AbstractID: 13407 Title: Direct measurement of absolute absorbed dose in scanning proton beams based on water calorimetry.

Purpose: To develop a novel primary standard for absorbed dose to water D_W measurement in scanning proton beams based on 4°C stagnant water calorimetry.

Method and Materials: An in-house built Domen-type water calorimeter was used to measure the absolute D_W directly in water at isocenter in a relatively flat SOBP region (peak-to-trough variation < 0.25%) of a scattered (250 MeV proton) and a scanned (15 layers painted with proton energies between 128-150 MeV) proton beam. The heat loss correction factor, defined as the ratio of the temperature in the calorimeter under ideal conditions to realistic conditions, was numerically calculated using COMSOL MULTIPHYSICS™. The calorimeter was modeled, proton beam scanning was simulated, and a time-dependent heat-transport module was used. The calorimetry measurements were compared to dose results from an Exradin T1 Mini Shonka following TRS-398 protocol.

Results: The heat loss correction factor was calculated to be 0.4% in scattered and 4.7% in scanned beams. We calculated the total 1-sigma uncertainty on dose measurements to be 0.38% (scattered) and 0.64% (scanned). This was in contrast to a 1.86% uncertainty on the dose measured using the ionization chamber. The chamber dose results agreed with the absolute dose to water measurements made using water calorimetry well to within uncertainty: A difference of 0.14% in scattered beams and 0.32% in scanned beams was observed between the two techniques.

Conclusions: Feasibility of performing water calorimetry in proton therapy and specifically in scanned beam delivery has been shown both numerically and experimentally. By adopting a water calorimetry-based primary standard and calibrating user ionization chambers directly in proton beams, national dosimetry laboratories can significantly reduce the uncertainty on dose determination in proton beams from the current 1.5%-2% level down to sub-percent regime similar to the current standard of practice in high energy photon beams.