



Theory and Practice of Breast Tomosynthesis

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Warning: Investigational Device. Not approved by the FDA. For investigational use only.

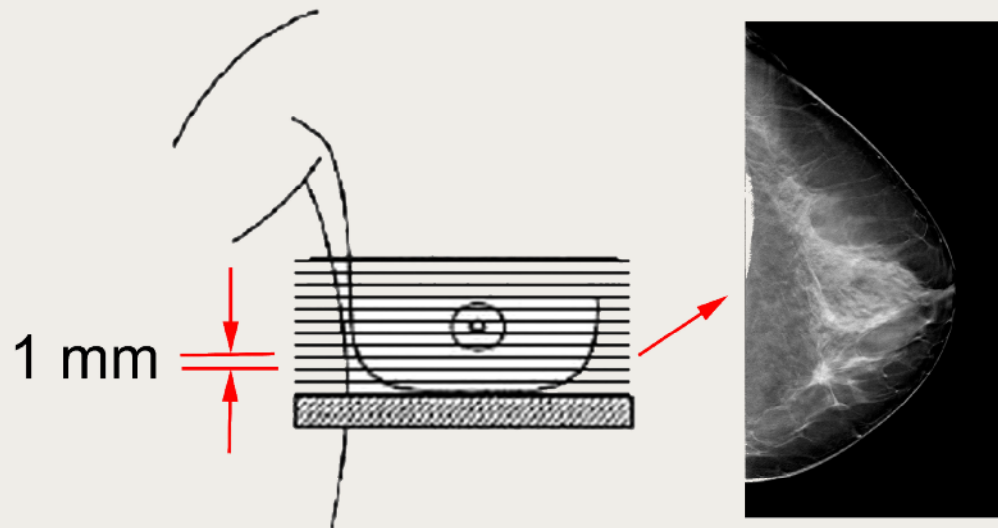


Talk Outline

- What is breast tomosynthesis?
- Why do breast tomosynthesis?
- How does breast tomosynthesis work?
- How do we use it clinically?
- Clinical examples
- What is its clinical performance?
- Summary of advantages

What is Breast Tomosynthesis?

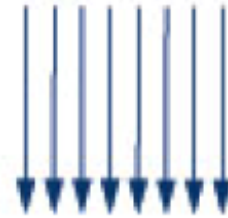
- A method of imaging the breast in three dimensions (3D)
- Image slices are 1 mm thick
- Image slices high resolution: like mammograms



Why do Breast Tomosynthesis?

- Because 2D images have tissue superposition
- 2D hides cancers
- 2D makes normal tissue look like pathology
- Clearer images

Conventional 2-D Imaging



Incident X-rays



Objects being imaged, at different heights



2-D image

Images
superimposed
on image

Potential Clinical Advantages of Tomosynthesis

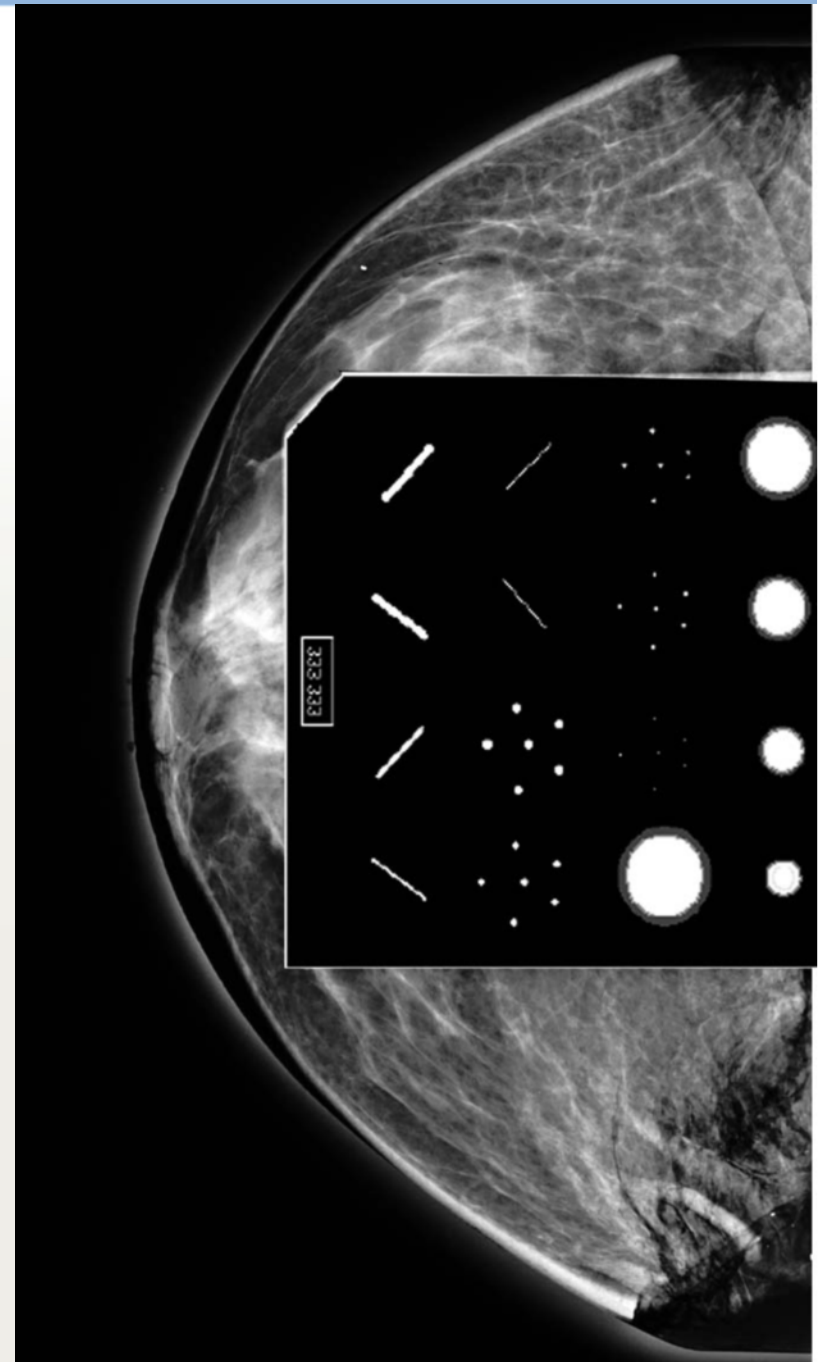
- Better sensitivity
- Fewer recalls
- Potential for lower dose
- Potential for less compression

Better Sensitivity

Removal of confusing overlying
tissue makes for clearer imaging

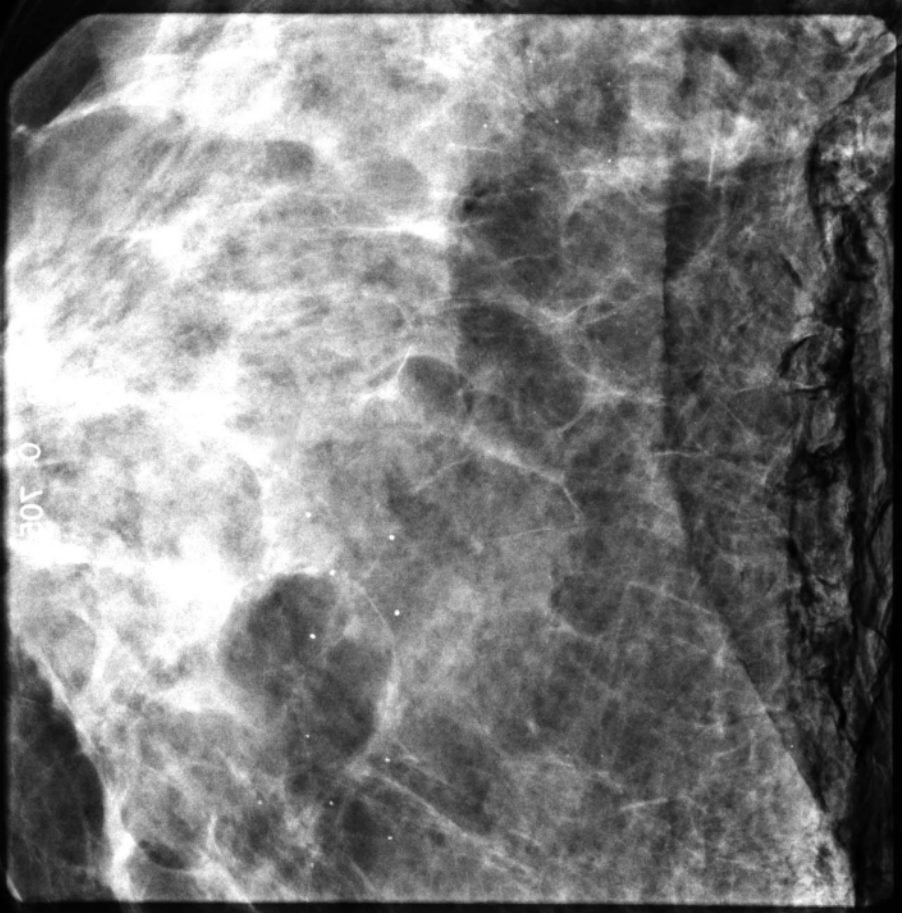
Better Sensitivity

- ACR Phantom imaged with 4 cm cadaverous breast
- Phantom has low contrast fibers, masses, and calcifications
- Overlying breast tissue obscures object visibility

