In-vacuum instrumentation reliability evaluation

Evaluation Team and examples of information sources

The evaluation team (pending)

- Bill Tyler
- Brian Lantz
- Jay Heefner
- Riccardo Desalvo
- Mike Zucker
- Rich Abbott
- Dennis Coyne
- Rai Weiss
- Vern Sandberg (chair)

Subsystem Assignments

- SEI sensors - Lantz, deSalvo, Coyne
- SEI actuators & lockers - Coyne, Weiss, deSalvo, Lantz
- SUS OSEMs - Heefner, deSalvo
- SUS violin-mode damping sensor/actuators - Zucker, Heefner, Weiss
- ISC photodiodes - Abbott, Weiss
- ISC other electronics - Abbott, Zucker
- IO mode-matching system - Coyne, Weiss
- IO other electronics - Tyler, Heefner

Approach:

Team Chair to compile data collected by team members of our in-house experience, using interviews with subsystem people as collected by evaluation team members.

Refine the points and pose follow up questions with team members. (Exploit the areas of expertise of team members in pursuing further discussions with vendors and AdL staff.)

Team Chair to balance members' tasks to keep individual loads reasonable; no need to bring entire team together, just make use of the resources.

Communication will be by emailsand telephone calls.

The evaluation should cover

* Flowing down Advanced LIGO requirements on equipment given desired availability
* Estimate of overall availability of the in-vacuum instruments (sole source, long lead, vendor QA)
* Pre- and post-installation test procedures
* Installation/setup failures and infant mortality
* Mean time before failure once installed (post-infant mortality)
* Anticipated impact of repairs on detector availability
* Approach to ensuring vacuum cleanliness (encapsulation techniques, cleaning, current limits)

The evaluation should use a variety of approaches to collecting the data:

* Vendor data sheets and contacts
* Our statistics for prototype test, installation
* Back-of-the-envelope analysis

Mitigation should include:

* Recommendation for redesign of in-house instrumentation, lockers
* Alternative commercial sources
* Addition of read-backs (position, temperature, etc.) to improve confidence and help debug
* Malfunctions
* Spares plans

In-Vacuum Electronics

1. Documentation for LIGO In-vacuum Cable Harness, LIGO-E070029-00-C, R. Abbott, Caltech, 15 February, 2007
This was a quick capture of the old initial LIGO vacuum cable. People were starting to re-order stuff, and there wasn't a central and agreed upon definition of the initial LIGO stuff.

2. Analysis and Optimization of LIGO In-vacuum Shielded Cables, LIGO-T070114-01-C, R. Abbott, C. Osthelder, Caltech, 25 May, 2007
This was the document that gave the basis for my choice to lower the copper coverage and improve the shielding of our in-vacuum cabling

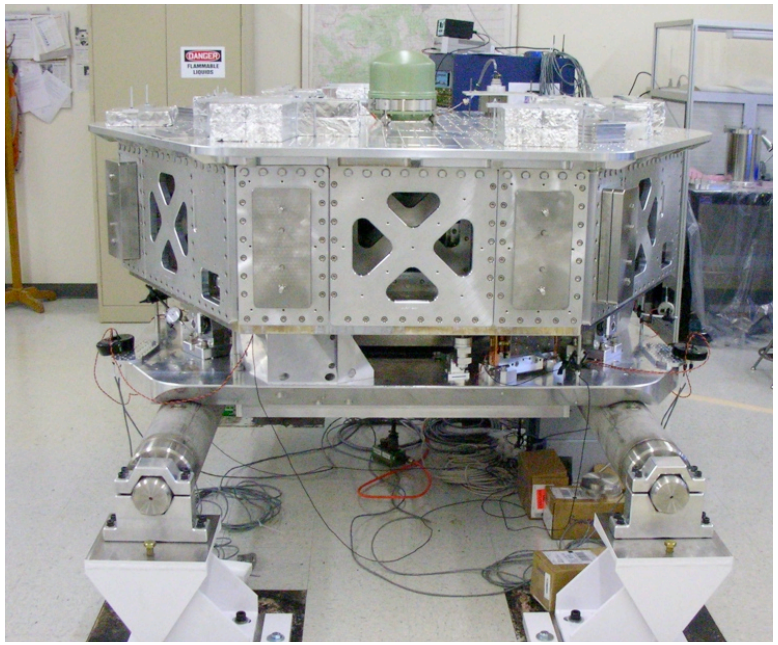
3. In-vacuum Ampacity of Cooner, CZ1105-FEP wire, LIGO T070183-01-C, Richard Abbott, Samuel Abbott, 20 August, 2007
This was a look at the current carrying capability of the Teflon coated wire inside the vacuum system. It shows some temperature vs Current data

