The future of Molecular Breast Imaging is 3D and low dose

Breast cancer represents 12% of new cancer cases and 25% of all cancers in women. Mammography is the most common modality used for breast imaging. Between 25% and 50% of women (depending on country and ethnic origins) have dense breast tissue, which limits mammography sensitivity.

Molecular Breast Imaging (MBI) is a scan that uses a radioactive tracer and special gamma cameras to find breast cancer. Unlike x-ray imaging, MBI is a type of functional imaging, meaning that the picture created shows differences in tracer metabolism.

Molecular Breast Imaging (MBI) with dual planar detectors:

- Independent from breast density unlike mammography
- Has been shown to increase the cancer detection rate in the dense breast by up to a factor of 4[1]
- Requires less compression

Current barriers to the widespread adoption of MBI include:

- Patient effective dose is up to five times higher than in mammography (0.5 mSv):
  - BSGI or scintimammography: injected dose of 740-1110 MBq, equivalent to 6-9 mSv
  - CZT MBI: 300 MBq, equivalent to 2.4 mSv
  - Lowest published CZT MBI dose measurements: 150 MBq, equivalent to 1.2 mSv
- Longer imaging time: 40 min (4 views x 10 min) vs < 10 min for 4 views in mammography

Our goals:

Kromek is working towards making the future of MBI low dose and 3D. This will be achieved by reducing the dose of radiation to the level of mammography and halving the scan time.

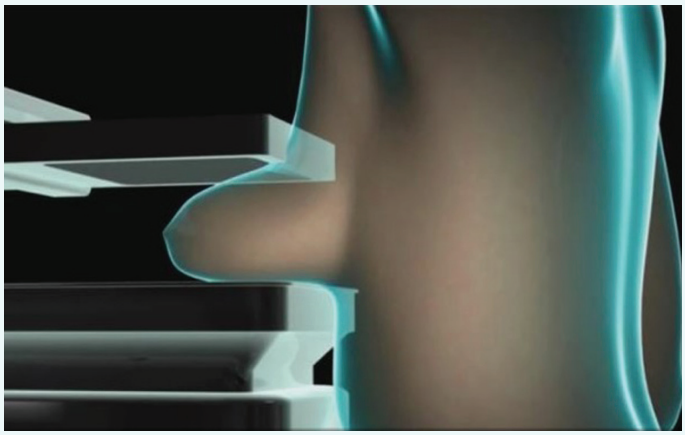
Kromek is developing a new technological approach based on combining tomographic image reconstruction with densely packed multi-pinhole collimation and Kromek's 3D CZT detectors.

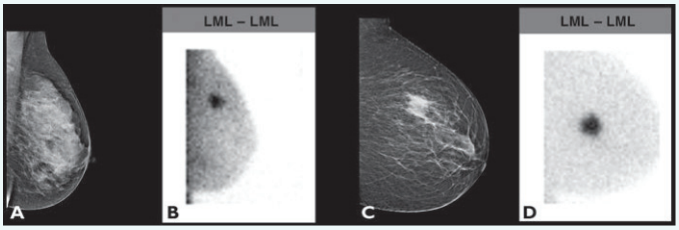
The variation in the angular sampling, with the depth of detection in the detectors, allows reducing artefacts in the reconstructed images which would appear due to overlapping projections through neighbouring pinholes (patent pending).

Our results so far:

Below are the results of a quantitative simulation study to evaluate the benefits of the new technology[3,4]:

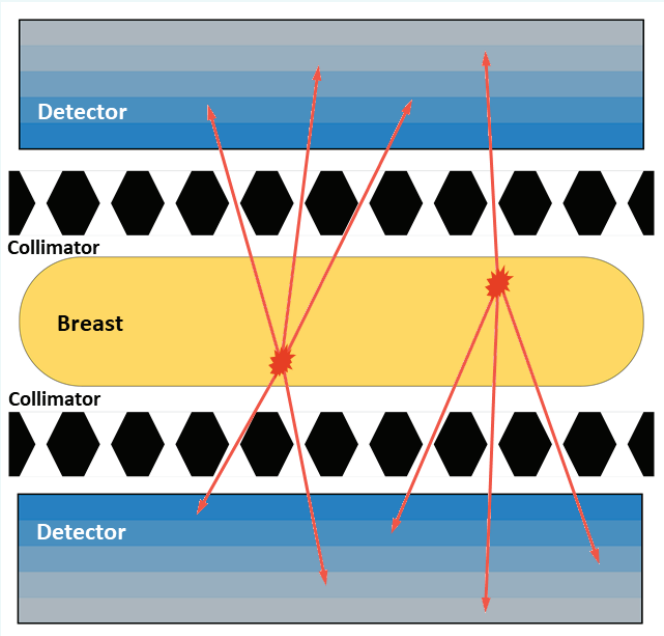
The Phantom used in the simulation study is comprised of multiple spheres of different diameter and activity representing lesions. The activity concentration corresponds to the activity measured in patients injected with 150 MBq dose of ^{99m}Tc.

