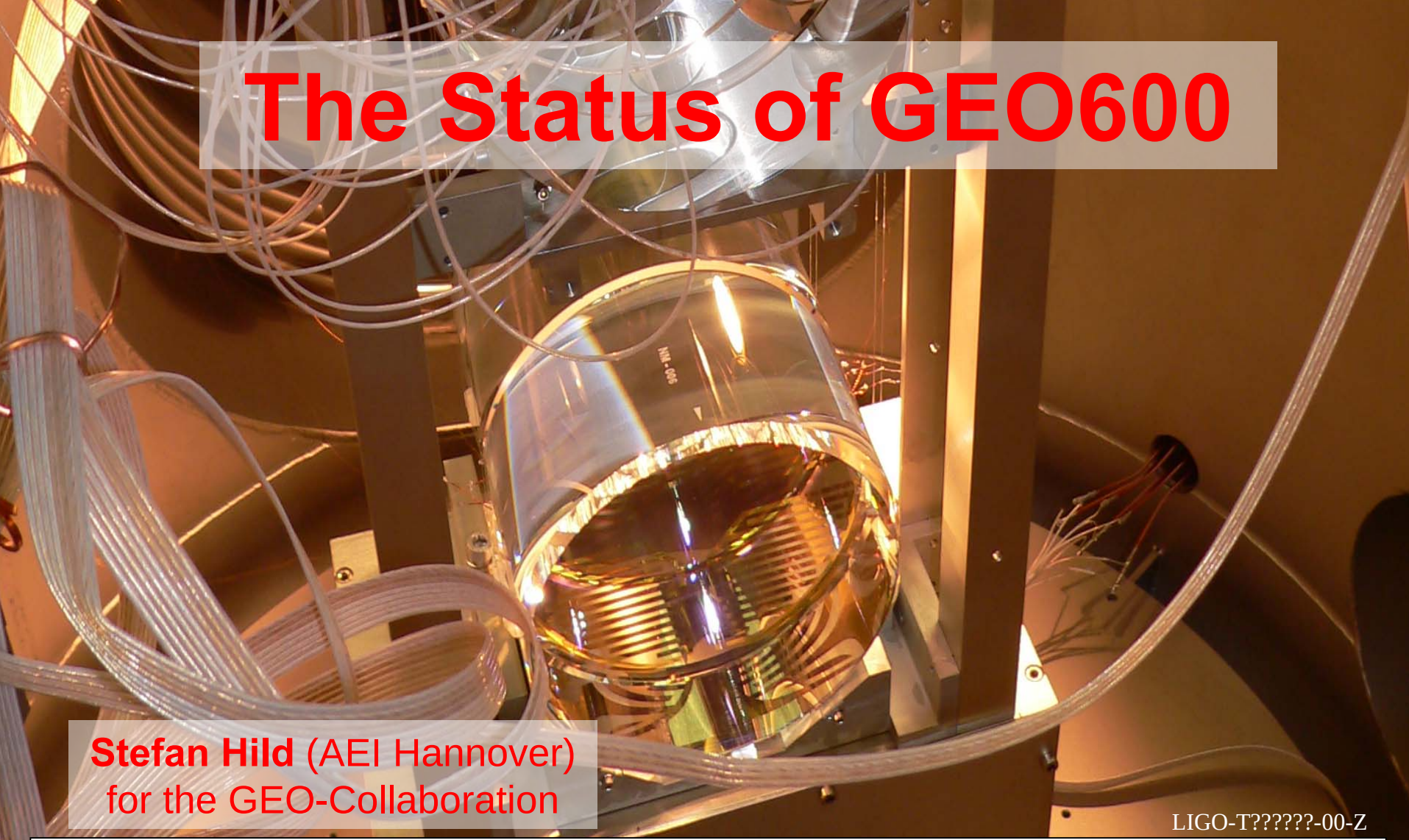
The Status of GEO600



Stefan Hild (AEI Hannover)
for the GEO-Collaboration

LIGO-T??????-00-Z

Leibniz Universität Hannover

UNIVERSITY OF BIRMINGHAM

IGR

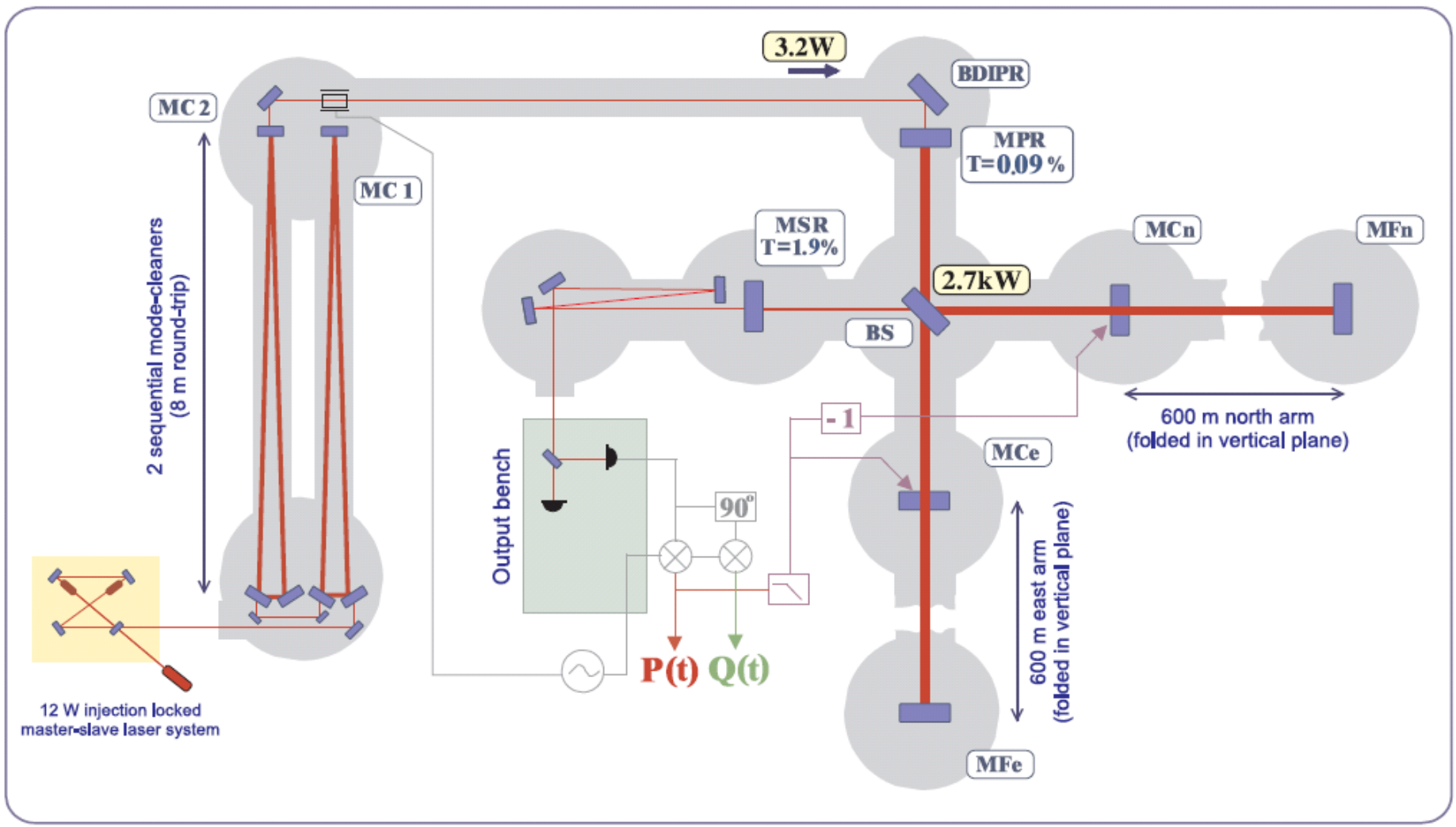
Universitat de les Illes Balears

CARDIFF UNIVERSITY

Overview

- **The GEO600 detector**
- **Participation / Performance in S5**
- **Recent efforts**
  - gain understanding of detector
  - improving the detector / reduction of glitches
  - necessary maintenance work
  - ESD autoalignment
  - DC-readout
- **Plans for the future**

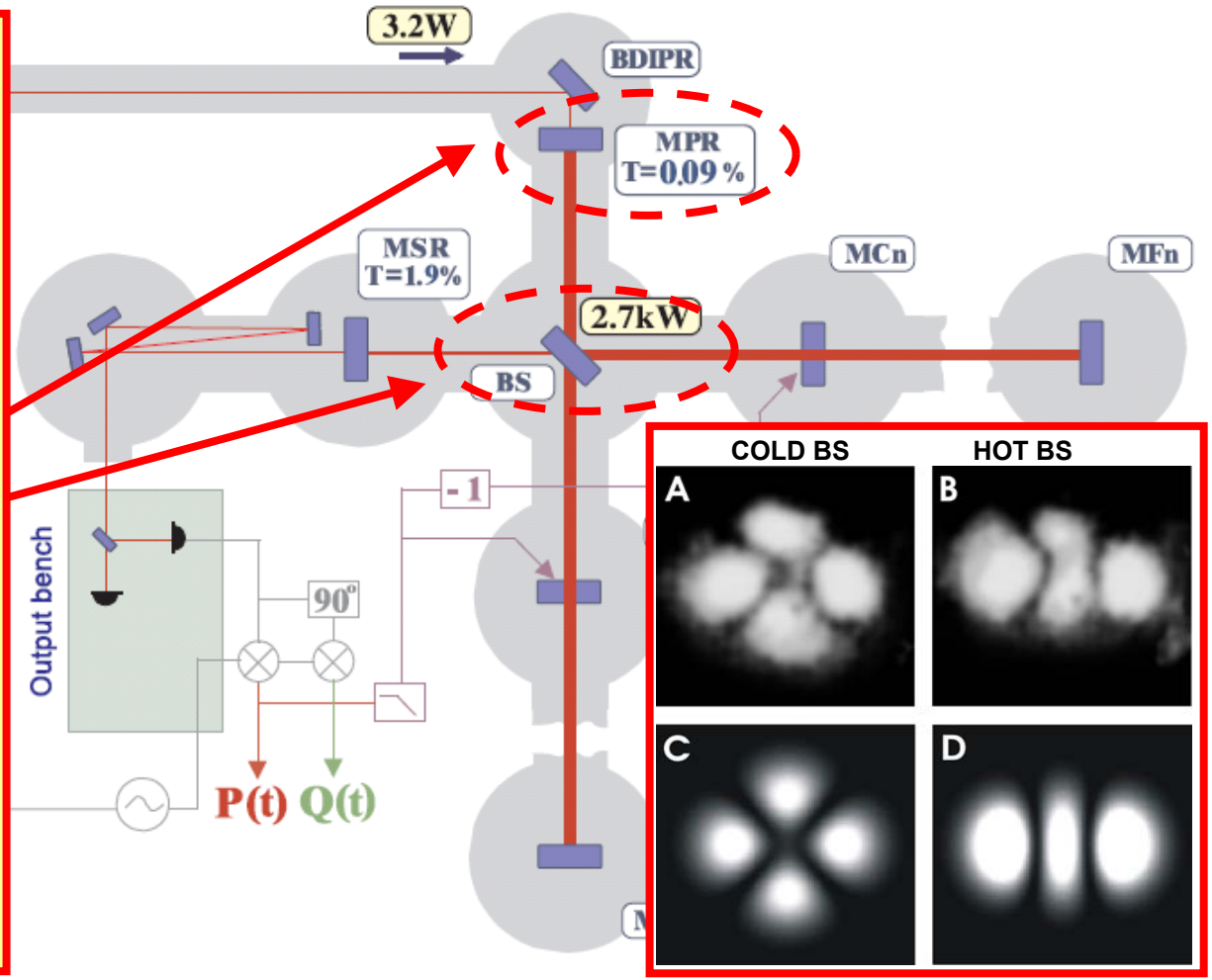
The GEO600 Interferometer



The GEO600 Interferometer

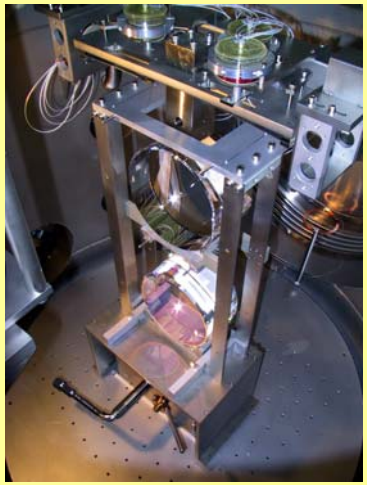
No arm cavities, but folded arms:

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

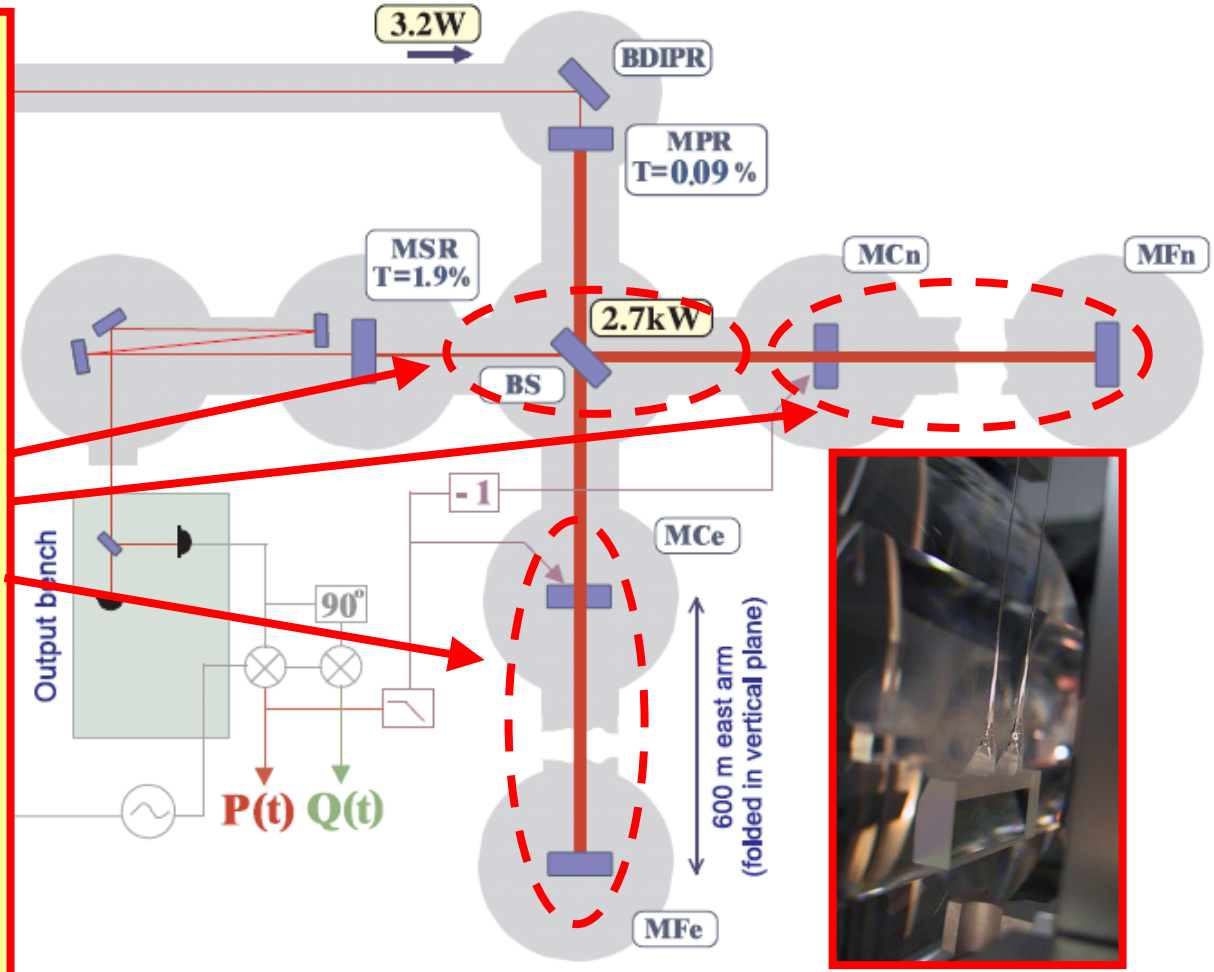


The GEO600 Interferometer

Triple suspensions:



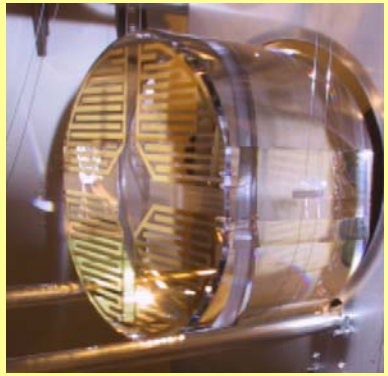
- **Monolithic stages**
- **Split-feedback (3 stage hierarchical control: longitu-dinal + alignment)**



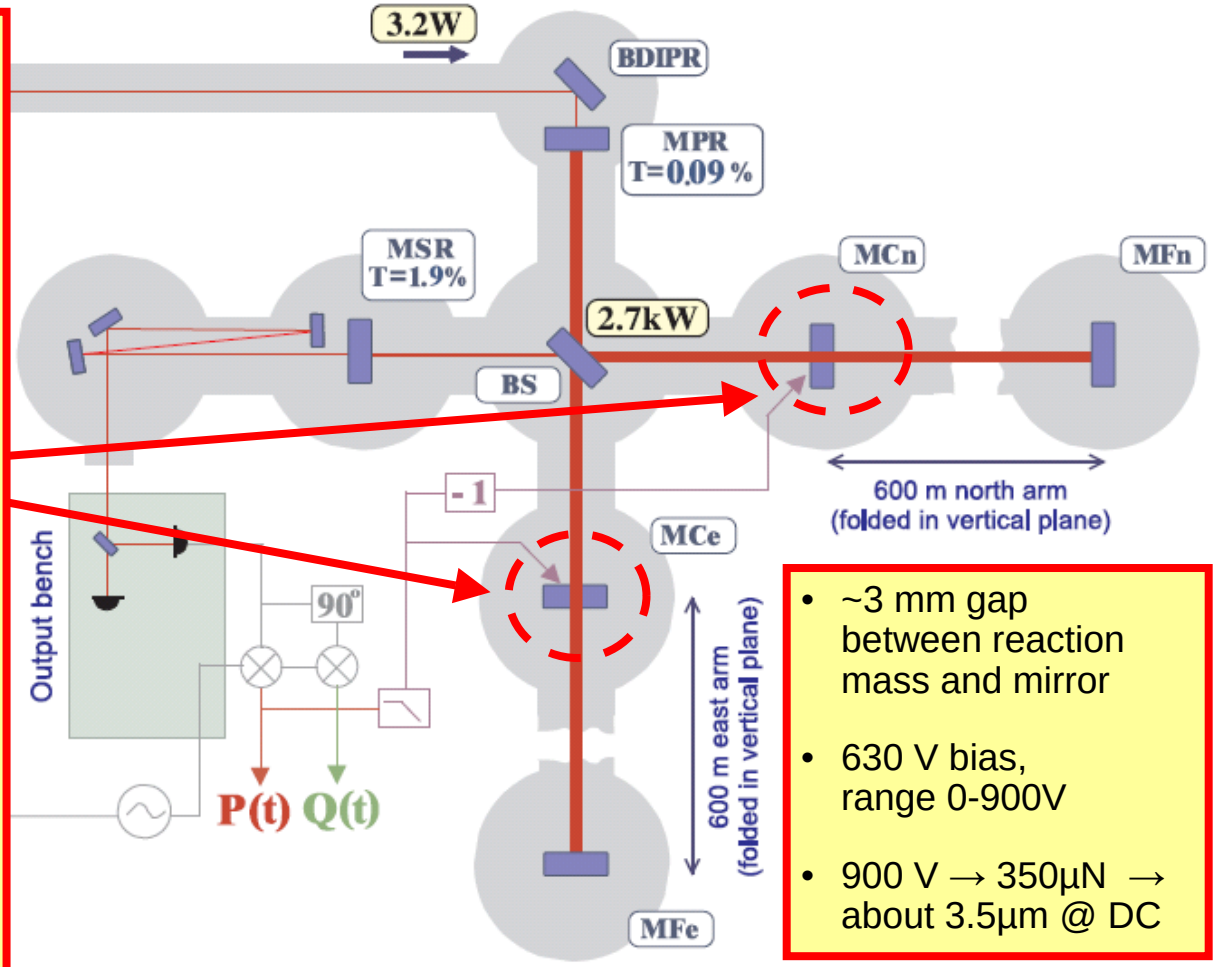
The GEO600 Interferometer

Electro-Static Drives:

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



- **Also used for fast autoalignment (quadrants).**

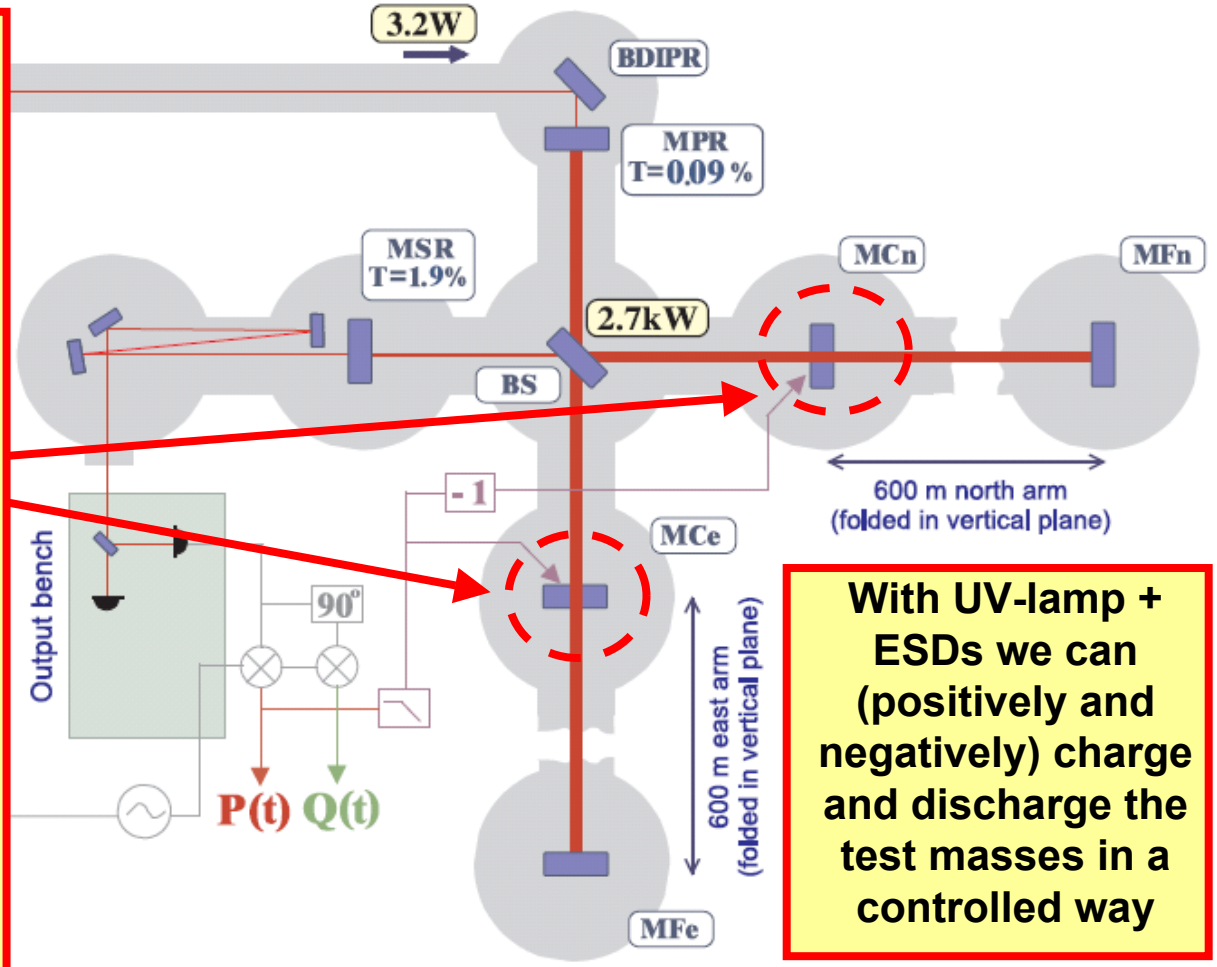


- ~3 mm gap between reaction mass and mirror
- 630 V bias, range 0-900V
- 900 V → 350µN → about 3.5µm @ DC

The GEO600 Interferometer

Charges on test masses

- Measured posi-tive charging of testmasses
- Discharged by using a UV-lamp
  (electrons are freed from ESD electrodes)

