Characterization of Clover Detector for an Offline detector array

Abhijit Bisoi[1], Sudatta Ray[1], Dibyadyuti Pramanik [2], Suparna Hazra[3], Punya Chatterjee[4], Supriti Sen[5], and M. Saha Sarkar [1]*

[1] *Saha Institute of Nuclear Physics, Kolkata - 700064, INDIA*
[2]*Bengal Engineering and Science University, Shibpur, Howrah - 711103, INDIA*
[3]*University of Calcutta, Kolkata-700009, INDIA*
[4]*IISER Kolkata, Mohanpur - 741252, INDIA*
[5]*Lady Brabourne College, Kolkata,- 700017, INDIA*
* *email: maitrayee.sahasarkar@saha.ac.in*

Introduction

Advances in nuclear spectroscopy are closely related to the innovations in detection techniques. Recently we have started setting up a dedicated detector array setup for offline studies, more specifically, gamma spectroscopy of fission fragments. We have procured composite high energy (Clover) with anti-Compton shields and low energy photon spectrometers (LEPS detectors), dedicated high density spectroscopic amplifiers and multi parameter systems for this setup. Eventually we are aiming to build the electronic set up based on digital technology. Only few days back, the digital pulse processing spectrometer has been delivered to our lab. We have just started working on it. Among the four Clover detectors, two have been procured from ORTEC. These ORTEC Clovers have several differences with the usual Clovers (Canberra: Eurisys Mesures) used in our country. In the present work we shall report on the characteristics of the ORTEC Clovers with BGO shield from Saint Gobain and compare them with similar ones from Canberra.

Experiments

The present experimental setup consists of two ORTEC Clover detectors placed at a distance 13 cm from the source. Two radioactive sources (^{152}Eu and ^{60}Co) have been used for characterization of these detectors. The angle between the detectors is 135 degree. The primary difference between ORTEC and other Clovers is that each crystal in ORTEC Clover need a separate preamplifier and high voltage power. So we have used two four channel high voltage power supply (CAEN N1417) and eight single channel preamplifier power supply modules to provide necessary power. The standard NIM electronics are used to process energy and timing signals from the detectors. Two types of spectroscopic amplifiers (single channel and high density multi- channel) with different shaping times were used during our experiment. Four quad analog to digital converters (ADC) were used to digitize the amplifier outputs. Each ADC contains four independent 16k (14bit) conversion range pulse height analyzing Wilkinson-type with 100MHz clock rate each. The timing signals from individual crystals of each Clover detector are 'OR'ed, followed by 'VETO' from their corresponding BGO signal, to get anti coincidence signal. The anti coincidence gate for each crystal of the detectors have been generated by using anti coincidence signal and put this gate individually for each ADC. The data was taken in list mode using a Multiparameter Data Acquisition (MPA) system. The data were sorted using two different sorting programs developed in our laboratory. Finally the generated spectra were analyzed by the graphical analysis software package RADWARE [1].

Results and Discussion

As we are planning to build up a dedicated detector array with four Clover and four LEPS, we have used a 16 channel Mesytec spectroscopic amplifier instead of single channel amplifier for each crystal. This high-density amplifier helps us to have a compact electronic setup. The shaping time of this multi channel amplifier can be adjusted to 1, 2, 3 and 8μs. The

present work has been carried out with 3 µs shaping time. The energy resolution for each crystal with 6 µs shaping time has been also measured by using single channel spectroscopic amplifier. In case of peak to total ratio, we defined the total counts as the counts in the energy region 100 keV to 1360 keV.

Table 1: Essential features of different crystals of Clover 1.

	FWHM at ~ 1 MeV with Shaping time		Peak to total ratio	Suppression factor
	6 µs	3 µs		
Crystal -1	2.05	2.36	.20	1.57
Crystal -2	2.06	2.19	.14	1.12
Crystal -3	2.15	2.76	.16	1.28
Crystal -4	1.91	2.07	.20	1.51
Addback	-	2.71	.29	1.42

Table 2: Same as Table 1 for Clover 2.

	FWHM with Shaping time		Peak to total ratio	Suppression factor
	6 µs	3 µs		
Crystal -1	1.98	2.00	.23	1.67
Crystal -2	2.01	2.67	.22	1.69
Crystal -3	1.96	2.33	.22	1.65
Crystal -4	2.07	2.55	.23	1.73
Addback	-	2.78	.43	2.04

The coincidence time window for Addback mode was selected inside the MPA data acquisition system. In this system, the coincidence resolving time from 150 ns to more than 3 ms can be selected in steps of 50 ns.

We also calculated the suppression factor for each crystal of the detectors. The suppression factor is defined as the ratio of peak to total ratio (P/T) for Compton suppressed spectra in BGO anti-coincidence mode to that without any suppression. The variation of energy resolution, peak to total ratio and the suppression factor in direct and Addback mode of these detectors are shown in Table 1 and 2 respectively. The Full Energy Peak detection efficiency of two clover detectors is shown in Fig.1. The detection efficiency in direct mode and add-back mode has been normalized at 121 keV. The Addback factors of Clover 1 & 2 have been calculated for two different energies (1.17 and 1.33 MeV) and different time windows have been chosen for Clover-1 to optimize it. Finally we selected 10 µs as our resolving time window for coincidence measurement.

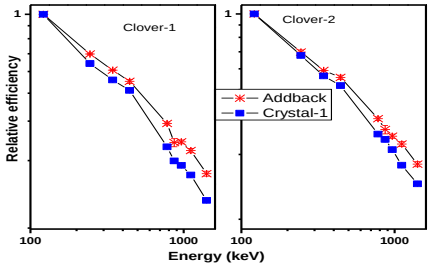

Fig. 1 Relative efficiency of two Clover detector.

Table 3: Variation of Addback factors with resolving time window

Timing window (µs)	At 1173 keV	At 1332 keV
0.5	1.20	1.22
1	1.33	1.34
5	1.31	1.37
10	1.34	1.36
15	1.34	1.36
20	1.30	1.34
25	1.30	1.33
10 (Clover-2)	1.36	1.39

From Fig. 1, it is clearly seen that the detection efficiency for energies higher than 300 keV in addback mode is better than the single crystal detection efficiency for both the detectors. The present setup is basically a slow coincidence setup. But the results are encouraging and to start with definitely shows acceptable performance level.

Conclusion

In the above experiment, we have utilised the coincidence gate generated within the multi-parameter DAQ system using the amplifier inputs. Characterization with digital DAQ system is being started to improve our results. We will also characterize other two Clovers (Canberra: Eurisys Mesures) and compare the results with ORTEC Clovers.

References

[1] D. C. Radford, Nucl. Instrum. Methods Phys. Res., Sect. A **361**,297 (1995)