Power Stabilization of the 35W Reference System

Frank Seifert, Patrick Kwee,
Benno Willke, Karsten Danzmann

Max-Planck-Institute for Gravitational Physics
(Albert-Einstein-Institute)

University of Hannover

LSC Caltech, March 19th, 2008

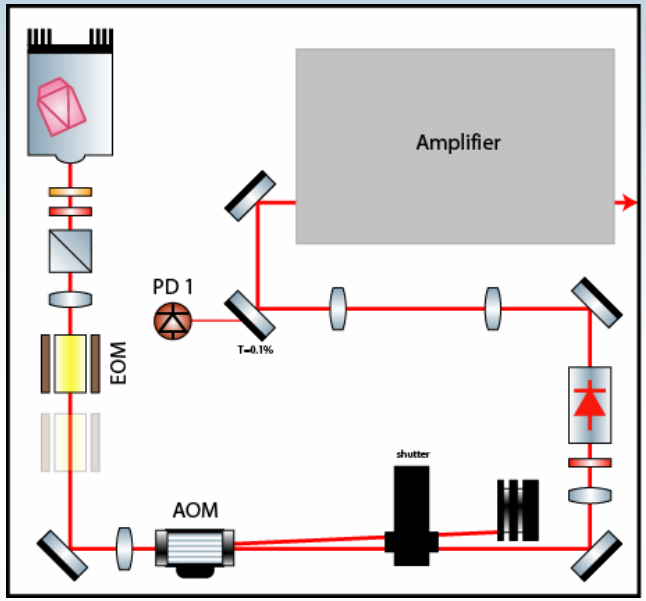
LIGO-G08xxxx-xx

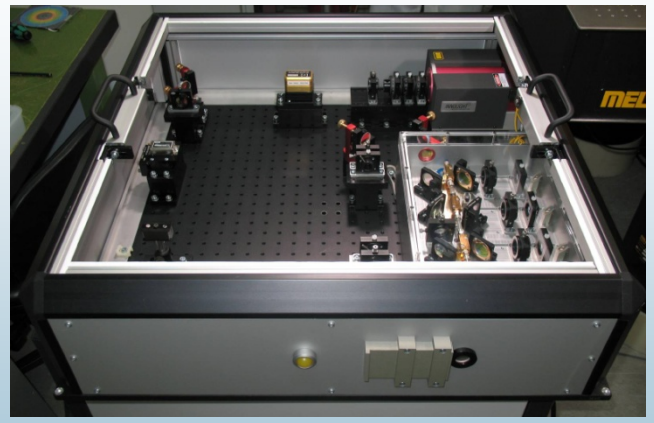
Max Planck Institute
for Gravitational Physics
(Albert Einstein Institute)

Leibniz
Universität Hannover
Institut für Gravitationsphysik

35W Laser Overview

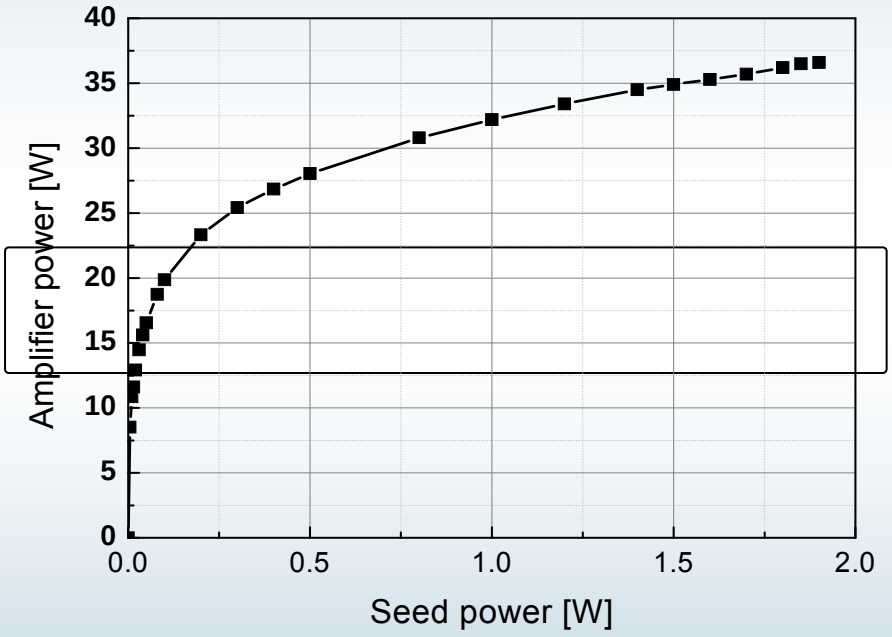
- Design & fabrication by LZH
- 2W NPRO seed laser
- 4-stage Nd:YVO amplifier
- > 35 W output power
- Assembled on breadboard in single housing
- AOM, EOM, isolator, and shutter included
- Running 24/7 @ AEI since 12/07

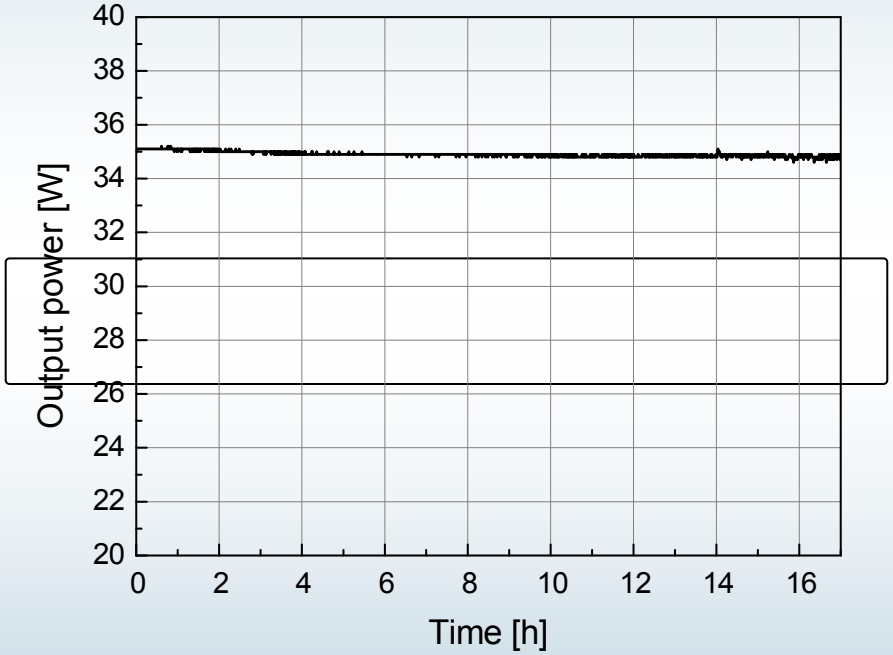




- More details see Saschas talk „ELIGO Laser„ wednesday afternoon

35W Laser Performance

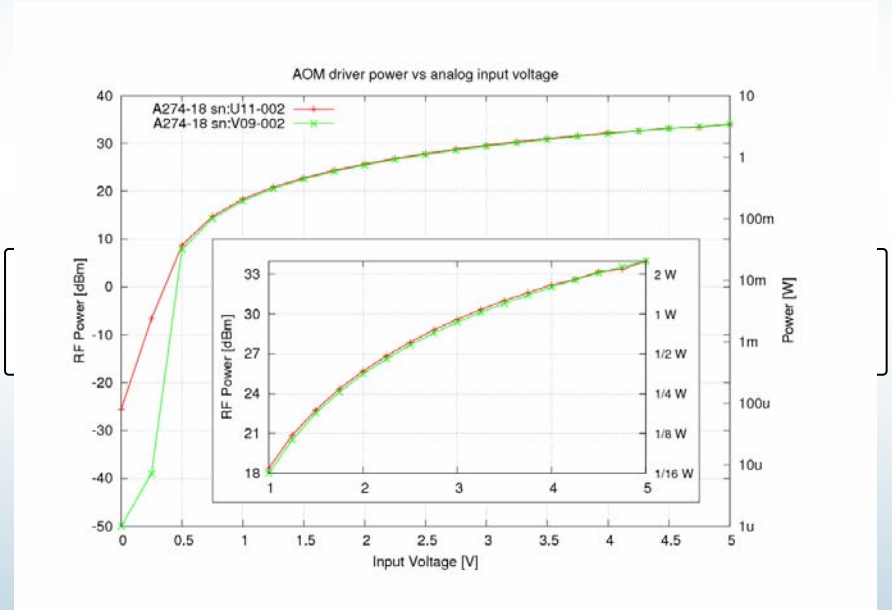


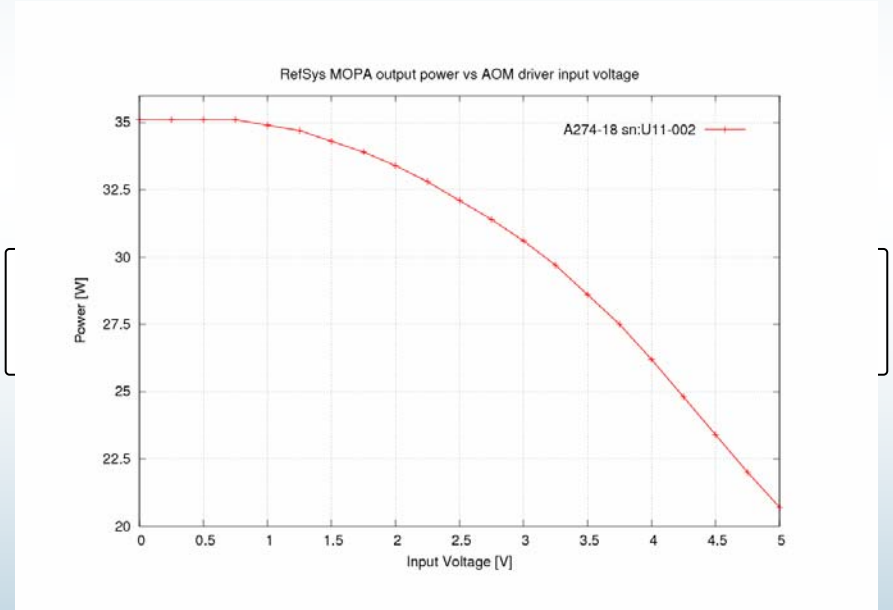


- More details (spatial profile etc.) see Saschas talk „ELIGO Laser„ wednesday afternoon