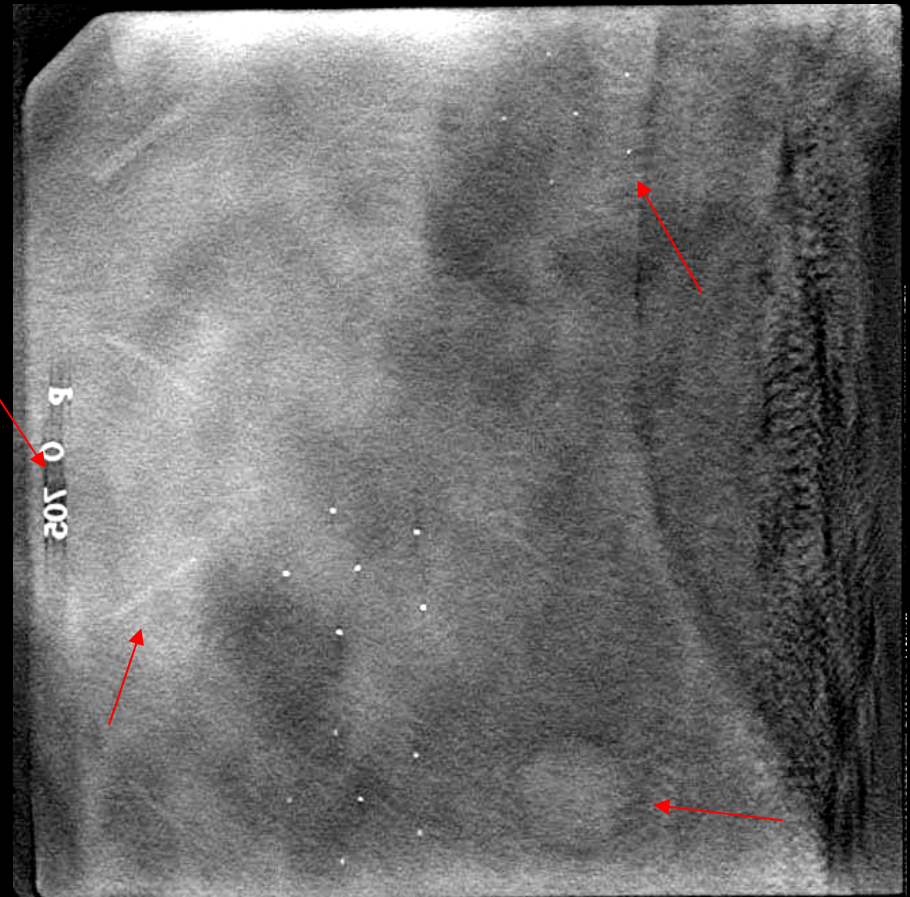


Better Sensitivity

Digital Mammogram **1X** dose



Tomosynthesis **1X** dose



Slice at plane of phantom insert

Tomosynthesis shows improved low contrast visibility over digital mammography

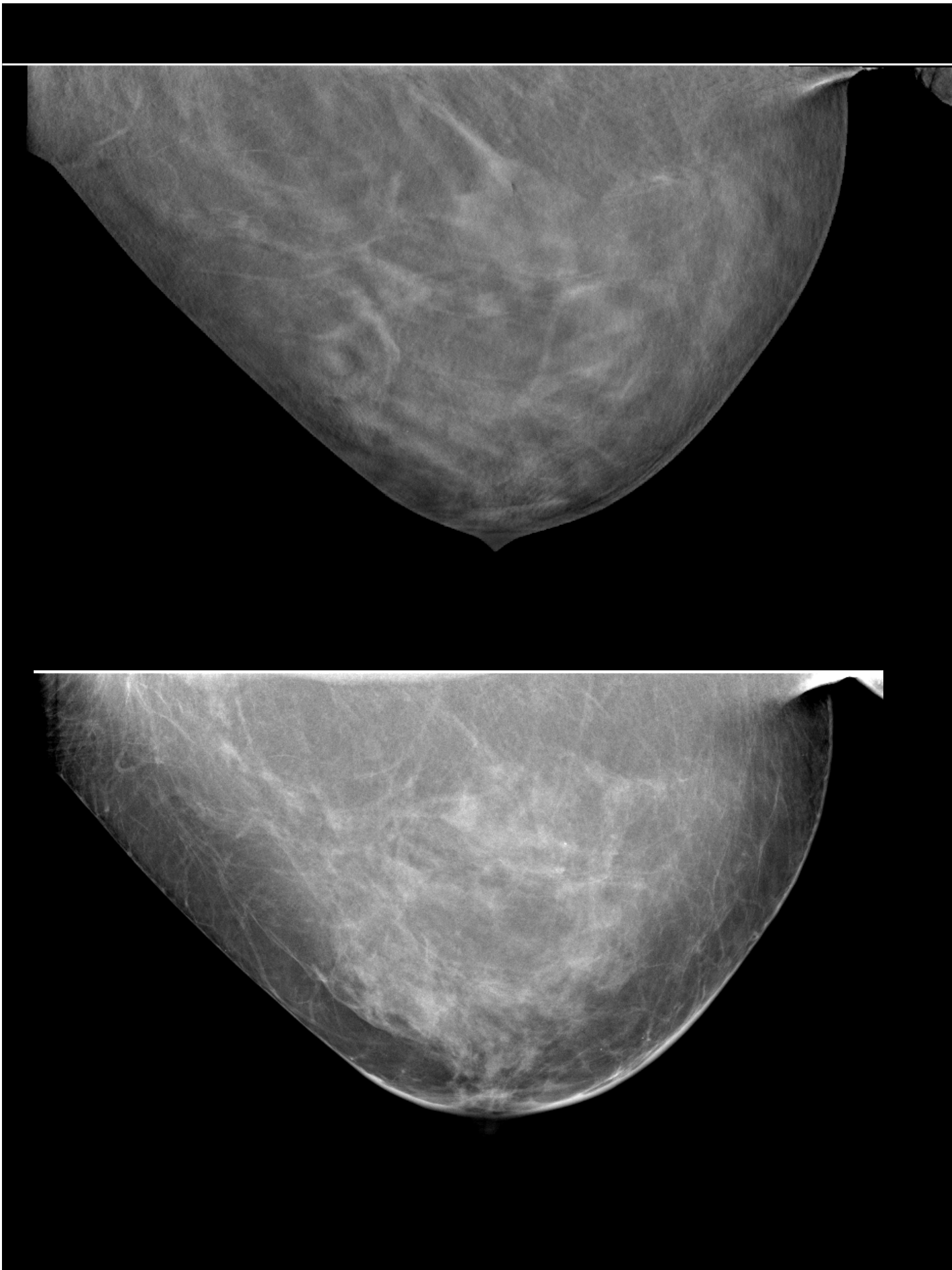
2D Mammogram

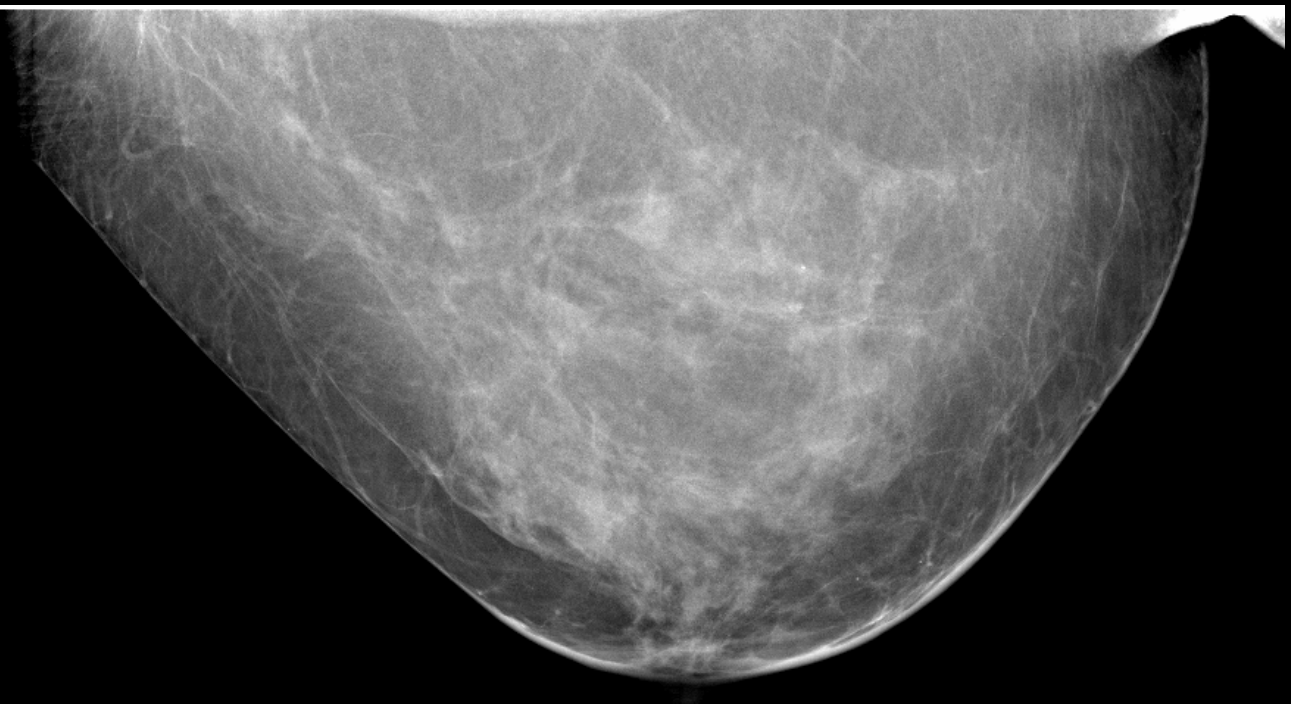
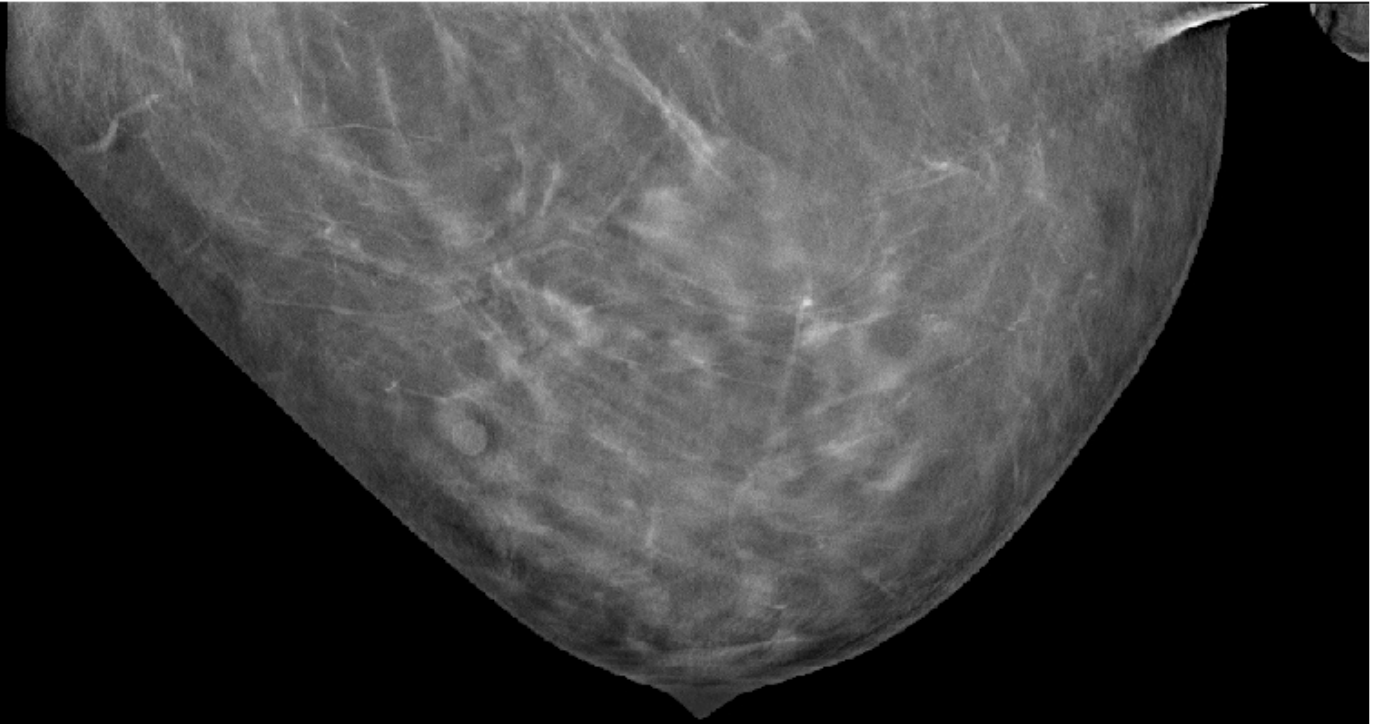


