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Positron emitting Radioactive ion beams for simultaneous treatment and imaging

Heavy ion particle therapy is a rapidly growing and potentially the most effective and precise radiotherapy technique. However, the sharp dose gradients in the distal ends make it extremely sensitive to range uncertainties, which remain one of its main limitations. In clinical practice, wide margins extending into the normal tissue are commonly used to guarantee tumor coverage, thus jeopardizing the benefits of the sharp Bragg peak. Online range verification techniques could potentially help to overcome this limitation. PET (positron emitting tomography) is one of the most established methods to verify the beam range. However, 12C-ion therapy, the physical shift in the β+ activity and dose peak, the low statistics compared to the delivered dose, and the long half-life of the most abundantly produced projectile fragment (11C) limits the PET-based range verification accuracy to approximately 2–5 mm. Direct use of β+ radioactive ion beams (RIB) for both treatment and imaging could help overcome this limitation by increasing the signal/noise ratio, mitigating the washout blur of the image, and reducing the shift between measured activity and dose. In this context, the BARB (Biomedical Applications of Radioactive Ion Beams) project was initiated at GSI aiming to assess the technical feasibility and investigate possible advantages of RIBs in preclinical studies. During the first year of experiments within this project, radioactive Carbon and Oxygen beams (10,11C and 15O) were produced by isotopic separation with the fragment separator and transported to the medical vault of GSI. Thanks to the upgrade of the SIS-18 in the FAIR in Darmstadt, it was possible to achieve RIB intensities sufficient to treat a small animal tumor. Besides showing the potential of RIB in a treatment planning study to estimate the magnitude of possible range margin reduction and its impact on the doses to organs at risk and on the normal tissue complication probability, the vast experimental campaign, including research ranging from basic nuclear physics and PET detectors developments to animal treatments, foreseen in this project will be presented.

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