Contribution ID: **117** Type: **not specified**

Monitoring of hadrontherapy treatments with a novel tracking devise based on charged particle detection

Protons and carbon ion beams are presently used in hadrontherapy to treat many different solid cancers. Compared to the standard X-rays treatments the main advantage of hadrontherapy technique is the better localization of the dose in the tumor region sparing healthy tissues and surrounding Organs At Risk (OAR). The intrinsic precision due to the peculiar features of dose release at the end of the range in hadrontherapy with respect to photon radiotherapy is somewhat threatened by uncertainties (inhomogeneities, Computed Tomography (CT) artifacts, inter session anatomical/physiological changes and others) in the knowledge of actual primary particle range. Nowadays these uncertainties are managed by means of safety margins around the tumoral region but for quality assurance a dose deposition monitoring is necessary.

The interaction of the incoming beam radiation with the patient body in hadrontherapy treatments produces secondary charged and neutral particles, whose detection can be used for monitoring purposes and to perform an on-line check of beam particle range. Charged particles are potentially attractive since they can be easily tracked with a high efficiency, in presence of a relatively low background contamination. In order to verify the possibility of exploiting this approach for in-beam monitoring in hadrontherapy, and to guide the design of specific detectors, both simulations and experimental tests are being performed with ion beams impinging on simple homogeneous tissue-like targets (PMMA).
The results obtained so far show that the measurement of charged particles can be successfully implemented in a technology capable of monitoring the dose profile and the position of the Bragg peak inside the target and finally lead to the design of a novel profile detector.

We present a new tracking device, developed in the framework of the INSIDE project. Charged tracks are detected using 6 planes of scintillating fibers ($0.5 \times 0.5\ mm^2$) with orthogonal views, readout by Silicon PM, followed by a plastic scintillator and by a small calorimeter made of a pixellated LFS crystal. The achievable spatial resolution for single charged particle has been studied by means of a full simulation of the device, benchmarked against experimental data, and a dedicated reconstruction code. Charged particle yield as a function of primary energy, thickness of material and device positions with respect to the patient have been considered in order to establish a possible procedure for real-time comparison of measurements with expectations in the actual clinical operation.

Summary

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