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Development of an ultra-high dose rate proton irradiation system for radiobiology studies at a 3 MV TandetronTM

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Small accelerators are capable of delivering ultra-high dose rates (UHDR) during proton irradiation, which makes them valuable tools in the development of FLASH radiotherapy. However, achieving accurate in-air irradiation at such dose rates demands exceptionally precise beam characterization. This work describes the way we addressed the challenge of accurate dosimetry while developing a new beamline at the 3 MV Tandetron™ from IFIN-HH, specifically in the context of radiobiology studies. We outline the beamline's design, construction, and calibration, emphasizing its critical components. Computational work, in the form of FLUKA simulations, blends seamlessly with experiments carried out during the commissioning process. Predicted high spatial precision in dose deposition has been validated through radiochromic film analysis. Accurate dose delivery over time is ensured by stringent regulation of both irradiation duration and dose rate, which we have measured comparatively using a Faraday cup and an Advanced Markus ionization chamber. Finally, we introduce a custom-designed sample holding and manipulation device that significantly improves irradiation efficiency and enhances experimental throughput.

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