AbstractID: 11315 Title: Evaluating 4D interplay effects for proton scanning beams in lung cancers

Purpose: The Intensity Modulated Proton Therapy, delivered with spot scanning, provides greater control over dose distributions than passive scattering proton therapy. However, interplay of spot scanning with respiratory organ motion may result in interplay effects in dose distributions. Such effects may cause some parts of the tumor to be under dosed and other parts to be overdosed. 4D dose averaged over 4DCT sets is the *de facto* standard to evaluate respiratory motion effects. Interplay effects may render this metric insufficient. The purposes of this work are to develop a dynamic 4D dose calculation algorithm incorporating interplay effects and evaluate the dosimetric consequences of such effect for lung IMPT plans. **Methods:** The complete flow of the scanning spot delivery process was simulated by coupling the information on proton cycles (acceleration, spills and pulses, switching of spots, etc.), beams, and energies, and respiratory cycles. At beginning of spot delivery of each beam or each fraction, the simulation started with a random respiratory phase. The dose contributed by each pulse was calculated on its corresponding phase in the 4DCTs and final dose was mapped to the reference CT phase using deformable image registration. Dose distributions and the biological effects were compared among simulations with different numbers of fractions and pulses per spot. **Results:** The prescription dose coverage for PTV was 95%, 94.2 %, 93.9%, 91%, and 84% for the designed dose, 4D static dose, 4D dynamic doses delivered in 30, 6 and 1 fractions respectively. Tumor control probability (TCP) was 76% for 4D and 30-fraction dose, compared to 72% for single fraction. **Conclusion:** The dose distributions converge to 4D dose only when the number of fractions or pulses per spot is large enough. A dynamic 4D simulation is necessary for evaluating the impact of organ motions in scanning beam proton plans.