Performance test of Clover detector and BEGe detector

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Absolute γ-ray efficiency curves were obtained for an unsuppressed Clover detector and a Broad Energy Germanium (BEGe) detector in the energy range E$\gamma \sim$ 50 - 1400 keV, by placing radioactive sources at 10 cm and 1 cm from face of the detectors. It was found that the absolute efficiency of an unsuppredssed clover detector is considerably higher than the BEGe detector. The summing effect for the unsuppressed clover detector in a close geometry setup is much less than that for a BEGe detector.

1. Introduction

The 3 MV tandem accelerator at the FRENA facility in SINP, Kolkata which is soon to be operational is primarily aimed at studying reactions of astrophysical interest, with beams of stable projectiles. The first phase of experiments will have to be carried out mainly by detecting the gamma rays emitted by the reaction products. At energies near the astrophysical domain, the cross-sections for these reactions are very small and so highly efficient detectors are one of the essential requirements for such measurements. Also, for such measurements, the gamma-ray detector has to be placed very close to the target to increase the efficiency, though one has to do summing correction for a close geometry setup. Usually large volume HPGe detectors are used for these measurements, as such detectors with large efficiencies are available nowadays. Such detectors are very expensive and presently, we do not have any in our laboratory. However, we have a number of clover detectors with Compton suppressors. A Compton-suppressed clover detector, in addback mode, is known to have efficiency much higher than a standard HPGe detector. But a clover detector with Compton suppressor cannot be placed very close to the target position, and placing the detector far away from the target position will result in a loss of efficiency. So working with an unsuppressed clover detector, in addback mode, is one of the options for some of the initial set of experiments once FRENA becomes operational. Also, it has been reported in Ref. [1, 2] that a Broad Energy Ge (BEGe) detector has higher efficiency and better resolution at low energy up to 1.5 MeV compared to standard HPGe detector of similar specification.

Therefore, in this work, we report the absolute efficiencies measured for an unsuppressed clover detector and a Canberra BEGe detector.

Experiment

The experiment was performed in our laboratory at SINP, Kolkata. Gamma-ray spectra were recorded in a CAEN desktop digitizer DT5725S, by placing the calibrated radioactive point sources, ^{152}Eu and ^{133}Ba at distances of 10 cm and 1 cm, respectively, from the face of an unsuppressed CANBERRA clover detector. The resolution of each crystal was less than 2 keV. The bias voltage +2700V was supplied by the ORTEC-660 high voltage power supply. The CAEN digitizer takes care of signal processing and data acquisition. Primary data analysis was done using the CoMPASS software [3]. The gamma ray spectrum, in addback mode was generated using the CoMPASS software. Final analysis of the addback spectra was done using ROOT Data Analysis Framework software.

The gamma ray spectra were also recorded by placing the same radioactive sources at the same distances from the face of an electri-

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cally cooled FALCON 5000 BEGe detector. The FALCON detector is a complete stand-alone system with a full version of data acquisition and analysis GENIE-2000 [4] software included. The unit includes electric cooling for Germanium detector, High Voltage Power Supply (HVPS) for detector and Digital Signal Processing (DSP) Unit. The DSP unit takes care of pulse processing and amplification. The GENIE-2000 software has great capabilities for acquiring and analyzing the spectra from Multichannel Analyzer (MCA). The data acquisition and analysis ware done using the GENIE-2000 software.

2. Analysis and Result

While analyzing the γ-ray spectra for both the detectors, the area under each γ-ray peak was determined by fitting the peak with a Gaussian. The absolute efficiencies and the corresponding errors were calculated using the Eqns. (1,2):

$$\eta = \frac{C/sec}{I_\gamma A_t}. \tag{1}$$

$$\Delta\eta = \eta\sqrt{\left(\frac{\Delta C}{C}\right)^2 + \left(\frac{\Delta I_\gamma}{I_\gamma}\right)^2 + \left(\frac{\Delta A_t}{A_t}\right)^2}. \tag{2}$$

Whare η, C, I_γ and A_t is the efficiency of detector, count under a γ-ray peak, intensity of a γ-ray and activity of source, respectively. Gamma-ray intensities were obtained from Ref. [5] and the radioactive source activities were calculated using Eqn. (3):

$$A_t = A_o \ \ exp\left(\frac{0.693t}{t_{1/2}}\right). \tag{3}$$

Whare A_t, A_o, t and $t_{1/2}$ are activities at time t, initial activity, duration, half-life of the source.

Fig -1 shows the absolute efficiency plots for the unsuppressed Clover detector and BEGe detector, in the γ-ray energy range 50-1400 keV, with radioactive source at 10 cm from each detector. We can clearly see that the absolute efficiency of the unsuppressed clover detector is much higher than the BEGe detector.

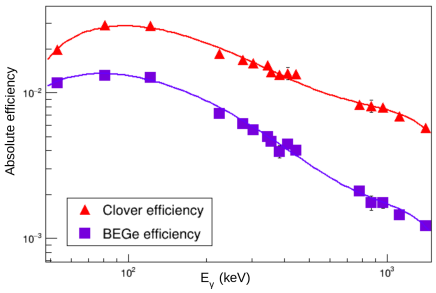

FIG. 1: Absolute efficiency for a clover detector and BEGe detector with radioactive point source at 10 cm from detector.

The analysis of the γ-ray spectra taken at 1 cm from the detector face, shows that the summing effect was much less for the clover detector compared to the BEGe detector. Details of the work will be presented at the symposium.

This study encourages us to place an unsuppressed clover detector very close to the target for detecting the gamma rays for the measurement of very low reaction cross-sections in some of the initial set of experiments at FRENA.

References

[1] Pawel Mekarski et al., J. Radioanal. Nucl. Chem. 314 (2017) 273-279
[2] Chuanlei Liu et al., J. Radioanal. Nucl. Chem. 312 (2017) 471-478.
[3] https://www.caen.it/products/compass
[4] G. Lutter et al., Appl. Radiat. Isot. 134 (2018) 200-204.
[5] http://nucleardata.nuclear.lu.se/toi/nucSearch.asp.