Fermilab Holometer Status Repo

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for the Holometer collaboration
(Fermilab E-990)

Patras Workshop

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Fermilab Holometer Collaboratio

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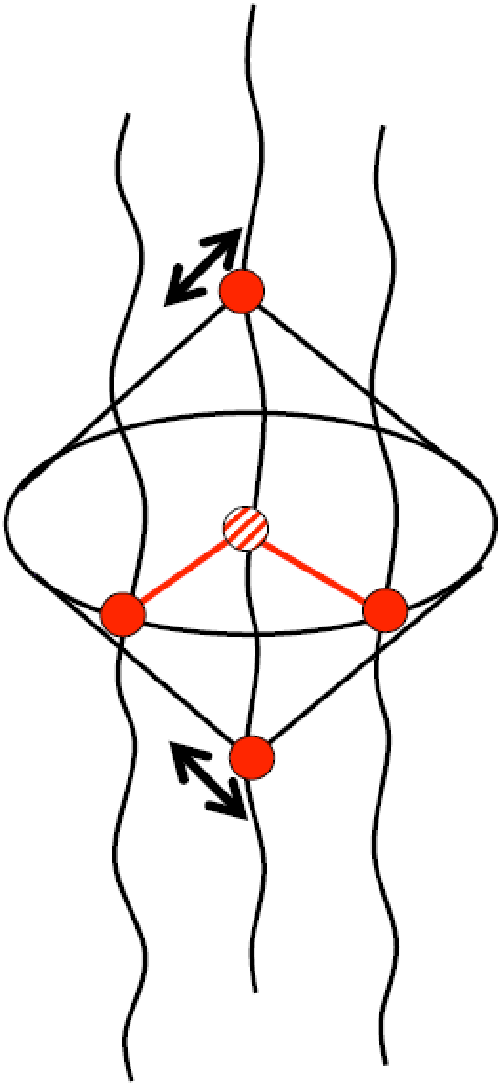
University of Chicago: Stephan Meyer, Ben Brubaker (now at Yale), Brittany Kamai, Bobby Lanza, Lee McCuller

MIT: Rainier Weiss, Sam Waldman (now at SpaceX)

University of Michigan: Dick Gustafson

Northwestern: Jason Steffen (formerly Fermilab)

Holometer Experiment Overview

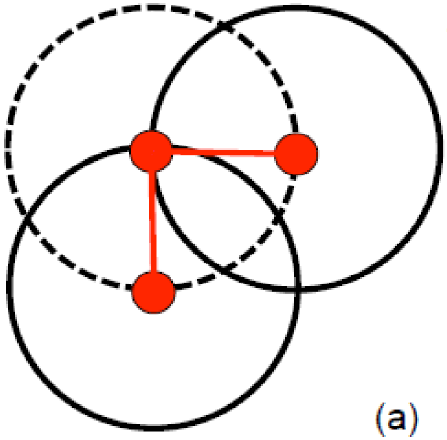


A single interferometer probes the spacetime that is enclosed within a cone-shaped spacetime volume.

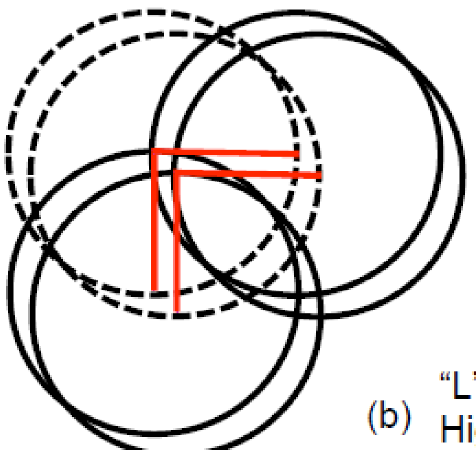
With two, nested interferometers we can compare two simultaneous measurements of the same volume.

Holometer Experiment Overview

Top view of diamonds for one interferometer

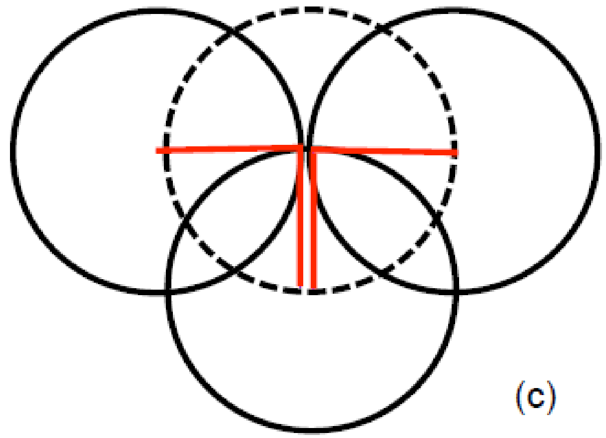


(a)



(b)

“L” configuration
Highly entangled diamonds
Highly correlated signals



(c)

“T” configuration
No overlap of diamonds
from end mirrors
No signal correlations

Holometer Site Information

Holometer Site Information

The MP tunnel (Meson Polarized) was retrofitted to create a >100m laser laboratory.

Three interlocked entrances.

Three clean rooms (two are moveable).

Holometer Construction

The east arms terminate in the newest Fermilab building.

Interlocked with the tunnel lab.

Climate controlled and lighted.

Clean room.

Concrete slab floor rests on 3 pillars driven ~2m deep.

