A novel monitoring technique for on line dose profiling in hadrontherapy treatments

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Hadrontherapy is a technique that uses accelerated charged ions for cancer treatment. The high irradiation precision and conformity achievable with heavy ions, enhance the Radio Biological Effectiveness (RBE) of such therapy while helping sparing the surrounding healthy tissues and Organs At Risk (OAR). To fully profit from the improved therapy spatial selectiveness, a novel monitoring technique, capable of providing a high precision in-treatment feedback on the dose release position, is required. Here we propose a novel approach based on the simultaneous detection of secondary protons and prompt photons that are emitted at large angles with respect to the therapeutical beam incoming direction and are correlated with the Bragg Peak (BP) position and the related dose release.

In the first part of this contribution we will review briefly the measured flux and energy spectra for secondary particles produced by $^4\text{He}$, $^{12}\text{C}$ and $^{16}\text{O}$ ion beams of therapeutical energies impinging on thick PMMA phantoms. Such measurements afford a solid evidence that the rate of produced protons on prompt photons is large enough to supply the particle sample needed for a fast online monitor operating during a typical treatment that will be capable to provide the required O(mm) spatial resolution.

In the second part of this contribution we will present the novel dual mode hadrontherapy monitor, named “DoseProfiler” (DP), exploiting, simultaneously, the backtracking of secondary charged particles and prompt photons emitted during the irradiation of the patient. The DoseProfiler, whose final layout has been optimized using a dedicated Monte Carlo simulation based on the aforementioned experimental results, combines a tracker detector made of scintillating fibers and a calorimeter built with pixelated LYSO crystals, for gamma detection and energy measurements. Six tracker squared layers, built from two orthogonal planes of squared scintillating fibers, will provide the particle direction information, while the LYSO crystals will measure the particle energy.

A first tracker layer has already been assembled and a preliminary evaluation of the detector performances has been done using cosmic rays. The fibers system detection efficiency and the optical cross talk as well as other preliminary performances obtained with dedicated test beams will be reviewed.