Material Decomposition using Multi-Energy Imaging With Photon Counting Detectors

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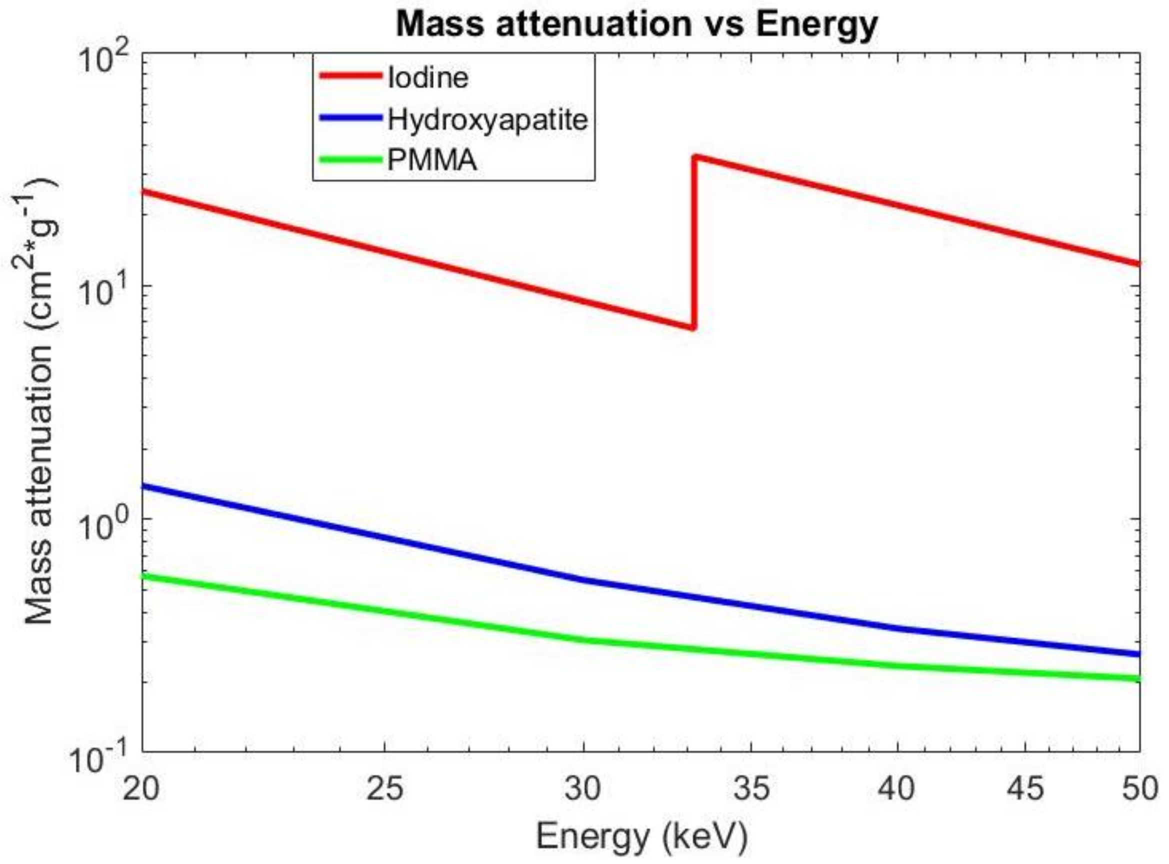
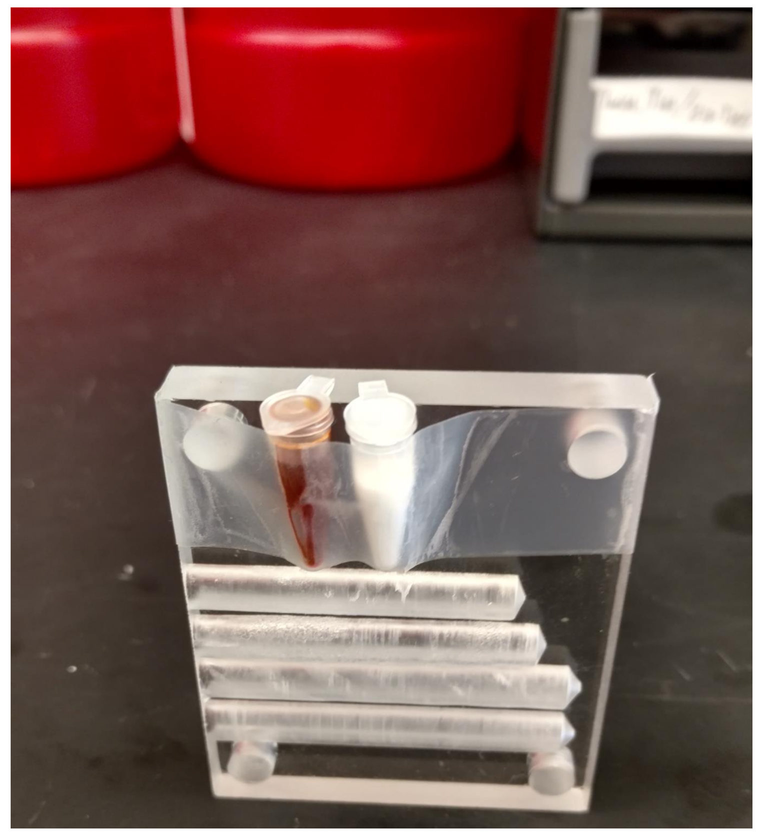
Abstract/Introduction

