

Slide 1

### Multi-Slice CT Artifacts and Quality Control



Dianna Cody, Ph.D.  
Chief, Radiologic Physics  
UT MD Anderson Cancer Center  
Houston, TX

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
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Slide 2

### What are the rules or recommendations for CT QC?

- AAPM SS 1995 (daily) & IPEM 91\* (daily or weekly)
  - CT Number of water
  - Image noise\*
- State rules or recommendations?

\*Institute of Physics & Engineering in Medicine



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Slide 3

### ACR CT Accreditation



- Continuous QC program must be established with aid of qualified medical physicist
- Physicist to determine test frequency
- Physicist to determine who performs tests



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Slide 4

 **ACR CT Accreditation**

- QC performed according to written procedures
- QC results monitored annually by medical physicist
- Corrective action documented for tests which fall outside limits
- Service records maintained

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Slide 5

What are the recommendations?

- Vendor specs? (criteria?)
- Minimal?
- Documentation standards?
- Action levels?



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Slide 6

How about an example of a CT QC Program?

- UT MD Anderson CT QC Program
  - Water phantom scans each morning
    - Automated numerical analysis off-line
    - Images reviewed for artifacts
    - Every scanner reviewed daily by physics QC tech
  - Air scan program being evaluated

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Slide 7

Why go to all this fuss?

- Serious problems with artifacts in past
- Limited to axial mode neuro studies
  
- Resulted in publication in Radiology
  - Radiology 236:756-761, 2005.
- Resulted in hiring physics techs
- Resulted in launching CT QC program

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Slide 8

CT Fleet at MDA

- Routine diagnostic CT scanners:
  - 2 64-slice
  - 7 16-slice
  - 4 4-slice
- Hybrid scanners
  - 4 PET/CT
  - 5 SPECT/CT
- Interventional CT scanners
  - 1 64-slice
  - 2 16-slice

15 scanners on QC  
8 scanners to add

White font: GE Healthcare  
Yellow font: Siemens Medical

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Slide 9

"Auto QC" Process

- Use QA protocol on water phantom
- Images automatically sent to computer
- Automatically placed into directory
- Numerical analysis automatically initiated
- (Similar program developed for MR)
  
- Artifact images reviewed manually

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**CT QC Scan Protocol**

- AXIAL only
- Numerical analysis:
  - 5mm thick, 240 mAs
  - Water & spatial res'l'n sections
- Artifact analysis:
  - THIN images
  - Cover detector surface
  - May require 2 image sets to achieve both

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**Numerical Analysis**

- Water values
  - Center - **MEAN, STD. DEV.**
  - Peripheral - **UNIFORMITY**
- Spatial Resolution section
  - Air, acrylic, water - **LINEARITY**
- Future?
  - Trend Analysis
  - Air Scan

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**Typical work flow**

- Morning CT Tech runs QA protocol
- Images are transferred and analyzed
- Physics tech evaluates results
- If results are outside criteria limit, QA image is re-acquired and re-analyzed
- Usually second time is a charm...

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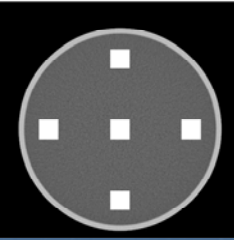
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### MSCT Daily QC Scan

- IDL used for image analysis
- CT# water  
 $0 \pm 3$  HU (GE)
- Uniformity Max Difference  
 $< 5$  HU (GE)
- Std Deviation  
 $< 5$  HU (GE)  
 $\leq 6$  HU (GE-VCT)



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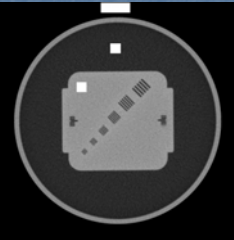
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### MSCT Daily QC Scan- Linearity

- Acrylic  
 $120 \pm 12$  HU
- Water  
 $0 \pm 5$  HU (MDA)
- Air  
 $-1000 \pm 20$  HU



