Experiences in ACR MRI Accreditation - Vendor Nuances That Every Clinical MRI Physicist Should Know

By

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Prepared for

The 2013 AAPM Spring Clinical Meeting

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Validating Me

- I began my career at Baylor Medical Center in Dallas, Texas and quickly dove into consulting
- I performed approximately 1000 annual evaluations in 8 years with over 200 magnets in one year
- I have given CAMPEP accredited lectures to individual consulting groups & MTMI and performed hands on training with these groups as well
- I am now a serial AAPM presenter
- I am the self proclaimed Low Field Magnet Whisperer!
- I have no affiliation with any particular vendor, nor the ACR – aside from membership

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Annual System Performance Evaluation

- Physicist's Annual QC Tests
  - Magnetic Field Homogeneity
  - Slice Position Accuracy –discussed below
  - Slice Thickness Accuracy– discussed below
  - Radiofrequency Coil Checks
  - Inter-slice RF Interference
  - Soft-Copy Displays (Monitors)

Magnetic Field Homogeneity

- Is the uniformity of the main magnetic field strength B_0 over a designated volume typically specified in parts per million of the field strength over a spherical volume
- Can be affected by a variety of factors:
  - Perturbations by ferromagnetic structures within the bore
  - OR re-arrangements of large ferromagnetic objects in the room (i.e. a metal staircase added to the room!)
- Room temperature (!), shim coils, passive shimming with pieces of steel or adjusting gradient offsets eliminate issues

Magnetic Field Homogeneity

- Inhomogeneities contribute to:
  - Geometric distortion of images
  - Can destroy image uniformity
  - Compromise SNR in fast imaging sequences

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Magnetic Field Homogeneity

- Kat's Derived Methodology:
- So in February 2009, I had my very first client get rejected from ACR because I had not attached an evaluation of MFH in my report
- Prior to that if the unit was GE, I was able to do Spectral Peak analysis…but any other vendor had me stumped
- This particular unit was a Philips Achieva

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Magnetic Field Homogeneity

- ACR suggested Chen et als paper, which I read but felt needed a lot of help and interpretation!

manufacturer	Siemens	Toshiba	Philips	GE Signa	Elscint	Siemens	Philips
model	Viva	Opart	Intera	LX	Prestige	Trio	Achieva
Sequence used for BW	SE/GE	FE	FFE	GRE	SE	GRE	FFE
Flip Angle	15	25	35	25	90	25	25
TR (ms)	500/6.5	160	49	51.6	300	49	40
TE (ms)	20/2.4	30	10	8.5	16/90	8	9.2
Thickness (mm)	10	10	6	6	6	6	5
Matrix	256x256	320x320	320x320	256x256	320x320	320x320	320x320
BW1 (Hz/pixel)	78	24	37	8	49	80	36
BW2 (Hz/pixel)	260	122	448	122	77	1150	290
Scan Time	4:19	2:39	1:02	1:06	1:36	0:17	2:34
Tesla	0.2	0.35	1.5	1.5	1.9	3	3
MFH(ppm) by BW method for DSVs 13-22.6 cm	6.7-12.9	2.7-5.5	0.8-1.3	0.1-0.2	0.43-1.03	0.1-0.3	0.06-0.14

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Kat's Unified Theory

- Shouldn't the sphere virtually fill the diameter of the bore? Why is there no accounting for sphere diameter, at least as a normalization for geometry???
- Shouldn't all sequences be the same???
  - For PETE'S SAKE! Spin echoes REPHASE phase differences due to field inhomogeneities!!!
- Shouldn't all parameters be the same, as much as feasibly possible, across all vendors?
- Flip Angle, TR, Matrix, FOV, Slice Thickness, even time should be roughly equivalent…

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Sequence Choice for MFH

- Gradient echoes DO NOT refocus the effects of main field inhomogeneity – generally used with a short TE (GRE echoes are used on Siemens, GE and Hitachi Scanners). Field Echoes (FE are used on FONAR & Toshiba)
- Or Coherent Gradient Echoes can be used as they are very sensitive to magnetic field inhomogeneity (they include: FFE (Philips), GRASS and FISP
- MPRAGE sequence can also be used on Siemens, but these typically are 3D, and converting to a slab of zero requires a little work

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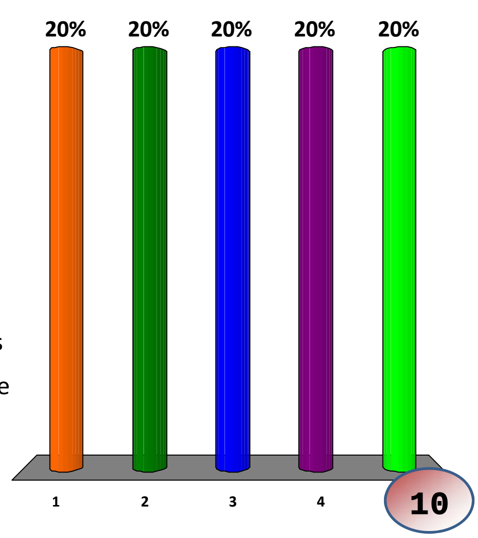
The appropriate sequence to capture magnetic field inhomogeneities is:

1. SE because it allows for full rephasing of the dephased proton
2. TSE because it applies a 180º rephasing pulse and multiple echoes
3. GRE because it does not refocus the effects of the main field inhomogeneity
4. STIR because it shows decreased sensitivity to field inhomogeneities
5. FLAIR because the time is set to the zero crossing point of fluid



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Ref: "Theory and application of static field inhomogeneity effects in gradient-echo imaging", Journal of Magnetic Resonance Imaging Volume 7, Issue 2 (March/April1997), p 266-279

Magnetic Field Homogeneity

- The Hitachi is rather straightforward
- Place their large sphere on the table (pad to isocenter)
- Plug in the GOEZINTO

MFH on Hitachi

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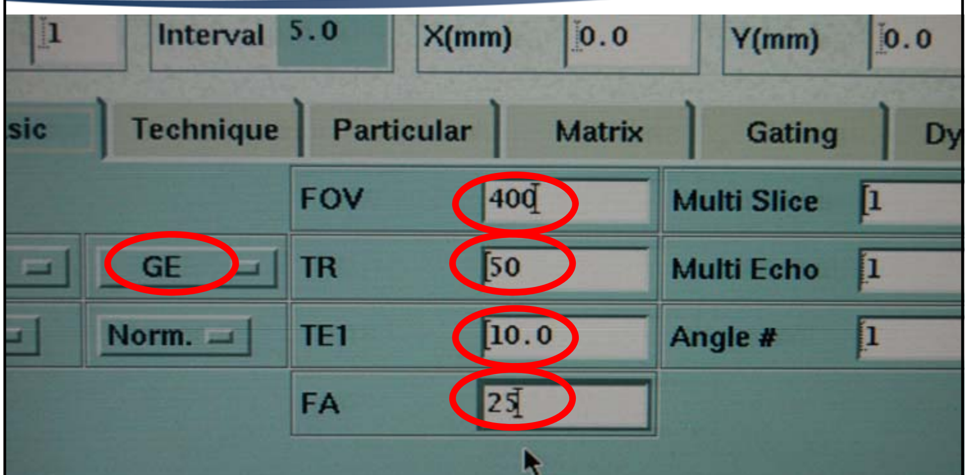
Setting Parameters on Hitachi



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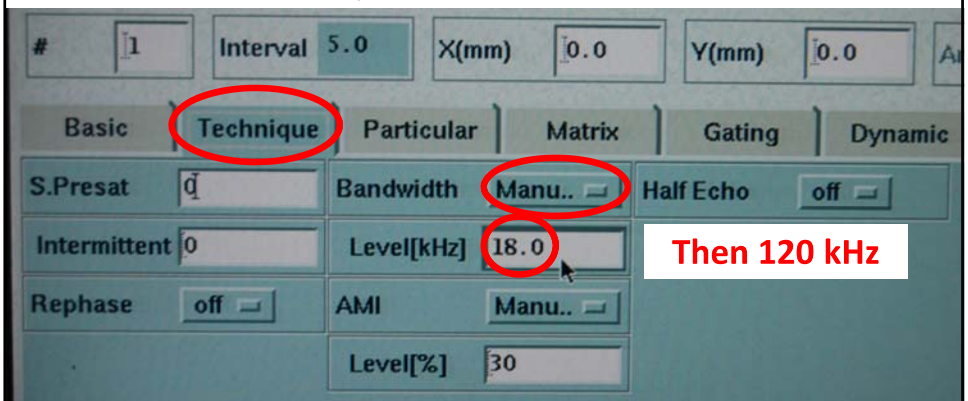
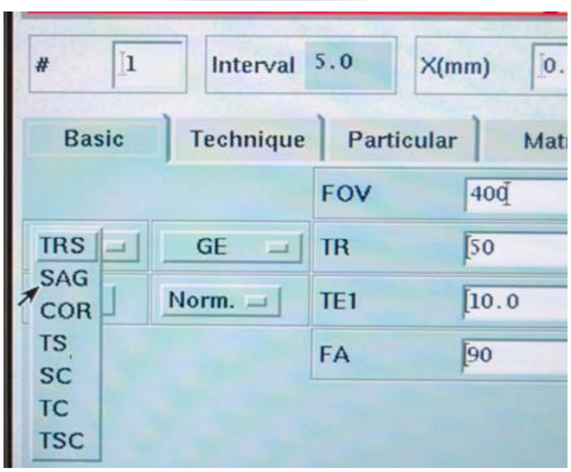
Adjusting Bandwidth

- Under the Technique tab, set Bandwidth to Manual and adjust kHz



Changing Planes



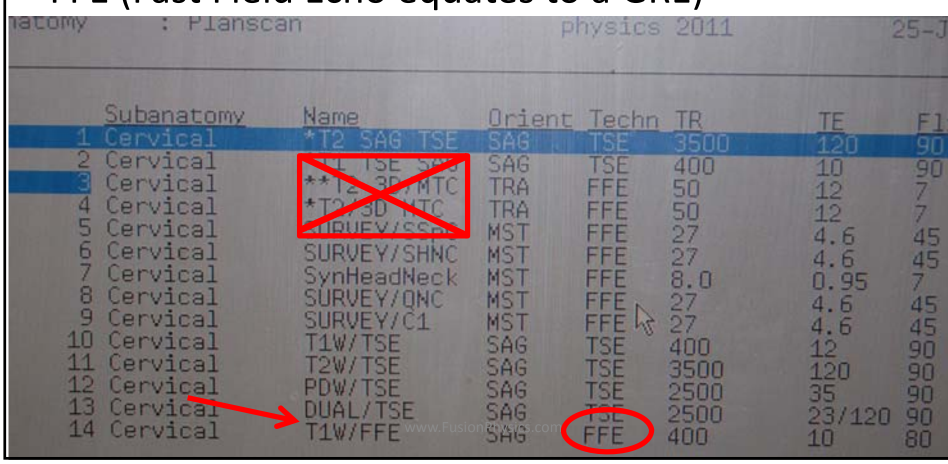
- Keeping all other parameters the same, change planes once you have run the scan at a low and high bandwidth

Creating MFH Test on Philips

- Check under the Contrast tab first
- From the ACR T1 protocol, you may simply be able to change the sequence from a SE to FFE
- If not, use the steps provided in the next slide

Creating MFH Test on Philips

- Under Anatomy, select cervical, find T1 weighted – FFE (Fast Field Echo equates to a GRE)



	Subanatomy	Name	Orient	Techn	TR	TE	Fl
1	Cervical	*T2 SAG TSE	SAG	TSE	3500	120	90
2	Cervical	[illegible]	SAG	TSE	400	10	90
3	Cervical	[illegible]	TRA	FFE	50	12	7
4	Cervical	[illegible]	TRA	FFE	50	12	7
5	Cervical	[illegible]	MST	FFE	27	4.6	45
6	Cervical	SURVEY/SHNC	MST	FFE	27	4.6	45
7	Cervical	SynHeadNeck	MST	FFE	8.0	0.95	7
8	Cervical	SURVEY/QNC	MST	FFE	27	4.6	45
9	Cervical	SURVEY/C1	MST	FFE	27	4.6	45
10	Cervical	T1W/TSE	SAG	TSE	400	12	90
11	Cervical	T2W/TSE	SAG	TSE	3500	120	90
12	Cervical	PDW/TSE	SAG	TSE	2500	35	90
13	Cervical	DUAL/TSE	SAG	TSE	2500	23/120	90
14	Cervical	T1W/FFE	SAG	FFE	400	10	80

