Purpose: To quantitatively assess the impact of motion correction in 4D-PET images on the accuracy of automatic lung tumour volume delineation for radiotherapy treatment planning and the resulting dosimetry modifications.

Methods: : Simulated 18F-FDG-PET data using the NURBS-based Cardiac-Torso phantom and Geant4 Application for Tomography Emission were considered. Homogeneous and heterogeneous spherical cases were designed with two tumor-to-background (T:B) contrasts (4 and 10) and 3 motion amplitudes (0.5, 1.5 and 2.5cm). Two more realistic cases derived from real clinical PET/CT datasets were also generated. Data were corrected for respiratory motion using two methods: reconstruction incorporating elastic transformations and super-resolution. The tumours were segmented with the Fuzzy Locally Adaptive Bayesian algorithm on each respiratory phase with or without correction and on the motion average image. For heterogeneous cases global and boost volumes were delineated. The union of the volumes at each phase with or without motion correction, the average PET volume and the volume with internal margins added to one respiratory phase were compared to the union of the simulated volumes (ground-truths). For each of these target volumes, IMRT planning was used to compare the different motion management approaches in terms of impact on dosimetry.

Results: The smallest and largest volumes were obtained on the average PET and the one with internal margins respectively. The best compromise between sensitivity and positive predictive value were obtained with corrected PET, with similar results for both corrections. The best compromise between ground-truth volume coverage and organs-at-risk sparing was achieved by the volumes with most accurate delineation. The volume with margins always covered the ground-truth.

Conclusions: 4D-PET with motion correction leads to more accurate delineation of lung tumours and boost volumes in the presence of respiratory motion. This also leads to improved margins for treatment planning.