Breast Tomosynthesis

<<diploma work presentation>>

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Breast tomosynthesis

- A new breast imaging technique
- Developed at the MGH
  (diploma work is based on Dr. EA Rafferty's work, leader of TOMO Research Team)
- So far just in experimental applications
  - results of latest trials are coming soon
- Unexploited research area
  - "we need Your help!" O

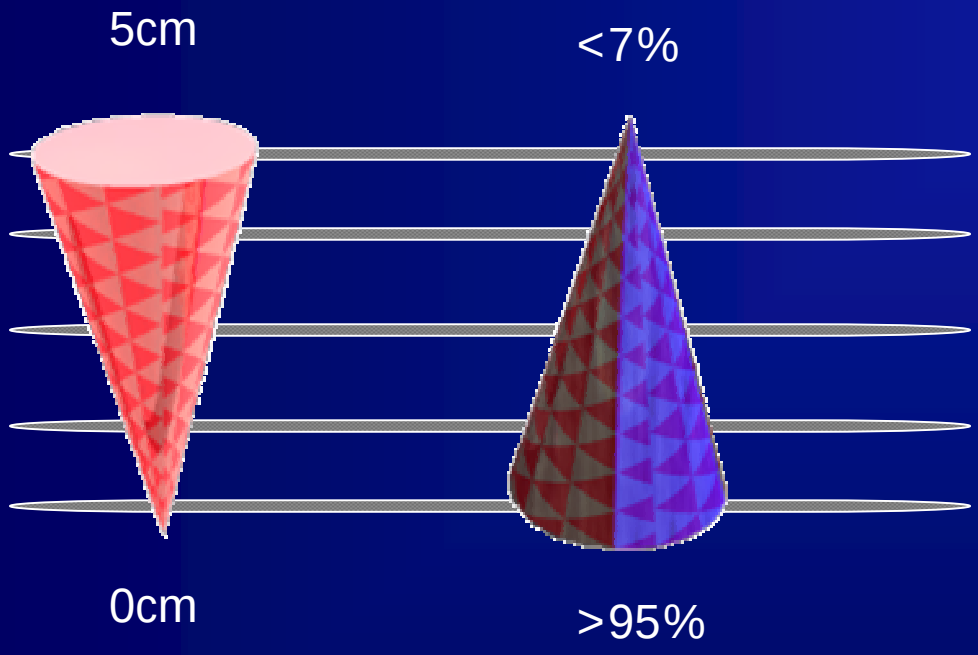
Breast tomosynthesis system

(EA Rafferty: “Advances in Imaging: Breast Tomosynthesis”, ASCO Virtual Meeting, 2004.)

Breast cancer

- The most frequent malignancy among women
  - 1 of every 8 women is diagnosed with breast cancer at some time in her life
  - a lots of new cases every year (in developed countries: US, WEU, except JAP)
  - the third leading cause of death (US survey)
- But
  - can be prevented (secondary prevention)
  - curable (wrong approach)

