



Performance of eLIGO Prototype HAM ISIs and improvements for aLIGO HAM ISIs

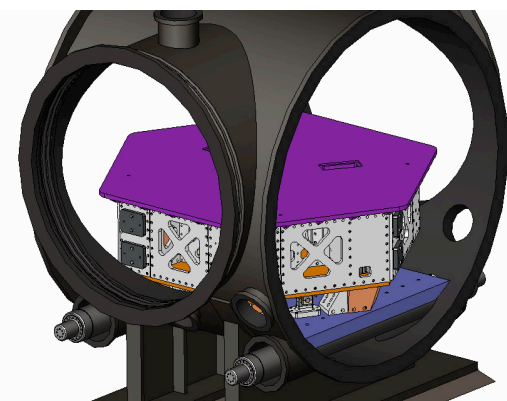
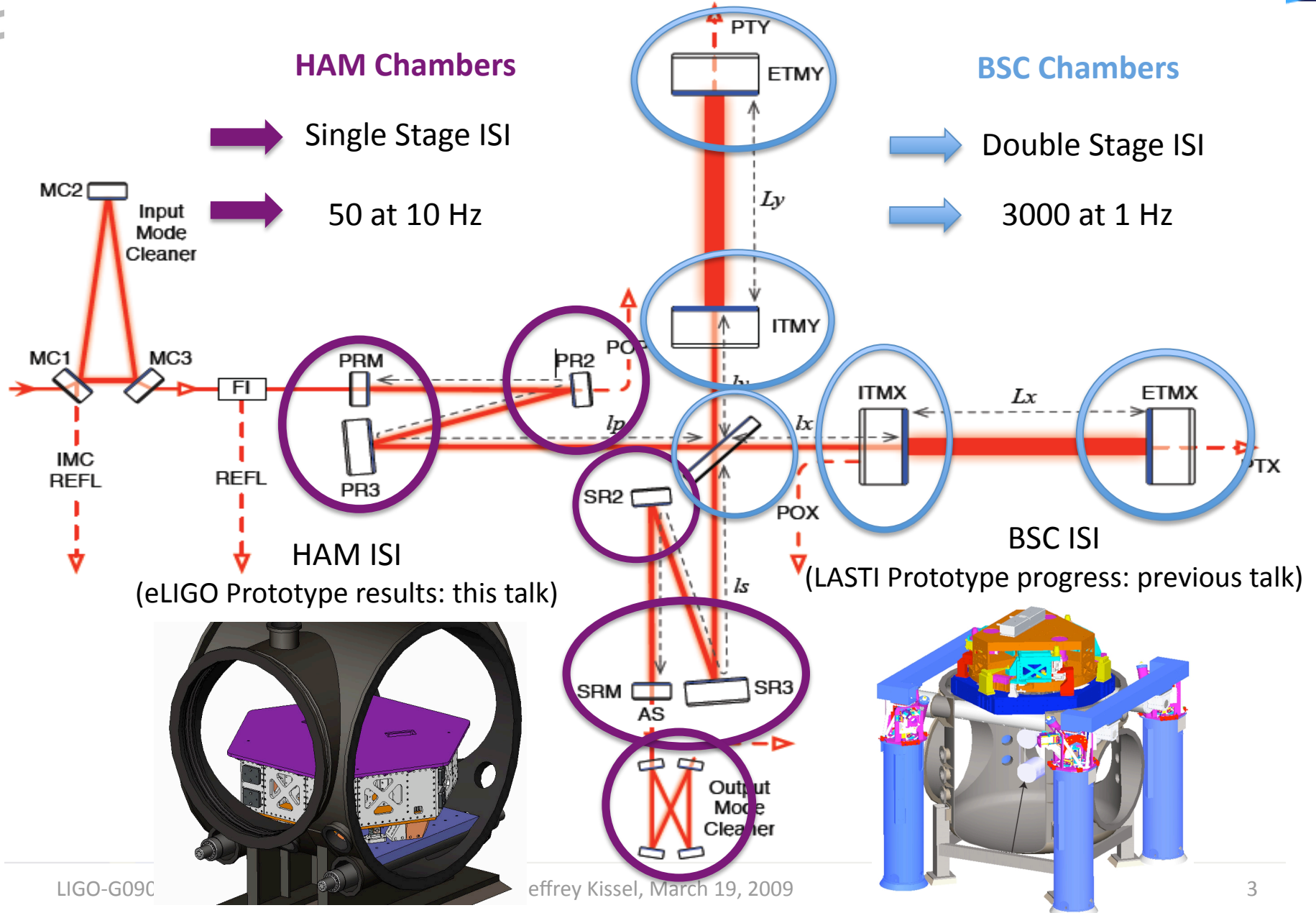
Jeffrey Kissel for the SEI team

