Purpose: Accurate estimation of the Bragg-peak-distal-edge (BPDE) location is crucial in proton therapy dose delivery. Current range verification techniques includes PET imaging which takes advantage of the Beta+ emitters produced following proton interaction within the patient body. However, such interactions produce negligible PET signal at the BPDE due largely to the decrease in proton energy with depth, which reduces the efficiency of Beta+ emitter production. The objective of this study is to investigate the feasibility of overcoming this limitation by infusing 18O into the treatment volume through 18O(p,n)18F interaction while leveraging the longer 18F t1/2 and its lower interaction energy threshold.
This study compares PET signals from irradiated 18O water with 16O water and heptane over different depths of BPDE to estimate the improvement 18O water brings about in BPDE estimation.

Methods: Petri dishes containing 2 mm depth of 18O water, 16O water, or Heptane (C7H16) were stacked on a water-equivalent plastic phantom of thickness chosen to position the samples in the distal 99% to 8% dose region of a proton beam. A dose of 10 Gy was delivered to the 100% dose point. The petri dishes were then positioned in FOV of a PET/CT scanner 20 min post irradiation and scanned for 15 min. Mean activities of all samples were obtained over different BPDE region and normalized to maximum of 18O water. MC activity simulation for the three sample materials was performed for comparison.

Results: Mean activities for each sample are as follow for BPDE 99%~87%, 87%~65%, 65%~20%, and 39%~8% regions. 18O water – 100%, 19%, 5%, 2%; 16O water – 29%, 4%, and negligible; heptanes – 12% and negligible. MC simulation showed consistent results with measurements.

Conclusions: Strong to reasonable activities from 18O water over all BPDE regions indicates the possibility of using 18O for reliable range verification.

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