Characterization of a Planar Ge Strip Detector and its Coupling with a Segmented HPGe Clover Detector.

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Introduction

Advances in high purity Ge (HPGe) detector technology play the central role in improving our knowledge of the nucleus. Recently, the focus of the HPGe detector research is to explore the segmentation of electrical contacts. The increased segmentation gives better information about the interaction position of the gamma rays in the detector. Many types of segmented coaxial and planar detectors have been used for different experiments in basic and applied nuclear physics. A relatively new configuration is the double sided strip planar detector. This type of detectors will provide better position resolution for the interaction point of γ-rays. In the present work, the characterization of a planar 10X - 10Y double sided Ge detector (fabricated by Canberra) is reported. This detector was also coupled with a Clover detector and the add-back of the energies deposited in the planar and clover was studied. The scope of planar detectors for the in-beam as well as decay spectroscopy has been discussed in Ref [1,2].

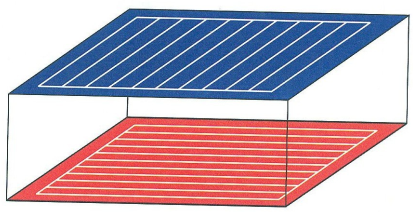

FIG. 1: Schematic diagram of the 10X - 10Y double sided Ge strip detector.

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Detector configuration and electronics

The schematic diagram of the planar detector is shown in Fig 1. The planar detector has 10X×10Y strips and size of 6 cm × 6 cm × 2cm. The X and Y strips were connected to the AC and DC coupled preamplifiers, respectively. A high voltage of -1800 V was required for the optimum bias condition for the detector. The 20 preamplifier signals were connected to a PXI-based digital data acquisition system based on Pixie-16 modules with 100 MHz sampling rate. The preamplifier pulses of a given event stored in the 100 MHz digitizers were shown in Fig 2 for the 662 keV transition of the ^{137}Cs source. The source was kept on the DC side of the detector. The total trace length was kept as 1.2 μsec for each of the pulses. The rise time of the pulses depend on the interaction position of the γ-ray in the detector. For the observed event, as the DC pulse has a smaller rise time compared to that of the AC pulse, the interaction has happened near to the DC strip. The rise time difference between the DC and AC pulses will provide the depth information of the interaction point. The digitized trace points were passed through a trapezoid filter in the onboard FPGA for the energy information of the pulses. The energy calibration for all the 20 strips is carried out using ^{57}Co, ^{133}Ba and ^{152}Eu radioactive sources. The full width at half-maximum (FWHM) for 81 keV for different strips vary between 1.8 to 2.0 keV, while for 1408 keV transition the FWHM is around 2.3 keV.

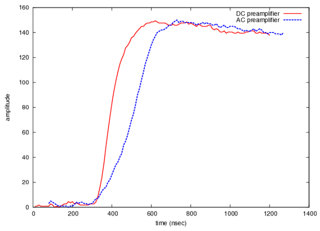

FIG. 2: Preamplifier pulses from DC and AC strips stored in the Pixie-16 module.

HPGe Clover & Planar geometry

The Clover and planar configuration is primarily studied to get better Doppler correction for detectors at 90^o. The HPGe clover and planar geometry are shown in Fig. 3. It shows that when a gamma-ray comes, it first hits the planar, deposits a part of its energy in the planar and rest in the clover, whereas for low energy gamma-rays get completely absorbed in the planar. In this configuration, the angle of incidence can be calculated and hence the recoil velocity of decaying nucleus can be used to do Doppler correction to a precise value.

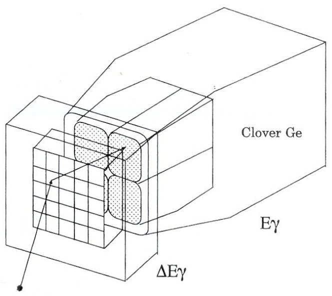

FIG. 3: The HPGe clover & Planar configuration, showing a prototype planar detector in front of the Clover detector [2].

The planar 10 × 10 X-Y strip detector was kept at distance of 1 cm from the clover detector surface. The source was kept on the DC side of the planar detector at a 14 cm distance. The γ-ray spectrum was recorded for a Eu-Ba mixed source of known strength.

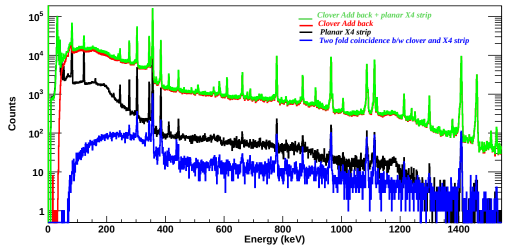

FIG. 4: Black: The X4 planar strip spectrum. Red: Clover add-back spectrum. Green: Sum spectrum of coincident events in the clover and X4 strip. Blue: 2-fold coincidence spectrum between clover addback and planar X4 strip.

The spectrum for the clover add back (in red) and planar X4 strip (in black) is shown in Fig 4, along with that the addition of coincident events in clover and planar strip is also shown in the same plot in green colour. The spectrum shown in blue is 2-fold coincidence spectrum of addition X4 strip and the clover add-back. For the X4 strip spectrum, it is clear that it has more efficiency of low energies than for high energy γ-rays. Therefore the low energies deposit most of their energy in the planar, whereas the high energy γ-rays get scattered from the planar detector and deposit more of their energy in clover.

Conclusion

Hybrid structure of clover and planar was investigated and the two-fold coincidence addback spectra indicates its usability for Doppler correction for higher energy gamma rays. Further work is under progress to do the pulse shape analysis to obtain better position resolution.

References

[1] S. Tashenov and J. Gerl NIM A 586, 224 (2008).

[2] Rainer M. Lieder, Report on TMR User Meeting on Gamma Ray Tracking Detectors, University of Cologne, Germany (2000).