

AbstractID: 1075 Title: Monte Carlo dose calculations including temporal effects of organ motion: 4D2, 4D, and 3.5D on the example of proton therapy of lung cancer.

Dynamic radiation therapy involves variable treatment head setup. In addition, the patient geometry may be time dependent due to respiratory motion. To calculate the dose for a time dependent geometry, the results of 3D calculations are usually considered separately. This method (multiple-3D or "3.5D") becomes cumbersome if high time resolution is required, if the geometry is complex, or if interplay effects between different, independently moving systems are to be studied. We recently implemented continuous "4D" Monte Carlo simulations to model electro-mechanical motion in the treatment head and to model respiratory organ motion.

Within this technique, the local dose is calculated as a function of moving sub-volumes and not as a function of position relative to a coordinate system. 4D dose calculation is applied using motion parameterizations or using patient specific 4DCT information. Deformable registration transforms individual sub-volumes to a reference point in time directly within the Monte Carlo code in contrast to dose calculations based on individual 3D runs, where dose distributions are warped retro-actively.

The 4D technique is also efficient to model time-dependent beam delivery under organ motion ("4D²"). Organ motion (single-dynamic) and interplay between organ motion and dynamic beam delivery (double-dynamic) can be studied for any given time resolution (dose rate).

On the example of a lung cancer treatment with protons we present the different techniques and discuss their differences and challenges. Monte Carlo dose calculation is used to re-calculate a proton treatment plan and the impact of motion on dose distributions and dose-volume histograms is shown.