Engineering Test Facility
Stanford University

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LIGO-G010193-00-Z

Test Facilities

Large facility in End Station 2, refurbished by NSF, Stanford, and Mike.

The goal of the Engineering Test Facility (ETF):

- Experiment with ideas for seismic isolation/ mirror suspensions/ interferometer alignment and control and configuration.
- Provide a facility which is flexible, easy to use, with reasonable turnaround times for engineering prototypes.

Large, flexible clean room (up to 3,000 sq. ft. class ~1,000)

perform exps. in air, staging area for vacuum, other special projects

10 meter vacuum system with easy access.

Let me tell you about:

Current work and plans for future work in the facility

How that work relates to Advanced LIGO R&D

ETF Vacuum System

ETF Vacuum System

Designed as a Test Facility

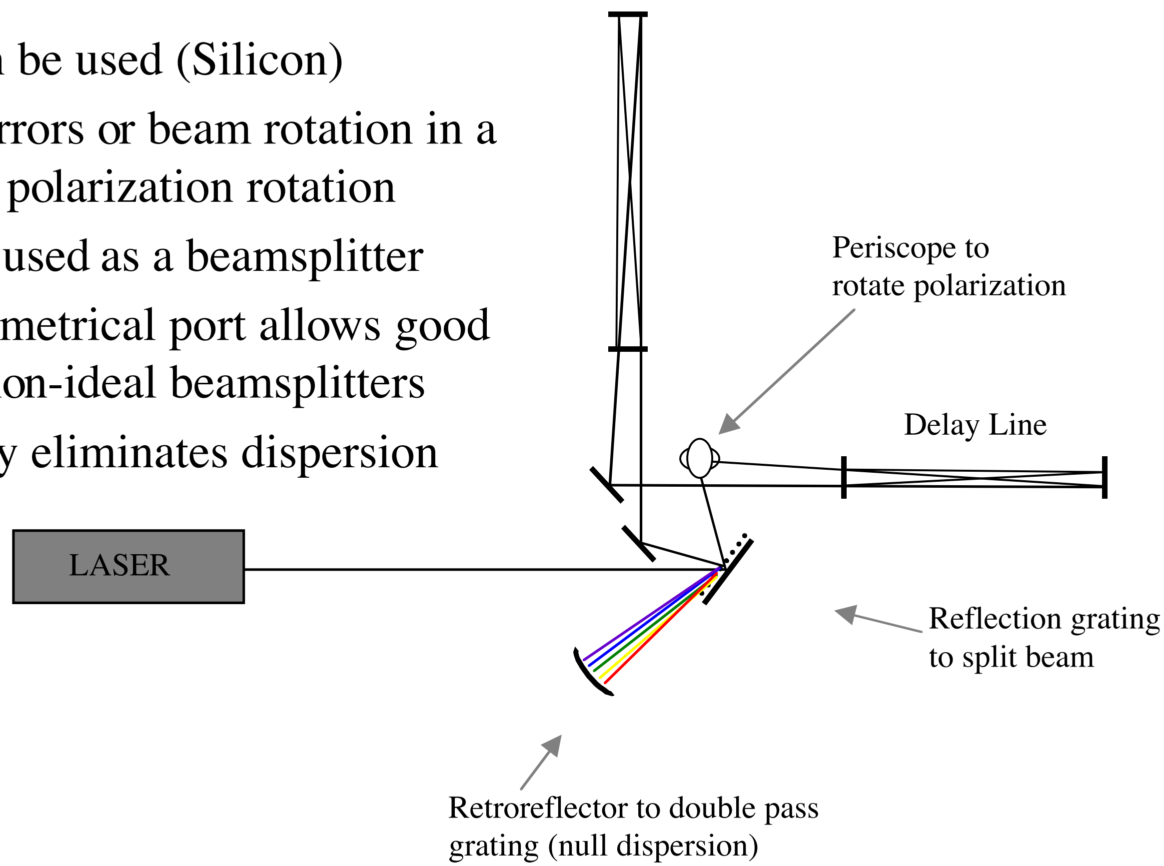
Hinged doors allow easy access.

1 day cycle time for vacuum.

Vacuum requirements not as strict as LIGO reqs.

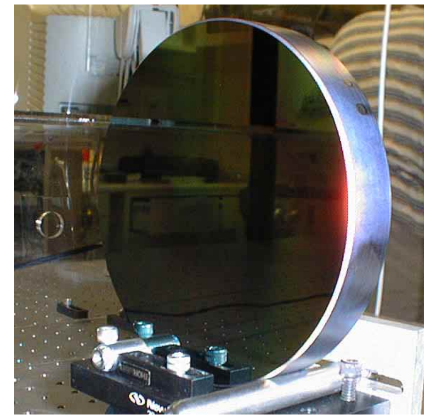
Layout of 10m suspended prototype all-reflective polarization Sagnac

- Core optics are only used in reflection
  - No thermal lensing
  - Opaque materials can be used (Silicon)
- Phase shift from tilted mirrors or beam rotation in a periscope can be used for polarization rotation
- Reflection grating can be used as a beamsplitter
  - Detection on the symmetrical port allows good fringe contrast with non-ideal beamsplitters
  - Double pass geometry eliminates dispersion