Stages of breast cancer



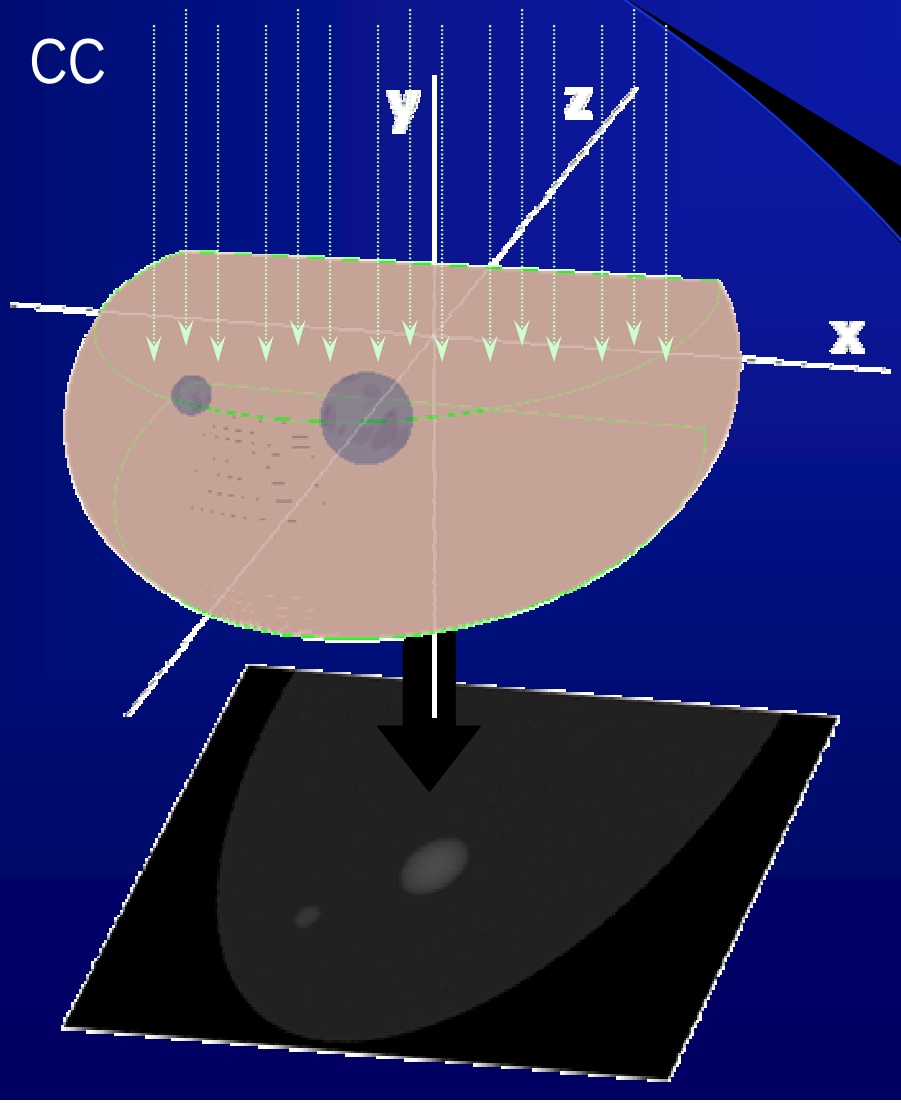
- Stage - Metastatic
- Stage
- Stage
- Stage
- Stage - Pre-cancerous

Tumor size 5 year surviving rate

Mammography

- The most efficient breast imaging technique in practice
- Image creation is based on x-ray attenuation
  - low radiation dose x-rays (0.1-0.2 rad)
  - grayscale images (mammograms)
  - radiological dense tissue will be white (functional tissue, abnormalities), fat will be black, everything else appear as levels of gray on the film
  - views: cranio-caudal (CC), mediolateral-oblique (MLO), lateromedial (LM), mediolateral (ML), etc.

Mammographic examination



Disadvantages of mammography

- Difficulties in detecting breast cancers
  - structure overlaps
    (it can obscure lesions or mimic abnormalities)
  - increased number of false-positiv and false-negativ screening examination recalls
- Difficulties in localization breast cancers
  - insufficient visual information (CC+MLO images)
  - further examinations are needed (US, MRI)
  - image guided biopsy

Breast tomosynthesis (technical bg)

- Similar to mammograph...
  - it’s an x-ray application
  - grayscale images
  - breast compression
- ...but there are some differences between them
  - reconstructed slices instead projection images
  - series of views (1 view – 1 projection)
  - lower radiation dose (1.5*mammo/exam)
  - fast (7 second examination)

