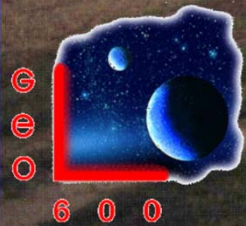


Photo: Jerome Degallaix

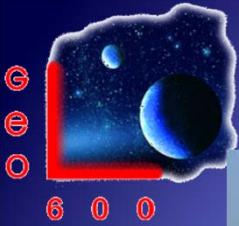


# GEO600 STATUS

Harald Lück for the GEO600 Team  
AEI Hannover



GW2010  
October 2010  
LIGO-G10000987-v1

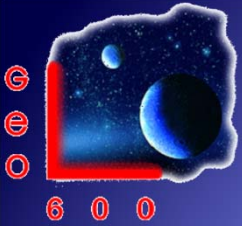


GEO600

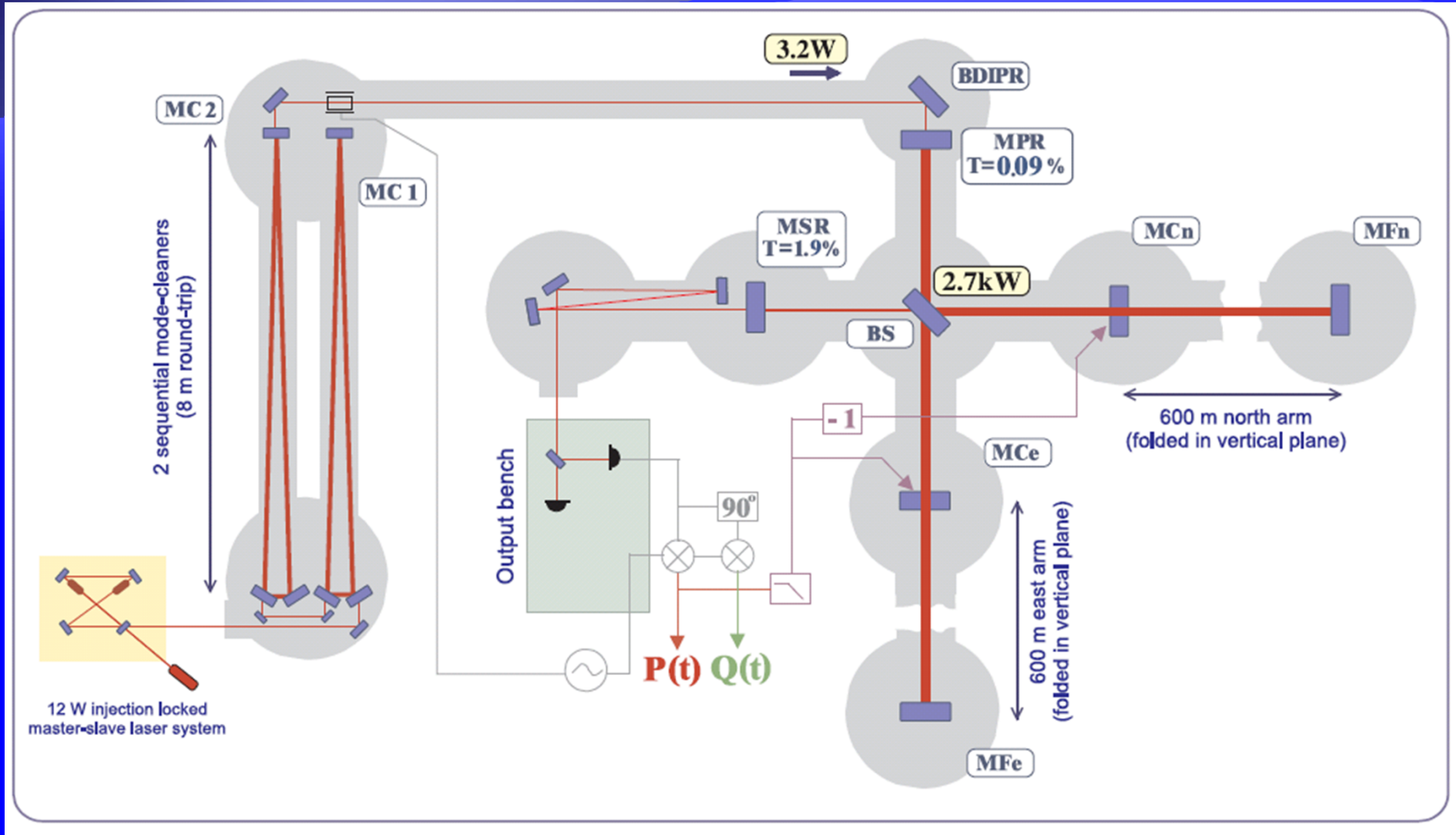
600m DR Michelson

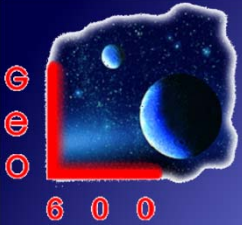
British / German Detector  
18km south of Hannover





# The GEO600 Interferometer

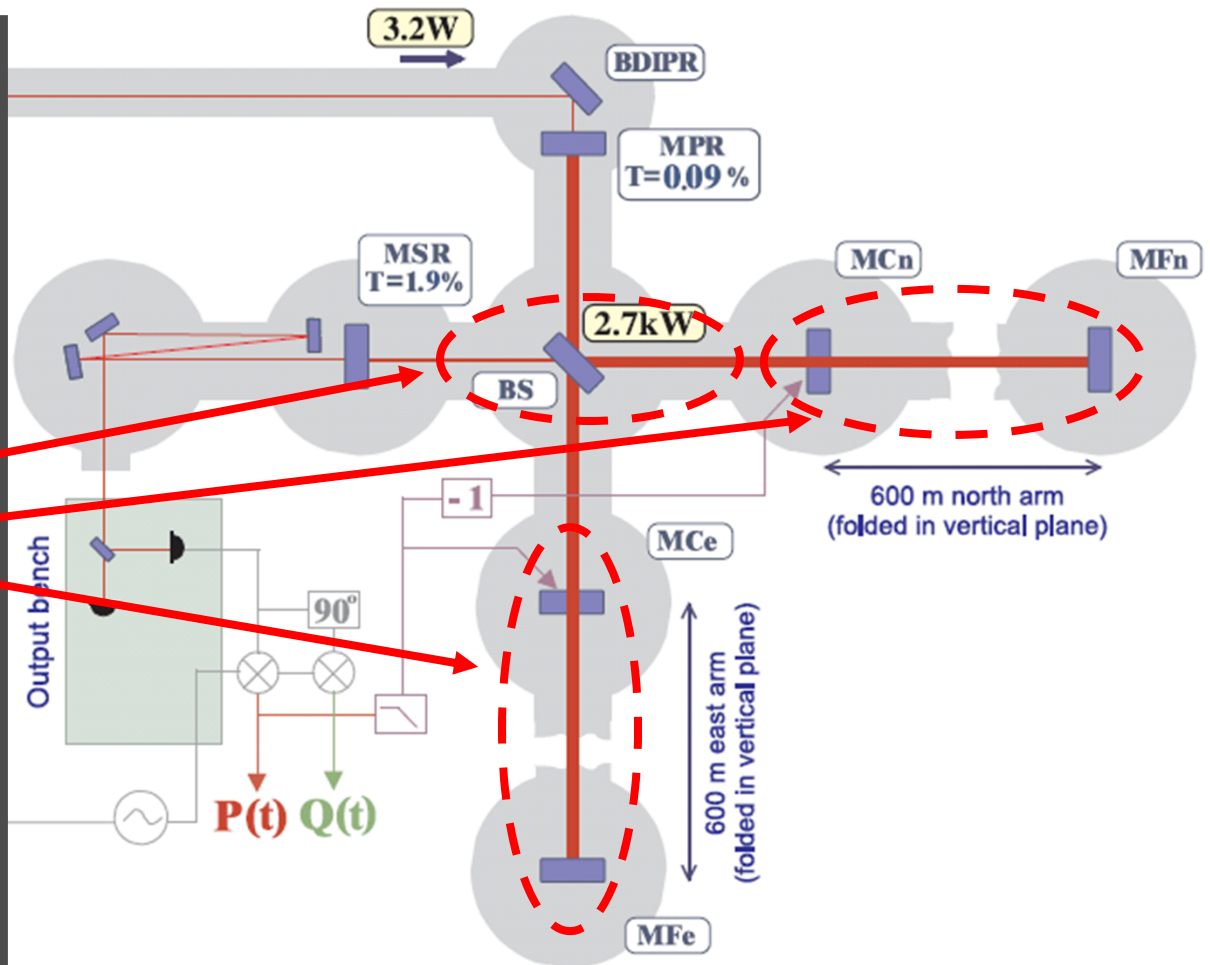
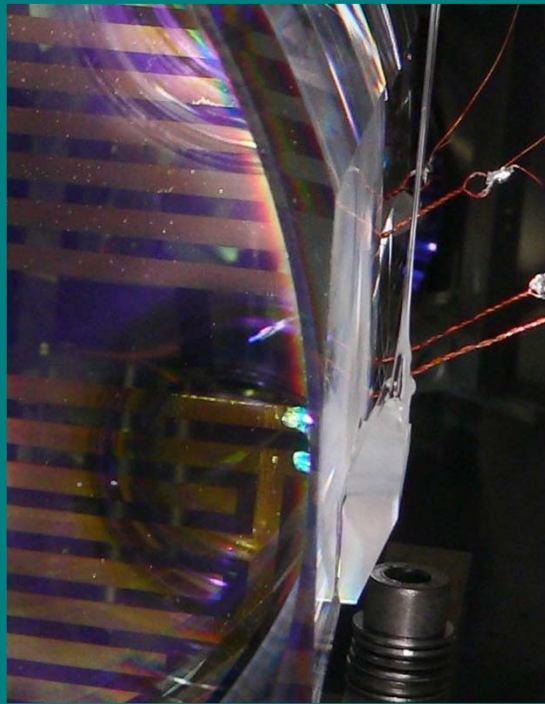




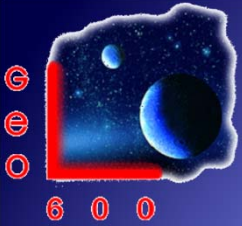
# The GEO600 Interferometer



Triple suspensions with monolithic ultimate stage



Approx. 150 fibre-years on running IFO with ~5 partial ventings

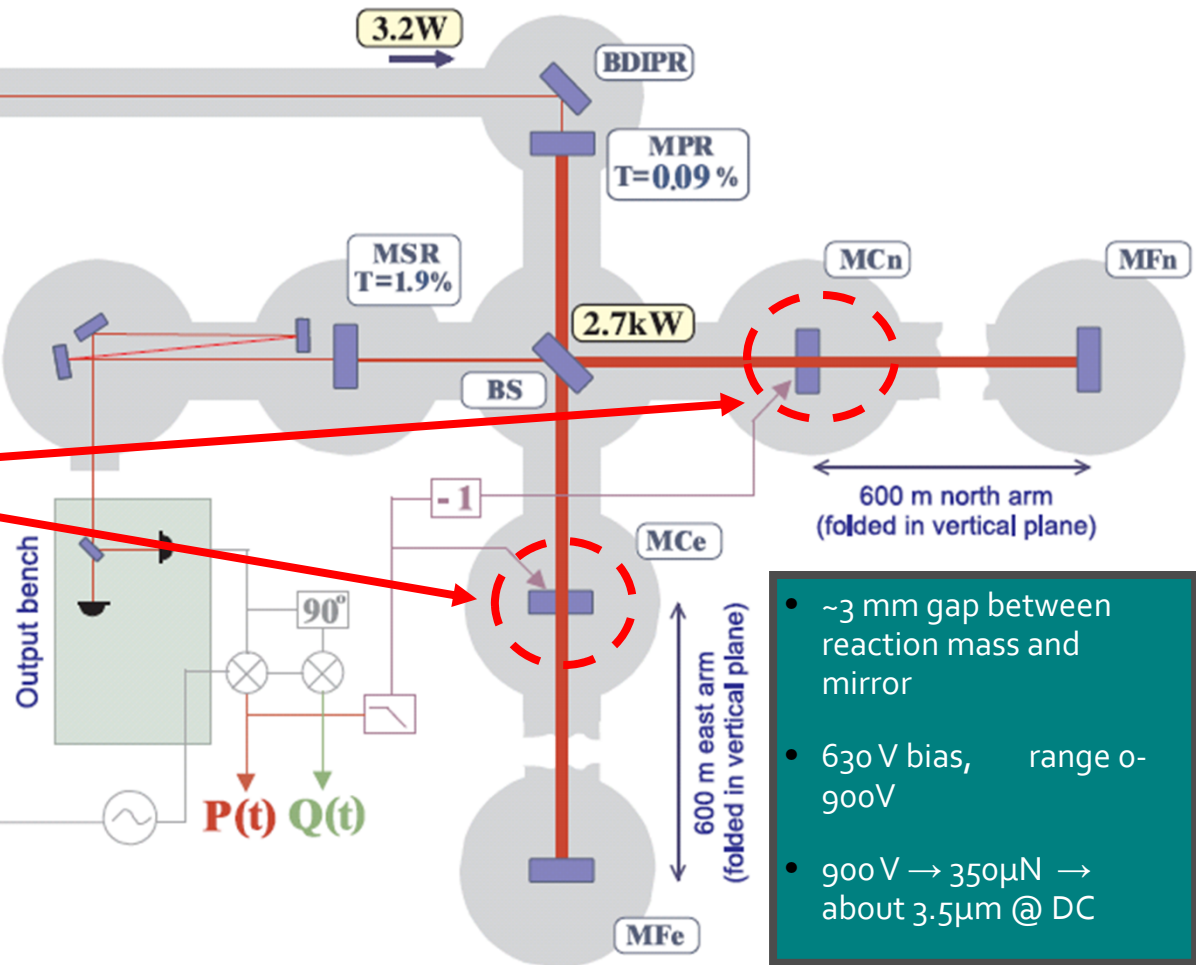
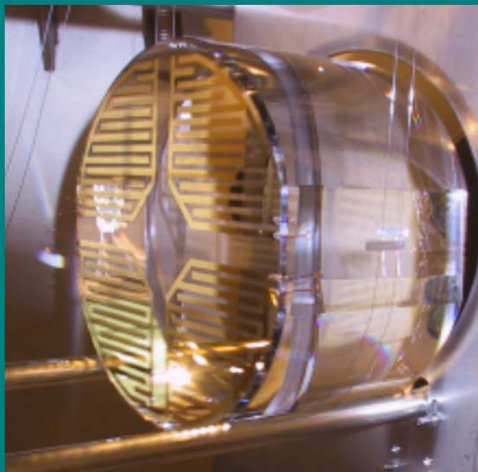


