

**SEARCH FOR A GW STOCHASTIC
BACKGROUND at kHz FREQUENCIES**

**BY CROSS-CORRELATING
THE H2 AND H4 IFO'S**

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WHY SEARCH AT HIGH FREQUENCY ?

TECHNICAL REASONS:

- (a) The Interferometers are resonant

4K	37.52	75.04 kHz	etc
2K		74.61 kHz	etc

Consequently the sensitivity is enhanced at these frequencies.

- (b) On resonance the signal has a characteristic spectral shape that can be used to extract the signal from the noise.
- (c) Seismic and suspension noise are absent.
- (d) Laser amplitude and phase noise can be identified and removed.
- (e) Shot noise is flat in frequency.
- (f) Test mass thermal noise can be measured directly.

WHY SEARCH AT HIGH FREQUENCY?

PHYSICS REASONS:

- (a) Certain models predict stochastic background from *primordial* sources at high frequency.
- (b) The stochastic signal from *astrophysical* sources is absent at these frequencies.

THE DOWN SIDE:

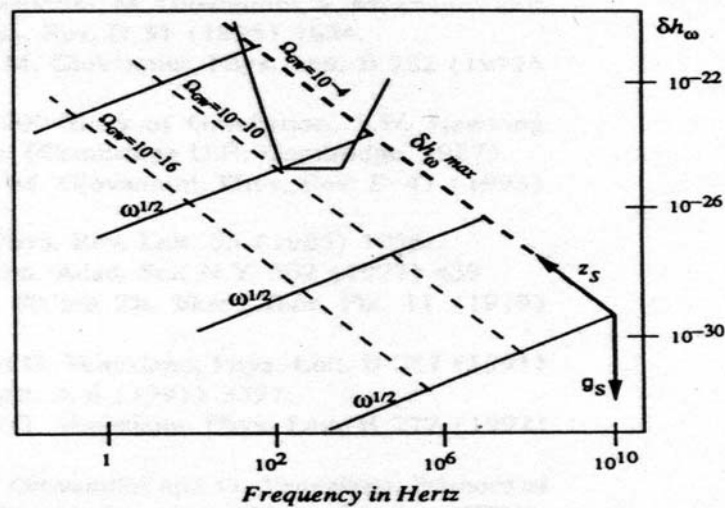
Even though one can reach very small strain, the energy content – even for spectra growing as f^3 – leads to large values of Ω_g .

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STOCHASTIC BACKGROUND SPECTRUM IN STRING MODEL (G.Veneziano et al)

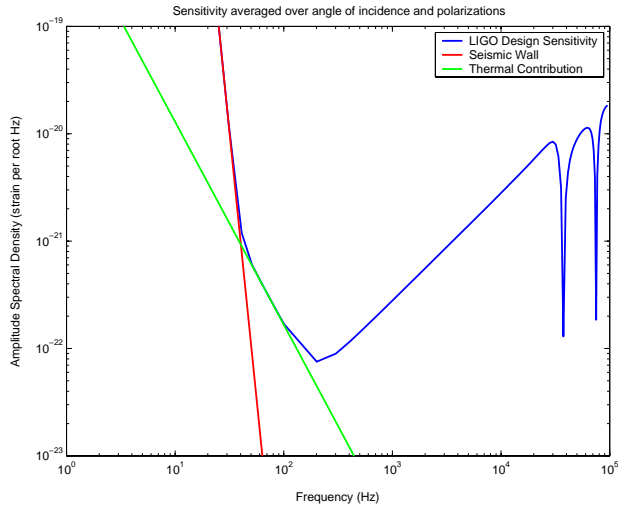


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Sensitivity of the 4K IFO extended to 100 kHz
 (IFO Inverse transfer function with seismic and suspension thermal noise)

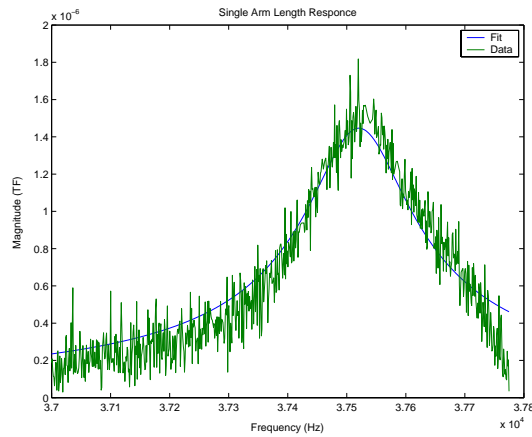


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Differential Mode spectrum at 37.52 kHz
 Obtained by shaking ITMX with single arm locked
 Note FWHM ~ 250 Hz
 as compared to Common Mode FWHM ~ 4 Hz



