AbstractID: 7737 Title: Breathing interplay effects during proton beam spot scanning: simulation and statistical analysis

Purpose: The transition from passive scattering to active scanning in proton radiation therapy introduces the problem of interplay effects, when elements of beam motion have a similar time scale to intrafractional tumor motion. This can lead to unacceptable deviation from the planned dose in a given fraction. The sum of fields over an entire treatment leads to a predictable broadening of the penumbra, but the limited number of fractions may not provide enough repetition to satisfactorily wash out interplay effects. A possible solution is the 'repainting' of each field several times at lower dose rate. This study looks at the dosimetric effect of interplay and compares different 'repainting' methods.

Materials & Methods: The broadening of the penumbra and the dose shift due to breathing asymmetry are characterized via simulation over a set of clinically relevant permutations including tumor amplitude, breathing period, energy change time, proton beam spot size, location within the field, and degree of breathing asymmetry. Several repainting methods are developed and compared for the conditions of worst-case delivery error. Breathing motion, normal to the beam direction, is modeled with an asymmetric sine function..

Results: The broadening of the penumbra depends only on the amplitude of tumor motion, and is responsible for narrowing the full prescription isodose volume and widening the low dose penumbra by as much as 2cm for large tumor amplitudes (3cm peak-to-peak). The systematic isodose shift by 10%-15% of the tumor amplitude was observed due to motion asymmetry. Of the five re-painting techniques studied, Breath Sampling Repainting was most effective in reducing dose errors with a minimal addition to treatment time.

Conclusions: Dose repainting is necessary in treatment of moving tumors with scanned proton beams. The dosimetric uncertainty can be reduced with certain 'repainting' techniques.