Material Quantification Accuracy of Calcium and Iodine using Deep Silicon Photon-Counting CT

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INTRODUCTION

Accurate quantification of calcium and iodine is critical for multiple clinical applications, including in cardiovascular and cancer imaging. Deep silicon photon counting CT can produce quantitative CT images with every scan, leveraging 8 energy bins to quantify material densities. This study evaluates the material decomposition (MD) and virtual monoenergetic image (VMI) accuracy of calcium and iodine.

METHODS

We scanned the Gammex Multi-Energy CT body phantom with HE Calcium and Iodine inserts on a deep silicon PCCT system (Photonova Spectra, GE HealthCare). Axial scans were performed at 120 kVp, Large bowtie, and 657 mAs, as well as a repeat scan and at approximately half dose (341 mAs). Deep learning image reconstruction (DLIR) was performed for MD (Calcium/Water and Iodine/Water) and VMI at 70 keV with a Standard kernel and 2.5 mm slices. ROIs were placed on the inserts to measure mean Calcium and Iodine densities, as well as pixel-level noise, and were compared with theoretical values based on elemental composition provided by Gammex and linear attenuation from NIST tables.

Gammex MECT Body Phantom

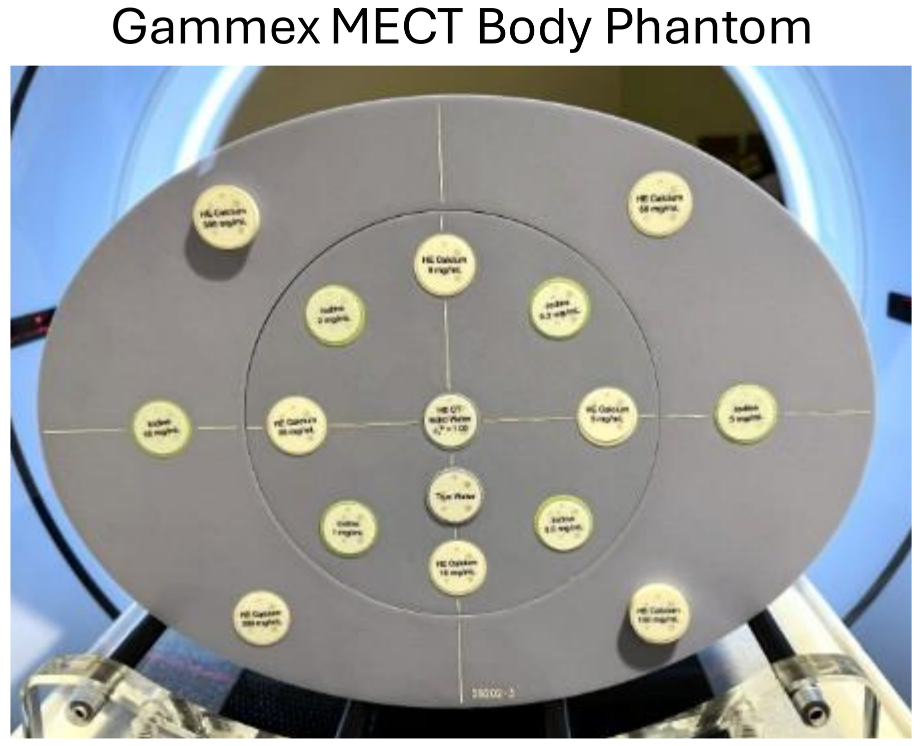
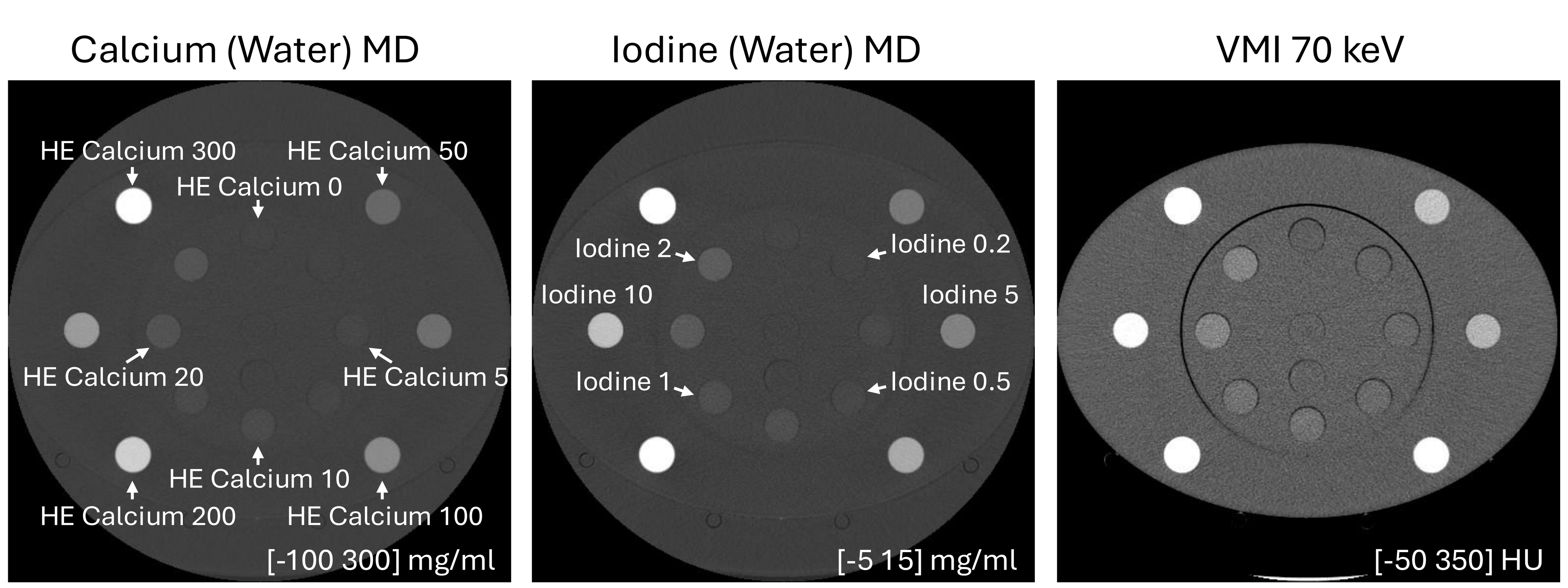


