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Detection of Delayed Neutrons

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David J. Loaiza

Introduction

The present work examines a high-neutron efficiency detector used to measure delayed neutron techniques. The measurement of delayed neutrons requires a detector system that has high neutron efficiency and a low dead-time. The detection system must also have low gamma-ray sensitivity, and in addition must be insensitive to small sample displacement. The operating characteristics of the high-efficiency He-3 proportional counter used for the measurement of β_i -delayed neutrons is reported here.

Description of Detection System

The detection system consists of a cylindrical array of 20 He-3 tubes imbedded in a polyethylene moderator. The entire arrangement of the detection system is shown in Figure 1. This device is 58 cm by 59 cm by 72 cm high. The counter has a central cavity of 17.78 cm in diameter and has an active depth of 40 cm where the delayed neutron samples are placed. The counter is surrounded by 10 cm of polyethylene lined with a sheet of cadmium about 1.5 mm thick. The layer of cadmium absorbs background thermal neutrons that originate outside the cavity. To further reduce the high-neutron background coming from the irradiation of samples, two additional neutron-absorber layers have been placed around the well counter. The first layer is a 2-cm thick sheet of Boral. The second layer consists of 7.62-cm thick borated polyethylene.

The He-3 tubes have an active length of 25 cm and an outside diameter of 2.54 cm. The tubes are filled with 98% He-3 at a pressure of 4 atm. The 20 He-3 detector tubes are arranged in five banks of four, making the counter a segmented device consisting of 5 segments. This arrangement was used to eliminate spurious data that might occur as a result of the failure

of one tube or one tube bank. Four of the counter segments (I, II, III and IV) are composed of four tubes in a row and correspond to each of the four sides of the counter. Segment V consists of the remaining tubes, each separated by four tubes of the I, II, III and IV sections in a way that corresponds to the four corners of the counter (Loaiza, 1997).

Figure 1. Cross sectional view of well counter.

The output signals from the neutron detector are also fed into the input synchronizer of the Pulse Arrival-Time Recording Module (PATRM). The PATRM, which was developed at Los Alamos approximately six years ago, sequentially records the arrival times of pulses received by the detectors. Other techniques convert the raw time history data into other data domains, such as a) the number of pulses in a gated window or b) the number of pulses in a shift register after a pulse exits. Because the original pulse arrival-time history is converted into other data domains, the raw data is completely lost and the analysis is limited to one or two algorithms. These other methods have parameters (such as gate width, clocks, shift-register

lengths, etc.) fixed in the hardware or software before the data collection begins. Therefore, once the data is taken, any change in the parameters requires running the experiment again. By using the PATRM, the original pulse arrival-time history can be recorded and saved. Thus, one can apply many algorithms on the same data and also change the parameters (gate width, shift register length) used in the analyses. This method of recording the original data also allows the user to employ newly developed algorithms that analyze data taken previously (Arnone et al., 1991).

Characteristics

This detection system has a low dead-time of 0.46 ± 0.02 μ sec. It is also displacement insensitive within a range of 10-cm, which makes it optimal for the measurement β_i -delayed neutrons. The absolute efficiency of the well counter was determined using a calibrated Am/Li neutron source. The absolute neutron emission rate of this source was determined to an accuracy of 3% relative to a standard source in a graphite pile and relative emission rates of the source were known to an accuracy of approximately 2%. The Am/Li source was placed in the well counter at the same position where the irradiated sample would be placed. The counting rate for the Am/Li source was taken several times to obtain acceptable statistics. The absolute efficiency calculated for the well counter is $29.04\% \pm 0.6\%$. This detector type has the qualities desired for the detection of delayed neutrons.

Reference:

G. Arnone, G. Brunson, and K. Coop, "A Pulse Arrival-Time Recording Module for Analyzing Neutron Multiplicities," Los Alamos National Laboratory report, LA-UR-91-8231 (1991).

D. J. LOAIZA, "Measurements of Delayed Neutron Parameters for U-235 and Np-237," Ph.D. Dissertation, University of New Mexico (also published as Los Alamos National Laboratory report, LA-13317-T, 1997).

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