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**aLIGO HEPI L1 ETMX (BSC4) Assembly Validation Report**

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Advanced LIGO Project

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## Introduction

This document summarizes the tests done to validate the HEPI L1 ETMX (BSC4) 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 have been updated since, and more importantly, the position of the ETMX support tubes (i.e. the position of the 4 HEPI ETMX boots), but not the one of the housings, was adjusted before ISI installation to accommodate for Initial Alignment needs. HEPI was initially kept locked for the 1<sup>st</sup> few months of use the X-arm. In order to allow for further adjustment of the optics position, HEPI was released on March 31<sup>st</sup> 2014. All tests were completed by the end of April 2014.

## 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	2271
	2	2410
<b>Pier 2</b>	3	2477
	4	2218
<b>Pier 3</b>	5	2598

	6	2330
<b>Pier 4</b>	7	1899
	8	2137

Source: <https://alog.ligo-la.caltech.edu/aLOG/index.php?callRep=10090>

**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/ETMX/Scripts/Perf\_Analysis/

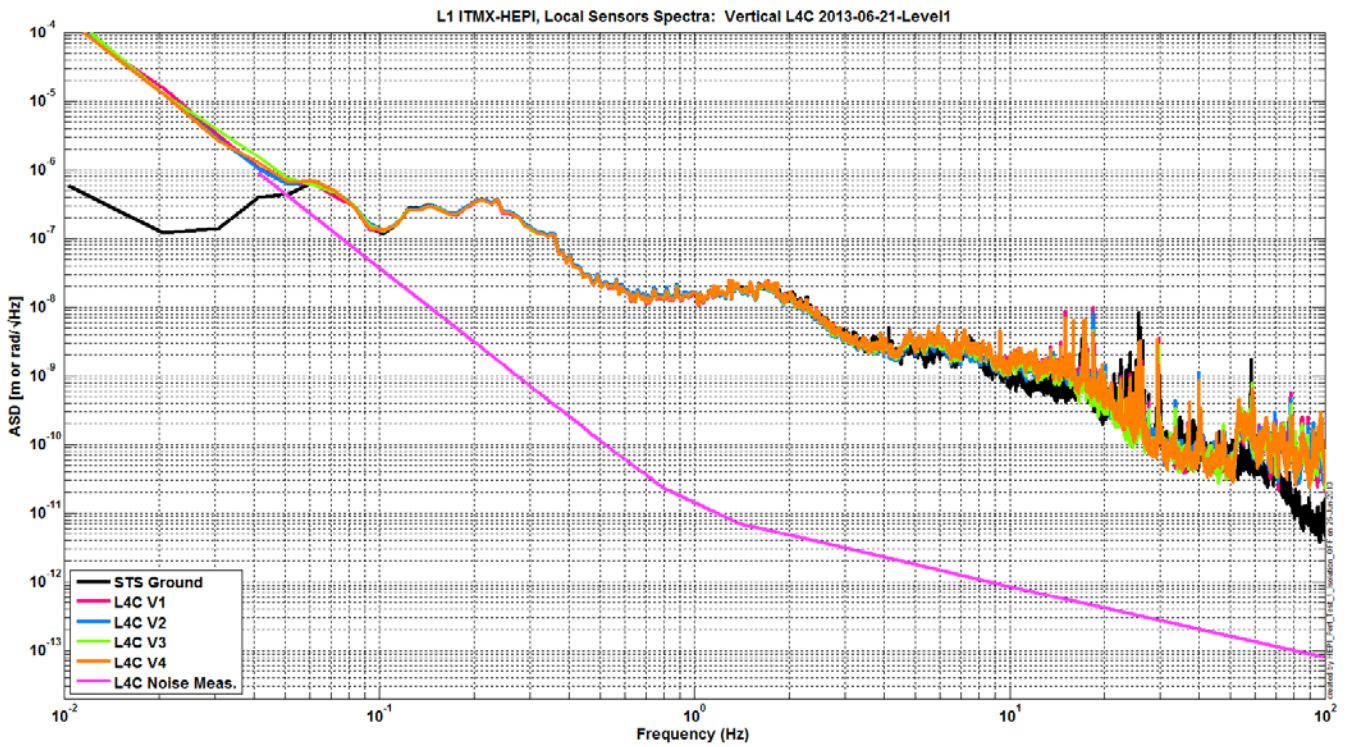
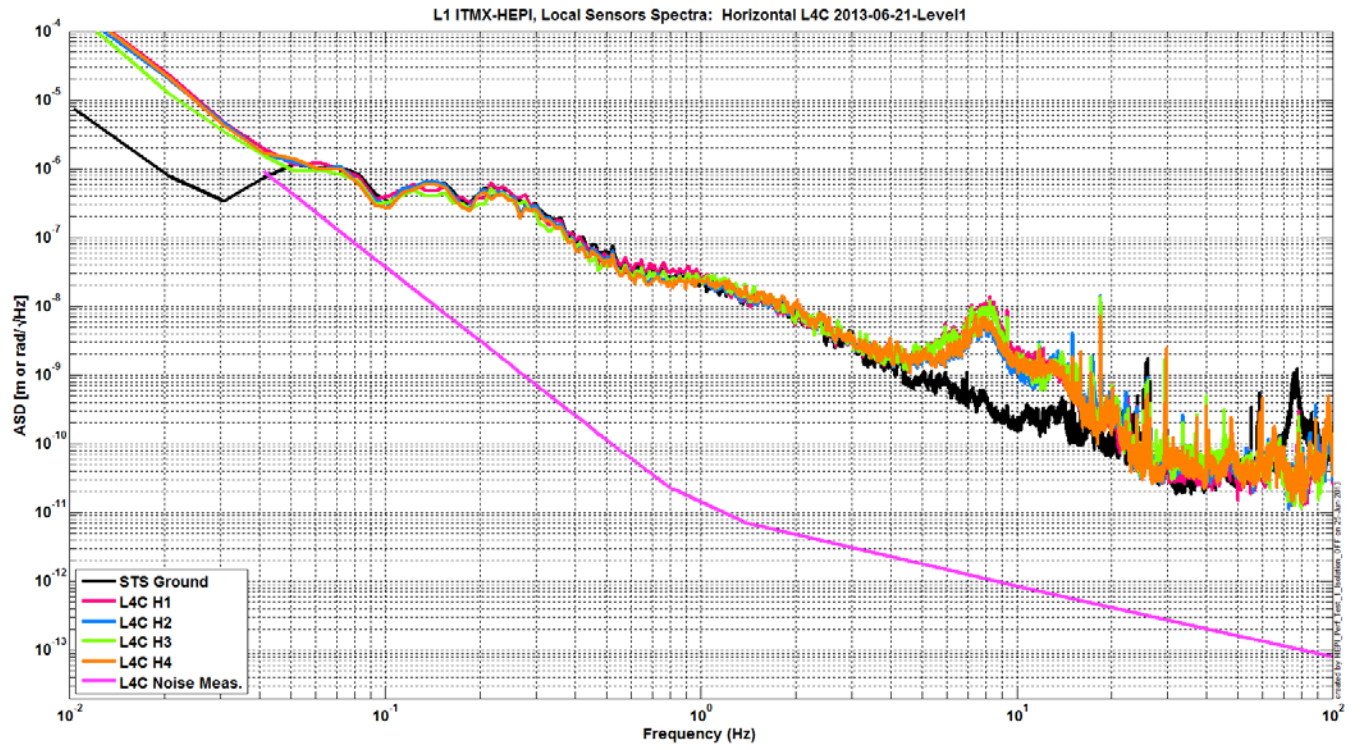
Data in SVN at:

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

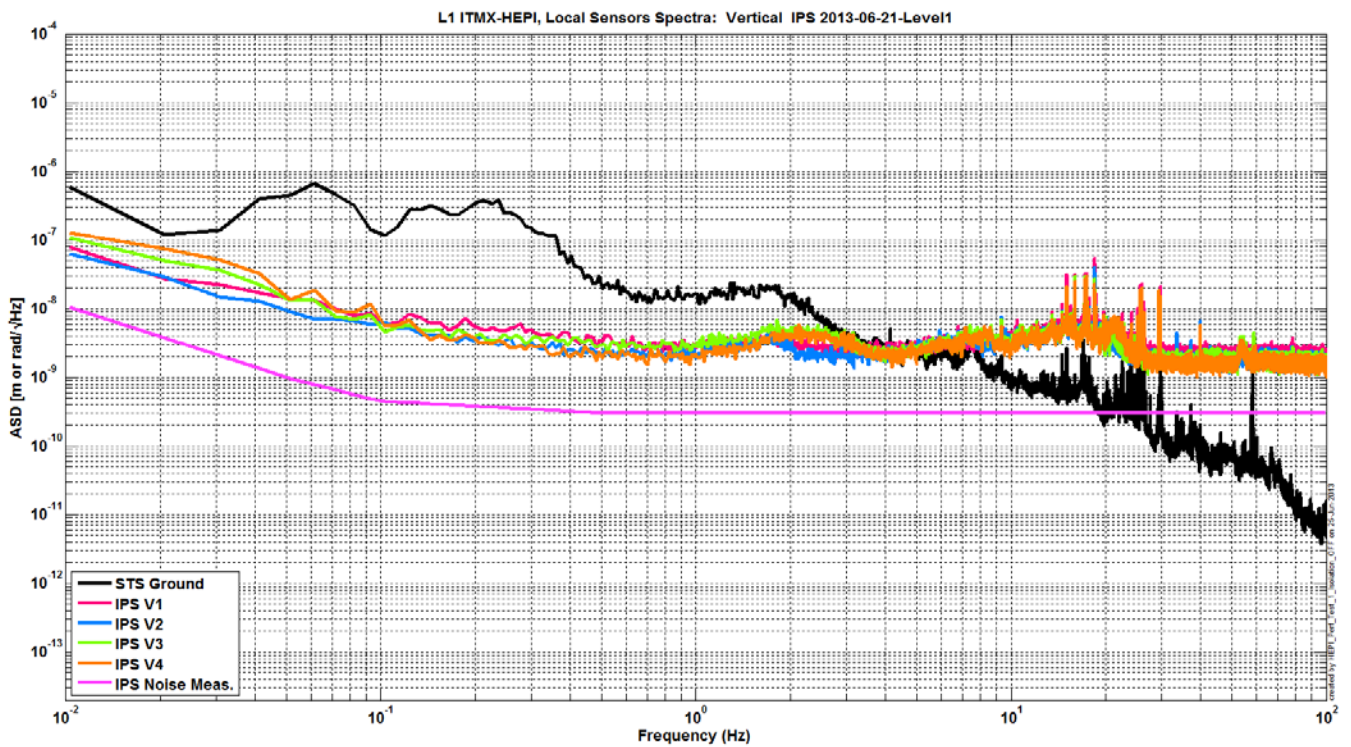
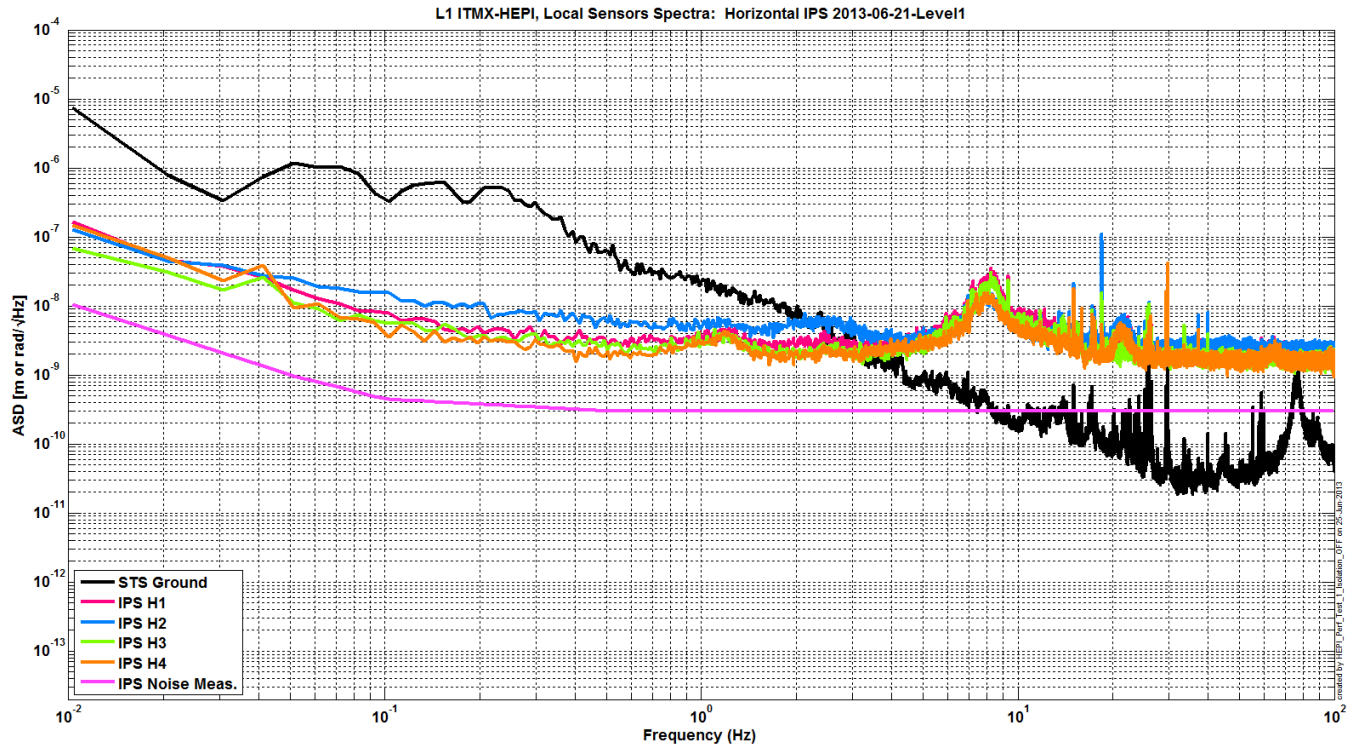
Figures in SVN at:

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

- HEPI\_L1\_ETMX\_Test\_1\_Fig\_a\_HPI\_L4C\_Hor\_2013-06-21-Level1.fig
- HEPI\_L1\_ETMX\_Test\_1\_Fig\_b\_HPI\_L4C\_Vert\_2013-06-21-Level1.fig
- HEPI\_L1\_ETMX\_Test\_1\_Fig\_c\_HPI\_IPS\_Hor\_2013-06-21-Level1.fig
- HEPI\_L1\_ETMX\_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/ETMX/Data/Static\_Tests/

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

	H1	H2	H3	H4	V1	V2	V3	V4
H1	-10946.6	4111.4	906.8	3766.8	16.1	-165.6	-46.6	193.7
H2	-1163.5	-7491.8	3013.8	2284.2	-113.3	-4.1	219.0	-12.8
H3	-3403.1	3479.1	-7750.0	4876.8	-62.8	128.6	3.4	-82.3
H4	-1323.8	2758.8	702.8	-6042.5	214.5	-87.2	-93.4	292.6
V1	-3767.1	1923.9	-2112.7	2322.3	-6031.8	-949.1	1537.8	-1175.6
V2	-3919.2	2117.8	-1920.7	2002.2	-1282.7	-6441.9	-1086.4	1562.0
V3	-3831.1	2301.1	-2076.2	1989.5	1210.1	-1569.0	-6251.2	-970.6
V4	-3623.6	2020.9	-2186.7	2367.3	-1514.9	1254.4	-1312.0	-6610.0

*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/ETMX/Data/Spectra/Undamped/

