# AAPM 55th Annual Meeting

# MRI QA Technologist's Tests

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# Outline

- Background
  - QC importance
  - Technologist's role
- QC test tips and problems
  - Table OK?
  - CF and TX Gain
  - Phantom distance
  - HR holes
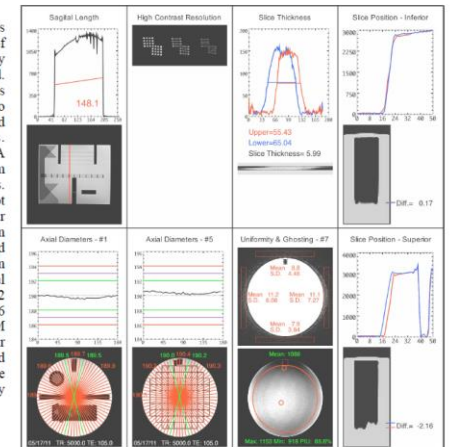  - LCD spokes
- Additional QC tests
- Questions

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# Background

**Dr. Moriel S. NessAiver's experience**

- 174 yearly performance tests (98 magnets over 3.5 years)
- 18 (10.3%) without deficiencies
- 19 (21.3%) with minor deficiencies, not affecting image quality
- 137 (78.7%) with deficiencies, directly affecting image quality
  - ➢ 144 phased array coils (19.2%) with significant problems
  - ➢ 22 systems (12.6%) with homogeneity problems
  - ➢ 10-20% scanners: excessive RF noise, excessive ghosting, poor gradient calibration, poor hard copy (film), and soft copy performance
- ➢ 1 vendor's TSE with slice thickness 18-23% thicker than specified
- ➢ 1 vendor's TSE with slice thickness 20-25% thinner than specified
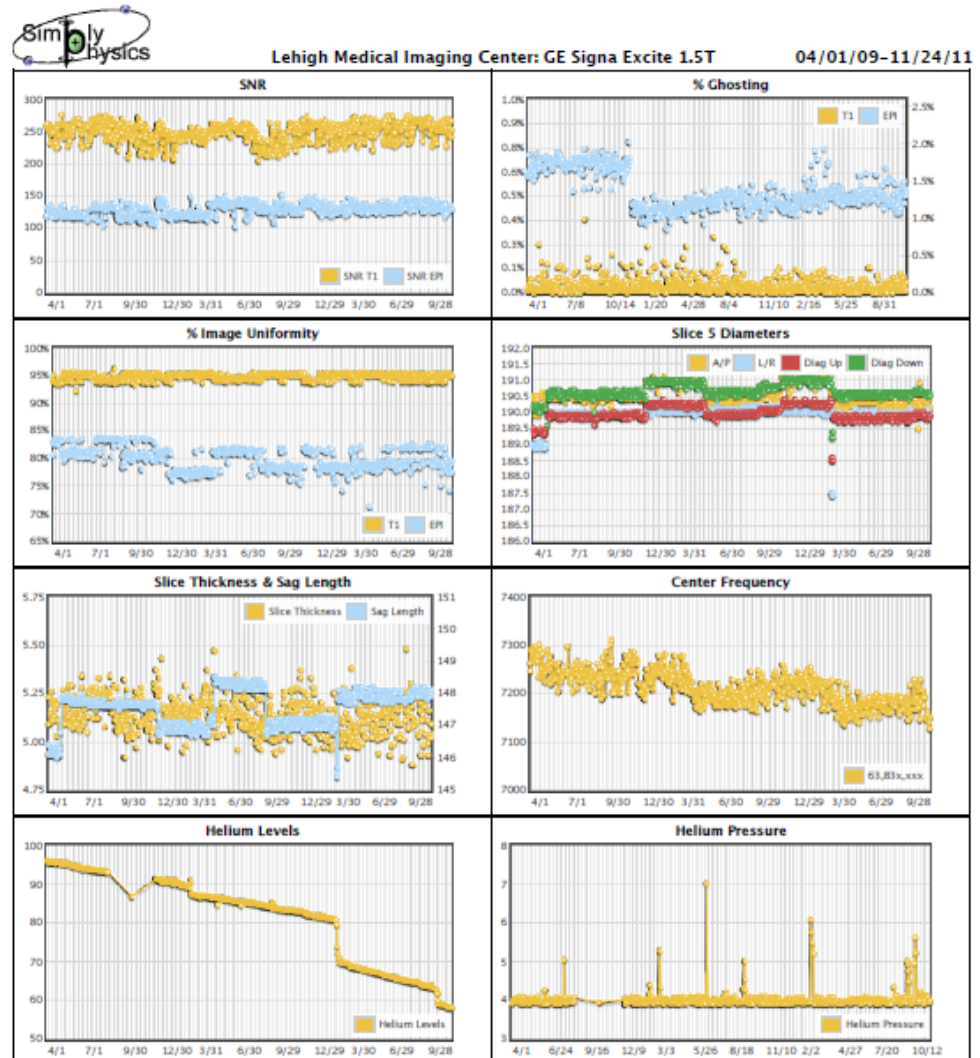


**Daily/Weekly QA Program**

The ACR requires that all facilities perform at least weekly testing of the ACR phantom, although daily testing is strongly recommended. While some sites are conscientious about this, others find the need to manually make all of the required measurements rather tedious. They would often run the QA scans and then only analyze them when they had a bunch to process. Additionally, most vendors do not provide very good tools for making the measurements. In April, 2009 an on-line, automated daily QA program was put in place. Technologists run a Sagittal Localizer, Axial T1 and Axial T2 study. Typical scan time is 5-6 minutes. The data is DICOM transferred to a remote server where the images are analyzed and the results stored in an online database which is reviewed daily for potential problems.

The graphs on the right depict 32 months of automated daily QA analysis. Of particular note are the jumps in the sagittal length values along with corresponding changes in the axial diameters. The deviations from the ideal ACR spec values occurred every time the GE service engineer performed a PM and were restored to the ideal values at the physicist's next visit.
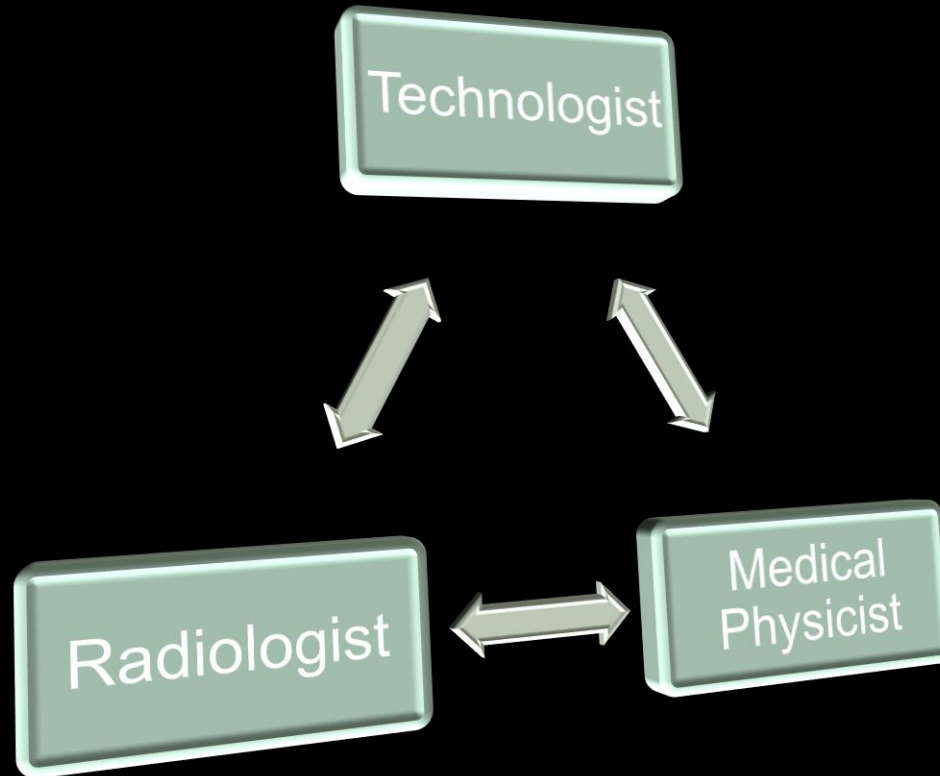


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# Technologist's Role

# Record Book Examples

## Data form for weekly QC

- Template from ACR MRI QC Manual
- Examples









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# Record Book Examples

## QC visual checklist
- Template from ACR MRI QC Manual
- Examples







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# "Table OK?"

**Table OK?**

- A test about the accuracy of the laser localizer
- Page 35 of ACR Manual 2004 version
- Frequently ignored by technologists
- Most technologists misunderstand that it is a check of whether the table move smoothly



Laser Light

# "Table OK?" on Siemens Scanner

**Procedure**

- Open the sagittal localizer image
- User "PixelLens" to check the top edge of the vertical bars
- The location should be within ± 2mm
- < H(ead)2 or F(oot)2
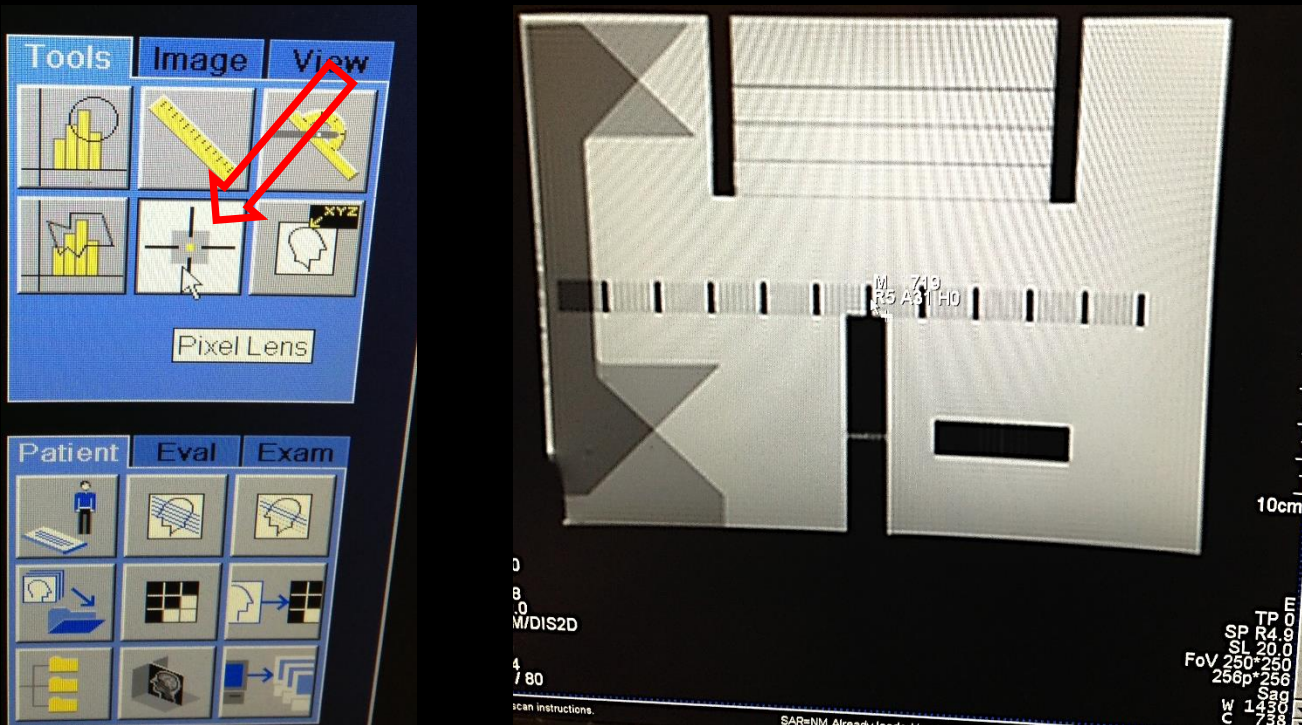
# "Table OK?" on GE Scanner

**Procedure**

- Open the sagittal localizer image
- User "Crosshair" to check the top edge of the vertical bars
- The location should be within ± 2mm
- < S2 or I2

# "Table OK?" Offline Measurement

**Philips EBW**
- Open the sagittal localizer image
- User "Crosshair" to check the top edge of the vertical bars

# "Table OK?" Offline Measurement

**Philips EBW**

- Open the sagittal localizer image
- User "Crosshair" to check the top edge of the vertical bars

# Magnetic Field Drift

- Definition
  - Center frequency run down over time
- Drift reasons
  - Windings are not perfect superconductors
  - Eddy current interactions
- Drift rate
  - < 0.01 ppm per hour
  - < 107 Hz per week for 1.5T
  - < 214 Hz per week for 3T
- Enshrined drift level
  - 3 ppm per day (AAPM report 34, 1992)
  - 1 ppm per day (AAPM report 100, 2010): 447 Hz/wk for 1.5T and 894 Hz/wk for 3T
  - 1.5 ppm per day (ACR MRI QC guide, 2004)
- Corrective action
  - Ask medical physicist or MRI scientist to re-check
  - Ask service to monitor the units to ensure
    1. $B_0$ field within RF transmit/receive frequency range
    2. Draft rate does not increase

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# Central Frequency on GE scanner: 1

- GE Signa Horizon 1.5T
  - ➤ Place the phantom
  - ➤ Click "Auto Prescan" before run the localizer sequence
  - ➤ Record TG (transmit gain) and AX (central frequency)
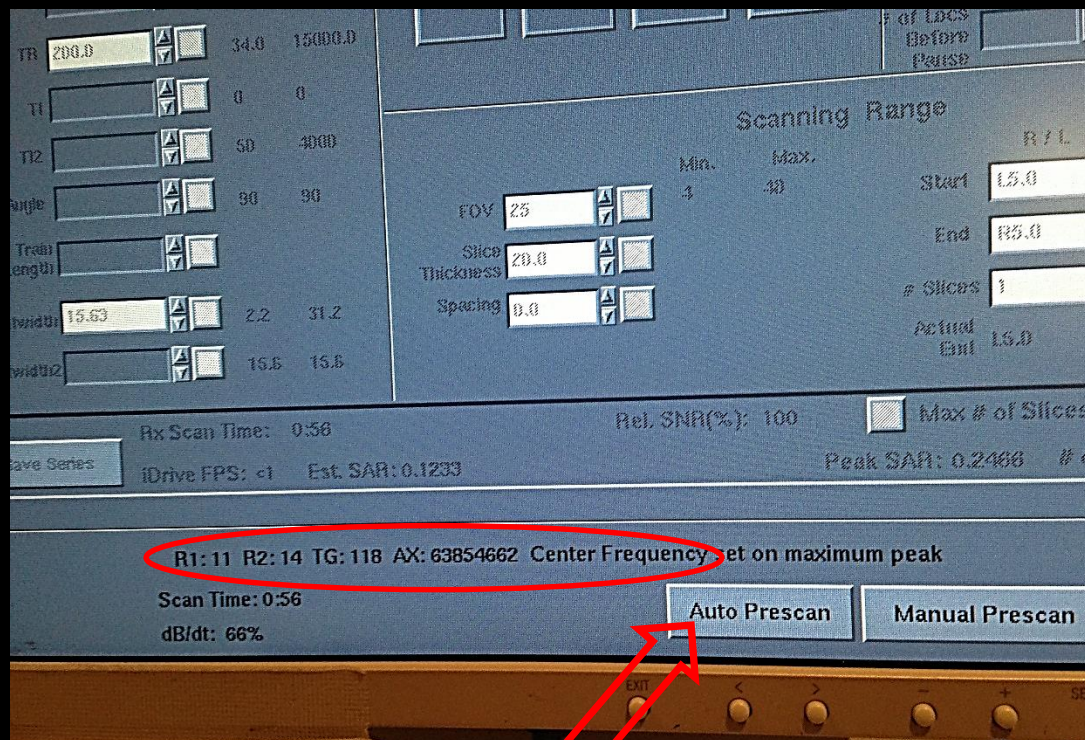
# Central Frequency on GE scanner: 2

- GE Signa Horizon 1.5T
  - Text page → Series page
  - Record central frequency and transmit gain

# Central Frequency on Siemens scanner

- Procedure

  ➢ Before run a sequence, e.g. ACR T1 axial

  ➢ "Options" → "Adjustments…"

  ➢ Record central frequency and transmit gain

# Distance Measurement: WW and WC

- Setting window and level/center
  - To have the edges at the half-maximum value of the signal intensity
  - Skipped by some Technologists
  - First set window to 0 or 1
  - Adjust level/center about ½ white and ½ black, record level value
  - width = recorded level value
  - level/center = ½ recorded level value



W = 606
C = 303

W = 1
C = 256

W = 256
C = 128

W = 768
C = 384

W = 1
C = 500

W = 500
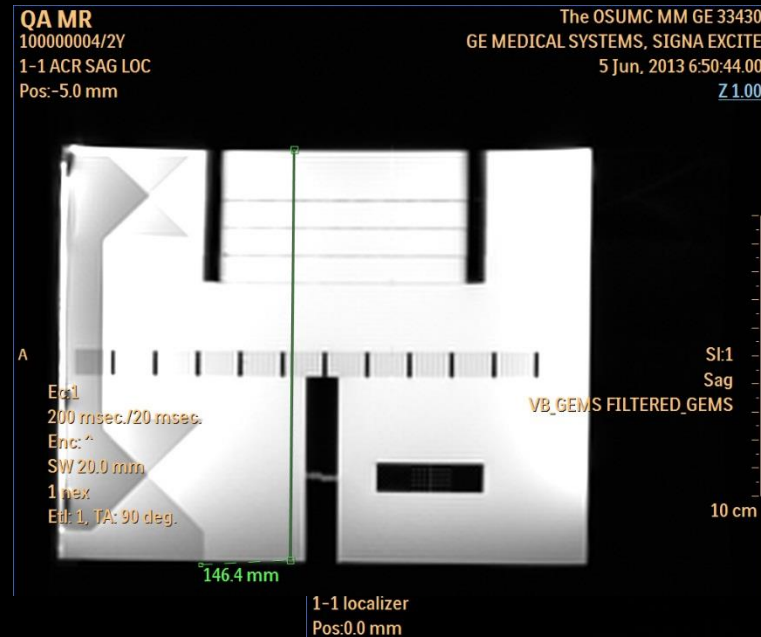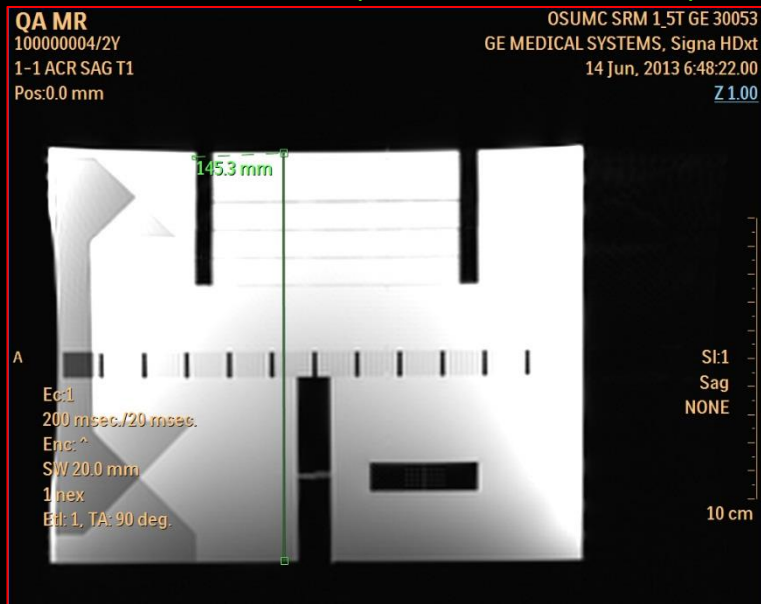C = 250
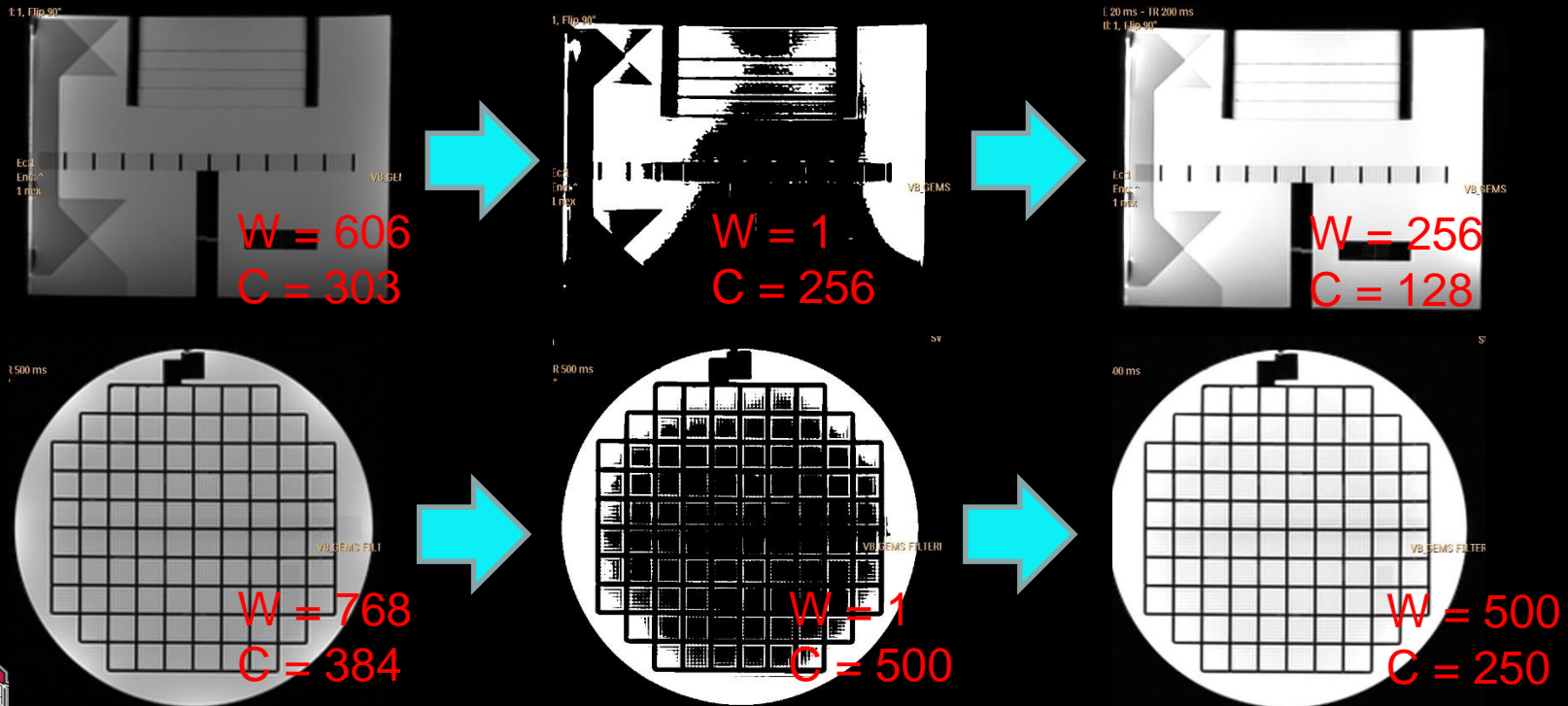
- Sagittal Image
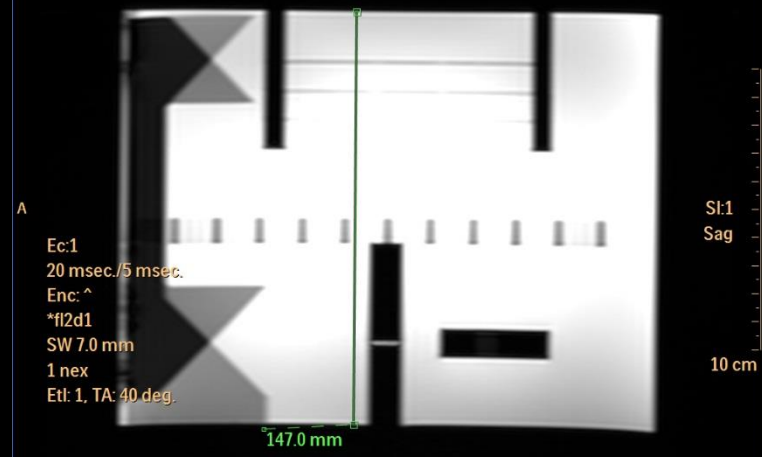  - ➢ Avoid going through the black bar
  - ➢ $< 148 \pm 2$ mm
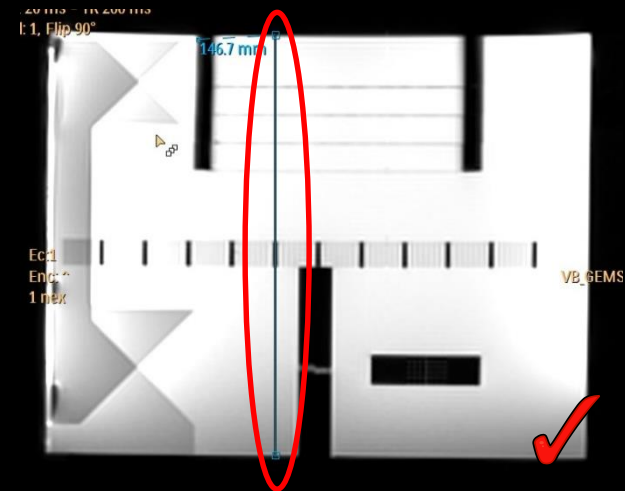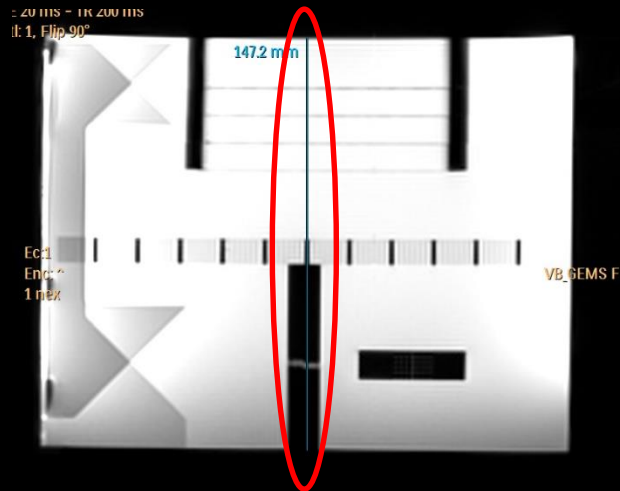
# Distance Measurement: Problem

