ALPS II: Overview and Status Report

The search for Axion-like particles with long baseline cavities

Aaron Spector
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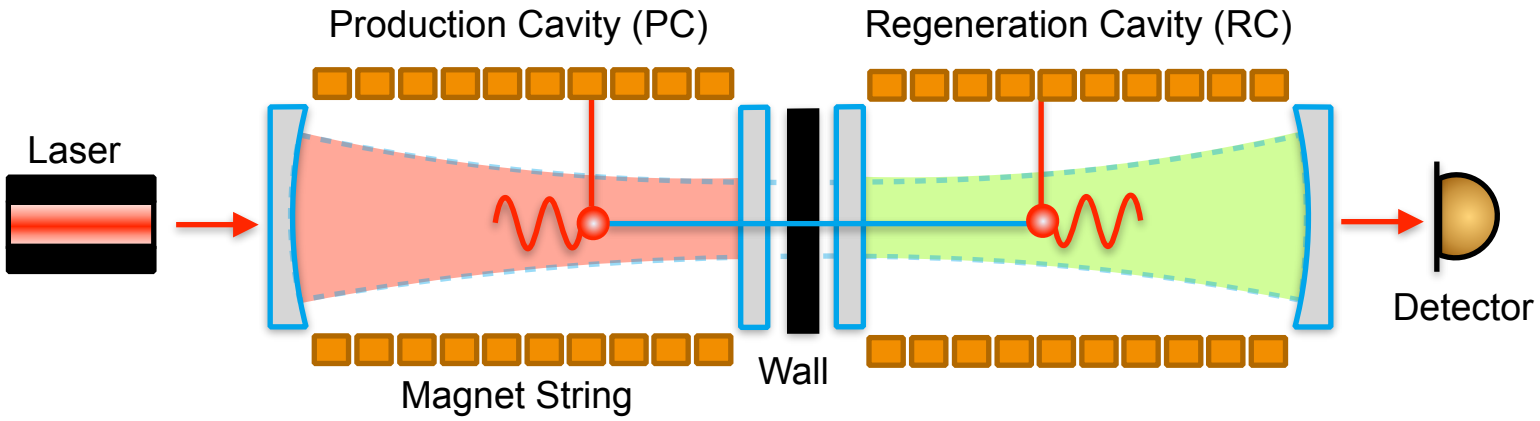
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Light Shining through a Wall Concept

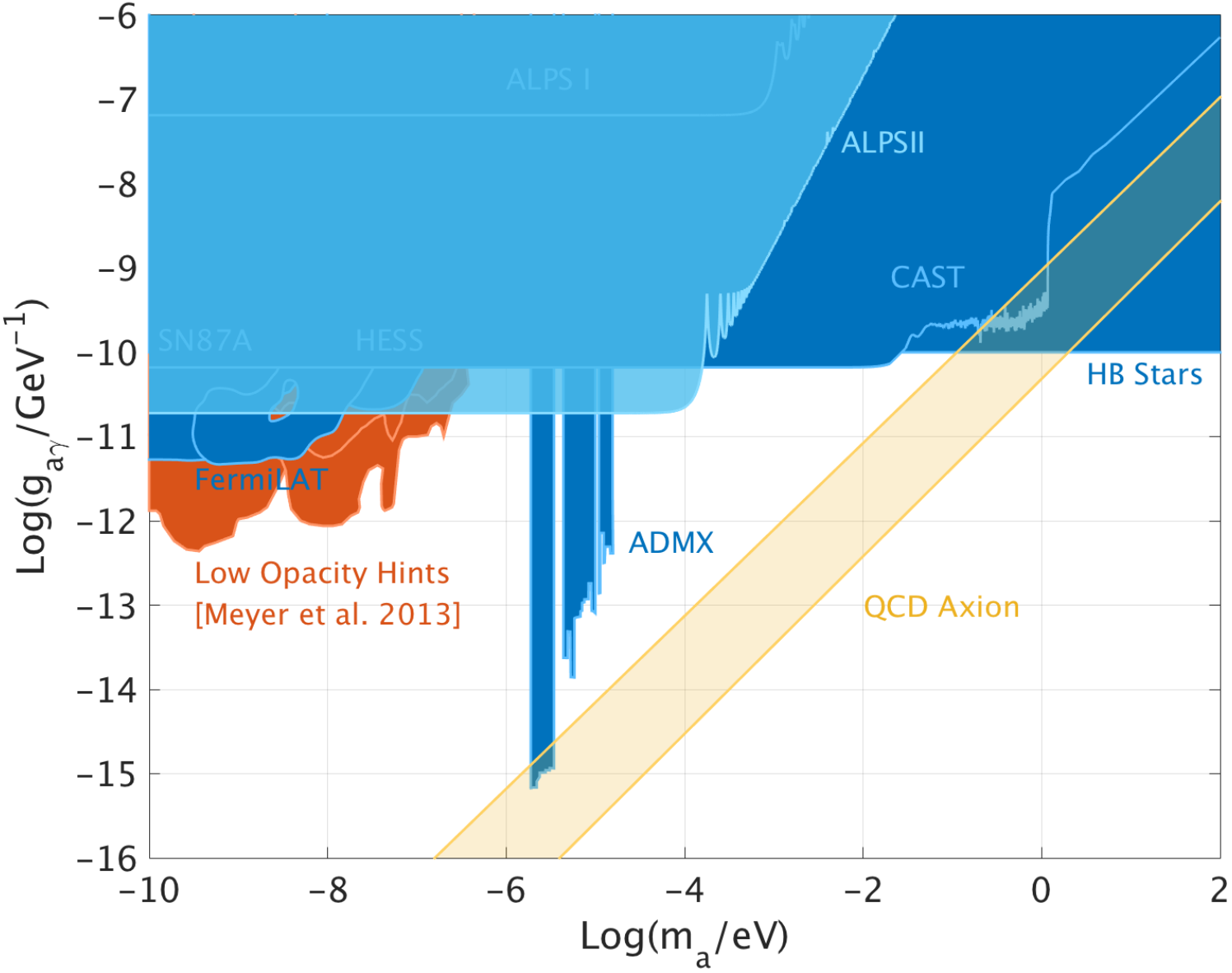
Measuring the conversion-reconversion of Axion-like particles

