



An Unusual Interaction

Between 1.5T MRI Scanner and a MEG System



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PMS Ingenia 1.5T



MRI – RF Shielding

Cu Thickness

$D=0.08$ mm



4D Magnes 2500 WH MEG System



MEG - Magnetically Shielded Room

Mu-Metal Thickness

$D=3.18 \text{ mm}$

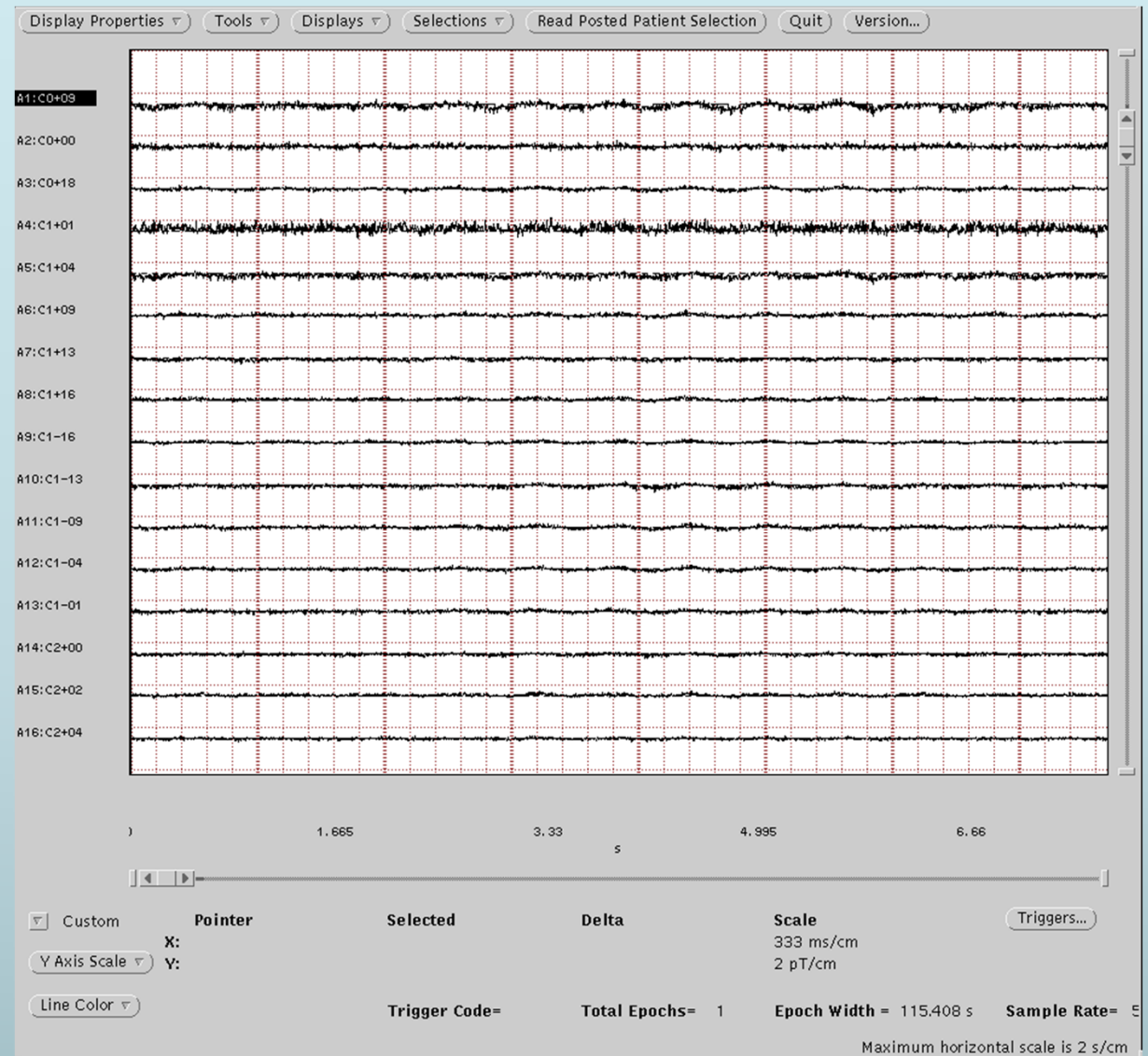


Baseline MEG Noise Pattern

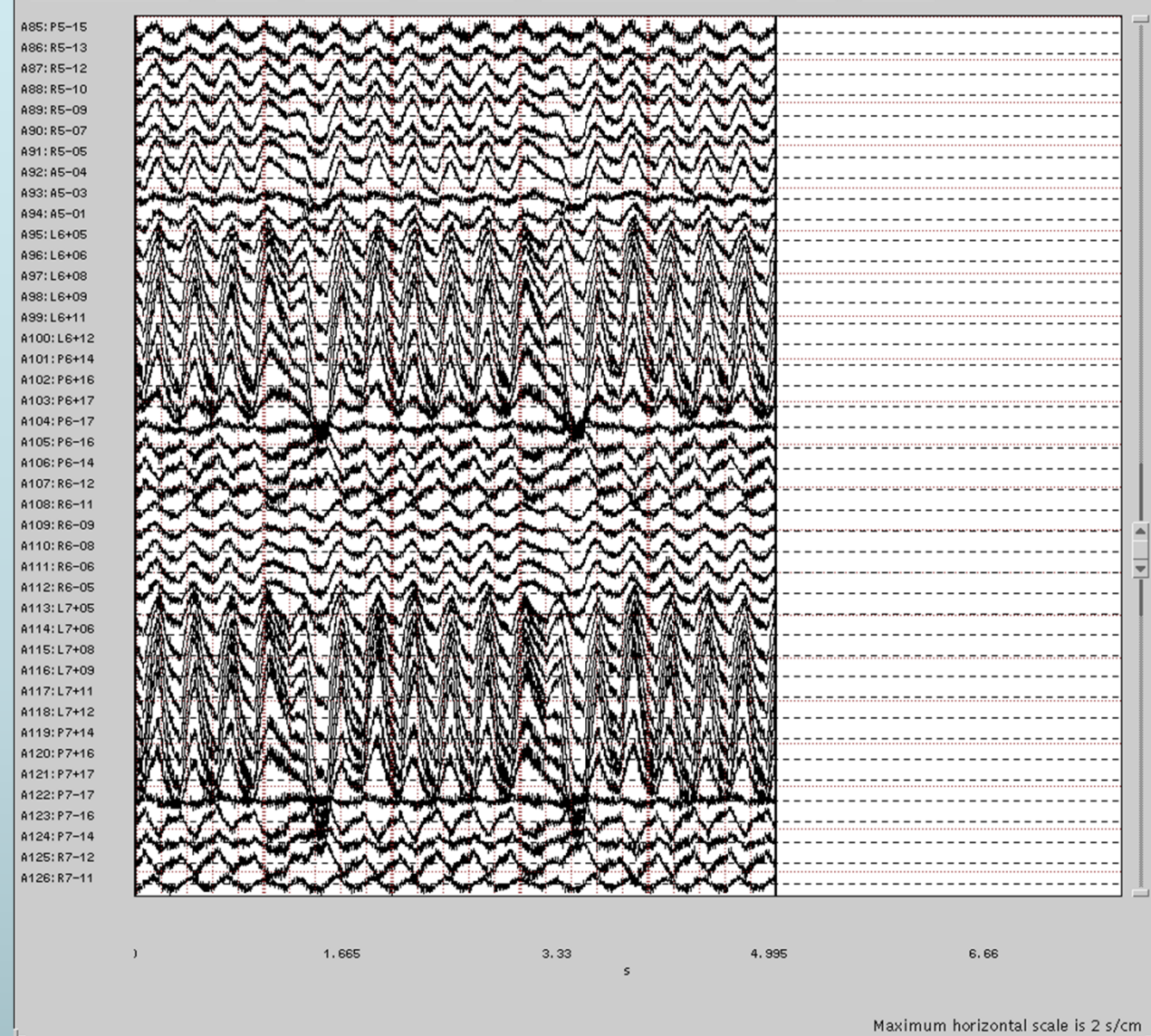
