LIGO-G070582-00-Z

Up-Conversion
Barkhausen Noise
Magnetization Discontinuities

R. Weiss

LSC Meeting July 25, 2007

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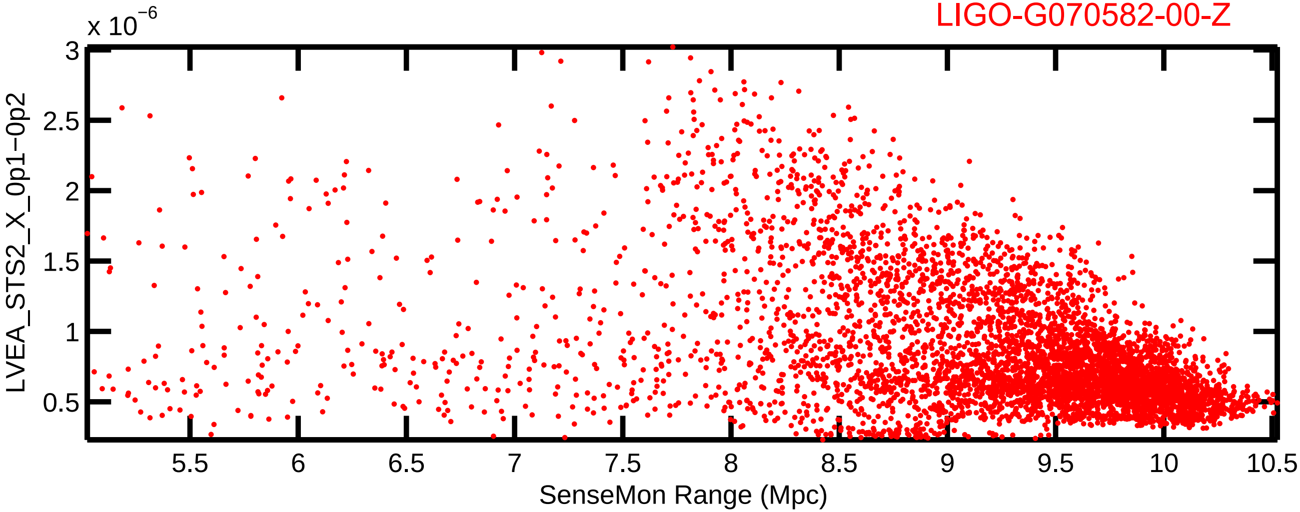
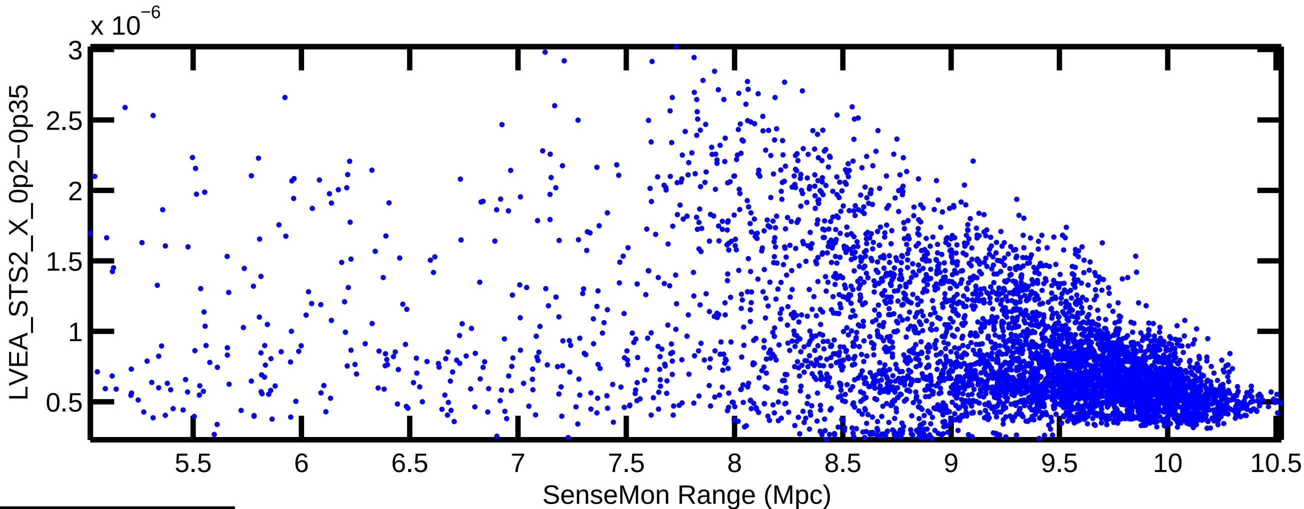
