AbstractID: 13941 Title: Dose uncertainty due to high-Z materials in clinical proton beam therapy

Purpose: In proton therapy, high-Z materials, such as dental alloys, sternal reconstruction plates, prosthesis, and metallic ports, can introduce significant dose perturbations. Our objective is to quantify the high-Z induced dosimetry uncertainty in clinical proton beams.

Method and Materials: Dose perturbations from one titanium vascular port and a steel injection port of a breast expander were studied. An extended CT-electron density (ED) curve for MVCT was obtained with an RMI CT phantom and metal plates (Al, Sn, Ti, Pb). Measurements taken with a 2D ion chamber array placed at different depths downstream from the high-Z-solid water interface were compared with dose calculations on the XiO treatment planning system based on both the MVCT and kVCT images. The Monte Carlo code FLUKA was used to verify accuracy of inhomogeneity corrections in the pencil beam algorithm. Dose perturbation factor (DPF) was defined as the ratio of the doses with and without the high-Z material.

Results: For MVCT, the CT-ED relationship is linear from lung to lead. There are considerable dose enhancement (>10%) near the high-Z interface due to secondary electrons from the metallic port. DPF as large as 20% was observed within the spread-out Bragg peak. MVCT images provided more accurate delineation of the metallic object compared to kVCT, which tends to overestimate the water equivalent thickness of the metal object, resulting in shallower proton depth than its actual value. The DPF calculated from MVCT planning agrees with the measured results within 10%. Results from Monte Carlo calculations are comparable to results from XiO although there are small differences.

Conclusions: Understanding dose uncertainty induced by high-Z material is very important in proton therapy. MVCT based treatment planning may be preferred with an extended CT-ED curve. Difference between measured and calculated dose distribution shall be quantified.