Radioactive ion beams for real-time PET-guided adaptive particle therapy

Daria Boscolo[1]
[1]GSI, Germany

Heavy-ion particle therapy provides superior dose conformity compared with conventional radiotherapy, but its clinical benefit is limited by strong sensitivity to range uncertainties at the distal edge of the Bragg peak. To ensure sufficient tumor coverage, large safety margins are typically applied, partially reducing the advantages of particle therapy. Reliable online range verification is therefore crucial, especially for adaptive treatment approaches. Positron emission tomography (PET) is one of the most established techniques for in-beam range verification; however, in conventional ^{12}C-ion therapy its performance is hindered by low signal-to-noise ratios, spatial discrepancies between activity and dose distributions, and long acquisition times.

Using β^+-emitting radioactive ion beams simultaneously for treatment and imaging represents a promising strategy to overcome these limitations. Within the BARB project, the feasibility of combining ^{11}C-ion beams with real-time in-beam PET has been systematically explored. Here, we present the first demonstration of real-time adaptive particle therapy using radioactive ion beams in a living mouse model. Dynamic beam repositioning produced spatially resolved PET signals that correlated with distinct treatment outcomes. These results highlight the potential of ^{11}C-beam–based imaging for accurate range verification, adaptive treatment delivery, and improved tumor control with reduced toxicity.