Purpose: Monte Carlo simulations of DQE(f) can greatly aid in the design of scintillator-based detectors by helping optimize key parameters including scintillator material and thickness, pixel size, surface finish, and septa reflectivity. However, the additional optical transport significantly increases simulation times, necessitating a large number of parallel processors to adequately explore the parameter space. To address this limitation, we have optimized the DQE(f) algorithm, reducing simulation times per design iteration to 10 minutes on a single CPU.

Methods: DQE(f) is proportional to the ratio, MTF(f)^2 /NPS(f). The LSF-MTF simulation uses a slanted line source and is rapidly performed with relatively few gammas launched. However, the conventional NPS simulation for standard radiation exposure levels requires the acquisition of multiple flood fields (nRun), each requiring billions of input gamma photons (nGamma), many of which will scintillate, thereby producing thousands of optical photons (nOpt) per deposited MeV. The resulting execution time is proportional to the product nRun x nGamma x nOpt. In this investigation, we revisit the theoretical derivation of DQE(f), and reveal significant computation time savings through the optimization of nRun, nGamma, and nOpt. Using GEANT4, we determine optimal values for these three variables for a GOS scintillator-amorphous silicon portal imager. Both isotropic and Mie optical scattering processes were modeled. Simulation results were validated against the literature.

Results: We found that, depending on the radiative and optical attenuation properties of the scintillator, the NPS can be accurately computed using values for nGamma below 1000, and values for nOpt below 500/MeV. nRun should remain above 200. Using these parameters, typical computation times for a complete NPS ranged from 2-10 minutes on a single CPU.

Conclusions: The number of launched particles and corresponding execution times for a DQE simulation can be dramatically reduced allowing for accurate computation with modest computer hardware.

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