Mitigation of environmental coupling for eLIGO

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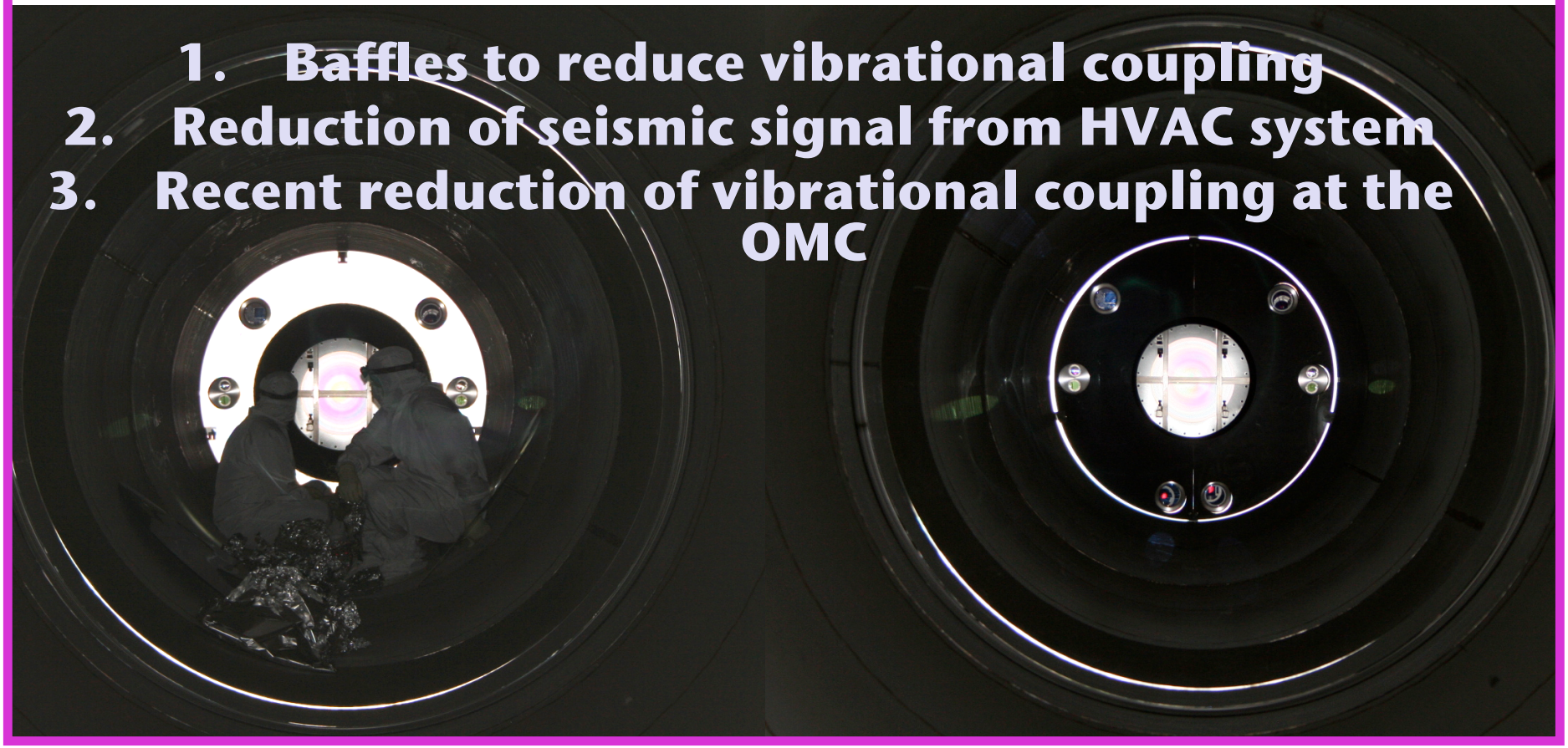
LIGO-G0900197

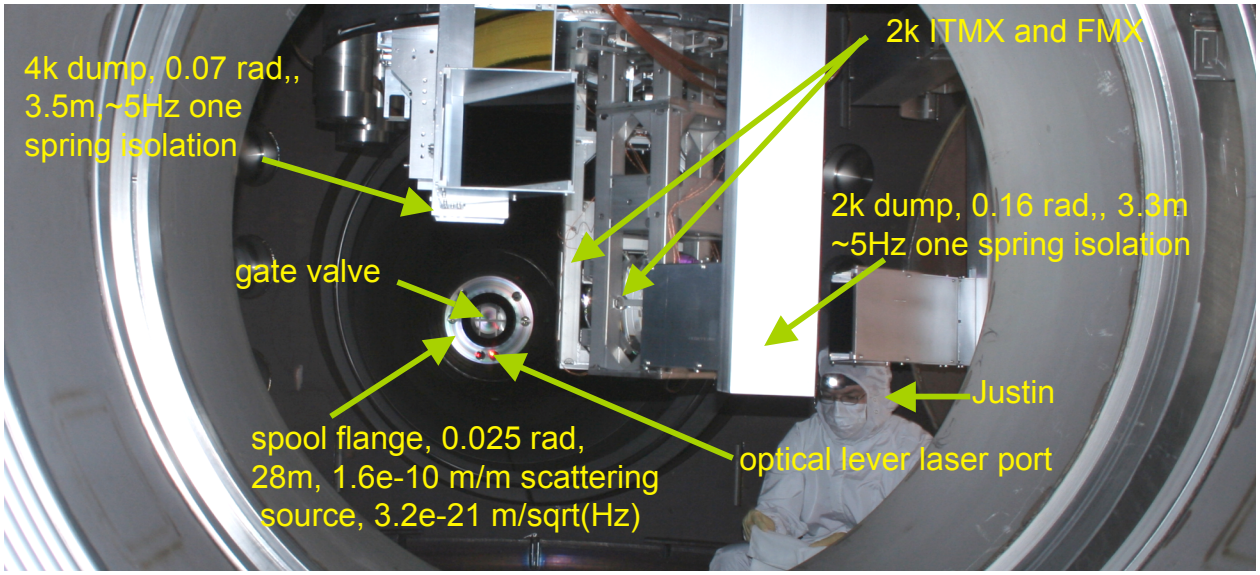
1. Baffles to reduce vibrational coupling
2. Reduction of seismic signal from HVAC system
3. Recent reduction of vibrational coupling at the OMC



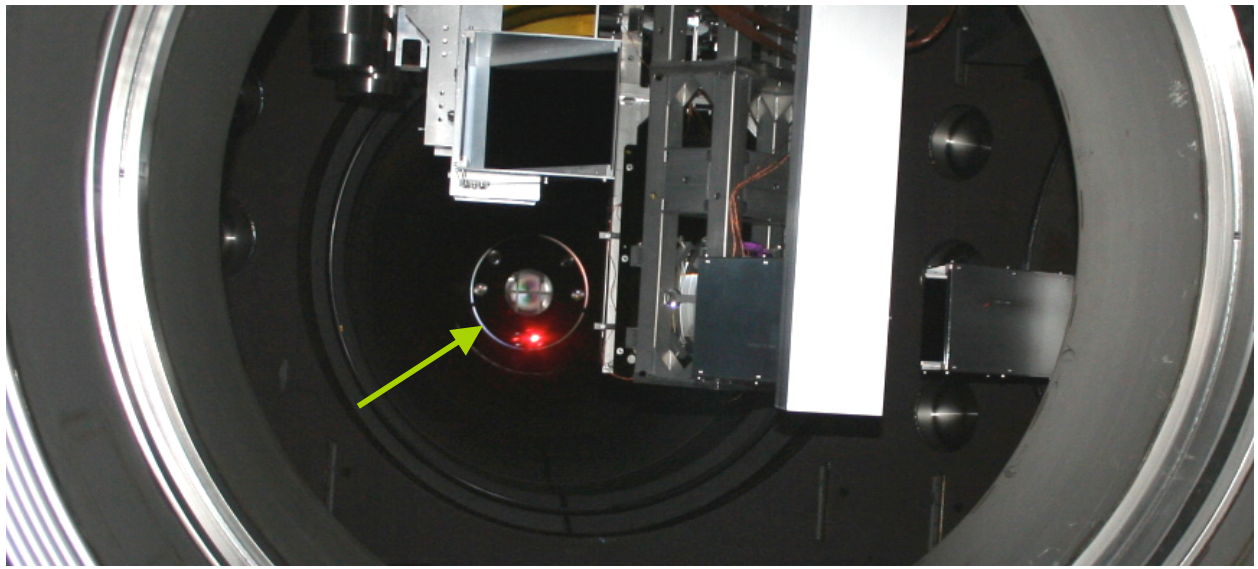
New baffles to reduce acoustic-scattering coupling