Philips MFH

- The trick for parameter manipulation is as clear as MUD for Philips
- BE AWARE!
- Philips boasts that changing the FOV also changes resolution, bandwidth and gradient waveform, so changing FOV also changes image quality
- You must determine FOV then manipulate pixel size to maintain a matrix of 256x256, which is not necessary on the exam card mode of scanning

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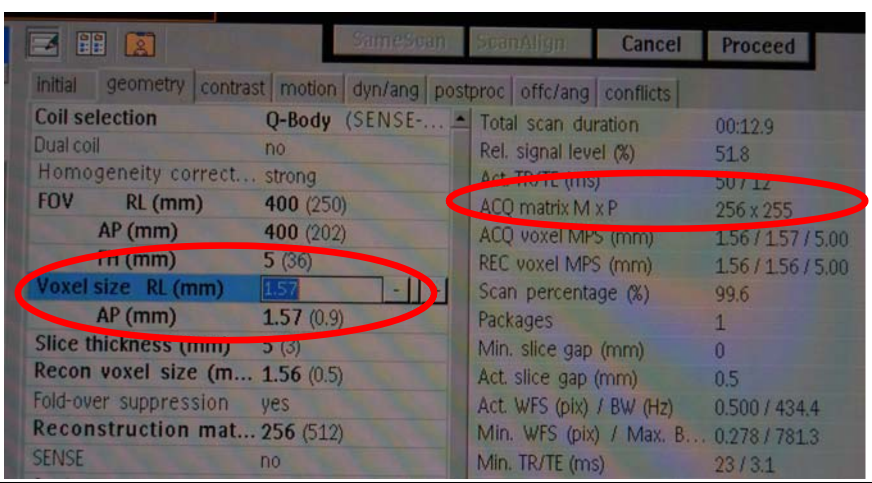
Philips MFH

- This is also very important during coil testing!



Easiest Way to Change Pixel Size on the Philips Scanner

- Right/Left arrow keys allow for greatest and fastest control
- Pretty spiffy, once you get used to it!

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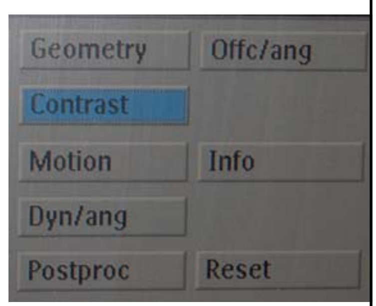
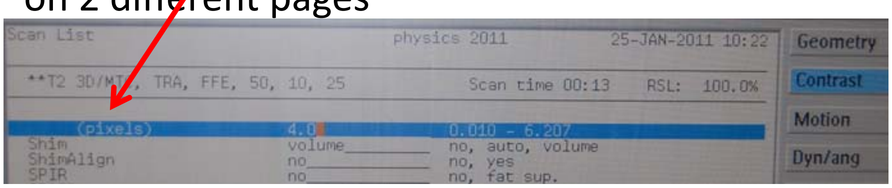
Philips MFH

- Set parameters TR, TE, FA, FOV, matrix, then under Contrast Tab—make sure you are 2D and adjust water/fat shift from

0.5 to 4 (this may appear on 2 different pages





Philips MFH

- Water-fat shift (in pixels) is inversely proportional to Bandwidth (if other parameters remain the same) – you MUST ensure this!!!
- I always force matrix to be 256 x 256 for ease

Water-fat shift	Bandwidth
Reduce water-fat shift to reduce chemical shift artifacts	**Increase bandwidth** to reduce chemical shift artifacts
Reduce water-fat shift to reduce metal artifacts	**Increase bandwidth** to reduce metal artifacts
Increased water-fat shift increases SNR	**Narrowing bandwidth** increases SNR
Reduce water-fat shift to reduce readout duration and echo spacing, and limit blurring	**Increase bandwidth** to reduce readout duration and echo spacing, and limit blurring

Philips Bandwidth Calculator

Calculating bandwidth from WFS or vice versa

To calculate bandwidth from WFS for 3.0T:

BW [kHz] = 0.22 x matrix_{freq} / WFS [pixels]

To calculate WFS from bandwidth for 3.0T:

WFS [pixels] = 0.22 x matrix_{freq} / BW [kHz]

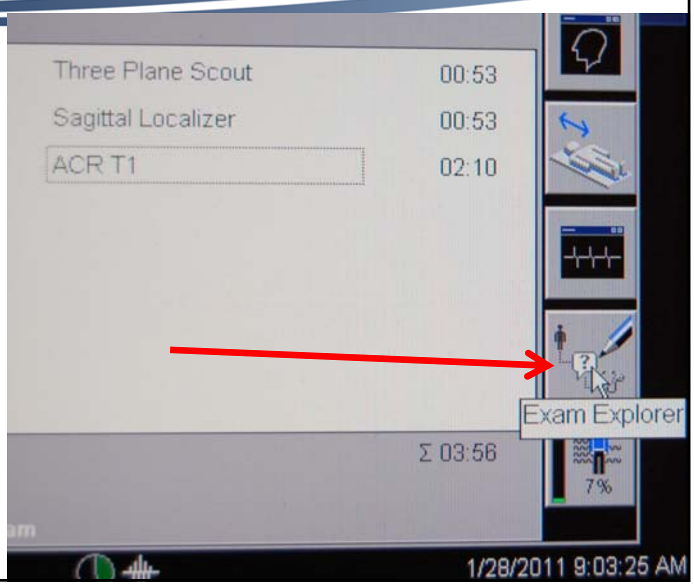
For other field strengths the same formulas apply, but replace 0.22 by 0.11 for 1.5T, or by 0.074 for 1.0T.

Philips Bandwidth Calculator

- FYI – on the Panorama software (0.23T) bandwidth is already displayed in kHz under the optimization in the Acquisition tab

Siemens MFH

- Click on the Exam Explorer which is the pencil scribbling icon in the lower right corner and you can build ANYTHING!



Siemens MFH

- Be sure to continually check your system tab throughout the testing of a Siemens unit to ensure that you are on the appropriate coil – my suggestion is to turn AutoCoil Select OFF during testing and be sure to turn it back ON when you leave!
- Also, regularly verify that the coil is correct when you are browsing through the images by looking in the bottom left corner

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Siemens Receiver Bandwidth

- Determining the Receiver Bandwidth – under the Resolution tab, record the Base Resolution (N_f). Under the Sequence tab, record the Bandwidth in Hertz/Pixel (Hz/Px)

Receiver Bandwidth = Pixel Bandwidth x ($1/2N_f$)

AGAIN! I force the Matrix to be 256x256, for ease of calculations

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ONI Extremity Magnet

Different diameter sleeves fill the bore – I choose 160 mm to scan the small ACR phantom

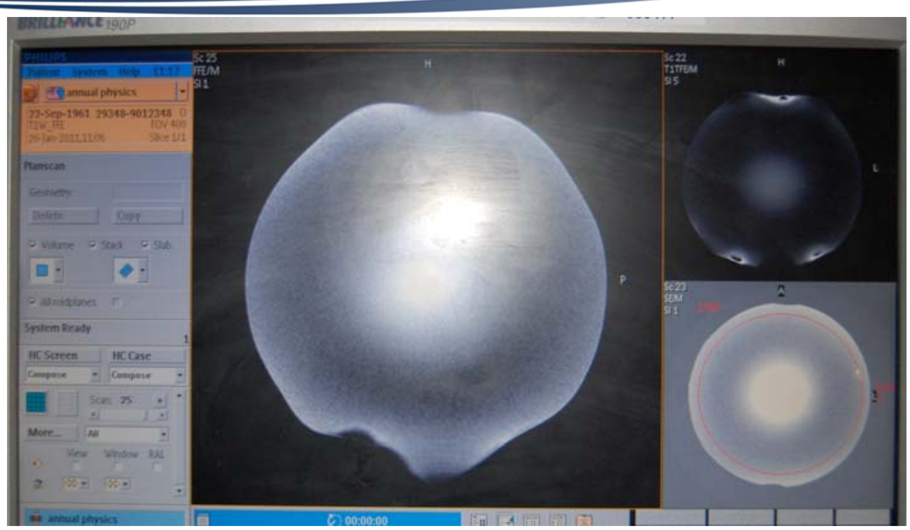
MFH For the Extremity Scanner

- I carry a small 10 cm, slightly larger than a baseball, GE sphere for doing magnetic field homogeneity on specialty magnets (you should get one too!)
- Again getting the phantom to isocenter can be challenging use blankets
- Manipulating bandwidth is easy on the ONI

MFH Values

- The 2004 ACR MRI Quality Control Manual states that typical values are around 2 ppm over a 30 to 40 cm diameter sphere
- My PQI project was done on >175 magnets of varying field strength with either a 24 cm, 28 cm or 30 cm sphere from 2009 - now
- I found standardly that low field magnets should display < 5 ppm and high field magnets should be < 1 ppm.

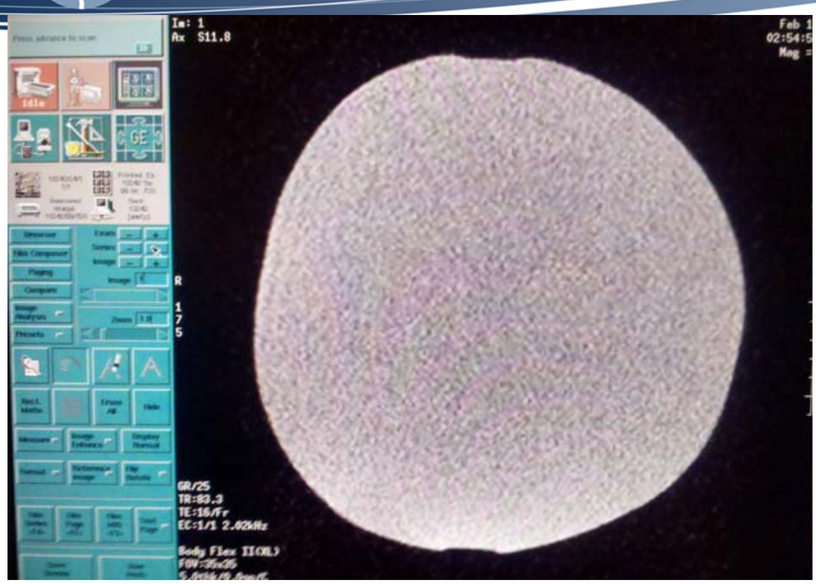
When MFH Fails



Nuances per Vendor

- GE almost never fails, but when it does, it requires service
- 1 time I found GE in need of a gradient shim (which if you can wait on service, only takes 20 min for them to complete)
- Most often if a failure happens it is in the ACR sagittal localizer (which is the Z gradient) GE always makes this short to keep other parameters in tolerance

Gradient Shim, Please!



From the ACR

- In an effort to maintain the Gold Seal of Accreditation, the ACR is implementing ICAMRL and JCAHO requirements for P&P manuals and safety
- The ACR states:

"The annual medical physicist/MR scientist performance evaluation must also include an assessment of the MRI safety program (signage, access control, screening procedures and cryogen safety) as well as an inspection of the physical and mechanical integrity of the system."

From the ACR

- As the MP, you may be questioned on these topics:
- The ACR states:

"The MR equipment specifications and performance shall meet all state and federal requirements. The requirements include, but are not limited to, specifications of maximum static magnetic field strength, maximum rate of change of magnetic field strength (dB/dt), maximum radiofrequency power deposition (specific absorption rate), and maximum auditory noise levels."

New from the ACR

- You are allowed to collect phantom images 6 months in advance of submission (although Phantom Data Scanning Form online entry only allows date < 4 months)
- "Annual" testing can be up to 14 months
- Image submission is now electronic
  - The site may select electronic at the onset of the application process
  - Use ClearCanvas Workstation
  - Use TRIAD at https://triad.acr.org/downloads.htm

You've evaluated MFH, now what?

