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MR Accreditation: Basics and Beyond

Robert A. Pooley, Ph.D.

May 1, 2011

Outline

- Basic Steps towards ACR MR Accreditation
- Basic Phantom Acquisition and Analysis
- Phantom Image Review
- On-going Quality Control
- Are You Prepared for an ACR Inspection?

Disclaimer

- The ACR pays me $$$ to review phantom images.

Steps Towards Accreditation

- Go to www.acr.org
- Click "Accreditation"
- Click "MRI"
- Read everything on these pages especially the "MRI Program Requirements"
- Apply for Accreditation

American College of Radiology - Windows Internet Explorer

http://www.acr.org/

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Clinical Research
Health Policy Research

Breast MR with gadolinium
June 21-22
In Seattle

ACR PRED

Case in Point

April 29, 2011
A 40-year-old woman with a history of slowly progressive numbness and weakness of the left side of her face

Special Sections
Cardiac CT Advanced Proficiency Examination
ACR Appropriateness Criteria®
ACR Radiation Oncology Section
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National Radiology Data Registry
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Concerned About RADIATION?

AMCLC Portal

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http://www.acr.org/accreditation.aspx

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ACR Homepage
Verify Your Accreditation Status
Accredited Facility Search
Getting Started: Apply for Accreditation
Mammography
Radiation Oncology
Breast Magnetic Resonance Imaging (MRI)
Breast Ultrasound
Computed Tomography
Magnetic Resonance Imaging (MRI)
Nuclear Medicine and PET
Stereotactic Breast Biopsy
Ultrasound
Breast Imaging Center of Excellence
Marketing Toolkit for ACR Accredited Practices

Accreditation

Why Get Accredited?
New: MIPPA/CMS Mandates
Getting Started: Apply for Accreditation
Already accredited in advanced imaging?
Learn more about CMS mandates that affect your practice
Accreditation Marketing Kit
10 Things You Need to Know About CMS/MIPPA Accreditation Requirements
Accreditation Requirements for Suppliers of the Technical Component of Advanced Imaging
Consumer Complaint Notice to Patients
Verify Your Accreditation Status
Accreditation E-newsletters
General Accreditation FAQs
Contact Us

Free Accreditation Webinars On-Demand
ACR specialists help you understand the policies and procedures of MIPPA/CMS accreditation.

Breast MRI Accreditation Webinar

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Magnetic Resonance Imaging (MRI) - Windows Internet Explorer

http://www.acr.org/accreditation/mri.aspx

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ACR Homepage
MRI Accreditation Program History
MRAP Program Requirements
MRI Frequently Asked Questions
MRI Testing and QC Forms
MRI Quality Control Manual

Magnetic Resonance Imaging (MRI)

The MRI Accreditation Program involves the acquisition of clinical and phantom images and corresponding data for each magnet. Click here for more information on the history of this program.

Contact Us
For additional information, contact us by:

- **Email:** mri@acr.org
- **Phone:** (800) 770-0145

Program Requirements

- Click here for a listing of MRI Program Requirements
- ACR CT, MRI, Nuclear Medicine and PET Accreditation Program Requirements for Medical Physicists/MR Scientists - 10/2009 Revision, FAQs Available

Frequently Asked Questions

- My facility plans to apply for ACR MRI Accreditation, where do I start?
- Will MRI accreditation become mandatory?
- Is my hospital required to be accredited under the new MIPPA legislation?
- Can any MRI facility apply for MRI accreditation?

More »

Apply for Accreditation
Click here for information on applying for accreditation.

Testing and QC Forms

MRI Accreditation Program Requirements

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OVERVIEW 2
Mandatory Accreditation Time Requirements 2
WITHDRAWN, ADDED, OR REPLACEMENT UNITS 2
LOANER UNIT 3
EMERGENCY USE OF UNITS 3
PERSONNEL QUALIFICATIONS 4
Physician 4
Technologist 8
Medical Physicist/MR Scientist 9
EQUIPMENT 10
QUALITY CONTROL 10
Acceptance Testing 10
Quality Control Testing 10
Continuous Quality Control 10
Preventive Maintenance 11
QUALITY ASSURANCE 11

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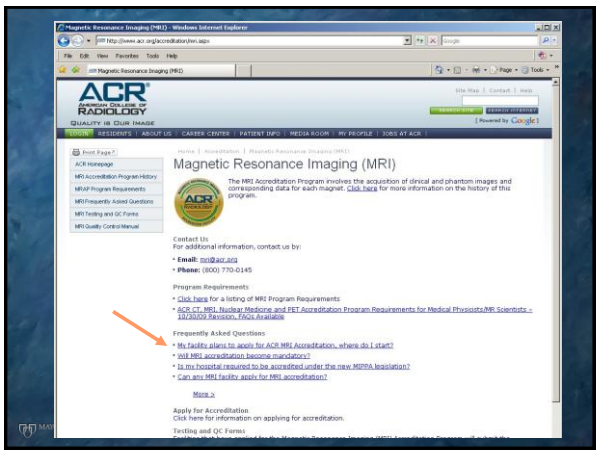
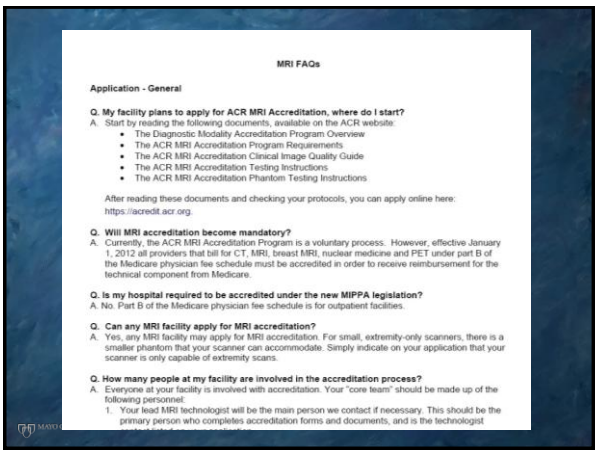




MRI FAQs

Application - General

Q. My facility plans to apply for ACR MRI Accreditation, where do I start?
A. Start by reading the following documents, available on the ACR website:
- The Diagnostic Modality Accreditation Program Overview
- The ACR MRI Accreditation Program Requirements
- The ACR MRI Accreditation Clinical Image Quality Guide
- The ACR MRI Accreditation Testing Instructions
- The ACR MRI Accreditation Phantom Testing Instructions

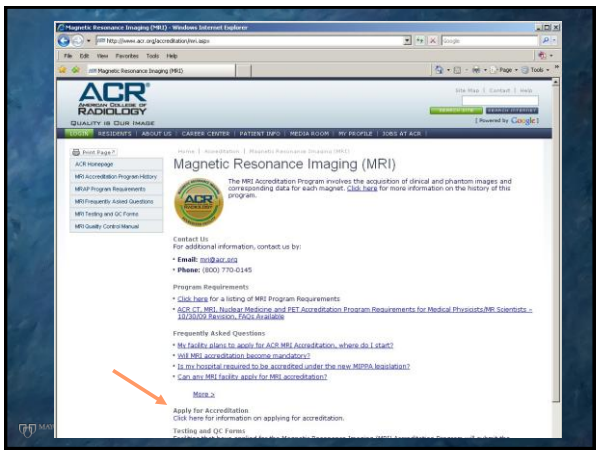
After reading these documents and checking your protocols, you can apply online here: https://acredit.acr.org.

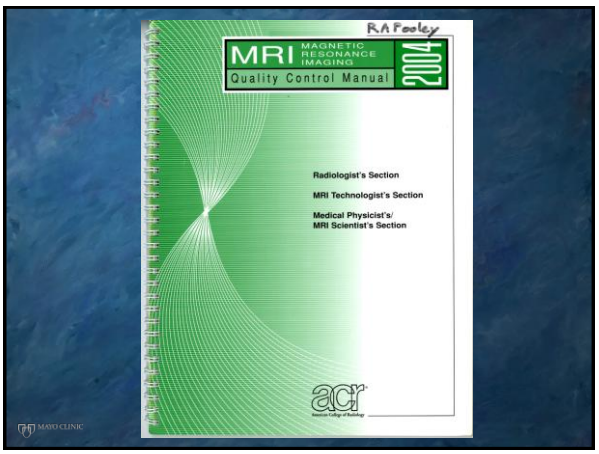
Q. Will MRI accreditation become mandatory?
A. Currently, the ACR MRI Accreditation Program is a voluntary process. However, effective January 1, 2012 all providers that bill for CT, MRI, breast MRI, nuclear medicine and PET under part B of the Medicare physician fee schedule must be accredited in order to receive reimbursement for the technical component from Medicare.

Q. Is my hospital required to be accredited under the new MIPPA legislation?
A. No. Part B of the Medicare physician fee schedule is for outpatient facilities.

Q. Can any MRI facility apply for MRI accreditation?
A. Yes, any MRI facility may apply for MRI accreditation. For small, extremity-only scanners, there is a smaller phantom that your scanner can accommodate. Simply indicate on your application that your scanner is only capable of extremity scans.

Q. How many people at my facility are involved in the accreditation process?
A. Everyone at your facility is involved with accreditation. Your "core team" should be made up of the following personnel:
1. Your lead MRI technologist will be the main person we contact if necessary. This should be the primary person who completes accreditation forms and documents, and is the technologist





"Application for Accreditation is a 2-step process."

- Step 1: Provide ACR with information regarding your practice
- Step 2: Submit data

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Note

- An annual performance evaluation must be submitted to the ACR
- Surprisingly, the ACR receives many reports with
  - Required tests not performed
  - Corrective action not documented if the physicist/MR scientist failed any tests

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Read "10 Things You Need to Know about CMS/MIPPA Accreditation Requirements"

- #1 Who needs to be accredited?
- The Medicare Improvements for Patients and Providers Act (MIPPA) calls for all providers of CT, MRI, breast MRI, nuclear medicine, and PET exams that bill under Part B of the Medicare Physician Fee Schedule to be accredited by Jan. 1, 2012, in order to receive payment for the technical component of these services. Currently, the CMS/MIPPA mandates apply to private outpatient facilities only, NOT to hospitals.

