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**aLIGO HEPI L1 ITMX (BSC3) Assembly Validation Report**

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Distribution of this document:  
Advanced LIGO Project

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## Introduction

This document summarizes the tests done to validate the HEPI L1 ITMX (BSC3) assembly and installation. As all L1 HEPI BSC, it had been installed since 2004 at Livingston. However, it had been grounded for the 2 to 3 years of aLIGO install. All electronics has been updated since, and more importantly, the position of the ITMX support tubes (i.e. the position of the 4 HEPI ITMX boots), but not the one of the housings, was adjusted to accommodate for Initial Alignment needs. All tests were completed by June 2013.

## Sub-Components Testing

- Kaman Inductive Position Sensors: calibration, linearity, factory data, noise measurements

The IPS sensors on this chamber haven't been changed since their original installation in 2004. No specific individual testing had been done then or since.

- HEPI actuator linearity test (E1100338 – aLIGO HEPI Actuators Test Results)

The HEPI actuators on this chamber haven't been changed since their original installation in 2004. No specific individual testing had been done then or since.

- L4C test

The L4C sensors on this chamber haven't been changed since their original installation in 2004. No specific individual testing had been done at the time or since on the "old units".

## Assembly Validation

### 1.1 Load Cells assembly

- Spring attachment

For the BSC HEPI springs, check the assembly per D030320-v4. See LLO aLOG 7162 for more details.



- Load cell values

BSC HEPI load cell capacity → 3000 lbs

	Spring	Left Spring (lbs)
<b>Pier 1</b>	1	
	2	
<b>Pier 2</b>	3	
	4	
<b>Pier 3</b>	5	

	6	
<b>Pier 4</b>	7	
	8	

**Acceptance criteria:**

- The values must not exceed 80% of the load cell capacity (2400lbs for BSC and 1600lbs for HAM).

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

### *1.2 Bellows*

The bellows are hard to access and tests are hard to proceed. After several discussions and brainstorming sessions, it has been decided not to measure the gaps on HEPI-HAM and HEPI-BSC.

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

### *1.3 Boot Location*

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

### *1.4 Check Stops Gaps*

The stops must not touch the boot.

If the valve check test is a success, we are sure there is no touching against the boot.

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

### *1.5 Gaps check*

If the valve check test is a success, we are sure there is no touching against the boot.

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

### 1.6 IPS Centering

**Scripts files for processing and plotting in SVN at:**

/SeiSVN/seismic/HEPI/Common/Testing\_Functions\_HEPI/Offset\_STD\_IPS\_HEPI.m

All the loops must be turned off during this test.

	H1	H2	H3	H4	V1	V2	V3	V4
Mean (counts)								
Acceptance	+/- 15000	+/- 15000	+/- 15000	+/- 15000	+/- 15000	+/- 15000	+/- 15000	+/- 15000

**Test result:**

**Passed:**  X

**Failed:**

### 1.7 Sensors ASD

**Scripts files for processing and plotting in SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Scripts/Perf\_Analysis/

