

LIGO Laboratory / LIGO Scientific Collaboration

LIGO- E1300824

LIGO

November 1st, 2013

aLIGO HEPI Assembly Validation Procedure

E1300824

Fabrice Matichard, Sebastien Biscans, Hugo Paris for the SEI Team

Distribution of this document:
Advanced LIGO Project

This is an internal working note
of the LIGO Laboratory

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

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Introduction

This document summarizes the steps to be done to validate HEPI assemblies. Corresponding reports must be posted in :

LIGO-E1300454: aLIGO HEPI Testing Reports

Sub-Components Testing

- Kaman Inductive Position Sensors: calibration, linearity, factory data, noise measurements (E0900426 – HEPI Kaman Sensor Receiving Analysis - Results posted in the SVN)
- HEPI actuator linearity test (E1100338 – aLIGO HEPI Actuators Test Results)
- L4C test (Q0900007)

Assembly Validation

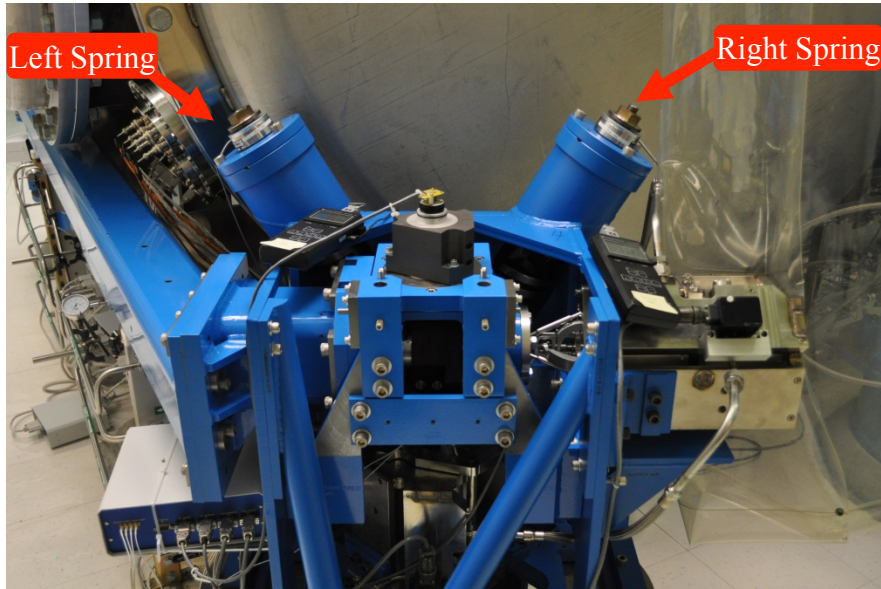
After installation along procedure Exxxxxx, and alignment along procedure Exxxxxx, and once HEPI is in final configuration (alignment completed).

1.1 Load Cells assembly

- Spring attachment
For the BSC HEPI springs, check the assembly per D030324. See LLO aLOG 7162 for more details.



- Load cell values
BSC HEPI load cell capacity → 3000 lbs
HAM HEPI load cell capacity → 2000 lbs



HAM-HEPI example at LASTI

	Left Spring (lbs)	Right Spring (lbs)
Pier 1	1347	949
Pier 2	1458	1631
Pier 3	1267	1157
Pier 4	1142	1722

Acceptance criteria:

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

Test result:

Passed:

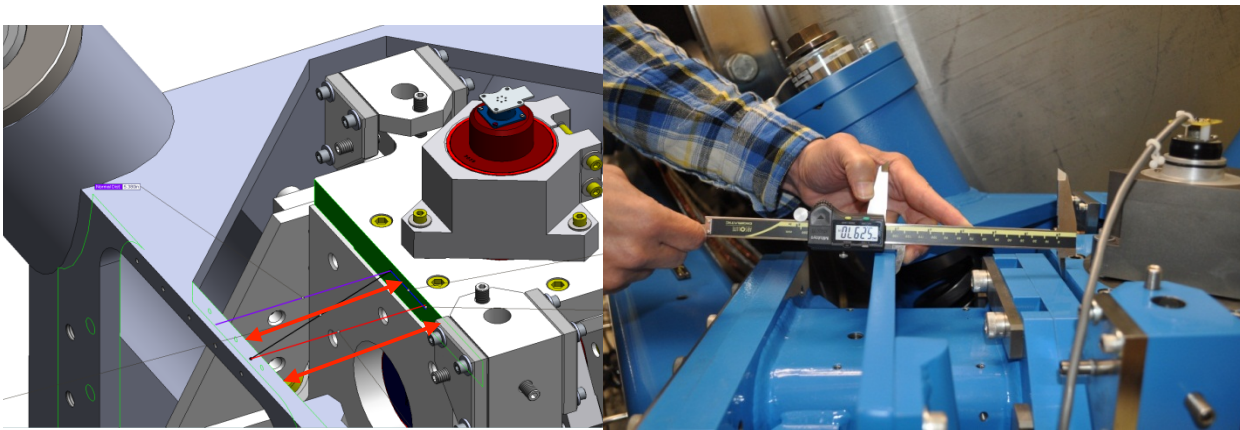
Failed: X

1.2 Bellows

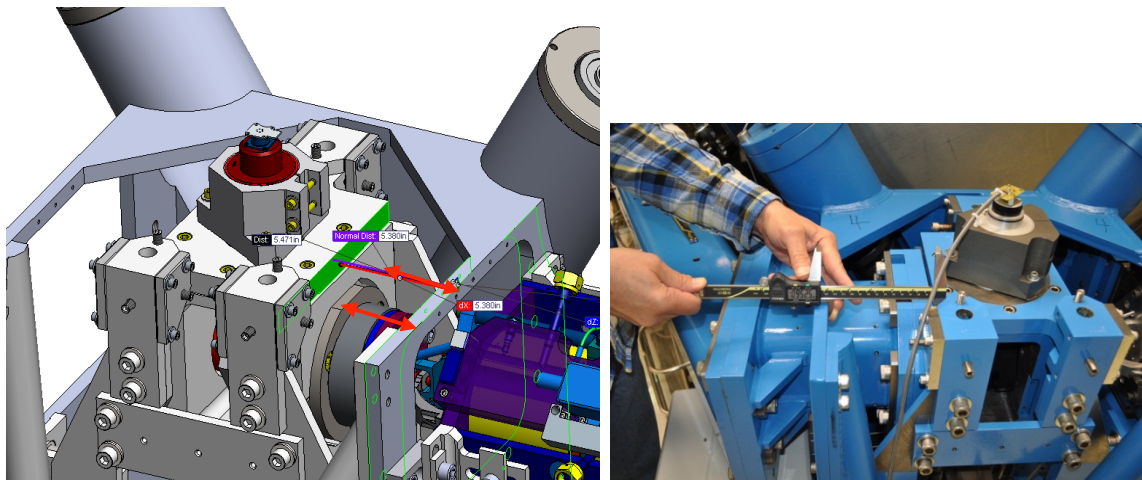
The bellows are hard to access and tests are hard to proceed. After several discussions and brainstorming sessions, it has been decided not to measure the gaps on HEPI-HAM and HEPI-BSC.

