LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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HAUX L1-IM3 test report

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LIGO Science Collaboration

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Contents

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:	L1
Suspension name:	IM3
Suspension SN:	004
Installed optics:	PMMT2-01
UL OSEM SN:	435
LL OSEM SN:	297
UR OSEM SN:	462
LR OSEM SN:	415

https://ics-redux.ligo-la.caltech.edu/JIRA/browse/ASSY-D1000120-003

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		**Pending**
PSDs, with ECDs		X		X		X	X		Passed
TFs, with ECDs		X		X		X	X		Passed
Q measurements									**Pending**
B&K Hammering		X					X		**Failed (but given a pass with SYS waiver)**

3 Tests results

3.1 OSEMs OLV

These measurements are the one in use as of 03-Jul-2013, based on measurements performed on HAM table with final electronics and cables.

	UL Channel	LL Channel	UR Channel	LR Channel
UL OSEM	27000			
LL OSEM		24700		
UR OSEM			25800	
LR OSEM				26500

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 22-Jun-2012. See LLO aLog 3600.

Measured value: 0 ⁓0.5 mrad

Requirements (from T1200469, § 2.1.1):

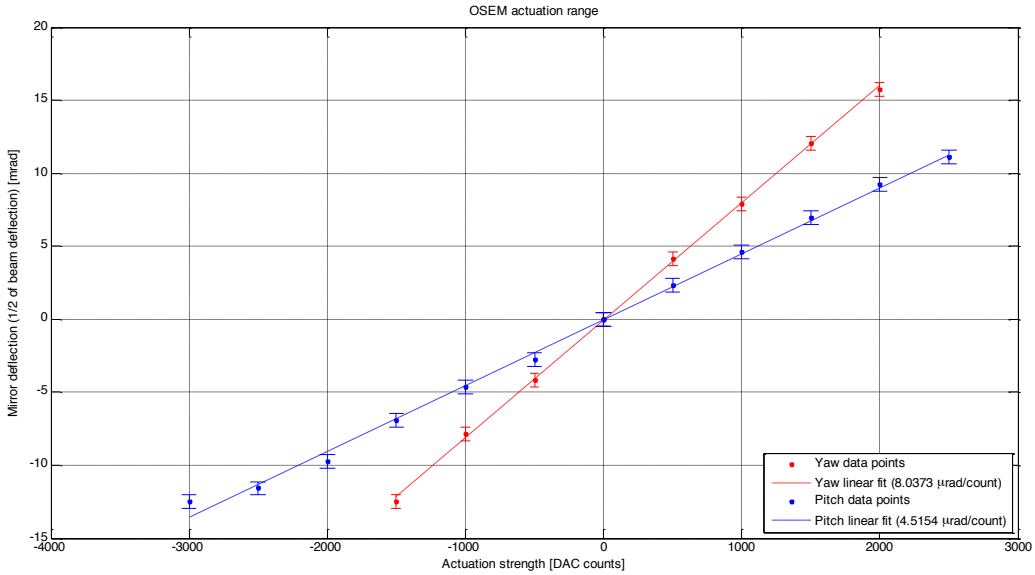
- Nominal value (0) ⁓ 1 mrad ***Passed***

3.3 OSEMs range and linearity

These measurements have been taken in April 2012 with a test setup using production-style electronics, although not the one to be installed in aLIGO). See LLO aLog 2962.

Please note: the employed electronics was a preliminary version with different actuation gain from the production units. In addition, 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.

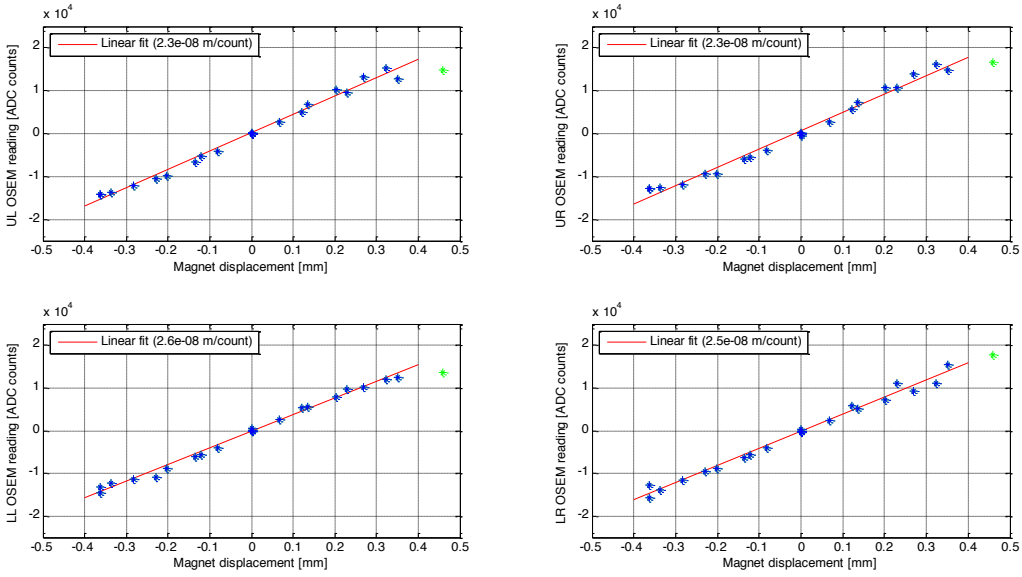
3.3.1 Mirror rotation Vs Actuation



Requirements (from T1200469, § 2.1.1):

