AbstractID: 7434 Title: Validation of a Prototype Deterministic Solver for Photon Beam Dose Calculations on Acquired CT Data in the Presence of Narrow Beams and Heterogeneities

Purpose: To evaluate a deterministic method for solving the neutral and charged particle transport equations in cases where electron disequilibrium is significant.

Methods and Materials: A prototype deterministic solver, Acuros®, has been developed and validated for photon beam radiotherapy. Acuros is based on the Attila® radiation transport code, which solves the differential form of the linear Boltzmann transport equation for neutral particles, and the linear Boltzmann-Fokker-Plank transport equation for charged particles. The angular and energy dependent photon and electron flux is solved at every spatial unknown in the computational domain, and quantities such as dose-to-medium (D_M) are obtained by multiplying the energy dependent particle flux by the energy dependent energy deposition cross section for the associated image pixel material.

Comparisons were made with the Monte Carlo code EGSnrc (DOSXYZnrc) for a head-and-neck case having eight 1.5x1.5 cm^2 photon beams with a 6 MV photon spectrum. The Acuros calculation used 123,000 elements. Since four spatial unknowns were solved in each element, this equated to 492,000 spatial degrees of freedom. The DOSXYZnrc calculation used 2.5x2.5x2.5 mm^3 voxels.

Results: Results were compared at 95,183 image pixels where dose > 5% of D_{max}. 99.02% of pixels satisfied the 3%/3mm criteria (94,251 out of 95,183 pixels). Computational times for the Acuros and DOSXYZnrc calculations were approximately 19.6 CPU minutes (2.2 GHz Opteron processor) and 2,890 CPU minutes (0.4% avg. uncertainty in voxels > $D_{max}/2$), respectively. Through a rewritten, radiotherapy specific solver, Acuros computational times were further reduced to 7.45 CPU minutes without affecting accuracy. When only doses in regions greater than 20% of D_{max} are of interest, computational times are further reduced to 3.08 CPU minutes.

Conclusions: A clinically viable combination of dose calculation speed and accuracy has been achieved using a radiotherapy specific deterministic solver.

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