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Comparison of photon-beam scans on 3D-positioning CZT with a defect-enabled numerical simulation

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Imagers capable of 3D positioning are useful for localizing photon-emitting sources as they enable Compton imaging, parallax correction and also spectral correction of collection inhomogeneities. In the case of pixelated-anode CZT detectors, one can take profit of signals induced on a group adjacent electrodes to compute sub-pixel position of the photon interaction inside the detector. This is combined with a depth estimation to obtain the 3D position of the interaction [1]. However, it is known that CZT detectors contain structural defects, which alter the measurement as they influence the physical properties of the detector, such as the electric field or internal conductivity [2]. These defects can be studied by various characterization methods but their effect on the inducted signal is not easy to estimate and understand; also, we wish to use simulations to improve knowledge of their effects.

To study the impact of these defects we developed 3D realistic simulations enabling to implement different types of geometrical defects (point, plane, sphere), each modifying differently the physics of the detector (Figure 1.). Using these simulations, we can observe the behavior of the detector on the collection of charges on the electrodes [3].

Therefore, we can also perform XY scans of the simulated detector to obtain interactions maps and compare it with the experimental results. The objective of this study is to replicate the observed measurements with the simulations to approach the intern structure of the real CZT detector (Figure 2.).

The strengths of our simulation approach are a fast computation and its versatility. In this way, we can get to an approximation of the physical behavior of the detector. Finally, this study might help us to have a better understanding of the defects structure in a CZT crystal, and the simulation may be a tool to improve the performances of these detectors correcting the induced signals impacted by the defects.

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[2] A.E. Bolotnikov, S. Babalola, G.S. Camarda, Y. Cui, R. Gul, S.U. Egarievwe et al., Correlations Between Crystal Defects and Performance of CdZnTe Detectors, IEEE Trans. Nucl. Sci. 58 (2011) 1972.
[3] A. Delcourt, G. Montémont, GPU-accelerated CZT detector simulation with charge buil-up effects, 2023 JINST 18 P02005

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