ACOUSTIC MITIGATION

PROGRESS

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AND MANY OTHERS
PROBLEM

Red shows coherence between H1 and H2 AS_Q over 12h during S2

Blue shows coherence between microphone near 4k dark port and 2k AS_Q
Noise played through speaker during S2 indicated that all three interferometers were close to being limited over a broad frequency range by acoustic coupling.

We would like to reduce acoustic-seismic contribution to noise by 100 to 1000.
HOW COUPLING SITES WERE IDENTIFIED

Burst propagation delays:

Predominant Coupling Sites: All 3 dark ports, LHO 4k PSL
21 Hz sawtooth played near LLO ISCT4 (top), ISCT1 (bottom)

For S2 coupling at other tables is at least a factor of 10 lower than at dark ports.
MAIN COUPLING MECHANISM:
clipping modulated by acoustic excitation.

Evidence: acoustically excitable peaks in GW channel gradually increase as an iris on the
dark port table is closed (see periscope peak just above 200 Hz). Calibration lines at harmon-ics of 50 Hz do not increase.

Blue: Normal; Red: Iris increased clipping

*T0=18/04/2003 01:11:58
Avg=1 BW=0.75

LIGO-G030496-00-Z
No evidence for parasitic interferometry noise from backscattering.

Red: Accelerometer on Dark Port Table; Blue: AS_Q
Solid: Normal; Dashed: Shaker shaking table at 14 Hz (sway resonance)
ACOUSTIC SOURCES

S2 LVEA sound levels are similar to those of an average residence

<table>
<thead>
<tr>
<th>Location</th>
<th>dBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>near LHO 2k dark port, outside of ISCT10</td>
<td>50</td>
</tr>
<tr>
<td>near LHO 4k dark port, outside of ISCT4</td>
<td>53</td>
</tr>
<tr>
<td>near LHO 2k reflected port, outside of ISCT7</td>
<td>56</td>
</tr>
<tr>
<td>1m from ajar electronics rack</td>
<td>59</td>
</tr>
<tr>
<td>1m from closed electronics rack</td>
<td>57</td>
</tr>
<tr>
<td>1m from vacuum pipe feed-through into mechanical room</td>
<td>56</td>
</tr>
<tr>
<td>mechanical room</td>
<td>65-70</td>
</tr>
<tr>
<td>bay between mechanical room and LVEA</td>
<td>52</td>
</tr>
</tbody>
</table>

Continuous sources: mostly HVAC and electronics fans

Transient: building relaxation, airplanes etc.; these are hard to control and comparable in loudness to our fans etc.

For Burst Group analysis there isn’t much to gain by reducing our lab sound level. However, continuous acoustic sources are important for the Stochastic Group.
LOUDEST CONTINUOUS SOURCES:
HVAC below 100 Hz, electronics cabinets above.

Rattling ducts may contribute to HVAC noise

Black: HVAC off, LVEA mic; Blue: HVAC on; Red: hand rattling of single walled duct.
PROPAGATION FROM SOURCE TO COUPLING SITE

Speaker on floor outside LLO triple PSL enclosure: comparison of inside to outside sensors

<table>
<thead>
<tr>
<th>Frequency Hz</th>
<th>Microphone: Outside/Inside</th>
<th>Accelerometer: Outside/Inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>200</td>
<td>114</td>
<td>89</td>
</tr>
<tr>
<td>500</td>
<td>111</td>
<td>67</td>
</tr>
<tr>
<td>800</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Enclosures appear to reduce table acceleration as well as sound pressure level.

Signal seems to travel predominantly through the air.
MITIGATION PLANS

I. REDUCE COUPLING (factor of 10 to 20)
   A. Clipping
      1) Eliminate some clipping sites (e.g. EO shutter)
      2) Larger optics where needed; lighter mounts for higher resonant frequencies
      3) Damp mounts and dumps etc.
      4) New periscopes with higher frequency resonances and damping
      5) Reduce table resonances around 100 Hz
   
   B. Backscattering from table (out of prudence - we haven’t seen coupling)
      1) Rigid legs or float table

II. ACOUSTICALLY ISOLATE WORST COUPLING SITES (factor of 10 to 20)
   A. Dark port enclosures with internal absorption kits

III. REDUCE CONTINUOUS SOURCES (factor of 3 to 5)
   A. Remove most electronics cabinets from LVEA
   B. Absorption and damping kits for vacuum electronics cabinets
   C. Damp single walled sections of ducts
   D. Insulate pipe feed through from mechanical room
   E. Insulate PSL chillers
CLIPPING MITIGATION SINCE S2

1) Replaced the top optic mount on the dark port periscope with a lighter one
2) Eliminated some small apertures since S2: EO shutter and associated polarizers
REDUCTION IN ACOUSTIC COUPLING SINCE S2

Red: AS_Q normal; Black: AS_Q with noise; Yellow & Orange: BSC7 mic

March 12

August 9

*T0=09/08/2003 04:10:03  Avg=1  BW=0.187499
TESTING OF NEW PERISCOPE DESIGN WITH DAMPING

Accelerometer on periscope top; Blue: no damping  Red: damping

Power spectrum

Magnitude

Frequency (Hz)

*T0=01/08/2003 02:31:49  Avg=1/Bin=8  BW=0.187499

H1:GDS-TEST_34_1_20(REF5)
H1:GDS-TEST_34_1_20(REF8)

LIGO-G030496-00-Z
TESTS OF RIGID AND FLOATING TABLE LEGS

Sum in quadrature of 3 accelerometer axes
DARK PORT ENCLOSURES WITH ABSORPTION KITS

Enclosure: attenuation factor of about 10 at low f; with absorption kit, 20 to 30
MITIGATION OF CONTINUOUS SOURCES:

Remove 4k electronics cabinets from LVEA, place 2k cabinets in acoustic enclosures, internal absorption for vacuum cabinets and PSL chiller enclosures.

Damp sections of single walled ducts.