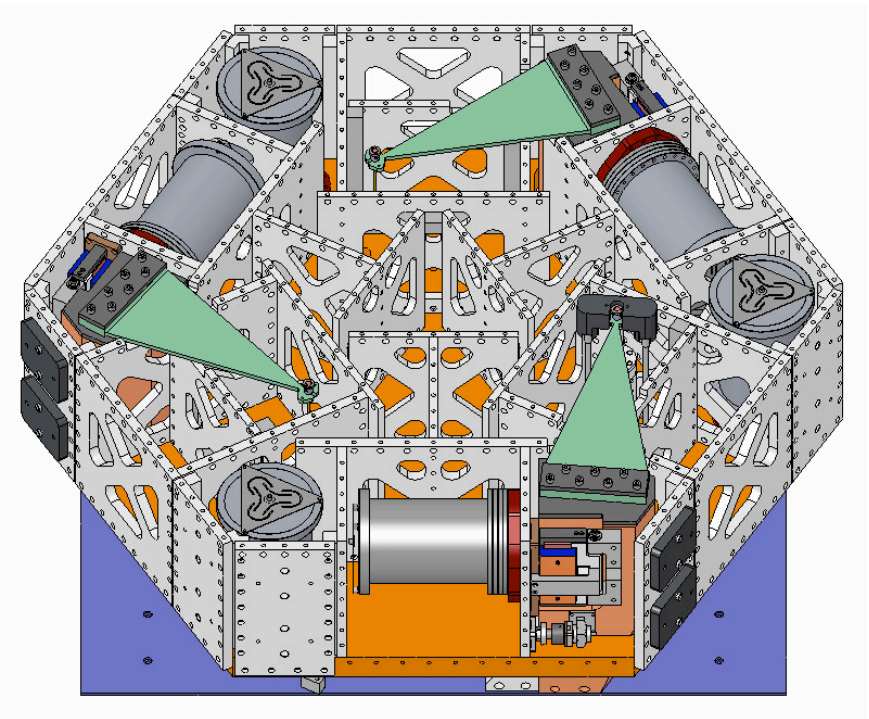
4. Thermal Coatings for In-vacuum Radiation Cooling, LIGO-T070054-00-C, R. Abbott, S. Waldman, Caltech, 12 March, 2007
This paper describes the use of ceramic coatings for cooling in vacuum.

5. Technical specifications of in-vacuum electronics cabling and packaging materials used in the ELIGO OMC
This data I have as distributed bits of ordering information. I have not written this up yet.

See: http://www.ligo.caltech.edu/~abbott/files

SEI - ISI





Actuator Electronics

1. The Coarse and Fine actuators used in the ISI are custom manufactured by PSI (Planning Systems Inc.).

2. The coarse actuators are used to actuate in the horizontal and vertical directions at each of the three locations around the HAM.

