

Quality control of tomosynthesis imaging systems

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Learning objectives

1. Analyze differences between tomosynthesis and projection radiography
2. Translate these differences into meaningful quality control evaluations

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Ground up approach

- We essentially have a radiography system that has been modified to perform tomosynthesis
 - The system can be used for both applications
- Which subsystems are used identically for both modalities?
 - Most of them
- What evaluations are needed and are they sensitive enough?

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What are the key differences?

And their implications...

- X-ray source moves to acquire basis images
 - Focal spot blurring
- Detector may move
 - Increased detector blurring
 - Unique artifacts
- Image reconstruction
 - Artifacts
 - Image quality
- Multiple basis images are used for image reconstruction
 - Radiation dose
- Localization required in the depth direction
 - Geometric calibration

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On what timescale do things vary?

- In what phases of the QA process do these aspects need to be addressed?
 - Acceptance
 - Commissioning
 - Acceptability
- Comparison of QC metrics to baseline

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Moving X-ray source

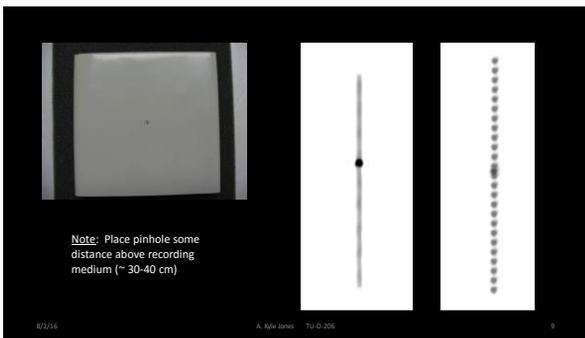
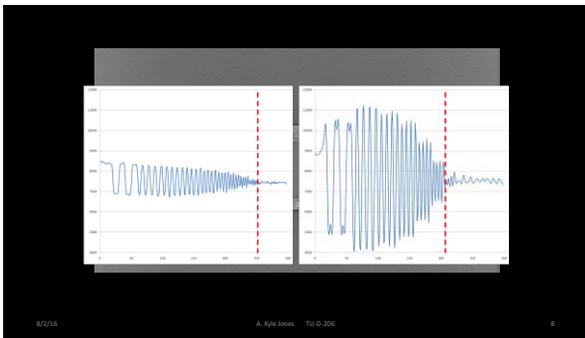
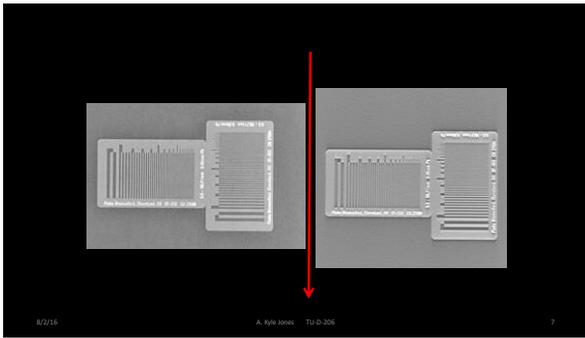
- Implication: focal spot blurring
- Evaluation: incorporate both focal spot blurring and receptor blurring in evaluation of tomosynthesis resolution
- Protocol optimization: compare expected blurring in object plane to pixel size and diagnostic task

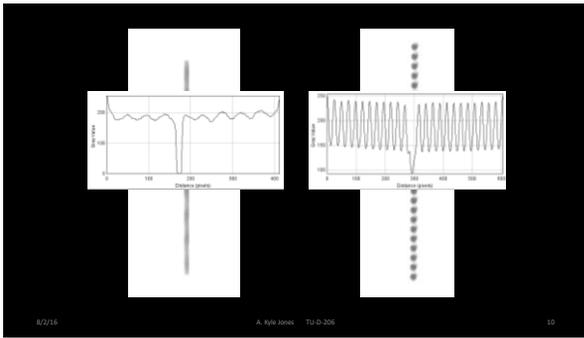
Zhao B and Zhao W. Med Phys 35:1978-1987 (2008)

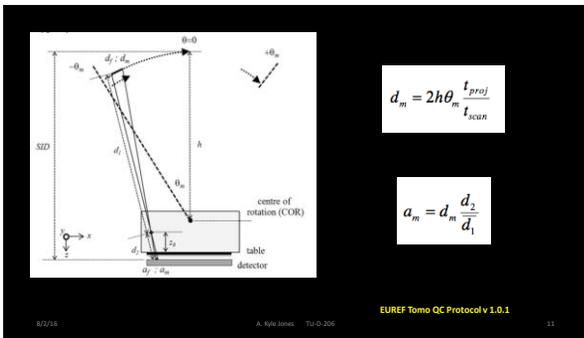
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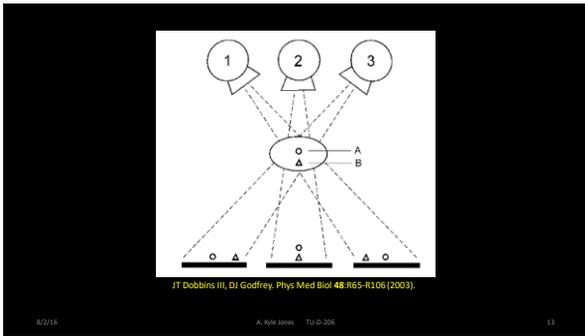






