A modular TAS Setup at VECC using BaF_2 detectors

G. Mukherjee,* Balaram Dey, S. Mukhopadhyay, Deepak Pandit, Surajit Pal, H. Pai and S.R. Banerjee

Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700064, INDIA

* email: gopal@vecc.gov.in

Introduction

A Total Absorption Spectrometer (TAS) is a setup to measure the total energy of all the γ rays emitted in an event. Such a setup is very useful for the measurement of β-decay feeding intensity free from pandemonium effect [1]. Recently a modular TAS array has been set up at VECC using 50 BaF_2 detectors.

The setup

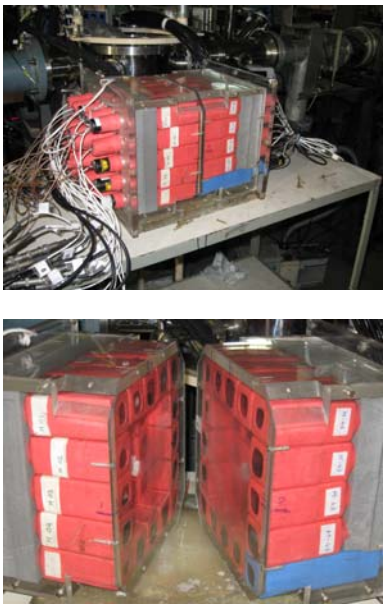

Fig. 1: (Top) The closed configuration and (bottom) two halves of the TAS array are shown.

Fig. 1 shows the TAS setup using smaller (3.5x3.5x5 cm^3) BaF_2 detectors at VECC [2]. The array consists of two blocks having 25 detectors in each. The detectors in each block were arranged in castle-type geometry. The blocks were brought together for a closed 4π configuration and the source was kept at the middle of the array. The closed configuration of the setup is shown in the top panel of Fig. 1 and the two blocks are shown in the bottom panel.

Measurements

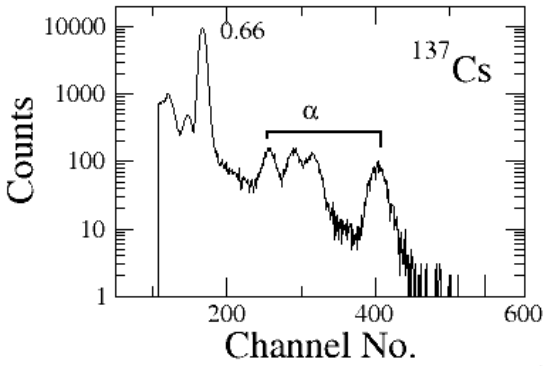

Fig.2: Raw spectrum of ^{137}Cs source obtained from a single BaF_2 detector.

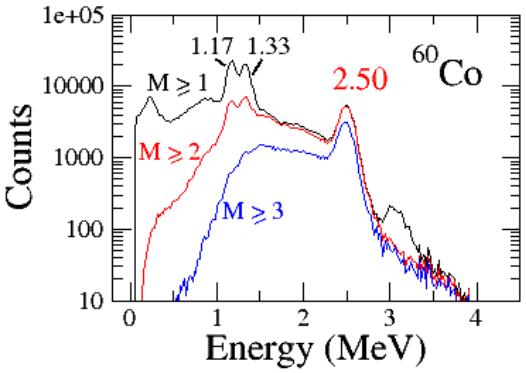

Fig.3: Sum spectrum of ^{60}Co source obtained from the TAS array for different multiplicity (M) condition.

The array can be used to measure the β-decay feeding intensity of radioactive elements. The array was tested using one-, two-, three- and multi-γ line sources ^{137}Cs, ^{60}Co, ^{22}Na and ^{152}Eu, respectively. A ^{137}Cs spectrum obtained from a single individual BaF_2 crystal is shown in Fig. 2.

The energy resolution of the BaF_2 detectors was about 8%. Energy calibration and gain matching of the crystals were done for obtaining the sum spectrum. A multiplicity spectrum, defined by the number of crystals hit in an event, was generated and the sum spectra were generated using different condition of multiplicity (M). A sum spectrum for ^{60}Co source is shown in Fig. 3.

