PROGRESS SINCE MARCH ON S3 ENVIRONMENTAL DISTURBANCES

Dust, Acoustic, Magnetic, and LHO Seismic Mitigation and Intersite Burst Search

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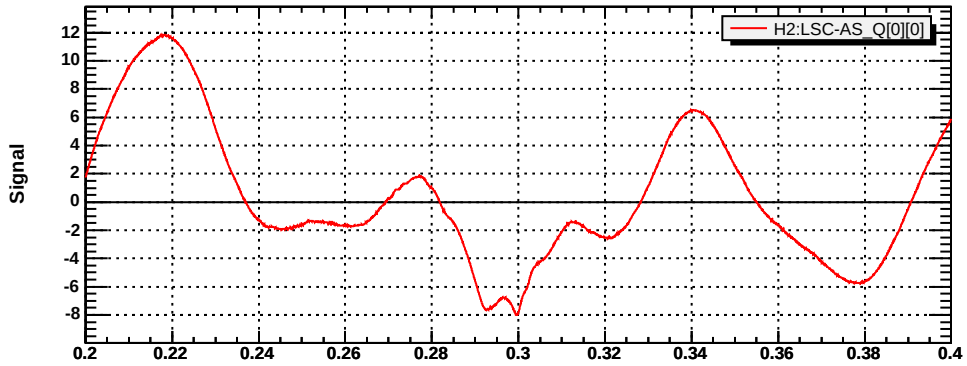
AND MANY OTHERS

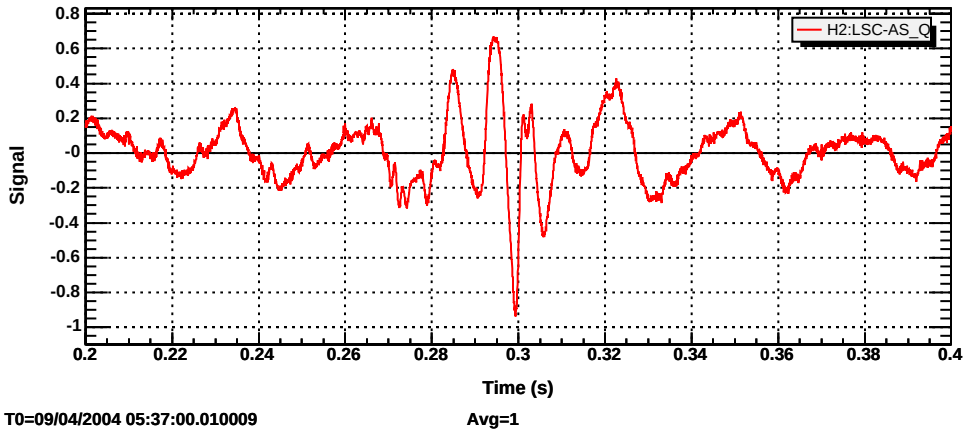
LIGO-G040391-00-W

DUST BURSTS

Dust burst in raw AS_Q time series:

