GEO600 status

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for the GEO team

LSC-Virgo meeting Budapest,
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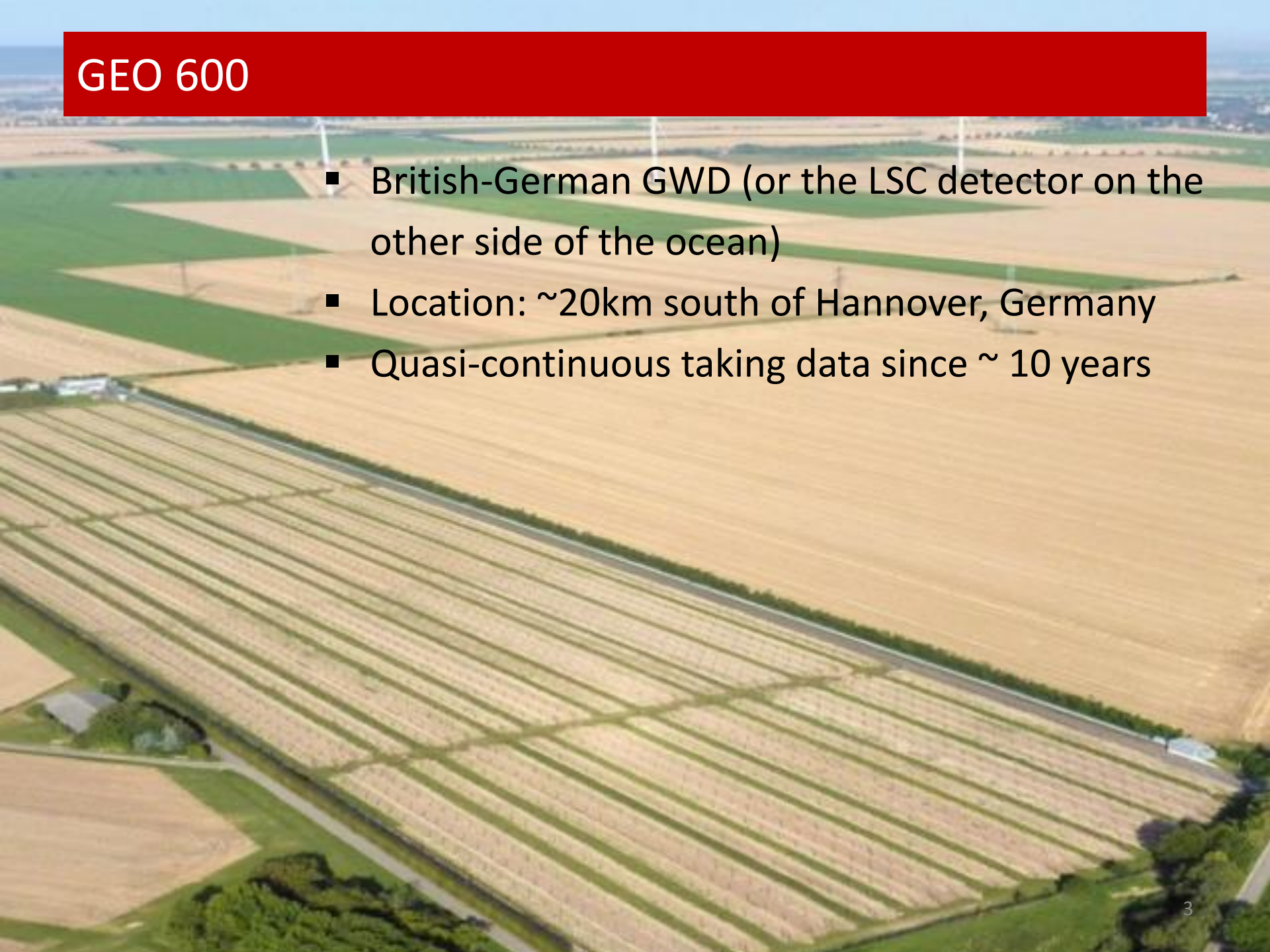
Outline

- GEO 600 & GEO-HF
- The actual status
  - Astrowatch
  - MDWS: a high bandwidth OMC AA schema
  - Squeezing: loss reduction
  - Laser power increase
- Going beyond GEO-HF?