X-manifold - view from ITMX

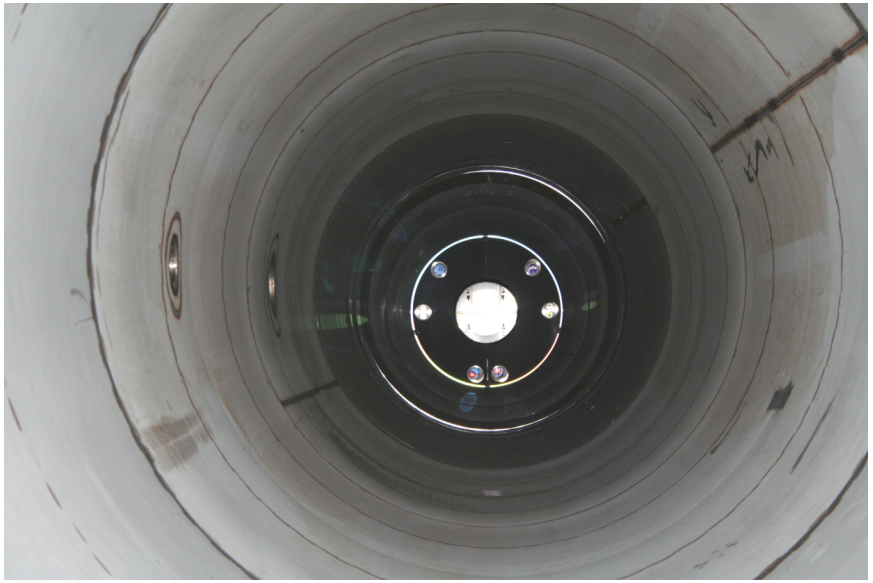
Before



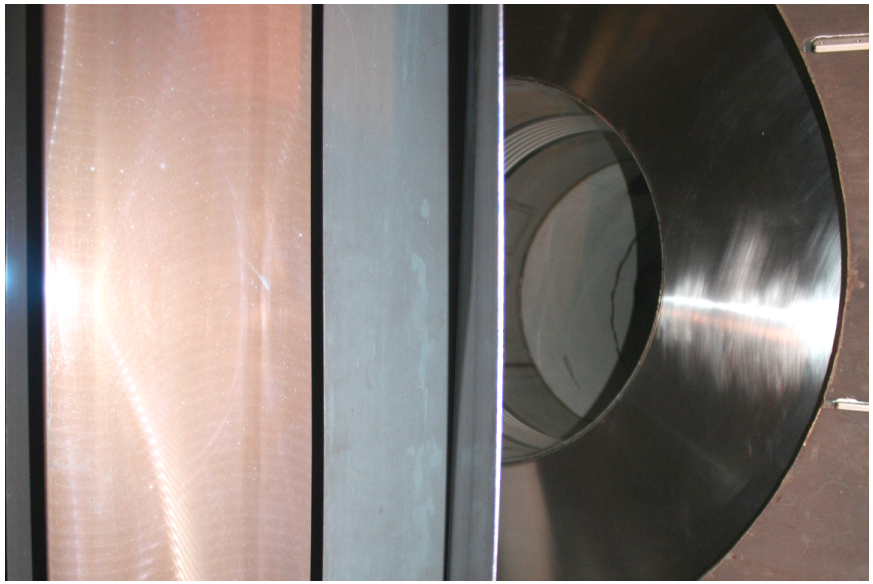
After



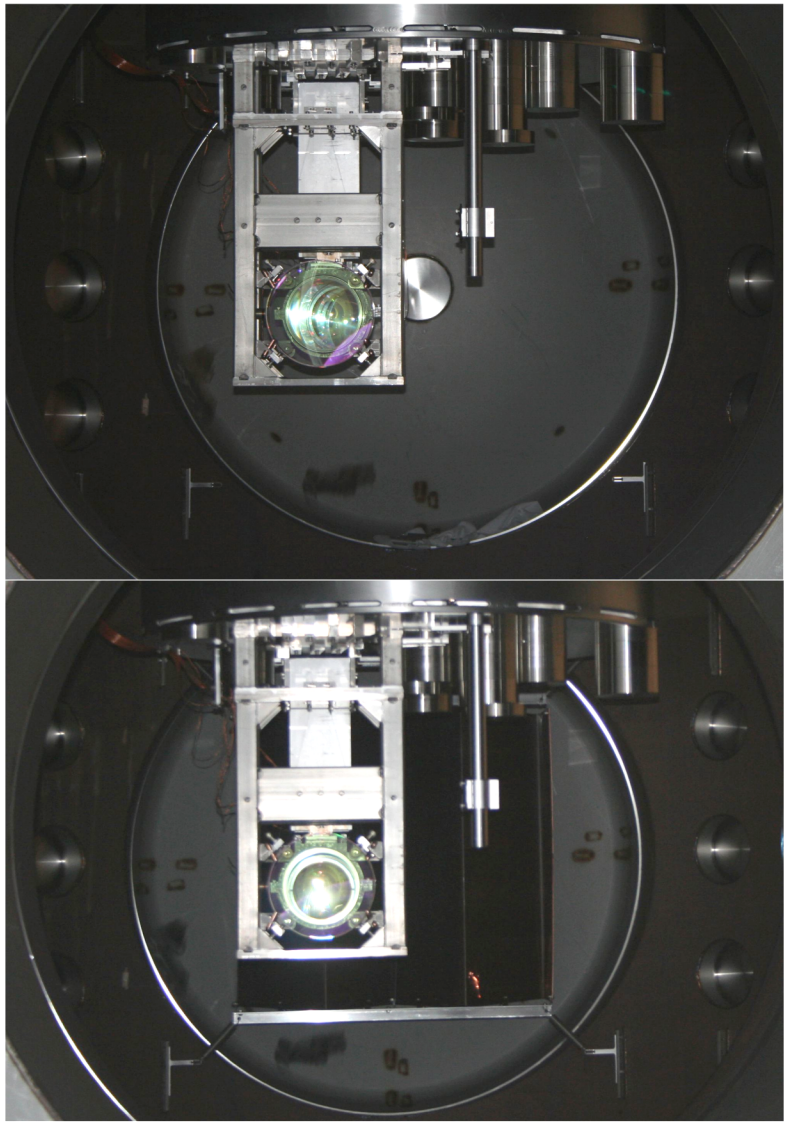
Y-manifold baffle



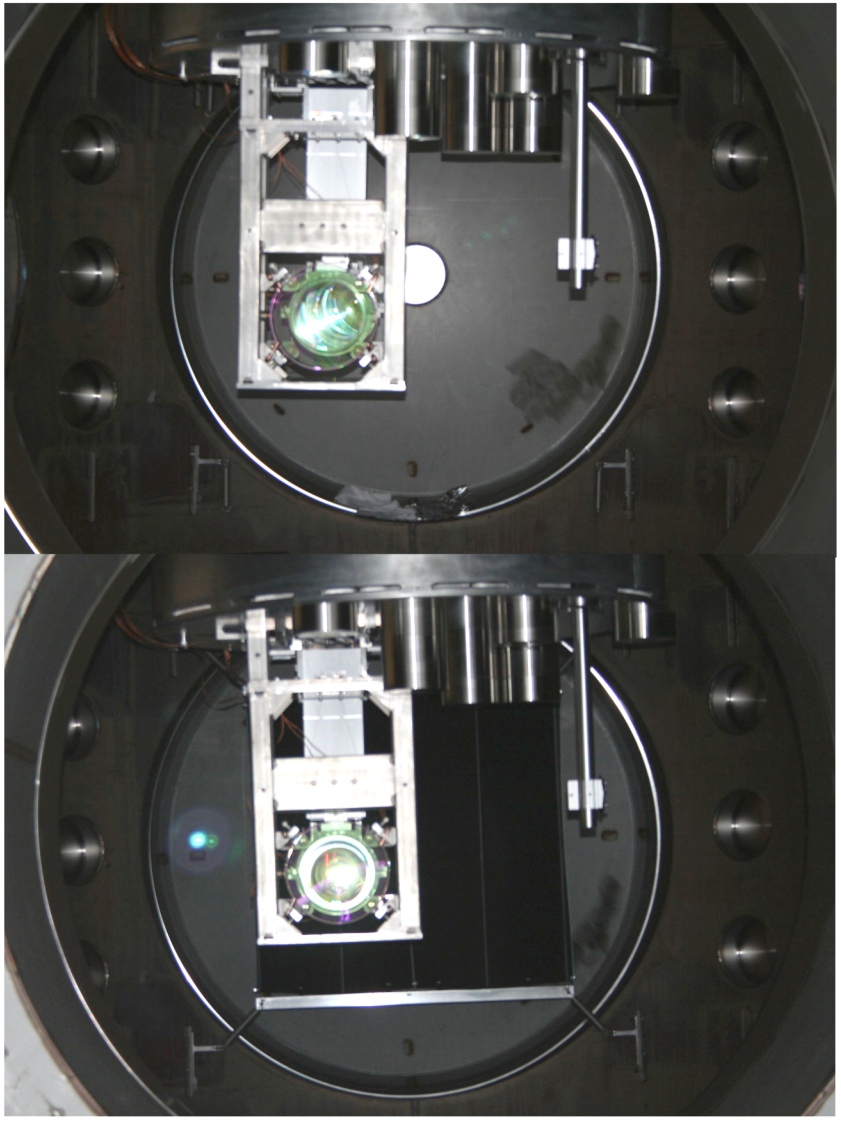
HAM5 baffle



X-endcap baffle



Y-endcap baffle

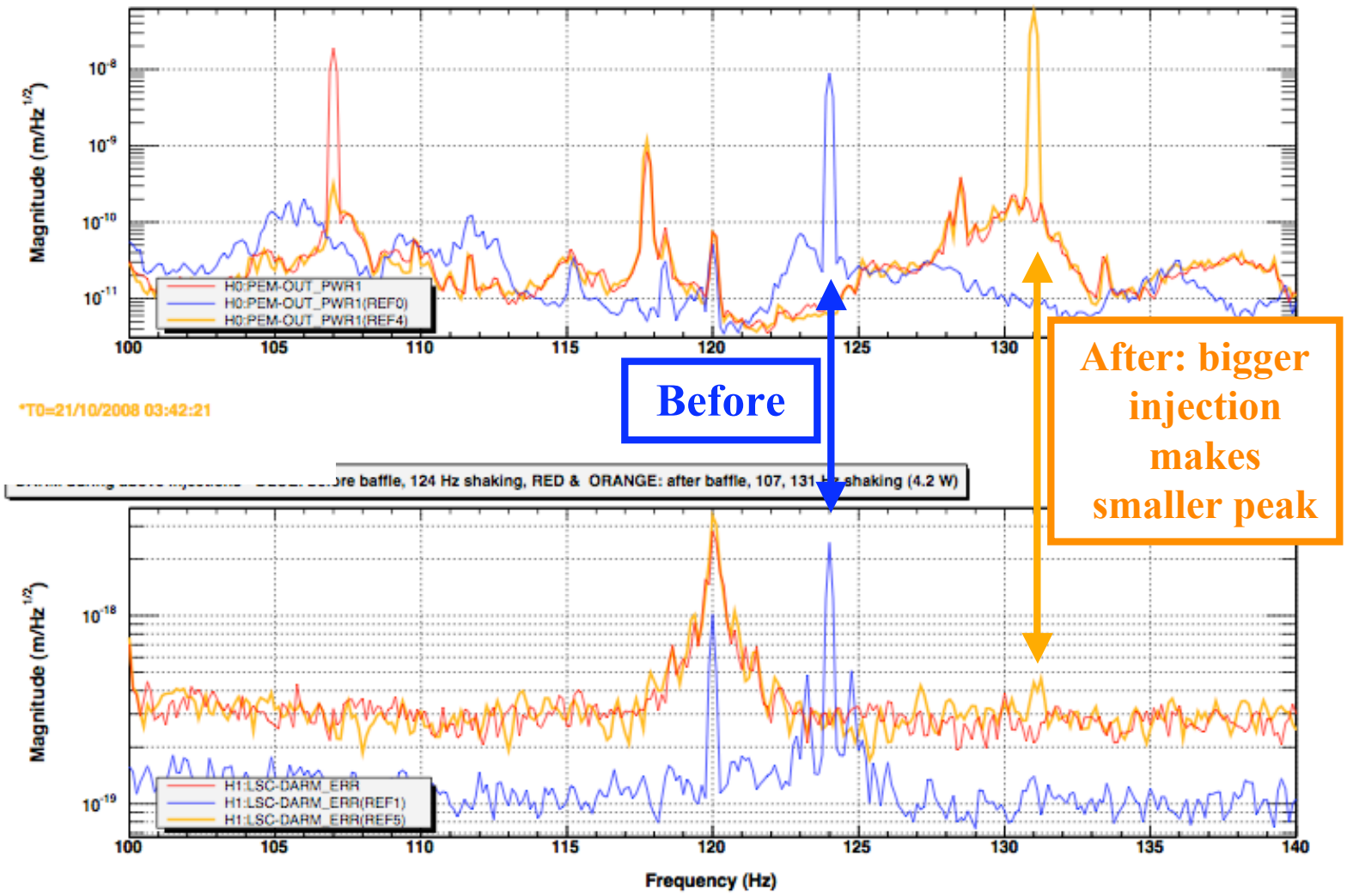


