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Scintillating fibers devices for Particle Therapy applications

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Particle Therapy (PT) is an increasingly widespread kind of radiation therapy in which solid tumors are treated with charged light ions beams to exploit the highly localized dose delivery that can be achieved, allowing to spare the healthy tissues surrounding the organs at risk. During the irradiation a large amount of secondary particles is produced as a consequence of the interactions between the beam particles and the patient tissues. Secondary charged fragments and photons, namely annihilation and excited nuclei de-excitation photons, show an emission spectrum correlated to the released dose distribution that can be used to monitor the beam range during the treatment. The development of a range monitoring technique capable of reaching a sub-millimetrical precision is considered one of the key steps in optimizing the PT efficacy and assuring the treatment quality. Besides charged fragments and photons there is also the secondary neutron component that contributes to an undesired and not negligible dose deposition far away from the tumor region, enhancing the risk of secondary malignant neoplasies development after the treatment. An accurate neutron production characterisation (flux, energy and emission profile) is hence needed to significantly improve the evaluation of possible long-term complications.

In this contribution two tracker detectors, that employ layers of scintillating fibres as active mean, are presented. The first one, named Dose Profiler (DP), is designed for secondary charged fragments measurements and is planned to be used as a beam range monitor in PT treatments with Carbon ions beam. The second one is dedicated to the fast and ultrafast neutron measurements for the characterisation of the secondary neutron component, in the frame of the MONDO (MOnitor for Neutron Dose in hadrOntherapy) project. The DP is currently under development within of the INSIDE collaboration (Innovative Solutions for In-beam Dosimetry in hadrontherapy)[1]. It is composed by six layers (20×20 cm^2) of BCF-12 square scintillating fibres (500 μm) coupled to Silicon Photo-Multipliers, followed by two plastic scintillator layers of ˜6 mm thickness. The detector characterisation with cosmic rays is currently undergoing and a data taking campaign with protons will take place in May 2017. The DP design and the performances measured with using MIPs and protons beam will be reviewed. The MONDO detector[2], that exploits the tracking of the recoil protons produced in double-elastic scattering neutron interaction to measure the neutron kinetic energy and incoming direction, is a matrix of scintillating fibres, arranged in x-y oriented layers (total active volume $10\times10\times20$ cm^3 filled with squared 250μm fibres BCF-12), that are read-out by a dedicated SPAD sensor produced by FBK (Fondazione Bruno Kessler). The detector is currently under development and its full completion and assembly is expected before the end of the year. The expected performances computed using a MonteCarlo simulation and the preliminary measurements obtained using MIPs and a tracker prototype will be presented.

[1] G. Traini et al., Physica Medica 34 (2017), pp. 18-27, doi: 10.1016/j.ejmp.2017.01.004.

[2] M. Marafini at al., Phys. Med. Biol. 62 (2017), pp. 3299–3312 , https://doi.org/10.1088/1361-6560/aa623a

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