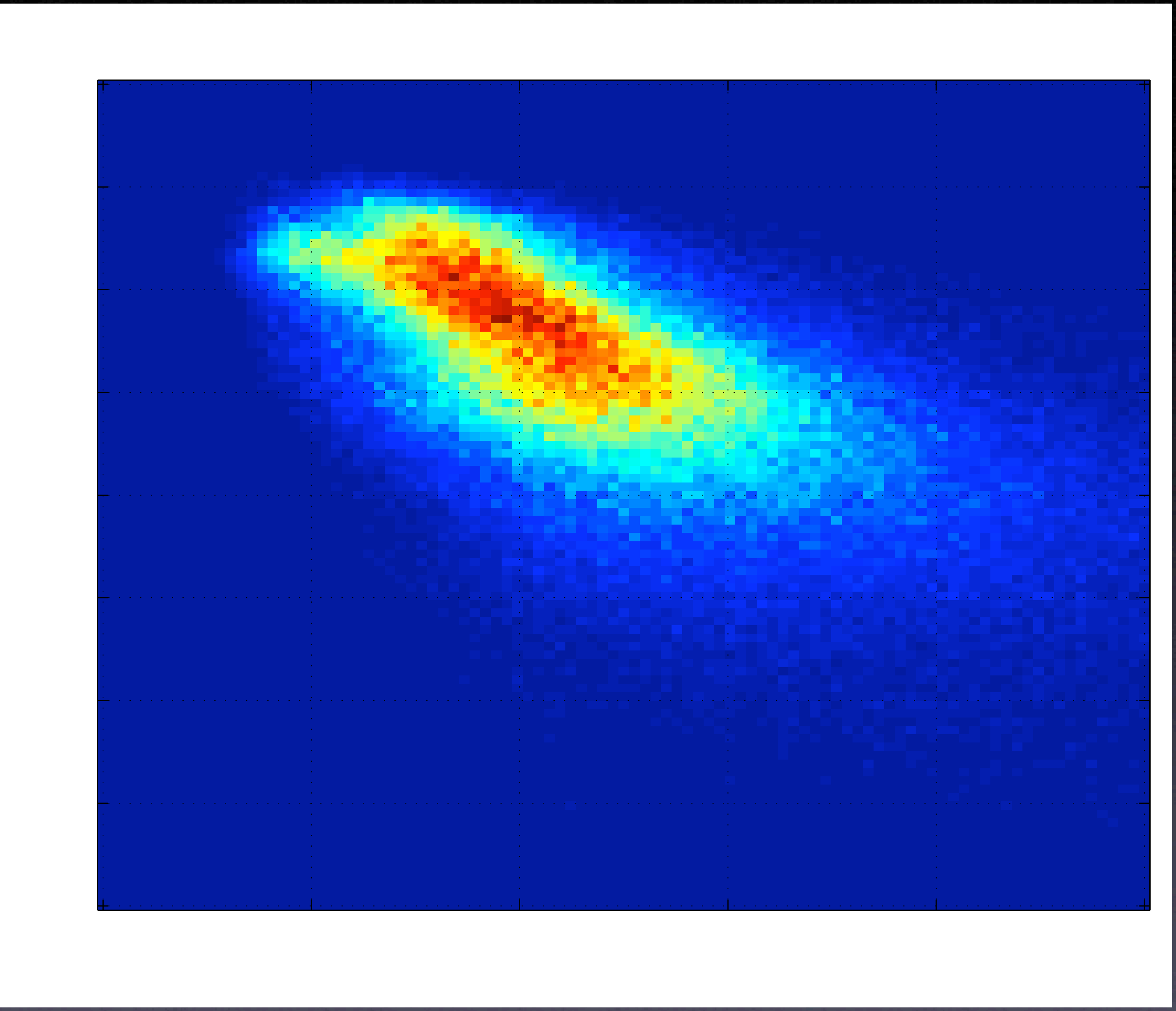
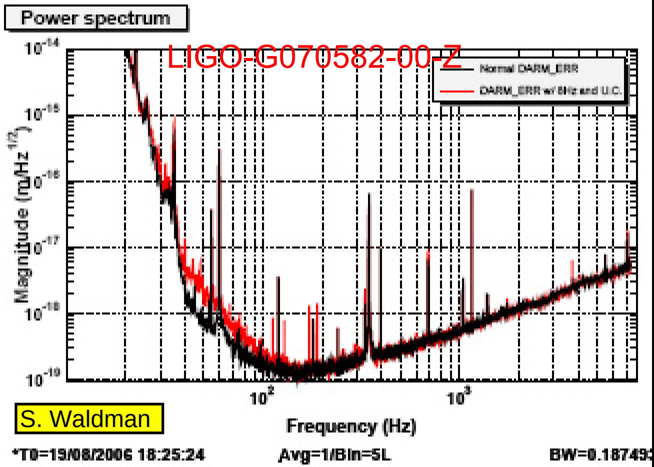




Brian O'Reilly
llo elog
01/24/2006



- Strong coil current correlation, better than seismic
- Physical machine signal
- Correlation ≠ Causation
- Other correlations?


