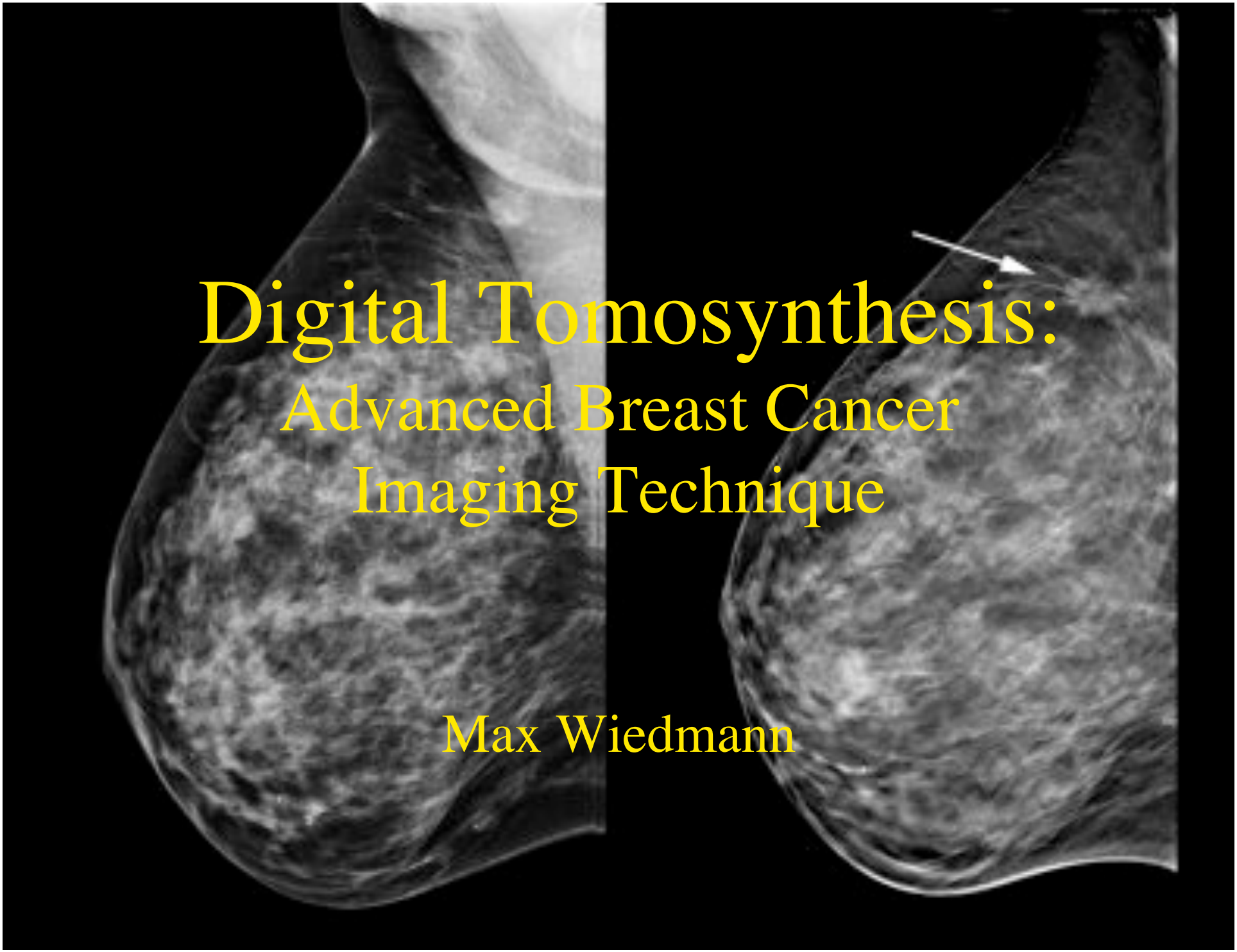

Digital Tomosynthesis:
Advanced Breast Cancer
Imaging Technique
Max Wiedmann

Digital Tomosynthesis

- An imaging technique in which multiple X-rays of one object are take from a discrete number angles.
- These cross-sectional images are used to reconstruct 3-D images of the object being scanned.
- Tomosynthesis differs from computed tomography because the range of angles used is less than 360˚, which is used in CT.