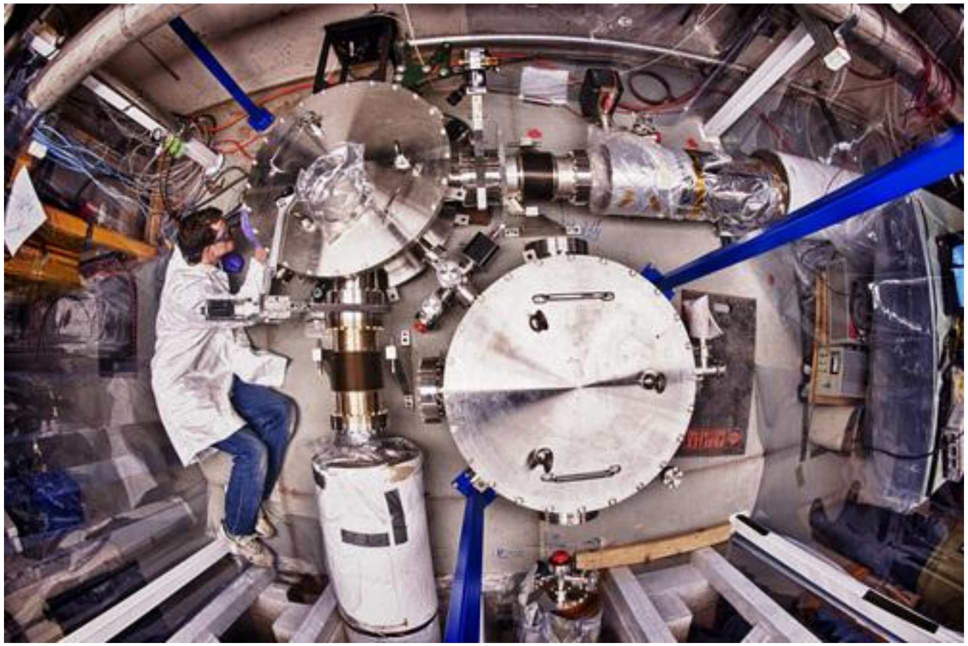
Holometer Construction

All arms are insulated for baking and temperature control.

Outdoor arms pass by the Holometer control room (portacamp 49).

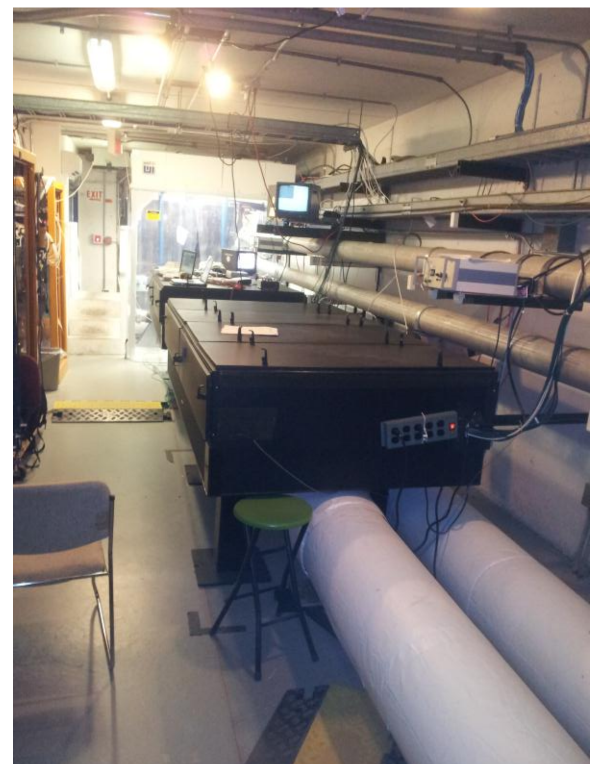
Outdoor arms were prepared and assembled in November 2011.

Holometer Construction



Corner stations located inside the tunnel, within a clean room.

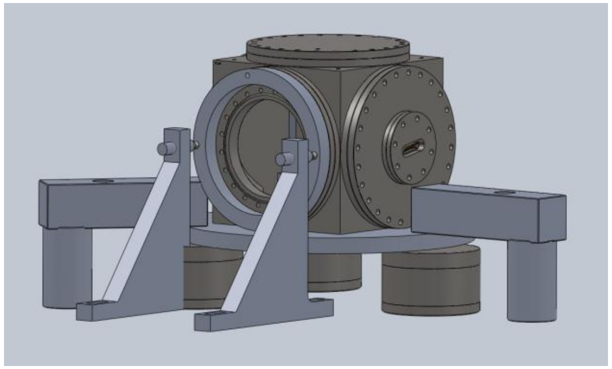
"T" interferometer is outside the "L" interferometer.

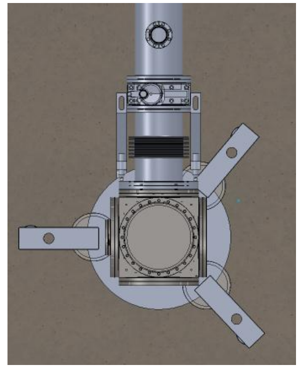


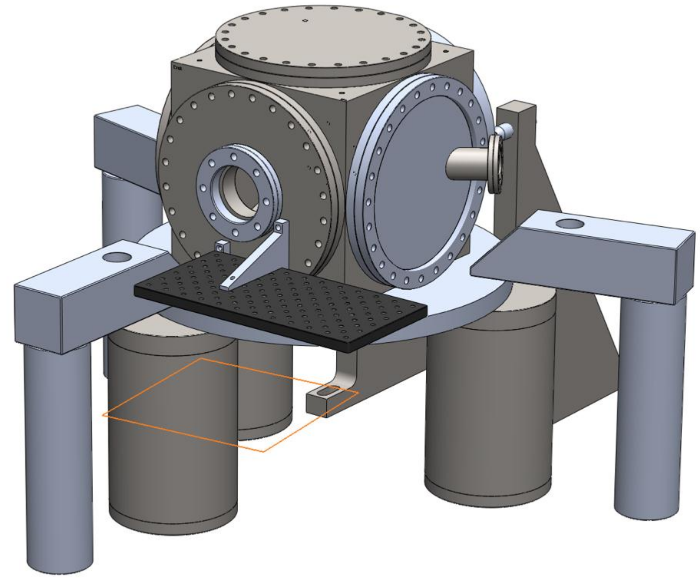
Two optical tables are near the corner stations.

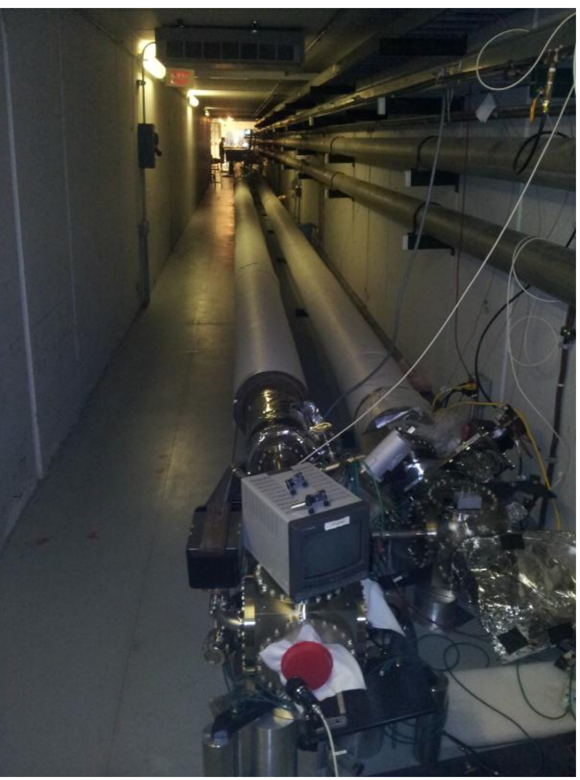
Electronics racks and work spaces are opposite the optical tables.