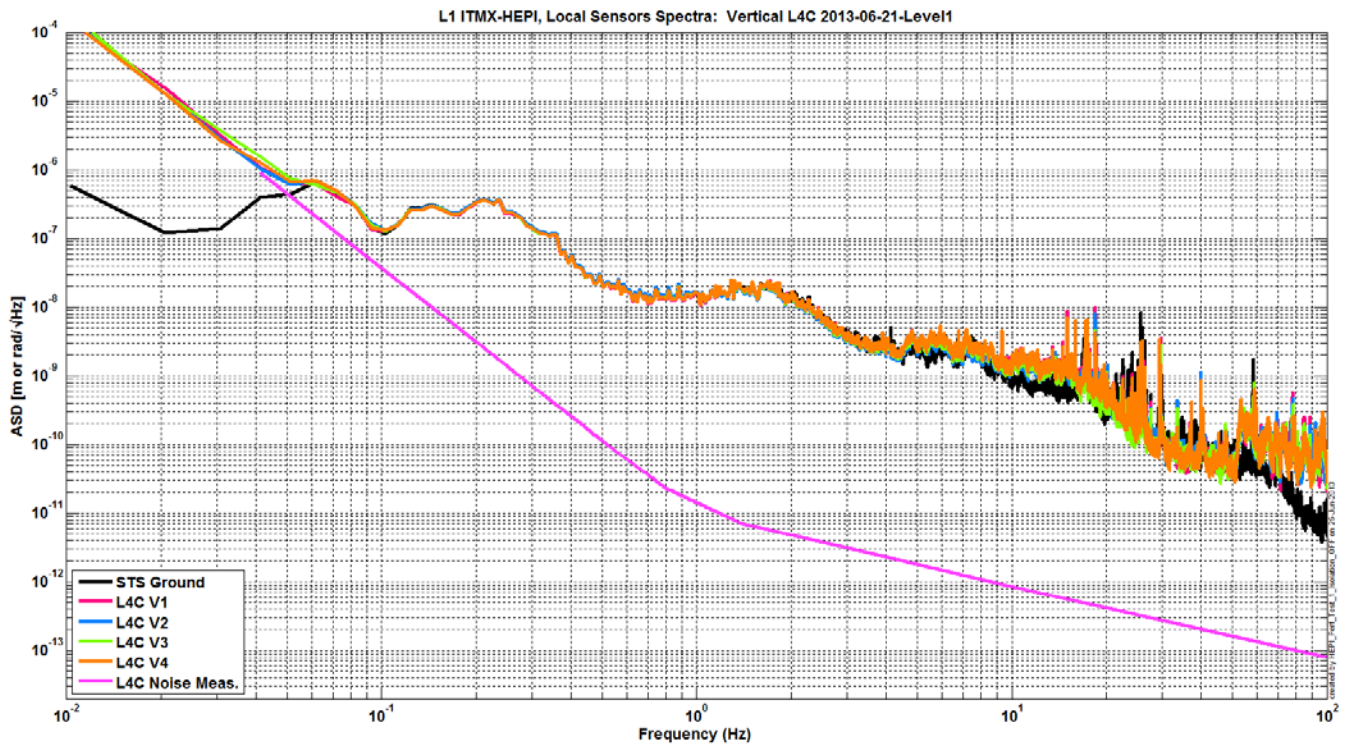
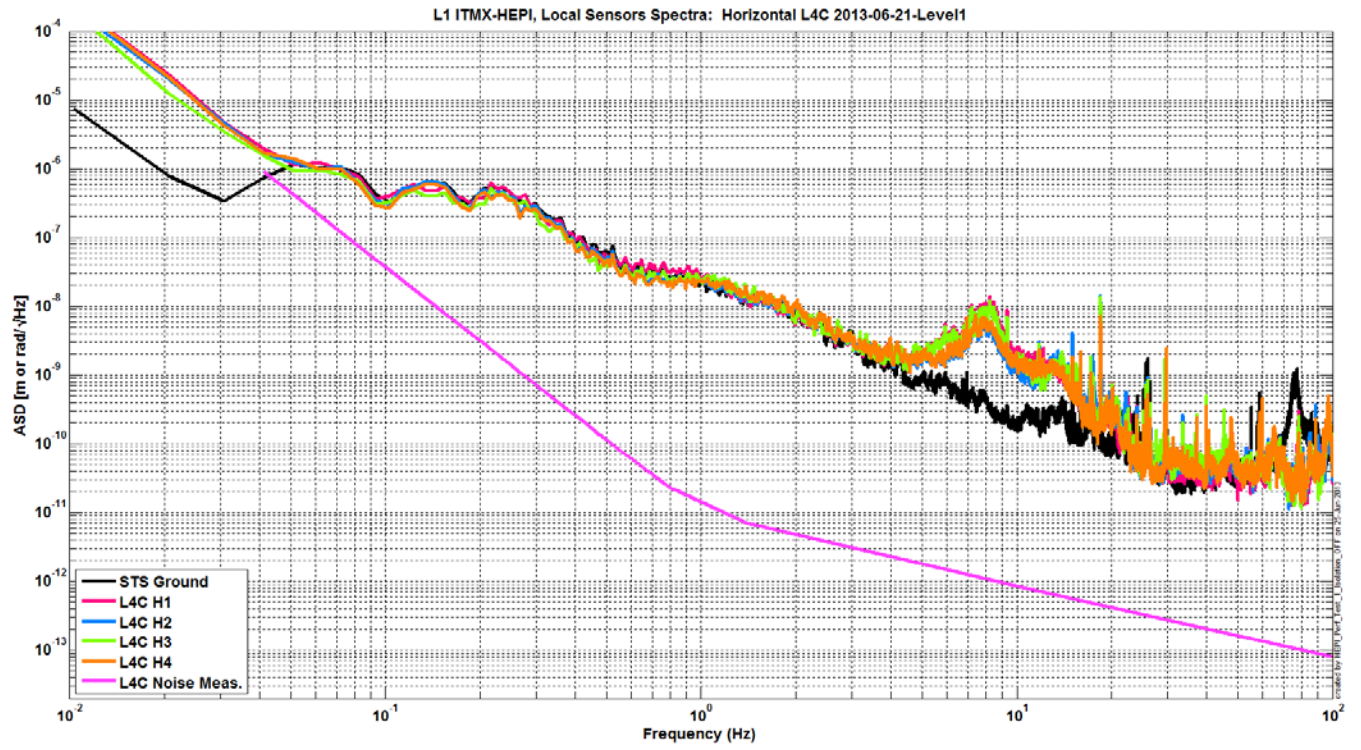
**Data in SVN at:**

