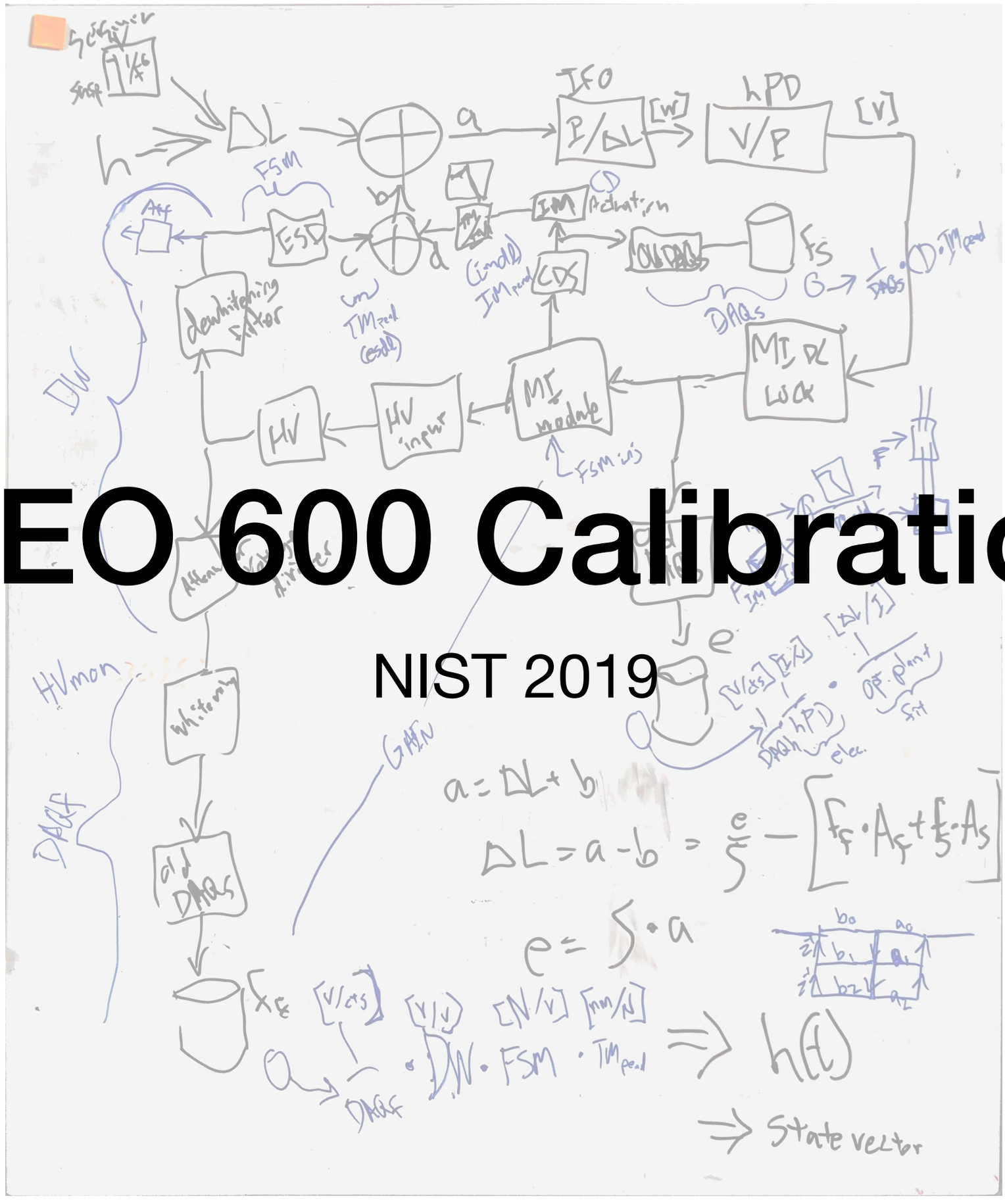


GEO 600 Calibration

NIST 2019

Jim Lough

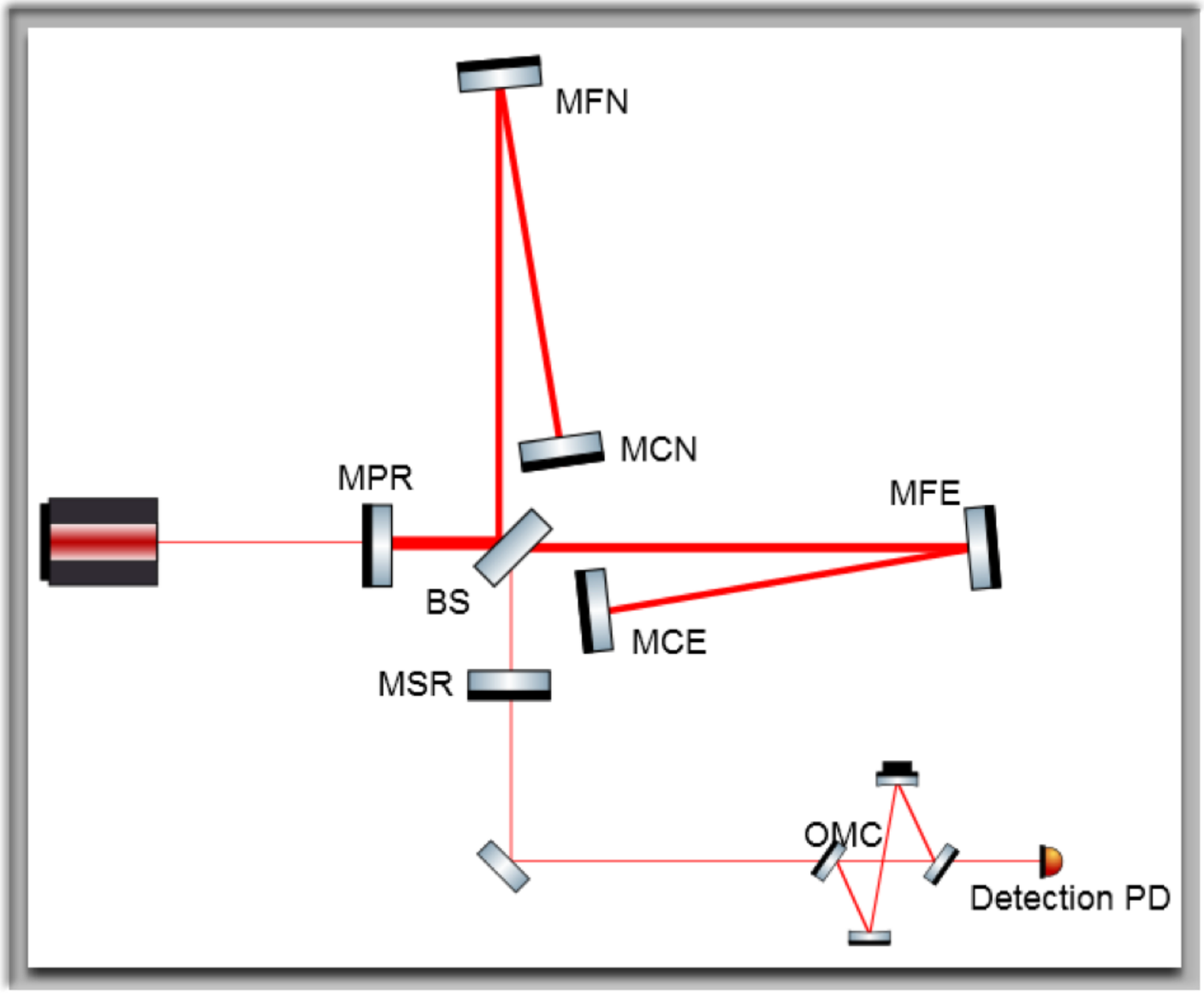
LIGO-G1900480-v1

Calibration at GEO