- > 10 mrad for full actuation (32000 counts) ***Passed***

3.3.2 OSEMs readout Vs Displacement



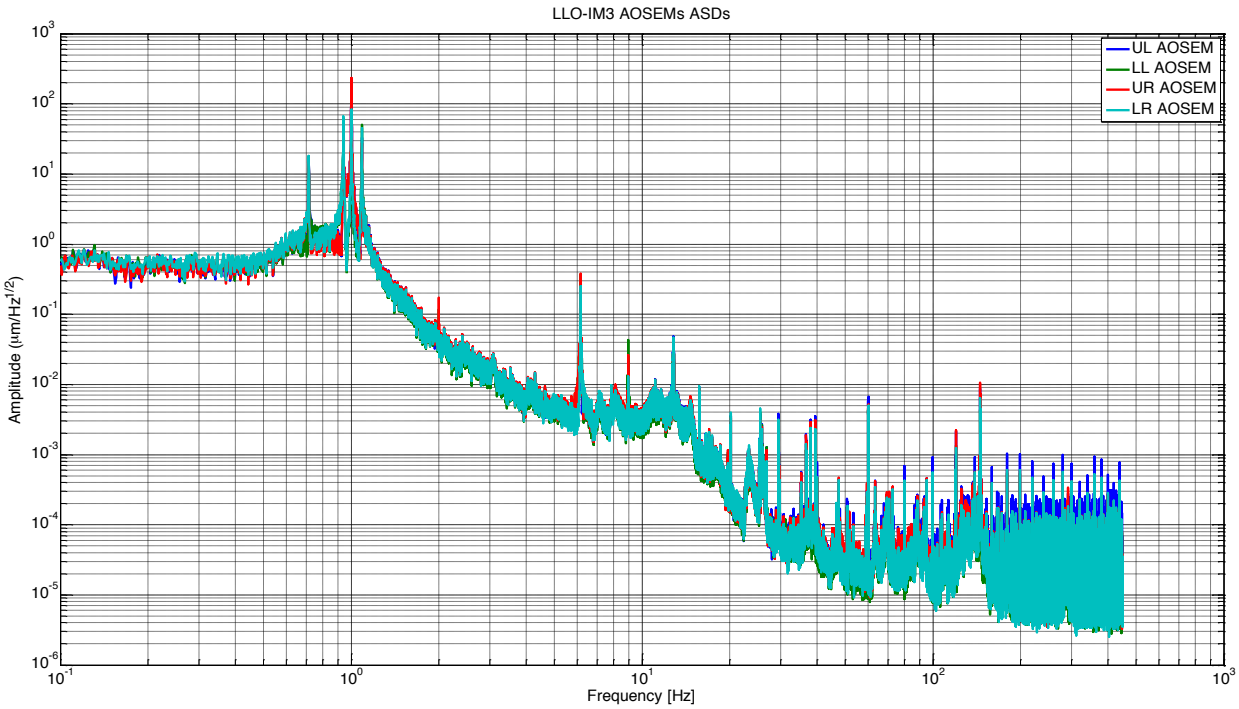
There are no requirements associated with this measurement. It is rather intended to be a sanity check looking for strange (e.g. non linear) behaviors and differences between OSEMs. ***Passed***

3.4 Linear spectra, no ECDs

These measurements have been taken in the LBR in April 2012. See LLO aLog 2962.

Data is stored in the SUS SVN repository:

HAUX/X2/PMMT2/dtt_data/1017309615_X2PMMT2_PSD_1mHz_ECDno_DampNo_Shadow_SoftAlCover.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 ~10^{-4} µm/$Hz^{1/2}$. ***Passed***

3.5 Measured resonances

These have been measured in the LBR in April 2012. See LLO aLog 2962.

Yaw: *0.714 Hz*

Pitch/Length 1: *0.939 Hz*

Pitch/Length 2: *1.001 Hz*

Transverse: *1.089 Hz*

Bounce: *6.20 Hz*

Roll: *8.97 Hz*

Requirements (from T1200469, § 2.1.1):

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

3.6 Transfer functions, no ECDs

These measurements have been taken in the LBR in April 2012. See LLO aLog 2962.

Data is stored in the SUS SVN repository:

HAUX/X2/PMMT2/dtt_data/1017280215_X2PMMT2_TFL1e4_1mHz_ECDno_DampNo_Shadow_SoftAlCover_PostProcess.xml

HAUX/X2/PMMT2/dtt_data/1017287415_X2PMMT2_TFP3e2_1mHz_ECDno_DampNo_Shadow_SoftAlCover.xml

HAUX/X2/PMMT2/dtt_data/1017291615_X2PMMT2_TFY3e2_1mHz_ECDno_DampNo_Shadow_SoftAlCover.xml

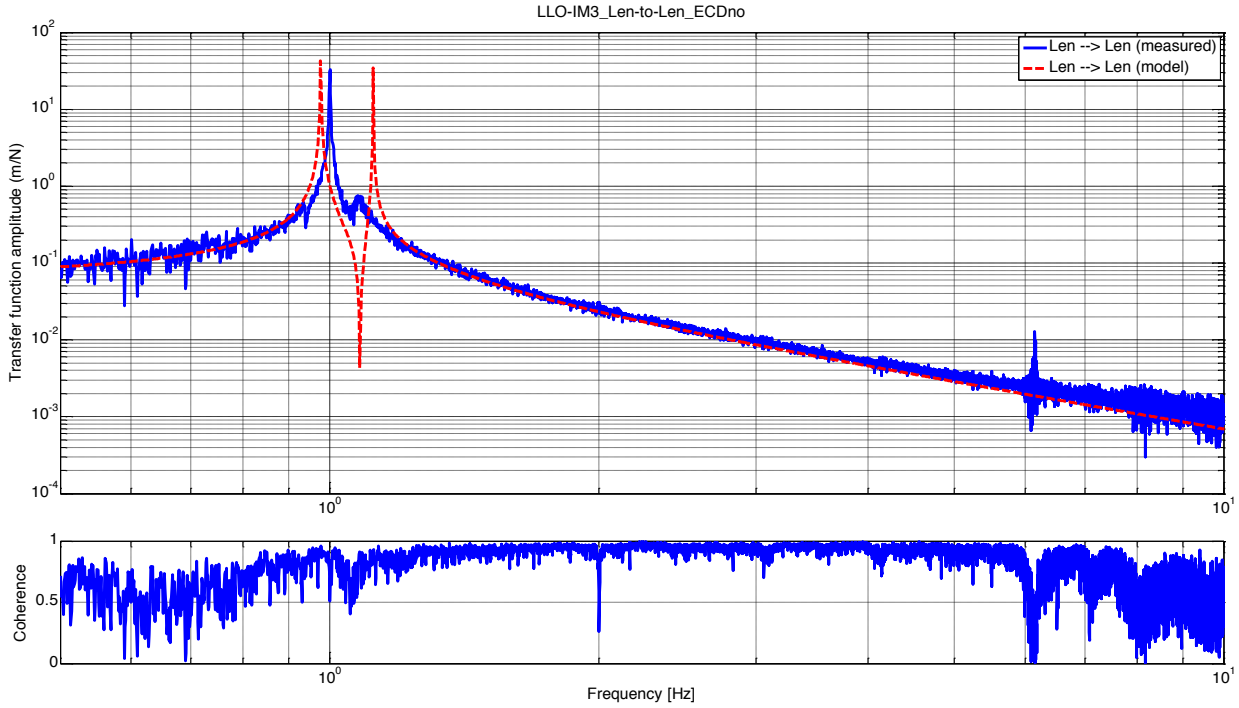
Please note:

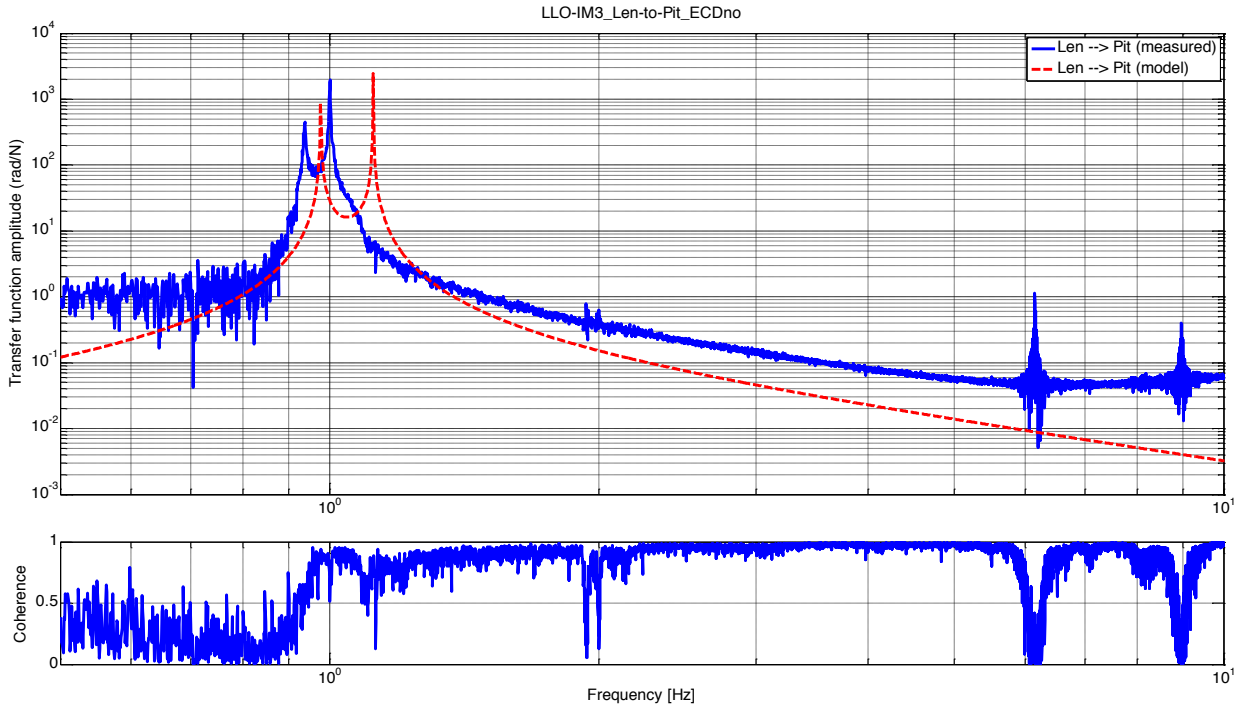
- Proper diagonalization of AOSEMs actuation and readout had not been performed at this stage; thus, cross-coupling between different DoF is visible.
- The "model" curve represents the TF obtained from the Mathematica model using nominal values for all parameters.
- We have been unable to properly reconstruct calibration data for the test electronics used at the time. The measured data has thus been scaled to approximately match the model.
- 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.

