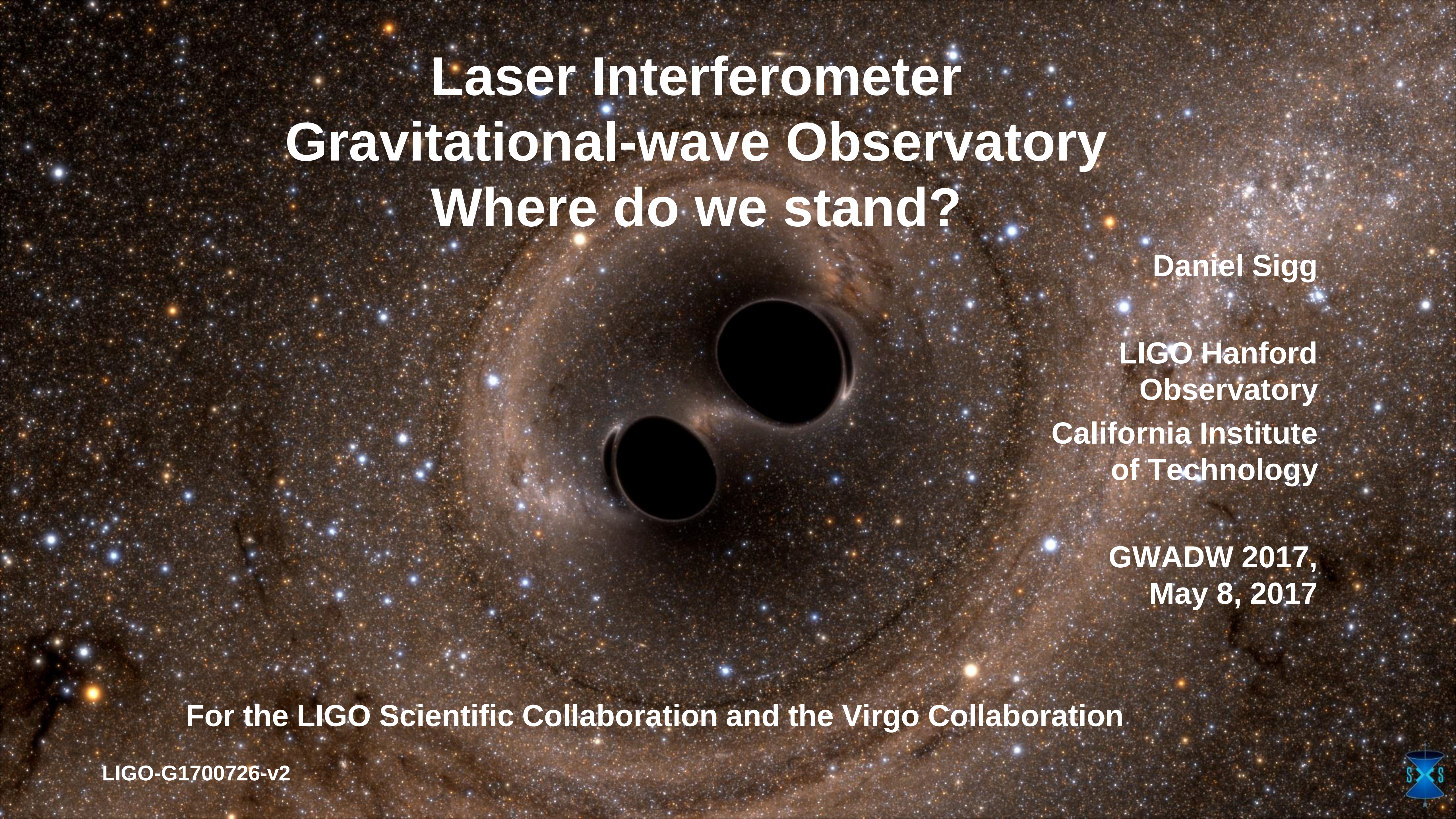


Laser Interferometer Gravitational-wave Observatory Where do we stand?

Daniel Sigg

LIGO Hanford Observatory

California Institute of Technology

GWADW 2017, May 8, 2017

For the LIGO Scientific Collaboration and the Virgo Collaboration

LIGO-G1700726-v2

Stated Goals for O2	How did we do?
Diagnose & reduce low frequency noise (f < 150 Hz)	Only small improvement on L1 Identified scattered light as needing work
Double the laser power (100 kW -> 200 kW arm power)	Got close with H1, but with a noise penalty
Work on transient noises and spectral lines	Some progress
More robust operation (low-noise duty cycle)	Definite payoff from suspensions dampers & seismic (tilt sensors)

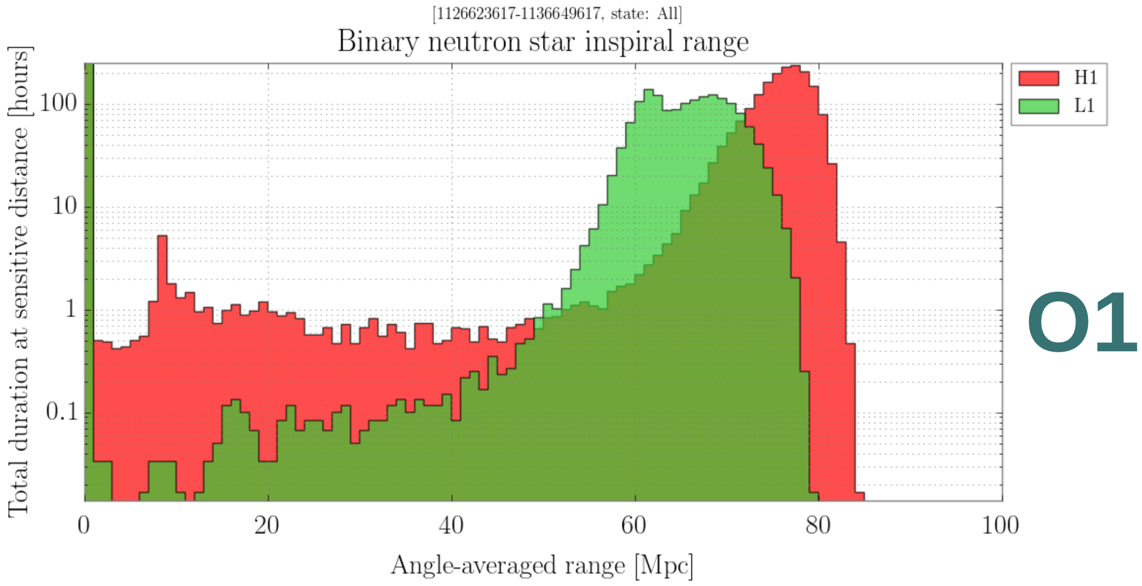
2nd Observation Run

Start:

