sum of the separate cross sections gave the $\pi^- + \underline{d}$ total cross section to be 183 ± 7 mb. (auth)

613

9811 ELASTIC SCATTERING OF 142 MeV NEGATIVE PIONS BY DEUTERONS. E. G. Pewitt, G. B. Yodh, M. Derrick, J. Fetkovich, and T. Fields (Carnegie Inst. of Tech., Pittsburgh, Penna.). p.196-8 of "Proceedings of the 1960 Annual International Conference on High Energy Physics at Rochester, The University of Rochester, Rochester, N. Y., August 25–September 1, 1960."

A measurement of elastic π-d scattering at 142 Mev was undertaken in order to provide experimental data to compare with the results of impulse approximation calculations. A negative pion beam was used to bombard a deuterium bubble chamber. The method used for the selection of elastic π-d scattering tracks is given. The experimental results were found to be at variance with the theory that is based on the impulse approximation and takes into account double scattering, some recoil effects, and the D state of the deuteron. (M.C.G.)

614

889 π^--p INTERACTIONS AT 905, 960, AND 1100 Mev. E. Pickup, D. K. Robinson, E. O. Salant, F. Ayer, and B. A. Munir (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 132: 1819-30(Nov. 15, 1963). (BNL-7125)

Single-pion production in π^--p interactions was studied at 905, 960, and 1100 Mev. Comparison with the isobar and one-pion-exchange (OPE) mechanisms of pion production shows that, below 1 Bev, pion production occurs primarily through the formation of an intermediate excited state of the nucleon (isobar), while at higher energies the influence of the ρ resonance in the $\pi\pi$ system becomes increasingly important. There is some evidence for an I = 2 state in the events at the lower energies. (auth)

615

41482 ON THE DECAY $\pi \rightarrow \mu + \nu + e^+ + e^-$. Pikin, S. A.; Kharkats, Yu. I. (Inst. of Engineering and Physics, Moscow). Soviet J. Nucl. Phys. (English Transl.), 1: 207-10(Aug. 1965).

Translated from Yadern. Fiz., 1: 291-5(Feb. 1965).

The decay $\pi \rightarrow \mu + \nu + e^+ + e^-$ is considered, where the e^+e^- pair is created by a virtual γ quantum from internal bremsstrahlung. The total decay probability, equal to 2.6×10^{-6} of the $\pi \rightarrow \mu + \nu$ probability, and the differential distribution with respect to energy and angle are obtained. The possibility of using this decay to determine the mass of the muonic neutrino is investigated. (auth)

616

18223 IONIZATION MEASUREMENTS OF DIFFUSION CLOUD-CHAMBER TRACKS. G. Piragino (Universita, Turin). Nucl. Instr. Methods, 25: 362-4(Jan. 1964).

An application of the relative photometric method for measuring the ionization of tracks in diffusion cloud-chamber pictures is described. One shows the possibility to recognize the proton and π-meson tracks from their momentum and ionization measurements in many cases when their visual identity is ambiguous. The results are also in good agreement with the known ionization energy loss of the π-mesons as a function of their momenta. (auth)

617

20090 CERN-59-27

European Organization for Nuclear Research, Geneva.

A PROPOSED FRACTIONAL-NANOSECOND TIME-OF-FLIGHT INSTRUMENT. H. L. Pizer. Aug. 10, 1959. 13p.

A fractional nanosecond time-of-flight instrument is proposed for a particular experiment on the muon gyromagnetic ratio. It will be possible to measure the phase of arrival of the μ meson and electron relative to a fixed frequency (175 Mc/s) and to measure this time difference to a precision of $\frac{1}{6}$ nS in any phase revolution. The instrument in addition is a general purpose time-of-flight device. The range-of-flight times may be arranged to be switched by choosing appropriate frequencies of the fixed generator such that the delay cables between the channels always give a 90° phase shift. (auth)

618

13524 PION-PROTON INTERACTIONS AT 450 Mev [Thesis]. Poirier, Charles Philip. Bloomington, Ind., Indiana Univ., 1965. 102p.

A study of π^+-p interactions at 450 Mev using the 14 inch Brookhaven National Laboratory liquid hydrogen bubble chamber is reported. The reactions studied are $\pi^+ + p \rightarrow \pi^+ + p$, $\pi^+ + p \rightarrow \pi^+ + \pi^0 + p$, and $\pi^+ + p \rightarrow \pi^+ + \pi^+ + n$. The angular distribution of the elastically scattered positive pions was fit with a fourth order polynomial in $\cos \theta_\pi$. Normalizing the data to a total cross section of 29.44 ±

1.63 mb gives an elastic cross section of 28.11 ± 2.88 mb. A phase shift analysis of the angular distribution with all inelastic parameters set equal to 1 yielded a set of $T = 3/2$ phase shifts. Introduction of inelastic parameters different from 1 did not produce any substantial changes in the original solutions. The $(p + 0)/(+ + n)$ ratio was found to be 3.57 ± 1.54, which agrees with the ratio 4.9 predicted by the (3,3) pion-nucleon isobar model of Olsson and Yodh. The pion kinetic energy spectra from (p + 0) also supports the isobar model. The angular distribution of the elastically scattered negative pions was fit to a fourth order polynomial in $\cos\theta_\pi$. Normalizing the data to a total cross section of 33.03 ± 0.69 mb gives an elastic cross section of 16.74 ± 1.73 mb. The distribution of events on the Dalitz plot for the (p − 0) production reaction is reasonably well accounted for by the Olsson and Yodh isobar model. However, for the (− + n) production reactions, the model does not describe adequately the distribution of events on the Dalitz plot. Analysis of the (− + n) data in terms of π-n pairings shows that the π^+ production process is dominated by the $(N^*_{33})^-$, and in fact the data are consistent with no $(N^*_{33})^{++}$ production. Thus, while the (3,3) pion-nucleon isobar is apparently the principal mechanism for single pion production at 450 Mev, the data indicate the existence of some T = 0 two-pion interaction that modifies the simple isobar model. (Dissertation Abstr.)

619

39793 π^-p INTERACTIONS AT 460 Mev. Poirier, C. P.; Tilger, C. A.; Alyea, E. D. Jr.; Martin, H. J. Jr.; Rhode, J. I.; Scandrett, J. H. (Indiana Univ., Bloomington). Phys Rev , 148: 1311-14(Aug. 26, 1966).

A total of 1589 two-prong events were observed in an exposure of the Brookhaven National Laboratory 14-in. bubble chamber at the Cosmotron. The fit to the elastic angular distribution requires terms through $\cos^4\theta_{c.m.}$. The ratio of the inelastic cross sections $\sigma(\pi^-p \rightarrow \pi^-\pi^+n)/\sigma(\pi^-p \rightarrow \pi^-\pi^0p)$ is 3.75 ± 0.46. The $\pi^-p \rightarrow \pi^-\pi^+n$ reaction is dominated by formation of the π^-n isobar and an enhancement in the di-pion mass spectrum previously reported by Kirz. The $\pi^-p \rightarrow \pi^-\pi^0p$ reaction shows no structure in the effective-mass spectra. (auth)

620

17384 π^+p INTERACTIONS AT T_π = 450 Mev. Poirier, C. P.; Tilger, C. A.; Alyea, E. D. Jr.; Martin, H. J. Jr.; Scandrett, J. H. (Indiana Univ., Bloomington). Phys. Rev., 143: 1092-5(Mar. 25, 1966).

Elastic and inelastic π^+p interactions at 450 Mev were studied. The inelastic cross section is (4.3 ± 0.4)% of the total cross section. The ratio of the single-pion production cross sections $\sigma(\pi^+p \rightarrow \pi^+\pi^0p)/\sigma(\pi^+p \rightarrow \pi^+\pi^+n)$ is 3.5 ± 1.0. Terms up through $\cos^4\theta_{cm}$ are needed to fit the elastic angular distribution. The effective-mass distributions for π^0 production show (π^+p) isobar formation and are compared with predictions of the Olsson-Yodh isobar model. (auth)

621

21293 $C^{12}(\pi^-,\pi^-n)C^{11}$ EXCITATION FUNCTION. A. M. Poskanzer and L. P. Remsberg (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 134: B779-82(May 25, 1964). (BNL-7687; CONF-439-1)

The $^{12}C(\pi^-,\pi^-n)^{11}C$ excitation function was measured with incident pions of energies from 0.45 to 1.9 Bev. The excitation function of this simple nuclear reaction shows effects of the elementary pion-nucleon resonances. The π^-−n resonances tend to be reproduced in the excitation function, while the π^- −p resonances tend to cause a reduction in the cross sections. The production of ^{11}C and ^{18}F by π^- interactions with Al targets was also studied over the same energy range. These excitation functions do not exhibit any structure. (auth)

622

8229 MUON CAPTURE IN HYDROGEN. H. Primakoff (Univ. of Pennsylvania, Philadelphia). p.128-39 of "Weak Interactions and Topics in Dispersion Physics." New York, W. A. Benjamin, Inc., 1963.

The quantitative theory of muon capture by a proton was investigated and the capture rate in $[p\mu^-p]\gamma$ was calculated, where $[p\bar{\mu}p]\gamma$ refers to the predominant formation of the $[p\mu^-p]$ molecule (ion) in an effectively stable 1s ortho configuration. The transition matrix element for muon capture by protons was developed, and the character of the nucleon states was determined. Dispersion-theoretical representations for the form factors were constructed, and explicit expressions for dispersion relation integrals were obtained from empirical data for electron scattering form factors. The muon capture rate, 560 sec^{-1}, was found to be in rough agreement with experimental values. (L.B.S.)

623

19044 STUDY OF MU-MESONIC X-RAYS: ELEMENTS FROM SULPHUR TO MOLYBDENUM. D. Quitmann (Technische Hochschule, Darmstadt, Ger.), R. Engfer, U. Hegel, P. Brix, G. Backenstoss, K. Goebel, and B. Stadler. Nucl. Phys., 51: 609-33(Mar. 1964).

For twelve elements between sulfur and molybdenum, the energy of the mu-mesonic 2p-1s transition and the difference of these energies for neighboring elements were measured. Special care was taken to reduce and to study systematic errors, and the measurements were repeated under different conditions. Some of the control measurements and the data analysis are described. Background spectra are reported. The mu-mesonic 2p-1s energies agree well with those calculated under the assumption that the maximum density of nuclear matter and the surface thickness are constant for the nuclei studied. The intensities of the 3p-1s transition and of an unresolved group of higher K lines were evaluated relative to the 2p-1s line. (auth)

624

11679 MEASUREMENTS OF MASS OF SINGLE CHARGED PARTICLES EMITTED BY ABSORPTION OF MESONS IN EMULSION NUCLEI. N. R. Rabin, A. O. Weissenberg, and E. D. Kolganova (Inst. of Theoretical and Experimental Physics, Moscow). Phys. Letters, 2: 110-12 (Aug. 15, 1962). (In English)

The mass of single charged particles emitted from stars produced by absorption of slow π^- mesons stopped in emulsion were measured in the range 20 to 100 Mev. Capture phenomena on light (C, N, and O) and heavy (Ag and Br) nuclei were differentiated on the basis of the standard criteria of Coulomb barrier and Auger electrons. The basic results were obtained by measuring the multiple Coulomb scattering by the constant sagitta method, and the measurements were repeated by counting the number of δ electrons versus residual range and by measuring ionization versus residual range. (H.D.R.)

625

43090 LOW-ENERGY D-WAVE π-π SCATTERING PHASE SHIFTS. Rae, H. C. (Univ. of Durham, Eng.). Nuovo Cimento (10), 39: 270-8(Sept. 1, 1965).

A solution of the D-wave $\pi\pi$ scattering inverse amplitude dispersion relations is obtained which satisfies crossing on the nearby left-hand cut. The D-wave $\pi\pi$ phase shifts are calculated at low energies for isospin 0 and 2. (auth)

626

14344

SCATTERING OF PI MESONS. J. Rainwater (Columbia Univ., New York). p.228-61 of "Proceedings of the International Conference on the Nuclear Optical Model, March 16 and 17, 1959, Florida State University, Tallahassee, Florida." Alex E. S. Green, Charles E. Porter, and David S. Saxon, eds. The Florida State University Studies, Number Thirty-Two. Tallahassee, Florida, The Florida State University, 1959.

Work at Nevis Cyclotron Lab. on negative pion scattering at 80 Mev is described. A transmission arrangement of the scatterer was used. The energy definition is well enough determined to separate between the elastic scattering and inelastic scattering with the excitation of the nucleus of the order of 5 Mev. (W.D.M.)

627

7411 PION STUDIES WITH SILICON DETECTORS. Raju, M. R.; Aceto, H.; Richman, C. (Univ. of California, Berkeley). Nucl. Instrum. Methods, 37: 152-8(Nov. 1965). (UCRL-16071).

Measurements are made of the most probable energy loss in silicon for pions of energies extending from 365 to 50 Mev. The results agree within 2% with the theoretical values. The behavior of the pion beam with its inherent muon and electron contaminants, as it passes through various thicknesses of absorbing material, is displayed. The energy distribution of negative pion stars in silicon is measured and found to be a constantly decreasing function of energy, with the high-energy tail extending beyond 60 Mev. (auth)

628

12531 SCATTERING OF PIONS FROM H_3 AND He_3. G. Ramachandran and K. Ananthanarayanan (MATSCIENCE, Madras). Nucl. Phys., 64: 652-6(Apr. 1965).

The scattering of pions from the three-nucleon systems ^3H and ^3He is studied taking into consideration the admixture of the S state of mixed symmetry. It is found that the differential cross section is most sensitive to the percentage admixture of this state at around 90°. (auth)

629

10834 ON THE SCATTERING OF PIONS BY DEUTERONS. Alladi Ramakrishnan, V. Devanathan, and K. Venkatesan (Univ. of Madras). Nuclear Phys., 29: 680-6(Feb. 1962). (In English)

The pion scattering by deuterons was studied under the impulse approximation, and explicit expressions for the cross sections for elastic, inelastic, and charge exchange scatterings were obtained using the Chew-Low amplitude for pion-nucleon scattering. Numerical calculations were carried out, and comparison was made with experimental results. (auth)

630

9223 ELASTIC SCATTERING OF PIONS BY ALPHA-PARTICLES. A. M. Harunar Rashid (Atomic Energy Centre, Lahore, West Pakistan). J. Nat. Sci. Math., 2: 73-82(Oct. 1962).

The elastic scattering of pions by alpha particles at 300 Mev is calculated using the variational technique which includes the effects of multiple scattering quite simply. The results of the calculation are compared with the experiment on angular distribution and reasonable agreement is obtained. (auth)

631

11650 (UCRL-10531) NUCLEAR REACTIONS INDUCED BY PIONS AND PROTONS (thesis). Paul L. Reeder (California. Univ., Berkeley. Lawrence Radiation Lab. and California. Univ., Berkeley. Dept. of Chemistry). Nov. 27, 1962. Contract W-7405-eng-48. 180p.

Effects due to elementary particle-like collisions within nuclear matter have been observed in several nuclear reactions caused by pions and protons. Simple nuclear reactions of the form $Z^A(a,an)Z^{A-1}$ and $Z^A(a,ap)(Z-1)^{A-1}$ have excitation functions that are sensitive to changes in the elementary-particle cross sections. The excitation function for the reaction $C^{12}(\pi^-, \pi^-n)C^{11}$ is measured from 53 to 1610 Mev by bombarding targets of plastic scintillator with pions. The intensity of the pion beam is monitored with a two-counter telescope and 40 Mc scaling system. The scintillator target is mounted on a phototube and becomes the detector for the carbon-11 positron activity. Corrections are made for muon contamination in the beam, coincidence losses in the monitor system, carbon-11 activity produced by stray background at the accelerator, carbon-11 activity produced by secondaries in the target, and the efficiency of the carbon-11 detection system. The

$C^{12}(\pi^-, \pi^-n)C^{11}$ cross sections rise to a peak of about 70 mb at 190 Mev, that corresponds to the resonance in free-particle π^-n scattering at 190 Mev. Calculations based on a "knock-on" collision mechanism and sharp-cutoff nuclear density reproduce the shape of the experimental excitation function, but the magnitudes of the calculated values are low by a factor of six. The calculation shows that the $C^{12}(\pi^-, \pi^-n)C^{11}$ reaction occurs in the nuclear surface region at all bombarding energies. The contributions to the (π^-, π^-n) reaction predominate on the front surface of the nucleus in order to give the pion the maximum probability of escaping. The excitation functions for the reactions $Zn^{68}(p,2p)Cu^{67}$ and $Fe^{57}(p,2p)Mn^{56}$ are measured radiochemically from 400 Mev to 6.2 Bev. The slight increase in the (p,2p) cross sections measured from 400 to 720 Mev is related to the occurrence of a quasi-free-particle pp collision within the nucleus. Due to the proton momentum distribution, the increase is not as pronounced as the rise in free-particle pp total cross sections from 400 to 1000 Mev. From 2.2 to 6.2 Bev, the $Zn^{68}(p,2p)Cu^{67}$ and $Fe^{57}(p,2p)Mn^{56}$ cross sections are constant at 21 ± 2 mb and 50 ± 8 mb, respectively. The difference in magnitudes of the (p,2p) cross sections is ascribed to the availability of only two protons in zinc-68 and of six protons in iron-57 for this particular reaction. The free-particle effects are not seen in more complex reactions as evidenced by the constant cross sections from 0.72 to 6.2 Bev for the yields of manganese-51 and -52 from the reactions of protons with iron and for the yields of copper-61 and -64 from the reactions of protons with zinc. Cross sections are presented for a few products from pion-induced reactions requiring several nucleons to be emitted. The yields of manganese-56 and -52 and iron-52 from the bombardment of natural copper by negative pi meson, the yields of copper-67, -61, and -64 and manganese-52 and -56 from the negative pi meson bombardment of natural zinc, and the cross section for sodium-24 from negative pi meson + aluminum-27 are compared to the yields for similar reactions induced by protons. At the high energies considered here, interaction of negative pi meson with these targets is shown to give yields that are of the same order of magnitude as the yields from proton reactions. These results are interpreted as experimental evidence that pion processes are very important for energy transfer in high-energy nuclear reactions. 99 references. (auth)

632

9394 EXCITATION FUNCTION FOR THE $C^{12}(\pi^-, \pi^-n)C^{11}$ REACTION. Paul L. Reeder and Samuel S. Markowitz (Univ. of California, Berkeley). Phys. Rev., 133: B639-46(Feb. 10, 1964). (UCRL-10924)

The excitation function for the reaction $C^{12}(\pi^-,\pi^-n)C^{11}$ was measured from 53 to 1,610 Mev by bombarding targets of plastic scintillator with pions. The intensity of the pion beam was monitored with a two-counter telescope and 40-Mc scaling system. The scintillator target was mounted on a phototube and became the detector for the C^{11} positron activity. Corrections were made for muon contamination in the beam, coincidence losses in the monitor system, C^{11} activity produced by stray background at the accelerator, C^{11} activity produced by secondaries in the target, and the efficiency of the C^{11} detection system. The $C^{12}(\pi^-,\pi^-n)C^{11}$ cross sections rise from a threshold at about 50 Mev to a peak of about 70 mb at 190 Mev after which they decrease to 30 mb at 373 Mev and are relatively constant at higher energies. The (π^-,π^-n) peak occurs at the same energy as the resonance in free-particle π^-n scattering at 190 Mev. Calculations based on a knock-on collision mechanism and sharp-cutoff nuclear density reproduce the shape of the experimental excitation function, but the magnitudes of the calculated cross sections are low by a factor of about 5 or 6. This simple model indicates that the $C^{12}(\pi^-,\pi^-n)C^{11}$ reaction occurs in the nuclear surface region at all bombarding energies. (auth)

633

19750

PRECISE MEASUREMENTS OF THE MEAN LIVES OF μ^+ and μ^- MESONS IN CARBON. R. A. Reiter, T. A. Romanowski, R. B. Sutton, and B. G. Chidley (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters 5, 22-3 (1960) July 1.

A one inch carbon target was bombarded by 70-Mev π^+ mesons. The muons from π^+ decays were randomly polarized, thus eliminating possible modulation of the decay curve. The weighted average of 14 runs gave a mean life of 2.211 ± 0.003 μsec for μ^+ mesons. The mean life of μ^- mesons was found to be 2.043 ± 0.003 μsec. (B.O.G.)

634

36319 INNER BREMSSTRAHLUNG IN MUON DECAY. Charles A. Rey (Univ. of Chicago). Phys. Rev., 135: B1215-24(Sept. 7, 1964).

A measurement of inner bremsstrahlung in muon decay was made using spark chambers, scintillators, and fast oscilloscopes. The electron range distribution in graphite and the absolute rates were determined for electron–gamma-ray angles between 130 and 180 deg. For the electron and gamma-ray energies studied, the branching ratio of $\mu \rightarrow e + \gamma + \nu + \bar{\nu}$ to $\mu \rightarrow e + \nu + \bar{\nu}$ is predicted to be about 10^{-4} over this angular range. The total number of inner bremsstrahlung events observed was 1805 ± 43, which is in agreement with an expected number of 1889 ± 283. The data were found to be in accord with the predictions given by electromagnetic corrections applied to the weak interaction. (auth)

635

27352 FILAMENT SCINTILLATION CHAMBER EXPERIMENTS IN WEAK INTERACTIONS. G. T. Reynolds, D. B. Scarl, R. A. Swanson, J. R. Waters, and R. A. Zdanis (Princeton Univ., N. J.). p.24-34 of "Proceedings of the

Symposium on Nuclear Instruments." New York, Academic Press Inc., 1962.

Filament scintillation chambers are described, and their uses in weak-interaction experiments are discussed. Meson (μ^-) capture by C^{12} is explained, and data from π^+ and μ^+ decay are given in tabular form. A schematic of the filament chamber designed to detect the decay $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ is presented. (L.N.N.)

636

4143 $\pi^{\pm}$ TRACKS IN A FILAMENT SCINTILLATION CHAMBER. G. T. Reynolds, R. A. Swanson, and D. B. Scarl (Princeton Univ., N. J.). Rev. Sci. Instr. 31, 1011-13 (1960) Sept.

The performance of a filament scintillation chamber system designed for studies on stopping mesons was studied by exposing it to the 90-Mev $\pi^{\pm}$ beam of the Nevis cyclotron and taking a total of 16,000 photographs. The results indicate that (1) except for meson tracks, the chamber appears clean even without the 200-μsec gating and the iron blockhouse, (2) the magnetic field has no effect on the performance and resolution, (3) three or four tracks can appear in a single picture of the 1-in.-diameter chamber without confusion, and (4) even at the highest beam fluxes, the gating restricts the tracks to those selected by the counter system. Pictures of the distinguishable stopping of π^+ and π^- mesons are included. (D.L.C.)

637

14945 (NYO-9279) PRECISE MEASUREMENTS OF THE MEAN LIVES OF μ^+ AND μ^- MESONS IN CARBON (thesis). Richard A. Reiter (Carnegie Inst. of Tech., Pittsburgh). Aug. 1960. Contract AT(30-1)-882. 64p.

The lifetimes of approx 6 million positive mu mesons were measured, using a crystal controlled oscillator as a clock. The resulting decay curve was analyzed on a digital computer and gave a mean life of 2.211 ± 0.003 μsec. The mean life of negative mu mesons in carbon was measured and found to be 2.043 ± 0.003 μsec. The resulting nuclear capture rate is (0.373 ± 0.011) × 10^5/sec, assuming that the decay rate of a negative mu meson bound in carbon is equal to the decay rate of the positive mu meson. (auth)

638

13457 (UCRL-16195) TOTAL AND DIFFERENTIAL CROSS SECTIONS FOR $\pi^-p \rightarrow \eta n$ FROM THRESHOLD TO 1300 Mev [Thesis]. Richards, Walter Bruce (Lawrence Radiation Lab., Univ. of California, Berkeley). Nov. 17, 1965. Contract W-7405-eng-48. 165p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

The reaction $\pi^-p \rightarrow \eta n$ was observed through the decay mode $\eta \rightarrow 2\gamma$ at T_{π^-} = 592, 655, 704, 875, 975, 1117, and 1300 Mev. Details are given of the detection apparatus, a cubic array of six steel-plate spark chambers, completely surrounding a liquid-hydrogen target. Showers produced in the spark chambers by decay photons were recorded photographically for analysis. Events attributed to the decay of an η were identified by the large c.m. opening angle between the two photons. The total cross section for η production was calculated. The differential cross section was obtained by taking the coefficients of a Legendre polynomial fit to the angular distribution of bisectors of selected two shower events, and converting them to the coefficients of the the η c.m. angular distribution. It is suggested that production at threshold is predominantly through an S state, with some P_1 and D_3 waves entering by 655 Mev. Speculation about a possible enhancement in the P_3 wave at 1100 Mev is given. It is suggested that all of the absorption in the S_{11} π-N state can be explained by the η production, and the nature of the η-N S-wave interaction at the η threshold is briefly discussed. (M.O.W.)

639

37044 (UCRL-11387(p.114-26)) ON THE DOSIMETRY OF NEGATIVE PIONS WITH A VIEW TOWARD THEIR TRIAL IN CANCER THERAPY. Chaim Richman, Henry Aceto, Jr., Mudundi R. Raju, Bernard Schwartz, and Mitchel Weissbluth (California. Univ., Berkeley. Donner Lab. and California. Univ., Berkeley. Donner Pavilion).

