

*LIGO Laboratory / LIGO Scientific Collaboration*

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**L1 BSC 1 BSC-ISI, Pre-integration Testing report,****Phase II**

E1100856-v2

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## *Introduction*

The BSC-ISI testing is performed in three phases:

- 1) BSC-ISI, Pre-integration Testing, Phase I (post-assembly, in the staging building)
- 2) BSC-ISI, Pre-integration Testing, Phase II: Final tests done before insertion in the chamber
- 3) BSC-ISI, Integration Phase Testing: Procedure and results related to the commissioning in the chamber.

The ISI-BSC2 was moved from the Staging building to the LVEA on July 17th, 2012. Then the ISI was placed on the test stand a few days later.

This document presents results from the series of tests (Phase II) performed on the ISI-BSC2 (BS) in the corner station. The tests were done with the ITMY quadruple suspension installed in its final version.

First tests started on October 24th, 2012. The first testing phase (II-a validation before cartridge installation) was completed on October 31<sup>st</sup> 2012.

All results are posted on the SVN at:

<https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/>

The following types of documents can be found in the SVN:

- Data location
- Figures location

## **1. Phase II-a**

### **1. Hardware changes**

#### **1. CPS – E1100369**

No change.

#### **2. GS13 – E1100740**

GS13 have not been replaced since phase I testing in the staging building.

#### **3. L4C – E1100740**

L4C have not been replaced since phase I testing in the staging building.

#### **4. T240 – E1100740**

T240s have not been replaced since phase I testing in the staging building.

#### **5. Cables – E1100822**

No cable have been replaced since phase I testing in the staging building.

#### **6. Misc**

No hardware changes since phase I testing in the staging building.

### 2. Electronic Inventory

This table reports the electronic equipment used in the LVEA.

Hardware	Ligo reference	S/N
Interface Chassis Pod 1	D1002432	S1201326
Interface Chassis Pod 2	D1002432	S1201325
Interface Chassis Pod 3	D1002432	S1201324
Anti-aliasing Chassis Pod 1	D1002693	S1203001
Anti-aliasing Chassis Pod 2	D1002693	S1203000
Anti-aliasing Chassis Pod 3	D1002693	S1202999
Binary Input Chassis 1	D1001726	S1101295
Binary Input Chassis 2	D1001726	S1101296
Binary Output Chassis	D1001728	S1101327
T240 Interface Pod 1	D1002694	S1201402
T240 Interface Pod 2	D1002694	S1201391
T240 Interface Pod 3	D1002694	S1201386
Anti-image Chassis	<i>D1000305</i>	<i>S1203007</i>
Coil driver Pod 1	D0902744	S1103328
Coil driver Pod 2	D0902744	S1103322
Coil driver Pod 3	D092744	S1103311
Expansion chassis	L1seibsc1	S1001147

Table 1 - Electronic inventory

### 3. Models Modifications

No model modifications were done between the beginning and the end of Phase 2a testing.

**4. Mass distribution**

This final mass distribution will be presented once all elements will be installed on the ISI (during phase II-b). These elements are the vibration absorbers on stage 1 and the QUAD structure.

**1. Seismic**

**Stage 1**

Stage 1	HighBay (lbs)	LVEA (lbs)	LVEA (kgs)
Corner 1	56.90	59.00	26.76
Corner 2	32.50	43.72	19.83
Corner 3	43.00	43.72	19.83
Total	132.40	146.44	66.42

**Stage 2**

The total of masses on Stage 2 is 1453.65 lbs (=663.90 kgs).

**2. Suspension**

The quad structure was weighed to be:

	Weight (lbs)	Weight (kgs)
Upper structure	266	120.66
Lower structure	531	240.86
Total	797	361.5128

**3. Misc**

20 dog clamps at 1.26 lbs each create an extra load of 25.2 lbs (=11.47 kgs)

**4. Total**

Nominal mass hanging on stage 0-1 blades (without stage 2): 912Kg – 2010lb

Nominal mass hanging on stage 1-2 blades: 2830Kg – 6239lb

Nominal payload on stage 1: 109Kg – 240lb

Nominal payload on stage 2: 1185Kg – 2612lb

		Plan	Staging Bldg 6/6/2012	LVEA		
				Detail	Overall	Difference
Stage 1 (kgs)		108.86	60.06	66.42	66.42	6.37
Stage 2 (kgs)	Masses	1183.42	1071.48	663.90	1036.88	-34.60
	Suspension	N/A	N/A	361.51		
	Miscellaneous	N/A	N/A	11.47		
Total (kgs)		1292.28	1131.53	1103.30	1103.30	-28.23







#### 4. Offsets CPS Unlocked vs locked

The table is not perfectly balanced but it is considered sufficiently good to perform the series of test before the cartridge installation. A fine balancing will be done during phase II-b.

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/)

- L1\_ISI\_ITMY\_CPS\_Read\_Back\_ISI\_Locked\_2012\_10\_26\_142944.mat
- L1\_ISI\_ITMY\_CPS\_Read\_Back\_ISI\_Unlocked\_2012\_10\_26\_170205.mat

Sensors	Table locked		Table unlocked		Difference locked - unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	Offset (Mean)	mil
ST1 - H1	-872.99	46.92	-104.30	5.47	-768.70	-0.92
ST1 - H2	1234.01	30.98	98.13	5.64	1135.88	1.35
ST1 - H3	-1121.20	66.05	386.94	6.78	-1508.13	-1.80
ST1 - V1	-213.83	47.66	476.14	6.05	-689.97	-0.82
ST1 - V2	639.41	58.47	-143.73	4.69	783.13	0.93
ST1 - V3	-805.52	50.14	-78.90	6.17	-726.62	-0.87
ST2 - H1	-656.49	70.03	1058.86	28.82	-1715.36	-0.51
ST2 - H2	1568.78	69.74	244.71	20.47	1324.07	0.39
ST2 - H3	-829.97	64.96	154.99	17.47	-984.96	-0.29
ST2 - V1	-755.05	121.50	-1091.32	29.12	336.28	0.10
ST2 - V2	-1091.14	146.86	-256.65	30.01	-834.49	-0.25
ST2 - V3	1049.88	142.61	601.49	23.19	448.39	0.13

Table 3 - Locked vs Unlocked Position

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

#### 5. Offset local drive

**Note:** Due to longer cables, offsets measured by CPS for a 7000 count drive are slightly lower than offsets measured in the staging building.

Results of this test can be found in the SVN at:

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/)

- L1\_ISI\_ITMY\_Offset\_Local\_Drive\_20121026.mat





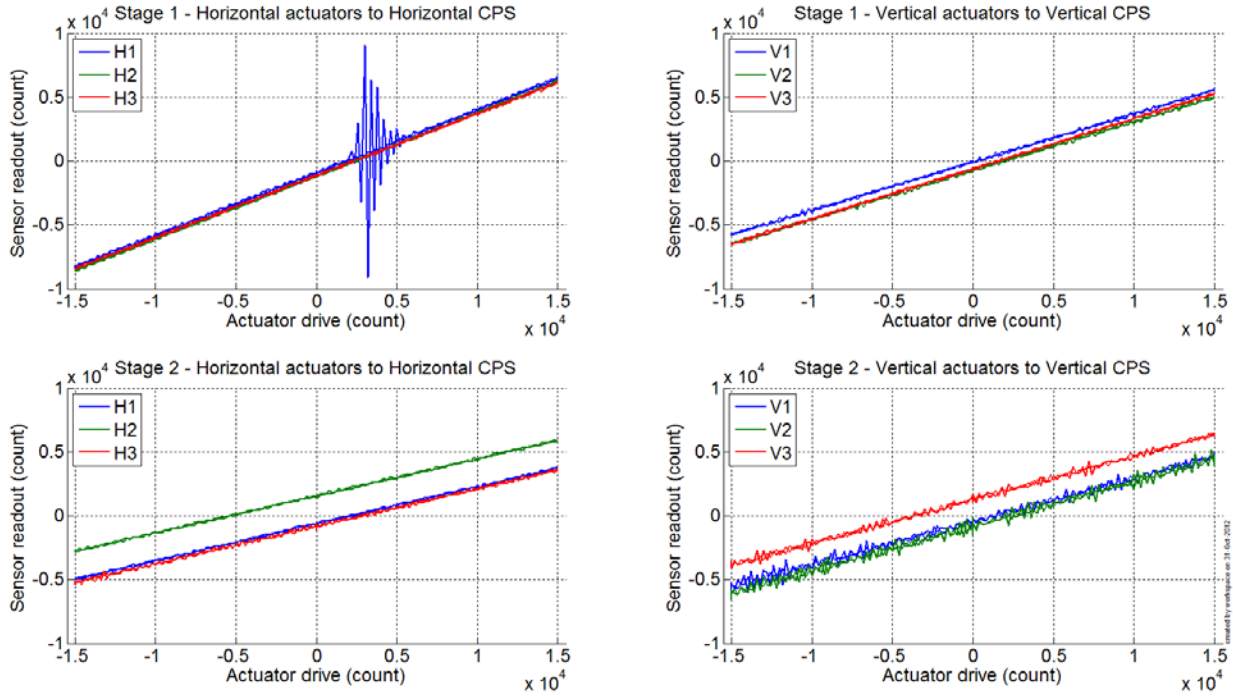


Figure 2 - Linearity test –L1 - BS – In LVEA

		Slope	Offset	Average slope	Variation from average(%)
Stage 1	ST1 - H1	0.491925	-895.194	0.490326	0.326181
	ST1 - H2	0.493962	-1178.07		0.741565
	ST1 - H3	0.48509	-1138.05		-1.06775
	ST1 - V1	0.377912	-88.2464	0.384375	-1.68135
	ST1 - V2	0.382807	-745.375		-0.40799
	ST1 - V3	0.392406	-604.221		2.08934
Stage 2	ST2 - H1	0.290144	-616.071	0.291044	-0.30894
	ST2 - H2	0.289504	1554.751		-0.52891
	ST2 - H3	0.293482	-826.434		0.837849
	ST2 - V1	0.338293	-448.857	0.34323	-1.43833
	ST2 - V2	0.350097	-821.769		2.000706
	ST2 - V3	0.341299	1257.176		-0.56237

Table 7 - Slope – Offset Linearity test

Note that this table was corrected after the fact to adjust based on the mis-cabling of Stage 2 corner 3 and stage 1 corner 2.

Test result: Passed:      Failed:      Waived:  X

## 6. Transfer functions and Comparison with measurements done in the staging building.

### 1. At the end station

The parameters for the measurements in the LVEA are slightly different from those in the staging building. We chose to have weaker excitation but longer averages in an effort to reduce risk of the attached suspension.

At this point, only the tuned mass dampers on the spring are installed (No vibration absorbers, no Viton under the keel masses, No vibration absorbers on the BS)

Measurements data can be found in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Data/Transfer\_Functions/Measurements/Undamped:

- LLO\_ISI\_BSC1\_Data\_L2L\_10mHz\_100mHz\_ST1\_ST2\_20121029-214002.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_100mHz\_700mHz\_ST1\_ST2\_20121029-161711.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_700mHz\_10Hz\_ST1\_ST2\_20121027-000402.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_10Hz\_100Hz\_ST1\_ST2\_20121026-212711.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_100Hz\_500Hz\_ST1\_ST2\_20121026-200720.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_500Hz\_1000Hz\_ST1\_ST2\_20121026-190253.mat

Data after processing can be found in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Data/Transfer\_Functions/Simulations/Undamped

- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_10mHz\_1000Hz\_2012\_10\_29.mat

The transfer functions can be found in the SVN at:

seismic/BSC-ISI/L1/ITMY/Data/Figures/Transfer\_Functions/Measurements/Undamped/

- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST1\_ACT\_to\_ST1\_CPS\_2012\_11\_07.fig
- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST1\_ACT\_to\_ST1\_L4C\_2012\_11\_07.fig
- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST2\_ACT\_to\_ST2\_CPS\_2012\_11\_07.fig
- LLO\_ISI\_BSC2\_TF\_L2L\_Raw\_from\_ST2\_ACT\_to\_ST2\_GS13\_2012\_11\_07.fig

**Note 1:** The transfer functions are measured from the Output filters bank excitation point to the input (IN1) of the input filters bank. The transfer functions presented below are raw transfer functions without any electronic compensation.