Tomosynthesis



Better Sensitivity

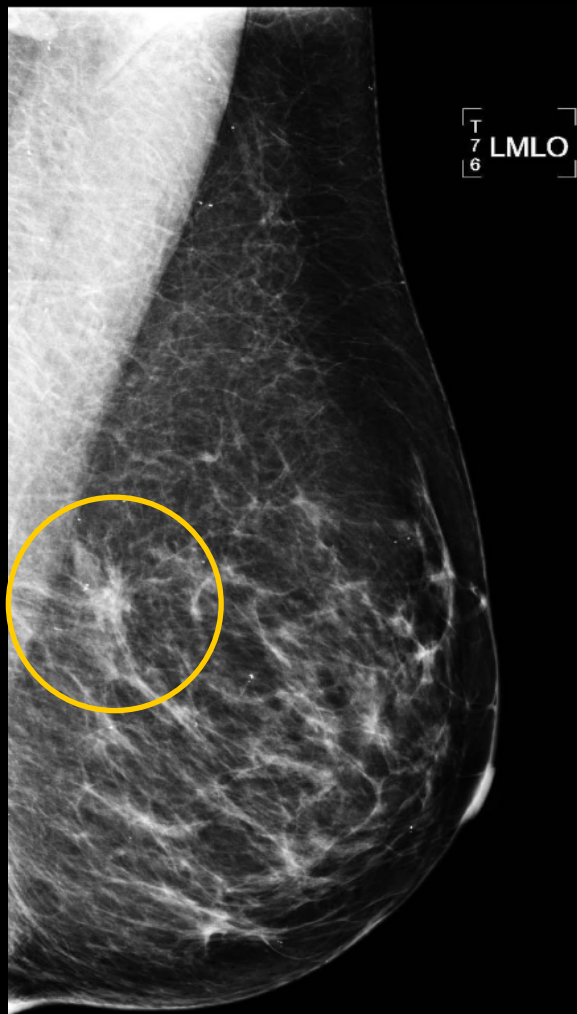




Fewer Recalls

Removal of confusing overlying
tissue makes for clearer imaging

2D Mammogram



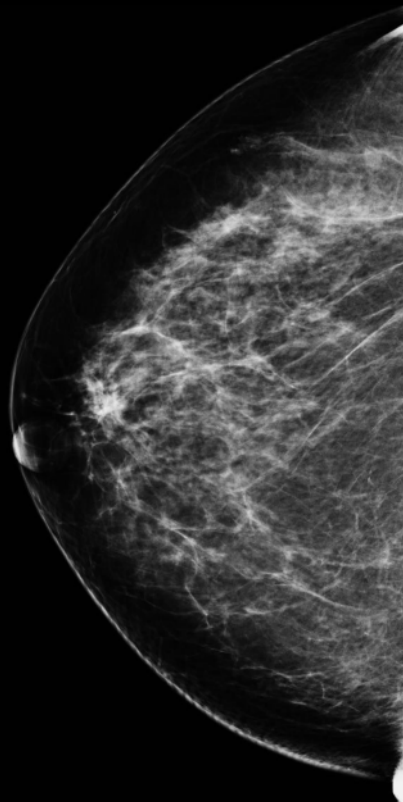
Tomosynthesis



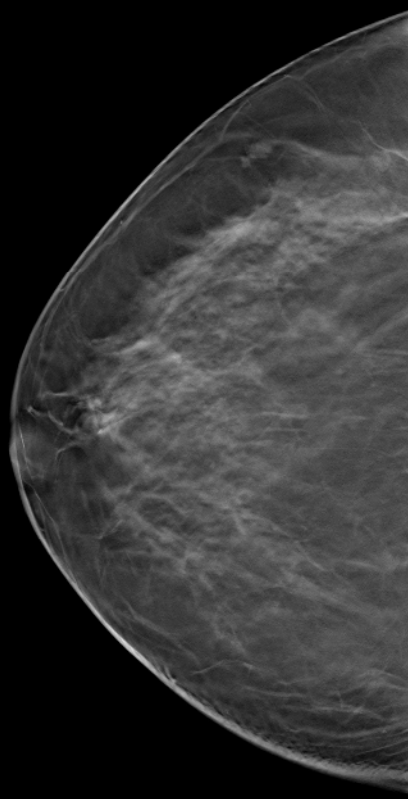
Fewer Recalls

Superimposed Tissue from Different Levels in the Breast Resolved with TOMO

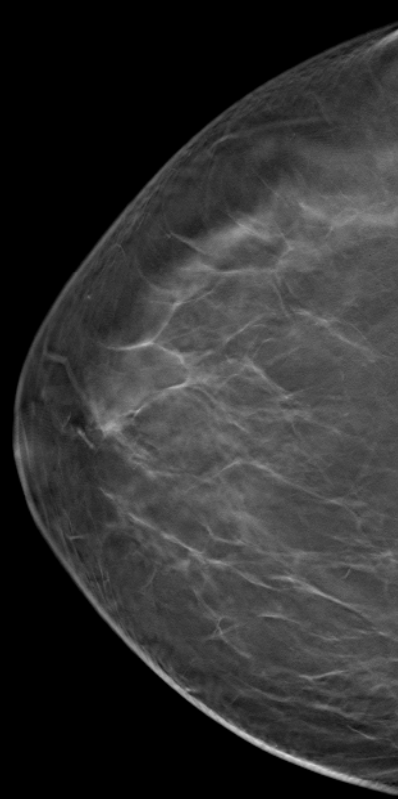
FFDM



TOMO slice 28



TOMO slice 43



TOMO slice 55

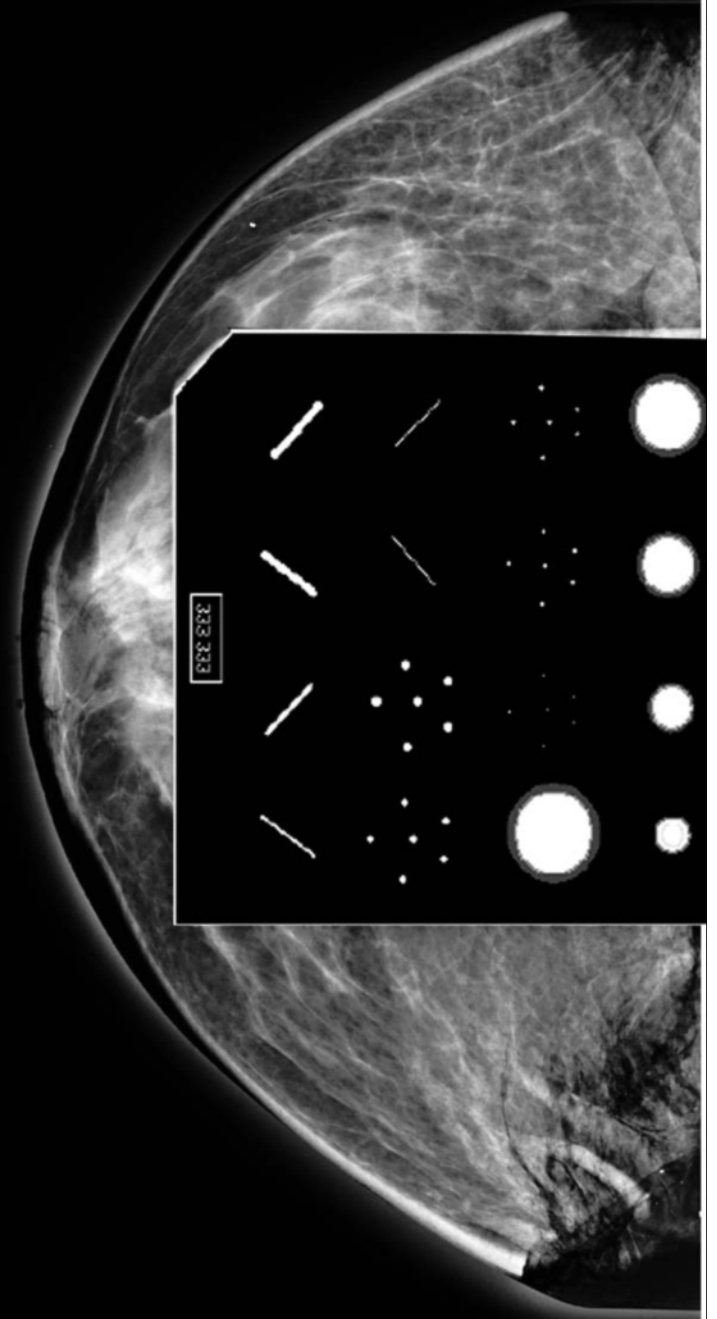


Potential for Lower Dose

- Reduced superimposed tissue reduces need for very low quantum noise
- Fewer recalls reduce additional diagnostic exposures
- Only one view needed? Unfortunately, probably not.

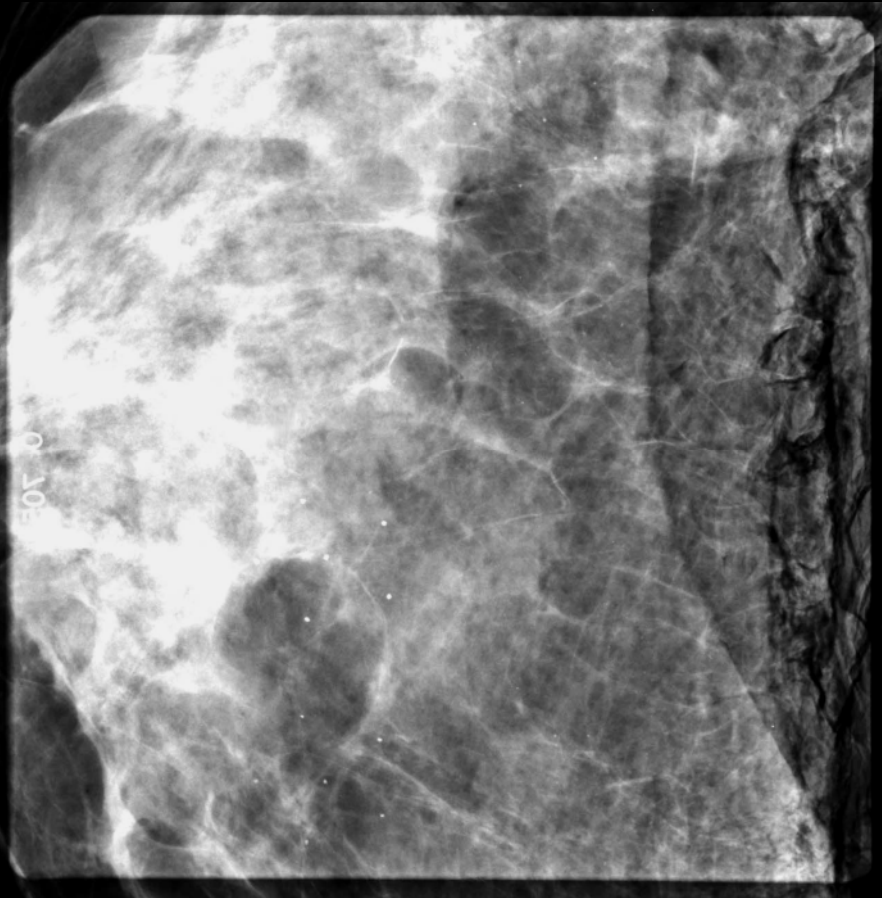
Lower Dose

- Phantom studied as function of tomosynthesis dose

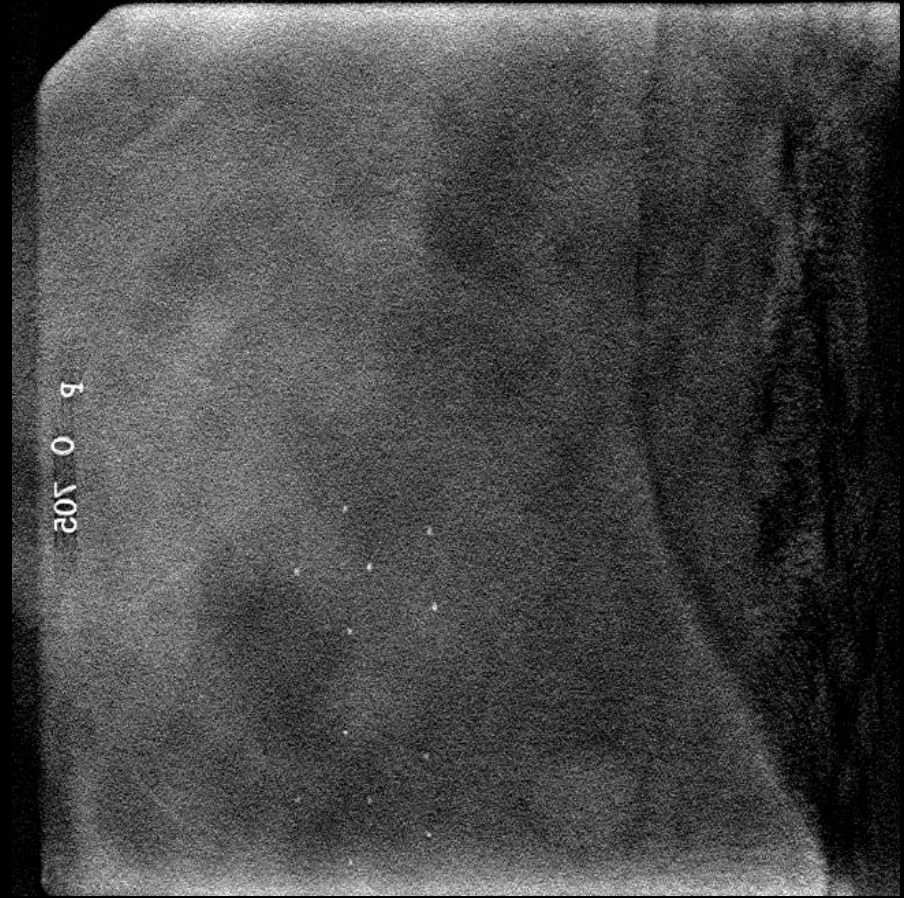


Lower Dose

Digital Mammogram **4X** dose



Tomosynthesis **0.5X** dose

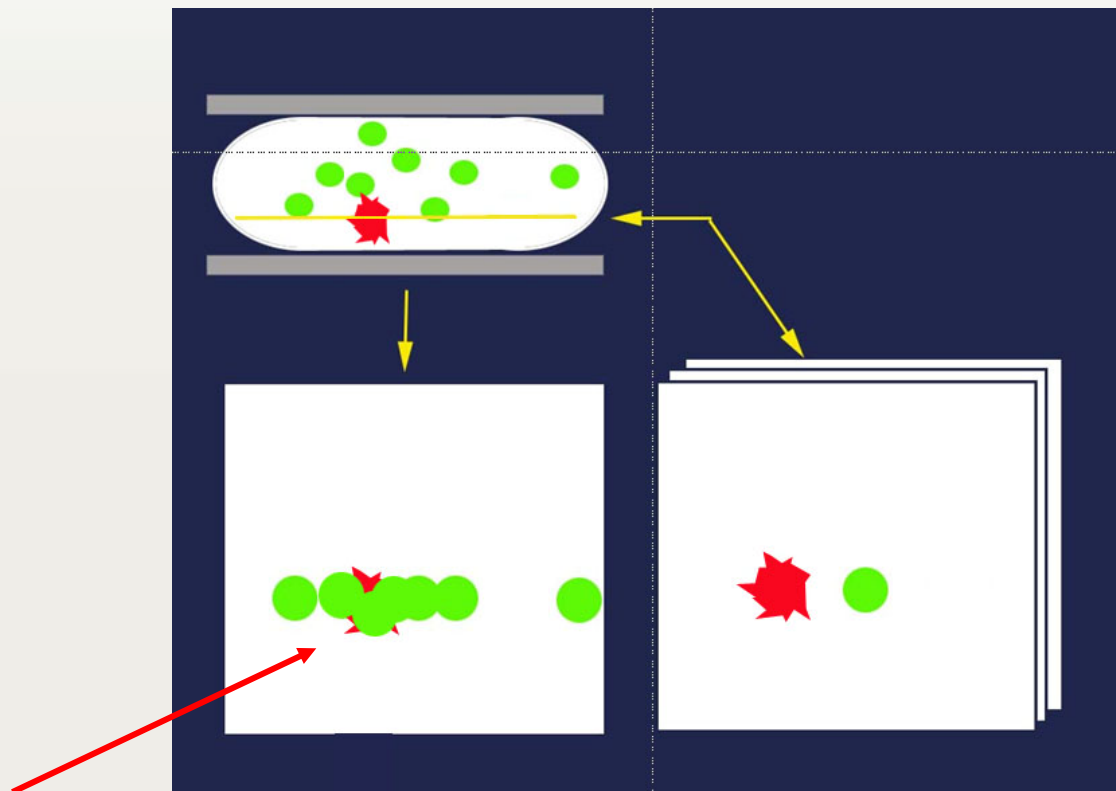


Slice at plane of phantom insert

Tomosynthesis shows improved low contrast visibility over FFDM, even at *much* lower dose