# The GEO600 Interferometer

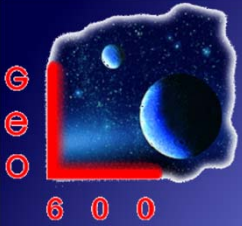


## Electro-Static Drives:

- Used for fast control of diff. arm length



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

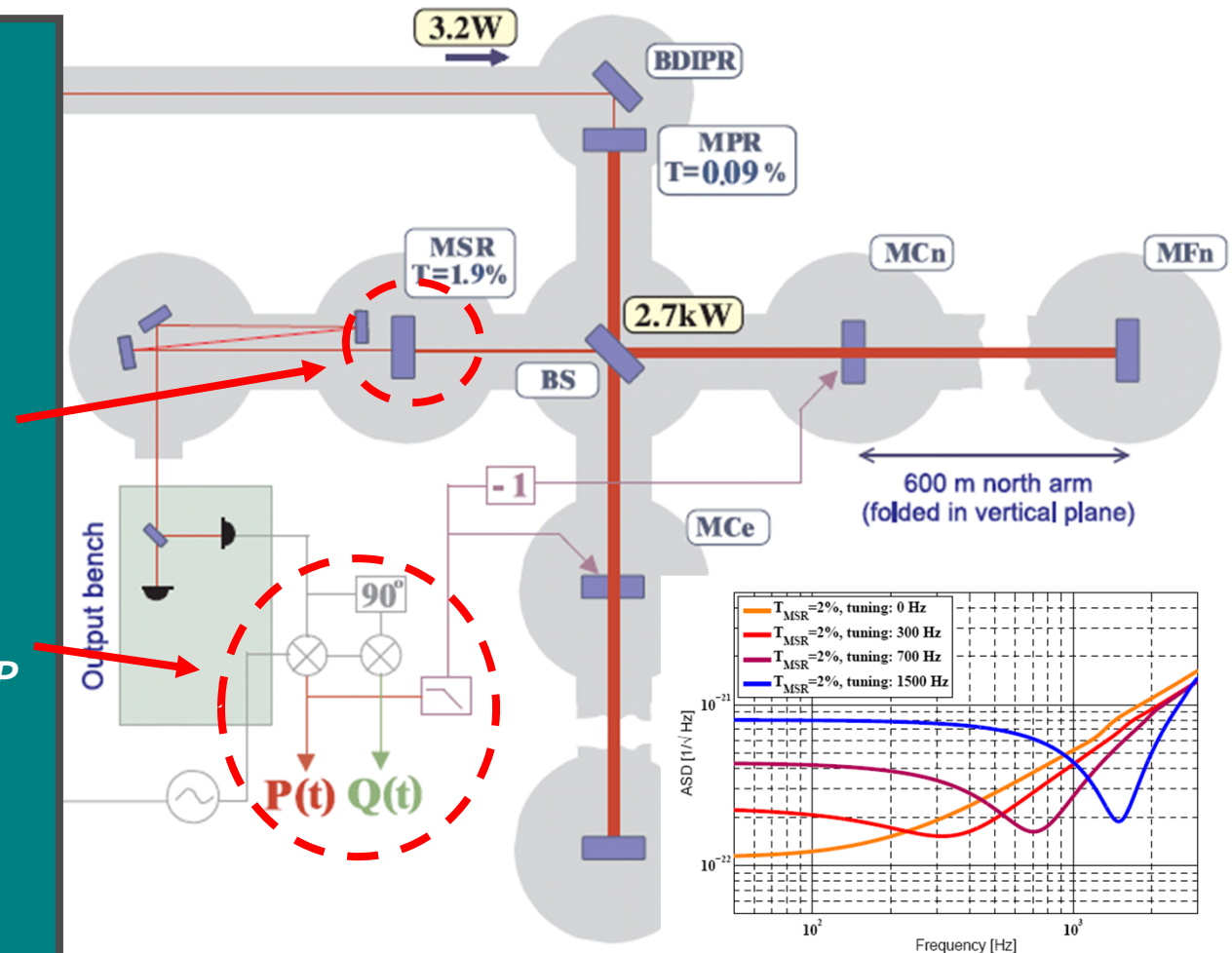


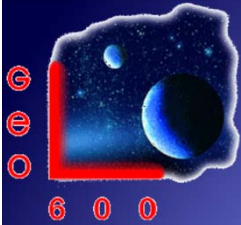
# The GEO600 Interferometer



## Signal-Recycling:

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



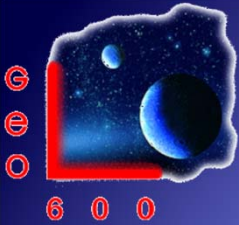


# GEO600 from 2007 to 2010

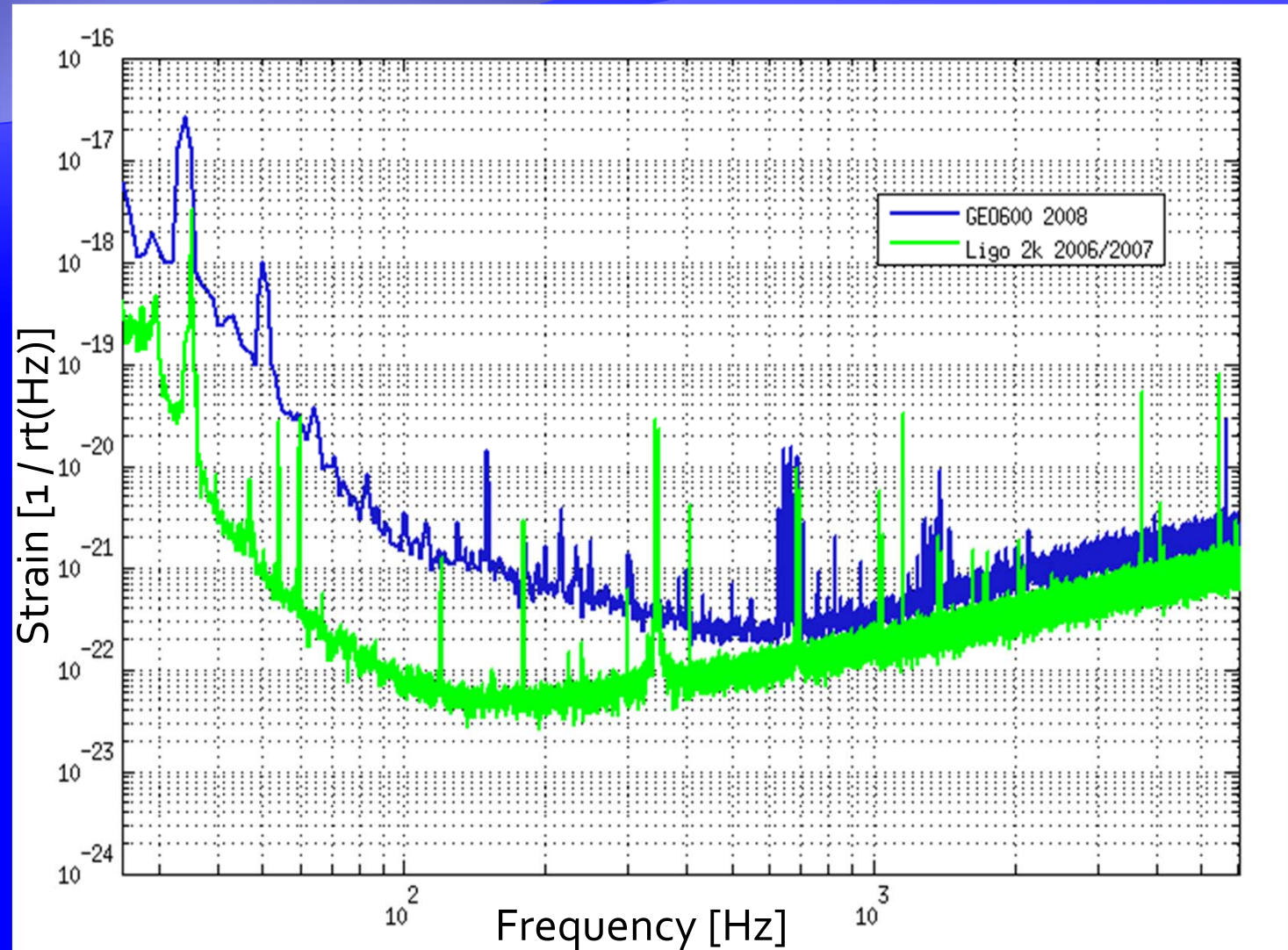


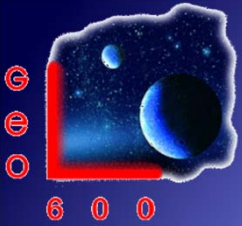
- ◆ Data-taking in *Astrowatch* program  
(Nov. 2007 – July 2009)
- ◆ Parallel to Astrowatch: Noise analysis and preparation of GEO for upgrades
- ◆ July 2009: Start of GEO-HF upgrade program
  - Change of signal rec. configuration and signal readout  
(broadband tuned, DC readout with OMC)
  - Squeezing
  - Laser Power increase  
(thermal compensations needed)



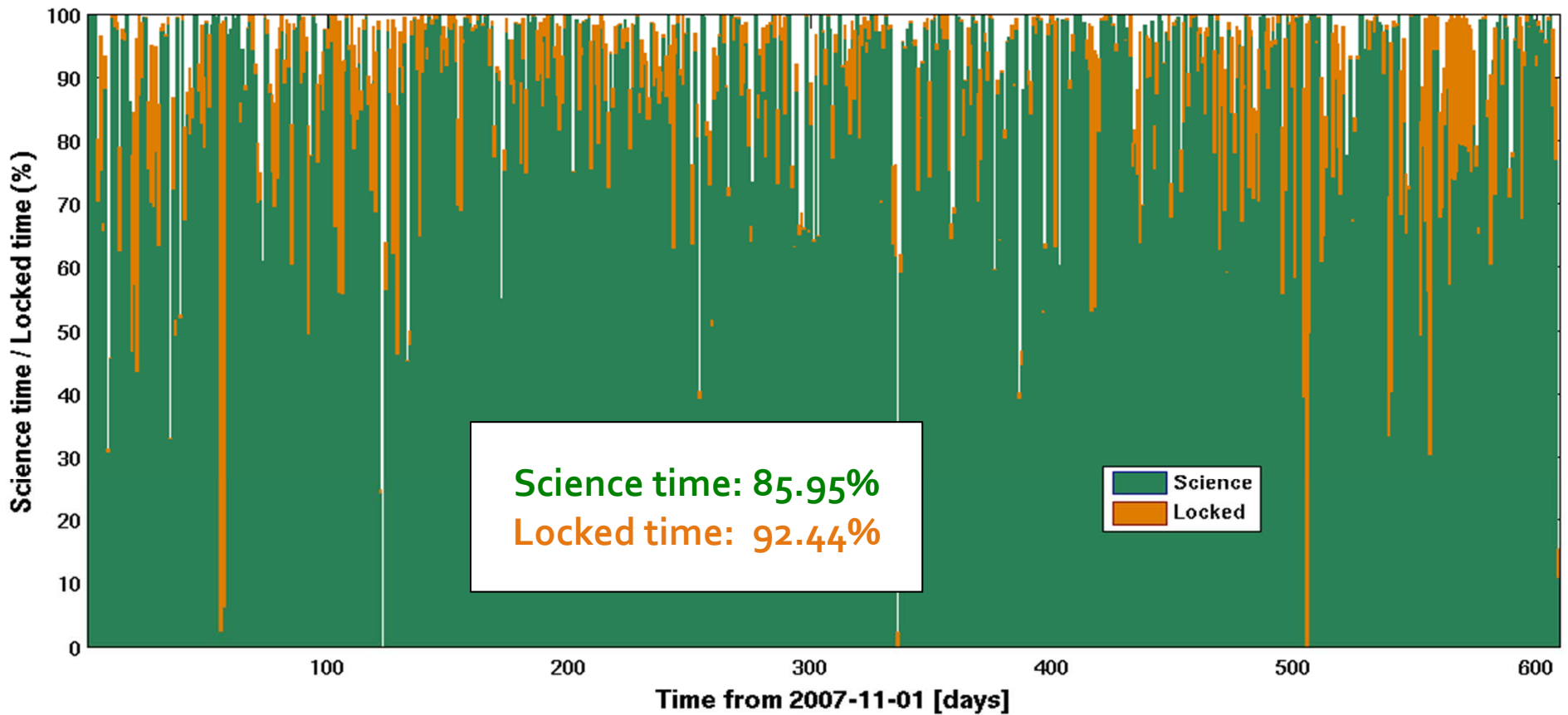


# GEO600 / Ligo H2 in Astrowatch

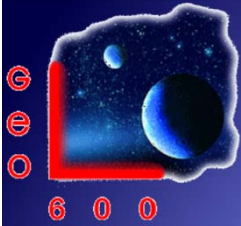




# GEO - Astrowatch Science Time



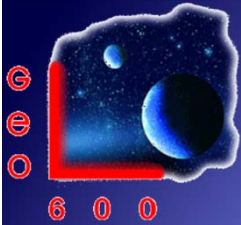
Nov 2007 – July 2009: 522 days of science data collected



# GEO600 from 2007 to 2010



- ◆ Data-taking in *Astrowatch* program  
(Nov. 2007 – July 2009)
- ◆ Parallel to Astrowatch: Noise analysis and preparation of GEO for upgrades
- ◆ July 2009: Start of GEO-HF upgrade program
  - Change of signal rec. configuration and signal readout (broadband tuned, DC readout with OMC)
  - Squeezing
  - Laser Power increase  
(thermal compensations needed)



# GEO-HF Upgrade



## 2009-2011

2009

- Tuned SR & DC readout
- OMC
- Adv. Ligo CDS system for SQZ, OMC, GEOcontrols

2010

- Squeezing
- SR Bandwidth Increase
- Circulating light power increase

2011

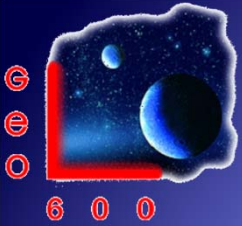
- modulation drives for suspension, thermal compensation for BS, 30W main laser, IMC mirror change, ...

2009

### Data taking

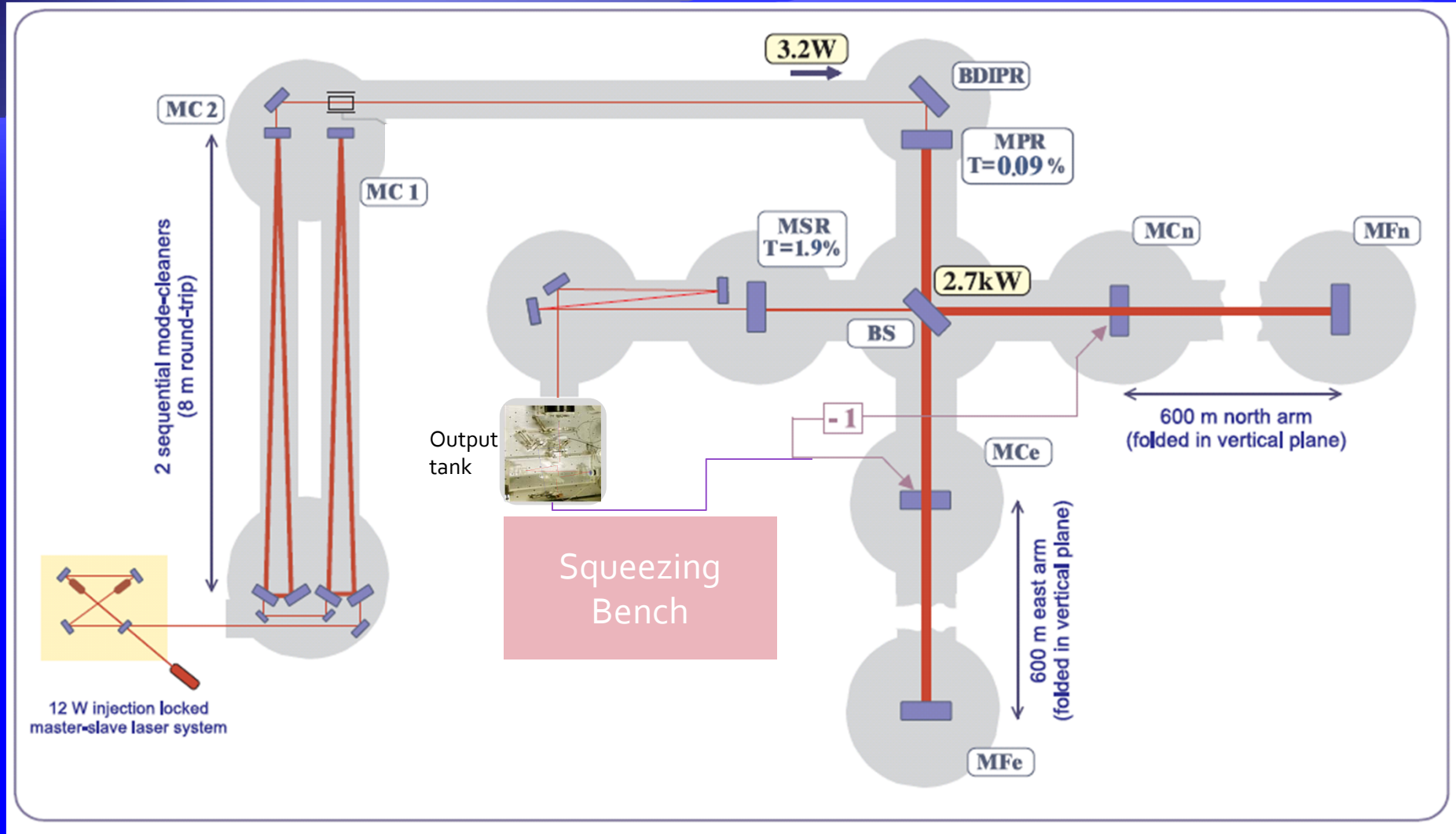
Night/weekend mode: already happening, and continuing  
Longer periods as GEO-HF progresses

