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Proton imaging for small animals

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Introduction

Precision small animal proton irradiators are emerging technologies. For in-situ image guidance they typically foresee integration of X-ray cone-beam CT cabinets established in small animal photon irradiators. However, for treatment planning, such imaging solutions cannot guarantee accurate prediction of the proton beam stopping within the small animal.

Materials & Methods

We are investigating different solutions of pre-treatment proton radiography and tomography for integration in an innovative system under development for precision small animal proton irradiation [1]. Compared to clinical applications, the low energies required to image small animals pose challenges, particularly enhanced scattering and more pronounced energy dependence of the stopping power ratio (SPR). Our most advanced solution under development in-house for single particle tracking with residual range measurement relies on micro-pattern gas detector technology of minimal material budget. Moreover, two alternatives using pixelated Si-based detectors providing spatially resolved detection of individual or integral proton energy deposition are being evaluated for operation at facilities of elevated instantaneous beam current (e.g., synchrocyclotrons) to overcome count rate issues, besides offering compact setup.

Results

First experimental results from pixelated silicon detectors for an imaged phantom with tissue equivalent inserts showed promising sub-millimeter spatial resolution with SPR retrieval accuracy better than 3 %. Moreover, the simulated performance of the proposed single particle tracking system for a realistic mouse anatomy showed average range errors below 1 %, when using the resulting proton computed tomography image (acquired with a dose < 100 mGy) for planning.

Summary

This presentation will highlight different imaging concepts and their ongoing development, including updates from upcoming experimental campaigns.

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References

[1] K. Parodi et al., Acta Oncol. (2019)