Potential for Less Compression

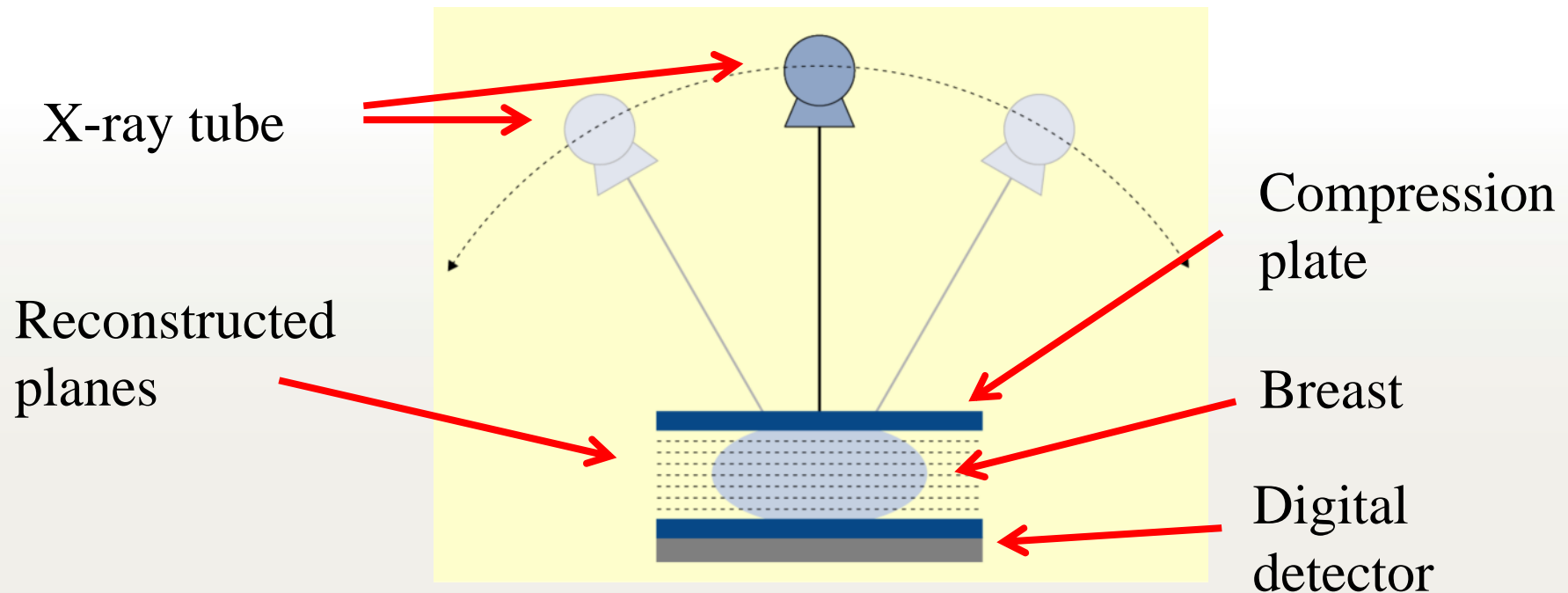
- Compression not needed to minimize tissue overlap (structure noise)
- Still need compression to reduce patient motion



How does tomosynthesis work?

- Image the breast from several angles
- Use the multiple images to reconstruct the 3D dataset
- Process is very similar to CT imaging: view the body from different angles and reconstruct the volume

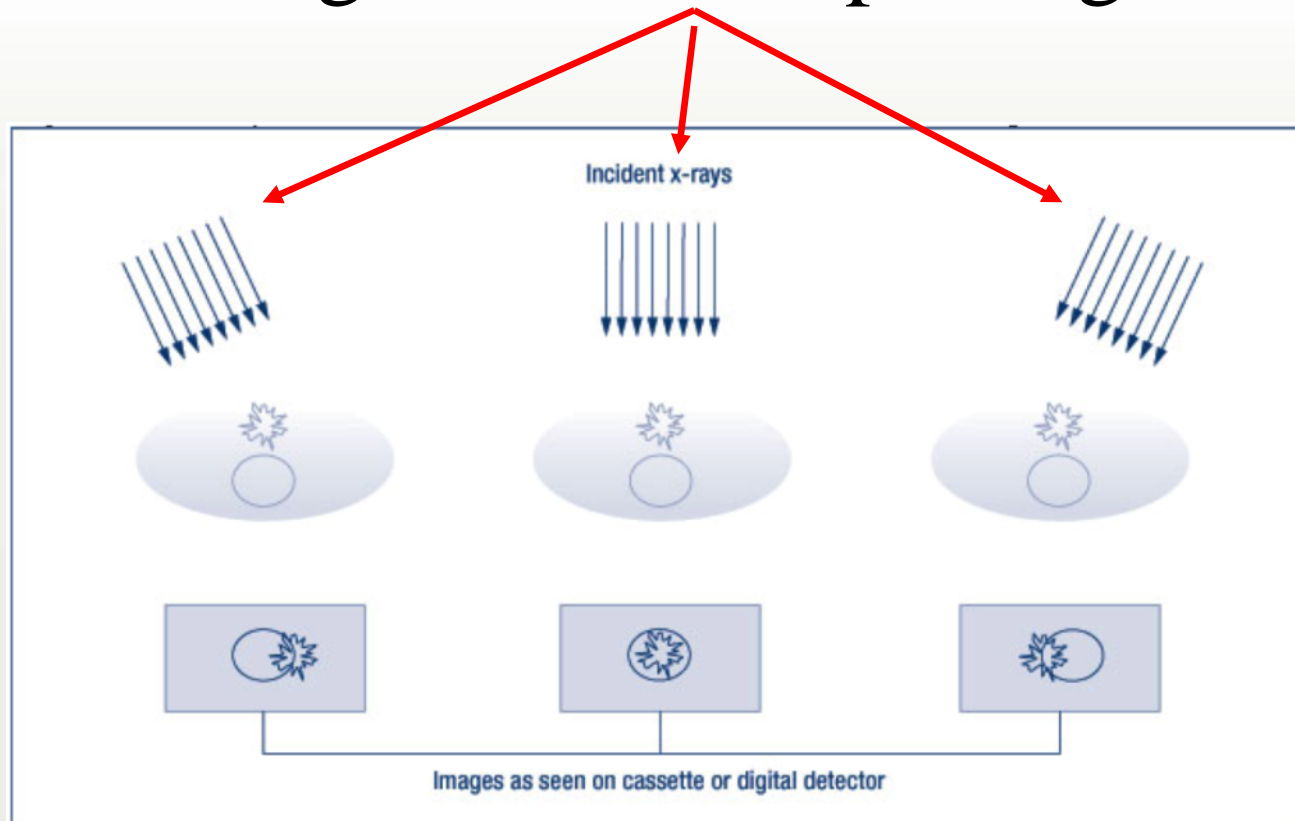
Tomosynthesis Acquisition



- X-ray tube moves in an arc across the breast
- Series of low dose images are acquired at different angles
- Total dose similar to single view breast exam

Tomosynthesis Acquisition

Image from multiple angles



Incident X-rays

Objects being imaged

2-D raw
data images

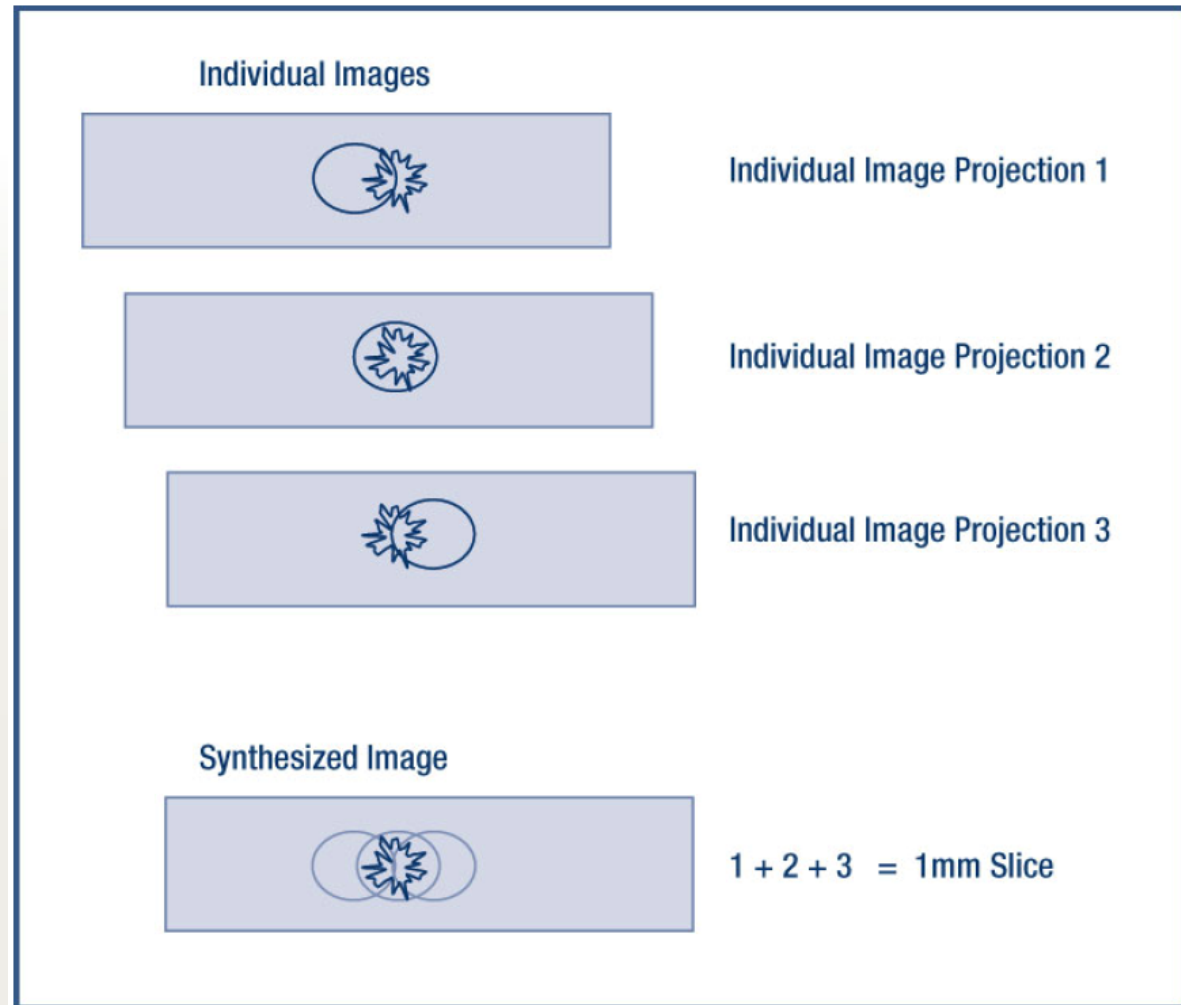
Exposure #1

Exposure #8

Exposure #15

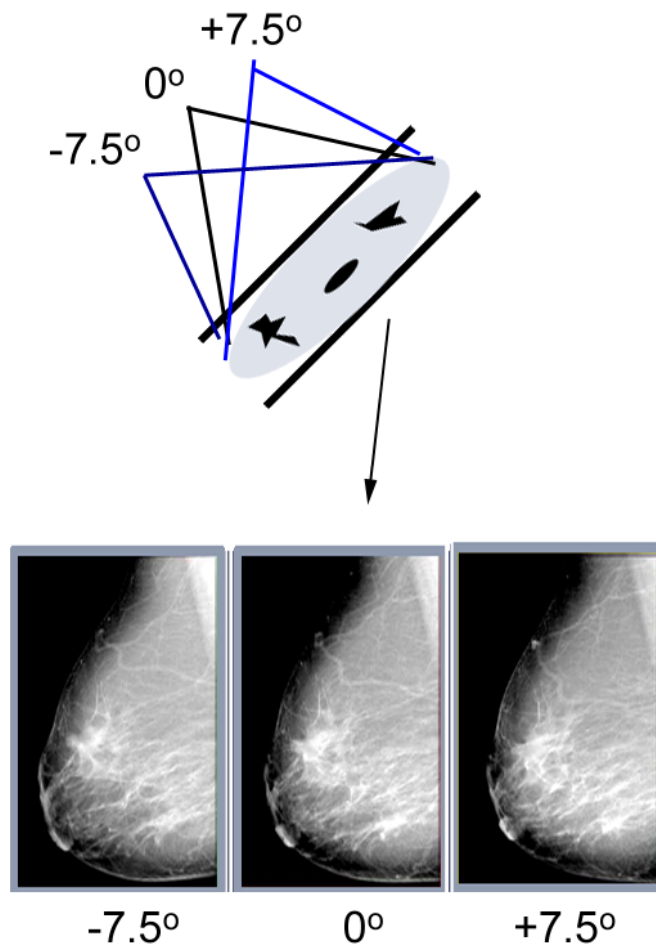
Tomosynthesis Reconstruction

Appropriate shifting and adding of raw data reinforces objects at specific height



