

THE STATUS OF GEO 600



**Stuart Reid
for the GEO600 group**

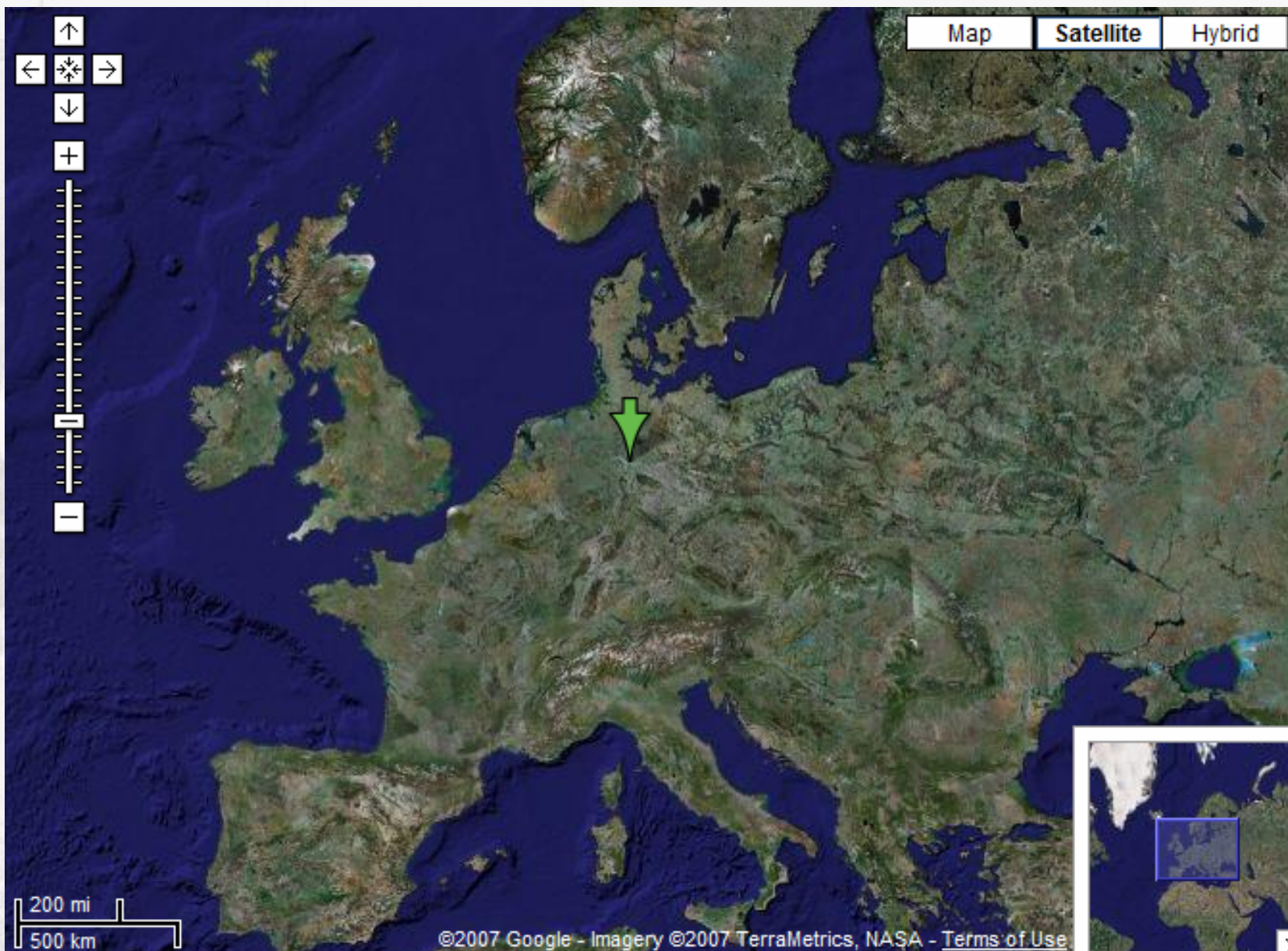
**TAUP
Sendai, Japan, 11th Sept 2007
LSC dcc no. LIGO-G070623-00-1**



