Toshiba Site
Yearly Performance Evaluation
Toshiba Opart Ultra
24-Feb-08

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MRI Equipment Evaluation Summary & Signature Page

Site Name: Toshiba Site **MRAP #**

Address: **Survey Date:** 2/24/08

City, State, Zip **Report Date:** 4/8/08

MRI Mfg: Toshiba **Model:** Opart Ultra **Field:**

MRI Scientist: Moriel NessAiver, Ph.D. **Signature:** Moriel NessAiver, Ph.D.

Equipment Evaluation Tests	Pass	Fail *	N/A
1. Magnetic field homogeneity Opart Ultra	X		
2. Slice position accuracy:	X		
3. Table positioning reproducibility:			X
4. Slice thickness accuracy:	X		
5. RF coils' performance:			
a. Volume QD Coils	X		
b. Phase Array Coils	X		
c. Surface Coils	X		
6. Inter-slice RF interference (Crosstalk):		X	
7. Soft Copy Display	X		

Evaluation of Site's Technologist QC Program	Pass	Fail *	N/A
1. Set up and positioning accuracy: (daily)			X
2. Center frequency: (daily)			X
3. Transmitter attenuation or gain: (daily)			X
4. Geometric accuracy measurments: (daily)			X
5. Spatial resolution measurements: (daily)			X
6. Low contrast detectability: (daily)			X
7. Head Coil SNR (daily)			X
8. Body Coil SNR (weekly)			X
9. Fast Spin Echo (FSE/TSE) ghosting levels: (daily)			X
10. Film quality control: (weekly)			X
11. Visual checklist: (weekly)			X

*See comments page for description of any failures.

Specific Comments and Recommendations

1. The ACR Phantom tests demonstrate significant problems with gradient linearity and magnet homogeneity. After near heroic efforts with your Toshiba engineer, we were able to calibrate the system so that it will pass (barely) ACR requirements.
2. The Ultra has two gradient modes, one that uses the other Opart gradient profiles and one that uses higher power Ultra profiles'. I tested 3 SE sequences (TE 7, 9 and 10) and all three fail slice thickness requirements. When I requested a 5 mm thick slice, I measured 3.88 mm with the TE 7 sequence. This will result in a 22% loss in SNR.
3. I originally suspected a problem with the wrist coil. After obtaining a temporary replacement I came to the conclusion that one channel produces most of the signal and the second channel is used to improve uniformity.
4. While there does not appear to be significant general RF noise, there is a well documented RF 'dot' that occurs exactly at 15 MHz.
5. I strongly recommend that you install a closed circuit TV system that will allow your technologists to monitor the hallway to ensure that no unauthorized individuals approach the scan room doors. I also recommend that you place some plastic chains to keep people away from the doors.
6.
7.
8.
9.
10.
11.
12.
13.

NOTE: Please be sure to read appendix D for an explanation of the format of this document.

MRI Equipment Performance Evaluation Data Form

Site Name: Toshiba Site

Contact	Title	Phone	eMail
	Office Manager		
	PACS Admin.		
	Radiologist		
	Toshiba Engr		

Equipment Information

MRI Manufacturer: Toshiba Model: Opart Ultra SN: R456 Software: 5.02 Ultra

Camera Manufacturer: Agfa Model: Drystar 5500 SN: Software:

PACS Manufacturer: Model: SN: Software:

ACR Phantom Number used: J6959

1. Table Positioning Reproducibility:

N/A

Table motion out/in:	IsoCenter	Out/In	Out/In	Out/In
Measured Phantom Center				

Comment: Table motion is all done manually.

2. Magnetic Field Homogeneity

See appendix A for field plots.

PASS

Last Year CF: N/A This Year CF: **15001678** CF Change: **NA**

GRE TR: 500, TE: 115 Flip Angle: 45, FOV: 36

10 mm skip 10 mm, BW: 10.4KHz, 256x128, 2nex

	15 cm	20 cm	25 cm
Axial:	2.4	4.2	7.2
Coronal:	0.9	1.6	3.1
Sagittal:	3.2	5.6	10.1

Comments: There is a region of poor homogeneity immediately posterior of isocenter. Is this a problem with the magnet or is there something in the coil causing this?

3. Slice Thickness Accuracy

FOV: 250mm Matrix: 256x256 (Slice #1 from ACR Phantom) All values in mm

Sequence	TR	TE	Flip	NSA	Calc	Target	% Error
SE (ACR)	500	20	90	1	4.54	5	-9.2%
SE (Site T1)	500	15	90	1	4.61	5	-7.8%
SE (20/80)	2000	300	90	1	4.96	5	-0.8%
SE (20/80)	2000	80	90	1	4.91	5	-1.8%
FSE(11)	4000	110	90	1	4.85	5	-3.0%
SE(Ultra)	500	7	90	1	3.88	5	-22.4%
SE(Ultra)	500	9	90	1	4.16	5	-16.8%
SE(Ultra)	500	10	90	1	4.18	5	-16.4%
SE(Opart)	500	12	90	1	4.35	5	-13.0%

Comments: All of the Ultra based sequence fail slice profile requirements.

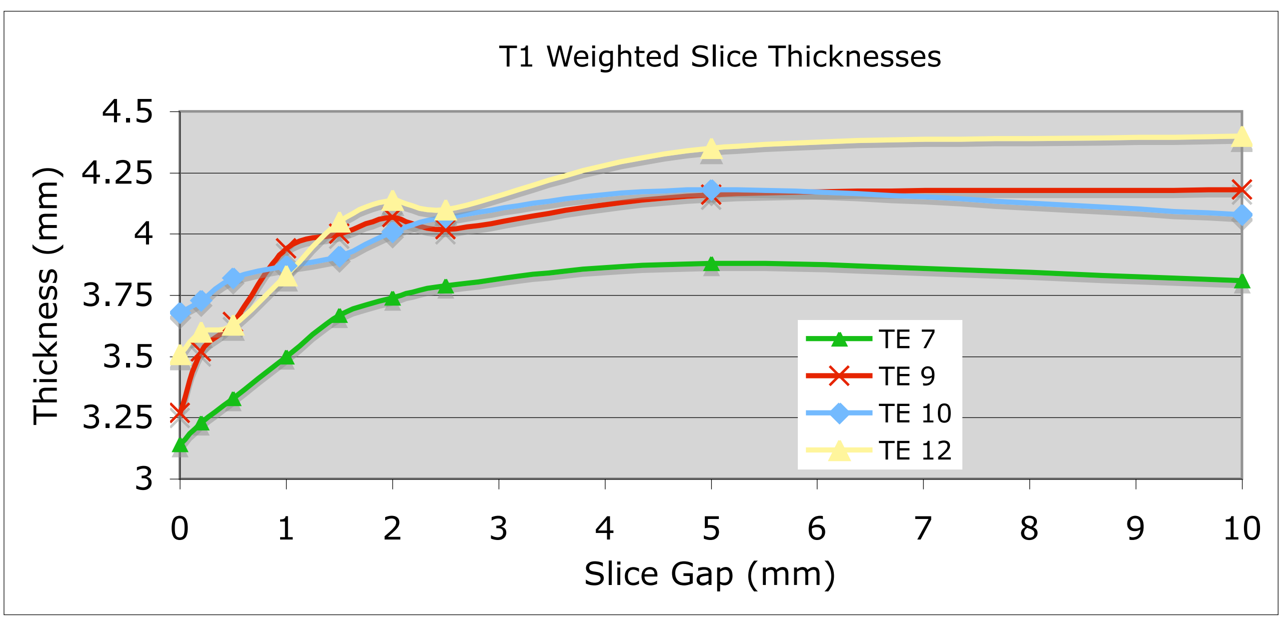
4. Slice Crosstalk (RF interference)

The following data were obtained using the ACR phantom slice thickness wedges to measure the slice profile of four T1 weighted sequences when the slice gap varies from 200% down to 0% (contiguous) As the slices get closer together it is expected that the edges of the slices will overlap causing a deterioration of the slice profile. The data shown below clearly demonstrates this effect. Once the slice gap reaches 40% of the slice thickness, the measured slice profiles begin to drop. Note that the TE 7 sequence has the worst profile and drops off very rapidly, as does the TE 9. The TE 7, 9 and 10 all use 'Ultra' gradients while the TE 12 uses Opart. All of these sequences were supposed to have an initial slice thickness of 5 mm. The ACR's spec is 5 ±.7. Only the TE 12 (Opart gradient) system meets this spec.

All of the slice profiles can be viewed in Appendix B.

Sequence Type	TR	TE	FOV (cm^2)	Matrix	NSA	Thickness	# of slices	Slice Measured
SE(ultra)	500	7	25	256x256	1	5	11	6
SE(ultra)	500	9	25	256x256	1	5	11	6
SE(ultra)	500	10	25	256x256	1	5	11	6
SE(Opart)	500	12	25	256x256	1	5	11	6

Skip	TE 7	TE 9	TE 10	TE 12
0	3.14	3.27	3.68	3.51
0.2	3.23	3.52	3.73	3.6
0.5	3.33	3.64	3.82	3.63
1	3.5	3.94	3.87	3.83
1.5	3.67	4	3.91	4.05
2	3.74	4.07	4.01	4.14
2.5	3.79	4.02	4.07	4.1
5	3.88	4.16	4.18	4.35
10	3.81	4.18	4.08	4.4



5. Soft & Hard Copy Displays

Luminance Meter Make/Model: Tektronix J16 Digital Photometer — Cal Expires: 4/6/06

Monitor Description: Eizo LCD

Luminance Measured: Ft. lamberts

Measured Data					
Which Monitor	Center of Image Display	Top Left Corner	Top Right Corner	Bottom Left Corner	Bottom Right Corner
Console	52.6	49	49	48.1	48.6

Uniformity		
MAX	MIN	Percent Delta
52.6	48.1	9%

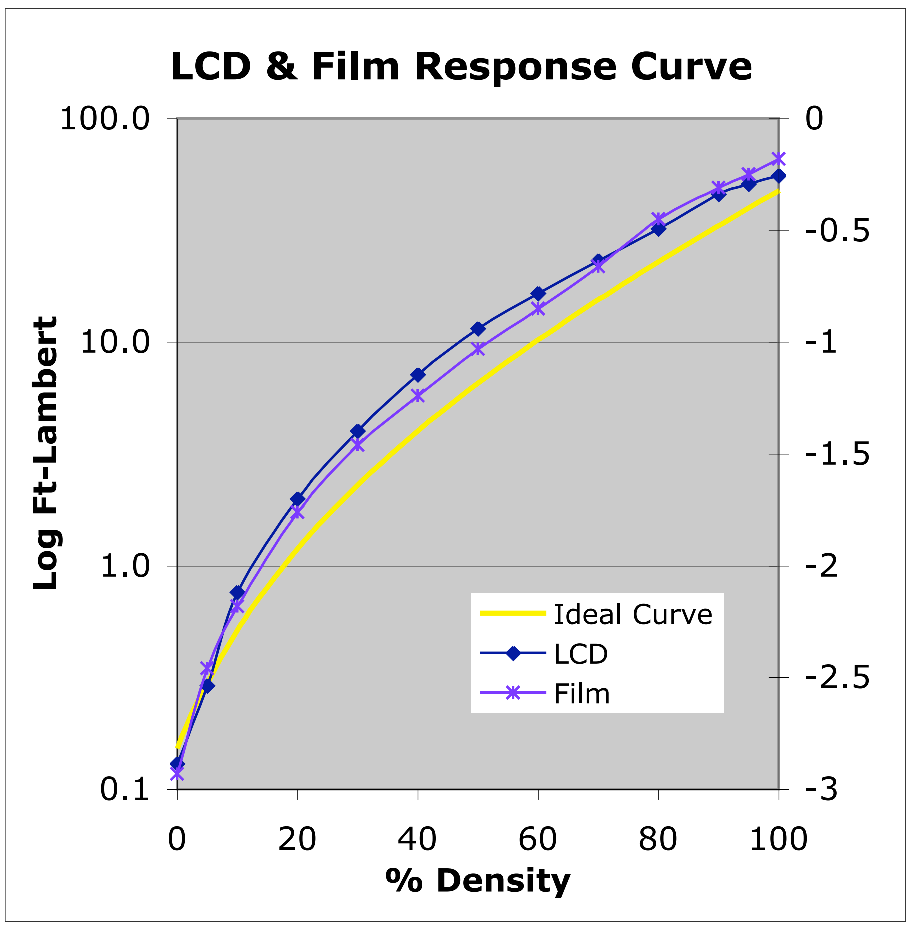
SMPTE
OK?
Y

% delta =200% x (max-min)/(max+center) (>30% is action limit)

Minimum Brightness must be > 26.24 Ft. Lamberts

The LCD and film are both very good and match each other very well.

Density	Ft-Lamber	Film Density
0	0.13	-2.93
5	0.29	-2.46
10	0.76	-2.18
20	2.00	-1.76
30	4.00	-1.46
40	7.17	-1.24
50	11.50	-1.03
60	16.50	-0.85
70	23.1	-0.66
80	32.1	-0.448
90	45.9	-0.31
95	50.9	-0.25
100	55.7	-0.18



Coil and Other Hardware Inventory List

Site Name Toshiba Site

ACR Magnet # ____________ Nickname Ultra

Active	Coil Description	Manufacturer	Model	Rev.	Mfg. Date	SN	Channels
☐	Body - XL	Toshiba	MJLB123-A	1	Jan, 2005	S1A0542077	1
☐	Body Flex Large	Toshiba	MJQB-133A			A2532025	1
☐	Body Flex Medium	Toshiba	1005075100001			B5512130	1
☐	Flexible Small Parts	USA Instruments	1005078130001	2	Sep, 2004	C4592141	1
☐	Head Coil QD	Toshiba	MJQH-133A	5	Dec, 2004	B4622116	1
☐	Knee/Foot Array QD	USA Instruments	MJAJ-152A	1	Apr, 2005	S1A0552008	2
☐	Neck Array QD	USA Instruments	MJAN-113A	1	Jan, 2005	A5512163	1
☐	Shoulder Array QD	USA Instruments	MJAJ-123A	1	Nov, 2004	E2A0572084	2
☐	Spine Array CTL QD	USA Instruments	MJAS-133A	2	Feb, 2004	A4532018	2
☐	Wrist Coil Array QD	Toshiba	MJAJ-143A	1	Jul, 2004	A5512007	2
☐	Wrist Coil Array QD	Toshiba	MJAJ-143A			Temp Replacement	2
☐							

RF Coil Performance Evaluation

Coil: Body - XL

Mfg.: Toshiba

Mfg. Date: 1/19/2005 **Coil ID:** 1554

Phantom: 32 cm sphere (GE)

Test Date: 2/24/2008

Model: MJLB123-A

Revision: 1

SN: S1A0542077

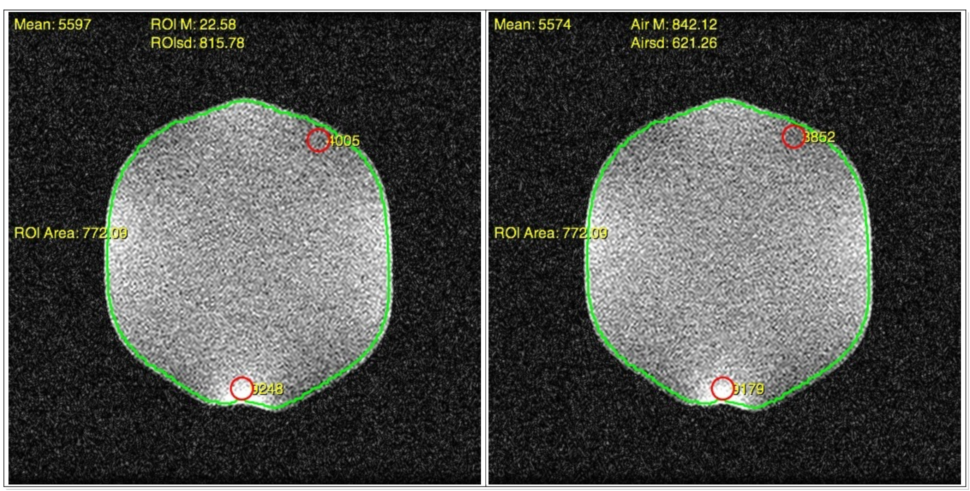
# of Channels 1

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	50	256	256	6.94	2	5	-

Coil Mode: Body XL

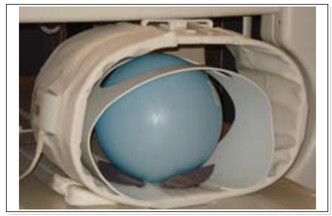
Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	5,597	9,248	4,005	22.6	815.78	NEMA	4.9	0.5	8.0	60.4%
A	5,574	9,179	3,852	842.1	621.26	Air	5.9	0.6	9.7	59.1%



Test Images

RF Coil Performance Evaluation



Coil:	Body Flex Large	Test Date:	2/24/2008
Mfg.:	Toshiba	Model:	MJQB-133A
Mfg. Date:	Coil ID: 1557	Revision:	
Phantom:	32 cm sphere (GE)	SN:	A2532025
		# of Channels	1

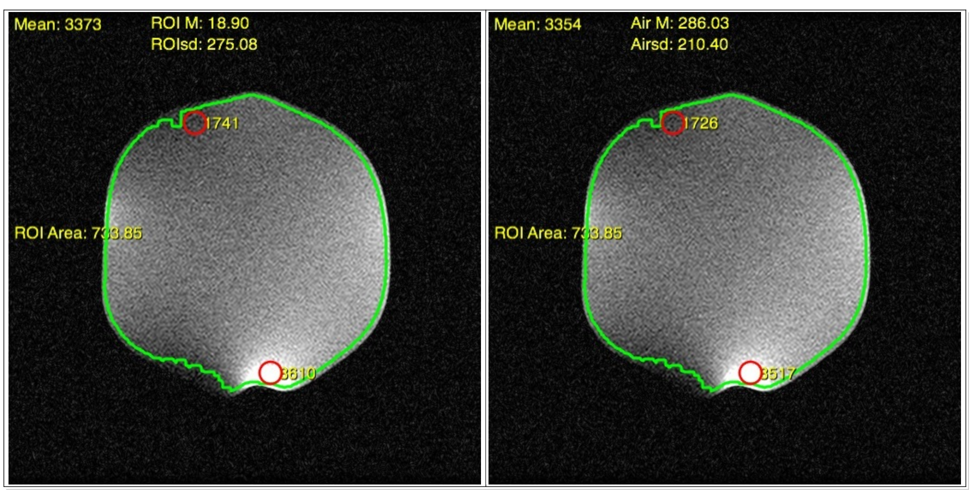
Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	50	256	256	6.94	2	5	-

Coil Mode: Body Flex Large

Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	3,373	8,610	1,741	18.9	275.08	NEMA	8.7	0.9	22.1	33.6%
A	3,354	8,517	1,726	286.0	210.40	Air	10.4	1.1	26.5	33.7%

Exceptionally bad geometric distortion due to gradient non-linearities and magnet inhomogeneities.



