
The LIGO E2 Investigation of Non-Stationary Noise

Robert Schofield, Oregon
Peter Saulson, Syracuse
Ed Daw, LLO & LSU

LIGO-G010159-00-Z

Procedure

- 1) Employed band-limited rms trend feature of J. Zweizig's pslMon
- 2) Monitored 34 channels in 10, 11 or 12 bands: 375 trends
- 3) Printed 10 trends per page
- 4) Identified interesting non-stationary features by eye
- 5) Examined current trends to see if behavior was still present and interesting
- 6) Used D. Sigg's DTT in exponential decay mode to watch time evolution at higher spectral resolution



Channels and Frequency Bands

H0:PEM-BSC1_MAG1X	H2:IOO-MC_F
H0:PEM-BSC5_ACCX	H2:LSC-CARM_CTRL
H0:PEM-BSC5_MIC	H2:LSC-DARM_CTRL
H0:PEM-BSC6_ACCY	H2:LSC-MICH_CTRL
H0:PEM-BSC6_MIC	H2:LSC-PRC_CTRL
H0:PEM-BSC7_ACCX	H2:PSL-FSS_FAST_F
H0:PEM-BSC8_ACCY	H2:SUS-BS_SENSOR_LR
H0:PEM-BSC8_MIC	H2:SUS-ETMY_SENSOR_LR
H0:PEM-LVEA_TILTX	H2:SUS-FM1_SENSOR_LR
H0:PEM-MX_SEISX	H2:SUS-FM2_SENSOR_LR
H0:PEM-MX_TILTX	H2:SUS-ITMX_SENSOR_LR
H0:PEM-MY_SEISY	H2:SUS-ITMY_SENSOR_LR
H0:PEM-MY_TILTY	H2:SUS-MC1_SENSOR_LR
H0:PEM-PSL2_ACCX	H2:SUS-MMT1_SENSOR_LR
H0:PEM-PSL2_ACCZ	
H0:PEM-PSL2_MIC	
H2:ASC-QPDX_DC	
H2:ASC-QPDY_DC	

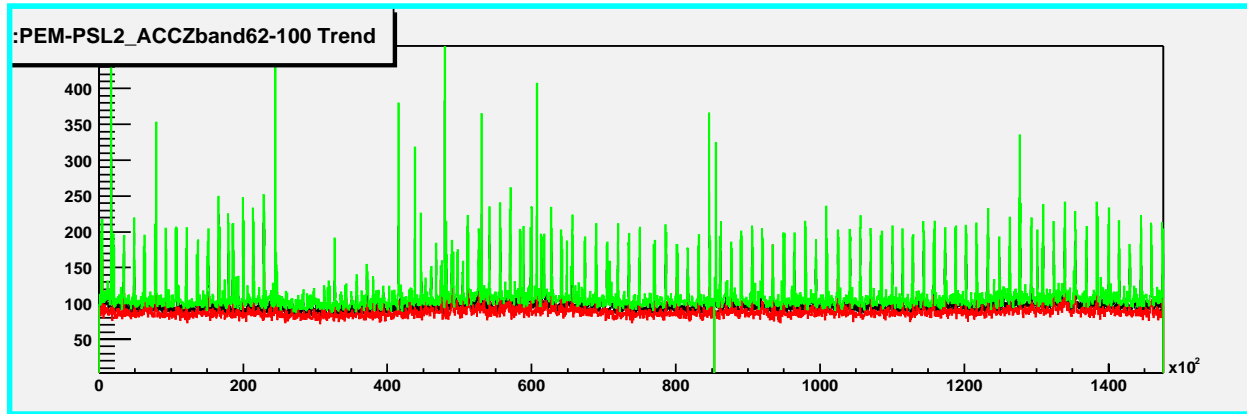
Frequency Bands for 16k channels:

1-12
12-16
16-28
28-33
33-40
40-56
56-60
60-62
62-100
100-400
400-900
400-7400

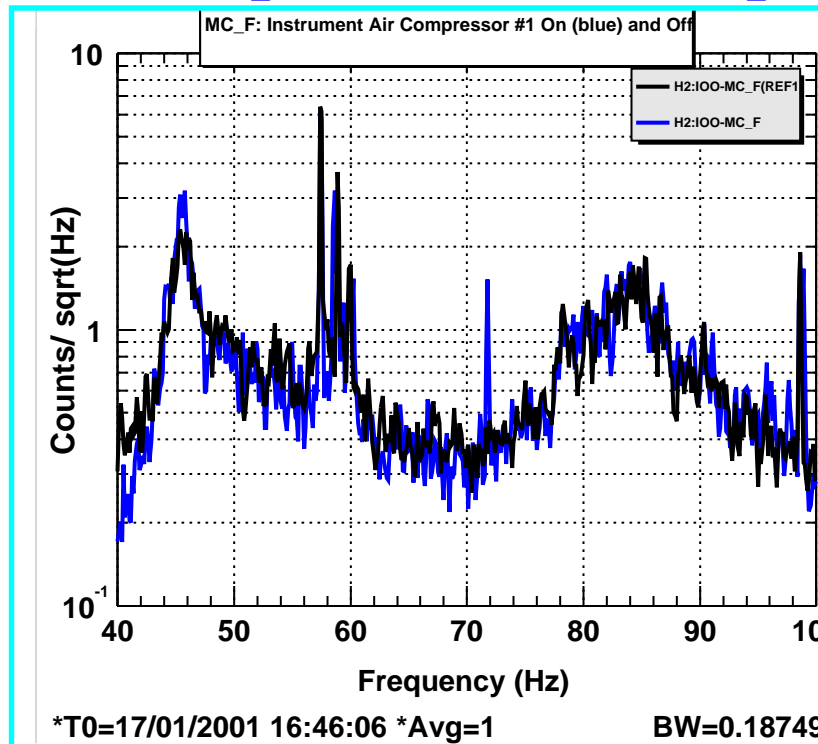
Total: 375 trends

Intermittent Frequency Noise from the Chiller-Pad Air Compressor (72 & 55 Hz)

42 Hour accelerometer trend (62 to 100 Hz):



Signal is not visible in MC_F trend but is visible in MC_F spectrum:



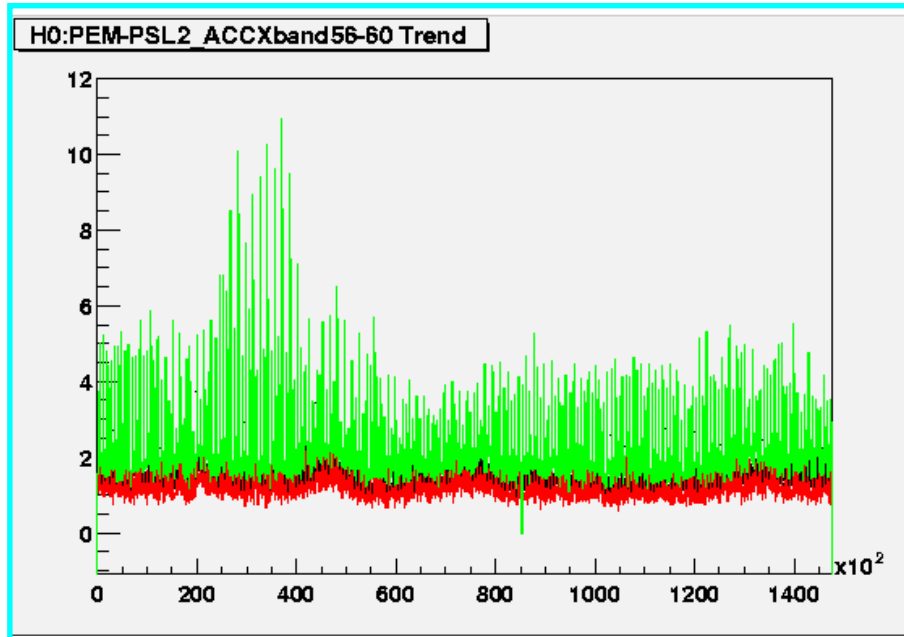
55 Hz not shown

Chiller-Pad Air Compressors



57-60 Hz: 12 Water-Chiller Compressors

42 hour accelerometer trend (56 to 60 Hz):