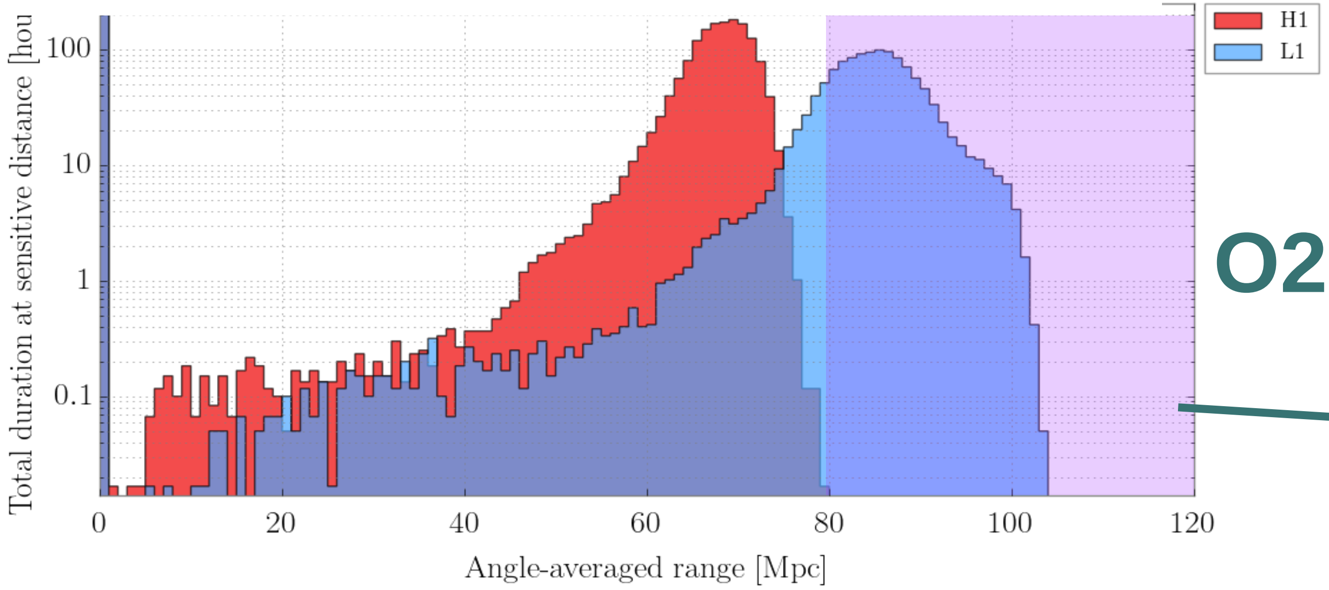
Dec 2016

End:

Aug 2017



O1



O2

Volume-Time product now about the same for O1 & O2

Goal was 80-120 Mpc

LHO High Power Work

~60 nm distortion over 20 mm

Hartmann Wavefront Sensor Image of ITMX

Small point absorber (~10mW)

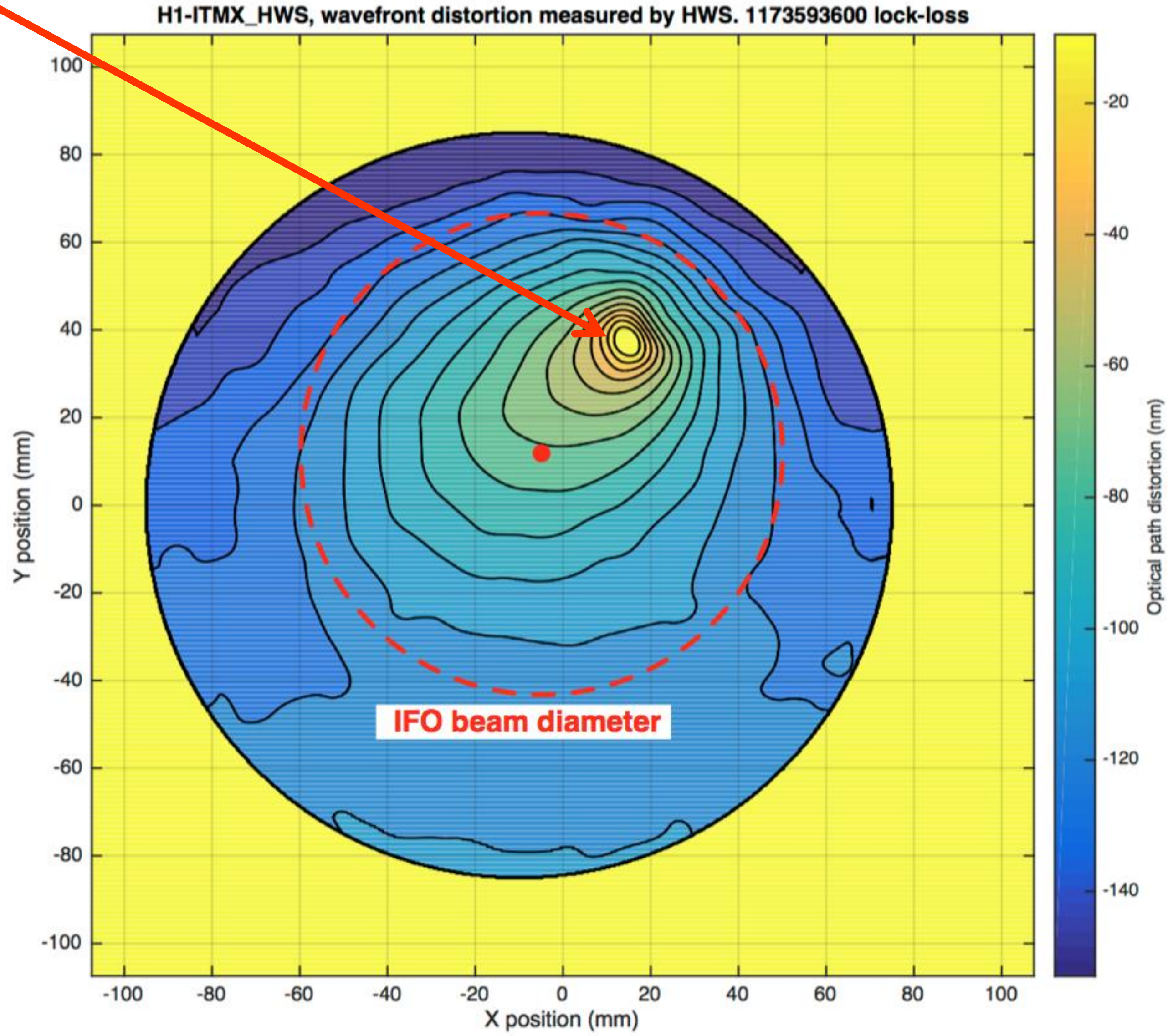
Resulting phase front distortion is problematic:

- RF sideband build-up
- Wavefront sensing
- Noise couplings
- Higher-order mode jitter!

