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# A PROGRAM IN MEDIUM-ENERGY NUCLEAR PHYSICS

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PROGRESS REPORT--AUGUST 1, 1991-AUGUST 31, 1992

## I. Overview

This report reviews progress on our nuclear-physics program for the last year, and includes as well copies of our publications and other reports for that time period. The structure of this report follows that of our 1991 Renewal Proposal and Progress Report: Sec. II outlines our research activities aimed at future experiments at CEBAF, NIKHEF, and Bates; Sec. III gives results of our recent research activities at NIKHEF, LAMPF, and elsewhere; Sec. IV provides an update of our laboratory activities at GWU, including the acquisition of our new Nuclear Detector Laboratory at our new Virginia Campus; and Sec. V is a list of our publications, proposals, and other reports. Copies of those on medium-energy nuclear physics are reproduced in the Appendix.

## II. Progress on Our Current Research Program

### A. Measurements with Real Photons at CEBAF

A large part of our effort this past year has gone into the planning and preparation for experiments with real photons at the CEBAF Large-Acceptance Spectrometer (CLAS). The present PI spent most of his sabbatical year at CEBAF, and

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recently was re-elected as chair of the Real-Photon Physics Working Group of the CLAS Collaboration. We are part of the collaborations for two CLAS proposals that were approved last year, and are heavily involved in assembling two additional proposals to be presented to the 1993 CEBAF PAC. Thus far, our primary interests at CEBAF are centered on the tagged-photon beam and CLAS in Hall B, but we plan to become involved in the more distant future in experiments in Hall A as well (see Sec. 6 below).

**1) Strangeness Production in Nuclei**

This proposal, on the photoproduction of strange particles on $^{3}$He, $^{4}$He, and $^{12}$C (spokesman, C.E. Hyde-Wright, Univ. of Washington), was approved by the 1991 CEBAF PAC. We have contributed acceptance calculations for a wide variety of strange-particle production channels, which are applicable as well to other experiments at CLAS; see CLAS Note 92-002, by P.L. Cole, in the Appendix.

**2) Photoproduction of $\eta$ and $\eta'$ Mesons**

This proposal, on the photoproduction of $\eta$ and $\eta'$ mesons on the proton (spokesman, B.G. Ritchie, Arizona State Univ.), also was approved by the 1991 CEBAF PAC.

**3) Photofission at CEBAF Energies**

A proposal is being prepared, in collaboration with a group at Frascati (intended co-spokesmen, B.L. Berman and N. Bianchi), on total photon absorption by nuclei. For the heaviest nuclei, the most convenient way to accomplish this is via the photofission channel, which for these nuclei is expected to constitute nearly all, if not all, of the total photon absorption strength. We have assembled the salient points of this proposal in the form of CLAS Note 92-010, by B.L. Berman *et al.*, also in the Appendix.

**4) Photoreactions on $^3$He**

A proposal is being prepared, in collaboration with groups at Genoa and Saclay (intended co-spokesmen, B.L. Berman, P. Corvisiero, and G. Audit), to measure a group of six reaction channels on $^3$He, namely, the ($\gamma$,any hadrons) channel to measure the total absorption cross section, the ($\gamma$,2$\pi$xN) channel to measure resonance decay strengths and widths in nuclei, the ($\gamma$,ppn) channel to measure three-body-force effects in photodisintegration, the ($\gamma$,$\pi$3N) channel to measure three-nucleon correlations in single-pion photoproduction, the ($\gamma$,$\Delta$N) channel to search for delta knockout, and the ($\gamma$,$\phi$xN) channel to search for hidden color. Monte-Carlo calculations in support of this proposal are well under way at GWU and in Genoa, and theoretical calculations are being performed at Saclay.

**5) Tagged Coherent Bremsstrahlung**

A program (by S.L. Rugari) has been written to compute the energy spectrum and polarization of tagged coherent bremsstrahlung produced with the CLAS photon tagger. The focal-plane detector array for the tagger is being designed and will be built at GWU, at our new Nuclear Detector Laboratory at our new Virginia Campus (see Sec. IV).