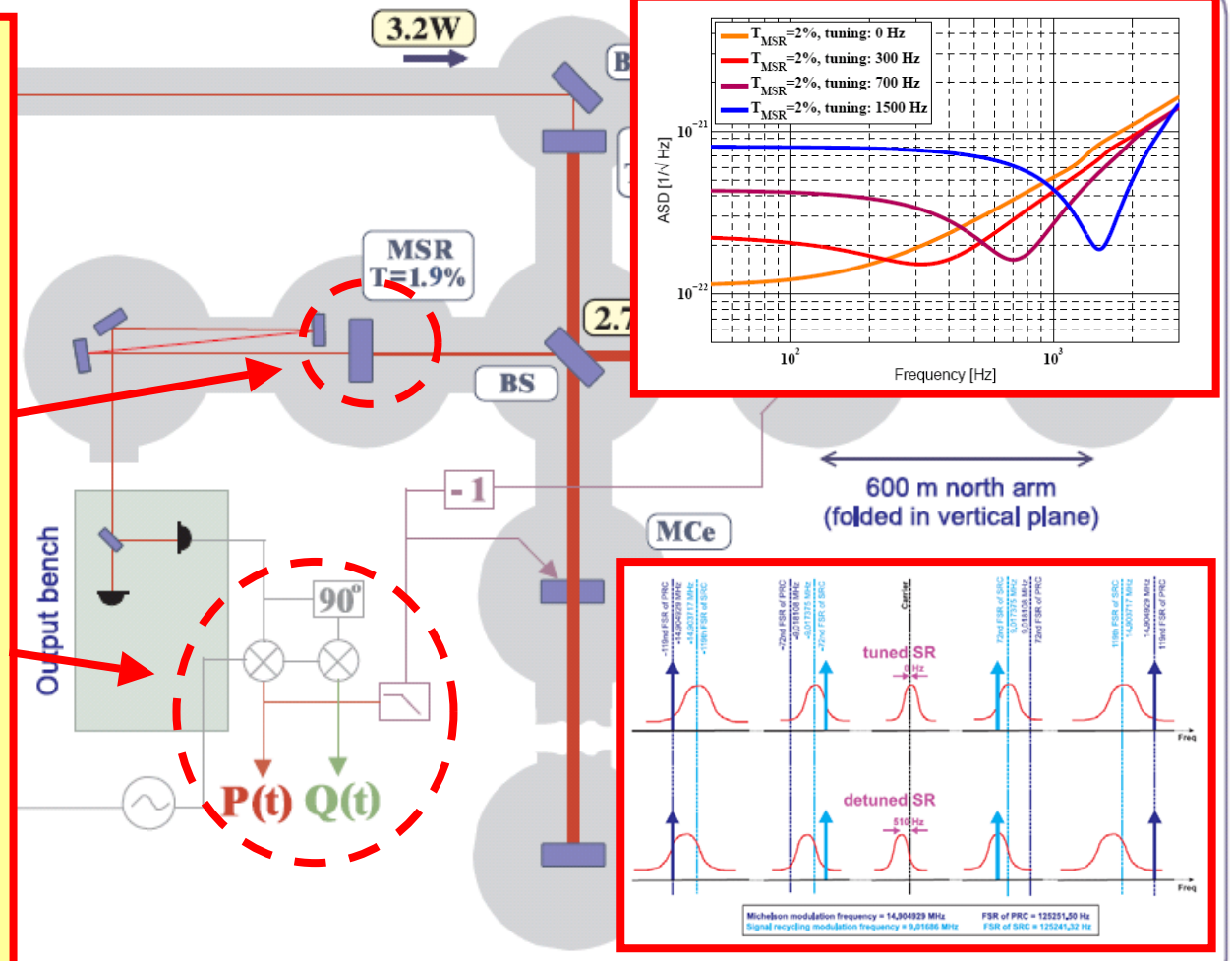


With UV-lamp + ESDs we can (positively and negatively) charge and discharge the test masses in a controlled way

The GEO600 Interferometer

Signal-Recycling:

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



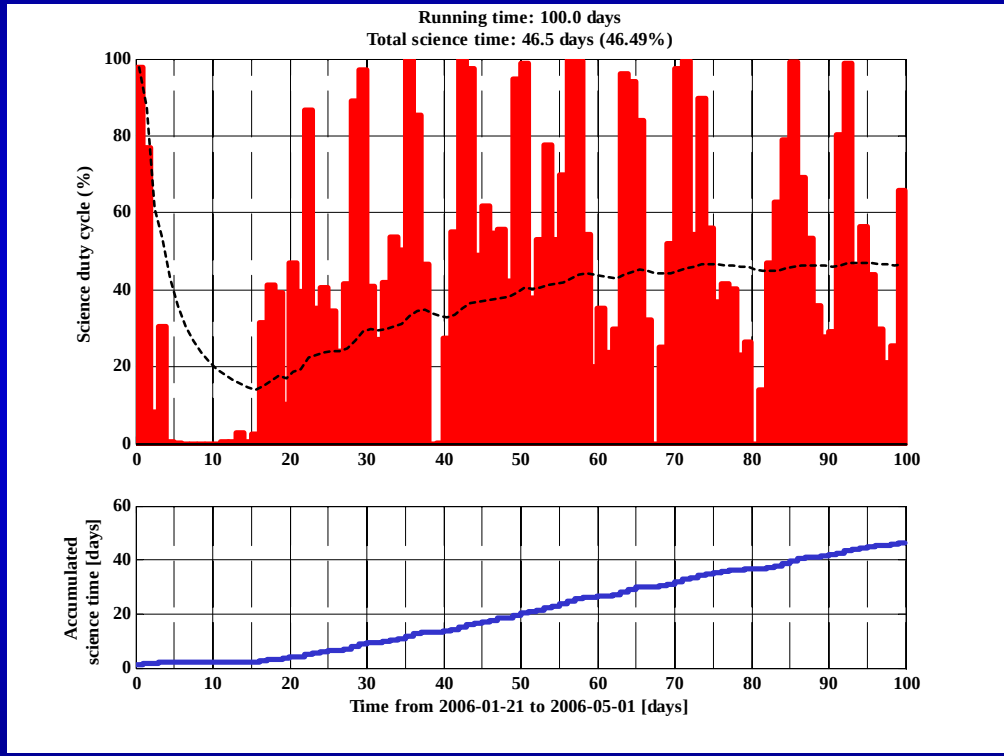
GEO600 in S5

Most of 2006 GEO600 participated in S5.

O&WE-mode 1:

20th January – 1st May

Science time = 46.5%



GEO600 in S5

Most of 2006 GEO600 participated in S5.

O&WE-mode 1:

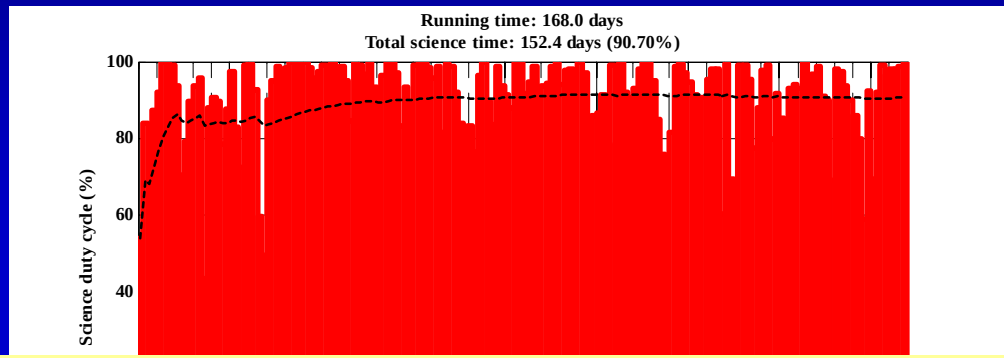
20th January – 1st May

Science time = 46.5%

24/7:

1st May – 16th October

Science time = 90.7%



Strategic Decision @ October GEO-meeting:

- **Input:** LSC data analysis groups, LSC operations committee, Benefit/Risk-analysis from commissioning team.
- **Result:** O&WE-mode period 2
  - Gain understanding of the detector
  - Improving GEO600
  - Maintenance work required to prepare GEO for a long science run in 2008

GEO600 in S5

Most of 2006 GEO600 participated in S5.

O&WE-mode 1:

20th January – 1st May

Science time = 46.5%

24/7:

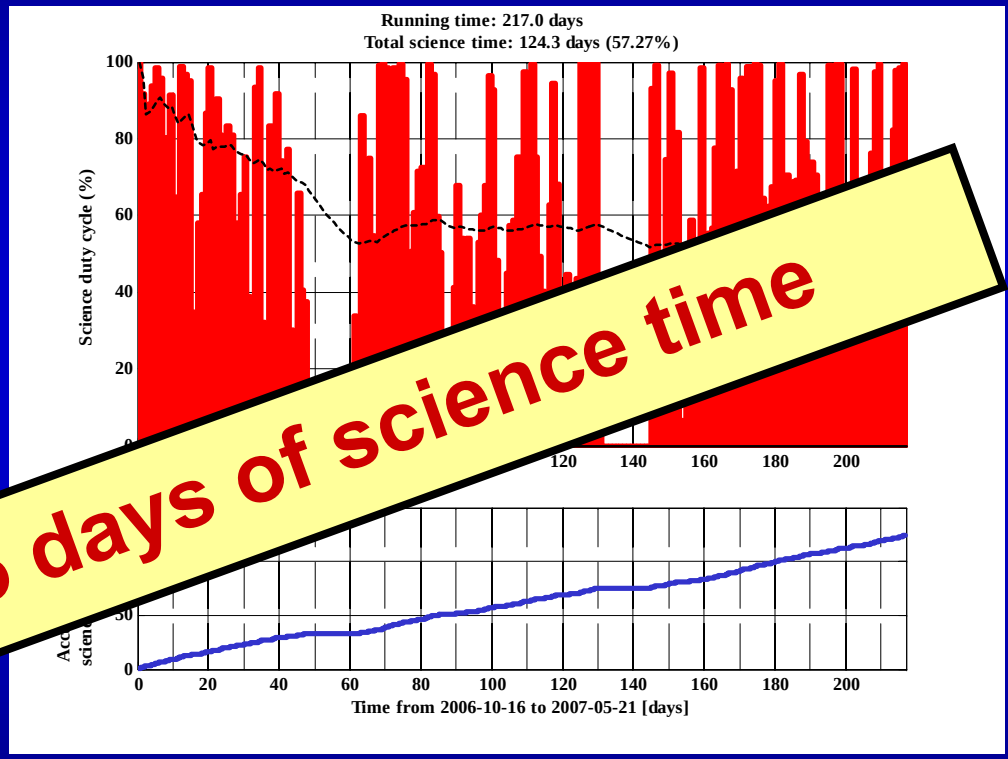
1st May – 16th October

Science time = 90.7%

O&WE-m

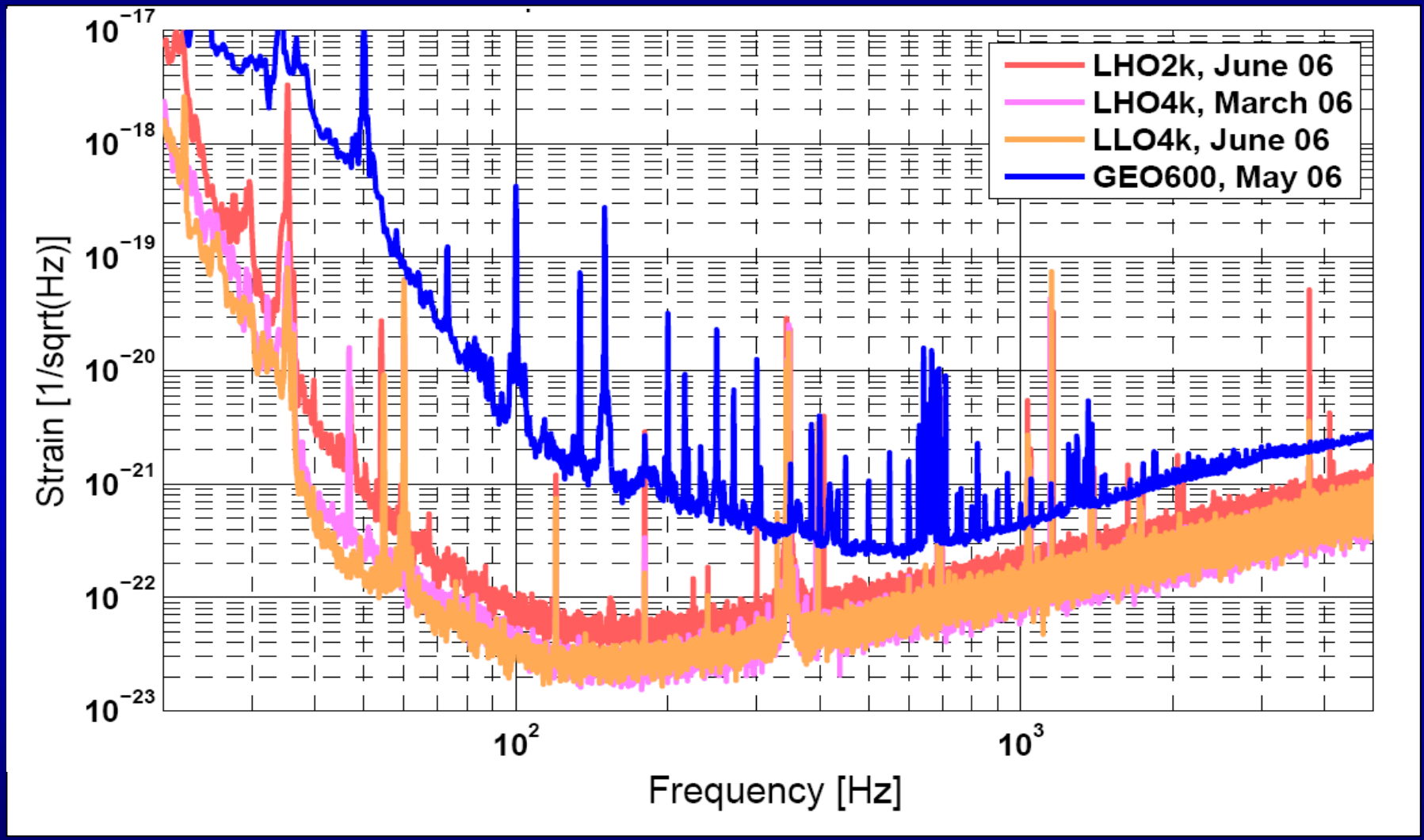
1

S ime = 57.3%

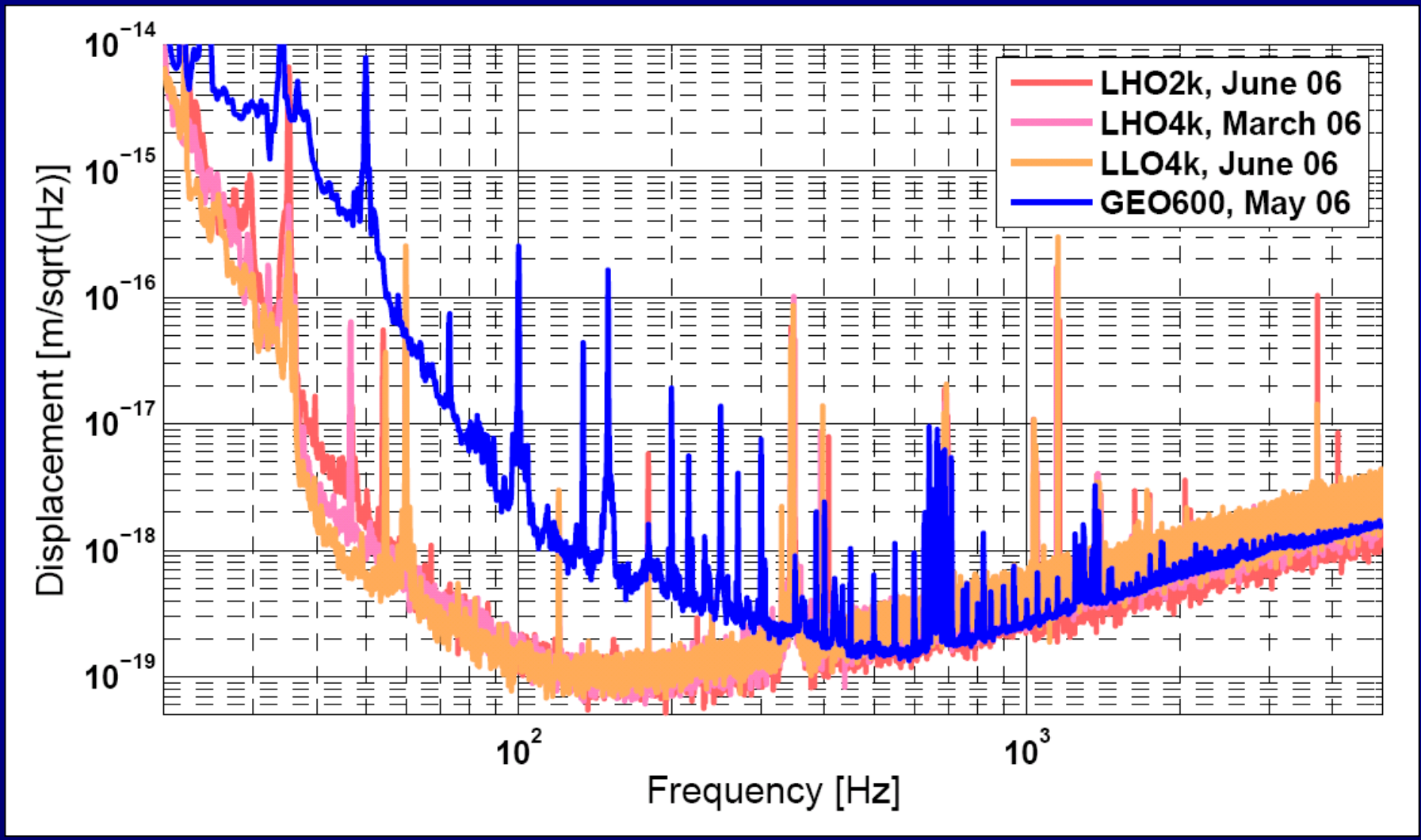


Overall about 325 days of science time

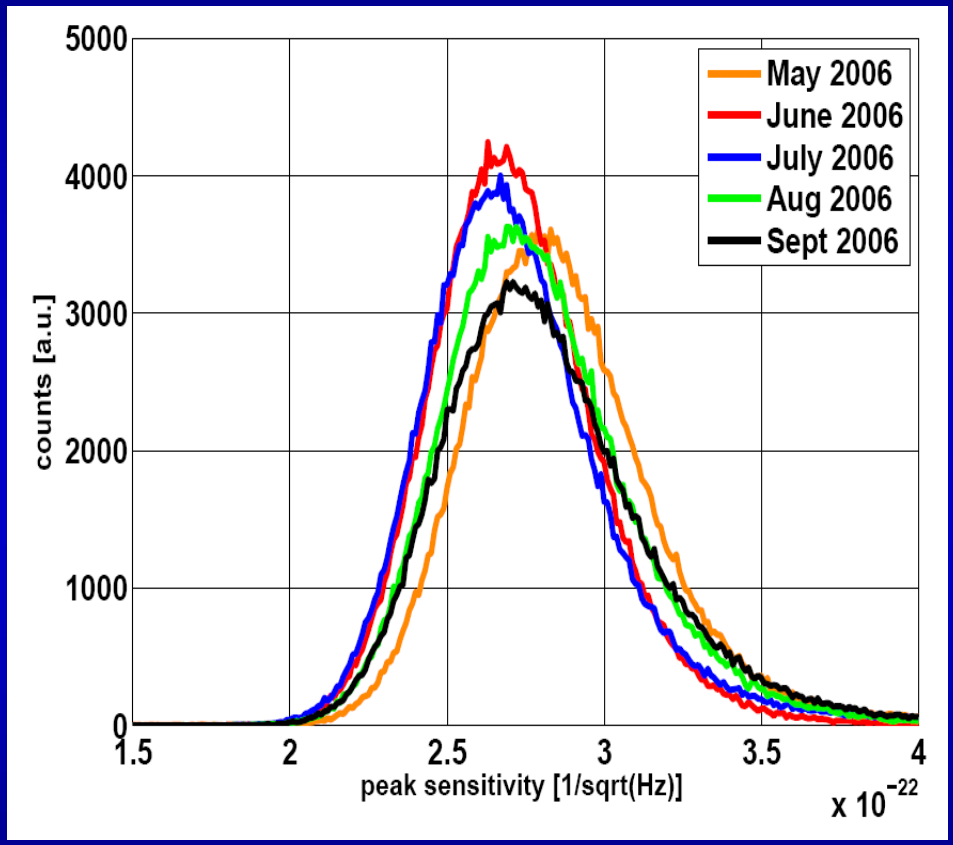
Strain sensitivity of LSC IFOs in S5



Displacement sensitivities in S5

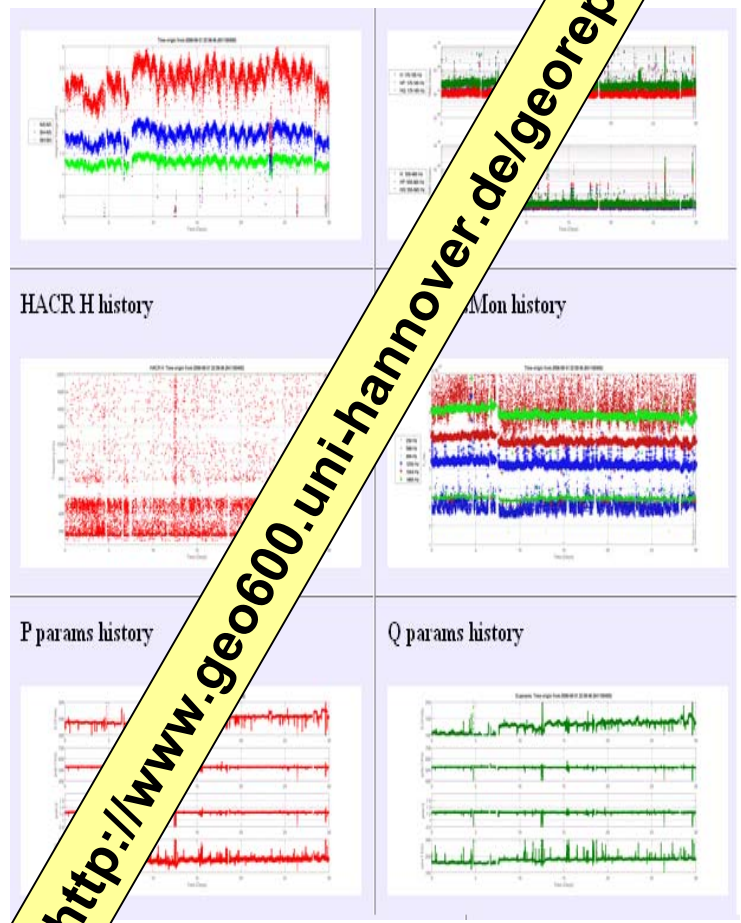


Detector stability in S5



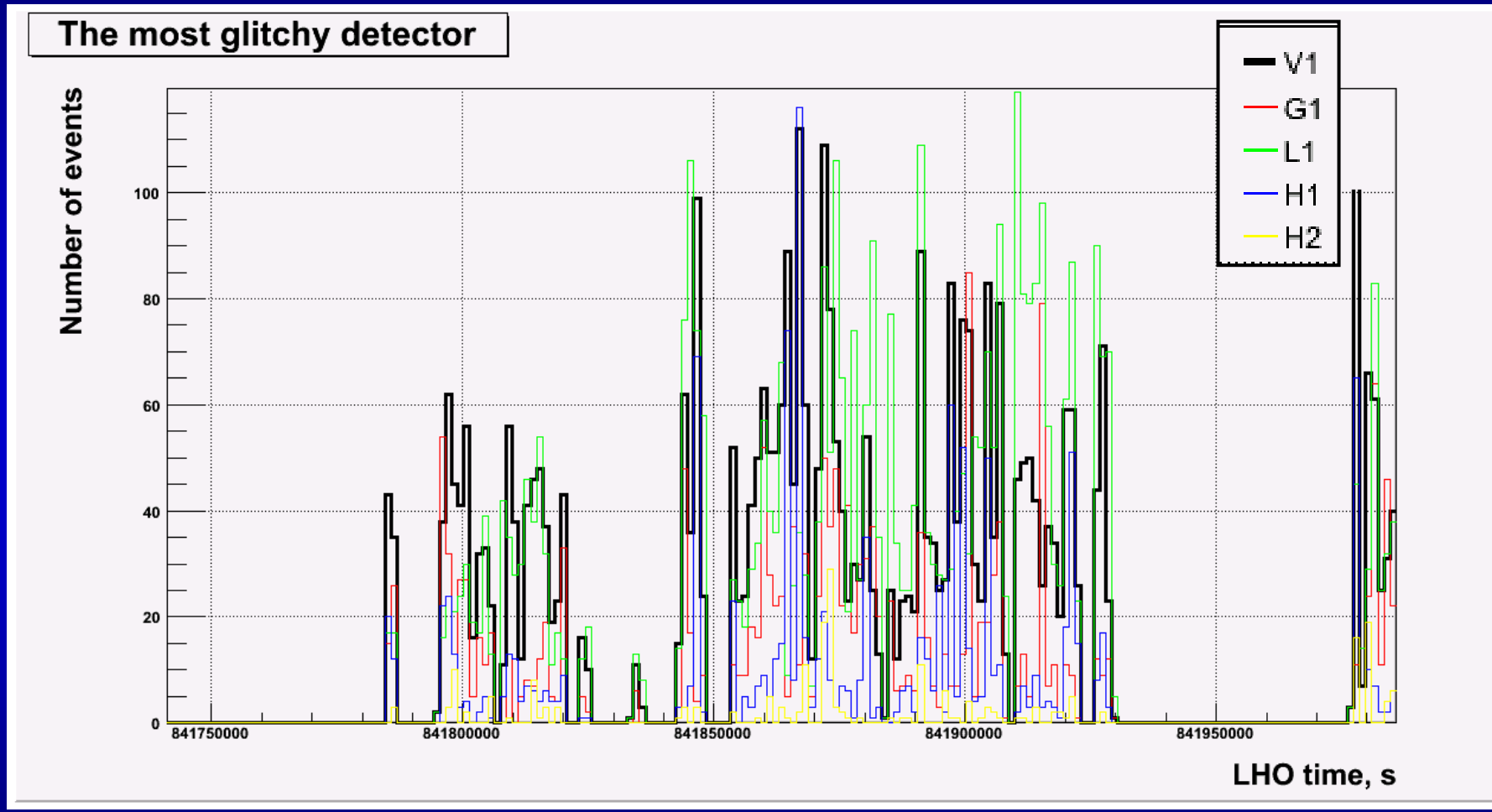
Average peak sensitivity better than 3e-22/sqrt(Hz)

Lots of DC info available.



http://www.geo600.uni-hannover.de/georeports/

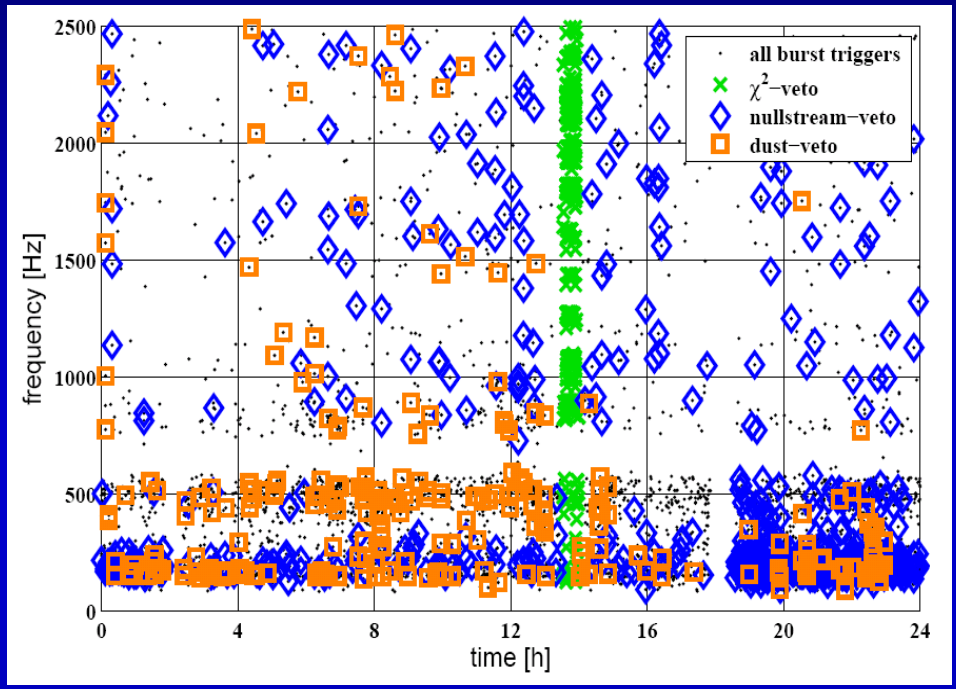
LIGO-VIRGO Project 2b using Coherent Waveburst

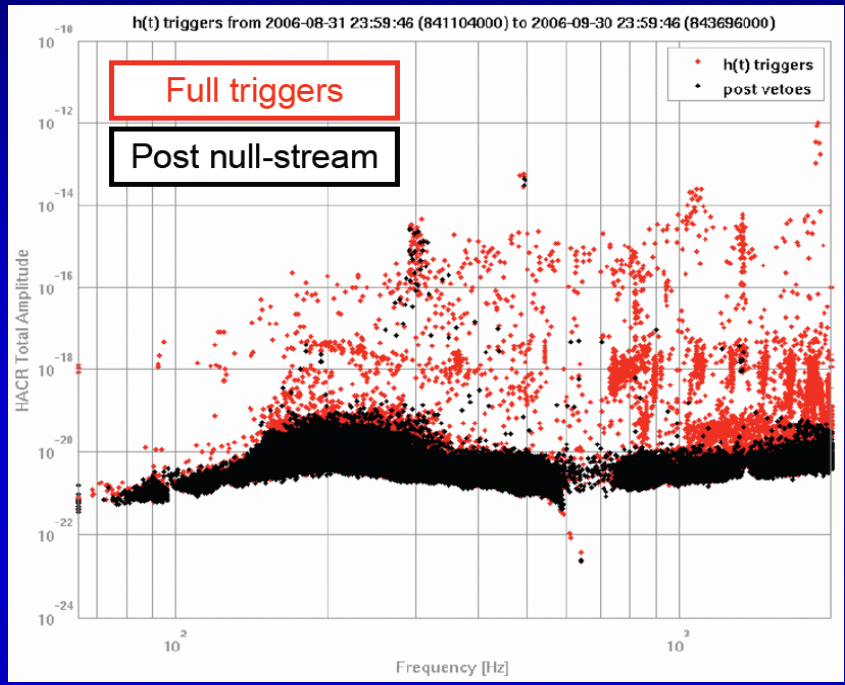


I. Yakushin and S. Klimenko

http://ldas-jobs.ligo-la.caltech.edu/~igor/LV2/lv.html#26

