LLO environmental excitation update

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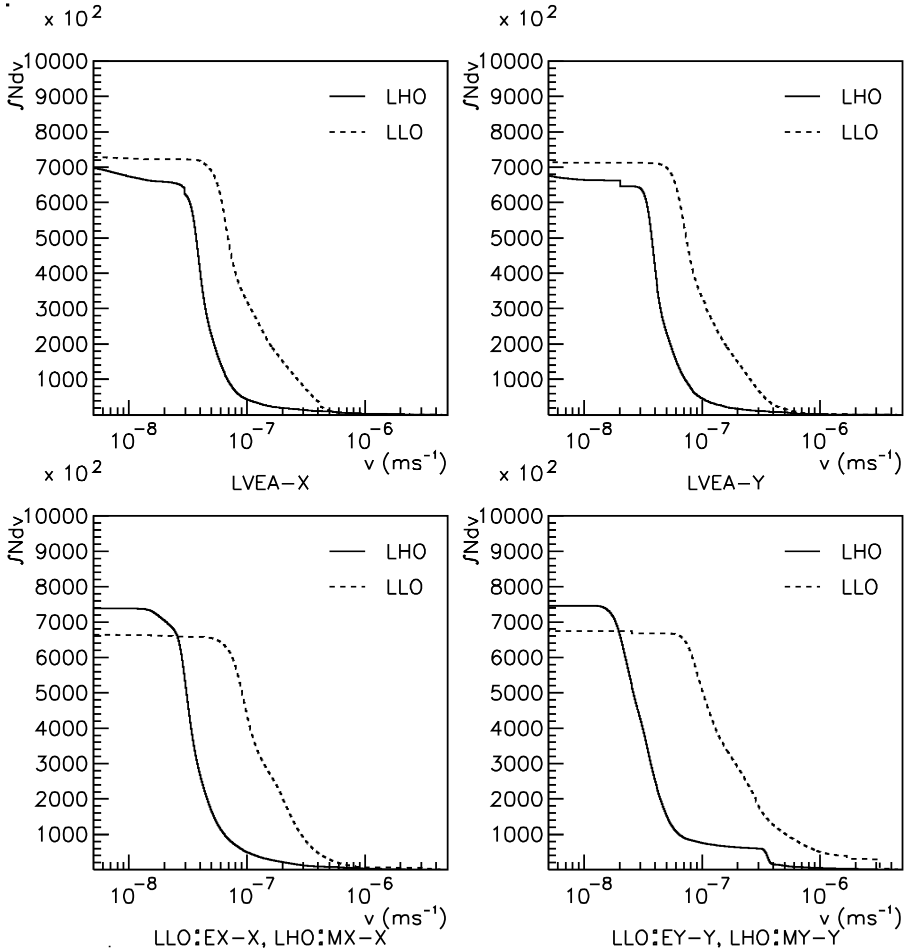
18 April, 2003.

Statistics of 1–3 Hz, band-limited rms velocities over two years.

90th percentile values

site	chan	90%, µm/s	llo/lho
LLO	lvea x	0.31	4.0
	lvea y	0.29	3.6
	ex x	0.34	4.5
	ey y	0.75	7.3
LHO	lvea x	0.078	
	lvea y	0.083	
	mx x	0.077	
	my y	0.10	



Required EPI improvement in 1–3 Hz band to make Hanford and Livingston similar.