► Noise Floor

$$N = \frac{10}{\sqrt{\text{Hz}}} [fT]$$

► Down to 0.5 Hz



MEG Noise During the MRI Scan



Scale of Biomagnetic Fields

Scale	B Value	Field	Frequency
10^0 [T]	1.5 T	MRI	0 Hz
10^{-3} [mT]	20 mT	Peak MFG Field	0 Hz, 3-6 kHz
10^{-3} [mT]	0.05 mT	Earth Magnetic Field	0 Hz
10^{-6} [μ T]	10 μ T	Peak BI of MR Body Coil	64 MHz, 200 Hz
10^{-9} [nT]	3-5 nT	Urban Noise	0.01-1,000 Hz
10^{-12} [pT]	80-100 pT	Heart Activity	0.01-100 Hz
10^{-12} [pT]	1-10 pT	Brain Activity	0.1-1,000 Hz
10^{-12} [pT]	5 pT	MRI Noise Artifact	0.1-3 Hz
10^{-15} [fT]	0.01-10 fT	MEG noise floor	0.1-2,000 Hz

EM Wave in Good Conductor

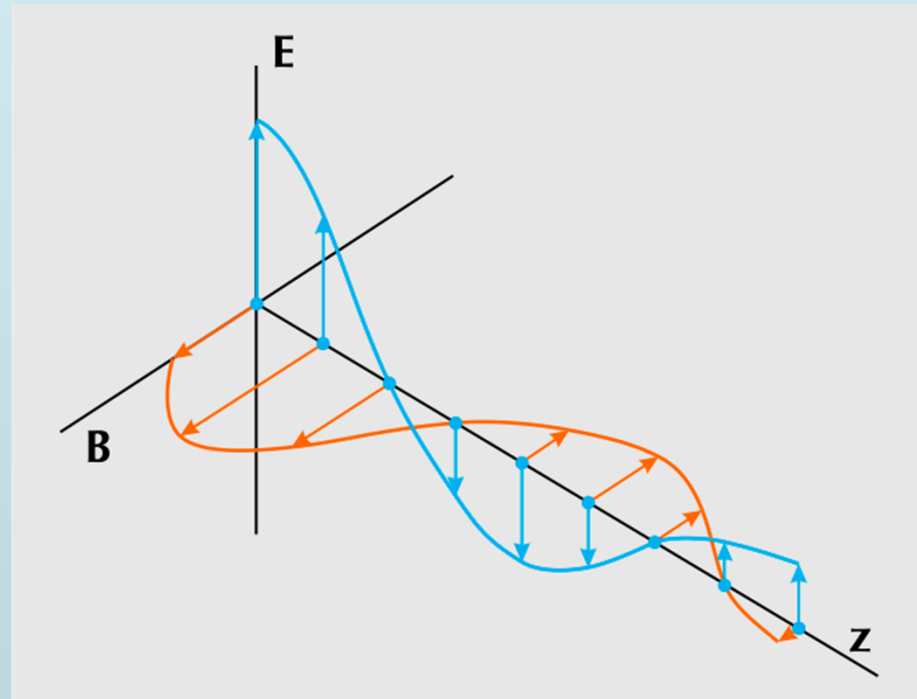
$$E_y = E_{y0} e^{-z/\delta} \cos\left(\omega t - \frac{z}{\delta}\right)$$

$$B_x = E_{x0} e^{-z/\delta} \cos\left(\omega t - \frac{z}{\delta} - \frac{\pi}{4}\right)$$