Baffling worked

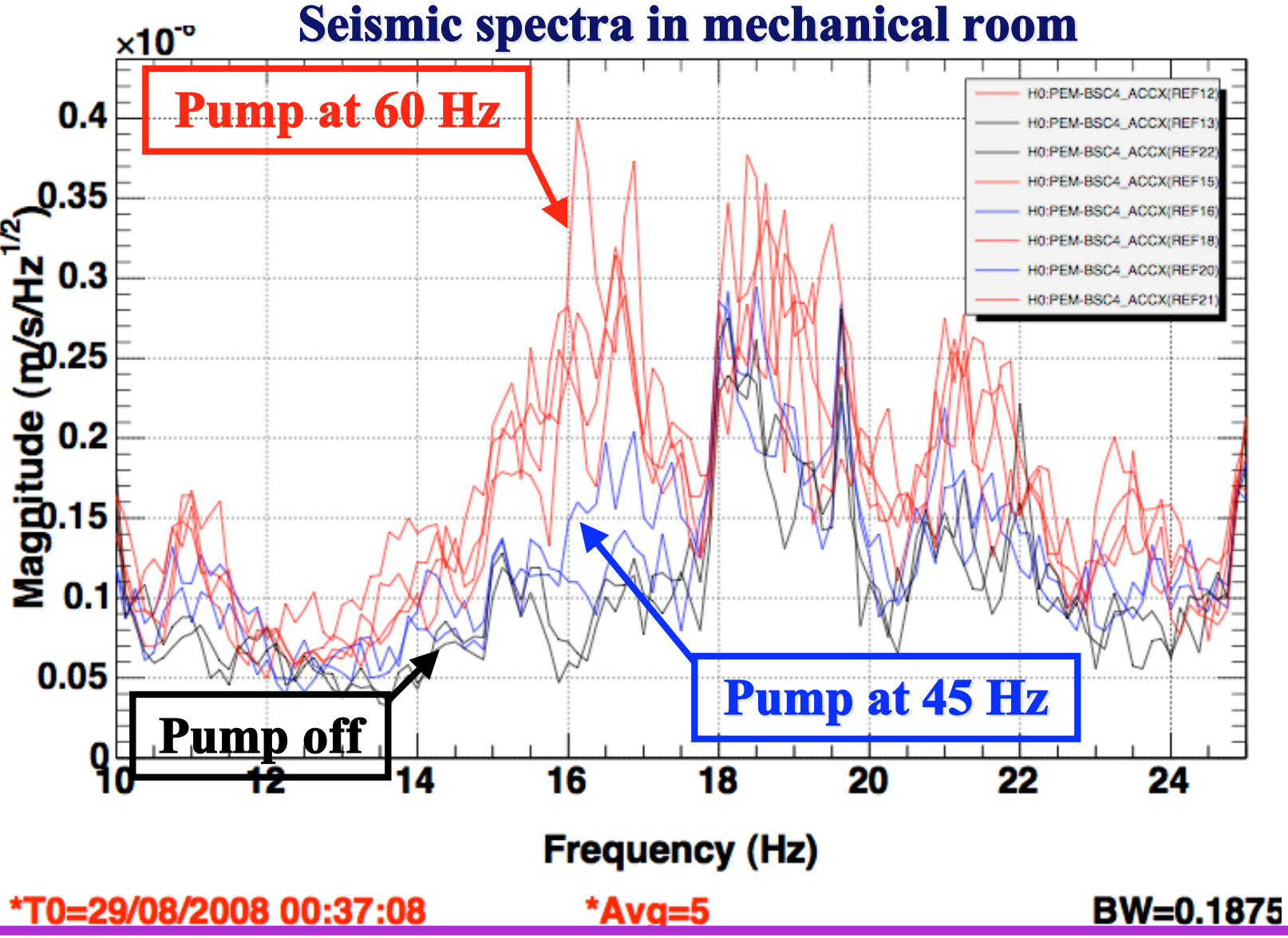
HAM5 baffle check

Acceler-ometer

DARM



Reducing seismic noise by running chilled water pumps at 45 Hz instead of 60 Hz

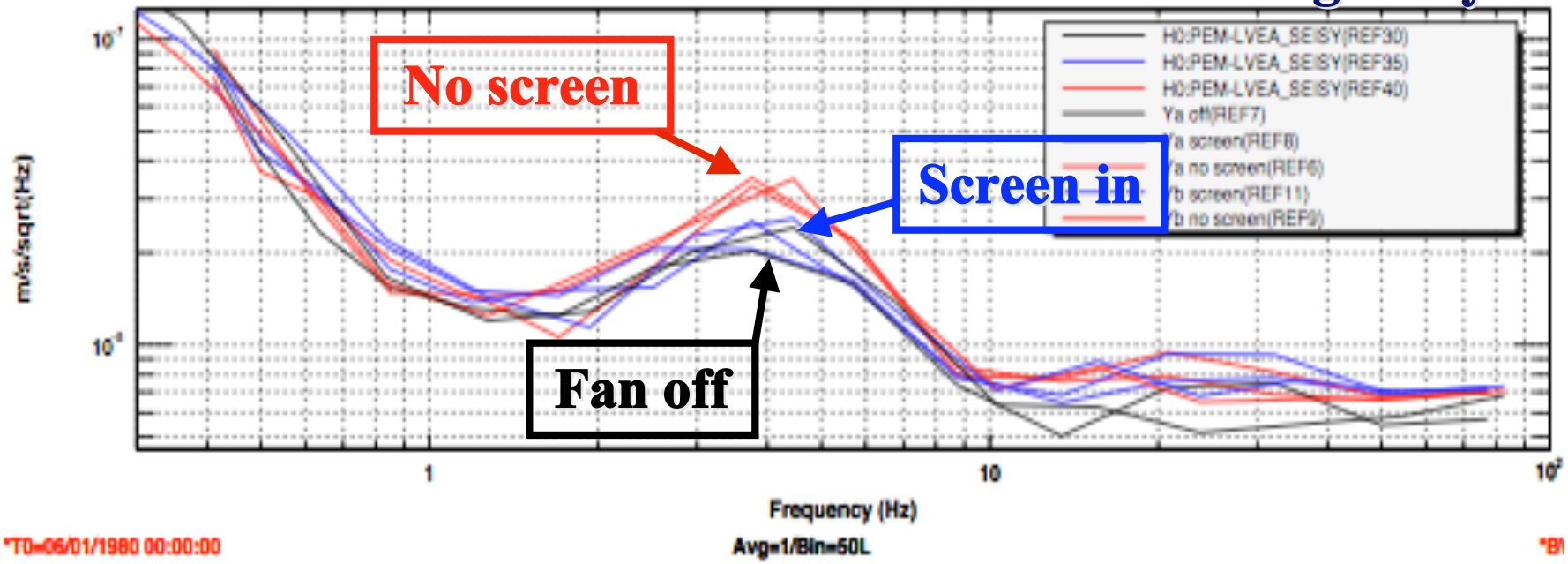


Screen reduces low-f noise from HVAC fans

Low frequency noise from large eddies.

