



LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1300585-v2

ADVANCED LIGO

19-Nov-13

HAUX H1-IM1 test report

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Distribution of this document:
LIGO Science Collaboration

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1 Introduction

This document summarizes the results of tests conducted to verify L1 HAM Auxiliary suspensions' compliance with requirements, as well as other useful information.

1.1 Suspension data

IFO: H1

Suspension name: IM1

Suspension SN: 006

Installed optics: SM1-05

UL OSEM SN: 204

LL OSEM SN: 454

UR OSEM SN: 199

LR OSEM SN: 262

<https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1000120-006>

1.2 Applicable Documents

1.2.1 LIGO Documents

[LIGO-T1200469](#), "HAUX test procedure and acceptance criteria"

2 Summary of tests

The following table helps to quickly identify in which condition the results of the tests reported in this document refer to.

Gray cells represent the minimum required condition for final testing. “X” indicates the conditions of the test which results are reported in this document.

	Table		Electronics		Cables		Pressure		Result
	Test	HAM	Test	Final	Test	Final	Air	Vac	
OSEMs OLV		X		X		X	X		Passed
DC pointing	X			X	X		X		Passed
OSEMs calibr.	X			X	X		X		Passed
PSDs, no ECDs	X			X	X		X		Passed
TFs, no ECDs	X			X	X		X		Passed
PSDs, with ECDs		X		X		X	X		Passed
TFs, with ECDs		X		X		X	X		Passed
Q measurements									Pending
B&K Hammering		X					X		Passed

3 Tests results

3.1 OSEMs OLV

These measurements have been performed on HAM table with final electronics and cables in date 29-Nov-2012.

	UL Channel	LL Channel	UR Channel	LR Channel
UL OSEM	27538			
LL OSEM		25505		
UR OSEM			23969	
LR OSEM				28020

Requirements (from [T1200469](#), § 2.2.4):

- >25k optimal, >20K acceptable

Passed

3.2 DC Pointing

This has been measured and corrected chamber-side in date 05-Sep-2012. See LHO aLog [4081](#).

Measured value: 0 ± 0.5 mrad

Requirements (from [T1200469](#), § 2.1.1):

- Nominal value (0) ± 1 mrad

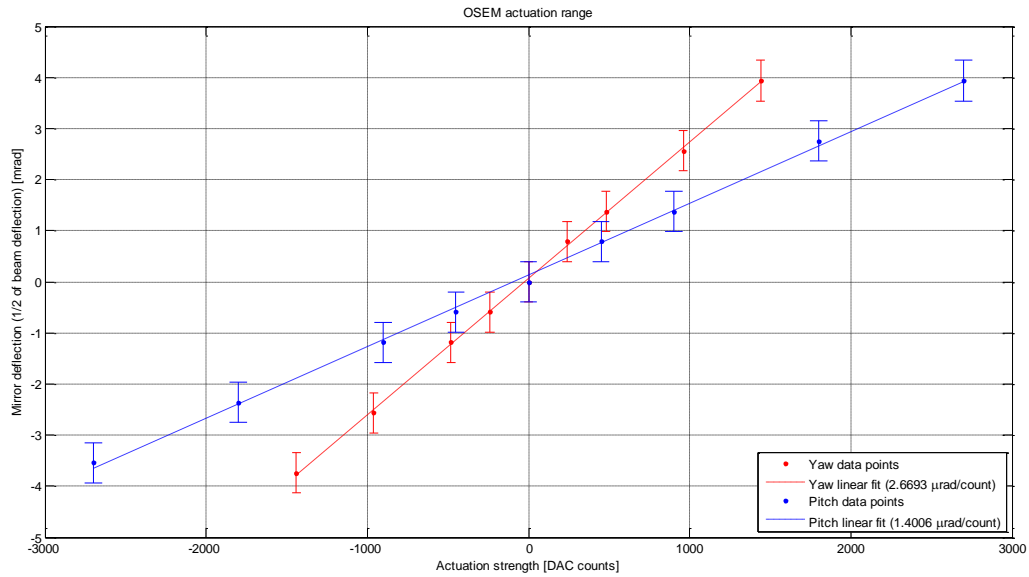
Passed

3.3 OSEMs range and linearity

These measurements have been taken chamber-side in date 04-Sep-2012. See LHO aLog [4054](#).

Please note: these measurements have been taken with the HAUX coil driver ([D1100117-v2](#) HAM-A coil drivers) “as designed”. During commissioning, proposals have been made to reduce the electronics output gain such that the actuation range of the HAUX would better correspond to what is actually needed (see for example LLO aLog [5213](#)). However, as of the time of writing this document, modifications have not yet been definitively approved or applied to all coil driver boxes and are not considered part of these acceptance tests.