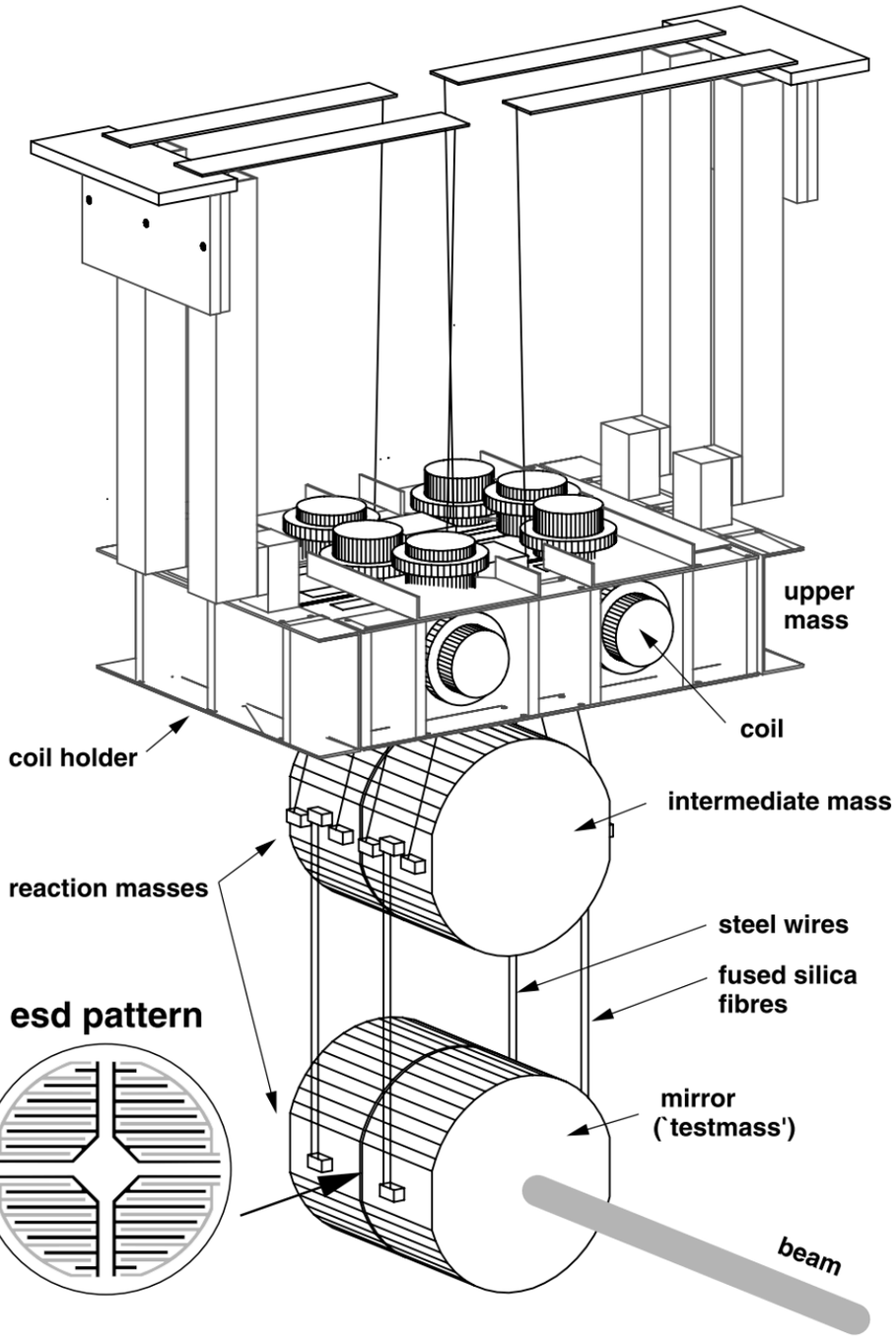
- GEO 600 overview
- Laser frequency reference
- Photon Pressure Calibration
- current online calibration process
- new realtime calibration under development