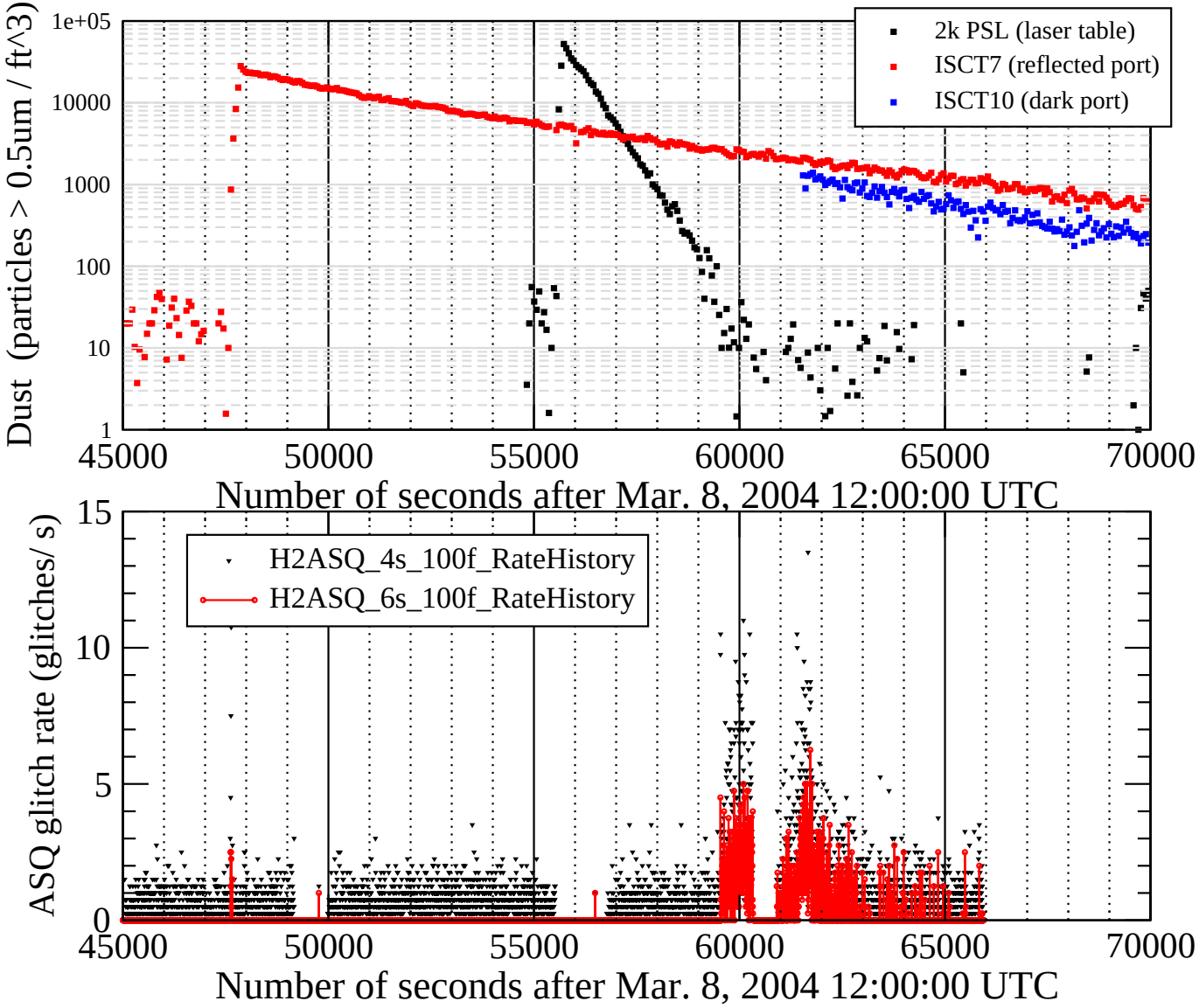


After ellip("HighPass",3,3,50,50) filter:

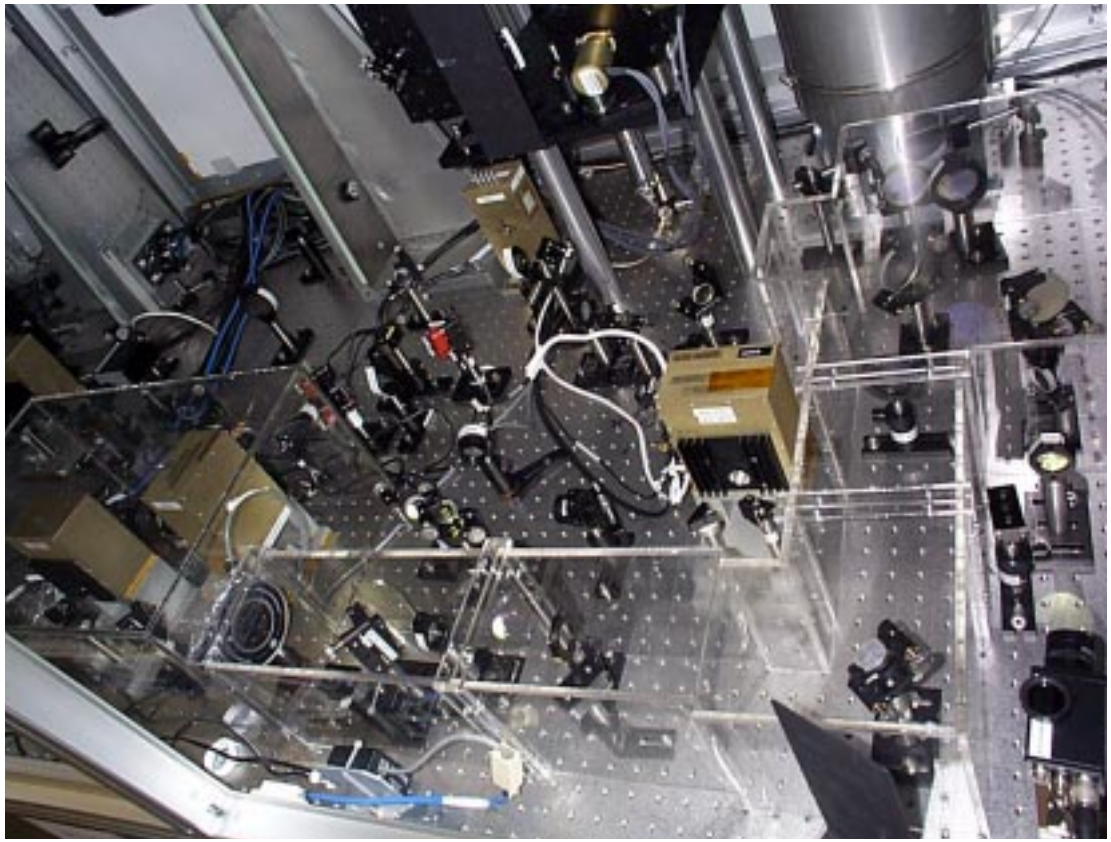


A generic step, filtered with the pendulum transfer function and injected onto a test mass also looks like a few cycles at 100s of Hz in an un-calibrated time series.

Stirred up dust produces AS_Q glitches only at dark port.



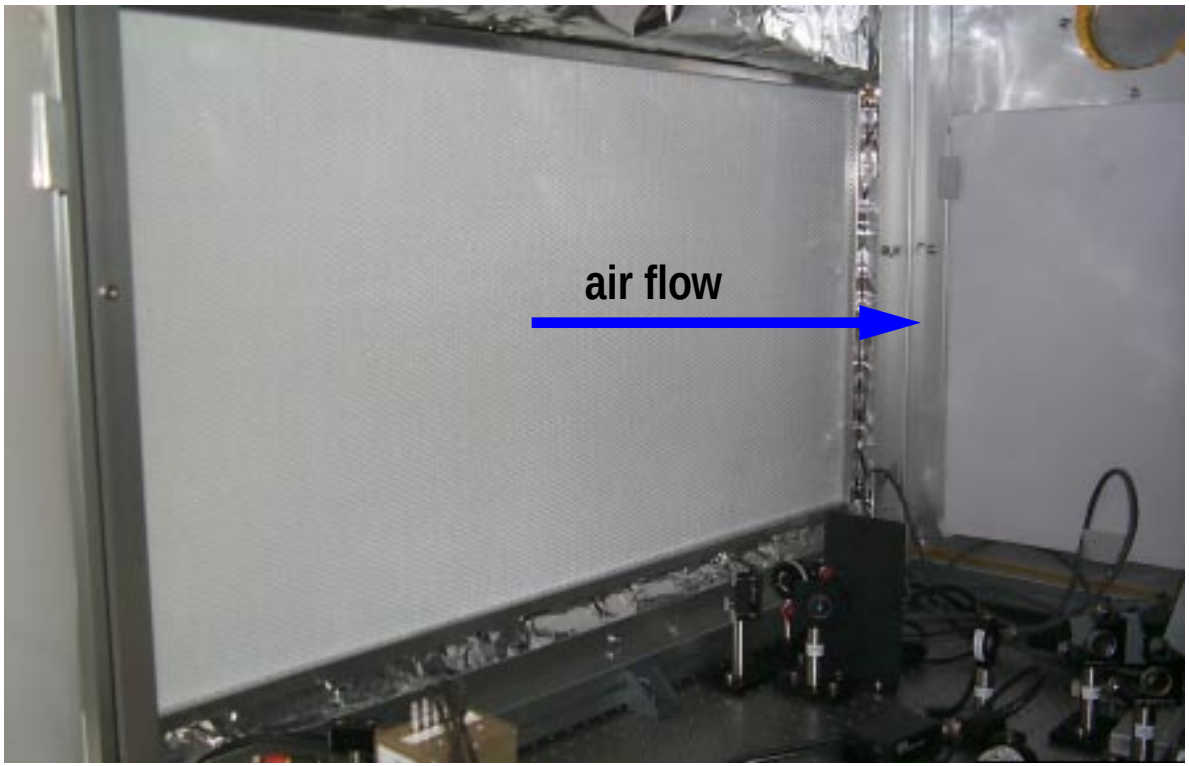
Prototype purged cast acrylic sheet dust enclosure for science runs covering areas where beam is small and dust produces large AS_Q glitches.



