

AAPM 55th Annual Meeting

MRI QA Technologist's Tests

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Wexner Medical Center

Wright Center of Innovation in
Biomedical Imaging

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



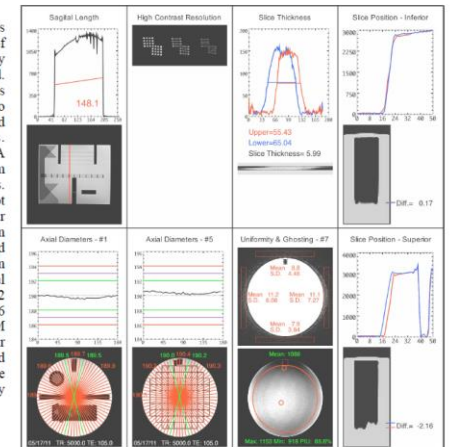
Background

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

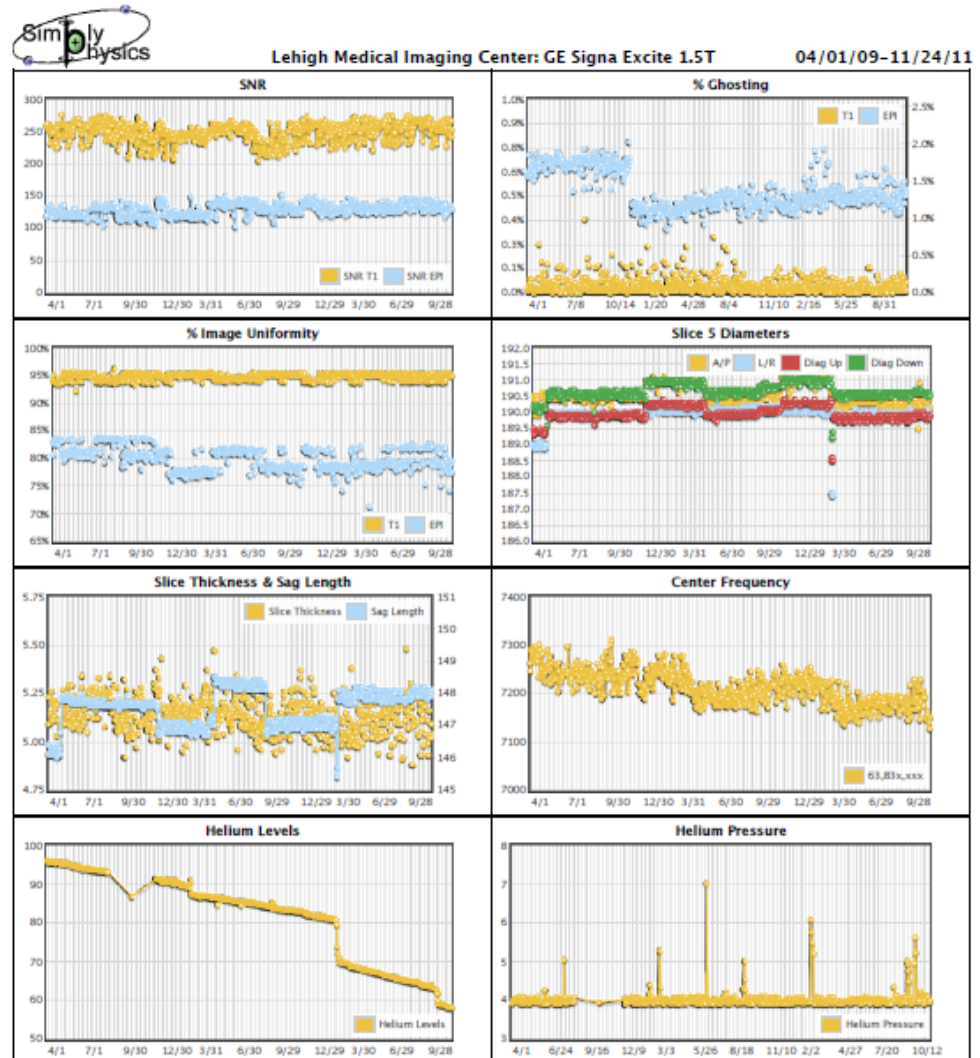
Daily/Weekly QA Program

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.



Daily/Weekly QA Program

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.

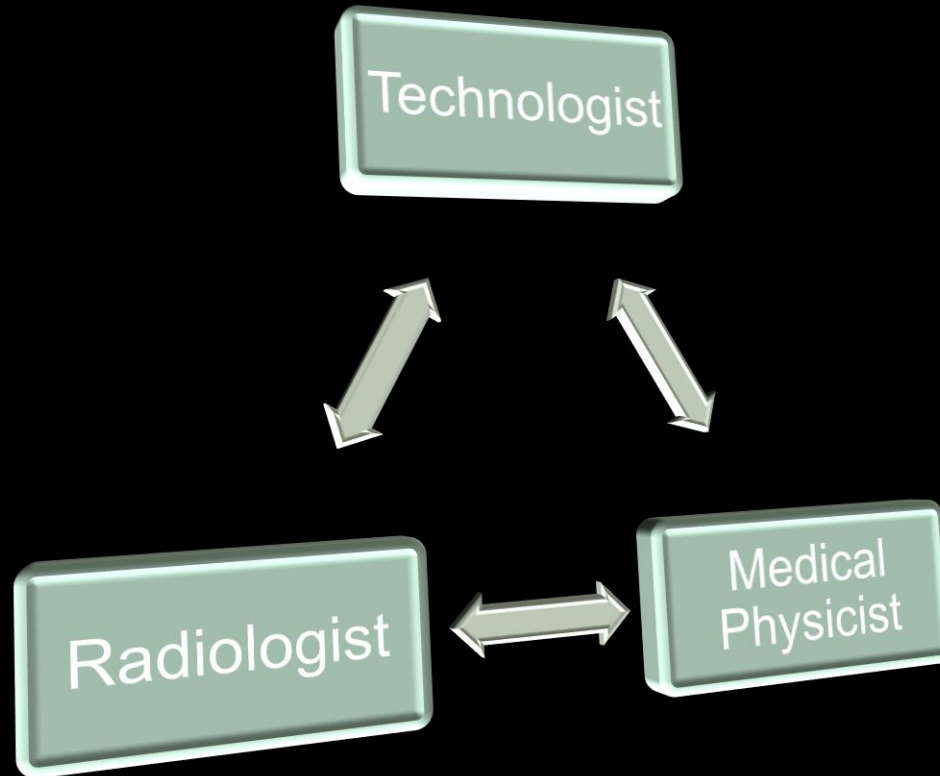


Generated 11/24/11 16:48 PM

http://localhost:4567/data-view/MR_1--10-25-2005--11-24-11



Technologist's Role



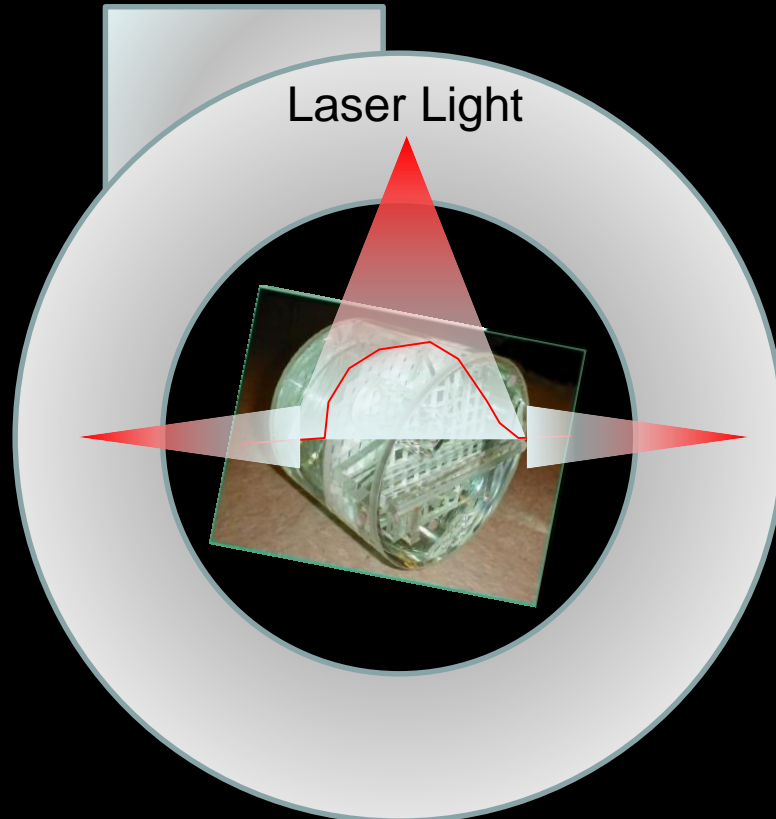
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“Table OK?”

