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Real time monitoring of density gradients for 4D treatment in ion-beam therapy

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In the past years, advanced techniques were developed for particle therapy to deliver a more conformal dose to the tumor while spearing healthy tissues. However, the treatment of moving tumors with ion beams is still challenging. In the case of lung cancer, the respiratory motion of the patient can induce strong doses inhomogeneities and range shifts during the treatment due to high density gradients between the lung, the tumor tissue and the bones in the case the beam misses the tumor volume.
Therefore, several range monitoring techniques were investigated, by using secondary radiation produced during the treatment (e.g., PET).
In this work include in my PhD, another approach is proposed by detecting the strong density gradients between lung, tumor tissue and bones, by using a CMOS-based tracker system, which can detect the secondary charged particles produced by the primary carbon ions. To verify if the treatment is delivered as planned, the vertex distribution will be computed after reconstruction of the secondary charged particle trajectories, and compared to the predicted one. The experimental setup uses several CMOS trackers placed at several angles behind a target, composed of a PMMA cylinder (representing the tumor) inserted inside a foam volume (representing the lung tissue). The phantom will be placed on a moving table to represent the respiratory motion of the patient.
After computing the production points of a sufficient number of secondary particles, a comparison with the predicted distribution allows to tell if the treatment is delivered as planned or if there was a mistake of targeting and the treatment would be stopped after producing a beam interlock.

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