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By Gay Bennett

RESEARCH PROPOSAL

LOS ALAMOS MESON PHYSICS FACILITY

VISUALIZATION OF STOPPING PION DISTRIBUTION

V. Perez-Mendez and J. Bradbury, Co-Spokesmen

Participants

J. Bradbury, LASL
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BEST COPY AVAILABLE

February 1975

FILE BARCODE
0133381

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SUMMARY

An important aspect of pion radiotherapy is the ability to visualize the spatial distribution of stopping pions. The proposed experiment will evaluate the suitability of using selected γ rays resulting from the pion capture process for routine on-line monitoring of the stopping distribution. The equipment to be used consists of multiwire proportional chambers with electromagnetic delay line readouts, honeycomb structures to convert the γ rays into charged particles, and, in some cases, Pb collimators. This equipment has been successfully used in a variety of imaging applications in nuclear medicine.

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PROPOSAL INFORMATION

Experimental Area: Biomed channel

Beam Requirements:

Particle type: Negative pions

Beam quality: Standard channel tune

Primary Beam Requirements: None

Running Time Required:

Installation: 8 hours

Tuneup and system checkout: 16 hours

Data collection: 80 hours

Scheduling: All experimental apparatus available by 1 July 1975.

Experiment can be scheduled as soon as convenient.

Shielding and enclosures: No special requirements

Special service: None

Space required: as available at biomed channel

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I. INTRODUCTION

An important aspect of pion radiotherapy is the ability to visualize the spatial distribution of stopping pions. Monitoring the depth distribution is especially important in view of the uncertainties associated with density inhomogeneities within the patient. Several methods for mapping the pion spatial distribution have been discussed[1] and tested.[2,3] Improved detection techniques are now available which should be evaluated for use in routine on-line monitoring of the pion stopping distribution in the LAMPF radiotherapy program. This monitoring should be performed throughout the patient treatment; if possible the technique should allow reasonable spatial resolution to be obtained with 1-5% of the total dose so that an initial check of the distribution can be performed with subsequent modification of the beam parameters if necessary.

The proposed experiment involves using multiwire proportional chambers (MWPC) to detect electrons produced by γ rays in two energy ranges emitted as a result of π^- capture in tissue nuclei. The first energy range, 5 to 100 MeV, contains γ rays resulting from pion radiative capture (~ 2% of the capture events), decay of some excited residual nuclei, and decay of neutral pions formed as a result of charge exchange. The second energy range, near 0.5 MeV, contains gammas resulting from the annihilation of positrons emitted by some of the unstable residual nuclei following pion capture. This annihilation process results in two 0.5-MeV γ rays emitted back-to-back.

II. APPARATUS

The experiment involves using one or more MWPC's with electromagnetic delay line readouts to establish the coordinates of the γ rays by their

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interaction with thin lead converters placed on the faces of the chamber. In order to obtain reasonable efficiencies the lead converters are made in a square honeycomb-like structure which increases the effective surface area and also permits the application of a drift field to extract the electrons into the active area of the MWPC. These chambers and honeycomb converters have been used in several physics and nuclear medicine applications.[4,5] The γ-ray direction is determined using a collimator or coordinate information from two MWPC. Using this digitized information the two dimensional projection of the spatial distribution of the stopping pions can be obtained using straightforward numerical techniques. This can be done on-line with a small computer; reconstruction of the stopping region using only hardware also appears possible. Two types of MWPC will be employed in the measurements: a linear MWPC which will provide the stopping distribution in depth (this relatively simple system may be sufficient for static beams applied to small deep-seated tumors) and a rectangular MWPC with dimensions 50 x 25 cm which will eventually be required for large volume irradiations requiring beam and patient scanning.

III. EXPERIMENTAL APPROACH

The specific experimental approaches to be evaluated include:

1. Detection of γ rays in the 5-100 MeV range using one MWPC and a lead collimator-converter system to define the γ direction.

2. Detection of γ rays in the 50-140 MeV range using a honeycomb converter and two MWPC's to define the γ direction.

3. Detection of the two 0.5 MeV γ rays from positron annihilation in coincidence using two MWPC-honeycomb converter combinations located on opposite sides of the stopping volume.

4. Detection of one 0.5 MeV γ ray using one MWPC-honeycomb converter and a Pb collimator to define the direction.

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The γ's detected in 1) and 2) originate from a variety of processes. It is likely that the background can be reduced and spatial resolution increased if a low energy cutoff for the γ's is established. This will be done by detection of the conversion electrons, after their traversal of the MWPC and an Al absorber, in scintillators. Using a scintillator - MWPC coincidence, one can vary the cutoff energy of the electrons, and thus the cutoff energy of the γ rays, by changing the thickness of the Al absorber.

For methods 3) and 4) it is possible to decrease the background of charged particles by gating the detectors and counting only during the off periods of the beam cycle (since the unstable nuclei have lifetimes ranging from a few msec to 20 minutes). These methods have the potential disadvantage of a long time lag in response if the beam characteristics should change during the irradiation. However, unplanned changes are expected to be rapidly detected by other monitoring systems in the biomedical channel.

