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COO-2231-37

ENERGETIC-NEUTRON SPECTROMETRY

Progress Report
for period

1 June 1975 to 31 May 1976

Principal Investigator: Richard Madey

Kent State University

Kent, Ohio 44242

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PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION UNDER CONTRACT E(11-1)-2231

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DISCLAIMER

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1. INTRODUCTION

This report describes progress made during the past year under Contract No. E(11-1)-2231 with Kent State University. The scope of the investigations under this program include the continued development and improvement of a spectrometer for measuring neutrons in the energy region from a few MeV to several hundred MeV, and the demonstration and utilization of this instrument in applications pertinent to ERDA programs.

2. RESEARCH ACCOMPLISHMENTS

The research accomplishments include the following:

2.1 Measurement of the Response of Four Scintillators to Protons from About 2 to 20 MeV.

In order to advance the detection of energetic neutrons, we measured the light output (relative to electrons) produced by protons from 2.43 to 19.55 MeV in NE-102, NE-224, NE-228, and NE-228A scintillators. The response measurements were carried out during the summer of 1975 with monoenergetic neutron beams from the Tandem Van de Graaf accelerator at Ohio University. A significant result of our work is that the measured response (in units of electron energy) of NE-102 to protons in the region from about 5 to 20 MeV is about 10 percent higher than that used in the Kurz (1964) and Stanton (1971) computer programs.

A reprint of an abstract of this work is appended as COO-2231-32. Also appended as COO-2231-33 are the remarks prepared for presentation at the 1975 fall meeting of the American Nuclear Society. A full paper is being prepared for submission to Nuclear Instruments and Methods.

2.2 Neutron Spectrum from 20 to Nearly 600 MeV Above the Roof Shielding of the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL).

We have analyzed the data from the measurements at Brookhaven and obtained the neutron spectrum leaking through the roof shield of the AGS. The shape of our measured spectrum agrees substantially with that predicted by the previous nucle-

onic cascade shielding calculations of O'Brien (1969, 1971). This work will be reported at the Toronto meeting of the American Nuclear Society in June. Appended as COO-2231-34 is the summary paper which will appear in the June 1976 issue of the Transactions of the American Nuclear Society.

2.3 A Two-Parameter Spectrometer for Unidirectional Neutrons from About 5 to 200 MeV.

A major advance in energetic-neutron spectrometry is the development of the two-parameter spectrometer. In comparison with the one-parameter spectrometer, the two-parameter version has two distinct advantages for measuring unidirectional neutrons in the energy region from about 5 to 200 MeV. One advantage is that backgrounds from neutron-carbon interactions and from plural-scattered neutrons can be determined from a single spectral measurement. The other advantage is that the two-parameter version is less sensitive to accidental coincidences; hence, the two-parameter spectrometer can operate in a higher background environment or at an accelerator with a poorer duty cycle than the one-parameter version.

We have documented the two-parameter spectrometer for measuring unidirectional neutrons in a paper which was published in the February 15, 1976 issue of Nuclear Instruments and Methods. A reprint of this paper is appended as COO-2231-35.

2.4 A Temperature-Stable Linear Gate for Nanosecond Signals from Photomultipliers and an Optional Stretcher Circuit.

We documented and published this development in Nuclear Instruments and Methods. A reprint of this paper is appended

as COO-2231-36.

