Purpose: Prompt gamma photons emitted during proton radiotherapy may provide a method to measure dose delivery and range. The utility of this method depends on how well the gammas can be detected and reconstructed. The purpose of this study is to demonstrate the feasibility of the stochastic origin ensemble (SOE) algorithm for reconstructing images of the origins of prompt gammas emitted during proton therapy and to introduce a metric for quantifying the accuracy of this image.

Methods: Using Geant4 we simulated a Compton camera detecting prompt gamma emission from proton irradiated tissue phantoms. The information recorded by the simulated detector is used as the input to the SOE reconstruction algorithm, which iteratively determines the likely gamma emission origin. We introduce a metric to quantify the accuracy of the reconstruction and use the metric to provide a quantitative analysis of the SOE reconstructions.

Results: We show both qualitatively and quantitatively that the SOE algorithm can reconstruct images which accurately predict the origins of prompt gammas emitted during proton therapy. We also show that the distal falloff of gamma production based on the reconstructed image agrees with the distal falloff in Monte Carlo calculated gamma origin distribution to within 1 mm for both the 50% and 20% regions.

Conclusions: The SOE algorithm was able to reconstruct usable images of prompt gamma emission during proton irradiation. We believe these results justify further investigation of this technique for in-vivo prompt gamma imaging.

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