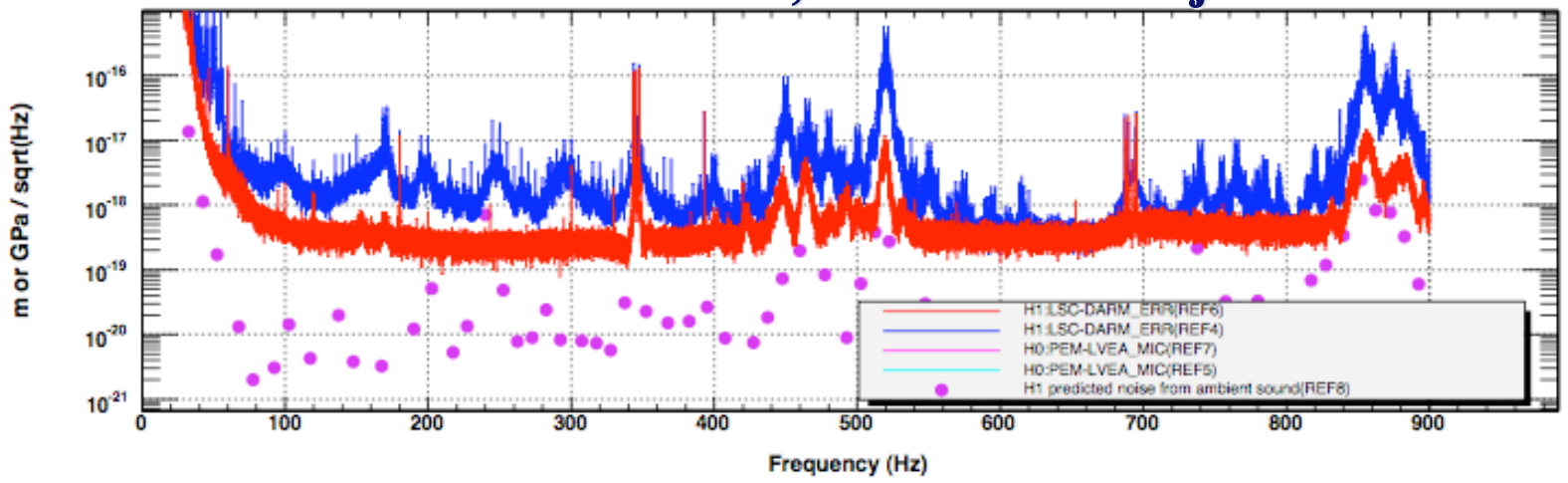
Reduce eddy size with screen

Screen reduces fan contribution to LVEA seismic signal by 2-3

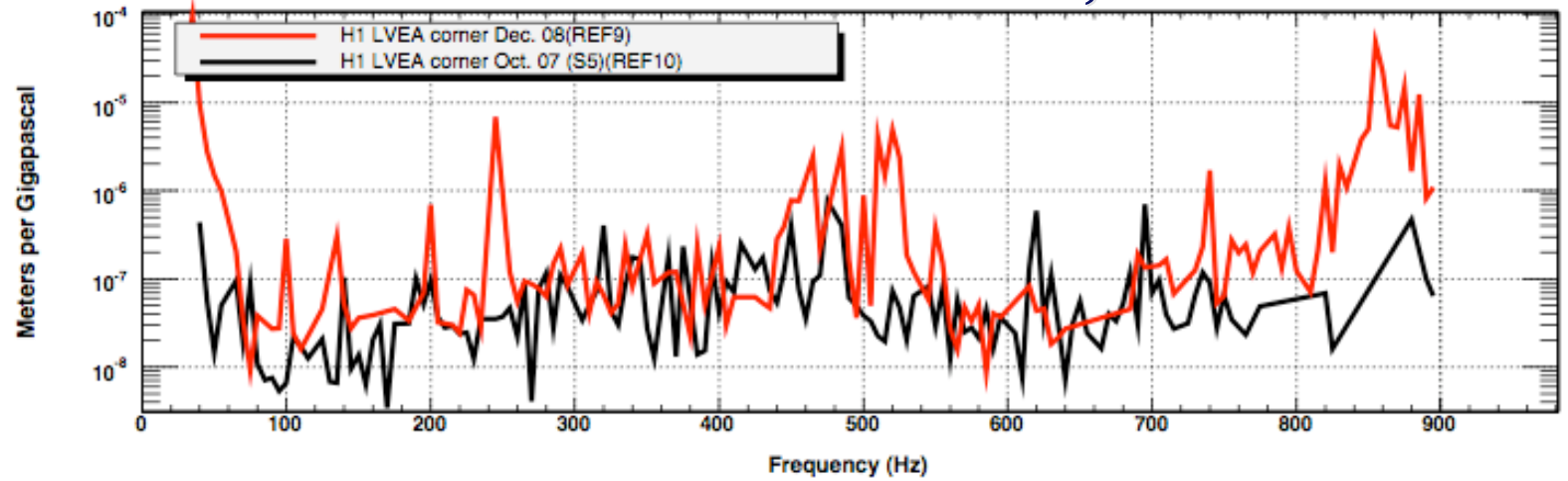


First DC acoustic coupling: like S5 except for new peaks

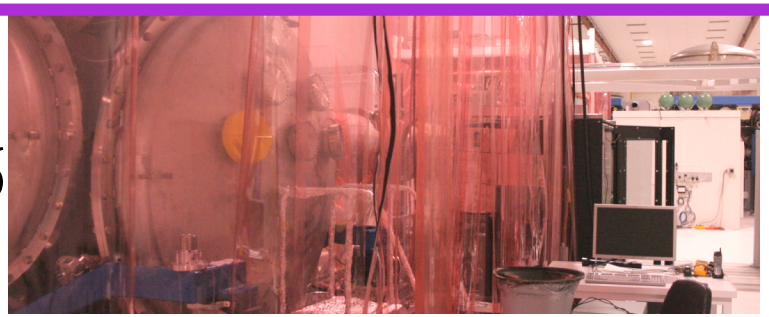
SPECTRA Red: nominal, Blue: acoustic injection



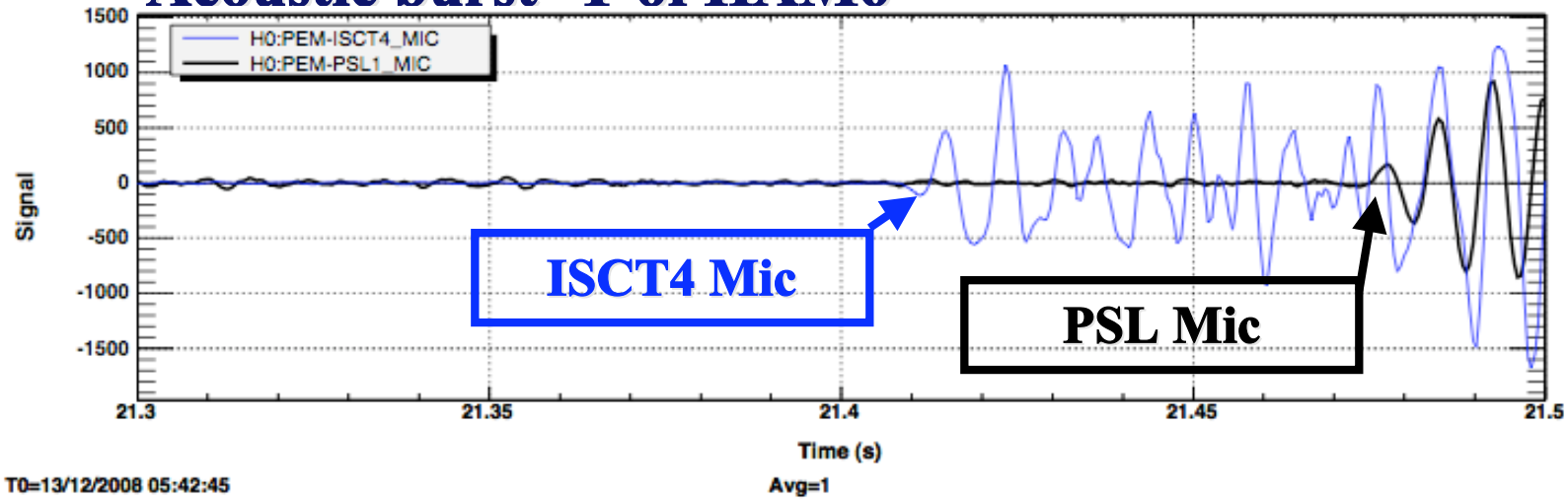
COUPLING FUNCTIONS Black: S5, Red: first DC



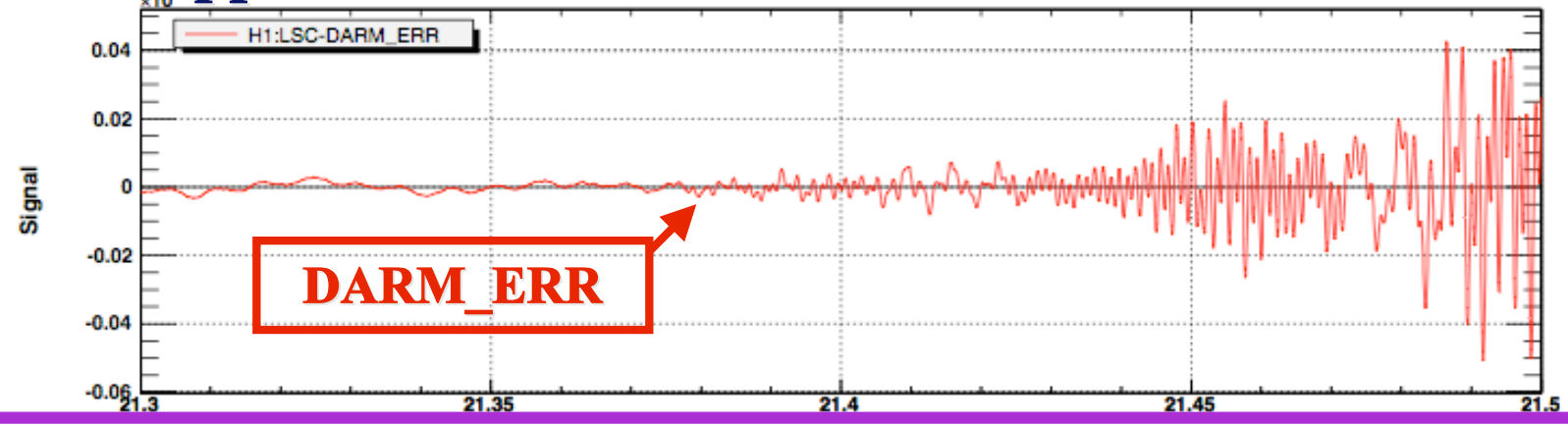
Coupling at the new output mode cleaner chamber, HAM6