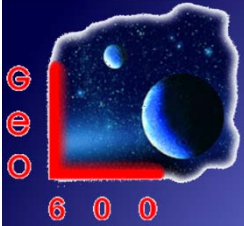
2015



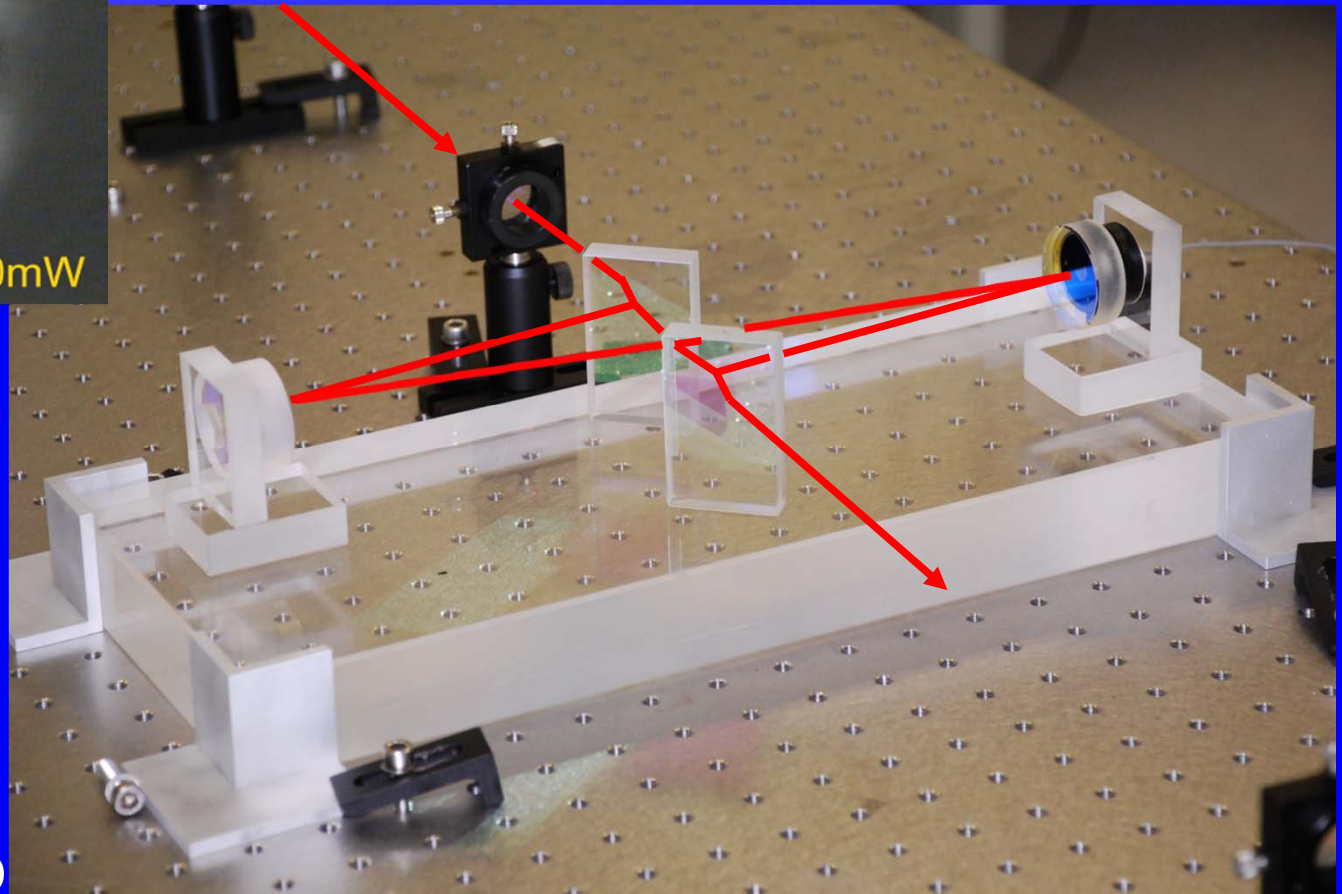
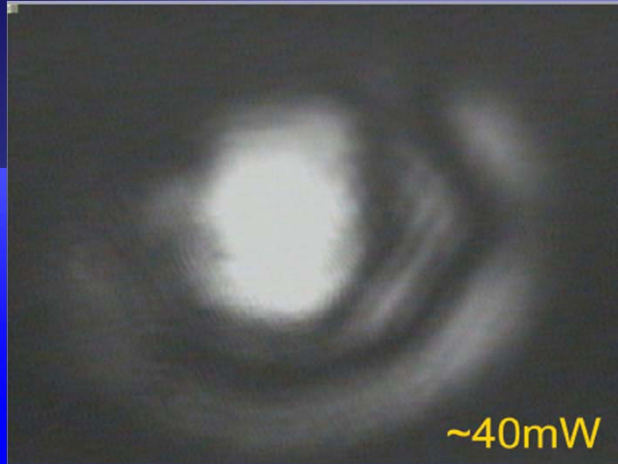
# The GEO600 Interferometer

## changed output section

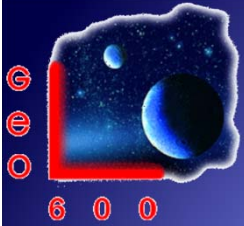




# GEO – Output Mode Cleaner

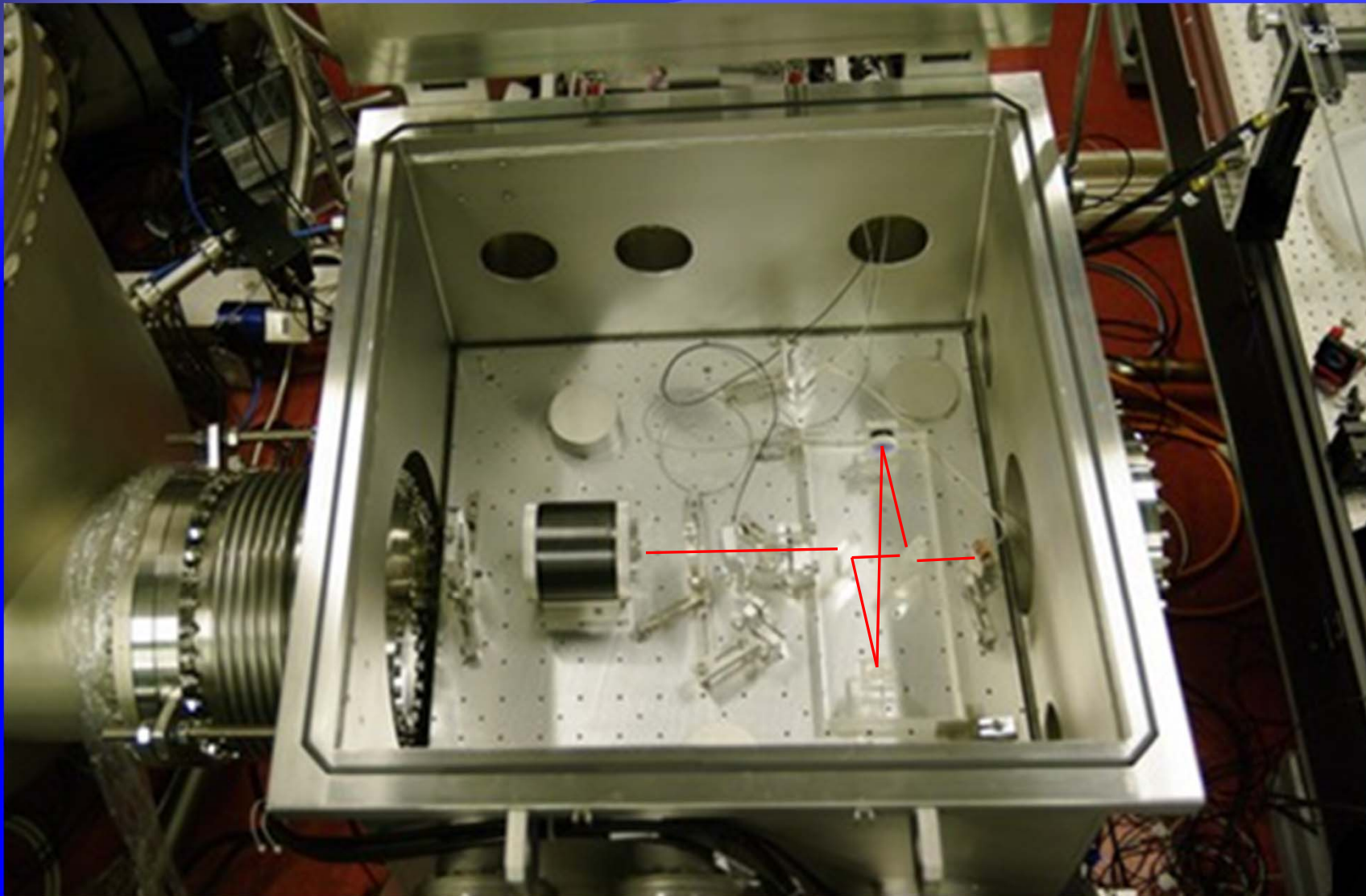


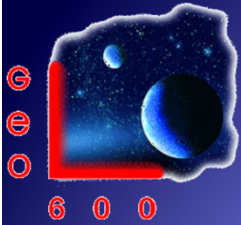
- ◆ Finesse 150
- ◆ Rejection of HOM and RF SBs power  $> 100$