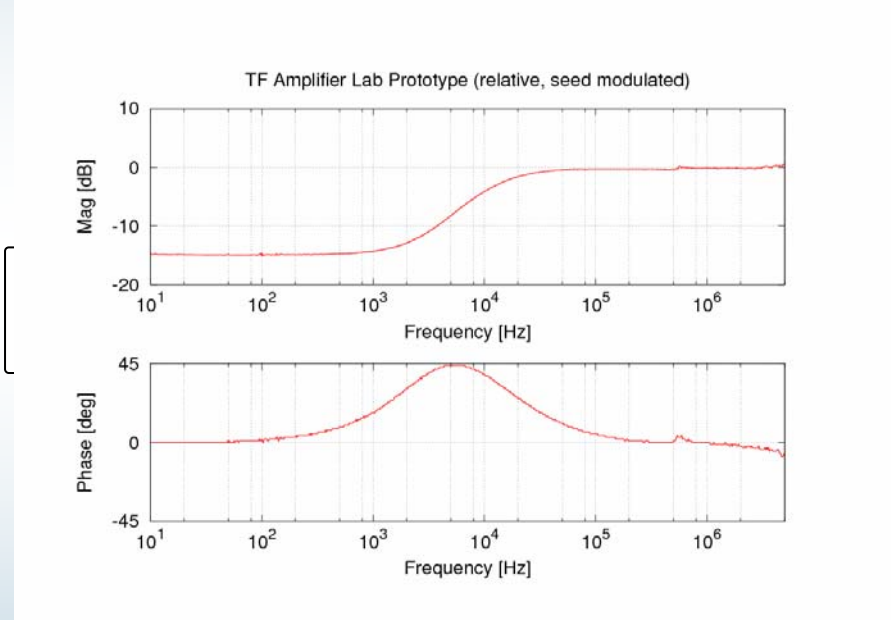
Power Actuators I : AOM

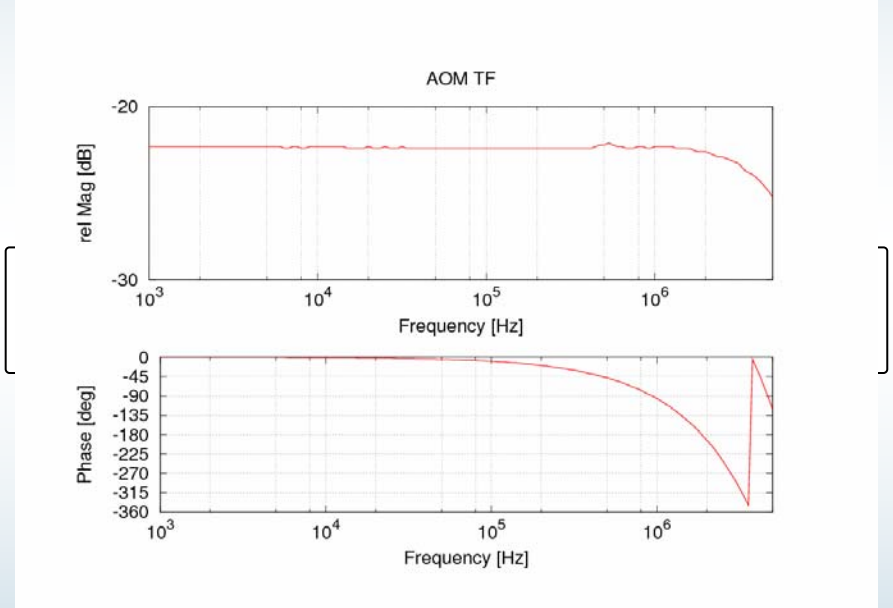
- AOM: Crystal Technology 3080-194
- Driver: Landwehr A274-18 (80MHz, 5W max)





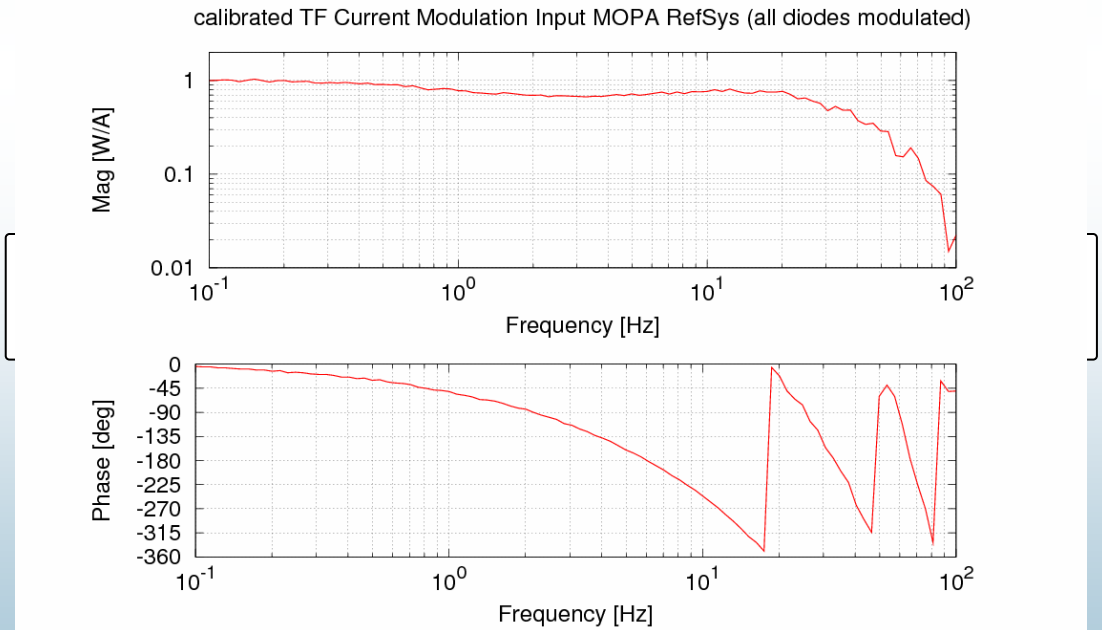
Power Actuators I : AOM (cont.)



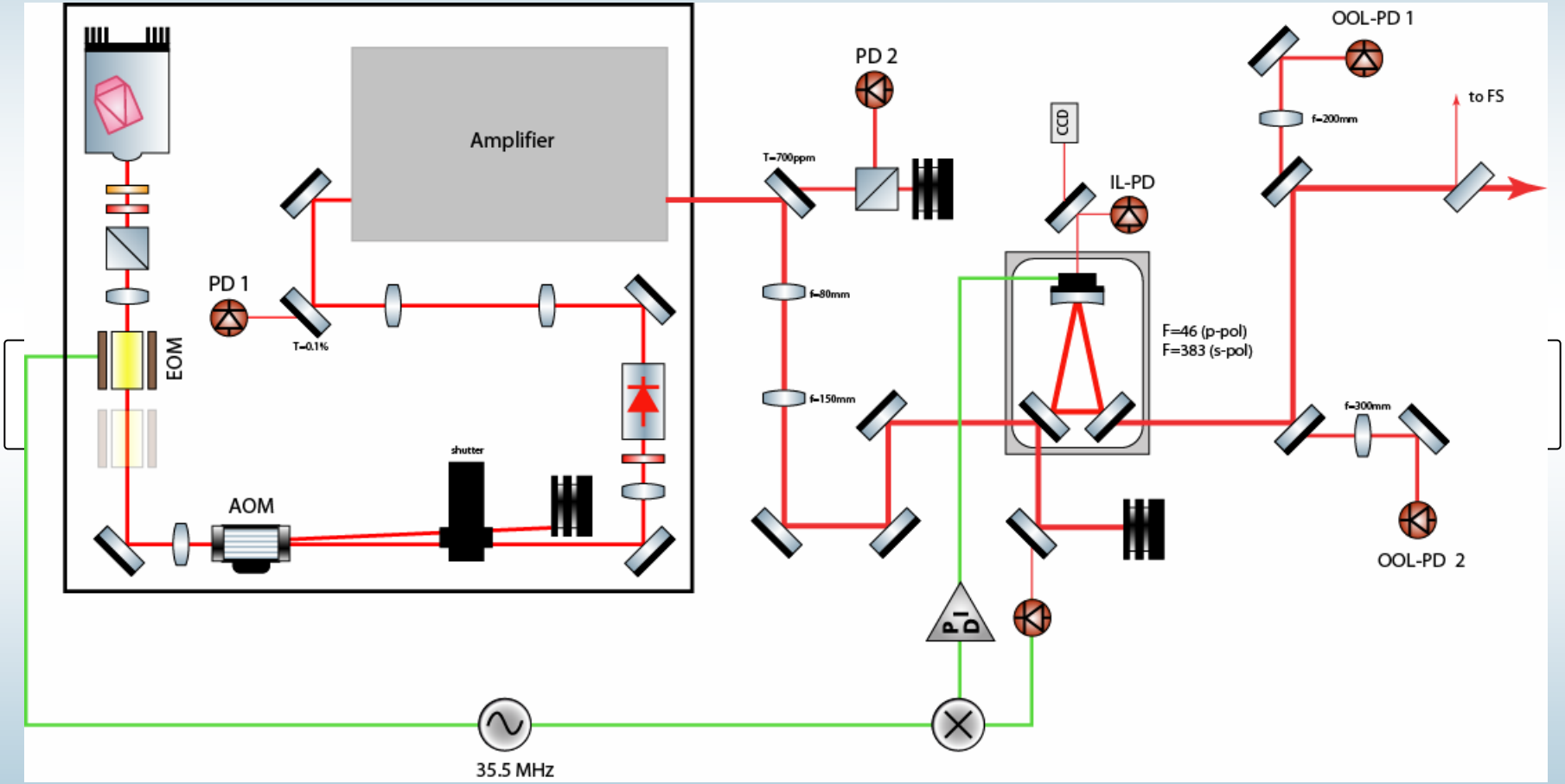


Power Actuators II: LD current

- „Digital modulation“ via Beckhoff @ diode control box
- 2 inputs → 2 laser diodes each (in series)
- Modulation index adjustable via touch panel
- On/Off-control via touch panel
- Low speed