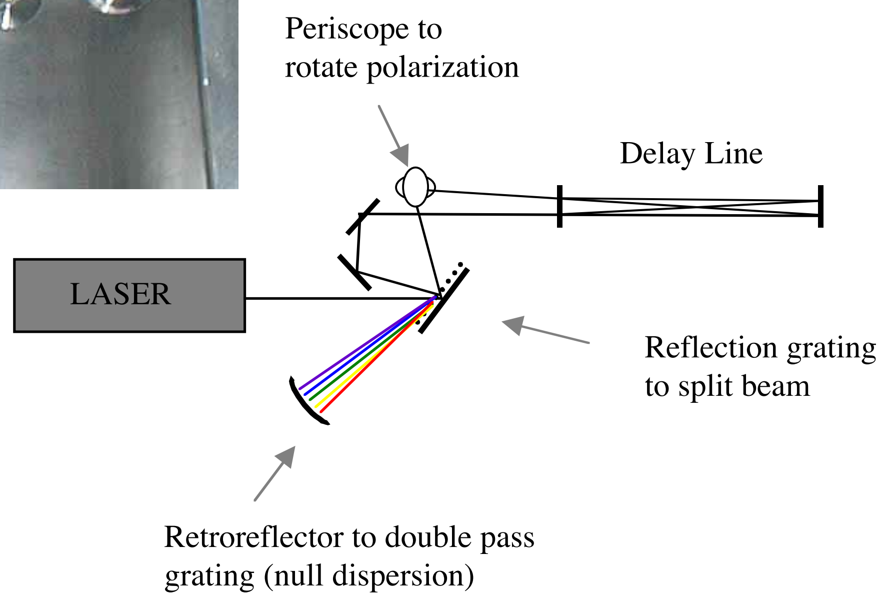


Layout of 10m suspended prototype all-reflective polarization Sagnac

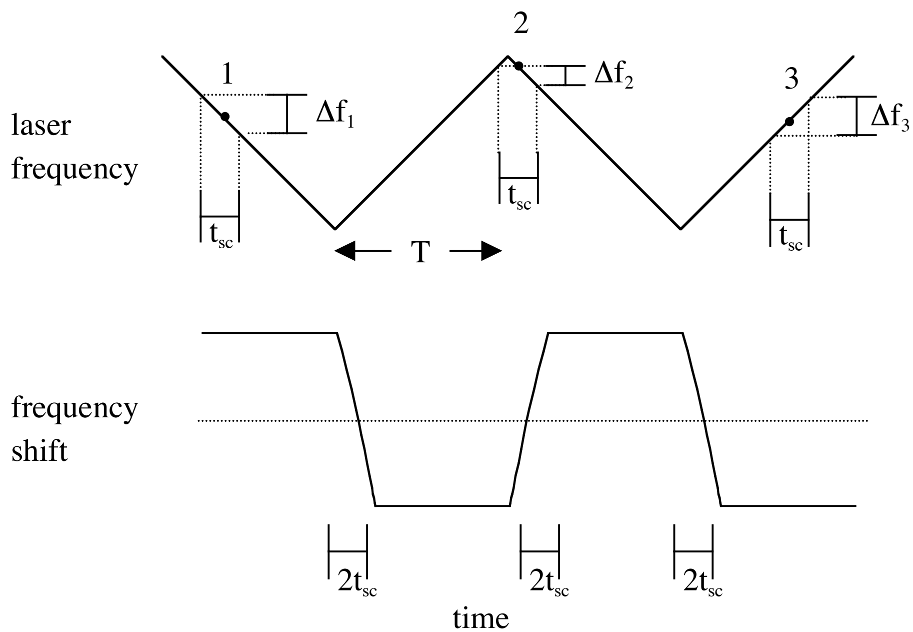
The delay line mirrors are dielectric coated 6” silicon substrates.

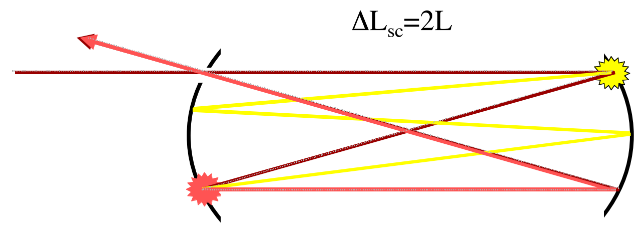


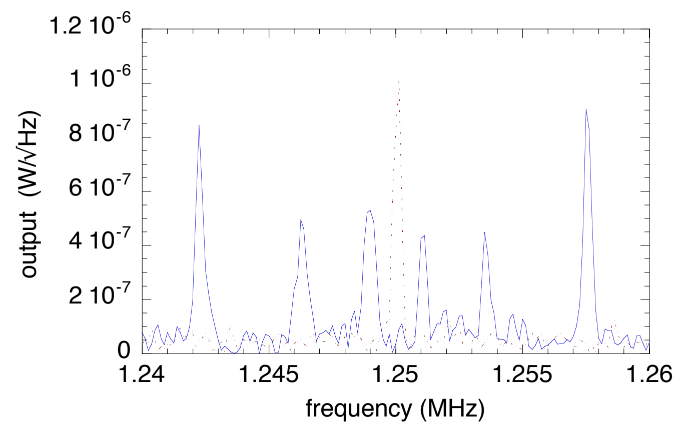
The suspended table in the vacuum system holds most of the components of the interferometer



Eliminating noise from scattered light

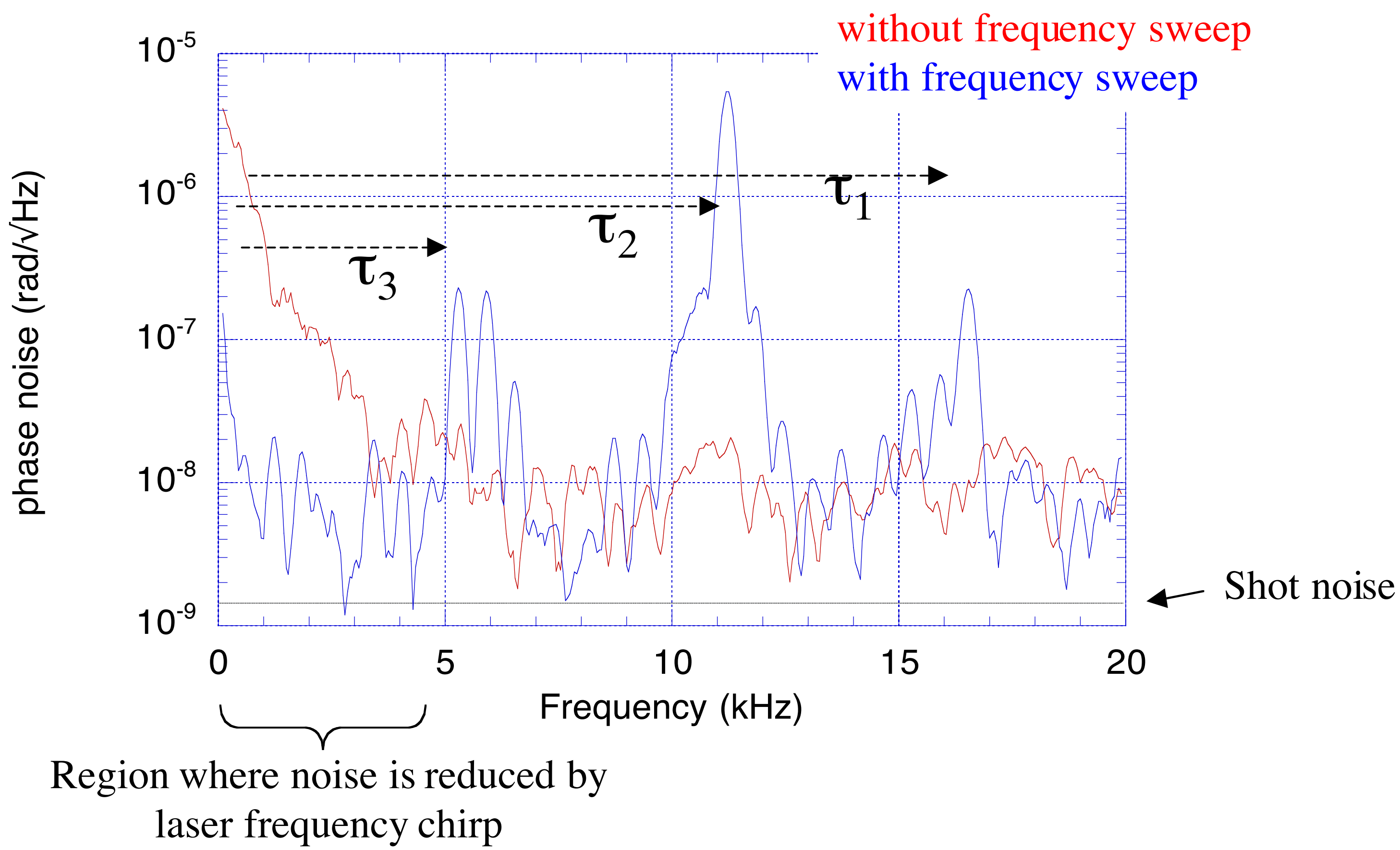






Any noise from scattered light with a delay, t_{sc},
much less than the modulation period, T, will be shifted