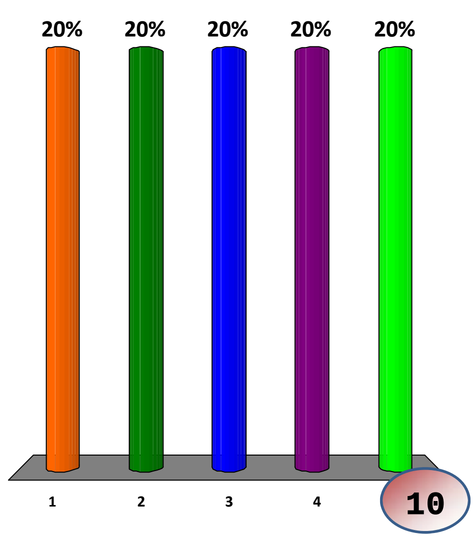
- You are the consultant physicist and you've been hired to test a magnet for ACR submission, you've never been to this facility and you have no idea how qualified the tech is…
- First, you must assess the phantom. Are there bubbles? If yes, you should fill the phantom with distilled water. You will need:
  - A 5/16th nut driver. Sears sells them individually for $7
  - A syringe, with a blunt tip needle, no need to injure anyone!
  - Distilled water
  - Gloves & tissues or paper towels

Why Gloves?

- The phantom is filled with 10 millimole Nickel Chloride and 45 mmol Sodium Chloride (which simulates biological conductivity and comes with it's own MSDS sheet – I URGE you to read this document!
- Nickel Chloride is toxic and potentially carcinogenic, particularly in dry form
- If a phantom (any MRI phantom) breaks please treat it as a hazardous materials spill

Nickel Chloride is

1. Toxic and potentially carcinogenic
2. Is most dangerous in dry form
3. Used in the ACR phantom to simulate biological tissue
4. Is green in color
5. All of the above



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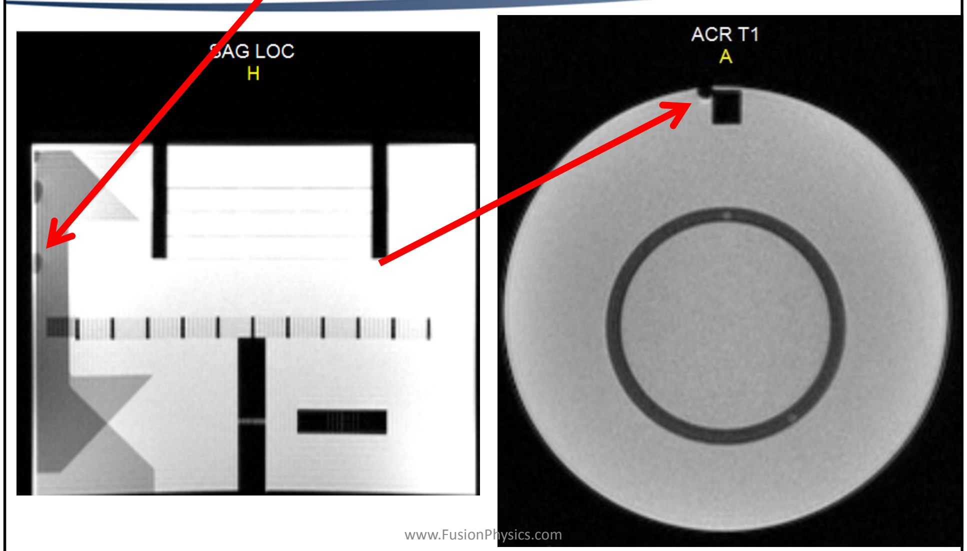
Ref: "Material Safety Data Sheet – Liquid Nickel Chloride" ScienceLab.com, (2012)

Bubble in the phantom



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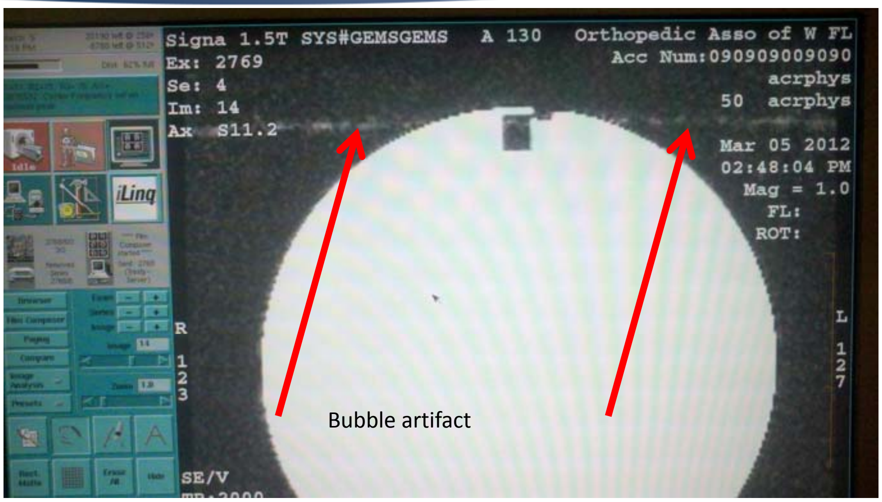
Bubble in the phantom



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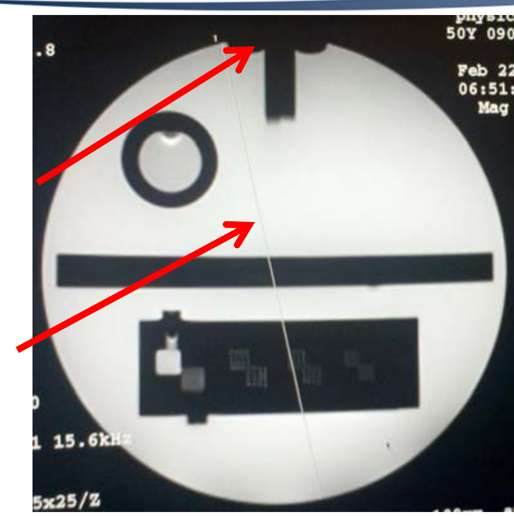
Bubble in the phantom



- The ACR suggests that the technologist measure slightly off-center for the weekly Geometric Accuracy QC if there is a bubble, but as the physicist, you should only submit the best images possible, so do your part and eliminate the bubble!

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Location, Location, Location

- Setting up the phantom is based on many parameters
- The most important element is that **you** are always consistent!
  - If you are not positioning the phantom yourself, you can't be sure from year to year that there is consistency
    - i.e. – Don't have the technologist position the phantom! Take your watch off and get in the game!

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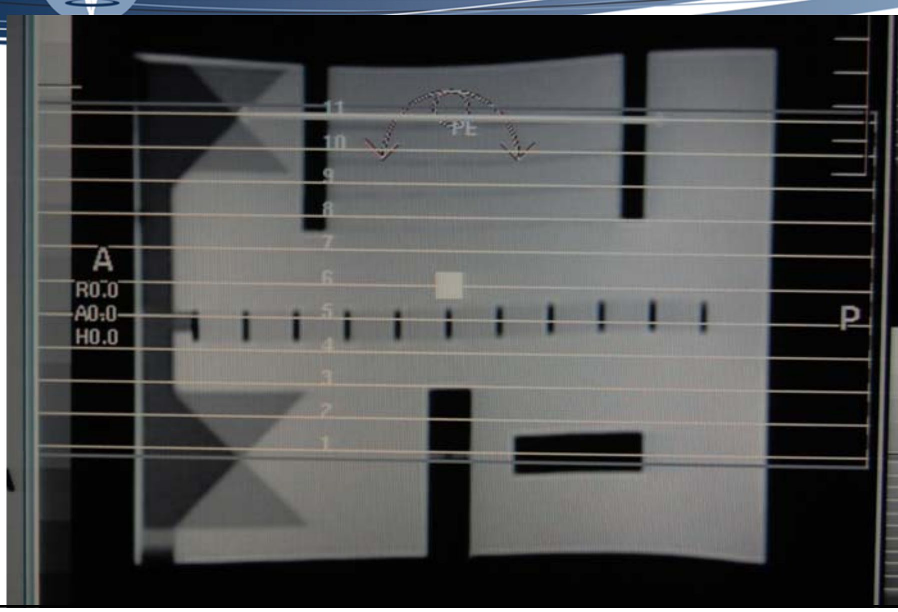
Well, it is an Opart…



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Something tells me….

- Susceptibility artifact, you bet!
- Metal in the magnet??? For sure!

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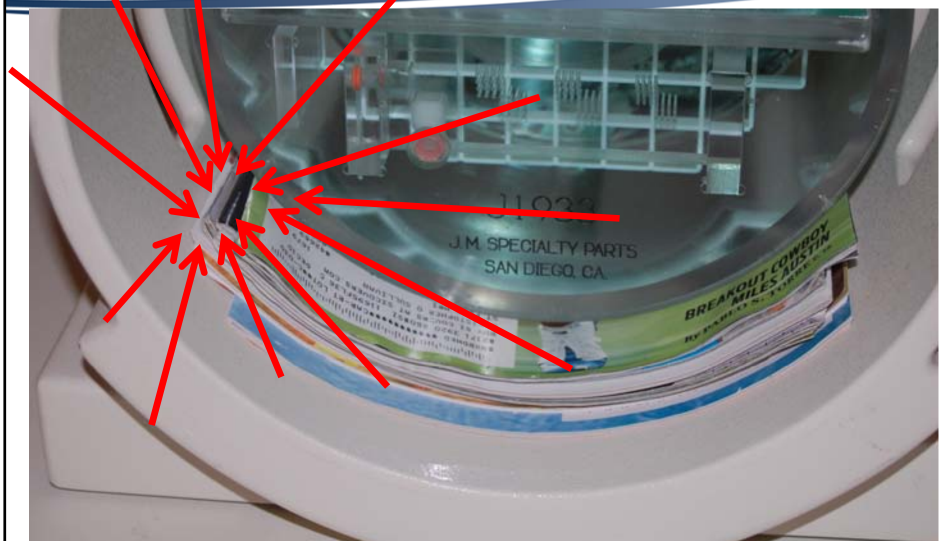
Anyone see a problem here?

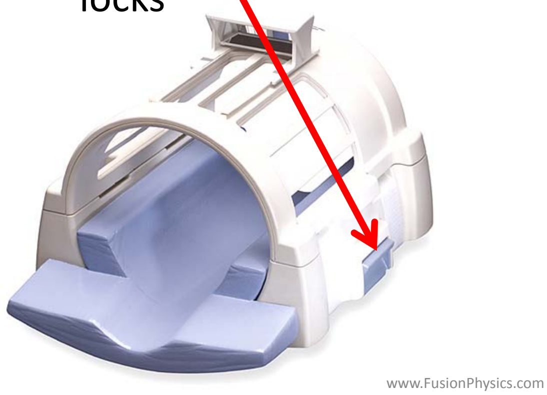


Choosing the Coil

- The ACR has mandated that the coil that is used for imaging clinical brains MUST be the coil that is used to scan the ACR phantom. PERIOD.
- If a facility has a Quadrature (Birdcage) Coil and an 8 Channel High Resolution Brain Coil, you MUST ask which coil is being used clinically (almost never is it the Birdcage – Bummer!)