Graduate, Physics

Louisiana State University

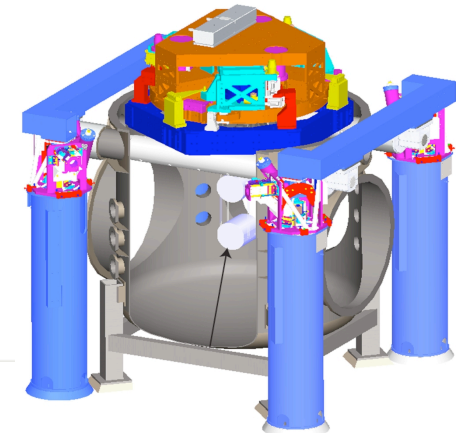
March 19, 2009

LIGO-G0900141



LIGO-G09C

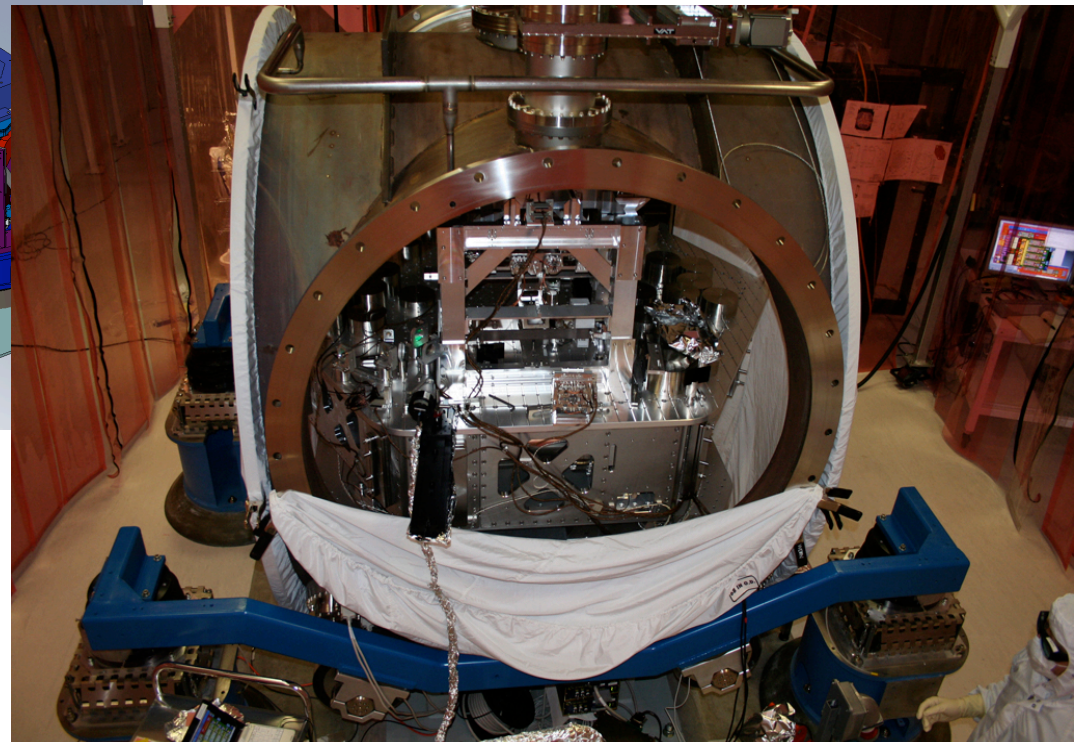
effrey Kissel, March 19, 2009





L1 HAM ISI built and installed Feb/Mar '08

H1 HAM ISI built and installed Apr/May 2008

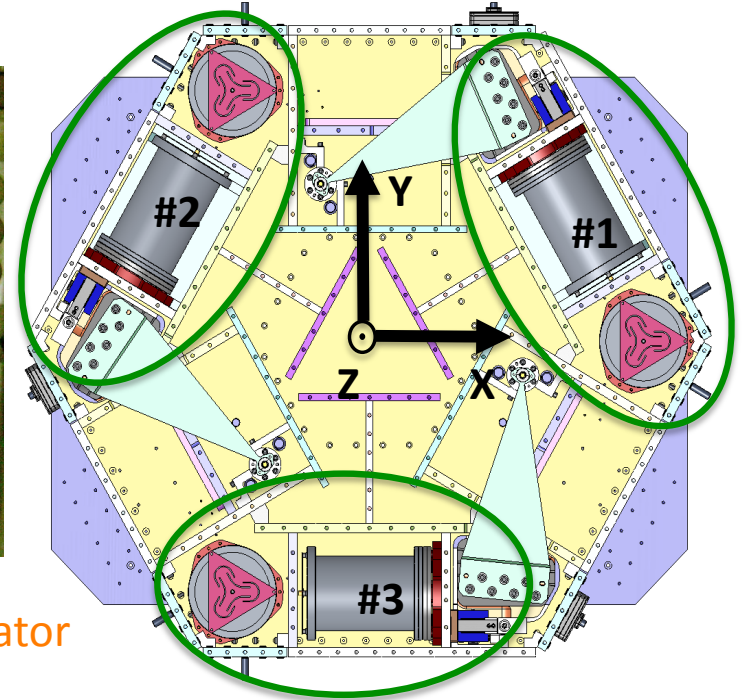
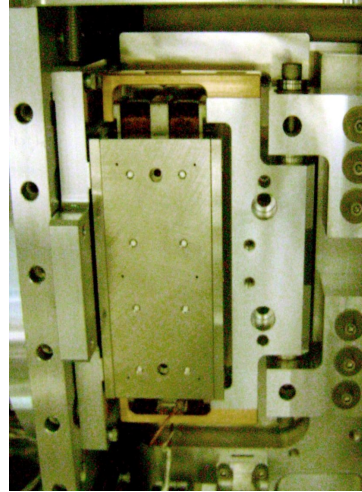
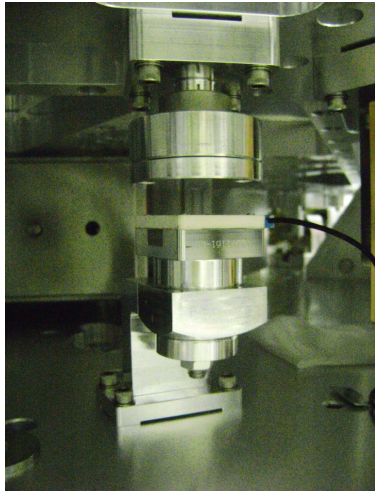


H1 HAM ISI commissioning June '08 and Feb/Mar '09

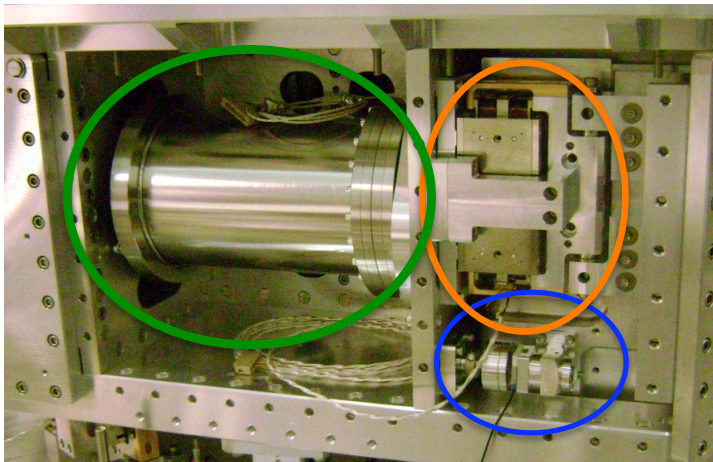
L1 HAM ISI commissioning Sep/Oct '08 and Jan '09

The HAM ISI

Active Components – Refresher!



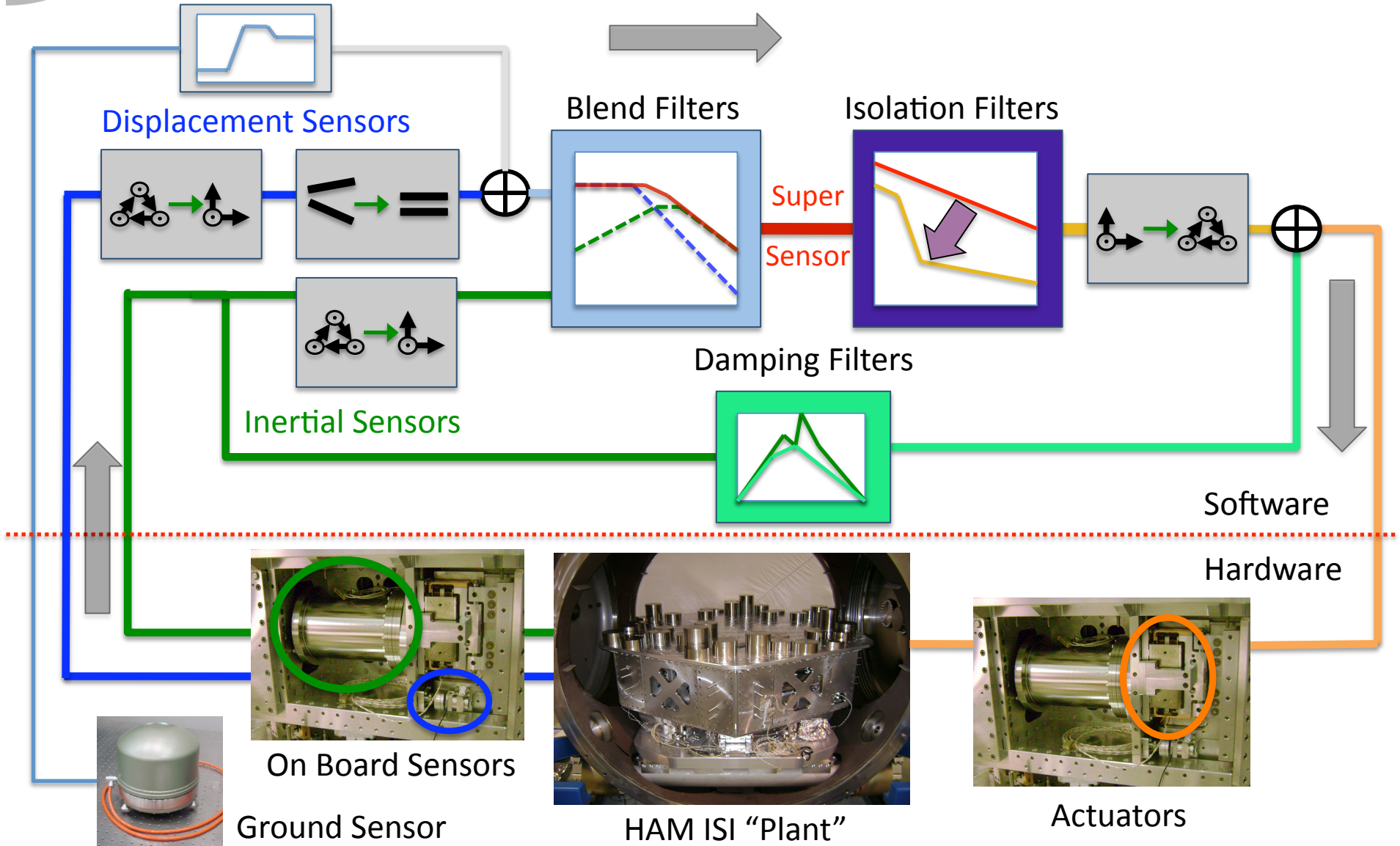
Displacement Sensor Inertial Sensor Electromagnetic Actuator



- **Displacement sensors** provide alignment and low frequency information
- **Inertial Sensors** (Geophones) provide high frequency information
- **Electromagnetic actuators** provide drive and control of the table at all frequencies
- Six sensor clusters mounted symmetrically on the table, one of each of the above in each cluster

The HAM ISI

Active Control Loops – Refresher!