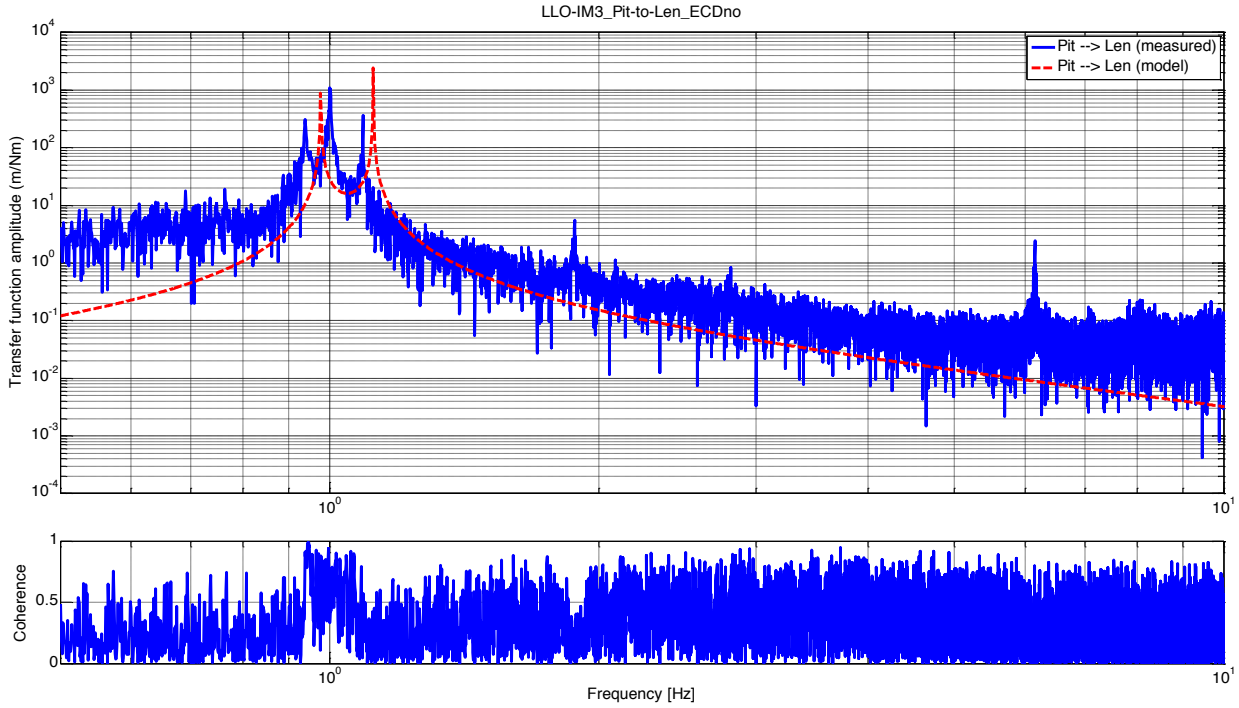
3.6.1 Length excitation

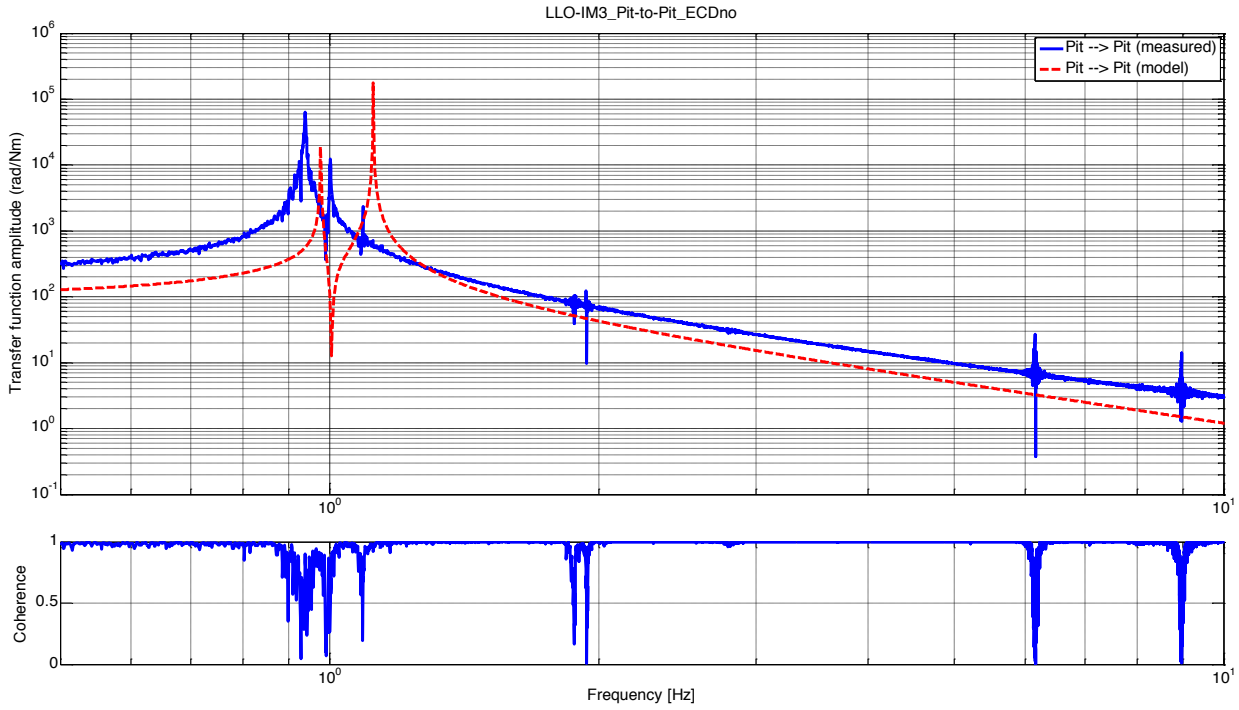




Evidence of rubbing or otherwise abnormal behavior. This is however not evident in the much more recent TFs with ECDs, and might not be a problem. ***Pending***

