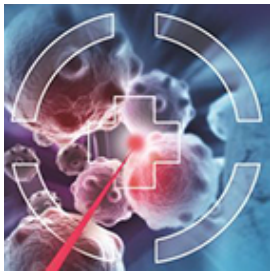

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Optimisation of graphite energy degrader geometry for proton therapy facility

Introduction: Cyclotron-based proton therapy facilities use an energy degrader of variable thickness to deliver the beam of the energy required by treatment plan. Together with the energy reduction, the transverse size and energy spread increase. The collimation and energy selection systems downstream of the degrader cut the beam to match the following beamline, that introduces energy-dependent beam losses. To mitigate it, alternative degrader designs were proposed and Monte Carlo simulations were performed to accurately reproduce the degrader performance.

Methods: Studies of several geometries of graphite energy degrader were conducted to decrease the beam emittance growth and improve the transmission. This included a single block and multi-slab degraders, along with multi-wedge geometry, currently used at the Centre for Proton Therapy at Paul Scherrer Institute (PSI), Switzerland. G4Beamline Monte Carlo simulations of the multi-wedge degrader were benchmarked against the measurements in the PROSCAN beamline at PSI.

Results: The beam transmission at the block degrader exit is significantly higher when compared to multi-wedges, particularly for lower energies (35% increase at 75 MeV). However, for the complete collimation system following the degrader, the transmission is the same for all geometries.

Discussion/Conclusions: None of the alternative designs showed transmission benefit over the currently used multi-wedge graphite degrader. Optimisation of the degrader geometry could be followed by studies into novel materials, i.e. boron carbide, to potentially minimise beam losses and mitigate their energy dependence. More complex geometries and degraders consisting of different materials could also be examined.

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