AbstractID: 10702 Title: Quantifying Uncertainty in Dose Deposition Resulting from Patient Breathing Variability

Purpose: To obtain more accurate predictions of dose deposition and elucidate discrepancies in planned and delivered treatments resulting from respiratory-induced target motion, we develope a stochastic model of dose deposition and a computational framework to determine the effects of patient breathing variability on stereotactic Body Radiation Therapy (SBRT) dose calculations.

Method and Materials: We developed a model to characterize the underlying day-to-day variability in patient breathing patterns and incorporated this model into a calculation of dose deposition. To accomplish this, we fitted Gaussian Mixture Models (GMM) to Realtime Position Management (RPM) breathing trace amplitude recordings from the same patient on different days. Using Principal Component Analysis, we identified the modes of greatest variation in the GMM fits. We then modeled each principal mode as an independent and uncorrelated random variable. Applying the stochastic computational methods, we determined statistical moments (e.g. mean and variance) of the predicted dose for a particular SBRT patient.

Results: For the patient study, the standard deviation in dose resulting from day-to-day breathing variation is as large as 7\% of the maximum prescribed dose. High-dose level variation is observed to occur near the boundaries of the lesion corresponding to regions of high dose gradient that experience large respiratory-induced organ deformation. Such areas are important because they indicate regions in which the planned dose may differ significantly from the true deposition during treatment and are likely candidates for over- or under-dosing. Additionally, the maximum calculated target dose resulting from incorporation of motion is 12.4\% lower than the maximum treatment-planning-predicted dose, indicating that organ motion can significantly alter the overall dose deposition for a treatment.

Conclusion: Our framework provides an accurate and efficient means of calculating the effect of respiratory-induced organ motion on SBRT dose deposition.