Abstract ID: 16698 Title: Applications of Proton Radiography to Image Guided Proton Therapy - A Monte Carlo Study Involving the Most Likely Path Algorithm

Purpose: To optimize, through Monte Carlo simulation, a proton imaging system in localization of lung tumor motion and in quantification of proton range variations for image-guided proton therapy.

Methods: The proton imaging system modeled consists of position detectors and a range telescope. The Monte Carlo N-Particle eXtended (MCNPX) code with a particle-tracking feature was used to evaluate imaging system performance in visualizing and quantifying proton radiological pathlength variations during respiration. Various proton path approximation algorithms were evaluated to improve the image quality and the optimal Most Likely Path (MLP) algorithm was selected. Tumor trajectories from proton radiographs were computed to image the real-time respiratory phases and to provide feedback for gated treatment. The dosimetric gain of image-guided gating treatment was quantified by calculating the equivalent uniform dose (EUD) and normal tissue complication probability (NTCP) of organs at risk (OARs).

Results: Image quality of proton radiograph with spatial resolution of ~ 1.1 mm and range resolution of < 1 mm was achieved by applying the optimal MLP algorithm. Proton radiographs of two patient cases were reconstructed to determine tumor trajectories and radiological pathlength variations. The extracted tumor trajectories were within 1 mm of ground truth as determined from 4DCT. Utilizing tumor tracking, the margin was reduced for gated therapy. The dosimetric analysis shows that with image guidance, the EUD of OARs reduced by as much as 11% and corresponding NTCP of organs at risk (OARs) reduced up to 16.5%. In our exploratory cases, we see potential gains from using proton radiography for lung cancer treatments.

Conclusions: Simulation of proton radiograph suggests that proton imaging system can detect tumor motion and provide useful feedback information for gated treatment. The proton imaging system is potentially clinical useful for every-day image-guided proton therapy to achieve better clinical outcome.