AbstractID: 3088 Title: The Role of Secondary Photons in the Quantum Absorption Efficiency of Megavoltage X-ray Detectors: Is d_{max} the Ideal X-ray Converter Thickness?

Purpose: To quantify the impact of x-ray converter thickness and determine the role of secondary photons on the quantum absorption efficiency of megavoltage x-ray detectors (metal plate/phosphor screen) used in portal imaging and megavoltage CT.

Method and Materials: The Electron Gamma Shower (EGSnrc) Monte Carlo code was used to simulate the coupled photon-electron transport within a copper (Cu) metal plate / gadolinium oxysulphide phosphor screen detector. The DOSRZnrc user code was used to score the spectrum of x-ray energy deposition within the phosphor layer of the detector. In the simulations, a wide range of metal plate thicknesses (0–60 mm), phosphor screen thicknesses (0.1–5 mm), and incident photon energies (1–10 MeV) were investigated. The quantum absorption efficiency (QAE) was calculated from each absorbed energy distribution (AED) simulation.

Results: Plots of QAE versus copper metal plate thickness indicate: the maximum QAE does not occur at the depth of maximum dose (d_{max}), but rather for a thicker metal plate; the metal plate thickness corresponding to maximum QAE increases with phosphor thickness; the magnitude of the QAE increases with phosphor thickness; and the maximum QAE is independent of the incident photon energy. For example, for a 1 MeV incident photon energy and 1 mm phosphor thickness, a factor of two improvement in the QAE can be achieved using a 12 mm thick metal plate.

Conclusion: Our results suggest that using thicker metal plate converters can increase the QAE of megavoltage x-ray detectors. This improvement in QAE can potentially lead to reductions in patient dose for megavoltage imaging. Furthermore, in terms of maximizing the QAE, higher order Compton scattered and pair annihilation photons that originate in the metal plate play a more important role than primary electrons.