The current screening tool for breast cancer is digital mammography (DM). DM is based on the principle that x-ray photons are absorbed by materials differently. Breast cancer screening relies on the detection of tumors and micro calcifications. One of the primary challenges in breast imaging is to differentiate healthy, glandular and adipose, versus unhealthy tissues in the breast. Certain plastics can be used as a substitute to mimic the x-ray absorption of breast tissue. Micro calcifications can be replaced with hydroxyapatite (HA). To improve diagnosis, contrast agents, like iodine, could be used in DM. Iodine is injected intravenously and the tumor will temporarily absorb it. Dual energy subtraction techniques are used for enhanced iodine contrast imaging [1]. In order to separate iodine from calcification, multi-energy imaging is desired. Multi-energy imaging is the acquisition of three or more different images at different energies. This data can be used for material decomposition where the distribution of each of the materials is found simultaneously [2].





Measured Thickness:
PMMA - 0.84 cm
HA (white) - 0.48 cm
Iodine (dark) - 0.48 cm

Our focus is the multi-energy imaging method for material decomposition using the new Medipix3 photon counting detector (PCD). Medipix3 detectors are developed at CERN (Geneva) Medipix collaboration [3].

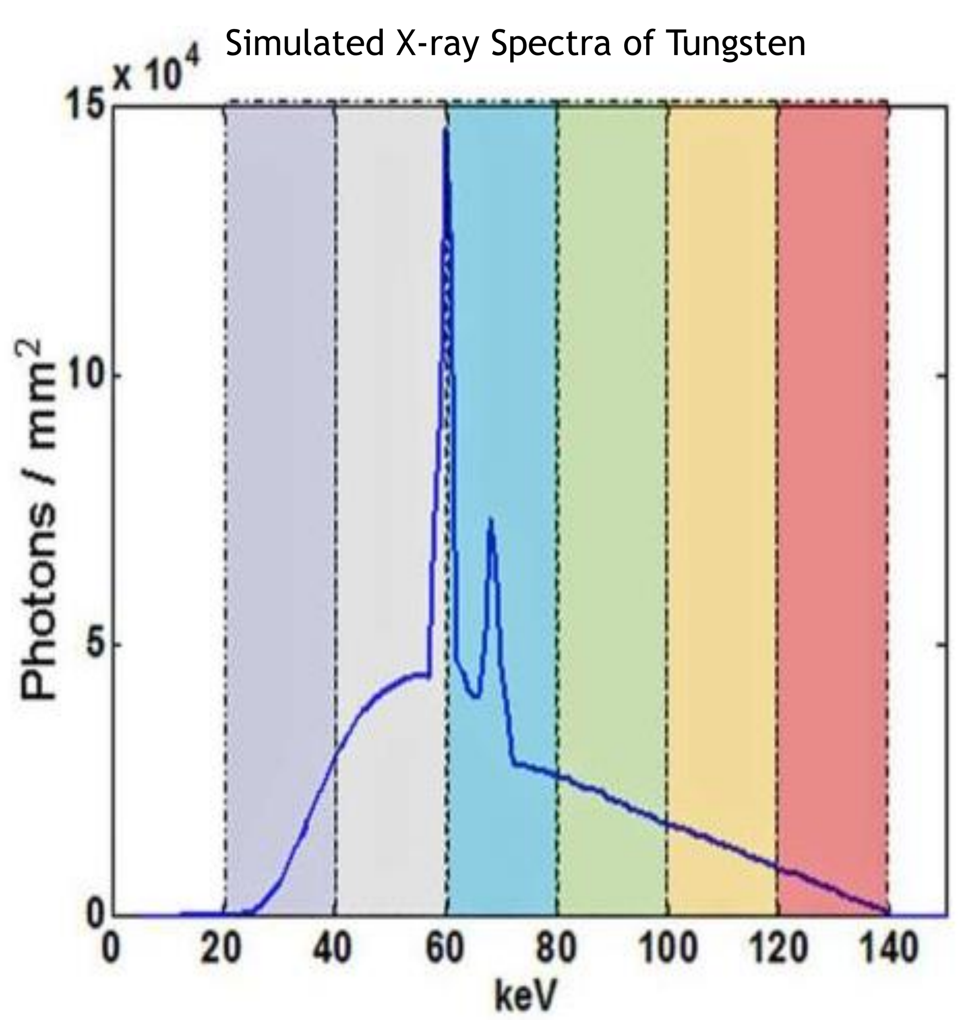
Methods

PCDs record each individual photon's energy. The detector separates the photons based on their energy and allowing us to obtain multiple energy bins.