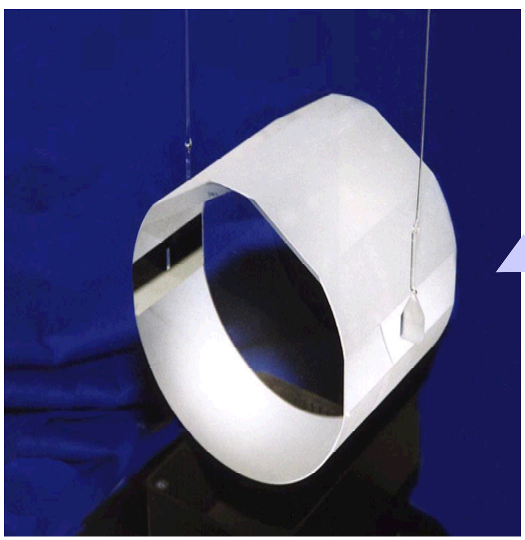
Benefits of Frequency Sweep

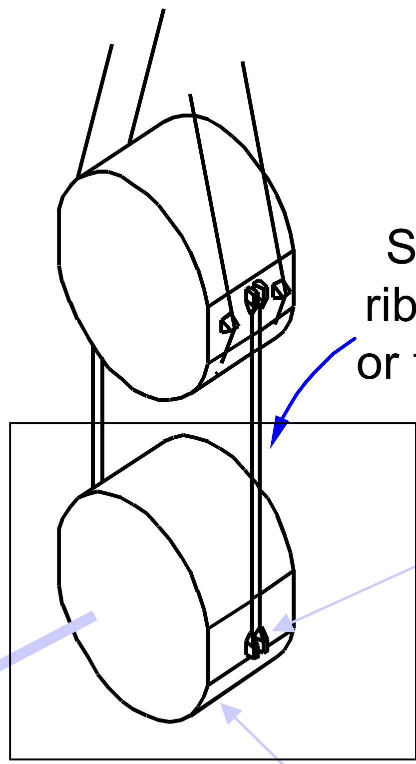


Advanced LIGO - thermal noise issues

Test mass

- Material
  - coating losses
  - bonding losses





Suspension

- Ribbon/fiber
  - strength
  - reliability
  - loss

Slide Courtesy of Sheila Rowan

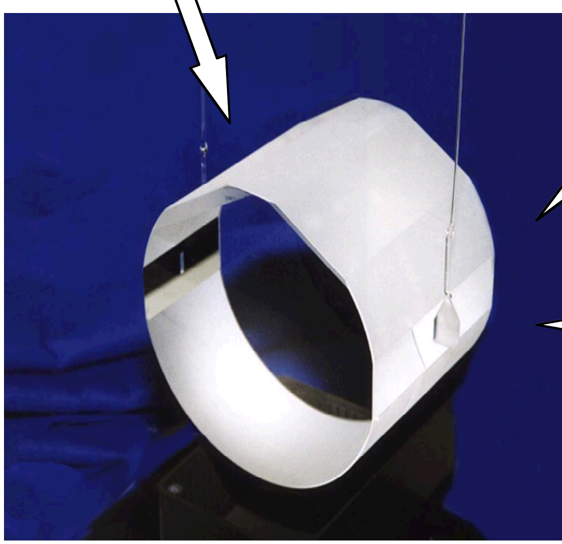
Advanced LIGO -Thermal Noise Issues

Suspension fiber and ribbon development

Optimize design of suspension elements

- Studies of fiber and ribbon strength, Q factor, surface effects

(MSU/GEO/ Stanford/ Caltech/Syracuse)



Slide Courtesy of Sheila Rowan

Test mass materials development:

Effect of dielectric coatings on thermal noise

- Measure mechanical losses of sapphire and silica substrates with and without dielectric coatings
- Use results to model effect on interferometer sensitivity

(Stanford/GEO/Syracuse/MIT/Iowa)

Effect of silicate bonding attachments to test mass

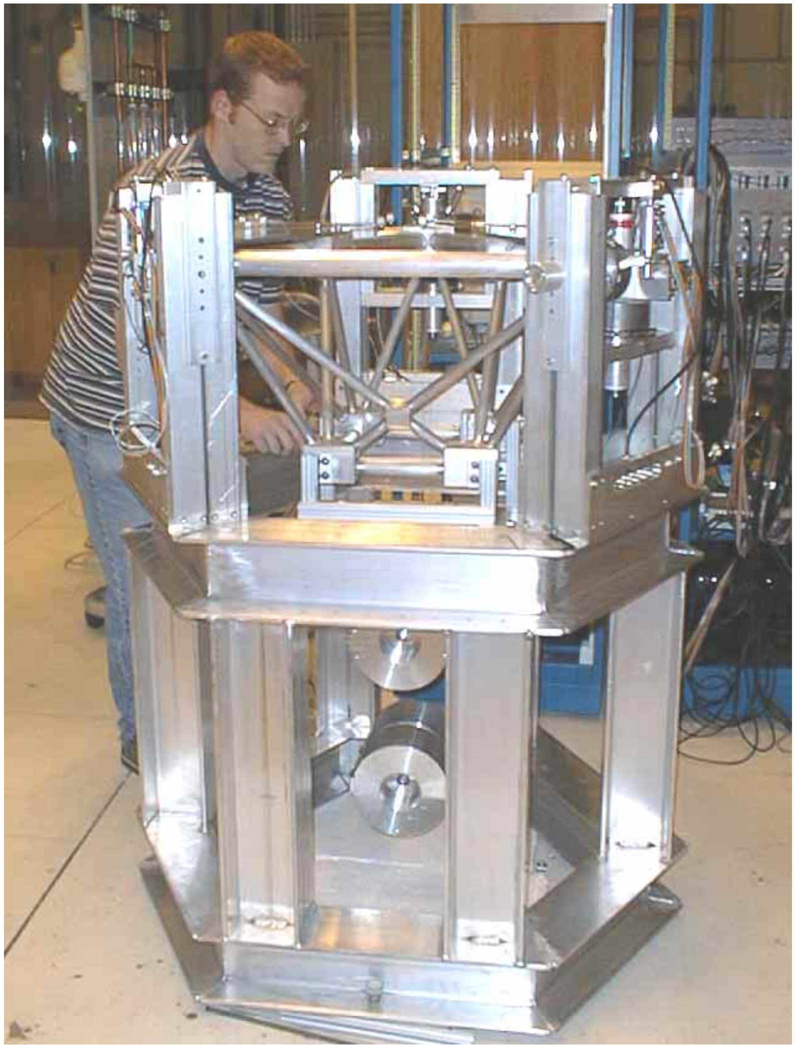
- Study strengths and mechanical losses associated with bonding:
  - fused silica to sapphire
  - fused silica to fused silica

