

QC in the ACR CTAP

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Introduction

- ◆ QC is essential for the consistent production of quality images
- ◆ Documentation is essential
- ◆ Active, not passive
- ◆ Does not need to be time-consuming

Manufacturer Programs

- ◆ Manufacturers required to provide QC phantom and recommendations [21 CFR Ch. 1 §1020.33(d)]
 - ◆ Contrast scale
 - ◆ Noise
 - ◆ Nominal tomographic section thickness
 - ◆ Spatial resolution - high and low contrast
 - ◆ Mean CT number - water or reference material

The Rest Might Be A Lie!



Renovated CT Submission

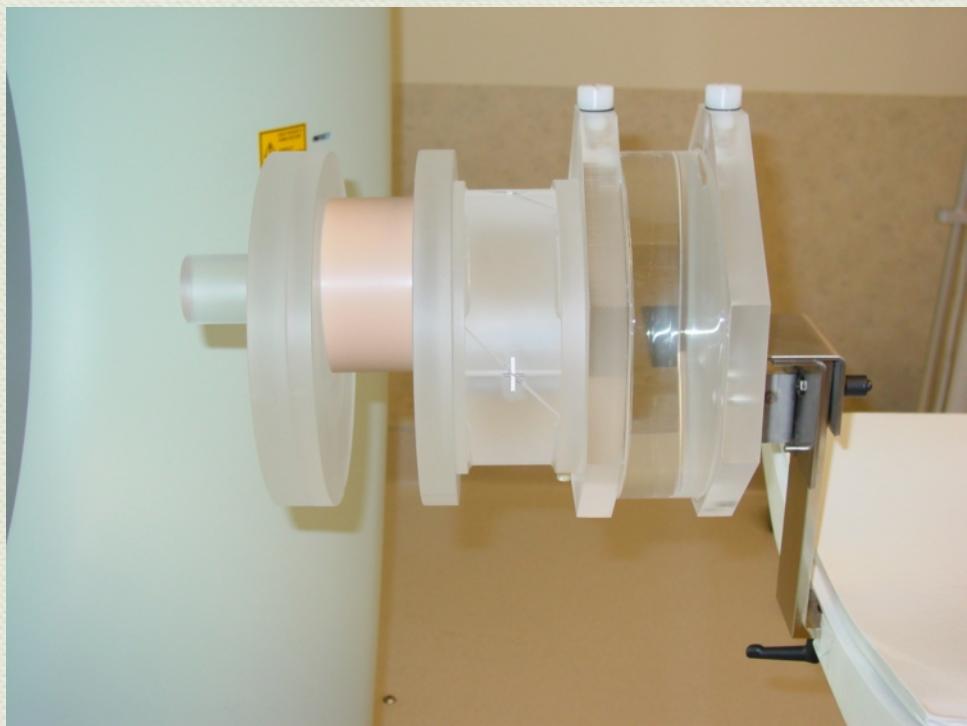
- ◆ CTAP submission WILL be changed
 - ◆ Streamlined process
 - ◆ No alignment test
 - ◆ No reconstructed scan width test
 - ◆ Scan phantom using clinical protocols
 - ◆ Adult head, abdomen
 - ◆ Pediatric head, abdomen

Renovated CT Submission

- ◆ Streamlined process...
- ◆ Submit DICOM data on CD
 - ◆ MRI model
- ◆ For now, dosimetry will remain the same
- ◆ Low contrast transitioning to CNR
- ◆ Spatial resolution going away

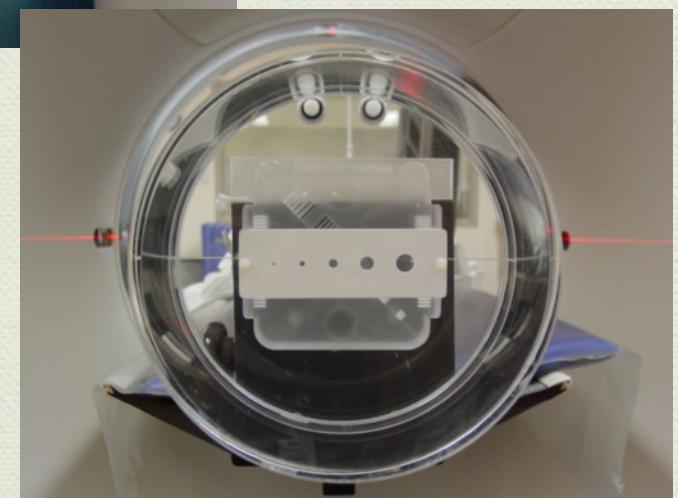
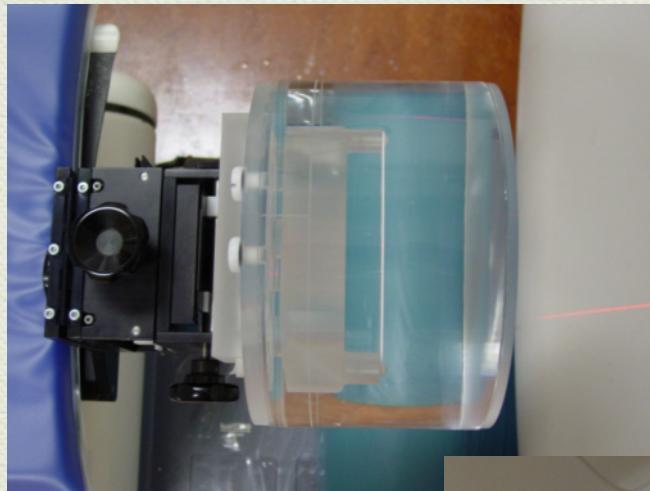
Siemens

- ◆ Measures
 - ◆ Slice position
 - ◆ Slice thickness
 - ◆ CT number homogeneity
 - ◆ Noise
 - ◆ Water CT number
 - ◆ MTF
 - ◆ Table positioning
- ◆ After alignment, scanner automatically scans phantom, computes, logs data



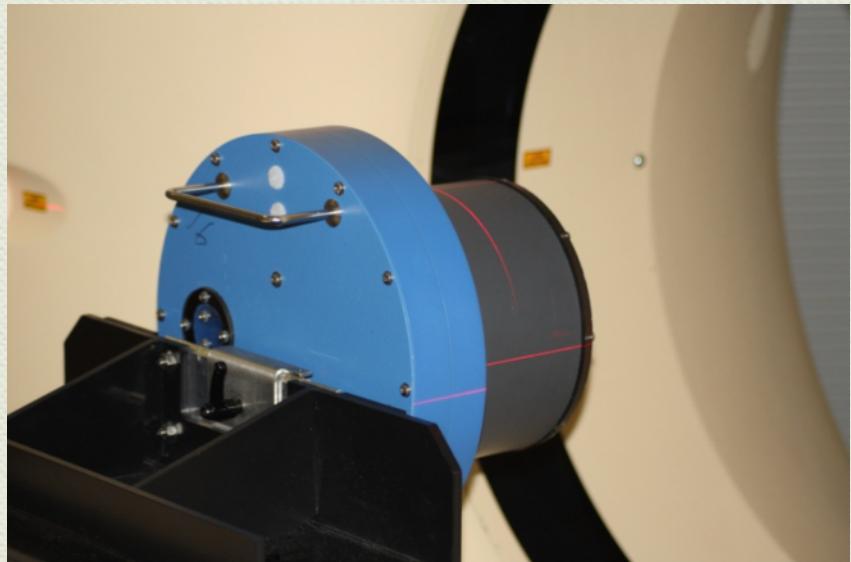
General Electric

- ◆ Measures
 - ◆ Slice position
 - ◆ Slice thickness
 - ◆ Spatial resolution
 - ◆ Low contrast
 - ◆ Noise
 - ◆ Water CT number
- ◆ Manual scan, calculation, documentation



Philips

- ◆ Measures
 - ◆ Slice Thickness
 - ◆ Noise & Uniformity
 - ◆ “Impulse Response” (MTF)
 - ◆ Contrast Scale
 - ◆ Low Contrast Detectability
 - ◆ Spatial Measurement Accuracy
- ◆ Manual scan of each module, automated analysis



Toshiba

- ◆ Multiple phantoms
- ◆ Measure
 - ◆ Slice Thickness
 - ◆ Noise & Uniformity
 - ◆ “Impulse Response” (MTF)
 - ◆ Contrast Scale
 - ◆ Low Contrast Detectability
 - ◆ Spatial Measurement Accuracy
- ◆ Manual scan, manual analysis



Technologist QC

- ◆ Image Quality
 - ◆ High contrast (spatial) resolution
 - ◆ Low contrast resolution
 - ◆ Image uniformity
 - ◆ Noise
 - ◆ Artifact evaluation
- ◆ Alignment light accuracy
- ◆ Slice thickness
- ◆ CT number accuracy and homogeneity
- ◆ Display devices
- ◆ Frequency determined by QMP

We're not allowed to specify any less than what's in the standards!

Personnel

- ◆ Best to identify a single individual
 - ◆ Greater consistency
 - ◆ Improved sensitivity to problems
- ◆ QC must be completed, regardless of individual
- ◆ Appropriate training must be provided

QC Notebook

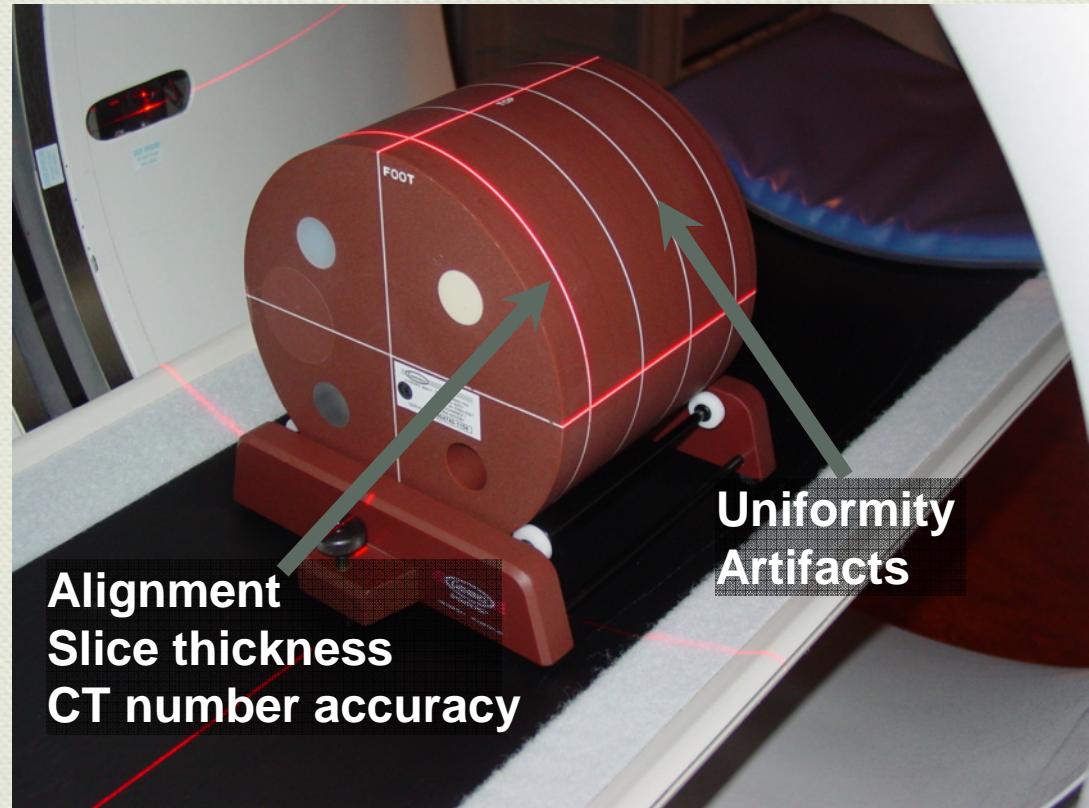
- ◆ QC policies and procedures
- ◆ Data forms for each test
- ◆ Area for comments and communications
- ◆ Service engineer should also utilize the notebook
- ◆ Data reviewed at least annually by physicist
- ◆ Supervising physician should also review

Procedures

- ◆ Daily
- ◆ Recommendations provided
- ◆ Alternatives acceptable
 - ◆ Manufacturer specific
 - ◆ Automated systems
 - ◆ As recommended by Qualified Medical Physicist

