LIGO Laboratory / LIGO Scientific Collaboration

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aLIGO HAM-ISI, Installation Test Report, Phase II, LLO HAM 5

E1200106-V2

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Table of contents:

Introduction

This document presents the tests performed to characterize and validate the HAM-ISI Unit # 5 built at LLO. This unit was built in July 2011, tested but had a LZMP issue, retested in September 2011 when it was approved, then kept in a storage container with weekly dry Nitrogen purge until July 2012.

This was the 5th and final unit pulled out from storage for installation at Livingston, to be installed in HAM 5 chamber. Horizontal seismometers and in-vacuum cables were installed. Also, the Capacitive Position Sensors cables were shielded.

There are 4 distinctive parts:
- Part I: side chamber testing results
- Part II: post insertion testing results
- Part III: Transfer functions taken during optics installation
    - 3.1 transfer functions after first triple install
    - 3.xx ....
- Part IV: Tests in final configuration

I. SIDE CHAMBER TESTING

Side chamber testing was conducted in the LLO LVEA with actual electronics and field cables from July 10th and 18th 2012. Temporary extensions to those cables were used to reach the test stand located further away from the electronics than the HAM chamber is.

Steps 1 and 2 capture data from testing done previously, whereas all the following steps were done (or waived) during that side-chamber testing period.

▪ *Step 1: GS13*

All the data related to GS-13 post podding testing can be found in the SVN at :
SeismicSVN\seismic\Common\Data\aLIGO_GS13_TestData\

E1000058 spreadsheet provides the status of each individual GS-13 at LLO site during aLIGO HAM assembly

Data files in SVN at:
seismic/Common/Data/aLIGO_GS13_TestData/PostMod_TestResults_RawASCII

Scripts files for processing and plotting in SVN at:
seismic/Common/MatlabTools
- gs13qatest.m

Figures in SVN at:
seismic/Common/Data/aLIGO_GS13_TestData/PostMod_TestResults_PDFs

▪ *Step 1.1 – Horizontal GS-13s*

Huddle testing
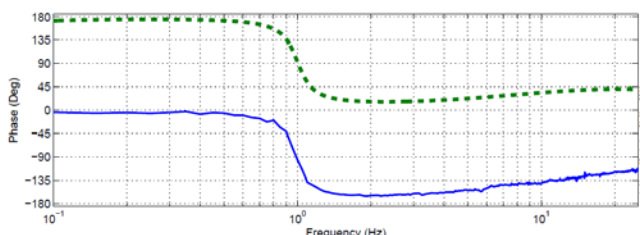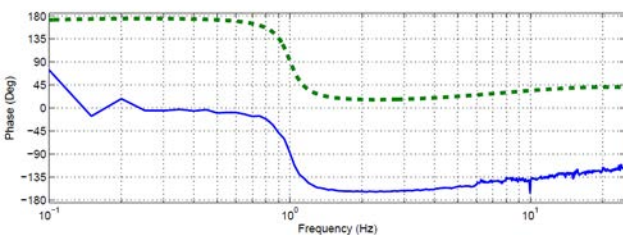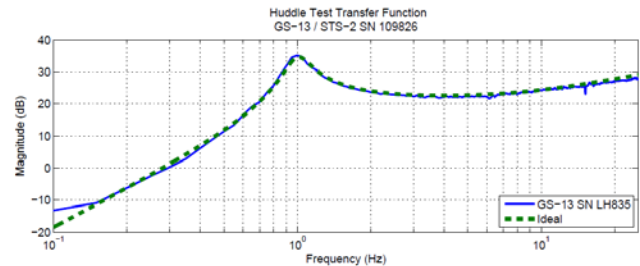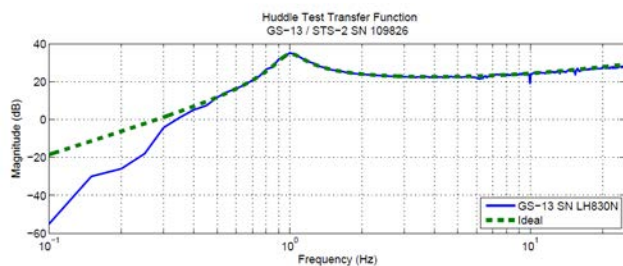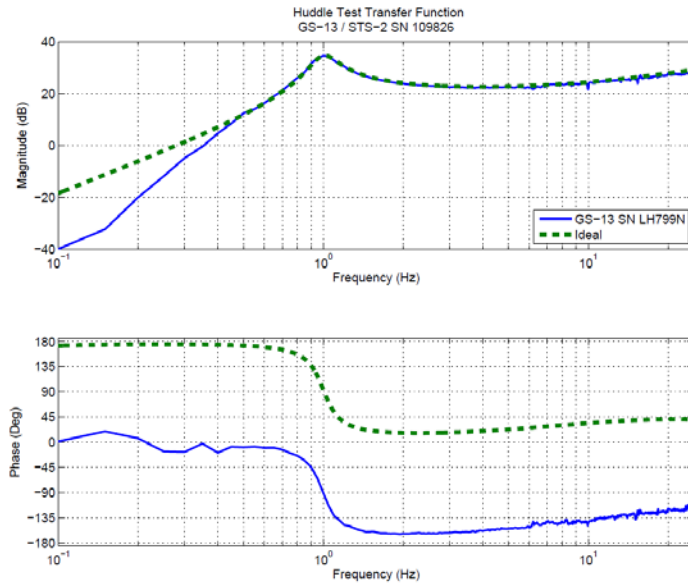
Figure - Huddle testing of Horiz GS-13 830, 835, and 799 after aLIGO modifications

Issues/difficulties/comments regarding this test:
Not all GS-13s have exactly the same resonant frequency. This parameter was adjusted as well as manageable after modifications of the instruments. Instruments were passed as long as their resonant frequencies were within 0.95 and 1.2 Hz.

Some instruments appear out of phase compared to the model. This only means the instrument was placed at 180 deg compared to the expected position when the model was created . This was ignored in order to approve the instrument for use.

Acceptance Criteria
- All instruments match their expected response.
-
  - *Step 1.2 – Vertical GS-13s*

The V2 corner instrument was changed because the previous instrument had a problem in the feedthru and the cable could not be screwed in tight.

Huddle Test Transfer Function
GS-13 SN LV711 / STS SN 109826
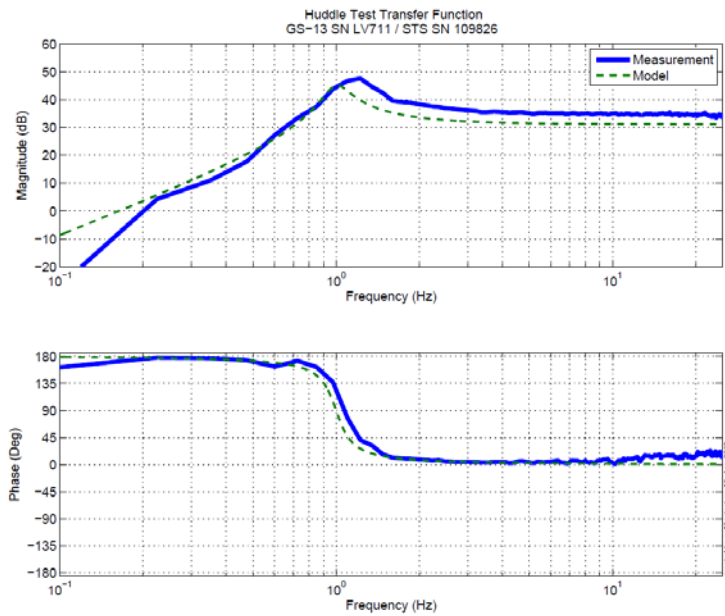
Figure - Huddle testing of Vertical 711 GS-13 after aLIGO modification

BL White Noise Driven Transfer Function
GS-13 SN LV711
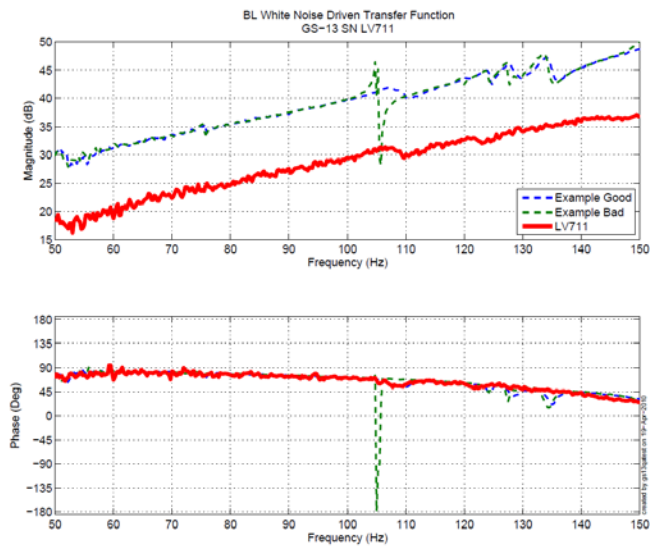
Figure - Driven test of Vertical 711 GS-13 after aLIGO modification

**Test result: Passed: X   Failed: **

▪ *Step 3: Inventory (E1000052)*

Data shown in red indicate changes made side-chamber. * are elements that will be installed after ISI chamber installation.

DCC/Vendor number	Part name	Configuration	S/N	S/N	S/N
D071001	Stage 0 base		12		
D071051	Stage 1 base		7		
D071050	Optical table				
D071002	Spring Post		38	39	36
D071100	Spring		28	19	9
D071102	Flexure		34	38	35
ADE	Position sensor	Horizontal	12077	12060	12045
ADE	Position sensor	Vertical	12068	12061	12031
D047812	GS-13 pod	Horizontal	54	24	87
D047812	GS-13 pod	Vertical	63	95?	8
D047823	L4C pod	Horizontal	141	077	055
D047823	L4C pod	Vertical	N/A*	N/A*	N/A*
D0902749	Actuator	Horizontal	L030	L009	L148
D0902749	Actuator	Vertical	L132	L160	L135

Acceptance Criteria

▪ Inventory is complete

Test result: **Passed: X**   **Failed:**

▪ *Step 4: Check level of Stage 1 Optical Table*

Due to past experience showing we had to adjust the shims both side chamber and in chamber we decided not to run this test.

Acceptance Criteria

▪ The maximum angle of the table with the horizontal mustn't exceed ~100µrad

Test result: **Passed:** __   **Failed:** __   **Waived: X**

▪ *Step 7 : Gap checks on actuators-after installation on Stage 1*

Gaps were inspected on all vertical actuators and adjusted to be within requirements. No records were taken. Horizontal actuators will be inspected/adjusted in chambers.

Acceptance Criteria

▪ Gaps must be within 0.010" of design (i.e. 0.090" and .070" pass, but 0.095" and 0.065" doesn't).