**Note 2:** The L4Cs are out of phase (should be -90 before 1Hz). A minus sign is added in the calibration filters that convert count to nm/s.

**Note 3:** On the ST1-ACT-H to ST1-CPS-H transfer functions, we can see the first resonances of the LVEA test stand at 21.6 Hz, 23.8Hz and 31Hz (matches within a few Hz our BSC 2 results).

**Note 4:** Even without vibration absorbers on the Quad structure, the first resonance visible on Stage 2 is at 154 Hz.

BSC-ISI - LLO - BSC1 - November 7th, 2012 -Test Stand LVEA with ITMY Unlocked & Damped - ISI Undamped

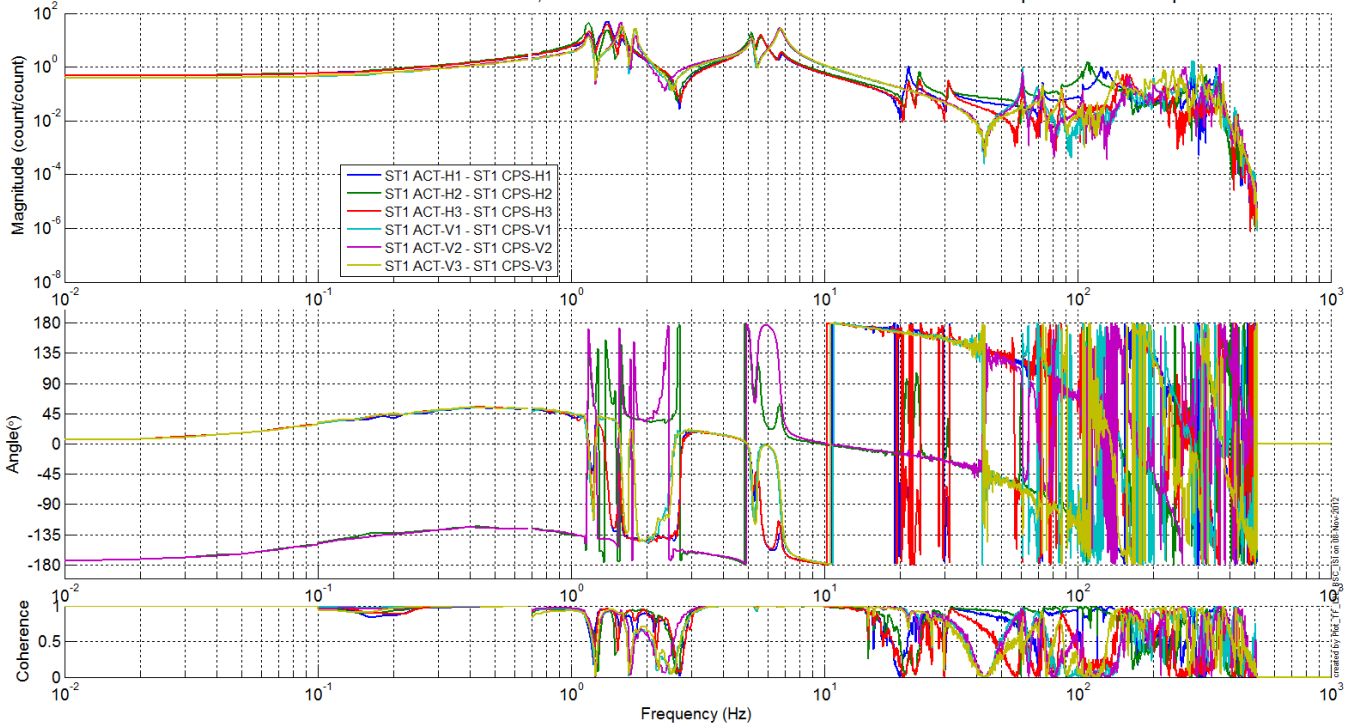


Figure 3 - TF ST1 ACT to ST1 CPS

BSC-ISI - LLO - BSC1 - November 7th, 2012 -Test Stand LVEA with ITMY Unlocked & Damped - ISI Undamped