**Universitat de les
Illes Balears**



GEO600 location

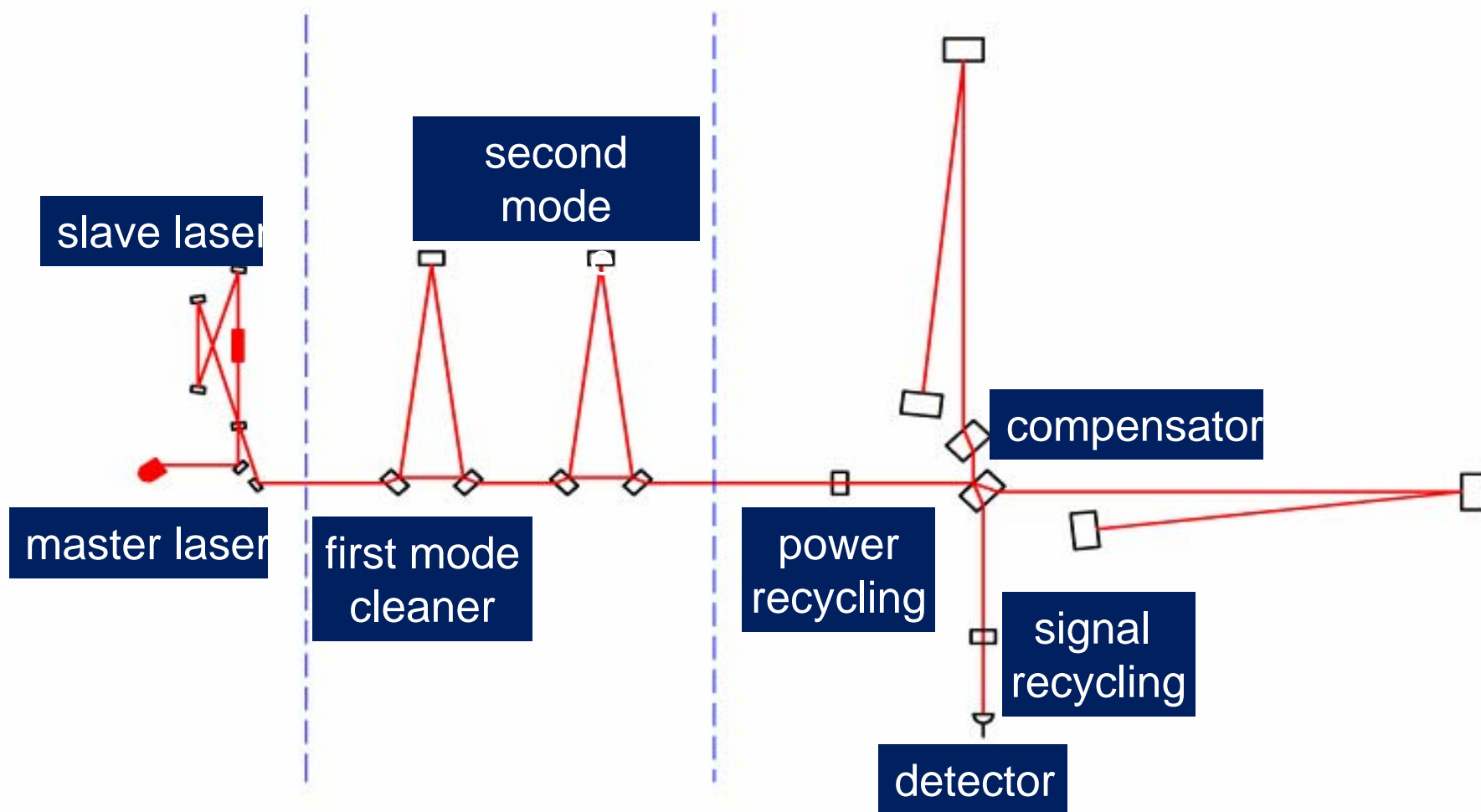


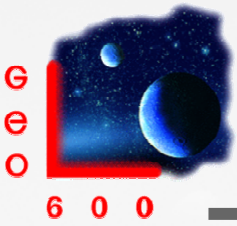
GEO600 – a different optical layout

laser system

mode cleaner

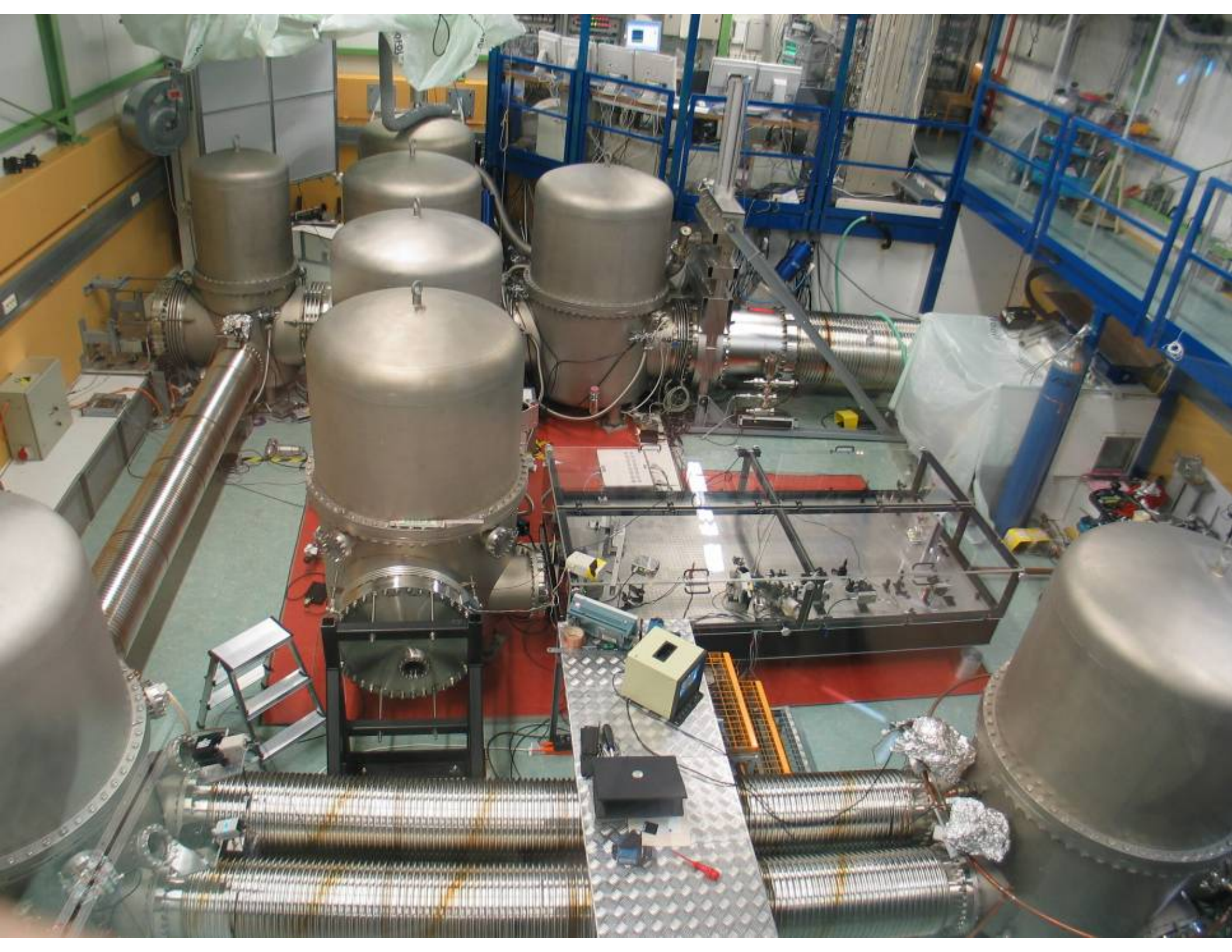
interferometer

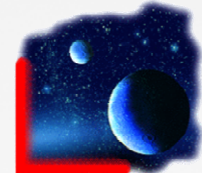




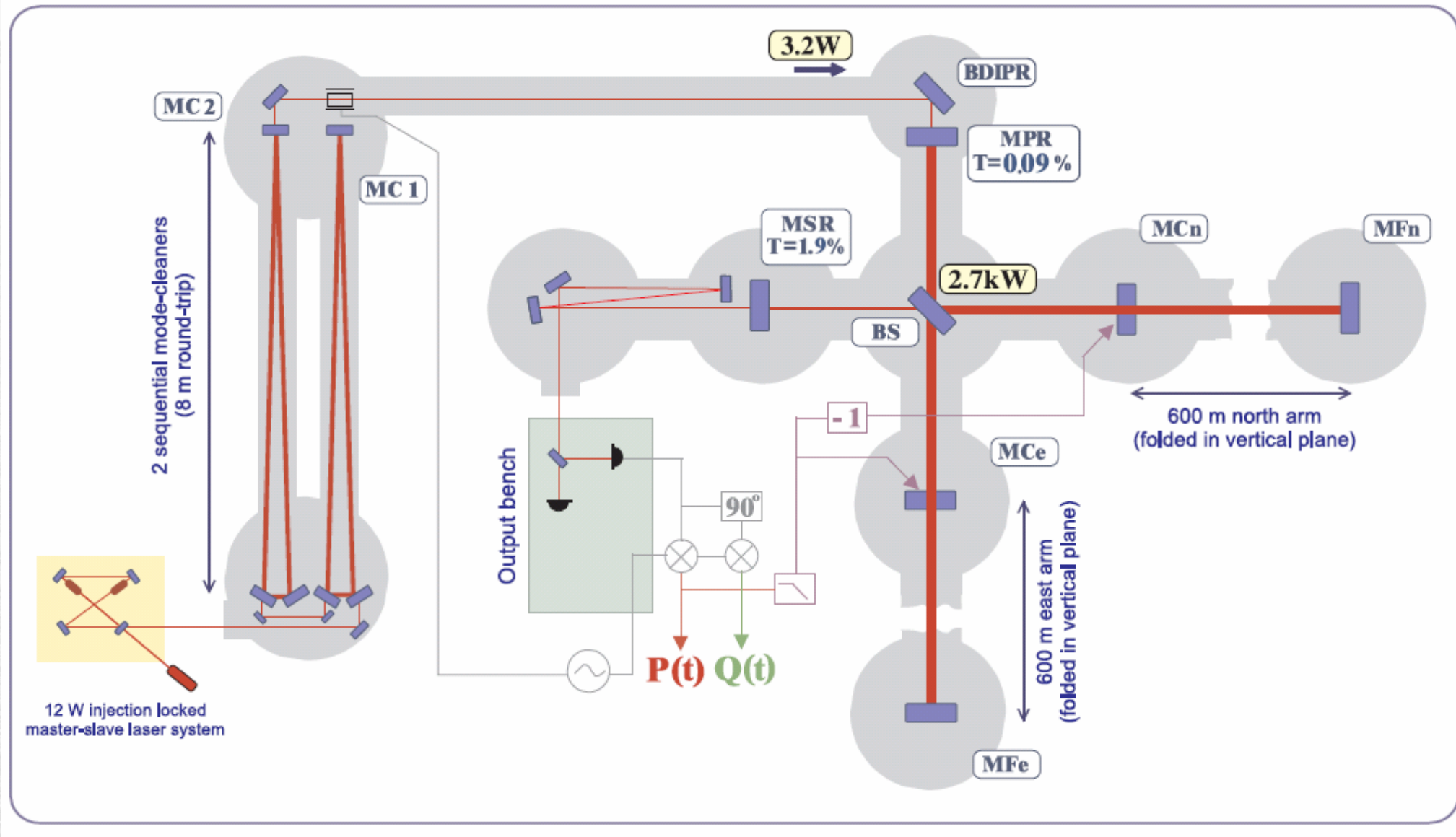
GEO600 – birds eye view







The GEO600 Interferometer



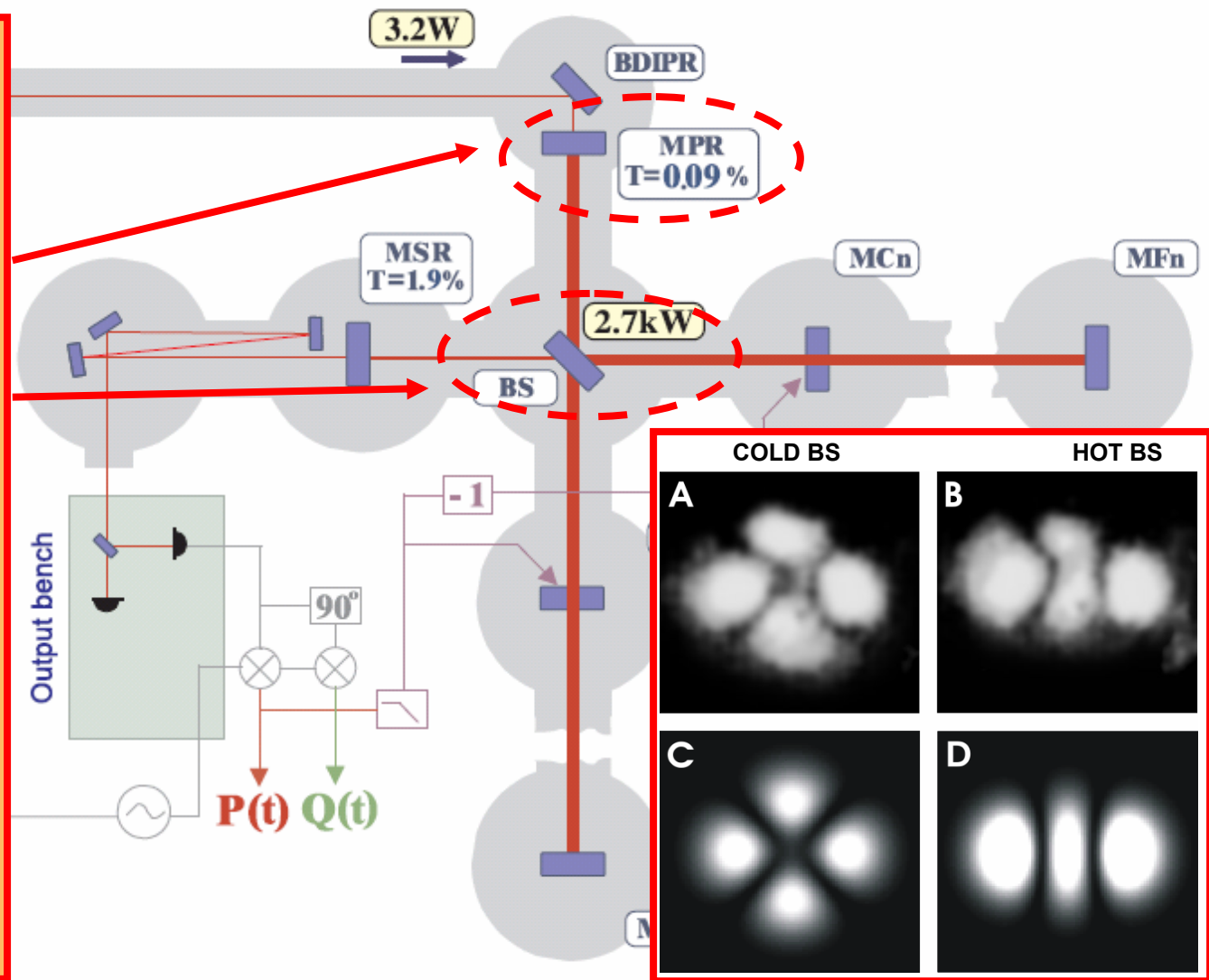


The GEO600 Interferometer



No arm cavities, but folded arms:

- High PR factor (~1000)
- High power in BS substrate (~kW)
- Very low absorption of BS substrate (< 0.25 ppm/cm)