No enclosure: 2.8 x 10^{-6} glitches/sec per particle/cubic foot.

Purged enclosure: 0.062 x 10^{-6}, a factor of roughly 50.

One wall of the ISCT4 table enclosure has been replaced with a HEPA filter, to keep the table clean and quickly reduce glitch rates during commissioning.



SUMMARY OF DUST INVESTIGATIONS

1) Dust glitches in AS_Q are produced only at dark ports, especially where the beam is small.

2) Larger than 6 sigma dust glitch rate is about $3x10^{-6}$ glitches/sec per particle/cubic foot (H1 and H2).

3) Long after entry into a clean (HEPA-vac'd table, wet moped floor) dark port enclosure, the particle count is about 1 particle/cubic foot (glitch rate $3x10^{-6}$ glitches/sec).

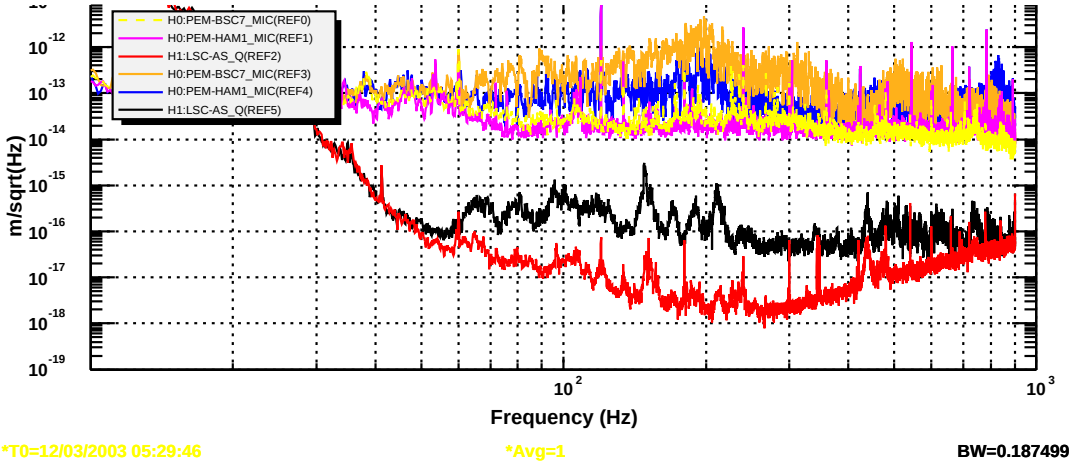
4) Prototype table top purged enclosure reduced glitch rate by about 50.

5) HEPA filter purging of table enclosure reduced glitch rate even more, but is noisy and should probably be used only during commissioning.

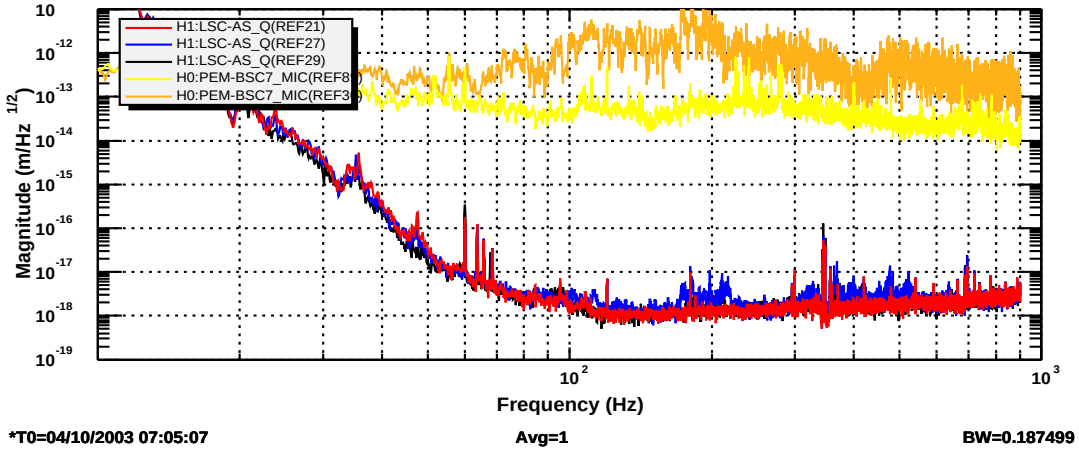
6) No individual veto found for S3 dust glitches. Epoch warning flag raised for about 24 hours after table entry. Dust glitch rates should be down to $3e^{-3}$/sec after 10 or 20 hours. Suggested S3 epoch flags: http://apex.ligo-wa.caltech.edu/~roberts/dustflags.txt

