MARP, Inc.

Physics Procedures for ACR MRI Accreditation

August 2006

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MARP
Medical & Radiation Physics, Inc.

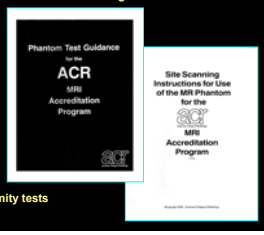
Department of Radiology
University of Texas Health Science Center at San Antonio

ACR MRI Program (MRAP) history

MARP, Inc.

- 1994
  - MRAP initiated by ACR
    - "qualified medical physicist" recommended, not required
    - initial & semi-annual ACR MRI phantom tests
      - Phantom Test Guidance
      - site scanning instructions
      - ACR MRI standards
    - daily technologist tests
      - SNR
      - center frequency
      - manufacturer's phantom

- geometric accuracy
- high-contrast spatial resolution
- slice thickness accuracy
- slice position accuracy
- image intensity uniformity
- percent signal ghosting
- low-contrast object detectability
- image artifacts



- Sep. 2000
  - phantom test guidance revised
    - changes in geometric accuracy & uniformity tests

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ACR MRI Program (MRAP) history

MARP, Inc.

- 2001
  - QC manual released
  - daily technologist QC tests with ACR phantom
    - central frequency
    - transmitter gain /attenuation
    - geometric accuracy
    - spatial resolution
    - low-contrast detectability
    - image artifact assessment
    - visual checklist & laser printer QC (weekly)
  - annual survey by medical physicist or MR scientist
    - magnetic field homogeneity
    - slice position accuracy
    - slice thickness accuracy
    - RF coil performance
      - SNR
      - uniformity
      - ghosting
    - inter-slice RF interference
    - soft copy displays

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ACR MRI Program (MRAP) history

MARP, Inc.

- August 2002
  - phantom tests changed to weekly
- 2004
  - QC manual revised
- 2005
  - 3T magnets added
    - LCD and uniformity scores changed
- July 2005
  - QC & annual survey documentation required for reaccreditation
    - 3 months documented QC
    - annual survey within past 12 months

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ACR MRI accreditation

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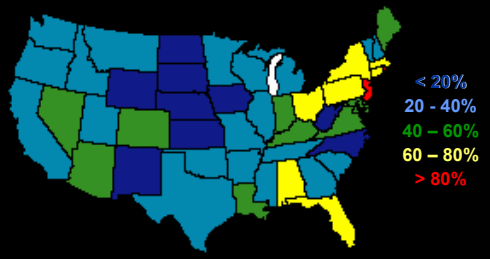
- ~46% US MRI sites are accredited
  - 7028 MRI sites in US in 2004 (ACR estimate)
  - 3235 ACR accredited MRI sites (Dec 2005)



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ACR MRAP medical physicist / MR scientist support*

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- medical physicist / MR scientist* participation in:
  - initial phantom tests
  - technologist daily/weekly QC program
  - acceptance testing
  - annual MR testing
- full-time MRI medical physicist/MR scientist *
  - on staff
  - consultant
- medical physicist with some MRI responsibilities
  - on staff
  - consultant

** in this talk , "medical physicist" will be used instead of "qualified medical physicist/MR scientist"*

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MR physics tests

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- review, repeat, expand technologist phantom tests
  - central frequency - transmitter gain /attenuation
  - geometric accuracy
  - spatial resolution
  - low-contrast detectability
  - image artifact assessment
- perform additional ACR phantom tests
  - slice position accuracy
  - slice thickness accuracy
  - image intensity uniformity
  - percent signal ghosting
- ACR annual tests
  - magnetic field homogeneity
  - RF coil performance
    - volume
    - surface
    - phased array
  - inter-slice RF interference
  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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MR physics tests strategies

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- communication
  - have there been changes?….problems?
- comparison
  - baselines from previous surveys
    - not just pass/fail
  - measurements from similar scanners
  - manufacturer's specs
  - QC values
- combine test results
- creativity
  - additional tests and measurements

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MR physics tests

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    - volume
    - surface
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  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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center frequency – high field

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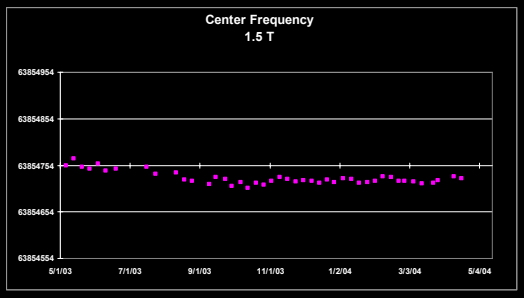

- Action limits: 63,854,754 +/- 100 Hz
  - horizontal gridlines = 100 Hz

MSIPC

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center frequency – low-field open

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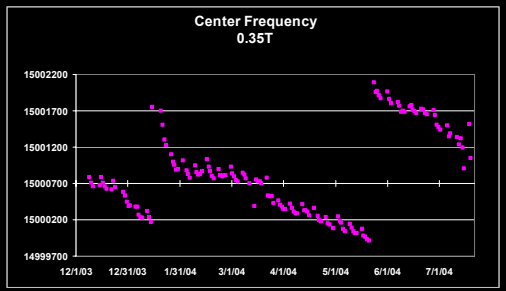

- Action limits: 15000700 +/- 500 Hz
  - horizontal gridlines = 500 Hz

SWOMRI

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center frequency – high field (high drift)