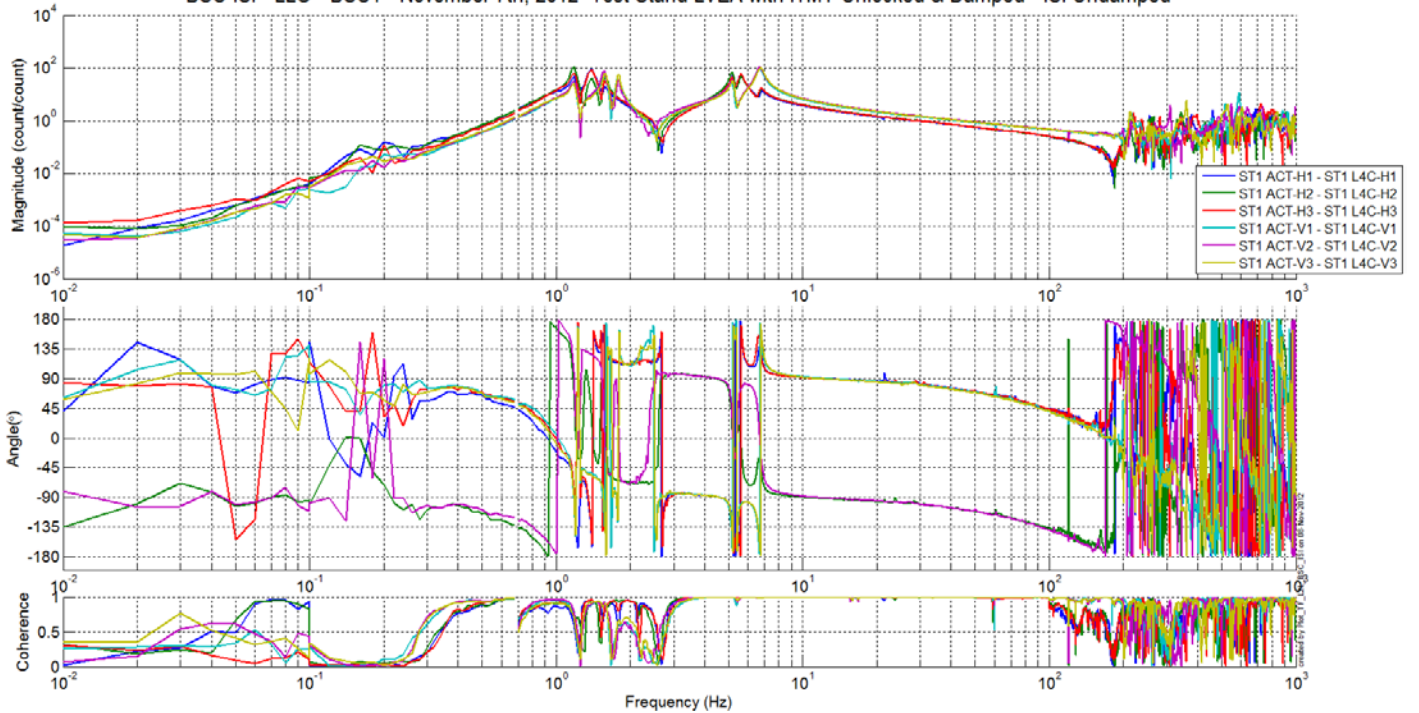


Figure 4 - TF ST1 ACT to ST1 L4C

Figure 5 - TF ST1 ACT to ST1 T240



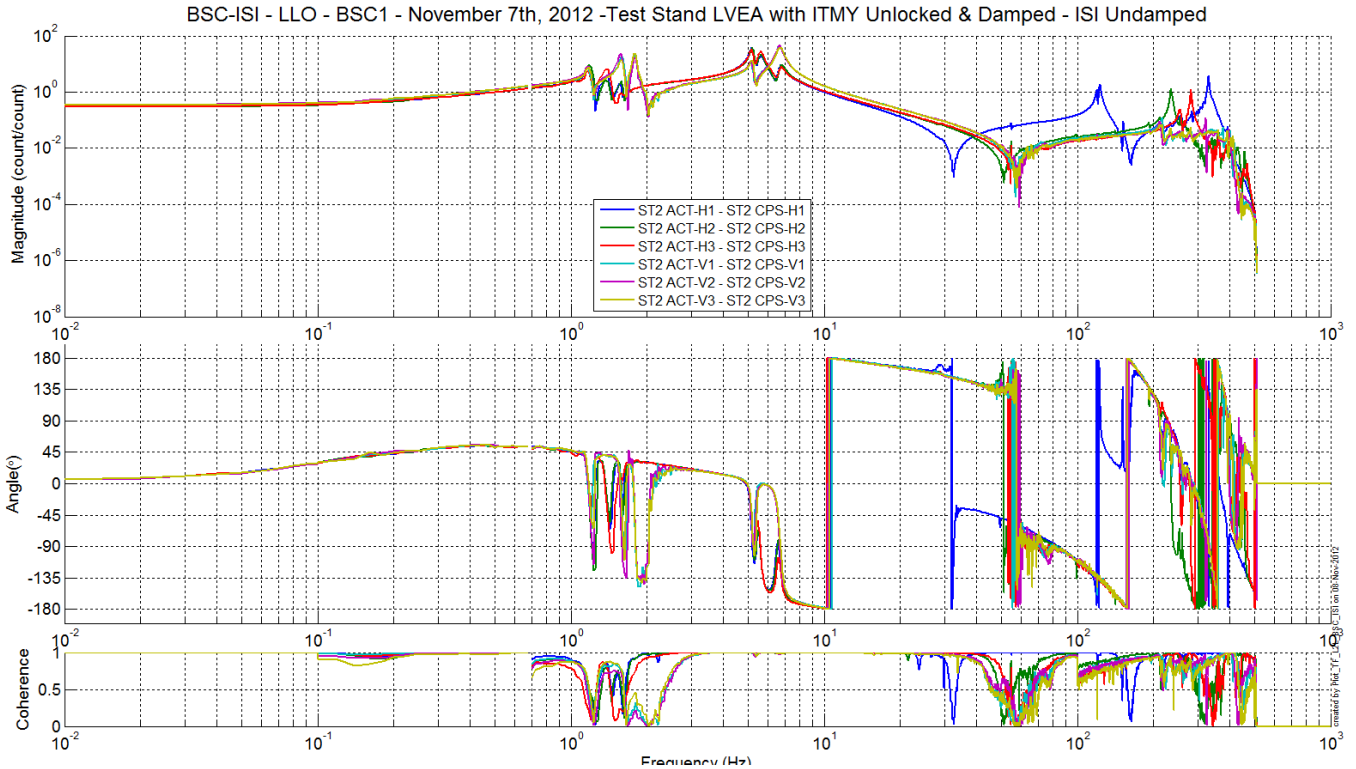


Figure 6 - TF ST2 ACT to ST2 CPS

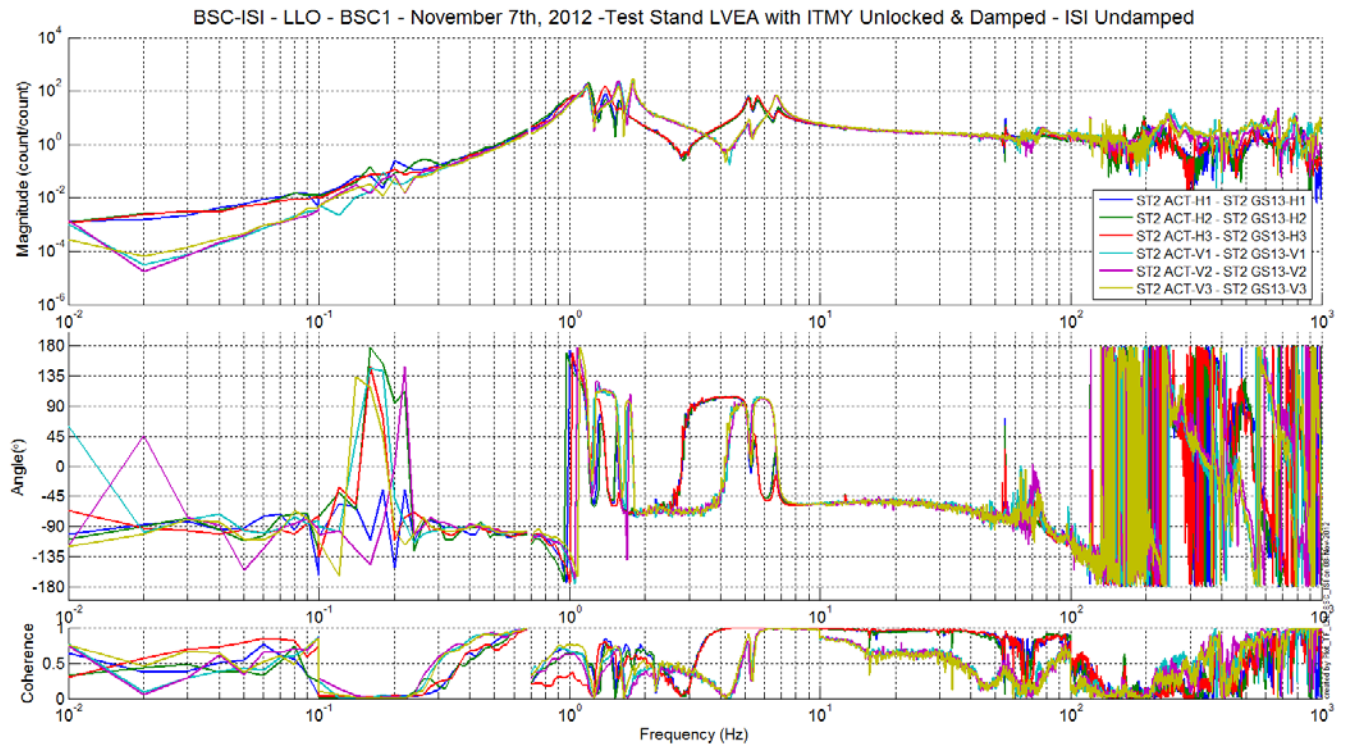


Figure 7 - TF ST2 ACT to ST2 GS13



## 2. Comparisons with measurements in the staging building –not done yet

The script used to compare transfer function can be found in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Scripts/Misc

- Comparison\_TF\_L2L\_LLO\_ISI\_BSC2.m

The figure that shows the comparison between the transfer functions of the staging building and the LVEA are located in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Data/Figures/Transfer\_Functions/Measurements/Comparison/

- COMP\_LVEA\_L1\_ISI\_ITMY\_ST1\_CPS\_2012\_10\_31\_.fig
- COMP\_LVEA\_L1\_ISI\_ITMY\_ST1\_L4C\_2012\_10\_31\_.fig
- COMP\_LVEA\_L1\_ISI\_ITMY\_ST2\_CPS\_2012\_10\_31\_.fig
- COMP\_LVEA\_L1\_ISI\_ITMY\_ST2\_GS13\_2012\_10\_31\_.fig

**Main differences are:**

- The DC gains (cables resistance is different due to the length difference)
- Resonances of the rigid body modes [1; 10]Hz (different payload) It is especially visible from 1 to 2 Hz on all sensors.
- ST1-CPS resonances different in the staging building and EY (Test stand short legs vs long legs).
- Resonance at 20.5 Hz on stage 2 sensors (4<sup>th</sup> vertical mode of the quad? –cf <https://lhocds.ligo-wa.caltech.edu/wiki/Resonances>)
- Similar at high frequencies

**Figure 8 - Transfer functions comparison - ST1 ACT to ST1 CPS**

**Figure 9 - Transfer functions comparison - ST1 ACT to ST1 L4C**

**Figure 10 - Transfer functions comparison - ST2 ACT to ST2 CPS**



## 2. Phase II-b

### 1. Hardware changes

#### 1. CPS – E1100369

No change.

#### 2. GS13 – E1100740

GS13s have not been replaced since phase II-a testing on the test stand.

#### 3. L4C – E1100740

L4Cs have not been replaced since phase II-a testing on the test stand.

#### 4. T240 – E1100740

T240s have not been replaced since phase II-a testing on the test stand.

#### 5. Cables – E1100822

2 T240 extension cables were swapped in order to allow connecting those cables to the vacuum feedthrus.

#### 6. Misc

No hardware changes since II-a testing on the test stand.

### 2. Electronic Inventory

No change since phase II-a testing on the test stand.

### 3. Models Modifications

The model was rebuilt 3 times between mid October and mid November:

- October 25<sup>th</sup> 2012: simple rebuild
- November 12<sup>th</sup> 2012 latest change from MIT/Hanford
- November 13<sup>th</sup> 2012: terminate IPC

**4. Mass distribution –not updated yet**

This final mass distribution will be presented once all elements will be installed on the ISI (during phase II-b). These elements are the vibration absorbers on stage 1 and the QUAD structure.

**1. Seismic**

**Stage 1**

12/17/2012	D0902612	D0902613	D0902616					D1001760		
			1	2	3	4	5			
	12	15	3.5	1	2	5	0.5	15.86	Lbs	kgs
C1-1									0	0
C1-2		1							15	6.81
C1-3						2		2	41.72	18.94088
C2-1									0	0
C2-2									0	0
C2-3			1	1		1		2	41.22	18.71388
C3-1									0	0
C3-2									0	0
C3-3			1			2		2	45.22	20.52988
Stage 1	0	1	2	1	0	5	0	6	143.16	64.99464

Stage 1	HighBay (lbs)	LVEA (lbs)	LVEA (kgs)	After Cartridge (lbs)	After Cartridge (kgs)
Corner 1	56.90	59.00	26.76	56.72	
Corner 2	32.50	43.72	19.83	41.22	18.71
Corner 3	43.00	43.72	19.83	45.22	20.53
Total	132.40	146.44	66.42	143.16	64.99

**Stage 2**

The total of masses on Stage 2 is 1453.65 lbs (=663.90 kgs).

12/17/2012	D1003136	D1003161	D071200								
			0	1	2	3	4	5			6
	50	47.62	0.6	1.1	2.2	4.5	7.9	15.6	27.2	lbs	kgs
Keel	12									600	272.40
Optical		16								761.92	345.91
E-1				2		1				6.7	3.04
E-2			3	1				2	1	61.3	27.83
E-3			1	2		3			1	43.5	19.75
F1										0	0.00
F2										0	0.00
F3										0	0.00
Stage 2	12	16	4	5	0	4	0	2	2	1473.42	668.93

Stage 2	HighBay (lbs)	LVEA (lbs)	LVEA (kgs)	After Cartridge (lbs)	After Cartridge (kgs)
Total	0	1453.65	663.9	1473.42	668.93

**2. Suspension**

The quad structure was weighed to be:

	Weight (lbs)	Weight (kgs)
Upper structure	266	120.66
Lower structure	531	240.86
Total	797	361.5128

**3. Misc**

20 dog clamps at 1.26 lbs each create an extra load of 25.2 lbs (=11.47 kgs)



**5. Basic functionalities just after installing the BSC-ISI on the test stand**

**5. Pressure sensors**

All pressure sensors are working.

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/LLO\\_ISI\\_ITMY\\_Pressure\\_Sensors\\_Check\\_Calibrated\\_2012\\_12\\_16\\_180617.mat](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/LLO_ISI_ITMY_Pressure_Sensors_Check_Calibrated_2012_12_16_180617.mat)

Sensors	Pressure (KPa)		
	Corner 1	Corner 2	Corner 3
<b>ST1-L4C-P</b>	100.31	100.00	99.36
<b>ST1-L4C-D</b>	-0.18	-0.47	0.81
<b>ST1-GS13-P</b>	100.34	100.44	99.67
<b>ST1-GS13-D</b>	-0.55	-0.19	-0.13
<b>ST1-T240-P</b>	154.28	154.38	154.50

Table 8 - Geophones Pressure sensors

Note/comment about this test: N/A.

Test result: Passed:  X  Failed:  \_\_\_  Waived:  \_\_\_

**6. Spectra**

Spectra of the instrument can be found in the SVN at:

[seismic/BSC-ISI/L1/ITMY/Data/Spectra/Undamped/L1\\_ISI\\_ITMY\\_ASD\\_m\\_LOC\\_CPS\\_T240\\_L4C\\_GS13\\_2012\\_12\\_16\\_222822.mat](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Spectra/Undamped/L1_ISI_ITMY_ASD_m_LOC_CPS_T240_L4C_GS13_2012_12_16_222822.mat)

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Figures/Spectra/Undamped/L1\\_ISI\\_ITMY\\_ASD\\_m\\_LOC\\_CPS\\_T240\\_L4C\\_GS13\\_2012\\_12\\_16\\_222822.fig](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Figures/Spectra/Undamped/L1_ISI_ITMY_ASD_m_LOC_CPS_T240_L4C_GS13_2012_12_16_222822.fig)



