

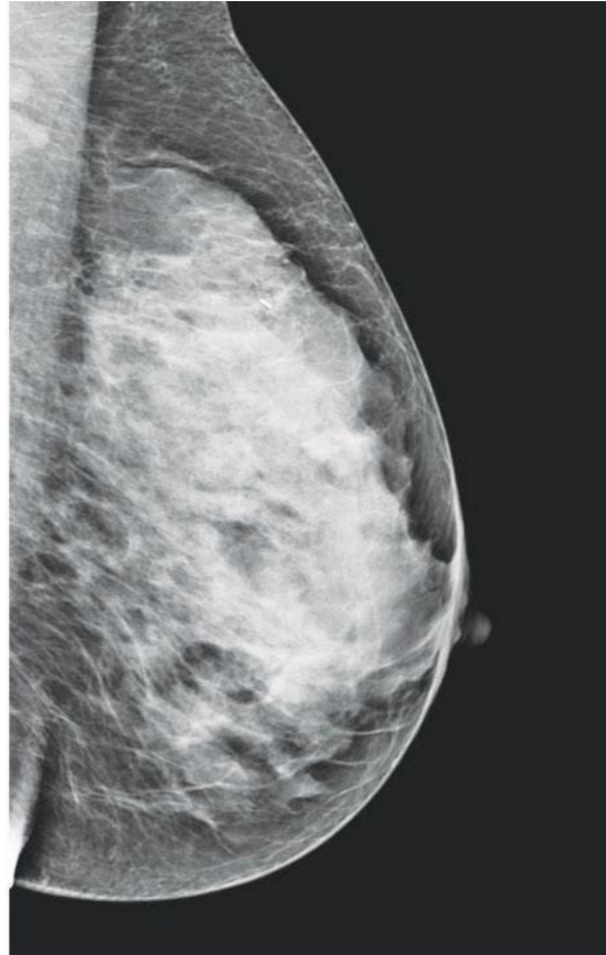
# The Use of Gold Nanoparticles and Spectroscopic Detectors in Contrast-enhanced Digital Mammography

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## Background and Motivation

- Mammography is less effective for dense breasts due to overlapping structures of similar attenuation
- This causes masking of lesions.
- Contrast agents can be injected to highlight cancers due to their increased blood supply.
- But, background removal is also needed due to cluttered backgrounds



- Attenuation of CA changes significantly over the K-edge
- BUT, tissue attenuation changes very little.
- One image above K-edge and one below can be taken.

### K-EDGE SUBTRACTION

- ▶ Log of Low E image is subtracted from log of High E image to remove background

