Measurement of Intrinsic Neutron Detection Efficiency of a Liquid Scintillator using Digital Data Acquisition System

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Introduction

In nuclear experiments, it is often required to distinguish between different types of charged and uncharged particles. Our interest is primarily in the detection of neutrons with a liquid scintillator coupled with a digital data acquisition system (DSP),.

The intrinsic neutron detection efficiency of a neutron detector has been measured using a spontaneous fission source ^{252}Cf (1.12 μCi) which decays via α particle emission (96.91%) and spontaneous fission (3.09%) [1]. It has a half life of 2.65 years. Standard neutron Time of Flight (TOF) technique has been used to measure the neutron detection efficiency (intrinsic) of the neutron detector. Generally, charged particle detectors are used to generate the start signal for the neutron TOF measurements. These detectors are also used to measure the total fission events [2]. Since large numbers of gamma-rays are also emitted from the excited fission fragments, a fast gamma detector can also be used to generate the start signal for neutron TOF [3]. In this present work, we shall discuss about the preliminary results from our recent experiment on neutron detection efficiency measurement of a liquid scintillator BC501A (active volume= 1.60 litre, dimension~4″×5.5″) with Digital Data Acquisition system (DSP) using TOF technique.

Experiments

Our present experimental set-up consists of one liquid scintillator BC501A, one $LaCl_3$ and two clover detectors (Fig.1). The liquid scintillator BC501A was placed at a distance of 100 cm from the source. As $LaCl_3$ (1″×1″) was used to generate start trigger, we kept it close (5 cm) to the ^{252}Cf source. Two clover detectors have been used to detect the gamma rays from the excited fission fragments. These detectors were placed at a distance of 15 cm from the source. The $LaCl_3$ and two clover detectors were placed at 90^0 and ± 45^0, respectively, with respect to the BC501A. Eventually, we shall generate neutron gated gamma spectra from these clover detectors. Due to the low activity of ^{252}Cf source used in the present experiment, the data have been taken for a long time (~ 2-3 days) to get sufficient statistics.

The experiment was carried out with the digital data acquisition system based on Pixie-16 modules with 100 MHz sampling rate, developed by XIA LLC [4]. The DSP parameters have been optimized accordingly to get better results. The resolution of $LaCl_3$ has been compared with both analog and digital data acquisition system. In digital system, the time stamp data have been collected from the detectors for E_{th} > 30 keVee.

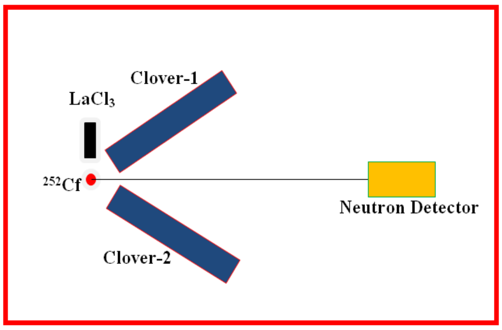

Fig.1 Schematic view of the experimental set-up.

The TOF spectrum (Fig. 2(a)) has been generated by taking the time differences between the events, registered in the start and stop detectors. Different offline energy thresholds in BC501A have been used to generate neutron

TOF spectrum. These selections helped us to remove the gamma-neutron pile-up in TOF spectrum.

Results and Discussion

The TOF spectrum for the neutrons has been converted to the energy spectrum by using the prompt gamma peak in the TOF as a reference. During this conversion, background subtraction has been done to remove the gamma contributions in neutron energy spectrum. The neutron energy spectrum of the BC501A is shown in Fig. 2(b). The detection efficiency of the neutron detector was obtained by dividing the experimentally observed neutron yields by the expected neutron energy distribution of the ^{252}Cf source [5] which was normalized by the total no of fission events, solid angle covered by the BC501A and the detection efficiency of the $LaCl_3$. The temperature was considered as T= 1.42 MeV as in Ref. [6]. The detection efficiency of $LaCl_3$ has been calculated from integrated detection efficiency using a ^{252}Cf source. The average numbers of gammas and neutrons per fission events have been taken from Ref. [6]. The energy dependence of neutron detection efficiency of the BC501A is shown in Fig. 3.

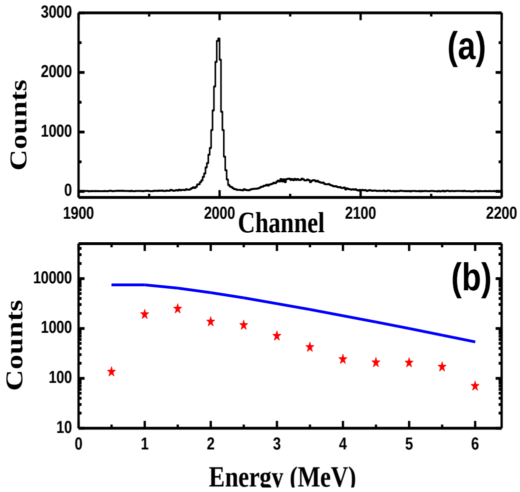

Fig. 2 (a) Neutron TOF spectrum and (b) Neutron energy spectrum of BC501A (stars) compared with the expected neutron energy spectrum from ^{252}Cf (continuous line).

The results have also been compared with analog system. The measured efficiency will be compared with GEANT4 [7] simulation.

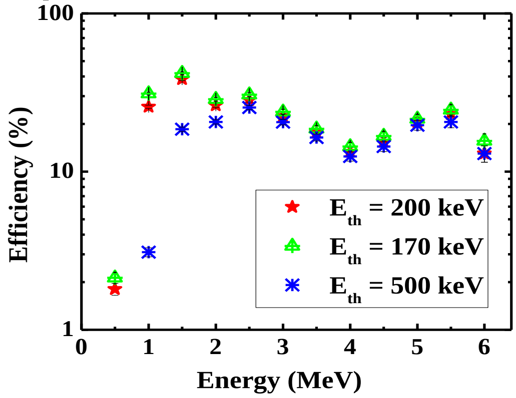

Fig. 3 Energy dependence of neutron detection efficiency of BC501A for three different offline energy thresholds in neutron detector.

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