Power spectrum
LIGO-G070582-00-Z
Normal DARM_ERR
DARM_ERR w/ 8Hz and U.C.
Magnitude (m/Hz$^{1/2}$)
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{2}
10^{3}
Frequency (Hz)
S. Waldman
*T0=19/08/2006 18:25:24
Avg=1/Bin=5L
BW=0.18749

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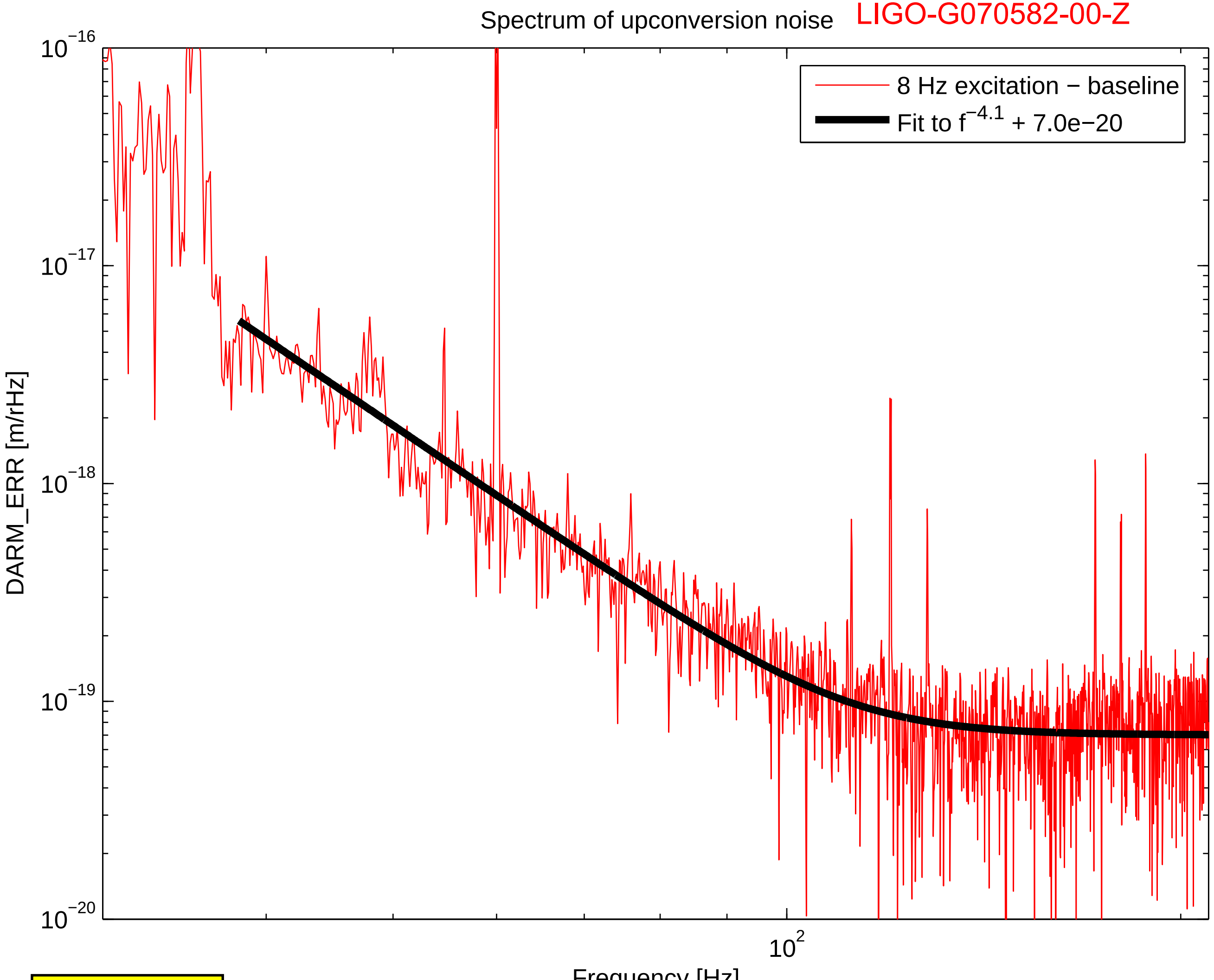

