LYSO crystal based position sensitive detector assembly for gamma-ray imaging.

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Introduction

Study of exotic nuclei and unknown states of stable nuclei has been gaining momentum since the last decade. It becomes very important to back up such nuclear physics experiments aimed at studying *terra-incognita* with equally efficient and robust detector systems. One of the many methods to do so in case of gamma ray spectroscopy is by using electrically segmented High Purity Germanium detectors. These detectors not only provide high efficiency in terms of peak to total ratio, but also eradicate perennially notorious issues related to germanium detectors, like, Doppler shift and Doppler broadening [1]. However in order to use an electrically segmented Germanium detector, it is important to understand the various pulse shapes arising from different points in the detector in response to an incident gamma radiation; it is needed to 'scan' the detector prior to use in-beam, with known gamma energy sources. There exist two methods which maybe used to scan a detector of this nature- a point to point scanning method and a one-shot scanning technique [2]. The former method is also conventionally known as coincidence scanning method; the latter uses much lesser time and also needs no auxiliary detectors unlike the coincidence scanning technique.

In this communication we report research work aimed towards developing a detector assembly which can fulfill the one-shot scanning setup. For the same it is important to use a precision based position sensitive detector; to serve this purpose, we have used a Hamamatsu manufactured position sensitive photo multiplier tube (PS-PMT). The principle governing such detection is based on precision achieved in being able to locate a point of interaction within the detector to the order of a few millimeters, and hence being able to re-create the image of a radiation source. This can be achieved using individual multi-anode wire readout technique. In order to trigger the PMT signals, we use a 3mm Cerium doped Lutetium Yttrium Orthosilicate (LYSO) crystal optically coupled to the PMT. [3]

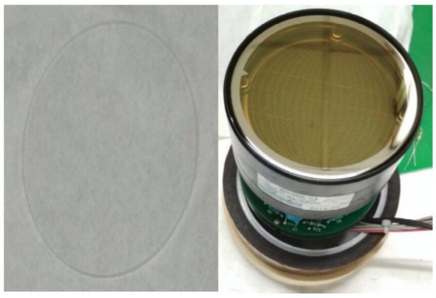

Fig. 1 LYSO (Ce) crystal and R2486-03 Hamamatsu PMT (top view).

Testing Details

The PMT was biased at -1300V. The primary outputs of the manufactured PMT base were the anode signals from either end of the horizontal (X axis) and vertical (Y axis) mesh grid; there is no energy information signal output It was necessary to amplify the raw signals using a Phillips 776 16-channel amplifier to be processed by a QDC. Further, in order to enable multiple outputs with various delays and dedicated CFD output, a home made active splitter was used [4].. Upon carrying out several trials with different γ-sources to efficiently test the assembly, we could zero-in on the technique of using ^{22}Na source with a coincidence detector- Cerium doped Lanthanum Bromide detector scintillator crystal ($LaBr_3$) placed exactly opposite the LYSO assembly in order to veto out any energy counts recorded by LYSO other than 511keV. However, it was observed that due to the extremely high internal activity of LYSO, the spectrum was crowded by background counts and it was impractical to try to estimate position information from such a setup. Hence, in order to augment the PMT readout performance, we modified the PCB in-home to additionally extract an output coming directly from the last dynode before the resistive chain based position signal division, using proper RC-circuitry. This additional signal served as energy output of the PMT and was used in a coincidence gating with the veto detector's energy output via an ADC. In the software we could gate the 511keV energy recorded by the veto detector to clean up the LYSO spectra. Appropriate and compact pulse processing was undertaken in order to not lose on the signal strengths and also to ensure faster processing times.

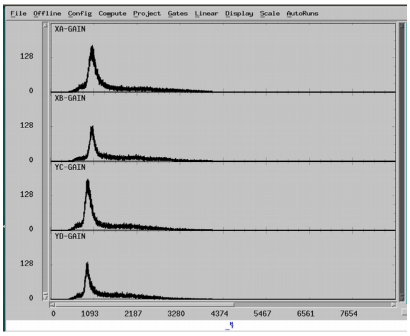

Fig. 2 Raw position signals from either ends each of the X and Y chains

Results

Detailed characterization and testings were carried out at the Nuclear Physics Laboratory of University of Delhi. Final data collection with gamma source was undertaken at IUAC. Preliminary analysis has been done using the *C*ollection & *A*nalysis of *N*uclear *D*ata using *L*inux n*E*twork (CANDLE) [5]. Figure 2 displays the individual position signals obtained after pulse processing using CAMAC based data acquisition system. A two-dimensional plot was generated, as well, to precisely estimate the position information that can be effectively extracted from the PS-PMT. For the same, the source was kept in various point with respect to the scintillator and a 2-d plot was obtained. Figure 3 mentions the 5 points at which the source was kept, around 5cm away from the crystal. A rough average of ~3mm has been determined for the position resolution of the crystal-PS-PMT combination over various positions. However, this number is strongly dependent on the position of the source, distance of the source from the crystal, algorithm chosen for analysis, among other factors such as ability to suppress LYSO internal radioactivity. Further in-depth analysis would be carried out using multiple algorithms aimed towards improving the information extracted from the signals.

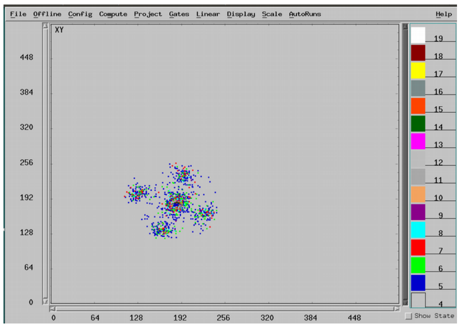

Fig. 3 Two-dimensional plot for different positions of ^{22}Na source facing the crystal

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