Characterization of NaI(Tl) Sum Spectrometer and its utilization

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Introduction

Recently, resurgence in the use of large NaI(Tl) detectors as total absorption spectrometers (TAS) has been observed throughout the world [1]. The large scintillators were used earlier as total gamma-energy spectrometers for selection of high spin states populated in compound nuclear reactions [2]. Large crystals are used as anti-Compton shields for high-resolution HPGe detectors. Due to their huge sizes, they should also be effective as passive shields to reduce the room background radiation. In their active usage the background due to the Compton distribution may be suppressed by a factor of 10 [2].

In the present work, a sum spectrometer consisting of six large NaI(Tl) detectors has been set up with a CAEN 5780 digitizer, characterized and then utilized to suppress room background.

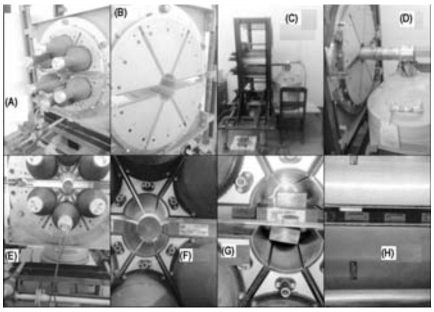

FIG. 1: (A) and (B) The two different views of the Sum Spectrometer with six NaI(Tl) detectors. (C) and (D) The HPGe detector inserted in the spectrometer for background suppression. (E), (F) provide closer view of the HPGe in the spectrometer and (G), (H) show additional Pb bricks for improved shielding.

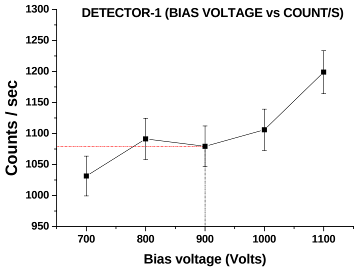

FIG. 2: The variation of count rate of the detector-1 with changing bias voltage.

Characterization and Utilization

The detector we dealt with in this project is a module of 6 large NaI(Tl) detectors of Harshaw/Filtrol make of 1980s (approx.) of dimension 45cm in length and 4.5cm in width (average), arranged in a hexagonal pattern having a cylindrical cavity in it, mounted on an iron frame (Fig. 1). No external preamplifier has been used. There is a single photomultiplier (PMT) at one end of each detector. The PMT has one signal and one bias voltage connection point. The sources had been placed inside the cylindrical cavity during testing of the detectors. The resolution of each of the six detectors were obtained separately by using standard power supply, amplifier and MCA with ^{60}Co and ^{137}Cs radioac-

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*Electronic address: `maitrayee.sahasarkar@saha.ac.in` tive sources. Later the same was tested using CAEN DT5780, a Dual Digital Multi Channel Analyzer (HV & Preamplifier PS) - Desktop module. Intially, it was necessary to figure out the optimum values of the parameters of the digitiser that gives the best spectrum for each of the crystals. We next studied the plateau characteristics i.e, variations in the spectrum with increasing bias voltage and found out the optimum bias voltage for which the response of the detector is the best from the count rate vs bias voltage curve (Fig. 2). However, we decided to give +800V bias to all these detectors for uniformity. As the detectors are much larger than the usual ones which we generally use in our laboratories, the effect of varying the position of the source in the responses of the detectors has also been studied. A special attachment has been fabricated in our workshop for this purpose.

For using all these detectors simultaneously, six high voltage units are needed. However, considering the current requirement of each detector, it was found that a single ORTEC 556 high voltage unit may provide bias to all of them through a high voltage distribution box fabricated in our laboratory.

In experimental low energy nuclear astrophysics experiments, most of the event rates are low and therefore extremely low gamma ray or other nuclear radiation environment is essential. For gamma spectroscopy experiments, the gamma peaks of interest are often weaker than those originated from the natural room background. Estimation of the background gamma ray level existing in the laboratory is therefore very important. In the present work, we have utilised the sum spectrometer as passive and active shields to set up low background gamma detection system [3]. We have compared different setups with and without the spectrometer to observe the differences in background gamma ray spectra detected by a 25% HPGe long-neck detector (Fig. 1C,D). The improvements have been quantitatively estimated and any additional contribution from spectrometer has also been checked. The figure (Fig. 3) visibly demonstrates more than 1 order of magnitude reduction in gamma ray background in the HPGe spectra with the spectrometer as a passive shield. The preamplifier pulses from six detectors have been gain matched to take the sum output from the spectrometer to use it as an active shield. The digitizer setup for using this spectrometer signal as veto to the HPGe is being optimized to estimate the active shield suppression factor.

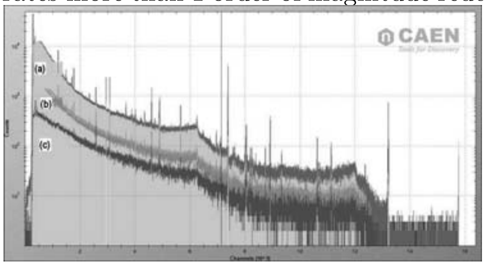

FIG. 3: Comparison of background gamma ray spectra detected by a HPGe detector (a) without any shielding, (b) with the sum spectrometer as a passive shield (Fig. 1 C,D,E,F) and also (c) with additional Pb blocks (Fig. 1 G,H).

This work demonstrates immense possibility of using this spectrometer in our future nuclear astrophysics experiments.

Acknowledgments

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References

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