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Miniaturized Microdosimeters for Hadron Therapy

Microdosimetry is a spectrometric technique which measures energy imparted by ionizing radiation in sensitive volumes of micrometric dimensions. Starting from microdosimetric quantities it is possible to derive radiation quality descriptors of interest for the clinics, such as the Linear Energy Transfer (LET) or a physics-based estimation of the Relative Biological Effectiveness (RBE), using specific weighting functions or radiobiological models. Moreover, microdosimetry offers a cheap and fast characterization of the radiation field, which could be performed as a routine procedure. For this reason, its introduction in Quality Assurance procedures for hadron therapy is gaining increasing interest, and has been recently recommended by the International Commission of Radiation Units [1].

To integrate this methodology into standard clinical practice, commercially available detectors must be developed for use by medical physicists as quality assurance instruments. The 4MiCa project, part of the Research for Innovation (R4I) 2021 call from the Technological Transfer of INFN, had the aim of developing such engineered microdosimeters for clinical facilities. The engineered detectors are miniaturized Tissue Equivalent Proportional Counters (mini-TEPCs) constructed at LNL-INFN and integrated with custom-made low-noise electronics developed at PoliMI. Specific versions of these detectors loaded with boron-10 atoms can be applied in BNCT and will be used in the new facilities in Pavia (CNAO) and Caserta (ANTHEM project).

Each new detector needs to be tested in-field, and its response must be characterized, preferably under irradiation conditions comparable to those used for proton therapy. We propose to use the proton beam from the new SPES cyclotron for this purpose. Previous experiments at the clinical Proton Therapy center in Trento (Italy) have shown that the new mini-TEPCs can be operated in a pile-up free condition up to a proton fluence rate of $10^6 - 10^7\ cm^{-2}\ s^{-1}$ [2]. The high intensity of the cyclotron proton beam will allow for this characterization in a short time, even in the distal part of the Bragg peak and in the lateral out-of-field regions, which are very interesting under the clinical point of view, since the radiation quality in these regions is crucial to determine the normal tissue complication probability (NTCP) and the risk of secondary cancers [3].

References

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