1.3 Boot Location

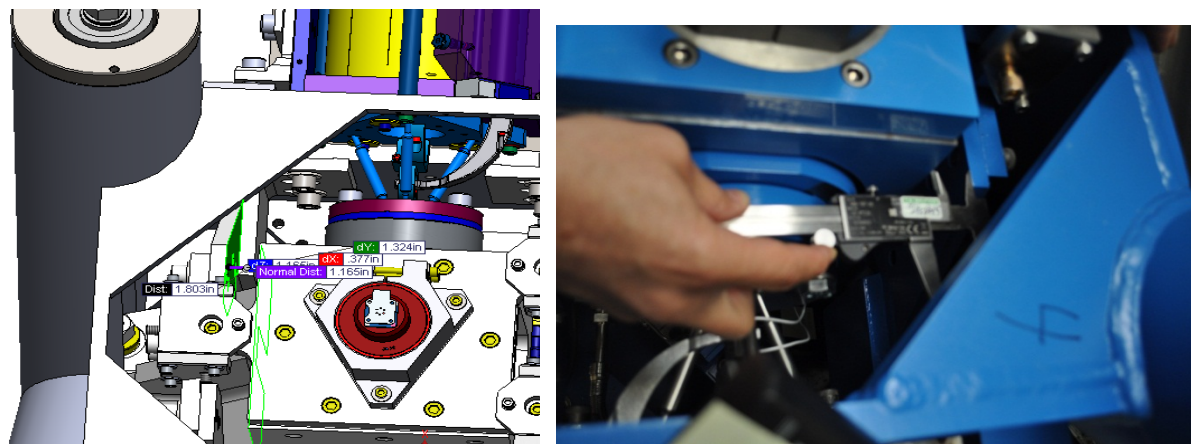
Tangential Left: 5.380"



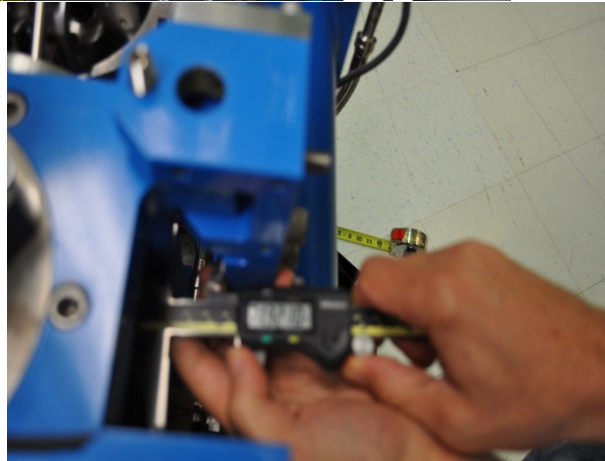
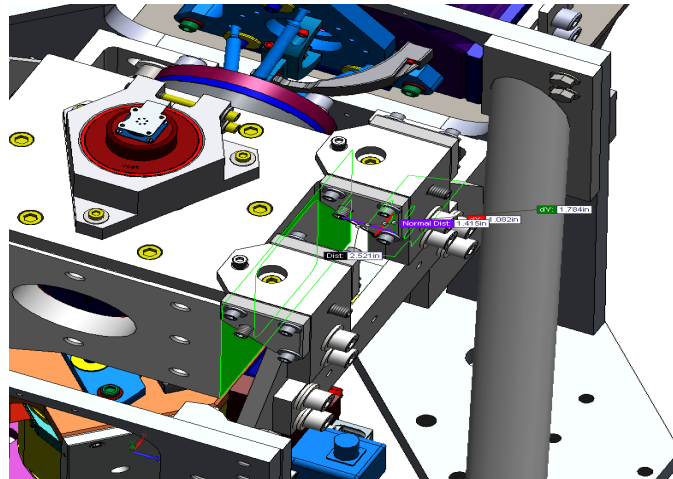
Tangential Right: 5.380"



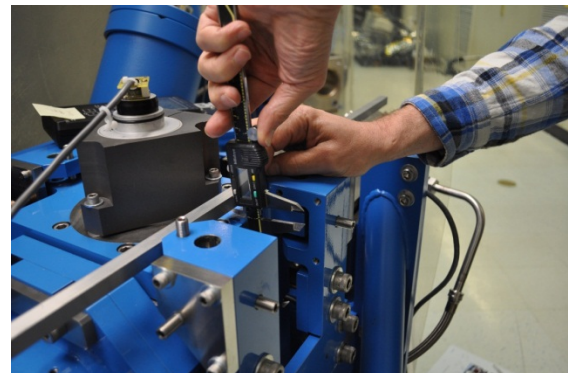
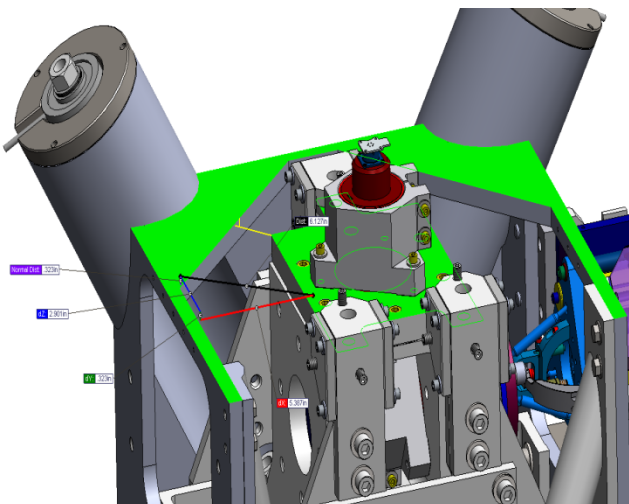
Radial Back: 1.17"



Radial Front: 1.42"



Vertical: 0.32"



	Pier 1	Pier 2	Pier 3	Pier 4	Nominal
Point 1 a (Tangential)	5.19	5.22	5.26	5.31	5.38
Point 1 b (Tangential)	5.20	5.23	5.28	5.26	5.38
Point 2 a (Tangential)	5.56	5.53	5.53	5.43	5.38
Point 2 b (Tangential)	5.54	5.53	5.49	5.49	5.38
Point 3 (Radial Back)	1.14	1.14	1.14	1.14	1.17
Point 4 (Radial Front)	1.35	1.41	1.31	1.34	1.42
Point 5 (Vertical)	0.44	0.44	0.44	0.47	0.32