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



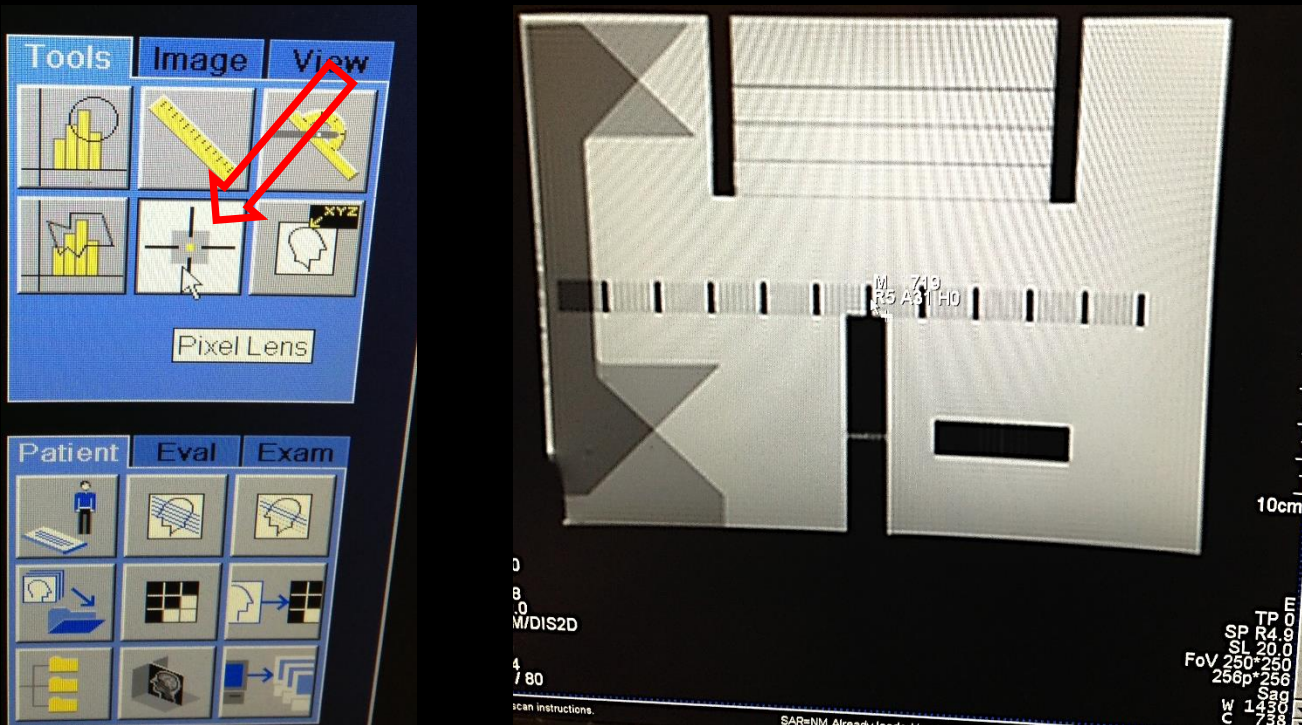
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"Table OK?" on Siemens Scanner

Procedure

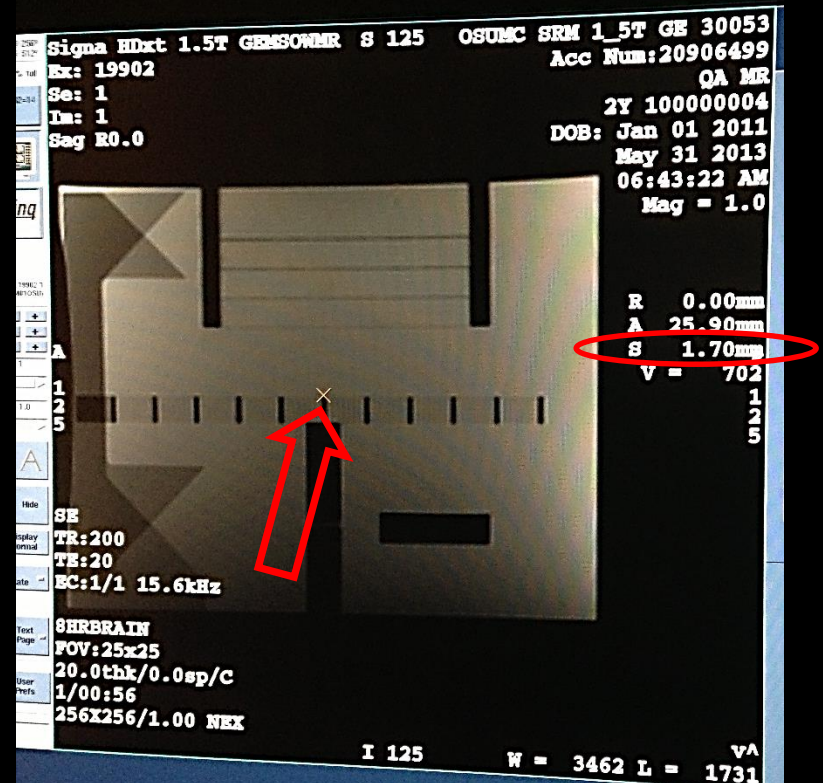
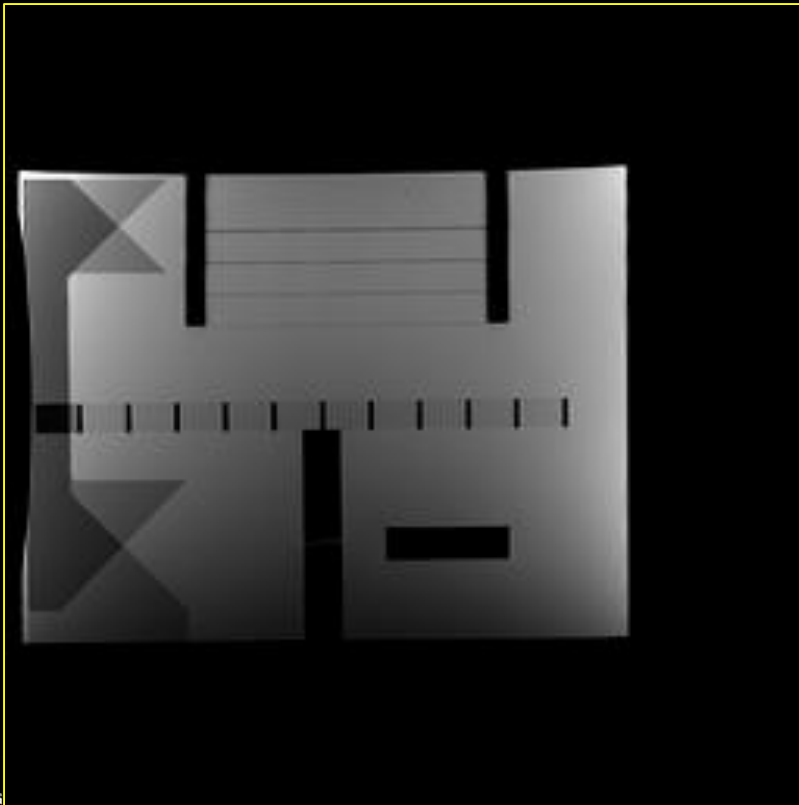
- Open the sagittal localizer image
- User "PixelLens" to check the top edge of the vertical bars
- The location should be within $\pm 2\text{mm}$
- $< H(\text{ead})2$ or $F(\text{oot})2$



