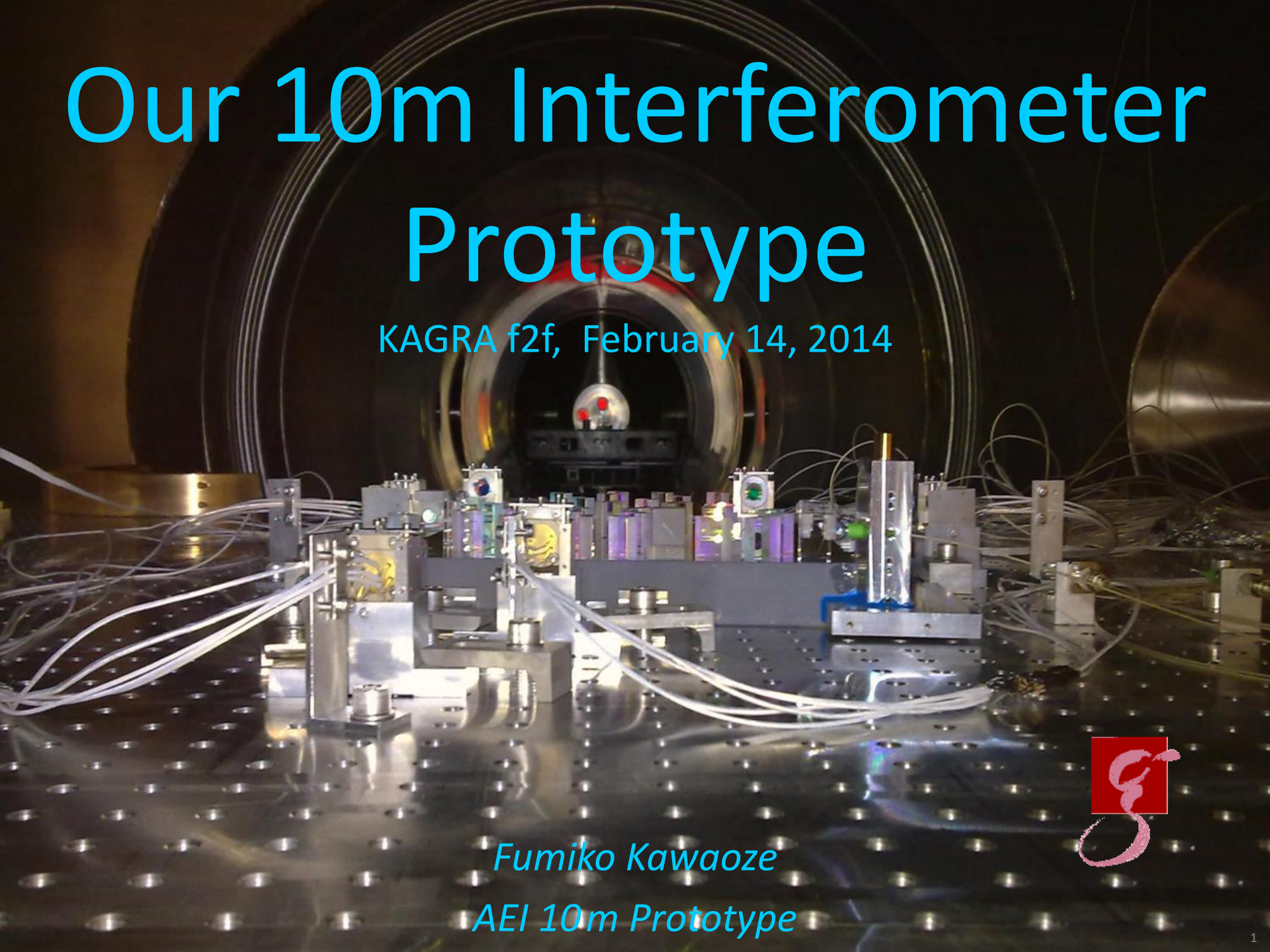


Our 10m Interferometer Prototype

KAGRA f2f, February 14, 2014



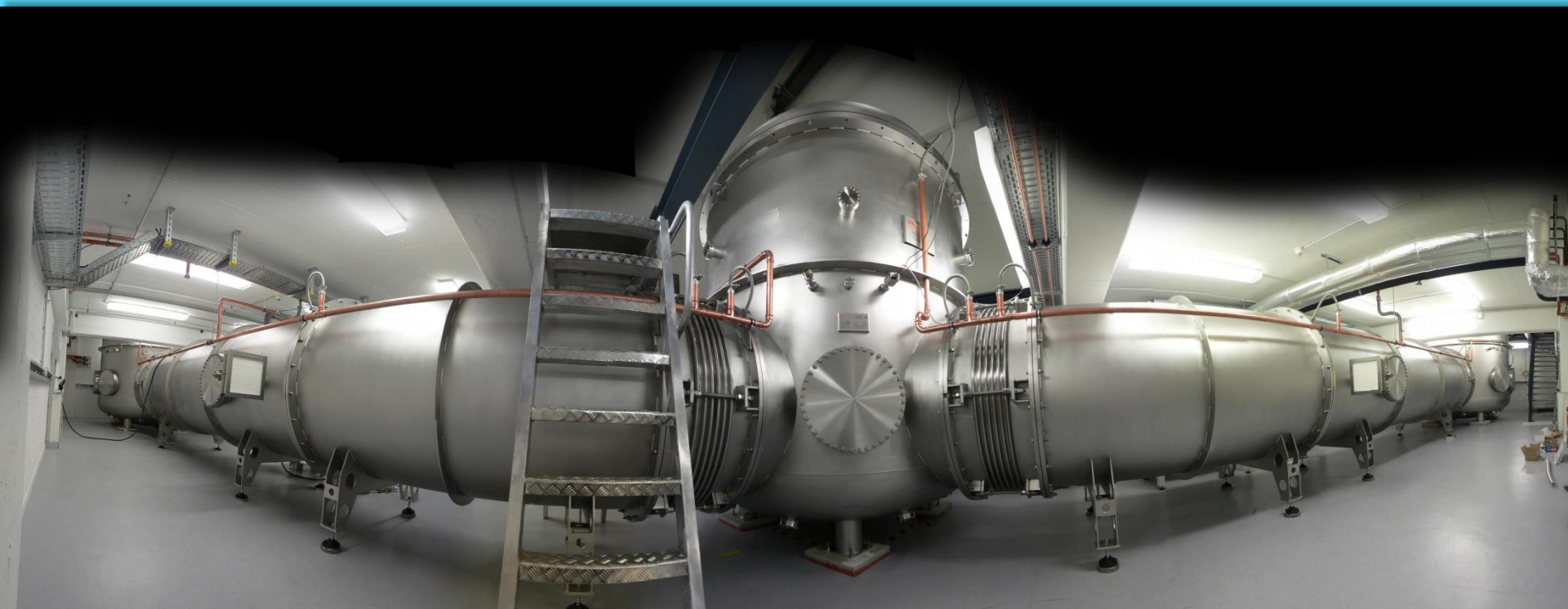
Fumiko Kawaoze
AEI 10m Prototype



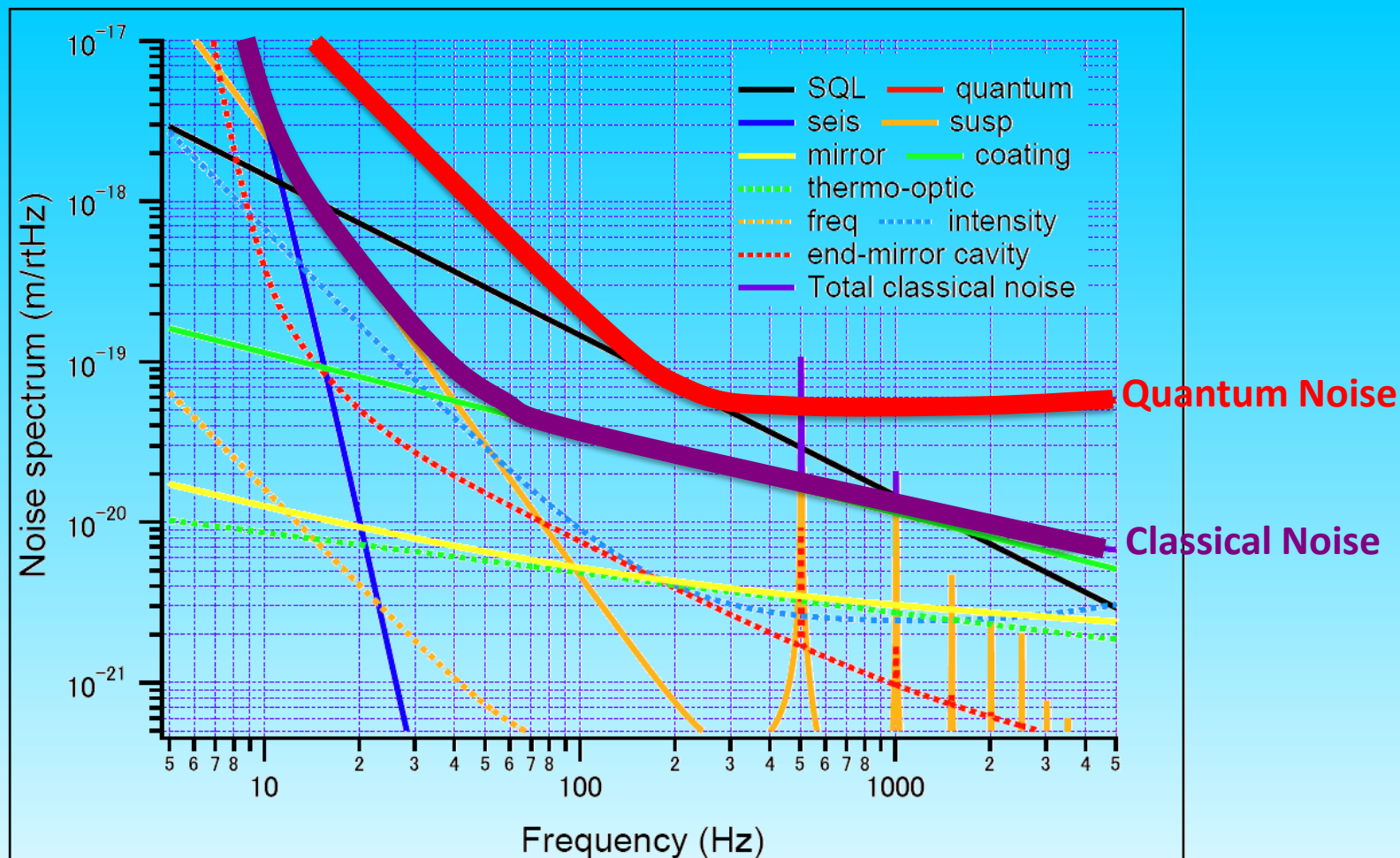
10m Prototype Interferometer



- Standard Quantum Limit experiment
- Macroscopic Quantum mechanics
- Thermal Noise Interferometer
- GEO-HF test facility (laser, control)

