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Radioactive carbon beams for simultaneous treatment and imaging

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Heavy ion particle therapy is a rapidly growing and potentially the most effective and preciseradiotherapy technique. However, the sharp dose gradients and very high doses in the distal ends make it extremely sensitive to range uncertainties, which remain one of its main limitations. In clinical practice, wide margins extending in the normal tissue are commonly used to guarantee the tumor coverage, thus jeopardizing the benefits of the sharp Bragg peak. Online range verification techniques could potentially help to overcome this limitation.

One of the most established methods to verify the beam range is to exploit the β+-emitting isotopes, produced by the ion beam in the patient's body by nuclear fragmentation processes, for positron emission tomography (PET) imaging [1]. However, PET in 12C-ion therapy still does not allow to reduce the range uncertainty as desired: the long half-lives of the radionuclidesin combination with the biological washout and the physical shift in the β+ activity anddose peak do not allow a straightforward dose reconstruction.

Direct use of β+ radioactive ion beams (RIB) for both treatment and imagingcould 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 [2].

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 [3].

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.

In the first two years of the project 10,11C and 15O beams have been produced with the GSI fragment separator (FRS) 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. Beam implantation in plastic phantoms was visualized by two independent imaging setups: a dual-panel PET scanner from the UMCG (Groningen) and a subset of a high resolution small animal PET detector in development at the LMU (Munich).Range and depth dose distribution measurements have been performed with a water column setup [4]. These first experimental results will be here also presented.

REFERENCES
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