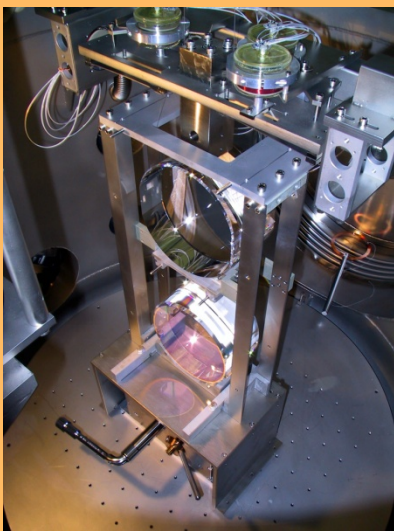




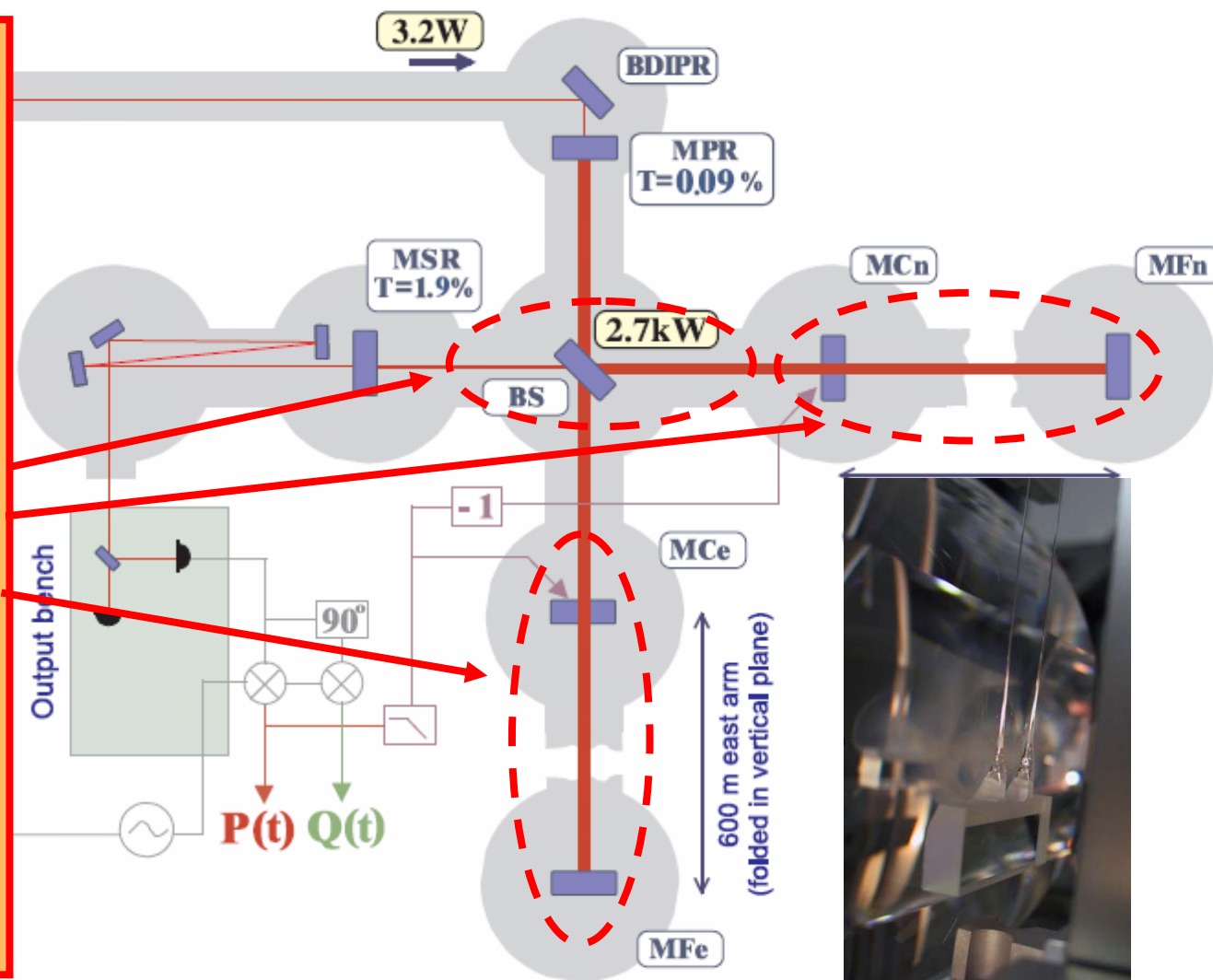
The GEO600 Interferometer



Triple suspensions:

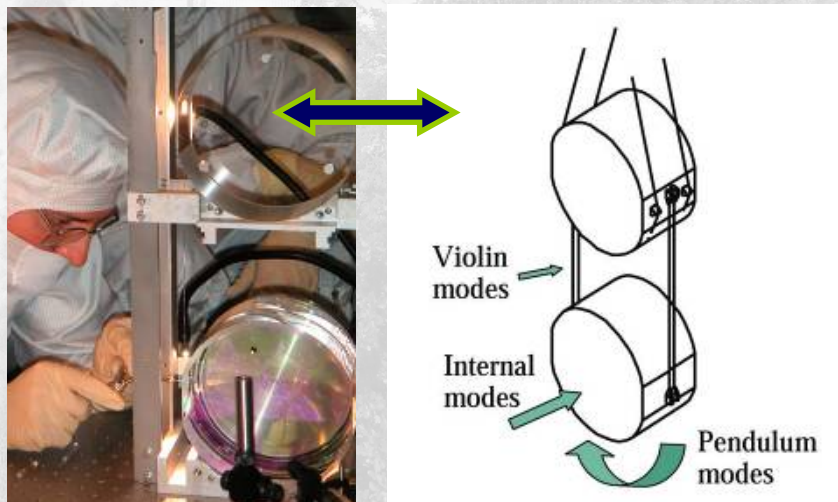
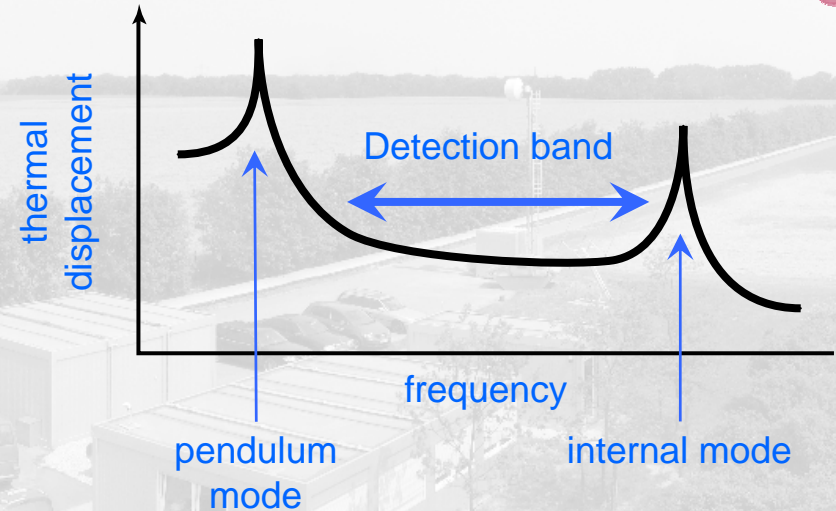
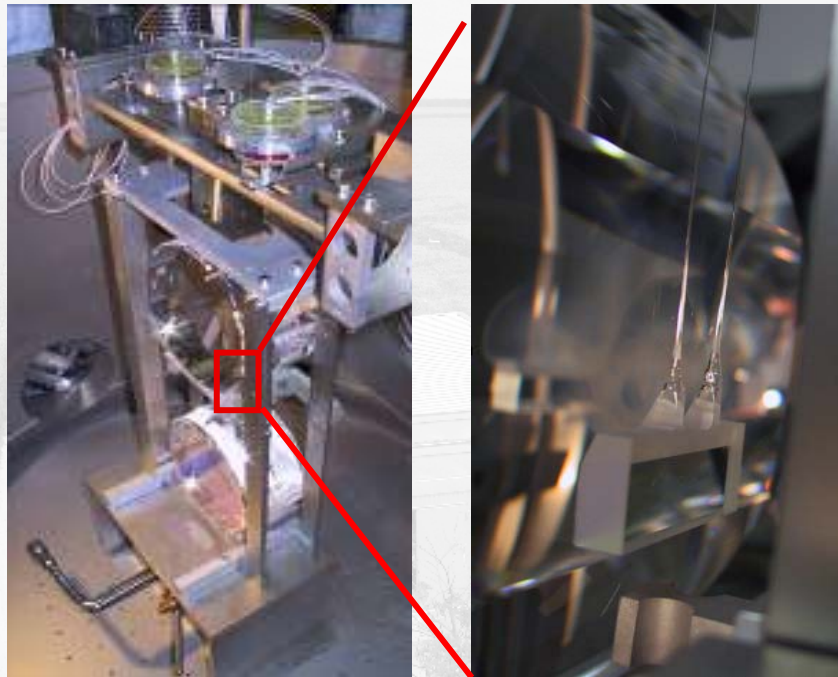


**Split-feedback
(3-stage hierarchical
control: longitudinal +
alignment)**



Monolithic stages: ~100 fibre years on running IFO with ~5 partial ventings

Ultra-low mechanical loss suspensions



Ultra-low mechanical loss suspension at the heart of the interferometer

- Reduces thermal noise
- Adopted as a core component of the upgrades for Advanced LIGO and Advanced VIRGO

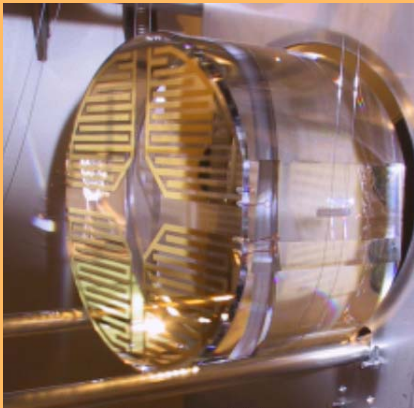


The GEO600 Interferometer

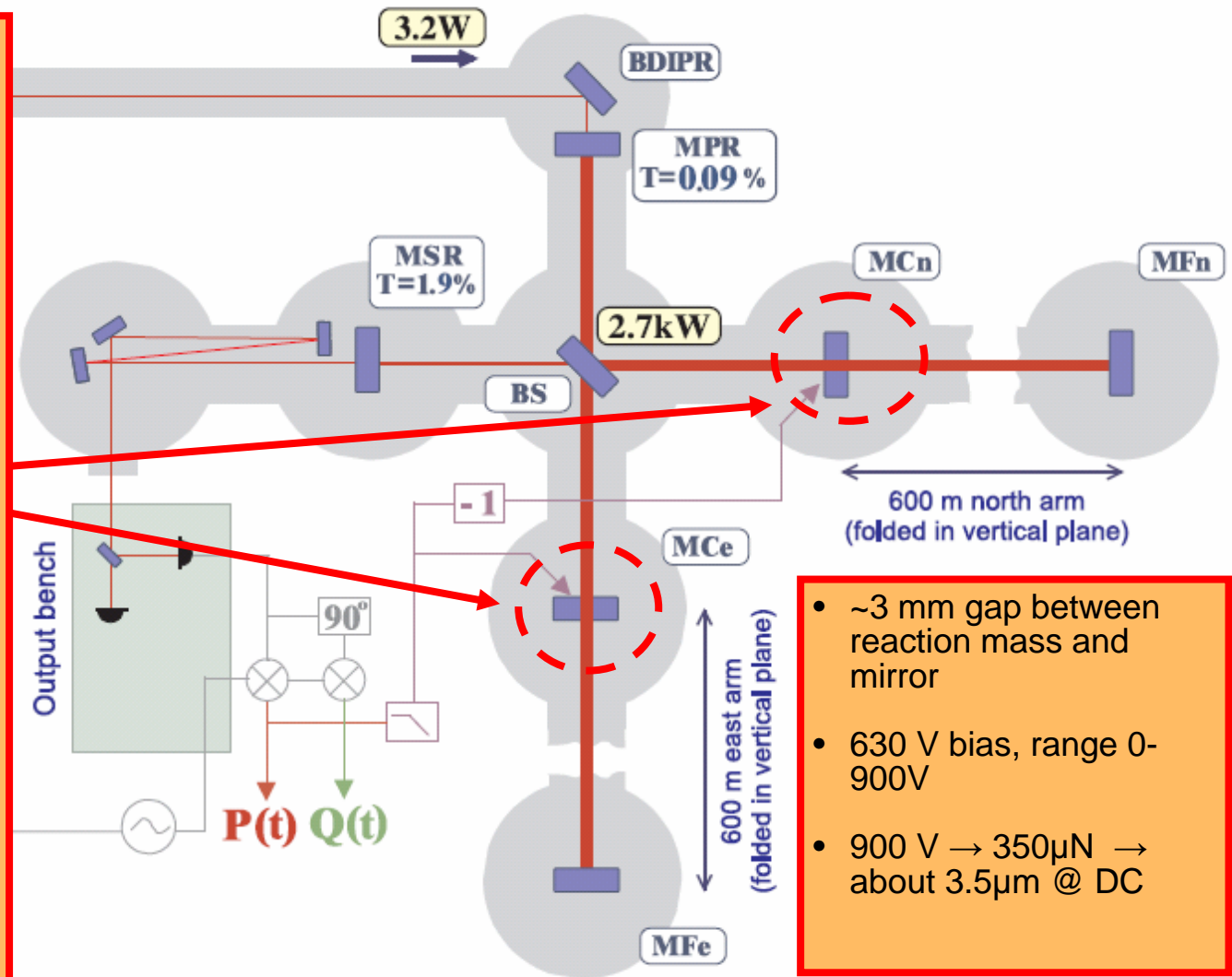


Electro-Static Drives:

- Used for fast control of diff. arm length.