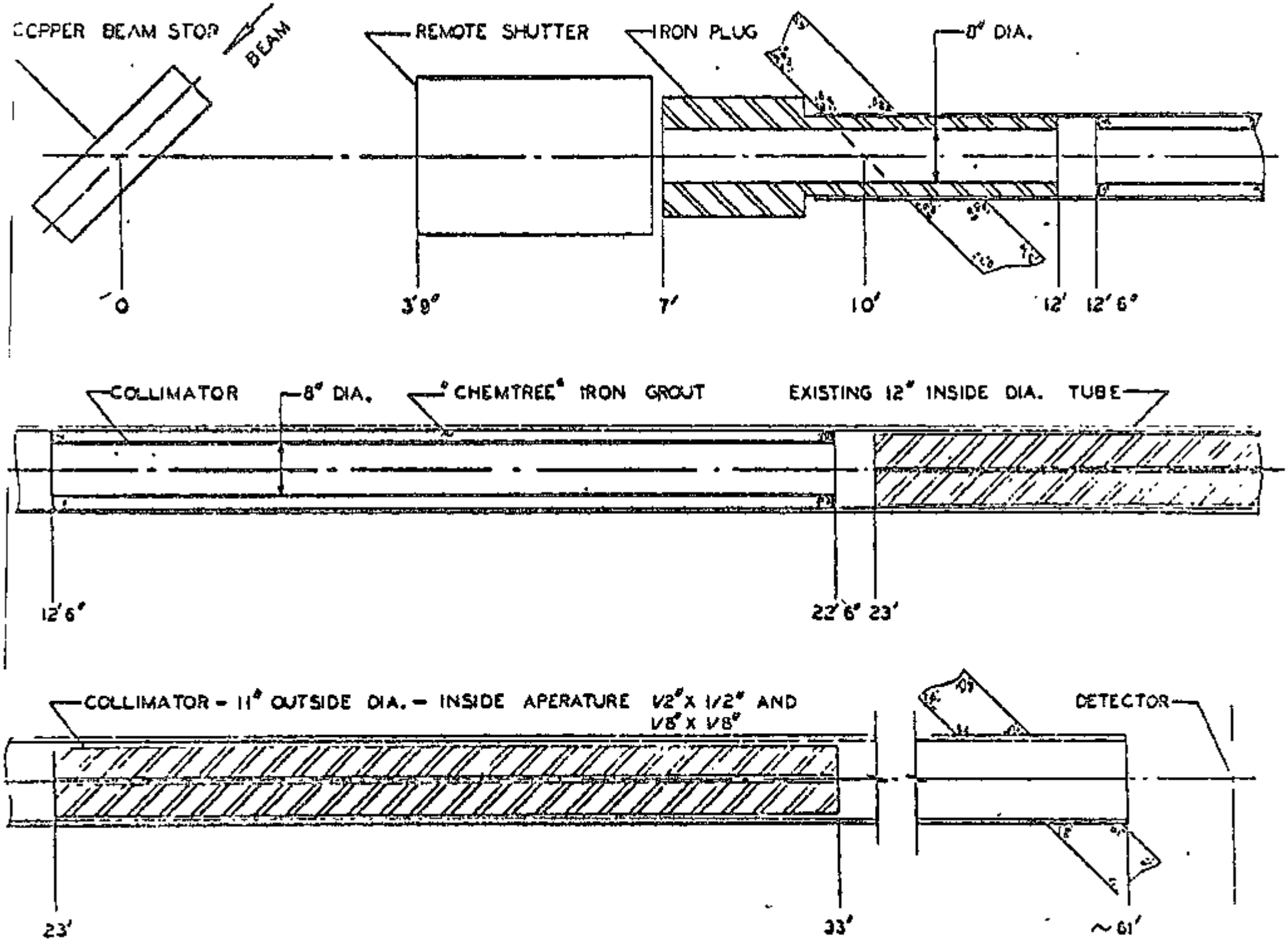
A combination of two of these linear gate and stretchers is linear to within 2% over a 300 : 1 range of pulse heights from 50 mV to 15 V. The stabilization of the gate circuit results in a baseline drift at the output with a 50 Ω impedance of less than a millivolt for a 50°C change in temperature from 0°C to 50°C. Previously, we used the wide-range linear gate and stretcher circuits in measurements at the University of Maryland Cyclotron and at the Brookhaven National Laboratory Alternating Gradient Synchrotron.

2.5 Planning a Measurement of the Neutron Spectrum at 135° from the Main Beam Stop at LAMPF.

Although the actual performance of these measurements has been delayed by the "great shutdown" at LAMPF, progress has been made in the detailed preparations for this experiment. This progress has been mainly in preparing the radiation damage facility to accomodate these measurements and in understanding the usefulness of these measurements for the proposed program of radiation damage studies. Some equipment procurements have also been made.

The 135° neutron-beam pipe has been installed through the concrete and earth shielding at the radiation damage target area at LAMPF. As shown in Fig. 1, this pipe is about 61 feet long and has a five-foot long iron plug inserted into it on the target end which reduces its diameter from 12" to 8" inside along that length. This iron plug is immediately followed by

igure 1 COLLIMATION SYSTEM FOR 135° TUBE AT BEAM STOP ~ A-6



ten feet of a similar sized collimator made of "Chemtree" iron grout. A remotely-controlled shutter of 3½' of steel has been installed in front of the first iron plug to severely attenuate neutrons produced at the proton beam-stop. The above collimation system was installed by the appropriate work crews at LAMPF under supervision by our LASL collaboration and Dr. Bryon Anderson, who was on leave of absence from KSU at LAMPF during the fall of 1975.

An additional iron collimator, ten foot in length, has been designed for insertion into the 61' pipe. Fabrication techniques have been devised. This collimator will reduce the cross section of the neutron beam to ¼" x 1". Further collimation inserted into this aperture will finally define the beam leaving the pipe to the size of 1/8" x 1/8" which is necessary for this experiment.

