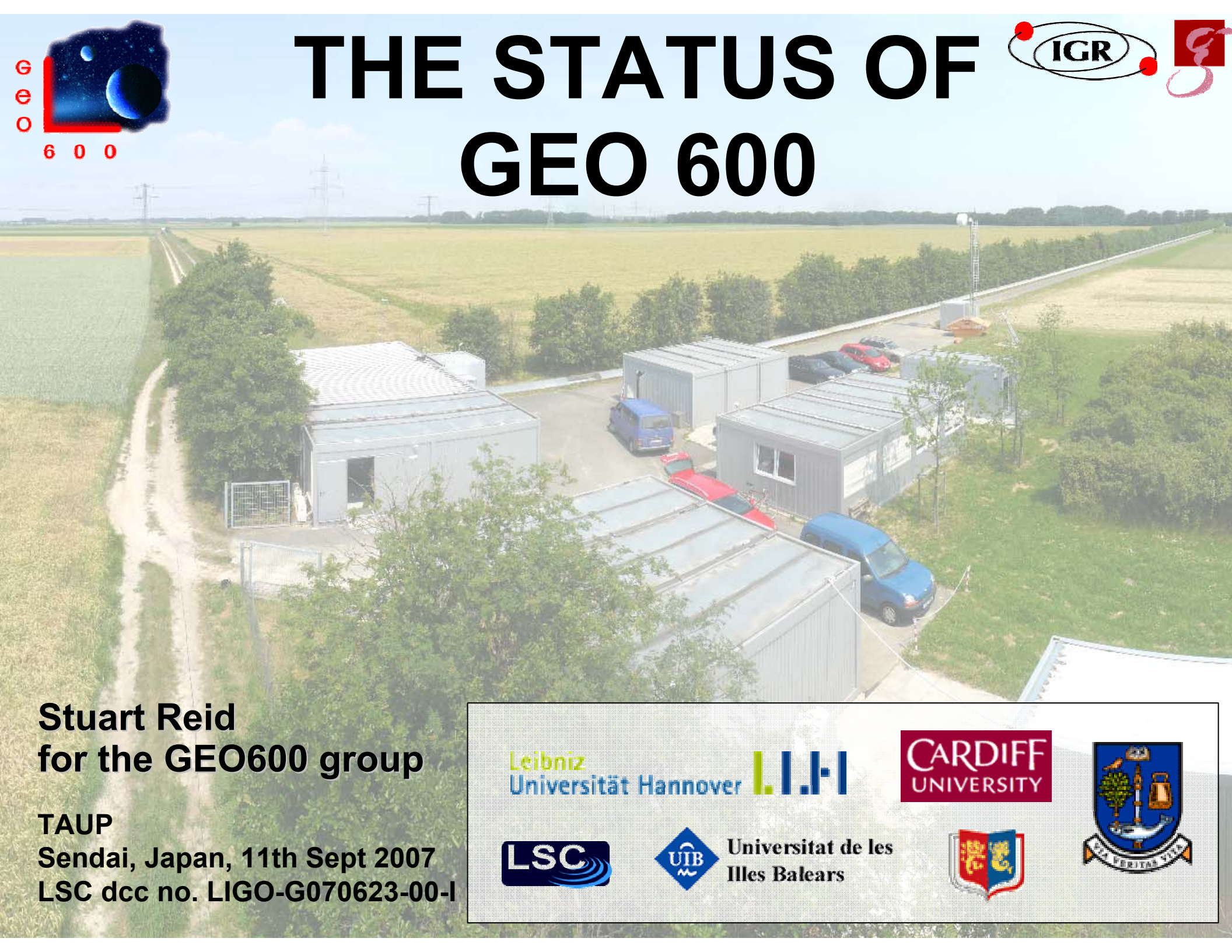
THE STATUS OF GEO 600



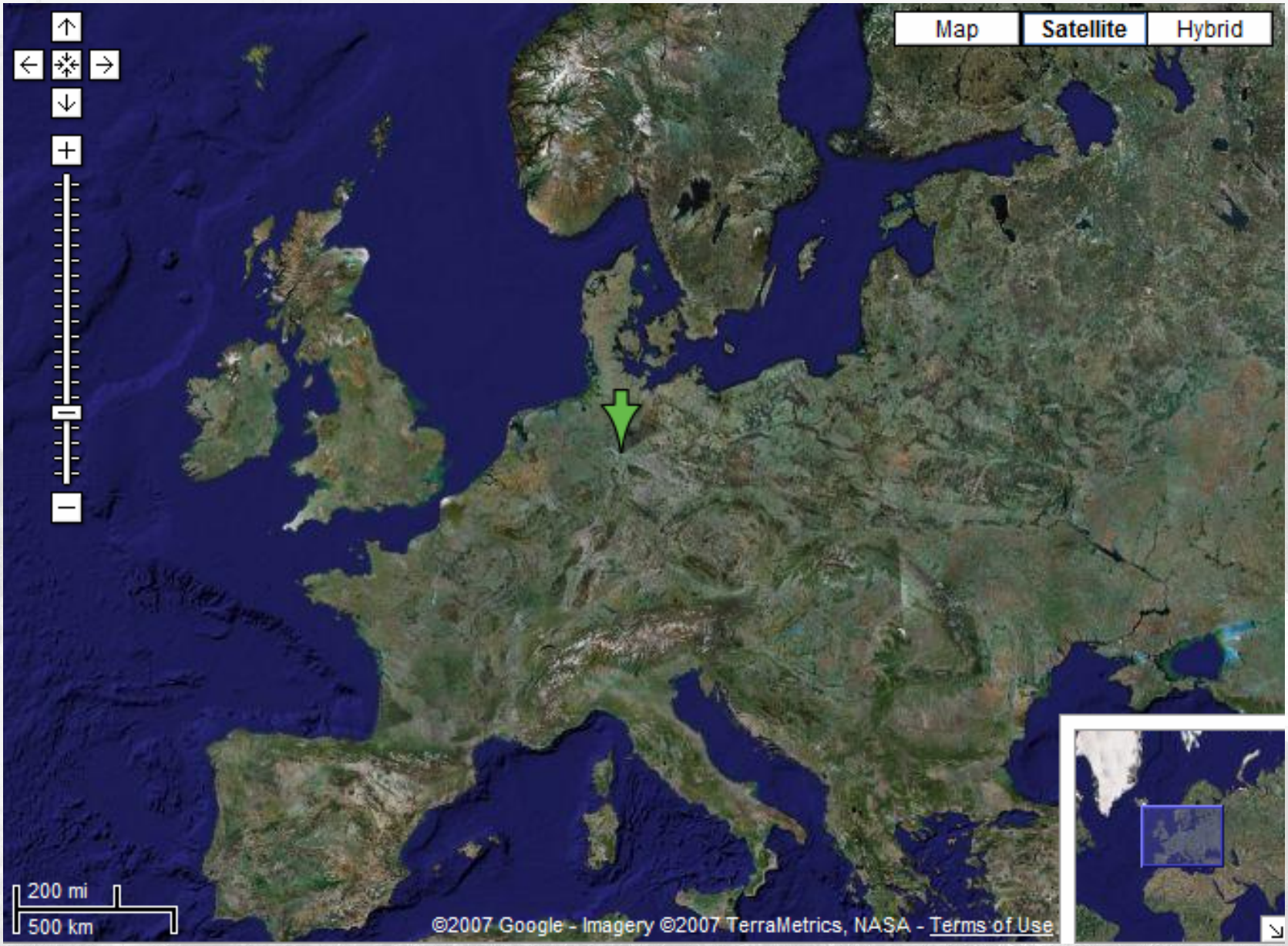
Stuart Reid
for the GEO600 group

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

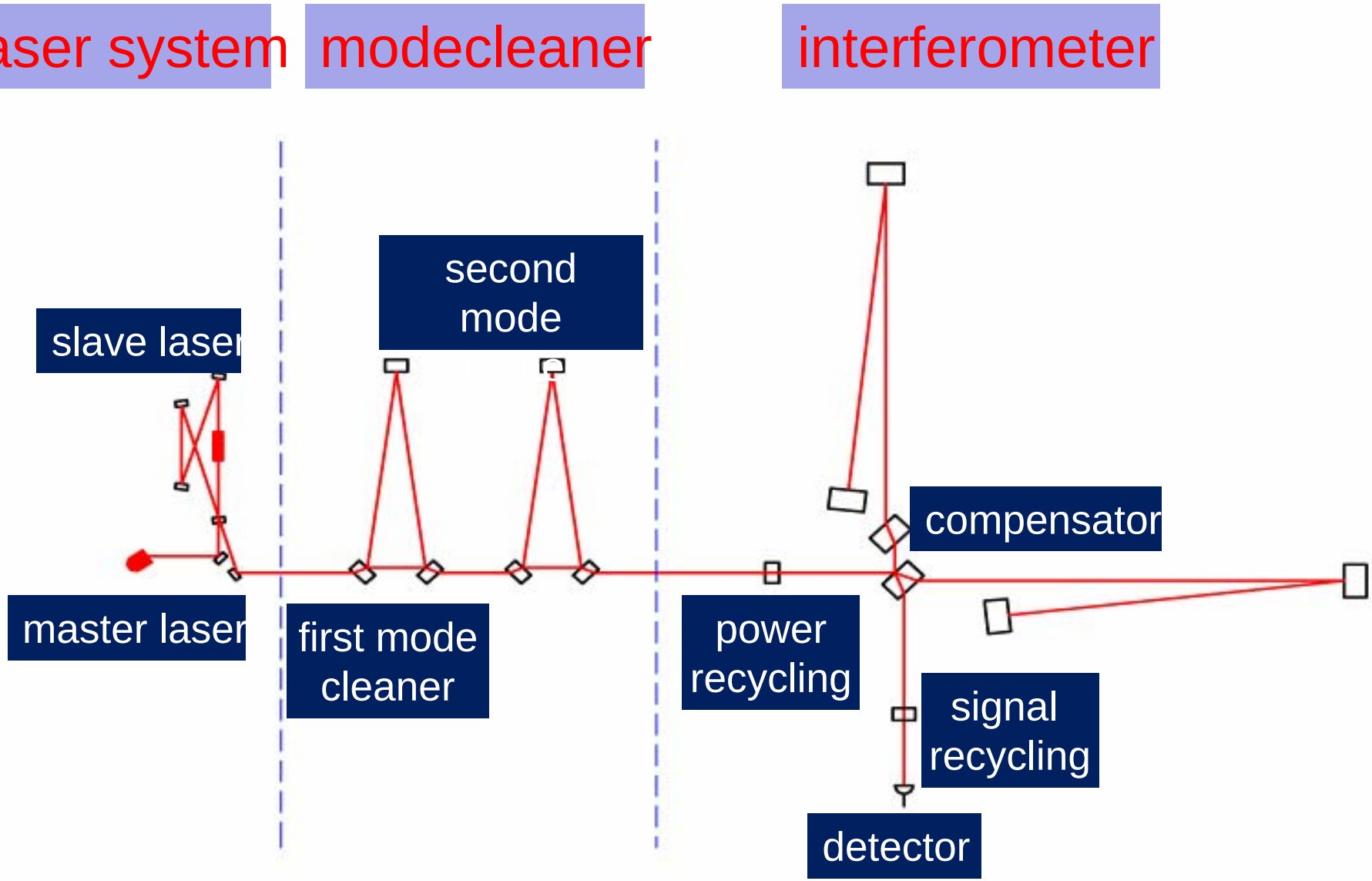
Leibniz Universität Hannover

Universitat de les Illes Balears

