# Intrinsic resolution of Compton electrons in $LaBr_3$:Ce and $LaCl_3$:Ce detectors using Compton Coincidence Technique

Snigdha Sharma*,V. Ranga, M. Dhibar, S. Rawat, G. Anil Kumar
[1]*Radiation Detectors and Spectroscopy Laboratory, Department of Physics, Indian Institute of Technology Roorkee, Roorkee-247667*
** email: himasnig@gmail.com*

## Introduction

Inorganic scintillators find wide applications in the field of safeguards, nuclear medicine, environmental and experimental physics [1]. Energy resolution is one of the important parameters which determines the productivity of the detector and is greatly affected by the intrinsic resolution of the scintillator. Rooney and Valentine have designed and implemented Compton Coincidence Technique(CCT) to determine the intrinsic resolution of Compton electrons in scintillation detectors [2]. The technique is based on the detection of Compton scattered γ-rays and the basic principle of the method is to register in coincidence the signals from scattering of γ-ray inside the tested scintillator followed by absorption of the scattered ray inside the reference detector.Energy dependent intrinsic resolutions of $LaBr_3$:Ce were reported by Swiderski *et al*. using CCT [3]. However, no data exists for $LaCl_3$:Ce detector. The present work aims to measure the intrinsic resolution of Compton electrons in $LaBr_3$:Ce and $LaCl_3$:Ce detectors.

## Experimental Details

Two $LaBr_3$:Ce scintillation detectors were kept face-to-face at a distance of 6cm. A $^{137}$Cs source was placed between them.The size of the $LaBr_3$:Ce crystal was 1″×1″. One of the two detectors was used as a reference detector. Both the detectors were biased with 643V. The schematic of the experimental setup is shown in Fig. 1. We have used a PIXIE-4 module which is a multi-channel data acquisition system incorporating internal amplification system. In PIXIE-4, coincident data acquisition across channels is possible. Therefore, no external coincidence module was required.

The signal from the tested detector through a preamplifier was directly fed to channel 0 of the PIXIE-4 module and that of the reference detector to channel 1 of the module. The hitpattern of PIXIE-4 was so adjusted that only the signals detected in coincidence in channel 0 and channel 1 were recorded.The same procedure was adopted for 1″×1″ $Lacl_3$:Ce detectors.Measurements were done for coincidence window of 2μs.

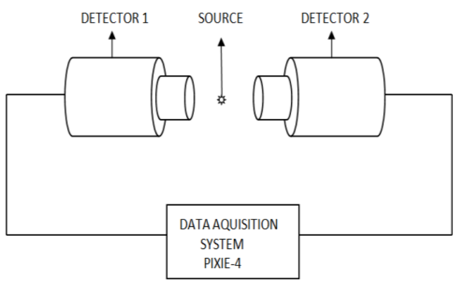


Fig. 1. Experimental setup using CCT

## Results and Discussion

Fig.2 shows the energy spectrum of $LaBr_3$:Ce recorded using $^{137}$Cs by employing Compton Coincidence Technique. Similarly, the energy spectrum of $LaCl_3$:Ce recorded using $^{60}$Co source is shown in Fig.3.We were able to observe Gaussian-shaped peak at the Compton edge energy in both cases. This enables to measure the energy resolution of the peak at Compton edge. It is well known that the energy resolution($\Delta E/E$) of scintillators depends mainly on factors such as the statistical contribution($\delta_{st}$), the intrinsic resolution($\delta_{int}$) which is associated with the properties of the scintillator and the transfer component which is associated with the light collection at the photocathode and transfer of photoelectrons to the first dynode. For the modern PMT's this effect can be neglected.

$$\left(\frac{\Delta E}{E}\right)^2 = (\delta_{st})^2 + (\delta_{int})^2 \qquad (1)$$

where, $\delta_{st} = 2.355 \times \sqrt{(1+\varepsilon)/Nphe} \qquad (2)$

Here, ε is the gain variance of the PMT and $N_{phe}$ is the number of photoelectrons. Thus, by measuring the energy resolution and the statistical contribution we can estimate the intrinsic resolution using Eq. (1).

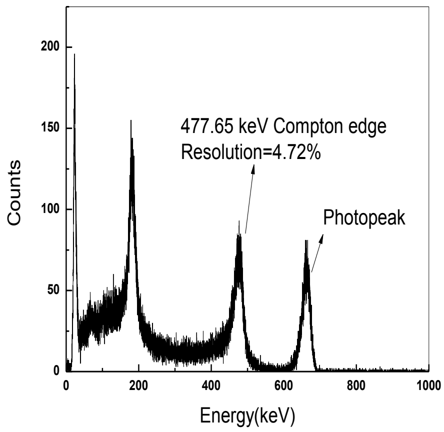


Fig. 2. $LaBr_3$:Ce energy spectrum irradiated by $^{137}$Cs source employing CCT.

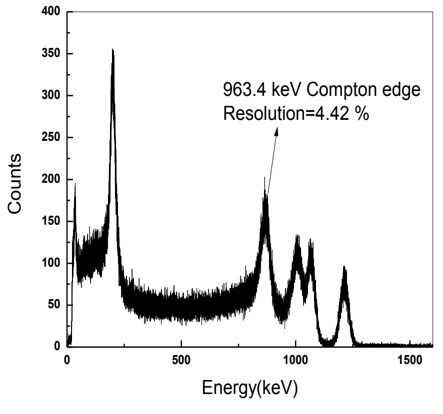


Fig. 3. $LaCl_3$:Ce energy spectrum irradiated by $^{60}$Co source employing CCT

The measured intrinsic resolutions of Compton electrons in $LaBr_3$:Ce and $LaCl_3$:Ce detectors are listed in Table-1.The measured values are found to be higher than those reported in the literature for $LaBr_3$:Ce[3].This difference can be attributed to the effect of energy gating which is absent in the present work and also due to small acquisition time.

Table 1: Intrinsic resolution of Compton electrons in $LaBr_3$:Ce and $LaCl_3$:Ce

| Source | Compton edge (keV) | Intrinsic Resolution (%) | | |
|---|---|---|---|---|
| | | $LaBr_3$ | | $LaCl_3$ |
| | | Present work | Ref.[3] | Present work |
| $^{137}$Cs | 477.6 | 3.6 | 2.3 | 5.7 |
| $^{60}$Co | 963.4 | 3.3 | 2.0 | 4.1 |

Realistic GEANT4 simulations were also made in order to understand the effect of detector size on the shape of Compton continuum. Work is in progress to incorporate the offline energy gating and to employ Wide Angle Compton Coincidence technique [1]. The results of measurements and simulations for both $LaBr_3$:Ce and $LaCl_3$:Ce detectors will be presented and discussed.

## References

[1]L.Swiderski *et al.*, *Nuclear Instruments and Methods in Physics Research A*,vol. 705, 2013, pp. 42-46.

[2]B.D. Rooney and J.D. Valentine, *IEEE Trans. Nucl. Sci.*, vol. 43, 1996, pp.1271-1276.

[3]L.Swiderski *et al., IEEE Trans. Nucl.Sci.*,vol. 57,2010, pp.1697-170.