TOMO examination

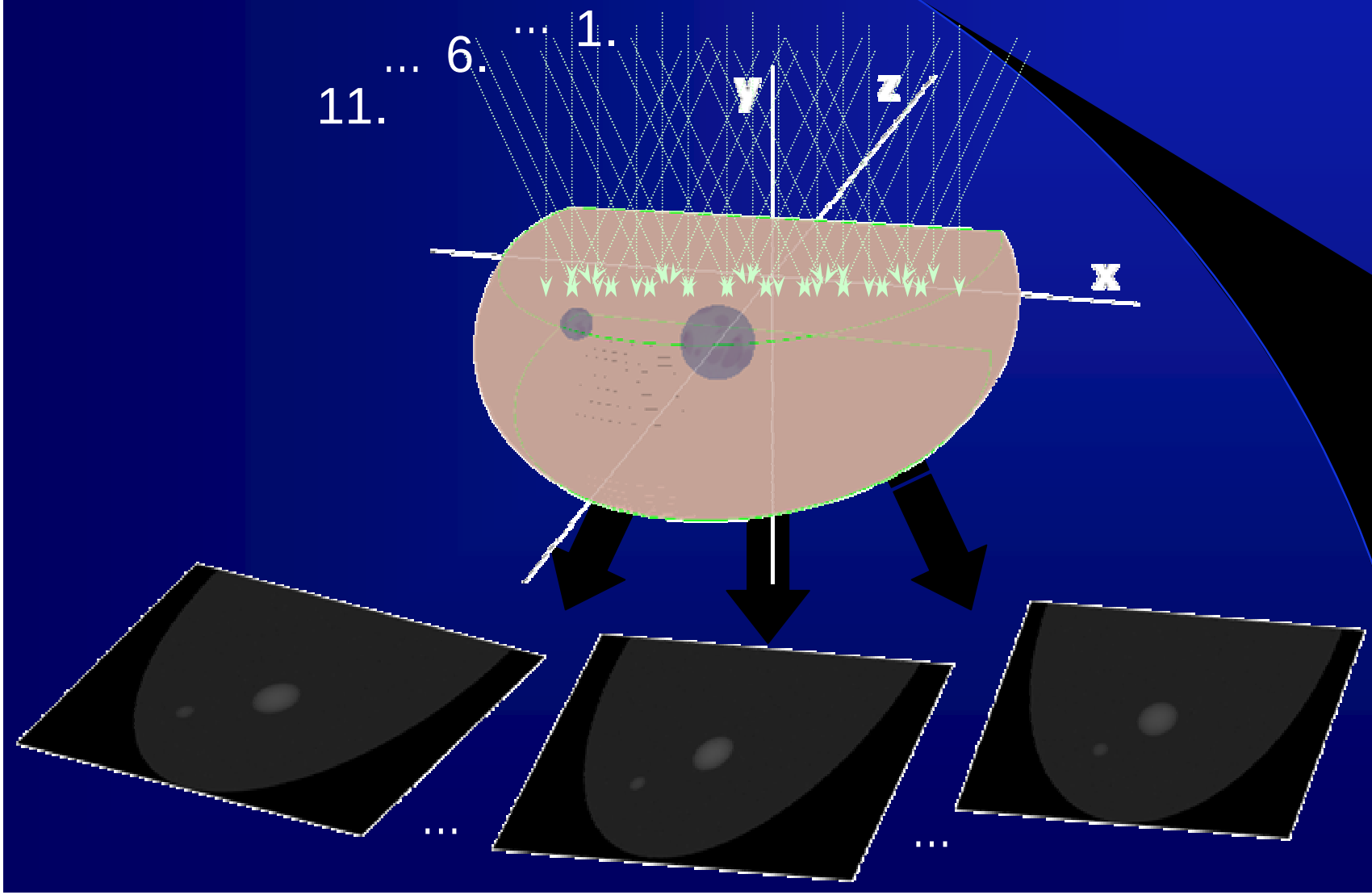
