A GEANT4 STUDY ON AIR GAP OPTIMIZATION FOR A CORRECTION-FREE SILICON DIODE ARRAY DETECTOR

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Introduction: The CyberKnife Robotic Radiosurgery System (Accuray Incorporated, Sunnyvale, USA) is used to deliver SBRT treatments, which use small fields to deliver the maximum dose to the target and the minimum dose to surrounding healthy tissues. Small field dosimetry, which applies whenever field sizes of dimensions smaller than the maximum range of secondary electrons are used, poses unique concerns due to loss of charged particle equilibrium, spectral changes as a function of field size, high dose gradients. In these cases, the measurement of output factors (OF) is very problematic and sensitive to the physical properties of the detector being used [1] whose response needs to be corrected. Charles et al. and Underwood et al. [2,3] firstly proposed the use of air gaps to correct for silicon detectors over-response in small fields, but it is necessary to ensure that these modifications are correctly compensating whatever the beam energy, the field size and measurements conditions [4].
OCTA is a monolithic silicon diode array detector, designed by the Centre for Medical Radiation Physics (CMRP), rendered correction-free with the use of an air gap. The detector has a sub-millimeter resolution, making it a suitable candidate for real-time high-resolution small field dosimetry.
The scope of this study was to investigate the effect of different air gaps on the OCTA response as a function of depth using a GEANT4 application.
To our knowledge, no previous study of this kind has been conducted using a GEANT4 application.

Materials and methods: A GEANT4 application has been developed which reads CyberKnife IRIS collimated field size dependent PHSP files provided on the *Phase-space database for external beam radiotherapy* maintained by IAEA. Available field sizes are 5, 7.5, 10, 15 and 60 mm diameters.
First, the GEANT4 application has been benchmarked against both TPS generated and experimental data acquired using response corrected SFD diodes at an IRIS collimated CyberKnife system at SCGH**,** Nedlands, WA. OF, defined as the ratio between the dose for a specified field size and the dose for a reference field, has been compared. For the CyberKnife system, the reference field is defined by the 60 mm collimator. Beam profiles have been compared for all available field sizes. TPR data, defined as the ratio between the dose at an arbitrary depth and the dose at a reference depth in a water phantom along the beam central axis has been compared. From the results of the benchmark, GEANT4 was found to reproduce very consistent results with TPS and experimental data.
Secondly, The GEANT4 application has been used to investigate the response of the OCTA detector with different air gaps in terms of OF at different SAD in a water phantom.

Results: The GEANT4 application TPR data results have been found to match both TPS generated and SFD experimental data for an IRIS collimated CyberKnife system 6 MV beam.
Furthermore, the GEANT4 application gave consistent results with previous experimental studies on air gap optimization for a silicon diode array detector conducted by Utitsarn et al. [5] and suggests that no statistically significant variations in the optimal air gap wih varying SAD exist for the OCTA detector. Therefore, this study suggests that the OCTA detector may be correction free when used with the same air gap for all SAD for an IRIS collimated 6 MV CyberKnife system delivered beam.

Conclusions: Results confirm that CyberKnife IRIS collimated field size dependent PHSP files provided by IAEA, read by a suitable GEANT4 application, may be used in conjunction with experimental measurements as a powerful investigation tool for silicon diode array detectors response in the case of MV photon beams.

References:
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