Minimizing Motion Artifact

- If there are locks on the head coil, be sure to click locks into place or slide head coil until it locks



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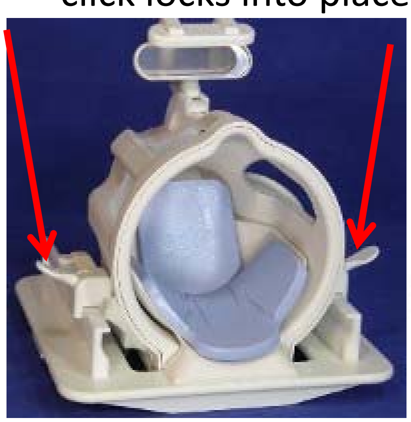

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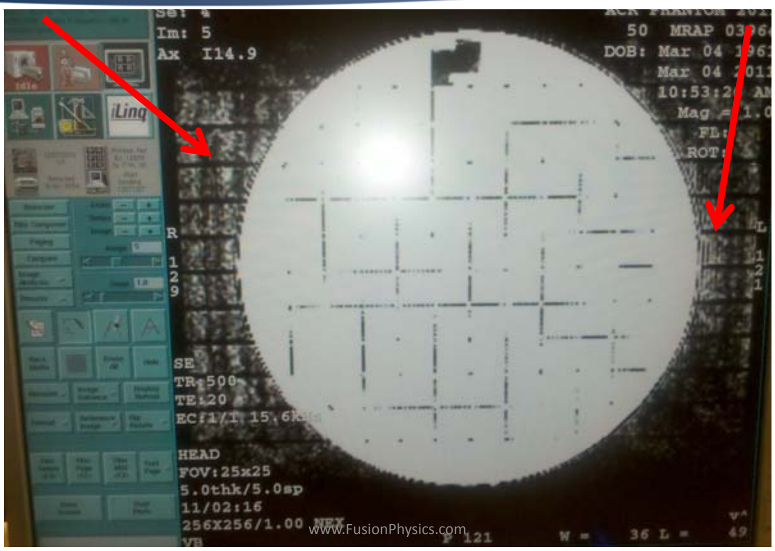


Minimizing Motion Artifact

- My trade secret is to use cushions or pads that are available in the MR suite to stabilize the phantom within the coil itself
- If the phantom cannot vibrate within the coil itself then we have eliminated 1 source of motion/ghosting artifact
- Actually worked with a service guy on a Hitachi Airis I who went into traffic trying to minimize road vibration!

Minimizing Motion Artifact

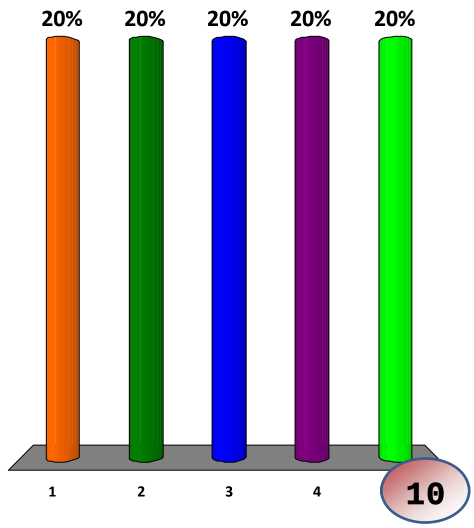
- Another trick is to flip PE with FE to diminish ghosting
- Motion is one of the few artifacts that is seen in the PE direction only. Why?
- FE fills in quickly (in the time of TE), PE fills in more slowly thereby allowing motion artifact to accumulate
- Flipping PE and FE will allow you to troubleshoot many artifacts

Minimizing Motion Artifact

- Additional sources of motion can occur outside the phantom and the coil
- To further eliminate motion:
  - It may be necessary to turn off the cold head (I have found this to be true on every model Toshiba makes and other vendors now due to the world-wide Helium shortage)
  - Scan with the room lights **OFF**! Loose filaments in the bulbs can cause a pulsing in the RF signal which leads to artifacts

These artifacts are seen only in the phase encode direction:

1. Ghosting and Flow
2. Chemical Shift and Aliasing
3. Susceptibility and Truncation
4. Zipper and FID
5. Partial Volume and Arcing



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Ref: "A short overview of MRI artefacts", SA Journal of Radiology (2004) p 13-17

Side Bar on Lights

- Please be aware that Compact Fluorescent Light bulbs (CFLs) diminish your SNR by 20% without creating a visible artifact
- If you notice that SNR has decreased by 20% on every coil from your previous year's measurements, suspect the light bulbs first
- So to steal signal wherever you can on a low field magnet, change your bulbs and of course....lower your bandwidth!

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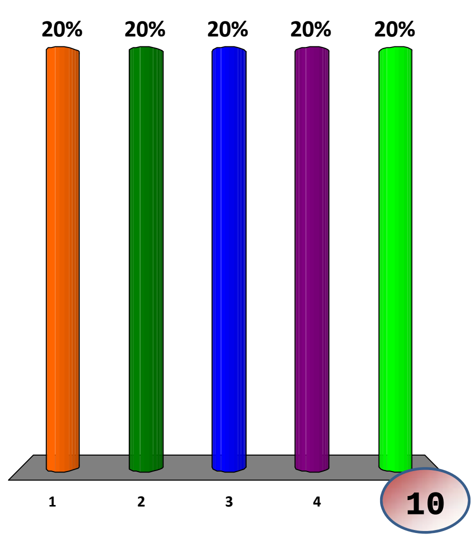
Which of the following is NOT a reason for motion in an MRI image?

1. Cryogen Boiling
2. Mechanical Vibrations
3. Large iron objects moving in the fringe field
4. Loose connections in the room lights
5. A leak in the Faraday cage



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Ref: "MRI artifacts and correction strategies", Future Medicine, (2010), 2(4), p. 445-457

Getting the Phantom to Isocenter of the Coil

- Tried and true method is the cheap stack of printer paper
- Do **NOT** use phantom cradles – expensive and induce artifacts!
- Every facility has paper and the stack should be taped and labeled for future use (once the proper number of sheets is determined)
  - Be sure to include in your kit: a plastic ruler, wooden shims, tape & a sharpie to label the paper
  - I suggest measuring the front edge of the phantom to the top of the coil and recording that measurement for future use

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Positioning the Phantom

- This particular skill set is an art, I assure you
- You will need a half a ream of printer paper for a birdcage coil, wood shims and a plastic level (also available at Sears)
- You will need a quarter of a ream of printer paper for an 8 Channel Brain coil, wood shims, plastic level and do **NOT** use alcohol prep pads (they can create a metal artifact seen on slice 11)
  - Positioning the phantom in the High Res coil requires finesse, but is fairly easy once you adjust!

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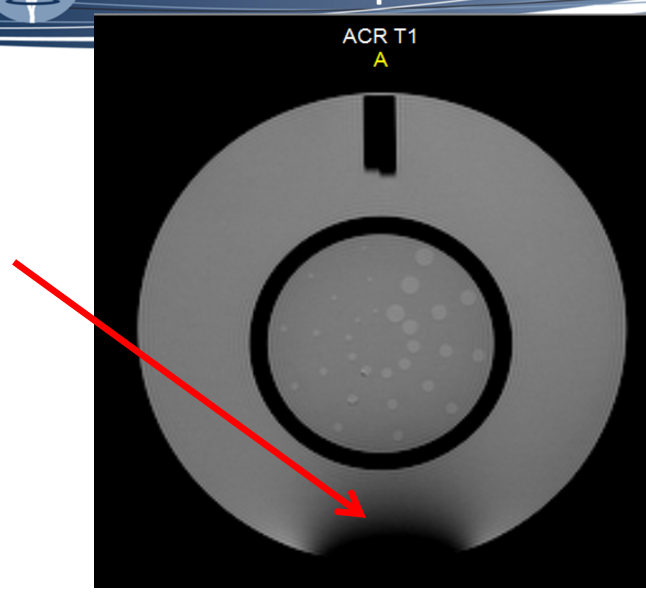
Alcohol Prep Pad Artifact



Positioning the Phantom

- It is vital that you position the phantom in all 3 planes within the coil
- Most physicists only try to level the phantom in the x and y dimensions of the coil, but the “yaw” of the phantom can fail a low field magnet for LCD in a heartbeat, it will also cause you to fail slice thickness accuracy on a Siemens 1.5 T, which is notoriously on the high side

3 Plane Localizer

- The use of a 3 plane loc
  - ACR does NOT require a 3 plane loc, only a sagittal loc
  - Typically any skew will be in the Z dimension (along the table), which is indicated by a tilt in the coronal plane
  - If you are on an open that does not have the ability to do a 3 plane loc in one scan, then you need to add an axial and coronal scout to the sagittal that is stored in the ACR protocol list. My suggestion is to drop the TR to 50 for these 2 scans so the total scan time is 13 sec per instead of the 56 sec scan for the ACR sag

3 Plane Localizer

- What the 3 plane loc also provides is a way to determine the phantom's location in the saddle
- If you are low axially, you are not at isocenter within the coil – which causes a multitude of issues with uniformity on any magnet, but is particularly problematic for low field strengths that are struggling for signal

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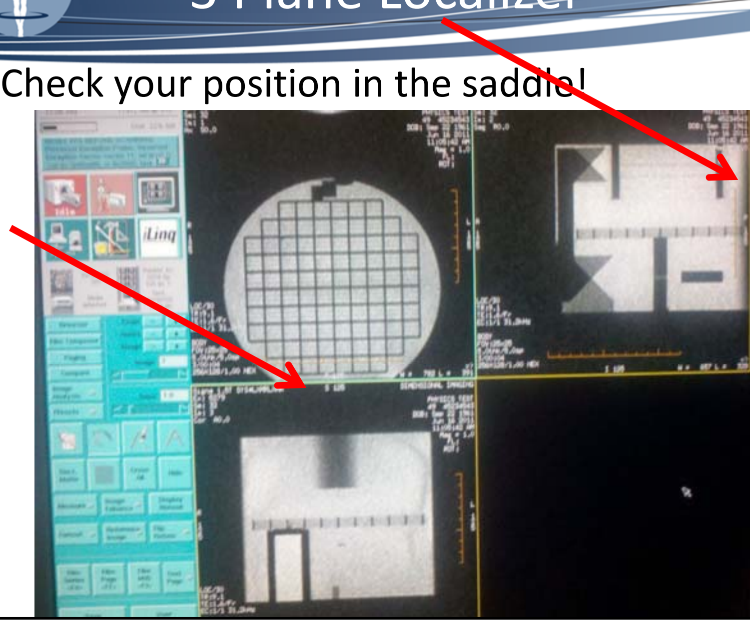
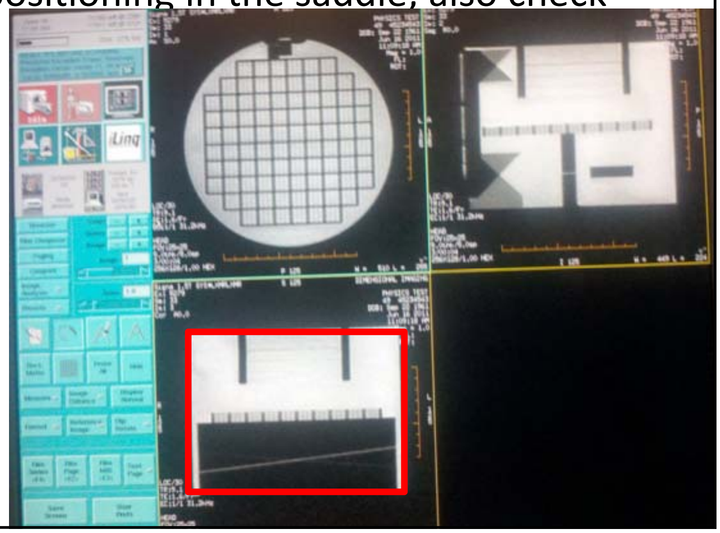
3 Plane Localizer

- Check your position in the saddle!



3 Plane Localizer

- Perfect positioning in the saddle, also check skew



Before you do anything else!!!

- I CANNOT emphasize this enough!!! VERIFY that all parameters for the ACR protocols are correct! NEVER EVER trust if someone else saved the protocols!

