Determination of the neutron detection efficiency of a liquid scintillator EJ301 array by γ multiplicity tagging

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Introduction

Knowledge of neutron spectra is essential for many areas of fundamental and applied science. Unlike charged particles, neutrons are generally detected via nuclear interaction that result in prompt energetic charged particles. Since the cross-section of nuclear interaction vary strongly with incident energy, the efficiency of detection depends on the energy of the incident neutron. Hence, the reliablity of the measured neutron energy spectra depends on the accuracy of the efficiency of the detection system used.

In the present contribution, we discuss a measurement to determine the efficiency of a EJ301 liquid scintillator array using a ^{252}Cf source. To determine efficiency, generally gas detector is used to tag fission event based on measurement of energy (loss) of fission fragments above a applied threshold. This may lead to some bias towards some mass and emission angle of the fragments. Recently, γ multiplicity tagging method has been suggested for unbiased measurement [1].

Experimental Details

To determine the efficiency of the liquid scintillator array [2] at the BARC-TIFR Pelletron LINAC facility, Mumbai for fast neutron spectroscopy, the neutron energy spectra of a ^{252}Cf source have been measured. The experimental setup is shown in Fig. 1. The ^{252}Cf source was mounted on the cathode of a small gas detector, to have 2π solid angle coverage for the fission fragment detection. The gas detector is made up of two circular PCB plates (7 cm in diameter and 2 mm thick) arranged in parallel with a 3 mm spacer of Teflon ring between them. In order to have better time/ energy resolution and to study the threshold effect of the gas detctor, 4 BaF_2 detectors (hexagonal cross section with 6 cm side to side distance and thickness of 8 cm) were also setup as shown in Fig. 1. The BaF_2 at the bottom is not visible and the top one was removed to show the inside of the chamber. The threshold of the BaF_2 detectors were kept at 300 keV to avoid triggering them with non-fission decay. The data acquisition was triggered either by the fission signal from the gas detector or by the coincidence in the BaF_2 detectors. The coincidence rate in the BaF_2 detectors was much lower compared to the gas detector signal rate, requiring larger acquisi-

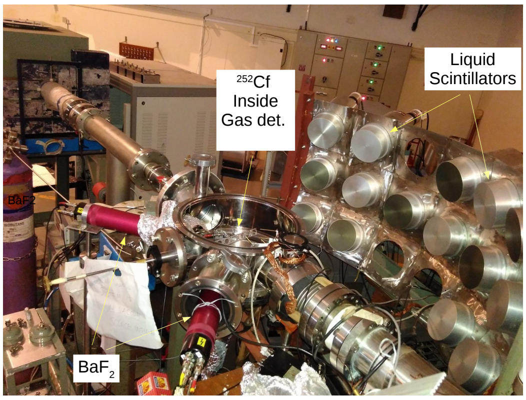

FIG. 1: The experimental setup to measure the efficiency of the liquid scintillator array for fast neutrons.

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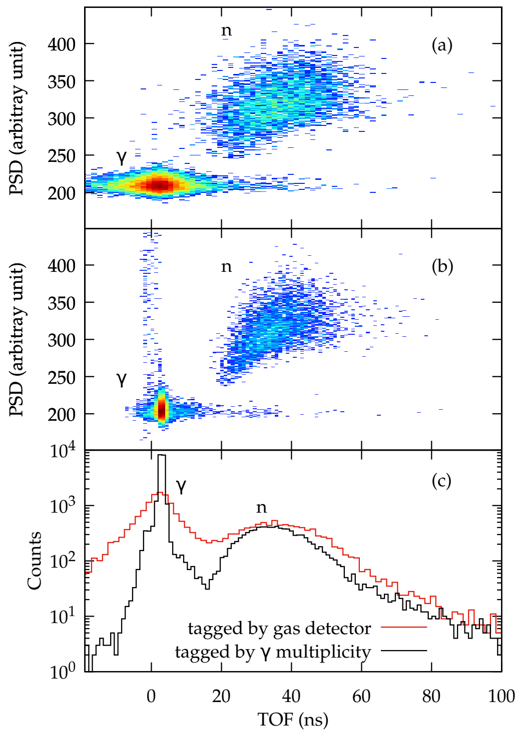

FIG. 2: (a) A typical TOF vs. PSD plot obtained using trigger from the gas detector. (b) same as (a) except using trigger from the coincidence in BaF_2 detectors. (c) 1D projection of (a) and (b) showing the much improved time resolution in case of γ multiplicity tagging.

tion time for the same statistics.

The neutron detector array consists of 15 EJ301 liquid scintillator (5 inch dia and 2 inch thick). The liquid scintillator detectors are kept at a distance of 70 cm from the target with angular separation of 16° between them, covering an angular range from 58.3° to 143.3° with respect to the beam direction. Pulse shape discrimination (PSD) technique have been used for n-γ discrimination. Data were collected in list mode using a VME based data acquisition system. TOF (time-of-flight), PSD and the pulse height information were recorded for the neutron detectors. Both timing and pulse height information were recorded from the BaF_2 detectors and the gas detector.

Analysis and Results

Typical TOF vs. PSD spectra obtained using trigger from the gas detector and γ multiplicity are shown in Fig. 2 (a) and (b), respectively. The 1D projections on the TOF axis for both the methods are shown in Fig. 2(c). As can be seen from Fig. 2(c), the time resolution ($\sigma \sim 0.6$ ns) obtained using trigger from the γ multiplicity is much better than that ($\sigma \sim 3.5$ ns) obtained using trigger from the gas detector. The TOF spectra were converted to energy spectra. The energy dependent efficiency values were obtained by taking ratio of the measured energy spectra with the Watt [3] spectrum for ^{252}Cf source. The measured efficiency values agree well with the simulation using the Monte Carlo code NEFF.

Summary & Conclusion

The neutron detection efficiency of the liquid scintillator array has been determined by measuring γ multiplicity tagging method. The measured efficiency values agree well with the results of the Monte Carlo simulation. The experimental efficiency values will be used to determine the neutron energy spectra for measurements (*e.g.* [4]) utilizing the setup.

References

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