

Relative Stopping Power (RSP) and Water Equivalent Thickness (WET) measurements of phantoms using x-ray flat panel detector and scanned proton beam

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Introduction

An x-ray flat panel detector was used to measure the WET of a head phantom measured via proton radiography and compare to the WET calculated from the DRR. The RSP of a tissue characterization phantom (Gammex model 467) was also calculated.

Previous experiments have shown the validity of using proton radiography for calculating WET values. In lieu of a dedicated proton tracking and range system, easy clinical integration can be realized by utilizing existing systems, such as a flat panel detector. [1]

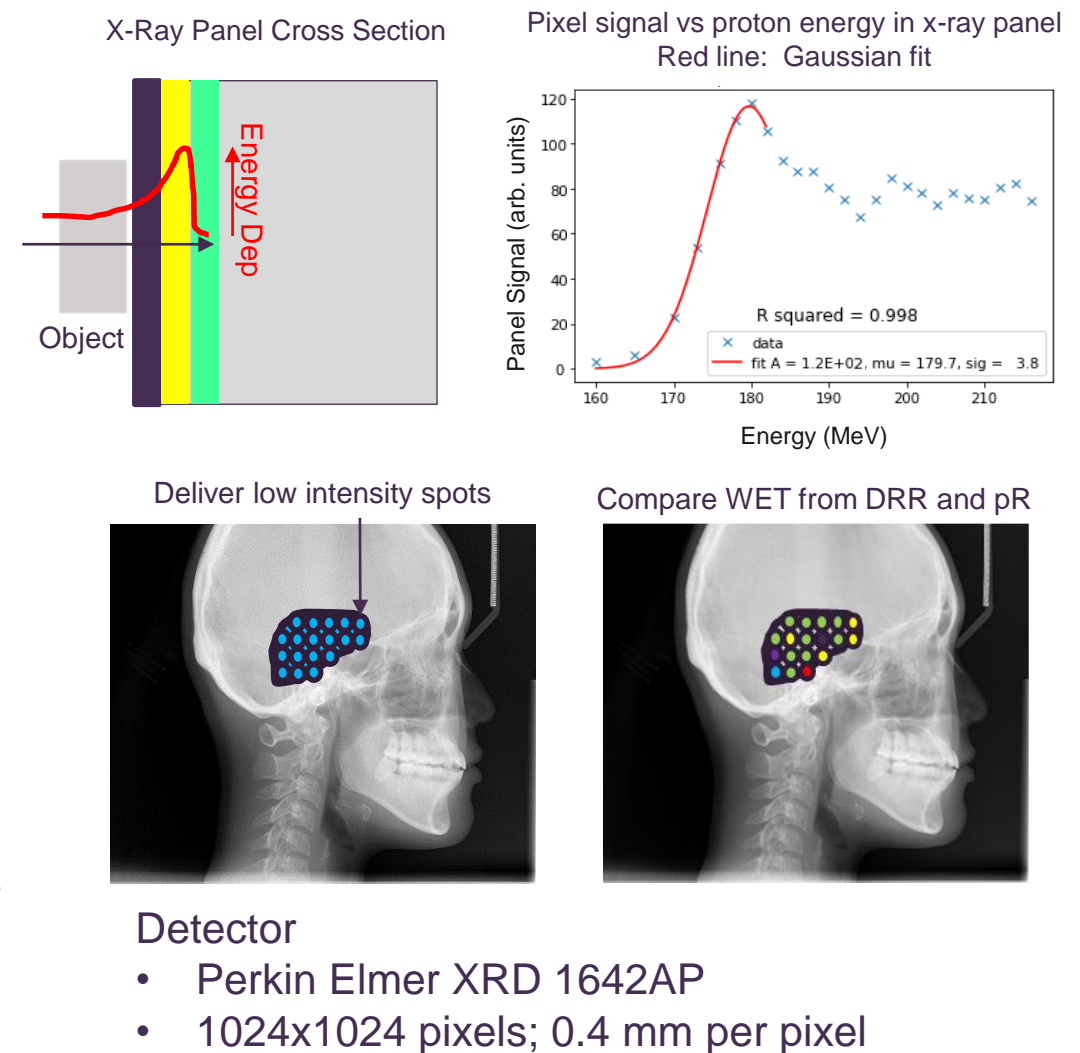
Methods

A total of 35 layers ranging from 140 MeV – 222 MeV were used to measure the phantom WET in 9 locations using the Energy Resolved Dose Function (ERDF) method. These values were compared to the WET calculated from the DRR of the head phantom (via HU lookup table) or the Bethe-Bloch relation (for the tissue phantom). [1]

Experimental Details:

Beam

- 140 MeV – 222 MeV in 2MeV increments
- Beam sigma: 3 – 5 mm
- 0.002 Gp/spot, <1 mGy per layer
- 25x25 cm² field size