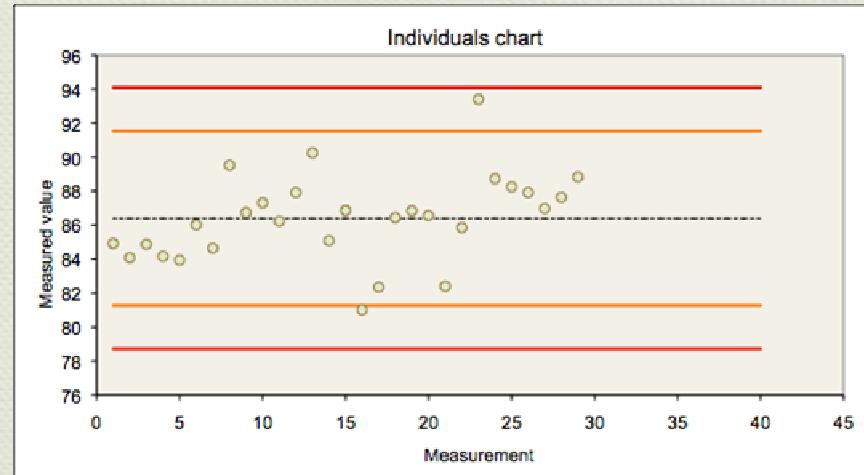
ACR Accreditation Phantom

- ◆ RMI Model 464



Action Limits

- ◆ Must be established for each test
- ◆ Over time, limits may be tightened based on scanner performance
- ◆ Medical physicist should establish and make recommendations at review

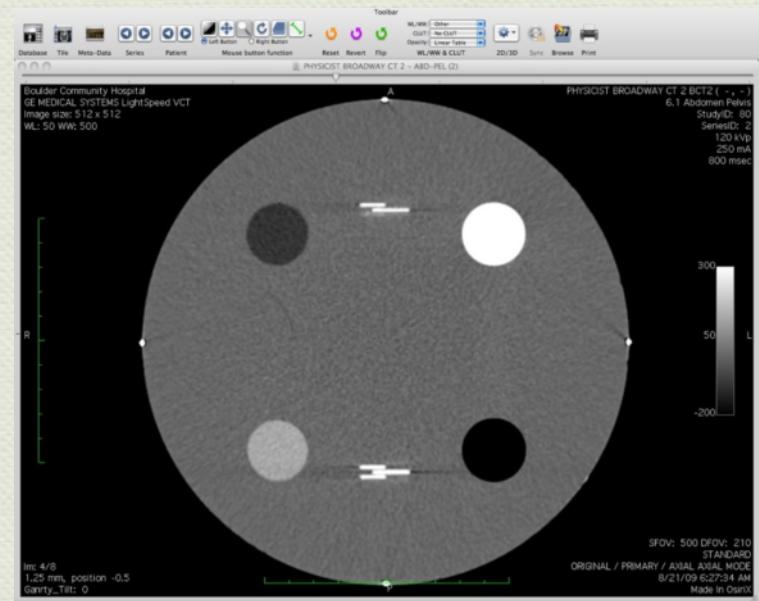


Alignment Light Accuracy

- ◆ Position phantom
 - ◆ If manufacturer's (MFG), use manufacturer's holder
 - ◆ If ACR, place on table or use optional stand
 - ◆ Use alignment lights
- ◆ Scan phantom
 - ◆ MFG: Use manufacturer protocol
 - ◆ ACR: Adult head technique
 - ◆ Thin slice: ~1 mm

Alignment Light Accuracy

- ◆ Action limits
 - ◆ MFG
 - ◆ Use manufacturer limits
- ◆ ACR
 - ◆ ± 2 mm
- ◆ Correction within 30 days

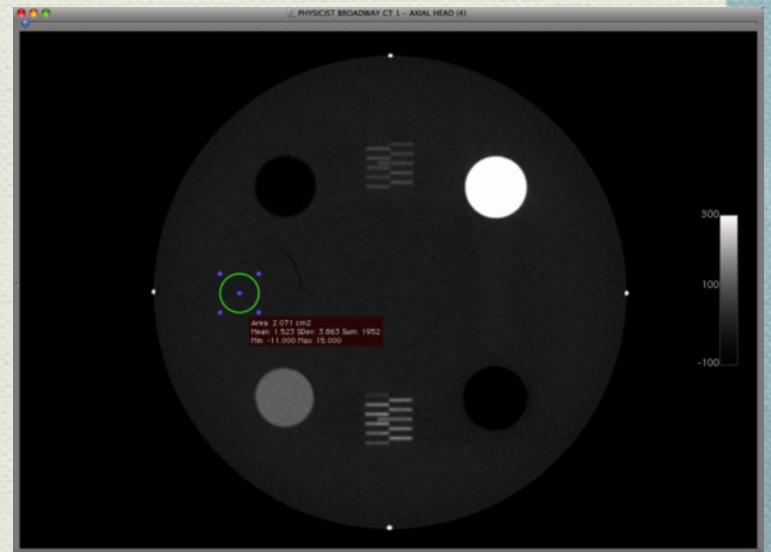


CT Number Accuracy and Noise

- ◆ Warm up scanner per manufacturer recommendations
- ◆ Perform air calibrations per manufacturer recommendations
- ◆ Position phantom
 - ◆ If manufacturer's (MFG), use manufacturer's holder
 - ◆ If ACR, place on table or use optional stand
 - ◆ Use alignment lights

CT Number Accuracy and Noise

- ◆ Scan phantom
 - ◆ MFG: Use manufacturer protocol
 - ◆ ACR: Adult head technique
 - ◆ Recommend both helical and axial
 - ◆ Consider alternating modes each day
- ◆ Place ROI on image
 - ◆ 400 mm²
 - ◆ Same location each time
 - ◆ Same slice if multi-slice

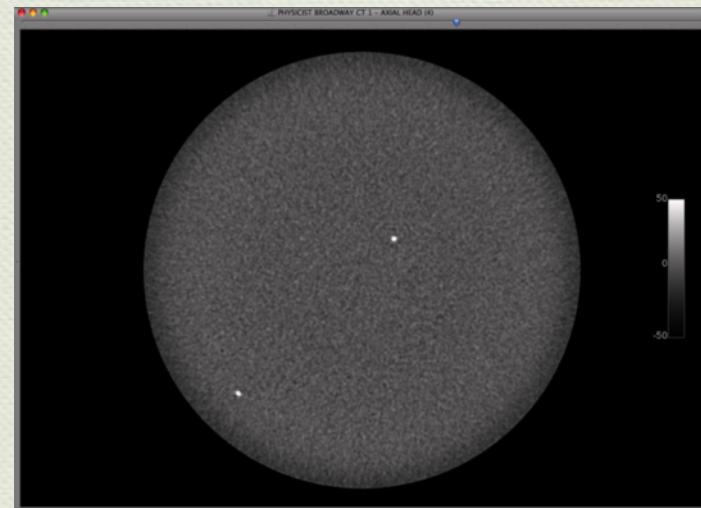


CT Number Accuracy and Noise

- ◆ Action limits
 - ◆ MFG
 - ◆ Use manufacturer limits
 - ◆ ACR
 - ◆ Water value: 0 ± 5 HU
 - ◆ Noise: Limits must be established by the medical physicist based on the scan protocol used
- ◆ Schedule service if either value exceeds action limits 3 days in a row or 3 times in one week

Artifact Analysis

- ◆ Position phantom
- ◆ Scan parameters (assume approx. 16 cm water)
 - ◆ Axial
 - ◆ 120 kVp
 - ◆ 350 mAs
 - ◆ Maximum number of slices possible
 - ◆ Want to check every data channel
 - ◆ 320 slices?
 - ◆ Helical
 - ◆ 120 kVp
 - ◆ 350 mAs
 - ◆ Reconstruct to about 2.5 mm



Artifact Analysis

- ◆ Visual analysis
 - ◆ Window width ≈ 100
 - ◆ Window level ≈ 0
 - ◆ Rings, streaks, lines
 - ◆ Record all findings



Artifact Analysis

- ◆ Corrective action
 - ◆ While still sub-clinical
 - ◆ Re-run air calibrations
 - ◆ Often cover just a sub-set of scan conditions
 - ◆ May need to run several times
- ◆ If still present
 - ◆ Determine if scanner can be used
 - ◆ Radiologist, medical physicist
 - ◆ Limited use?
 - ◆ Schedule service

Artifacts





Laser Printer QC

- ◆ NEMA
 - ◆ Density Constancy
 - ◆ Making measurements on the TG18-QC or SMPTE test pattern, four density steps. For dry development systems that are self-calibrated, this test should be performed weekly. For wet processing systems, this test should be performed **daily**.
 - ◆ Fixer Retention
 - ◆ A fixer retention test is required only for wet processing systems. Similar to that for conventional film processing systems.
 - ◆ Low-Contrast Visibility
 - ◆ An image containing low contrast objects in a background of known surrounding densities should be analyzed **semi-annually** to ensure that low contrast objects are accurately reproduced.

Laser Printer QC

- ◆ NEMA (continued)
 - ◆ Spatial Resolution
 - ◆ An image containing high contrast spatial resolution targets should be analyzed **semi-annually** to ensure that fine details can be adequately visualized.
 - ◆ Darkroom Fog
 - ◆ If darkroom used. The applicable MQSA regulation [21 CFR 900.12(e)(4)(i)] for conventional film processors must be followed.
 - ◆ Artifact Analysis
 - ◆ Images including large areas of uniform mid-density, such as the AAPM TG18-UN or TG18-UNL, should be reviewed **annually** for such artifacts.

Laser Printer QC

- ◆ Very few wet lasers left in the field
- ◆ Dry lasers generally have self-calibration feature
- ◆ Is QC necessary?

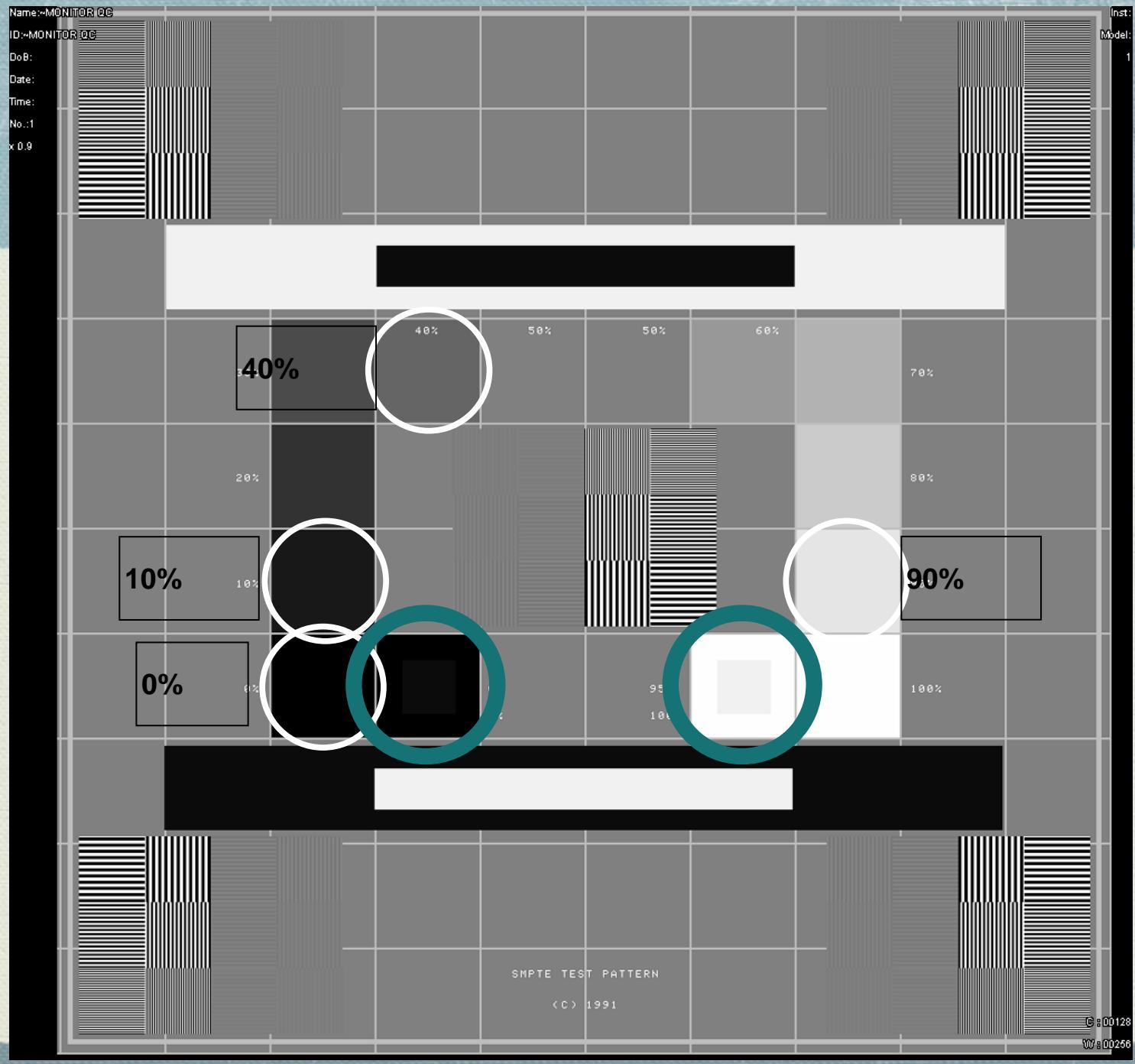
YES!