ACOUSTIC COUPLING

During S2 (Black: AS_Q with injected noise, Red: AS_Q, no injections)



Just Before S3 (see previous talks for progress with each mitigation step)



Still to be done:

I. REDUCE CONTINUOUS SOURCES (factor of 3 to 5)

- A. Continue with plans to acoustically house or remove electronics cabinets
- B. Insulate pipe-feed through from mechanical room
- C. Insulate PSL chillers

II. REDUCE COUPLING (factor of 5 for H1 & L1, less for H2)

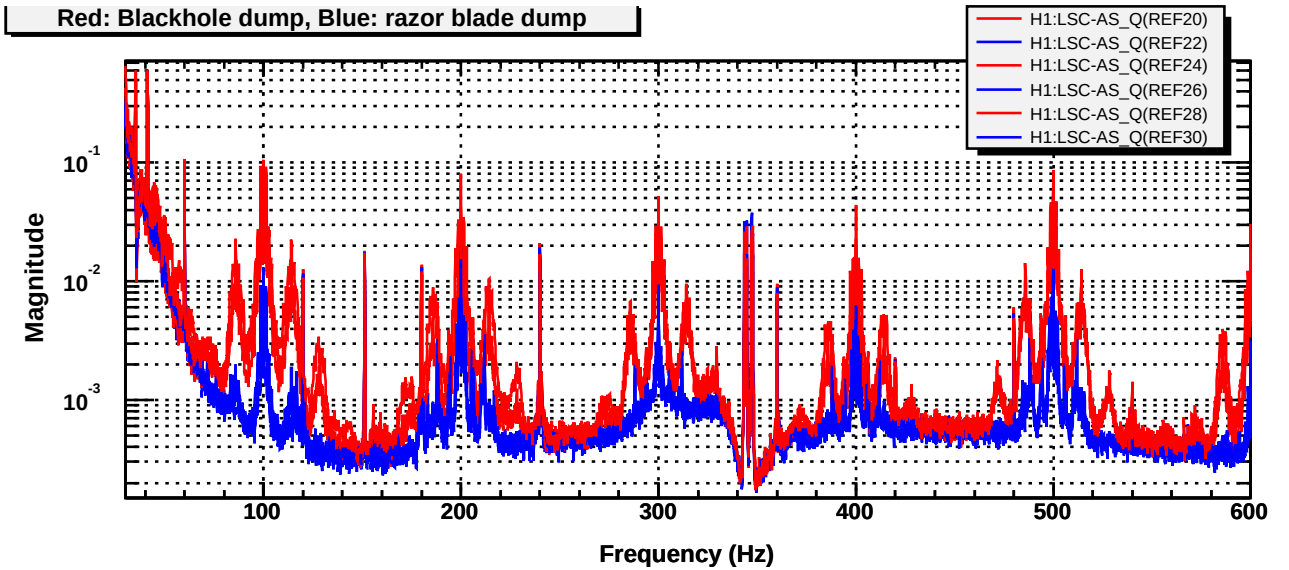
- A. Clipping
  - 1) Replace AS and REFL periscopes with V3 of new design
  - 2) Enlarge or remove 1/2 lambda plate and polarizer in REFL path
  - 3) Damp PSL periscopes
  - 4) Damp mounts and dumps etc.
  - 5) Continue testing floating legs for low f
- B. Backscattering from table (out of prudence - we haven't seen coupling)
  - 1) Grouted damped rigid legs, unless interferes with clipping reduction above

III. ACOUSTICALLY ISOLATE WORST COUPLING SITES

- A. REFL port enclosures with internal absorption kits? Reevaluate after above REFL work.

STEPPING BACKWARDS:

Acoustic coupling increased by a factor of ten between S3 and May. Tracked to a new back-scattering Blackhole beam dump.]



MAGNETIC COUPLING

- During S3, pulsed heaters created side bands in AS_Q around 60 Hz
- S3 PEM injections suggest that the 60 Hz peak in AS_Q can not be substantially reduced without reducing 60 Hz magnetic fields or magnetic field coupling.