3.3.1 Mirror rotation Vs Actuation

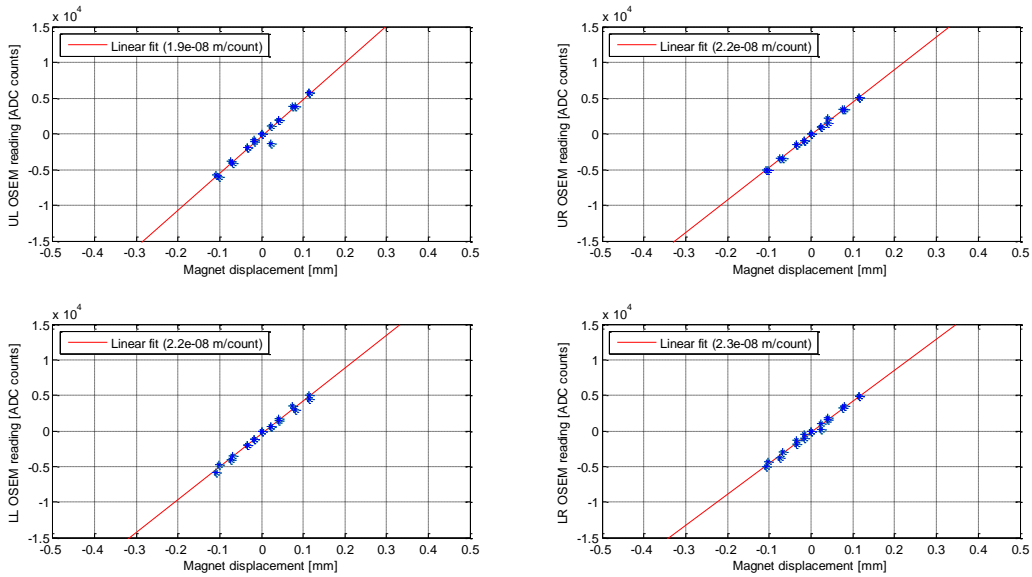


Requirements (from [T1200469](#), § 2.1.1):

- > 10 mrad for full actuation (32000 counts)

Passed

3.3.2 OSEMs readout Vs Displacement



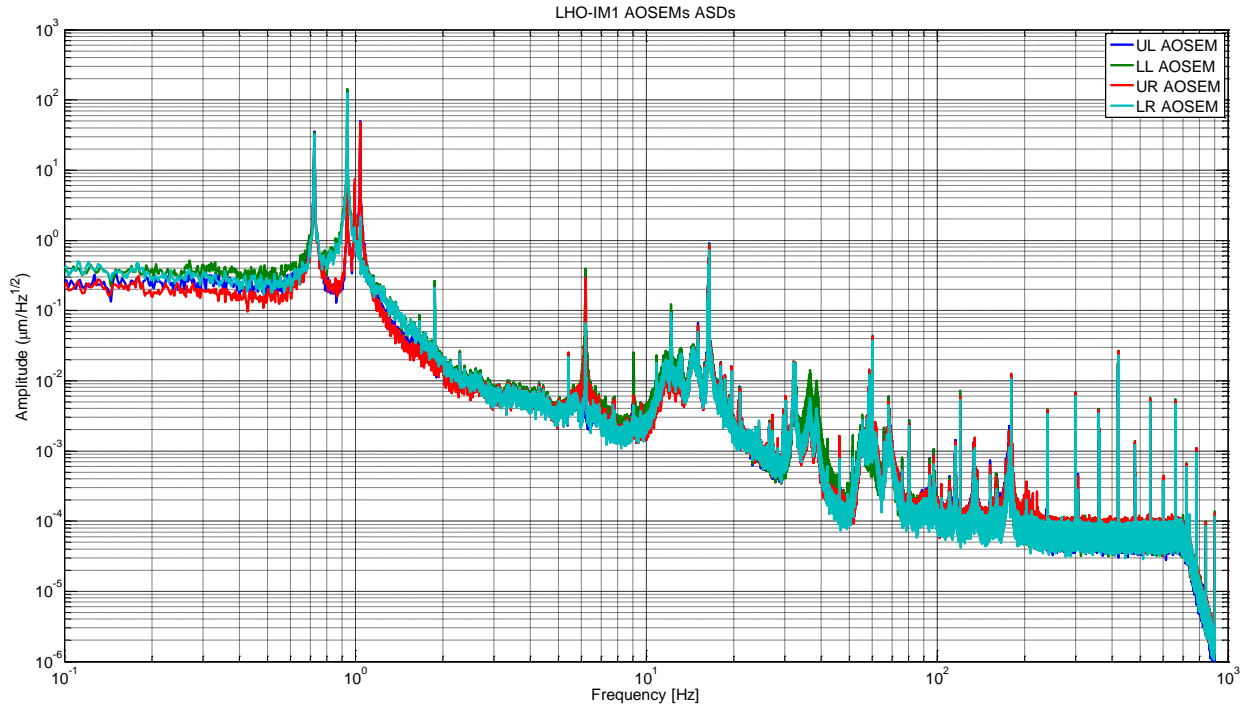
There are no requirements associated with this measurement. It is rather intended to be a sanity check looking for strange (e.g. non linear) behaviors and differences between OSEMs. Passed

3.4 Linear spectra, no ECDs

These measurements have been taken chamber-side in date 31-Aug-2012. See aLog [4034](#).

Data is stored in the SUS SVN repository:

HAUX\H1\Common\1030461878_IMall_PSD_2mHz_ECDno_DAMPno_Barrel.xml



There are no requirements associated with this measurement. It is rather intended to be a sanity check looking for strange behaviors and differences between OSEMs. As a reference, high frequency electronic noise is expect to be $\sim 10^{-4} \mu\text{m}/\text{Hz}^{1/2}$. **Passed**

3.5 Measured resonances

These have been measured chamber-side in date 04-Sep-2012. See LHO aLog [4054](#).

Yaw: 0.707 Hz

Pitch/Length 1: 0.939 Hz

Pitch/Length 2: 1.041 Hz

Transverse: 0.996 Hz

Bounce: 6.19 Hz

Roll: 9.03 Hz

Requirements (from [T1200469](#), § 2.1.1):

- Pitch, Yaw, Length < 10 Hz (mandatory)
- Transverse, Bounce, Roll < 10 Hz (recommended)

Passed

Passed

3.6 Transfer functions, no ECDs

These have been measured chamber side in date 31-Aug-2012. See LHO aLog [4034](#).

