Advanced Sensing & Controls for GEO-HF?

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AEI, Jan 2010

topics

- DC readout
- DWS -> beam centering sensing
  - PD circuits
- in-vacuum readout
- local control improvement
- seismic feedforward
- noise subtraction schemes
- Adaptive filtering? Wiener filtering?
- thermal comp. sensing & control?

DC readout

- from heterodyne to DC readout:
  - lower shot noise,
  - lower RF phase- and ampl. noise (was close to limiting),
  - easier power scaling
  - compatible with squeezing implementation
  - laser power dependence, autoalignment signal contamination

DC-Readout

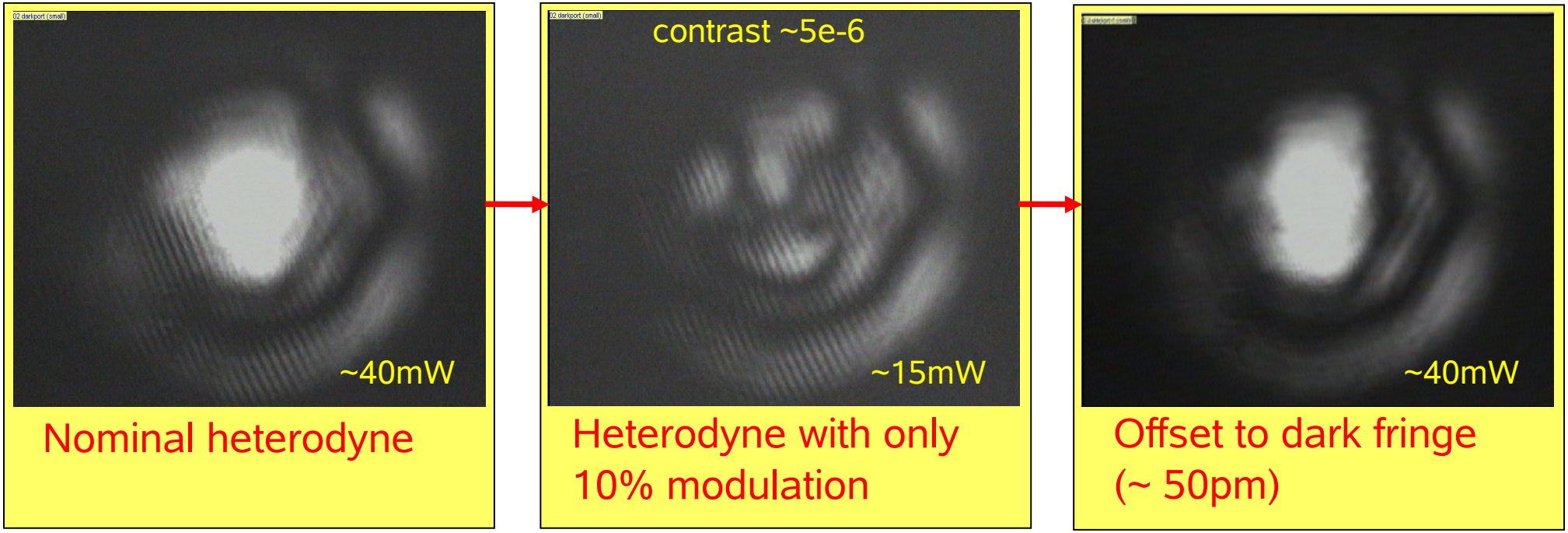
Turning down the RF-modulation (power) by factor 10