Test Images

RF Coil Performance Evaluation

Coil:	Body Flex Medium
Mfg.:	Toshiba
Mfg. Date:	
Coil ID:	1558
Phantom:	32 cm sphere (GE)
Test Date:	2/24/2008
Model:	1005075100001
Revision:	
SN:	B5512130
# of Channels	1

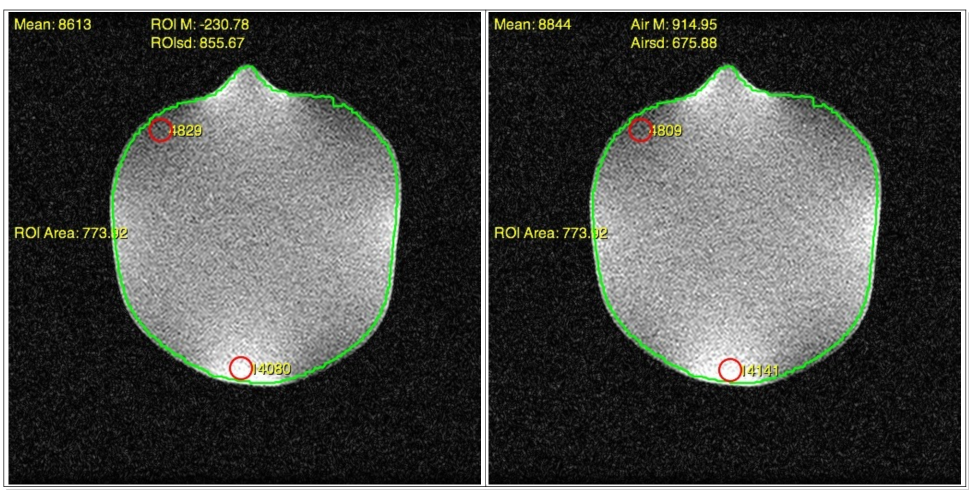
Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	50	256	256	6.94	1	5	-

Coil Mode: Body Flex Medium

Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	8,613	14,080	4,829	-230.8	855.67	NEMA	7.1	1.0	11.6	51.1%
A	8,844	14,141	4,809	915.0	675.88	Air	8.6	1.2	13.7	50.8%

Bad geometric distortion due to gradient non-linearities and magnet inhomogeneities.



Test Images

RF Coil Performance Evaluation

Coil: Flexible Small Parts
Mfg.: USA Instruments
Mfg. Date: 9/9/2004 Coil ID: 1555
Phantom: Small Wrist Bottle

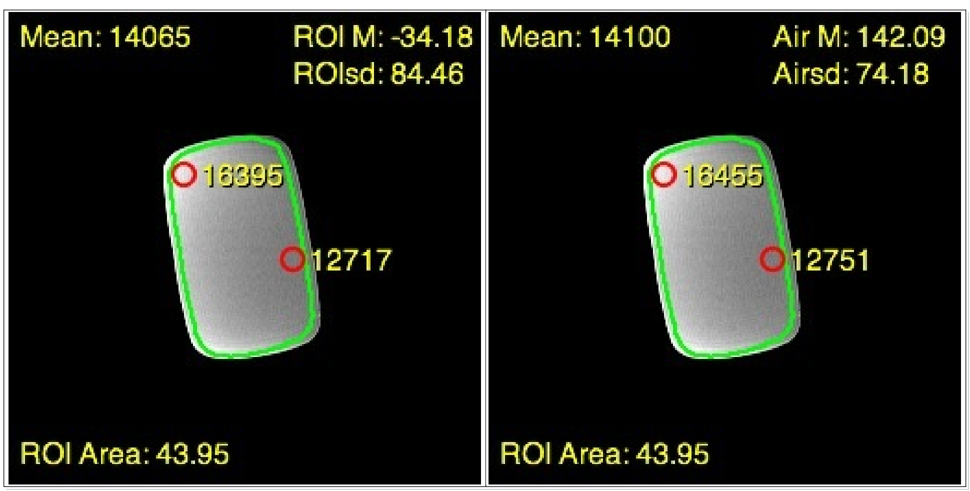
Test Date: 2/24/2008
Model: 1005078130001
Revision: 2
SN: C4592141
# of Channels: 1

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	45	256	256	6.94	1	5	-

Coil Mode: Small Parts

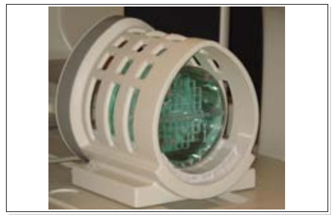
Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	14,065	16,395	12,717	-34.2	84.46	NEMA	117.8	20.9	137.3	87.4%
A	14,100	16,455	12,751	142.1	74.18	Air	124.6	22.2	145.4	87.3%



Test Images

RF Coil Performance Evaluation



Coil: Head Coil QD

Mfg.: Toshiba

Mfg. Date: 12/11/2004 Coil ID: 1556

Phantom: ACR Phantom

Test Date: 2/24/2008

Model: MJQH-133A

Revision: 5

SN: B4622116

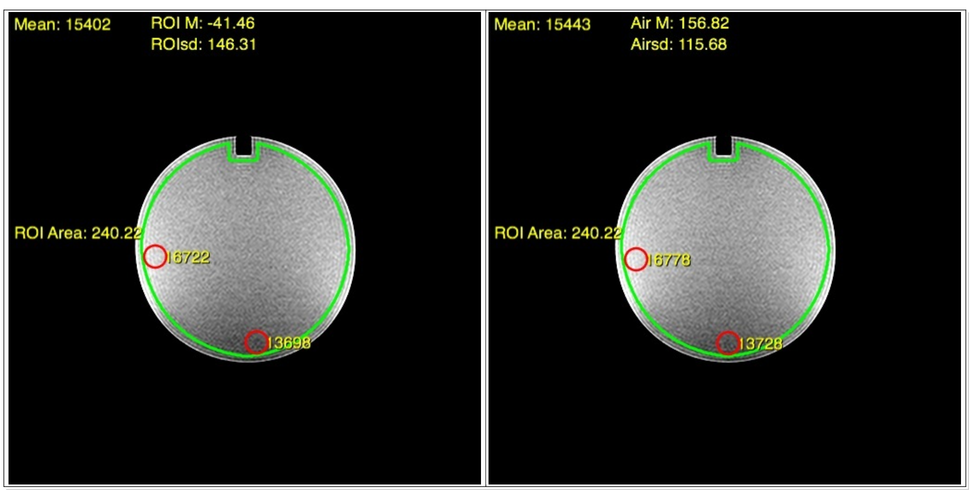
# of Channels 1

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	40	256	256	6.94	1	5	-

Coil Mode: Head

Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	15,402	16,722	13,698	-41.5	146.31	NEMA	74.4	16.8	80.8	90.1%
A	15,443	16,778	13,728	156.8	115.68	Air	87.5	19.7	95.0	90.0%



Test Images

RF Coil Performance Evaluation

Coil:	Knee/Foot Array QD
Mfg.:	USA Instruments
Mfg. Date:	4/1/2005
Coil ID:	1551
Phantom:	USAI Foot phantom
Test Date:	2/24/2008
Model:	MJAJ-152A
Revision:	1
SN:	S1A0552008
# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	S	50	256	256	6.94	1	5	-

Coil Mode: Array Knee

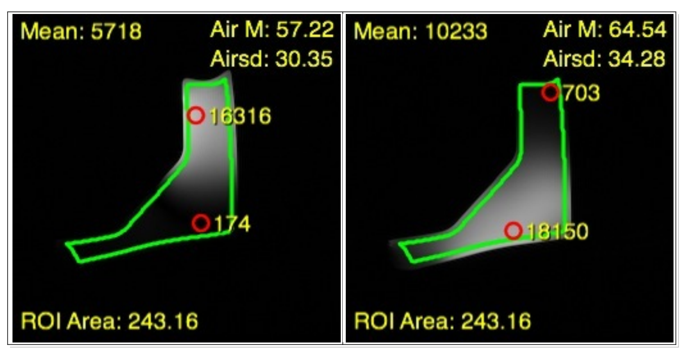
Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	13,337	16,642	4,490	64.9	37.25	NEMA	253.2	36.5	316.0	42.5%
A	13,272	16,566	4,453	84.6	32.05	Air	271.4	39.1	338.7	42.4%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	5,718	16,316	30.35	Air	123.5	63%	352.3	100%
2	10,233	18,150	34.28	Air	195.6	100%	347.0	98%

Composites



Channel 1 Channel 2

RF Coil Performance Evaluation

Coil: Knee/Foot Array QD

Mfg.: USA Instruments

Mfg. Date: 4/1/2005 **Coil ID:** 1551

Phantom: Knee Bottle

Test Date: 2/24/2008

Model: MJAJ-152A

Revision: 1

SN: S1A0552008

# of Channels 2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	C	30	256	256	6.94	1	5	-

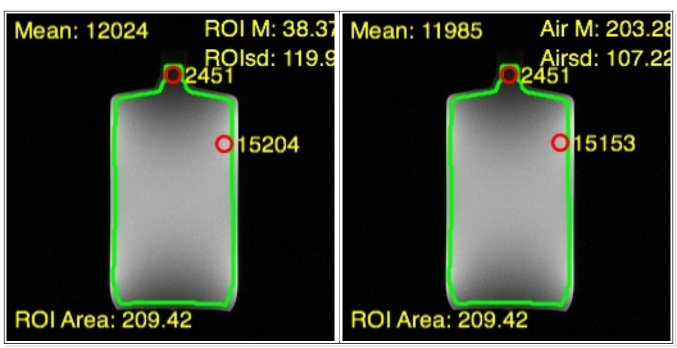
Coil Mode: Array Knee

Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	12,024	15,204	2,451	38.4	119.94	NEMA	70.9	28.4	89.6	27.8%
A	11,985	15,153	2,451	203.3	107.22	Air	73.3	29.3	92.6	27.8%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	9,973	16,300	65.28	Air	100.1	82%	163.6	89%
2	11,197	16,685	59.78	Air	122.7	100%	182.9	100%



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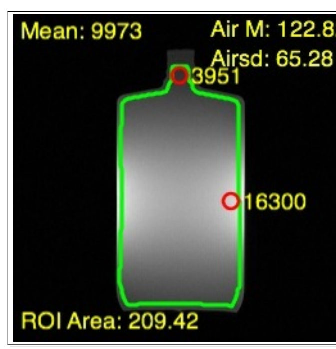
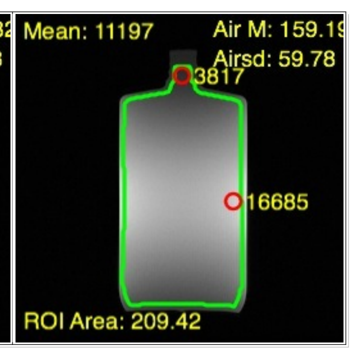


Channel 1



Channel 2

RF Coil Performance Evaluation

Coil:	Knee/Foot Array QD	Test Date:	2/24/2008
Mfg.:	USA Instruments	Model:	MJAJ-152A
Mfg. Date:	4/1/2005 Coil ID: 1551	Revision:	1
Phantom:	Knee Bottle	SN:	S1A0552008
		# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	30	256	256	6.94	1	5	-

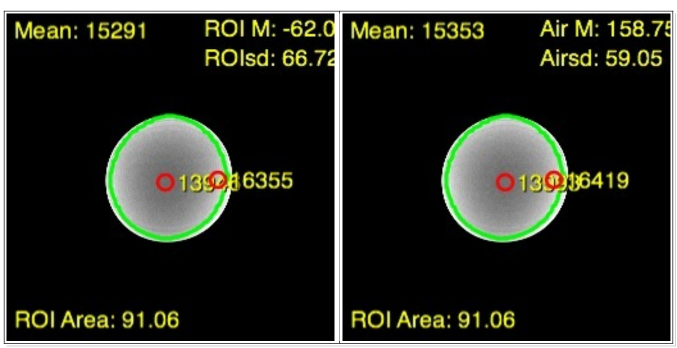
Coil Mode: Knee

Analysis of Composite Image

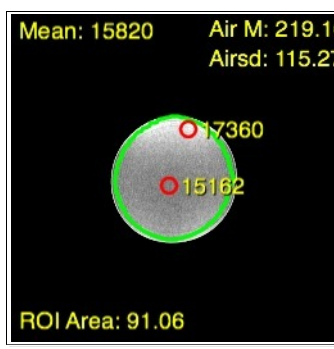
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	15,291	16,355	13,946	-62.1	66.72	NEMA	162.1	64.9	173.4	92.0%
A	15,353	16,419	13,993	158.8	59.05	Air	170.4	68.2	182.2	92.0%

Analysis of Uncombined Images

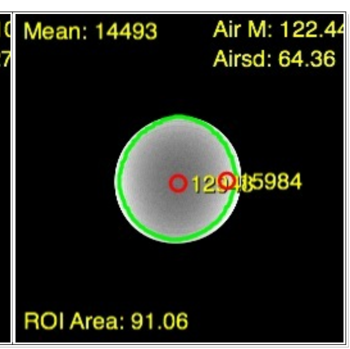
Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	15,820	17,360	115.27	Air	89.9	61%	98.7	61%
2	14,493	15,984	64.36	Air	147.6	100%	162.7	100%



Composites



Channel 1



Channel 2

RF Coil Performance Evaluation

Coil: Neck Array QD

Mfg.: USA Instruments

Mfg. Date: 1/7/2005 Coil ID: 1559

Phantom: Knee Bottle

Test Date: 2/24/2008

Model: MJAN-113A

Revision: 1

SN: A5512163

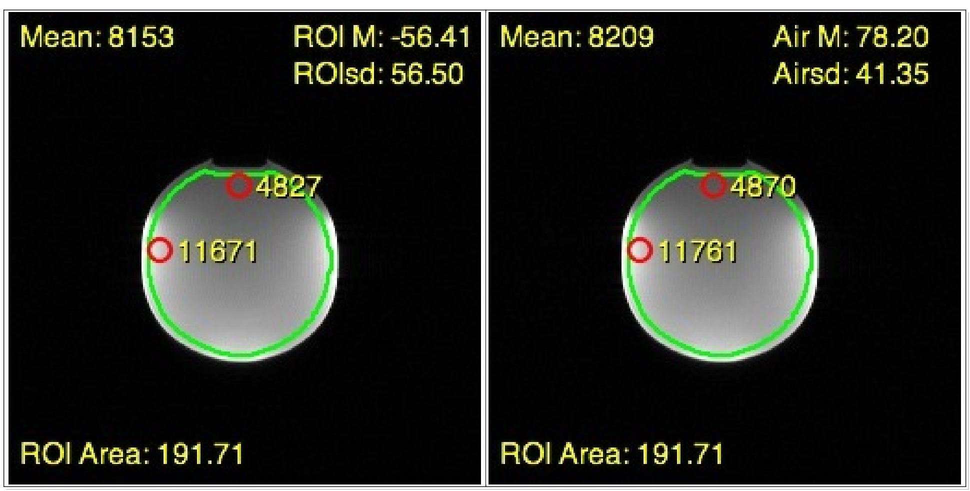
# of Channels 1

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	40	256	256	6.94	1	5	-

Coil Mode: Neck

Analysis of Test Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal- ized	Max SNR	Uni- formity
N	8,153	11,671	4,827	-56.4	56.50	NEMA	102.1	23.0	146.1	58.5%
A	8,209	11,761	4,870	78.2	41.35	Air	130.1	29.3	186.4	58.6%



Test Images

RF Coil Performance Evaluation

Coil:	Shoulder Array QD	Test Date:	2/24/2008
Mfg.:	USA Instruments	Model:	MJAJ-123A
Mfg. Date:	11/24/2004	Revision:	1
Coil ID:	1552	SN:	E2A0572084
Phantom:	Knee Bottle	# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	S	20	256	256	6.94	1	5	-

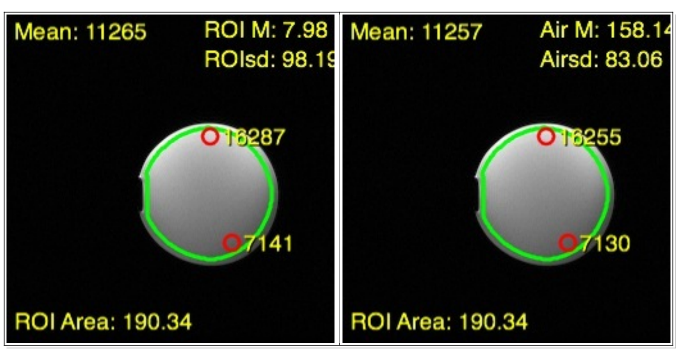
Coil Mode: Shoulder

Analysis of Composite Image

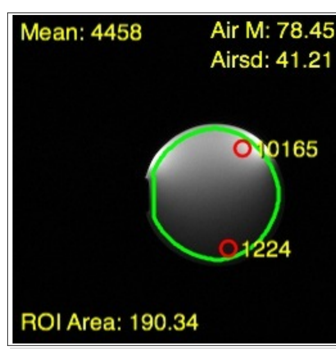
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	11,265	16,287	7,141	8.0	98.19	NEMA	81.1	73.1	117.3	61.0%
A	11,257	16,255	7,130	158.1	83.06	Air	88.8	80.0	128.2	61.0%

