Energy resolution and efficiency measurements of a 1.5″x1.5″ $CeBr_3$ scintillator

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Introduction

The availability of new generation scintillators, with much better energy resolution compared to other fast scintillators, such as, BaF_2, along with reasonably good time resolution, has created the opportunity to measure both energy and lifetime of nuclear excited states. In particular, the $CeBr_3$, $LaBr_3$(Ce) and other Lanthanum halide scintillators, coupled with suitable PMT offer the measurements of lifetime of nuclear excited states from few hundred picosecond to nanosecond range using various techniques [1-3]. A combined coincidence setup of high resolution HPGe detectors and these fast scintillators has been utilized in recent times for such measurements [4-6]. The $CeBr_3$ scintillators, having similar properties as that of $LaBr_3$(Ce), are less costly and also do not suffer from the intrinsic radioactivity, typical for Lanthanum Halide detectors. The present paper reports some of the basic characteristics, such as, energy resolution and efficiency, of $CeBr_3$ scintillator detectors with diameter 1.5″ and height 1.5″. $CeBr_3$ crystal has a density of 5.2 gm/cc, emission wavelength 380 nm and decay time 17 ns.

Experimental setup

The 1.5″x1.5″ $CeBr_3$ scintillators used for the present measurements are coupled to the Hamamatsu PMT R13089-100. Measurements of same size $CeBr_3$ detectors coupled to Hamamatsu PMT R6231-100 have been reported earlier [7]. The present experimental setup is shown in Fig.1. The detector bias voltage was set at -900V. The ORTEC spectroscopy amplifier of Model 672 with shaping time of 0.5μs was used and the data were collected using a data acquiring system of 8K MCA connected to a PC. The spectrum was calibrated using standard radioactive sources of ^{152}Eu, ^{133}Ba, ^{60}Co, ^{57}Co and ^{137}Cs, in the energy range of 14-1408 keV. The energy response, energy resolution and absolute efficiency of the detector at various incident gamma ray energies have been measured. Analysis of all the spectra has been carried out using LAMPS software [8].

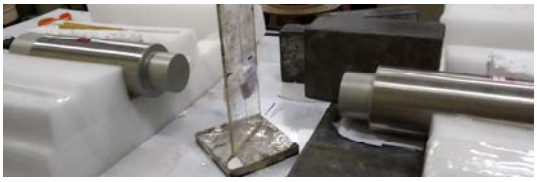

Fig.1: Experimental setup

Result and Discussions

A graph of energy calibration using the radioactive sources is shown in Fig.2, for the energy range of 14-1408 keV. It is observed that the detector exhibits almost a linear response.

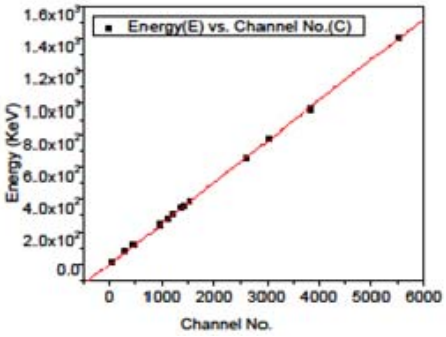

Fig.2: Energy calibration curve

The energy spectrum of all the sources, with known activity (dps) were recorded. A typical energy spectrum obtained with a ^{60}Co source is shown in Fig.3. The FWHM of each photopeak

were measured in keV and the variation of $(FWHM)^2$ as a function of energy is plotted in Fig.4 for the energy range 14-1408 keV.

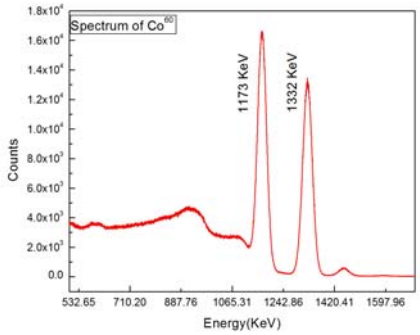

Fig.3: Energy spectrum using ^{60}Co source.

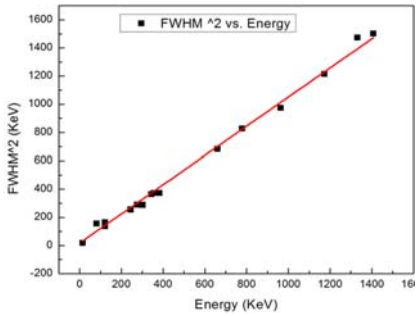

Fig.4: $FWHM^2$ vs. photopeak energy

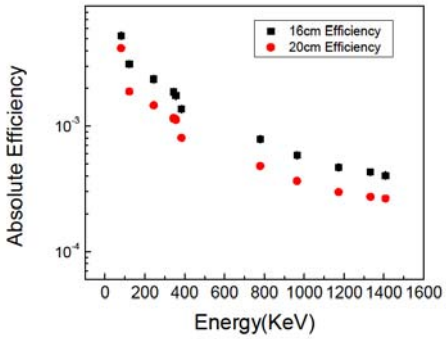

Fig.5: Absolute Efficiency of 1.5″x1.5″ $CeBr_3$ detector as a function of energy.

The absolute efficiency of the detector was measured at two distances of 16 cm and 20 cm in the energy range of 80-1408 keV using ^{152}Eu, ^{133}Ba and ^{60}Co sources with known activities. Fig.5 shows the variation of absolute efficiency of this detector as a function of energy. To compare the energy resolution and efficiency of 1.5″x1.5″ $CeBr_3$ detector with a Clover HPGe detector, energy spectrum of ^{152}Eu source was recorded with both types of detectors. Fig.6 shows the overlaid energy spectrum of ^{152}Eu of both Clover HPGe (one crystal) and 1.5″x1.5″ $CeBr_3$ scintillator detectors. Though HPGe detector is showing much better resolution, as expected, compared to the $CeBr_3$ detector, but major photopeaks of ^{152}Eu spectrum can be clearly identified in both the spectra. This graph reveals that resolution of $CeBr_3$ detector is poorer than that of Clover. The FWHM (keV) and the absolute efficiency of both the detectors are further compared in Table-I at 1332 keV energy of ^{60}Co source.

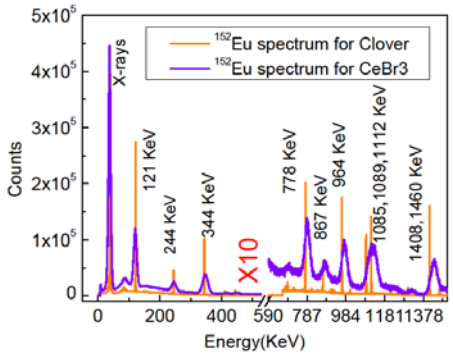

Fig.6: ^{152}Eu spectra of $CeBr_3$ and Clover detector

Table-I

Detector	FWHM @1332keV	Absolute Eff. at 20 cm @ 1332 keV
$CeBr_3$ 1.5″x1.5″	38.49 ± 0.06 keV	$2.71 \times 10^{-4} \pm 7.04 \times 10^{-7}$
Clover Addback	2.78 ± 0.05 keV	$2.03 \times 10^{-3} \pm 3.5 \times 10^{-5}$

Acknowledgement

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References

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