

AbstractID: 13848 Title: Photon counting radiography and CT: upper limits of SNR with polyenergetic x-rays

**Purpose:** To determine upper limits of signal to noise ratio (SNR) in radiography and computed tomography (CT) with polyenergetic x-rays sources. **Methods:** Photon energy weighting increases SNR in polyenergetic x-ray and CT imaging. SNR can be further increased if tube voltage is optimized in combination with x-ray energy weighting. The SNR achieved with energy weighing at optimized tube voltage is the highest SNR possible in radiography and CT with polyenergetic x-ray sources. The optimal tube voltages were determined for energy weighting and highest SNR were calculated for contrast elements of  $\text{CaCO}_3$ , iodine, adipose, and tumor with thicknesses of  $280 \text{ mg/cm}^2$ ,  $15 \text{ mg/cm}^2$ ,  $1 \text{ g/cm}^2$ , and  $1 \text{ g/cm}^2$ , respectively, inserted in soft tissue with 10 cm and 20 cm thicknesses. The tube voltages were in 30 kVp – 140 kVp range and skin exposure was 20 mR. Energy weighting improves contrast to noise ratio (CNR) in CT when monoenergetic projections are optimally weighted. Alternatively, monoenergetic CT images are reconstructed, optimally weighted, and combined providing final CT image. It was determined analytically which method provides upper limit of CNR in CT. **Results:** A generalized weighting theorem was formulated and proven, which expands weighting method into the imaging areas other than x-ray and CT. An optimal x-ray tube voltage in energy weighting x-ray imaging was determined for each contrast/background combination. Depending on imaging task, the highest SNR achieved in energy weighted polyenergetic x-ray imaging were close to the SNR provided by monoenergetic x-rays. It was proven that in CT the projection based weighting provides higher CNR than image based weighting thus determining upper limit of CNR. **Conclusion:** A unique tube voltage exists in energy weighting x-ray and CT that provides highest SNR with polyenergetic x-rays which can approach the SNR of monoenergetic x-ray and CT. Projection based weighting provides highest CNR in CT.