(Stanford/ GEO/Caltech/Syracuse)

ETF Silicate Bonding Area

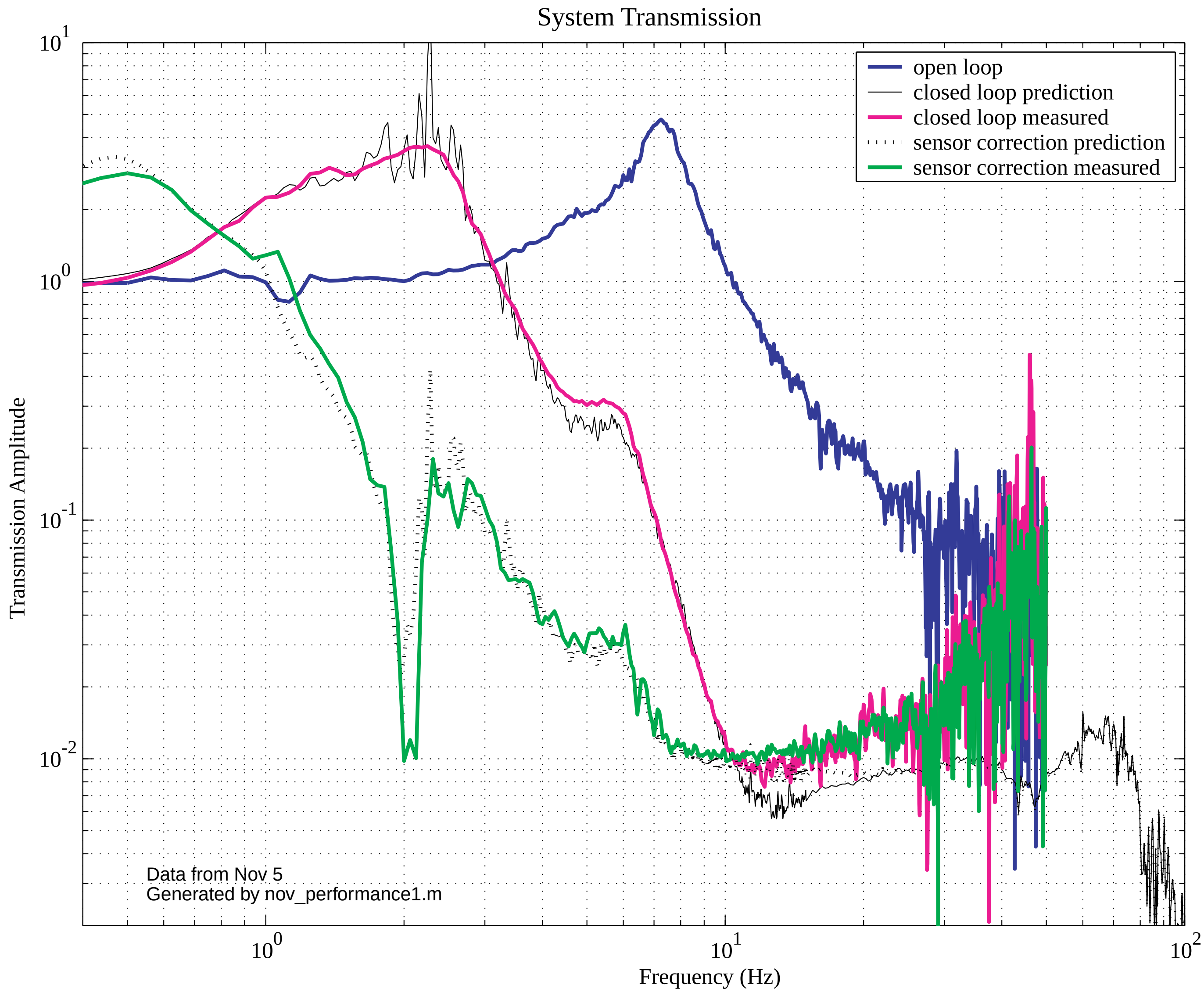
Testmass Ringdown Apparatus

Seismic Isolation for Advanced LIGO

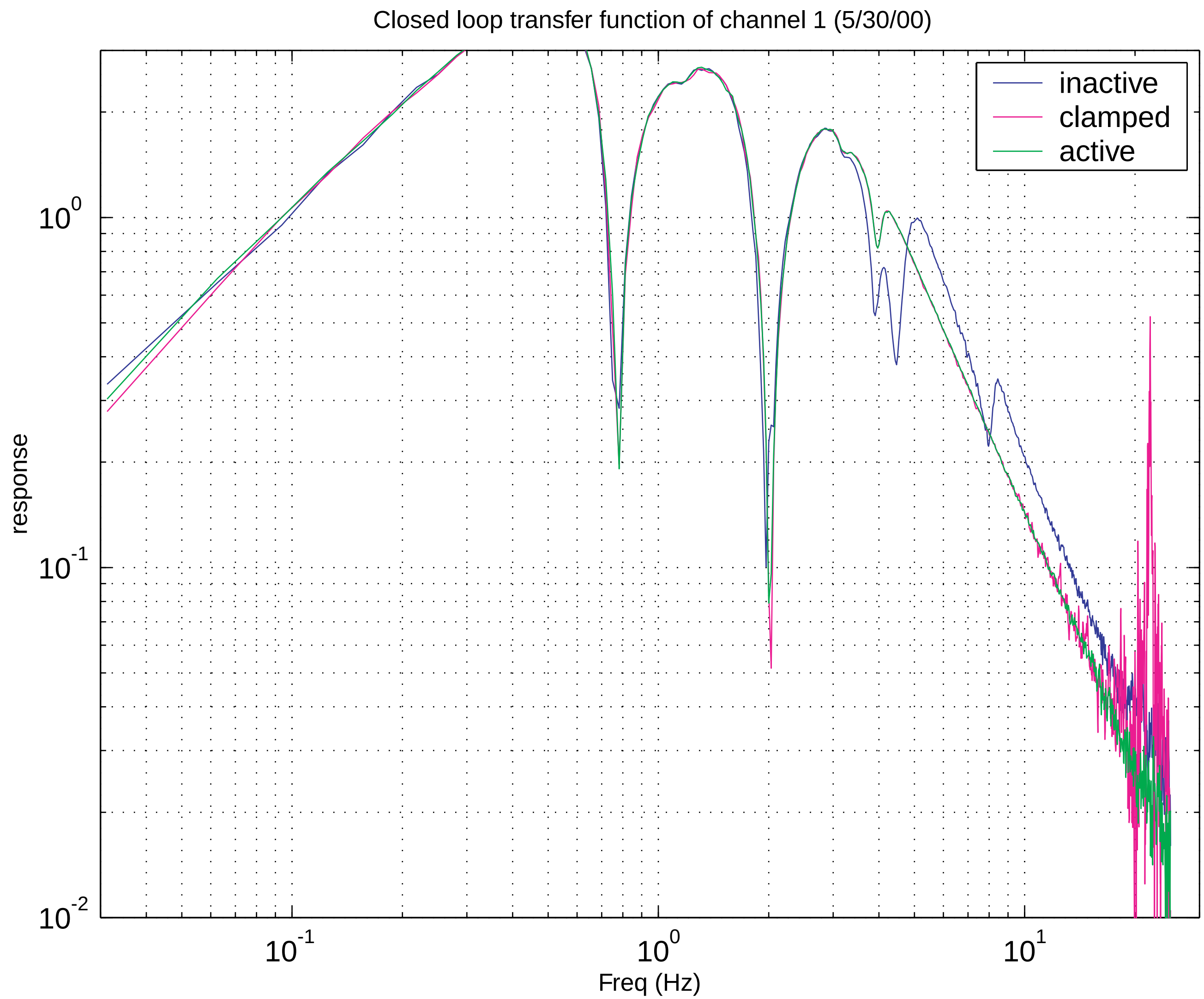


- Demonstrate 6 DOF active platform with collocated sensors and actuators.
- Demonstrate sensor blending.
- Validate computer model used to design the Advanced LIGO seismic system.
- Demonstrate sensor correction for reduction of ground motion.
- Demonstrate reliable operation of stiff platform and pendulum working together.

