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Hybrid Compton-PET imaging for ion-range monitoring in hadron therapy

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Hadron therapy offers advantages over conventional radiotherapy due to the maximization of the dose at the Bragg peak. However, further advantages could be obtained if a quasi-real-time monitoring system for ion-range verification would be available. In particular, this would help to reduce safety margins and enhance its potential benefits, due to various sources of systematic uncertainty. Two of the most promising methodologies for in-room real-time monitoring are positron emission tomography (PET) and prompt-gamma imaging (PGI). The PGI technique is well suited for real-time monitoring because of the prompt nature of the emitted radiation [Ler22], whereas PET imaging can provide tomographic and functional information relevant for studying physiological processes and tumor response.

In 2016, the concept of PGI-PET hybrid imaging system was discussed by Parodi as an alternative to overcome some of the limitations for each technique [Par16]. As suggested in Ref. [Lang14], this concept could be implemented by adapting systems based on multiple Compton cameras. Hybrid PGI-PET systems are expected to open new perspectives for in-vivo real-time range monitoring [Par16]. This expectation is based on the complementarity of the two techniques: prompt-gamma emission is more suitable for real-time monitoring, while PET imaging can provide tomographic and functional information valuable for monitoring physiological processes and tumor response.

We have implemented for the first time in hadron therapy a hybrid imaging system based on the combination of both PGI and PET within the same setup [Bal22], thereby exploring the advantages of both techniques. This is achieved using an array of Compton cameras in a twofold front-to-front configuration operating in synchronous mode.

In this contribution, I will present a summary of the hybrid imaging monitoring system, the results from a proof-of-concept experiment conducted under pre-clinical conditions at the HIT-Heidelberg facility with proton, alpha, and carbon ion beams, and the outlook for upcoming experimental campaigns.

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Abstract

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