AbstractID: 4788 Title: Model-based statistical image reconstruction for 4D PET

Purpose: Four-dimensional (4D) PET can be acquired with gated, dynamic or list mode. In reality, a major problem limiting its clinical application is the poor statistics, since the total coincidence counts in conventional 3D PET are divided into several phase bins and each of them is treated as an independent entity in 4D image reconstruction. We develop a mathematically rigorous system approach that allows one to maximally enhance the signal-to-noise ratio (SNR) of 4D PET by simultaneously considering the coincidences acquired at all time points when reconstructing the phase-resolved images.

Method and Materials: A GE Discovery-ST PET/CT scanner was used to acquire 4D-CT/PET images. A Real-time Position Management (RPM) system was used to determine the respiration phases and to correlate temporally the PET and CT images. By deformable registration of the 4D-CT images, a *patient-specific* motion model was derived and incorporated into our “spatial-temporal PET reconstruction” algorithm based on the *maximum likelihood* principle. The approach was quantitatively evaluated with numerical and physical phantom experiments. Five clinical studies of pancreatic, lung and liver cancer patients were then carried out.

Results: Via a novel concept of “virtual curved line-of-response”, we proved that the PET “4D likelihood” can be maximized with a modified expectation-maximization algorithm. Numerical/physical phantom experiments and patient studies showed that the algorithm converged monotonically. In the former two cases, the “ground truths” were reached within 40 iterations, and the SNRs were enhanced by more than 80% over the regular 4D PET and 35% over 3D PET. Similar level of improvement was observed for the patient studies.

Conclusion: A spatial-temporal reconstruction formalism has been established to fully take advantage of the coincidence information acquired in the 4D acquisition process when reconstructing phase-resolved PET images. It allows us to obtain the statistically optimal 4D solution and substantially improved SNRs in 4D PET.