GEO 600

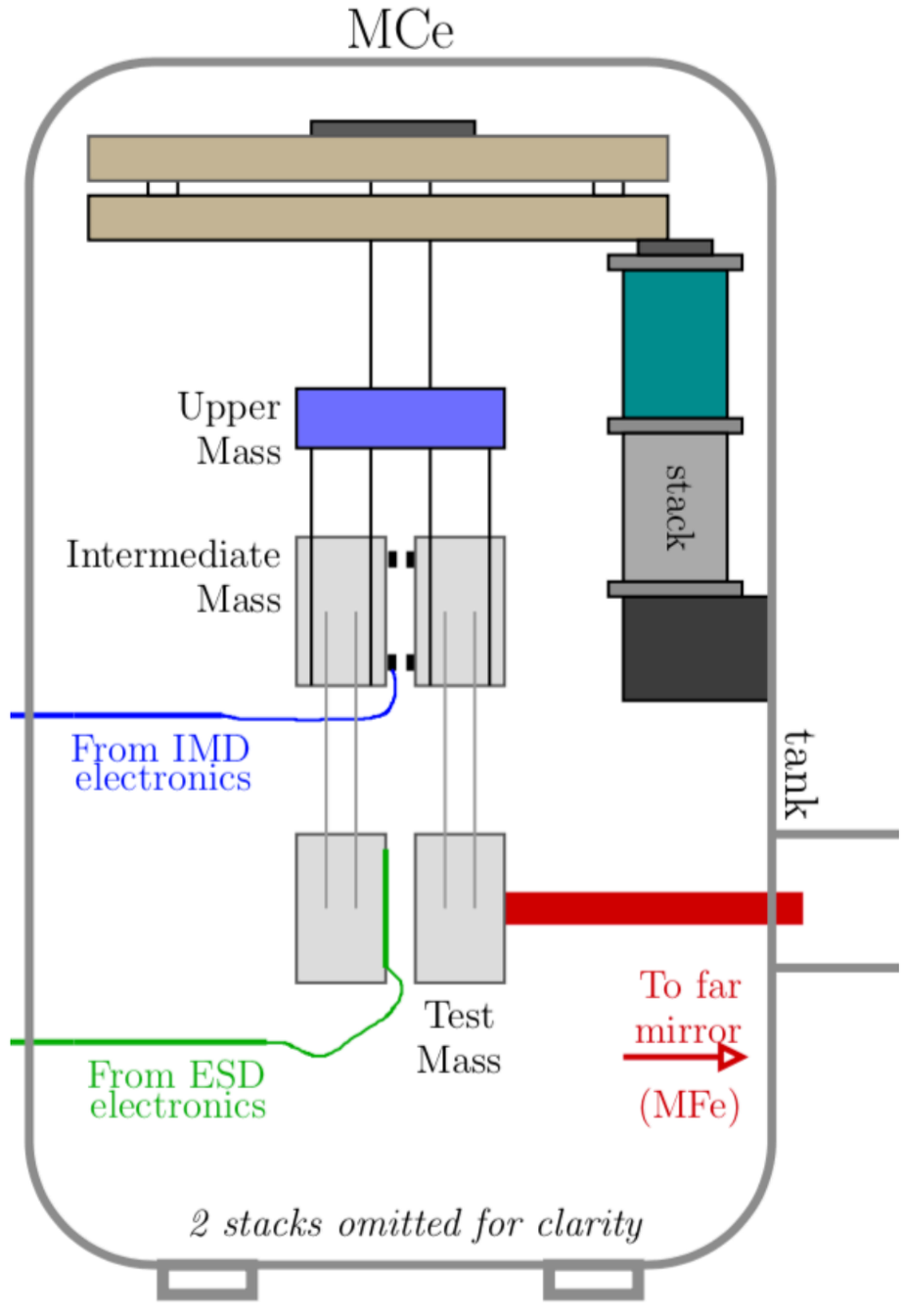
- Dual recycled folded Michelson - no arm cavities!
- IFO control is all in one building (essentially)
- ESD actuators
- DC readout, Dark Fringe Offset
- Squeezing enhanced -> equivalent to about 4 times more circulating power



Length Actuation



Leong, et al. CQG 2012



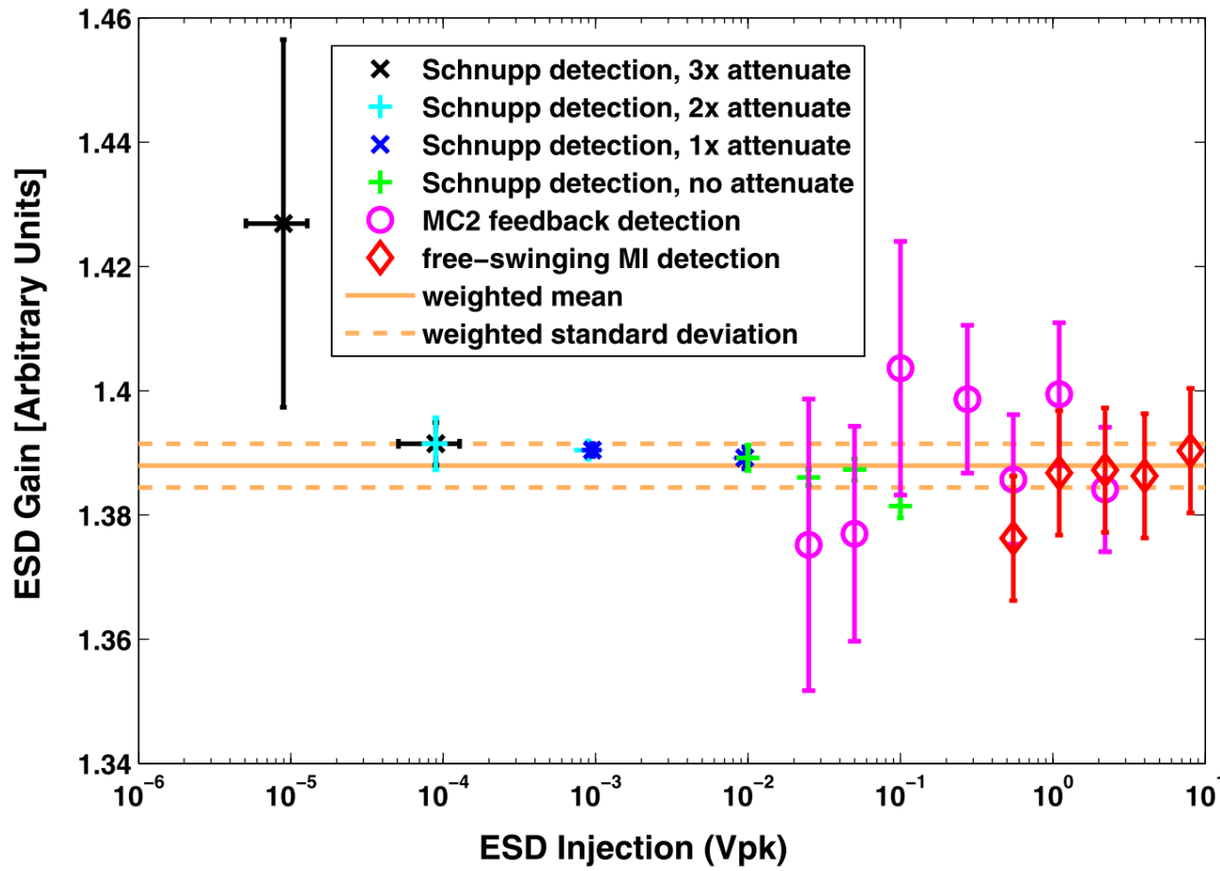
Hewitson, PhD thesis 2004

Free Swinging Michelson

- mirrors aligned swing through resonance freely. force modulation applied using ESD.

