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A Complete MRI Physics Services Provider

Education, ACR Accreditation, Quality Assurance,
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RF Coil Testing - The Simply Physics way

As part of the 2019 AAPM meeting I was invited to give a talk on RF Coil testing. Like most speakers, I will be uploading my PowerPoint slides (probably at the tail end of this document). However, there are a LOT of slides… with lots of pictures and not a lot of words. They are meant to support my speaking and not necessarily stand on their own. Therefore, I am beginning with this textual description of my basic philosophy/approach to RF coil testing. Read this and then start in on the slides.

Qualifications

Just so that whoever reads this understands my background from which I have based the opinions expressed in this document:

1) I started my Ph.D work in MRI in 1985 (USC - Surface Coil Intensity Correction of Endo-Rectal Prostate Images)
2) Post graduation I developed imaging sequences for Elscint for one year and then headed Picker's Cardiac MRI R&D program for roughly 5 years.
3) I was on the radiology faculty at the University of Maryland Med School for 10 years.
4) I wrote the introductory textbook "All You Really Need to Know About MRI Physics".
5) I have been providing MRI QA services since 2001.
6) I was (and am) on the ACR MRI Physics Subcommittee for many years and was active in writing the ACR's MRI Quality Control manual in which I made major contributions to the RF coil testing and Magnet homogeneity testing sections.
7) As of June, 2019 I have conducted over 1500 annual performance reviews or acceptance tests including systems from every major MRI vendor.
8) I have performed over 35,000 RF coil tests on 5800 separate RF coils.

Basic Assumptions or Testing Principals

Over the 19 years that I have been testing scanners I have identified several important principals regarding the best design of RF coil and magnet homogeneity testing sequences. I have written several white papers and one RSNA poster (all of which are available upon request) that go into more details regarding these principals but I shall summarize the conclusions here.

RF Coil Testing

1) The single most important requirement for good SNR measuring is REPRODUCIBILITY. In particular:
   a) Reproducibly positioning the phantom in the coil and the combination in the magnet.
   b) Reproducibly choosing the imaging slice(s) location.
   c) Reproducibly measuring the signal mean in the phantom (drawing and positioning the ROI).
   d) Reproducibly measuring the background noise.
2) When measuring the Signal to Noise Ratio (SNR) it is easy to measure the signal, the values are typically large in amplitude and it does NOT take a large number of pixels to obtain a reasonable estimate of the mean.
3) Measuring noise is the more challenging task. Because it is typically a small number in the denominator of the SNR, small errors in the estimate of the noise can have a large affect on the SNR. Problems associated with noise measurements include:
   a) Spatially varying (usually due to geometric distortion correction and/or adaptive combination of channel data.
   b) Ghosting and/or wrap around in PE direction
   c) RF noise lines
   d) Limited # of pixels available to make the measurements
   e) All MR images are integer. When the background noise has a low amplitude the noise pixels are often truncated (or rounded) to a limited number of values, i.e. 0, 1 & 2. This makes it very difficult to get a good estimate of variance of the Rayleigh distribution.
4) In addition to the above consider this. A typical 256x256 image has 64K pixels. At the very least I want no more than half of those pixels used for measuring the signal mean, more typically only 1/3rd to 1/5th thereby leaving potentially 1/2 to 4/5th of the pixels available for measuring the noise. Keep in mind that not all of the noise pixels may be available for measuring due to ghosting or other artifacts.
5) Keeping the above in mind, I make the following choices when designing a test imaging protocol:
   a) Choose a FOV that is roughly twice the diameter of the phantom in the phase encode (PE) direction thereby minimizing the chance of ghosting wrapping around into the phantom. Additionally, if using a spherical phantom this results in a 4:1 ratio of noise pixels to signal pixels. With a square phantom it is a 3:1 ratio.
   b) Choose a thin slice thickness, often the thinnest slice that the system is capable of obtaining, somewhere between 1mm and 3mm. This increases the background noise level. (Yes, the measured SNR is low, but it is REPRODUCIBLE!)
   c) Similarly, choose a moderately high receiver BW. For 0.7T systems and higher I have settled on 244 Hz/pixel which corresponds to 31.2 KHz on GE systems or 62 KHz on most other systems.
   d) Choose a moderately short TR. I have settled on 200 msec. This results in shorter scan times and lower SNR (again, increasing the relative background noise.)
   e) I use a 256 x 256 matrix. Yes, 256 x 128 is faster but it would reduce the background noise by 40% when we want to increase the noise. It would also result in the acquisition of asymmetric pixels which I am never a fan of.
   f) Whenever possible, I turn off ALL post-processing filters especially Geometric Distortion correction which results in the the background noise becoming spatially variant.

g) When testing phased array coils I choose vector combination (square root of the sum of the squares) instead of adaptive combination.
h) I run every sequence twice. This allows the option of using the NEMA subtraction method and also helps to identify intermittent behavior.

6) When analyzing the images my automated analysis software does the following:
a) It uses thresholding to identify all the edges of the phantom defining an ROI that includes ALL of the phantom and then shrinks the ROI by 4 pixels all around to help avoid edge artifacts. This is an EXTREMELY reproducible method of measuring the signal mean since it does not depend on positioning a small ROI in a non-uniform signal phantom.
b) It starts with the original thresholded ROI of the phantom and then expands it by 5 pixels to define an exclusion region and then uses ALL of the rest of the pixels in the image to determine the noise region. The software then analyzes the noise to exclude pixels that are most likely affected by ghosting or roll-off filtering at the edge of the image or other types of artifacts.
c) The underlying sigma of the background noise is estimated from the Std Dev of the noise, from the Mean of the noise and from the Std Deviation of the pixels used for calculating the signal mean after subtracting the two repeats. (NEMA method). The 'goodness' of the estimate can be evaluated by looking at the ratio of the Mean of the noise to the Std Dev of the noise which should follow a well defined pattern depending upon the number of receiver channels.
d) The SNR is reported using all three estimates of sigma. Typically, the NEMA method results in an SNR value much lower than the others due to poor subtractions caused by either ghosting or swirling of the fluid in the phantom and is ignored. Therefore, I typically focus on the average of the non-NEMA SNR results.

7) When testing Phased Array (PA) coils it is imperative that ALL channels be evaluated individually but preferably from a SINGLE scan. This requires that a phantom be used that is large enough to cover the sensitive volume of each channel at one time.
8) Sometimes the phantom is large enough but no one imaging plane properly evaluates all of the channels. In such circumstances using both a sagittal and a coronal sequence (separately of course) going through the middle of the phantom is preferred to using multiple axial planes because it is very difficult to ensure reproducible axial slice positioning from year to year. Typical examples would be NVA, CTL Spine, Foot/Ankle and Wrist coils.
9) Finally, when testing a PA coil with an unknown coil configuration, I always look for symmetry between pairs of coil. There should ALWAYS be L/R symmetry, often A/P symmetry as well.

<u>Magnet Homogeneity Testing (bonus section)</u>

1) The only way to measure magnet homogeneity is with the Phase Difference method. FWHM of an FID spectrum or changes in geometry with different receiver BWs are both useless.
2) Two 3D sequences with a spherical phantom is preferred over 2D sequences because 2D sequences require 3 pairs of scans in the Axial, Coronal and Sagittal planes.
3) This requires that the scanner either output a set of Phase Difference image or that it provides EITHER a pair of Real and Imaginary images or Magnitude and Phase images. (I have written software that can perform the phase subtraction and unwrapping of the difference images, both 3D and 2D)
4) The spherical phantom should be as large as possible. I use the 32 cm diameter sphere that comes with every GE scanner. (30 cm diameter is OK, 24 cm is not.)

5) The sphere should be placed directly on the scan table or on a stack of unused printer paper, NEVER with a plastic support ring. For some reason, every support ring I have ever seen used has caused a localized distortion of the field. (And the toner used in all laser printers is ferromagnetic so you never want to use paper with printing on it.)
6) Color coded contour maps of the field in slices in all three orthogonal planes are useful for identifying localized distortions in the magnetic field caused by either bad shims or metal in the magnet.

Best Method to Estimate Noise (sigma)?

While preparing our presentations there was some limited communication between the various speakers. It became apparent that there was some differences of opinion as to what was the best method for measuring the SNR, or more precisely, the best method to estimate the variance of the background noise, the denominator of the Signal-to-Noise ratio. Some advocated for the NEMA subtraction method. I, on the other hand, am convinced that using the mean of the air pixels is the most reliable.

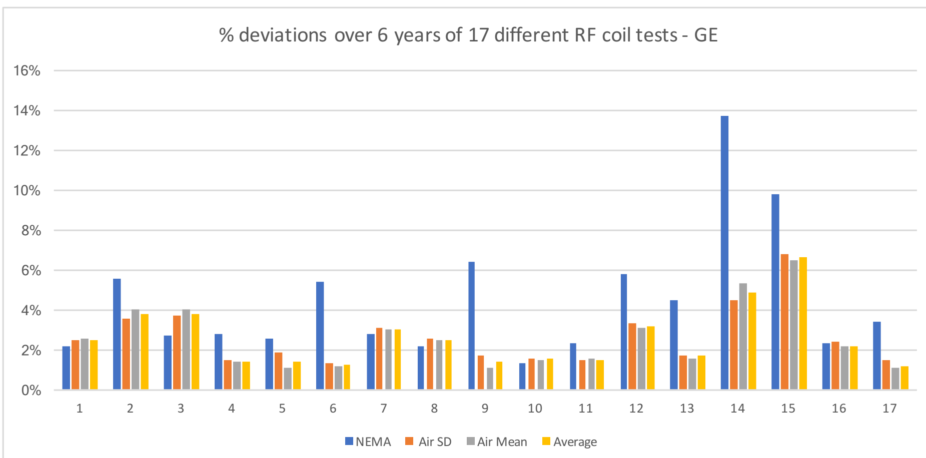
I hope to one analyze the 35,000+ RF coil tests that I have in my database to unequivocally answer that question. For the moment, I have chosen 3 magnets at 3 sites, 1 GE, 1 Siemens and 1 Philips, where I have 5 to 6 years of good data (consistent coils, consistent phantoms and consistent protocols) and looked at how the year to year SNR values of all of their RF coils change. I threw out any data points where I identified a problem with the coil (bad channel, artifacts in the background, etc.). Below are three tables summarizing those data. In addition to the three methods of estimating sigma, I looked at the variation of taking the average of the SNR produced using the Std Dev and the Mean of the background pixels, ignoring the NEMA method.

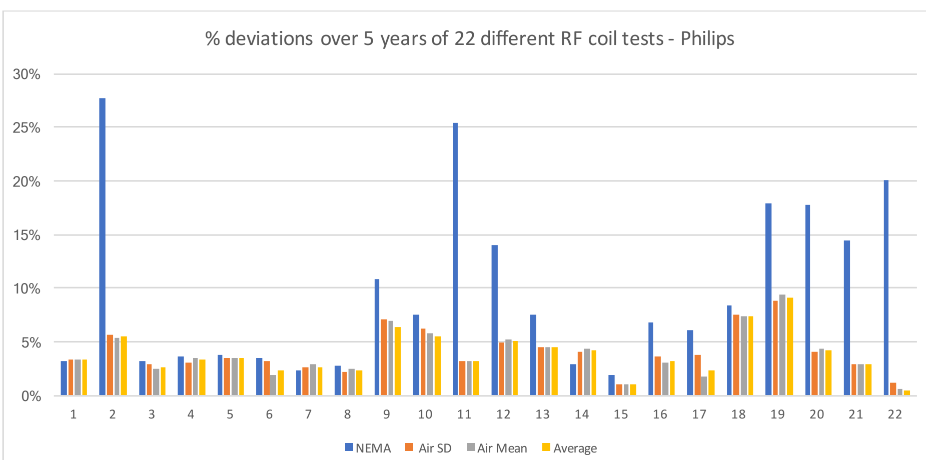
GE Magnet N = 17				
	NEMA	Air S.D.	Air Mean	Average
Average % deviation	4.46%	2.66%	2.58%	2.59%
Std Dev of % deviations	3.21%	1.43%	1.58%	1.50%
# of times this method best	5	3	7	2

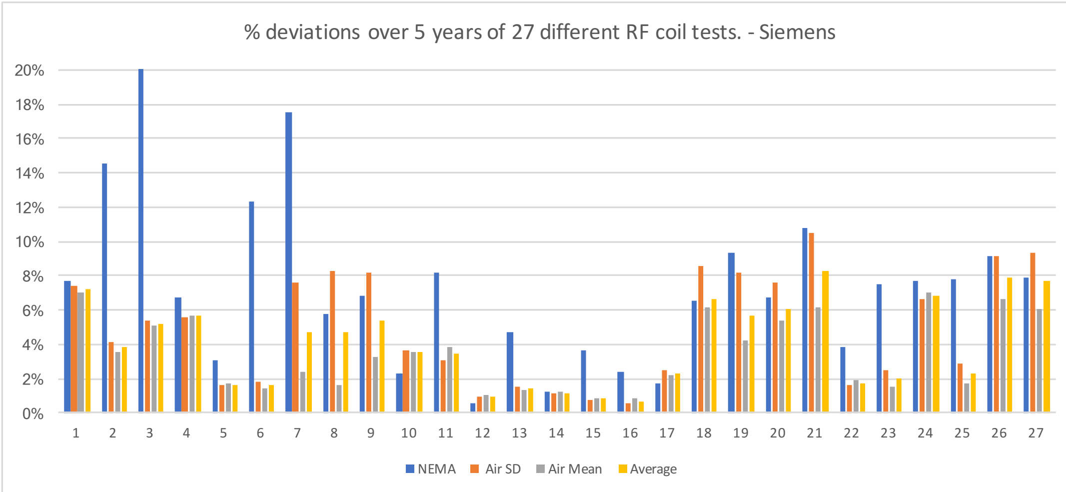
Philips Magnet N = 22				
	NEMA	AIR S.D.	Air Mean	Average
Average % deviation	9.63%	4.09%	3.91%	3.88%
Std Dev of % deviations	7.83%	1.96%	2.13%	2.03%
# of times this method best	3	6	12	2

Siemens Magnet N = 27				
	NEMA	**AIR S.D.**	**Air Mean**	**Average**
Average % deviation	6.79%	4.85%	3.47%	4.06%
Std Dev of % deviations	4.07%	3.22%	2.15%	2.47%
# of times this method best	3	8	16	0

And here are plots of the SNR variations for all of the coils tests:







From these data we can see that while there is little absolute difference between estimating the sigma from the air pixels, using the mean is consistently a little better. Using the NEMA subtraction method works when things are absolutely perfect but if there is any swirling of the phantom liquid or ghosting in the system then the SNR results can fail miserably. Personally, I most often report the average value.

I hope you have found this useful.

Moriel NessAiver, Ph.D.
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RF Coil Testing
Ins & Outs and Ups & Downs

Moriel NessAiver, Ph.D.

SimplyPhysics

the home of MRI physics put simply

www.simplyphysics.com

It's Too Hot in Texas!

My Qualifications

- Doing MRI since 1985
- Worked in industry for 6 years
- Worked in Academia for 10 years
- Started QA testing in 2001
- Have conducted over 1500 annual performance reviews (about 120/yr now)
- Have tested over 5800 individual RF coils
- For a total of >35,500 separate tests

How often do I find problems?

Out of 800 Yearly Performance Evaluations on 1.5T and 3T GE, Siemens and Philips scanners I found problems at 472, or 59% of every site visit.

- One or more bad RF coils (≈15% of all coils)
- Magnet Homogeneity
- Gradient Calibration
- System wide artifacts (RF Noise lines or ghosting)
- Soft Copy Display (no clinical affect)

How often do others find problems?