Breast Cancer

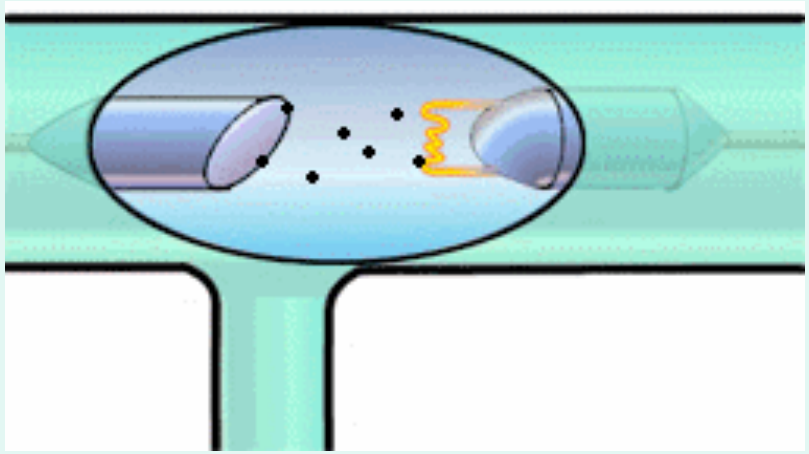
- The leading Cause of death for women ages 40-55.
- Is only behind lung and bronchus cancer in terms of number of deaths in US.
- Early detection of breast cancer is believed to save thousands of lives

Mammography

- A method for detecting growths in breasts using a dedicated machine.
- Achieved by compressing the breast tissue to both spread it out and reduce motion blur, followed by X-ray exposure.
- X-rays will be absorbed to different degrees with different tissue.
- Bone absorbs the most while soft tissue allows the rays to pass through.

