AbstractID: 3777 Title: An integrated CT-based Monte Carlo dose-evaluation system for brachytherapy and its application to permanent prostate implant postprocedure dosimetric analysis

Purpose: To develop a novel integrated CT-based Monte Carlo (MC) dose-evaluation system and use it to investigate the effect of tissue heterogeneities and interseed attenuation on brachytherapy dose distributions.

Method and Materials: A MC photon-transport (MCPT) brachytherapy dose-calculation engine, PTRAN_CT, which uses x-ray CT to estimate tissue cross-sections, is developed based on PTRAN_CCG version 7.44. PTRAN_CT uses fast ray tracing that combines patient anatomy modeling via 3D voxel arrays with modeling of sources and applicators via a general combinatorial geometry code. A generalized phase-space source is used for further increasing efficiency. PTRAN_CT uses cross-section data derived from a single-energy CT image. PTRAN_CT was incorporated into an integrated system for performing postimplant dosimetric analysis of permanent prostate implants. A clinical implant consisting of 78 Model-6711 I-125 seeds was investigated to quantify interseed and tissue heterogeneity effects. Three scenarios were simulated a) comprehensive MC simulation including tissue heterogeneities and complete seed geometry b) complete seed geometry in homogeneous water and c) homogeneous water using 2D TG-43 source superposition.

Results: Compared to case b), tissue heterogeneities (case a)) reduce doses by 5.8% on average in the target volume, after excluding artifacts from CT data. Interseed effects (case b) vs c)), reduce doses by 3% on average. The seed streaking artifact in CT data can affect MC result as large as 6%. The efficiency of PTRAN_CT relative to the predecessor code PTRAN_CCG is increased by factors of two and five, respectively, with and without enabling the phase-space option. In case b), PTRAN_CT yields the same dose distribution as benchmarked PTRAN_744.

Conclusion: A novel post-implant dose evaluation system, based upon an accelerated CT-based Monte Carlo brachytherapy dose-calculation engine, has been developed and its accuracy and efficiency demonstrated. Preliminary results suggest that tissue heterogeneity effects can be incorporated into the clinical planning process.