Laser Printer QC

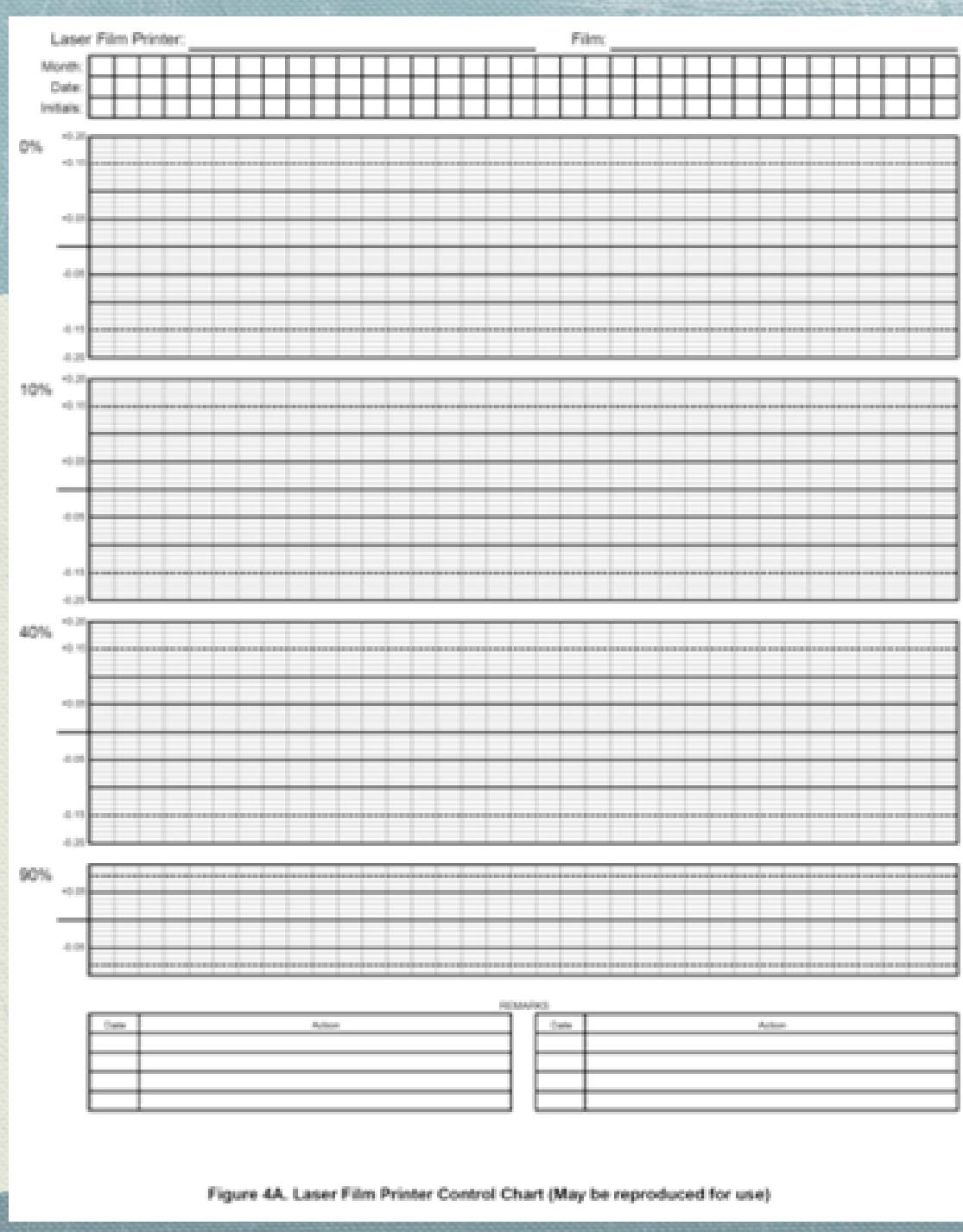
- ◆ Case study
 - ◆ Kodak 8700 laser printer
 - ◆ Self-calibration performed on schedule
 - ◆ QC not performed
 - ◆ Got complaints regarding image quality
 - ◆ Sensitometric curve significantly different from same model
 - ◆ Internal densitometer had drifted and needed replacement
- ◆ Recommend **monthly** QC

Laser Printer QC

- ◆ Visual analysis
 - ◆ 5%, 95% patches visible
- ◆ Quantitative analysis
 - ◆ Measure 0%, 10%, 40%, 90% squares
 - ◆ Plot values
 - ◆ Action limits of ± 0.15 from operating level



From the ACR MRAP QC Manual



Follow Up

- ◆ Quality control must be active, not passive
- ◆ Data must be analyzed immediately
- ◆ All results must be logged or plotted
- ◆ Corrective action must be taken promptly

Oversight

- ◆ The QMP should review the QC data at least annually
 - ◆ Be visible
 - ◆ Be accessible
- ◆ Data should be presented to the service engineer
- ◆ Radiologists must be involved
 - ◆ Reporting artifacts

Phantoms

- ◆ Manufacturer
 - ◆ Designed specifically for unit
 - ◆ Automated testing
 - ◆ May not allow all “physics” measurements
- ◆ ACR CT Accreditation
 - ◆ Good general, all purpose phantom
 - ◆ Direct comparison to ACR standards
- ◆ Phantom Lab
 - ◆ “Gold standard”
 - ◆ Many advanced measurement capabilities



Physicist Tests



- ◆ Alignment light accuracy
- ◆ Alignment of table to gantry
- ◆ Gantry tilt
- ◆ Slice localization from scanned projection radiograph (localization image)
- ◆ Table incrementation accuracy
- ◆ Slice thickness
- ◆ Image quality
 - ◆ High-contrast (spatial) resolution
 - ◆ Low-contrast resolution

Physicist Tests



- ◆ CT number accuracy and linearity
- ◆ Display devices
 - ◆ Video display
 - ◆ Hard-copy display
- ◆ Dosimetry
 - ◆ Computed tomography dosimetry index (CTDI)
 - ◆ Patient radiation dose for representative examinations
- ◆ Safety evaluation
 - ◆ Visual inspection
 - ◆ Audible/visual signals
- ◆ Postina requirements

Contrast Scale

$$CS = \frac{(\mu_r - \mu_w)}{(CT_r - CT_w)}$$

where r, w refer to reference material and water, respectively

- ◆ Must accurately know μ_r
- ◆ μ_r and μ_w are constant
- ◆ If CT_r and CT_w constant, CS constant
- ◆ Not used

Gantry-Table Alignment

- ◆ Fixed at installation
- ◆ Earthquake? MVA?
- ◆ Determine exact midline of cradle
- ◆ Verify that sagittal alignment light remains within ± 5 mm of cradle midline as couch translates

Scatter Survey

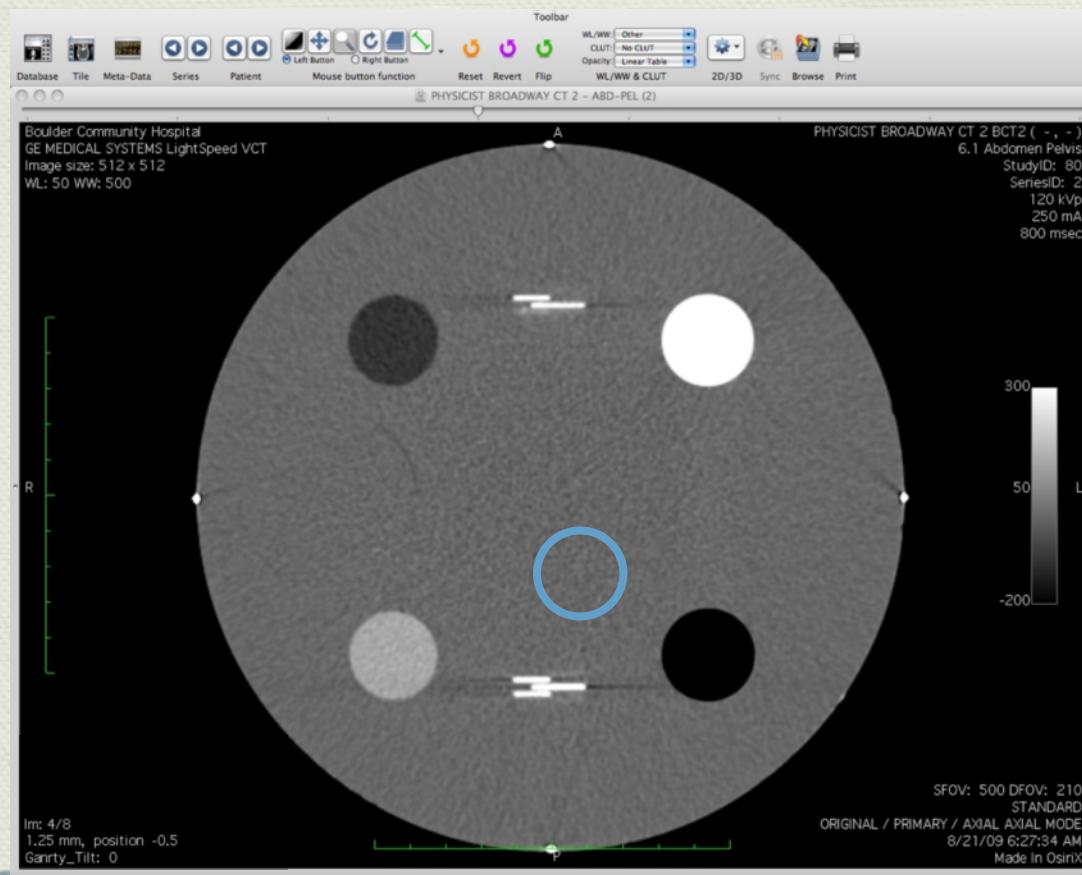
- ◆ Should not change with time
- ◆ Worst case
 - ◆ Large dosimetry phantom
 - ◆ Maximum radiation beam width
 - ◆ High mAs, 140 kVp

Alignment Light Accuracy

- ◆ Most important when biopsies are performed
- ◆ Required Test Equipment
 - ◆ Phantom incorporating externally visible radiopaque fiducial markers or an image center indication (ACR CTAP Phantom Module 1)
- ◆ Test Procedure Steps
 1. Using the alignment lights, carefully position the phantom to the radiopaque markers in all three orthogonal planes.
 2. Zero the table location indication.
 3. Scan the phantom in axial mode, using a reconstructed scan width less than 2 mm at the zero position. Use technique to allow accurate visualization of the fiducial markers; for most phantoms, the Adult Abdomen technique works well.
 4. Useful to scan also at ± 0.5 , ± 1.0

Alignment Light Accuracy

◆ Data evaluation

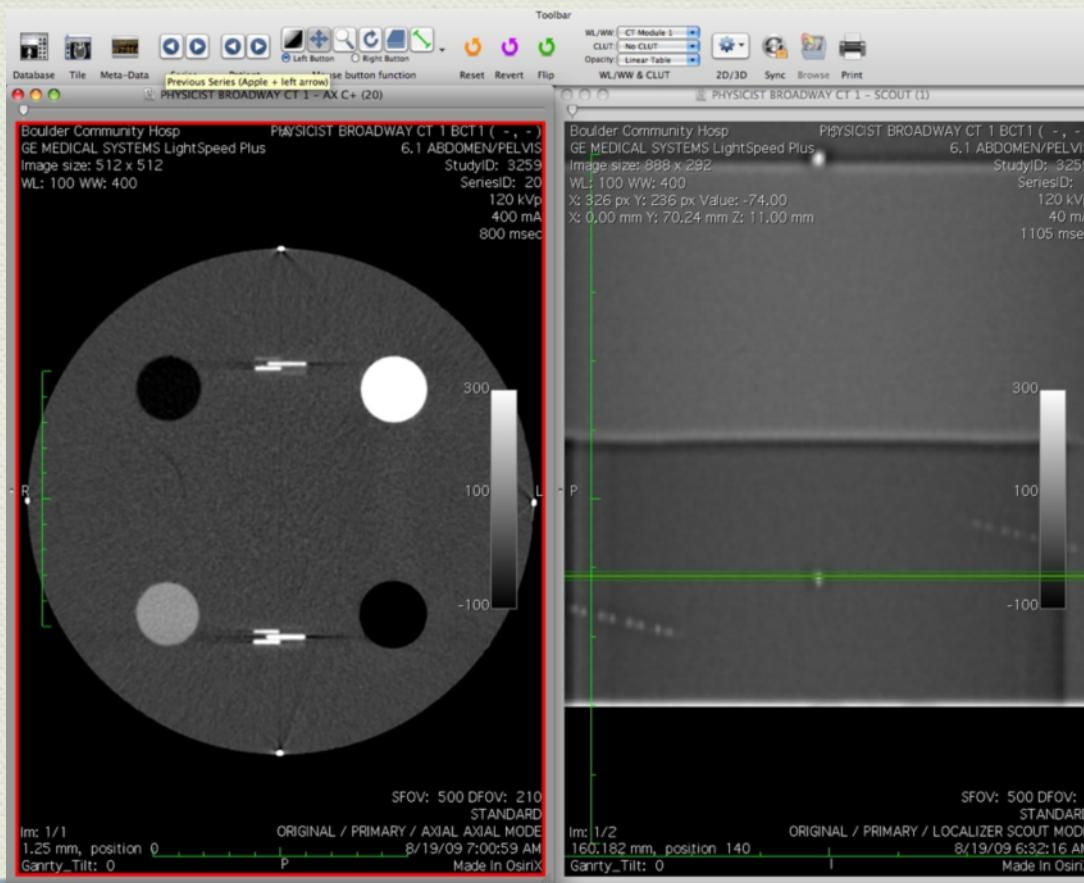


Scout Prescription Accuracy

- ◆ Required Test Equipment
 - ◆ Phantom incorporating radiopaque fiducial markers or an image center indication (ACR CTAP Phantom Module 1)
- ◆ Test Procedure Steps
 1. Scan the entire phantom in scout mode.
 2. Magnify the image, if possible, and position a single cut at the location of the radiopaque fiducial markers.
 3. Perform an axial scan using a reconstructed scan width less than 2 mm, or as thin as the scanner can produce in axial mode.