The multiple energy images can be used to estimate the thickness of each composite material in the object by solving a system of equations that govern the spectrally dependent x-ray attenuation process (Equation 1).

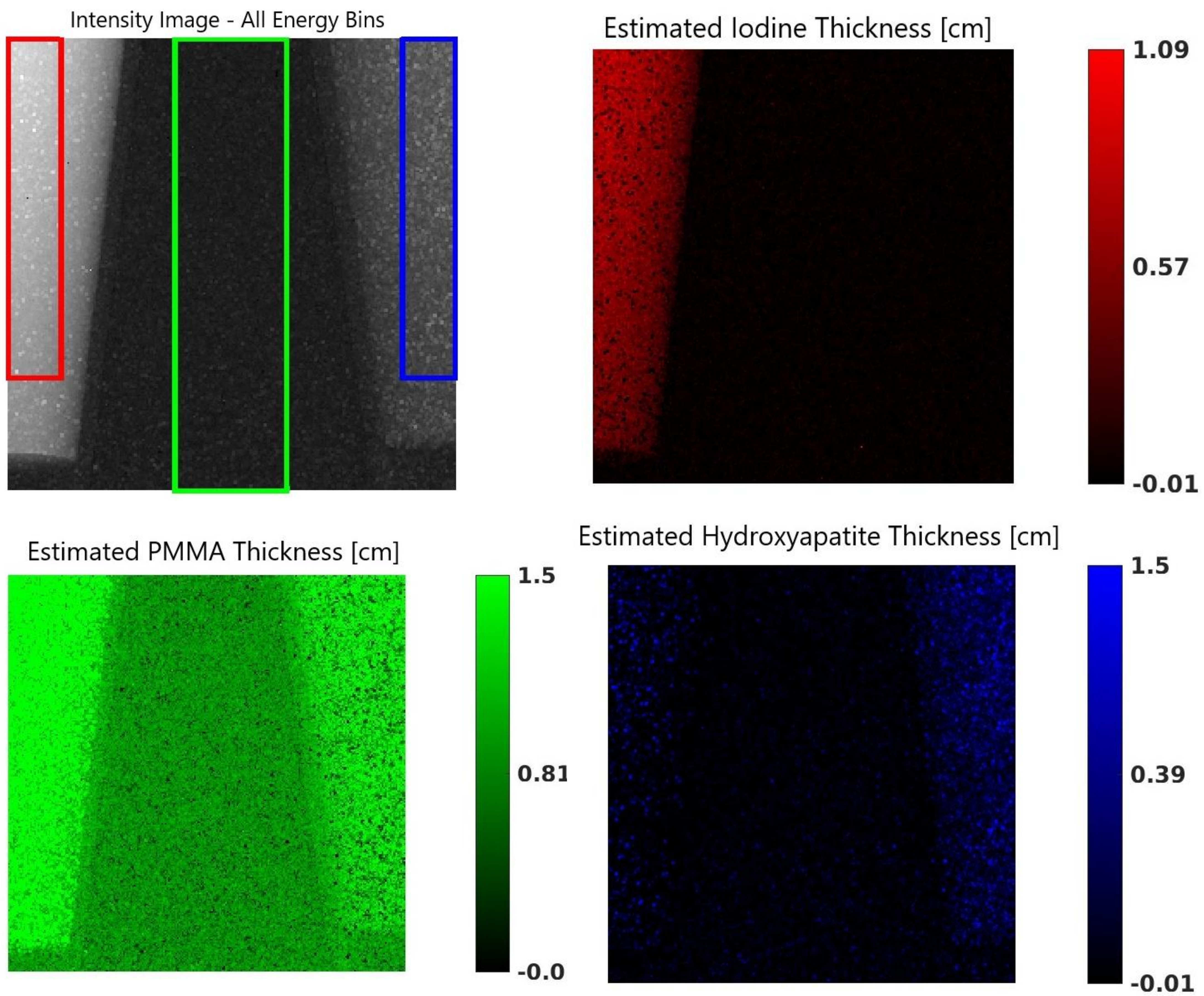
$$ln\left[\frac{I(E,\vec{r})}{I_o(E,\vec{r})}\right] = \sum_{i=1}^{3} \mu_i(E) t_i(\vec{r}) \quad (1)$$

This is solved by using the bounded variable least squares method.



Results

Material Decomposition for Iodine (42 -63.3 mg/ml), PMMA, and HA.



Conclusion

- Multi-Energy imaging technique using photon counting detectors can reduce radiation dose and contrast agent (like iodine) concentration required in diagnostic mammography.
- Photon counting detectors facilitate the acquisition of energy bins where clinical detectors are incapable without additional radiation dose.

Acknowledgements

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References

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[2] N. R. Fredette, C. E. Lewis, and M. Das, Proc. SPIE Med. Imaging **10132**, 101321C (2017).
[3] R. Ballabriga, G. Blaj, M. Campbell, M. Fiederle, D. Greiffenberg, E. H. M. Heijne, X. Llopart, R. Plackett, S. Procz, L. Tlustos, D. Turecek, and W. Wong, J. Instrum. **6**, C01052 (2011).