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Basic Phantom Acquisition

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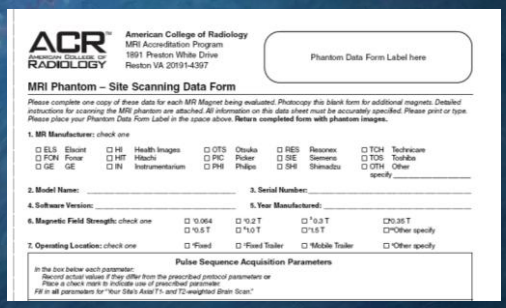
Acquiring The Phantom Data



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American College of Radiology
MRI Accreditation Program
1891 Preston White Drive
Reston VA 20191-4397

Phantom Data Form Label here

MRI Phantom – Site Scanning Data Form

Please complete one copy of these data for each MR Magnet being evaluated. Photocopy this blank form for additional magnets. Detailed instructions for scanning the MRI phantom are attached. All information on this data sheet must be accurately specified. Please print or type. Please place your Phantom Data Form Label in the space above. **Return completed form with phantom images.**

1. MR Manufacturer: *check one*

☐ ELS Elscint ☐ HI Health Images ☐ OTS Otsuka ☐ RES Resonex ☐ TCH Technicare
☐ FON Fonar ☐ HIT Hitachi ☐ PIC Picker ☐ SIE Siemens ☐ TOS Toshiba
☐ GE GE ☐ IN Instrumentarium ☐ PHI Philips ☐ SHI Shimadzu ☐ OTH Other specify _____

2. Model Name: _____ **3. Serial Number:** _____

4. Software Version: _____ **5. Year Manufactured:** _____

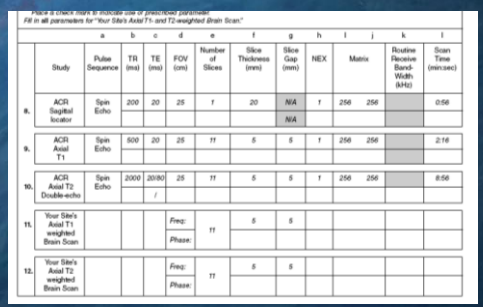
6. Magnetic Field Strength: *check one* ☐ 0.064 ☐ *0.2 T ☐ *0.3 T ☐0.35 T ☐ *0.5 T ☐ *1.0 T ☐ *1.5 T ☐*Other specify

7. Operating Location: *check one* ☐ *Fixed ☐ *Fixed Trailer ☐ *Mobile Trailer ☐ *Other specify

Pulse Sequence Acquisition Parameters

In the box below each parameter:
Record actual values if they differ from the prescribed protocol parameters or
Place a check mark to indicate use of prescribed parameter.
Fill in all parameters for "Your Site's Axial T1- and T2-weighted Brain Scan."

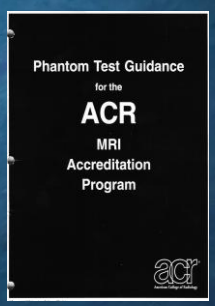
Acquiring The Phantom Data



Place a check mark to indicate use of prescribed parameter.
Fill in all parameters for "Your Site's Axial T1- and T2-weighted Brain Scan."

		a	b	c	d	e	f	g	h	i	j	k	l
	Study	Pulse Sequence	TR (ms)	TE (ms)	FOV (cm)	Number of Slices	Slice Thickness (mm)	Slice Gap (mm)	NEX	Matrix		Routine Receive Band-Width (kHz)	Scan Time (min:sec)
8.	ACR Sagittal locator	Spin Echo	200	20	25	1	20	N/A	1	256	256		0:56
								N/A					
9.	ACR Axial T1	Spin Echo	500	20	25	11	5	5	1	256	256		2:16
10.	ACR Axial T2 Double-echo	Spin Echo	2000	20/80	25	11	5	5	1	256	256		8:56
				/									
11.	Your Site's Axial T1 weighted Brain Scan				Freq:	11	5	5					
					Phase:								
12.	Your Site's Axial T2 weighted Brain Scan				Freq:	11	5	5					
					Phase:								

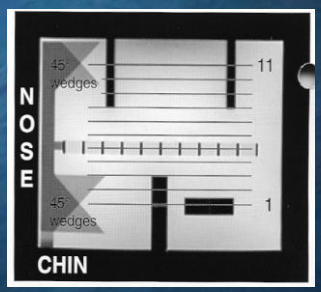
ACR MRAP



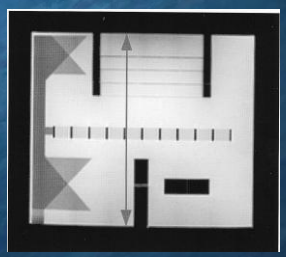
Phantom Tests

- Geometric accuracy
- High contrast spatial resolution
- Slice thickness accuracy
- Slice position accuracy
- Image intensity uniformity
- Percent signal ghosting
- Low contrast object detectability

Sagittal Localizer



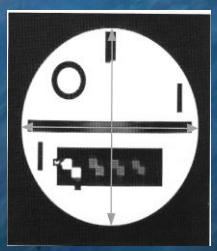
Geometric Accuracy



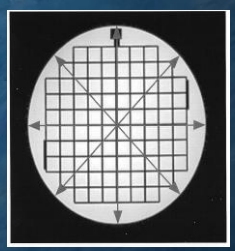
Criteria:
148 ± 2 mm

Sagittal Localizer

Geometric Accuracy



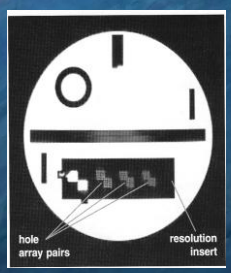
Slice 1



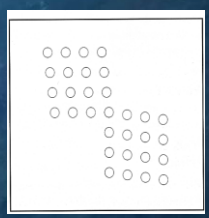
Slice 5

Criteria: 190 ± 2 mm

High Contrast Spatial Resolution

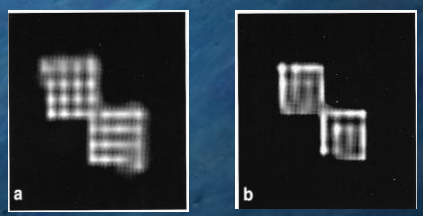


Slice 1



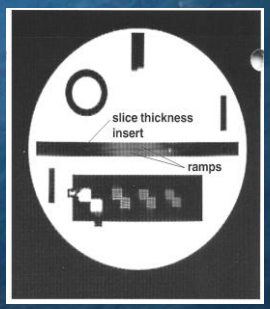
Criteria: 1.0 mm

High Contrast Spatial Resolution



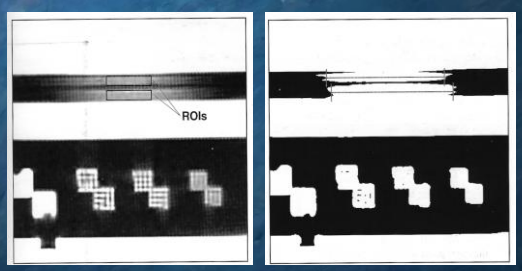
Slice Thickness Accuracy

Slice 1



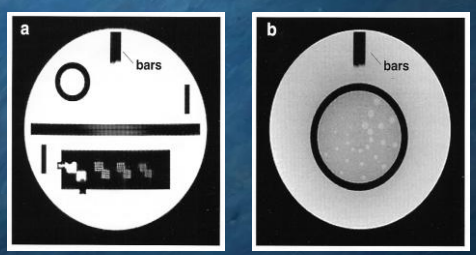
Criteria:
5.0 ± 0.7 mm

Slice Thickness Accuracy



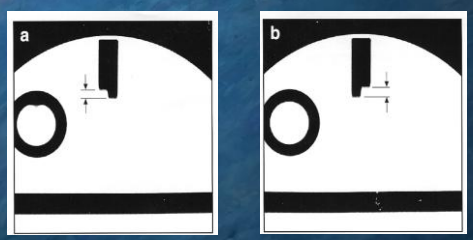
slice thickness = 0.2 x (top x bottom)/(top + bottom)

Slice Position Accuracy



Slice 1 Slice 11

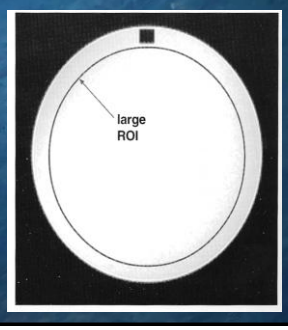
Slice Position Accuracy



Criteria: |bar length difference| < 5 mm

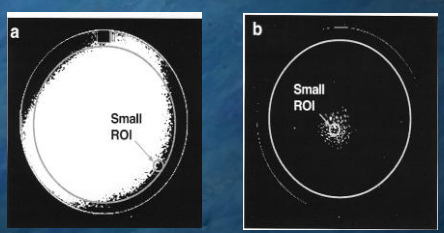
Image Intensity Uniformity

Slice 7



Criteria:
PIU ≥ 87.5%

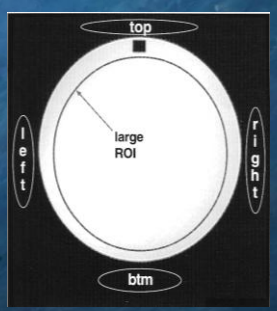
Image Intensity Uniformity



PIU: 100 x (1-((high - low)/(high + low)))

Percent Signal Ghosting

Slice 7

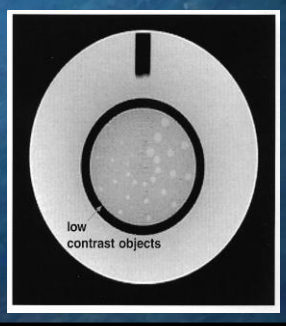


Criteria:
ghosting ratio ≤ 0.025

$$\text{ghosting ratio} = \frac{|((T+B)-(L+R))|}{2 \times \text{large ROI}}$$

Low Contrast Object Detectability

Slice 11



Criteria: 9 spokes

Low Contrast Object Detectability

Slice 8

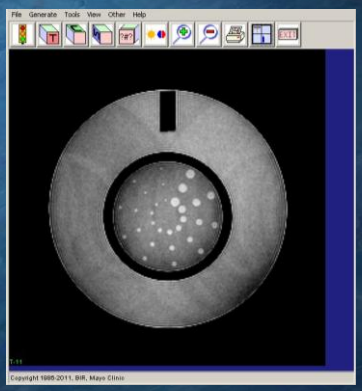
When Bad Images Happen to Good People

Most Common Image Problems

- Ghosting
- Per cent image uniformity (PIU)
- Low contrast detectability (LCD)
- Geometric distortion
- Filter issues

Ghosting

1



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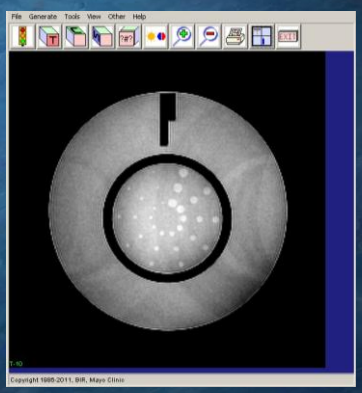

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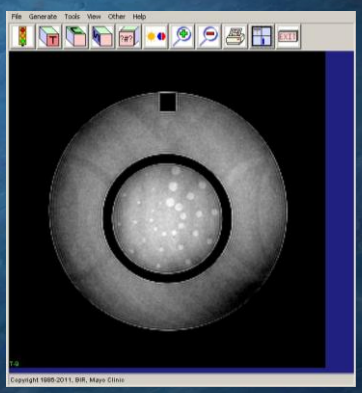

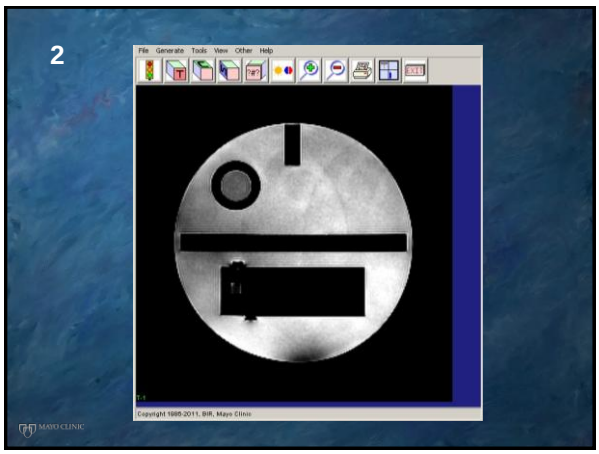

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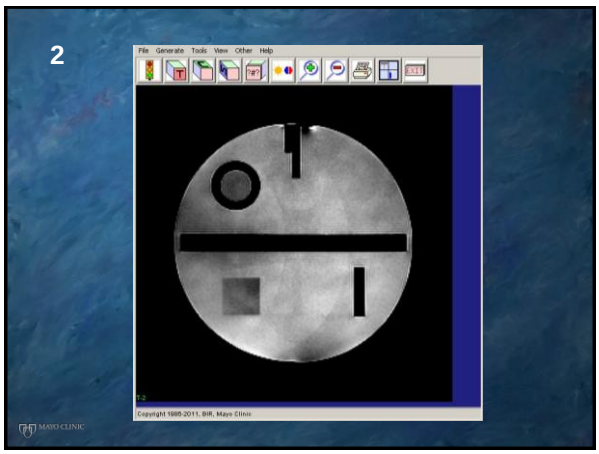

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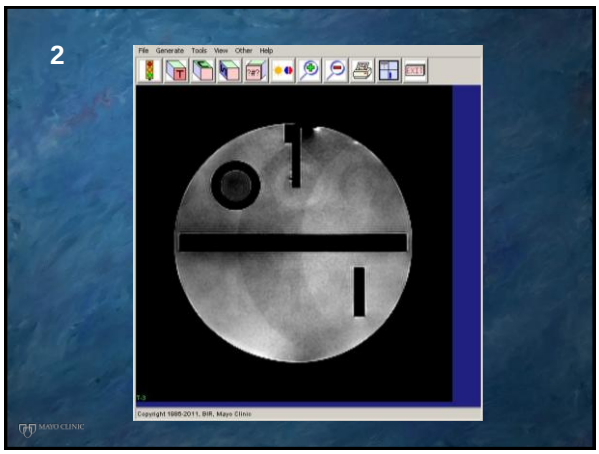

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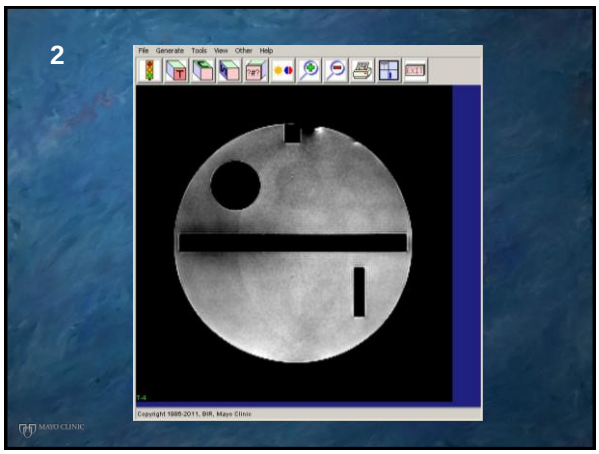

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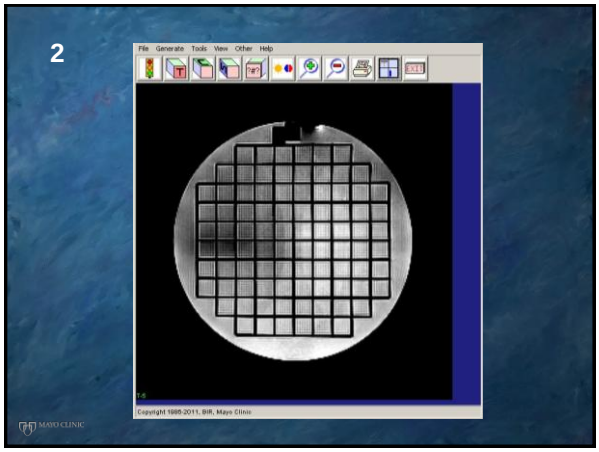
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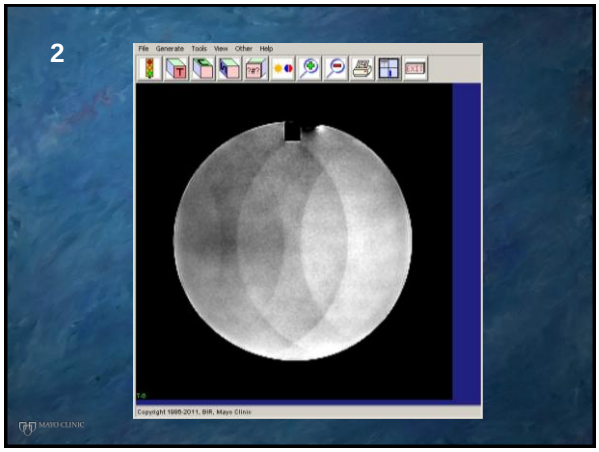
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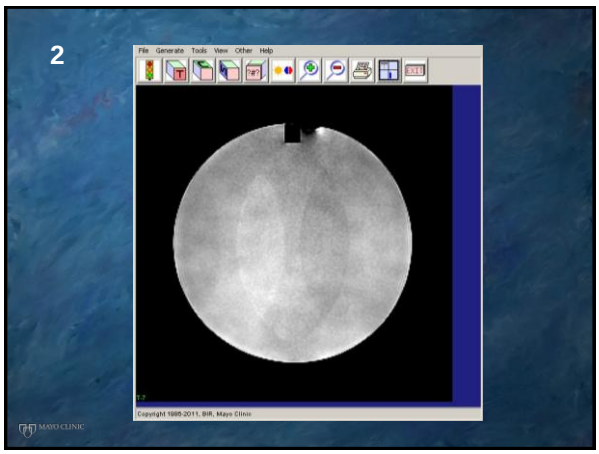
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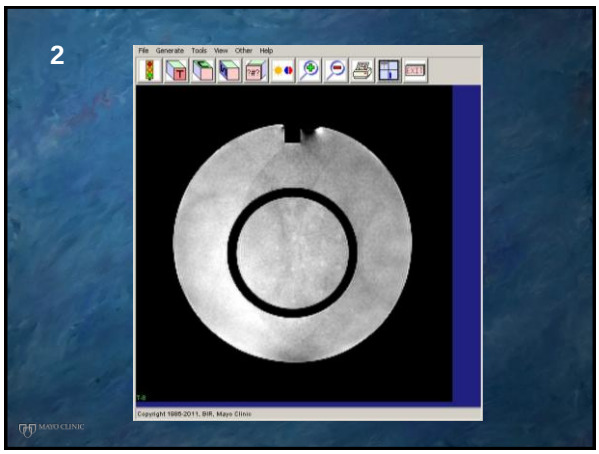
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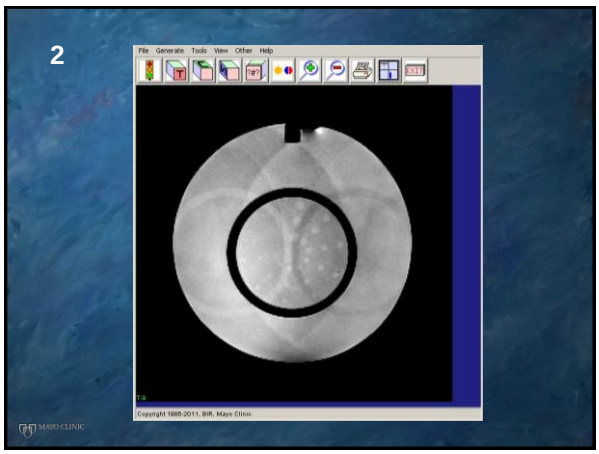
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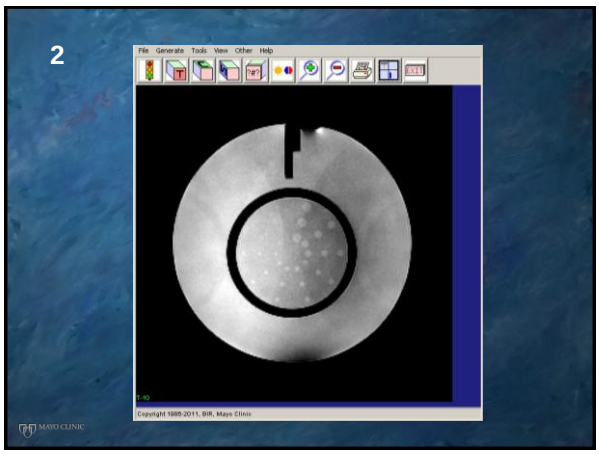
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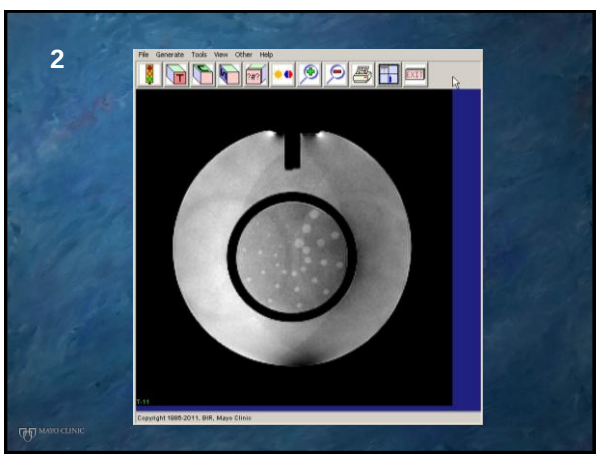
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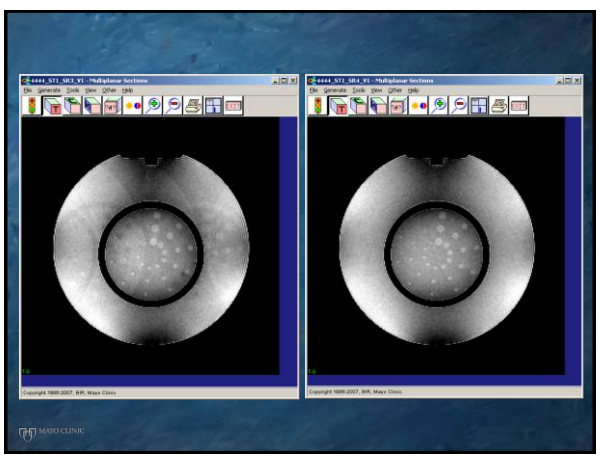
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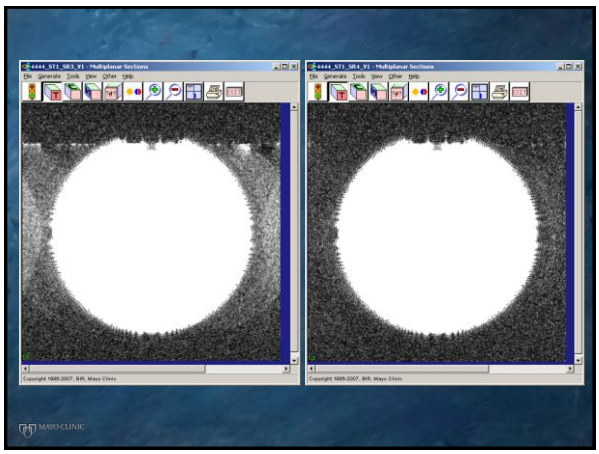
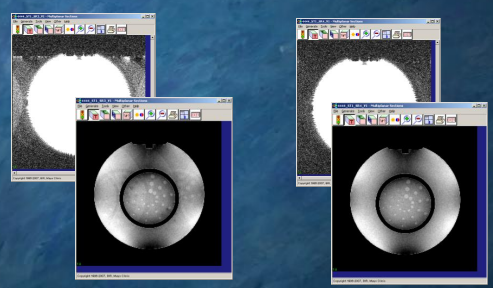


Ghosting - Cold Head Issue

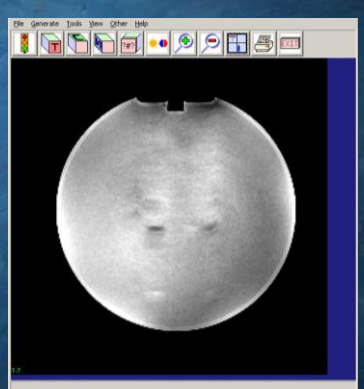


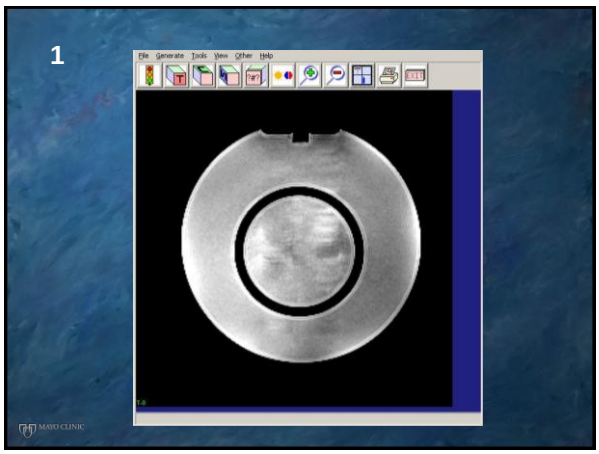
ON

OFF

Percent Image Uniformity

1

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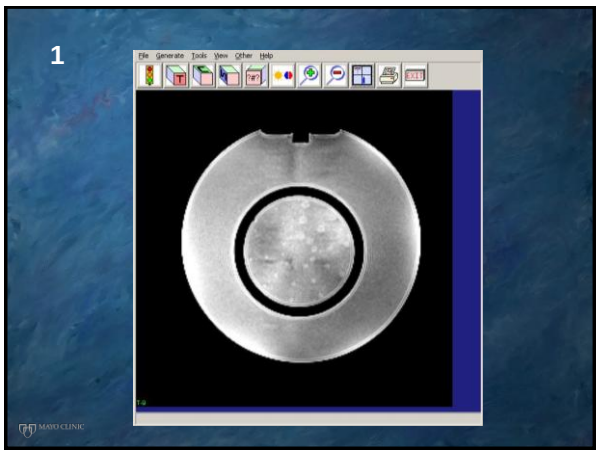
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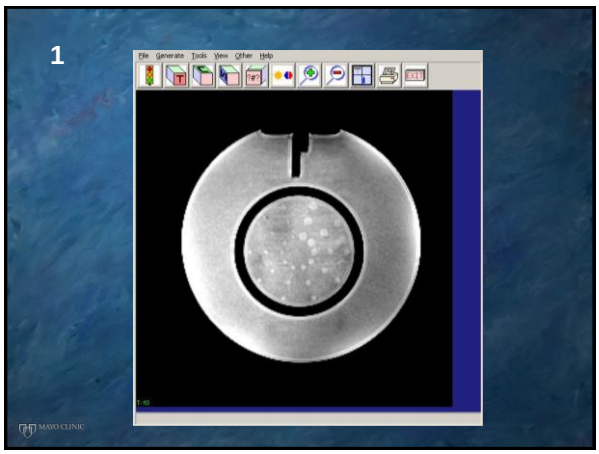
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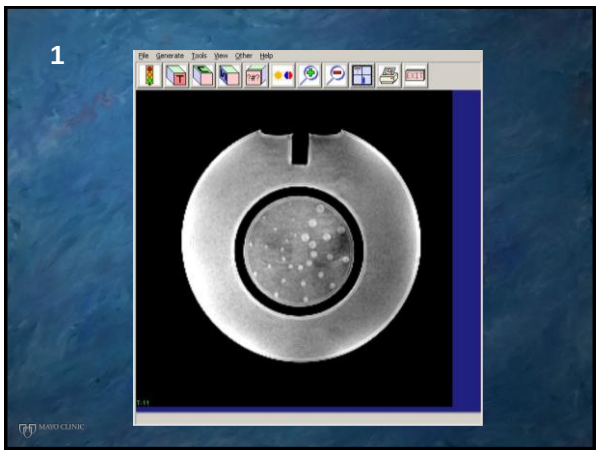
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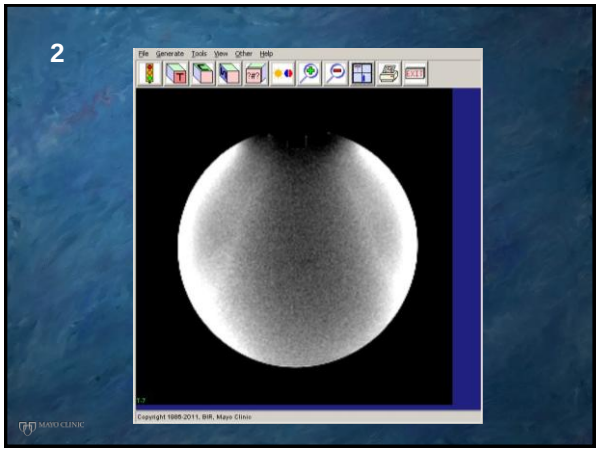
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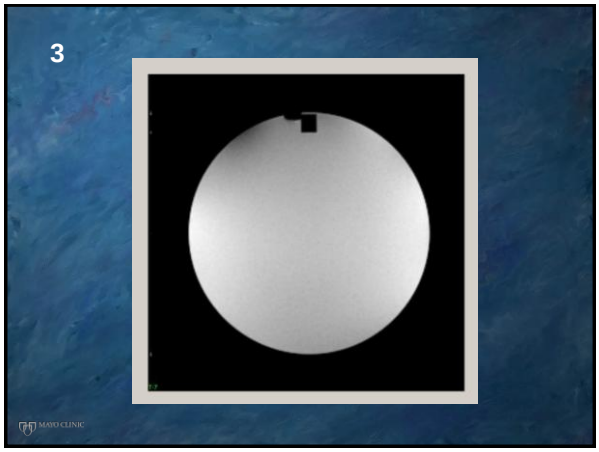
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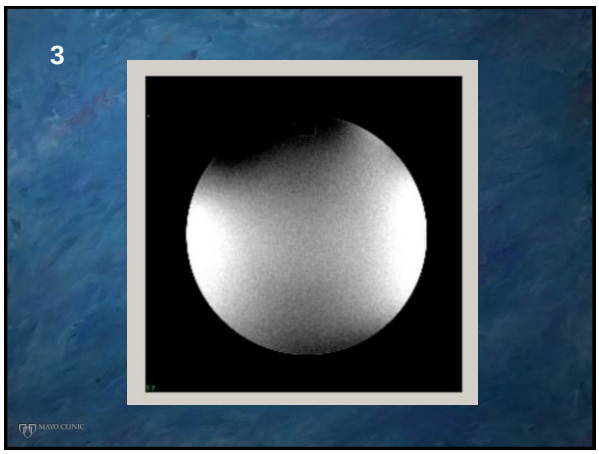
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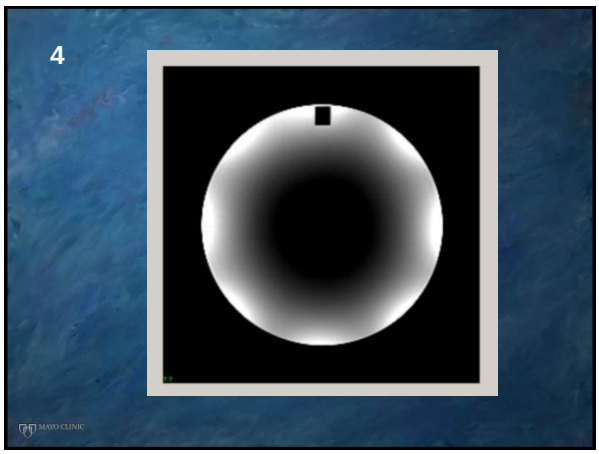
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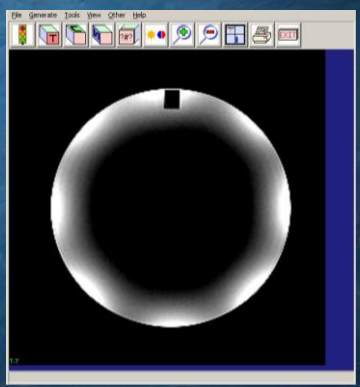
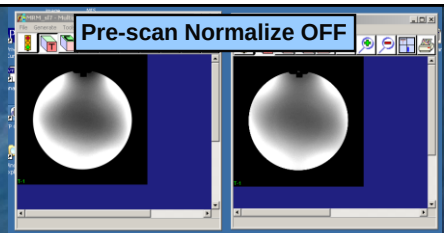
MAYO CLINIC

5



Siemens 12 Ch Head Matrix

Pre-scan Normalize OFF



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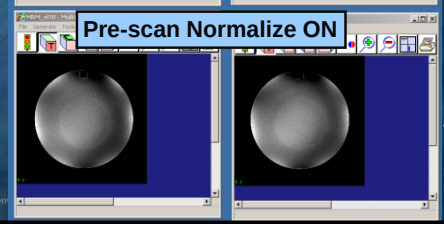


PIU

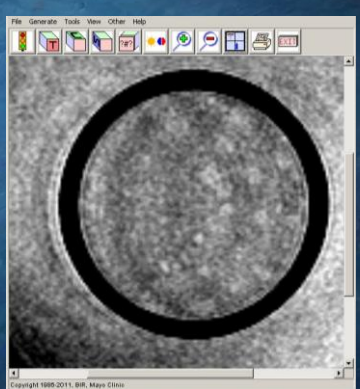
~82%

~94%

ACR Link

Low Contrast Detectability

1



ACR T2 slice 11

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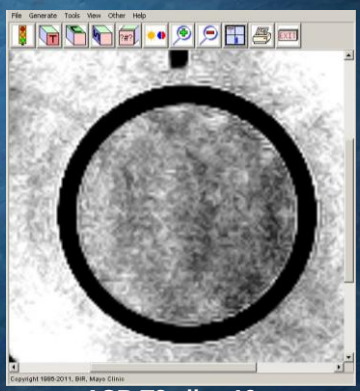
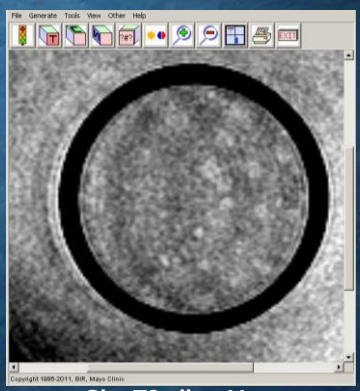


ACR T2 slice 10

1



Site T2 slice 11

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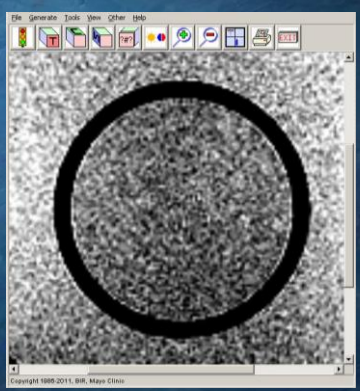

ACR T1 slice 11

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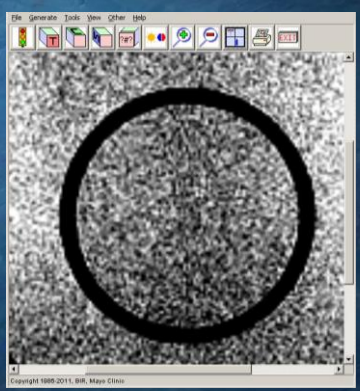

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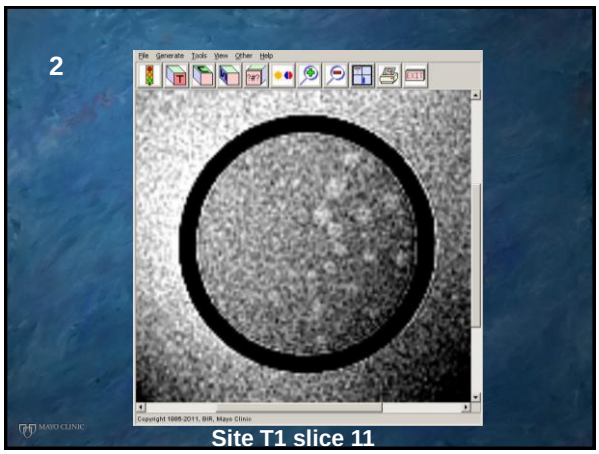
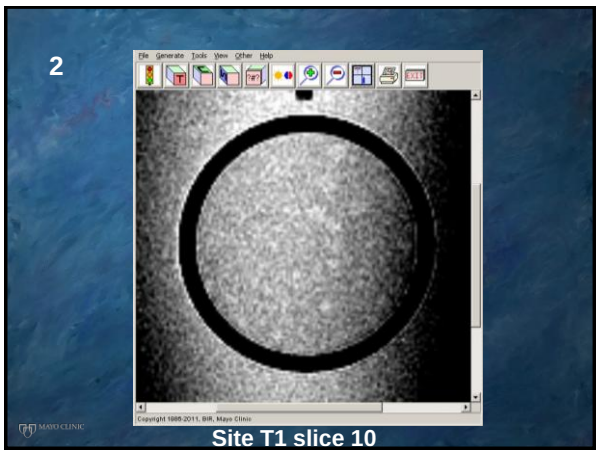
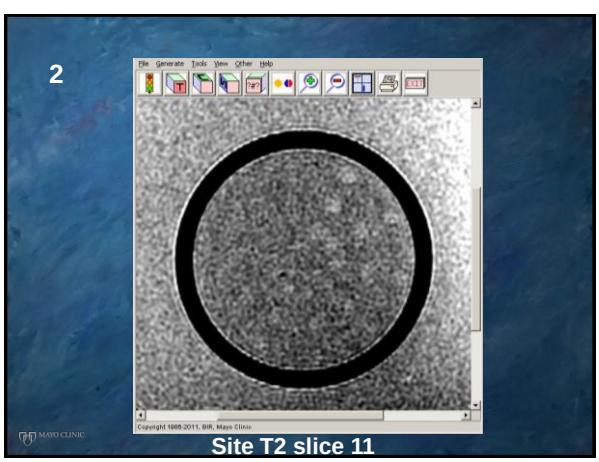


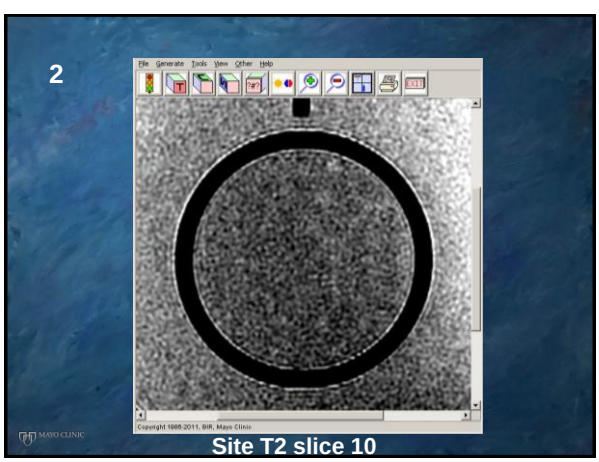
Site T1 slice 11



Site T1 slice 10



Site T2 slice 11



Site T2 slice 10

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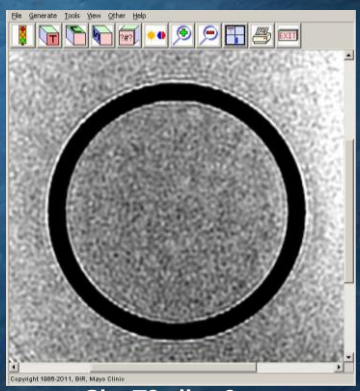

Site T2 slice 9

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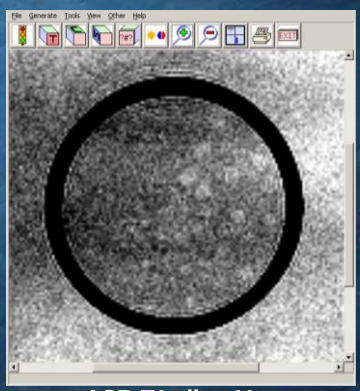

ACR T1 slice 11

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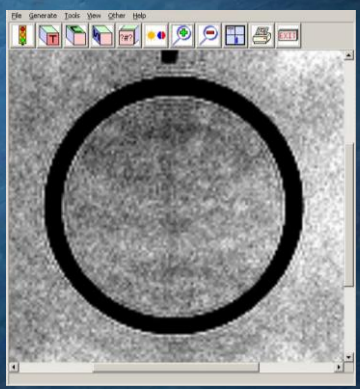

ACR T1 slice 10

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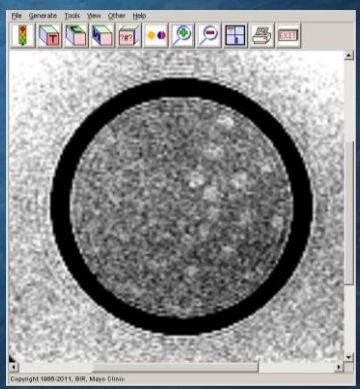

ACR T1 slice 11

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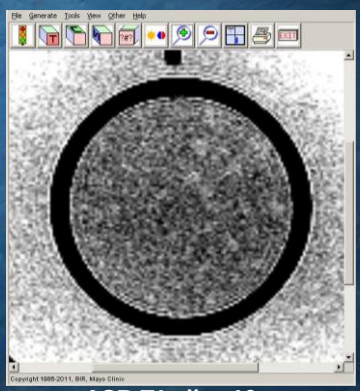
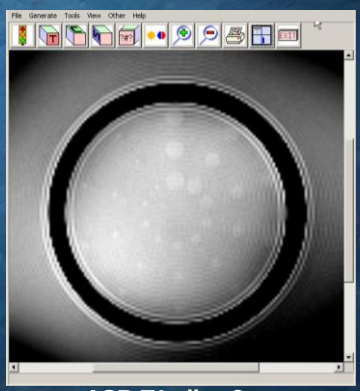


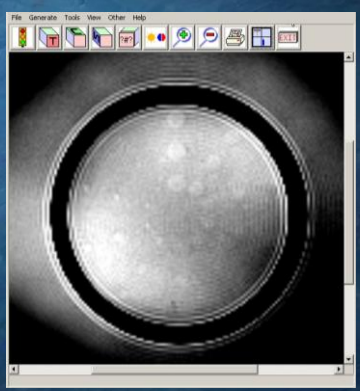
ACR T1 slice 10

5
3T



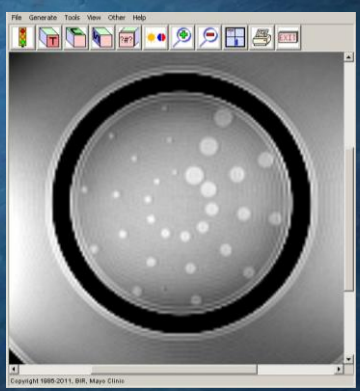
ACR T1 slice 8

5
3T



ACR T2 slice 8

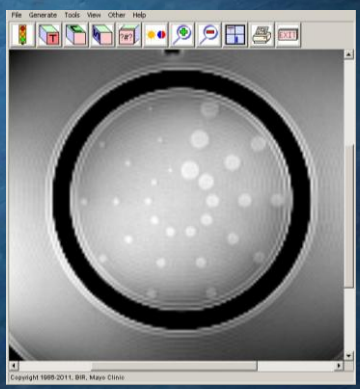
6
3T



ACR T1 slice 11

6

3T



ACR T1 slice 10

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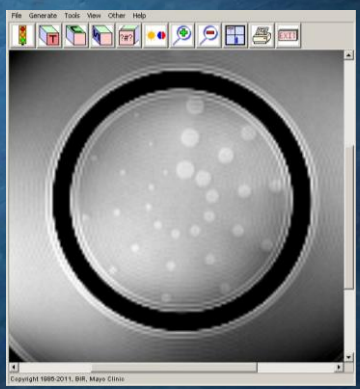

ACR T1 slice 9

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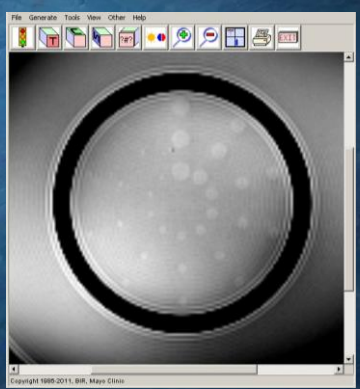
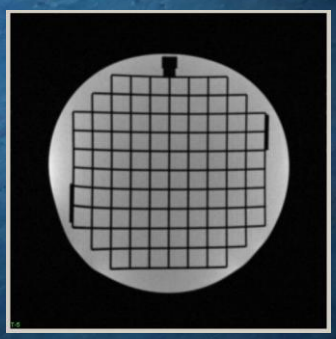
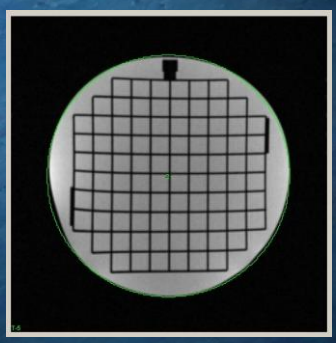


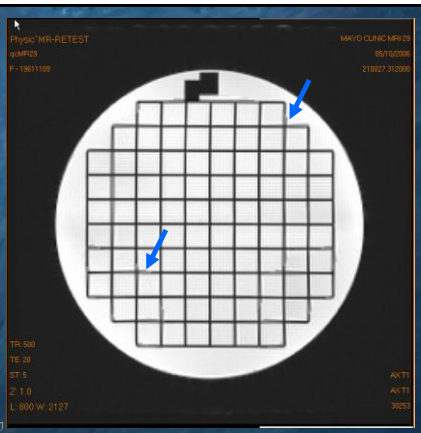
ACR T1 slice 8

Geometric Distortion



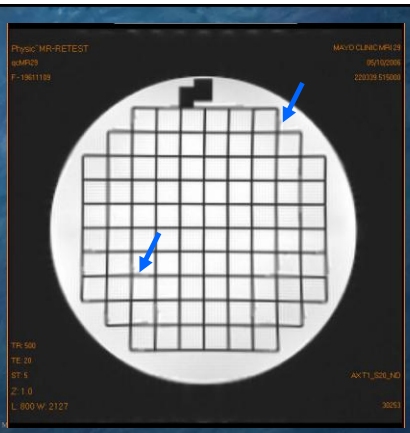


Distortion Correction Issue



2D Distortion Correction ON

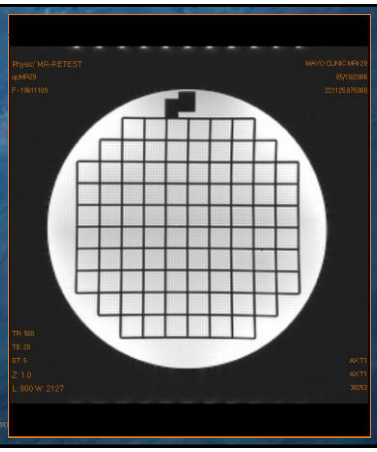
Courtesy
Mayo Clinic
Rochester



2D Distortion Correction ON

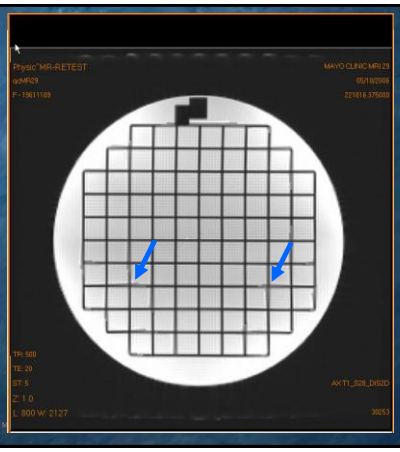
Applied "Undo 2D Distortion Correction" as post-processing

Courtesy
Mayo Clinic
Rochester



2D Distortion Correction OFF

Courtesy
Mayo Clinic
Rochester

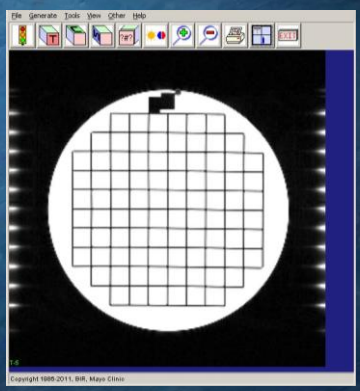


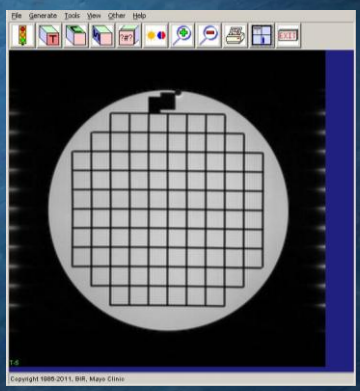
2D Distortion Correction OFF

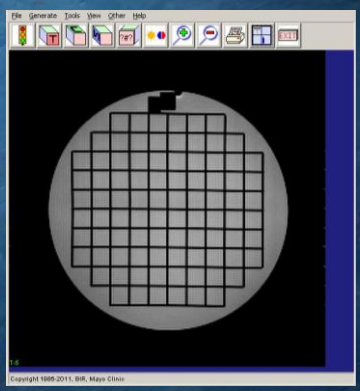
"2D Distortion Correction" applied as post-processing

Courtesy
Mayo Clinic
Rochester

Edge Artifact







Quality Control Testing

- Regular
  - Weekly testing
  - One or two scanners
- Advanced
  - Daily testing
  - 20+ scanners at one institution
  - Could this be automated?

Weekly QC Data Sheet

A. DATA FORM FOR WEEKLY MRI EQUIPMENT QUALITY CONTROL

MR Facility Name _____

MR Scanner Identifier _____

1 Date of Test Year ____	2 Table OK?	3 Console OK?	4 CF (Hz)	5 TX Gain/ Atten-uation (dB)	Phantom Distances (mm) Sag Loc Length	Axial Slice #5 ←Diameters→		Slice 1 HR Holes #		Slice # ____ Number of LCD Spokes	Artifacts ?	Test By
					6	7	8	9	10	11	12	13
					H/F (148)	A/P (190)	R/L (190)	UL	LR			
	Action Limits →											

1 of 1

104.27 MB of 1.03 GB) :

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What if you have 20 scanners?

- Complete ACR Phantom Testing on DAILY Basis for 20 Scanners with Automated Analysis and Interactive Real-Time Remote Monitoring!
- Dream or Reality?

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Automated ACR Phantom Analysis

- It is Reality!
- Vision and prototype software by Joel Felmlee, Ph.D.,
- Clinical implementation by Kiaran McGee, Ph.D., et. al.,
- Slides courtesy of J. Felmlee, K McGee, Diana Lanners and Renee Jornsgard
- Unfortunately, this software is not yet available outside the institution

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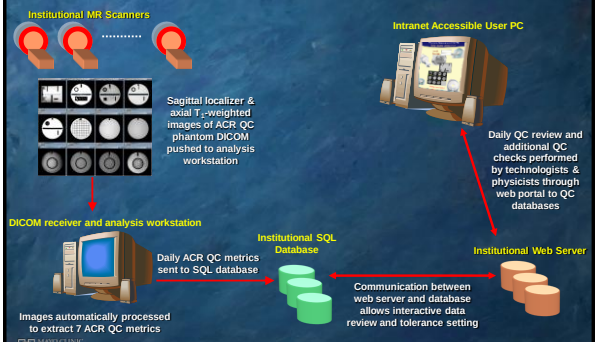
Materials & Methods

Application overview



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Materials & Methods

Automated Analysis

Data Extracted from DICOM header

Center frequency
Transmit Gain/Attenuation

Metrics calculated directly from ACR Phantom images (and required by ACR)

Geometric accuracy
High-contrast spatial resolution
Slice thickness
Slice position
Image intensity uniformity
Percent-signal ghosting
Low-contrast object detectability
Signal-to-noise ratio

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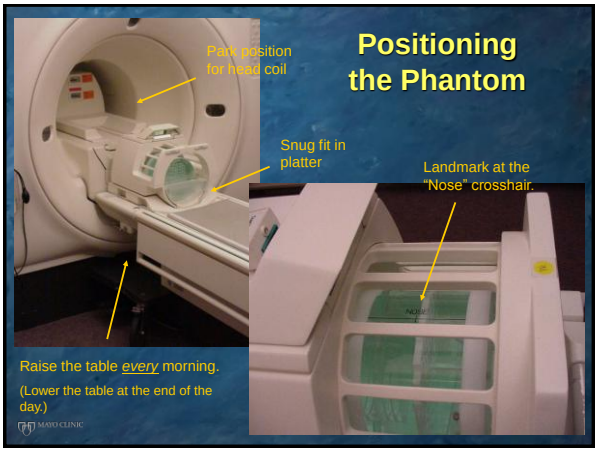
Positioning the Phantom



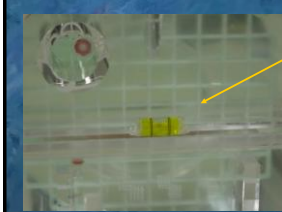
Raise the table *every* morning.

(Lower the table at the end of the day.)

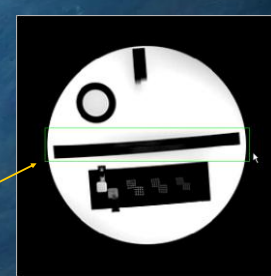
MAYO CLINIC

MAYO

NX & NY Positioning



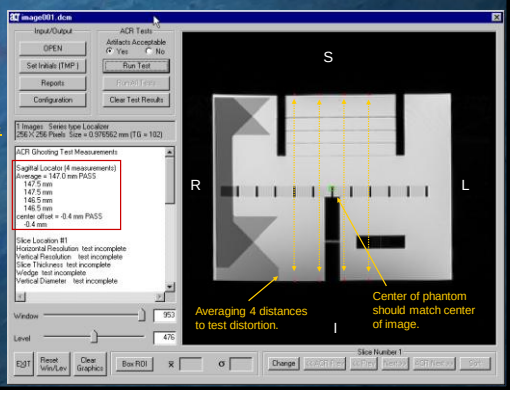
Spirit Level will aid in positioning.



Poor positioning will decrease SNR value and may result in a repeat exam. Image is angled 5°.

MAYO CLINIC

Series 1: Image 1 Sag. Scout

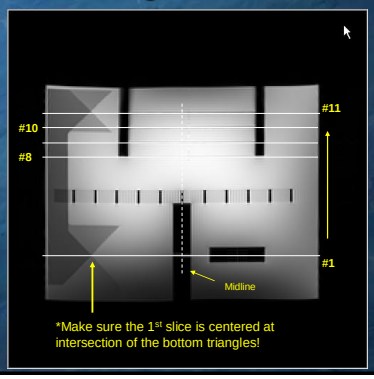


Control limits:

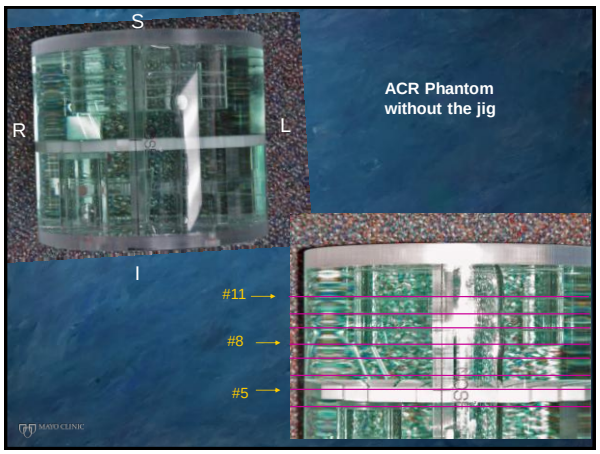
S-I distance 148 mm +/- 2 mm

Center Offset +/- 7mm

Prescribing Series 2 Axials

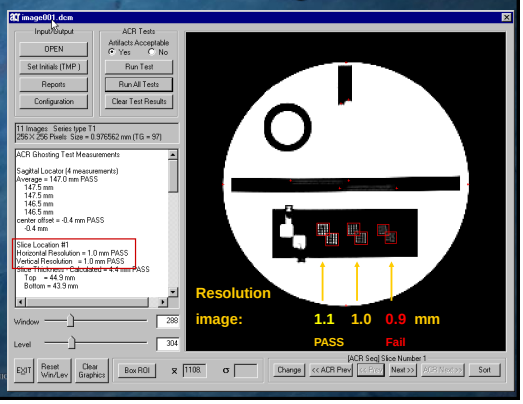


*Make sure the 1st slice is centered at intersection of the bottom triangles!



ACR Phantom without the jig

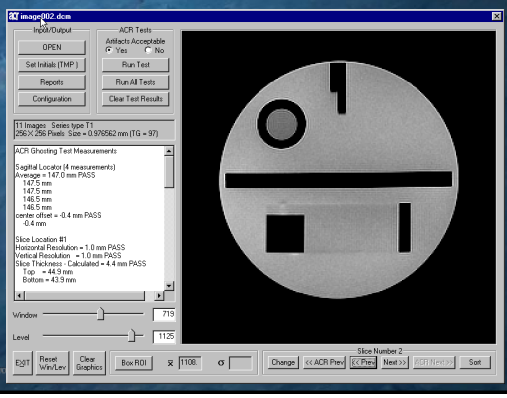
Series 2: Image 1



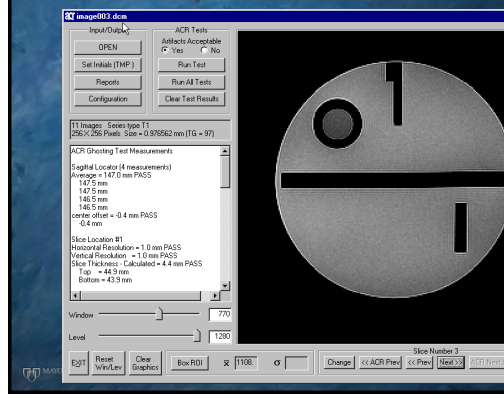
Control limit:

At least 1.0 mm in both directions

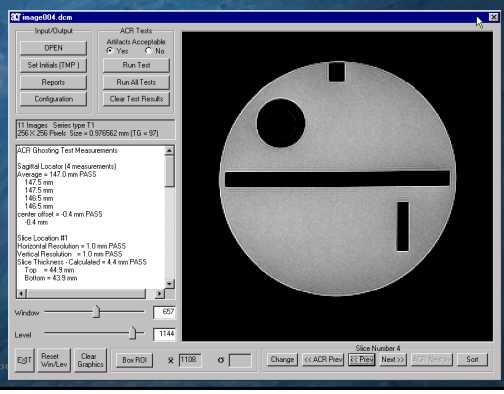
Series 2: Image 2



Series 2: Image 3



Series 2: Image 4

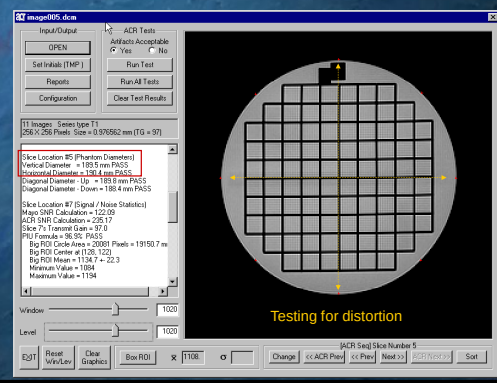


Series 2: Image 5

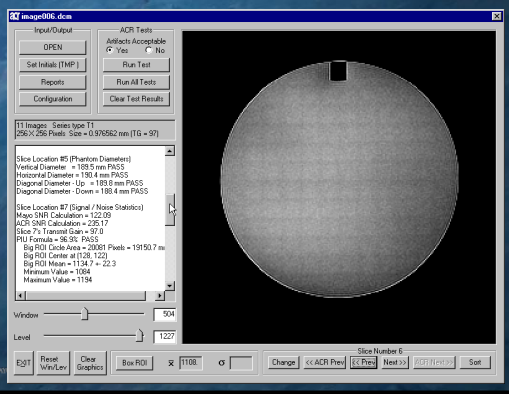
Control Limit:

190 mm

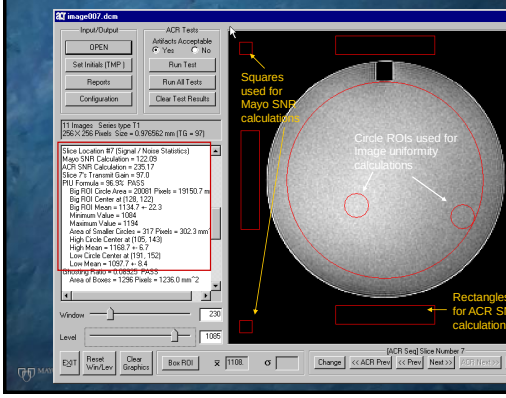
+/- 2 mm.



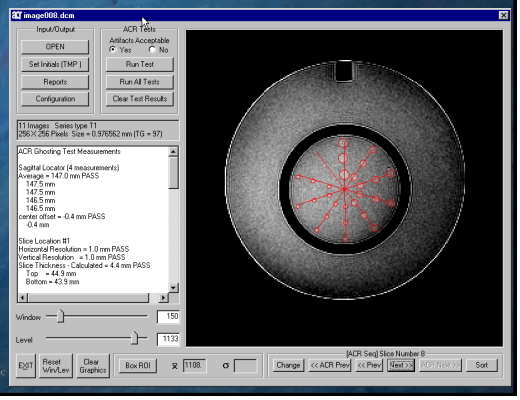
Series 2: Image 6



Series 2: Image 7



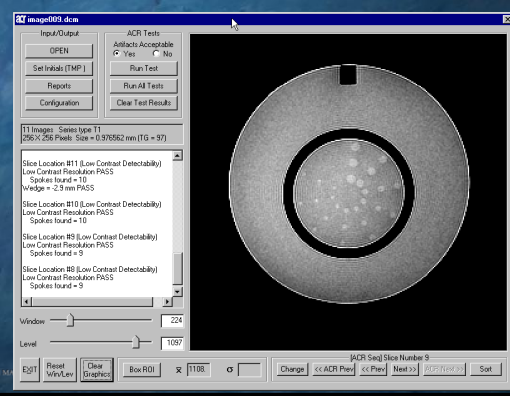
Series 2: Image 8



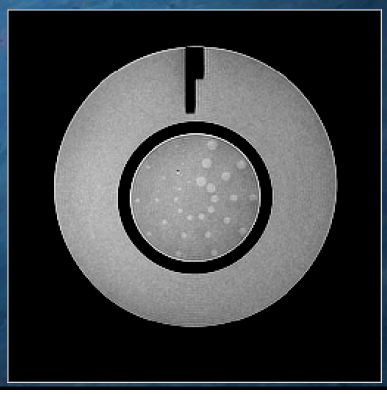
Control Limit:

7 spokes (lines+circles) +/- 4 spokes

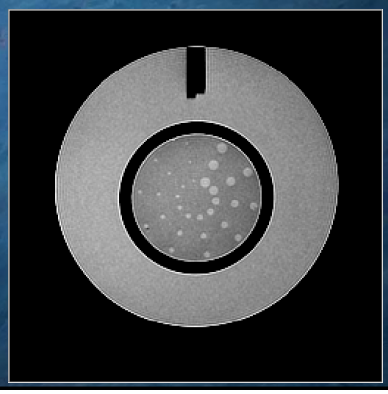
Series 2: Image 9



Series 2: Image 10



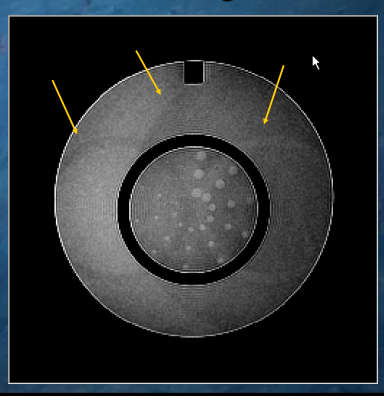
Series 2: Image 11



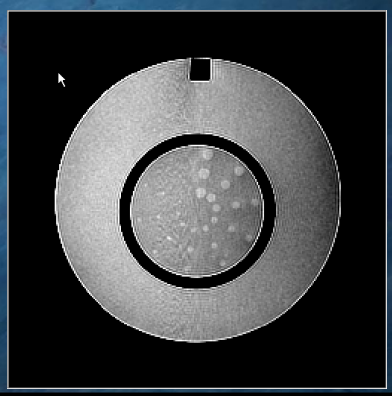
Then What???

- Review <u>ALL</u> phantom images
- End the exam
- Send the ACR Exam to the Analysis PC
- Go to the MRI QC website

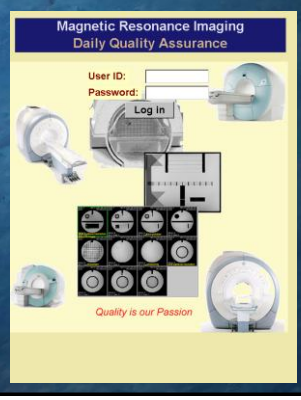
Artifacts: Ghosting



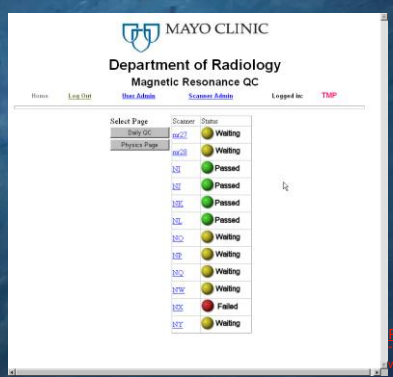
Artifacts: Streaks/Smearing



"Auto ACR QC" website



ACR Profile QC website



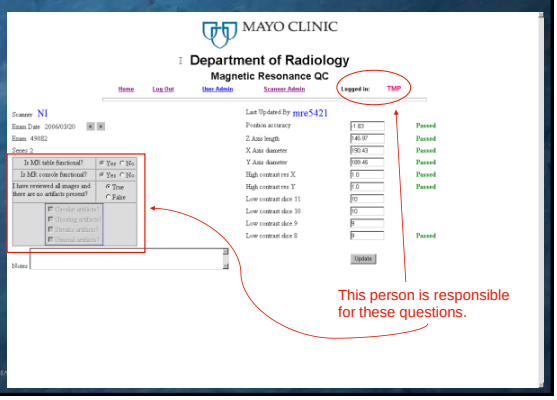
Blue: Images have not been sent to MITS PC

Yellow: Images received; awaiting tech review

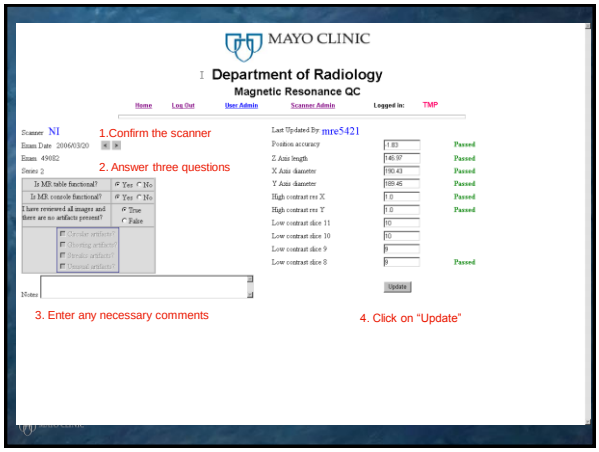
Green: Questions answered and image analysis "Passed"

Red: Image analysis "Failed". Rescan phantom w/ new Accession #.

Technologist Responsibilities

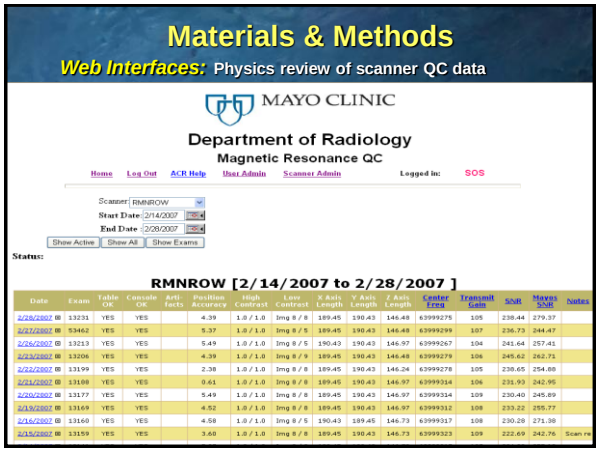


This person is responsible for these questions.



Materials & Methods

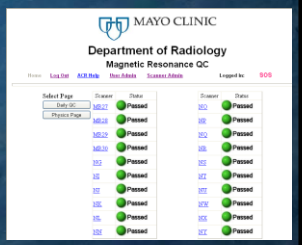
Web Interfaces: Physics review of scanner QC data



Date	Exam	Table OK	Console OK	Arti-facts	Position Accuracy	High Contrast	Low Contrast	X Axis Length	Y Axis Length	Z Axis Length	Center Freq	Transmit Gain	SNR	Mayes SNR	Notes
2/28/2007	13231	YES	YES		4.39	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.48	63999275	105	238.44	279.37	
2/27/2007	53462	YES	YES		5.37	1.0 / 1.0	Img 8 / 5	189.45	190.43	146.48	63999299	107	236.73	244.47	
2/26/2007	13213	YES	YES		5.49	1.0 / 1.0	Img 8 / 5	190.43	190.43	146.97	63999267	104	241.64	257.41	
2/23/2007	13206	YES	YES		4.39	1.0 / 1.0	Img 8 / 9	189.45	190.43	146.48	63999279	106	245.62	262.71	
2/22/2007	13199	YES	YES		2.38	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.24	63999278	105	230.65	254.88	
2/21/2007	13188	YES	YES		0.61	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.97	63999314	106	231.93	242.95	
2/20/2007	13177	YES	YES		5.49	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.97	63999314	109	230.40	245.89	
2/19/2007	13169	YES	YES		4.52	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.97	63999312	108	233.22	255.77	
2/16/2007	13160	YES	YES		4.58	1.0 / 1.0	Img 8 / 5	190.43	189.45	146.73	63999317	108	230.28	271.38	
2/15/2007	13159	YES	YES		3.68	1.0 / 1.0	Img 8 / 8	189.45	190.43	146.73	63999323	109	222.69	242.76	Scan re

Materials & Methods

Web Interfaces: Scanner main page & QC quick check



ACR On-site Survey

- Verify equipment information
- Check most recent physicist report
  - Confirm date within past year
  - Confirm that tests passed, or issues addressed
  - Check if recommendations were made
- Evaluate Site's QC program
- Check documentation of scheduled maintenance
- Scan and analyze ACR phantom

Thank You

MAYO CLINIC