

ACOUSTIC MITIGATION *STATUS FOR S3*



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Doug Cook, Akiteru Takamori, Daniel Sigg, LHO

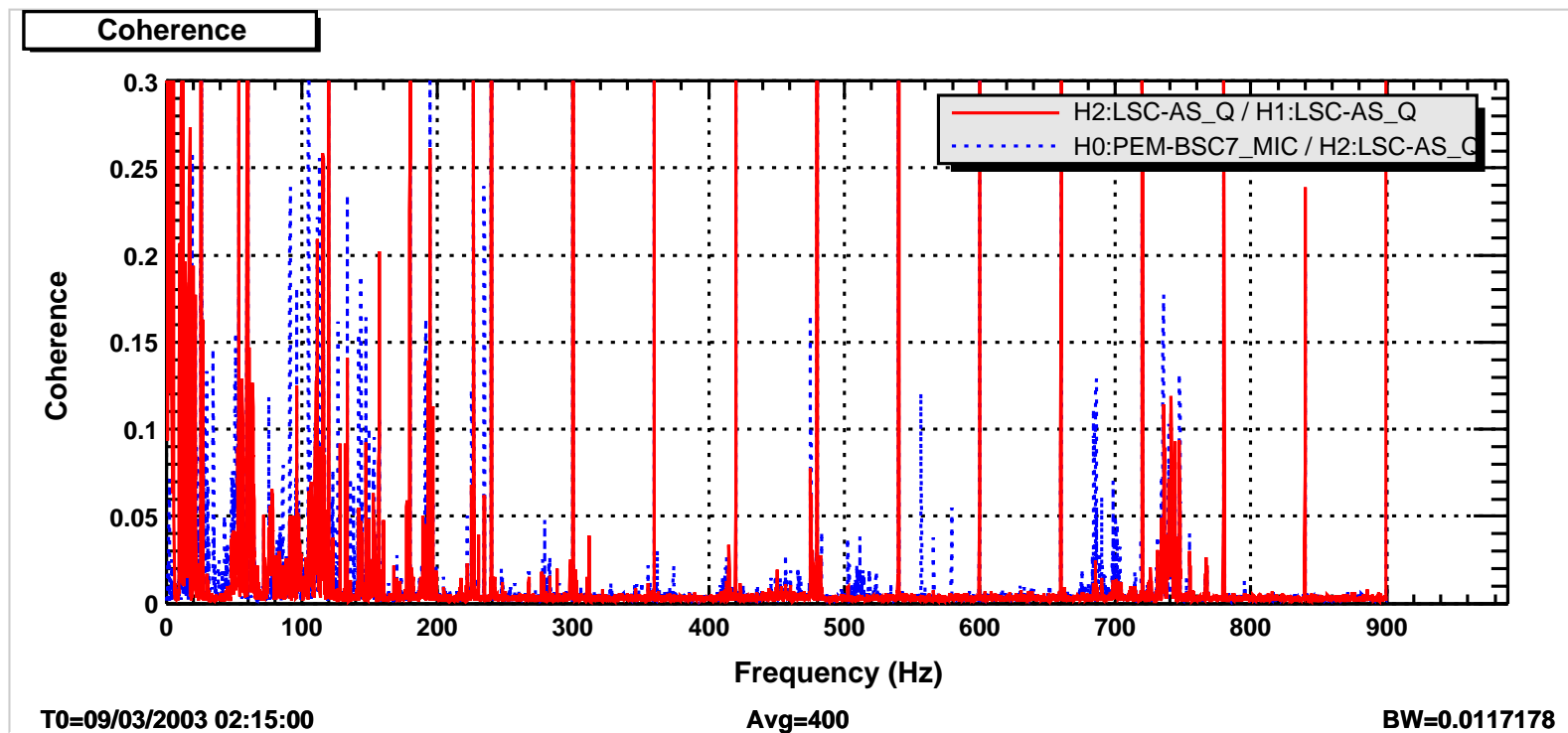
Jonathan Kern, Joe Kovalik, LLO

Peter Fritschel, Ken Mason, MIT

AND MANY OTHERS

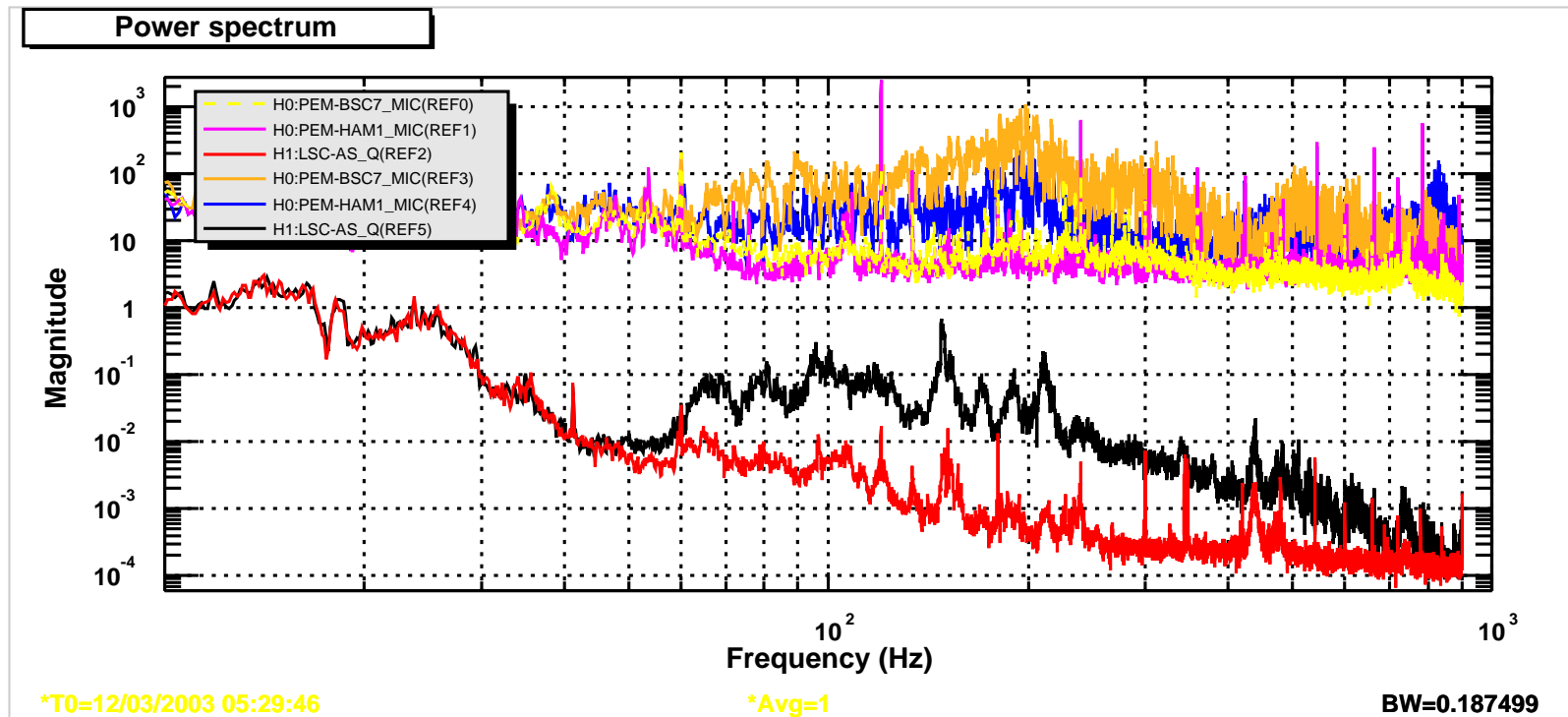
PROBLEM

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

At some frequencies, the sensitivities of all 3 interferometers were limited by acoustic coupling during S2.



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

We would like to reduce acoustic-seismic contribution to noise by **100 to 1000**

S2 INVESTIGATION OF ACOUSTIC COUPLING

COUPLING SITES confirmed using propagation delays; if a sound shows up on AS_Q before it shows up on a certain mic, there is a coupling site between the sound source and the microphone.

Localized injections showed that the coupling was at least 10x worse at the dark port tables than at other coupling sites.

MAIN COUPLING MECHANISM was shown to be clipping modulated by acoustic excitation; experiments included manipulation of clipping with irises and experiments to assess back-scattering.