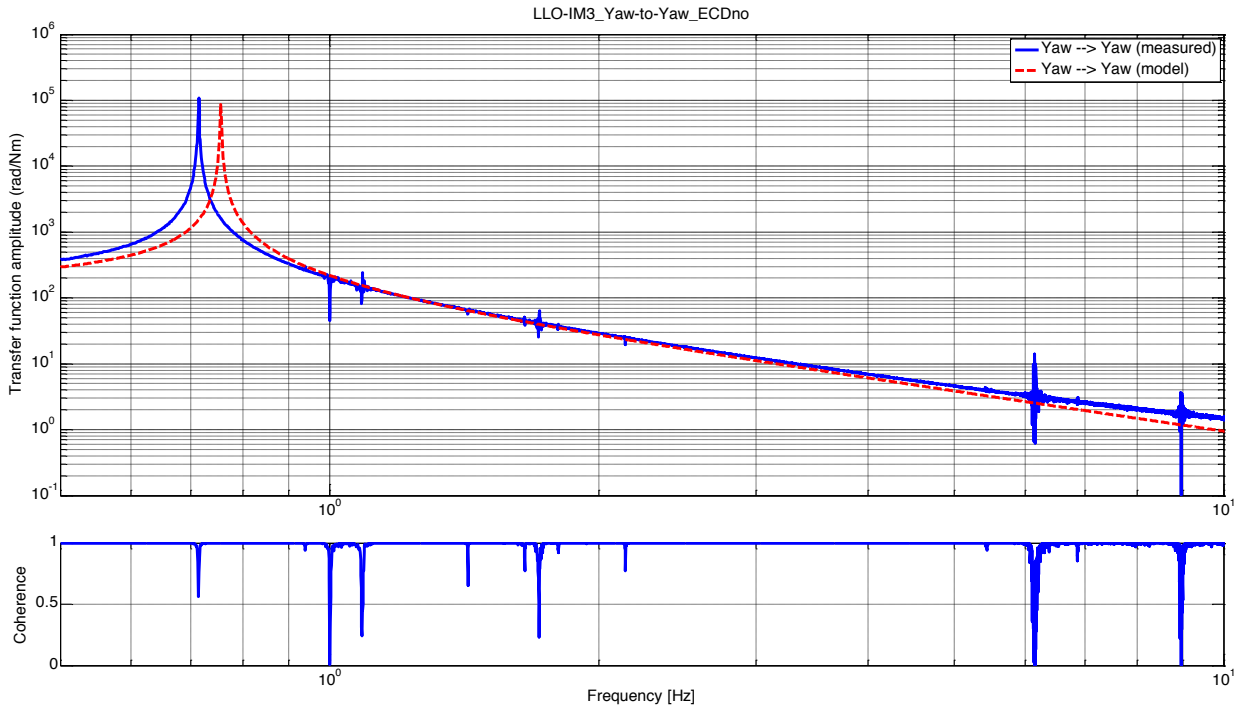
3.6.2 Pitch excitation





Evidence of rubbing or otherwise abnormal behavior. This is however not evident in the much more recent TFs with ECDs, and might not be a problem. ***Pending***

3.6.3 Yaw excitation



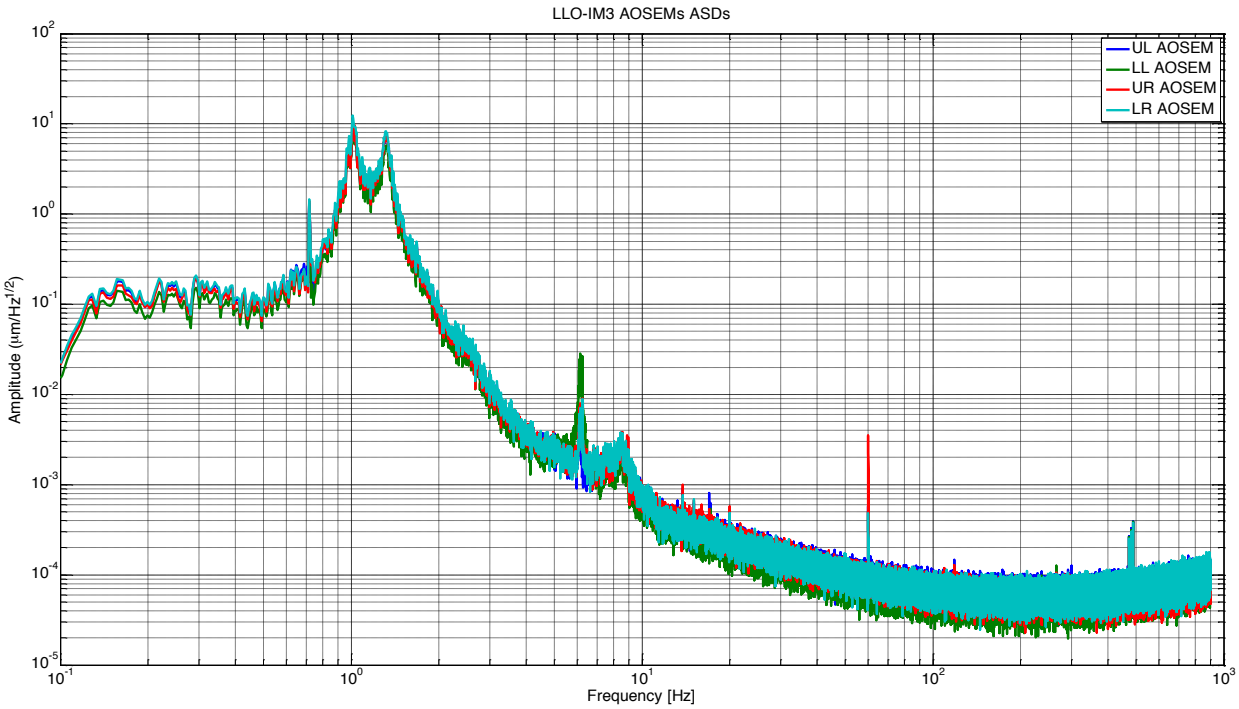
No abnormal behavior observed. ***Passed***

3.7 Linear spectra, with ECDs

These measurements have been in vacuum in April 2012.

Data is stored in the SUS SVN repository:

HAUX/L1/Common/dtt_templates/Review/1017309615_IM3inLBR_PSD_1mHz_noECD_unDAMPed.txt



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 ~10^{-4} μm/$Hz^{1/2}$. ***Passed***

3.8 Transfer functions, with ECDs

These measurements have been taken on the HAM table, with purge air on, in date 26-Jul-2012. See LLO aLog 4011.

