Power Stabilization to 3E-9 level

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New Power Stabilization Setup

- laser system:
  - as simple as possible
  - prevent x-coupling of laser diode current into other observables (frequency, beam geometry, etc.)

  ➔ **NPRO & power actuator independent from laser system (e.g. AOM)**

- beam pointing:
  - may limit at 10^{-9}-level at low frequencies
  - filtering or active stabilization required ?
  - use of different photodiodes? (larger ?)

  ➔ **filtering by PMC (F≈4100) & whole setup in vacuum & same photodiodes as before**

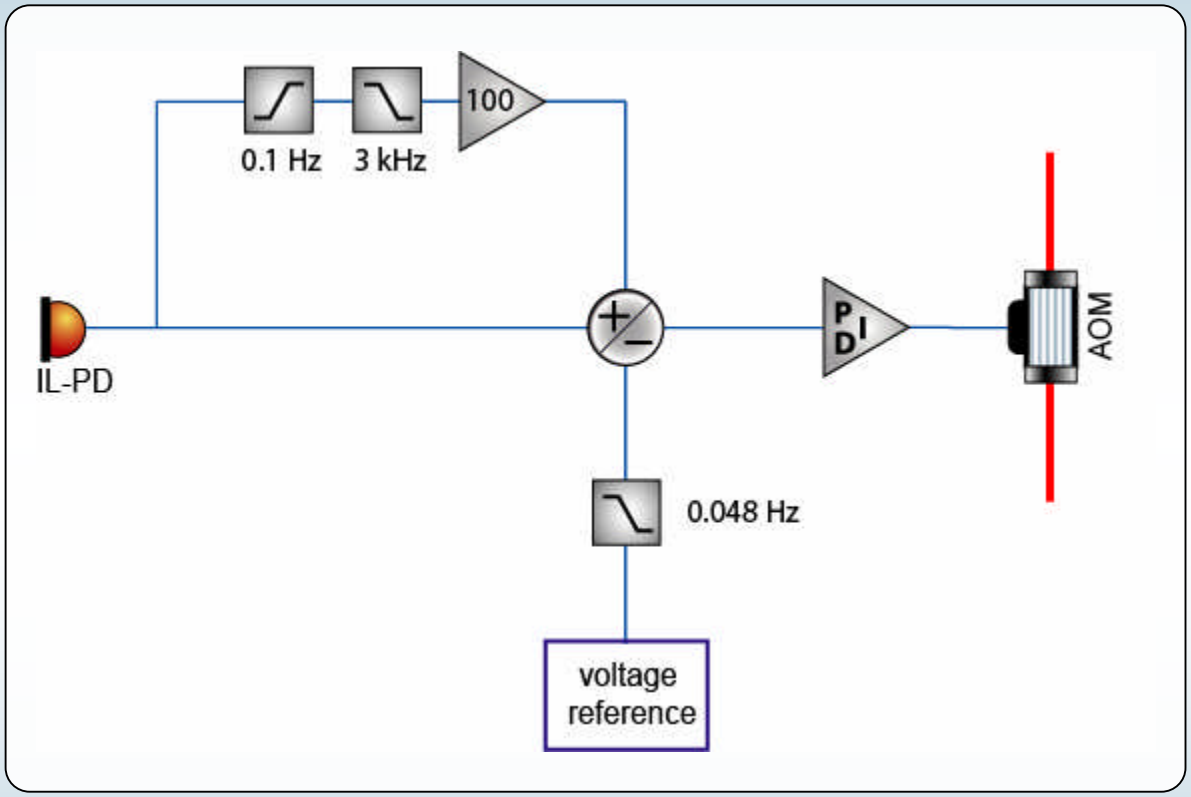
- photodiode temperature:
  - chip temperature increases ≈ 10K (P=130mW)
  - temperature coefficient ≈ 0.039 %/K (Datasheet Perkin Elmer)

  ➔ **active temperature stabilization**

- optimization of stabilization loop
  - DC-coupled loop for stable operating point
  - AC-coupled loop for lowest noise

  ➔ **DC & AC-coupled loop**

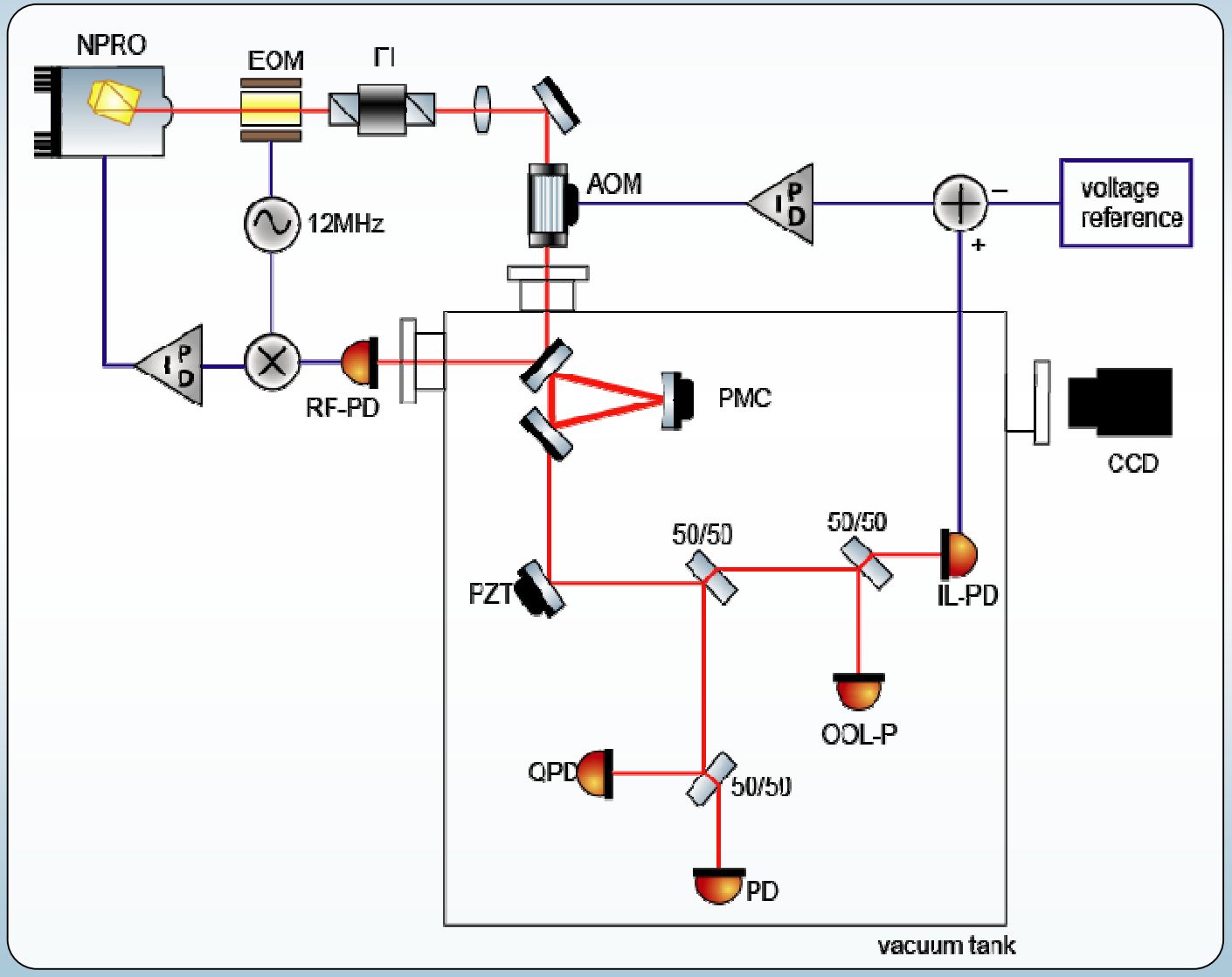
DC & AC-coupled loop - Principle



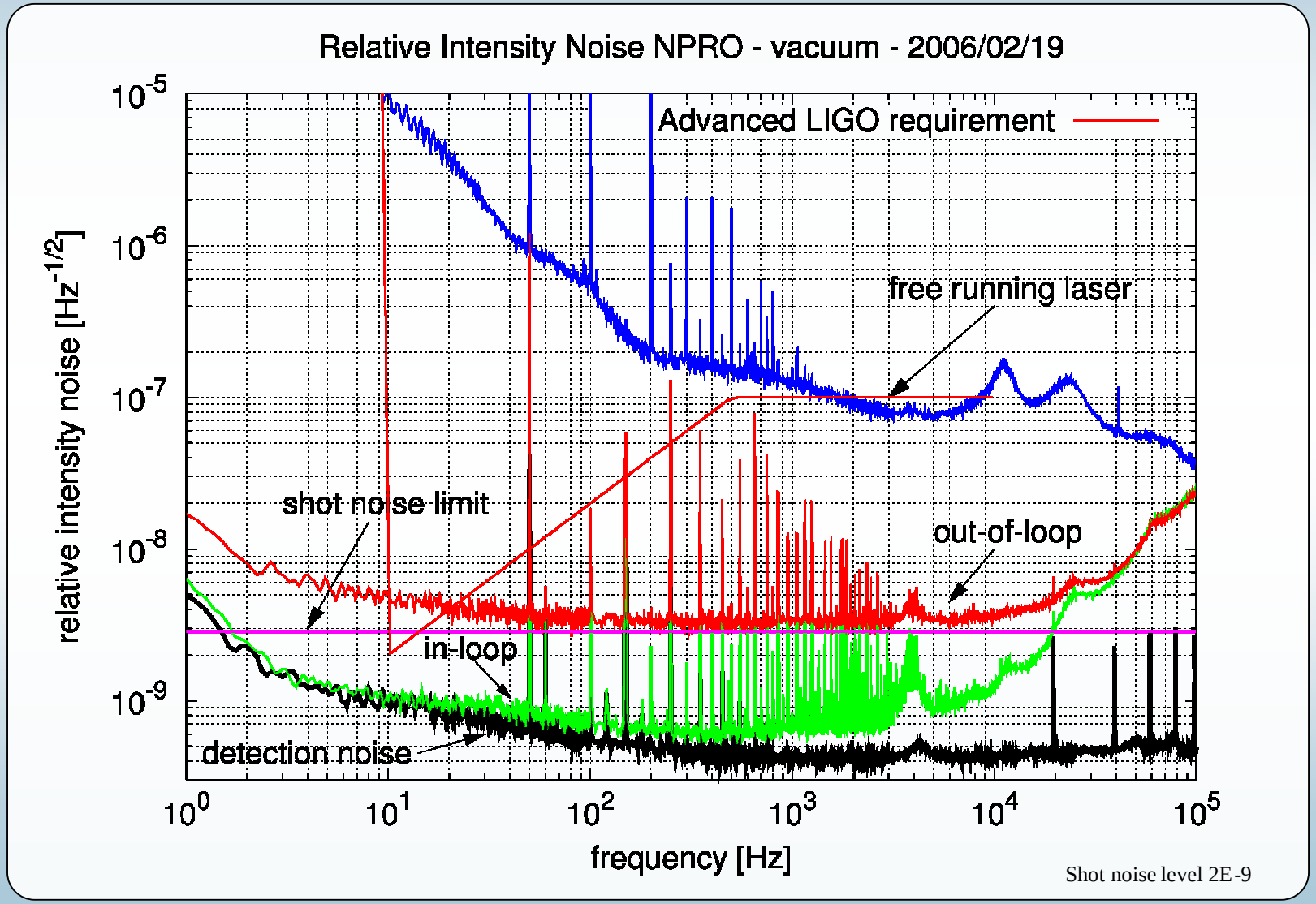
Advantage:

- DC-coupled loop for stable operating point
- AC-coupled loop for lowest noise (not limited by noise of voltage reference)

Power Stabilization Setup



Results – DC & AC Coupled Loop



Critical Factors

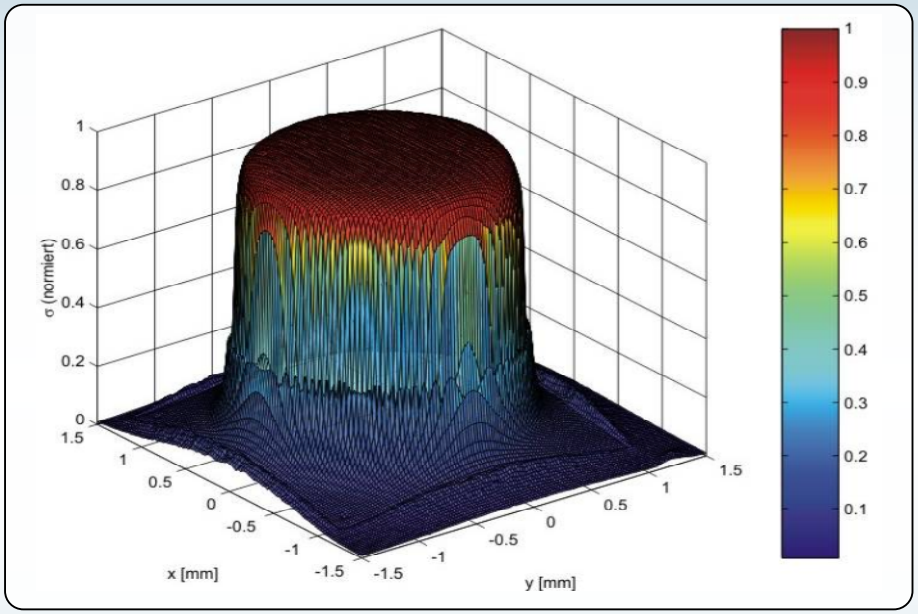
- **very** (!) sensitive to ground loops
  - ➔ avoid **any (!)** ground loop, even at RF (capacitive coupling)
  - ➔ independent supply of components
  - ➔ battery powered devices

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

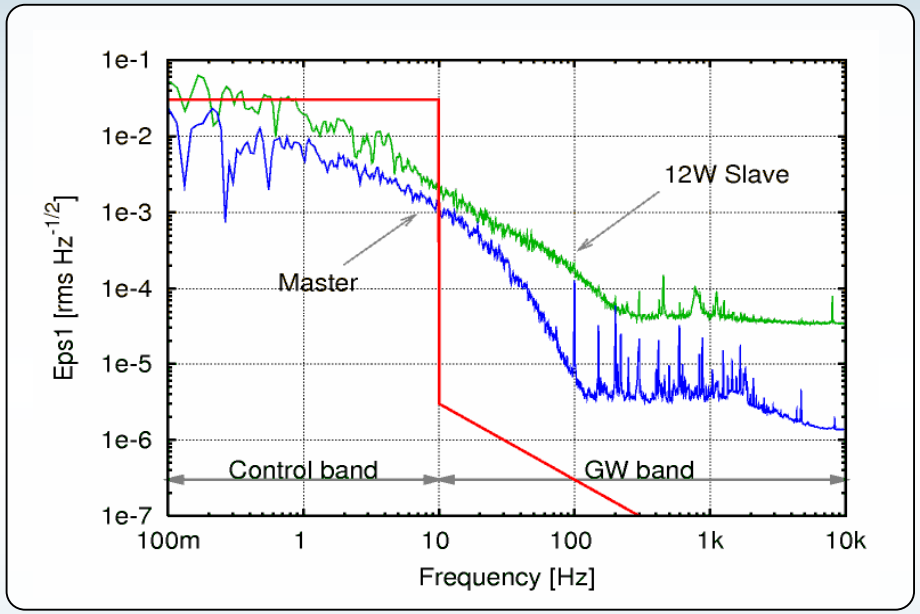
- acoustics
  - ➔ shielded environment
  - ➔ proper mechanical design

- air currents
  - ➔ vacuum

Photodiode Non-uniformity & Pointing



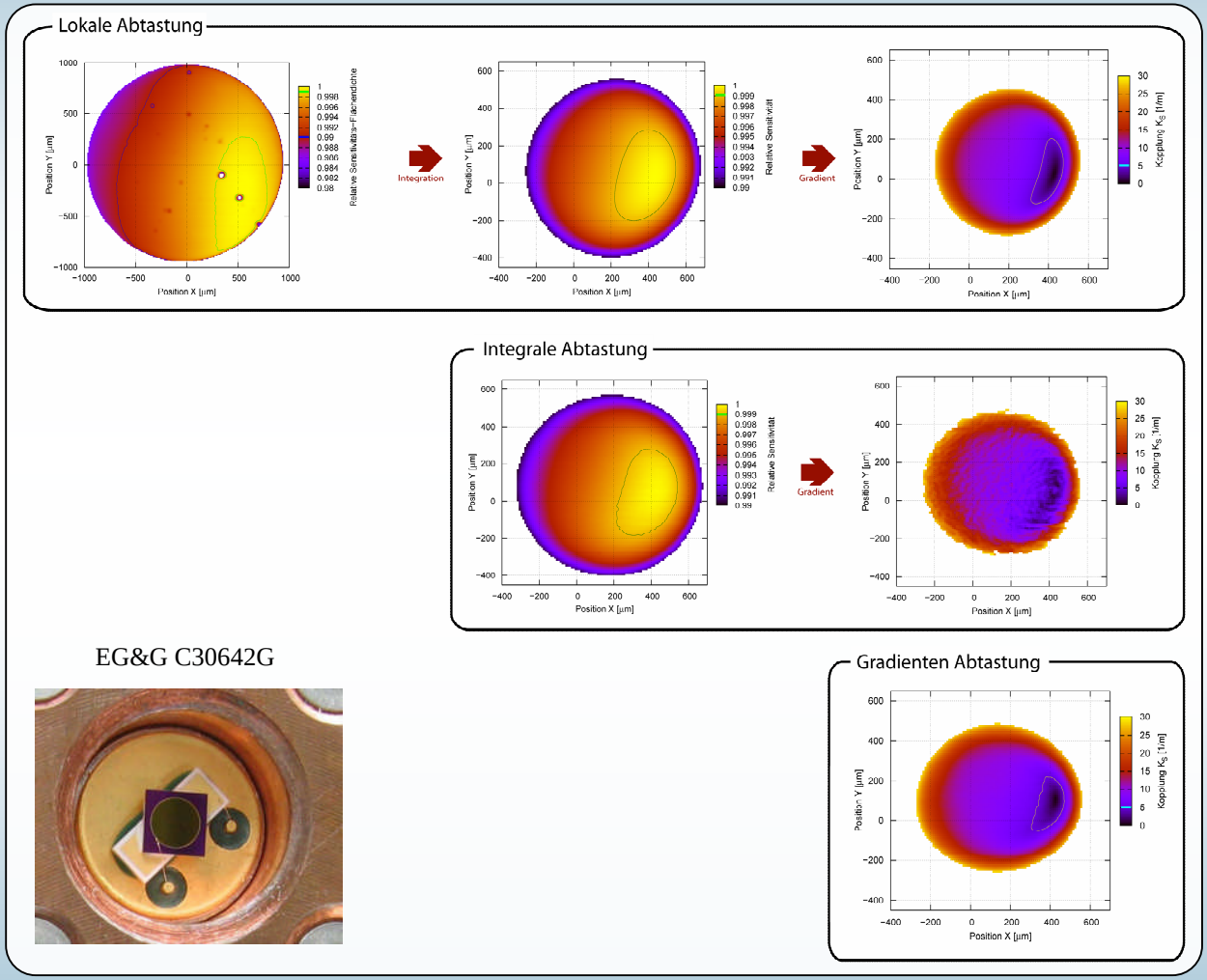
spatial uniformity measurement



pointing measurement

(when) does it limit the performance ?

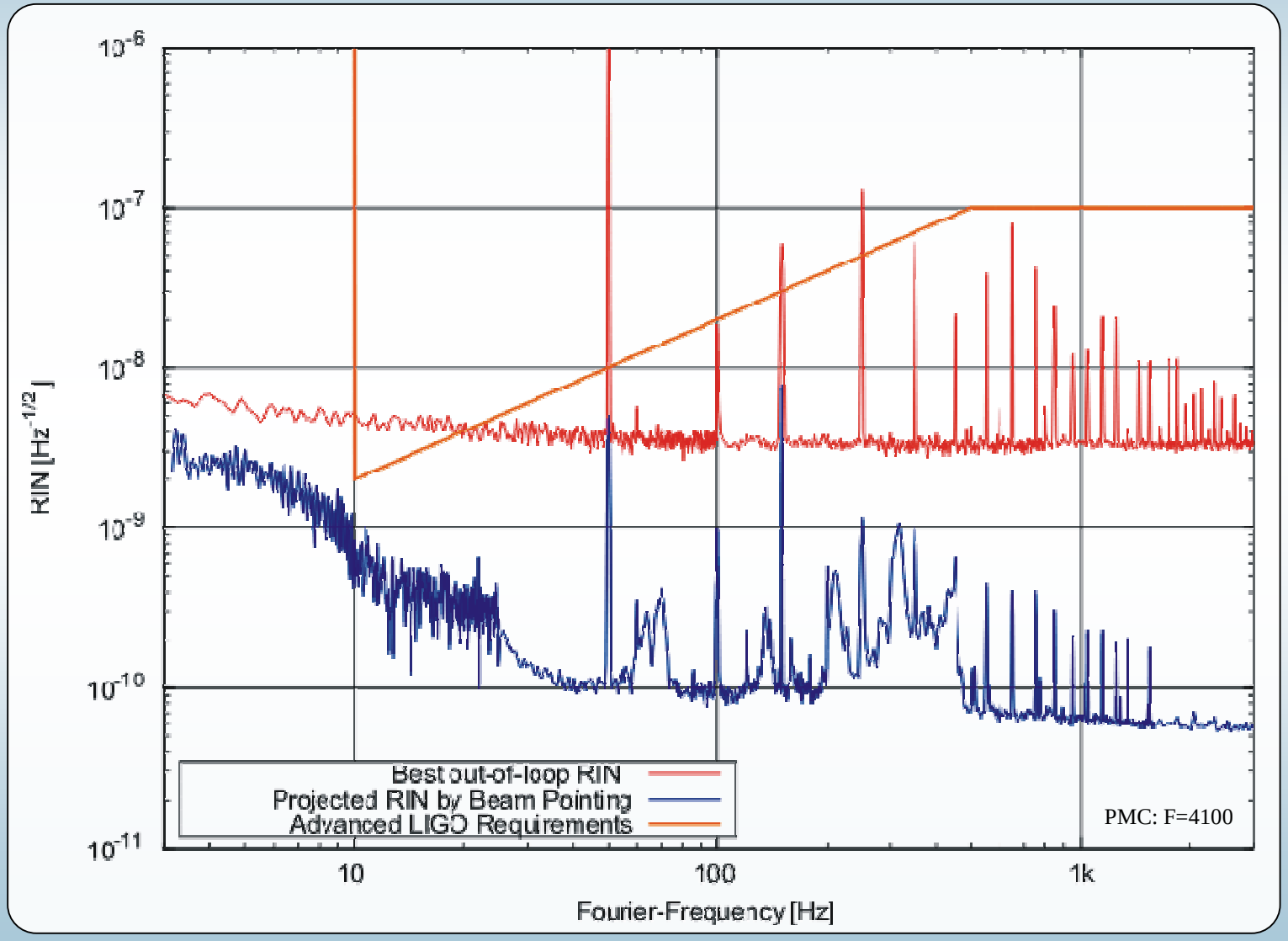
Pointing Sensitivity Measurement



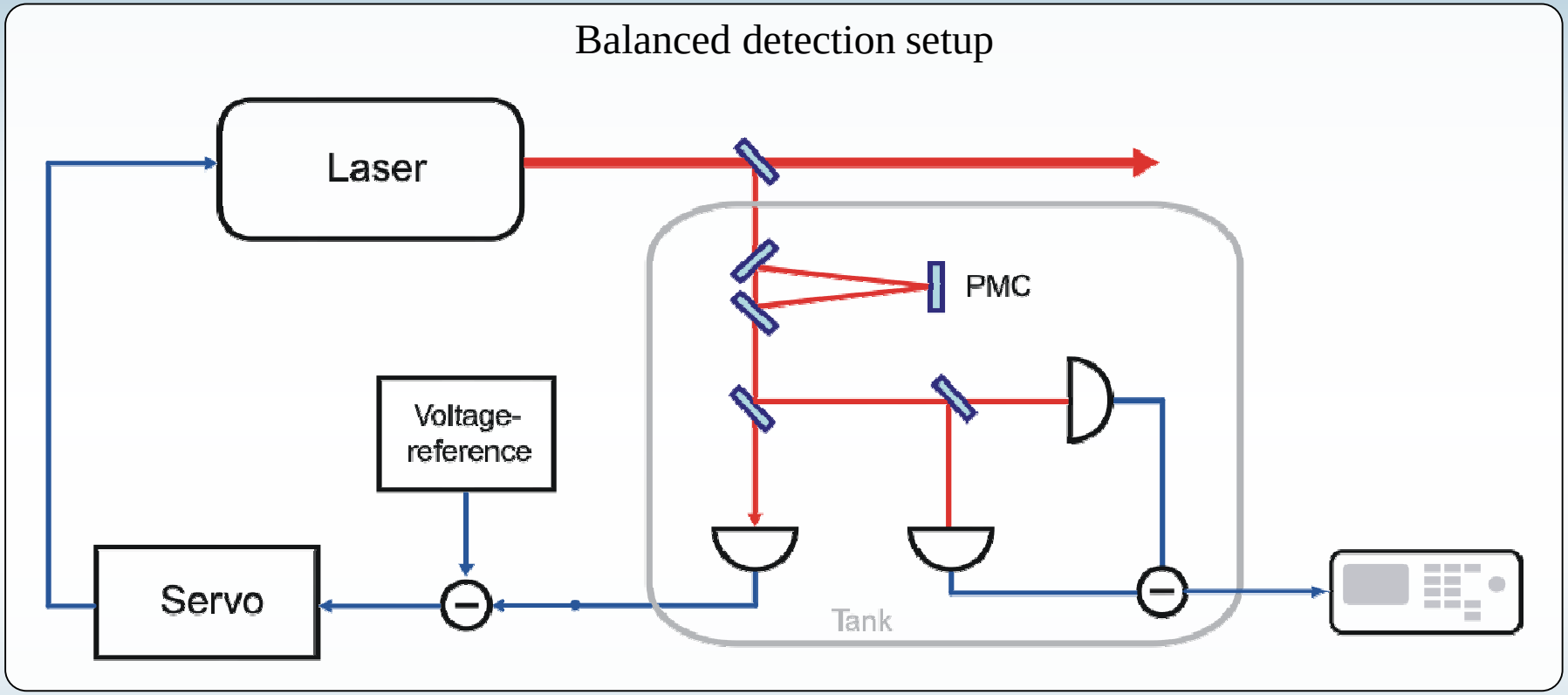
EG&G C30642G

3 different methods ➔ very good agreement

Power Fluctuations Due To Pointing

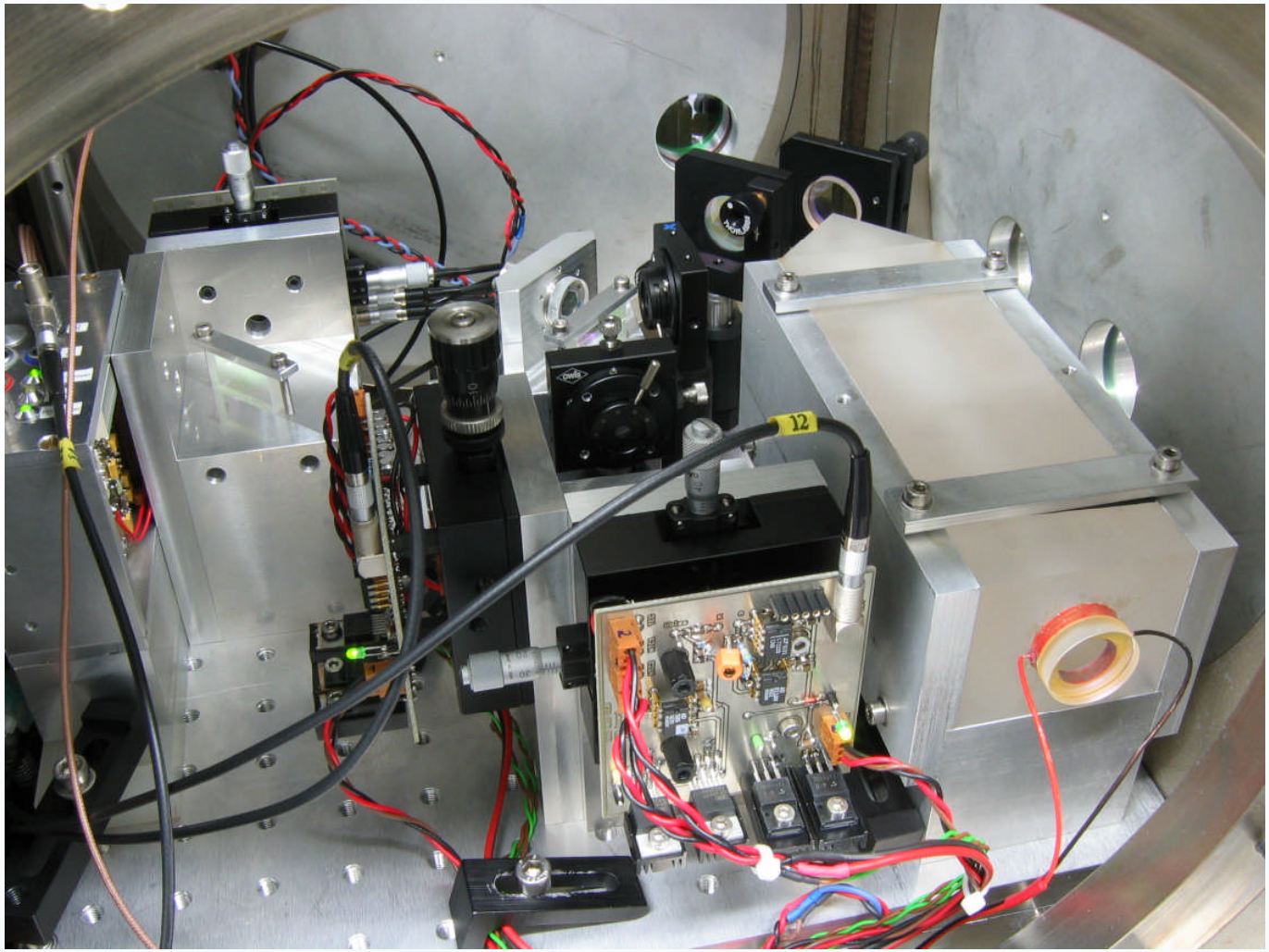


Low Frequency Noise in PD‘s



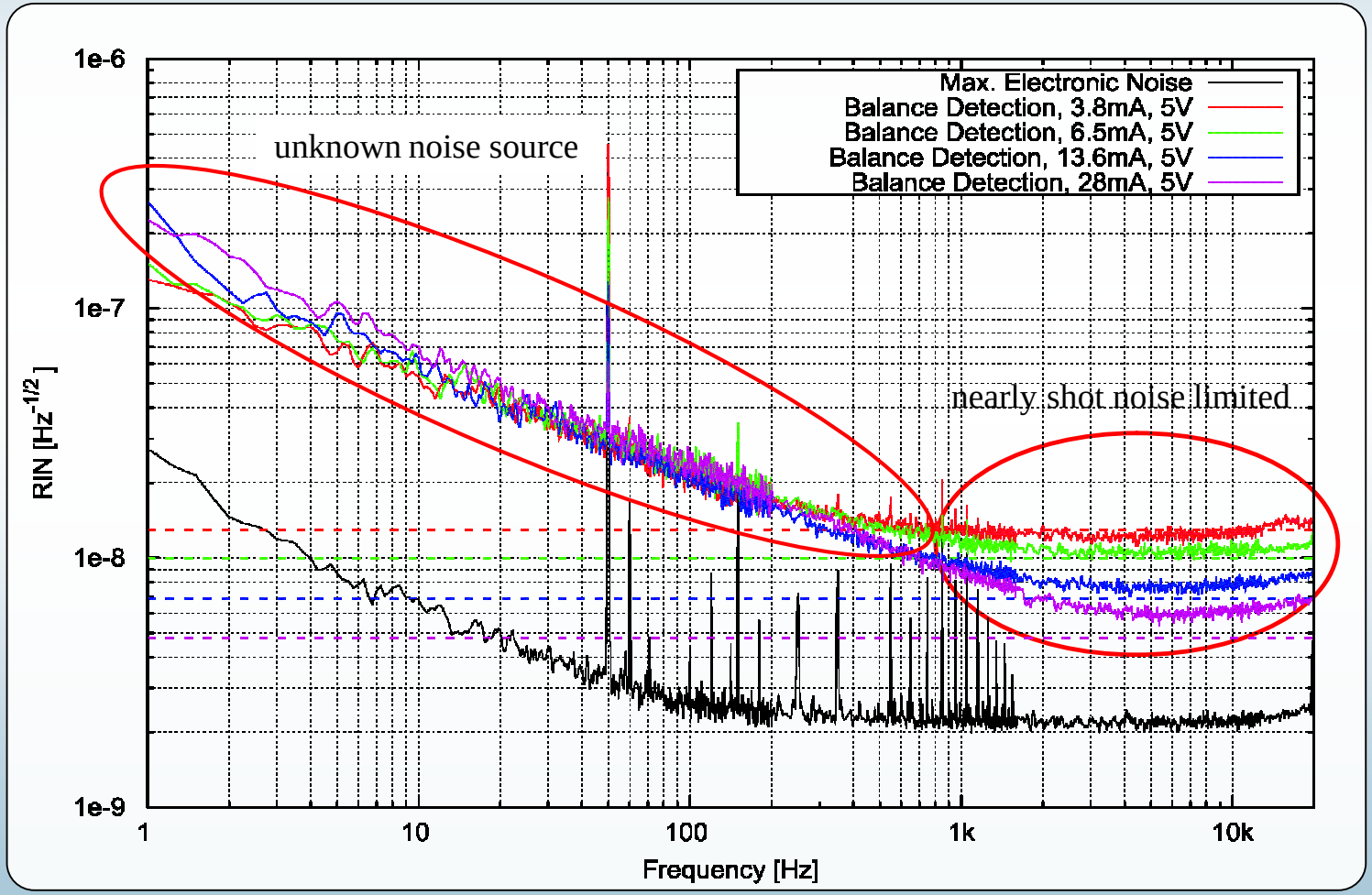
- pre-stabilized laser system below 1E-8 level
- amplification **after** substraction of photocurrents
- temperature stabilized photodiodes
- vacuum tank

Balanced Detection Setup



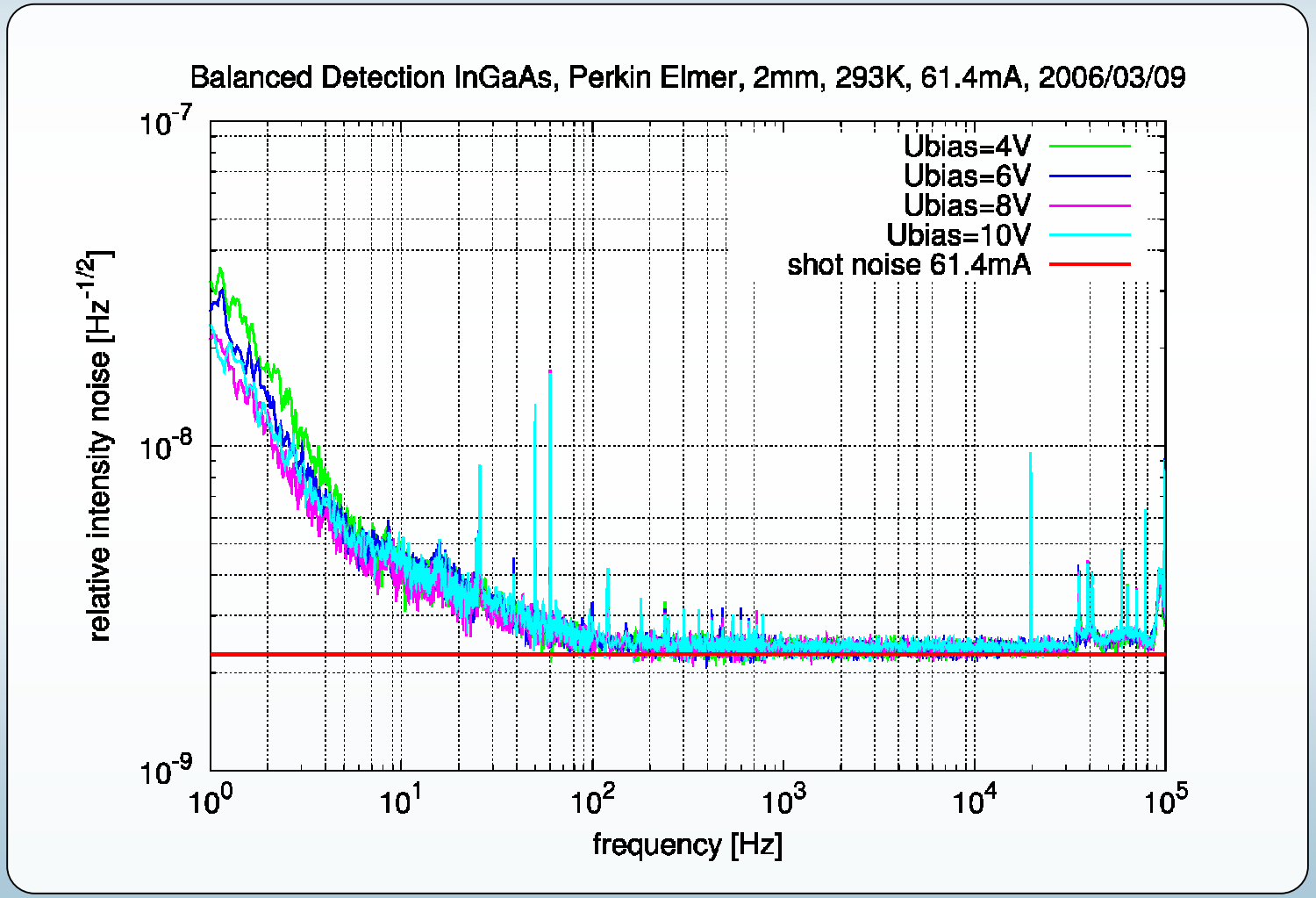
Balanced Detection – First Experiment

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



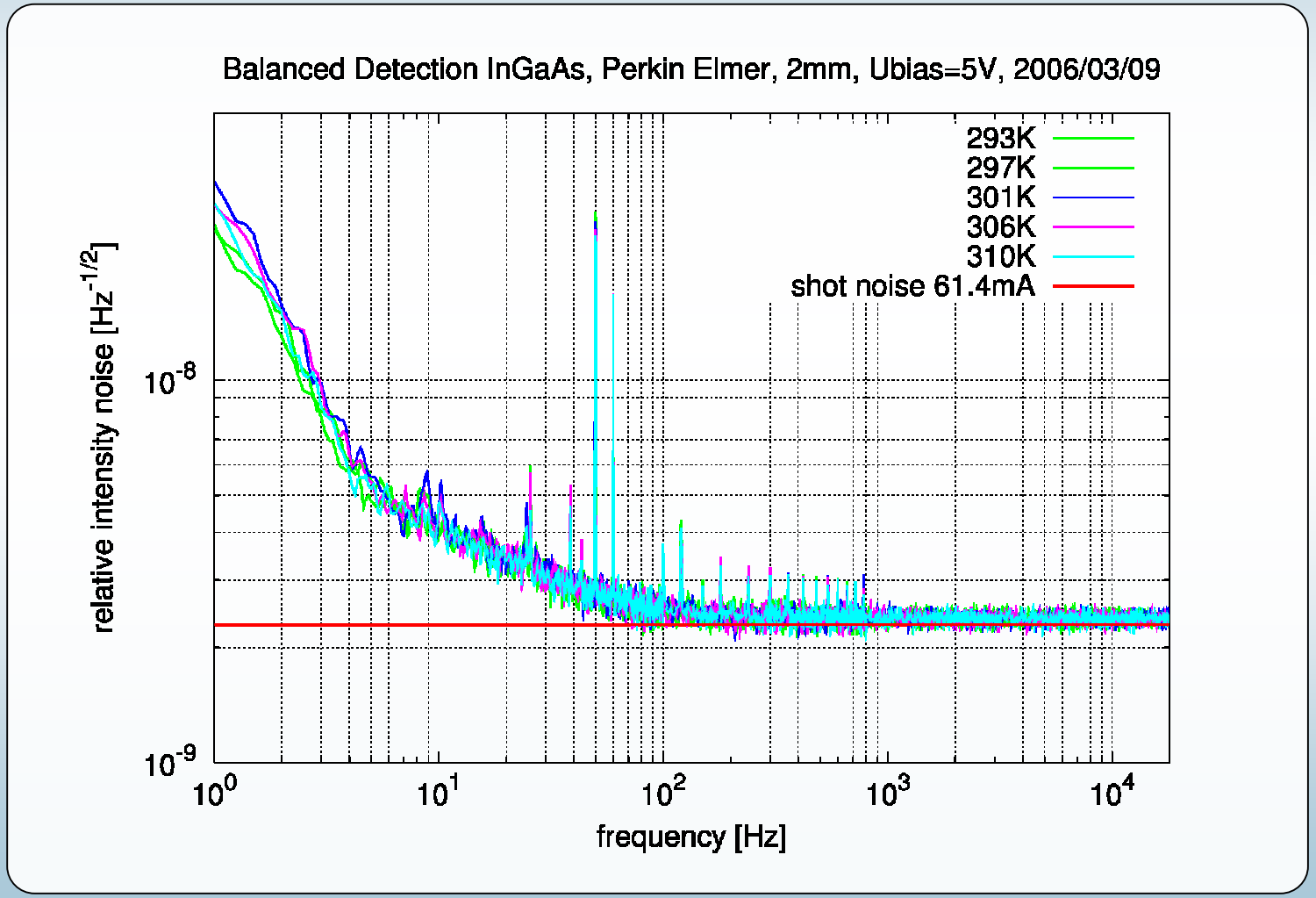
Balanced Detection – Results (1)

bias voltage dependence:



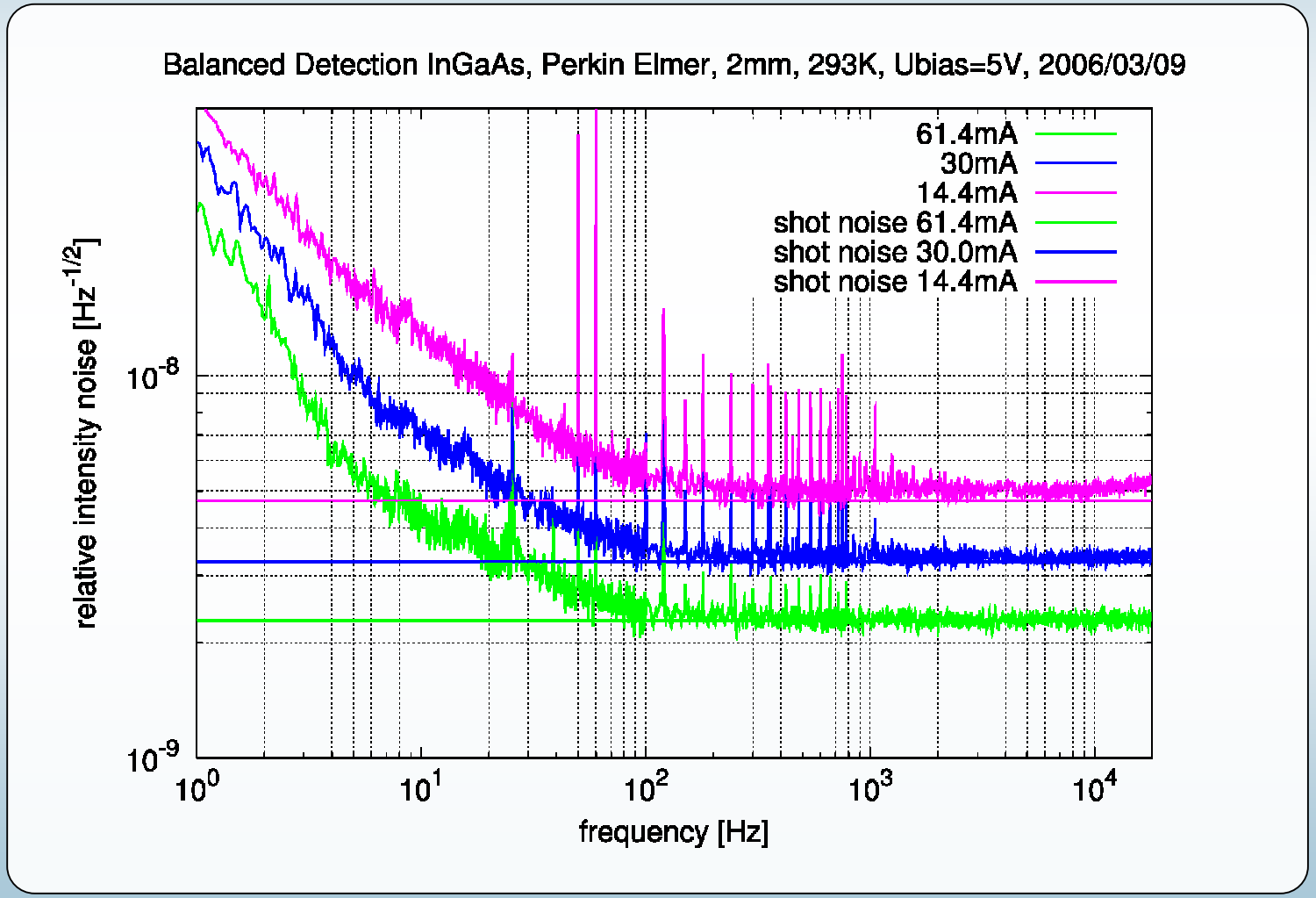
Balanced Detection – Results (2)

temperature dependence:



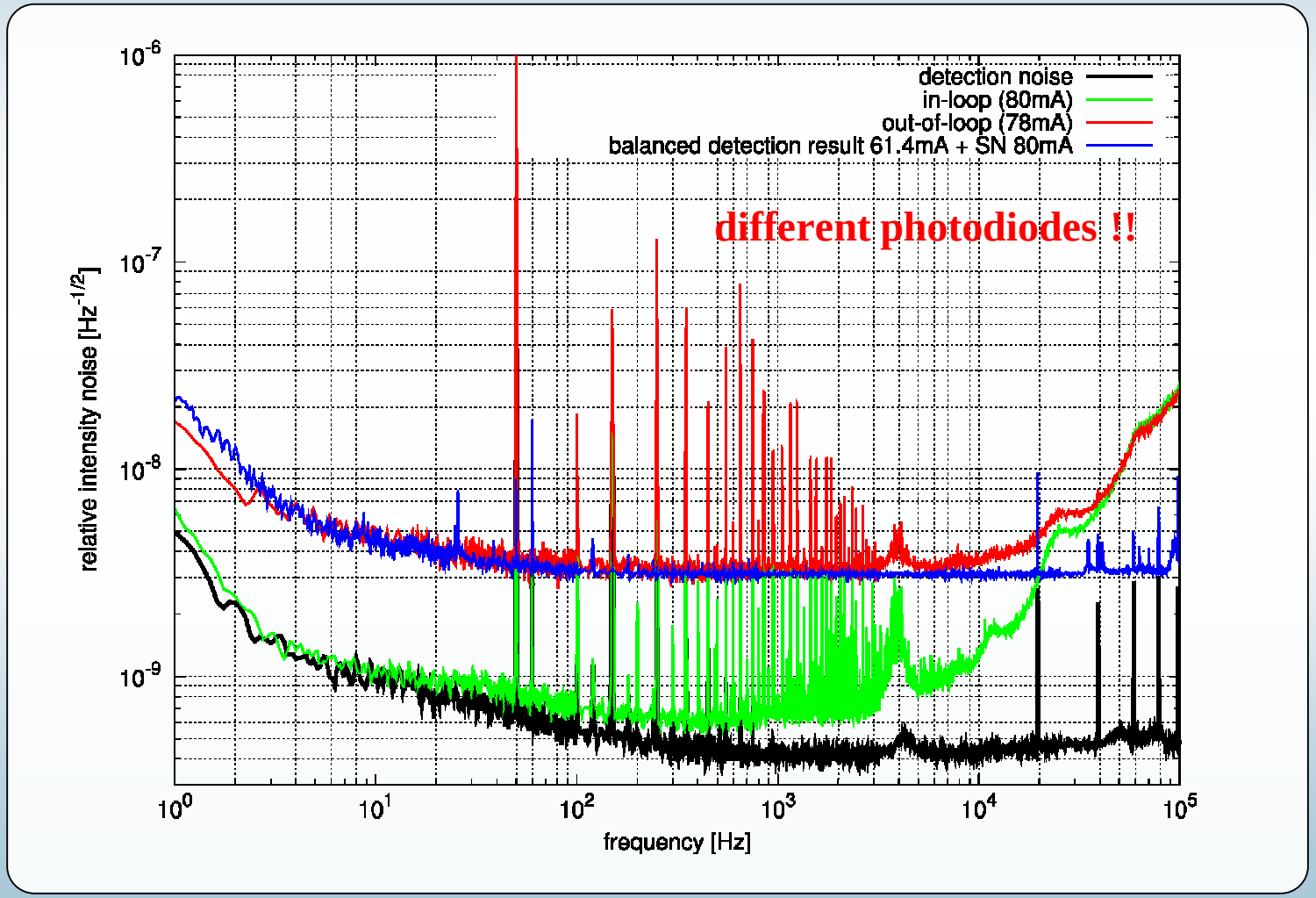
Balanced Detection – Results (3)

power dependence:



Low Frequency Limit

PD low frequency noise limiting ?:



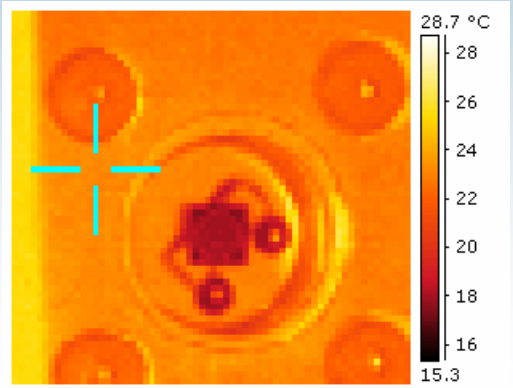
Conclusion & Next Steps

- Still limited by unidentified noise source at low frequencies
  ➔ low frequency noise in PD‘s good candidate

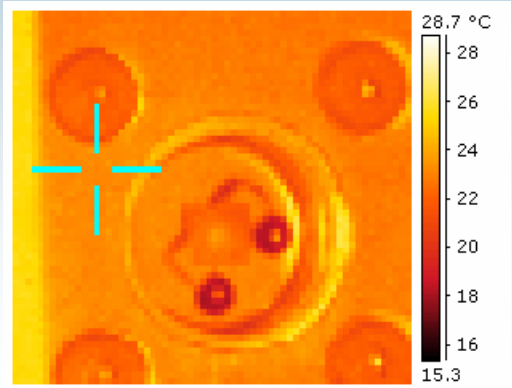
- future experiments:
  - low frequency noise in photodiodes
    ➔ detailed characterization of different photodiodes
    (dependence on bias voltage, temperature, photocurrent, manufacturer, material (InGaAs, Ge), size (2mm, 3mm))
  - influence of temperature fluctuations at the beamsplitter
    ➔ temperature coefficient of the BS
    ➔ TF temperature to RIN
  - influence of photodiode temperature fluctutions
    ➔ temperature coefficient of PD‘s
    ➔ TF temperature to RIN

spare slides

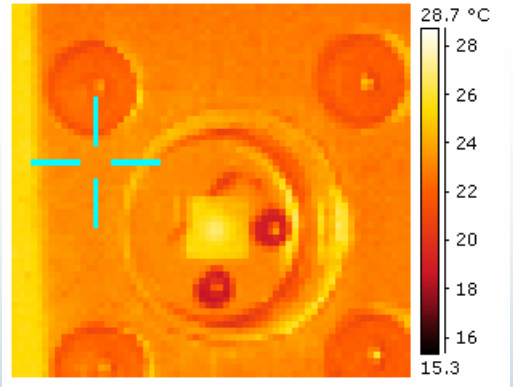
Photodiode Temperature Measurements



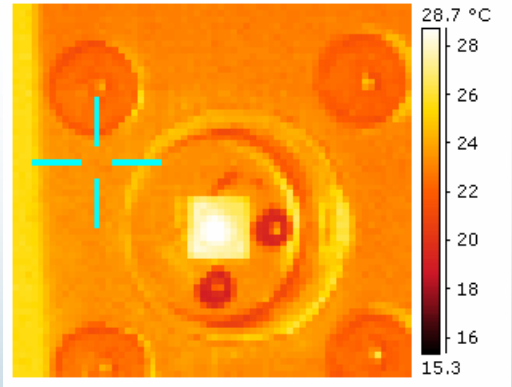
P = 0 mW



P = 65 mW



P = 105 mW



P = 130 mW

- ΔT only $\approx$ 10K
- real chip temperature ?

PD EG&G C30642G
without window