Glitches and vetoes





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

M Hewitson *et al: Using the null-stream of GEO 600 to veto transient events in the detector output, CQG 22 No 22, 4903-4912*

M Hewitson: *Detector and data characterisation at GEO 600, in preparation*

P Ajith *et al: Robust vetoes for gravitational-wave burst triggers using known instrumental couplings, CQG 23 No 20, 5825-5837*

S Hild *et al: A statistical veto employing an amplitude consistency check, submitted to CQG*

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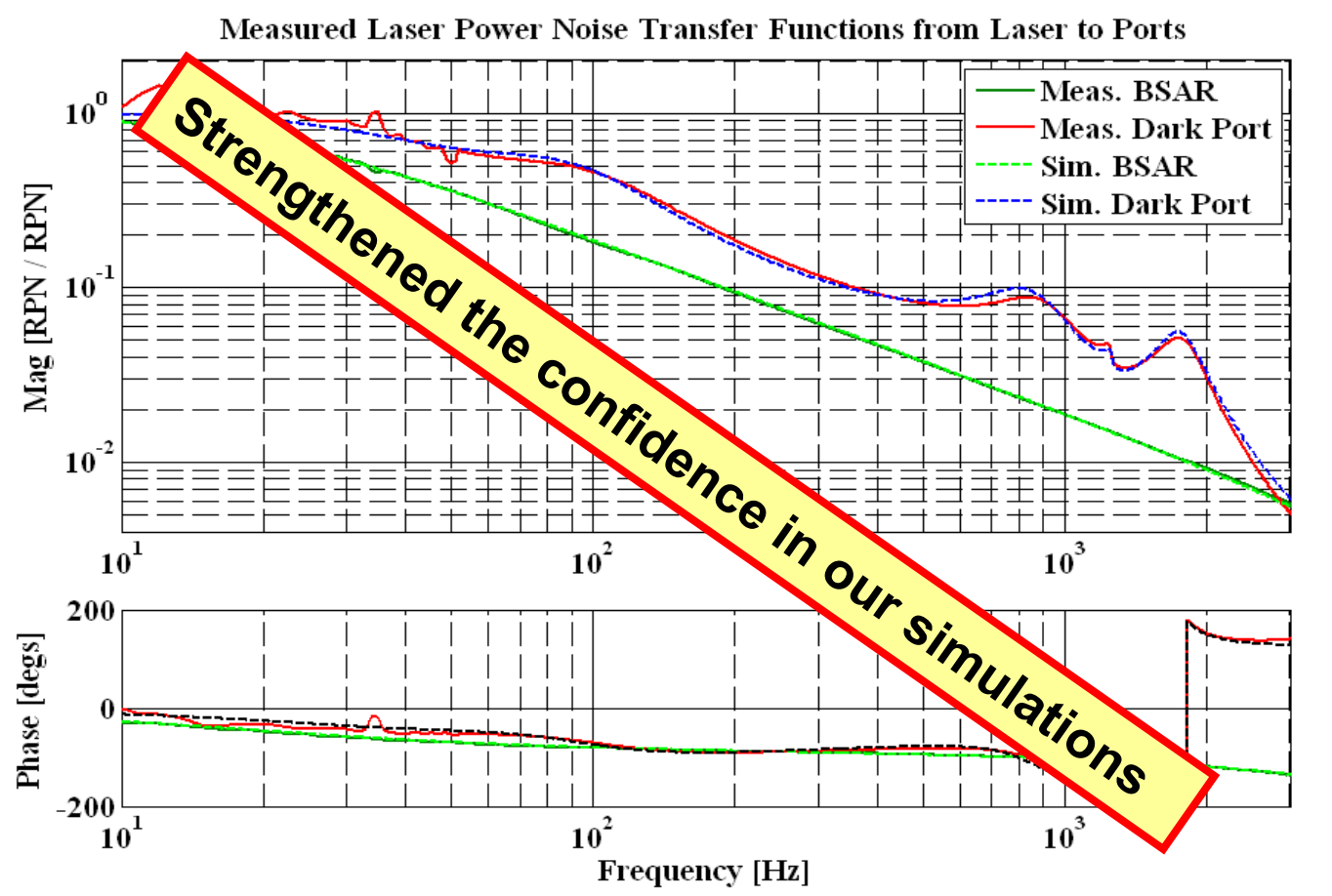
Improved understanding of the detector: Laser power noise coupling

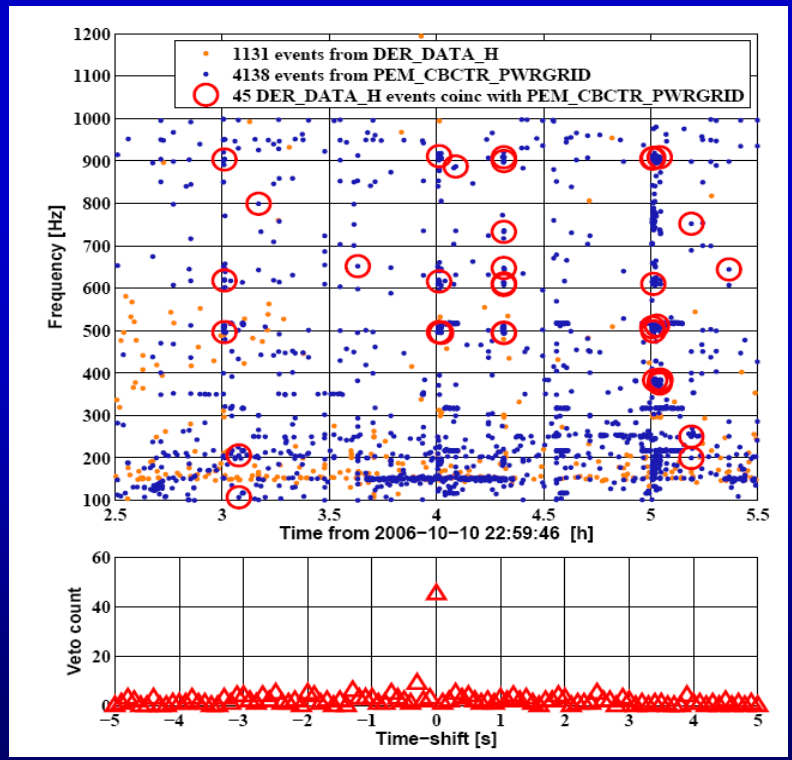
Laser power noise TFs using FINESSE match our measurements.