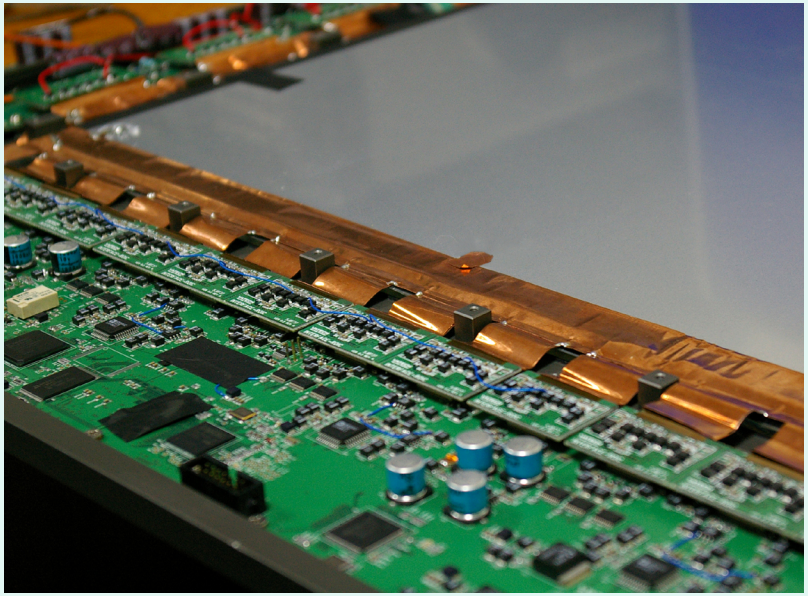
Mammography part 2

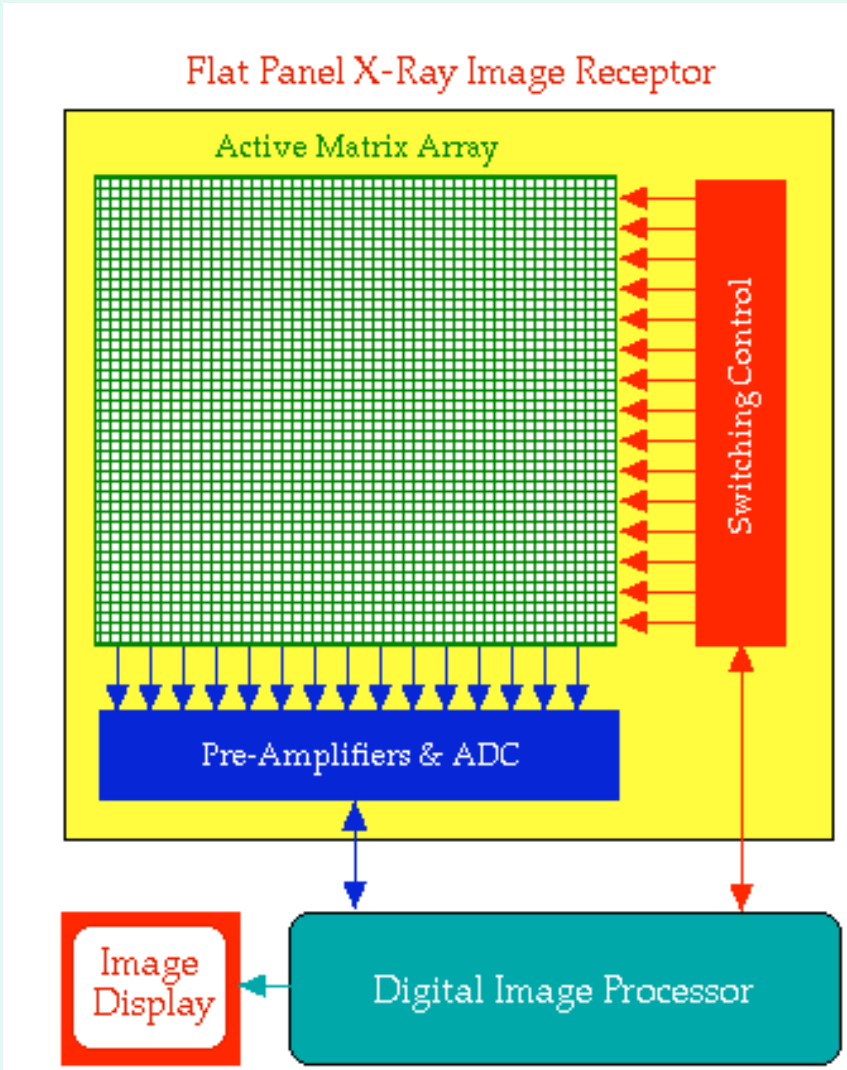
- X-rays are produced using Bremsstrahlung, a process in which electrons are accelerated against an anode, causing photons to be fired off across a continuous spectrum.
- The rays that pass through the tissue cause photographic film to expose creating an image.
- A newer process, called full field digital mammography uses digital receptors.

