THE USE OF MONTE CARLO METHODS TO STUDY THE EFFECT OF X-RAY SPECTRAL VARIATIONS ON THE RESPONSE OF AN AMORPHOUS SILICON ELECTRONIC PORTAL IMAGING DEVICE

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Intensity modulated radiation therapy (IMRT) is delivered with segments of various dimensions and off-axis positions and hence of variable x-ray spectra. The presence of attenuating material (e.g. the patient) in the beam also modifies spectra. Electronic Portal Imaging Devices (EPIDs) are a good candidate to verify IMRT beams but they are sensitive to spectral variations. The goal of this project was the quantification of spectral variation effects of on EPID response. The linac, attenuating material and EPID geometries were simulated in a Monte Carlo model using BEAMnrc and DOSXYZnrc. A leaf position prediction method, taking into account the systematic errors introduced during the multileaf collimator calibration, was incorporated in the model and predicted leaf positions to within 1 mm. An analytical expression for the flood field intensity distribution, used for EPID calibration, was derived from Monte Carlo simulations and used to correct inhomogeneities in the standard calibration (up to 12%). The Monte Carlo model predicted EPID response to within 2% for open fields. For IMRT fields, over 96% of the pixels had a gamma value (3%-2mm criteria) below 1 except for large IMRT fields with attenuating material. An analytical model of the ratio between the EPID response and that of a water detector allowed prediction of response from water detector simulations to within 5% for static fields. Over 97% of the points had a gamma index below 1 for the IMRT field tested. EPID design modification was studied to achieve water detector equivalence and the use of a thick high atomic number metallic plate (5453 $mg.cm^{-2}$ lead) allowed the EPID to behave like a water detector for most cases, but at the cost of a decrease in image quality. The effect of spectral variations on EPID response is not negligible and is different from effects in a water detector.

A copy of the thesis can be requested by email.