	Reported SNR Values			% change	
Coil	**2012**	**2013**	**2014**	**2013**	**2014**
Flex Large 2ch	598	1552	998	160%	-36%
Flex Medium 2ch	520	4626	1005	790%	-78%
SENSE Body 4ch	2258	1781	1726	-21%	-3%
Head/Neck 3ch	956	5729	907	499%	-84%
SENSE Spine 123 3ch	4147	2569	1035	-38%	-60%
SENSE Spine 345 3ch	2208	2420	948	9.6%	-61%
Flex Large 2ch	1154	495	1267	-57%	156%
SENSE Torso 6ch	1168	1866	456	60%	-76%

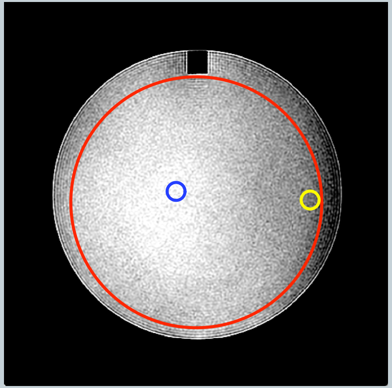
Types of RF Coils

ACR	Simply Physics

• Volume Coils
• Surface Coils
	• Volume Coils – 1 ch
	  ○ Body, Head, Knee, Wrist
	• Surface Coils – 1 ch
	  ○ Simple Loops, Flex Coils
	• Phased Array Coil
	  ○ **Everything Else!**

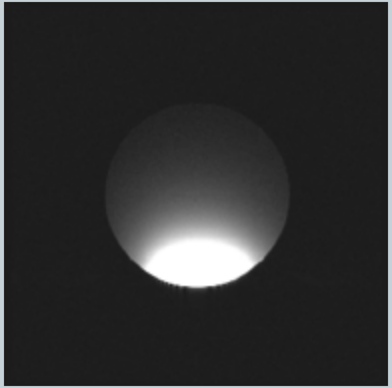
Types of RF Coils

Quintessential Volume Coil



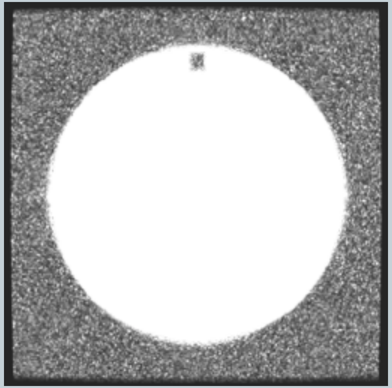
PIU = 96.0%

Quintessential Surface Coil



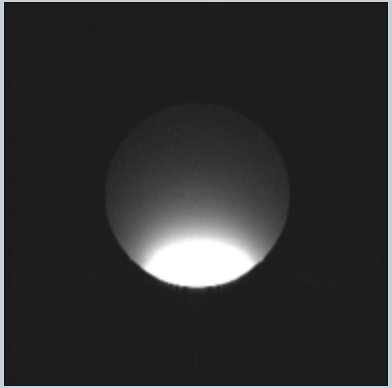
Types of RF Coils

Quintessential Volume Coil



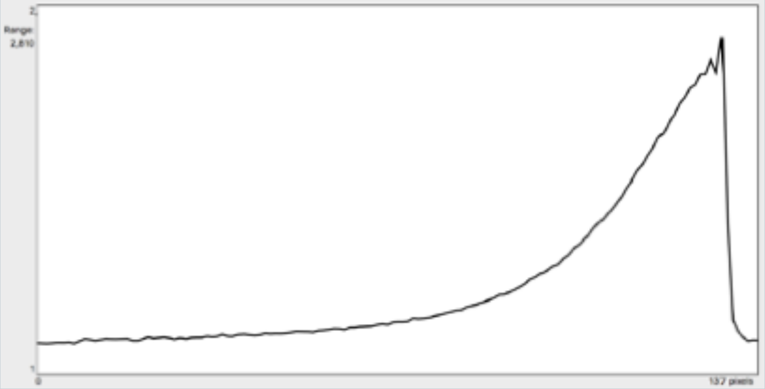
Background
sort of uniform

Quintessential Surface Coil

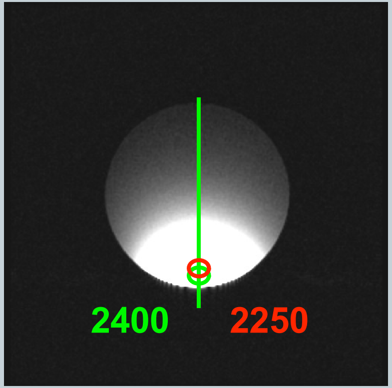


Types of RF Coils

Quintessential Surface Coil

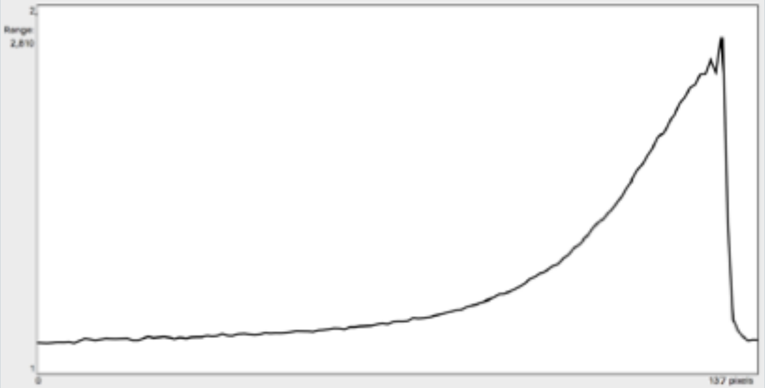


Signal profile through green line

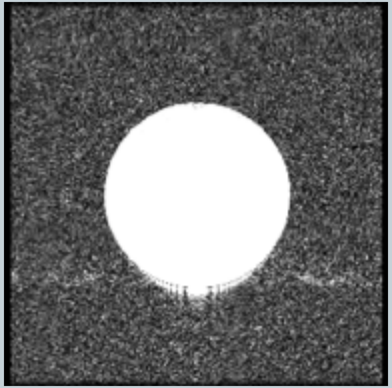


Types of RF Coils

Quintessential Surface Coil



Signal profile through green line

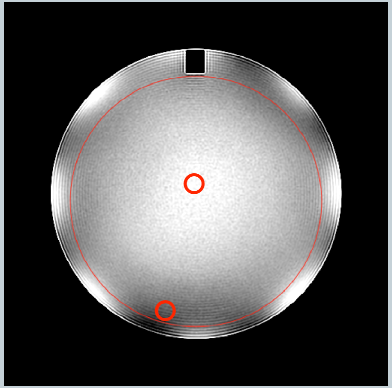


Background
sort of uniform

Types of RF Coils

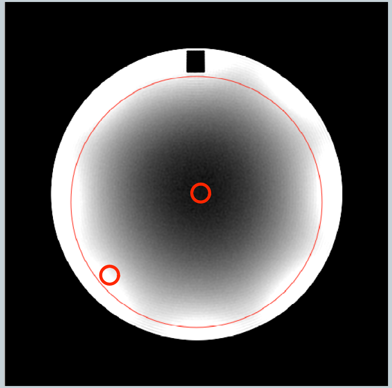
8 Channel Phased Array Head Coil - Volume or Surface?

PURE

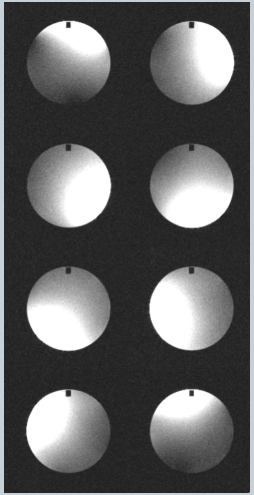


PIU = 94.3%

No PURE



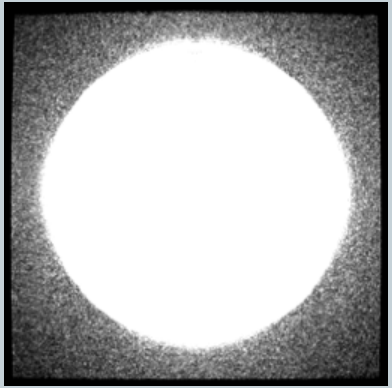
PIU = 75.4%



Types of RF Coils

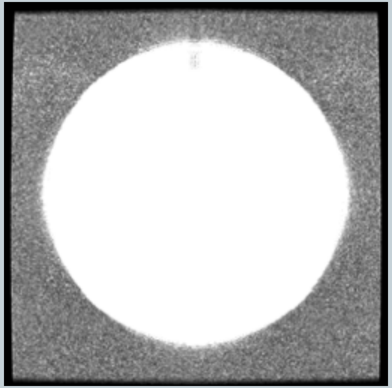
8 Channel Phased Array Head Coil - Volume or Surface?

PURE



Spatially varying noise

No PURE



Moderately Uniform Noise

Most image processing methods adversely affect background noise.

Questions to be answered:

- What is the single most important concept in RF Coil Testing?
- When measuring the SNR of any RF coil, is it more important to improve the accuracy of the signal or the noise?
- What is the best way to measure the SNR of a surface coil?

REPRODUCIBILITY

- Documenting the type of phantom used
  - Match the phantom size/shape to the coil's sensitive volume
- Positioning the phantom in the coil
  - Securely position in center of sensitive volume
- Location of imaging slice(s) through the phantom
  - Easily identified reference position
  - Be sure to cover sensitive volume of <u>every</u> channel
  - May need multiple planes

REPRODUCIBILITY

- Scan parameters
  - Try to use the the exact same protocol each time. (But what if you don't?)
  - Design the sequence to maximize reliability (reproducibility) of SNR value.
- Analysis – Drawing the ROIs
  - Signal ROI – Almost all of the phantom!
  - Noise ROI – All of the air without ghosting or artifacts

Document by Taking Pictures!

Defining SNR

$$P_{ixels} / \sigma_{sigma}$$

Measuring SNR is Complex

Image Pixel → Magnitude of Complex FFT

$$P = \sqrt{(R \pm \sigma)^2 + (I \pm \sigma)^2}$$

$$Set\ I = \emptyset$$

$$P = \sqrt{R^2 \pm 2R\sigma + 2\sigma^2}$$

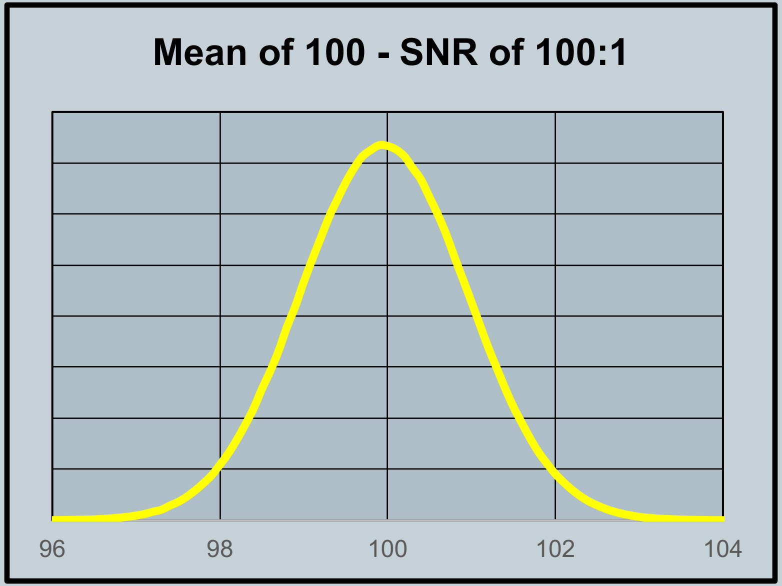
Measuring the Signal is Easy - Theoretically

Signal = Mean of (P) and has Rician Distribution

$$P = \sqrt{R^2 \pm 2R\sigma + 2\sigma^2}$$

If $R \gg \sigma$

$$P = |R| \pm \sigma$$



Measuring the Signal is Easy - Theoretically

Signal = Mean of (P) and has Rician Distribution

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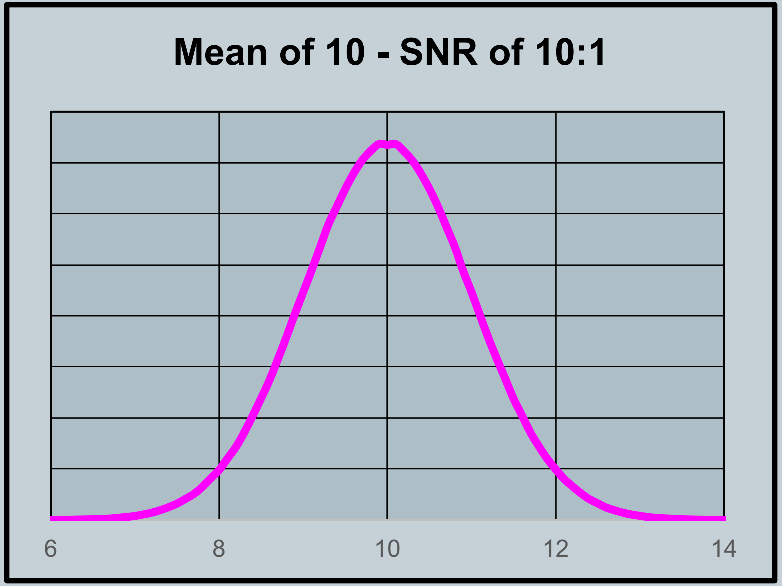
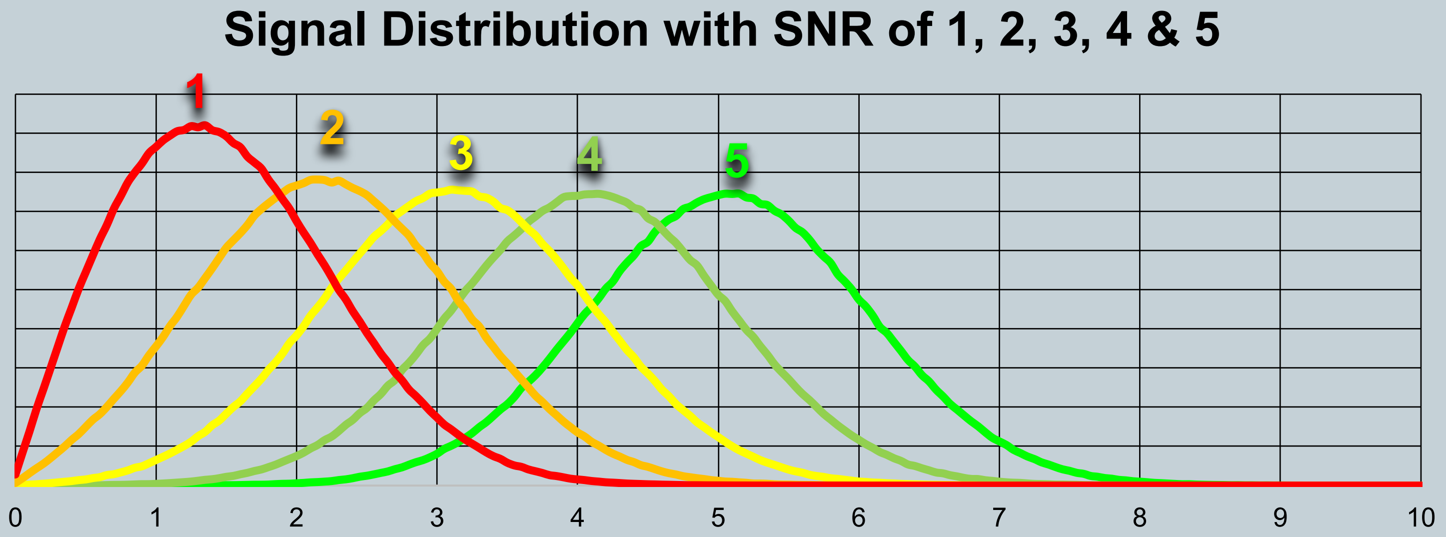


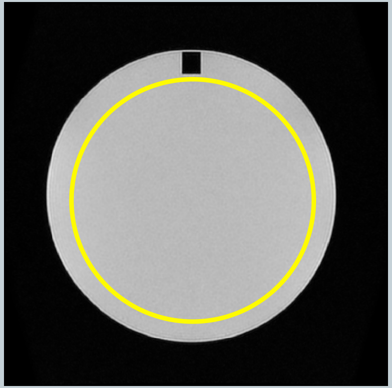
Measuring the Signal is Easy - Theoretically

