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Modification of a Medical Isotope Production Cyclotron Beamline for in-vitro proton therapy studies

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Background and Objectives: The 18 MeV medical cyclotron at Bern University Hospital (Inselspital) is designed for routine radiopharmaceutical production. It is equipped with a Beam Transfer Line (BTL), accessible in a separate bunker, for research in medical applications of particle physics. In an effort to make pre-clinical proton therapy studies more accessible to research groups, the BTL has been adapted to generate a proton beam suitable for in-vitro irradiations at both conventional and FLASH dose rates. In upcoming tests, we aim to modify the delivered beam to be suitable for spatially fractionated proton therapy (SFPT) studies.

Methods: The beam is passively scattered and shaped to deliver a uniform dose to a target in air. The delivered dose rate is measured in real time, using an in-beam ionization chamber (IC) paired with fiber-coupled scintillators to ensure reliable dosimetry over a large range of dose rates. For SFPT, the use of several collimator configurations is being investigated to optimize the spatial distribution of the delivered beam.

Results: The beam is extracted into air at 15.2 MeV, with a dose uniformity of 6% within a 1.5 cm diameter, extending to 15% uniformity within a 5 cm diameter. The real-time IC current has been calibrated to delivered dose rate from 0.027 Gy/s to 160 Gy/s, and will also be used in the SFPT configuration to measure the average dose rate over the entire beam field.

Conclusion: Successful adaptation of the BTL enables the production of a flat proton beam with variable dose rates, accommodating both conventional and FLASH applications. Initial cell irradiation experiments at conventional rates in collaboration with the University of Bern Institute of Anatomy have been conducted, with plans for further experiments at FLASH rates and SFPT.

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