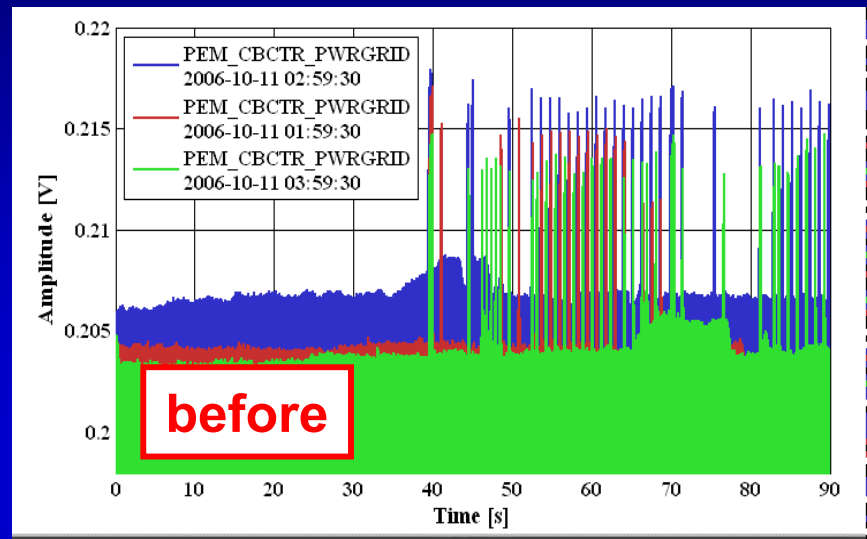


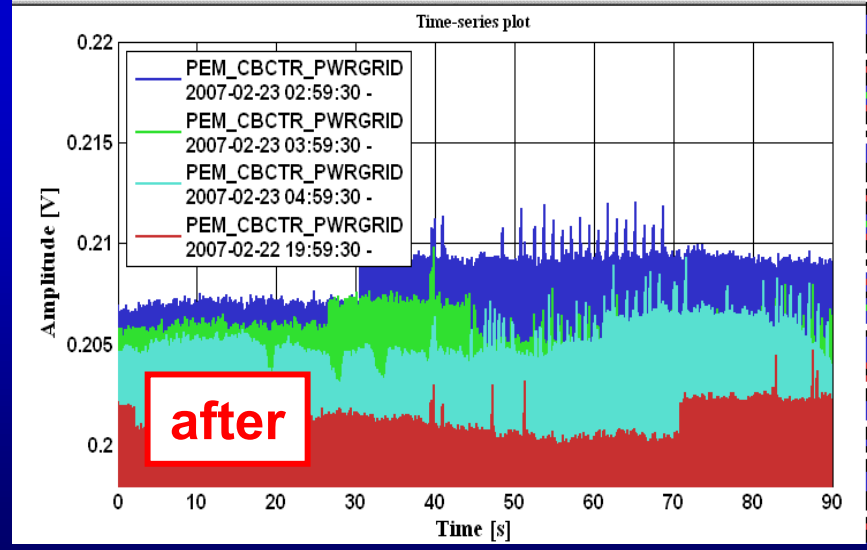
"Laser power noise coupling in GEO600" , JR Smith, A Freise, H Grote, M Hewitson, S Hild, H Lück, KA Strain, B Willke, in preparation

Installation of mains filter

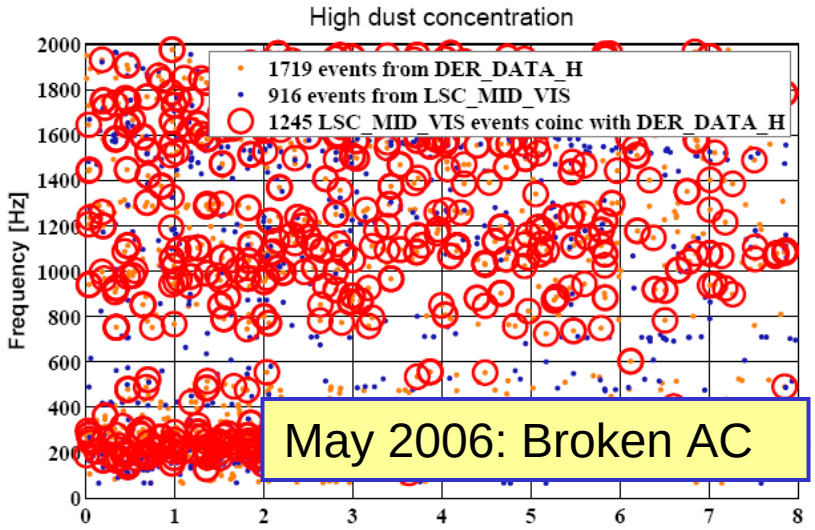
- Found many glitches in GW signal at hour boundary (10 sec after)
- Coincident events in mains monitors
- Control signals created by power companies.
- Solution: Installation of mains filter.

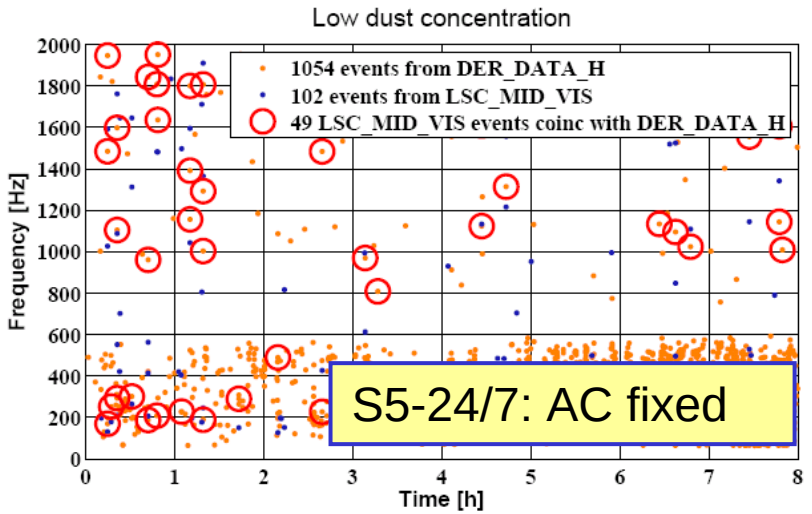






Reduction of particle concentration in the cleanroom

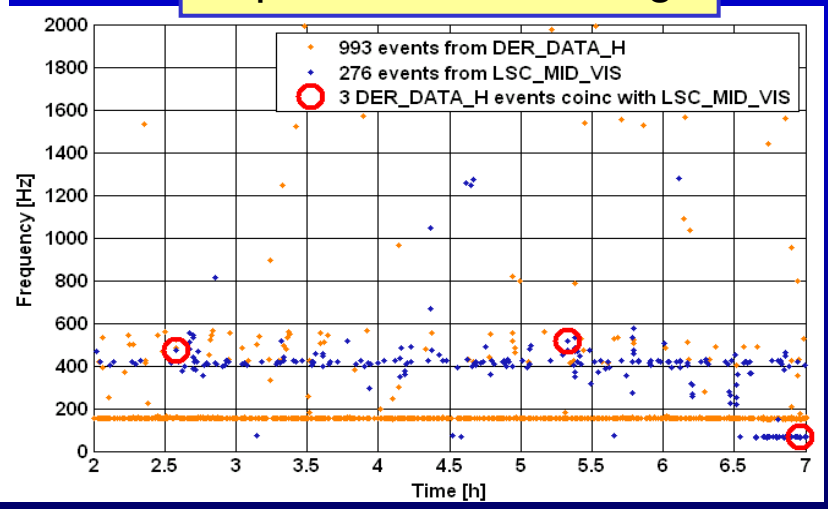




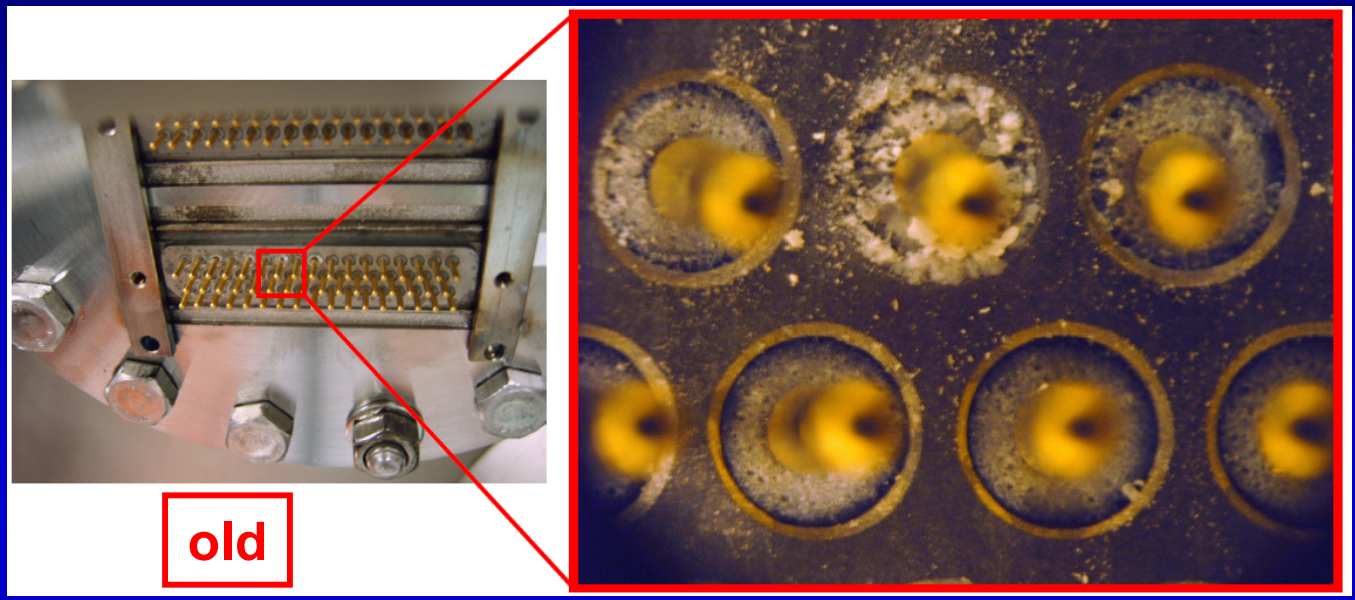
Glitches caused by dust falling through the laser beam in front of main photo diode.

(veto available for dust glitches)

January 2007:
Improved dust filtering



Exchanged HV-feedthroughs

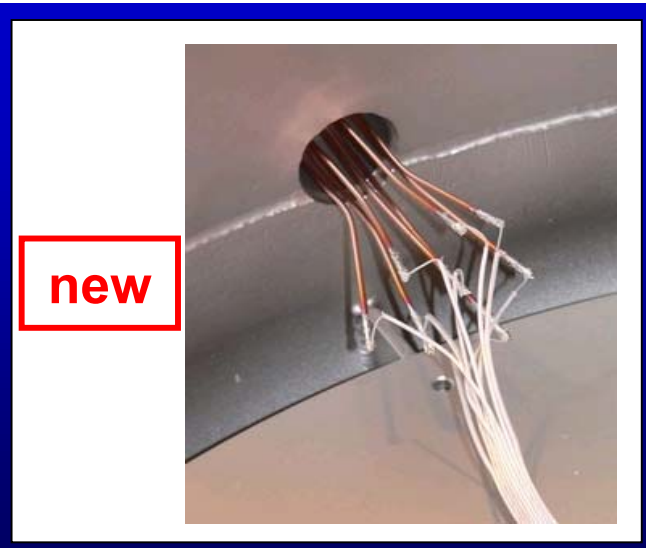


Installation in March 2001

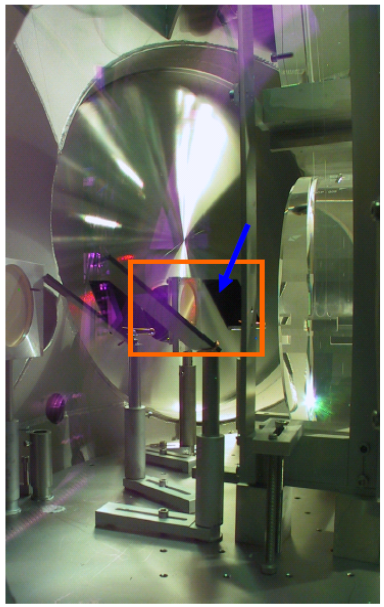
Failed due to corrosion in August 2004

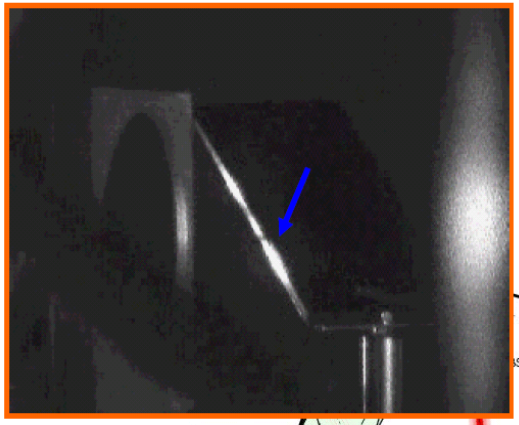
Since then using the spares !!