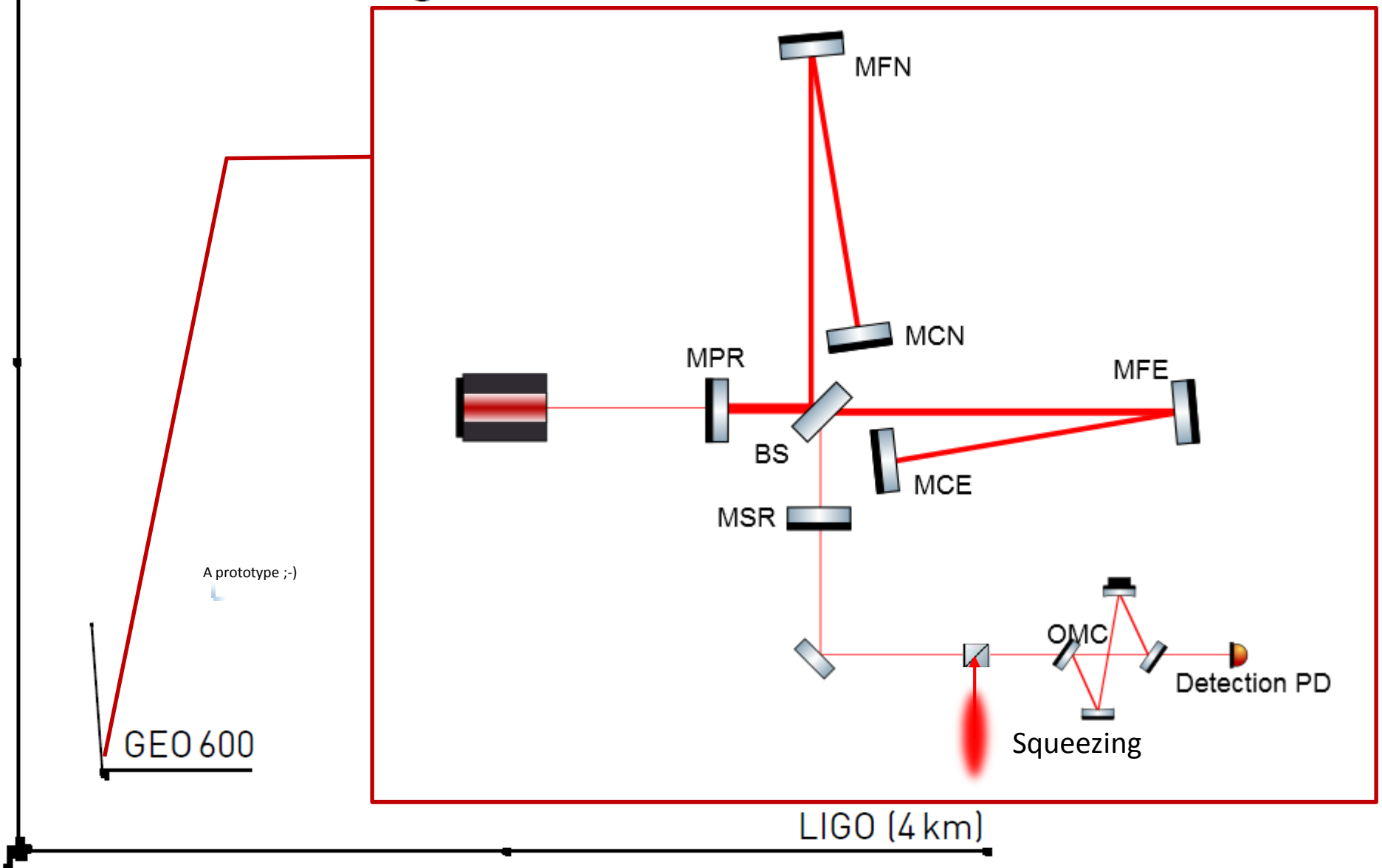
GEO 600



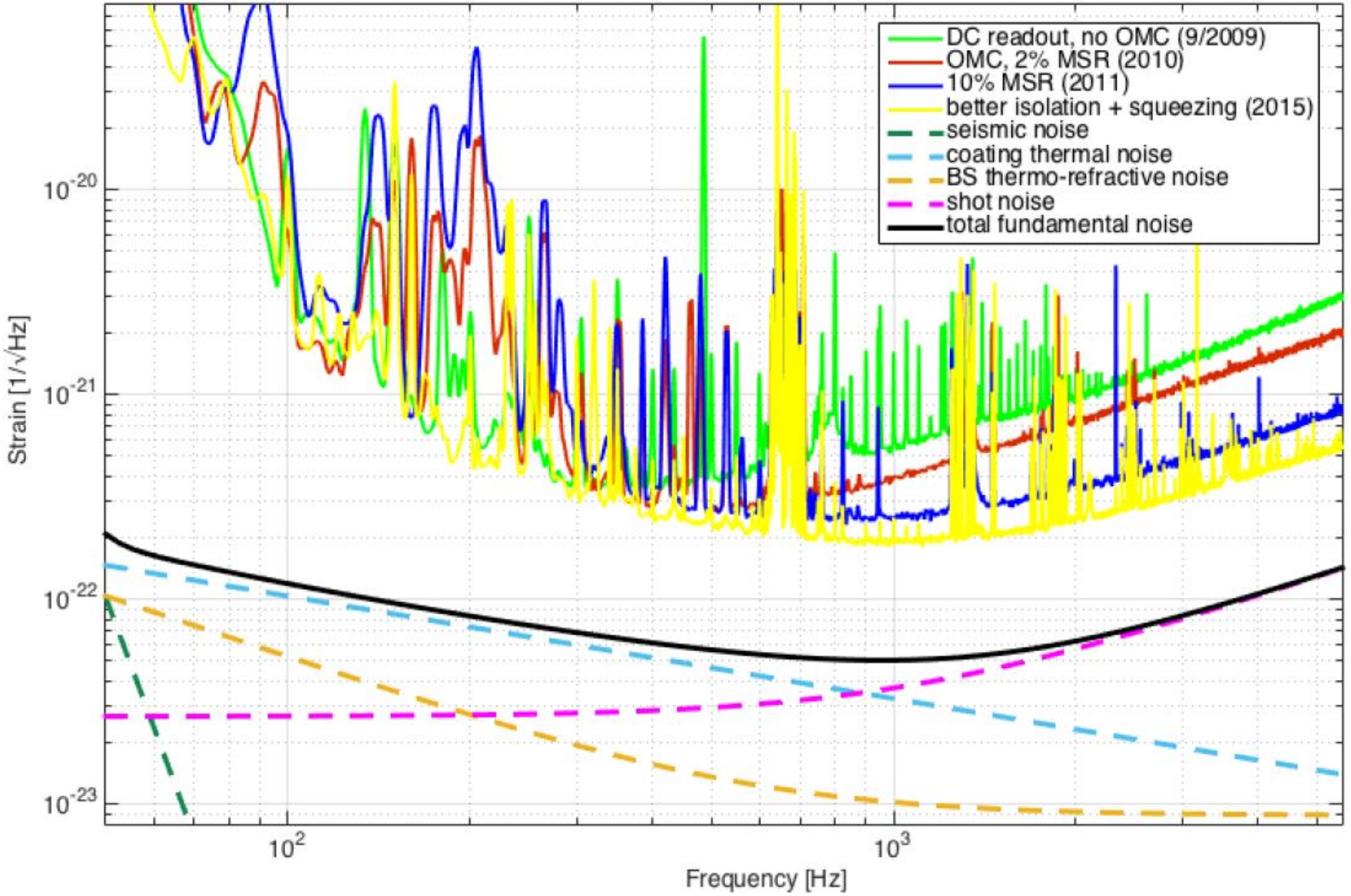
- British-German GWD (or the LSC detector on the other side of the ocean)
- Location: ~20km south of Hannover, Germany
- Quasi-continuous taking data since ~ 10 years