Data is stored in the SUS SVN repository:

HAUX/L1/Common/dtt_templates/1027378807_IMall_TF-L_100000_10mHz_ECD_unDAMPed.xml

HAUX/L1/Common/dtt_templates/1027383286_IMall_TF-Y_10000_10mHz_ECD_unDAMPed.xml

HAUX/L1/Common/dtt_templates/1027384091_IMall_TF-P_10000_10mHz_ECD_unDAMPed.xml

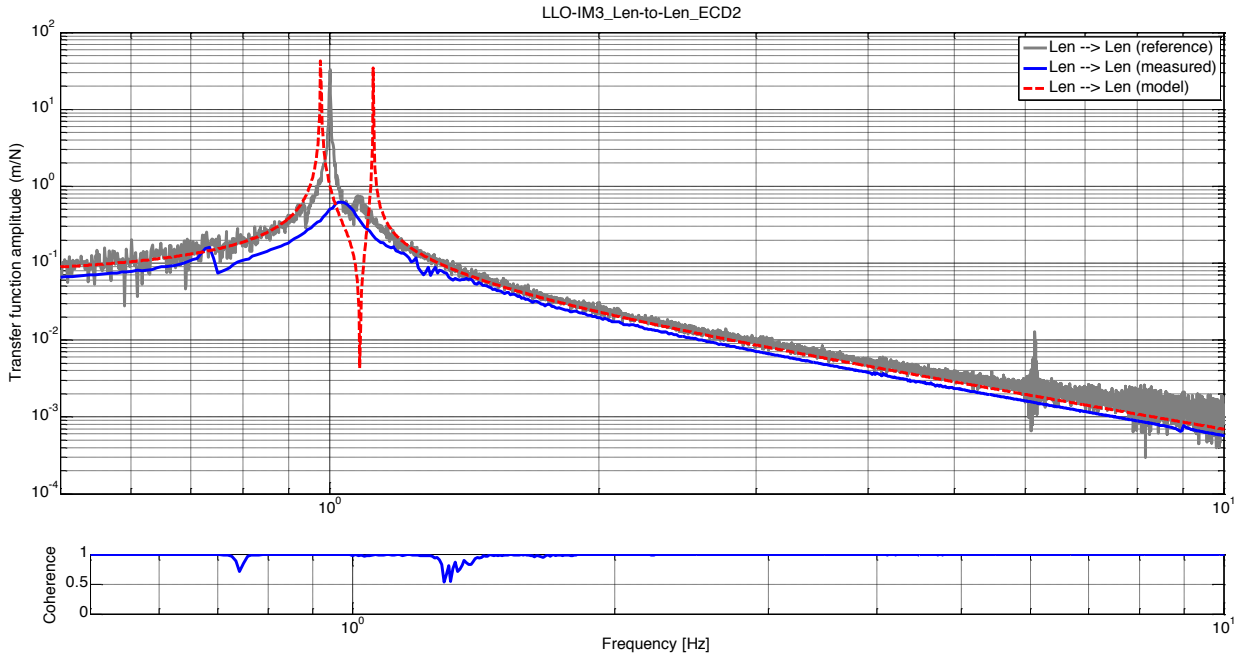
These measurements need to be repeated in vacuum when the occasion arises.

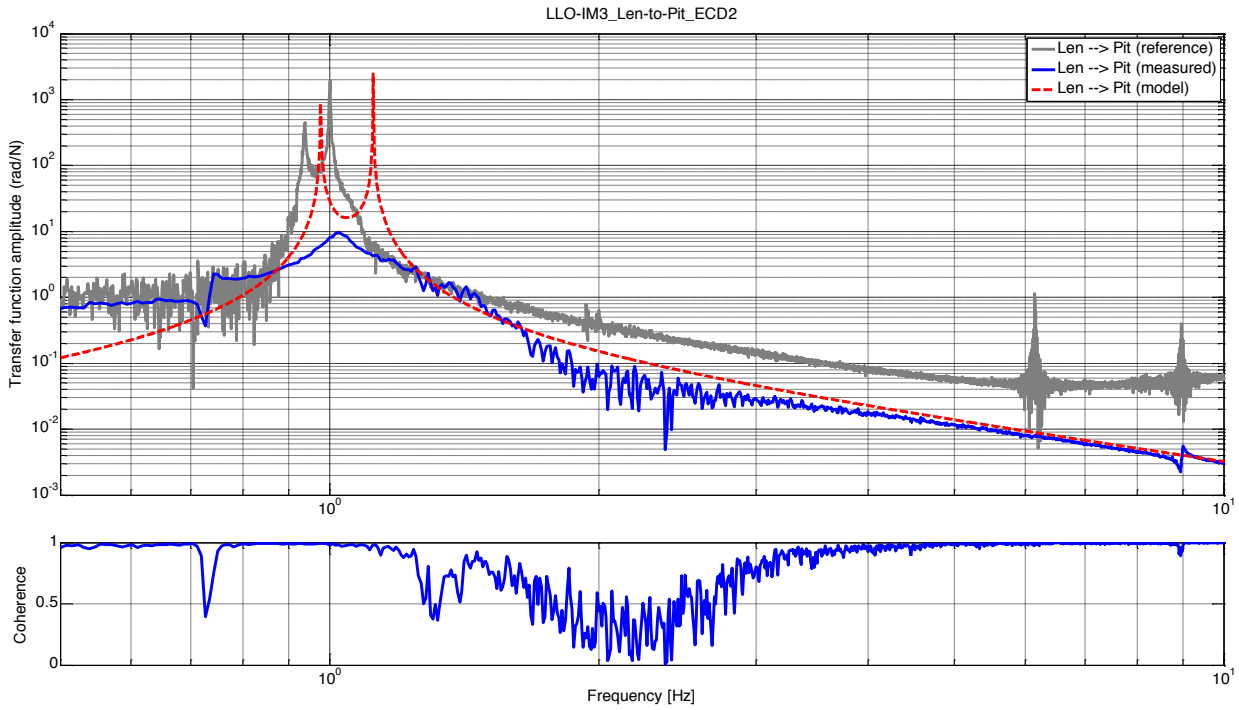
Please note:

- Although a preliminary diagonalization of AOSEMs actuation and readout has been performed, it has not been fully optimized and 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.
- 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.