Discussion

The advantage of a modular sum spectrometer to distinguish between a single-peak and a sum-peak is evident from the spectrum shown in Fig. 3. In a modular set up it is possible to choose different multiplicity conditions for obtaining the sum. We have shown here spectra obtained with three ($M \geq 1$, $M \geq 2$ and $M \geq 3$) different multiplicity conditions for summing. It can be seen in Fig. 3 that the intensity of the sum peak at 2.5 MeV remains almost same while there is a drastic reduction in intensity of the individual (1.17 and 1.33 MeV) peaks for $M \geq 2$ and $M \geq 3$. Therefore, the lines observed in the high-M gated sum spectrum can be directly considered as the energies of the levels to which most of the β-decay take place.

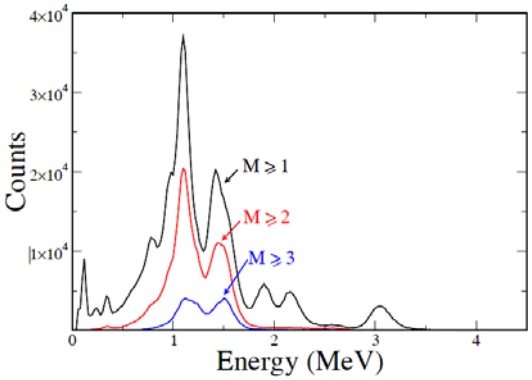

Fig. 4: Sum spectrum of ^{152}Eu source for three multiplicity conditions.

The sum spectrum obtained using a ^{152}Eu source is shown in Fig. 4 for three different conditions of multiplicity M. The ^{152}Eu source has a complicated decay scheme with several γ-rays as observed in Fig. 4 for $M \geq 1$ but at higher multiplicity condition, many of these peaks disappear and only three peaks are seen at 1.1, 1.3 and 1.5 MeV energies. These correspond to the energy of the levels of the daughter nuclei to which maximum β-feeding take place for ^{152}Eu [3].

Simulation

To understand the sum spectrum, we have done a simulation in the GEANT-3 platform for the γ-rays in ^{60}Co source. The simulated spectrum is shown in Fig. 5 overlaid with the experimental data. Both the simulation and the data are for multiplicity condition $M > 1$. There is a good agreement between the data and the simulation except for the low energy part. It may be noted that the low energy absorption in the source casing and in the structure of the array were not considered in the simulation.

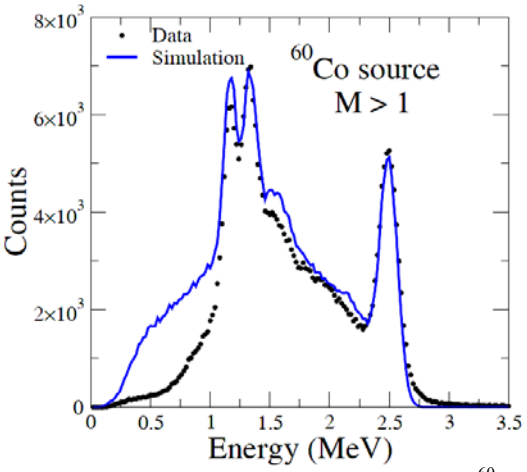

Fig. 5: Simulated spectrum (solid line) of ^{60}Co along with the experimental data (solid circle). Both are for multiplicity $M > 1$.

Conclusions

TAS measurements, performed with several γ-ray sources using a modular BaF_2 array at VECC, show the advantage of multiplicity gating in obtaining a sum spectrum. The GEANT-3 simulation agrees well with the experimental data. The details of the array and the results will be presented in the symposium.

References

[1] G. Mukherjee et al., DAE Symp. on Nucl. Phys. **55**, 708 (2010) & references there in.
[2] Deepak Pandit et al., Nucl. Inst. Meth. Phys. Res. **A624** (2010) 148
[3] http://www.nndc.bnl.gov/nudat2/