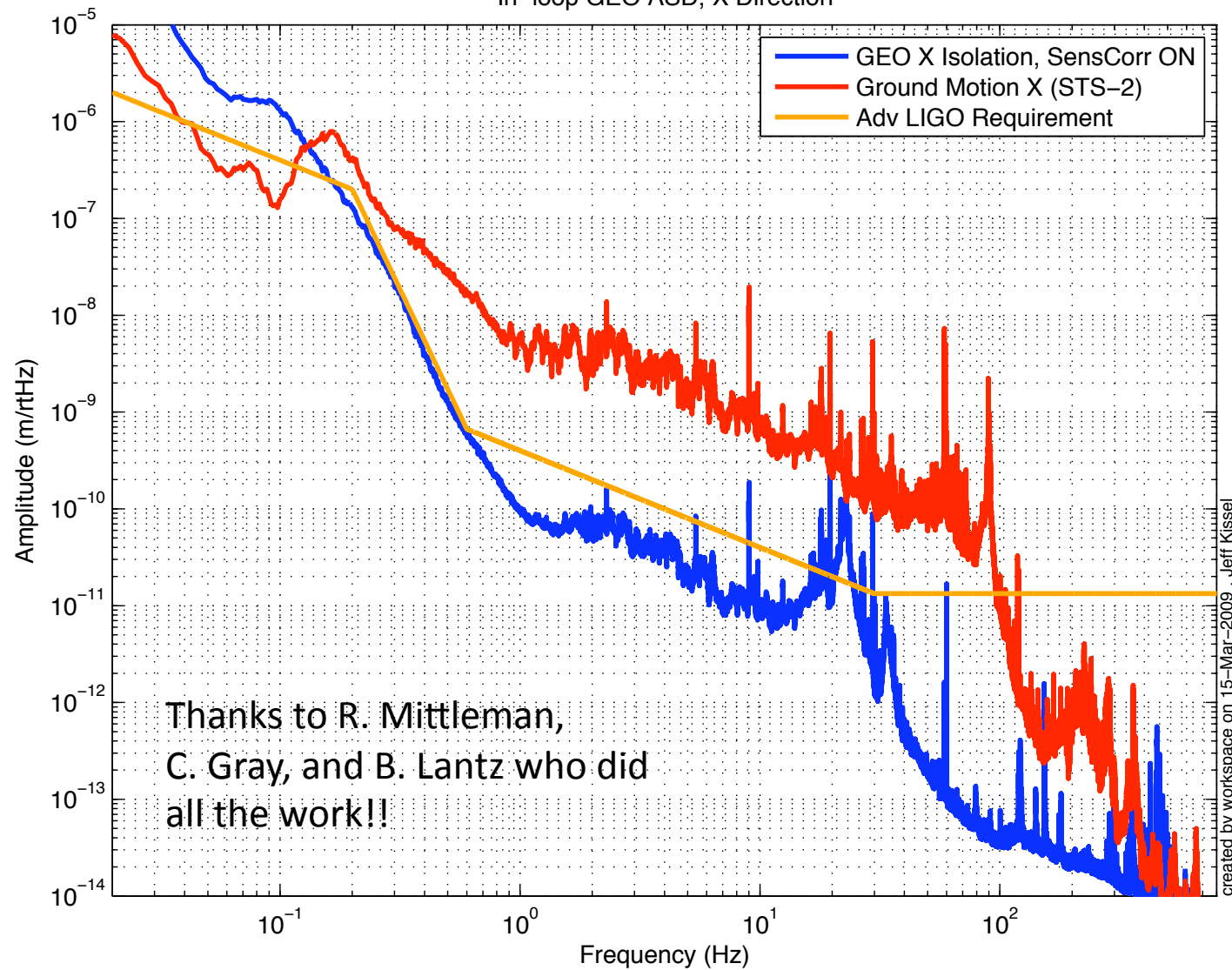




Enhanced LIGO Seismic Isolation RESULTS!!



H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, X Direction

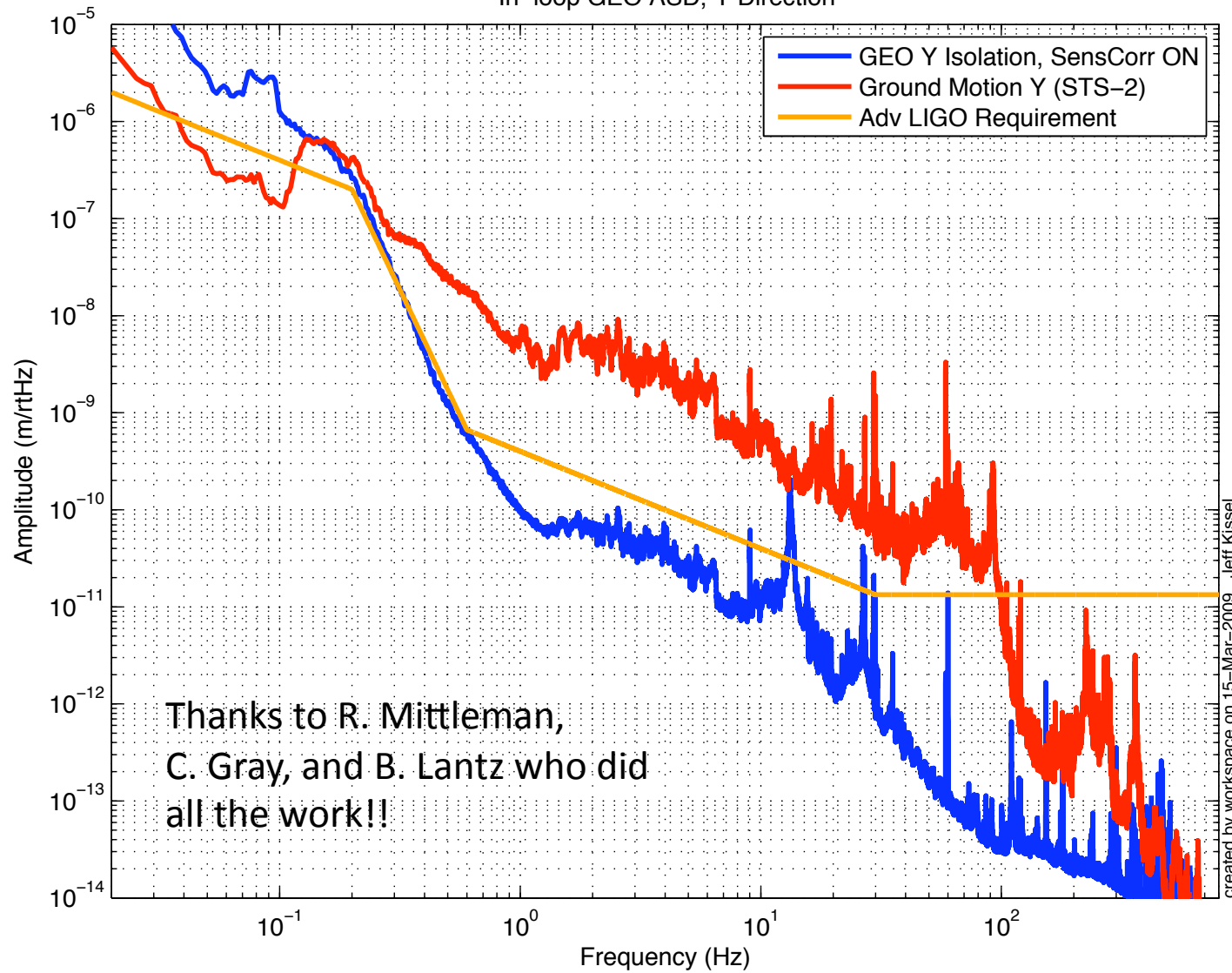




Enhanced LIGO Seismic Isolation RESULTS!!