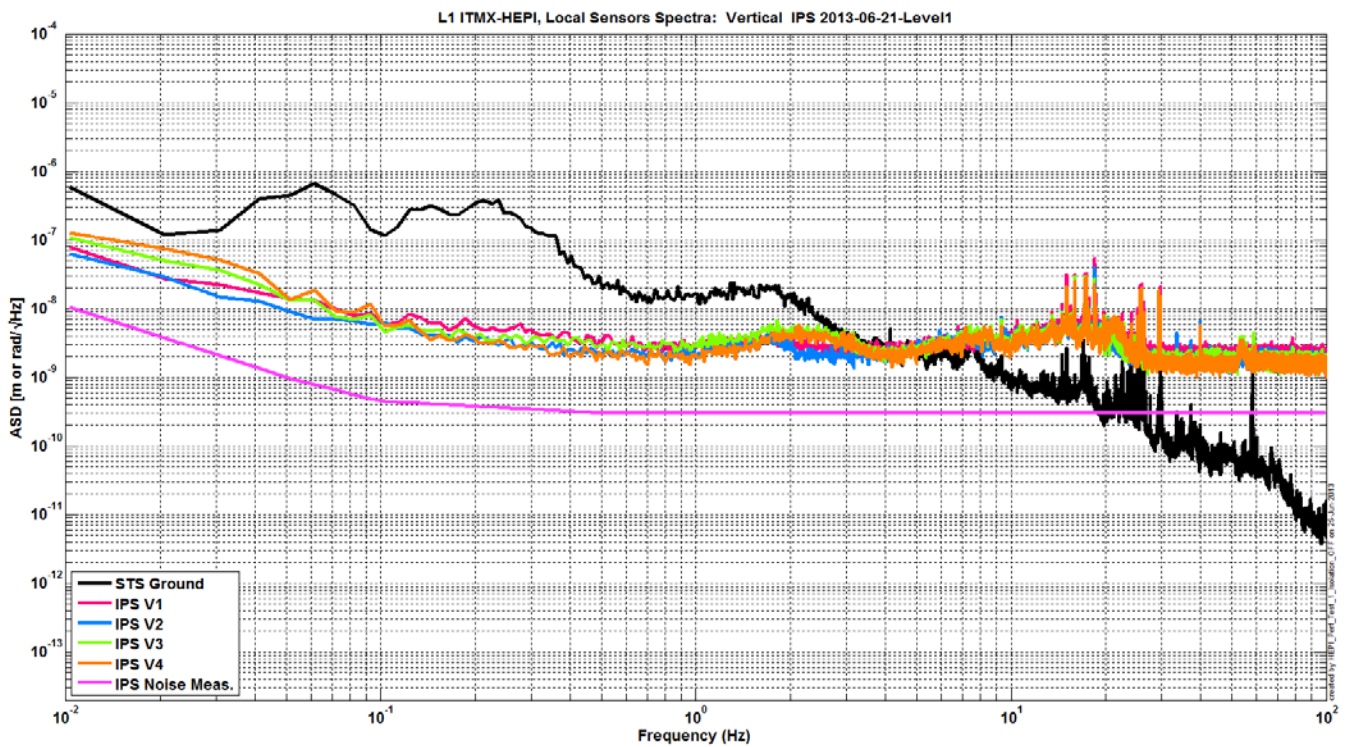
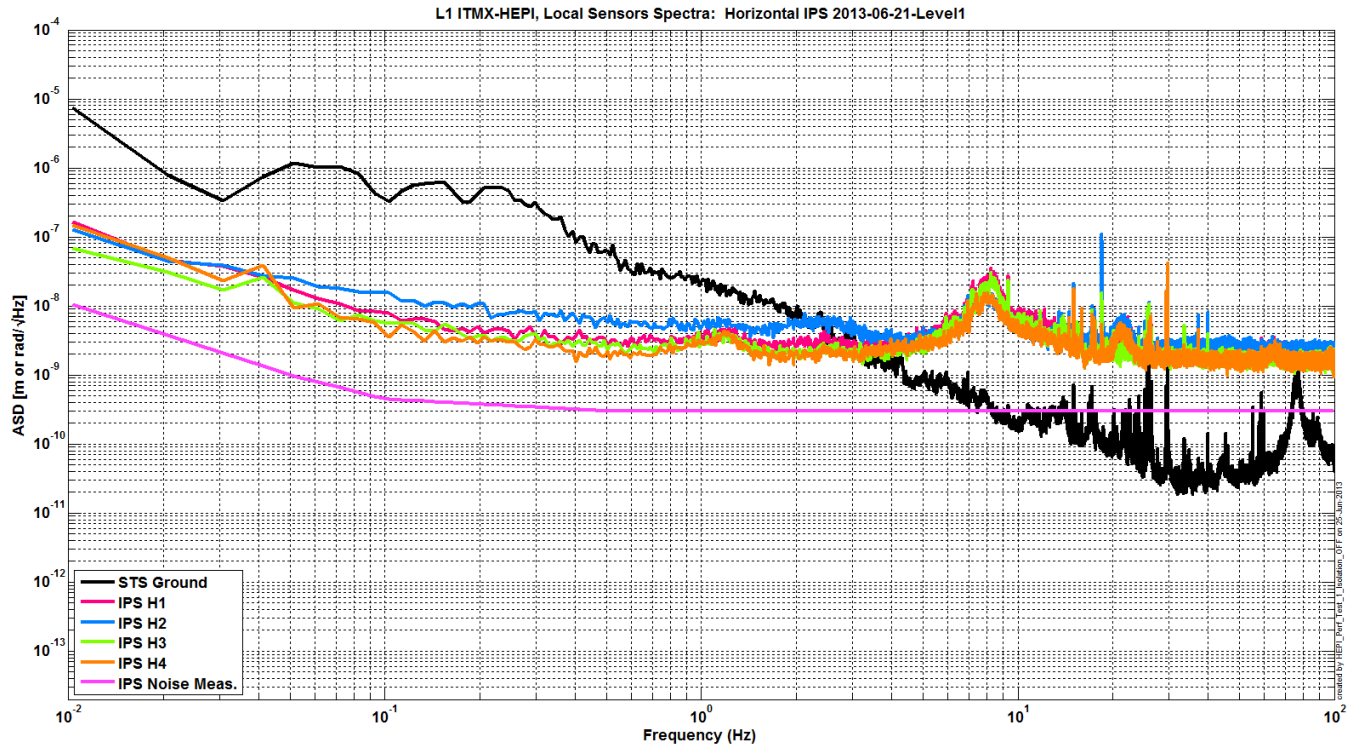
SeiSVN/seismic/HEPI/L1/ITMX/Data/Figures/Perf\_Analysis/2013-06-21-Level1/  
L1\_HPI\_ITMX\_Test\_1\_2013-06-21-Level1.mat

