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The Monitor for Neutron Dose in Hadrontherapy Project: Secondary Neutron Measurement in Particle Therapy

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Abstract : The particle therapy (PT) is a very modern technique of non invasive radiotherapy mainly devoted to the treatment of tumours untreatable with surgery or conventional radiotherapy, because localised closely to organ at risk (OaR). Nowadays, PT is available in about 55 centres in the word and only the 20\% of them are able to treat with carbon ion beam. However, the efficiency of the ion-beam treatments is so impressive that many new centres are in construction. The interest in this powerful technology lies to the main characteristic of PT: the high irradiation precision and conformity of the dose released to the tumour with the simultaneous preservation of the adjacent healthy tissue. However, the beam interactions with the patient produce a large component of secondary particles whose additional dose has to be taken into account during the definition of the treatment planning. Despite, the largest fraction of the dose is released to the tumour volume, a non-negligible amount is deposed in other body regions, mainly due to the scattering and nuclear interactions of the neutrons within the patient body. One of the main concerns in PT treatments is the possible occurrence of secondary malignant neoplasm (SMN). While SMNs can be developed up to decades after the treatments, their incidence impacts directly life quality of the cancer survivors, in particular in pediatric patients. Dedicated Treatment Planning Systems (TPS) are used to predict the normal tissue toxicity including the risk of late complications induced by the additional dose released by secondary neutrons. However, no precise measurement of secondary neutrons flux is available, as well as their energy and angular distributions: an accurate characterization is needed in order to improve TPS and reduce safety margins. The project MONDO (MOnitor for Neutron Dose in hadrOntherapy) is devoted to the construction of a secondary neutron tracker tailored to the characterization of that secondary neutron component. The detector, based on the tracking of the recoil protons produced in double-elastic scattering interactions, is a matrix of thin scintillating fibres, arranged in layer x-y oriented. The final size of the object is 10 x 10 x 20 cm3 (squared 250µm scint. fibres, double cladding). The readout of the fibres is carried out with a dedicated SPAD Array Sensor (SBAM) realised in CMOS technology by FBK (Fondazione Bruno Kessler). The detector is under development as well as the SBAM sensor and it is expected to be fully constructed for the end of the year. MONDO will make data tacking campaigns at the TIFPA Proton Therapy Center of Trento, at the CNAO (Pavia) and at HIT (Heidelberg) with carbon ion in order to characterize the neutron component and predict the additional dose delivered on the patients with much more precision and to drastically reduce the actual safety margins. Preliminary measurements with charged particles beams and MonteCarlo FLUKA simulation will be presented.

Keywords : secondary neutrons, particle therapy, tracking detector, elastic scattering
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