AbstractID: 11413 Title: The effect of lung heterogeneity and respiration on proton therapy treatment margins

Purpose: A critical parameter in lung proton therapy is the range determination, which is related to the treatment margins required to build the PTV. Factors affecting treatment margins include intrafractional tumor motion, interfractional tumor deformation, and anatomic changes. This work investigates the effect of lung heterogeneity and respiratory motion on proton dose distributions using CT scans at different respiratory phases.

Method and Materials: Ten previously treated lung patients were recruited for this study. For each patient 4D CT scans were obtained with 10 respiratory phases. The variation of lung density at different respiratory phases and the effective distance from the patient surface to the back of the target volume were analyzed using specially designed software. Monte Carlo simulations were performed to calculate proton dose distributions with different energies and field sizes. The average lung density for a 1cm beamlet was computed for different target locations and beam orientations to provide useful information for advanced proton therapy treatment planning. The density calculation was performed in lung regions without major heterogeneities. Tumor motion and setup uncertainties were not included in this study.

Results: Results showed a density difference between the inhale and the exhale phases of up to 0.25g/cm^3 (the lung average density is 0.17g/cm^3 for the inhale phase). Taking into account the real lateral size of the lung for each patient, this difference leads to a 1.3cm difference between the two extreme phases. The effects of lung heterogeneity vary based on the target location and beam orientation. Monte Carlo calculated dose distributions showed variable distal edge shifts and SOBP plateau deformation.

Conclusion: The effects of lung heterogeneity and respiration vary significantly, which require precise margin determination for individual patients in advanced proton therapy with beam scanning and intensity modulation. Additional margins will be needed for population-based PTV.