Analysis of fold distributions of segmented clover detectors

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Introduction

Apart from physical segmentation of spectroscopic grade Ge detectors (ex. clover detector), even greater granularity can be achieved by electrically segmenting each of the Ge crystals. Further support from efficient algorithms result in an improvement in the determination of the position of interaction that allows a more precise correction of the Doppler broadening of gamma-rays from recoiling nuclei to be performed [1].

We have studied the effect of segmentation on the full energy energy deposition of a gamma-ray through the studies on fold distribution [2]. The response of seven segmented TIGRESS detectors up to an energy of 8 MeV has been studied by utilizing standard sources of ^{152}Eu, ^{56,60}Co and a radioactive ^{11}Be beam with an energy of 16.5 MeV. Experiment was performed at the ISAC-II facility at TRIUMF, using a thick gold target. The β^- decay of ^{11}Be ($\tau_{1/2}$ = 13.81(8) sec) produces high energy gamma-rays up to 7974 keV [3]. A 1 mm thick annular double-sided silicon detector of the BAMBINO detector, was mounted 19.4 mm downstream of the target position and used for detection of the electrons in coincidence with the gamma-rays from the seven TIGRESS detectors. The master trigger allowed data to be collected either in Ge singles mode or with a Ge-Si coincidence condition. Standard sources of ^{152}Eu and ^{56,60}Co were also used to obtain low energy data [2].

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Fold distributions

We will consider the following two types of fold distributions (fd) as discussed below:

- **Clover fold distribution of TIGRESS array:** This distribution gives information about the distribution of hits in the seven TIGRESS clover detectors of the array for full energy absorption of a gamma-ray.
- **Segment fold distribution of TIGRESS crystal:** This distribution gives information about the distribution of hits in eight segments of a TIGRESS detector for full energy absorption of the gamma-ray in the detector.

The clover fold distribution is shown in inset A of figure 1. It is observed that the single hit distribution decreases with increasing energy while the distribution for multiple hits increases. The change in clover fd is much slower compared to that of crystal fd. At 8 MeV, the number of two clover hit events is $\approx$ 6% while higher hit events are negligible. The array addback factor has been calculated for the first time and shown in inset B of figure 1. Its value increases very slowly from 1.0 attaining 1.06 at 8 MeV.

The segment fold distribution for single crystal hit events is shown in figure 2. It is observed that the full energy peak efficiency is dominated by multiple hit events above $\approx$ 800 keV. The single hit distribution crosses double, triple and quadruple hit distributions at 923, 2484 and 4665 keV, respectively. The full energy peak efficiency is dominated by double hit events above 1 MeV for single crystal events. This shows the relative importance of double hit events, for instance in gamma-ray position reconstruction. At 8 MeV, the percentage of multiple hit events which contribute

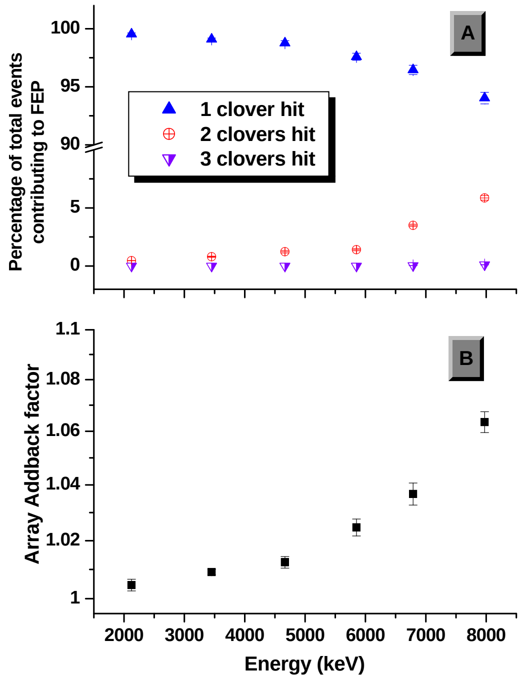

FIG. 1: Figure A shows the experimental clover fold distribution of seven TIGRESS detectors. Figure B shows the array addback factor.

to full energy peak is found to be ≈ 90%. This is almost twice the number of multiple hit events from the crystal fold distribution at 8 MeV. In a TIGRESS detector, the average volume of a segment is ≈ 1/8th of crystal volume. It seems that a reduction in size by 8 times increases the multiple hit events by a factor of 2 at 8 MeV. Around 8 MeV, there are events (≈ 4%) where more than six segments have fired. Further investigations are warranted for practical use of these fold distributions.

References

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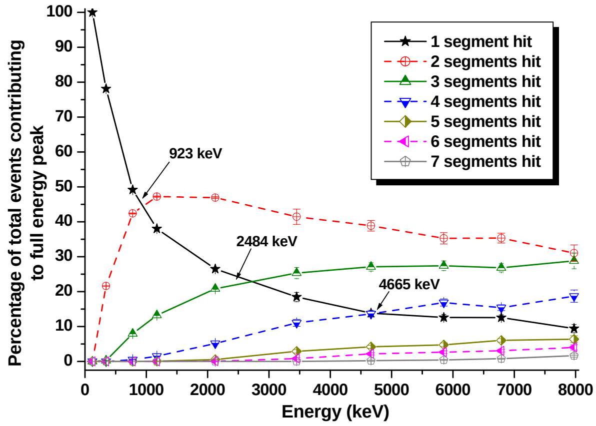

FIG. 2: Experimental single crystal segment fold distribution for a TIGRESS crystal.