Skin Depth

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} = \lambda [m]$$

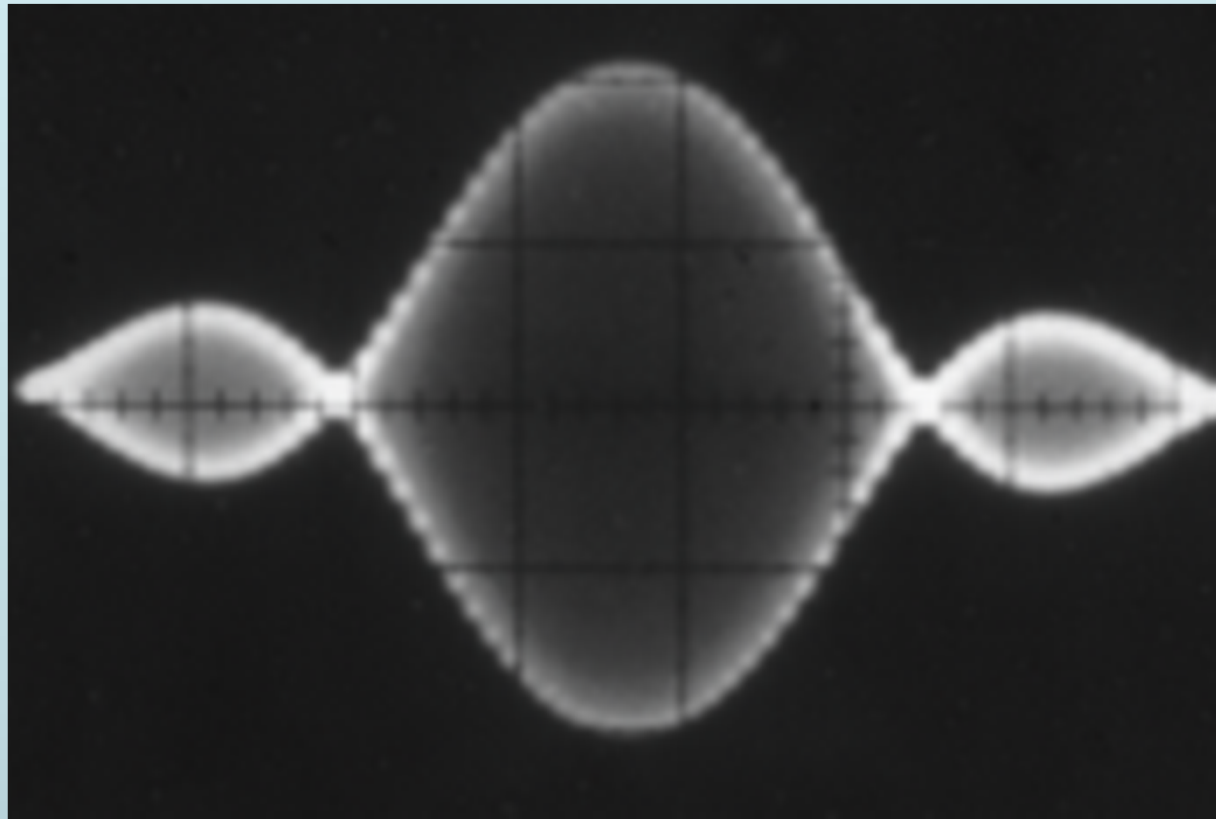
$$= \frac{66.08}{\sqrt{f \mu_r \sigma_r}} [mm]$$



Plane Wave Attenuation - Installed Shield

Material	Frequency	Skin Depth [μm]	Attenuation
0.08 mm Cu	64 MHz	8.25	$6.15 \cdot 10^{-5}$
	3 kHz	$1.20 \cdot 10^3$	0.936
	200 Hz	$4.67 \cdot 10^3$	0.983
3.18 mm MuMetal	64 MHz	2.13	0
	3 kHz	49.2	$9.1 \cdot 10^{-29}$
	200 Hz	191	$5.8 \cdot 10^{-8}$