**Figures in SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Data/Figures/Perf\_Analysis/2013-06-21-Level1/

- HEPI\_L1\_ITMX\_Test\_1\_Fig\_a\_HPI\_L4C\_Hor\_2013-06-21-Level1.fig
- HEPI\_L1\_ITMX\_Test\_1\_Fig\_b\_HPI\_L4C\_Vert\_2013-06-21-Level1.fig
- HEPI\_L1\_ITMX\_Test\_1\_Fig\_c\_HPI\_IPS\_Hor\_2013-06-21-Level1.fig
- HEPI\_L1\_ITMX\_Test\_1\_Fig\_d\_HPI\_IPS\_Vert\_2013-06-21-Level12.fig





Issues/difficulties/comments regarding this test:

Calibration of IPS on those plots is slightly off I believe. However, those are enough to ensure proper functioning of all sensors.

Test result:

Passed:  X

Failed:



### 1.8 SUS-watchdogs interaction test

**This test will be obsolete very soon, as the payload-HEPI WD connection is planned for removal.**

- . Set up a zero value on the payload watchdogs.
- . Check that the payload watchdog screen of HEPI tripped.
- . In the payload watchdog screen, click on the OVERRIDE button and reset the watchdog.
- . Do the same process for all the payloads

**Acceptance criteria:**

- The HEPI must trip when the payload watchdogs are tripped
- The HEPI watchdogs could be reset when the OVERRIDE button is ON

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

When this test is done, reset everything (OVERRIDE button OFF, put back the value on the payload watchdog).

### 1.9 Static Test local drive

**Scripts files for processing in SVN at:**

/SeiSVN/seismic/HEPI/Common/Testing\_Functions\_HEPI/Static\_Test\_Local\_Basis\_HEPI.m

**Data files in SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Data/Static\_Tests/

*Drive of 5000 counts (Nominal value handled by testing script)*

	H1	H2	H3	H4	V1	V2	V3	V4
H1	-10347.8	4054.0	1032.3	3696.3	-14.1	-52.3	-86.2	235.3
H2	2213.6	-8271.2	2921.5	864.8	-150.3	56.7	227.5	-90.3
H3	410.9	3475.1	-10313.7	3685.4	-122.6	282.6	-73.4	-228.5
H4	2333.9	1018.0	2954.0	-8909.2	108.2	-3.9	-205.5	-55.9
V1	-377.7	141.2	-221.0	230.6	-5924.4	-863.5	1601.3	-1299.0
V2	-493.0	259.9	-10.4	30.5	-913.1	-5415.2	-1149.8	1344.2
V3	-462.6	524.7	-214.3	-69.6	1342.6	-2132.2	-6899.4	-793.5
V4	-188.1	220.0	-324.8	105.5	-1461.9	777.0	-1571.8	-6540.9

*Drive of 100 counts (in progress)*

	H1	H2	H3	H4	V1	V2	V3	V4
H1	8350.9418	-5056.1049	-327.0384	-1879.51872	-178.9088	209.3388	192.18836	-370.0864
H2	-4104.049	8306.5349	-1822.531974	-448.11792	134.8916	-100.465	-301.80668	139.7868