Sam Waldman

Data from Feb. 07

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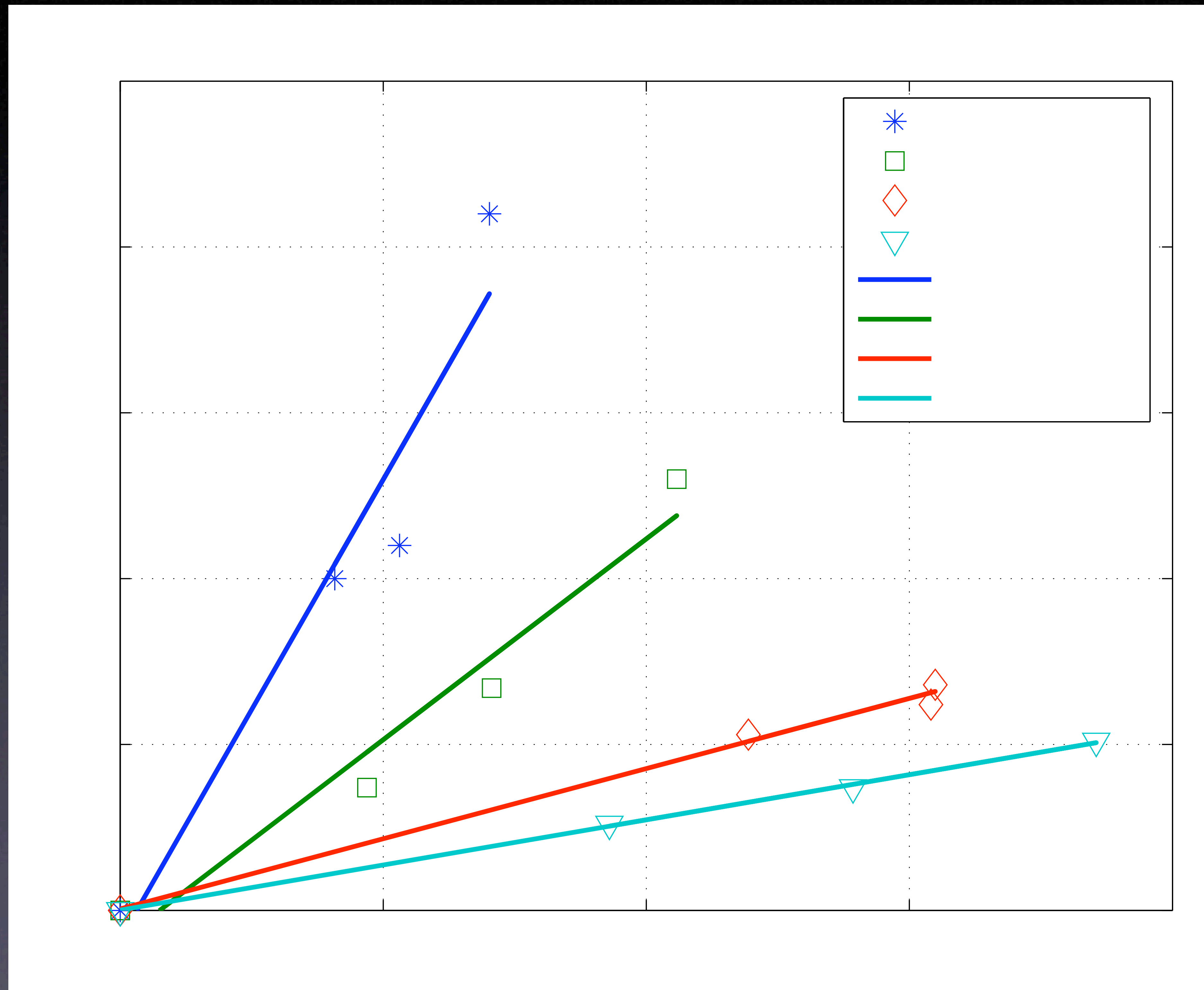
- Non-trivial frequency dependence
- Need more data
- Not yet predictive



