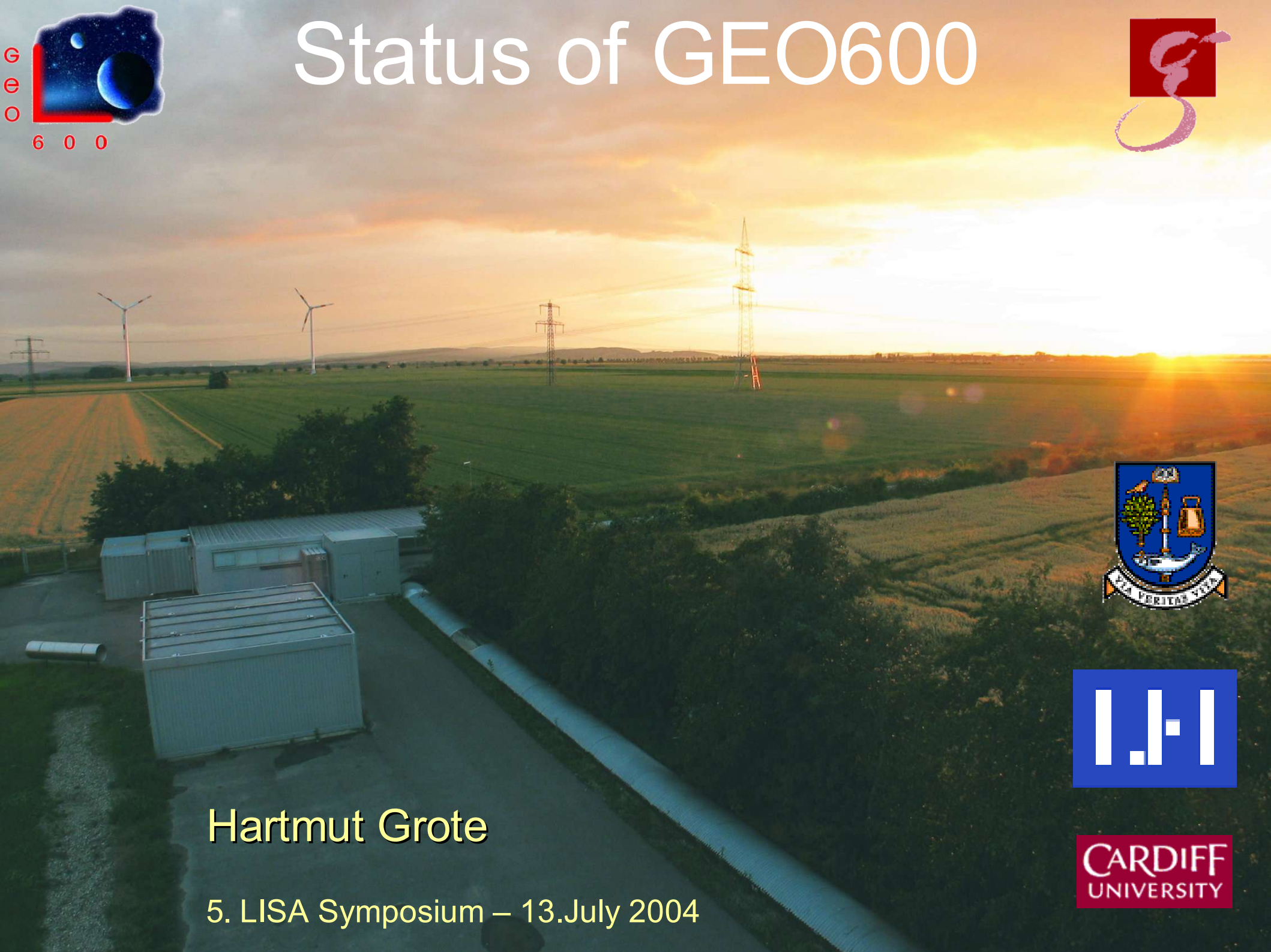
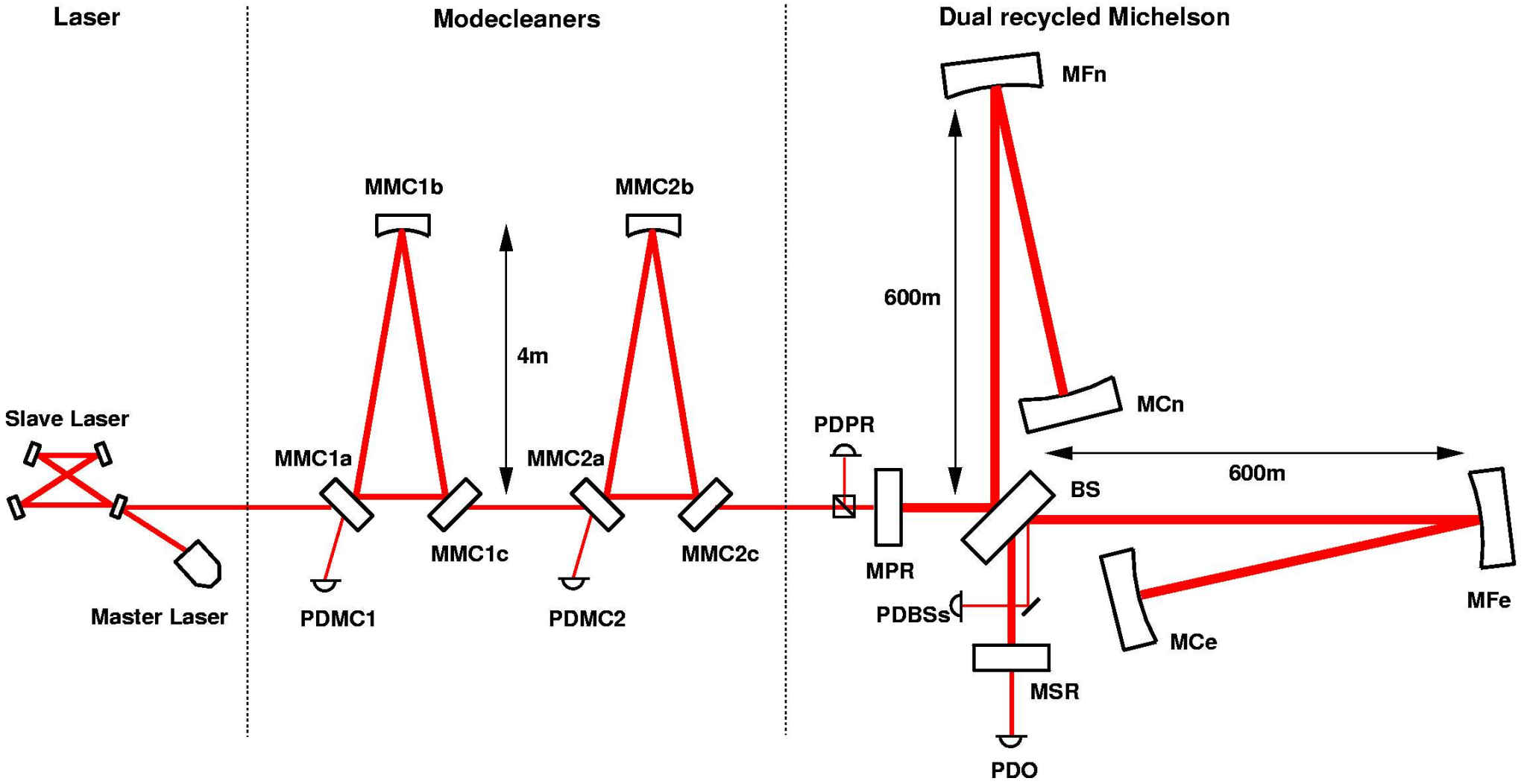
Status of GEO600



Hartmut Grote

5. LISA Symposium – 13.July 2004

GEO600 Optical Scheme



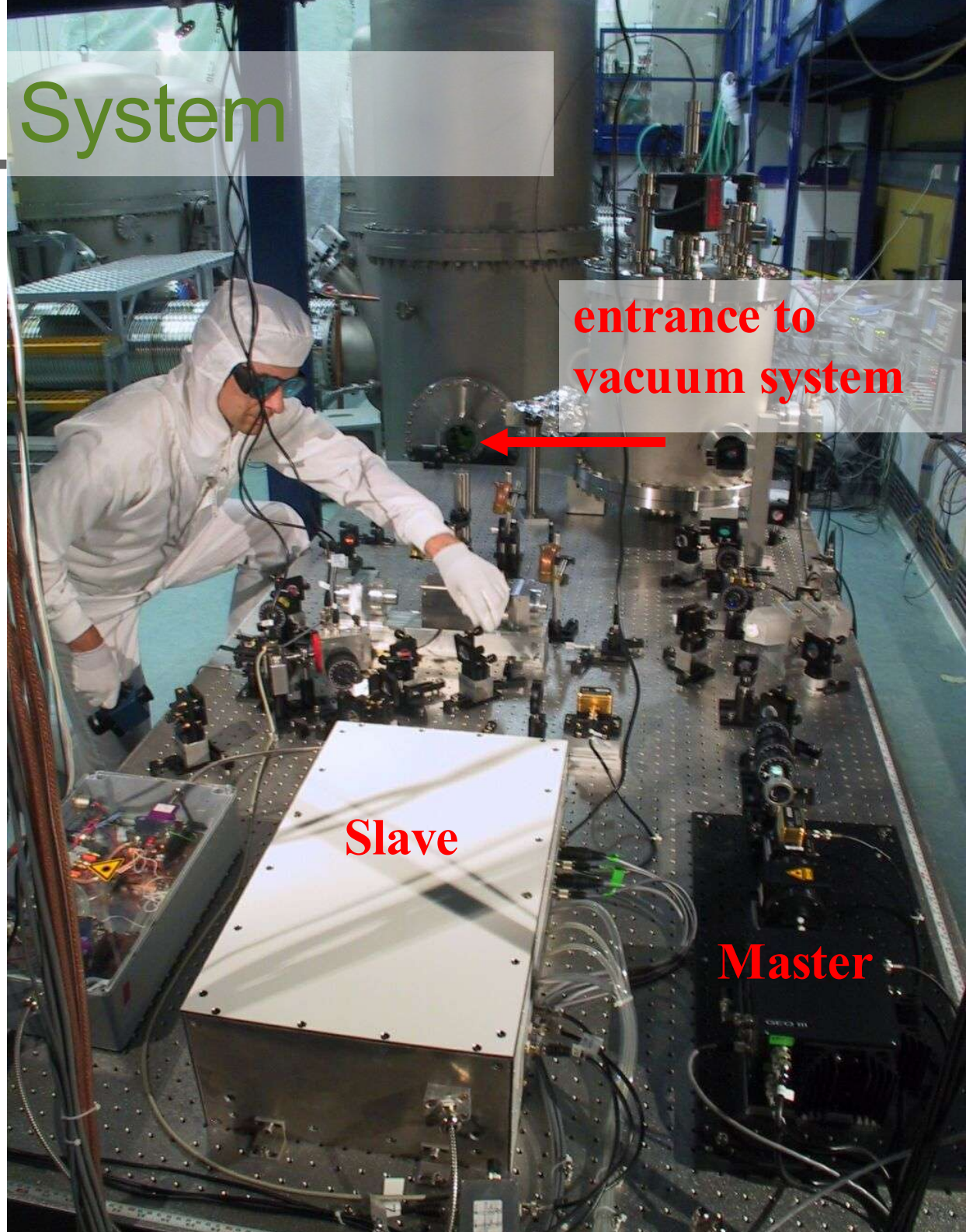
Laser System

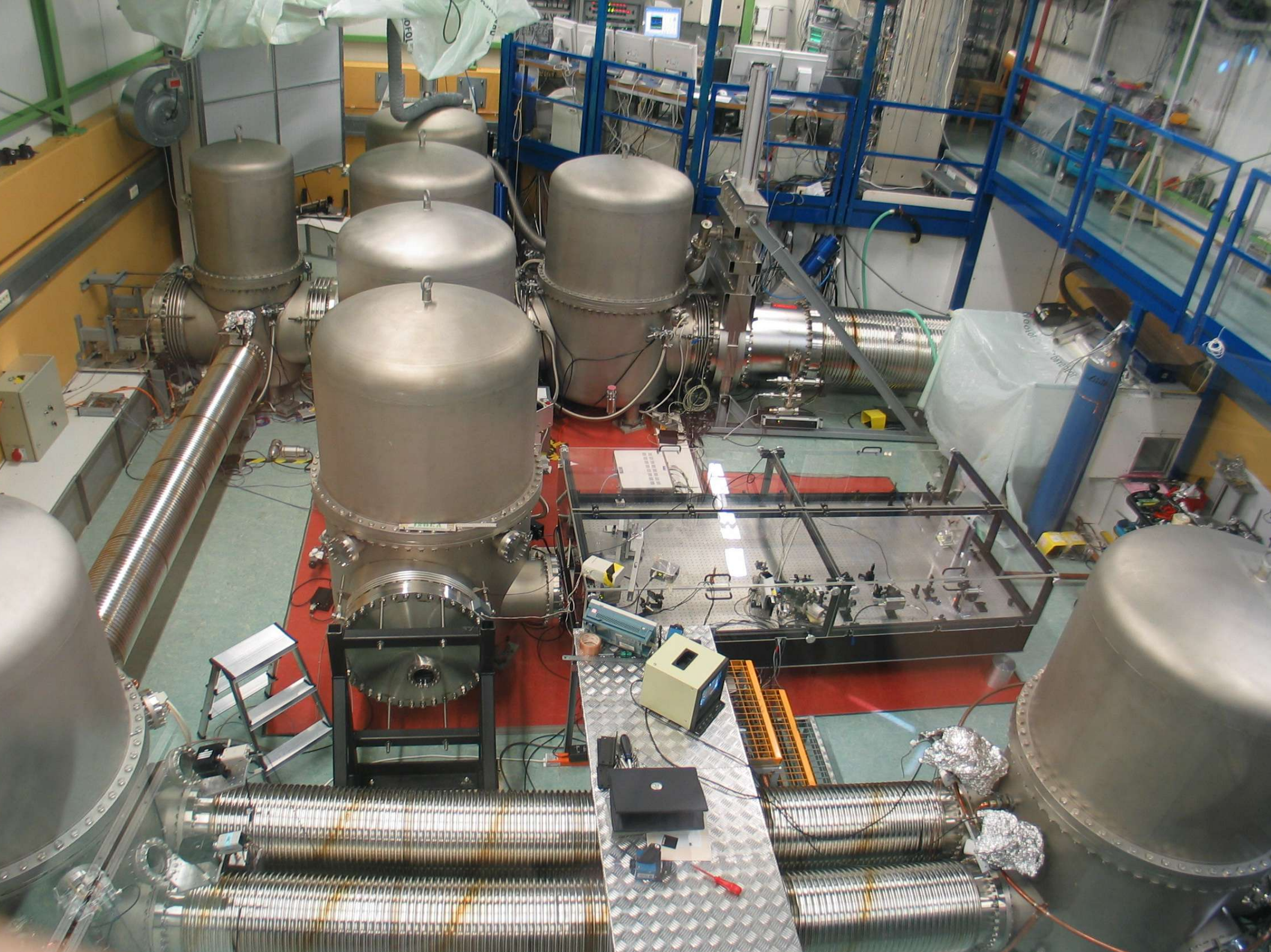
Master Laser:

- Nd:YAG
- NPRO (non-planar ring oscillator)
- 800mW @ 1064 nm

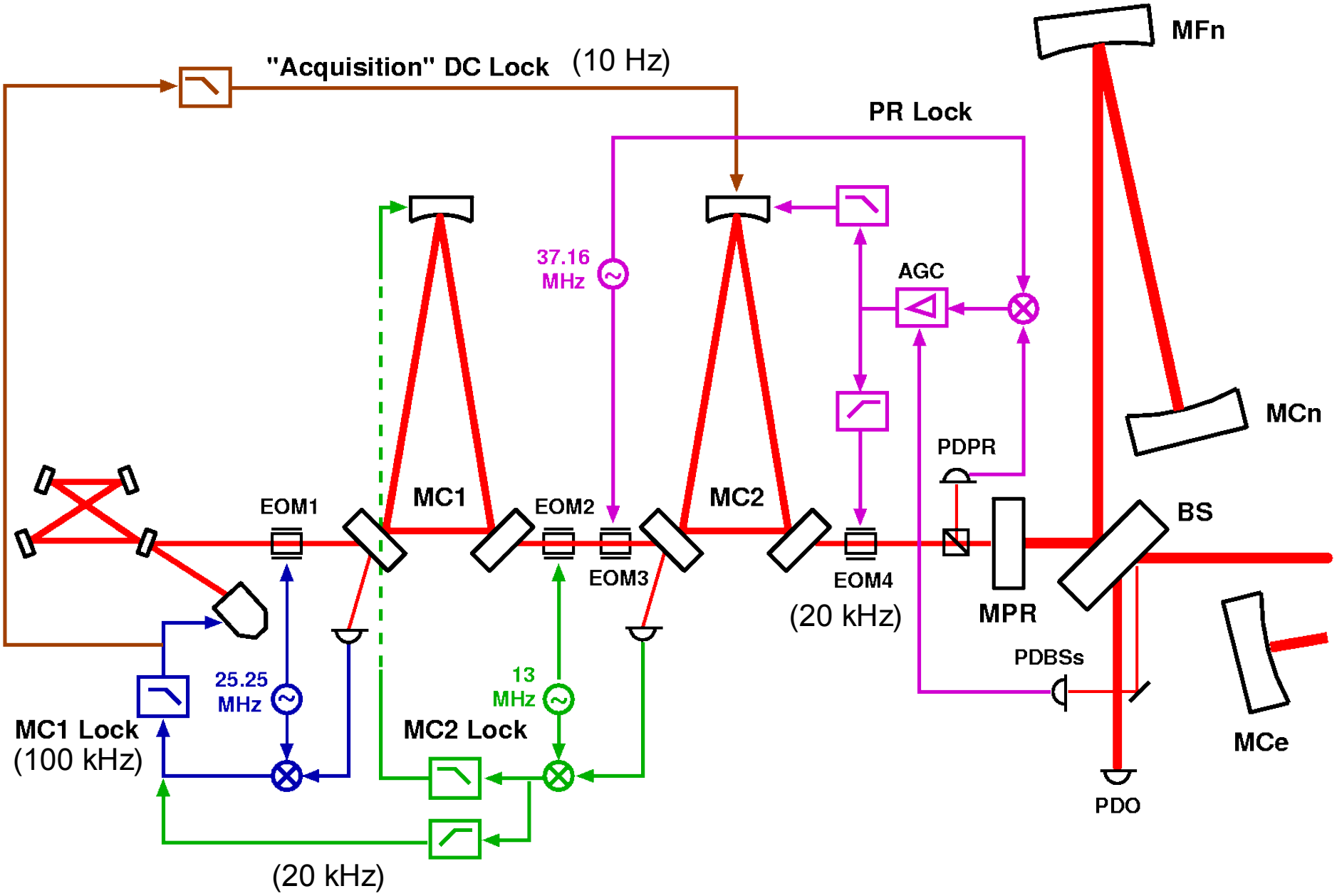
Slave Laser:

- Nd:YAG
- injection-locked ring cavity
- 12 W @ 1064nm
- less than 5% in higher modes

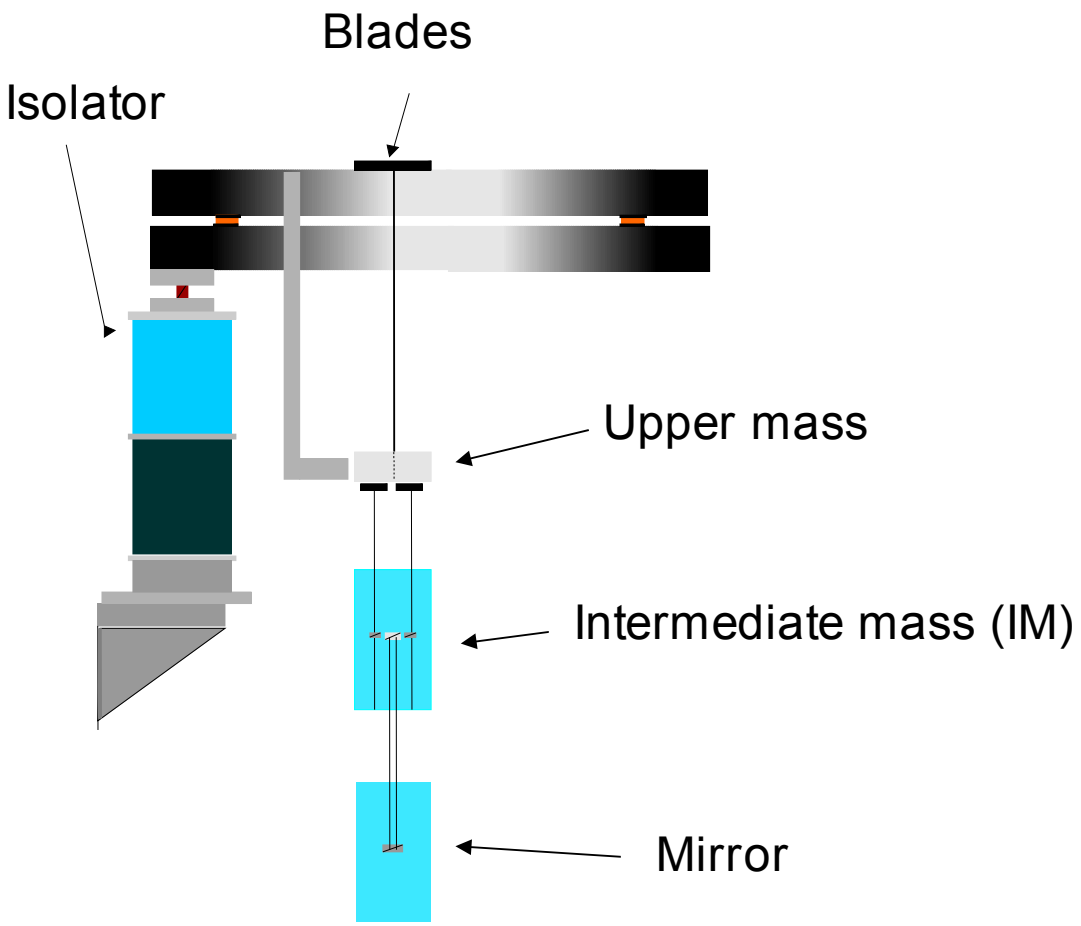


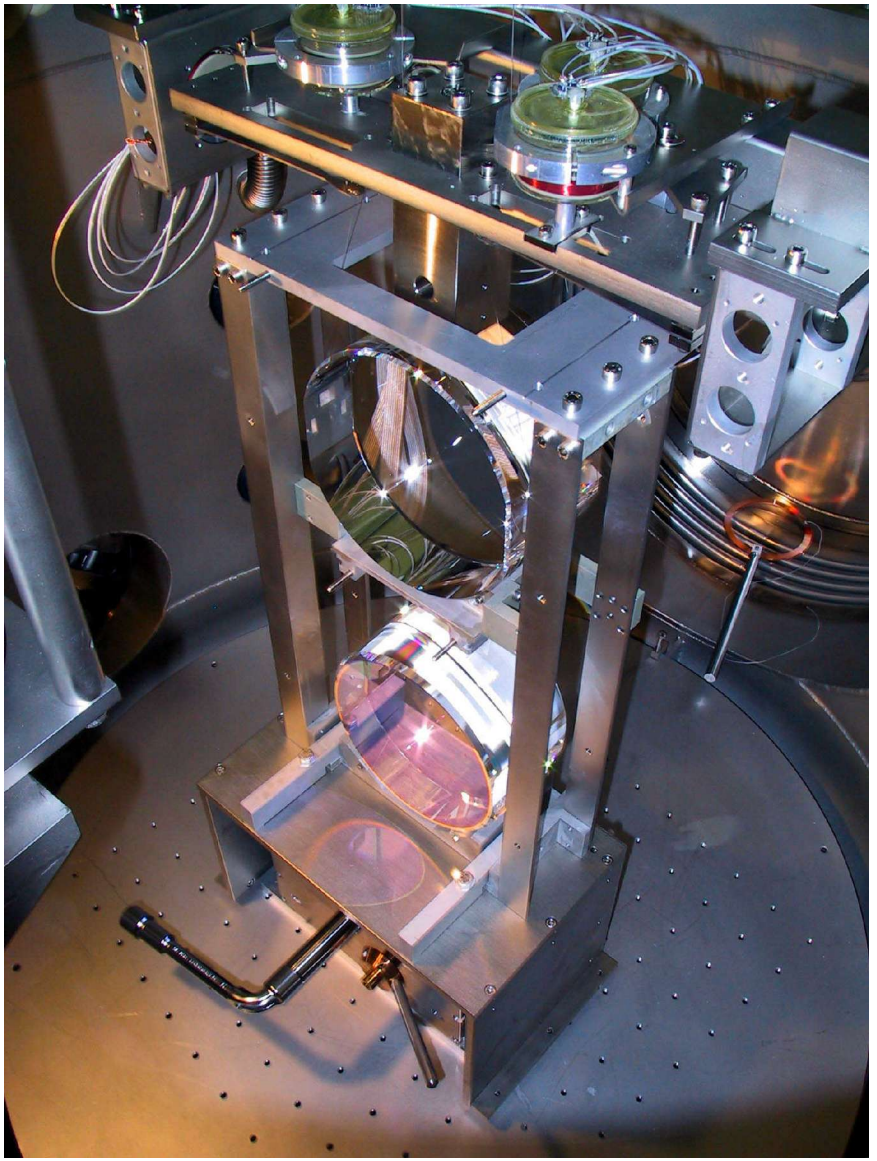


Frequency stabilisation



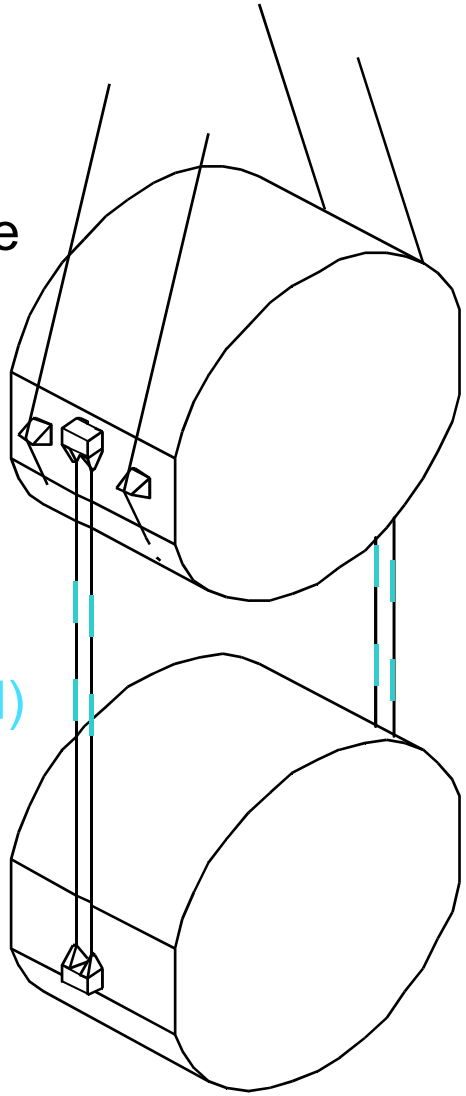
Triple pendulum

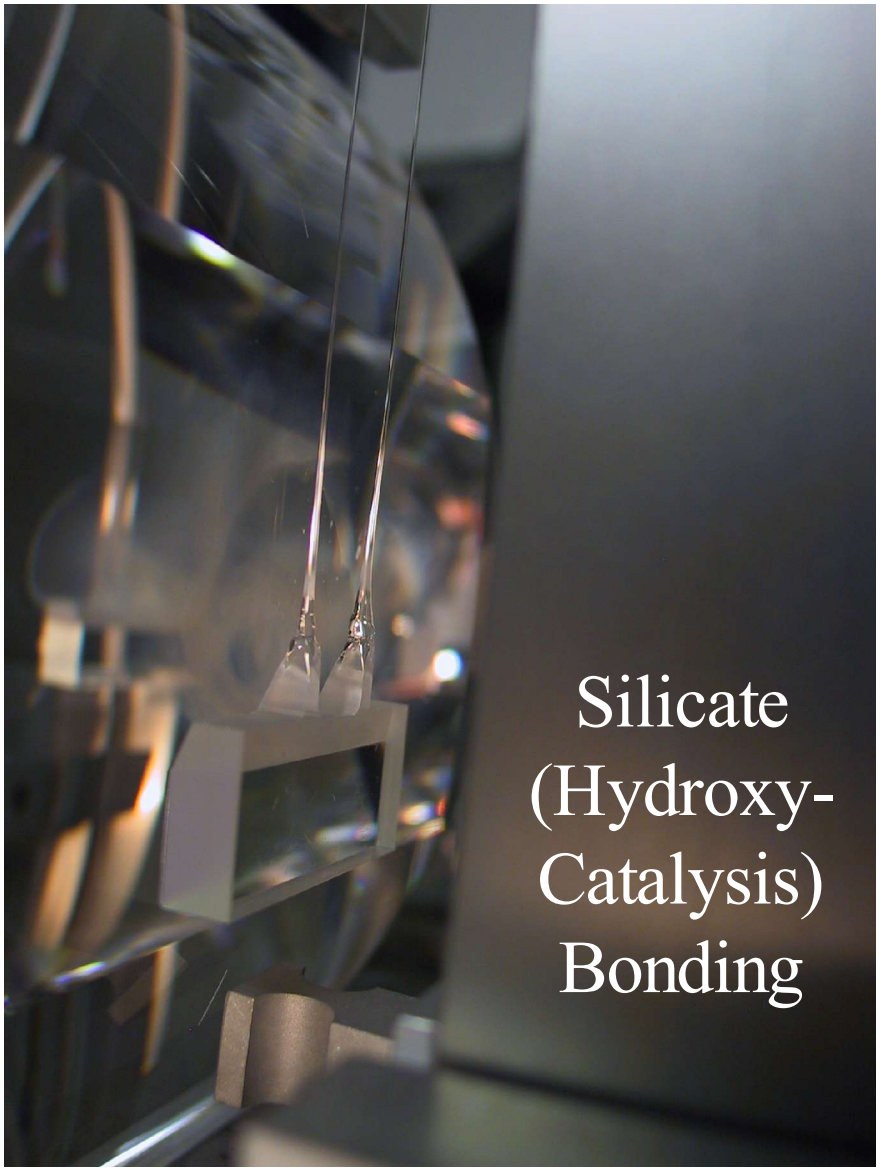




Thermal Noise Issues

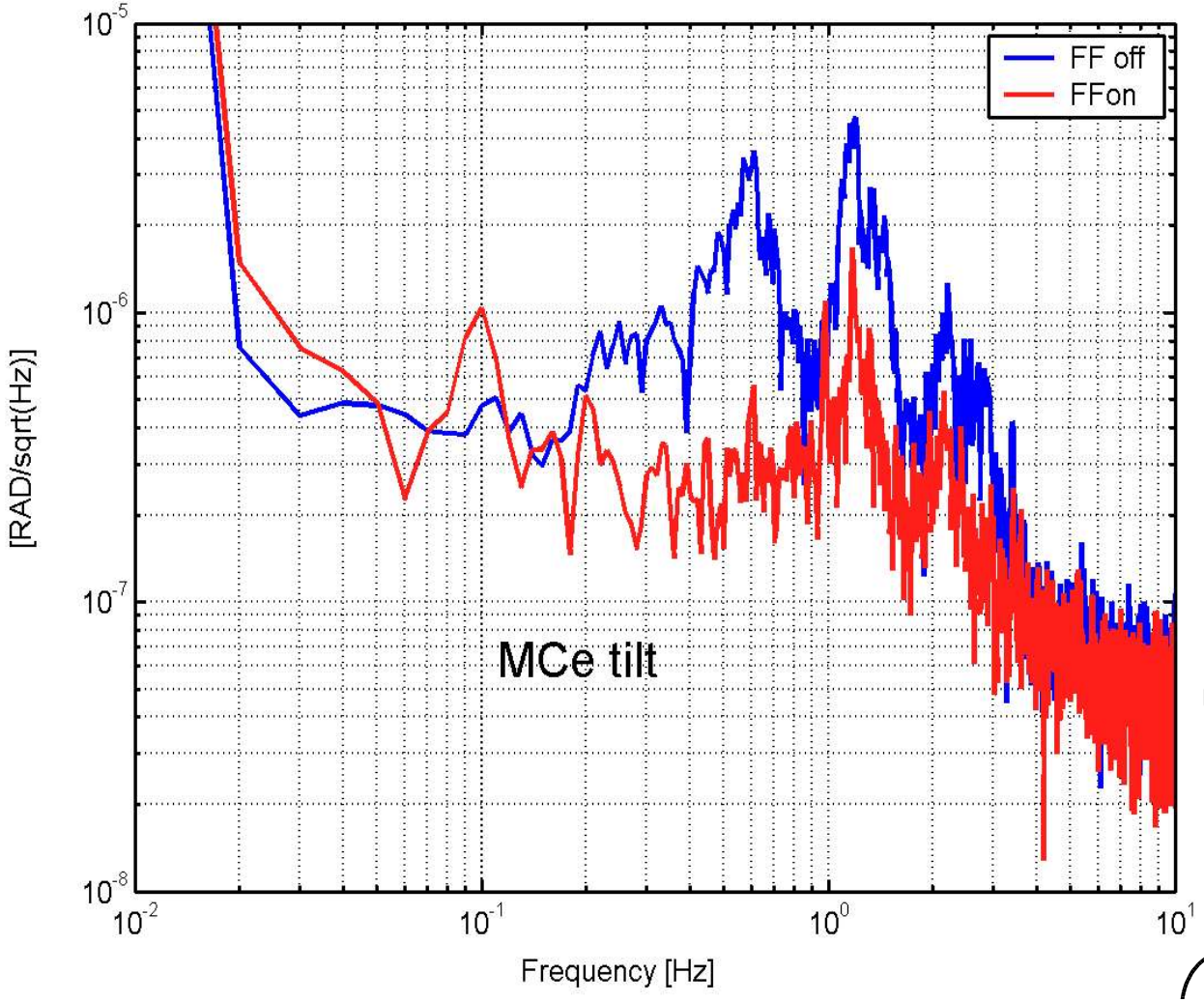
→Monolithic Suspension

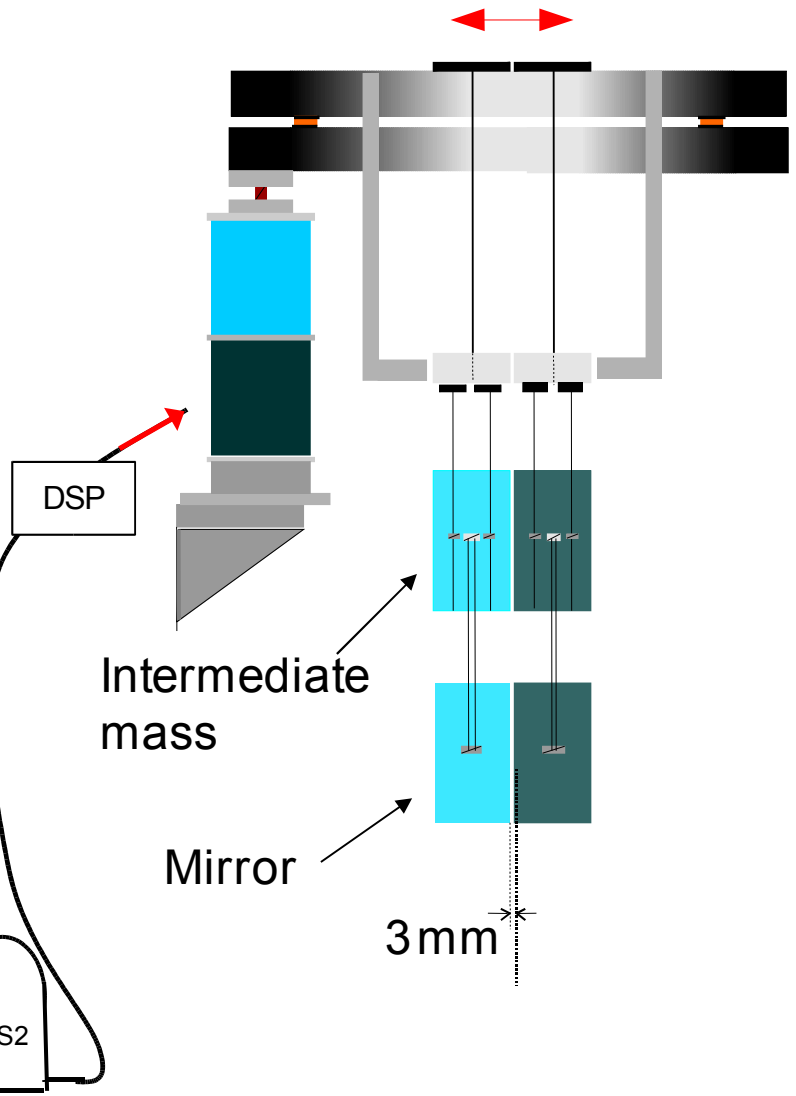




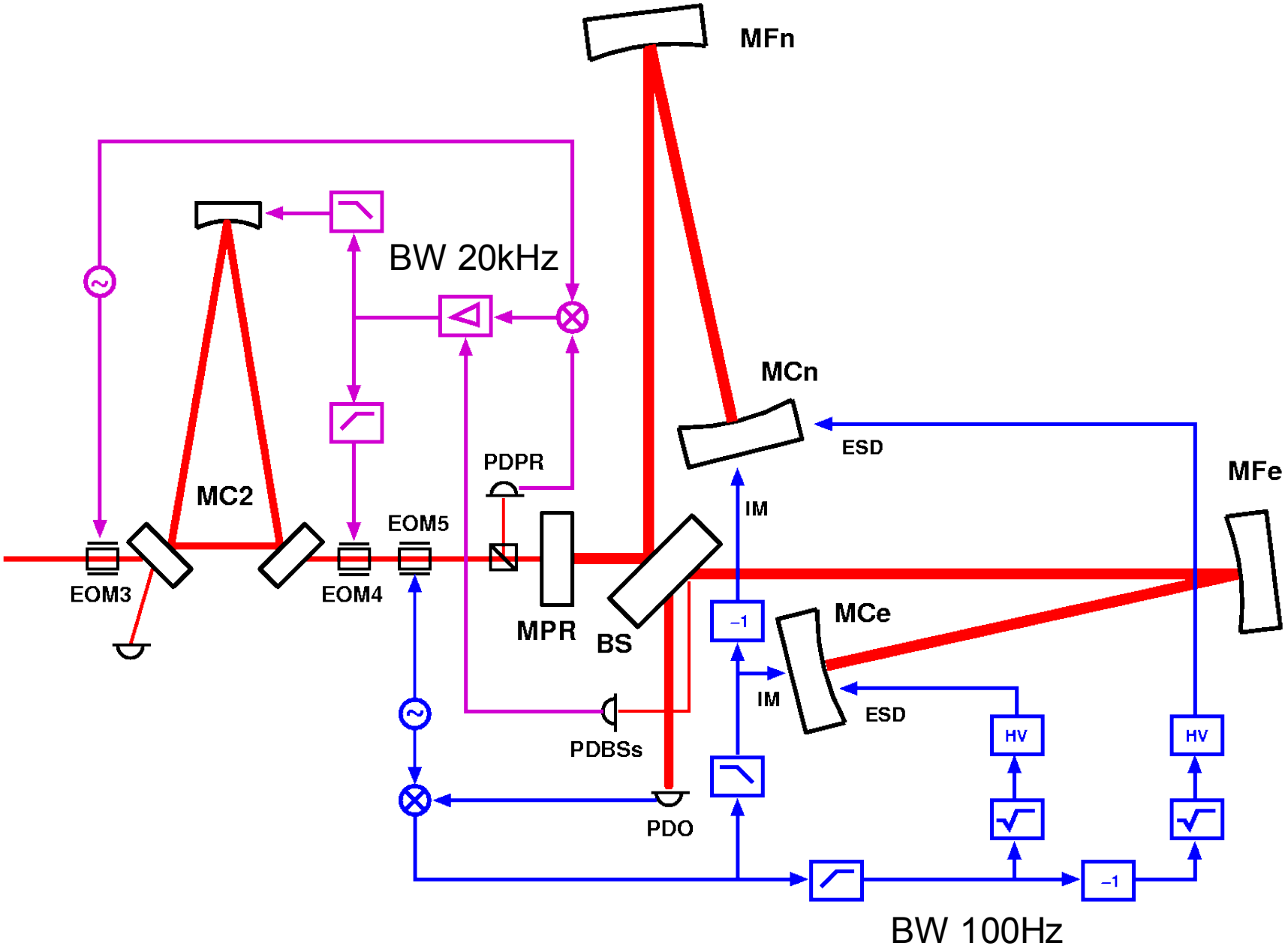
Excursion: Reducing mirror tilt

- Digital feedforward of ground motion to suspension point

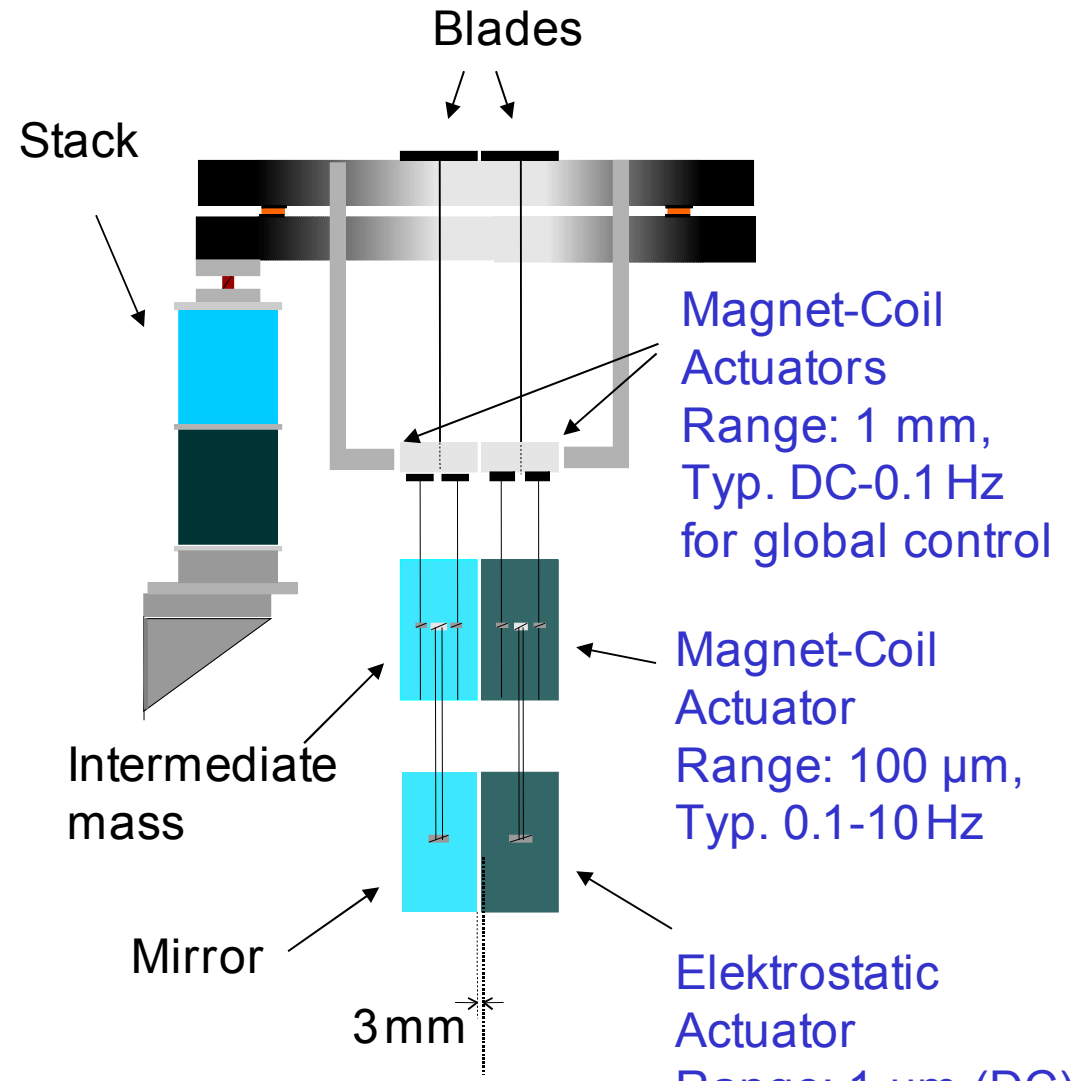


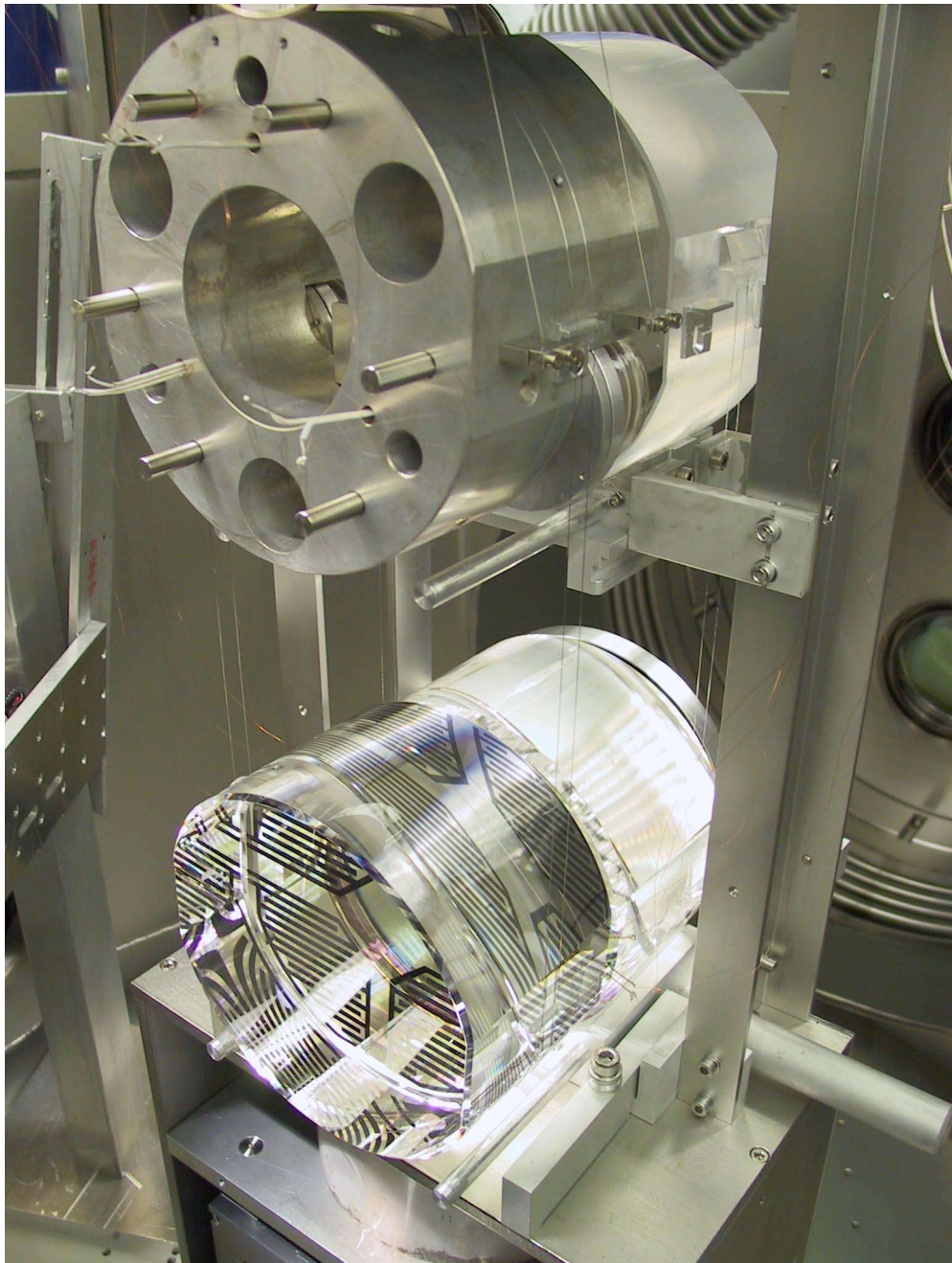


Michelson Control



Double – Triple Pendulum





Electrostatic Actuator

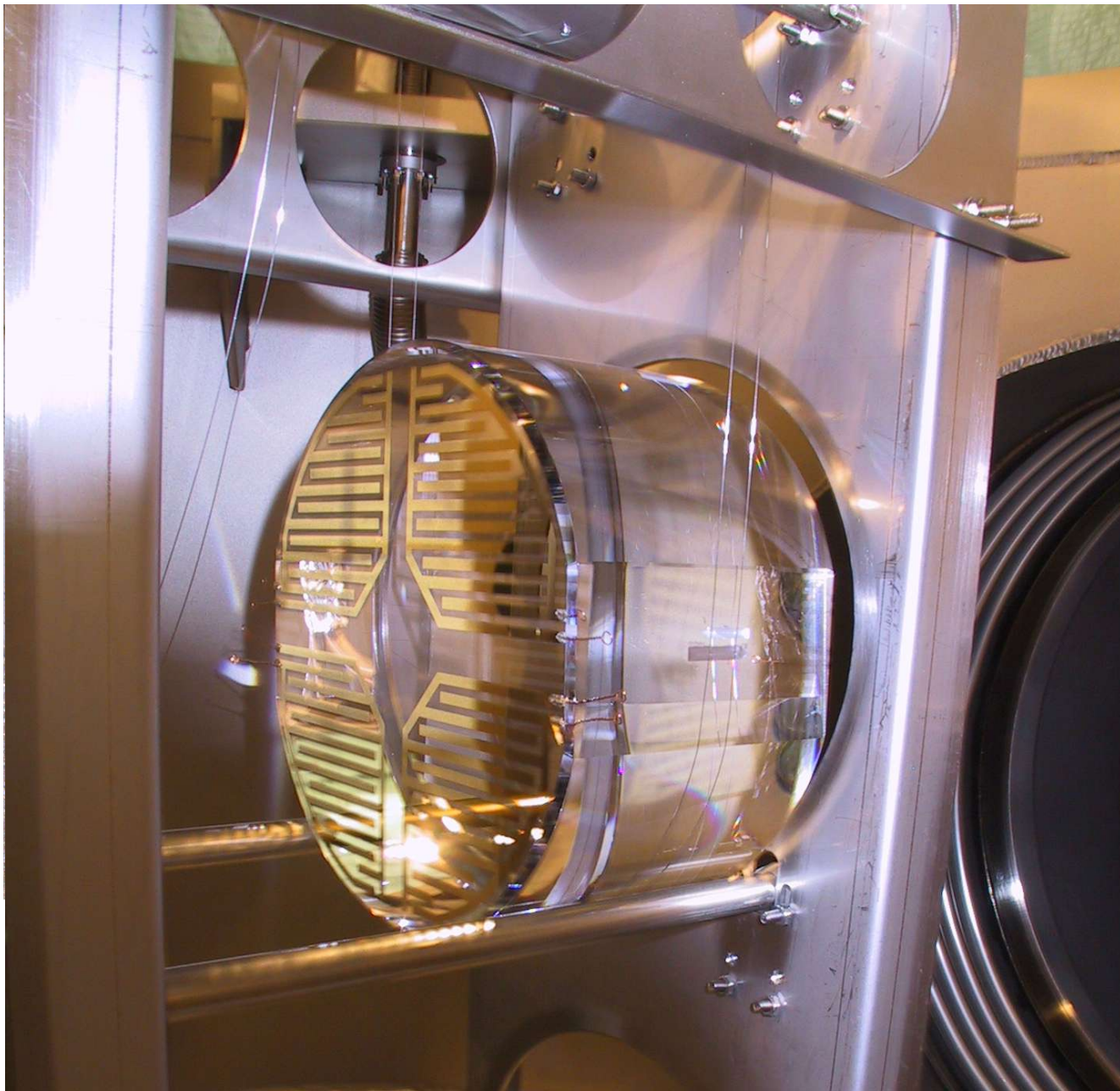
$$F = U^2 * \varepsilon\varepsilon_r d^x a$$

Processing square root with analog electronics

Peak force: 30 µN

Needed for acquisition

Maximal mirror speed for lock acquisition with PR gain 300 is 100 nm/s



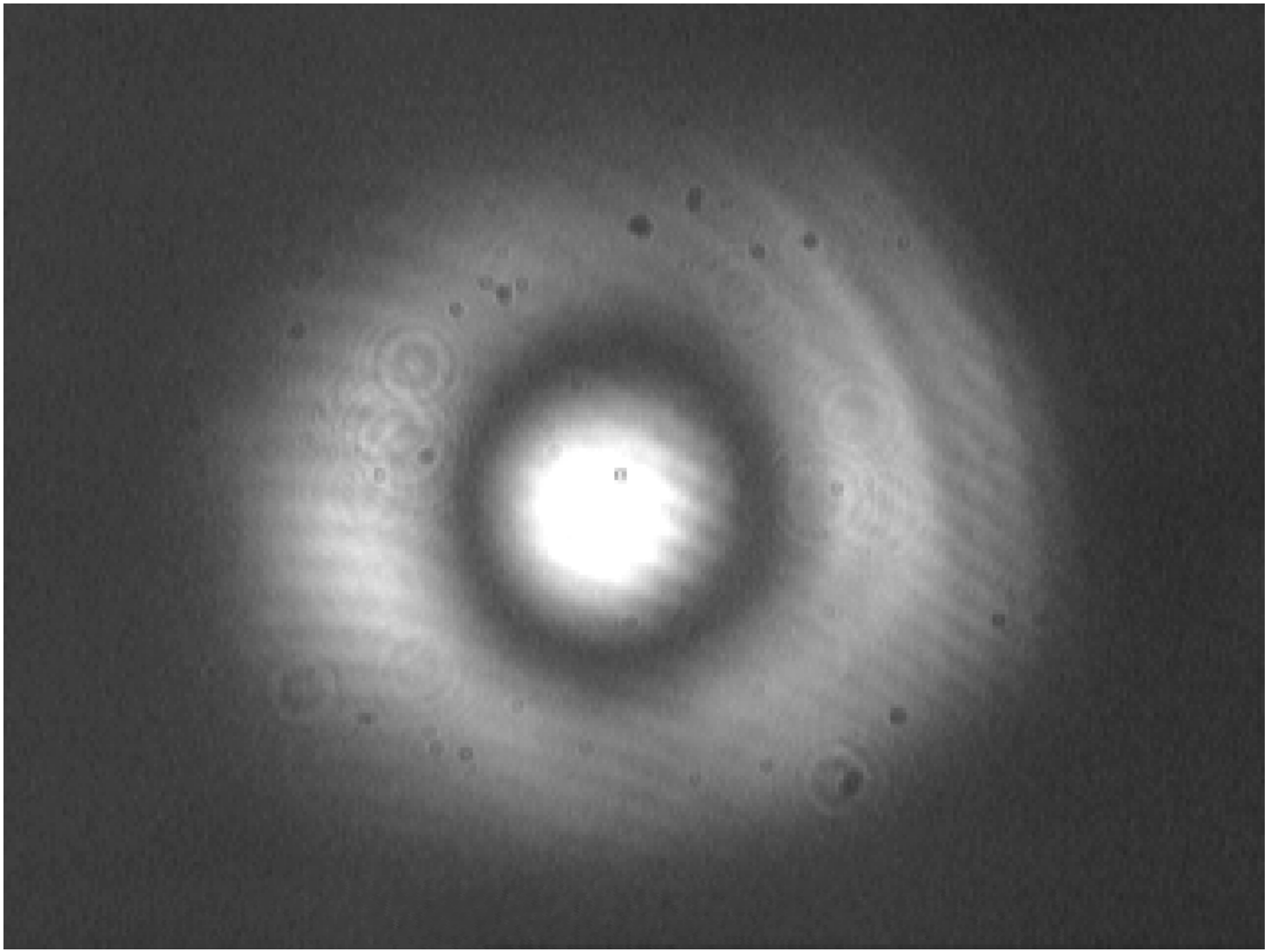
Output mode (no signal recycling)

Radii Of Curvature of folding mirrors do not match

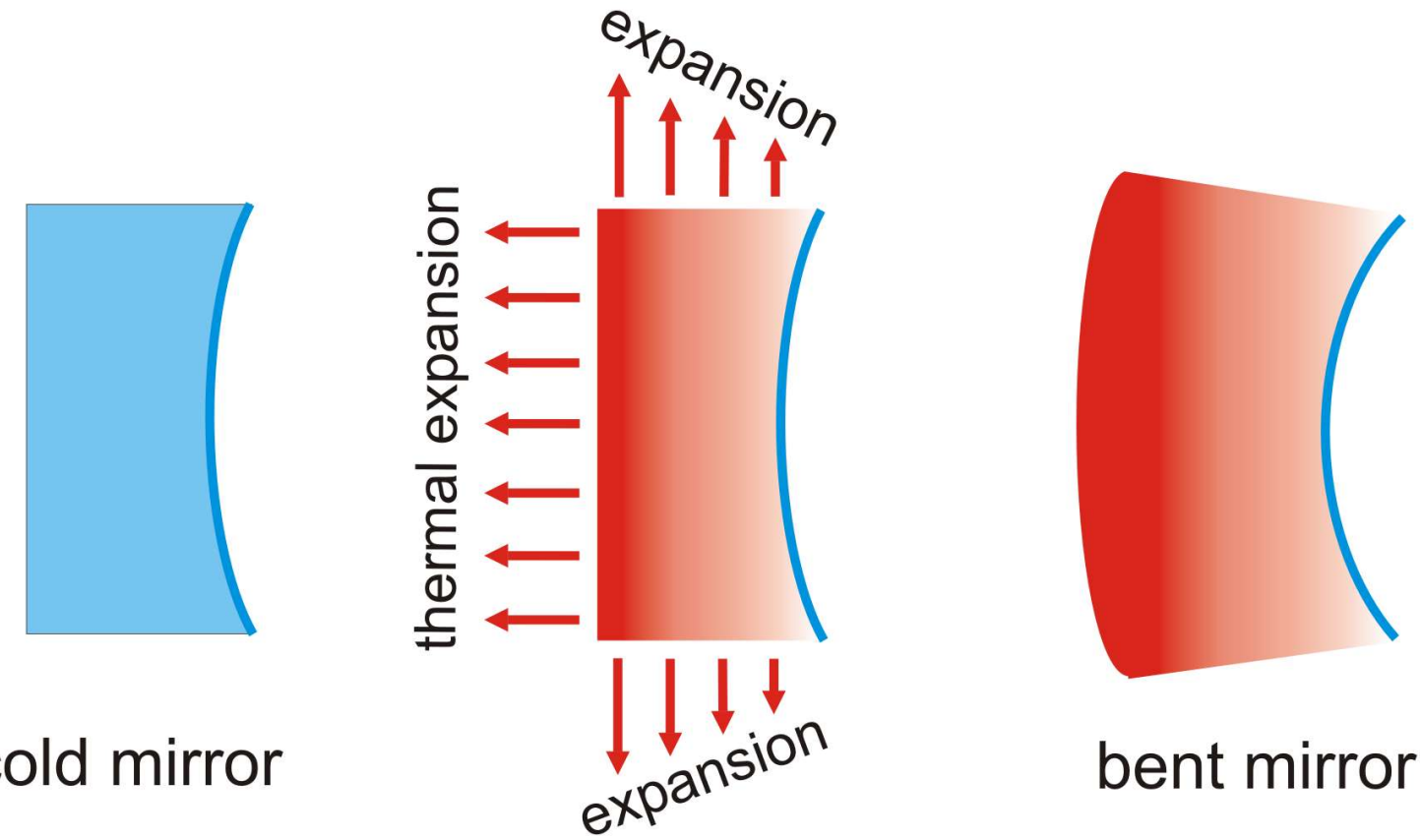
East ROC: 687m

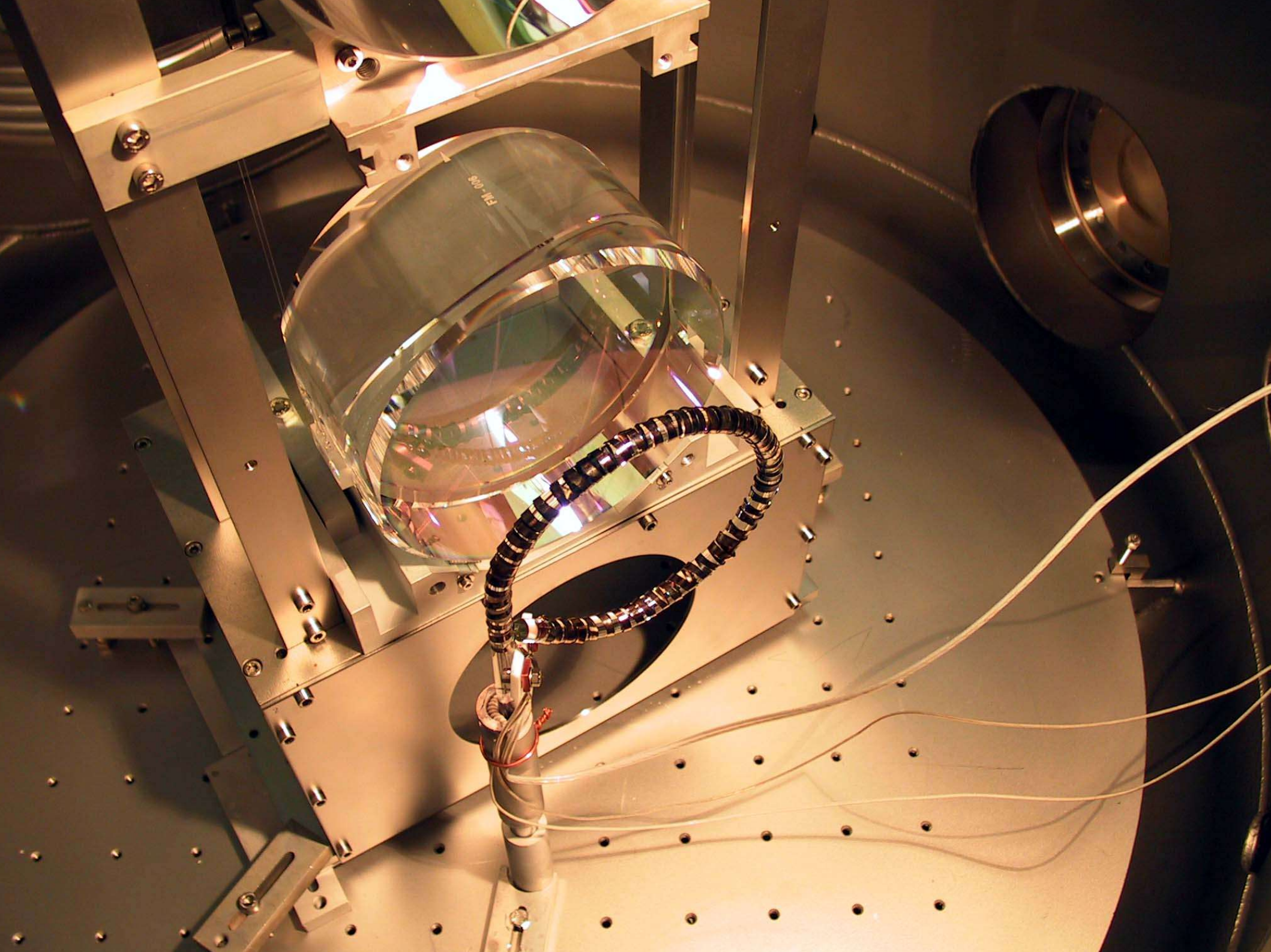
North ROC: 666m

(Spec: 640m)

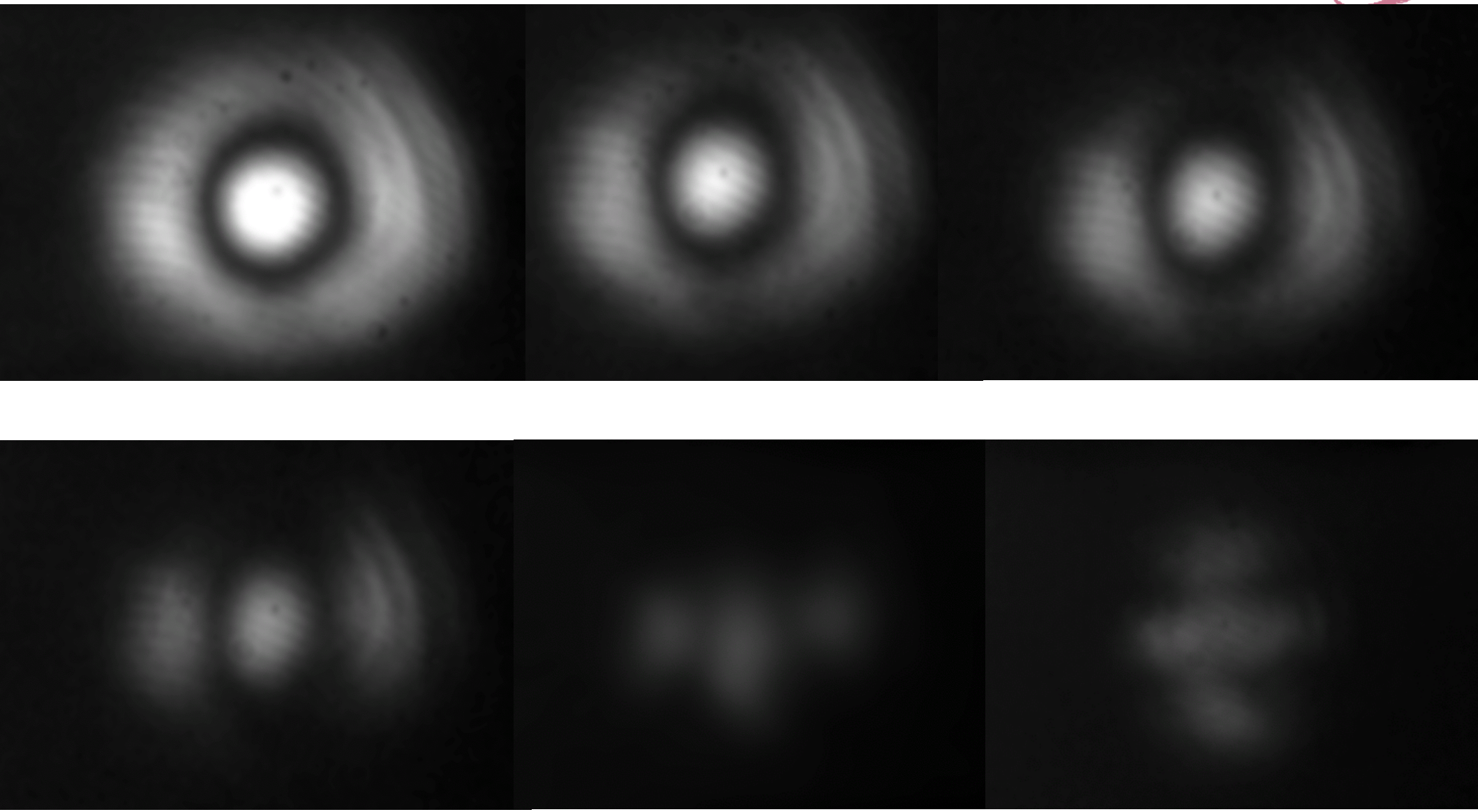


Thermal adjustment of ROC





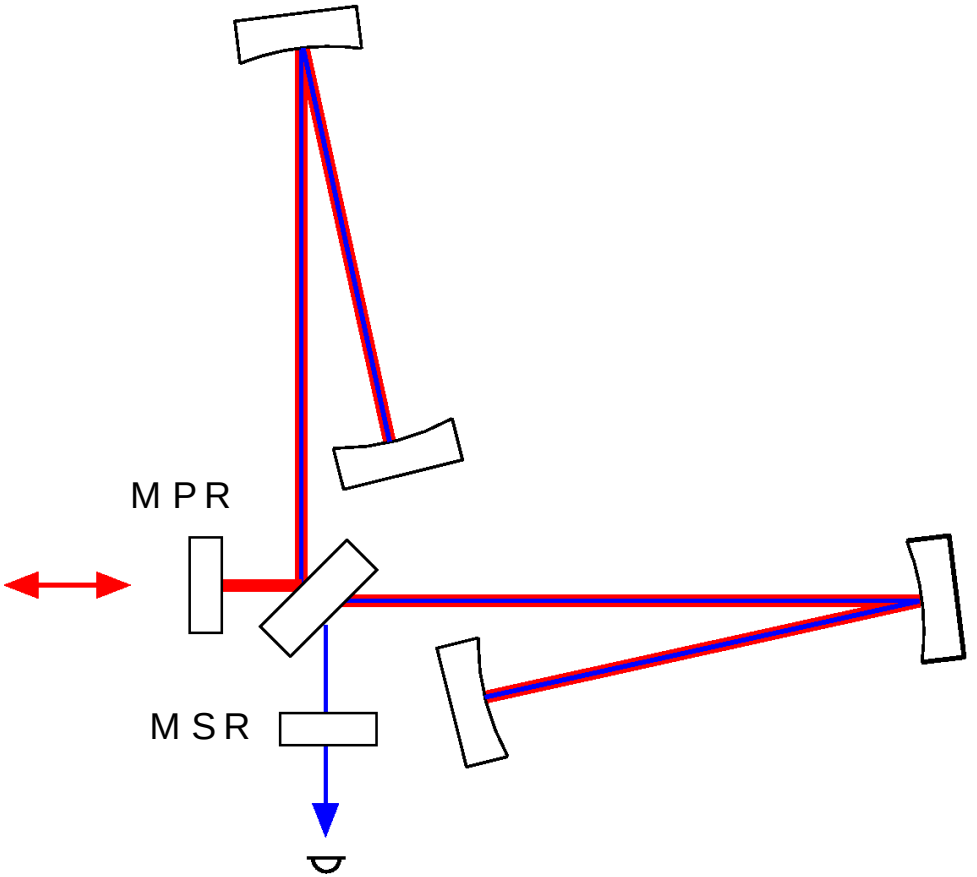
Heating Sequence



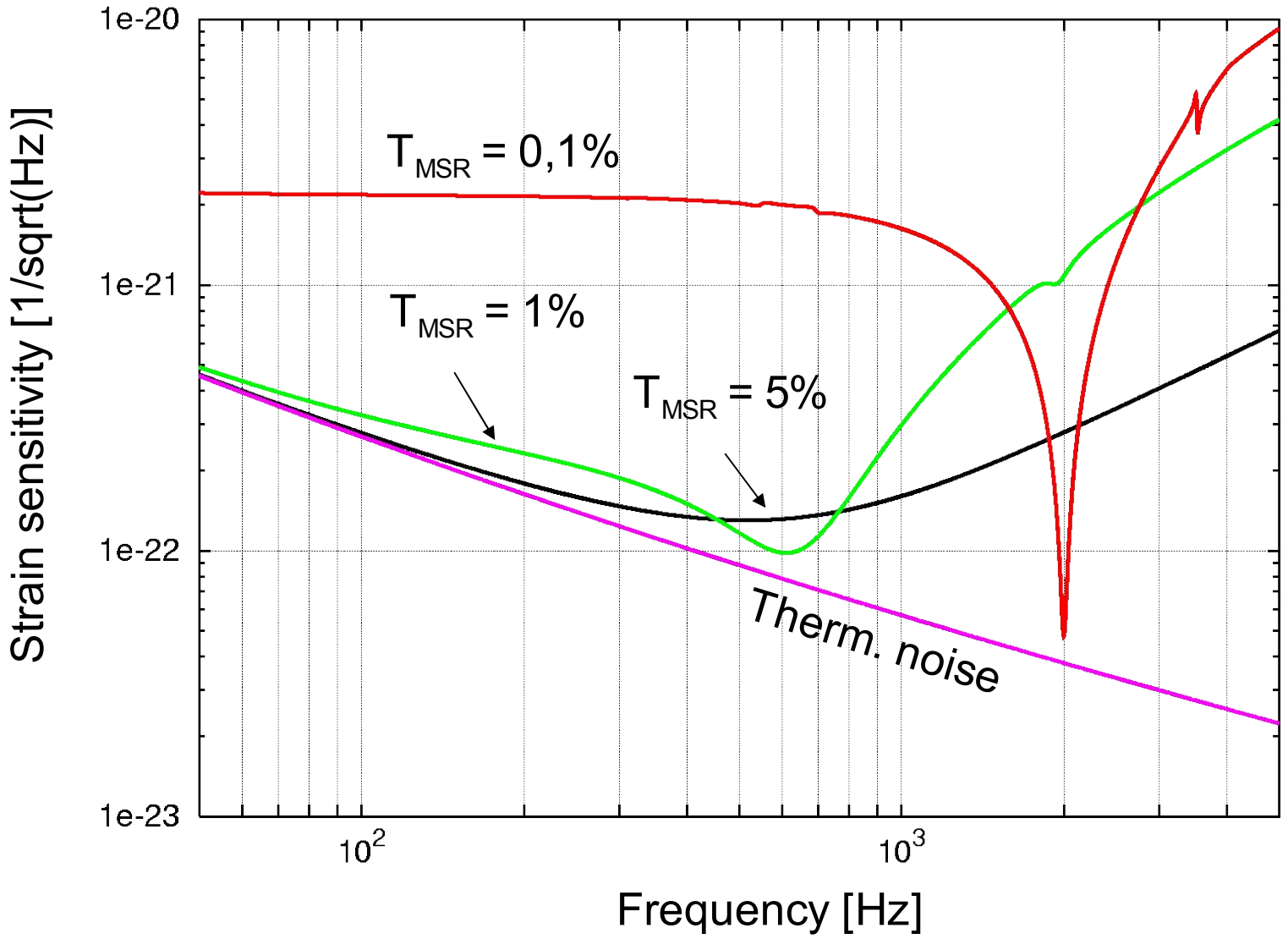
Dual Recycling Concept

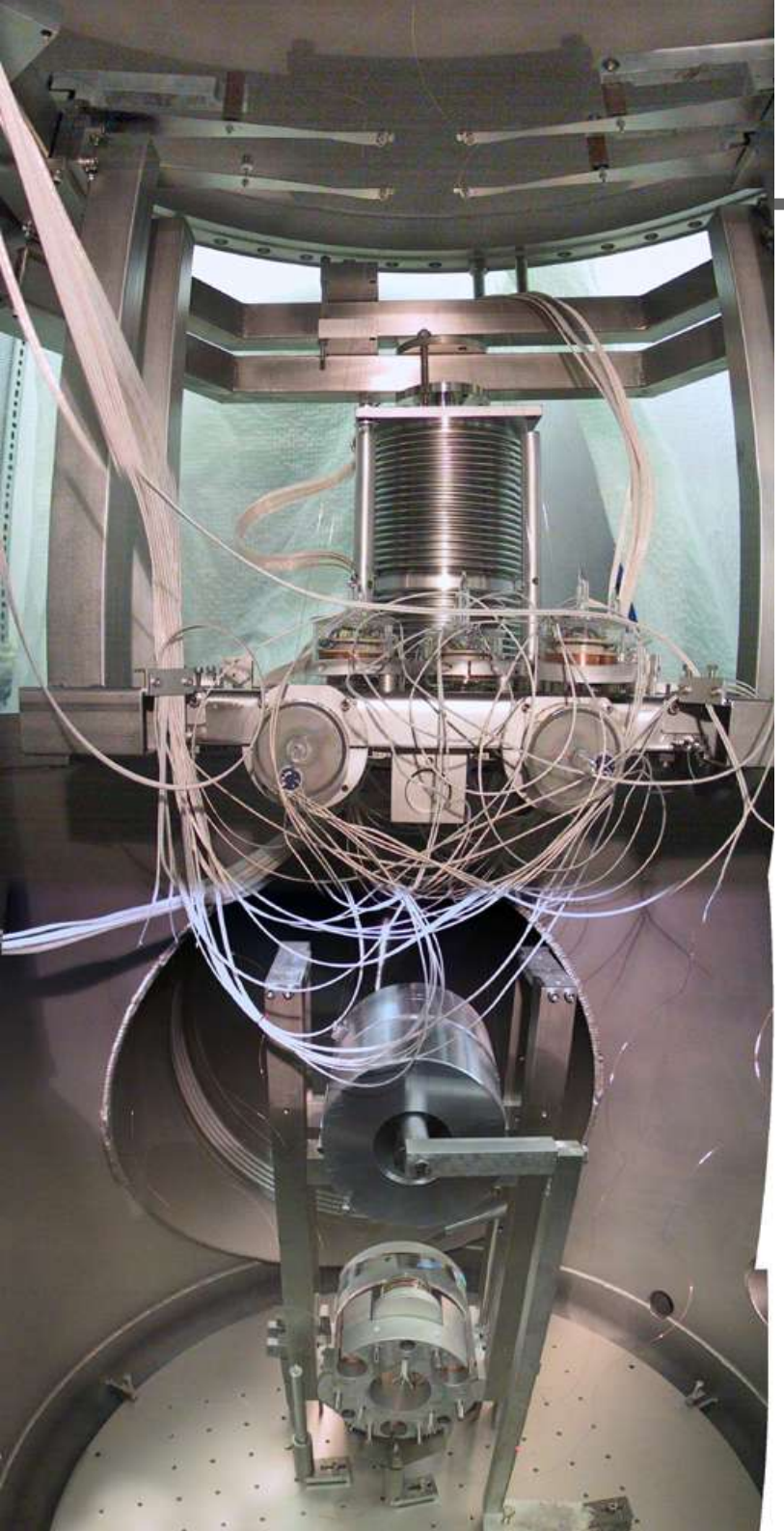
- two recycling cavities enhance independently the carrier light and the signal sidebands
- shot noise limited sensitivity is improved (typically by a factor of 10^2 to 10^3)

$$\mathrm{SNR}_{\mathrm{shot}} \approx \frac{4}{\sqrt{T_{\mathrm{MSR}} T_{\mathrm{MPR}}}}$$



Adjustable Sensitivity

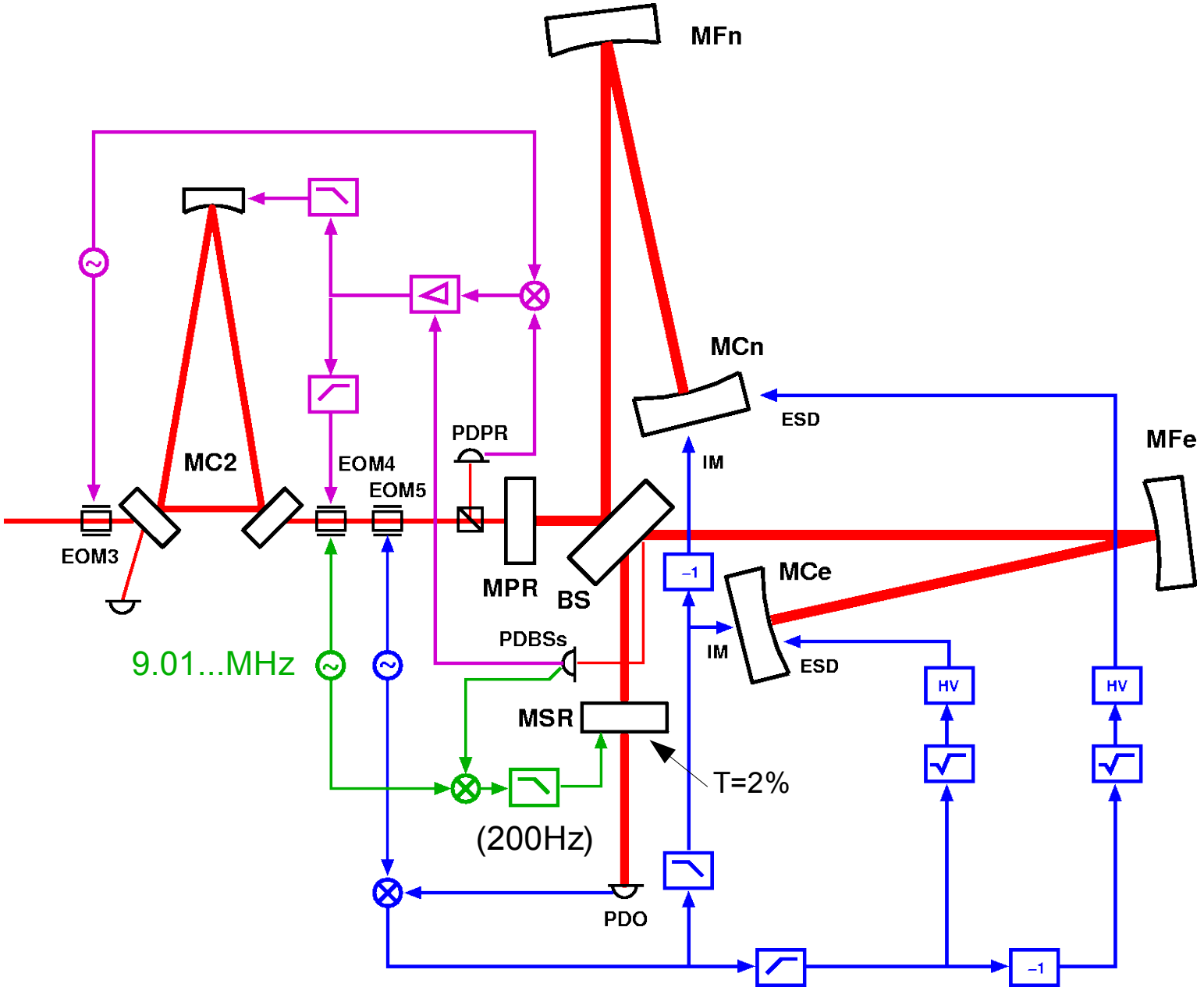




Signal Recycling

- Mirror Transmissivity = 2%
- Coil/magnet actuation directly to mirror
- Triple pendulum suspension with reaction pendulum chain
- Tunable between 550Hz and 5kHz

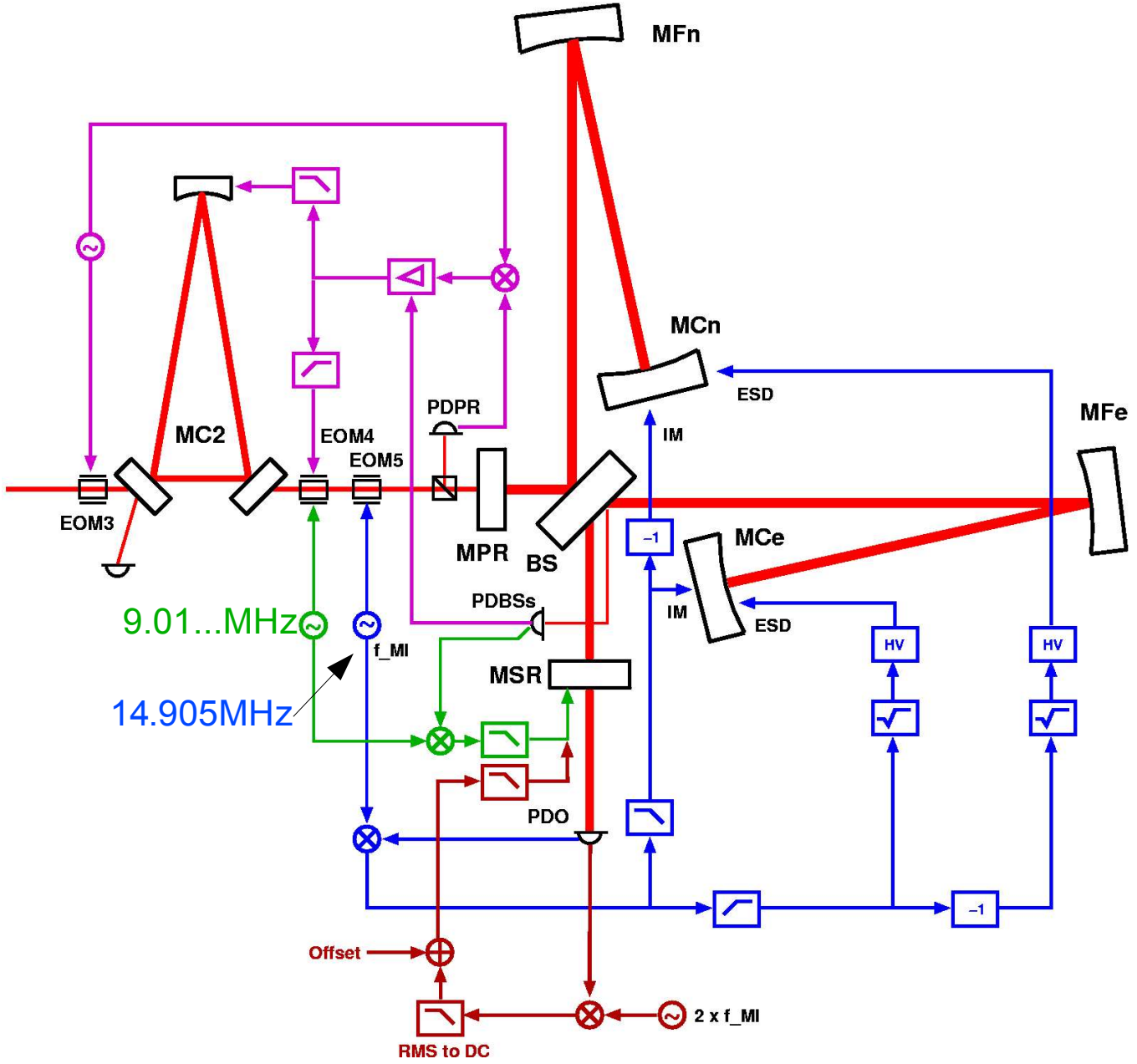
Dual Recycling Control



DR locking scheme

- Lock PR, then lock MI,
  while MSR is 'far' detuned (~5 kHz)
- Then directly locking MSR to SR-sideband signal
  works, but is practically not usable
- Need a more robust signal sensitive to MSR
  longitudinal position, usable for acquisition
- Use power around twice the MI modulation
  frequency ('2f') at dark port
- 2f signal also used for MI gain normalization

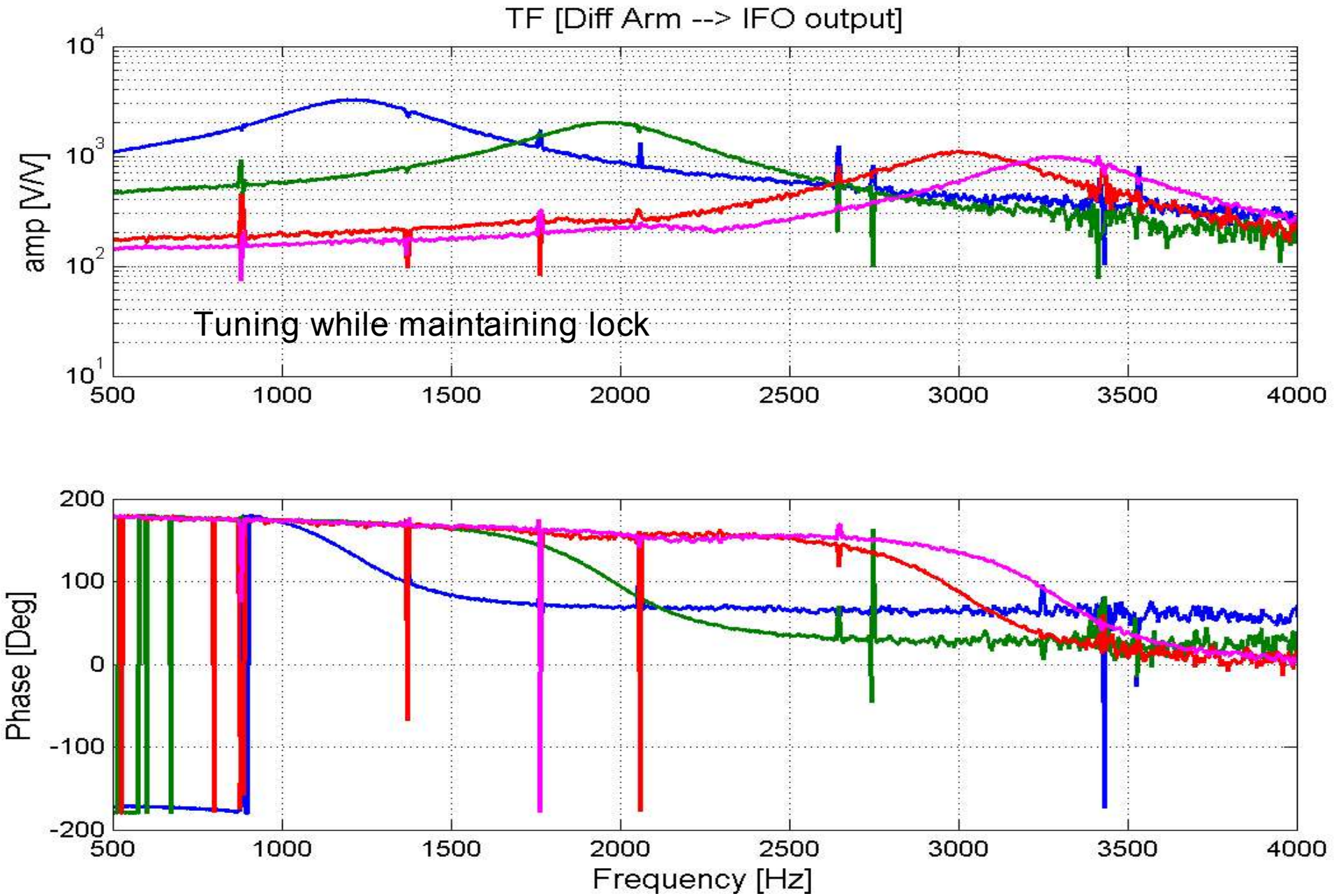
Acquisition of Dual Recycling



Complete DR locking sequence

- Lock PR, then lock MI (2f as normalization), lock MSR to 2f signal
- Switch on IM feedback and MI fast autoalignment
- Switch to SR-sideband signal
- Switch additional integrator for SR loop
- LabView-control starts tuning process with steps of 50Hz, while setting MI,SR phase and gain and MI alignment gain (lookup table)
- When tuning finished, switch to high power detector lock, enable MI + SR drift control
- More switching...

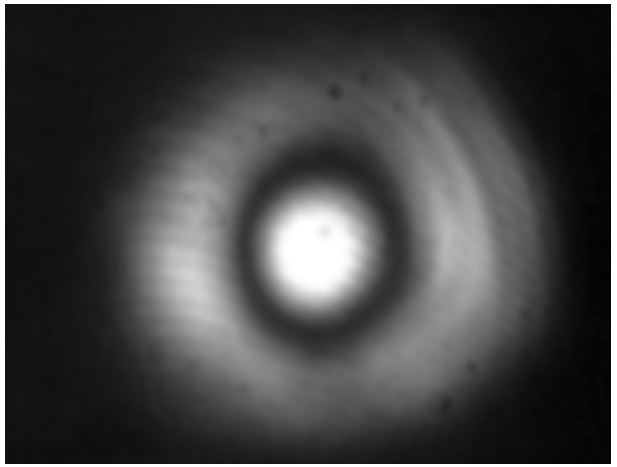
Tunable Optical Gain



Dark port contrast

-Ratio of carrier light power at dark port / power incident on beamsplitter

~ 1 %

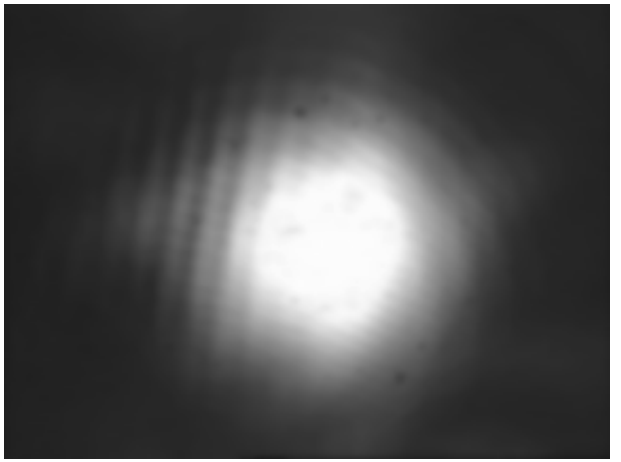


Power rec. MI.
without therm.
compensation

~ 0.05%

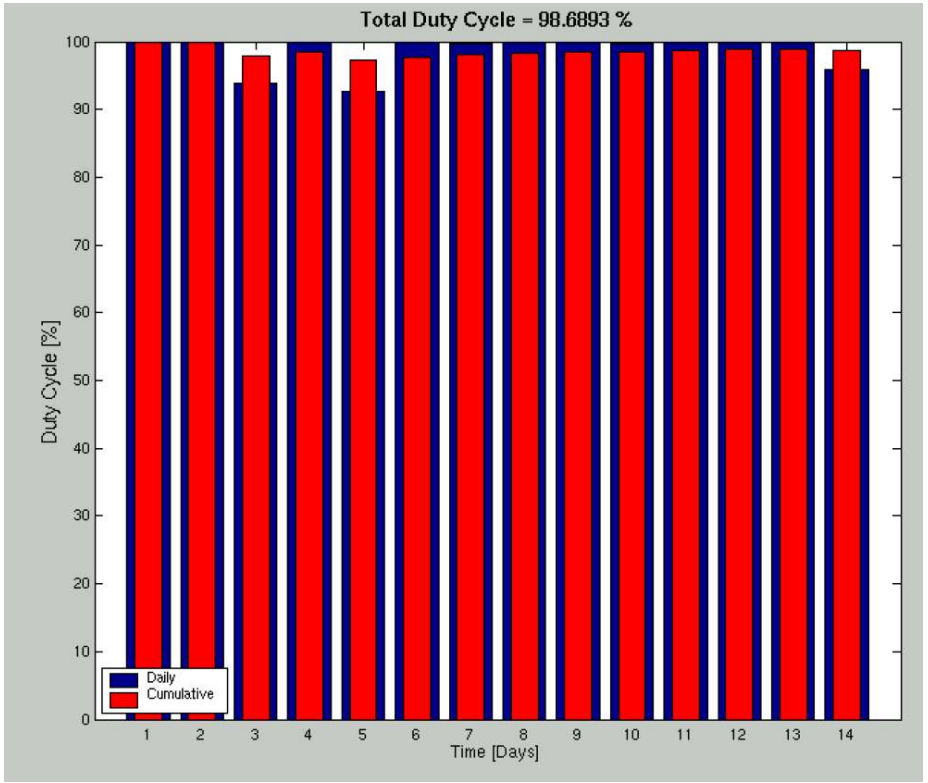
Power rec. MI
with therm.
compensation

< 0.001 %
(SB-dominated)



Dual rec. MI
with therm.
compensation

GEO600 - Participation in S3



S3 part I (7 days)
Nov 5th – Nov 12th

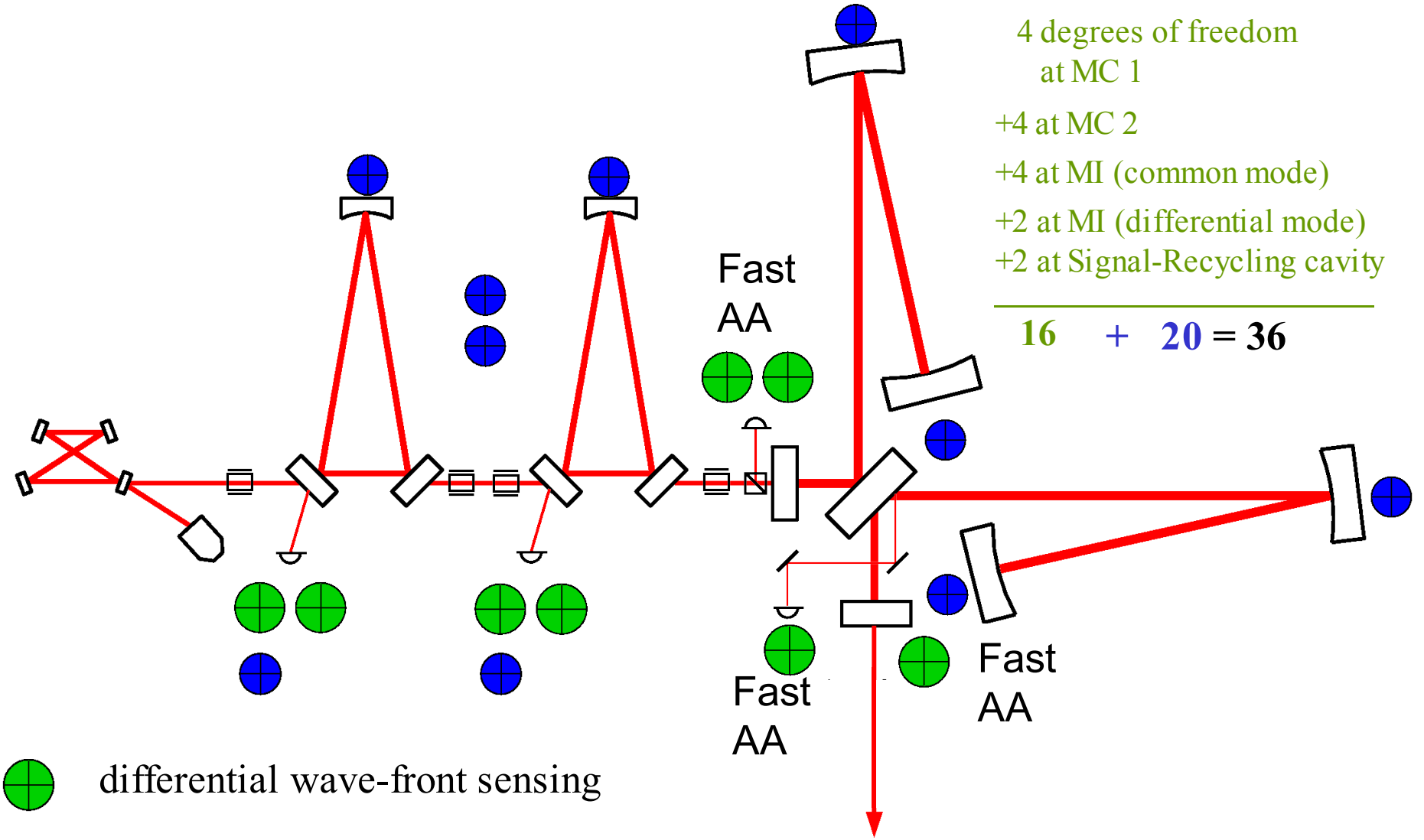
duty cycle > 95%
longest lock > 27h

S3 part II (14 days)
Dez 30th - Jan 13th

duty cycle > 98%
longest lock > 95h

followed by 2 days for burst and inspiral injections

Alignment Control



4 degrees of freedom
at MC 1

+4 at MC 2

+4 at MI (common mode)

+2 at MI (differential mode)

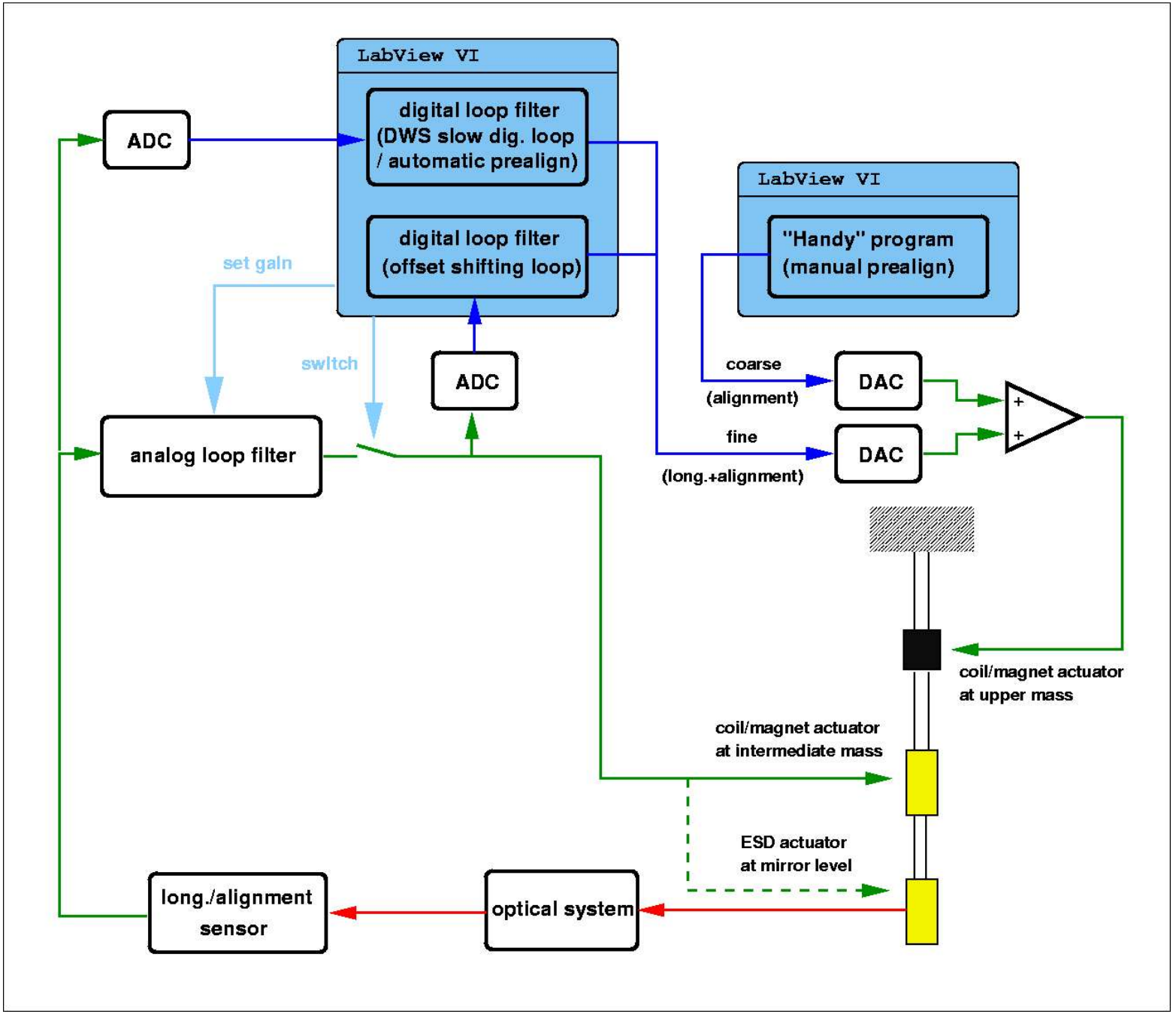
+2 at Signal-Recycling cavity

16 + 20 = 36

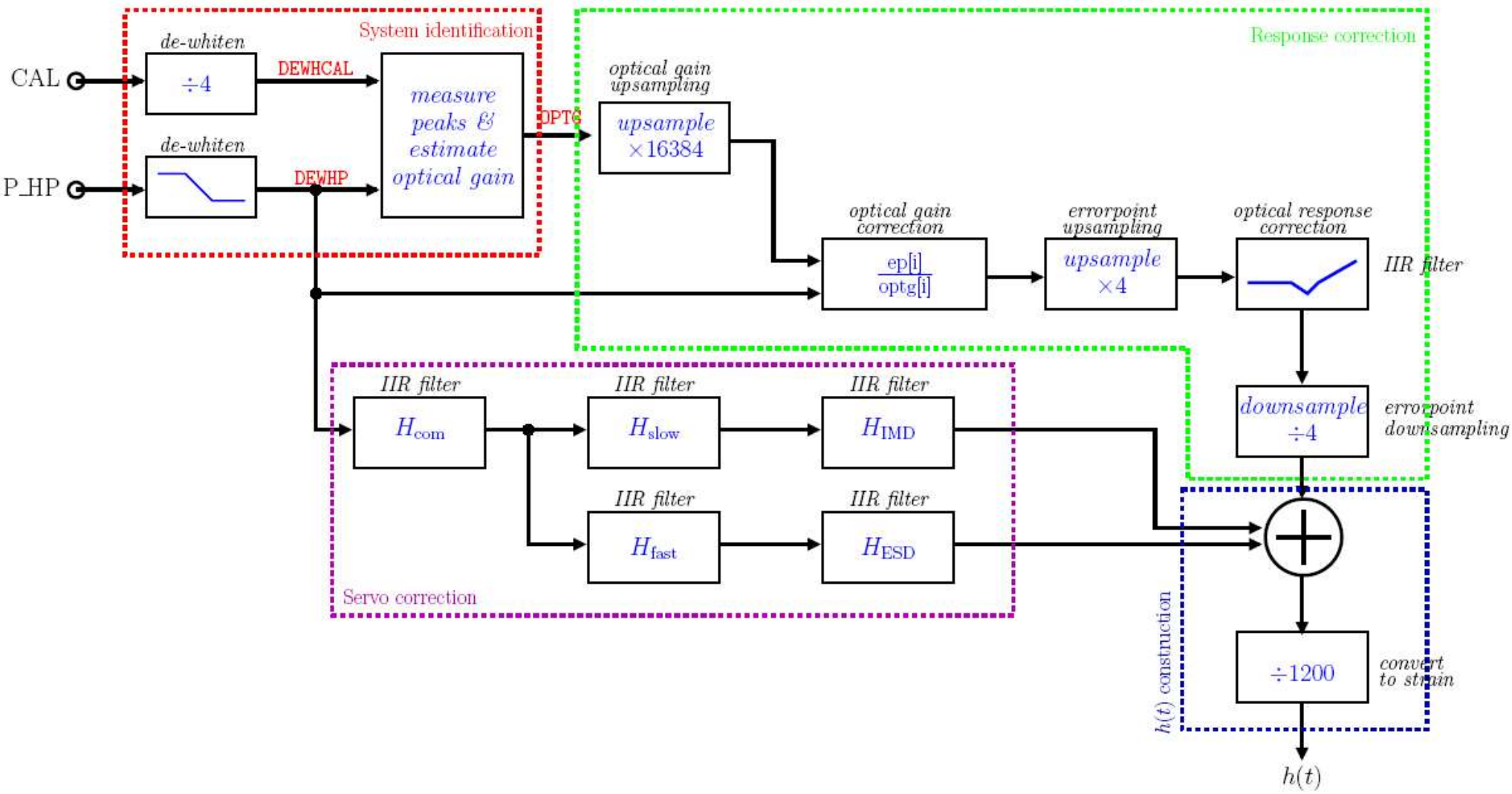
differential wave-front sensing

spot position control (< 0.1Hz)

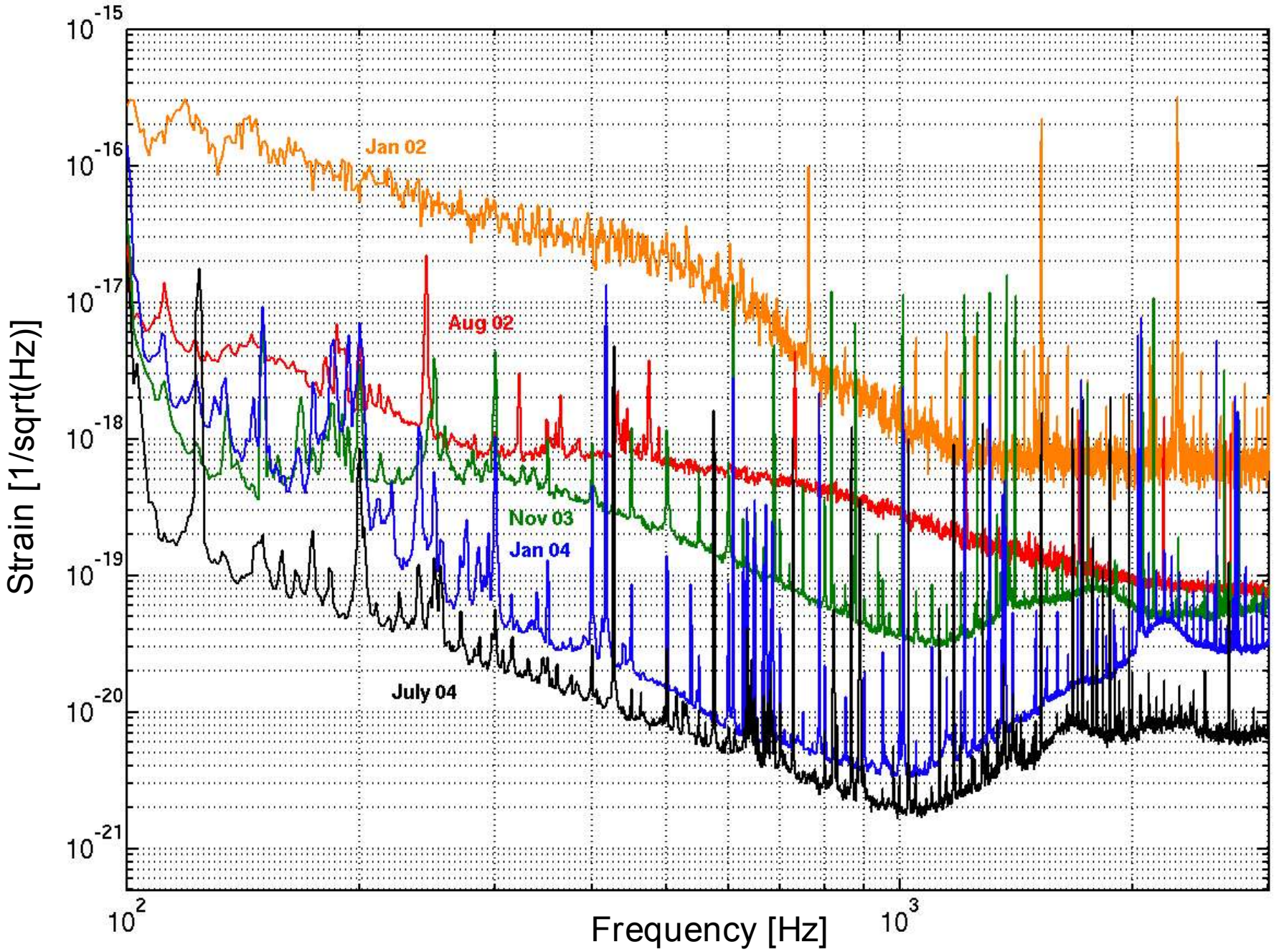
LabView Control - Example



DR Michelson Online Calibration



Sensitivity Development

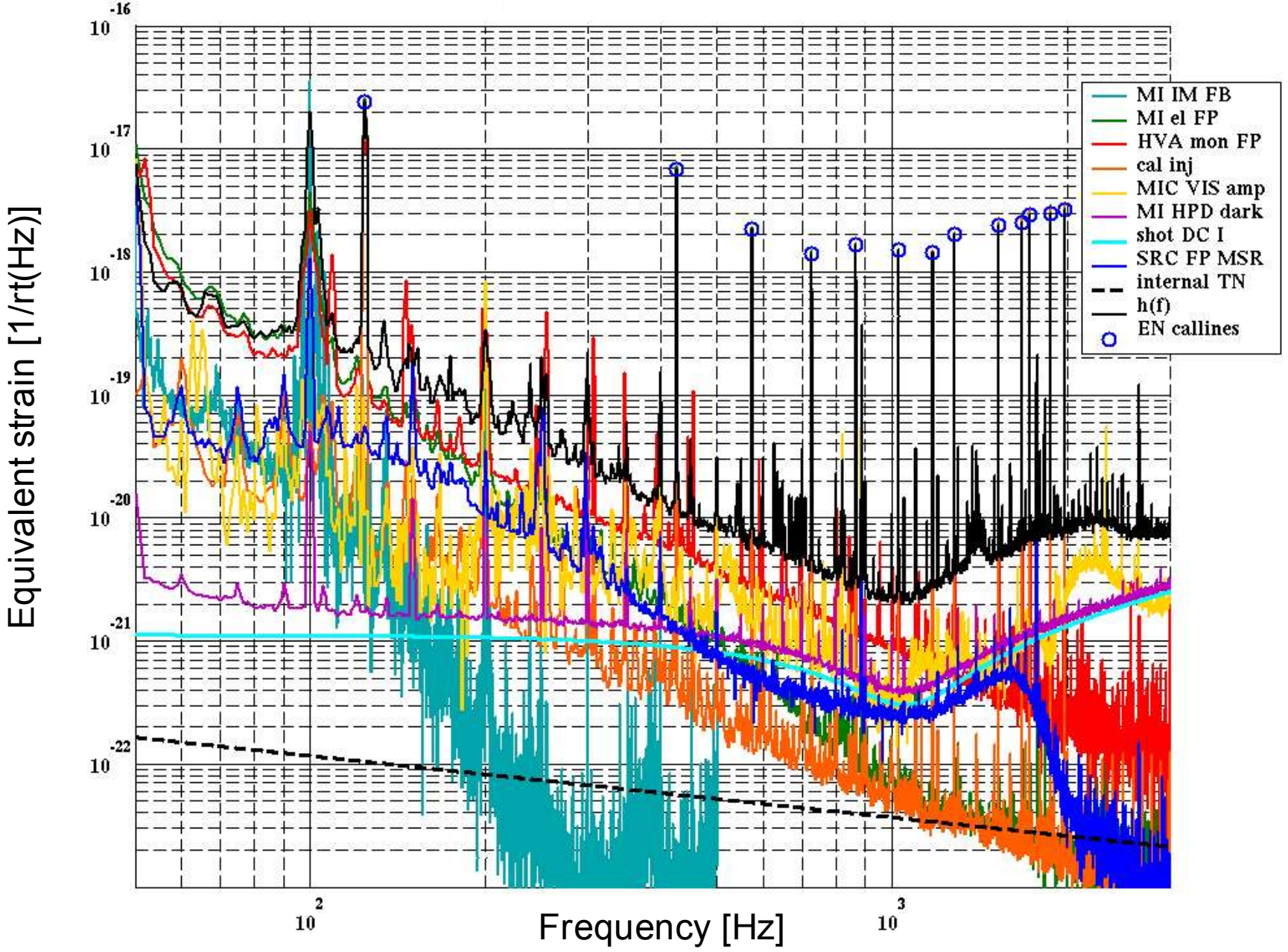


Jan. 2002

Aug. 2002
Nov. 2003
Jan. 2004

July 2004

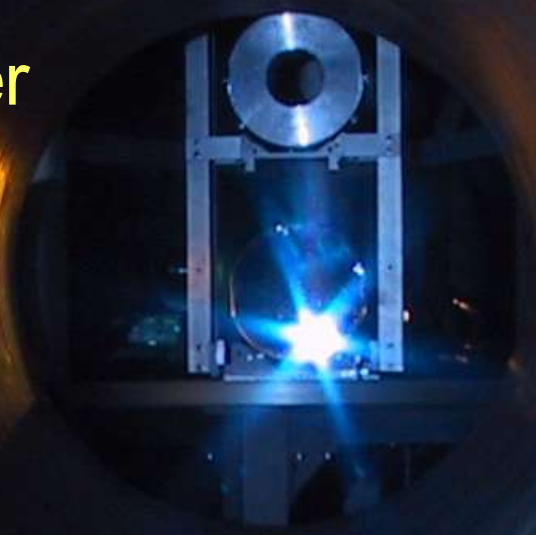
Some known noise sources



Status Summary

- GEO uses Dual recycling, monol. Susp., and ESDs with triple pendulums
- New DR lock acquisition scheme ('2f'-offset signal)
- Autoalignment for all DOF (including SR)
- Use seismic feedforward,
  and thermal ROC compensation
- High duty cycle (S3 II: >98% - 14 days)
- Current peak strain sensitivity: 2e-21/ rt(Hz) @ 1kHz

Ongoing and Future



- Installation of output optics and high-power detector in (pre-) vacuum (now)
- Identify and eliminate noise sources
- When shot-noise limited:
  - Increasing laser power (by ~5 x)
  - Increasing power rec. factor (by ~10 x)
- Output modecleaner ?