LSW concept

- High power source directs light through a magnetic field creating a flux Axion-like particles through a wall
- Magnetic field converts Axion-like particles back to photons
- ALPS II: Optical cavities amplify the conversion-reconversion probability
  - Coupling sensitivity: 2×10^{-11} GeV^{-1} Mass: < 0.1 meV



ALPS II Sensitivity



Experimental Infrastructure at DESY

Providing the foundation for ALPS II

Optics Lab

- Optical subsystems tested in ALPS IIa lab
- ALPS IIc (100 m cavities) in HERA tunnel

HERA Infrastructure

- 5 T superconducting dipole magnets
- Use existing HERA cryogenic infrastructure
  - 10 have been unbent (need 20)
  - See poster by Dieter Trines

ALPS II Optical System

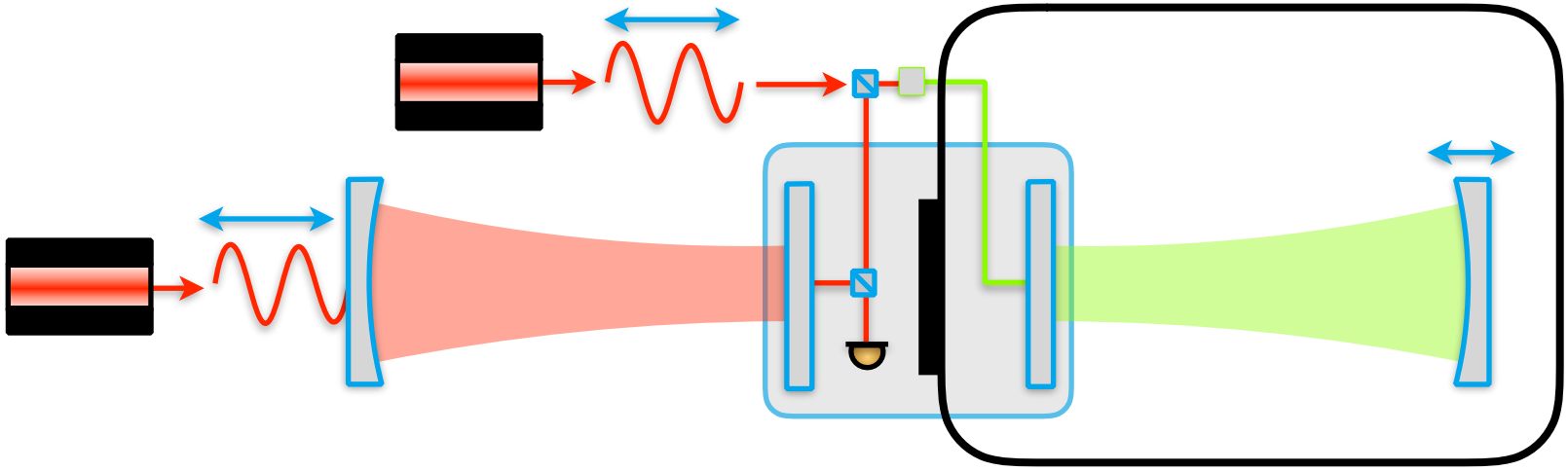
A unique set of challenges

Two 100 m optical resonators

- 30 W amplified NPRO input laser
- PC: 150 kW circulating power
- RC: 120,000 finesse

Challenges

- Maintenance of dual resonance
- Maintenance of spatial overlap
- Light tightness 1 photon / 2 weeks



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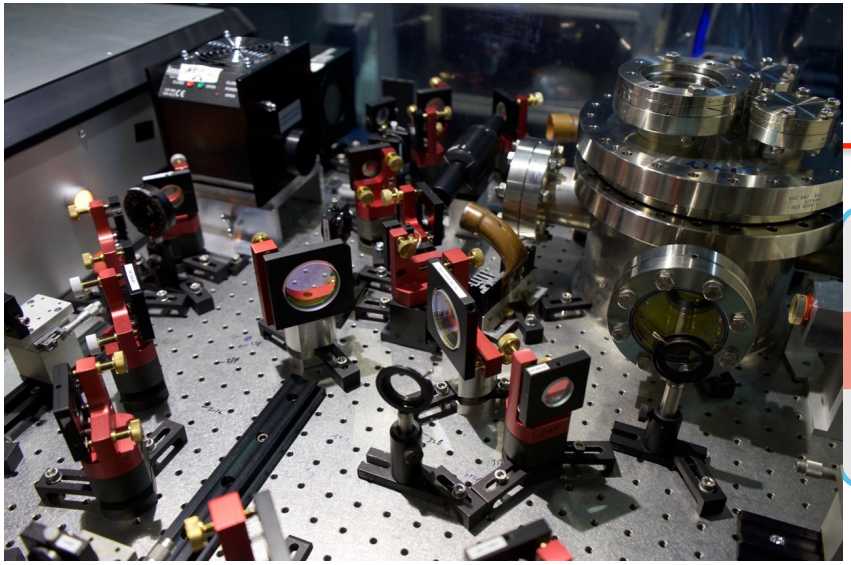