**6) The HARP at CEBAF**

The High-Acceptance Recoil Polarimeter (HARP) is a high-efficiency, large-solid-angle neutron detector and polarimeter being designed and constructed by a collaboration of five university groups in North America and Europe, including GWU. Although it will be used initially for (e,e'n) and (e,e'pn) experiments at NIKHEF (see Sec. B below), it will be eminently suitable for similar measurements at higher energies at CEBAF. To this end, an overture was made to the Hall A Collaboration (by T. Bauer, Univ. of Utrecht), to bring the HARP to CEBAF, several years

hence, to be used there, and this was approved by the Hall A Collaboration in June, 1992.

**B. (e,e'n) Measurements at NIKHEF**

We are now planning a program of (e,e'n) measurements on few-body nuclei, namely, $^{2}H$, $^{3}He$, $^{4}He$, and $^{6}Li$. For these measurements we intend to employ a hydrogen-recoil detection system which will detect knockout protons having energies between 30 and 150 MeV. For the construction of such a large-scale neutron detector, we have formed a collaboration with groups from the University of Utrecht (Netherlands), the Institute of Nuclear Physics at Grenoble (France), the University of Regina (Canada), and the University of Maryland. The GWU participation in this collaboration is funded in part by the DOE University Research Instrumentation Program. In the following sections we describe the progress made in the development of such a detector.

**1) High-Acceptance Recoil Polarimeter Collaboration**

A Memorandum of Understanding outlining the detector-related responsibilities and tasks has been agreed upon by the founding member institutions (GWU, Utrecht, Grenoble, and Regina). K.S. Dhuga is leading this effort at GWU. The objective is to perform experiments at energies up to 800 MeV at NIKHEF, and then to relocate to CEBAF to continue the research program in the 1-to-5 GeV range. The HARP will be our contribution to the Hall A instrumentation at CEBAF.

**2) Physics Proposal**

Currently, a proposal is being prepared, by K.S. Dhuga and S.L. Rugari (see Appendix), to carry out a systematic study of the (e,e'n) knockout reaction on $^{3}He$. We plan to extract all four unpolarized-electron response functions (L, T, LT, and TT) that contribute to the one-neutron knockout cross

section in the quasielastic, dip, and delta excitation-energy regions.

**3) HARP Detector Development**

The requirements for the detector are an excellent signal-to-background ratio and polarization information on the detected neutron. The detection scheme is based on the proton-recoil principle. The design issues are discussed in detail in the HARP Conceptual Design Report (CDR), a copy of which is available upon request.

**4) (n,p) Cross-Section Measurements**

The critical element of the HARP detector is the neutron-to-proton converter. In order to decide whether liquid hydrogen, with all its inherent difficulties and cost, must be used, or whether another material rich in hydrogen, such as polyethylene, is adequate for the job, a series of (n,p) cross-section measurements on carbon and polyethylene were carried out recently at the LAMPF/WNR facility. A preliminary analysis, by S.L. Rugari (see Appendix), of these data indicates that while the proton yield from the hydrogen in the polyethylene target appears to be large, it is not yet clear that it would be cleanly distinguishable from the sizeable proton yield from the carbon contained in the target. The measurements were begun last summer and were completed this summer; a full analysis of all of these data is underway.

**5) Monte-Carlo Simulations**

With the aid of computer codes such as GEANT and EGS, one of our graduate students, R.W. Caress, as a part of her Master's Thesis project, has carried out the initial Monte-Carlo studies of the $^{2}H(e,e'n)$ reaction under various geometrical arrangements of the detection system. This has allowed us to extract several important parameters of the HARP detector, including energy resolution, efficiency, and

the overall dimensions of the assumed liquid-hydrogen converter. The overall generalized efficiency (i.e., figure of merit) of the HARP is about 50% of that of a perfect detector, and is about 5 to 6 times higher than a competing design based on the neutron time-of-flight technique.