When π mesons come to rest in tissue, they are captured by the heavier elements, mainly C, O, and N, causing the nuclei to explode into short-range and heavily ionizing fragments that are capable of delivering a large localized radiation dose. This capture can be caused to take place in the tumor by selecting the energy of the pion of the required range so that the pion will pass through the healthy tissue and stop in the tumor. The possible advantages of the technique in cancer therapy are reviewed critically. The production of π^- and π^+ mesons and the effect of charged pions in tissue are discussed. Results are reported from preliminary dosimetry studies using a lucite phantom with sheets of x-ray film layered between the slabs or Argon–CO_2-filled ionization chambers using one chamber as a monitor followed by different thicknesses of lucite absorber and using the second ionization chamber as a detector. Results indicate that the presently available pion beams, both positive and negative, can be used for dosimetric evaluations. (C.H.)

640

1621 (UCRL-16387) STUDIES OF VICIA FABA ROOT MERISTEMS IRRADIATED WITH A π^- BEAM. Richman, Stephen P.; Richman, Chaim; Raju, Mudundi R.; Schwartz, Bernard (Lawrence Radiation Lab., Univ. of California, Berkeley). Sept. 3, 1965. Contract W-7405-eng-48. 18p. (CONF-650924-5). Dep. mn; CFSTI $1.00 cy, $0.50 mn.

From Workshop Conference on Space Radiation Biology, Berkeley, Calif.

The biological effects of π^- mesons, produced by the 184-in. cyclotron 90-Mev beam, were studied in Vicia faba root meristem cells. The roots were exposed in the plateau region and in the peak region of the π^--meson Bragg curve. It is pointed out that the Bragg curve for these particles is not the usual Bragg curve obtained for a beam of α particles or protons. Two ionization chambers, one used as a monitor and the second as a detector, were used in determining the curve. The irradiation technique is described. Data are reported on the percentage of

total anaphases that were abnormal at intervals after the end of 20-hr irradiation, the percentage of cells containing micronuclei at similar intervals, and the growth rate after irradiation measured as a fraction of the control rate. (C.H.)

641

24263 (BNL-6934) EMPIRICAL SYSTEMATICS OF THE PION-NUCLEON SYSTEM. K. F. Riley (Brookhaven National Lab., Upton, N. Y.). [1963]. Contract [AT(30-2)-Gen-16]. 13p.

Recent measurements of the total cross sections for π^+-p and π^--p interactions are presented and compared with existing pion-nucleon data. Systematic behavior noted in the occurrence of pion-nucleon system isobars and their quantum numbers is discussed. (D.C.W.)

642

19678 (UCRL-10127) SCATTERING OF 310-Mev POSITIVE PIONS BY PROTONS: EXPERIMENTS AND ANALYSIS (thesis). Ernest H. Rogers (California. Univ., Berkeley. Lawrence Radiation Lab.). Mar. 19, 1962. Contract W-7405-Eng-48. 65p.

The differential cross section for elastic scattering of 310-Mev positive pions on protons was measured at 23 angles between 14 deg and 165 deg in the center-of-mass system. The fractional rms errors were typically 3%. A liquid hydrogen target was bombarded by a beam of 2×10^6 pions/sec. The scattered pions were detected by a counter telescope. The data at small angles clearly showed constructive interference between nuclear and Coulomb interactions. A total cross section of 60.0 ± 1.4 mb was measured by attenuation. These data were combined with data on the polarization of the recoil proton, which were taken simultaneously with the cross-section measurements, and a phase-shift analysis was made. This analysis was hampered by the small angular region covered by the polarization data (114 deg to 145 deg), but even this limited amount of information about the polarization proved extremely valuable. It was impossible to obtain an adequate fit to the data in terms of only S- and P-wave phase shifts. However, a very satisfactory fit was obtained when D waves were also included. Moreover, this solution was unique. Only one set of SPD-wave phase shifts agreed with the data. This set was of the Fermi type. When F waves were also included in the analysis, the fit to the data was not improved significantly. However, the errors on the S-, P-, and D-wave phase shifts increased from about ½ deg to around 2½ deg, and additional sets of phase shifts that fit the data arose. The S-, P-, and D-wave phase shifts differed considerably among the various sets, even though the F-wave phase shifts were quite small. (auth)

643

25415 310 MEV Pi^+-p POLARIZATION AND CROSS-SECTION EXPERIMENTS. PHASE-SHIFT ANALYSIS. Ernest H. Rogers, Owen Chamberlain, James H. Foote, Herbert M. Steiner, Clyde Wiegand, and Tom Ypsilantis (Univ. of California, Berkeley). Revs. Modern Phys., 33: 356-61(July 1961).

The cross sections and proton polarizations in π^+-p interactions at 310 Mev are measured, in an attempt to find an unambiguous set of SP, SPD, or SPDF phase shifts for the system. The experimental data can be made to fit unambiguously a given set of SPD phase shifts. The data cannot be fitted adequately by a set of SP shifts alone, and the data are fitted ambiguously by several sets of SPDF shifts. (T.F.H.)

644

37546 (UCRL-12383) COMPARISON OF RECENT PION-NUCLEON PHASE SHIFT ANALYSES. Roper. L. David (Lawrence Radiation Lab., Univ. of California, Livermore). Apr. 26, 1965. Contract W-6405-eng-48. 74p. Dep.(mn); $3.00(cy), 2(mn) CFSTI.

An attempt is made to evaluate which of several pion-nucleon phase-shift analyses in the 300- to 700-Mev region best fits the experimental data. The various solutions were compared by fitting them with the parameterization used in one analysis, and a χ^2 determination was used to improve the fit. Results are presented, giving phases shifts, absorption parameters, and real and imaginary parts of partial wave amplitudes. Polarizations for the various solutions are also compared. The behavior of the polarizations and the spin-rotation parameters as functions of energy is shown for the best solution. that of Auvil et. al. (Phys. Letters 12, 76, 1964) combined with the P_{11} and S_{11} resonances from other solutions. (M.J.T.)

645

16791 EVIDENCE FOR A P_{11} PION–NUCLEON RESONANCE AT 556 Mev. L. David Roper (Univ. of California, Livermore). Phys. Rev. Letters, 12: 340-2(Mar. 23, 1964). (UCRL-7692-T)

A energy-dependent pion-nuclear phase shift was analyzed quantitatively in search for a P_{11} resonance. The solution to the parametric equation for pion-nucleon phase shifts and absorption parameters using available data between 0 and 700 Mev is graphically represented. (L.B.S.)

646

42370 (UCRL-7846) ENERGY-DEPENDENT PION-NUCLEON PHASE-SHIFT ANALYSIS; 0-700 Mev, $l_m = 4$ SOLUTION. L. David Roper and Robert M. Wright (California. Univ., Livermore. Lawrence Radiation Lab.). June 4, 1964. Contract W-7405-eng-48. 87p.

The equations used in an energy-dependent pion-nucleon phase shift analysis are listed. A list of pion-nucleon scattering data references is included. The best solution obtained using $l_m = 4$ for a selected set of 0- to 700-Mev data is given and graphical comparisons between the solution and the data are given. This solution's predictions for observables that have not yet been measured are given. There

are three resonances in this solution: P_{33} at 193 Mev laboratory kinetic energy (mass = 1234 Mev); P_{11} at 575 Mev (mass = 1497 Mev); and D_{13} at 638 Mev (mass = 1534 Mev). (auth)

647

25352 PION-NUCLEON PHASE-SHIFT ANALYSIS: 0-350 Mev. L. David Roper and Robert M. Wright (Univ. of California, Livermore). Phys. Rev., 138: B921-32 (May 24, 1965). (UCRL-12198)

Several sets of energy-dependent pion-nucleon phase shifts were obtained in the 0–350-Mev energy range. These solutions differ near the end of the energy range and in the signs and magnitudes of some of the small phases. There is very little difference among these solutions in their prediction of the observables, including the spin-rotation parameters. Some very difficult experiments are suggested to distinguish among the solutions. (auth)

648

18870 ENERGY-DEPENDENT PION-NUCLEON PHASE-SHIFT ANALYSIS. L. David Roper (Univ. of California, Livermore), Robert M. Wright, and Bernard T. Feld. Phys. Rev., 138: B190-210(Apr. 12, 1965). (UCRL-7904)

Energy-dependent pion-nucleon phase-shift analyses were carried out in the energy ranges 0–50, 0–100, 0–350, 0–700, and 300–800 Mev. An outline of the procedure is given. The results obtained with all available data are presented. The best solution in the 0–350-Mev range is obtained by starting from Donnachie, Hamilton, and Lea's predicted phases, although the final results differ widely from the input. The best solution obtained in the 0–700-Mev range contains three resonances: in the P_{33} state at 193 Mev, the P_{11} state at approximately 585 Mev, and the D_{13} state at 638 Mev. The last two are strongly absorptive. A good solution was obtained without the P_{11} phase shift actually going through 90°, but it must be large (about 80°) at 700 Mev. The 0–100-, the 0–350-, and the 0–700-Mev solutions are consistent with each other in the large phases. The P_{11}, P_{13}, and P_{31} phases cannot be precisely determined by using only the 0–50-Mev data. (auth)

649

2645 MUON CAPTURE IN NEON. J. L. Rosen, E. W. Anderson, E. J. Bleser, L. M. Lederman, S. L. Meyer, J. E. Rothberg, and I-T. Wang (Columbia Univ., New York). Phys. Rev., 132: 2691-2(Dec. 15, 1963).

By exploiting the transfer process $(\mu^- p) + Ne \rightarrow p + (\mu^- Ne)$, the disappearance rate of negative muons bound to neon nuclei was measured to be $\lambda = (0.658 \pm 0.010) \times 10^6$ sec^{-1}. (auth)

650

17271 MURA-574
Midwestern Universities Research Assn., Madison, Wis.
ON THE NEUTRINOS EMITTED IN β-DECAY AND μ-CAPTURE. S. P. Rosen. [1960]. 5p. Contract AT(11-1)-384. OTS.

The assumption that the neutrinos ν_1 and ν_2 emitted in μ-capture and β-decay, respectively, have opposite helicity is shown to be consistent with experimental data. A crucial test of this assumption is shown to be the measurement of the helicity of muons emitted in $(\pi$-$\mu)$-decay. (auth)

651

35033 (UCRL-14202) PION-PROTON INELASTIC DATA. Rosenberg, R. L.; Roper, L. D. (Lawrence Radiation Lab., Univ. of California, Livermore). May 21, 1965. Contract W-7405-eng-48. 18p. Dep.(mn); $1.00(cy), 1(mn) CFSTI

Tables of $\pi^+ + p$ and $\pi^- + p$ total and partial inelastic cross sections known in August, 1964 are listed up to ~1 Bev. The good agreement between the London-Livermore π-p phase shifts and the total inelastic cross sections is shown. (auth)

652

28200 PHYSICAL ASPECTS OF PARTICLE BEAM THERAPY. J. Rotblat (St. Bartholomew's Hospital Medical Coll., London). Proc. Roy. Soc. Med., 58: 159(Mar. 1965).

The advantage of particle beams in radiotherapy arises from properties such as: well-defined range in tissue, little scattering in passage through the body, gradual increase of the specific ionization along range with high peak near the end of the range (Bragg peak); and high LET (linear energy transfer), with the consequent elimination of the disadvantageous difference in radiation sensitivity between oxygenated and hypoxic tissue. The particles that could be used in radiotherapy are: electrons, neutrons, protons, and π mesons. The use of π mesons is based on their property of producing α particles and heavier ions when they are stopped in matter. Electrons have only the first property and even this is not well defined, but nevertheless there are advantages in using electrons in some cases in radiotherapy. The claim for the advantage of neutrons rests entirely on the last property. High-energy protons, deuterons, and α particles have the first three properties, and are particularly useful for radiosurgery. Heavy ion and π-meson beams possess all the advantageous properties enumerated above, and therefore offer the best hope for a major advance in radiotherapy; however, the accelerators necessary to produce such beams in usable intensity are extremely expensive. (BBB)

653

33002 (NEVIS-116) MUON CAPTURE IN HYDROGEN (thesis). Joseph E. Rothberg (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). June 1963. Contract Nonr-266(72). 150p. (AD-409501)

The muon capture rate in liquid hydrogen was measured by scintillation counter techniques. The experiment tests muon-electron universality in interaction with a proton at a momentum transfer of 100 Mev/c. The use of ultra-pure liquid hydrogen, a purified muon beam, neutron-gamma ray discriminating detectors and oscilloscope photography

made possible the detection of the 5.2-Mev neutron from the relatively improbable capture reaction ($\mu^- + p \rightarrow n + \nu$). Observation of the well known pion capture reaction ($\pi^- + p \rightarrow n + \gamma$) served as a check on many aspects of the experimental arrangement as well as on the neutron detector efficiency calculation. Interpretation of the muon capture experiment depends on knowledge of the muon molecular wave function and the muon-proton spin configuration; these are known from detailed calculations. The muon molecular formation rate was measured in an independent experiment, but the present result is relatively insensitive to it. The stability of the muon molecular ortho state against transitions to the para ground state for times comparable to the free muon lifetime is confirmed. The experimental result of the capture rate measurement, 464 ± 42 sec^{-1} is compared with 562 ± 60 sec^{-1}, the rate expected on the basis of the conserved vector current theory, muon-electron universality and the accepted value of the "induced pseudoscalar" coupling constant. 42 references. (auth)

654

26271 (BNL-837(p.277-91)) MUON CAPTURE IN HYDROGEN. Carlo Rubbia (European Organization for Nuclear Research, Geneva).

The reaction $\mu^- + p \rightarrow n + \nu$ is considered. Experiments—one type using a liquid hydrogen bubble chamber and determining the total capture rate, the other type using a Brooks neutron counter and measuring the time dependence of the capture process—are reviewed. The evolutions of a μ meson after thermalization in hydrogen and the formation of mesomolecular systems are discussed. Experimental results are compared with the predictions of the universal Fermi interaction theory. (M.J.T.)

655

20965 RECENT EXPERIMENTS WITH THE C.E.R.N. SYNCHRO-CYCLOTRON. C. Rubbia (CERN, Geneva). Proc. Roy. Soc. (London), Ser. A, 278: 323-31(Apr. 7, 1964).

Experiments performed with the CERN proton synchrotron that yield new information about the weak and electromagnetic properties of the π and μ mesons are described. The $\pi^+ \rightarrow \pi^0 + e^+ + \nu$ decay mode, capture of μ^- by hydrogen, and the anomalous magnetic moment of μ^+ are considered. (R.E.U.)

656

38130 DIRECT MEASUREMENT OF μ^- MESONIC MOLECULE FORMATION RATES IN LIQUID HYDROGEN. G. Conforto (CERN, Geneva), C. Rubbia, E. Zavattini, and S. Focardi. Nuovo Cimento (10), 33: 1001-19(Aug. 16, 1964).

A measurement of the μ^-pp and μ^-pd mesonic molecule formation rate in liquid hydrogen is described. The capture probability of μ^- from the neon nucleus is given. The results are compared with those obtained by others. (auth)

657

26093 (UCRL-10252) SCATTERING OF NEGATIVE PIONS ON PROTONS AT 310 Mev: DIFFERENTIAL AND TOTAL CROSS-SECTION AND PHASE-SHIFT ANALYSIS (thesis). Hugo R. Rugge (California. Univ., Berkeley. Lawrence Radiation Lab.). May 20, 1962. Contract W-7405-eng-48. 91p.

The differential cross section in π^--p elastic scattering at 310 Mev incident-pion energy was measured for 28 angles in the angular region $25° \leq \theta_{lab} \leq 160°$. The reaction was observed by counting the scattered pions emerging from a liquid hydrogen target with a counter telescope consisting of scintillation and Cherenkov counters. A measurement of the total cross section by attenuation as a function of cutoff angle was also performed, using scintillation counters. These data were incorporated with polarization and other differential cross section data at this energy, and a phase shift analysis was performed. An IBM 7090 search program was developed for this purpose. Analysis of all data for spd waves (up to $\ell = 2$) has resulted in a single acceptable solution that has I-spin $^3/_2$ phase shifts in excellent agreement with results of a previous π^+-p phase shift analysis, and has I-spin $^1/_2$ phase shifts that are <6° for the $D^{1/}$ shift which is ≈15°. Errors on the phase shifts vary from 0.4 through 1.1° An extension of the analysis to spdf waves (up to $\ell = 3$) results in two probable solutions, and one that is rather unlikely. These, as well as the spd solution, are discussed. Errors on the spdf solution are larger, ranging up to 2°. (auth)

658

13436 π^--p ELASTIC SCATTERING AT 310 Mev: DIFFERENTIAL CROSS-SECTION AND RECOIL-PROTON POLARIZATION. Hugo R. Ruggo and Olav T. Vik (Univ. of California, Berkeley). Phys. Rev., 129: 2300-10(Mar. 1, 1963). (UCRL-10420)

The differential cross section and recoil proton polarization in π^--p elastic scattering at 310-Mev incident-pion energy has been measured. The differential cross section was measured at 28 angles in the angular region $25 \leq \theta_{lab} \leq 160$ deg. The fractional rms errors were typically 3%. The reaction was observed by counting the scattered pions emerging from a liquid-hydrogen target with a counter telescope consisting of scintillation and Cherenkov counters. Simultaneously, the recoil-proton polarization was measured at four angles in the angular region $114 < \theta_{c.m.} < 146$ deg. The recoil protons from the liquid-hydrogen target were scattered from a carbon target and the left-right asymmetry was measured. Scintillation counters were used throughout to detect the particles. (auth)

659

41819 RESONANCE INTERACTIONS IN STATISTICAL THEORY OF MULTIPLE PARTICLE PRODUCTION. V. I. Rus'kin. Tr. Inst. Yadern. Fiz., Akad. Nauk Kaz. SSR, 6: 3-63(1963). (In Russian)

Statistical theory of multiparticle production was reviewed, and methods for determining resonance particle production are discussed. Experimental data are given on resonance π-π interactions, and their analysis using the periphery interaction theory is discussed. The statistical theory of π-π interactions was used for describing p-$\bar{p}$ annihilation and meson-nucleon interactions. 161 references are included. (R.V.J.)

660

1556
A SCINTILLATION COUNTER SYSTEM FOR THE DETECTION OF POSITIVE AND NEGATIVE PIONS. J. G. Rutherglen and J. K. Walker (Univ. of Glasgow). Nuclear Instr. & Methods 8, 239-43(1960) Aug. (In English)

A three-counter telescope was developed in which pions are separated from particles of different mass by measurement of dE/dx and E. Identification of positive pions is made by means of the characteristic $\pi^+ - \mu^+$ decay. The arrangements for recording this information both photographically and by means of a pulse-height analyzer are described. (auth)

661

22622 BRANCHING RATIOS OF REACTIONS OF π^- MESONS STOPPED IN HYDROGEN AND DEUTERIUM. James W. Ryan (Univ. of California, Berkeley). Phys. Rev., 130: 1554-67(May 15, 1963). (UCRL-9884(Rev.))

The Panofsky ratio $P = \omega(\pi^- + p \rightarrow \pi^0 + n)/\omega(\pi^- + p \rightarrow \gamma + n)$ and the branching ratio $S = \omega(\pi^- + d \rightarrow n + n)/\omega(\pi^- + d \rightarrow \gamma + n + n)$ were measured by stopping π^- mesons in liquid hydrogen and liquid deuterium and detecting the γ rays produced. A high-resolution γ-ray spectrometer of the 180-deg-focusing type is employed. Sixty-six Geiger tubes and nine scintillation counters are used in the spectrometer to define the electron-positron orbits, providing an intrinsic instrument resolution of 0.8%. The values obtained for the branching ratios are $P = 1.51 \pm 0.04$ and $S = 3.16 \pm 0.12$. This value for P is in good agreement with that obtained in previous measurements, while the value for S is significantly larger than previous results. With regard to the conventional phenomenological analysis of S-wave pion physics, the Panofsky ratio is in good agreement, whereas the value obtained in this experiment for the branching ratio S is considerably larger than predicted. (auth)

662

24462 MEASUREMENT OF THE nn SINGLET S-STATE SCATTERING LENGTH. James W. Ryan (Univ. of Rochester, N. Y.). Phys. Rev. Letters, 12: 564-6 (May 18, 1964).

The γ spectrum from the reaction $\pi^- + d \rightarrow n + n + \gamma$ was measured. A comparison with folded theoretical spectra for various values of the n-n scattering length is made. (M.J.T.)

663

38608 (CU(PNPL)-227(p.171-2)) SONIC SPARK CHAMBER MEASUREMENT OF THE BETA SPECTRUM FROM MU DECAY. Allan M. Sachs (Columbia Univ., New York).

An experiment designed to measure the momentum spectrum of the electrons in mu-decay is described. Each decay electron passes through a hodoscope, a magnetic field, and a second hodoscope. The hodoscopes consist of sonic spark chambers with several transducers per gap. The output of the transducers is digitalized using individual units and their outputs are buffered in a small computer and stored on magnetic tape. The tape is transferred later to a large computer where the momentum corresponding to each event is calculated. (auth)

664

28597 INTERACTION OF 78 Mev π^+-MESONS IN PROPANE. R. G. Salukvadze and D. Neagu (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 78-80(July 1961). (In Russian)

A propane bubble chamber was employed to study the interaction between 78 ± 3 Mev π^+ mesons and hydrogen and carbon. The scattering cross sections in hydrogen and carbon and also the absorption cross section in carbon were also determined. The prongs of stars produced by the absorption of mesons are predominantly directed toward the front hemisphere and this indicates that the mesons suffer quasielastic collisions in the nucleus prior to their absorption. (auth)

665

15298 ABSORPTION OF π^+ MESONS WITH ENERGY OF 80 Mev BY CARBON NUCLEI. R. G. Salukvadze and D. Niyagu. Tr. Inst. Fiz. Akad. Nauk Gruz. SSR, 9: 77-84(1963). (In Russian)

The stars produced by π^+-mesons with the energy of 78 ± 3 Mev at their absorption by carbon nuclei were investigated by means of a small propane bubble chamber. The results are based on the analysis of 201 interaction events. (auth)

666

45105 PION-PION SCATTERING. [PART] III. Saperstein, A. (Wayne State Univ., Detroit); Uretsky, J. Phys. Rev., 140: B352-9(Oct. 25, 1965).

The left-hand partial-wave discontinuities are calculated in fourth-order perturbation theory. The s-wave and p-wave dispersion relations are solved by standard N/D techniques. It is found that the relative contributions arising from the double-spectral terms and the inelastic single-spectral functions are negligible. As a perturbation theory the procedure appears to be sensible for coupling constants $|\lambda|$ less than about 0.1. High-energy p-wave resonances can be made to occur for $|\lambda|$ of about 0.2, but with very large widths. It is suggested that the physical pion-pion system

may not be describable in terms of a one-parameter theory, and this notion is given experimental meaning. (auth)

667

29102 CALCULATION OF THE POLARIZATION OF THE RECOIL PROTON IN πN-SCATTERING NEAR THE INELASTIC THRESHOLD. Elmar Sauter (Universitat, Heidelberg). Z. Physik, 185: 263-8(1965).

The polarization of the recoil proton in πN-scattering was calculated as a function of the scattering angle at the energies 150, 170, and 190 Mev. It is shown that this polarization depends sensitively on the πN-scattering phase-shift P_{11}. Slight changes of the other phase-shifts do not affect the polarization to the same extent. New measurements of the differential cross section and of the polarization in the process $\pi^- + p \rightarrow \pi^- + p$ are suggested. They would allow for a new precise phase-shift analysis, which could possibly determine the sign of the P_{11}-phase at the inelastic threshold. This sign is important in connection with the bound-state picture of the nucleon. (auth)

668

47375 EXTRA RESTRICTION ON THE FORWARD SCATTERING AMPLITUDES. Sawada, Tetsuo (International Centre for Theoretical Physics, Trieste). Phys. Rev. Letters, 15: 567-71(Sept. 27, 1965).

In the case of the first sheet function the value of the function itself cannot be computed in a small neighborhood of certain points from the unitary condition alone without introducing any approximation, since although the pole term dominates, there still remains finite background contribution and there is no way to compute it exactly. The discussion is restricted to the case of meson (π)-nucleon scattering, and the spin of the nucleon is neglected for reasons of simplicity. A new method is developed which may be used not only to obtain the relation between the total cross section and the coupling constant, but also to compute the subtraction constant from the total cross section without introducing any approximation. (J.F.P.)

669

9209 PI MINUS INTERACTIONS IN PROPANE NEAR THE SECOND RESONANCE. John Harvey Scandrett. Thesis, Madison, Wis., Univ. of Wisconsin, 1963. 107p.