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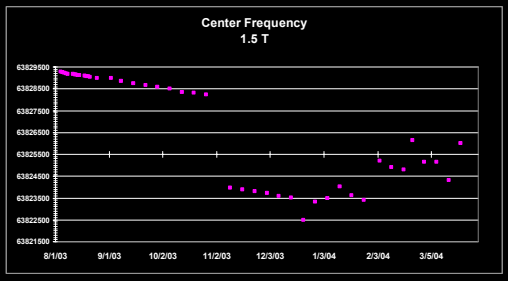

- Action limits: > 63,825,500 MHz
- change/week < 100 Hz
  - horizontal gridlines = 1000 Hz

HSA

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MR physics tests

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- **review, repeat, expand technologist phantom tests**
  - central frequency - transmitter gain /attenuation
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    - volume
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  - inter-slice RF interference
  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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geometric accuracy

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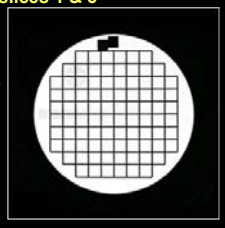
- **sagittal localizer & ACR axial T1 slices 1 & 5**
  - specific window & level:
  - window as narrow as possible
  - set level where ½ of water is dark (mean)
  - set window width = mean value
    & window level = ½ mean value



- window/level must be set separately for localizer & axial T1
  - both axial slices use same window/level

* change in September 2000 version of ACR Phantom Guidance

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geometric accuracy - measurements

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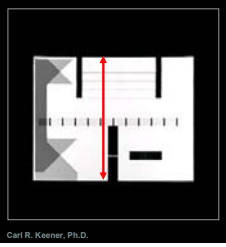
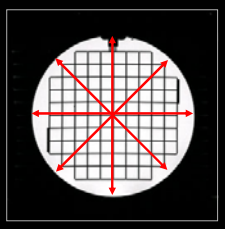
- sagittal localizer
  - top-bottom (z)
  - 148 mm
- action limits
  - ± 2 mm
- slice 1 & 5 of ACR axial T1
  - horizontal & vertical (x & y)
  - diagonal on slice 5
  - 190 mm
  - different W/L than localizer
- action limits
  - ± 2 mm





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geometric accuracy

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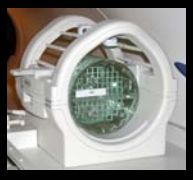
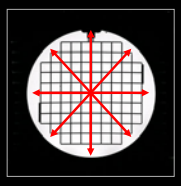
- standard ACR phantom orientation gives more information in x & y planes than in z plane
- other orientations offer additional measurements in z plane





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ACR phantom – other orientations

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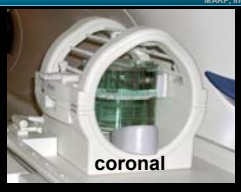
- head coil
- tests
  - geometric accuracy
  - high-contrast spatial resolution
  - slice thickness accuracy
  - slice position accuracy
  - image intensity uniformity
  - percent signal ghosting
  - low-contrast object detectability
  - image artifacts



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geometric accuracy

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sequence	phantom orientation	slice location	measurement orientation	measured (mm)	actual (mm)	difference (mm)
SE	coronal	slice 5	top-bottom	186.2	190	3.8
SE	coronal	slice 5	left-right	192.2	190	-2.2
SE	coronal	slice 5	diagonal (/)	187.5	190	2.5
SE	coronal	slice 5	diagonal (\)	187.3	190	2.7
SE	coronal	slice 1	top-bottom	189.3	190	0.7
SE	coronal	slice 1	left-right	192.5	190	-2.5
SE	coronal	slice 11	top-bottom	186.5	190	3.5
SE	coronal	slice 11	left-right	191.7	190	-1.7
SE	sagittal	slice 5	top-bottom	186.7	190	3.3
SE	sagittal	slice 5	left-right	192.7	190	-2.7
SE	sagittal	slice 5	diagonal (/)	188.6	190	1.4
SE	sagittal	slice 5	diagonal (\)	189.5	190	0.5
SE	sagittal	slice 1	top-bottom	188.3	190	1.7
SE	sagittal	slice 1	left-right	193.4	190	-3.4
SE	sagittal	slice 11	top-bottom	189.6	190	0.4
SE	sagittal	slice 11	left-right	192.7	190	-2.7

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MR physics tests

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- **review, repeat, expand technologist phantom tests**
  - central frequency - transmitter gain /attenuation
  - geometric accuracy
  - **spatial resolution**
  - low-contrast detectability
  - image artifact assessment
- perform additional ACR phantom tests
  - slice position accuracy
  - slice thickness accuracy
  - image intensity uniformity
  - percent signal ghosting
- ACR annual tests
  - magnetic field homogeneity
  - RF coil performance
    - volume
    - surface
    - phased array
  - inter-slice RF interference
  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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high-contrast spatial resolution

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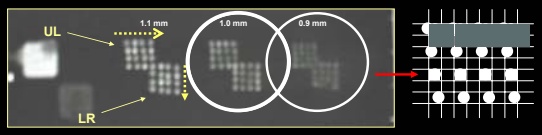

- measurements
  - use slice 1 of ACR T1 & ACR T2
  - magnify slice 1 by 2 to 4
  - observe UL holes ; adjust window/level
    - observe rows; if all 4 holes in a single row are distinguishable, score image as resolved at this hole size
    - view all three sets (1.1 mm, 1.0 mm, 0.9 mm)
    - score = smallest holes resolved
  - repeat for LR array with columns of holes
- performance criteria: 1.0 mm
  - for ACR T1 & T2 series (250 mm FOV 256 x 256)
  - many scanners have 0.9 mm resolution
  - resolution should not change

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  - RF shielding
  - magnetic fringe field
  - **SNR**