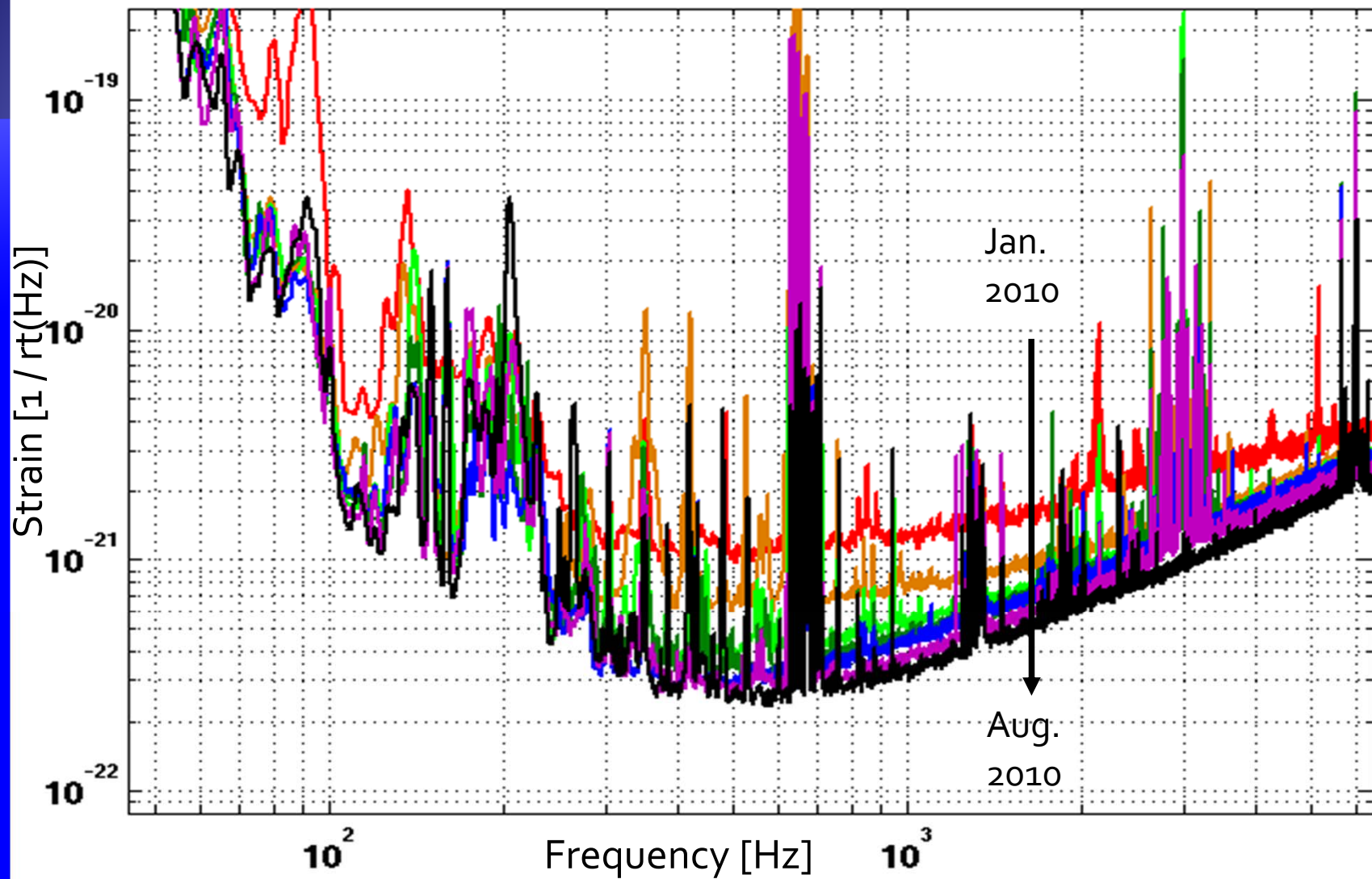
# OMC in new Vacuum Vessel

## In vacuum DC photodiode

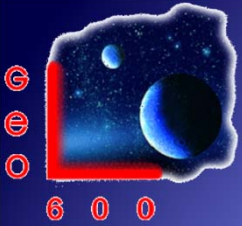




# Progress with Tuned SR, DC & OMC



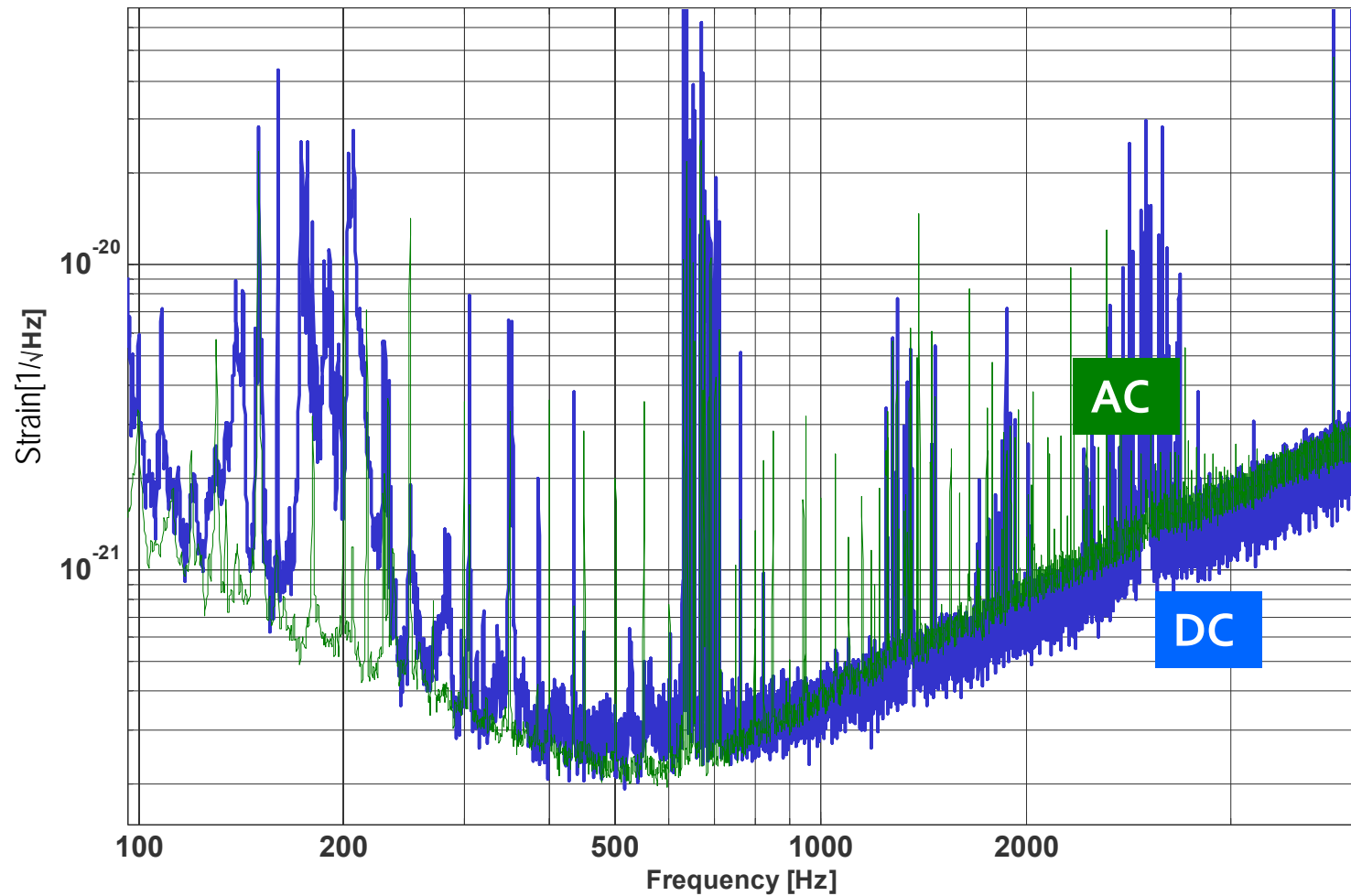


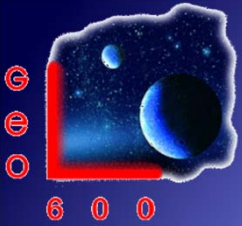


# From AC to DC read-out



Spectrum plot using Kaiser window

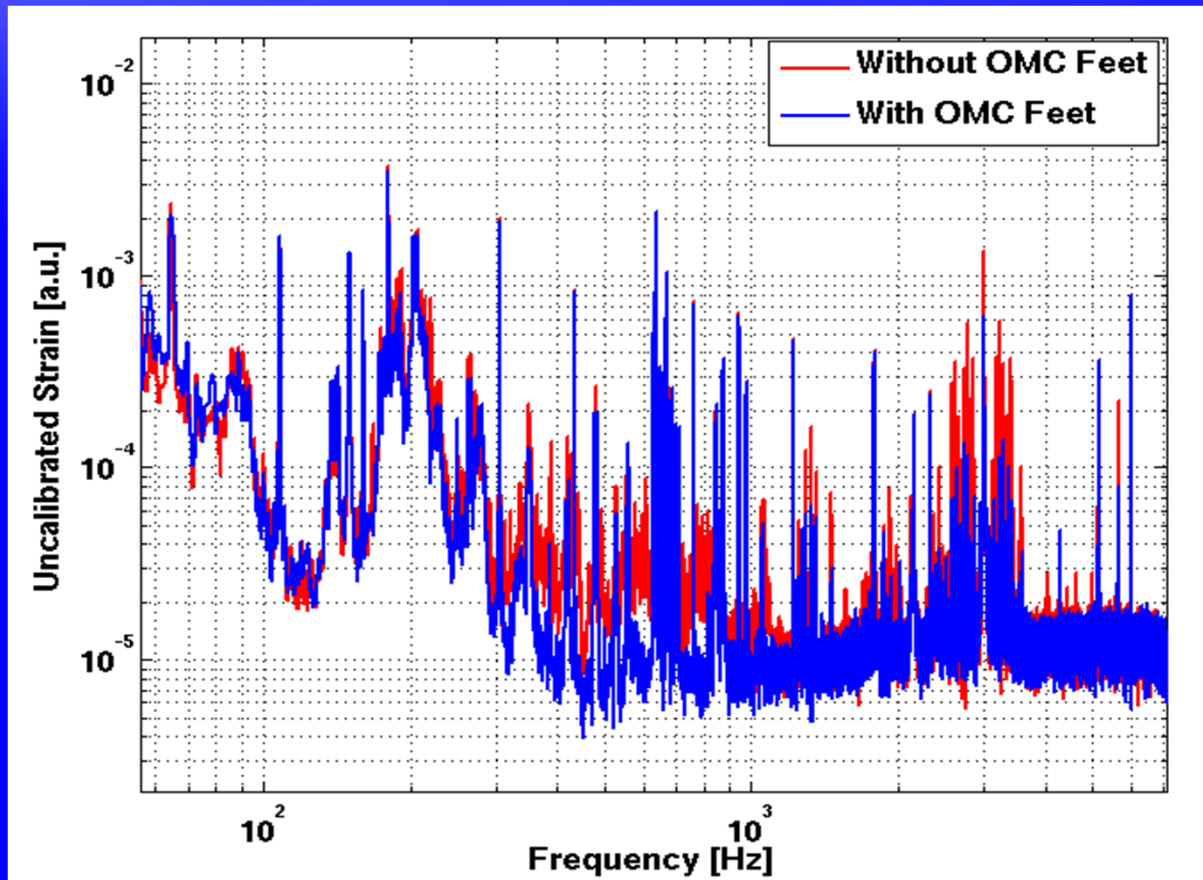




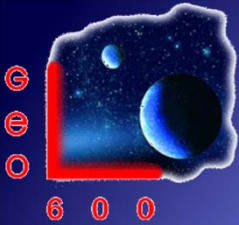
# Acoustic Noise Coupling



- ◆ Fully automated lock acquisition
- ◆ Auto-alignment for 4 degrees of freedom
- ◆ Improved seismic isolation of OMC
- ◆ Will add another stage



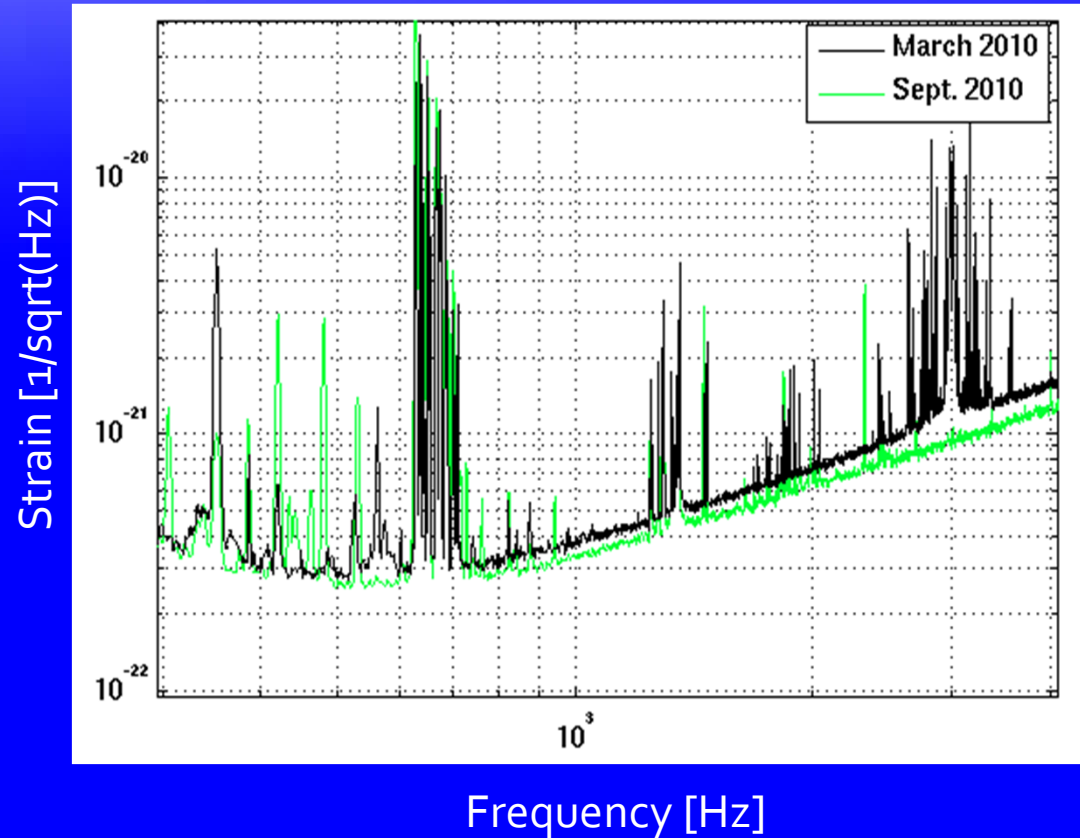
Broadband Acoustic Noise Injection

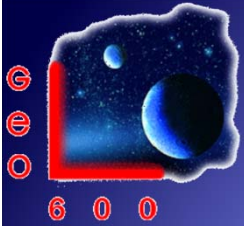


# Some HF-Sensitivity Increase

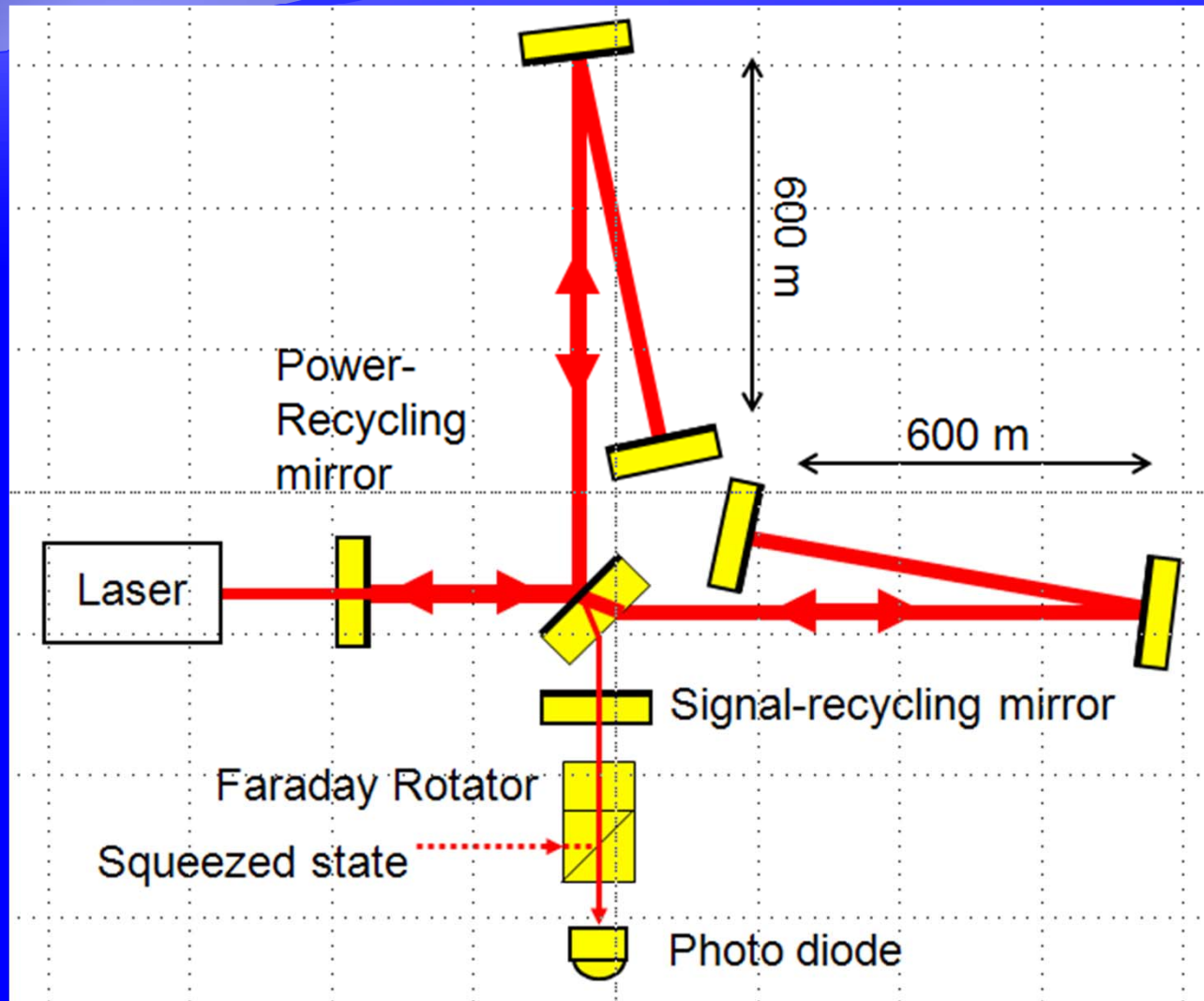


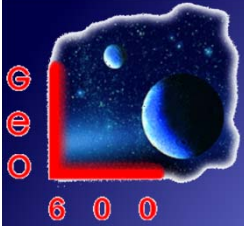
- ◆ Improved OMC Mode matching: **5%**  
(now ~95% for modulation sidebands)
- ◆ PD change: **4%**  
(8% higher QE than PE C30642)
- ◆ Lowered PD readout-noise: **8+3%** (now factor 8 below shot noise)
- ◆ Acoustic noise coupling to OMC reduced