H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, Y Direction

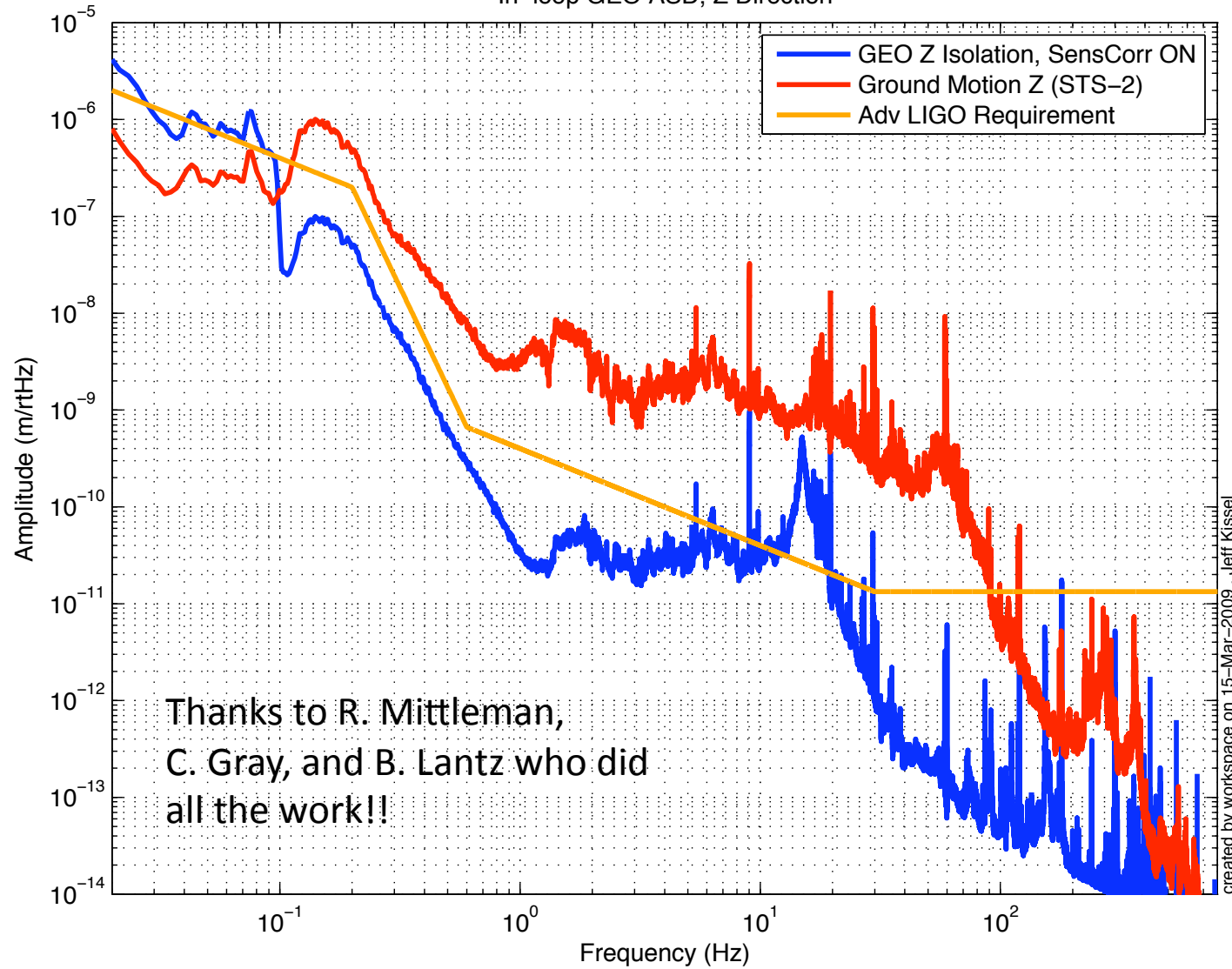




Enhanced LIGO Seismic Isolation RESULTS!!



H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, Z Direction





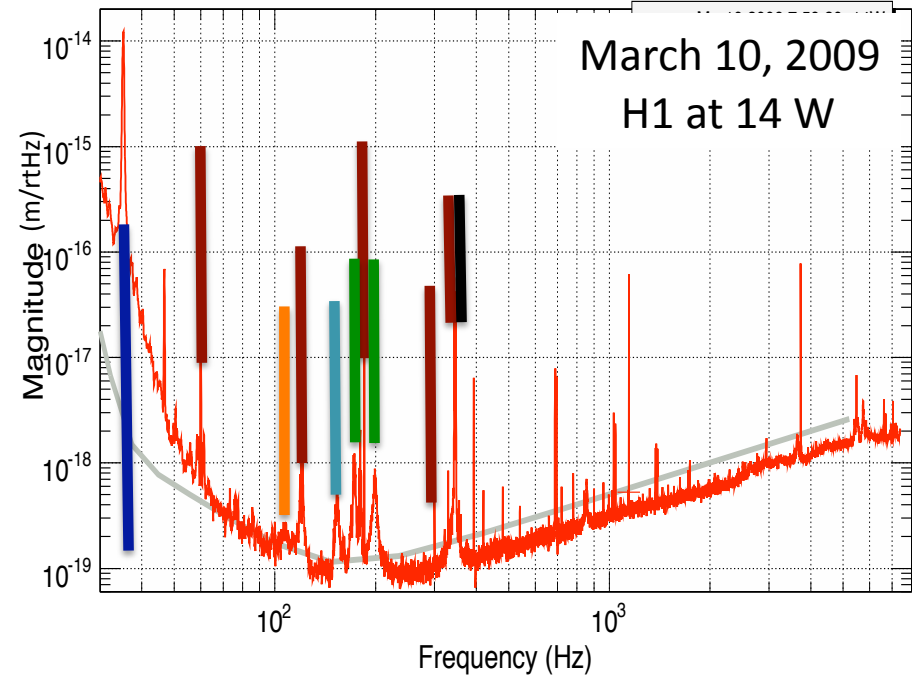
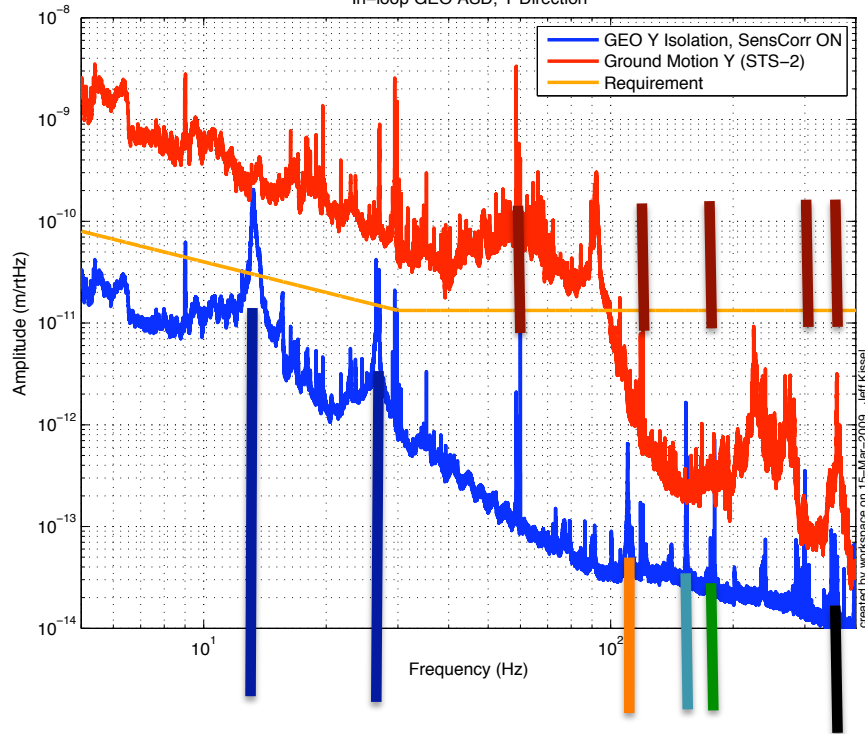
The eLIGO HAM ISI