- Sagittal Loc Length
  - 145.3 mm (Stoneridge)
  - 146.4 mm (Morehouse)
  - 147.0 mm (Siemens SSCBC)



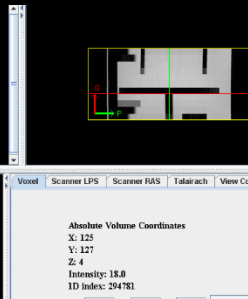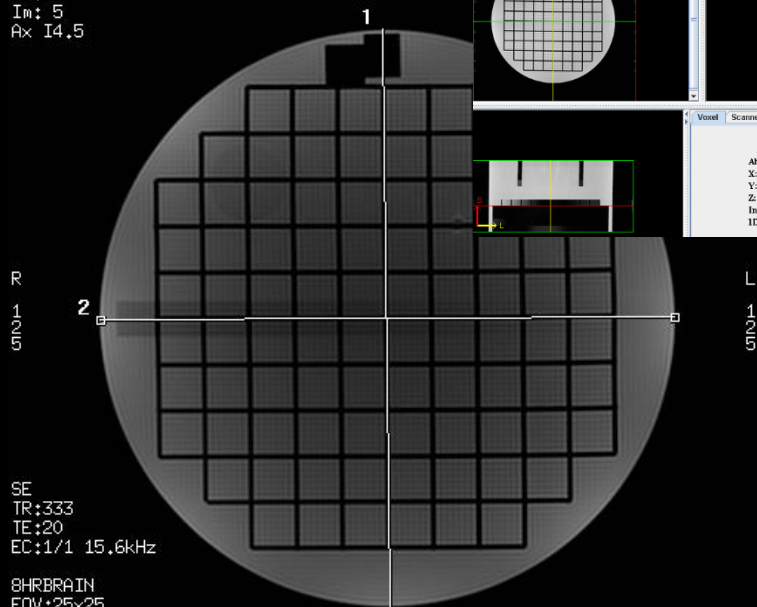Wexner Medical Center

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# Distance Measurement: Axial

- Axial slice #5
  - One vertical
  - One horizontal
  - < 190 $\pm$ 2 mm
  - Examples:

# Distance Measurement: Problem

- Vertical distance
  - 194 mm (Siemens SSCBC 3T MRI)
  - Out of spec



Axial

191.40 mm

193.36 mm

Curved border

Out of spec

Axial
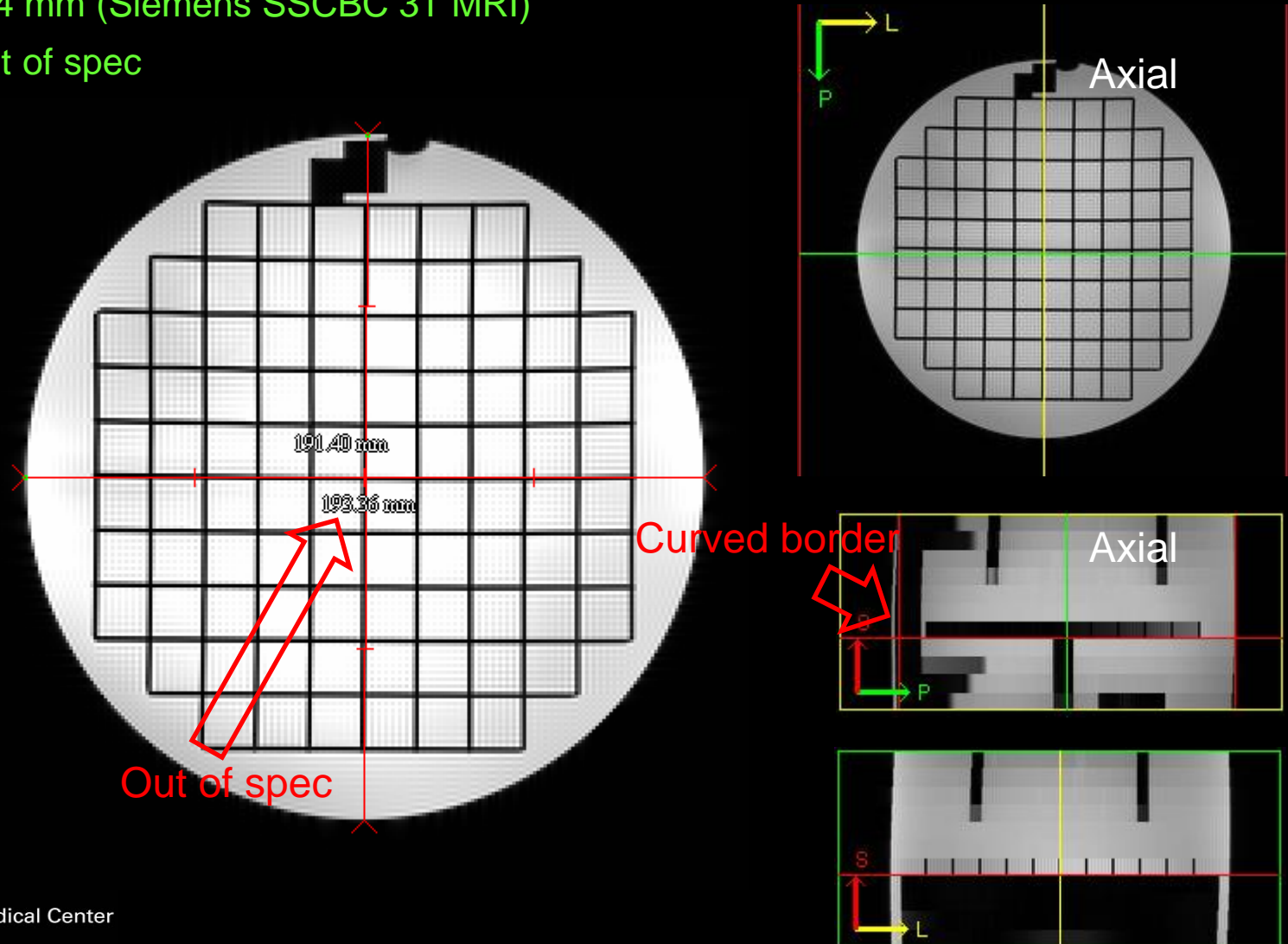
# Spokes

- GE Signa Horizon 1.5T
  - ➤ Assign image 8 or 9?
  - ➤ # of spokes on the image?
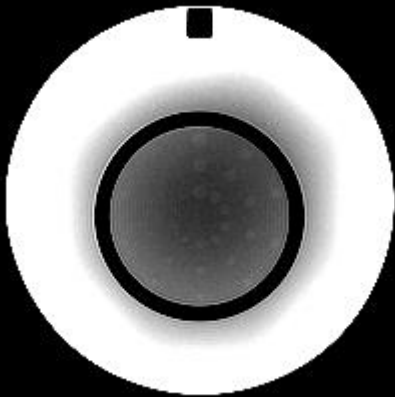


Image 8

Image 9

Image 10

Image 11

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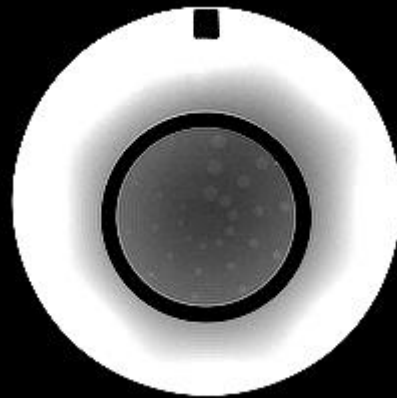Biomedical Imaging
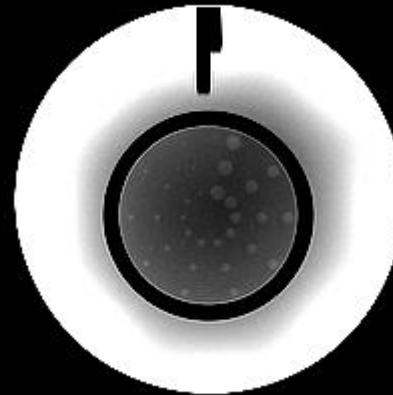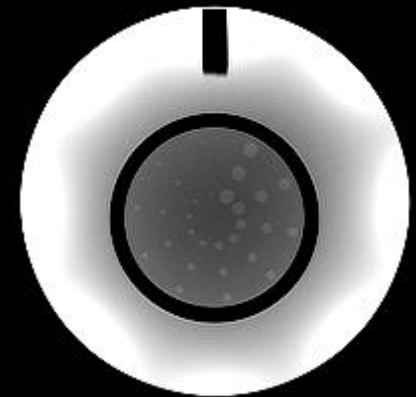
# Resolution

- GE Signa Horizon 1.5T
  - (1.0) Rows 1 through 4 of the UL array are resolved
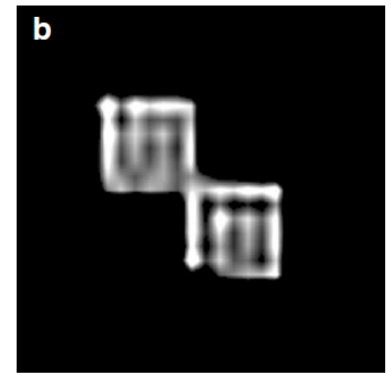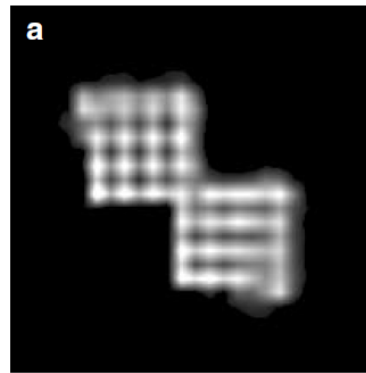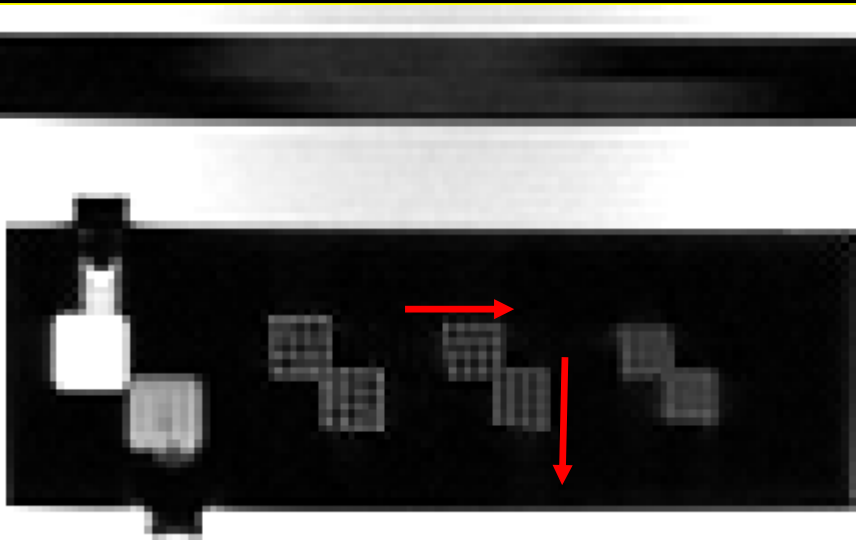  - (1.0) no columns or column 4 of the LR array could be resolved?