- Also used for fast auto-alignment (quadrants).



- ~3 mm gap between reaction mass and mirror
- 630 V bias, range 0-900V
- 900 V \rightarrow 350 μ N \rightarrow about 3.5 μ m @ DC

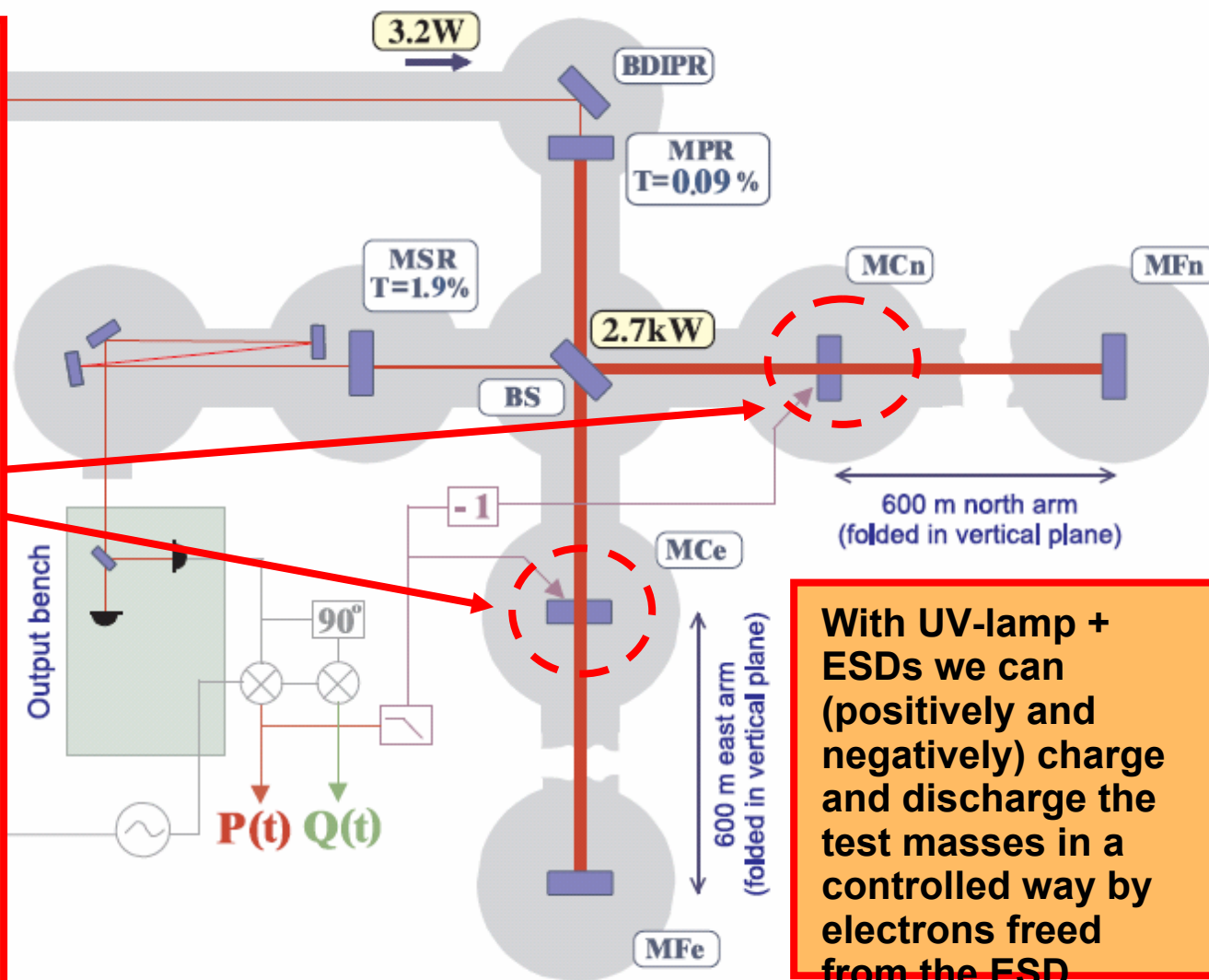
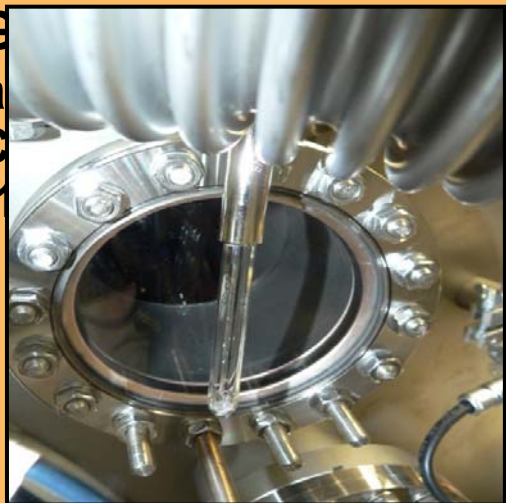


The GEO600 Interferometer



Charges on test masses

- Measured positive charging of test masses
- Discharged by using a UV-lamp, technique first demonstrated in



With UV-lamp + ESDs we can (positively and negatively) charge and discharge the test masses in a controlled way by electrons freed from the ESD electrodes.

