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Role and challenges of PET imaging in proton therapy

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Proton therapy is the most precise external radiotherapy modality offering better dose distribution (exact-precision dosimetry, i.e., precise radiation dose and location) and, as a result, less radioactivity exposure to healthy tissues and a lower likelihood of unneeded radioinduced side effects.
The fact that protons have a limited range when they enter the body is one of the key benefits of proton treatment. The energy of the proton beam and the physical properties of the biological tissue they pass through—primarily the atomic number and density—determine that range. Additionally, protons deposit the majority of their energy where they stop (Bragg peak), in contrast to photon treatment. It is feasible to tailor proton irradiation to the tumor's volume by adjusting the proton beam's energy. This situation is ideal since the irradiation does not affect the tissue beyond the range of the protons. However, if a little error is made in the range estimate or proton therapy planning, irreparable harm will result and, in the worst case, affecting to a vital organ neighbor to the tumor.
Several positron emitters are created in the living tissue during proton therapy irradiation as a result of proton interactions. Therefore, positron emission tomography (PET) cameras may be used to detect the photons released from the positron radioisotopes produced and create an image of the radioactivity generated, assisting in determining whether the calculated proton range was correct. In order to quantify the activity before it decays, it is crucial that the image be captured for this purpose as soon as possible and in the same location as the patient when they were exposed to radiation.
Nowadays and in this context, our group is developing a PET system with open geometry to avoid interfering with the proton treatment beam. Specifically, we are developing a two-paddle PET device with a detection area of 256x256 mm2 among which the patient will be located. Open geometries introduce severe elongation artifacts in the images due to the lack of angular information. This contribution will show the challenges we face and the direction of our research to overcome them in the field of detector development and time-of-flight determination, as well as image reconstruction techniques.

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