Data is stored in the SUS SVN repository:

HAUX\H1\Common\1030842823_IMall_TF-L_1e5_5mHz_ECD2_DAMPno_OSEMoffset_Barrel.txt

HAUX\H1\Common\1030844369_IMall_TF-P_5e3_5mHz_ECD2_DAMPno_OSEMoffset_Barrel.txt

HAUX\H1\Common\1030845884_IMall_TF-Y_5e3_5mHz_ECD2_DAMPno_OSEMoffset_Barrel.txt

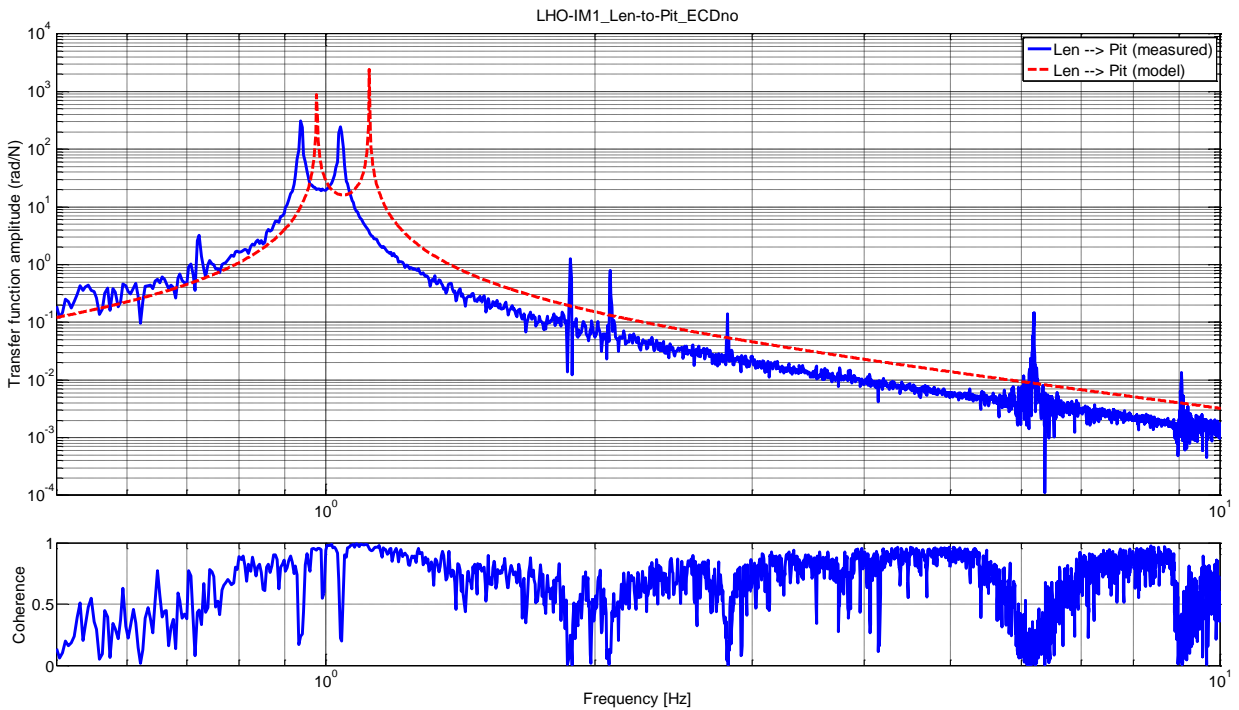
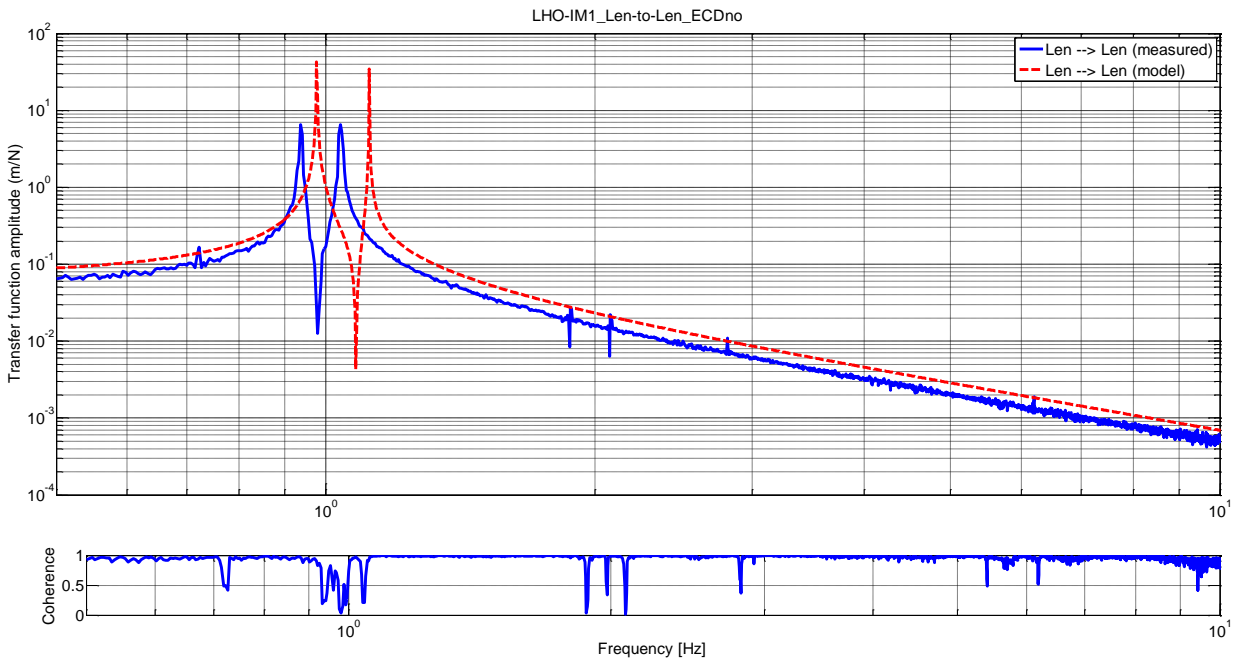
Please note:

- Proper diagonalization of AOSEMs actuation and readout had not been performed at this stage; thus, cross-coupling between different DoF is visible.
- The “model” curve represents the TF obtained from the Mathematica model using nominal values for all parameters.
- Calibration of the measured data is done using nominal values for all elements involved in the actuation/readout chain.
- Due to the small weight of the HAUX optics and the need to perform testing in a clean environment under flowing filtered air, many TFs are affected by a comparatively high level of noise.

