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Dose Profiler: development of a device for online beam range monitoring in charged particle therapy treatments

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In Charged Particle Therapy (CPT) beams of protons or carbon ions are used for treatment of tumors. The higher precision in dose deposition achieved by charged ions with respect to X-Rays, used in conventional radiotherapy, allows to reduce the undesired dose released to the healthy tissues surrounding the cancer region. This makes the CPT particularly suitable for deep situated tumors close to organs at risk. A strong control on the ion beam delivery is required in order to reduce the impact of patient mispositioning or anatomical changes, that cause an over-dosage to healthy tissues avoiding to fully profit from the CPT precision: the development of an on-line range monitor represents a crucial issue for the quality assurance of the CPT treatments.

The strong interaction between the beam particles and the patient tissues produces secondary particles, whose emission spatial coordinate is correlated to the released dose distribution. Such particles can be exploited for beam range monitoring purpose as mentioned in [1],[2],[3]. The after-treatment measurement with PET-scanners of the β^+ emitters activity is a technique already tested in clinical environment, but suffer for the metabolic washout. Prompt photons measurement, thanks to their high production yield, seems to be a promising method. Finally the detection at large angle with respect to the beam direction of secondary charged particles, easy to backtrack, could represent a good approach especially for carbon ions beams treatments in which the production yield is higher compared to protons beams.

We propose a detector, *Dose Profiler* (DP), designed for the measurement of the secondary charged particles with the aim of performing on-line beam range monitoring. The device is currently under development in the frame of the INSIDE collaborations (Innovative Solutions for In-beam Dosimetry in hadrontherapy) and is going to be tested at CNAO (Centro Nazionale di Adroterapia Oncologica) within 2016. The DP is composed by a tracker, that provides the information of the particles position for the back-tracking, and by a calorimeter, that performs the measurement of the energy. The tracker is built out by six layers (20×20 cm^2) of square scintillating fibers (500×500 μm^2) coupled to Silicon Photo-Multipliers (SiPMs), the calorimeter by a set of 16 pixellated LFS crystals ($5 \times 5 \times 2$cm^3) coupled to multi-anode PMTs; in order to increase the efficiency of the track reconstruction process a plastic scintillator absorber is inserted between the two devices to stop the back-scattered electrons. The read-out electronics, composed of more than 4000 channels, is performed by ASICs specifically designed for SiPM read-out applications. The data acquisition and the trigger system are realized by a set of FPGAs.

In this contribution the design and the expected performances of the DP, evaluated by Monte Carlo simulations based on experimental data, will be presented.

References:

[1] L.Piersanti et al., PMB, 59 (2014), 1857

[2] I.Mattei et al., JINST 10 (2015), P010034

[3] K.Parodi et al., PMB, 47 (2002), 21

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