AbstractID: 4583 Title: Dose-guided particle therapy with PET imaging

Positron emission tomography (PET) is increasingly considered a promising technique for in-vivo, non invasive verification of the actual treatment delivery in ion therapy. Positron-emitting isotopes such as ^{11}C (half-life $T_{1/2}$=20.4 min) and ^{15}O ($T_{1/2}$=2 min) are produced in tissue along the ion beam penetration as a by-product of irradiation and can be potentially visualised by PET as a spatial marker of radiation dose deposition. PET image guidance can contribute to a better clinical exploitation of the physical advantages of ion beams. It may improve confidence in the planning and delivery of more conformal treatments or allow for adaptive strategies in case of detected disagreements between the intended and actually delivered fields during fractionated radiotherapy.

As opposed to heavier ions like carbon, the positron activation induced by proton beams is limited to target (no projectile) fragments of the irradiated tissue. This results in a weak spatial correlation between PET images and dose. Nevertheless, previous phantom studies of several groups indicated feasibility and usefulness of the method for proton therapy. Information on the dose delivery and the beam range in the patient can be gained by comparing the measured activity with a model prediction, as already clinically implemented for therapy with stable carbon ion beams elsewhere in Germany.

Issues related to the possible on-line (i.e. during treatment) or off-line (i.e. after treatment) imaging strategies will be briefly addressed. The presentation will focus on the first clinical pilot study recently concluded at Massachusetts General Hospital, Boston. Nine patients with a variety of tumour types and anatomical sites were imaged at a commercial, LSO-based PET/CT scanner for 30 min starting within 20 min after single or multi-field proton irradiation. Measured PET/CT images are compared to predictions based on Monte Carlo techniques combined with functional information taken from the literature and from the measured activity decay curves. The same Monte Carlo methods were also used to calculate the pattern of dose deposition for an additional direct comparison with the treatment plan, to enforce the clinical value of the comparison between measured and calculated PET images. First conclusions on clinical feasibility, potential and limitations of off-line PET/CT imaging of proton therapy will be discussed.

This lecture will provide an overview on the physical principles and issues of the unconventional application of PET to treatment verification in ion therapy, with a more detailed insight on the role of PET/CT image guidance after proton treatment.

Educational objectives:

1. Understand the physical principles of positron activation induced by therapeutic ion irradiation
2. Understand the issues related to ion treatment verification by means of PET imaging, including the strategies for data acquisition and analysis
3. Understand the issues related to clinical application of PET/CT imaging after proton therapy