ACOUSTIC SOURCES: HVAC below 100 Hz, electronics cabinets above 100 Hz, and transients (e.g. building relaxation creaks), about as loud as continuous sources.

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PROPAGATION FROM SOURCE TO COUPLING SITE; investigations with LLO PSL enclosure showed that acoustic isolation reduced motions on tables, indicating that propagation was mainly through the air.

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MITIGATION PLANS (red indicates completed)

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)

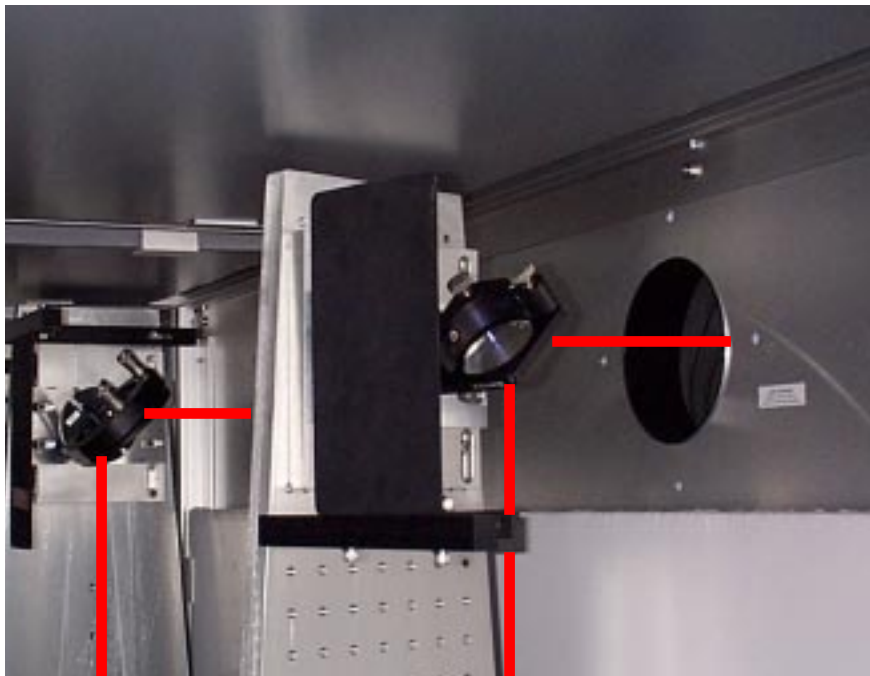
- A. Remove most electronics cabinets from LVEA
- B. Absorption and damping kits for vacuum electronics cabinets
- C. Damp single walled sections of ducts
- D. Insulate pipe feed through from mechanical room
- E. Insulate PSL chillers

OPTICS UPGRADE SINCE S2 TO REDUCE MODULATED CLIPPING

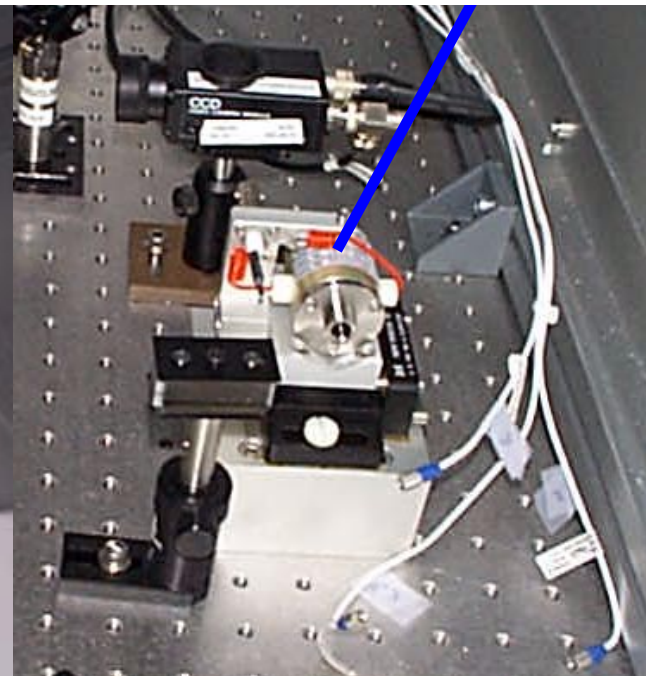
Dark and reflected ports on all three interferometers