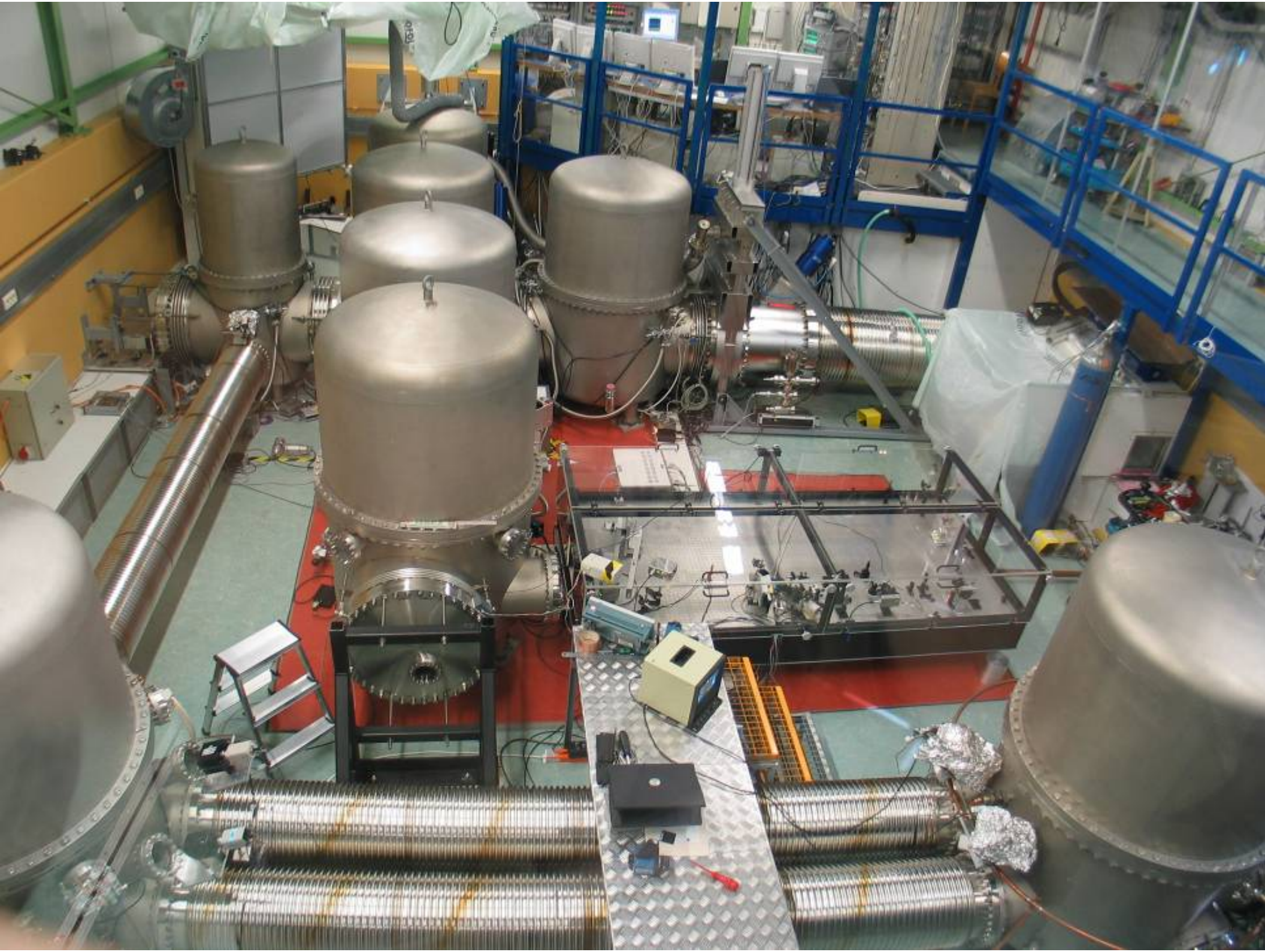
GEO600 location



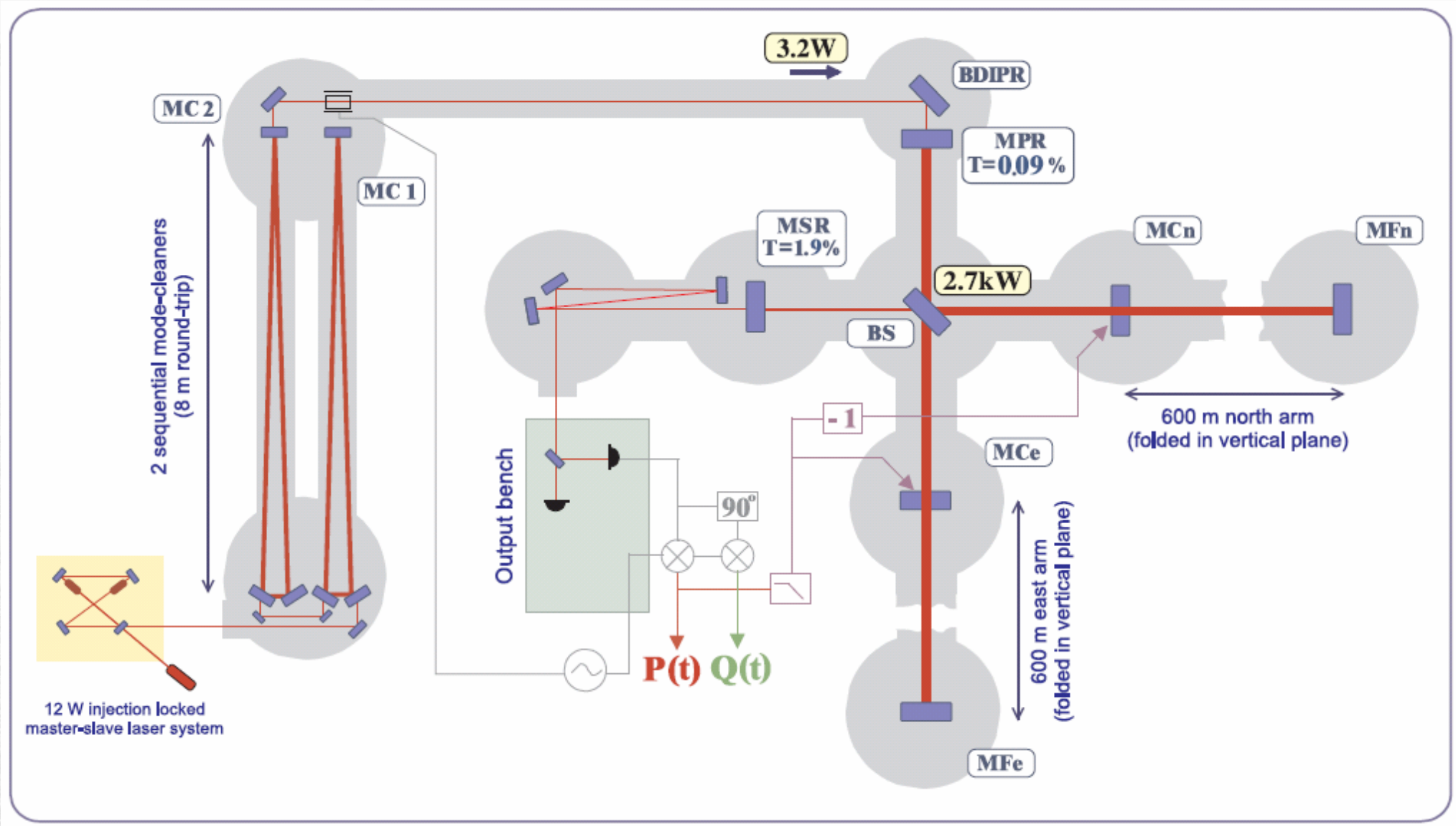
GEO600 – a different optical layout



GEO600 – birds eye view



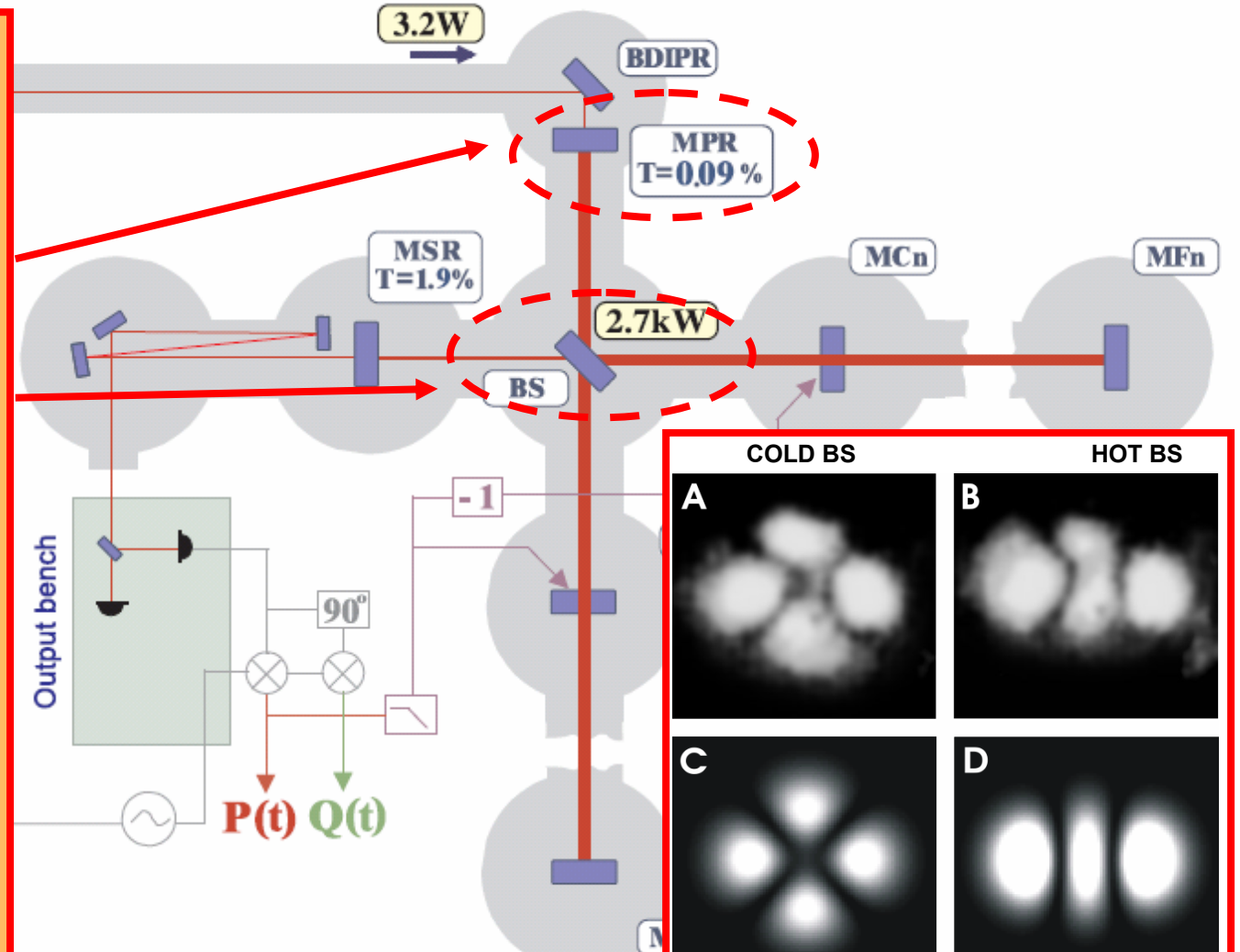
The GEO600 Interferometer



The GEO600 Interferometer

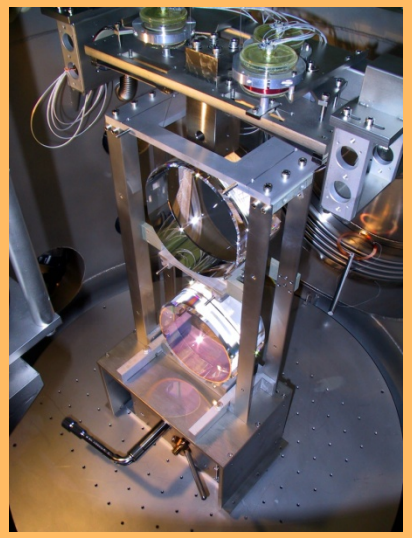
No arm cavities, but folded arms:

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

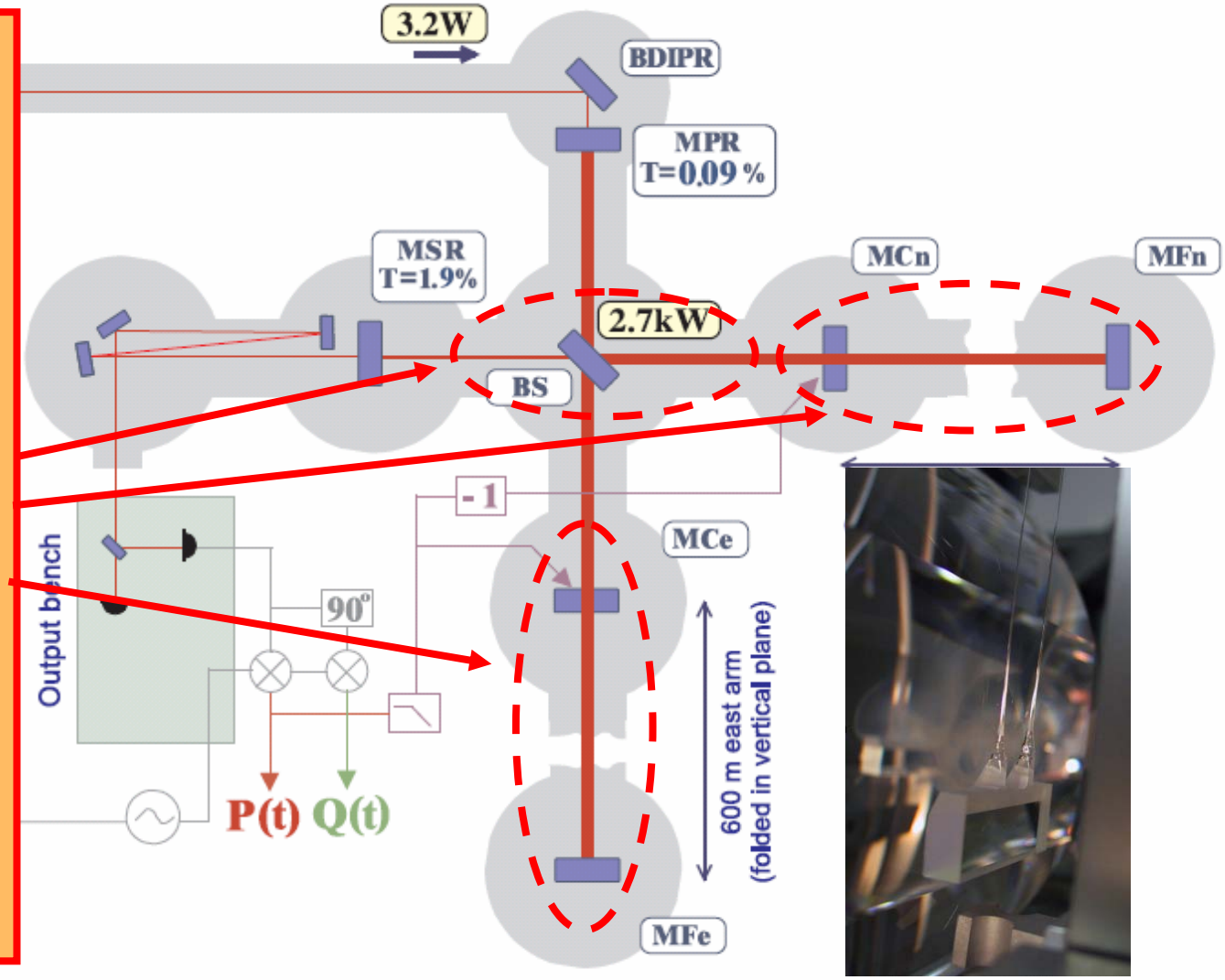


The GEO600 Interferometer

Triple suspensions:

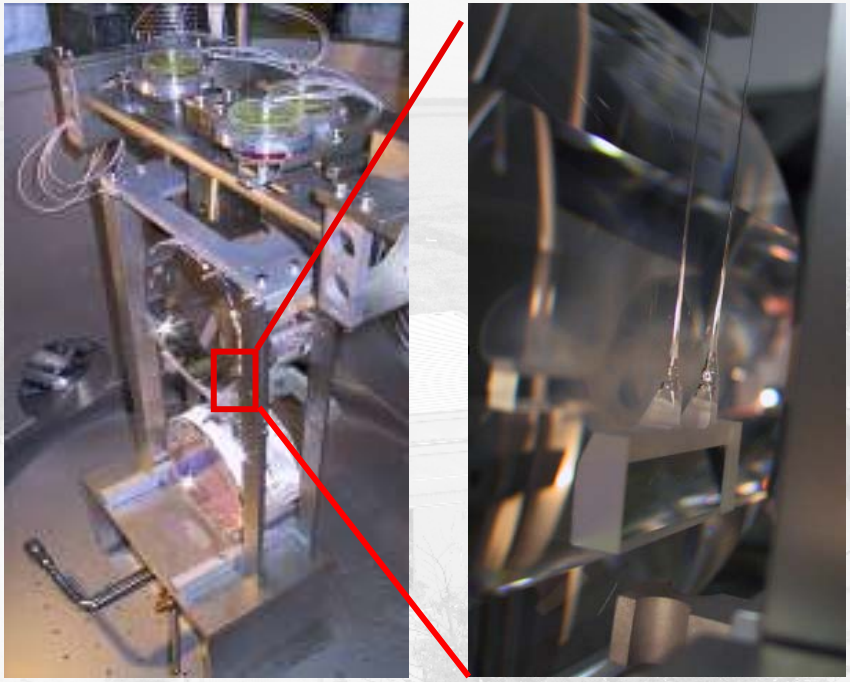


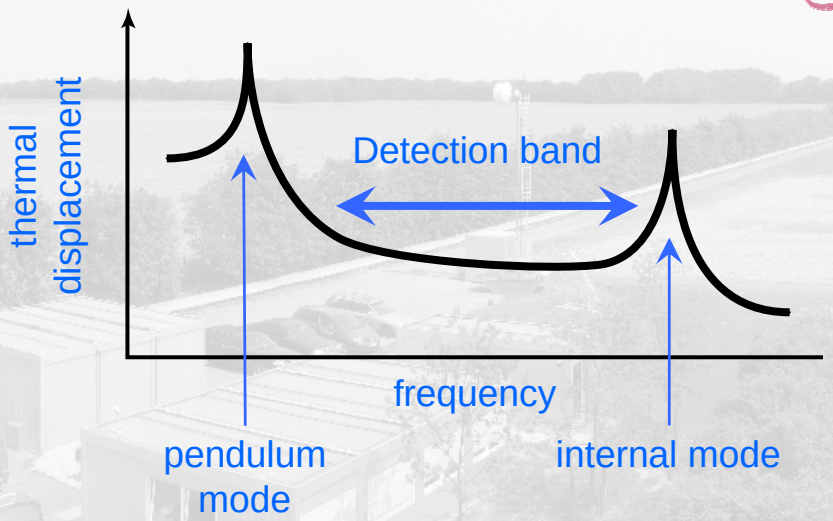
Split-feedback (3-stage hierarchical control: longitudinal + alignment)