**6) Wire Chambers**

In collaboration with our colleagues at Grenoble, we are in the process of selecting an optimal design for the HARP wire chambers. We have narrowed our design choices to two candidates: 1) a multiwire proportional chamber (MWPC), or 2) a multiwire drift chamber (MWDC). We expect to settle on a final design by the end of this year. P.L. Cole is leading this effort for the GWU group, and has written a series of design reports for the Collaboration (see Appendix).

**7) Mechanical Support**

The initial considerations of the mechanical support structure are discussed in detail in the HARP CDR. One of the primary tasks for the GWU group is the design of the support structure needed for an out-of-plane capability for the HARP. Another important task of the GWU group is to make sure that the mechanical structure is compatible with the CEBAF Hall A environment without compromising the HARP's capabilities at NIKHEF. W.R. Dodge is leading the GWU effort on the mechanical-support design.

**C. Nuclear-Structure Measurements at Bates**

A priority-A experiment left undone in our previous program of nuclear-structure measurements at the Bates Accelerator is inelastic electron scattering from collective states in $^{21}$Ne and $^{23}$Na [co-spokesmen D.M. Manley (Kent State Univ.), B.L. Berman, and R.A. Lindgren (Univ. of Virginia)]. These measurements were postponed because of the upgrade of the

Bates facility to high duty factor. The physics argument for performing these measurements remains cogent, however, and we expect to obtain data on at least one of these nuclei in 1993.

## III. Results of Previous Experiments

Over the past several years, we have performed a number of medium-energy nuclear-physics experiments with both electromagnetic and hadronic probes. A summary of the current status of those measurements that had not been completed and published in prior years is given in Tables I and II. During the past year, we have made considerable progress in analyzing data from these previous experiments and in publishing some of the results. In particular, we have concentrated on the analysis of the coincidence electron-scattering data obtained at NIKHEF and the pion-scattering data obtained at LAMPF. More detailed discussions of these and other experiments that we have done are given in our previous progress reports, particularly our 1991 Progress Report.

### A. (e,e'x) Experiments at NIKHEF

In our series of (e,e'x) measurements on $^{6}$Li and $^{12}$C at NIKHEF, where x=d, $\alpha$, t, or $\tau$, we have almost completed the analysis of the last in the series, namely, $^{6}$Li(e,e'$\tau$). These results, when combined with those for $^{6}$Li(e,e't), will elucidate the reaction mechanism, since the final-state interactions will be the same for both mirror reactions. The results show that the q-dependence deviates markedly from that which would be expected from a system in which the trinucleon clusters were the same as they are in free space. The $^{6}$Li(e,e'$\alpha$) results were published this year (see J.H. Mitchell *et al.*, in the Appendix); the (e,e'd) results for both nuclei were published earlier as Letters, and a

comprehensive paper covering all of the (e,e'd) results is currently in preparation.