Replaced in Febuary 2007

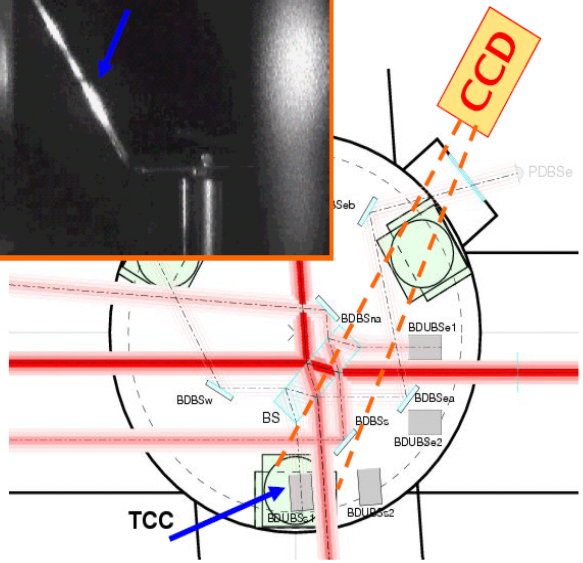


Fixed beam clipping inside Signal-Recycling cavitiy





old



Suspect the beam dump to clip the beam (blue arrows)

new

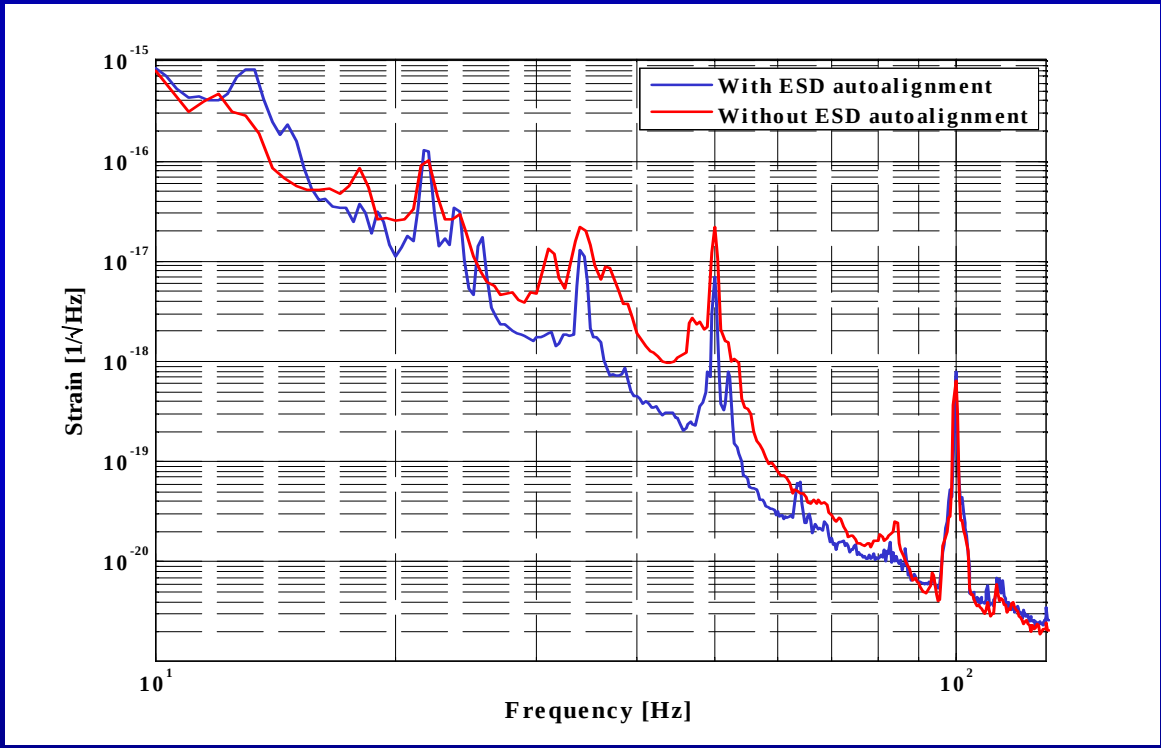
Solution: Beam dump on translation stage

- Piezo actuator
- Range of 28 mm
- Load: up to few 100g

Sensitivity improvement from fast autoalignment using ESD-actuators

Old: Used **coil-magnet actuators** at intermediate masses (UGF = 5 – 8 Hz)

New: In additon also using **electro-static actuators** for fast autoalignment



ESDs give additional phase margin:

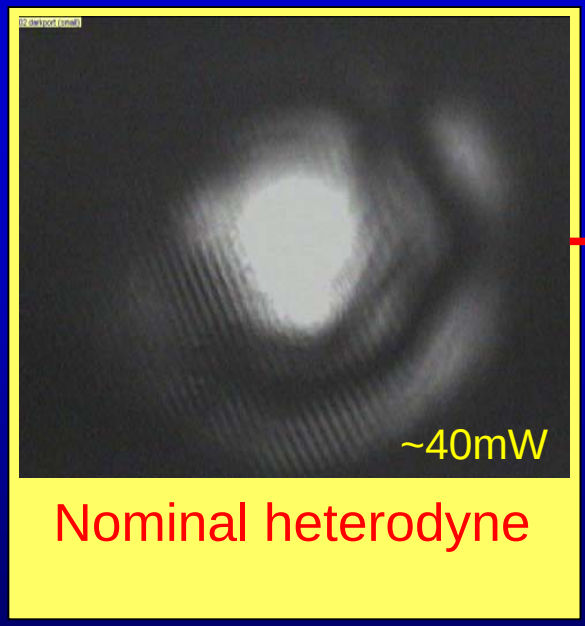
- Increased stability
- Used for steeper filtering (lowpass)

DC-readout without OMC

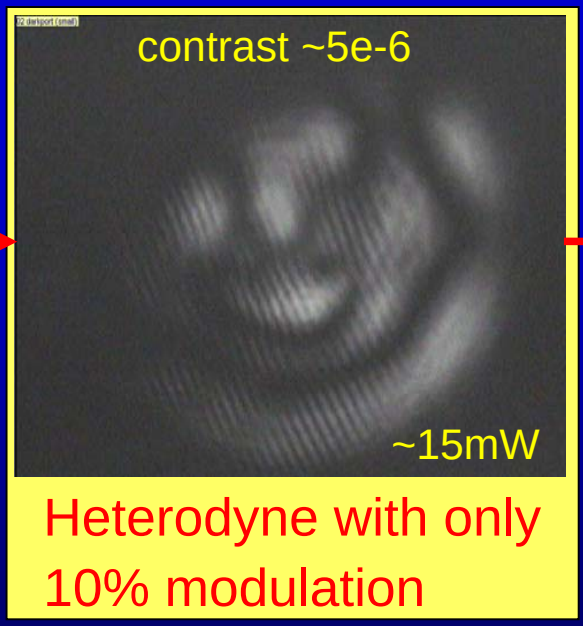
IDEA:

- Turning down the RF-modulation *(factor 10 is possible)*
- Using an offset from dark fringe *(of the order of 20pm)*

$\Rightarrow$ Dark port dominated by carrier light



Nominal heterodyne

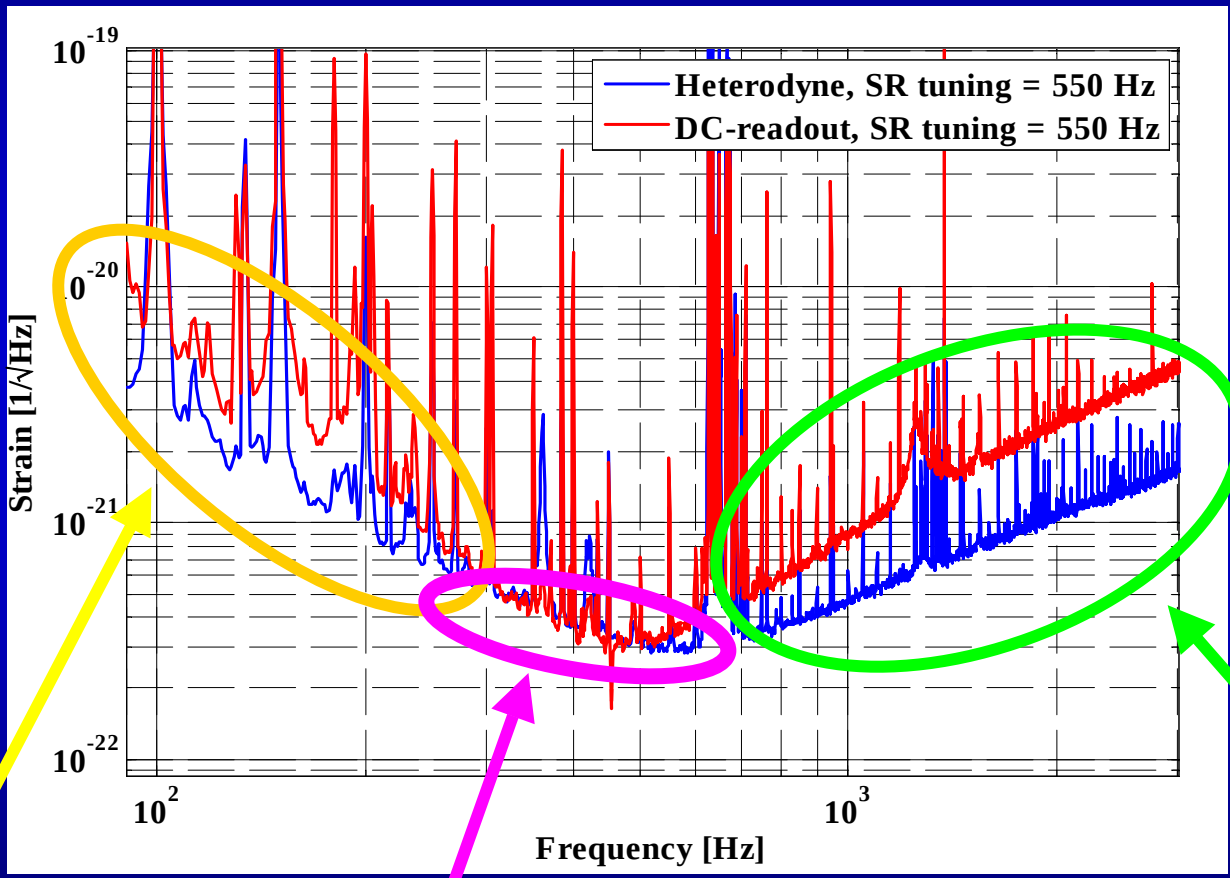


Heterodyne with only 10% modulation

Offset to dark fringe (~ 20pm)

Results from first Experiments with DC-readout (detuned SR)