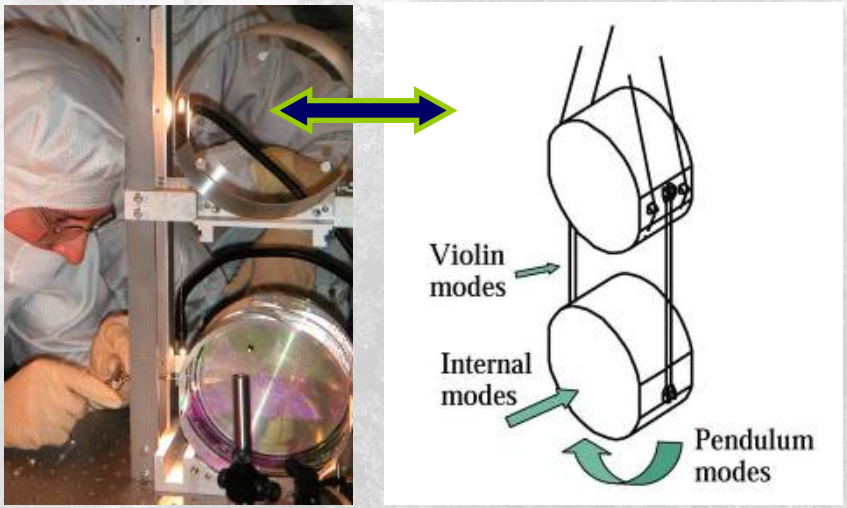


Monolithic stages: ~100 fibre years on running IFO with ~5 partial ventings

Ultra-low mechanical loss suspensions







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

- Reduces thermal noise

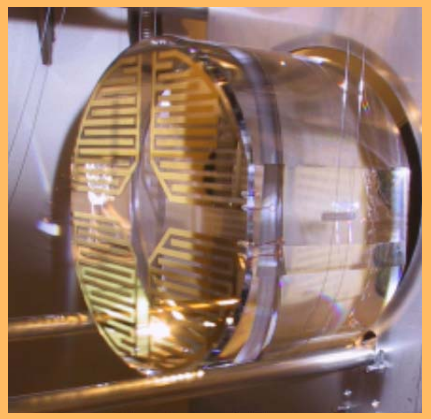
- Adopted as a core component of the upgrades for Advanced LIGO and Advanced VIRGO

See following talk by A. Heptonstall – Development of fused silica suspension fibres for Advanced

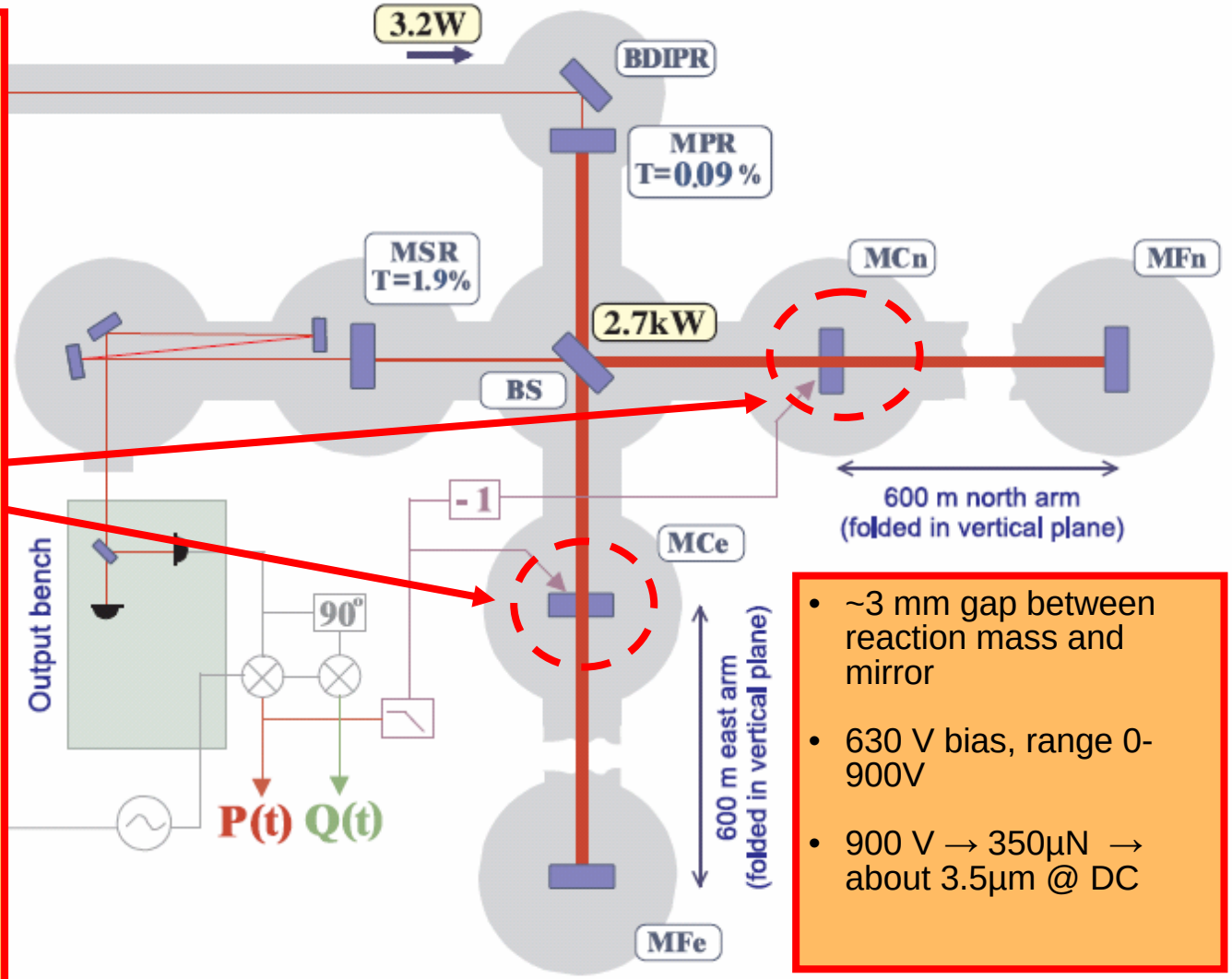
The GEO600 Interferometer

Electro-Static Drives:

- **Used for fast control of diff. arm length.**



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

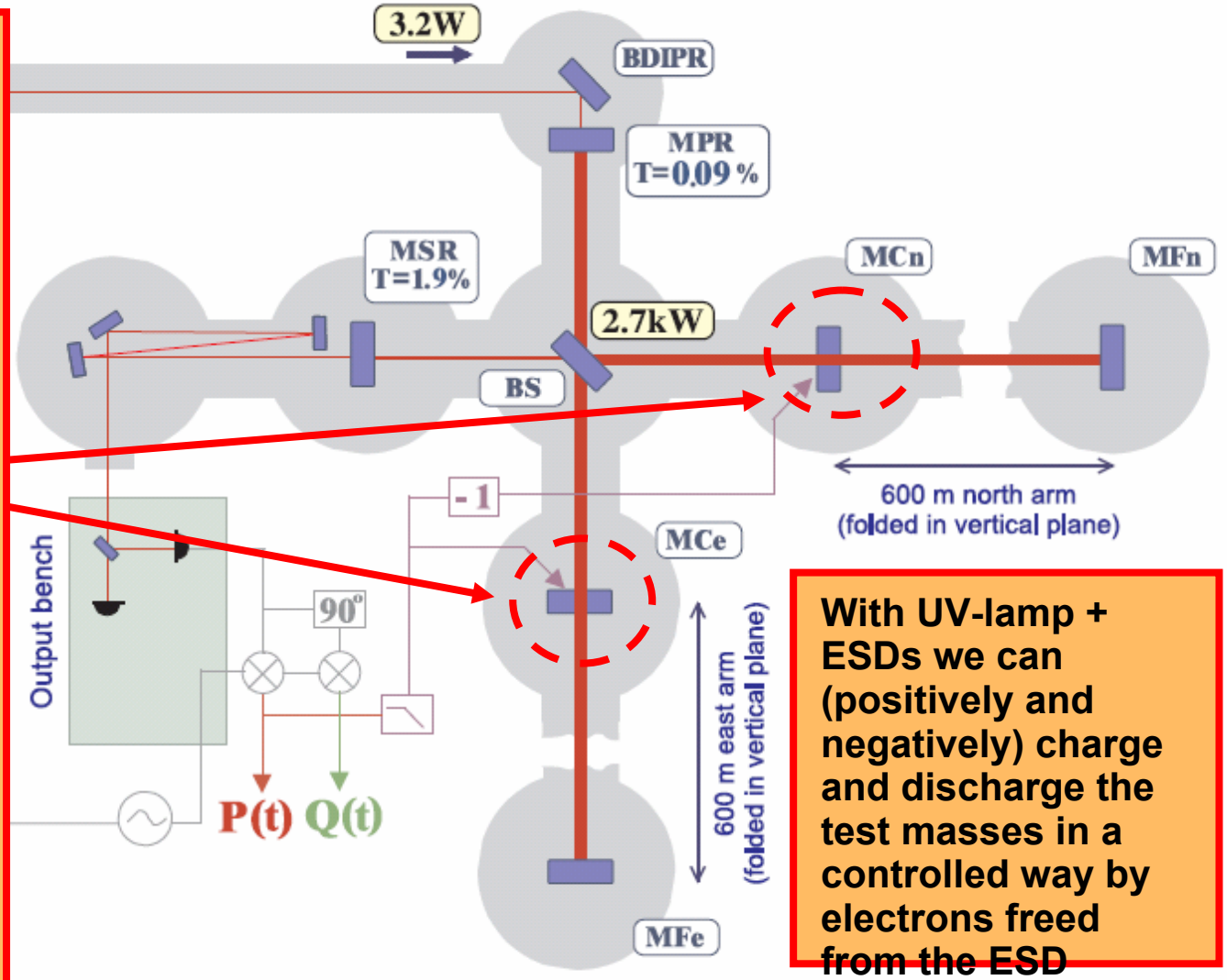


- ~3 mm gap between reaction mass and mirror
- 630 V bias, range 0-900V
- 900 V → 350µN → about 3.5µm @ DC

The GEO600 Interferometer

Charges on test masses

- **Measured positive charging of test masses**
- **Discharged by using a UV-lamp, technique first demonstrated in G t a C (1**



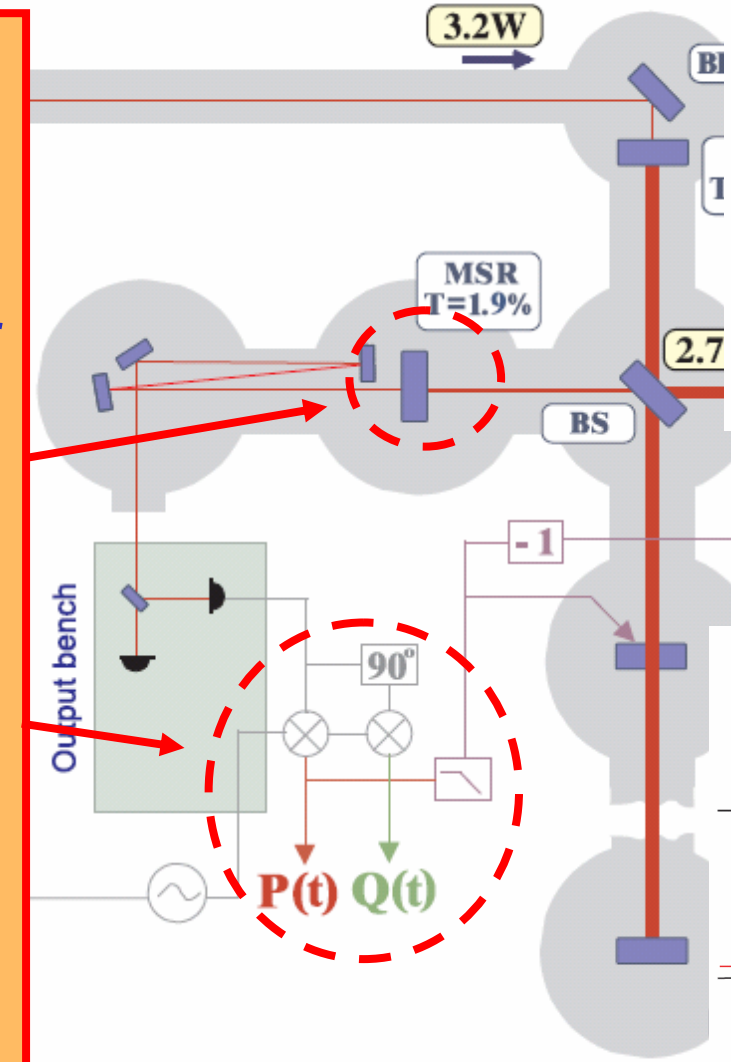
With UV-lamp + ESDs we can (positively and negatively) charge and discharge the test masses in a controlled way by electrons freed from the ESD electrodes.

