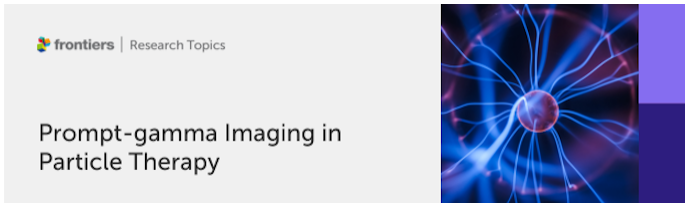

Contribution ID: **6** Type: **Oral**

Labeling the tumor with 31-P, 63-Cu and 89-Y provides an in vivo prompt gamma-based range verification for therapeutic protons

Thursday, 6 July 2023 17:15 (30 minutes)

Range uncertainty is a main limitation to fully exploiting the benefits of proton therapy. Its reduction will improve treatment effectiveness by increasing both dose conformality in the tumor and normal tissue sparing.

We present a proof of principle investigation of a range verification approach based on the detection of prompt gammas (PG), whose production is artificially enhanced with a non-radioactive element transported selectively to the tumor with a drug carrier. Nuclear interactions of this element with protons generate a signature PG spectrum, from which both the absolute proton range and the tumor position can be reconstructed by exploiting the existing PG Spectroscopy (PGS) methods.

Combining experimental data and calculations obtained both with TALYS and TOPAS Monte Carlo code, we selected three stable elements: 31-Phosporous (^{31}P), 63-Copper (^{63}Cu), and 89-Yttrium (^{89}Y). We measured signature PG energy lines emitted by solutions of water and the candidate materials ($CuSO_4$+H_2O, NaH_2PO_4+H_2O and $Y(NO_3)_3$+H_2O) when exposed to clinical proton beams. From measurements, we evaluated that, at a realistic element concentration in the tumor of 0.4 mM, 10^9 protons for an iso-energy slice, and an advanced detection system, the produced PG signature is large enough to be distinguished from the normal tissue background. In addition, using the ^{31}P label, we experimentally proved that the proposed methodology predicts the absolute proton range with a 2 mm accuracy on a simplified patient geometry.

Range assessment is not the only feature of PGS. Paulo Martins et al. Sci Rep (2020) demonstrated that it is possible to determine the elemental composition of the target from the energies and intensities of the measured gamma lines. In this work, we studied with TOPAS MC the impact of tumor heterogeneity on element uptake ditribution in a real patient's geometry. By detecting the inter-fraction variations in element concentration, it could be possible to assess the biological response of the tumor to the radiation.

The presented approach can open a new avenue of improvement for monitoring the proton range and the tumor response at the same time.

Primary authors: Dr CARTECHINI, Giorgio (University of Miami, Radiation Oncology department, Miami, FL, USA); Ms FOGAZZI, Elena (University of Trento, Physics department, Trento, Italy); Dr PELLEGRI, Luna (4iThemba LABS, Cape Town, South Africa); Dr VANSTALLE, Marie (Université de Strasbourg, Strasbourg, France); Dr LA TESSA, Chiara (University of Miami, Radiation Oncology department, Miami, FL, USA)

Presenter: Dr CARTECHINI, Giorgio (University of Miami, Radiation Oncology department, Miami, FL, USA)

Session Classification: Contributed Talks II