Test result: **Passed: __X__**   **Failed: ____**

▪ *Step 8: Mass budget*
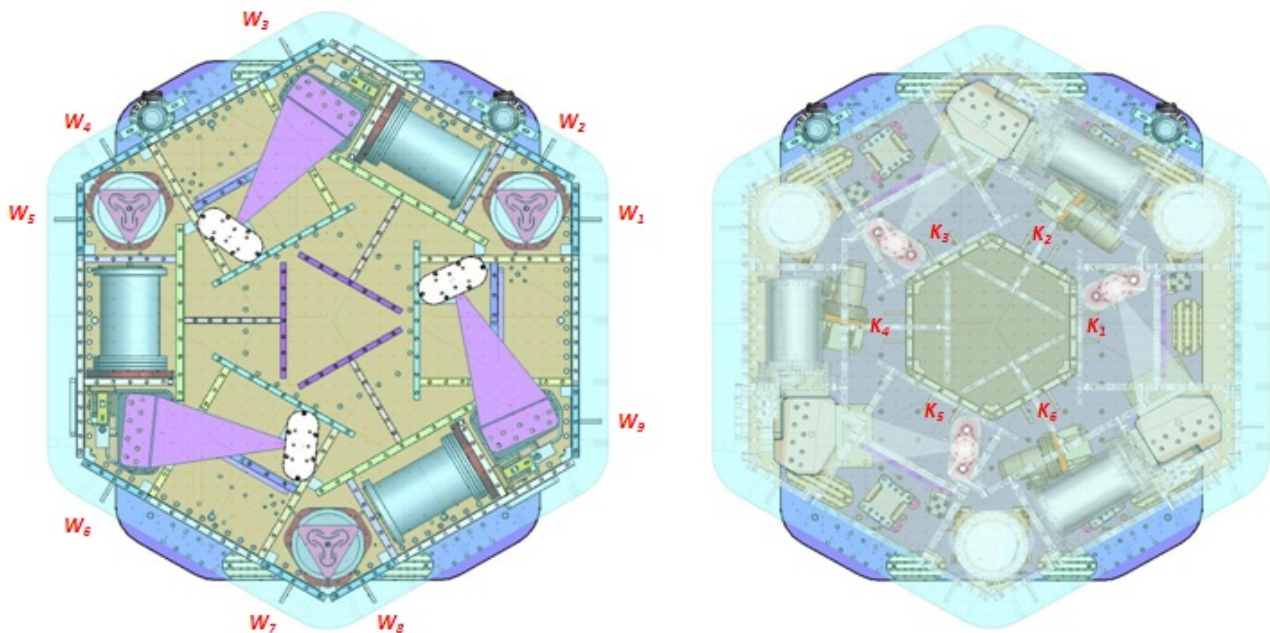
Figure – Keel Masses and Wall masses location

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
w9						3		46.8	21.23
w1	1		1			1	1	45.6	20.68
w2			1			1	1	45	20.41
w3	1	1			0	1	1	44.5	20.18
w4	1	1	1	1		1	1	51.2	23.22
w5	1		1	2		2	0	43	19.50
w6	1		1			1	1	45.6	20.68
w7		1	1	1		1	1	50.6	22.95
w8	.		1			1	1	47.3	21.45
Side Masses Total	5	3	6	5	0	12	7	419.6	190.33

Table – Wall masses distribution

	00	01	02	03	04	05	06		
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
k1					1		1	35.1	15.92
k2	1	1	1				1	31.1	14.11
k3					1		1	35.1	15.92
k4	1	1	1				1	31.1	14.11
k5					1		1	35.1	15.92
k6	1	1	1				1	31.1	14.11
	3	3	3	0	3	0	6	198.6	90.08

Table – Keel masses distribution

	D972213	D972214	D972215	D0901075				
				2.5 kg	5 kg	10 kg		
	610	375	230	5.5	11	22	lbs	kgs
A		1	1			1	616	279.41
B							0	0.00
C							0	0.00
D							0	0.00
E-1						1	22	9.98
E-2						1	22	9.98
E-3						1	22	9.98
Top Masses	0	1	1	0	1	3	682	309.35

Table - Optical Table Masses distribution

	Side	Keel	Top	Total
Weigh (kg)	190.33	90.08	309.35	589.76

Table - Masses distribution (computed using T1100261)

Acceptance Criteria

The Mass budget must be
- 579.1 Kg (cf E1100427) +/-25Kg (5%)

Test result: **Passed: X**   **Failed: ___**

- *Step 9: Lockers adjustment*

We used dial indicators for initial balancing, but fine balancing and locker adjustment was done using the CPSs. (See Step 12).

Test result: **Passed: ___   Failed: ___   Waived: X**

▪ *Step 10 - Electronics Inventory*

Hardware	LIGO reference	S/N
Binary Input*	D1001726	S1101288
Binary Output*	D1001728	S1101323
Coil driver	D0902744	S1103326
		S1103324
Anti Image filter	D1100202	S1200318
Anti aliasing filter	D1000269	S1107530
		S1107531
Interface chassis	D1002432	S1107869
		S1107870
		S1107871

Table - Inventory electronics

Issues/difficulties/comments regarding this test: Binary Input and Output interfaces are shared between HAM 4 and HAM 5.

Acceptance Criteria

▪ Inventory is complete

Test result: **Passed:** __X__   **Failed:** ___

▪ *Step 11 – Cables inventory – E1100822*

The location of all cables must be reported in the spreadsheet E1100822.

Cable Connects		Cable S/N		
Part Name	Configuration	Corner 1	Corner 2	Corner 3
GS13	Horizontal	S1104651- S1104697	S1104645- S1104597	S1104607- S1104644
GS13	Vertical			
L4C	Horizontal	S1104611- S1104664	S1104698- S1104692	S1104696- S1104672
L4C	Vertical			
Actuator	Horizontal	S1104744	S1104724	S1104736
	Vertical	S1104496	S11047	S11047

Table – Cables inventory

Acceptance Criteria
- Cable inventory completed
- E110082 spreadsheet updated

Test result: **Passed:** __X__   **Failed:** ___

- *Step 12 - Set up sensors gap*

Table locked	No mass	
	ADE boxes on	
Sensors	Offset (Mean)	Std deviation
H1		
H2		
H3		
V1		
V2		
V3		

Table – Capacitive position sensor readout after gap set-up

Issues/difficulties/comments regarding this test: Those met requirements but did not get recorded.

Acceptance criteria:
- All mean values must be lower than 400 cts (a bit less than .0005").
- All standard deviations below 5 counts.
- No cross talk

Test result: **Passed: X**   **Failed: __**

- *Step 13 - Measure the Sensor gap*

This test was not done any more due to risk of damage to sensor targets.

Test result: **Passed: ___   Failed: ___   Waived: X**

11

§ *Step 14 - Check Sensor gaps after the platform release*

Sensors	Table locked		Table unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Difference
H1	-52	NR	-658	606
H2	-914	NR	-970	56
H3	-230	NR	-4750	4520
V1	200	NR	1035	-835
V2	-861	NR	-699	-162
`V3	176	NR	232	-56

Table – Sensor gaps after platform release

Issues/difficulties/comments regarding this test: The offensive locker making H3 move more than the authorized limit was later adjusted, but data was not recorded after that.

Acceptance criteria:

- Absolute values of the difference between the unlocked and the locked table must be below:
    o 1600 cts for horizontal sensors (~0.002")
    o 1600 cts for vertical sensors (~0.002")
- Considering the acceptance criteria of step 4, all mean values must be lower than
    o 2000 cts for horizontal sensors (~0.0025")
    o 2000 cts for vertical sensors (~0.0025")

Test result: **Passed: X**   **Failed: ___**

- *Step 15– Performance of the limiter*
- *Step 15.1 - Test Nº1 - Push "in the general coordinates"*

Sensors	CPS read out		Calculated after calibration	
	UP (Counts)	Down (Counts)	UP (mil)	Down (mil)
V1				
V2				
V3				
	CPS read out		Calculated after calibration	
Sensors	CW(-RZ)	CCW (+RZ)	CW (mil)	CCW (mil)
H1				
H2				
H3				

Table - Optic table range of motion

Issues/difficulties/comments regarding this test: This test was not done by lack of time.

Acceptance criteria:
- The vertical sensor readout be positive when the optic table is pushed in the +Z direction
- The horizontal sensor readout be negative when the optic table is pushed in the +RZ direction

Step 15.1
- Absolutes value of all estimated motions must be higher than 16000counts (~0.020")

Test result: **Passed: ___   Failed: ___   Waived: X**

- ***Step 16 - Position Sensors unlocked/locked Amplitude Spectral Densities***

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Spectra/Undamped/
- LLO_ISI_HAM5_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_07_17.pdf

Scripts files for taking and processing the data, and plotting it in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Plot_ASD_Unlocked_Locked_HAM_ISI.m
- Plot_ASD_Unlocked_Locked_Group_HAM_ISI.m

Figures in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Figures/Spectra/Undamped/
- LLO_ISI_HAM5_ASD_m_CPS_Requirements_Locked_vs_Unlocked_2012_07_17.pdf
- LLO_ISI_HAM5_ASD_m_GS13_Requirements_Locked_vs_Unlocked_2012_07_17.pdf

CPS calibration:
The CPS power spectrums are calibrated by using a sensitivity of 30.2 nm/count.

Figure - Calibrated CPS power spectrum

ASD GS13 - Table Unlocked

ASD GS13 - Table Locked

Figure – Power spectrum Calibrated GS13s

ASD L4C - Table Unlocked

ASD L4C - Table Locked
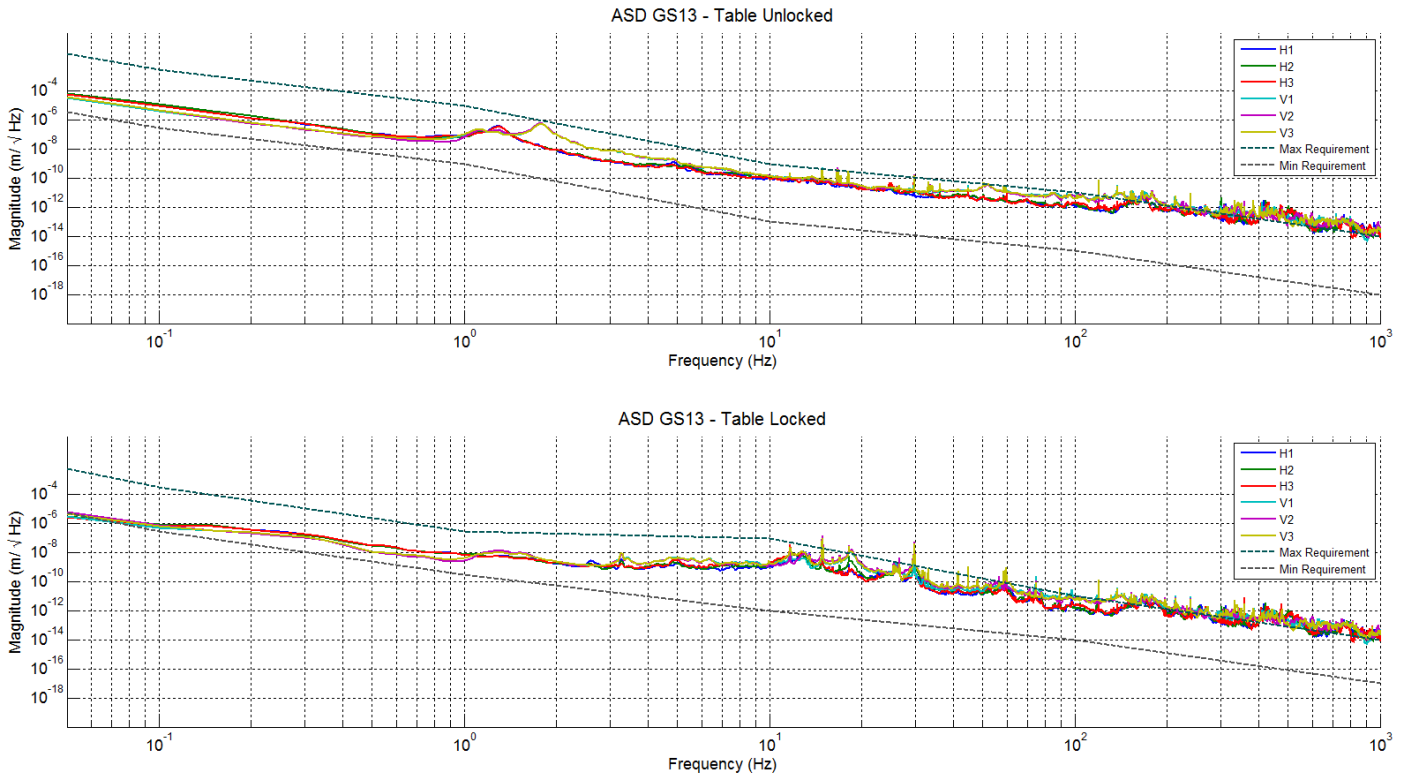
Figure – Power spectrum Calibrated L4Cs