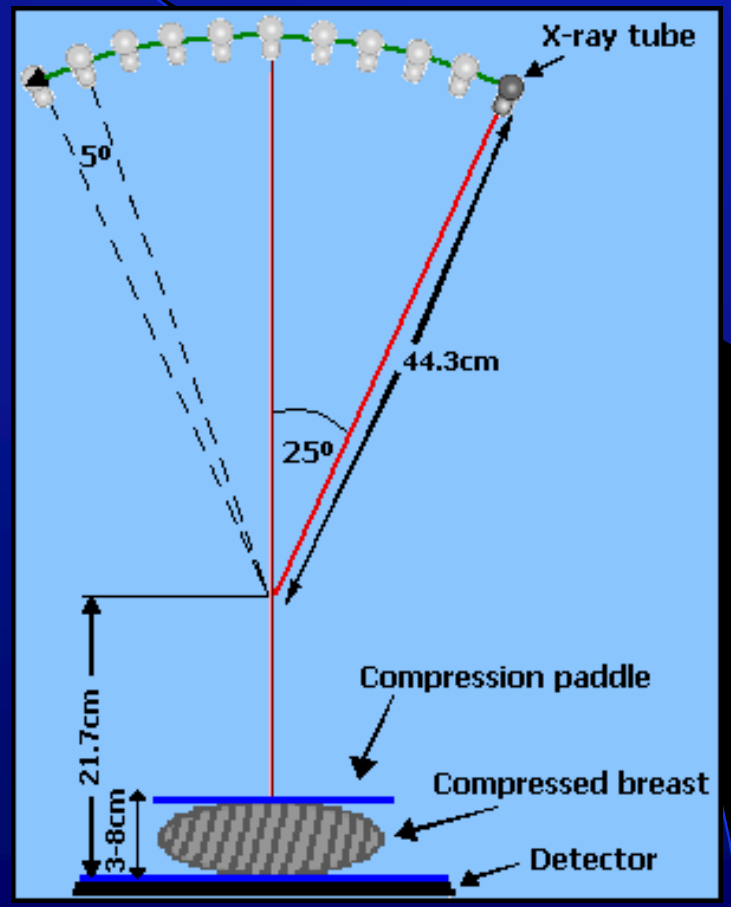