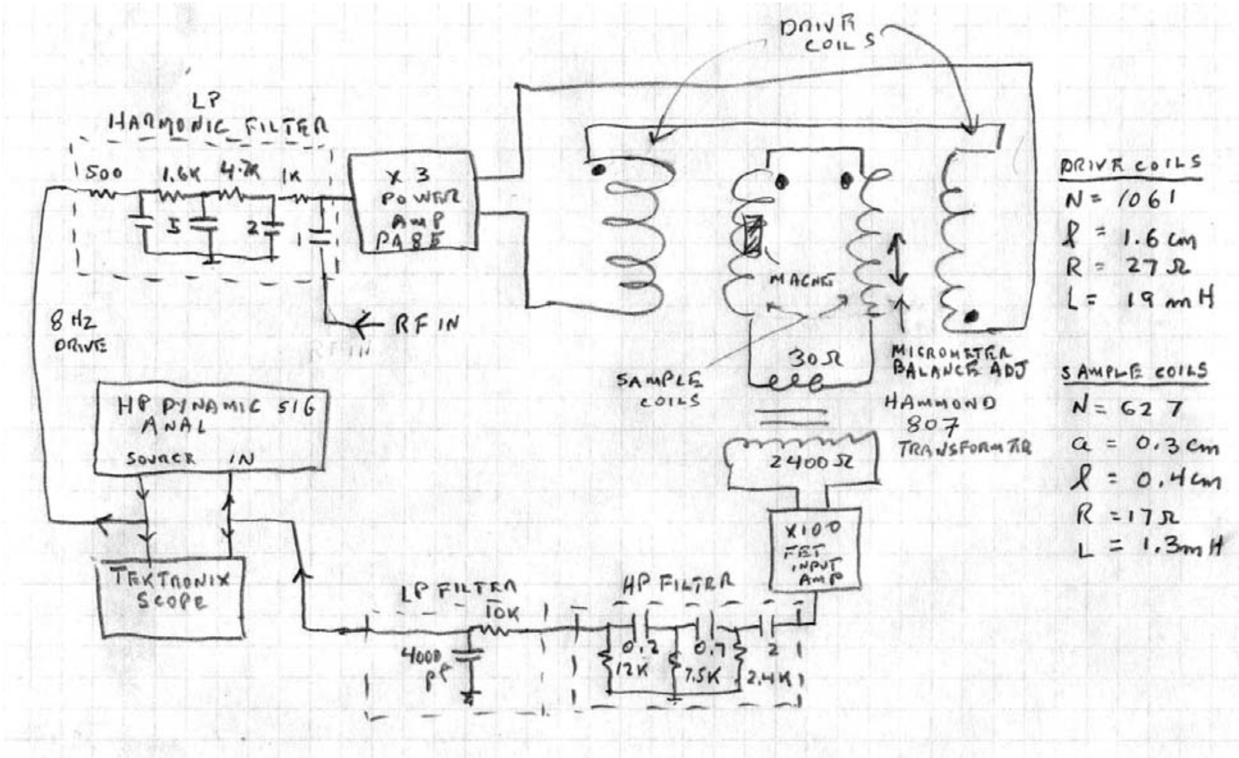


Figure 2 Schematic of the latest (May 2007) version of the “bridge” apparatus. The major change has been to make the position of the sample coils adjustable along the length of the drive coils. This to determine if the magnet non-linearity was dependent on the field or gradient of the field at the magnet. It turned out that the non-linearity was only a function of the field and that what was thought to be a gradient sensitivity had to do with motion of the magnet in the sampling coils due to inadequate clamping in some earlier measurements. The trimming to null the fundamental drive frequency current in the primary of the transformer is done by moving one of the sample coils longitiudinaly in its drive coil with a micrometer.