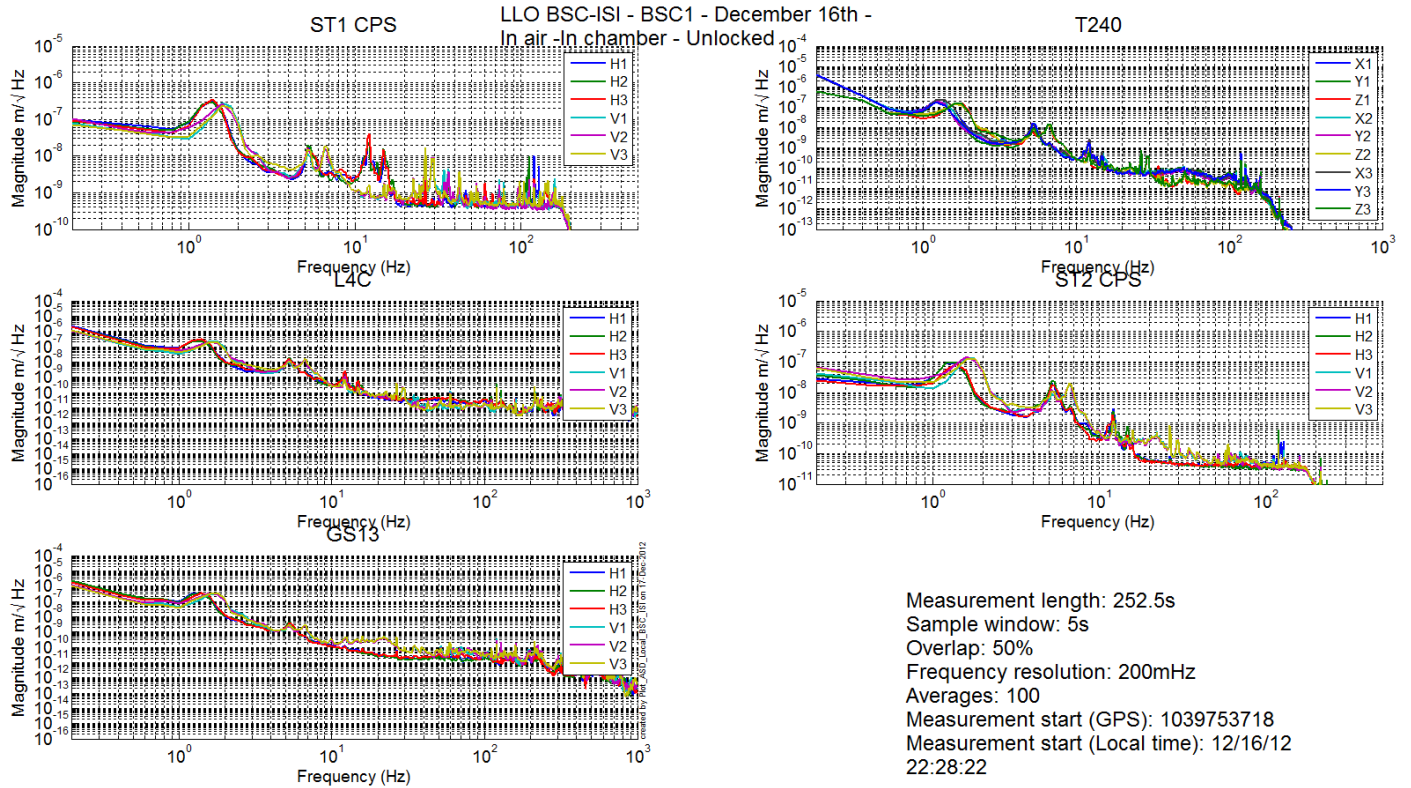


Figure 12 - Spectra inboard instruments - ISI Unlocked

Test result: Passed: X Failed:     Waived:    

7. Actuators-cables resistance

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/L1\\_ISI\\_ITMY\\_Actuators\\_Resistance\\_20121026T175017.mat](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/L1_ISI_ITMY_Actuators_Resistance_20121026T175017.mat)

	Stage 1						Stage 2					
	H1	H2	H3	V1	V2	V3	H1	H2	H3	V1	V2	V3
Script												

Test result: Passed: X Failed:     Waived:

**8. Offsets CPS Unlocked vs locked**

The table is not perfectly balanced but it is considered sufficiently good to perform the series of test before the cartridge installation. A fine balancing will be done during phase II-b.

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/)

- L1\_ISI\_ITMY\_CPS\_Read\_Back\_ISI\_Locked\_2012\_12\_17\_094105.mat
- L1\_ISI\_ITMY\_CPS\_Read\_Back\_ISI\_Unlocked\_2012\_12\_05\_171334.mat

Sensors	Table locked		Table unlocked		Difference locked - unlocked	
	Offset (Mean)	Std deviation	Offset (Mean)	Std deviation	Offset (Mean)	mil
ST1 - H1	-120.098	4.818902	-844.736	27.99514	724.6376	0.862664
ST1 - H2	-416.744	5.614173	-1234.19	32.54445	817.4503	0.973155
ST1 - H3	-179.702	8.446006	-975.728	30.68611	796.0263	0.94765
ST1 - V1	604.8375	4.357051	1087.314	55.51869	-482.476	-0.57438
ST1 - V2	175.6026	7.864287	-940.162	33.23999	1115.764	1.328291
ST1 - V3	891.1182	7.266689	-187.756	41.18756	1078.875	1.284375
ST2 - H1	-104.458	8.561111	-888.362	41.0035	783.904	0.233305
ST2 - H2	-811.872	6.992354	683.6736	48.2142	-1495.55	-0.4451
ST2 - H3	-1557.67	9.110095	3242.06	38.5595	-4799.73	-1.42849
ST2 - V1	2178.387	14.96533	1006.21	117.4369	1172.177	0.348862
ST2 - V2	1081.196	15.60391	-2935.81	84.84448	4017.011	1.195539
ST2 - V3	825.0956	16.02009	306.4185	91.47976	518.6771	0.154368

Table 9 - Locked vs Unlocked Position

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

**9. Offset local drive**

**Note:** Due to longer cables, offsets measured by CPS for a 7000 count drive are slightly lower than offsets measured in the staging building.

Results of this test can be found in the SVN at:

[https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static\\_Tests/](https://svn.ligo.caltech.edu/svn/seismic/BSC-ISI/L1/ITMY/Data/Static_Tests/)

- L1\_ISI\_ITMY\_Offset\_Local\_Drive\_20121205.mat

		Sensors					
		ST1 - H1	ST1 - H2	ST1 - H3	ST1 - V1	ST1 - V2	ST1 - V3
Actuators	ST1 - H1	3782.413	1537.945	1503.76	8.15604	-16.9929	31.74798
	ST1 - H2	-1517.71	-3791.08	-1528.08	-2.59626	-48.2496	18.19501
	ST1 - H3	1498.112	1511.087	3722.614	-3.01758	-17.4626	34.44715
	ST1 - V1	49.55296	-113.163	84.20534	2892.656	-508.902	-437.901
	ST1 - V2	-61.3174	-23.8398	133.4533	487.9887	-2926.83	477.7768
	ST1 - V3	-118.392	37.1654	15.01116	-461.584	-474.996	2879.417

Table 10 - Static Tests – Local to Local - Stage 1

		Sensors					
		ST2 - H1	ST2 - H2	ST2 - H3	ST2 - V1	ST2 - V2	ST2 - V3
Actuators	ST2 - H1	2168.75	342.1649	310.843	41.63178	9.7978	11.4344
	ST2 - H2	360.5707	2134.287	333.9448	7.63996	-39.5812	59.91491
	ST2 - H3	326.1505	321.9442	2142.294	69.3909	-8.9448	5.23701
	ST2 - V1	113.7671	69.66098	-93.753	2515.065	339.811	70.92607
	ST2 - V2	-153.323	102.8306	87.9056	71.23128	2584.927	348.6969
	ST2 - V3	120.6902	-170.311	50.2812	355.5377	38.24	2472.573

Table 11 - Static Tests – Local to Local - Stage 2

It is apparent from this test that St1 corner 2 actuator cables are plugged in the opposite direction. This issue was corrected before closing the dome.

Test result: Passed:     Failed:     Waived:   X  

**10. Offset Cartesian drive**

The test was not performed because it only tests the matrices, which can be changed at any time.

Test result: Passed:     Failed:     Waived:   X



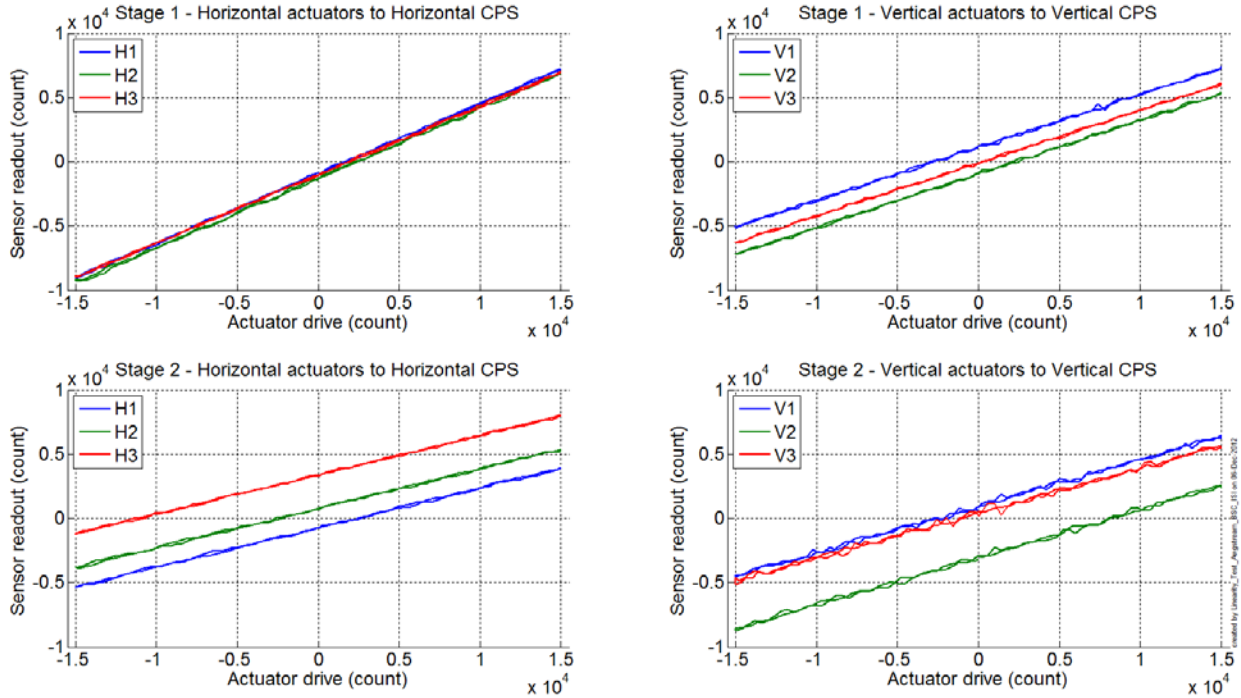


Figure 13 - Linearity test –L1 - BS – In LVEA

	Slope	Offset	Average slope	Variation from average(%)	
Stage 1	ST1 - H1	0.54184	-906.475	0.538735	0.576286
	ST1 - H2	0.542533	-1281.66		0.704927
	ST1 - H3	0.531833	-1016.26		-1.28121
Stage 2	ST1 - V1	0.412395	1107.798	0.413989	-0.38512
	ST1 - V2	0.417982	-948.447		0.964468
	ST1 - V3	0.411591	-110.754		-0.57935
	ST2 - H1	0.3081	-725.737	0.306914	0.386534
	ST2 - H2	0.306895	775.5541		-0.00608
	ST2 - H3	0.305746	3395.5		-0.38045
	ST2 - V1	0.362764	952.3927	0.361424	0.37093
	ST2 - V2	0.371469	-3034		2.779329
	ST2 - V3	0.350038	404.1597		-3.15026

Table 13 - Slope – Offset Linearity test

Test result: Passed:      Failed:      Waived:  X

## 6. Transfer functions and Comparison with measurements done in the staging building.

### 13. At the end station

The parameters for the measurements in the LVEA are slightly different from those in the staging building. We chose to have weaker excitation but longer averages in an effort to reduce risk of the attached suspension.

At this point, only the tuned mass dampers on the spring are installed (No vibration absorbers, no Viton under the keel masses, No vibration absorbers on the BS)

Measurements data can be found in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Data/Transfer\_Functions/Measurements/Undamped:

- LLO\_ISI\_BSC1\_Data\_L2L\_10mHz\_100mHz\_ST1\_ST2\_20121029-214002.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_100mHz\_700mHz\_ST1\_ST2\_20121029-161711.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_700mHz\_10Hz\_ST1\_ST2\_20121027-000402.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_10Hz\_100Hz\_ST1\_ST2\_20121026-212711.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_100Hz\_500Hz\_ST1\_ST2\_20121026-200720.mat
- LLO\_ISI\_BSC1\_Data\_L2L\_500Hz\_1000Hz\_ST1\_ST2\_20121026-190253.mat

Data after processing can be found in the SVN at:

SeiSVN/seismic/BSC-ISI/L1/ITMY/Data/Transfer\_Functions/Simulations/Undamped

- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_10mHz\_1000Hz\_2012\_10\_29.mat

The transfer functions can be found in the SVN at:

seismic/BSC-ISI/L1/ITMY/Data/Figures/Transfer\_Functions/Measurements/Undamped/

- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST1\_ACT\_to\_ST1\_CPS\_2012\_12\_16.fig
- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST1\_ACT\_to\_ST1\_L4C\_2012\_12\_16.fig
- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST1\_ACT\_to\_ST1\_T240\_2012\_12\_16.fig
- LLO\_ISI\_BSC1\_TF\_L2L\_Raw\_from\_ST2\_ACT\_to\_ST2\_CPS\_2012\_12\_16.fig
- LLO\_ISI\_BSC2\_TF\_L2L\_Raw\_from\_ST2\_ACT\_to\_ST2\_GS13\_2012\_12\_16.fig

**Note 1:** The transfer functions are measured from the Output filters bank excitation point to the input (IN1) of the input filters bank. The transfer functions presented below are raw transfer functions without any electronic compensation.