**B. Pion Scattering from $^3$H and $^3$He at LAMPF**

In a series of four experiments at LAMPF, we have measured both $\pi^+$ and $\pi^-$ scattering from both $^3$H and $^3$He, at a wide variety of energies and angles. The results of the first (survey) measurement were published previously, and we now have completed the data reduction for the other experiments: results at 256 MeV and forward angles; at several energies at the angle corresponding to the non-spin-flip dip; at 180 MeV at backward angles; and at several energies near 180°. Several striking results have emerged, including the sharp decrease of the superratio $(\pi^+-^3\mathrm{H})(\pi^-\text{-}^3\mathrm{H})/(\pi^-\text{-}^3\mathrm{He})(\pi^+\text{-}^3\mathrm{He})$ near the non-spin-flip dip with increasing pion energy, from values larger than unity below and on the delta resonance to values smaller than unity at higher energies; the relative constancy (greater than unity) of the superratio with pion energy near 180°; and the complete reversal of roles of the simple charge-symmetric ratios $(\pi^+-^3\mathrm{H})/(\pi^-\text{-}^3\mathrm{He})$, sensitive to the odd-nucleon distributions in the trinucleons, and $(\pi^-\text{-}^3\mathrm{H})/(\pi^+-^3\mathrm{He})$, sensitive to the even-nucleon distributions, as a function of pion scattering angle at 180 MeV. The former ratio changes from nearly equal to unity at forward angles to distinctly greater than unity at backward angles, and the latter ratio does the reverse; the changeover occurs near 115°. We also have completed the data analysis for our earlier inelastic-scattering data; here the pion cross sections evolve into the same slope as the electron-scattering form factors as the pion energy increases from 142 to 220 MeV. Most of these results have been reported at international conferences in the last year (see B.L. Berman *et al.* and W.J. Briscoe *et al.* in the Appendix). We plan to publish all of them shortly; four papers are in preparation at the present time.

**C. Pion Scattering from Shell-Model Nuclei**

We have concentrated our efforts mainly in two kinematic regions: 300-500 MeV (i.e., above the delta resonance) and large-angle scattering at and around the delta resonance. In the region above the delta resonance, we have measured differential cross sections for $\pi^+$ and $\pi^-$ elastic scattering on $^{12}C$, $^{16}O$, $^{40}Ca$, $^{90}Zr$, and $^{208}Pb$ at 400 and 500 MeV, in the angular range from $15^o$ to $60^o$. A preliminary analysis of these data has shown curious inconsistencies between $\pi^+$ and $\pi^-$ cross-section magnitudes for several nuclei at 400 MeV. In order to resolve these inconsistencies, several normalization data points were measured for $^{12}C$ and $^{40}Ca$ last year by C.L. Morris and M. Rawool (LANL). These data are currently being analyzed by Rawool. The large-angle data on $^{12}C$, $^{16}O$, $^{28}Si$, and $^{40}Ca$ are currently being analyzed by K.S. Dhuga; a paper is being prepared by G.R. Burleson (New Mexico State Univ.).

**D. Photonuclear Reactions**

The last three of a long series of papers on the photonuclear reaction cross sections performed at Livermore and Melbourne have been completed. Papers on the $(\gamma,p)$ cross sections for $^{14}C$ and $^{17}O$ were published this year, and a long review paper on the isospin composition of the giant dipole resonance in light nuclei has been submitted for publication.

**E. Electromagnetic Dissociation of Heavy Ions**

The last of a series of papers on measurements of the electromagnetic dissociation of oxygen isotopes at the Bevalac has been published and the results reported at an international conference.

## IV. The GWU Nuclear Detector Laboratories and Center for Nuclear Studies

### A. The GWU Nuclear Detector Laboratories

The exciting news is that we are about to move into our new Virginia-Campus laboratory. The University, in keeping with its strong commitment to nuclear-physics research, has made available to us 3100 sq. ft. in the first building of the new GWU Virginia Campus, for three laboratories, one of them 48 ft. long (comfortably larger than the 36-ft CLAS photon-tagger focal plane), seven offices, and a conference area. Moreover, GWU has finished the space, furnished the offices, and provided us with new machine tools, including numerical milling and lapping machines, at a cost to the University of $280,000, exclusively for our use. In addition, the Virginia Campus has a research library, and is connected by computer link to the main Washington Campus. We are moving all activities connected with the CEBAF Photon-Tagger project to the new laboratory (leaving the HARP project and our student-training activities in Washington), which now can move into high gear so as to provide the focal-plane detector array for the CLAS in a timely way.