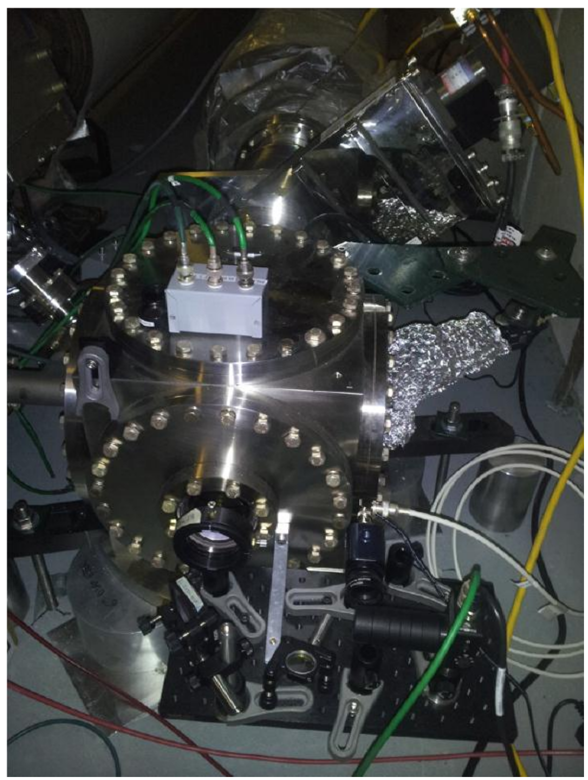
Holometer Construction











End stations made from 10” cubes.

End mirror mount is attached to the upper flange.

Holometer Vacuum Assembly

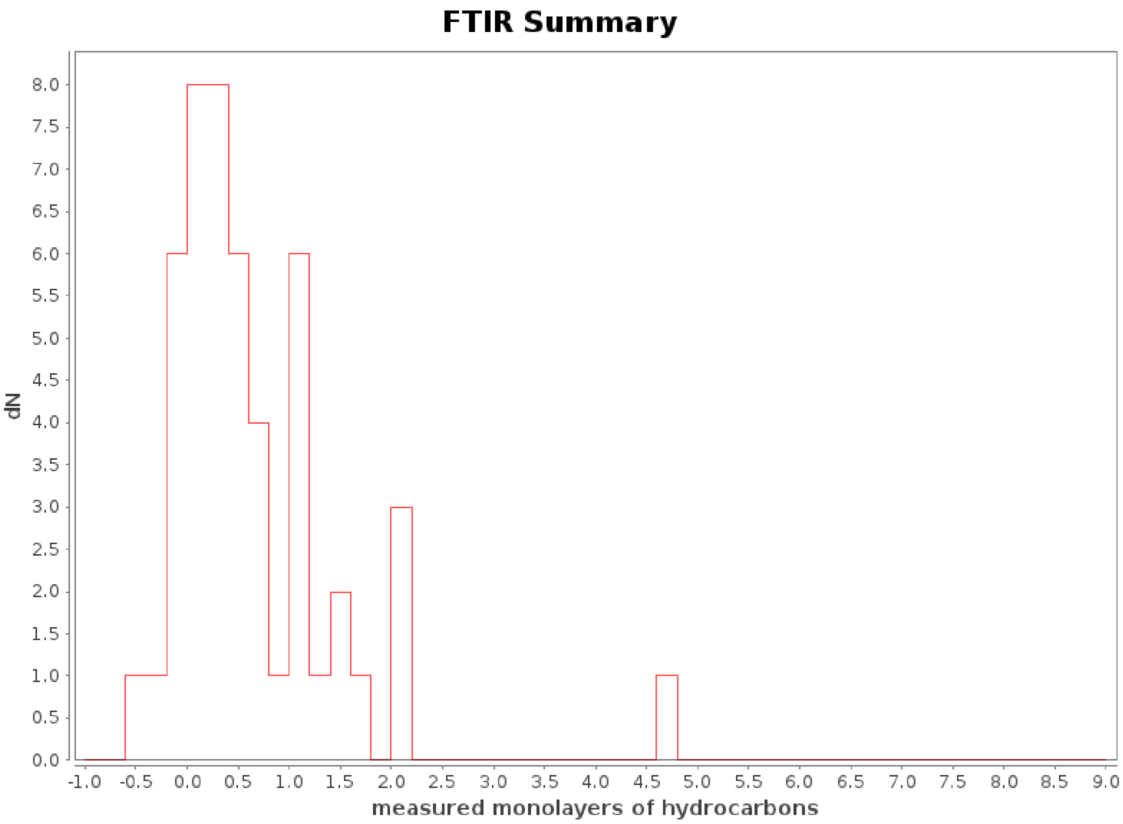
Hydrocarbons is the primary concern with the vacuum system.

For prototype assembly we re-cleaned all of the arriving parts (trust but verify).

Deemed too costly for the balance of the holometer.

Now employ Fourier Transform Infrared Spectroscopy (FTIR) method used for LIGO.