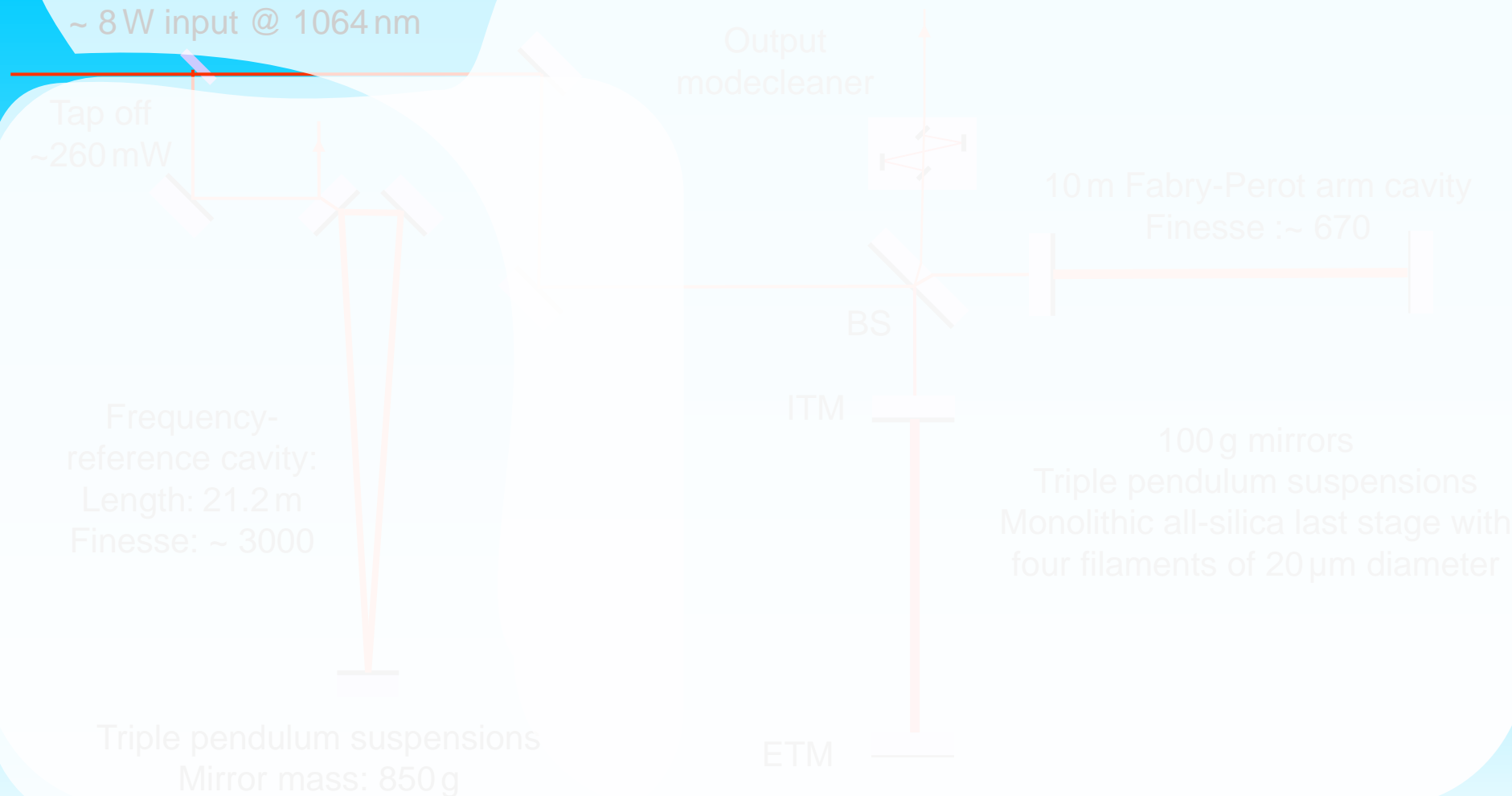


Measure Standard Quantum Limit above Classical Noise



Design sensitivity SQL-IFO with Khalili cavities and titania doped coatings
Today: Direct bonded monocrystalline multilayer coatings of AlGaAs

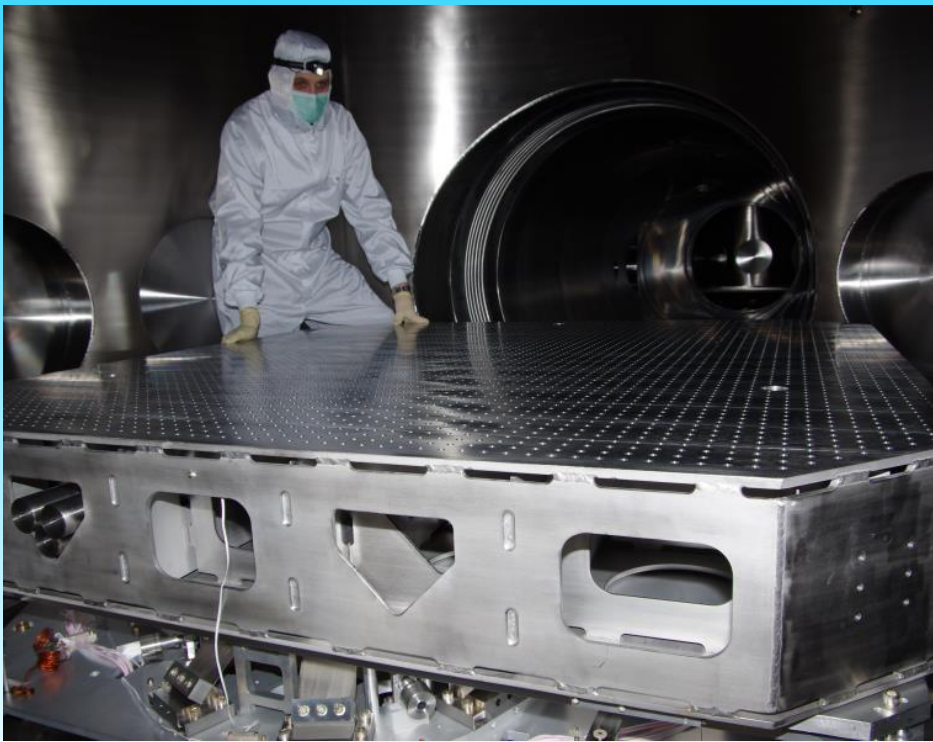
Optical Layout sub-SQL Interferometer



Progress over the last year



January 2013



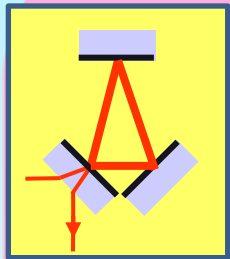
January 2014



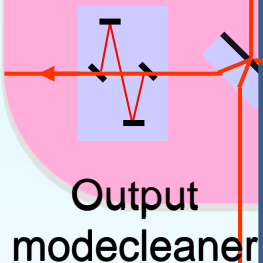
Sub Projects



PMC:
Length: 0.53 m
Finesse: ~ 1000

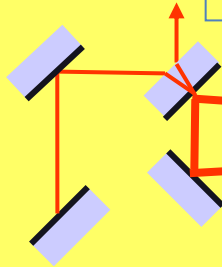


~ 8 W
input @
1064 nm



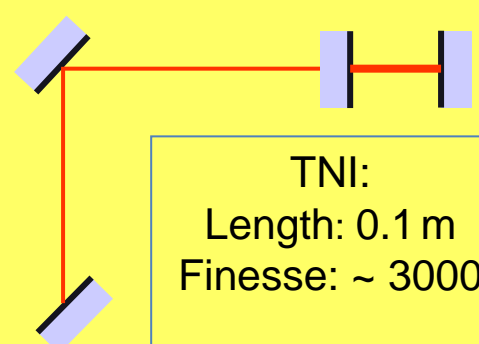
Tap o
 ~ 260 m

Frequency-ref.cav.:
Length: 21.2 m
Finesse: ~ 3000



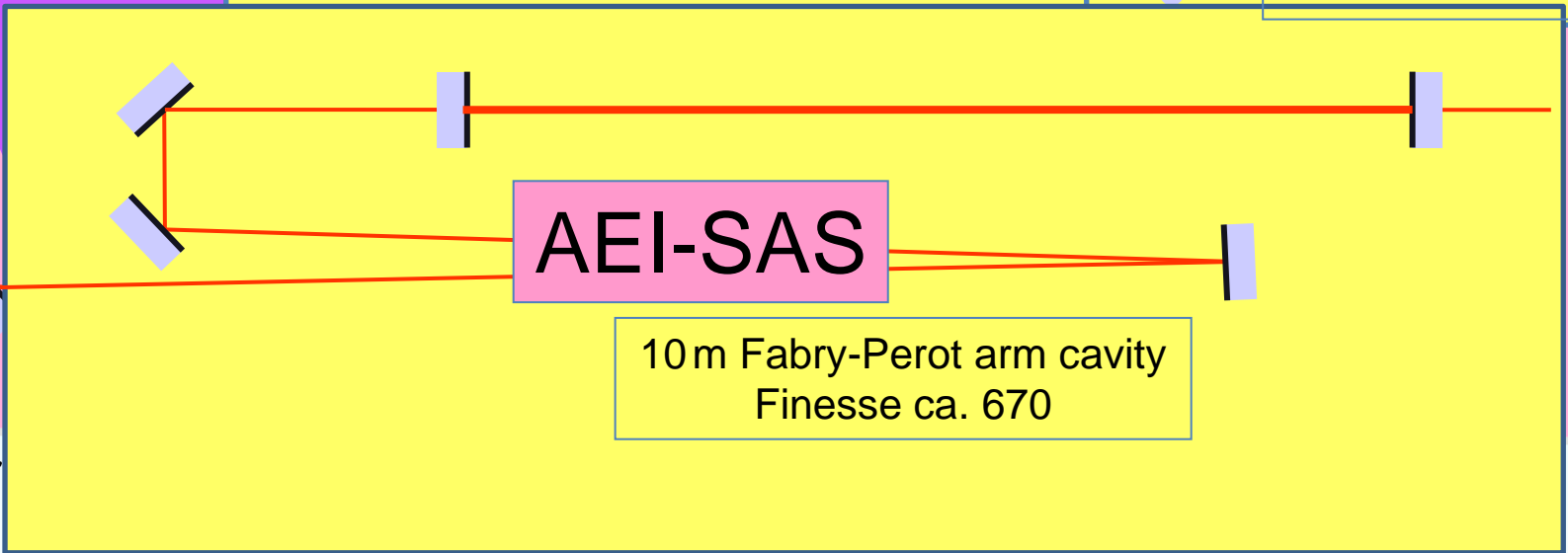
Suspended 860g mirrors
Substrate: Fused silica