Applying offset from dark fringe *(~ 50pm)*

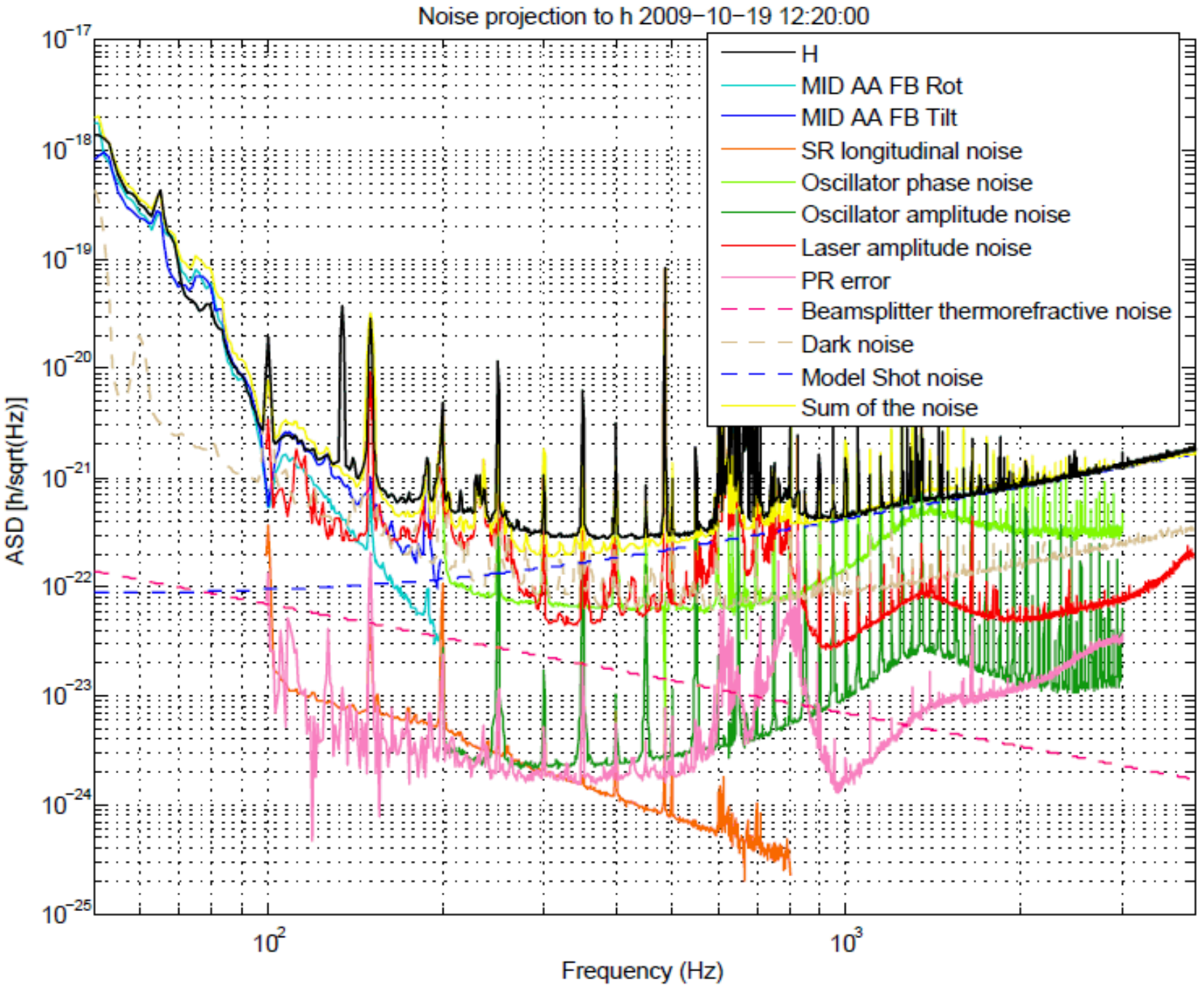
Dark port dominated by carrier light

<u>EXPERIMENT in GEO600:</u>

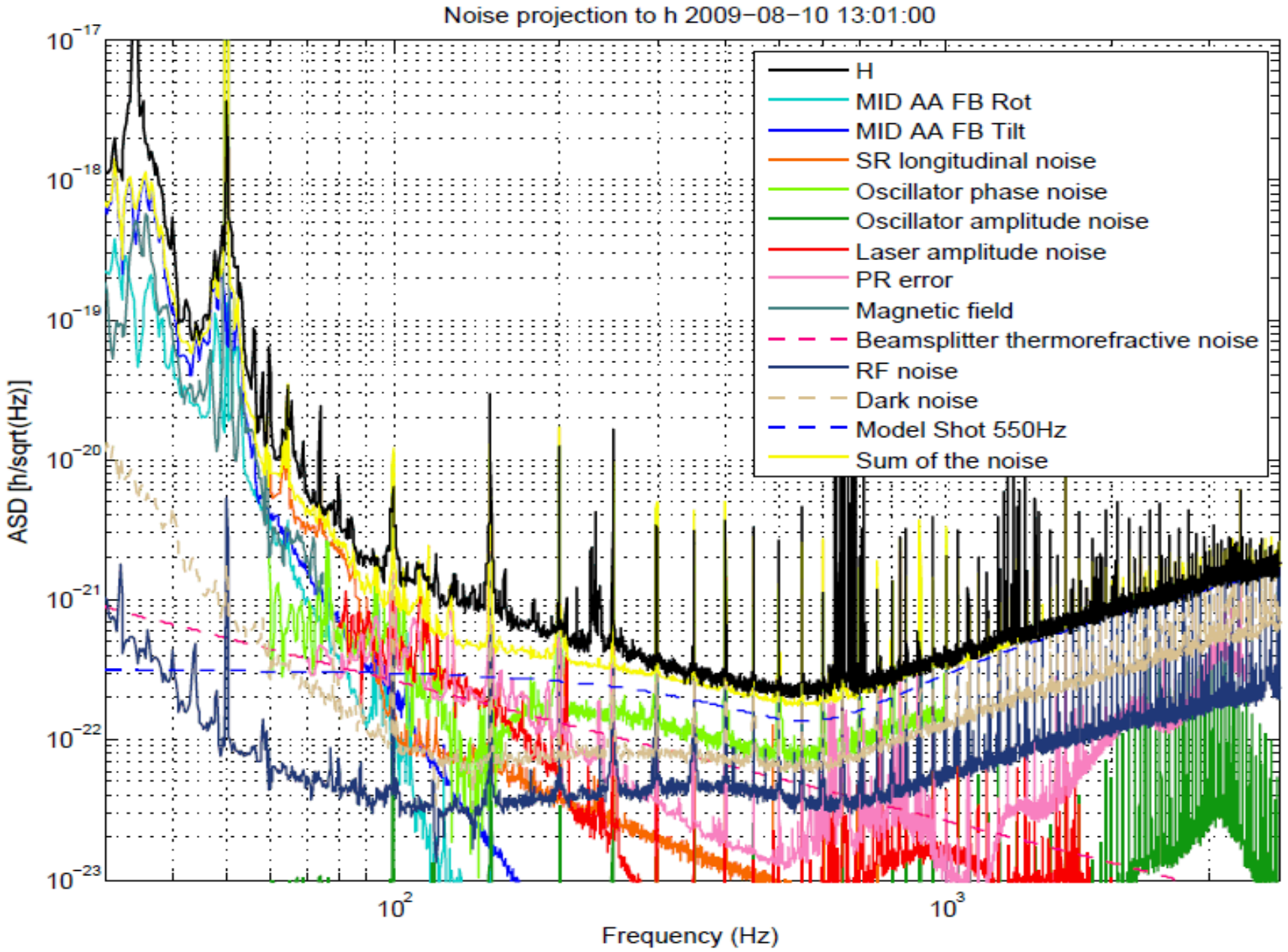
Locked to dark port power



Laser power coupling (DC)



Laser power coupling (het.)