Scout Prescription Accuracy

◆ Data Evaluation



Slice Thickness

- ◆ Detected / Reconstructed scan width
 - ◆ Rarely an issue
- ◆ Radiation beam width
 - ◆ Often an issue

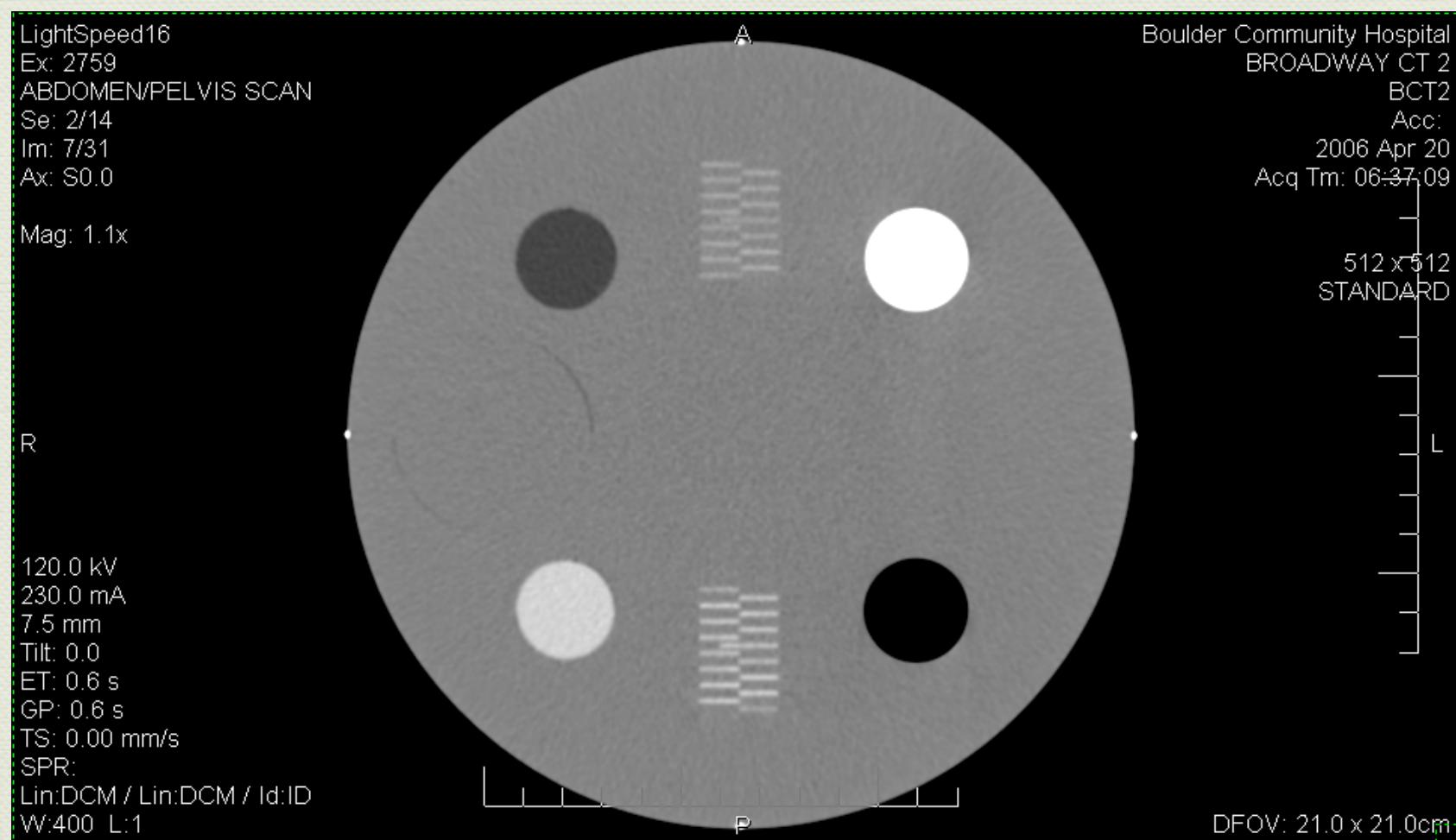
Reconstructed Scan Width

- ◆ Required Test Equipment
 - ◆ Phantom with internal targets allowing determination of reconstructed image thickness (Module 1 of the ACR CTAP Accreditation Phantom)
- ◆ Test Procedure Steps
 1. Align the phantom to the reconstructed image thickness determination targets in the phantom.
 2. Using zero table increment and techniques adequate to allow unambiguous visualization of the targets (for most phantoms, 120 kVp, 200 mAs is adequate), scan the phantom in axial mode using each reconstructed image thickness used clinically
 - ◆ As many different data channel (detector) configurations should be used as possible.

Reconstructed Scan Width

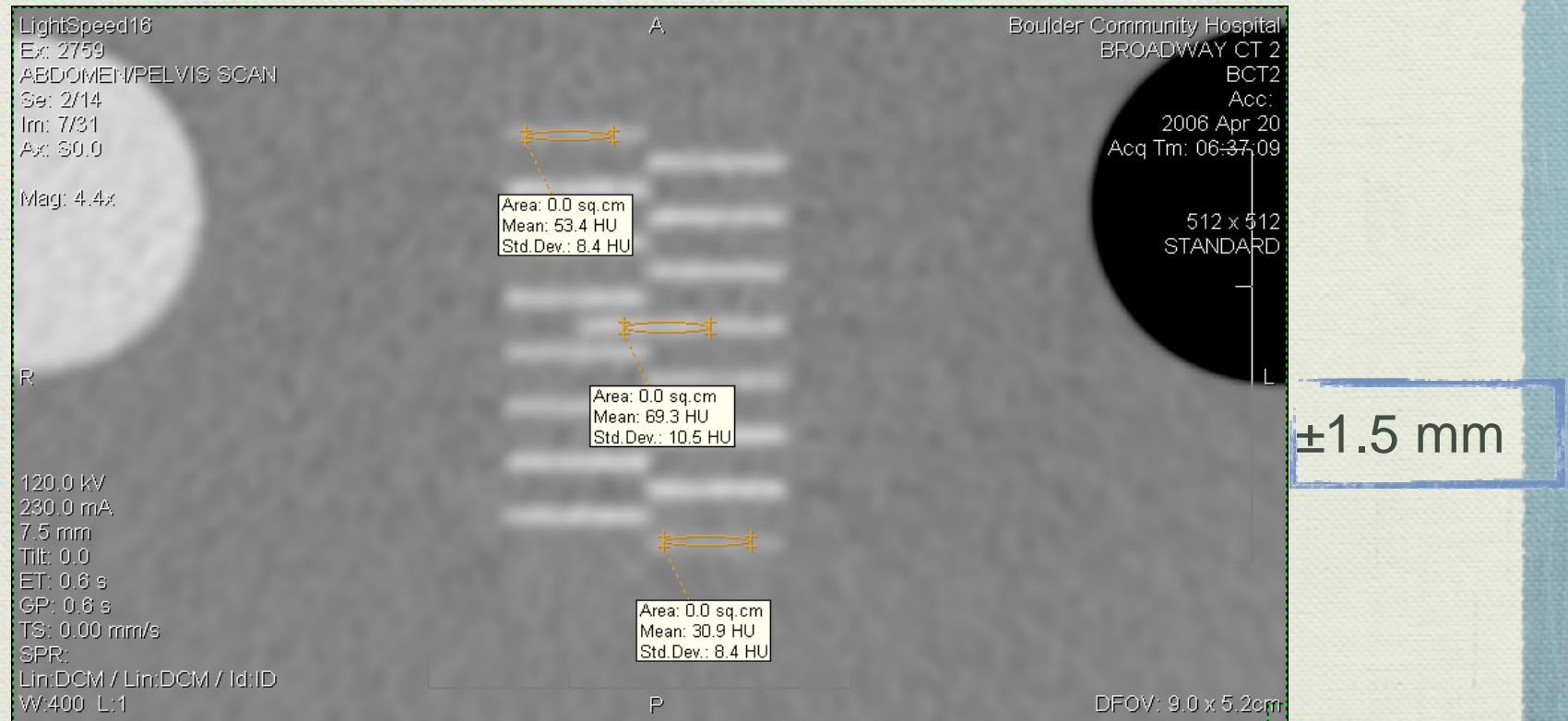
- ◆ Data Interpretation and Analysis
 - ◆ View the axial images collected above
 - ◆ Determine the reconstructed image thickness of each nominal thickness tested
 - ◆ For the ACR CTAP Phantom, each line represents $\frac{1}{2}$ mm thickness
 - ◆ Count each line that is at least 50% of the brightness of the brightest line

Reconstructed Scan Width



Reconstructed Scan Width

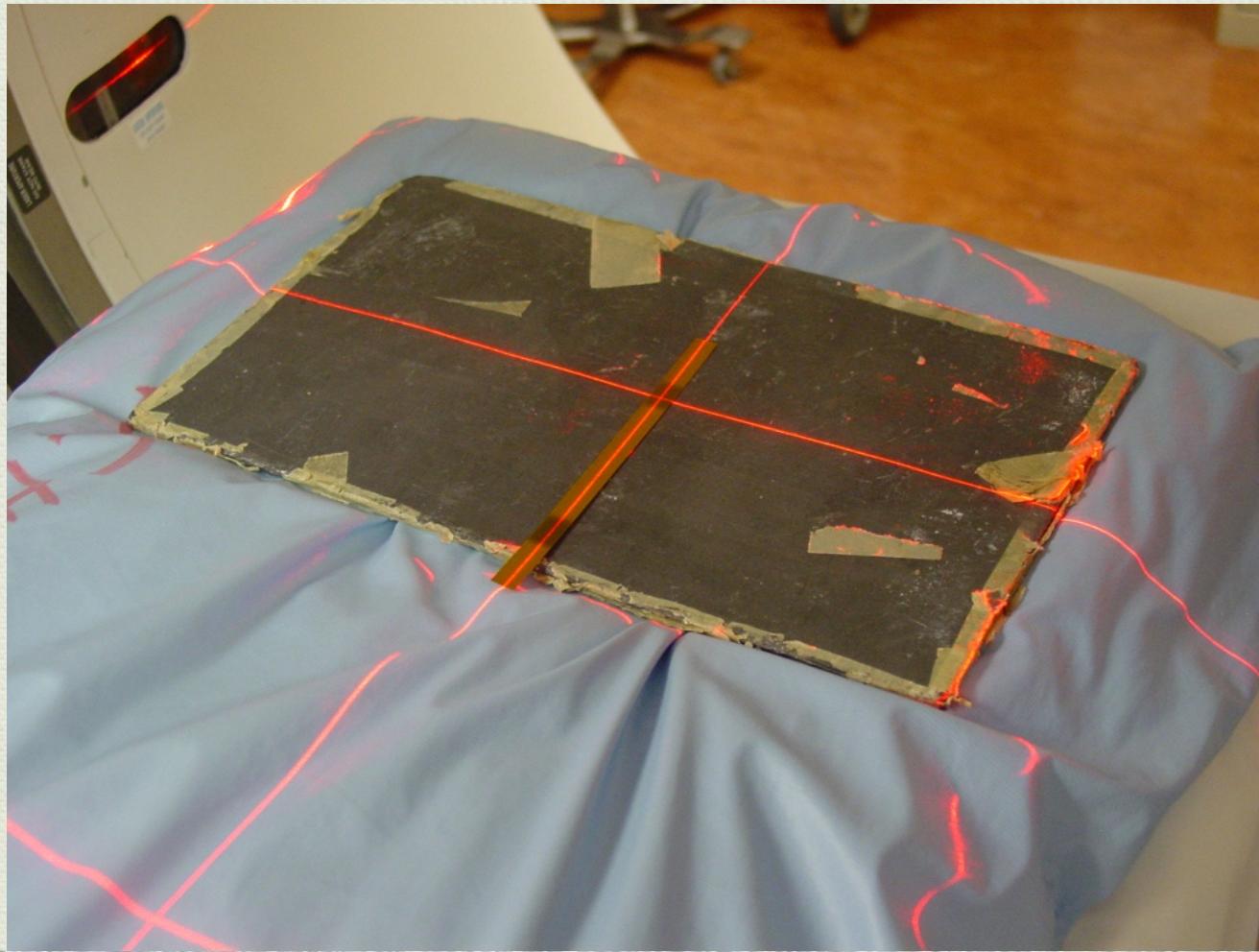
- ◆ Count if half the brightness of the brightest



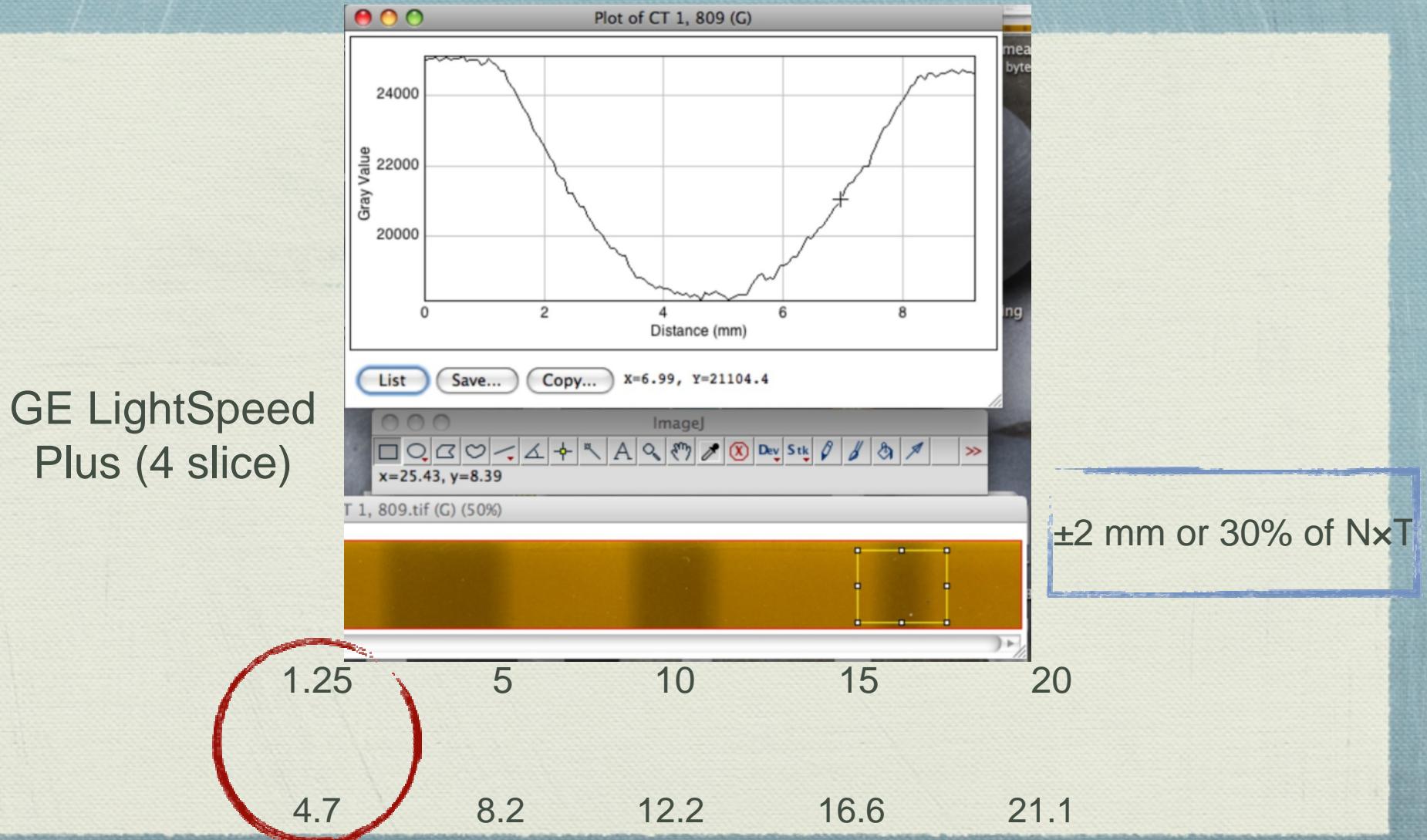
Radiation Beam Width

- ◆ Required Test Equipment
 - ◆ External radiation detector (CR plate, self-developing film, electronic test tool)
 - ◆ Flat radiation attenuator (1/8" lead)
- ◆ Test Procedure Steps
 1. Place the radiation attenuator on the table, unless contra-indicated by the test device being used.
 2. Place the external radiation detector on the flat attenuator.
 3. Adjust the table height so that the external radiation detector is at the isocenter.
- ◆ Scan using each unique NxT combination available, adjusting table position as appropriate for the beam width being used.

Radiation Beam Width



Radiation Beam Width



Radiation Beam Width

- ◆ Data Interpretation and Analysis
 - ◆ Using a method appropriate for the external radiation detector used, determine the actual radiation beam width for each unique NxT combination. For film and CR-based measurements, determination should be made at the full width at half maximum (FWHM).
- ◆ Precautions and Caveats
 - ◆ Many manufacturers have standards that are in excess of the criteria stated below. It has been the experience of the ACR CTAP Physics Subcommittee that most scanners can be calibrated to meet these tighter standards.
 - ◆ The above notwithstanding, scanners may exhibit over-beaming that can impact these tolerances.

Table Travel Accuracy

- ◆ Required Test Equipment
 - ◆ Phantom with two sets of external fiducial markers of known separation (ACR CTAP Phantom Modules 1 and 4)
 - ◆ If possible, additional weight on the table to simulate the weight of a typical patient.
- ◆ Test Procedure Steps
 1. Using the alignment light, carefully position the phantom to the first set fiducial markers in the axial plane.
 2. Zero the table position indication.
 3. Move the table to the second set of external fiducial markers.
 4. Record the table position.
 5. Translate the table to full extension and return to the first set of fiducial markers.
 6. Record the table position.

Table Travel Accuracy

- ◆ Data Interpretation and Analysis
 - ◆ Using the number recorded in Step 4, Compare the distance between the fiducial markers as determined by the table travel to the known distance.
 - ◆ Compare the number recorded in Step 6 to the zero position.
- ◆ Precautions and Caveats
 - ◆ Some scanners have specific limitations on the extent of table travel under which the performance specifications are valid. Scanner-specific limitations must be noted.

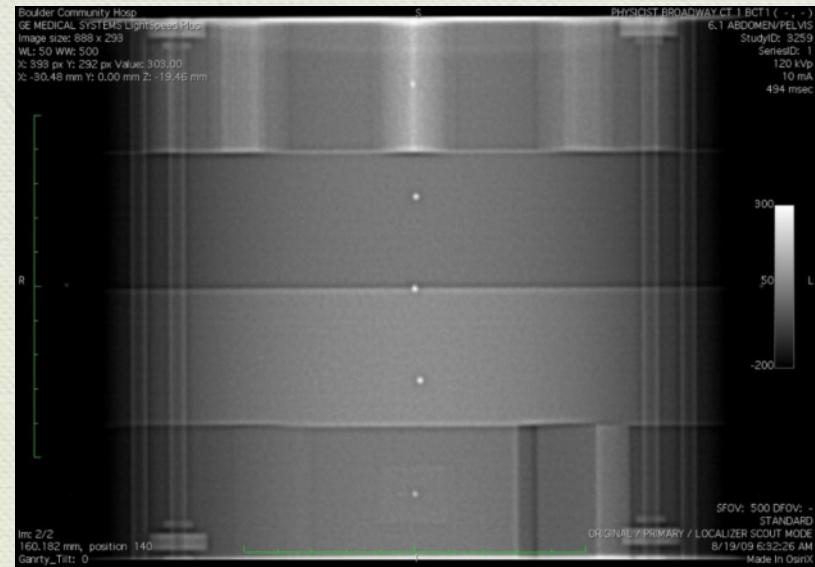
Gantry Tilt

- ◆ Required Test Equipment
 - ◆ “Ready Pack” film or CR image recording device
 - ◆ Protractor
 - ◆ OR phantom with radiopaque markers appropriately placed
- ◆ Test Procedure Steps
 1. Position the image recording device parallel to the sagittal laser, perpendicular to the scan plane
 1. It is helpful to use an acrylic slab
 2. Expose the film at various gantry angles
 1. Use ~1 mm image width
 2. Include +, - and 0
 3. Process the image
 4. Measure the angles with a protractor

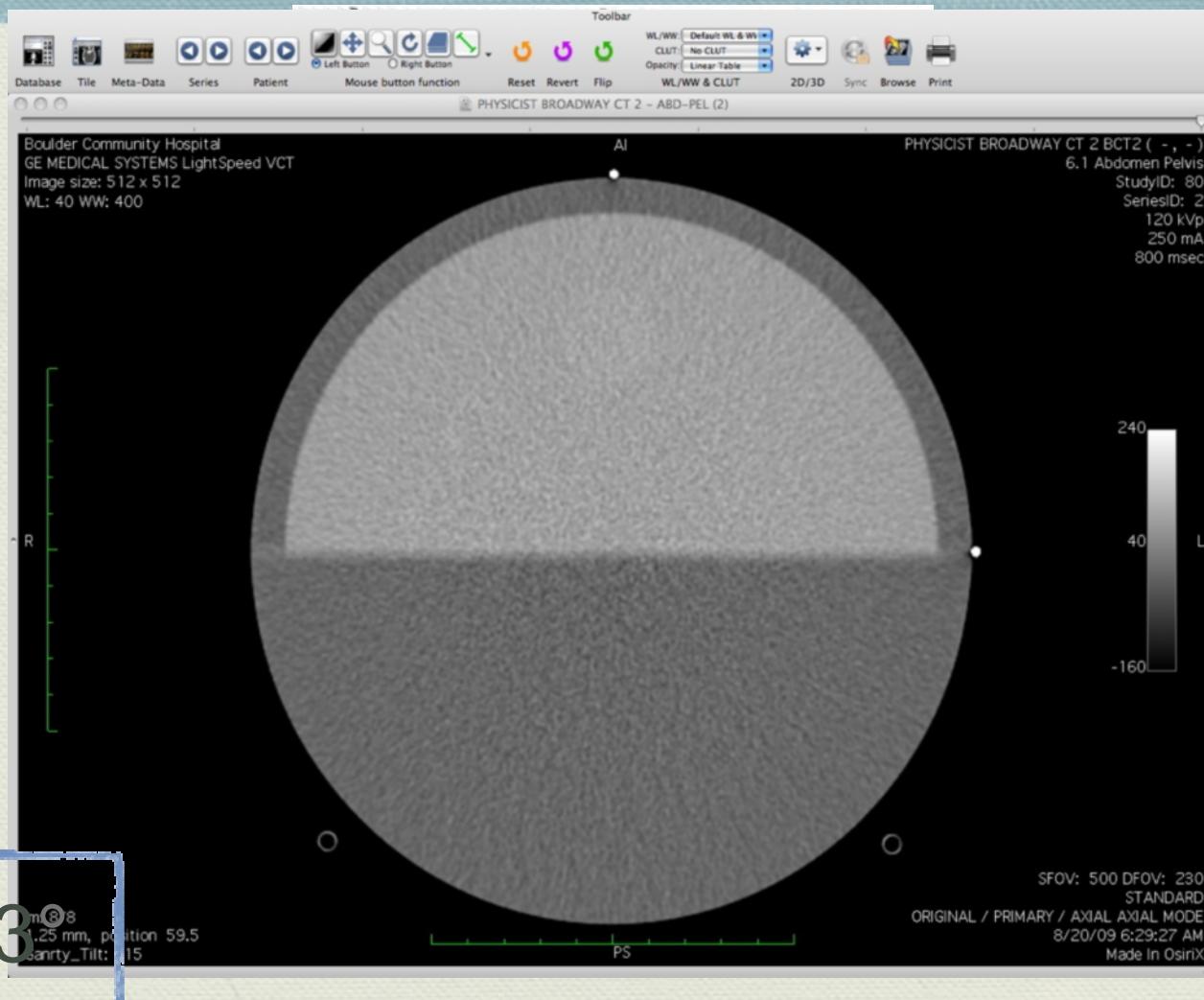
Gantry Tilt

◆ Alternate Test Procedure Steps

1. Position the phantom with the markers on the cradle, centering it to the markers at isocenter
2. Scan the phantom at the gantry tilt angles prescribed by the markers
3. Observe the images, verifying the visibility of the angle markers
 1. If needed, rescan with the gantry angle offset until the markers are visible



Gantry Tilt



Low Contrast Detection

- ◆ Required Test Equipment
 - ◆ Phantom incorporating low contrast targets of known contrast (Module 2 of the ACR CTAP phantom)
- ◆ Test Procedure Steps
 1. Align the phantom.
 2. Perform clinical scans covering the low contrast section.
 1. Any Auto mA feature must be disabled
 2. Use an mAs value appropriate for an average sized patient.
 3. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 year old)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)