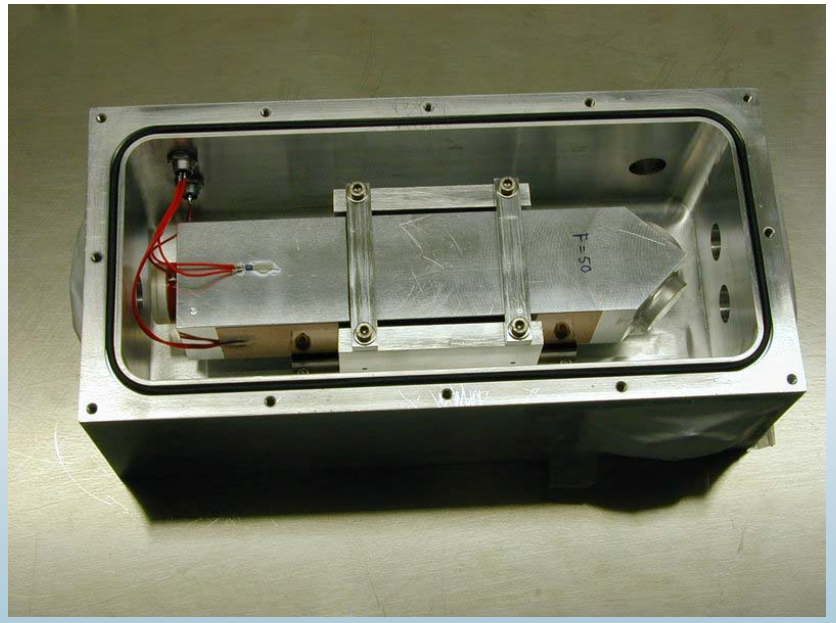


Reference System Setup

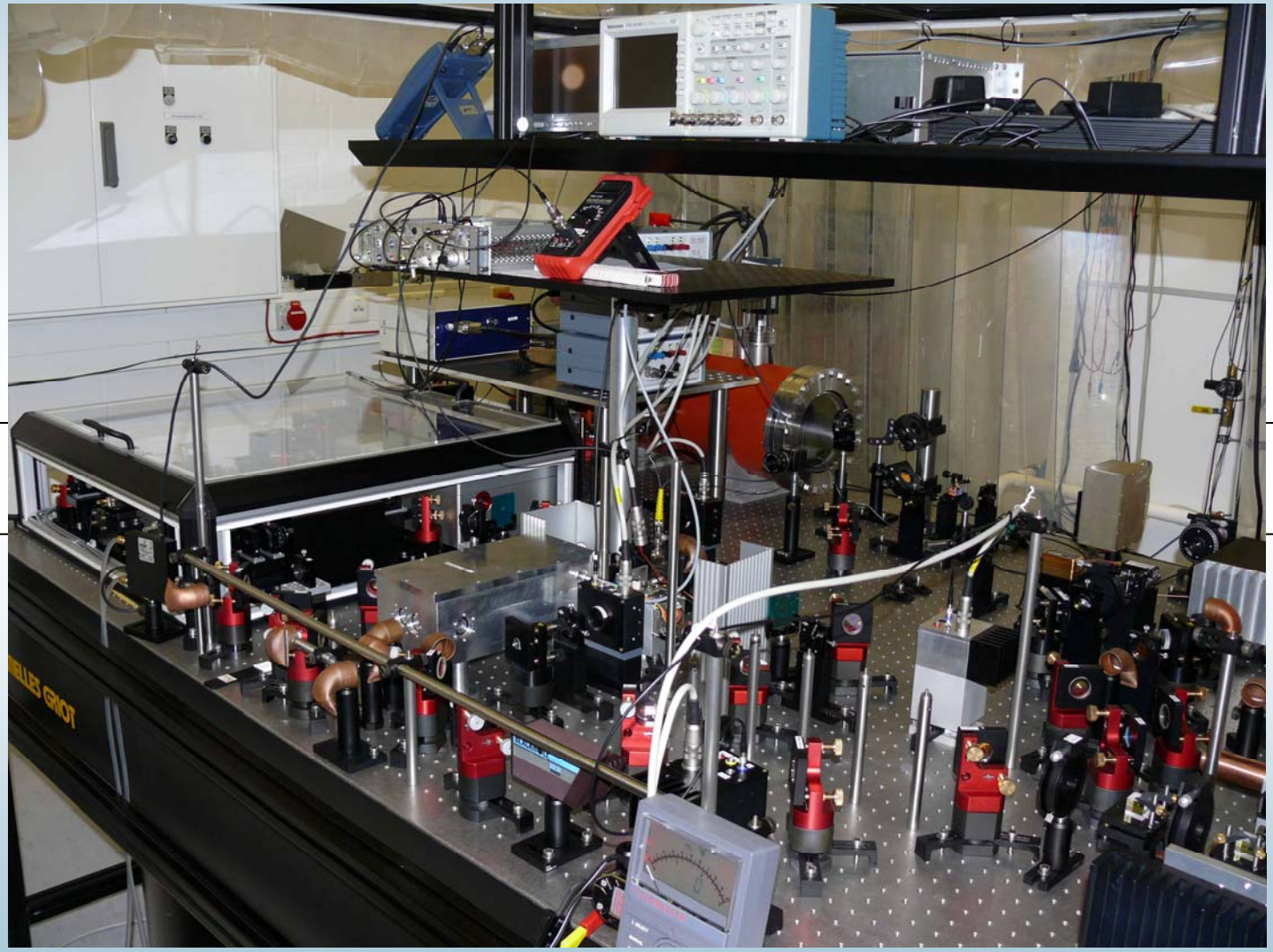


Spatial filtering

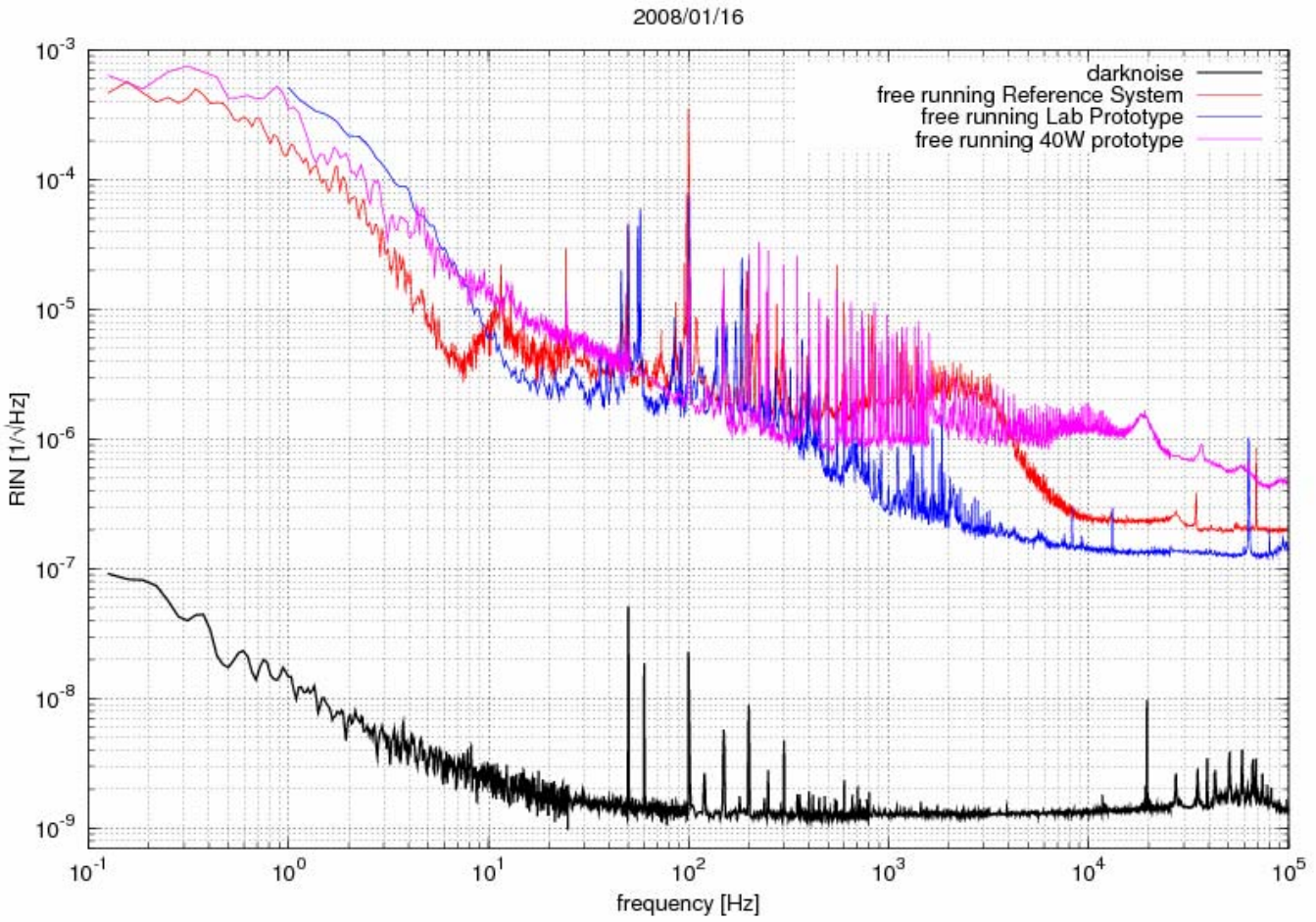
- Classical PMC design (only reflectivities changed)
- F≈46 (p-pol) / F≈383 (s-pol)
- Locked in s-pol most of the time since 12/07
- higher circulating power as for the 200W laser system (factor 8.3 between s and p → 33W x 8.3 = 275W)
- Curved mirror T=20ppm (for power stabilization in-loop PD)
- Small acoustic enclosure



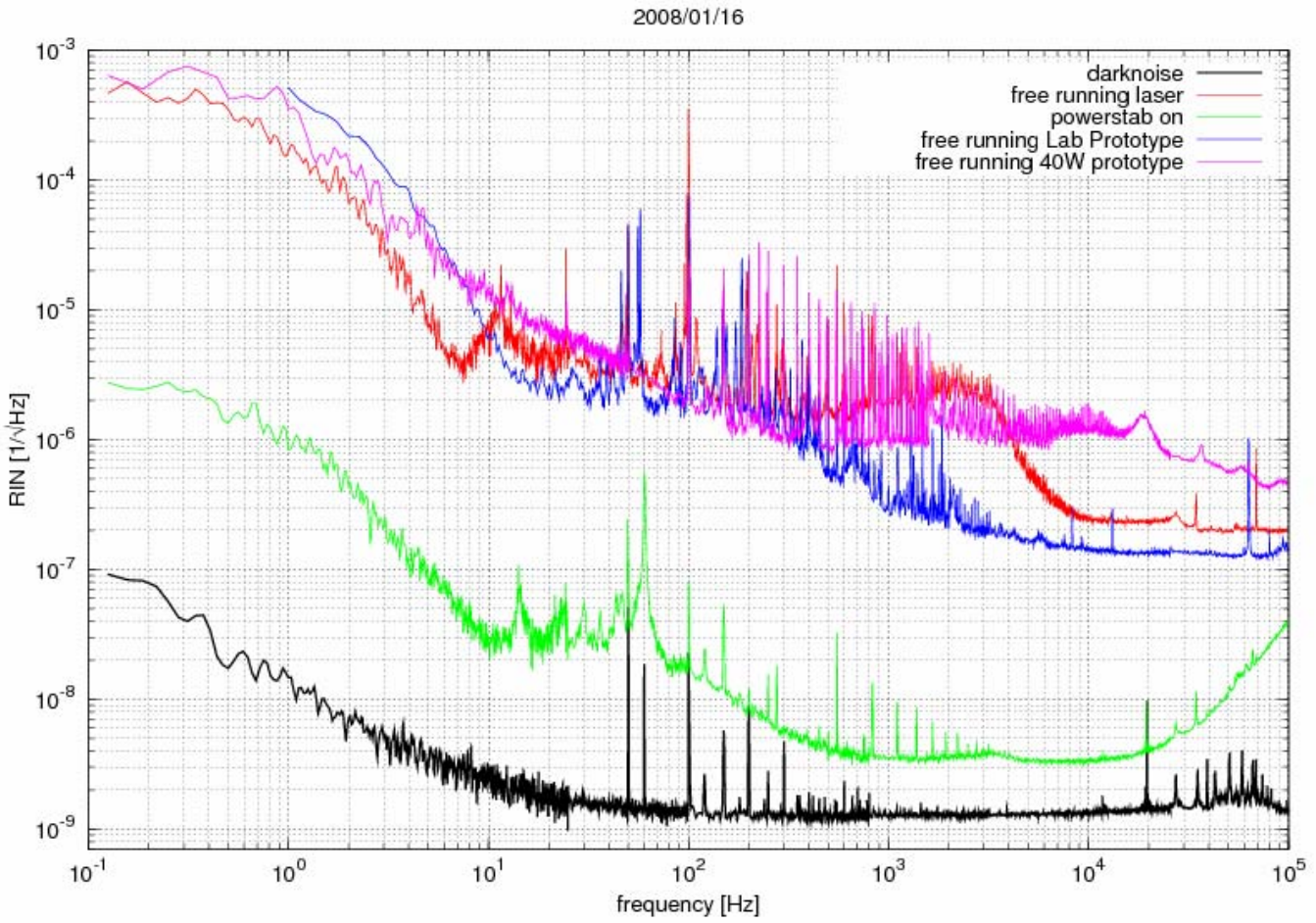
Reference System Setup (cont.)