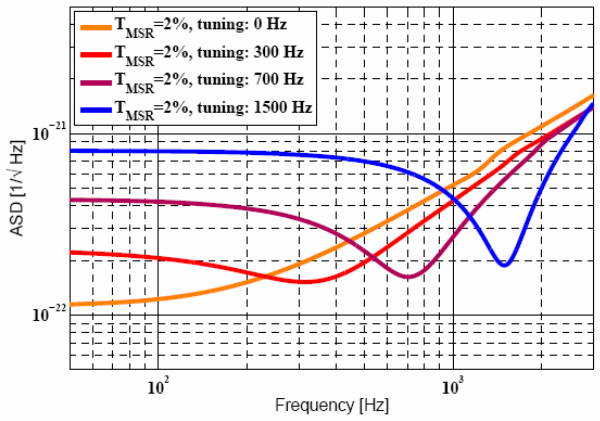
Hewitson et al, in press, CQG
LIGO-P070087-00-Z

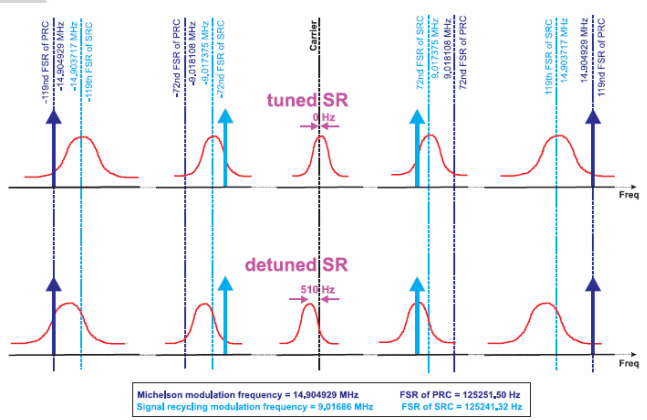
The GEO600 Interferometer

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*.**

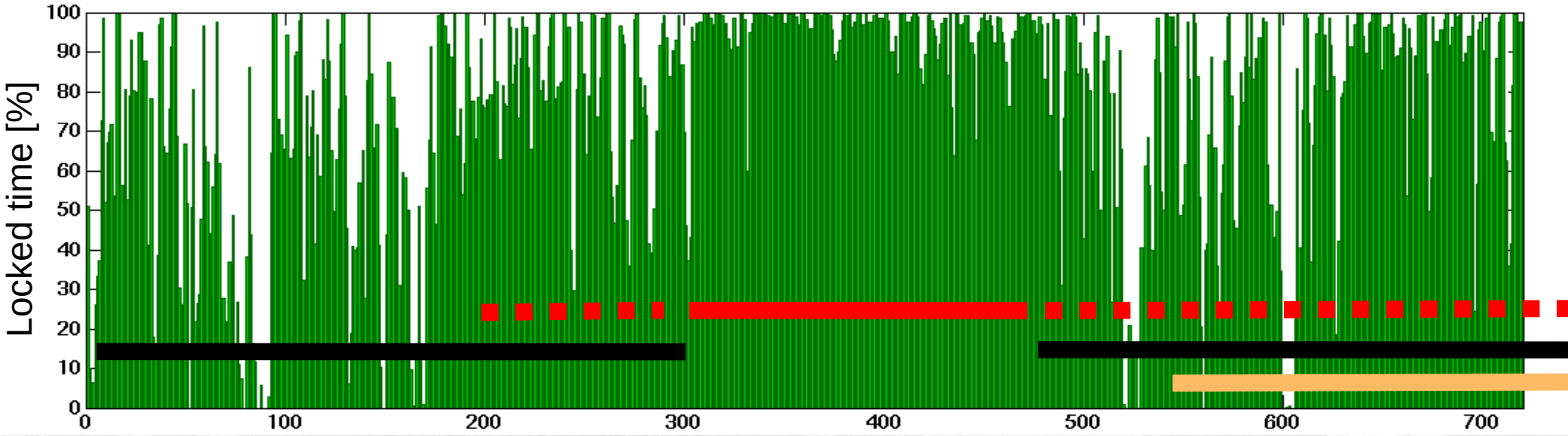






The Last Two Years

Locked state and main activities at the site



S5 N&W

S5 24/7

Noise hunting

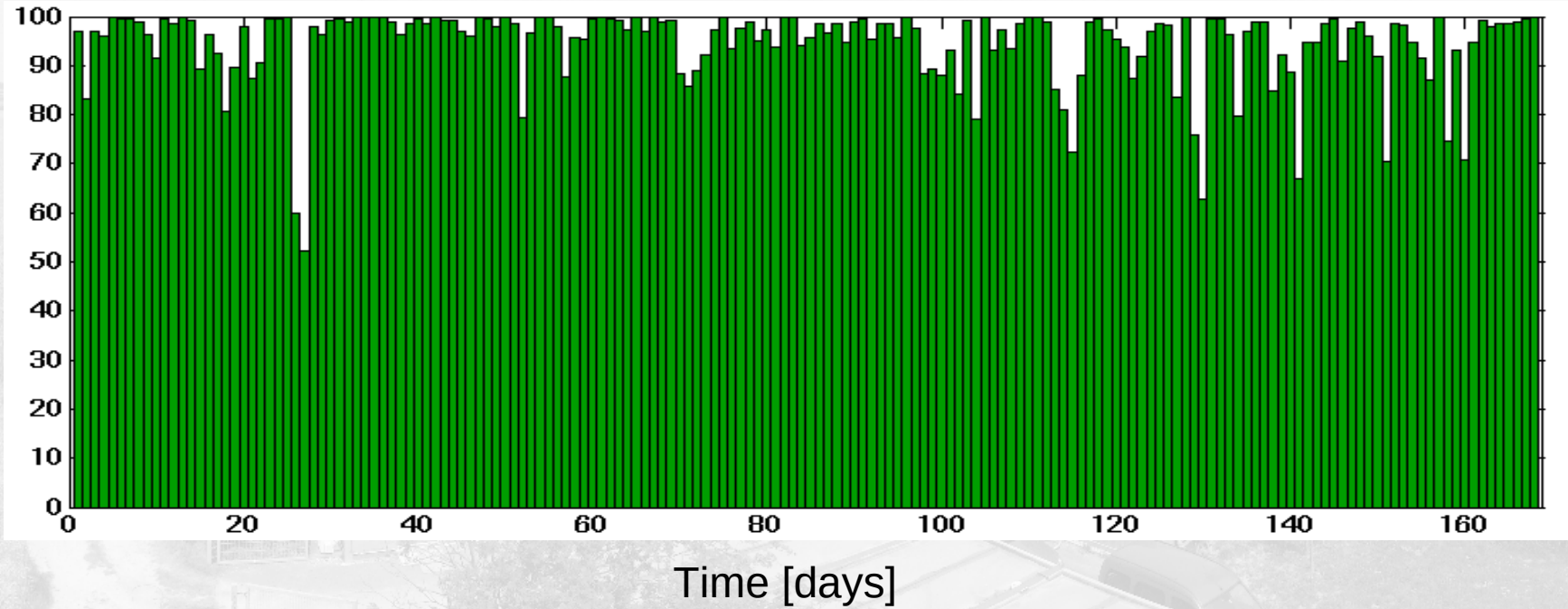
Infrastructure work

~190 days science time [57%]

~152 days science time [91%]