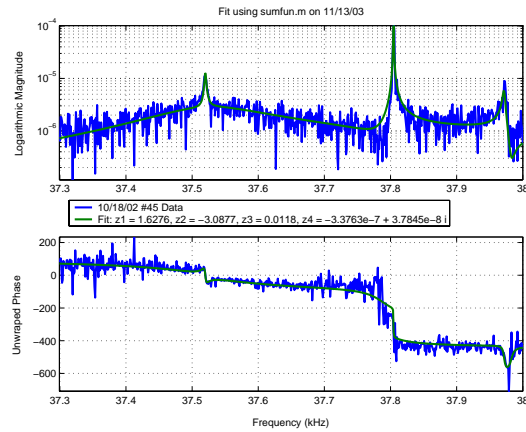
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Differential and common mode signals Obtained by shaking ITMX with full IFO locked

Note logarithmic scale as compare to previous slide, and extended frequency range to include a test mass thermal resonance at 37.8 kHz



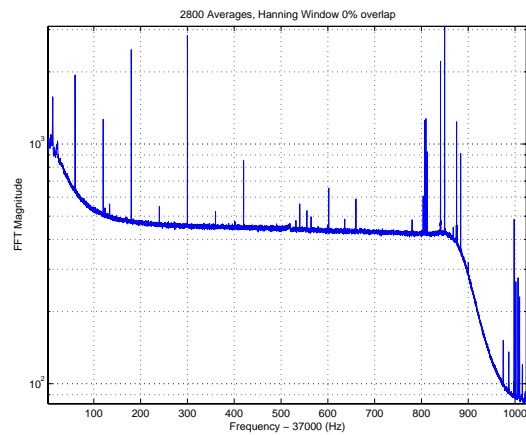
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Measured spectrum around 37.52 kHz on the H4K during the S3 run (12/2003)

Note harmonics of line frequency and test mass resonances
(in groups of four as expected)



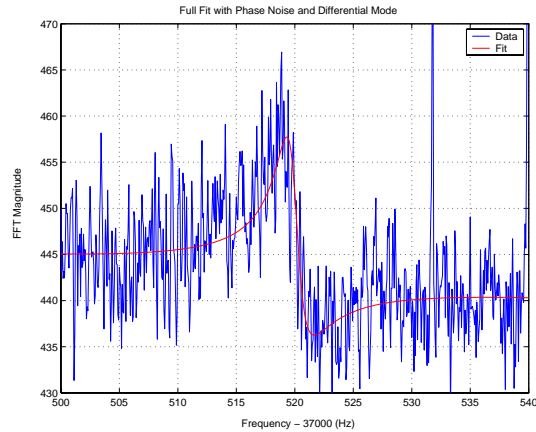
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40 Hz span of the spectrum with fit including the laser phase noise contribution

The narrow feature is due to common mode leakage



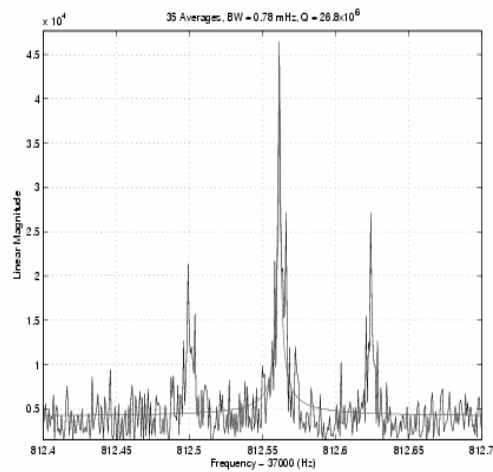
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Test Mass Thermal Resonance at 37.81255 kHz

The sidebands at 70 mHz are most probably instrumental



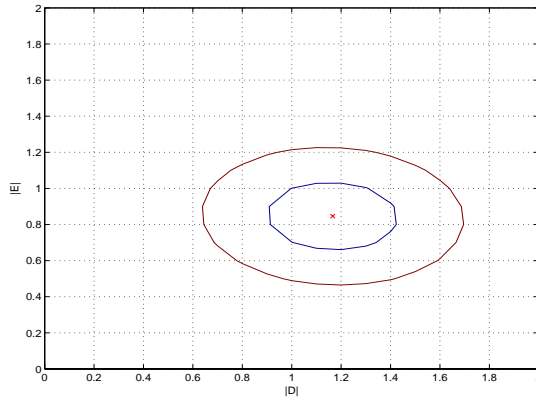
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CONFIDENCE CONTOURS (1 σ AND 2 σ) FROM A FIT TO S3 DATA FOR DM SPECTRAL SHAPE

Horizontal axis is the DM signal, Vertical axis is the contribution from nearby test mass resonances