Noise and Resonance Couplings to DARM



H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, Y Direction

Calibrated H1:DARM_ERR



*T0=10/03/2009 07:59:20

*Avg=20/Bin=3L

*BW=0.187493

33 Hz (in X)

n*60 Hz

153 Hz

110 Hz

169 - 200 Hz

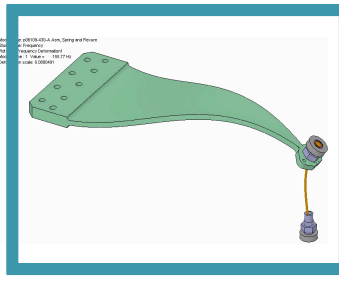
362 Hz



iLIGO Gullwing
LIGO-G0900141

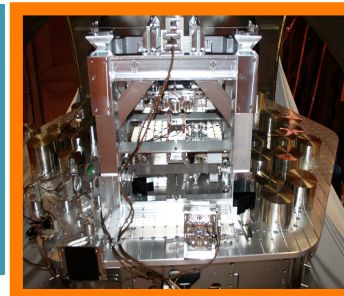


Power Lines

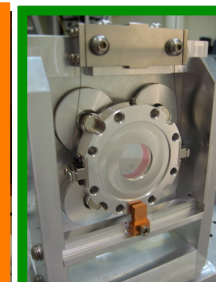


ISI Blade Spring

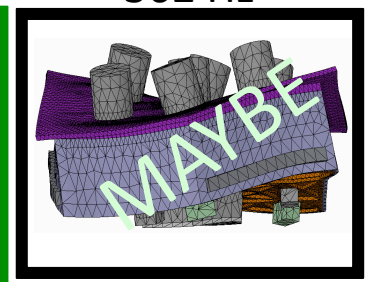
Jeffrey Kissel, March 19, 2009



The OMC Cage



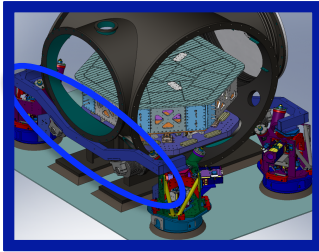
The TT
Bounce



ISI Pringle

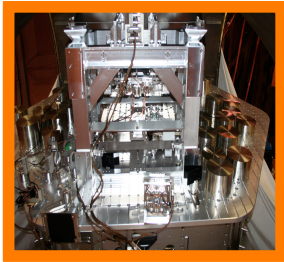


33 Hz (in X)



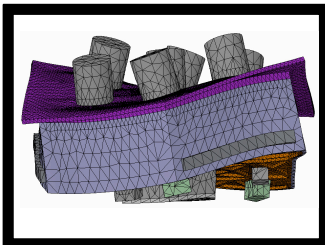
iLIGO Gullwing

110 Hz



The OMC Cage

362 Hz



ISI Pringle

LIGO-G0900141

The eLIGO HAM ISI

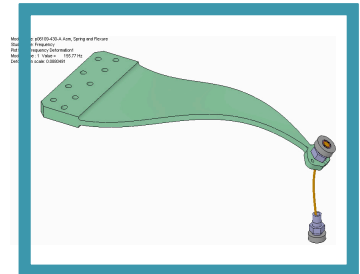
Noise and Resonance Couplings to DARM

Ideas / Solutions?

- Squeezed film damping (Dash Pot)
- Constrained layer damping (Viton)
- Mo-better clamping (Dog Clamps),
- Constrained layer damping (Viton)
- Blade springs or thinner suspension wiring
- Hrmm.....

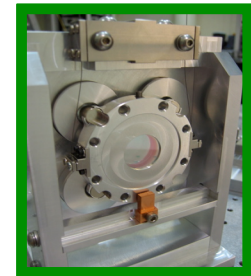


153 Hz



ISI Blade Spring

170 - 200 Hz

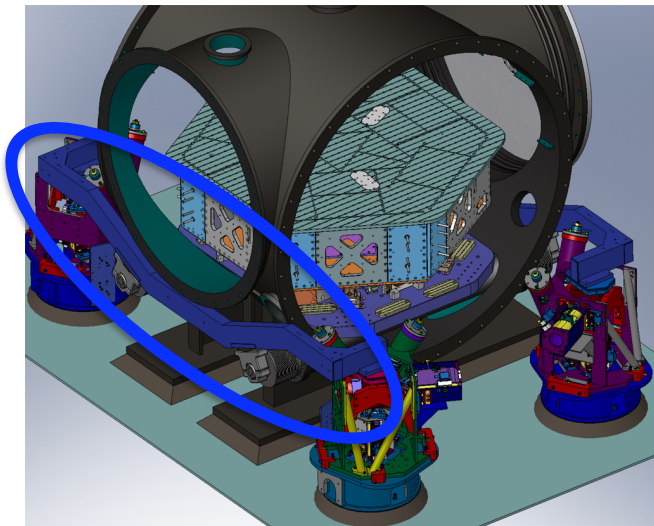
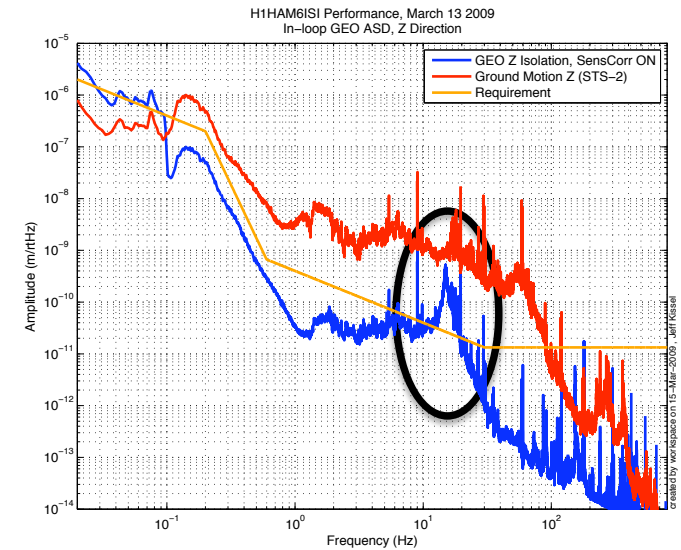


The TT Bounce

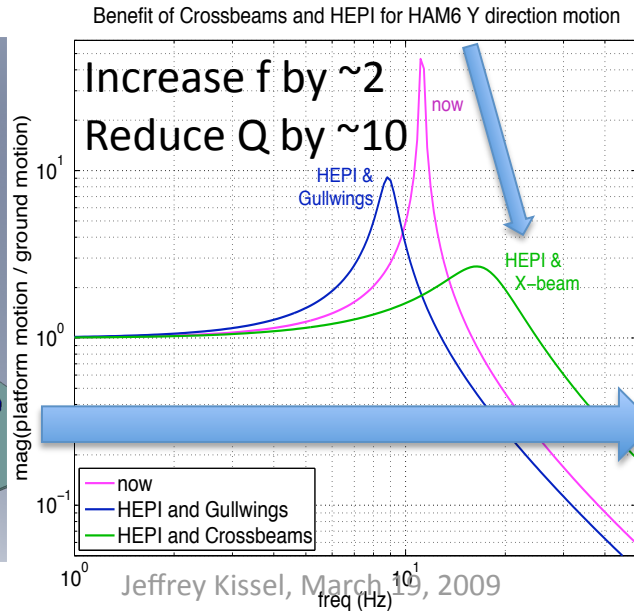
The Dreaded Gullwing Resonance: Build a better support structure, and add HEPI!

Gullwings \longrightarrow Crossbeams

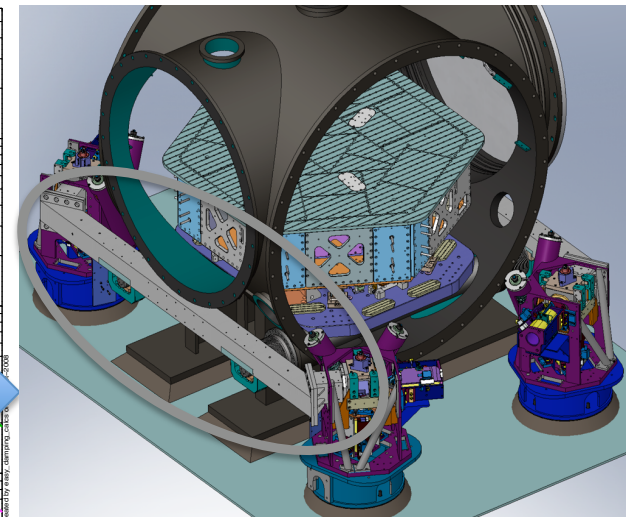
- Support structure has been redesigned for aLIGO, have already been purchased! (Thanks to Andy Stein @ MIT!)
- HEPI will be installed under HAMs, redesigned to use the new crossbeams