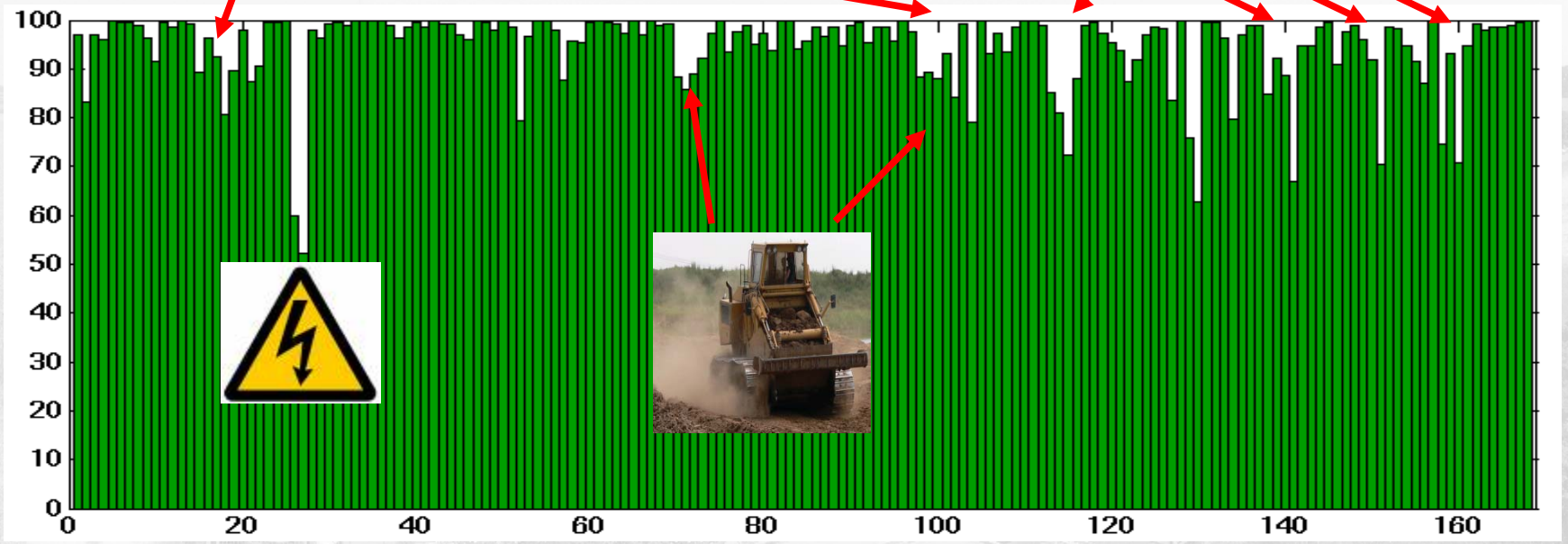
~342 days

S5: 24/7 Mode



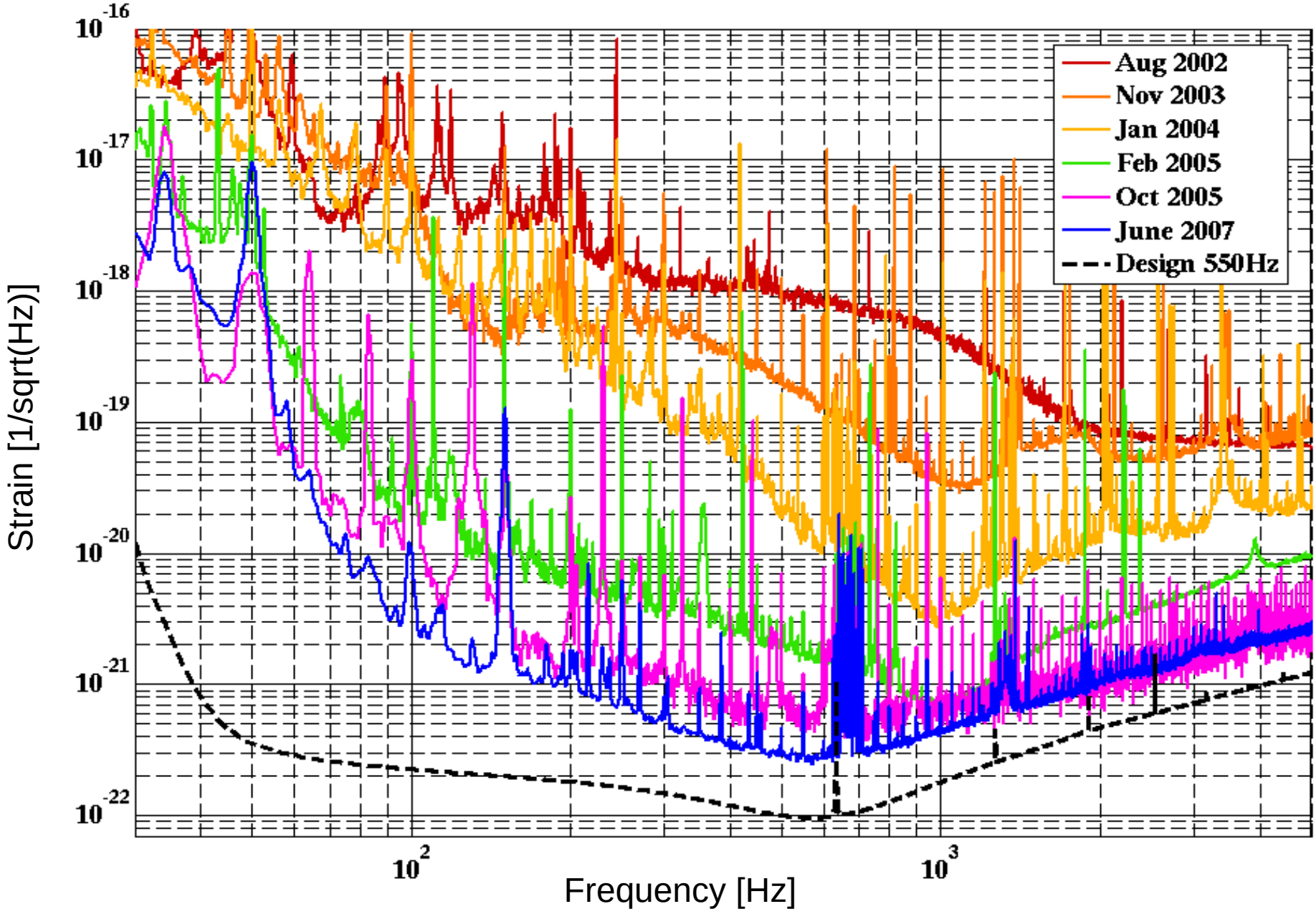
- 1. May - 15. October, 168 days
  - Instrumental duty cycle: 94.3%
  - Science time duty cycle: 91 %
- Longest lock: 102 hours

S5: 24/7 Mode

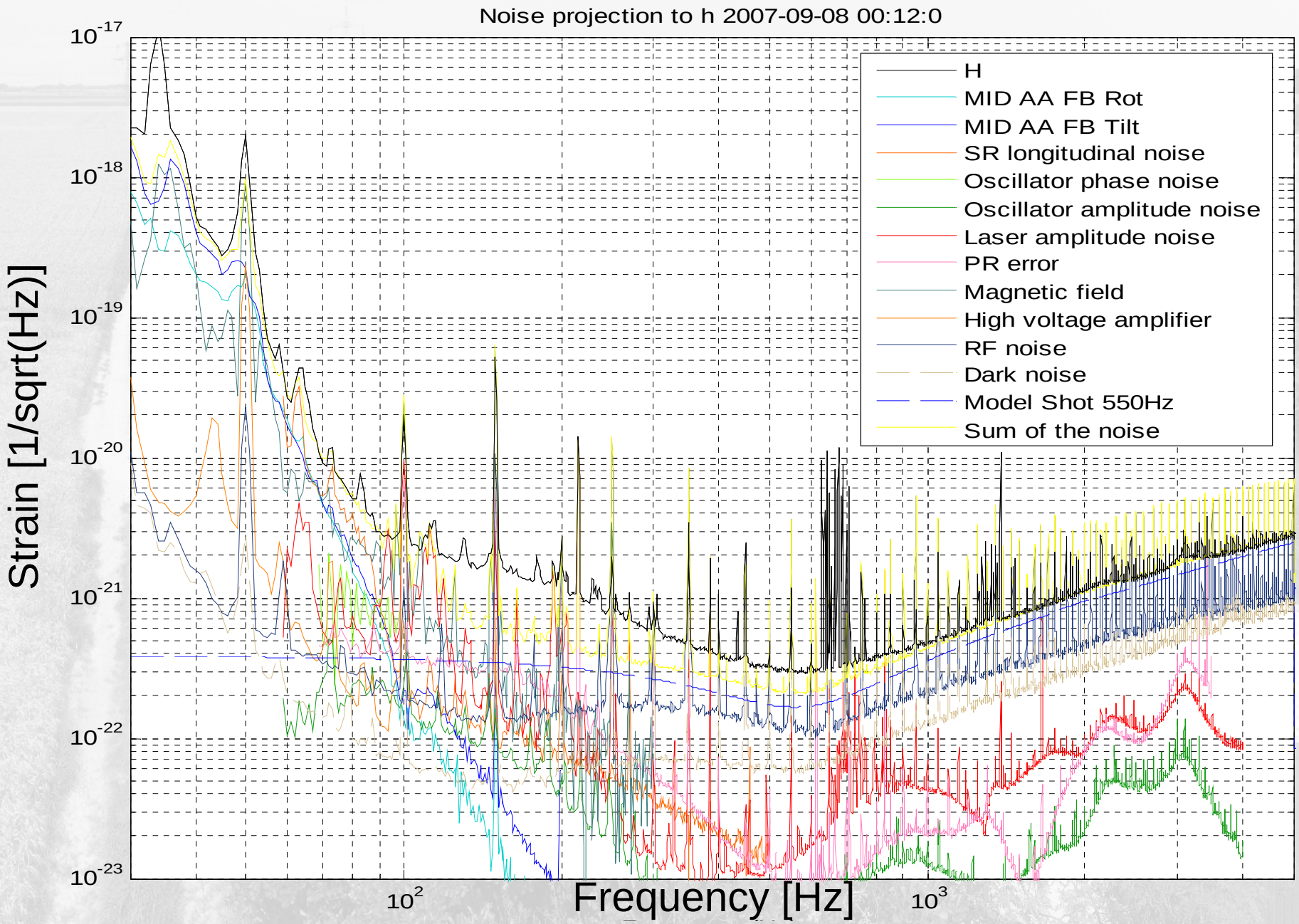


- 1. May - 15. October, 168 days
  - Instrumental duty cycle: 94.3%
  - Science time duty cycle: 91 %
- Longest lock: 102 hours