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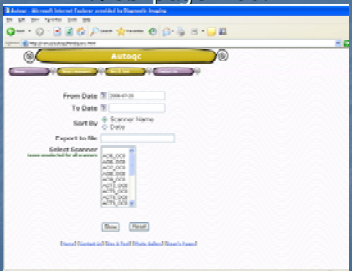
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### Web-page Tool



The screenshot shows a web browser window with a tool titled "Settings". It includes fields for "From Date" and "To Date", a "Search By" dropdown menu, and a "Report to file" section with a "Select operation" dropdown menu. The "Select operation" menu is open, showing a list of dates from 2008-01-01 to 2008-01-08. There are "Save" and "Cancel" buttons at the bottom.

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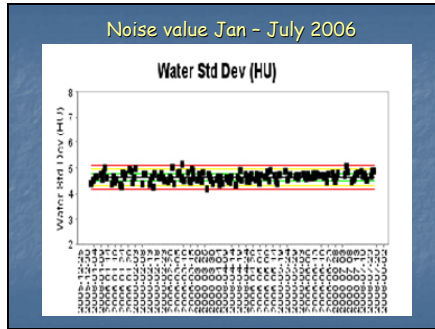
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- Main goal for numerical analysis QC
- Predict X-ray tube failure based on patterns of QC data over long term
  - So far, no patterns have emerged.
  - Has been quite helpful in establishing scanner performance
  - Especially when radiologists question image quality aspects of exams.

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- Artifacts
- Water phantom images sent to specific directories for each scanner
  - Water images reviewed every morning by dedicated physics technologist
  - Using NIH-Image for review
  - Currently reviewing ~400 images from the 15 scanners on board each day
  - Requires ~20-30 min from an experienced technologist (minimum)

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### Artifacts

- Why go through all that trouble???
- What an enormous pain in the neck!!!
- What is the payback from such a huge investment???



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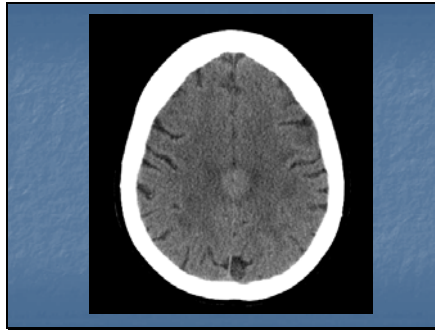
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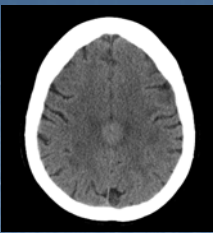
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- "Lesion" similar to Previous patient
- "Lesion" present on multiple images
- "Lesion" on every 4<sup>th</sup> image in stack
- 4-channel scanner

Previous patient went on to have an MR exam to characterize the "lesion"