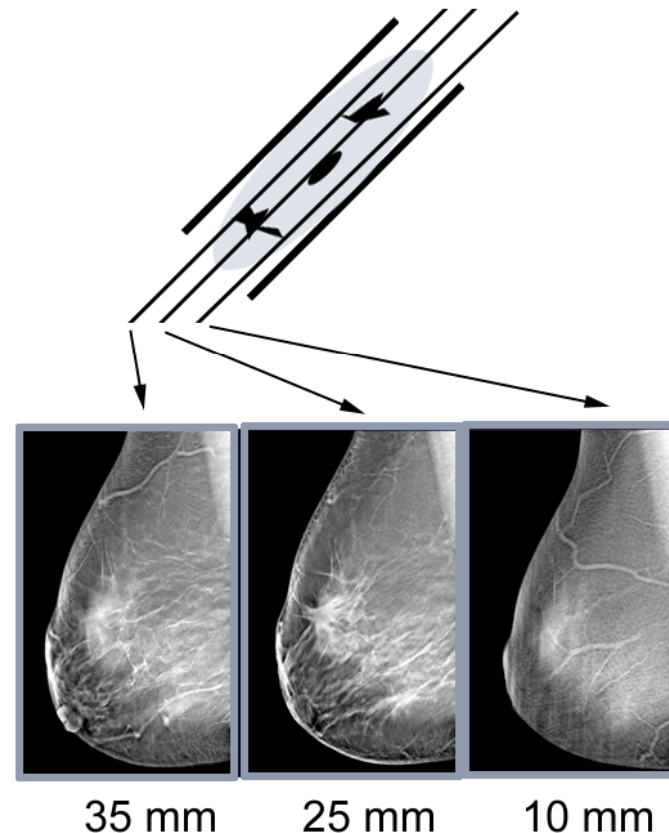
Data Formats

Projection images



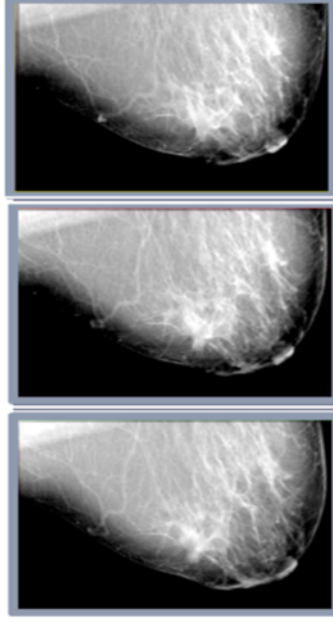
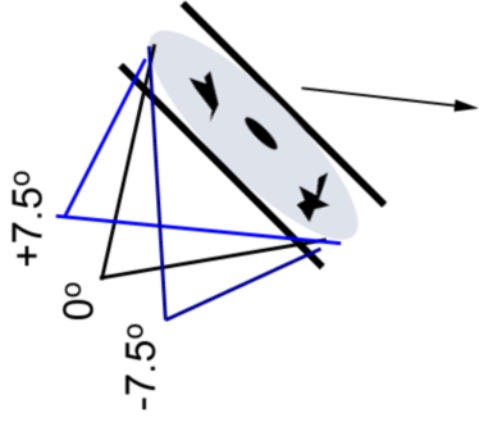
Views from different x-ray tube angles

Reconstructed slices

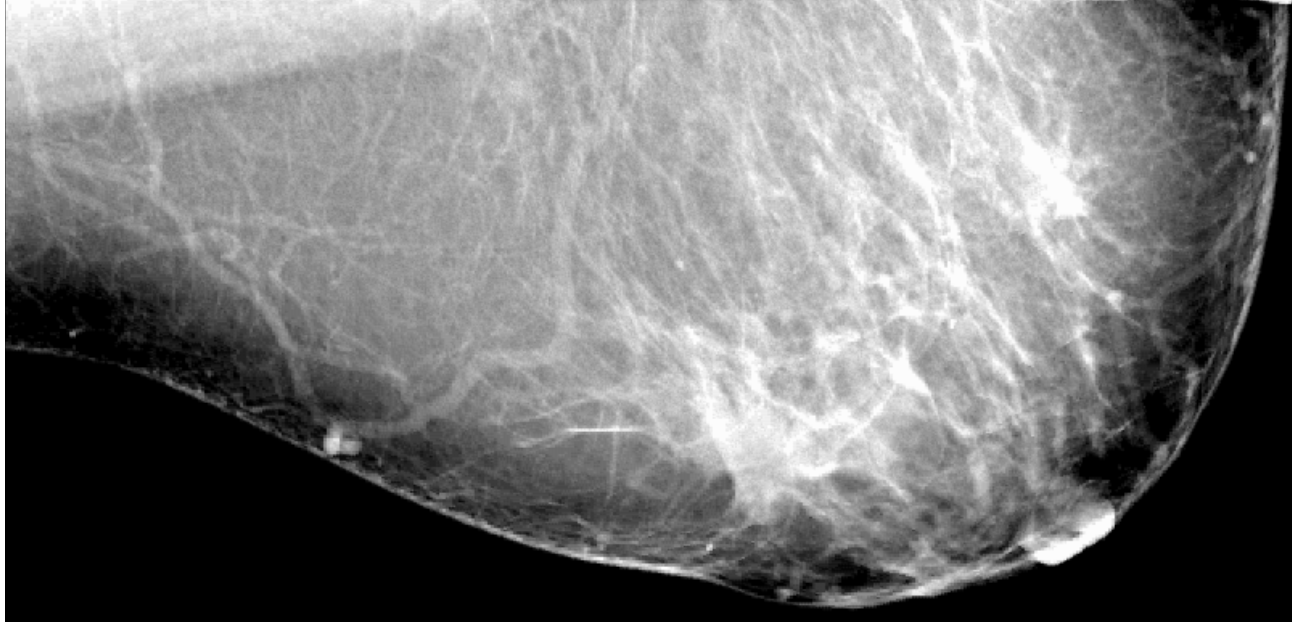


Slices at different heights

Projection images

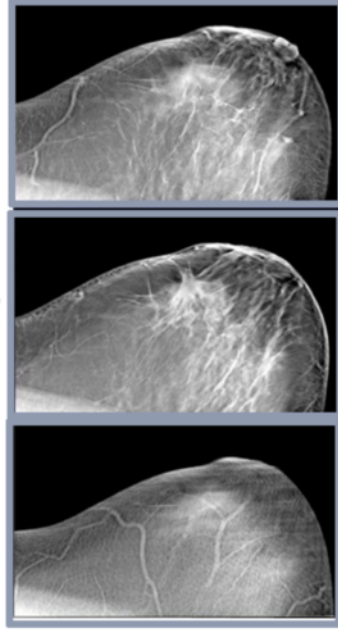
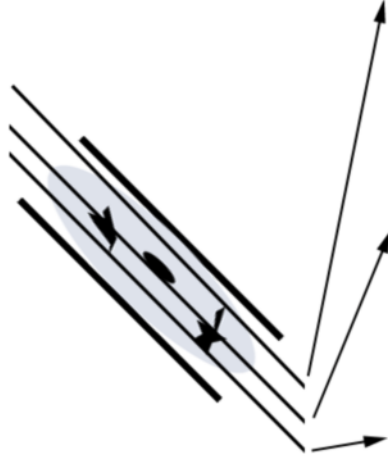


Views from different x-ray tube angles





Reconstructed slices



35 mm 25 mm 10 mm

Slices at different heights

Tomo... the movie!

How to use tomo clinically

- Choice is to take either 2D, 3D or both 2D+3D in one examination
- Can take tomo images in CC, MLO, or any standard mammography view
- Clinical experience is with CC + MLO, both 2D and 3D
- Doing both 2D and 3D requires additional dose...
- Unclear what is needed long term

Do we need both CC and MLO?

OLD NEWS...

RSNA 2004

Breast Tomosynthesis: Will a Single View Do?

Rafferty, Kopans, Wu, Moore

Conclusion: MLO tomo is adequate

LATEST NEWS...

RSNA 2006

Breast Tomosynthesis: One View or Two?

Rafferty, Niklason, Jameson-Meehan.

34 Lesions, imaged both CC and MLO tomo.

65% seen equally on both

12% more visible on MLO

15% more visible on CC

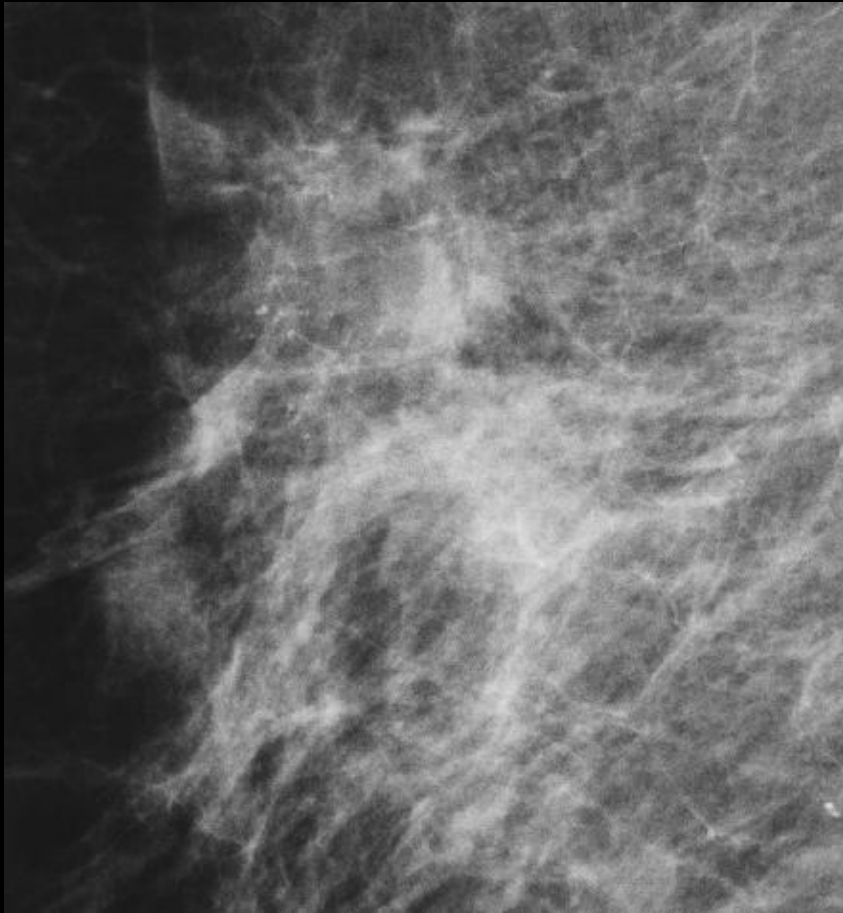
9% only seen on CC (all malignant).

→ lesions have both spherical & planar components

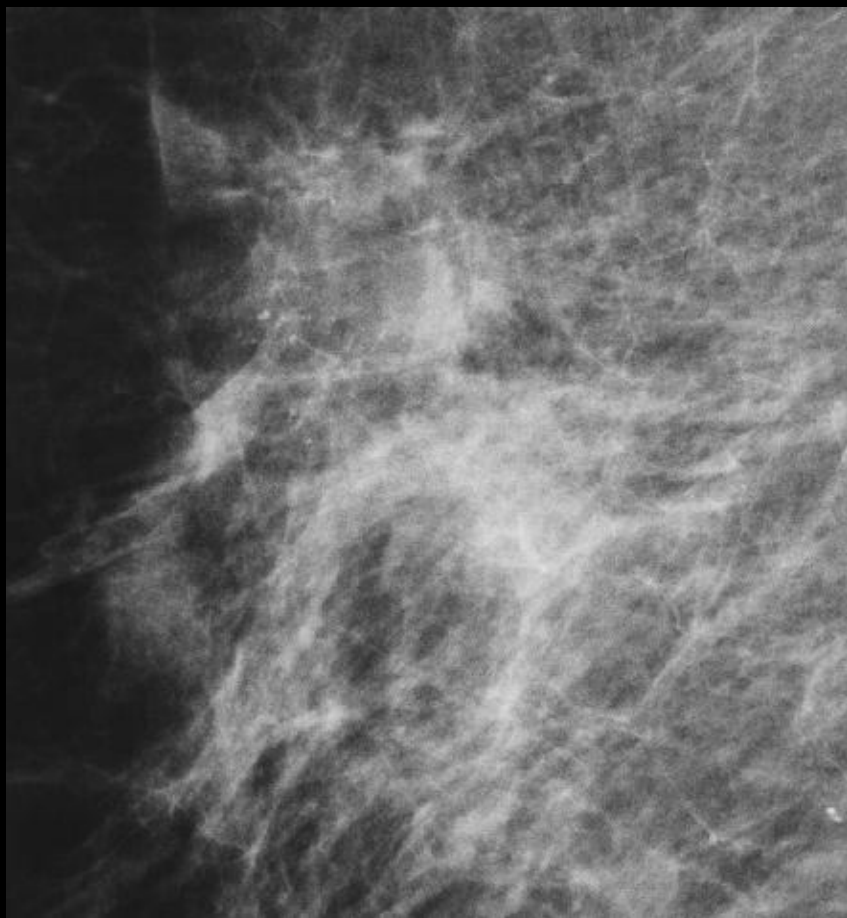
→ tomosynthesis clinical use likely to need 2 views

Clinical Examples

- Collected from six sites:
 - MGH Boston MA USA
 - Dartmouth Hitchcock Medical Center, Lebanon NH USA
 - University of Iowa, Iowa City, IA USA
 - Magee Women's Hospital, Pittsburgh, PA USA
 - Yale University, New Haven, CT USA
 - AVL Cancer Hospital, Amsterdam Holland



