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Quantification of thermal neutron fluence in high-energy LINAC radiotherapy for quality assurance dose enhancement

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Radiotherapy based treatment involving a linear accelerator (LINAC) is one of the most widely used treatment modalities for cancer patients. LINACs utilize a high energy photon beam to penetrate the body and deliver a pre-determined dose to the tumour. However when LINAC energies greater than 10MV are used during treatment, photo neutrons are produced through nuclear interactions within the LINAC and its components. These neutrons are capable of delivering large amounts of damage through indirect methods to undesirable regions of the body. This effect increases the risk for induction of a secondary cancer due to unwanted exposure.

While photo neutrons produced by a LINAC are inevitable, their high damaging capabilities are of high interest. An investigation is carried out within this study towards determining whether Boron Neutron Capture Therapy (BNCT) techniques can be implemented in addition to a radiotherapy treatment. This technique can aid in administering additional dose to a tumour thus increasing the probability of a successful treatment. This work presents a new direction towards experiments evaluating the possible damage that can be caused due to BNCT during a radiotherapy treatment.

This study examines the effectiveness of a silicon on insulator (SOI) microdosimeter developed by the Centre of Medical and Radiation Physics (CMRP) known as the Bridge, in determining microdosimetric quantities such as the dose equivalent (H) and relative biological effectiveness (RBE) in a mixed photon-neutron radiation field. Cell uptake of a {10}^B compound is modelled through the use of a {10}^B_{4}C thin film converter. The radiobiological properties neutrons possess outside the treatment field are determined in this work. Implementing microdosimetric techniques, it was found that for a distance of 50cm from isocenter, the dose equivalent is approximately 0.14mSv/photon-Gy with an RBE10 value of 1.6 for cells with a modelled {10}^B uptake. For a patient undergoing a head and neck treatment procedure, this can correspond to an integral dose of 9.8mSv to just the abdominal region during a 70Gy radiotherapy treatment.

This work also explores a newly developed SOI device designed by CMRP that will further aid in investigating the effect BNC techniques may have within the body. The "mushroom" microdosimeter is a 3D device with free standing sensitive volumes (SVs) called "mushrooms". Utilizing 3D micro-electro-mechanical systems (MEMS) technology at SINTEF, Norway, as well as deep reactive ion etching (DRIE), these 3D sensitive volumes possess outstanding energy resolution. Each SV is 2µm in thickness allowing for an accurate determination of the lineal energy in a mixed radiation field, such as the one present in a high energy LINAC. These devices have been characterized in terms of their charge collection efficiency (CCE) utilizing an ion beam induced charge (IBIC) collection technique with 1.78MeV and 5.5MeV He^{2+} ions at the 6MV SIRIUS accelerator located at ANSTO. The reduced SV thickness of the mushroom microdosimeter when compared to the 10µm thick Bridge microdosimeter used in this work, will aid in addressing some of the issues that arose during this study.

Speakers Gender

Male

Travel Funding

No

Level of Expertise

Student

Do yo wish to take part in the poster slam

Yes

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