- 1) Removed EO shutters and associated polarizers
- 2) Replaced several 1" optics with 2" optics
- 3) Replaced heavy optics mounts with light mounts
- 4) Simplified beam path

Old Mount



New Mount



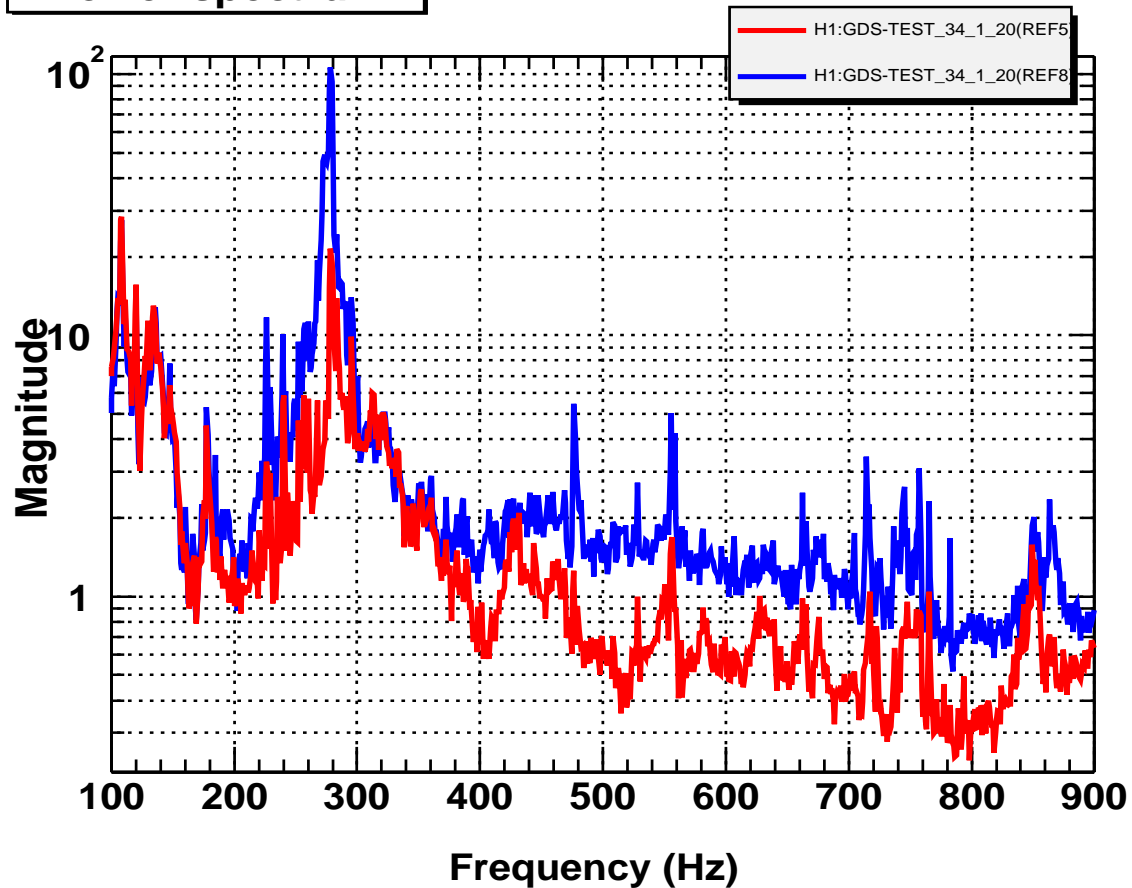
EO shutter removed

NEW PERISCOPE DESIGN WITH DAMPING

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

Damping

Power spectrum



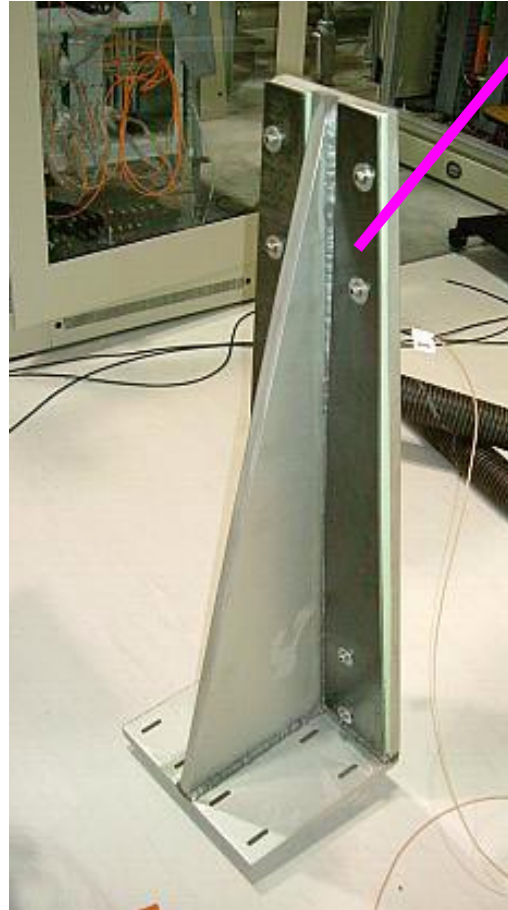
*T0=01/08/2003 02:31:40 Avg=1/Bin=8

BW=0.187499



AT MOST LOCATIONS WE ARE CURRENTLY USING OLD PERISCOPES WITH DAMPING

Steel plate and damping foam attached to back of periscope



Latest version of new periscope design should be compared to this modified periscope

TABLE LEG TESTING

Compared 5 leg designs using the following figures of merit:

- 1) lower rms amplitude of table motion above 70 Hz (to reduce in-band modulation of clipping)
- 2) lower rms velocity (to reduce potential back-scattering noise - this is less important because we did not find back-scattering noise [next slide], and table motion amplitudes are less than 1/10 laser wavelength).

