Interesting commissioning results

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GEO 600

Overview

Some intersting results from commissioning:

- Measuring bulk absorption of Suprasil 311SV
- Jumping to lower signal-recycling sideband
- Some experiments related to broadband scattering in GW interferometers

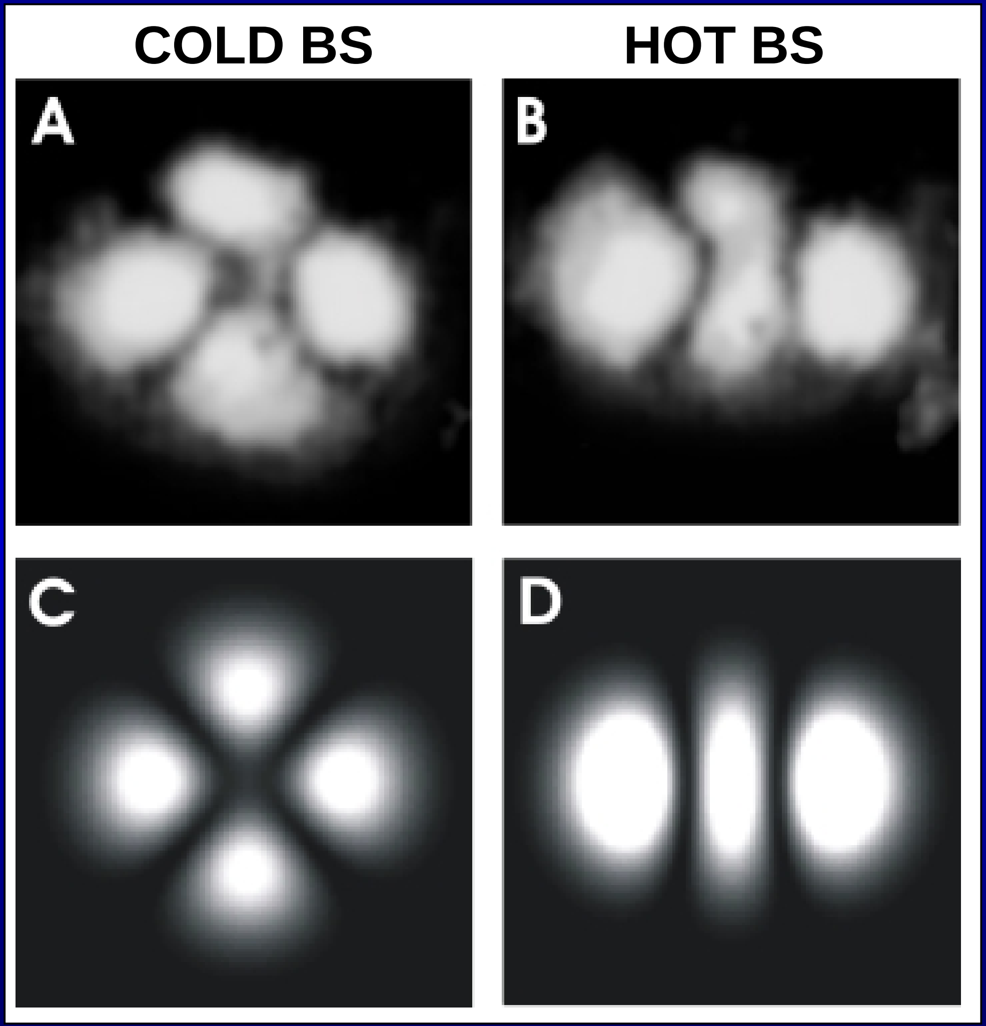
Measurement of the absorption

Strength of thermal lens proportional to absorption inside BS

Idea:
Using effect of thermal lensing to measure the absorption in BS substrate.

Observation (A+B):
Change of darkport image after lock acquisition

Simulations (C+D):
To explain observed change in the darkport image we have to introduce a thermal lens of f = 13km.



Upper limit of GEO BS bulk absorption

Thermal lensing:

$$\delta s = 1.3 \cdot \frac{\beta}{4\pi\kappa} \cdot p_{\rm a} \cdot d \cdot P,$$

Absorption:

$$p_{\rm a} = \frac{4 \cdot \pi}{2.6} \cdot \frac{w^2 \cdot \kappa}{\beta \cdot d \cdot P \cdot f_{\rm therm}}$$

Upper Limit for bulk absorption inside the GEO BS:

$$p_{\rm a} = 0.25 \pm 0.1 \, {\rm ppm/cm}.$$

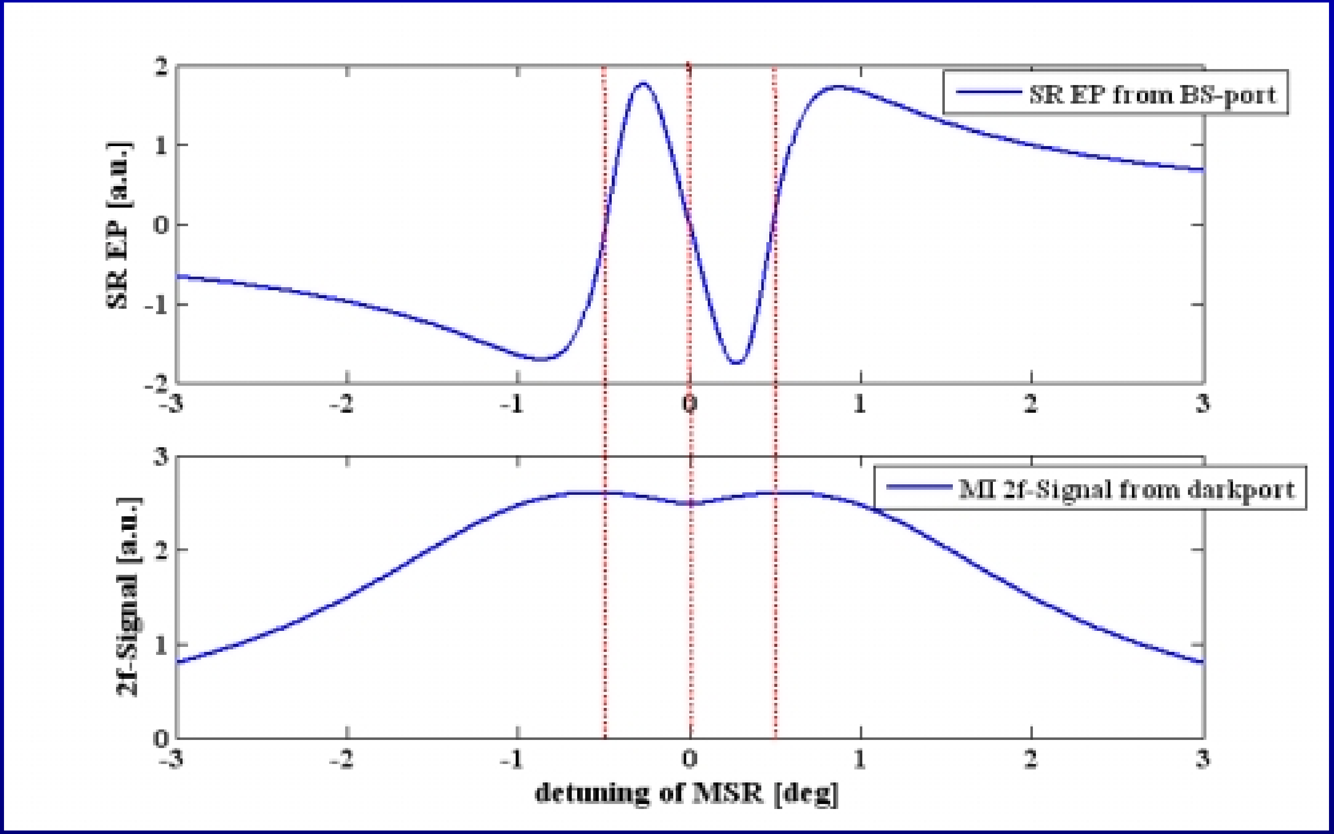
δs	= pathlength difference
β	= dn/dT
κ	= thermal conductivity
p_a	= absorption per lenght
d	= geometrical length in substrate
P	= optical power in substrate
ω	= beam radius
f_{therm}	= focal length of thermal lens

