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Range and dose verification for proton therapy using using gamma spectroscopy of contrast agents. (G)*

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Proton therapy is gaining popularity as a tumor irradiation method due to the superior dose distribution offered by heavy charged particles. The subject of range and dose verification has been approached from several angles and fields.

Upon interaction with low-energy protons, certain nuclei undergo fusion-evaporation reactions. The resulting reaction products emit a cascade of characteristic gamma rays as they decay to their ground state. The product of these fusion-evaporation reactions is highly dependent on the energy of the incident proton. This means that the relative intensity of the competing fusion-evaporation channels can be correlated with the energy of the proton beam, and, by extension, its range. By administering an appropriate contrast agent to the tumor being irradiated, we are able to measure the intensity of characteristic prompt gamma rays resulting from fusion-evaporation reactions occurring inside the tumour.

We propose to take advantage of the timing and energy resolutions of a fast scintillator detector to measure beam range and dose administered in proton radiation therapy. Fast scintillator detectors are used frequently in nuclear research due to their good timing resolution and reasonable energy resolution, and have begun to make their way into the medical field.

Our Geant4 simulation results show that this technique would allow for accurate measurement of beam range relative to the position of the tumour within the body, as well as dose administered to the tumour. Additionally, the excited states resulting from the reactions of interest are very short-lived and as such this measurement is taken while the beam is online. This is advantageous because it allows for dose monitoring during the treatment as opposed to afterwards.

The presented approach combines the unique expertise at TRIUMF in the fields of both gamma ray spectroscopy in nuclear physics research and proton therapy in order to strive towards improved cancer radiation therapy.

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