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Performance of CdTe and CZT detectors

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CdTe and CZT detectors are used in various environments in high-energy, nuclear, medical and astrophysics. The material itself is high-Z material and has high interaction probability with high energy X-rays and gamma rays. However, the crystal properties, especially various defects have an impact on the charge collection efficiency. We have seen that for shallow energy deposition, such as for 2 MeV protons, the main impact is coming from surface defects [1]. We have also noticed that defects can distort the current transients under laser irradiation [2].

We have further developed several methods to characterize the crystallographic defects in the materials [3-5]. The defects and boundaries are located and measured with infrared scanning setup that we have developed. Samples are also measured with laser transient current technique which allows to study the charge accumulation and drift times within the crystals. In addition to direct effects, we have also studied the performance of the sensors with temperature cycle chamber. The measurements are compared to results with commercial detectors.

In addition to measurements, we have extended the simulation models to include the effects of zinc density in the crystal lattice under irradiation. In this contribution we will briefly show the various characterization methods and simulations. The focus is to combine the results and give estimate of the effects of various defects to the performance of the detectors. Both beam tests and irradiation measurements are discussed.

[1] M. Kalliokoski et al., "Effects of Defects to the Performance of CdTe Pad Detectors in IBIC Measurements" , IEEE Trans. Nucl. Sci., 66 (2019).
[2] M. Golovleva et al., "Modeling the impact of defects on the charge collection efficiency of a Cadmium Telluride detector", JINST 16 P08027 (2021).
[3] M. Kalliokoski et al., "Characterization and Identification of Defects in CdTe Detectors Using Scanning Laser Transient Current Technique", Proc. 2020 IEEE NSS MIC RTSD (2021).
[4] M. Bezak et al., "Analysis and Characterization of CdTe Material Surface Defects,"J. Inst. 18 (2023).
[5] M. Väänänen et al., "Defect detection and size classification in CdTe detector samples in 3D", abstract submitted to iWoRiD 2024.

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