Analysis of Uncombined Images

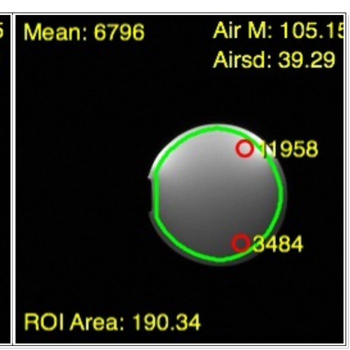
Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	4,458	10,165	41.21	Air	70.9	63%	161.6	81%
2	6,796	11,958	39.29	Air	113.3	100%	199.4	100%



Composites



Channel 1



Channel 2

RF Coil Performance Evaluation

Coil:	Shoulder Array QD
Mfg.:	USA Instruments
Mfg. Date:	11/24/2004
Coil ID:	1552
Phantom:	Knee Bottle
Test Date:	2/24/2008
Model:	MJAJ-123A
Revision:	1
SN:	E2A0572084
# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	C	50	256	256	6.94	1	5	-

Coil Mode: Shoulder

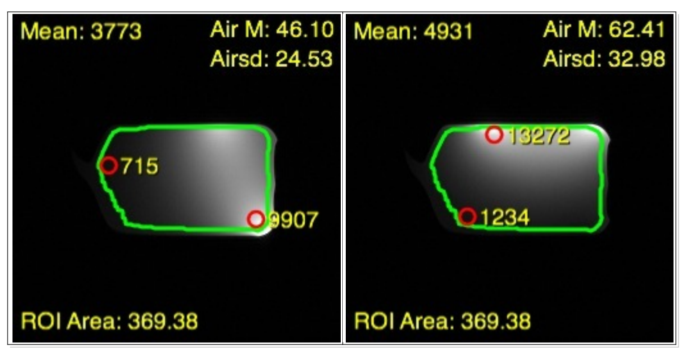
Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	5,614	11,558	1,326	2.7	28.41	NEMA	139.7	20.1	287.7	20.6%
A	5,611	11,548	1,321	66.9	25.18	Air	146.0	21.0	300.5	20.5%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	3,773	9,907	24.53	Air	100.8	100%	264.7	100%
2	4,931	13,272	32.98	Air	98.0	97%	263.7	100%

Composites



Channel 1 Channel 2

RF Coil Performance Evaluation

Coil:	Spine Array CTL QD	Test Date:	2/24/2008
Mfg.:	USA Instruments	Model:	MJAS-133A
Mfg. Date:	2/27/2004 Coil ID: 1553	Revision:	2
		SN:	A4532018
Phantom:	USAI Phantom set	# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	40	256	256	6.94	1	5	-

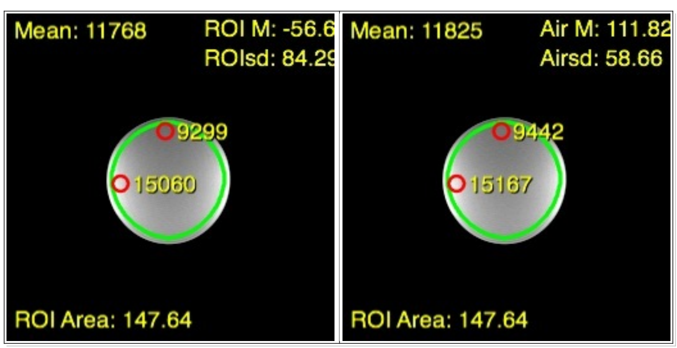
Coil Mode: C Spine

Analysis of Composite Image

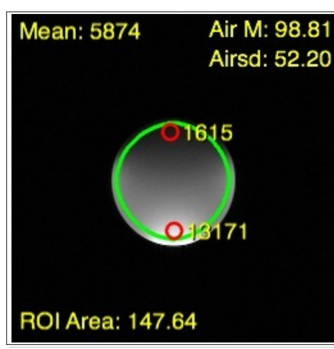
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	11,768	15,060	9,299	-56.7	84.29	NEMA	98.7	22.2	126.4	76.3%
A	11,825	15,167	9,442	111.8	58.66	Air	132.1	29.7	169.4	76.7%

Analysis of Uncombined Images

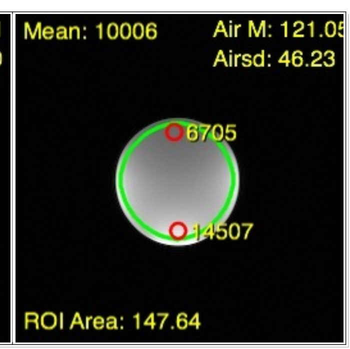
Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	5,874	13,171	52.20	Air	73.7	52%	165.3	80%
2	10,006	14,507	46.23	Air	141.8	100%	205.6	100%



Composites



Channel 1



Channel 2

RF Coil Performance Evaluation

Coil:	Spine Array CTL QD
Mfg.:	USA Instruments
Mfg. Date:	2/27/2004
Coil ID:	1553
Phantom:	USAI Phantom set
Test Date:	2/24/2008
Model:	MJAS-133A
Revision:	2
SN:	A4532018
# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	50	256	256	6.94	1	5	-

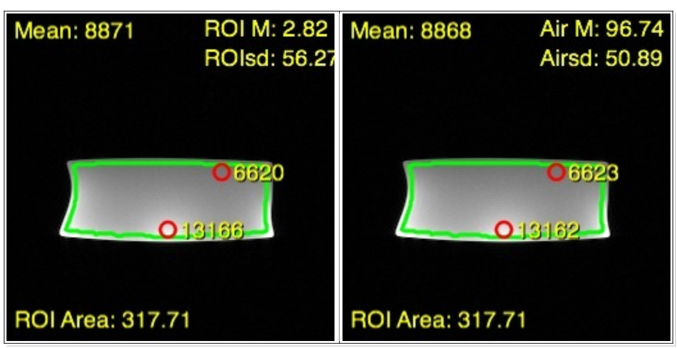
Coil Mode: L Spine

Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	8,871	13,166	6,620	2.8	56.27	NEMA	111.5	16.1	165.5	66.9%
A	8,868	13,162	6,623	96.7	50.89	Air	114.2	16.5	169.5	66.9%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	4,816	10,588	40.01	Air	78.9	58%	173.4	74%
2	6,878	11,853	33.28	Air	135.4	100%	233.4	100%



Composites

Channel 1

Channel 2

RF Coil Performance Evaluation

Coil:	Spine Array CTL QD	Test Date:	2/24/2008
Mfg.:	USA Instruments	Model:	MJAS-133A
Mfg. Date:	2/27/2004	Revision:	2
Coil ID:	1553	SN:	A4532018
Phantom:	USAI Phantom set	# of Channels	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	50	256	256	6.94	1	5	-

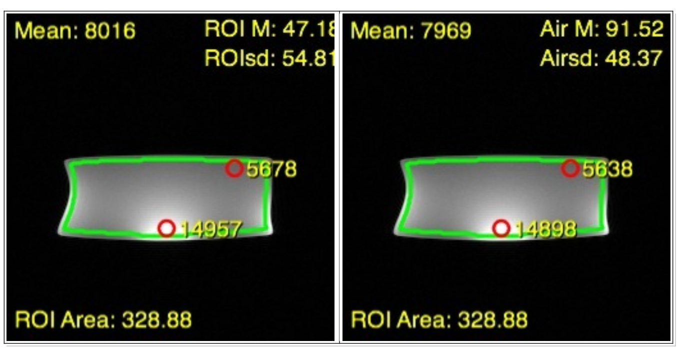
Coil Mode: T Spine

Analysis of Composite Image

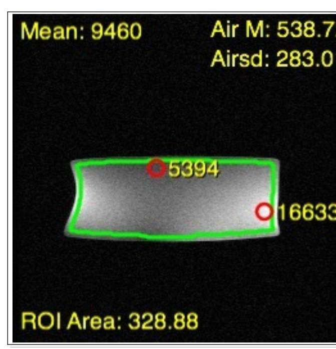
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	8,016	14,957	5,678	47.2	54.81	NEMA	103.4	14.9	193.0	55.0%
A	7,969	14,898	5,638	91.5	48.37	Air	108.0	15.6	201.8	54.9%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	9,460	16,633	283.01	Air	21.9	20%	38.5	19%
2	7,969	14,898	48.37	Air	108.0	100%	201.8	100%



Composites



Channel 1

Channel 2

RF Coil Performance Evaluation

Coil: Wrist Coil Array QD

Mfg.: Toshiba

Mfg. Date: 7/1/2004 **Coil ID:** 1560

Phantom: Small Wrist Bottle

Test Date: 2/24/2008

Model: MJAJ-143A

Revision: 1

SN: A5512007

# of Channels 2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	20	256	256	6.94	1	5	-

Coil Mode: Wrist

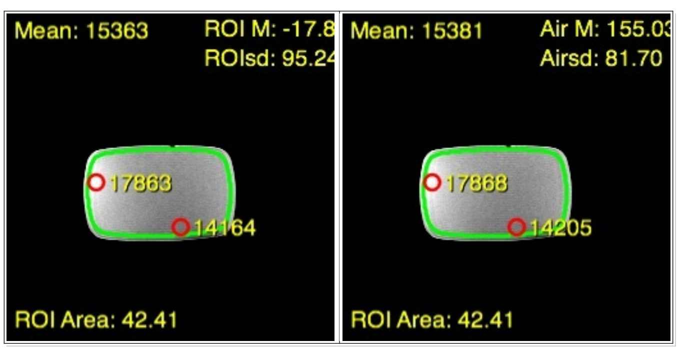
Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	15,363	17,863	14,164	-17.9	95.24	NEMA	114.1	102.7	132.6	88.5%
A	15,381	17,868	14,205	155.0	81.70	Air	123.4	111.1	143.3	88.6%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	4,546	8,147	288.71	Air	10.3	10%	18.5	15%
2	15,252	17,691	92.34	Air	108.2	100%	125.5	100%

Original Coil. I was initially very concerned about the low signal in channel 1. After examining the replacement coil, I found no significant change in SNR. I obtained a sagittal series and discovered that channel 1 is designed to obtain signal in the 8 corners of an imaging volume and are not properly evaluated in a center-line axial or coronal. Therefore, this original coil is OK.



Composites

Channel 1

Channel 2

RF Coil Performance Evaluation

Test Date: 2/24/2008

Coil: Wrist Coil Array QD

Model: MJAJ-143A

Mfg.: Toshiba

Revision: 1

Mfg. Date: 7/1/2004 **Coil ID:** 1560

SN: A5512007

Phantom: Small Wrist Bottle

# of Channels 2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	C	20	256	256	6.94	1	5	-

Coil Mode: Wrist

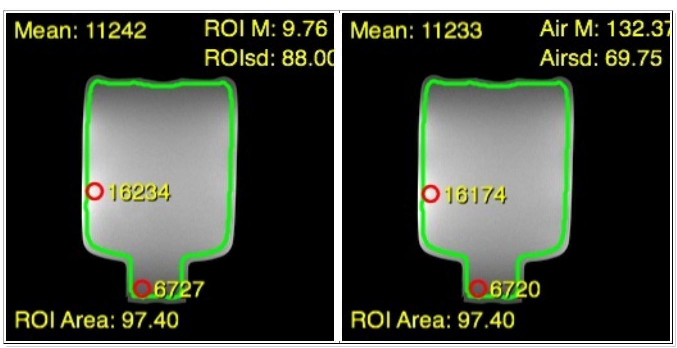
Analysis of Composite Image

Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	11,242	16,234	6,727	9.8	88.00	NEMA	90.3	81.4	130.5	58.6%
A	11,233	16,174	6,720	132.4	69.75	Air	105.5	95.0	152.0	58.7%

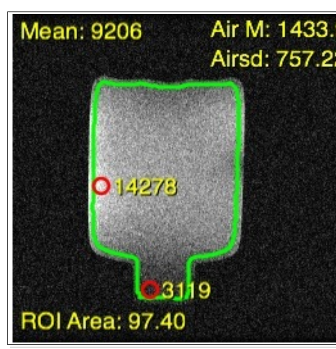
Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	9,206	14,278	757.22	Air	8.0	8%	12.4	9%
2	11,231	16,177	78.33	Air	94.0	100%	135.3	100%

Original Coil



Composites



Channel 1

Channel 2

RF Coil Performance Evaluation

Coil: Wrist Coil Array QD

Mfg.: Toshiba

Mfg. Date: ______ Coil ID: 1623

Phantom: Small Wrist Bottle

Test Date: 2/24/2008

Model: MJAJ-143A

Revision: ______

SN: Temp Replacement

# of Channels 2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	T	20	256	256	6.94	1	5	-

Coil Mode: Wrist

Analysis of Composite Image

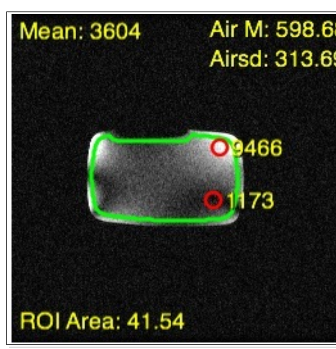
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	12,805	14,882	11,525	43.3	81.84	NEMA	110.7	99.6	128.6	87.3%
A	12,762	14,834	11,484	139.0	73.32	Air	114.1	102.7	132.6	87.3%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	3,604	9,466	313.69	Air	7.5	11%	19.8	25%
2	12,363	14,341	117.50	Air	68.9	100%	80.0	100%

Replacement coil doesn't have as high SNR as the original.

Composites



Channel 1

Channel 2

RF Coil Performance Evaluation

Coil:	Wrist Coil Array QD	**Test Date:**	2/24/2008
Mfg.:	Toshiba	**Model:**	MJAJ-143A
Mfg. Date:		**Revision:**	
Coil ID:	1623	**SN:**	Temp Replacement
Phantom:	Small Wrist Bottle	**# of Channels**	2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	C	20	256	256	6.94	1	5	-

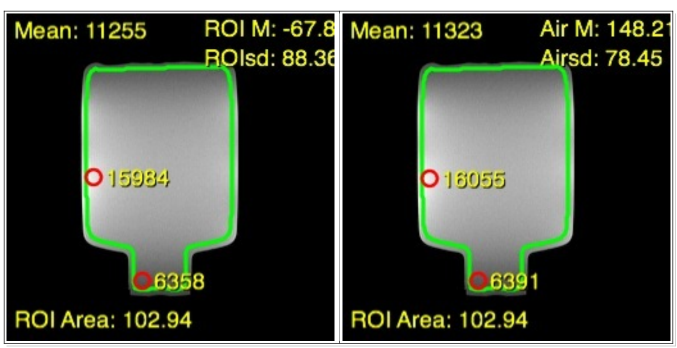
Coil Mode: Wrist

Analysis of Composite Image

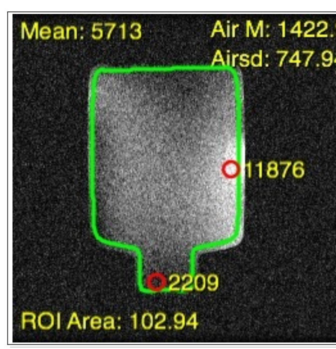
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal- ized	Max SNR	Uni- formity
N	11,255	15,984	6,358	-67.9	88.36	NEMA	90.1	81.1	127.9	56.9%
A	11,323	16,055	6,391	148.2	78.45	Air	94.6	85.2	134.1	56.9%

Analysis of Uncombined Images

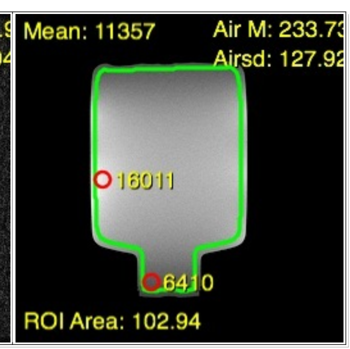
Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	5,713	11,876	747.94	Air	5.0	9%	10.4	13%
2	11,357	16,011	127.92	Air	58.2	100%	82.0	100%



Composites



Channel 1



Channel 2

RF Coil Performance Evaluation

Test Date: 2/24/2008

Coil: Wrist Coil Array QD

Model: MJAJ-143A

Mfg.: Toshiba

Revision:

Mfg. Date:

Coil ID: 1623

SN: Temp Replacement

Phantom: Small Wrist Bottle

# of Channels 2

Sequence	TR	TE	Plane	FOV	Nx	Ny	BW	NSA	Thickness	Gap
SE	300	20	S	20	256	256	6.94	1	5	-

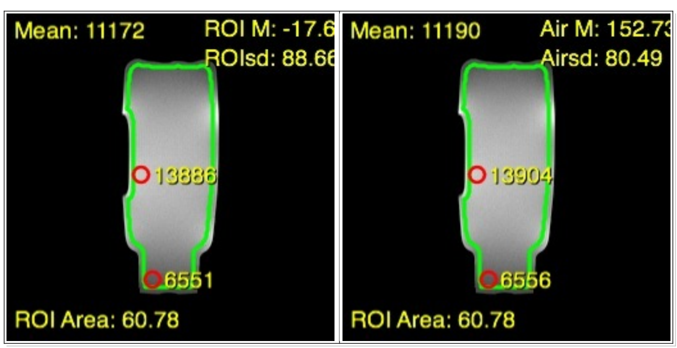
Coil Mode: Wrist

Analysis of Composite Image

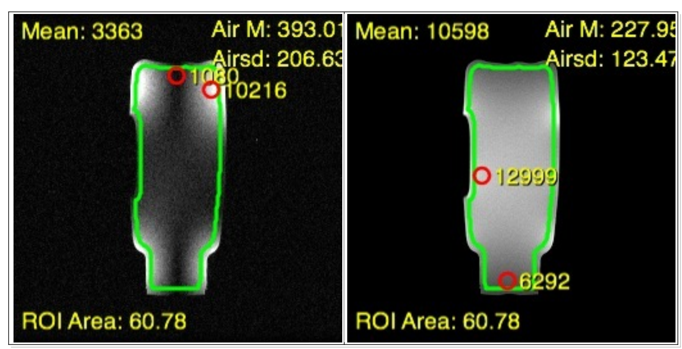
Measured Data							Calculated Results			
Label	Mean	Max	Min	Back ground	Noise SD	Noise Type	Mean SNR	Normal-ized	Max SNR	Uni-formity
N	11,172	13,886	6,551	-17.7	88.66	NEMA	89.1	80.2	110.8	64.1%
A	11,190	13,904	6,556	152.7	80.49	Air	91.1	82.0	113.2	64.1%

