iWoRiD 2022
23rd International Workshop on Radiation Imaging Detectors
26 – 30 June 2022
Riva del Garda, Italy

Contribution ID: **83** Type: **Oral**

Timepix3-based mini-tracker of charged nuclear fragments to detect anatomical changes in radiotherapy with carbon ions

Monday 27 June 2022 12:30 (20 minutes)

Cancer treatments have been performed with X-rays and ions (e.g., protons and carbon ions) over the years. The high dose conformity that allows better sparing of healthy tissue is a demonstrated advantage of carbon ions over x-rays [1]. This dose conformity can be impacted by to anatomical changes between treatment fractions, which can lead to an increase of the dose to healthy tissue and to a dose reduction in the tumor. Therefore, it is of great interest to monitor those anatomical changes to ensure such dose conformity. When carbon ions interact with human tissue, charged fragments are generated in nuclear interactions, which, if energetically enough, can escape the patient and provide valuable information about the ion beam during the treatment delivery [2-3]. This contribution presents a monitoring method to detect anatomical changes between treatment fractions based on charged nuclear fragment tracking.

To evaluate the performance of this treatment monitoring method, a treatment plan was delivered to a head-sized PMMA model with a typical clinical dose of 3 Gy (RBE) at the Heidelberg Ion Beam Therapy Center in Germany. Charged nuclear fragments were detected with a mini-tracker of 2 cm2 sensitive area, based on the silicon pixel Timepix3 (ADVACAM s.r.o. in Prague) detector technology developed at CERN [4]. To mimic anatomical changes inside the head model, a disk-shaped air cavity of 2 cm diameter and 0.2 cm thickness was inserted at different transverse positions (see fig.1). Moreover, three measurements for each cavity were performed: a first measurements as reference, a second measurement as fraction with no anatomical change, and a third measurement with the inserted cavity. During the data analysis, the tumor area was divided into 9 sub-regions in order to group the irradiated carbon-ion pencil beam spots (see fig.1).

By comparing the charged nuclear fragment emission profiles of the three measurements (see fig.2a), significant changes were found in the sub-regions where the air cavity was located. The detectability of the air cavity, taken as the significance of a measurement above 3⊠, was then calculated (see fig.2b). It was found that the air cavity located closer to the mini-tracker reached a detectability of 4.8⊠. When the cavity was located in the center position, a significance of 3.9⊠ was obtained. A value slightly below 3⊠ was found when the cavity was located on the far side of the mini-tracker due to the lower number of tracked fragments. Other more sophisticated data analysis strategies are being further investigated.

This contribution has quantitatively demonstrated the ability of a non-invasive monitoring method for the detection of small anatomical changes in realistic treatment deliveries, as well as its limitations. The obtained results are found to be of high clinical relevance. Therefore, this method is promising to be further investigated in clinical trials.

[1] Jäkel, Br. J. Radiol. 93 (2020) 20190428
[2] Félix-Bautista et al., Med. Phys. 48 (2021) 4411–4424
[3] Ghesquière-Diérickx et al., Med. Phys. 49 (2022) 1776–1792
[4] Poikela et al., J. Instrum. 9 (2014) C05013–C05013

Primary author: Dr FÉLIX BAUTISTA, Renato (German Cancer Research Center (DKFZ))

Co-authors: OCHOA PARRA, Pamela (German Cancer Research Center (DKFZ)); Dr KELLETER, Laurent (German Cancer Research Center (DKFZ)); ECHNER, Gernot (German Cancer Research Center (DKFZ)); Dr WIN-

TER, Marcus (Heidelberg Ion-Beam Therapy Center (HIT)); Prof. DEBUS, Jürgen (Heidelberg University Hospital,); Prof. JÄKEL, Oliver (German Cancer Research Center (DKFZ)); Dr GEHRKE, Tim (German Cancer Research Center (DKFZ)); Dr MARTIŠÍKOVÁ, Mária (German Cancer Research Center (DKFZ))

Presenter: Dr FÉLIX BAUTISTA, Renato (German Cancer Research Center (DKFZ))

Session Classification: Applications