Lowest value ever measured @1064nm !!

This low absorption: So GEO (HF) can operate with much higher intracavity power than expected (without any thermal compensation at the BS)

Jumping to the other SR sideband

For various reasons we are not able to tune further down to the tuned case and then to the other sideband

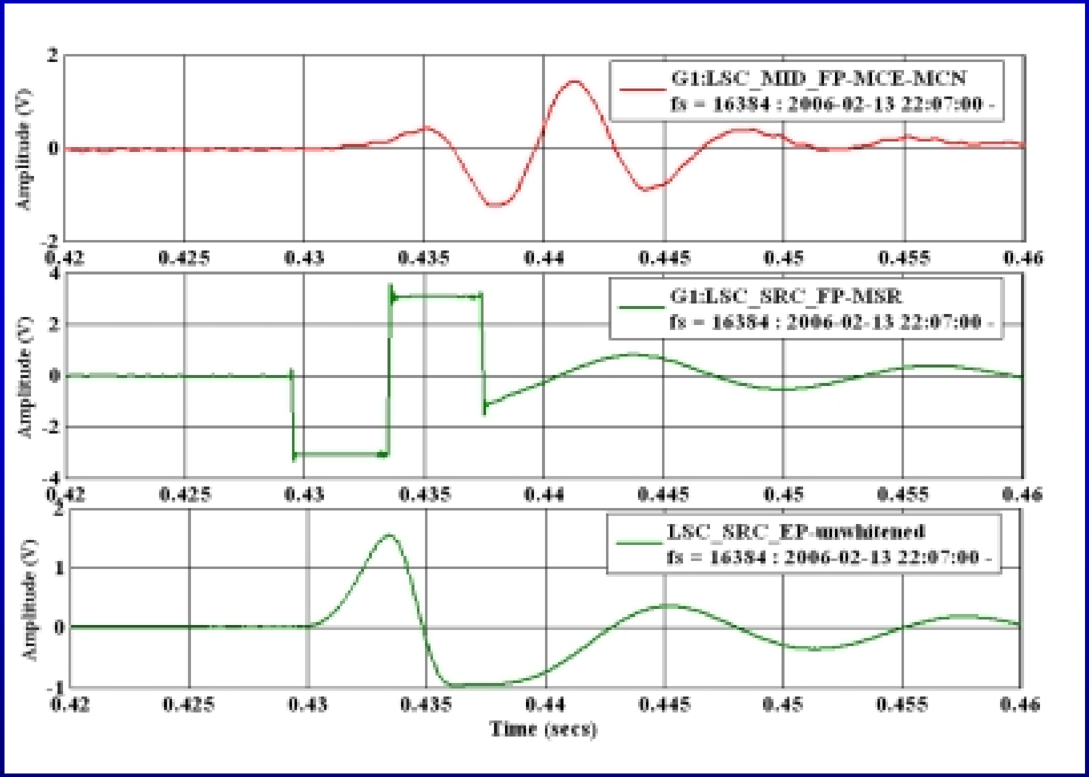


Idea: But maybe we can jump to the other sideband (only 2.8 nm for MSR), or to the tuned case ???

Kicking MSR

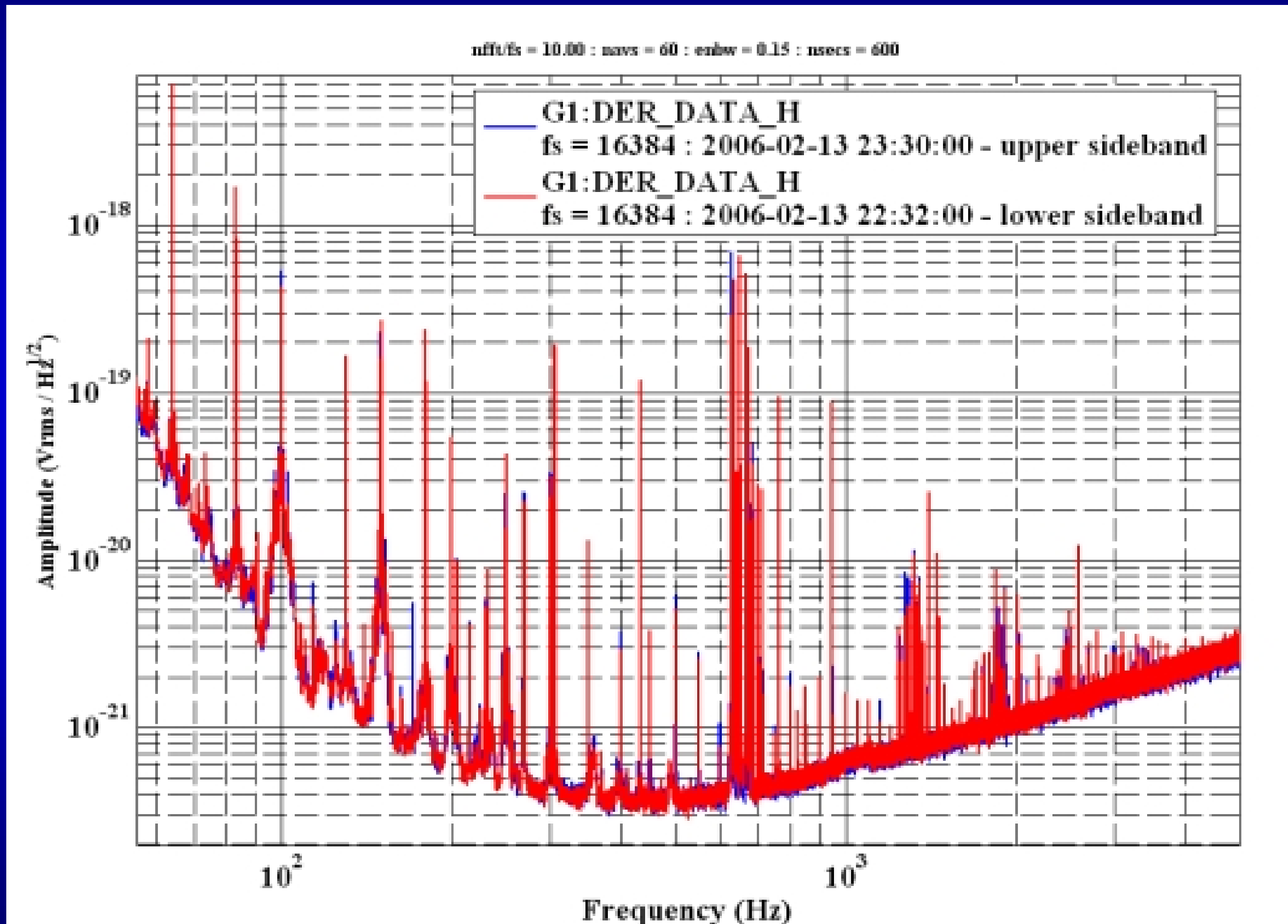
Kicking MSR in a controlled way:

- Fast enough that all other loops can‘t recognize.
- 4 ms of acceleration and 4 ms of deceleration.



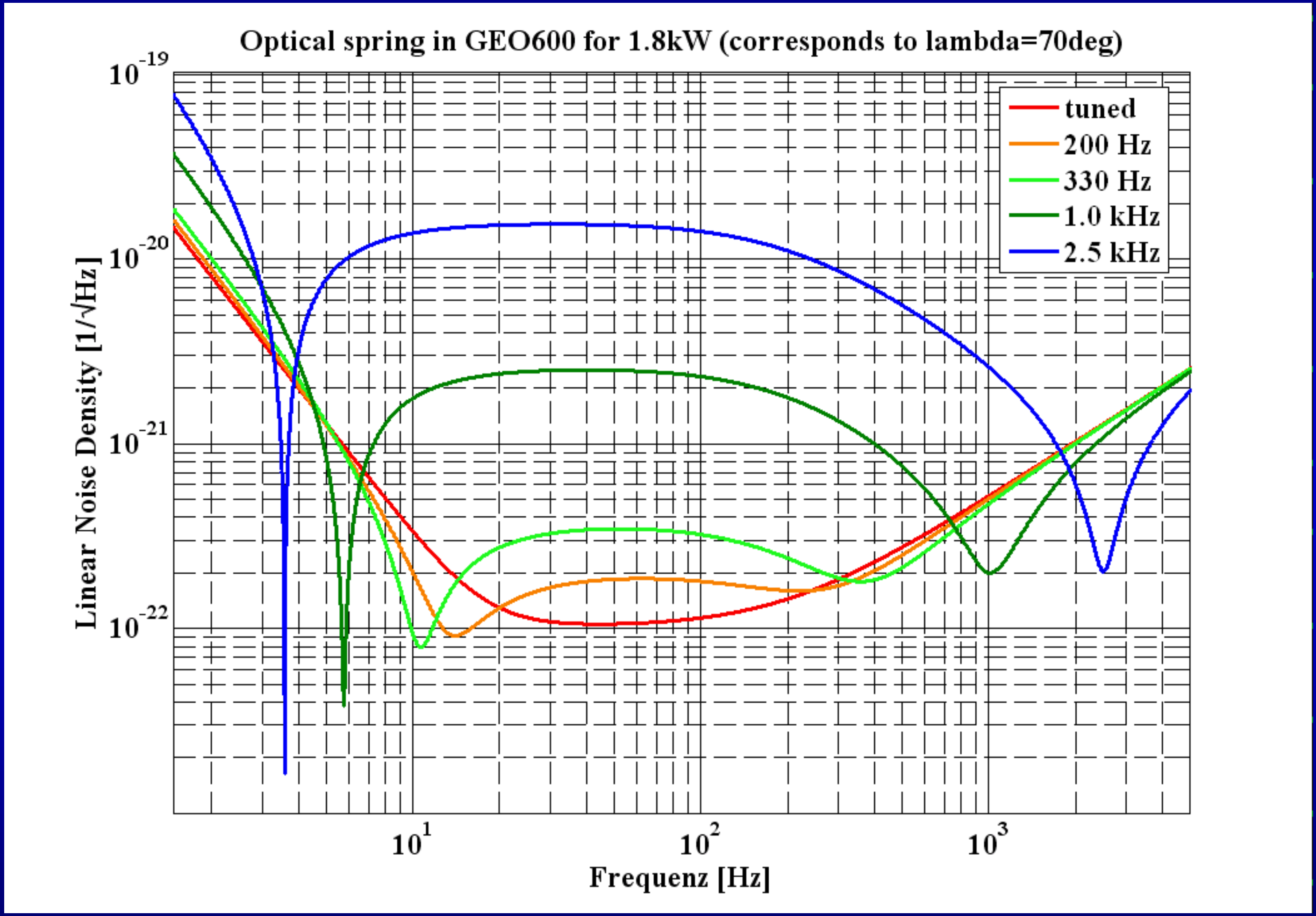
Works fine !!