IV. SENSITIVITY ESTIMATES AND BEAM REQUIREMENTS

Using available apparatus, placed about 40 cm from the stopping volume it is estimated that the count rate per stopped pion will range from 3×10^{-6} to 5×10^{-5} for the methods described above. These estimates are based on the use of converters thin enough (40 μm) to permit a theoretical spatial resolution of ≤ 1 cm. At 10 μA proton current the biomed channel delivers a therapeutically useful beam of about ~ 10^7 pions sec^{-1} which would result in at least 30 counts per second. Sufficient recorded events to determine the spatial resolution of each of the various approaches should be obtained in several hours of beam time. About three shifts will be required to assess the effects of different Al absorbers in methods 1 and 2. Setup time and system checkout is estimated to require two shifts.

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V. TIME SCHEDULE

All necessary equipment will be available by July 1975. Since a practical visualization system for routine use in the LAMPF radiotherapy program would be highly desirable by January 1976 it is important to perform the preliminary experiments for defining the most appropriate techniques as soon as possible after experimental beam is available.

VI. RELATED LAMPF PROPOSALS

Experiments #83 and #196 also involve evaluating visualization methods with MWPC's. However, neither experiment involves the use of collimators or honeycomb converters which have proved to be very effective in other applications.

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STAFF MEMBER BACKGROUND INFORMATION

Name: James Norris Bradbury

Date of Hire - MP Division: January 2, 1974

Immediate Prior Employment: [redacted]

Education:		**Institution:**	**Date of Degree:**
BA	X	[redacted]	[redacted]
BS			
MA			
MS			
PhD	X	[redacted]	[redacted]
Others:			

Thesis Title: "Photoproduction of K Mesons from Hydrogen near Threshold"

Professional Societies:

American Geophysical Un.
Sigma Xi

List of Publications:

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James N. Bradbury

PUBLICATIONS AND TALKS

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1091120

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Born [redacted]

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Thesis: Angular Distribution of Photopions from Hydrogen

Work: Group Leader, Los Alamos Scientific Laboratory, 1959-1968

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Organizations: American Physical Society

Publications attached

00133381.011

1091121

PUBLICATIONS BY E. A. KNAPP

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YU-LA-15

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The Los Alamos Meson Physics Facility
E. A. Knapp
To be published in the Proceedings of the XVth International Conference on High Energy Physics, Kiev, USSR, 8/26-9/4/70

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CC [illegible] OR
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1091125

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Date of Hire - MP Division: September 8, 1971

Immediate Prior Employment: [redacted]

Education:		Institution:	Date of Degree
BA			
BS	X	[redacted]	[redacted]
MA	X	[redacted]	[redacted]
MS			
PhD	X	[redacted]	[redacted]
Others:			

Thesis Title:

Elastic Scattering of Positive Pions on Protons in the Energy Range 500 to 1600 MeV

Professional Societies:

American Physical Society
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List of Publications:

Attached

COPY FOR

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J. A. Helland

Published Papers

1. "High Energy Total Cross Sections for Positive Pions and Protons on Hydrogen," with M. J. Longo, W. N. Hess, B. J. Moyer, and V. Perez-Mendez, Phys. Rev. Letters 3, 568 (1959). UCRL-8955 (publication of Lawrence Radiation Laboratory, Berkeley).

2. "π^--p Elastic Scattering at 550, 600, 720, 900, and 1020 MeV," with C. D. Wood, T. J. Devlin, M. J. Longo, B. J. Moyer, and V. Perez-Mendez, Phys. Rev. Letters 6, 481 (1961). UCRL-9622.

3. "Angular Distributions in π^--p Elastic Scattering in the Range 530 to 1550 MeV," with T. J. Devlin, D. E. Hagge, M. J. Longo, B. J. Moyer, and C. D. Wood, Proceedings of 1962 International Conference on High Energy Physics at CERN, Geneva, page 3. UCRL-10263.

4. "Angular Distributions in π^--p Elastic Scattering in the Range 500 to 1600 MeV," with T. J. Devlin, D. E. Hagge, M. J. Longo, B. J. Moyer, and C. D. Wood, Phys. Rev. Letters 10, 27 (1963). UCRL-10478.

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12. "Experimental Determination of Re ξ from $K^0_{\mu 3}$ Decay," with M. J. Longo and K. K. Young, Phys. Rev. Letters 21, 257 (1968).

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. A. Helland

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D. Ortendahl is a graduate student at the [redacted]

His CV will be forthcoming later.

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VICTOR PEREZ-MENDEZ - VITA

1. BIOGRAPHICAL

Name: Victor PEREZ-MENDEZ
Born: [redacted]
Naturalized: 1951

2. EDUCATIONAL

M.S. ([redacted], [redacted] in Physics, Mathematics.
Ph.D. ([redacted], [redacted] Physics.

3. EMPLOYMENT

1951-1953: Research Assistant and Research Associate, [redacted]
1953-1956: Staff Physicist, [redacted]
1956-1960: Staff Physicist, [redacted]
1960-present: Senior Scientist, Lawrence Radiation Laboratory, Berkeley.
1969- : Professor of Physics (Radiology), Univ. of California, San Francisco.
1969- : Head, Physics Section Radiology Department, Univ. of California, San Francisco.

4. HONORS

[redacted]
Visiting Lecturer, Hebrew University 1959-60.
Sigma XI
Fellow Amer. Phys. Soc.

CO[illegible]

List of Publications

of

Victor Perez-Mendez

1952

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1953

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1954

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1957

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1971

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