The design and fabrication of the beam pipe and apertures have led to a closer collaboration between KSU personnel and the LAMPF collaborators. This collaboration is now involved in discussions of the impact of these measurements on the radiation damage studies to be performed; as a result, a calculational effort has been initiated to determine a more precise relationship between the neutron fluxes to be measured at the end of the 61' pipe and those that will be present at the site of radiation damage samples.

We expect that the collimator will be completed and that the calculations on neutron fluxes will have been performed by about September 1976.

2.6 Publications and Presentations

R. Madey and A.R. Baldwin, "A Temperature-Stable Linear Gate for Nanosecond Signals and an Optional Stretcher Circuit," Nuclear Instruments and Methods 128, 557-559 (1975).

R. Madey with F.M. Waterman and A.R. Baldwin, "A Two-Parameter Spectrometer for Unidirectional Neutrons from About 5 to 200 MeV," Nuclear Instruments and Methods 133, 61-70 (1976).

R. Madey with A.R. Baldwin and F.M. Waterman, "Neutron Spectrum from 20 to About 600 MeV Above the Brookhaven National Laboratory AGS Shielding," Transactions of the American Nuclear Society , (June 1976).

R. Madey with F.M. Waterman, A.R. Baldwin, J.D. Carson, and J. Rapaport, "The Response of NE-102, NE-228, NE-228A, and NE-224 Scintillators to Protons from 2.43 to 19.55 MeV," Bulletin of American Physical Society 20, 1168 (September 1975).

3. ACTIVITIES IN PROGRESS

During the remainder of this contract period and the forthcoming year, we plan to continue work in progress leading to publications on the following topics:

(1) Neutron spectrum at 0° from 83.7 MeV deuterons on beryllium.

(2) Neutron spectra at 0° from 83.7 MeV deuterons and 100.2 MeV protons on beryllium.

(3) The response of NE-228A, NE-228, NE-102, and NE-224 scintillators to protons from 2.43 to 19.55 MeV.

(4) A two-parameter spectrometer for measuring the spectra of omnidirectional neutrons from 5 to 150 MeV.

(5) The neutron skyshine and the skyshine source spectra from the Brookhaven Alternating Gradient Synchrotron.

(6) A study of plural scattering and carbon backgrounds in energetic-neutron spectrometry.

(7) A pulse-shape discrimination system for high data acquisition rates.

(8) A transportable, multiparameter, minicomputer system for data collection and analysis.

We plan also to continue with the necessary preparations for performing the measurements of neutron spectra at 135° from the beam-stop at LAMPF. These preparations include completion of the collimator for the 61' pipe, preparing neutron detectors of the exact geometries necessary, and making some modifications to our existing software for data acquisition.

4. CONTRACT COMPLIANCE

The principal investigator devoted more than 10 percent of his time during the 1975-76 academic year and more than one month during the summer of 1975. To the best of our knowledge, there have been no failures to comply with the contract requirements.

5. BIBLIOGRAPHY

This bibliography list papers, presentations, and reports prepared under Contract E(11-1)-2231 since 1 June 1975. Reprints of documents COO-2231-32 through COO-2231-37 are appended to this progress report (COO-2231-37).

COO-2231-32
The Response of NE-102, NE-228, NE-228A, and NE-224 Scintillators to Protons from 2.43 to 19.55 MeV, R. Madey, F.M. Waterman, A.R. Baldwin, J.D. Carlson, and J. Rapaport, Bulletin of the American Physical Society 20, 1168 (September 1975).

COO-2231-33
The Response of NE-102, NE-228, NE-228A, and NE-224 Scintillators to Protons from 2.43 to 19.55 MeV, Remarks prepared for presentation by Richard Madey on 30 October at the 1975 fall meeting of the Division of Nuclear Physics of the American Physical Society at Austin, Texas.

COO-2231-34
Neutron Spectrum from 20 to About 600 MeV Above the Brookhaven National Laboratory AGS Shielding, R. Madey, A.R. Baldwin, and F.M. Waterman, Transactions of the American Nuclear Society , (June 1975).

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A Two-Parameter Spectrometer for Unidirectional Neutrons from About 5 to 200 MeV, R. Madey, F.M. Waterman, and A.R. Baldwin, Nuclear Instruments and Methods 133, 61-70 (1976).

COO-2231-36
A Temperature-Stable Linear Gate for Nanosecond Signals and an Optional Stretcher Circuit, R. Madey and A.R. Baldwin, Nuclear Instruments and Methods 128, 557-559 (1975).

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Energetic-Neutron Spectrometry, R. Madey, Progress Report for the period from 1 June 1975 to 31 May 1976.

6. REFERENCES

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