GEO 600 and GEO-HF

A *small* large-scale detector



GEO 600 and GEO-HF

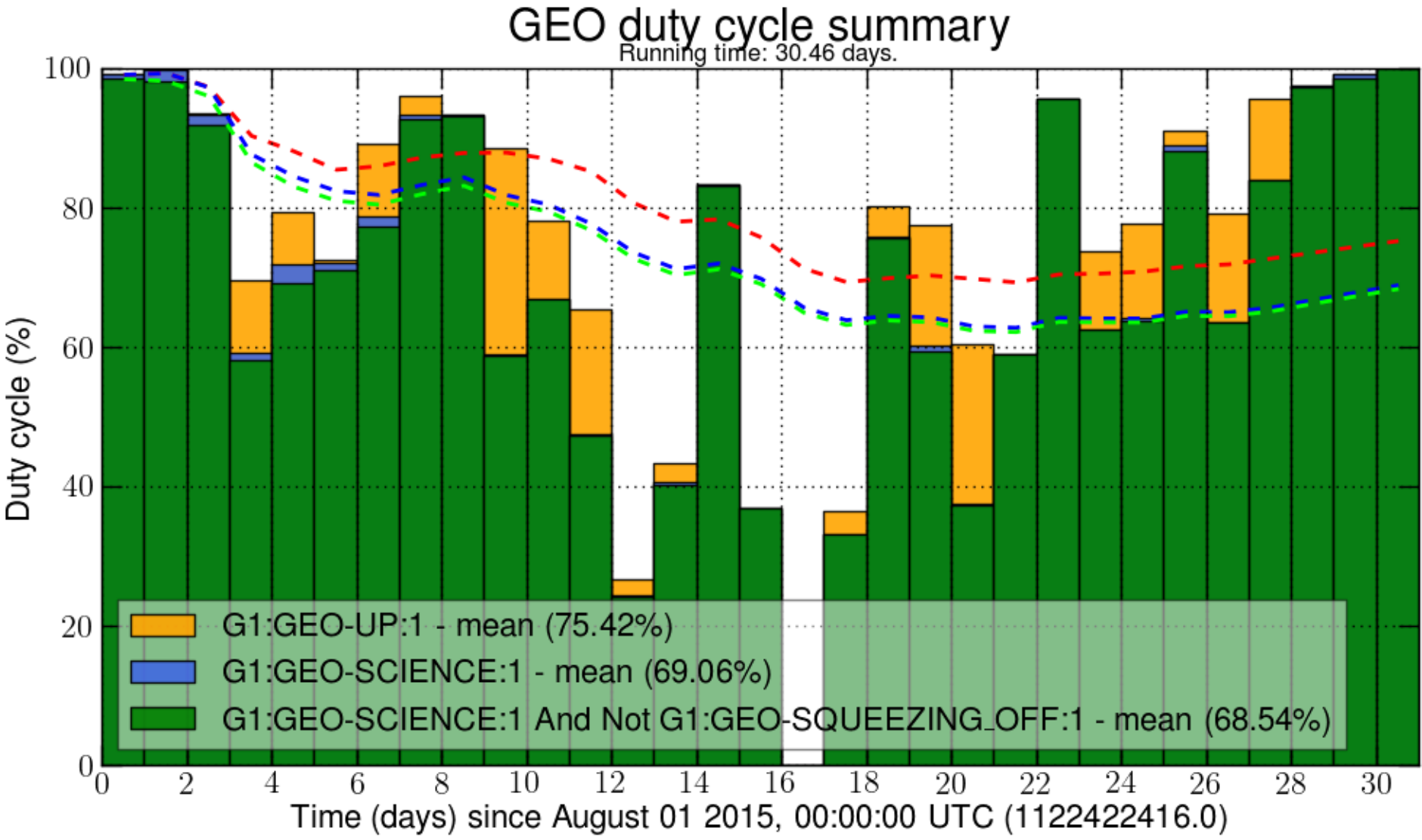


Learn more about GEO 600 and GEO-HF: **K.L. Doodley et al,** GEO 600 and the GEO-HF upgrade: successes and challenges. (P1500140-v1)

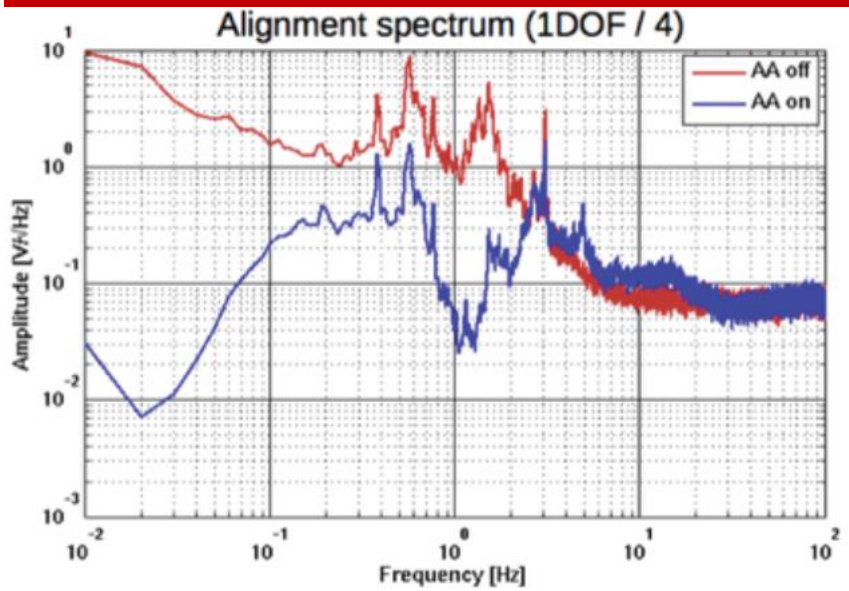
Astrowatch

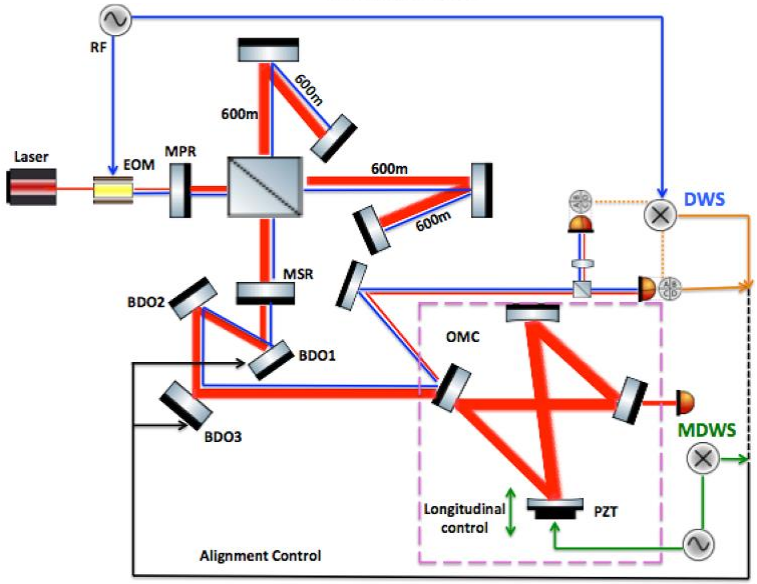
https://losc.ligo.org/timeline/show/tenyear/

Astrowatch


GEO duty cycle summary
Running time: 30.46 days.
Duty cycle (%)
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Time (days) since August 01 2015, 00:00:00 UTC (1122422416.0)
G1:GEO-UP:1 - mean (75.42%)
G1:GEO-SCIENCE:1 - mean (69.06%)
G1:GEO-SCIENCE:1 And Not G1:GEO-SQUEEZING_OFF:1 - mean (68.54%)