Sensitivity on different locking points



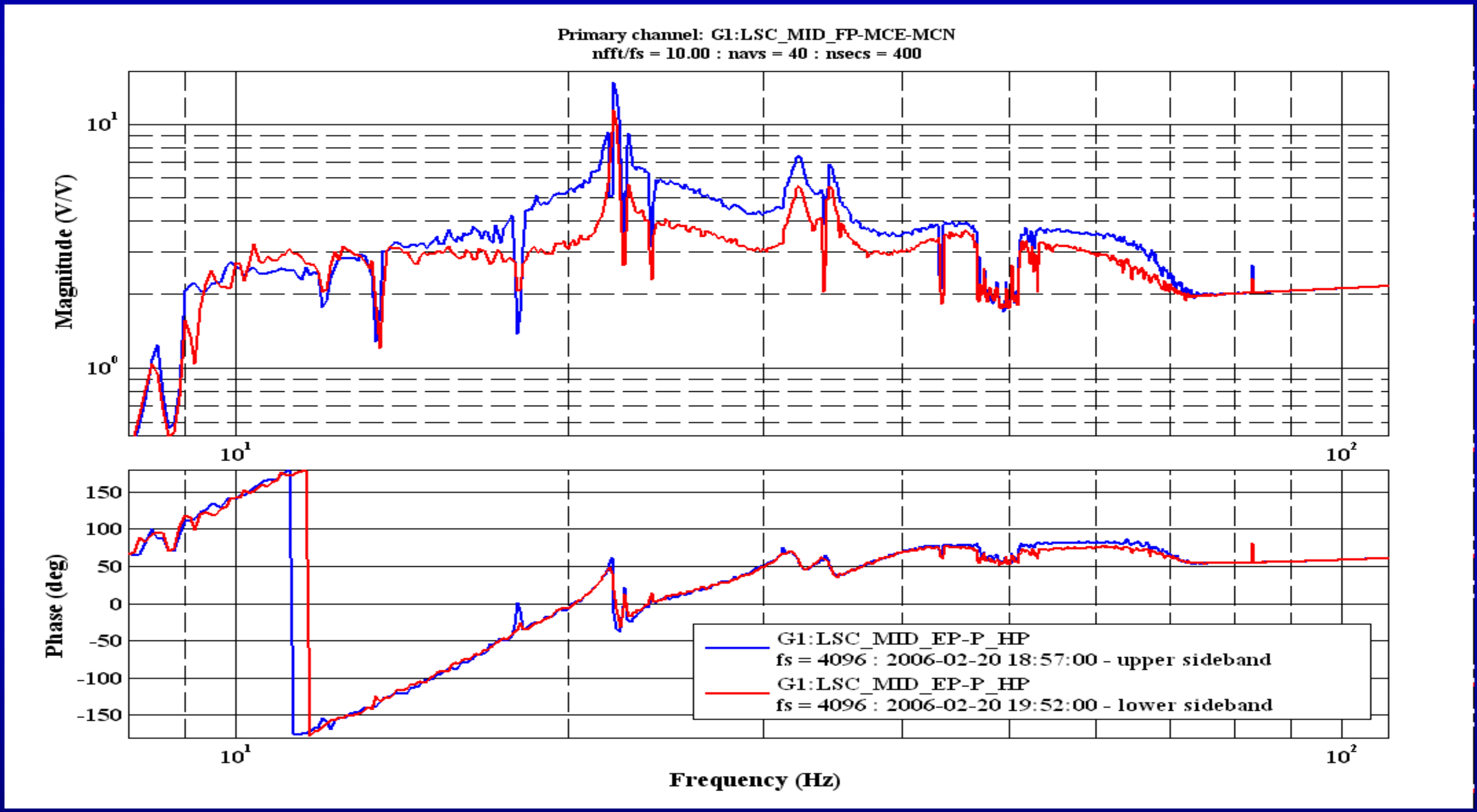
Sensitivity is identical for the two different locking points.

Optical spring in GEO



Trying to measure optical spring

Idea: Trying to measuring optical spring by direct comparison of optical TF for lower and high SR sideband:

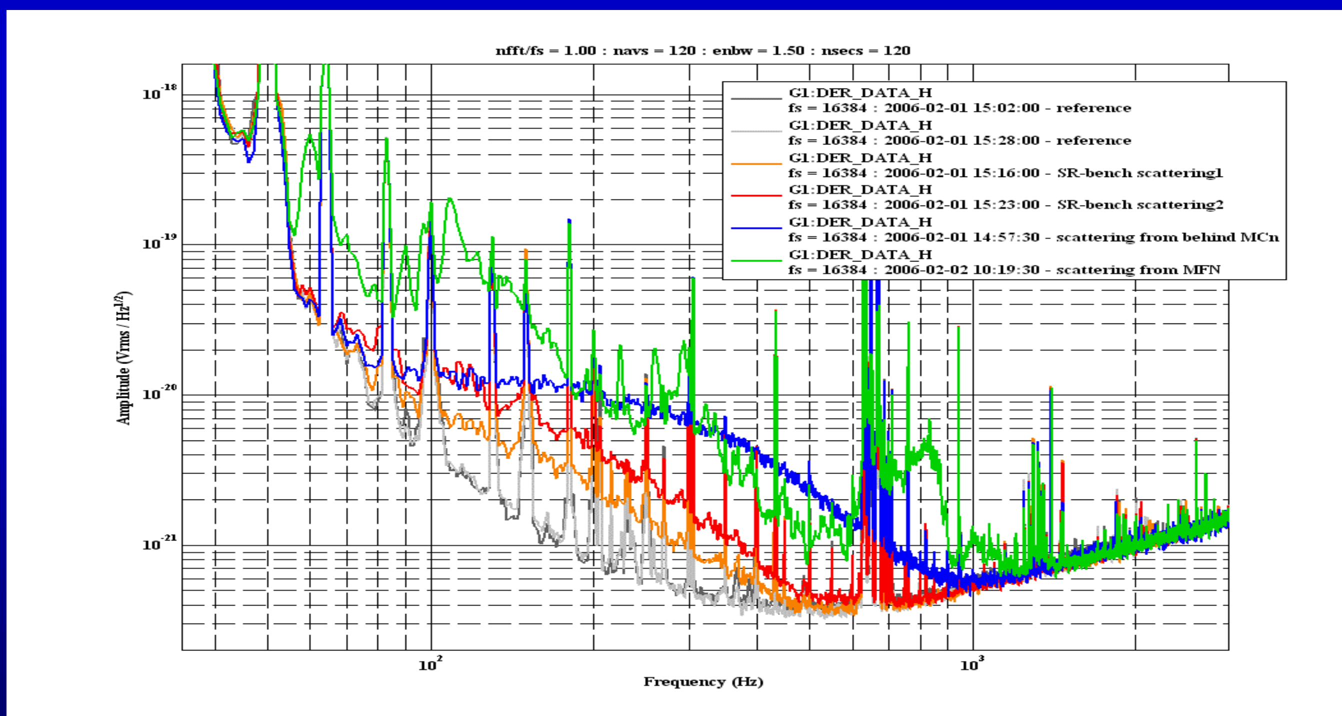


So far no success in measuring optical spring.

Scattering characteristics from different interferometer ports

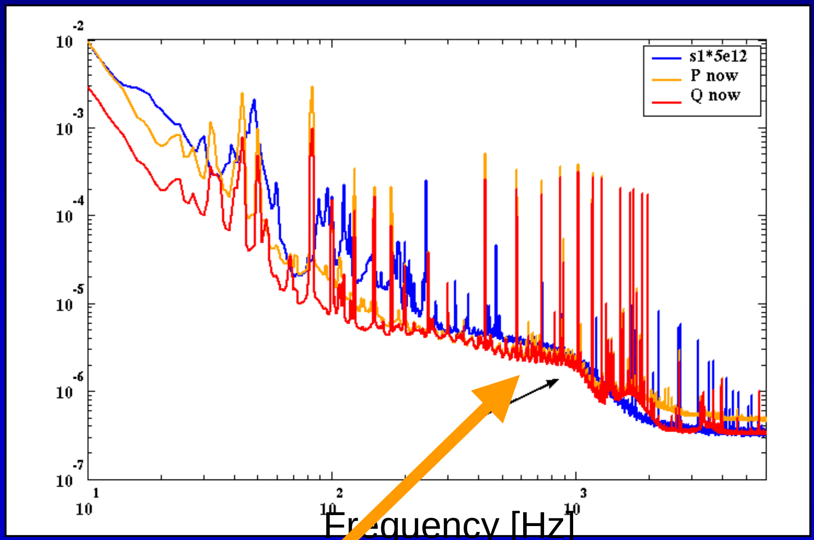
During the last two years scattered light noise was found to be a limiting noise sources in GEO 600. It has often been difficult to determine the exact scattering mechanism.