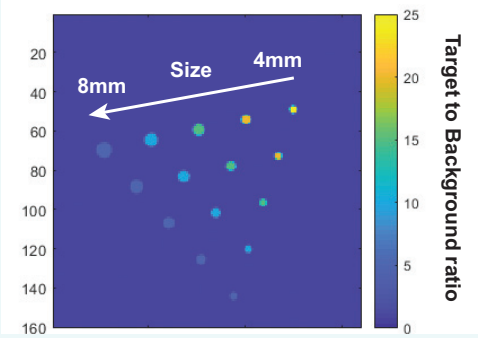




Dense tissue breast left – mammography, right - MBI [2]

Fatty tissue breast left – mammography, right - MBI [2]



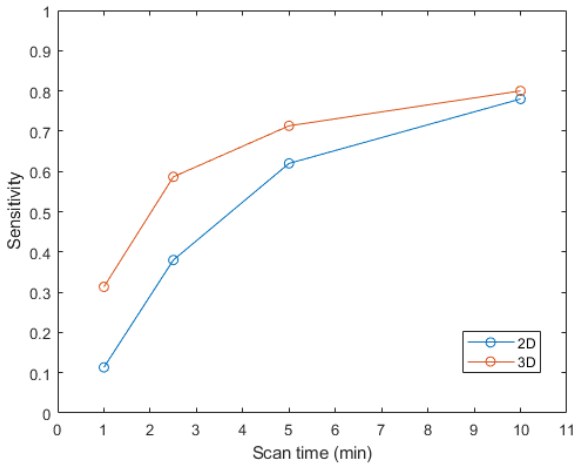


[1] *AJR Am J Roentgenol. 2015, February 204(2): 241–251.*

[2] *AJR Am J Roentgenol. 2014, February 202(2): 293-298.*

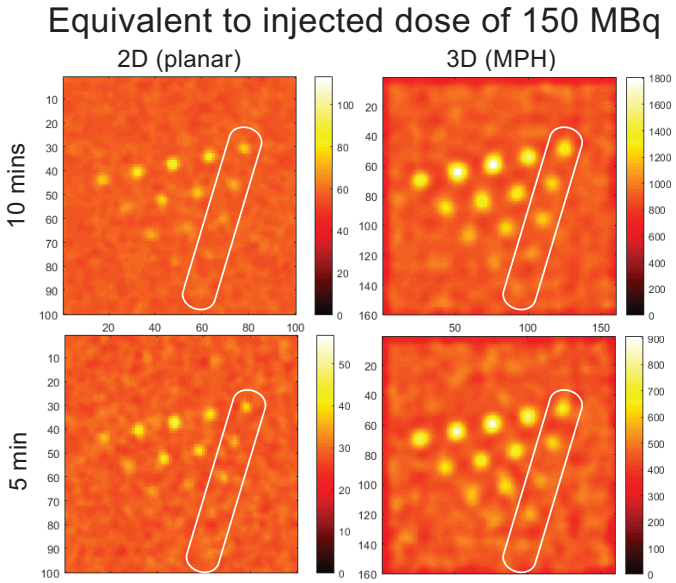
[3] *Hutton, B. F. et al (2021, October). Design of an ultra-low-dose, stationary, tomographic Molecular Breast Imaging system. Virtual IEEE MIC 2021.*

[4] *Erlandsson, K. et al (2021, October). Challenges in optimization of a stationary tomographic Molecular Breast Imaging system. Virtual IEEE MIC 2021.*



Sensitivity (number of true lesions detected).

Twice shorter scan time and tomographic reconstruction produce the same sensitivity as 10 min scan with 2D imaging.



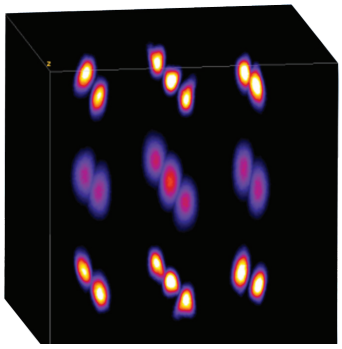
Comparison between a simulated 2D image and a maximum intensity projection (MIP) of a 3D image:

- The contrast is better in MIP 3D
- The 4 mm lesions are much better recognised in MIP 3D

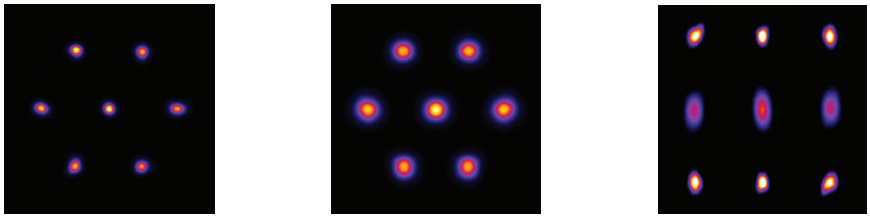
First experimental results

Multi-layered point source "activity-printed" phantom[5] was used in the measurements

- 45 x 45 x 45 mm volume
- 14 mm distance between source positions
- 30 µCi (1.1 MBq) Ø 1 mm point source
- 40 sec/point acquisition time



Maximum Intensity Projection (MIP) rendering



Resolution (FWHM), mm		
	Lateral	Depth
Top/Bottom plane	1.67	2.38
Middle plane	2.92	5.75

- The lateral resolution is better than depth due to wider angular sampling
- Points in the middle slice are bigger due to magnification

Summary

- Simulations suggest that significant dose reduction can be achieved (injected activity of 75MBq, or effective dose of 0.6mSv)
- Reduced scanning time may be possible due to 3D localisation without additional views
- First simulated and experimental results suggest improved detection capability for lesions down to 5 mm in diameter

[5] *Cherlin, A. et al (2021, October). A new concept for a low-dose stationary tomographic Molecular Breast Imaging camera using 3D position sensitive CZT detectors. Virtual IEEE RTSD 2021.*

The technology is developed in a collaboration with a group of Prof. Brian Hutton at University College London (UCL)

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