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

**Figures in SVN at:**

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

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

**Data in SVN at:**

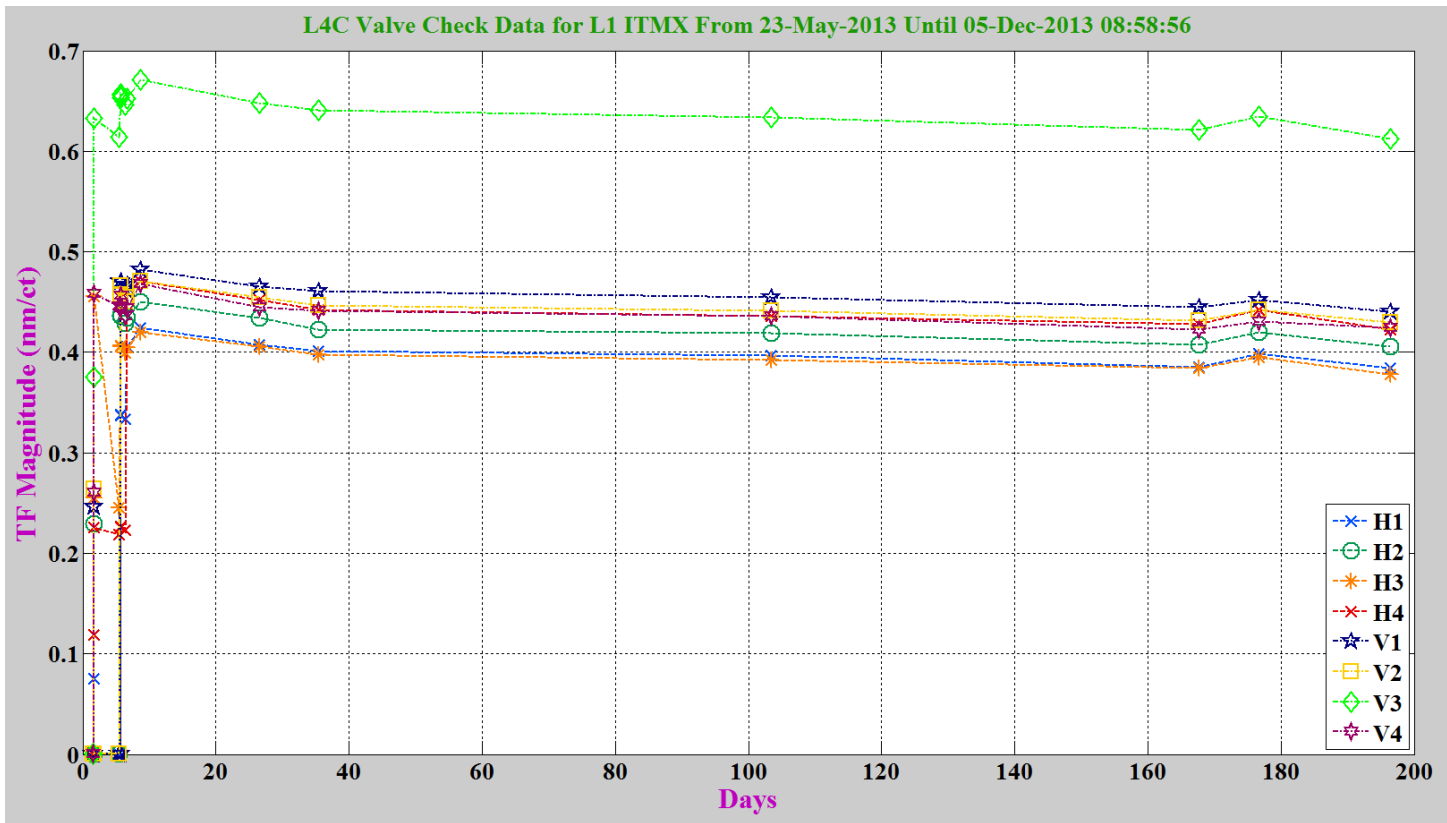
/SeiSVN/seismic/HEPI/L1/ETMX/Data/Spectra/Undamped/