PI damping successful (10 modes at 50W)

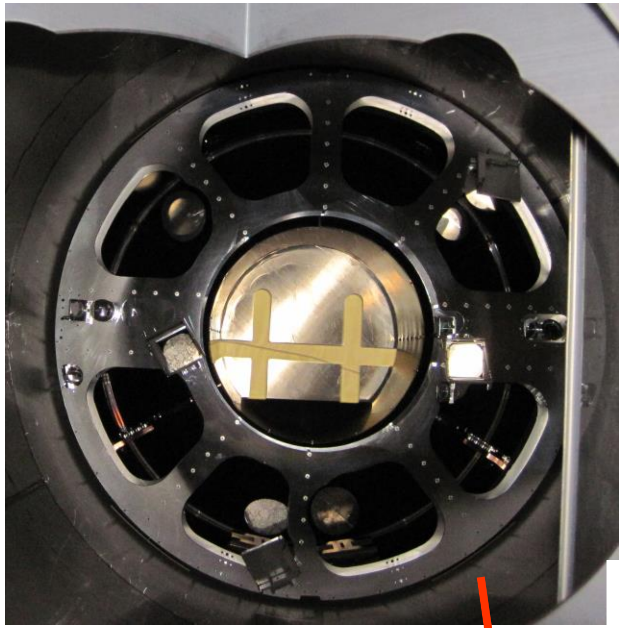
Thermal compensation worked

But: Noise worse at 50W

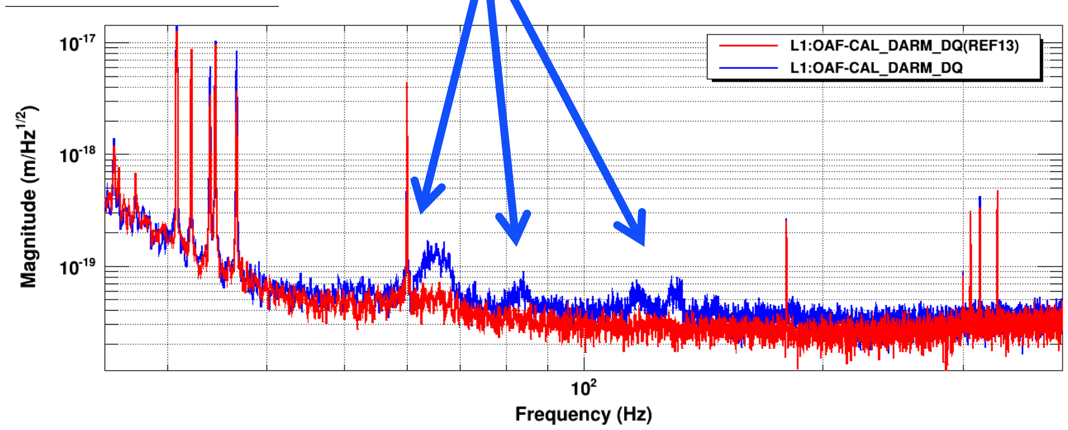


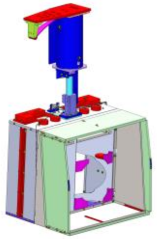
LLO Scattered Light

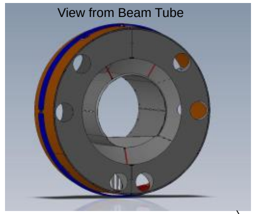
End Stations: ETM wide angle scattering



‘Pcal Periscope Structure scattering’





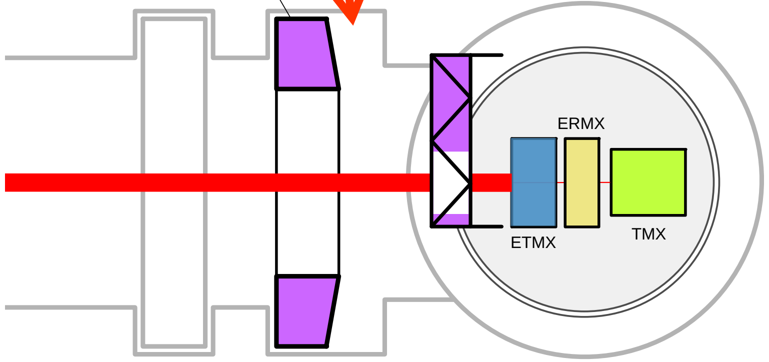


Arm Cavity Baffle, ETM

D1200656, ETMX; D1200653, ETMY

Catches small angle scatter from ITM & wide angle scatter from ETM

Oxidized SS
Aperture: D = 343.9 mm
Mounted on ISI Stage 0



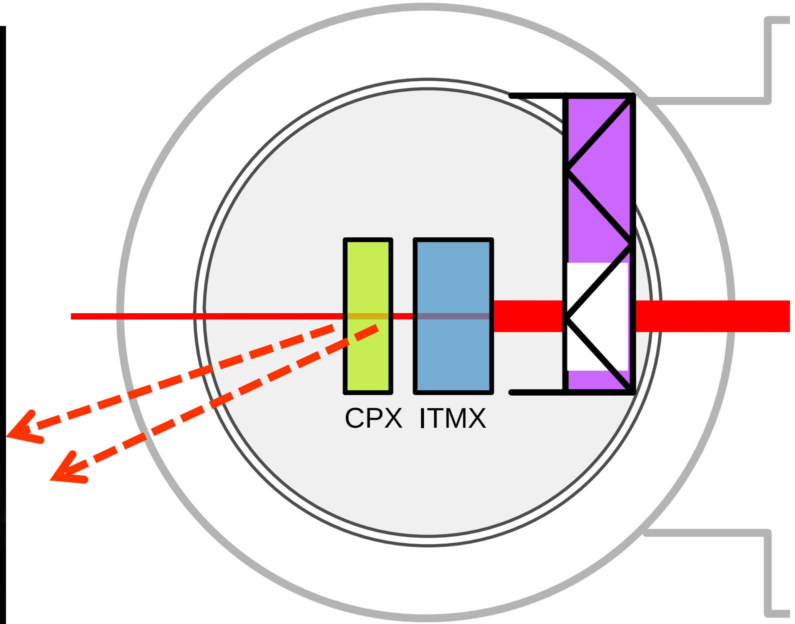
Light scattered from the ETM is directed through a viewport and then scattered/reflected back in – hitting vibrating components along the way

