PROTON THERAPY VERIFICATION WITH PET IMAGING

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Introduction

The Proton Therapy Facility at TRIUMF is in routine operation treating ocular tumours using 74 MeV protons extracted from the 500 MeV H cyclotron. Proton therapy results in the activation of the irradiated tissue and provides an opportunity for in-vivo verification via the measurement of irradiation induced activity. The activity distribution resulting from these irradiation induced positron emitters is measurable through post-therapeutic positron emission tomography (PET) scans. The feasibility of using PET as a verification tool for eye treatment is being investigated in this project. A lucite target and a 3-D printed eye were irradiated with a pristane/rae Bragg Peak (RBP) and a Spread-out Bragg peak (SOBP). The isotopic activity inside the targets was calculated with Monte Carlo codes GEANT4 and FLUKA and validated with data from PET scanners taken 15 minutes after end of beam (EOB).

Aims

- Compare the performance of GEANT4 and FLUKA for measuring isotopic inside targets after ocular melanomas treatment conditions.
- Study the activity from two different lucite targets from a RBP and a SOBP.
- Study the feasibility of using High Resolution Research Tomography (HRRT) and μPET to verify depth dose deposition inside target by comparing data with simulations.

Materials and Methods

A simple geometry involving a homogeneous phantom was used to compare the two codes. A beam of 300M protons irradiating a cylindrical lucite phantom of PMMA (ρ = 1.19 g/cm³, C₁₂H₂₅O₂) and a 3-D printed human eye placed in air was simulated as shown in Fig. 1. When a proton beam passes through human tissue or lucite phantom, short-lived radionuclides are produced such as Carbon-11, Nitrogen-13 and Oxygen-15 with half lives of 20, 10 and 2 minutes respectively and decay exponentially [1].

Setup Scheme

![Setup Scheme](image)

Results

For axial activities in Fig. 5a and 5b, the simulation results agreed very well with each other. Due to the resolution of the scanners, the data show a marginally wider area of activation than the simulations. The type of beam used can be clearly interpreted from the slope of the activity profile. A RBP results in a steeper negative slope whereas a SOBP has less drastic slope inside phantom.

Conclusions and Future Work

- GEANT4 and FLUKA simulations of the proton-therapy beam line has been created and verified against experimental measurements. All results have excellent agreement with the distal fall-off agreeing to sub-millimetre levels. However, the further investigations must be carried out due to the discrepancy in the entrance dose deposited.
- External cross sections of the PET isotope produced during proton irradiation has been validated. Due to the large uncertainties involved in the values for reaction cross section, the yield calculated vary depending on the libraries used.
- The μPET scanner proved to have sufficient resolution to identify target region inside 3-D phantom.
- The 3-D eyeball has been irradiated and scanned, next the CAD model of the eyeball will be imported into GEANT4 and FLUKA then irradiated under the same ‘treatment conditions’. The obtained results will then be compared with data.