H3	-233.5984	-2065.5751	8170.4572	-4615.56692	178.7694	-183.7838	-239.1095	118.1154
H4	-1807.7793	-701.3897	-4558.2268	9000.50088	-488.2914	367.591	-1.00976	-441.0128
V1	-87.0864	1.56718	302.0506	-174.51156	7490.8344	918.82254	-1656.35338	784.3534
V2	182.2748	-404.56522	-128.0876	486.57564	833.8752	7402.042	675.00182	-1629.1482
V3	309.8688	-477.33554	-80.087	272.82164	-1436.731	1099.12212	7236.42762	695.124
V4	-177.839	74.78868	291.7698	-126.46464	955.694	-1414.8926	824.44686	7487.4108

*. Drive of 1000 counts (in progress)*

	H1	H2	H3	H4	V1	V2	V3	V4
H1	8350.9418	-5056.1049	-327.0384	-1879.51872	-178.9088	209.3388	192.18836	-370.0864
H2	-4104.049	8306.5349	-1822.531974	-448.11792	134.8916	-100.465	-301.80668	139.7868
H3	-233.5984	-2065.5751	8170.4572	-4615.56692	178.7694	-183.7838	-239.1095	118.1154
H4	-1807.7793	-701.3897	-4558.2268	9000.50088	-488.2914	367.591	-1.00976	-441.0128
V1	-87.0864	1.56718	302.0506	-174.51156	7490.8344	918.82254	-1656.35338	784.3534
V2	182.2748	-404.56522	-128.0876	486.57564	833.8752	7402.042	675.00182	-1629.1482
V3	309.8688	-477.33554	-80.087	272.82164	-1436.731	1099.12212	7236.42762	695.124
V4	-177.839	74.78868	291.7698	-126.46464	955.694	-1414.8926	824.44686	7487.4108

*Table - Main couplings and cross couplings*

Issues/difficulties encountered during this test:

**Acceptance criteria:**

- The results in these three tables must be the same (within xxx%)

**Test result:**

**Passed:** \_\_\_\_

**Failed:** \_\_\_\_

### ***1.10 Linearity Test/Range of motion in the local basis***

**Scripts files for processing and plotting in SVN at:**

/SeiSVN/seismic/HEPI/Common/Testing\_Functions\_HEPI/Linearity\_Test\_Awgstream\_HEPI.m

**Data in SVN at:**

SeiSVN/seismic/HEPI/L1/ITMX/Data/Spectra/Undamped/

L1\_ISI\_ITMX\_ASD\_m\_CPS\_T240\_L4C\_GS13\_Locked\_vs\_Unlocked\_2012\_02\_07.mat

**Figures in SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Data/Figures/Spectra/Undamped

	Slopes	Offsets
H1	1.63	1800.40
H2	1.88	-522.55
H3	1.63	1959.94
H4	1.76	-177.98
V1	1.54	-4082.29
V2	1.54	-1558.79
V3	1.42	-516.54
V4	1.56	-5144.56

Issues/difficulties encountered during this test:

**Acceptance criteria:**

▪

**Test result:**

**Passed:** \_\_\_\_

**Failed:** \_\_\_\_

### 1.11 Actuator Plate to Shields gap

Perform this test ONLY if the range of motion test failed.

Test result: Passed:     Failed:     Waived:   X  

### 1.12 Valve Check

Scripts files for processing and plotting in SVN at:

/SeiSVN/seismic//HEPI/L1/ITMX/Scripts/Valve\_Check/plot\_valve\_check.m

/SeiSVN/seismic/HEPI/L1/ITMX/Scripts/Valve\_Check/dtt2mlab\_Valve\_Check.m

Data in SVN at:

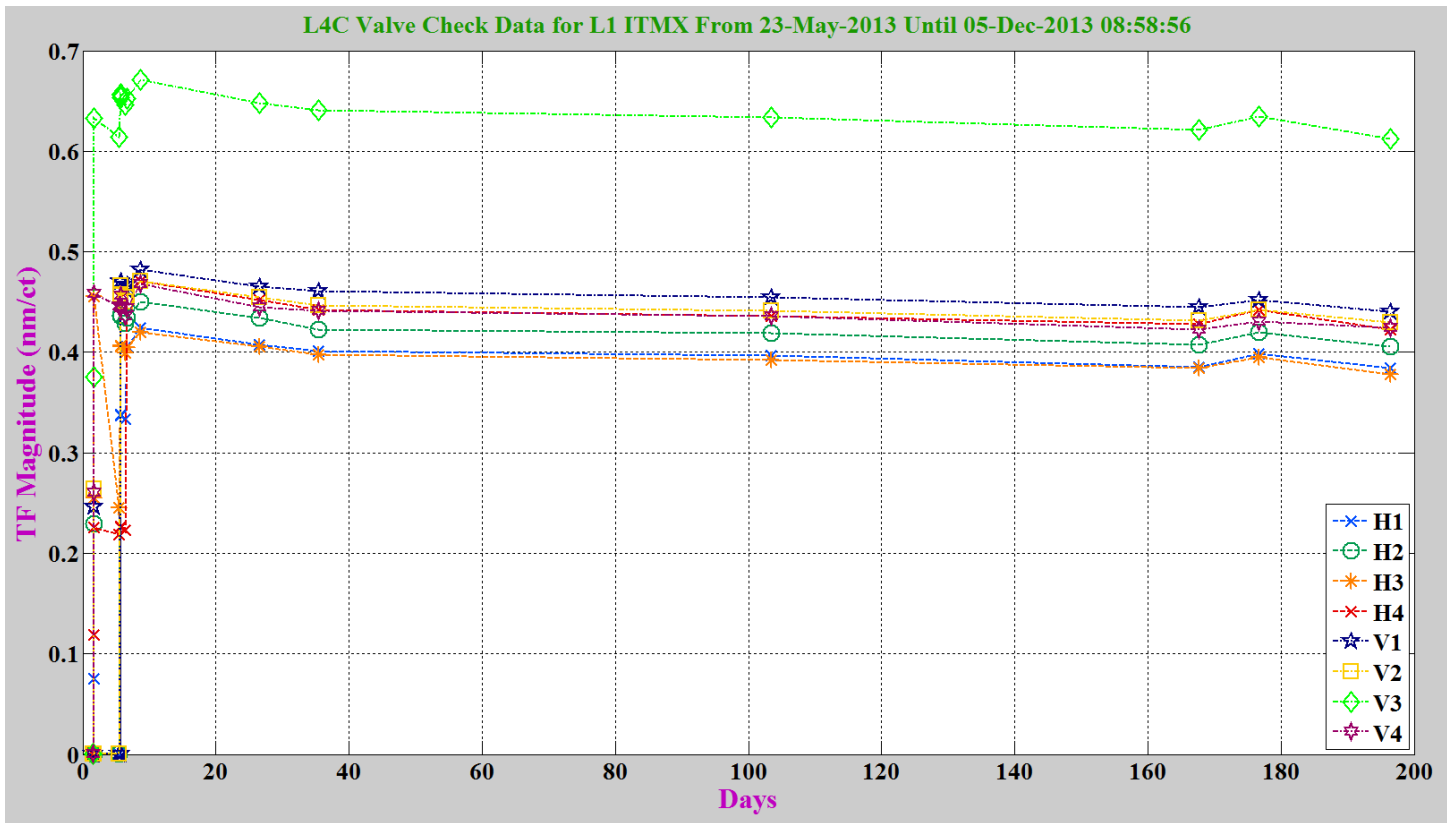
/SeiSVN/seismic/HEPI/L1/ITMX/Data/Spectra/Undamped/

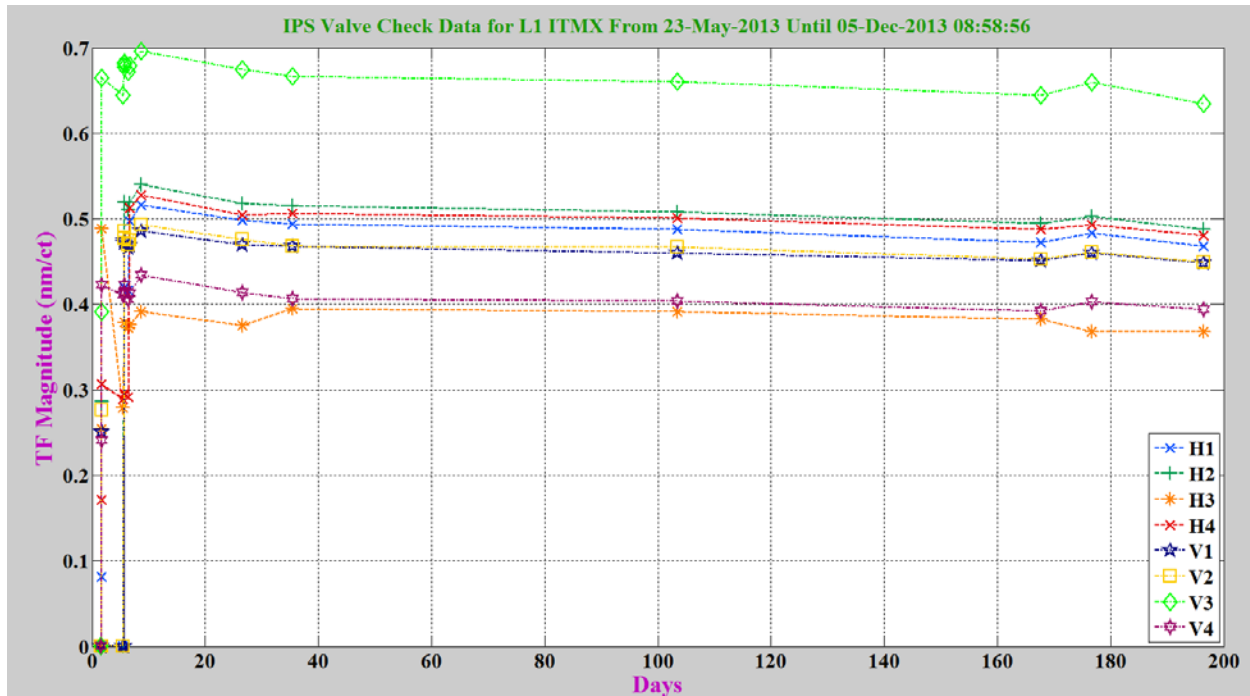
/SeiSVN/seismic/HEPI/L1/ITMX/Scripts/Valve\_Check/