Stray Beams

View into HAM5 chamber

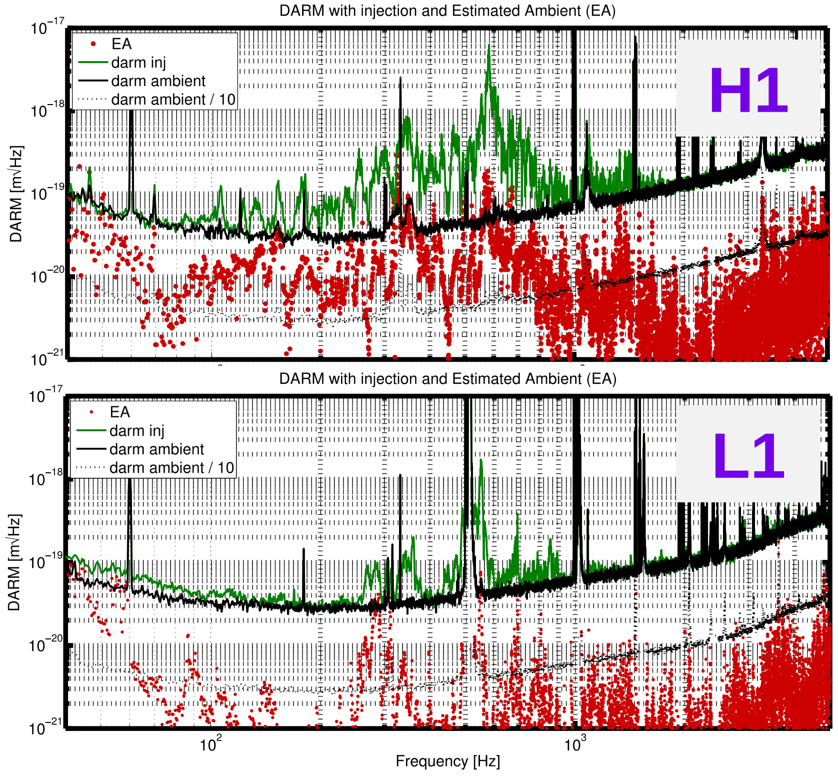
Signal recycling mirror

SR3: folding mirror in SRC



A campaign to improve in-vacuum scattered light baffling in underway this will be one of the main post-O2 upgrades

Beam Jitter Coupling

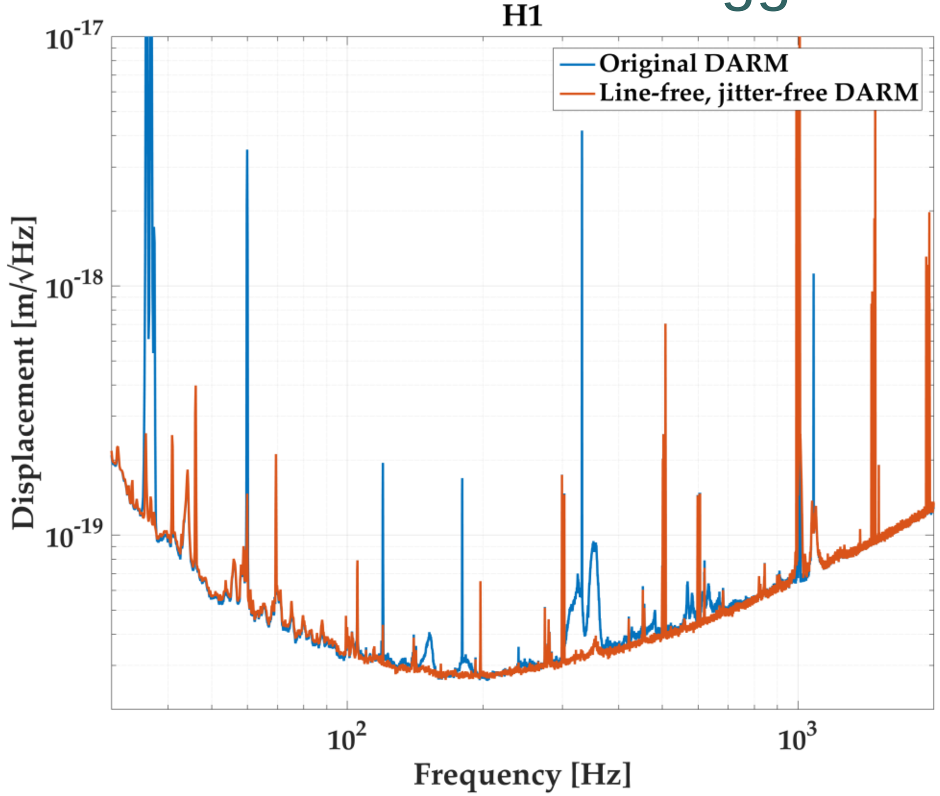


LHO has higher coupling

- ❑ **Injection locked laser generates large amounts of beam jitter**
- ❑ **Including higher order modes!**

- ❑ **Long term: May require Jitter Attenuation Cavity**
  - ➢ Fixed mirror
  - ➢ Triangular, in vacuum
- ❑ **Suppression: ~50**

