



The Performance of CeBr₃ Detectors
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Introduction

High-resolution scintillation detectors are now offering improved performance with lower intrinsic background. Standard cerium bromide (CeBr₃) detectors are now available from BNC in 2x2 inch encapsulated sizes with greatly improved sensitivity. This paper discusses the merits of CeBr₃ from the standpoint of energy resolution and reduction of intrinsic background from actinium-227 (²²⁷Ac) contamination.

Detector Resolution

CeBr₃ detectors have several advantages over lanthanum bromide (LaBr₃) detectors even though LaBr₃ is widely accepted as the highest resolution scintillation detector. LaBr₃ boasts a resolution of 3% at 662 keV and CeBr₃ has a resolution of about 4% at 662 keV. This allows both detectors to achieve distinct separation of the 609 keV peak of bismuth-214 (²¹⁴Bi) from the 662 keV peak of cesium-137 (¹³⁷Cs) (which cannot be accomplished with sodium iodide (NaI(Tl)) detectors). Generally, the ability to resolve spectra at high energies can be accomplished quite well with NaI(Tl). Resolving lower energy spectra of uranium (U) and plutonium (Pu) is important, and it is in this lower energy region that the resolution of CeBr₃ outperforms that of LaBr₃ [1]. This is noted when observing the plutonium-239 (²³⁹Pu) spectrum as shown in Fig. 1. The primary ²³⁹Pu peaks (332, 375 and 414 keV) stand out clearly with CeBr₃. Also the X-rays at ~105 keV and the 201 keV gamma line are more pronounced with CeBr₃. The low energy lines of weapons-grade uranium are also better resolved with CeBr₃. At even lower energies the resolution of LaBr₃ continues to fall off dramatically such that the resolution of the 60 keV energy line of americium-241 (²⁴¹Am) is worse than NaI(Tl).

Filename: SPEC0085.N42 CeBr Pu-239 Primary peaks are 332, 375 and 414

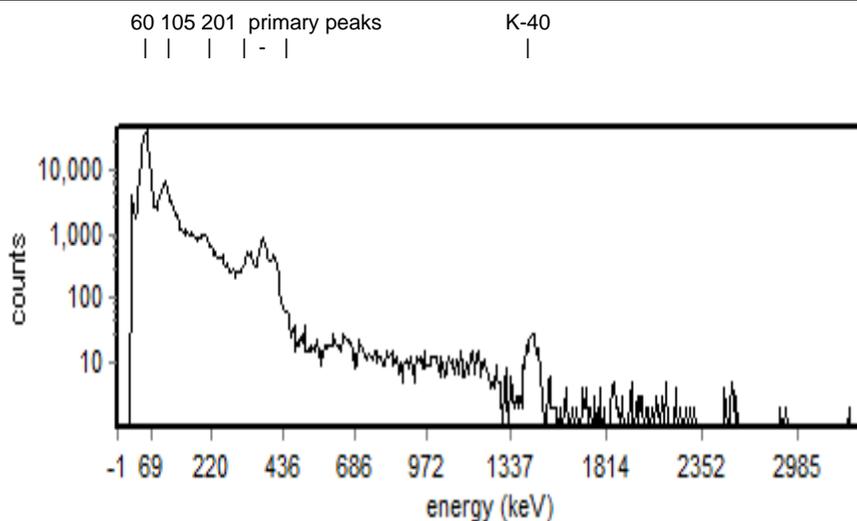


Fig.1. CeBr₃ spectrum of ²³⁹Pu

Intrinsic Background

The typical background for CeBr₃ detectors is primarily from ²²⁷Ac (the parent nucleus is uranium-235 (²³⁵U)). This contribution to background from the ²²⁷Ac contamination is approximately 0.02 counts/sec/cm³ [2]. The concentration of ²²⁷Ac atoms per cerium (Ce) atoms is of the order of 4x10⁻¹⁶. Even though this is a small amount of contamination, it does represent a significant contribution to the background, especially in the 1.2 to 2.2 MeV region of the energy spectrum as seen in Fig. 2. Ac, Ce, and lanthanum (La) are all chemically homologous elements and therefore, they are extremely difficult to separate one from another. Through the selection of material being screened before processing, the ²²⁷Ac background can now be essentially eliminated (about 0.001 counts/sec/cm³ [2]). Also seen in Fig. 2 is the much higher background in the LaBr₃ detectors. In addition to the ²²⁷Ac, there is significant contamination from lanthanum-138 (¹³⁸La) which is responsible for a very high background near 32 keV and continuing up to the 1461 keV region. Another region of background in LaBr₃ begins at about 1520 keV through 2800 keV. This is from natural uranium (primarily the ²¹⁴Pb progeny) giving CeBr₃ a sensitivity greater than LaBr₃ by an order of magnitude in this region of the spectrum. The reason this is so important is that detection of weapons-grade Pu and weapons-grade U relies on the detection of the 2615 keV energy line to verify its presence. Depending on the activity and the distance to the source, a longer acquisition may be necessary for verification. Therefore, it is not only important to have the highest sensitivity at this energy (CeBr₃ improves it by a factor of 10) but with LaBr₃, high background in this region could mislead first-line responders with a false positive for weapons-grade material.

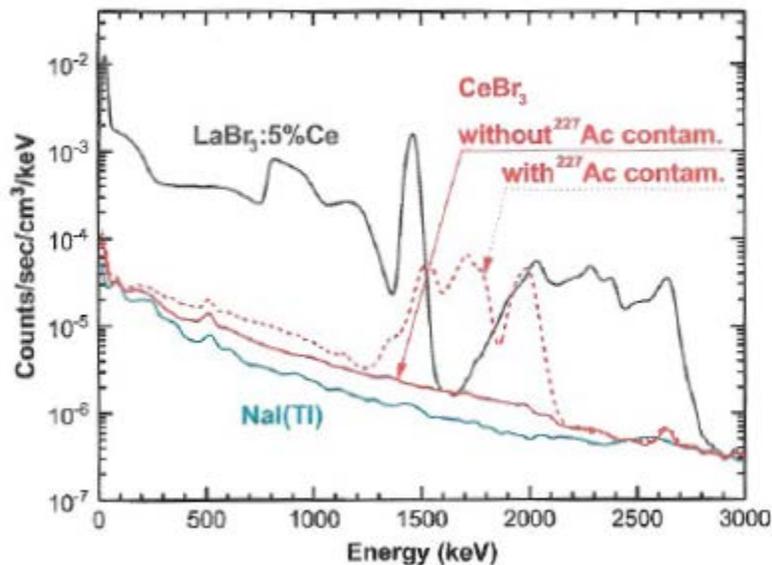


Fig. 2. Intrinsic Activity Spectrum of CeBr₃, LaBr₃ and NaI(Tl) 2x2 Spectrometers

References

- [1] Comparison of LaBr₃: Ce and NaI(Tl) Scintillators for Radio-Isotope Identification Devices, B. D. Milbrath, et. al., Pacific Northwest National Laboratory (PNNL)
- [2] P. Schotanus, et al., Nuclear Instruments and Methods in Physics Research A 729 (2013) 596-204