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Imaging of prompt gamma emissions during proton cancer therapy for geometric and dosimetric verification

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The demand for proton therapy as a form of cancer treatment has been growing rapidly over the past decade. This is due to the sharp Bragg peak of the protons, which potentially enables radiation dose to be closely conformed to tumour dimensions, hence sparing normal tissues.

However, uncertainties in the proton range in tissue, beam delivery and resulting dose deposition in the patient, could lead to serious adverse effects [1]. Therefore, it is necessary for in vivo proton range verification during therapy. Prompt gamma-ray emissions whose energies are above 2 MeV can offer a check of in vivo proton range [2]. These emissions result from the interaction of protons with the tissue nuclei within the body. Currently, different techniques are being explored for imaging these emissions.

One of the techniques being used is Compton Camera Imaging. The University of Liverpool is working in collaboration with University College London and Clatterbridge Cancer Centre to develop a detector for prompt gamma-ray imaging. This system known as GRI+ is a three layer detector system, comprising of one Si(Li) scatter detector and two High Purity Germanium absorber detectors. Pulse Shape Analysis (PSA) is used to determine the interaction position and energy in each detector. Using code written at the University of Liverpool, it is possible to determine the gamma-ray emission position and hence proton range in 3D space.

In this presentation, the characterisation of the GRI+ system using laboratory isotopes such as Y-88 for high photon energies will be discussed. It will be compared with system simulations performed using GAMOS (Geant4-based Architecture for Medicine-Oriented Simulations)[3][4]. We will discuss about measurements on radiation and neutron background we performed at the Clatterbridge Cancer Cancer. We will use Compton Camera in realistic conditions during proton therapy. The first preliminary results will be presented.

[1] H. Paganetti, Phys. Med. Biol. 57, R99-R117 (2012).

[2] C.H. Min et al., Appl. Phys. Lett. 89, 183517 (2006).

[3] P. Arce et al. NIM A 735, 304-313 (2014).

[4] L.J. Harkness et al. NIM A 671,29-39 (2012).

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