TNI:
Length: 0.1 m
Finesse: ~ 3000



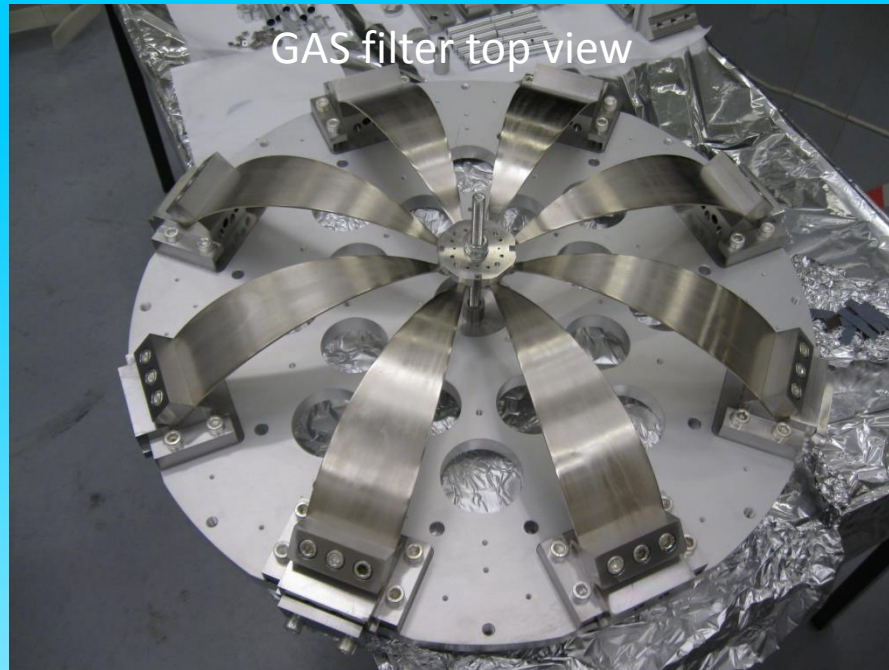
AEI-SAS

10 m Fabry-Perot arm cavity
Finesse ca. 670



All can be done in parallel.

Geometrical Anti-Springs



GAS filter top view



GAS filter side view



Installation of first AEI-SAS (07.03.2011)



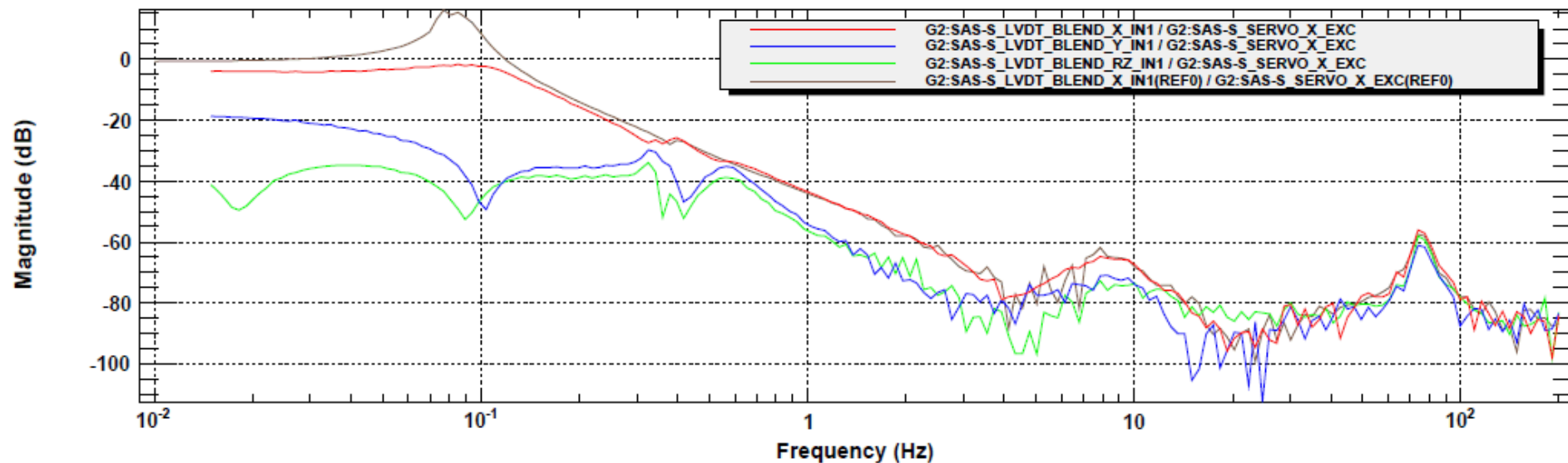
AEI-SAS as installed in UHV system

Two out of three AEI-SAS installed, the third will be installed this year.
Work done independently from other sub systems.



