Study of Hybrid Detector Sensitivity by Coincidence Scanning Technique

T. Arici[1,2], *I. Kojouharov*[1], *and J. Gerl*[1]
[1]GSI, Darmstadt, Germany; [2]Istanbul University, Turkey

Gamma-ray spectrometry with Ge and scintillation detectors is a well-established tool applied in many fields of investigation. The task is achieving the lowest detection limit in shortest measurement time, higher efficiency is supported by the technological progress in manufacturing new detection systems for a wide spread use of nuclear experiments [1].

The latest generation of Ge detectors, e.g. AGATA, have position sensitivity in order to enhance their capability of Doppler shift correction, background reduction and eventually tracking, thus improving the efficiency and the sensitivity. Due to the enormous complexity of such a system, the search for alternatives has led to the idea of a hybrid detector made out of a non-segmented HPGe detector and a position sensitive element. This element can be either another small segmented HPGe detector or a suitable position sensitive scintillator and will realize a system possessing position sensitivity for the first photon interaction, high efficiency typical for the large volume HPGe detectors and at the same time being simple, slim and less expensive. The hybrid system is based on photon scattering in a scattering detector and absorption in a large volume absorber detector. Useful events are selected as the sum of the energy deposited in the two detectors. Since the energy resolution of the system is the mean of scatterer and absorber detectors energy resolution, besides the HPGe detector, it is needed a new generation scintillation crystal which has respectively good energy resolution,e.g. $LaBr_3$.

A Geant4 simulation has been used to optimize the geometry of the assembly. There are a number of factors that influence the performance of a hybrid system which contribute to the sensitivity of the device.The major factors are thickness of the crystals, and the distance between the detectors. The results of the simulations have shown that the optimum configuration is a 15 mm thick scatter detector coupled to the absorber detector with 1 mm distance.

Triple Coincidence Measurement

An initial experiment with a ^{22}Na source was carried out using the coincidence scanning technique at the GSI scanning table[2]. Since the self-activity of employed LYSO scintillator results in peaks in the gamma spectrum due to random coincidences, the measurements were done by using an external p-type HPGe detector in coincidence with the system, as shown Fig. 1, to trigger the acquisition only when the both 511 keV photons of the source are observed.

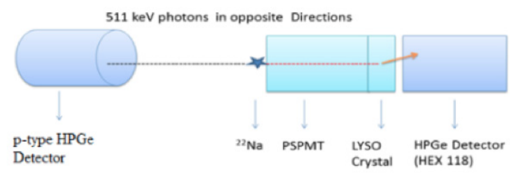

Figure 1: Geometry of the coincidence measurement using a p-type HPGe detector.

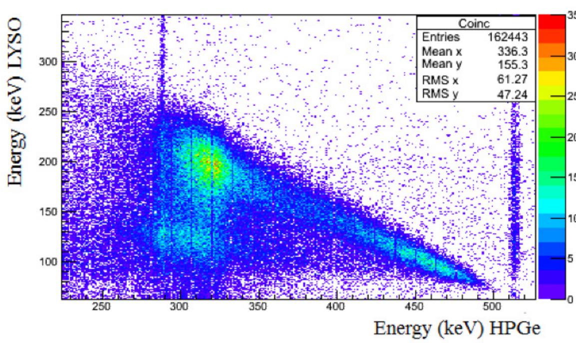

Figure 2: Coincidence energy matrix of energy deposition in LYSO scintillation detector and HPGe (Hex 118) detector.

Coincidence events appear in the central distribution of the 45 degree line, as shown in Fig. 2. The sum of each event around this distribution gives the total energy of 511 keV corresponding to different scattering angles from the LYSO crystal. The vertical lines in the matrix which are originating on the HPGE axis indicates the events which trigger in random coincidence, owing to self-activity of the LYSO crystal and the background which is absorbed by the HPGe detector.

The hybrid detector can be used with superior energy and position resolution and large efficiency. Replacing the HPGe with a segmented planar HPGe one or it can be used for tracking and imagining.

References

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