LIGO-G0900141



Jeffrey Kissel, March 19, 2009



12

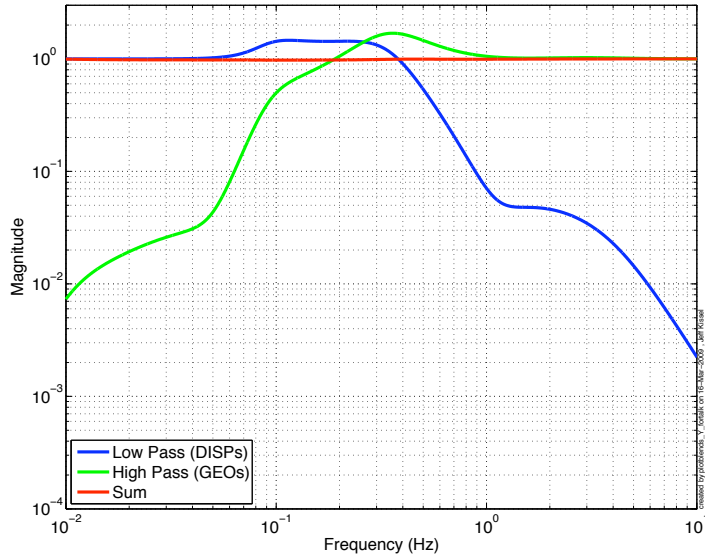


The aLIGO HAM ISI



Improving the Performance in Advanced LIGO

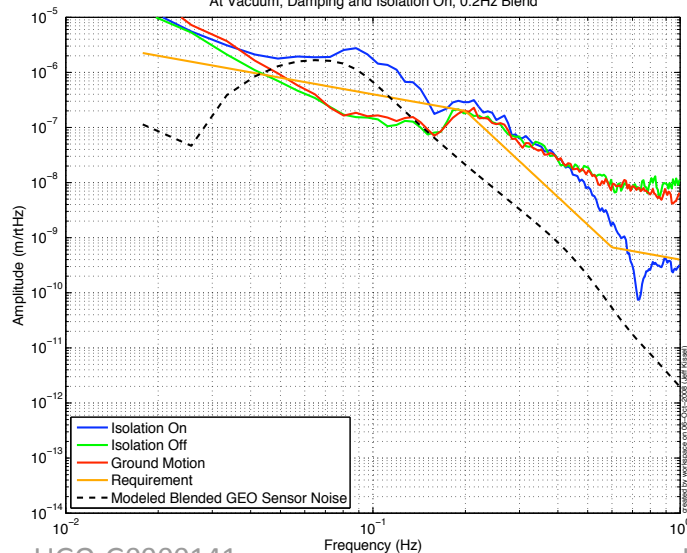
H1 HAM6 ISI, March 12 2009
Y Blend Filters



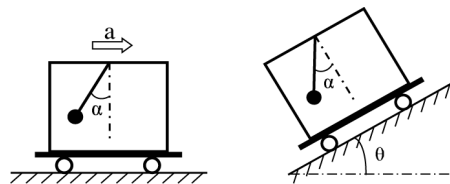
**Optimize DISP to GEO (Isolation),
and STS to DISP (Sens. Corr.) blend filters!**

- Found that noise in vertical GS-13s is misconstrued as differential motion >> TILT
- TILT couples into horizontal motion degrades performance at low frequencies
- Tilt Sensor anyone??

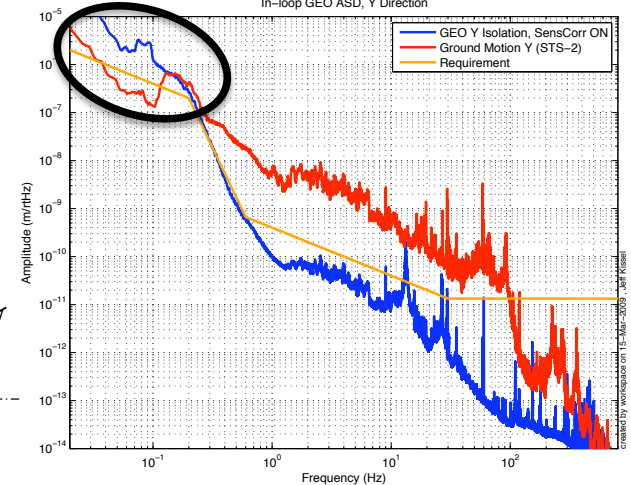
LHO HAM6 ISI, June 27 2008
In-loop GEO ASD, X Direction
At Vacuum, Damping and Isolation On, 0.2Hz Blend



$$\frac{\text{tilt translation}}{\omega^2} = \frac{g}{\omega^2}$$



H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, Y Direction



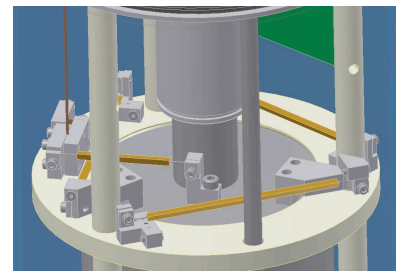
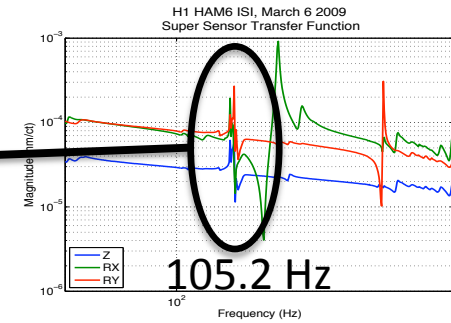
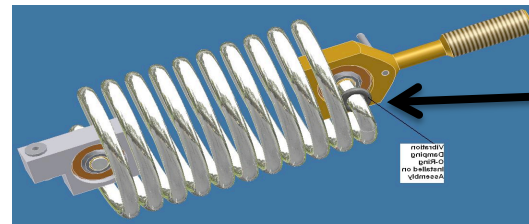
The tricked-out SUPER GS-13s See Dan Clark's Poster (G0900128)

Example Features

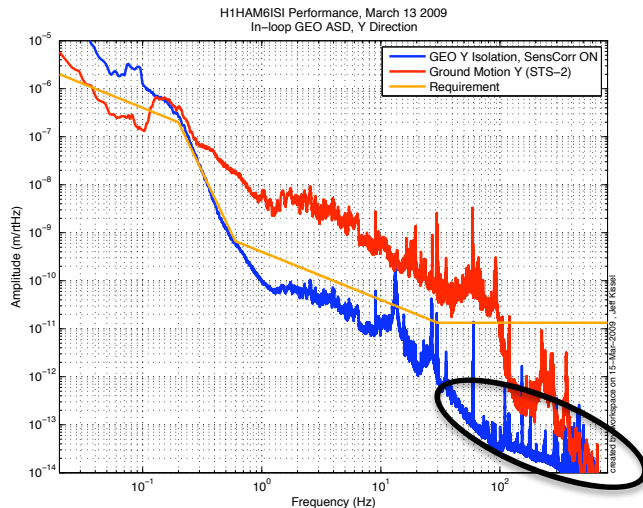
- Damping ring on vertical configuration's restoring springs