Mitigation Plans

I. REDUCE SOURCES

a. Eliminate 1 Hz pulsed heating (successfully tested at LHO EX and LVEA)

b. Eliminate or smooth cycling of heaters (current experiment to control temperature in LVEA and EX with variable chilled water and fixed power heaters).

c. Reduce 60 Hz from heaters by reducing current loop areas, and arranging so fields cancel (successfully tested reduced area heating elements).

II. REDUCE COUPLING?

III. INSULATE COUPLING SITES (mu-metal)?

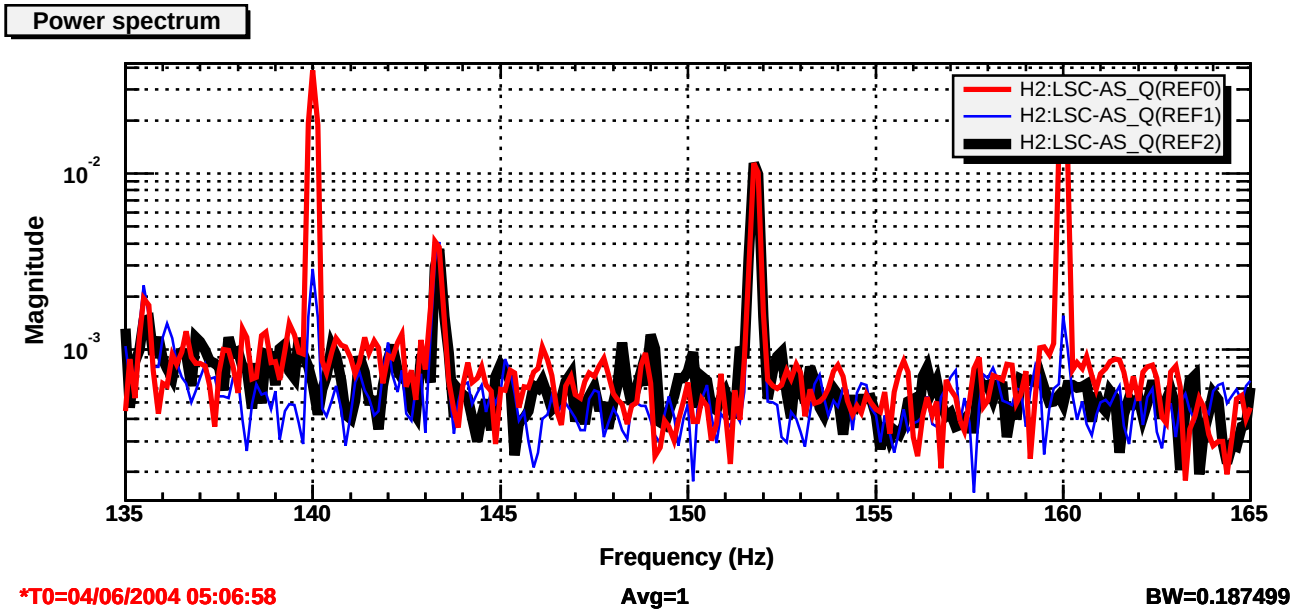
For II and III the first step is to identify coupling sites.

Replacing U-bent elements (shown below) with 2-pass elements and cleaning up loops in heater current distribution reduced 60 Hz magnetic field from this heater by a factor of 3.

Magnetic Field Coupling Sites

Searched with small magnetic field generating coil for most important coupling sites at LHO MY and EY stations

Black: no injection; Blue: coil near electronics cabinets; Red: coil at vacuum chamber wall



Most important coupling location seems to be test mass.