GEO Sensitivities



Noise Projections Update



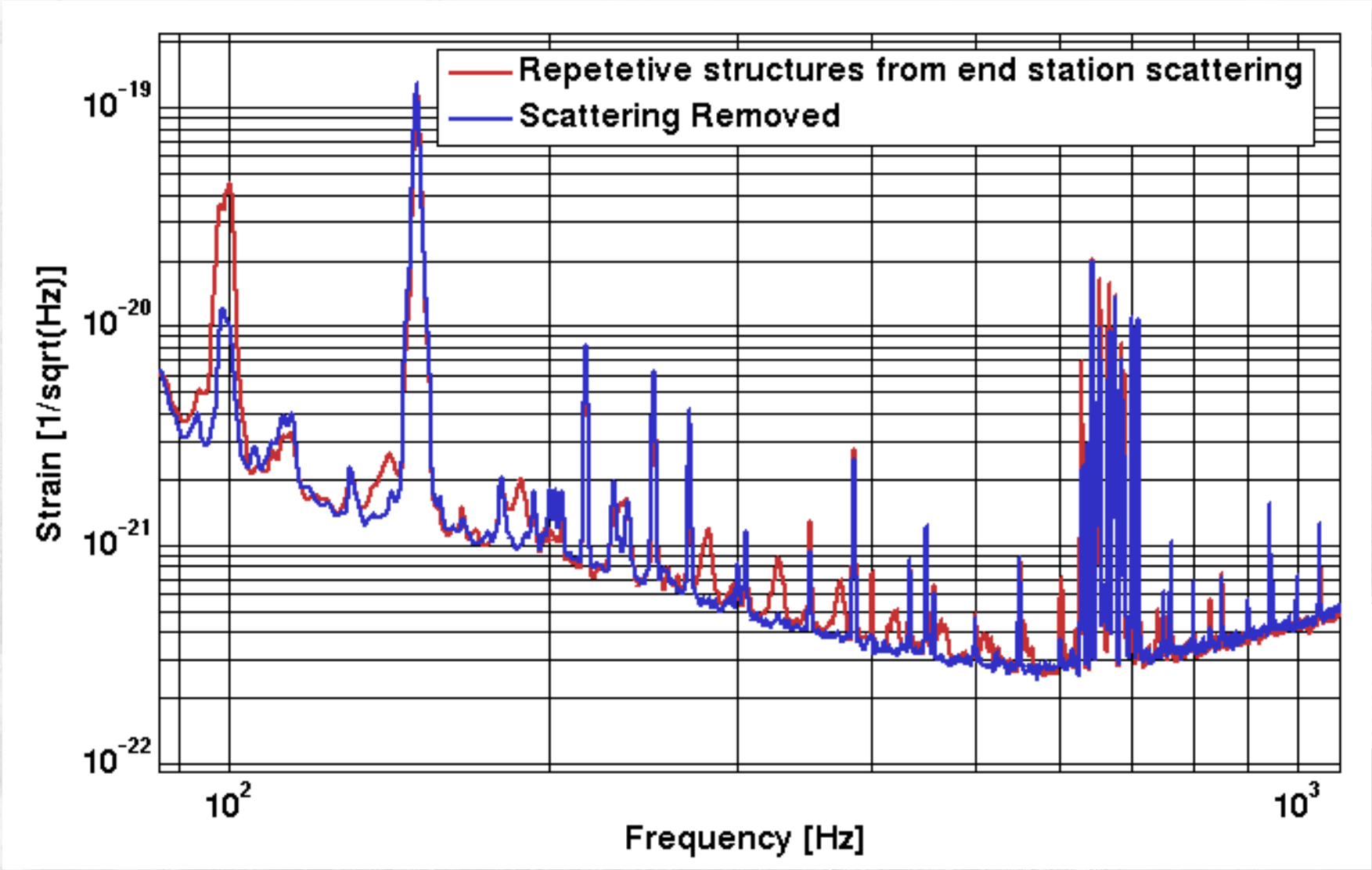
Main Noise Reduction Topics

- Low-frequency (< ~200Hz):
  - Signal recycling feedback
  - Michelson auto-alignment feedback
- Mid & high frequency (> ~200Hz):
  - 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, ...

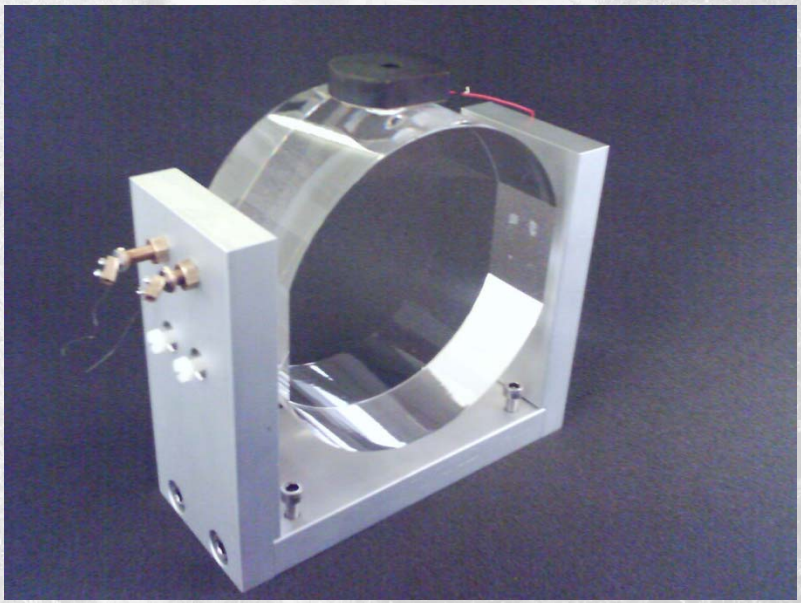
Scattered Light Reduction



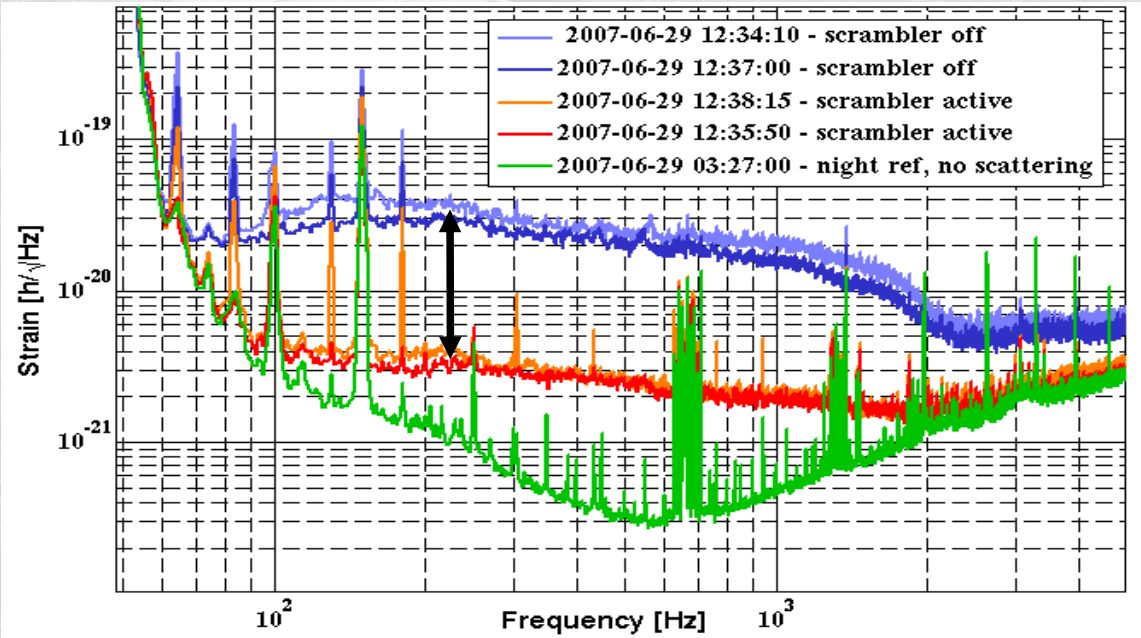
Acousto-Optic Phase Shifter...

...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

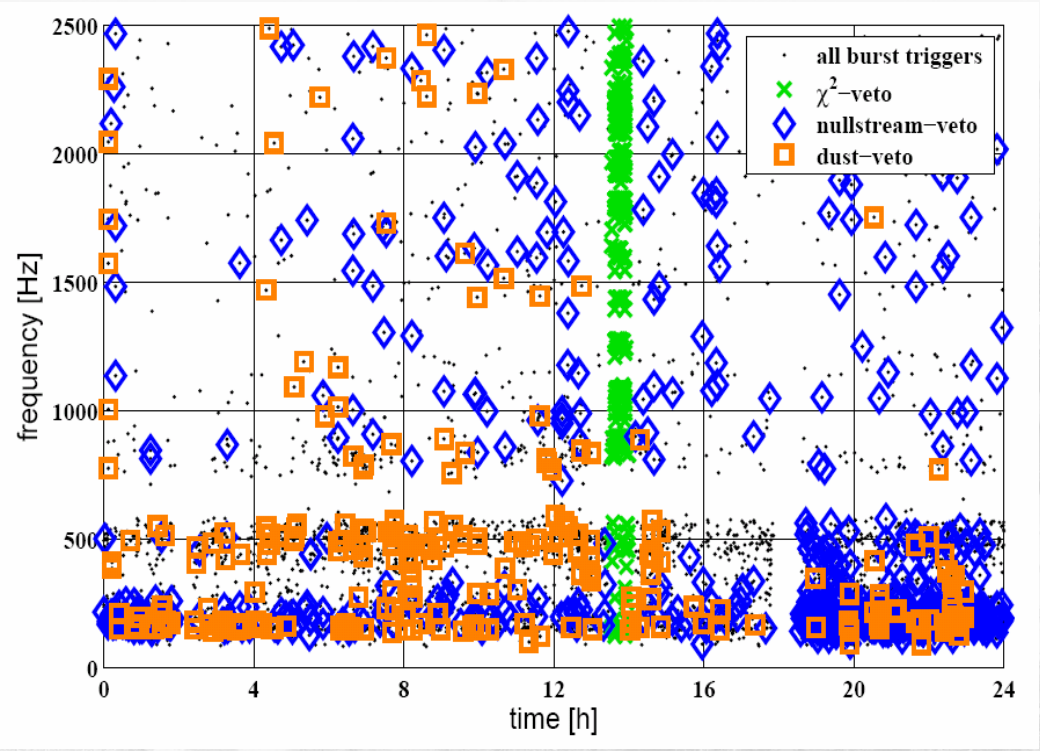


Infrastructure Work

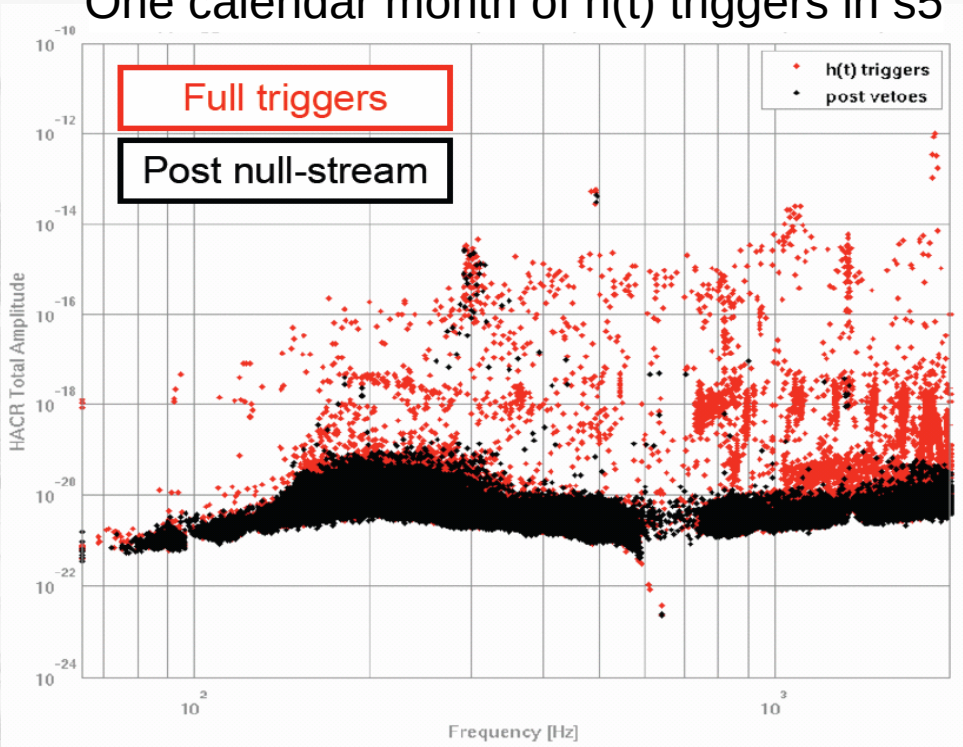
- New HV feedthroughs for electrostatic drives,
  improved ESD wiring
- Cleanroom: particle reduction by HEPA fiters in main airconditioning stream
- Debugging of mains power routing done.
  Work ongoing on balancing of currents