**Upper limit (3 σ)
h(37.52 kHz)
< 8.0 $\times 10^{-24}$ / $\sqrt{\text{Hz}}$**

**Single IFO result
10 hrs of data**

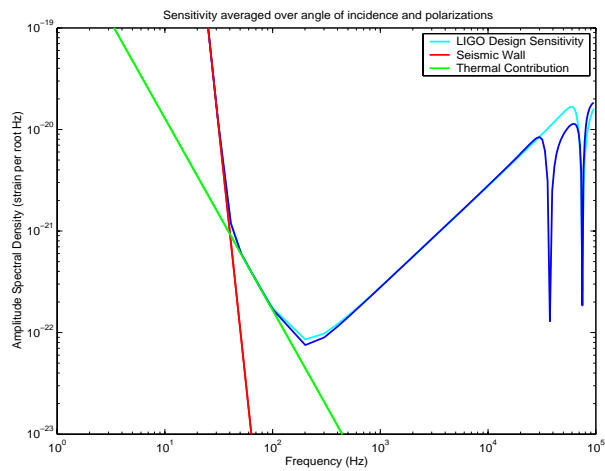
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H2K – H4K Correlation measurements

Blue 4K Cyan 2K



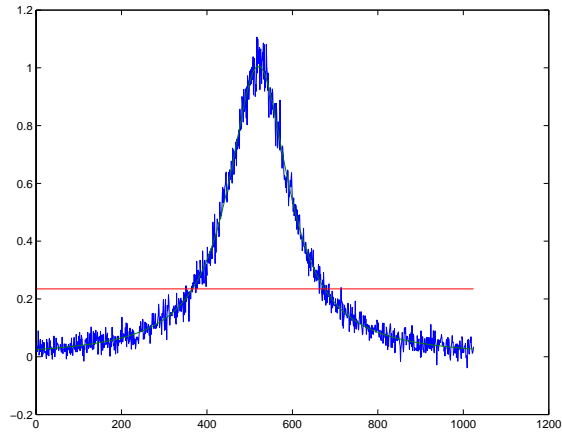
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**CROSS-CORRELATION OF TWO CO-LOCATED
IFO's at fsr FREQUENCY when S/N = 1**

Simulation for $T = 10^3$ s



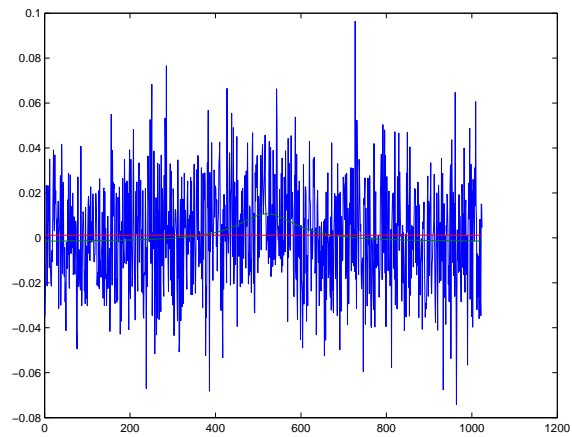
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**CROSS-CORRELATION OF TWO CO-LOCATED
IFO's at fsr FREQUENCY when S/N = 0.1**

Simulation for $T = 10^3$ s



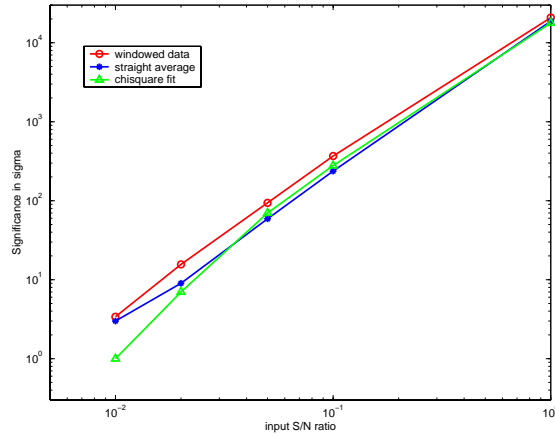
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SIGNIFICANCE OF THE SIGNAL (in σ) AS A FUNCTION OF THE INPUT S/N

Simulation of the cross-correlation of two co-located IFO's at their
fsr frequency for a total time $T = 10^7$ s



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Minimum detectable $\Omega(f)$ for different frequency bands ($T=10^7$ s)

f (kHz)	37.52	74.8	0.2 - 1.2
Δf (Hz)	160	160	1,000
$h_4(f)$ ($\text{Hz}^{-1/2}$)	1.2×10^{-22}	1.6×10^{-22}	3×10^{-22}
$h_2(f)$ ($\text{Hz}^{-1/2}$)	10^{-20}	2.5×10^{-22}	3×10^{-22}
$ h_4 h_2 / \sqrt{T \Delta f}$ (Hz^{-1})	3×10^{-47}	10^{-48}	10^{-48}
$ h_g _{S/N=1}$ ($\text{Hz}^{-1/2}$)	5.5×10^{-24}	10^{-24}	10^{-24}
$\Omega(f)$	2,000	530	10^{-3}

Upper limits from single interferometer measurement

$ h_g _{S/N=1}$ ($\text{Hz}^{-1/2}$)	3×10^{-27}	4×10^{-27}	-
$\Omega(f)$	6×10^{-4}	8×10^{-3}	-

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