Contribution ID: **28** Type: **not specified**

Enhancing prompt-gamma production for real-time dose verification in proton therapy

Tuesday 6 September 2022 11:00 (25 minutes)

The main rationale for using protons in cancer treatment is based on the highly conformal dose distribution and normal tissue spearing compared to conventional radiotherapy. One of the main limits of proton therapy is the particle range uncertainty due to patient setup, dose calculation and imaging. A mispositioning potentially translates into an under-dosage of the tumor as well as an over-dosage of the normal tissue, which can significantly hinder the treatment efficacy.

We developed a novel strategy for real time range verification in proton therapy [1]. The methodology is 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 the tumor position can be reconstructed exploiting existing PG Spectroscopy (PGS) methods [2].

In this study, we present the results obtained with three stable elements: 31-Phosphorous, 63-Copper and 89-Yttrium. We characterized the gammas emitted by solutions of water and the candidate elements ($CuSO_4+H_2O$, $NaH_2PO_4+H_2O$ and $Y(NO_3)_3+H_2O$) when exposed to proton beam up to 70 MeV. We investigated the minimum element concentration in water required to detect a PG enhancement compared to a pure water solution. Using TOPAS MC, we also reproduced all experiments, as well as we studied the feasibility of the proposed methodology in a geometry closer to a clinical scenario. Both measurements and simulations indicated that 31P and 89Y are the most promising elements, as they produce signature PGs in the 0.8 MeV - 1.4 MeV range, with an enhancement of about 4% (31P) and 1.4% (89Y) at a concentration of 0.5%.

REFRENCES

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Session Classification: New experimental developments in hadrontherapy

Track Classification: Hadrontherapy and associated technologies