AbstractID: 6536 Title: A kerma-dose hybrid scheme for variance reduction in Monte Carlo dose calculations of photon beams

Purpose: To improve the performance of Monte Carlo dose calculation for photon beams, a kerma-dose hybrid dose calculation scheme is introduced in this work.

Material and methods: Due to the high scoring efficiency of kerma, the statistical uncertainty of kerma can be reduced to a lower level than for dose with the same number of histories. However, kerma only equals dose in regions where charged particle equilibrium (CPE) exists. Our approach is to first determine the regions where CPE exists and then replace the dose by kerma to improve statistical accuracy in these voxels. To perform this hybrid kerma-dose calculation, the kerma and the energy imbalance function are simultaneously recorded for each voxel at the time of dose calculation. The energy imbalance function (Q) is defined as $Q=\Sigma_i E_i-\Sigma_j (edep_j)$, where E_i is the initial energy of the i-th charged particle starting its track in the voxel and $edep_j$ is the energy deposited by the j-th charged particle passing through this voxel. In a voxel where CPE exists, Q should be close to zero. In the current work, dose is replaced by kerma in voxels where Q is less than 10% of kerma.

Results: Calculations were done in a multi-layer slab geometry and a CT voxel phantom. In both geometries, the results show that the energy imbalance function is sufficiently sensitive to distinguish regions where CPE exists. The replacement of dose by kerma significantly reduces the statistical uncertainty (by a factor of 3) and the isodose curves become much smoother in those regions.

Conclusions: The proposed hybrid scheme can significantly reduce the statistical uncertainty in the dose calculation while accurately accounting for the inhomogeneity effect caused by loss of CPE.