Analysis of Uncombined Images

Measured Data					Calculated Results			
Ch	Mean	Max	Noise SD	Noise Type	Mean SNR	% of Mean	Max SNR	% of Max
1	3,363	10,216	206.63	Air	10.7	19%	32.4	47%
2	10,598	12,999	123.47	Air	56.2	100%	69.0	100%

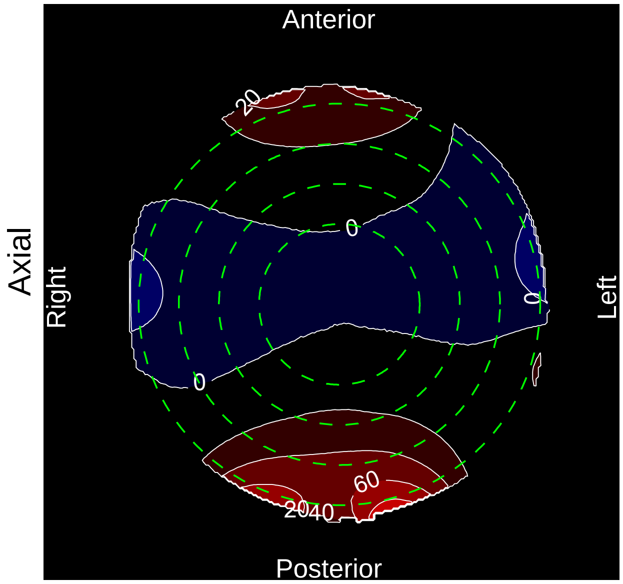


Composites



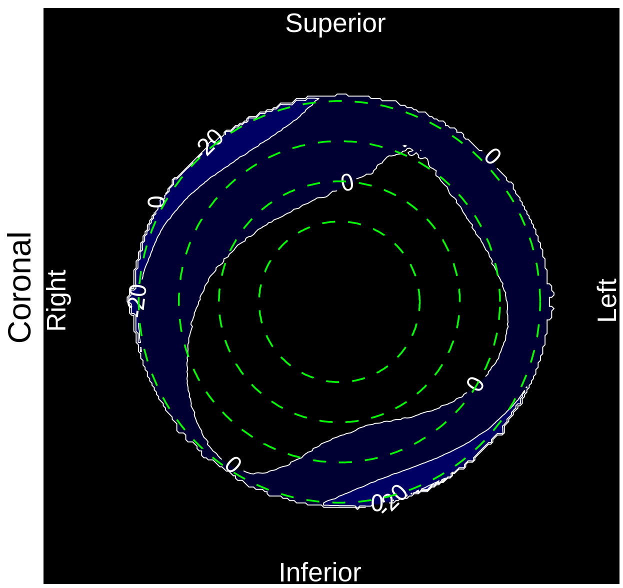
Channel 1 Channel 2

Appendix A: Magnet Homogeneity Field Maps
Toshiba Ultra 0.35T - 3 central planes
Measured February 24, 2008



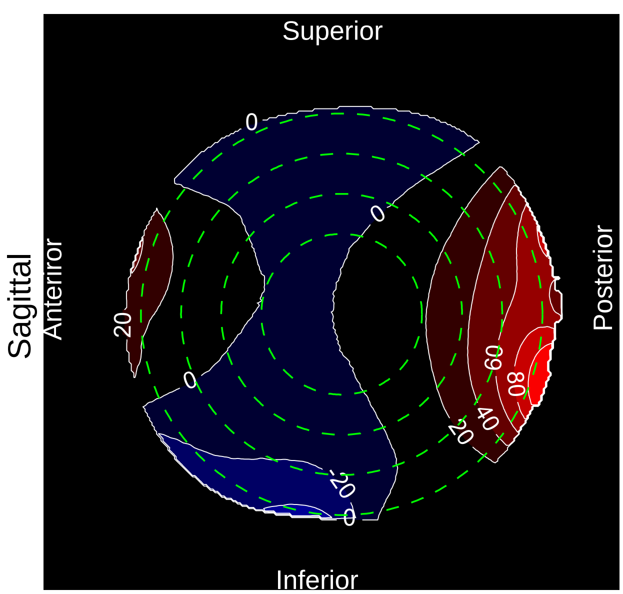
Axial

DIAMETER	MIN	MAX	RANGE	PPM	MEAN	STDEV
10	-5	11	16	1.1	-0.6	3.4
15	-9	26	35	2.4	1.1	6.5
20	-15	46	62	4.2	3.5	11.2
25	-29	78	108	7.2	6.6	17.2



Coronal

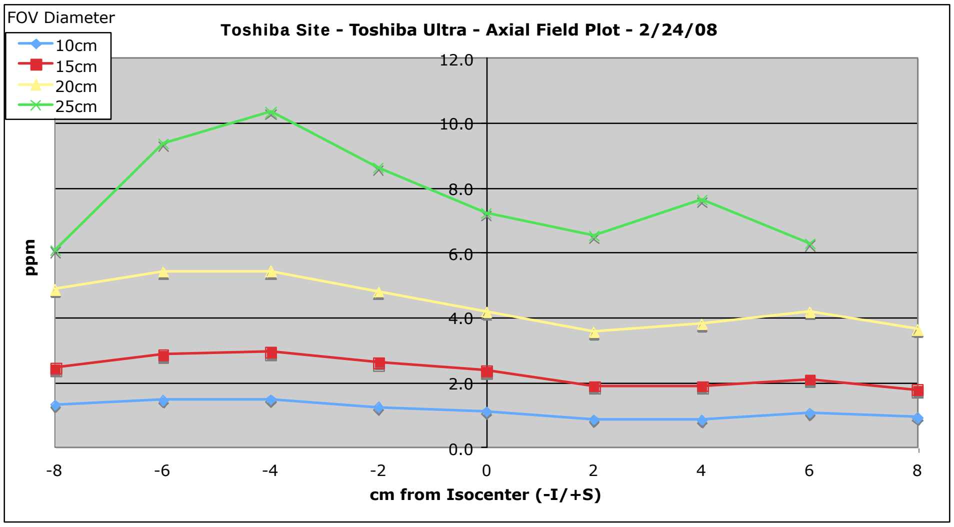
DIAMETER	MIN	MAX	RANGE	PPM	MEAN	STDEV
10	3	9	6	0.5	8.1	1.4
15	-3	9	13	0.9	6.3	2.8
20	-14	9	24	1.6	3.6	4.9
25	-35	9	45	3.1	-1.2	9.2

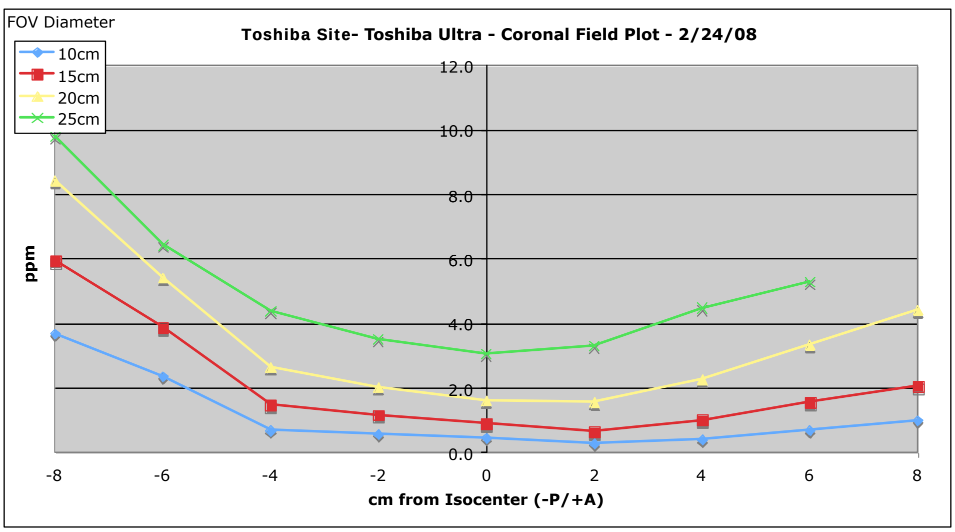


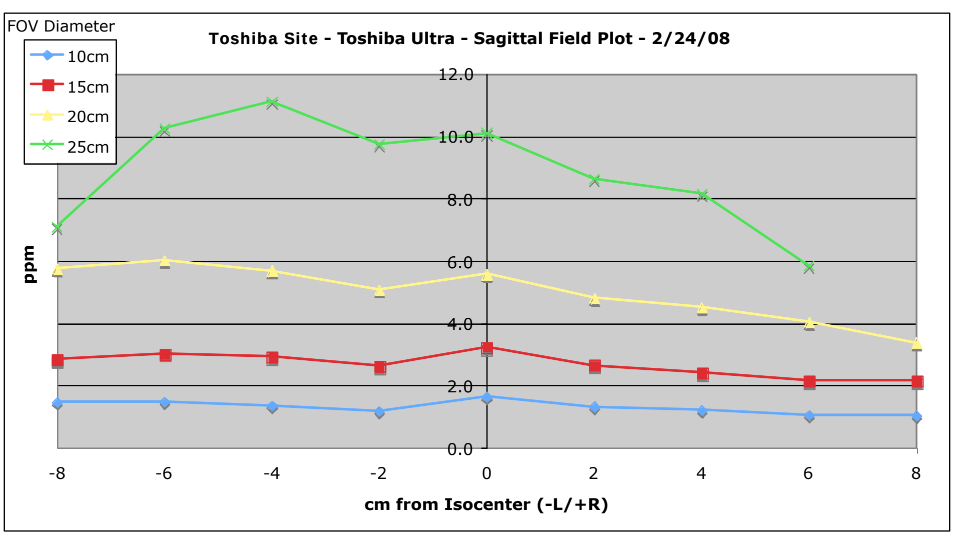
Sagittal

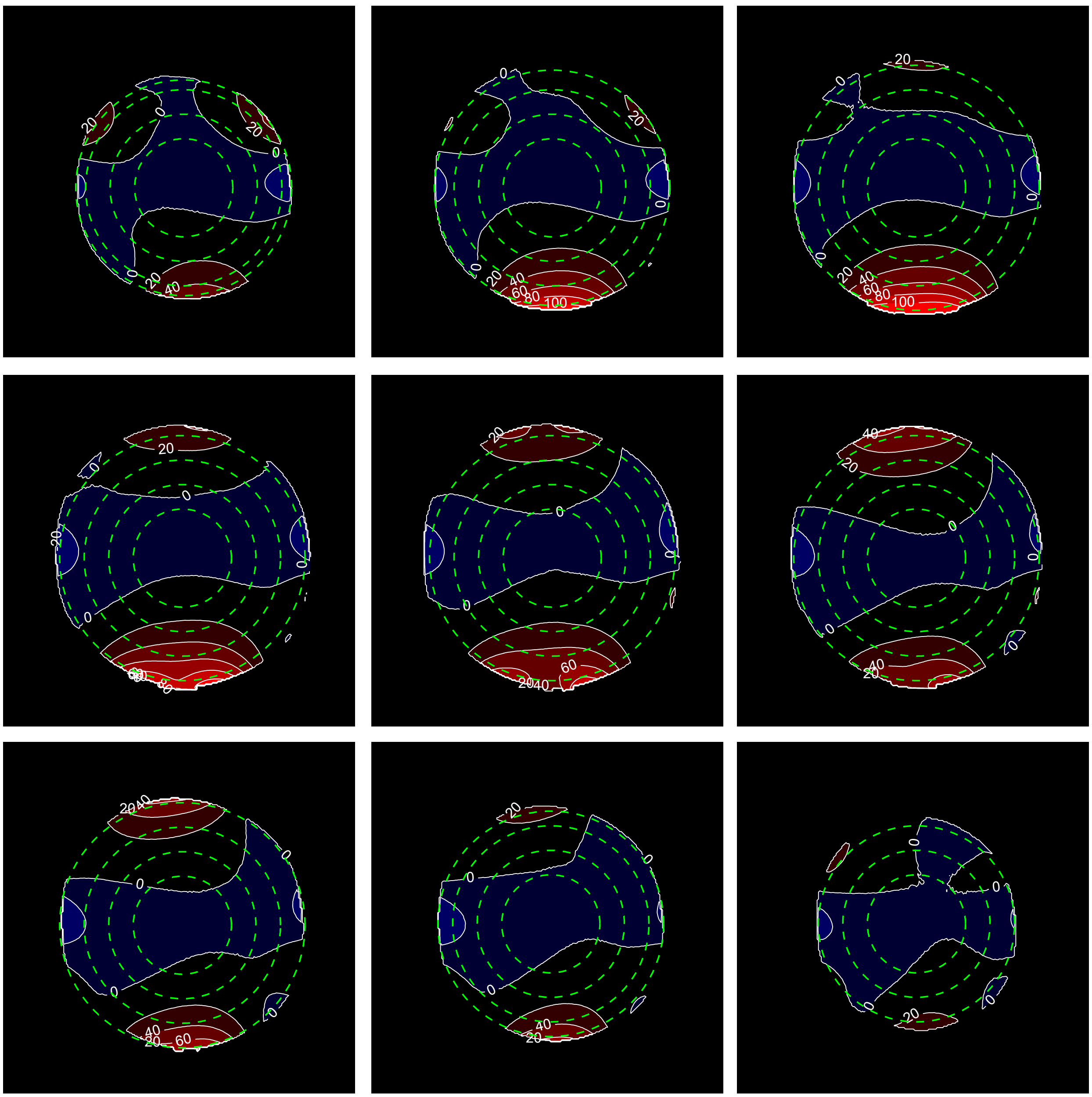
DIAMETER	MIN	MAX	RANGE	PPM	MEAN	STDEV
10	-6	18	24	1.6	2.0	5.4
15	-12	35	48	3.2	3.1	9.1
20	-22	60	83	5.6	4.9	14.5
25	-44	107	151	10.1	7.1	21.9

Appendix A: Magnet Homogeneity Field Maps
Toshiba Ultra 0.35T
Measured February 24, 2008









