Energy Response of Liquid Scintillator using Compton tagged Electrons

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Introduction

Liquid scintillation detectors have been widely used for the fast neutron spectroscopy. These detectors have very good time resolution($\lesssim$ns) comparable to the plastic scintillators [1]. In addition, these detectors have pulse shape discrimination (PSD) property which enables unambiguous detection of the neutrons in the presence of gamma rays. The knowledge of absolute efficiency which is a function of incident neutron energy and threshold is essential for folding of the neutron spectra. Accurate determination of threshold for the analysis of the neutron spectra and neutron response function require very precise energy calibration. The position of pulse height associated with the maximum energy of recoil electrons is taken in between the maximum edge and the 'half maximum' of the spectrum and the arbitrary selection of the calibration point introduced the error in the energy calibration. A coincidence between Compton scattered gamma rays and the recoil electron is used for the energy calibration in the scale of electron energy equivalent [1, 2]. In this paper, the response of the liquid scintillator (EJ-301 equivalent to NE-213) to the electron is reported along with the neutron time of flight (TOF) and pulse shape discrimination.

Experimental Details

A coincidence experiment has been carried out using a 5" diameter and 2" thick cylindrical liquid scintillator(LS) and a hexagonal, ~6 cm face to face, 8 cm thick BaF_2 detector for the study of the electron response and neutron TOF and PSD of the LS. The LS belongs to the existing mini neutron detector array consists of 20 detectors at the Pelletron Linac Facility, Mumbai. For the measurement of pulse height response, the gamma source was collimated using 2" thick Pb bricks and the collimated gamma rays got Compton scattered from the LS and the scatted gamma rays were detected by the BaF_2 detector placed at θ ~125° with respect to the incident direction. The recoil electron energy(E_e) which deposited in the LS depends on the scattering angle and given by, $E_e = \frac{\alpha E_\gamma (1-cos\theta)}{1+\alpha(1-cos\theta)}, \alpha = E_\gamma / m_e c^2$ in Compton scattering of γ-rays. For the measurement of the TOF and PSD, the LS was placed at 50 cm from the BaF_2 detector. The anode signal from the LS was split, one fed to the constant fraction discriminator(CFD) for the TOF measurement and the other one send to the Mesytec MPD4 for the

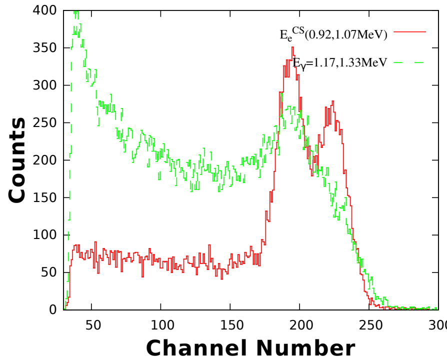

FIG. 1: Comparison between spectra of liquid scintillator using ^{60}Co source for measurements without and with coincidence with Compton scattered (CS) gamma rays

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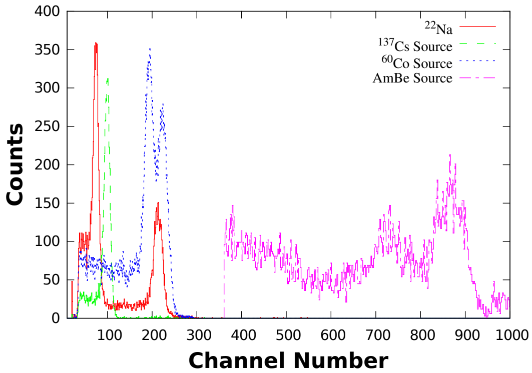

FIG. 2: pulse height response of liquid scintillator up to ∼4MeV electron equivalent energy using ^{22}Na,^{137}Cs, ^{60}Co and ^{241}Am-^{9}Be sources

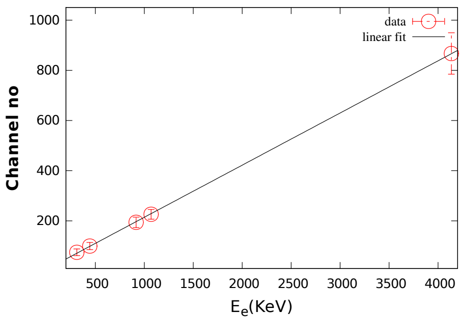

FIG. 3: Linearity of light output in electron equivalent energy(E_e).

pulse height and the pulse shape discrimination(PSD) informations. The anode signal of the BaF_2 detector was sent to the CFD for generating the start signal to the time analyser for the TOF. The dynode signal from the BaF_2 detector was fed to the spectroscopic amplifier for the pulse height information of the scatterd gamma rays. The parameters, energy of the BaF_2 detector, energy, PSD and TOF with respect to the BaF_2 detector, were recorded in an event-by-event mode using a VME based data acquisition system. A coincidence between the LS and BaF_2 detector was used as the master trigger.

Results and Discussion

The recoil electron spectrum obtained using ^{60}Co source tagged with the back scattered gamma rays showed two well resolved

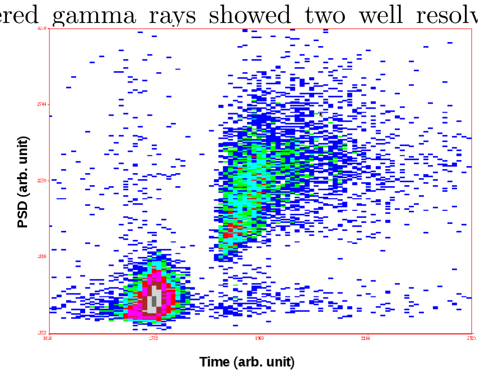

FIG. 4: Two-dimensional plots of PSD vs. TOF using ^{241}Am-^{9}Be neutron source

peaks with energies 0.9 and 1.1 MeV respectively, while no peak like structure observed for the measurement without coincidence as shown in FIG.1. This method demonstrated the unambiguous peak definition of the pulse height for the purpose of the calibration of the LS as discussed for the plastic scintillators [1].The resolution of the LS was found to be 8.5% at ∼1.0 MeVee(MeV electron equivalent). FIG.2 shows the pulse height response measured in the coincidence method using radioactive sources up to ∼4 MeVee. In the present experiment, the measured response of the LS to the electrons was found to be linear up to 4 MeV as shown in FIG. 3. The neutron TOF spectrum of the LS measured with respect to the BaF_2 trigger detector using ^{241}Am-^{9}Be neutron source. FIG. 3 shows a clear separation of neutron events from the back ground gamma events in the two dimensional plot between the TOF and PSD.

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References

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