AbstractID: 8384 Title: Quantification of clinical limitations of proton beam range verification using offline PET/CT due to biological washout effects

Purpose: The use of offline positron emission tomography/computed tomography (PET/CT) scans after proton beam delivery as quality assurance tool is currently under investigation at the Massachusetts General Hospital. A specific aim is to validate the planned proton range in the patient. This study investigates restrictions on the accuracy of the offline method due to washout effects in perfused tissue.

Method and Materials: Imaging was performed at a commercial PET/CT scanner for 30min, starting within 20min after treatment. Measured PET/CT images were coregistered to the planning CT and compared with corresponding PET distributions, obtained from CT-based Monte Carlo simulations.

For 5 patients with tumors in the head and neck region the range was verified at positions where the proton beam ended in bone as well as at positions where the beam stopped in well-perfused tissue. Besides a range comparison at specific positions in the fall-off region of the activity depth profiles (pointwise), a range analysis taking the entire fall-off region into account (shift) was performed.

Results: For treatment beams ending in bone it was found that pointwise range verification at the 20% (50%) position in the last activity fall-off within 1.2mm (2.5mm) and shift range verification within 2.4mm is feasible. In soft tissue pointwise range verification turned out to be not practicable due to the washout of the activity signal. The shift method showed the potential for range verification within 4.3mm in soft tissue and within 2.4mm if only the last 50% of the final activity fall off-region lay in well-perfused tissue. However in soft tissue it is complex to distinguish reasons for observed deviations.

Conclusion: Offline PET/CT scans permit mm-accurate range verification only in well-coregistered bony structures, thus at limited positions. In soft tissue biological washout effects degrade the measured activity distribution and therefore prevent mm-accurate offline PET/CT range verification.