	Pier 1	Pier 2	Pier 3	Pier 4	Requirements
Point 1 a (Tangential)	-0.19	-0.16	-0.12	-0.07	+/- 0.20
Point 1 b (Tangential)	-0.18	-0.15	-0.10	-0.12	+/- 0.20
Point 2 a (Tangential)	0.18	0.15	0.15	0.05	+/- 0.20
Point 2 b (Tangential)	0.16	0.15	0.11	0.11	+/- 0.20
Point 3 (Radial Back)	-0.03	-0.03	-0.03	-0.03	+/- 0.10
Point 4 (Radial Front)	-0.06	-0.01	-0.11	-0.08	+/- 0.15
Point 5 (Vertical)	0.12	0.12	0.12	0.15	+/- 0.20

Acceptance criteria:

-

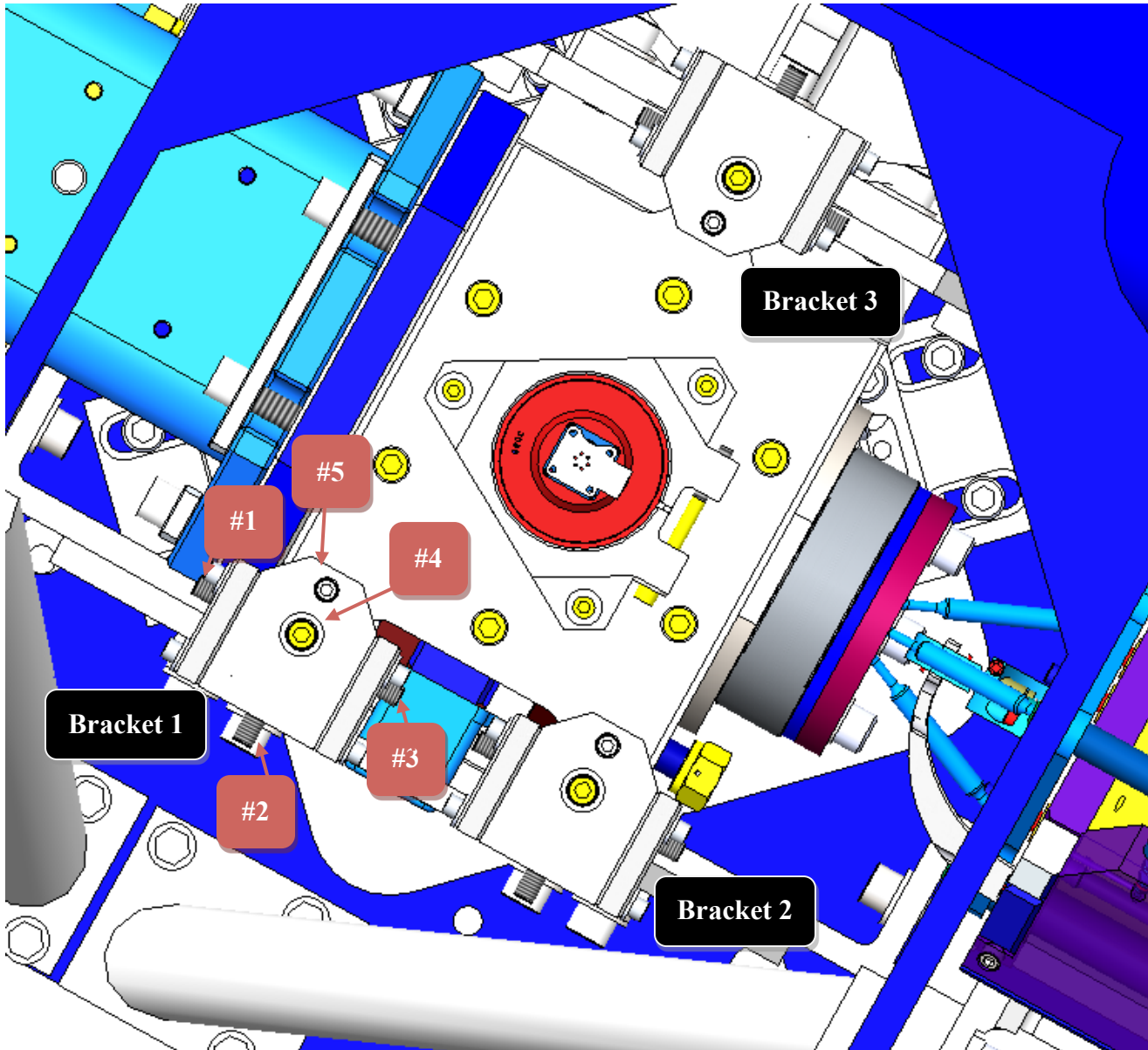
Test result:

Passed: X

Failed:

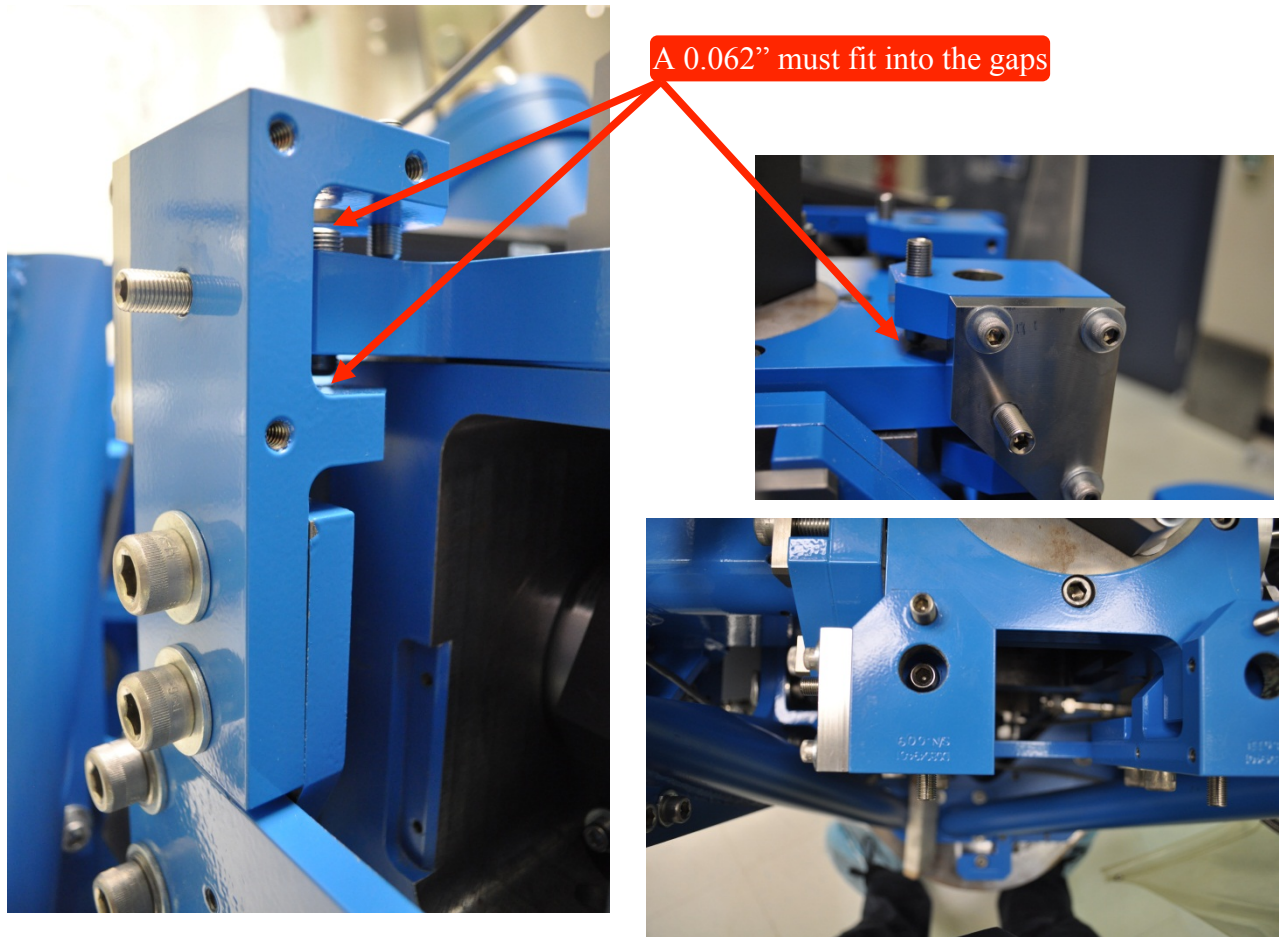
1.4 Check Stops Gaps

The stops must not touch the boot. There is 15 stops per boot, 5 per F bracket.



Acceptance criteria:

- A 0.062” shim must fit into the gaps



	Bracket 1						Bracket 2						Bracket 3					
	Gap 1	Gap 2	Gap 3	Gap4 above	Gap4 under	Gap 5	Gap 1	Gap 2	Gap 3	Gap4 above	Gap4 under	Gap 5	Gap 1	Gap 2	Gap 3	Gap4 above	Gap4 under	Gap 5
Pier 1	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go
Pier 2	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go
Pier 3	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go
Pier 4	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go

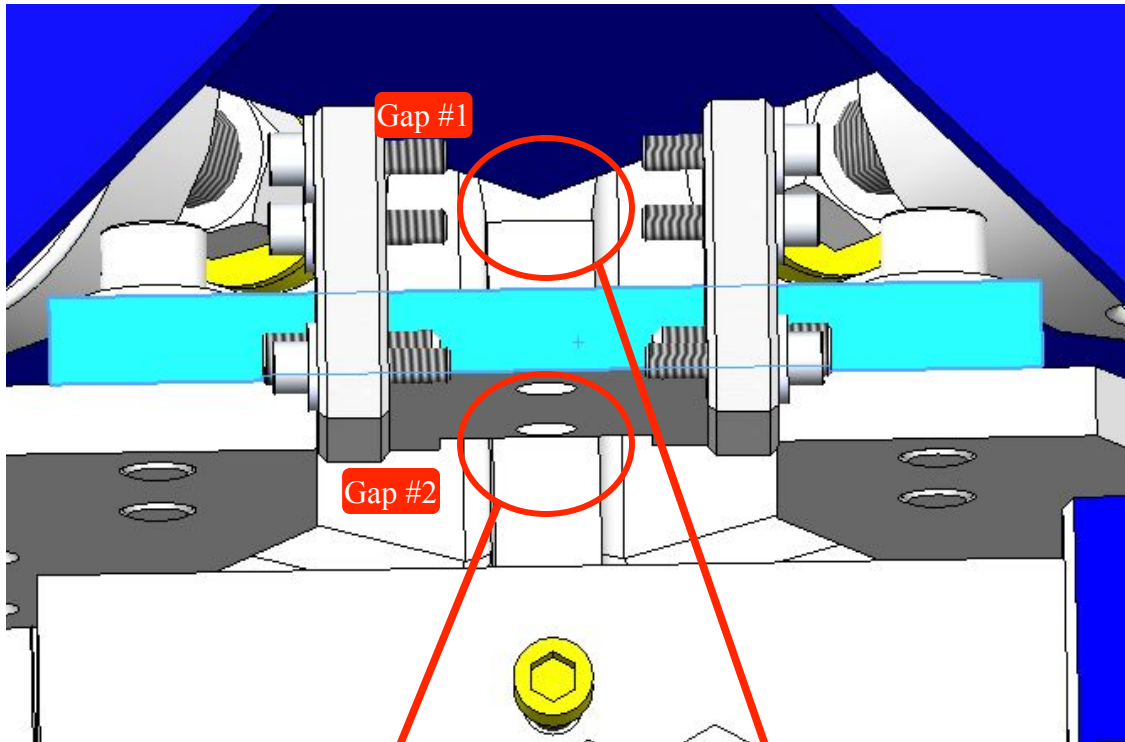
Test result:

Passed: X

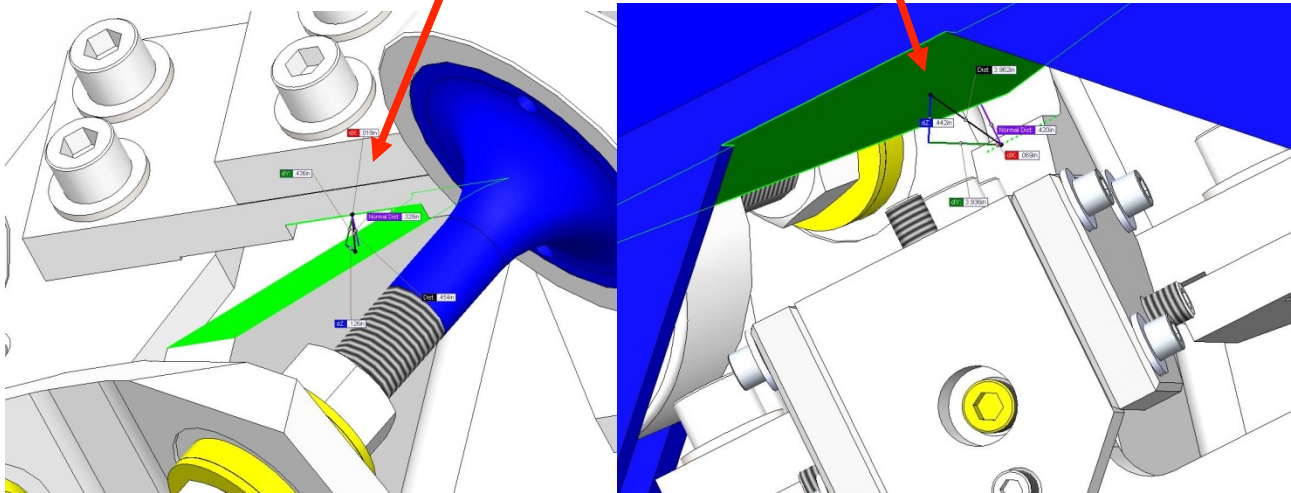
Failed:

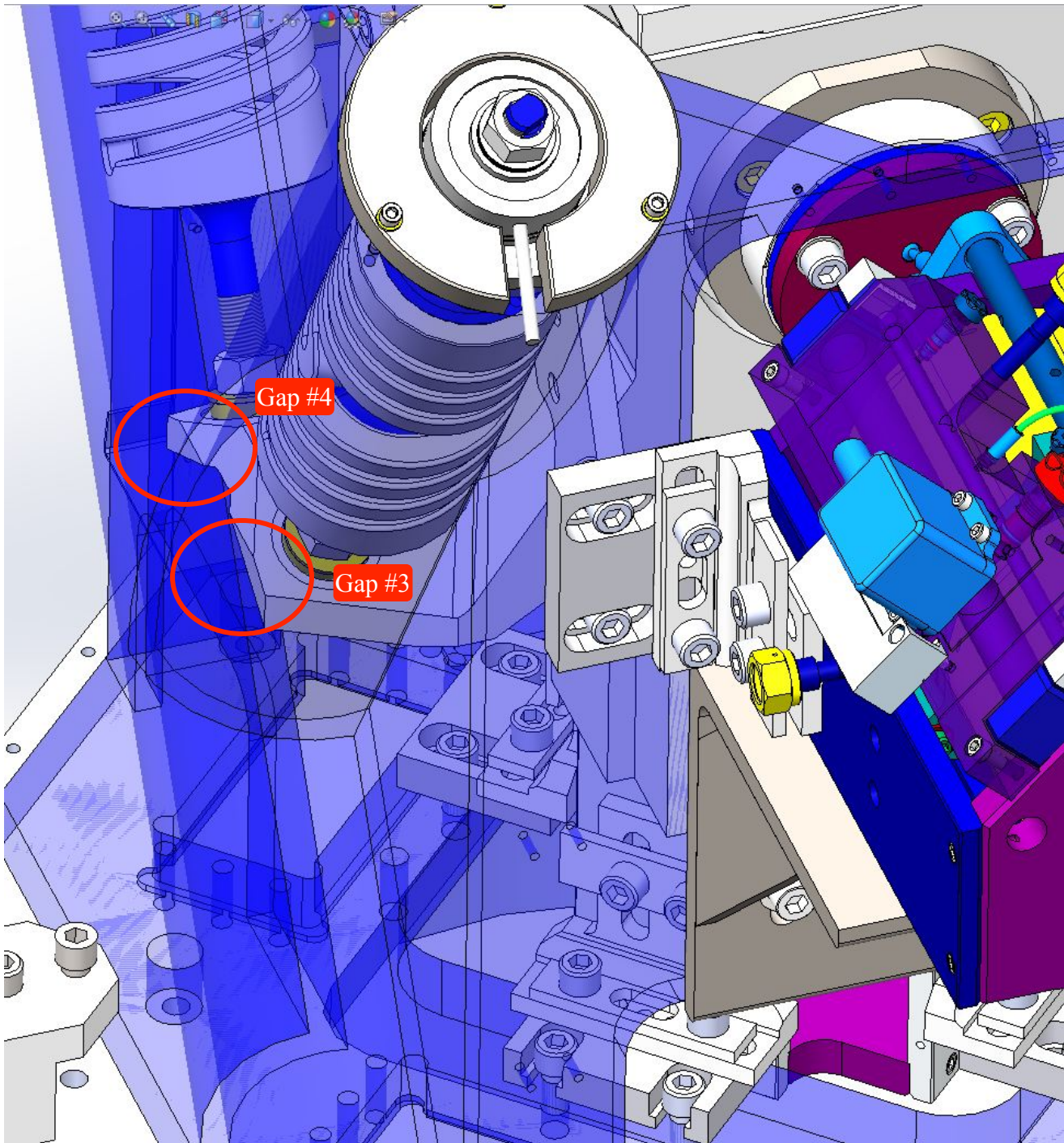
1.5 Gaps check

Four particular gaps need to be check.



The F bracket has been removed for a better visibility





Acceptance criteria:

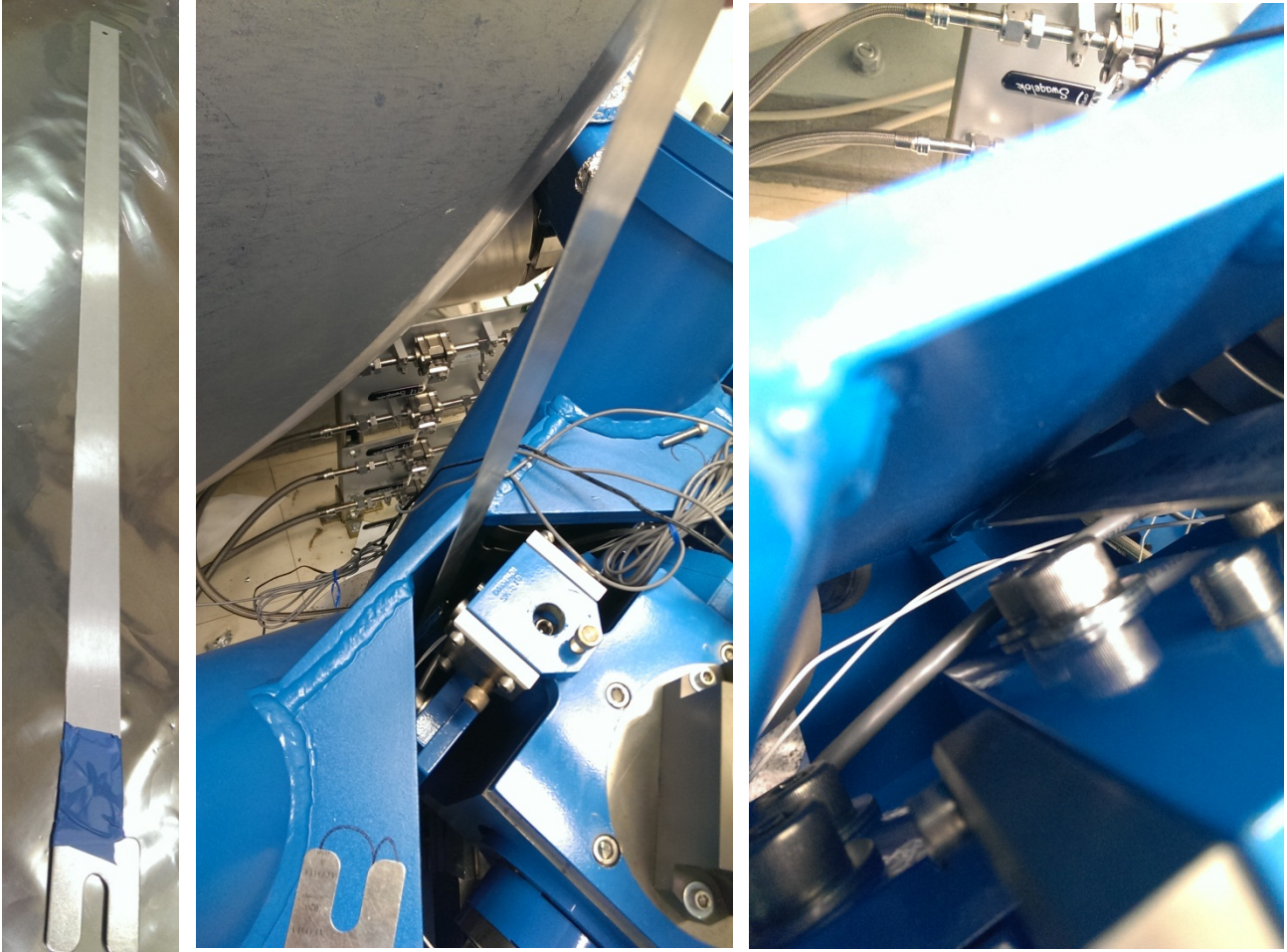
- a 0.08” shim must fit in these two gaps

