Response of fast plastic scintillator detector

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Introduction

Plastic scintillator detector is widely used now a days for the time of flight measurement of high velocity charged and non charged particle in many experiment of nuclear and high energy physics [1, 2]. The important parameters of a plastic scintillator are its luminescence response to various types of radiation, its time response characteristics (i.e., rise time, decay time, transit time of the light), and the attenuation of the light traveling through it. We are planning to build an array of detectors for TOF measurements of high energy reaction fragments. For this purpose, we have tested various types of ultra fast plastic scintillator with different types of readout using different types of sources and cosmic muons at our SINP laboratory. Details of our testing results on the response of these detectors to electron (^{137}Cs), gamma (^{60}Co) and heavy charge particle like alpha (from ^{241}Am) will be presented in the symposium..

Experimental setup:

In house facility at SINP offers us to measure various intrinsic properties of those detector like measurement of rise time as well as the decay time and most important is the optical attenuation of the material.

A coincidence circuit was made specially to find out the timing resolution of the detector. Two detector were used and placed side by side for coincidence measurement and radioactive sources were kept in between the two detector. Scintillator are coupled to PMT's at both end and the anode signals are used for energy from one end and timing from the other. Anode pulses are fed to CFD's and Shaping Amplifier for timing and energy information, respectively. Start and Stop signal from the two detectors were used to obtained the TAC spectrum and to generate GATE for the DAQ. The rise time, decay time were observed from shape of Anode pulse stored on a digital oscilloscope. In order to determine the optical decay constant source was kept at different distance from the PMT(s) across the length of plastic scintillator. Now if we consider simple exponential photon loss after the interaction across the length, the optical attenuation coefficient may be easily calculated in the following way.

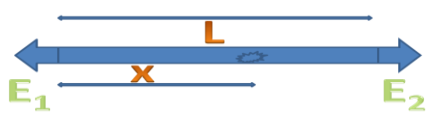

Fig. 1 Energy measured from two PMT(s)

Then $I_1 = I_0 exp(-x/\lambda)$ and $I_2 = I_0 exp(-(L-x)/\lambda)$. Using this two relation it can be easily estimated the optical attenuation coefficient λ.

Fig 2: Detector of several dimension and their testing

Table 1: Detector characteristics

Detector specification (PMT type)	Bias Voltage	Rise time	Decay time	Pulse Height
HPK H3164-10	-1200 V	0.8-1.2 ns	~80 nS	200-300 mV
HPK H6533	-2000 V	0.2-2 ns	~80 ns	200-320 mV

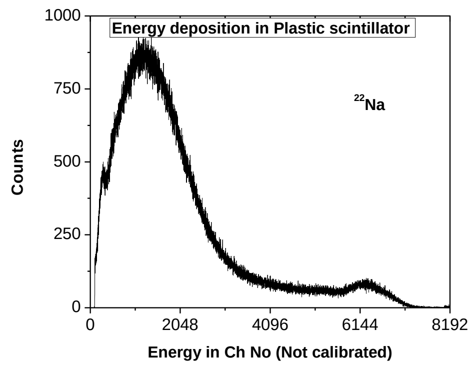

Fig 3: Energy deposition using ^{22}Na source

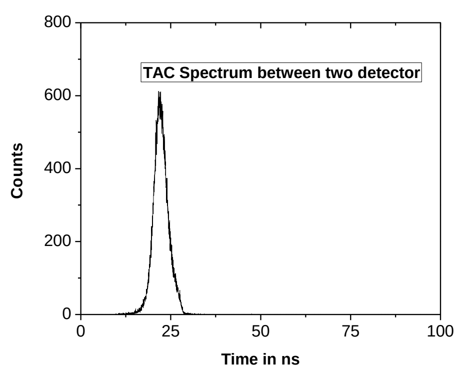

Fig 4: Time to amplitude converter peak using coincidence between two plastic scintillator where also ^{22}Na was used.

Table 1. shows various response parameters of these detectors which are measured at our laboratory. Figure 3 and 5 show measured energy loss in the detectors due to various radiations. Figure2. Shows the timing spectra of two detectors.

These detectors is planned to use for time of flight measurement for fast neutron, charged particle and fragments. It's performance may be studied with other fast detectors like MMRPC , [3]. LaBr3 etc.

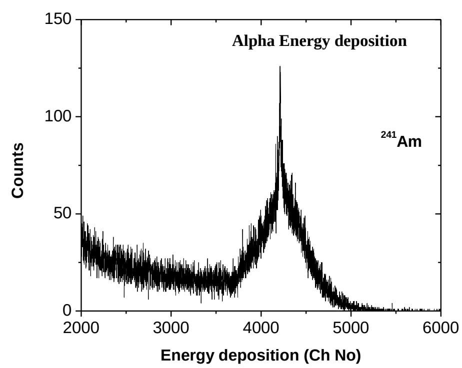

Fig 5: Energy deposition spectrum using ^{241}Am (5.38, 5.44, 5.48 MeV alpha)

References:

[1] U.DattaPramanik et al, PLB551, 63 (2003)

[2] T. Blaich *et al.NIM***A314**(1992)136,

B. Luther et al NIM A505 (2003) 33.

[3] U. Datta Pramanik et al. Nuclear Instruments and Methods in Physics Research A 661 (2012) S149–S152