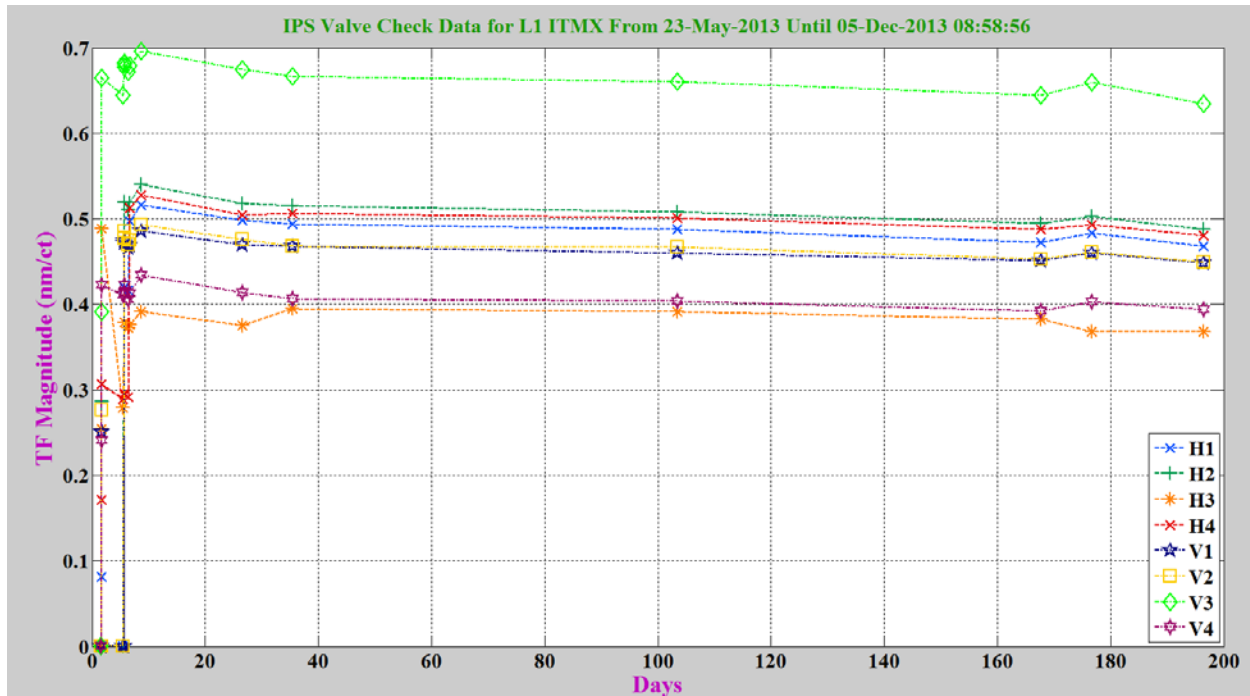
/SeiSVN/seismic/HEPI/L1/ETMX/Scripts/Valve\_Check/

**Figures in SVN at:**

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

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

- L1\_HEPI\_BSC4\_100\_to\_250Hz\_20130530-003431.mat
- L1\_HEPI\_BSC4\_20\_to\_100Hz\_20130529-221752.mat
- L1\_HEPI\_BSC4\_2\_to\_20Hz\_20130529-202353mat
- L1\_HEPI\_BSC4\_0p5\_to\_2Hz\_20130529-171514.mat
- L1\_HEPI\_BSC4\_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\_ETMX.m

**Figures in SVN at:**

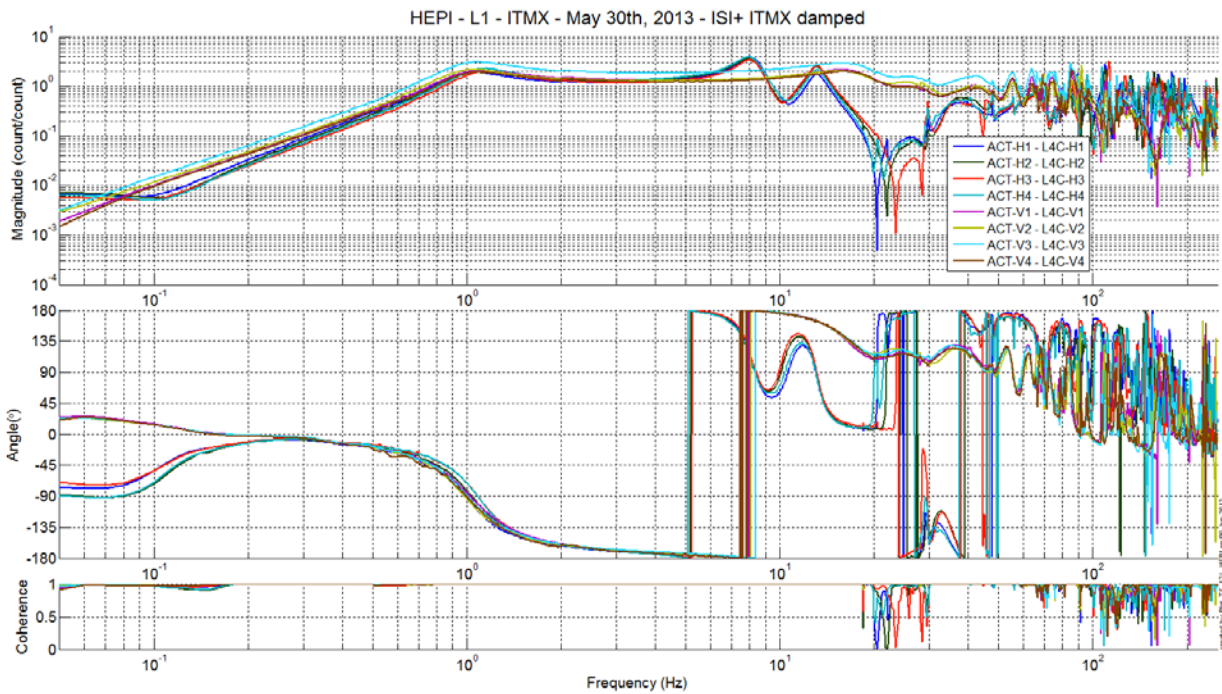
/SeiSVN/seismic/HEPI/L1/ETMX/Data/Figures/Transfer\_Functions/Measurements/Undamped/

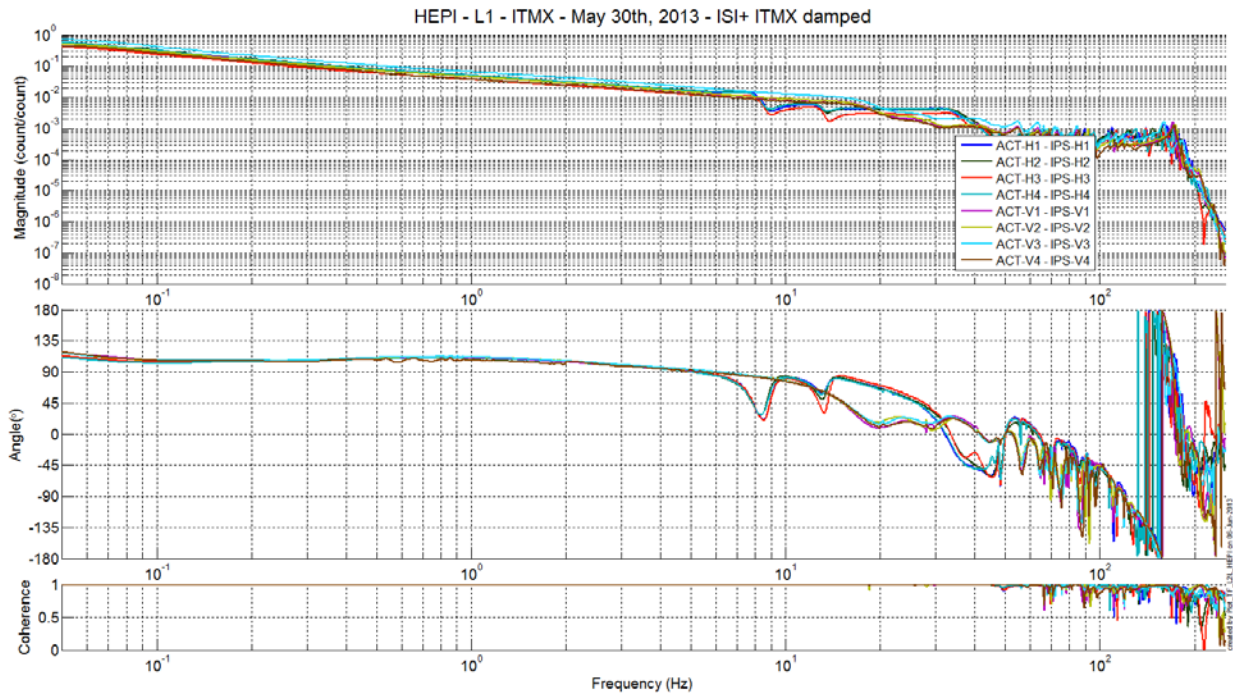
- L1\_HPI\_ETMX\_TF\_L2L\_Raw\_from\_ACT\_to\_IPS\_2013\_05\_30.fig
- L1\_HPI\_ETMX\_TF\_L2L\_Raw\_from\_ACT\_to\_L4C\_2013\_05\_30.fig

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

/SeiSVN/seismic/HEPI/L1/ETMX/Data/Transfer\_functions/Simulations/Undamped/  
 L1\_HPI\_ETMX\_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:*

After HEPI was unlocked, commissioners applied necessary RY (=pitch) displacement in order to facilitate the X-arm locking. Here are the IPS values once that displacement was applied (measured on 04/11/14)

	IPS Readouts
H1	4766
H2	8290
H3	111
H4	665
V1	682
V2	-12309
V3	-6037
V4	14712

**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.