Abstract ID: 15399 Title: Comprehensive Uncertainty Analysis of Proton Stopping-power-ratio Estimation using a kV-MV Dual Energy CT Scanner for Margin Reduction

Purpose: To analyze the uncertainties in proton stopping-power-ratios (SPRs) calculation using a kV-MV DECT and evaluate the potential for margin reduction for proton therapy

Methods: Sources of uncertainties in SPR estimation were broken into five categories: CT imaging uncertainties, CT modeling error, uncertainties in the mean-excitation-energy, SPR variation with proton energy and uncertainties due to variations in human tissue compositions. Additionally, lung, soft and bone tissues were analyzed separately because their uncertainties are too different to be considered as the same tissue type. The uncertainty of 1-standard-deviation (1-SD) was determined for each category and each tissue type. To derive a realistic composite uncertainty, tissue proportions of each tissue type were measured in three treatment sites: prostate, lung and head-and-neck, with 5 proton patient cases for each site. The beam angles and treatment target in the original treatment plan were used. Ray tracing technique was used to determine the tissue proportion from the skin surface to the distal surface of the target volume. The range uncertainty was determined for each ray line, and the 95th-percentile uncertainty was determined for the population of the ray lines belonging to the same tumor site.

Results: The total uncertainty in SPR estimation (1-SD) was estimated to be 3.8%, 0.8% and 1.3% for lung, soft and bone tissues, respectively. The combined range uncertainty estimates (95th-percentile) for prostate, lung and head-and-neck treatment sites were 1.6%, 2.1% and 1.6%, respectively.

Conclusions: The current practice uses a 3.5% range uncertainty for SPR estimation for all treatment sites. We found it is important to separate tissue types in order to better estimate the site-specific range uncertainties. The use of kV-MV DECT can reduce current margin by half for prostate and head-and-neck sites (1.6% vs. 3.5%) but can only reduce the uncertainty by 40% for lung cancer site (2.1% vs. 3.5%).

Funding Support, Disclosures, and Conflict of Interest:

Research partially sponsored by Varian Medical Systems.