### B. The GWU Center for Nuclear Studies

The Center for Nuclear Studies is now the organizational focus for most of our research-related activities, and continues to be supported by GWU as one of only six "Centers of Excellence" within the University. Through it, we derive funding for our Electro-Mechanical Technician (Dr. W.R. Dodge) and two Graduate Research Assistants (this year Mr. S. Adrian and Mr. P. Eftis). Under its auspices, we not only administer the Nuclear Detector Laboratories, but we hold our Friday Bag-Lunch Seminars as well, which have, over the years, become a popular fixture of the Washington-area nuclear-physics community. Later this year, the three-year funding cycle of the Center is up for renewal, and we hope

for a substantial increase so that we can support a half-time executive aide and perhaps another GRA, but of course in these days of budgetary stringency at universities generally and at GWU in particular, we cannot be too sanguine about our prospects for any substantial increase. Still, we hope for the best; our track record with the GWU administration and GWU's strong commitment to SURA and CEBAF serve to keep us optimistic.

**C. Junior Personnel Supported by the Grant**

The grant currently supports two postdoctoral research physicists and three graduate students (two for the summer only). Dr. P.L. Cole is primarily engaged in CEBAF-related activities, including the physics of high-energy photoreactions and a variety of calculations of event generators and acceptance functions for the CLAS, and is also involved with the wire-chamber design for the HARP. Dr. S.L. Rugari is primarily engaged with the HARP project, including the physics of the (e,e'n) reaction, the $^{12}C(n,p)$ experiments conducted at LAMPF/WNR during the summers of 1991 and 1992, and Monte-Carlo calculations in support of the HARP, and is also involved with the tagged-coherent-bremsstrahlung work at CEBAF. Mr. J.C. Sanabria's efforts are devoted to the Photon-Tagger project; Mr. D. Pang and Mr. Z. Guo are aiding in the data analysis (comparison with theory) of the pion-scattering data on the three-body nuclei obtained at LAMPF. Miss R.W. Caress achieved her Master's degree this May and is now working at Los Alamos; her thesis was on Monte-Carlo calculations for the HARP.

## V. Publications, Proposals, and Reports, 1991-92

### A. Journal Articles

1. D. McLean, M.N. Thompson, D. Zubanov, K.G. McNeill, J.W. Jury, and B.L. Berman
   Photoproton Cross Section for $^{14}C$
   Phys. Rev. C 44, 1137 (1991)

2. D.L. Olson, M. Baumgartner, D.E. Greiner, P.J. Lindstrom, T.J.M. Symons, R. Wada, M.L. Webb, B.L. Berman, H.J. Crawford, and J.M. Engelage
   Direct Observation of the Giant Dipole Resonance of $^{16}O$ via Electromagnetic Dissociation
   Phys. Rev. C 44, 1862 (1991)

3.* J.H. Mitchell, H.P. Blok, B.L. Berman, W.J. Briscoe, M.A. Daman, R. Ent, E. Jans, L. Lapikas, and J.J.M. Steijger
   Mechanism of the $^{6}Li(e,e'\alpha)$ Reaction
   Phys. Rev. C 44, 2002 (1991)

4.* B. Brinkmoller, C.L. Blilie, D. Dehnhard, M.K. Jones, G.M. Martinez, S.K. Nanda, S.M. Sterbenz, Yi-Fen Yen, L.G. Atencio, S.J. Greene, C.L. Morris, S.J. Seestrom, G.R. Burleson, K.S. Dhuga, J.A. Faucett, R.W. Garnett, K. Maeda, C. Fred Moore, S. Mordechai, A. Williams, S.H. Yoo, and L.C. Bland
   Elastic Scattering of $\pi^+$ and $\pi^-$ from $^{4}He$ between 90 and 240 MeV
   Phys. Rev. C 44, 2031 (1991)

5. D. Zubanov, M.N. Thompson, B.L. Berman, J.W. Jury, R.E. Pywell, and K.G. McNeill
   Photoproton Cross Section for $^{17}O$
   Phys. Rev. C 45, 174 (1992)

6. K.G. McNeill, M.N. Thompson, A.D. Bates, J.W. Jury, and B.L. Berman
   Isospin Effects in the Photodisintegration of Light Nuclei
   Phys. Rev. C (submitted)

