AbstractID: 13627 Title: Theoretical limits to system performance of high efficiency, direct detection, megavoltage active matrix flat-panel imagers based on polycrystalline mercuric iodide

Purpose: Megavoltage active matrix, flat-panel imagers (MV AMFPIs), in which a phosphor screen/copper plate serves as the x-ray detector, are the de facto gold standard in portal imaging. Nevertheless, the poor efficiency of conventional MV AMFPIs, which detect only ~2% of the incident radiation at 6 MV, has stimulated efforts to develop more efficient detectors, potentially facilitating high-contrast tomographic imaging at low, clinically practical doses. In one approach, multiple thick layers of polycrystalline mercuric iodide (HgI_2) photoconductor replace the phosphor screen to increase x-ray detection efficiency. In this presentation, theoretical limits to MTF and DQE for this approach are examined through variation of photoconductor thickness and the composition and thickness of the metal plate.

Method and Materials: Monte Carlo simulations of the interaction of a 6 MV beam with various photoconductor/metal plate combinations were performed. From the resulting MTF and NPS for HgI_2 (in the form of particle-in-binder, PIB) up to 6 mm thick, in combination with metal plates up to 3 mm thick, DQE was determined.

Results: Various trends are apparent. Increasing the thickness of the PIB layer results in lower MTF and higher DQE, as expected. However, for a given thickness of PIB, MTF is observed to decrease with increasing plate thicknesses – with this effect becoming less pronounced as PIB thickness increases. Moreover, increasing plate thickness enhances DQE at low spatial frequencies while diminishing it at higher spatial frequencies – with the absolute changes in DQE becoming greater as PIB thickness increases.

Conclusion: As thicker PIB detectors exhibiting good mechanical and signal properties are developed, the composition and thickness of the overlying metal plate (which also serves to absorb scattered radiation) will require optimization, based on considerations such as the trade-off of DQE at low spatial frequencies against DQE at high spatial frequencies.