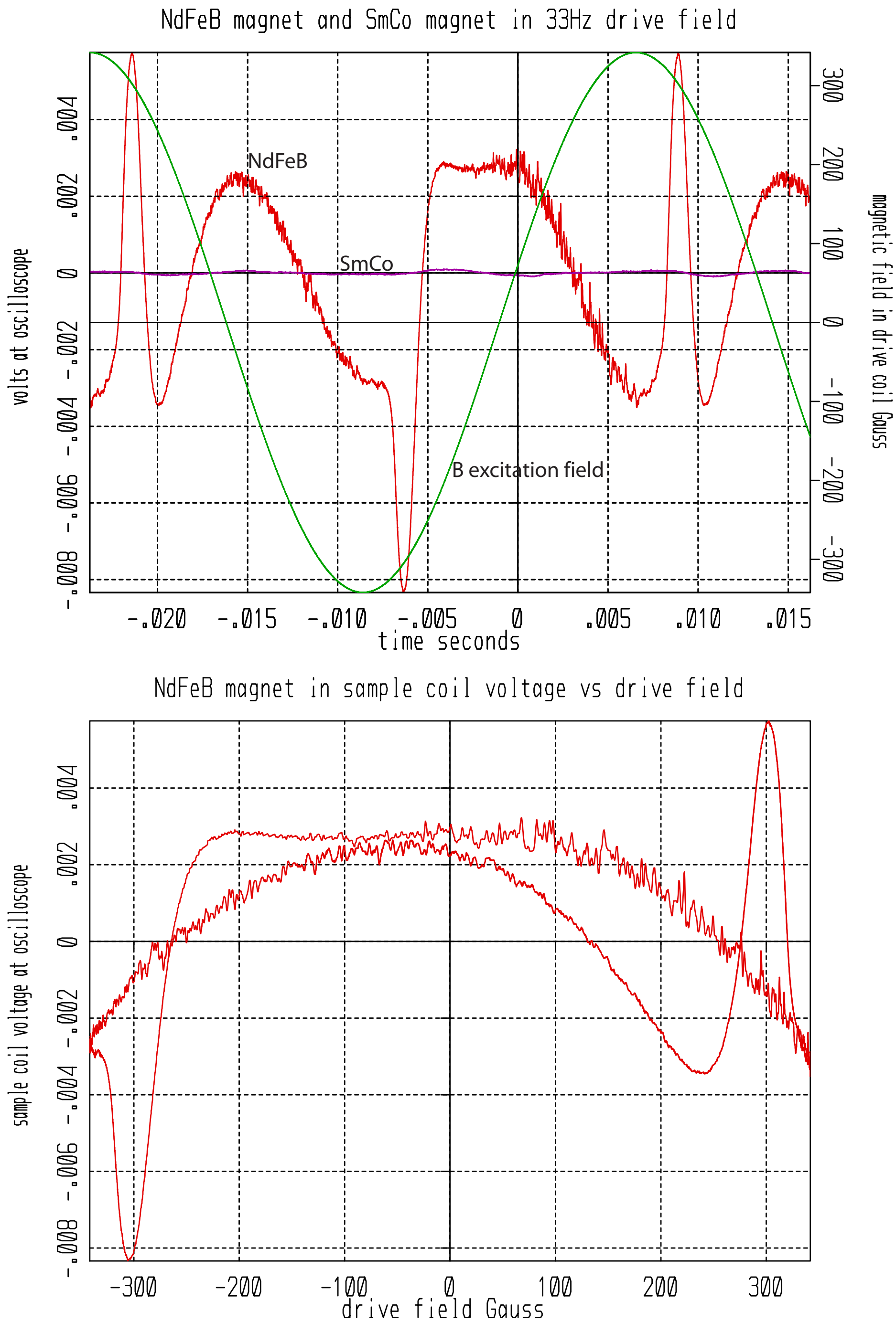


Figure 2a and 2b The complex magnetization discontinuities and the Barkhausen noise in NdFeB magnets as well as the behaviour of SmCo magnets with comparable magnet moment (consistent with amplifier noise) are shown with the time dependent exciting field in **Figure 2a.** The hysteretical behaviour of the NdFeB is seen most easily by replotting the oscilloscope voltage against the drive field. **Figure 2b**. The frequency of the drive field is 33Hz. The signal to noise on the magnetization non-linearities in these representations is so high that 33Hz is a good place to carry out go/nogo testing on the magnets. The magnetization discontinuities occur 35 degrees in phase after the field extrema, the Barkhausen noise occurs after the field zero crossings.

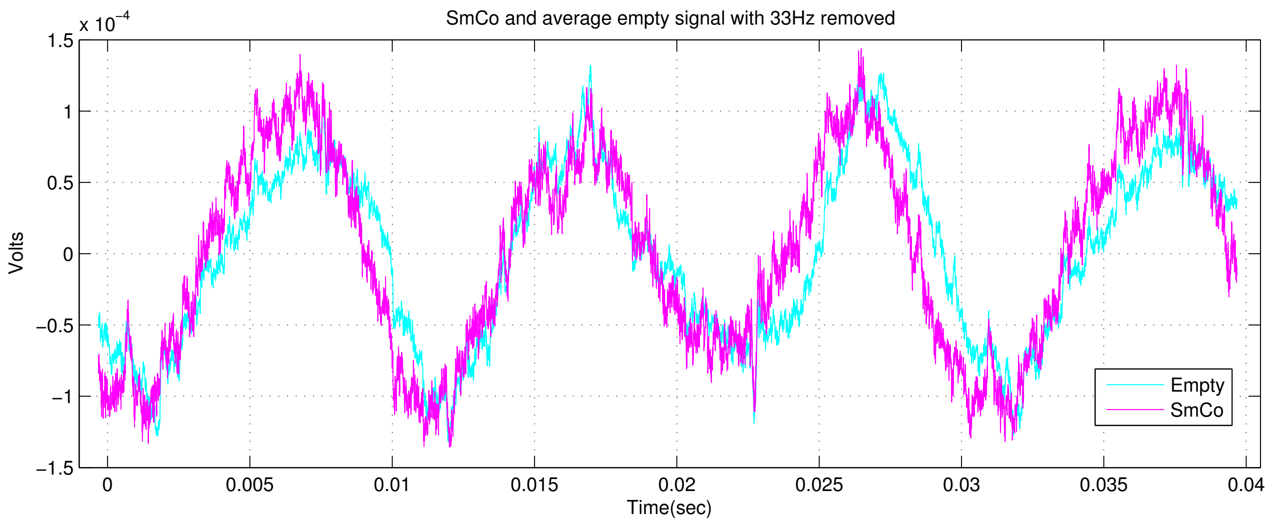


Figure 2. Average of seven signals from the apparatus run without a magnet in it compared with the SmCo signal. 33Hz removed from both.