There is no quantitative requirement associated with this measurement. TFs are expected to be consistent with the model (see, [T1200469](#), § 2.1.5), although close matching of resonances is not necessarily expected.

In general, all resonances appear to be lower than predicted by the model. This is common to all HAUX instances and does not pose a problem from a performance point of view. The TFs are considered acceptable as long as they do not show abnormal behaviors that can suggest rubbing or similar problems.

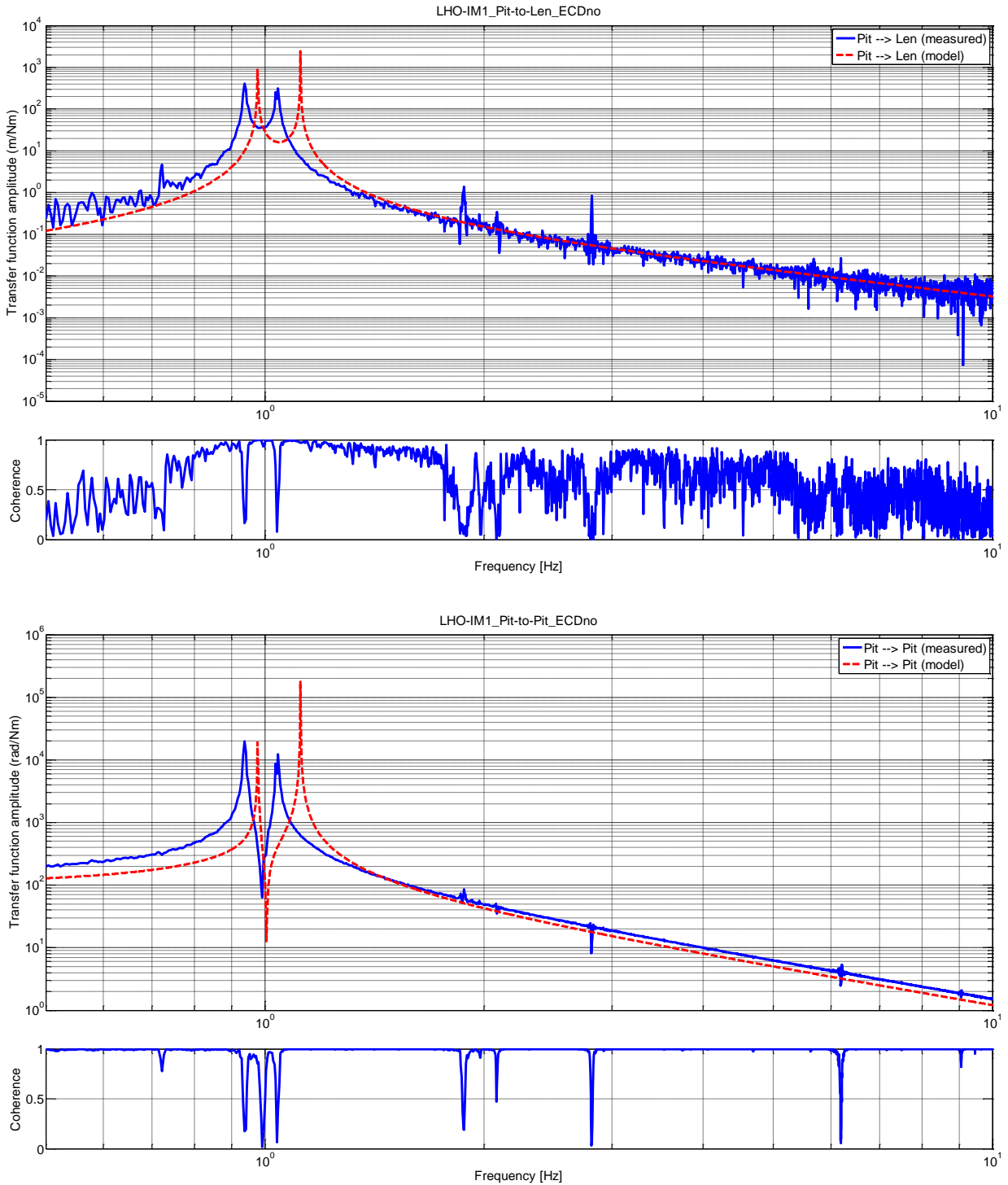
3.6.1 Length excitation



No abnormal behavior observed.