Times will vary based on Vendor

Pulse Sequence Acquisition Parameters

Study	Pulse Sequence	TR (ms)	TE (ms)	Field of View (cm)	No. of Slices	Slice Width (mm)	Slice Gap (mm)	NEX	Matrix		Receiver BW (kHz)	Scan Time (min:sec)
ACR Localizer	Spin Echo	200	20	25	1	20	N/A	1	256	256	Not Reported	0:56
		√	√			√	√		√	√		√
ACR Axial T1	Spin Echo	500	20	25	11	5	5	1	256	256	Not Reported	2:16
		√	√		√	√	√		√	√		√
ACR Axial T2	Spin Echo	2000	20/80	25	11	5	5	1	256	256	Not Reported	8:56
		√	√		√	√	√		√	√		√

Toshibas use 25/90

The entire ACR program was built on GE, so times are almost always correct for GE

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Helping the Technologist & Yourself

- Before you plan to scan the phantom according to the site's protocols, I suggest that you verify that their pixel resolution meets the ACR guidelines
  - In plane pixel (phase) = FOV_p/N_p
  - In plane pixel (frequency) = FOV_f/N_f
  - Pixel area = $(FOV_p/N_p) \times (FOV_f/N_f)$

FOV_p = Field of View phase — N_p = # of phase encode steps

FOV_f = Field of View frequency — N_f = # of freq encode steps

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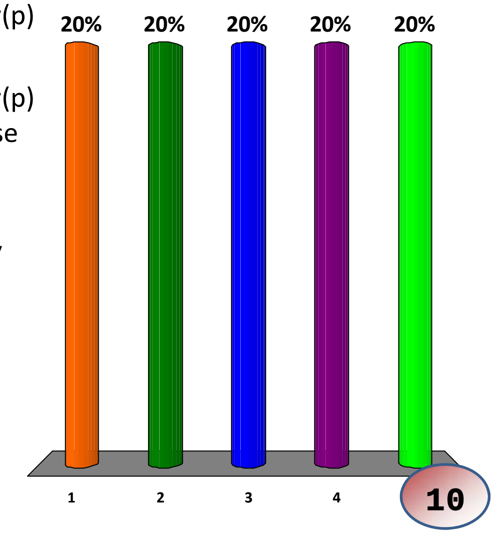
Pixel Resolution is:

1. Measured by the Field of View(p) divided by the pixel area
2. Measured by the Field of View(p) divided by the number of phase encode steps
3. Measured by the Number of phase encode steps divided by the Field of View(p)
4. Measured by the pixel area divided by the Field of View(p)
5. None of the above



Pixel Resolution is:

1. Measured by the Field of View(p) divided by the pixel area
2. Measured by the Field of View(p) divided by the number of phase encode steps
3. Measured by the Number of phase encode steps divided by the Field of View(p)
4. Measured by the pixel area divided by the Field of View(p)
5. None of the above

Ref: "MRI Accreditation Program Clinical Image Quality Guide", American College of Radiology, (2012) p 4

Pixel Resolution

- You may be asked to assist in doing the math on all clinical studies, refer to MRAP Clinical Guide under MRI Testing and QC Forms for limits
- For the clinical brain –
  - slice thick $\leq$ 5.0 mm
  - slice gap $\leq$ 2.0 mm
  - In plane pixel (read) $\leq$ 1.0 mm
  - In plane pixel (phase) $\leq$ 1.2 mm
  - Pixel area $\leq$ 1.2 mm^2

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Large Phantom Data Scanning Form

Pulse Sequence Acquisition Parameters

Study	Pulse Sequence	TR (ms)	TE (ms)	Field of View (cm)	No. of Slices	Slice Width (mm)	Slice Gap (mm)	NEX	Matrix		Receiver BW (kHz)
ACR Localizer	Spin Echo	200	20	25	1	20	N/A	1	256	256	Not Reported
		√	√			√	√		√	√	
ACR Axial T1	Spin Echo	500	20	25	11	5	5	1	256	256	Not Reported
		√	√		√	√	√		√	√	
ACR Axial T2	Spin Echo	2000	20/80	25	11	5	5	1	256	256	Not Reported
		√	√		√	√	√		√	√	
Site's T1 Brain	Spin Echo			Freq: Phase:	11	5	5				
Site's T2 Brain	Fast Spin Echo			Freq: Phase:	11	5	5				
				T1				T2			
	ACR T1 and T2 Filters Applied:										
	Site T1 and T2 Filters Applied:										
	Phantom Serial Number:			0							

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Nuances per Vendor

- GE 8 Ch. Head Coil vs. Birdcage – Any HR Brain coil requires SCIC or PURE be turned on to pass uniformity
- The button is next to the Graphic RX button on the control panel
- NEVER EVER use the ZIP512 filter on GE when collecting a phantom image on the site protocols, this filter was designed for even # of slices!

Nuances per Vendor

- Siemens – tricks to pass the phantom on a Viva or Concerto – struggles with LCD, must run Site Protocols with NO FILTERS on and increase the NEX as high as possible to still stay under the 35 min time limit on the brain protocol.
- Siemens – Symphony if it fails, it will fail slice thickness accuracy by being too large – turn on Large FOV, Distortion Correction, Prescan Normalize. If playing with filters doesn't help, adjust the bandwidth to minimum. I have also had to play with gradient speed.
- Siemens – Espree – due to short bore, the unit is more susceptible to uniformity & homogeneity issues

Nuances per Vendor

- Philips – Intera or Achieva subtle differences in every magnet I have sat in front of.
- MFH on their 3T struggles in the Z direction
- When a Philips 3T struggles with uniformity – you must play with CLEAR on and SENSE off and homogeneity strength to find what works

Nuances per Vendor

- Philips – I have not yet met a Panorama 1.0T
- Panorama software (0.23T) is completely different than the software that is used on the Intera or Achieva. One edition of their software allows for use in Exam Card Mode and Scan List, but not true for the Panorama or Ingenia
- Ingenia and Achieve R3.2.1.0 software and newer requires exiting the imaging platform to obtain CF and TG information for each scan
- Also, to properly tune a Philips coil, a new patient must be created for each and every coil.

Nuances per Vendor

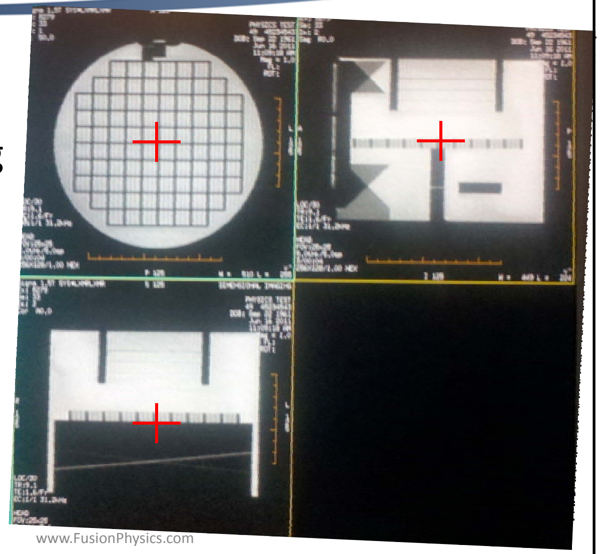
- Toshiba – Both high and low field strengths (yes, the Opart has a chiller) -requires that the cold head be turned OFF prior to collecting phantom images for submission to eliminate ghosting/motion artifact – most good techs know how to do this **REMEMBER** to turn the cold head on again prior to clinical scanning or your magnet might quench.
- Be sure to tell Service to address the motion caused by the vibration of the cold head

Nuances per Vendor

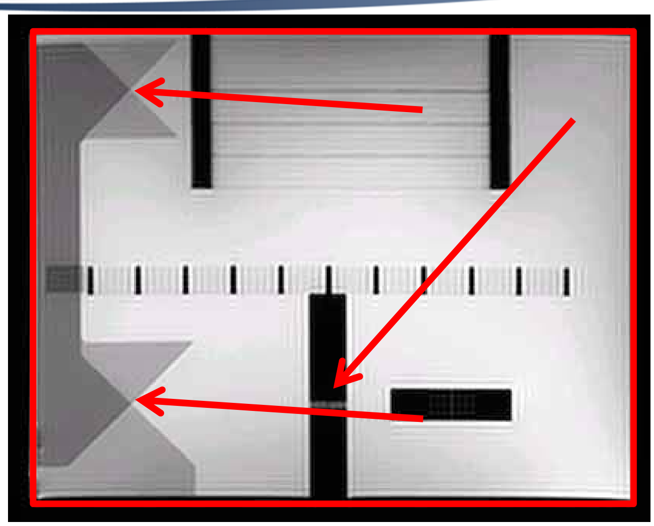
- Fonar – (all software) requires that Fonar service through the facility's phone line turn off the weighting factor for phantom image collection to pass uniformity **REMEMBER** call Fonar service again prior to clinical scanning and have weighting factor turned on
- The first time you do a Fonar, bite your tongue and schedule WITH FSE, it will save time. You will not be used to thinking in the planes that Fonar uses the ACR phantom and the software is tedious at best

Planning the Sagittal Loc

- From the 3 plane loc, position the sag loc so that it is perfectly centered



Perfectly Positioned Sagittal



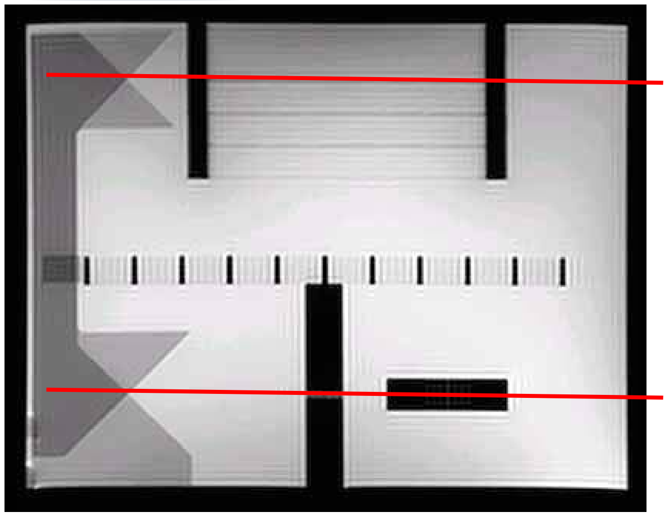
Verifying the Sagittal Loc

- If you have positioned everything perfectly, the sag loc should fit in a rectangle
  - And the two ramps at the centered will form 1 straight line
  - 2 wedges should be of equal prominence, if they aren't check that your slice thickness is the required 20 mm

Oddities you may note

- In the sagittal localizer:
- There maybe a swoop in the upper right corner, this is due to geometric distortion. This is expected! Don't kill yourself trying to get rid of it.
- There maybe a hump in the middle as we saw above (if you are on a Siemens with Syngo software – apply distortion correction & normalize filters to eliminate these expected artifacts)
- There maybe a zipper artifact slightly left of off-center due to the width of the slice being so large (20 mm) – seen typically on GEs

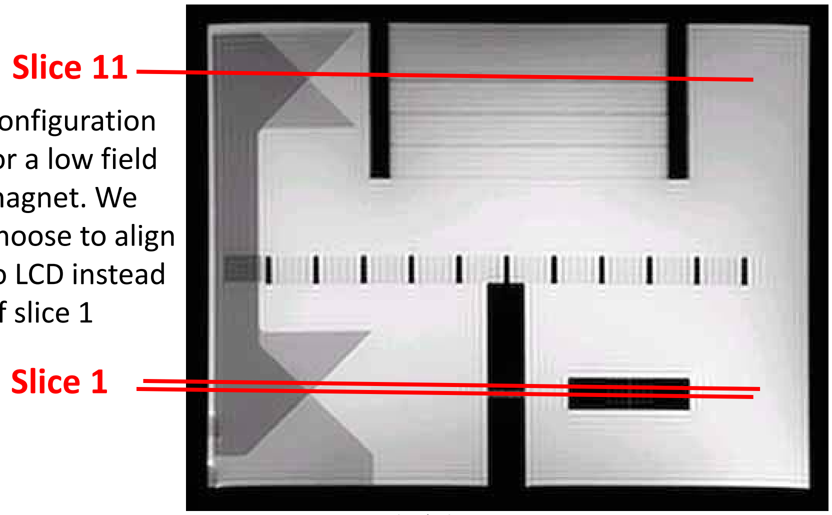
Planning the ACR T1



Planning the ACR T1

- Ideal position of slice prescriptors is right through the apex of both wedge sets
- HOWEVER, this almost never works out
- You must choose which way to plan your scan, bear in mind the limitations of the system you are on
- As low field magnets struggle with LCD it is best to make sure that the center of slice 11 is perfectly aligned to the last row of LCD objects