Acceptance criteria:
- No cross talk (peaks at low frequencies + harmonics on measurements)

-   Magnitudes of power spectra must be between requirement curves such as in the following figures (dashed lines)

Issues/difficulties/comments regarding this test:
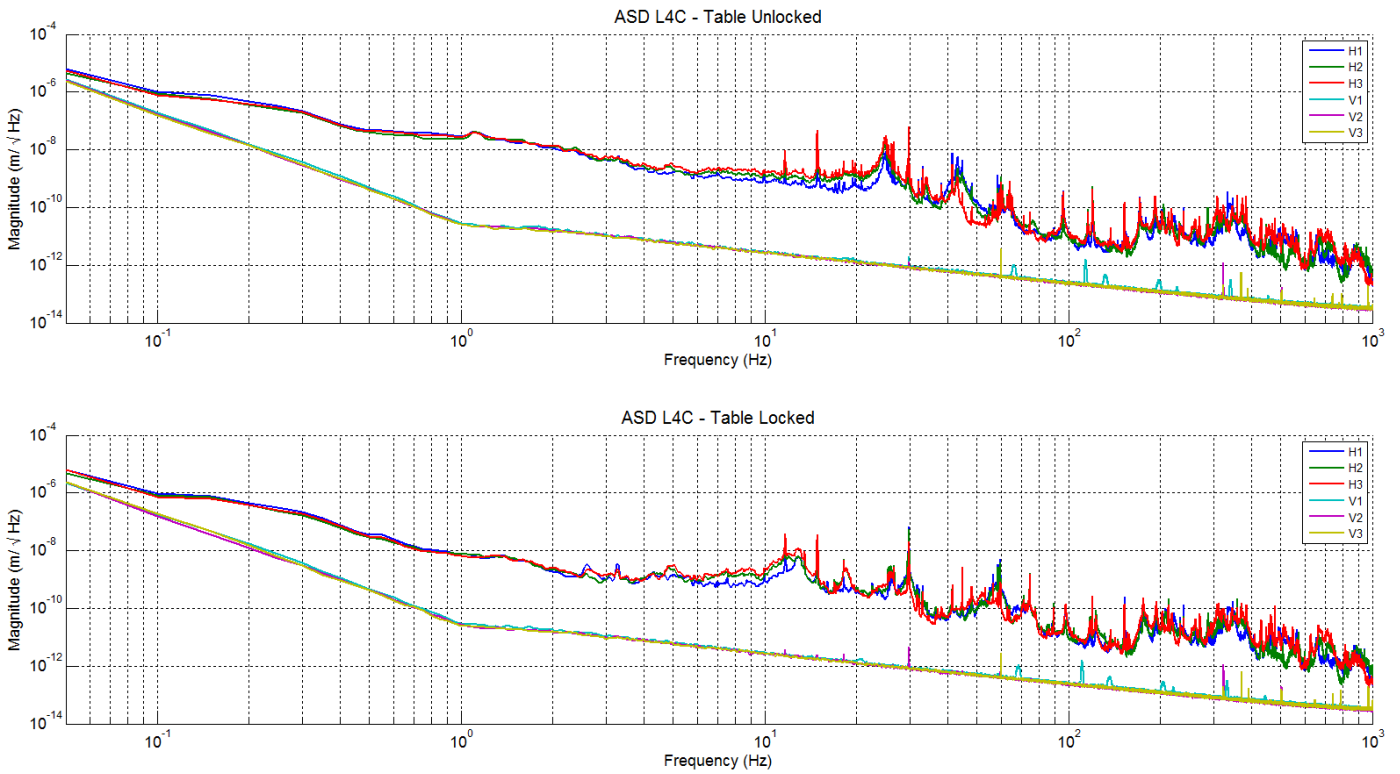Vertical L4Cs are not connected because they are in the way of the screws linking the HAM-ISI to the support tubes (those screws need to be accessible at the time of install). Differences between the locked and unlocked state of the L4Cs are only due to ground motion differences. Indeed these sensors are not on the suspended stage.

Test result: **Passed: __X__**   **Failed: ____**

▪ *Step 17 - GS13 ASD -tabled tilted*

The figure below presents the GS13 power spectrum when the table is unlocked and loaded with a 20Kg mass at one of its corner.
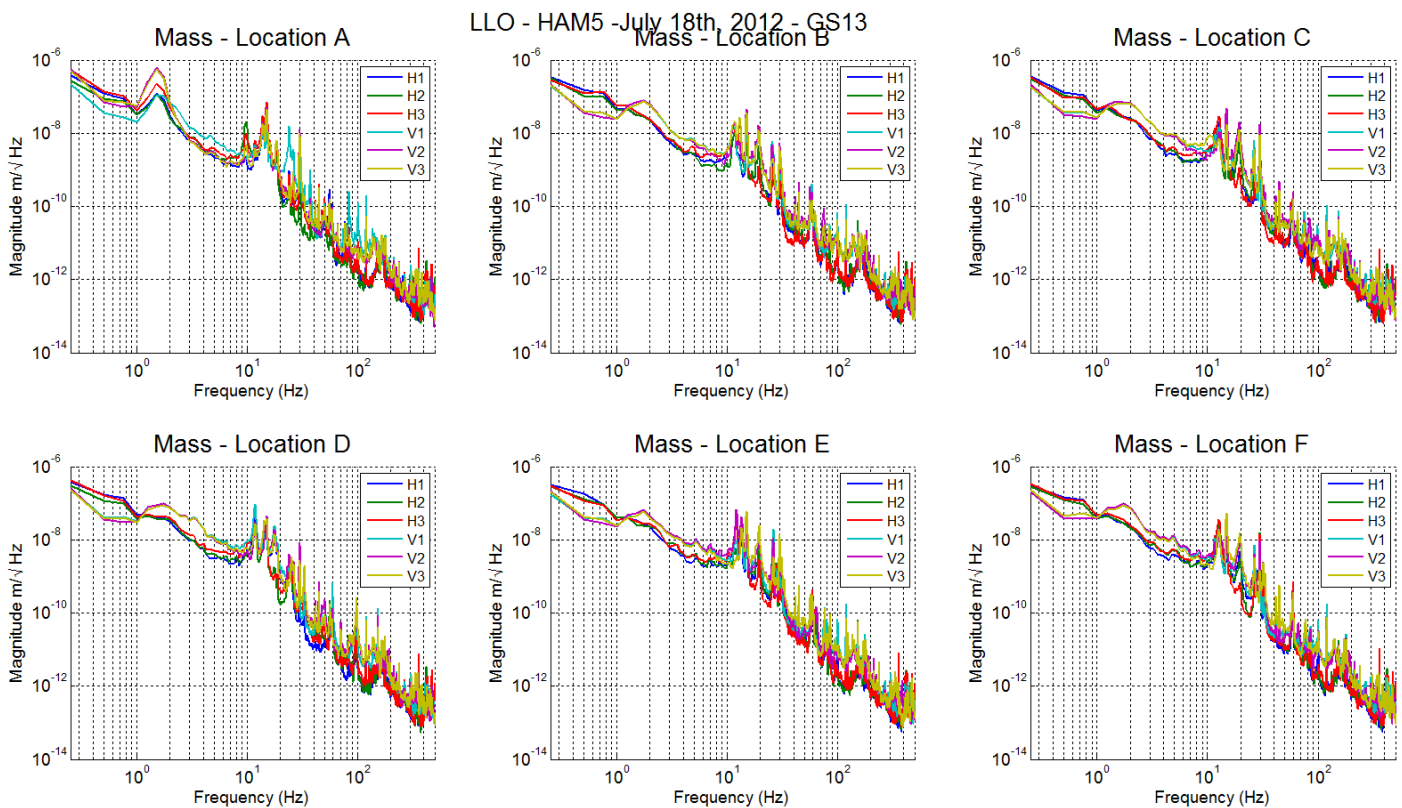
Figure – ASD Calibrated GS13 with mass at corner

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Spectra/Undamped/
- LLO_HAM_ISI_Unit_3_Calibrated_PSD_GS13_Table_Tilted_2012-07-18.mat

Scripts files for taking and processing the data, and plotting it in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
-   Plot_ASD_Tilted_Stage_HAM_ISI.m

Figures in SVN at:

seismic/HAM-ISI/L1/HAM5/Data/Figures/Spectra/Undamped/
- LLO_ISI_HAM5_ASD_CT_GS13_Tilted_2012_07_18.pdf

Acceptance criteria:
- With table unlocked and tilted, magnitudes of power spectra must be fully included within:

Issues/difficulties/comments regarding this test:
One can notice that V1 seismometer, even though displaying similar behavior than the other vertical seismometers, has an amplitude about half as those. This was due to a connection issue between the field cable and the HAM-ISI interface. Those tests were not taken again after the find.

Test result: **Passed: _X_**   **Failed: ____**

> ▪ *Step 18- GS13 pressure readout*

As of 07/17/12, readout was as follow:

	Corner 1	Corner 2	Corner 3
L4-C Direct Pressure	30	30	30
L4-C Diff Pressure	-9	-9	-9
GS-13 Direct Pressure	76	77	75
GS-13 Diff Pressure	0	0	0

Acceptance criteria:
- The pressure on direct channels must be 102KPa +/-8 KPa
- The pressure on differential channels must be 0KPa +/-8 KPa

Issues/difficulties/comments regarding this test:
The channels in yellow do not pass because seismometers are not connected yet (L4-C V1, V2, V3).
The channels in orange do not pass because of a gain difference in the GS-13 channels of the HAM-ISI interfaces. Those out of vacuum electronics will be corrected.