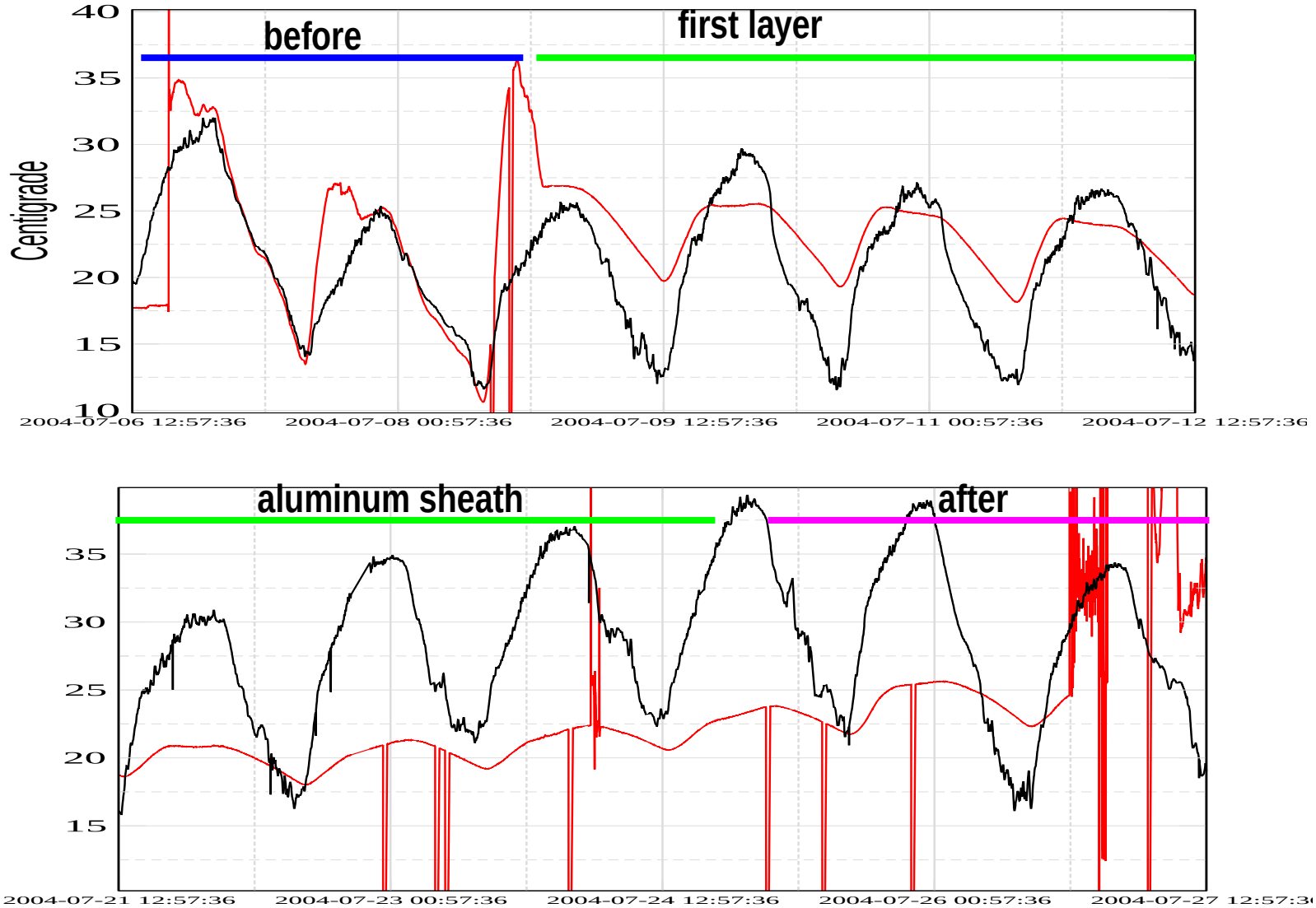
SEISMIC COUPLING

Dewar Glitches

In an attempt to reduce the glitch rate, a dewar was insulated (2 inch polystyrene foam, aluminized mylar layer, 2 more inches of foam, outer mylar layer and aluminum sheath).

normal **insulated**

Red: dewar thermocouple; Black: outside temperature



Got the anticipated factor of 4 reduction in diurnal variation plus direct sun shielding.