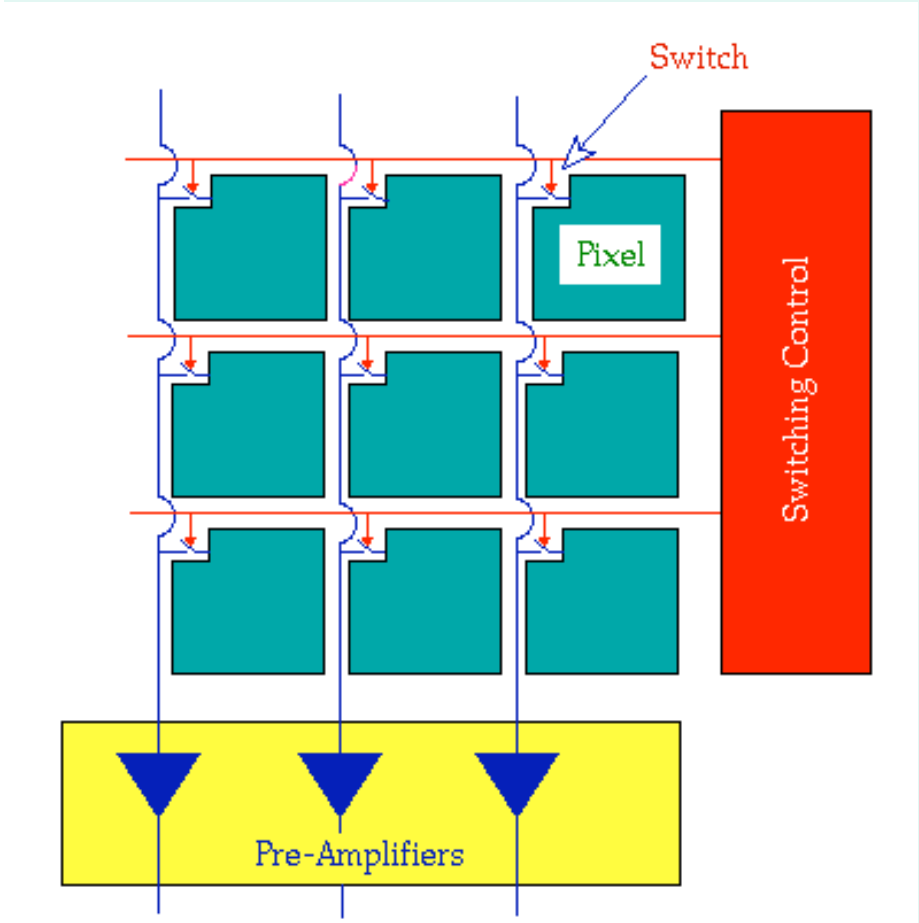


Full Field Digital Mammography

- The use of a reusable digital flat panel to detect incoming X-rays.
- The energy from incoming photons is converted to a voltage then run through an ADC and processed.
- An image is generated in seconds.
- Digital imaging appeared later in mammography than most of radiology due to the high contrast and resolution requirement for mammograms.