Planning the ACR T1



Configuration for a low field magnet. We choose to align to LCD instead of slice 1

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Planning the ACR T1

- Ideal position of slice prescriptors is right through the apex of both wedge sets
- HOWEVER, this almost never works out
- You must choose which way to cheat
- As low field magnets struggle with LCD it is best to make sure that the center of slice 11 is perfectly aligned to the last row of LCD objects
- For high field magnets its (especially 1.5 T Siemens) aim for slice 1 to be perfect, as LCD isn’t even a test on this field strength

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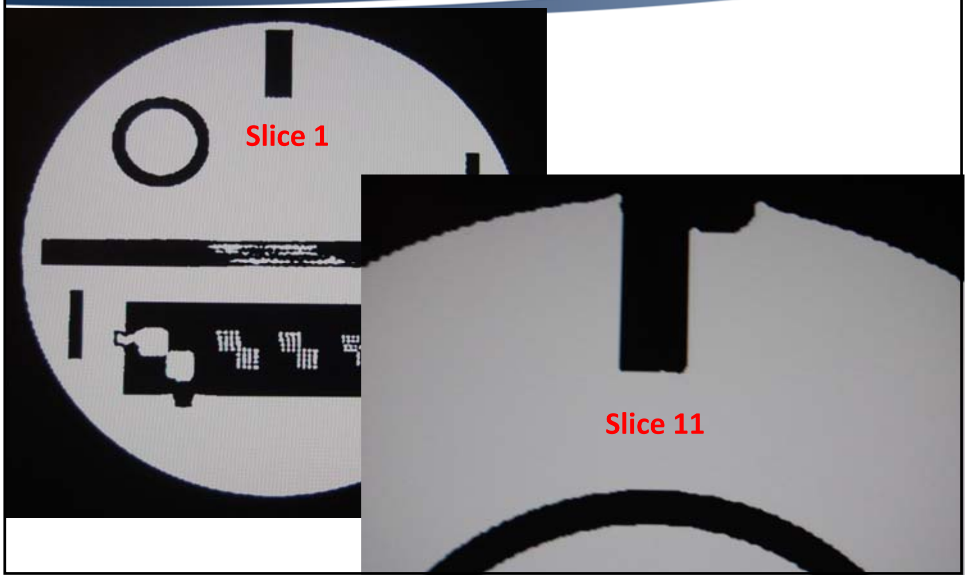
Checking Positioning on T1



Scanning the ACR T1

- If the wedge is long on the same side this is a positioning error
- If the wedges are long on opposite sides, this is a GAP error and service must be called if slice position accuracy fails (GE's downfall because they shorten the distance in the table direction, making the sag geometric accuracy fail, so the gap is shortened AND this does cause slice position accuracy to fail)

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Geometric Accuracy

- GE chronically fails this test by making the sag loc too short, normally on the order of 145 mm by calibrating the gradient along the table axis according to their specs
- If the unit is a low field GE (Profile or Ovation) speak to FSE prior to you visiting. Ask them to exceed their specs in the table direction (keep in mind this is NOT the Z gradient on a low field) in order to pass slice position accuracy

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Geometric Accuracy

- Why do we check accuracy on Sag Loc and both directions on Axial Scan?
- Why do we check accuracy on slice #1 AND #5? Or slice #1 and #3 on the small phantom?
- Typical failure is on the diagonal, whether it be short or long. This is the Z dimension (on a high field)! So why is the Z dimension so susceptible to failing this test? Bore gradient design is different for Z than for X and Y

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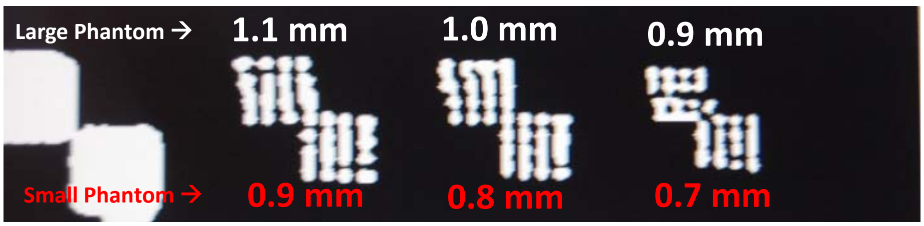
High Contrast Resolution

- I only mention this test here, as it causes more confusion than any other test
- Trick is to Window to min & Level independently!
- You MUST see 4 dots across 1 row in UL and 4 dots in 1 column in LR!

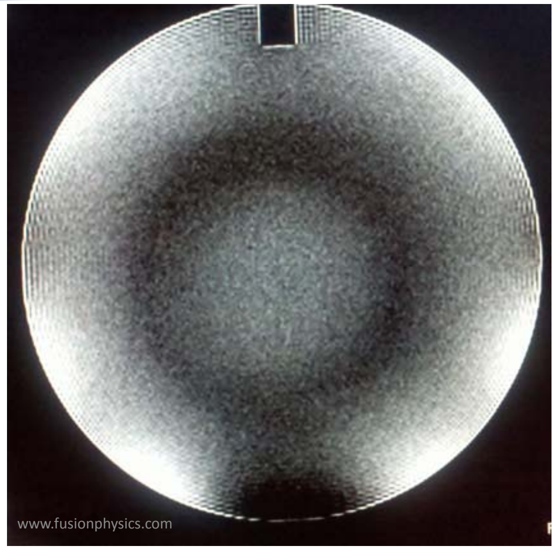


Measuring Slice Thickness

- The only scanners I have seen this fail on is Siemens 1.5T, turn on Large FOV, Normalize and Distortion Correction Filters
- If you still struggle to pass this test, try minimizing the bandwidth and you should pass
- If you still fail, contact service, typically this indicates a problem with the RF amplifier
- Philips Enhanced DICOM shortens the slice thickness as visualized by KPACS! Measure again in KPACS prior to submission

Ever seen this on a Siemens?

- Slice 7 on a Siemens scanner, doesn't appear uniform, there appears to be cross talk from slice 8… why is this visible? Remember, Siemens is always large on their slice thickness measurement??



Uniformity Measurement

- Window to minimum
- Raise level until first signal is seen in the large ROI that you have created
- Record this as the Minimum signal (I know this sounds dumb, but make sure this value is LESS than your mean)
- Raise level until the last pixel of signal is seen
- Record this as the Maximum signal (again, this number will be MORE than your mean!)
- My point is to ensure that you don't end up with a uniformity measurement of > than 100%

Uniformity Failure

- Location is everything! Make sure the phantom is at isocenter of the head coil!
- If the top of the birdcage is not secured to the bottom, you may see a failure (ALWAYS check the coil!)
- Poor uniformity goes hand in hand with decrease SNR
- If the phantom is properly positioned, call service
- Philips 3Ts require that you play with a number of factors to pass uniformity – including SENSE, Clear and Homogeneity strength (remember reduced criteria for 3T!)
- On a 8 Ch. Brain coil, make sure to turn SCIC on!

Percent Signal Ghosting

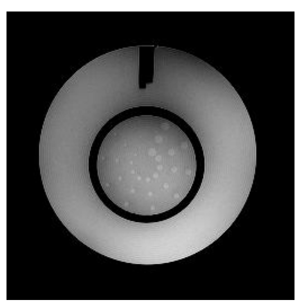
- First, if you fail this test numerically, every other test has already failed, which should be ridiculously obvious and shouldn't require a single measurement

Ghosting Artifacts

- Phantoms may rarely fail the percent signal ghosting numerically, but there will often be mention of a ghosting artifact
- Site T2s because they are chronically a Fast/Turbo Spin Echo will show increased ghosting, this is expected, but don't let it be excessive
- Shove pads into the head coil to minimize motion of the phantom, this should help with ghosting on the site T2

Improving LCD

- Make sure the prescription slices that you choose cheat to slice # 11
- Make sure you are not skewed in the Z direction



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Establishing the Tech's QC

- The Medical Physicist's job is to establish the Tech QC's limits and perform any training that maybe required
- Training a tech on their system means you need to know where to find the data they need
- So let's go!

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Tracking Center Frequency and Gain on GE

- This could not be easier on the GE scanner select the idle button then while the T1 is scanning, in the upper left hand corner AX is displayed, as is TG.
- AX is center frequency and TG is transmitter gain
- Or you can use the text page button below if the scan is already complete – see next slides

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Tracking Center Frequency and Gain on GE

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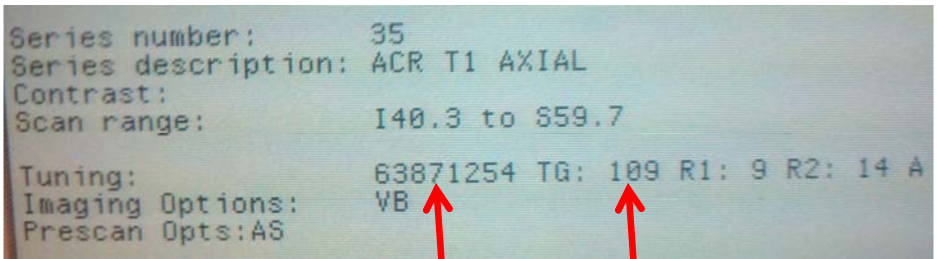
Tracking Center Frequency and Gain on GE



Center Frequency

Transmitter Gain

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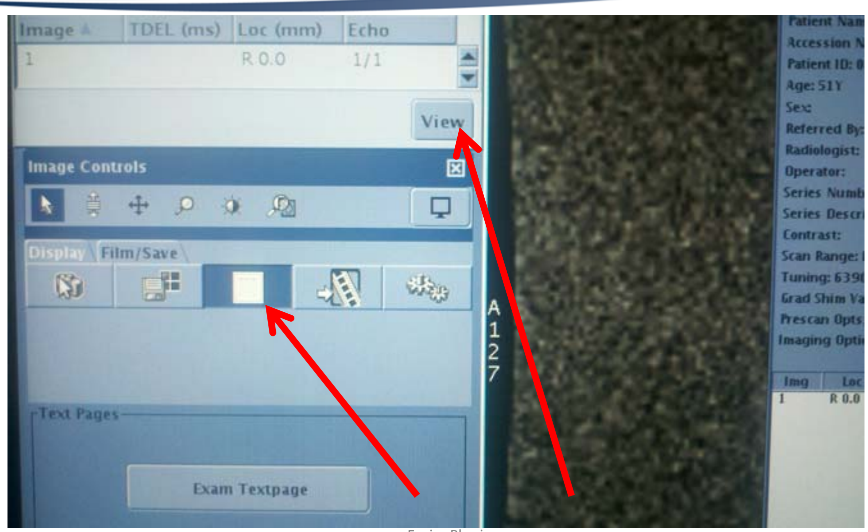
Tracking Center Frequency and Gain on New GE Software



