performance testing and development of a micro-calorimeter based on Superconducting QUantum Interference Devices (SQUIDs) (1). Unlike other microdosimetric detectors that are used for investigating the energy distribution, this detector provides a direct measurement of energy deposition at the micrometer scale, that can be used to improve our understanding of biological effects in particle therapy application, radiation protection and environmental dosimetry. Temperature rises of less than 1μK are detectible and when combined with the low specific heat capacity of the absorber at cryogenic temperature, extremely high energy deposition sensitivity of approximately 0.4 eV can be achieved (2).
The detector consists of 3 layers: a tissue equivalent (TE) absorber, a superconducting absorber and a silicon substrate. Ideally all energy would be absorbed in the TE absorber and heat rise in the superconducting layer would arise due to heat conduction from the TE layer. However, in practice direct particle absorption occurs in all 3 layers and must be corrected for.
To investigate the thermal behavior within the detector, and quantify any possible correction, particle tracks were simulated employing Geant4 (v9.6) Monte Carlo simulations. The track information was then passed to the COMSOL Multiphysics (Finite Element Method) software. The 3D heat transfer within each layer was then evaluated in a time-dependent model. For a statistically reliable outcome, the simulations had to be repeated for a large number of particles. An automated system has been developed that couples Geant4 Monte Carlo output to COMSOL for determining the expected distribution of proton tracks and their thermal contribution within the detector.
Preliminary results of a 3.8 MeV proton beam showed that the detector reaches the equilibrium state after 8 ns. It is estimated that 20% of the temperature rise in the superconducting absorber is due to heat conduction from the adjacent absorber which needs to be corrected for. The simulations were repeated for proton beams with energies of 2, 10, 62 and 230 MeV.

Keywords: micro-dosimetry, Monte Carlo simulations and micro-calorimeter

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Assessment tool to quantify and visualize treatment plan robustness regarding patient setup
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Purpose: Nowadays, during the evaluation process of patient treatment plans in radiotherapy, the plan robustness is typically not taken into account. This evaluation of treatment plans can be improved if a user friendly and efficient tool to assess the robustness of the treatment plan is provided. Thus, the aim of this work is to develop tools and methods to quantify and visualize the robustness for treatment plans including random and systematic patient setup uncertainties.
Materials and Methods: A setup error phase-space including systematic and random setup errors for translation and rotation is explored to determine the treatment plan robustness. For this purpose a robustness-map is created based on user-defined criteria defining the robustness for the treatment plan considered. These criteria subdivide the robustness-map for the setup error phase-space into a region compatible with these criteria and into another one that is not. Several different approaches were implemented to quantify the plan robustness. One approach transforms the optimized dose distribution relatively to the patient geometry and, thus, dosimetric parameters or DVHs can be quickly estimated, but are limited with respect to accuracy. Hence, approaches using further dose calculations for the setup error phase space are needed to achieve reliable conclusions of the robustness. For this purpose, additional dose calculations using a different resolution of the setup error phase-space are performed guided by the robustness-map achieved using the dose-transformation approach. The intermediate dose distributions are determined by nearest neighbor or triangular interpolation.
Results: A graphical user interface based on QT version 5.3.1 was developed to calculate and visualize robustness-maps. These robustness-maps allow treatment plan evaluation by analyzing the corresponding dose-differences and DVHs. Additionally, correlations of all quantities can be displayed such that the user is able to efficiently view the data by scrolling through the setup error phase-space. The creation of robustness-maps is useful to assess and compare the robustness of different treatment plans and was successfully applied to plans covering different tumor-sites. For the cases investigated in this work, differences in DVH parameters using the different approaches are within 5%.
Conclusions: The developed tool for visualization and analysis of robustness-maps is an easy and efficient way to compare the robustness of treatment plans. Moreover, clinical tolerance and action levels for patient setup can be determined in order to keep specified dosimetric parameters within a certain limit. This work was supported by Varian Medical Systems.

Keywords: treatment planning, plan robustness, patient setup

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Treatment of moving targets with active scanning carbon ion beams
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Purpose: In this paper we report the preliminary results of clinical use of organ motion mitigation strategies in the treatment of moving target with active scanned carbon ion beams.
Material and methods: Since September 2014 25 patients with tumors located in the upper abdomen and chest were treated with active scanned carbon ion beams.
Patients were affected by pancreatic adenocarcinoma, HCC, biliary tract cancers and sarcoma of the spine retroperitoneum and heart. Tight thermoplastic mask was selected as the optimal abdominal compression device. 4D CT scan with retrospective reconstruction, with phase signal obtained with Anzai system (Anzai Medical CO., LTD), was employed for planning. Automatic assignment of raw data to respiratory phases was checked and, if necessary, modified by the medical physicist. Planning was performed using end expiration phase. Planning CT scan were visually checked for motion artifacts. Contouring was performed on end expiration phase and on the adjacent 30% expiration and 30% inspiration phases. Beam entrance was selected in order to avoid the bowel in the entrance channel. The lung diaphragm interface was contoured in the different respiratory phases and beam angles were chosen to avoid passing tangential to the lung diaphragm ITV. IMPT was used for plan optimization. Plans were recalculated in adjacent phases and if DVHs were degraded in an unacceptable way they were modified iteratively. Weekly verification 4D CT scans were performed