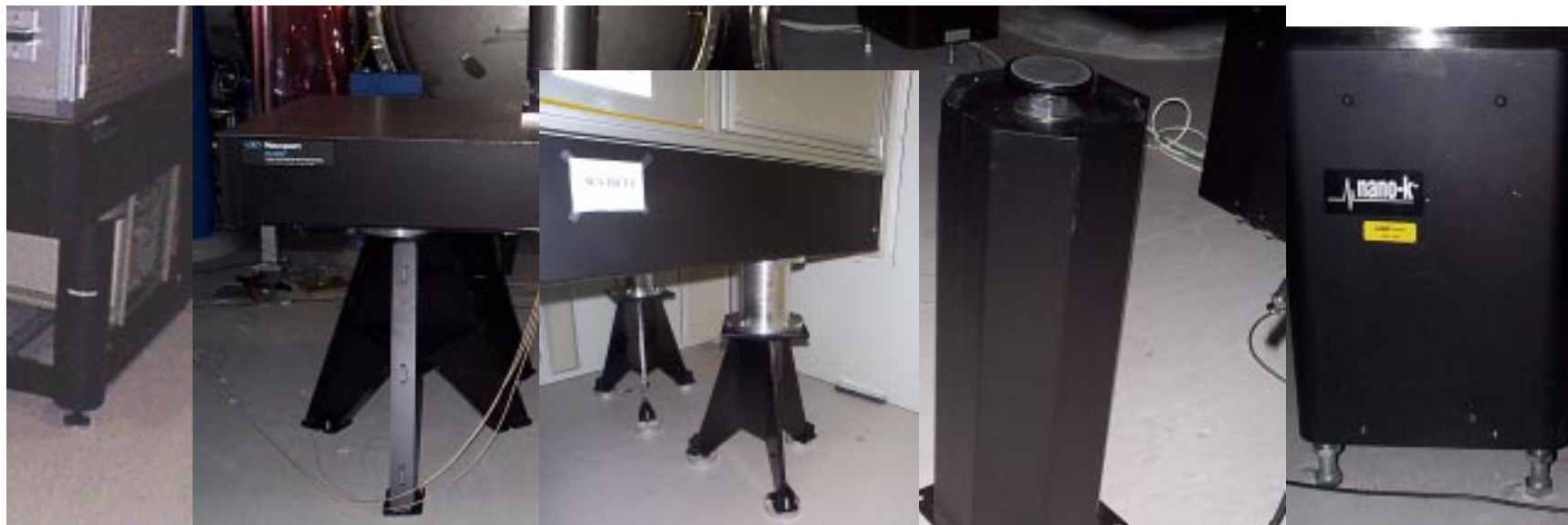
current

tall tripod

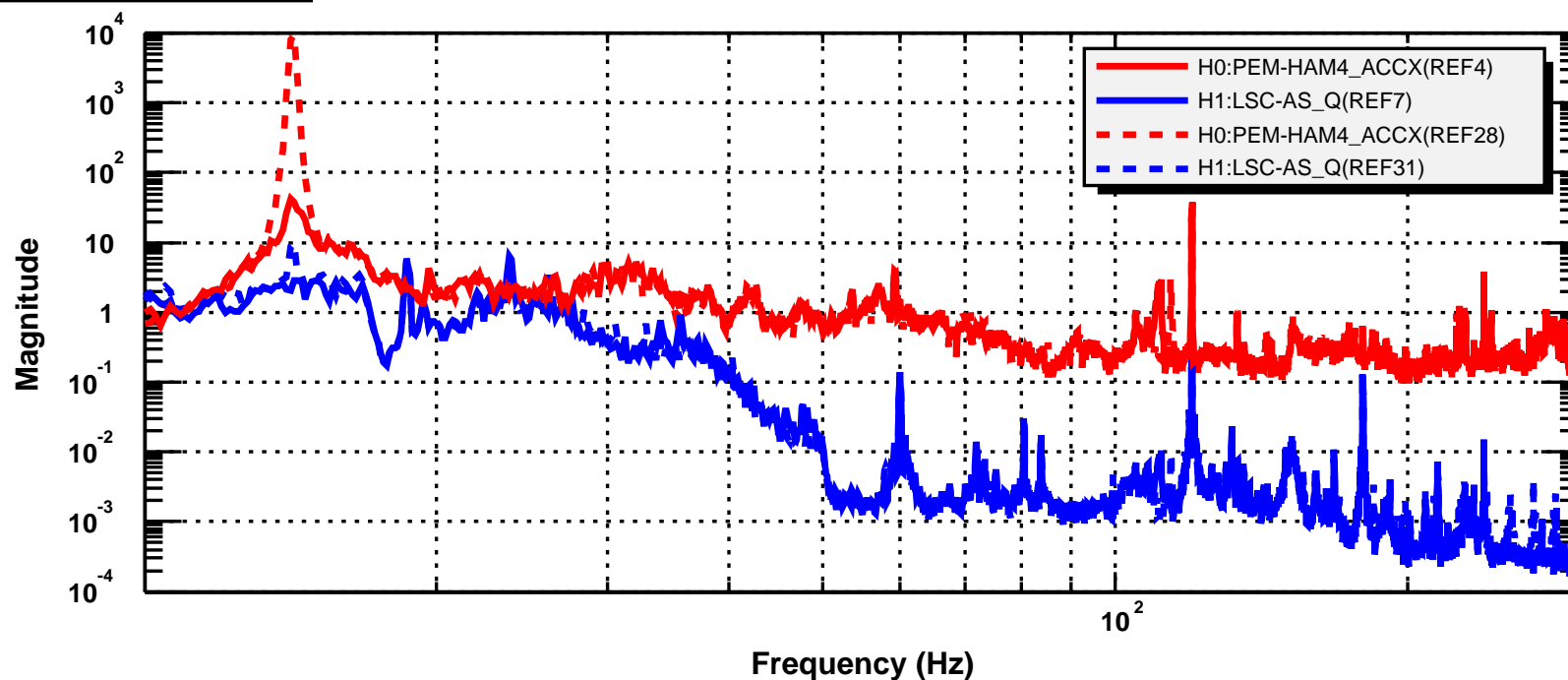
small tripod (damped)

pneumatic

minus-k (spring)



