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The Simulation and Optimisation of Position-Sensitive LaBr3 Detectors for Compton Imaging

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The Simulation and Optimisation of Position-Sensitive LaBr3 Detectors for Compton Imaging

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Abstract: Scintillator-based Compton cameras are a practical choice for nuclear security applications; however, the energy resolution is comparatively poorer than semiconductor-based approaches and accurate determination of interaction position is challenging. This work aims to improve the position sensitivity and energy resolution of LaBr3-based scintillator detectors for use in nuclear security. In this investigation, various novel crystal geometries were designed, their performance characterised, and their geometry optimised. To assess the performance of the novel detectors, Monte Carlo simulations were conducted for multiple positions within a geometry using GEANT4. Pulse Shape Analysis (PSA) was then performed, in which simulated experimental responses were compared to a pre-simulated basis at known positions. In this comparison, the figure of merit was determined, where the minimum is considered the position of the γ-ray interaction.

It was found that using a novel crystal geometry provided additional information to the PSA, leading to an increased position sensitivity of the detector when compared to simpler crystal geometries. Whilst the use of these novel geometries results in a poorer intrinsic energy FWHM, by utilising the simulated efficiencies from GEANT4 and effective PSA, it was determined that the corrected energy FWHM could be significantly improved beyond conventional detectors. Finally, novel detector responses were used to perform two interaction PSA. It was found that both interactions could be successfully identified and located within the crystal.

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