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A dedicated dual-head TOF-PET system for in-vivo quality control of beam delivery in proton therapy

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We are developing a prototype dual-head time-of-flight (TOF)-PET system for in-vivo verification of beam delivery in proton therapy. Such a system will allow PET image acquisition shortly after irradiation, profiting from imaging of short-lived O-15 and reduced biological washout effects, whereas TOF-PET reduces image degradation due to incomplete acquisition of projection data from the planar detectors. Our proposed detector has a modular design with two parallel planar heads of approximately 20 cm by 20 cm active area, each consisting of 8 x 8 detector modules, composed of a LYSO:Ce array of 3.14 mm x 3.14 mm x 20 mm elements, optically coupled to SiPM arrays with TOF-enabling HRFlexToT ASIC readout [1]. The expected performance of the detector has been assessed via realistic Monte Carlo simulations of anonymized real patient treatments, by comparing the PET images from the original treatment with images obtained with artificially-modified proton ranges. Using a range estimation method developed by our group, we have concluded that the proposed PET system is capable of identifying range differences of the order of 1 mm with over 80% specificity and specificity, and 100% for range variations of 2 mm or larger [2-3]. We are presently developing a small field of view prototype with two planar heads of 10 cm by 10 cm to validate the proposed PET detector design.

[1] D. Sánchez, IEEE TRPMS 6 (2022) 51-67.
[2] P. Rato Mendes et al., Radioter Oncol 161 Suppl.1 (2011) S1286. [3] P. Arce et al., presented at 2022 IEEE NSS MIC.

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