7. S.L. Rugari, R.H. France III, B.J. Lund, Z. Zhao, and M. Gai
   Broken Reflection Symmetry and Isospin Dependence of Enhanced E1 Decays in $^{114}Xe$
   Phys. Rev. Lett. (submitted)

## B. Papers in Conference Proceedings

8. C.S. Lindsey et al.
Results from E735 at the Tevatron Proton-Antiproton Collider with $s^{1/2}$ = 1.8 TeV
Proc. Int. Conf. on Quark Matter (Gatlinburg, 1991)

9.* B.L. Berman, W.J. Briscoe, K.S. Dhuga, D.A. Hanson, S.K. Matthews, A. Mokhtari, C.S. Smith, D.B. Barlow, B.M.K. Nefkens, C. Pillai, J.W. Price, S.J. Greene, and I. Slaus
Pion Scattering from $^3$H and $^3$He
Pions in Nuclei (Proc. Int. Workshop, eds. E. Oset, M.J. Vicente Vacas, and C. Garcia Recio, World Scientific, Singapore, 1992), p. 161

10. B.L. Berman, D.L. Olson, D.E. Greiner, P.J. Lindstrom, and H.J. Crawford
Electromagnetic Dissociation of Heavy Ions
Dynamical Aspects of Nuclear Fission (Proc. Int. Workshop, eds. J. Kristiak and B.I. Pustylnik, JINR, Dubna, 1992), p. 269

11.* W.J. Briscoe, D.B. Barlow, B.L. Berman, R.W. Caress, K.S. Dhuga, S.N. Dragic, S.J. Greene, D. Isenhower, D. Knowles, D. Macek, S.K. Matthews, A. Mokhtari, B.M.K. Nefkens, N.J. Nicholas, C. Pillai, J.W. Price, M.E. Sadler, I. Slaus, I. Supek, and M.F. Taragin
$\pi^{\pm}$ Elastic and Inelastic Scattering from $^3$H and $^3$He
Proc. Int. Conf. Nucl. Phys. (Wiesbaden, 1992)

12. P. Cole et al.
Average Transverse Momentum vs Pseudorapidity Density for Mass-Identified Particles at Tevatron Energies
Nucl. Phys. B (Proc. Suppl.) 25B, 40 (1992)

## C. Abstracts

13.* C. Pillai, D. Barlow, S. Greene, B.M.K. Nefkens, R.S. Kessler, G.J. Kim, J.W. Price, I. Slaus, J.A. Wightman, W.J. Briscoe, B.L. Berman, K.S. Dhuga, S. Matthews, M.E. Sadler, C. Smith, and D. Smith
Pion Scattering on $^3$He and $^3$H in the Non-Spin-Flip Dip
Bull. Am. Phys. Soc. 37, 915 (1992)

14.* M.W. Rawool-Sullivan, J.A. Faucett, G.R. Burleson, K.W. Johnson, G.P. Kahrimanis, A.L. Williams, C. Whitley, C.F. Moore, J.A. McGill, C.L. Morris, D.J. Ernst, K.S. Dhuga, E. Insko, J.M. O'Donnell, and H.T. Fortune
Pion-Nucleus Elastic Scattering at the Energies above the Δ(1232) Resonance
Bull. Am. Phys. Soc. 37, 916 (1992)

15. S.L. Rugari, R.H. France III, Z. Zhao, and M. Gai
Broken Reflection Symmetry and Isospin Dependence of Enhanced E1 Decays in $^{114}$Xe
Proc. 6th Int. Conf. on Nuclei Far from Stability (Bernkastel-Kues, Germany, 1992)