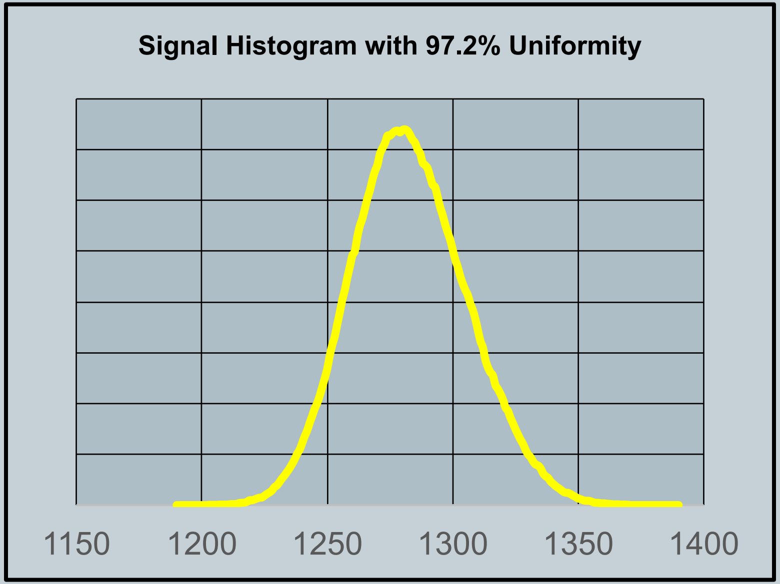
Signal = Mean of (P) and has Rician Distribution



Actually Measuring the Signal

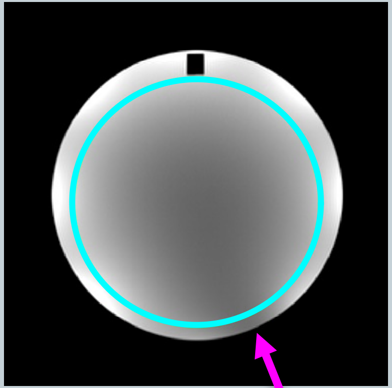
Rician Distribution convolved with Sensitivity Profile

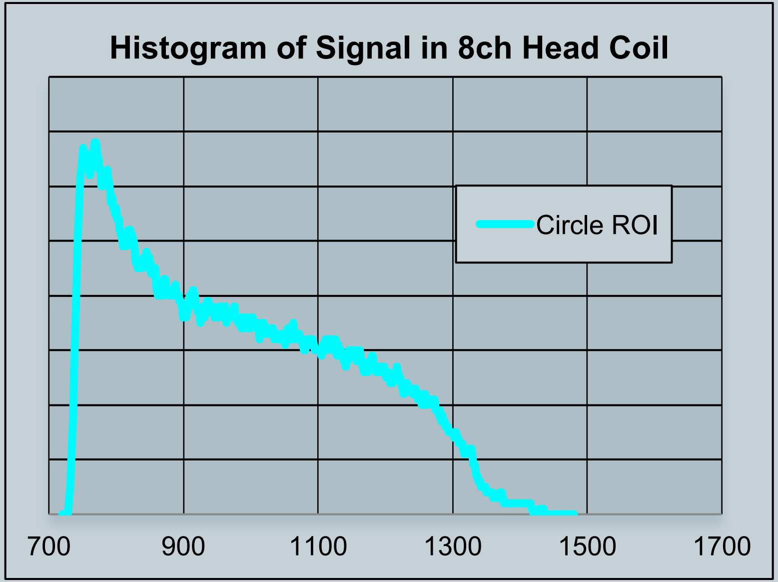




Actually Measuring the Signal

Rician Distribution convolved with Sensitivity Profile

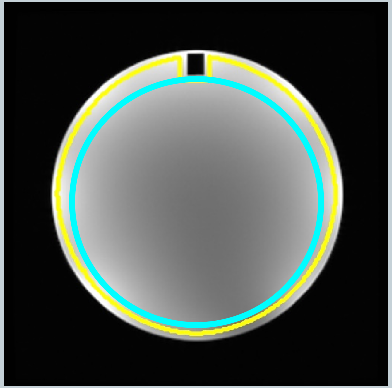




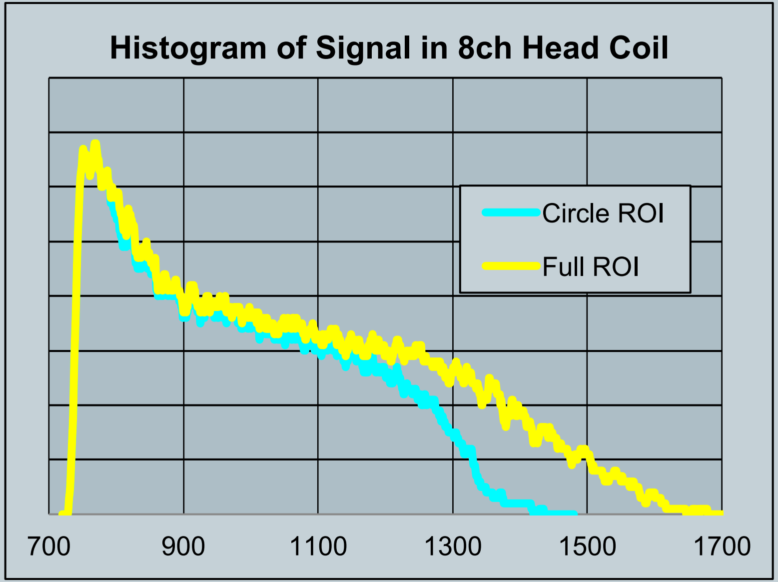
Bad Channel

Actually Measuring the Signal

Rician Distribution convolved with Sensitivity Profile



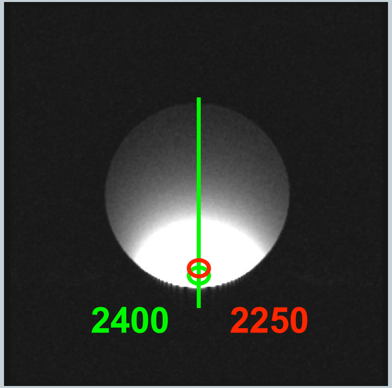
15% threshold
4 pixel shrink



Actually Measuring the Signal

Measuring the Signal of Surface Coils

- ACR says to draw small ROI at high signal point.
- Small change in ROI location or size can make big change in signal.



6% delta

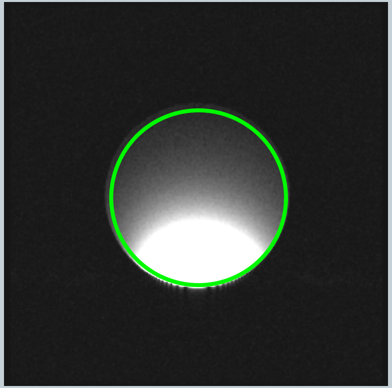
Actually Measuring the Signal

Measuring the Signal of Surface Coils

- Draw an ROI including ALL of the phantom signal.
- Last 4 yrs of SNR values:

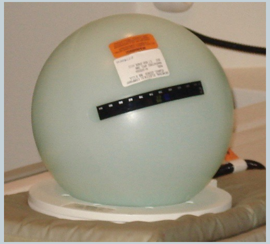
182, 179, 174, 180

178.8 ± 3.4 (1.9%)



Actually Measuring the Signal

Measuring the Signal of Surface Coils

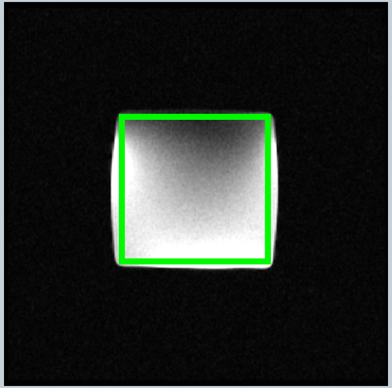





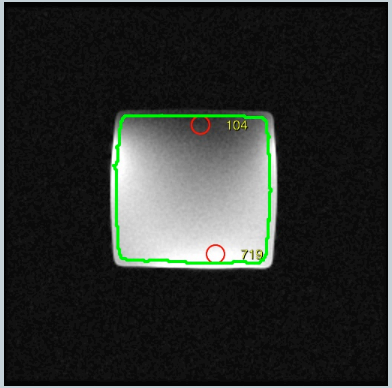
All of these surface coils should use a simple circular ROI

Actually Measuring the Signal

Measuring the Signal of Surface Coils



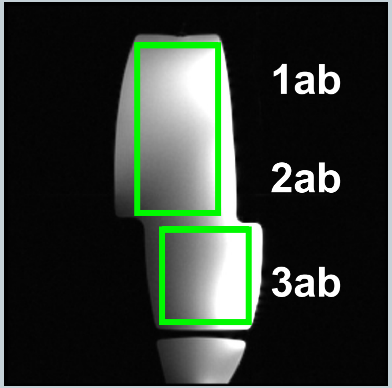
Simple Square



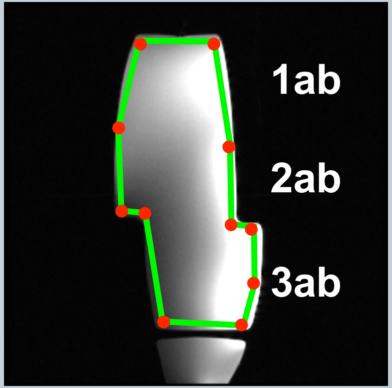
3% Threshold
4 pixel shrink

Actually Measuring the Signal

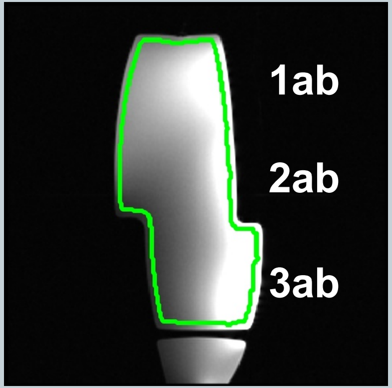
What about odd shaped phantoms?



2 squares



Polygon



2% Threshold
4 pixel shrink

Actually Measuring the Signal

My Rule of Thumb for Measuring the signal.

- The phantom should take up about 20% of the FOV.
- If 256 x 256 pixels then 20% of 64K = 12-15K pixels

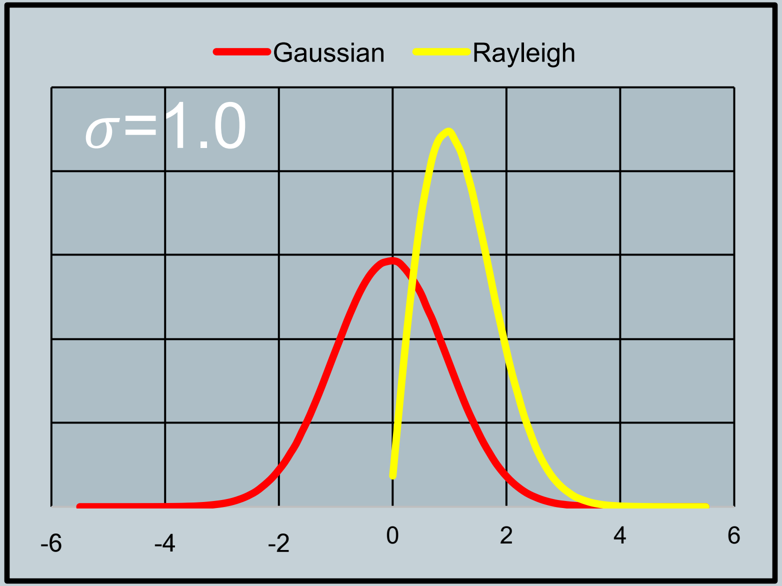
What about the Noise (σ)?

Noise has Rayleigh distribution (floating point)

$$\sigma = SD_{meas}/0.655$$

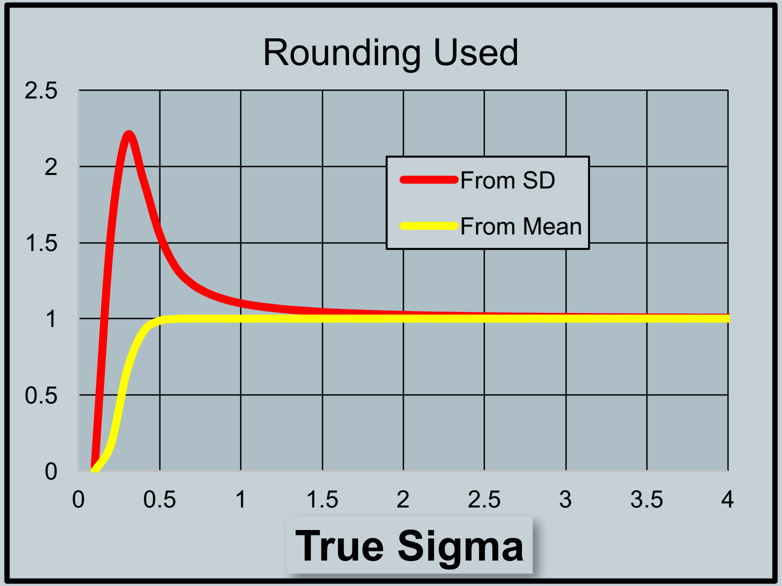
or

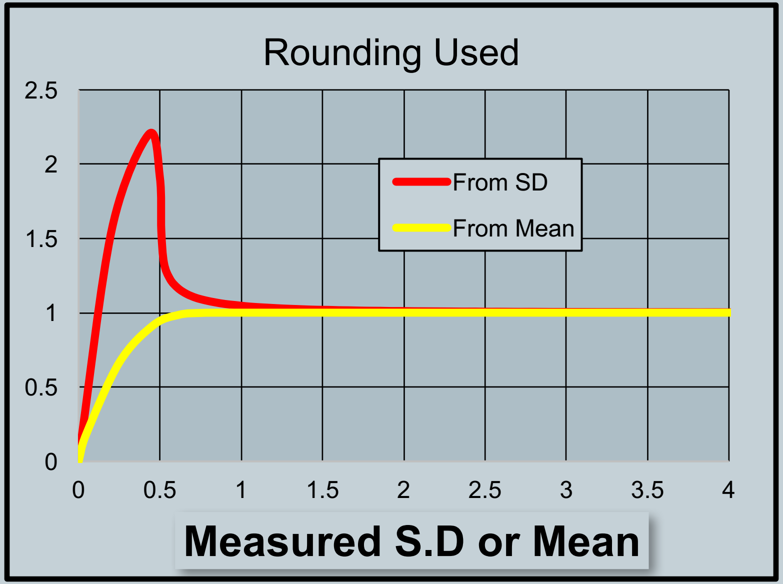
$$\sigma = Mean_{meas}/1.253$$



What Can Affect the Noise?

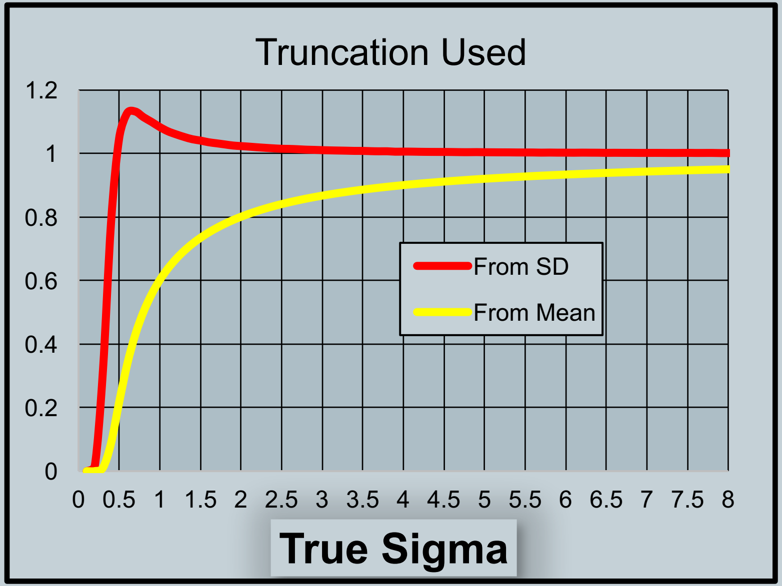
1) Images are Integer – Do they truncate or round?