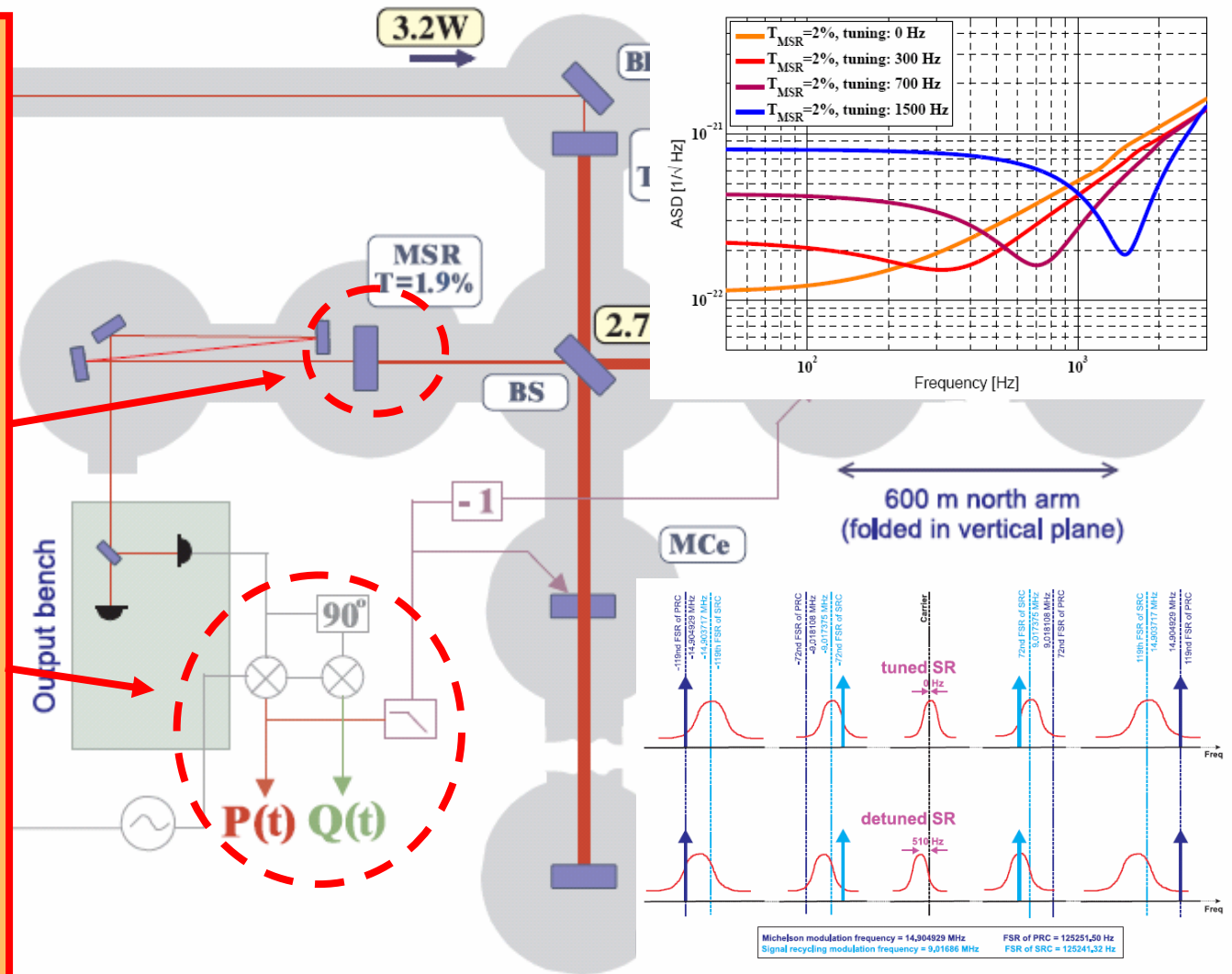


The GEO600 Interferometer



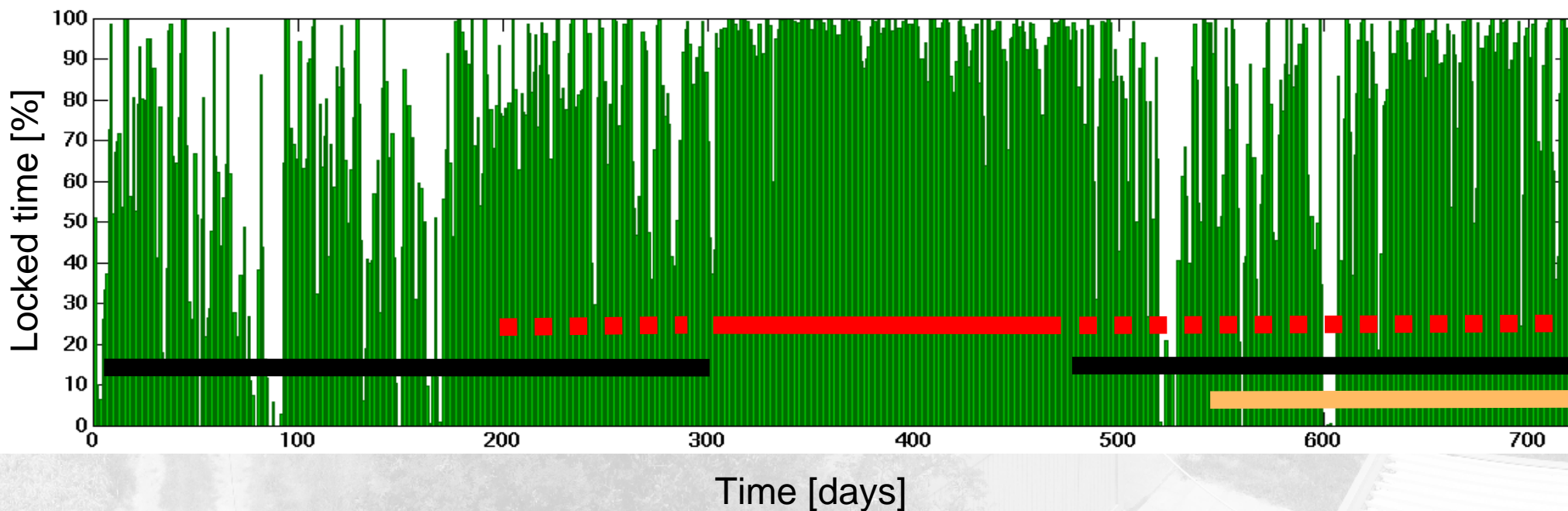
Signal-Recycling:

- Shaping detector response
trades bandwidth for sensitivity
- Complex detector (resonance conditions with detuned SR)
- GW signal is spread over both quadratures P and Q .



The Last Two Years

Locked state and main activities at the site



S5 N&W



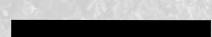
~190 days science time [57%]

S5 24/7



~152 days science time [91%]

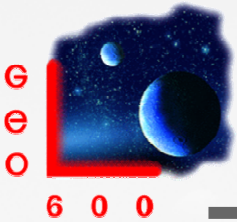
Noise hunting



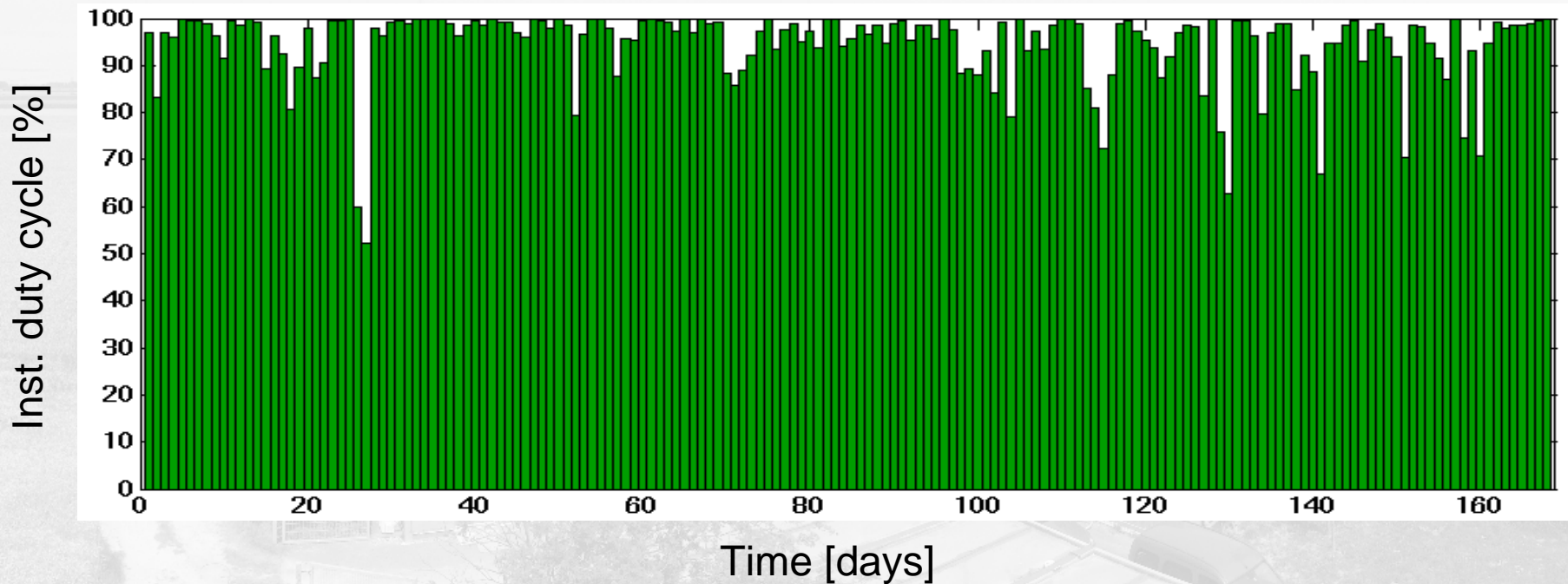
Infrastructure work



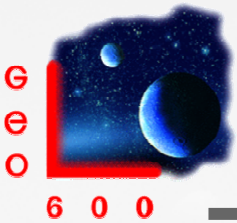
}
 ~342 days



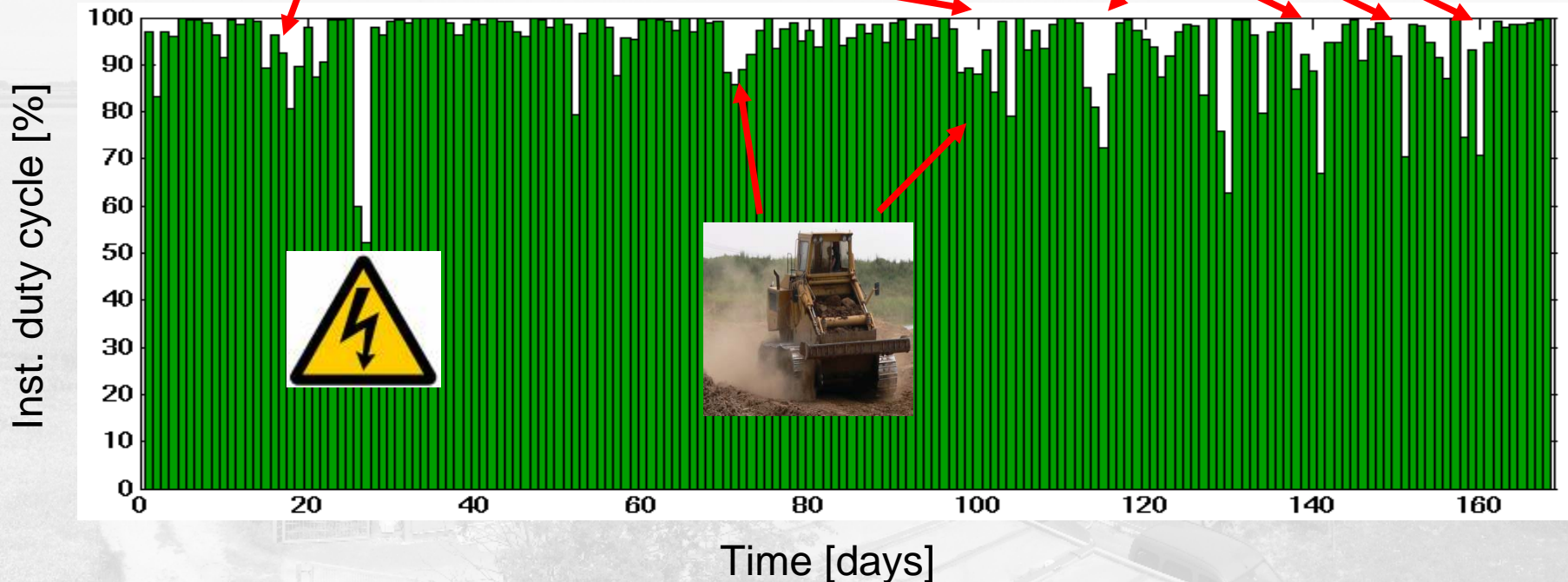
S5: 24/7 Mode



- 1. May - 15. October, 168 days
 - Instrumental duty cycle: **94.3%**
 - Science time duty cycle: **91 %**
- Longest lock: **102 hours**