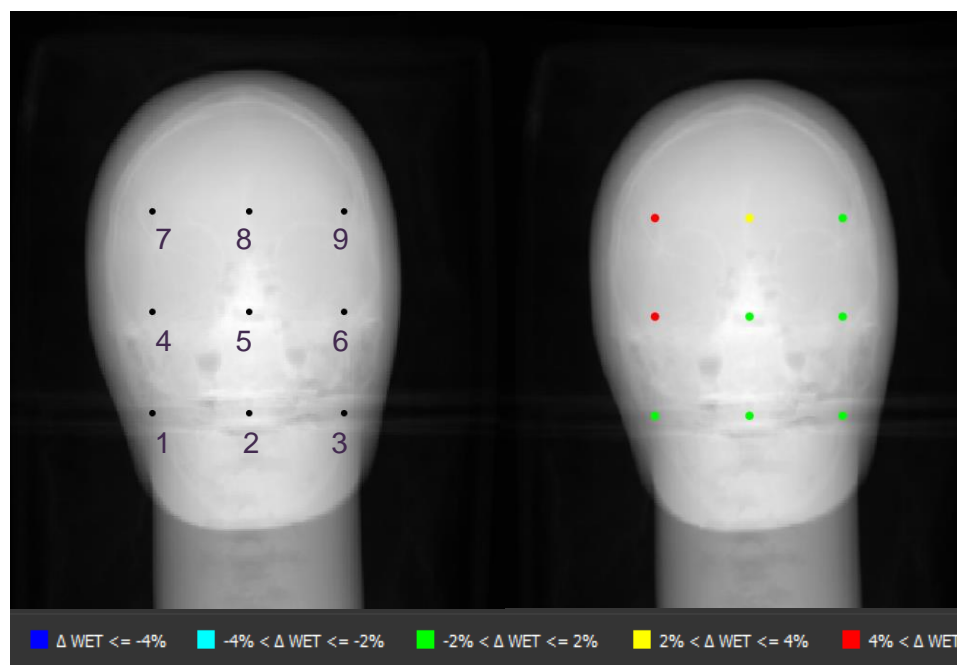


Results

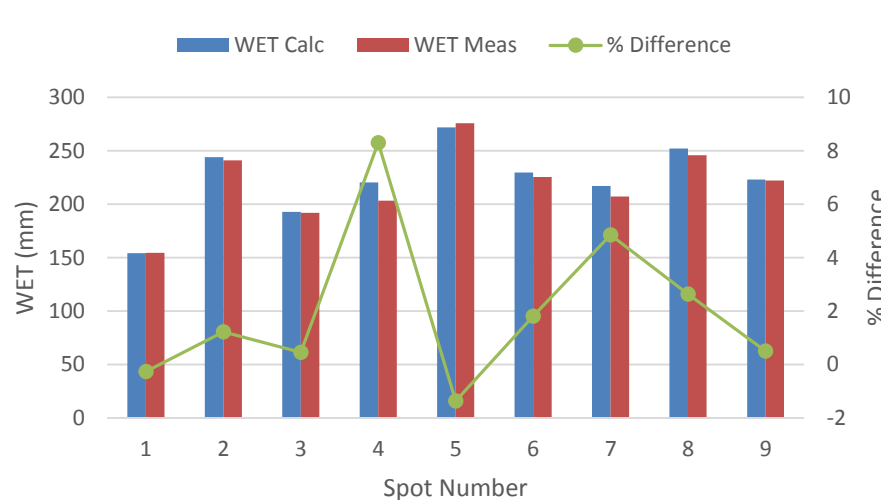
- 6 of the 9 regions of interest (ROI) show good agreement with the WET calculated from the DRR.
- 2 ROIs show deviations of >4%. Regions with a large deviation can be attributed to misalignment/registration errors or anatomical changes (only applicable to patients).
- Tissue Phantom RSP values found via proton radiography were all within 1.5% of calculated values, with the exception of adipose tissue.