No Evidence for Parasitic Interferometry Noise From Backscattering



*T0=21/05/2003 08:11:03

Avg=1

BW=0.187499

Red: Accelerometer on Dark Port Table

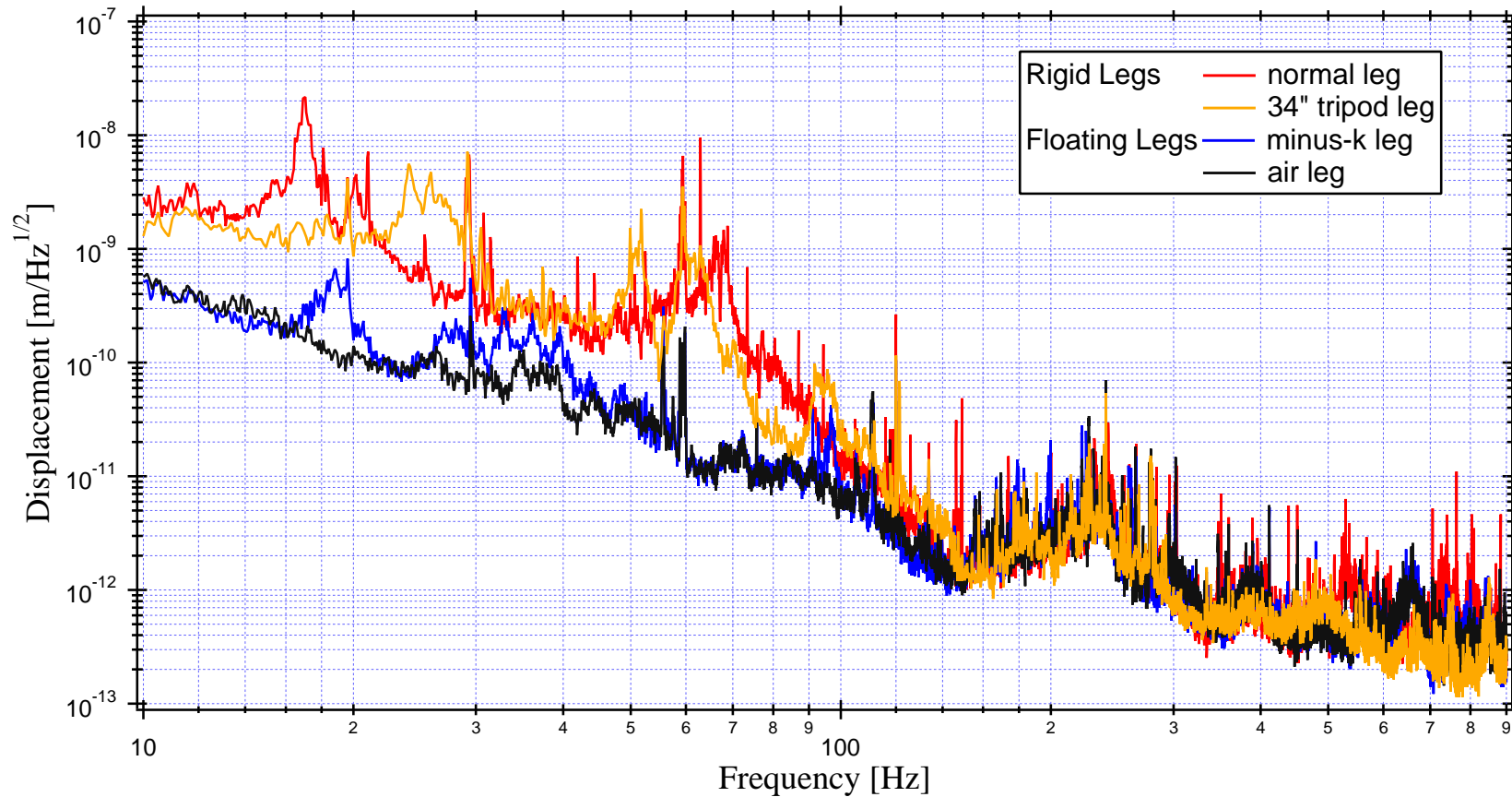
Blue: AS_Q

Solid: Normal;

Dashed: Shaker shaking table at 14 Hz (sway resonance)

