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Characterisation of angular response in an improved tissue-equivalent microdosimetry probe for proton therapy applications

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Proton therapy offers a more conformal dose distribution and higher linear energy transfer (LET) than conventional X-ray therapy, reducing dose to healthy tissue while enhancing tumour control. The relative biological effectiveness (RBE) quantifies radiation-induced tissue damage, and accurate RBE values are critical for treatment planning. Although an RBE of 1.1 is commonly assumed for proton therapy, in reality, RBE varies with factors such as LET. Neglecting these variations can lead to incorrect dose prescriptions and range shifts, which are particularly critical for surrounding sensitive organs.

Microdosimetry provides useful quantities such as yD (close form of LETd) and to derive RBE for treatment plan verification. The Centre for Medical Radiation Physics (CMRP) has developed a portable, low-voltage supplied SOI microdosimeter with high spatial resolution, demonstrated as an effective tool for quality assurance for proton and heavy ion therapy. However, advanced techniques such as ARC therapy and intensity-modulated proton therapy (IMPT) plans involve multiple beam angles, requiring a redesign to minimise high-Z material surrounding the detector. To address this CMRP developed a new SOI microdosimeter probe with thin PCB packaging instead of previous ceramic-gold DIL package. The angular dependence of this improved design was evaluated at the Paul Scherrer Institute (PSI), Switzerland using a proton beam of 70, 150 and 230 MeV delivered at 0°, 30°, 60°, 90° and 180° with both spot and layer techniques. 10 mm thick PMMA cylindrical sheath was used to house the probe ensuring a consistent PMMA thickness at any angle of incidence.

Results showed that angular dependence increased above 60°, with reduced dependence at higher proton energies. For oblique angles, pathlength corrections can be used to correct the energy deposition spectra.

Overall, the current microdosimeter design demonstrated an acceptable response for incidence angles up to 60°.

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