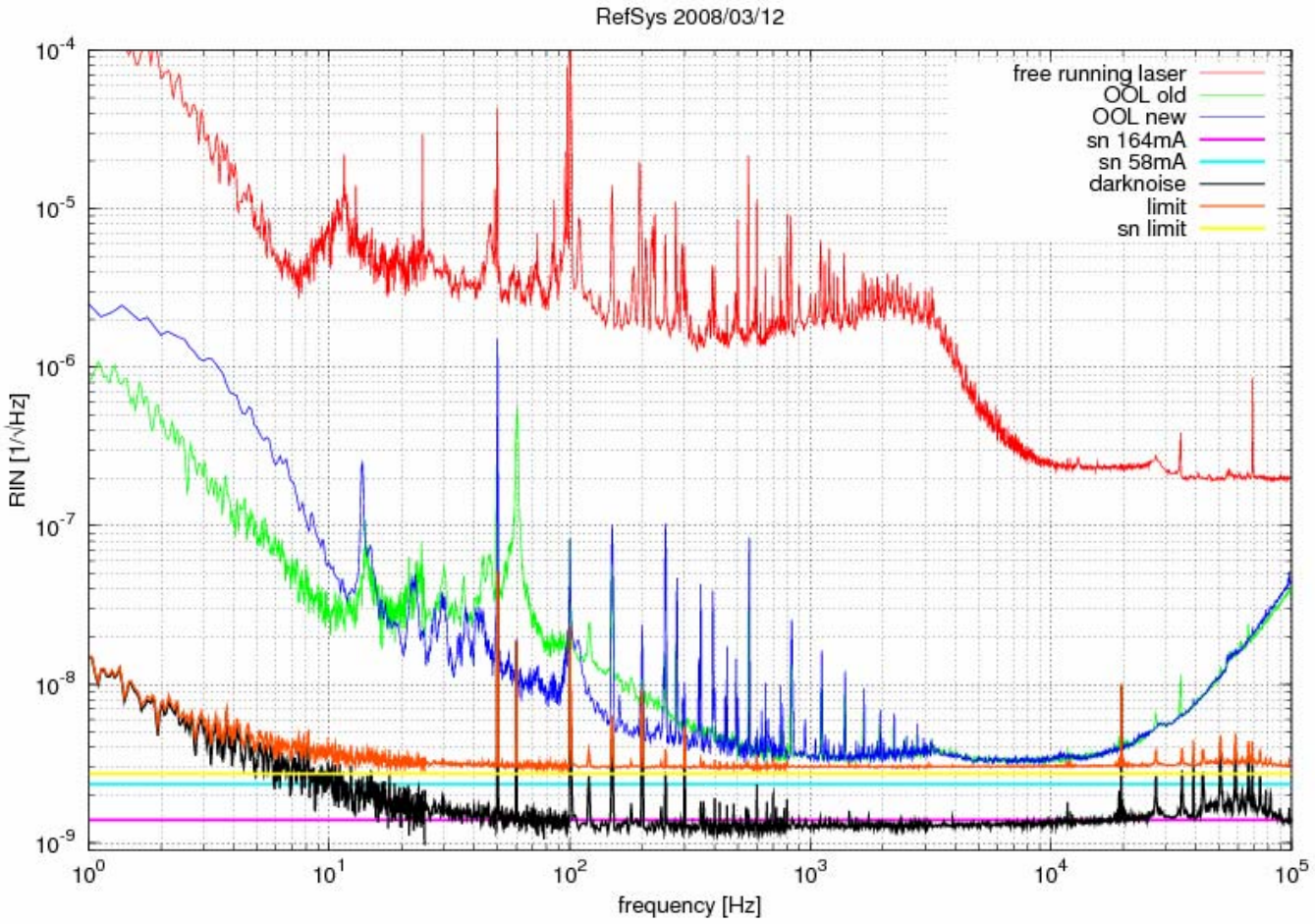
Free Running Noise



First Results



First Results (cont.)



Work In Progress

- Further reduction of beam pointing → shorter beam pathes, beam tubes(?)
- Reduction of scattered light → superpolished mirrors, block ghost beams
- Increasing loop gain and bandwidth
- More in-loop power → (second) in-loop detector behind PMC
- Reduction of particle count → beam tubes (?)

Other related work

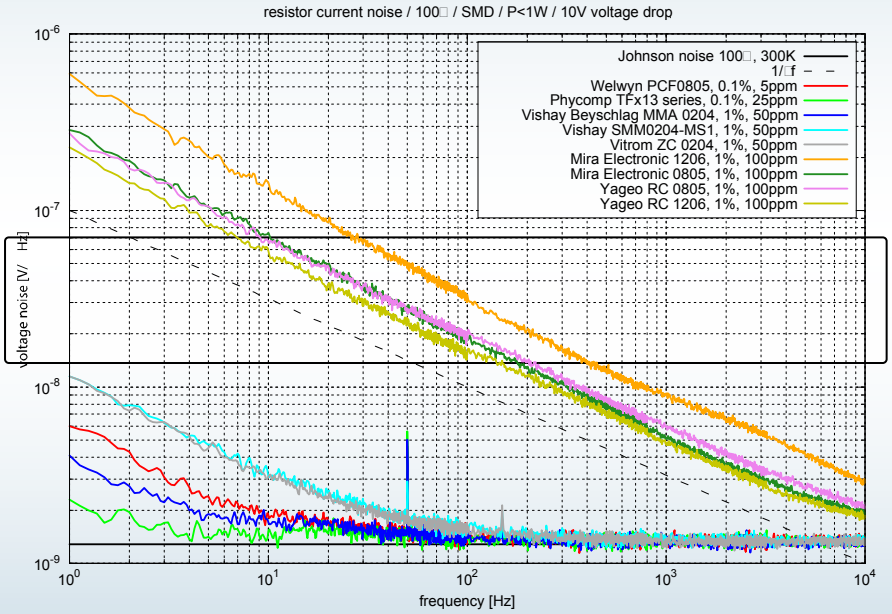
- Photodiode characterization for >500mA detector:
  - breakdown voltage (dark current vs bias)
  - linearity
  - thermal impedance

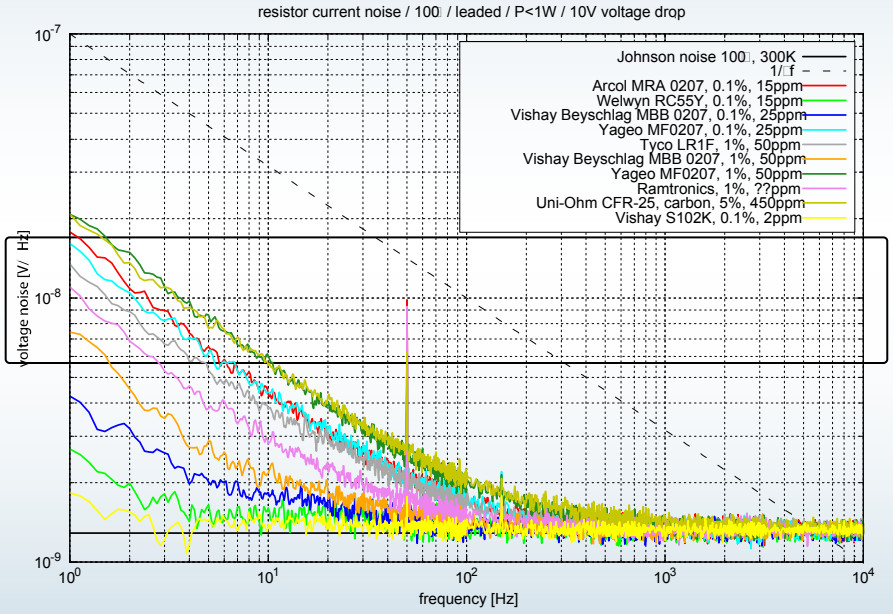
- Resistor current noise:
  - 40 different types measured so far (100 Ohm)
  - higher values next couple of weeks

- New high current photodetector topologies:
  - lower input referred noise / higher photocurrent without decreasing effective gain