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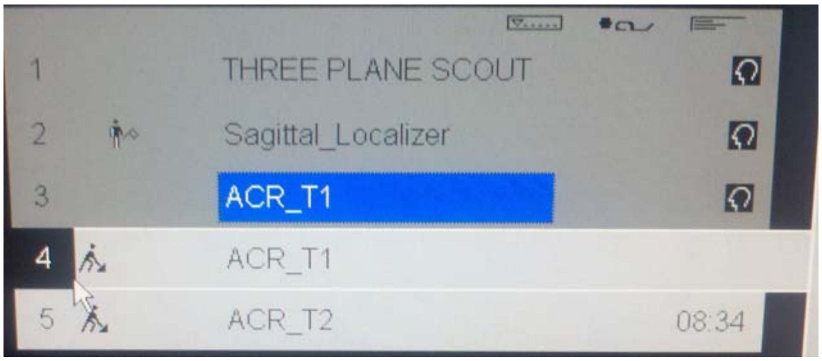
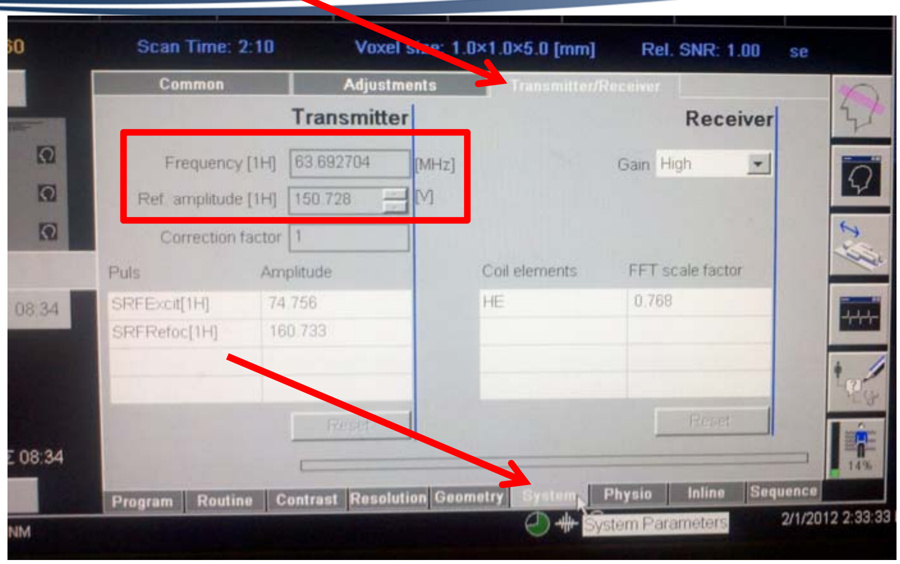
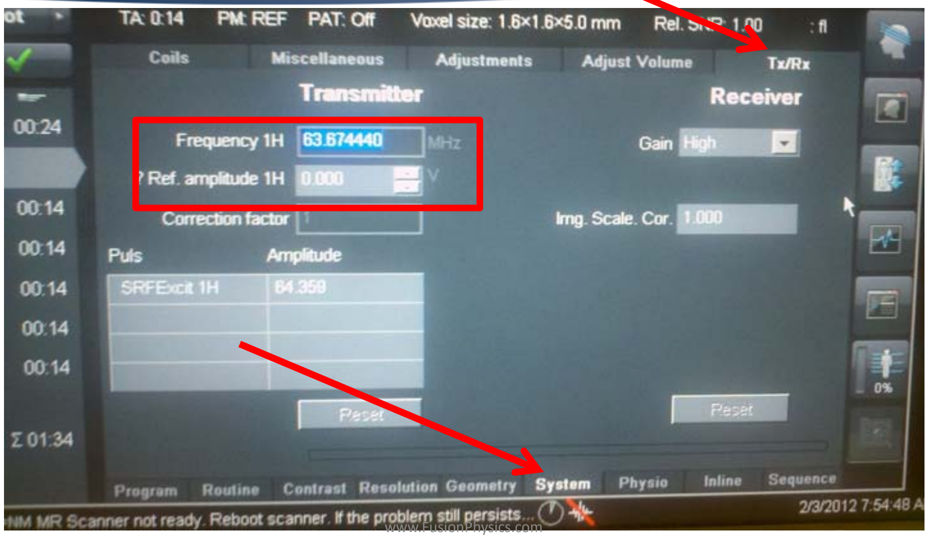
Tracking CF and TG on Siemens



Tracking CF and TG on Siemens

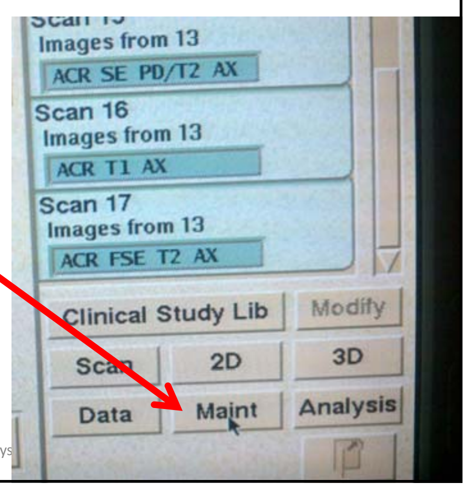


Tracking CF and TG on Siemens New Software



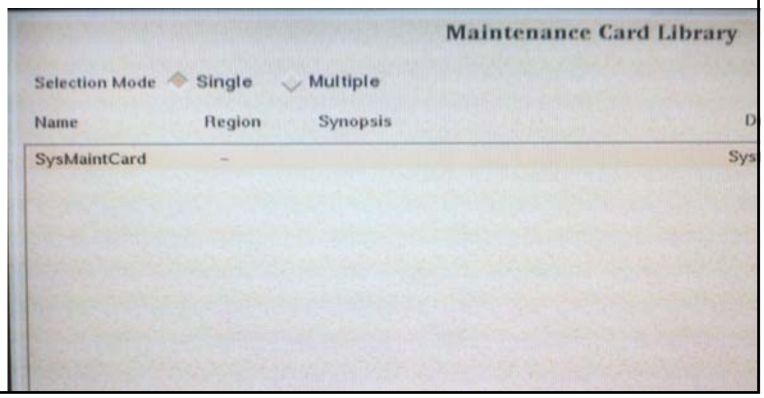
On Hitachi

- If Maintenance card is not at the bottom of your list, put it there!
- Hit Maint button in the center

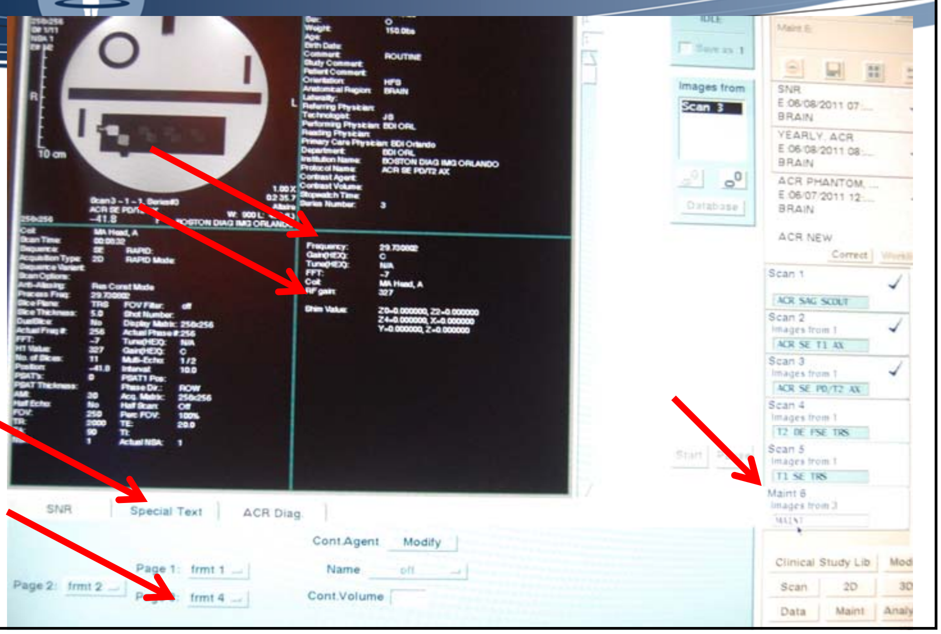


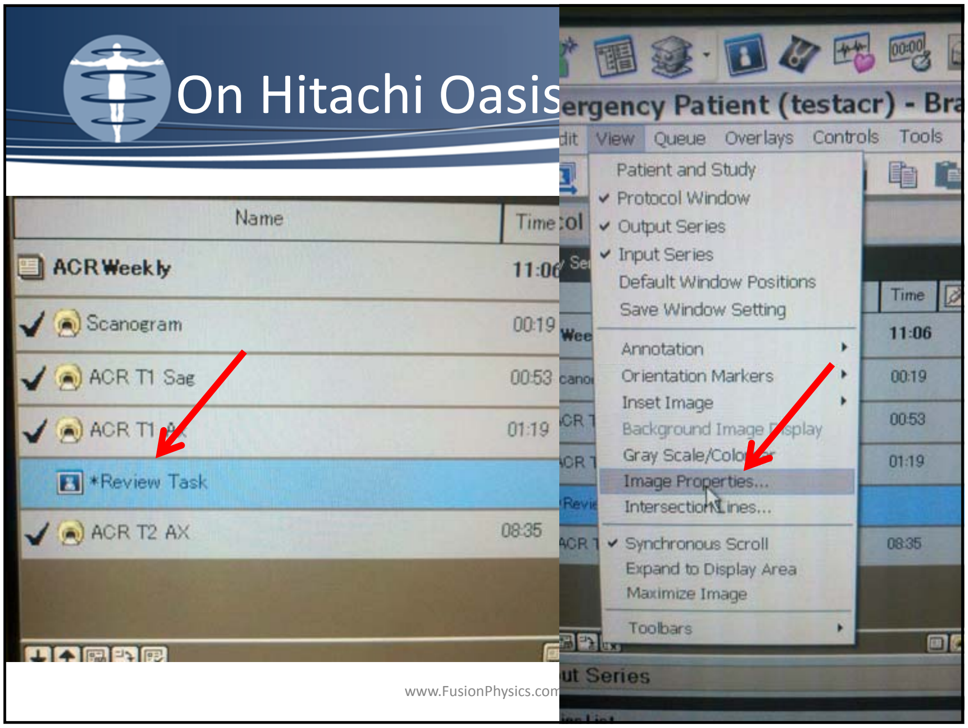
Adding System Maintenance Card

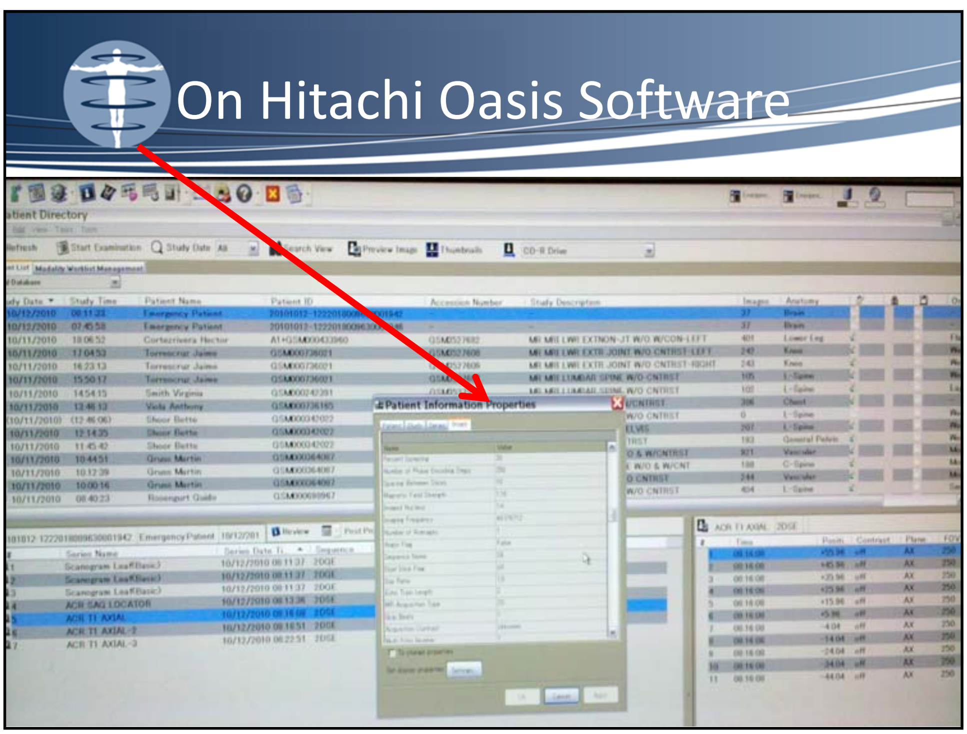
- Choose SysMaintCard then hit done
- You should know how to do this to train your techs!