In order to get an estimate of the ratio of the SmCo signal to the NdFeB signal, we will model the SmCo signal as a proportional function of the NdFeB signal plus a noise term.

$$V_{Sm}(t) = V_{noise}(t) + \alpha V_{Nd}(t)$$

α is plotted for the 43 SmCo magnets tested in Figure 3.

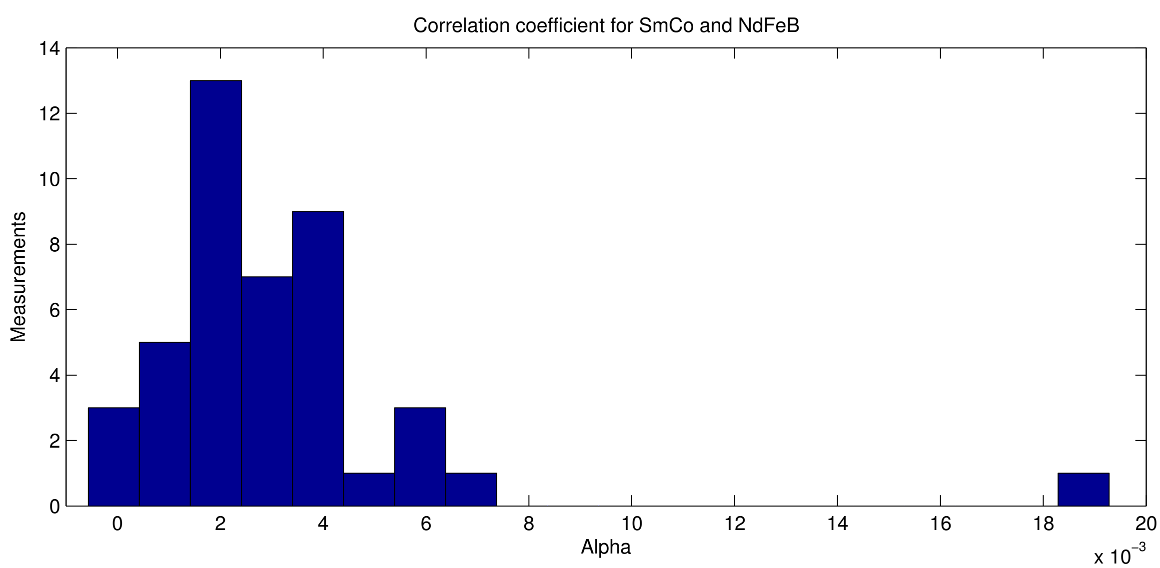


Figure 3. Cross-correlation coefficient between the two signals. The measurement on the far right comes from human error on a measurement. [2]

[2] For following calculations, we're ignoring that measurement on the right of Figure 3. I tested the magnet 3 times at a later time and it acted normally.

David Kelley

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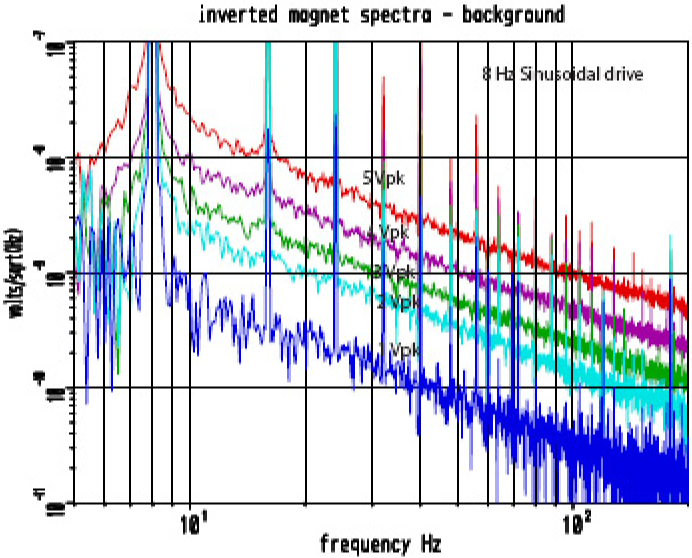

Figure 2 Up_conversion spectra of the case with two coils and two magnets oppositely polarized. The spectrum displayed is the difference between the 8Hz drive on with amplitude indicated in the figure and the background of the undriven case. The resistance of the coil and series resistor is 43 ohms (23ma for 1volt). The spectra above 40Hz have been fit by $\frac{A}{(f\text{-}f_0)}$, see **table 1.**