**Figure 9:**
(a) Typical appearance of well-resolved holes. Rows 2 through 4 of the UL array are resolved, and columns 1 through 3 of the LR array are resolved. (Rows and columns are numbered starting from the upper left corner of each array.)
(b) Example of barely resolved rows and unresolved columns. Row 2 of the UL array is resolved because all 4 holes are discernible from each other, even though the holes at either end of the row blur together with their neighbors in the row below. So, the horizontal direction would be scored as resolved at this hole size. None of the columns of the LR array show more than 3 discernible spots within the column, so the vertical direction is not resolved at this hole size.

# Resolution: ZIP

- Zero filled interpolation (ZIP)
  - ➤ ZIP512: zero fill up to 512x256
  - ➤ Better image resolution
  - ➤ Cost
    1. Slower reconstruction times
    2. Longer to transfer
    3. Takes up more disk space



FT

Unfiltered Image
256x256

k-space data
256x256
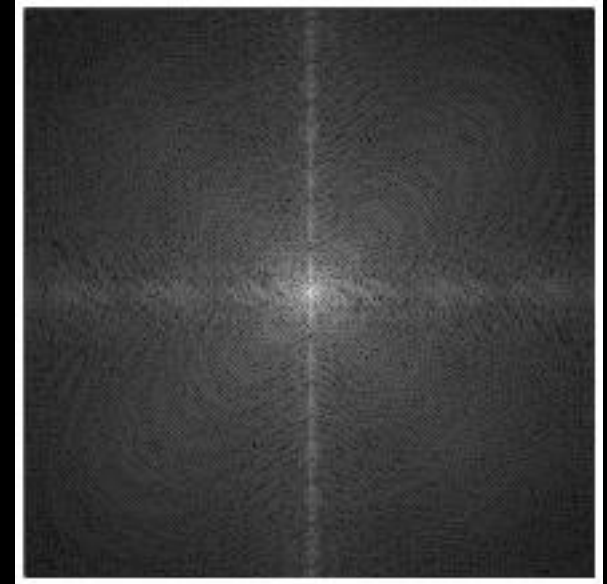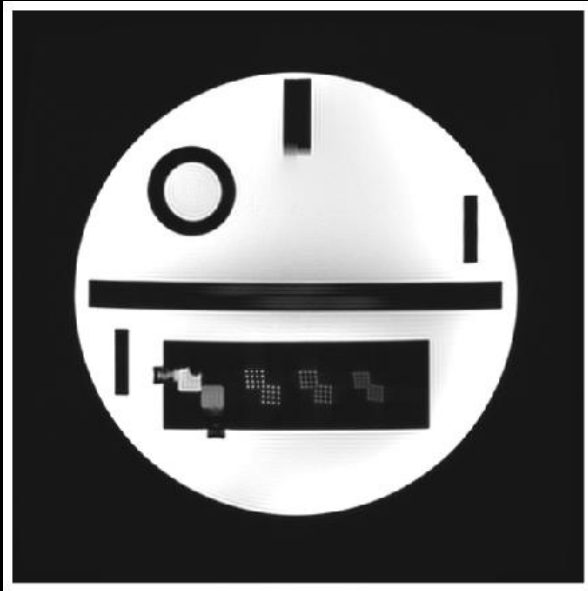
Courtesy of Dr. Moriel S. NessAiver
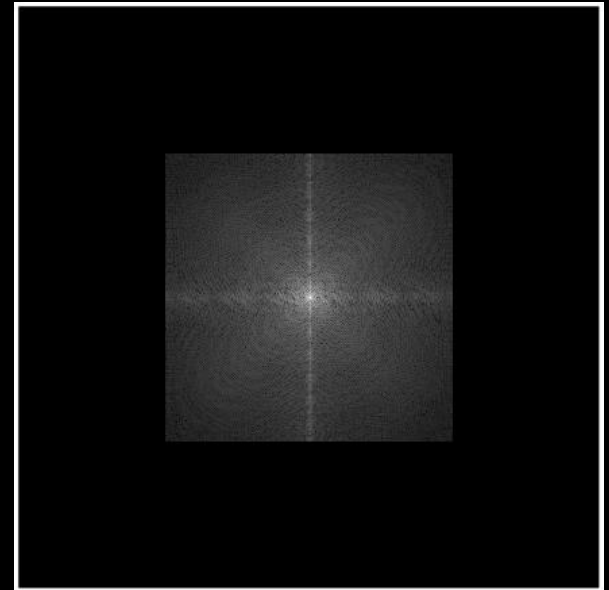
# Resolution: ZIP

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FT

Unfiltered Image
512x512

k-space data
512x512

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Courtesy of Dr. Moriel S. NessAiver
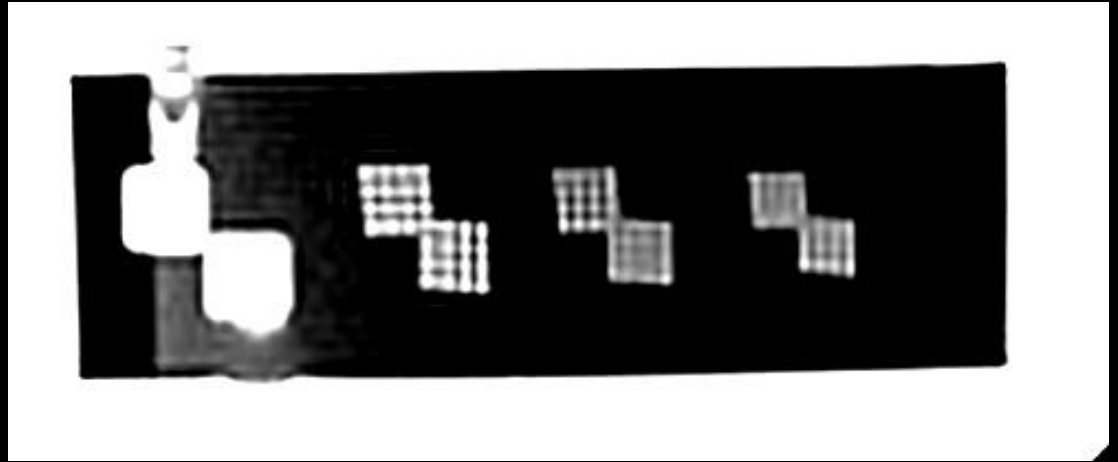
# Resolution: ZIP

