Comparative performances of $LaBr_3(Ce)$ and BaF_2 scintillators

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Introduction

Inorganic scintillation detectors have wide applications in nuclear spectroscopy, medical imaging, space science, geological exploration etc. [1]. The detectors that are recently attracted to the nuclear and particle physics experimentalists are La-halide, Lu_2SiO_5 (LSO) and BaF_2 because of their superior energy and time resolutions. A BaF_2 detector is known to have very good timing properties because of its ultrafast decay time component (600 ps) but a poor energy resolution (∼10% at 662 keV). On the other hand, La-halide detectors have subnanosecond time resolutions as well as excellent energy resolution because of their high light output and faster scintillation decay time (16 ns). Here, we have performed comparative studies of $LaBr_3(Ce)$ and BaF_2 detectors with same crystal sizes (38×25 mm^2).

Experimental details

The $LaBr_3(Ce)$ scintillators have been produced from M/S Saint Gobain with Ce concentration of 5 at%. Emission of light from the scintillator is maximum at 380 nm. This has been coupled to Philips XP2020/Q photo multiplier tube (PMT). For comparison of light output of $LaBr_3(Ce)$ and BaF_2, the same PMT is used where the HV and amplifier settings remain same. For comparison of energy resolution, the same XP2020/Q PMT is used for both $LaBr_3(Ce)$ and BaF_2. For comparison of prompt time resolutions, two $LaBr_3(Ce)$ and two BaF_2 scintillators of identical sizes have been coupled successively to the same two XP2020/Q PMT. A standard slow-fast coincidence set up is used for measurements of prompt time resolution. Anode pulses are used for timing which are fed directly to ORTEC 584 CFDs.

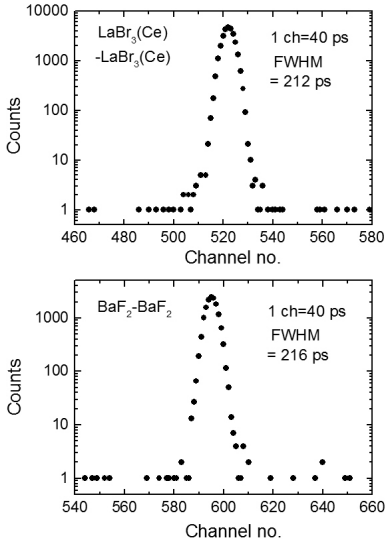

FIG. 1: Prompt time spectra of ^{60}Co γ-rays. Crystal sizes : 38 × 25 mm^2; PMT : XP2020/Q

TABLE I: Comparative results of $LaBr_3(Ce)$ and BaF_2

Scintillators /Scintillator combination	R(%) at 662 keV	Relative light output	Prompt FWHM (ps) (511 -511 keV)	Prompt FWHM (ps) (1173 -1332 keV)
$LaBr_3(Ce)$	4.1(1)	6		
BaF_2	10.1(1)	1		
$LaBr_3(Ce)$-$LaBr_3(Ce)$			310(5)	212(4)
BaF_2-BaF_2			304(5)	216(4)
$LaBr_3(Ce)$-BaF_2			304(5)	216(4)

Results and discussion

Comparative results of $LaBr_3(Ce)$ and BaF_2 detectors are shown in table I. For $LaBr_3(Ce)$, an energy resolution of ∼4% at 662 keV is found. For this scintillator, a slightly better energy resolution of 3.65% at

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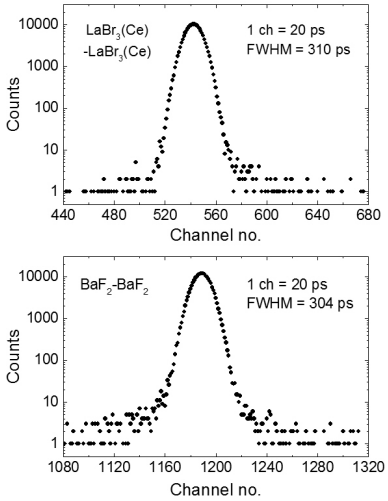

FIG. 2: Prompt time spectra of ^{22}Na γ-rays. Crystal sizes : 38 × 25 mm^2; PMT : XP2020/Q

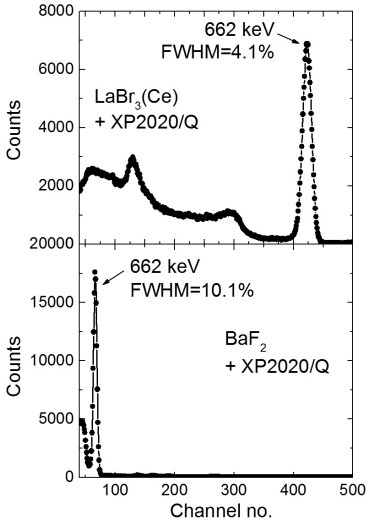

FIG. 3: γ-ray spectrum of ^{137}Cs showing relative light output of $LaBr_3(Ce)$ and BaF_2. PMT, HV, amplifier settings remain same.

511 keV using Photonis XP20D0 PMT was reported [2]. However, a non linear response in γ-ray energy was found for the same combination ($LaBr_3(Ce)$ + XP20D0) [3]. We have obtained linear response to γ-ray energy using XP2020/Q with $LaBr_3(Ce)$ scintillator. From present measurements, it is found (Table I) that both $LaBr_3(Ce)$-$LaBr_3(Ce)$ and BaF_2-BaF_2 combinations of identical crystal sizes and for same PMTs produce same values of prompt time resolutions. The measured values of prompt FWHM for the 511-511 keV γ-rays of ^{22}Na and 1173-1332 keV γ-rays of ^{60}Co yield ∼219 ps and ∼150 ps, respectively, as individual contributions for a single $LaBr_3(Ce)$ detector. These results can be compared with the values reported by Moszyński et al. [2] for a single $LaBr_3(Ce)$ contribution of size 25×25 mm^2 as 154±5 ps and 107±4 ps using XP20D0 PMT for ^{22}Na and ^{60}Co γ-sources, respectively. Since, we have used crystals of volume ∼2.3 times to that uesd by Moszyński et al. [2], our measured FWHM values are expected to be slightly larger than reported earlier [2].

Conclusion

Comparing the results obtained from $LaBr_3(Ce)$ and BaF_2 detectors using the same crystal sizes and same PMT, we find that, i) a $LaBr_3(Ce)$ produces much improved energy resolution, ii) a $LaBr_3(Ce)$ gives light output ∼6 times to that obtained with a BaF_2 detector, iii) a $LaBr_3(Ce)$ and a BaF_2 gives the same prompt time contribution (for same crystal sizes) and iv) a $LaBr_3(Ce)$ produces a linear pulse height response to the γ-ray energy when used with XP2020/Q PMT.

References

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[3] J.-M. Reǵis et al., Nucl. Instru. and Meth. A 684 (2012) 36.