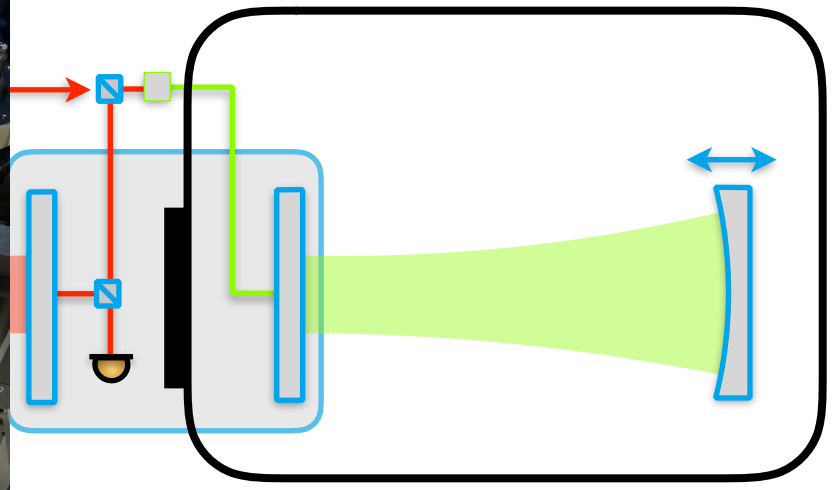

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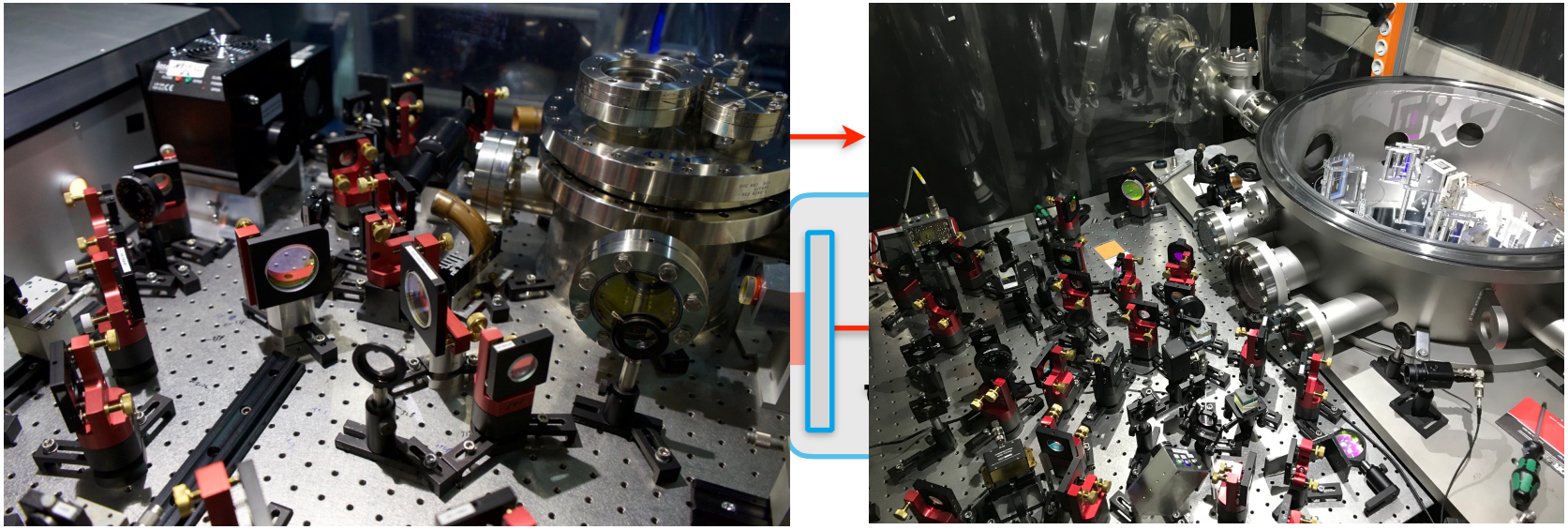
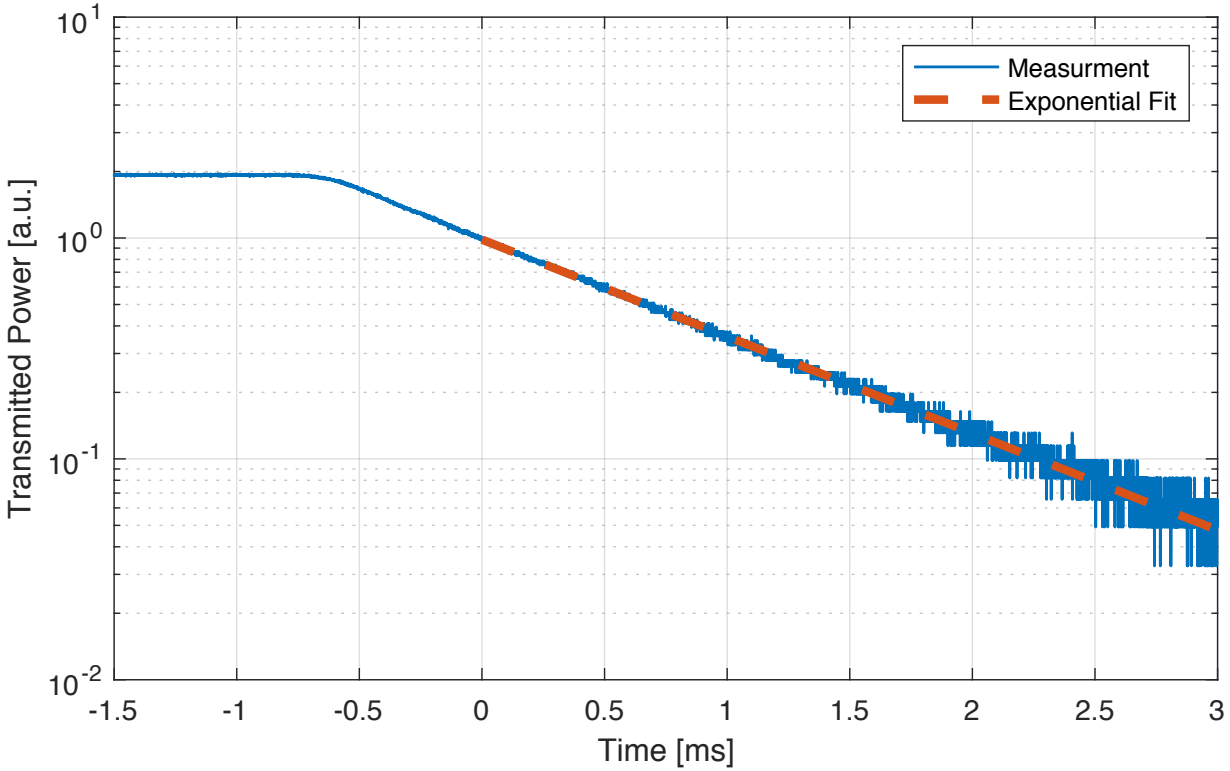