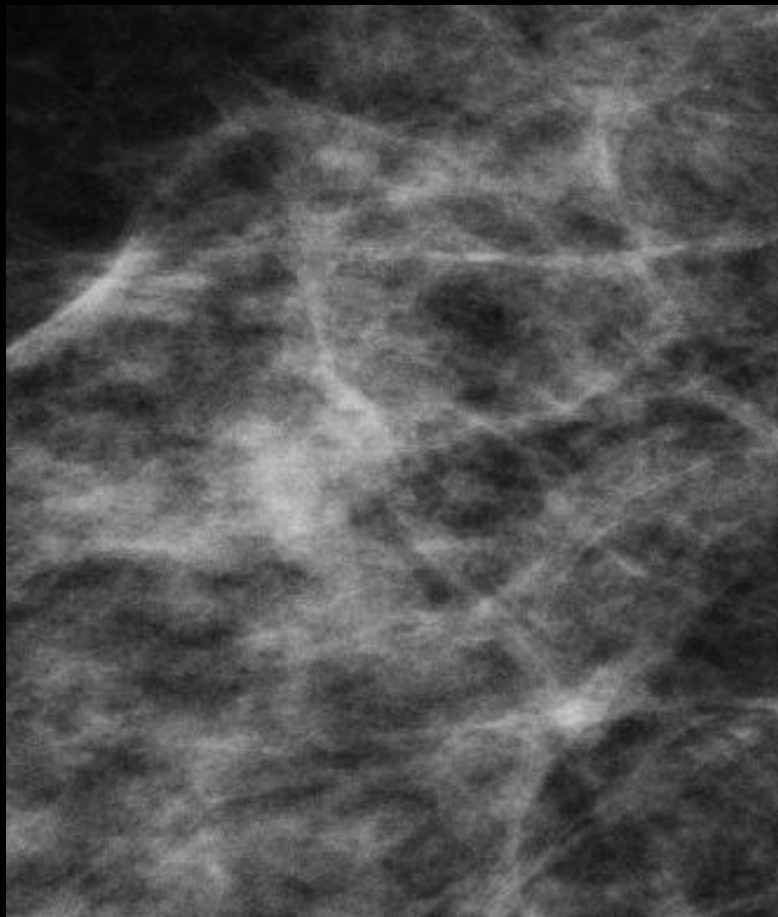
FFDM IMAGE



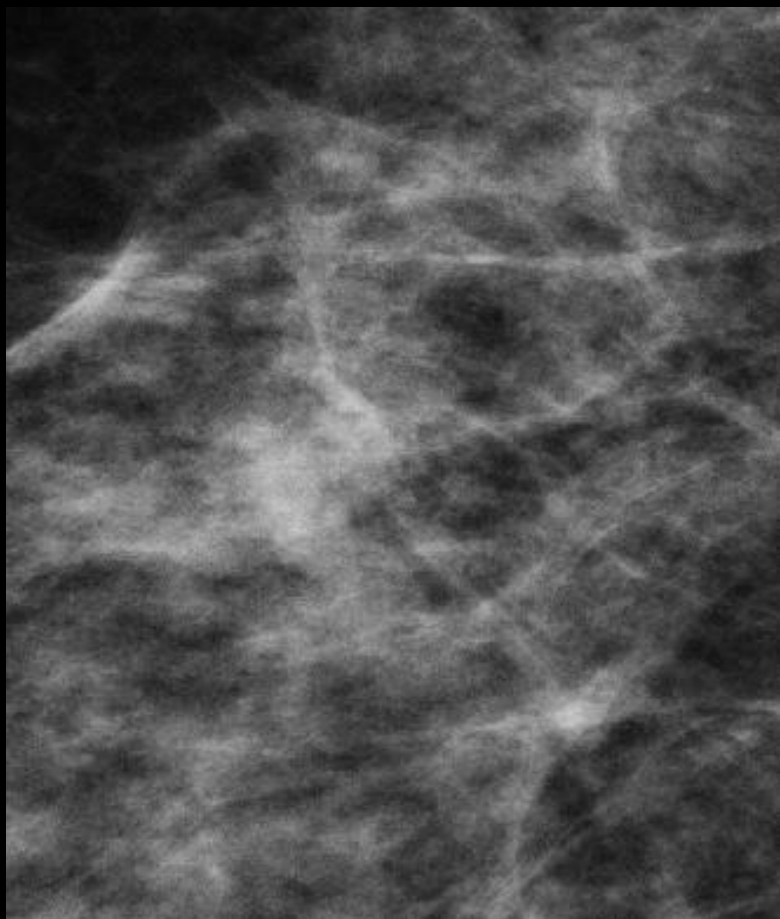
FFDM IMAGE



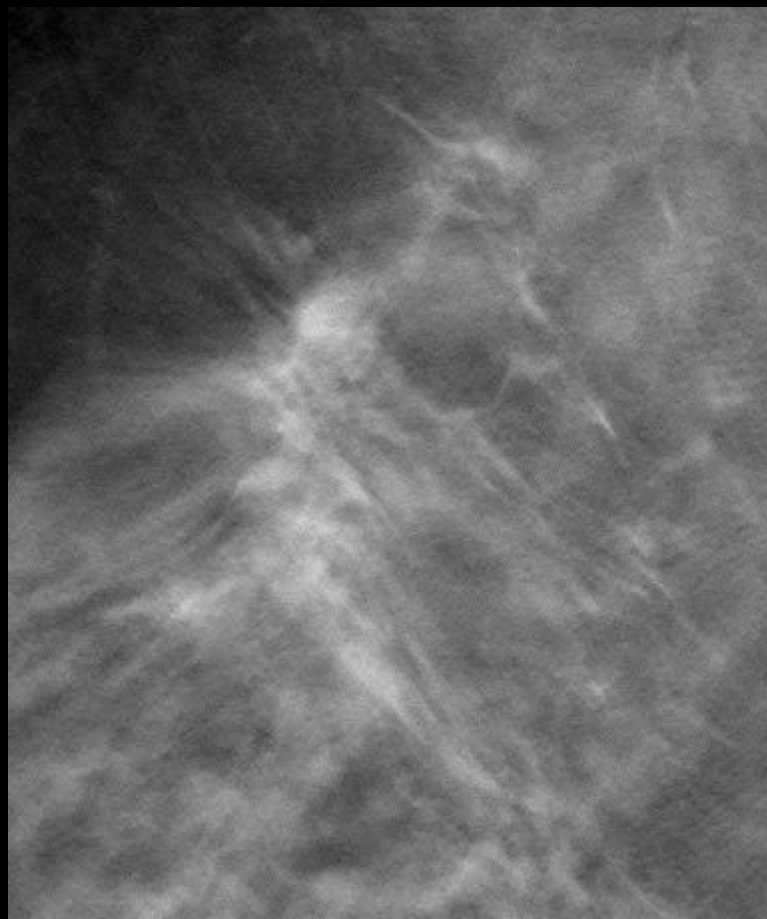
TOMO IMAGE



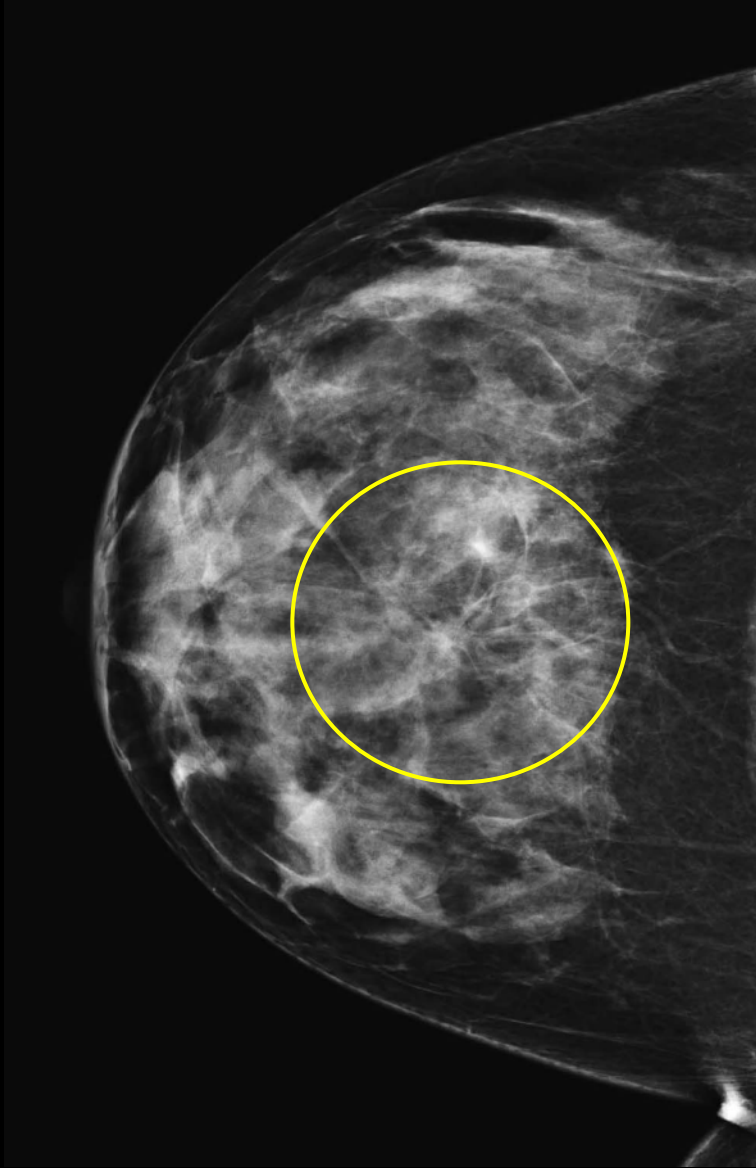
FFDM IMAGE



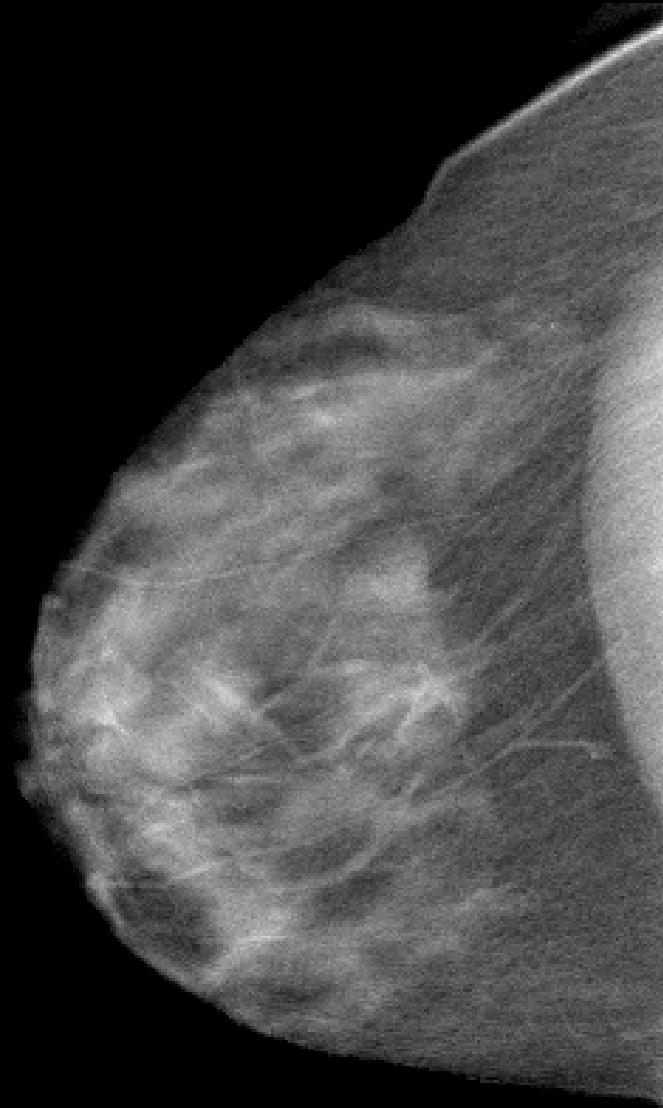
FFDM IMAGE



TOMO IMAGE



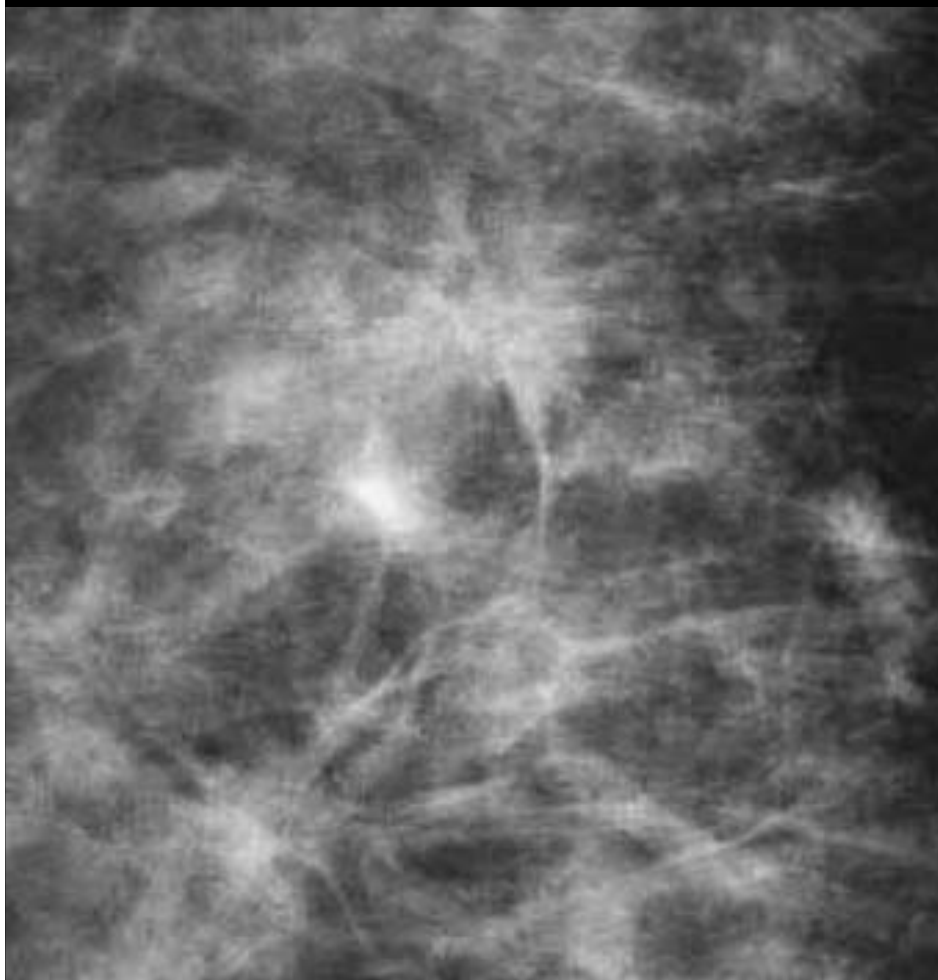
Digital Mammogram



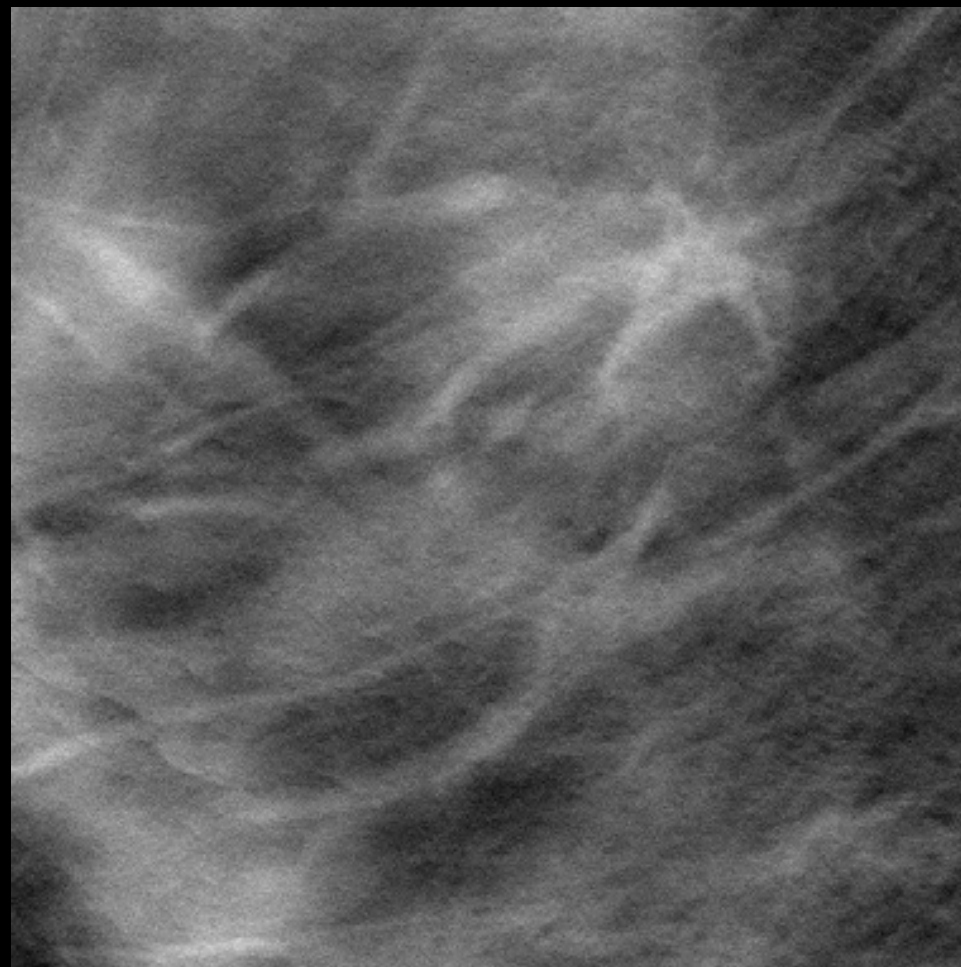
Tomosynthesis Image

Recalled for subtle architectural distortion. Tomo shows two adjacent spiculated masses. Multifocal invasive lobular carcinoma.