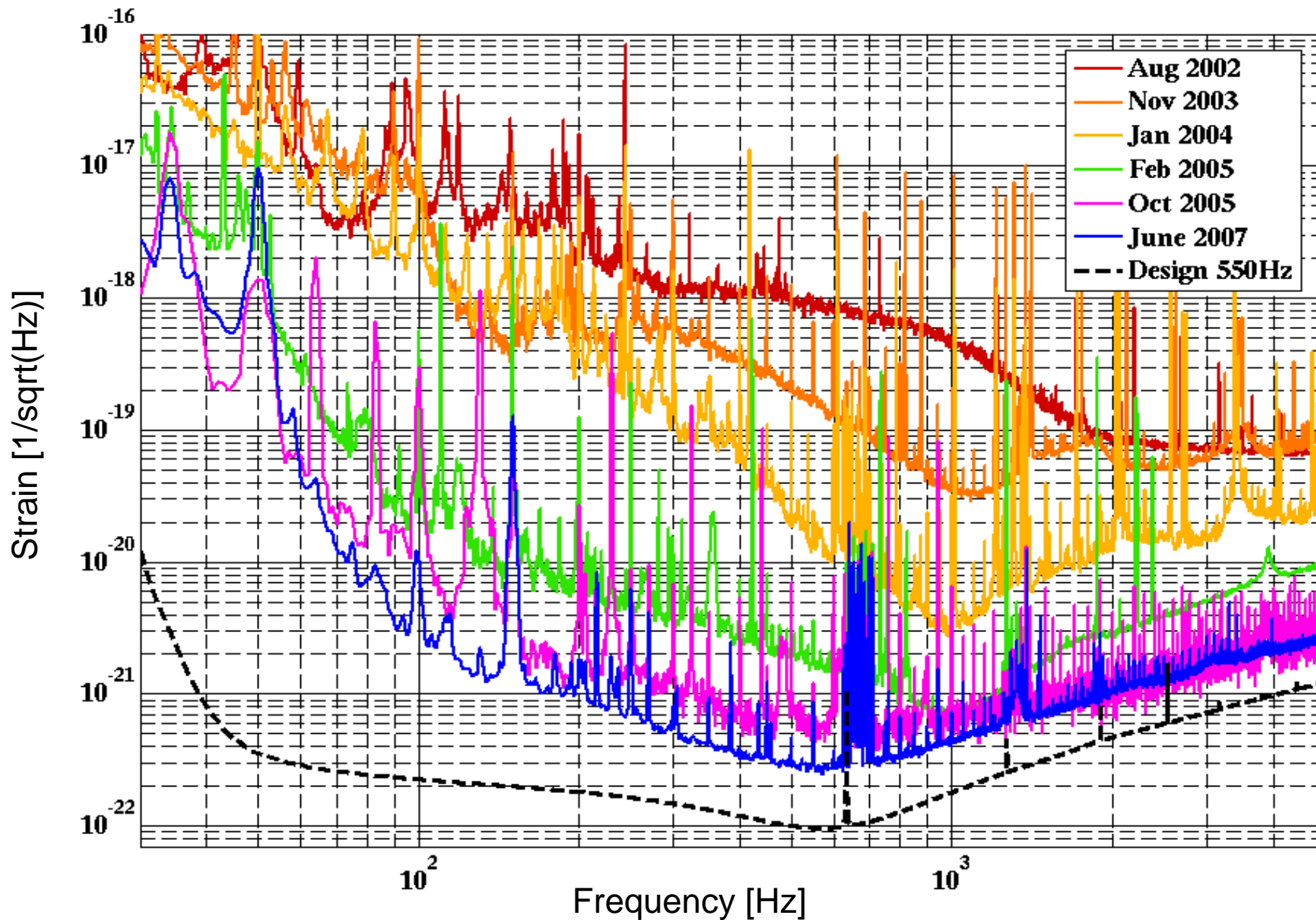


S5: 24/7 Mode



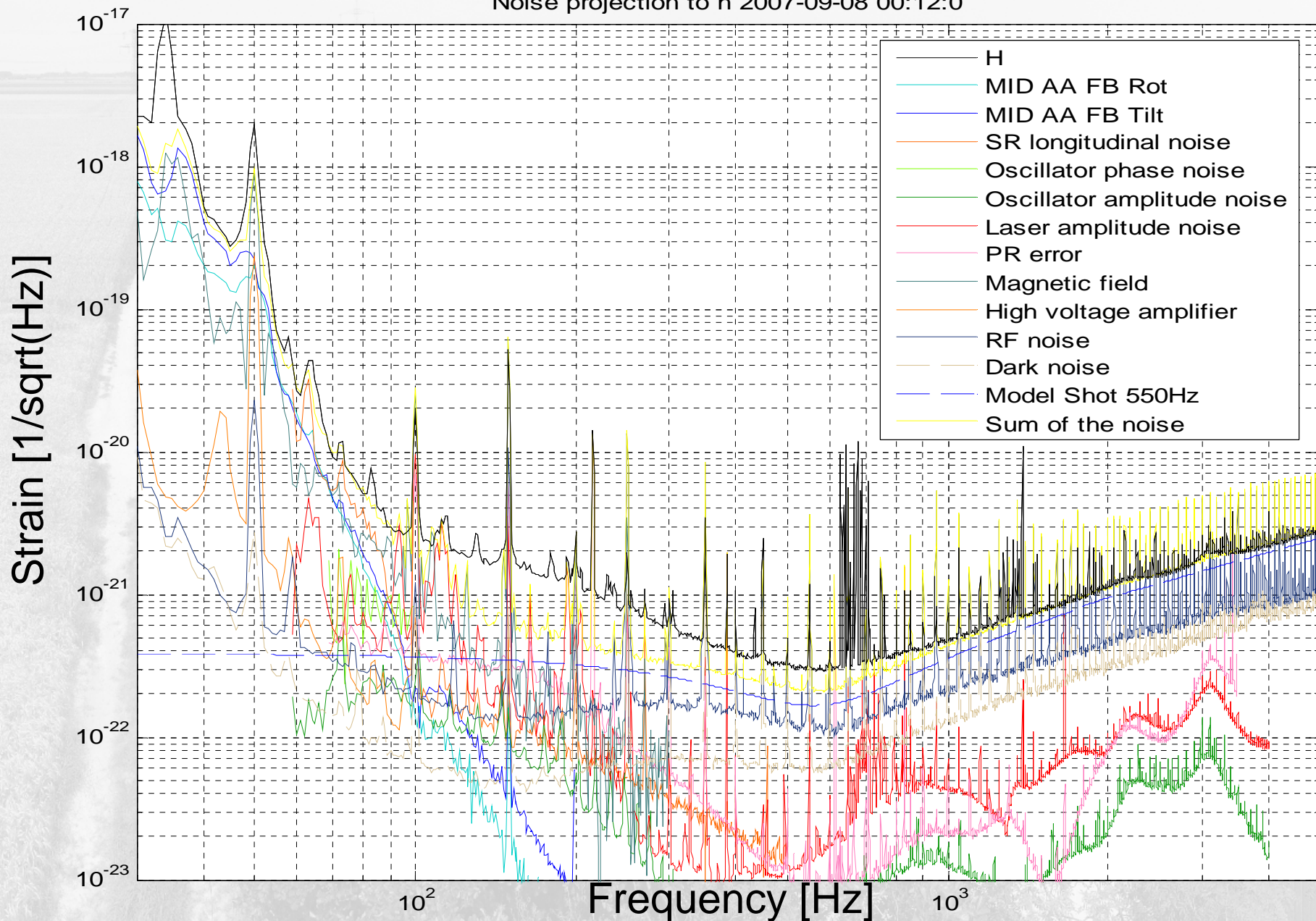
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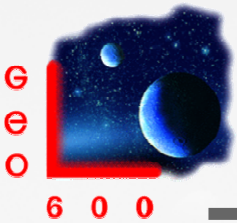
GEO Sensitivities



Noise Projections Update

Noise projection to h 2007-09-08 00:12:0





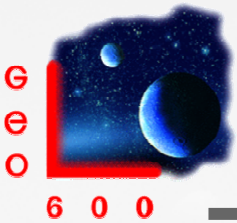
Main Noise Reduction Topics



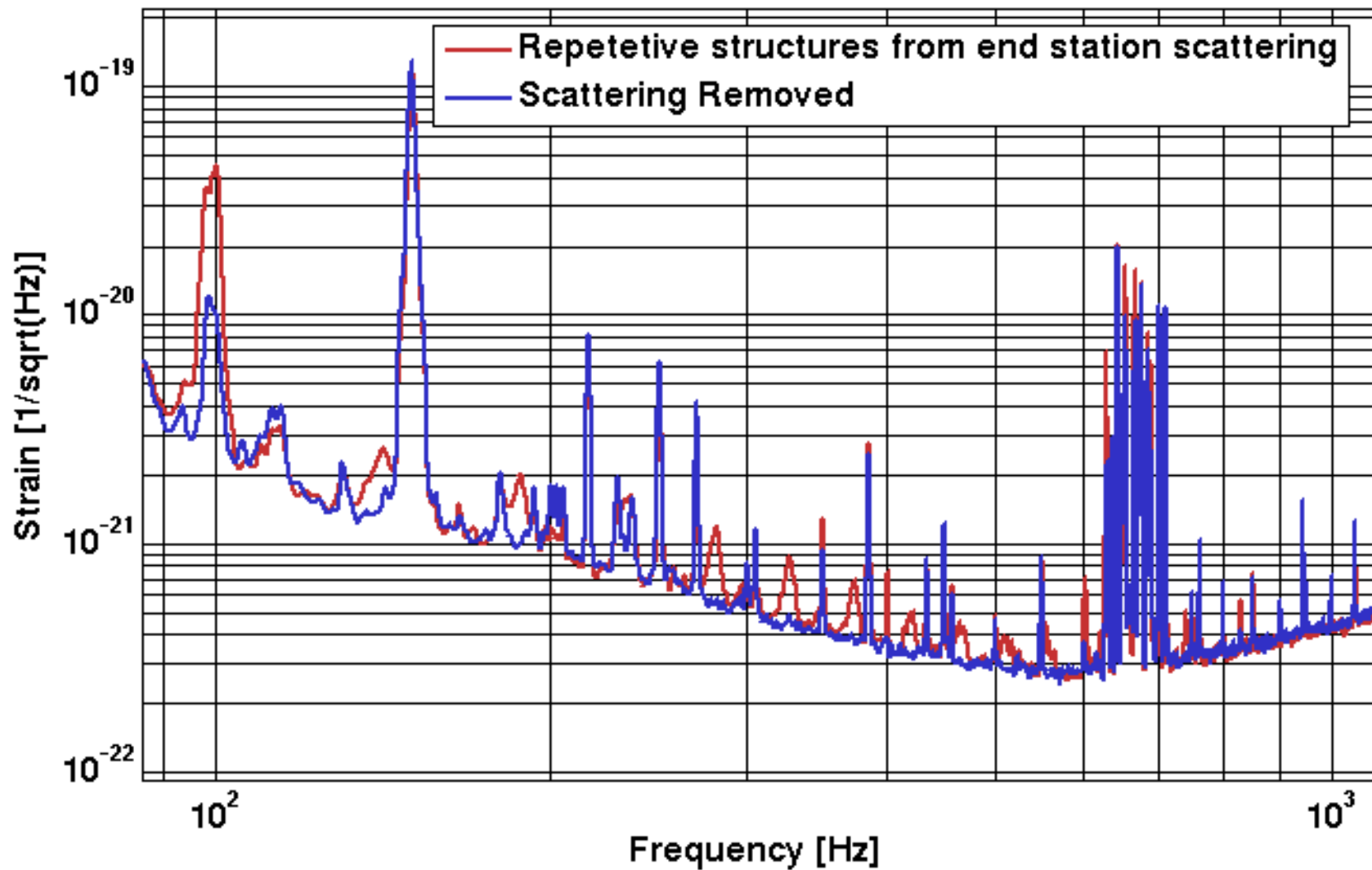
- Low-frequency ($< \sim 200\text{Hz}$):
 - Signal recycling feedback
 - Michelson auto-alignment feedback
- Mid & high frequency ($> \sim 200\text{Hz}$):
 - Detection noise (dynamic range of photodetector)
 - RF Modulation: phase noise and glitches
 - Acoustics / scattered light

Digital controls,
ESD autoalignment,
noise subtraction, ...

PD design, crystal oscillators, SMA
connectors, RF power stabilization,
acoustic shielding, larger optics,
cleaner air, ...