# Schematics of injecting squeezed vacuum

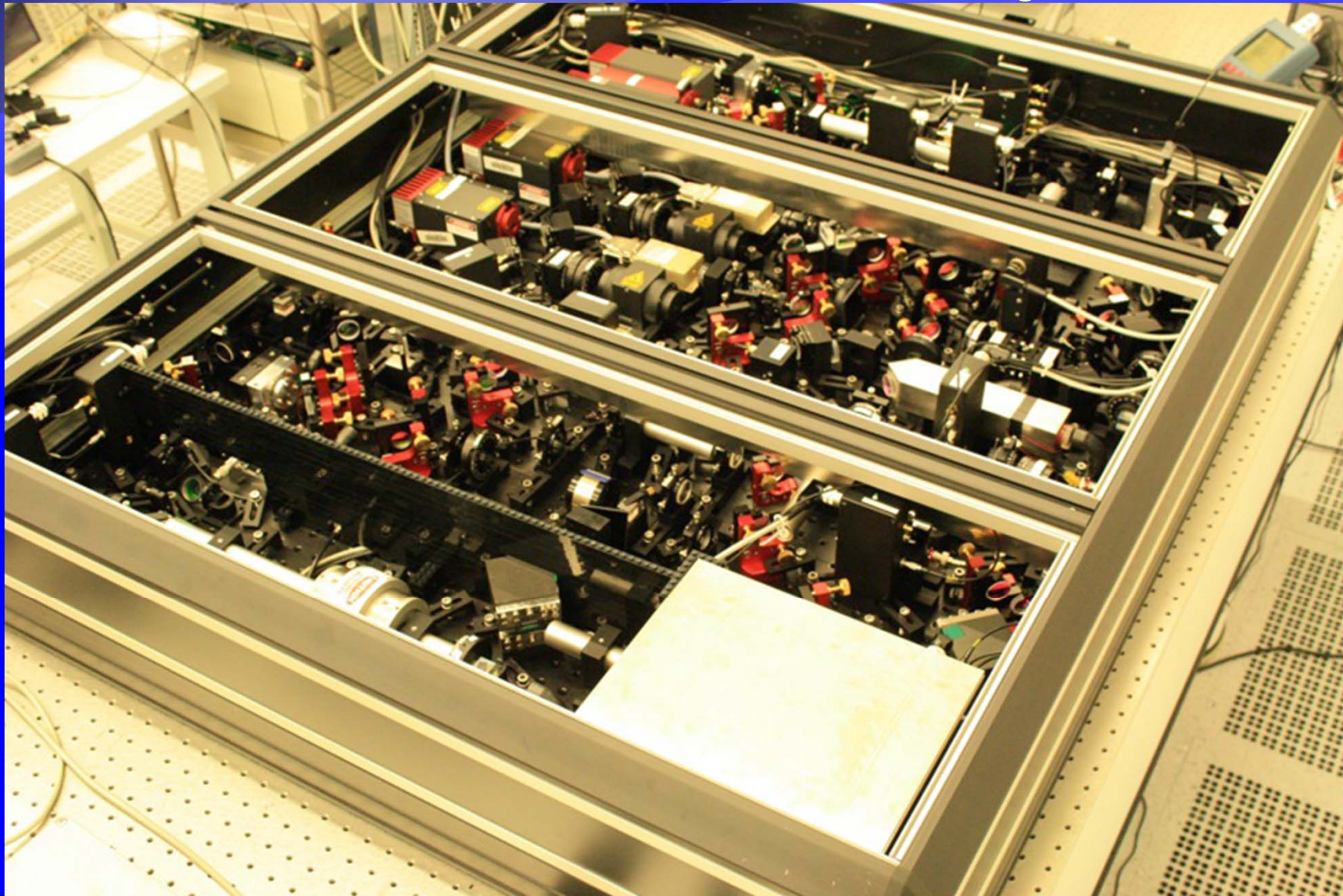




# The Squeezing breadboard

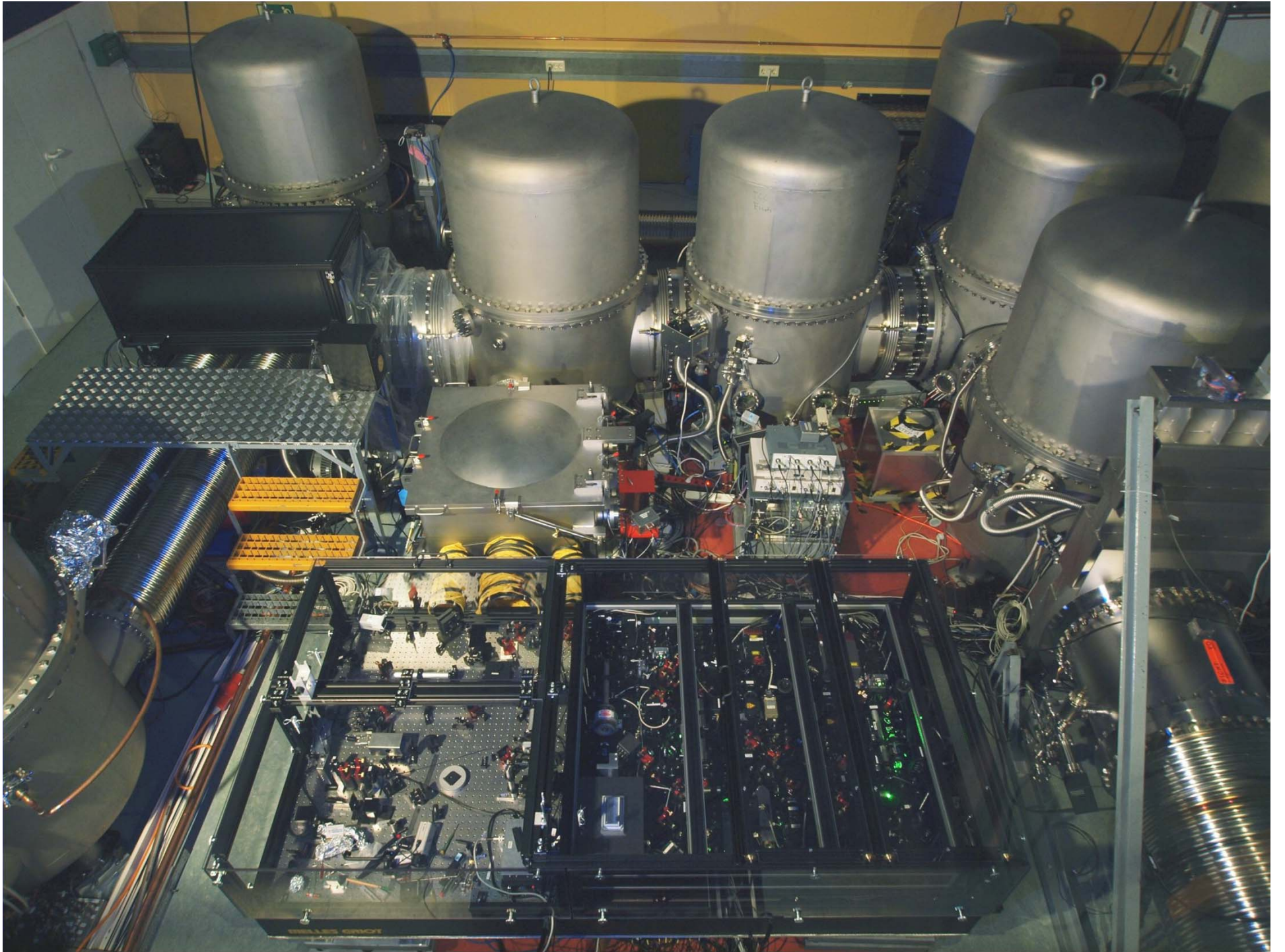


Custom made breadboard: 1,35m x 1,15m, 120kg

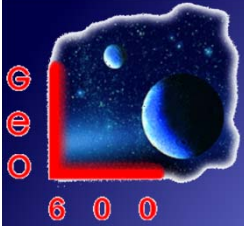




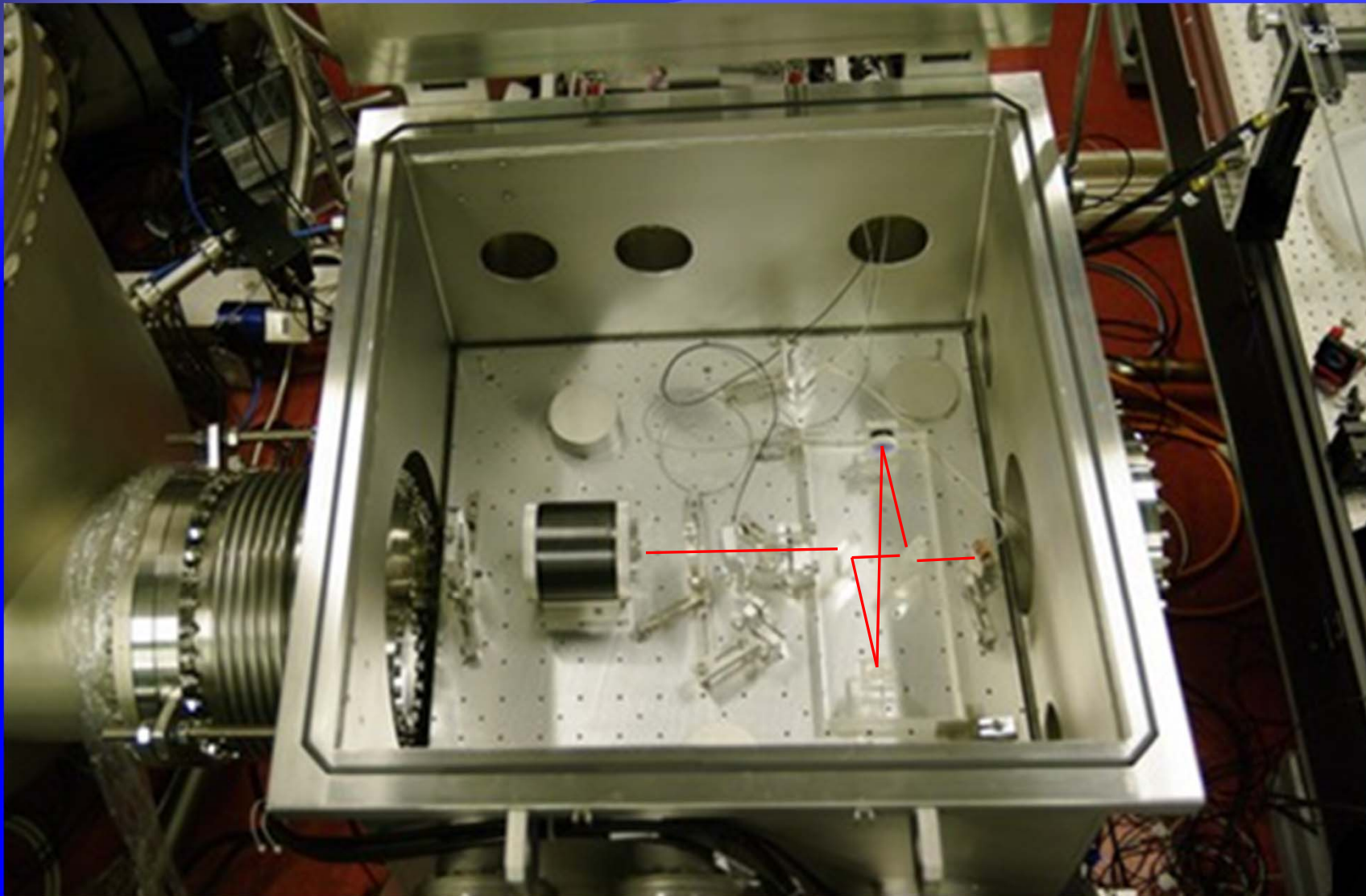


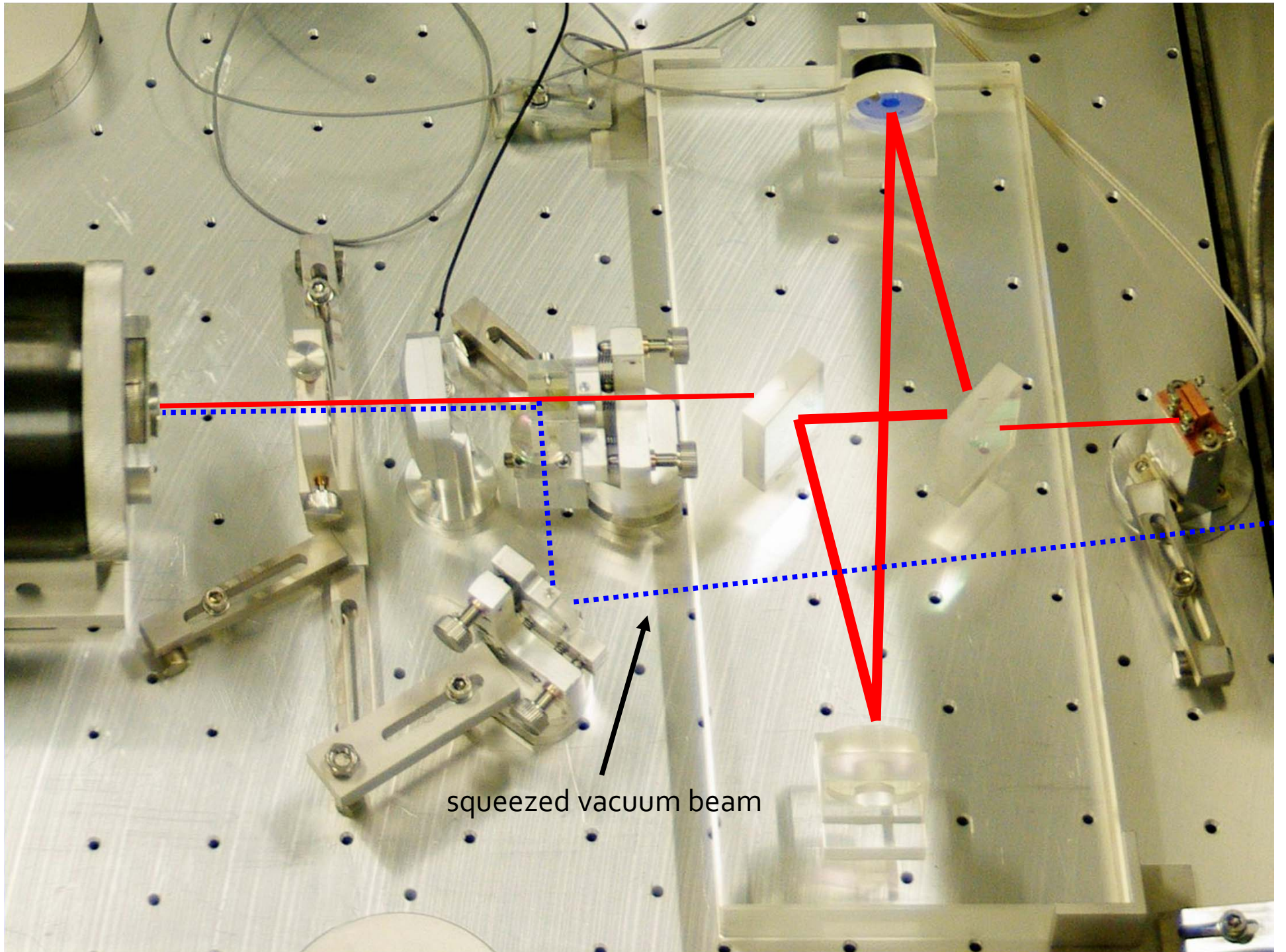






# Squeezing injection



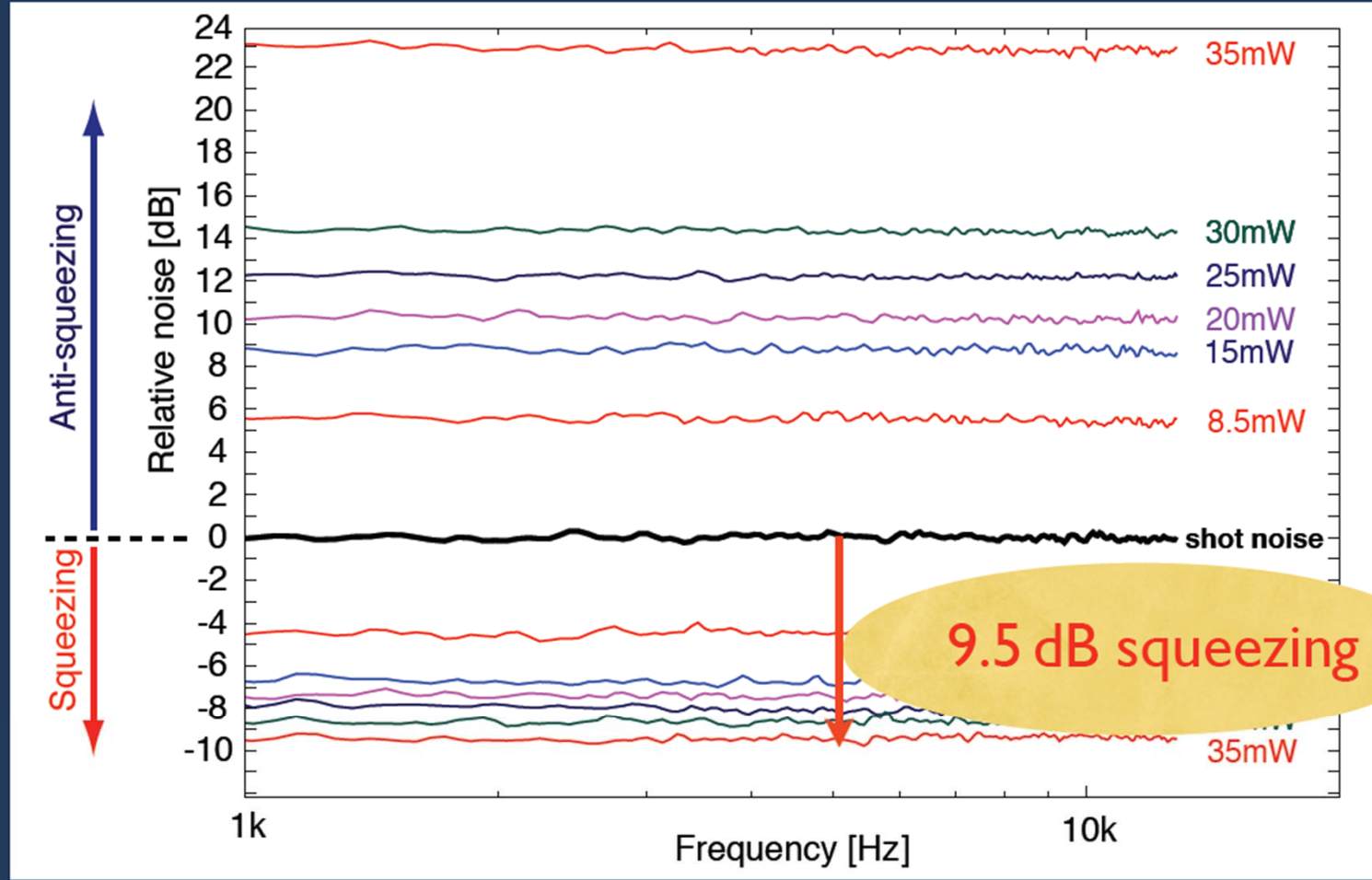


squeezed vacuum beam



# Lots of squeezing input available

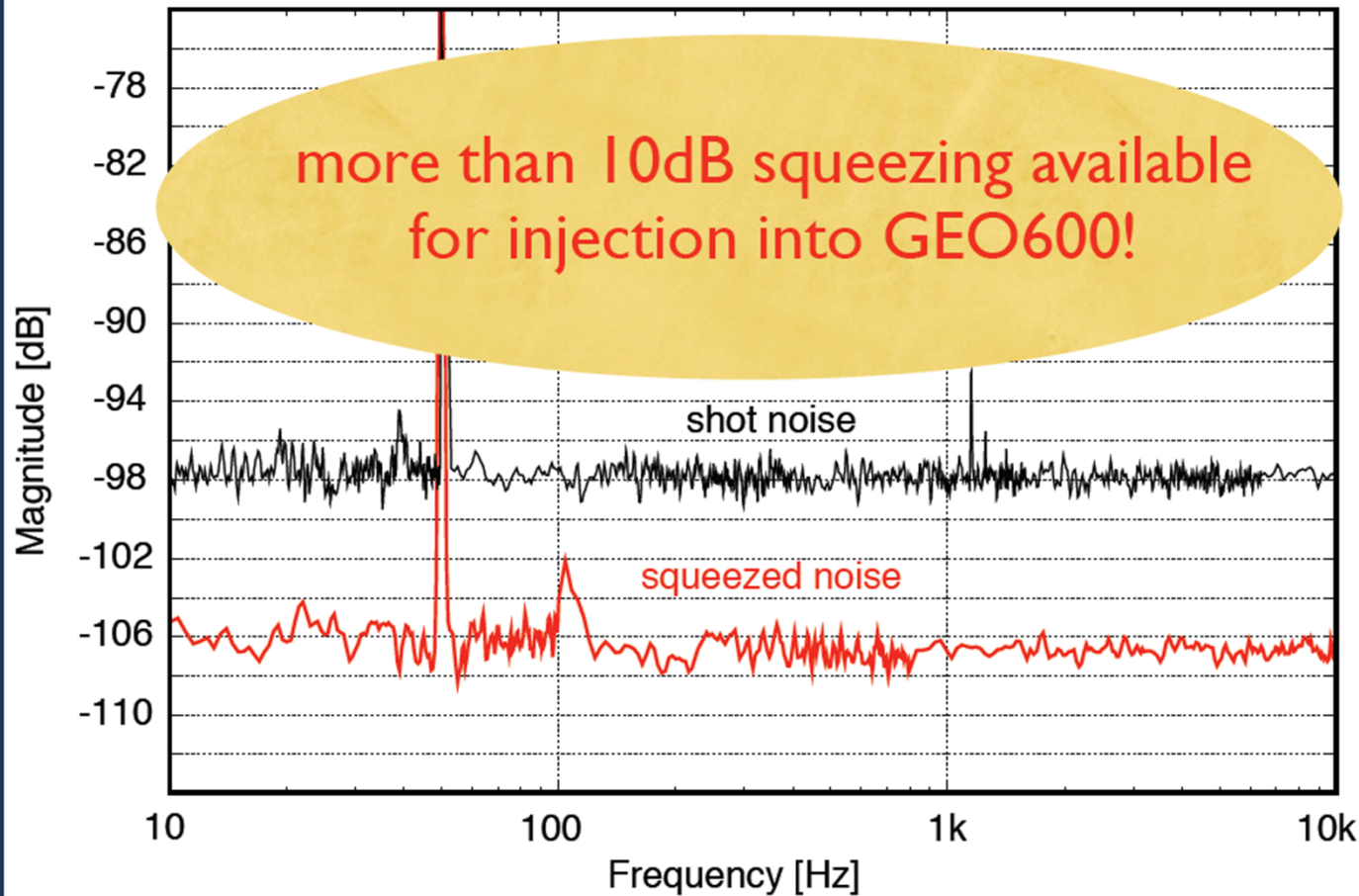
with only some mW pump power - less expensive next time



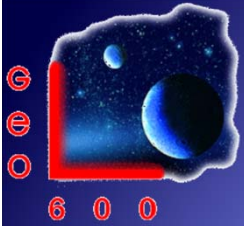