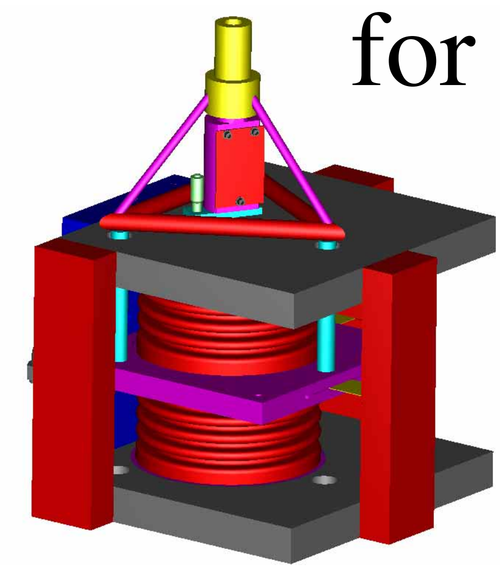
Isolation Performance

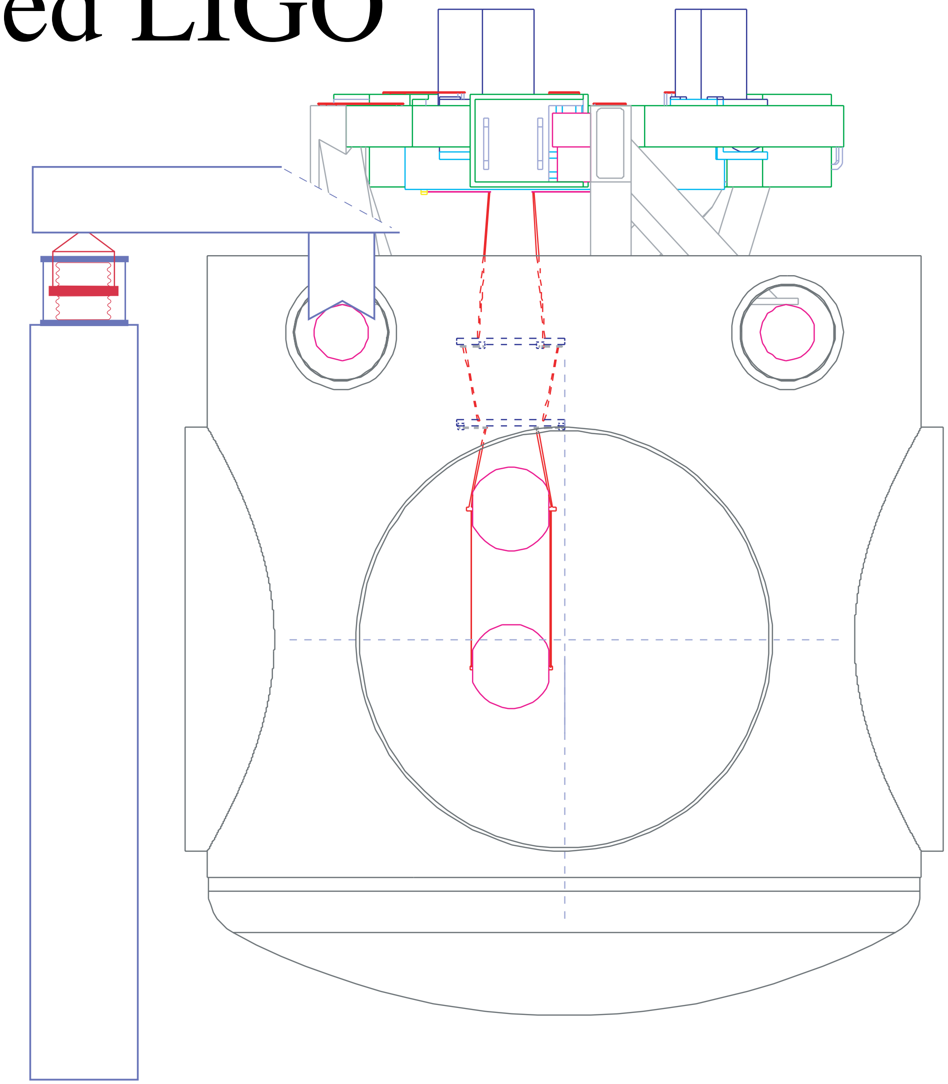


Pendulum Interaction

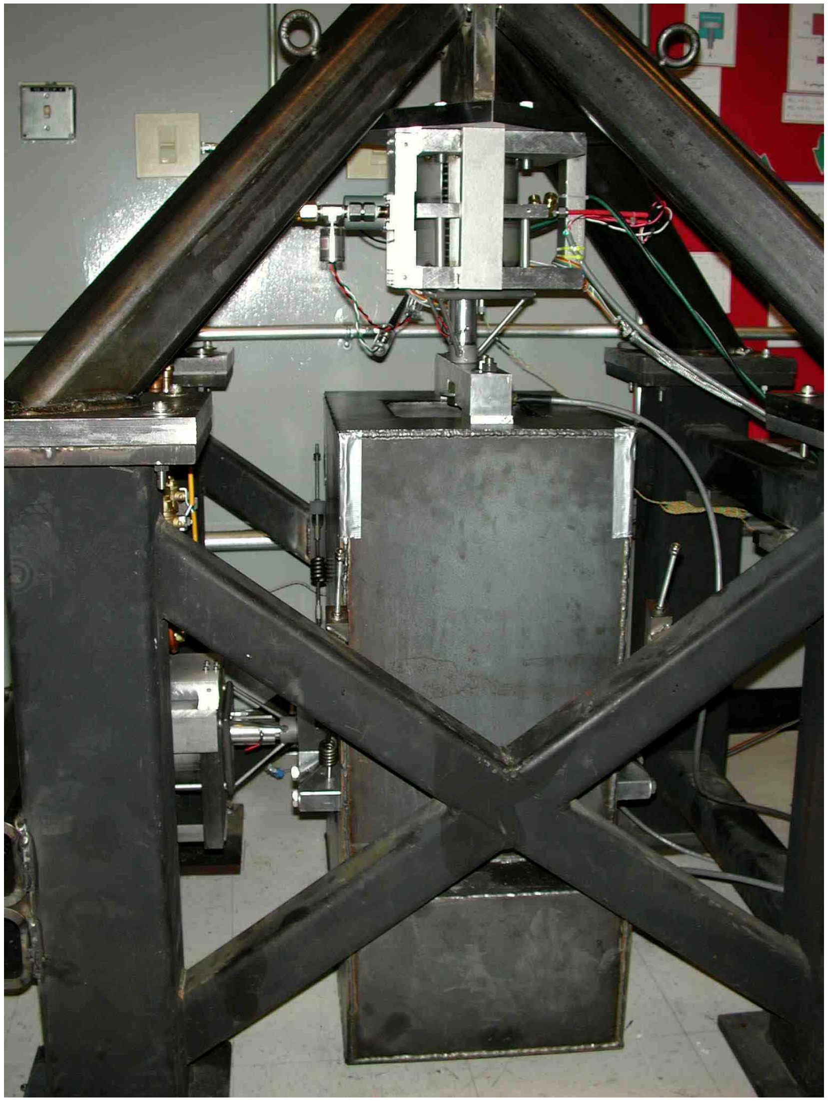


Hydraulic Actuators for Advanced LIGO