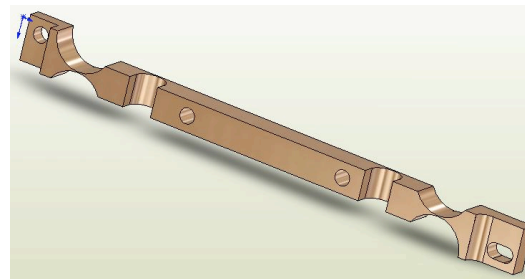
Inertial Sensor

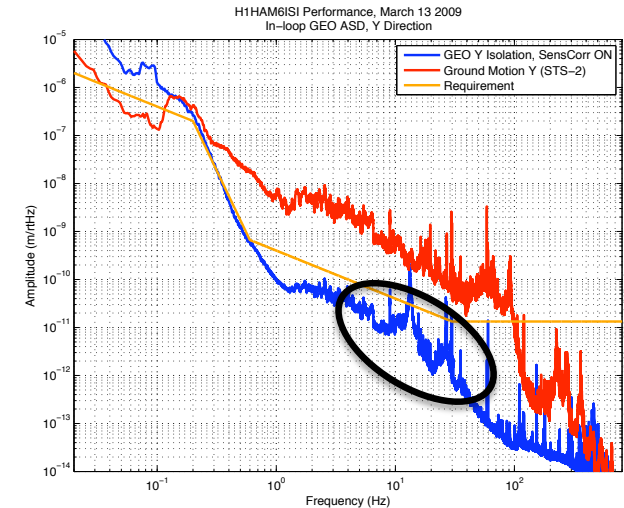
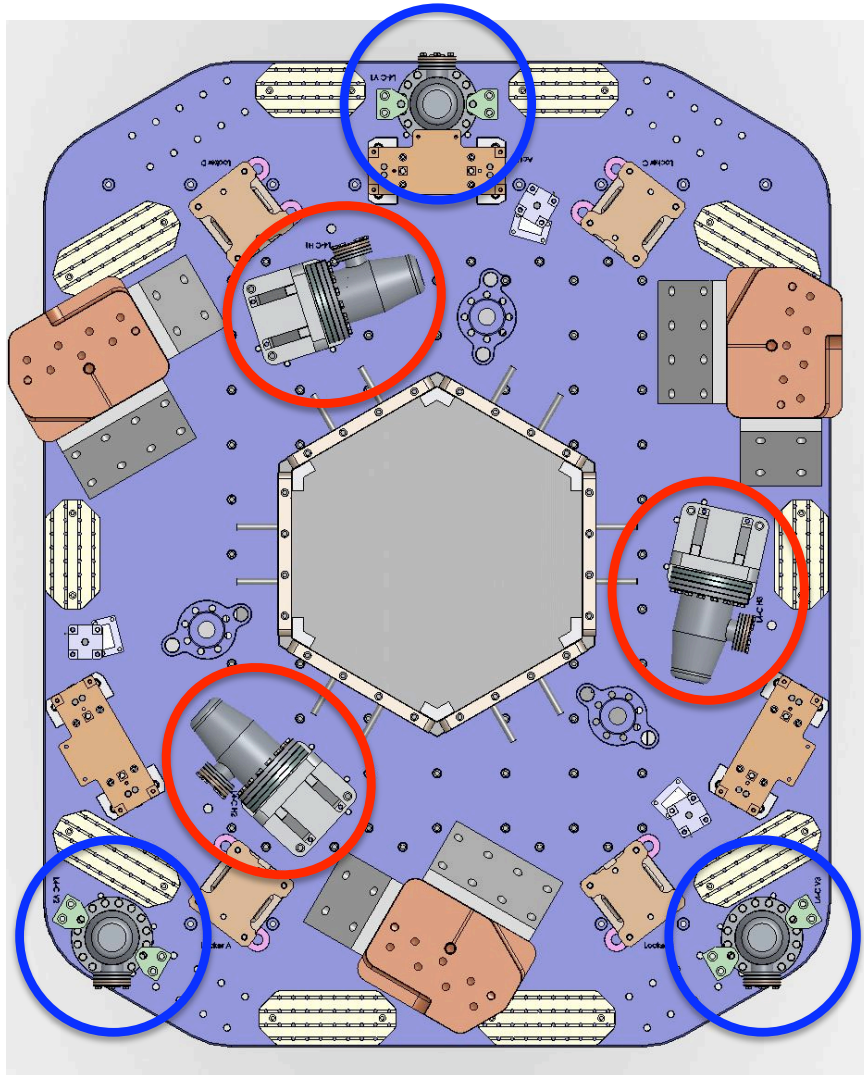


- Stripped down horizontal configuration



- NO MORE LOCKING MOTORS!





More Feed-forward!

- ISC Group says they need performance *better than the requirements* between 5 and 20 Hz
- We'll try 6 additional seismometers (L4-Cs) that feed-forward from support stage to suspended stage (Three **Horizontal**, Three **Vertical**)
- Prototyping fall/winter of 2009 at LASTI



The HAM ISI

So what's next?

H1HAM6ISI Performance, March 13 2009
In-loop GEO ASD, Z Direction

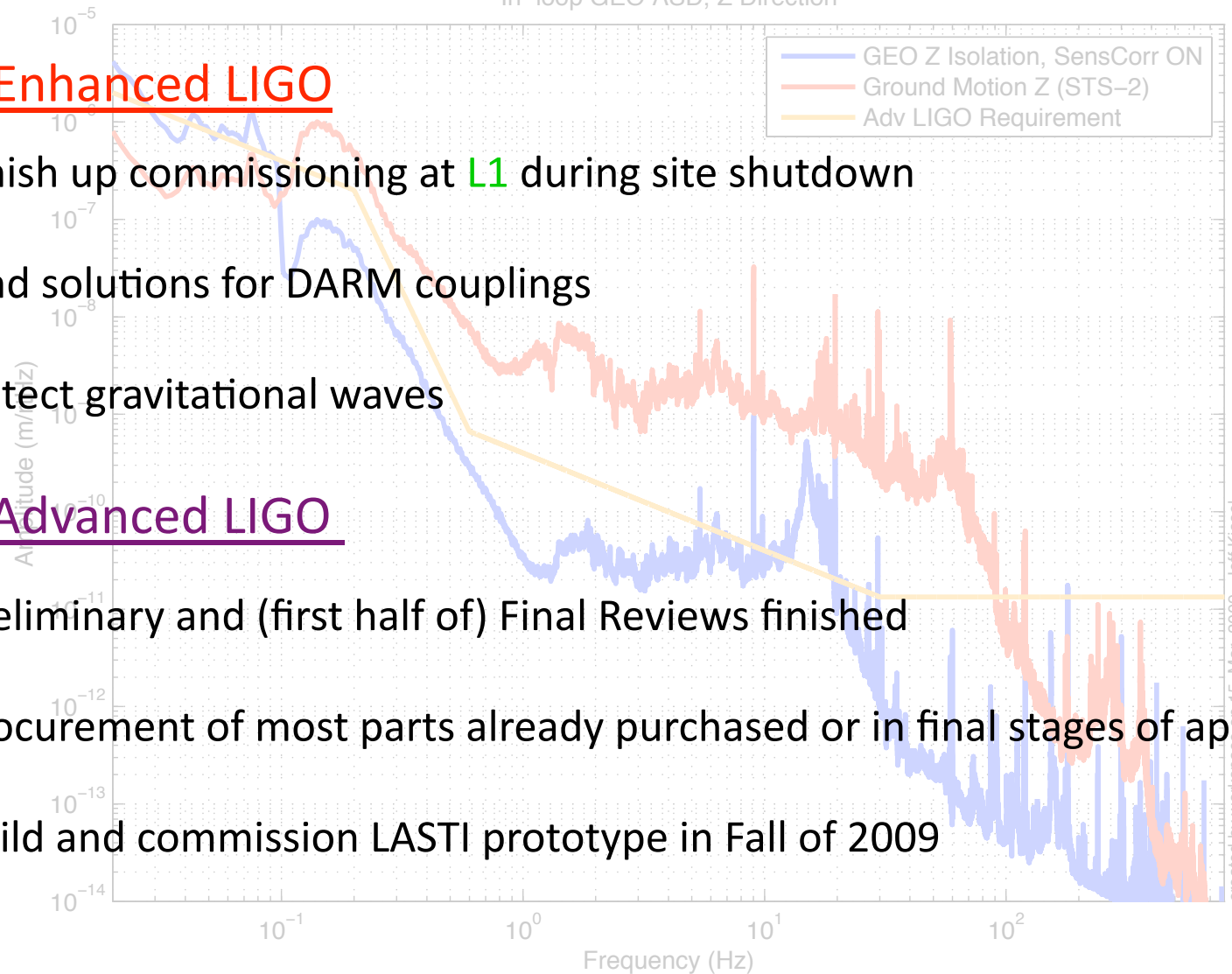


Enhanced LIGO

- Finish up commissioning at L1 during site shutdown
- Find solutions for DARM couplings
- Detect gravitational waves

Advanced LIGO

- Preliminary and (first half of) Final Reviews finished
- Procurement of most parts already purchased or in final stages of approval
- Build and commission LASTI prototype in Fall of 2009