"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 $\pm 2\text{mm}$
- $< S2$ or $I2$



“Table OK?” Offline Measurement

Philips EBW

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

The screenshot displays the Philips EBW software interface. The main window shows a sagittal localizer image of a patient's head. A red crosshair is positioned on the top edge of the vertical bars. A red arrow points to the crosshair. The measurement data is displayed as follows:

158
X -23.4
Y 1.2

The Y value, 1.2, is circled in red. The text "VB_GEMS FILTERED_GEMS" is visible on the right side of the image. The software interface includes a top menu bar with options like 2D, Slab, Volume, and Endo. The left sidebar shows the Series list with the following items:

- Jun 5, 2013 - QA MR
- 1 ACR SAG LOC
- 2 ACR T1
- 3 ACR T2

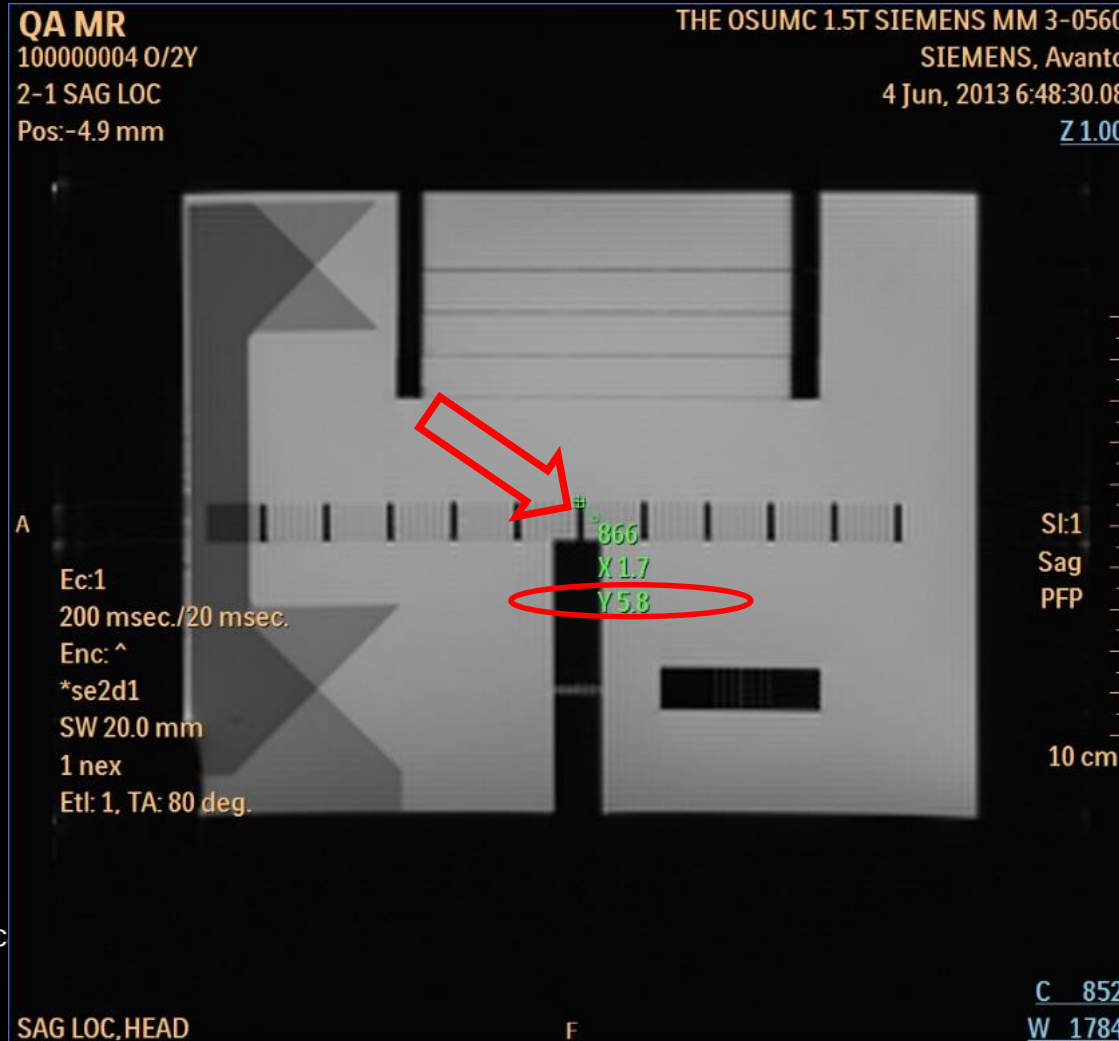
The bottom status bar shows the following information:

ACR TEST/8HRBRAIN F
C 303
W 606
34 of 34 images have been loaded... 6/5/2013 4:38:44 PM

“Table OK?” Offline Measurement

Philips EBW

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

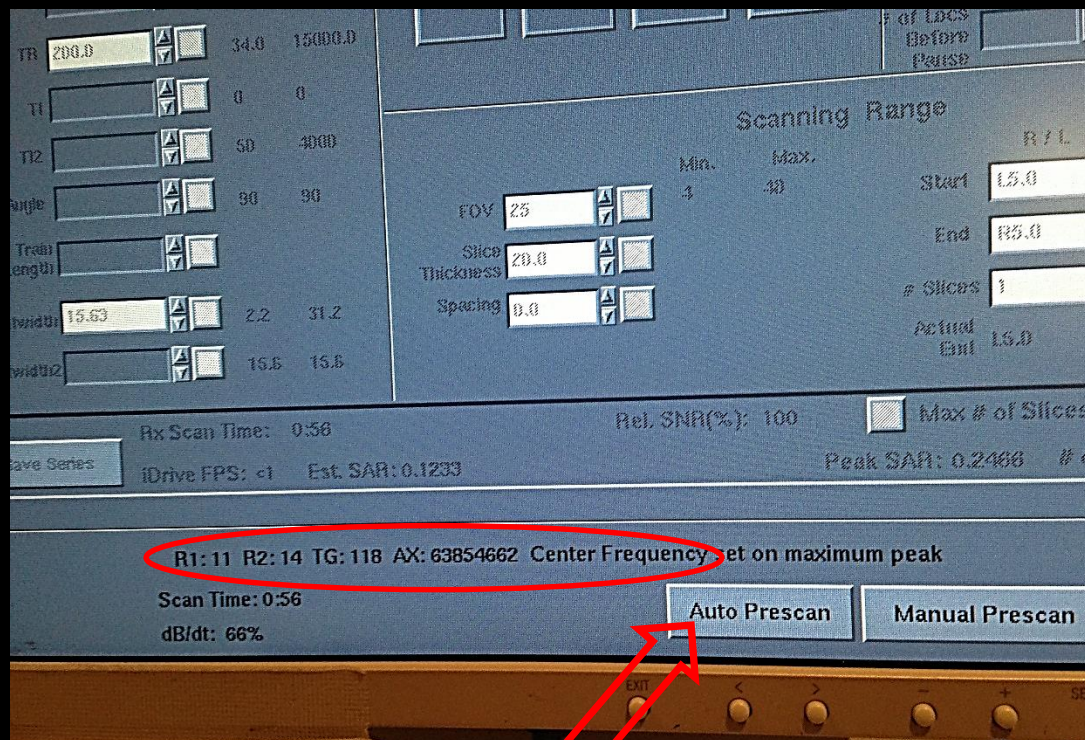


Magnetic Field Drift

- 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

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

Pat. name: QA MR
Accession Number: 20906499
Pat. ID: 10000004
Age: 2Y Sex: DOB: Jan 01 2011 Weight: 91 kg
May 31 11
Signa HDxt 1.5T

Referred by: other Other 0
Radiologist:
Operator: no_name_19902
Position: Supine
Entry: Head First

Series number: 2
Series description: ACR AX SE T1
Contrast:
Scan range: 143.6 to 356.4
PSD: SE
Data type: PROSP
Coil: 8HRBRAIN

Tuning: 63865218 TG: 90 R1: 10 R2: 14 H
Gradient Shim Values: X:-5 Y:-1 Z:-3
PreScan Opts: TG/s1,CF/s1,AS/s1