ALPS IIa Status

Addressing challenges in the lab

Cavity Power Buildup

- 50 kW circulating in 10 m Production Cavity
- Finesse of ~ 93,000 in 10 m Regeneration Cavity



ALPS IIa Status

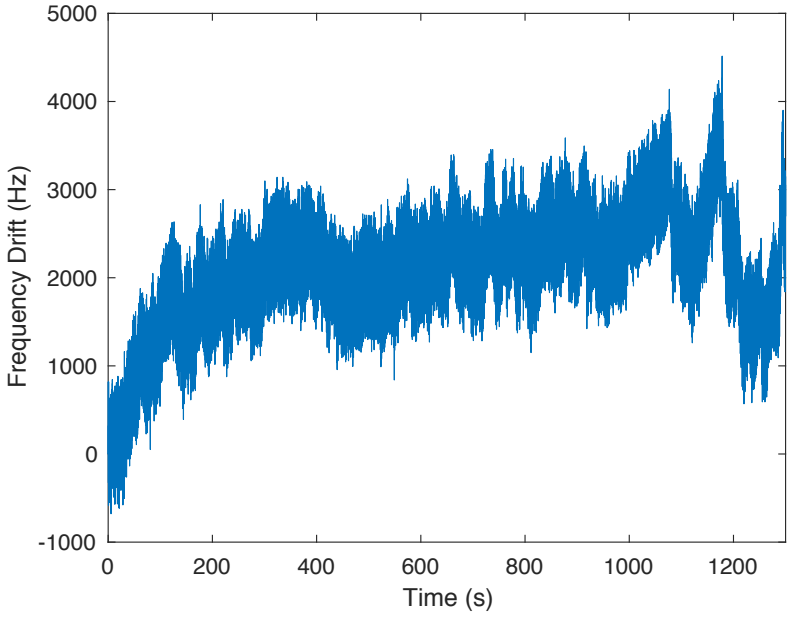
Addressing challenges in the lab

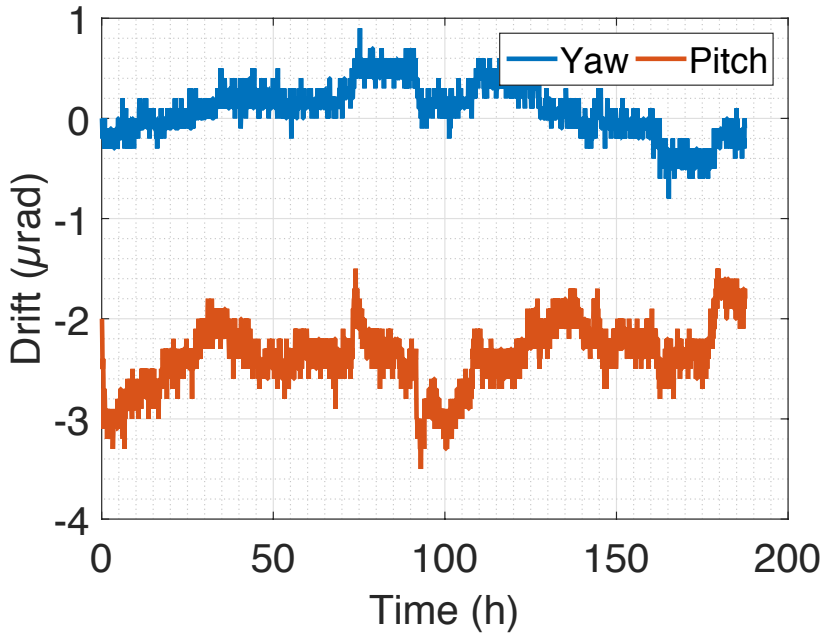
Dual Resonance

- Length stabilization system meets relative stability requirements without additional seismic isolation
  - 5 kHz actuation on a 2” mirror
  - Stability ~ 0.5 pm (532 nm)
  - Meas. of EPR changes see poster by Dennis Schmelzer

Spatial Overlap

- Alignment drift of CBB mirrors measured for 2 different mounts
- Both meet requirements