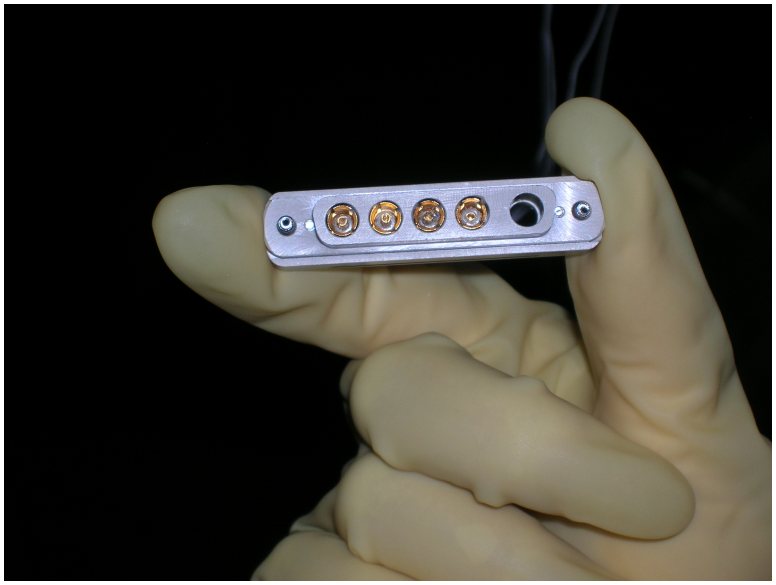
3. Coarse actuator is capable of generating a continuous force of maximum 20 lb and the Coil Driver is capable of providing the current to produce this force.

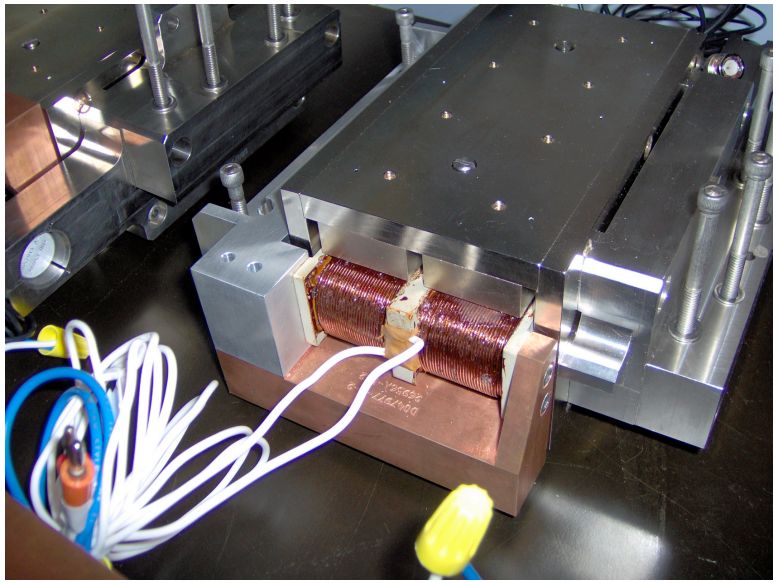
Actuators	Coarse	Fine
Magnitude Wire Gauge	**18 AWG round wire**	**24 AWG round wire**
Continuous Force	**20 lb**	**10 lb**
Resistance(@25 deg C)	**6.1 ohm**	**9.3 ohm**
Inductance	**~5 mH**	**~3 mH**
Self-resonant frequency	**~200 KHz**	**~275 KHz**
Hi-Pot Test(500 VDC for 60 sec)	**>500 MOhm**	**>500 MOhm**
Force Constant at Central Position	**6.74 lb/amp**	**6.9 lb/amp**