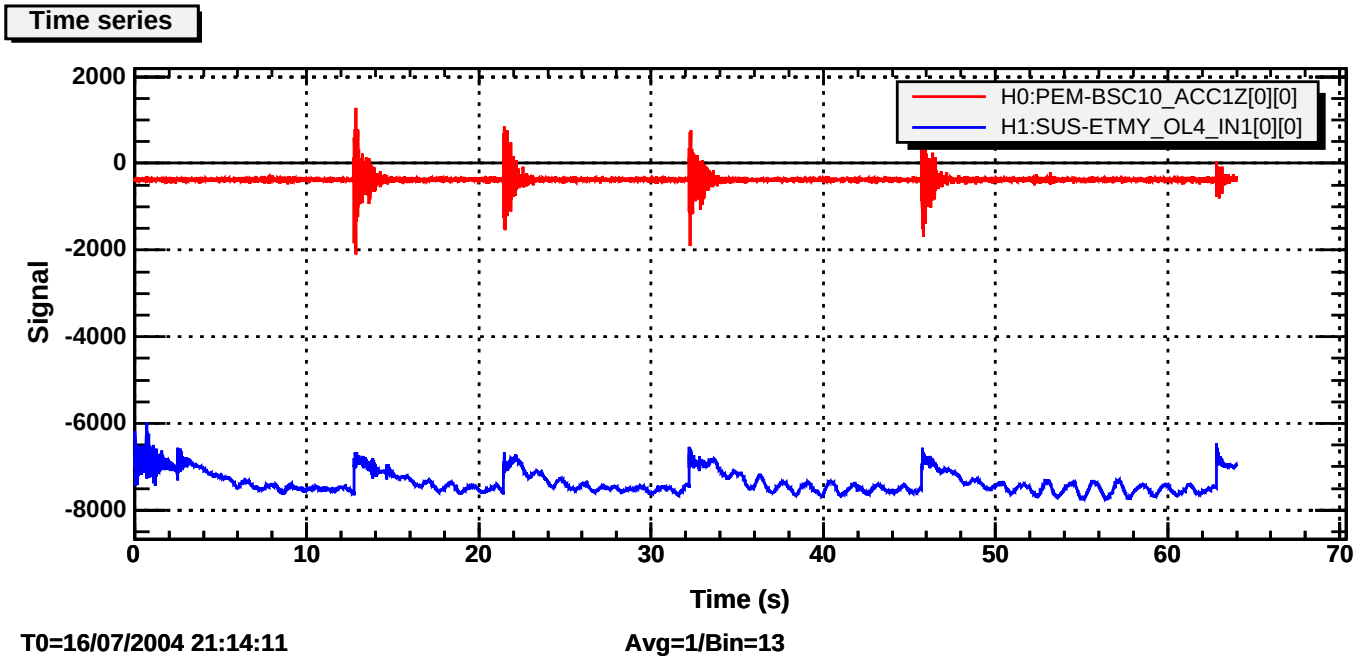
First indications are that the insulation has helped.

Night Time Seismic Spikes Peaking in the 12 to 17 Hz Band

Period	Number of Event	Rate (events per night)
5/31 - 6/30 (Before)	17	0.6
7/20 - 8/11 (After)	2	0.1

Seismic Sensitivity

S3 PEM injections showed that H1 would loose lock even with very small acoustic and seismic disturbances at the EY station. This was traced to an optical lever interface board.



The bad board produced a “DC” offset every time there was an event. New board doesn’t, and station is no longer so sensitive. No similar problems at other LHO out-stations.

INTERSITE BURST SEARCH

magMon algorithm for detecting PEM bursts that are coincident between sites

- Modification of an older version of glitchMon
- Coincidence before trigger generation to explore low thresholds
- Can insist on coincidence between multiple channels (e.g. on 2 of 3 voltage monitors at each site)
- Coincident event rates for aligned and offset LHO and LLO time series

No excess over chance coincidence found in coil magnetometers:

L0:PEM-COIL_MAGX; H0:PEM-COIL_MAGX; 560-580 Hz 4th order butterworth; 5,888,200 seconds of S3

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
5.5	4	1	3	2.23607
4.7	119	109	10	15.0997
3.9	4752	4686	66	97.1494
3.1	136256	136051	205	521.83
2.7	655400	656130	-730	1145.22

No excess found in LLO and LHO line voltage monitors:

L0:PEM-EX_V1;;L0:PEM-EY_V1;L0:PEM-LVEA_V1;H0:PEM-LVEA2_V2; H0:PEM-MY_V1; H0:PEM-LVEA2_V1;

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
4.7	1	0	1	1
4.06	3	2	1	2.23607
3.42	117	119	-2	15.3623
2.78	16757	16507	250	182.384
2.14	1830483	1829148	1335	1913.02

5888200 second of S3 data; only 1 event allowed each second; only 2 signals in excess of threshold demanded from each site.

No excess found in radio channels:

H0:PEM-RADIO_LVEA; H0:PEM-RADIO_LVEA; 5888200 s

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
6.7	209	236	-27	21.095
5.66	688	756	-68	38
4.62	3554	3720	-166	85.2877

Threshold (sigma)	Events exceeding threshold	Events for offset time series	(on - off)	sqrt(on+off)
4.1	15576	15554	22	176.437
3.06	2002687	2000813	1874	2000.87