AbstractID: 8182 Title: Simultaneous Tracking and Four-Dimensional Radiotherapy Delivery: Accounting for spatial and morphological tumor changes

Purpose: The aim of this work was to develop the formalism for, and experimentally verify, radiotherapy delivery to tumors undergoing spatial and morphological changes induced by respiration.

Method and Materials: To determine the leaf sequence to be delivered at a given time based on a 4D plan, $L_{Plan}(M,\theta)$, in which the leaf sequence varies not only with monitor units, M, but also respiratory phase θ can be summarized by $L_{Del}(t) = L_{Plan}(M,\theta) + R\left[T_{Del}(x,y,z) - T_{Plan}(x,y,z,\theta)\right]$ where T is the 3D target position and L are leaf positions. A 4D treatment plan of a translating, rotating, deforming tumor exhibiting hysteresis with values well above those typically observed clinically was created. The theory derived was coded into a prototype 4D MLC controller. The treatment plan was loaded onto the controller, and delivered on a linear accelerator. The motion was detected by the monitoring of the marker block by the RPM system. The RPM signal was output in real time to the MLC controller that reshaped the beam according to the position and phase of the incoming signal. An EPID, operating in cine mode was used as the detector.

Results: The treatment plan from phase T0-T9 matched the real-time EPID images. The EPID images demonstrate the ability of the MLC leaves, driven based on the theory derived above, to conform to spatial and morphological changes.

Conclusion: A theory has been developed to deliver 4D plans in which the leaf sequences can vary as a function of phase to account for the spatial and morphological tumor and normal tissue changes with respiration. This theory has been integrated into a MLC controller. A 4D radiotherapy treatment plan that includes translation, rotation, hysteresis and deformation was delivered. The method allows for variable respiratory patterns during treatment delivery.

Conflict of Interest: Research supported by Varian Medical Systems.