Modulated differential wave front sensing





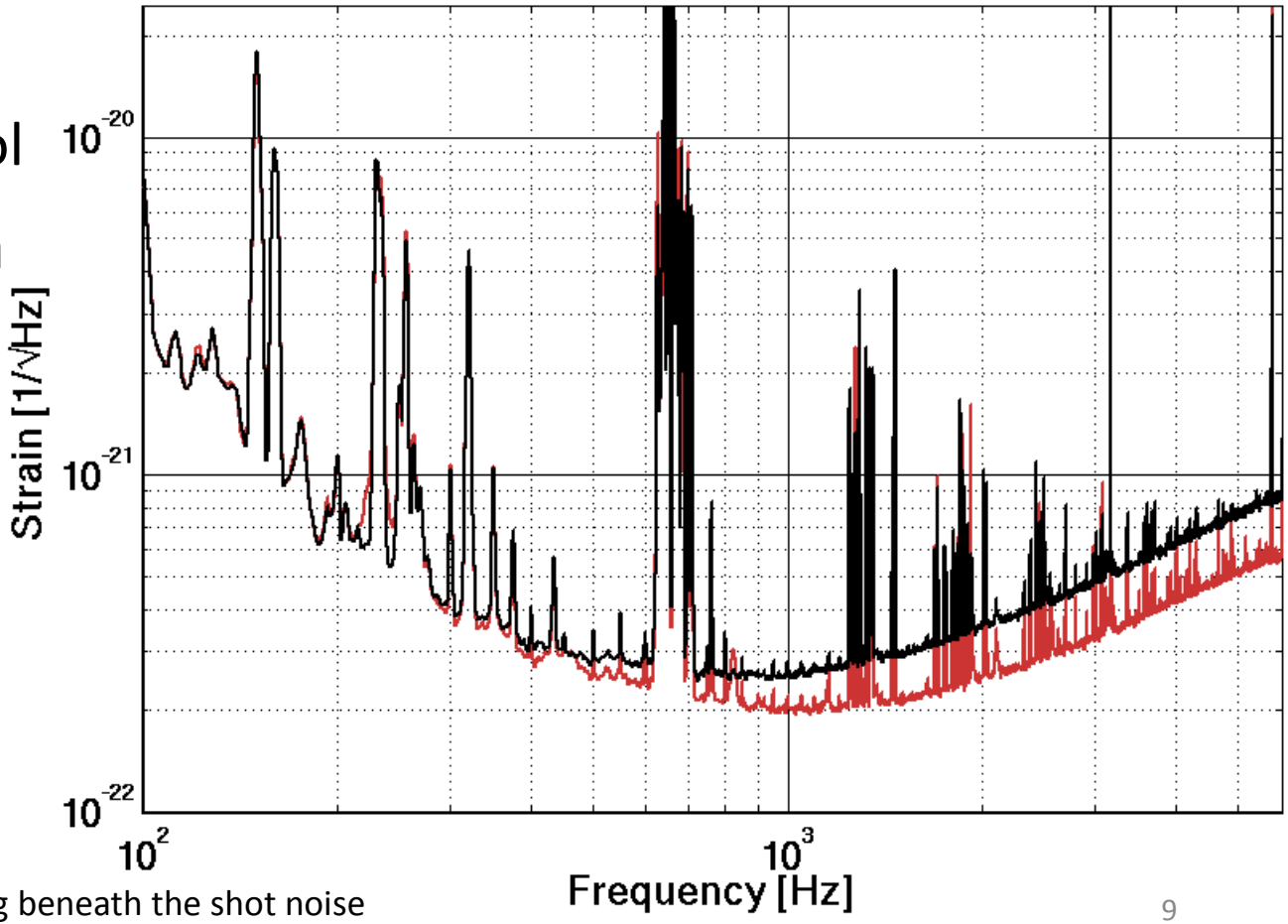
- Control bandwidth of a few Hz achieved. Goal: ~10 Hz
- Long term performance (~months) comparable to beacon dither
- uses 2f centering on sensors
- To do: decoupling of actuator DOFs, bandwidth increase and investigate benefit for operation at GEO

Poster by Aparna Bisht: Modulated Differential Wavefront Sensing: High Bandwidth Autoalignment Scheme for the Output Mode Cleaner of GEO600

Squeezing at GEO 600

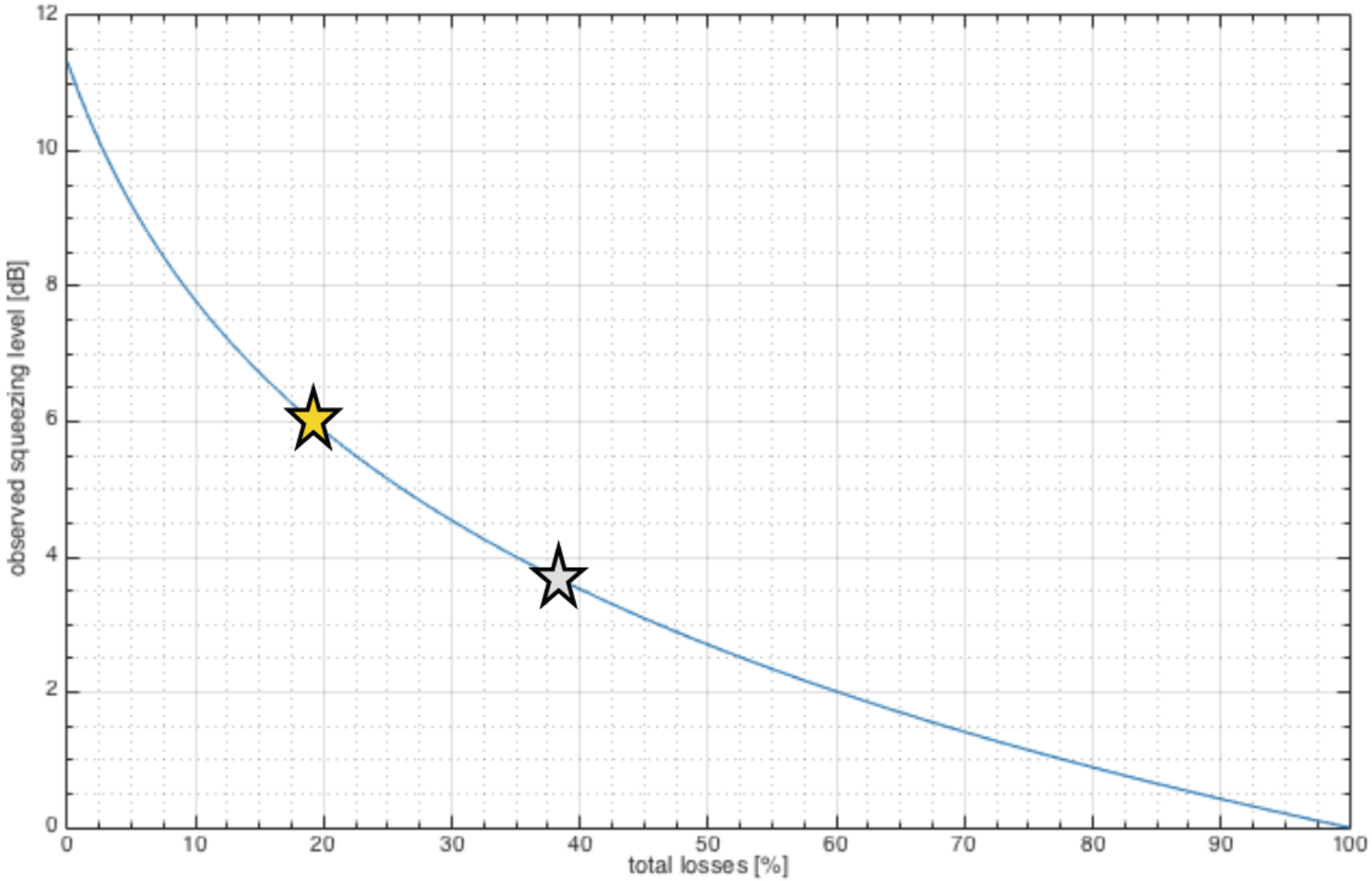
Focus in the (recent) past:

- Long term performance
- Phase control
- Alignment control
- **Loss reduction**



Poster by Emil Schreiber: Peeking beneath the shot noise

Squeezing at GEO 600

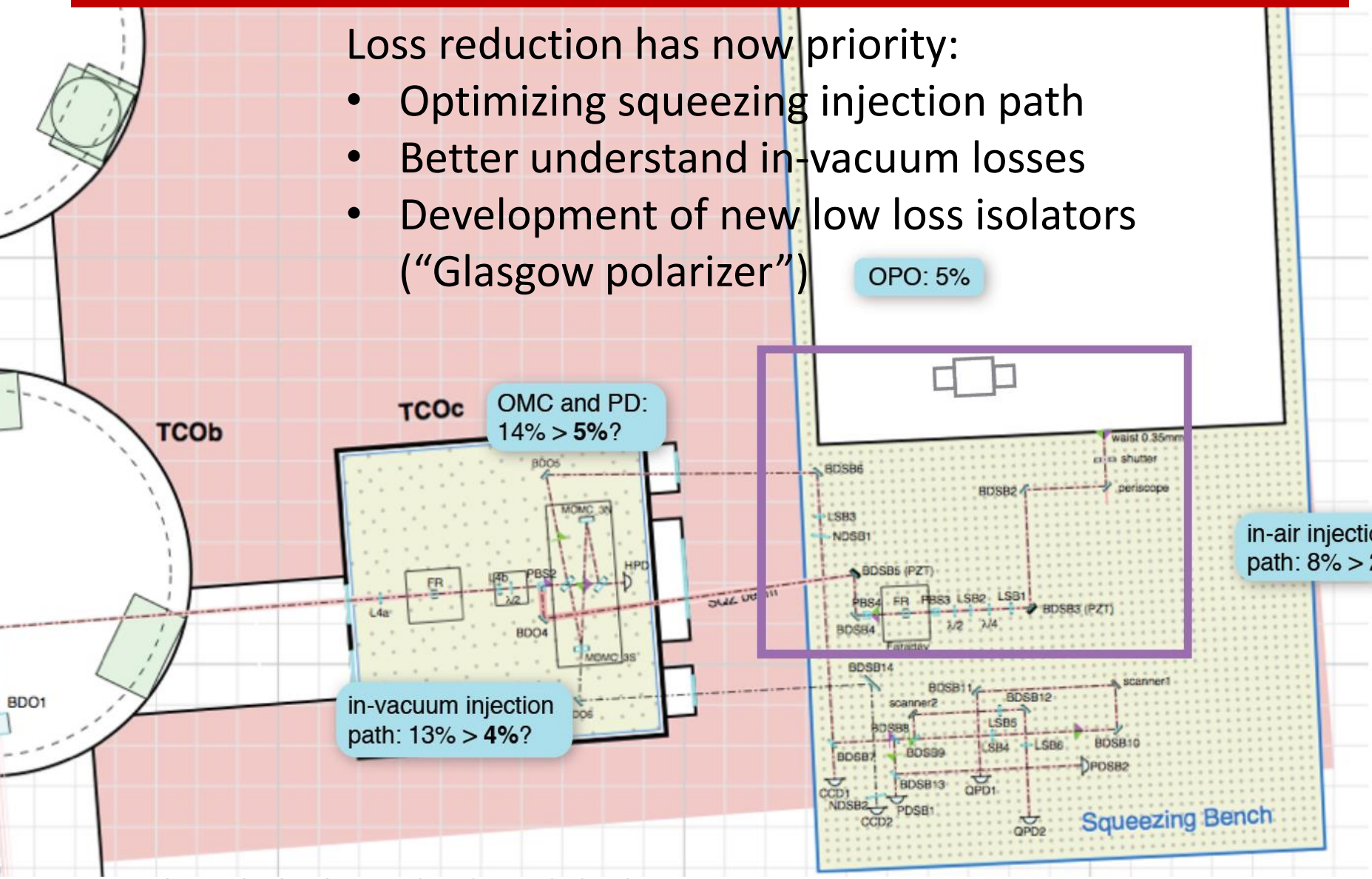


Poster by Emil Schreiber: Peeking beneath the shot noise

Squeezing: loss reduction

Loss reduction has now priority:

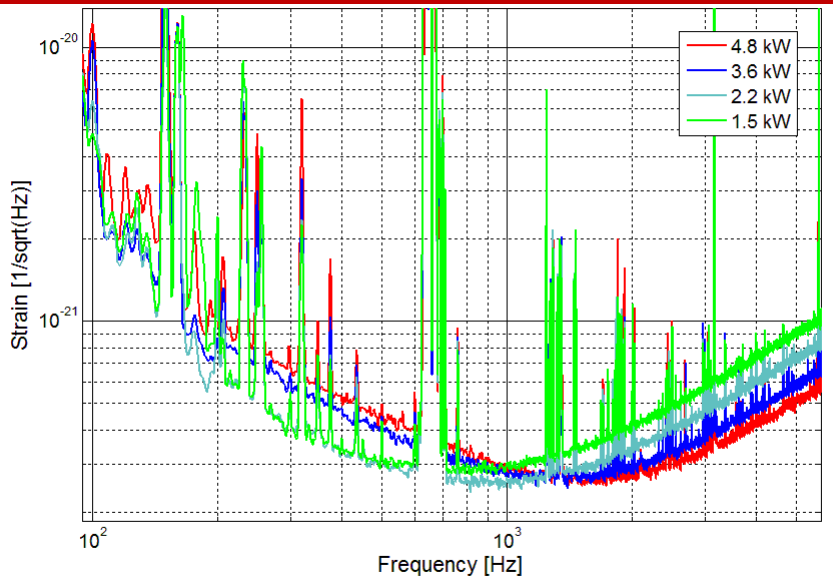
- Optimizing squeezing injection path
- Better understand in-vacuum losses
- Development of new low loss isolators ("Glasgow polarizer")

