AbstractID: 11466 Title: Respiratory-gated delivery of synchrotron-based proton irradiation

Purpose: To investigate the precision of synchrotron based passively scattered respiratory gated delivery of proton irradiation. A simulation study was undertaken for the analysis of the residual target motion uncertainty during synchrotron based respiratory gated proton treatment.

Method and Materials: In-house software was developed to simulate a synchrotron based respiratory gated proton treatment. The interactions of respiratory motion traces (70 traces, 22 patients), respiratory gate threshold levels (10%, 20% and 30% duty cycle around peak exhalation) and synchrotron T_{cyc} patterns (fixed T_{cyc} =2.7, 3.0 ~ 6.0 second, average patient breathing-cycle and variable T_{cyc}) were plotted along the same time scale, similar to an oscilloscope display. Proton beam delivery within a gate threshold only occurred during a portion of each T_{cyc} pattern. A specific pattern of T_{cyc} acts as a "gate-within-a-gate", which produces a smaller effective gating window. Precision of respiratory gated proton delivery was analyzed by examining distribution of distance from the respiratory gate threshold where 95% of gated beam delivery (DGT_{95}) occurred.

Results: With shorter fixed T_{cyc} (< 4 sec), average DGT_{95} values were 0.30 cm, 0.23 cm and 0.17 cm respectively for 30%, 20% and 10% respiratory gate duty cycles. With longer fixed T_{cyc}s (> 4 sec) average DGT_{95} values were 0.25 cm, 0.19 cm and 0.14 cm respectively for 30%, 20% and 10% respiratory gate duty cycles. With $T_{cyc} \approx$ average patient breathing cycle, average DGT_{95} values were 0.27 cm, 0.20 cm and 0.15 cm for 30%, 20% and 10% respiratory gate duty cycles. With variable T_{cyc}, DGT_{95} values were 0.21 cm, 0.17 cm and 0.14 cm for 30%, 20% and 10% respiratory gate duty cycles.

Conclusion: Variable T_{cyc} mode offered the greatest precision of respiratory gated delivery for passively scattered synchrotron proton irradiation.