LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1200171-v1 *LIGO* April 13, 2012

Status of acoustic isolation of H2 PSL enclosure

Robert Schofield

Distribution of this document:
LIGO Scientific Collaboration

This is an internal working note
of the LIGO Laboratory.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 159
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

Summary: we are close to reaching our goal of at least a factor of 10 attenuation down to 10 Hz. Further improvements could be made with acoustic damping tuned to the room modes, a new acoustic door, and reduction in make-up air flow.

I studied the acoustic isolation of the H2 PSL enclosure even though it is not quite complete because it will become more difficult when the laser arrives and it becomes a clean room. In addition to its current performance, I also studied what might improve the isolation should we be limited by acoustic coupling at the PSL in aLIGO.

Low frequency attenuation is about 20dB

I injected 5 Hz combs using a large speaker at distant locations in the LVEA and compared the signal on a microphone inside the enclosure to the signals from a microphone at 5 locations around and above the enclosure. The microphones were calibrated in situ and huddle tested. Figure 1 shows the resulting amplitude attenuation plot. Currently, sound pressure levels are attenuated by a factor of about 10 at 100 Hz, nearly as good as the smaller (and thus more rigid) acoustic enclosures for iLIGO that had a factor of about 20 attenuation. Although low frequency attenuation is difficult, we hoped to have a factor of 10 down to 10 Hz for aLIGO. Figure 1 shows that we mostly reached this, though there are a few high points that are likely associated with chamber modes and scatter associated with the difficulty of generating high signal to noise around 5-30 Hz.

Damping would improve low frequency performance

Figure 2 shows that I got a slight reduction in amplitude at low frequencies when a single tuned damper and two bales of fiberglass were in the room (I moved them in, blue, and out, red, several times). If we placed tuned corner dampers (as in the iLIGO acoustic enclosures) to fill all vertical corners we would have about 5 times as much damping material as in this test.

A better door should improve high frequency performance

The acoustic door was of inferior quality and will be replaced. Figure 3 shows that I reduced high frequency noise by stuffing the poorly sealed edges of the door with foam.

Make-up air at 100% flow increases sound by at least 1.5 at low and high frequencies

Figure 4 shows that the make-up air increases the sound level by 1.5 at high frequencies, and also down at the putative room resonances below 100 Hz. The increase over background (no make-up air) is expected to be even larger when the LVEA does not have a lot of noisy clean rooms running. Running at a lower speed may help.

Room modes

Figure 4 also shows room resonances at about 11, 14, 22, 41 and 64 Hz. The 3 highest of these are consistent with the calculated lowest room modes: axial – 23 Hz, tangential – 42 Hz, oblique – 63 Hz. The microphone was hung above the table for Figure 4. When the mic was hung near the wall, there was also a strong 31 Hz peak, possibly the second lowest axial mode calculated at 35 Hz. The 11 and 14 Hz peaks may be due to structural resonances of the enclosure or the clean room structure within.

Penetrations

I tested the stuffing of the penetrations by adding additional stuffing. Extra stuffing didn't help on the feed-throughs without cables, but did on those with cables. It takes careful packing around the cables to maximize performance.

I corked the output duct and saw no reduction in sound, suggesting that our acoustic labyrinth is working well.

Robert, Rick

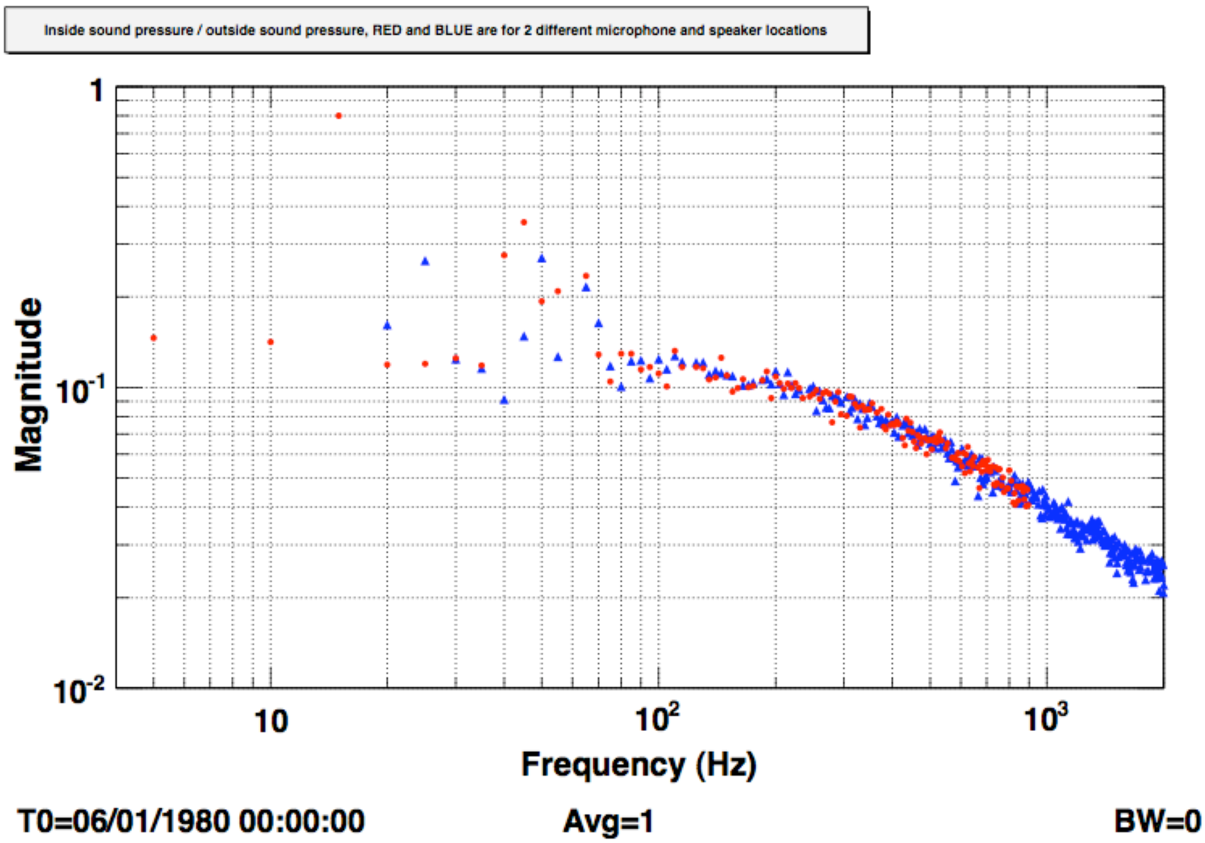
Inside sound pressure / outside sound pressure, RED and BLUE are for 2 different microphone and speaker locations
1
Magnitude
10^{-1}
10^{-2}
10
10^{2}
10^{3}
Frequency (Hz)
T0=06/01/1980 00:00:00
Avg=1
BW=0

Figure 1.

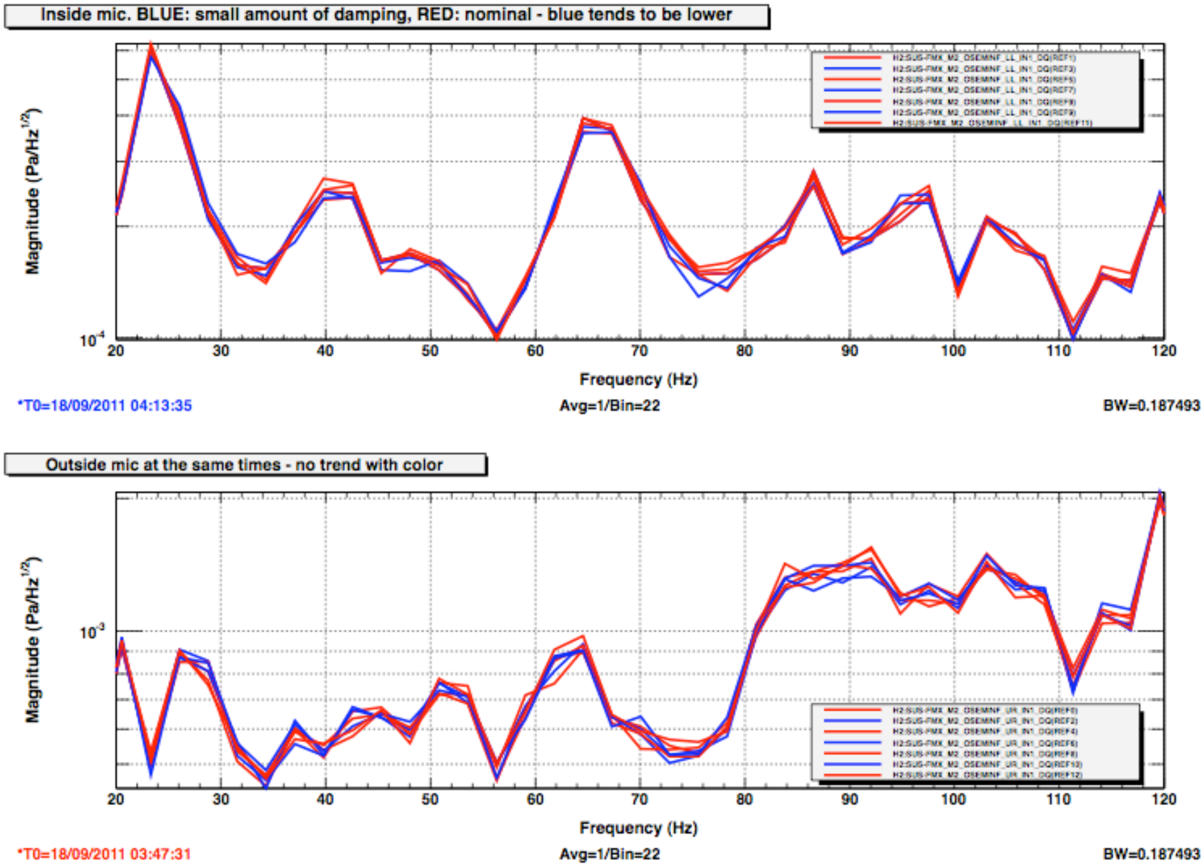
Inside mic. BLUE: small amount of damping, RED: nominal - blue tends to be lower
Magnitude (Pa/Hz$^{1/2}$)
10^{-4}
20
30
40
50
60
70
80
90
100
110
120
Frequency (Hz)
*T0=18/09/2011 04:13:35
Avg=1/Bin=22
BW=0.187493
Outside mic at the same times - no trend with color
Magnitude (Pa/Hz$^{1/2}$)
10^{-3}
20
30
40
50
60
70
80
90
100
110
120
Frequency (Hz)
*T0=18/09/2011 03:47:31
Avg=1/Bin=22
BW=0.187493

Figure 2

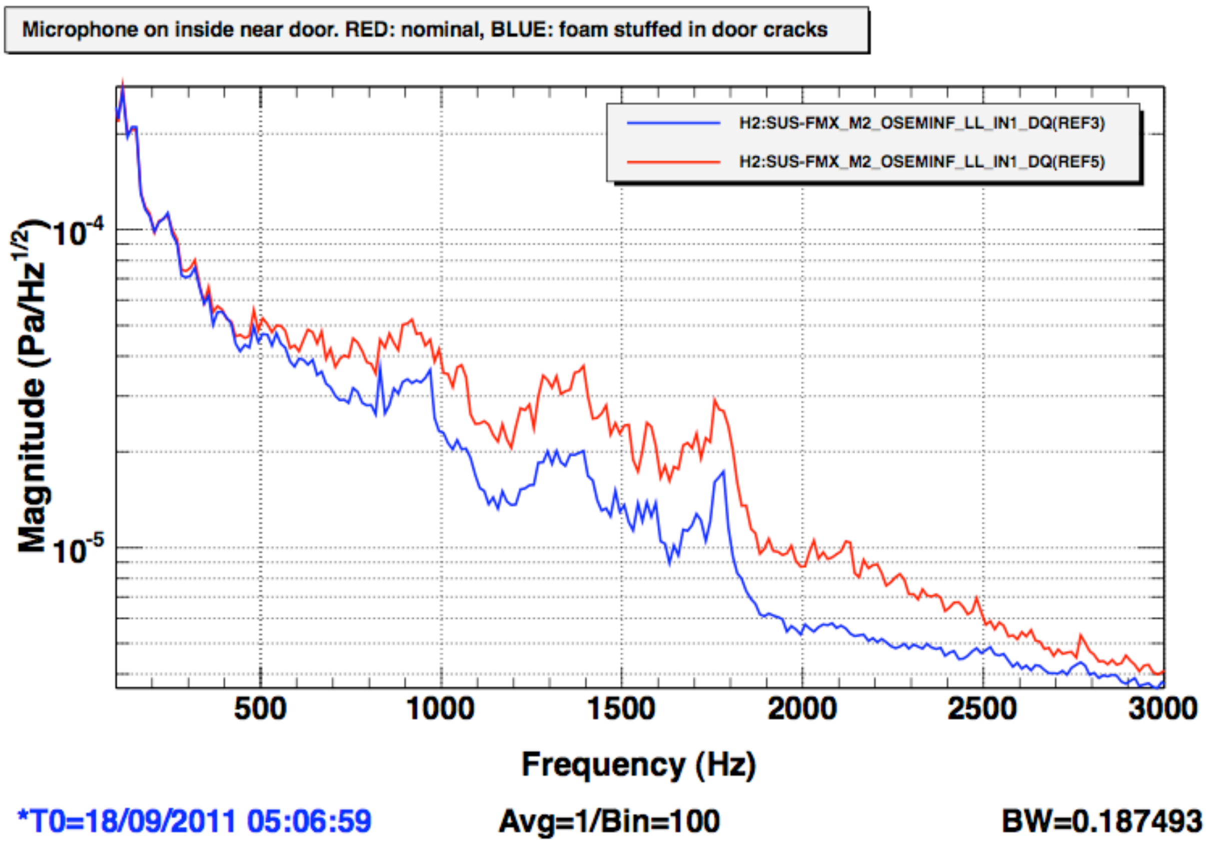
Microphone on inside near door. RED: nominal, BLUE: foam stuffed in door cracks
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF3)
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF5)
Magnitude (Pa/Hz^1/2)
10^-4
10^-5
500
1000
1500
2000
2500
3000
Frequency (Hz)
*T0=18/09/2011 05:06:59
Avg=1/Bin=100
BW=0.187493

Figure 3

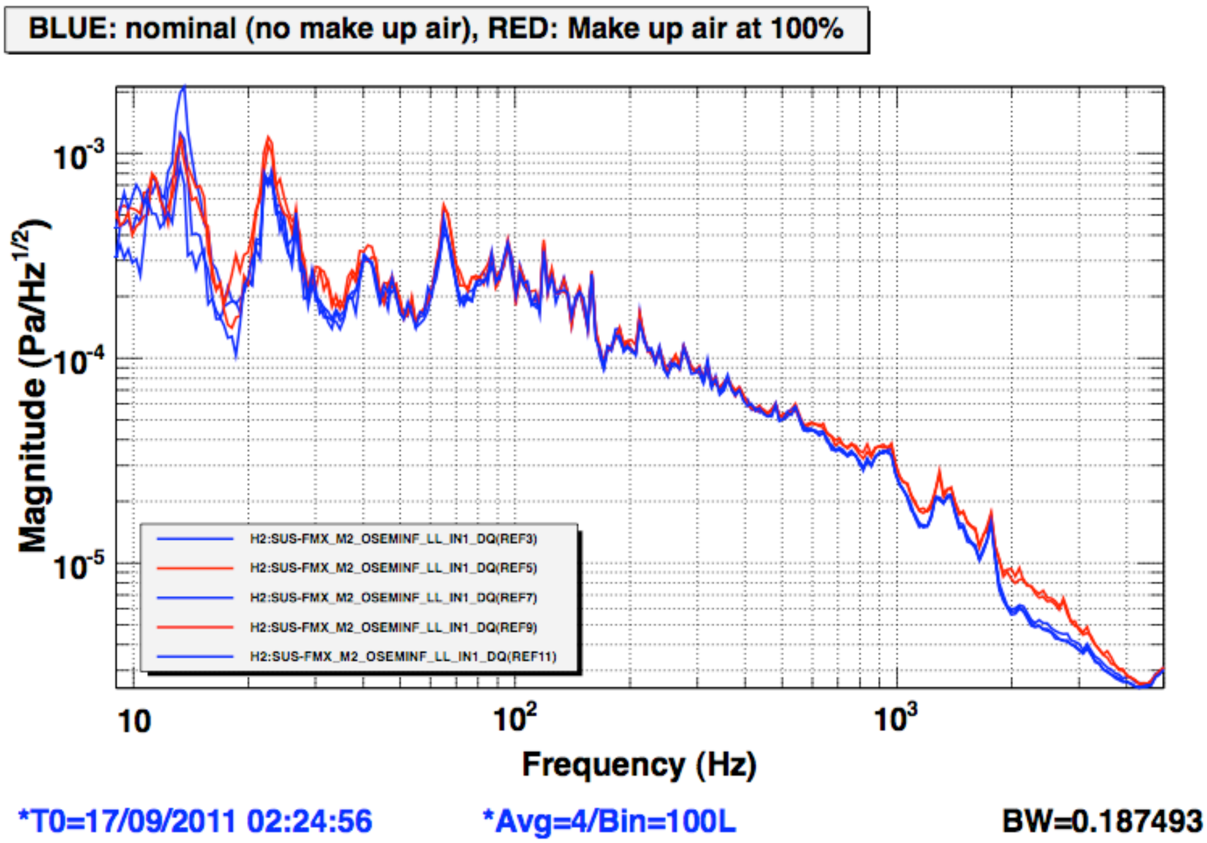
BLUE: nominal (no make up air), RED: Make up air at 100%
Magnitude (Pa/Hz^1/2)
10^-3
10^-4
10^-5
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF3)
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF5)
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF7)
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF9)
H2:SUS-FMX_M2_OSEMINF_LL_IN1_DQ(REF11)
10
10^2
10^3
Frequency (Hz)
*T0=17/09/2011 02:24:56
*Avg=4/Bin=100L
BW=0.187493

Figure 4.