Test result: **Passed: _X_**   **Failed: __**

▪ *Step 19 - Actuators Sign and range of motion (Local drive)*

	Negative drive	Positive drive
H1 readout (count)	-24197.3	22924.55
H2 readout (count)	-23936	23005.72
H3 readout (count)	-24570.5	23878.59
V1 readout (count)	-18096.9	20789.3
V2 readout (count)	-25590.8	23632.4
V3 readout (count)	-21047.5	21671.66

Table - Range of motion - Local drive

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Static_Tests/
- LLO_ISI_HAM5_Range_Of_Motion_20120717.mat

Scripts files for taking and processing the data, and plotting it in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Range_Motion_HAM_ISI.m

Acceptance criteria:
- Main couplings sensors readout must be at least 16000 counts (~0.02")
- A positive offset drive on one actuator must give positive sensor readout on the collocated sensor. Signs will also be tested when measuring local to local transfer functions.

Test result: **Passed: _X_**   **Failed: ___**

▪ *Step 20 - Static Testing (Tests in the local basis)*

	H1	H2	H3	V1	V2	V3
H1	1806.983	1122.662	1131.683	-18.8173	-4.3736	-10.9464
H2	1127.371	1802.792	1137.809	-14.4154	-9.8228	0.8884
H3	1133.993	1118.373	1810.005	4.869976	-4.8254	5.7738
V1	154.1558	150.886	-323.964	1245.45	-23.1238	-539.816
V2	-325.989	154.4982	154.6064	-555.545	1256.533	-20.2632
V3	155.0274	-324.622	168.1276	-50.4133	-547.605	1277.98

Table - Main and cross coupling

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Static_Tests/
- LLO_ISI_HAM5_Offset_Local_Drive_20120719.mat

Scripts files for taking data in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Static_Test_Local_Basis_HAM_ISI.m

Acceptance criteria:

- **Vertical**
   For a +1000 count offset drive on vertical actuators
   o Collocated sensors must be 1400 counts +/- 10%

- **Horizontal**
   For a +1000 count offset drive on horizontal actuators
   o Collocated sensors must be 2000 counts +/- 10%
   o Non-collocated horizontal sensors must be 1250 counts +/-10%

Test result: **Passed: _X_**   **Failed: ___**

▪ *Step 21- Linearity test*

	Slope	Offset	Average slope	Variation from average(%)
H1	1.817506	-32.6828		0.444588
H2	1.803415	-901.031	1.809461	-0.33414
H3	1.807463	-186.191		-0.11044
V1	1.2482	185.5445		-0.59229
V2	1.254925	-853.818	1.255637	-0.05671
V3	1.263786	178.789		0.649002

Table - Slopes and offset of the triplet Actuators - HAM-ISI - Sensors

Scripts files for taking data in SVN at:
/seismic/HAM-ISI/Common/ Common/Testing_Functions_HAM_ISI
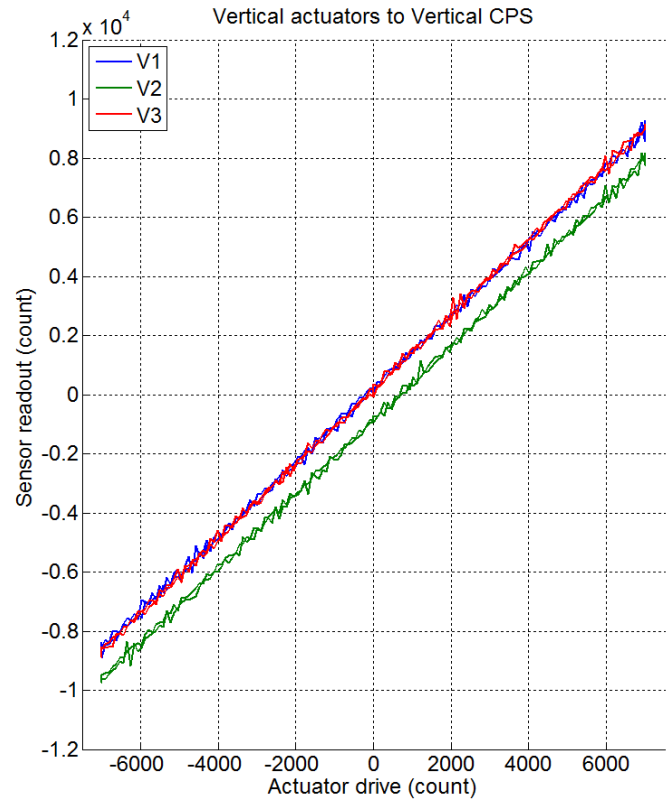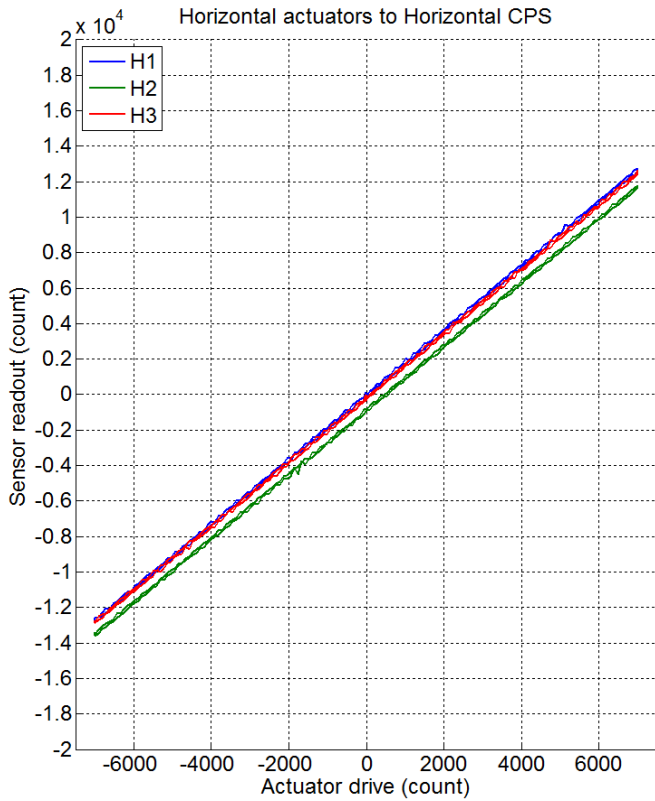
- Linearity_Test_Awgstream_HAM_ISI.m

Figure - Horizontal and vertical actuators x HAM-ISI x sensors

Data files in SVN at:

seismic/HAM-ISI/L1/HAM5/Data/Linearity_Test/
- LLO_ISI_HAM5_Linearity_test_20120717.mat

Figures in SVN at:

seismic/HAM-ISI/L1/HAM5/Data/Figures/Linearity_Test/
- LLO_ISI_HAM5_Linearity_test_20120717.pdf

Acceptance criteria:

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/-
  1%

Test result: **Passed: X**   **Failed:**

▪ *Step 22 Cartesian Basis Static Testing*

1000 counts Drive	H1	H2	H3	V1	V2	V3
X Drive						
Y Drive						
Z Drive						
Rx Drive						
Ry Drive						
Rz Drive						

Table - Tests in the local coordinate basis

1000 counts Drive	X	Y	Z	RX	RY	RZ
X Drive						
Y Drive						
Z Drive						
Rx Drive						
Ry Drive						
Rz Drive						

Table - Tests in the general coordinate basis

Acceptance criteria:
- For a positive drive in the Cartesian basis Local sensor readout must have the same sign that in the following table:

1000 counts Drive	H1	H2	H3	V1	V2	V3	Direction read out
X Drive	+	+	-				+
Y Drive	-	+	0				+
Z Drive				+	+	+	+
Rx Drive				-	+	-	+
Ry Drive				-	+	+	+
Rz Drive	-	-	-				+

Table – Reference table

For a positive drive in the Cartesian basis:
- Local sensor readout must have the same sign that the reference table (**CONT2ACT check**)
- Cartesian sensors read out must be positive (**DISP2CEN check**) in the drive direction

Issues/difficulties/comments regarding this test:
We did not get enough time to do this test. But at worst, there would be a matrix error, which would not interfere with the decision to install the HAM-ISI.

Test result: **Passed: ___   Failed: ___   Waived: X**

- ▪ *Step 23- Frequency response*

- ▪ *Step 23.1 - Local to local measurements*

Local to local transfer functions have been measured with 90 repetitions.

Data files in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM5_Data_TF_L2L_50mHz_500mHz_20120719-032956.mat
- LLO_ISI_HAM5_Data_TF_L2L_500mHz_5Hz_20120718-212023.mat
- LLO_ISI_HAM5_Data_TF_L2L_5Hz_200Hz_20120718-194650.mat
- LLO_ISI_HAM5_Data_TF_L2L_200Hz_800Hz_20120718-181317.mat

Data collection script files:
seismic/HAM-ISI/L1/HAM5/Scripts/Data_Collection/
- Run_Exc_Batch_L1ISIHAM5.m

Scripts files for processing and plotting in SVN at:
seismic/HAM-ISI/L1/HAM5/Scripts/Control_Scripts/release/
- Step_1_TF_Loc_2_Loc_L1_ISI_HAM5.m

(note that here release was soft linked to Version_1)

Figures in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Figures/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM5_TF_L2L_Raw_from_ACT_to_CPS_2012_07_18.fig
- LLO_ISI_HAM5_TF_L2L_Raw_from_ACT_to_GS13_2012_07_18.fig

Storage of measured transfer functions in the SVN at:
seismic/ HAM-ISI/L1/HAM5/Data/Transfer_Functions/Simulations/Undamped
- L1_ISI_HAM5_TF_L2L_Raw_2012_07_18.mat
-