Transfer function

— Horizontal isolation performance: -80 dB at 4 Hz



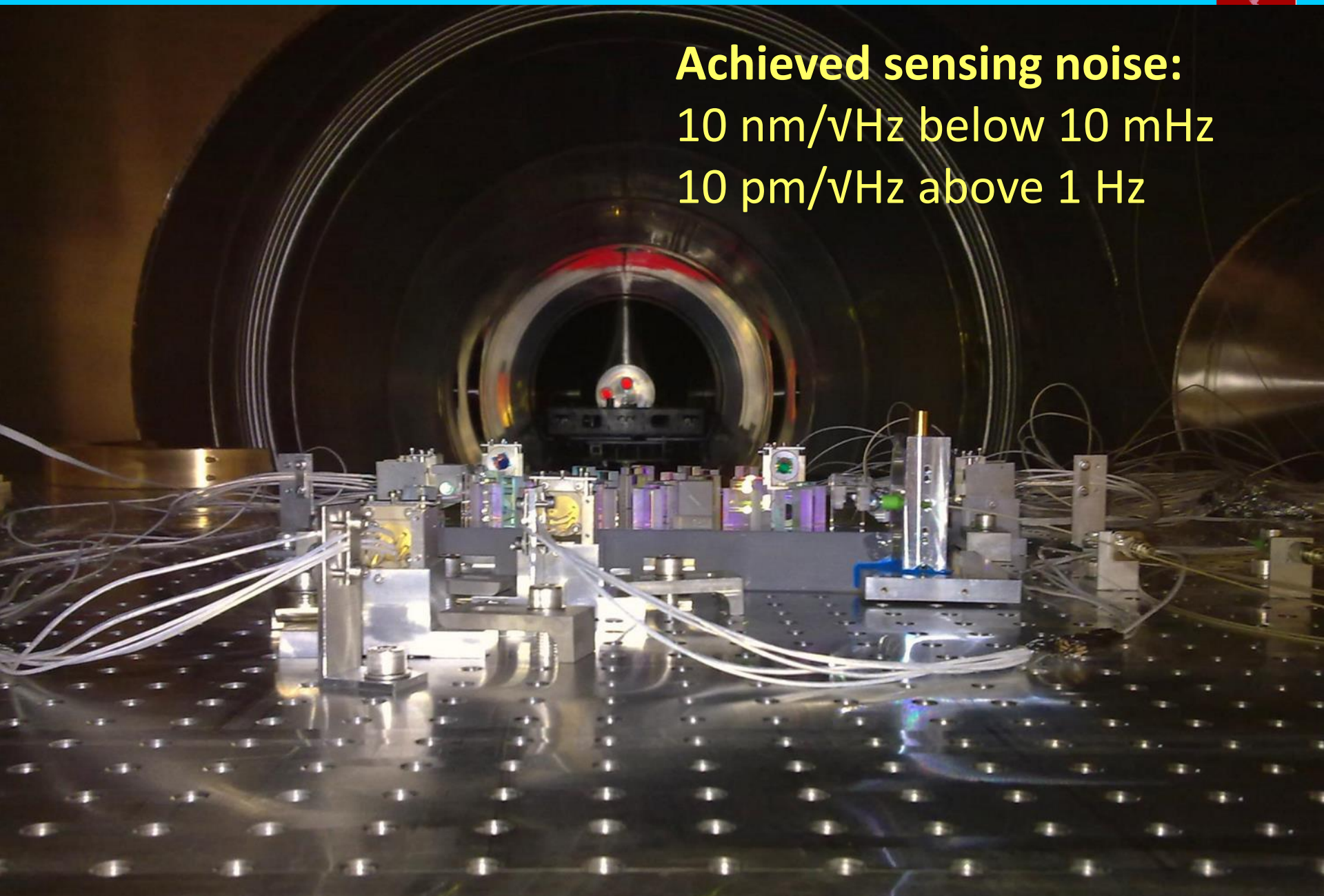
Suspension Platform Interferometer Installation (Spring 2013)