MRI RF Pulse Modulation



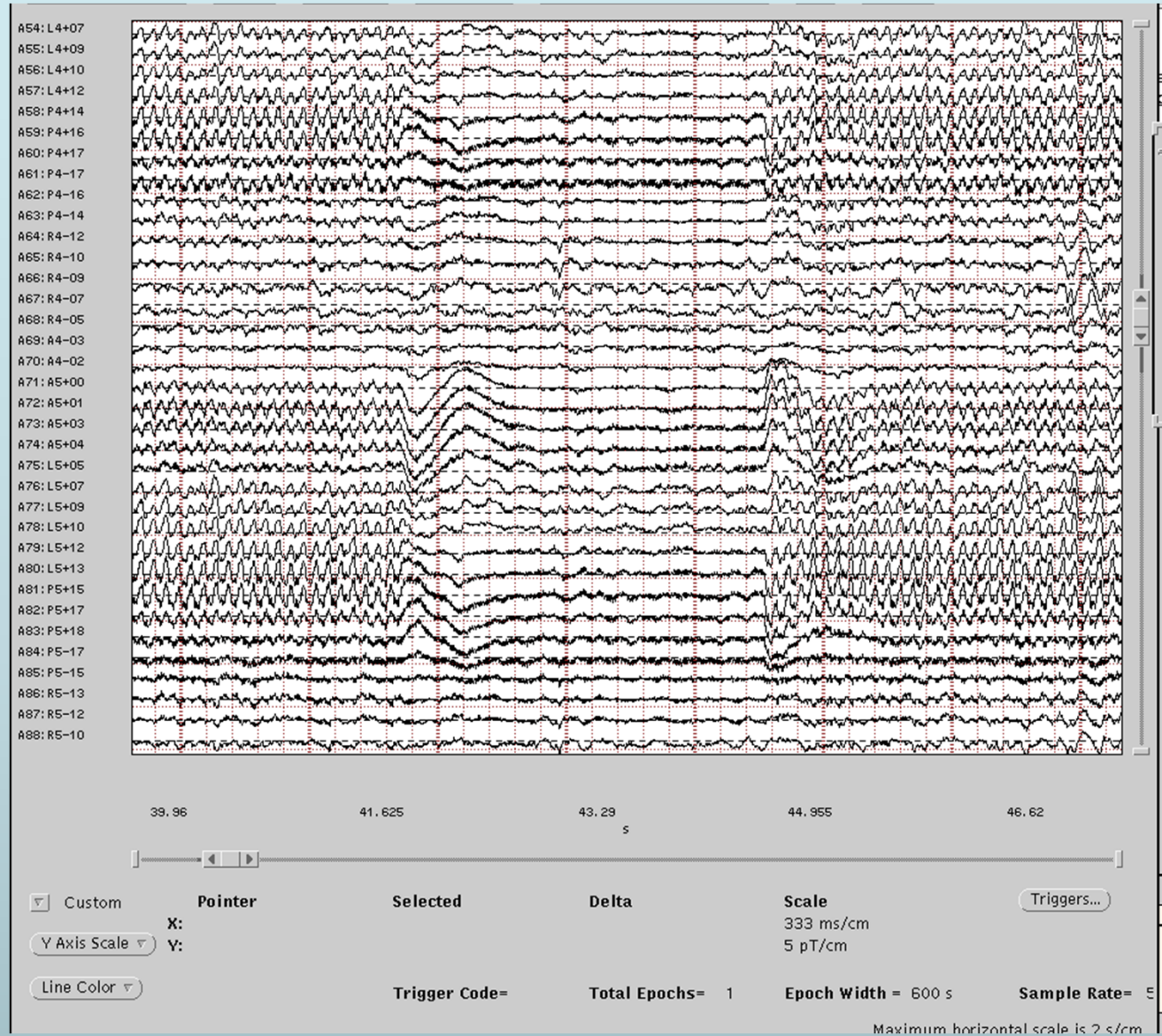
RF Pulse Modulation is the only factor that could possibly affect the MEG signal

Possible Remedies

- ▶ **Change Equipment Location**
- ▶ **Add Additional Shielding**
 - ▶ Would have to be a Thick Layer of Mu-Metal
- ▶ **Work With Flexible Schedule**
 - ▶ Identify Sequence Producing Most Severe Artifacts (SPAs)
 - ▶ Avoid Using SPAs During MEG Examinations

Top Sequence Producing Severe Artifacts

► **FSE !**



THINK