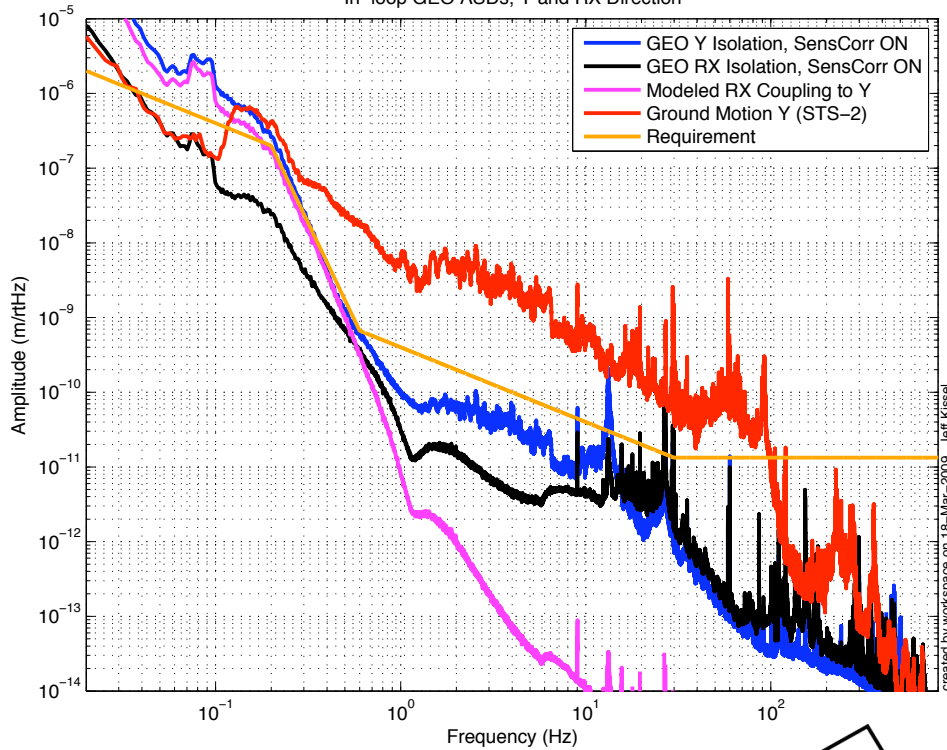
created by workspace on 15-Mar-2009, Jeff Kissel



Enhanced LIGO Seismic Isolation

Why No Isolation Microseism for X and Y??

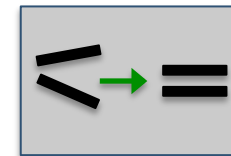
H1HAM6ISI Performance, March 13 2009
In-loop GEO ASDs, Y and RX Direction



AAAHHHH!!!

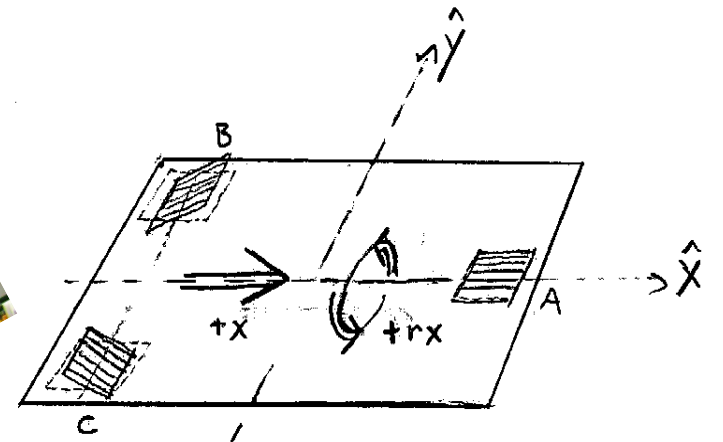
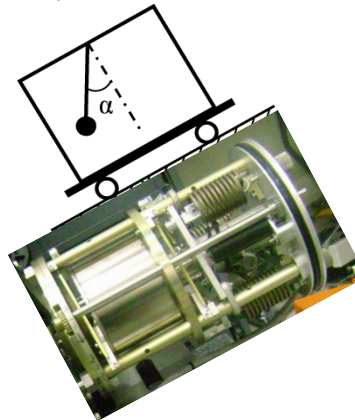
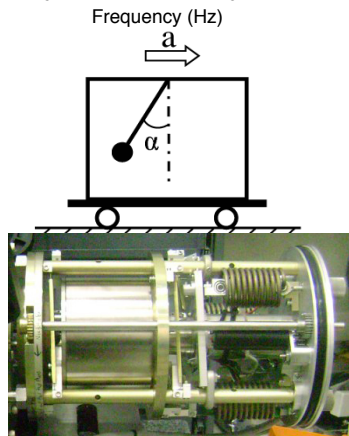
TILT HORIZONTAL COUPLING!!

- We have not yet redone the displacement sensor alignment since last June

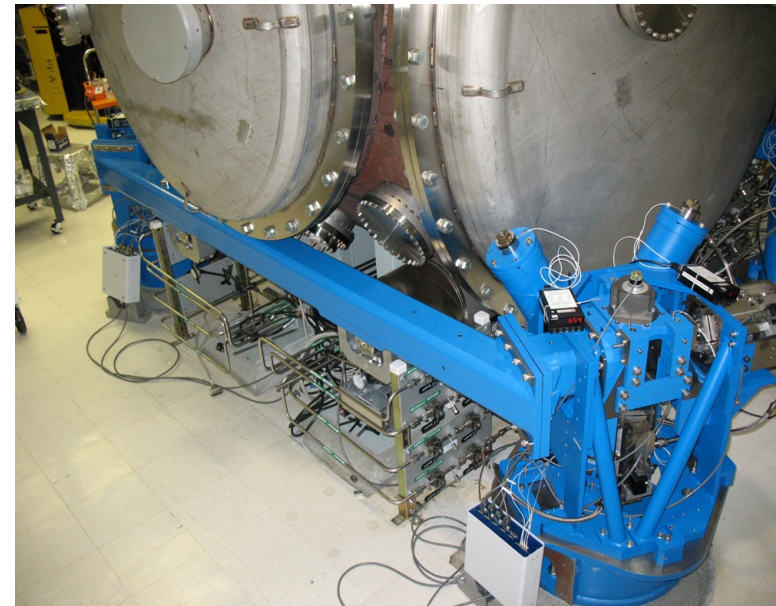
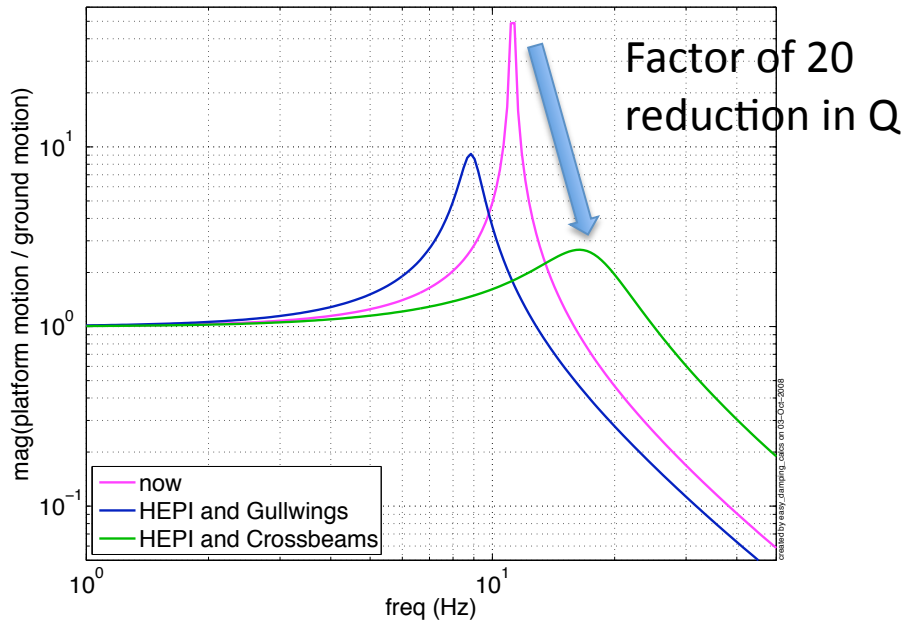


- Model (Shown in Purple) shows Y Spectrum dominated by tilt

$$\frac{\textit{tilt}}{\textit{translation}} = \frac{g}{\omega^2}$$



Benefit of Crossbeams and HEPI for HAM6 Y direction motion



Installed at LASTI on Dec 18th 2008

<u>Direction</u>	<u>Gullwing FEA</u> (Hz)	<u>X-Beam FEA</u> (Hz)	<u>Gullwing Meas.</u> From eLIGO (Hz)	<u>X-Beams Meas.</u> @ LASTI (Hz)
X	6.9	11.8	7.5	9.5
Y	11.4	24.0	9.5	19
Z	11.4	16.5	12	16