Study of Compton electrons in $LaBr_3$:Ce using compact CCT

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Introduction

Inorganic scintillators are most widely used detectors in the field of radiation spectroscopy. This has been possible due to excellent radiation detection properties of inorganic scintillators. They have much higher detection efficiency owing to their high effective atomic number. They can be grown in different shapes and sizes. However, energy resolution of inorganic scintillators is poor as compared to semiconductor detectors. This has led researchers to investigate the physical processes that are responsible for their poor energy resolution. An important contribution to energy resolution comes from the crystal itself, which is called intrinsic energy resolution. In our earlier work, we have used compact Compton Coincidence Technique(CCT) to study the intrinsic resolution of $CeBr_3$ crystal [1]. This technique was first developed by Valentine and Rooney in 1994 to study non-proportionality and intrinsic resolution of scintillators [2]. It consists of acquiring coincident data from tested detector($LaBr_3$:Ce) and reference detector(HPGe). Subsequently, spectrum of reference detector is gated and projected spectrum on tested detector is generated. The projected spectrum consists of electron response of scintillator only due to single Compton scattering events. CCT eliminates contribution of multiple Compton scattering. The Compton electron response provides valuable information about energy resolution and non-proportionality. In the present work, initial results of measurement of intrinsic energy resolution of $LaBr_3$:Ce crystal are presented.

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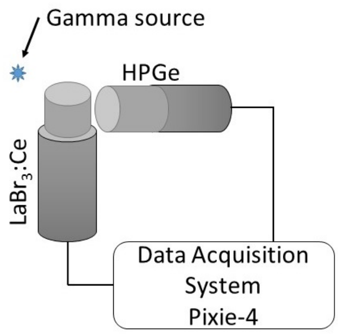

FIG. 1: Experimental setup of compact CCT.

Experimental Details

The schematic of experimental setup is shown in Fig. 1. $LaBr_3$:Ce crystal of dimension $1'' \times 1''$ was aligned at 90° with respect to $2.18'' \times 2.36''$ HPGe detector. The gamma ray source of ^{137}Cs was placed at an angle of 40° with respect to axis of HPGe. Data was acquired from both the detectors in coincidence mode using PIXIE-4. It is a digital data acquisition system which makes the whole setup very compact as no external amplifiers and coincidence units are required. Effect of coincidence time window on energy resolution of detector has been studied in our previous measurements [3]. Accordingly, we had set the coincidence time window of $1\mu s$ for the acquisition.

Results and Discussion

Fig. 2 shows the spectrum of $LaBr_3$:Ce after gating in HPGe at 430 keV. The spectrum shows peak at 232 keV which is due to Compton electron produced in $LaBr_3$:Ce. This peak

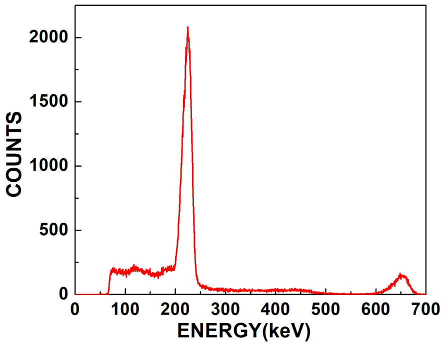

FIG. 2: Spectrum of $LaBr_3$:Ce when HPGe is gated at energy 430 keV.

can be fitted with Gaussian to obtain the energy resolution of $LaBr_3$:Ce at 232 keV. HPGe was gated at various energies to obtain energy resolution of the scintillator in wide energy range. Fig. 3 shows the energy resolution of $LaBr_3$:Ce at various energies obtained using CCT along with resolution due to gamma rays without using CCT. Energy resolution in both cases is found to be almost same. Assuming that a constant statistical contribution from photomultiplier will be there for every energy, it indicates that multiple Compton scattering doesn't play a significant role in energy resolution of the detector. These results suggest that electron scattering is responsible for the intrinsic energy resolution as suggested by previous studies [4].

Work is in progress to acquire coincident data for other gamma sources and to determine the statistical contribution of photomultiplier tube to the total energy resolution.

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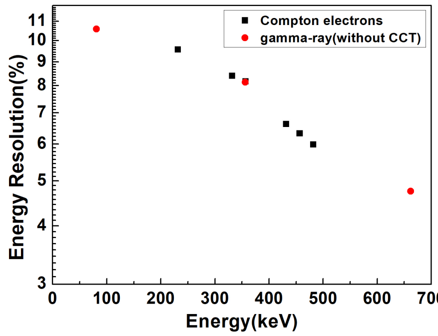

FIG. 3: Energy resolution of $LaBr_3$:Ce at various energies obtained using CCT

References

[1] V. Ranga *et al.*, IEEE Trans. Nucl. Sci., 65(2018)616-620

[2] J. D. Valentine, B. D. Rooney, NIM A, 353(1994)37-40

[3] V. Ranga *et al.*, DAE Symposium on Nuclear Physics, 62(2017)1108

[4] L. Swiderski *et al.*, IEEE Trans. Nucl. Sci., 57(2010)1697-1701