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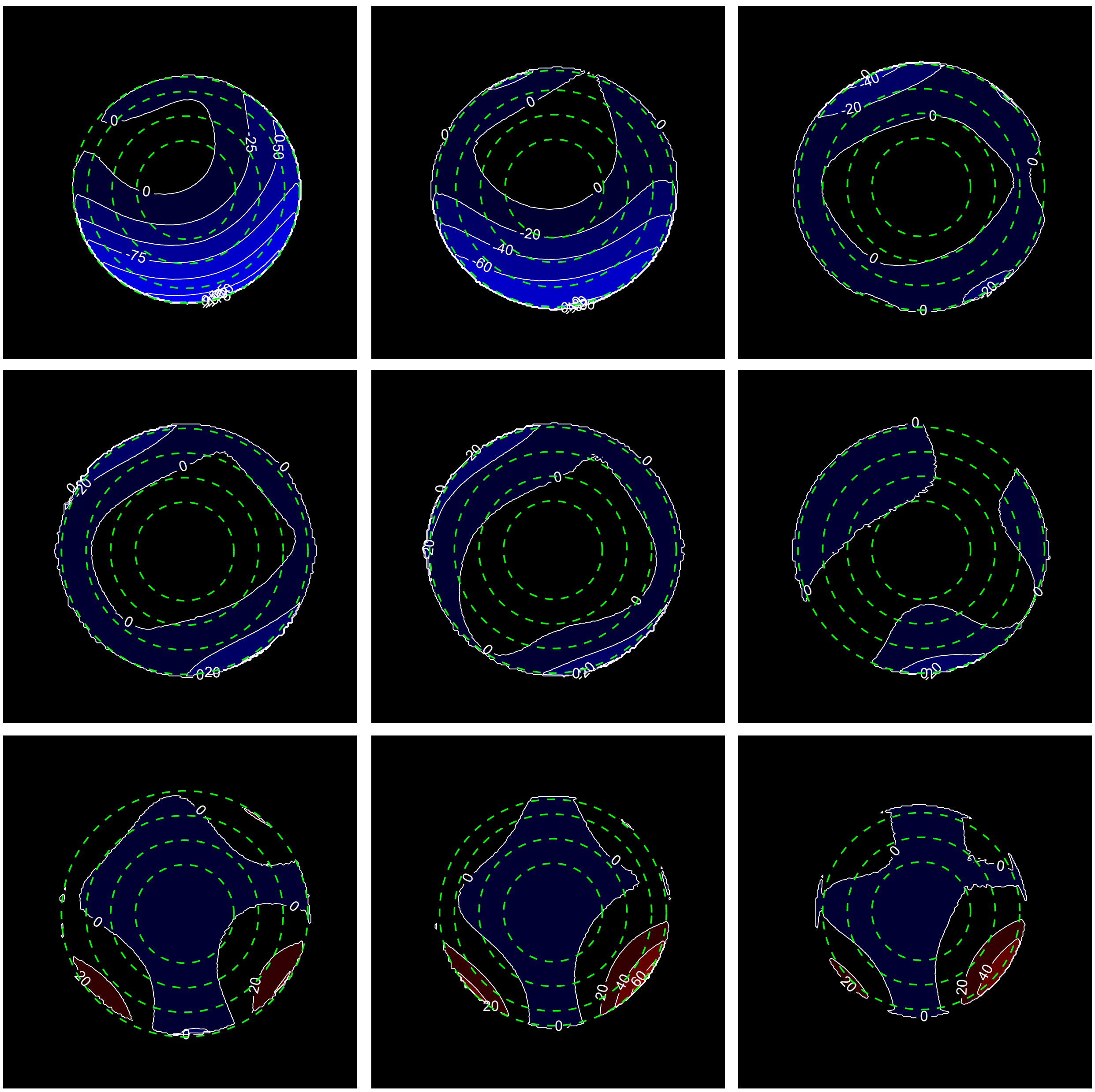
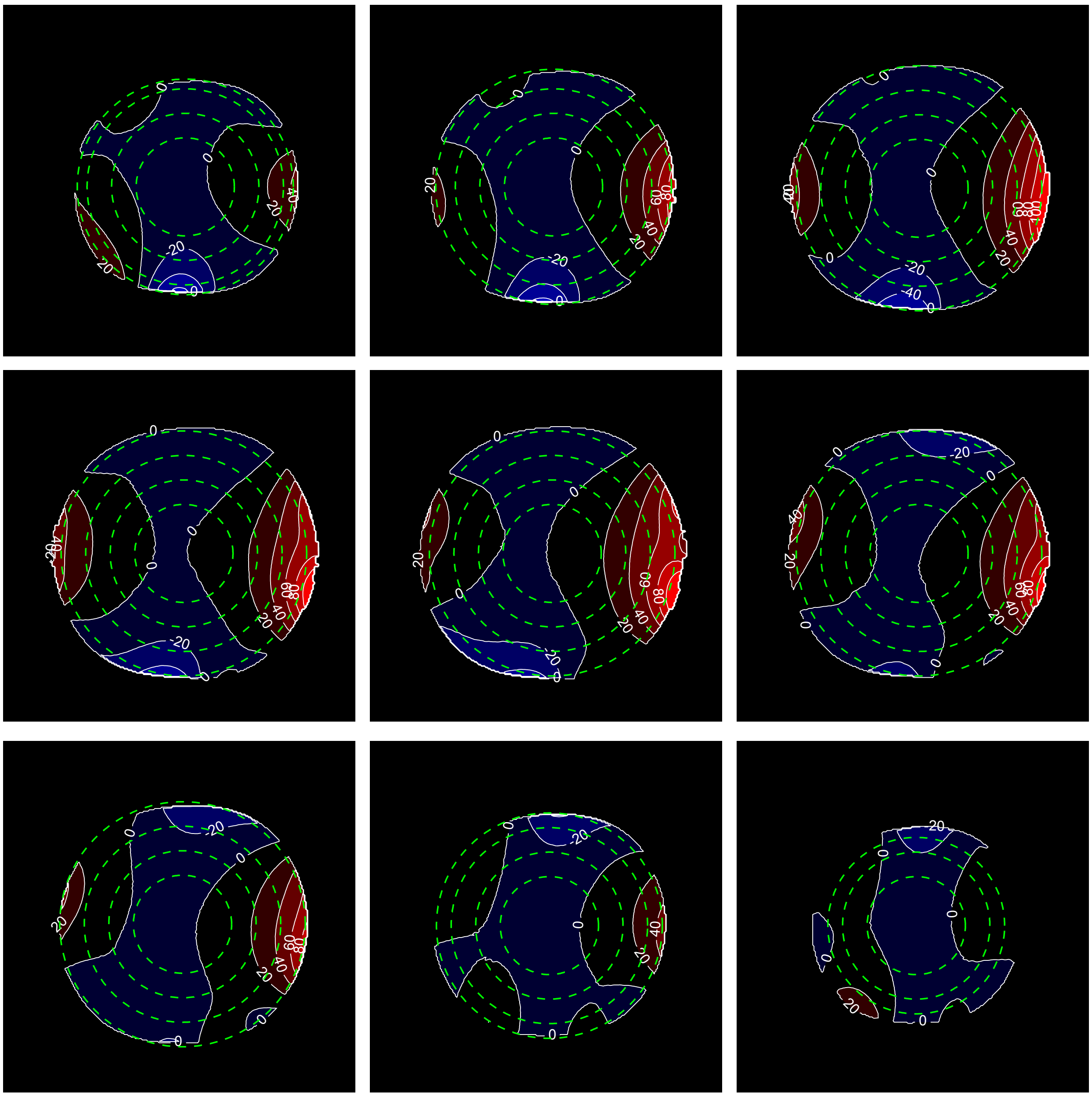
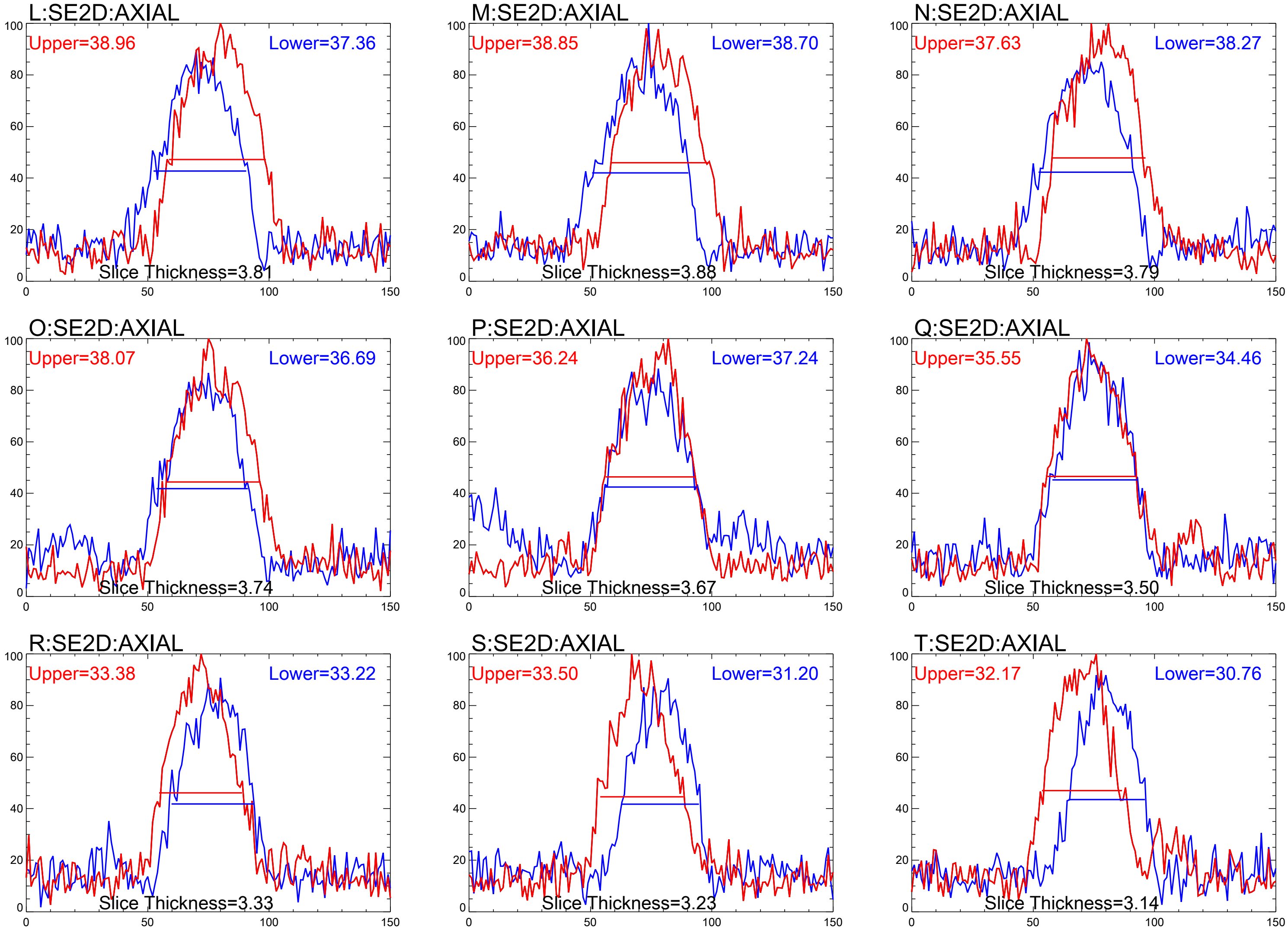
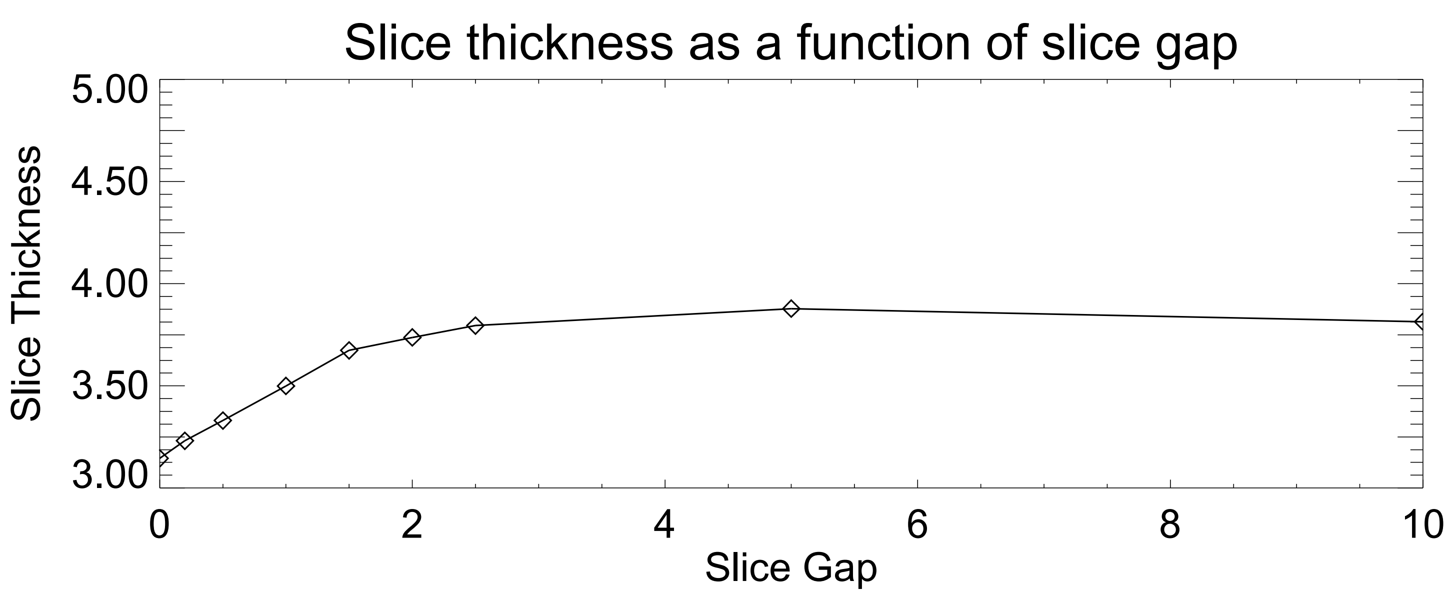




Appendix B: RF Slice Profiles and Crosstalk

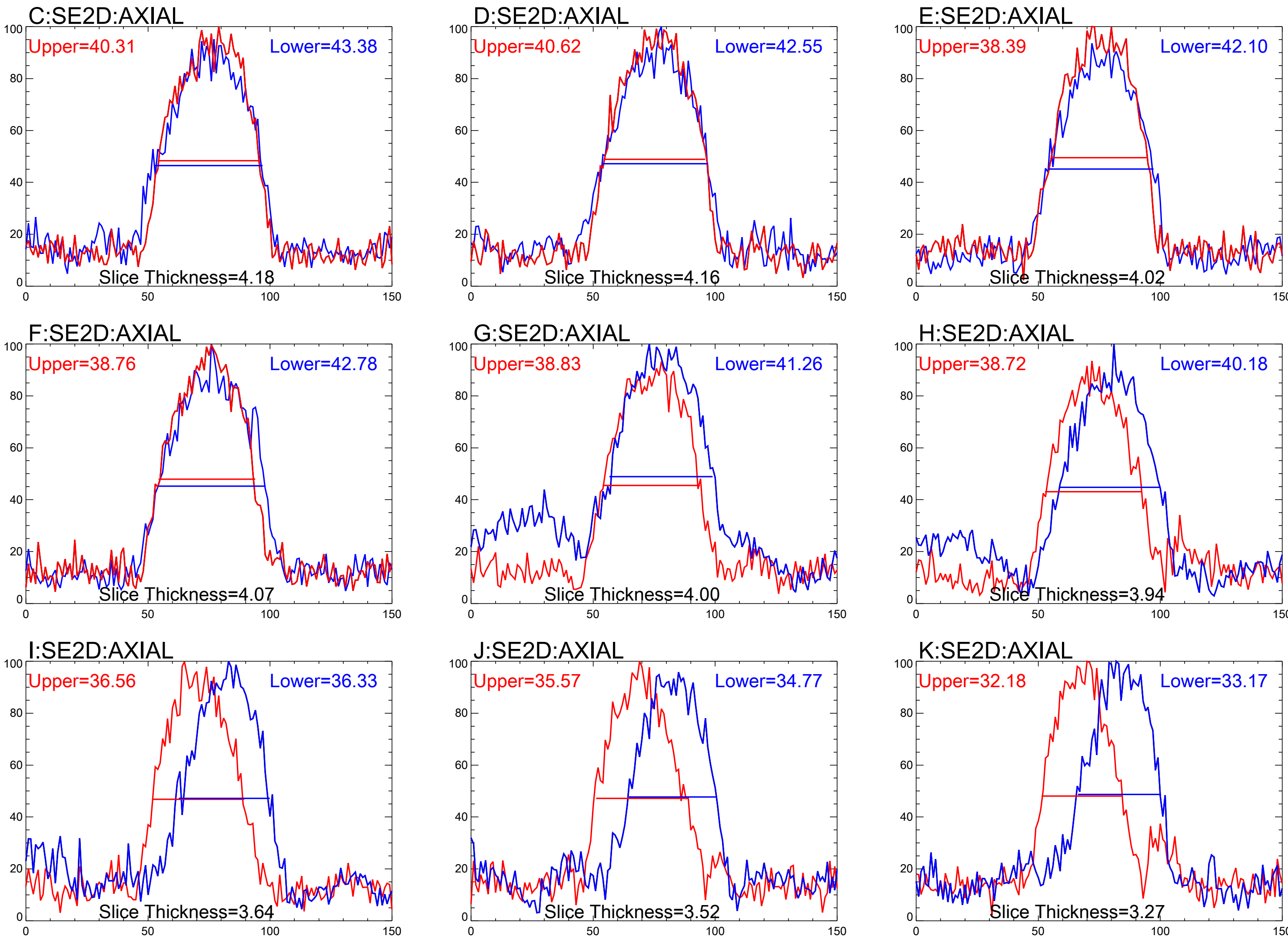
Spin Echo : ACR T1
TR/TE = 500/7
BW = ?KHz
nex = 1.0
Scan time: 2:09