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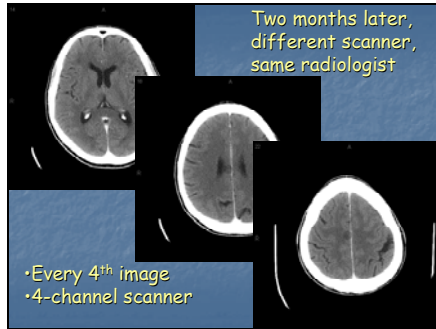
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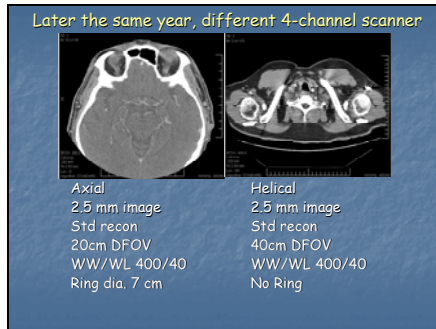
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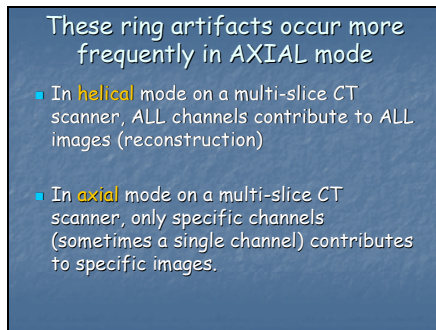
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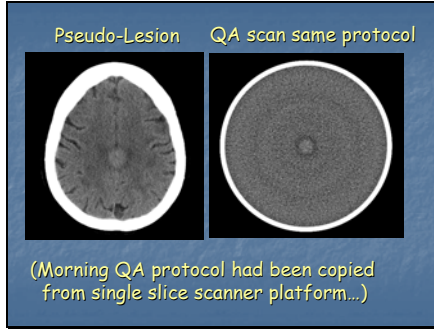
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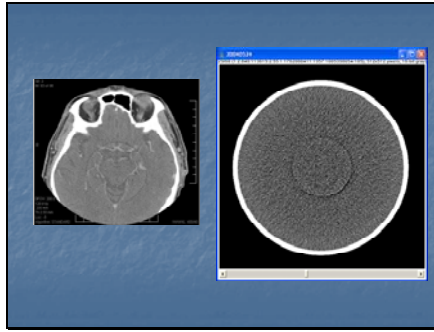
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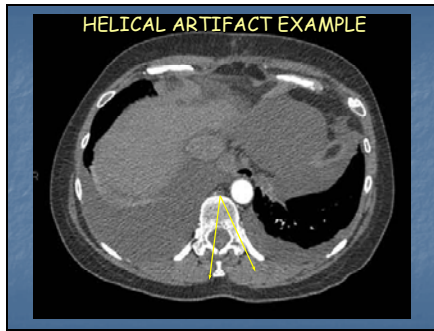
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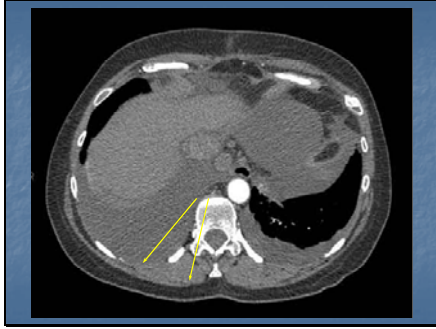
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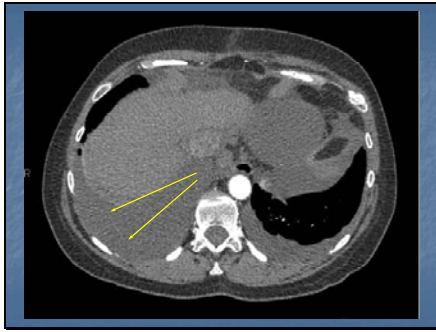
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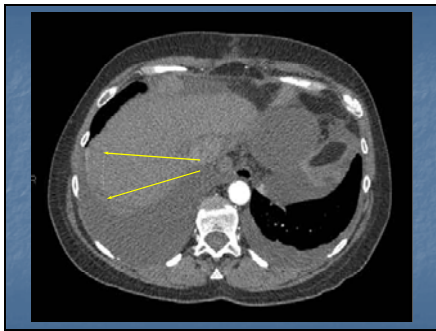
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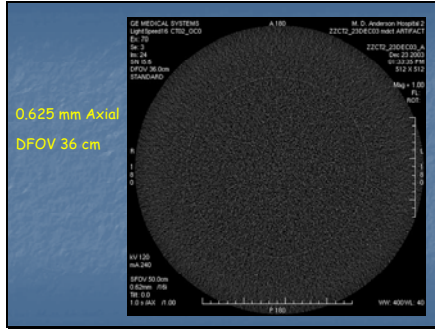