Subtraction: J. Driggers

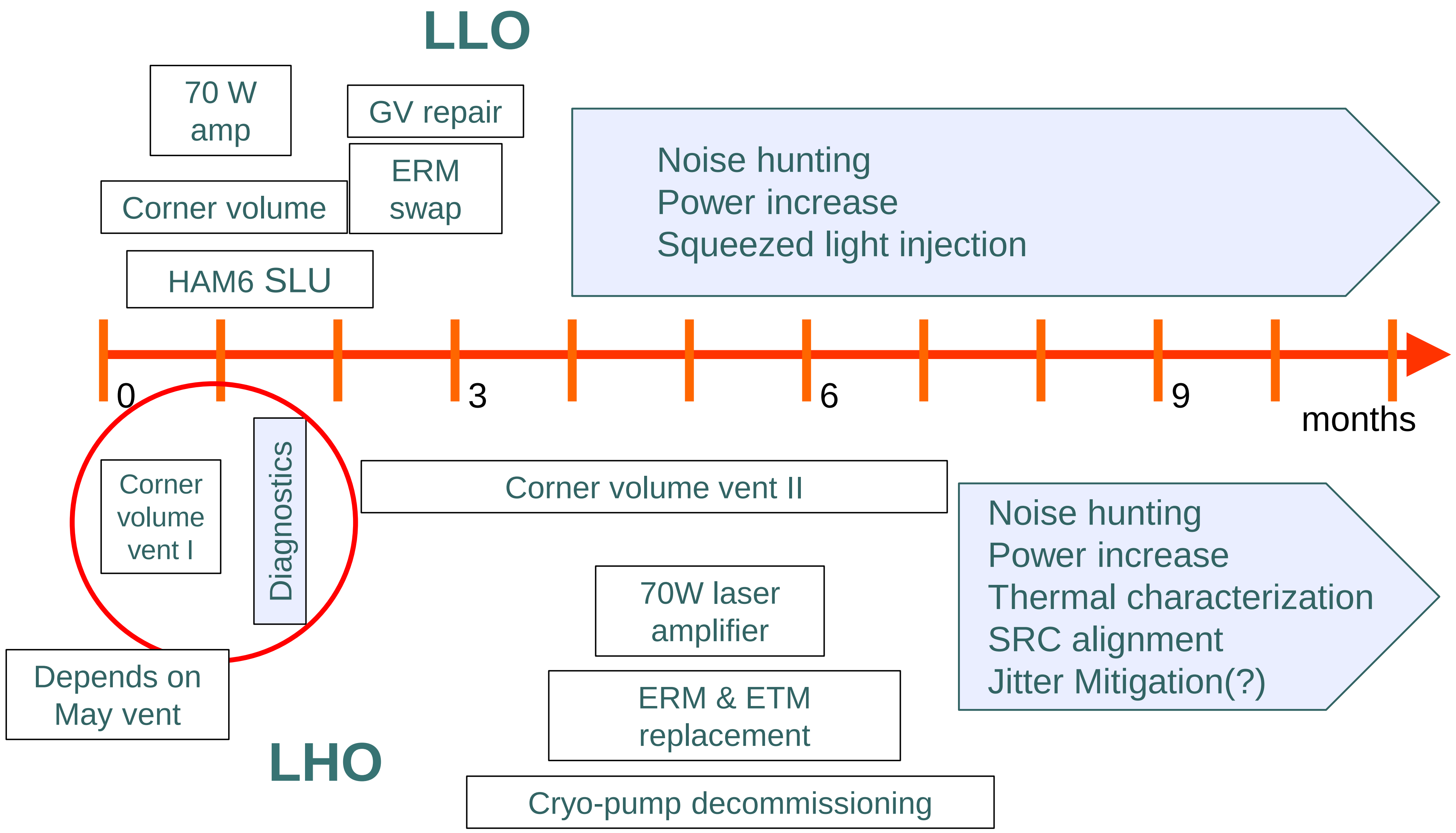


LHO alog 34631

Next Commissioning After the Run

- Fix LHO-ITMX Contamination
  - Will try to clean ITMX in early now
  - If successful, will try to go back to 50W
  - If unsuccessful, will require ITMX replacement after O2
- Squeezed Light Injection at LLO
  - Target is 3 dB of effective squeezing:
    equivalent to doubling the laser power
  - Possibly LHO as well?
- Stray Light Control Improvements
- 70 W Amplifier Stage at LLO to Double the Laser Power
  - LHO: likely to move from the HPO to a 70 W amplifier as well
- Replace End Reaction Masses with Annular Versions
  - Squeezed film damping; possibly electro-static charge
  - May also replace ETMs at LHO
- Monolithic Signal Recycling Mirrors
- LHO: Long vent