Figures in SVN at:

/SeiSVN/seismic/HEPI/L1/ITMX/Scripts/Valve\_Check/

/SeiSVN/seismic/HEPI/L1/ITMX/Scripts/Evolution/





Issues/difficulties/comments regarding this test:

One can see that the V3 actuator/valve is 25% more effective than the others (and the average seen on other chambers). However, this can be taken into account by the symmetrization filters and therefore was deemed not worth changing the actuator control valve.

**Acceptance criteria:**

- All corners should behave consistently (usually displacement > 0.4 nm/ct)

**Test result:**

**Passed:**   X  

**Failed:**     

### *1.13 Local-to-local measurements*

**Data files in SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Data/Transfer\_Functions/Measurements/Undamped/

- L1\_HEPI\_BSC3\_100\_to\_250Hz\_20130530-003431.mat
- L1\_HEPI\_BSC3\_20\_to\_100Hz\_20130529-221752.mat
- L1\_HEPI\_BSC3\_2\_to\_20Hz\_20130529-202353mat
- L1\_HEPI\_BSC3\_0p5\_to\_2Hz\_20130529-171514.mat
- L1\_HEPI\_BSC3\_0p05\_to\_0p5Hz\_20130531-182134.mat

**Data collection script files:**

/SeiSVN/seismic/HEPI/Common//Transfer\_Function\_Scripts/

- Run\_TF\_L2L\_10mHz\_100mHz.m
- Run\_TF\_L2L\_100mHz\_500mHz.m
- Run\_TF\_L2L\_500mHz\_5Hz.m

- Run\_TF\_L2L\_5Hz\_100Hz.m
- Run\_TF\_L2L\_100Hz\_1000Hz.m

**Scripts files for processing and plotting in SVN at:**

/SeiSVN/seismic/HEPI/L1/BS/Scripts/Control\_Scripts/release/  
 - Step\_1\_TF\_Loc\_to\_Loc\_L1\_HEPI\_ITMX.m

**Figures in SVN at:**

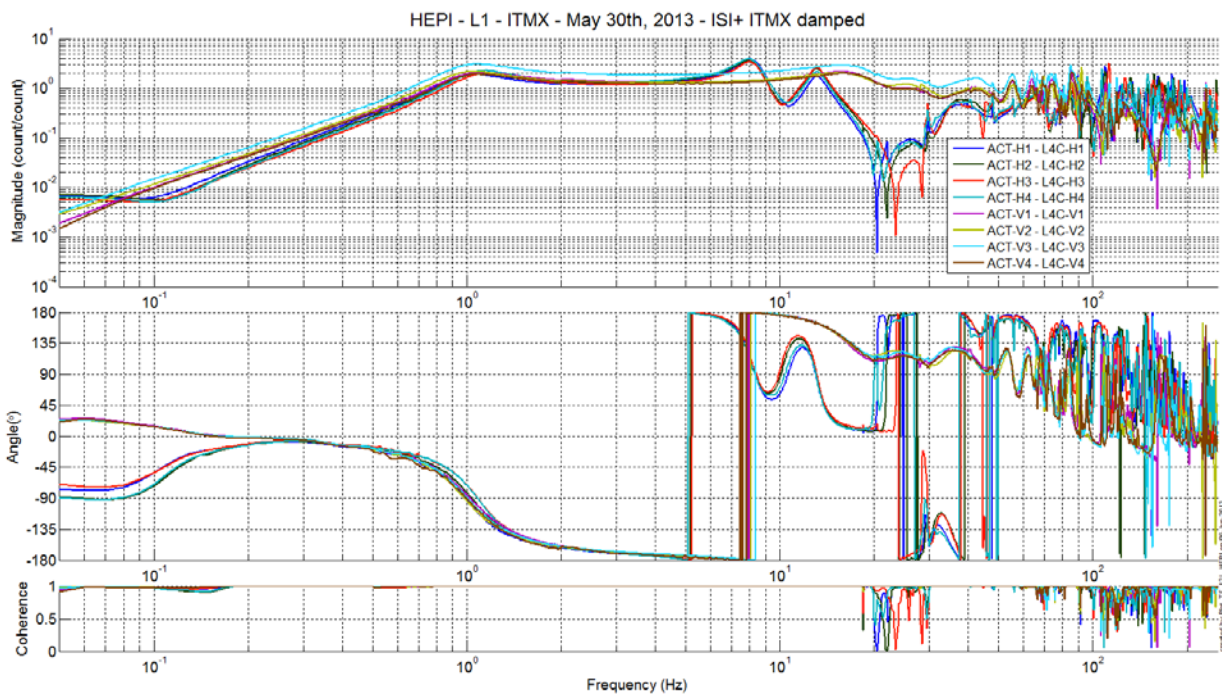
/SeiSVN/seismic/HEPI/L1/ITMX/Data/Figures/Transfer\_Functions/Measurements/Undamped/