A 12 in. propane bubble chamber was exposed to π^- mesons from the Brookhaven Cosmotron. Pictures at 600 and 770 Mev were analyzed for interactions in H and C. Careful attention was paid to quasi-elastic C contamination in the $\pi^- + p$ differential elastic cross sections. Total cross sections for $\pi^- + p \rightarrow \pi^0 + n$, $\pi^+ + \pi^- + n$, $\pi^0 + \pi^- + p$, and $\pi^0 + \pi^0 + n$ are estimated for the H interactions, normalized to total $\pi^- - p$ and $\pi^- - C$ cross sections from counter experiments. The results are presented. C interactions were tabulated as to prong distribution, and $\pi^- - C$ elastic scattering was compared with predictions of the optical model, using no adjustable parameters. Semi-quantitative π^--neutron differential scattering cross sections were obtained, giving information about the T = 3/2 state at these energies. The γ-ray angular distribution from charge exchanges at 460 Mev was analyzed and used to test the forward dispersion relations. A complete phase shift analysis was attempted, including D waves at 600 Mev and F waves at 770 Mev. The results, while not decisive owing to the great number of parameters, are that no single state appears to pass through a resonance at 600 Mev. There is absorption in many states, with strong absorption in S_{11}, S_{31}, P_{11}, D_{13} at 600 Mev, and in S_{11}, S_{31}, P_{13}, D_{13} at 770 Mev. (Dissertation Abstr.)

670

24788 (NP-11796) A FILAMENT SCINTILLATION CHAMBER MEASUREMENT OF THE RATE FOR $\mu^- + C^{12} \rightarrow B^{12} + \nu$. Technical Report No. 30. Donald B. Scarl (Princeton Univ., N. J. Palmer Physical Lab. and Princeton Univ., N. J. Naval Ordnance Lab.). May 29, 1962. Contract Nonr-1858(06). 73p.

To check the predictions of a Universal Fermi Interaction, negative muons were brought to rest in a $1\frac{1}{2}$ inch filament scintillator chamber and the rate for the reaction $\mu^- + C^{12} \rightarrow B^{12} + \nu$ was measured. 97 B^{12} events were observed, giving a capture rate of $(6.6 \pm 0.9) \times 10^3$ per second. This number is in agreement with the predictions of a Universal Fermi Interaction, a pion induced pseudoscalar term with $g_P = +8\, g_A$, and a conserved weak vector current. An extensive discussion of the construction and operation of the filament chamber and associated image tubes is included. (auth)

671

32537 (PPAD-304D) AN EXPERIMENT TO DETERMINE (g – 2) FOR THE FREE MUON. Glen Schrank (Princeton-Pennsylvania Accelerator, Princeton, N. J. and Princeton Univ., N. J. Palmer Physical Lab.). Mar. 29, 1960. Contract [AT(30-1)-937]. 58p.

General considerations for determining the properties of mesons (μ) and an experiment for determining the g-factor are described. (R.E.U.)

672

5882 TRANSFER OF NEGATIVE MUONS TO GASES DISSOLVED IN A HYDROGEN BUBBLE CHAMBER. M. Schiff (Univ. of Chicago). Nuovo cimento (10), 22: 66-91 (Oct. 1, 1961). (In English)

The transfer reactions $(\mu^- H) + X \rightarrow (\mu^- X) + H$, where H = p or d and X = Ne or He, were studied by observing variations in the fractions of μ^- undergoing nuclear capture or catalyzing the fusion process $p + d \rightarrow He^3$. In deuterium-free hydrogen with a neon contamination of $(105^{+50}_{-25}) \cdot 10^{-6}$, half of the muons are transferred to neon. Transfer to neon is 3 times more frequent if the hydrogen contains enough deuterium to saturate the reaction $(\mu^- p) + d \rightarrow (\mu^- d) + p$. Transfer to helium is at least two orders of magnitude slower than to neon. Stars induced by μ^- and π^-

were analyzed. No transfer of π^- was detected. The effect of the transfer reactions on the measurement of μ^- capture by hydrogen is discussed. It is shown that the transfer reactions can be used for experiments on μ^- capture by separated neon isotopes and possibly by He^3. (auth)

673

14954 PION RESONANCES AND NUCLEON-NUCLEON SCATTERING BELOW 400 Mev. A. Scotti and D. Y. Wong (Univ. of California, La Jolla). p.173-84 of "Proceedings of the Athens Topical Conference on Recently Discovered Resonant Particles." Athens, Ohio, Ohio University, 1963.

The effects of the multi-pion resonances η, ρ, ω, and φ on nucleon interactions are considered. Relativistic dispersion relations that include the exchange of these resonances are used to calculate elastic N-N scattering amplitudes, differential cross sections, polarization, and depolarization in the energy range from zero to 400 Mev. In addition to the single pion exchange and the exchange of the resonances, the exchange of an S-wave π-π pair in the form of an effective scalar particle is also included. (C.E.S.)

674

3349 SEARCH FOR A SECOND π^0. W. Selove and M. Gettner (Univ. of Pennsylvania, Philadelphia). Phys. Rev. 120, 593-8(1960) Oct. 15.

The energy distribution of neutrons from the charge exchange reaction $\pi^- + p \rightarrow \pi^0 + n$ was studied, for π^- mesons stopped in liquid hydrogen, to investigate the possible existence of a second π^0 with mass within a few Mev of the mass of the "ordinary" π^0. No neutron group corresponding to such a second π^0 was seen. The sensitivity of the measurement was such that a second group of relative intensity above 10 to 20% would have been seen for any second π^0 with a mass in the range between about $^3/_4$ Mev and 2 Mev away from the mass of the ordinary π^0. The data give a lower limit to the π^0 lifetime: $\tau > \sim 5 \times 10^{-21}$ sec. (auth)

675

9894 (NAS-NRC-PUB-1133(p.187-203)) ENERGY-LOSS STRAGGLING OF PROTONS AND MESONS: TABULATION OF THE VAVILOV DISTRIBUTION. Stephen M. Seltzer and Martin J. Berger (National Bureau of Standards, Washington, D. C.).

The Vavilov distribution, which describes the energy-loss straggling of charged particles traversing a thin layer of matter, is tabulated. The distribution depends on the particle velocity and on a parameter, κ, indicative of the ratio of the mean energy-loss over the pathlength considered to the largest energy-transfer possible in a single collision with an atomic electron. As $\kappa \rightarrow 0$, the Vavilov distribution goes over into the Landau distribution; for $\kappa \gtrsim 10$ it becomes Gaussian. Intermediate values of κ occur for protons and mesons of moderate velocity traversing very thin targets or for extremely fast particles in targets of moderate thickness. (auth)

676

8060 (NP-11232(p.302-7)) THE SCATTERING OF DECAYING μ-MESONS. S. N. Sen Gupta and M. S. Sinha (Bose Research Inst., Calcutta).

Meson (μ) scattering was studied in the momentum region $40 < p\beta < 170$ Mev/c. The projected scattering angles were measured to an accuracy of 0.2 degree directly on the film with a goniometer eyepiece fitted in a microscope. For each measured projected angle of scattering, the corresponding value of $p\beta$ was determined by estimating the residual range of the particle from the center of the plate in which the scattering was observed up to the point of stopping and decay. From these measurements, a differential distribution of the quantity $p\beta\theta$ was determined. The experimental distribution was then compared with theory. (P.C.H.)

677

15298 SCATTERING OF μ-MESONS BY COPPER NUCLEI. S. N. Sen Gupta and M. S. Sinha (Bose Inst., Calcutta). Nuovo Cimento (10), 26: 1279-91(Dec. 16, 1962). (In English)

An experimental study of the scattering of μ mesons by $^1/_4$ inch copper plates was made in the momentum interval $40 < p\beta < 170$ Mev/c by using a multiplate cloud chamber. The μ mesons were identified by their decay produced inside the cloud chamber, and their momenta were individually estimated from the residual ranges after scattering. The triggering system was such that there was no bias in recording large angle events. Altogether 2,606 scatterings were analysed and the resulting scattering distributions were found to agree satisfactorily with the distributions calculated on the basis of a purely electromagnetic interaction between the μ-meson and the nucleus. (auth)

678

25392 PION IONIZATION AT 321 Mev. Senent, F.; Sanchez, J.; Gil, G. (Facultad de Ciencias, Valencia). An. Real Soc. Espan. Fis. Quim. (Madrid), Ser. A, 62: 51-4(Jan.-Feb. 1966). (In Spanish).

An investigation of the tracks produced in a hydrogen-filled bubble chamber by 321-Mev mesons (π) is summarized. (D.C.W.)

679

10500

CAPTURE OF NEGATIVE MUONS BY NUCLEI. J. C. Sens (Univ. of Chicago). Phys. Rev. 113, 679-87(1959) Jan. 15.

An experiment conducted to obtain precise values for the rates at which negative muons are captured by nuclei is described. These capture rates were deduced from muon disappearance rates measured by determining the time distribution of electrons resulting from the decay of muons in their lowest atomic orbit. 30 ele-

ments were investigated, using scintillation counters as detectors. The data are compared with the general theory of Primakoff and the specific predictions of Tolhoek and Luyten for nuclei with $20 \leq Z \leq 28$. Primakoff's predictions for the effect of the Pauli principle are well born out by this experiment, and the inferred capture rate of muons by protons is in good agreement with the hypothesis of a universal Fermi interaction. New values of effective nuclear charge densities (analogous to Wheeler's Z_{eff}^4) were computed for analyzing the data, using a recent muon mass and up-to-date experimental information on charge distributions. These new values are presented in tabular form. (auth)

680

36646 (CERN-63-28(p.143-71)) MUONS AND NUCLEAR STRUCTURE. J. C. Sens (European Organization for Nuclear Research, Geneva).

The properties of the meson(μ), particularly those permitting its use in nuclear structure studies, are summarized. Theory behind the use of muonic x rays and muon capture by nuclei for such studies is presented along with some experimental results. (D.C.W.)

681

45051 DISPERSION THEORY OF LOW-ENERGY SCATTERING. Serebryakov, V. V.; Shirkov, D. V. (Inst. for Mathematics, Novosibirsk, USSR). Fortschr. Physik, 13: 227-76(1965).

A review is presented which is based largely on the lectures delivered at the Dubna International Winter School of Theoretical Physics on March 1964. Some materials on kinematics, isotopic structure and unitarity of the π-π scattering are given. The original papers by Chew and Mandelstam which have, in fact, given rise to the systematic theoretical studies in this field are included. The works of theoretists of Dubna and Novosibirsk which led to the consistent approach to the theory of strong interactions at low energies are treated. Comparisons are made with experiments. (auth)

682

33023 PION-MASS MEASUREMENT BY CRYSTAL DIFFRACTION OF MESONIC X RAYS. Shafer, Robert E.; Crowe, Kenneth M.; Jenkins, David A. (Univ. of California, Berkeley). Phys. Rev. Letters, 14: 923-5(May 31, 1965). (UCRL-16056)

Measurement of the 4F–3D transitions in π-mesonic calcium and titanium is reported along with the preliminary results of a new determination of the charged pion mass. (M.O.W.)

683

15798 DIRECT REACTIONS WITH TWO-NUCLEON TRANSFER. Shapiro, I. S.; Timashev, S. F. (Inst. for Theoretical and Experimental Physics, Moscow). Nucl. Phys., 79: 46-64(1966).

Angular distributions in the direct nuclear reactions (t,p) and (^{3}He,n) on light nuclei are calculated. Satisfactory agreement with experimental data in the region of small momentum transfers is obtained. (auth)

684

46785 AN ON-LINE MEASUREMENT OF MUON DECAY USING WIRE SPARK CHAMBERS. Sherwood, Bruce (Univ. of Chicago). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-12: No. 4, 49-51(Aug. 1965).

The electron-momentum spectra from muon decay are measured using wire spark chambers with ferrite-core readouts and on-line computation. Systems used and results are printed. (T.F.H.)

685

45050 ON POLARIZATION PROPERTIES OF MUONS IN ELASTIC NEUTRINO PROCESSES ($\tilde{\nu}_\mu + p \rightarrow n + \mu^+$, $\nu_\mu + n \rightarrow p + \mu^-$). Shishkin, G. V. (Inst. of Heat and Mass Exchange, Academy of Sciences, Belorussian SSR). Dokl. Akad. Nauk BSSR, 9: 160-3(Mar. 1965). (In Russian).

To distinguish the two kinds of neutrino and antineutrino a relation is established between the polarization s_ν and the polarization vector of muons in the elastic neutrino reactions $\tilde{\nu}_\mu + p \rightarrow n + \mu^+$ and $\nu_\mu + n \rightarrow p + \mu^-$. It is assumed that the neutrino and antineutrino are always completely polarized longitudinally, that is, $s_\nu = \pm 1$. Wave functions of the free fermions are determined by simultaneously solving the Dirac equation and an equation with a projection operator. The hamiltonian of a weak four-fermion interaction is then written with only the vector and axial-vector terms being retained. An expression is written for the matrix element of the reaction $\tilde{\nu} + N \rightarrow N' + \nu$. Here N and N' are nucleons. By using perturbation theory an expression is obtained for the spatial components of the polarization vector of the muons. The probability of muon neutrinos reacting with a proton or neutron and the polarization-vector components of the resulting muons depends strongly on the longitudinal polarization of the neutrino, that is, on s_ν. The neutrino imposes its polarization on the muon that is formed. The polarization vector component depends only on the energy and emergence angle of the muon. The polarization vector of the muons lies in the plane of the reaction, that is, in the momentum plane of the neutrino and the muon. (TTT)

686

7962 (UCRL-9362) DIFFERENTIAL ELASTIC PION–PROTON SCATTERING AT 600, 650, AND 750 MEV (thesis). John I. Shonle (California. Univ., Berkeley. Lawrence Radiation Lab.). Aug. 12, 1960. 70p. Contract W-7405-eng-48.

The differential elastic cross sections for π^--p scattering were measured at 610 ± 20, 655 ± 20, and 750 ± 20 Mev in a propane bubble chamber. The elastic events were selected by a χ^2 test. The total elastic cross sections are 17.7 ± 2.3, 16.6 ± 1.4, and 14.8 ± 1.4 mb, respectively. Cosine-power series were fitted to the angular distributions. The variation of the coefficients with energy indicates $J = 3/2$ for the 600-Mev resonance and $J = 5/2$ for the 890-Mev resonance in the π^--p interaction. The data were more compatible

with odd relative parity for the two: $P_{3/2}$ and $D_{3/2}$ or $D_{5/2}$ and $F_{5/2}$. Thus the scattering data independently give the same assignments for the peaks as the photoproduction data. Resonance at the peaks is not established but is the most plausible explanation for them. Strong absorption of the $J = 3/2$ resonant wave is suggested. (auth)

687

24804

NEGATIVE PION-PROTON ELASTIC SCATTERING AT 600 TO 750 Mev. John I. Shonle (Univ. of California, Berkeley). Phys. Rev. Letters 5, 156-9(1960) Aug. 15.

The experiment was conducted to establish the angular momentum at the peaks from elastic scattering of negative pions at 610 ± 20, 655 ± 20, and 750 ± 20 Mev on hydrogen. The pions were focused, deflected, and collimated to give a momentum spread of ±1.5%. The mean beam momentum was measured by three methods; all gave consistent results. The events were given a χ^2 test for elasticity using configuration-dependent errors. Good agreement with the expected χ^2 distribution was found. About 40% of the measured events were elastic. (B.O.G.)

688

34812 SCATTERING OF 300-Mev PIONS ON HYDROGEN AND DEUTERIUM. I. B. Sokolova. Tr. Fiz. Inst., Akad. Nauk SSSR, 14: 61-116(1962). (In Russian)

The cross sections and the angular distributions for the elastic scattering of 300-Mev negative and positive pions on hydrogen and deuterium were determined. The phase analysis for the scattering of positive mesons on hydrogen requires S and P waves; the inclusion of D waves does not change the angular distribution and within experimental error it is not possible to say just what the D-wave contribution is. For S and P waves the phase shifts α_1 and α_3 do not have a linear dependence on the meson momentum as proposed by Orear. The α_{33} phase shift does not agree with the Chew and Low relation, but rather is in agreement with the energy dependence proposed by Mukhin and Pontecorvo. The phase analysis is not unique. For the isotopic spin ½ state two series of phases are possible. The determined phase shifts agree with the dispersion relations for both negative and positive mesons assuming that the meson-nucleon interaction constant, f^2, is 0.08 to 0.10. The angular distributions for the elastic scattering of mesons on deuterium do not agree with the Green and Rockmore calculation in the impulse approximation. Agreement is obtained if it is assumed that the nucleon mass goes to infinity. The disagreement is apparently connected with the inconsistent calculation of the nucleon recoil. (TTT)

689

24274 (UCRL-10585) A STUDY OF THE π^+ IN THE REACTION $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ AT 365 AND 433 Mev (thesis). Julius Solomon (California. Univ., Berkeley. Lawrence Radiation Lab.). Jan. 17, 1963. Contract W-7405-eng-48. 101p.

The differential distributions in energy and angle of the π^+ in the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ have been measured with a scintillation counter telescope used for π^+ detection and a magnetic spectrometer for π^+ energy determination at π^- incident energies of 365 and 432 Mev. At each of the laboratory-system angles 20, 50, 80, and 110° π^+ were detected in scintillation counters placed after the spectrometer. This system covered a major portion of the kinematically allowed π^+ energy spectrum. The values of T and $\Delta T \Delta\Omega$ for each counter after the spectrometer were determined by suspended-wire measurements. Loss in π^+ detection efficiency due to the decay of the π was calculated. The e^+ contamination in the π^+ telescope was calculated and found to agree with a measurement made at 20°. The total cross sections at 365 Mev, 2.39 ± 0.20 mb, and at 432 Mev, 3.98 ± 0.20 mb, are in agreement with other recent measurements. The angular distributions in the center-of-mass system (c.m.) are $d\sigma/d\Omega^*)_{365\ Mev} = [(190 \pm 16) + (10 \pm 27) \cos\theta^*]$ μb/sr and $d\sigma/d\Omega^*)_{432\ Mev} = [(317 \pm 16) + (35 \pm 26) \cos\theta^*]$ μb/sr. At the higher energy the forward peaking of the π^+ is less pronounced than in a previous measurement of that characteristic. Both total cross section and angular distribution can be explained to present accuracy with two models: a π-π interaction model and an isobaric model. The π^+ c.m. energy distributions were observed to peak at lower energies than predicted by a phase-space distribution, thereby suggesting the presence of isobar formation in the final state. An attempt was made to fit the energy-spectrum data to an isobaric model using as many as three parameters. At 375 Mev moderately good fits are obtained, whereas at 432 Mev no reasonable fit to the measured energy spectrum could be found. 38 references. (auth)

690

944

A MEASUREMENT OF THE TOTAL ABSORPTION RATE OF MUONS IN CARBON. F. Russell Stannard (Univ. of California, Berkeley). Nuovo cimento (10), 17, 599-606 (1960) Aug. 16. (In English)

Negative muons stopped in a propane bubble chamber form mesic atoms with carbon nuclei. Subsequently they either decay by their usual mode or interact with the nucleus. Based on a sample of 2519 mesons, the probability for interaction was found to be (7.4 ± 0.8)%, and the total absorption rate of muons in carbon became $(0.36 \pm 0.04) \cdot 10^6\ s^{-1}$. The result was found to be in satisfactory agreement with theory. (auth)

691

16229

TOTAL ABSORPTION RATE OF MUONS IN CARBON. F. Russell Stannard (Univ. of California, Berkeley). Phys. Rev. Letters 4, 523-4(1960) May 15.

The absorption rate was studied for muons in carbon with

a 30-in. propane bubble chamber. The muon beam had a 1% pion background. Of the 2519 particles stopping in the chamber, 2334 decayed and 185 interacted. The pion contamination was estimated from prong distributions of pion and muon capture stars. It is expected that ~18% of muon captures lead to a formation of B^{12}, which β decays to C^{12}. If a decay lifetime of 2.22×10^{-6} sec is assumed, the estimate of the total capture rate becomes $\Lambda_1 = (0.36 \pm 0.04) \times 10^5$ sec^{-1}. (B.O.G.)

692

24185 REVIEW OF PION RESONANCES. Jack Steinberger (Columbia Univ., New York). p.185-210 of "Eastern Theoretical Physics Conference." New York, Gordon and Breach, Science Publishers. 1963.

The pion resonances ρ, ω, and η, are discussed. The ρ resonance was found in the reactions: $\pi^- + p \rightarrow \pi^- + \pi^0 + p$ and $\pi^- + p \rightarrow \pi^+ + \pi^+ + n$. The central mass is 750 Mev, and the ρ has spin 1 and negative parity. The ω was discovered in the reaction $p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + \pi^0$. The mass is ~782 Mev, and the isotopic spin is 0. The η was found in the 3-pion system of the reaction $\pi^+ + d \rightarrow p + p + \pi^+ + \pi^- + \pi^0$. The isotopic spin is 0, and the mass is ~548 Mev. Interpretations of the reactions and properties of the resonances are discussed. The resonances are found in large quantities in p-p collisions, π-p and π-d collisions, and proton-antiproton annihilation. (M.P.G.)

693

10330 MUON SCATTERING EXPERIMENT ON NUCLEAR STRUCTURE OF C^{12}. Richard O. Stenerson and Robert W. Williams (Univ. of Washington, Seattle). Phys. Rev., 137: B260-71(Jan. 25, 1965).

The differential cross section for the scattering of 1.09 Bev/c muons in carbon, summed over all final energies, was measured in the laboratory angular range 10 to 20° using a spark-chamber detector. The experimental results agree in a general way with the theoretical predictions for reasonable wave functions, but both theory and experiment lack the precision necessary for a critical test of the best available wave functions. The future utility of muon beams, as compared to electrons, is briefly discussed. (auth)

694

41379 π-α SCATTERING AND THE PIONIC FORM FACTOR. Sternheim, M. M. (Yale Univ., New Haven); Hofstadter, R. Nuovo Cimento (10), 38: 1854-60(Aug. 16, 1965).

Theoretical calculations are carried out on π^--α and π^+-α elastic scattering processes. Results are presented at a typical incident pion energy of 100 Mev. The results are sensitive to the pion's electromagnetic form factor since the form factor of the α-particle may be taken from electron scattering experiments. If the pion size is large the burden on the theoretical calculations is not great. However if the pion size is small the calculations must be refined. In any case the comparison of π^--α and π^+-α scattering is worthwhile, and suggestions are made as to how to carry it out. (auth)

695

34911 SCATTERING OF PIONS BY LIGHT NUCLEI. Morton M. Sternheim (Yale Univ., New Haven). Phys. Rev., 135: B912-20(Aug. 24, 1964).

The scattering of pions by light nuclei is calculated using an approximate, high-energy, small-angle multiple-scattering expansion which neglects off-the-energy-shell scattering. The approximations needed to obtain this expansion from an exact multiple-scattering theory are examined. It is found that the unknown contribution of the off-the-energy-shell scattering makes any calculation of pion-nucleus scattering unreliable for large angles. Using π-N phase shifts and electron-scattering data, results are obtained for the scattering of pions of about 80 Mev by Li, C, and O. (auth)

696

25779 (CEA-R-2838) MESURE DES SECTIONS EFFICACES TOTALES π^+p ET π^-p ENTRE 700 ET 1700 Mev ET APPLICATIONS AUX RELATIONS DE DISPERSION [Theses]. (Measurement of the π^+p and π^-p Total Cross Sections From 700 to 1700 Mev and Applications to the Dispersion Relations [Thesis]). Stirling, Alexandre V. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1966. 64p. Dep. mn.

Submitted to Paris Univ., Orsay (France). Faculte des Sciences.

The π^+p and π^-p total cross sections were measured between 500 and 1700 Mev to eliminate discrepancies in the experimental data. These new values have permitted a more precise calculation of the forward dispersion relation These relations are well satisfied by the experimental data up to 18 Bev for charge exchange scattering. The dispersion relation for the spin-flip amplitude gives an efficient test for the phase-shift analysis solutions. (auth)

697

24247 PION-PION INTERACTION IN PION-PRODUCTION BY π^+-p COLLISIONS. D. Stonehill, C. Baltay, H. Courant, W. Fickinger, E. C. Fowler, H. Kraybill, J. Sandweiss, J. Sanford, and H. Taft (Yale Univ., New Haven and Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Letters, 6: 624-5(June 1, 1961).

The reactions $\pi^+ + p \rightarrow \pi^+ + \pi^0 + p$ and $\pi^+ + p \rightarrow \pi^+ + \pi^+ + n$ are studied at 910, 1090, and 1260 Mev, in an attempt to detect a π-π resonance. For the outgoing $\pi^+\pi^0$ pair, peaks in the Q-values lead to a di-pion resonance with a mass of 5.0 to 5.5 pion masses and I = 1 or 2. No resonance is observed in the outgoing $\pi^+\pi^+$ (I = 2) pair, leading to the conclusion that the $\pi\pi$ resonance is a I = 1 state. (T.F.H.)

698

15636 (TID-15425) PION-PION INTERACTIONS IN π^+–p COLLISIONS. D. L. Stonehill and H. L. Kraybill (Yale Univ., New Haven). Feb. 28, 1962. Contract AT(30-1)-1173. 23p.

Results of a study are presented concerning the occurrence of pion-pion interactions in collisions of positive pions with protons, at incident pion kinetic energies of 910, 1090, and 1260 Mev. The interactions of principal interest are $\pi^+ + p \rightarrow p + \pi^+ + \pi^0$, and $\pi^+ + p \rightarrow n + \pi^+ + \pi^+$. (J.R.D.)