Imaging Options:

Img	Loc mm	Flip deg	TE	TI	TR ms	TDEL ms	Thck/Sp mm	FOV cm	Matrix	NEX
1	143.6	90	20	0	500		5.0/5.0	25x25	256X256	1.00
2	133.6	90	20	0	500		5.0/5.0	25x25	256X256	1.00
3	123.6	90	20	0	500		5.0/5.0	25x25	256X256	1.00
4	113.6	90	20	0	500		5.0/5.0	25x25	256X256	1.00
5	13.6	90	20	0	500		5.0/5.0	25x25	256X256	1.00
6	56.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00
7	518.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00
8	526.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00
9	536.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00
10	546.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00
11	556.4	90	20	0	500		5.0/5.0	25x25	256X256	1.00

Quit Film ScreenSave

Exam - +
Series - +
Image - +
Image 8
Zoom 1.0
Erase All Hide
Image Enhance Display Normal
Reference Image Flip Rotate
Film Page <F2> Film MID <F3> Text Page
Save State User Prefs

11/02/11
11/11
Sent: 19902/2 (WFM010SU)

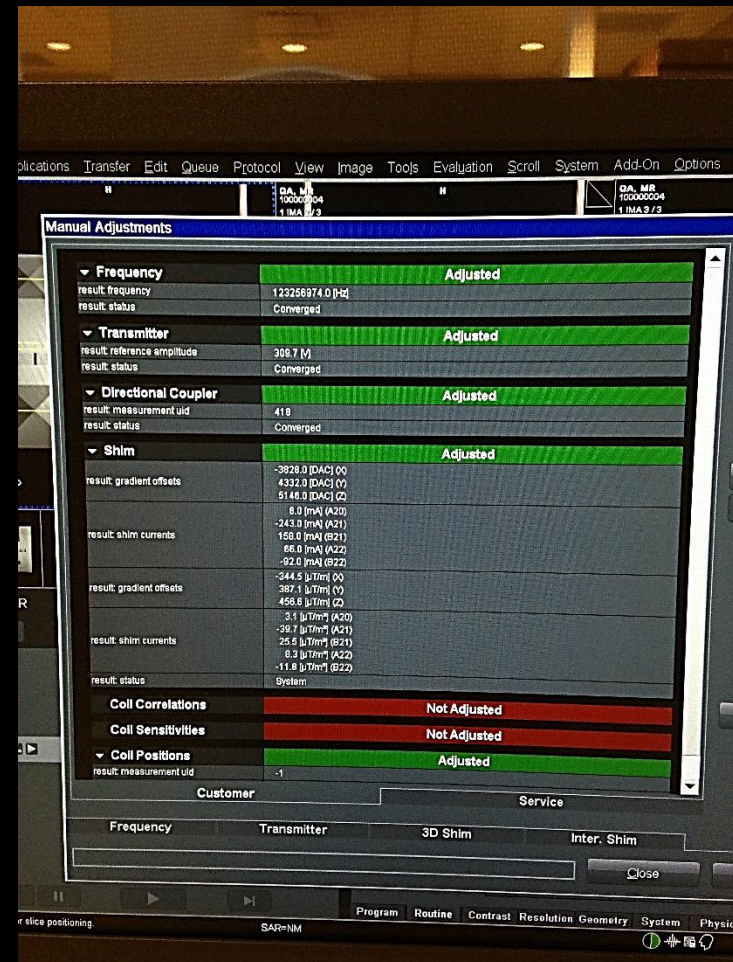
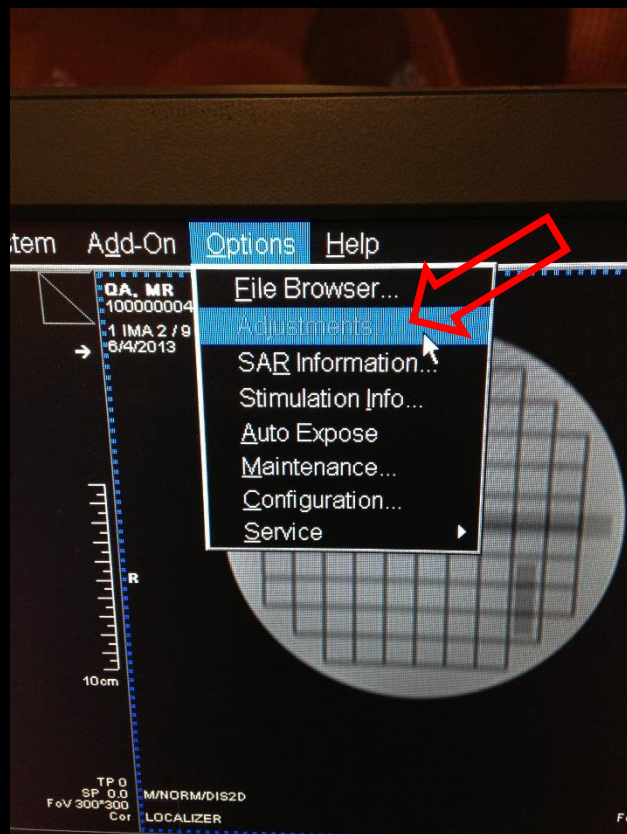
R
1
2
2

SE
TR:500
TE:20
EC:1/1 15.6kHz
8HRBRAIN
FOV: 25x25
5.0thk/5.0sp
11/02/16

Central Frequency on Siemens scanner

• Procedure

- Before run a sequence, e.g. ACR T1 axial
- “Options” → “Adjustments...”
- Record central frequency and transmit gain



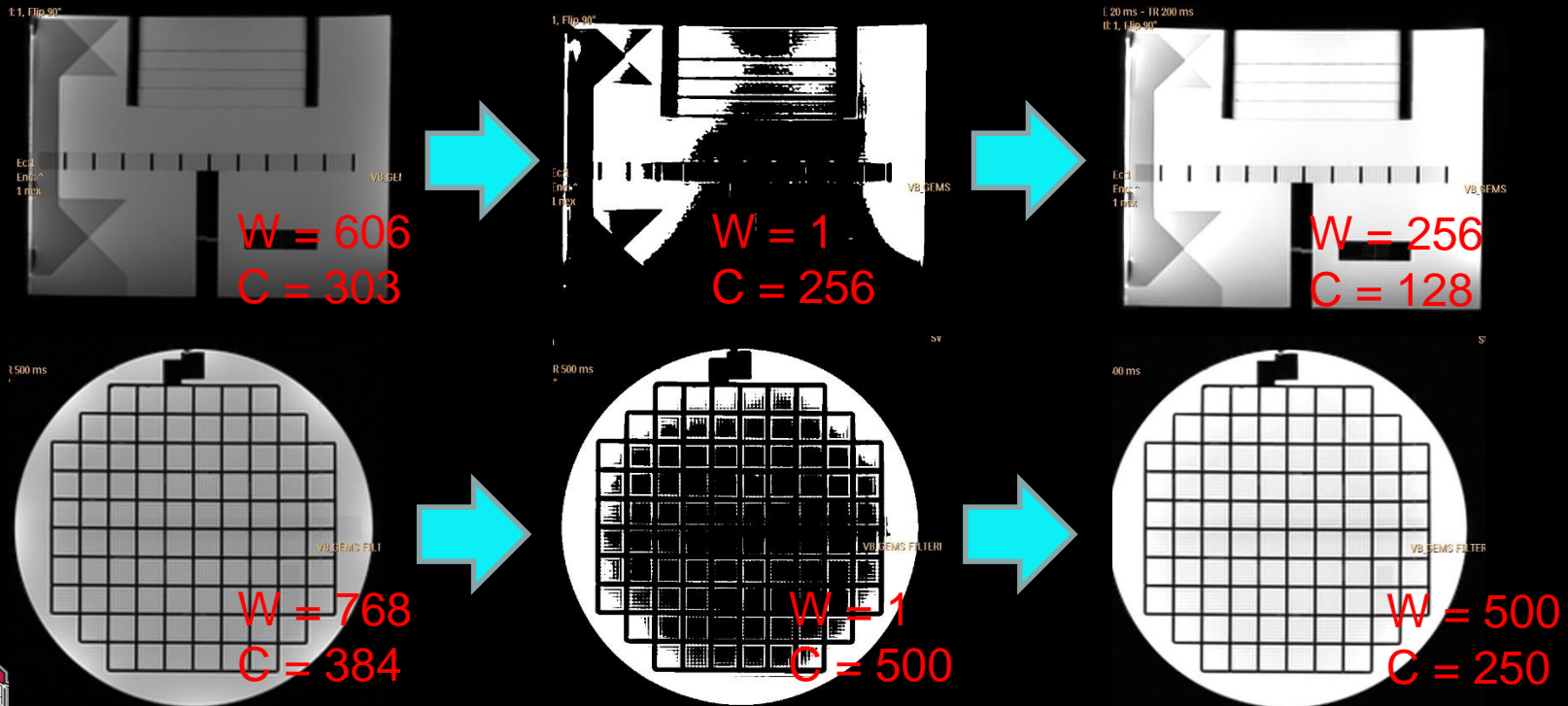
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Distance Measurement: WW and WC