Kieran Maher, 2000

Problems with Mammograms

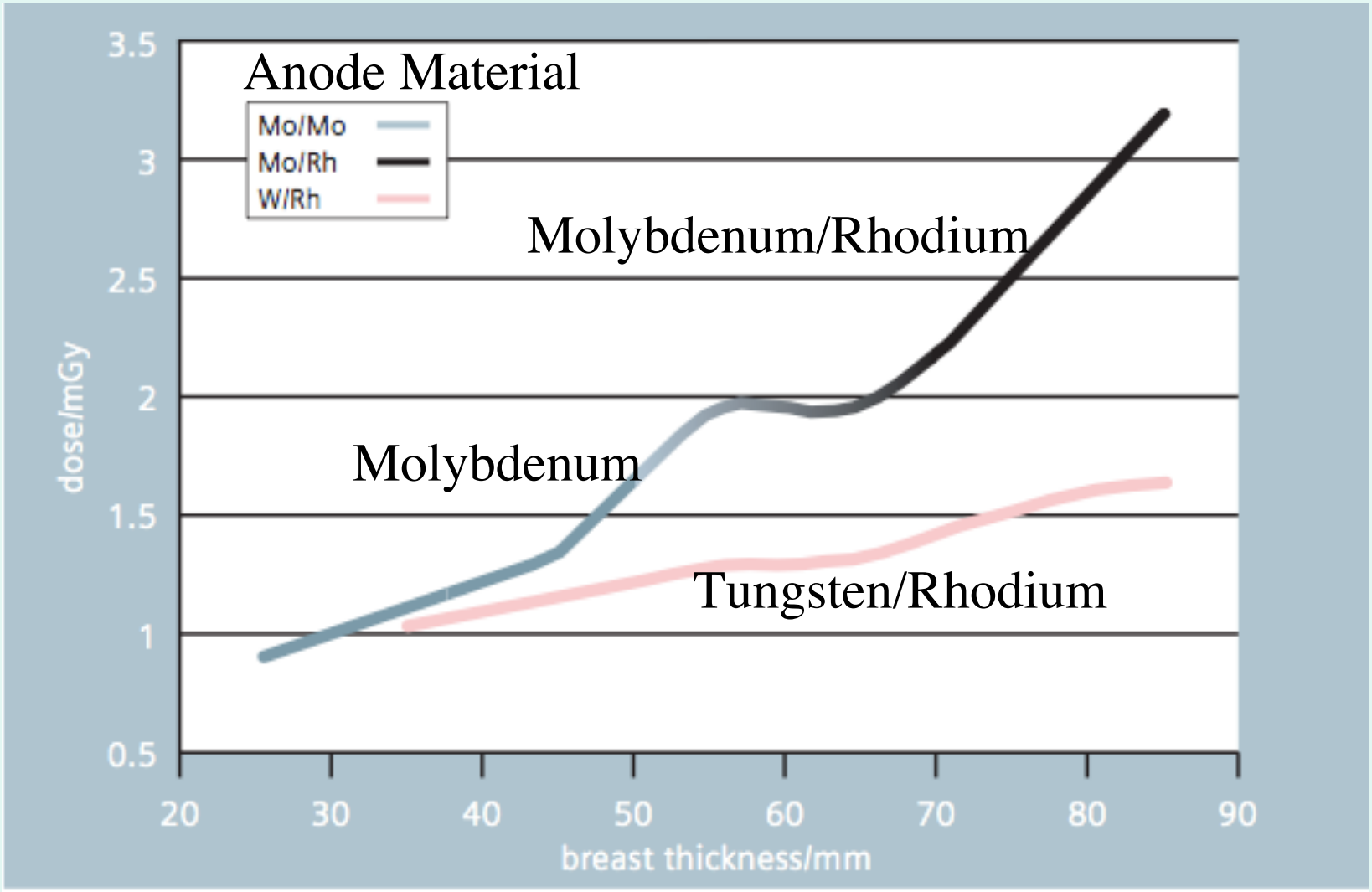
- Mammograms require the breast tissue to be compressed between two plates of glass.
- Many women dislike the feeling, which reduces the likeliness of getting tested often.
- Compression causes overlapping in the breast tissue, which can obscure imaging.
- Mammograms typically only take 2 images at orthogonal axes.
- Mammograms produce false positives and false negatives.

  Of all biopsies taken from breasts that tested positive, only 20% came back with cancer.

Advantages of DTS

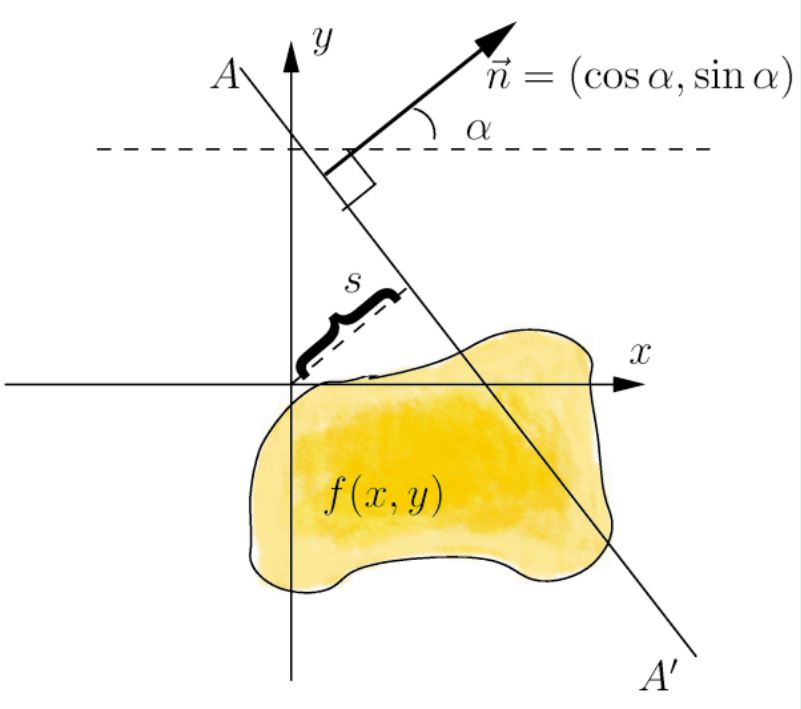
- Minimal pressure is needed, just enough to hold the breast in place.
- A lower dose of radiation is required, up to 50% reduction for dense breasts.
- The cost of DTS is expected to drop below the cost a of traditional mammogram.
- It is the only procedure that is expected to fully replace mammography.