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low-contrast detectability

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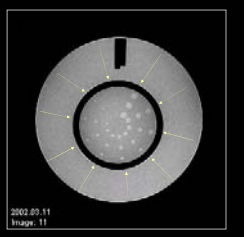
- **4 slices with low-contrast holes**
  - slices 8-11
    - decreasing contrast levels (11→ 8)
  - 10 spokes per slice
    - 3 holes per spoke
    - decreasing size (clockwise)
- **count complete spokes**
  - all 3 disks must be discernible
    - more apparent than background
  - end with last complete spoke



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low-contrast detectability

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- **4 series / 4 slices for phantom evaluation**
  - performance criteria ≥ 9 (out of 40)
- **1 series / 1 slice for daily / weekly QC**
  - action level: within 3 of baseline
- **pass/fail**
- **can also be used to track performance**
  - used in place of SNR
- **correlates w/ SNR but….**
  - subjective
  - sensitive to unrelated artifacts

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SNR

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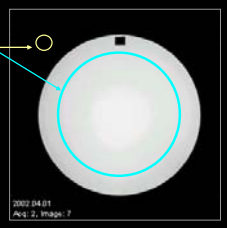
- single image of uniform slice
  - signal is mean of uniform area
  - noise is SD of area outside phantom

$$SNR = \frac{Signal}{Noise}$$

- ACR tests
  - interslice gap
  - coils
  - optional, but useful, on uniform slices
- easy to use, but…….
  - sensitive to technique
  - different than NEMA method or manufacturer's specs
  - not adjusted for Rician noise distribution
  - sensitive to fluctuations in noise



$$SNR \propto M_{xy(TE)} \Delta z \cdot FOV_x FOV_y \sqrt{\frac{NEX}{BW_{receiver} N_x N_y}}$$

$$SNR \propto pulse\ sequence, phantom, setup, hardware$$

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low contrast detectability / SNR

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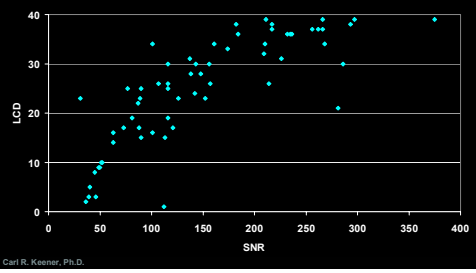
- LCD & SNR correlate closely
  - 17 scanners (0.2 – 3.0T)
  - various series on ACR phantom
  - 1 operator (physicist) 2002-2004

SNR vs MRAP LCD



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LCD ~ SNR

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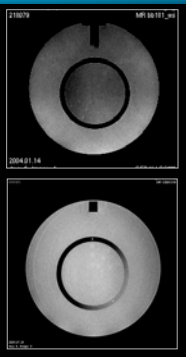

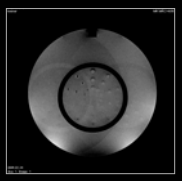

- if LCD ~ SNR, we cannot have:
- misalignment
  - larger spokes disappear before smaller spokes
  - ring in slice 8 disappears unevenly
- artifacts
- LCD score ↓, but SNR does not ↓

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SNR - simple method

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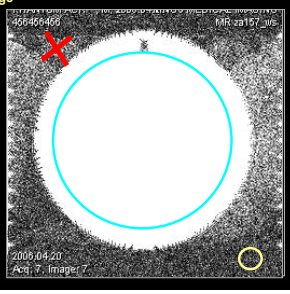
- noise must be measured in uniform portion of background
  - check background for
    - ghosting
    - DC offset artifacts
    - edge of image



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ACR T1 LCD / SNR

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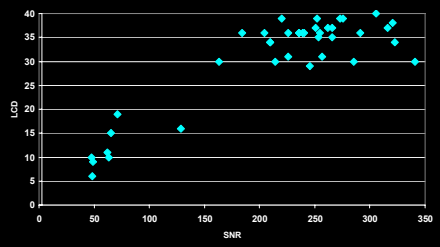
- LCD & SNR track closely for given phantom & protocol
  - ACR T1 series on ACR phantom
  - 1 operator (physicist) 2004-2006
  - 24 scanners (0.2 – 3.0T)

SNR vs. ACR T1 LCD



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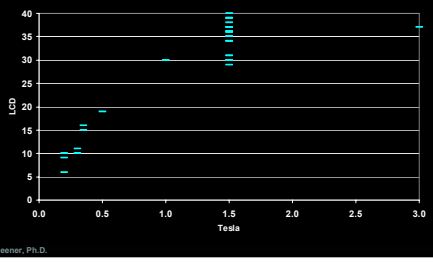
field strength vs. LCD

MARP, Inc.

- LCD correlates with field strength
  - ACR T1 series on ACR phantom
  - 1 operator (physicist) 2004-2006
  - 24 scanners (0.2 – 3.0T)
- @ 1.5T (17 scanners):
- mean = 35.2 SD = 3.0 n = 30

Field Strength vs. ACR T1 LCD



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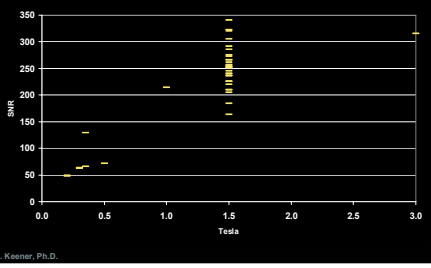
field strength vs. SNR

MARP, Inc.

- SNR correlates with field strength
  - ACR T1 series on ACR phantom
  - 1 operator (physicist) 2004-2006
  - 24 scanners (0.2 – 3.0T)
- @ 1.5T (17 scanners):
- mean = 256 SD = 44, n = 30

Field Strength vs. ACR T1 SNR



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low contrast detectability / SNR

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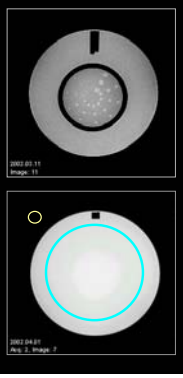
- LCD & SNR correlate closely
  - 1 scanner, 1 survey
  - tracked within survey

series	LCD	SNR
ACR T1	39	297
ACR T2	39	211
site T1	38	182
site T2	28	78



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low contrast detectability / SNR

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- LCD & SNR
  - tracked within survey
  - tracked between surveys

	LCD		SNR	
series	2001	2002	2001	2002
ACR T1	36	29	333	111
ACR T2	27	27	220	68
site T1				
site T2	15	8	76	30
GRE				80

- why did LCD & SNR drop in 2002?
  - QC scores for slice 8 = 10,10, 10, 10, 10, 10, etc.
  - 2002 physicist score for slice 8 = 4

LM

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low contrast detectability / daily QC

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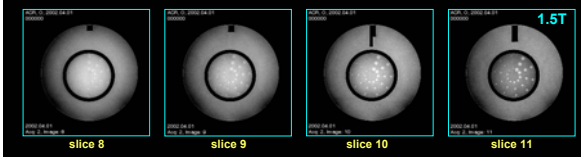
- why did LCD & SNR drop in 2002?
  - technologist was scoring slice 11 instead of slice 8
    - slice 11 score = 10; slice 8 score = 4



- SNR was 50-60% lower on phantom
  - SNR had not dropped on other coils

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low contrast detectability / SNR

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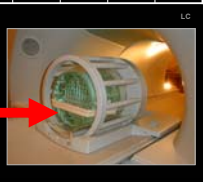
- head coil was defective

	ACR T1 LCD					ACR T1 SNR				
series	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
ACR T1	36	29	39	40	39	333	111	297	306	271
ACR T2	27	27	39	39	34	220	68	211	223	250
site T1			38	32	26			182	147	134
site T2	15	8	28	21	18	76	30	78	80	99
GRE							80			

LC

- typical ACR T1 numbers:
  - LCD = 35.2 +/- 3.0
  - SNR = 256 +/- 44
- ↑ numbers after coil corrected
- site QC program corrected
- LCD & SNR stable following corrections

BAD COIL



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MR physics tests

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  - magnetic fringe field
  - SNR

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slice position accuracy

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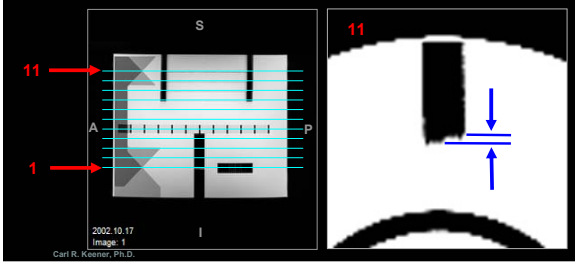
- measurements
  - use slices 1 & 11 of ACR T1 & ACR T2.
  - magnify by 2 to 4 & adjust window/level
  - measure difference of left & right bars
    - if left bar is longer assign a minus sign to the length.



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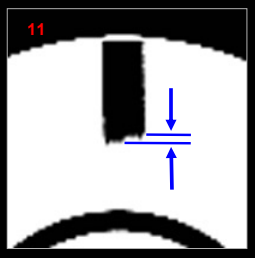
slice position accuracy

MARP, Inc.

- performance criteria:
  - magnitude of bar length difference ≤ 5 mm.
    - actual displacement is 1/2 of the measured difference (wedges have 45° slopes)



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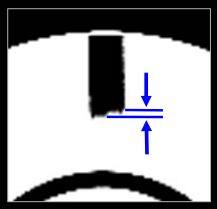
slice position accuracy

MARP, Inc.

- slice positioning measurements should not change during survey
  - if phantom has not been moved
  - if slices have not been replanned
- changes in slice position may be due to a temporal magnetic field or gradient drift



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MR physics tests

MARP, Inc.

- review, repeat, expand technologist phantom tests
  - central frequency - transmitter gain /attenuation
  - geometric accuracy
  - spatial resolution
  - low-contrast detectability
  - image artifact assessment
- perform additional ACR phantom tests
  - slice position accuracy
  - slice thickness accuracy
  - image intensity uniformity
  - percent signal ghosting
- ACR annual tests
  - magnetic field homogeneity
  - RF coil performance
    - volume
    - surface
    - phased array
  - inter-slice RF interference
  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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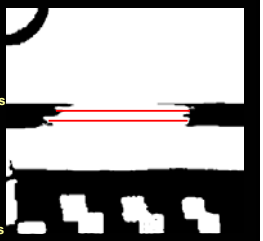
slice thickness accuracy

MARP, Inc.

- slice 1 of ACR T1 & ACR T2
  - crossed ramps (10:1 slope)
  - measure mean
    - magnify by 2 to 4
    - adjust window/level to see signal ramps
    - 2 ROIs
      - mean of middle of each signal ramp
    - take average
  - measure width
    - lower level to ½ average
    - set window at minimum
    - measure lengths of top & bottom ramps
  - calculate slice thickness
  - performance criteria:
    - 5.0 ± 0.7 mm



$$slice\ thickness = 0.2 \times \frac{(top \times bottom)}{(top + bottom)}$$

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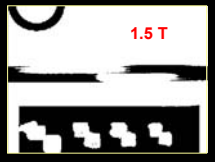
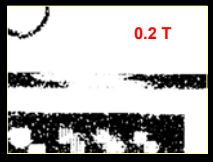
slice thickness accuracy

MARP, Inc.

- edges of ramps difficult to determine
  - Gibbs artifacts
  - noise (low field magnets)
  - 1 mm measurement error = 1/10 mm error in slice thickness
- if slice thickness fails, try another pulse sequence file

pulse sequence file	slice thickness
se_20b65.wfc	5.9 mm
se_15b130.wfc	5.6 mm





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slice thickness

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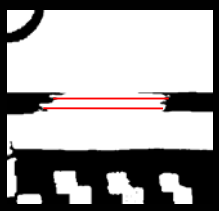
- slice thickness based on RF pulse & gradient

$$\Delta z = \frac{\Delta\omega}{\gamma \cdot G_z}$$

- do changes in slice thickness correlate with gradient nonlinearities (based on geometric measurements)?



sequence	orientation	top length (mm)	bottom length (mm)	measured thickness (mm)	actual thickness (mm)	difference (mm)	% difference
ACR T1	axial	57.7	58.3	5.8	5.0	0.8	16%
ACR T1	sagittal	51.4	60.5	5.6	5.0	0.6	11%
ACR T1	coronal	50.5	69.0	5.8	5.0	0.8	17%

RIC

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MR physics tests

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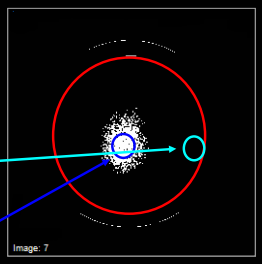
image intensity uniformity

MARP, Inc.

- slice 7 of ACR T1 & T2
  - make large ROI (195-205 cm²)*
  - low-signal region:
    - set window width to minimum
    - lower level until entire ROI is white
    - raise level until 1 cm² region of black appears
    - use 1 cm² ROI to record mean of this low-signal region
  - high-signal region:
    - raise level until only 1 cm² region of white remains
    - use 1 cm² ROI to record mean of this high-signal region



$$\text{percent integral uniformity} = 100 \times \left(1 - \frac{(high - low)}{(high + low)}\right)$$

* change in September 2000 version of ACR Phantom Guidance

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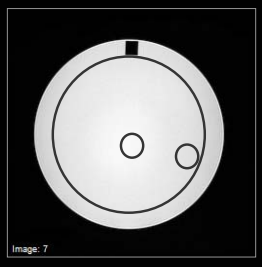
image intensity uniformity

MARP, Inc.

- performance criteria:
  PIU ≥ 87.5%*
  - if there is not a well-defined high/low intensity level… …..uniformity is very high!
- for 3.0T:
  PIU ≥ 82% *(July 2005)*



* change in September 2000 version of ACR Phantom Guidance

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uniformity problems

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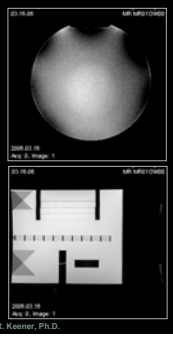
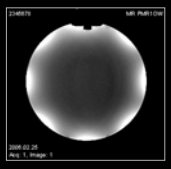
- poor positioning



- smaller coil
  - 8 channel brain



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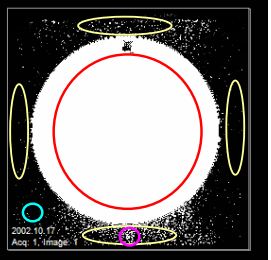
percent signal ghosting

MARP, Inc.

- use slice 7 of ACR T1
  - make large ROI (195-205 cm²)*
    - record mean
  - make 4 elliptical ROIs
    - 10 cm² with 4:1 ratio
    - left, right, top, bottom
    - record mean of each

$$\text{ghosting ratio} = \left| \frac{(top + bottom) - (left + right)}{(2 \times (\text{large ROI})} \right|$$

  - performance criteria:
    - ghosting ratio ≤ 0.025 (2.5%)
  - for coil checks:
    - only two background ROIs used
      - background signal
      - phase-encoding (ghost) signal



* change in September 2000 version of ACR Phantom Guidance

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MR physics tests

MARP, Inc.

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  - SNR

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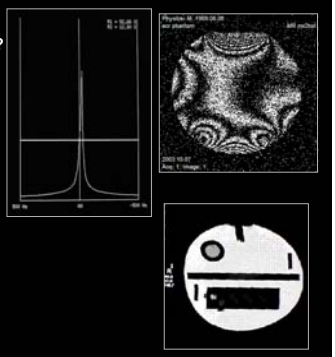
homogeneity

MARP, Inc.

- concerns
  - geometric distortion?
  - problems with fat saturation?
- methods
  - spectral
  - phase-difference
  - visual distortion



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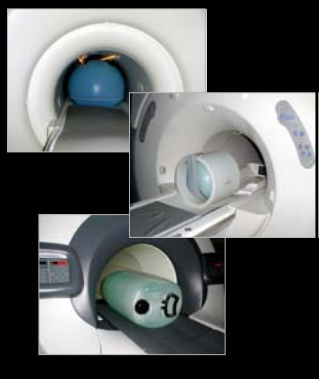
homogeneity – spectral analysis

MARP, Inc.

- measures frequency of signal-producing phantom in magnet
  - DSV
    - ↑ homogeneity at center & with ↓ FOV
    - Δ FOV… Δ phantom size
  - spectrum displayed on screen (Hz)
  - homogeneity measured in ppm
  - compare to specs or baseline values



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homogeneity – spectral analysis

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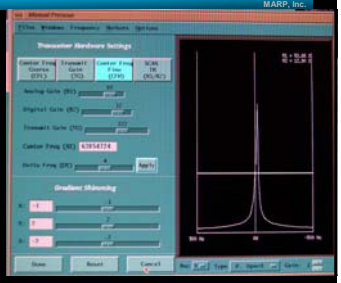
- manual prescan
  - GE
- EPI tuning
  - Elscint
- FWHM (Hz)

$$ppm = \frac{Hz_{FWHM}}{MHz_{LarmorFrequency}}$$

  - volume ~ phantom



date	orientation	cm	ppm
2004	DSV	26	0.38
2003	DSV	26	0.35

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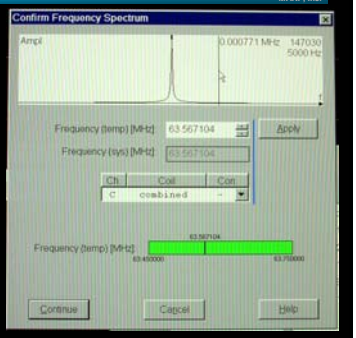
homogeneity – spectral analysis

MARP, Inc.

- Siemens
  - "system" "adjustments"
  - check "confirm adjustments"



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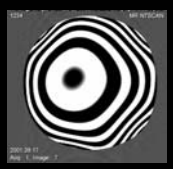
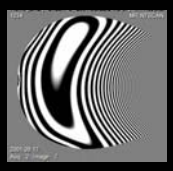
magnetic field homogeneity – phase difference

MARP, Inc.

- 2 FE (GRE) scans
  - slightly different TEs
  - subtracted phase images show phase differences
    - inhomogeneities
  - change (ppm) depends on change in TE in protocol
    - specified in manufacturer's documentation
- allows you to view inhomogenieties
  - multiple slices
  - three planes





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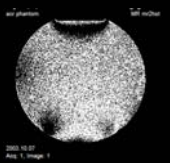
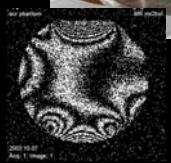
phase-difference (Siemens)

MARP, Inc.

- fast-field mapping
  - selectable resolution based on TE
  - B→W→B = 1/TE/B_0



B→W→B = 0.39ppm



B→W→B = 0.039ppm

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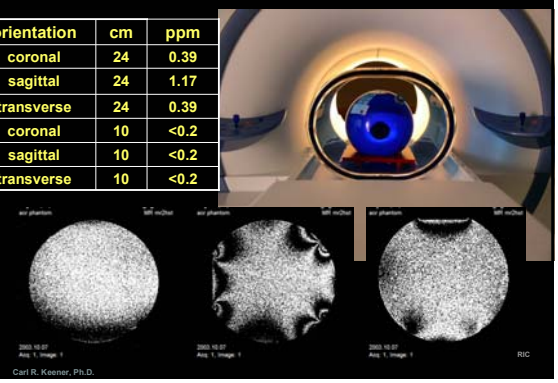
fast field mapping (Siemens)

MARP, Inc.

orientation	cm	ppm
coronal	24	0.39
sagittal	24	1.17
transverse	24	0.39
coronal	10	<0.2
sagittal	10	<0.2
transverse	10	<0.2



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phase-difference (Philips)

MARP, Inc.

- shim_check
  - option under phantom studies
  - FFE, fixed technique & FOV
- 40 cm cylindrical phantom
  - holder to center phantom
  - 3 orientations
- view real images
  - count B→W transitions

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shim_check (Philips)

MARP, Inc.

- example:
  - 1.5T, FFE, TR=400, TE=16, 30º, 450 mm FOV
  - B→W = 1 ppm
- example:
  - coin taped to phantom

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shim_check (Philips)

MARP, Inc.

orientation	cm	ppm	
		5/11/04	5/6/03
coronal	40	5	8
sagittal	40	3.5	6
transverse	40	6	12
coronal	20	0.25	1
sagittal	20	0.25	2
transverse	20	1.0	2

DHL

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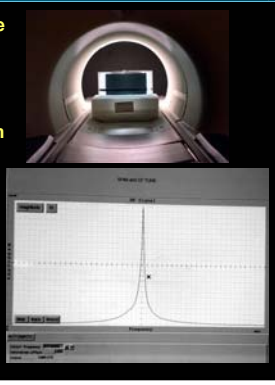
spectral – three planes

MARP, Inc.

- Picker / Marconi Eclipse
- "Shim and CF Tune"
  - graph of spectrum
- 30 cm x 10 cm cylinder
- holder centers phantom in 3 orientations



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shim & CF tune (Picker /Marconi)

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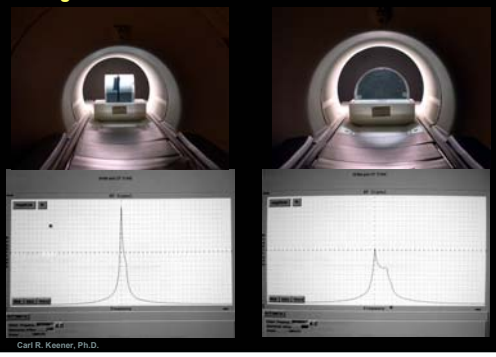
- sagittal
- transverse



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shim & CF tune (Picker /Marconi)

MARP, Inc.

- ↓ homogeneity in transverse plane
- poor fat saturation
  - ½ bright / ½ dark
- metal objects removed from bore
  - ↑ homogeneity
  - ↑ fat sat

date	orientation	cm	ppm
3/29/04	coronal	30	0.31
3/29/04	sagittal	30	0.31
3/29/04	transverse	30	2.7
4/26/04	coronal	30	0.30
4/26/04	sagittal	30	0.24
4/26/04	transverse	30	1.27

LMRIIC

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homogeneity – geometric distortion

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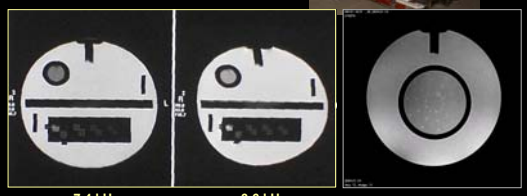
- most low-field open magnets do not have software to check homogeneity
  - observe effects on geometric distortion
    - lower bandwidth
  - warped images



7.4 kHz 3.6 kHz

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different bandwidths

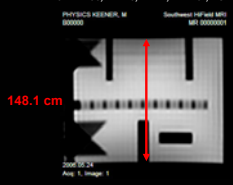
MARP, Inc.

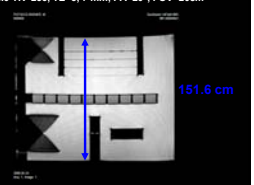
- measure distortion in frequency-encoding direction with different bandwidths *(Clarke & Chen)*

$$MFH(ppm) = \frac{(BW_1 \times BW_2) \times (x_1 - x_2)}{(\gamma/2\pi) B_0 FOV (BW_2 - BW_1)}$$

BW=33 Hz (8448 kHz)
FE45 TR=256, TE=45, 7 mm, FA=70°, FOV=20cm

BW=244 Hz (62464 kHz)
FE5.0 TR=256, TE=5, 7 mm, FA=20°, FOV=20cm





SI	2.68 ppm
AP	0.84 ppm
LR	0.31 ppm

SWOMRI

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lower receiver bandwidth

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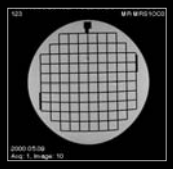
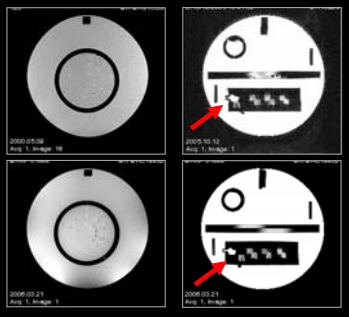
- ↓ BW ↑ SNR



↑ geometric distortion



↑ susceptibility artifacts ↑ chemical shift

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MARP, Inc.

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coils

MARP, Inc.

- same coil
  - consistent from year to year
    - SNR
    - ghosting
    - uniformity
- different coils
  - are they comparable?
- ghosting
  - from coil or gradient?

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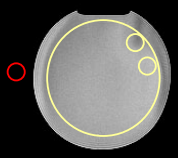
volume coils

MARP, Inc.

- similar to head coil
  - uniformity
    - mean
    - high
    - low
  - SNR
    - mean
    - background noise
  - ghosting
    - mean
    - background signal
    - ghost signal (PE direction)
  - phased-array coils
    - may be treated as volume if they have volume configuration

MR NTSCAN



2006.05.18
Acq: 18, Image: 1

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surface coils

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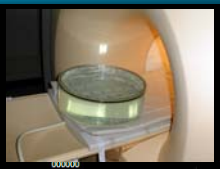
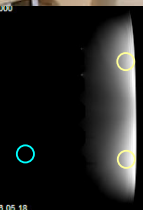
- max SNR
  - max ROI
  - background noise
- uniformity
  - subjective
- ghosting
  - subjective
- phased-array coils
  - may be treated multiple surface coils if you can distinguish the location of the arrays



MR NTSCAN



2006.05.18
Acq: 23, Image: 1

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phased-array coils

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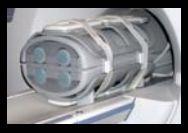
- multiple types

~ volume coil



~ multiple surface coils
(arrays distinguishable)

more complicated

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phased-array coils

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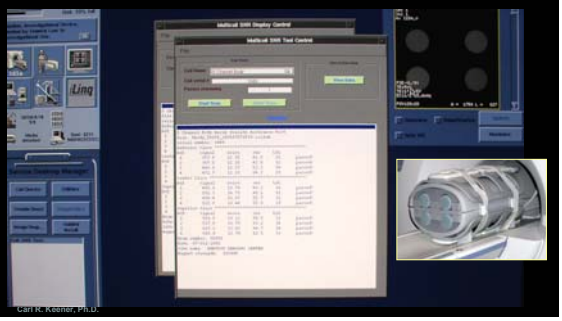
- some 8-channel coils have phantom & built-in software for checking coils
  - "Desktop Manager" "Service Tools" "Troubleshoot" "Coil SNR Test" " Start"



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coils – year to year

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- is coil performing similar to previous years?
  - same setup
  - same phantom
  - same technique
  - photos

date	ghosting	uniformity	SNR
10/21/1999	1.03%	93.6%	189
8/7/2000	0.02%	93.9%	127
9/27/2001	0.58%	93.6%	129
12/20/2002	0.02%	94.9%	251
1/30/2004	0.11%	94.3%	235
2/1/2005	0.08%	93.9%	239

NCBIC

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comparing coils

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- similar coils on same scanner
  - same phantom
    - head SNR sphere
  - same techniques
    - SE, TR=500, TE=20, 20 cm FOV, 256x128, 15.6 kHz
  - measured max signal & noise

HSJVR

coil	max signal	noise	max SNR
new shoulder coil	2402	2.31	1040
old shoulder coil	144	1.88	77

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ghosting – comparing coils

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Coil	Ghosting
Body	0.20 %
Head	1.03 %
Quad knee	0.11 %
Volume neck	0.06 %
Wrist	0.35 %
NVA	0.04 %
Small joint	*none*
Shoulder	*none*
CTL	*noticeable*

???

"When troubleshooting the ghosting, concentrate on the head coil as it may be the source of the problem. There is also noticeable ghosting on the CTL spine coil. All other coils have minimal ghosting or none at all."

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ghosting – most coils

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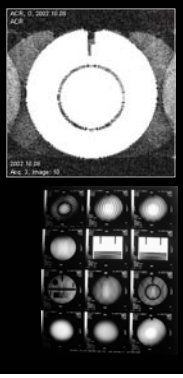
- ghosting on most coils
  - problem in scanner, not coils
  - alternate phase-encoding direction to determine malfunctioning gradient
  - documentation



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MR physics tests

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- review, repeat, expand technologist phantom tests
  - central frequency - transmitter gain /attenuation
  - geometric accuracy
  - spatial resolution
  - low-contrast detectability
  - image artifact assessment
- perform additional ACR phantom tests
  - slice position accuracy
  - slice thickness accuracy
  - image intensity uniformity
  - percent signal ghosting
- ACR annual tests
  - magnetic field homogeneity
  - RF coil performance
    - volume
    - surface
    - phased array
  - inter-slice RF interference
  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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rf inter-slice interference

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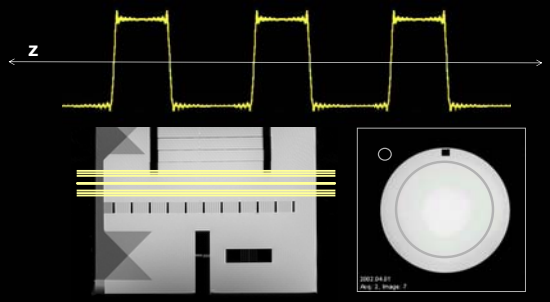
- how close can slices be before adjacent slices interfere with each other?



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rf inter-slice interference

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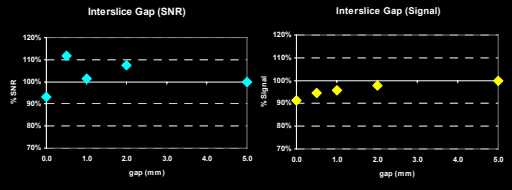
- measure SNR of uniform slices with different gaps

gap (mm)	mean	SD	SNR	%SNR	%mean
5.0	1318.23	5.04	262	100.0%	100.0%
2.0	1288.08	4.58	281	107.5%	97.7%
1.0	1261.38	4.75	266	101.5%	95.7%
0.5	1247.20	4.27	292	111.7%	94.6%
0.0	1202.58	4.93	244	93.3%	91.2%



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MR physics tests

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  - soft copy displays
- additional tests
  - RF shielding
  - magnetic fringe field
  - SNR

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RF shielding

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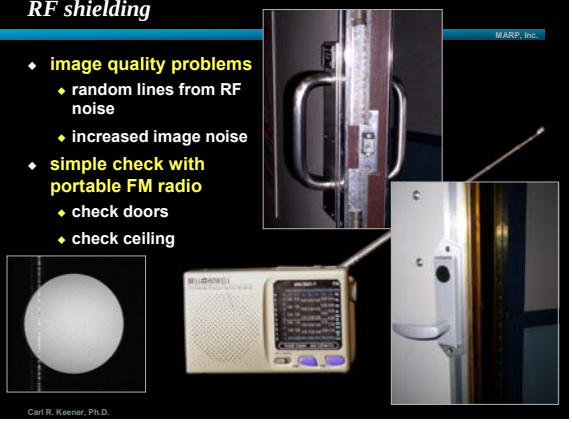
- image quality problems
  - random lines from RF noise
  - increased image noise
- simple check with portable FM radio
  - check doors
  - check ceiling



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RF shielding

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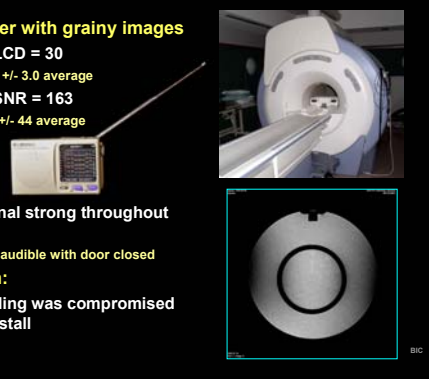
- new scanner with grainy images
  - ACR T1 LCD = 30
    - vs. 35.2 +/- 3.0 average
  - ACR T1 SNR = 163
    - vs. 255 +/- 44 average
  - radio signal strong throughout room
    - slightly audible with door closed
- conclusion:
  - RF shielding was compromised during install



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RF problems

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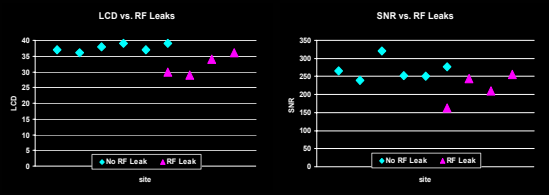
- images, SNR & LCD improved after RF noise eliminated



LCD
no RF Leaks : 37.7 ± 1.2
RF Leaks : 32.3 ± 3.3

SNR
no RF Leaks : 267 ± 29
RF Leaks : 218 ± 42

9 1.5T sites ACR T1 series

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magnetic fringe field

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- 5 gauss line must be posted
  - pacemakers
- actively shielded magnets
  - 5 gauss line inside scan room or very close
- unshielded magnets
  - 5 gauss line ~ 30 feet away
    - outside scan room
    - outside building
- affects neighboring scanners

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magnetic fringe field

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- are signs appropriate?
  - has scanner been changed?
  - gauss meter

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conclusions

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- number of ACR MRAP continues to increase
  - requests for physics support increasing
- physics support includes
  - reviewing technologist QC
  - repeating technologist tests
  - performing additional ACR phantom tests
  - performing additional ACR tests
- physicists can add other tests and analyze data to provide site with more information than just 'pass/fail"

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