- Setting window and level/center

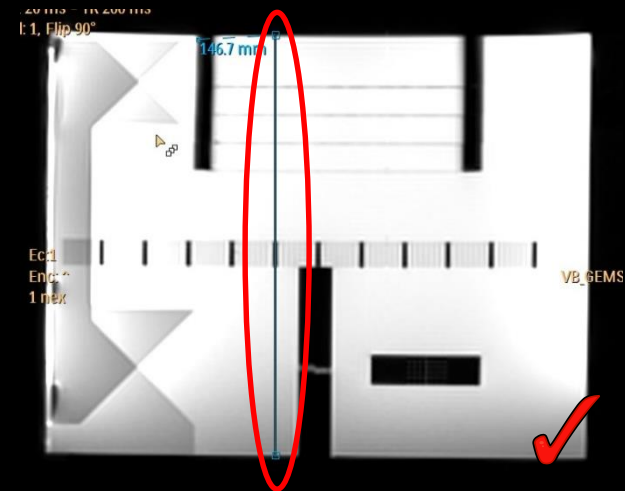
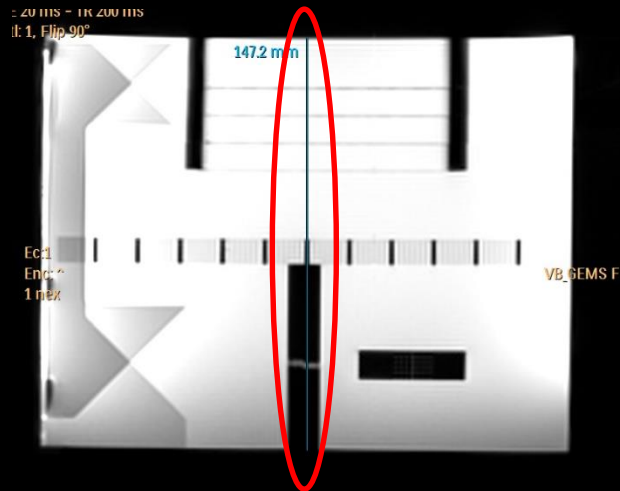
- To have the edges at the half-maximum value of the signal intensity
- Skipped by some Technologists
- First set window to 0 or 1
- Adjust level/center about ½ white and ½ black, record level value
- width = recorded level value
- level/center = ½ recorded level value



Distance Measurement: Sagittal

- Sagittal Image

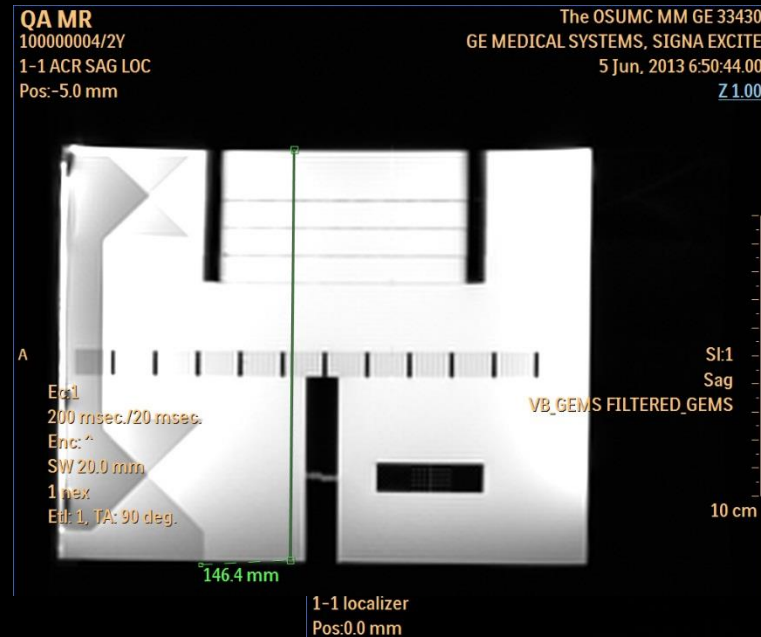
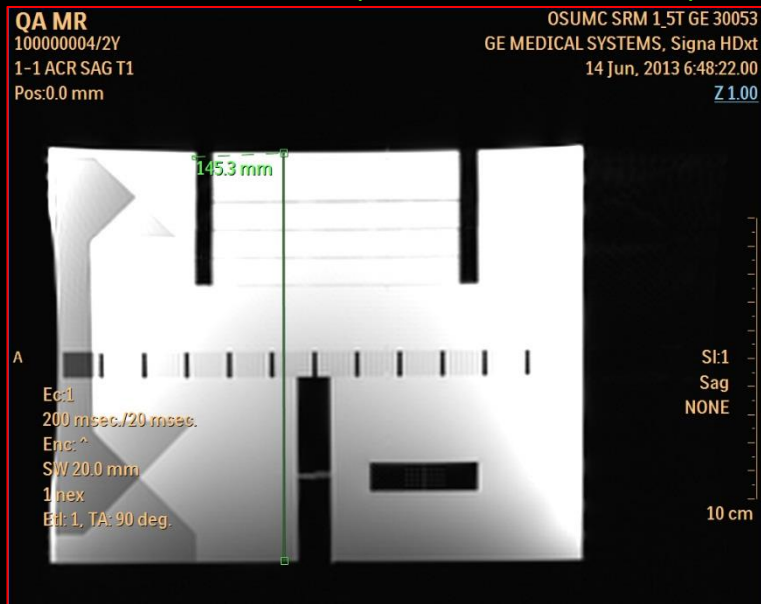
- Avoid going through the black bar
- $< 148 \pm 2$ mm



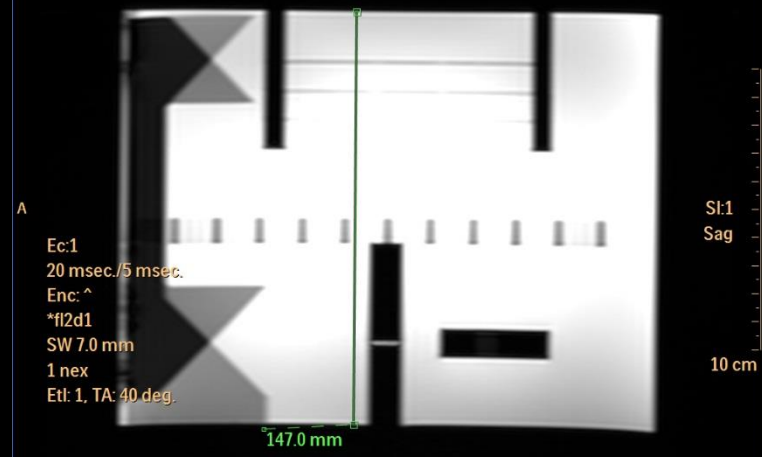
Distance Measurement: Problem

- Sagittal Loc Length

- 145.3 mm (Stoneridge)
- 146.4 mm (Morehouse)
- 147.0 mm (Siemens SSCBC)



are Comprehensive Breast Center 87
SIEMENS, Skyra
13 Jun, 2013 16:21:36.78
Z 1.00



