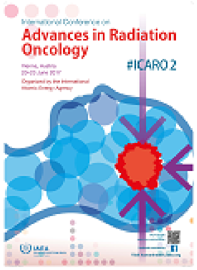

Contribution ID: **180**

Type: **Oral Presentation**

Feasibility of prompt gamma imaging for passive-scatter proton radiotherapy treatments

Wednesday, June 21, 2017 5:00 PM (10 minutes)

During proton beam radiotherapy, an ideal treatment plan has all the primary protons stopping at the edge of the tumour volume. Due to the sharp fall-off at the end of the Bragg peak, an in-vivo verification of the delivered dose has become a priority to ensure minimal radiation damage to the normal tissue surrounding the tumour and to ensure uniform dose deposition within the tumour. However, there are no primary particles exiting the patient to be used to develop an imaging device for in-vivo treatment verification. An alternate option is to use secondary radiation, like the prompt gammas produced by proton-nuclei inelastic collisions. Several detector designs have been proposed that use prompt gammas produced within the patient. These prompt gamma emissions mainly depend on the clinical proton energy and the atomic composition of the tissue, producing a wide energy range of possible gammas. For passive-scatter proton therapy, there is the additional challenge of extensive background radiation from the passive-scatter beam. The primary aim of this work is to investigate the feasibility of prompt gamma imaging in the passive-scattering proton therapy context, specifically for high-dose, low-fraction treatments, using a Monte Carlo simulation method with the Geant4 (v9.6.04) radiation transport code.

The initial experiment measurements for this work were carried out at the proton therapy facility at iThemba LABS in Cape Town, South Africa. Detection of the prompt gammas produced by a 200 MeV passively scattered proton beam was performed with a LaBr3 detector surrounded by lead shielding. The detected prompt gamma energy spectra emitted from the water target is shown in Figure 1(a). This measurement looked at the discrete prompt gammas emitted from the dominant element ^{16}O found in water. The 6.13 MeV gamma-ray emission line with its first and second escape peaks is clearly visible as well as the emission line at 4.44 MeV due to the $^{16}O(p,\alpha)^{12}C^{*}$ reaction.

A Monte Carlo model for iThemba passive-scatter proton treatment nozzle was built for comparison to the above-mentioned prompt gamma measurements. The model was validated using experimental depth and lateral dose data for clinical dose delivery. The Precompound model was selected for proton inelastic nuclear reaction and optimised against available experimental cross section data[1]. The water target, the $LaBr_3$ detector and the lead shielding was added to the Geant4 beamline simulation to replicate the experimental results, shown in Figure 1(b). While the Monte Carlo model under-estimates the background radiation, the relevant prompt gamma peaks are clearly visible and provide a good validation for the Geant4 simulation.

This prompt gamma Geant4 model was then used to evaluate the prompt gamma production from a typical brain arteriovenous malformation (BVM) treatment. A typical BVM treatment at iThemba LABS delivers 54.5 Gy over 3 fractions to a 5 x 4 cm cylindrical volume using a 10-cm water equivalent proton beam. Unfortunately, ethical clearance has not yet been granted to use patient data, so a simple model of bone, water, and tissue was used to mimic a patient. The prompt gamma production from several single-material targets (bone, water, tissue, lung, fat) was also simulated. These results will be discussed as well as the feasibility and the challenges of PGI for a passive-scatter proton therapy treatment.

Figure 1: (a) Detected prompt gamma energy spectra (b) Comparison between measured and simulated energy spectra emitted from water target for proton energy corresponding to a 24-cm range in water.

[1] Jeyasingam Jeyasugiththan and Stephen W Peterson "Evaluation of proton inelastic reaction models in Geant4 for prompt gamma production during proton radiotherapy" 2015 Physics in Medicine & Biology 60, 7617–7635.

Country

Sri Lanka

Institution

Department of Nuclear Science, University of Colombo,

Primary author: JEYASUGITHTHAN, Jeyasingam (Department of Nuclear Science, University of Colombo)

Co-author: PETERSON, Steve (Department of Physics, University of Cape Town)

Presenter: JEYASUGITHTHAN, Jeyasingam (Department of Nuclear Science, University of Colombo)

Session Classification: Session 14a - Imaging for planning and treatment delivery in External Beam Radiotherapy - Part 2

Track Classification: New Technologies in Radiation Oncology/Radiotherapy