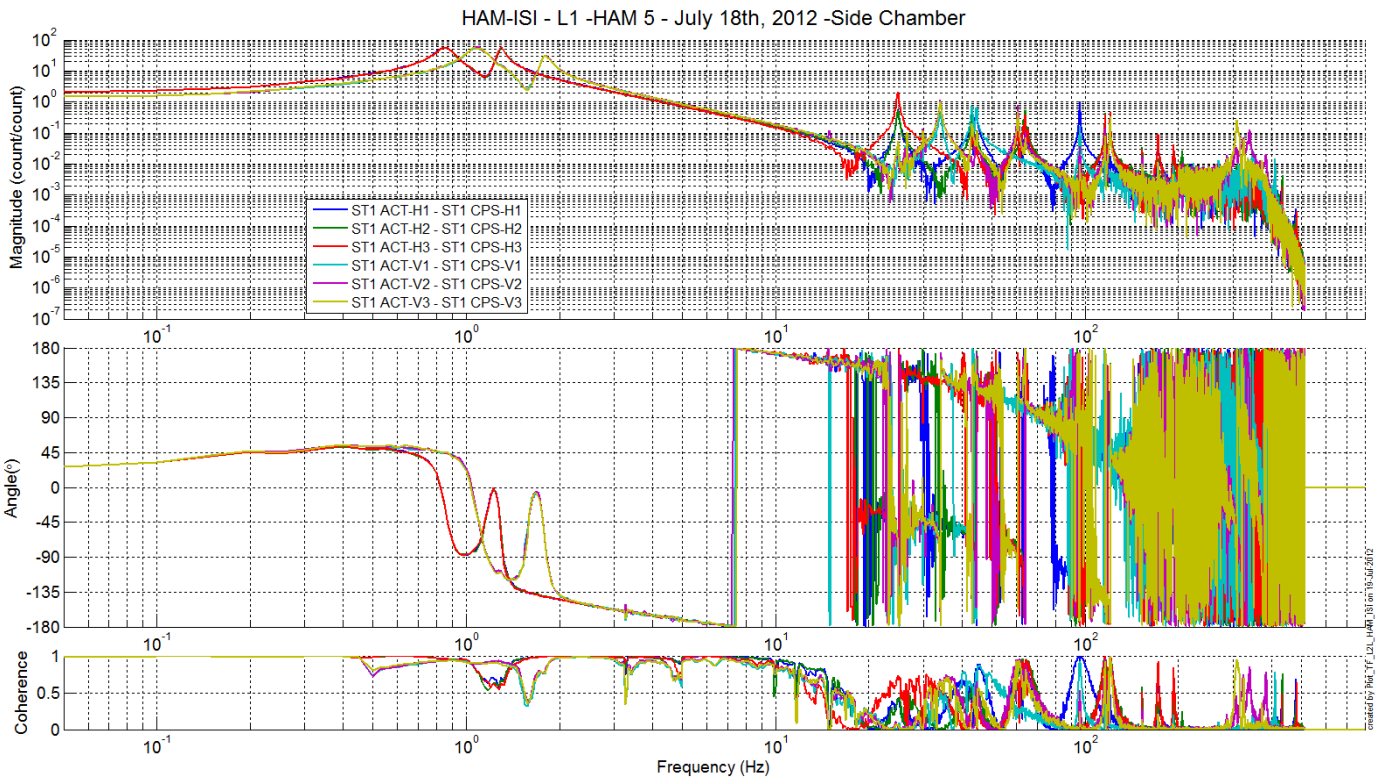The local to local transfer functions are presented below.

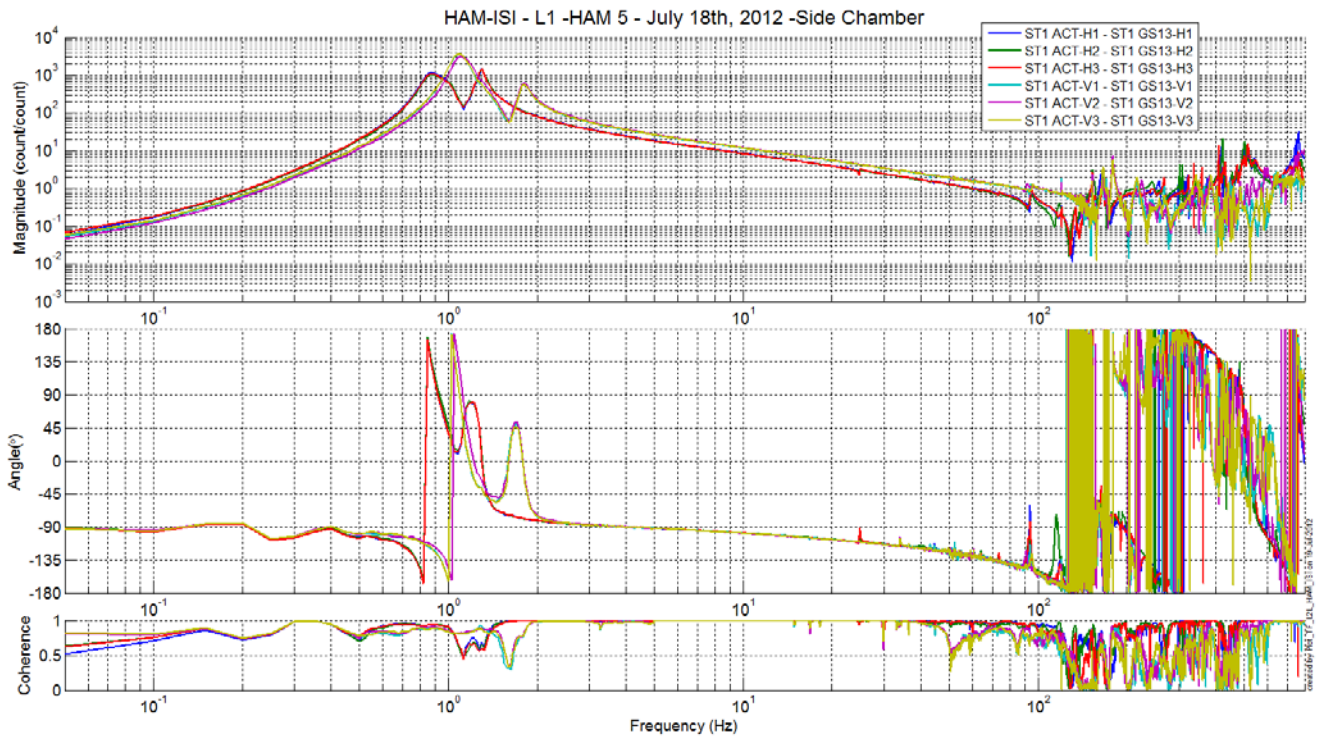**Figure - Local to Local Measurements –Capacitive Position Sensors**

Figure - Local to Local Measurements – Inertial sensors

Issues/difficulties/comments regarding this test:

We can see that the horizontal inertial sensors in corner 2 seem to see a slightly different behavior around 1 Hz. We tried to assess whether this could be due to the GS-13 characteristics themselves by extracting the sensor response from the transfer function and comparing them together.

Data collection script files:
seismic/HAM-ISI/L1/HAM5/Scripts/Data_Collection/
- L1_HAM5_GS13_Resp_Extraction_Fitting.m

Figures in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Figures/Instrument_Responses/GS13/

Here is the comparison between extracted data of all GS-13s (zoomed in around 1 Hz):
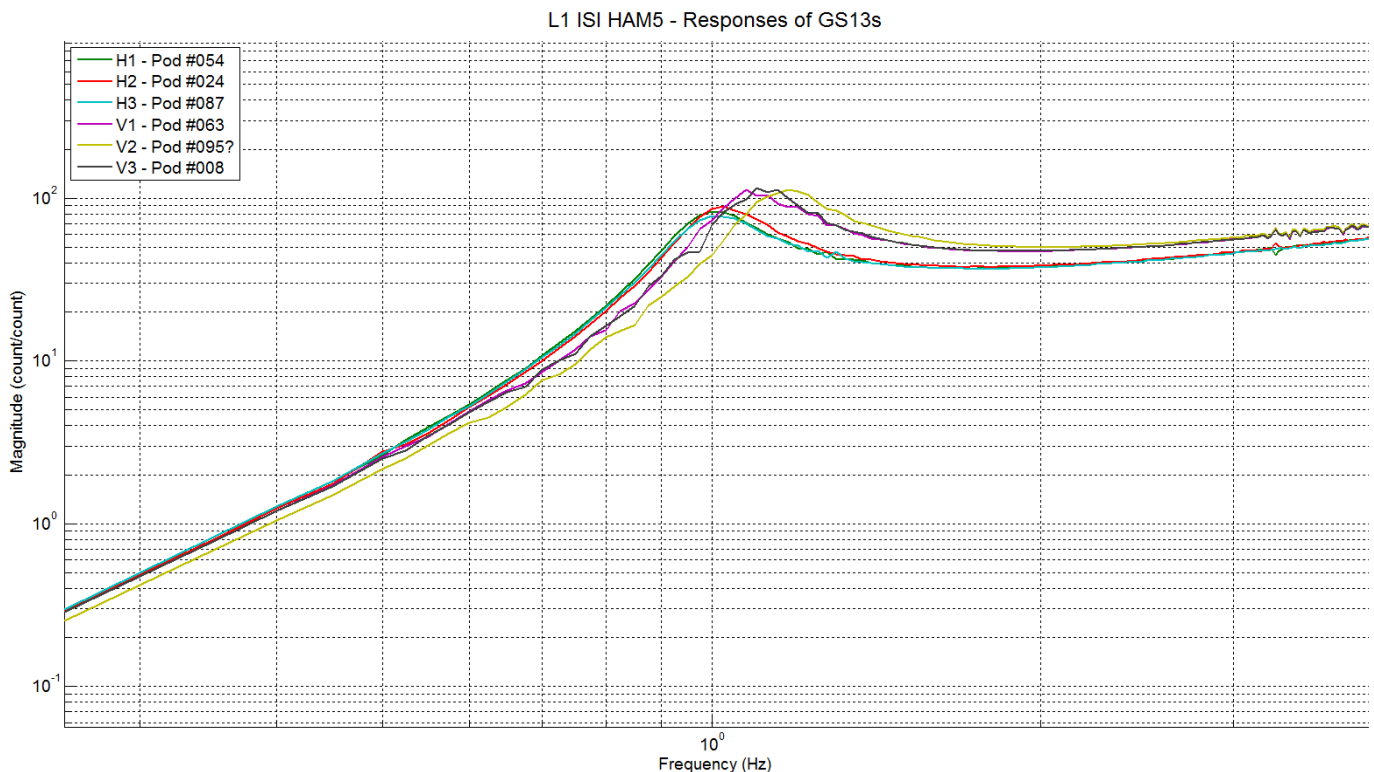
Figure – Comparison between the responses of the extracted GS-13s installed on HAM-ISI 5

From this plot, we can see that V2 appears to have its resonance higher than the other 2 sensors. This difference in the sensors could explain why the vertical resonance on the inertial sensors transfer functions look slightly different between the vertical sensors, even though all three corners are look perfectly identical on the CPS transfer function.

Conclusion of Side Chamber testing

Only a few minor issues were found during testing of this ISI:
- Slightly different response of the V2 GS-13 (in comparison to V1 and V3) between 0.8 and 1.1 Hz. This appears to be explained by the different sensors responses.
-

A number of mechanical tests (and adjustments) were waived at the time of side-chamber testing, leaving this for in-chamber initial testing:
- Level of the optical table
- Spring flatness measurements
- Actuator gaps
- Manual range of motion

II. INITIAL IN-CHAMBER TESTING

This HAM-ISI was installed inside HAM 5 on July 20th 2012. It got connected and balanced quickly but did not get tested until the week of August 5th 2012. The chamber was finally closed on August 16th.

- ▪ *Step 1: Check level of Stage 1 Optical Table*

Issues/difficulties/comments regarding this test:
Initially this test was failed, but we adjusted the shim thickness to pass this test (see following step for new locker shims).
The table here does not appear to be really tilted. Most of the difference can be included within the .005" flatness of the table.

Issues/difficulties/comments regarding this test:
Note that this test was done in conjunction with placing the ISI on HEPI springs.

Acceptance Criteria

- ▪ The maximum angle of the table with the horizontal mustn't exceed ~100μrad

Test result: **Passed: _X_   Failed:**

- ▪ *Step 2: Ground loops*

We checked that there was no electrical connection between the actuator coil and the chamber.

Test result: **Passed: _X_   Failed: ___   Waived:__**

- ▪ *Step 3: Blade spring profile*

Because we adjusted the shims, we retook this measurement:

Blade #	Base (")	Tip(")	Flatness (mils)
1	0.495	0.488	+7
2	0.500	0.495	+5
3	0.490	0.4915	-1.5

Table 1 - Blade profile

Acceptance Criteria:

- ▪ Blades must be flat within 0.015" inches.

