Contribution ID: **129**

Type: **not specified**

MONDO: a neutron tracker for Charged Particle Therapy secondary emission measurements

The Charged Particle Therapy (CPT) is a relatively recent and widely diffused technology for which several additional treatment centers have recently been planned or approved for (and are under) construction, that uses accelerated particles and ions to perform tumor control. However, the neutron component of the secondary radiation is still affected by large experimental uncertainties and is almost, yet, unexplored˜\cite{uno, due}. Neutrons, characterized by a small attenuation length, are contributing to a substantial dose deposition in body regions not directly targeted or crossed by the beam, and are representing the most abundant and harmful radiation exiting from the patient body. Moreover, the risk of developing a radiogenic second malignant neoplasm (SMN), years or decades after undergoing a treatment is one of the main concerns in CPT administration and planning˜\cite{uno}. A complete characterization of the neutron production, and the related dose deposition, is of outmost importance in order to provide a better treatment plan to patients, maximizing the therapy effectiveness while reducing secondary effects. The MONDO (MOnitor for Neutron Dose in hadrOntherapy)˜\cite{tre} project aims for the development of a compact, high-resolution tracking detector tailored for the observation and measurement of the secondary ultra-fast neutron production in CPT treatments.

The n-p events are the most useful for neutron detection since the elastic scattering correlates the neutron and proton momenta. If both proton recoils are measured, the neutron energy and direction can be reconstructed. In this latter case, the tracking and energy resolution achievable on the detection and reconstruction of the two recoiling protons will drive the final neutron energy and angular resolutions.

The tracker, composed of subsequent orthogonal layers of 0.250 mm square scintillating fibers. The geometrical parameters are mainly dictated by the neutrons interaction length in the fibers plastic scintillator, ranging from ~ 10 cm to ~ 60 cm in the $10 - 200$ MeV kinetic energy range. The choice of the final layout foresee a total tracker active volume of $10 \times 10 \times 20$ cm^3.

The technology that has been considered for the readout of the MONDO tracker is based on CMOS Single Photon Avalanche Diode (SPAD) arrays. The SPAD matrix will have high spatial resolution (0.250 mm) and will implement the self trigger logic that matches the tracker readout requirements. Currently, the evaluation kit of a sensor with similar features known as SPADnet-I˜\cite{quattro,cinque} is being used to test the tracker's signal detection efficiency under the self triggering approach. The signal over background ratio is being characterized to assess the feasibility of a CMOS SPAD based readout of the fibers, without image intensification.

A preliminary MonteCarlo simulation of the detector

has been performed using the FLUKA software, in order to finalize the detector layout while maximizing the expected efficiency and resolution of the detector.The results expected for MONDO project will improve the knowledge of the secondary neutron produced in particle therapy treatments measuring their flux as a function of the neutron energy and angle.
Those informations are essential in order to fully validate with data the MC simulations and analytical models used so far in particle therapy for the development of the Treatment Planning System (TPS); in particular, the estimation of the contribution to the total dose induced by neutrons in region away from the tumor volume is essential in pediatric TPS. The measurement of this dose contribution will significantly help the understanding and reduction of unwanted secondary effects related to the therapy.
Moreover, the neutrons back tracking up to their emission point allows to infer the Bragg peak position. It's worth to be stressed that such monitoring techniques have been already investigated using prompt photons and charged fragments as probes, but the neutrons study is still unexploited, namely because of the lack of neutron tracking device in the energy range of interest. The use of the neutrons as probe is of evident utility: the neutrons are produced with larger abundance than other secondary particles and their long interaction length can provide dose shape information even for deep-seated tumors. The tracking capability of the proposed device allows to exploit also the secondary charged particle component for dose profile monitoring, having a twofold and more reliable determination of the Bragg peak position in the patient.

\begin{thebibliography}{1}

\bibitem{uno} P.Durante, W.D.Newhauser, Review:Assessing the risk of second malignancies after modern radiotherapy, Nature Reviews Cancer 11 (2011) 438-448. %http://dx.doi.org/10.1038/nrc3069

\bibitem{due} Hultqvist, Gudowska, Importance of nuclear fragmentations in light ion therapy Monte Carlo simulations of secondary doses to the patient, Phys. Med. Biol. 55.

\bibitem{tre} M.Marafini et al., High granularity tracker based on a Triple-GEM optically read by a CMOS-based camera, arXiv:1508.07143 (submitted to JINST).

\bibitem{quattro} L.H.C.Braga et al., A fully digital 8×16 sipm array for pet applications with per-pixel tdcs and real-time energy output, Solid-State Circuits, IEEE Journal of 49 (1) (2014) 301-314. http://dx.doi.org/10.1109/JSSC.2013.2284351

\bibitem{cinque} L.H.C.Braga et al., Complete characterization of SPADnet-I
— a digital 8×16 SiPM array for PET applications,
2013 IEEE Nuclear Science Symposium and Medical Imaging Conference
(2013 NSS/MIC).
http://dx.doi.org/10.1109/NSSMIC.2013.6829587

\end{thebibliography}

Summary

Author: MARAFINI, Michela (INFN Roma1 - Centro Fermi)

Co-authors: SCIUBBA, Adalberto (Universita e INFN, Roma I (IT)); SARTI, Alessio (Universita e INFN, Roma I (IT)); PINCI, Davide (Universita e INFN, Roma I (IT)); SPIRITI, Eleuterio (Istituto Nazionale Fisica Nucleare Frascati (IT)); PATERA, Vincenzo (Dipartim.di Fisica G.Marconi RomeI)

Presenter: MARAFINI, Michela (INFN Roma1 - Centro Fermi)