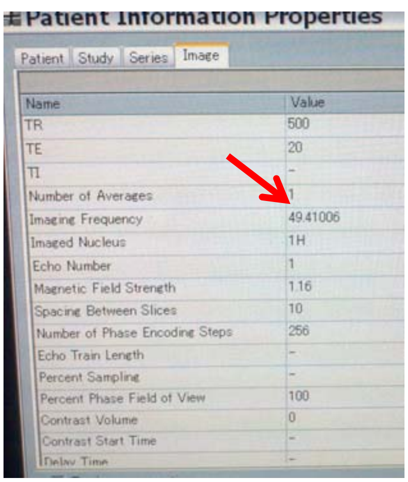
Under Maintenance Card

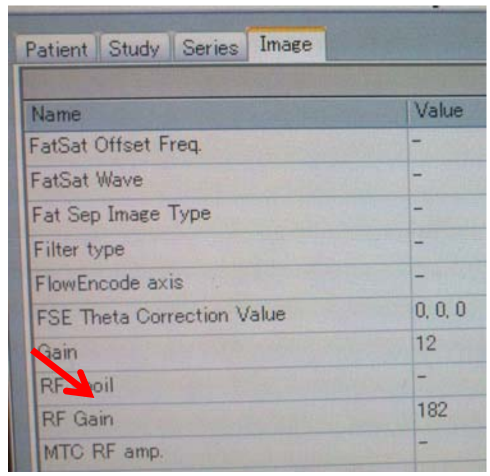



On Hitachi Oasis
Name
Time
ACR Weekly
11:06
Scanogram
00:19
ACR T1 Sag
00:53
01:19
*Review Task
ACR T2 AX
08:35
View
Queue
Overlays
Controls
Tools
Patient and Study
Protocol Window
Output Series
Input Series
Default Window Positions
Save Window Setting
Annotation
Orientation Markers
Inset Image
Gray Scale/Color
Image Properties...
Synchronous Scroll
Expand to Display Area
Maximize Image
Toolbars


On Hitachi Oasis Software
Patient Information Properties

On Hitachi Oasis Software





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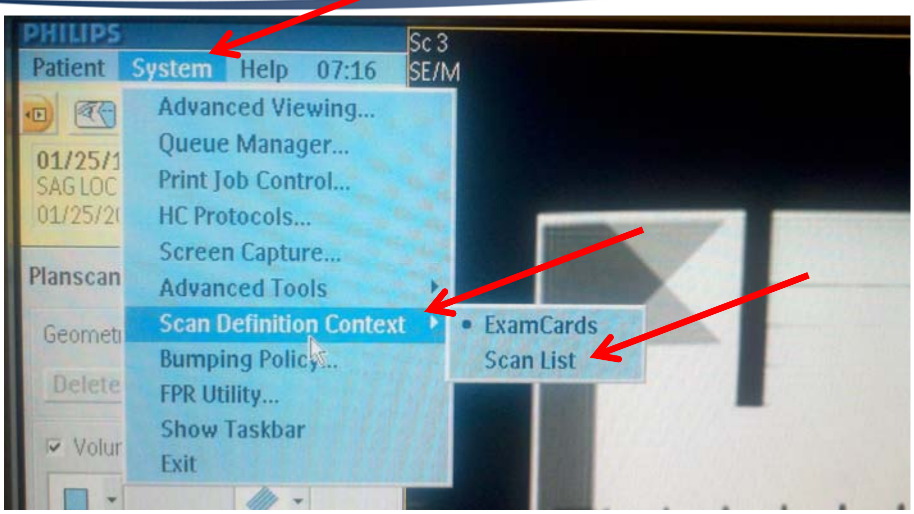
Tracking Center Frequency and Gain on Philips



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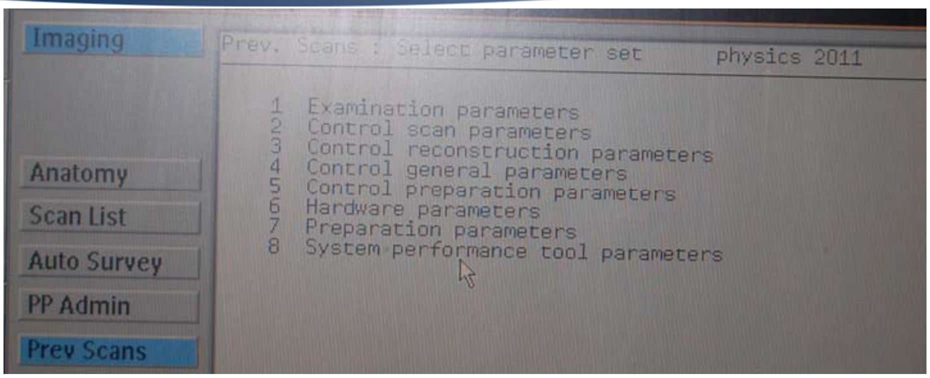
Tracking Center Frequency and Gain on Philips



- Under previous scan choose #8, then click on double arrows until you see sp_proton_freq and SP_receiver_att

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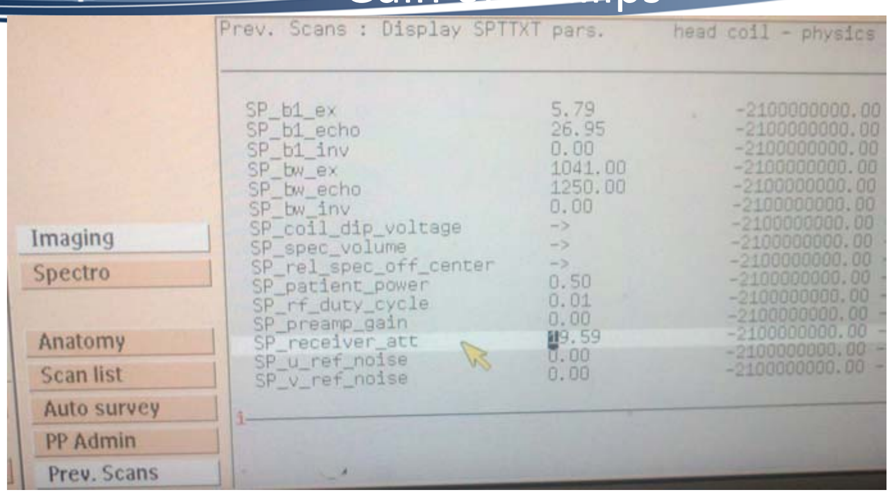
Tracking Center Frequency and Gain on Philips



click on double arrows until you see SP_receiver_att

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Tracking Center Frequency and Gain on Philips Ingenia

Ingenia:

- While the sequence is running, on the Main Menu (Upper Left) choose **System**, and **DataMonitoring**
- This will bring up a window showing the preparation phases for the **currently running sequence**. You must review this page prior to the next sequence beginning, or use a different method to bring up the data.

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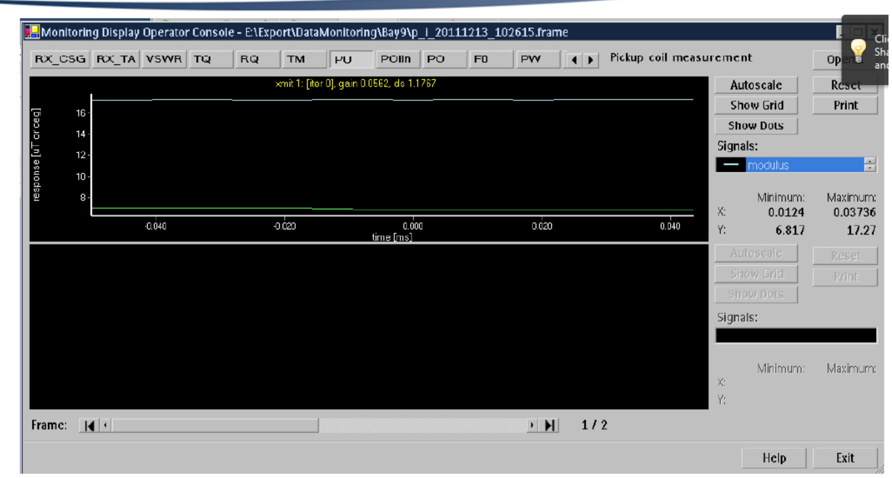
Tracking Center Frequency and Gain on Philips Ingenia



Click on the **PU** tab at the top to find **Transmit Gain**

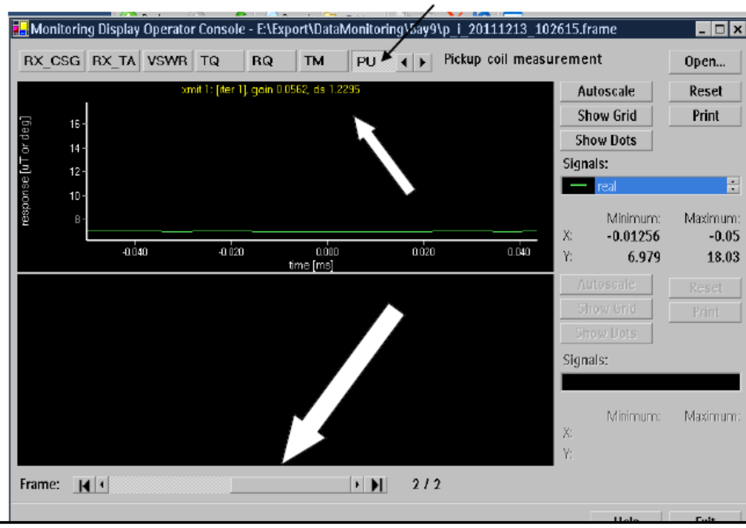
Click on the **F0** tab at the top to find **Center Frequency** (you may have to use the right arrowhead to

Move the Frame: slider to 2/2 (large white arrow)

Note that in the top window you will see

xmit 1: (iter 1),gain 0.xxxx, **ds x.xxxx** (in yellow)

ds is the abbreviation for **d**rive **s**cale, and is the number for you to use as transmit gain on the ACR document (small white arrow)



Center Frequency (f0):

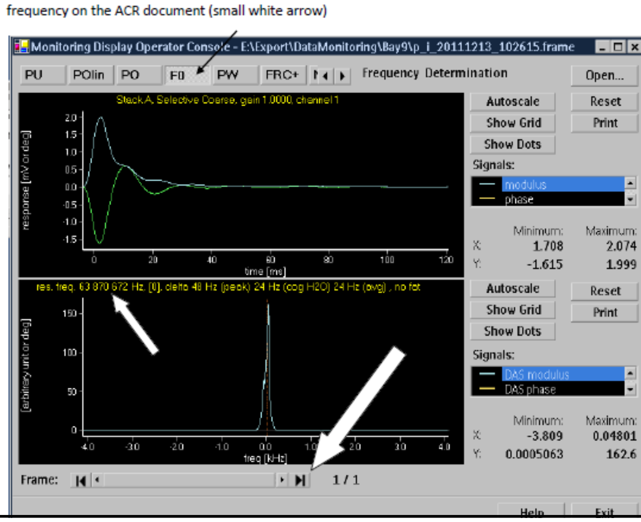
Click the F0 button at the top (black arrow)

Move the Frame: slider to last iteration 1/1, 2/2, 6/6, etc. (large white arrow)

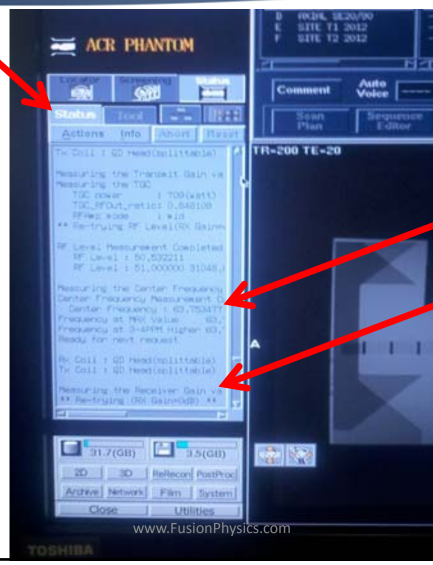
Note that in the bottom window you will see

res. freq. **63 870 xxx Hz …etc.** (in yellow) **(128 xxx xxx Hz for 3.0T)**

res. freq. is the resonant frequency for this sequence, and is the number for you to use as Center frequency on the ACR document (small white arrow)



Tracking Center Frequency and Gain on Toshiba



Tracking Center Frequency and Gain on FONAR

- Open info tab while in viewing mode:
- Then follow the next slide

Tracking Center Frequency and Gain on FONAR