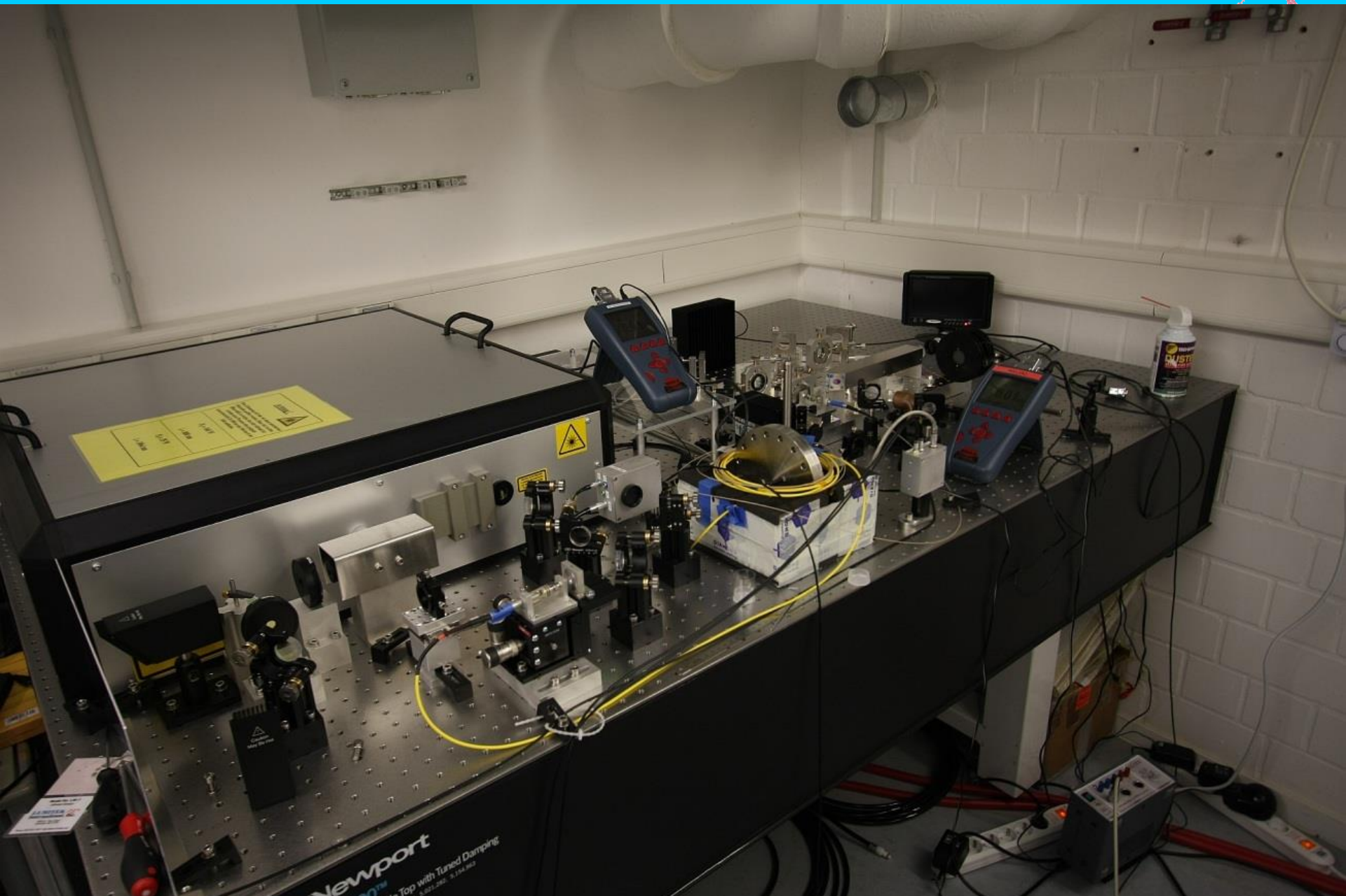
SPI as installed inside UHV system



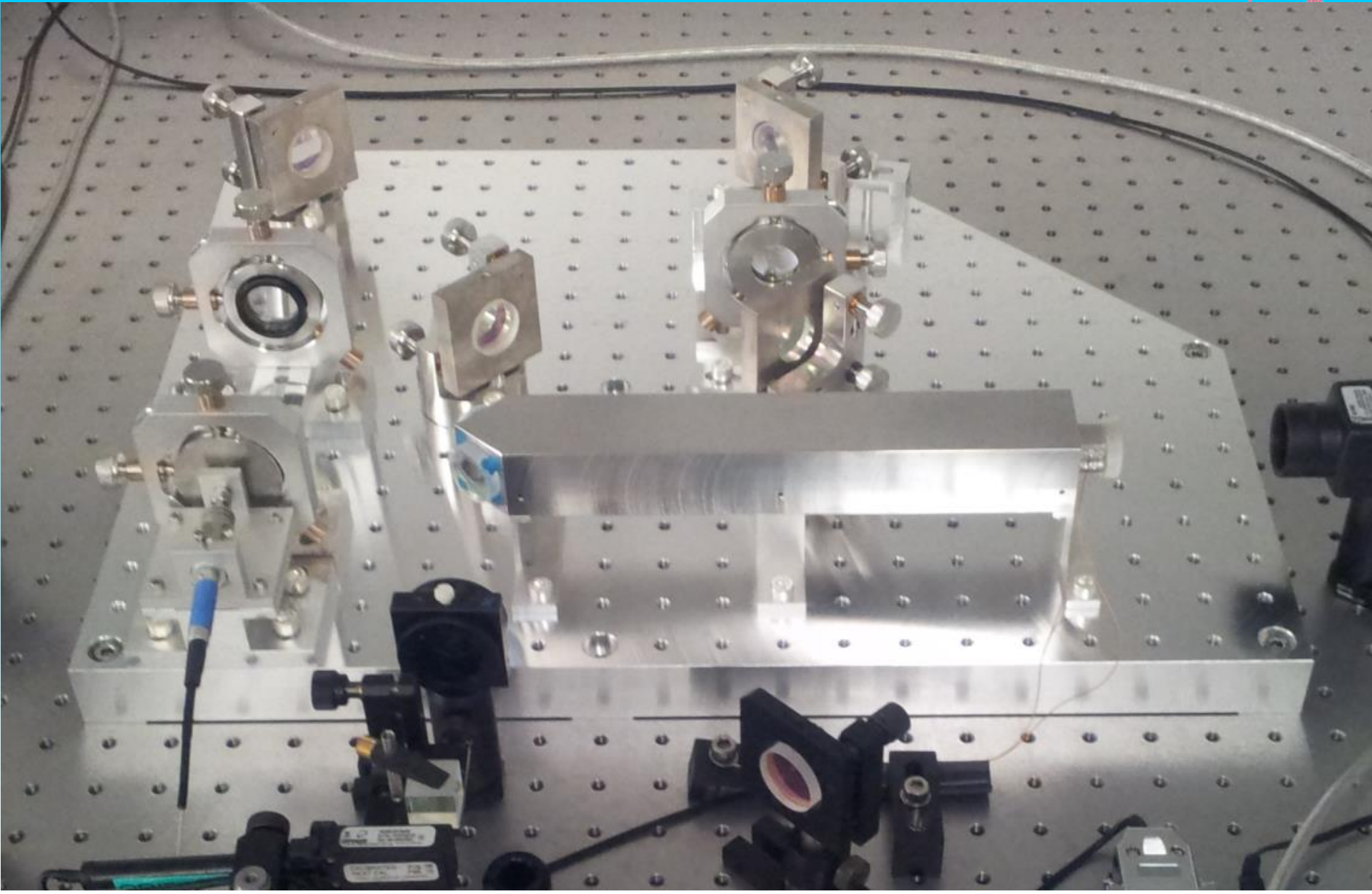
Achieved sensing noise:
10 nm/√Hz below 10 mHz
10 pm/√Hz above 1 Hz



LZH-AEI 35 W Laser



Pre Mode Cleaner



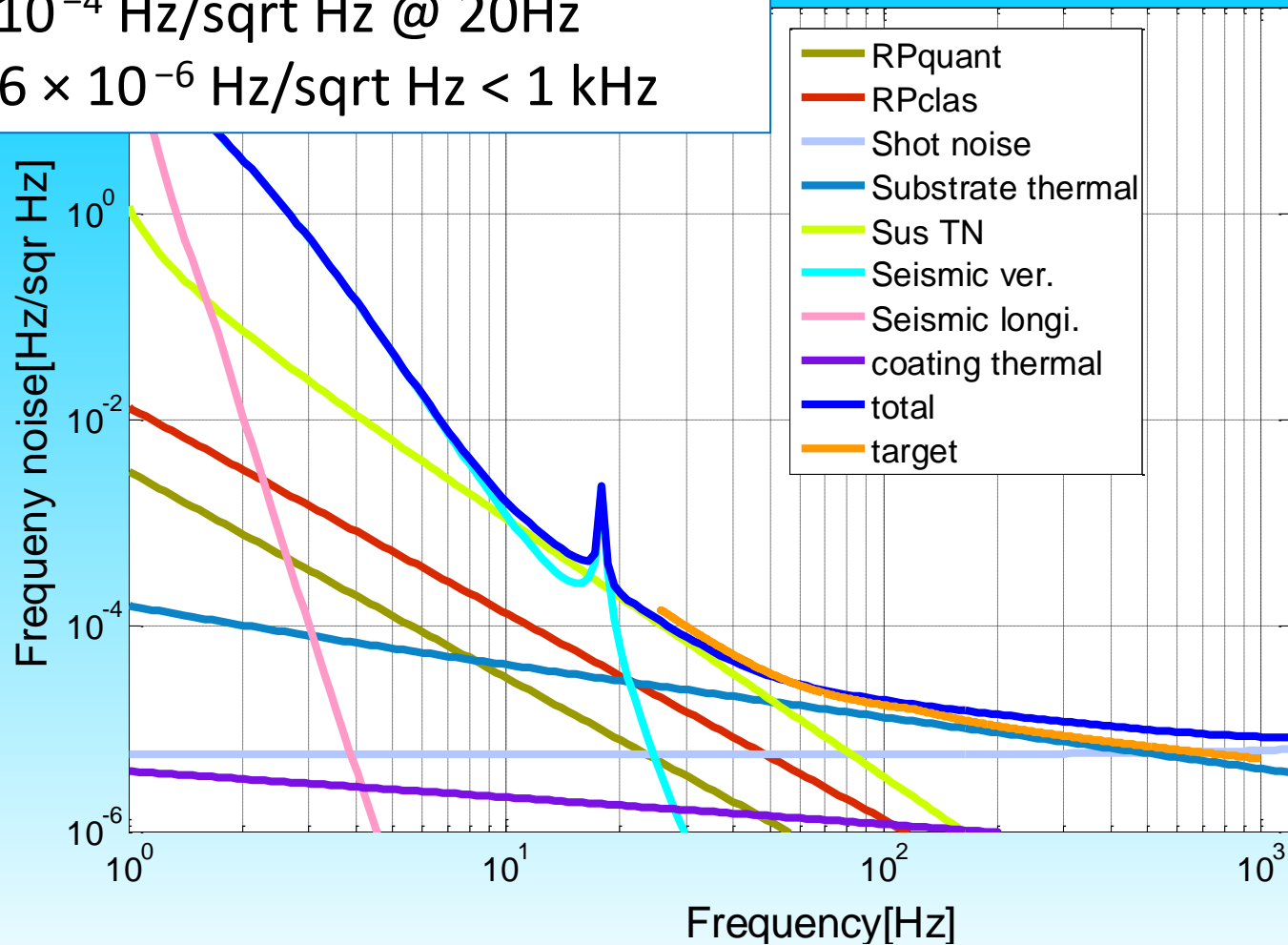
Reference Cavity



Target Sensitivity:

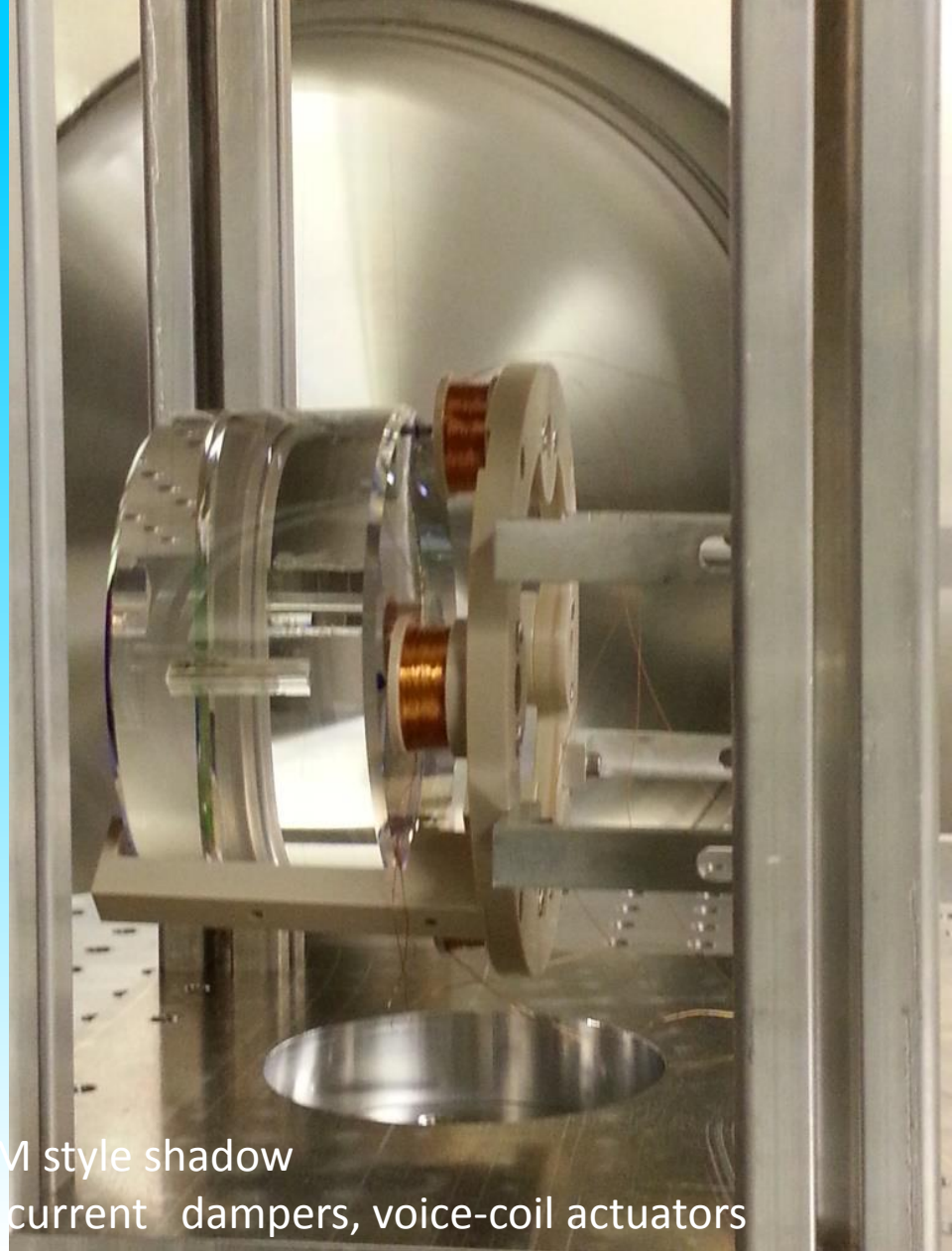
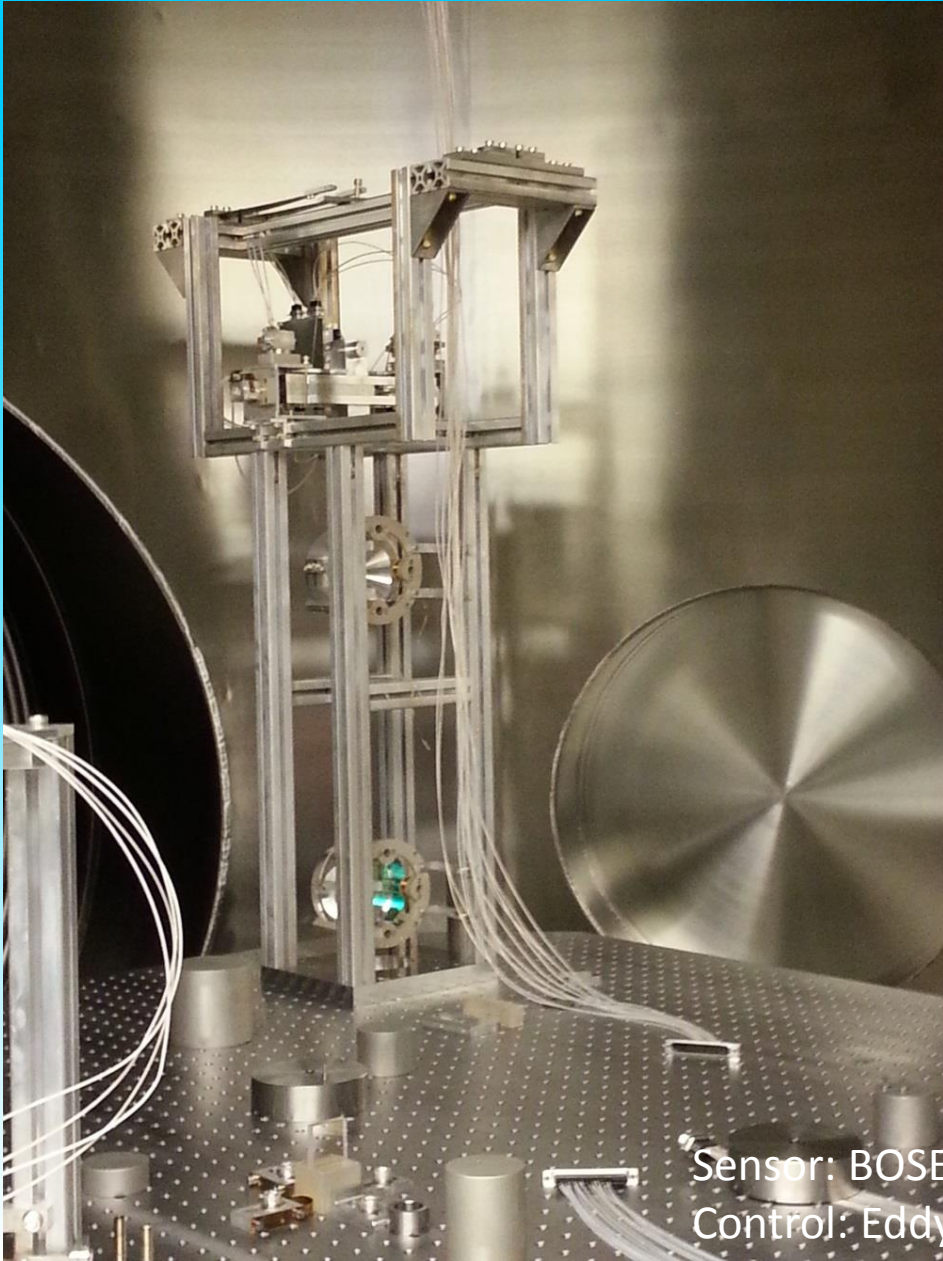
10^{-4} Hz/sqrt Hz @ 20Hz