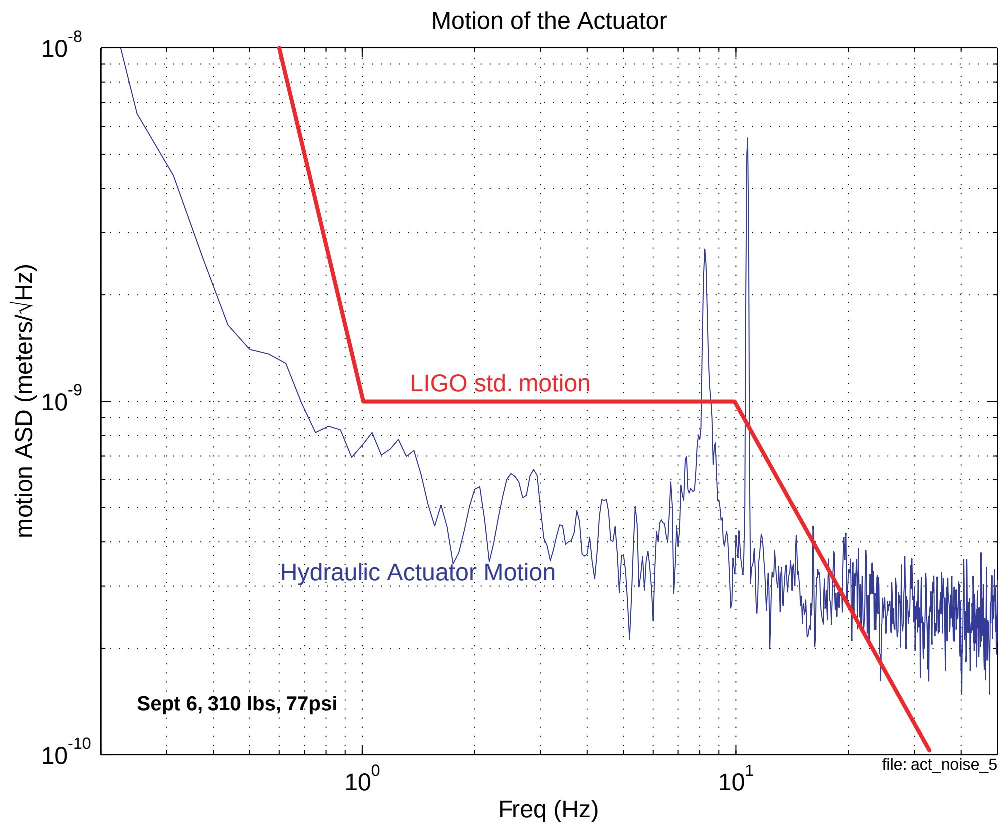




System provides active alignment and isolation,
  +-1mm range,
  10 Hz bandwidth.
Two systems are placed at the top of each pier, providing 6DOF control