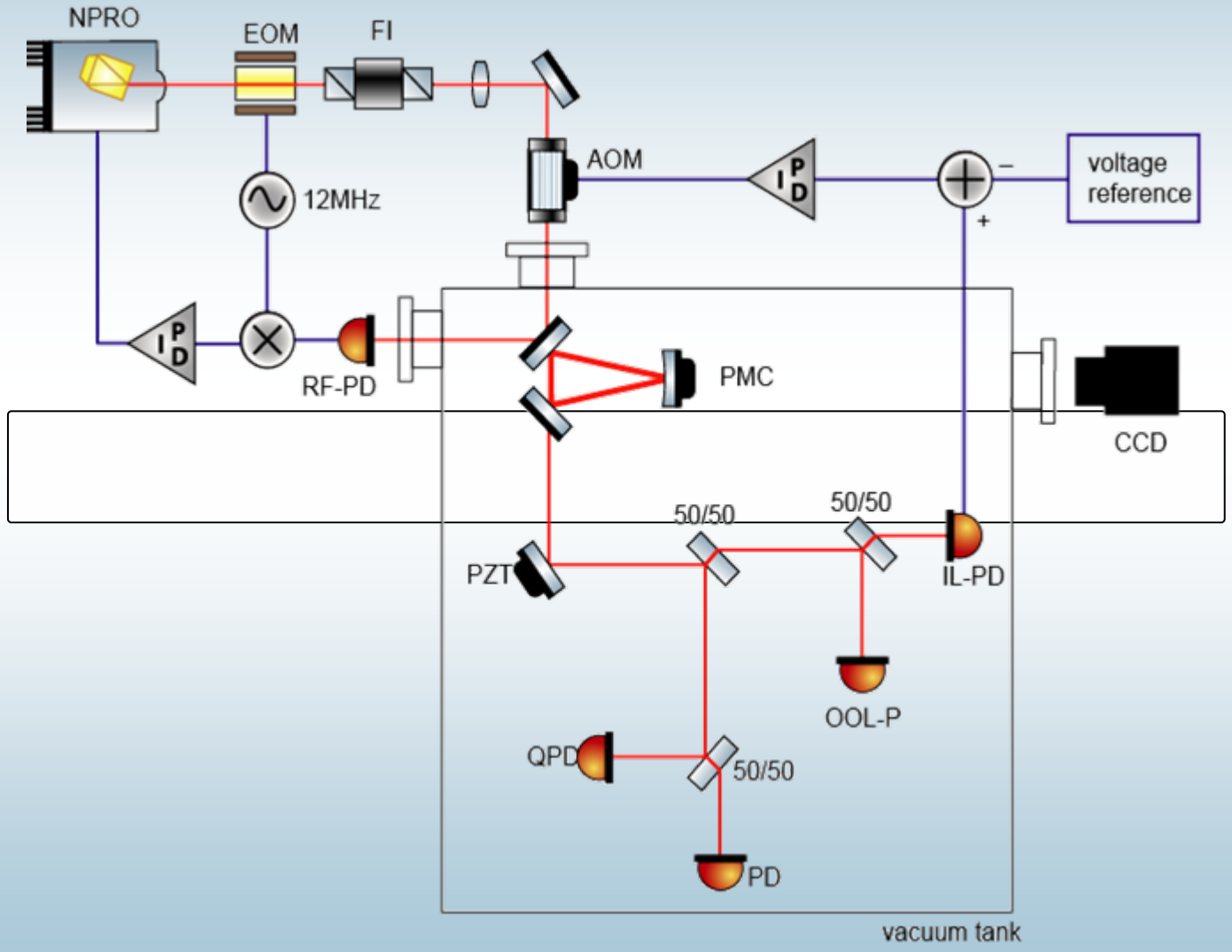
spare slides

Resistor Current Noise

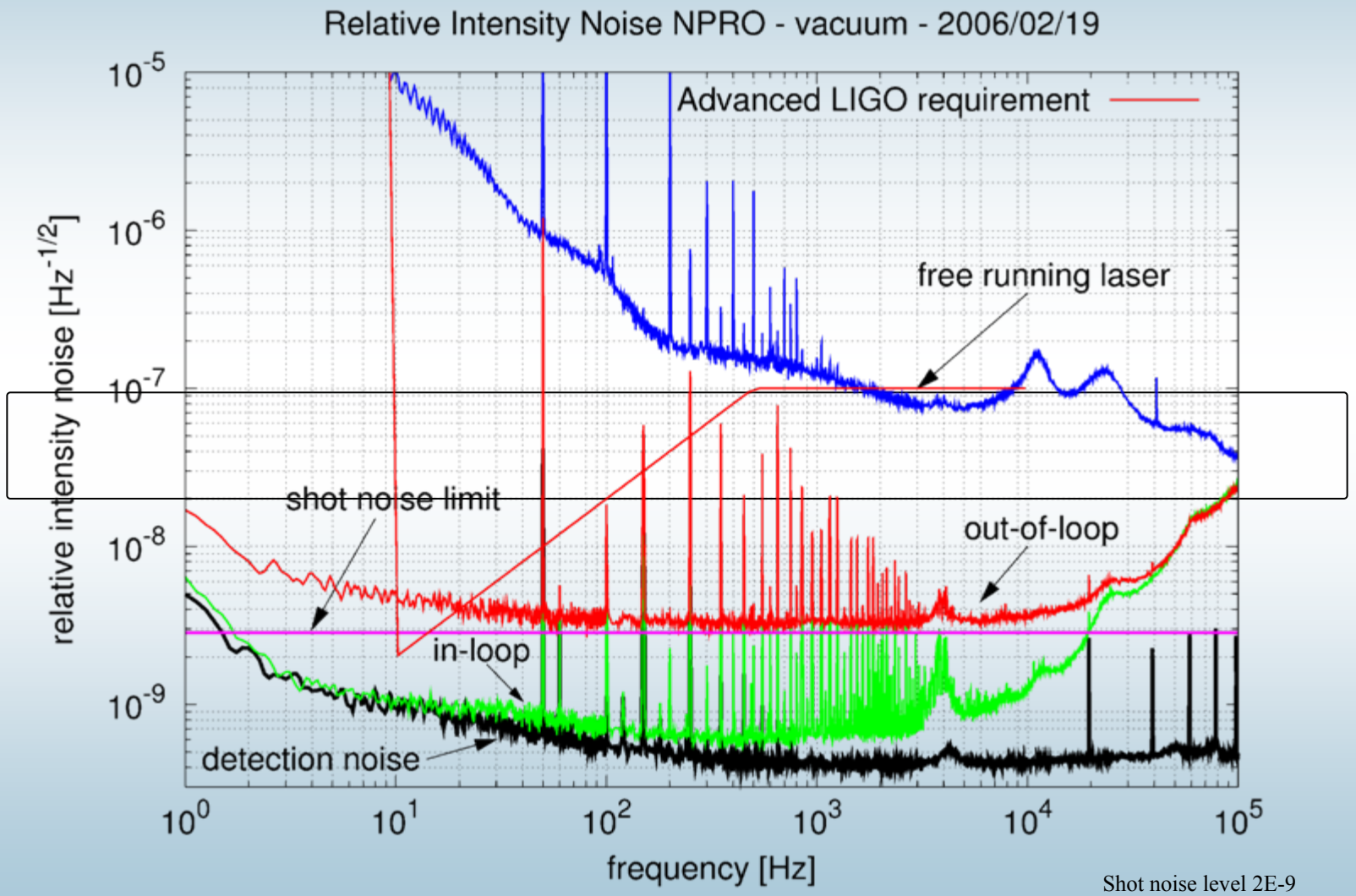




Power Stabilization Setup



Results – DC & AC Coupled Loop



Shot noise level 2E-9

Critical Factors

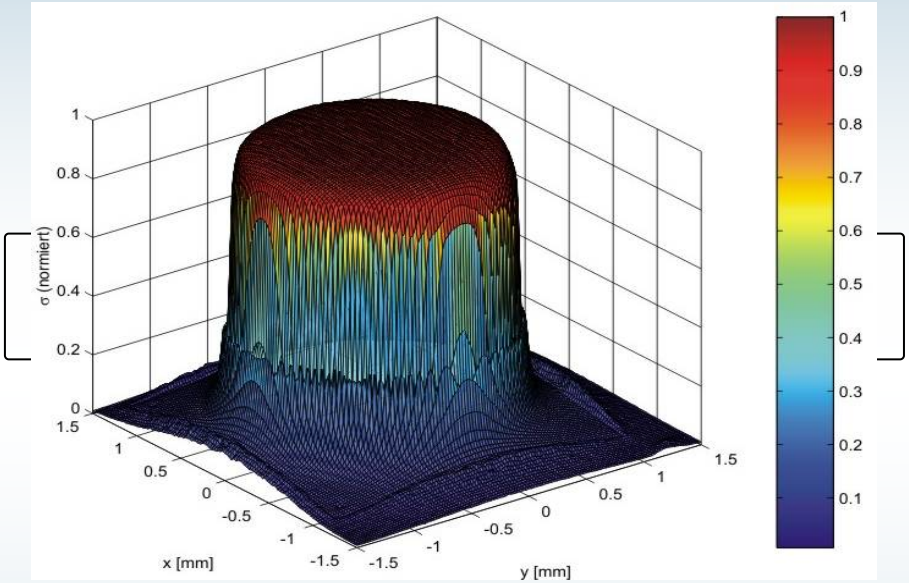
- **very** (!) sensitive to ground loops
  - ➔ avoid **any (!)** ground loop, even at RF (capacitive coupling)
  - ➔ independent supply of components
  - ➔ battery powered devices

- beam pointing
  - ➔ reduction by PMC (passive filtering)
  - ➔ proper adjustment of photodiodes (minimize with impressed pointing) (PZT behind PMC)

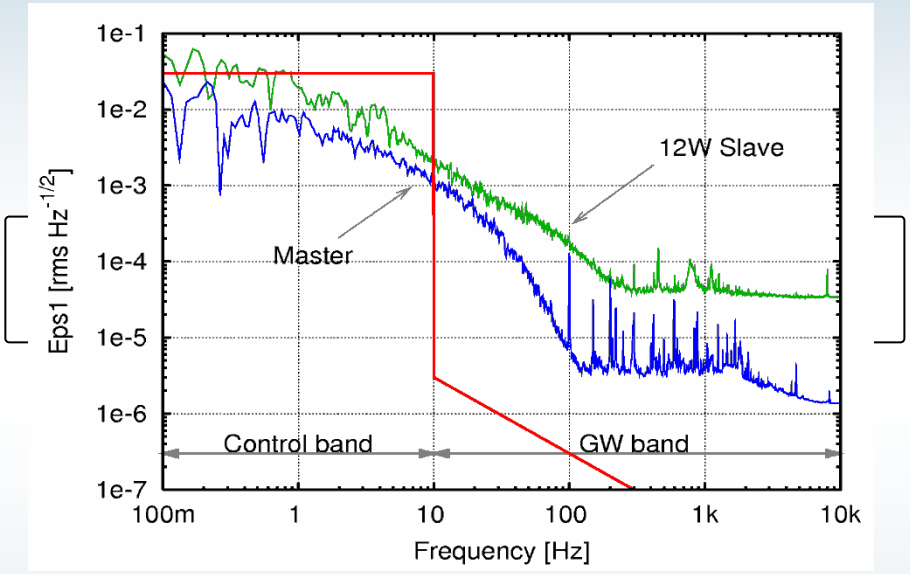
- acoustics
  - ➔ shielded environment
  - ➔ proper mechanical design

- air currents
  - ➔ vacuum

Photodiode Non-uniformity & Pointing



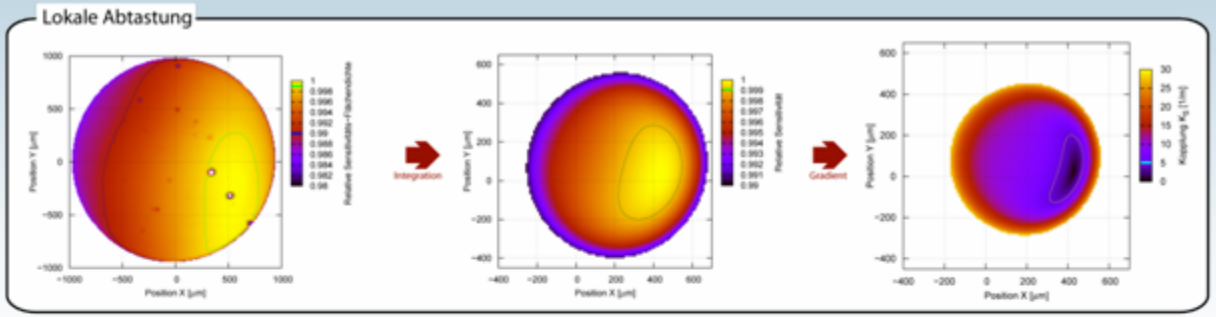
spatial uniformity measurement

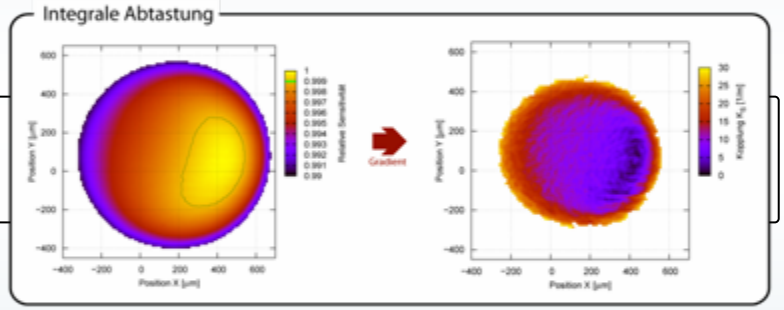


pointing measurement

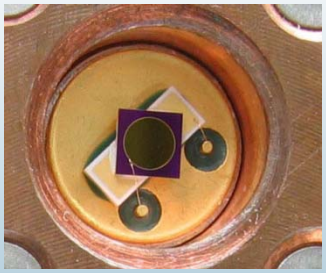
(when) does it limit the performance ?

