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# $CeBr_3$ as a High-Resolution Gamma-Ray Detector

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## INTRODUCTION

Lanthanum halide ($LaBr_3$:Ce) scintillators have been well-documented as high-resolution gamma-ray detectors that are operated at room temperature [1]. These scintillators have better resolution (<3% at 662 keV) relative to sodium iodide (NaI(Tl)) scintillators (7% at 662 keV), but the naturally-occurring radioactive isotope $^{138}$La causes self-activity in the crystal that occludes portions of the gamma-ray spectrum [2]. This self-activity limits the use of $LaBr_3$:Ce in high-sensitivity applications. Cerium, the dopant in the $LaBr_3$:Ce matrix possesses useful scintillation properties, and its self-activity is on the order of 3750 times less than La [3]; however, Ce has not been fully characterized as the chief component in a scintillation detector. This work investigated Ce as the key scintillation matrix component in a scintillation detector with the hypothesis that $CeBr_3$ promises energy resolution comparable or superior to $LaBr_3$:Ce. The researchers involved with this work believe that $CeBr_3$ may be the answer to obtaining high-temperature, high-resolution spectra with greater sensitivity than $LaBr_3$:Ce.

## DESCRIPTION OF THE ACTUAL WORK

This work benchmarked each of two sizes of $CeBr_3$ crystals produced by Saint-Gobain against NaI(Tl) and $LaBr_3$:Ce crystals of comparable sizes. The team has documented the volume effects on self-absorption in $CeBr_3$ and $LaBr_3$:Ce crystals as well as characteristics of energy resolution, light output, timing, and counting efficiency using a series of isotopes as test sources. All background and source measurements were taken in a lead-shielded environment to help maintain consistency across measurements and to ensure that background in the spectra was dominated by the self-activity in the two types of detection matrices.

MCNPX was benchmarked on 0.5"x0.5" and 1"x1" $CeBr_3$ crystals and 1"x1" and 2"x2" $LaBr_3$:Ce crystals to refine self-activity models for both crystal types. This model was used to predict background spectra for larger $CeBr_3$ crystals.

## RESULTS

Figure 1 shows the 0.5"x0.5" $CeBr_3$ crystal attached to the photomultiplier tube (PMT) during an intermediate stage of production.

Fig. 1. 0.5"x0.5" $CeBr_3$ crystal and PMT during manufacturing.

Figures 2 and 3 show background spectra for the 2"x2" $LaBr_3$:Ce crystal and 0.5"x0.5" $CeBr_3$ crystal, respectively.

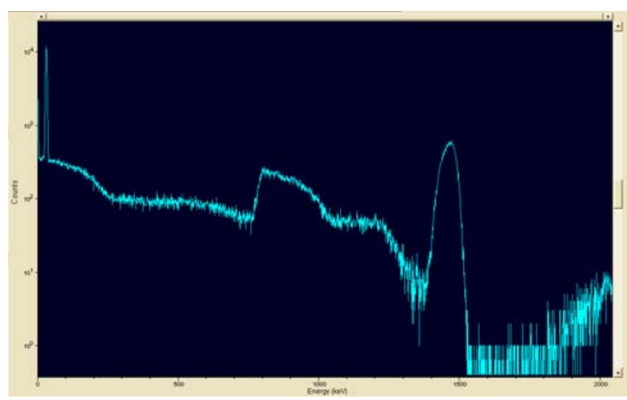


Fig. 2. Background spectrum for 2"x2" $LaBr_3$:Ce crystal.

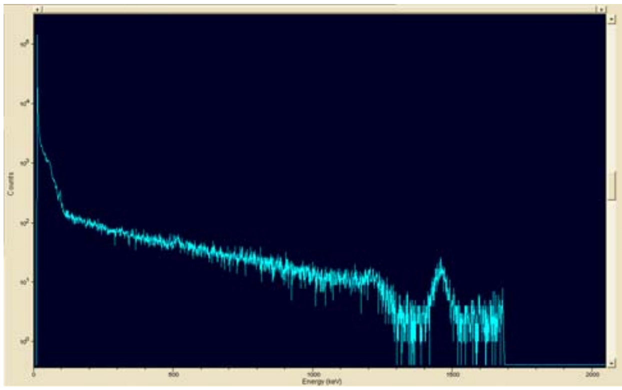

Fig. 3. Background spectrum for 0.5"x0.5" $CeBr_3$ crystal.

The background spectra shown in Figures 2 and 3 illustrate the increased self-activity component of $LaBr_3$:Ce over $CeBr_3$. These spectra in addition to the documented data from this study regarding such characteristics as energy resolution, counting efficiency, and light output for $CeBr_3$ culminate into an excellent case for the production and use of $CeBr_3$ crystals in radiological detection devices where high-sensitivity is paramount.

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