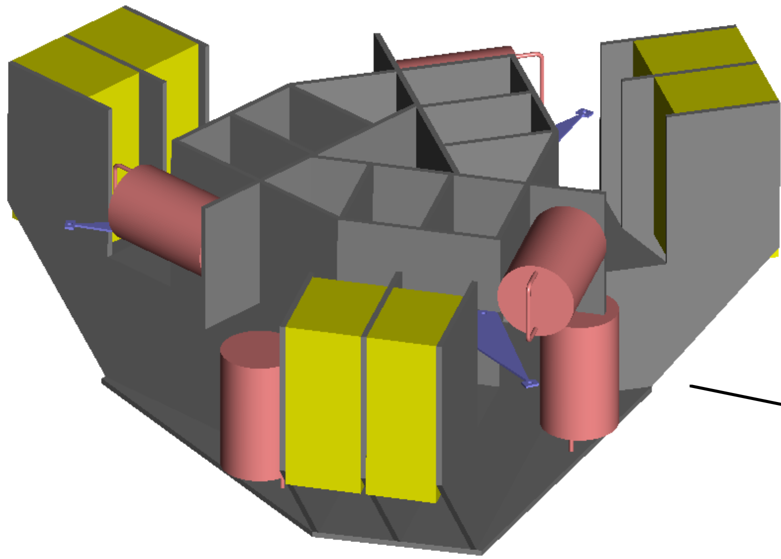
Hydraulic Development

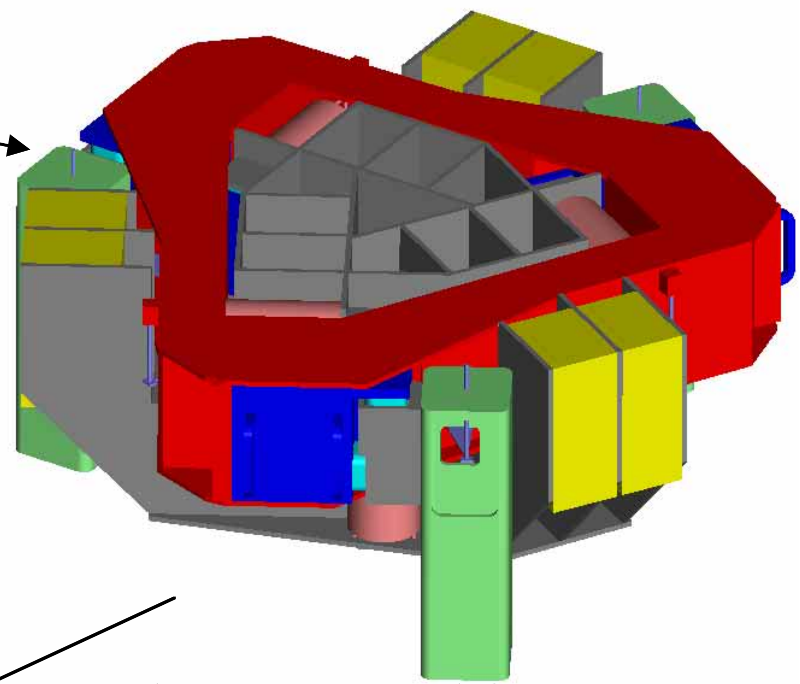


Next Step:
Two Stage Prototype
for Advanced LIGO

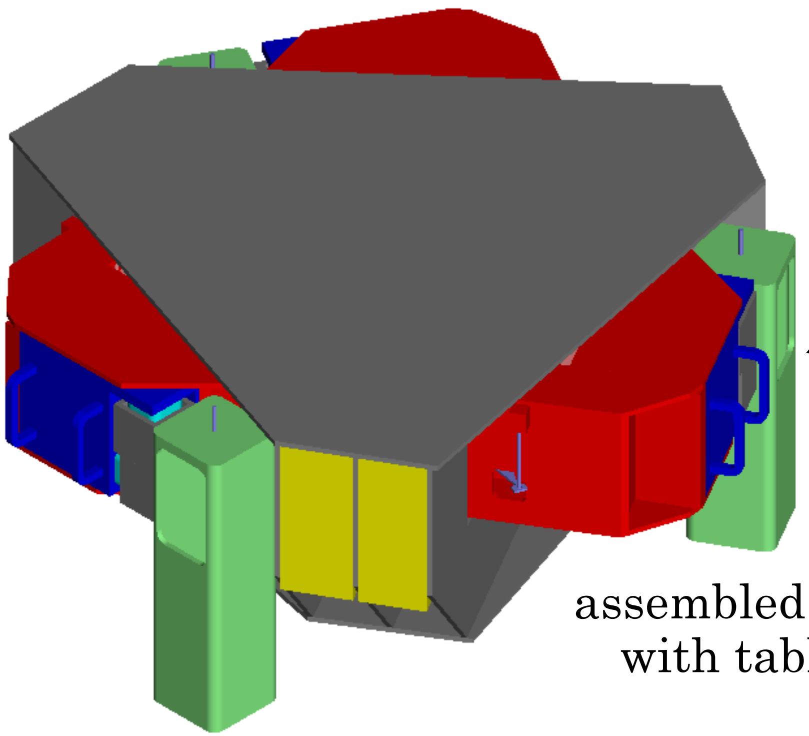
- Prototype for the HAM chamber system,
  to be installed in vacuum at the Stanford ETF.
- Same sensors, similar actuators as the Advanced LIGO system.
- Same dynamics as the Advanced LIGO system.
- Centers of mass of two stages at the same location.
- Sensors and actuators well aligned.
- How well does it work? Feed design information to the Pathfinder design at LASTI.