Test result: **Passed: _X_   Failed: ___   Waived:__**

- *Step 3: Inventory (E1000052)*

Data shown in red indicate changes made in-chamber.

DCC/Vendor number	Part name	Configuration	S/N	S/N	S/N
D071001	Stage 0 base		12		
D071051	Stage 1 base		7		
D071050	Optical table				
D071002	Spring Post		38	39	36
D071100	Spring		28	19	9
D071102	Flexure		34	38	35
ADE	Position sensor	Horizontal	12077	12060	12045
ADE	Position sensor	Vertical	12068	12061	12031
D047812	GS-13 pod	Horizontal	54	24	87
D047812	GS-13 pod	Vertical	63	95?	8
D047823	L4C pod	Horizontal	141	077	055
D047823	L4C pod	Vertical	011	019	025
D0902749	Actuator	Horizontal	L030	L009	L148
D0902749	Actuator	Vertical	L132	L160	L135

Acceptance Criteria

- Inventory is complete

Test result: **Passed: X**   **Failed: ___**

- *Step 4: Mass budget*
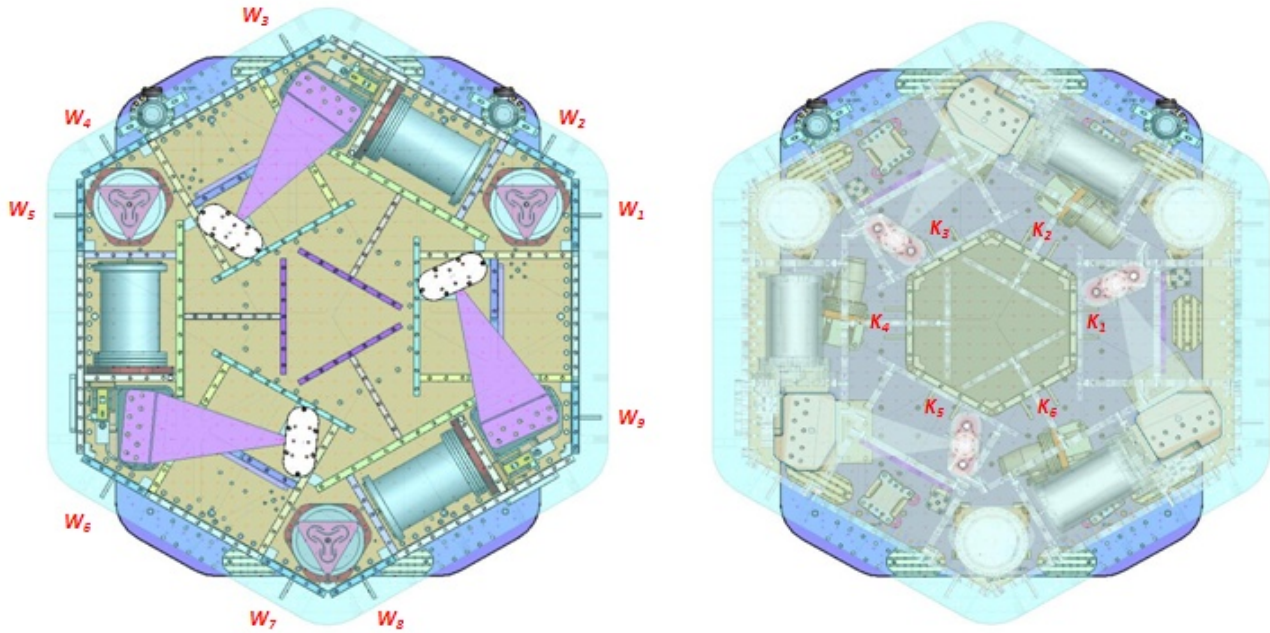
Figure – Keel Masses and Wall masses location

08/15/12	00	01	02	03	04	05	06			kgs
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs		
w9	0	0	1			3	0	51.3		23.27
w1	0		2			1	1	47.2		21.41
w2		1	1			1	1	46.1		20.91
w3	1	1	0	0	0	1	1	44.5		20.18
w4	1	1	1	1		1	1	51.2		23.22
w5	1		1	2		2		43		19.50
w6	1		1			1	1	45.6		20.68
w7	1		1	1		1	1	50.1		22.72
w8			1			1	1	47.3		21.45
Side Masses Total	5	3	7	6	0	12	7	426.3		193.37

Table – Wall masses distribution

	00	01	02	03	04	05	06			kgs
	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs		
k1					1		1	35.1		15.92
k2	1	1	1				1	31.1		14.11
k3					1		1	35.1		15.92
k4	1	1	1				1	31.1		14.11
k5					1		1	35.1		15.92
k6	1	1	1				1	31.1		14.11
	3	3	3	0	3	0	6	198.6		90.08

Table – Keel masses distribution

8/15/2012	D972213	D972214	D972215	D0901075				
				2.5 kg	5 kg	10 kg	lbs	kgs
	610	375	230	5.5	11	22	lbs	kgs
A		1	1		1		616	279.41
B							0	0.00
C							0	0.00
D							0	0.00
E-1						1	22	9.98
E-2						1	22	9.98
E-3						1	22	9.98
Top Masses	0	1	1	0	1	3	682	309.35

Table - Optical Table Masses distribution

	Side	Keel	Top	Total
Weigh (kg)	193.37	90.08	309.35	592.80

Table - Masses distribution (computed using T1100261)

Acceptance Criteria

The Mass budget must be
- 579.1 Kg (cf E1100427)+/-25Kg (5%)

Test result: **Passed: X   Failed: ___**

- *Step 5: Lockers adjustment*
- Not recorded but within.

Test result: **Passed: X   Failed: ___**

▪ *Step 7 - Check Sensor gaps after the platform release*

Sensors	Table locked		Table unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Difference
H1	203.73	8.39	740.66	-536.93
H2	-1318.19	22.23	-495.70	-822.50
H3	-157.61	9.61	-1368.25	1210.64
V1	117.82	10.88	-724.28	842.10
V2	-319.91	21.28	224.18	-544.09
`V3	-107.11	20.69	-751.11	644.00

Table – Sensor gaps after platform release

Acceptance criteria:

- Absolute values of the difference between the unlocked and the locked table must be below:
  o 1600 cts for horizontal sensors (~0.002")
  o 1600 cts for vertical sensors (~0.002")
- Considering the acceptance criteria of step 4, all mean values must be lower than
  o 2000 cts for horizontal sensors (~0.0025")
  o 2000 cts for vertical sensors (~0.0025")

Issues/difficulties/comments regarding this test:

Test result: **Passed: X   Failed: Waived:**

▪ *Step 8 - Position Sensors unlocked/locked Amplitude Spectral Densities*

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Spectra/Undamped/
- LLO_ISI_HAM5_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_08_09.mat

Scripts files for taking and processing the data, and plotting it in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Plot_ASD_Unlocked_Locked_HAM_ISI.m
- Plot_ASD_Unlocked_Locked_Group_HAM_ISI.m
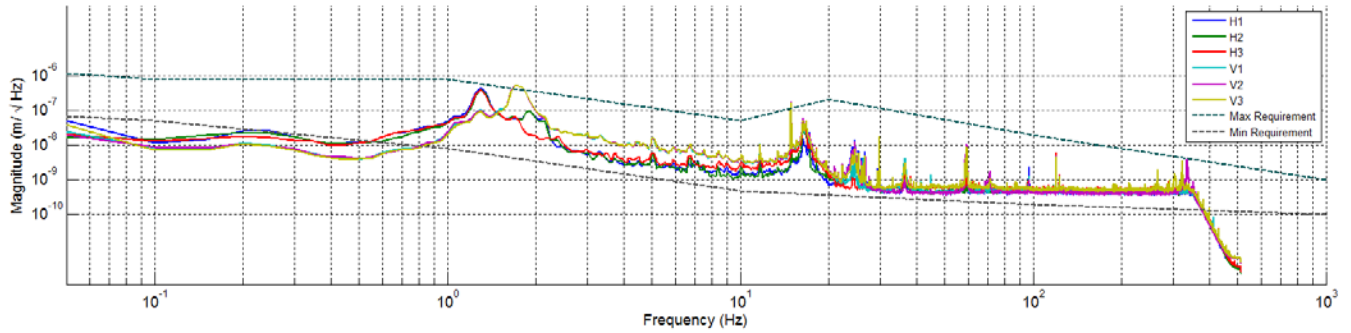
Figures in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Figures/Spectra/Undamped/
- LLO_ISI_HAM5_ASD_m_CPS_Requirements_Locked_vs_Unlocked_2012_08_09.fig
- LLO_ISI_HAM5_ASD_m_GS13_Requirements_Locked_vs_Unlocked_2012_08_09.fig
- LLO_ISI_HAM5_ASD_m_L4C_Requirements_Locked_vs_Unlocked_2012_08_09.fig
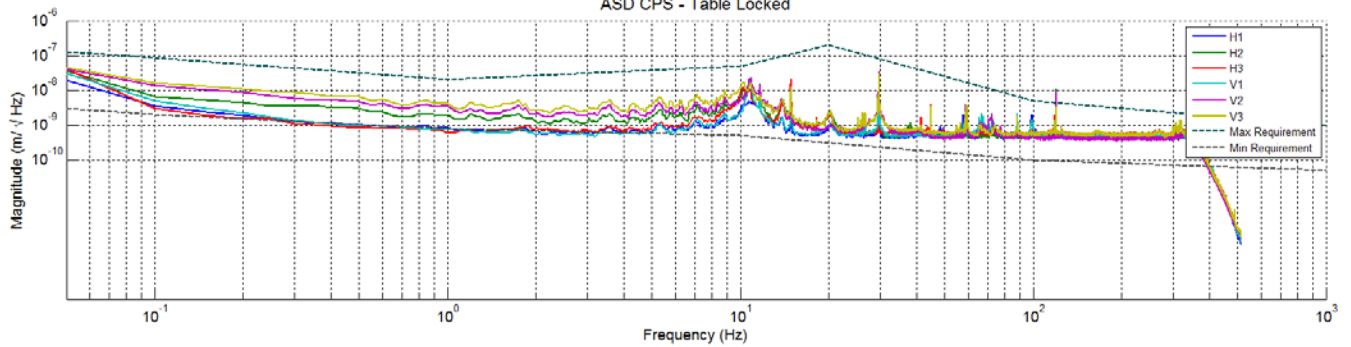
CPS calibration:

The CPS power spectrums are calibrated by using a sensitivity of 30.2 nm/count.
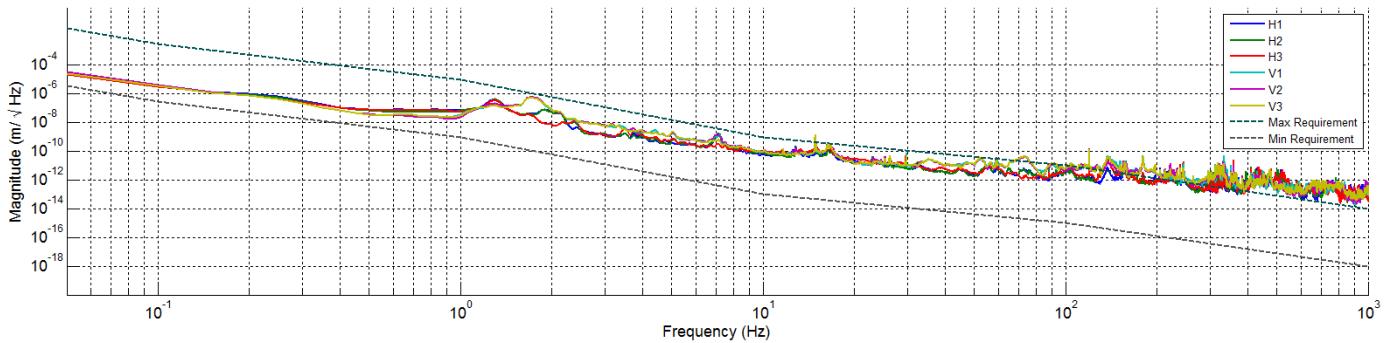
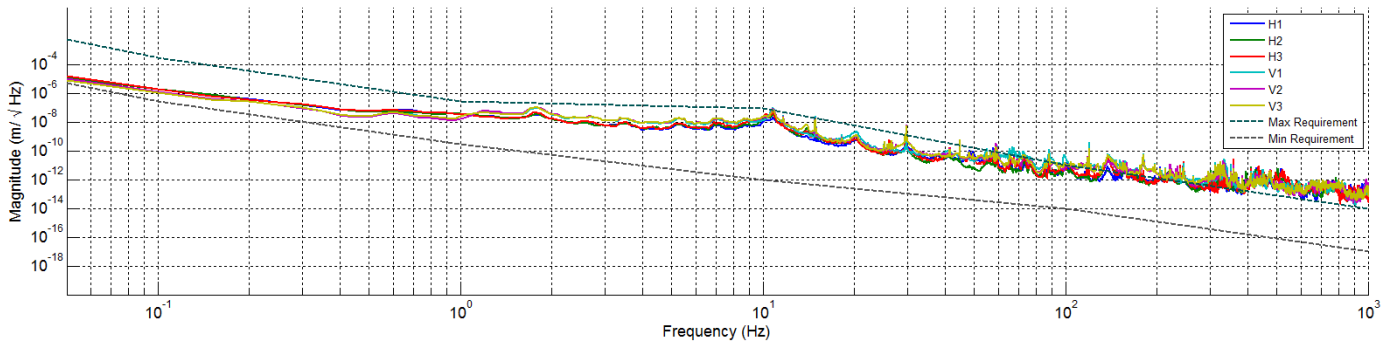**Figure - Calibrated CPS power spectrum**

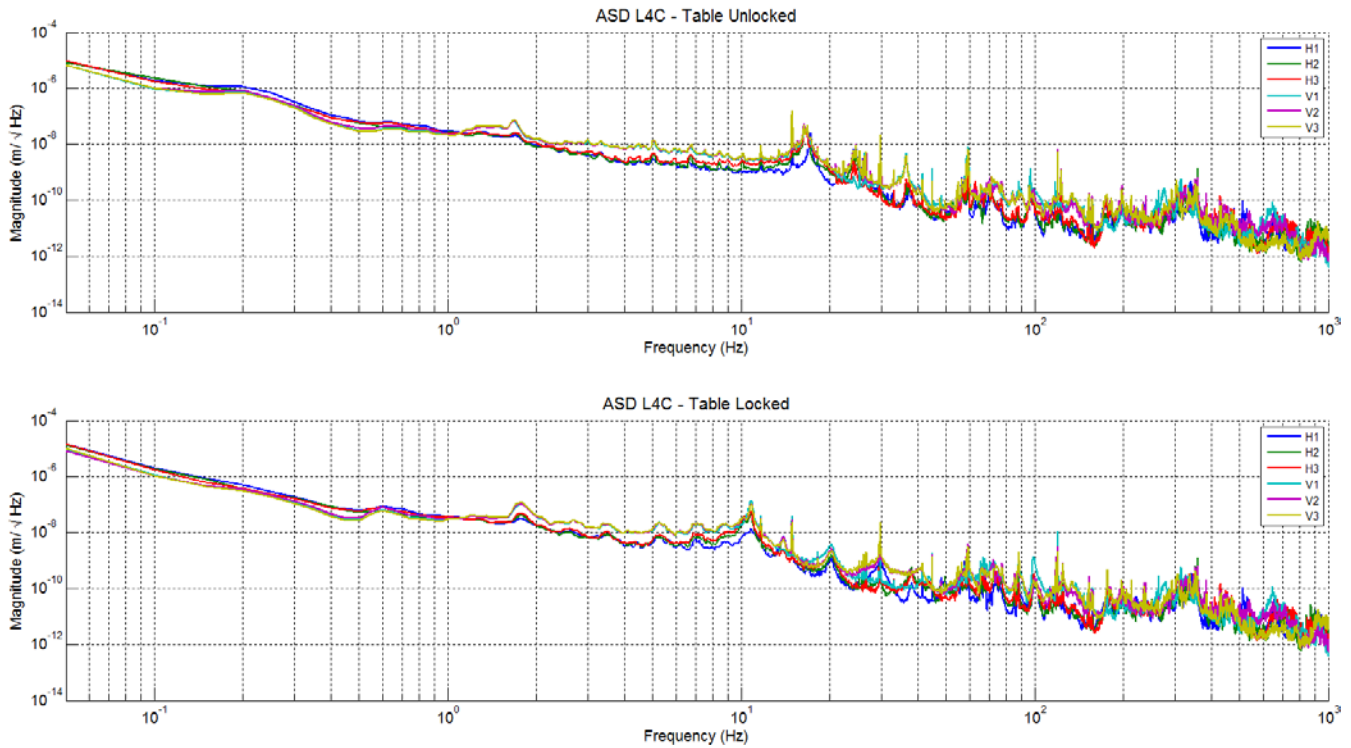**Figure – Power spectrum Calibrated GS13**

Figure – Power spectrum Calibrated L4C

Acceptance criteria:
- No cross talk (peaks at low frequencies + harmonics on measurements)
- Magnitudes of power spectra must be between requirement curves such as in the following figures (dashed lines)

Issues/difficulties/comments regarding this test:
Vertical L4Cs are not connected because they are in the way of the screws linking the HAM-ISI to the support tubes (those screws need to be accessible at the time of install). Differences between the locked and unlocked state of the L4Cs are only due to ground motion differences. Indeed these sensors are not on the suspended stage.

Test result: **Passed: X**   **Failed: ___**

■ *Step 9 - GS13 ASD -table tilted*

The figure below presents the GS13 power spectrum when the table is unlocked and loaded with a 20Kg mass at one of its corner.

- This test was not done at that time.

Test result: **Passed: __**   **Failed: __ Waived: X**

▪ *Step 10- GS13 pressure readout*

As of 09/18/12, readout was as follow:

	Corner 1	Corner 2	Corner 3
L4-C Direct Pressure	100	100	98
L4-C Diff Pressure	-1	0	-1
GS-13 Direct Pressure	76	77	76
GS-13 Diff Pressure	0	0	0

Acceptance criteria:
- The pressure on direct channels must be 102KPa +/-8 KPa
- The pressure on differential channels must be 0KPa +/-8 KPa

Issues/difficulties/comments regarding this test:
The channels in orange do not pass because of a gain difference in the GS-13 channels of the HAM-ISI interfaces. Those out of vacuum electronics will be corrected.

Test result: Passed: __   Failed: __ Waived: X

▪ *Step 11 - Actuators Sign and range of motion (Local drive)*

	Negative drive	Positive drive
H1 readout (count)	-23675.6	23338.45
H2 readout (count)	-24033.4	23043.45
H3 readout (count)	-25044.8	24202.27
V1 readout (count)	-18569.9	20274.83
V2 readout (count)	-25359.6	24900.28
V3 readout (count)	-21534.9	21961.55

Table - Range of motion - Local drive

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Static_Tests/
- LLO_ISI_HAM5_Range_Of_Motion_20120806.mat

Scripts files for taking and processing the data, and plotting it in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Range_Motion_HAM_ISI.m

Acceptance criteria:
- Main couplings sensors readout must be at least 16000 counts (~0.02")
- A positive offset drive on one actuator must give positive sensor readout on the collocated sensor. Signs will also be tested when measuring local to local transfer functions.

Test result: **Passed: X**   **Failed: ___**

- *Step 12 - Static Testing (Tests in the local basis)*

	H1	H2	H3	V1	V2	V3
H1	1808.117	1148.476	1131.185	-40.2755	12.98996	10.64634
H2	1160.816	1883.459	1184.111	-6.0676	-1.34108	1.330891
H3	1118.378	1145.817	1851.45	-23.791	0.59722	-5.588
V1	154.6632	157.0639	-350.623	1308.172	-33.2181	-555.766
V2	-226.921	218.755	222.7774	-520.425	1293.727	-29.2579
V3	192.0629	-330.64	185.9558	-24.5991	-602.377	1334.262

Table - Main and cross coupling

Data files in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Static_Tests/
- LLO_ISI_HAM5_Offset_Local_Drive_20120806.mat

Scripts files for taking data in SVN at:
seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
- Static_Test_Local_Basis_HAM_ISI.m

Acceptance criteria:

- **Vertical**
  For a +1000 count offset drive on vertical actuators
  o Collocated sensors must be 1400 counts +/- 10%

- **Horizontal**
  For a +1000 count offset drive on horizontal actuators
  o Collocated sensors must be 2000 counts +/- 10%
  o Non-collocated horizontal sensors must be 1250 counts +/-10%

Test result: **Passed: X**   **Failed: ___**

▪ *Step 13 - Linearity test*

	Slope	Offset	Average slope	Variation from average(%)
H1	1.889289	1019.171		0.081693
H2	1.882807	-886.91	1.887747	-0.26171
H3	1.891146	-1557.84		0.180022
V1	1.311875	1258.767		-0.94369
V2	1.319145	-563.562	1.324373	-0.39473
V3	1.342099	-5.08478		1.338424