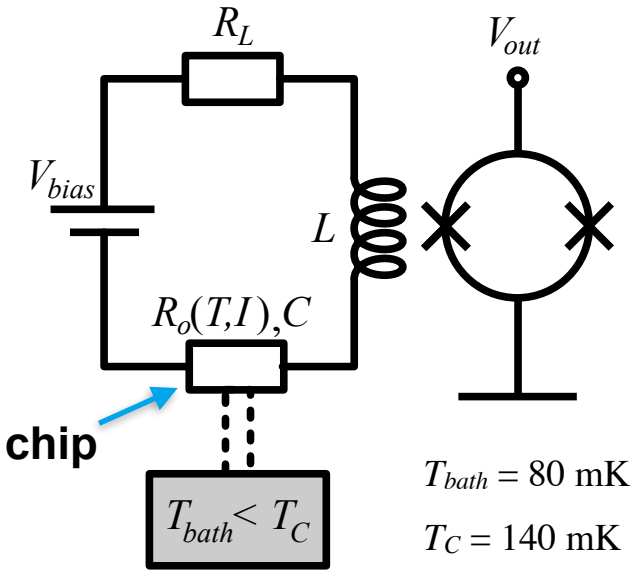


ALPS II Detectors

Two independent measurement systems

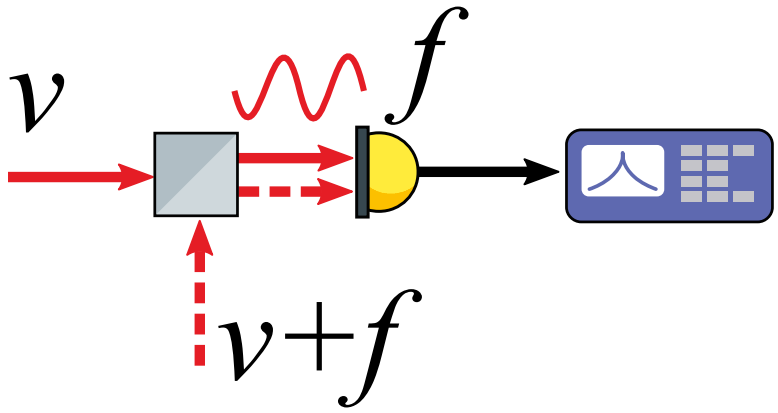
Transition Edge Sensor

- Microcalorimeter measures temp. change induced by absorbed photon
- Squid readout
- New cryostat being installed



Heterodyne detection system

- AC measurement of interference of regenerated field with local oscillator
- Stable path length between cavities
- No fundamental background
- Demonstrated in testbed at UF
- See poster by Giuseppe Messineo



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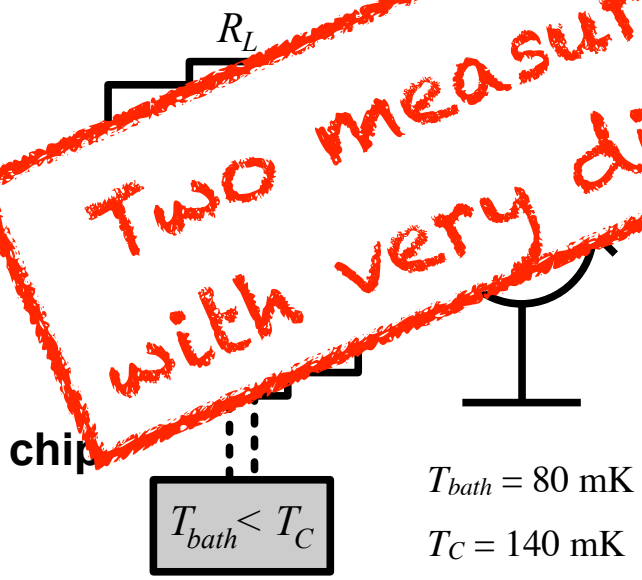

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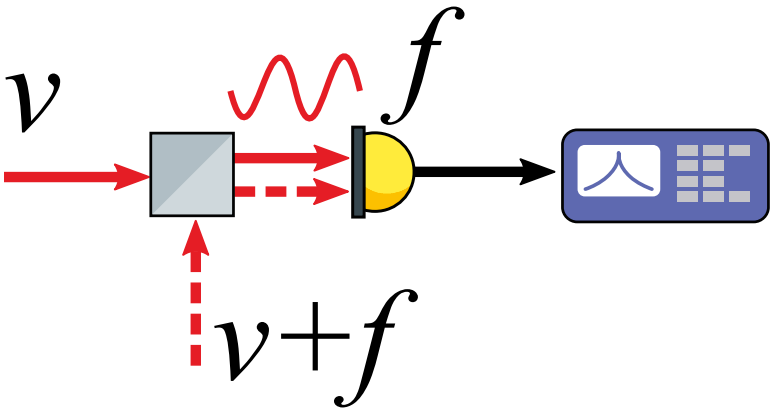


Two measurement techniques with very different systematics

ALPS II Timeline

- HERA tunnels and hall currently being cleared
- Magnet installation will begin before the end of the year
- Optics installation will begin in the middle of 2019
- ALPS II data run scheduled 2020

Conclusions

- ALPS II is making progress in the three key areas of the experiment
  - Infrastructure:
    - Clearing of the tunnels
    - Magnet unbending
  - Optics:
    - Development of the cavity systems in ALPS IIa
  - Detection technologies:
    - Demonstration of Heterodyne
    - New cryostat for TES

- ALPS II data run scheduled 2020

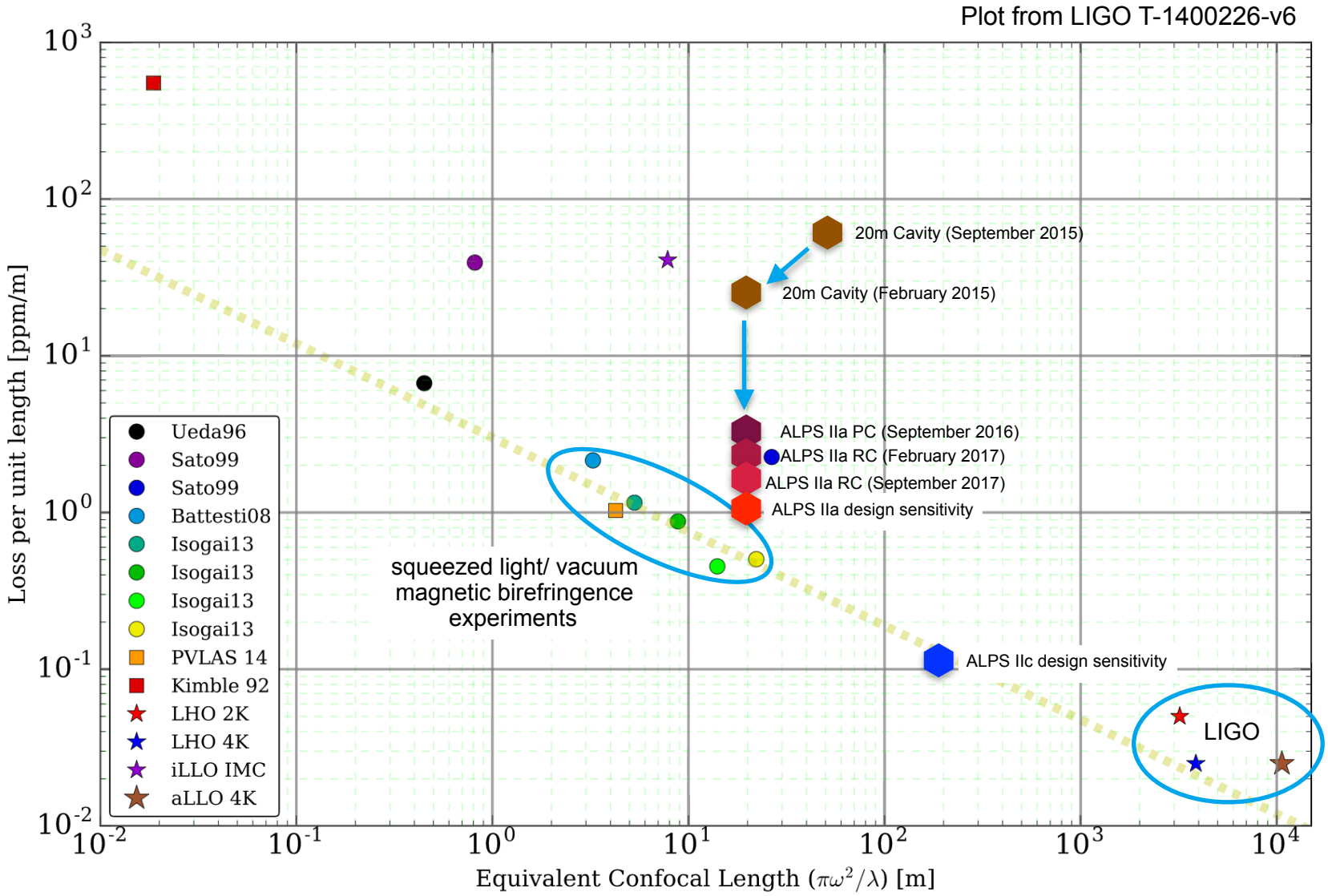
Thank you!

- This work would not be possible without the support of the DESY infrastructure groups.

Questions?