Imax = (20 lb) / (6.74 lb/amp) = 3A

Vmax = (3 A) * (6.1 ohm) = 18.3 volts

Pdiss ~55 W



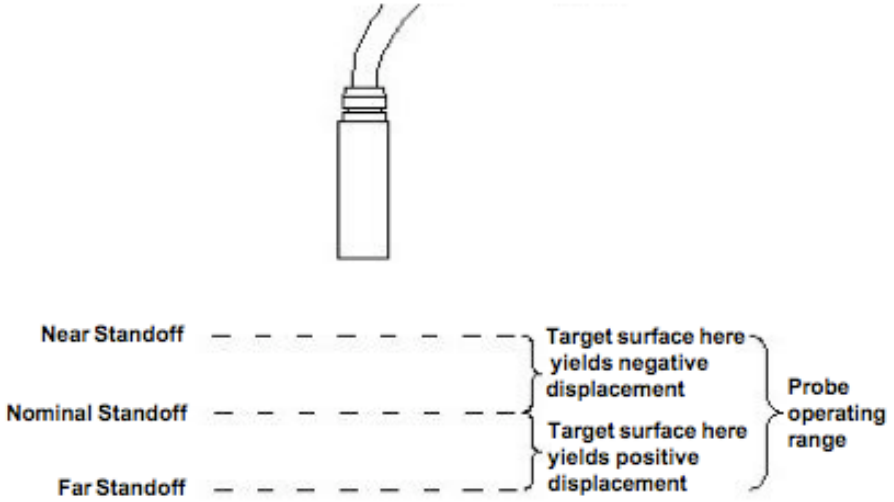


Concern: Notice the variety of polymers used in the fabrication

Capacitive Position Sensor: ADE Technologies

The 4810/4800 gaging modules are a non-contact capactive dimensional gaging family

Model 4810 & 4800
Gaging Systems



Power Requirements The 4810/4800 modules must be powered with regulated +15 VDC (+ 0.1 volts) power at its power pins as tabulated below.

About the System's Probes
The patented measurement probes which are included with the 4810/4800 modules may be selected from a vast variety of available models which vary in diameter and operating range. The probes are quite rugged, but should be handled with care. Try to avoid scratching the probe's sensor.
Each probe has been calibrated for use with a particular Gage board, and should be used with that Gage board for most accurate operation. Most probes have a 3-meter (10-foot) cable which connects to the Gage board.
The probes are transducers which form a capacitor with the target surface. Because the area of the formed capacitor is constant, variations in capacitance are related to variations in the distance between the probe and the target surface.

advancedligo

DCC Number: E080348-00-X
Date Prepared: 6/24/08

Originator	Cognizant Engineer	Ext./Phone#	Project	Account Number
Name Stephany Foley	Name Stephany Foley	617-324-5250	Ad LIGO	

Dwg/Part Number	Rev	Part Description / Material	Serial Number	Qty
0756-LIGO-PHSIII		actuator: SmCo magnets, aluminum housing, polyimide coated coils		7

Used In (next higher assembly):

Vendor Name	PO/Contract Number

Data Package, Receiving/Inspection Remarks:

Inspection Required Y/N	Visual Damage Y/N	Comments	Name/ Initials	Date Comp.

Process Flow:

#	Operation	Start Date	Work Area	Instructions	Name/ Initials	Date Comp.
1	Clean		LHO	Actuators should be treated as FRAGILE (see notes) -check for and remove any visible large particles between coil and magnet with plastic tweezers or methonal spray -remove shipping screws -ultrasonic in methonal for 10 minutes or spray out gaps and holes with methonal if ultrasonic cleaner is insufficient. -let dry under a heat lamp for 24 hours or until all gaps, holes or tight areas have had a chance to dry out		
2	Vacuum Bake			bake per E960022's instruction on lowest temperature part of this assembly: aluminum: 150°C for 96 hours.		
3	Control Point			Review/Approve RGA scan		
4	Wrap & Tag vacuum clean parts					
5	Ship and Deliver/File paperwork			Please send to: LASTI c/o Stephany Foley File one copy of traveler with the DCC. **Note: Ship original traveler with these parts.**		
END: Go to Traveler or procedure associated with next higher assembly processing						

Special Instructions (Handling/Packaging Constraints, Remarks, etc.) or Notes:

Actuators for the Advanced LIGO BSC ISI prototype at LASTI.

Actuators should be treated as FRAGILE. Special care should be taken to avoid damage to the magnets on the interior and to the peek wire connector.

OSEMs

Part Number	Description	Material	Surface cm2
D060109	Adjuster Shaft	Titanium	
D060110	Adjuster Nut	PEEK 450G	???
D060117	PD Sleeve	Macor	
D060116	IRLED Sleeve	Macor	
D060115	IRLED Lens Retainer	Phosphor Bronze	???
D060114	PD Retainer	PEEK 450G	???
D060113	IRLED Retainer	PEEK 450G	???