Stable interferometer with DC-readout and DC-lock

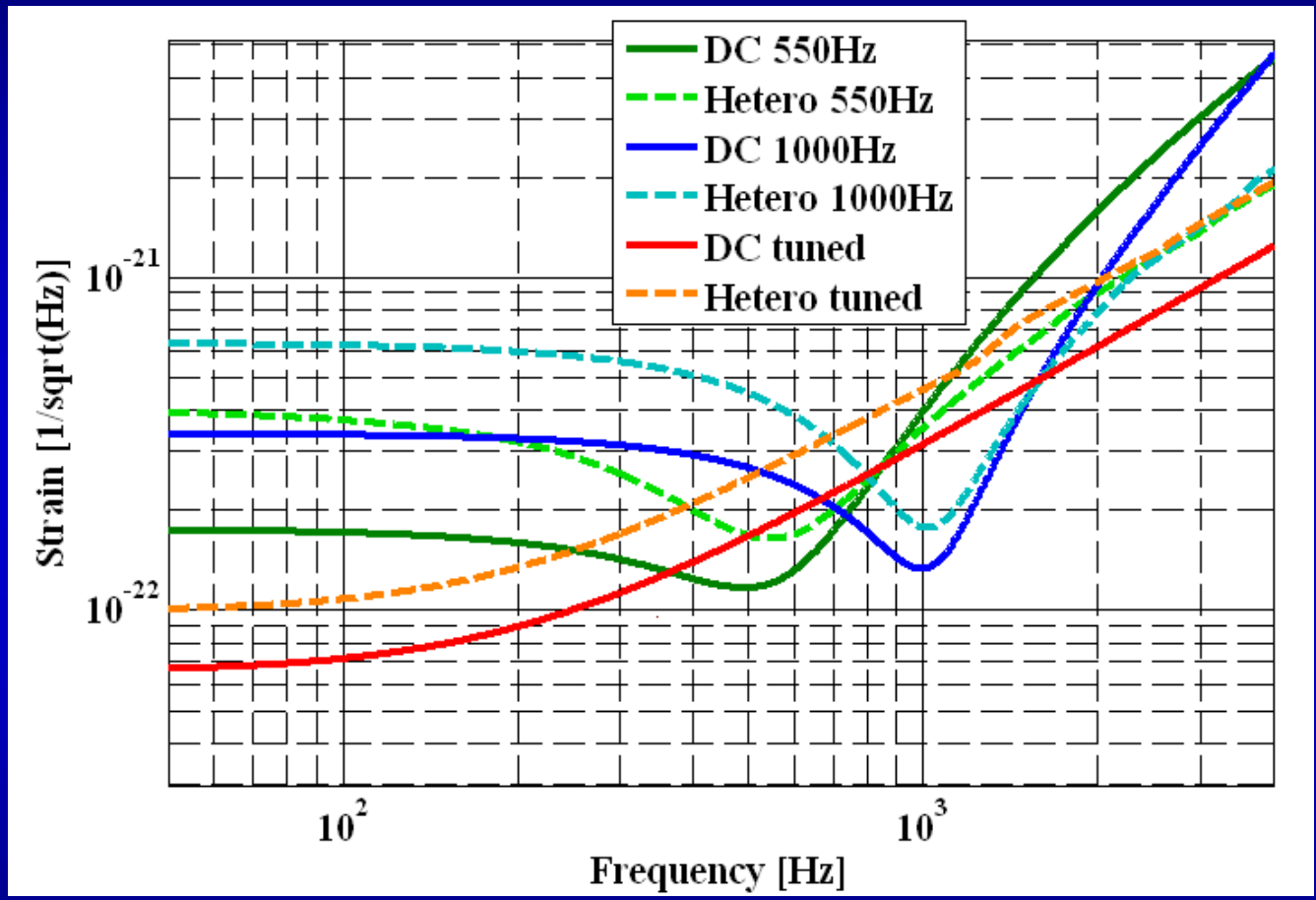


Laser intensity noise

Slightly better than with heterodyne

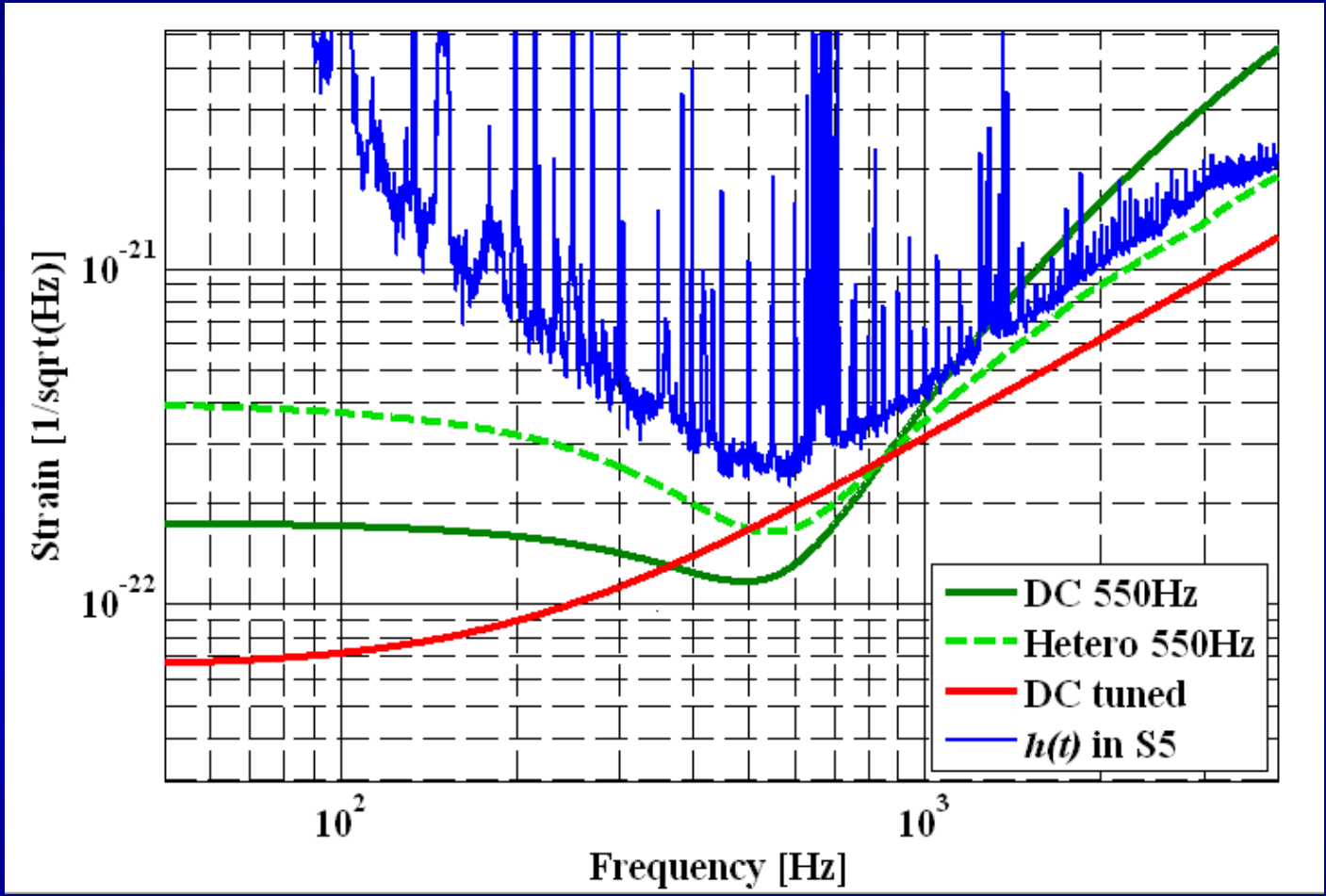
Shot noise
⇒Increased in DC-readout

Simulated shotnoise heterodyne vs DC-readout for various tunings.



- Shot noise in DC-readout smaller than in heterodyne readout
- In detuned Signal-Recycling the shape of the detector response is different for heterodyne and DC-readout

What might be gained from DC-readout



Tuned DC-readout might be a useful precursor for GEO-HF
(option for squeeezed light input => no filter cavity necessary)

Overview

- **The GEO600 detector**
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  - gain understanding of detector
  - improving the detector / reduction of glitches
  - necessary maintenance work
  - ESD autoalignment
  - DC-readout
- **Plans for the future**

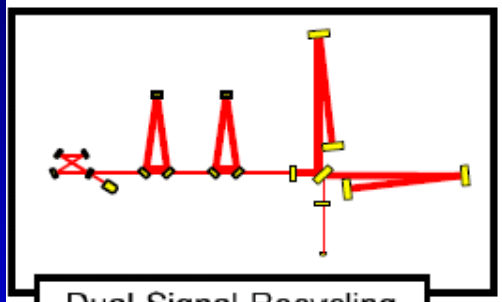
Plans for the near future

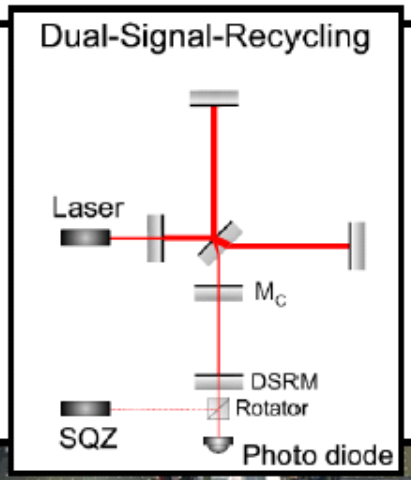
- **Improving sensitivity & detector stability:**
  - Find the optimal detector configuration for 2008:

  - Reduce scattered light (larger viewports in endstations / baffles)
  - Reduction of glitchrate

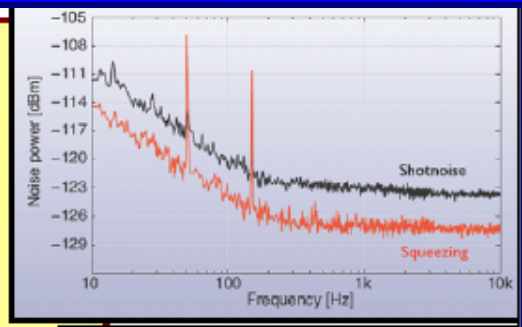
- **Data taking in 2008 to cover the period when LIGO and Virgo are going to upgrade.**

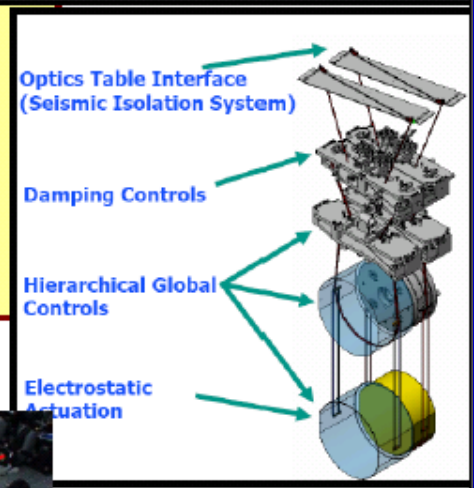
Plans of the GEO collaboration

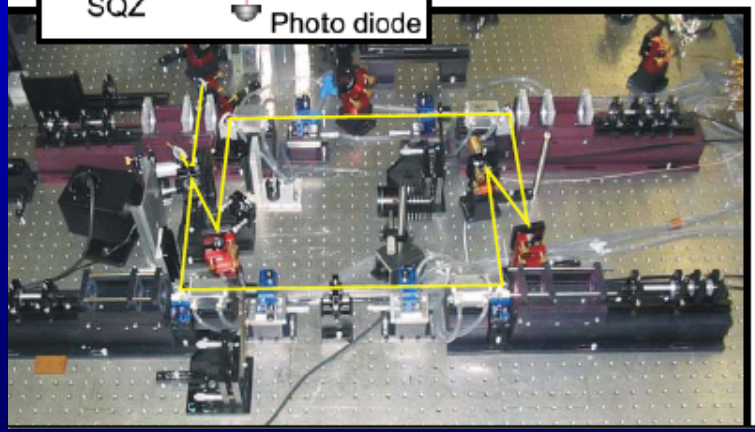


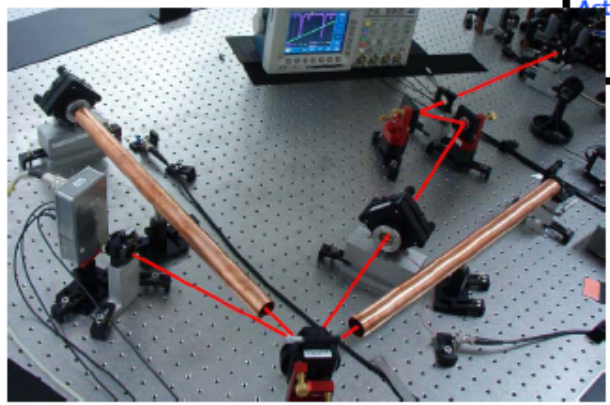


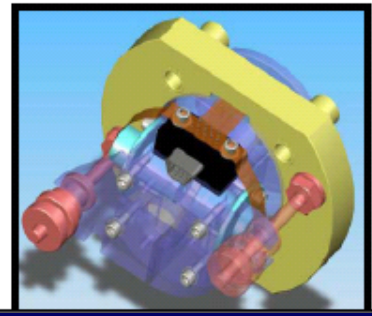
- operate GEO600 / GEO-HF as LSC detector
- LSC data analysis
- laser and suspensions for AdvLIGO (laser for Enh. LIGO)
- contribute to AdvVIRGO design
- R&D and design towards third generation detectors











E N D