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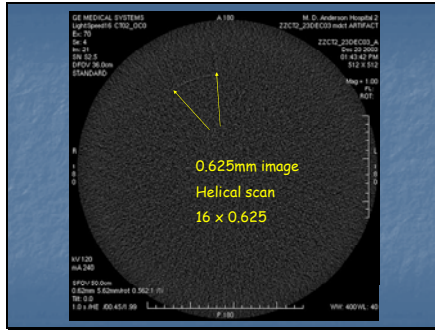
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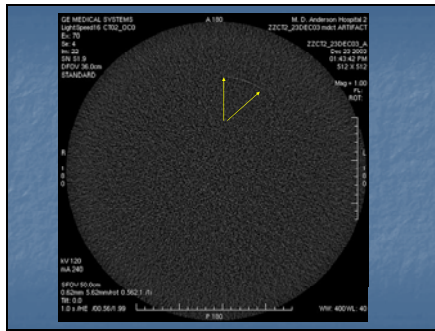
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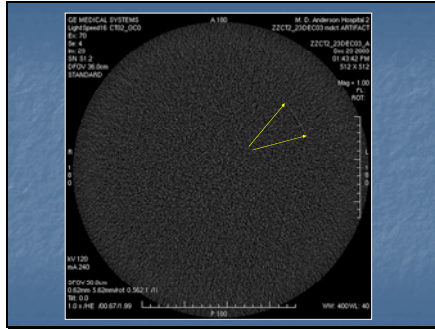
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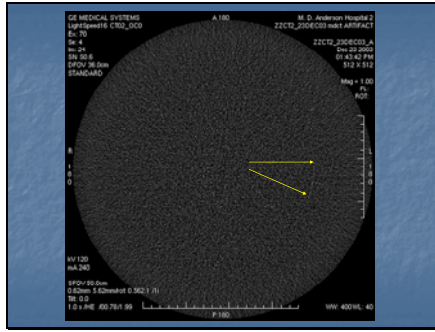
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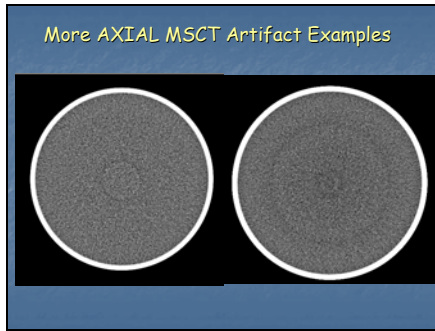
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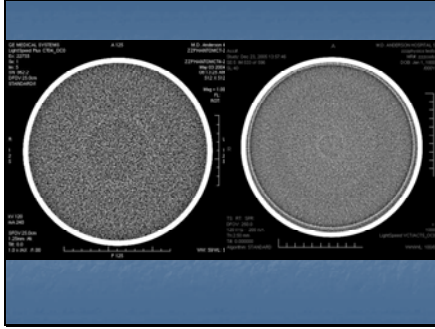
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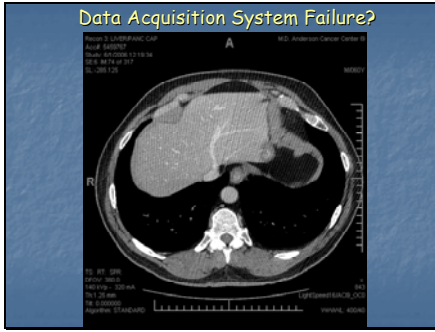
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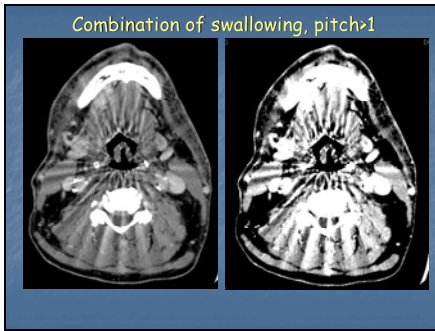
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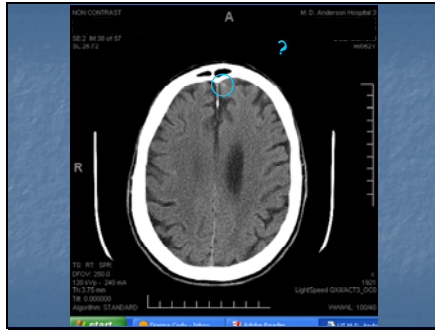
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Slide 45