Image acquisition model

- 11 projection
- 50° angular range
- equidistant tube positions



(EA Rafferty: “Advances in Imaging:
Breast Tomosynthesis”, ASCO Virtual Meeting, 2004. – /reproduction/)

“Ingredients” of image creation

- Image reconstruction from projections
  (Simple Backprojection algorithm)
- Tomosynthesis basics
  (Haaker-Klotz-Koppe-Linde, Hamburg, GE, 1985.)
  - leave common aproaches
  - back to backprojection
  - modify the BP algorithm, to be suit for tomo-synthesis (1985. – coronary angiography)

Reconstruction problem

- Reconstructing horizontal slices (50-80 slice)
- Difficulties
  - we have only 11 projection
  - taken from small angular range

Difficult limited-angle tomography problem

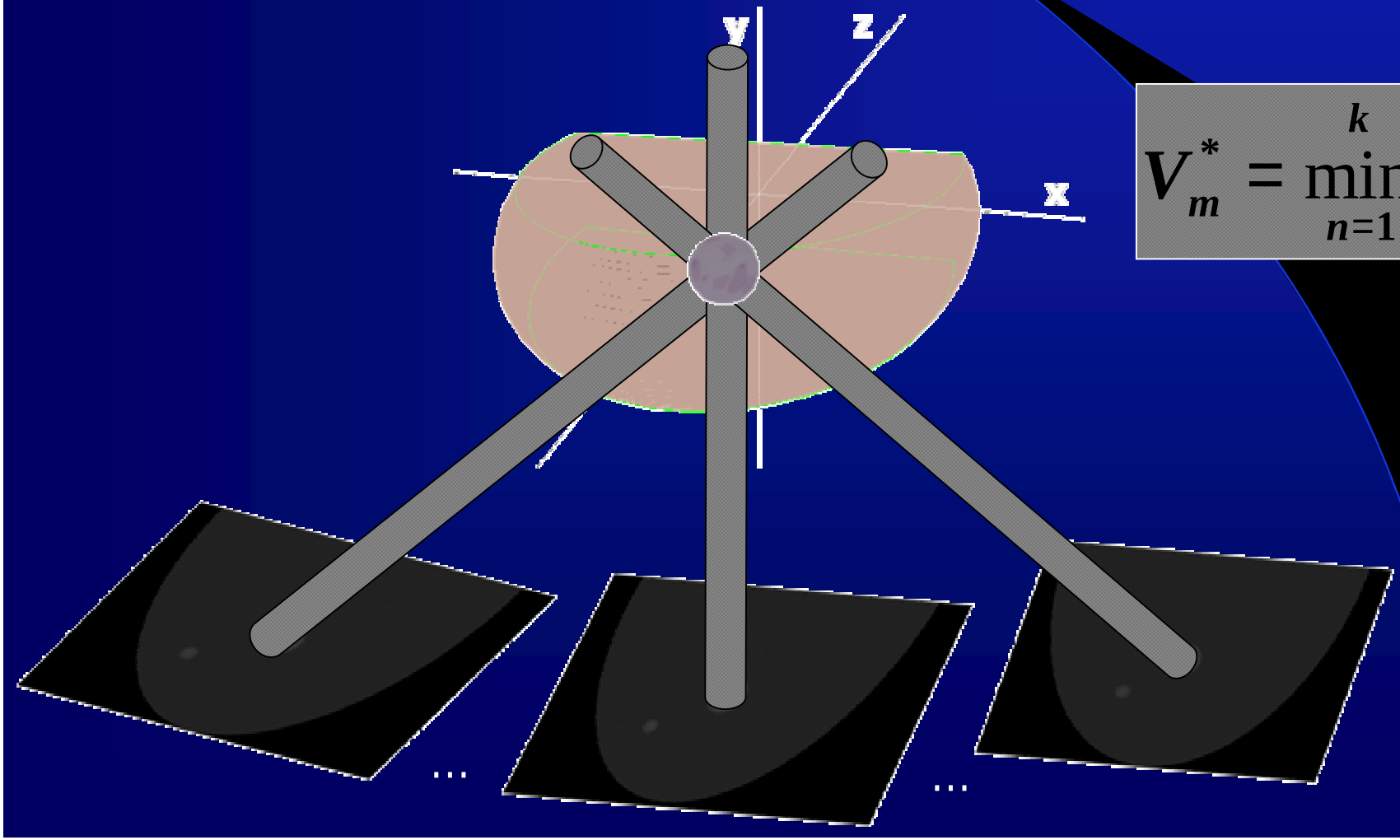
- General solution: discrete tomography
  (non-linear iterative algorithms,
  optimalization methods)

Tomosynthesis reconstruction theorem

- Making an appropriate modification on SB alg.
- Perceptions
  - bright areas are more important for us (angio with contrast material, mammography)
  - we have to concentrate to higher pixel-values
  - also, we are looking for structure-intersections

Minimum-operator for combining projections
(this will lead us to extrem-value reconstruction)

Explanation of using minimum-op.



$$V_m^* = \min_{n=1}^{k} P_n$$

Further perceptions and modifications

- Minimum-operator collects noise
  (average-operator has a noise-minimizing effect)
- Combining the operators
  - to eliminate noise (averaging)
  - for qualitative reconstruction (minimum)

Minimum-type operator (GOS-filter, L-filter)

$$V_m^{**} = \frac{1}{k - K - L} * \sum_{n=L+1}^{k-K} P_n$$

$$P_{\min} \le \ldots \le P_L \le \underbrace{P_{L+1} \le \ldots \le P_{k-K}}_{\text{1442443}} \le \ldots \le P_{\max}$$

Consequence of using min-type op.