COMPARISON OF RIGID AND FLOATING TABLE LEGS ON ISCT3

Red: current leg; Orange: tall tripod; Blue: minus-k; Black: pneumatic



Sum in quadrature of 3 accelerometer axes, converted to displacement

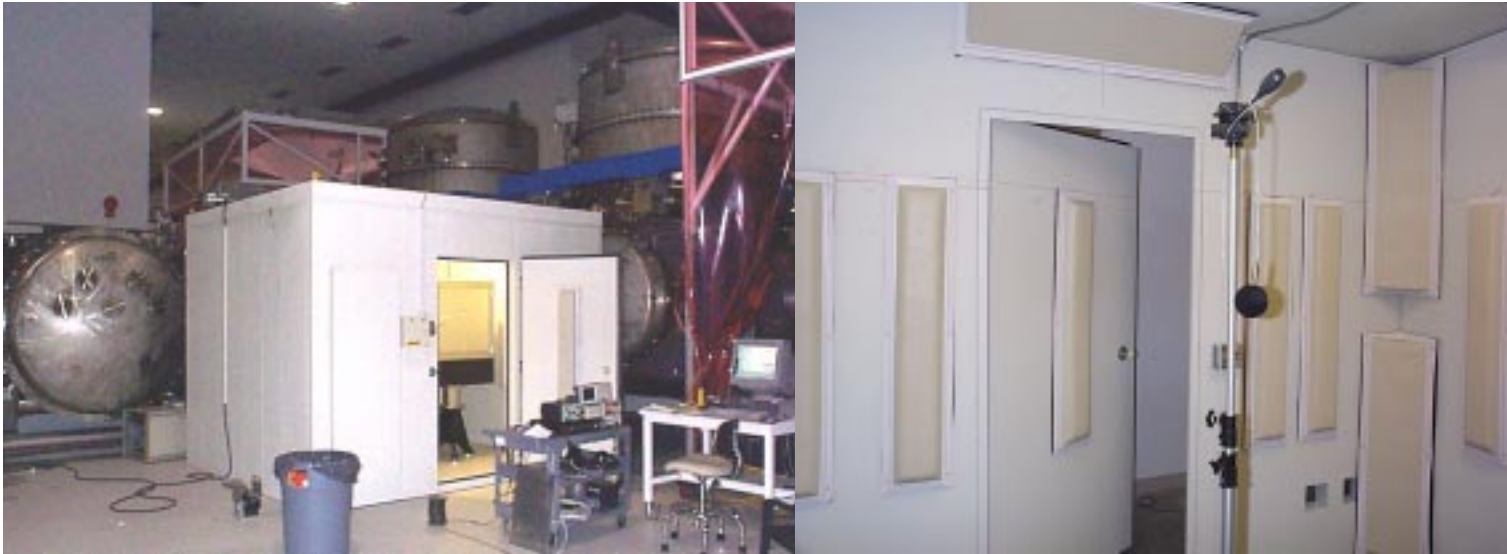
TABLE LEG CONCLUSIONS

1) The rigid tripod legs have not proven to be substantially better than our current legs, either for rms velocity or rms amplitude above 70 Hz. However, we have not yet tried bonding the tripod legs to the floor.

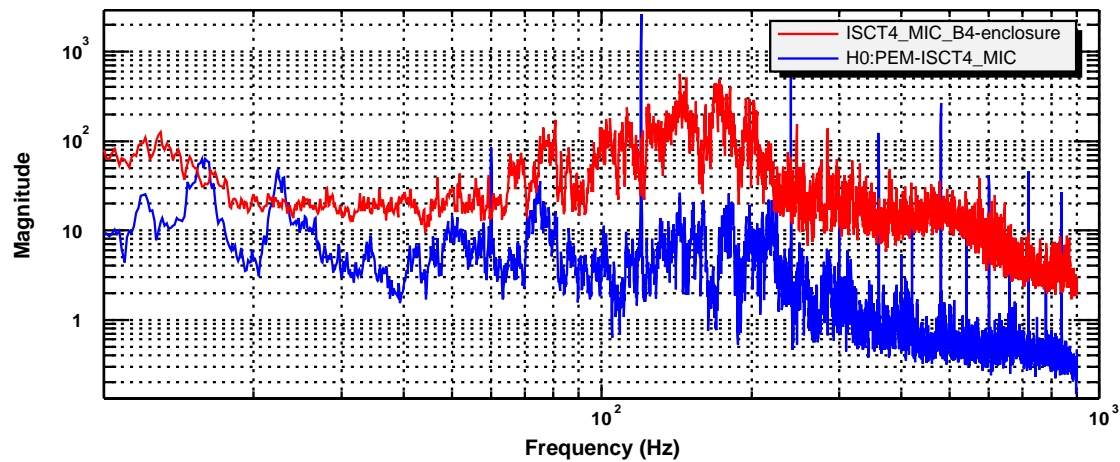
2) The two sets of legs that float the table (pneumatic, minus-k spring) were comparable (pneumatic, slightly better) and resulted in a factor of about ten lower rms velocity and nearly a factor of ten lower rms amplitude above 70 Hz.

We are installing the minus-k legs at ISCT3 to study drift of floating tables.

DARK PORT ENCLOSURES WITH ABSORPTION KITS



Installed ISCT4 enclosure is giving a factor of about 20 above 100 Hz; red: before; blue: after



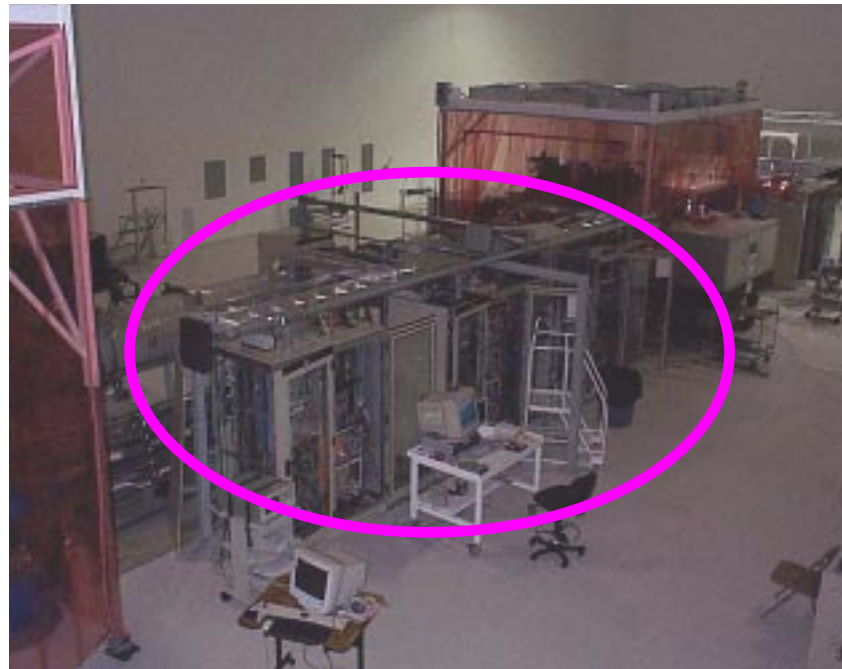
MITIGATION OF CONTINUOUS SOURCES:

Damped visibly vibrating sections of single walled ducts at LHO.



Completed just before S3, so havent had a chance to test completely, but looks like, at most, a factor of 2 reduction in LVEA levels around 100 Hz.