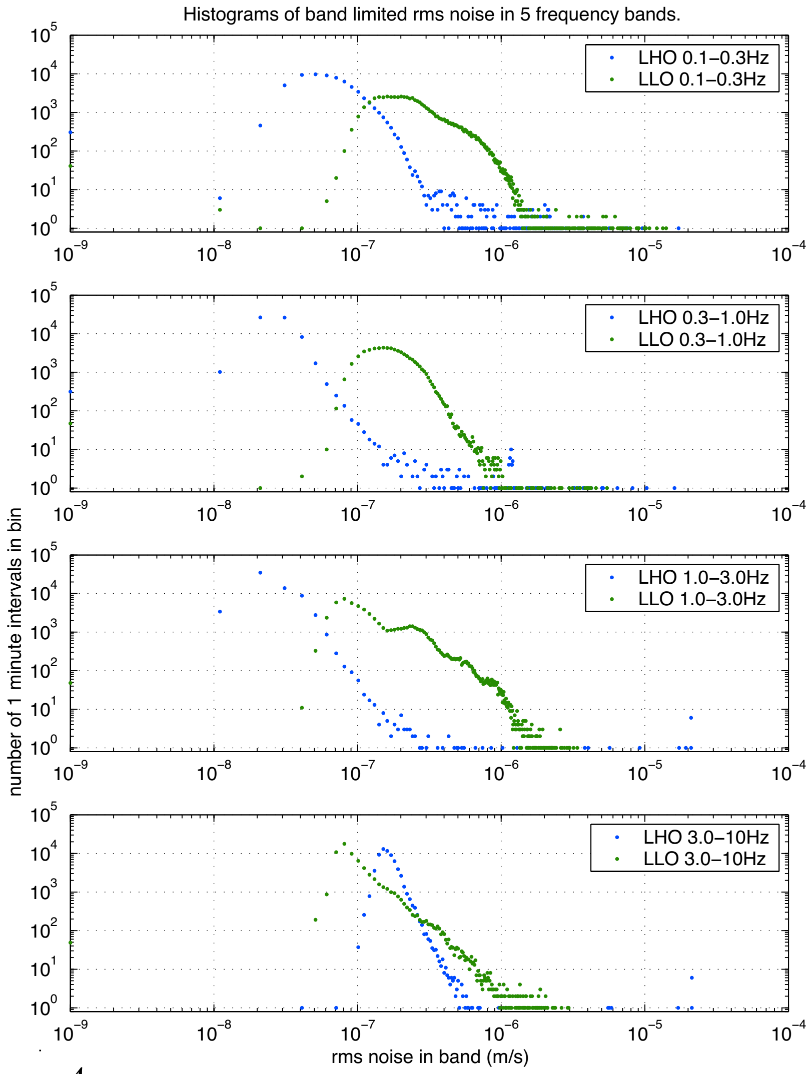
- LLO has a ratio of almost 10 between p-p motion and rms ground motion (see later slide).

- Assume LHO has a ‘normal’ factor of 5 between these quantities.

- We should require 2 • 7.5 = a factor of **15** reduction in this band.

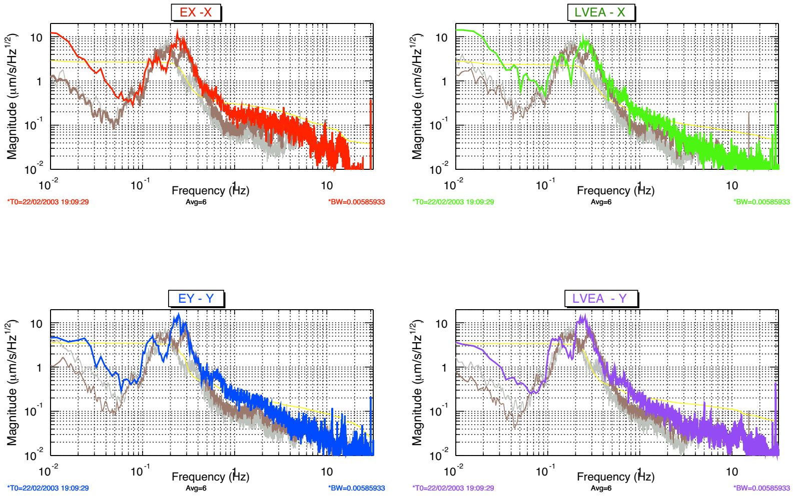
0.1–1 Hz Band

- Sub-hertz band covers suspension pendulum resonances, both in POS and for angles.
- LLO's noise in this band is quite bad, requiring perhaps factor of **5** improvement.