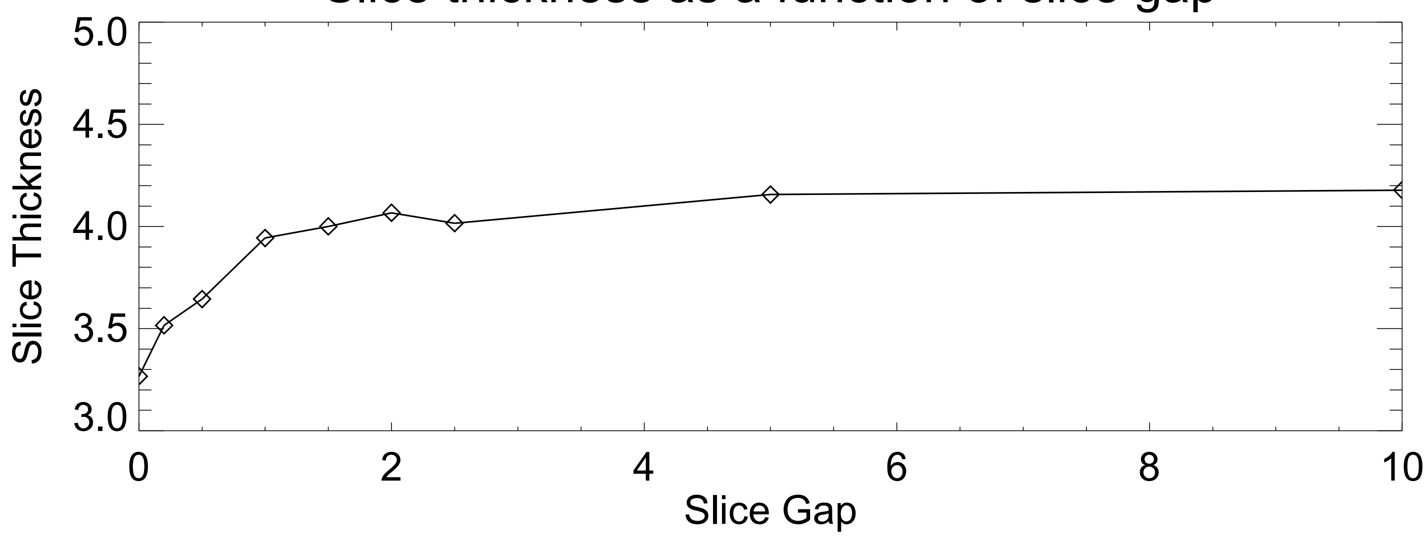


Appendix B: RF Slice Profiles and Crosstalk

Spin Echo : ACR T1
TR/TE = 500/9
BW = ?KHz
nex = 1.0
Scan time: 2:09

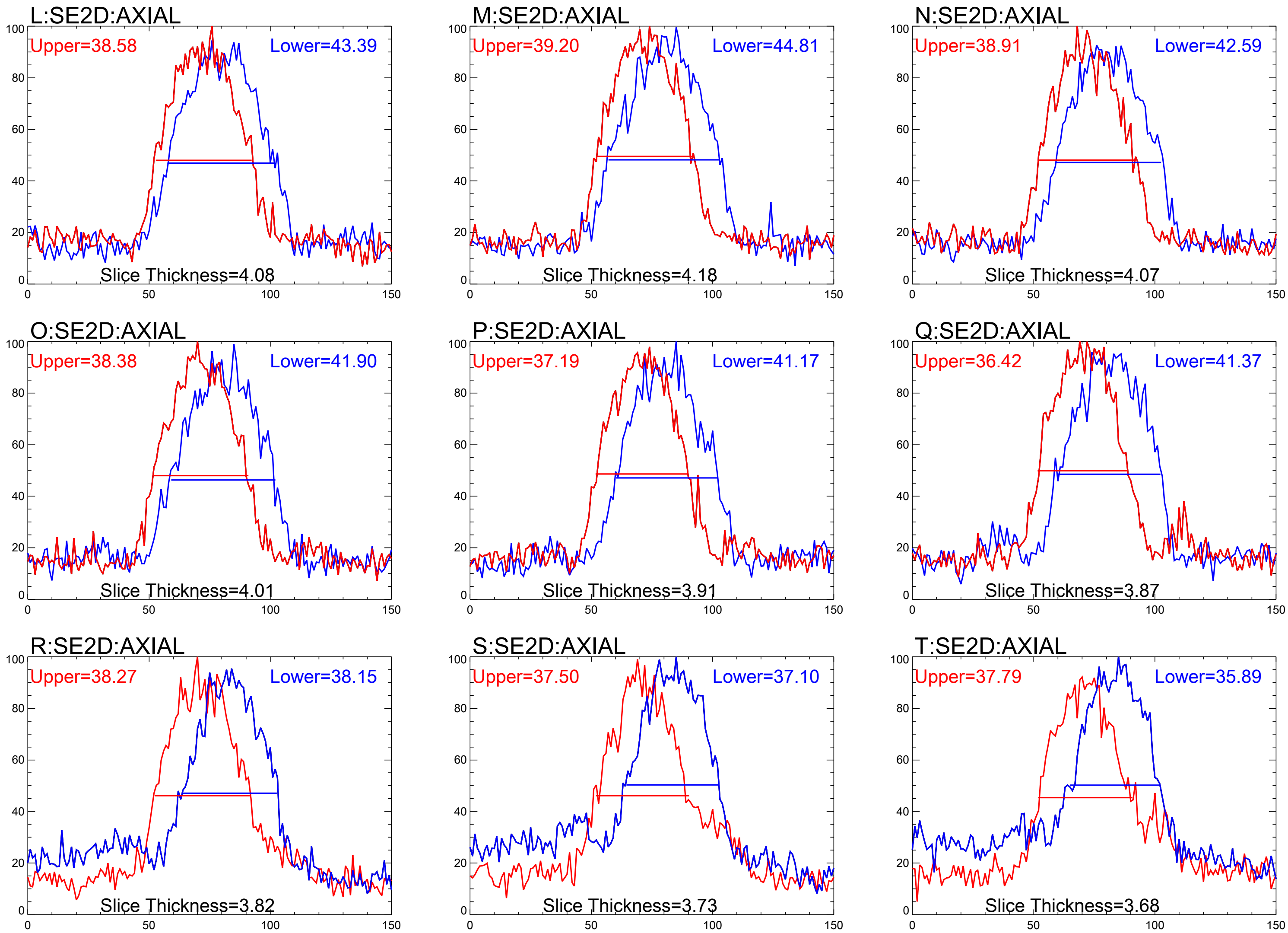


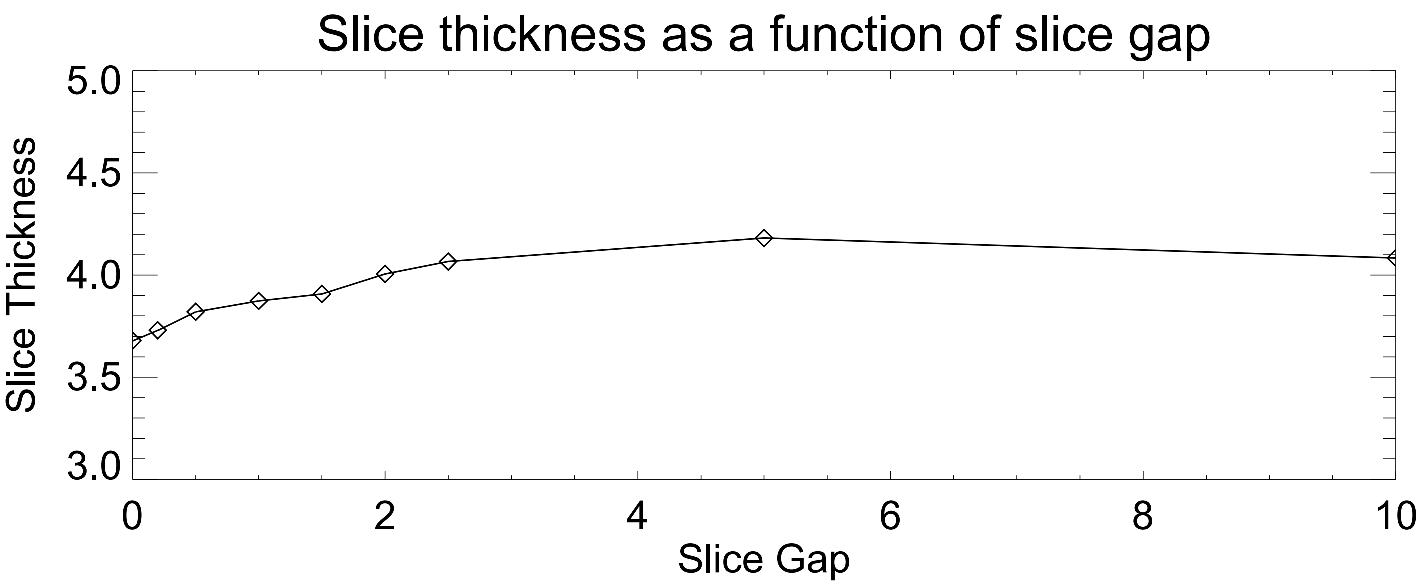
Slice thickness as a function of slice gap



Appendix B: RF Slice Profiles and Crosstalk

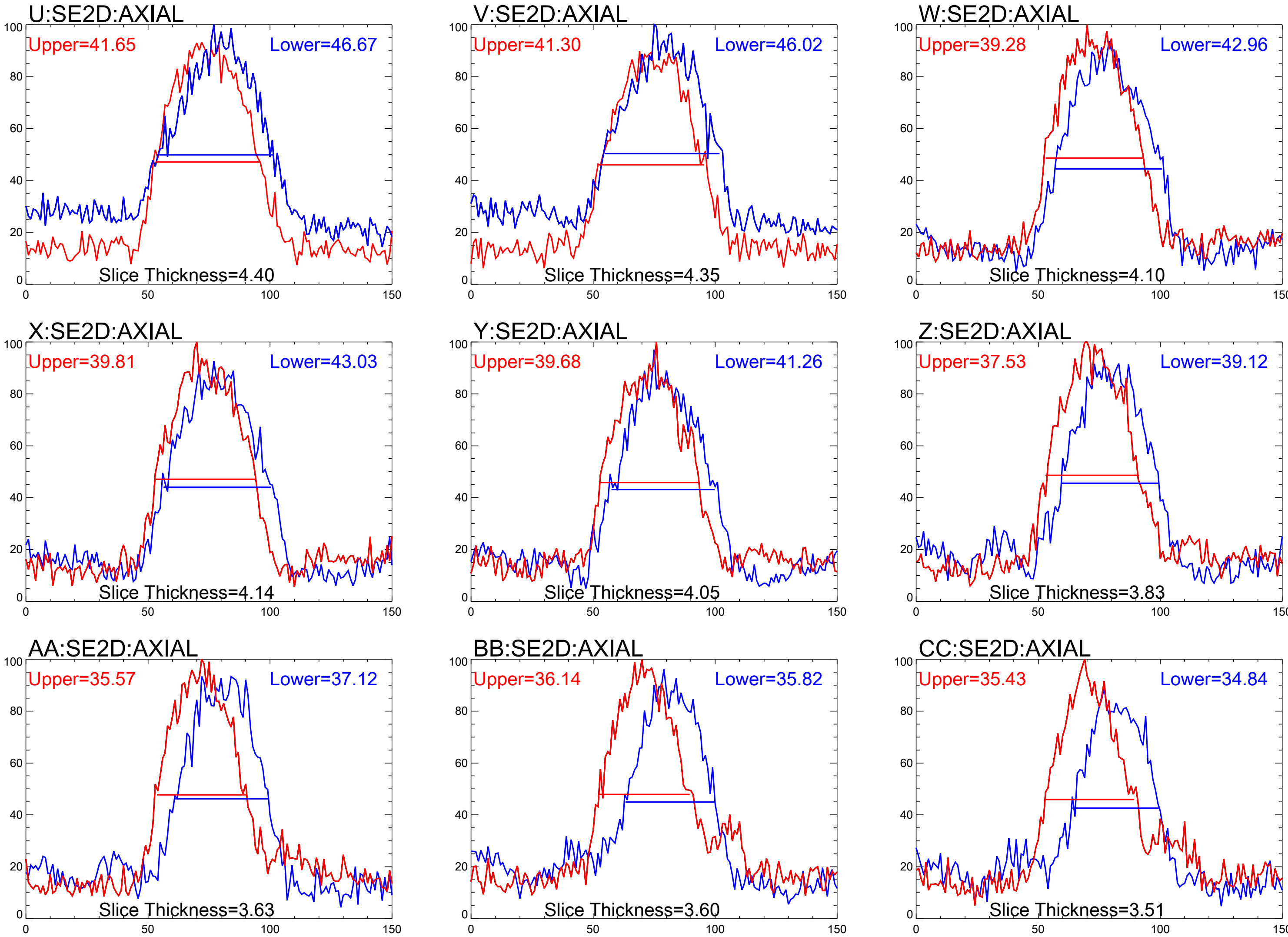
Spin Echo : ACR T1
TR/TE = 500/10
BW = ?KHz
nex = 1.0
Scan time: 2:09

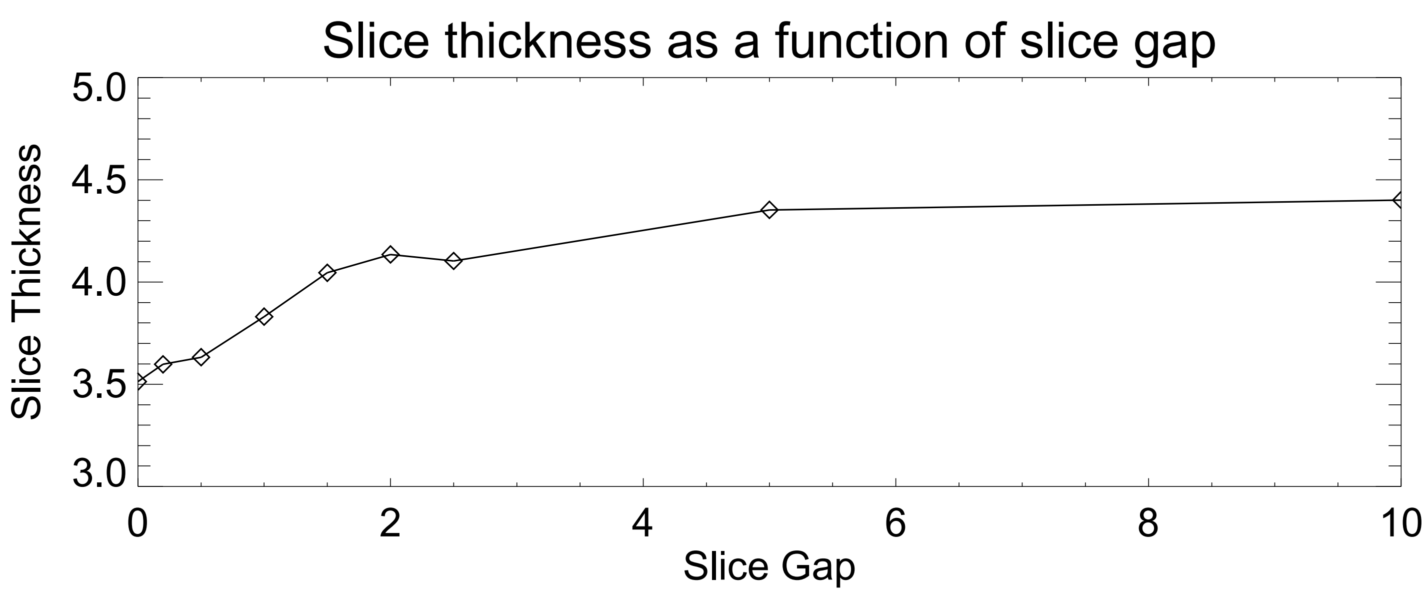




Appendix B: RF Slice Profiles and Crosstalk

Spin Echo : ACR T1
TR/TE = 500/12
BW = ?KHz
nex = 1.0
Scan time: 2:09





Toshiba Site **Ultra**

Coil Used: **Head Coil QD** Test Date: 2/27/2008

	Sagittal Locator	
1	Length of phantom, end to end (mn 148± 2)	146.2

= calculated field

		(SE 500/20)	(SE 2000/20)	(SE 2000/80)	(Site T1)	(Site T2)
	Slice Location #1	ACR T1	ACR PD	ACR T2	Site T1	Site T2
2	Resolution	1.0	0.9	0.9	0.9	0.9
3	(1.10, 1.00, 0.90 mm)	0.9	0.9	0.9	0.9	0.9
4	Slice Thickness Top	47.1	52.9	52.8	48.3	54.1
5	(fwhm in mm) Bottom	43.8	46.8	46.0	44.1	44.1
6	Calculated value 5.0±0.7	4.54	4.96	4.91	4.61	4.85
7	Wedge (mm) = + = -	2.8	2.8	2.7	2.8	3.2
8	Diameter (mm) (190±2)	190.1	190.9	190.3	190.4	190.6
9		191.3	190.8	190.9	191.0	190.6
	Slice Location #5					
10	Diameter (mm) (190±2)	191.5	192.2	191.4	191.7	192.1
11		190.6	190.3	190.3	190.4	189.9
12		188.4	188.7	188.5	188.5	192.1
13		191.4	191.8	191.4	191.4	189.9
	Slice Location #7					
14	Signal Big ROI	12679	12609	12580	12425	12846
15	(mean only) High	13782	13611	13644	13485	14157
16	Low	11372	12043	11810	11262	11193
17	Uniformity (>87.5%)	90.4%	93.9%	92.8%	91.0%	88.3%
18	Background Noise Top	320.0 ± 194	344 ± 198	512 ± 301	208 ± 157	260 ± 178
19	Bottom	327.0 ± 206	355 ± 210	532 ± 312	223 ± 164	276 ± 189
20	(mean ±std dev) Left	330.0 ± 200	350 ± 215	515 ± 298	221 ± 161	283 ± 189
21	Right	334.0 ± 200	348 ± 197	525 ± 304	227 ± 160	263 ± 168
22	Ghosting Ratio (<2.5%)	0.1%	0.0%	0.0%	0.1%	0.0%
23	SNR (no spec)	63	62	42	77	72
	Low Con Detectability					
24	Slice Location #8 1.4%	1	1	0	1	0
25	Slice Location #9 2.5%	3	3	1	5	1
26	Slice Location #10 3.6%	6	2	1	7	3
27	Slice Location #11 5.1%	8	5	5	9	7
28	Total # of Spokes (>=9)	18	11	7	22	11
	Slice Location #11					
29	Wedge (mm) = + = -	-3.6	-3.8	3.9	-3.6	-3.4
30	Slice Position Error	-6.4	-6.6	1.2	-6.4	-6.6

Toshiba Site Ultra

Sequence parameters Test Date: 2/27/2008

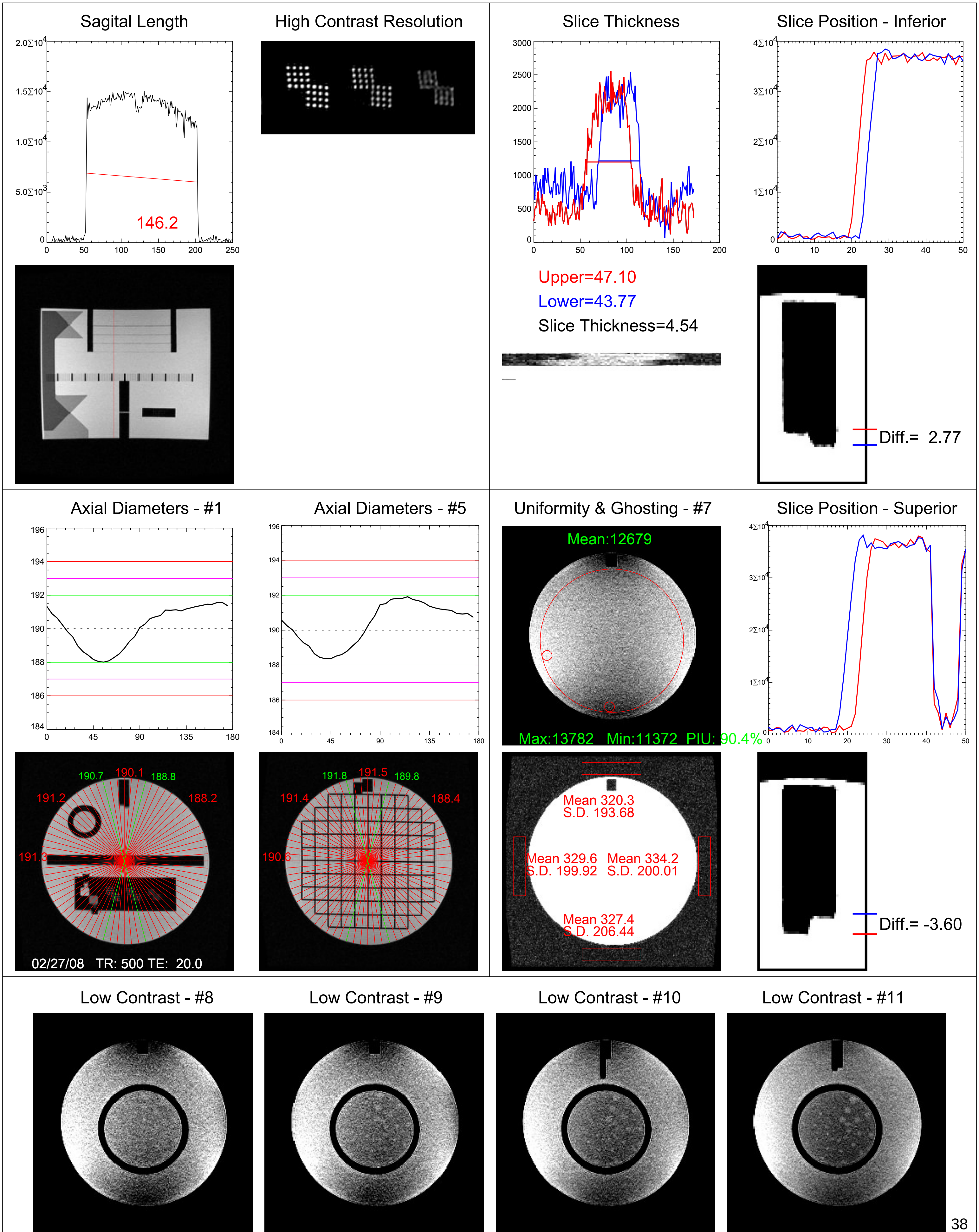
Coil Used: **Head Coil QD** Test ID 263

Study Description	Pulse Sequence (ETL)	TR (ms)	TE (ms)	FOV (cm)	Phase Sample Ratio	Number of Slices	Thick-ness (mm)	Slice Gap	NSA (Nex)	Freq Matrix	Phase Matrix	Band Width (kHz)	Scan Time (min:sec)
ACR T1	SE	500	20	25	1	11	5	5	1	256	256	6.94	2:09
ACR PD	Dual Echo SE	2000	20	25	1	11	5	5	1	256	256	6.94	8:32
ACR T2	Dual Echo SE	2000	80	25	1	11	5	5	1	256	256	6.94	8:32
Site T1	SE	500	15	24	2	11	5	5	1	256	256		4:18
Site T2	FSE(11)	4000	110	24	1	11	5	5	1	256	252		6:06