Required Dose vs. Breast Thickness for varying anode materials



Mathematics Behind DTS

- Filtered back projection is used to reconstruct 3D structures from 2D images.
- This is a form of an inverse Radon Transformation.
- A radon transformation is an integral of some function all lines passing though the object of interest.
- Here, in the two dimensional we could integrate over all lines parameterized in the following way: (x(t),y(t)) = t(sin a, -cos a) + s(cos a, sin a)
- The resulting Radon transform would be:



$$\mathcal{R}[f](\alpha, s) = \int_{-\infty}^{\infty} f(x(t), y(t))\, dt = \int_{-\infty}^{\infty} f(t(\sin\alpha, -\cos\alpha) + s(\cos\alpha, \sin\alpha))\, dt$$

Application of Math

- What's been done here is an integral of all line integrals in the space this object is in.
- In practice, there is no actual integral, rather, the function is the exponential attenuation caused by the X-rays penetrating the tissue.
- Now, given the functions, we want to put it back together, using an inverse Radon transformation.
- However, the inverse Radon transformation is very unstable when dealing with noisy data so an alternative is used: filtered back projection.

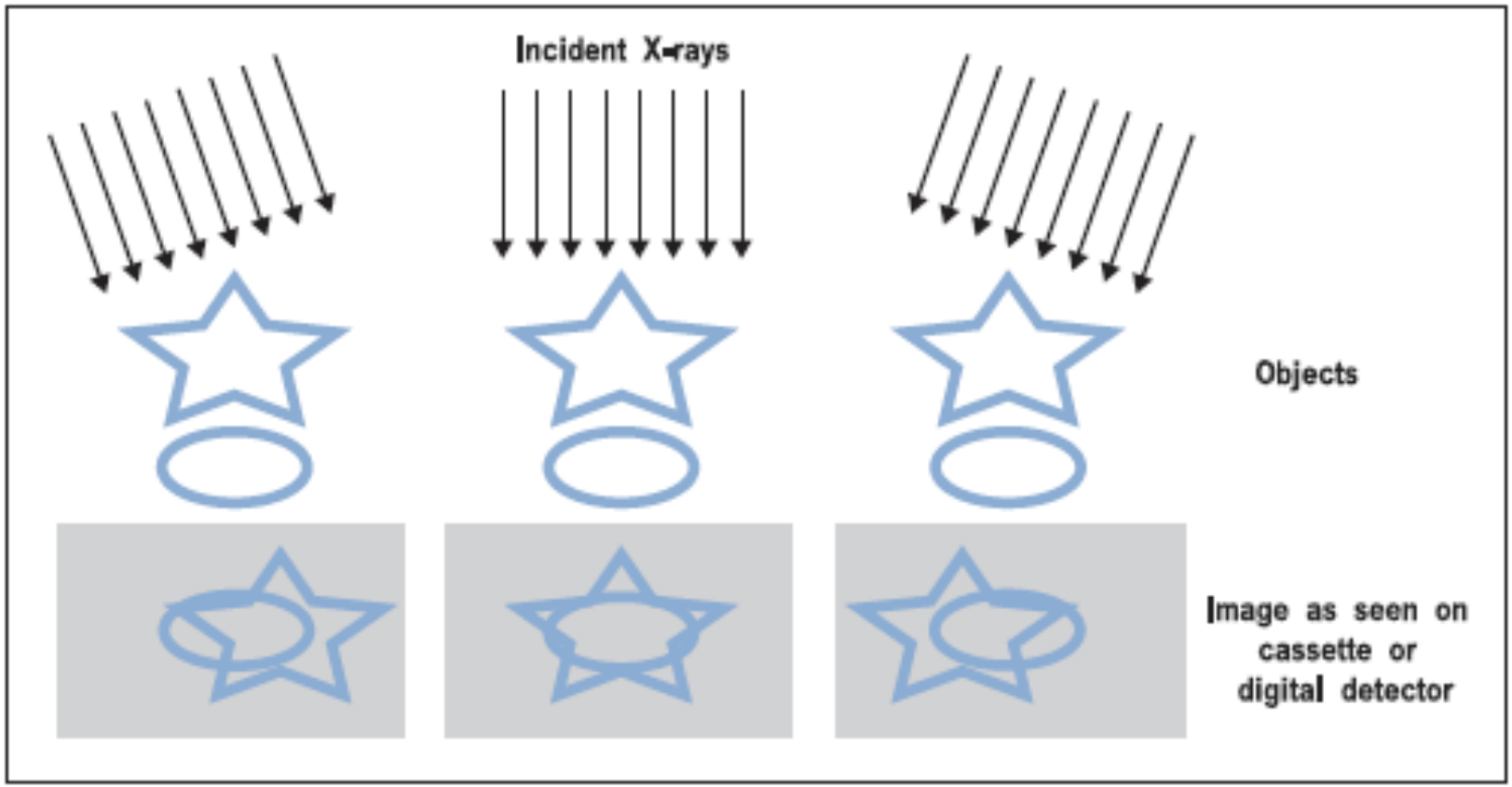
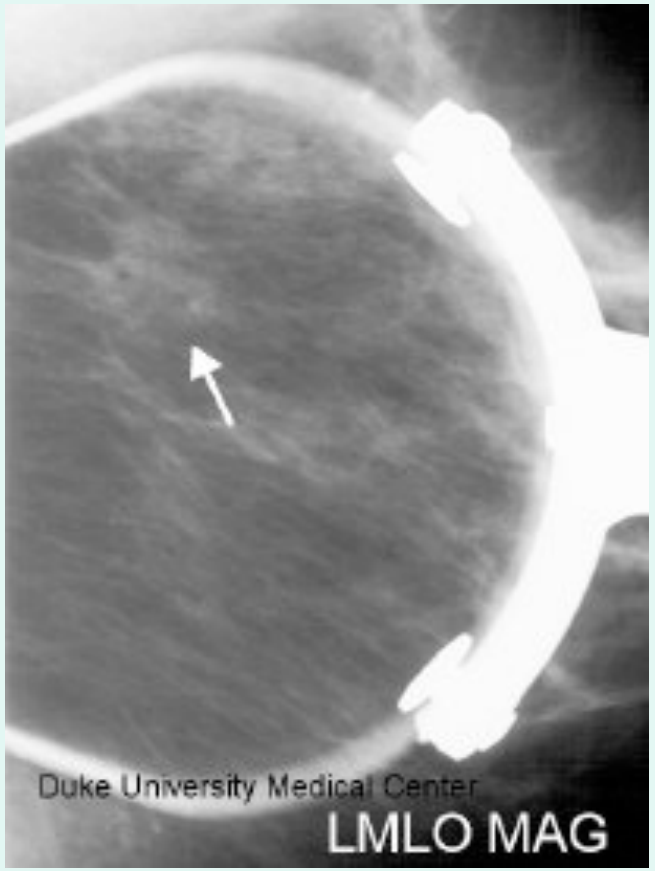


Figure 4 . Tomosynthesis Imaging acquires the images from different angles separating structures at differing heights. Conventional mammography would acquire only the central image.

Left Mediolateral Oblique, Mammogram



Same Left Mediolateral Oblique, DTS

Mammomat Inspiration

- The Mammomat is a prototype developed by Siemens.
- Comes with complete setup (X-ray machine and computer)
- Fast, improves workflow.
- Can be combined with computer aided diagnosis (CAD),
- Upgradeable
- User friendly.