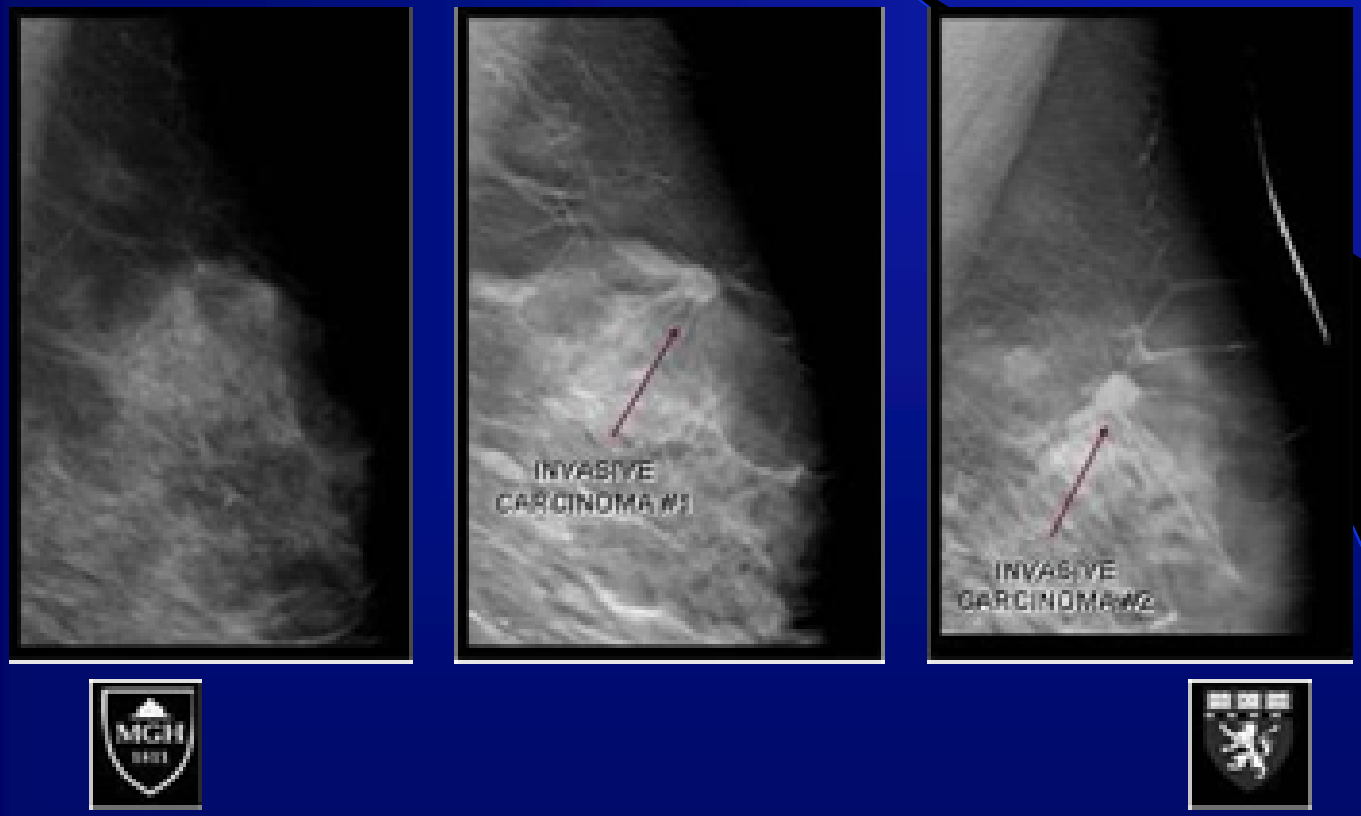
- Re-projection consistency constraint won't be satisfied (the K largest and the L smallest values won't be taken into account)
- Replacing original values of projections with "suitably enhanced" values, and performing a second reconstruction, it will solve the problem
- "Suitably enhanced" values can be determined in the first, so called order-statistic based reconstruction step

$$\tilde{P}(\bar{x}) = \frac{N}{N - card(\mathrm{k})} * \left(P(\bar{x}) - \frac{1}{N} * \sum_{i \in \mathrm{k}} S_i(x) \right)$$

Reconstruction algorithm

- 1. Step Reconstruction with an appropriate minimum-type operator
- 2. Step Enhancing contrast of projections to correct operator's error
- 3. Step Reconstruction with the same operator, but from the enhanced projections

Mammography vs. TOMO



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Thank You for you attention!