Fig. 1: (Top) Gammex phantom scanned on deep silicon PCCT (Photonova Spectra) with HE Calcium 0-300 mg/ml and Iodine 0.2-10 mg/ml inserts.
(Bottom) Quantitative Calcium (Water) MD, Iodine (Water) MD, and VMI 70 keV images



RESULTS

We found a strong linear relationship between measured and theoretical values for Calcium densities (slope=0.937, offset=2.07, R^2=0.9999) and VMI (slope= 0.975, offset=6.08, R^2=0.9999). Absolute and relative root-mean-squared-errors for Calcium density were 9.00 mg/ml and 4.47% (for HE Calcium ≥5), with pixel-level noise of 4.13 mg/ml. Consistency between repeat scans and at half dose were 0.42 and 0.88 mg/ml, respectively, in absolute RMSE and 2.70% and 2.73% in relative RMSE.

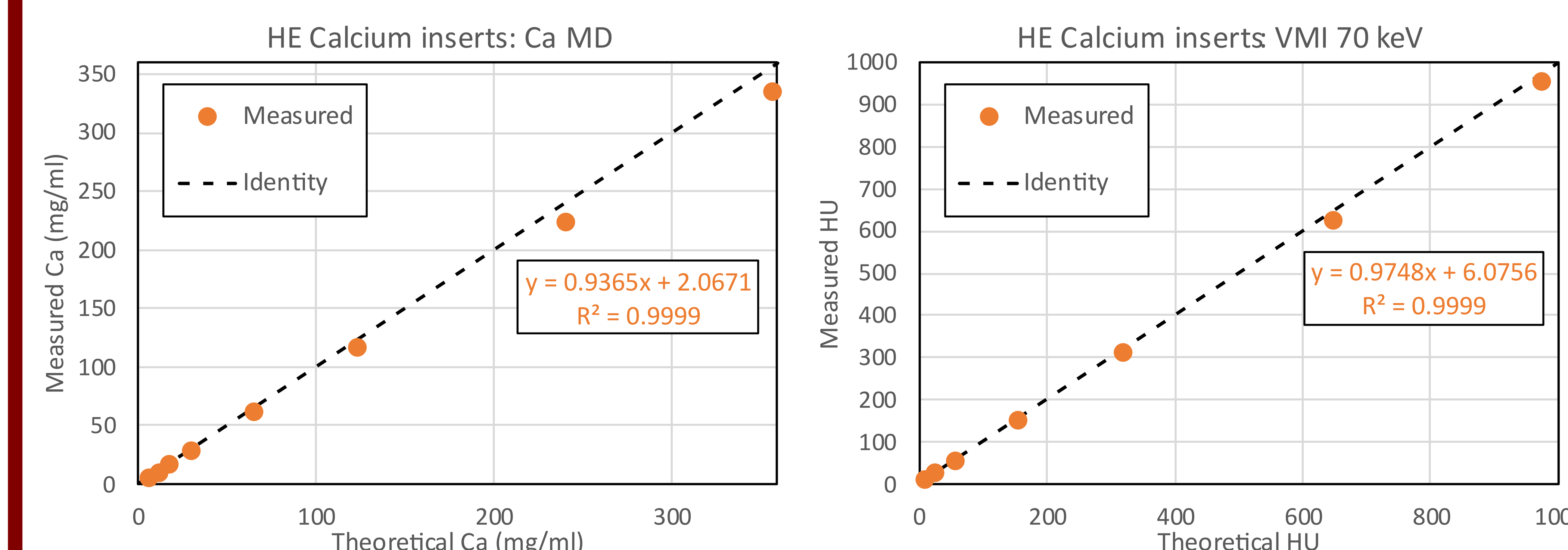