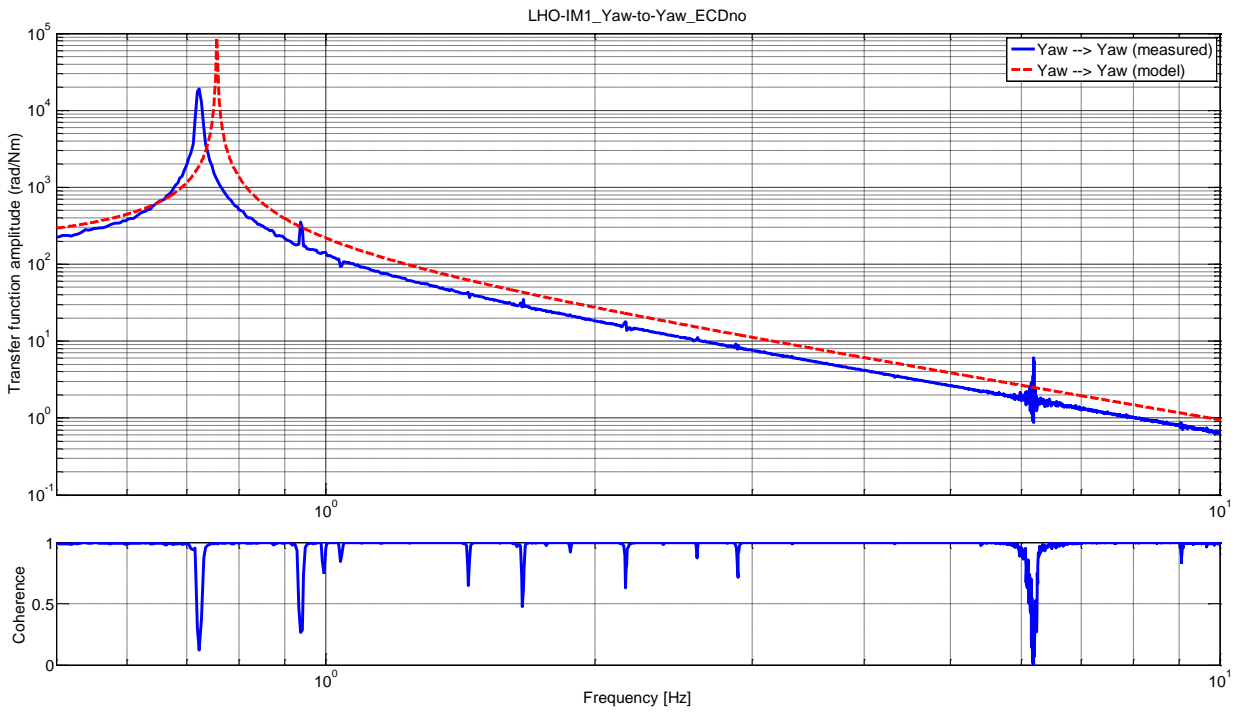
Passed

3.6.2 Pitch excitation



Possible double peak visible above 1Hz. However, the coherence in that region is low and there is no other indication of anomalies in the remaining TFs. **Passed**

3.6.3 Yaw excitation



No abnormal behavior observed.

Passed

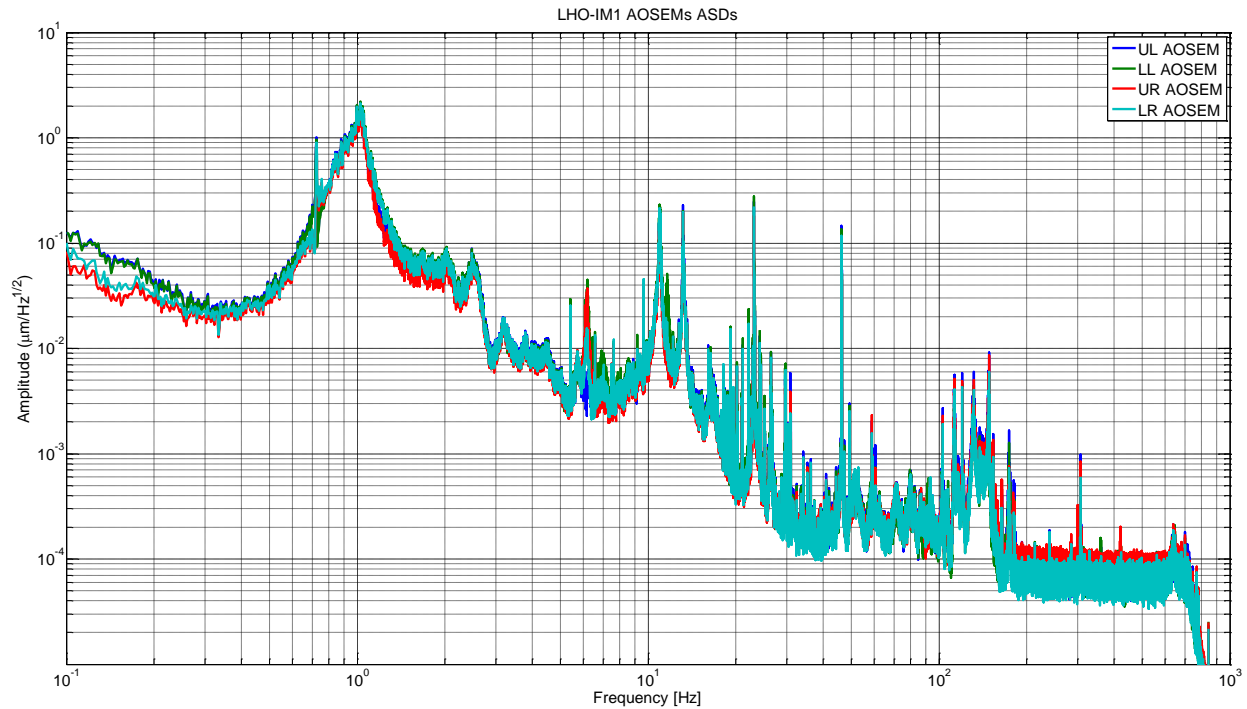
3.7 Linear spectra, with ECDs

These measurements have been taken on the HAM table, with purge air on, in date 06-Dec-2012.

Data is stored in the SUS SVN repository:

HAUX\H1\Common\1038891763_IMall_PSD_2mHz_ECD2_DAMPno_AlignOffset_PurgeAirOn.xml

These measurements need to be repeated in vacuum when the occasion arises.



There are no requirements associated with this measurement. It is rather intended to be a sanity check looking for strange behaviors and differences between OSEMs. As a reference, high frequency electronic noise is expect to be $\sim 10^{-4} \mu\text{m}/\text{Hz}^{1/2}$. **Passed**

3.8 Transfer functions, with ECDs

These measurements have been taken on the HAM table, with purge air on, in date 06-Dec-2012.

