INTRINSIC BACKGROUND OF $LaBr_3$:Ce AND $CeBr_3$ SCINTILLATORS

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$LaBr_3$:Ce and $CeBr_3$ scintillators are candidates for gamma ray diagnostics at JET during deuterium-tritium campaigns when high count rates are expected. Both crystals are characterised by short scintillation decay times ~15-25 ns and a similar energy resolution ~3% at 1 MeV. The naturally occurring ^{138}La radioisotope (0.09%) present in $LaBr_3$:Ce crystals explains the higher intrinsic background in comparison with $CeBr_3$.

We report on a comparison of the internal activity of $LaBr_3$:Ce and $CeBr_3$ scintillators of the same size: 3”×3”. The scintillators were coupled to a Hamamatsu R6233 photomultiplier (PMT). Signals from the PMT were sent to a spectroscopy amplifier ORTEC 672 and finally to a TUKAN 8K USB multichannel analyser.

In Fig. 1 measured spectra normalised to the same live time are presented. The spectra are divided into two regions: a low energy interval up to 2.5 MeV (upper part) and a high energy region from 3 MeV (lower part).

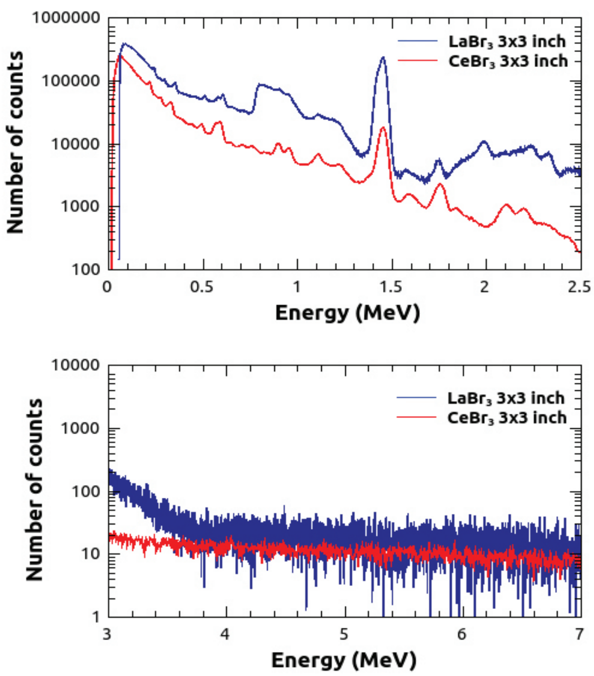

Fig. 1. Comparison of natural background and internal activity for $LaBr_3$ and $CeBr_3$. In the upper part the low energy spectrum up to 2.5 MeV is shown, in the lower part the high energy region from 3 MeV is presented.

At the energy range above ~4 MeV (lower figure) no structure is observed. This is important because in deuterium-tritium experiments observation of a 4.4 MeV gamma ray gives evidence that the reaction of interest has occurred.

$$^{9}Be + \alpha \rightarrow {}^{13}C \xrightarrow{n} {}^{12}C^{*} \xrightarrow{\gamma(4.44\ MeV)} {}^{12}C_{g.s.}$$

The biggest differences in spectra registered with the $LaBr_3$:Ce and $CeBr_3$ scintillators are observed for lower energies, see Fig. 2 for details.

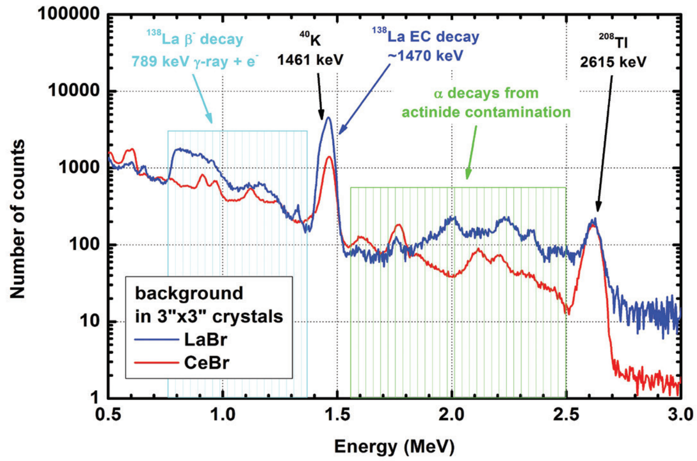

Fig. 2. Response of 3”×3” $CeBr_3$ and $LaBr_3$:Ce scintillators to natural and intrinsic background. Events due to internal contamination by actinides, observed between 1.5 MeV and 2.5 MeV, are seen for both scintillators. In the case of $LaBr_3$:Ce, events connected with the presence of ^{138}La are registered for energies below 1.5 MeV.

^{138}La decays by an electron capture (EC) or β^-. EC is followed by emission of a 1.436 MeV γ-ray and X-ray cascade, giving a contribution to a peak at about 1.470 MeV. In addition, β^- decay produces a continuum above 0.789 MeV. An additional background in the energy region between 1.5 and 2.75 MeV is connected with a progeny of ^{227}Ac contaminating both $LaBr_3$:Ce and $CeBr_3$ scintillators.

Peaks originating from gamma transitions observed in a natural background (1.461 MeV from ^{40}K and 2.615 MeV from ^{208}Tl) are also clearly seen. The 1.461 MeV gamma line overlaps with the 1.470 MeV gamma line from ^{138}La.

In conclusion, $CeBr_3$ has the advantage in comparison with $LaBr_3$:Ce because of its lower internal radioactivity below 1.5 MeV due to the lack of any radioactive isotopes.

This work was partly supported by the Polish Ministry of Science and Higher Education within the framework of the scientific financial resources in the years 2015-2017 allocated for the realization of international co-financed projects.