DWS beam centering sensing / 2f-Beam Centering Technique

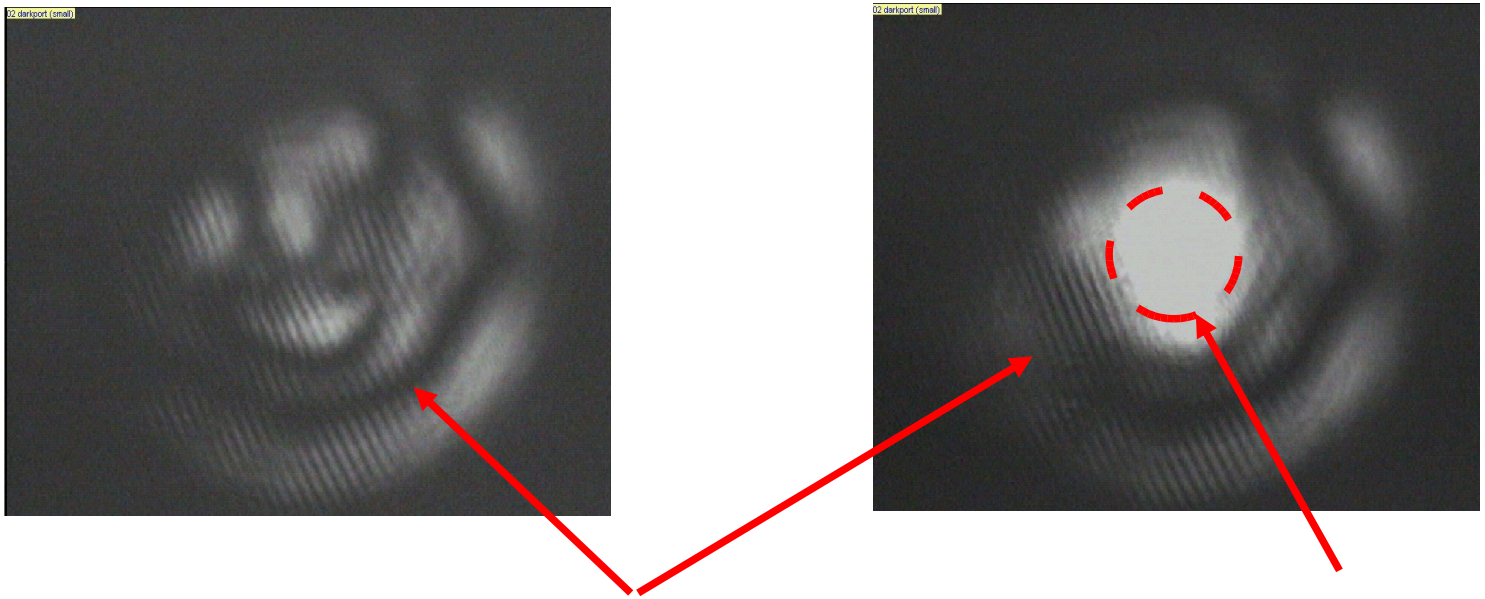
Problem:

A dark fringe offset (as needed for DC readout) introduces 1. order coupling of beam position on wavefront sensor to IFO alignment information.
-> Beam centering servo is highly desirable.

But: higher order modes from contrast defects are a poor reference

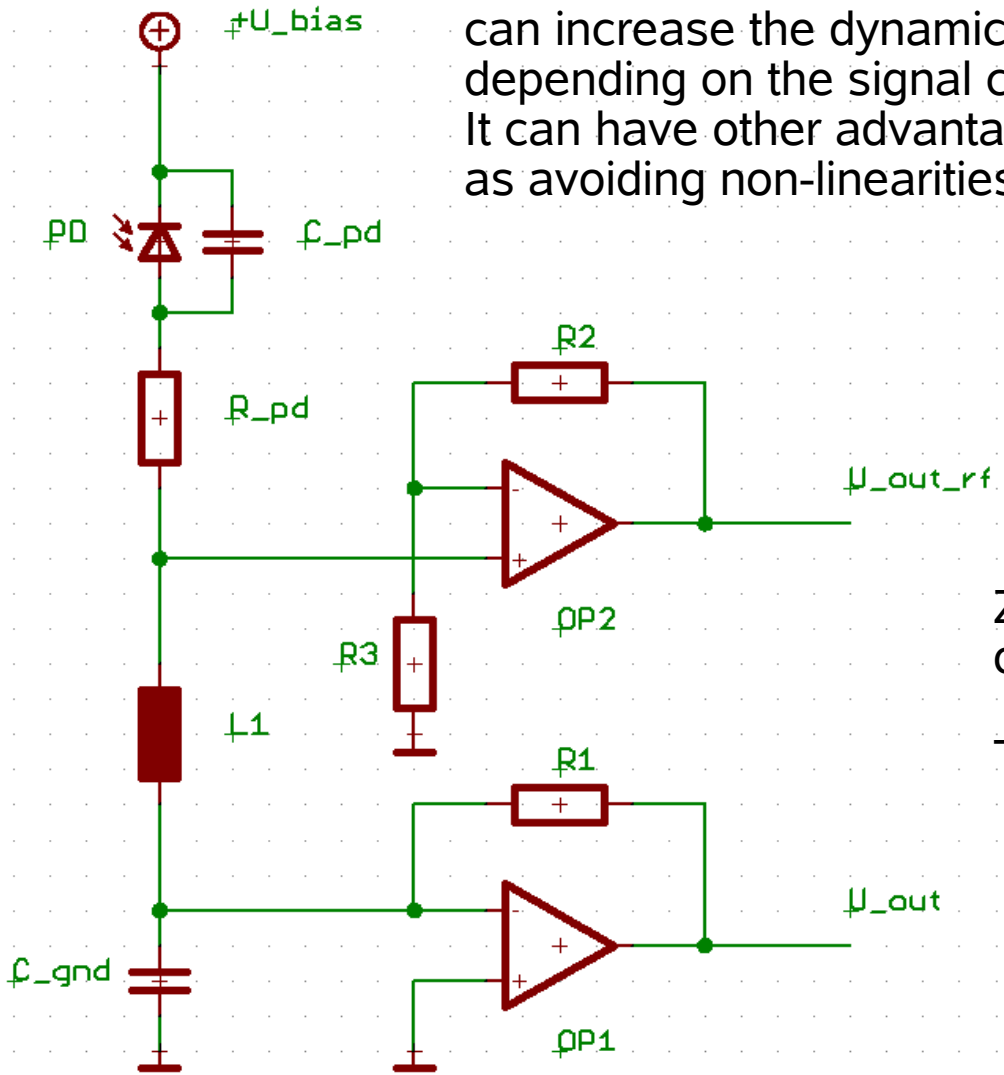
Idea:

Use modulation sideband power distribution as position information



J. Degallaix: 'Its bloody robust now...'

Resonant PD

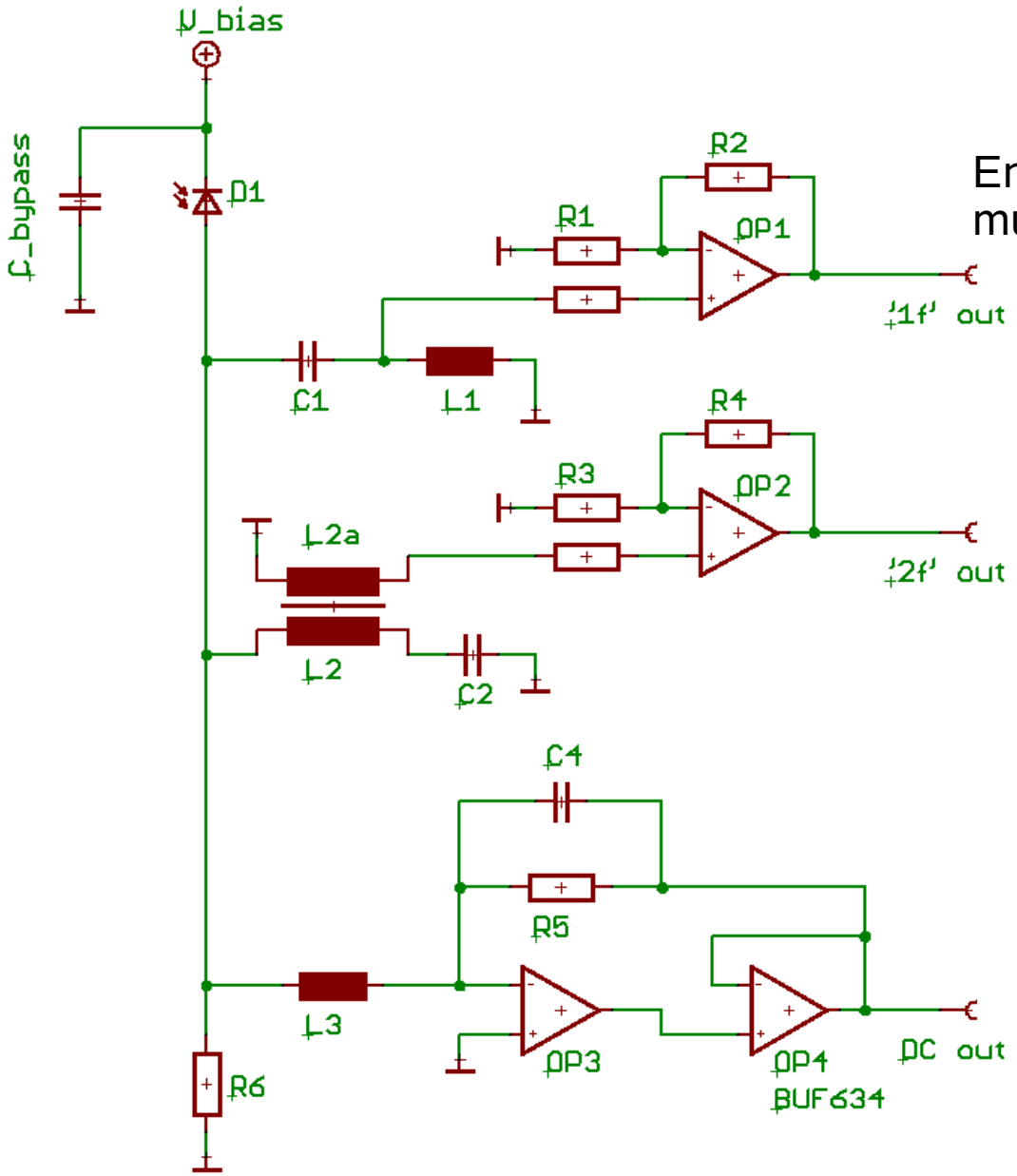


A resonant circuit around the PD (here: C_pd and L1)
can increase the dynamic range,
depending on the signal content.
It can have other advantages,
as avoiding non-linearities

Z = L1 / (R_pd * C_pd)
on resonance

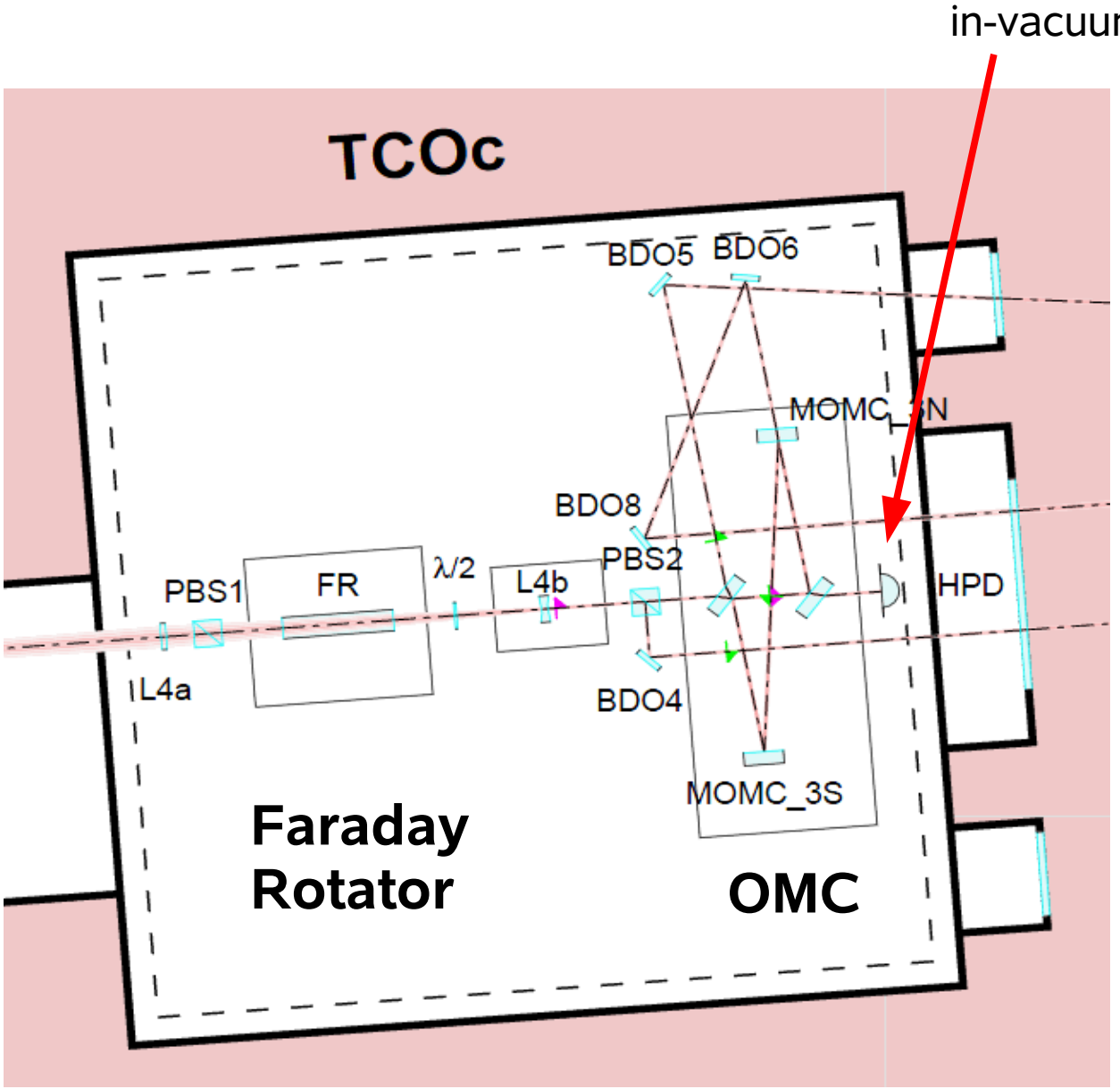
Thermal noise according to Z

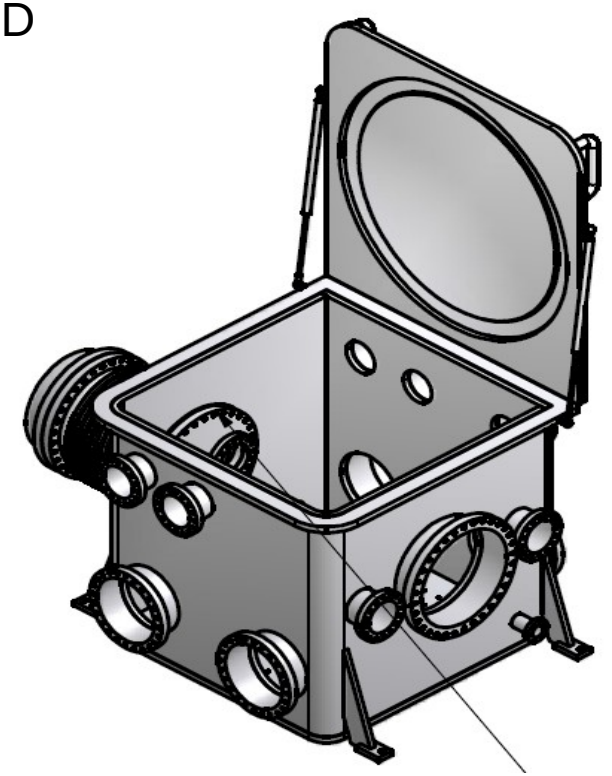
New style GEO PD circuit



Enhanced dynamic range, multiple resonant outputs

In - Vacuum Readout





in-vaccum readout for DC only.

GEO-HF: 1 or 2 PD's,
50-200mW

PD'S in vacuum

why?
acoustic / vibration coupling to beam jitter on PD.
Jitter can couple to photocurrent and to back-scattering.

- PD only, DC only (needs low-noise feedthrough, GEO-HF)
- PD & pre-amp, DC only (enh.&adv. LIGO)
- PD only, RF (adv. LIGO)
  - also quad-PDs with RF
  - RF needs impedance matched feedthrough design.

Take care of sufficient heat-sinking

Local control improvement

- modulation of local control shadow sensors
- perhaps digital filters
  (new tiny digital control system?)

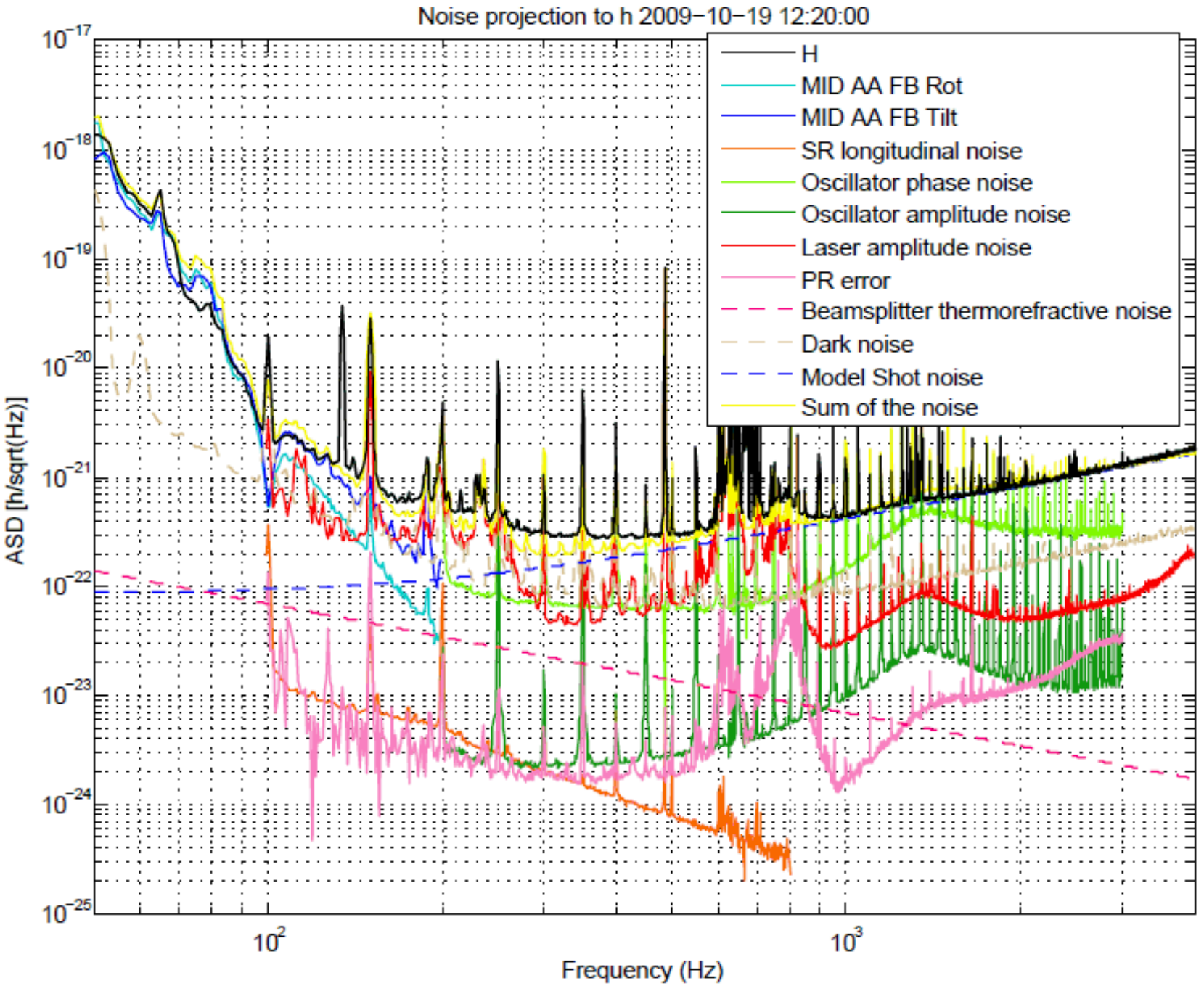
Seismic feedforward

- Revival of seismic feedforward: focus on 1-3Hz range, where less dynamic range is needed.
- STS2 -> CDS -> Stack PZT's
- Optional: STS -> CDS -> ISC

Noise subtraction schemes

- We have: 'IM feedforward'
- We may need:
  - MI AA feedback noise subtraction
    - 1.: in hardware
    - 2.: in software (post-processing)

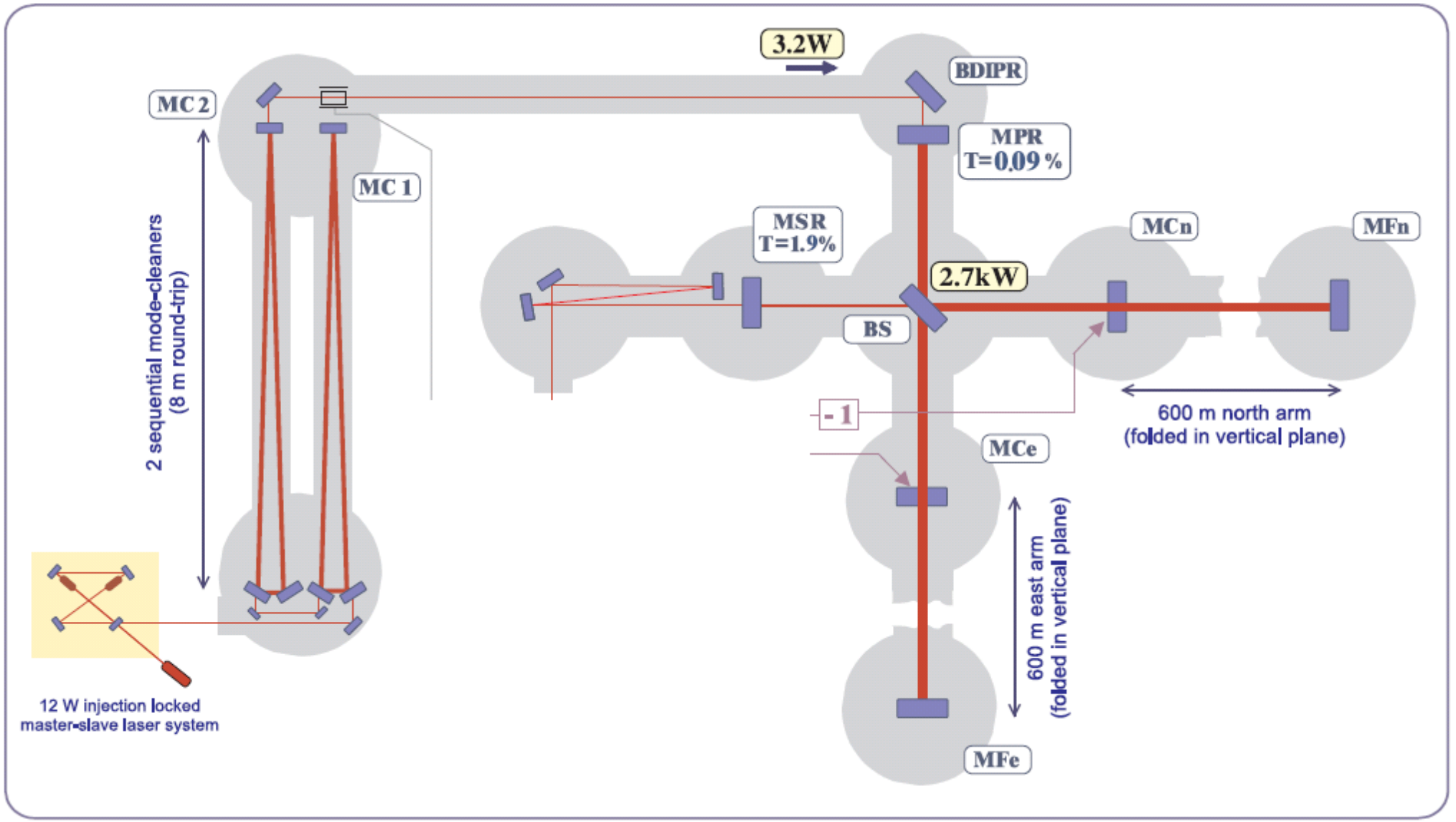
Low freq: alignment noise



Advanced Controls

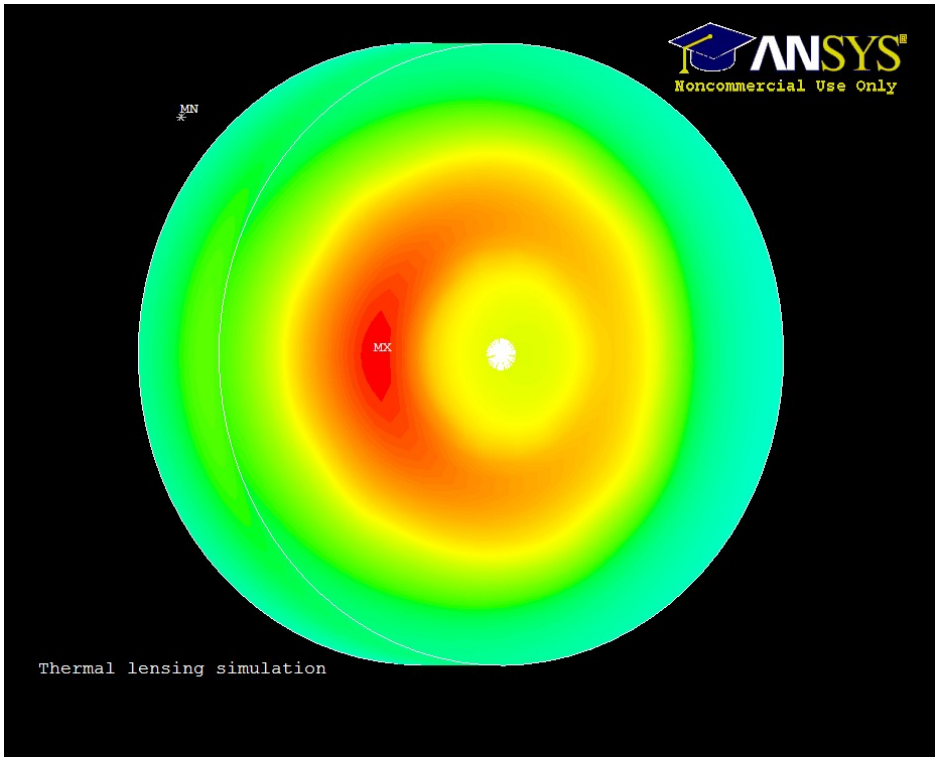
- Adaptive filtering?
  - perhaps for varying seismic conditions
  - perhaps to track slightly shifting resonances with notch filters
- Wiener filtering

