AbstractID: 3975 Title: Measurements and Monte Carlo Simulations of Dose Perturbations Due to Metallic Implants in Proton Radiotherapy

Purpose: To quantify the dose perturbation behind implanted metallic appliances and fiducials in proton radiotherapy.

Method and Materials: Dose perturbations from stainless steel spheres of 6.4-15.9 mm diameter were investigated in proton therapy beams. Passive lateral spreading was combined with collimation to produce 17.8-cm diameter fields. Penetration ranges were varied between 40 and 160 mm. Dose profiles were measured in planes perpendicular to the proton beam axis, at distances of 0-150 mm behind the implants, using radiographic film exposed to 0.4-0.5 mGy. The experiments were modeled in detail with Monte Carlo simulations that included hadron and electron transport physics. 120×10^6 proton histories were simulated, corresponding to 8% or less statistical uncertainty.

Results: Edge effects are most prominent at the highest proton beam energies and produce concentric perturbations of +/-10-40% for the implants considered here. Thick implants (w.r.t. the beam range) may stop the protons, leaving a zero dose shadow behind it. For thin and intermediate implants, the range loss in the implant produces a cone of dose enhancement of up to 20% directly behind the implant due to in increase in the stopping power values. In an air cavity, shadows reduce the dose by up to 60% at 15 cm distance downstream from the implant. The Monte Carlo simulations agree with the measurements to better than 8% in all cases and typically to within 4%. Additional simulations will be presented for implants of gold and tantalum, ranging in size from 0.8 to 3 mm.

Conclusion: We have identified several representative cases in which implants produce significant dose perturbations. In such cases, a treatment plan should include suitable simulations or measurements to ensure that the implants do not result in cold spots in the tumor or hot spots in normal tissue.