The Induced Charge Effect on Gamma-ray Spectrum and Position Resolution in a Planar Segmented Germanium Detector

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The position-sensitive gamma-ray detectors based on semiconductor crystals have shown capability of identifying interaction points for gamma rays inside the detectors. A segmented germanium detector is suitable for Doppler correction [1], linear polarization measurement, and gamma-ray imaging. In order the detector to function with good position sensitivity, the position resolution for interaction points need to be determined with accuracy much less than its segment size. Recently, it has been suggested that the induced charges on both collecting and spectator segments could be used to improve the in-plane position resolutions at least by a factor of two [2]. The depth position resolution could also be improved either by using the exponential attenuation law or by taking advantage of the induced charge effect.

We investigated the induced charge effect for a planar-type segmented germanium detector. The detector, manufactured by Eurisys Mesures, was a high-purity, p-type germanium crystal with dimensions of $5 \times 5 \times 2$ cm^3 and highly segmented into 25 segments with each area of 1×1 cm^2 on the front face [3]. We used two standard sources of ^{60}Co and ^{152}Eu as well as in-beam gamma rays of ^{155}Gd. Two- or higher-fold coincidences among segments enabled us to distinguish Compton and photoelectric events. Outer segments showed asymmetrical peaks with low-energy tails in energy spectrum, which could not be simply accounted for by incomplete charge collection. The time difference spectrum between a segment and an anode also showed photoelectric events missing from a distribution expected by the usual exponential attenuation law and further showed strong dependence on gamma-ray energy as well as on the segment location.

The observed low-energy tails and strong deviation from the exponential attenuation law are believed to be associated with the induced charge effect and the threshold set on each segment in a conventional analog signal processing. We performed the three-dimensional Green's function method in cartesian coordinates and obtained the shape of induced charges for all the segments. Our calculational method closely resembles a recent work done in Ref. 1. Our result and explanation based on the induced charge effect will be compared with two previous works [1,2]. We will also present our progress made in developing a GUI-based software to optimize design parameters in a Compton camera as the three-dimensional gamma-ray imaging device.

References

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[2] M. Momayezi et al., XIA Documents, http://www.xia.com.
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