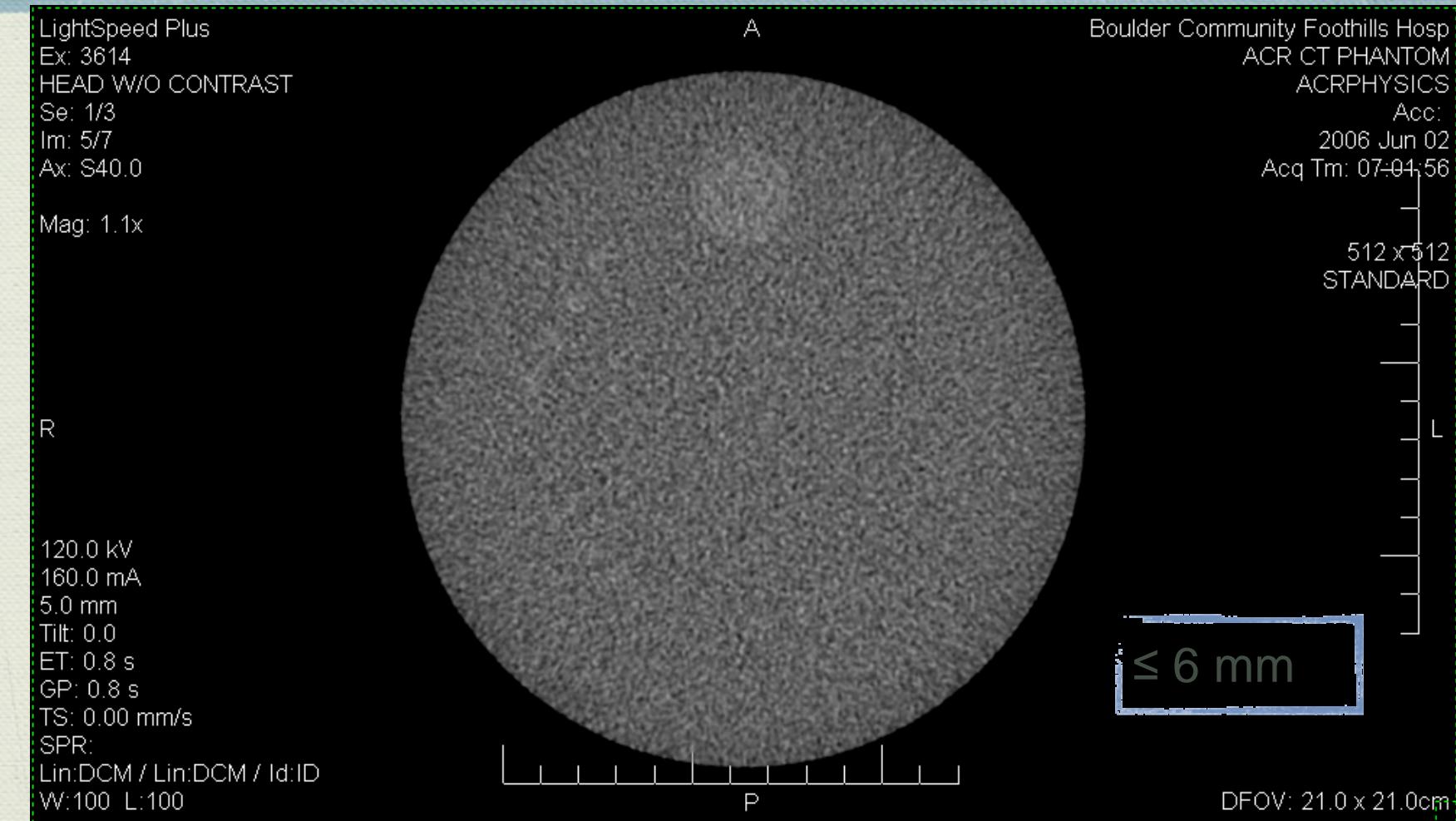
Low Contrast Detection

- ◆ Data Interpretation and Analysis
 - ◆ Visual Analysis
 - ◆ View each series and determine the slice providing the visually best low contrast performance.
 - ◆ Adjust the window width and window level to optimize visibility of the low contrast targets. On the ACR CTAP phantom, this is WW=100, WL=100.
 - ◆ Record the size and contrast of the smallest visualized target.
 - ◆ Numeric Analysis
 - ◆ Select the slice most central to the module containing the low contrast targets.
 - ◆ Place a Region of Interest (ROI) over the largest representative target and record the mean HU value.
 - ◆ Place an ROI adjacent to the target and record both the mean HU and the HU standard deviation.
 - ◆ Calculate the Contrast-Noise Ratio as $CNR = \frac{\text{target mean HU} - \text{background mean H}}{\text{background HU std dev}}$

Low Contrast Detection

- ◆ Noise limited
- ◆ Specific realization of the noise may hide a target
- ◆ For ACR
 - ◆ OK to select any slice in Module 2 for low contrast performance evaluation
 - ◆ If all 4 lower rods visible, count larger
 - ◆ Use best slice

Low Contrast Detection



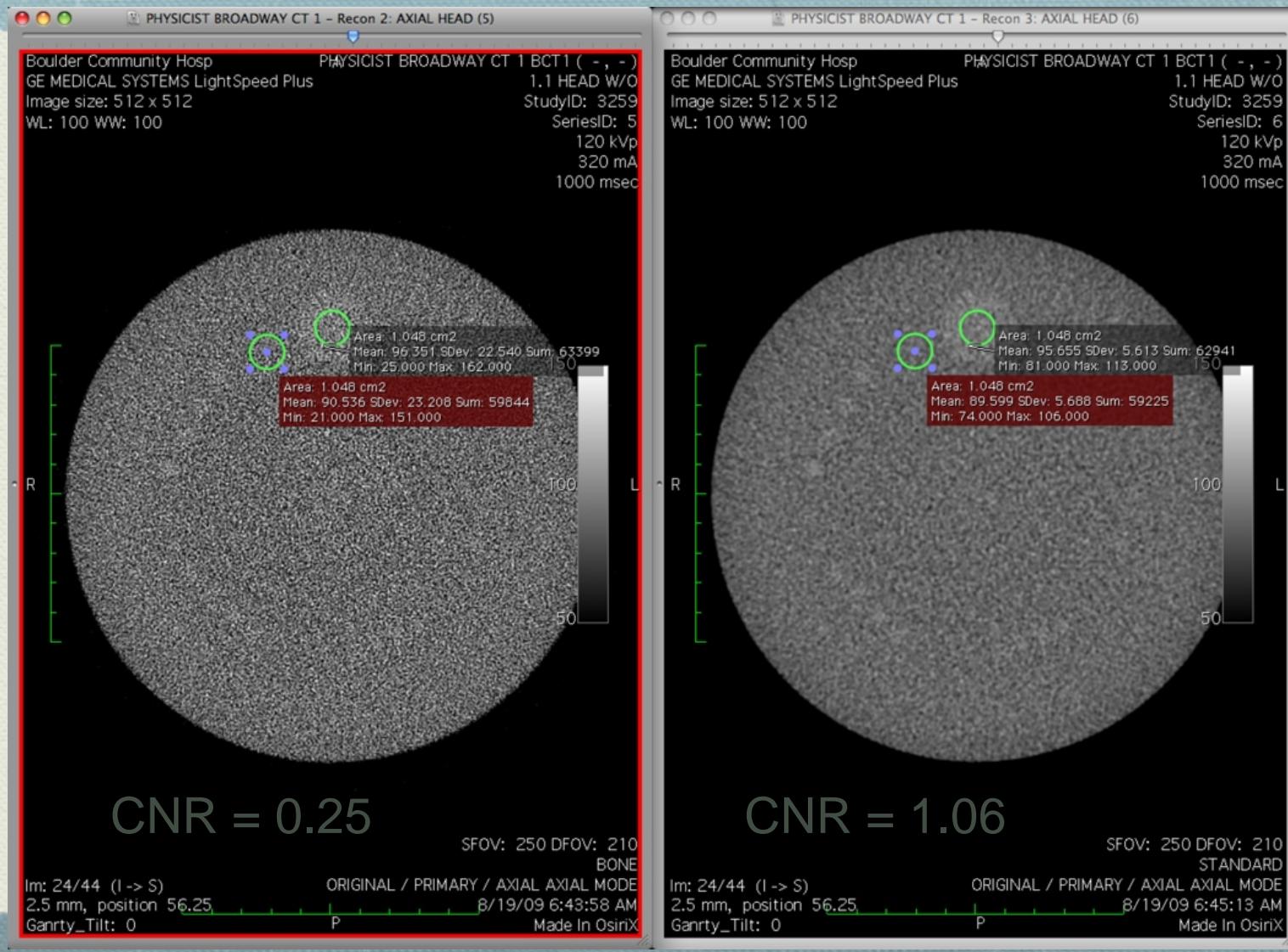
Low Contrast Detection

- ◆ CNR measurements
$$\text{CNR} = (S_{25 \text{ mm}} - S_{\text{bkgd}}) / SD_{\text{bkgd}}$$
- ◆ Extremely sensitive to reconstruction algorithm
- ◆ The specific algorithm used must be recorded for each clinical protocol.
- ◆ Auto mA features must be disabled
 - ◆ Failure to do this leads to a low mA value
 - ◆ Poorer performance than should be

The Use of a Simple
Contrast to Noise
Ratio (CNR) Metric to
Predict Low Contrast
Resolution
Performance in CT

Med. Phys. Volume 36,
Issue 6, pp. 2451-2451
(June 2009)

Low Contrast Detection



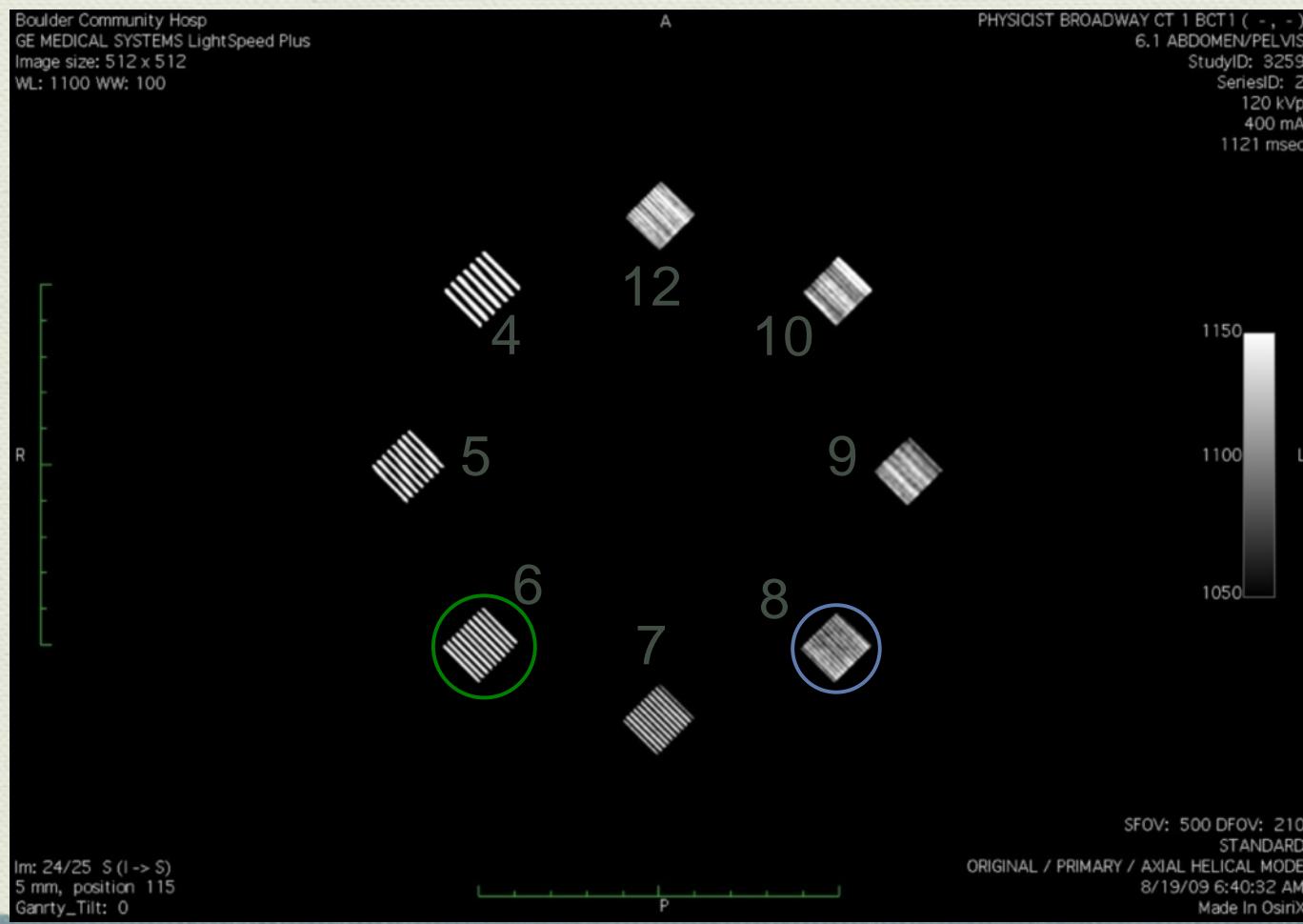
High Contrast Resolution

- ◆ Line pair pattern
- ◆ MTF
- ◆ Point response
- ◆ Via line pair standard deviation per Droege and Morin. A practical method to measure the MTF of CT scanners. Med. Phys. (1982) vol. 9 (5) pp. 758-60