Case 030928



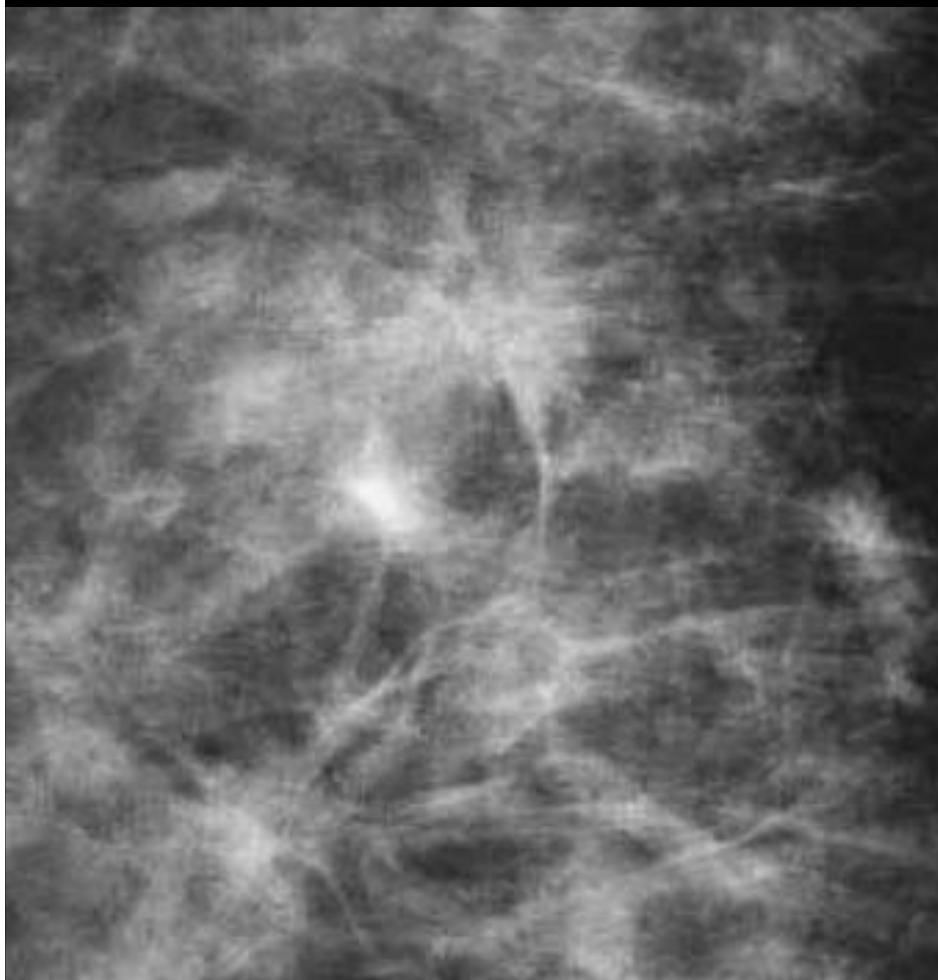
Digital Mammogram



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Digital Mammogram



Tomosynthesis Image

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Digital Mammogram

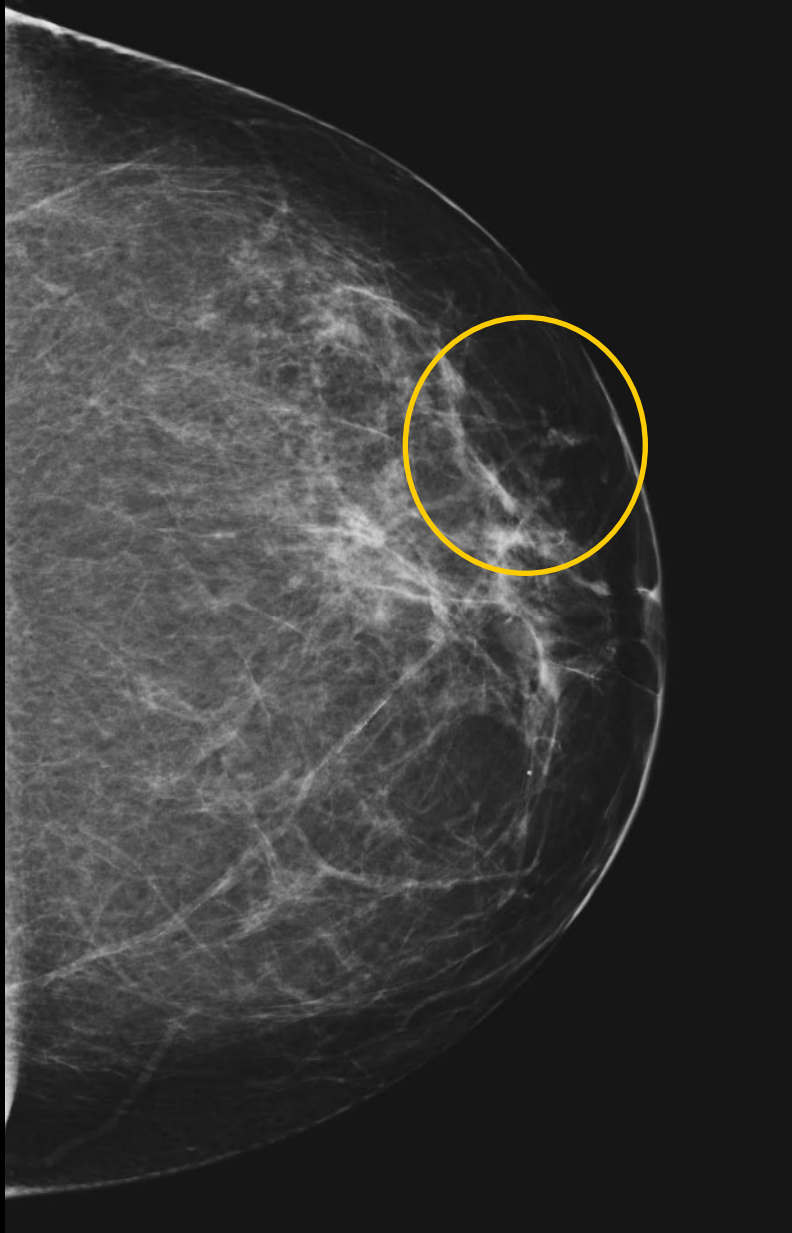


Tomosynthesis

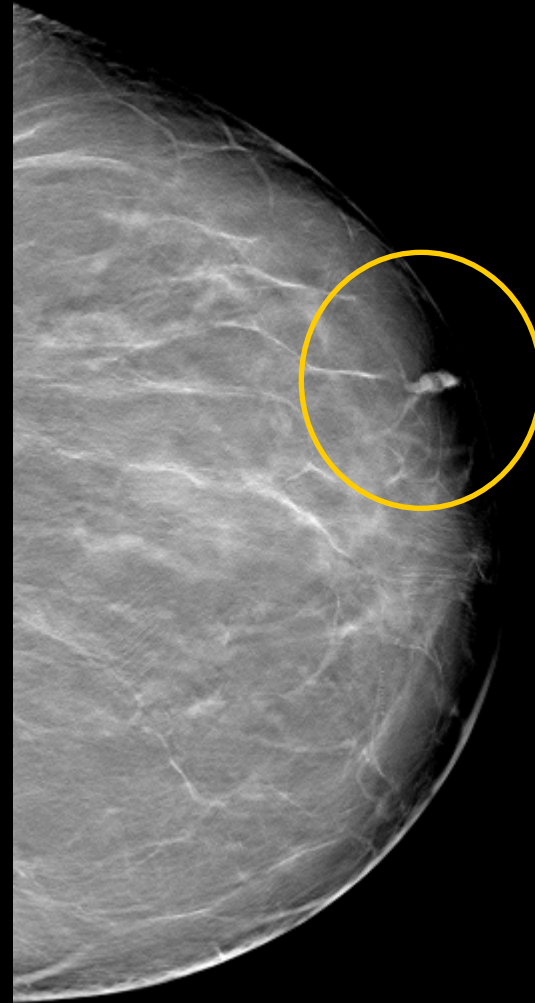


Mammographically occult biopsy proven cancer

Digital Mammogram

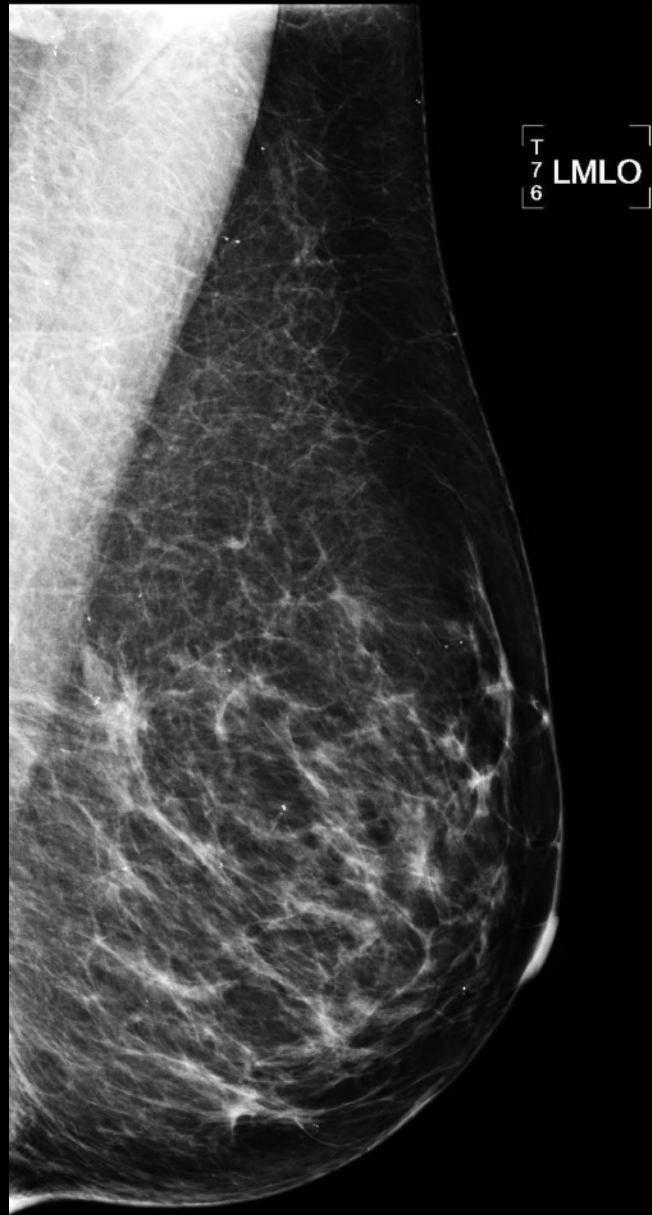


Tomosynthesis



Mammographically occult biopsy proven cancer

Digital Mammogram

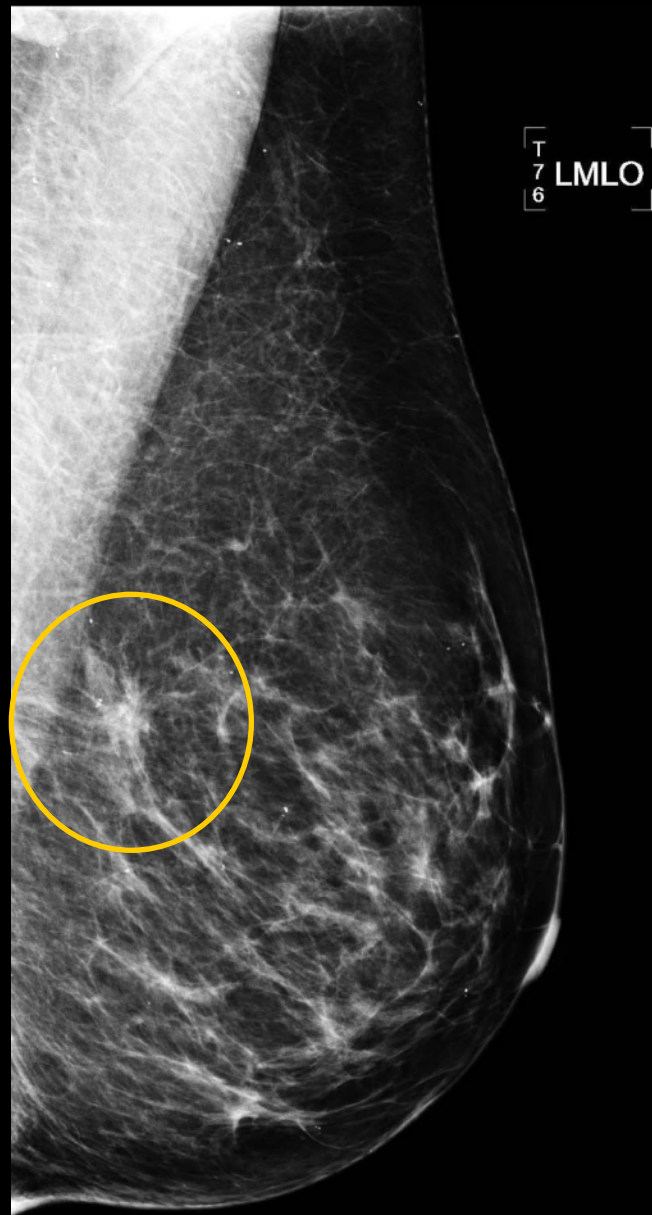


Tomosynthesis



Mammo false positive: benign. Superimposed parenchyma

Digital Mammogram



Tomosynthesis



Mammo false positive: benign. Superimposed parenchyma