**Note 2:** The L4Cs are out of phase (should be -90 before 1Hz). A minus sign is added in the calibration filters that convert count to nm/s.

**Note 3:** On the ST1-ACT-H to ST1-CPS-H transfer functions, we can see the first resonances of the LVEA test stand at 21.6 Hz, 23.8Hz and 31Hz (matches within a few Hz our BSC 2 results).

**Note 4:** Even without vibration absorbers on the BS structure, the first resonance visible on Stage 2 is at 154 Hz.

BSC-ISI - LLO - BSC1 - December 16th, 2012 -In Chamber LVEA with ITMY Unlocked & Damped - ISI Undamped

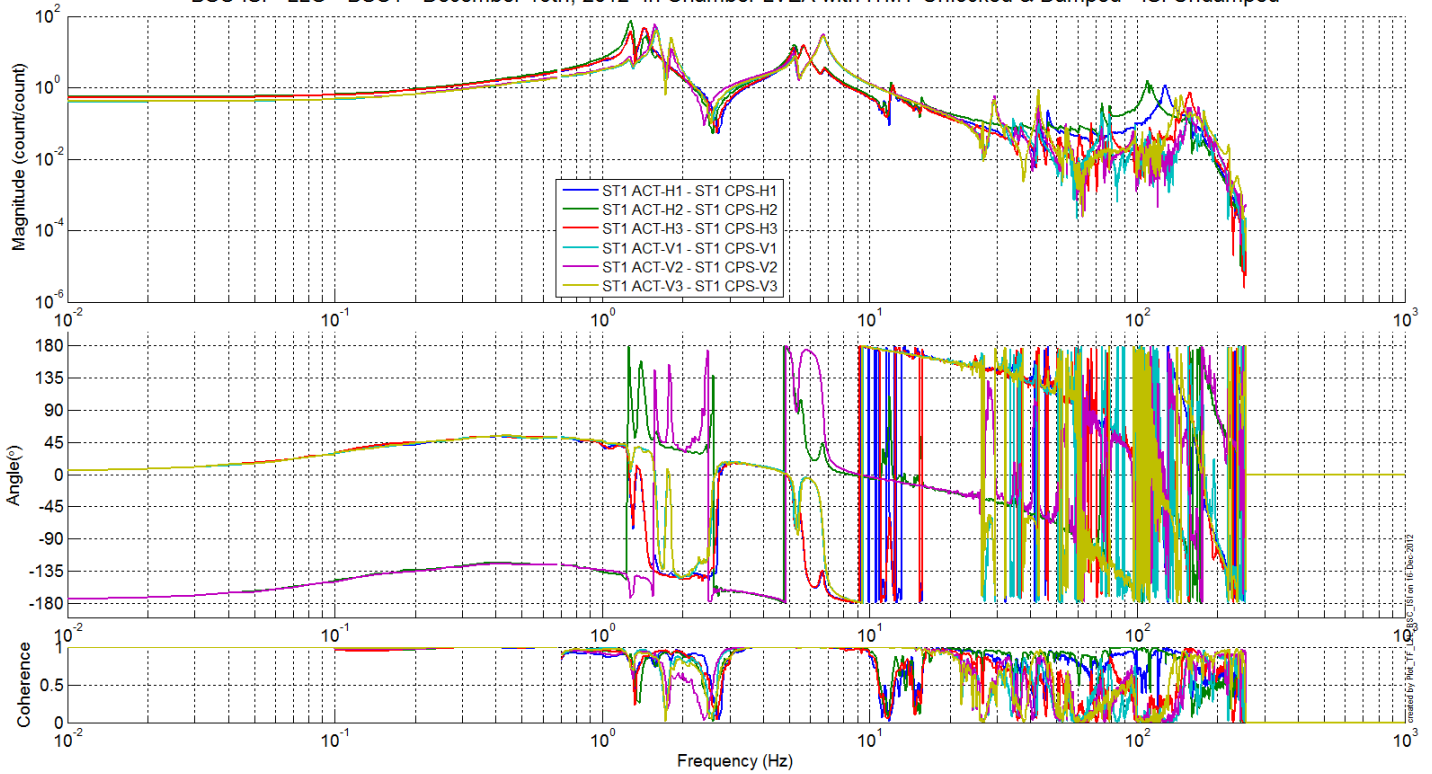


Figure 14 - TF ST1 ACT to ST1 CPS

BSC-ISI - LLO - BSC1 - December 16th, 2012 -In Chamber LVEA with ITMY Unlocked & Damped - ISI Undamped

