Rapid Monte Carlo Simulations of DQE(f) of Scintillator-Based Detectors

Innovation and Impact
Monte Carlo calculations of DQE(f) can greatly aid in detector design but have traditionally been too time consuming to perform without access to a large computing cluster. We have increased computational efficiencies by several orders of magnitude to allow accurate simulations to be performed on a single CPU in less than 10 minutes.

Methods and Results
Our approach was tested using the GOS-based detector simulated by Kausch [1] consisting of a 1 mm thick tungsten build-up plate, a 0.5mm thick GOS screen and a photodiode array. Radiative and optical transport was modeled using GEANT4 [2]. Optical scattering was isotropic. The goal of the study was to determine minimum values for \( n_{\text{Run}} \), \( n_{\text{Gamma}} \) and \( n_{\text{Opt}} \) for the NPS and DQE profiles to remain accurate. The results are shown in Figures 1, 2 and 3 respectively.

Figure 1: NPS profiles plotted as a function of the number of runs averaged (\( n_{\text{Run}} \)). The curves are offset vertically from each other to permit shape comparisons to be made. At least 200 runs should be used.

Figure 2: The number of launched gammas per run (\( n_{\text{Gamma}} \)) are reduced from 100,000 to 1000 without affecting the DQE curve.

Figure 3: Only 40 detected optical photons per gamma are required. Depending on the optical attenuation of the screen, the number of scintillation photons \( n_{\text{Opt}} \) should be between 200-500 photons/MeV.