Study of Neutron Damaged Germanium Detectors with Pulse Shape Comparison

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Neutron damage of Germanium detectors is very frequent in nuclear physics experiments. It decreases the energy resolution of the detector and it is necessary to anneal it or to characterize its damage to recover its performance. The neutron damage of an EUROBALL crystal was studied using a 511 keV source and the pulse shape comparison technique.

Experimental Set-up

A neutron-damaged EUROBALL crystal was studied using a coincidences scanning approach at the scanning table of GSI [1]. In this set-up a ^{22}Na source is placed between a position sensitive detector (PSD) and the Germanium detector to be scanned. The PSD is a LYSO scintillator glued to a Hamamtsu R2486 position sensitive photomultiplier and the source is surrounded by a Tungsten shielding with conical opening. Two 511 keV γ rays are emitted in opposite directions by the source. One going to the Ge detector and the other one to the PSD, allowing a 2D image of the Ge detector to be generated. With the setup it is possible to obtain an image from the front and an image from the side of the detector. Event by event the pulse shape from the Ge detector is recorded as well as the energy deposited in it. By using a novel analysis technique, the images can be used to select particular interaction positions inside the detector and to study the signals coming from that position.

Results

Fig. 1 shows the FWHM of the photopeak as a function of the radial distance in the detector. Near the surface of the detector the width of the peak is smaller, indicating a higher resolution. In the central part of the detector the photopeak becomes wider.

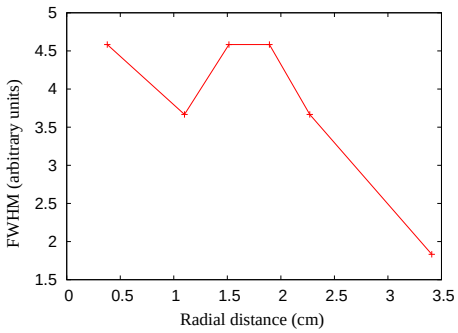

Figure 1: FWHM of the 511 keV photopeak as a function of the radial position.

For a coaxial Ge detector is expected that the rise time of the signals increase with the radial distance. For the EUROBALL crystal two cases were studied: Events dominated by full charge collection, in the central part of the photopeak and events with incomplete charge collection, recorded in the low energy tail. In both cases the behavior was as expected and no clear difference between the cases was found.

Signals associated with the same position in the detector were compared by pairs and the χ^2 value of this comparison was calculated. The distribution obtained is shown in Fig. 2. A comparison with the result obtained for an AGATA crystal is shown. Differences in the shape of the distributions, may be related to an effect of neutron damage, nevertheless a comparison with a non-damaged EUROBALL crystal is necessary.

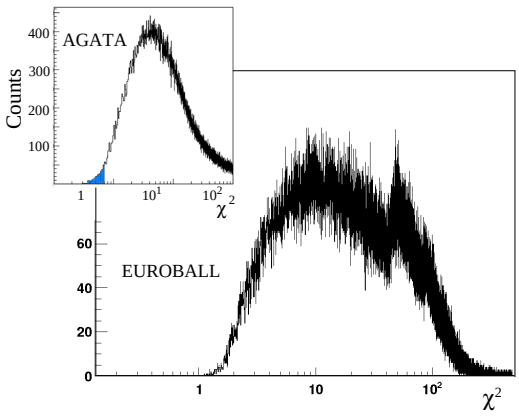

Figure 2: χ^2 distribution in the EUROBALL crystal compared to the distribution in an AGATA crystal

Conclusions

The neutron damaged EUROBALL crystal shows a radial dependence of the neutron damage. The shape of the χ^2 distribution suggest the possibility to quantify the neutron damage, but a comparison with a non-damage detector is needed to make a final conclusion.

References

[1] C. Domingo-Pardo, *et. al.*. NIM A643 (2011) 79-88