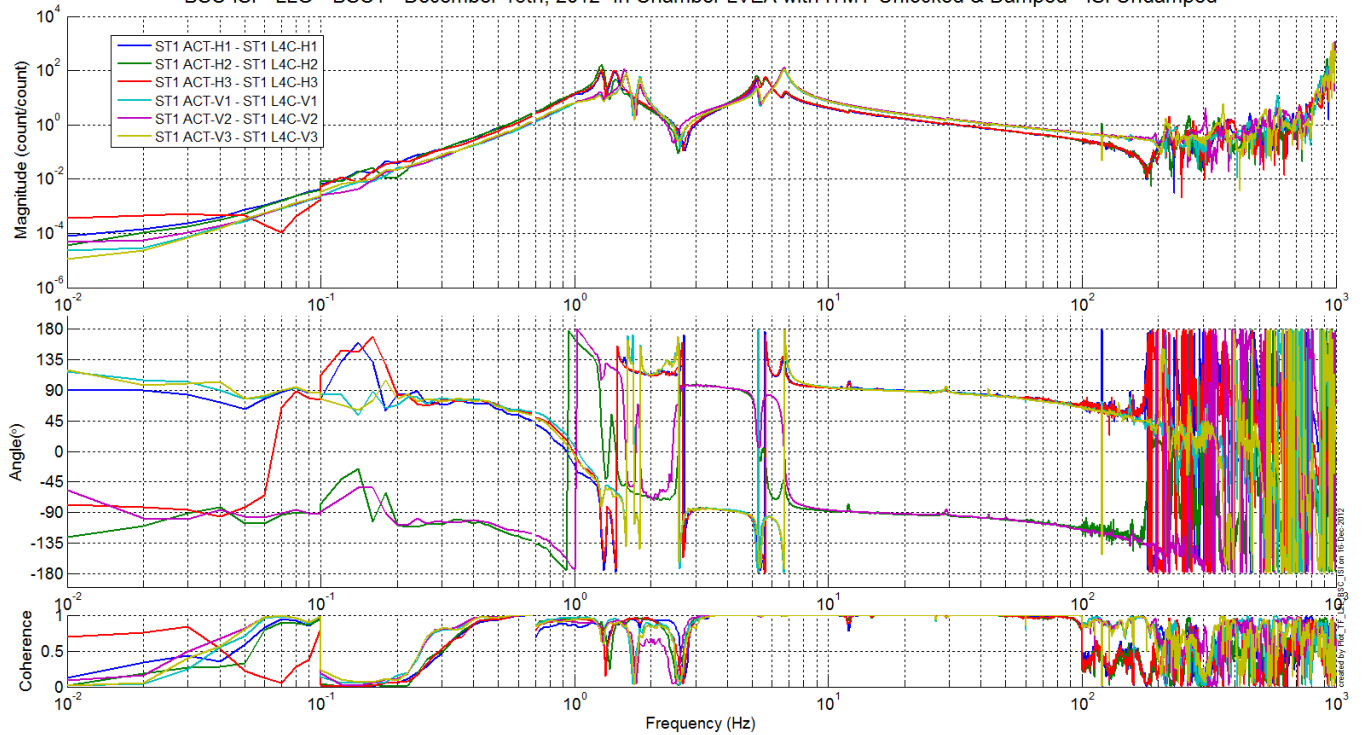


Figure 15 - TF ST1 ACT to ST1 L4C

Figure 16 - TF ST1 ACT to ST1 T240

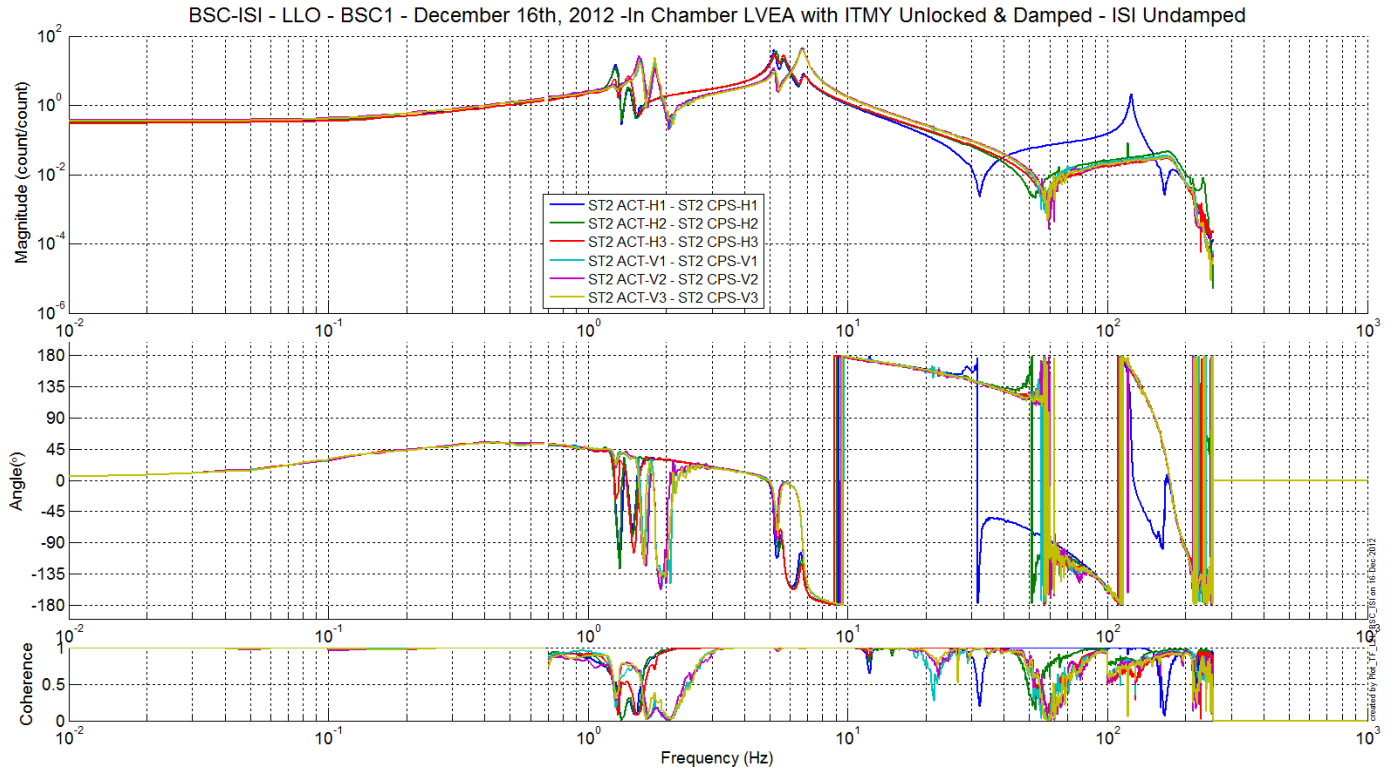


Figure 17 - TF ST2 ACT to ST2 CPS

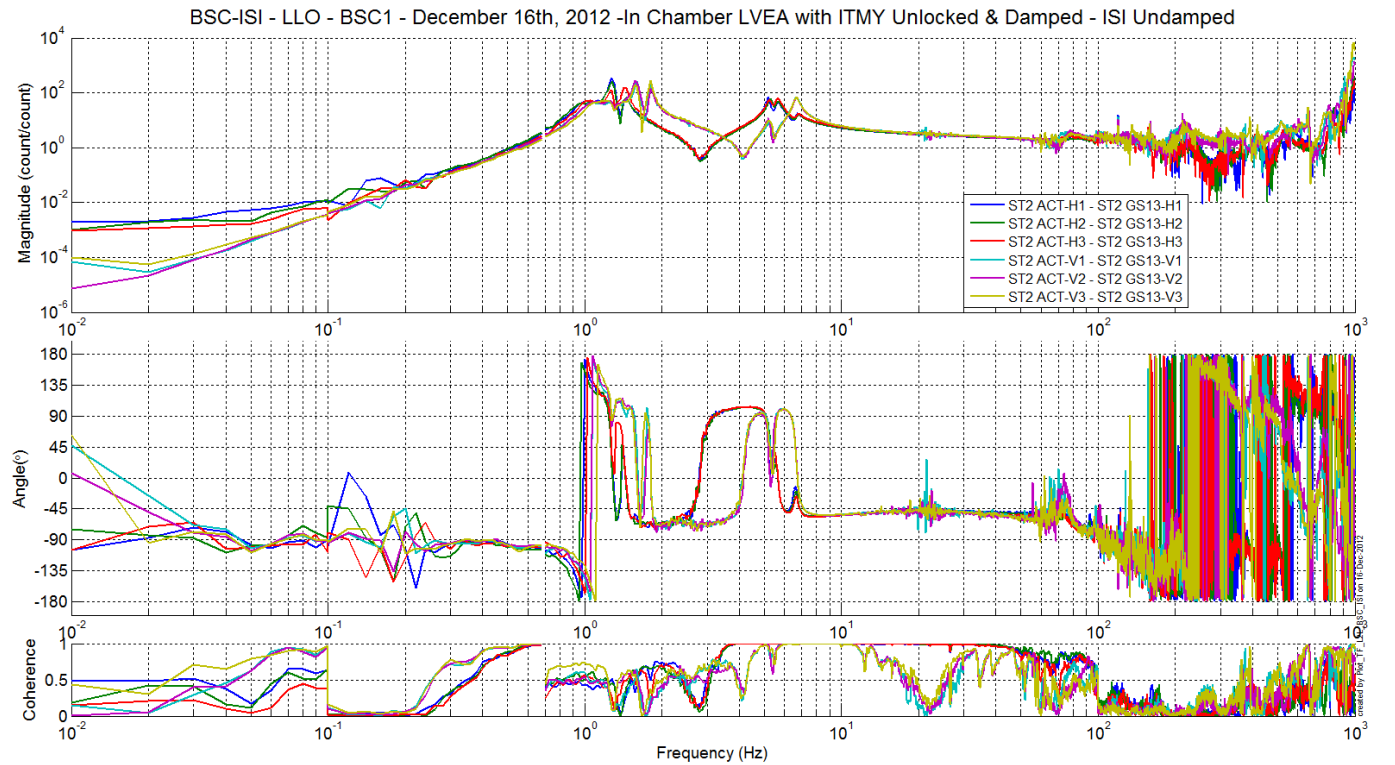


Figure 18 - TF ST2 ACT to ST2 GS13



#### 14. Comparisons with measurements on test stand-not done yet

The script used to compare transfer function can be found in the SVN at:

seismic/BSC-ISI/L1/ITMY/Scripts/Control\_Scripts

- Comparison\_TF\_C2C\_LHO\_ISI\_BSC2.m

The figure that shows the comparison between the transfer functions of the staging building and the LVEA are located in the SVN at:

seismic/BSC-ISI/L1/ITMY/Data/Figures/Transfer\_Functions/Comparisons/L2L/

- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST1\_ACT\_H\_to\_ST1\_CPS\_H\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST1\_ACT\_H\_to\_ST1\_L4C\_H\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST1\_ACT\_V\_to\_ST1\_CPS\_V\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST1\_ACT\_V\_to\_ST1\_L4C\_V\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST2\_ACT\_H\_to\_ST2\_CPS\_H\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST2\_ACT\_H\_to\_ST2\_GS13\_H\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST2\_ACT\_V\_to\_ST2\_CPS\_V\_20120512\_vs\_20121107.fig
- LLO\_ISI\_BSC1\_vs\_LHO\_ISI\_BSC8\_Comparison\_TF\_L2L\_ST2\_ACT\_V\_to\_ST2\_GS13\_V\_20120512\_vs\_20121107.fig

#### Main differences are:

- The DC gains (cables resistance is different due to the length difference)
- Resonances of the rigid body modes [1; 10]Hz (different payload) It is especially visible from 1 to 2 Hz on all sensors.
- ST1-CPS resonances different on the test stand and on the HEPI piers
- Resonance at 20.5 Hz on stage 2 sensors (4<sup>th</sup> vertical mode of the quad? –cf <https://lhocds.ligo-wa.caltech.edu/wiki/Resonances>) that had been visible during test stand measurement with the quad locked is somewhat visible here, even though not as clearly
- High frequency behavior different due to data rate change between test stand test and cartridge test