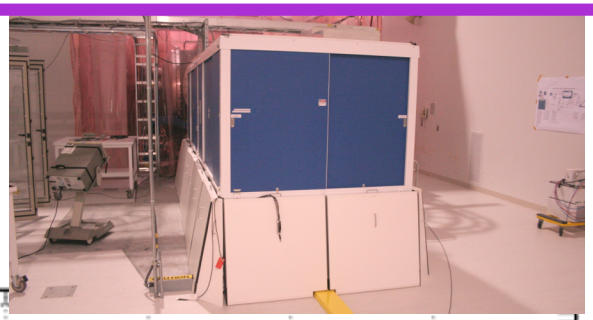
Acoustic burst -Y of HAM6



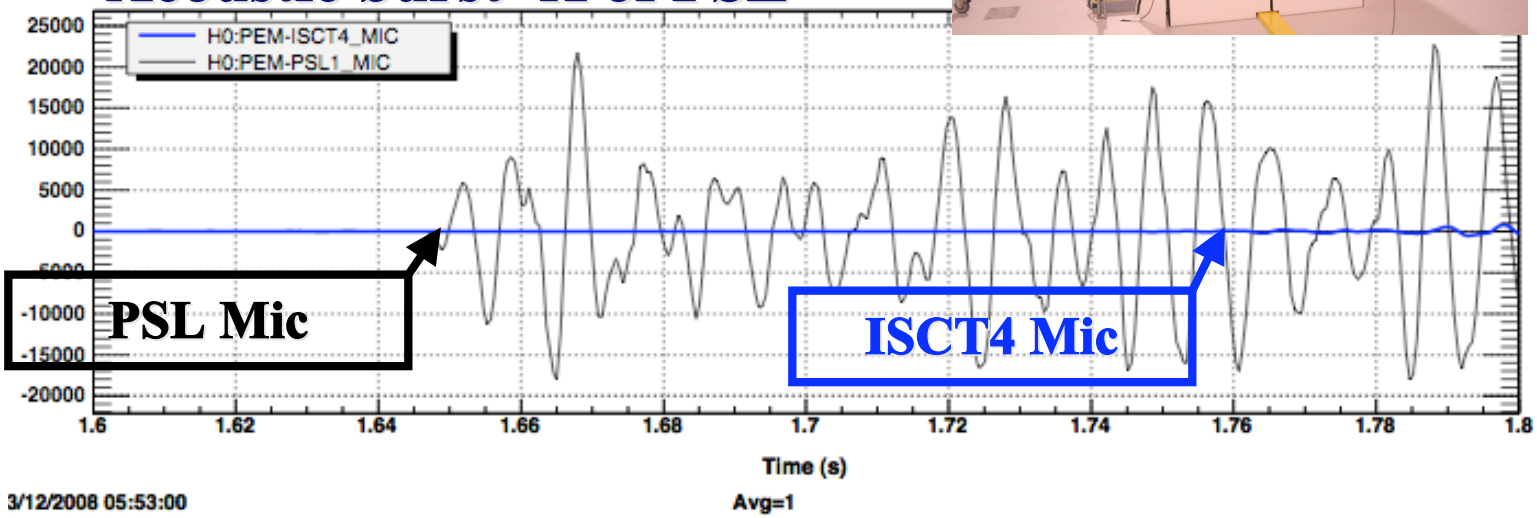
Appears on DARM before it reaches ISCT4



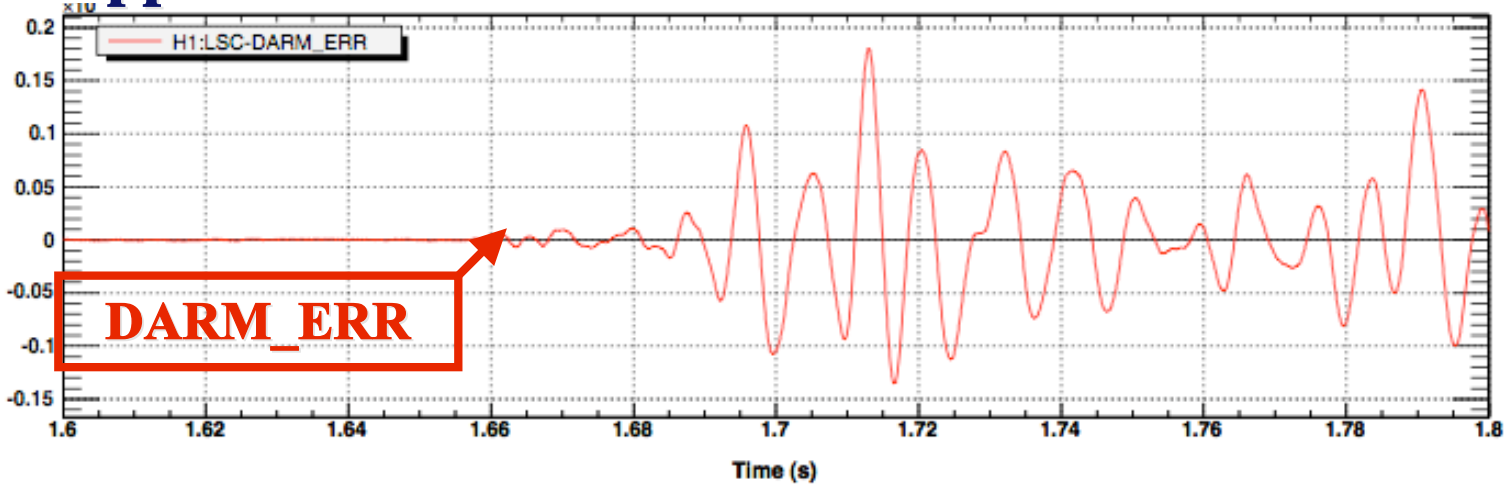
Coupling at the PSL



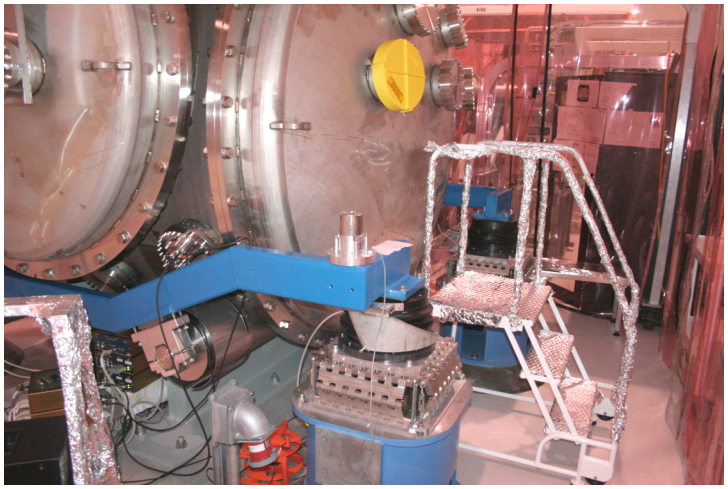
Acoustic burst -X of PSL

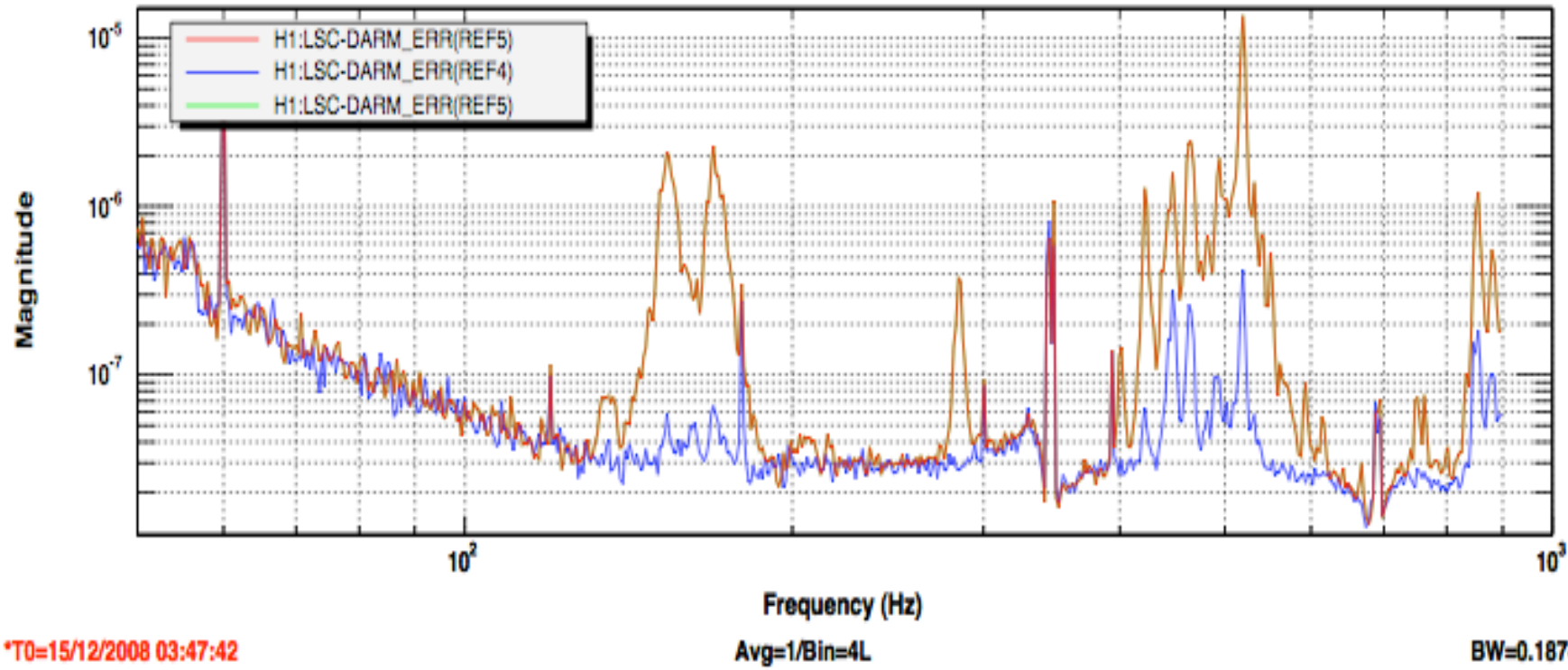


Appears on DARM before it reaches ISCT4



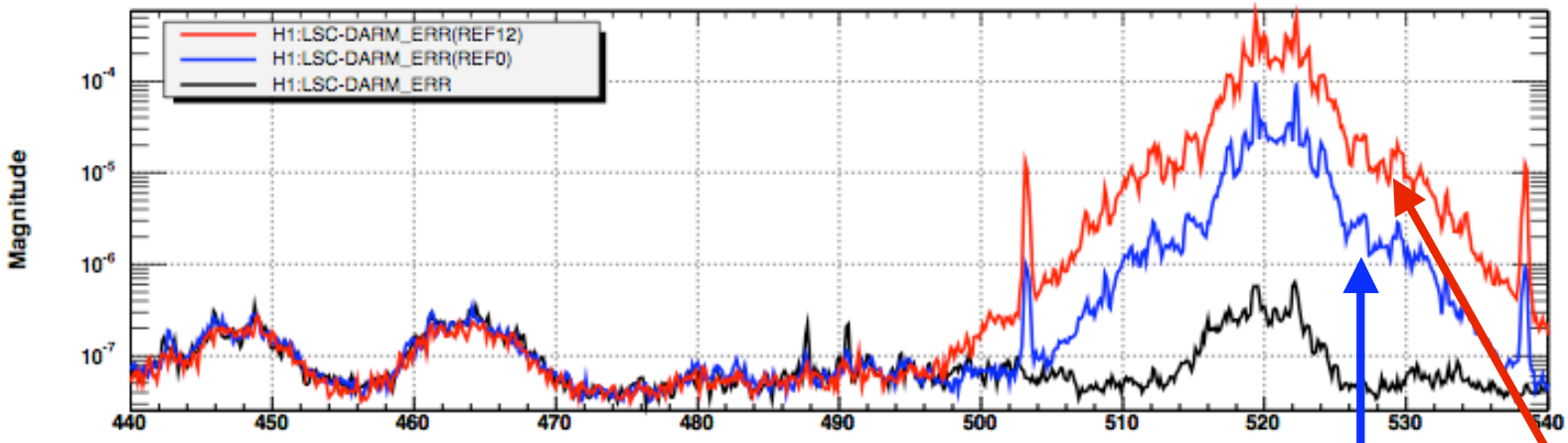
Old fashioned tap test



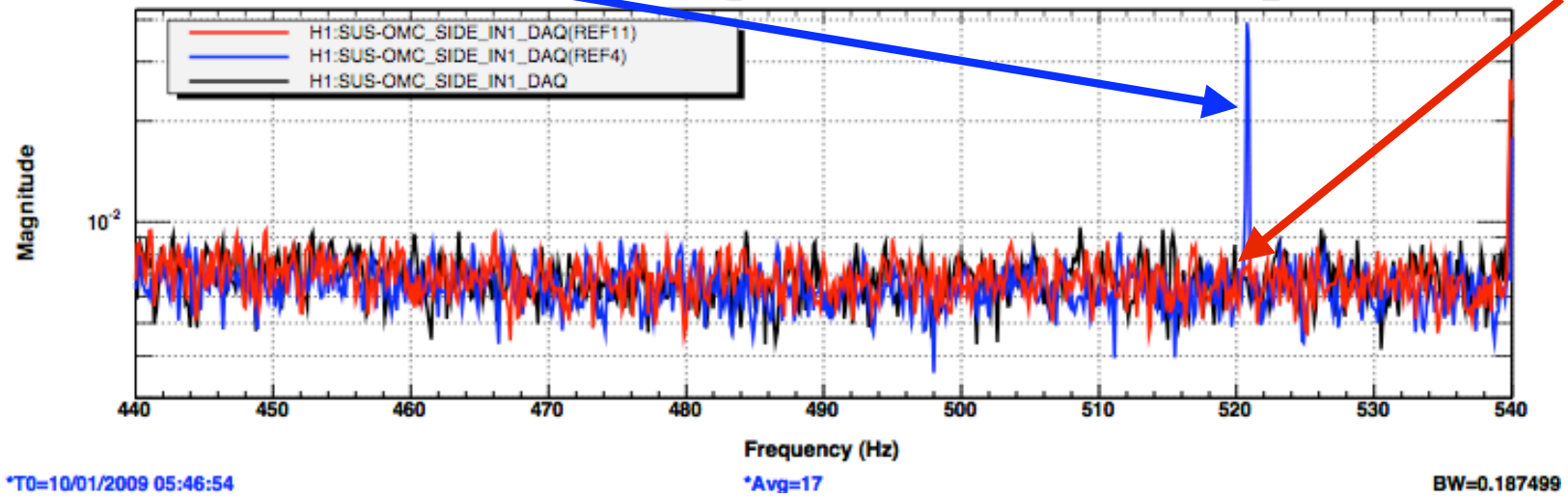


Blue: not tap, Red: tap on HAM6 blue cross beams

Investigating coupling from outside the vacuum



OSEM shaking of OMC produces blue peaks in DARM and OMC shadow sensor. Shaking table from outside produces red.

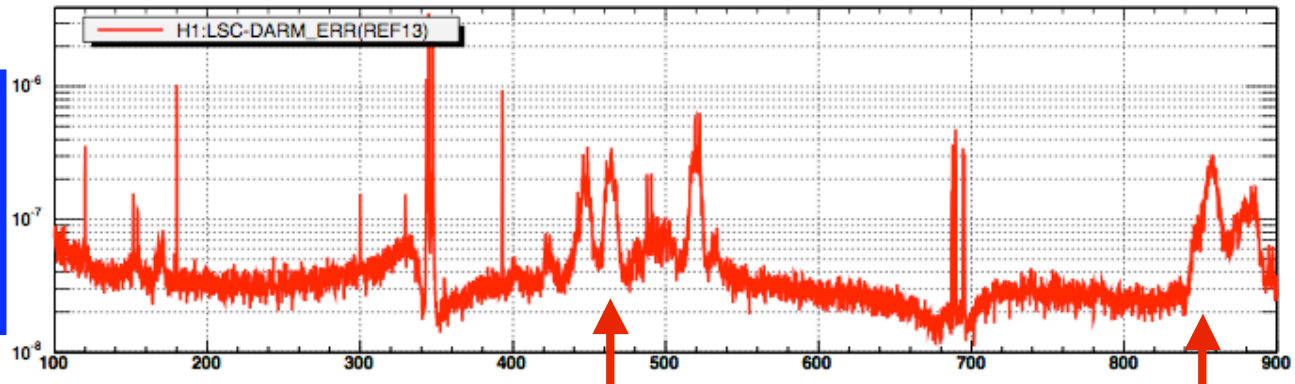


Conclusion: coupling site not OMC

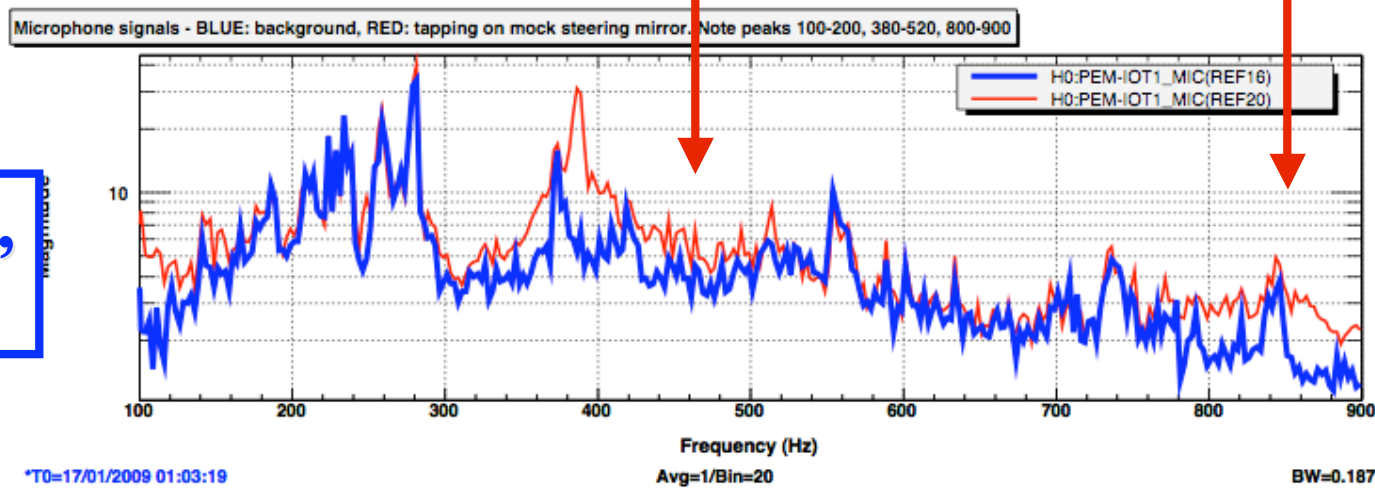
Un-eliminated mirror has resonances in same region - & is only unsuspended HAM6 mirror upstream of OMC

Tap test on mock up of un-eliminated mirror

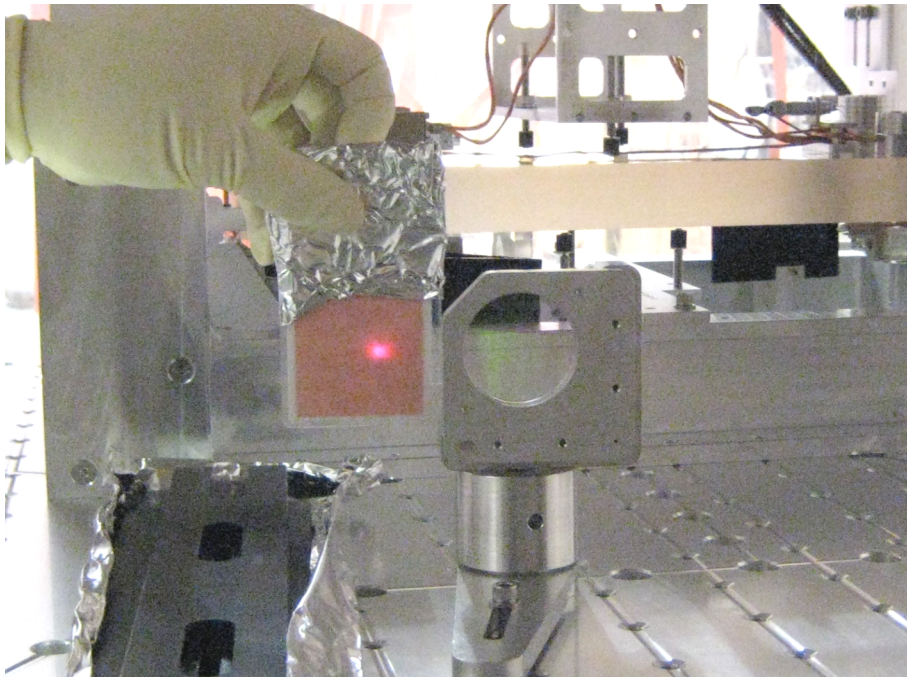
DARM showing peak locations

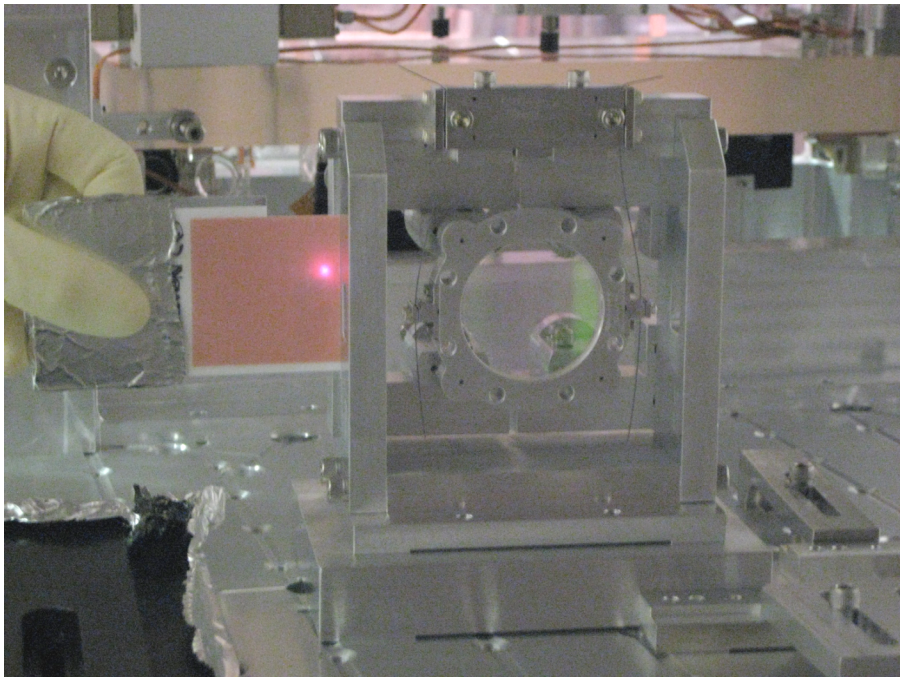


Microphone, RED: tap



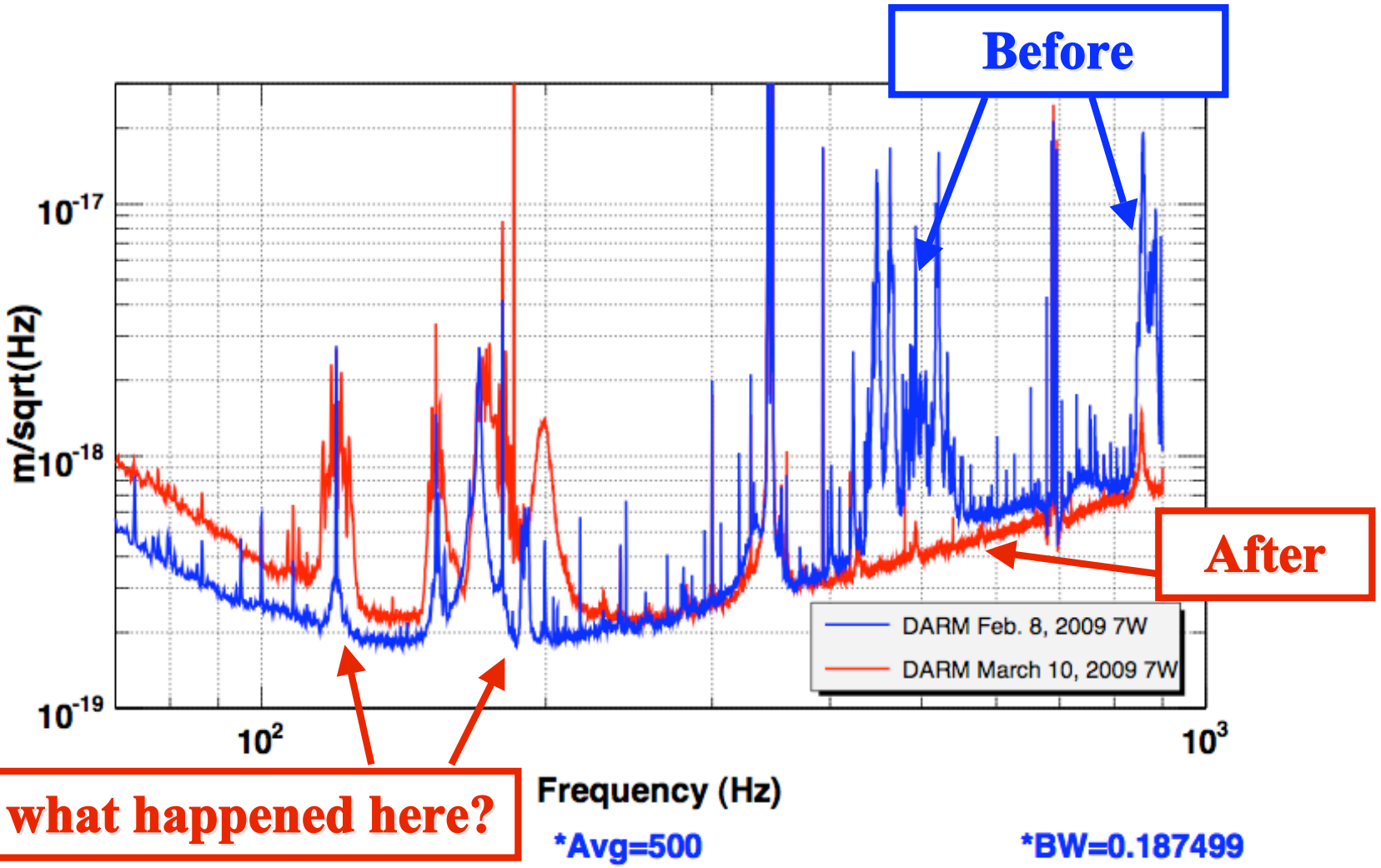
Rigid mount replaced with suspended mount





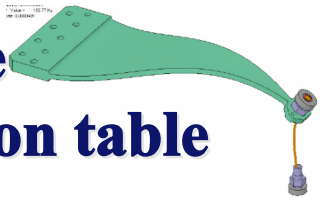
adLIGO tables have only 1 (HAM) or 2 (BSC) stages of isolation in the audio band, while iLIGO had 3 or 4. We will have to avoid rigid mounts and worry more about scattering from tables and cages.

Most peaks gone, LHO & LLO



Study of new/enlarged peaks in bucket

- 3 vibrationally excitable peaks:
  - 153.0 Hz peak from leaf spring resonance
  - 169.2 and 178.2 resonances of structures on table

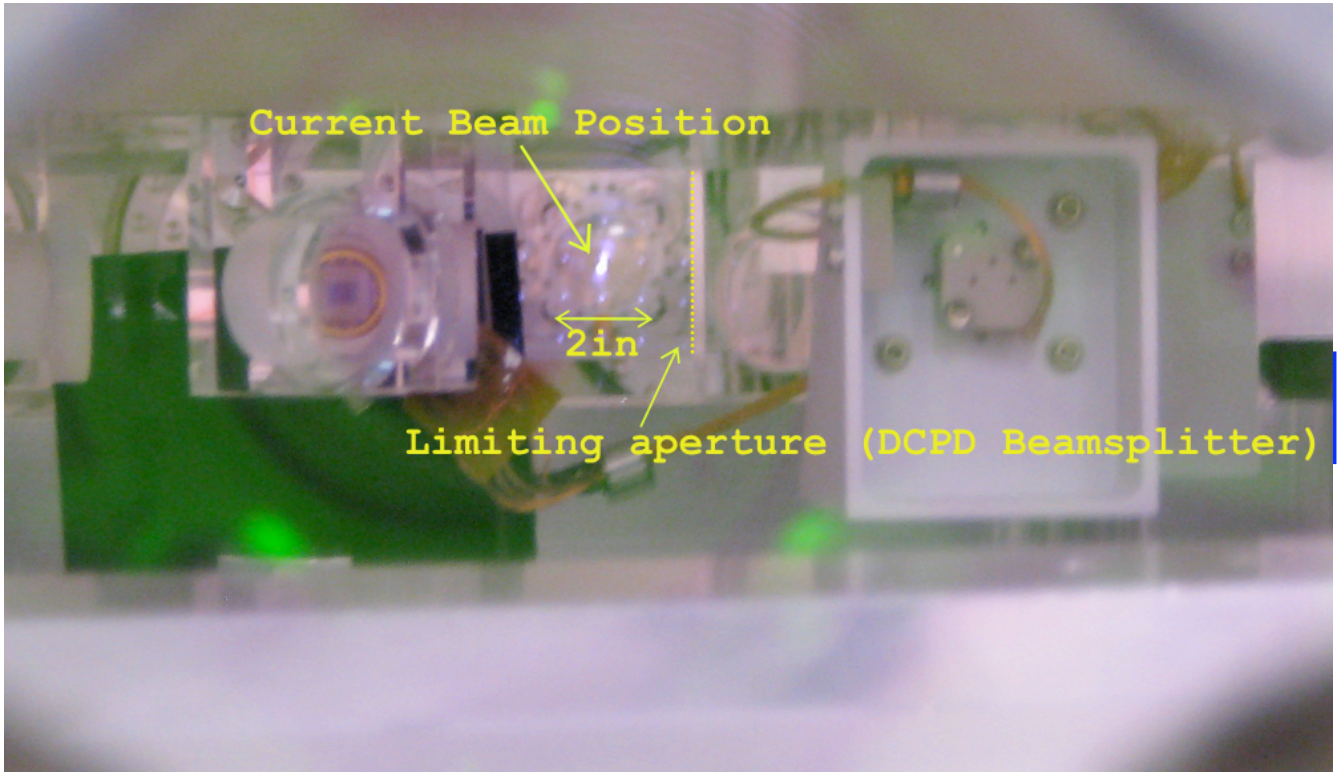


- 3 peaks that arent excited vibrationally (electronics)
  - 120 and 180 : increased 60 Hz harmonics
  - 200 Hz peak
- On quad photodiodes these peaks appear more in pitch/yaw than sum: beam jitter
- Side bands more prominent on all peaks

Clipping is the only single problem that can account for all of these observations

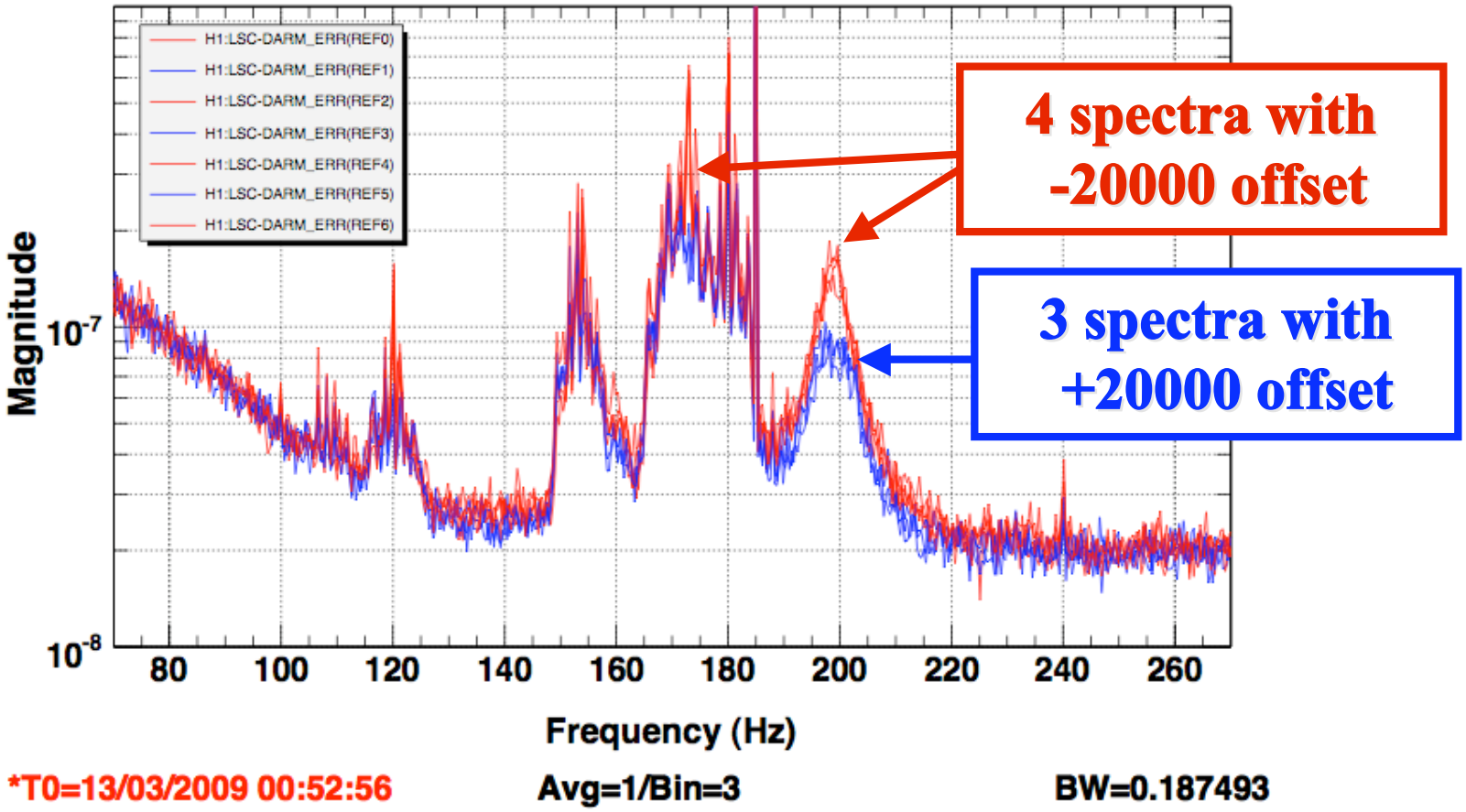
Potential clipping sites?

In an ilog, Nic Smith noted a tight squeeze as the beam traverses the output mode cleaner



Testing clipping hypothesis

Remotely move OMC & putative clipper relative to beam



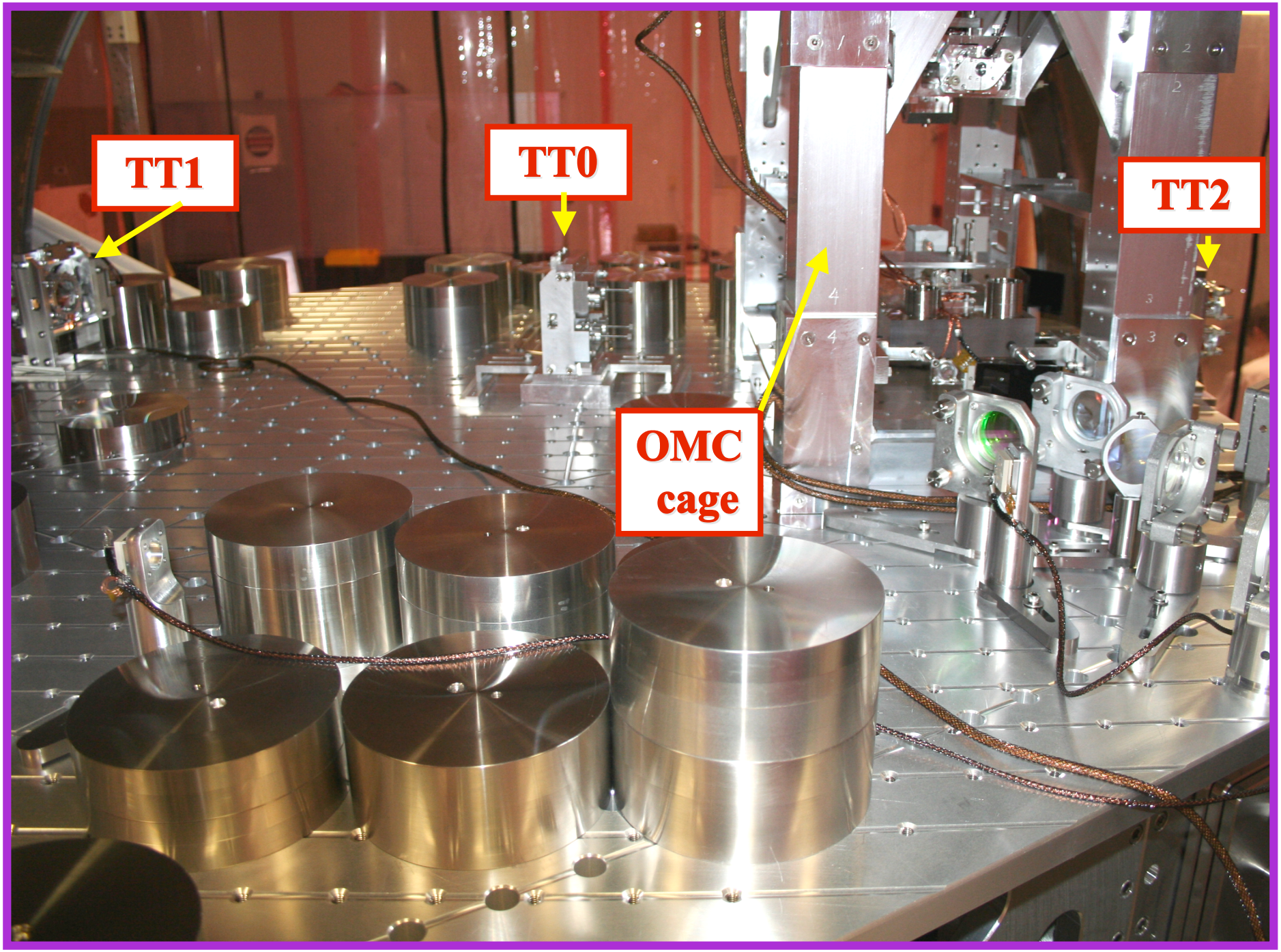
Consistent with clipping!

Solutions?

Move OMC ~1 inch, rotating around beam spot on TT2

Jitter will couple even without clipping, so reduce jitter:

1. **Replacing TT0,1,2 wires with 0.017 mil SOS wires will reduce bounce mode from 350 to 40 Hz providing ~15 vertical isolation for 153, 169.2, 178.2 Hz, and 20% of yield stress. OR redesign with leaf springs.**
2. **Constrained layer damping of TT cages would likely reduce 169.2 178.2 Hz.**
3. **Constrained layer damping of OMC cage would likely reduce 110 Hz (Jeff Kissel).**
4. **Damping of 153 Hz blade resonance may be possible**
5. **Find source of 200 Hz jitter**


TT1
TT0
TT2
OMC
cage

Important new channels for environmental coupling

Substitute L1 for H1 for LLO
Output Mode Cleaner (OMC):
H1:OMC-*
Here are a couple of examples I have used lately
H1:OMC-TT1_SUSYAW_IN1_DAQ tip tilt mirror 1 shadow sensor yaw
H1:OMC-QPD1_P_OUT_DAQ quad photo diode pitch signal

Vibration sensors, etc. on the new HAM6 table:
H1:ISI-OMC_*
Here are the vibration sensors I have been using lately:
H1:ISI-OMC_GEOPF_H1_IN1_DAQ horizontal geophone 1 (also H2 and H3)
H1:ISI-OMC_GEOPF_V1_IN1_DAQ vertical geophone 1 (also 2 and 3)
H1:ISI-OMC_DISPPF_V1_IN1_DAQ vertical displacement sensor 1 (also 2 and 3)
H1:ISI-OMC_DISPPF_H1_IN1_DAQ horizontal displacement sensor 1 (also 2 and 3)

Planned environmental sensors outside HAM6:
H0:PEM-HAM6_ACCX and Y and Z
H0:PEM-HAM6_MIC

These two new TCS channels are particularly important for environmental coupling:
H1:TCS-ITMX_PD_ISS_OUT_AC
H1:TCS-ITMY_PD_ISS_OUT_AC