Online monitoring of the Bragg peak during pig irradiation*

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Overview and Experiment

With the increasing number of medical accelerator facilities available there is a growing interest to broaden the field of applications to non-cancer diseases and radiosurgery[1]. Atrial fibrillation is the most common form of cardiac arrhythmia and results in unorganized atrial activity which leads to an abnormal rhythm of the heart. The strain of catheter ablation as a standard treatment to the human body is quite severe due to long anesthetization and therefore radiosurgery is a promising treatment modality[2]. Recently first experiments where performed in pigs with doses ranging from 25 to 55 Gy[3]. The irradiation was observed online with a 6 plane CMOS-based particle tracker[4] monitoring prompt particle emission from the target volume[5] to verify the treatment.
Six MIMOSA-28 silicon pixel sensor where placed approximately 51 cm away from the target volume under an angle of bigger than 90 degree. Prompt particle tracks resulting from the nuclear fragmentation inside the irradiated tissue where recorded in order to verify the planned dose deposition. The tracking system worked stable during the complete measurement campaign and a total of seven pig-irradiation were monitored. A picture of the experimental setup is presented in fig.1. Sensor alignment was performed with primary carbon in a dedicated run in Cave A.

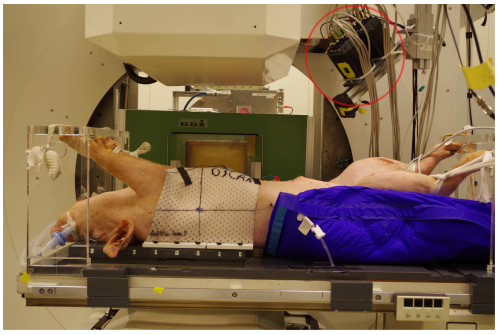

Figure 1: Picture of the experimental conditions in Cave M during irradiation. The tracker (red circle) was approximately 51 cm away from the target volume.

Status

The need for a special run in Cave A due to specific intensity requirements for the alignment of the used sensors poses a problem during data analysis. While removing and rebuilding the tracker in Cave A the relative position of some sensors changed slightly in respect to the holder (approximately 100 - 150 microns) which resulted in a non-optimal alignment of the tracker and lower than expected statistics of reconstructed charged particle tracks. Preliminary reconstructed data is presented in fig.2. The observed time structure of both monitoring systems is in good agreement, but the total number of reconstructed tracks at the moment is low. Currently different alignment procedures are tested to increase the tracking efficiency.

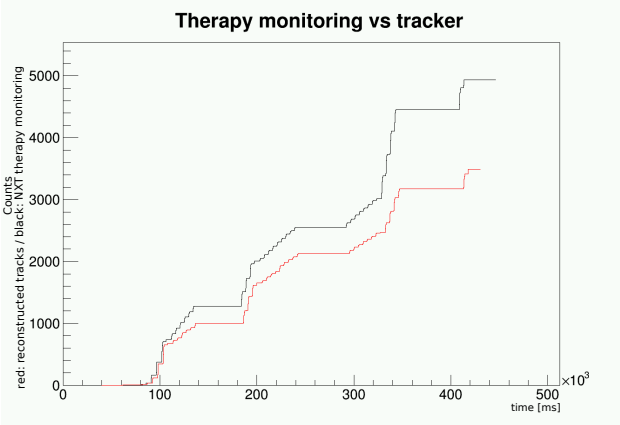

Figure 2: Comparison of the reconstructed tracks vs. time and the change of beam position (NXT) as monitored by the therapy control system.

References

[1] C. Bert, R. Engenhart-Cabillic and M. Durante, “Particle therapy for noncancer diseases”, Med. Phys. 39, 1716 (2012).

[2] A. Constantinescu, “Planning studies for non-invasive treatment of atrial fibrillation with scanned ion beams”, Phd-Thesis (2014).

[3] H. Immo Lehmann, C. Graeff, A. Constantinescu, et al., “Arrhythmia ablation using scanned carbon ion pencil beams in a porcine model: First outcomes from ^{12}C catheter-free ablation”, Abstract for Heart Rhythm Society (2015).

[4] M. Rovituso, C. La Tessa, C. Schuy and M.Durante, “Online Bragg peak monitoring for radiotherapy with ions using pixel sensors”, GSI SCIENTIFIC REPORT (2013).

[5] L. Piersanti, F. Bellini, F. Bini, et al., “Measurement of charged particle yields fromm PMMA irradiated by 220 MeV/u ^{12}C beam”, Phys. Med. Biol. 59 (2014).

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