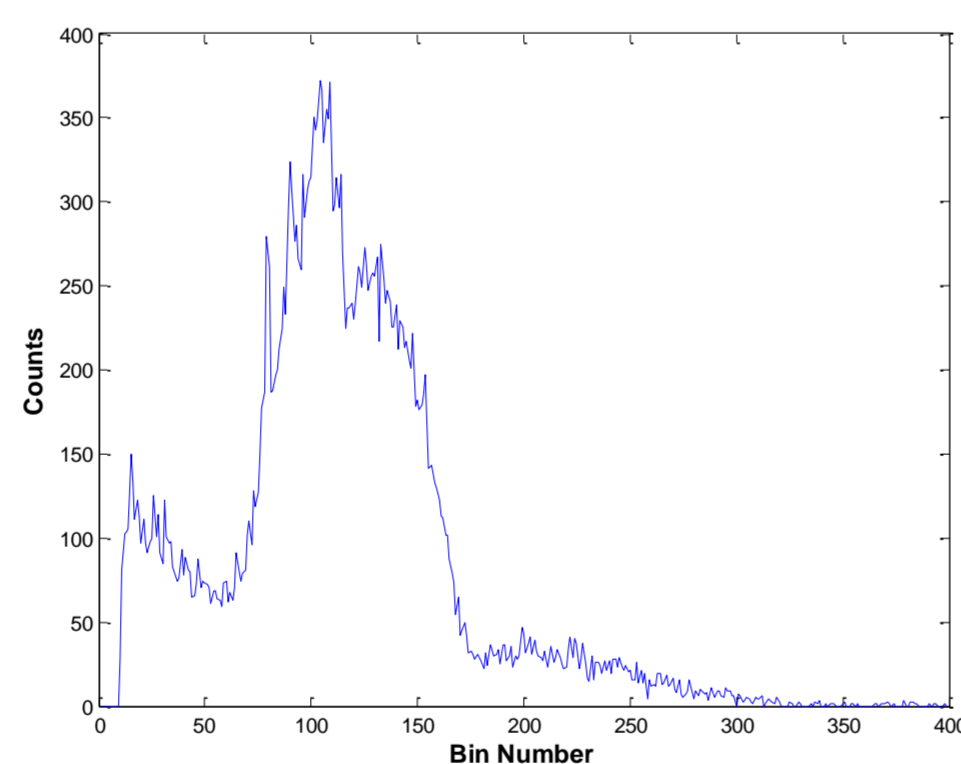
### DUAL ENERGY DECOMPOSITION

- ▶ Each pixel is seen as a vector, which is projected onto a basis (contrast agent, water)
- ▶ Iodine and water components treated separately, resulting in water and contrast agent equivalent images

## Spectroscopic Detectors

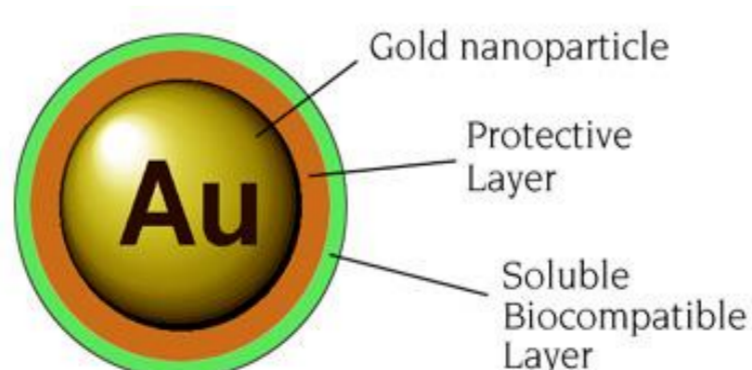
- Provide energy information of detected photons.
- From one acquisition it is possible to obtain either a whole spectrum per pixel or a set of simultaneous images using different energy thresholds.

- In both cases, different energy images can be obtained from a single acquisition.
- Reduces dose
- No possibility of patient movement between exposures.