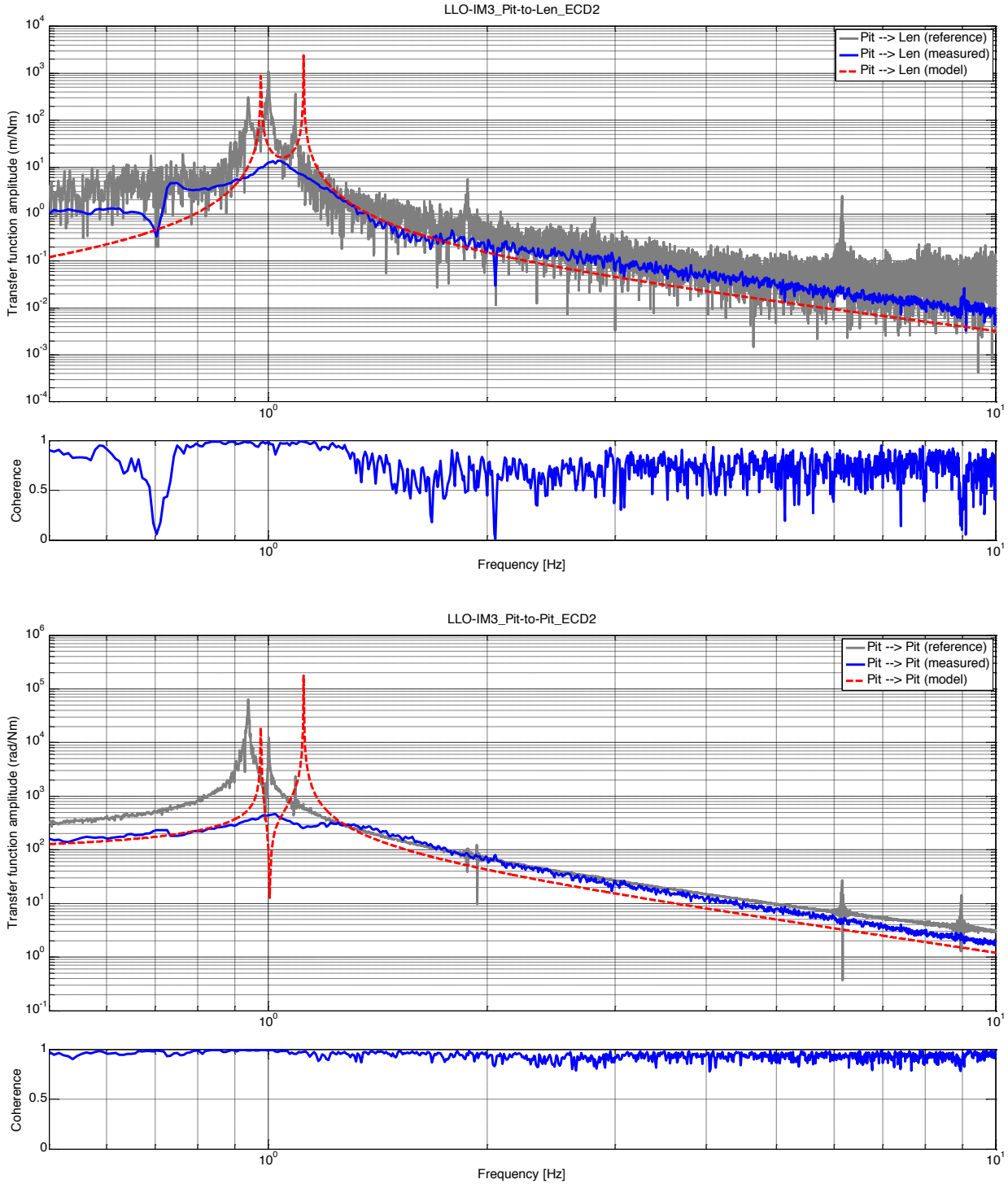
3.8.1 Length excitation





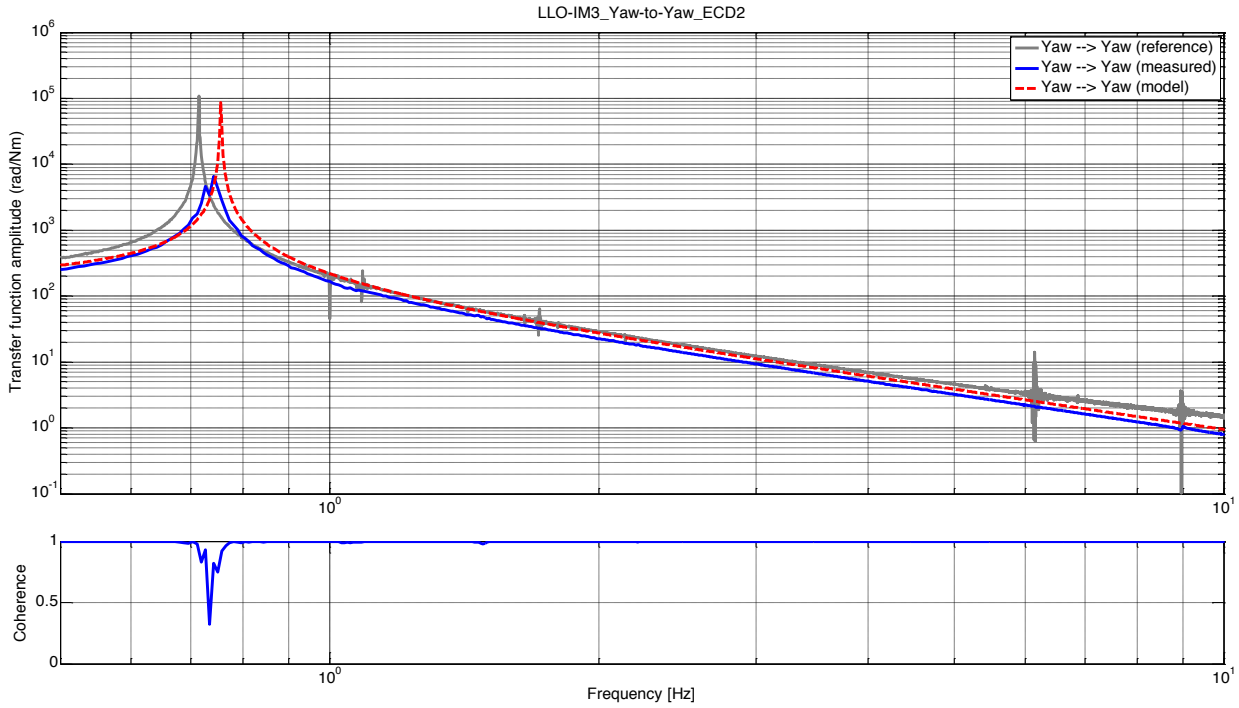
Evident cross-talk with yaw (probably a sensing issue, since coherence is low); otherwise no abnormal behavior observed. ***Passed***

