Response of long liquid scintillator detector to mono-energetic neutrons

T. Basak[1], S.P. Behera[2], P.C. Rout[2], D.R. Chakrabarty[2], V.M. Datar[2]*, Suresh Kumar[2], A. Mitra[2] and R.Kujur[2]

[1]*UM-DAE Centre for Excellence in Basic Sciences, Univ. of Mumbai-Kalina Campus, Mumbai – 400098, INDIA*

[2]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*

* *email: vivek.datar@gmail.com*

Introduction

An array of liquid scintillation (LS) detectors with pulse shape discrimination (PSD) property, to separate neutron and γ-ray induced events, is being set up at the Pelletron Linac Facility, Mumbai. The array will consist of sixteen 1m long detectors with a cross section of 6cm x 6cm coupled to 5 cm diameter PMTs at either end [1]. We report here measurements of the time of flight (TOF), pulse height and PSD response using mono-energetic neutrons from the $^{7}Li(p,n)^{7}Be$ reaction for one detector.

Experimental details

The experiment was performed with a 5.6 MeV proton beam at the FOTIA facility, BARC bombarding a 200 μg/cm^2 LiF target on 150 μm Ta backing. Neutrons populating the first excited state in ^{7}Be were measured in coincidence with the 429 keV γ-rays depopulating this excited state. The neutrons were detected in the LS detector whose centre was at a distance of 1 m from the target. The target to detector centre vector made an angle of 50° with the beam direction. The γ-ray was detected in an 8 cm thick BaF_2 detector placed at ~ 2 cm from the target.

The anode signals from each end (L and R) of the LS detector were used to generate the timing, energy (E_L, E_R) and PSD (PS_L, PS_R) pulses. The BaF_2 anode and dynode signals were processed to generate the time and energy (E_B) information. The event trigger was a coincidence between the timing signals from both ends of the LS detector and the BaF_2 detector. The time differences between the BaF_2 and L and R timing signals (T_L, T_R) were measured using time to amplitude converters. The pulse shape discrimination signals were generated using the zero crossover timing technique. The parameters recorded for each event were E_L, E_R, T_L, T_R, PS_L, PS_R and E_B using a CAMAC based data acquisition system. The TOF information was derived from $(T_L+T_R)/2$ while the position of the interaction point was derived from (T_L-T_R) [2]. The energy deposited in the LS for each event was derived from the geometric mean (E_{gm}) of E_L and E_R. The energy calibrations of LS and BaF_2 detectors were done using ^{137}Cs and ^{60}Co sources.

Results and discussion

Fig. 1 shows the TOF spectrum with a condition of the 429 keV γ-ray detected in the BaF_2 and selecting a ~30 cm wide position gate in the central region of the LS detector. The time difference between the neutron and γ-ray peaks of ~39 ns is consistent with that expected of a 3.1 MeV neutron from the $^{7}Li(p,n_1)$ reaction. The time resolution (FWHM) of the prompt γ-ray peak is ~1.8 ns.

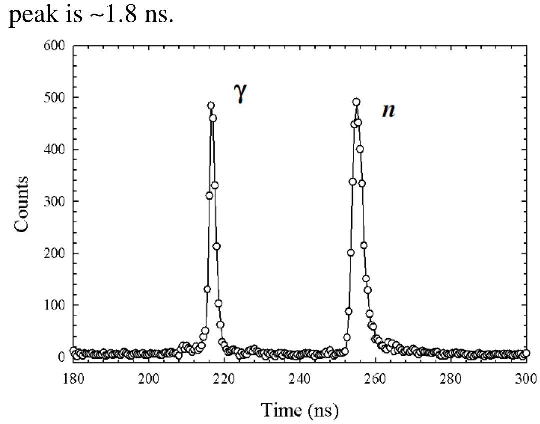

Fig. 1 TOF spectrum showing the γ-ray and neutron groups.

Fig. 2 shows one of the PSD spectra with the two conditions mentioned above. The neutrons and γ-rays show moderate separation. This is mainly because of the low energy of the neutron and the PSD should improve at higher energies.

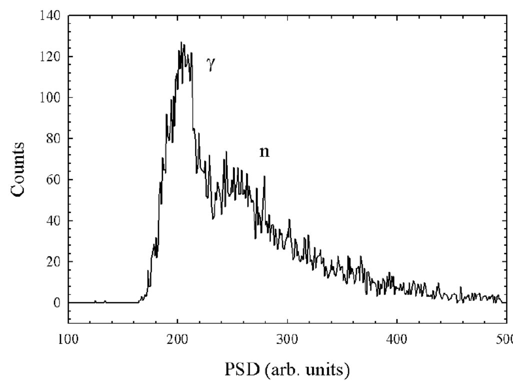

Fig. 2 PSD spectra derived from PMT signals from one side.

Fig. 3 shows the energy spectrum (in keV electron equivalent) of the LS detector for the above two gates and another gate on the TOF parameter selecting neutrons. In order to compare this response with that for mono-energetic electrons a separate measurement was made using a ^{60}Co source. The γ-rays were collimated using a lead shield to illuminate a ~1 cm region in the central region of the LS detector. Events in the LS were measured in coincidence with the Compton scattered γ-rays detected at angles between 130° and 150° in the BaF_2 detector. This selects events with an electron energy deposit ~1 MeV and a spread of ~0.1 MeV. Care was taken to shield the BaF_2 detector from the γ-ray source. The energy spectrum is also shown in Fig. 3. As can be seen the pulse height response to neutrons, detected mainly via proton recoils in *n-p* scattering, is about 4 times lower than that for recoil electrons. This is not inconsistent with published data.

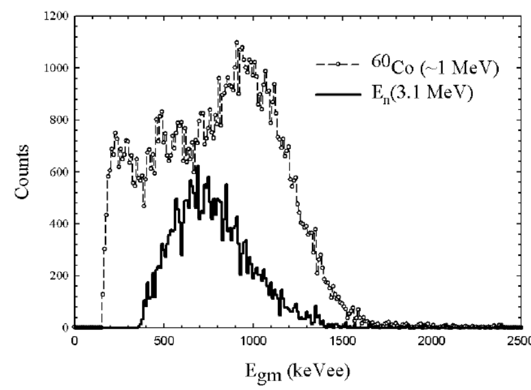

Fig. 3 Energy spectra for neutron and γ-ray induced events.

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References

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