Holometer Vacuum Assembly



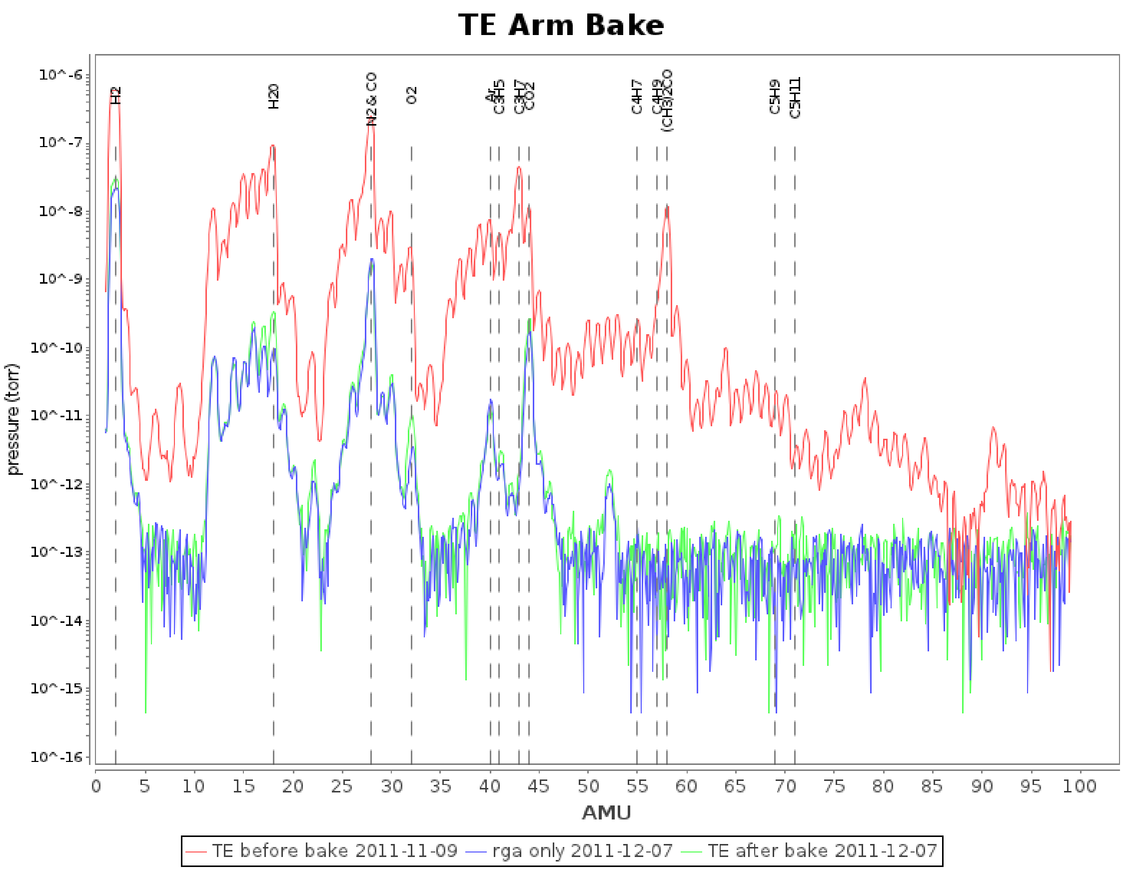
Flow a solvent down the pipe.

Measure the concentration of hydrocarbons in the solute with FTIR.

Convert the result to "number of monolayers".

5 monolayers is the specification for the manufacturer.