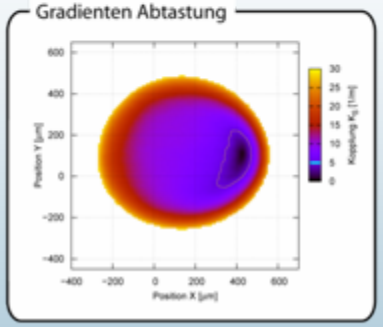
Pointing Sensitivity Measurement





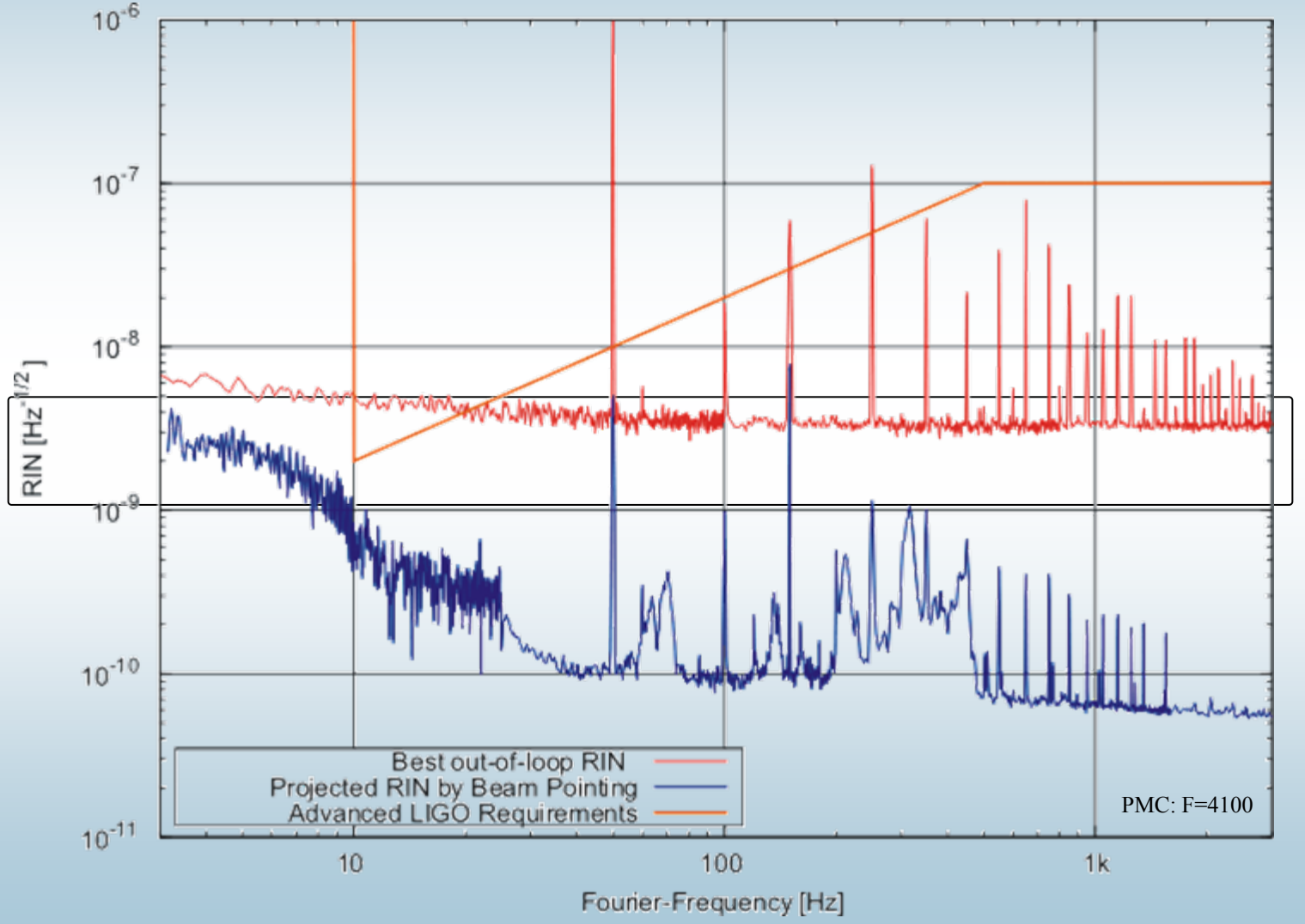
EG&G C30642G





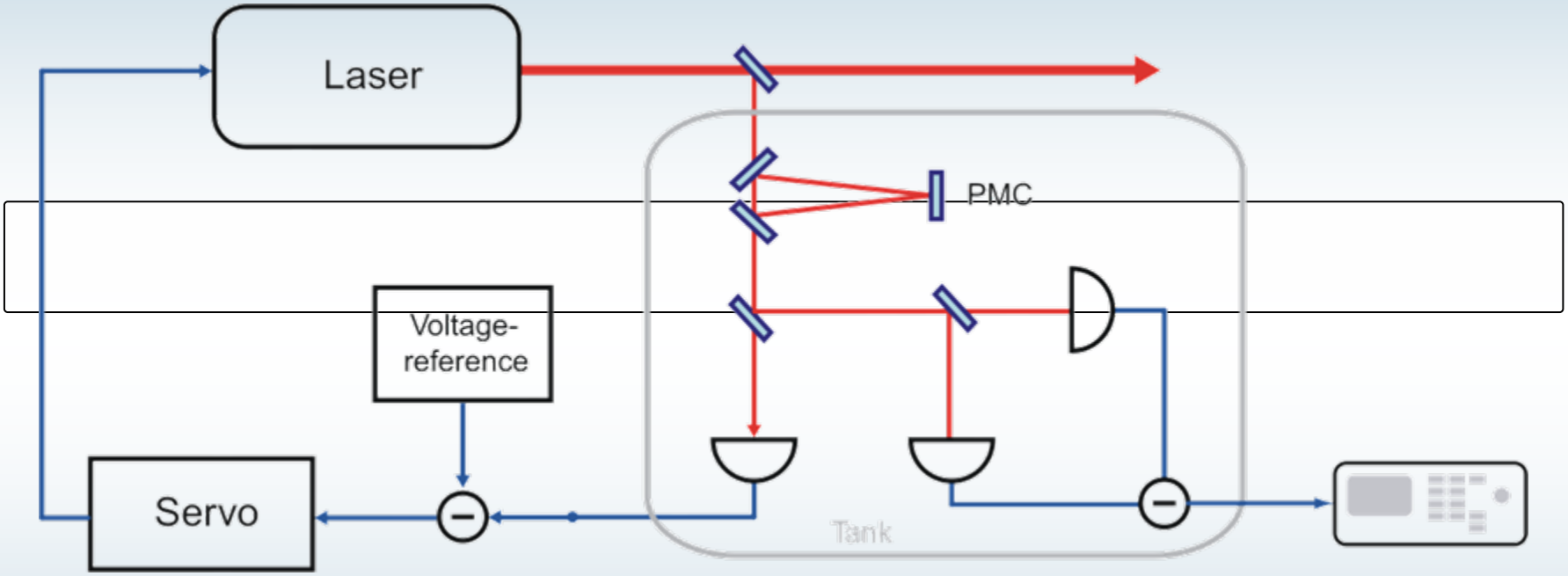
3 different methods ➔ very good agreement

Power Fluctuations Due To Pointing



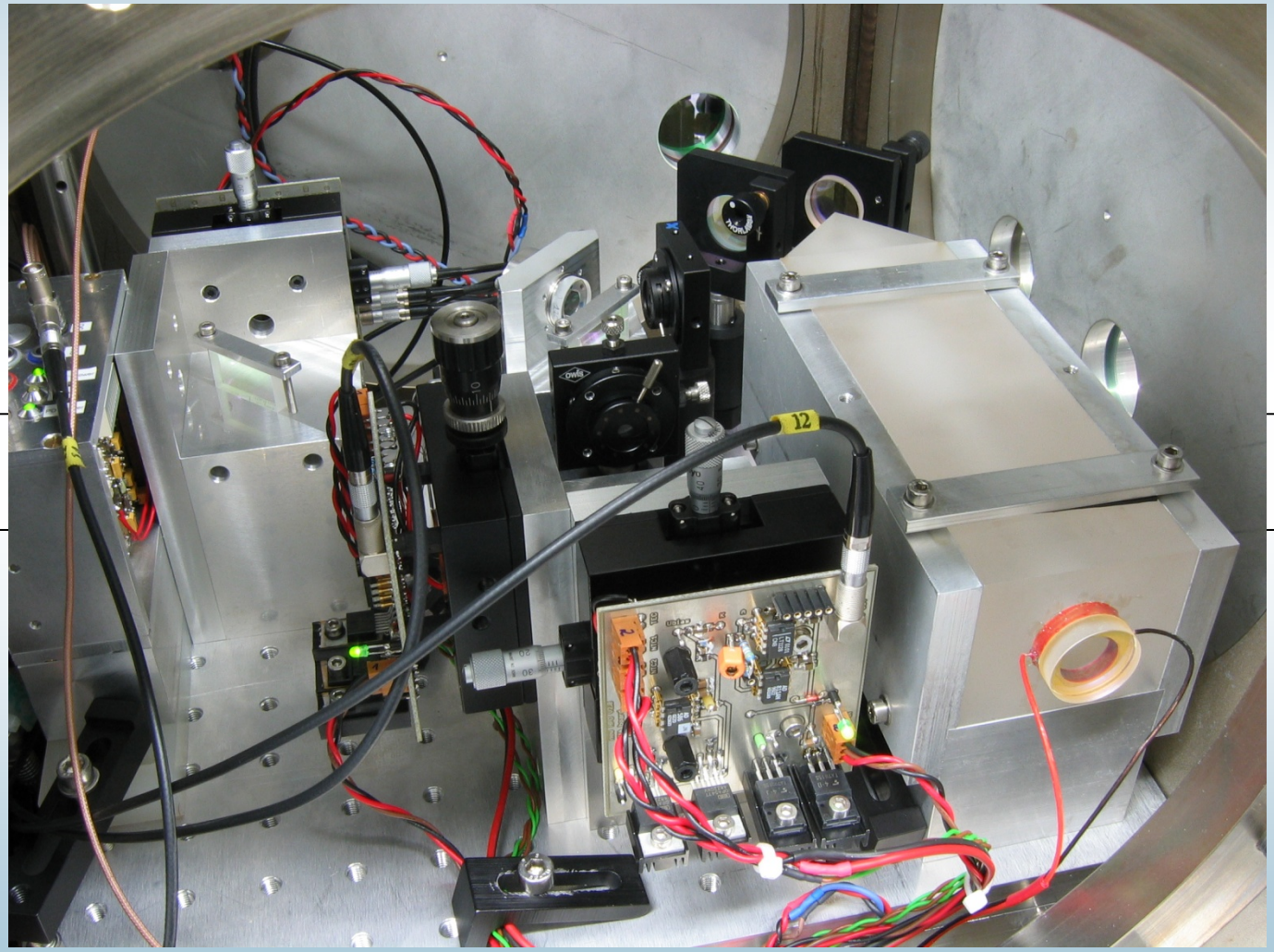
Low Frequency Noise in PD‘s

Balanced detection setup



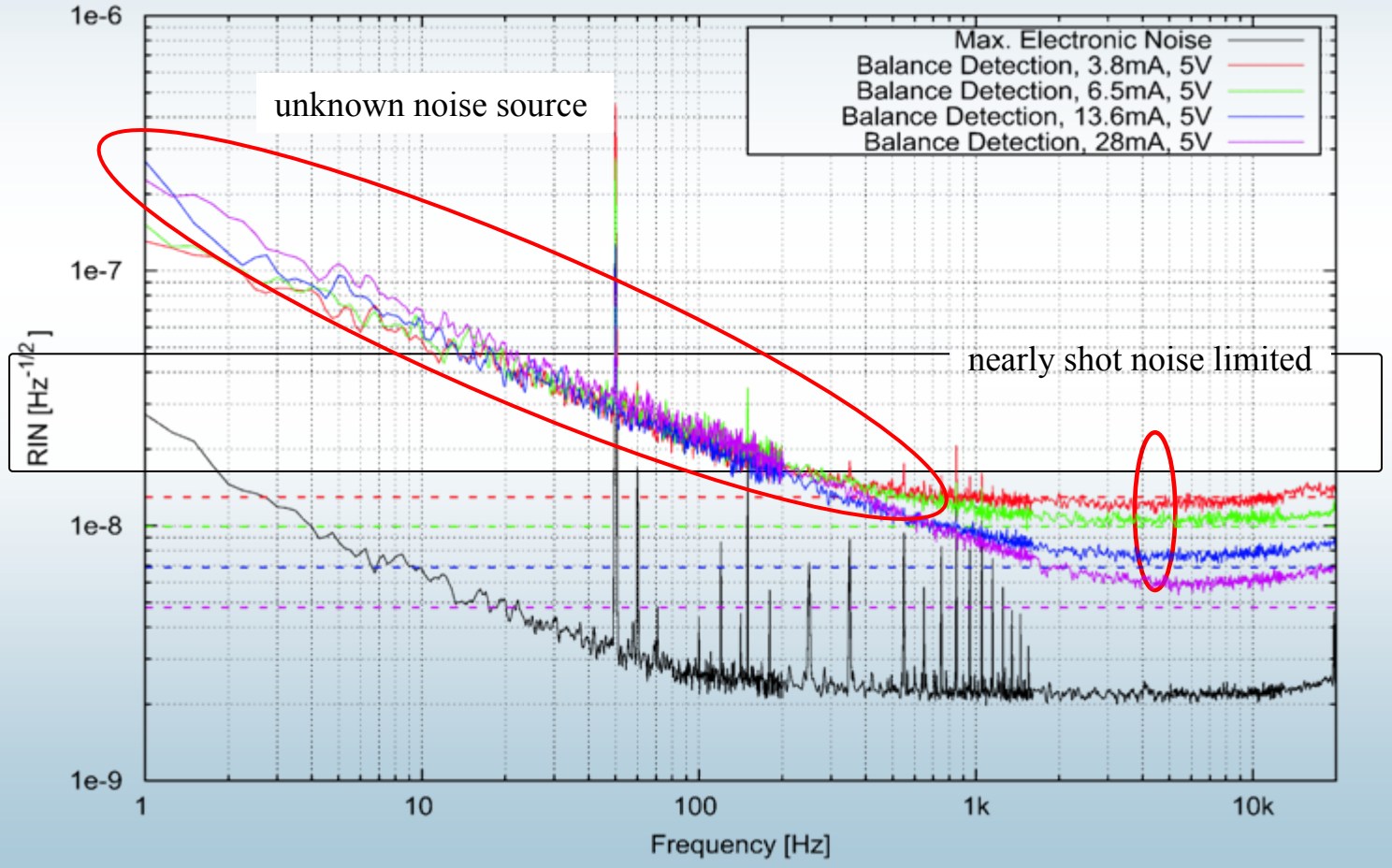
- pre-stabilized laser system below 1E-8 level
- amplification **after** substraction of photocurrents
- temperature stabilized photodiodes
- vacuum tank

Balanced Detection Setup



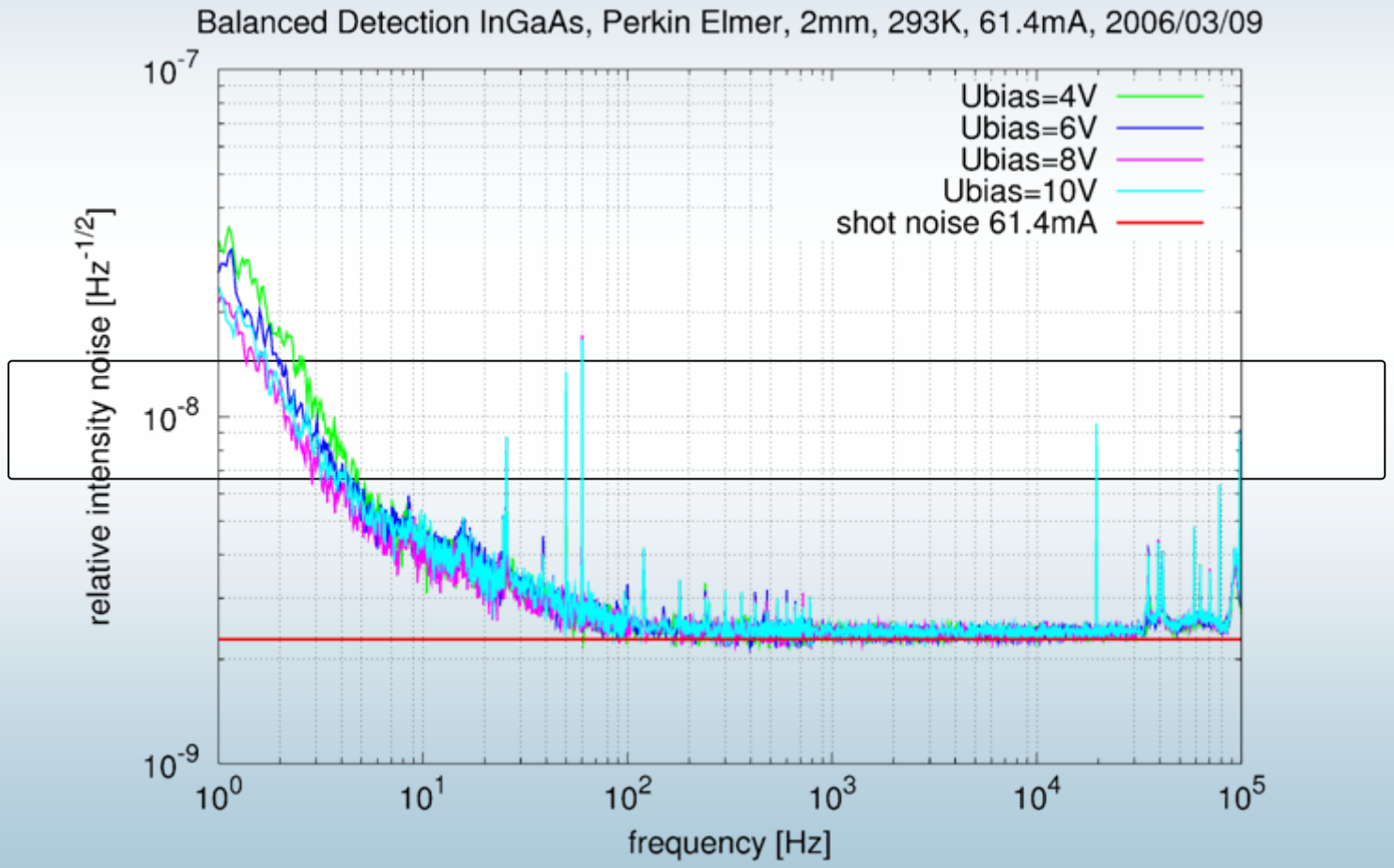
Balanced Detection – First Experiment

first test of balanced detection setup with large area Si photodiodes without temperature stabilization:



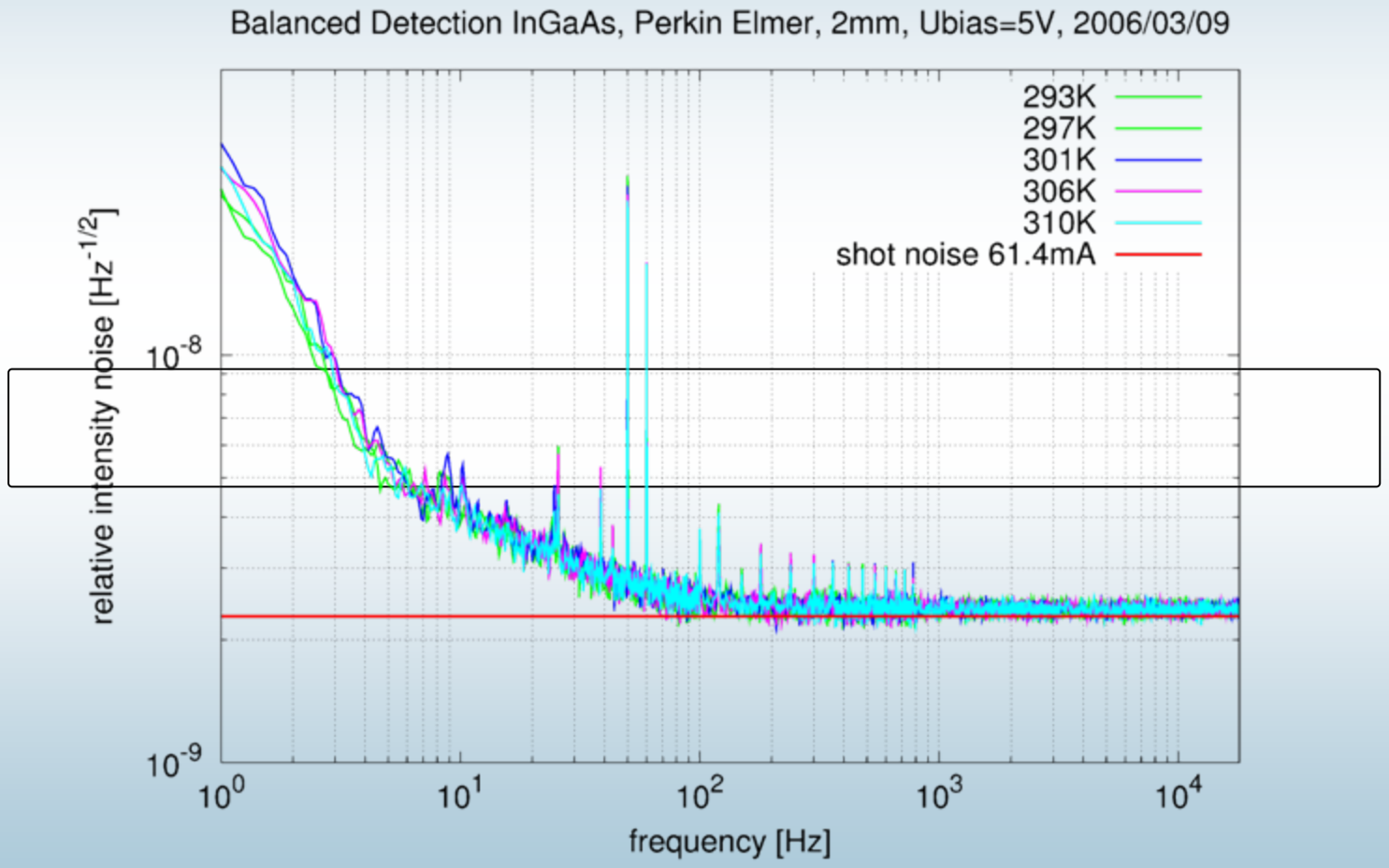
Balanced Detection – Results (1)

bias voltage dependence:



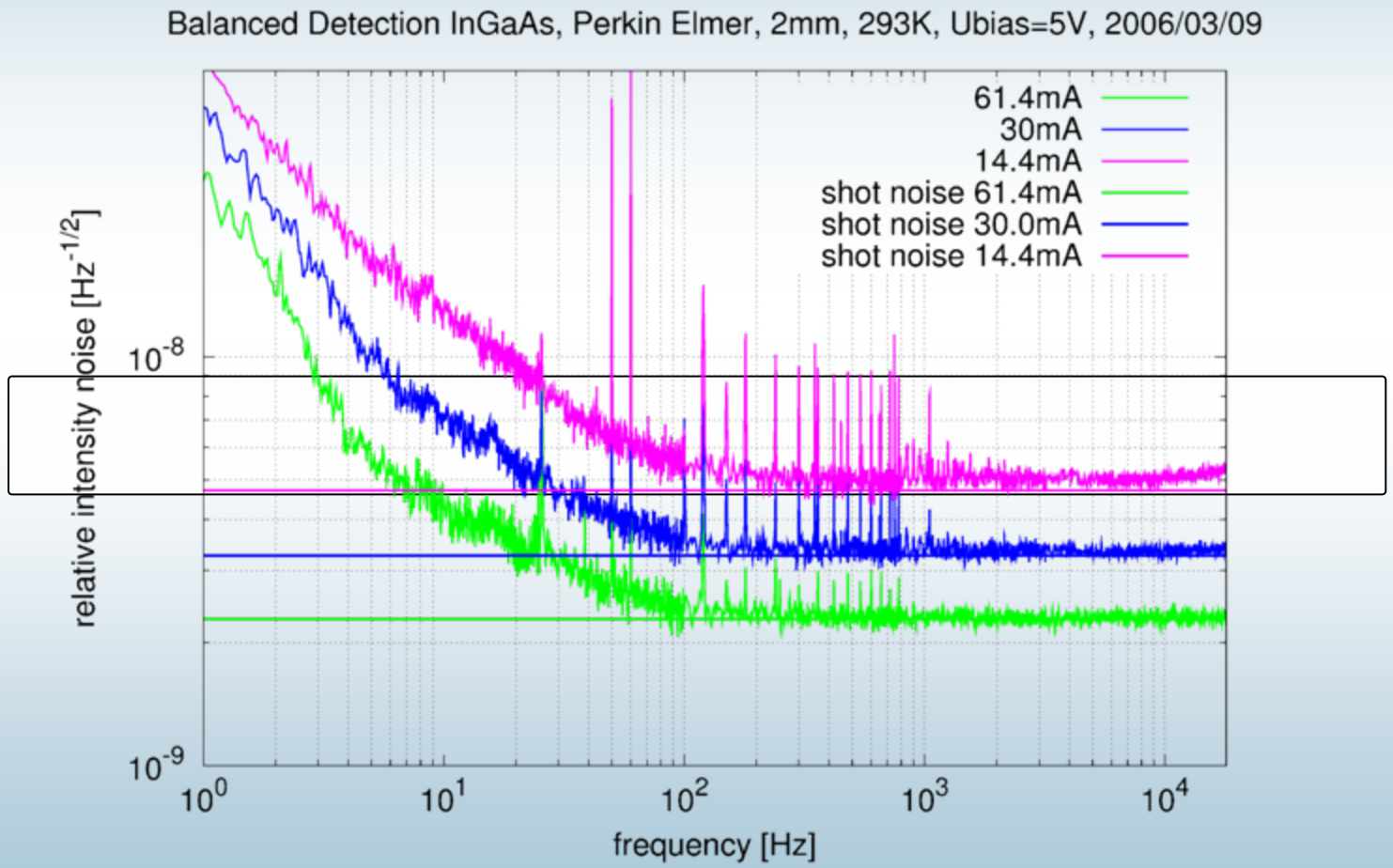
Balanced Detection – Results (2)

temperature dependence:



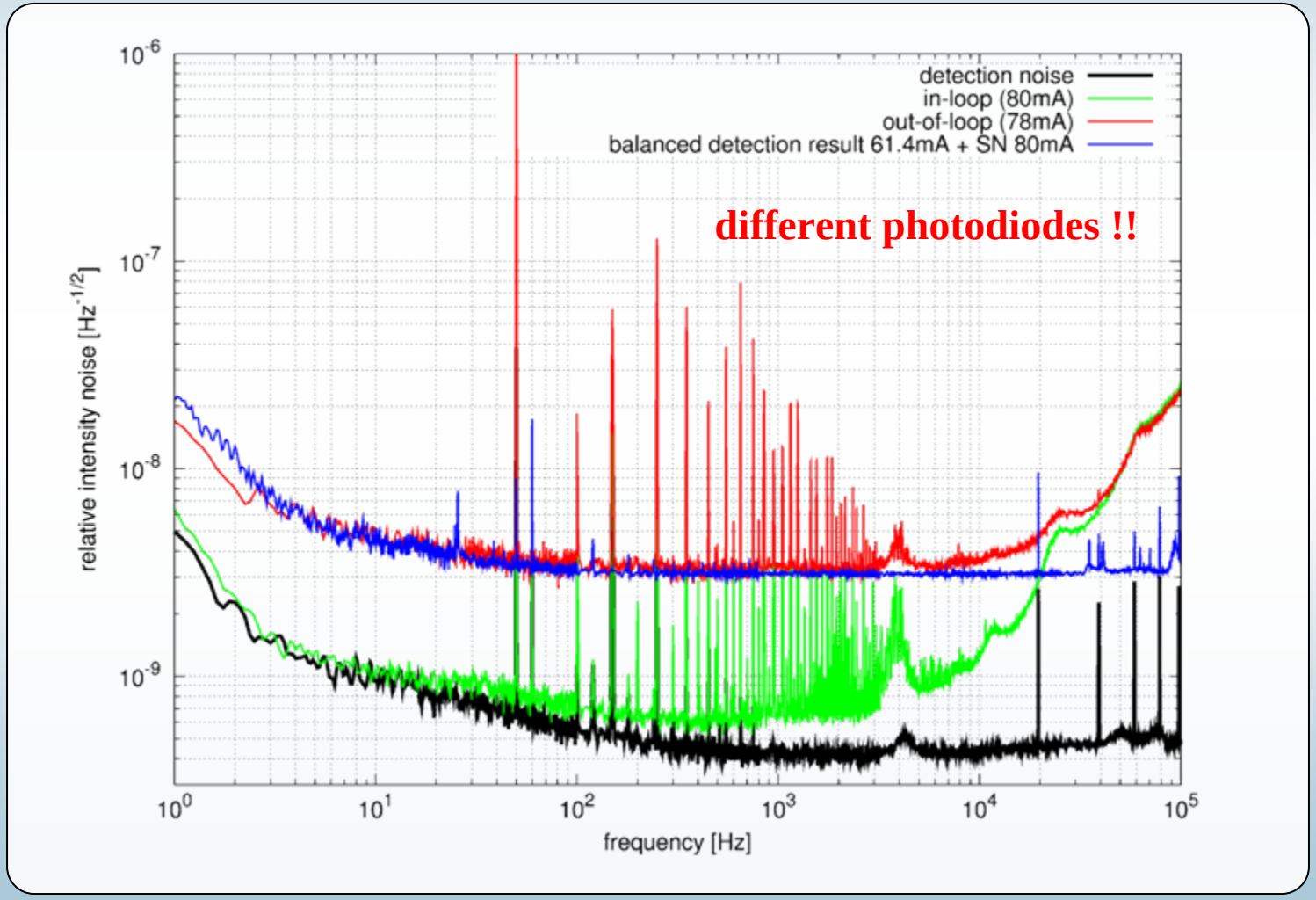
Balanced Detection – Results (3)

power dependence:

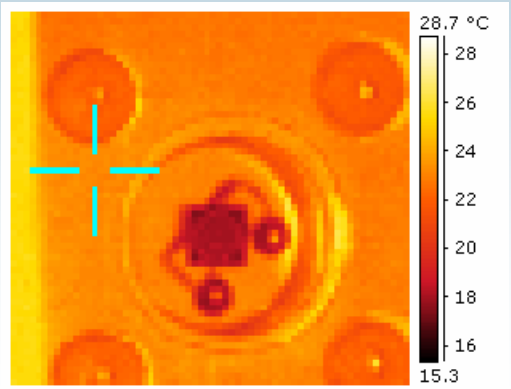


Low Frequency Limit

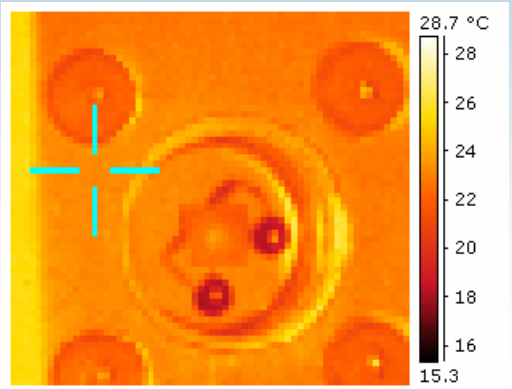
PD low frequency noise limiting ?:



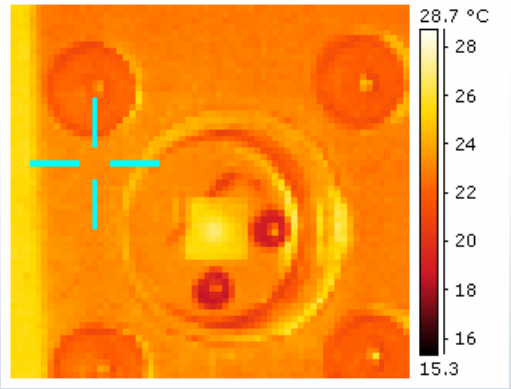
Photodiode Temperature Measurements



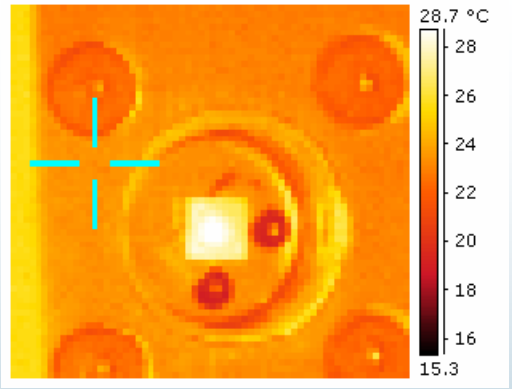
P = 0 mW



P = 65 mW



P = 105 mW



P = 130 mW

- ΔT only ≈ 10K
- real chip temperature ?

PD EG&G C30642G
without window