Head Phantom

Measured vs Calculated WET values at 9 locations

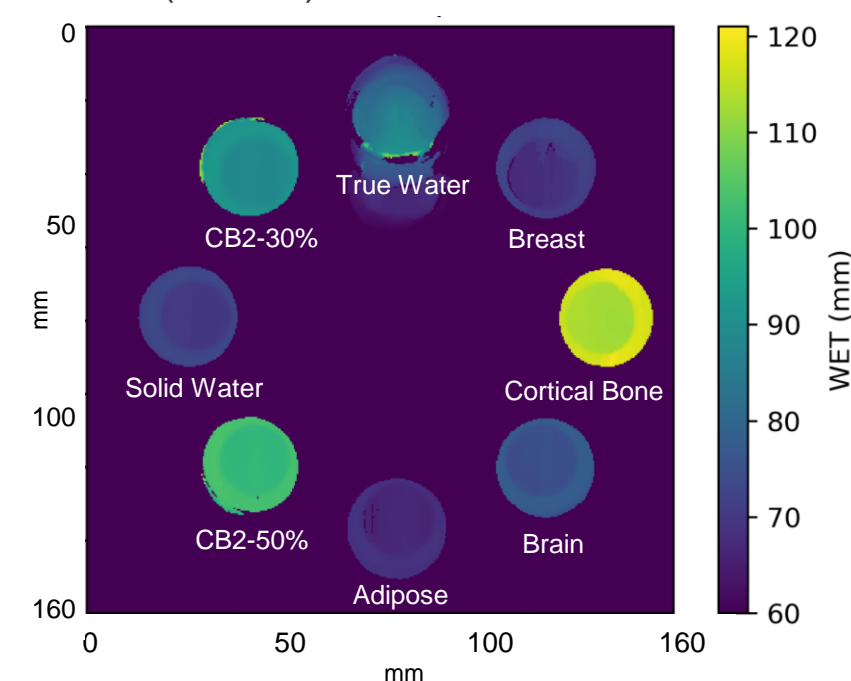


WET Calc (DRR) vs WET Meas (pRT)

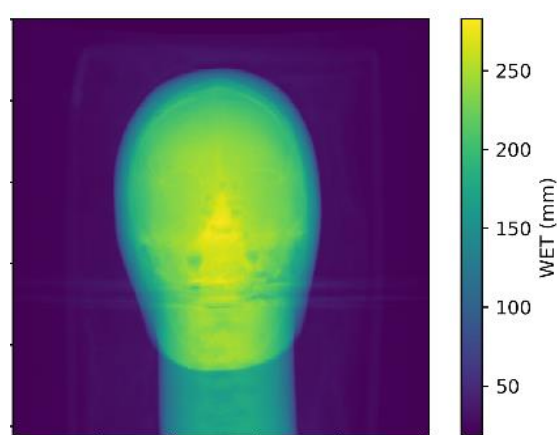
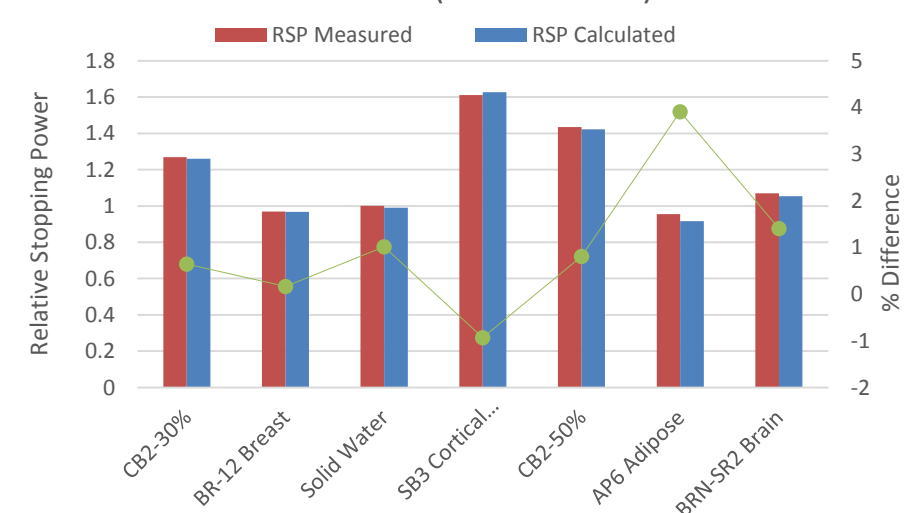


Tissue Phantom

Measured vs Calculated WET (top) and RSP (bottom) values



RSP: Calculated (Bethe-Bloch²) vs Measured

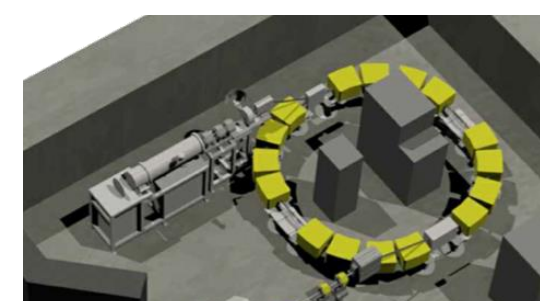


WET map calculated from DRR

Discussion

Proton radiography with a scanned pencil beam can be used to check the WET of a patient immediately before treatment, allowing immediate detection of any anatomical changes. Use of an x-ray flat panel simplifies clinical integration by utilizing readily available equipment.

The Radiance 330[®] is the first proton therapy system specifically designed and built for proton therapy. With up to 330 MeV beam energy, future capabilities include proton tomography and proton radiography.



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1. El H Bentefour et al "Concept of proton radiography using energy resolved dose measurement" 2016 Phys. Med. Biol. 61 N386
2. Chee-Wai Cheng, et al. "Comparison of tissue characterization curves for different CT scanners: implication in proton therapy treatment planning", Transl. Cancer Res 2012;1(4):236-246