Geometry calibration

- For any system that reconstructs images from a series of projections, the imaging geometry must be known for each projection
- Calibration can be verified and/or projection-by-projection correction maps generated using phantoms



Geometry calibration

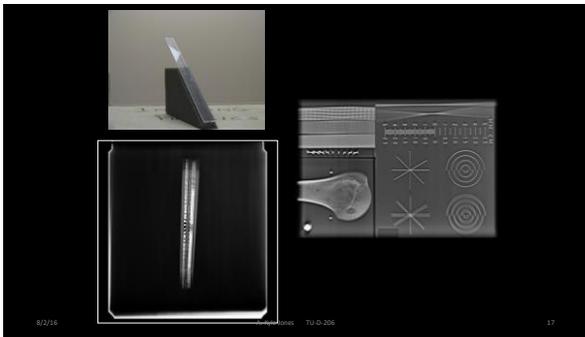
- Possible impacts
 - In-plane contrast
 - In-plane object localization
 - Depth localization
- In mammographic tomosynthesis, a fixed offset of 1.4° or an interprojection variability (SD) of 0.14° introduces a shift in object localization and contrast, respectively*

*Mainprize et al. Med Phys 38:3090 (2011)

Spatial accuracy

- Little discussion of spatial accuracy
 - No mention in the operator's manual of radiographic systems
 - Is part of tech QC (semi-annual) for one breast tomosynthesis manufacturer
- More of a potential concern for radiographic tomosynthesis systems?
 - SID calibration
 - Regulatory compliance is not sufficient
 - In fact, image plane accuracy may be the most sensitive SID evaluation we have!
 - Regular evaluation of in-plane contrast, location, and depth location





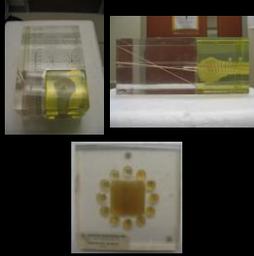
Artifact spread function

- Proposed by Wu in 2004 to quantify the intensity of out-of-plane artifacts in tomosynthesis
- Plots the out-of-plane signal as a function of distance from the plane in which the object is located

[Wu et al. Med Phys 31:2636-2647 \(2004\).](#)

Phantoms

- Littleton phantom
- "Number" phantom
- "Stack" phantom
- Angled wire
- Many other things



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Dosimetry

- Dosimetry paradigm:
 - Measure beam quality
 - Measure total EAK
 - Apply CF(bp, view, HVL)
- AAPM Report 223 addressed breast tomosynthesis
- Work on body tomosynthesis dosimetry is ongoing

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Published recommendations!

- NCRP 99 – the following performance aspects should be monitored
 - Section level
 - ± 5 mm accuracy
 - Level incrementation
 - ± 2 mm reproducibility
 - Section thickness
 - Limits established by comparing to baseline
 - Exposure angle
 - $\pm 5^\circ$ for angles greater than 30° , better for smaller angles
 - Exposure uniformity and pattern
 - Resolution
 - 40 mesh screen pattern resolved
 - Patient exposure
 - Should not vary by more than 20% between identical units

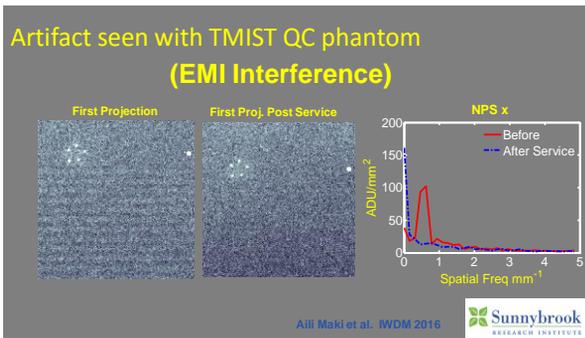
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Works in progress at AAPM

- TG 245: Task Group on Tomosynthesis Quality Control
- TG 223: Task Group on Dosimetry in Tomosynthesis Imaging
 - Report on dosimetry for breast tomosynthesis published
 - Report on dosimetry for body tomosynthesis forthcoming

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