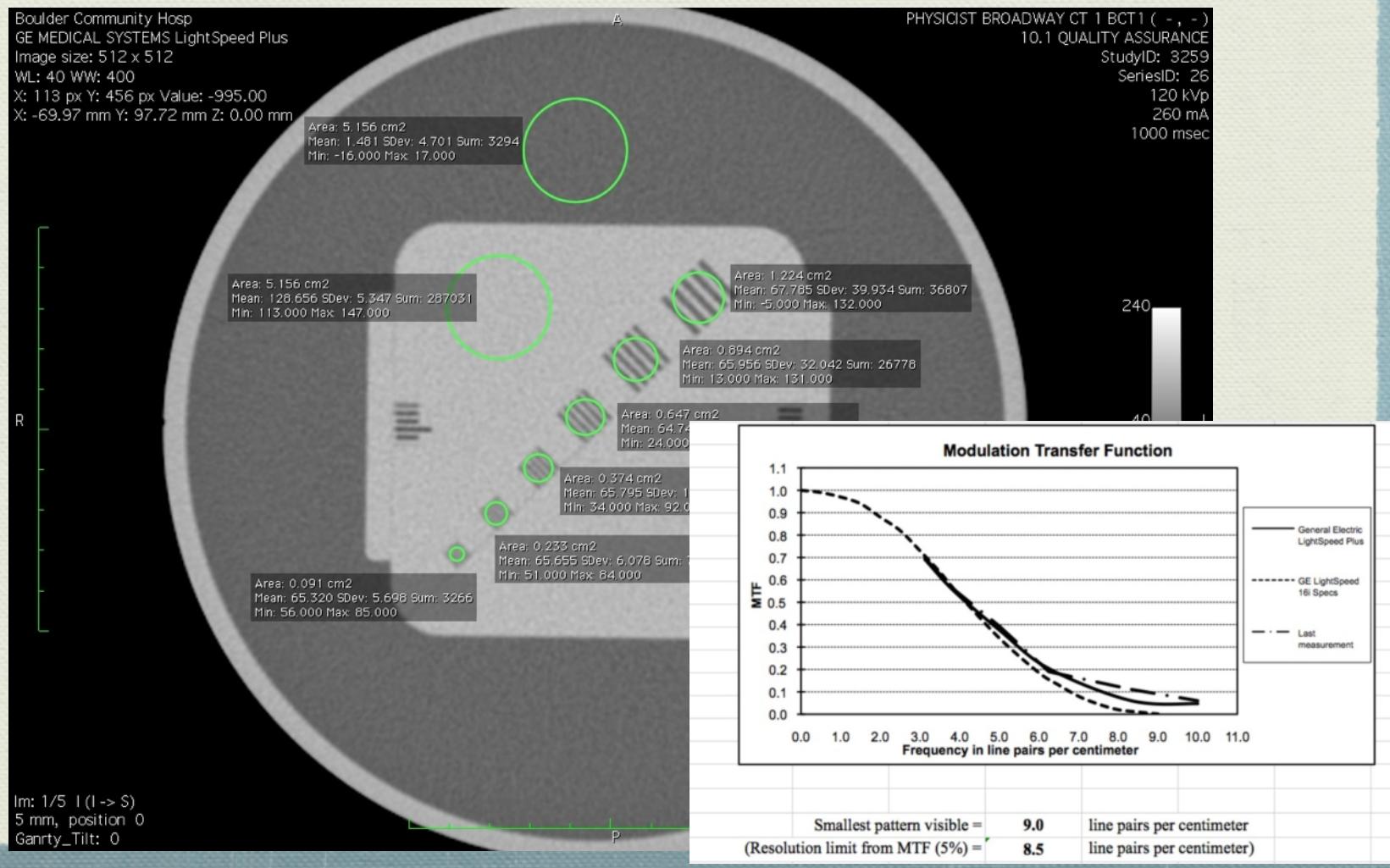
High Contrast Resolution

- ◆ Required Test Equipment
 - ◆ Phantom incorporating high contrast targets of known resolution
(Module 4 of the ACR CTAP phantom)
- ◆ Test Procedure Steps
 1. Align the phantom
 2. Perform clinical scans
 1. Auto mA feature must be disabled
 2. Use an mAs for average sized patient.
 3. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)
 - ◆ High Resolution Chest

High Contrast Resolution



High Contrast Resolution



CT Number Accuracy

- ◆ Why is this important?
 - ◆ Diagnosis
 - ◆ Bolus tracking
 - ◆ Treatment planning

CT Number Accuracy

- ◆ Required Test Equipment
 - ◆ Phantom incorporating targets providing at least three different, known CT number values including water (or water equivalent material) and air. (ACR CTAP Phantom Module 1)
- ◆ Test Procedure Steps
 1. Align the phantom
 2. Perform clinical scans covering the CT number accuracy section
 1. Disable any Auto mA features
 2. Use an mAs value appropriate for an average sized patient
 3. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)
 4. Perform scans of the CT number accuracy section of the phantom with each kVp setting available on the scanner. (Adult abd technique works usually)

CT Number Accuracy

- ◆ Data Interpretation and Analysis
 - ◆ Select the image most central to the module containing the CT number accuracy targets.
 - ◆ Adjust the window width and window level to optimize visibility of the targets. On the ACR CTAP phantom, this is WW=400, WL=0.
 - ◆ In the image from the 120 kVp scan, place a circular ROI, approximately 80% of the size of the target, in each target.
 - ◆ Record the measured CT number mean for each target.
 - ◆ For the images from each kVp scan, place a circular ROI, approximately 80% of the size of the water target, in the water target.
 - ◆ Record the measured **water** CT number mean in each image.

CT Number Accuracy

- ◆ All available kVp stations must be calibrated and tested.
- ◆ The CT number accuracy targets in most phantoms are calibrated only for 120 (or 130) kVp.
- ◆ CT numbers other than water will vary with kVp
 - ◆ Need to know for bolus threshold setting
 - ◆ May be useful information for scanners used for RT
- ◆ For ACR Phantom, use 200 mm² ROI

CT Number Accuracy



Material	CT # Range
Water	-5 to +5 HU
Air	-970 to -1005 HU
Teflon (bone)	850 to 970 HU
Polyethylene	-107 to -87 HU
Acrylic	110 to 135 HU

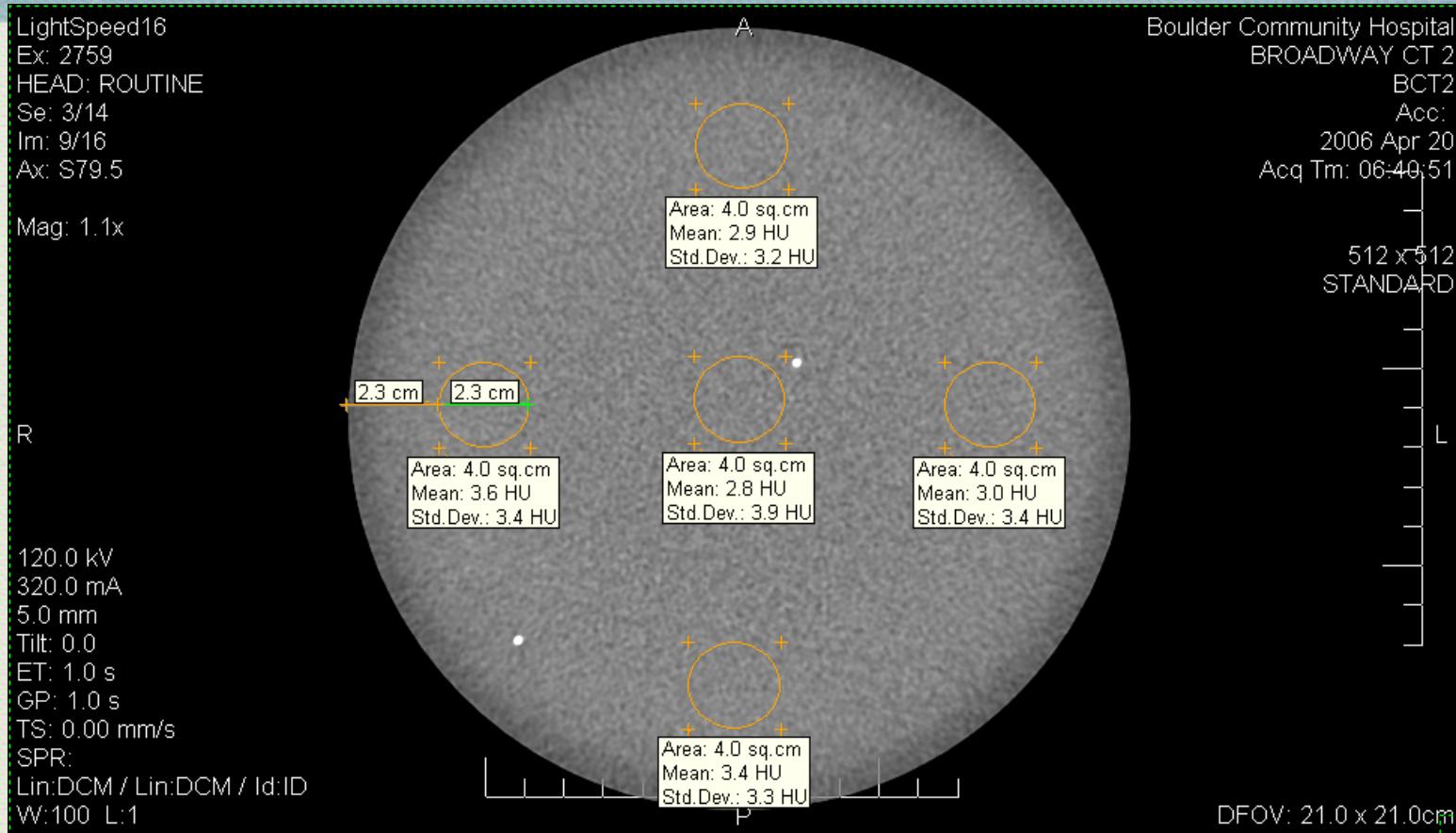
CT Number Uniformity

- ◆ Required Test Equipment
 - ◆ Phantom incorporating a uniform region, preferably water or water-equivalent
- ◆ Test Procedure Steps
 1. Align the phantom.
 2. Perform clinical scans covering the CT number uniformity section.
 1. Disable any Auto mA features
 2. Use an mAs value appropriate for an average sized patient.
 3. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)
 4. Perform scans of the CT number uniformity section of the phantom with each kVp setting available on the scanner. (Adult abd technique works usually)

CT Number Uniformity

- ◆ Data Interpretation and Analysis
 - ◆ Select the image most central to the CT number uniformity module.
 - ◆ In each image, place a circular ROI, approximately 400 mm² (ACR phantom), at the center of the phantom.
 - ◆ Place similar ROIs at 12:00, 3:00, 6:00 and 9:00, one ROI diameter in from the periphery.
 - ◆ Record the measured CT number mean and standard deviation.