Parts of concern:

LED, possible polymer component outgassing, possible failure
Photodiode, possible polymer component outgassing, possible failure
Teflon biomed Teflon coated wire, 36 feet, possible outgassing, possibility of overheating? Protection?
Solder flux, ,
Magnet wire, kapton coated, 100 feet, possible outgassing, possibility of overheating? Protection?
If coil support replaced with carbon fiber coated PEEK, vacuum compatibility should be re-evaluated

The BOSEM is a new instruments but it has no moving parts, no enclosed gas volumes, no high voltage, low surface of dangerous materials, well established clean assembly procedure.

The (how many?) BOSEMs considered reliable instruments and have low outgassing risk

Uses: where, how many in each use

Failure consequence
Need immediate replacement/vacuum access (how many)
Can survive without (how many)

An excerpt from a draft on "OSEM risk assessment"

LLO det-elog entries
http://ilog.ligo-la.caltech.edu/ilog/pub/ilog.cgi?group=detector&date_to_view=05/22/2008&anchor_to_scroll_to=2008:05:23:18:41:45-kissel

Topic: general Author: Jeff Kissel
Fri May 23 23:55:54 2008 UTC
Geophones are working
The geophones were uncharacteristically easy to turn on to full functionality.
Starting with the table locked and the power from the rack off, we connected each of the D25 pin GS-13 cables to flange, and turned on the power. They immediately shows signs of life in all channels.
Since I wanted to do what I knew worked, Tobin and I unlocked the GS-13s from the flange using a D25pin breakout board between the external side of the feedthrough and the field cable. Connecting the GS-13 locker/unlocker box to the Lock +/- pins, and picking of Signal +/- and reading it on an oscilliscope (see when we did this during testing for correct pins), the unlocking process when as well as can be. Every GS-13 except for H1 showed the expected time series behavior, after using 12V to unlock. H1, though it did not fall off the container ring immediately, it had fallen off by the time we had finished unlocking the others. The H1 seismometer is known to be sticky.

Attached is a power spectum of the unlocked GS-13s with the table unlocked (and no dial indicators).

Topic: general Author: Tobin Fricke
Sat May 24 19:55:07 2008 UTC
ISI capacitive displacement sensor
The symptoms of the misbehaving displacement sensor were:

1. The DAQ channel for the sensor gave zeros.

2. The monitor point on the field box for this channel showed a flat DC signal of about 12 volts.

I think reading 0 is a known behavior for the OMC/ISI ADC's when the input voltage is out of range (as opposed to railing at ±215 counts as one might expect).

3. Looking at several displacement sensors on an AC-coupled scope, we could clearly see "earthquake" signals when pounding on the floor/chamber in all channels except for the misbehaving one, which appeared completely flat.

4. Swapping two channels at the input to the field box revealed that the problem was upstream of the field box (i.e. with the feedthrough, cabling, or the sensor itself) as the symptoms followed the swap.

Because the readout of the capacitive displacement sensors is complicated, it's unclear whether the problem was an open circuit, a poor connection, or a short circuit.

B.Abbott directed me to this users' manual for the displacement sensors: http://www.adetech.com/suppdocs/48104800.pdf

Topic: general Author: Jeff Kissel
Fri May 23 23:41:45 2008 UTC
Position sensors are working
There were two problems we found when we turned on the position sensors.
1) V2 channel showed identically zero
Cause: Grounding / Unknown
Solution:
After a half day's worth of commissioning, it turned out to be internal connection to the feedthrough was (we think) shorted. The realization/evidence that this was the case occured at the stage where we were going to switch the cables on the in-vacuum side to see if the badness swapped channels as the cables were swapped.
First, when reaching in, I noticed the metal tag that indicates the serial number was wedged up and against the connection. A freed this, but it did not change the badness, but is something to be concerned with. Second, I disconnected V1 (in order to swap with V2) and as I did this the V2 channel came alive. Rolling with it, I reconnected V1, and both channels worked. Who knows (see second page of attachement for image of in-vacuum conflat).