Holometer Vacuum Assembly

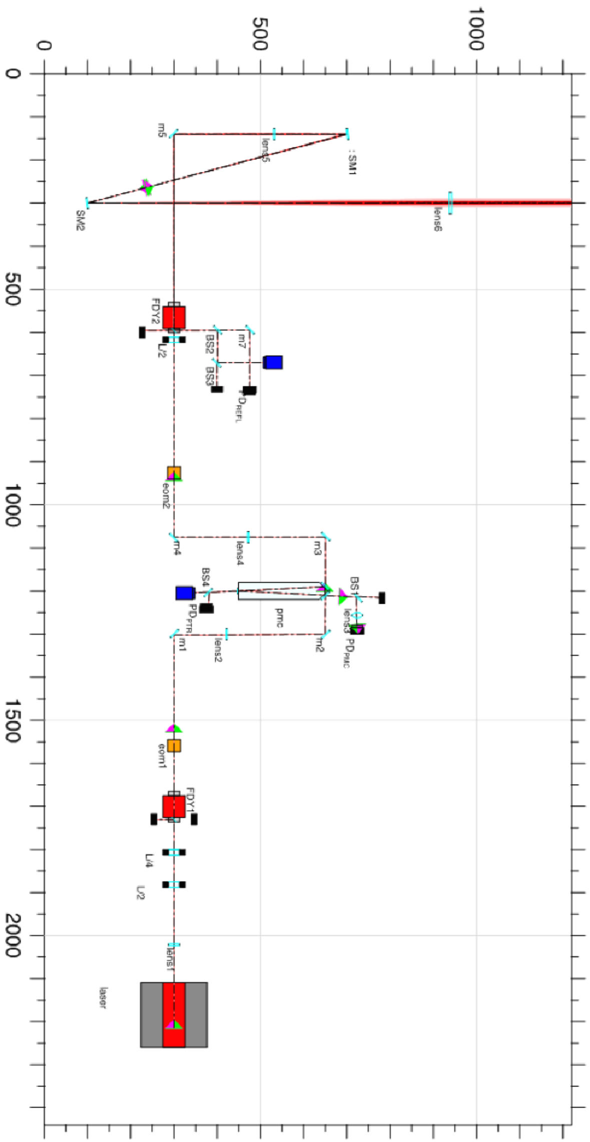


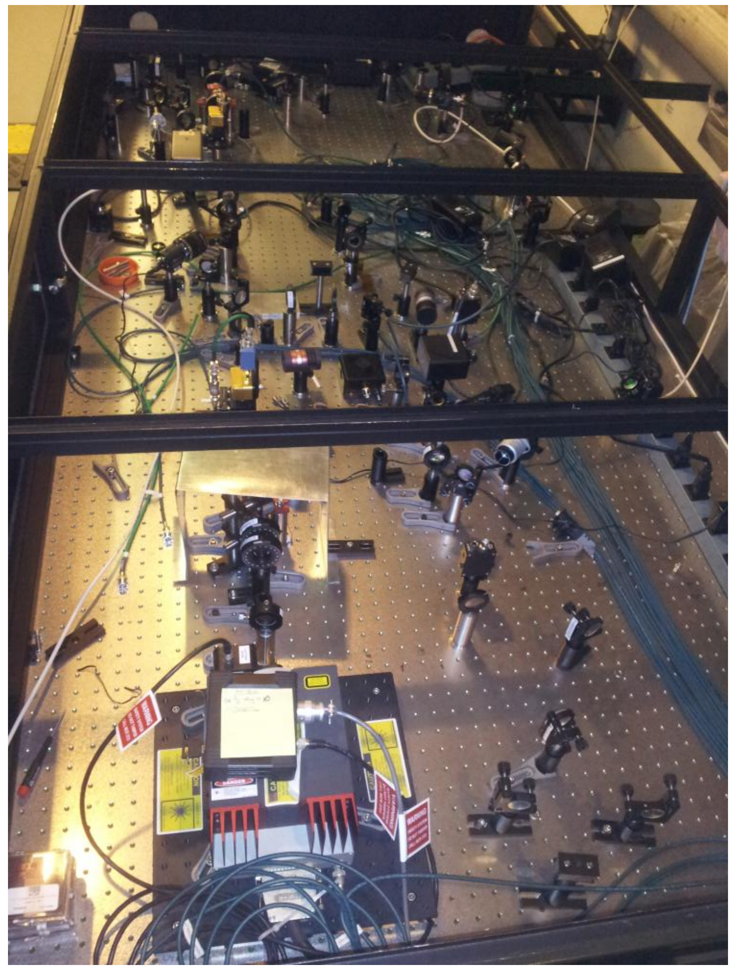
Bake each arm to > 150C independently by flowing current down the pipe itself.

300 A at 10-12 V, 3-7 days with turbopumps running.

Combination of baking and FTIR specification yield acceptable hydrocarbon partial pressure (1e-12 Torr).

Holometer Optical System





Continuous 2 W Mephisto Nd:YAG input laser.

Mode cleaning ring cavity “pre mode cleaner”.

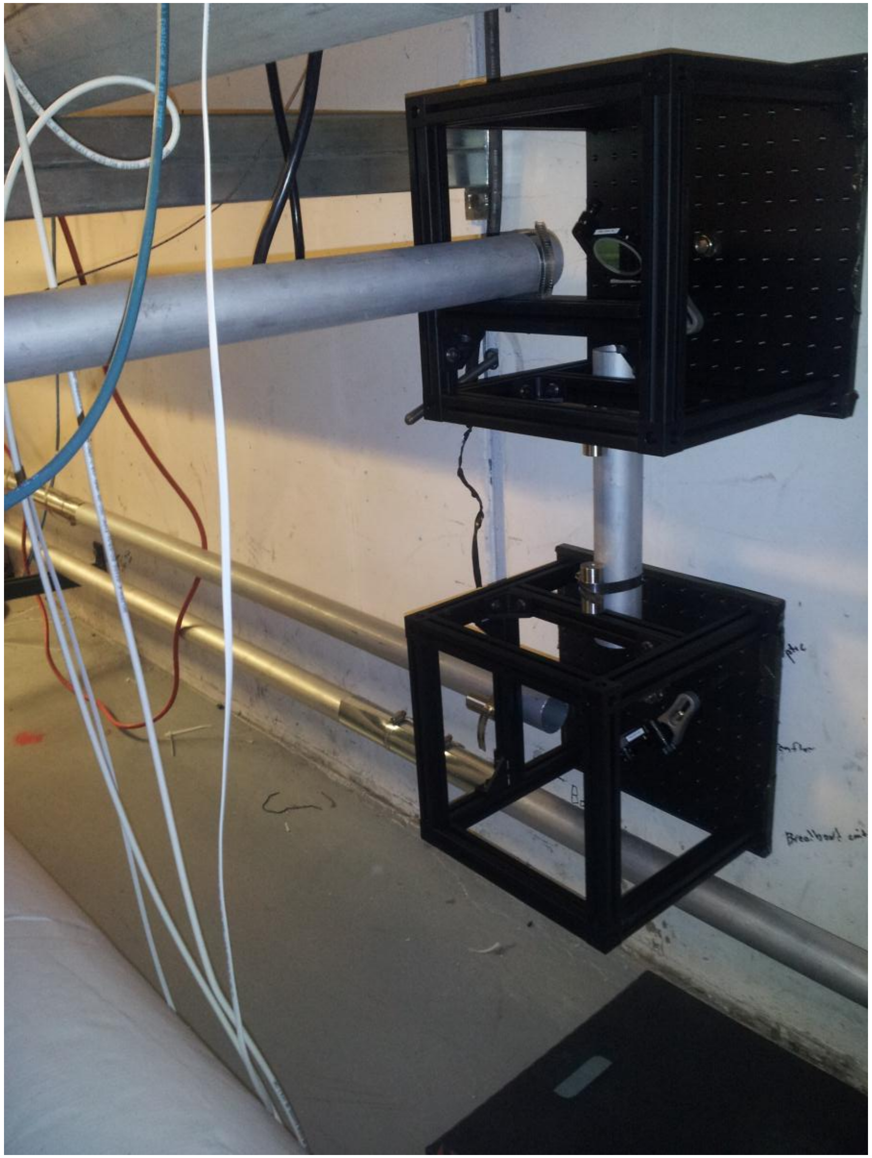
Sidebands added for mode cleaning and for power recycling.

Holometer Optical System

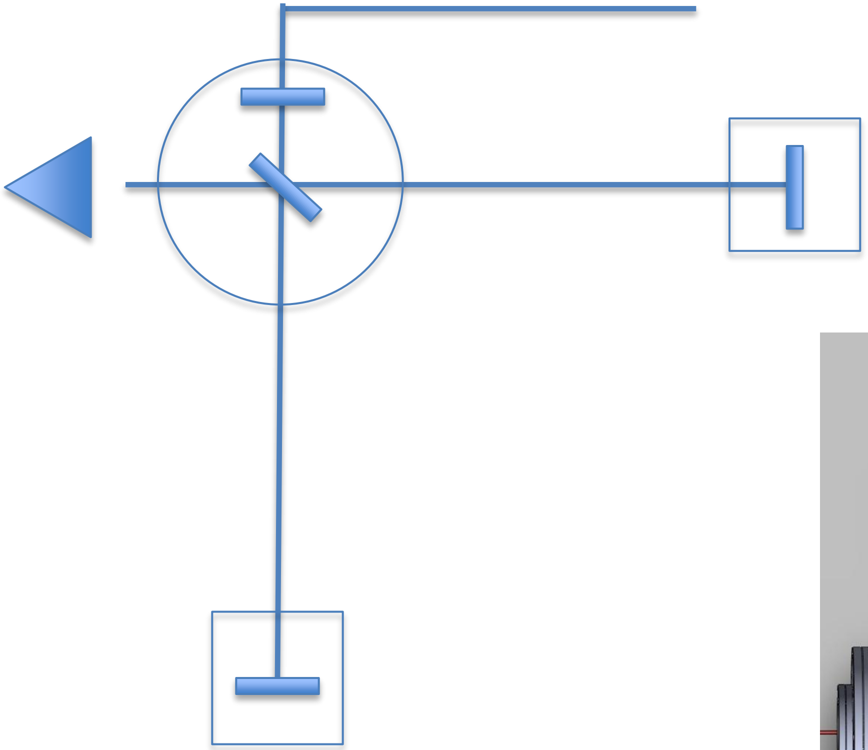
Beam exits the table and is directed to the interferometer using a multi-stage periscope fixed to the tunnel walls.

