Purpose:
To investigate the feasibility of a real-time EPID-based 4D dose verification method for adaptive SBRT lung treatment.

Methods:
Patients with fiducial markers were scanned with 4D-CT for SBRT planning. Before the treatment, an in-room 4D-CT scan (CT-on-rail) was obtained. Both the fiducial markers and MLC movements were tracked by continuously acquiring EPID images during the treatment. Instead of using the directly measured photon fluence, we reconstructed the incident fluence using the MLC apertures measured by the EPID and the MUs recorded by the R&V system. The delivered dose was then calculated by Monte Carlo simulations for every breathing phase using the in-room 4D-CT. The EPID-measured fiducial marker locations were correlated with the corresponding respiratory phases and the total dose was the sum of each breathing phase with a proper weighting factor after deformable registration. The accuracy of MLC aperture detection and fluence reconstruction was evaluated. A solid water phantom and a dynamic thorax phantom were used to validate the reconstructed 4D dose distributions. Clinical SBRT plans of 10 patients were selected to demonstrate the proposed method.

Results:
With patient heterogeneity, the field edges for 1x1 to 5x5 cm2 field sizes are still correctly defined (±0.8 mm). The reconstructed doses agree well with measurements and TPS calculations (0.87%). The EPID measured tumor movements represent the pre-set movements. The dose calculation with detected tumor movements larger than the PTV margin showed poorer coverage to the PTV and the ITV.

Conclusions:
The proposed method provides a practical way to reconstruct the incident fluence from on-line EPID-measured transit images and R&V recorded MUs and to calculate the fractional 4D doses received by a SBRT patient. With superior geometric and dose calculation accuracy, this method will enable adaptive SBRT to verify and correct the fractional doses received by the patient.