Issues/difficulties/comments regarding this test: Gap#1 is tricky to reach. At LASTI, the solution found was to tape the shim to an extension (rod, rigid ruler, etc.).

Gap#2 should be reachable by hand.

Gap#3 and 4 are tricky, but should also be doable (no picture)

Gap#1



Gap#2



	Gap#1	Gap#2	Gap#3	Gap#4
Pier 1	Go	Go	Go	Go
Pier 2	Go	Go	Go	Go
Pier 3	Go	Go	Go	Go
Pier 4	Go	Go	Go	Go

Test result: Passed: X Failed:

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 *Sensor ASD*

Scripts files for processing and plotting in SVN at:

/SeiSVN/seismic/HEPI/Common/Testing_Functions_HEPI/ASD_Measurements_Local_HEPI.m

Data in SVN at:

SeiSVN/seismic/HEPI/M1/HAMX/Data/Spectra/Undamped/
M1_HPI_HAMX_ASD_m_IPS_L4C_2013_06_03_120859.mat

Figures in SVN at:

/SeiSVN/seismic/HEPI/M1/HAMX/Data/Figures/Spectra/Undamped

- 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

. 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

Table - Main couplings and cross couplings

. 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

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

	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/M1/HAMX/Data/Spectra/Undamped/

M1_ISI_HAMX_ASD_m_CPS_T240_L4C_GS13_Locked_vs_Unlocked_2012_02_07.mat

Figures in SVN at:

/SeiSVN/seismic/HEPI/M1/HAMX/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:

▪

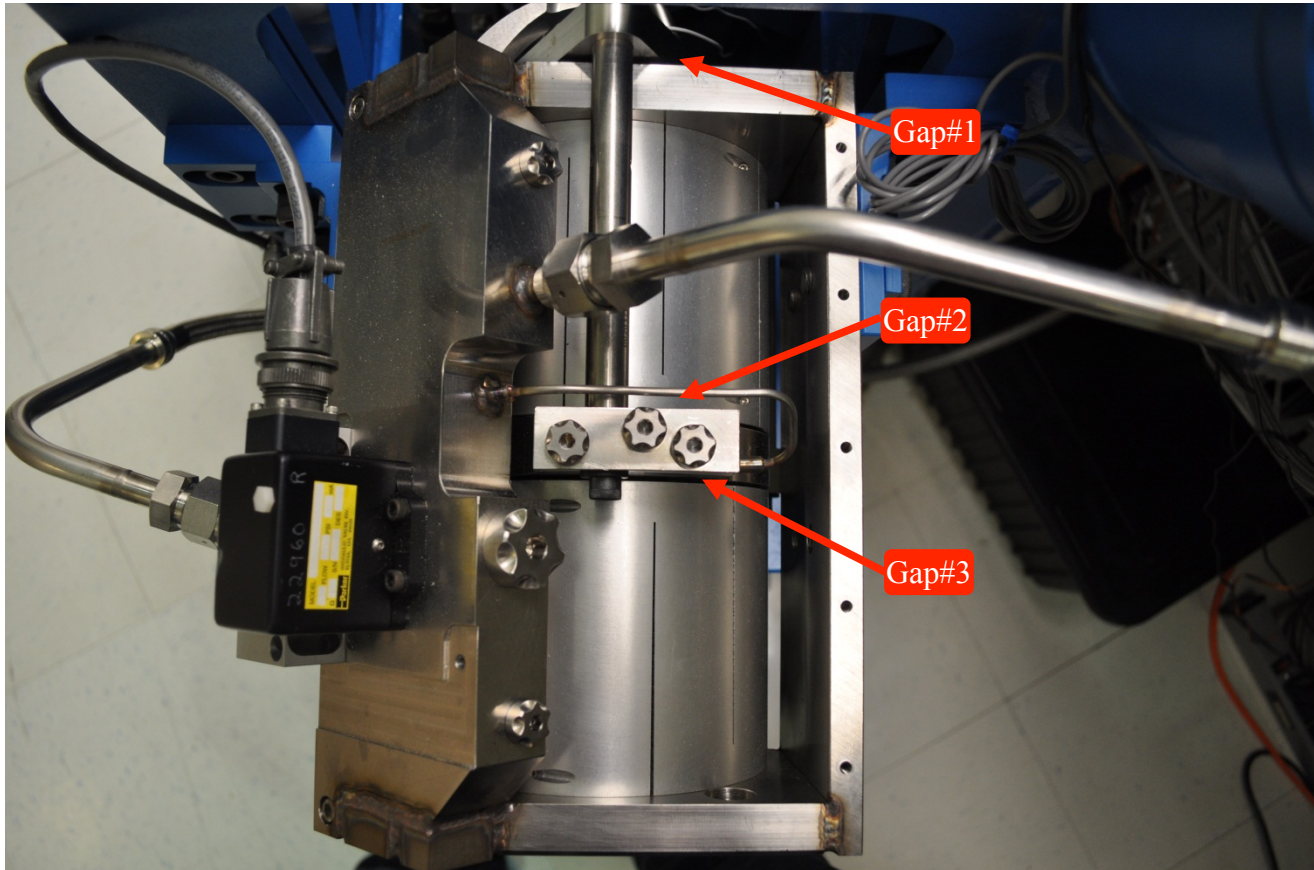
Test result:

Passed: X

Failed:

1.11 Actuator Plate to Shields gap

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



Three gaps per actuator need to be checked.