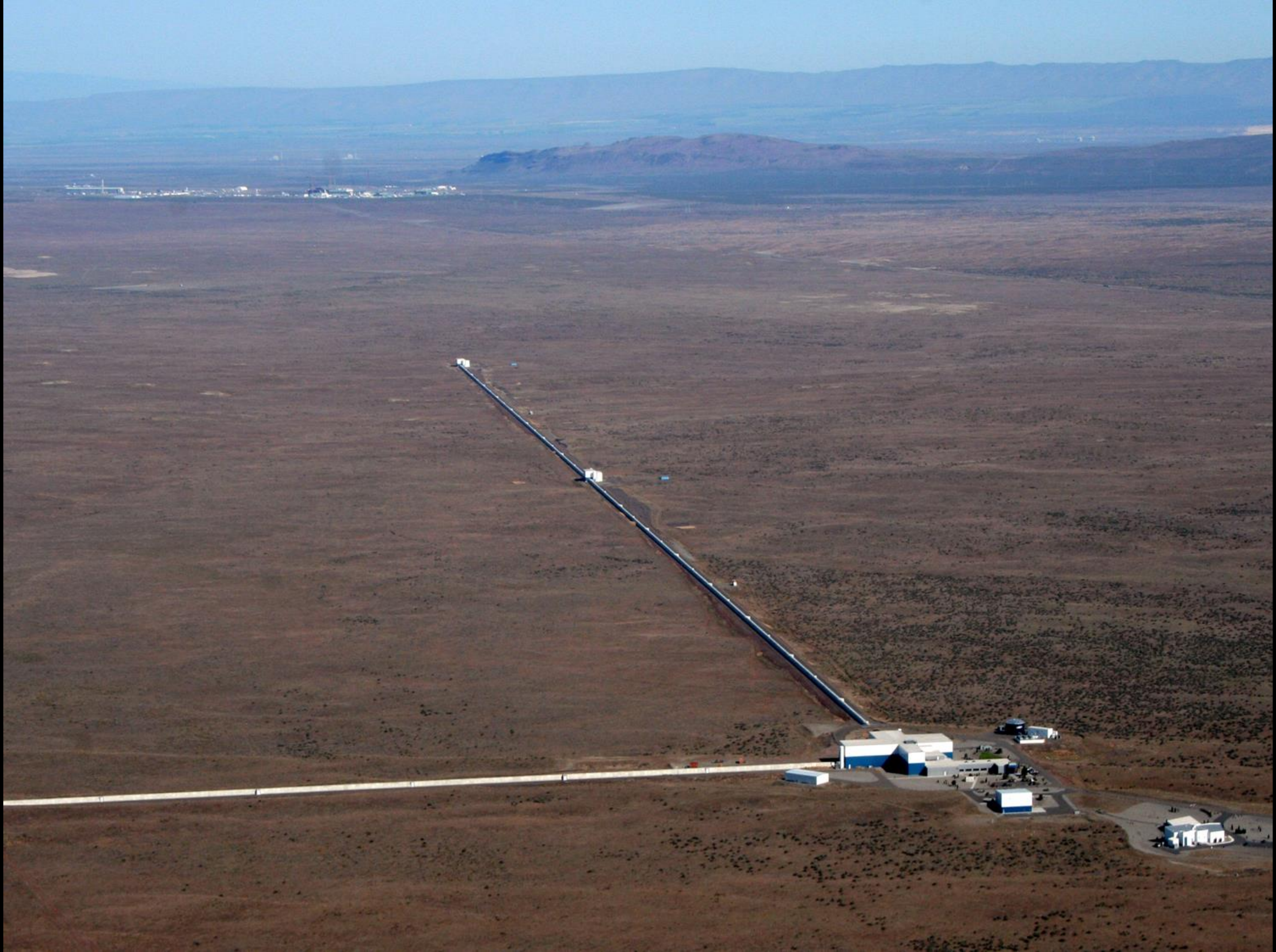
Strawman Schedule



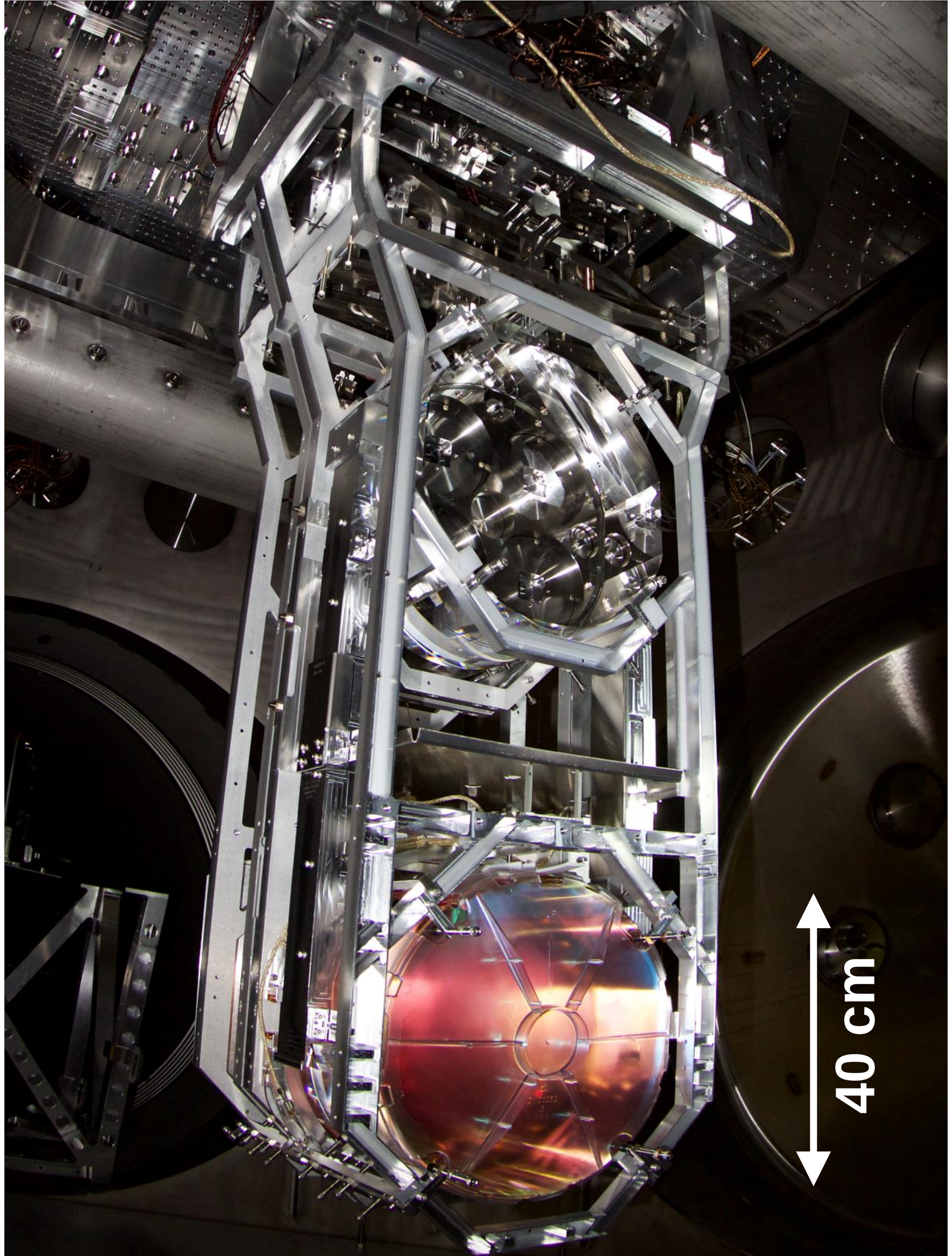
O3 readiness will be driven by achieving a significant sensitivity increase over O2