Scattered Light Reduction

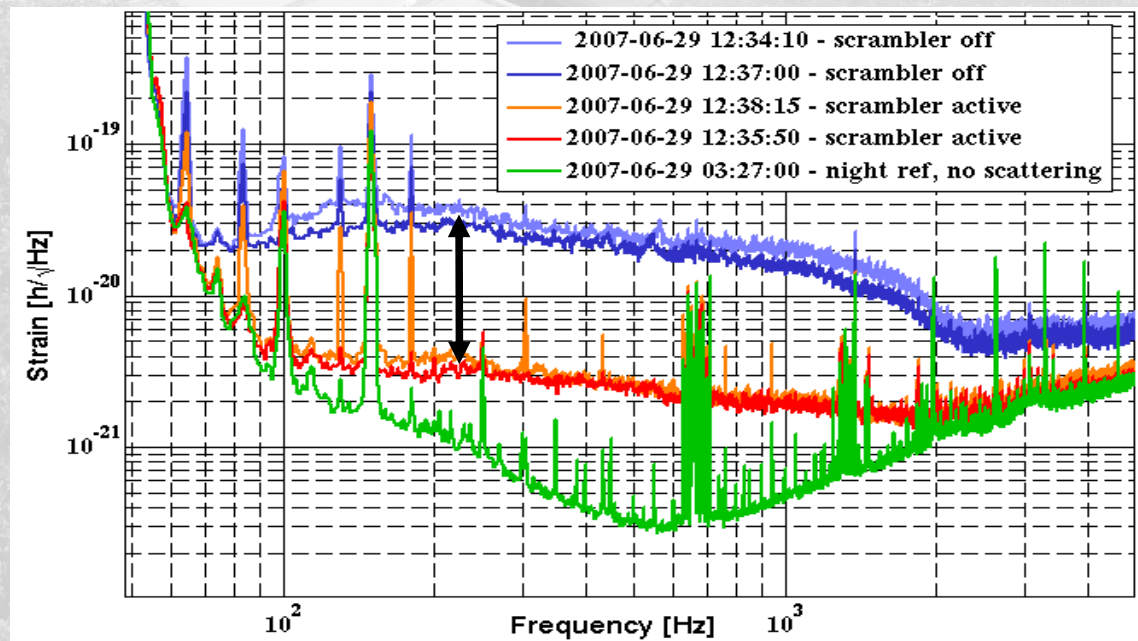
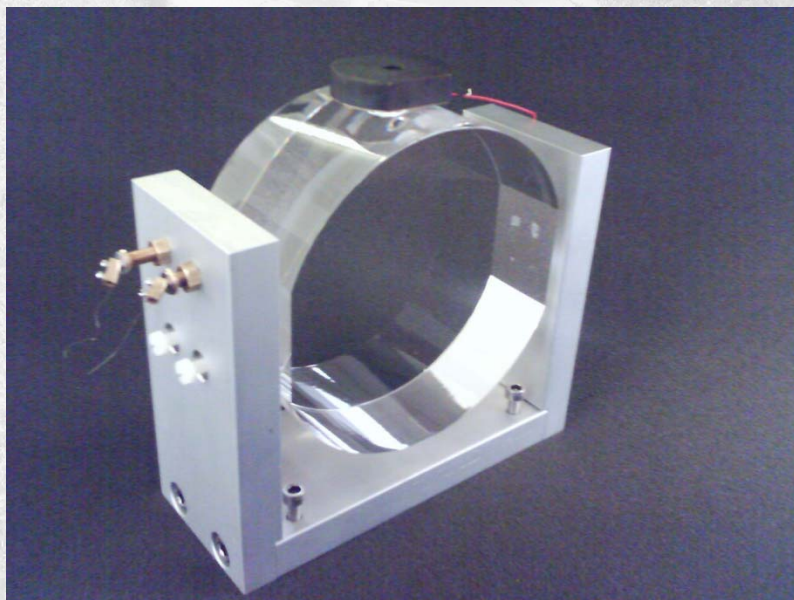


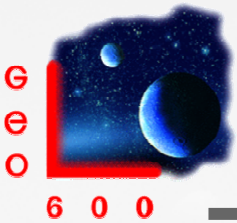
Acousto-Optic Phase Shifter...

...to suppress back-scattering from optics beyond

- Phase-modulate beam via excitation of substrate eigenmode
- Can handle large apertures and is polarization independent
- Place as first component on output beams in places where scattering cannot be avoided, e.g. photodiodes

Scattering provoked and suppressed at end station





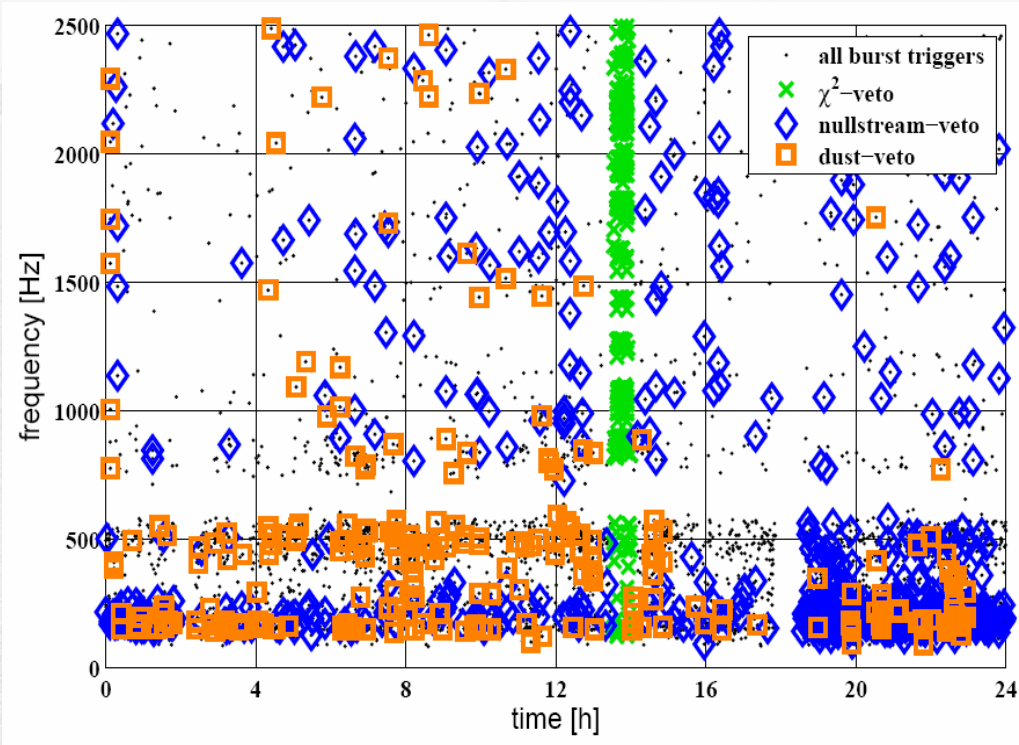
Infrastructure Work



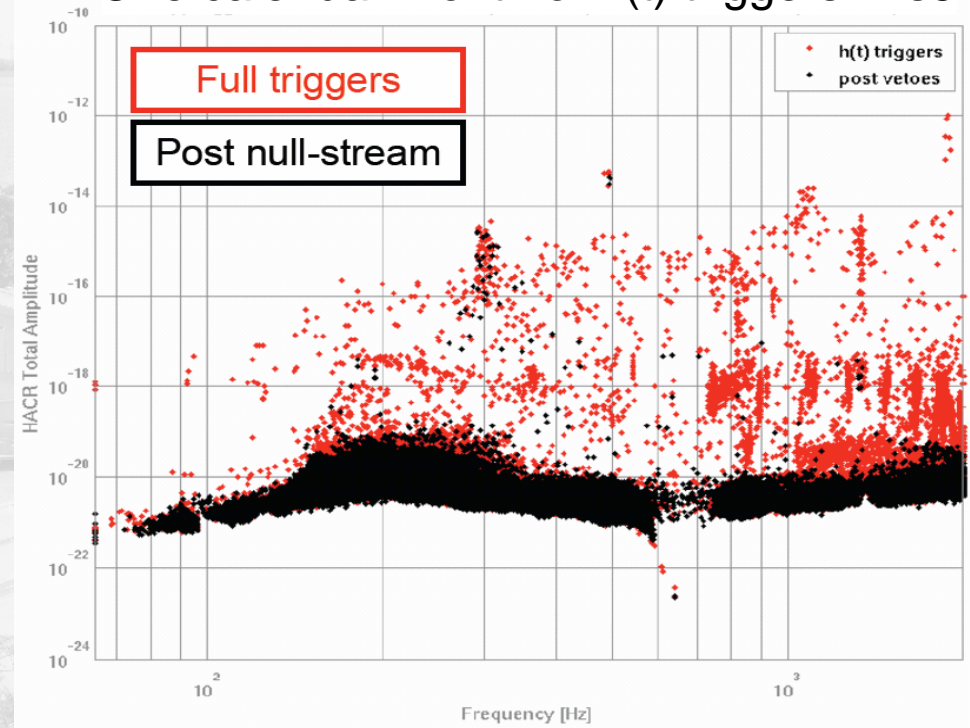
- New HV feedthroughs for electrostatic drives, improved ESD wiring
- Cleanroom: particle reduction by HEPA filters in main airconditioning stream
- Debugging of mains power routing done. Work ongoing on balancing of currents

We are ready for a long data run

Glitches and Vetoes



One calendar month of $h(t)$ triggers in s5



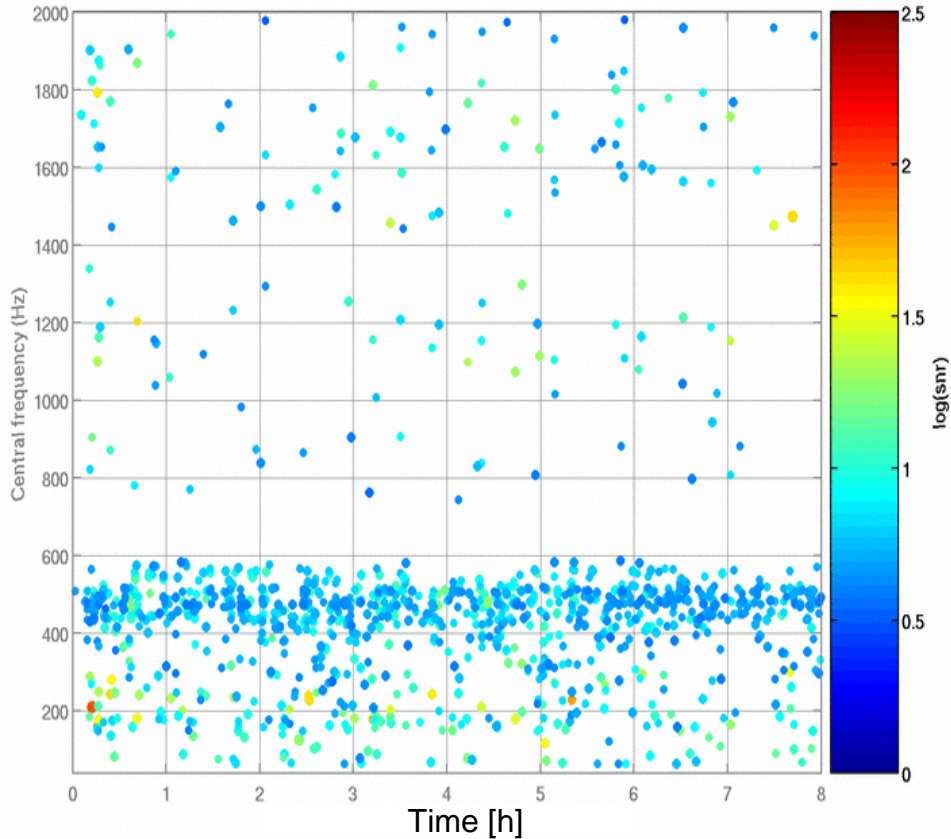
- Nullstream veto
- Noise projection vetos