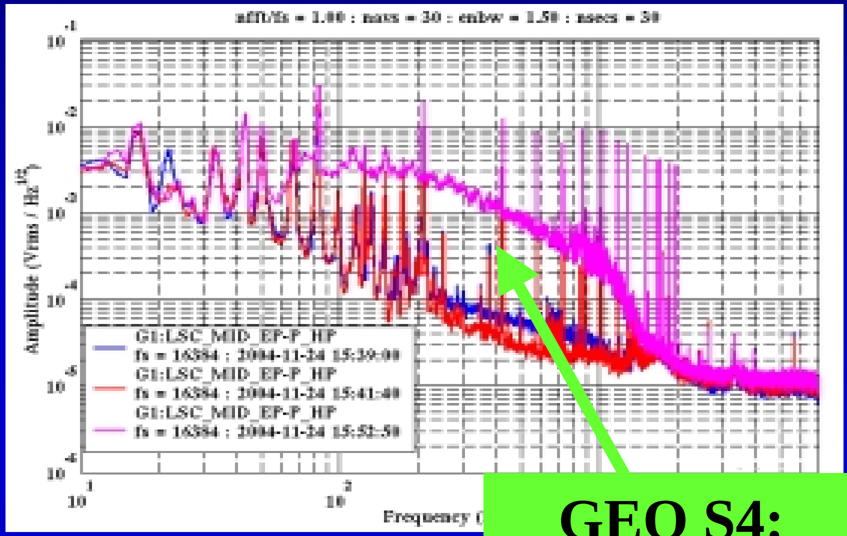
Checking various interferometer ports (outside the vacuum) for scattering.
Inserting a ‚not moving' piece Perspex into beam.



Result: Scattering shoulder as we saw already earlier.

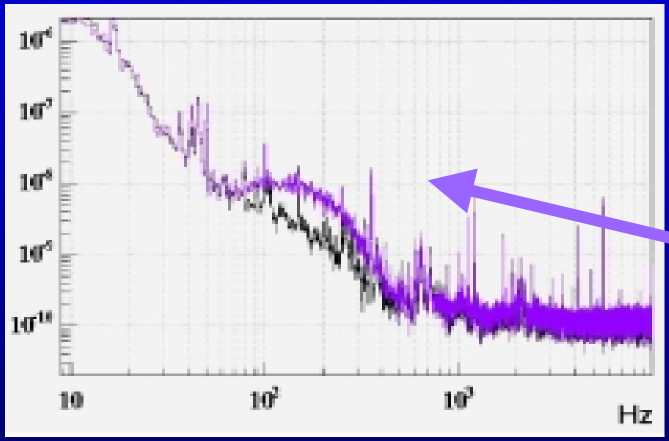
The scattering shoulder





GEO S4: DRMI (folded arms)

GEO S1: PRMI (folded arms)



VIRGO: PRMI (arm cavities)

Shoulder seems to show up in all present IFO configurations

What are we looking for ?

We worry just about a very small light level !
≈ 10^{-17} W (≈100 photons/sec)

The phase shift needed to create noise up to 1 kHz could be due to:

- a surface moving at 1 kHz with an amplitude of much less than the a wavelength
- a surface moving at low frequencies with a much larger amplitude (pendulum modes or microseismic)

However we have not found a convincing explanation, as it seems the motion we have is too small or too slow to produce the observed effect.

Controllable scattering device

Idea: To have a controllable scattering surface.

2 different modes are required:
- moving at high frequency, but with small amplitude
- moving at low frequency (1Hz), but with larger amplitude (several fringes)

Cheap solution:

Audio speaker driven by an audio amplifier

Artikel-Abbildung | Verwandte Produkte | Höherwertige Produkte

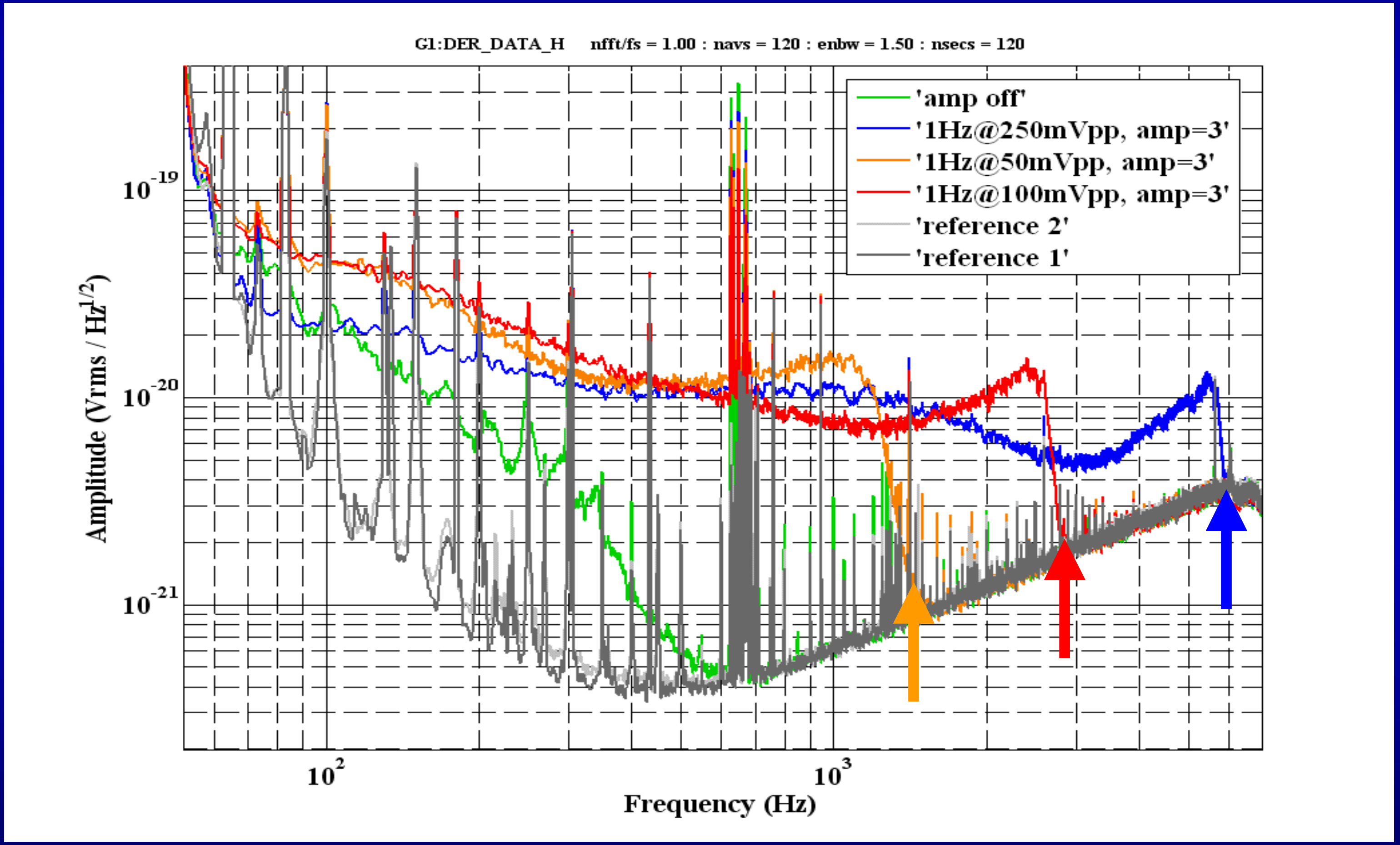
1 2 3

130mm MITTEL-TIEF-TÖNER
Artikel-Nr.: 369039 - 62

Modell	DS-050
Musik-/Sinusbelastbarkeit	80/40 W
Frequenzbereich	35 - 5500 Hz
Resonanz	48 Hz
Schalldruck	85 dB
Qts	0,420
Vas	8,02
Korb Ø mm	131,5 mm
Einbau Ø mm	111 mm
Einbautiefe Ø	72 mm

Scattering shoulder cutoff

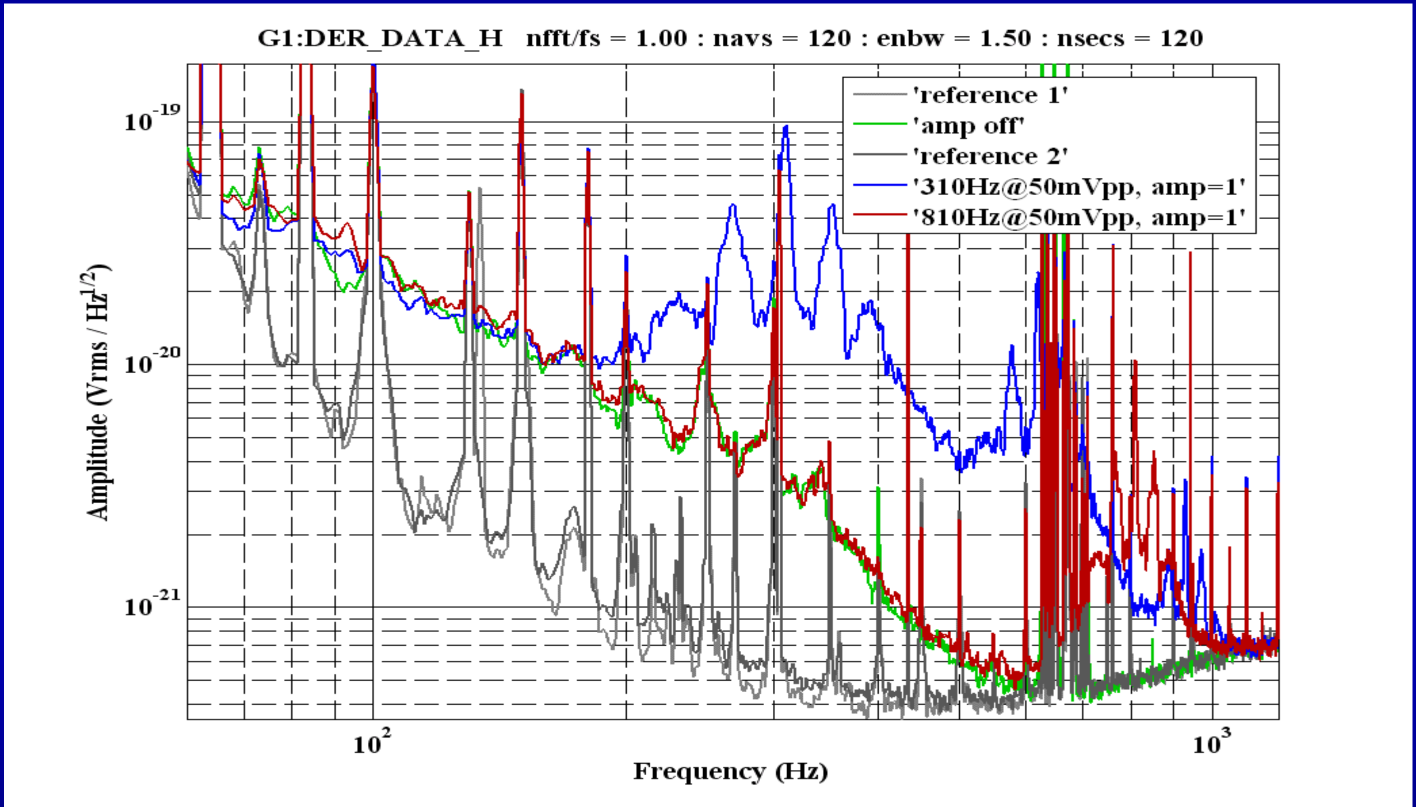
Driving speaker with 1Hz triangle and varying amplitude:



Result: cutoff frequency scales linearly with amplitude.

Injecting single frequency scattering

Driving speaker with single frequency of 310 / 810 Hz.