The GEO600 Interferometer

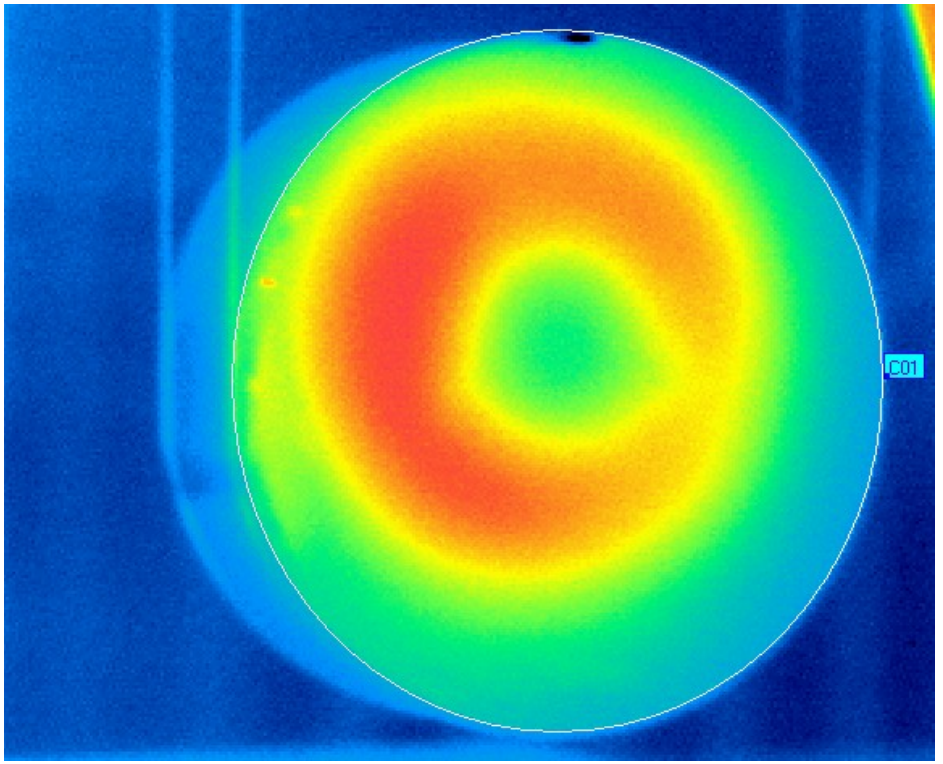


TCS: Proof of Principle

Simulated heating profile
In vacuum



Measured heating profile
in air

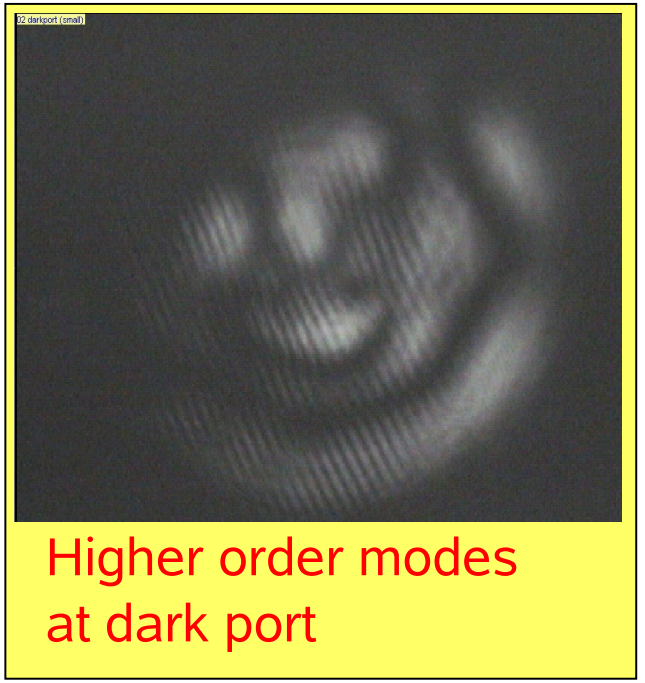


Wittel/Degallaix

Thermal comp. sensing&control

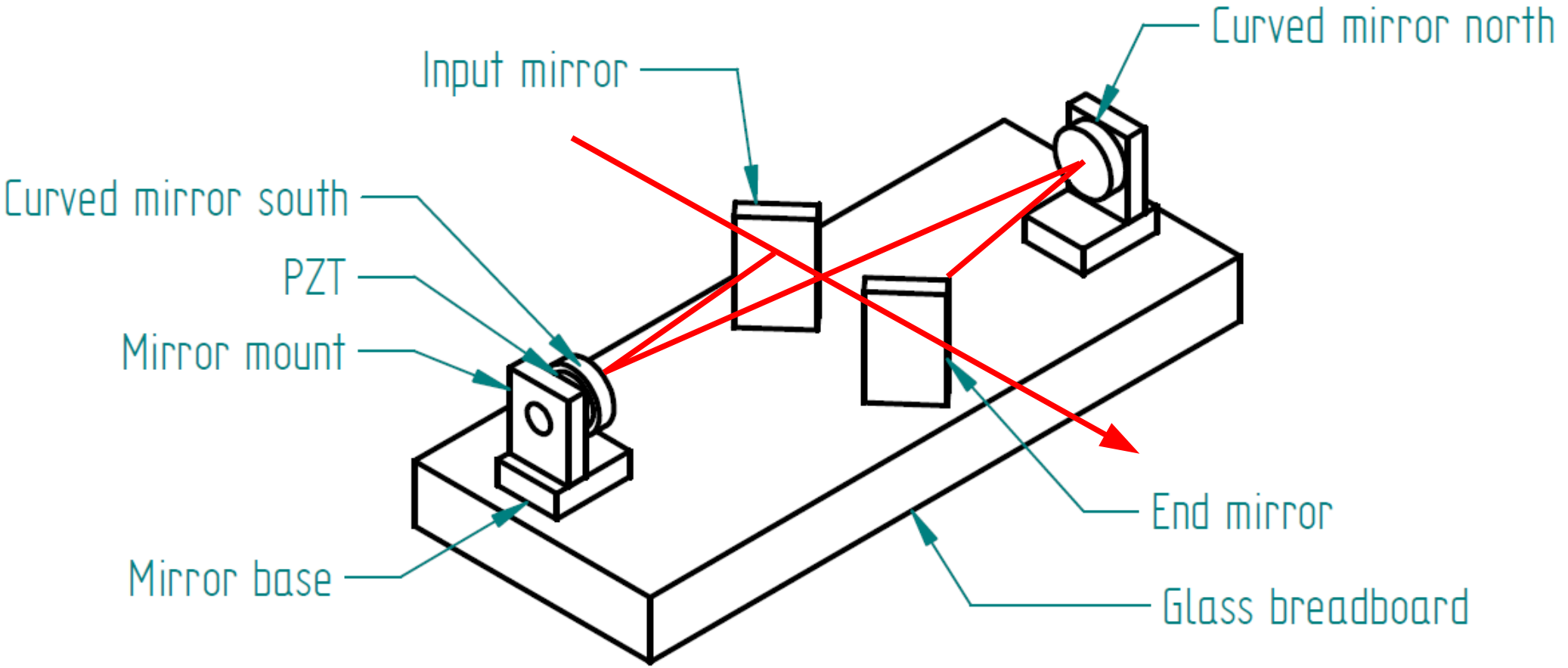
Problem: „Kartoffelacker“ is a function of total power (thermal lensing, mainly in BS).

Solution: Thermal compensation system tracks power in IFO.
Perhaps with sensing dark port beam (high-res. DWS) and feedback control.



Higher order modes
at dark port

GEO - OMC


Curved mirror north
Input mirror
Curved mirror south
PZT
Mirror mount
End mirror
Mirror base
Glass breadboard