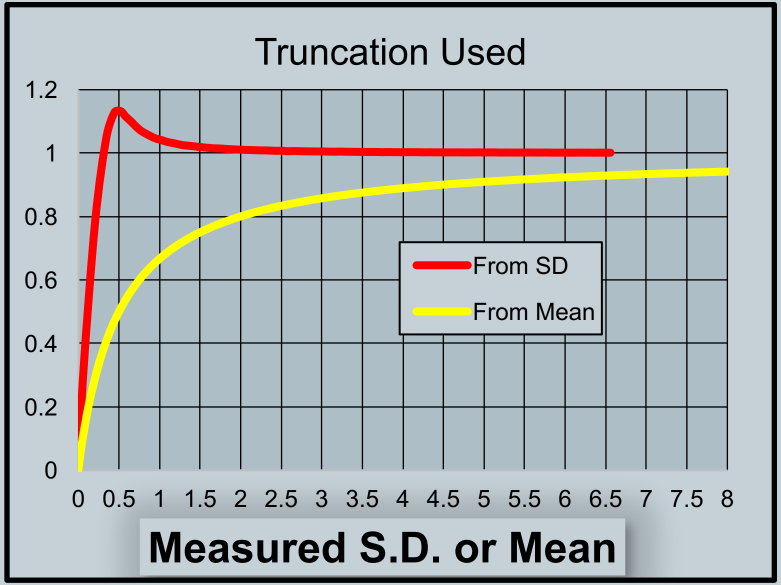




What Can Affect the Noise?

1) Images are Integer – Do they truncate or round?





What Can Affect the Noise?

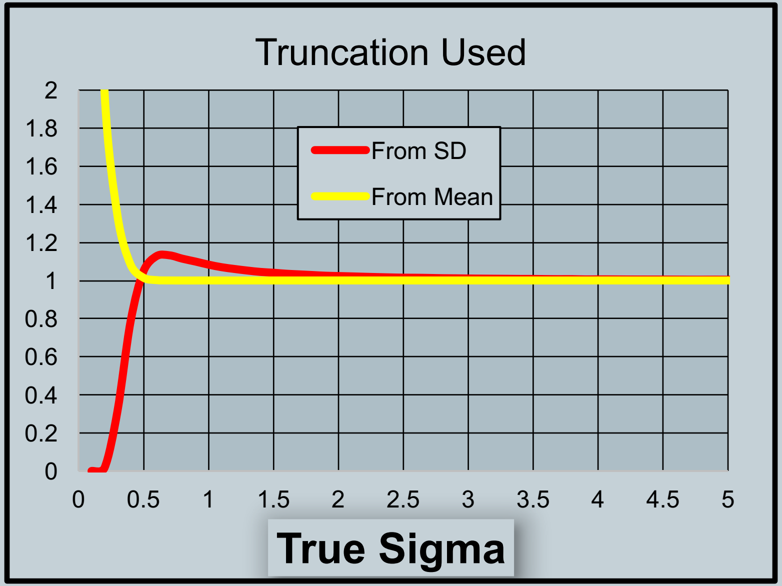
1) Images are Integer – Do they truncate or round?

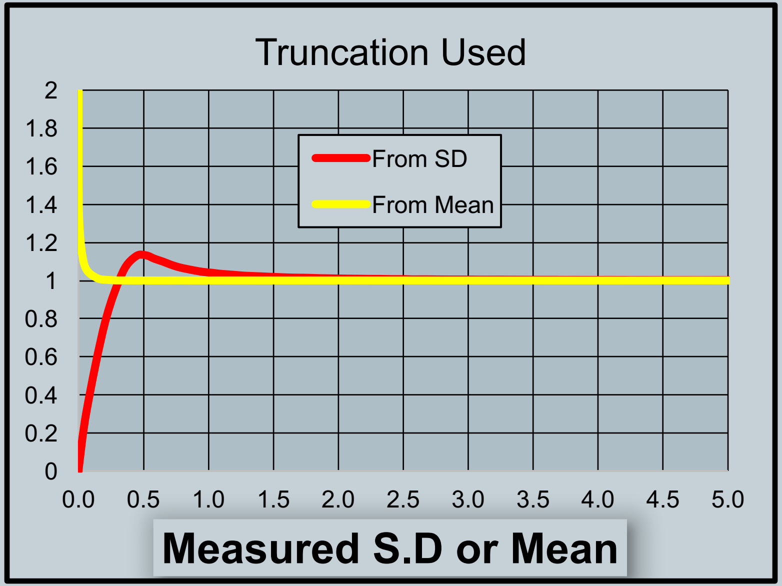
However…

The true mean = measured mean + 0.5

What Can Affect the Noise?

True Mean = Measured Mean + 0.5

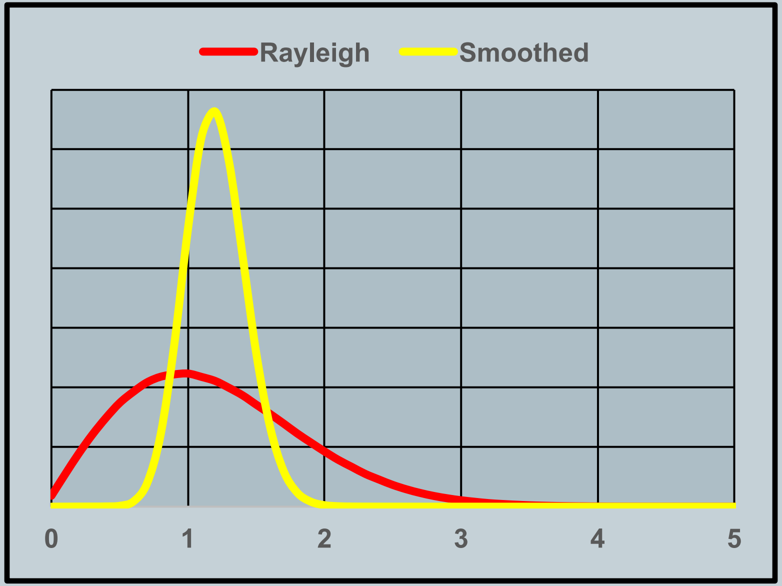




What Can Affect the Noise?

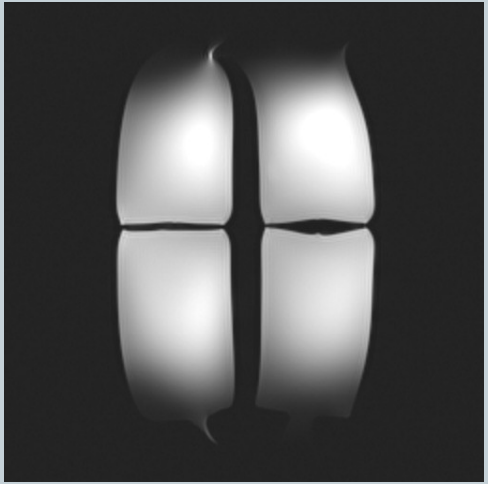
2) Almost any filter

- Basic Rayleigh Distribution
  - Mean=1.25
  - S.D. = 0.655
- 3x3 Smoothing Filter
  - Mean=1.25
  - S.D. = 0.220



What Can Affect the Noise?

3) Geometric Distortion Correction

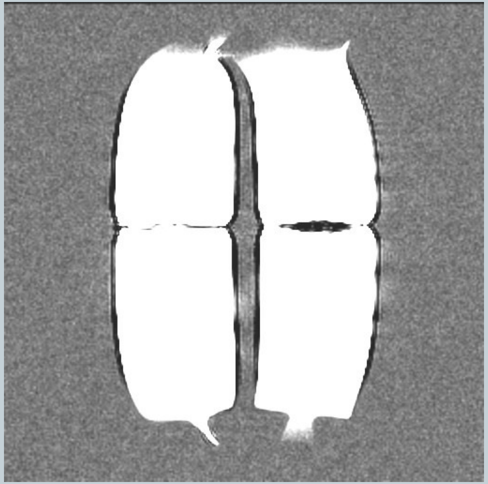


What Can Affect the Noise?

3) Geometric Distortion Correction

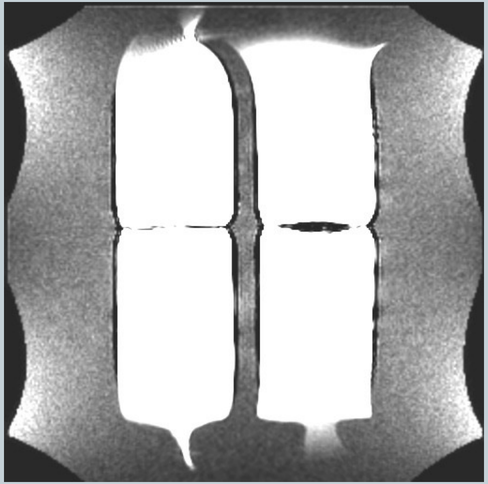
- Non-corrected image
  - $SNR_{S.D.}$ = 249
  - SNR_{Mean} = 225
  - SNR_{NEMA} = 198
- Distortion corrected image
  - $SNR_{S.D.}$ = **137**
  - SNR_{Mean} = 216
  - SNR_{NEMA} = 231

S.D. = 3.6



Mean = 19.3

S.D. = 6.5



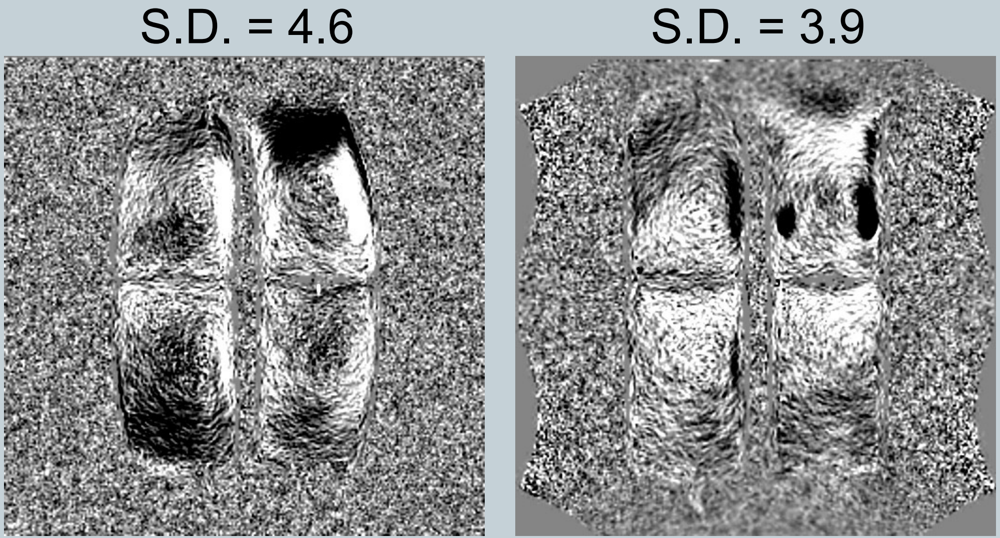
Mean = 20.0

What Can Affect the Noise?

4) NEMA method to estimate noise – SWIRLING!

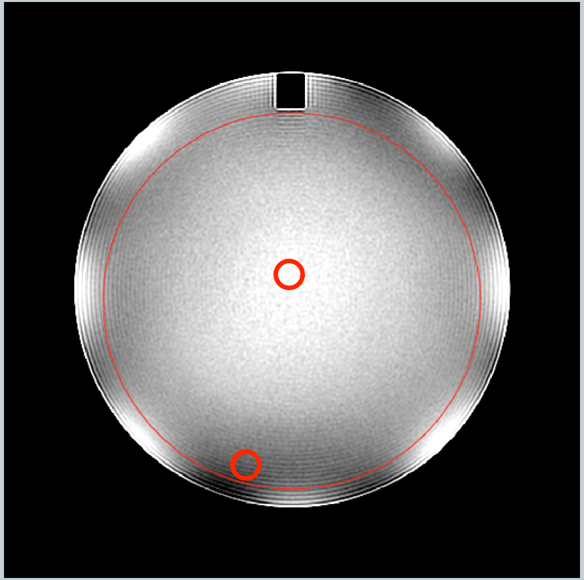
- Run the scan twice
- Subtract the 2nd image from the 1st.
- Measure S.D. in Phantom

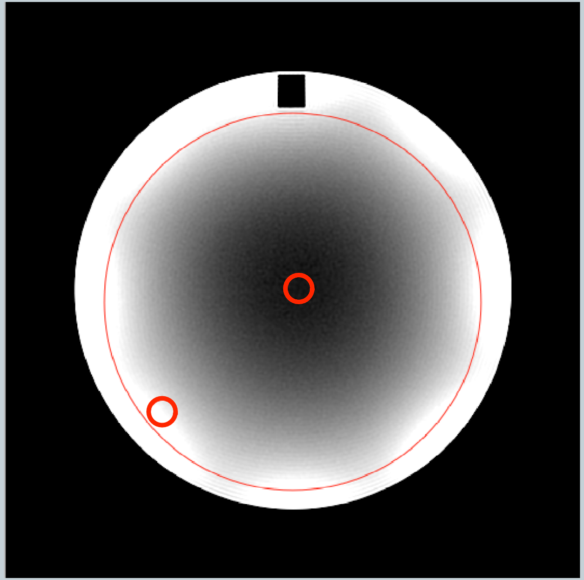
$$\sigma \approx S.D. * \sqrt{2}$$



What Can Affect the Noise?

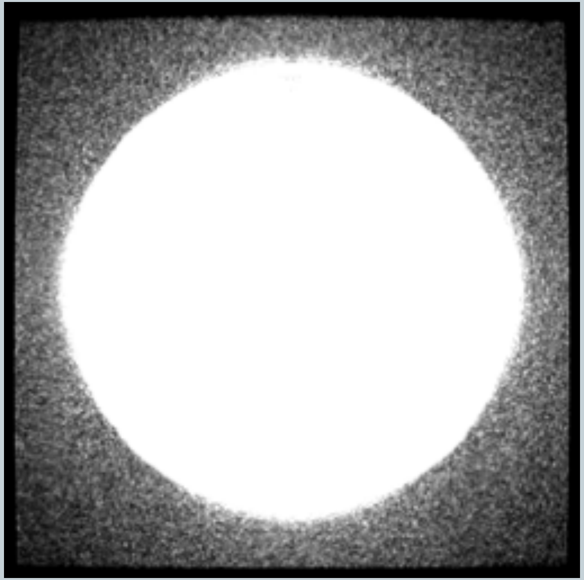
5) Signal Intensity Correction or Normalization

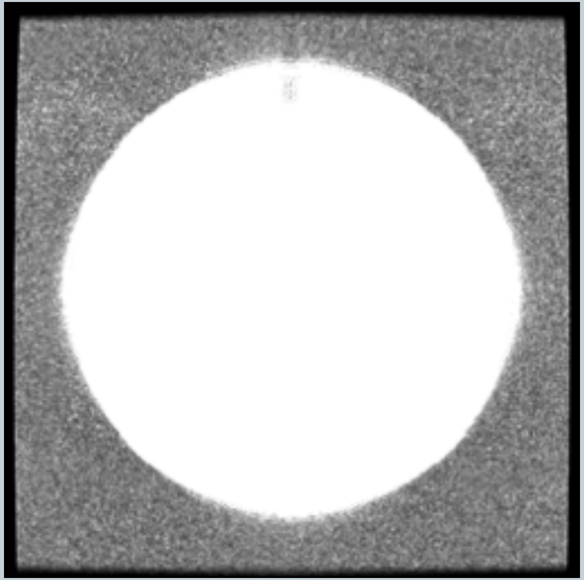




What Can Affect the Noise?

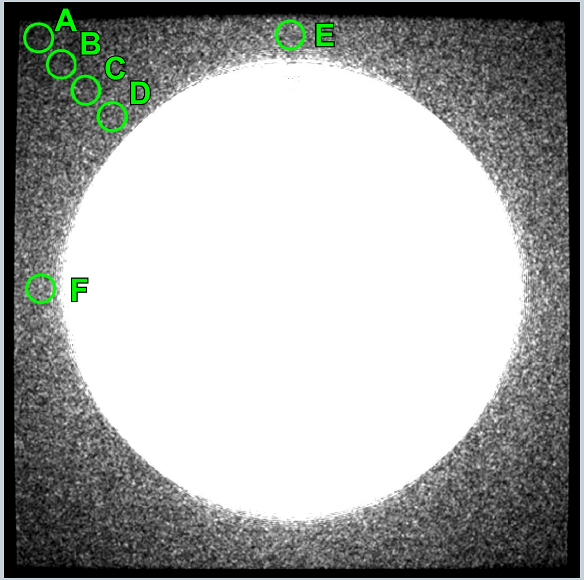
5) Signal Intensity Correction or Normalization





What Can Affect the Noise?