## Gold Nanoparticles

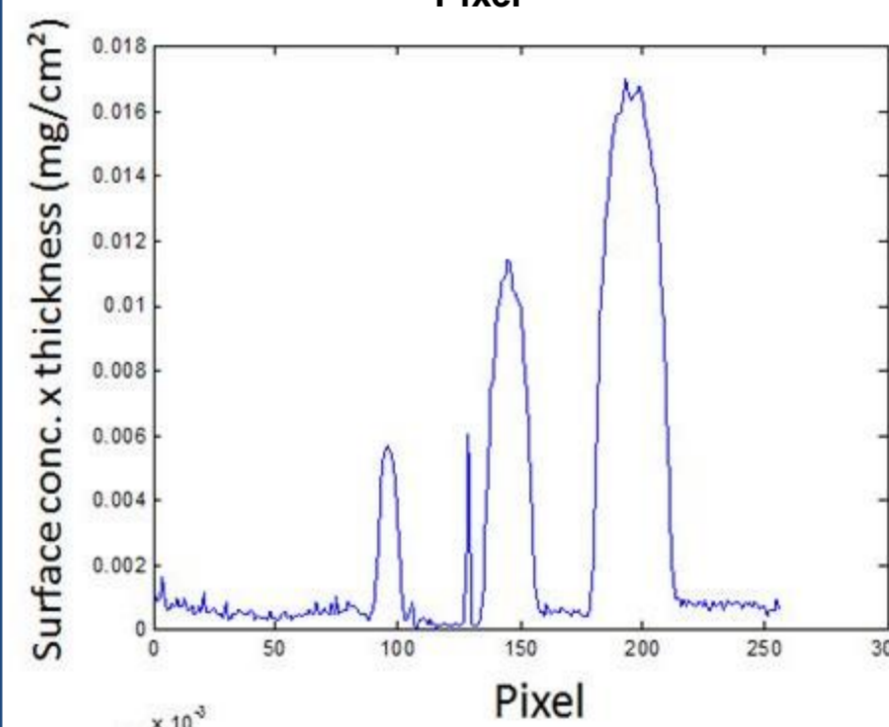
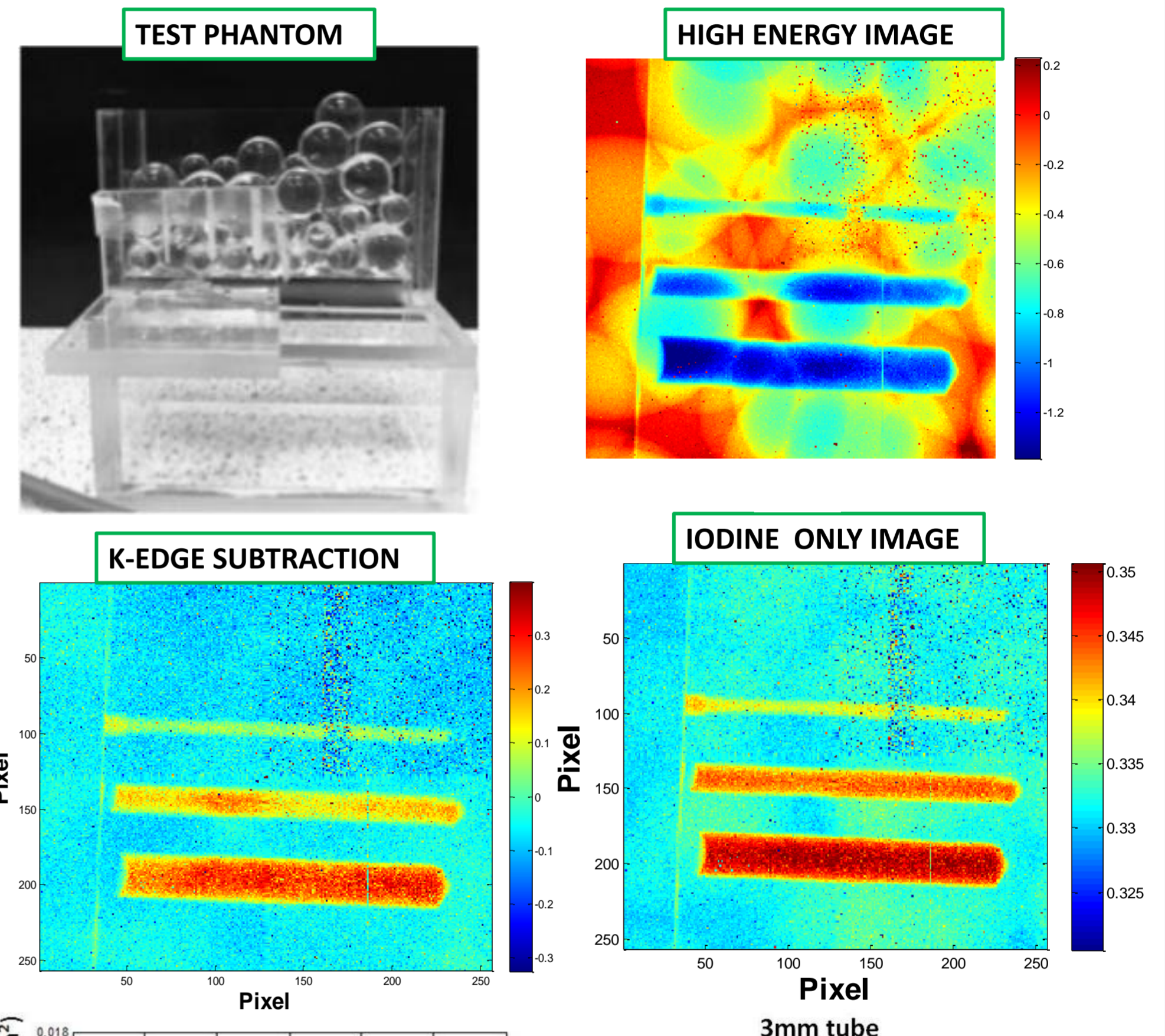
- Iodinated contrast agents are restricted by short imaging times due to fast clearance and may cause problems for patients with reduced kidney function.
- Gold has a higher atomic number and higher photoelectric absorption and is non-toxic.
- Shown to be a good radiosensitizer in radiotherapy and can be made to be preferentially taken up in specific cells.
- The radiobiological effects of nano-gold are yet to be fully understood and will be investigated.