16.* S.K. Matthews, B.L. Berman, W.J. Briscoe, R.W. Caress, K.S. Dhuga, S.N. Dragic, D. Knowles, D. Macek, N.J. Nicholas, M.F. Taragin, D.B. Barlow, B.M.K. Nefkens, C. Pillai, J.W. Price, L.D. Isenhower, M.E. Sadler, S.J. Greene, I. Slaus, and I. Supek
Comparison of Elastic Scattering Cross Sections for Pions from $^{3}$H and $^{3}$He in the Backward Hemisphere
Proc. Int. Conf. Nucl. Phys. (Wiesbaden, 1992)

17.* W.J. Briscoe, B.L. Berman, R.W. Caress, K.S. Dhuga, N.J. Nicholas, S.K. Matthews, B.M.K. Nefkens, D.B. Barlow, C. Pillai, J.W. Price, S.J. Greene, and I. Slaus
$\pi^{\pm}$ Elastic and Inelastic Scattering from $^{3}$He and $^{3}$H in the Region of the Non-Spin-Flip Dip
Ibid.

18.* S.J. Greene, W.J. Briscoe, B.L. Berman, R.W. Caress, K.S. Dhuga, S.N. Dragic, S.K. Matthews, N.J. Nicholas, D.B. Barlow, B.M.K. Nefkens, C. Pillai, J. Price, and M.E. Sadler
Back-Angle Cross Sections for $\pi^{\pm}$ Scattering from $^{3}$H and $^{3}$He near the Δ Resonance
Ibid.

19.* B.M.K. Nefkens, G.C. Anderson, D.B. Barlow, B.L. Berman, W.J. Briscoe, A. Mokhtari, A.M. Petrov, C. Pillai, and M.E. Sadler
Comparison of Pion and Electron Inelastic Scattering on $^{3}$H and $^{3}$He Close to Breakup
Bull. Am. Phys. Soc. 37 (in press)

**D. Proposals**

20.* B.L. Berman, W.J. Briscoe, R.W. Caress, K.S. Dhuga, W.R. Dodge, S.L. Rugari, J.L. Ullmann, N.J. Nicholas, and D.S. Sorenson
Large-Angle Protons from Neutron Bombardment of Carbon
LAMPF/WNR Proposal 4N0041 (Continuation) (1992)

21.* K.S. Dhuga, B.L. Berman, W.J. Briscoe, P. Cole, W.R. Dodge, S.L. Rugari, and M.F. Taragin
Medium Effects on the (e,e'n) Reaction
NIKHEF-K Electron Scattering Letter of Intent (1992)

**E. Reports**

22.* P.L. Cole
Hyperon Acceptance Studies with the CLAS
CEBAF CLAS Note 92-002 (1992)

23.* B.L. Berman, K.S. Dhuga, W.R. Dodge, and B. G. Ritchie
Photofission at CEBAF Energies
CEBAF CLAS Note 92-010 (1992)

24.* P.L. Cole and J.C. Sanabria
Feasibility Studies for a Proposed MWPC Design for the HARP
GWU HARP Note (1992)

25.* P.L. Cole and J.C. Sanabria
Feasibility Studies for a Proposed Design for a Drift Chamber for the HARP
GWU Center for Nuclear Studies Note (1992)

26.* P.L. Cole
Effects of Multiple Scattering for the HARP
GWU Center for Nuclear Studies Note (1992)

*--Reproduced in the Appendix

Table I. Recent Studies of Few-Body Nuclei with Electromagnetic and Hadronic Probes

