AbstractID: 13137 Title: Considerations of inter-observer and inter-fractional anatomical variability in estimating the beam range uncertainty in proton therapy of prostate cancer

Purpose: For estimates of proton range, conversion of CT Hounsfield units (HU) to stopping powers is complicated due to limited knowledge of atomic composition of tissue, and ionization potentials. Historically, the overall range uncertainty of 3.5% is stipulated, regardless of tumor site. We evaluate the variation in CT anatomy traversed by proton beam in transit to the prostate, and evaluate the range uncertainty specific to that site.

Method: CT scans were analyzed for 10 patients, representing a range of body constitution: body-mass index (BMI) between 22-39 kg/m^2. Proton range compensators were designed following standard planning protocol. The distribution of HU was histogrammed for various raytraces (beam paths through 5x5 mm^2 compensator elements). Based on HU, voxels were stratified into 3 categories: adipose, "soft" (muscle, skin, connective, hematopoietic), and bony tissue. From literature, maximum range uncertainties were taken to be 1.8% in bone, and 1.1% in soft tissue. Amounts of different tissue types per raytrace, and accumulated uncertainty in proton range, were estimated for individual patients. Inter-fractional variations were evaluated with serial CT data.

Results: Although the HU frequency histograms differ substantially between raytraces for the same patient, the inter-fractional variability (assuming image-guided set-up) was found to be insignificant. Across the patient selection, the relative share of adipose tissue in the beam path correlated with BMI, however, the share of bony tissue was stable. Relative range uncertainty averaged across the compensator was within 1.20-1.27% for all 10 patients, and the maximum among all patients' raytraces was 1.43%.

Conclusion: Estimated range uncertainty resulting from CT conversion was under 1.5% for all patients. Combined with scanner calibration errors (~1%), the overall range uncertainty in prostate treatments is below 2.5%. This may allow for a safe range margin reduction by 2-3 mm, leading to 1-1.5 Gy drop in dose to skin and proximal tissue.