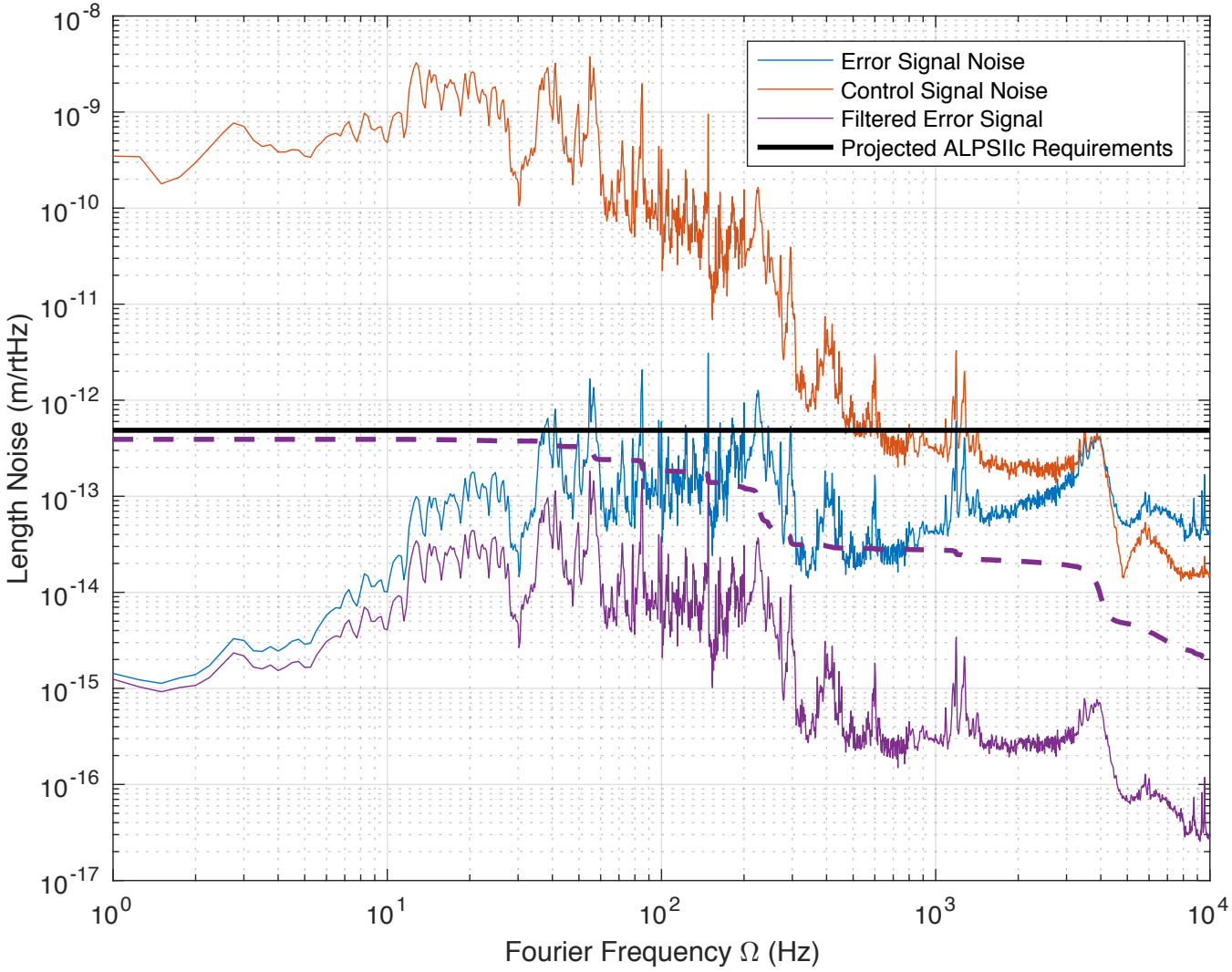
ALPS II cavities in context

Approaching the state of the art



Length Stabilization Results

Actuating on a 2” mirror with a 5 kHz bandwidth

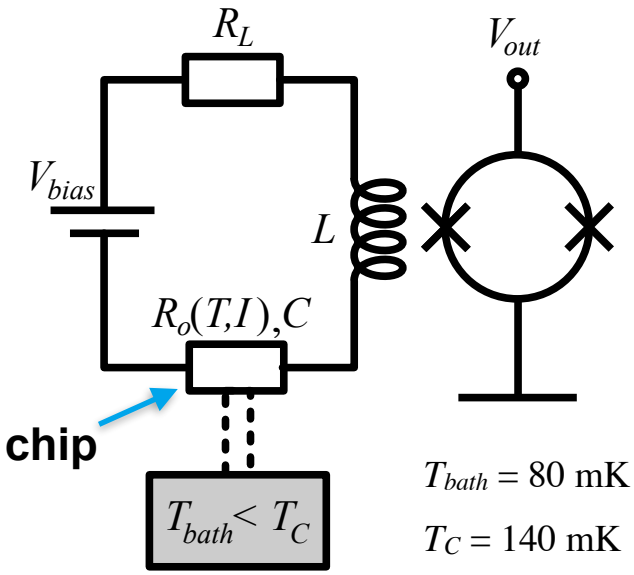


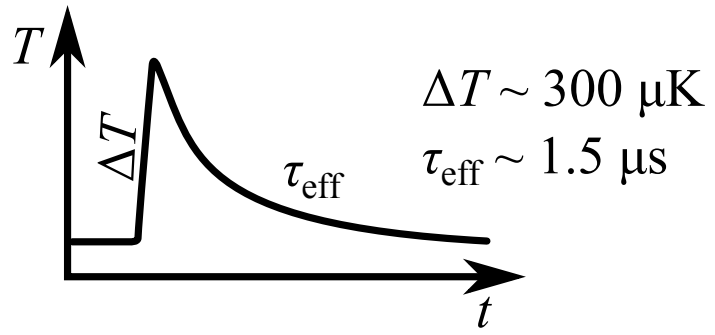
Transition Edge Sensor

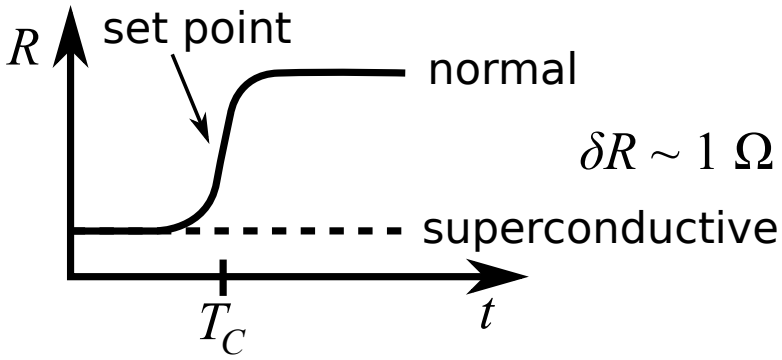
Two independent measurement systems

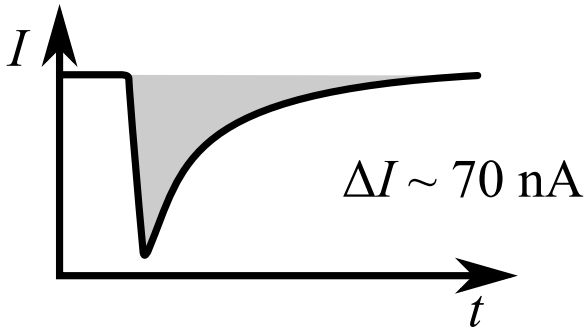
Transition Edge Sensor

- Microcalorimeter measures temp. change induced by absorbed photon
- Squid readout
- 7% energy resolution