| Reaction | Laboratory | Physics Emphasis | Status | Reference |
|---|---|---|---|---|
| $^{3}H,^{3}He(\pi^{\pm},\pi^{\pm})$, $(\pi^{\pm},\pi^{\pm\prime})$ | LAMPF-EPICS | 142- to 220-MeV cross sections, form factors, charge asymmetry | Two papers published, one in preparation | 1 |
| $^{3}H,^{3}He(\pi^{\pm},\pi^{\pm})$ | LAMPF-EPICS* | 180- to 295-MeV cross sections, form factors, charge asymmetry, spin-flip amplitudes | Data analyzed, two papers in preparation | 2 |
| $^{3}H,^{3}He(\pi^{\pm},\pi^{\pm})$ | LAMPF-EPICS* | $180^{o}$ cross sections, 142 to 256 MeV, form factors, non-spin-flip amplitudes | Data analyzed, paper in preparation | 3 |
| $^{3}H,^{3}He(\pi^{\pm},\pi^{\pm})$ | LAMPF-EPICS* | 180-MeV cross sections and angular distribution, charge asymmetry | Data analyzed, paper in preparation | 4 |
| $^{4}He(\pi^{\pm},\pi^{\pm})$ | LAMPF-EPICS | Large-angle scattering, partial-wave analysis | Published | 5 |
| $^{6}Li(e,e'd)$ | NIKHEF | Spectral functions, q-dependence | One paper published, one in preparation | 6 |
| $^{6}Li(e,e'\alpha)$ | NIKHEF | n-p momentum distributions, validity of three-body model | Published | 7 |
| $^{6}Li(e,e't)$ | NIKHEF* | Momentum distributions, reaction mechanism, q-dependence | Data analyzed, paper in preparation | 8 |
| $^{6}Li(e,e'^{3}He)$ | NIKHEF* | Momentum distributions, reaction mechanism, validity of 2-body model | Data being analyzed, two papers in preparation | 9 |
| $^{6}Li(\pi^{+},2p)$ | PSI | Energy dependence near the delta resonance | Data analyzed, paper in preparation | 10 |

* Spokesman or co-spokesman

Table II. Recent Studies of Selected Shell-Model Nuclei with Electromagnetic and Hadronic Probes

| Reaction | Laboratory | Physics Emphasis | Status | Reference |
|---|---|---|---|---|
| $^{12}C(e,e'd)$ | NIKHEF | Spectral functions, q-dependence | Data analyzed, one paper published, one in preparation | 11 |
| $^{12}C, ^{16}O, ^{40}Ca$ $(\pi^+, \pi^+)$ | LAMPF-EPICS* | Excitation functions at large angles, medium modifications | Data analyzed, two papers published, one in preparation | 12 |
| $^{12}C, ^{16}O, ^{40}Ca,$ $^{48}Ca, ^{90}Zr, ^{208}Pb$ $(\pi^+, \pi^+), (\pi^+, \pi^{+'})$ | LAMPF-$P^3$* | Exploratory (300-500 MeV); test of optical models | Data being analyzed, invited paper presented, paper in preparation | 13 |
| $^{14}C(\gamma,p)$ | Melbourne | Isospin structure | Published | 14 |
| $^{16}O(e,e')$ | Bates | High-excitation, isovector states | Data analyzed | 15 |
| $^{16}O(\pi^+, \pi^-)^{16}Ne$ | LAMPF-EPICS* | Interference effects in double charge exchange | Data being analyzed | 16 |
| $^{16}O$ Dissociation | Bevalac* | Electromagnetic dissociation into $^{15}N+p$ (coincidence experiment) | Published | 17 |
| $^{17}O(\gamma,p)$ | LLNL* | Isospin structure | Published | 18 |
| $^{17,18}O(p,p')$ | IUCF | 135-MeV cross sections, comparison with (e,e') | Data analyzed, two papers in preparation | 19 |

* Spokesman or co-spokesman

Table II. Recent Studies of Selected Shell-Model Nuclei with Electromagnetic and Hadronic Probes (continued)

| Reaction | Laboratory | Physics Emphasis | Status | Reference |
|---|---|---|---|---|
| $^{18}O(e,e')$ | Bates | Stretched-spin states; isospin structure | Data analyzed, paper in preparation | 20 |
| $^{30}Si(e,e')$ | Bates* | Stretched-spin states | Data analyzed, paper in preparation | 21 |
| A(γ,n and p) | LLNL, Melbourne | Isospin Structure of GDR | Submitted for publication | 22 |

* Spokesman or co-spokesman

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