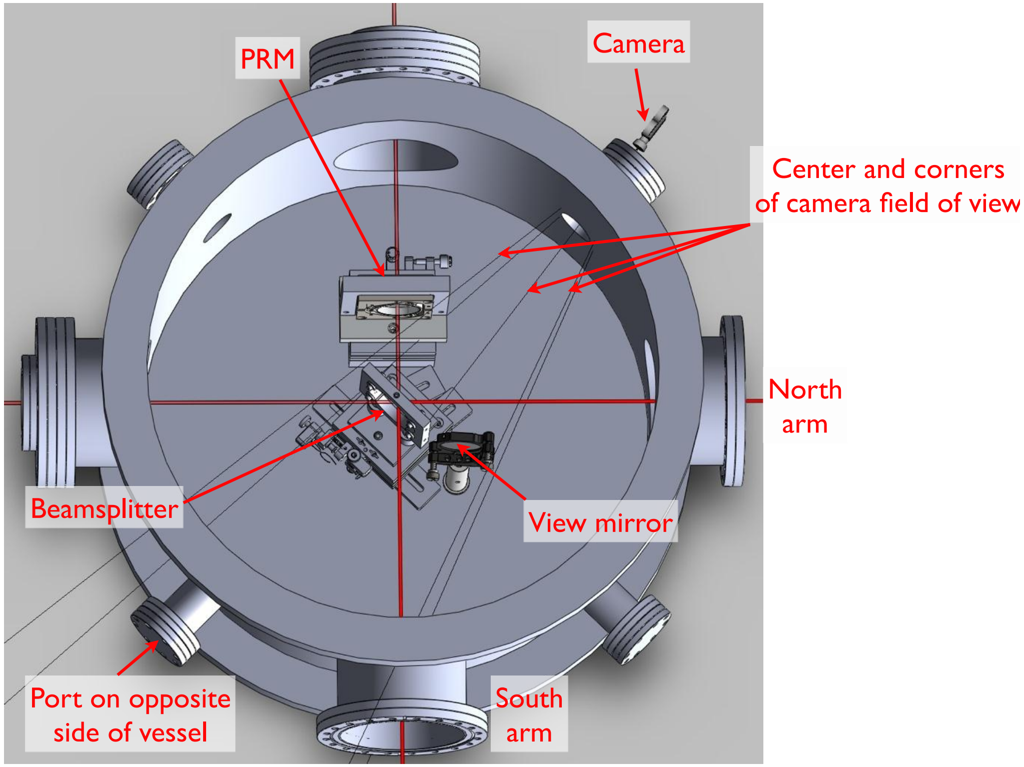
Aluminum pipes shield the beam from air currents and prevent beam cross contamination.

Tunnel walls are very thick yielding low ground noise.



Holometer Optical System

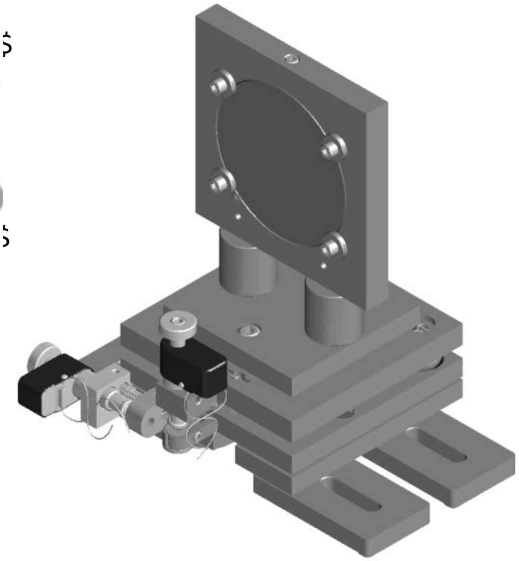


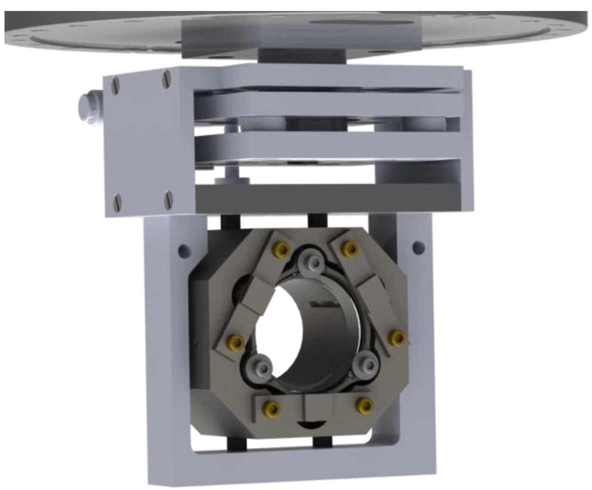


Holometer Optical System

Power recycling mirror and beamsplitter are steered by picomotors.

Custom 3” beamsplitter mount.





End mirrors driven by piezo stacks.

Custom mounts supported from above.

Optical mounts in the interferometer are quite stable---no need for suspended optics.

Holometer Optical System

We have maintained interferometer lock for several minutes.

Measured the power spectrum and are now tracking down noise sources.