**Physics QC Tech Program**

- Recruit recent graduates of physics or engineering programs (B.S.)
- "Face Time" in clinic - QC primary goal
- Train in all modality areas, rotate
  - CT
  - MR/US
  - Nuclear Medicine
  - General X-ray/Fluoro
  - (Hybrid)

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Slide 46

**CT QC worth all the fuss?**

- Extremely difficult to quantify benefits
- Service group noticed:
  - Service initiated by physics techs (not CT techs)
  - Identifying scanner problems sooner
  - Fewer 'scanner down' situations
  - Service can be scheduled during weekdays
  - Avoids expensive overtime charges
- Overall image quality improved (?)

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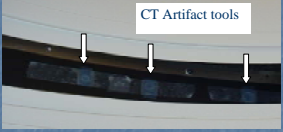
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Slide 47

**Air Scan Project**  
Rachel Liu, Ph.D., Donna Stevens, M.S.



Diluted clinical contrast medium (gunk)  
(Optiray 320)  
Attached to detectors

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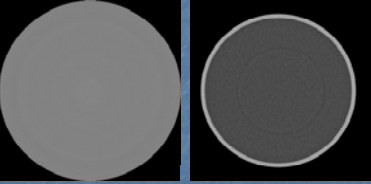
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With GUNK on detectors,  
AFTER Air Calibrations ("fast cal"):

Air Scan - looks fine    Water QA - uh oh



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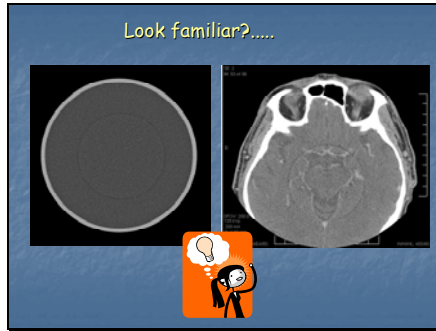
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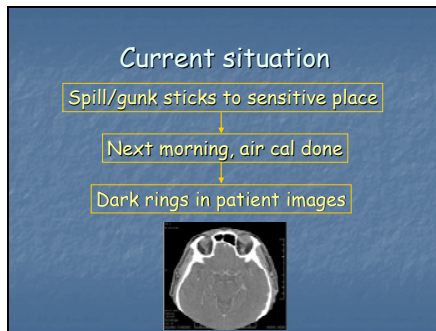
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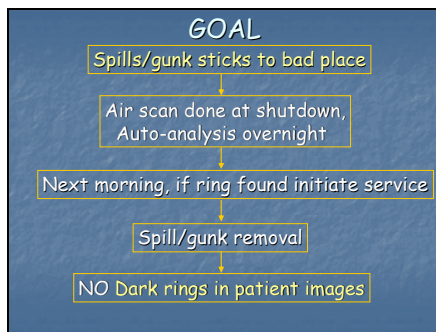
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Slide 52

Easy to detect air scan rings?

ww: 300  
wl: -1000



(Same gunk)

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Slide 53

Work in progress...

- Will require change in CT technologist routine at end of shift
- Will require programming to detect rings
- Will require quick response by service engineers to locate and remove gunk
- SHOULD result in further improvement in patient image quality...

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THE END

- Thanks to AAPM
- Thanks to co-workers
  - Donna Stevens, M.S.
  - Rachel Liu, Ph.D.
- OUTSTANDING Physics tech team
  - Brad Lofton
  - Adam Springer
  - David Zamora
  - Tony Blatnica
  - Brandon Darensbourg
  - Mike Silosky



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