2) X and Y channels showed sawtooth looking noise
Cause: Empty STS-2 witness channel was being fed into coordinate displacement sensor channels
Solution: H1H2H3 were reading out normally, but both X and Y channels showed sawtooth type noise (see second page of attachement). This quickly led us to suspect software (vs. electronics or hardware). Using the isi simulink model as his guide, Tobin found that, though not visible in the medm overview, after the disp's are converted to the ifo's coordinate basis, the X Y and Z signals are sent to the STS sensor correction filters, and then fed back into the blend filters. The input to the empty STS-2 channels were on, injecting ambient noise into the X Y and Z channels (the Z input noise was small, so the effect was not visible). Turning the inputs off cured the problem.

Once these were fixed, the positions sensors are working well. Their power specta (see third page of attachement) show that H3 has some excess noise between 8 and 60 Hz that is not seen by H1 or H2. V2 as has some unique noise between 40 and 50 Hz. We won't know what these are until we can take transfer functions.

https://gold.ligo-wa.caltech.edu/ilog/pub/ilog.cgi,DanaInfo=ilog.ligo-wa.caltech.edu+?group=detector&task=view&date_to_view=06/27/2008&anchor_to_scroll_to=2008:06:27:22:10:54-kissel

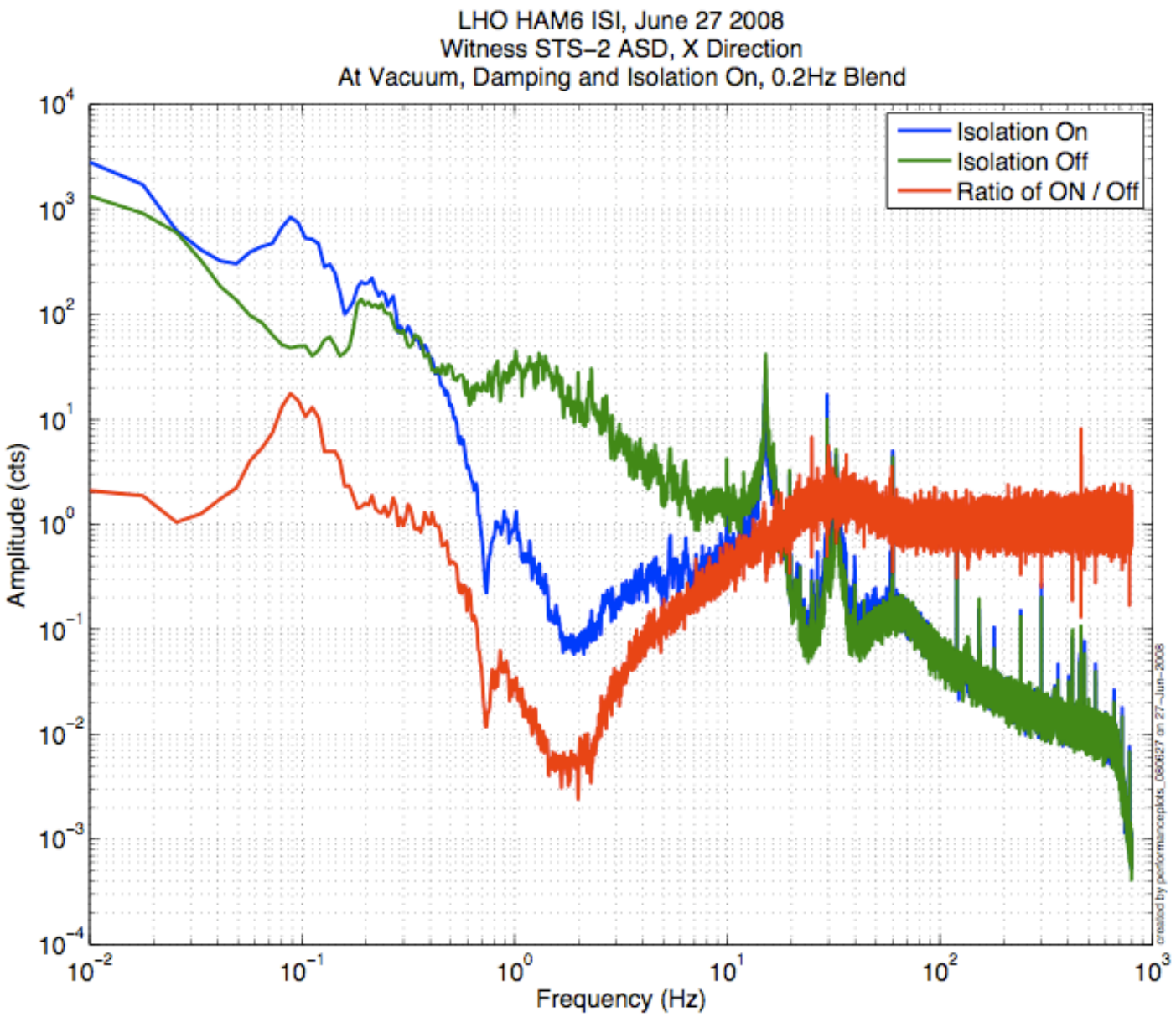
22:10:54
Fri Jun 27
2008
(Local)
Subentry

