Environmental Disturbances: Early S5 and S4

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I. HVAC flow rate reduction improves sensitivity
II. Seismic up-conversion experiments
III. S4 H1-H2 coincident events from site activity
IV. PEM injections
V. Electronics rack diagnostic magnetometer
VI. Crab protection
Gravitational wave sensitivity improves when HVAC off

Blue: All site turbines and chiller pad equipment off; Red: normal
Half-normal flow rate about as good as fans off

Red: pre-Feb. 15 flow rate, Black: all off, Blue: half flow rate

DARM

Black: off; Blue: ½ flow; Red: full flow

seismometer

*T0=15/02/2006 06:35:00
Avg=9/Bin=30  BW=0.0234374
Seismic noise likely from fan and plenum, not ducts (at X-end)

Black: off; Red: normal flow; Blue: like red but ducts closed off at plenum

*T0=17/02/2006 03:07:00  *Avg=30/Bin=4  BW=0.1875
Broad-band seismic signal from HVAC possibly produced by plenum turbulence

Pitch of blades controls flow rate through turbine

Flow from turbine ~50 mph
Summary: HVAC effect on range

- Shutting HVAC down improves H1 & H2 range about \( \frac{3}{4} \) Mpc.

- Influence likely seismic – air flow into LVEA/VEA not needed for range reduction.

- Half-flow about as good as HVAC off (seismic level 55\% of full flow in 1-50 Hz band).

- For \( \frac{3}{4} \) LVEA flow level, seismic rms is only 61\% of full flow level. This provides better temperature control and is what we are currently using.

- Seismic noise possibly from turbulence in supply plenum.

- DARM noise at 100 Hz was likely from up-conversion of lower frequency HVAC seismic signal instead of direct coupling.
Simple back-scattering model doesn’t explain tail

Predicted cutoff ~52 Hz

Predicted cutoff ~12 Hz

Tail not proportional to velocity (differs from single frequency injections)
Up-conversion **not** from “squeaky” optic suspension point

Red: 0.75 Hz injection, Blue: 1.2 Hz injection

- shadow sensors (displacement)
- large test mass displacement produces no upconversion
- smaller test mass displacement produces up-conversion

DARM

Blue peak is smaller than red in displacement and velocity but not in acceleration.
Ground or isolation system motion not needed to produce up-conversion

Black: ETMY coil injection; Red: ground shaking at ETMY

DARM
low f

matched ground and coil injections produce similar upconversion

DARM
high f

thick lines: no injection
Up-conversion *not* from RF saturation

uncalibrated DARM (proportional to RF current)

large DARM_EXC injection does not produce upconversion
Up-conversion best predicted by acceleration of optic

DARM: acceleration

peak heights in acceleration plot (but not velocity or displacement) match up-conversion amplitude

DARM: displacement

Magnitude (m/s^2/Hz^0.5)

Magnitude (m/Hz^1)

Frequency (Hz)

*T0=10/06/2005 05:15:18
Avg=1/Bin=6L
BW=0.0468742
Up-conversion summary

- At low seismic amplitudes, not consistent with back-scattering
- Not suspension point mechanical up-conversion
- Ground or stack motion does not appear to be necessary (is produced by direct ETMY coil injection)
- Acceleration of test mass predicts up-conversion better than velocity or displacement.
- Not RF saturation

- Up-conversion in actuation system?
- Magnetic domain-flipping (Barkhausen) noise?
What produced coincident H1 H2 bursts during S4?

Accelerometers at time of S4 H1 & H2 DARM burst

Arrival not consistent

Accelerometers during jump in control room
Door slams and water bottle drop also not consistent (delay, amplitude, f), but fork lift set-down at shipping is.

Accelerometers at time of S4 H1 & H2 DARM burst

Accelerometers during set-down of fork lift forks
“Floating” H2 dark port should reduce H1-H2 coincidences

Filtered DARM_ERRs during S4 H1-H2 coincident burst

FILTERED DARM_ERRs during lowering of fork lift forks (H2 AS table now floating)

H1 DARM, H2 DARM during forklift event: with floating H2 dark port, very little signal is seen on H2
S5 PEM Injections

• LLO: Dec 10 2005 elog has burst injection times and transfer functions. Summary:
  • ACOUSTIC/SEISMIC - coupling lower than S4; no coupling found in electronics bays.
  • MAGNETIC - coupling about the same as S4; we can not reduce DARM 60 Hz substantially without reducing 60 Hz ambient magnetic field; LVEA pulsed heating should be turned off.
  • RF - external sources loud enough to occasionally show up in DARM - radio channels are important veto channels

• LHO: Jan 8 2006 elog has burst injection times, transfer functions. Summary:
  • ACOUSTIC/SEISMIC-coupling 5x lower than S4; possible backscattering problem from end-station transmitted ports.
  • SEISMIC UPCONVERSION-same for all H1 and H2 out-stations, would be seen daily in H2 except for mystery noise.
  • RF-about the same as S4: signal on RADIO_LVEA about 100x SNR of DARM.
  • MAGNETIC-about the same as S4: a substantial or dominant contributor to DARM 60 Hz, 3 Hz sidebands need fixing...
Electronics racks magnetometer diagnostic

Magnetometer near electronics racks previously used to identify peaks in DARM from sources in electronics racks. During S5 break, broad band coherence between magnetometer and DARM led to discovery of bad board (which put ripple on power supply).

before anti-imaging board replacement; after

cohherence between DARM and magnetometer
Kyle Ryan improves the seismic isolation of the office area air handler, which has been running recently at 59.6 Hz.
# LVEA HVAC experiments

<table>
<thead>
<tr>
<th>CONFIGURATION</th>
<th>TOTAL LVEA FLOW (CFM)</th>
<th>SEIS_Z BAND (counts)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>33-50 Hz</td>
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<tr>
<td>A) Original flow</td>
<td>40,000</td>
<td>15.7</td>
</tr>
<tr>
<td>B) 2 LVEA fans and labs at 50% flow</td>
<td>20,000</td>
<td>8.6</td>
</tr>
<tr>
<td>C) Full LVEA flow with 2 fans. Labs at 50%</td>
<td>40,000</td>
<td>12.3</td>
</tr>
<tr>
<td>D) Full LVEA flow with 3 fans. LABs at 50%</td>
<td>40,000</td>
<td>9.2</td>
</tr>
<tr>
<td>E) 75% LVEA flow with 3 fans. LABS at 50%</td>
<td>30,000</td>
<td>9.2</td>
</tr>
<tr>
<td>F) 2 LVEA fans at 75% 2 LAB fans at 50%</td>
<td>30,000</td>
<td>9.5</td>
</tr>
<tr>
<td>G) 2 LVEA fans at 50% 2 LAB fans at 75%</td>
<td>20,000</td>
<td>9.8</td>
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