

Characterization of a liquid scintillator detector using mono-energetic neutrons

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Introduction

An array of liquid scintillator (LS) detectors is being planned to be set up at the Pelletron Linac Facility (PLF), Mumbai, for the measurement of fast neutron spectra. This will be used to measure neutron cross section as low as $\sim 1 \mu\text{b}/\text{sr}$ and will complement the existing array of plastic scintillators [1]. The slow component of the scintillation allows the discrimination of neutrons and γ rays on the basis of pulse shape discrimination (PSD) whereas the fast component is used for time of flight (TOF) measurements. In this paper we report the PSD, TOF and energy response of one of these detectors belonging to this array.

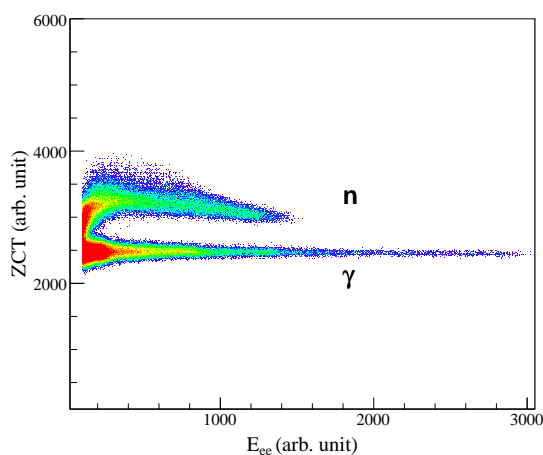


FIG. 1: PSD spectra discriminating n and γ events for 8 MeV proton beam.

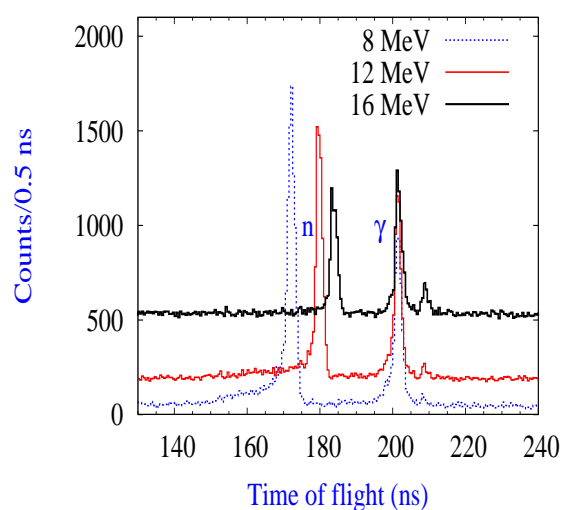


FIG. 2: Measured neutron TOF spectra at three proton energies.

Experimental details

The experiment was performed to measure mono-energetic neutrons in ${}^7\text{Li}(p, n){}^7\text{Be}$ reaction using 8, 12, 16 MeV proton beam at the PLF, Mumbai. The neutrons were measured in coincidence with 429 keV γ -rays from the first excited state of ${}^7\text{Be}$. A 127 mm diameter and 51 mm thick LS detector (EJ 301 equivalent NE213) coupled to 127 mm diameter photo multiplier tube was used to detect neutrons. The detector was placed at an angle of 45° with respect to the beam direction and at a distance of 1m from the target. An array of seven closed-packed hexagonal BaF_2 detectors was placed close (~ 3 cm) to the target for detecting the γ -ray. In each event, the

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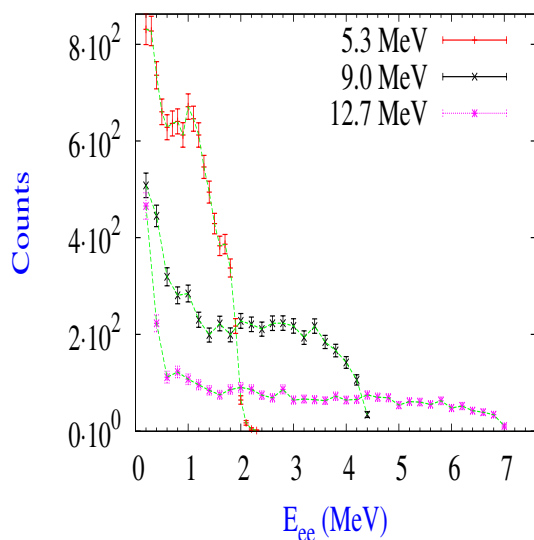


FIG. 3: Pulse height responses for three neutron energies.

zero cross over time (ZCT), energy deposited in the LS, TOF with respect to the BaF₂ array and energies of BaF₂ detectors were recorded using a CAMAC based data acquisition system. The TOF was calibrated using an ORTEC time calibrator. The energy calibration of the LS was performed by measuring the energy of the Compton scattered electrons which were tagged by the back scattered γ rays detected in a NaI(Tl) detector. This was done for various γ ray energies using radioactive sources. The resolution of LS detector was found to be $\sim 10\%$ at 1 MeV electron equivalent energy (E_{ee}).

Results and discussion

The ZCT measured with respect to the leading edge timing signal is a measure of the PSD. Fig.1 shows the measured PSD spectrum exhibiting an excellent neutron and γ discrimination for $E_{ee} \geq 30$ keV. The figure of merit (M) for this discrimination is defined as the ratio of the peak separation to the sum of their full widths at half maxima for $E_{ee}=1$ MeV. For the present case $M \sim 1.8$ has been obtained. Neutron TOF spectra measured in coincidence with 429 keV γ rays are shown in Fig. 2. The extracted neutron energies from the TOF spectra were found to be in agreement with the kinematic calculations. The pulse height spectrum of LS was extracted after applying suitable prompt and random gates on the TOF parameter. The random subtracted spectra are shown in Fig. 3 for various neutron energies. The end point energies in these spectra agree with the values calculated using the non-linear response of the LS to the corresponding proton recoil energies [2]. A Monte Carlo simulation will be performed to calculate the full spectrum for comparing with the data.

Acknowledgments

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References

- [1] P. C. Rout et al. Nucl. Instr. Methods Phys. Res., sect. A **598**, 526 (2009).
- [2] R. A. Cecil et al. Nucl. Instr. and Meth. **161**, 439 (1979).