5) Signal Intensity Correction or Normalization



Mean Noise Values

A = 13.0

B = 14.4

C = 16.8

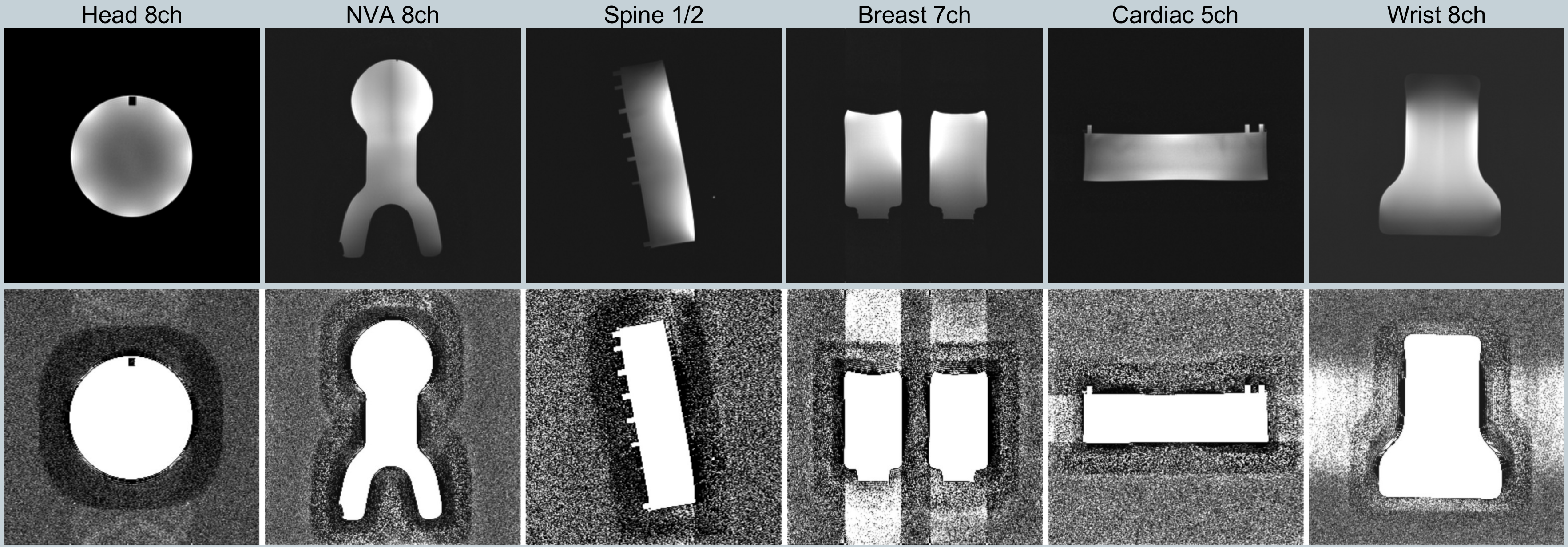
D = 18.6

E = 20.7

F = 21.8

What Can Affect the Noise?

6) Adaptive Coil Combination



What Can Affect the Noise?

6) Adaptive Coil Combination

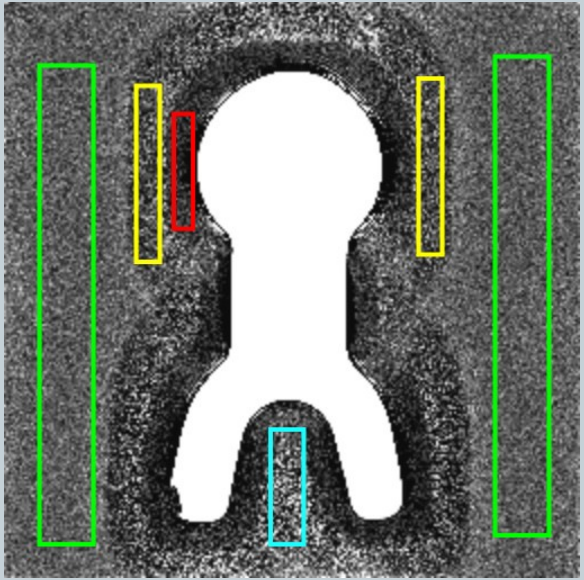
Mean / Std. Dev

9.1 / 3.7

7.6 / 5.8

3.7 / 3.8

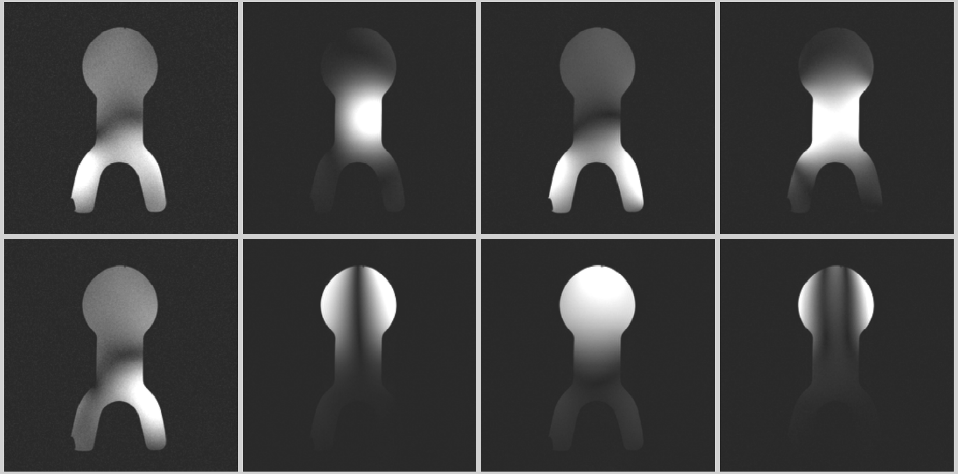
10.5 / 9.3

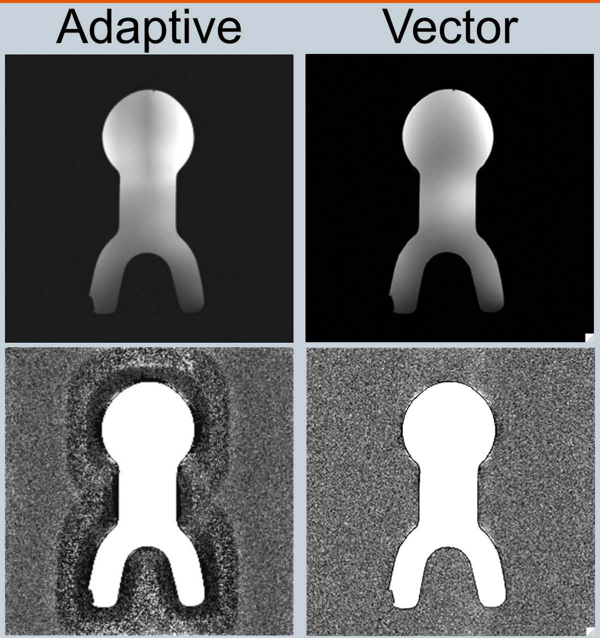


What Can Affect the Noise?

7) Adaptive Coil Combination Compared to Vector Sum

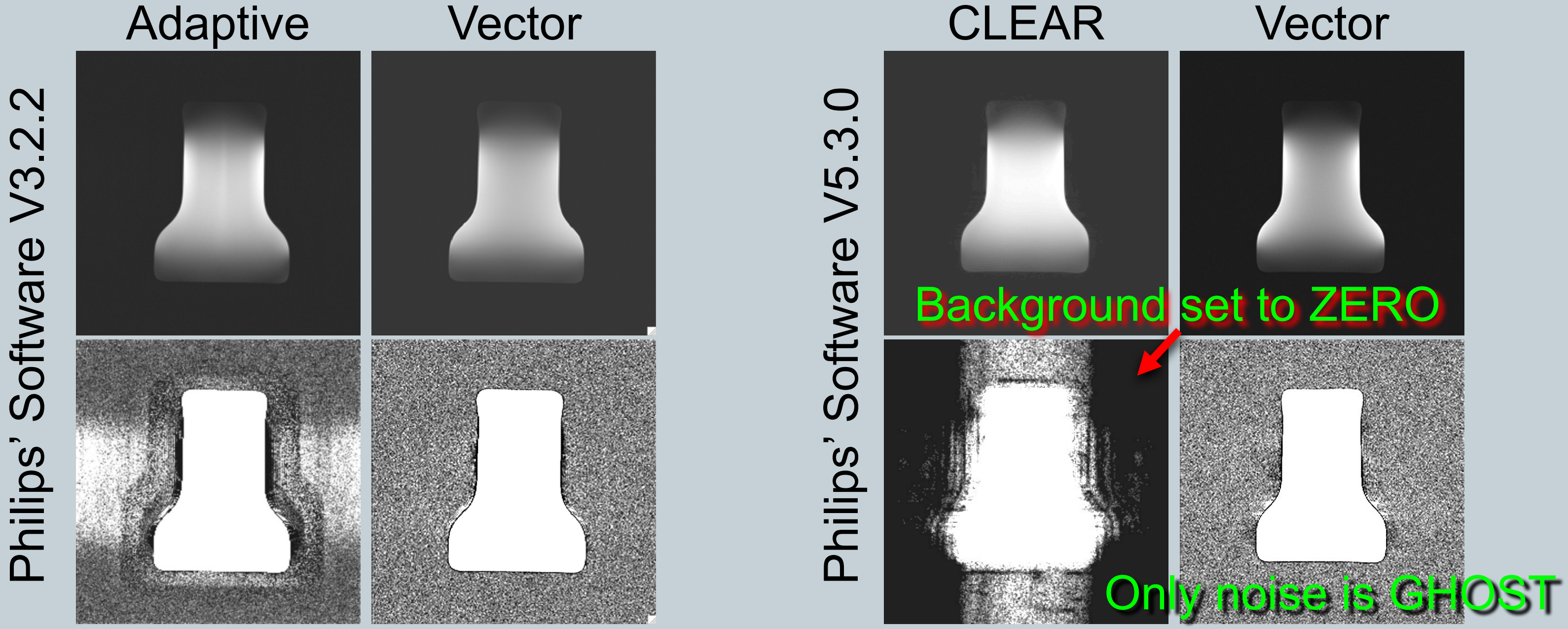
8 Channels to be combined





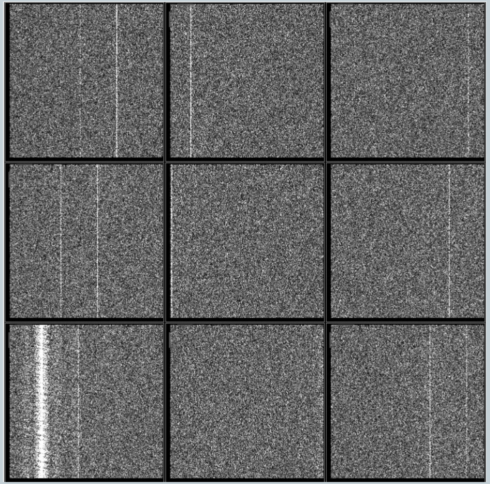
What Can Affect the Noise?

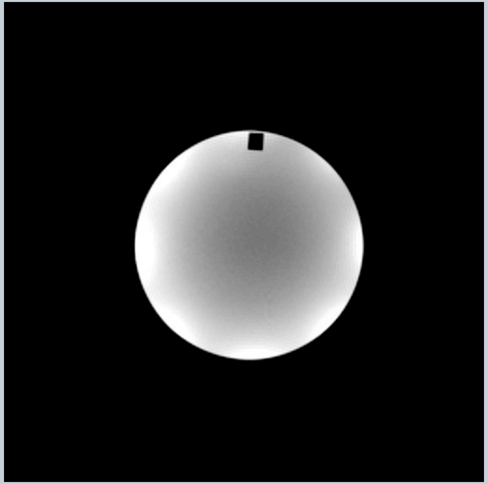
7) Adaptive Coil Combination Compared to Vector Sum

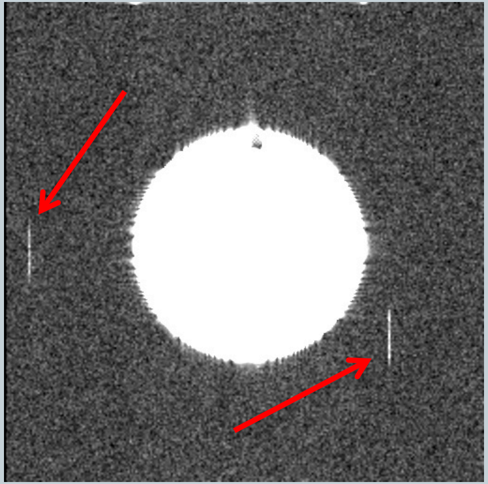


What Can Affect the Noise?

8) RF Noise lines (and other artifacts)

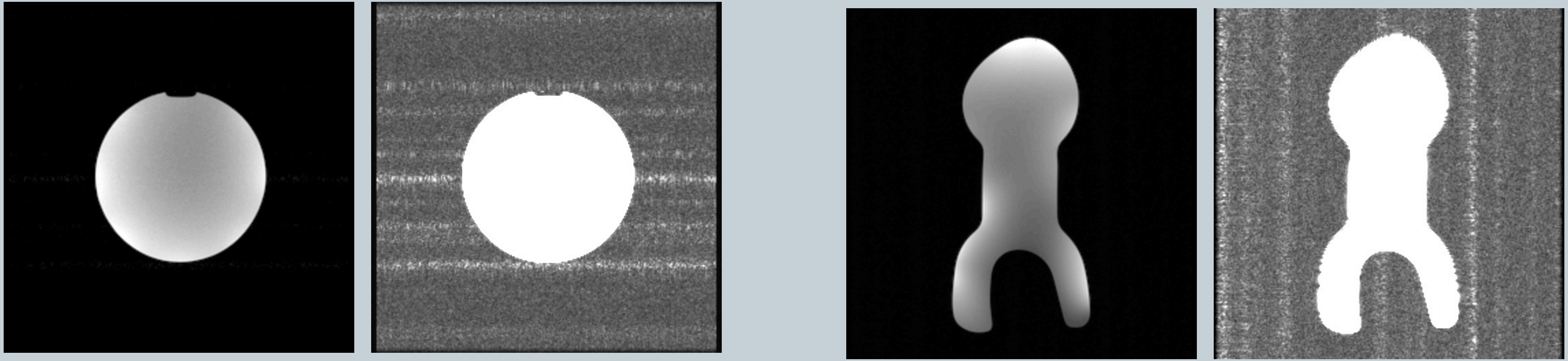






What Can Affect the Noise?

8) RF Noise lines (and other artifacts)

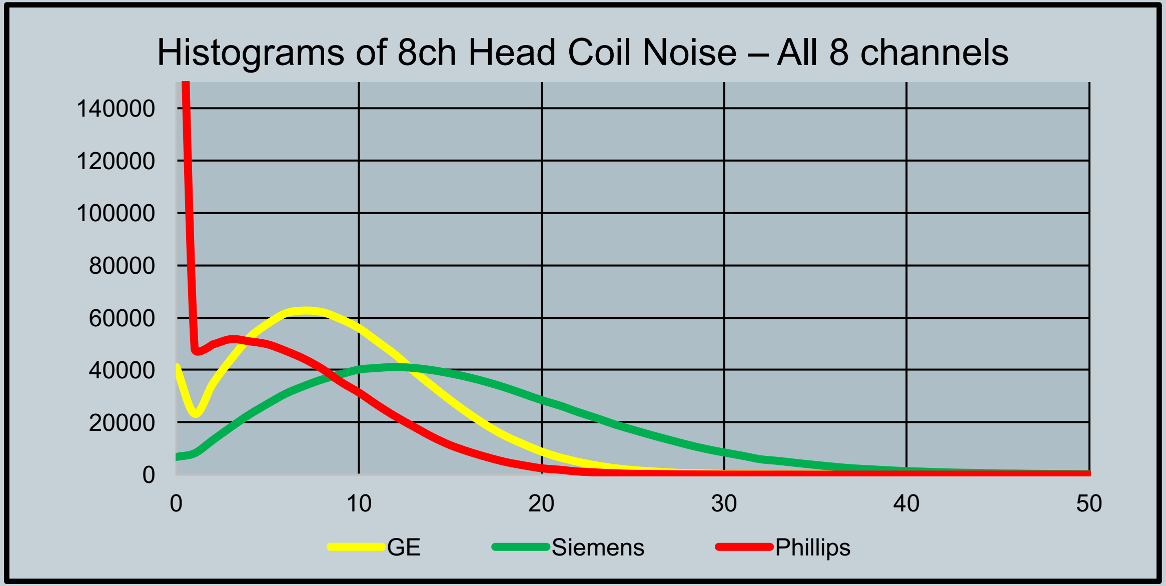


What Can Affect the Noise?