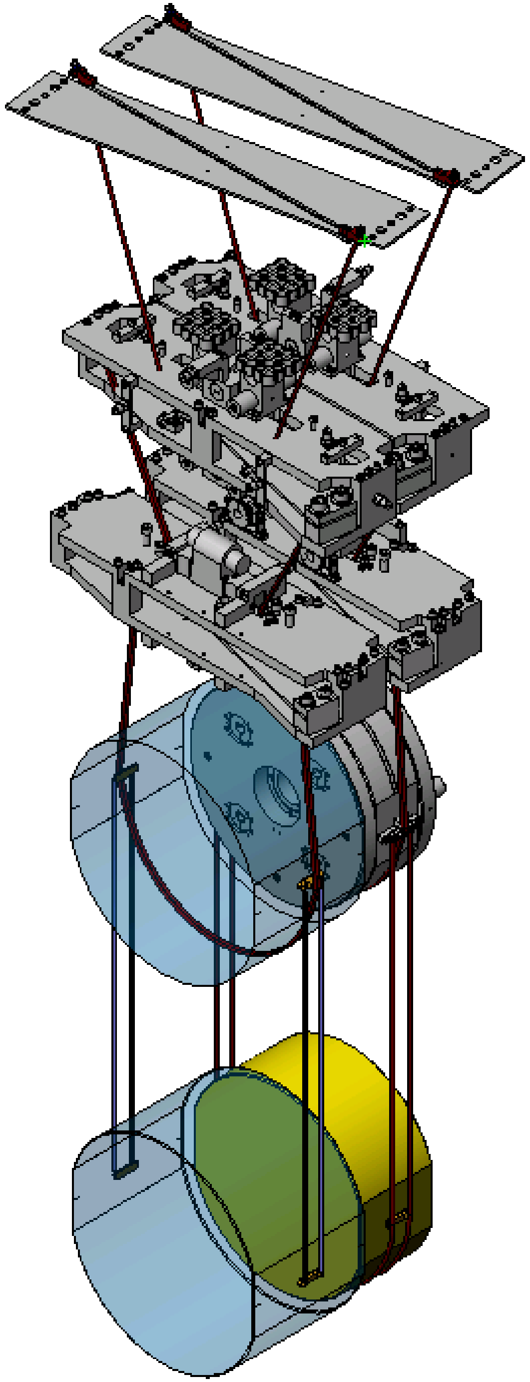
Livingston Observatory

Hanford Observatory



Test Mass Suspension

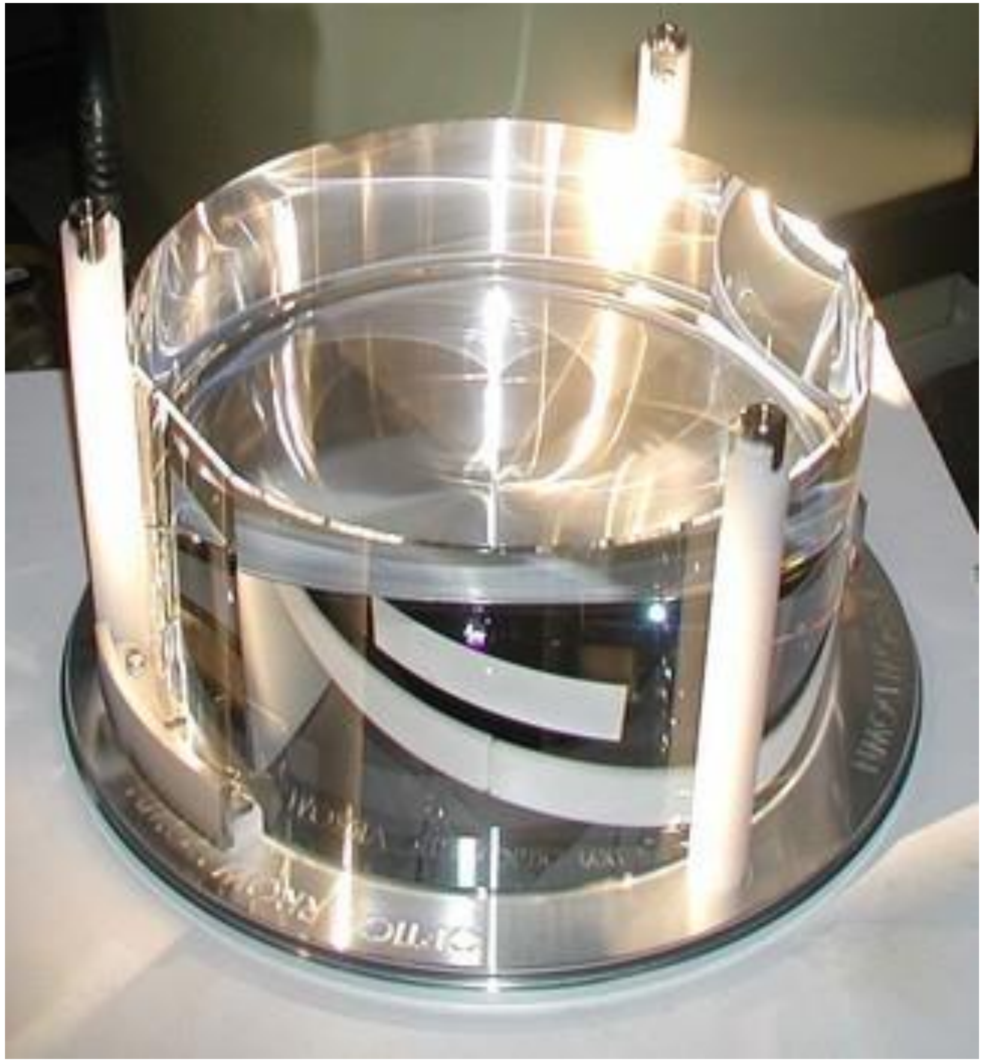




Large Test Mass Optics

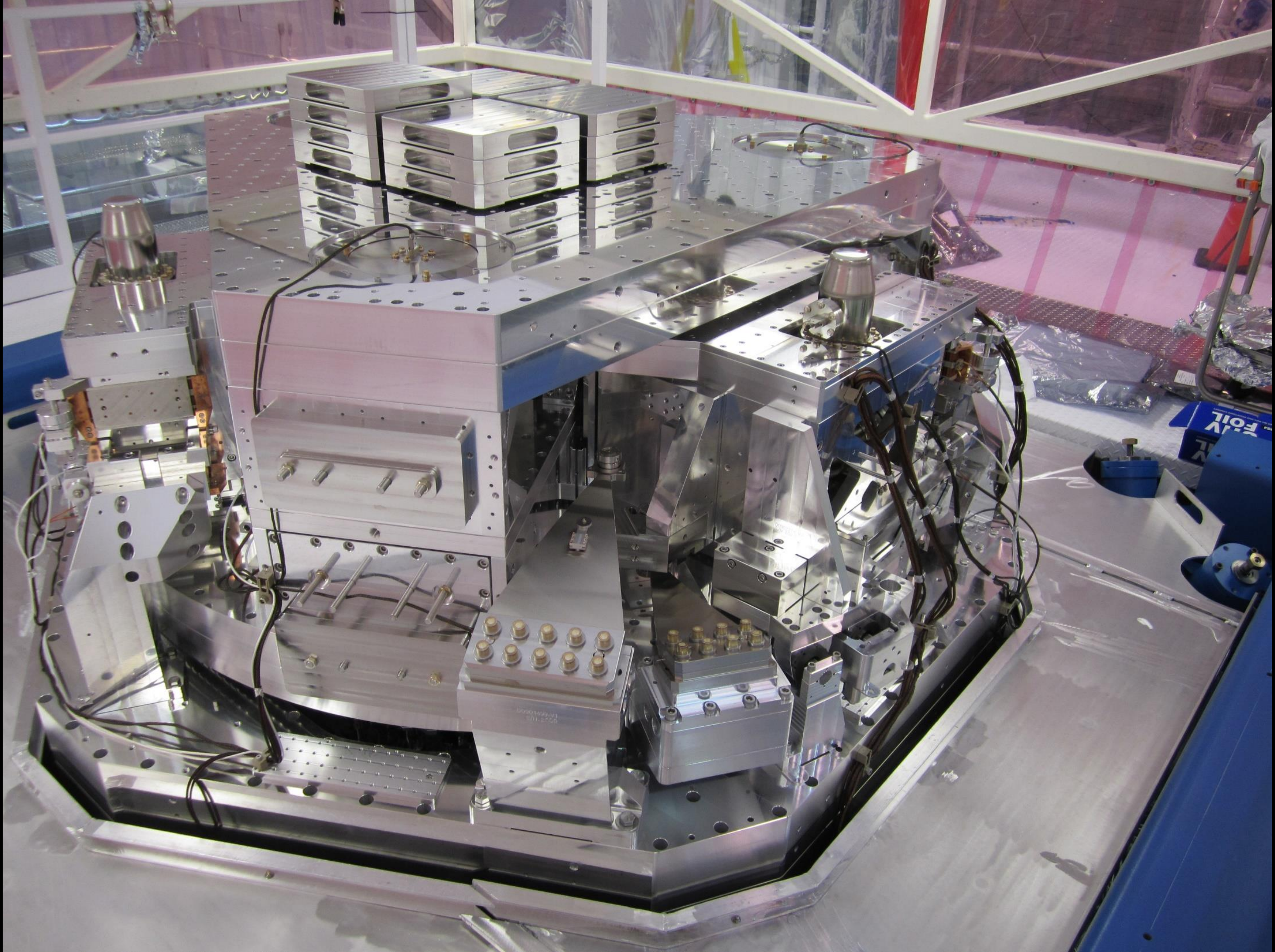
Specifications:

- Diameter: 340 mm
- Thickness: 200 mm
- Mass: 39.6 kg
- ROC: 2250 m / 1940 m
- Figure: <1 nm rms
- Scatter: ~10 ppm
- Surface absorption: ~0.3 ppm
- Bulk absorption: ~0.2 ppm/cm
- HR transmission: ~4 ppm
- AR reflectivity: ~200 ppm