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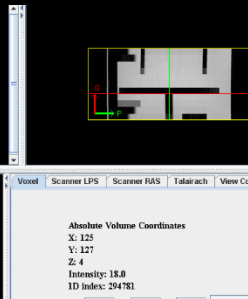
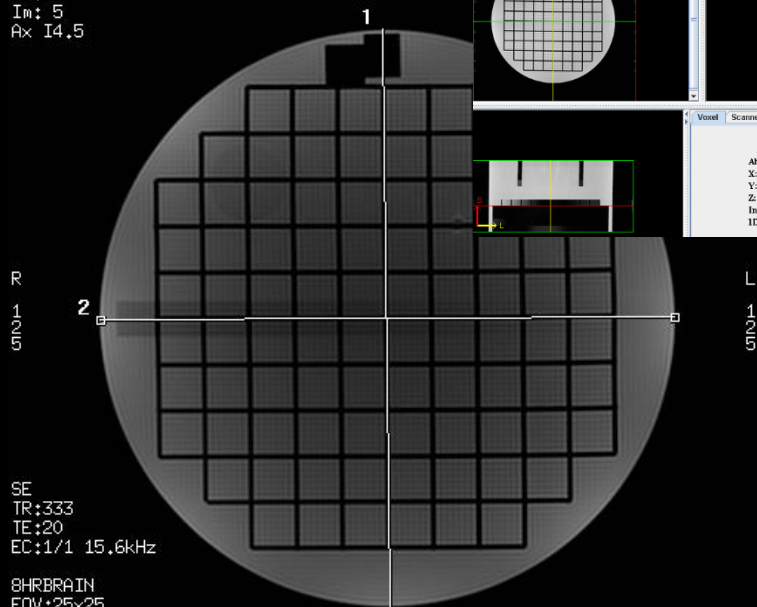
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Distance Measurement: Axial

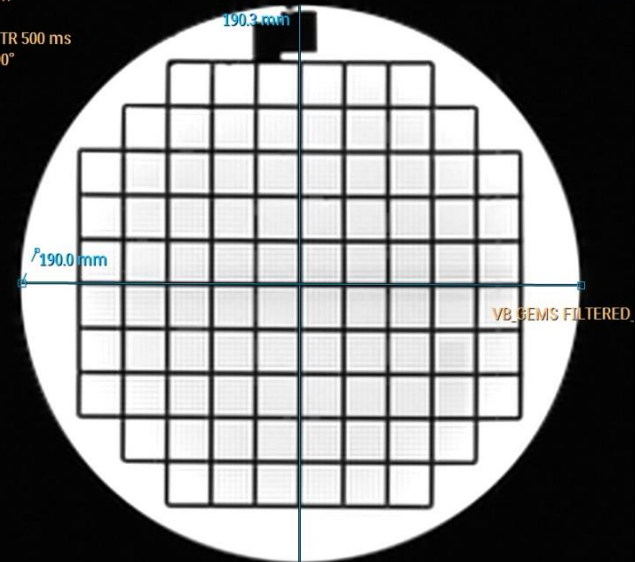
- Axial slice #5
 - One vertical
 - One horizontal
 - $< 190 \pm 2$ mm
 - Examples:

Signa HDxt 1.5T GEMSOVMR
Ex: 20034
Se: 3
Im: 5
Ax: 14.5

A 151



TR 500 ms
10°



SE
TR:333
TE:20
EC:1/1 15.6kHz
BHRBRAIN
FOV:25x25
5.0thk/5.0sp
11/01:31
256X256/1.00 NEX
1512

1: distance 190mm, angle 1°
2: distance 190mm, angle 90°

P 99



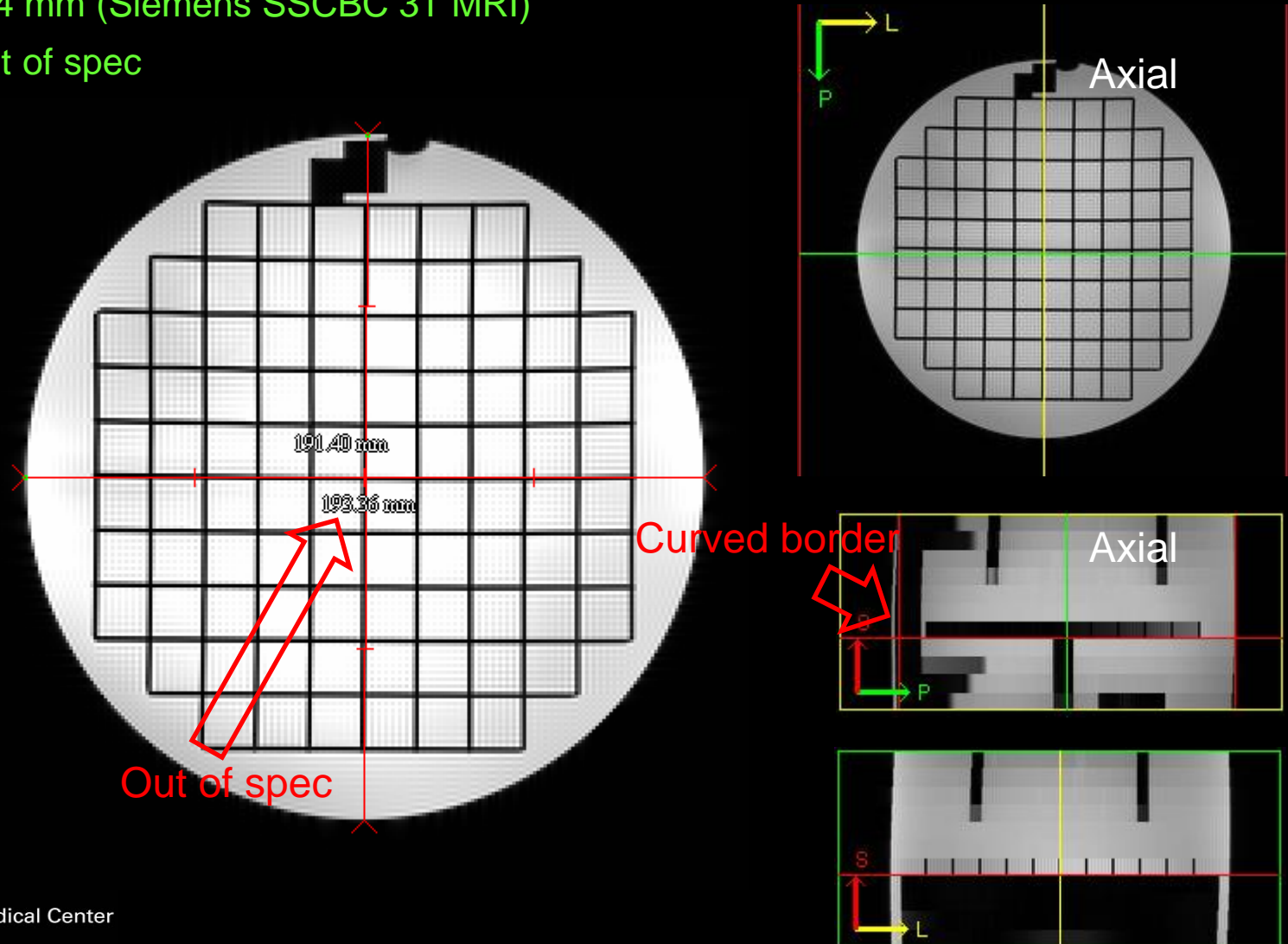
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Distance Measurement: Problem