Fig. 2: Calcium MD (mg/ml) and VMI 70 keV (HU) of Measured vs Theoretical for HE Calcium inserts.

The agreement between measured and theoretical values was similarly close for Iodine densities (slope=0.980, offset=0.16, R^2=0.9998) and VMI (slope=0.976, offset=4.18, R^2=0.9997), with absolute and relative errors for Iodine density of 0.12 mg/ml and 0.44% (for Iodine ≥5), and noise of 0.30 mg/ml.

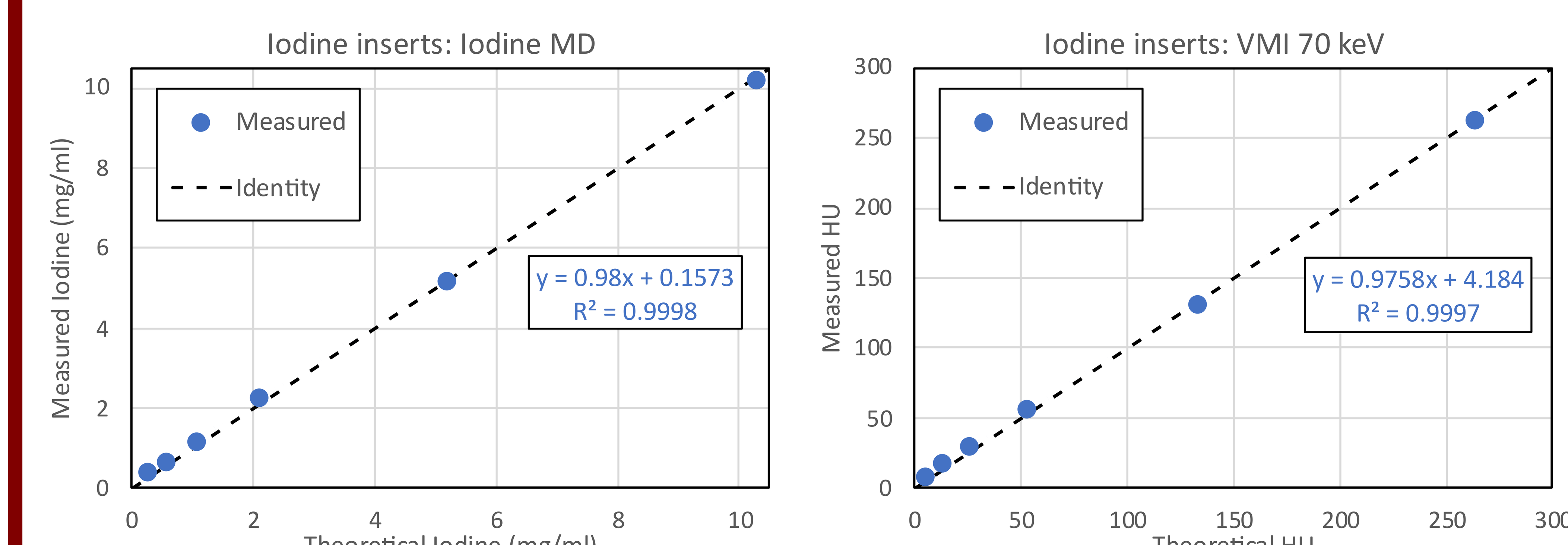


Fig. 3: Iodine MD (mg/ml) and VMI 70 keV (HU) of Measured vs Theoretical for Iodine inserts.

CONCLUSION

Deep silicon PCCT yields strong agreement between measured and theoretical densities of Calcium and Iodine, with demonstrated repeatability and consistency across dose, supporting reliable quantitative spectral imaging.

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