Characterization of a $LaBr_3$:(Ce+Sr) crystal for γ-rays spectroscopy

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The importance of scintillation detectors in nuclear γ-ray spectroscopy is well established for many decades. The synthesis and commercial production of new scintillation crystals with superior detection properties are part of continued global efforts. The recent discovery and marketing of Lanthanum Halide crystals, namely Lanthanum Bromide and Lanthanum Chloride bear testimony to these efforts. A complete characterization of such crystals involve determination of all the major properties, like, energy and timing resolution, homogeneity, uniformity of response, linearity etc. The Lanthanum Bromide ($LaBr_3$:Ce) has best energy resolution of all known scintillators primarily because of its much higher light yield per MeV deposition of radiation energy. The light yield of $LaBr_3$:Ce is much higher than the time tested scintillators like NaI(Tl), CsI(Na) etc [1,2]. The fundamental reason for the superior performance of the Lanthanum Bromide scintillator lies in the exact concentration of the Ce dopant. The tremendous success of the $LaBr_3$:Ce in gamma ray spectroscopy has spurred attempts to grow even superior scintillators by changing the nature and concentration of the dopant. In this contribution we present the result of our studies to fully characterize a crystal of $LaBr_3$ by Saint Gobain Inc. with combined dopants of Ce and Sr ($LaBr_3$:Ce+Sr). The crystal under study is of dimension 1.5″ × 1.5″ and encased in Al casing with one end having a glass window. The crystal was coupled with different photo multiplier tubes to determine the most suitable tube for optimum performance

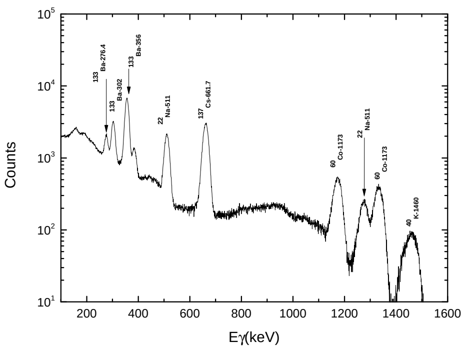

FIG. 1: Spectrum of $LaBr_3$:(Ce+Sr) with multiple gamma ray sources

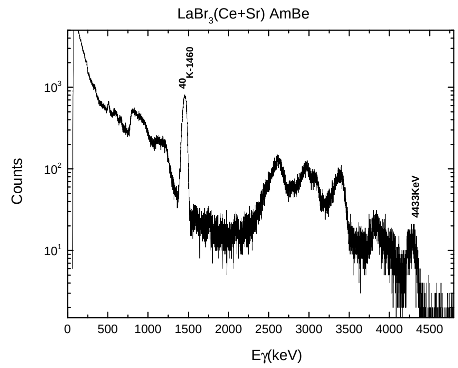

FIG. 2: Typical spectrum for high energy γ-ray source AmBe

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of the crystal. Figure 1 presents a typical spectrum with multiple gamma ray sources. The

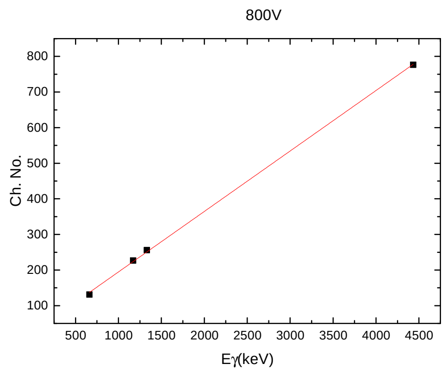

FIG. 3: Linearity from 662 keV to 4.44 MeV

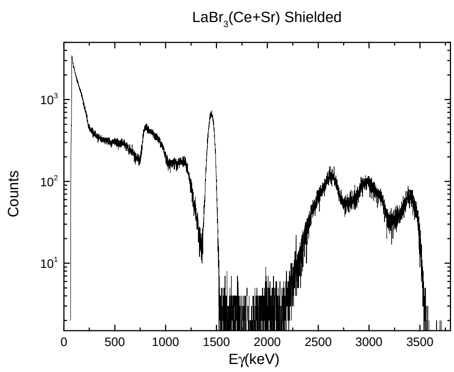

FIG. 4: Internal activity spectrum for $LaBr_3$:(Ce+Sr)

measured energy resolution for 662 keV was found to be 3.3%. Figure 2 presents the spectrum corresponding to high energy 4.44 MeV gamma rays from an AmBe source. Figure 3 presents the linear response of the crystal from 662 keV to 4.44 MeV. The energy resolution is very similar to the resolution of $LaBr_3$:Ce and was not better than $LaBr_3$:Ce. The timing resolution at Co energy was found out to be 368 ps. This is somewhat inferior to what we get from a $LaBr_3$:Ce crystal of similar dimensions. The internal activity of the crystal was also measured and, as expected, was found to be exactly similar to that of a $LaBr_3$:Ce crystal of similar volume.

The internal activity spectrum is shown in Figure 4 for a heavily shielded crystal. The photopeak detection efficiency of the crystal was also measured using a calibrated Cs source and was found to be 20% and same as regular $LaBr_3$:Ce crystal of similar dimension. As mentioned before the type and concentration of the dopant, namely, Ce, is responsible for the superior performance of lanthanum halide crystals. Our primary effort in this work is to check whether addition of Sr by the manufacturer results in better performance than a regular Lanthanum Bromide crystal with Ce doping. We have fully characterised the $LaBr_3$:(Ce+Sr) in terms of the major properties like energy and timing resolutions, detection efficiency, linearity, and internal activity. We conclude that there is no significant difference in performance, because of addition of Sr as dopant vis-a-vis only Ce doped [$LaBr_3$:(Ce)] crystal.

Acknowledgments

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References

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