- Vertical distance

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



Spokes

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

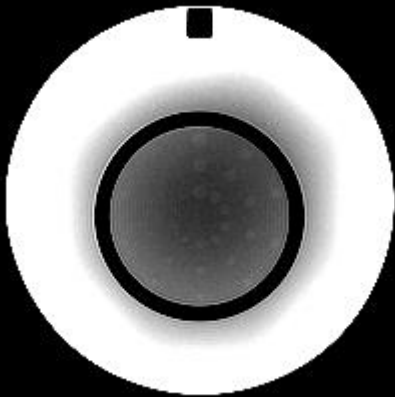


Image 8

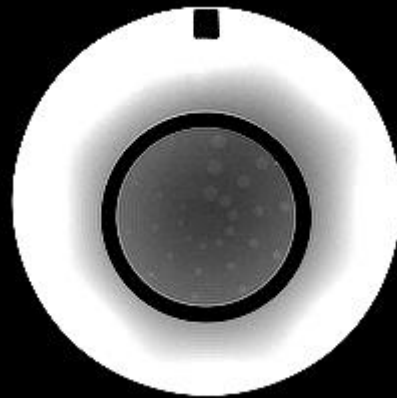


Image 9

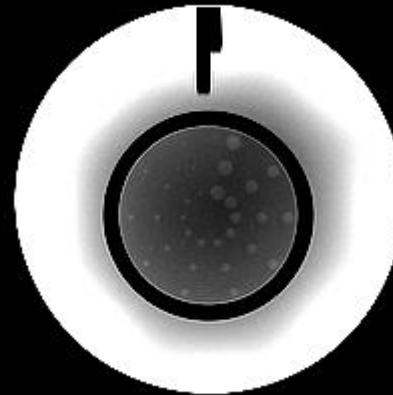


Image 10

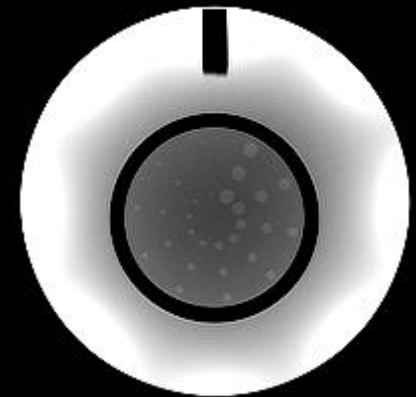


Image 11

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?

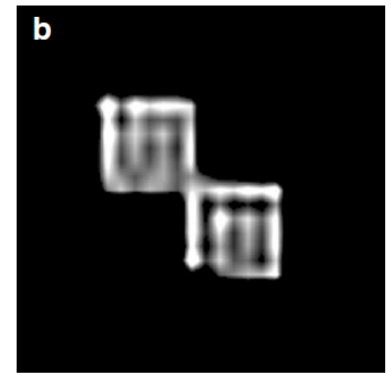
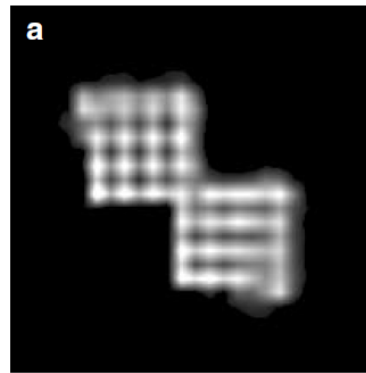
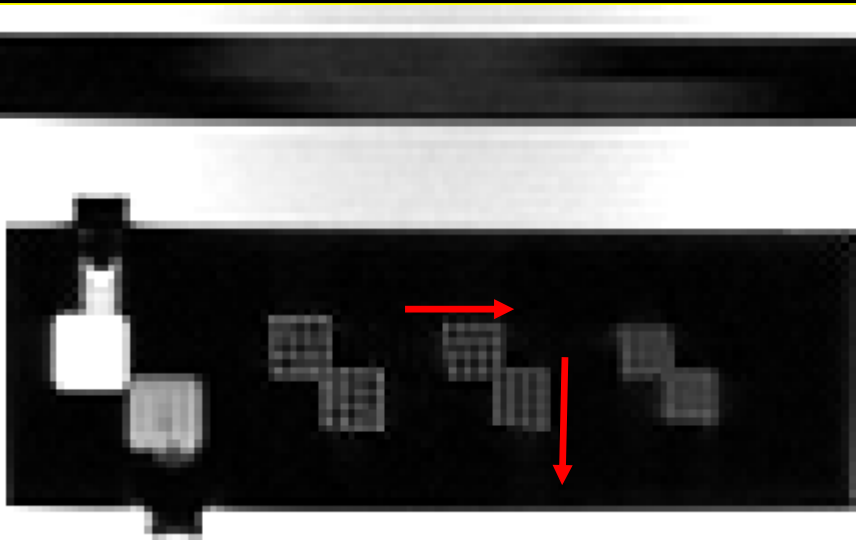


Figure 9:

- (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.

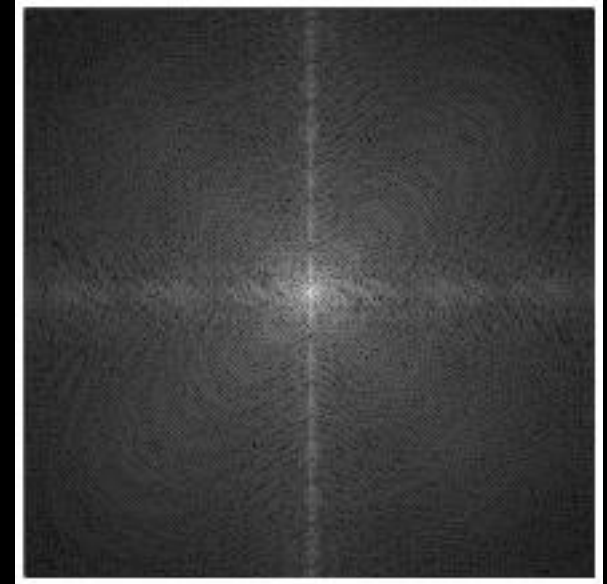
Resolution: ZIP

- 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



Unfiltered Image
256x256

FT



k-space data
256x256



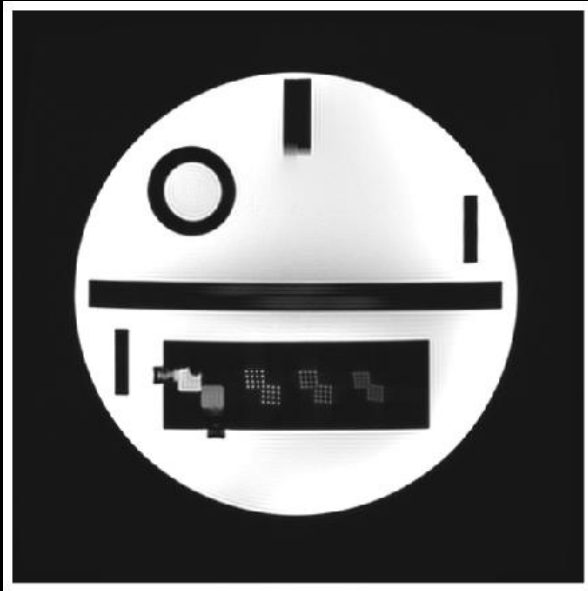
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Courtesy of Dr. Moriel S. NessAiver

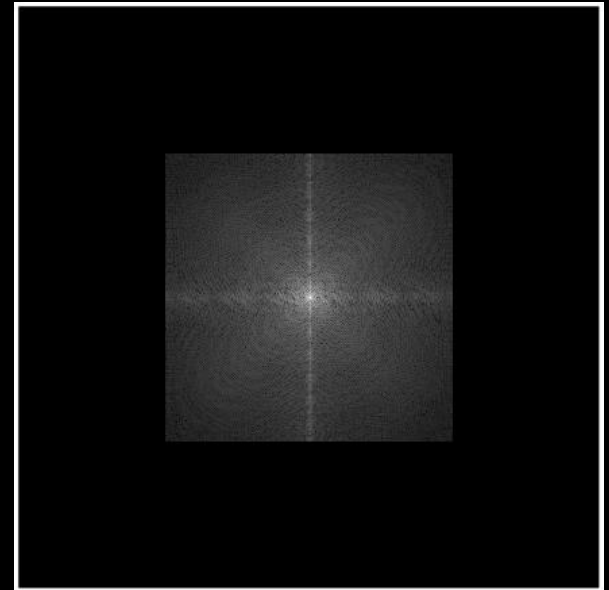
Resolution: ZIP

- Zero filled interpolation (ZIP)
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Unfiltered Image
512x512

FT

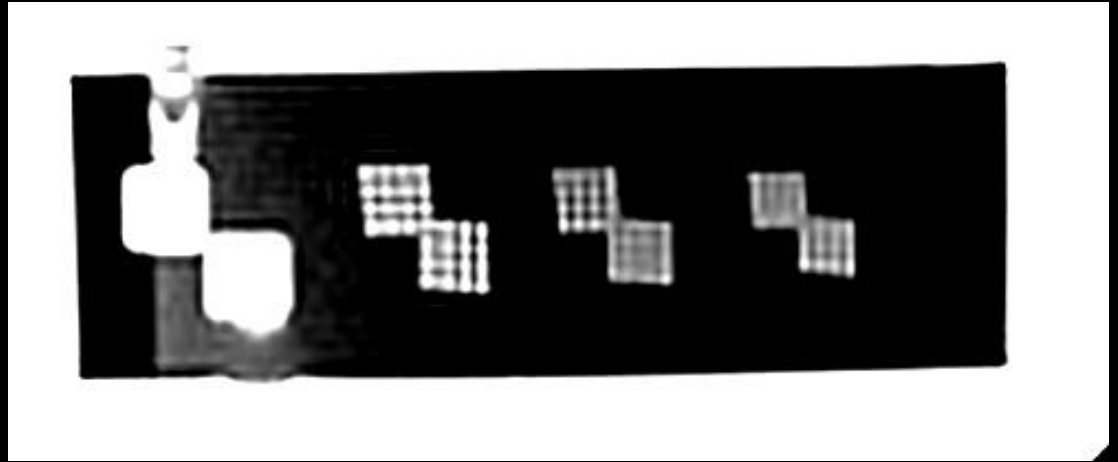


k-space data
512x512

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

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



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A. DATA FORM FOR DAILY MRI EQUIPMENT QUALITY CONTROL

MR Facility Name _____

MR Scanner Identifier _____

1 Date of Test Year	2 Table OK?	3 Console OK?	4 CF M(Hz)	5 TX Gain/ Attenu- ation (dB)	Phantom Distances (mm)			Slice 1 HR Holes #		Slice # 8 Number of LCD Spokes	Artifacts ?	Test By
					Sag Loc Length	Axial Slice #5 ← Diameters →		9	10			
Action Limits →					6 Z (148)	7 Y (190)	8 X (190)	UL	LR	11	12	13
3/15	✓	✓	123.2	305.8	148	193	190	1.0	1.0	10	N	
3/29	✓	✓	123.2	307.7	149	194	190	1.0	1.0	10	N	
4/5	✓	✓	123.2	316.5	149	194	190	1.0	1.0	10	N	
4/12	✓	✓	123.2	296.8	148	192	190	1.0	1.0	10	N	
4/19	✓	✓	123.2	306.2	148	193	190	1.0	1.0	10	N	
4/26	✓	✓	123.2	290.9	149	193	191	1.0	1.0	10	N	
5/3	✓	✓	123.2	294.6	148	191	189	1.0	1.0	10	N	
5/10	✓	✓	123.2	291.3	148	191	189	1.0	1.0	10	N	
5/17	✓	✓	123.2	285.8	147	190	190	1.0	1.0	10	N	
5/24	✓	✓	123.2	283.6	146	191	190	1.0	1.0	10	N	
5/31	✓	✓	123.2	302.6	147	190	190	1.0	1.0	10	N	
6/7	✓	✓	123.2	295.0	148	190	190	1.0	0.9	10	N	
6/14	✓	✓	123.2	296.0	147	190	190	1.0	1.0	10	N	
6/21	✓	✓	123.2	288.5	147	190	190	1.0	1.0	10	Y	
6/28	✓	✓	123.2	291.7	147	191	190	1.0	1.0	10	Y	
7/5	✓	✓	123.2	292.4	147	191	190	1.0	1.0	10	Y	
7/12	✓	✓	123.2	294.6	147	191	190	1.0	1.0	10	Y	
7/19	✓	✓	123.2	287.6	147	191	190	1.0	1.0	10	Y	
7/26	✓	✓	123.2	289.8	147	191	190	1.0	1.0	10	Y	
8/2	✓	✓	123.2	292.8	147	190	190	1.0	0.9	10	Y	

Reviewed by: _____

Qualified Medical Physicist/MRI Scientist

_____ Review

NOTES

Write in on loc. scanner problem

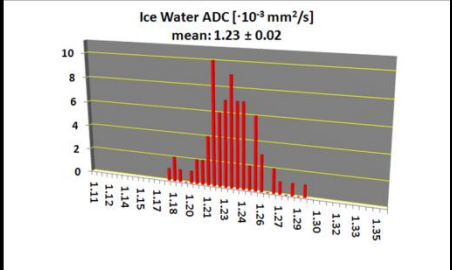
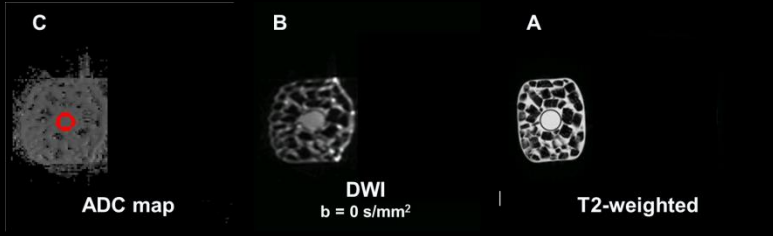
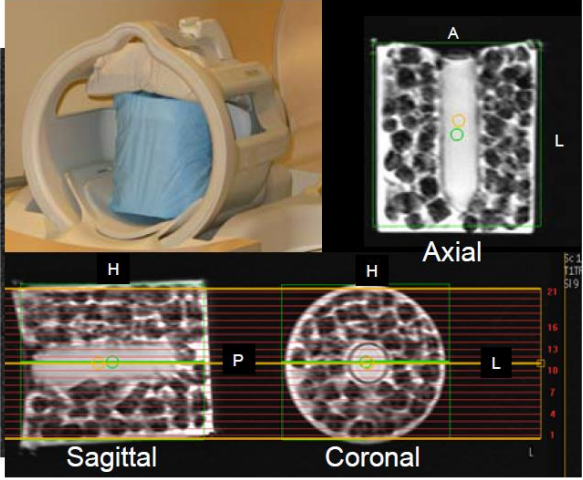
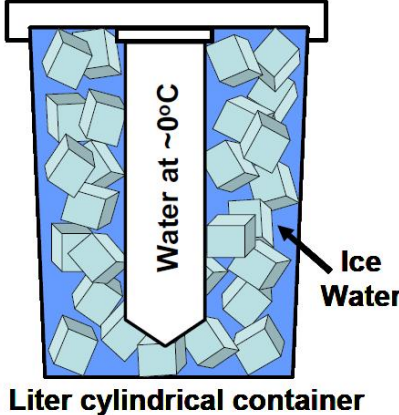
Additional Tests

- Advanced clinical MRI procedures
 - MR spectroscopy
 - Diffusion imaging
 - Blood oxygen level dependent contrast (BOLD) imaging
 - Angiographic and blood perfusion methods
 1. DCE-MRI



Diffusion

MRI Diffusion (ADC) Phantom



DCE-MRI

Purpose of the DCE-MRI Phantom Tests:

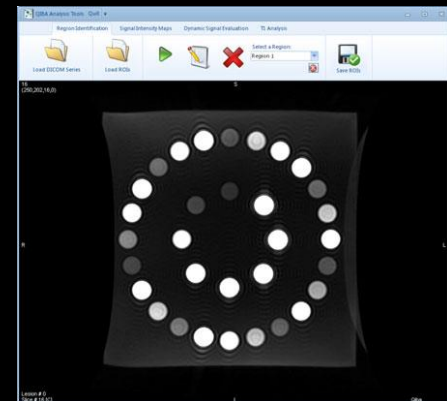
- Provide means for qualitative and quantitative evaluation, including T1 map error estimation, temporal resolution and image quality.
- Evaluate compliance with image acquisition protocols.

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

References

1. Sobol WT, NessAiver MS, Orton CG, Point/counterpoint. The physics components of the ACR MRI Accreditation Program are overly tedious and beyond what is needed to ensure good patient care. *Med Phys* 35(8):3419
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