11 % optical loss on the squeezing board, including diagnostic homodyne detector



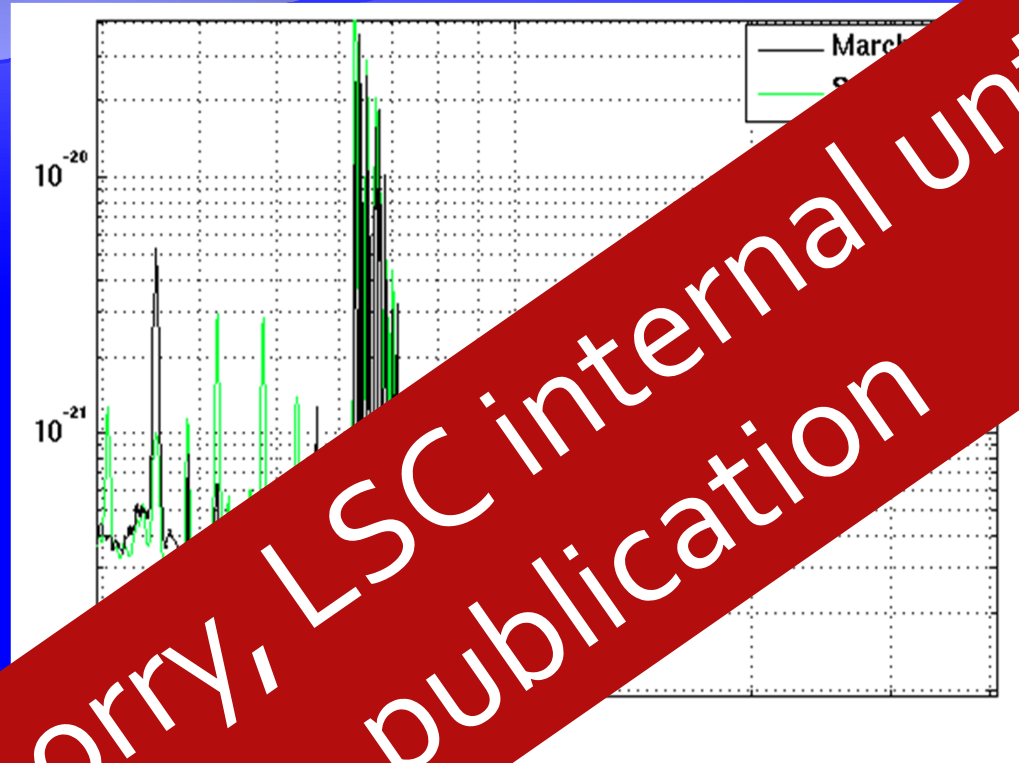
## Lots of squeezing input available



- Diagnostic homodyne detector introduces extra loss of 4% which can be subtracted for application in GW-detector
- Lower pump power can be used to inject a 10dB squeezed vacuum state

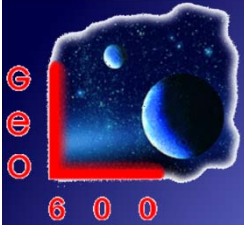


# Squeezing results

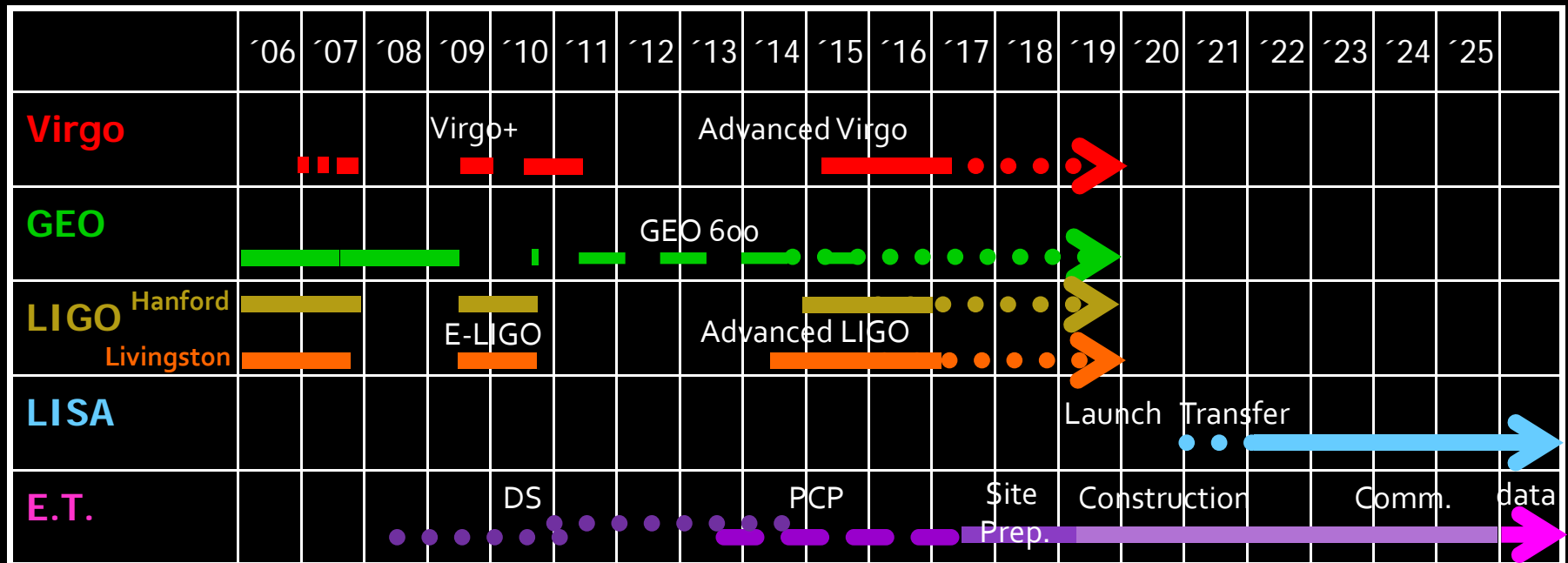


Sorry, LSC internal until publication

# Roadmap

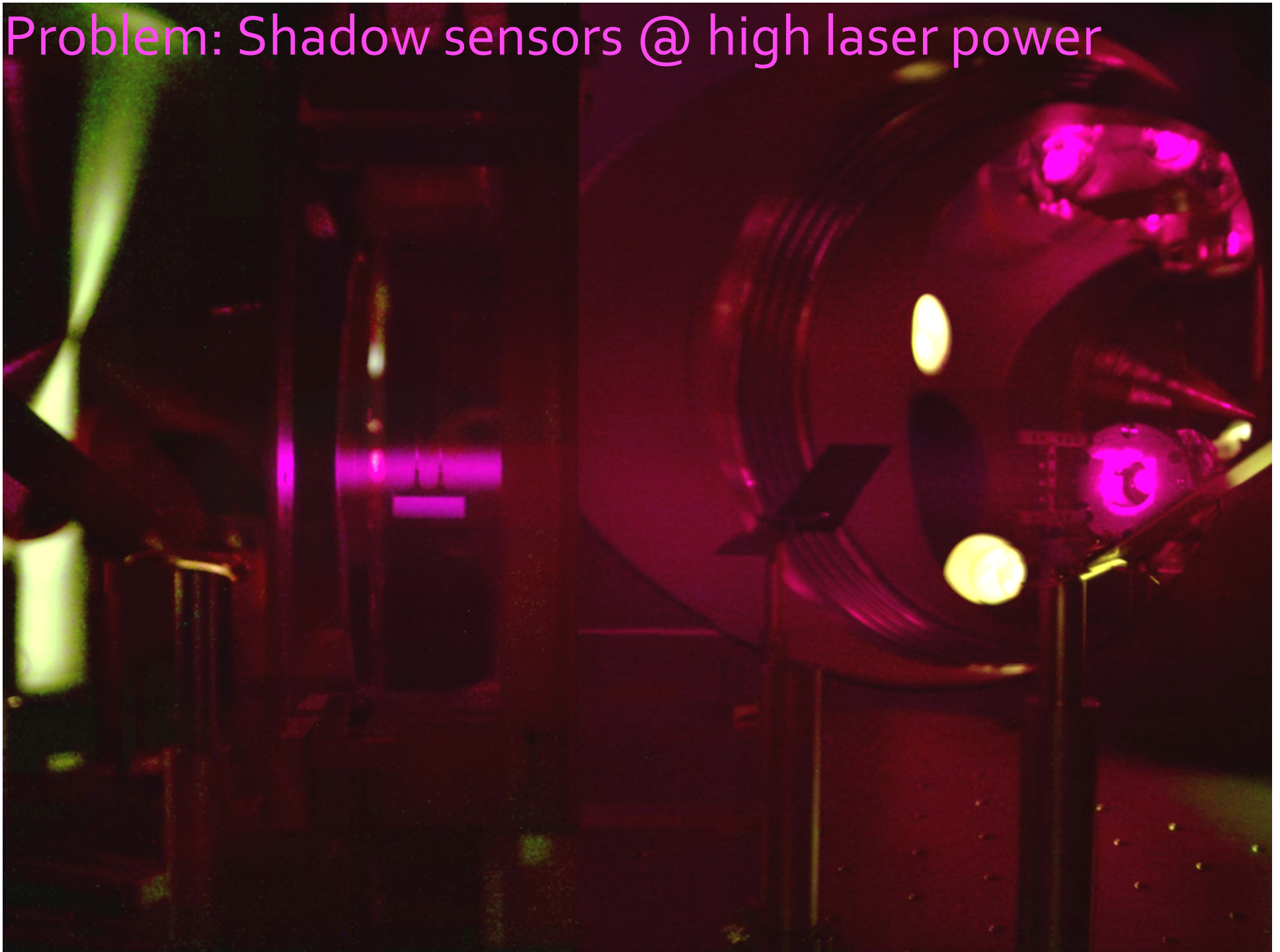


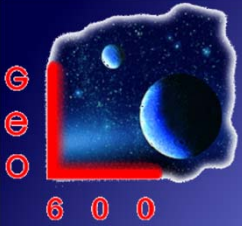
You are here

1st Generation      2nd Generation      3rd Gen.

