AbstractID: 5562 Title: A novel filtering approach for local PET verification of proton radiotherapy

Purpose: Proton radiotherapy activates positron emitters in tissue, which can be imaged with PET. However, the resulting PET image is not directly proportional to the delivered dose. We are investigating the spatial relationship between the dose distribution and its PET image without reverting to Monte Carlo methods. The first goal is to validate the proton range in the patient, and ultimately to reconstruct the spatial distribution of the actually delivered dose from its PET image.

Method and Materials: The relationship between the proton dose and its PET image can be described mathematically as a convolution (filtering). We derive the convolution kernel analytically. This filter is unique for a given activation channel, independent of beam energy and specific absorber. The straightforward application of the method to determine the PET signal by locally filtering the planned dose distribution was validated through comparisons with Monte Carlo calculations and measured PET data in homogeneous and inhomogeneous media. The challenging inversion of the relationship, determining the dose from the PET signal, was initially explored for a simplified mono-energetic case in a homogeneous absorber.

Results: Activity depth profiles obtained with the convolution approach agreed with measured and Monte Carlo data within 1 mm in depth. In terms of absolute intensity, the agreement was within 1.5% between filtered and simulated profiles and 10% between filtered and measured data in the distal region. Attempts to recover the dose distribution from its PET image through a de-convolution yielded promising results for idealized data but were strongly noise dependent.

Conclusion: We have derived the spatial relationship between dose and positron activation and demonstrated the possibility to obtain the PET image measured after proton treatment by locally filtering the planned dose distribution. The inverse approach, i.e., direct dose quantification from the measured PET, seems possible but is very sensitive to noise.