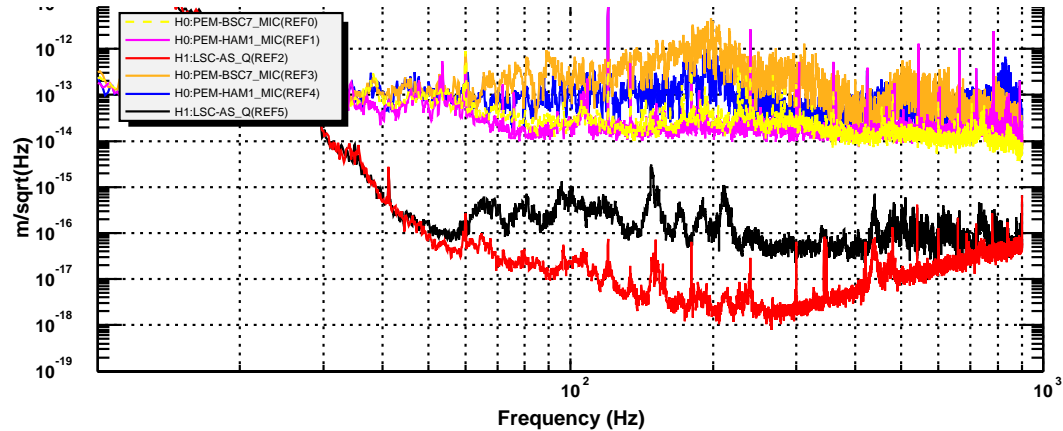
Plan to remove 4k electronics cabinets from LVEA, place 2k cabinets in acoustic enclosures, internal absorption for vacuum cabinets and PSL chiller enclosures.