9) Unkown and weird filtering!

The Philips images had close to **29,000** pixels set to exactly Zero!

The S.D. was greater than the mean!



Phased Array Coils

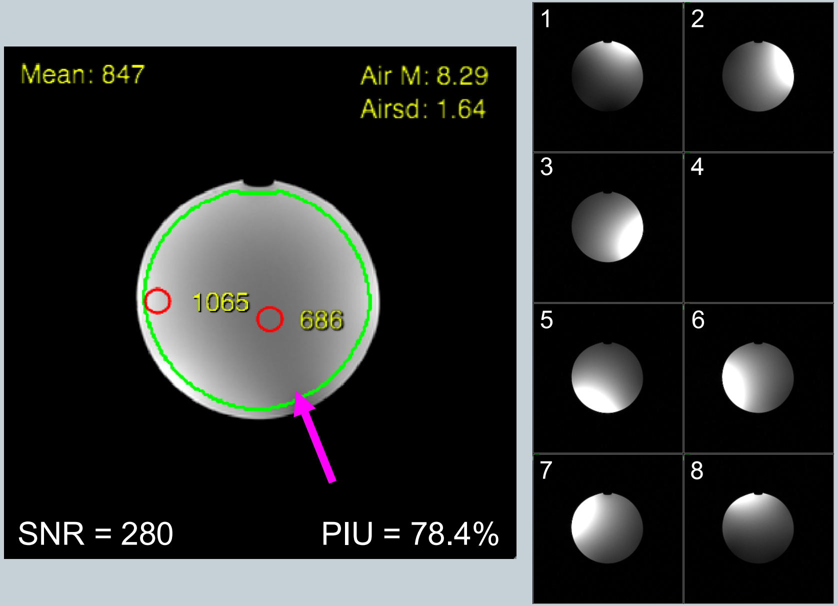
Test EVERY channel of EVERY phased array (PA) coil

- SNR $\propto \sqrt{(\# \; channels)}$
- Affects image uniformity
- Large affect on parallel imaging techniques
- Client paid for ALL channels to be working

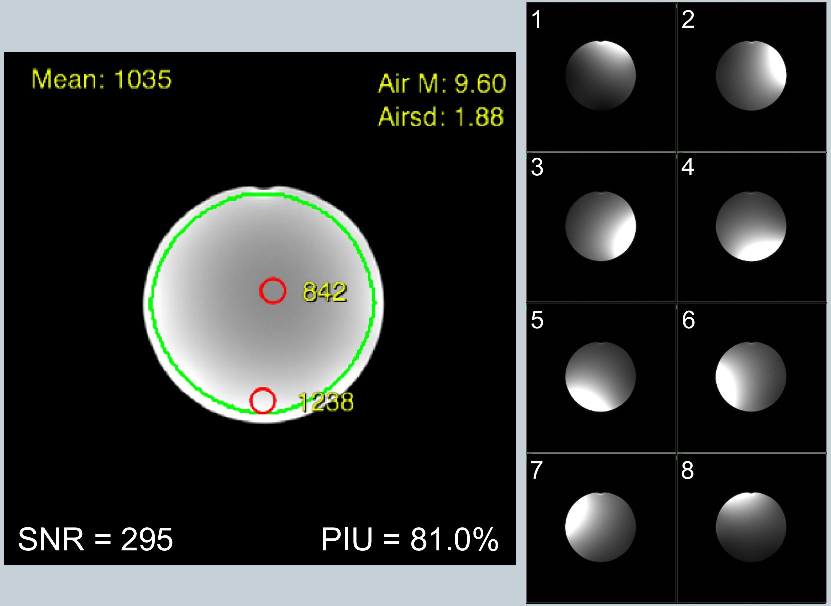
# channels	signal drop for 1 dead channel
2	29.3%
4	13.4%
8	6.5%
16	3.2%
32	1.6%

8 Ch Head PA Coil – Example

Channel #4 is dead



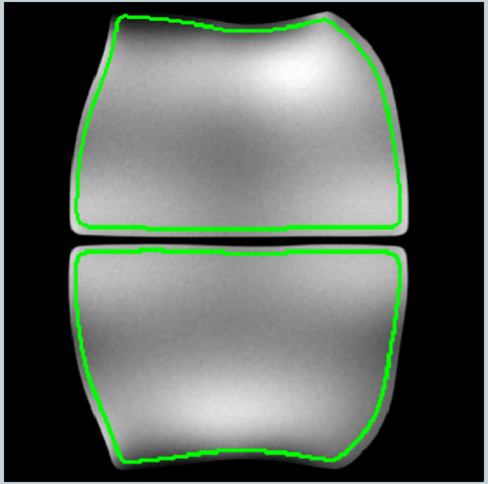
Same coil - repaired

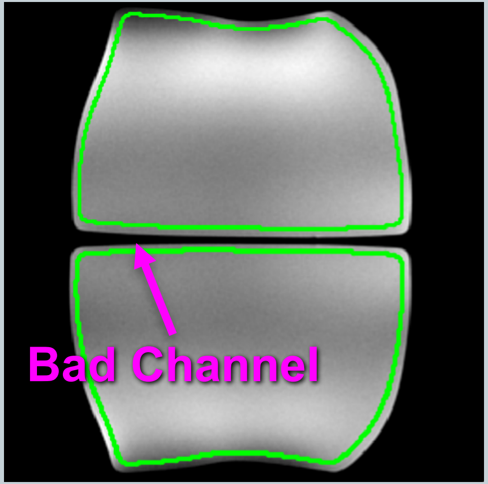


8 Ch Body Array Coil – Example

SNR: 98.8

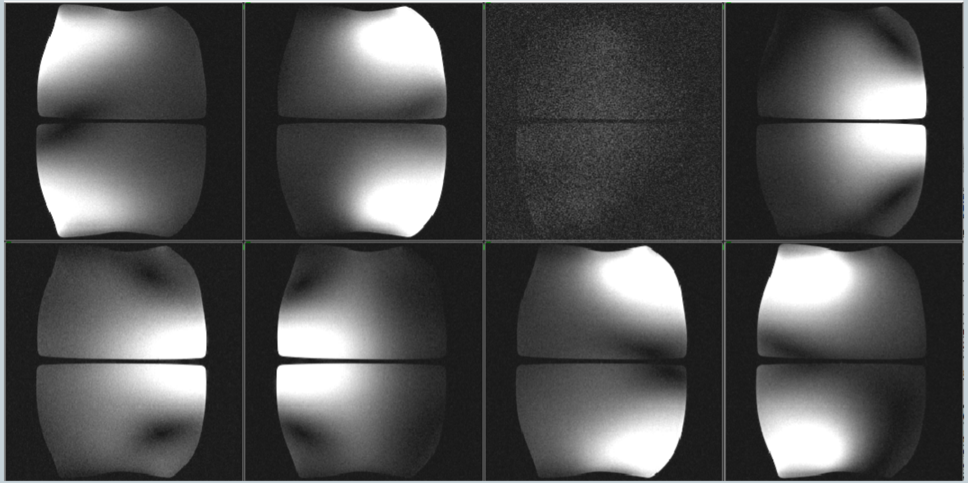
SNR: 95.6

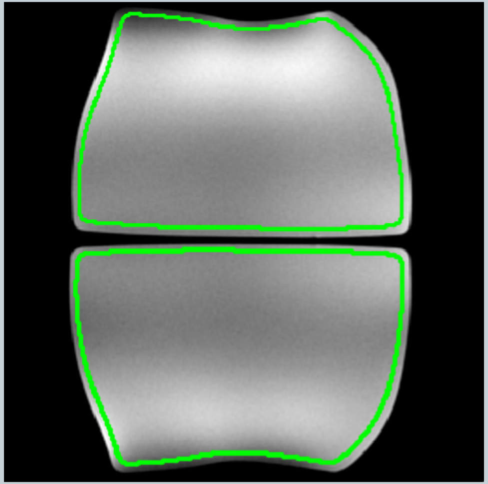




8 Ch Body Array Coil – Example

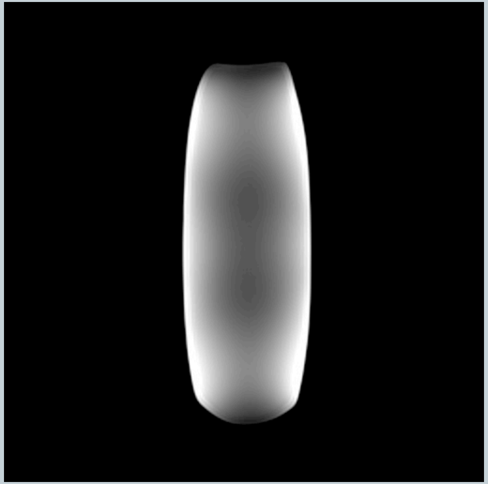
Channel # 3 is dead! **SNR: 95.6**



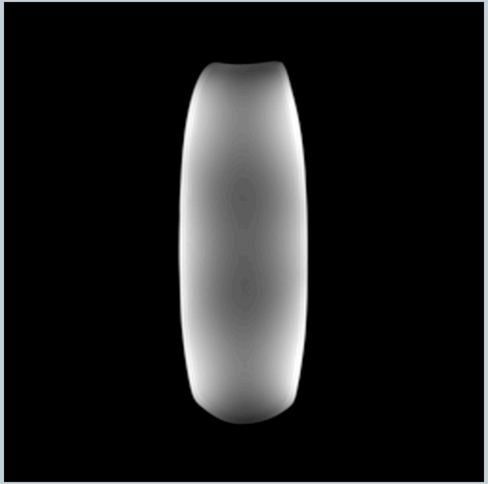


18 Ch Body Array Coil – Example

SNR: 206.4



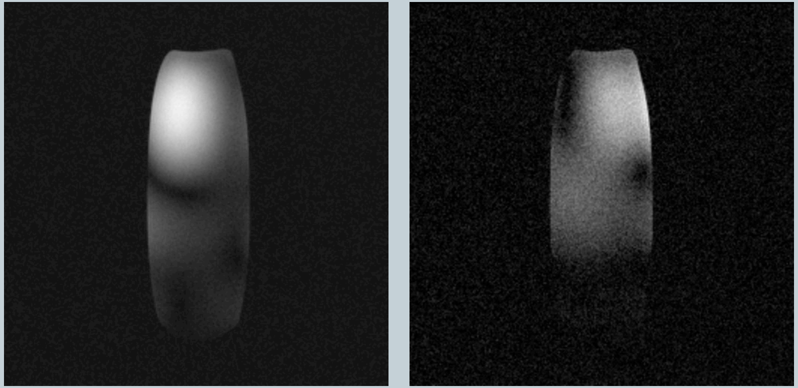
SNR: 200.6



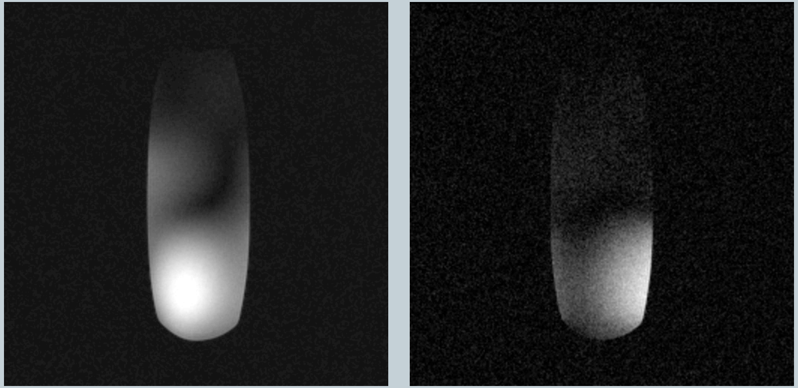
Where is the Bad Channel?

18 Ch Body Array Coil – Example

SNR: 16.1 **SNR: 4.6** **SNR: 21.0** **SNR: 3.3**



Siemens Channel B14

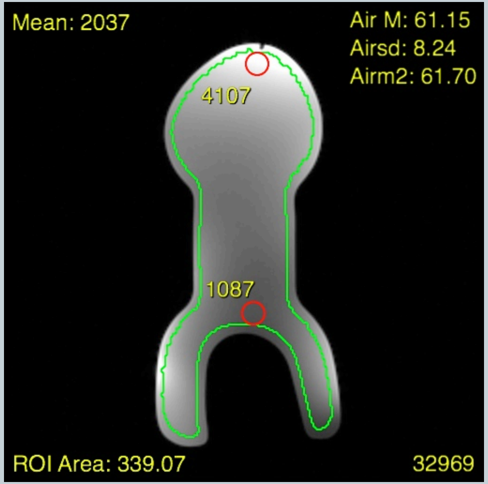


Siemens Channel B34

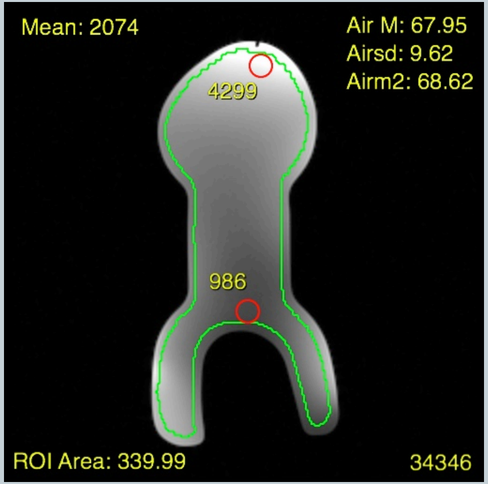
<u>TWO</u> Bad Channels!

16 Ch Head/Neck/Spine – Example

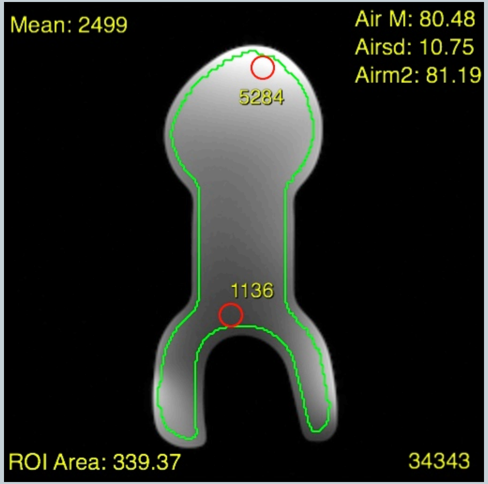
SNR:211	SNR:189	SNR:198



2017



2018

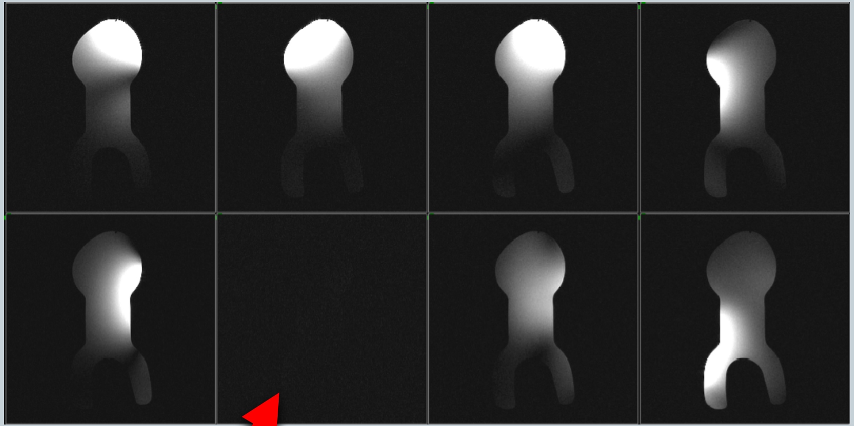


2019

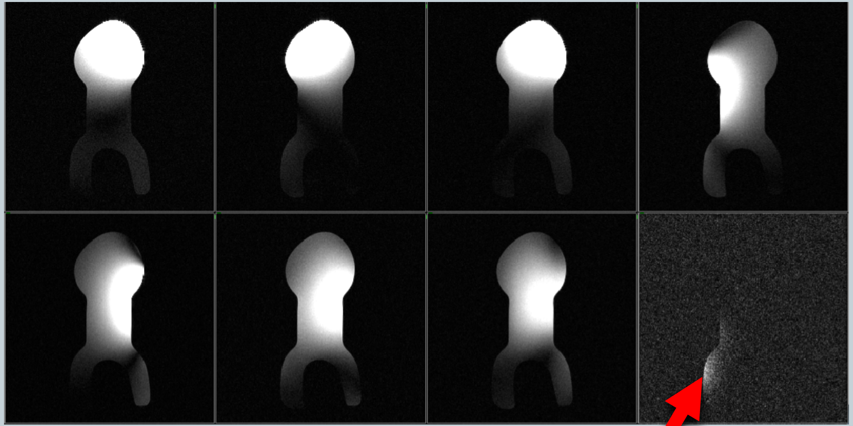
Can you tell the difference?