Data is stored in the SUS SVN repository:

HAUX\H1\Common\1038897341_IMall_TF-L_1e5_5mHz_ECD2_DAMPno_AlignOffset_PurgeAirOn.xml

HAUX\H1\Common\1038901324_IMall_TF-P_5e3_5mHz_ECD2_DAMPno_AlignOffset_PurgeAirOn.xml

HAUX\H1\Common\1038899227_IMall_TF-Y_5e3_5mHz_ECD2_DAMPno_AlignOffset_PurgeAirOn.xml

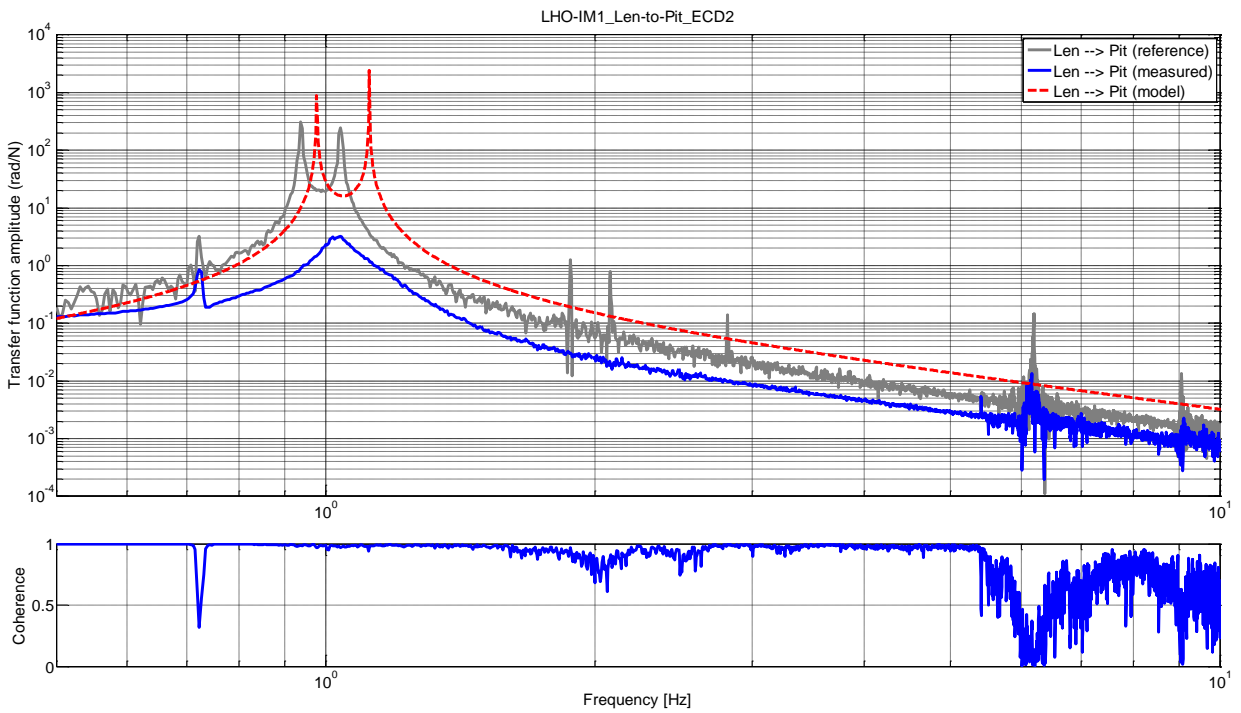
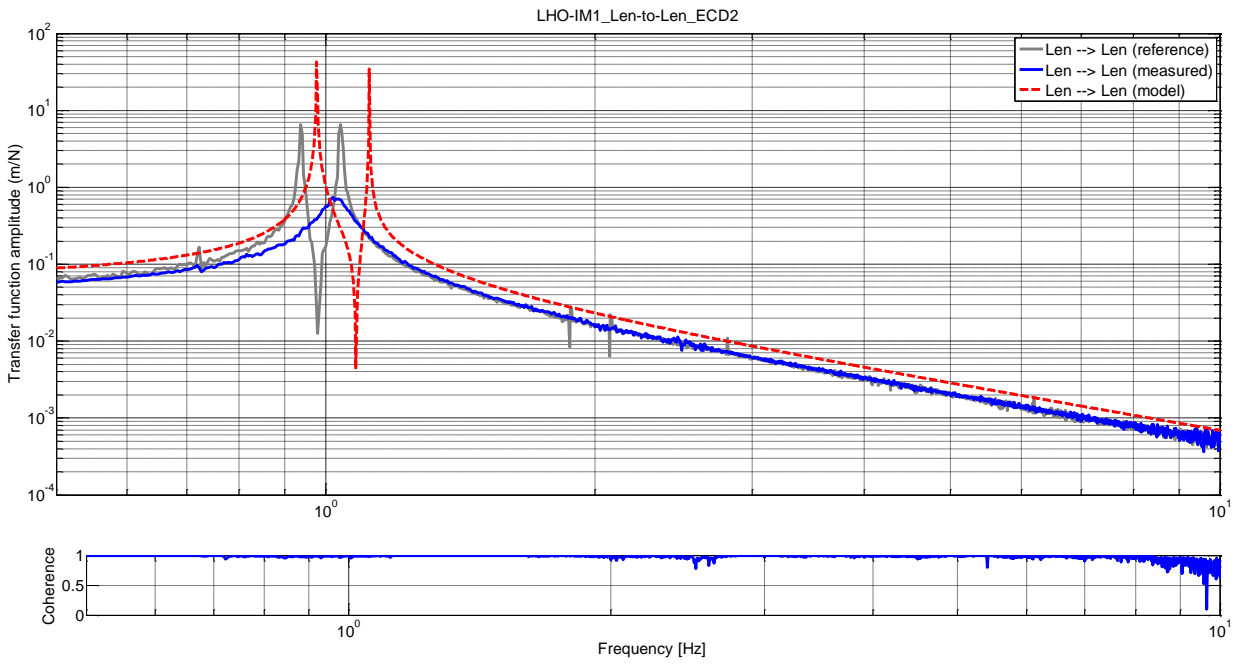
These measurements need to be repeated in vacuum when the occasion arises.

