# $CeBr_3$ SCINTILLATOR COUPLED TO A COMPACT PHOTODETECTOR FOR DETECTION OF HIGH ENERGY GAMMA-RAYS IN FUSION PLASMA DIAGNOSTICS

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Production of energy in fusion experiments can be realized by fusing deuterium and tritium ions. As a result, an alpha particle and a neutron are produced and energy is released. The distribution of plasma in DT experiments is measured by, e.g., observing the alpha particles present in the plasma. Alpha particles undergo reactions with impurities present in the plasma, for example Be ions. In the α+Be reaction a γ-ray of 4.44 MeV energy is emitted. Therefore, detection of 4.44 MeV γ-rays is a fingerprint of producing alpha particles confined in the plasma. Large stopping power and the feasibility of growing large sizes make scintillators ideal candidates for high energy γ-ray detection. A detector based on the fast, bright scintillator $CeBr_3$ coupled to a PIN-diode is presented as a possible device for plasma diagnostics.

The experimental setup comprised various size $CeBr_3$ scintillators coupled to a 10×10 $mm^2$ PIN-diode (S3590 from Hamamatsu). Due to their high hygroscopicity, $CeBr_3$ crystals were encapsulated by the manufacturer (Scionix Holland B.V.) in aluminum housings with quartz windows. The space between the crystal surface and the housing was filled with Teflon in order to preserve the light output of each sample.

The scintillators were coupled to the PIN-diode using silicone optical grease. The PIN-diode was biased with a high voltage of 60 V. The signal from the PIN-diode was integrated by a Cremat CR-110 charge sensitive preamplifier. The output from the preamplifier was sent to an Ortec 672 spectroscopy amplifier, where a 1 µs Gaussian shaping time was used to achieve optimal signal to noise ratio. The signal from the amplifier was read out by a Tukan8K multichannel analyzer.

The response of $CeBr_3$ scintillators to a PuBe source, emitting 4.44 MeV γ-rays, is presented in Fig. 1. Detection of high energy γ-rays in scintillators is mostly connected with positron-electron pair creation. The kinetic energy of the created particles is absorbed in the scintillator and at the end of this process the positron annihilates producing two 511 keV γ-rays. Subsequently, these γ-rays may be absorbed, or they may escape from the scintillator. Therefore, besides a full energy peak (FEP) at 4.44 MeV, a single escape peak (SEP) is observed at 3.93 MeV if one 511 keV quantum escapes from the scintillator without interaction and the second one is absorbed. A double escape peak (DEP) occurs at 3.42 MeV, when both 511 keV quanta escape without interaction.

For the 10×10×5 $mm^3$ cuboid $CeBr_3$ (upper part of Fig. 1) only the DEP from the 4.44 MeV gamma-rays is present. The small size of the scintillator results in a poor absorption efficiency for 511 keV quanta, which usually escape from the crystal giving a rise only to the DEP at 3.42 MeV. A distinct structure is observed for a cylinder shaped crystal with a diameter of 20 mm and a height of 20 mm, see middle part of Fig. 1. The FEP is seen at 4.44 MeV, SEP at 3.93 MeV and DEP at 3.42 MeV. In the case of the largest $CeBr_3$ scintillator available in our laboratory (a 25 mm diameter and 25 mm height cylinder), well pronounced FEP, SEP and DEP were observed when the scintillator was irradiated with a PuBe source, see the lower part of Fig. 1.

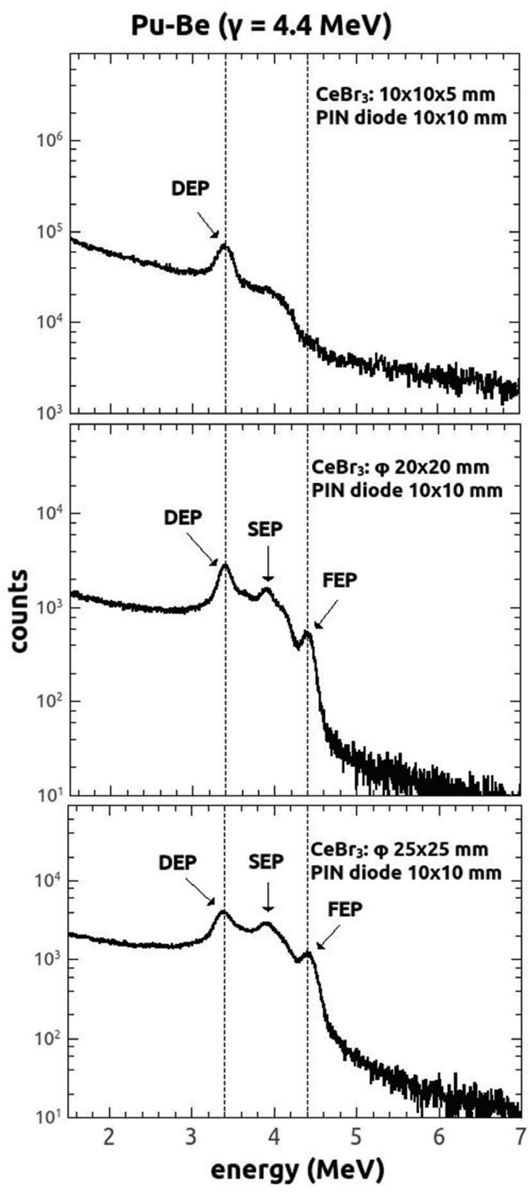


*Fig. 1. Comparison of gamma spectra from a PuBe source recorded with CeBr3 scintillators coupled to a 10×10 mm² PIN-diode. Dashed vertical lines denote the GC region of interest.*

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