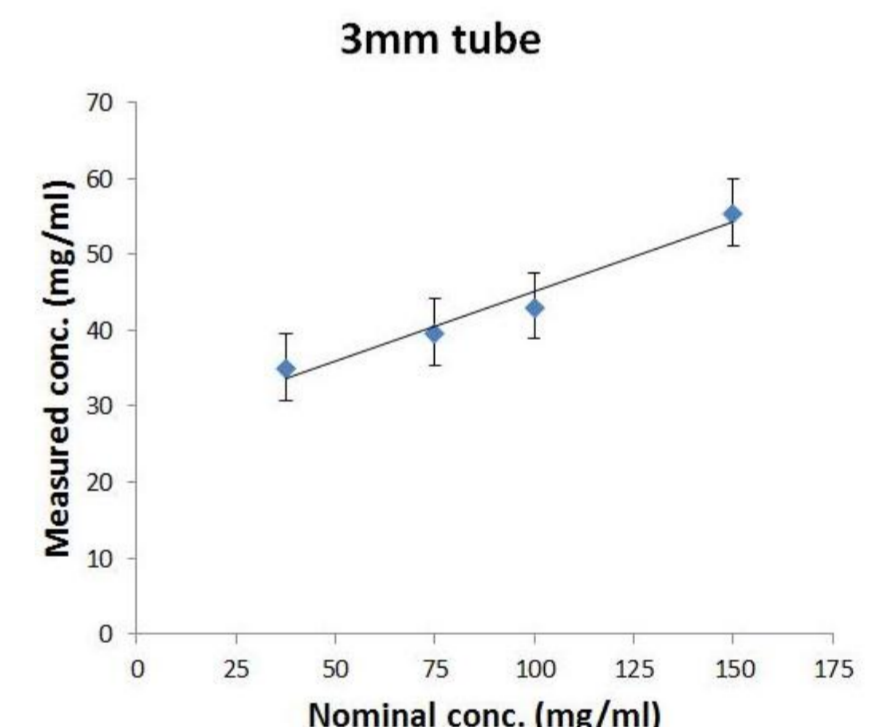
## Results

A test phantom is used, designed to mimic breast tissue. Three tubes (1-3 mm diameter) are filled with contrast agent.

Images were taken of the phantom on the Medipix3 Detector [1] using an iodinated contrast agent with a concentration of 150 mg/ml. Energy windows above and below the K-edge of iodine were used to decompose the image into contrast agent and water equivalent images.



TUBE PROFILES FROM I IMAGE



RECONSTRUCTED IODINE CONCENTRATION (for largest 3mm tube at different concentrations)

## Future Work

- A full set of images will be acquired on the HEXITEC detector [2], a fully spectroscopic detector that gives an energy spectrum for every pixel
- Iodine contrast agents will be used initially as a basis.
- The images will be repeated using gold nanoparticles.
- The radiobiological effects of using gold will be investigated by irradiating cells.

## References

- [1] Ballabriga, R., et al. "Medipix3: A 64k pixel detector readout chip working in single photon counting mode with improved spectrometric performance." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 633 (2011): S15-S18.
- [2] Jones, Lawrence, et al. "HEXITEC ASIC—a pixellated readout chip for CZT detectors." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 604.1 (2009): 34-37.

## Acknowledgements

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