- χ^2 veto
- Statistical vetos

Reduction of Glitches

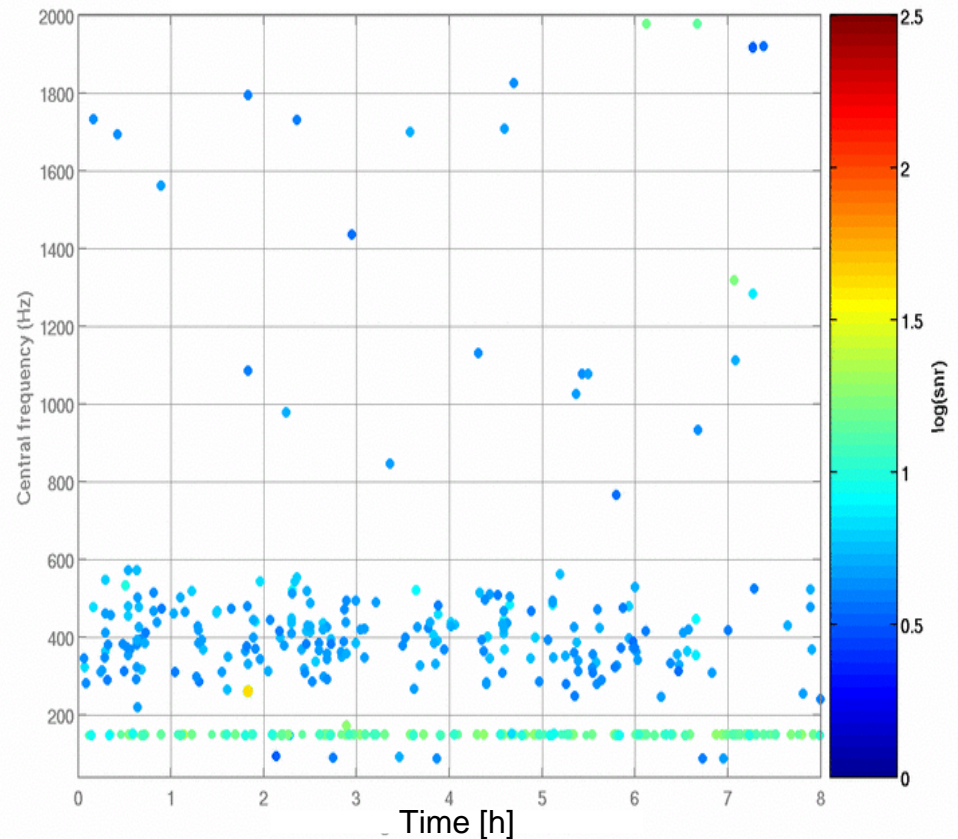
Comparizon of glitchiness of LIGO /GEO /VIRGO data with coherent waveburst showed GEO glitchiness around the average of all detectors (Sept. 2006). Since then we further reduced glitches.

H triggers in HACR mon:
n=1067

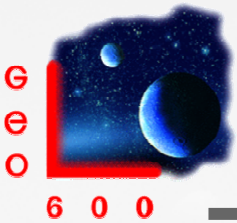


Typical s5 in 2006

H triggers in HACR mon: n=392



End of June 2007



DC Detection: A New World



- From heterodyne (AC) to homodyne (DC) detection
- Anticipated advantages:
 - Reduced modulation noise coupling (in particular important for detuned signal recycling)
 - Better sensitivity (~20 to ~40 %)
- But pay attention to:
 - Larger power noise coupling: OK, but get optical filter for LO !
 - Output mode-cleaner: Alignment to power coupling, scattering

DC-Readout without OMC

IDEA:

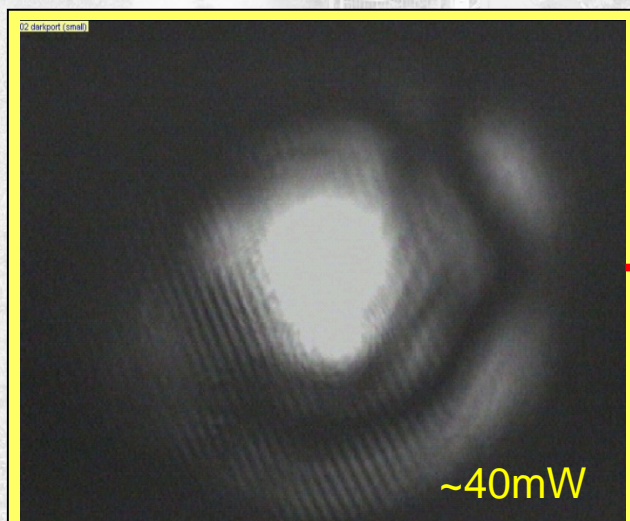
Turning down the RF-modulation (*factor 10 is possible*)

Using an offset from dark fringe (*of the order 50pm*)

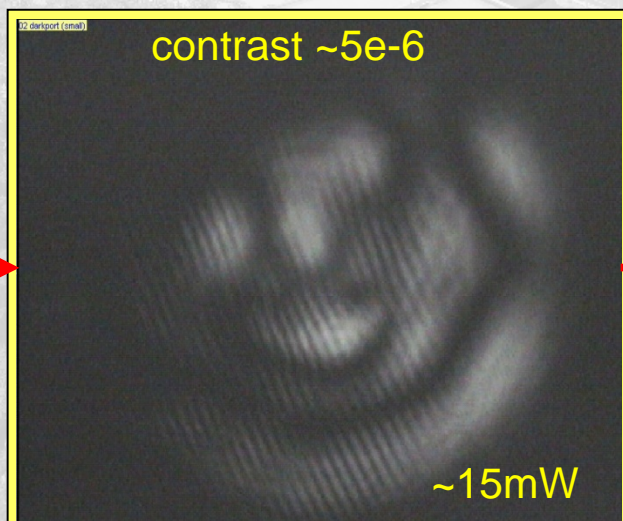
Dark port dominated by carrier light

EXPERIMENT in GEO600:

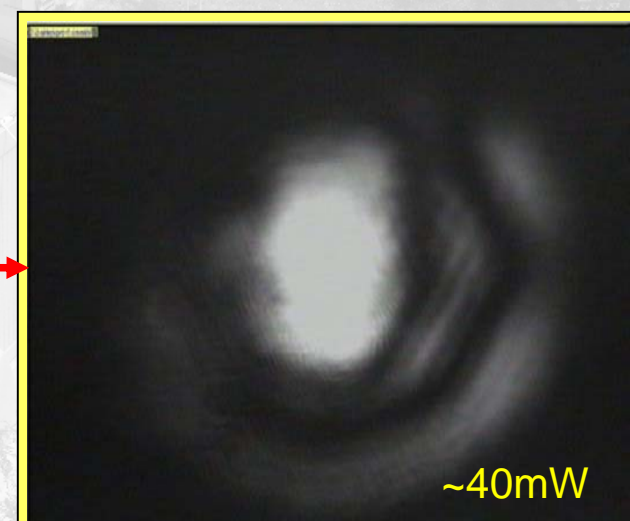
Locked to dark port power



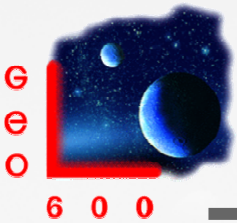
Nominal heterodyne



Heterodyne with only 10% modulation



Offset to dark fringe (~ 50pm)

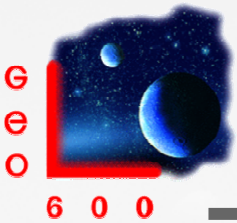


Results from first Experiments with DC-readout



It works !

- Slightly better (10-20%) sensitivity than heterodyne at high frequencies ($> \sim 2\text{kHz}$)
- Not much worse sensitivity at mid frequencies
- Power noise coupling is not terrible !



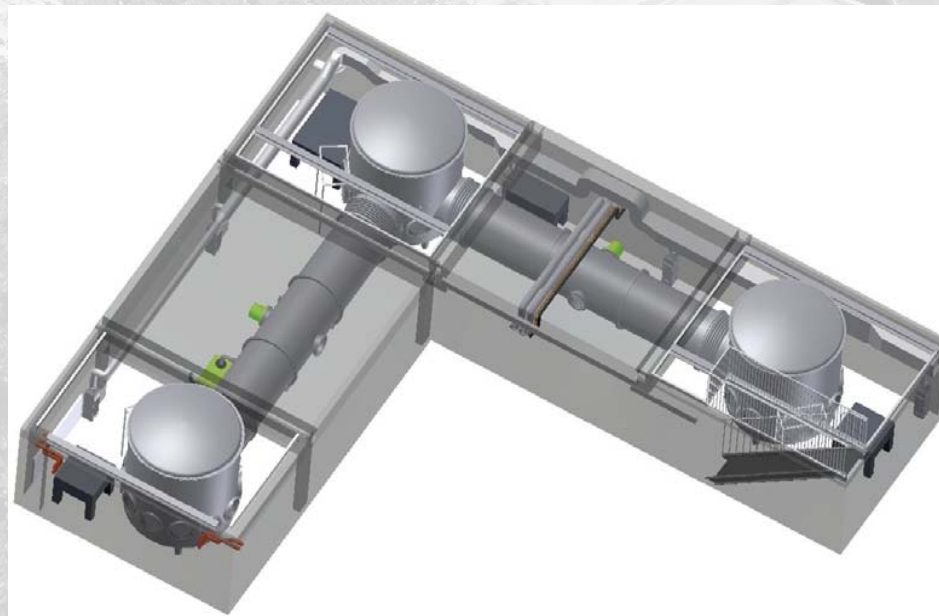
Astrowatch

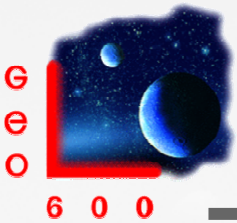


- The current plan is to start 24/7 run in October 2007
- Run until Enhanced IFOs start science run (LSC: S6, ~early 2009)
- 2009 and beyond:
 - Sequential upgrades in the GEO-HF frame, minimizing downtime (and take science data when possible) during construction of advanced detectors

GEO-HF and the AEI Prototype

- GEO-HF is the frame for sequential upgrades of the GEO600 detector
- Topics: high-power, squeezing, DC readout, digital controls, new mirrors to lower thermal noise, ...
- A new prototype will be built at AEI-Hannover serving as a platform for different types of experiments, including testing of GEO-HF upgrades





Summary



- We have ~1 year of S5 science data
- Noise and glitch reduction, infrastructure work, detector characterization work etc. done and ongoing, ready for
- Long observation from Oct. 2007 to the end of 2008...



Even in the highest Tension, just see what happens