AbstractID: 11248 Title: Fast 4D Monte Carlo dose calculations in deforming anatomies

Purpose: The voxel warping approach to 4D dose calculation calculates the dose deposition on a deformed dose grid in order to determine the contribution of dose deposited at one anatomical state to a reference state. The current implementation of this method in the defDOSXYZnrc Monte Carlo code resulted in a significant increase in computation times. The purpose of this work was an efficient implementation of the voxel warping method in the VMC++ Monte Carlo. Three alternative deformed voxel geometry definitions were investigated to see how they influence the remapped dose calculation efficiency and accuracy.
Method and Materials: A set of new deformable geometry classes was created for VMC++ which were compiled as dynamic shared libraries that could be loaded at run time. We implemented three different deformable geometries: a deformed dodecahedron geometry and two geometries based on tetrahedral elements with alternate divisions of the voxel faces. Dose calculations using the new deformable VMC++ geometry were validated by comparison with defDOSXYZnrc by calculating remapped dose in a deforming water phantom and a lung patient deformed from Inhale to Exhale. Dose distributions were compared using the gamma index as well as the Kawrakow-Fippel test to distinguish systematic discrepancies from dose differences due to random statistical uncertainties.
Results: Efficiency gains of the order of 100 were obtained relative to defDOSXYZnrc. A further factor of 1.2 gain in efficiency was realized with the tetrahedral geometries. VMC++ and defDOSXYZnrc calculations were found to agree within 1% in the deforming phantom. Although it could be demonstrated that different folding of the voxel faces influences the dose calculation no differences were found in the patient dose distributions calculated using the different geometries.
Conclusion: We have implemented a new deformed geometry class in the VMC++ Monte Carlo code which makes possible efficient and accurate 4D dose calculations.