Views of the Prototype



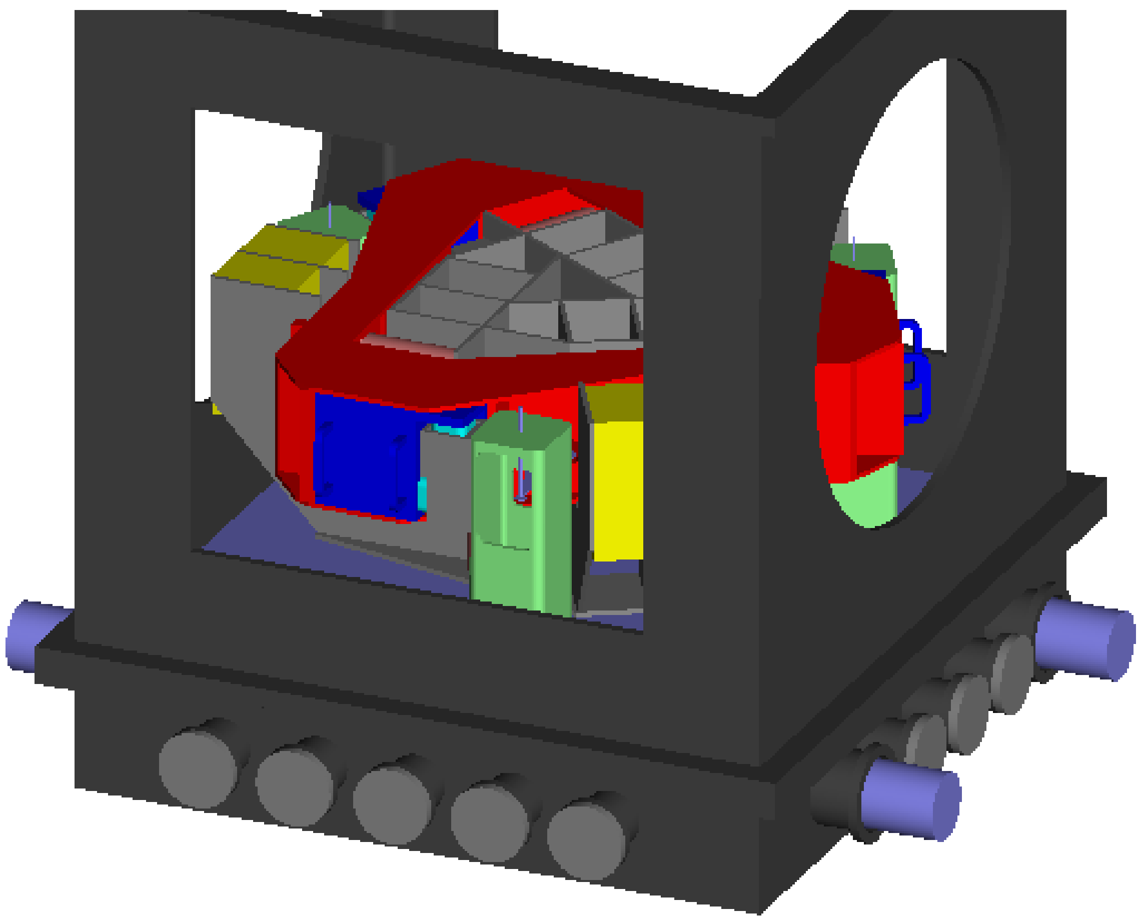


inner stage with outer stage
and supports



assembled system
with table top

Prototype installed in the ETF vacuum system



Ideal Facility for
Engineering Prototype

- Easy access to system
- Modest requirements for vacuum components

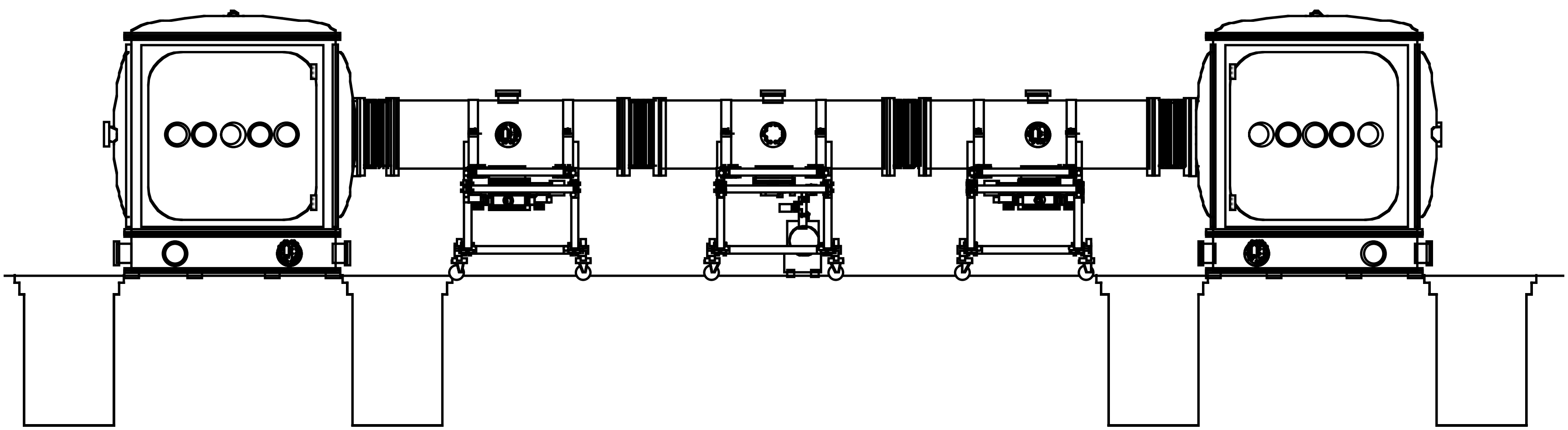
RFQ on the way to contractors

Install in ~4 months

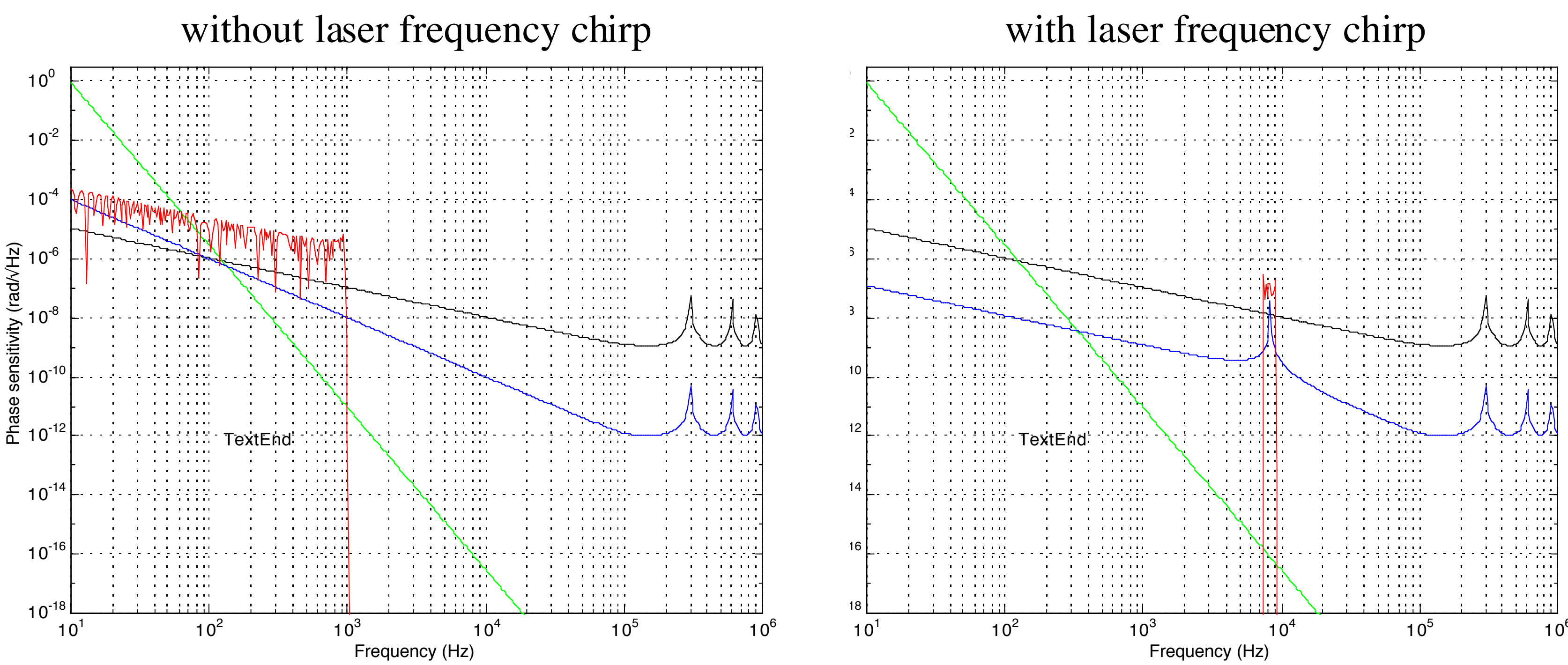
2 sets of data to the LASTI Pathfinder

Vacuum System

- Ten meter system
- Reasonable chamber sizes (6’ x 6’ x 7’9”)
- Hinged doors.
- Arm length access to entire chamber from the door.
- Rapid (1 day) vacuum system cycle time.



Expected Sensitivity of Prototype Sagnac



P=300mW f_o=1

λ=1.064μm Δx_{max}=1mm

shot noise
seismic noise
laser frequency noise
upconverted mirror noise