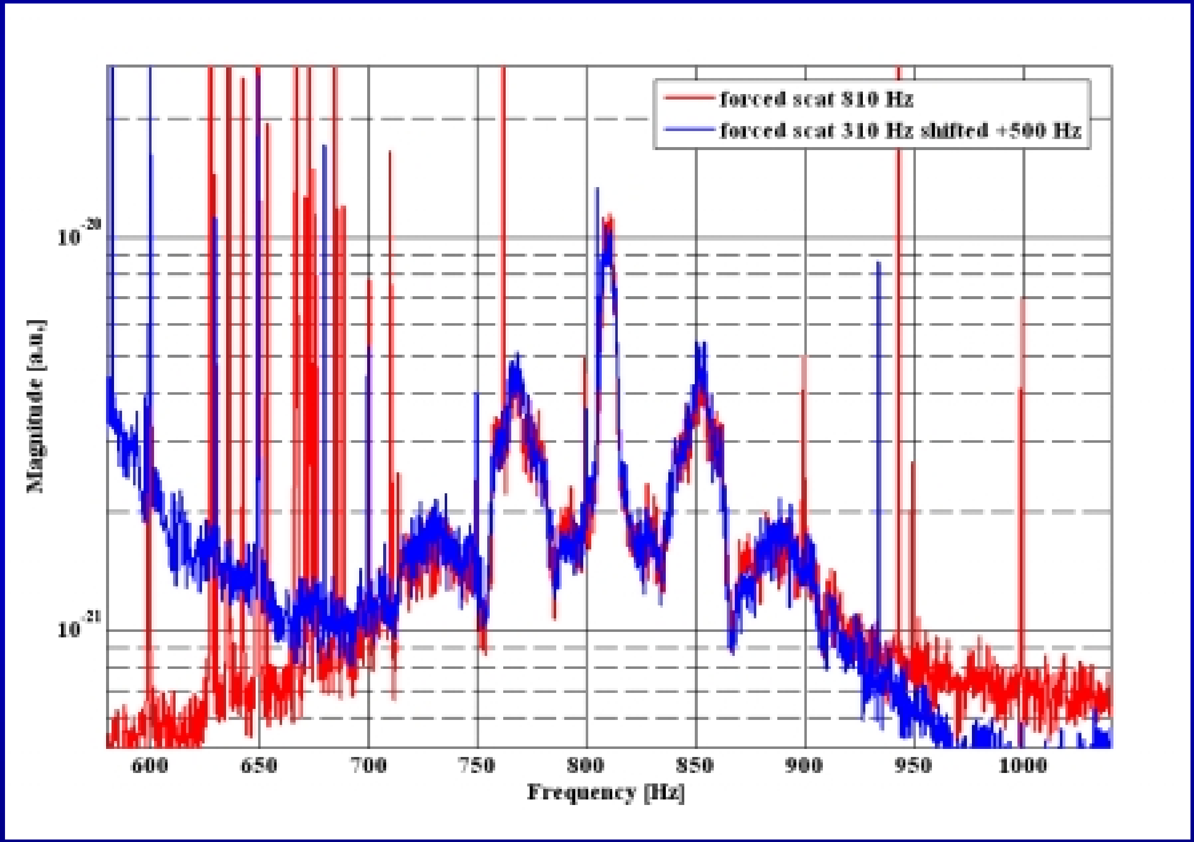


Results: - Large scattering peak at injected frequency

- Huge sideband structures

Sideband structure of an injected scattering line.

Sidebands have exactly the same structure !



Idea: Maybe we can use the sideband structure to learn about the origin of the scattering.

End

Thermal lensing in the beamsplitter

- Causes scattering into higher order modes.
- Cavity needs to stay stable:

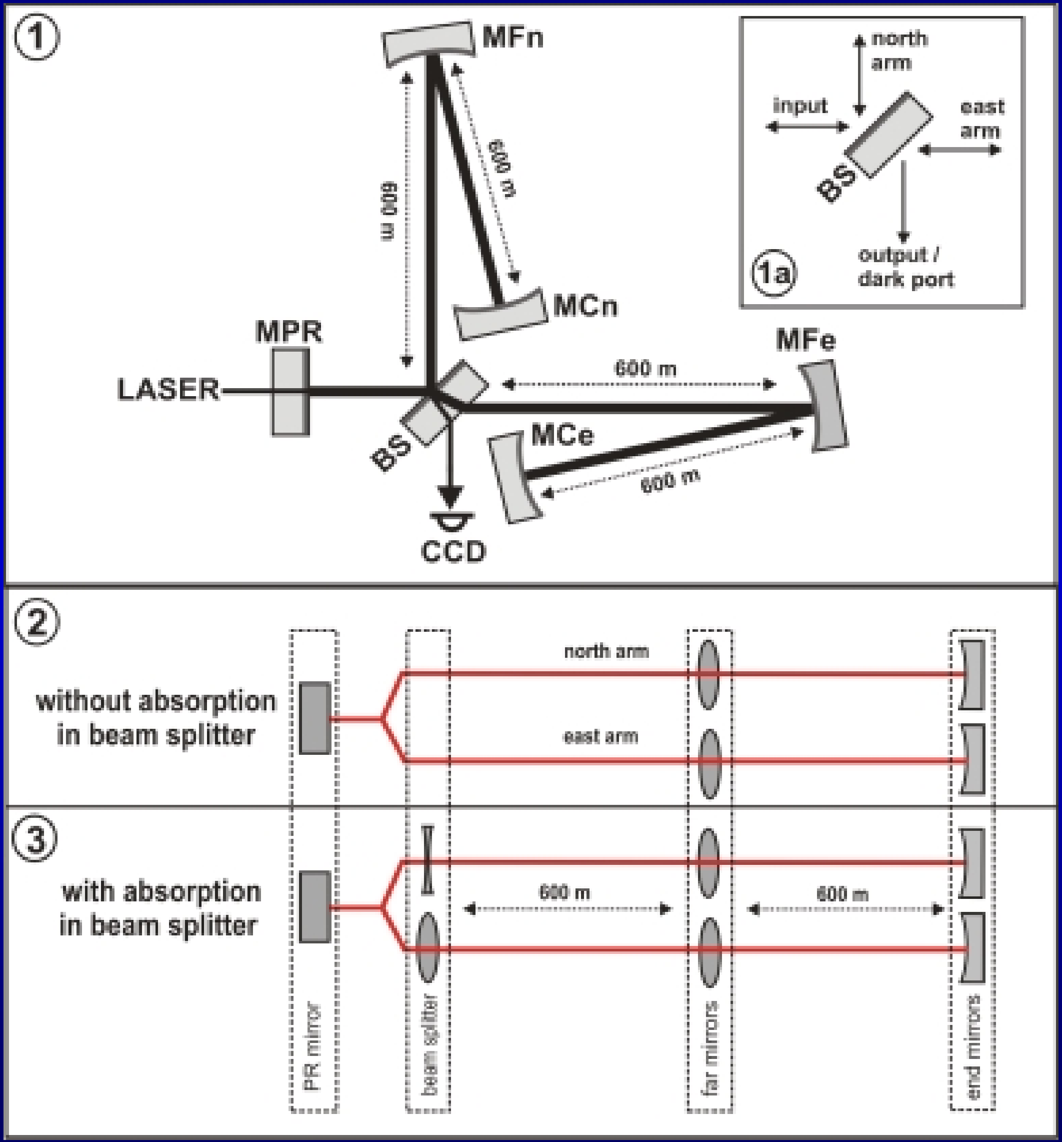
$$G_1 = 1 - 2d_2/R_1 - d_0/R_0$$
$$G_2 = 1 - 2d_1/R_1 - d_0/R_2.$$