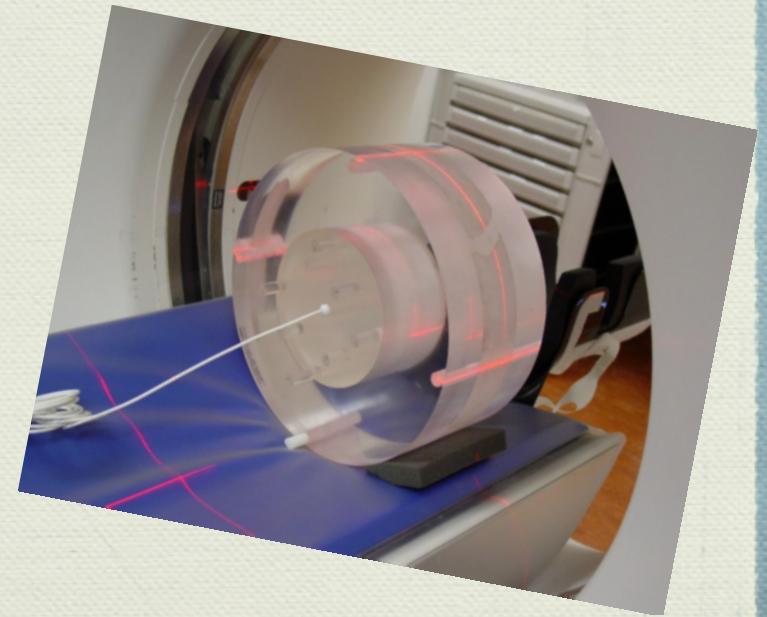
CT Number Uniformity



$ROI_{center} = ROI_n \leq 5$

Dosimetry

- ◆ Not just for patient dose estimates
- ◆ Generator calibration
- ◆ Tube condition
- ◆ Dose characterization



Dosimetry

- ◆ Acceptance testing

- ◆ Air

- ◆ Output every kVp
 - ◆ Output for every filter



Characterization and
potential dose calculation

- ◆ Phantom

- ◆ CTDI₁₀₀ for every kVp
 - ◆ CTDI₁₀₀ for every filter
 - ◆ CTDI₁₀₀ vs. mA
 - ◆ Compare scanner CTDIvol with measured CTDIvol, every filter with matched phantom
 - ◆ CTDIvol for adult head and body, ped head and body clinical protocols
 - ◆ Compare to reference levels

Characterization,
calibration and potential
dose calculation

±10%

Less than ref. level

Dosimetry

- ◆ Annual testing
 - ◆ Air
 - ◆ Output at every kVp
 - ◆ CTDIvol for four clinical protocols
 - ◆ Compare to reference levels
 - ◆ Verify scanner CTDIvol

$\pm 5\%$ of baseline

Less than ref. level

$\pm 10\%$

Artifact Evaluation

- ◆ Arguably the most important evaluation to be done
 - ◆ Most likely to impact clinical scans
 - ◆ Most likely to have deficiency

Artifact Evaluation

- ◆ Required Test Equipment
 - ◆ Phantom incorporating uniform section of adequate length for all data channels to be simultaneously used.
(ACR CTAP Phantom Module 3)
- ◆ Test Procedure Steps
 1. Align the phantom.
 2. Perform clinical scans covering the uniformity section.
 1. Disable any Auto mA features
 2. Use an mAs value appropriate for an average sized patient.
 3. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)
 4. One scan in axial mode using approximately Adult Head techniques but with thin (approximately 1 mm) images using the maximum number of data channels available on the scanner.
 5. Repeat 4 for all kVp stations.
 6. Repeat 4 for all bow tie filters

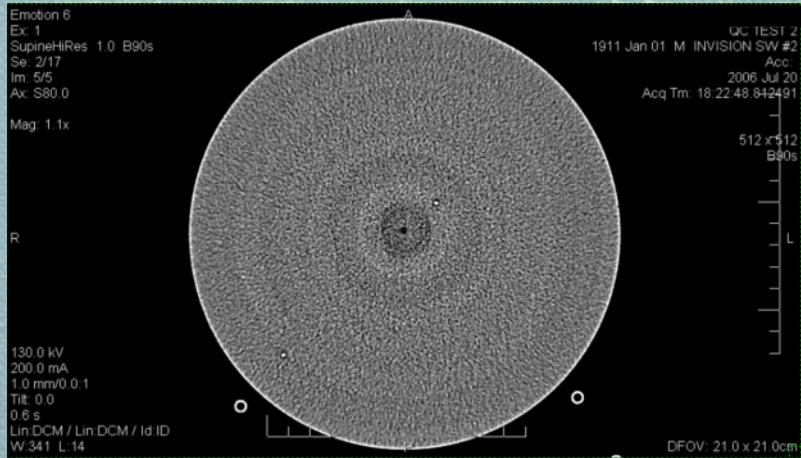
Artifact Evaluation

- ◆ Required Test Equipment
 - ◆ Phantom incorporating uniform section of adequate length for all data channels to be simultaneously used. (ACR CTAP Phantom Module 3)
- ◆ Test Procedure Steps
 1. Align the phantom
 2. Perform clinical scans covering the uniformity section of the phantom. Use an mAs value appropriate for an average sized patient. The scans performed should include at least
 - ◆ Adult Head (average)
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Adult Abdomen (average)
 - ◆ Pediatric Abdomen (50 lb, 20 kg; 5 y.o.)
 3. One scan in axial mode using approximately Adult Head techniques but with thin (approximately 1 mm) images using the maximum number of data channels available on the scanner
 4. Repeat 3 for all kVp stations
 5. Repeat 3 for all filters at 120 kVp

Artifact Evaluation

- ◆ Data Interpretation and Analysis
 - ◆ Select the image most central to the uniformity module
 - ◆ Adjust the window width and window level to optimize visibility of the phantom material. On the ACR CTAP phantom, this is WW=100, WL=0.
 - ◆ Inspect each slice for evidence of artifacts, including specifically streaks and rings, cupping, or capping
- ◆ Some scanners will demonstrate a noticeable bright halo just inside the phantom border, due to automatic corrections for a skull that it assumes will be present. This artifact may be excluded from consideration.

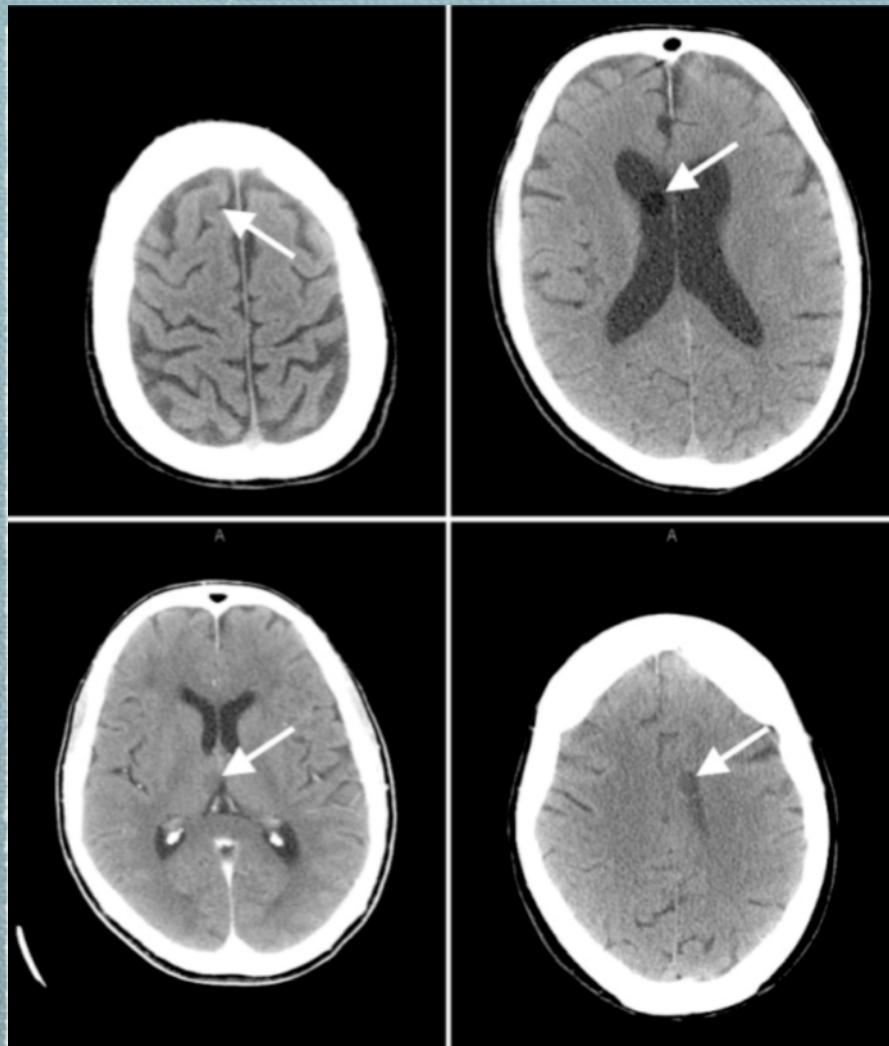
Artifact Evaluation



QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

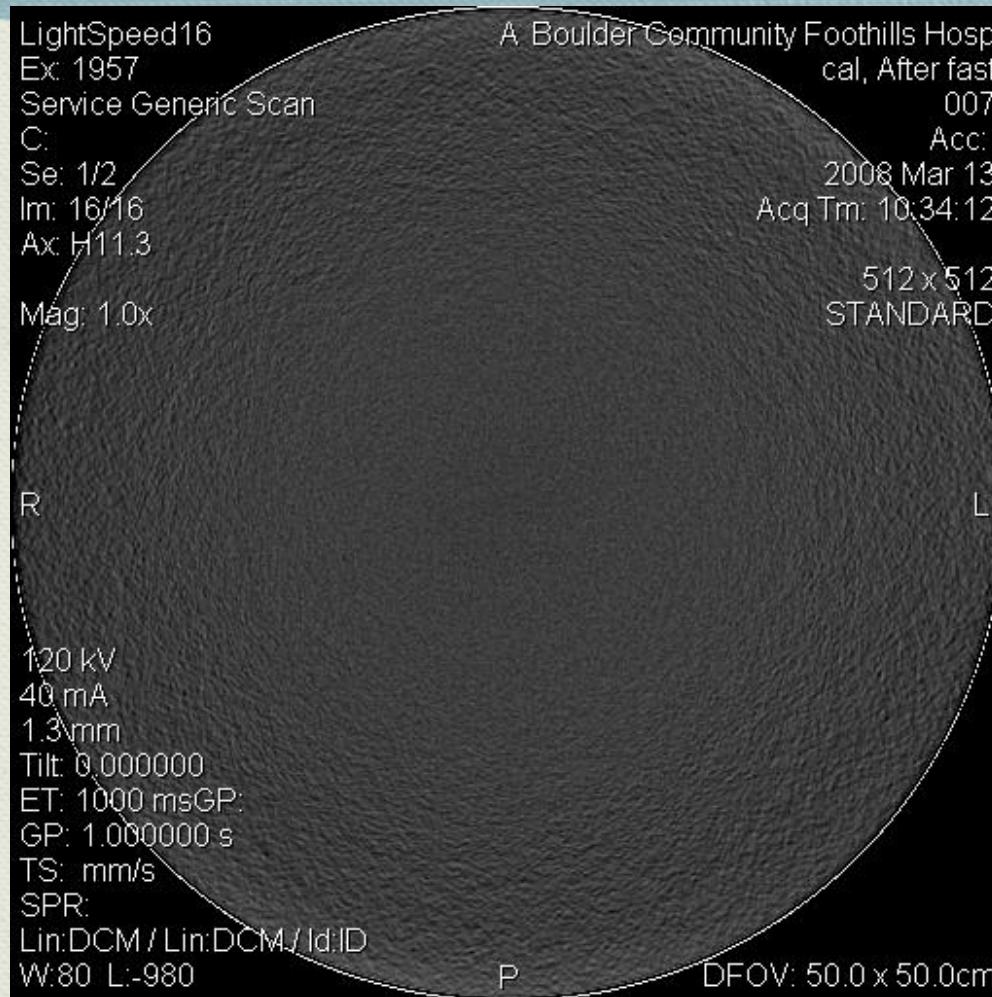
Clinically relevant - address immediately

Artifact Evaluation



Radiology 2005; 236:756 –761

Artifact Evaluation



Protocol Review

- ◆ Review at least five clinical protocols, including
 - ◆ Pediatric Head (1 y.o.)
 - ◆ Pediatric Abdomen (50 kb, 20 kg; 5 y.o.)
 - ◆ Adult Head
 - ◆ Adult Abdomen
 - ◆ High Resolution Chest
- ◆ Pay specific attention to
 - ◆ kVp
 - ◆ Mas

Protocol Review

- ◆ Firm rules for clinical imaging are difficult to establish. The ACR has set several practice standards:
 - ◆ Reconstructed scan width for standard Adult Head and standard Adult Abdomen should not be less than ~5 mm.
 - ◆ Pitch for Pediatric Abdomen should not be less than 1.
- ◆ Several other rules of thumb should be kept in mind:
 - ◆ On a multi-slice scanner, the largest number of images for the chosen reconstructed scan width should be used, as this improves dose efficiency. For example, 5 mm x 4 slices is up to 30% more dose efficient than 5 mm x 2 slices in axial mode with no image quality penalty.
 - ◆ The facility may wish to be able to reconstruct to thinner in addition to the standard scan. NxT should allow for this.
- ◆ Lower kVp settings should be used for pediatric scans and scans in which contrast media is used.

Protocol Review

- ◆ High Resolution Chest (HRC) protocol should incorporate a very sharp reconstruction algorithm (GE recommends the BONE algorithm).
- ◆ HRC should be axial, thin slices separated by 10-20 mm. If HRC image are extracted from a helical chest scan, it must be verified that the chest scan is used appropriately for diagnosis.
- ◆ Doses should be as low as reasonably achievable. For the two stated head protocols and the two stated abdomen protocols, the CTDIvol must not exceed ACR Pass/Fail levels and should not exceed ACR reference levels.

Conclusion

- ◆ A well-designed QC program is essential to quality imaging
- ◆ Focus on likely failure modes for the specific scanner
- ◆ Technologist QC does not need to take a lot of time