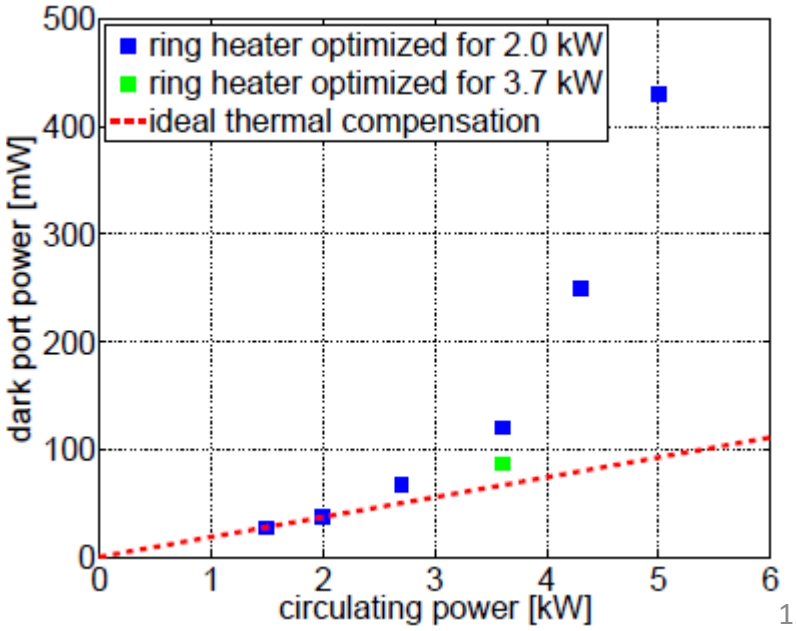


Poster by Emil Schreiber: Peeking beneath the shot noise

Laser power increase

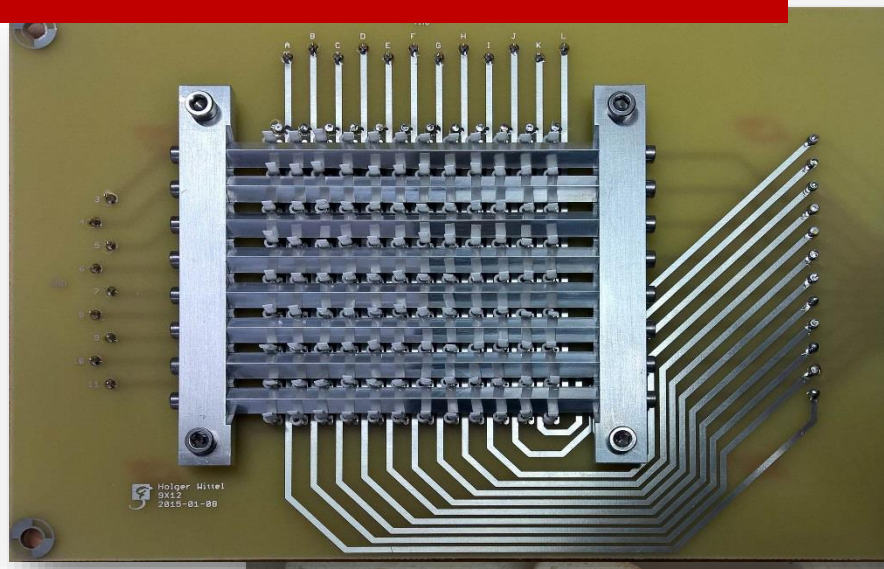
- Operation with low power, i.e. 2 to 3kW impinging on the BS
- Main reason: power dependent noise at medium frequencies & thermal compensation
- Increase (again) effort to commission GEO for high power operation
- thermal compensation of the BS thermal lens:
  - At one folding mirror
  - **At the beam splitter**

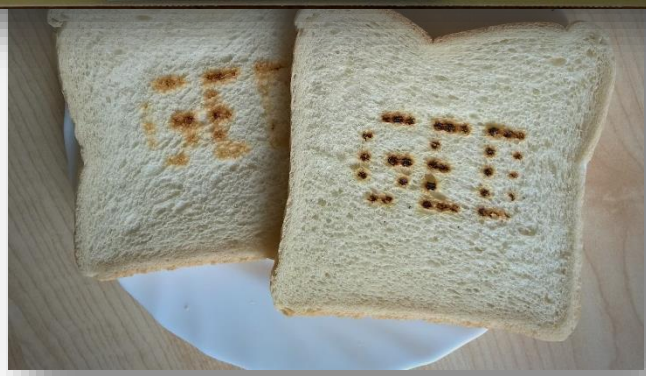




TCS at the BS

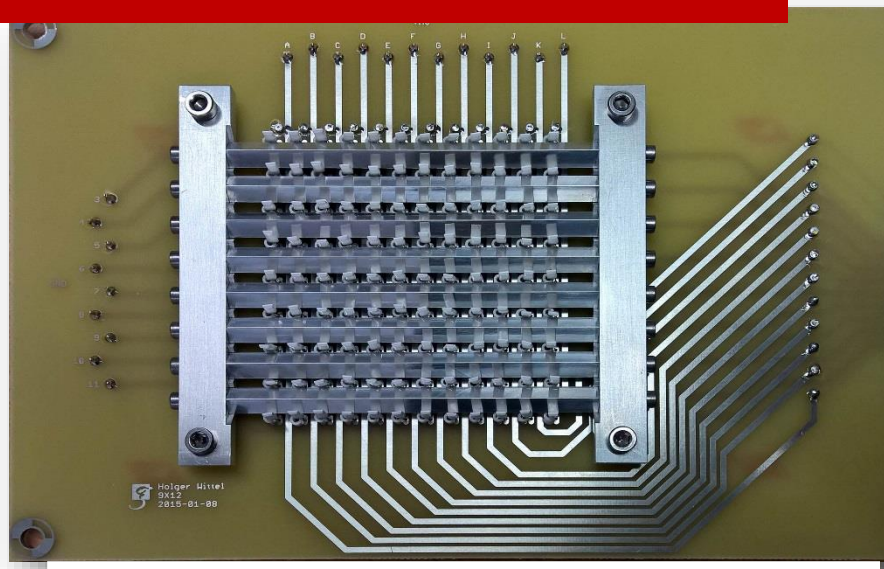
- Matrix heater: 9x12 small heaters, projected to BS surface and can act on:
  - thermally induced HOMs
  - “cold“ HOMs, caused by mirror imperfections
  - Heat the BS – mitigate cold locking