Topic: H1 Author: Jeff Kissel
This entry replaces a previous version.

Sat Jun 28 05:10:54 2008 UTC
LHO HAM6 ISI Performance Measurements
Attached here are the results from today's work. As you're looking at them, imagine the hours upon hours of frame builder reboots, awg failures, matlab crashes, dtt mismeasurements, and ENJOY VICTORY.

These plots were taken as a before and after, with isolation loops on, and isolation loops (and damping loops) off. The displacement sensors and geophones have been blended at 0.2 Hz (note that Z, RX, RY, and RZ were not the intended blend filters). Also remember the loops were designed to be good. Once we have models and requests from optics folks, we can tune and tailer the isolation to needed shapes. In addition, these plots are taken *without* feed-forward sensor correction in place for these loops. This last feature will be implemented soon, and only give as more performance.

Many thanks to Lantz, O'Reilly, Mittleman, Landry, Hanson, Garofoli, Gray, Radkins, Barker, Waldman, Adhikari, McCarthy, Abbott, Abbott, Sandberg, and Smith for helping me getting to this point.


LHO HAM6 ISI, June 27 2008
Witness STS–2 ASD, X Direction
At Vacuum, Damping and Isolation On, 0.2Hz Blend
Isolation On
Isolation Off
Ratio of ON / Off
Amplitude (cts)
Frequency (Hz)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

LIGO CDS BUGZILLA

http://bugzilla.ligo-wa.caltech.edu/

LIGO CDS Bug Reporting Tool (Bugzilla)
Please Use Your Email Address For Your Account

Mon Jul 14 2008 05:28:01 PDT
35 bugs found.

ID	Sev	Pri	OS	Assignee	Status	Resolution	Summary
59	enh	LOW	All	barker@ligo-wa.caltech.edu	NEW		ilog doesn't handle special characters well
58	nor	MED	Mac	barker@ligo-wa.caltech.edu	ASSI		New H1 ISI and OMC epics chans not in conlog
55	nor	MED	Othe	barker@ligo-wa.caltech.edu	NEW		control1 workstation at LLO has wrong /data mounted
54	enh	LOW	Linu	barker@ligo-wa.caltech.edu	NEW		Code-generator phase rotator should be in degrees
53	enh	FYI	Linu	barker@ligo-wa.caltech.edu	ASSI		LHO Matlab license server king dies
52	maj	MED	All	barker@ligo-wa.caltech.edu	ASSI		Matlab Flakiness
51	cri	HIG	Linu	barker@ligo-wa.caltech.edu	RESO	DUPL	Matlab has restarted the "polyfit"-type errors
50	maj	MED	Linu	barker@ligo-wa.caltech.edu	ASSI		Firefox claims it's not responding, does not open with certain methods
48	maj	MED	Linu	barker@ligo-wa.caltech.edu	ASSI		CONTROL14 cannot open medm
47	maj	HIG	Linu	barker@ligo-wa.caltech.edu	RESO	DUPL	Matlab still still not fully functional on CONTROL 4
46	cri	HIG	Linu	barker@ligo-wa.caltech.edu	ASSI		dtt open once per workstation reboot