New Gamma Imager for Highly-Segmented Position-Sensitive HPGe Detectors

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Introduction

The research and development are being carried out globally in producing highly segmented Ge detectors, understanding the signal, and developing tracking algorithms. The interaction points associated with a particular gamma-ray can be identified based on their position and energy using gamma-ray "tracking", and the tracking can provide direction and location based on the known source point. The advancement in the field of gamma spectroscopy investigations is marked by the development of highly segmented position-sensitive germanium detectors. The highly segmented detector arrays offer notable characteristics such as gamma-ray tracking and Pulse Shape Analysis (PSA), which provides exact information about the location of the gamma interaction within the detector based on the comparison of pulses acquired from two orthogonal data sets [1]. Because of the complexity of pulses at diverse sites, characterization of such segmented detectors is required to record pulses for each gamma interaction point inside the detector [2].

Experiment and Analysis

The new Position Sensitive Detector (PSD) consists of a cylindrical LYSO scintillator crystal of dimensions 7 cm x 3 mm has been developed. The scintillator has been coupled to the matrix of Sensl-manufactured c-type 3 mm x 3 mm 96 SiPMs using RTV615 silicone compound-based optical glue, with a high dielectric strength of the order of 20 kV per mm and a refractive index of ≈ 1.4 for efficient light transmission from LYSO to SiPM. The compound is mixed with a curing agent in a ratio of 10:1 by weight. The array has been constructed on a PCB with a back-end containing an RC circuit for pulse readout, i.e., reading electrical pulse produced after electron-hole pair generated by scintillation light falling on the SiPM p-n junction.

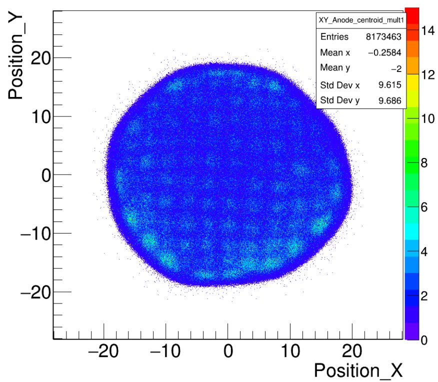

FIG. 1: Typical 2D spectrum obtained for coincidence setup using the GSI scanner.

In the present work, the output has been taken from the p-side (Anode), implying negative biasing to the detector for reverse biasing condition. In the next characterization step, the coincidence was set up between the GSI scanner and the PSD. The distance between the ^{22}Na source and the PSD was ≈ 8.2 cm. The distance was optimized for full solid angle

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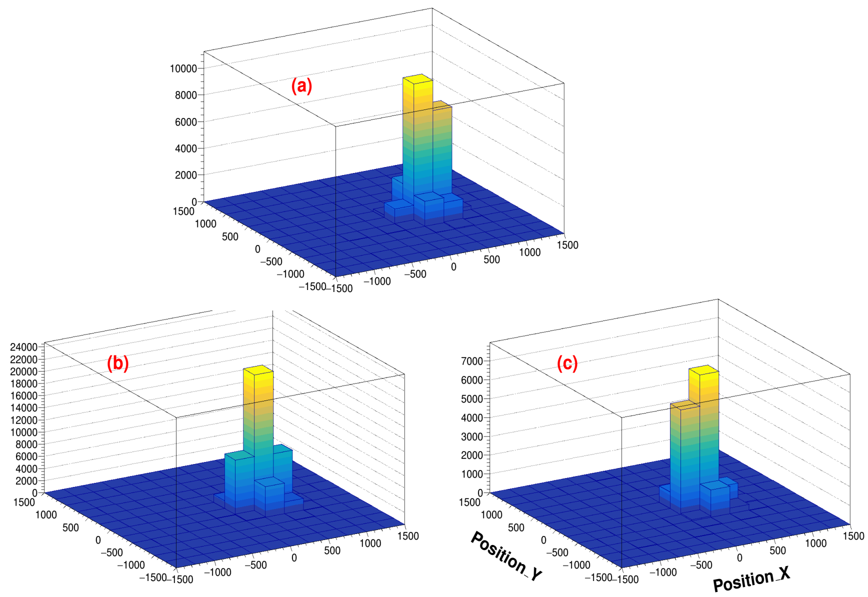

FIG. 2: The 2D distribution plot for various position cuts in the scanner (a) left edge, (b) middle, and (c) right edge. The intensities have been plotted as a function of Position_X and Position_Y of the SiPM matrix.

coverage around the PSD by checking 2D images using GO4. The setup was connected to the GSI-developed new FPGA-based digitizer, TAMEX.

A 2D image has been reconstructed using the GSI scanner for the coincidence setup. The image shows a uniform distribution of the charge for the coincidence data. This measurement has been obtained after many threshold settings to get an optimized charge distribution. Further, the 2D image has been reconstructed from the scanner for one of the reference SiPM firing. A minimum threshold has been applied on the Time Over Threshold (TOT) spectrum to investigate the amplitude of neighboring channels being fired.

Additionally, the intensity distribution of a reference channel has been examined in the presence of different gated neighbors, numbered 1, 2, and 3, which are shown in FIG.2 (a), (b), and (c), respectively. The image shows the sensitivity of the detector for different position cuts. The analysis has been further extended to determine position resolution by calculating the difference in amplitudes of neighboring channels for a selected reference channel. The outcome of these calculations indicates a remarkable position resolution ≈ 1 mm.

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References

[1] N. Goel et al., Nucl. Instr. Meth. A, **652**, 591-594 (2011).

[2] Arzoo, S. et al., Nucl. Instr. Meth. A, **1051**, 0168-9002 (2023).