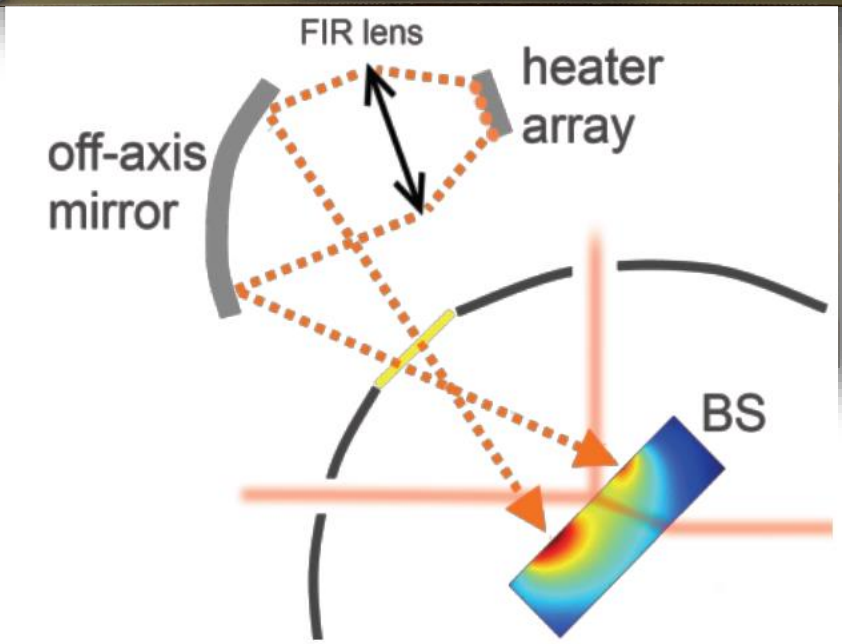




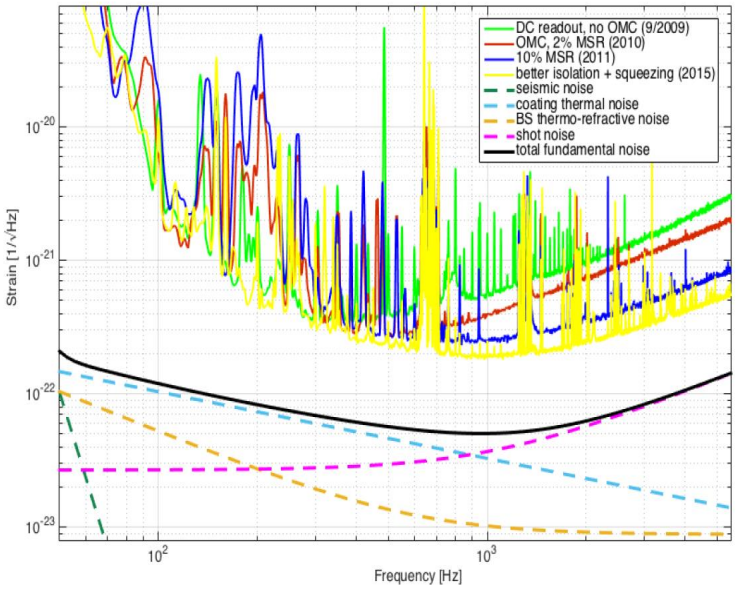
TCS at the BS

- Matrix heater: 9x12 small heaters, projected to BS surface and can act on:
  - thermally induced HOMs
  - “cold“ HOMs, caused by mirror imperfections
  - Heat the BS – mitigate cold locking
- Optimization of heating pattern ongoing
- Many strategies possible: (Simulation-driven guessing, using phase images, optimization algorithms)
- Preliminary results:
  - ~30% reduction of thermal HOMs
  - ~30% reduction of cold HOMs

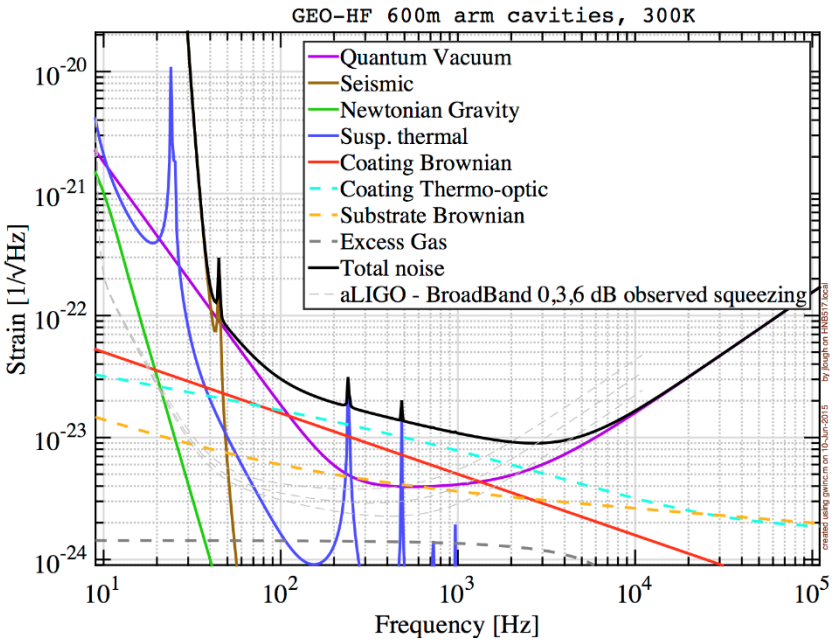




Beyond GEO-HF?