We are ready for a long data run

Glitches and Vetoes



One calendar month of h(t) triggers in s5

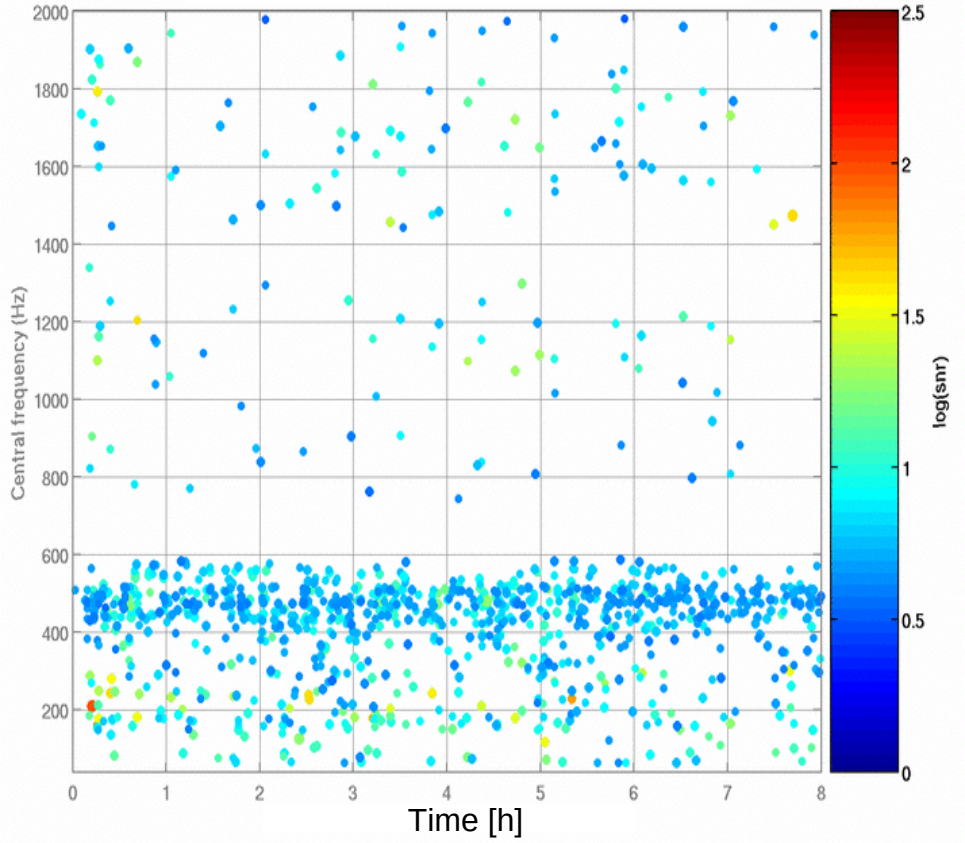


- Nullstream veto
- Noise projection vetos
- Chi^2 veto
- Statistical vetos

Reduction of Glitches

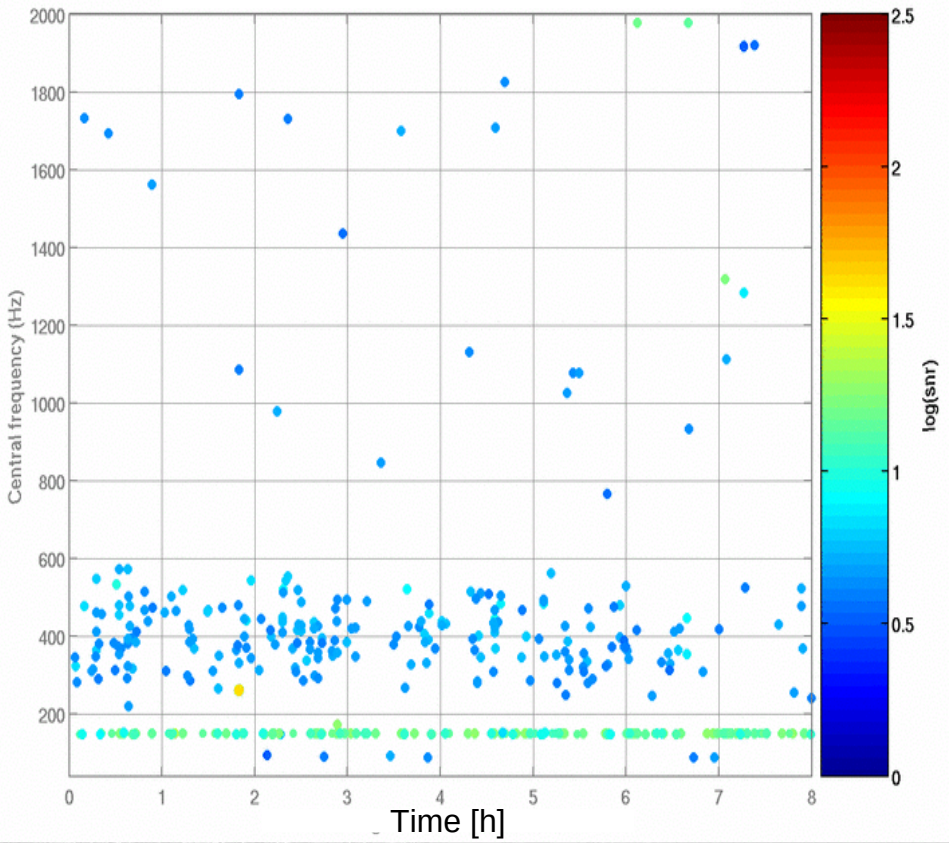
Comparizon of glitchiness of LIGO /GEO /VIRGO data with coherent waveburst showed GEO glitchiness around the average of all detectors (Sept. 2006). Since then we further reduced glitches.

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:

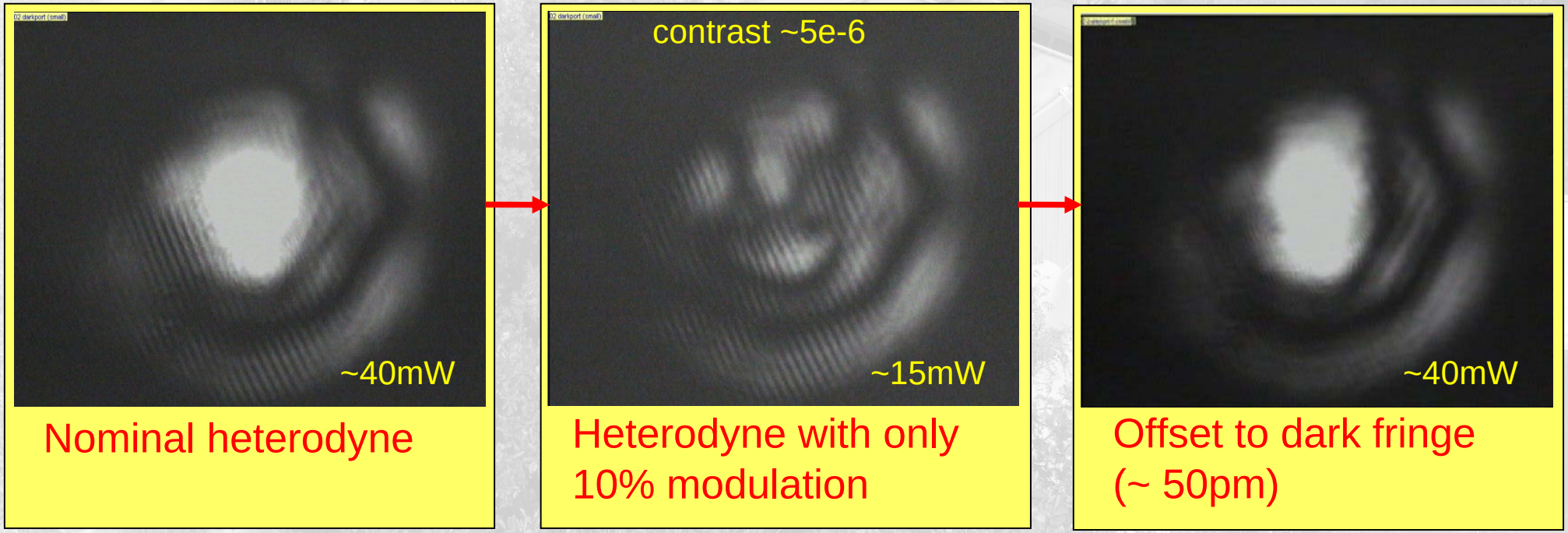
Turning down the RF-modulation *(factor 10 is possible)*

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 !

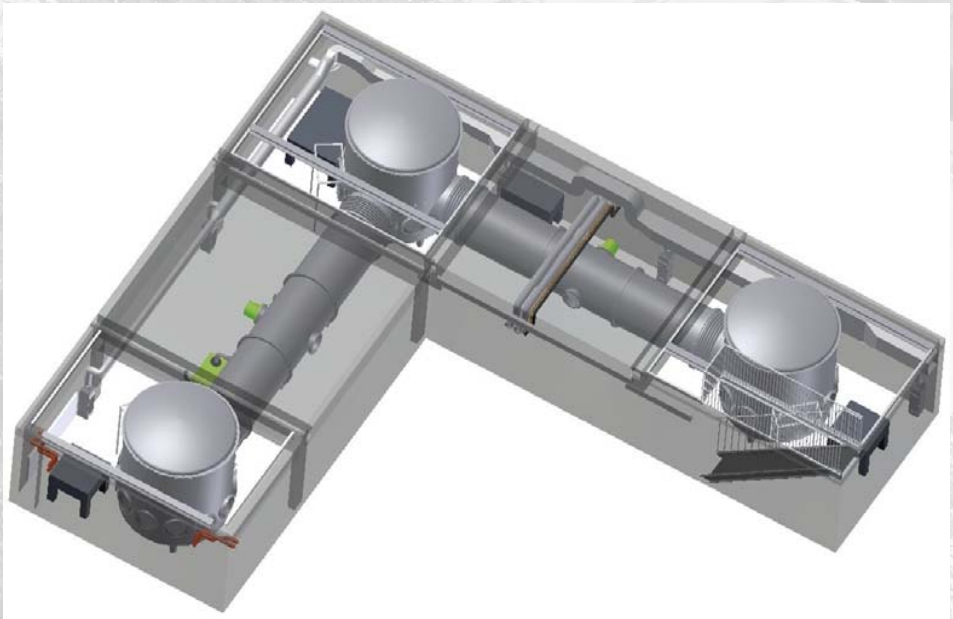
- Slightly better (10-20%) sensitivity than heterodyne at high frequencies (> ~2kHz)
- Not much worse sensitivity at mid frequencies
- Power noise coupling is not terrible !

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