- No ZIP
  - UL: 1.0
  - LR: 1.1
  - Not passing ACR criteria



- with ZIP512
  - UL: 0.9
  - LR: 0.9
  - Passing ACR criteria

# Common Problems

- Problems
    1. Central frequency: 4 digits? (should be 9 at 3T)
    2. Phantom distance: 3 digits? (should be 4)
    3. LCD spokes: Always 10 spokes? (because the tech used slice #11, should use specified slice # 8)



Slice 11

Slice 8

# Additional Tests

- Advanced clinical MRI procedures

  - MR spectroscopy

  - Diffusion imaging

  - Blood oxygen level dependent contrast (BOLD) imaging

  - Angiographic and blood perfusion methods

    1. DCE-MRI

# Diffusion
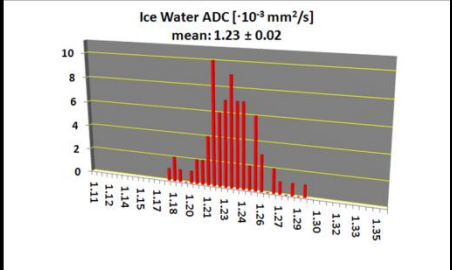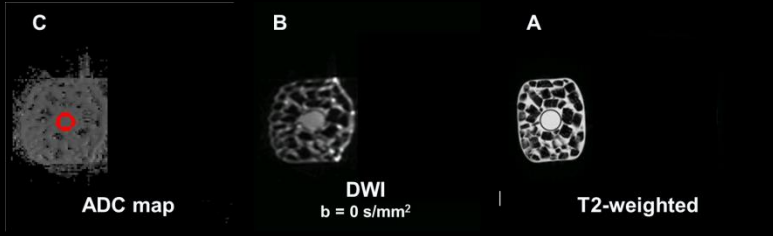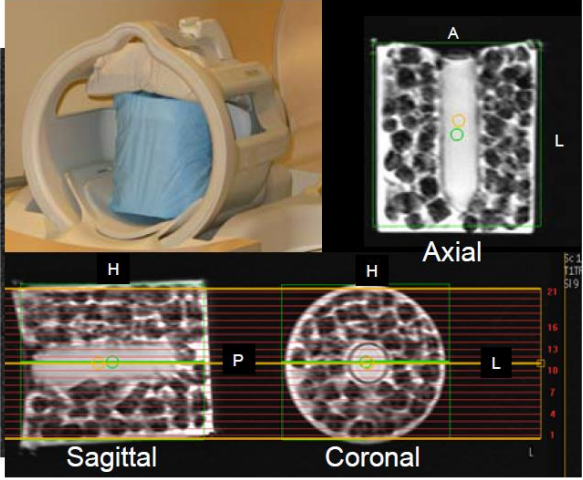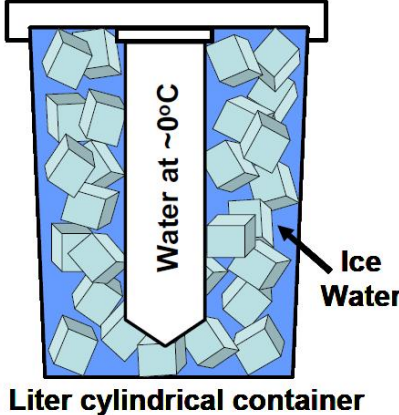
# DCE-MRI

## Purpose of the DCE-MRI Phantom Tests:

- Provide means for qualitative and quantitative evaluation, including T1 map error estimation, temporal resolution and image quality.
- Evaluate compliance with image acquisition protocols.

## ACRIN CQIE Body Phantom



**Phantom Scans: Body DCE-MRI**

- 3 Plane Localizer
- Body Coil Map – 15°   (tuned, with pre-scan)
- Array Coil Map – 15°   (not tuned, no pre-scan)
- T1 Map – 30°   (tuned, with pre-scan)
- T1 Map – 15°   (not tuned, no pre-scan)
- T1 Map – 5°   (not tuned, no pre-scan)
- Dynamic Scan – 30°   (not tuned, no pre-scan)
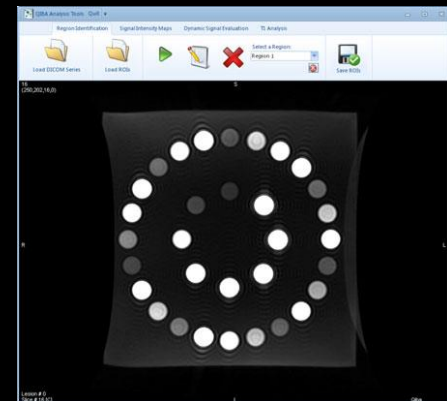
# Question 1: Allowed weekly CF drift from ACR Manual?

| | |
|---|---|
| 20% | 1. 0.1 ppm |
| 20% | 2. 1.0 ppm |
| 20% | 3. 1.5 ppm |
| 20% | 4. 2.0 ppm |
| 20% | 5. 2.5 ppm |

# Question 2: Transaxial image measurements on slice #?

20%   1. 1

20%   2. 3

20%   3. 5

20%   4. 11

20%   5. Any slice

# Question 3: Table OK is for checking?

20%  1. Bed position and lights

20%  2. Laser light alignment

20%  3. Patient monitors

20%  4. Horizontal bed movement

20%  5. Vertical motion smoothness

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# References

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7. AAPM Report No. 34, Acceptance Testing of Magnetic Resonance Imaging Systems (Reprinted from Medical Physics, Vol. 19, Issue 1)

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