Tomo clinical performance

RSNA 2007

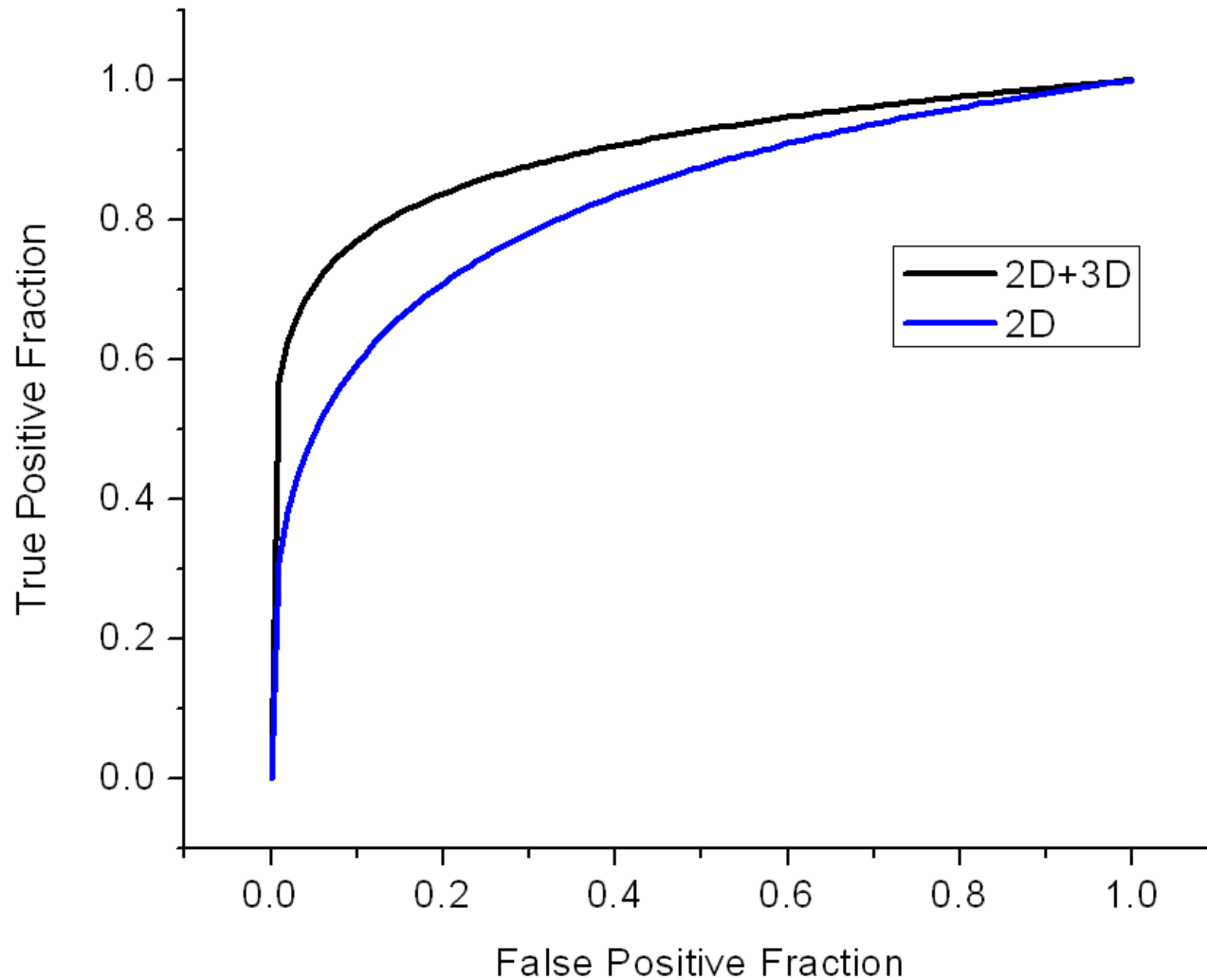
Assessing Radiologist Performance Using Combined Full-Field Digital Mammography and Breast Tomosynthesis Versus Full-Field Digital Mammography Alone: Results of a Multi-Center, Multi-Reader Trial

E Rafferty, L Niklason, et al.

- 1083 women imaged
- 316 women in reader study with 12 radiologists
- Study performance 2D vs. 2D+3D

→ Sensitivity increased from 66% to 76%
→ Specificity increased from 81% to 89%
→ Recall rate reduced by 43%

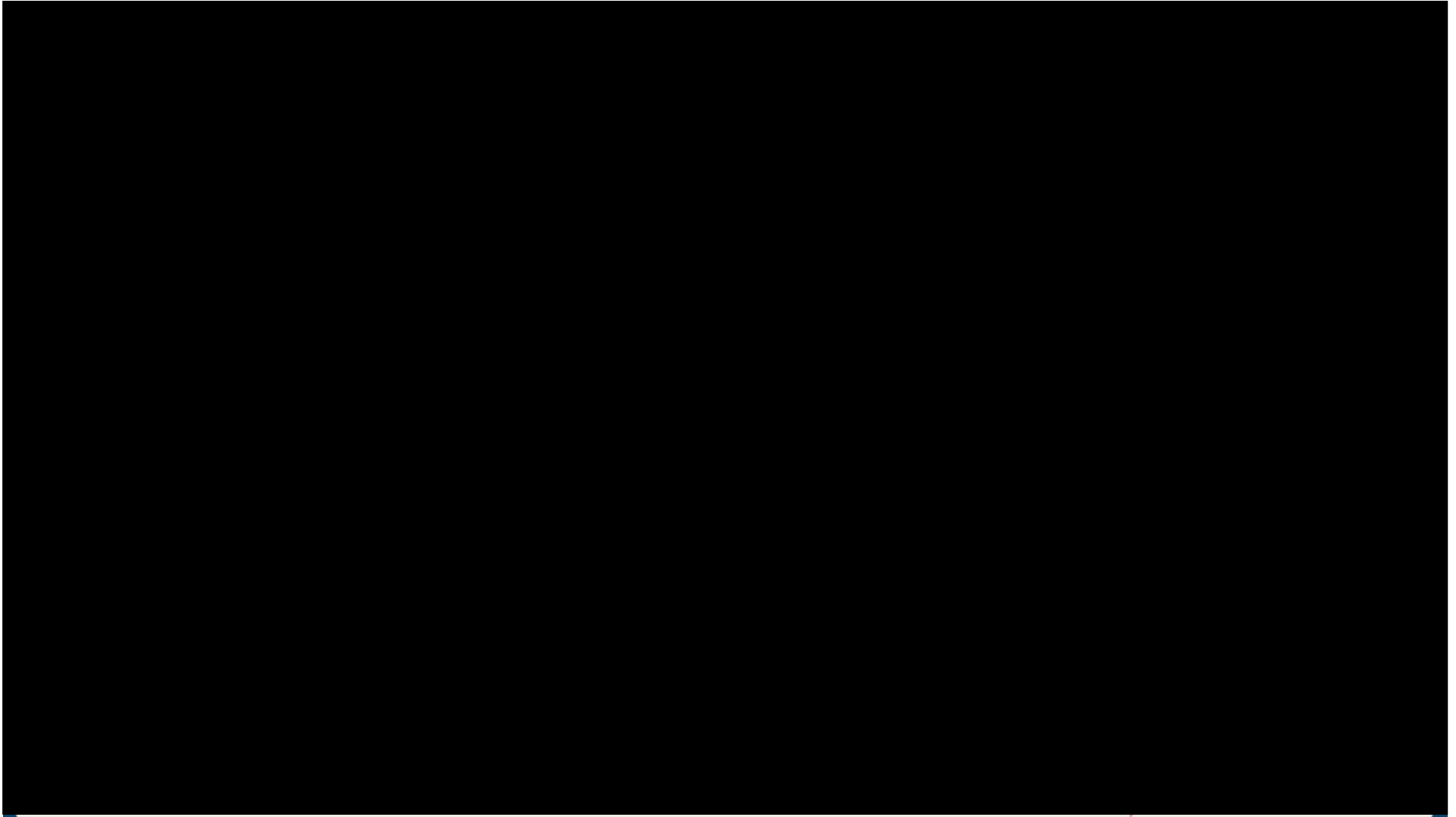
Tomo clinical performance



Summary of tomo advantages

- Better sensitivity
- Fewer recalls
- Potential for lower dose
- Potential for less compression

Tomo Acquisition





Thank You.