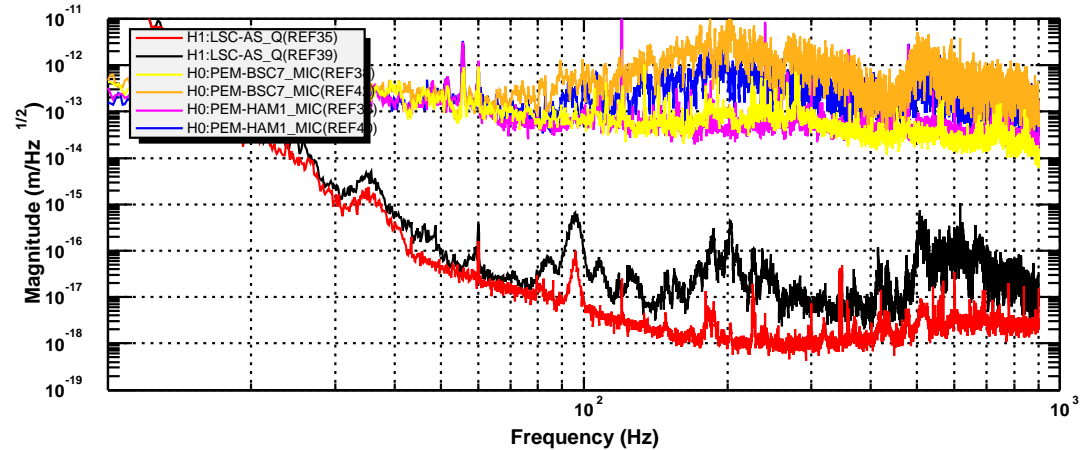
REDUCTION IN ACOUSTIC COUPLING SINCE S2

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

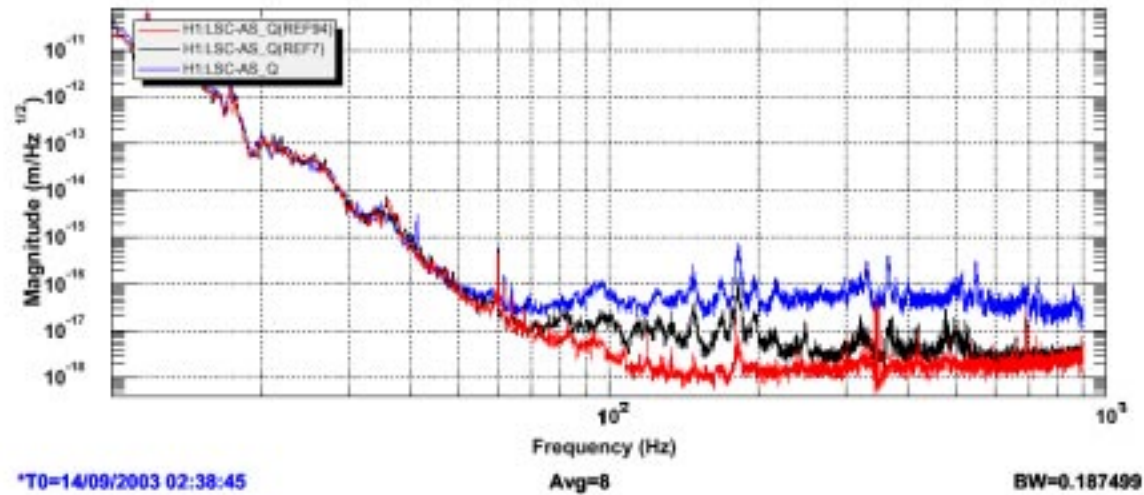
March 12: S2



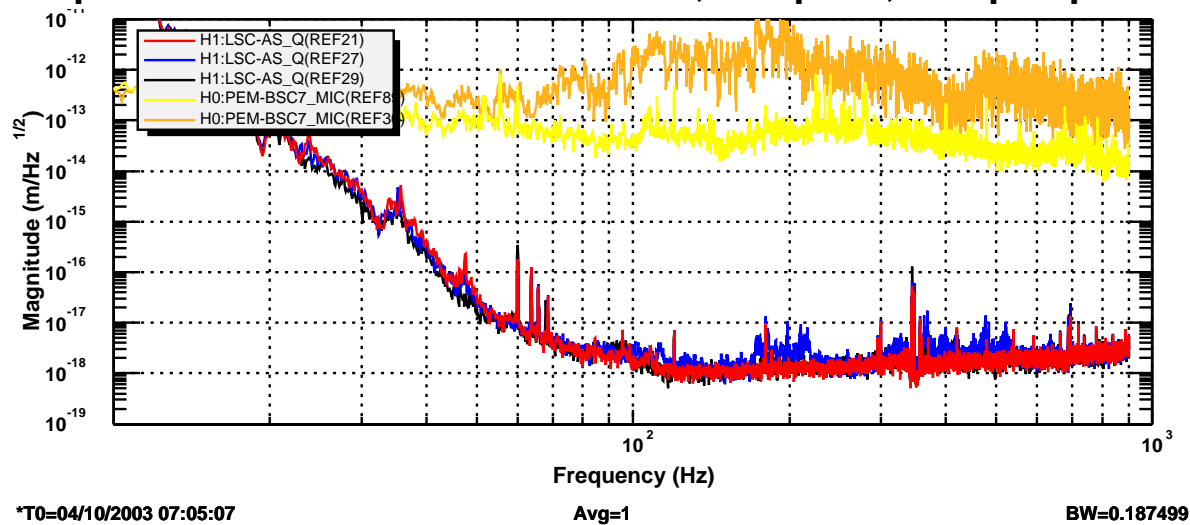
August 9: EO shutter out, periscope mount replaced



Sept 13: after enclosure, 2 inch optics; **Blue: injection at REFL port (now limiting)**



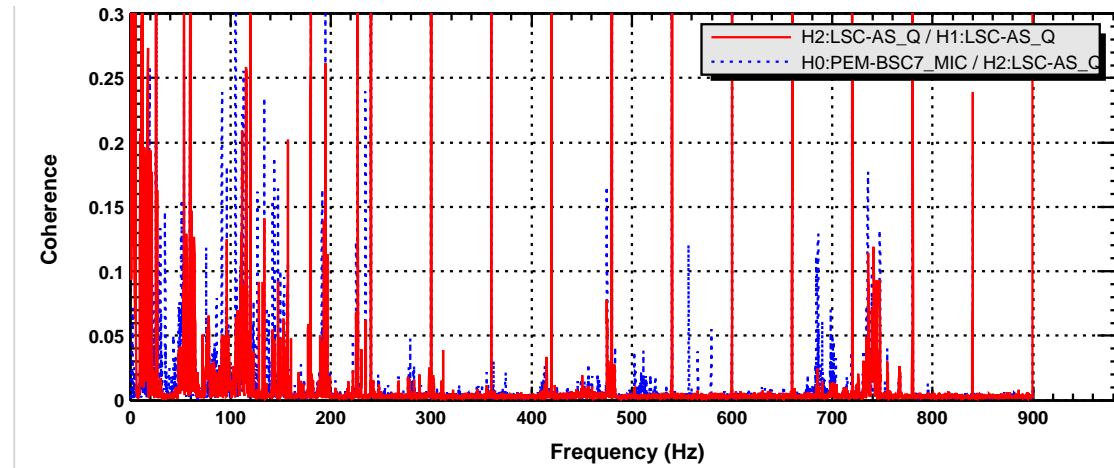
Oct 4: after REFL port work - removal of EO shutter, 2" optics, damped periscope



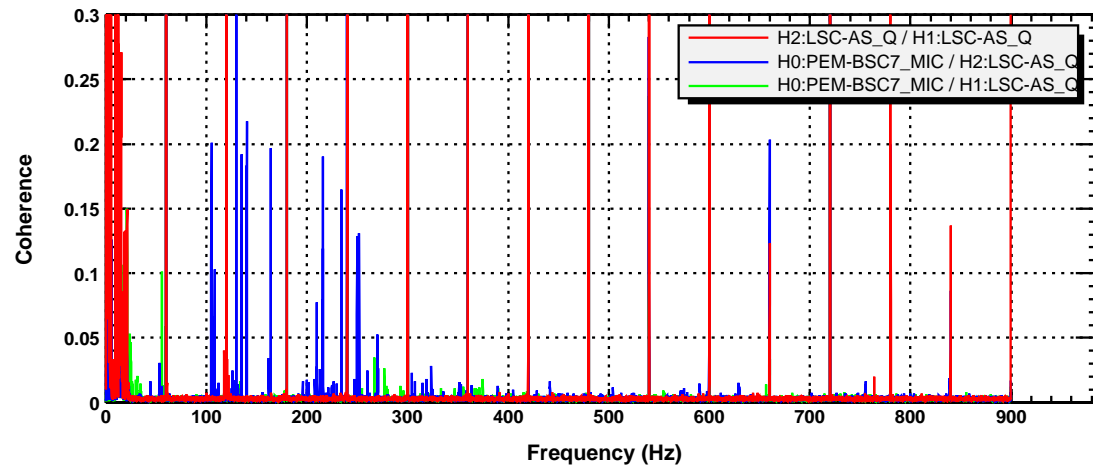
Red shows coherence between H1 and H2 AS_Q over about 12h

Blue shows coherence between microphone near 4k dark port and 2k AS_Q

S2:



S3:



T0=08/11/2003 06:30:00

Avg=400/Bin=11

BW=0.0117178

PEM UPGRADE IS PUTTING MICROPHONES AND ACCELEROMETERS ON ALL TABLES

Microphone on ISCT1, (the worst 4k coupling site) indicates that we have to increase the ambient sound level by a factor of about 100 to produce acoustic peaks reaching 10^{-17} m/sqrt(Hz), suggesting that ambient levels will produce peaks reaching 10^{-19} m/sqrt(Hz).

CONCLUSIONS:

- 1) WE HAVE REDUCED H1 ACOUSTIC COUPLING BY A FACTOR OF OVER 100 SINCE S2***
- 2) AMBIENT SOUND LEVELS ON H1 NOW LIMITING AT ABOUT 10^{-19} m/sqrt(Hz) AT 200 Hz***
- 3) A LITTLE LESS THAN A FACTOR OF TEN TO GO TO REACH DESIRED INSENSITIVITY***
- 4) FURTHER IMPROVEMENTS WILL NOT BE VISIBLE IN TYPICAL SPECTRA***
- 5) MAKING SURE THESE BENEFITS ARE FULLY EXTENDED TO H2 AND L1***