Clover detector setup at VECC

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Introduction

One of the main interests of the present day nuclear structure studies is to carry out both yrast and non-yrast gamma ray spectroscopy to identify various single particle excitations and new symmetries of nuclei around the stability line on one hand and on the other hand to explore new structure information of nuclei away from stability line. These aspects of studies can be pursued effectively with both light and heavy ion beams from the cyclotron at the Variable Energy Cyclotron Centre (VECC), Kolkata. For this purpose, various detector facilities have been planned, a moderate Clover HPGe detector array is one of those.

Clover HPGe detectors form an essential part of any high efficiency experimental facility for exploring the structure of nuclei. In this paper, the initial performances for six newly purchased clover detectors are being reported. Clover detector consists of four tapered crystal in closed pack configuration and put in a single cryostat. The main advantage of Clover configuration over single crystal HPGe detector is its granularity which allows us for a) precise correction of Doppler Broadening by knowing the angle of the incident gamma more accurately b) determination of polarity by measuring the ratio of parallel and perpendicular component of Compton scattering from crystals of a clover c) Addback property to get back the compton scattered data to increase the photopeak efficiency.

Characterization

The basic characteristics of the detectors, viz., resolution, addback factor, efficiency and timing properties have been tested with ^{152}Eu, ^{133}Ba and ^{60}Co radioactive sources. The data were collected in singles mode with an MCA for estimation of resolution of detectors with shaping time 6μs for 1 kcps and with 3μs for 5 kcps. The typical energy resolutions were found between 1.85-2.02 keV at energy 1332 keV at 6μs. To estimate the addback properties, the data were collected in LIST mode using a CAMAC based data acquisition system with master gate generated from the OR of all four crystals of the Clover detector. The addback spectra of various sources were generated after gain matching the individual crystals. The absolute addback efficiency was obtained at various distances considering the absolute strength of the source. The absolute addback efficiency of the Clover detector at 20cm is shown in Fig. 1. It is clear that the efficiency in addback mode effectively increases for energies greater than 200 keV due to the recovering of Compton scattered events. The calculated addback factor is shown in Fig.2 as a function of energy. At 1332 keV the addback factor was found to be about 1.48±0.03 which slightly lower than the reported value 1.52 at 1332 keV in previous measurements [1]. It is also observed that at lower distances, due to summing effect, the addback factor becomes less than 1.0 at lower energies.

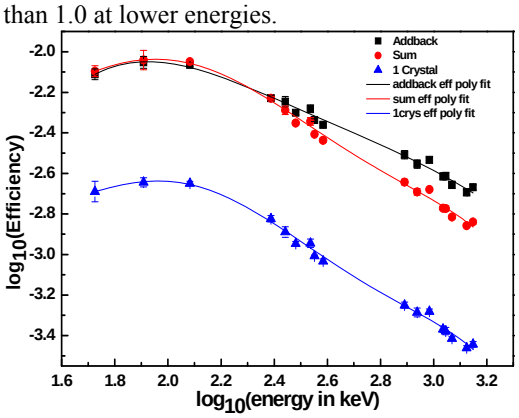

Fig. 1 Addback efficiency, direct sum of four crystals and one single crystal at 20 cm.

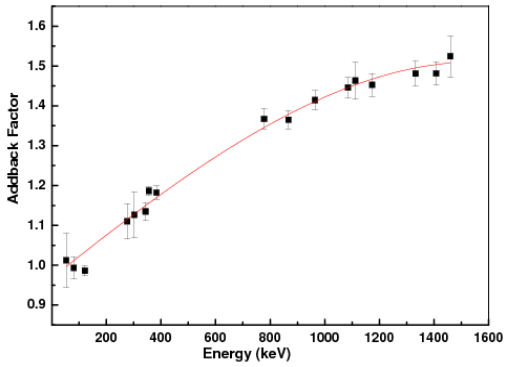

Fig 2: Addback factor as a function of energy.

Timing response of the detector was obtained with respect to a BaF_2 detector. For this purpose, the BaF_2 detector of size 1″ × 1″ and of timing response 300ps was set up and coincidence data was taken with ^{60}Co source with a trigger condition of (BaF_2). AND. (OR of all crystal). In Fig. 3a the total TAC along with the TAC projections choosing the individual crystals are shown. It is seen clearly that there is a time mismatch (of about 5ns) between the individual crystals. In Fig.3b, the same projection with selection of 1332 keV in BaF_2 and 1173 keV in individual crystal is shown. The typical time resolution of the Clover detector without energy selection is obtained about 8ns, without time matching of individual crystals. The individual crystals show the time resolution of about 5ns, which is improved to about 4ns after particular energy selection in BaF_2 and one crystal.

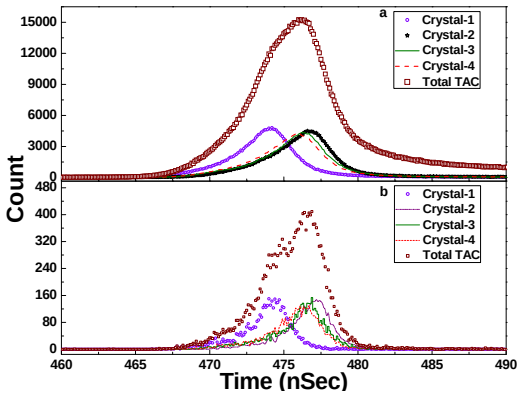

Fig. 3 Total TAC and projection of TAC of individual crystal (a) without and (b) with energy selection.

Geant4 Simulation

Geant4 simulation [2] has been initiated for a clover detector by reproducing the shape of each crystal close to actual shape. The tapered shapes of the crystals are reproduced by considering each crystal as a combination of a rectangular box with a trapezoidal shape in front of it, keeping the total volume as 470 cm^3, which is the effective volume of the Clover detector. The detector simulation is performed using a series of Geant4 classes like detector construction and material building, particle and physics process definition, particle tracking, event action, etc. The particle (gamma) are randomly generated by a particle generator (G4ParticleGun) and tracked through the detector volume. The energy deposition are recorded step by step and added for each event. For interaction of γ-ray with matter all possible electromagnetic processes are included. The Geant4 simulation reproduced the background subtracted addback spectrum for ^{60}Co source reasonably well, as shown in Fig. 4, except for the higher energy background part, which is slightly underestimated in simulation. Further refinement in simulation with accurate geometry is being carried out.

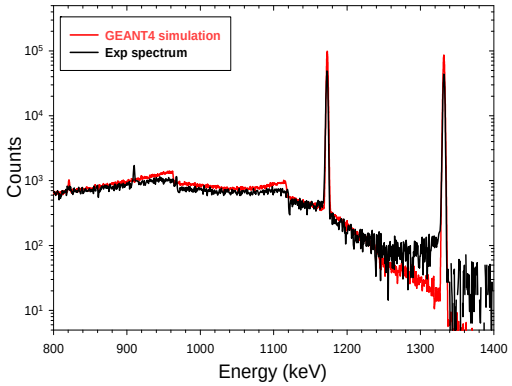

Fig. 4 ^{60}Co spectrum compared with GEANT4 simulation.

References

[1] G. Duchene et al., NIM A 432, 90 (1999).
[2] S. Agostinelli et al., NIMA 506, 250 (2003).