Please note:

- Proper diagonalization of AOSEMs actuation and readout had not been performed at this stage; thus, cross-coupling between different DoF can be visible.
- The “reference” curve represents the TF measured with no ECDs; it is the same plotted in section 3.6.
- Due to the small weight of the HAUX optics and the need to perform testing in a clean environment under flowing filtered air, many TFs are affected by a comparatively high level of noise.
- In principle, we are not interested in any passive damping of yaw, pitch and length, as they can be controlled actively. However, coupling with these DoFs is a known issue of the ECD system designed to damp the other DoFs.

There is no quantitative requirement associated with this measurement, which is mostly intended as a sanity check.

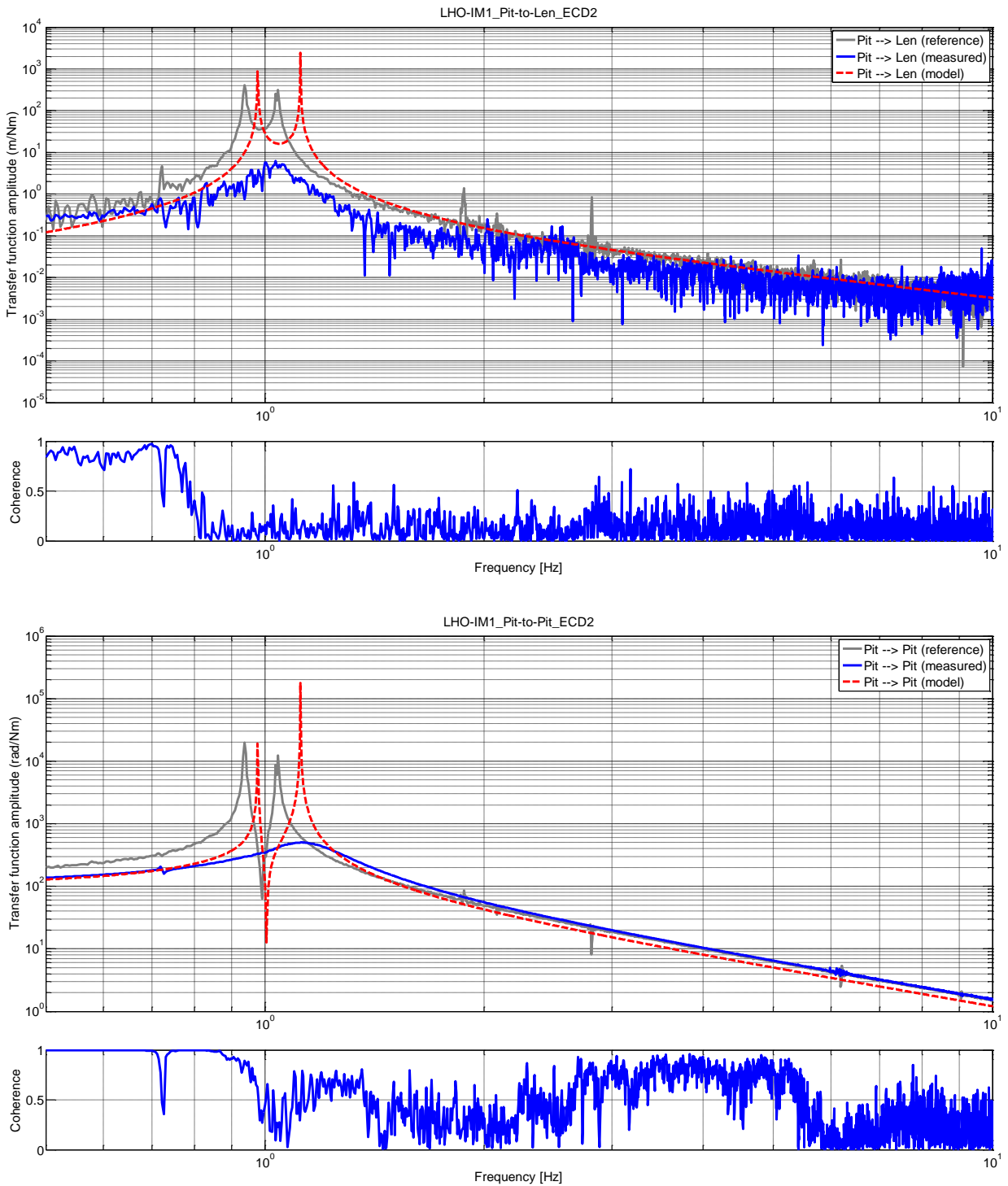
3.8.1 Length excitation



No abnormal behavior observed.

