# Parameter vs logfile based 4D proton dose tracking for small movers in the abdomen region

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## Einleitung

Motion compensation strategies in particle therapy depend on the anatomic region, motion amplitude, and the underlying beam delivery technology. The quantification of the interplay effect is an prerequisite for improving treatment concepts for moving targets in particle therapy. While retrospective logfile-based analysis gives insight into the patient's breathing and beam-delivery dynamic, prospective 4D dose-tracking (4DDT) allows patient-specific adaptations before treatment start.

## Material und Methode

Dose distributions of 4 pancreatic and 3 liver cancer patients with motion amplitudes below 4mm were analyzed. All patients were treated with quasi-discrete spot scanned proton beams delivered by a synchrotron. The dose prescription was 5x7.5 Gy(RBE) for pancreatic and 15x4.68 or 10x5 Gy(RBE) for liver tumors. The treatment planning system RayStation8B (MCv4.2) (RaySearch) was used employing robust optimization for mitigating different organ fillings. The motion and interplay effect was determined using two different tools, namely (1) file-based (f-4DDT) considering the time structure from accelerator logfiles and surface scanner breathing patterns (C-Rad) for each fraction; (2) parameter-based (p-4DDT). Input parameters for (2) encompassed the averaged dose rate extracted from the accelerator logfiles over all fractions, scanning speed as well as constant breathing cycle length. The p-4DDT method was used additionally to investigate the influence of the starting phase (0%, 25%, 50%, 75%) and dose rate (min, max, and mean dose rate). Both methods recomputed

the static dose distribution on 8 4D-CT phases followed by dose accumulation on the planning CT using deformable image registration. Once performed for every fraction, the total accumulated dose was summed up according to the prescription. Dose volume histogram (DVH) parameters for the clinical (CTV) and the planning target volume (PTV), as well as organs-at-risk and γ-pass rates (2%/2mm) for the respective PTV region were evaluated.

## Resultate

Considering the interplay effect, D50% was preserved within 2% for the target structures. D98%_PTV varied up to 15% compared to the static scenario, while the results from the file and parameter-based 4DDT agreed within 2%. For the liver patients, D33%_liver deviated up to 35% compared to static and 10% comparing the two 4DDT tools, while for the pancreas patients the D1%_stomach varied up to 45% and 11%, respectively.

For all patients, except one, the gamma pass ratio was 98.1%±2.4%. For one patient with the largest surface motion amplitudes up to 1.5 mm and a 4 mm PTV movement the γ-pass rate decreased to 70%.

The 12 different scenarios with varying starting 4D-CT phases and dose rates were compared to the reference scenario assuming the mean dose rate and the 0% starting breathing phase. This revealed a variation of up to 3% for D33%_liver, D98%_PTV and D2%_PTV for liver and pancreatic cancer patients. Since this variation was within the dose prediction accuracy, the mean dose rate and a starting phase of 0% served as a basis for all further investigations.

## Diskussion

The p-4DDT could be used prospectively to determine the impact of beam and organ motion for pancreatic and liver cases in scanned proton therapy. In a next step the variation of the energy switching time (1, 2, and 4s) will be included in the analysis as well. The systematic uncertainties covered by the PTV margins compensated well for the motion effects of the investigated indications preserving an excellent CTV coverage when motion of small movers was considered.