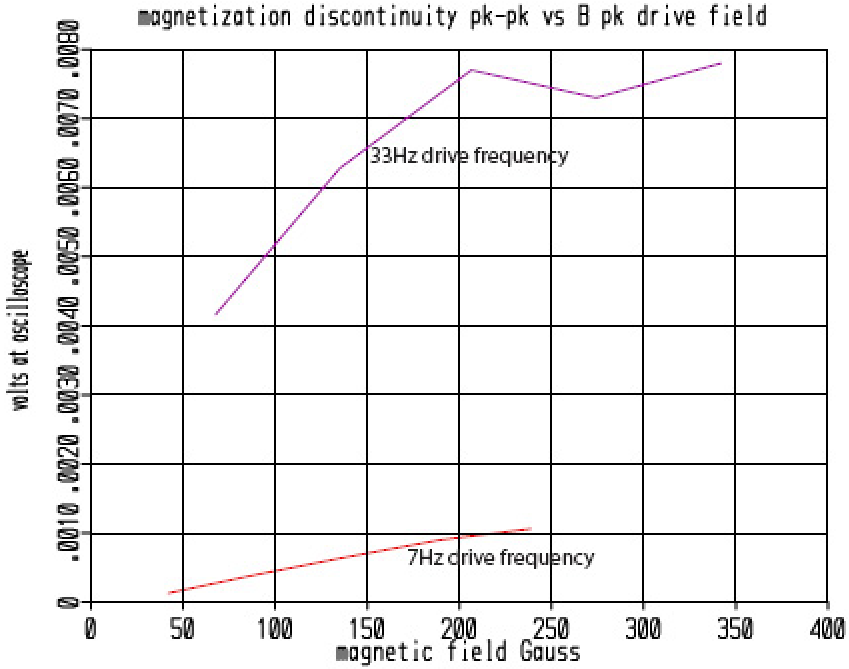

Figure 5 The pk to pk magnetization discontinuity voltage on the oscilloscope vs the drive field at 7Hz (red) and at 33Hz (Violet).

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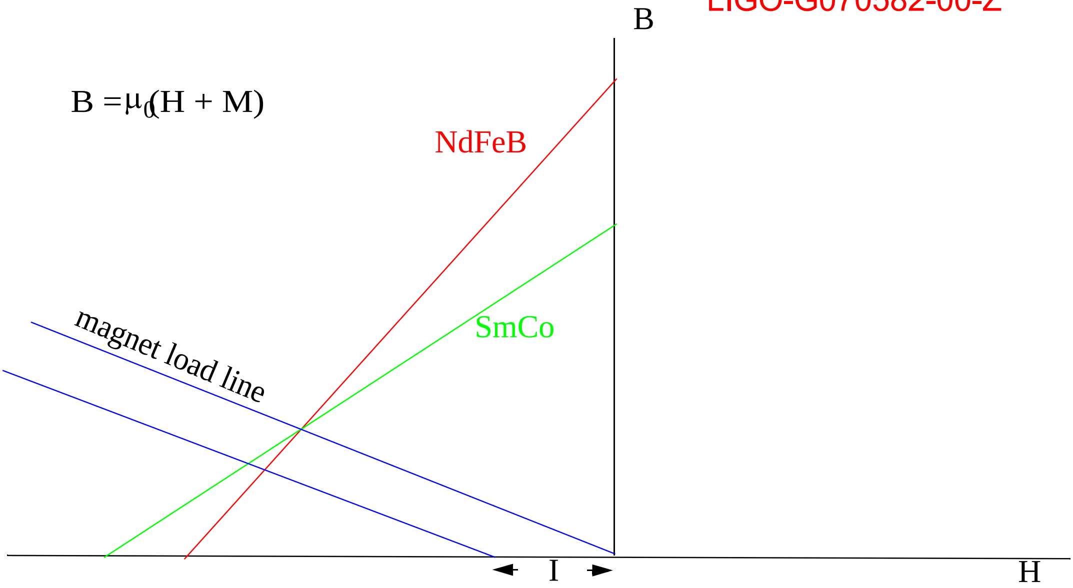

Results and Conclusions

- Reduction in up-conversion: reduce coil current, redistribute control: present technique
- Connect: V(f)-> B(f) -> F(f) -> x(f) $\sim A/((f - f_{drive})\, f^3)$
- Barkhausen noise envelope coherent between magnets
- Scaling with current between linear to 3/2 power
- Gives: x(50Hz) ~ 7 x 10^{-18} m/sqrt(Hz) , x(100Hz)~ 3 x 10^{-19} m/sqrt(Hz) @ I = 20ma
  - Ample to explain upconversion
- Scaling with frequency not well understood
- Role of the magnetization discontinuity in the interferometer ?

Results and Conclusions

- SmCo and NdBFe magnets in the open circuit application have equal dipole moment to within 5%
- SmCo magnets do not show Barkhausen noise or magnetic discontinuity, at least 1/300 smaller.

- Fundamental question: besides the up-conversion associated with large low frequency coil currents, what is the noise from the much smaller damping signals. Does one need to replace the magnets on both ETM and ITM?

references: http://emvogil-3.mit.edu/~weiss/barkhausen_noise