$$d_0 = d_1 + d_2 - 2d_1 d_2/R_1.$$

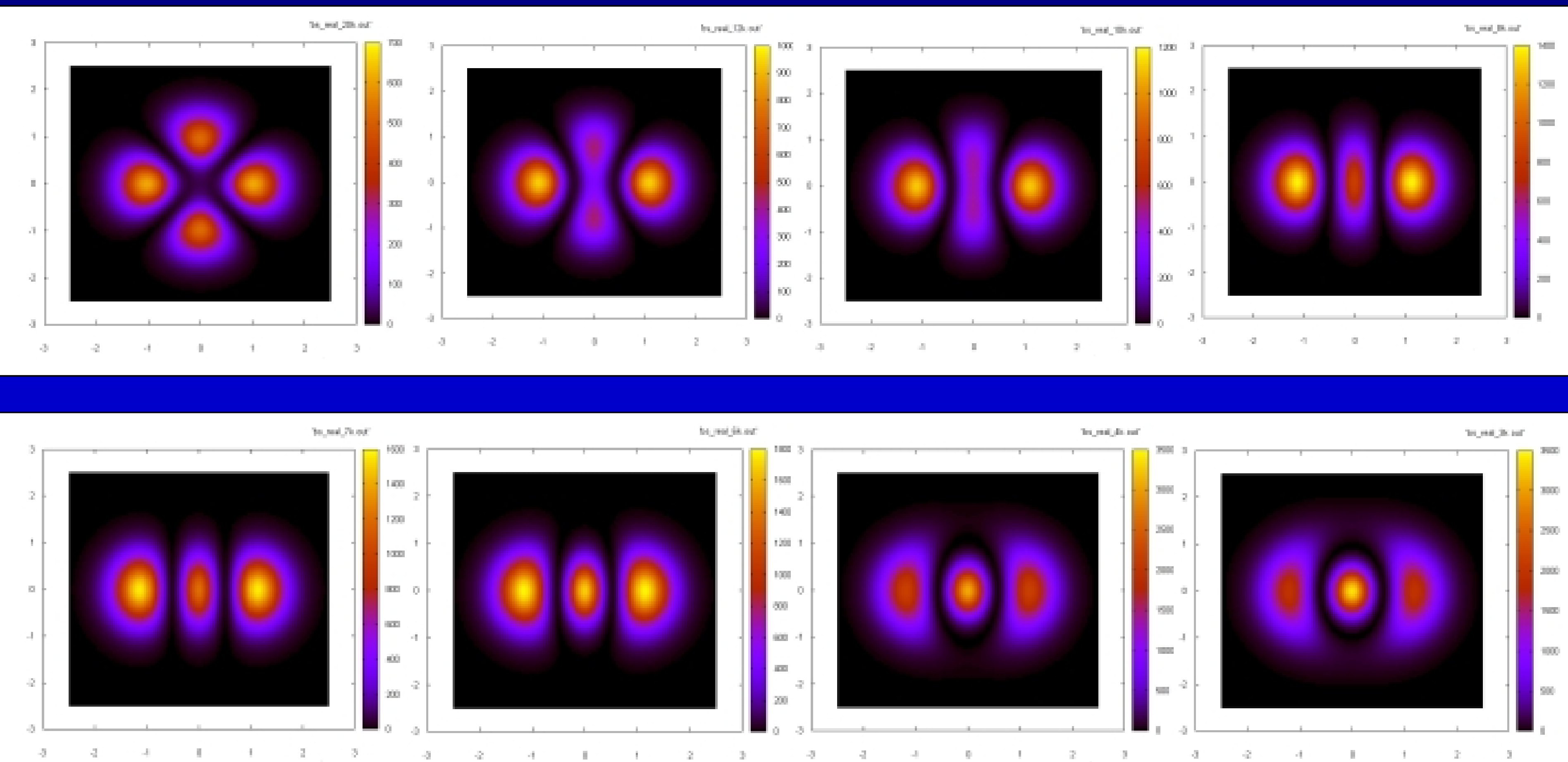
$$0 \leq G_1 G_2 \leq 1.$$

Instable for thermal lens
f < 600m

Sets an upper limit on intracavity power. Shot noise!

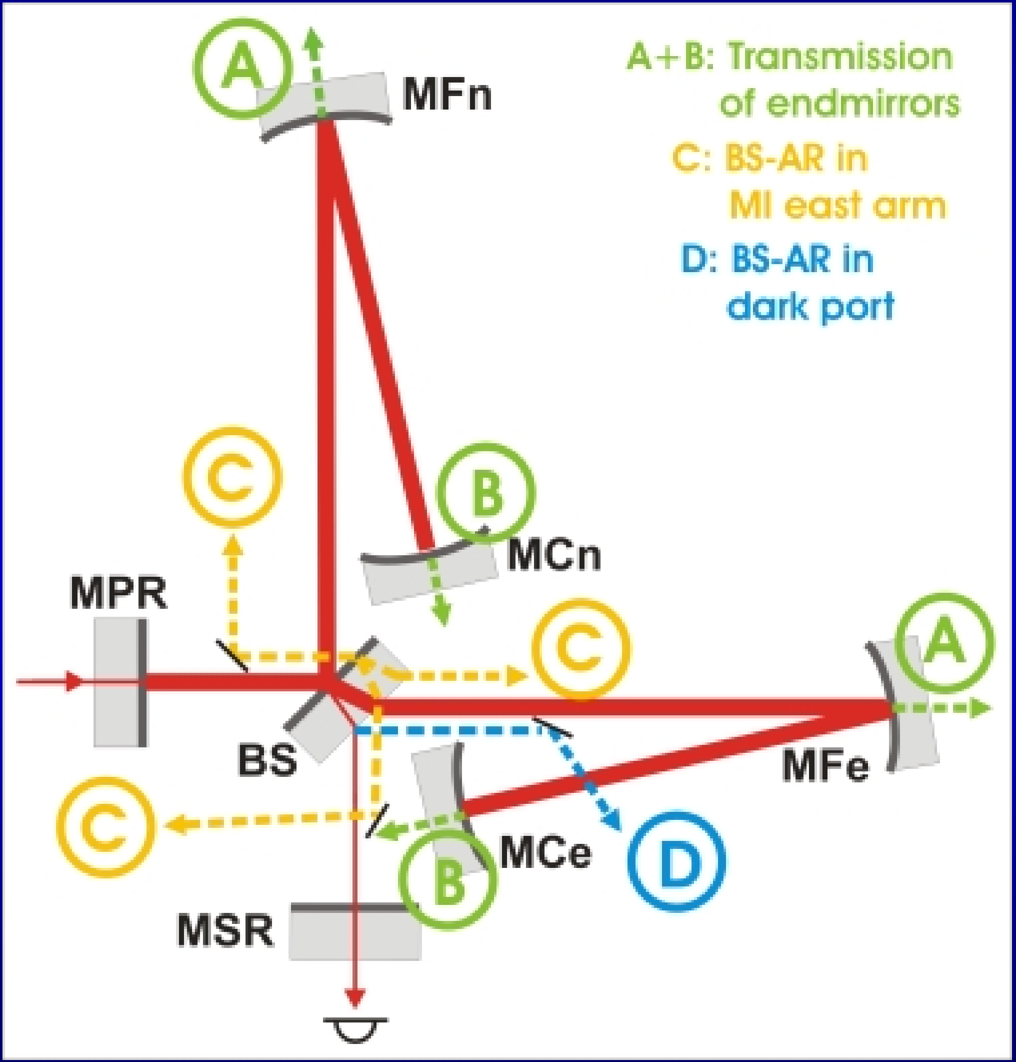


Change of darkport mode with incav-pwr



GEO600 was initially designed for using intracavity power of about 10 kW

Our experience with scattering so far



- Differential ports are especially sensitive
- Scattering near a waist is fatal (cat's eye effect)

How to avoid trouble:

- Avoid beam waists
- If you can't avoid waists, then don't place any optics near the waist
- Use only high qualtiy optics (AR coated diode windows, ...)