# Measurement of Decay Time Constant of a Plastic Scintillator by a Delayed Coincidence Method

Sonali Das[1],* J. Saini[1], and A.K Dubey[1]
[1] *Variable Energy Cyclone Centre, Deptartment of Nuclear and Atomic Energy Physics,VECC,Kolkata,India*

## Introduction

Plastic organic scintillator is one of the most convenient options for many timing measurements in both high energy and low energy experiments. The major advantage being the ease of fabrication into desired shapes, resonable costs and the possibility to work with a very high count rate upto$10^7$pulses persec with very fast rise time and very short decay time constant. Generally, the decay time of scintillator detector indicates the time duration required by a scintillator to emit photoelectron which later contribute to draw the complete information of scintillation pulse height fluctuations. The high yield and fast response time allows the possibility of subns timing resolution. The fraction of the light emitted during the decay"tail"can depend on the incident exciting particles, which helps in particle identification. This Report presents a novel method of measuring the decay time constant by a simple delayed coincidence circuit using Field Programmable Gate Arrays(FPGA)based electronics. The basic principle of single photon method involves measuring of average real photoelectron pulse of scintillation without distorting the signal by signal shaping effects of PMT. In general terms, this method for determining the timing dependance of the scintillation intensity consists of measuring the distribution of the difference in time obtained between "Formation" of scintillation light pulse by detecting scintillations in one PMT and the "Arrival" of individual single photoelectron at the cathode of another PMT.

*Electronic address: sonasonalika7@gmail.com

## Experimental Setup

All measurements have been carried out in a custom-made black wodden box to ensure a dark enviornment to control light leakage.The schematic of the experimental setup is shown in Fig 1. A general purpose plastic scintillator of the size $5*10*10cm^3$ whose decay time constant has to be determined is directly coupled to a photomultiplier tube referred to as PMT-1. The scintillator is made up of Polyvinyltoluene(PVT) with density$1.032gm/cm^3$. Another PMT (PMT-2) is placed at distance of few cm from the open face of this scintillator as shown in the figure. A Ru-106(weak) beta source having a maxmimum energy of 39.4 KeV and end point energy of 3.541 MeV is kept on top of the scintillator. The scintillation produced in PMT-1 gives the start pulse. Per one beta disintegration 0.34 photons are emitted by Ru-106 source. The strength of the source is few hundred Hz. The surface of PMT-2 is covered with Al foil of 1 $mm$ diameter hole. This leads to the detection probability of the PMT-2 decreases drastically to less than 1, thus ensuring the detection of single photons only. The signal from PMT-2 is delayed by 8 ns to ensure that the decay pulse (from single photons) arrive sufficiently later than that of PMT-1. The analog signal from PMT's are converted to TTL via the schematic shown in the figure. This TTL signal is then fed to LVDS (Low voltage differential signal) box, this LVDS signal is then fed to the two auxiliary inputs of a FPGA based readout controller(ROC). Traditionally, a Time to Digital Converter (TDC) is used for timing information. An alternative method of measuring the time difference was thought of by using FPGA based electronics, wherein the time stamp of the signals arriving

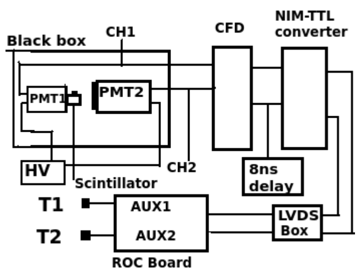


FIG. 1: Schematic view of Experimental Setup to measure the decay time constant of plastic scintillator

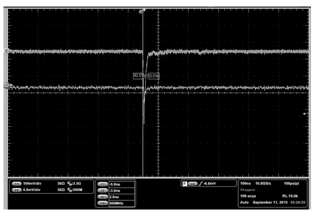

FIG. 2: Raw pulse obtained from PMT(1) and PMT(2) by Oscilloscope

from the PMT is recorded in the data. Analyzing the data offline, one measures the time difference between these signals. As shown in the figure, the signal from PMT-1 and PMT-2 is fed to the auxiliary inputs of the ROC, from where the data is recorded on to the PC.

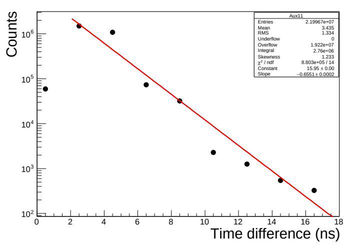


FIG. 3: Time difference spectrum to obtain the average scintillation pulse

## Results and Discussion

Fig 1 shows the typical raw pulse of both signals from PMT-1(upper signal) and PMT-2(lower one) respectively, obtained on the oscilloscope. It was triggered using the PMT-2 signal, since this comes much less frequently as those from PMT-1. To achieve the required statistics, data was taken for several days. Time difference spectrum bewtween AUX1 and AUX2 is shown in Fig. 3. This spectrum is without background substraction. Background data was recorded by putting an opaque screen in front of the PMT-2 for both the scenarioes with source and without source on the scintillator coupled with PMT-1. The background data was very small as compared to that taken with source and screen removed. The time difference data has been fitted to an exponential function $\mathrm{I(t)}\sim \mathrm{e}^{-}(\mathrm{t}/\tau)$. Where, $\tau$ is the decay time constant of scintillator and I(t) is the intensity of the scintillation light yield. The decay time constant is calculated by taking the negative of the inverse of the slope of single exponential decay curve. The decay time constant of the plastic scintillator is found to be 1.6ns. This method of using single photo-electrons takes large amount of time to gather enough statistics for analysis. Further studies by varrying different parameters such as distance of PMT-2 varying the source intensity, varying the source type is underway to understand the detailed systematics. These will be presented and discussed.

## References

[1] Measurement of the Time Dependance of Scintillation Intensity by delayed Coincedence Method,L.M Bollinger and G.E Thomas**32**,1044(1961)