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COSMIC AND SOLAR GAMMA–RAY AND NEUTRON EXPERIMENTS:

"ANALYSIS OF ACCELERATOR AND MONTE CARLO DATA FOR SOLAR NEUTRON DETECTORS"

1.0 INTRODUCTION

This report summarizes the results of the research supported by NASA grant NAGW–2734 and lists the papers and publications produced through the grant. The basic goal of the work was to complete analysis of data from exposure of a large NaI scintillation detector to fast neutrons and to disseminate the results of the analysis. A secondary goal was to compare the measured detector response to neutrons with Monte Carlo calculations of the response. In Section 2.0, we discuss the goals of the research. In Section 3.0, we summarize the results of the research. In Section 4.0, we list the papers and publications produced under the grant. Preprints or reprints of the ppublications are attached as Appendices.

2.0 GOALS OF THE RESEARCH

Under NASA Grant NAGW-534 entitled "Development of Prototype High–Energy Gamma–Ray and Neutron Concepts for Space Use," we studied techniques for measuring high–energy (>10 MeV) neutrals from solar flares. Because of redirection of funding for the Max '91 program, analysis of related accelerator data and Monte Carlo calculations was left unfinished.

Our primary objective, therefore, was to complete the analysis of the (36 - 709 MeV) neutron measurements in NaI scintillators and publish the results. Our other objectives were to: compare the results to a Monte Carlo simulation; apply the results to previous and planned detectors (e.g., SMM and BATSE); and evaluate the capability of a layered high–Z detector to discriminate between high–energy γ–rays and neutrons.

The publication of this work was important because there is a dearth of reports in the literature on the response of high–Z radiation detectors to neutrons in the energy range relevant to solar neutrons. Such information

is necessary for the design of future high–energy solar detectors.

3.0 RESULTS OF THE RESEARCH

The primary objective of the research, which was to complete the analysis of the accelerator data was accomplished. The results were published in the journal *Experimental Astronomy* (Dunphy *et al.* 1992a, see Appendix A). This paper reported on the efficiency and energy response of a large, layered NaI scintillator to medium–energy neutrons (36–709 MeV). In the same paper, these measurements were also used to evaluate the accuracy of Monte Carlo calculations that had been done for the Gamma–Ray Spectrometer on the Solar Maximum Mission satellite.

One of the motivations for the research was the belief that the data would be useful in studying the response of other instruments intended for high–energy solar observations. It appears that this hope was justified, since other researchers have used the data prior to publication. Dr. Glenn Frye at Case Western Reserve University requested, and was given, access to the data for a GRO Guest Investigator program to determine the neutron response of detectors on the Compton Observatory. Dr. David Forrest at the University of New Hampshire used the data to aid in a study of the high–resolution detector planned for HESP.

A secondary objective of the research was to compare the accelerator measurements with Monte Carlo simulations of the detector. The Monte Carlo calculations were done by Dr. Craig Jensen, presently at George Mason University. This work has also been completed and the results were reported at the Spring meeting of the American Physical Society in Washington, D.C., April 20–24, 1992 (Dunphy *et al.* 1992b). We are also submitting a paper to *Nuclear Instruments and Methods* that compares the measured data with the Monte Carlo simulation (Dunphy *et al.* 1992c, see Appendix B).

4.0 PUBLICATIONS AND PAPERS PRESENTED

We list below, the titles and authors of the publications and papers produced under the grant. Reprints of the publications are included as Appendices.

"Accelerator Measurement of NaI Response to Medium Energy Neutrons and Application to a Satellite–Borne Spectrometer," P. P. Dunphy, E. L. Chupp, M. Popecki, D. J. Forrest, D. Lopiano, T. Shima, H. Spinka, G. Glass, G. Burleson, and M. Beddo. *Experimental Astronomy* **2**, 233 (1992a).

"Monte Carlo Simulation of the Response of NaI Scintillator to Medium Energy Neutrons," P. P. Dunphy, E. L. Chupp, and C. M. Jensen. Paper presented at the Spring Meeting of the American Physical Society, Washington, D. C., April 20–24 (1992b).

"Monte Carlo Simulation of the Response of NaI Scintillator to Medium Energy Neutrons," P. P. Dunphy, E. L. Chupp, and C. M. Jensen. To be submitted to *Nuclear Instruments and Methods* (1992c).

APPENDIX A

ACCELERATOR MEASUREMENT OF NaI RESPONSE TO MEDIUM ENERGY NEUTRONS AND APPLICATION TO A SATELLITE–BORNE SPECTROMETER