Acceptance criteria:

- A 0.1” shim must fit into the gap #1
- A 0.05 shim must fit into gap #2 and #3

	Horizontal			Vertical		
	Gap #1	Gap #2	Gap #3	Gap #1	Gap #2	Gap #3
Pier 1	Go	Go	Go	Go	Go	Go
Pier 2	Go	Go	Go	Go	Go	Go
Pier 3	Go	Go	Go	Go	Go	Go
Pier 4	Go	Go	Go	Go	Go	Go

Test result:

Passed: X

Failed:

1.12 Valve Check

Scripts files for processing and plotting in SVN at:

/SeiSVN/seismic/HEPI/M1/HAMX/Scripts/Valve_Check/plot_valve_check.m

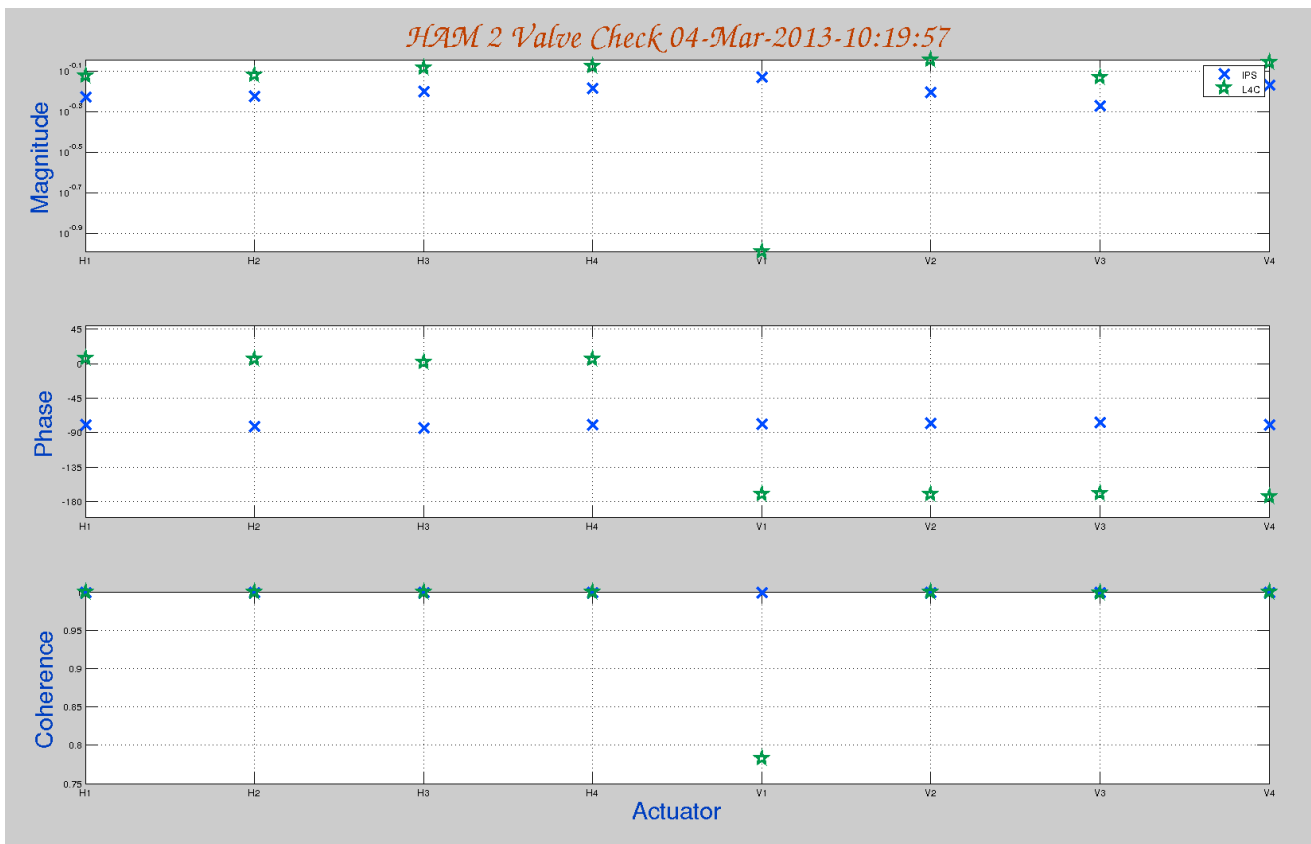
Data in SVN at:

SeiSVN/seismic/HEPI/M1/HAMX/Data/Spectra/Undamped/

/SeiSVN/seismic/HEPI/M1/HAMX/Scripts/Valve_Check

Figures in SVN at:

/SeiSVN/seismic/HEPI/M1/HAMX/Scripts/Valve_Check



Acceptance criteria:

-

Test result:

Passed: ____

Failed: ____

1.13 Local-to-local measurements

Band (Hz)	Resolution	Amplitude	Nreps	Time (s)	Time (min)	Time (h)
100 - 500	0.5	4000 - 4000	250	4176	69.6	1.2
10 - 100	0.25	4000 - 4000	200	6592	109.9	1.8
0.7 - 10	0.05	4000 - 4000	75	12320	205.3	3.4
0.1 - 0.7	0.025	4000 - 4000	30	10080	168.0	2.8
0.01 - 0.1	0.01	4000 - 4000	10	8960	149.3	2.5
0.002 - 0.01	0.002	4000 - 4000	2	12160	202.7	3.4
						15.1

Data files in SVN at:

- /SeiSVN/seismic/HEPI/M1/HAMX/Data/Transfer_Functions/Measurements/Undamped/
 - M1_HPI_HAMX_Data_TF_L2L_200Hz_1000Hz_20120201-174407.mat
 - M1_HPI_HAMX_Data_TF_L2L_5Hz_200Hz_20120201-183140.mat
 - M1_HPI_HAMX_Data_TF_L2L_500mHz_5Hz_20120201-191513.mat
 - M1_HPI_HAMX_Data_TF_L2L_100mHz_500mHz_20120201-202848.mat
 - M1_HPI_HAMX_Data_TF_L2L_10mHz_100mHz_20120201-212025.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/M1/HAMX/Scripts/Control_Scripts/release/
 - Step_1_TF_Loc_to_Loc_M1_HEPI_HAMX.m

Figures in SVN at:

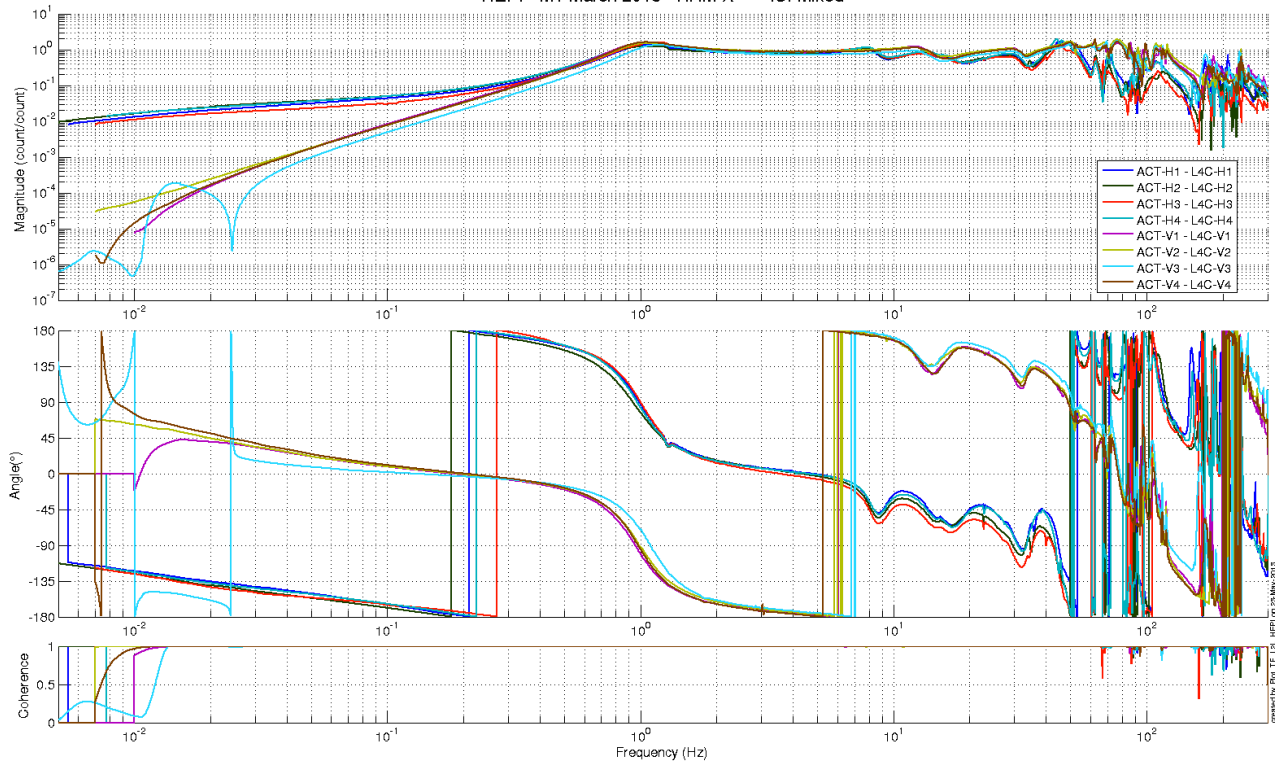
- /SeiSVN/seismic/HEPI/M1/HAMX/Data/ Figures/Transfer_Functions/Measurements/Undamped/
 - M1_HPI_Unit_1_TF_L2L_Raw_from_ACT_to_CPS_2012_02_02_With_3_Washers_Under_Top_Mass.fig
 - M1_HPI_Unit_1_TF_L2L_Raw_from_ACT_to_GS13_2012_02_02_With_3_Washers_Under_Top_Mass.fig

Storage of measured transfer functions in the SVN at:

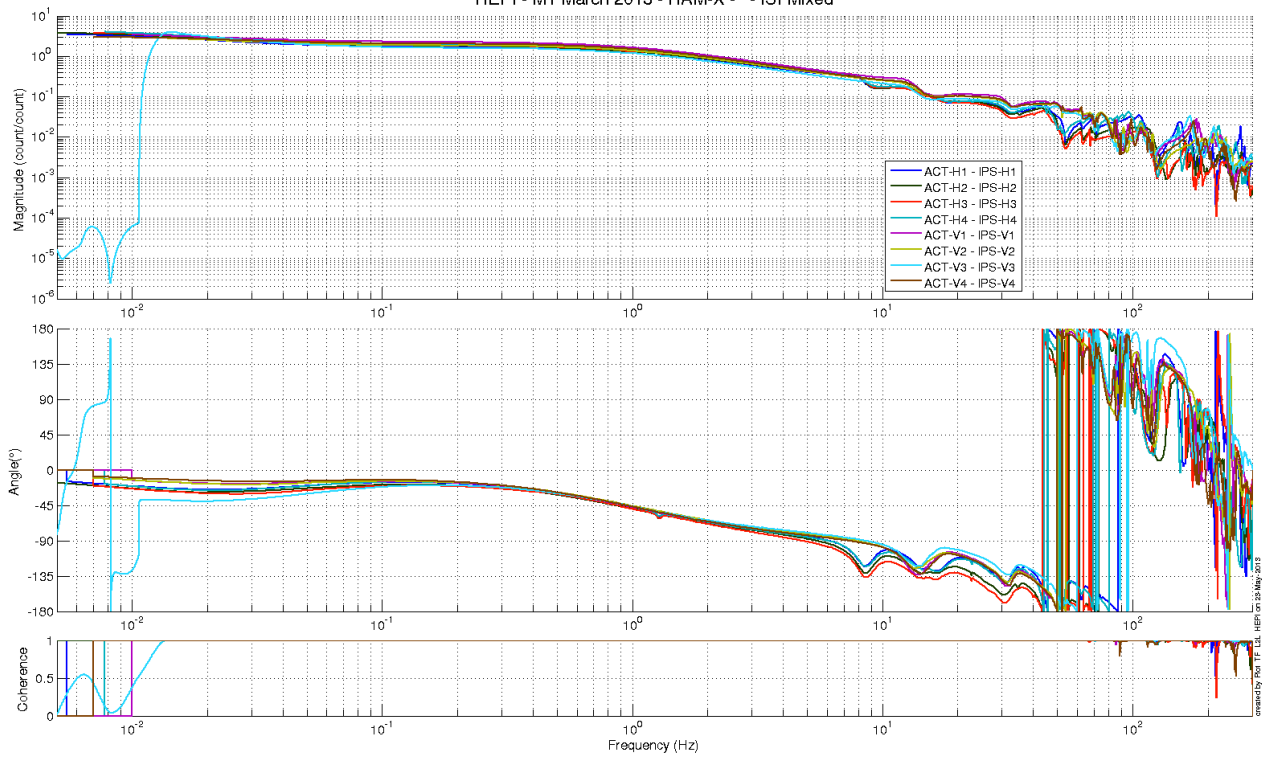
- /SeiSVN/seismic/HEPI/M1/HAMX/Data/Transfer_functions/ Simulations/Undamped/
 - M1_HPI_Unit_1_TF_L2L_Raw_2012_02_02_With_3_Washers_Under_Top_Mass.mat

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

HEPI - M1 March 2013 - HAM-X - - ISI Mixed



HEPI - M1 March 2013 - HAM-X - - ISI Mixed



Issues/difficulties/comments regarding this test:

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: X

Failed:

1.14 Alignment offsets:

Those are the IPS readouts that were recorded with HEPI locked, after alignment work was performed. The opposite of those values is to be installed as offset of the IPS filter banks when the Isolation loops are turned on. This way, HEPI will be operating in its *preferred alignment* state.

	IPS Readouts HEPI Locked	Offset Value
H1	1331.1	-1331.1
H2	957.72	-957.72
H3	2157.4	-2157.4
H4	-1303.6	1303.6
V1	-2742.7	2742.7
V2	-511.83	511.83
V3	1034	-1034
V4	-2882.9	2882.9

Acceptance criteria:

Offsets were recorded.

Test result:

Passed:

Failed: