AbstractID: 10509 Title: Proton Computed Tomography Reconstruction using Compressed Sensing and Prior Image Constrained Compressed Sensing

Purpose: To study the feasibility of proton computed tomography (CT) reconstruction using compressed sensing (CS) and prior image constrained compressed sensing (PICCS). Proton CT images can be used for pre-therapy planning, image guidance and registration verification.

Method and Materials: Projections of 200 MeV proton beams onto an ellipsoid phantom was simulated using Geant4 Monte Carlo simulation toolkit. The position and energy of the entrance and exit protons were recorded. Straight-line path (SLP) estimation was used to represent proton paths, and simultaneous algebraic reconstruction technique (SART) with CS was used to reconstruct a proton stopping power image for a 2-mm thick slice of the phantom. PICCS was used to reconstruct the image from highly undersampled data with an accurate and well-registered prior image. A Gradient transform was used to yield a sparse data set for CS and PICCS.

Results: SART with CS reconstructed a 320x320 proton stopping power image of the central slice of the phantom after 10 iterations. A proton/pixel ratio of 0.2 is sufficient to reconstruct an image of correct geometry. The average proton stopping power of the reconstructed materials cortical bone, water, and air were found to agree with the expected values from ICRU Report 49 within 8.3%, 0.6%, and 3.8% respectively. Employing a prior image and PICCS in the reconstruction, a proton/pixel ratio as low as 0.05 was found to be sufficient, and the reconstruction time of less than 2 minutes was achieved using a serial algorithm. Reconstruction artifacts in the images were minimal.

Conclusion: With CS, or with PICCS plus a prior image, SART can reconstruct a proton CT image of good quality within minutes. This paves the road to a clinically feasible approach toward low-dose pre-proton therapy treatment planning and image guidance using a fast-reconstructed proton CT image with a well-registered kV-CT prior image.