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Monte Carlo Simulations of Scintillation Detectors for Time-of-Flight X-ray Imaging

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Time-of-Flight x-ray imaging uses the Time-of-Flight of scattered photons to determine the point of scatter, providing three dimensional information about an object under inspection. The spatial resolution of the method is dependant upon the timing resolution of the detector. When applied to security cargo screening a large array of detectors is required, however large dimension detectors result in poor timing resolution. The present work describes Monte Carlo simulations, using GEANT4, of scintillation detectors of varying sizes for Time-of-Flight x-ray imaging, and the dependence of timing resolution on dimensions, photomultiplier tube (PMT) characteristics, scintillation material, and reflector material. Simulations indicate that timing resolution is strongly dependant upon the number of reflections that occur inside of the crystal and the PMT should be well matched with the scintillator dimensions. A timing resolution of less 700 ps (FWHM) is possible using either a 3" or 2" diameter plastic scintillator, when exposed to x ray photons that have undergone a large angle Compton scatter. Experimental coincidence measurements are compared with simulation results to determine the validity of the simulations.

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