‘Bayou torture test data’

- 1500 s stretches of STS-2 data taken at LLO during periods of **interesting** ground motion.
- 7 sets so far:
    1. oddly high 0.6 Hz bump
    2. enormous microseism
    3. train, during weekday.
    4. weekday, w/o train
    5. another day, another train.
    6. borderline day, LLO able to lock
    7. borderline, LLO unable to lock.



Torture test analysis

- Quantities listed are for the greatest arm length peak-to-peak excursion, and for the differential rms arm length deviation.
- Displacement integrated down to 30 mHz, acceleration up to 16 Hz.

data file	Displacement	Velocity	Acceleration
Enormous µseism	63 µm p-p	35 µm/s p-p	180 µm/s^2 p-p
	11 µm rms	4.8 µm/s rms	17 µm/s^2 rms
Day Train	13 µm p-p	13 µm/s p-p	150 µm/s^2 p-p
	1.7 µm rms	1.6 µm/s rms	17 µm/s^2 rms
Borderline day	30 µm p-p	18 µm/s p-p	150 µm/s^2 p-p
	4.6 µm rms	2.5 µm/s rms	17 µm/s^2 rms

System should not ‘break’ when exposed to the following:

Expected maximum displacement excitation:

- Ultra-high microseism from torture test: **63 µm**.
- 6, 166 lb postdocs walk up to the PEM area. This causes the slab to distort, tilting the STS-2 by 0.1 µrad. The STS-2 tells the sensor correction system to move the payload by about **60 µm**. (This assumes a 20 mHz highpass, about what would be required for effective sensor correction.)
- Earth tide requirements: +/- **120 µm**.

Expected maximum velocity:

- Torture test: **35 µm/s p-p.**

Expected maximum acceleration:

- Torture test: **180 µm/s^2 p-p.**

LLO detector modifications.

Underlying assumptions

- To achieve the performance that the EPI prototypes have seen, **Local sensor correction** is used.
- In order to match gain and phase well enough at the microseism, the measured ground motion can only be high-pass filtered at ≈ **20 mHz**.
- This means that essentially all of the ground velocity will contribute to a relative rms velocity between the in-vacuum payloads and the technical slab.

Parasitic interferometer avoidance

- There is something like a consensus that the relative velocity between the interferometer optics and anything that can scatter light back should be $\mathbf{v_{rms} < 10\ \mu m/s}$.
- This value is rarely maintained over a minute (from the blrms data in any band).
- However, during ‘interesting’ times the peak values can be comparable to this.
- It is probably prudent to modify the main output tables to permit slow actuation, allowing them to follow the horizontal sensor correction signals being applied to the in-vacuum payloads.
- We may also consider mounting potentially scattering components on the crossbeams.

Optical levers

- Currently, optical levers are used continuously during both lock acquisition and science mode to control the core optics angles.
- If the proposed retrofit is carried out, there will be a significant relative motion between the optical lever piers and the optics.
- This will be detected as an angle; the numbers on pages 2 & 6 would be divided by of order 10 m to get the false angle noises.
- Since we know the sensor correction signal, we can attempt to subtract it electronically.
- Or, we can require the higher-bandwidth wavefront sensors be solely used during science mode.

The laser table, etc.

- The fringe-wrapping worry also applies to the laser table components: We can consider augmenting the periscope output mirror with a beam-direction long-throw piezo actuator, which would track the sensor correction signal in that direction. Or, we can float the table like we do with the output table(s).

- Every vacuum port window is suspect. If we are really pressed, and we find noise coupling this way, we could attach the windows to compensated bellows, allowing them to be attached to the 'corrected' output tables, moving with the payload.