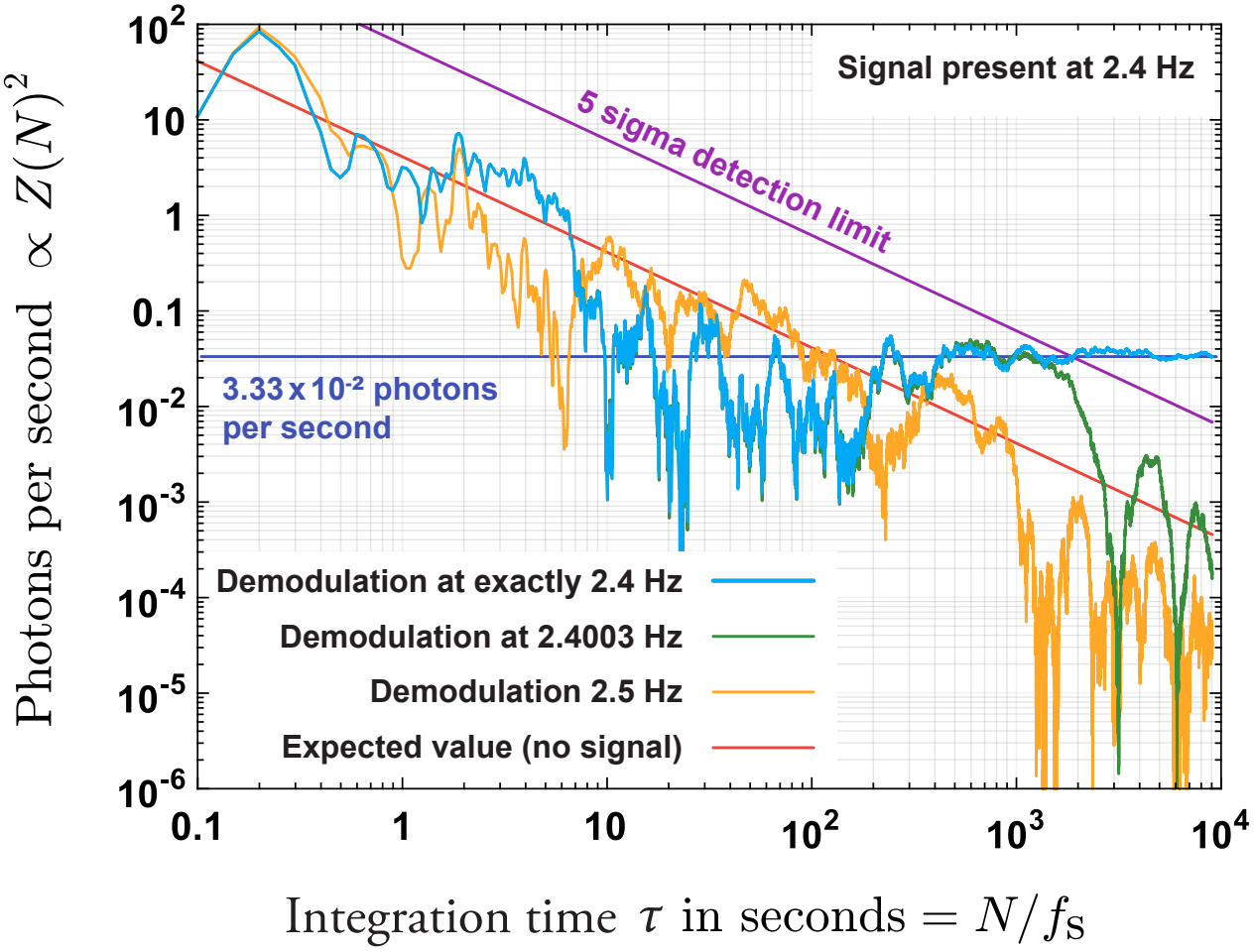






Heterodyne Detector

- Backgrnd. signals:
- < 1 photon/10^6 s
- Meas. signals:
- ~ 3 photons/100 s



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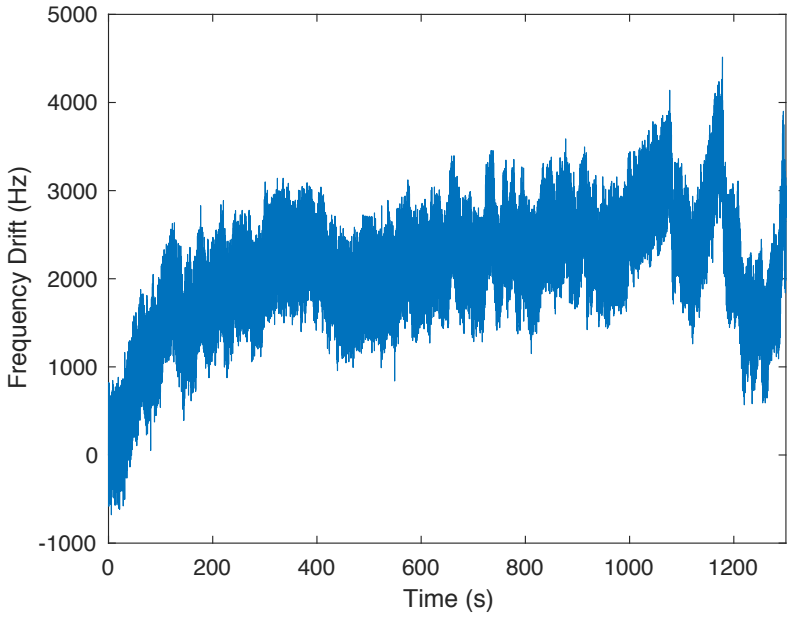

Demonstration of the length stability requirements for ALPS II with a high finesse 10 m cavity

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arXiv:1710.06634v1 [physics.ins-det] 18 Oct 2017