L1-BSC1-ISI-BSC1-In LVEA - with ITMY unlocked - covered:20121107

L1-BSC1-ISI-BSC1-In LVEA - with ITMY unlocked - covered:20121107

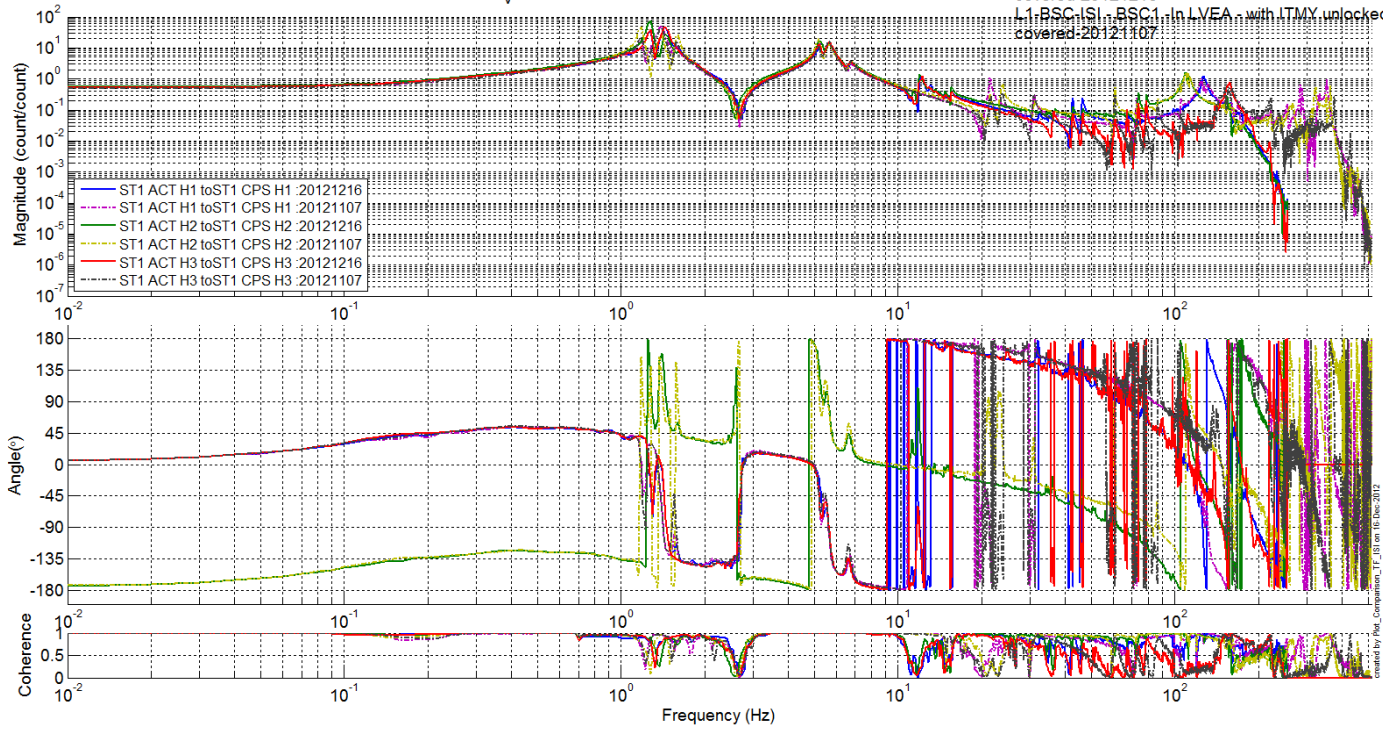


Figure 19 - Transfer functions comparison - ST1 ACT to ST1 CPS H

L1-BSC1-ISI-BSC1-In LVEA - with ITMY unlocked - covered:20121107

L1-BSC1-ISI-BSC1-In LVEA - with ITMY unlocked - covered:20121107

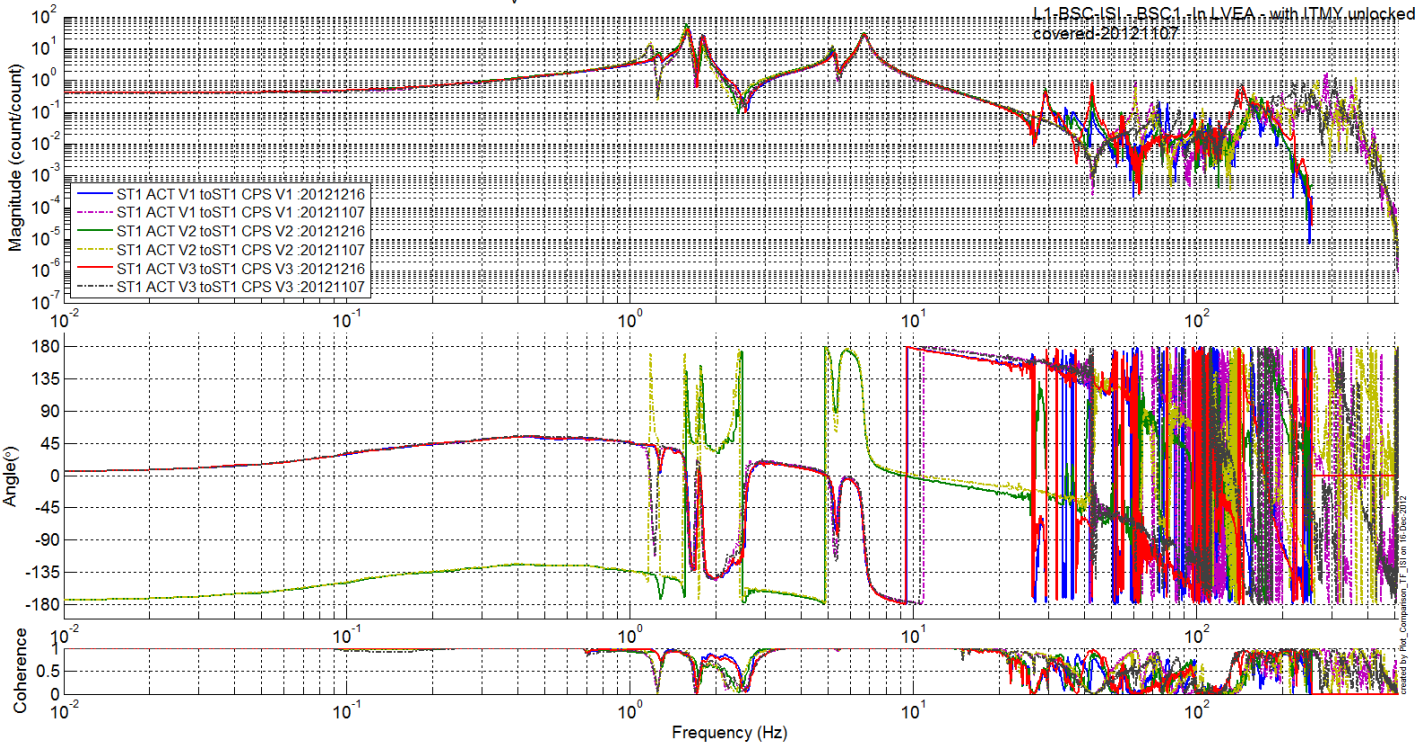


Figure 20 - Transfer functions comparison - ST1 ACT to ST1 CPS V

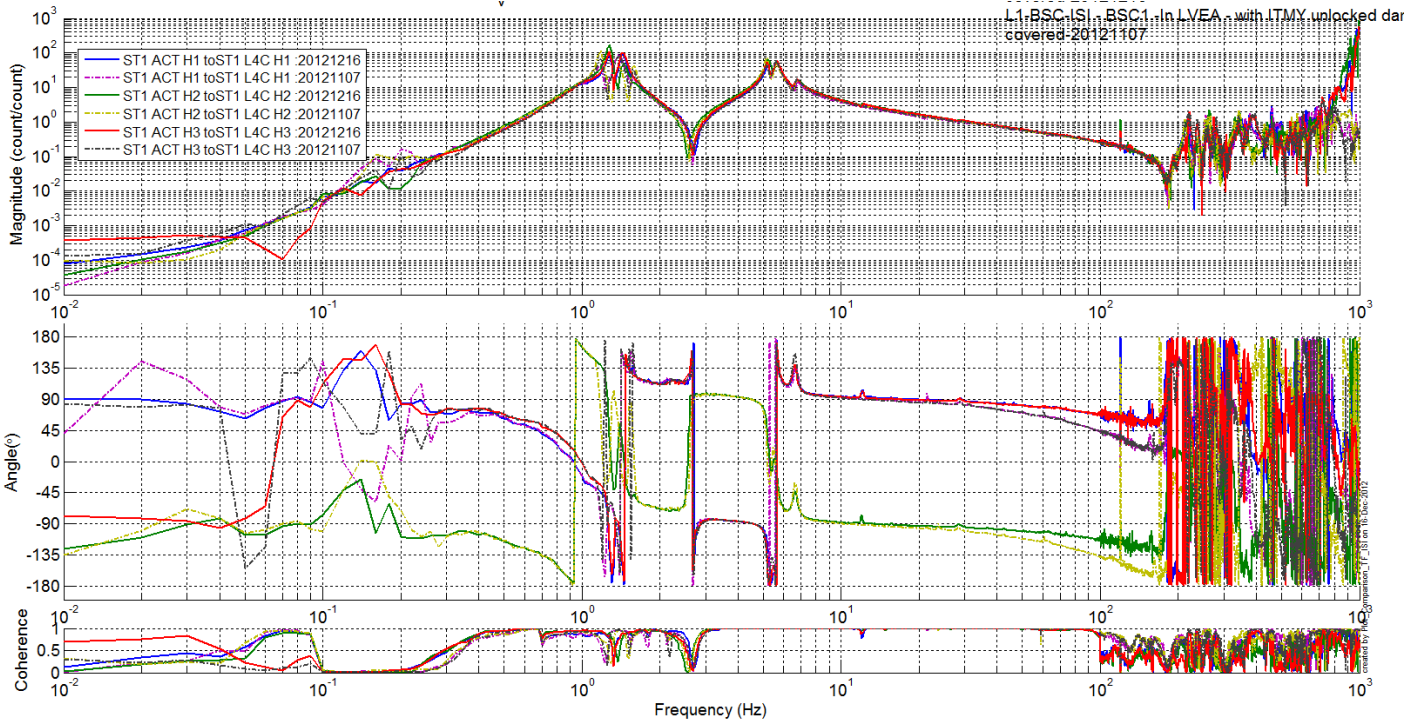


Figure 21 - Transfer functions comparison - ST1 ACT to ST1 L4C H

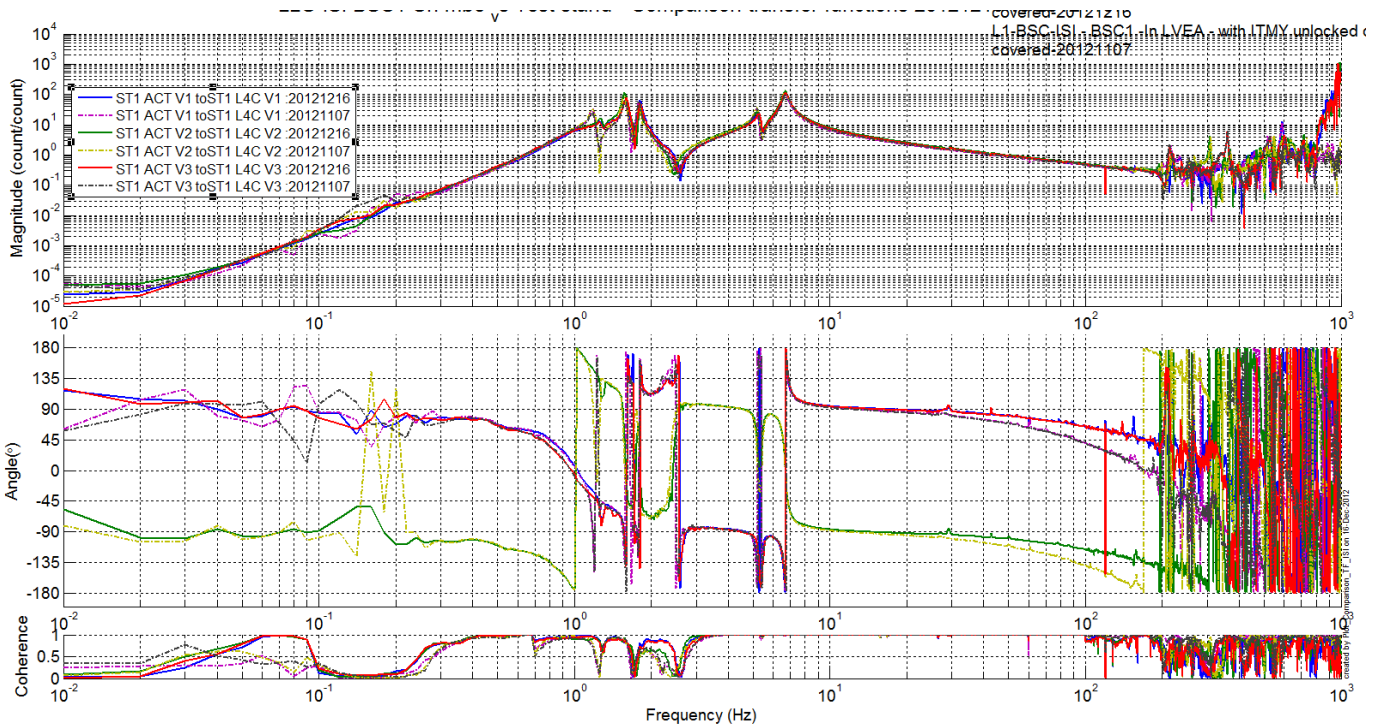


Figure 22 - Transfer functions comparison - ST1 ACT to ST1 L4C V

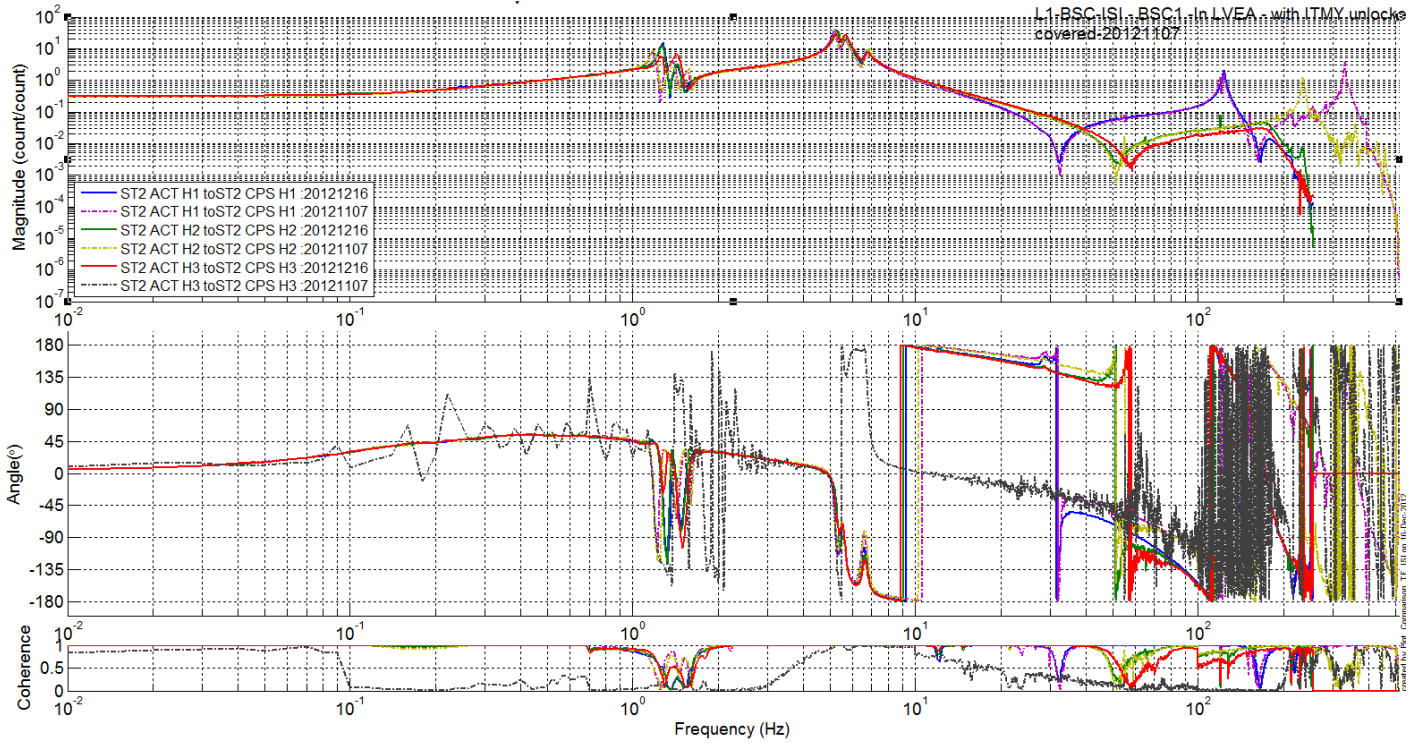


Figure 23 - Transfer functions comparison - ST2 ACT to ST2 CPS H

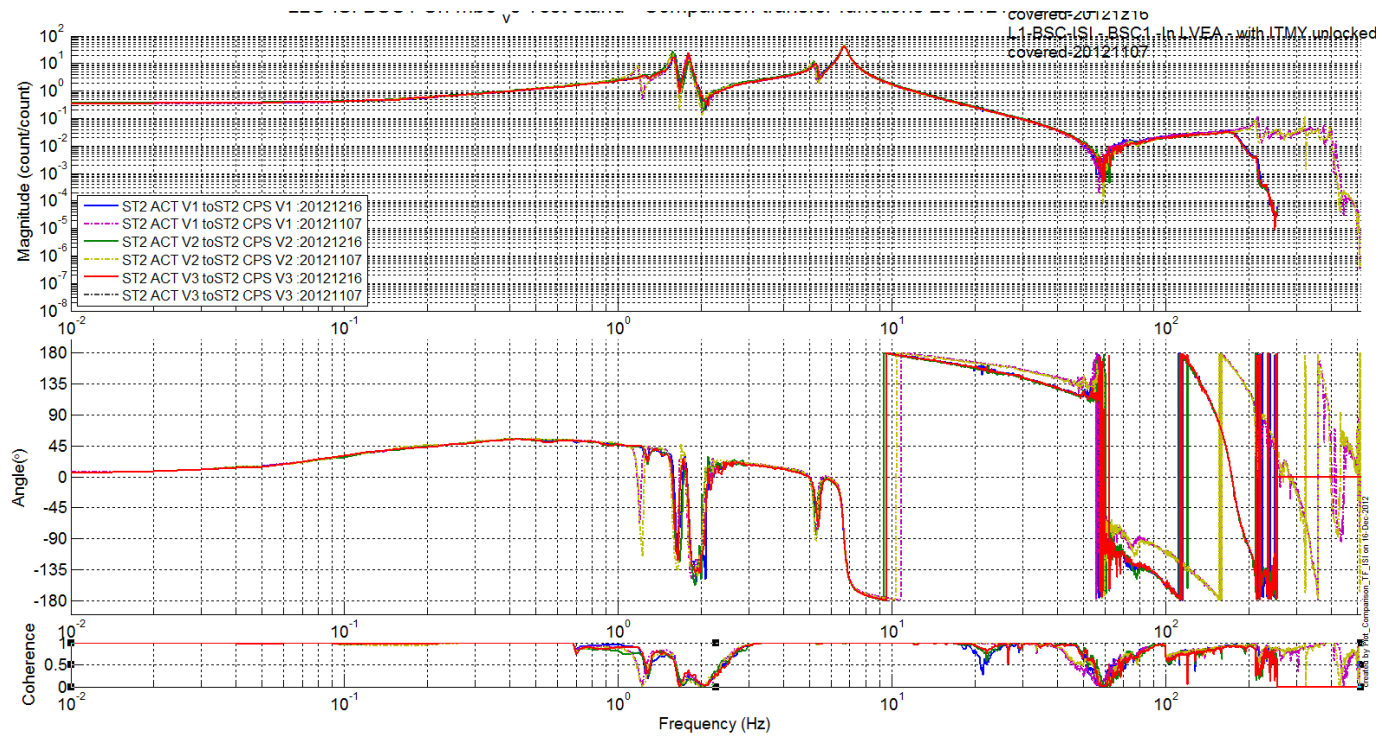


Figure 24 - Transfer functions comparison - ST2 ACT to ST2 CPS V



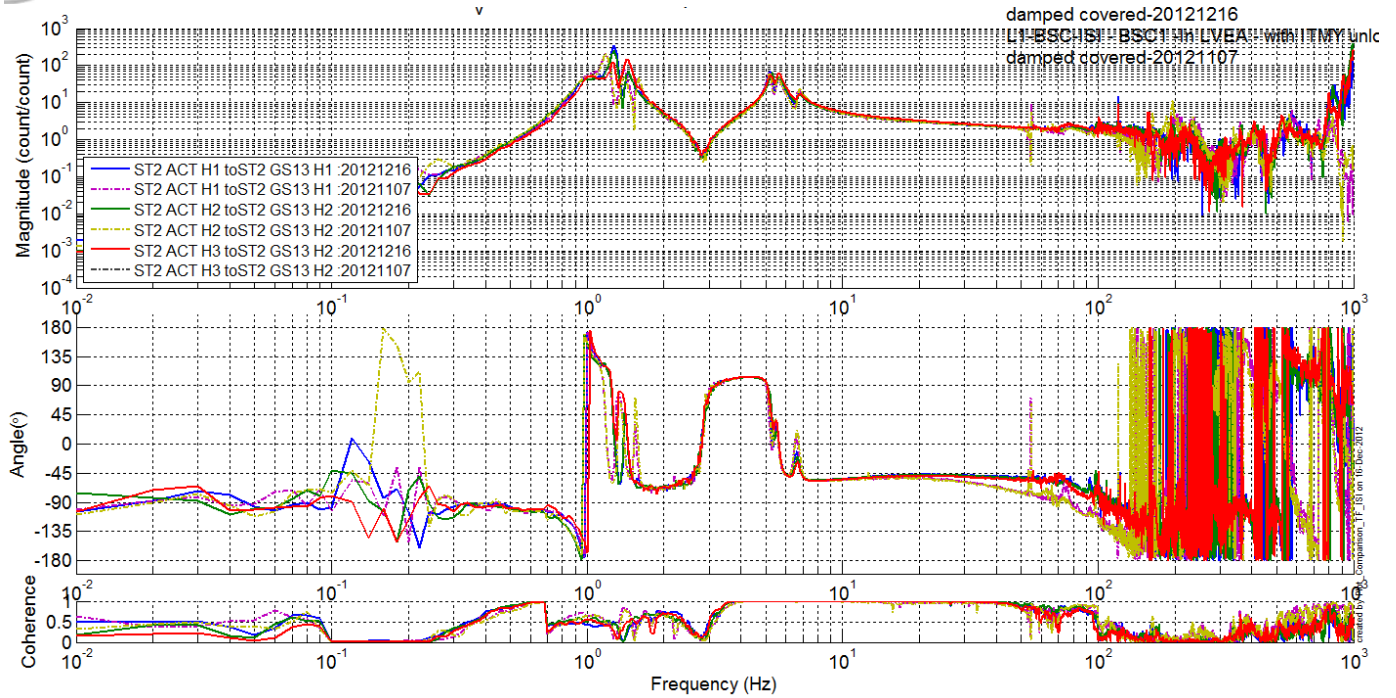


Figure 25 - Transfer functions comparison – ST2 ACT to ST2 GS13 H

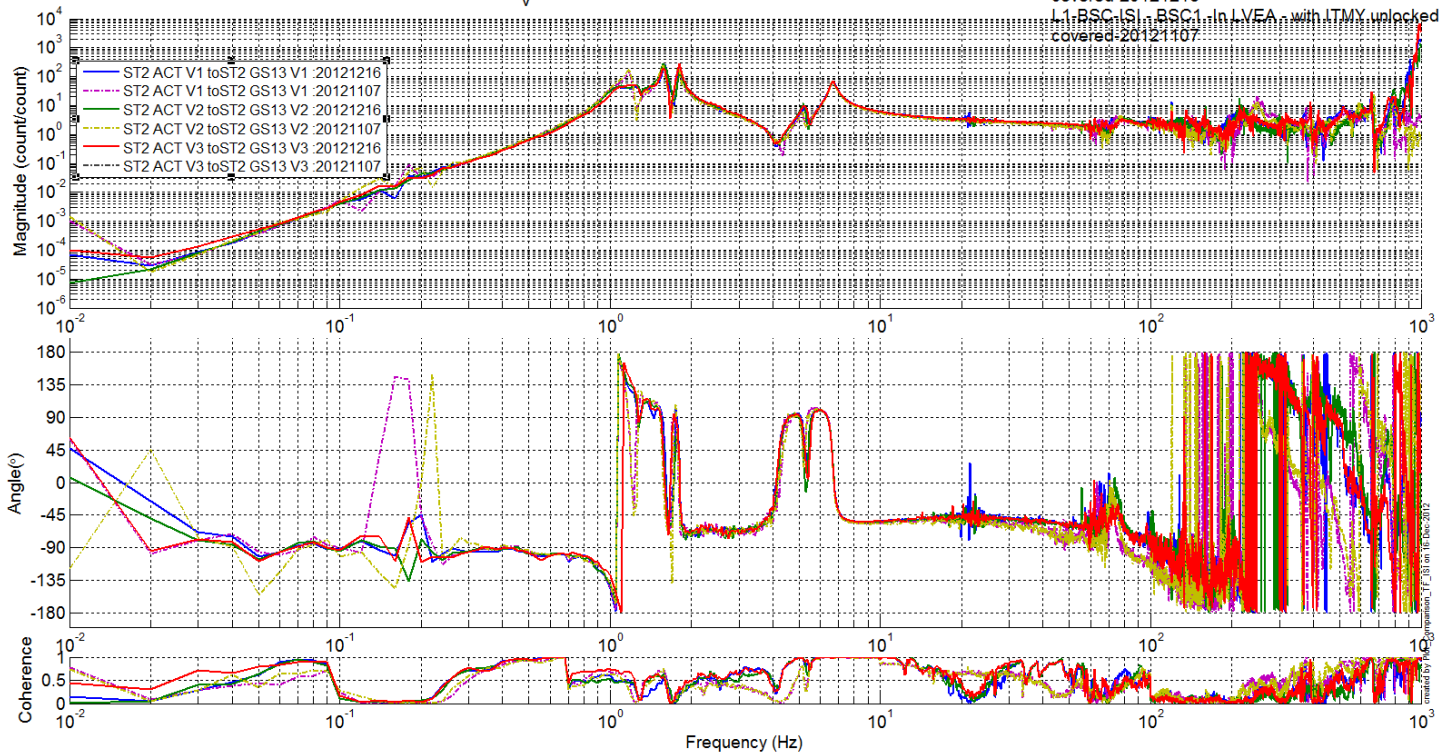


Figure 26 - Transfer functions comparison – ST2 ACT to ST2 GS13 V

Note that St 2 H3 and V3 transfer function from 11/07/12 were removed from those past 4 plots as we had some cabling issues later resolved.

Test result: Passed:  X  Failed:      Waived:

## 7. Conclusion Phase II-b

All results appear satisfying, apart from a few test waived (will be done during phase II-b):

- 
- Static tests in the Cartesian basis (redundant with the static test in the local basis)
- Linearity test: some corners have slightly different slopes but nothing strikingly alarming. We have seen in the past (HAM-ISI phase 2 testing) stronger slopes different, blamed on different cable lengths inside the LVEA.
- St 1 corner 2 actuators are wired in the opposite direction in some of the static tests. This was corrected before closing the dome.

**Test result:**

**Passed:**   X  

**Failed:**     

**Waived:**

## *Conclusion*

The ISI-BSC1 was moved from the Staging building to the LVEA test stand on July 17<sup>th</sup> 2012.

This document presents series of tests (Phase II) performed on the ISI-BSC1 (ITMY) after the ITMY quad suspension (in final configuration) was mated with the ISI and the ISI rebalanced.

Phase 2-a tests started in on October 24<sup>th</sup> 2012. Testing was completed on November 7<sup>th</sup> , the cartridge install tool place November 12<sup>th</sup> 2012.

Phase 2b testing was conducted between December 5<sup>th</sup> and December 17<sup>th</sup> 2012. The dome was approved to be closed and closed on December 17<sup>th</sup> 2012.