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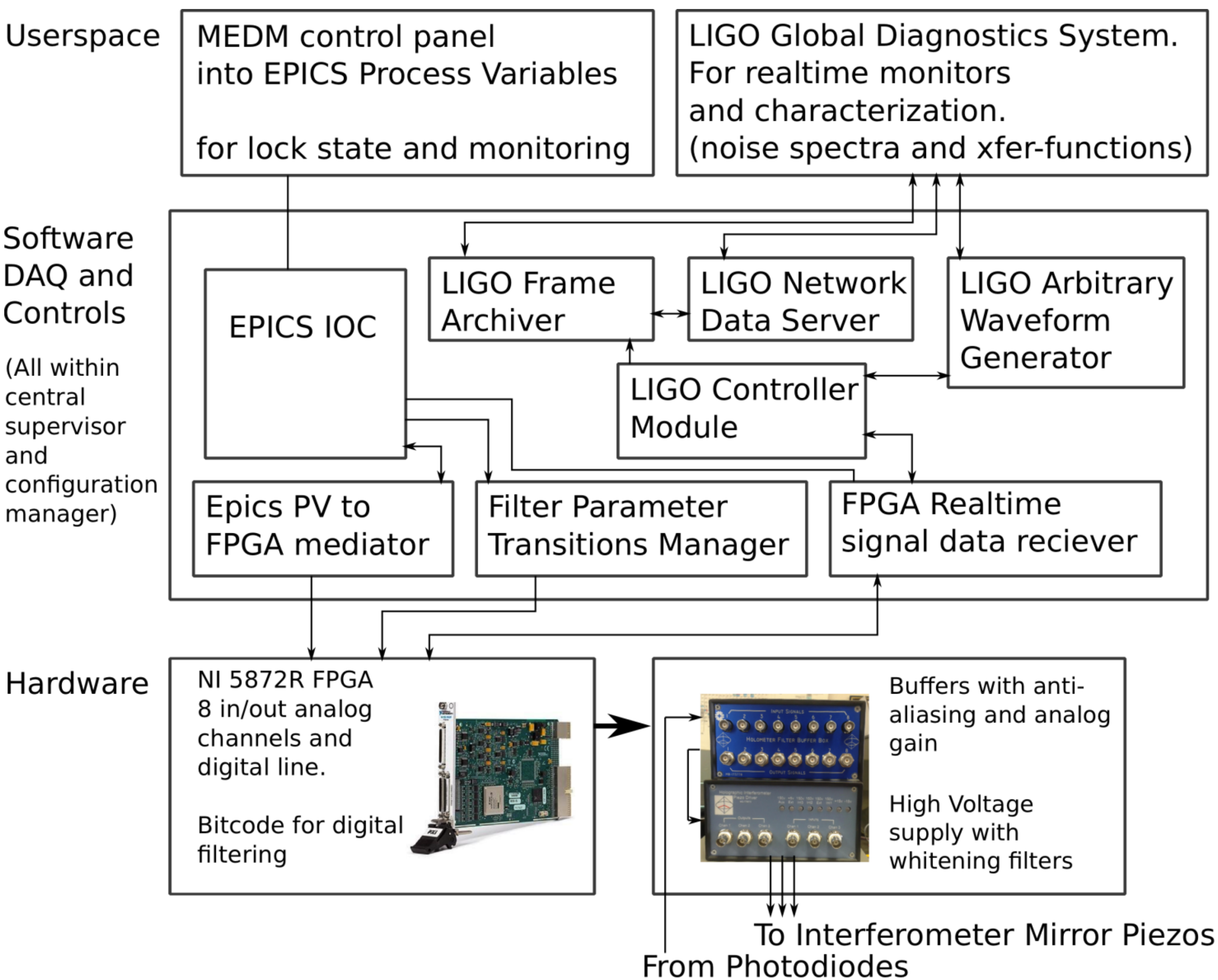
Holometer Control and Data



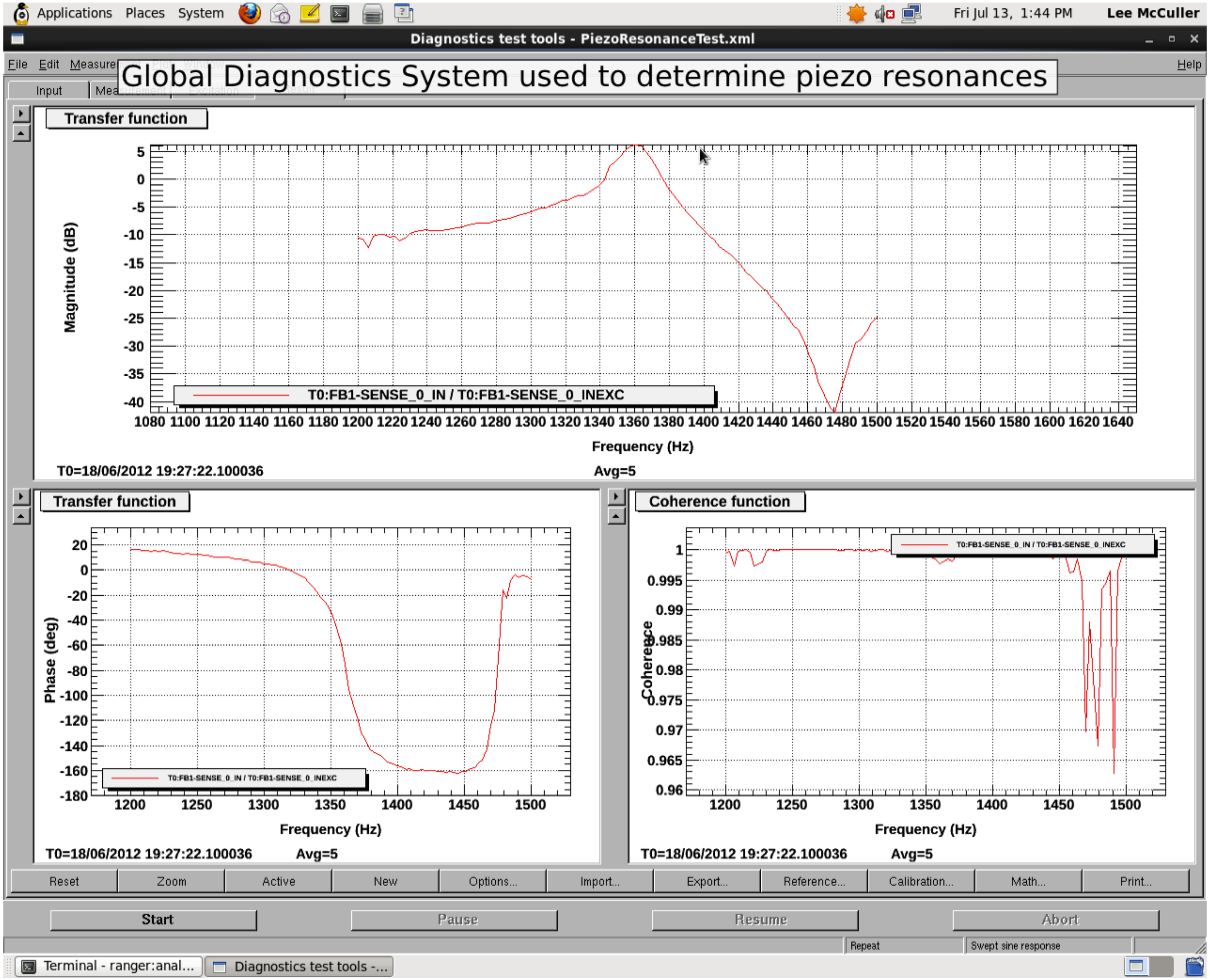
EPICS:

Experimental Physics and Industrial Control System

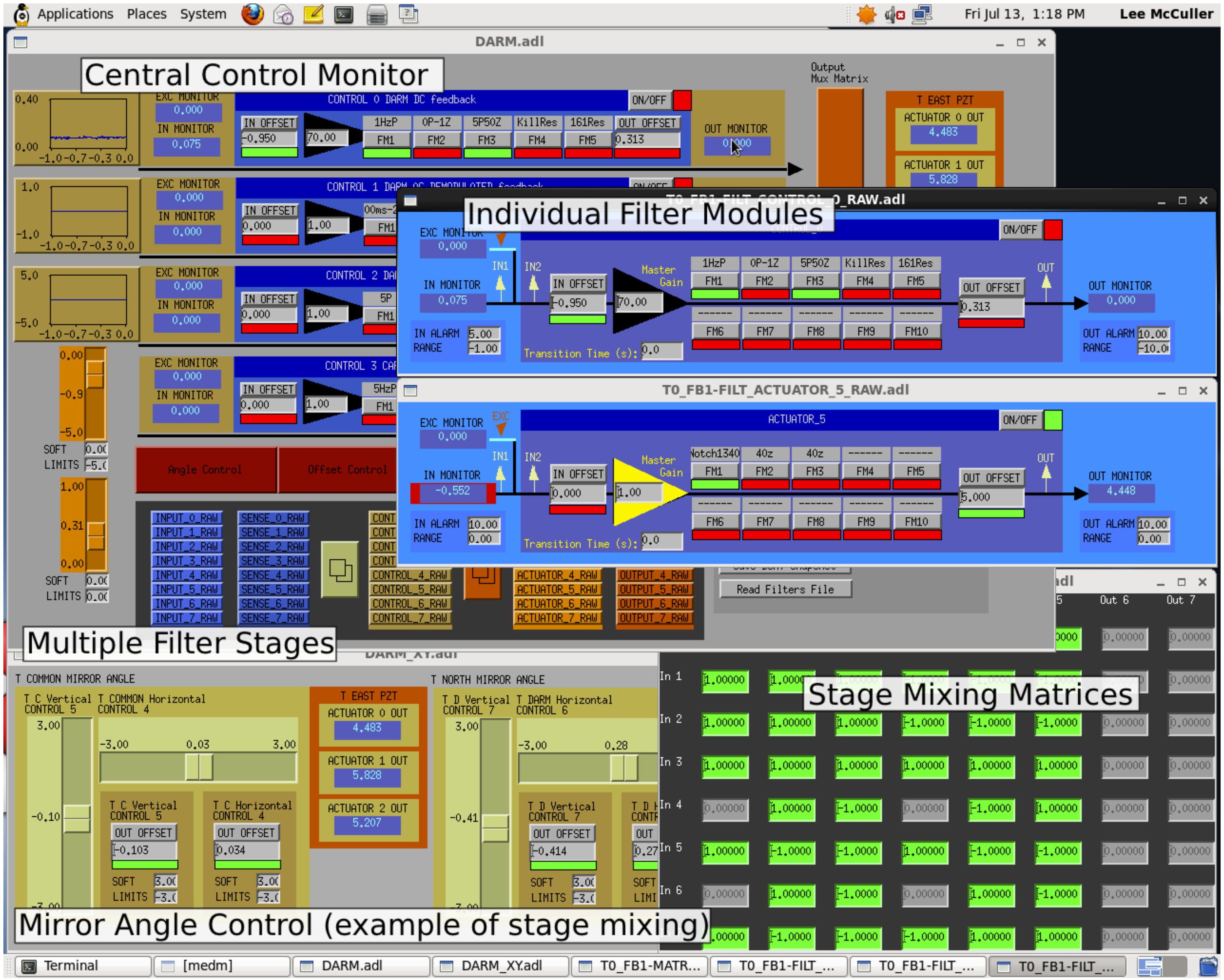
MEDM:

Motif EPICS Display Manager

Holometer Control and Data



Holometer Control and Data



Holometer Plans

Current:

- The first interferometer is operating reliably, now exploring the mechanical and electrical transfer functions and system noise sources.
- Implementing a servo system with all computers far from the ADCs and electronics.
- We are installing the injection optics and interferometer optics in the second system.

Remaining major milestones:

- Finish assembly and commissioning of L interferometer.
- Finish assembly and commissioning of T-south interferometer.
- Begin science operations

Conclusions

1. We have a stable and very good, clean vacuum in both interferometers. We were able to bake the vacuum system in place. Optics surfaces will remain good.

2. We have optics, mirrors and beamsplitters, and optics actuators that are working as expected so far - we have not really pushed them but so far so good.

3. We have interferometer injection and transfer optics that work well launching from a table 5 meters from the beamsplitter

4. We have extremely stable optics mounting. Mount drifts are low - we did not know if non-suspended mounts would work at all before we started.

5. We have developed a flexible FPGA digital servo system that we expect will be able to run all the systems we need to lock.

6. We have been able to lock differential arm length loop and common arm length loop simultaneously for periods of minutes with the digital servo in the first of our interferometers.