Table - Slopes and offset of the triplet Actuators - HAM-ISI - Sensors

Scripts files for taking data in SVN at: seismic/HAM-ISI/Common/Testing_Functions_HAM_ISI/
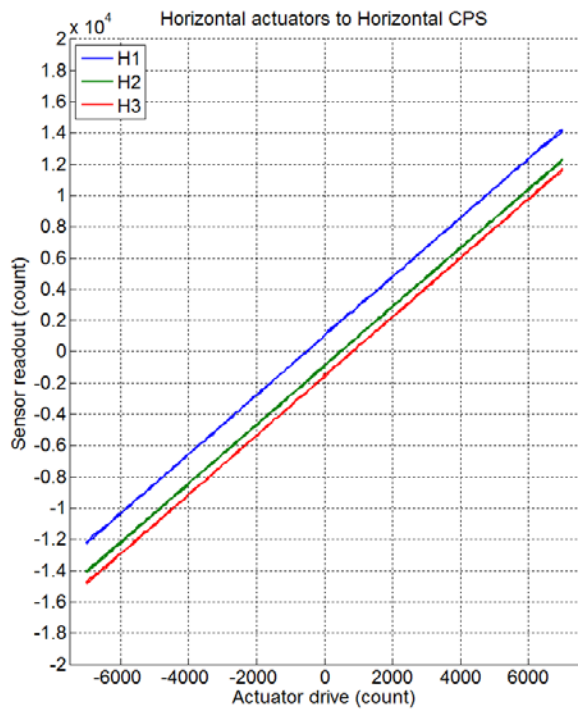- Linearity_Test_Awgstream_HAM_ISI.m
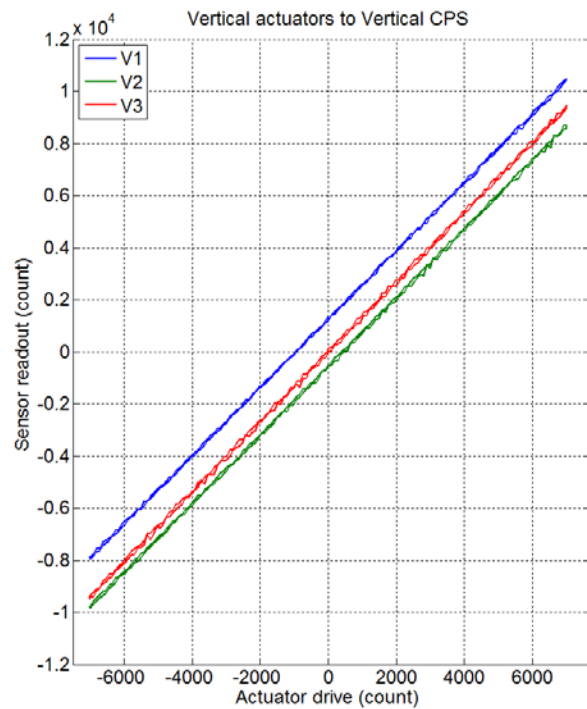
Figure - Horizontal and vertical actuators x HAM-ISI x sensors

Data files in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Linearity_Test/
- LLO_ISI_HAM5_Linearity_test_20120806.mat

Figures in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Figures/Linearity_Test/
- LLO_ISI_HAM5_Linearity_test_20120806.pdf

Acceptance criteria:

- Horizontal and vertical slopes of the triplet actuators x HAM-ISI x sensors: Average slope +/- 1%

Issues/difficulties/comments regarding this test:
We can notice that the V3 slope barely fail the requirements, we therefore call the test waived, but performances are not worrisome here.
The differences in slopes in comparison to the side chamber testing can likely be explained by the fact that we used field cables extensions for side chamber test.

Test result: **Passed:** __   **Failed:** ___   **Waived: X**

▪ *Step 14- Frequency response*

Compensation filters of the new GS13 interface chassis are located in the geophone pre-filters bank.

▪ *Step 14.1 - Local to local measurements*

Local to local transfer functions have been measured with 90 repetitions, before the chamber was closed.

Data files in SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM5_Data_TF_L2L_50mHz_500mHz_20120814-035828.mat
- LLO_ISI_HAM5_Data_TF_L2L_500mHz_5Hz_20120813-214855.mat
- LLO_ISI_HAM5_Data_TF_L2L_5Hz_200Hz_20120813-201522.mat
- LLO_ISI_HAM5_Data_TF_L2L_200Hz_800Hz_20120813-184149.mat

Data collection script files:
seismic/HAM-ISI/L1/HAM5/Scripts/Data_Collection/
- Run_Exc_Batch_L1ISIHAM5.m

Scripts files for processing and plotting in SVN at:
seismic/HAM-ISI/L1/HAM5/Scripts/Control_Scripts/
- Step_1_TF_L2L_L1_ISI_HAM5.m

Figures in SVN at:
/seismic/HAM-ISI/L1/HAM5/Data/Figures/Transfer_Functions/Measurements/Undamped/
- LLO_ISI_HAM5_TF_L2L_Raw_from_ACT_to_CPS_2012_08_13.fig
- LLO_ISI_HAM5_TF_L2L_Raw_from_ACT_to_GS13_2012_08_13.fig

Storage of measured transfer functions in the SVN at:
seismic/HAM-ISI/L1/HAM5/Data/Transfer_functions/Measurements/Undamped/
- L1_ISI_HAM5_TF_L2L_Raw_2012_08_13.mat

The local to local transfer functions are presented below.
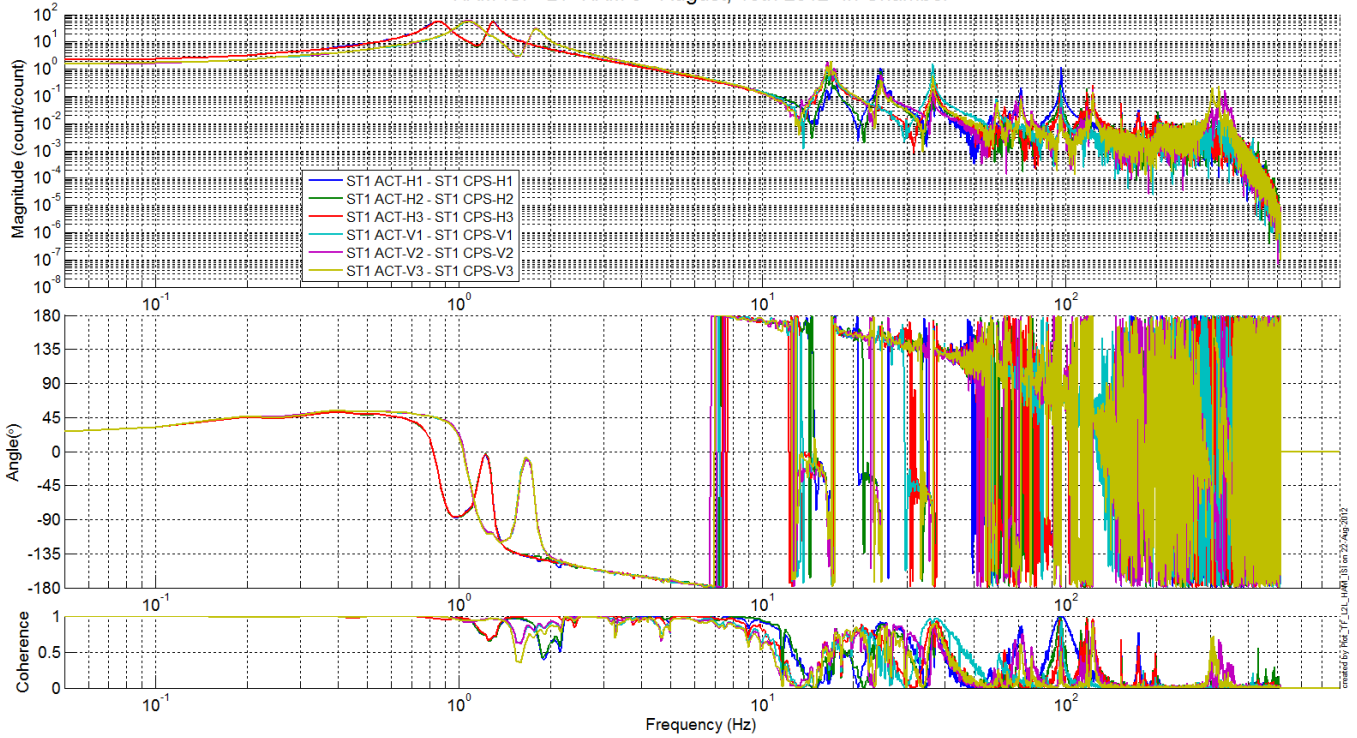
Figure - Local to Local Measurements –Capacitive Position Sensors
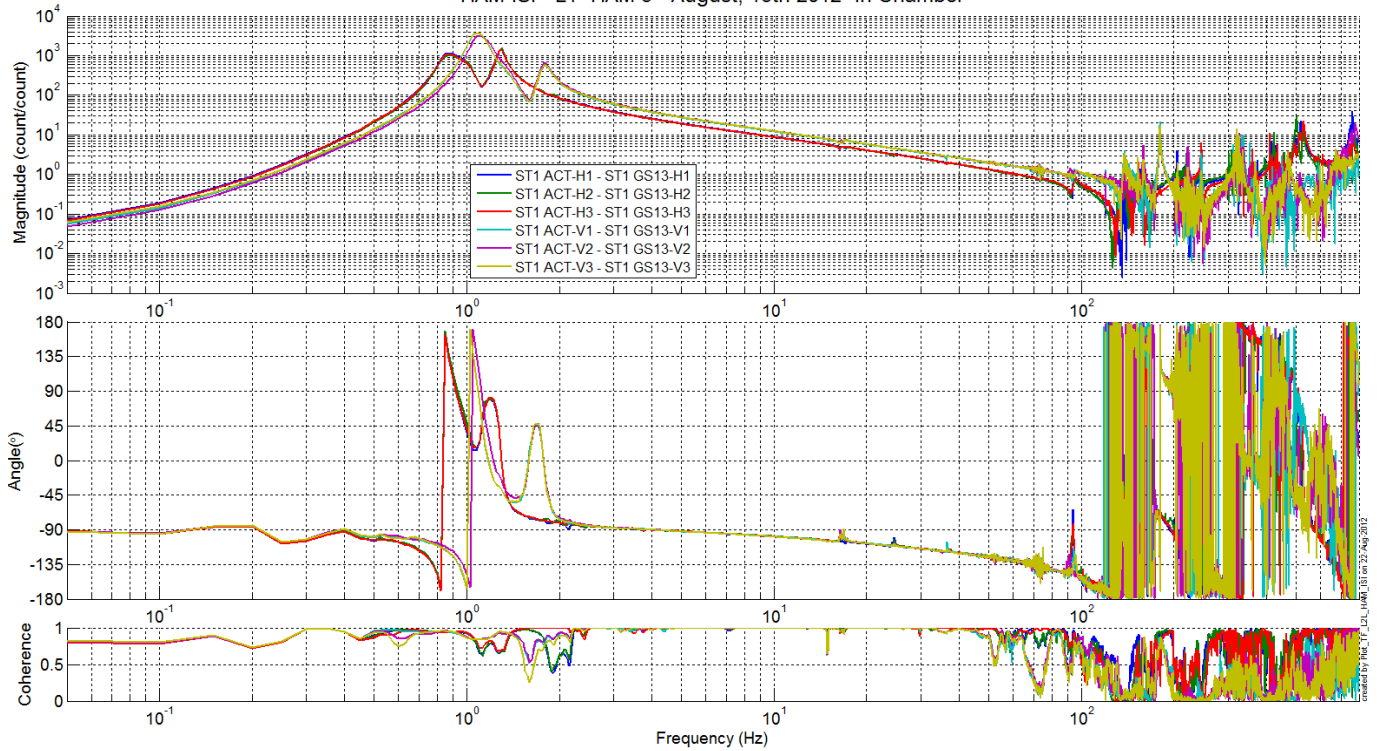

Figure - Local to Local Measurements – Inertial sensors

Conclusion of Initial In-Chamber testing

All tests were easily passed on this ISI after the installation in chamber. We omitted to do the tilt test, but all sensors appear fine. Additionally, the manual range of motion test and actuator gaps check were not redone. The chamber was closed on August 15th 2012. Subsequently, additional transfer functions were taken, which all confirmed good working conditions of the ISI.