16 Ch Head/Neck/Spine – Example

SNR:189	SNR:198



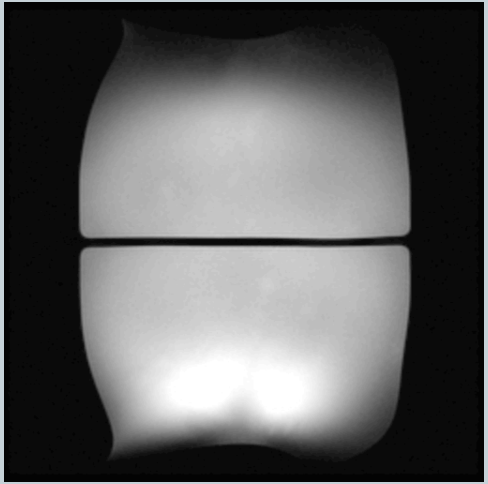
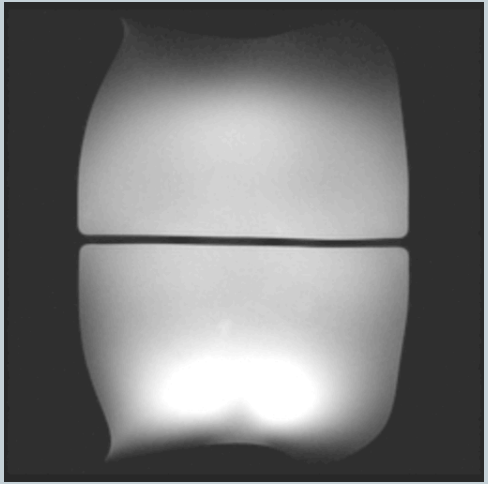
2018



2019

Each year a different channel went bad.

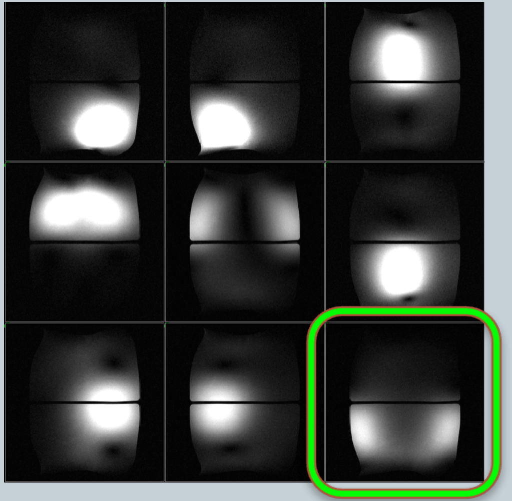
9 Ch Spine Table – Example

	SNR:109	SNR:107
		

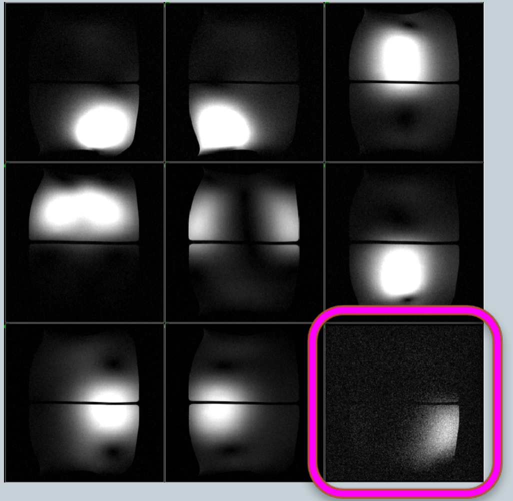
Is there really any difference?

9 Ch Spine Table – Example

SNR:109



SNR:107



Yes!

Sequence Design Considerations

Measuring the Signal

- Signal Mean is EASY
- Signal area ≈ 1/3 to 1/5 of FOV.
- ROI includes whole phantom to average out non-uniformity.

Measuring the Noise

- Sigma of Noise is harder.
- Area ≈ 2/3 to 4/5 of FOV
- Must avoid artifacts
- Want spatially uniform

My Scan Parameters

- TR / TE = 200 / 20
- BW = 244 Hz/pixel (31.25 KHz on GE, 62.5 KHz on others)
- Matrix = 256 x 256
- FOV ≈ Twice the phantom diameter in PE direction
- With large phantoms sometimes use NPW (anti-aliasing)
  - Phase encode in the long direction to leave AIR in Frequency direction
- Slices as thin as possible
  - @ 1.5T and 3T use 1.0 to 2.0
  - @ Lower fields usually no higher than 3 mm
  - Real low SNR coils on open magnets use 5 or even 10 mm

Questions to be answered:

- What is the single most important concept in RF Coil Testing?
- When measuring the SNR of any RF coil, is it more important to improve the accuracy of the signal or the noise?
- What is the best way to measure the SNR of a surface coil?

1st Question: What is the single most important concept in RF Coil testing?

REPRODUCIBILITY

- Document your setup (take pictures)
- Choose you slice location well.
- Include complete phantom in your ROI

2^{nd} Question: When measuring the SNR of any RF coil, is it more important to improve the accuracy of the signal or the noise?

Short Answer: The noise

- You want both to be accurate.
- Noise is harder to measure.
- Design your sequence to provide lots of space to measure the noise.
- Design your sequence to avoid integer truncation problems.

3^{rd} Question: What is the best way to measure the SNR of a surface coil?

- Match the size of the phantom to the sensitive volume of the coil.
- Use a FOV twice the diameter of the phantom
- Measure the signal by including ALL of the phantom.
- Measure the noise in the frequency encode direction.

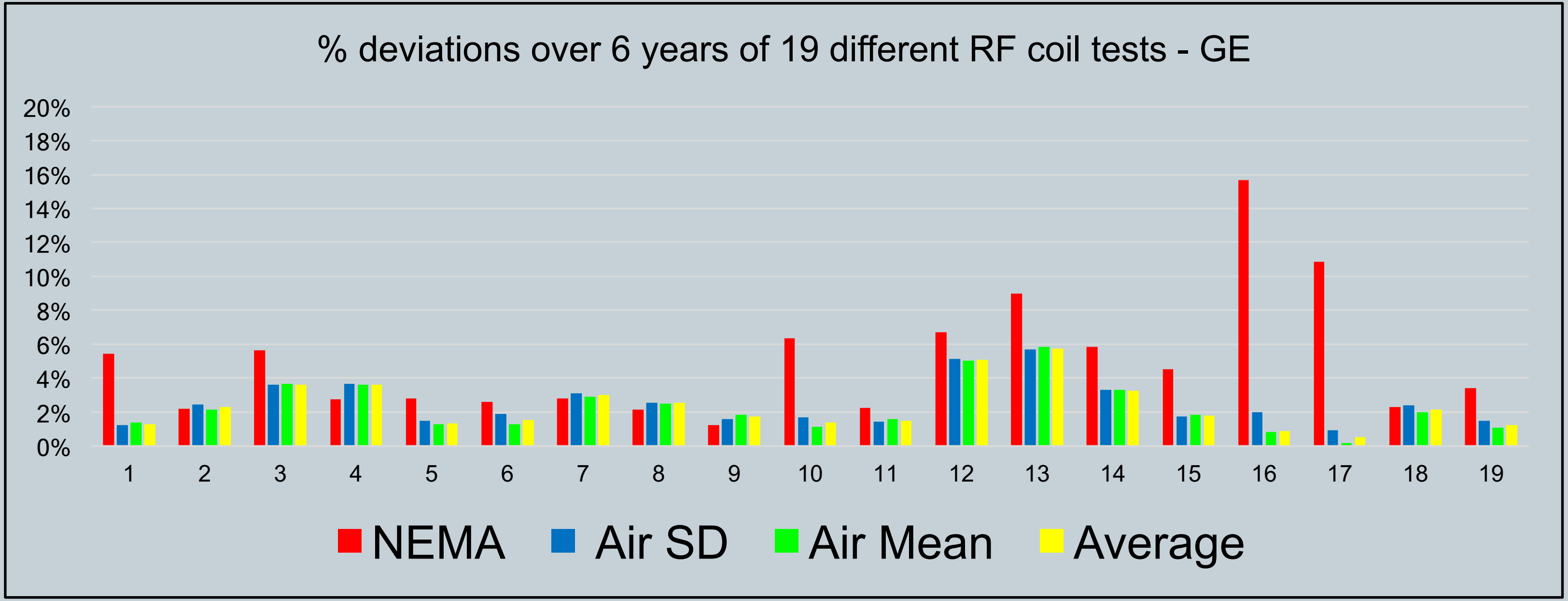
Final Question – What Method is Best?

NEMA: 10 **StdDev of Air: 17** **Mean of Air: 38**

GE Magnet N=19				
	NEMA	Air SD	Air Mean	Average
Average % deviations	4.97%	2.50%	2.29%	2.34%
Std Dev of % deviations	3.63%	1.30%	1.46%	1.40%
# time this method best	4	4	9	2
Philips Magnet N=22				
Average % deviations	9.63%	4.09%	3.85%	3.87%
Std Dev of % deviations	7.83%	1.96%	2.13%	2.03%
# time this method best	3	6	12	1
Siemens N=27				
Average % deviations	6.82%	4.71%	3.45%	3.97%
Std Dev of % deviations	4.08%	3.21%	2.18%	2.45%
# time this method best	3	7	17	0

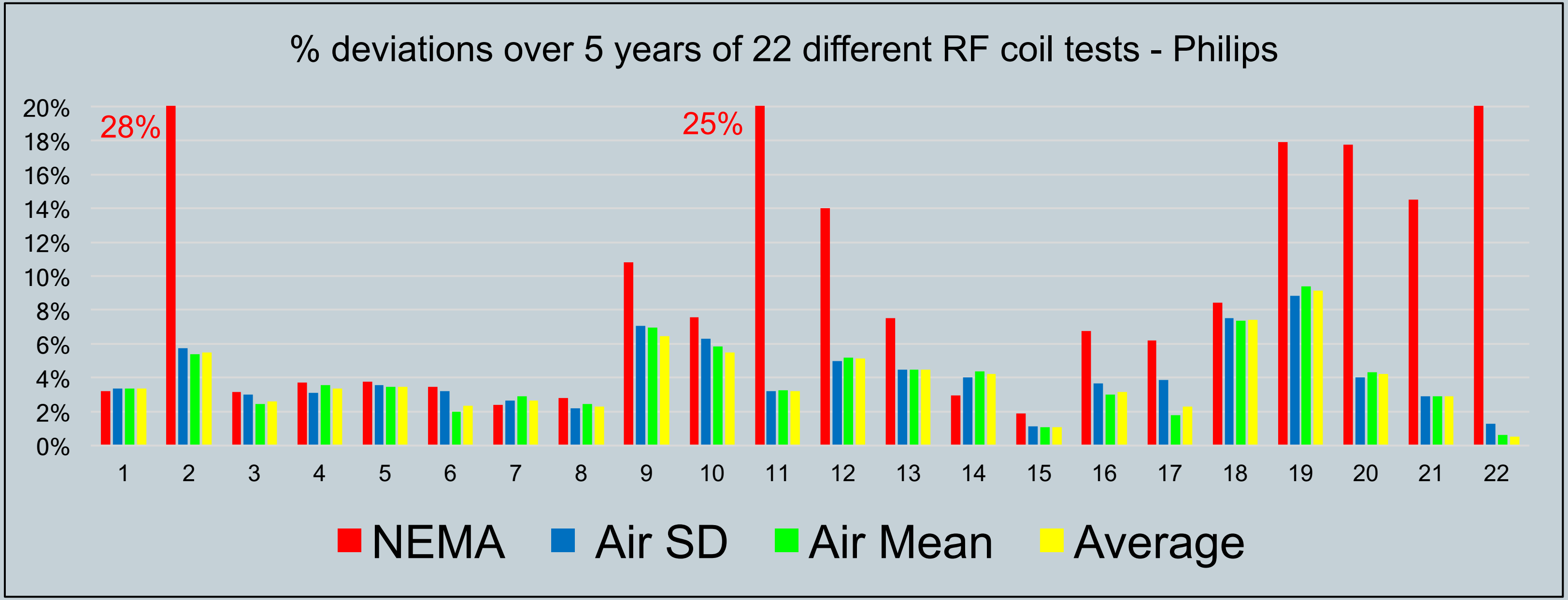
Final Question – What Method is Best?

NEMA? **StdDev of Air??** **Mean of Air???**



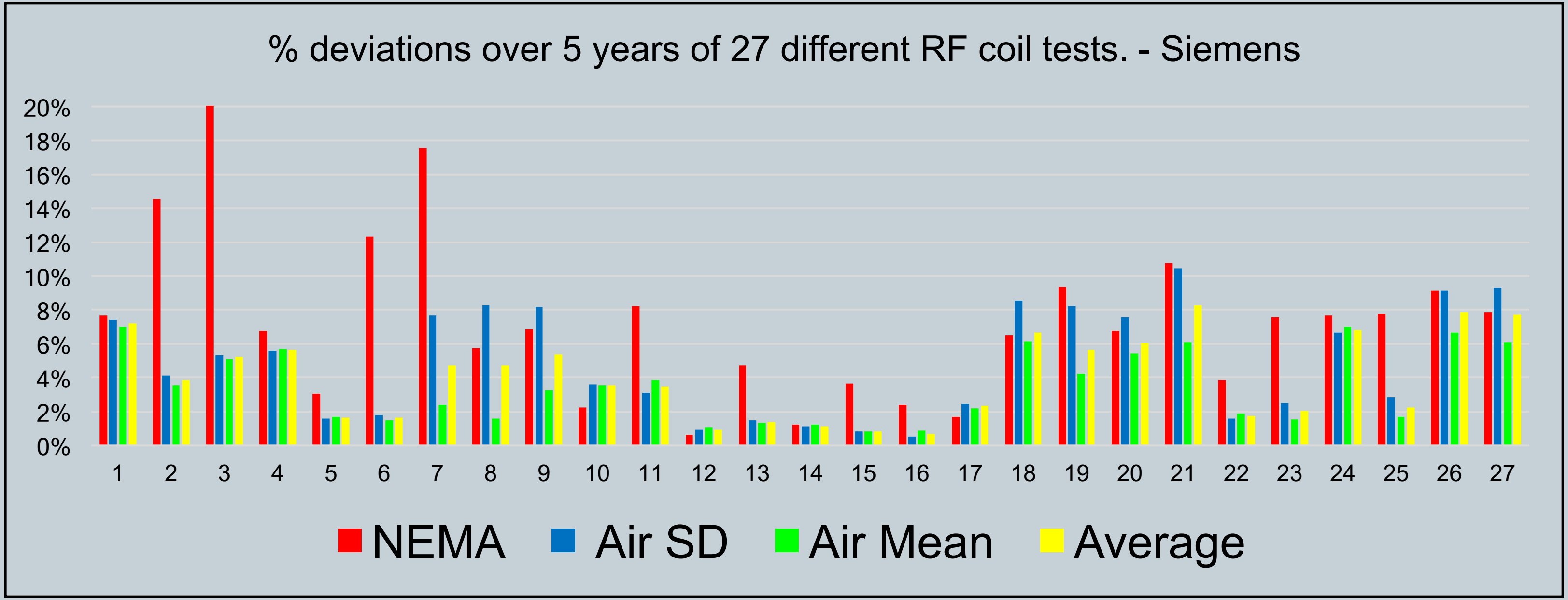
Final Question – What Method is Best?

