Purpose:Respiration induced tumor motion may greatly deviate from the planned dose delivery to the tumor and surrounding healthy structures, which is a more serious problem for proton radiotherapy due to its unique characteristics. This project aims to statistically analyze the effects on 4D dose distribution of various motion patterns and beam delivery starting phases using scatting proton beam and uniform scanning proton beam (USPB).

Methods:A 4D dose calculation system has been implemented which consider synchronized tumor motion and proton beam delivery mechanism. Studies were performed retrospectively on a lung treatment plan with prescribed dose of 42.5Gy, GTV-to-PTV margin of 7mm and smearing margin of 7.5mm. Scatting proton beam delivers dose to the entire SOBP simultaneously while USPB deliveries dose layer by layer at different time scale. Several distinctive respiratory motion patterns, with considerable amplitude and frequency variation, are applied in the study where the beam delivery starting times are set a different phases of a breathing cycle. Statistical analysis of the DVH is performed to compare the 4D dose distribution.

Results:The dose covered by 95% of the GTV (D95) showed that there is no significant difference between scattering and scanning proton beam if the breathing motion is regular. Even for motion with dramatic amplitude variation, if the overall amplitude changes are comparable to the plan margins, the effects are limited. For motion with large frequency and amplitude changes, the effects of breathing patterns and beam starting phases are considerable, up to 10% difference of the D95 values. The effects on USPB and scattering proton beam are very similar, with slightly better performance for scattering proton beam under most conditions.

Conclusions:The effects of the respiratory motion patterns and beam starting phases will affect both scattering and USPB and should be carefully take into treatment planning.