Contribution ID: **347** Type: **Oral Presentation**

Monte Carlo simulation of secondary gamma production during proton therapy for dose verification purposes – Part I

Thursday, 10 July 2014 10:20 (20 minutes)

Abstract content
   (Max 300 words)
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Cancer treatment through the use of gamma radiation has a long history and is a well-defined treatment modality. The recent growth of radiation therapy by attacking the tumor with accelerated protons presents an unprecedented level of control over the dose deposition and a great reduction in treatment side-effects. These benefits are a direct result of the gradual rise and then steep decline of the energy deposited by the protons traveling in the patient. This benefit can quickly become a detriment if the dose is not delivered to the correct location. Unfortunately, there is no device to determine where the dose has been deposited within the patient during treatment, only estimates calculated from treatment planning. Proton-nucleus collisions during treatment could be the solution to this problem. Secondary (prompt) gammas produced in these reactions have been shown to correlate well with the energy deposited by the protons and could be used to produce an in-vivo dose image. These prompt gammas also provide additional information about the elemental composition of the patient due to their characteristic energies. Recent Monte Carlo studies have shown the feasibility of a three-stage Compton camera for detecting the prompt gammas during patient treatment. The limitation of these design simulations was the accuracy of the simulated prompt gammas production numbers. Due to holes in the proton inelastic cross-section data and inaccuracies in the physics models in Geant4, it is very hard to get an idea of the absolute number of the prompt gammas produced during a typical patient treatment. This work takes a look at the accuracy of these simulated prompt gamma production numbers for a typical treatment at the Proton Therapy Center in Houston, TX USA and at iThemba LABS in Somerset West, WC South Africa. The uncertainty in these results has prompted a more detailed look at the physics surrounding the proton inelastic collisions in Geant4 and a series of experimental measurements of prompt gamma production to further validate the Monte Carlo results.

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Session Classification: NPRP

Track Classification: Track B - Nuclear, Particle and Radiation Physics