NEMA? **StdDev of Air??** **Mean of Air???**



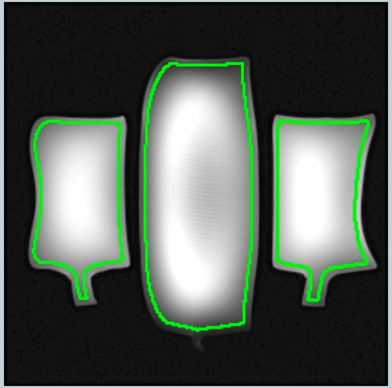
Final Question – What Method is Best?

NEMA? **StdDev of Air??** **Mean of Air???**



Phased Array Coil – Case Study

Siemens Verio (3T) Spine Coil (example of good)



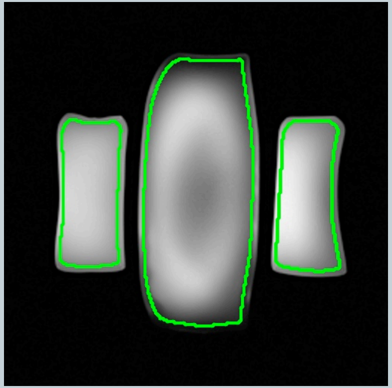
Yearly Composite SNR values

	2015	2016	2017	2018
SP12	105	96	103	106
SP34	102	95	102	104
SP56	102	99	102	105
SP78	103	99	102	105

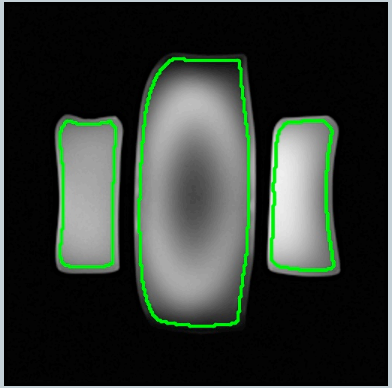
Phased Array Coil – Case Study

Siemens Verio (3T) Spine Coil (example of bad)

SP12



SP34



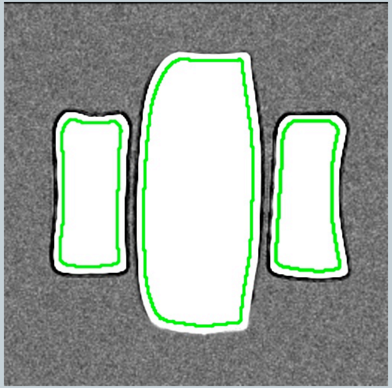
Yearly Composite SNR values

	2015	2016	2017	2018
SP12	121	127	118	120
SP34	93	90	95	92
SP56	120	126	119	119
SP78	122	125	121	122

Phased Array Coil – Case Study

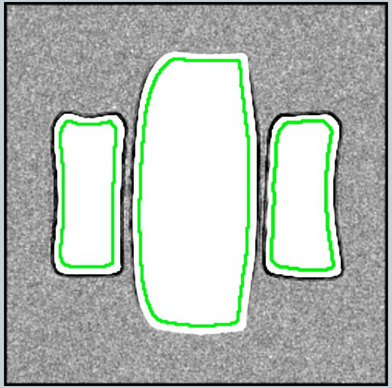
Siemens Verio (3T) Spine Coil (example of bad)

SP12



Noise Mean = 19.3

SP34



Noise Mean = 28.4

Yearly Composite SNR values

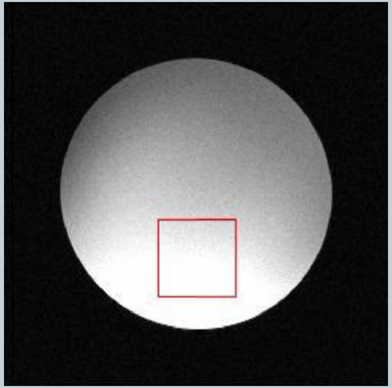
	2015	2016	2017	2018
SP12	121	127	118	120
SP34	93	90	95	92
SP56	120	126	119	119
SP78	122	125	121	122

Phased Array Coil – Case Study

Siemens Verio (3T) Spine Coil

All channels pass?

Siemens Test Image



Siemens QA Test Results: Spec > 30

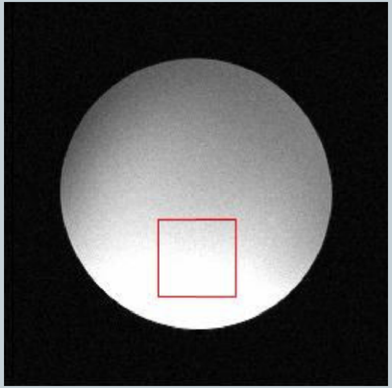
	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8
Initial Test	44.5	43.0	37.0	32.8	45.9	44.1	47.1	47.3

Siemens measures one composite image at each coil position. However, each coil position actually consists of **3** channels.

Phased Array Coil – Case Study

Siemens Verio (3T) Spine Coil **All channels pass!**

Siemens Test Image



Siemens QA Test Results: Spec > 30

	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8
Initial Test	44.5	43.0	37.0	32.8	45.9	44.1	47.1	47.3
New Coil	46.9	44.5	46.4	44.9	49.9	45.6	50.2	46.3

QA results should be ≈ > 1.5 times spec!
(On some systems they should be >2x spec.)

Obtaining Channel Images - GE

1. Enter Patient ID: geservice
2. Setup and save test sequence
3. DOWNLOAD sequence
4. Right Click on Research
5. Display CVs (Control Variables)
6. Set 'saveinter' to 1

   Save Intermediate
7. Set 'nograd' to 1

   No Gradient Warp correction
8. ACCEPT
9. DOWNLOAD
10. RUN

Obtaining Channel Images - Siemens

1. Go to System tab
2. Find and select “Save Uncombined Images”
   (Depends on Software Level)
3. Go to Resolution tab
4. Go to Filter sub-tab
5. Turn off ALL filters.

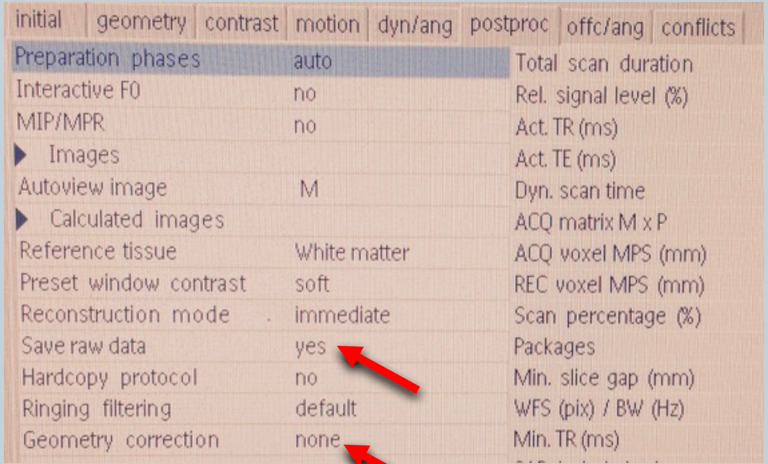
Much easier!

6. On some pre-Aera/Skyra systems there is an additional option under System tab: “Double” or ”Triple” which affect Body Matrix and Head Matrix coils.

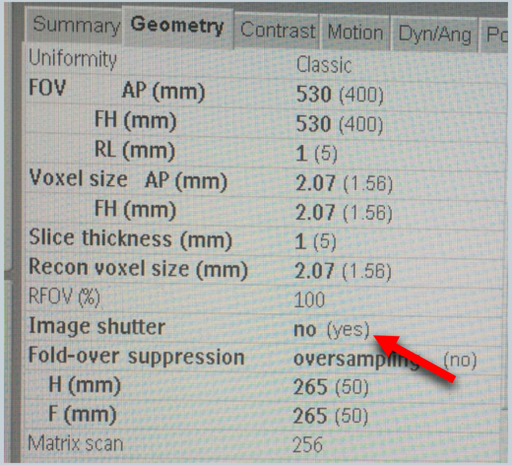
Channel Images – Philips: Pre-Ingenia

Much Much HARDER!

1. Go to ”Postproc” tab
2. Select “Save Raw Data”
3. Turn off all filters



4. Go to “Geometry” tab
5. Set “Image Shutter” to ‘no’

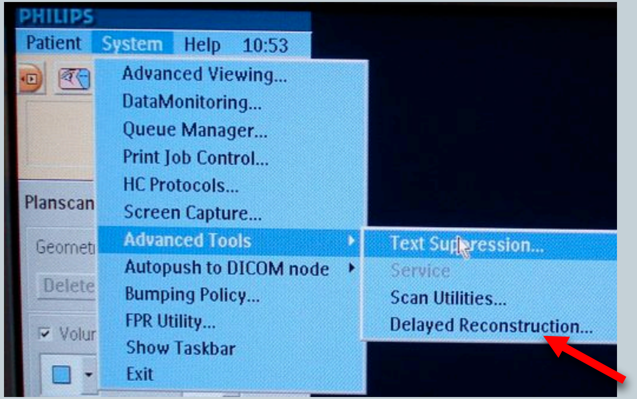


Much Much HARDER!

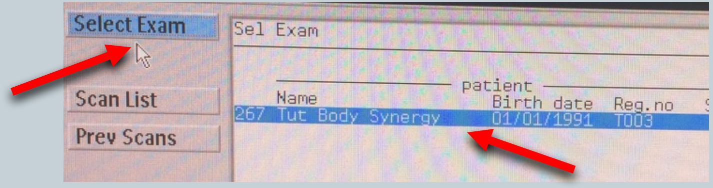
Channel Images – Philips: Pre-Ingenia

Much Much HARDER!

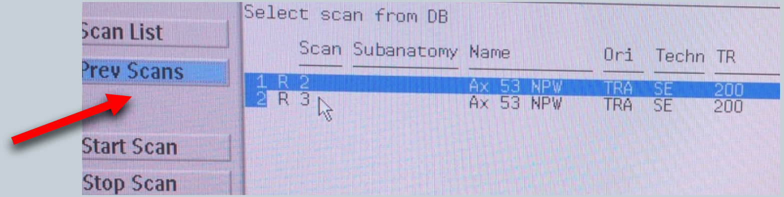
6. Run the scan
7. Now comes the hard part! Find the "Delayed Reconstruction" option



8. Select the Exam to reconstruct



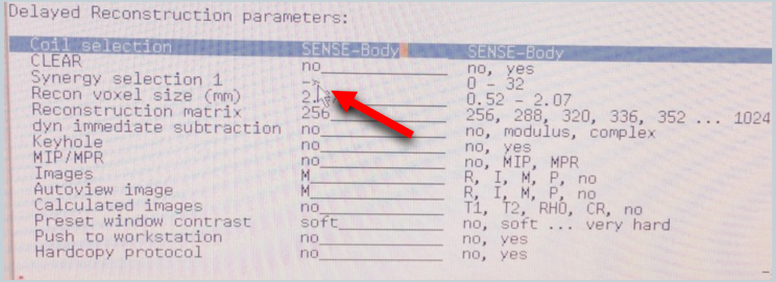
9. Select the "Prev scan" to reconstruct.



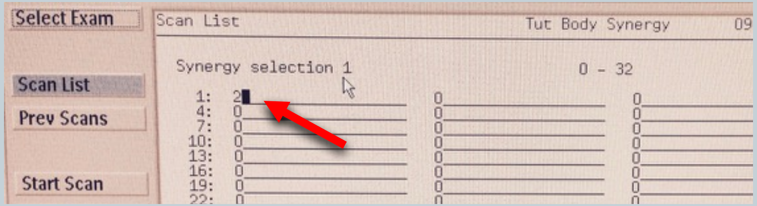
Channel Images – Philips: Pre-Ingenia

Much Much HARDER!

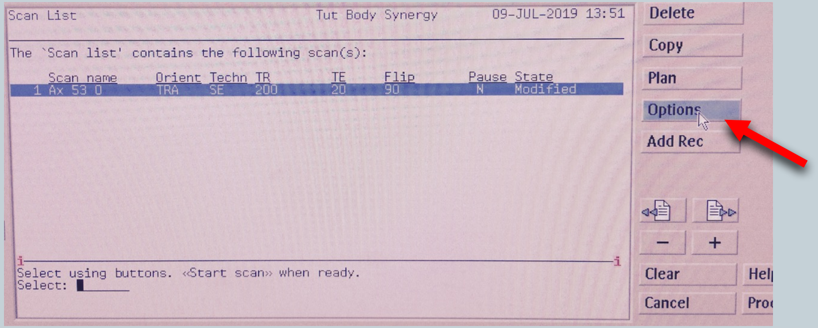
10. Select "Synergy Selection"



11. Enter the *single* channel to reconstruct.



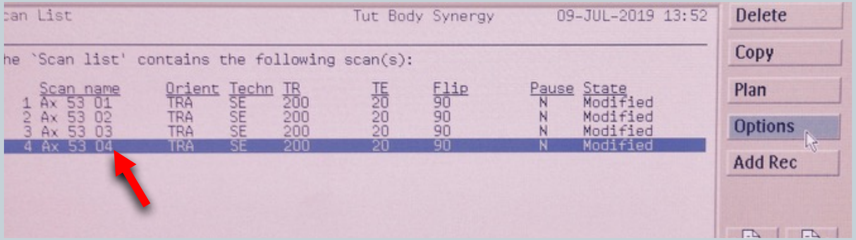
12. Go to Scan List
13. Select the scan line
14. Use "Options" to rename it with channel



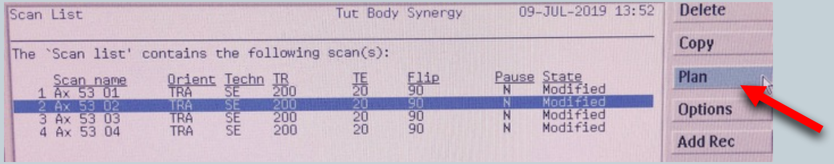
Channel Images – Philips: Pre-Ingenia

Much Much HARDER!

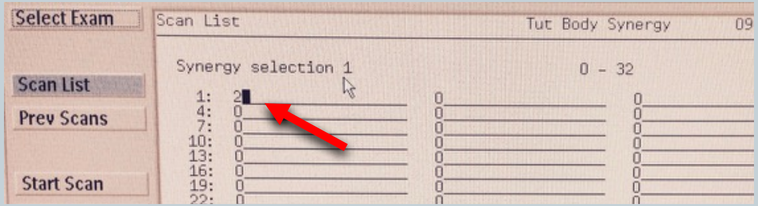
15. Copy the line for all of the channels to reconstruct. Max is 9!
16. Rename each line so you know the channel.



17. Select Plan for EACH and EVERY line, one at a time!



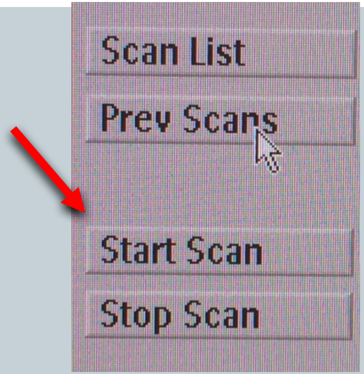
18. Change the channel #



Channel Images – Philips: Pre-Ingenia

Much Much HARDER!

19. Start Scan



20. After all channels have been reconstructed, download images to your laptop.

21. Calculate the composite image as the square root of the sum of the squares of all of the channels!

22. You're done!

(Wasn't that fun?)