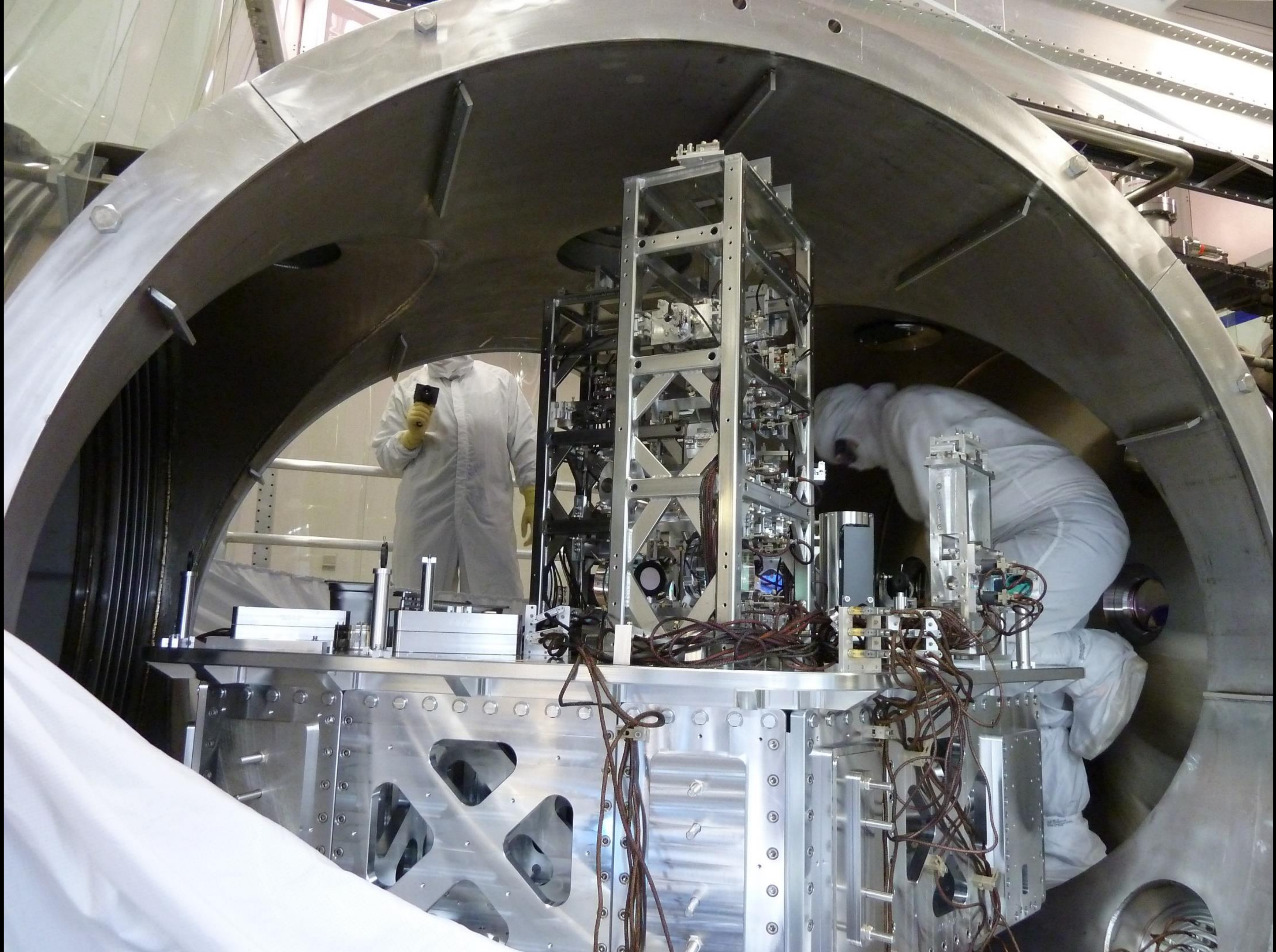


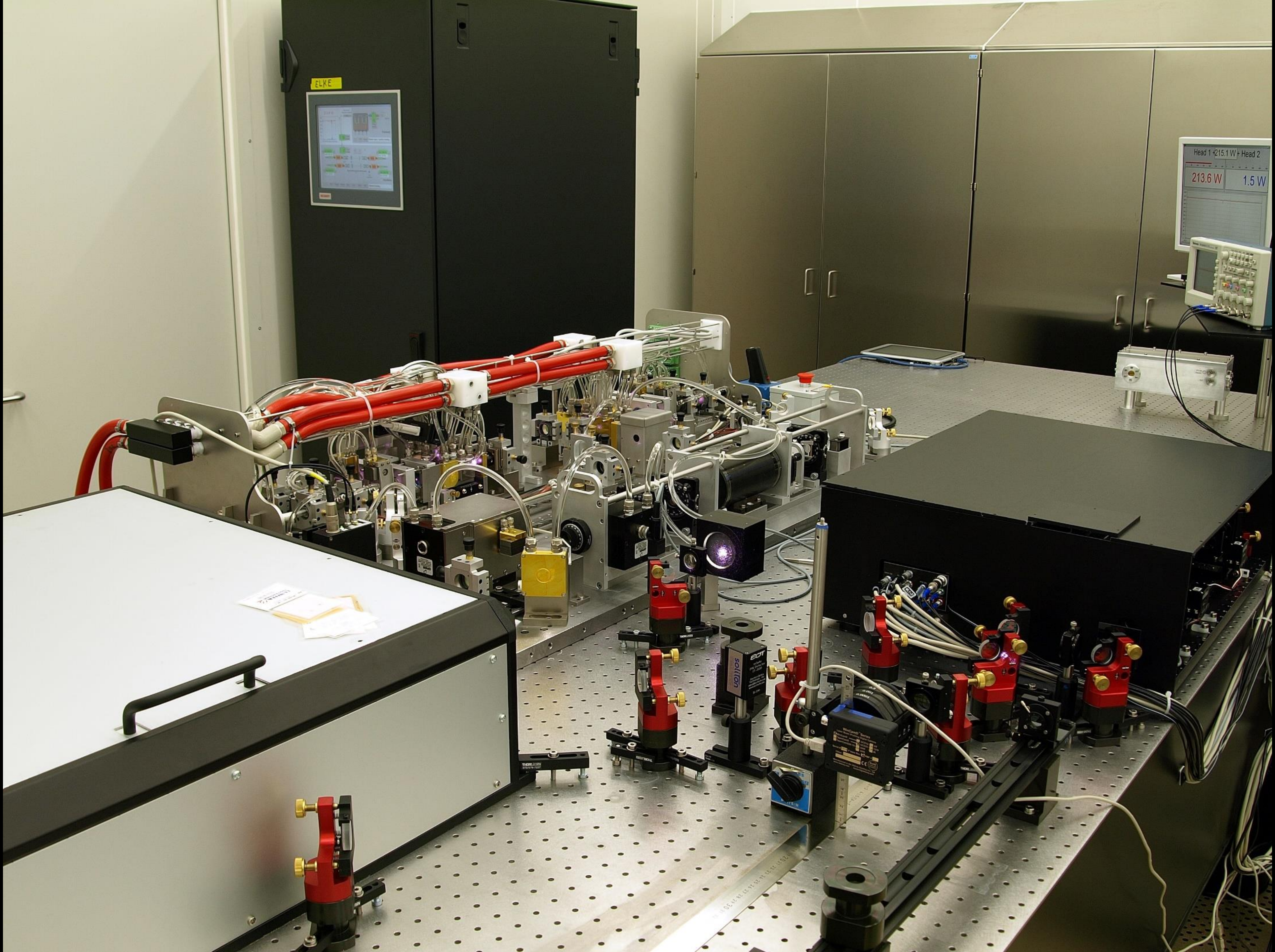
Vacuum System Vertex

Seismic Isolation Platform



Input Optics Table





200W Pre-Stabilized Laser


Control Room