Cross-talk correction in a planar HPGe strip detector

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Introduction

The next generation of detection systems in γ-spectroscopy measurements have been projected to be based on the concept of γ-tracking [1] for which highly segmented detectors will be required. Position information from such detectors will be used for reconstructing the path of the Compton scattered γ-rays and thus events that are otherwise vetoed in most present generation spectrometers would also be recovered, thus improving the detection efficiency tremendously. Towards this goal, properties of planar HPGe strip detectors which are proposed for their probable use in phase III of the DESPEC Germanium Array (DEGAS) [2], to be used for experiments within the DEcay SPECtroscopy (DESPEC) of exotic nuclei [3] project at the upcoming FAIR [4] facility at GSI, Germany, are currently being investigated.

Segmented detectors like AGATA [5], which have been developed for HISPEC [3] studies, have shown to exhibit cross-talk between its different segments, arising due to electronic coupling between them [6]. Within the γ-tracking procedure, when the partial energy signals due to Compton scattered events within two or more segments are summed to get the total energy deposited, the resultant peak is seen to shift in energy due to the effect of cross-talk, as compared to the photo-peak energy corresponding to full energy deposition in only one segment. If this shift is not corrected for, the tracking algorithms will give wrong position reconstruction as they rely on the energy of the Compton scattered γ. In the present work, this cross-talk effect for a planar HPGe strip detector has been investigated and a correction method for it is described.

Experiment Details and Analysis

The measurement was performed at GSI, Germany, employing a planar HPGe strip detector and using ^{60}Co, ^{137}Cs and ^{152}Eu standard γ sources to investigate the cross-talk effect in the γ energy range of 100 keV to 1.5 MeV, typical in most spectroscopy measurements. The detector has dimensions of 6 cm $\times$ 6 cm $\times$ 2 cm and consists of 10 horizontal and 10 vertical strips on the two faces of the detector which were respectively DC and AC coupled to the pre-amplifier. The detector was operated at -1900 V and the pre-amplifier output signals were fed to SIS3316 FADCs [7] having a sampling rate of 125 MHz. The signals were processed by a trapezoidal filter giving a digitized output. The VME based MBS [8] data acquisition was employed for collecting the data on an event by event basis with a trigger condition of OR of DC and AC side signals.

Following the calibration of the spectrum from each strip, the energies from each strip were summed (SumE) for different multiplicity (M) events (up to M=4 events considered in analysis), plotted in Fig. 1 as solid lines for both sides. For M>1, due to the cross-talk between different strips, the SumE peak is seen to split into two components around the photo-peak energy. The one at higher en-

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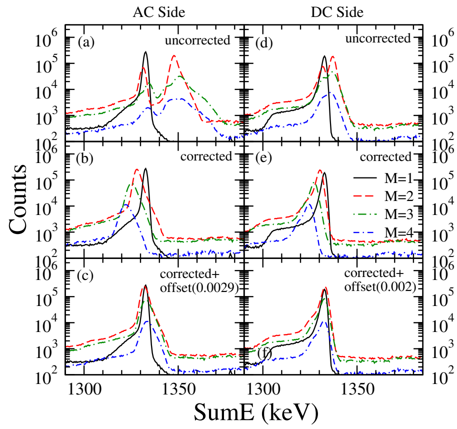

FIG. 1: Summed energy from all strips for events having different multiplicity, corresponding to Eγ=1332.49 keV impinging on the detector.

ergy is due to adjacent strips hit while the one at lower energy is due to far away strips hit. To correct for this shift, a linear model was used in which the true energy is E^t given by $\vec{E}^t$=$\mathbf{B}\cdot\vec{E}^m$, where E^m is the measured energy and **B** are the cross-talk coefficients. For the detector used, this equation becomes a 10 × 10 matrix.

$$\begin{pmatrix} E_1^m \\ E_2^m \\ \vdots \\ E_{10}^m \end{pmatrix} = \begin{pmatrix} 1 & \delta_{1,2} & \cdots & \delta_{1,10} \\ \delta_{2,1} & 1 & \cdots & \delta_{2,10} \\ \vdots & \vdots & \ddots & \vdots \\ \delta_{10,1} & \delta_{10,2} & \cdots & 1 \end{pmatrix} \begin{pmatrix} E_1^t \\ E_2^t \\ \vdots \\ E_{10}^t \end{pmatrix} \quad (1)$$

Here, for eg., $\delta_{1,2}$ is the contribution to the energy signal from strip 2 in strip 1 when a photoelectric interaction takes place in strip 1. As an illustrative example, to find $\delta_{1,2}$ the following was done: Using M=1 events, from the 2D spectrum generated from energy in strip 1 on one axis and of strip 2 on the other, the photo-peak in strip 1 was selected to be within 1332.49±10 keV in strip 1 and in strip 2 energy signals only above 35 keV were processed. This second condition was used as a threshold for distinguishing which strip (1 or 2) got hit. $\delta_{1,2}$ is thus given by $\delta_{1,2}$=$E_{1,2}/E_\gamma$, where $E_{1,2}$ is the energy in strip 2 when the photo-peak in strip 1 is selected. A similar procedure was applied for all combinations of strips and the extracted $\delta_{i,j}$s were plugged into eqn. (1). To recover the true energies, only the sub-matrix from eqn. (1) corresponding to adjacent strips was inverted. For eg., for M=2 events, inversion of the sub-matrix gives,

$$E_1^t + E_2^t = \frac{E_1^m(1-\delta_{1,2}) + E_2^m(1-\delta_{2,1})}{1-\delta_{1,2}\delta_{2,1}} \quad (2)$$

Results

The corrected SumE obtained from the above described procedure is plotted as the dash (M=2), dot-dash (M=3) and dot-dash-dash (M=4) lines in Fig. 1 (b),(e). We note that the above procedure was done for AC and DC sides separately as cross-talk arising on the AC side due to DC side and vice versa was not observed. The correction procedure above utilizes only the photo-peak events for estimation of cross-talk coefficients. It was expected that the above procedure would affect the Compton scattered events linearly. However, non-linearity in the scattered events corresponding to equal energy deposition in adjacent strips, was observed leading to the mismatch seen between the M=1 and the SumE events plotted in Fig. 1 (b),(e). This was accounted for, in an average way, by subtracting an offset value from the $\delta_{i,j}$ such that the corrected SumE peaks for different multiplicities coincide with the true photo-peak energy (as in M=1). Results of applying the correction along with the offset is shown in Fig. 1(c),(f) where a very good recovery of the SumE energies for M>1 events is seen.

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