Technical Specifications: X-Ray Generator

- Power output - 5kW
- kV Range - 23kV-35kV
- Exposure Time:

  10 ms to 4 s (large focus)

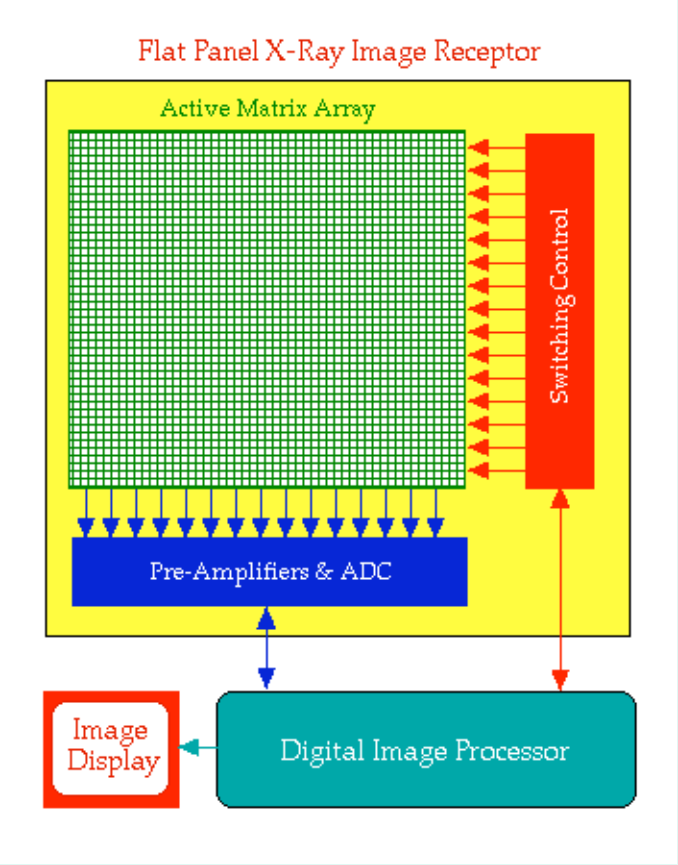
  60 ms to 6 s (small focus)

Source: MAMMOMAT Inspiration - Technical Specifications, Siemens

Technical Specifications: Flat Detector

- Solid-state detector of amorphous selenium.
- Dimensions: 24 cm x 30 cm (9.5" x 12")
- Pixel Size: 85 μm
- Image matrix :2816 x 3584 (24 cm x 30 cm)

  2016 x 2816 (18 cm x 24 cm)



Source: MAMMOMAT Inspiration - Technical Specifications, Siemens

Approval Status

The Mammomat Inspiration has been approved in the EU but not in the US by the FDA.

Prototype work is being conducted in both the EU and the US.

Summary

- Digital tomosynthesis is a process used to reconstruct 3-D images of from 2-D scans.
- Advantages of DTS include comfort, speed, and lower radiation dosage.
- It may eventually replace conventional mammography as it become less expensive.
- Currently, it is only approved in the EU.

Sources

- *Breastcancer.org*
  http://www.breastcancer.org/symptoms/testing/types/dig_tomosynth.jsp
- Joseph Y. Lo, Ph.D. research pages
  http://deckard.mc.duke.edu/~jyl/bme.html
- *MAMMOMAT Inspiration - Technical Specifications, Siemens*
  http://www.medical.siemens.com/
- *Duke Advanced Imaging Laboratory*
- http://dailabs.duhs.duke.edu/research.html
- *Kieran Maher Flat X-Ray Panel Receptors*
- http://homepage.mac.com/kieranmaher/digrad/DRPapers/FlatPanel/index.html

Questions

- 1) What are the advantages of Digital Tomosynthesis vs. conventional Mamography
- A. Comfort
- B. Lower radiation dose
- C. Better for dense breast tissue
- D. All of the above
- E. None of the above

- 2) Tomosynthesis involves which of the following:
- A. Application of electrodes to the skin
- B. Radio waves
- C. Images taken at multiple angles
- D. Consuming chemicals to show up on images
- E. None of the Above