$> 6 \times 10^{-6}$ Hz/sqrt Hz < 1 kHz



Substrate Q $\sim 10^6$ (wire sling suspension)

Ref Cavity Mirror hanging



Sensor: BOSEM style shadow

Control: Eddy current dampers, voice-coil actuators

Thermal Noise Interferometer



TNI Cartoon

2013-10-25

Curved mirror
ROC = 10 cm
Cavity
 $L = 10 \text{ cm} + \epsilon$

Flat mirror
with Test Coating

QWP

Near-Field QPD

PBS

Far-Field QPD

Beam Directors
(BDs)

Fabry Perot Interferometer

Cavity length: 10cm

Finesse: 3000

Tunable small spot-size

Suspended 860g mirrors

Substrate: Fused silica

Coating: Tantalum/Silica

$P_{in} = 0.1 \text{ mW}$

Ref Cav

pick-off
from RefCav
input light

Main
IFO

Beam
Expansion
Telescope

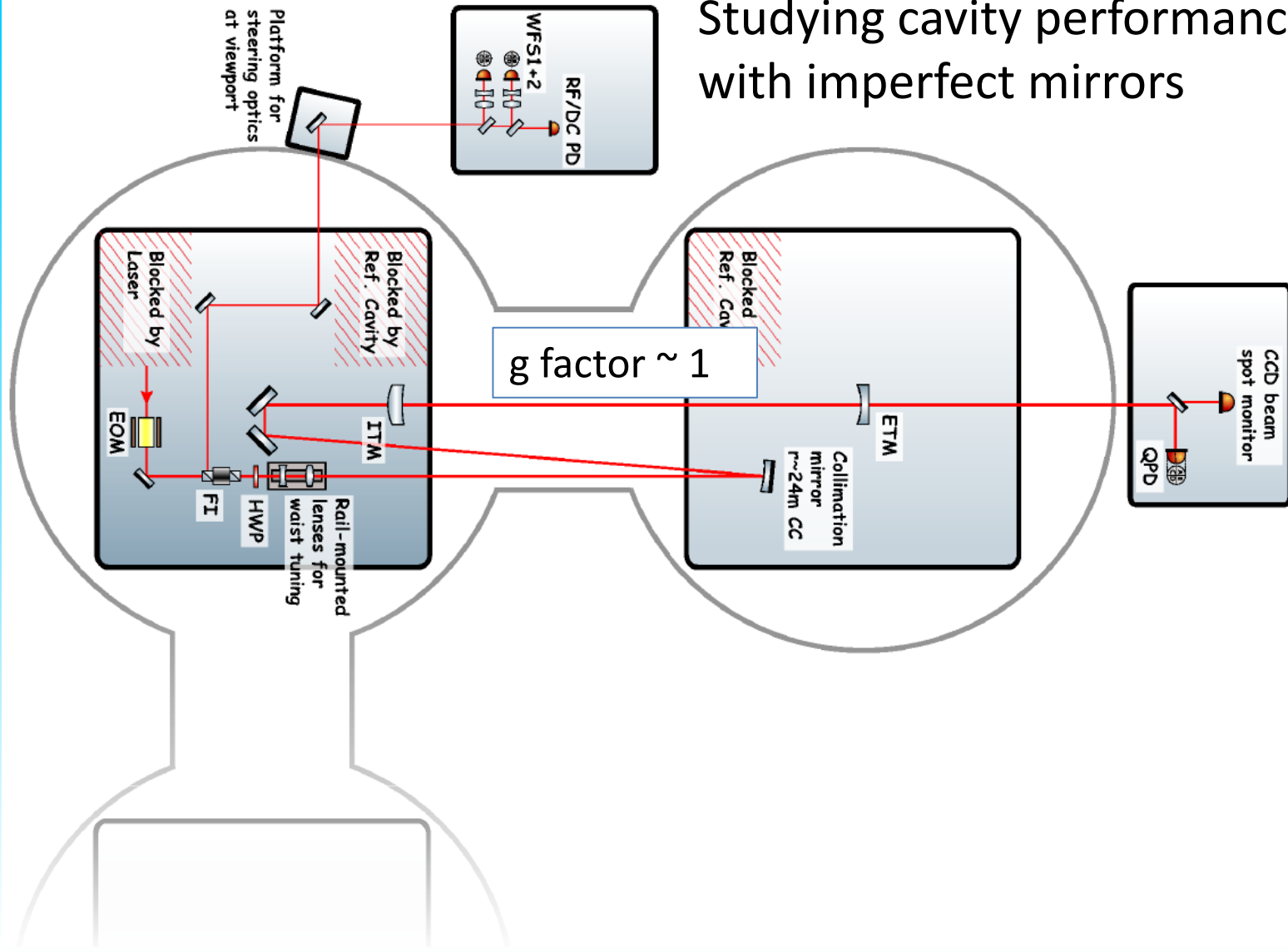
The future (exchange a single mirror) ALGAs coatings, Gratings, Bonding loss

Single Arm IFO



Goal:

Studying cavity performance with imperfect mirrors



Program of each sub project



Sub project	2014-2015	What can be learned
AEI- SAS	Third Table Installation, Characterization	Suspension system
SPI	Optical Lever installation, Third SPI Installation	Optical system, suspension system, Phase meter, interferometry
Ref.Cav.	Suspension installation, Angular control components setup	Suspensions, Laser frequency control & CDS, interferometry, Angular Control system
TNI	Suspension installation, Angular control system setup	Thermal noise, suspension system, Gaussian optics, interferometry
Sub SQL	Building suspensions	Interferometry, suspension system

All the sub systems use the Digital Control System (CDS).

Theses completed:



Alexander Wanner PhD **SAS**

Now CEO **QUEST**

Katrin Dahl PhD **SPI**

Now at Diehl

Christian Gräf PhD **Optical simulations**

Now postdoc position in Glasgow

Oliver Kranz Diploma **SPI**

Now PhD student at PTB

Thimotheus Alig Master **Laser characterisation and PMC**

Now PhD student at LZH

Sina Köhlenbeck Diploma **Digital Interferometry**

Now PhD student with us

Kai Voges Bachelor **Calibrated IR Camera**

Daniel Gering Diploma **Phasemeter Interface**

Look into the future



- The world's first measurement below the SQL
- Experiences transfer to future GW detectors





Thank you for your attention.