AbstractID: 13496 Title: Kernel Based Dose Calculation in Heterogeneous Media Using Fast Fourier Transform

Purpose: This study evaluates the accuracy of the scatter dose calculation using FFT method in heterogeneous medium against Monte Carlo simulation.

Method and Materials: Point spread kernels for scatter doses are generated using Monte Carlo simulation in water for both 6X and 15X photon beams. Primary collision kerma K_c and scerma S_{cp}, are determined using the photon energy spectrum $\Phi(E)$ as, $K_c(l_R) = \int \left(\mu_{en} / \rho \right) \cdot e^{-\mu/\rho \, l_R} \cdot \Phi(E) \, dE$, and $S_{cp}(l_R) = \int \left(\mu_s / \rho \right) \cdot e^{-\mu/\rho \, l_R} \cdot \Phi(E) \, dE$, respectively, where the mass scattering coefficient $\mu_s/\rho = \mu/\rho - \mu_{en}/\rho$. Note that beam hardening effects in primary collision kerma and scerma have been corrected at different depth by $e^{-\mu(E) \, l_R}$. Heterogeneity is accounted for by a fast ray-tracing algorithm developed in-house which determines the radiological length distribution within the heterogeneous phantom. The fast ray-tracing algorithm is capable of accommodating both divergent and parallel beams when calculating the primary collision kerma and scerma. The kernels are assumed to be space invariant and fast Fourier transform is used to evaluate the convolution integral. The scatter dose is obtained as the convolution between the scatter kernel and scerma.

Results: Two cylindrical heterogeneous lung phantoms, one narrow and the other wide, are used to examine the accuracy of this method. It is found that the ray-tracing algorithm can calculate both the kerma and scerma to within 1%. Convolutions of the kerma and scerma with the scatter kernel are evaluated against the results obtained from full Monte Carlo simulation to examine the beam hardening correction factor. Effect of beam divergence is also evaluated by comparing divergent and parallel beams.

Conclusion: Kernel based real-time dose calculation is a fast and viable alternative to the current correction-based treatment planning system. In this implementation, we implemented a fast ray-tracing algorithm that accounts for heterogeneity and incorporates the beam hardening effect. Initial testing shows that the accuracy is within 1% of full Monte Carlo dose simulation.