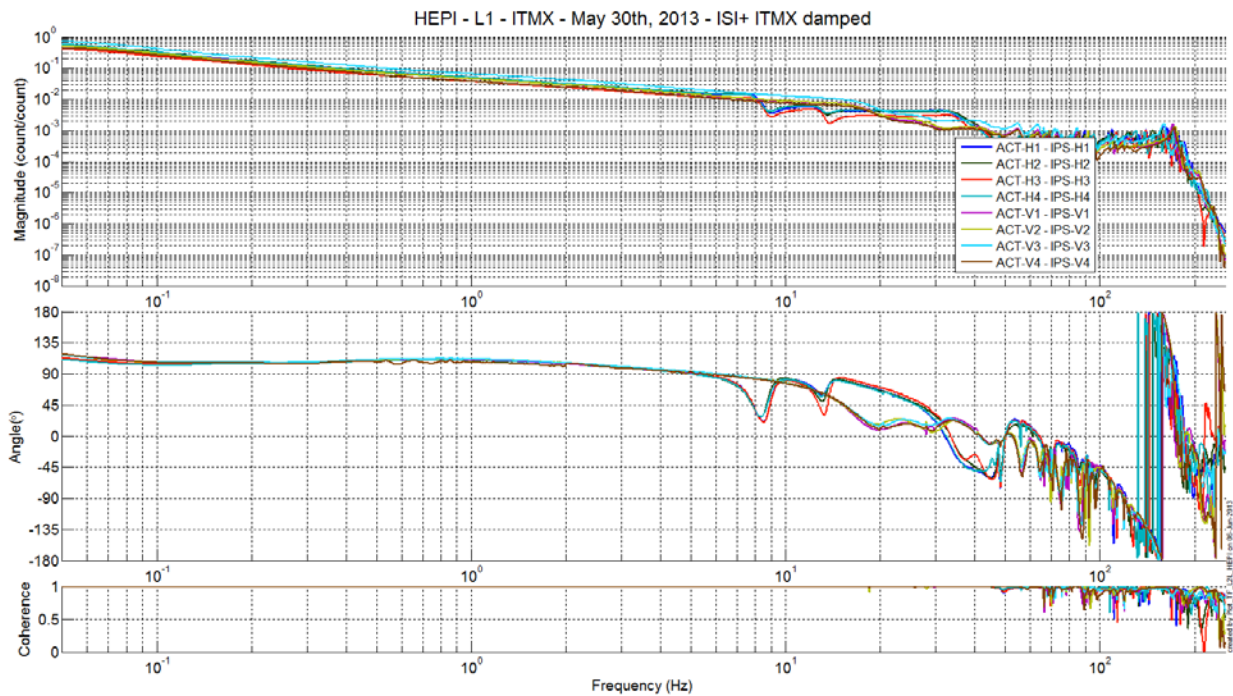
- L1\_HPI\_ITMX\_TF\_L2L\_Raw\_from\_ACT\_to\_IPS\_2013\_05\_30.fig
- L1\_HPI\_ITMX\_TF\_L2L\_Raw\_from\_ACT\_to\_L4C\_2013\_05\_30.fig

**Storage of measured transfer functions in the SVN at:**

/SeiSVN/seismic/HEPI/L1/ITMX/Data/Transfer\_functions/Simulations/Undamped/  
 L1\_HPI\_ITMX\_TF\_L2L\_Raw\_2013\_05\_30.mat

The local-to-local transfer functions are presented below.





Issues/difficulties/comments regarding this test:

We can still notice the higher actuation of V3 in comparison to the other corners. As stated before this is not an issue.

Note additionally that the L4C sign is opposed to expectations, this is due to the old L4C cables.

**Acceptance criteria:**

- On IPS, the phase must be 0° at DC
- On geophones, the phase must be 90° at DC
- Identical shape in each corner

**Test result:**

**Passed:**   

**Waived:**   X  

**Failed:**

### *1.14 Alignment offsets:*

The IPS readouts recorded below are for HEPI unlocked, when on 06/12/13, the commissioning crew made their first attempt at DRMI alignment check (cf LLO alog 7383)

	IPS Readouts
H1	-7303
H2	11371
H3	464
H4	140
V1	9062
V2	5412
V3	-769
V4	1970

Note at the moment, for this chamber, the offsets are re-computed every time HEPI loops are started.

**Acceptance criteria:**

Offsets were recorded.

**Test result:**

**Passed:**   X  

**Failed:**



## **Conclusion**

The only tests run for initial approval of this systems were the valve checks, the sensors ASDs and the transfer functions. All have looked good since June 2013. Position loops have been used routinely on this chamber.