3.8.2 Pitch excitation



Evident cross-talk with yaw (probably a sensing issue, since coherence is low); otherwise no abnormal behavior observed. ***Passed***

3.8.3 Yaw excitation



Resonance seems to be somewhat shifted with respect to previous measurements, but it s difficult to exactly tell by how much; we don't anticipate any problem related to this.

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

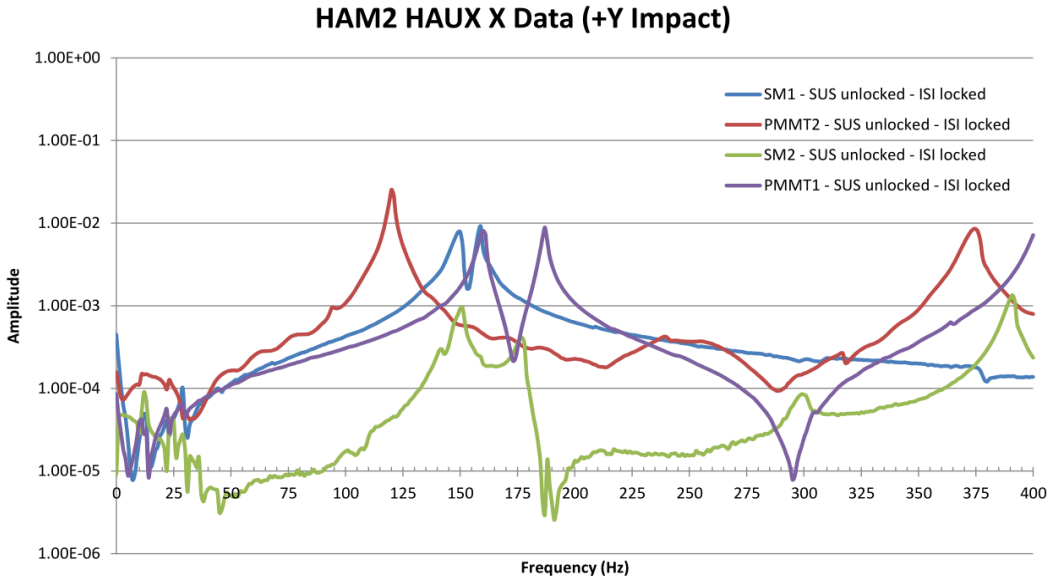
3.9.3 Roll

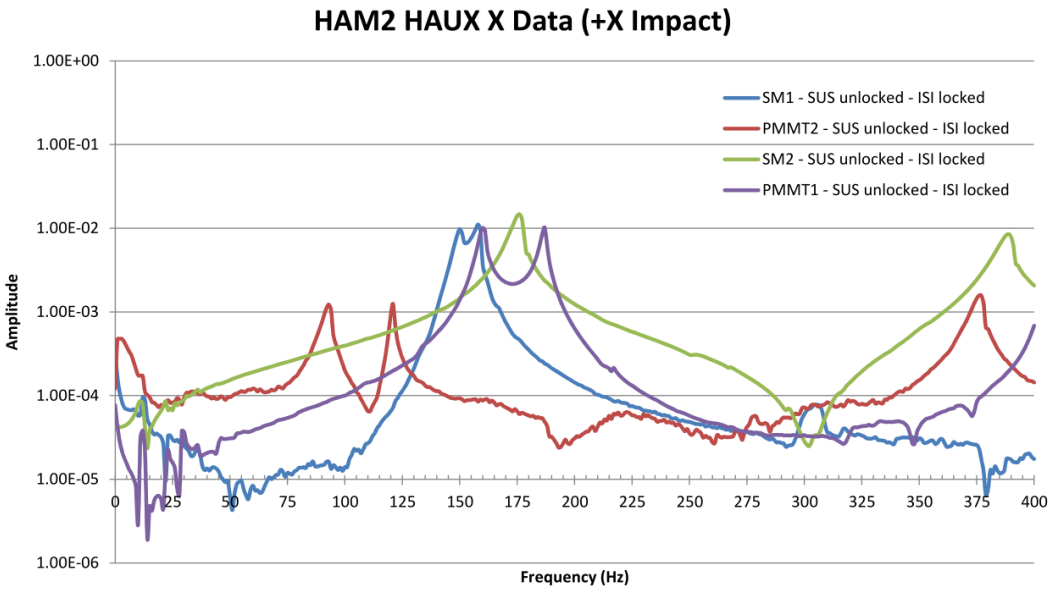
3.10 Structural resonances

Measurements have been taken on the HAM table, in final clamping configuration, on 22-Jul-2012. See LLO aLog 3948.

Suspected cause of low resonance peak of PMMT2 due to loose dog clamps. All dog clamps checked and retightened and results repeated (LLO alog: 7349). Problem persists. Left unresolved.

- Later discovered on HTTS (OM3) in HAM6 a similar symptom. Discovered loose structural bolts and tightening these and redoing tests (LLO alogs: 8357 & 8362, comparing red trace to cyan trace) showed the issue has been resolved. Suspect this may be the problem with IM3 .
- SYS have granted a waiver on IM3 not meeting the 150Hz requirement due to the assumed low modal mass of this item. An inspection for loose structural bolts should be performed at next available opportunity though.





Requirements (from T1200469, § 2.1.4):

- All resonances >150 Hz ***Failed but given a pass with SYS waiver***