Magnet ID: 197 **Coil ID:** 1556 **TestID:** 263

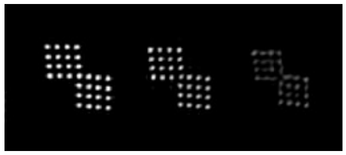
Appendix C: ACR Phantom Analysis

ACR T1

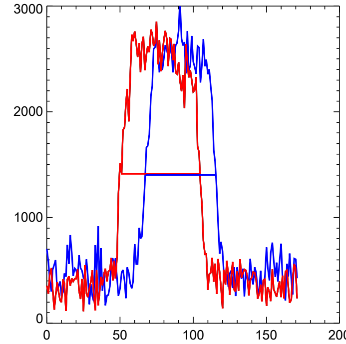


Appendix C: ACR Phantom Analysis

High Contrast Resolution



Slice Thickness

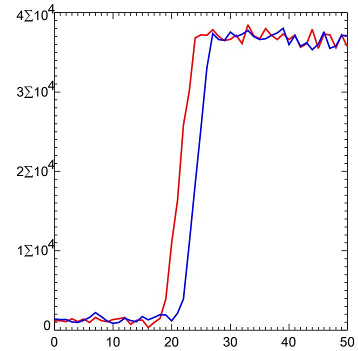


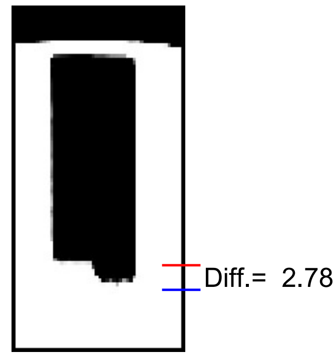
Upper=52.87

Lower=46.78

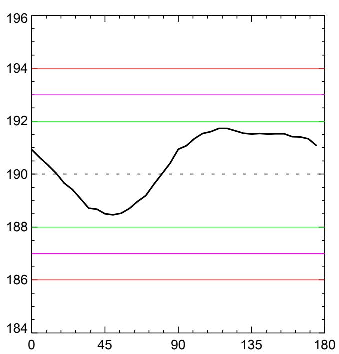
Slice Thickness=4.96

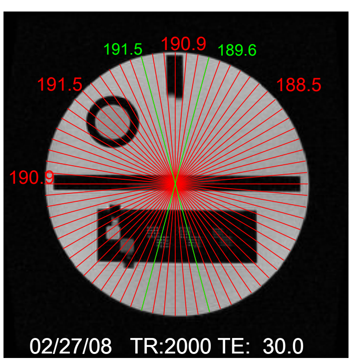
Slice Position - Inferior



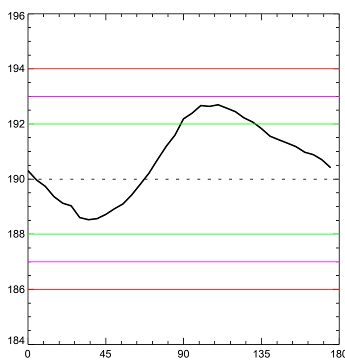


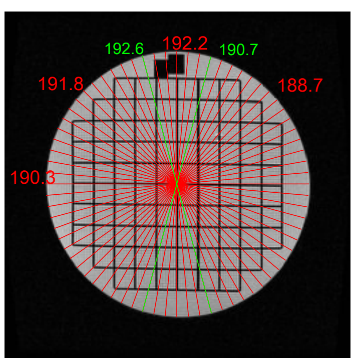
Axial Diameters - #1



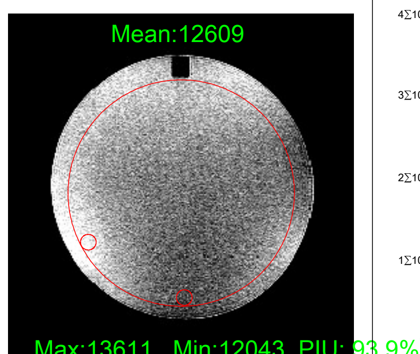


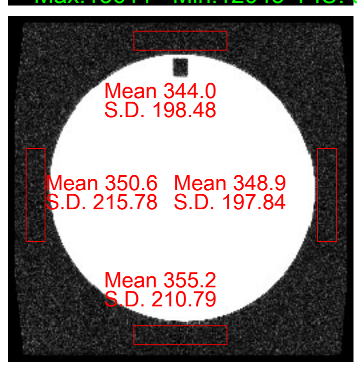
Axial Diameters - #5



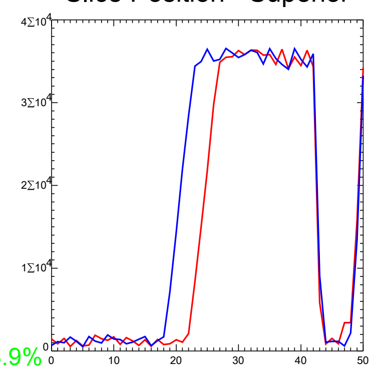


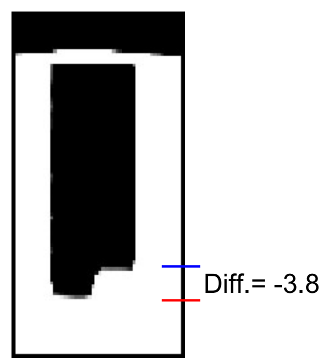
Uniformity & Ghosting - #7



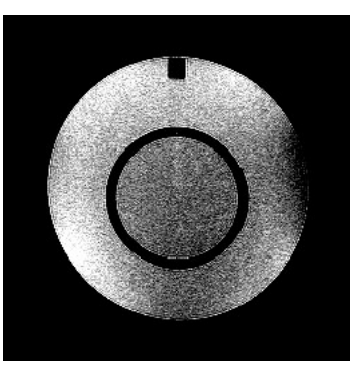


Slice Position - Superior

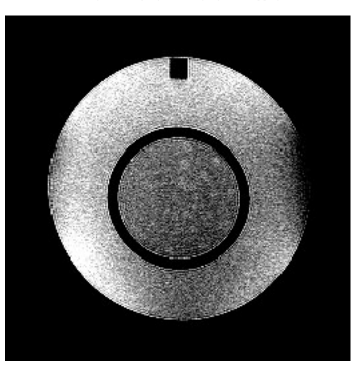




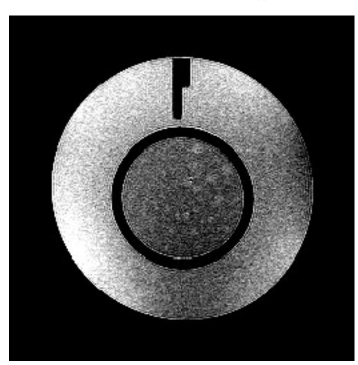
Low Contrast - #8



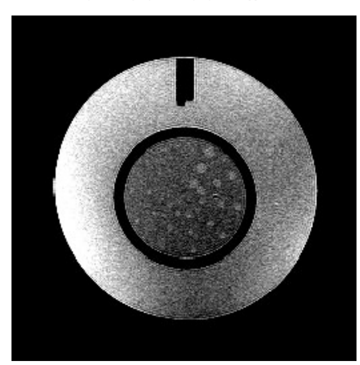
Low Contrast - #9



Low Contrast - #10



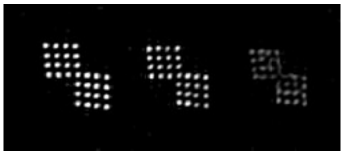
Low Contrast - #11



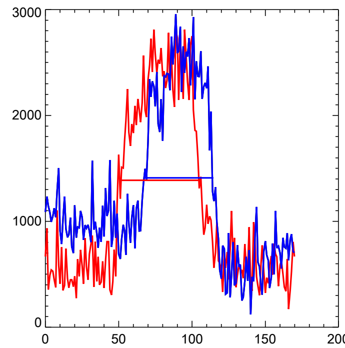
Appendix C: ACR Phantom Analysis

ACR T2

High Contrast Resolution



Slice Thickness

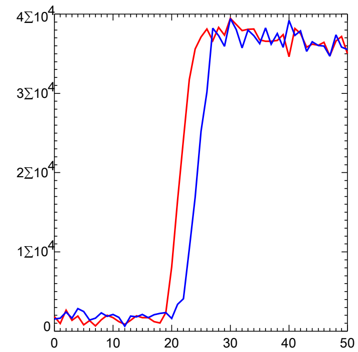


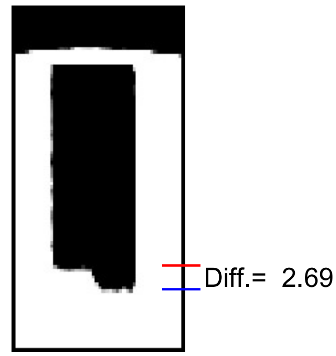
Upper=52.78

Lower=45.98

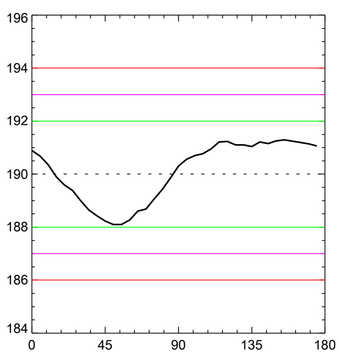
Slice Thickness=4.91

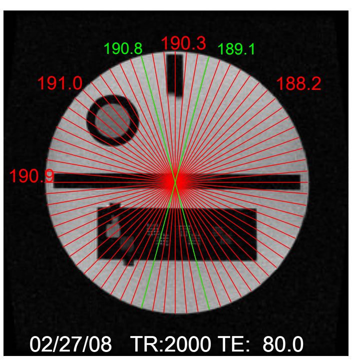
Slice Position - Inferior



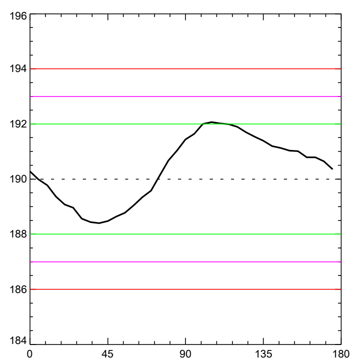


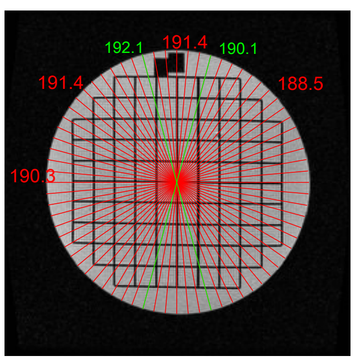
Axial Diameters - #1



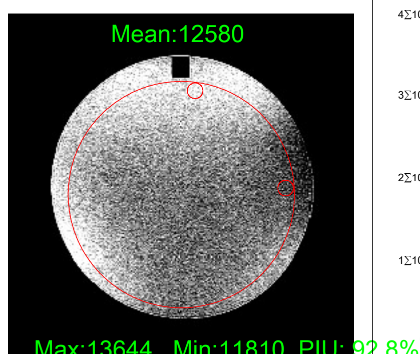


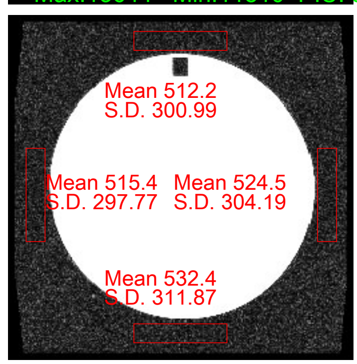
Axial Diameters - #5



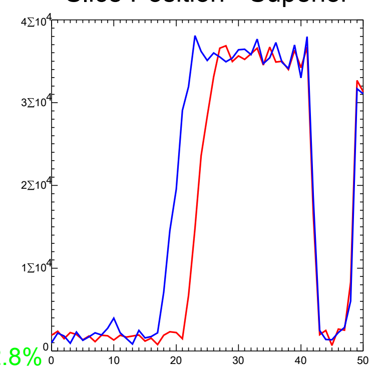


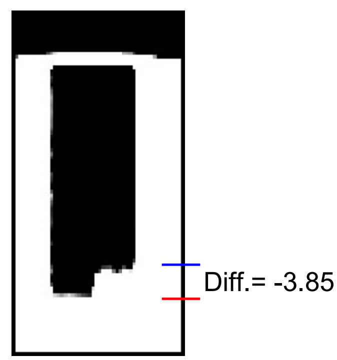
Uniformity & Ghosting - #7



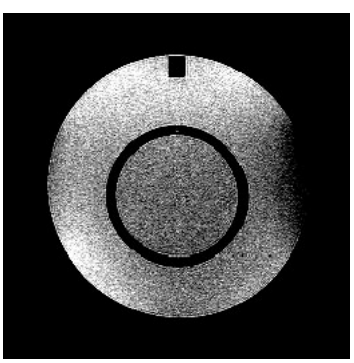


Slice Position - Superior

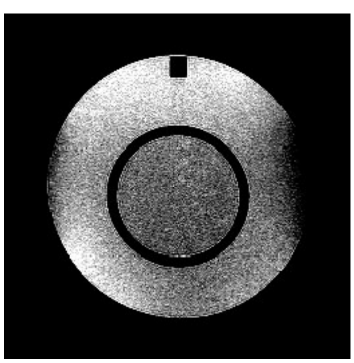




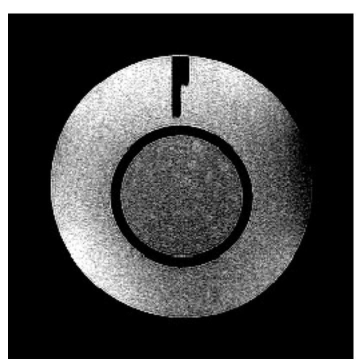
Low Contrast - #8



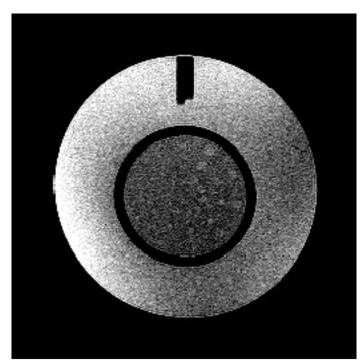
Low Contrast - #9



Low Contrast - #10



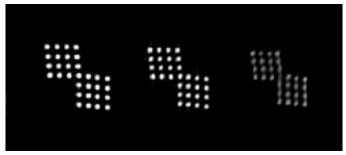
Low Contrast - #11



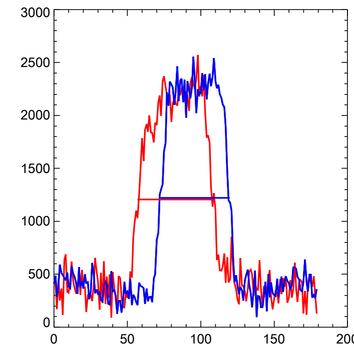
Appendix C: ACR Phantom Analysis

Site T1

High Contrast Resolution



Slice Thickness

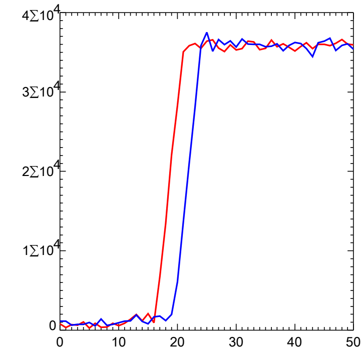


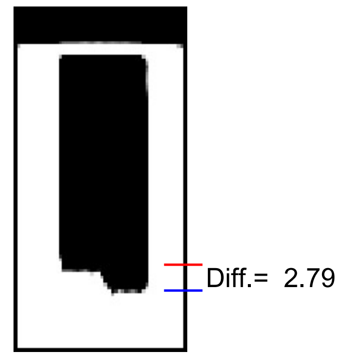
Upper=48.32

Lower=44.07

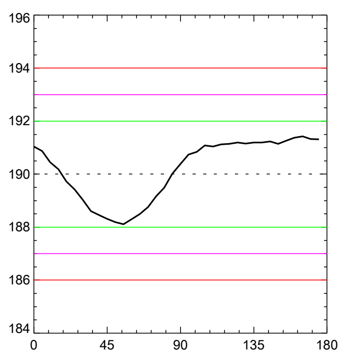
Slice Thickness=4.61

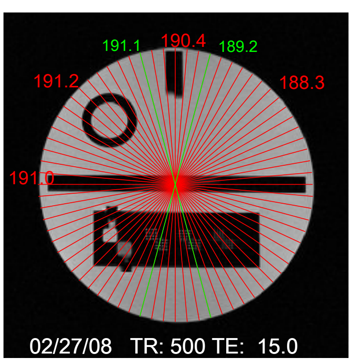
Slice Position - Inferior



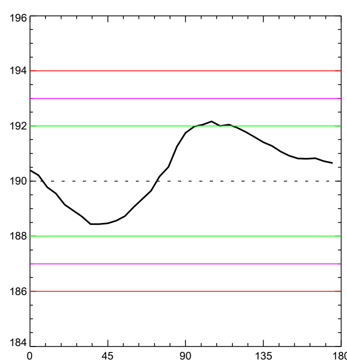


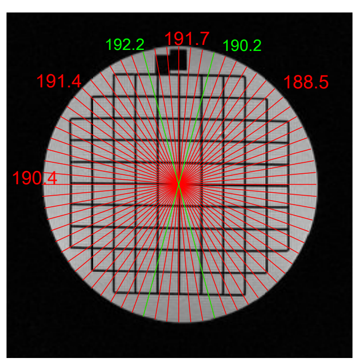
Axial Diameters - #1



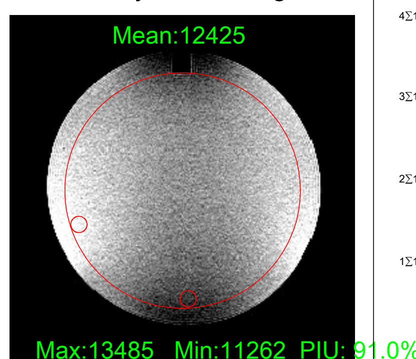


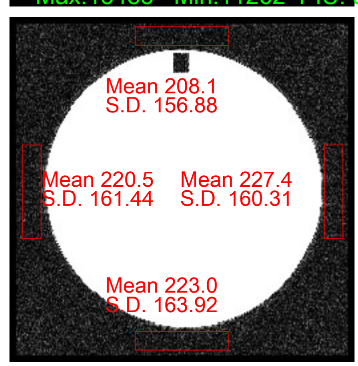
Axial Diameters - #5



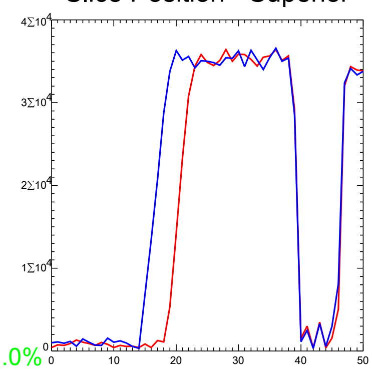


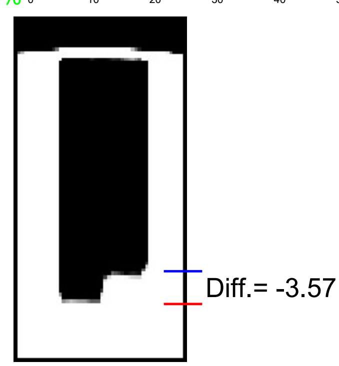
Uniformity & Ghosting - #7



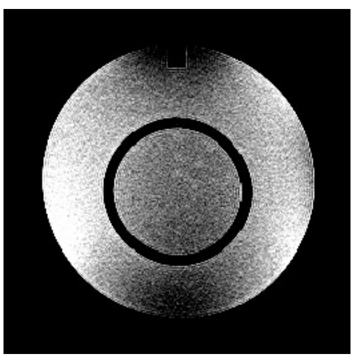


Slice Position - Superior

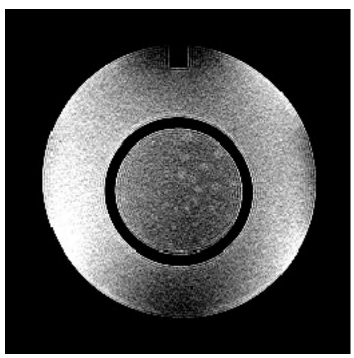




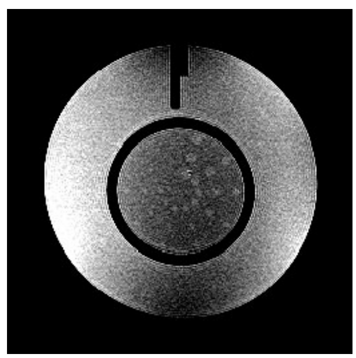
Low Contrast - #8



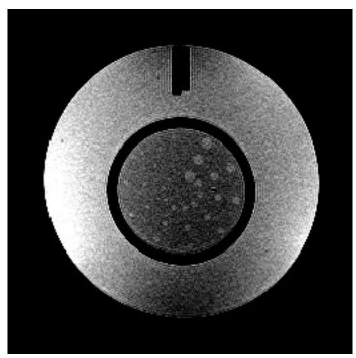
Low Contrast - #9



Low Contrast - #10



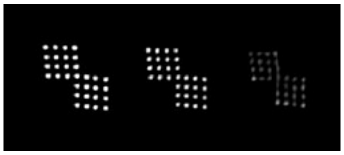
Low Contrast - #11



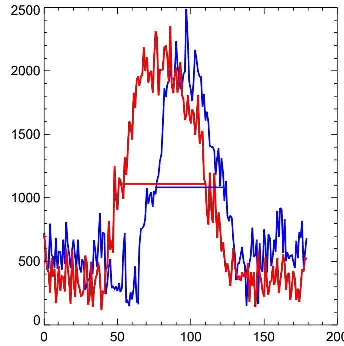
Appendix C: ACR Phantom Analysis

Site T2

High Contrast Resolution



Slice Thickness

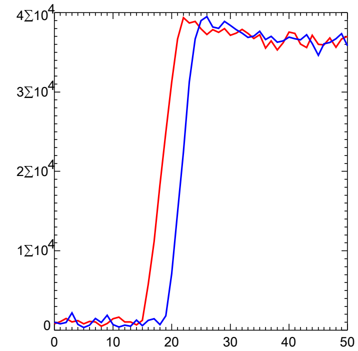


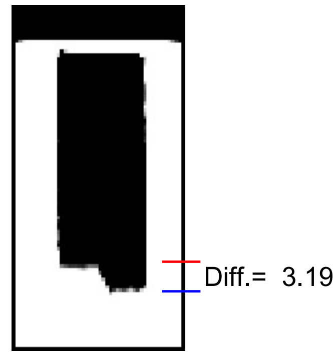
Upper=54.07

Lower=44.05

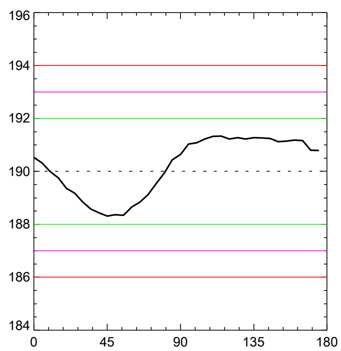
Slice Thickness=4.85

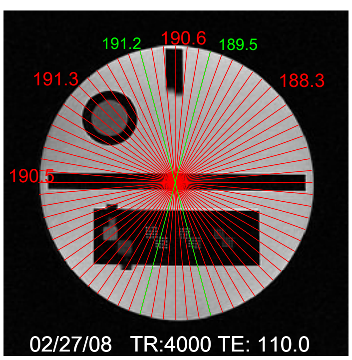
Slice Position - Inferior



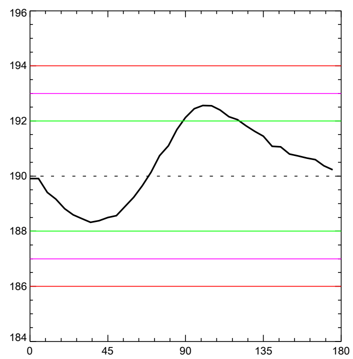


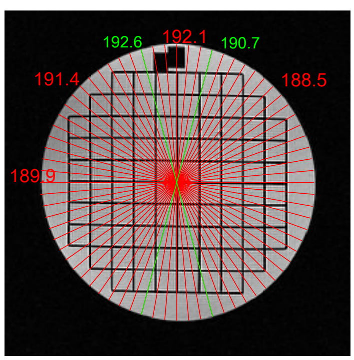
Axial Diameters - #1



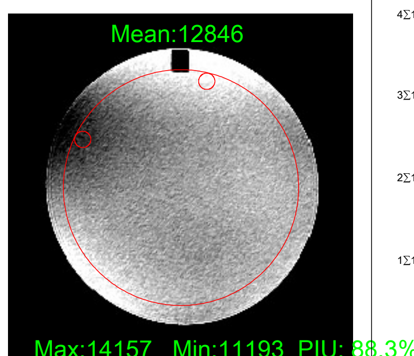


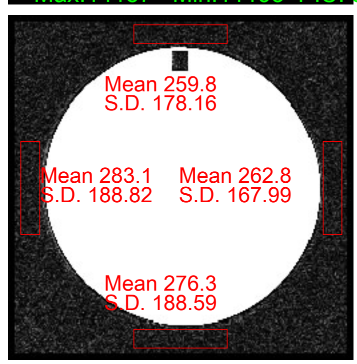
Axial Diameters - #5



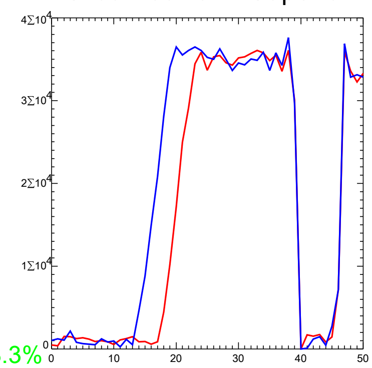


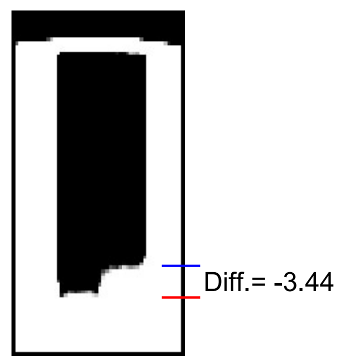
Uniformity & Ghosting - #7



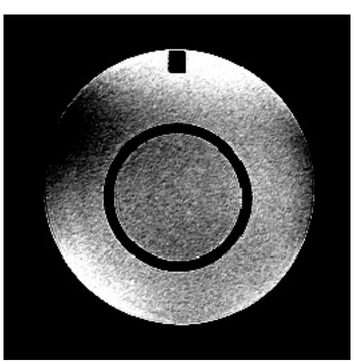


Slice Position - Superior

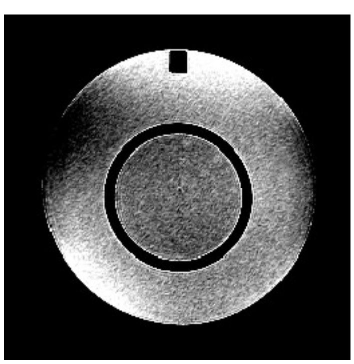




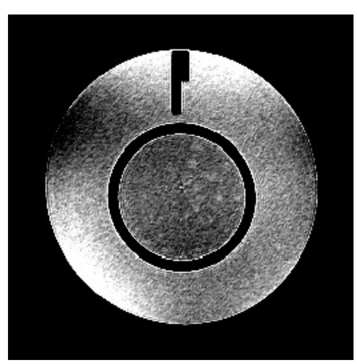
Low Contrast - #8



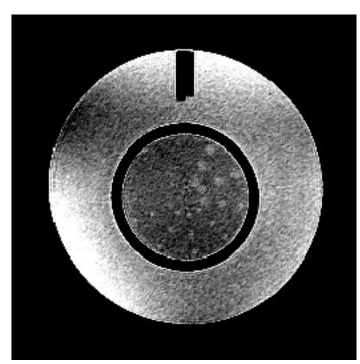
Low Contrast - #9



Low Contrast - #10



Low Contrast - #11



Appendix D:
Explanation of RF Coil Testing Report

Introduction

The primary goal of RF coil testing is to establish some sort of base line for tracking coil performance over time. The most common measure is the Signal to Noise Ratio or SNR. In addition, we can look at overall signal uniformity, ghosting level (or better - lack of ghosting) and in the case of phased array coils we look at the SNR of each and every channel and at symmetry between channels. Unfortunately, there is no single best method for measuring SNR. Below I explain the different methods used and the rationale for each.

SNR

One needs to measure the signal in the phantom (either mean or peak or both) and then divide that by the background noise. Measuring the signal is fairly straightforward, the noise can be more problematic. The simplest method is to measure the standard deviation (SD) in the background 'air'. However, MRI images are the magnitude of complex data. The noise in the underlying complex data is Gaussian but it follows a Rician distribution when the magnitude is used. The true noise can be estimated by multiplying the measured SD by 1.526.

During the reconstruction process, most manufacturers perform various additional operations on the images, This could include geometric distortion correction, low pass filtering of the k-space data resulting in low signal at the edge of the images, RF coil intensity correction (PURE, CLEAR, SCIC, SPEEDER, etc), and other processing during the combination of phased array data and parallel imaging techniques. All of these methods distort the background noise making it impossible to obtain an accurate (and reproducible) estimate of the image noise in the air region. The alternative is to use a method which I shall refer to as the NEMA (National Electrical Manufacturers Association) method. The signal in the phantom area is a sum of the proton signal and noise. Once the signal to noise ratio exceeds 5:1, the noise in the magnitude image is effectively Gaussian. To eliminate the proton signal, you acquire an image twice and subtract them. The measured SD in the phantom region should now be the true SD times the square root of 2. When determining the SNR using the NEMA method, calculate the mean signal of the average of the two source images then divide by .7071 x the SD measured in the same area as the mean signal.

Unfortunately, this doesn't always work. It is absolutely imperative that the RF channel scalings, both transmit and receive, be identical with both scans. Any ghosting in the system is not likely to repeat exactly for both scans and will cause a much higher SD. Finally, the phantom needs to be resting in place prior to the scan long enough for motion of the fluid to have died down. Depending on the size and shape of the phantom, this could take any where from 5 to 20 minutes.

One of the most common causes of ghosting is vibration from the helium cold-head. The best way to eliminate this artifact is to turn off the cold head, which will increase helium consumption. Because this vibration is periodic, the ghosting is usually of an N over 2 (N/2) nature. The affect inside the signal region of the phantom can be minimized by using a FOV that is twice the diameter of the phantom (measured in the PE direction.) If the noise is to be measured in the air, then be sure to NOT make measurements to either side of the phantom in the PE direction.

Scan parameters also significantly affect measured SNR. For most of the testing performed in this document I used a simple Spin Echo with a TR of 300, a TE of 20 and a slice thickness of 3mm and a receiver BW of 31.2 KHz (a 1 pixel fat/water chemical shift). The FOV was varied depending on the size of the coil and the phantom used. All of the parameters used for each test can be found on each page immediately below the coil description.

Report Layout
Each page of this report lists the data from a single test. The top third of the page describes the coil and phantom information, followed by the scan parameters used. The middle third contains the numbers measured and calculated results. This section will contain one table if the coil being tested is a single channel coil (i.e. quadrature or surface coils) and two tables if it is a multi-channel phased array coil. The entries in the table will be described further below. The bottom section contains a few lines of comments (if necessary), a picture of the coil with the phantom as used for the testing and one or more of the images that were used for the measurements.

There is usually one image for each composite image measurement and one image for each separate channel measurement. Each image shows the ROI (red line) where the mean signal was measured and two smaller ROIs (green lines) where the signal minimum and maximum was found. In the top left corner of each image is the mean signal in the large ROI. The bottom left corner contains the large ROI's area (in mm^2). The top right corner contains two numbers a mean and a standard deviation. If the NEMA method was used, then the top right corner will list the mean and SD of the large ROI (labeled ROI M and ROIsd) applied to the subtraction image. If the noise was measured in the background air the the numbers are labeled Air M and AirSD.

Data Tables
The meaning of most of the entries in the data table are should be self evident with a few exceptions. The first column in each table is labeled "Label". In the composite analysis, this field may be empty or contain some sort of abbreviation to identify some aspect of the testing. Some possibilities are the letter N for NEMA, A for Air, L for Left, R for Right, C for CLEAR, NoC for No CLEAR. In the Uncombined Image table, the label usually contains the channel number or similar descriptor. The column labeled "Noise Type" will be either Air or NEMA. Both tables contain a column for Mean SNR and Max SNR which are the Mean or Max signal divided by the SD of the noise scaled by either 1.526 (Air) or 0.7071 (NEMA).

Composite Image Table: The final two columns in this table are "Normalized" and "Uniformity". It can be rather difficult to compare the performance of different coils particularly if different scan parameters are used. (Of course, it's even more difficult from one scanner to another.) I have standardized most of my testing to use a spin echo with a TR/TE of 300/20msec and a thickness of 3 mm. The FOV changes to depending on the size of the phantom used although I try to use a FOV that is at least twice the diameter of the phantom as measured in the PE direction. For one reason or another, a change may be made in the scan parameters (either accidentally or intentionally such as turning on No Phase Wrap to eliminate aliasing, etc.). In order to make it easier to compare SNR values I calculate a "Normalized" SNR value. This value is theoretically what the SNR would be if a FOV of 30cm, 256x256 matrix, 1 average, receiver BW of 15.6 KHz and slice thickness of 3mm had been used. Obviously, the final number is affected by the T1/T2 values of the phantoms used as well as details of the coil and magnet field strength but it can be useful in certain situations.

The "Uniformity" value is defined by the ACR as 1 - (max-min)/(max+min). This is most important when looking at volume coils or for evaluating the effectiveness of surface coil intensity correction algorithms (such as PURE, CLEAR, SCIC or SPEEDER).

Uncombined Image Table: This table has two columns labeled "% of Mean" and "% of Max". When analyzing multi-channel coils it is important to understand the relationship between the different channels, the inherent symmetry that usually exists between channels. In a 8 channel head or 4 channel torso phased array coil, all of the channels are usually have about the same SNR. These two columns list how the SNR (either Mean or Max) of each channel compares to the SNR of the channel with the maximum value.