Passed

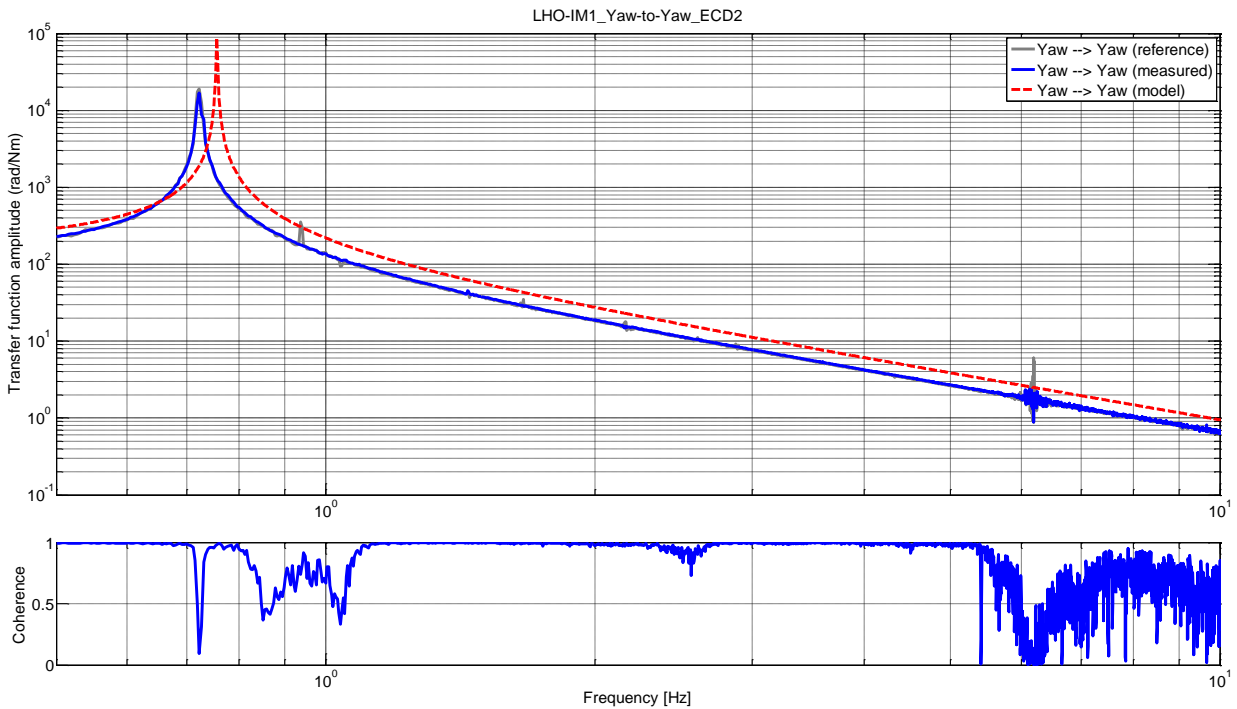
3.8.2 Pitch excitation



No abnormal behavior observed.

Passed

3.8.3 Yaw excitation



No abnormal behavior observed.

Passed

3.9 Quality factors with ECDs

Data for these measurements have been taken with different techniques and yielded mixed results. They need to be measured again in a more controlled and uniform way. This can be easily repeated without physically accessing the suspensions, but requires waiting for the right window of opportunity while the IFO is being commissioned.

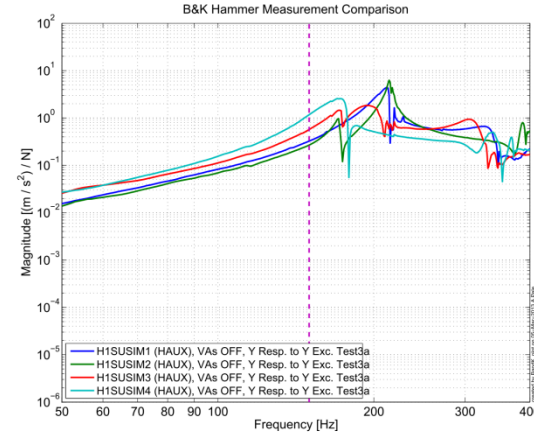
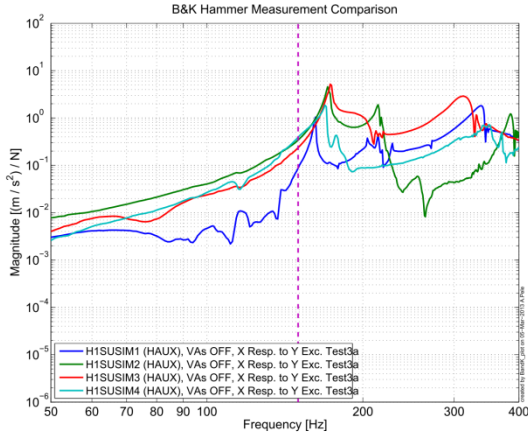
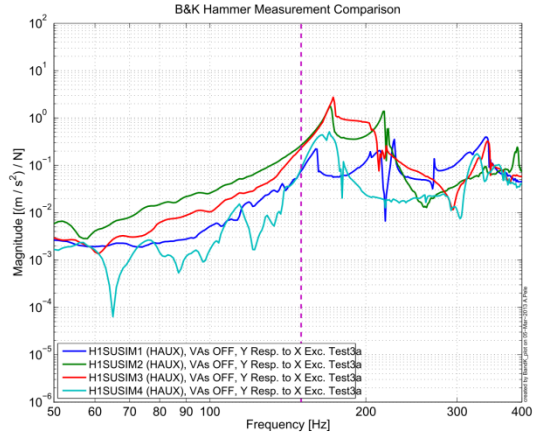
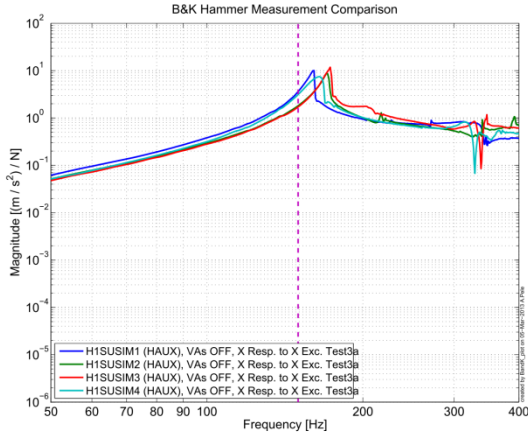
3.9.1 Bounce

3.9.2 Trans

3.9.3 Roll

3.10 Structural resonances

Measurements have been taken on the HAM table, in final clamping configuration, in date 05-Mar-2013. See LHO aLog [5652](#).



Requirements (from [T1200469](#), § 2.1.4):

- All resonances >150 Hz

Passed