699

22726 (NEVIS-121) ELECTRON DECAY BRANCHING RATIO OF THE PION (thesis). Alan Strelzoff (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). Mar. 1964. Contract Nonr-266(72). 62p. (CU-227; R-419)

The ratio of the pion decay rates for the processes, $\pi \rightarrow e + \nu$ and $\pi \rightarrow \mu + \nu$, was measured. A large NaI(Tl) crystal was used to separate the high energy pion decay electrons from the continuous spectrum of the π-μ-e chain. Counting decay electrons immediately following a pion stop, the ratio was determined by a direct comparison of π-e and π-μ-e electrons. From an observed 10,891 π-e electrons a precision of 1.8% was attained in the quantity (pion lifetime × branching ratio). Considering the present uncertainty in the pion lifetime the branching ratio, $(1.247 \pm 0.028) \times 10^{-4}$ is obtained. This is in good agreement with the theoretical value, 1.233×10^{-4}, required by the V-A theory when radiative corrections are included. (auth)

700

39042 PROSPECTIVE USE OF NEGATIVE Pi-MESONS IN THERAPY. C. Stuart and G. Cittadini (Università, Siena, [Italy]). Radiazioni Alta Energia, 1: 209-18(Oct. 1962). (In Italian)

A synthetic and critical view of the present physical and biological notions on the mesons is drawn underlining the importance which they may have on the future of high energy therapy and major prominent practical and theoretical points are synthesized on the following three considerations: the distribution of the dose at the focus is excellent and definitely superior to the one obtained with other particles including rapid protons; the RBE of the mesons is difficult to evaluate although, on the strength of a preliminary approximation, they may be identified as that of other particles; the negative pi-mesons are not presently utilized in therapeutical practice in view of the fact that the mesonic beam obtained with the normal accelerators is not intense enough in order to reach acceptable focus doses. (auth)

701

19912 EXCITED STATES OF ^{4}He AT ABOUT 30 Mev. Tang, Y. C. (Univ. of Minnesota, Minneapolis). Phys. Lett., 20: 299-301(Feb. 15, 1966).

Analysis of the result from the reaction ^{6}Li(π^+,2p)^{4}He shows that there are excited states of ^{4}He at about 30 Mev excitation, which can be best interpreted as having the structure of two deuteron clusters in relative oscillation. (auth)

702

29492 (BNL-7033) Mu-p SCATTERING EXPERIMENT—TRIGGER AND DRIVE CIRCUITS. Mu-p No. 26. Michael J. Tannenbaum (Columbia Univ., New York and Brookhaven National Lab., Upton, N. Y.). May 1963. Contract [AT(30-2)-Gen-16]. 67p.

Block diagrams of the apparatus to be used in the experiment are presented; and the design, behavior, and operation of the various circuits are discussed. (D.C.W.)

703

25264 (NYO-2262-86) ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 903 Mev (thesis). Internal Report No. 108. Merlin Gene Taylor (Brown Univ., Providence, R. I.). Feb. 1965. Contract [AT(30-1)-2262]. 58p. Dep.(mn); $3.00(cy), 2(mn) CFSTI.

The meson (π^-)-proton interaction was investigated at 903 Mev using a hydrogen bubble chamber. The measuring techniques and event construction and selection are discussed. The elastic scattering cross sections and angular distributions were determined. (C.E.S.)

704

8224 HYPERFINE EFFECTS IN MUON CAPTURE. V. L. Telegdi (Univ. of Chicago). p.16-25 of "Weak Interactions and Topics in Dispersion Physics." New York, W. A. Benjamin, Inc., 1963.

Experimental evidence on the nature of (NP)($\bar{\nu}_\mu$) coupling in complex nuclei is reviewed. Arguments are presented of the presence of V coupling in relation to the hyperfine effects. Other hyperfine experiments are mentioned: capture of μ by a $j = l - \frac{1}{2}$, $d_{\frac{5}{2}}$ proton; capture by ^{11}B; and inner bremsstrahlung in μ^- capture. (L.B.S.)

705

14798 (CEA-2306) CONTRIBUTIONS A L'ÉTUDE DES RÉACTIONS $\pi^\pm + p \rightarrow \pi^\pm + p + \pi^0$ ENTRE 0.5 ET 1.5 GeV/c. (Contribution to the Study of the Reaction $\pi^\pm + p \rightarrow \pi^\pm + p + \pi^0$ Between 0.5 and 1.5 Gev/c). Bernard Thevenet (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucleaires, Saclay). 1963. 79p.

Thesis submitted to Universite, Paris.

The total production cross section of γ accompanied by charged secondaries in $\pi^\pm$ p interactions between 0.5 and 1.5 Bev/c was measured. The cross section of the reaction $\pi^+ p \rightarrow \pi^+ \pi^0 p$ was obtained. Only the cross section of $\pi^- p \rightarrow \pi^0 +$ (charged particles) could be determined because the lack of information on multiple production. The experimental results were compared with the predictions of simple production models. A method for calculation of high energy γ-ray efficiency of detectors with lead converters is given. (auth)

706

14335 EXPECTED ENERGY PEAKS IN MESON-MESON INTERACTION. Charles Thompson (Marquardt Corp.,

Orange, Calif.). Can. J. Phys., 43: 163-7(Jan. 1965).

The nature of unstable meson-meson interactions is considered. A discussion is given of the type of energy peaks expected on the basis of the crossed one-meson exchange diagram where the unstable vertices represent decay vertices and can lead to singularities near the physical region and whether such peaks will actually appear in the three-body final-state interaction when the diagram is joined by unitarity to the final (and initial) system involving stable mesons only. (C.E.S.)

707

25276 PION-NUCLEON SCATTERING AND J = 2, T = 0 PION-PION INTERACTION. Charles Thompson (Applied Science, Minneapolis). J. Phys. Soc. Japan, 20: 297-302(Mar. 1965).

The effect of the J = 2, T = 0, $\pi-\pi$ interaction on the $\pi-N$ invariant amplitude $B^{(+)}$ is analyzed. It was found that the $\pi-N$ scattering data is inconsistent with a J = 2, T = 0, $\pi-\pi$ phase, due to δ_2^0, which rises to above 13° around 650 Mev. From the data it is impossible to say whether the results correspond to a resonant phase or only a sharp peak in the corresponding absorptive part of the amplitude. (auth)

708

33029 ANALYSIS FOR THE PRODUCTION OF AN ISOSCALAR S-WAVE DI-PION RESONANCE. Thurnauer, Peter G. (Univ. of Rochester, N. Y.). Phys. Rev. Letters, 14: 985-8(June 14, 1965).

Outlined is a fully relativistic and unitarity-preserving, phenomenological model for the one-pion production reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$. The effects of the (3,3) pion-nucleon resonance on the final two-pion system and the possibility of a di-pion resonance are examined. The tests of the model for a wide range of data serve to ensure its validity and likewise to define its parameters. (M.O.W.)

709

29691 MEAN LIFETIME OF THE π^0 MESON. J. Tietge and W. Pueschel (Max-Planck-Institut für Physik und Astrophysik, Munich). Phys. Rev., 127: 1324-7(Aug. 15, 1962).

An estimate of the π^0 mean lifetime has been obtained by a method first attempted by Harris, Orear, and Taylor in 1957. The decay distances of monoenergetic π^0 mesons, produced by the $K_{\pi 2}$ decay at rest ($K^+ \rightarrow \pi^+ + \pi^0$) and decaying via the Dalitz mode ($\pi^0 \rightarrow e^+ + e^- + \gamma$), were measured. In two stacks of nuclear emulsion (Ilford K5), exposed to the 700-Mev/c K^+ beam at the Berkeley Bevatron, 45 events of this type were found. For the π^0 mean lifetime a value of $\tau = (2.3^{+1.1}_{-1.0}) \times 10^{-16}$ sec has been obtained. (auth)

710

37637 PION-PROTON INTERACTIONS AT 780 Mev. Tilger, Clarence Arthur Jr. Thesis, Bloomington, Ind., Indiana Univ., 1964. 83p.

The interactions of protons with pions having a laboratory kinetic energy of 780 Mev are examined. Using the optical theorem and the value of the total cross section determined in previous work by Devlin et al., the elastic angular distribution is $(0.24 \pm 0.03) + (0.82 \pm 0.09) \cos\vartheta + (2.40 \pm 0.22)\cos^2\vartheta + (0.37 \pm 0.15)\cos^3\vartheta - (1.45 \pm 0.26)\cos^4\vartheta$ where the coefficients are in mb/sterad. The elastic cross section is 10.1 ± 1.4 mb and the one-pion production cross section is 12.2 ± 1.4 mb. The ratio of the cross section for neutral pion production to charged pion production is 4.35 ± 0.30 : 1. The kinetic energy and angular distributions of the particles in the one-pion production final states are examined and compared with the predictions of various models. In particular, the $D_{\frac{3}{2}}$ isobar model and the vector meson exchange model are examined. While both of these fit the data in part, neither agrees with the whole of the data and further theoretical analysis is necessary to fully explain the one pion production process. (Dissertation Abstr.)

711

15341 π^+p INTERACTIONS AT T_π = 781 Mev. Tilger, C. A.; Poirier, C. P.; Alyea, E. D. Jr.; Martin, H. J. Jr.; Scandrett, J. H. (Indiana Univ., Bloomington). Phys. Rev., 142: 972-6(Feb. 25, 1966).

Interactions of 781-Mev π^+ mesons with protons were investigated using a 14-in. hydrogen bubble chamber. A total of 2305 events were observed. The data were normalized to a total cross section of 22.2 mb, giving partial cross sections $\sigma(\pi^+p \rightarrow \pi^+p) = 9.5 \pm 0.5$ mb, $\sigma(\pi^+p \rightarrow \pi^+p\pi^0) = 9.3 \pm 0.5$ mb, $\sigma(\pi^+p \rightarrow \pi^+\pi^+n) = 2.15 \pm 0.17$ mb, and a multiple-pion-production cross section of 1.15 ± 0.17 mb. The elastic angular distribution was obtained and is $d\sigma/d\omega = (0.25 \pm 0.03) + (0.90 \pm 0.11)\cos\theta_{c.m.} + (2.57 \pm 0.24)\cos^2\theta_{c.m.} + (0.19 \pm 0.22)\cos^3\theta_{c.m.} - (1.73 \pm 0.34)\cos^4_{c.m.}$. The kinetic-energy and angular distributions of the outgoing particles in single-pion production are given. The data are compared with other experiments in this energy region and their relevance to the shoulder in the π^+p total cross section near 830 Mev is discussed. (auth)

712

36703 THE INDUCED PSEUDOSCALAR INTERACTION IN MUON CAPTURE AND NUCLEAR STRUCTURE. H. A. Tolhoek (Rijksuniversitet, Groningen, Netherlands). p.336-48 of "Selected Topics in Nuclear Spectroscopy." New York, John Wiley and Sons, 1964.

It is shown that the induced pseudoscalar coupling constant in muon capture can be determined, assuming the CVC hypothesis. Determination of the constant from the partial transition rates for muon capture by ^{16}O and from radiative muon capture is discussed. (D.C.W.)

713

44993 (CEA-R-2778) CALCUL DE LA CONTAMINATION EN MUONS D'UN FAISCEAU DE MESONS π. (Calculation of the Muon Contamination in a π-Meson Beam). Tran, Anh Ha (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1965. 17p. Dep. mn.

A method is presented for calculating the μ contamination of a π meson beam which is parallel and of cylindrical symmetry. The CONTAMU program used in carrying out this calculation is also given. An evaluation of the μ contamina-

tion is necessary for correcting the experimental values of the cross sections of various reactions using the π meson beam as the incident particle beam. The two following cases are treated: (1) the beam is defined by an S_1 counter and the μ contamination is calculated when the beam passes through this counter and (2) the beam is defined by two counters S_1 and S_2 and the μ contamination is calculated when the beam passes through the two counters successively. The calculation is given in detail following the order of the program. A table of results for a few of the parameters defined is given as an example. (tr-auth)

714

40252 (UCRL-11537) SCATTERING OF 250-Mev POSITIVE PIONS BY PROTONS: EXPERIMENT AND ANALYSIS (thesis). Wladyslaw Kilian Troka (California. Univ., Berkeley. Lawrence Radiation Lab.). Sept. 18, 1964. Contract W-7405-eng-48. 102p.

The differential cross section for elastic scattering of positive pions on protons was measured at a nominal incident-meson kinetic energy of 250 Mev. The angular range covered in the center of mass by the 13 data points was 14.9 to 160°. The fractional rms errors were typically 1.5%. A liquid hydrogen target was bombarded by a beam of 2.5×10^6 mesons/sec. The scattered pions were detected by a counter telescope. Recoil protons were eliminated by means of a Cherenkov counter. A phase-shift analysis was performed combining the above-mentioned data with the recoil-proton polarization measurements taken recently with the help of a polarized proton target. Only one acceptable SPD Fermi-type phase-shift set was found. When F waves were included, a total of three possible phase-shift solutions emerged from the analysis. However, arguments based on the data could still be made to eliminate all but one phase-shift set. On the other hand, the remaining phase-shift set, similar in type to the SPD solution, suffers from the disadvantages of large rms errors assigned to its small phase shifts. (auth)

715

18907 A NOTE ON THE LOW ENERGY PION-NUCLEON (3.3) PARTIAL WAVE SCATTERING. Chang-chie Tsao, Wai-shen Wang, and Ho-chang Huang (Peking Univ.). Wu Li Hsueh Pao, 20: 1210-15(Dec. 1964). (In Chinese)

An approximate expression for the (3,3) partial wave amplitude is given from the analyticity, unitarity, and threshold behavior considerations, in which only two parameters, namely the coupling constant and resonance level, are introduced. This expression is in good agreement with the experimental data from the threshold up to the pion laboratory kinetic energy of about 350 Mev. In comparison with Chew-Low's result, it gives the variation of $(q^3/\omega)\mathrm{ctg}\,\delta_{33}$ with ω not following a straight line but a curve concave downward. Such an improvement is just required by the experimental data. It is shown that there is some inadequacy concerning analyticity in the Chew-Low's expansion and that this inadequacy has been overcome in the present formulation. (auth)

716

24677 (CEA-2136) CONTRIBUTION A L'ÉTUDE DES RÉACTIONS $\pi^- + p \rightarrow \pi^0 + n$ et $\pi^- + p \rightarrow \pi^0 + \pi^0 + n$ AUX ÉNERGIES DES MAXIMA DE LA SECTION EFFICACE TOTALE DE L'INTERACTION π^- NUCLÉON DANS L'ÉTAT DE SPIN ISOBARIQUE $T = \frac{1}{2}$ (THÈSES). (Contribution to the Study of $\pi^- + p \rightarrow \pi^0 + n$ and $\pi^- + p \rightarrow \pi^0 + \pi^0 + n$ Reactions at the Energies of the Maxima of the π^--Nucleon Interaction in the $T = \frac{1}{2}$ State Total Cross Section (thesis)). René Turlay (France. Commissariat à l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay). 1962. 71p.

Submitted to Université, Paris.

The total cross sections for processes yielding only neutral particles from 300 to 1600 Mev were determined. For this, the number of incident π^- was counted, which interact in a liquid-hydrogen target without giving charged particles in a 4 π counter surrounding the target. The reactions $\pi^- + p \rightarrow \pi^0 + \pi^0 + n$ between 300 and 1100 Mev were separated. By supposing that only these two reactions were realized by placing lead absorbers between the target and 4 π counter and by comparing the counting rate for neutral events with and without lead. The transmission measured is a function of the average number of photons produced and therefore of the ratio between the two neutral channels, $\pi^0 + n$ and $\pi^0 + \pi^0 + n$. The experimental results are discussed and compared to those obtained in the study of photoproduction and the π^- nucleon interaction. (auth)

717

8940

THE EFFECT OF THE STRUCTURE OF THE NUCLEON ON THE CAPTURE OF μ^- MESON BY PROTON. H. Y. Tzu, T. H. Ho, and Y. B. Dai (Inst. of Atomic Energy Research and Inst. of Mathematics, Academia Sinica, Peking). Wu Li Hsüeh Pao 15, 521-4(1959) Oct. (In Chinese)

It is noted that, owing to the similarity existing between electromagnetic interaction and the vector part of the weak interaction proposed by Feynman and Gell-Mann, the contribution of the vector part of the weak interaction to μ^- capture by a proton is closely related to the electromagnetic form factors of the nucleon. Formula for the capture probability calculated with the renormalized V−A, weak interaction is given. The correction to the contribution of the vector part of the weak interaction due to the charge and magnetic moment distribution of the nucleon is estimated on the basis of the data from electron-nucleon scattering experiments. (auth)

717a

28350 (JPRS-8182(p.24-8)) EFFECT OF THE STRUCTURE OF THE NUCLEON ON THE CAPTURE OF THE μ-MESON BY THE PROTON. H. Y. Tzu, T. H. Ho, and Y. B. Dai. Translated from Wu Li Hsüeh Pao, 15: 521-4 (Oct. 1959).

This paper was previously abstracted from the original language and appears in NSA, Vol. 14, abstract no. 8940,

718

35453 GIANT DIPOLE GAMMA-DECAY FOLLOWING MU-MESON CAPTURE IN ^{12}C. Ueberall, H. (Catholic Univ. of America, Washington, D. C.). Nuovo Cimento (10), 38: 669-72(July 1, 1965).

In an attempt to verify the presence of the giant dipole mechanism in meson (μ) capture in a more direct experimental fashion, neutron spectra and γ rays should be studied near 10 Mev. An order-of-magnitude estimate of γ versus neutron decay widths is given to indicate whether an experimental search for these photons would be feasiblo. (J.F.P.)

719

22812
HYPERFINE SPLITTING EFFECTS IN THE CAPTURE OF POLLARIZED μ^- MESONS. H. Uberall (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. 114, 1640-5 (1959) June 15.

The effect of hyperfine splitting of μ-mesic atom ground states on the neutron asymmetry from muon capture was investigated in hydrogen, deuterium, and complex nuclei. It is shown that this can provide more information on the capture interaction than the neutron asymmetry from spinless nuclei. Muon polarizations and gyromagnetic ratios in the hyperfine states are also discussed. (auth)

720

15562 NEUTRINOS FROM STOPPED π AND μ MESONS. H. Ueberall (Univ. of Michigan, Ann Arbor). Nuovo cimento (10), 23: 219-21(Jan. 1, 1962). (In English)

Neutrino spectra from π and μ decay and from μ^- capture in heavy materials were determined and plotted. Identity determination is discussed. (L.N.N.)

721

44801 SCATTERING OF PIONS FROM NUCLEI. R. K. Umerjee (MATSCIENCE, Inst. of Mathematical Sciences, Madras). Nucl. Phys., 60: 497-502(Dec. 1964).

Elastic scattering of pions from complex nuclei is studied using the shell model and the impulse approximation. Numerical results are presented in the energy range 65 to 150 Mev for targets C and O. Comparison is made with experimental results. (auth)

722

28598 μ^--MESON CAPTURE IN CARBON INVOLVING THE FORMATION OF B^{12}. A. O. Vaisenberg (Inst. of Theoretical and Experimental Physics, Academy of Sciences, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 109-12(July 1961). (In Russian)

Approximately 500 two-prong stars produced in the capture of μ^- mesons by light photographic emulsion nuclei are examined. The probability for emission of an Auger electron in a capture of this type is of the order of a tenth of a percent. Nine stars of the type $\mu^- + C^{12} \rightarrow B^{12*} + \nu$; $B^{12*} \rightarrow Li^8 + He^4$ were detected. The probability of such a reaction is 2×10^{-3} per capture in a carbon nucleus. It is shown that there should be excited levels in the B^{12} nucleus with an energy ~19-26 Mev from which breakup into Li^8 and He^4 may be possible. (auth)

723

8213 MASS SPECTRUM OF CHARGED PARTICLES EMITTED IN THE ABSORPTION OF π^--MESONS BY PHOTOGRAPHIC EMULSIONS. A. O. Vaisenberg, E. D. Ivlganova, and N. V. Rabin. Zh. Eksperim. i Teor. Fiz., 47: 1262-9(Oct. 1964). (In Russian)

The yield and spectrum of charged particles produced in photographic emulsion nuclear disintegrations induced by slow and fast (300 Mev) π^- mesons were studied. The yields of deuterons and tritium nuclei with energies ≥10 Mev from light nuclei (C, N, O) disintegrated by slow π^- mesons (σ_π stars) are, respectively, approximately 40 and 15%. The yields of deuterons with energies ≥20 Mev from heavy nuclei (Ag,Br) is close to 40% and is small for energies <20 Mev. Absorption of fast π^- mesons does not result in appreciable emission of complex particles. (auth)

724

24720 THE SCATTERING OF 87 Mev POSITIVE PIONS ON CARBON AND OXYGEN. F. P. G. Valckx, E. S. Gelsema, and M. Kruiskamp (Rijksuniversiteit, Utrecht). Nuovo cimento (10), 23: 1005-20(Mar. 16, 1962). (In English)

Elastic and inelastic scattering angular distributions of 87-Mev positive pions on carbon and oxygen are measured with a total-absorption scintillation spectrometer of high energy resolution. The elastic angular-distribution data can be fitted with the Kisslinger theory. The inelastic angular distributions are strongly peaked in the backward direction. The inelastic differential cross section appreciably surpasses the elastic cross section at angles above about 100°. At several angles a peak is seen in the energy spectra of pions scattered from carbon, which must be explained as resulting from quasi-free pion-nucleon scattering. (auth)

725

19220 SPALLATION OF LIGHT NUCLEI BY SLOW π MESONS. A. T. Varfolomeev. Tr. Fiz. Inst., Akad. Nauk SSSR, 22: 101-28(1964). (In Russian)

The products from the absorption of mesons(π^-) by ^{12}C, ^{14}N, and ^{16}O were measured on Ilford C-2 emulsions 400 microns thick. The meson(π^-) beam was obtained by irradiating carbon targets in the gamma beam of a synchrotron. The angular distributions of the slow fragments are peaked at large angles when compared to the distributions of the fast protons. Average values of the momenta of ^8Li, α, and p products were determined for reactions giving charged products of $2\alpha p$, $3\alpha p$, ^8Li2p, and $^8Li\alpha$. It is generally

assumed that singly charged products are protons; however in up to 30% of the cases they were determined to be deuterons and tritons. Neutron spectra were determined for the reactions $^{12}C + \pi^- \rightarrow {}^8Li + {}^3He + n$; $^{12}C + \pi^- \rightarrow 2\alpha + t + n$; and $^{16}O + \pi^- \rightarrow 3\alpha + t + n$. The maximum energies of the neutron spectra for these reactions are 87, 102, and 97 Mev, respectively. The spectra coincide < 80 Mev, indicating that these neutrons arise from the reaction $p + \pi^- \rightarrow n$. The measured momentum distributions agree better with calculations based on the one-nucleon model ($p + \pi^- \rightarrow n$) than with the two-nucleon model ($p + n + \pi^- \rightarrow 2n$; $2p + \pi^- \rightarrow p + n$). The distributions of the excitation energy of the ^{11}B nucleus were found to be the same for the $^{12}C(\pi^-,n)^{11}B$ and $^{12}C(p,2p)^{11}B$ reactions above 30 Mev, indicating that excitation states of ^{11}B < 25 Mev are even, but >25 Mev are odd. The only observed reaction on nitrogen was $^{14}N + \pi^- \rightarrow 3\alpha + 2n$. (TTT)

726

9287 ENERGY LOSSES OF STRONGLY INTERACTING PARTICLES PASSING THROUGH HYDROGEN. Yu. L. Vartanyan (Inst. of Physics, Academy of Sciences, Armenian SSR). Zh. Eksperim. i Teor. Fiz., 43: 2143-5 (Dec. 1962). (In Russian)

Energy losses due to strong interactions are calculated on the basis of experimental data for nucleons and pions passing through hydrogen. (auth)

727

14325

ELASTIC SCATTERING OF 300 Mev π^--MESONS ON HYDROGEN. I. M. Vasilevskiĭ and V. V. Vishnyakov. Zhur. Eksptl'. i Teoret. Fiz. 38, 441-4(1960) Feb. **(In Russian)**

The elastic scattering of 300 Mev π^--mesons on hydrogen was studied using a hodoscope in which the counters were fed by pulsed voltage. On the assumption that elastic scattering is mainly due to S- and P-waves, an equation was derived for the angular distribution. (auth)

728

19769

THE POLARIZATION OF RECOIL PROTONS IN π^- MESON SCATTERING IN HYDROGEN AT 300 MEV. I. M. Vasilevskiĭ and V. V. Vishnyakov (Joint Inst. for Nuclear Research, [Dubna, USSR]). Zhur. Eksptl'. i Teoret. Fiz. 38, 1644-6(1960) May. (In Russian)

The polarization of recoil protons in 300-Mev π-meson scattering by hydrogen was measured. 305 events of elastic π-meson scattering and proton scattering in the hydrocarbon target or in the counter walls were divided into three groups according to the angle of recoil protons. The obtained data are tabulated, and the polarization as a function of the π-meson scattering angle for two sets of phases was plotted. (R.V.J.)

729

2544 NP-8058

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems.

HODOSCOPE SYSTEM OF GEIGER COUNTERS WITH CONTROLLED PULSE SUPPLY FOR INVESTIGATION OF π^--PROTON SCATTERING. I. M. Vasilevskii (Vasilevsky) and V. V. Vishnyakov. 1959. 13p. (P-287).

The hodoscope system of gas-discharge counters with controlled pulse supply which was used on the synchrocyclotron for investigation of π^--proton scattering is described. The system consisted of 426 hodoscope counters. The details of the use of such systems in some experiments made on accelerators are given. (auth)

730

20837 (JINR-D-1202) **POLARIZATSIYA PROTONOV OTDACHI PRI RASSEYANII π-MEZONOV S ENERGII 300 Mev NA VADORODE. (Polarization of Recoil Protons in 300 Mev π-Meson Scattering on Hydrogen). I. M. Vasilevskii and V. V. Vishnyakov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1963. 5p.**

Recoil proton polarization was studied in π meson scattering on hydrogen at 300 Mev. A hodoscope system with 800 Geiger counters was used for measuring elastic π^- and proton scattering on carbon targets at 8 to 30° angles. 777 events of recoil proton scattering were found at 16 to 31° recoil angles. The results were tabulated and compared to published data. (R.V.J.)

731

46366 RECOIL PROTON POLARIZATION IN ELASTIC π^-p SCATTERING AT 300 Mev AND THE PHASE SHIFT ANALYSIS OF PION-NUCLEON SCATTERING. Vasilevskii, I. M.; Vishnyakov, V. V.; Ivanchenko, I. M.; Lapidus, L. I.; Silin, I. N.; Tyapkin, A. A.; Schegelskii, V. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 23: 174-6(Oct. 10, 1966).

The results of a measurement of recoil proton polarization for $\pi^-p \rightarrow \pi^-p$ at 300 Mev are given, and a phase shift analysis is made with the help of other data. (auth)

732

46369 MASS DIFFERENCE ON THE NEGATIVE AND NEUTRAL PIONS. Vasilevskii, I. M.; Vishnyakov, V. V.; Dunaitsev, A. F.; Prokoshkin, Yu. D.; Rykalin, V. I.; Tyapkin, A. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Phys. Lett., 23: 281-2(Oct. 24, 1966).

The angular correlation of gamma-quanta emitted in the capture of stopping π^--mesons by protons was measured. Measurements were made with a hodoscope of scintillation and gas discharge counters. The mass difference of the negative and neutral pions turned out to be (4.6034 ± 0.0052) Mev/c^2. (auth)

733

22728 (NP-13870) REPORT ON RECENT EXPERIMENTAL DATA, 1963. Matscience Report 17. K. Venkatesan (Institute of Mathematical Sciences, Madras). 11[0]p

Data from the 1963 monthly reports (since April) on strong, weak, and electromagnetic interactions are compiled. Experiments on the third sound in liquid helium films and on the energy gap in superconductors are also reported. The data include interaction, resonance production, and particle production cross sections; nucleon form factors; particle and resonance properties; π-p phase shifts; and meson(μ^-) capture rates. (D.C.W.)

734

28139 (ISS-63/28(p.1-11)) ASSORBIMENTO DI MESONI π^- IN NUCLEI COMPLESSI. (Absorption of π^- Mesons in Complex Nuclei). G. Campos Venuti, G. Fronterotta, and G. Matthiae (Italy. Istituto Superiore di Sanità, Rome).

The deexcitation processes in a nucleus as a result of the absorption at rest of a π^- meson were studied by measurement of the energy of the neutrons emitted from 1 to 50 Mev. The experimental set-up for measurement of the neutrons emitted is described. Targets of Cu, Sn, and Pb were used. The results are given as a function of number of neutrons emitted per pion absorbed and per 1-Mev energy interval. The three spectra show quite similar characteristics. The mean number of neutrons emitted per pion absorbed is 6.9 ± 0.4 for Cu, 8.0 ± 0.5 for Sn, and 8.9 ± 0.5 for Pb. The results are in satisfactory agreement with Monte Carlo calculations. (J.S.R.)

735

8437 THE ABSORPTION OF NEGATIVE PIONS BY COMPLEX NUCLEI (COPPER, TIN AND LEAD). G. Campos Venuti, G. Fronterotta, and G. Matthiae (Istituto Superiore di Sanità, Rome and Istituto Nazionale di Fisica Nucleare "Sottosezione Sanità", Rome). Nuovo Cimento (10), 34: 1446-57(Dec. 16, 1964).

An experiment performed at the electron synchrotron is described for measuring the energy spectrum of neutrons emitted in the energy range from about 1 to 50 Mev in the capture of negative pions at rest in complex nuclei. The experimental data obtained using targets of Cu, Sn, and Pb are presented and discussed. Each of the energy spectra of neutrons emitted is characterized by a low-energy evaporation part with a maximum at about (2 – 3) Mev. Comparison of data obtained in π^- absorption in the almost double magic nucleus of Pb, with results of other experiments using the same excitation energies, shows shell-model effects on evaporation processes. (auth)

736

32733 (ISS-64/10) ASSORBIMENTO DI MESONI π^- IN Cu, Sn E Pb. (Negative Pion Absorption in Cu, Sn, and Pb). G. Campos Venuti, G. Fronterotta, and G. Matthiae (Italy. Istituto Superiore di Sanita, Rome). Apr. 3, 1964. 27p.

An experiment performed at the Electron Synchrotron in Frascati is described for measuring the energy spectrum of neutrons emitted at 1 to 50 Mev in the capture of negative pions at rest in complex nuclei. The experimental data obtained using targets of Cu, Sn, and Pb are presented and discussed. Each of the energy spectra of neutrons emitted is characterized by a low-energy evaporation part with a maximum at about 2 to 3 Mev. Comparison of data obtained in π^- absorption in the almost double magic nucleus of Pb, with results of other experiments using the same excitation energies, shows shell-model effects on evaporation processes. (auth)

737

19084 NEUTRON SPECTRA FROM π^- CAPTURE IN Cu, Sn, AND Pb. G. Campos Venuti, G. Fronterotta, and G. Matthiae (Istituto Superiore di Sanità, Rome). Phys. Letters, 9: 45-8(Mar. 15, 1964).

The energy spectra of neutrons emitted per pion capture in Cu, Sn, and Pb were investigated for an incident momentum of 150 Mev/c. Information about both the evaporation process at high excitation energy and the prompt emission of nucleons was obtained. (C.E.S.)

738

25902 (LNF-62/37(p.138-42)) CATTURA DI MESONI π^- IN NUCLEI COMPLESSI. (Capture of π^- Mesons in Complex Nuclei). G. Campos Venuti and G. Matthiae (Italy. Istituto Superiore di Sanità, Rome).

A study to determine the neutron spectrum emitted from nuclei as a result of the absorption of π^- mesons is described. The time-of-flight method is to be used for the detection and measurement of the neutrons. The corrections which must be made with the experimental apparatus used are described. (J.S.R.)

739

17108 (ISS-62/21) SULL'ASSORBIMENTO DI MESONI π^- IN NUCLEI COMPLESSI. (On the Negative Pions Absorption in Complex Nuclei). G. Campos Venuti and G. Matthiae (Italy. Istituto Superiore di Sanità, Rome). May 30, 1962. 45p.

The existing experimental data on the absorption of negative pions in complex nuclei are presented and discussed in connection with the present theories and hypotheses. It is shown that further information is needed about the energy spectrum of the particles, particularly of the neutrons, emitted after absorption. The project and the experimental arrangement for measuring the energy spectrum of neutrons emitted in the energy range from about 1 to 50 Mev at the electron synchrotron in Frascati are described. 39 references. (auth)

740

19175
PHYSICAL METHOD FOR DEVELOPING TRACK PICTURES OF LOW IONIZING PARTICLES. Ya. M. Veprik, S. P. Protsanova, and G. P. Faerman (Joint Inst. of Nuclear Research, Dubna, U.S.S.R.). Pribory i Tekh. Ekspt. No. 3, 128-9(1959) May-June. (In Russian)

Development of 15-Mev proton and 300-Mev π^+ meson tracks in 200 μ layers of NIKFI-R emulsion with n-oxyphenylglycerin physical developer was studied. It is shown that with the physical developing method it is possible to regulate the size of silver granules in the track and to improve discrimination of proton tracks from the γ background. (tr-auth)

741

31021 (UCRL-10253) SCATTERING OF NEGATIVE PIONS ON PROTONS AT 310 Mev: RECOIL-NUCLEON POLARIZATION AND PHASE-SHIFT ANALYSIS (thesis). Olav T. Vik (California. Univ., Berkeley. Lawrence Radiation Lab.). May 21, 1962. Contract W-7405-eng-48. 71p.

The recoil-proton polarization in π^--p elastic scattering at 310 Mev was measured in the angular region 114 deg < $\theta_{c.m.}$ < 146 deg. These data were incorporated with other polarization and differential cross-section data at this energy, and a phase-shift analysis was performed. Recoil-proton polarization was measured at four angles with results: 0.784 ± 0.132 at 114.2 deg, 0.648 ± 0.076 at 124.5 deg, 0.589 ± 0.072 at 133.8 deg, and 0.304 ± 0.055 at 145.2 deg. A beam of 3×10^6 pions/sec was incident on a liquid H_2 target; the resultant recoil protons were then scattered from C target and the left-right asymmetry measured. Plastic scintillation counters were used throughout. An IBM 7090 search program was developed, and the above data were incorporated with data on π^+-p polarization and differential and total cross section, π^--p differential and total cross section, and charge-exchange differential cross section. A phase-shift analysis was performed. Analysis for spd waves (up to $\ell = 2$) shows the existence of a single satisfactory solution to all the available data. This solution is of the Fermi type in the $I = 3/2$ phase shifts, and its $I = 1/2$ phase shifts are all small (<6 deg), with the exception of the $D^{\frac{1}{2}}$ shift, which is ≈15 deg. Errors on the phase shifts vary from 0.4 through 1.1 deg. Extension of the analysis to spdf waves ($\ell = 3$), allows three satisfactory solutions, one of which is an extension of the spd solution. The other two solutions are also of the Fermi type with $I = 3/2$ phase shifts, but the dominant $I = 1/2$ phase shift is the $P^{\frac{1}{2}}$ shift, which is >20 deg in both cases. The phase-shift errors are larger for these three solutions, ranging up to 2 deg. The single spd solution and the three spdf solutions are discussed and compared with theoretical predictions. (auth)

742

13437 PION-NUCLEON ELASTIC SCATTERING AT 310 Mev: PHASE-SHIFT ANALYSIS. Olav T. Vik and Hugo R. Rugge (Univ. of California, Berkeley). Phys. Rev., 129: 2311-22(Mar. 1, 1963). (UCRL-10436)

A phase-shift analysis of π^+-p and π^--p elastic scattering at 310 Mev has been performed. The data include differential and total cross-section and recoil-proton polarization data for both π^+-p and π^--p elastic scattering, as well as differential cross-section data for charge-exchange scattering. Inclusion of d waves was necessary to attain an adequate fit to the data; in the case of π^--p differential cross section, the best fit included f waves. A general phase-shift search using s, p, and d waves was carried out; a single solution was obtained that adequately fit all the available data. The most notable characteristics of this solution are isotopic-spin $3/2$ phase shifts similar to those obtained in a previous analysis of the π^+-p data and a relatively large $D_{1,6}$ phase shift equal to approximately 15 deg. Errors on the isotopic-spin $1/2$ phase shifts of this solution range from 0.3 to 0.9 deg. The isotopic-spin $3/2$ phase-shift errors are similar to those obtained previously. Because the π^--p differential cross section data indicated a possible need for f waves, and since the only satisfactory spd solution displayed a large d-wave phase shift in the isotopic-spin $1/2$ state, the analysis was extended to include f waves. The result of allowing f waves was to increase the errors on each of the phase shifts (up to about 2 deg), and also to introduce two new solutions, neither of which can be ruled out statistically. These new solutions are similar to the d-wave solution in the isotopic-spin $3/2$ phase shifts, but vary rather widely in isotopic-spin $1/2$ phase shifts. Inelastic scattering processes were neglected throughout most of the analysis; however, a study of their effects on the final solutions was made and these effects were seen to be unimportant. (auth)

743

28389 π^--p INTERACTIONS AT 604 Mev. C. N. Vittitoe, B. R. Riley, W. J. Fickinger, V. P. Kenney, J. G. Mowat, and W. D. Shephard (Univ. of Kentucky, Lexington). Phys. Rev., 135: B232-40(July 13, 1964).

The interactions of 604-Mev mesons (π^-) in a hydrogen bubble chamber were systematically analyzed. In 33000 pictures a total of 8052 usable events were found, corresponding to cross sections of 18.9 ± 1.3 mb for σ (elastic), 4.98 ± 0.54 mb for $\sigma(\pi^- p \pi^0)$, 7.87 ± 0.91 mb for $\sigma(\pi^- n \pi^+)$, 14.0 ± 1.0 mb for σ (neutrals), with σ (two-pion production) <0.2 mb, for a total cross section of 45.9 ± 1.9 mb at this energy. The angular distribution for elastic scattering was fitted with a fifth-order polynomial in cosθ which gave a value of $d\sigma/d\Omega(0°)$ consistent with dispersion theory. The π-π effective mass distributions for both single-pion production channels showed pronounced peaking at high mass values, strongly inconsistent with simple isobar-production kinematics. Simple one-pion exchange does not appear to play a significant role. (auth)

744

4624 MUON CAPTURE IN HELIUM-3. Richard L. Wagner, Jr. Thesis, Salt Lake City, Univ. of Utah, 1963. 86p.

Negative muons were stopped in a He^3 gas scintillation counter, and the rate of the interaction $\mu^- + He^3 \rightarrow H^3 + \nu$ was measured, where the produced H^3 nucleus is in the ground state. The interaction was identified by the characteristic 1.9 Mev pulse produced in the He^3 scintillant by the monoenergic recoil tritium nucleus. Decay electrons from the competing muon decay process were counted in a xenon gas scintillation counter that surrounded the cubical He^3 target on 5 sides. The efficiency of electron detection was measured directly. The counters were constructed almost entirely of materials with high atomic number, and muon interactions in the materials were distinguished by their characteristic short muon-disappearance mean lives. Contamination of the data by muons stopping in residual low-Z material was evaluated by replacing the He^3 in the target counter with xenon, so that the only counts exhibiting a long mean-life were due to that contamination. The capture rate was found from the ratio of the number of captures to the number of decays times the known decay rate. The result for the capture rate to the ground state is $(g_{nd}/c) = (1.48 \pm 0.29/0.27) \times 10^3$ sec^{-1}. This result is in agreement with theoretical calculations based on the universality of the V-A Fermi interaction and the validity of the Feynman-Gell-Mann conserved vector current hypothesis. (Dissertation Abstr., 24: No. 4, Oct. 1963)

745

18444

DEPOLARIZATION OF μ^+ MESONS IN NUCLEAR EMULSIONS. A. O. Waissenberg, N. V. Rabin, and V. A. Smirnitskii (Inst. of Theoretical and Experimental Physics, Academy of Sciences, S.S.S.R.). Zhur. Eksptl'. i Teoret. Fiz. 36, 1680-6(1959) June. (In Russian)

The asymmetry coefficient in $\pi^+ - \mu^+ - e^+$ decay was measured in an ordinary and diluted NIKFI-R emulsion as well as in this emulsion placed in a strong magnetic field. An analysis of the results obtained and also of those contained in the literature indicates that the asymmetry coefficient in the NIKFI-R emulsion ($a = -0.077 \pm 0.012$) is significantly smaller than that for the Ilford G-5 emulsion ($a = -0.139 \pm 0.014$). A two-fold dilution of the NIKFI-R emulsion with gelatin leads to a sharp increase of the asymmetry coefficient ($a = -0.127 \pm 0.028$). The polarization in the NIKFI-R emulsion is restored by application of a magnetic field, the asymmetry coefficient being increased up to $a = -0.28 \pm 0.02$ at a field strength of 17,000 G. (auth)

746

18381

π-NUCLEON PHASE SHIFTS IN THE ENERGY RANGE 350 to 600 Mev. W. D. Walker, J. Davis, and W. D. Shephard (Univ. of Wisconsin, Madison). Phys. Rev. 118, 1612-14(1960) June 15.

The results of attempts to obtain a set of phase shifts valid in the energy region just above the 3-3 resonance are presented. It is possible to extend the family of phase shifts found by the workers at Dubna at an energy of about 300 Mev. The features of this set of phase shifts are that α_1, α_{11}, are positive and α_{13} is negative and small. In addition it was found that δ_{13} is positive and δ_{15} negative. At 600 Mev the results are probably consistent with a resonance in the $d_{\frac{3}{2}}$ state, but do not conclusively indicate such a resonance. This resonant state, however, decays a sizable fraction of the time into a final state with two π mesons. There are indications that at energies of 400 to 500 Mev that most of the single pion production comes from s and $p_{\frac{3}{2}}$ states. (auth)

747

12913 (TID-7686(p.69-107)) REPORTS ON THE EXPERIMENTAL STATUS OF NEW RESONANCES OR HIGHLY UNSTABLE PARTICLES. W. Walker (Wisconsin. Univ., Madison).

Some experiments on meson(π) production and resonances in p-d, π^--p, p-p, π^+-d interactions are discussed, together with the currently known particles and data on mesons(η) and mesons(ρ). (D.C.W.)

748

29254 (NEVIS-128 and Add.) MUON CAPTURE IN $(p\mu d)^+$ MOLECULES (thesis). I-Tung Wang (Nevis Labs., Columbia Univ., Irvington-on-Hudson, N. Y.). Jan. 1965. Contract Nonr-266(72). 99p. (R-473 and Add.; CU 234 and Add.; AD-613615)

The $(p\mu d)^+$ molecules and μ-^{3}He atoms formed in liquid hydrogen were used to detect neutrons from muon capture by deuterons and from muon capture by ^{3}He. A purified muon beam was stopped in a target containing ultra-pure liquid hydrogen with 0.32% deuterium added. Neutron-gamma ray discriminating detectors and oscilloscope photography were used to measure the time distribution of neutrons from the following rare muon capture processes: $\mu^- + d \rightarrow \nu + 2n$, $\mu^- + {}^3He \rightarrow \nu + n + d$, and $\mu^- + {}^3He \rightarrow \nu + 2n + p$. Knowledge of the time distributions of the various $(p\mu d)^+$ hyperfine states and of the μ-^{3}He atoms was used to obtain the various muon capture rates of interest. Converted to the μd atom case, the measured rate gives 388 ± 101 sec^{-1} for muon capture from the doublet state of μd. This is to be compared with the theoretical rate of 348 sec^{-1} predicted by the current phenomenological muon capture theory; and it provides the clearest verification of the Pauli exclusion principle effect in muon capture. The neutron rate from muon capture by ^{3}He was determined to be $(1.20 \pm 0.17) \times 10^3$ sec^{-1}, which is again in good agreement with theory. A theoretical investigation of the μd capture and μ-^{3}He capture into break-up channels was carried out. Neutron energy spectra for muon capture in the separate μd hyperfine states were obtained, with particular emphasis on the use of two-nucleon wave functions and the inclusion of target-proton momentum terms and induced-pseudoscalar terms. The μ-^{3}He capture processes were studied in the plane-wave approximation, with Gaussian-type wave function for the ^{3}He nucleus. The results obtained are in fair agreement with the closure-approximation results. (auth)

749

33386 DESINTEGRATION OF PHOTOEMULSION NUCLEI BY SLOW μ-MESONS. Weissenberg, A. O.; Kolganova, E. D.; Rabin, N. V. (Inst. of Theoretical and Experimental Physics, Moscow). Yadern. Fiz., 1: 652-8 (Apr. 1965). (In Russian)

The desintegration of photoemulsion nuclei due to the capture of slow μ^--mesons was investigated. The distribution of the stars with respect to the number of rays was obtained for light (C, N, O) and heavy (Ag, Br) nuclei. The probabilities of emitting a charged particle were estimated and proved to be equal to $W_L = 0.15$ and $W_H = 0.030$ for light and heavy nuclei respectively. Measurements of the secondary particle masses showed, that the output of deuterons and tritium nuclei with energies in the region 5 to 25 Mev, is approximately equal to 50% of all charged particles for light nuclei and is not larger than 15% for the Ag and Br nuclei. (auth)

750

14221 (UCRL-10317) COUNTER DATA RECORDING FOR ANALYSIS BY COMPUTERS. Clyde Wiegand (California. Univ., Berkeley. Lawrence Radiation Lab.). June 12, 1962. Contract W-7405-eng-48. 12p. (CONF-432-1)

From Conference on Nuclear Physics, Claremont, Ferrand, France, June 1962.

The use of a computer system to record data from a large counter array is described and is illustrated by consideration of an experiment on beta decay of mesons(π^+). (D.C.W.)

751

6894

π^+-p INTERACTIONS AT 500 MEV. William J. Willis (Yale Univ., New Haven and Brookhaven National Lab., Upton, N. Y.). Phys. Rev. 116, 753-9(1959) Nov. 1.

The interaction of π^+ mesons with protons at an energy of 500 Mev was studied in a hydrogen bubble chamber. Phase-shift analyses with S and P waves were made, and a near degeneracy was found between the Fermi and Yang solutions. When D waves were included, an additional ambiguity was found. The D-wave phase shifts are small but they have a considerable effect on the other phase shifts. The cross section for single pion production is 2.85 ± 0.5 mb. The ratio (p + 0)/(n++) is $1.5^{+1.3}_{0.5}$. The cross section leading to p++− was found to be of the order of 30 μb. (auth)

752

16761 (NIRL/R/56) ANALYSIS OF NEUTRAL CASCADE EVENTS FROM A HEAVY LIQUID BUBBLE CHAMBER. A. G. Wilson (Gt. Brit. National Inst. for Research in Nuclear Science. Rutherford High Energy Lab., Chilton, Berks, England). Oct. 1963. 21p.

Complete neutral cascade events are observed in heavy liquid bubble chambers. Both photons from the π^0 decay are converted to electron pairs. The data for the problem consist of angles and momenta for the two charged prongs of the Λ^0 decay, angles for the photons calculated from the electron angles, and the coordinates of all the charged vertices. These are supplied by a geometrical reconstruction program. The traditional fit of a bubble chamber event to kinematical constraints is extended to include the geometrical constraint that four of the neutral tracks pass through one point. The coordinates of this point, the Ξ^0 decay vertex, and the Ξ^0 mass are varied in the fit together with the usual kinematical variables. (auth)

753

17229 OBSERVABLE HYPERFINE EFFECTS IN MUON CAPTURE BY COMPLEX NUCLEI. Roland Winston (Univ. of Chicago). Phys. Rev., 129: 2766-85(Mar. 15, 1963).

The capture rates, $\Lambda_{\pm}^{cap}$, of the two hyperfine states of $F_{\pm}$ of the ($p\mu$) atom are, in general, expected to be different (spin dependence of muon capture). This difference depends quantitatively on the details of the interaction Hamiltonian, being maximum for an F−GT (i.e., V−A type) interaction. An experimental comparison for the ($p\mu$) system appears at present difficult, but related spin dependence effects will be exhibited by bound protons, i.e., complex nuclei. Observable hyperfine (hf) effects of this kind are summarized. The character of such effects is dominated by the rate R at which the upper hf state can be converted into the true ground state (through an M1 Auger process). A detailed calculation of R is given for all cases of practical interest. A variety of possible experiments are discussed. The considerations show that F^{19} constitutes the ideal target, leading to the largest and most readily analyzable effects. Three experiments were performed with this target, viz., measured (1) the time distribution of the neutral capture products, (2) the asymmetry of the decay electrons, and (3) the time distribution of the latter; these measurements are described and analyzed. It is concluded on the basis of measurements (1) and (3) that the interaction is definitely of the F−GT (as opposed to F + GT) type, assuming that both F and GT interactions are present. Invoking independent observations on muon capture by complex nuclei, this assumption becomes redundant, and we may conclude that the universal Fermi interaction ("V−xA") is implied by the results. This conclusion is in agreement with recent results on muon capture in liquid hydrogen. The conversion rate observed in experiments (1) and (3) ($6.1 \pm 0.7\ \mu sec^{-1}$) agrees with the prediction ($R = 5.8\ \mu sec^{-1}$), which is qualitatively confirmed by experiment. (auth)

754

6923 (UCRL-9507) ELASTIC SCATTERING OF PI MESONS ON PROTONS IN THE ENERGY REGION 550 TO 1020 MEV (thesis). Calvin D. Wood (California. Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1, 1961. Contract W-7405-Eng-48. 80p.

The differential cross section was measured for elastic scattering of negative π mesons from protons at incident pion kinetic energies of 550, 600, 720, 900, and 1020 Mev.

Pions were produced when the Bevatron circulating proton beam struck a copper target. Pions of the requisite momentum were brought to a focus at a liquid hydrogen scattering target by a magnetic system for beam optics. Elastic scattering events were selected from a background of inelastic events by demanding coincidences between pairs of scintillation counters that were placed at the proper kinematical angles to count elastically scattered pions and their corresponding recoil protons. The resulting angular-distribution curves were least-squares fitted with a cosine power series. A study of the coefficients of the power series permitted certain inferences to be made about the angular momentum states contributing to the second and third maxima in the total π^--p cross section which occur at 600 and 900 Mev, respectively. The 600-Mev peak appears to be due to a D state, with a total J value of $^3/_2$ rather than $^5/_2$. The data at 900 Mev cannot be well explained by a single (F_{5_2}) state in resonance, but rather there is strong evidence for at least D and F waves in superposition. The forward "diffraction" peaking of the angular distribution indicates that absorptive processes may be predominant. (auth)

755

17519 π^--p ELASTIC SCATTERING AT 550, 600, 720, 900, AND 1020 Mev. Calvin D. Wood, Thomas J. Devlin, Jerome A. Helland, Michael J. Longo, Burton J. Moyer, and Victor Perez-Mendez (Univ. of California, Berkeley). Phys. Rev. Letters, 6: 481-3(May 1, 1961). (UCRL-9447)

The π^--p differential elastic scattering cross sections ($d\sigma/d\Omega$) are measured at 550, 600, 720, 900, and 1020 Mev. The coefficients a_l in the cosine power series for $d\sigma/d\Omega$ are fit to the data by a least squares method to $l = 5$ at each energy. The functional dependence of a_l (for each l) on incident π^- energy is studied. (T.F.H.)

756

22326

CHARGE-EXCHANGE SCATTERING OF NEGATIVE PIONS AT 61 Mev AND 95 Mev. C. M. York, W. J. Kernan, and E. L. Garwin (Univ. of Chicago). Phys. Rev. 119, 1096-9(1960) Aug. 1.

The charge-exchange scattering of negative pions by liquid hydrogen was measured at 61 ± 1 and 95 ± 2 Mev bombarding energy. The measurements were made with a gamma spectrometer which employs a lead glass Cherenkov counter. If the charge exchange scattering cross section is expanded as a series of Legendre polynomials in the center-of-mass system of the collision, it is found that at 61 Mev, $d\sigma/d\Omega = (1.00 \pm 0.05)[0.613 \pm 0.030 - (0.830 \pm 0.068)P_1(\cos\theta') + (0.183 \pm 0.150)P_2(\cos\theta')]$, and at 95 Mev, $d\sigma/d\Omega = (1.00 \pm 0.03)[1.05 \pm 0.05 - (1.15 \pm 0.12)P_1(\cos\theta') + (0.33 \pm 0.25)P_2(\cos\theta')]$. The total cross section for charge exchange, obtained by integration, is: $\sigma_{tot}(\pi^- \rightarrow \pi^0) = 7.7 \pm 0.6$ mb at 61 Mev and $\sigma_{tot}(\pi^- \rightarrow \pi^0) = 13.2 \pm 0.8$ mb at 95 Mev. A table summarizing the measurements performed at 61, 95, 128, and 150 Mev is given. (auth)

757

21408

SEARCH FOR THE REACTION $\mu^+ + e^- \rightarrow \gamma + \gamma$. C. M. York, C. O. Kim, and W. Kernan (Univ. of Chicago). Phys. Rev. Letters 3, 288-91(1959) Sept. 15.

One of few reactions in which the direct interaction of two light fermions can be studied is the annihilation process $\mu^+ + e^- \rightarrow \gamma + \gamma$. This reaction can be compared directly with the more familar positron annihilation process. A beam of π^+ mesons was brought to rest in a $^1/_4$-in.-thick disk of copper. A schematic diagram of the experimental setup and a block diagram of the electronic circuits are given. (W.D.M.)

758

14288

DECAY RATES OF BOUND NEGATIVE MUONS. D. D. Yovanovitch (Univ. of Chicago). Phys. Rev. 117, 1580-9 (1960) Mar. 15.

The decay rate of negative muons bound to nuclei of atomic number Z, $\Lambda_d(Z)$, was investigated experimentally by two independent methods: (a) the "sandwich" method, and (b) the "calibrated efficiency" method. Both methods are based on the fact that the negatron yield per muon, $y^-(Z)$, is proportional to $\Lambda_d(Z)/\Lambda_t(Z)$, where $\Lambda_t(Z)$ is the total disappearance rate of negative muons for element Z, and are designed to avoid absolute measurements of $y^-(Z)$. In method (a), μ^- are stopped in a multilayer "sandwich" target made by alternately stacking sheets of two elements Z, Z', and the resultant e^- time distribution is decomposed into components due to Z and Z'. The ratio of muon stops in Z and Z' is established empirically; knowing $\Lambda_d(Z')$, $\Lambda_d(Z)$ can be computed. This method was applied to Al, Fe, Zn, Cd, Mo, W, and Pb. In method (b), μ^- and μ^+ of identical range distributions are stopped in a given target, and the e^+ yield, y^+, is used as a calibration of the e^- counting efficiency. This method was applied to C, Ca, Ti, V, Mn, Fe, Co, Ni, Zn, I, and Pb. The sources of error of either method are discussed in detail. The results indicate: (1) In the range $20 < Z < 30$, $\Lambda_d(Z) > \Lambda_d(0)$, i.e., the bound decay rate exceeds the vacuum (i.e., μ^+) decay rate; $\Lambda_d(Z)$ presents a sharp peak near $Z = 26$. (2) For $Z > 30$, one finds $\Lambda_d(Z) < \Lambda_d(0)$, i.e., the decay is inhibited by binding. The effect is very marked for the heaviest elements, e.g., $\Lambda_d(82)/\Lambda_d(0) = 0.34 \pm 0.04$. These results are compared with the predictions of simplified theoretical models. The peak near $Z = 26$ is tentatively attributed to the Coulomb enhancement of the outgoing electron wave function at the point of decay. (auth)

759

42751 INVESTIGATIONS OF A LARGE PLASTIC SCINTILLATOR. Yudin, E. P.; Dovzhenko, O. I.; Denisov, E. V. (Inst. of Physics, Moscow). Pribory i Tekhn. Eksperim., No. 4, 77-82(July-Aug. 1965). (In Russian).

The methodics of work with a plastic scintillator with large dimensions ($100 \times 100 \times 10$ cm^3) were described.

The logarithmic amplifier with large amplification range for the pulse to be amplified was considered. The probable size of the pulse produced by passage through the scintillator of a single μ meson was determined. Different conditions for the pulse collection were investigated. (tr-auth)

760

17278 MEASUREMENTS OF PROBABILITIES OF $\mu^- + He^3 \rightarrow H^3 + \nu$ REACTION. FINAL RESULTS. O. A. Zaimidoroga, M. M. Kulyukin, B. Pontecorvo, et al. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 389-90(Jan. 1963). (In Russian)

The results of 200 events of $\mu^- + He^3 \rightarrow He^3 + \nu$ reaction studied in a He^3-filled diffusion chamber showed that $(\lambda_{He^3})_{exp} = (1.41 \pm 0.14) \cdot 10^3 sec^{-1}$ and is in good agreement with previous experiments studying 90 events. The universal theory with muon-electron symmetry in reaction with a nucleon is in agreement with the results obtained within 10% order of error. (R.V.J.)

761

36656 (JINR-D-1324) MEASUREMENT OF THE TOTAL MUON CAPTURE RATE IN HELIUM-3. O. A. Zaimidoroga, M. M. Kulyukin, B. Pontecorvo, R. M. Sulyaev, I. V. Falomkin, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Scherbakov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1963. 8p.

By using a high pressure diffusion cloud chamber the total capture rate for muons in helium-3 was measured to be $\lambda = \exp (2140 \pm 200) sec^{-1}$. This result is in agreement with Primakof's calculations done on the basis of Universal Fermi interaction theory. (auth)

762

11281 MEASUREMENT OF THE TOTAL MUON CAPTURE RATE IN He^3. O. A. Zaimidoroga, M. M. Kulyukin, B. Pontekorvo, R. M. Sulyaev, I. V. Falomkin, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Shcherbakov (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 45: 1803-7(Dec. 1963). (In Russian)

The total muon capture rate in He^3 is measured with a high pressure diffusion chamber. It is found to be $\lambda_{exp} = 2140 \pm 200 sec^{-1}$. This result is in agreement with the calculations of Primakoff carried out on the basis of the theory of universal weak interaction. (auth)

763

31124 MEASURING THE PROBABILITY FOR THE REACTION $\mu^- + He^3 \rightarrow H^3 + \nu$. O. A. Zaimidoroga, M. M. Kulyukin, B. Powtekorvo, R. M. Sulyaev, I. V. Falomkin, A. I. Filippov, V. M. Tsupko-sitnikov, and Yu. A. Shcherbakov (United Inst. of Nuclear Studies, USSR). Zhur. Eksptl', i Teoret. Fiz., 43: 355-8(July 1962). (In Russian)

A diffusion chamber in a magnetic field H = 6000 Oe was filled with He^3 gas at a pressure of 20 atm, and was irradiated with a beam of mesons having a momentum of 217 Mev/c. The mesons were slowed down with a copper filter placed in front of the chamber. About 10^5 photographs were subjected to a double scan for tracks having a length $L_0 > 20$ mm in order to identify the mesons that were stopped. The total number of events from the reaction $\mu^- + He^3 \rightarrow H^3 + \nu$ was established by counting all stars at a range of 2.0 to 2.6 mg/cm^2. A total of 106 events was observed at $L_0 > 20$ mm. The number of μ-e decays observed was 35,500. The absolute capture probability was determined from the known lifetime of the muon (2.21×10^{-6} seconds) and the above data. The probability of the above reaction was found to be $\Lambda\,(He^3)_{exp} = (1.36 \pm 0.18)\ 10^3\ sec^{-1}$. This value agrees well with a theoretical value of $\Lambda\,(He^3)_{theor} = 1.54 \times 10^3\ sec^{-1}$. (TTT)

764

12550 OBSERVATION OF THE REACTION $\mu^- + He^3 \rightarrow H^3 + \nu$. O. A. Zaimidoroga, M. M. Kulyukin, B. Pontecorvo, R. M. Sulyaev, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Shcherbakov (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz., 41: 1804-8 (Dec. 1961). (In Russian)

A diffusion chamber filled with He^3 is used to observe the $\mu^- + He^3 \rightarrow H^3 + \nu$ reaction. The upper limit of the mass m_ν of the neutral particle emitted in the capture of muons by nucleons ($m_\nu < 6$ Mev) was determined by measuring the recoil energy of H^3. Preliminary data indicate that the probability of this reaction is $(1.30 \pm 0.40) \times 10^3\ sec^{-1}$, which is consistent with the value predicted by the universal theory of weak interactions. (auth)

765

38011 (JINR-P-2805) IZUCHENIE ZAKHVATA PIONOV GELIEM-3. II. REAKTSII S RAZVALOM YADRA. (Capture of Pions by ^{3}He. II. Nuclear Decay Reactions). Zaimidoroga, O. A.; Kulyukin, M. M.; Sulyaev, R. M.; Falomkin, I. V.; Filippov, A. I.; Tsupko-Sitnikov, V. M.; Shcherbakov, Yu. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 15p. Dep. mn.

A high pressure diffusion chamber was used in the investigation of π meson capture by ^{3}He leading to the processes of nuclear decay. Relative probabilities of these processes and the pulse spectra of the secondary charged particles were measured. (B.G.D.)

766

33080 FORMATION OF MESIC HELIUM ATOMS IN A GAS MIXTURE CONTAINING HELIUM AND HYDROGEN. O. A. Zaimidoroga, M. M. Kulyukin, R. M. Sulyaev, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Shcherbakov (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1853-8(June 1963). (In Russian)

The formation of helium mesic atoms in a mixture of

helium and hydrogen is studied in a diffusion cloud chamber at 19 atmospheres. It is shown that the probability of capture of μ mesons by helium from a hydrogen mesic atom in the ground state is at least three orders of magnitude smaller than the probability of capture by carbon or oxygen nuclei and cannot exceed appreciably 10^6 sec^{-1}, a result which is in agreement with the theoretical estimates. There are indications that for direct attachment of the mesons to the nuclei of the gas mixture agreement with the "Z-law" should hold. (auth)

767

20842 (JINR-P-1168) OBRAZOVANIE MEZOATOMOV GELIYA V GAZOVOI SMESI VODORODA S GELIEM. (Helium Mesic Atom Production in Gaseous Mixture of Hydrogen with Helium). O. A. Zaimidoroga, M. M. Kulyukin, R. M. Sulyaev, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Scherbakov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1963. 12p.

In order to clarify the possibility of carrying out an experiment on μ^- capture in He^3 using small amounts of He mixed with H_2, the process of He mesic atom production in such a mixture was investigated. Use was made of a diffusion chamber filled with mixtures of H_2 and He^4 and H_2 and He^3 with methyl alcohol as operating liquid, the nuclear concentrations of He^4 and He^3 being 4.9 and 14.3%, respectively. It is shown that the determination of the number of stars due to μ^- capture by C, O, and He at two different concentrations of the He together with the use of data on π^- capture in the same mixture make it possible to determine the probability λ_{He} of μ^- transfer to He from the ground state of the H mesic atom. Data on π^- capture, the transfer of which from mesic H is possible only from high levels, allow estimation of the probability of direct H mesic atom production in the mixture. In the experiment with He^3 it was possible to evaluate directly the total probability of He mesic atom production through the yield of the reaction $\mu^- + He^3 \rightarrow H^3 + \nu$ and the reaction rate expected on the basis of the universal weak interaction theory. The value λ_{He} turned out to be $-(1.4 \pm 3.8)\ 10^6$/sec, i.e., it cannot be considerably larger than 10^6/sec, if it is in agreement with the theoretical value. This value is at least 10^3 times smaller than the transfer rate to C and O nuclei which may be found if λ_{He} is known. The experimental data are consistent with the "Z-law" for the atomic capture probability of the mesons in gaseous mixtures H–He and H–CH_3OH. (auth)

768

10845 (JINR-P-1454) K OTSENKE MASSY MYUONNOGO NEITRINO. (On the Upper Limit of the Muon Neutrino Mass). O. A. Zaimidoroga, M. M. Kulyukin, R. M. Sulyaev, I. V. Falomkin, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Shcherbakov (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Problems). 1963. 9p.

The range-energy relation for 0.2 to 3.0 Mev tritons moving through helium was obtained experimentally and was used to evaluate the mass of the neutrino in the interaction $\mu^- + He^3 \rightarrow H^3 + \nu$ as 6 Mev/c^2. (D.C.W.)

769

33392 A STUDY OF PION CAPTURE BY He^3. I. CHARGE EXCHANGE AND RADIATIVE CAPTURE. Zaimidoroga, O. A.; Kulyukin, M. M.; Sulyaev, R. M.; Falomkin, I. V.; Filippov, A. I.; Tsupko-Sitnikov, V. M.; Shcherbakov, Yu. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 48: 1267-78(May 1965). (In Russian)

A high-pressure diffusion chamber in a magnetic field was used to measure the ratio of the probabilities for charge exchange and radiative capture of pions by He^3 (Panofsky ratio). The ratio was found to be 2.28 ± 0.18. The magnitude of the nuclear form-factor was estimated on basis of this ratio and was found to be $F^2 = 0.75 \pm 0.06$ (transferred momentum $q^2 = 0.47$ fm^{-2}). The relative probabilities of charge exchange and radiative capture are $W(H^3\pi^0) = (15.8 \pm 0.8\%$ and $W(H^3\gamma) = 6.9 \pm 0.5\%$. (auth)

770

21236 (JINR-P-1952) O YADERNYKH FORMFAKTORAKH V PROTSESSE ZAKHVATA MYUONOV GELIEM-3. (Nuclear Form-Factors in Muon-Capture by Helium 3). O. A. Zaimidoroga, B. V. Struminskii, R. M. Sulyaev, I. V. Falomkin, V. M. Tsulko-Sitinkov, and Yu. A. Shcherbakov (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 7p. Dep.(mn).

The $\mu^- + {}^3He \rightarrow {}^3H + \nu$ reaction rate (Λ) has been calculated on the basis of data on form-factors obtained in experiments on pion capture by ^3He and the scattering of electrons on ^3He and ^3H. Its value turned out to be 1515 ± 55 sec^{-1} with $g_A^\beta / g_V^\beta = 1.16$ and $g_p^\mu / g_A^\mu = 7$. From the comparison of experimental and theoretical results, the pseudoscalar constant $g_p^\mu = (8 \pm 3) g_A^\mu$ has been evaluated. (auth)

770a

37851 NUCLEAR FORM FACTORS IN MUON CAPTURE BY HELIUM-3. Zaimidoroga, O. A.; Struminskii, B. V.; Sulyaev, R. M.; Falomkin, I. V.; Tsupko-Sitnikov, V. M.; Scherbakov, Yu. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Nuovo Cimento (10), 38: 1285-90 (Aug. 1, 1965).

The $\mu^- + {}^3He \rightarrow {}^3H + \nu$ reaction rate was calculated on the basis of data on form factors obtained in experiments on pion capture by ^3He and the scattering of electrons on ^3He and ^3H. Its value turned out to be $\Lambda^{theor}_{^3He} = (1515 \pm 55)$ s^{-1} and $g_A^\beta / g_V^\beta = -1.16$ and $g_p^\mu / g_A^\mu = 7$. From the comparison of $\Lambda^{theor}_{^3He}$ to experimental results the pseudoscalar constant $g_p^\mu = (8 \pm 3) g_A^\mu$ was evaluated. (auth)

771

39579 (JINR-P-2838) IZMERENIE VREMENI KASKADNOGO PEREKHODA π^--MEZONA V GAZOOBRAZNOM GELII-3. (Measurement of the Cascade Time of Negative Pions in Gaseous ^3He). Zaimidoroga, O. A.; Sulyaev, R. M.; Tsuko-Sitnikov, V. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nu-

clear Problems). 1966. 7p. Dep. mn.

The cascade time of negative pions in gaseous helium-3 was measured by using a diffusion chamber in a magnetic field. It was found to be $(1.4 + 0.7)\ 10^{-10}$ sec. The measured time coincides with that of analogous measurement in liquid helium. This means that the cascade time of pions in helium does not depend on the medium density. (auth)

772

20223 FISSIONING OF NUCLEI BY π-MESONS. D. F. Zaretskii and V. M. Novikov. Zhur. Eksptl'. i Teoret. Fiz., 40: 982-3(Mar. 1961). (In Russian)

Presence of mesons increase the fission barrier of the nucleus; the effect of mesons in the 1S state increases the probability of fission as a function of the nearness of the threshold energy to the excitation energy. For uranium-238 the fission threshold is higher than the excitation energy while in case of plutonium-239 it is about 0.3 Mev lower. Fissioning of nuclei by mesons according to the above mechanism was studied for uranium-238 but it is proposed that plutonium-239 presents a better subject for such investigations. (TTT)

773

27476 THE ABSORPTION OF STOPPED π^- MESONS BY C^{12} NUCLEI. N. S. Zelenskaya, Yu. F. Smirnov, and N. P. Yudin (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 29: 186-90(Jan. 1965). (In Russian)

Experimental data of A.T. Varfolomeyev (Zhur. eksp. i teor. fiz. 42: 713, 1962) on the $^{12}C + \pi^- \rightarrow 2\alpha + t + n$ reaction are interpreted. Varfolomeyev measured the excitation curve of ^{11}B, the energy spectra of the emitted α particles and tritons, and the t-n angular correlation. The ^{11}B excitation curve had two maxima, at 20 and about 35 Mev. The 20-Mev maximum is due to ejection of a nucleon from the s shell. The 35 Mev maximum is ascribed to absorption of the π^- meson by an α-particle cluster in the ^{12}C nucleus. The α-particle and triton energy spectra and the t-n angular correlation were calculated on the basis of the α-particle absorption mechanism, and the agreement obtained between theory and calculation was very good in the case of the angular correlation and not bad in the case of the energy spectra. The peaks in the energy spectra are due to α-α and α-t interaction in the final state. It is concluded that π^- capture in ^{12}C is due to single-nucleon and α-particle absorption. It is suggested that the α-particle absorption mechanism will also be important in π^- capture in ^{16}O, but that in other nuclei, specifically in ^{14}N, the two-nucleon absorption mechanism may predominate. (ATD)

774

30508 (CERN-64-26) CERN WORK ON WEAK INTERACTIONS. A. Zichichi (European Organization for Nuclear Research, Geneva). June 3, 1964. 25p.

The validity of the universality of the Fermi interaction and of the conserved vector current hypothesis, the validity of the $(1 + \gamma_5)$ version of the universal Fermi interaction, the weak structure of the π-meson, the existence of induced pseudoscalar coupling (g_p), and neutrino physics are discussed. Experiments accompanying the studies are described. Invited paper presented at the Royal Society, London, Feb., 1964. (R.E.U.)

775

23551

SEARCH FOR THE ρ^0-MESON AND A CHECK OF THE DISPERSION RELATIONS IN π N-SCATTERING. V. G. Zinov, A. D. Konin, S. M. Korenchenko, and B. Pontekorvo (Pontecorvo) (Joint Inst. for Nuclear Research, Dubna, USSR). Zhur. Eksptl'. i Teoret. Fiz. 38, 1708-14(1960) June. **(In Russian)**

The total π^-p-interaction cross sections (σ_t^-) were measured with an accuracy of 1.5 to 2% for about 50 pion energies at 140 to 360 Mev. The pion energy was known to within ±1%. No anomalies in the energy dependence of σ_t^- were found which could indicate the existence of a ρ^0-meson with a mass in the interval of 270 to 410 Mev. The data are inconsistent with the energy value $E_2 = 650$ Mev for the second maximum in σ_t^- found by Frisch et al. but agree with the conclusion drawn by Brisson et al. that it should be located at a smaller energy ($E_2 \approx 610$ Mev). The data are in agreement with the dispersion relations for π^-p-scattering. It is demonstrated that the Puppi—Stanghellini problem as such no longer exists and that it arose as a result of inaccurate knowledge of the total π^-p-interaction cross section. (auth)

776

39366 (JINR-P-2185) ATOMNYI ZAKHVAT OTRITSATEL'NYKH MYUONOV V KHIMICHESKIKH SOEDINENIYAKH. (Atomic Capture of Negative Muons in Chemical Compounds). Zinov, V. G.; Konin, A. D.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 19p. Dep. mn.

The atomic capture of negative muons in binary compounds is studied. The ratio of probabilities of the muon atomic capture in oxides changes periodically with the growth of the charge in accordance with the Mendeleev Chart. It also depends on the type of a compound. The ratio of probabilities of the atomic capture in compounds of metals with halogens and metal alloys is described satisfactorily by a linear dependence. (auth)

777

7732 ATOMIC μ^--MESON CAPTURE IN CHEMICAL COMPOUNDS. Zinov, V. G.; Konin, A. D.; Mukhin, A. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 2: 859-67(Nov. 1965). (In Russian).

The atomic capture of mesons (μ^-) in binary compounds was investigated. The ratio of the probabilities of atomic capture in the oxides changes with the increase of the atomic number in accordance with the periods in Mendeleev's table. This ratio depends on the type of the compound (e.g., MgO and MgO_2, etc.). The probability ratio of capture in the metal-halogen compounds and in alloys is shown to be described satisfactorily by the linear dependence 0.66 (Z_1/Z_2). (auth)

778

28991 (JINR-P-2039) ISSLEDOVANIE STRUKTURY K-MEZORENTGENOVSKOI SERII PRI ATOMNOM ZAKHUATE μ^--MEZONOV V KHIMICHESKIKH SOEDINENIYAKH. (Study of the K-Mesic X-Ray Series Structure in the μ^--Atomic Capture in Chemical Combinations). V. G. Zinov, A. D. Konin, and A. I. Mukhin (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1965. 11p. Dep.(mn).

The structure of the K mesic x-ray series was investigated in μ^- atomic capture in vanadium and vanadium pentoxide as well as in chromium and chromium oxide. A noticeable redistribution of the different K-line yields is observed in the pure substance and its oxide. (auth)

779

34947 THE TRANSITION OF NEGATIVE μ MESONS FROM PROTON TO CARBON. V. G. Zinov, A. D. Konin, and A. I. Mukhin (Joint Inst. of Nuclear Investigations, USSR). Zh. Eksperim. i Teor. Fiz., 46: 1919-20(May 1964). (In Russian)

In the case of the stoppage of negatively charged mesons in H-containing compounds, some of the mesons are captured on the mesoatomic orbits of the proton, forming a mesoproton atom. As a result of the collisions with the atoms of the surrounding material, processes involving the fast transition of mesons to be lower energy levels of the mesoproton atom take place in the condensed media; the mesons are also strongly taken up by atoms with a charge of $Z > 1$. Similar processes occur also in the case of the stoppage of the negatively charged muons in gaseous H containing admixtures of the heavier elements. The meson transfer from the proton to the heavy ion in condensed media occurs at highly excited levels; the take-up of muons exclusively at the excited level of the Z μ-mesoatom, with subsequent cascade transition of the system to the ground state under emission of a K-meso x-ray series may be used to study the mesoatomic phenomena in H-containing media. From the experimental viewpoint, this involves the comparison of the intensities of the K series from C mesoatoms formed by the stoppage of the negatively charged muons in graphite and in polyethylene. Uptake of the muon directly at lower energy levels of the C μ-atoms may result in losses of the meso x-radiation of the K series. The problem was examined by determining the x-quantum yield from the graphite and polyethylene targets. (TTT)

780

19757

CHARGE EXCHANGE SCATTERING OF 240-330 MEV π^--MESONS ON HYDROGEN. V. G. Zinov and S. M. Korenchenko (Joint Inst. for Nuclear Research, [Dubna, USSR]). Zhur. Eksptl'. i Teoret. Fiz. 38, 1399-1406(1960) May. (In Russian)

Results are presented on measurement of the differential cross sections for charge exchange scattering of 240, 270, 307, and 333 Mev π^--mesons on hydrogen. (auth)

781

10365

SCATTERING OF π-MESONS ON HYDROGEN AT 240 TO 270 MEV. V. G. Zinov and S. M. Korenchenko (Joint Inst. of Nuclear Research (Dubna, U.S.S.R.). Zhur. Eksptl'. i Teoret. Fiz. 36, 618-19(1959) Feb. (In Russian)

The elastic and reverse scattering of π^- mesons in hydrogen at 240 to 270 Mev was measured with a scintillation counter and liquid hydrogen target. The total cross sections of π^- meson interactions with hydrogen at 240 to 270 Mev are $(48.3 \pm 3.3) \times 10^{-27}$ cm^3 and $(36.5 \pm 2.4) \times 10^{-27}$ cm^2, respectively. (R.V.J.)

782

17330

ELASTIC SCATTERING OF 240 TO 330 Mev π^--MESONS ON HYDROGEN. V. G. Zinov and S. M. Korenchenko. Zhur. Eksptl'. i Teoret. Fiz. 38, 1099-1105(1960) Apr. (In Russian)

Results of measurement of the differential cross sections for elastic scattering of 240, 270, 307, and 333 Mev π^--mesons on hydrogen are presented. (auth)

783

19758

PHASE SHIFT ANALYSIS OF SCATTERING OF 240-330 MEV π-MESONS ON HYDROGEN. V. G. Zinov, S. M. Korenchenko, N. I. Polumordvinova, and G. N. Tentyukova (Joint Inst. for Nuclear Research, [Dubna, USSR]). Zhur. Eksptl'. i Teoret. Fiz. 38, 1407-18(1960) May. (In Russian)

Results are presented of a phase shift analysis of data on the π meson scattering by nucleons at 240 to 330 Mev. Information on phase shifts for the interaction of π-mesons in states with a spin $T = \frac{1}{2}$ is obtained which is of satisfactory accuracy. (auth)

784

28158 (UCRL-10720) THE REACTION $\pi^-p \rightarrow \pi^-\pi^+n$ BELOW 800 Mev. (thesis). Janos Zirz (California. Univ., Berkeley. Lawrence Radiation Lab.). Mar. 12, 1963. Contract W-7405-eng-48. 81p.

The reaction $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ is studied in the Lawrence Radiation Laboratory 72-inch hydrogen bubble chamber. Events are located by scanning the pictures for π^+ tracks. Cross sections, Dalitz plots, angular distributions, and $\pi^+\pi^-$ and π^+n mass spectra are given at beam energies of 360, 430, 460, 480, 555, 605, 673, and 780 Mev. No clear evidence is found for $\pi^+\pi^-$ resonances between threshold and $M_{\pi\pi} = 680$ Mev. However, there is a strong preference for high $\pi^+\pi^-$ effective masses, especially at the lowest beam energies. Arguments are given to ascribe this anomaly to the $I = 0$ state of the π-π system. Production of the $N^*_{3/3}$ (1238) isobar is observed in its negative charge state. 33 references. (auth)

785

32915 (TID-7668(Sect.VII)) NEW DETECTION METHODS. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 29p.

Apparatus for detecting gamma rays (particularly spark and discharge chambers) are discussed, and the design and operation of a π^0 detector are described. The design and development of a sonic spark chamber is reported. Measurement of the cross section for gamma attenuation in hydrogen is discussed, as is the tagging of gamma rays by coinciding them with bremsstrahlung-producing electrons. A spark chamber automatic scanning system is also explained, and automatic or semi-automatic data reduction systems developed or in development for bubble chamber work are reviewed. (D.C.W.)

786

14444

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON THE NUCLEAR OPTICAL MODEL, MARCH 16 AND 17, 1959, FLORIDA STATE UNIVERSITY, TALLAHASSEE, FLORIDA. Alex E. S. Green, Charles E. Porter, and David S. Saxon, eds. The Florida State University Studies, Number Thirty-Two. Tallahassee, Florida, The Florida State University, 1959. 292p.

A conference on the nuclear optical model was held at the Florida State University in Tallahassee on March 16 and 17, 1959. The purpose of the conference was to assemble scientists actively engaged in large-scale optical model calculations in order to compare techniques, ideas, and results and make other interchanges helpful toward advancing the understanding of this model of the nucleus.

787

26792 (NP-10301) INTERNATIONAL WORKING MEETING ON COSMIC RAYS, BUCHAREST, MAY 8–14, 1959. (Academia R.P.R. Institutul de Fizca Atomica, Bucharest). 1960. 236p.

Studies of high and low energy interactions of cosmic mesons, nucleons, and nuclei with emulsion nuclei and nucleons are reported. The properties of jets, stars, and combinations of these two are examined. Interaction models are reviewed. The absorption of cosmic radiation by lead, air, and earth is investigated. Thirty-three papers were presented at the conference.

788

8023 (NP-11232) PROCEEDINGS OF THE COSMIC RAY SYMPOSIUM, AHMEDABAD, MARCH 16-19, 1960. (India. Dept. of Atomic Energy. Cosmic Ray Research Committee, Bombay). 447p.

Sixty-two papers are included on various aspects of cosmic rays, such as time variations, solar and terrestrial relationships, origin, extensive air showers, and high energy nuclear interactions.

789

9771 PROCEEDINGS OF THE 1960 ANNUAL INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS AT ROCHESTER, THE UNIVERSITY OF ROCHESTER, ROCHESTER, N. Y., AUGUST 25–SEPTEMBER 1, 1960. E. C. G Sudarshan, J. H. Tinlot, and A. C. Melissinos, eds. New York, Interscience Publishers, Inc., 1960. 910p. $13.50.

Two hundred and twelve papers are included.

790

25916 (NP-11977) RACCOLTA DELLE COMUNICAZIONI DEL CONGRESSINO 1960 SULLA FISICA E LA RICERCA DI ALTA ENERGIA, FRASCATI, 16-17 DICEMBRE 1960. (Compilation of the Reports to the 1960 Congress on High Energy Physics and Research, Frascati, December 16-17, 1960). (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Mar. 1961. 186p. (In English and Italian)

Fifty-one papers are included. The topics discussed are programs relative to the design and construction of new accelerators and the research at available accelerators.

791

20821 PROCEEDINGS OF THE INTERNATIONAL SCHOOL OF PHYSICS "ENRICO FERMI." COURSE XIX. COSMIC RAYS; SOLAR PARTICLES AND SPACE RESEARCH. VARENNA ON LAKE COMO. VILLA MONASTERO. MAY 23–JUNE 3, 1961. B. Peters, ed. New York, Academic Press, 1963. 427p. $16.00.

792

29647 (NP-11950(Vol.I)) LECTURES ON HIGH ENERGY PHYSICS DELIVERED AT THE SIXTH SUMMER MEETING OF NUCLEAR PHYSICISTS, JULY-AUGUST 1961, HERCEGNOVI, YUGOSLAVIA, VOLUME I. B. Jakšić, ed. (Yugoslavia. Nuclear Energy Commission, Belgrade). 281p.

Six lectures on high energy physics delivered at the Sixth Summer Meeting of Nuclear Physicists, July to August 1961, Hercegnovi, Yugoslavia are given.

793

16925 (NP-11592(Vol.I)) THE AIX-EN-PROVENCE INTERNATIONAL CONFERENCE ON ELEMENTARY PARTICLES, SEPTEMBER 14-20, 1961. VOLUME I. PARALLEL SESSIONS. E. Cremieu-Alcan, P. Falk-Vairant, and O. Lebey, eds. (France. Commissariat a l'Energie Atomique. Centre d'Etudes Nucléaires, Saclay). 511p.

A total of seventy-six papers is included, thirteen of which are presented in French.

794

27350 PROCEEDINGS OF THE SYMPOSIUM ON NUCLEAR INSTRUMENTS, HARWELL, SEPTEMBER 1961. J. B. Birks, ed. New York, Academic Press Inc., 1962. 252p.

Photoelectric devices, scintillation chambers and counters, semiconductor detectors, spark chambers, etc., are discussed. Methods for recording and analyzing complex nuclear data are explained.

795

12804 (TID-7686) ARGONNE ACCELERATOR USERS GROUP MEETING HELD AT ARGONNE NATIONAL LABORATORY, DECEMBER 8-9, 1961. (Argonne National Lab., Ill.). Contract W-31-109-eng-38. 129p.

796

25886 (LNF-62/37) RACCOLTA DELLE COMUNICAZIONI DEL CONGRESSINO 1962 SULLA FISICA E LA RICERCA DI ALTA ENERGIA, FRASCATI, 7-8-9 FEBBRAIO 1962. (Compilation of the Reports to the 1962 Congress on High Energy Physics and Research, Frascati, February 7, 8 and 9, 1962). (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). May 1962. 255p. (In English and Italian)

Thirty-three papers are included. Topics discussed are experiments with the Frascati electron synchrotron and with the CERN accelerator.

797

18510 (CERN-63-3) PROCEEDINGS [ON] 1962 EASTER SCHOOL FOR PHYSICISTS, USING THE NUCLEAR EMULSION TECHNIQUE IN CONJUNCTION WITH THE CERN PROTON SYNCHROTRON AND SYNCHROCYCLOTRON, HELD AT ST. CERGUE, APRIL 8-18, 1962. N. Doble and W. O. Lock, eds. (European Organization for Nuclear Research, Geneva). Feb. 6, 1963. 394p.

An introductory lecture is presented to state the purposes of the school and to provide background material for the information presented in subsequent lectures. The CERN synchrotron, its targets, and beam transport are considered. General problems of emulsion irradiations, handling, and processing are included along with measurement techniques. Production of high magnetic fields by the CERN pulsed magnet apparatus, typical emulsion experiments, and the organization of emulsion experiments at CERN are outlined.

798

9303 1962 INTERNATIONAL CONFERENCE ON HIGH-ENERGY PHYSICS AT CERN, GENEVA, JULY 4-11, 1962. J. Prentki, ed. 970p. Geneva, European Organization for Nuclear Research, 1962.

Two-hundred-and-seven papers presented at the conference are given. Subjects discussed include pion and nucleon physics, strange particle physics, weak interactions of non-strange particles, and theories of elementary particles and high-energy physics.

799

28420 PROCEEDINGS OF THE INTERNATIONAL SCHOOL OF PHYSICS "ENRICO FERMI." COURSE XXVI, SELECTED TOPICS ON ELEMENTARY PARTICLE PHYSICS. VARENNA ON LAKE COMO. VILLA MONASTERO. JULY 23-AUGUST 4, 1962. M. Conversi, ed. New York, Academic Press, 1963. 303p. $10.00.

Nine papers are included.

800

38171 DIRECT INTERACTIONS AND NUCLEAR REACTION MECHANISMS. Proceedings of the Conference Held at the Institute of Physics of the University of Padua, September 3-8, 1962. E. Clementel and C. Villi, eds. Nuclear Physics. Volume 1. New York, Gordon and Breach, Science Publishers, 1963. 1239p. $39.50.

Progress in the field of direct interactions was discussed and the points of paramount importance that deserve further investigation were outlined. Information relating to nuclear structure, the generalized optical model, inelastic scattering, and compound nucleus processes obtained from direct interactions is presented. Other topics include direct and compound nuclear reactions from the point of view of time delay technique, stripping and pickup reactions, polarization in direct reactions, direct reactions between complex nuclei, direct reactions other than stripping, and direct reactions at high temperatures. Abstracts of several related papers and discussion of a number of the presented papers are also included.

801

24176 PROCEEDINGS OF THE EASTERN THEORETICAL PHYSICS CONFERENCE, UNIVERSITY OF VIRGINIA, OCTOBER 26-27, 1962. M. E. Rose, ed. New York, Gordon and Breach, Science Publishers, 1963. 468p. $5.00.

Twenty-four papers were presented on the general topics of nuclear physics, particle physics, and general relativity.

802

38583 (CU(PNPL)-237) PROCEEDINGS [OF] CONFERENCE ON THE UTILIZATION OF MULTIPARAMETER ANALYZERS IN NUCLEAR PHYSICS [HELD AT] GROSSINGER, NEW YORK, NOVEMBER 12-15, 1962. L. J. Lidofsky, ed. (Columbia Univ., New York). 185p. (NYO-10595)

803

34319 MATSCIENCE SYMPOSIA ON THEORETICAL PHYSICS. Volume 1. Lectures Presented at the 1963 First Anniversary Symposium of the Institute of Mathematical Sciences, Madras, India. Ramakrishnan, Alladi (ed.). New York, Plenum Press, 1966. 180p. $9.50. (CONF-630102).

804

32908 (TID-7668) PROCEEDINGS OF THE CONFERENCE ON PHOTON INTERACTIONS IN THE BEV-ENERGY RANGE, HELD IN CAMBRIDGE, MASSACHUSETTS, JANUARY 26–30, 1963. Bernard T. Feld, ed. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). Contract [AT(30-1)-2098]. 168p.

Experimental and theoretical developments in quantum electrodynamics, electromagnetic form factors, scattering (Regge theory), and photoproduction are included. New techniques for producing and detecting particles and radiations are outlined, and developments in scanning and data reduction systems for spark chambers are described. Current worldwide electron accelerator development is summarized, and experiments in progress at the Cambridge Electron accelerator are reviewed.

805

36640 (CERN-63-28) 1963 INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS AND NUCLEAR STRUCTURE HELD AT CERN, FEBRUARY 25–MARCH 1, 1963. Torleif Ericson, ed. (European Organization for Nuclear Research, Geneva). July 1963. 195p.

Separate abstracts were prepared for seven papers on the investigation of nuclear properties with electrons, mesons(μ), mesons(π), strange particles, and protons, and on fragmentation in high-energy nuclear reactions. Use of complex nuclei to examine strange particles is also treated. (D.C.W.)

806

10625 (LNF-63/47) RACCOLTA DELLE COMUNICAZIONI PRESENTATE AL CONGRESSINO ANNUALE DELL'ISTITUTO NAZIONALE DI FISICA NUCLEARE, FRASCATI, 6-7-8-9 MAGGIO 1963. (Compilation of the Papers Presented at the Annual Congress of the Istituto Nazionale di Fisica Nucleare, Frascati, May 6-9, 1963). (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). June 1963. 264p.

Forty-two papers presented at the Annual Congress of the Istituto Nazionale di Fisica Nucleare are compiled. An appendix presents preliminary survey of possible researches with an electron and positron linear accelerator.

807

28138 (ISS-63/28) RELAZIONI PRESENTATE AL CONGRESSINO DEI LABORATORI NAZIONALI DI FRASCATI (6-8 MAGGIO 1963). (Papers Presented at the Congress of the National Laboratories in Frascati (May 6-8, 1963)). Italy. Istituto Superiore di Sanità, Rome). 42p.

The summaries of the papers presented by the Physics Laboratory of the Istituto Superiore de Sanita at the High Energy Physics Congress held in Frascati are compiled. The papers deal with the following subjects: π^- absorption in complex nuclei, preliminary study of (e,e'p) experiment to be carried out at Frascati, preliminary study of (e,e'γ) experiment to be carried out at Frascati, analysis of track chamber pictures, and double π meson photoproduction on protons.

808

12803 (TID-7685) ARGONNE ACCELERATOR USERS GROUP MEETING HELD AT ARGONNE NATIONAL LABORATORY, MAY 10-11, 1963. (Argonne National Lab., Ill.). Contract W-31-109-eng-38. 48p.

Information on the status of the accelerator and experimental facilities, the experimental program, and users' arrangements and procedures is presented. The apparatus and procedures for measuring and analyzing bubble chamber data are also described. Additionally, the design and performance of a polarized proton target are discussed, and preliminary results on elastic π^+-p interactions are presented. (D.C.W.)

809

37958 NUCLEON STRUCTURE. Proceedings of the International Conference at Stanford University, June 24-27, 1963. Robert Hofstadter and Leonard I. Schiff, eds. Stanford, Calif., Stanford University Press, 1964. 428p. $12.50.

810

32378 ATOMIC COLLISION PROCESSES. The Proceedings of the Third International Conference on the Physics of Electronic and Atomic Collisions, University College, London, 22nd-26th July, 1963. M. R. C. McDowell, ed. Amsterdam, North-Holland Publishing Company, 1964. 1176p. fl26; £12.12s; $35.-. (CONF-186)

Slow electron scattering by atoms, resonances, polarization of radiation emitted on electron impact, excitation and ionization atoms by electron impact, electron-molecular collisions, recombination, negative ions, photo processes, elastic and inelastic heavy particle collisions, and collisions with molecules are discussed.

811

41671 (LADC-6186) PIONS, MUONS AND NUCLEAR STRUCTURE. Critchfield, Charles L.; Heller, Leon; Lee, Clarence E.; Young, James E. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). [1963]. Contract W-7405-eng-36. 30p. Dep. mn; CFSTI, $2.00 cy, $0.50 mn.

A summary of the papers presented at the pions, muons, and nuclear structure conference held at LASA in August 1963 is presented. The papers concern: muon interactions with nuclei, mesic x rays, pion-nucleon resonances effect on some simple nuclear reactions, pion optical potential, pion capture on complex nuclei, elementary particles and the boundary condition model, pion production facilities, and a discussion on neutrino experiments. (M.O.W.)

812

1311 PROCEEDINGS OF THE SIENNA INTERNATIONAL CONFERENCE ON ELEMENTARY PARTICLES, 30 SEPTEMBER-5 OCTOBER, 1963. VOLUME I. Gilberto Bernardini and G. P. Puppi, eds. Bologna, Societa Italiana di Fisica, 1963. 708p. (CONF-216)

813

26260 (BNL-837) INTERNATIONAL CONFERENCE ON FUNDAMENTAL ASPECTS OF WEAK INTERACTIONS, HELD AT BROOKHAVEN NATIONAL LABORATORY, SEPTEMBER 9-11, 1963. (Brookhaven National Lab., Upton, N. Y.). Contract AT-30-2-GEN-16. 488p.

Thirty-two papers are included.

814

14659 PROCEEDINGS OF THE EASTERN THEORETICAL PHYSICS CONFERENCE, OCTOBER 25-26, 1963. Chapel Hill, N. C., University of North Carolina, 1963. 146p.

Various topics in theoretical physics were discussed including equilibrium statistical mechanics, second-order phase transitions, collective motion in many-body systems, Toeplitz determinants and Coulomb gases, superconducting condensation energy, complex spectra, group theory, momentum distributions in boson systems, quantum observations and measurements, equivalence of states, effects of strong interactions in peratization theory, π-p interactions, inelastic effects in π-N interactions, magnetic and electric geons, unitary symmetry, perturbation theory, fermion propagators, Yukawa field theory, Lamb shift calculations, lattice thermal conductivity, intramolecular statistics of chain molecules, and the application of Lie groups to the nuclear many-body problem.

815

7339 (ISS-63/40) RIASSUNTI DELLE COMUNICAZIONI PRESENTATE AL 49° CONGRESSO NAZIONALE DI FISICA BARI, 6-13 NOVEMBRE 1963. (Summaries of the Papers Presented at the 49th National Congress of Physics, Bari, November 6-13, 1963). (Italy. Istituto Superiore di Sanita, Rome). Sept. 25, 1963. 24p.

Eight papers on single meson (π^0) photoproduction on protons, statistical analysis of excitation curves of recoil protons in photoproduction, meson (π^-) absorption in complex nuclei, 662-kev γ-ray scattering on bound electrons, search for radioactivity induced by tetraneutrons in stable isotopes, measurements on radiation emission by accelerated electrons in the Frascati synchrotron, acoustic detection of spark position in a cylindrical spark chamber, and a precision trigger circuit are summarized. (auth)

816

34964 INTERNATIONAL CONFERENCE ON COSMIC RAYS, JAIPER, DECEMBER 2-14, 1963, PROCEEDINGS. VOLUME 6. MUONS AND NEUTRINOS. Under the Auspices of The International Union of Pure and Applied Physics and The Department of Atomic Energy, Government of India. Daniel, R. R.; Lavakare, P. J.; Menon, M.G.K.; Naranan, S.; Nerurkar, N. W.; Pal, Yash; Sreekantan, B. V., eds. Bombay, The Commercial Printing Press Limited, 1964. 261p. Available from Tata Inst. of Fundamental Research, Bombay. (CONF-320)

817

14943 PROCEEDINGS OF THE ATHENS TOPICAL CONFERENCE ON RECENTLY DISCOVERED RESONANT PARTICLES. Bascharat A. Munir and Lawrence J. Gallaher, eds. Athens, Ohio, Ohio University, 1963. 316p.

The present knowledge of the various resonance states, including their production, properties, and decays, are discussed.

818

31869 (CERN-64-30) PROCEEDINGS OF THE INFORMAL MEETING ON FILMLESS SPARK CHAMBER TECHNIQUES AND ASSOCIATED COMPUTER USE, GENEVA, MARCH 1964. G. R. Macleod and B. Maglic, eds. (European Organization for Nuclear Research, Geneva). 405p.

819

37640 VOPROSY FIZIKI ELEMENTARNYKH CHASTITS. Chetvertaya Sessiya Vessenei Shkoly Teoreticheskoi i Eksperimental'noi Fiziki Nor-Amberd, 16-26 Aprelya 1964 g. (Problems in Physics of Elementary Particles. The Fourth Session of the Spring School of Theoretical and Experimental Physics, Nor-Ambert, April 16-26, 1964). Alikanyan, A. I. (ed.). Erevan, Publishing House of Academy of Sciences, 1964. 600p.

Thirty-six lecture papers and one scientific communication are included.

820

36688 SELECTED TOPICS IN NUCLEAR SPECTROSCOPY. Proceedings of the NUFFIC International Summer Course in Science at Nijenrode Castele, The Netherlands, July 30–August 17, 1963. B. J. Verhaar, comp. New York, John Wiley and Sons, 1964. 355p. $12.50.

821

44383 (CERN-65-4(Vol.II)) Vth INTERNATIONAL CONFERENCE ON NUCLEAR PHOTOGRAPHY HELD AT CERN, GENEVA, 15–18 SEPTEMBER 1964. Dahl-Jensen, E. (ed.) (European Organization for Nuclear Research, Geneva (Switzerland)). Jan. 1965. 387p. (CONF-787 (Vol.II)). Dep. mn.

Seventy-one papers are presented on various aspects of nuclear photography.

822

42564 (STI/PUB/91(Vol. II)) CHEMICAL EFFECTS OF NUCLEAR TRANSFORMATIONS. VOL. II. Proceedings Series. Proceedings of the Symposium Held in Vienna, 7–11 December 1964. (International Atomic Energy Agency, Vienna). Apr. 1965. 567p. (CONF-773(Vol.II)). IAEA $11.00; S 231,-; £3.6.0; F.Fr. 44,-; DM 38,50 cy.

Thirty-five articles and one single abstract are included;

823

15398 RESONANT PARTICLES. Proceedings [of the] Second Topical Conference, Ohio University, Athens, Ohio, June 10–12, 1965. Munir, B. A. (ed.). Contract AT(49-12)-2802. 560p. Fazl-i-Umar Research Inst., Athens, Ohio $12.00.

824

9472 BIBLIOGRAPHY ON WEAK INTERACTIONS. PERIOD JANUARY 1961 TO MAY 1962. p.857-66 of "1962 International Conference on High-Energy Physics at CERN." Geneva, European Organization for Nuclear Research, 1962.

A list of about 300 papers on the theory of weak interactions covering the period January 1961 to May 1962 is presented. References are grouped first by subject and then listed in alphabetic order by authors. (A.G.W.)

825

9433 (NP-11294) NUCLEAR REACTIONS BIBLIOGRAPHY. (Library of Congress. Aerospace Information Div., Washington, D. C.). Dec. 15, 1961. 96p. (AID-Report-61-7)

A bibliography is presented as a guide to Soviet literature on nuclear reactions. The material covered are the Soviet sources available at the Aerospace Information Division and the Library of Congress prior to June 1960. The 682 entries are arranged alphabetically by author within each of the followings 13 subject headings: Coulomb excitation, deuteron-induced reactions, neutron-induced reactions, proton-induced reactions, reactions induced by alpha particles, reactions induced by gamma quanta and electrons, reactions induced by light nuclei, reactions induced by heavy ions, reactions induced by mesons (π), nuclear fission, thermonuclear reactions and plasma, photonuclear reactions, and general and miscellaneous. (M.C.G.)

826

7690 (ORNL-3499(Vol.II)(p.54-6)) LITERATURE SURVEY OF NONELASTIC NUCLEON AND PION REACTIONS WITH COMPLEX NUCLEI. H. W. Bertini (Oak Ridge National Lab., Tenn.).

Abstracts in Physics Abstracts are examined for literature on neutron yields and cross sections for particle-particle reactions and for meson (π) and secondary nucleon production in meson (π) and nucleons reactions with complex nuclei at 20 Mev to 30 Bev. A typical page from a previously issued report is included. (D.C.W.)

827

34883 (ORNL-3455) A LITERATURE SURVEY OF NONELASTIC REACTIONS FOR NUCLEONS AND PIONS INCIDENT ON COMPLEX NUCLEI AT ENERGIES BETWEEN 20 Mev AND 33 Gev. H. W. Bertini (Oak Ridge National Lab., Tenn.). Aug. 23, 1963. Contract W-7405-eng-26. 117p.

Experimental data on nonelastic reactions of protons, neutrons, π^+, and π^- with complex nuclei at incident energies of 20 Mev to 33 Bev were surveyed. The material is grouped according to the incident particle in the above order. Information on the measured quantity, experimental arrangement, and the experimental error is included. The 200 publications used in the survey, most of them abstracted for Physics Abstracts, are listed. (D.C.W.)

828

4428 (BNL-809) MUON BIBLIOGRAPHY. Marjorie Comstock, comp. (Brookhaven National Lab., Upton, N. Y.). Apr. 1963. Contract AT-30-2-GEN-16. 22p.

References relating to μ mesons are presented for 1958 to April 1963 and are arranged according to year. Sources for the 625 references are Nuclear Science Abstracts, Science Abstracts, Series A, Physics, and the Brookhaven Research Library. Subjects included are static properties, electromagnetic interactions, mesic atoms and molecules, weak interactions, μ-meson structure and anomalous interactions, cosmic rays, and μ-meson beams. (R.E.U.)

829

13872 (UCRL-9999) BIBLIOGRAPHY ON PION-PION INTERACTION. M. Lynn Stevenson (California. Univ.,

Berkeley. Lawrence Radiation Lab.). Nov. 7, 1961. Contract W-7405-Eng-48. 63p.

A bibliography on pion-pion interactions is presented. The 241 references are those available through November 7, 1961. A chronological listing is given together with excerpts or comments. In another part the references are grouped according to subject. An author index is included. (M.C.G.)

830

20354 (BNL-929) ANNUAL REPORT, JULY 1, 1965. (Brookhaven National Lab., Upton, N. Y.). Nov. 1965. Contract AT(30-2)-Gen-16. 249p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

Research and development activities are summarized in eight sections.

19273 (BNL-929, pp 3-43) PHYSICS. (Brookhaven National Lab., Upton, N. Y.).

Research efforts devoted to particle physics, atomic and molecular physics, neutron physics, nuclear structure, and solid state physics are summarized. (J.R.D.)

18185 (BNL-929, pp 126-47) MEDICAL RESEARCH. (Brookhaven National Lab., Upton, N. Y.).

Medical research is summarized on uses of extracorporeal irradiation of blood, hemopoietic colony-forming cells in mice, radioinduced eye lens opacification, effects of 2.2 Bev protons on mammals, dosimetry using mesons (π^-), epithermal neutron beam dosimetry, use of swine skin in radiation effects evaluation, Sr and Ca metabolism in man, radiosensitivity of antibody responses, and bile effects on gastrointestinal syndrome of dogs. Research results are also reported on bioenergetic mechanisms involving free radicals, properties of hydroxylysine and collagen, inheritance and protein synthesis, physiology of trace metals, insulin protein structure and activity, tracer studies of obesity and diabetes, distribution of insulin in muscle, mechanisms of neurohypophyseal peptide actions, effects of genetics and sodium on hypertension, conversion of glycine-2 ^{14}C to cyanide by chromobacterium, synchronous growth and division in cell cultures, nucleic acid metabolism, skeleton growth and aging, effects of tritiated thymidine incorporation in DNA, studies of fallout-exposed Marshall islanders, blood culture cytology, neutron radiography, Ga neutron capture, ^{99}Tc as a scanning agent, computer uses, and positron scanning. (J.R.D.)

831

11331 (TID-17023) REPORT OF RESEARCH IN HIGH-ENERGY NUCLEAR PHYSICS, NOVEMBER 1, 1961-OCTOBER 31, 1962. (Carnegie Inst. of Tech., Saxonburg, Penna. Nuclear Research Center). Contract AT(30-1)-882. 33p.

Status reports are given for research on the reaction rate for $\mu^- + He^3 \rightarrow H^3 + \nu$, on liquid helium scintillation counters, on solid state radiation detectors, on proton spallation in light elements, on μ^- lifetimes, on spark chamber investigation of Dalitz pairs from π^0 decay, on π^- - p interactions at 560 and 650 Mev, on radiative capture of μ

832

862 (TID-19590) REPORT OF RESEARCH IN HIGH ENERGY NUCLEAR PHYSICS, NOVEMBER 1, 1962 THROUGH OCTOBER 31, 1963. (Carnegie Inst. of Tech., Saxonburg, Penna. Nuclear Research Center). Contract AT(30-1)-882. 25p.

Research progress on elementary particle interactions, properties, scattering, and theory; nucleon reactions and scattering; spark chambers; superconducting magnet bubble chambers; beam production and handling; and solution of integral equations is reported. (D.C.W.)

833

25781 (COO-1195-56) ANNUAL PROGRESS REPORT [ON ELEMENTARY PARTICLE PHYSICS, 1965]. (Illinois Univ., Urbana. Dept. of Physics). Apr. 1966. Contract AT(11-1)-1195. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Some investigations of resonance production in π^--p, π^+-d, K^--p, and p-p interactions at high energies, strange particle production in p-p interactions, π-N coupling, photoproduction of mesons (π^-), and the decay of mesons (K_2^0) are summarized. Efforts in the development of counters, wire spark chambers, and data analysis systems are also outlined. (D.C.W.)

834

25924 (NP-11977(p.55-7)) PROGRESS REPORT OF THE TRIESTE GROUP FROM JANUARY TO OCTOBER 1960. C. Cernigoi (Italy. Istituto Nazionale di Fisica Nucleare, Trieste).

The cross section at 0° for the charge-exchange scattering of negative pions at 170 Mev is being measured directly by detecting pairs of gamma rays from the π^0 decay. The gamma pairs are detected by two total-absorption Cherenkov counters and simultaneously by two gamma telescopes. The arrangement is shown schematically. The Cherenkov counters were calibrated by the electrons present in the 150-Mev π^- beam. (J.S.R.)

835

6792 (ISS 62/14) THE PHYSICS LABORATORIES OF THE ISTITUTO SUPERIORE DI SANITA UP TO 31ST MARCH 1962. (Italy. Istituto Superiore di Sanita, Rome). Apr. 1962. 86p.

Research and development progress is reported on high-energy physics, nuclear physics, molecular physics, x-ray physics, electron microscopy, solid-state physics, and theoretical physics and computers. The technical services performed are also described. (M.C.G.)

836

2585 (ISS-63/37) RELAZIONE SULL'ATTIVITÀ DEI REPARTI 1° E 2° DEI LABORATORI DI FISICA (SOTTO-

SEZIONE "SANITA" ASSOCIATA ALL'INFN) NEL 1962-63. (Progress Report of the Sanità Subsection of the INFN During the Period 1962-63). (Italy. Istituto Superiore di Sanità, Rome). June 18, 1963. 27p.

Research dealt with meson(π^0) photoproduction, the lifetime of mesons (π^+) in flight, neutron spectra following meson(π^-) absorption at rest in nuclei, fluorescence yield and coherent scattering in the interaction of 662-kev gamma rays with bound electrons, and the interaction of positrons at rest with matter. Technological development included techniques for high precision measurements of radioactivity, an acoustic spark chamber, and equipment for nuclear physics and for track chamber scanning. Numerical tables of the kinematics of multiple meson photoproduction were calculated, and programs were prepared for the IBM 7040 computer. (D.C.W.)

837

21388 (LNF-63/11) ACTIVITY AT THE NATIONAL LABORATORIES OF FRASCATI. Report No. 13, July 1, 1962–December 31, 1962. (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Feb. 1963. 40p.

The electron synchrotron operated at about 90% efficiency in 1962 with an average beam intensity at 1000 Mev of about 5×10^{11} quanta/min. Cryogenic work involved testing of a new liquefier, construction of a magnetic susceptibility thermometer, experiments on superconducting magnets, and construction of an adiabatic demagnetization facility. A r-f power-supply for the storage ring "AdA" was tested along with an amplifier for the electron synchrotron. The effect of electron loading on the accelerating cavity was theoretically studied. Fast coincidence and gating circuits, a pulse height digitizer, a spark chamber films semiautomatic reading table, a saw-tooth generator, and various other apparatus were developed. For pulse height digitalization, a fully-transistorized convertor that accepts pulses from 50 mv to 0.8 v at 10 + 40 ns width was developed. A transistorized binary decade counter was also developed, and correct decoding for the decimal counter was achieved. A smaller frame for the pulse magnets proved insufficient; a 135 kjoule condenser bank was designed; Nb–Zr superconducting magnets were tested; α-radiation effects on superconductors were studied; and an electron gun was tested. Improvement of construction techniques for image-intensifying tubes was studied. A card-type input-output unit was installed permitting the statistical elaboration of experimental data. Work on didactic activity continued. The calculation that includes the contributions of hard photons in the production of pairs of μ mesons in electron-positron collisions was completed. Calculations on η meson decay were made, particularly the decay ratios of two γ's to three π's, and to two π's plus γ. Classification of leptons was investigated, and a study of weak interactions concerning inelastic processes induced by fast neutrinos was concluded. Data relative to μ^- capture were found to disagree with theoretical models for this process. Activities of the health physics and other supporting services are reported. (D.C.W.)

838

33203 (UCRL-11213) CHEMISTRY DIVISION ANNUAL REPORT, 1963. J. M. Hollander, F. L. Reynolds, and J. C. Wallmann, eds. (California. Univ., Berkeley. Lawrence Radiation Lab.). Feb. 1964. Contract W-7405-eng-48. 200p.

Progress is reported in the following sections: radioactivity and nuclear structure, fission, nuclear reactions, physical chemistry, instrumentation, and chemical engineering.

32747 (UCRL-11213(p.64-86)) NUCLEAR REACTIONS. (California. Univ., Berkeley. Lawrence Radiation Lab.).

Measurements of the proton polarization produced in the elastic scattering of 22-Mev protons by deuterons were made which show substantial polarization. In an optical-model analysis of 48-Mev alpha particles scattered by ^{12}C, real and imaginary potentials were derived for several sets of parameters that gave good fits to the elastic scattering data. Energy spectra and angular distributions were measured for the reactions $^{16}O(p,t)^{14}O$ and $^{16}O(p,^3He)^{14}N$ at 43.7 Mev. The elastic and inelastic scattering of 65-Mev helium ions by ^{16}O and the resulting excited levels of ^{16}O were studied. The strong formation of high-spin levels in several (α,d) reactions was studied. Results are summarized for calculations of μ capture transition rates in ^{12}C and ^{16}O. Differential cross sections and angular distributions were measured for the elastic and inelastic scattering of 64.3-Mev alpha particles by ^{58}Ni and ^{58}Fe. Alpha scattering by ^{63}Cu and ^{62}Ni were used to study the excited energy levels of these nuclei. The range and range straggling of recoil Tb and Dy, produced by heavy-ion-induced reactions, in gases and Al were studied, and the anisotropy and neutron and photon energies for ^{149}Tb were determined. Excitation functions are presented for (^3He,^7Be) and (^4He,^7Be) reactions of ^{27}Al and ^{12}C. The excitation function of the $^{12}C(\pi^-,\pi^-n)$ reaction was also measured at 53 to 1610 Mev. (D.L.C.)

839

9842 UCRL-9017

California. Univ., Berkeley. Lawrence Radiation Lab. PHYSICS DIVISION SEMIANNUAL REPORT [FOR] MAY THROUGH OCTOBER 1959. Dec. 10, 1959. 55p. Contract W-7405-eng-48. OTS.

Work by the various general physics research groups in the Laboratory is briefly summarized in terms of bubble chambers, strange particles, anti-particles, elementary particle reactions, accelerator studies, etc. Operation of the 60-inch cyclotron and the heavy-ion linear accelerator is discussed. (For preceding period see UCRL-8936.) (W.D.M.)

840

2305 (UCRL-9704) PHYSICS DIVISION SEMI-ANNUAL REPORT, NOVEMBER 1960 THROUGH APRIL 1961. (California. Univ., Berkeley. Lawrence Radiation Lab.). May 1961. Contract W-7405-eng-48. 83p.

Development and operation of liquid hydrogen bubble chambers are discussed. The following investigations are summarized: particle interactions; search for Dirac monopoles; strange-particle research; spark chamber developments; emulsions; electron linear accelerators; particle production and scattering; charge independence; and space physics. Theoretical studies are described for the physics of the nucleus; strong and weak interactions; mesons-π and -μ; field theory; atomic, high-energy, and plasma physics; and accelerators. Computer programs written for various applications are described. The operation of the 60-Inch Cyclotron is summarized. (B.O.G.)

841

32177 (UCRL-10349) PHYSICS DIVISION SEMIANNUAL REPORT, NOVEMBER 1961 THROUGH APRIL 1962. (California. Univ., Berkeley. Lawrence Radiation Lab.). May 17, 1962. Contract W-7405-eng-48. 80p.

A large part of the research with bubble chambers was devoted to the operation of the separated high-energy K^- beam and analysis of the resulting data. Details of experiments in this area are given along with work on data reduction, bubble chamber development, and superconductivity studies for development of high-field magnets. Research on the decay modes of Σ hyperons is reported along with other strange-particle investigations and heavy ion research. Development work on a video track analyzer was continued. Work on the S-matrix theory is described in published reports along with various applications of the S-matrix theory. Work on theoretical plasma physics is summarized along with work on atomic physics, particle accelerators, and nuclear physics. The work in the mathematics and computing group was devoted to program development for bubble chamber data analysis and several miscellaneous mathematical programming developments. Work in physics research is reported on K^+-proton interactions, π-π interactions, phase shift analysis of π-p scattering, pion-proton interactions, properties of radioisotopes, and other research projects. Data analysis by the FOG program is reported along with development of the CLOUDY program and the FAIR program. Continued research on single meson production in π + p collisions is reported. A summary of work is also included on the 184-in. cyclotron and the 60-in. cyclotron. (J.R.D.)

842

20594 (UCRL-10572) PHYSICS DIVISION SEMI-ANNUAL REPORT, MAY 1962 THROUGH OCTOBER 1962. (California. Univ., Berkeley. Lawrence Radiation Lab.). Nov. 28, 1962. Contract W-7405-eng-48. 121p.

Research is reported on pion beta decay, neutron polarization in π^- + p charge-exchange scattering, π-π interactions, plastic scintillator detection efficiency for 4 to 76-Mev neutrons, K^+ and K^0 decay, K^+-p interactions, meson exchange and K^* spin alignment in K^+ + p reactions, beta decay of hyperons, π-π resonances, π^+-p scattering, neutron polarization from Σ decay, the muonic decay rate of the lambda hyperon, sigma-hyperon production, lambda lifetime, double hyperon production in D, three and four-pion mass spectra, pion production in π-p interactions, nuclear excitation from μ^- capture, proton polarization in elastic π-p scattering, phase-shift analysis in π-p scattering, radiative capture of π^- in flight, polarization in nuclear scattering of 740-Mev protons, K^--p interactions, mesic x rays, bound muon decay, meson production in p + d collisions, K^- reactions in complex nuclei, hyperfragment production processes, π^0 mean life, 16-Bev π^- interactions with protons, multiple scattering of heavy ions, charged particles from O^{16} interactions and mirroring of geomagnetically trapped protons on satellites. Bubble chamber development, operation, and research are included. Theoretical work dealt with s-matrix and elementary-particle theory, lepton physics, nuclear theory, atomic and plasma physics, liquid He, particle orbit theory and accelerator design problems, complex angular momentum, Regge poles, dispersion relations, and various other topics. Many computer programs were written, and data handling systems were developed. Construction of a video track analyzer is reported, and accelerator development and operation are summarized. 139 references. (D.C.W.)

843

31091 (UCRL-10862) PHYSICS DIVISION SEMI-ANNUAL REPORT, NOVEMBER 1962 THROUGH APRIL 1963. (California. Univ., Berkeley. Lawrence Radiation Lab.). May 20, 1963. Contract W-7405-eng-48. 82p.

Progress in strange-particle research, bubble chamber operation and development, accelerator development and theory, data processing, computer programming, plasma physics, atomic and nuclear physics, scattering theory, meson studies (capture, decay, interactions, production), hyperon properties and production, nuclear reactions, cosmic proton research, particle physics, and spark chamber development is reported. (D.C.W.)

844

16552 (UCRL-11132) PHYSICS DIVISION SEMI-ANNUAL REPORT MAY–OCTOBER 1963. (California. Univ., Berkeley. Lawrence Radiation Lab.). Nov. 22, 1963. Contract W-7405-eng-48. 111p.

Research progress on interactions, strange particles, scattering, elementary particles, nuclear and plasma physics, cosmic particles, Dirac monopoles, heavy ion reactions, and resonances is summarized. Development and operation of accelerators, bubble chambers, and data reduction systems are also reported, together with computer operation, development, and programming. (D.C.W.)

845

9775 (UCRL-11466) PHYSICS DIVISION SEMIANNUAL REPORT, NOVEMBER 1963–APRIL 1964. (California. Univ., Berkeley. Lawrence Radiation Lab.). May 25, 1964. Contract W-7405-eng-48. 59p. Dep.; $3.00(cy), 2(mn) OTS.

Research and development is reported on bubble chambers, strange particles, heavy ions, scattering, many-body problems, weak interactions and other general physics areas. Developments in data handling, computer programs, and accelerator operations are also reported. (J.R.D.)

846

25265 (UCRL-11776) PHYSICS DIVISION SEMIANNUAL REPORT MAY–OCTOBER 1964. (Lawrence Radiation Lab., Univ. of California, Berkeley). Nov. 16, 1964. Contract W-7405-eng-48. 73p. Dep.; $3.00(cy), 2(mn) CFSTI.

Research using bubble chambers is summarized along with work on data reduction and programming. Results of research on strange particles and pions is also reported along with space research and development of track analyzing microscopes. Theoretical work in physics is summarized, and other work devoted primarily to elementary particles is reported. A summary of work on accelerator operation and development is included. (J.R.D.)

847

40426 (NYO-10063) PROGRESS REPORT [ON NUCLEAR SCIENCE]. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). May 1, 1963. Contract AT(30-1)-2098. 134p.

Progress in nuclear science is reported under the following topics; chemistry of fission elements, nuclear chemistry (organic), nuclear chemistry (inorganic), cosmic radiation, bubble chamber, linear accelerator, high-energy accelerator physics, ONR generator, radioactivity, cyclotron, and theoretical. Separate abstracts were prepared for each topic. (M.C.G.)

40433 (NYO-10063(p.71-89)) HIGH ENERGY ACCELERATOR PHYSICS GROUP. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science).

Apparatus for the π^0-photoproduction experiment, hodoscopes, magnet platform, magnets and associated electronics, were placed in operation. Cross sections for the $\gamma + p \rightarrow \pi^0 + p$ reaction were plotted for 0 to 2.3 Mev. Events in the interactions of photons with deuterium are being analyzed. Apparatus for studying the Λ^0 gyromagnetic ratio was assembled. Data on $\pi - p$ and $K^- - p$ elactic scattering are presented in graph form. Evidence for the formation of quasi-deuterons in the nitrogen nucleus was sought in π^+ reactions with nitrogen. A search is being made for ζ^+ in $\pi^+ + p$ reactions. A momentum-analyzing spark chamber with scintillation-counter triggers was designed. The elastic scattering cross sections for gamma rays by protons in the energy range from 550 to 850 Mev were measured. An experiment to measure the cross section for the photoproduction of μ pairs from carbon is being carried out. Proton-proton and meson(π)-proton scattering studies were also carried out. The cross section for photoproduction of intermediate boson pairs in the reactions $\gamma + p \rightarrow p + W^+ + W^-$ and $\gamma + p \rightarrow Z + W^+ + W^-$ was calculated. (M.C.G.)

848

5569 (MIT-2098-64) LABORATORY FOR NUCLEAR SCIENCE PROGRESS REPORT. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). May 1, 1964. Contract AT(30-1)-2098. 134p. Dep.(mn); $4.00 (cy), 3(mn) OTS.

Progress is reported in research on chemistry of the fission elements, nuclear chemistry, cosmic radiation, particle interactions in bubble chambers, particle physics using accelerators, physics measurements using radioisotopes, and theoretical elementary particle physics, and nuclear physics. (J.R.D.)

849

19713 TID-6081

Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Cyclotron Labs.

QUARTERLY PROGRESS REPORT [FOR] MARCH 1, 1960 TO MAY 31, 1960. Warren F. Goodell, Jr. June 1, 1960. 20p. Contracts AT(30-1)-1932; AT(30-1)-1019; AT-30-1-GEN-72; Nonr-266(72); and N6-ori-110-1. OTS.

Stable operation of the synchrocyclotron since February, construction progress on the high-energy research building and neutron velocity spectrometer flight path tube, and continued work to provide satisfactory optics for the 30-in. propane bubble chamber are reported. Analysis of the decay curve for μ^- mesons stopped in Zn and Nb was continued. Magnetic moments of the muons were measured in a field of 13.8 kilogauss and an r-f frequency of 180 Mcps. The mass of the μ^- was measured by determining the mass absorption in Pb of the phosphorus 3D-2P mesonic x ray. Fine structure splittings were observed in the 2P-1S and 3D-2P transitions of the Pb μ-mesonic atom. Differential cross sections were measured for π^-–carbon scattering at 69.5 and 87.5 Mev and π^-–oxygen scattering at 87.5 Mev and at 20 to 125°C. Preparations were made to measure the capture cross sections of μ^- mesons by protons and to determine the sign of the asymmetry parameter in μ decay. A search was completed for the decay mode $\mu^+ \rightarrow e^+ \gamma$, and muonium ($\mu^+ + e^-$) formation was observed in highly purified Ar gas. The possibility and methods for observing interactions of neutrinos for high-energy, high-intensity accelerators were studied. A general purpose 650 space reconstruction program was written for use with the Columbia bubble chambers and computers. The mass difference of the π^- and π^+ mesons was measured by measuring the momenta of the two internally converted electron-positron pairs from π^0 decay. Scanning and analysis of the 12-in. hydrogen bubble chamber pictures were completed for Cosmotron $\pi^- + d$ interactions and $\pi^- + N^* \rightarrow \Sigma^- + \theta^+$ events and proposed for the reaction $\pi^- + p^+ \rightarrow \Lambda^0 + \theta^+$. Measurement of the polarization of recoil protons in 600-

Mev $\pi^- - p$ scattering was proposed to determine the character of the scattering resonance. Extensive slow neutron transmission measurements were made with a flat detector in As, PbI_2, $PbBr_2$, Mn, Pr_6O_{11}, Tm_2O_3, Cs and Th at 20 ev to 5 kev. Filament scintillation chambers were exposed to the meson beam of the cyclotron. Work was continued on the energy variation of Ag fission and on (p, pn) reactions. (M.C.G.)

850

22593 (SLAC-27) TWO-MILE ACCELERATOR PROJECT. Quarterly Status Report, October 1–December 31, 1963. (Stanford Univ., Calif. Stanford Linear Accelerator Center). Feb. 1964. Contracts AT(04-3)-400 and AT(04-3)-476. 93p.

Development of accelerator structures, klystrons, the physical slant, magnets, vacuum system, electronic and microwave equipment, and beam control and handling equipment is reported. Operation and modification of the Mark IV accelerator are also summarized, together with experimental and theoretical studies of particle production and interactions. (D.C.W.)

851

16852 (NP-14647) ANNUAL REPORT, APRIL 1963–MARCH 1964. (Tokyo Univ. (Japan). Inst. for Nuclear Study). May 1, 1964. 78p. Dep.(mn).

The experimental facilities available for use in low-energy physics research are described, and experiments with a synchrocyclotron are reported. An evaluation of proposals for long-range low-energy physics research is included. The experimental facilities available for use in high-energy physics research are described, and experiments with an electron synchrotron are reported. Measurements on cosmic air showers are reported, and data on cosmic radiation obtained in balloon flights are analyzed. Research on theoretical physics is reported along with activities at the chemical laboratory. (J.R.D.)

852

15325 (TID-17766) YALE STUDY ON HIGH INTENSITY PROTON ACCELERATORS. A PROGRESS REPORT ON THE DESIGN OF A VERY HIGH INTENSITY LINEAR ACCELERATOR FOR PROTONS AT AN ENERGY OF 750 Mev. Internal Report Y-C. (Yale Univ., New Haven). Oct. 30, 1962. Contract AT(30-1)-2726. 121p.

The design of a very high intensity proton linear accelerator and its associated facilities, that together form a complete meson factory is discussed. The accelerator will deliver a 1 ma (average) primary proton beam at an energy that is variable from 200 to 750 Mev. Polarized protons can also be accelerated. The intense primary proton beam, that can be fully extracted from the accelerator, will produce intense well-defined secondary beams of pions, muons, neutrons, and neutrinos. These secondary beams will be separated from the proton beam and transported to various experimental areas where adequate shielding, both flexible and fixed, is provided. The sections of the report outline the justification, establish the feasibility, and estimate the cost of the installation. Tentative characteristics of the accelerator and the beams are presented, as are a number of studies that can be made with the assembly. 72 references. (auth)

853

16953 (TID-20352) SUMMARY OF PROGRESS REPORT [ON NUCLEON-NUCLEON INTERACTION] PERIOD ENDING, FEBRUARY 1964. McAllister H. Hull, Jr., and Gregory Breit (Yale Univ., New Haven). Mar. 1964. Contract AT(30-1)-1807. 12p.

Research progress on N-N interactions, π-N interactions, nucleon-nucleus scattering, deuteron photodisintegration, heavy ion reactions and scattering, and higher order effects in Coulomb excitation is summarized.

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