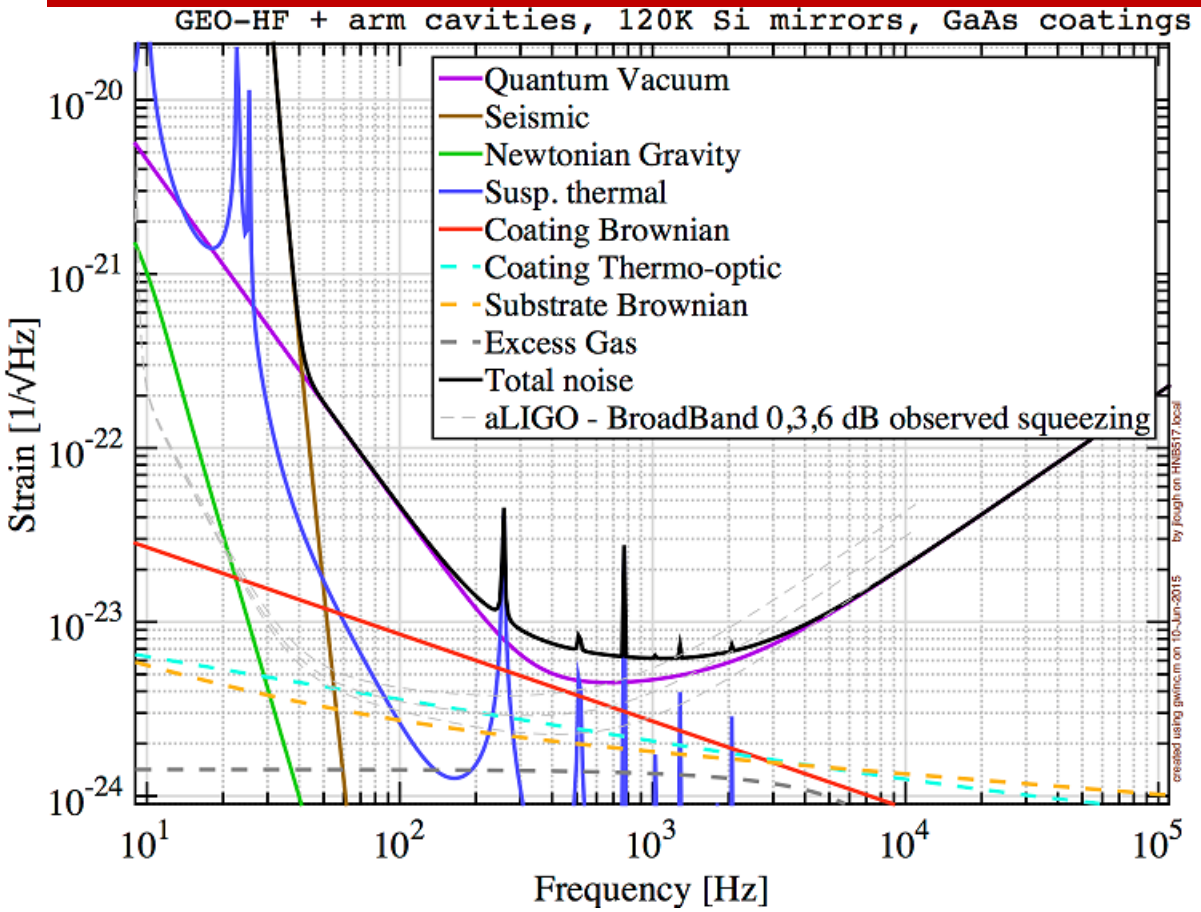
?



1. **Options for GEO 600 as a data-taking instrument**
2. Options for GEO 600 as a non-data-taking instrument
   - Large prototype
   - Fundamental Physics aspects like vacuum QED
   - …

   Option 2. needs to be discussed

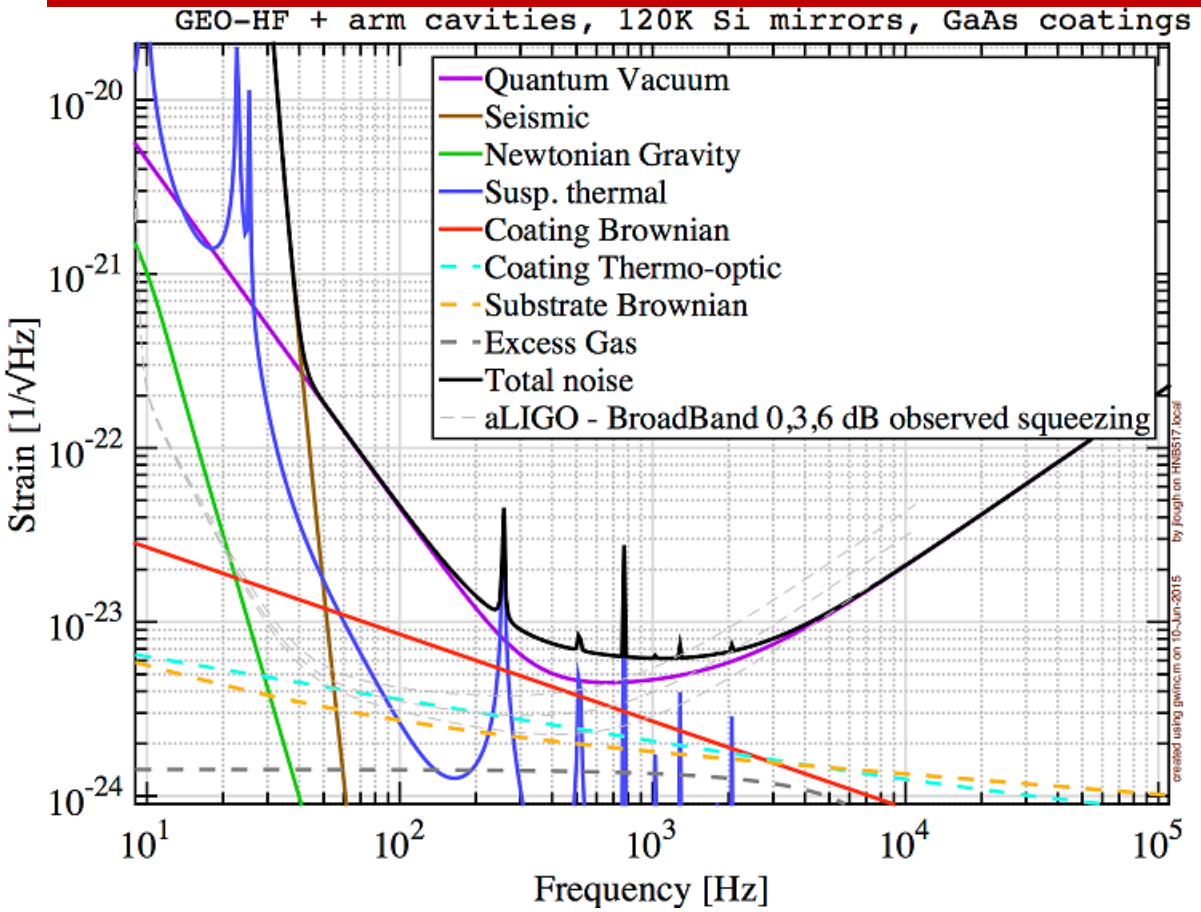
Going beyond GEO-HF: matching AdvLIGO at HF?



How to:

- Arm cavities
- Laser powers ~MW in the arms
- 6dB squeezing
- Cryogenic?
- Si mirrors? (1550nm)
- AlGaAs coatings
- …

Going beyond GEO-HF: matching AdvLIGO at HF?



How to:

- Arm cavities
- Laser powers ~MW in the arms
- 6dB squeezing
- Cryogenic?
- Si mirrors? (1550nm)
- AlGaAs coatings
- …

→ Challenging but possible!

- ➢ Significant man power needed
- ➢ Not compatible with our other commitments
- ➢ Continue with discussing non-data-taking options
- ➢ Until O2: Astrowatch + instrument science

Summary

- Options for a large scale upgrade of GEO 600 to match AdvLIGO design sensitivity above a few kHz was carefully analyzed. It seems possible but not compatible with our other commitments. (Astrowatch, contribute to 2nd and 3rd generation…)

- Continue Astrowatch with high duty cycle until O2

- Carry out a solid instrument science program (such as):
  - Squeezing, in particular loss reduction
  - Control like MDWS as new OMC AA system
  - Laser power increase/thermal compensation
  - Continue discussion of a program which makes full use of the existing infrastructure!

Thank you!