Problem: Shadow sensors @ high laser power

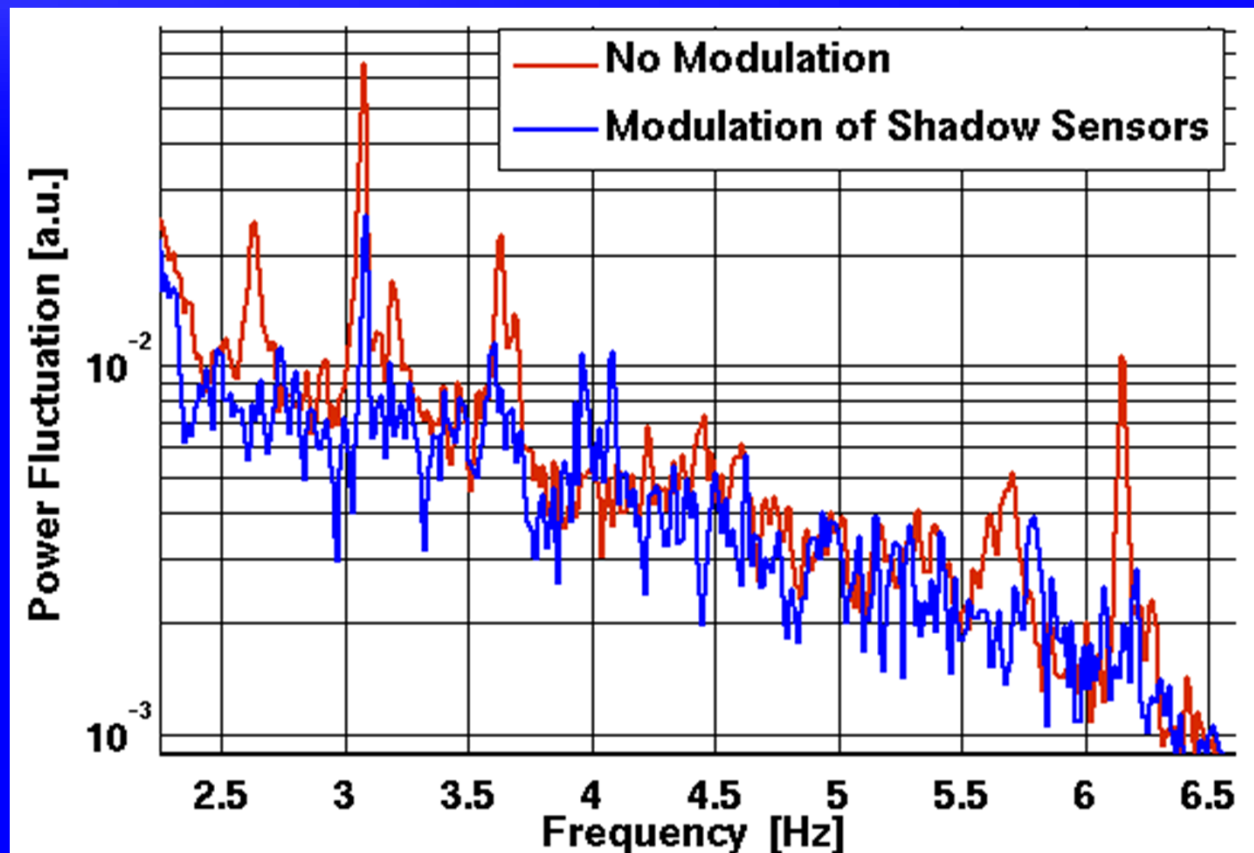




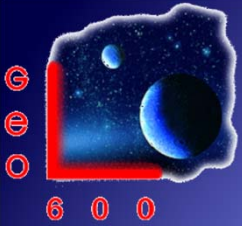
# Power Increase Investigations



- ◆ Tested modulation drives for shadow sensors







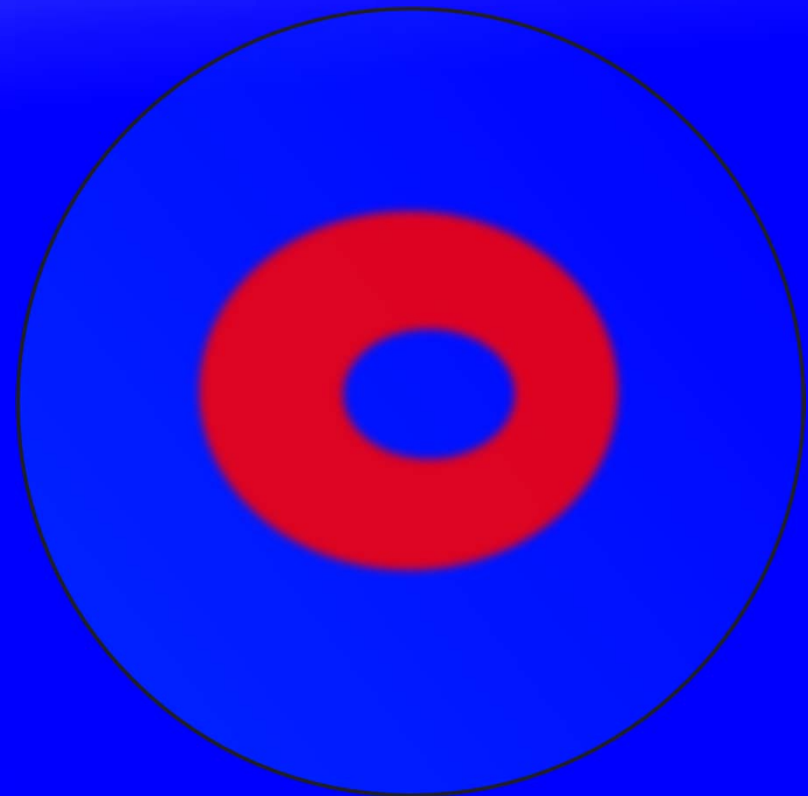
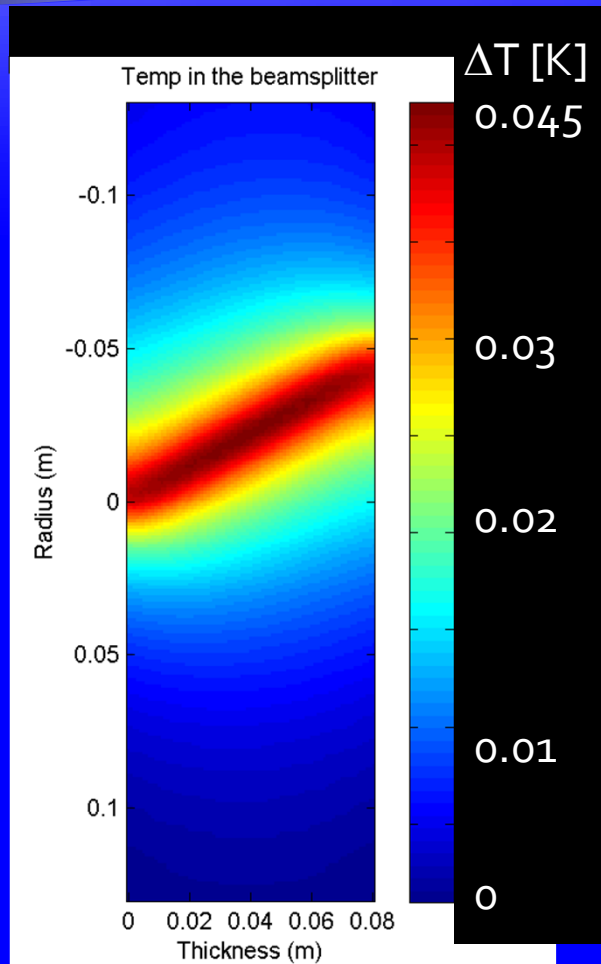
# Thermal compensation



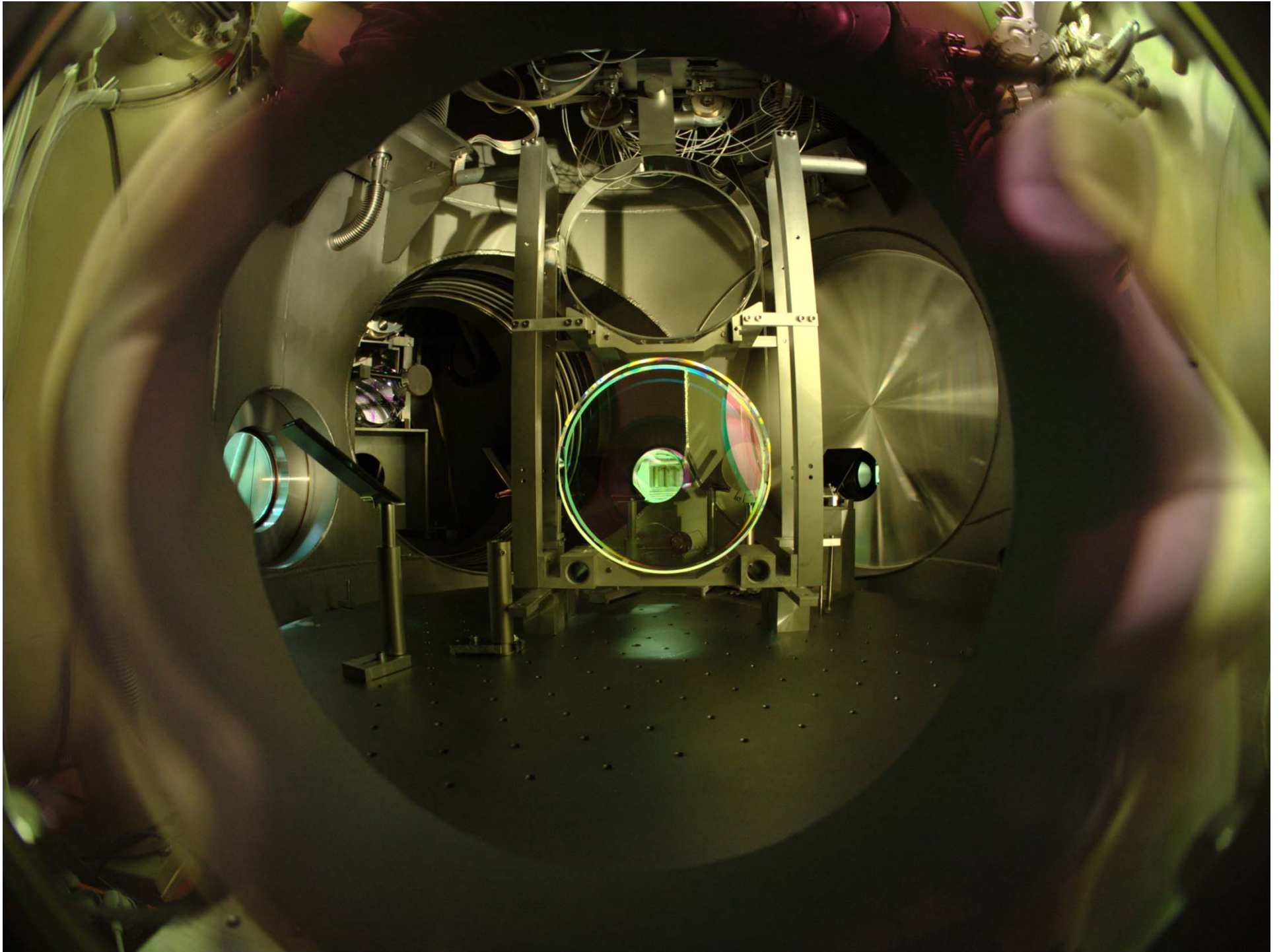
The Problem:

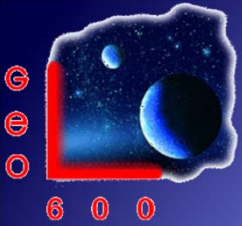
The Solution:

Heating the BS surface

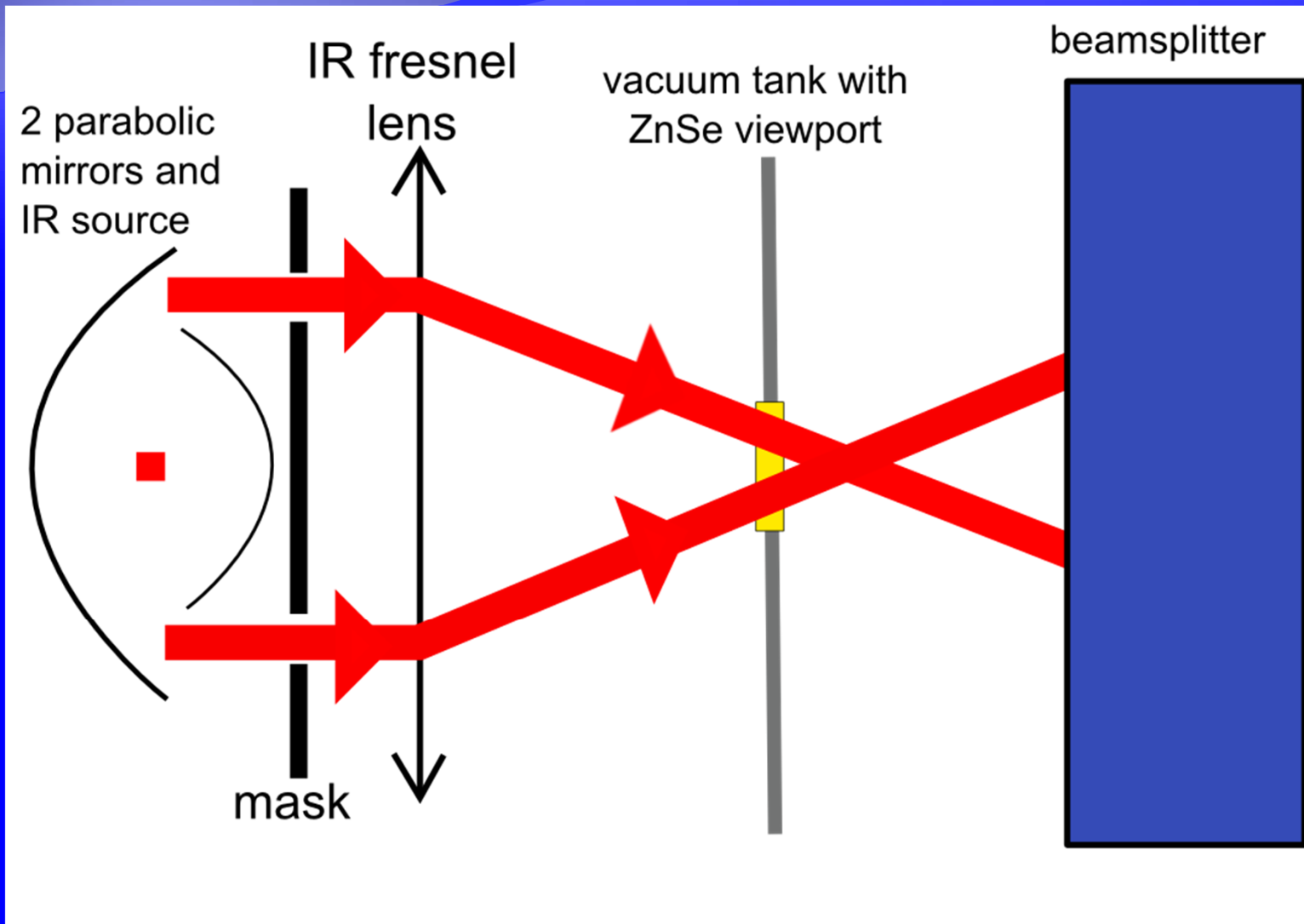


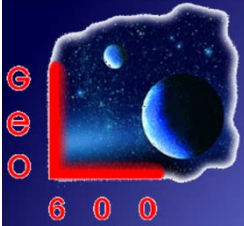
Need about **10 W** of heating power for full Laser power, i.e. ca. 30kW of circulating light power