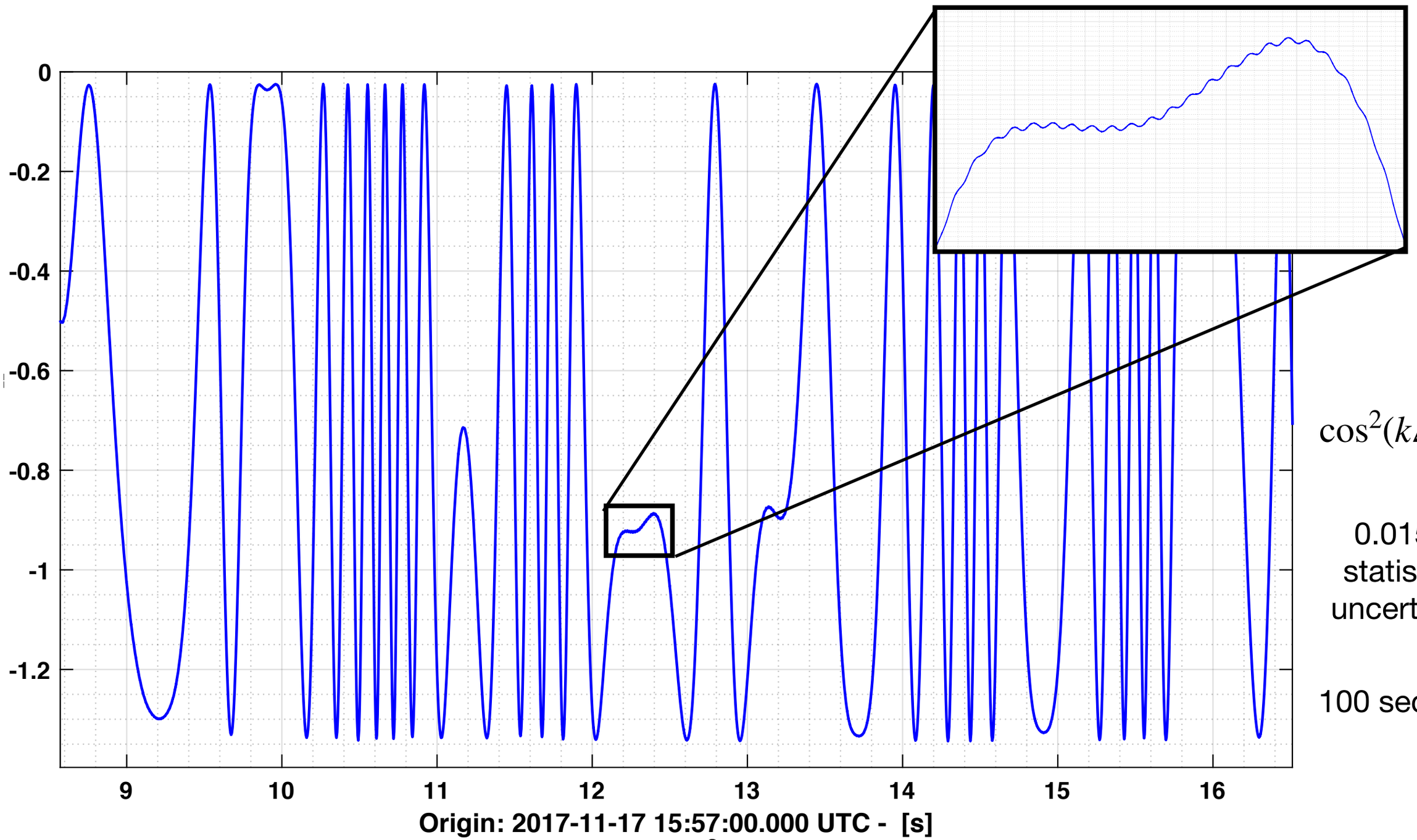
- overall amplitude (light to dark) represents lambda/4 motion |north-east|. Calibrates modulation length measurement.

- test for linearity over 5 orders of magnitude: ~0.3%



Leong, et al. CQG 2012

Free Swinging Michelson

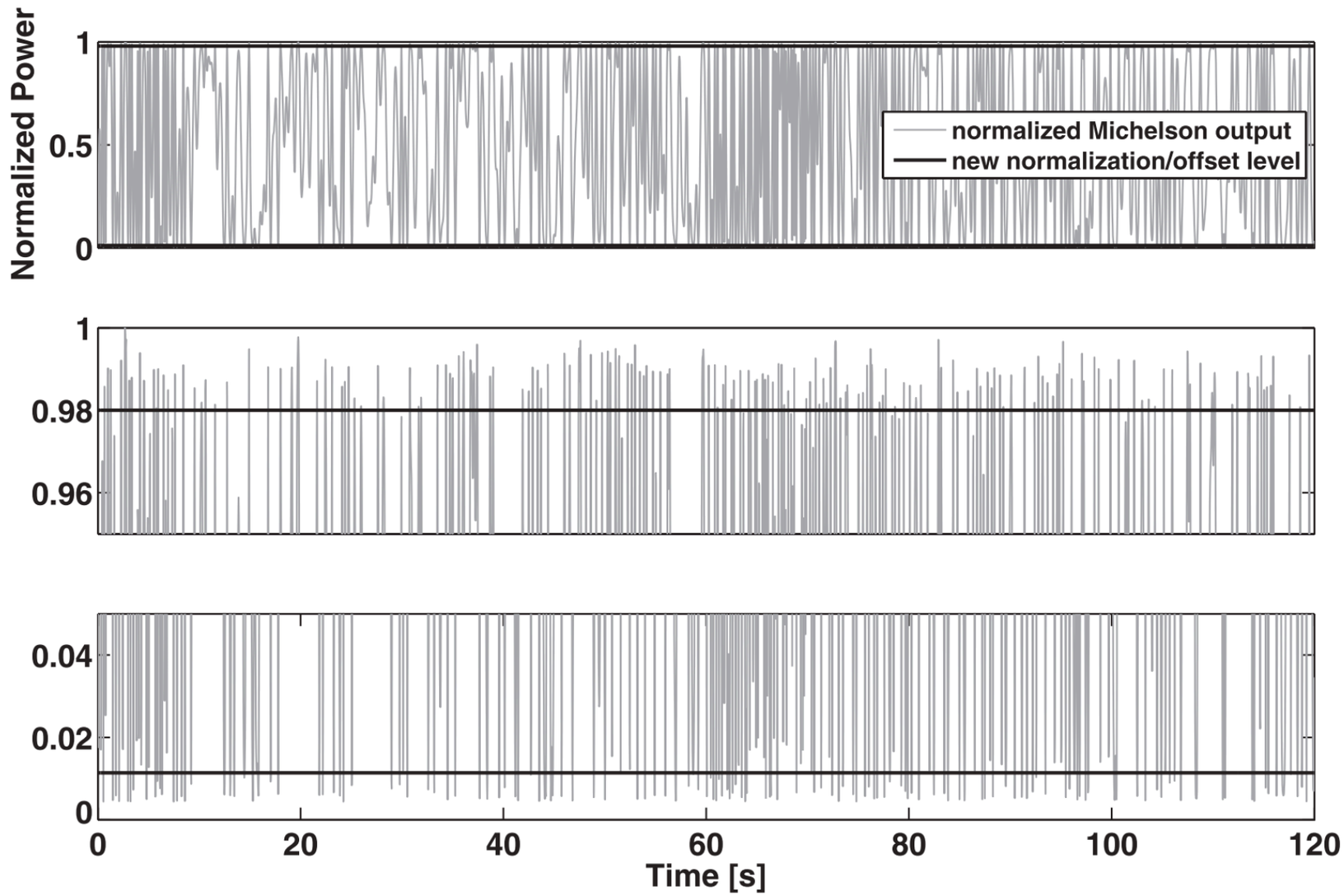


$\cos^2(k\Delta L)$

0.015% statistical uncertainty

100 seconds

Free Swinging Michelson

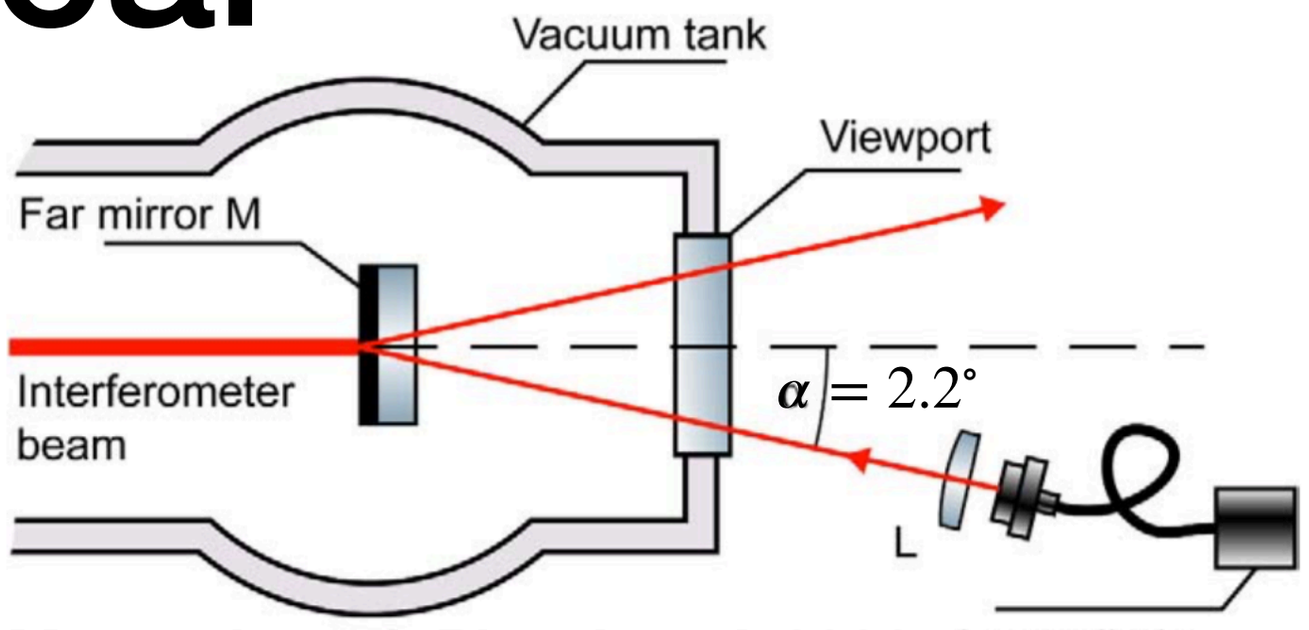


Leong, et al. CQG 2012

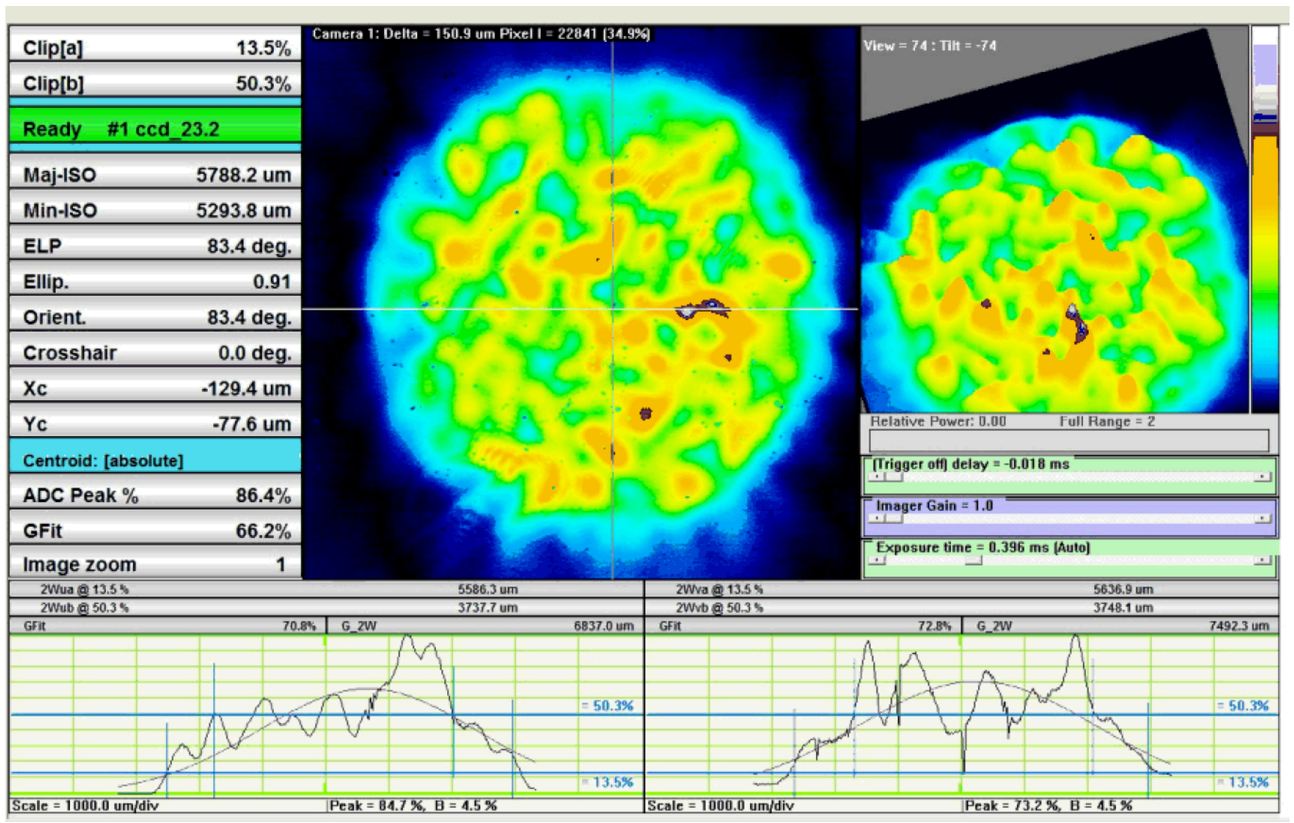
Test for systematic uncertainty related to power fluctuations and alignment: <3%

Pcal

- Multimode fiber coupled 1035nm laser
- Far North folding mirror
- unknown ~20% loss on reflection
- beam profile kind of not nice…

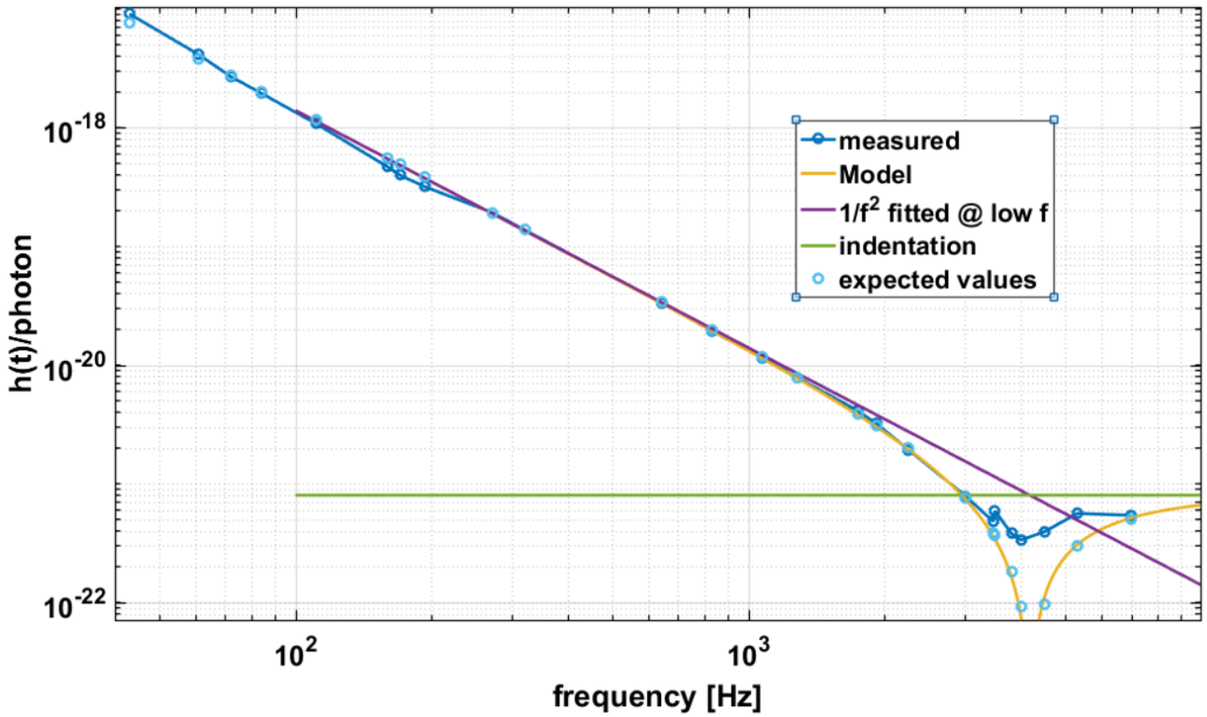


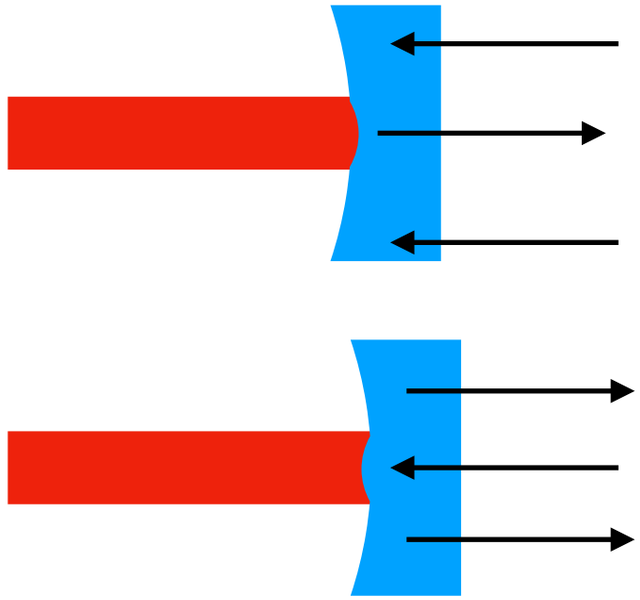
Mossavi, et al. Phys Lett A 2006

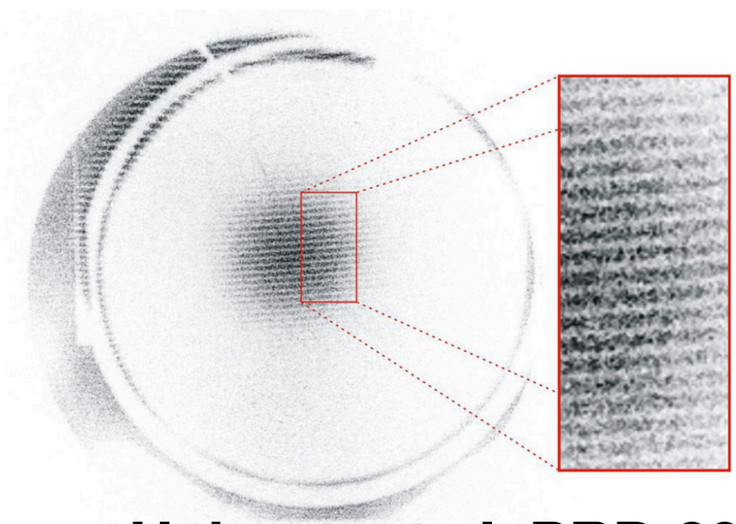


Pcal

- beam is reflected from center of HR surface where the main interferometer beam is. This causes a problem.







Heinert, et al. PRD 2014

Pcal

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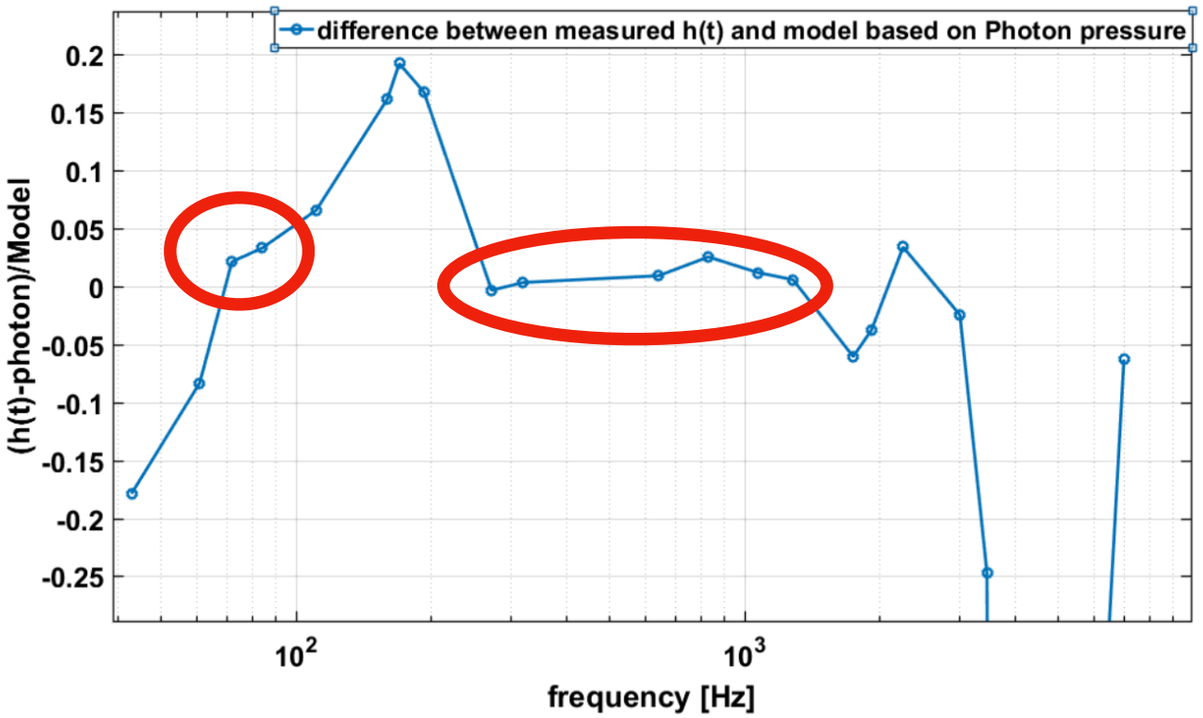
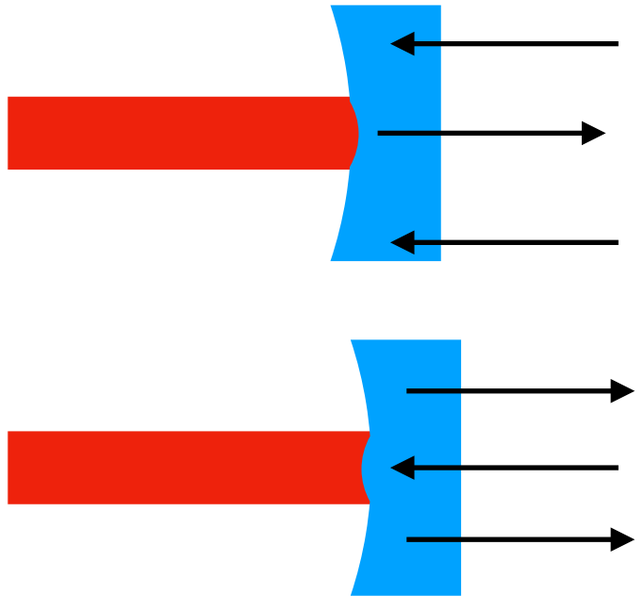
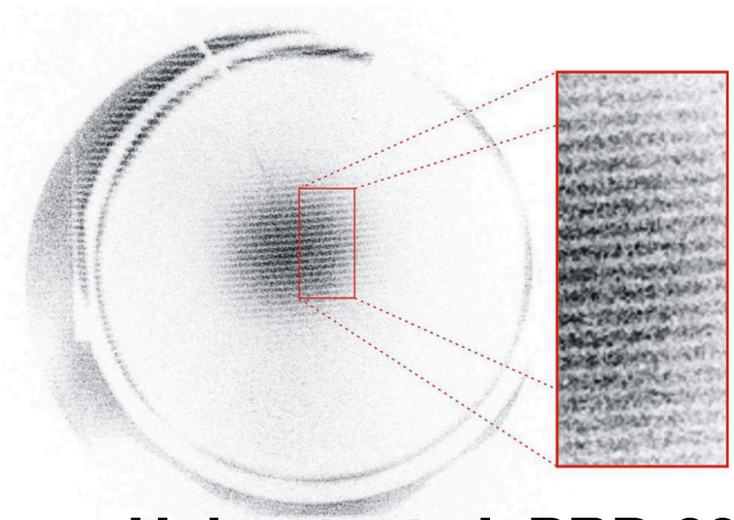
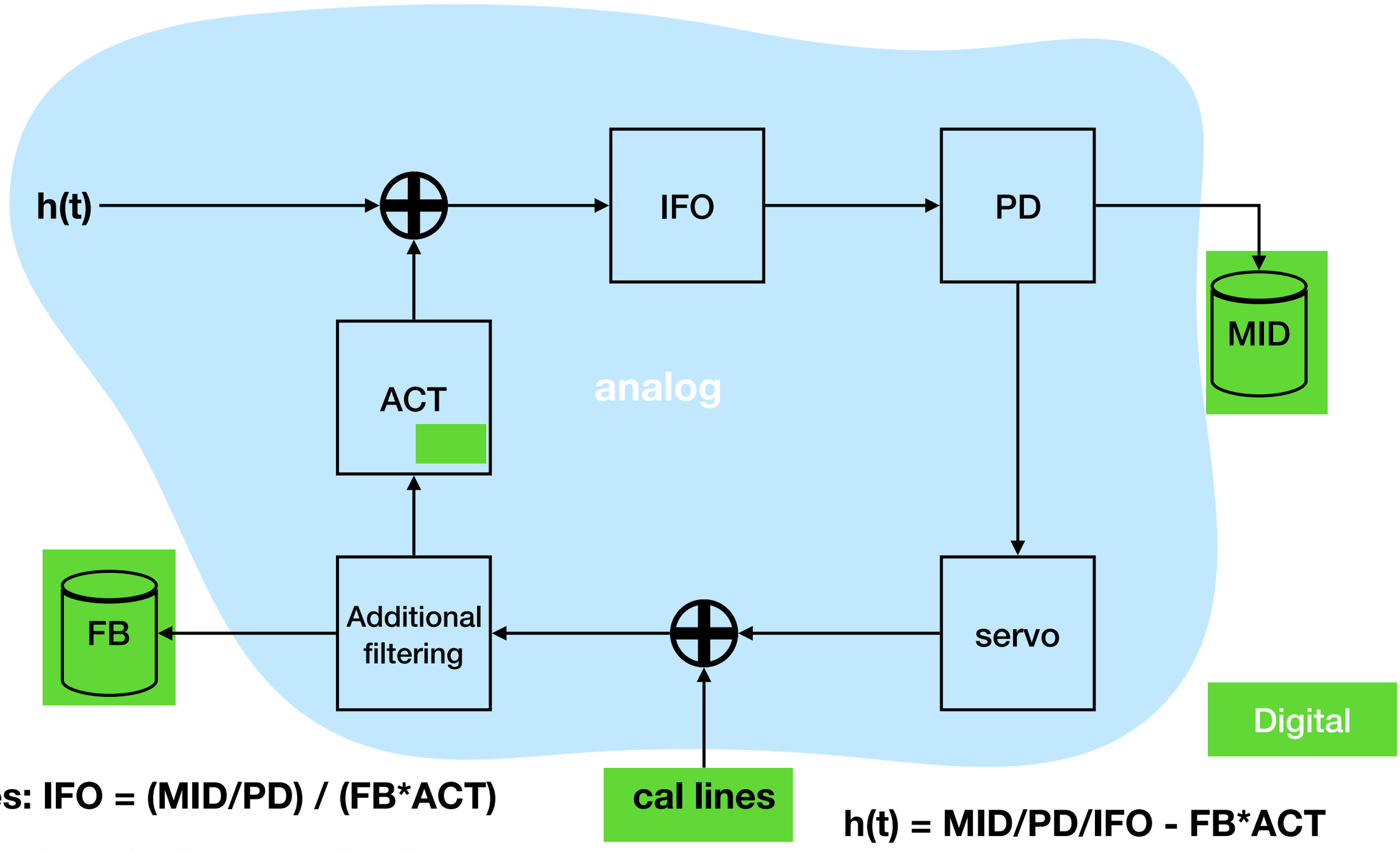






