AbstractID: 6687 Title: Linear systems analysis for a new Solid State X-ray Image Intensifier (SSXII) based on electron-multiplying charge-coupled devices (EMCCDs)

Purpose: To objectively evaluate and optimize performance of a new SSXII using linear-systems analysis with varying constituent elements.

Method and Materials: An imaging module of the SSXII consists of a fluorescent phosphor, a minifying fiber-optic taper (FOT), and a fiber-optic plate (FOP) coupled directly to the sensor of an EMCCD camera. An array of such modules is used to achieve the desired field-of-view (FOV). Linear-systems analysis was applied to a module to determine system performance for various combinations of components whose properties were estimated using known physical constants and manufacturer specifications. A 350µm thick CsI(Tl) structured phosphor deposited on an additional FOP was considered in this analysis; however the phosphor may be grown directly on the FOT for improved optical transfer efficiency. New back-thinned sensors, offering high optical quantum efficiencies (>90%), are also considered. Various FOT minifications were studied to evaluate the tradeoffs between a larger field-of-view (FOV) per module and potential DQE degradation.

Results: Initial calculations indicate elimination of a FOP in the imaging chain could improve the integral DQE by 30-80%, depending on the FOT minification. Use of a back-thinned sensor could offer additional improvements of 10-25% over a front-illuminated EMCCD. Increasing the FOT minification factor from 3:1 to 6:1 would tend to decrease the integral DQE by ~50%, which could be more than compensated for by making the above two design improvements. Calculated MTFs and DQEs will be presented for various minifications, exposures, and gains. A prototype SSXII (16µm pixels) demonstrated 20 lp/mm bar-pattern resolution radiographically and fluoroscopic image sequences with exposures of <3 µR/frame.

Conclusion: The linear-systems analysis indicates current designs for the SSXII will provide high-resolution, low-noise, real-time imaging. With component optimization, an acceptable DQE can be maintained with taper minifications as large as 6:1.

(Partial support: the UB Foundation and NIH grants R01-EB002873, R01-NS43924.)