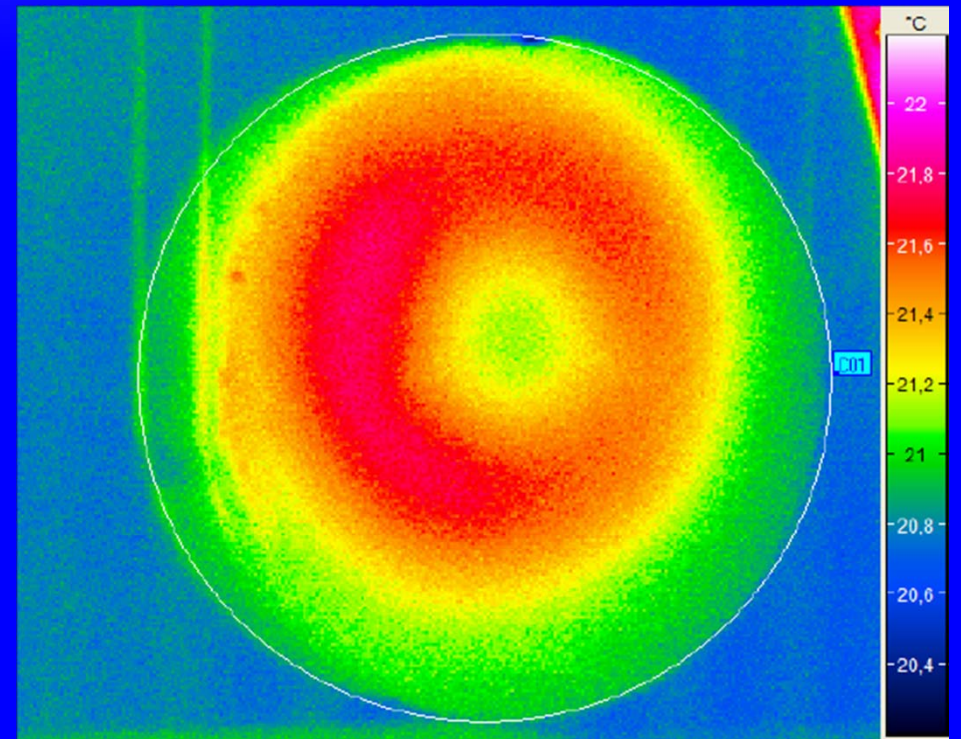
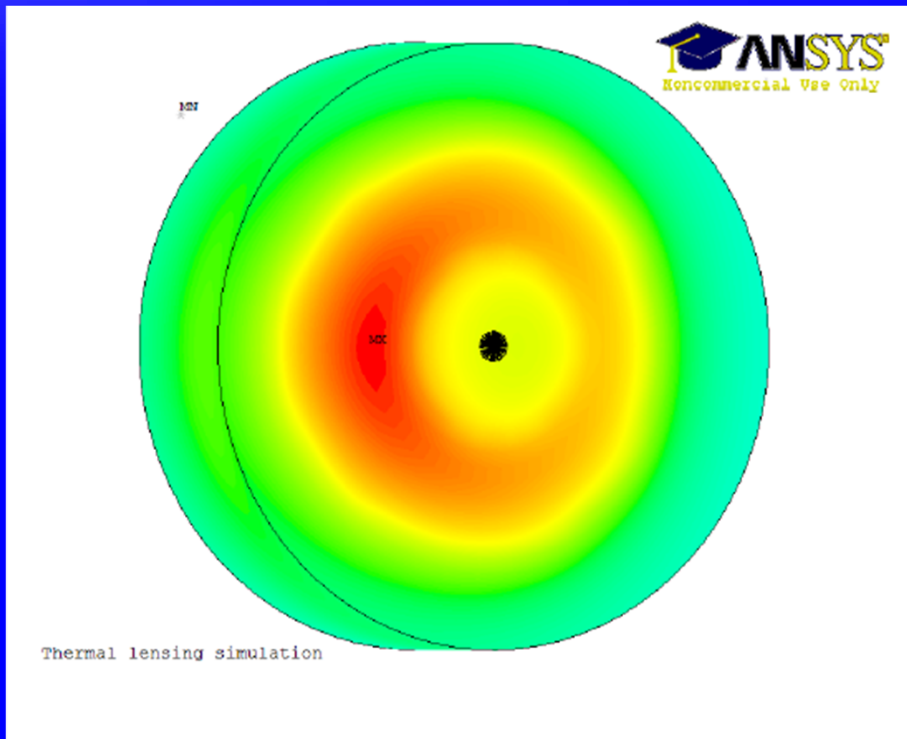


# Thermal compensation



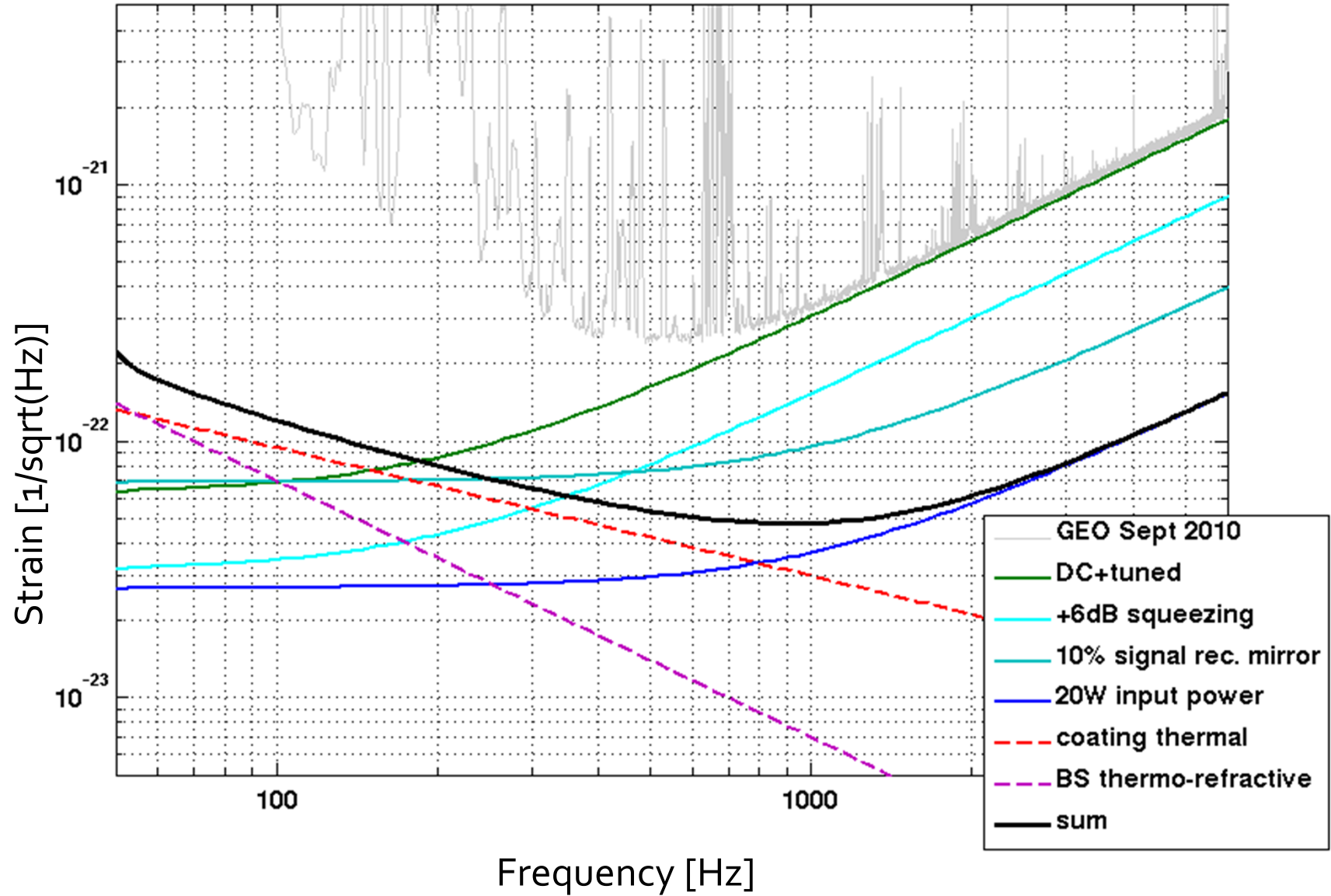


# First tests in air

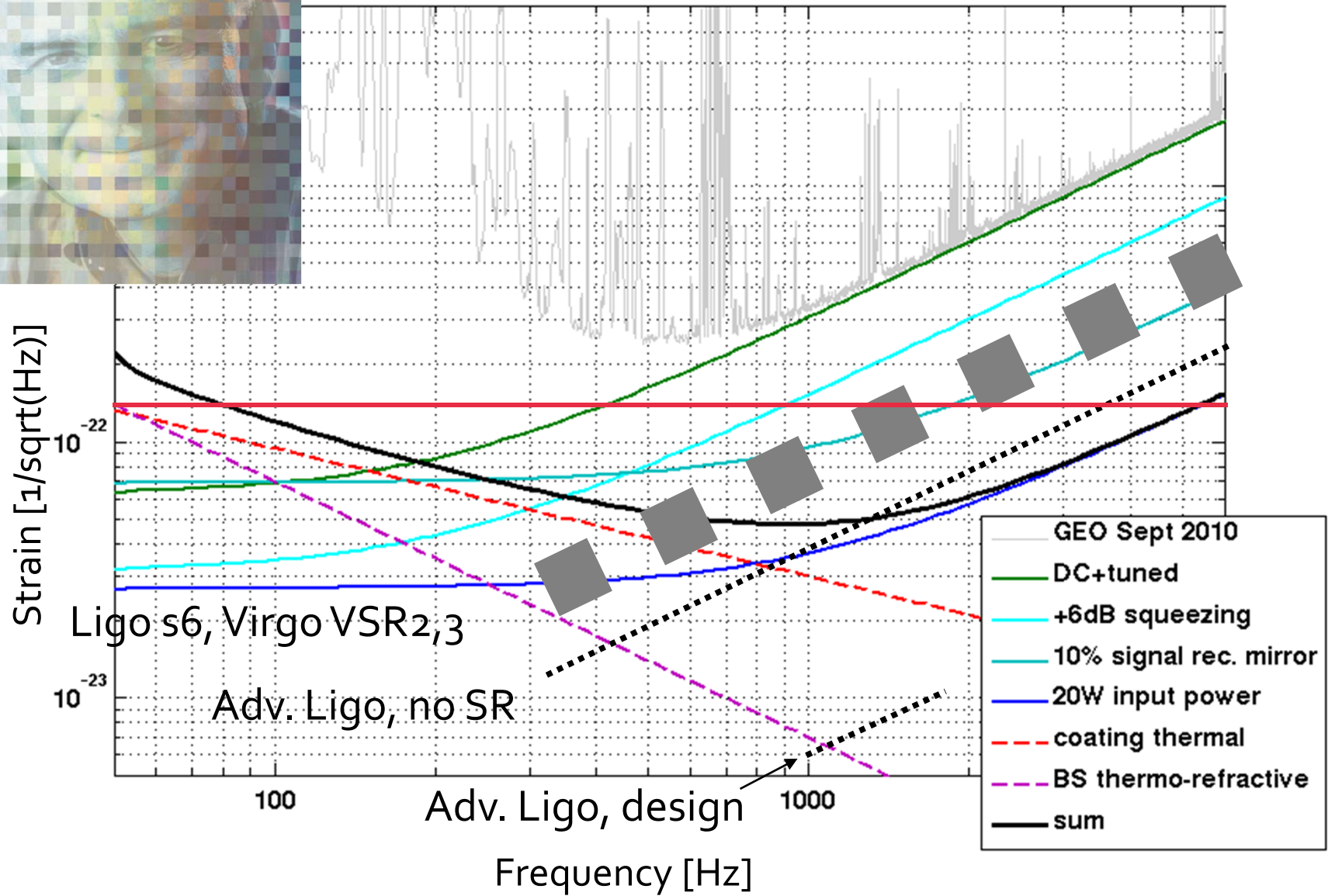


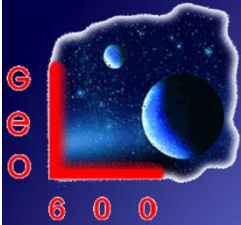


# GEO-HF Sensitivity



# GEO-HF Sensitivity





# Next Steps



## ◆ Commissioning

**2010**

- ◆ Squeezing: automation, permanent use, goal 6dB, DetChar
- ◆ Signal recycling bandwidth increase

**2011**

- ◆ Circulating light power increase,
  - ◆ new IMC mirrors, thermal compensation for BS, 35W main laser, modulated shadow sensor drives

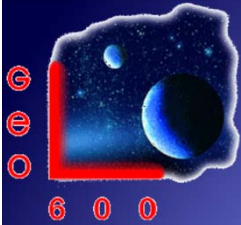
**2012**

- ◆ ...

## ◆ Data taking

**2015**

- ◆ Back to night/weekend mode after end of **S6** (Aug-Oct 2010).
- ◆ Longer periods / higher duty cycle as GEO-HF progresses



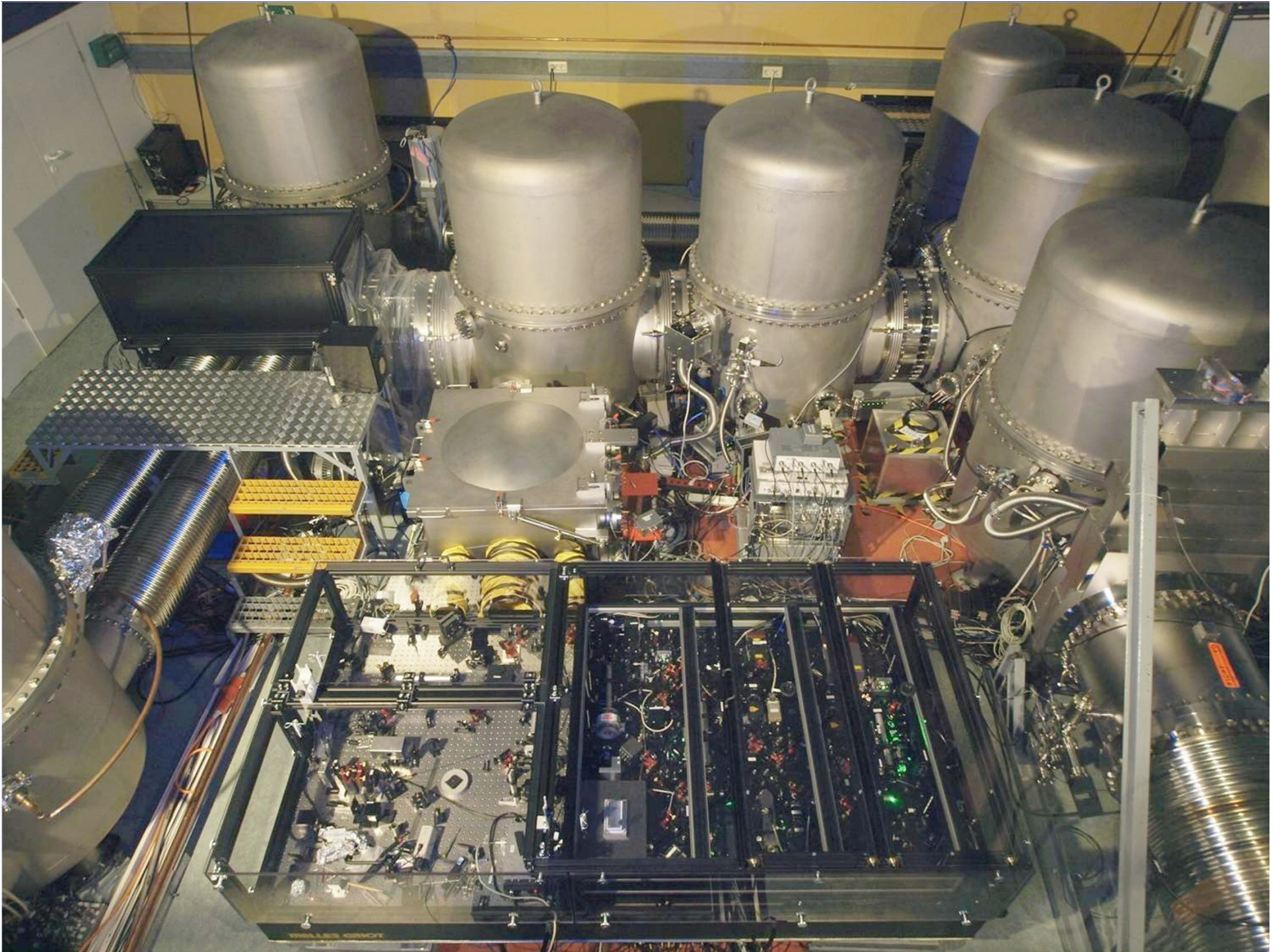
# On-site GEO600 team

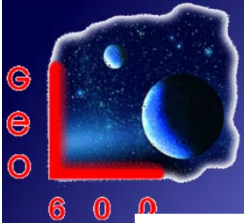


- ◆ Squeezing-group (Schnabel):  
*Henning Vahlbruch*  
*Alexander Khaleidowski*

- ◆ Operators/Technician:  
*Michael Weinert*  
*Marc Brinkmann*  
*Volker Kringel*  
*Walter Grass*
- ◆ PhD students:  
*Mirko Prijatelj*  
*Christoph Affeldt*  
*Dmitry Simakov*  
*Holger Wittel*
- ◆ Post-docs:  
*Jonathan Leong*
- ◆ Staff Scientists:  
*Hartmut Grote*  
*Harald Lück (~50%)*







# Noise Projections



Strain [ $1/\sqrt{\text{Hz}}$ ]

