ST 7: Ion Radiation Therapy 2: Target Motion Management

Chair: Gerhard Kraft

Zeit: Mittwoch 15:30–17:00 Raum: A021

ST 7.1 Mi 15:30 A021

Motion management in radiation therapy — •Christoph Bert — GSI Helmholtzzentrum für Schwerionenforschung, Abteilung Biophysik, Darmstadt, Germany

Radiotherapy of tumors that move during irradiation requires dedicated means to ensure target coverage despite the motion influence. Motion can occur inter-fractionally (e.g. position of the prostate) or intra-fractionally; the most dominant reason for intra-fractional motion is respiration. The standard procedure to reduce the influence of target motion is the use of margins encompassing the clinical target volume (CTV) to form a planning target volume (PTV) that covers all uncertainties. This approach ensures CTV coverage for most treatment modalities but results in therapeutic dose to normal tissue.

With the opportunities given by improved imaging techniques such as time-resolved computed tomography (CT) or (cone-beam) CT in treatment position as well as motion mitigation techniques such as gating or tracking the dosimetric influence of target motion could be reduced. Especially for conformal techniques such as intensity modulated radiotherapy (IMRT) or particle therapy only advanced motion mitigation techniques and/or adaptive therapy concepts lead to preservation of the target conformation established for stationary targets in treatments of moving targets.

In the scope of the talk an introduction to motion management will be given with an emphasis on application in scanned particle beam therapy.

ST 7.2 Mi 15:45 A021

Compensation of dose changes due to intrafractional tumor motion — •Robert Lüchtenborg[1], Nami Saito[1], Naved Chaudhri[1], Marco Durante[1], Eike Rietzel[1,2], and Christoph Bert[1] — [1]GSI Biophysik, Darmstadt — [2]Siemens Healthcare Sector, Workflow & Solutions, Particle Therapy, Erlangen

Treating tumors that are subject to intrafractional motion with scanned ion beams leads to deterioration of the deposited dose pattern. Thus techniques to mitigate motion effects are currently investigated. The most favorable among them in terms of target conformity and sparing of organs at risk is tracking, i.e. individually adapting Bragg peak positions to the changing tumor position.

While the main part of dose delivered by an ion pencil beam is deposited at the Bragg peak position some dose is delivered in the plateau before the Bragg peak. These dose contributions can be considered in treatment planning for stationary tumors but are subject to unpredictable changes in case of intrafractional tumor motion.

When tracking is used motion induced changes in dose deposition to the plateau region have to be considered. That means not only the position but also the particle number of each ion beamlet has to be adapted. Because the adaptation values depend on the a priori not exactly known trajectory (e.g. breathing period of patient changes) they have to be determined during treatment delivery.

Functionality to compensate for motion induced dose changes has been implemented to the beam tracking system at GSI and first experimental results will be presented.

ST 7.3 Mi 16:00 A021

Volume rendering in treatment planning for moving targets — •Alexander Gemmel[1,2], John A Wolfgang[2], and George TY Chen[2] — [1]GSI-Biophysics, Darmstadt, Germany — [2]Massachusetts General Hospital, Boston, USA

Advances in computer technologies have facilitated the development of tools for 3-dimensional visualization of CT-data sets with volume rendering. The company Fovia has introduced a high definition volume rendering engine (HDVR^{TM} by Fovia Inc., Palo Alto, USA) that is capable of representing large CT data sets with high user interactivity even on standard PCs. Fovia provides a software development kit (SDK) that offers control of all the features of the rendering engine. We extended the SDK by functionalities specific to the task of treatment planning for moving tumors. This included navigation of the patient's anatomy in beam's eye view, fast point-and-click measurement of lung tumor trajectories as well as estimation of range perturbations due to motion by calculation of (differential) water equivalent path lengths for protons and carbon ions on 4D-CT data sets. We present patient examples to demonstrate the advantages and disadvantages of volume rendered images as compared to standard 2-dimensional axial plane images. Furthermore, we show an example of a range perturbation analysis. We conclude that volume rendering is a powerful technique for the representation and analysis of large time resolved data sets in treatment planning.

Coffee Break

ST 7.4 Mi 16:45 A021

Ion-optically driven depth compensation for ion beam tracking — •Naved Chaudhri[1], Nami Saito[1], Christoph Bert[1], Bernhard Franczak[1], Marco Durante[1], Eike Rietzel[2], and Dieter Schardt[1] — [1]GSI, Abt. Biophysik, Darmstadt — [2]Siemens Healthcare, Particle Therapy, Erlangen

The beam delivery system for scanned carbon ion beam radiotherapy at GSI has been extended in research mode to irradiate moving targets. For beam tracking, the ion beam is adapted laterally as well as in range corresponding to the target's three dimensional (3D) motion. A beam tracking system with a motorized double wedge system for fast and accurate range adaptation has been developed.

In addition to the current range adaptation system a much faster method for online energy modulation is being investigated where a fine focused ion beam is dynamically positioned, controlled by fast dipole magnets, on a small static wedge shaped absorber within the beam line.

Experiments were performed at the therapy beam line to study the beam shift from central axis by the first dipole magnet up to the maximum limit where the beam can be deflected back to central axis by the second dipole magnet. Beam profiles were measured at different locations of the beam delivery system. The particle transmission was measured as well at the target position. Experiments were supported by Monte Carlo simulations for energy variation studies and for assessing the influence on beam profiles using MOCADI code.