AbstractID: 2834 Title: Improving simulation efficiency of MLCs for Monte Carlo based dose calculation of IMRT

Purpose: Dose accuracy of Monte Carlo simulation (MCS) may critically depend on how MLCs are modeled for IMRT, however computation time increases significantly with the complexity of the MLC modeling. The purpose of this work are to determine (1) whether detailed modeling of complex leaf geometry is needed for clinical applications of MCS in IMRT; (2) whether simulation efficiency can be improved with simplified models of the MLC without sacrificing dose accuracy of MCS.

Method and Materials:We studied leaf modeling for Varian 120-leaf MLCs with very sophisticated leaf design. The full MLC model used in MCS included rounded leaf end, and all details of tongue-groove design and leaf tips. In the simplified version, the rounded leaf end and leaf divergence were preserved; however, the leaves were approximated by rectangular regions with straight edges and no tongue-groove. The parameters for the simplified model (leaf density, leaf geometry, leaf gaps) were determined by measured transmission ratios and intensity maps. Intensity distributions and doses in water phantom and Rando phantoms for various testing leaf sequences and actual patient treatments were compared between the full and simplified leaf models.

Results: It was possible to fine tune leaf geometry and air gaps in the simplified MLC model to match the measured transmission ratios. However with the simplified models, it was more challenging to match intensity maps with significant tongue-groove effects. Applying the simplified model along with appropriate variance reduction techniques (Ecut: from 0.7 to 5 MeV, Russian Roulette) could improve simulation efficiency by a factor of 17. The agreement between the full and simplified models for actual patient fields was clinically acceptable.

Conclusion: Composite dose in patient fields delivered through multiple IMRT beams may not be sensitive to the detailed tongue-groove design of the MLCs. Varian reduction techniques are important for IMRT to improve simulation efficiency.