Heinert, et al. PRD 2014

calibration process



Cal lines: IFO = (MID/PD) / (FB*ACT)

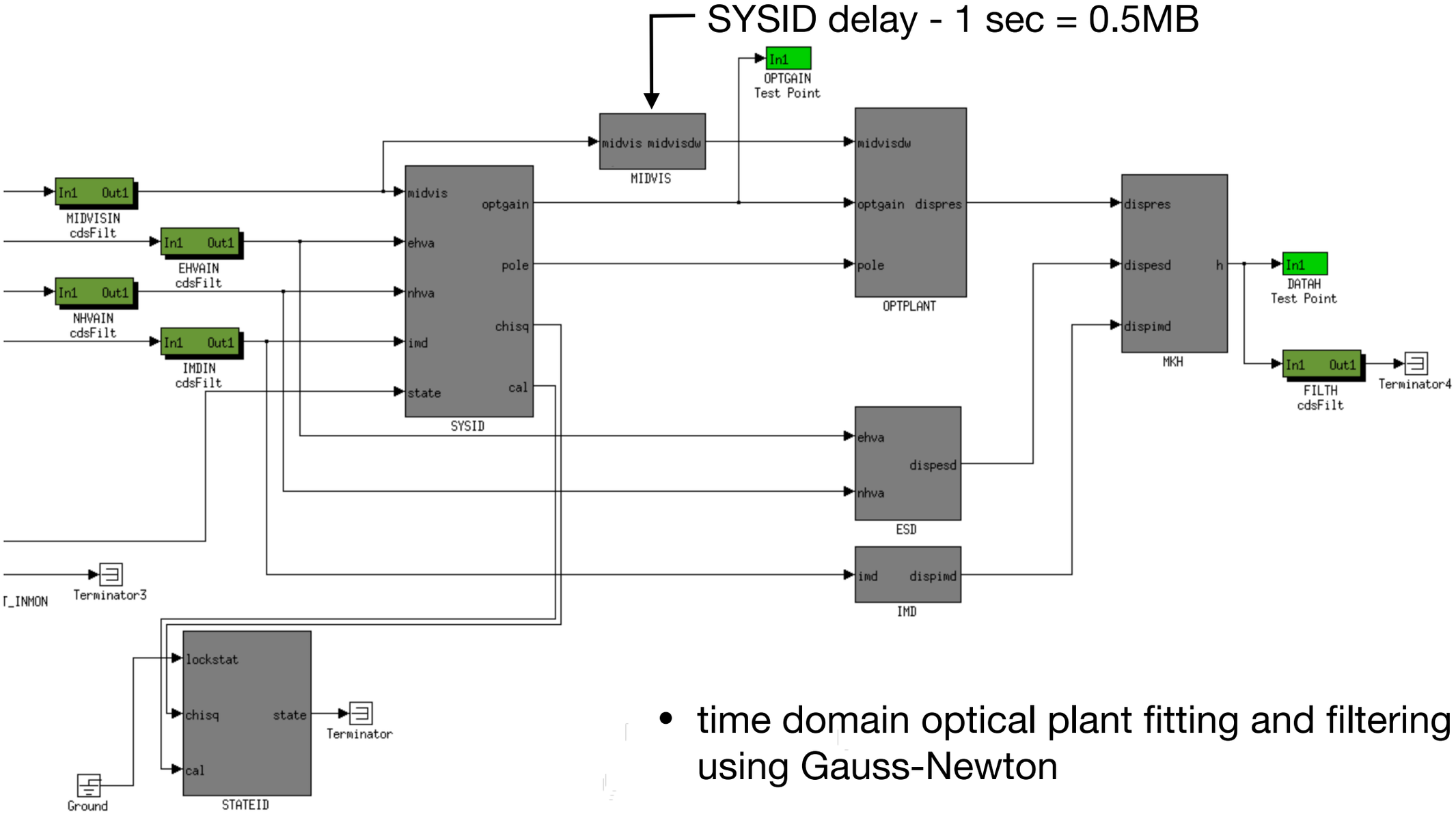
→ **fit optical gain and pole**

h(t) = MID/PD/IFO - FB*ACT

low latency calibration

- Currently using the same method from the original implementation, with some tweaks
    - power recycled -> dual recycled
    - heterodyne -> DC readout (tuned)
- frequency domain measurements of optical plant
- time domain filtering
- latency: order seconds

realtime calibration



- time domain optical plant fitting and filtering using Gauss-Newton
- latency determined by the SYSID filtering

What’s next?

- better understanding of free swinging Michelson systematics
- better pcal - cross check for FSM/other detectors, online actuator strength calibrator
- finish realtime calibration
  - Gauss-Newton -> Kalman filtering
  - detuned signal recycling SYSID
- complete review of electronics calibration

Newtonian Calibrator at GEO? NO!

THE END