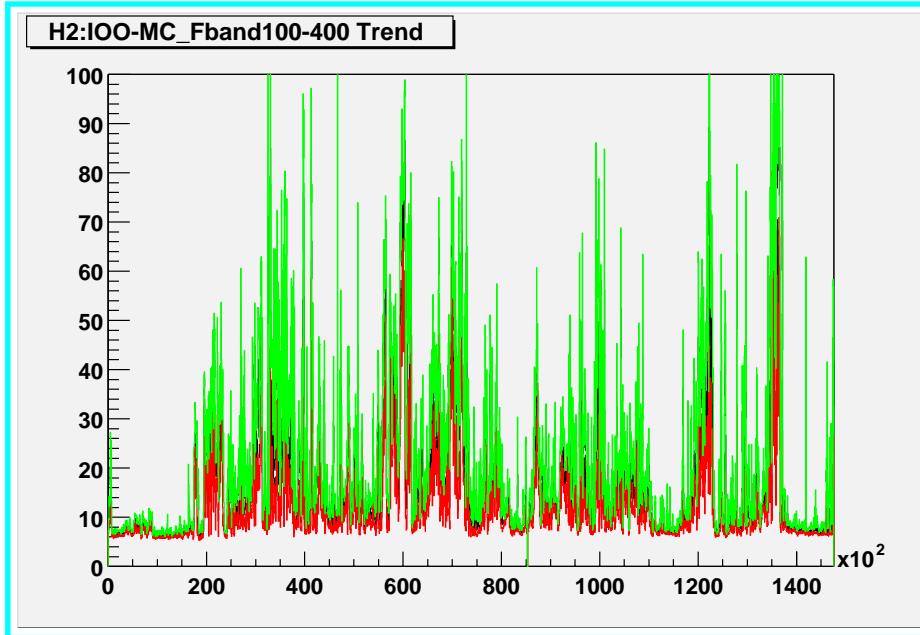


6 of the 12 compressors (only 2 were running this day):

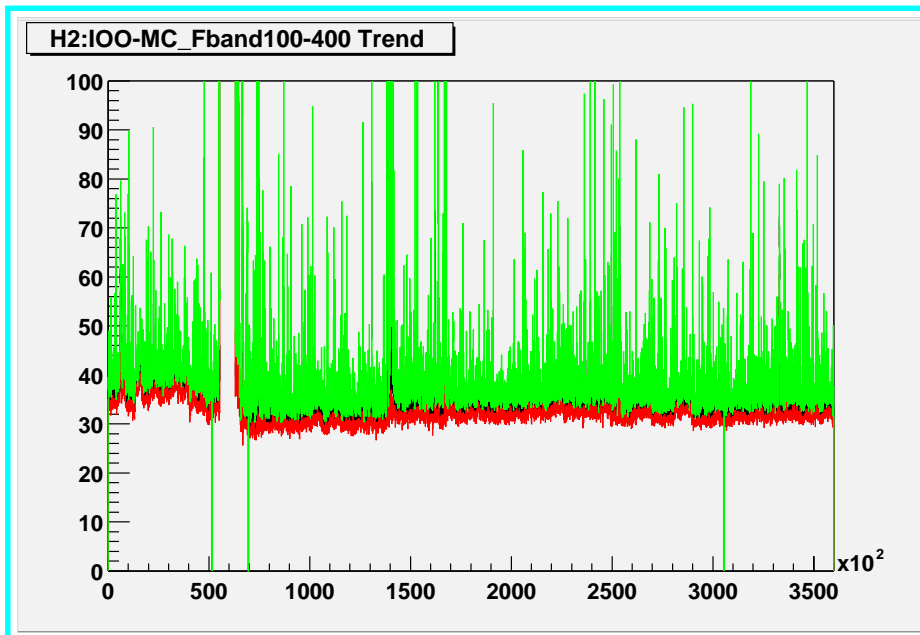


MC-F 100-400 Hz During and After E2

During:

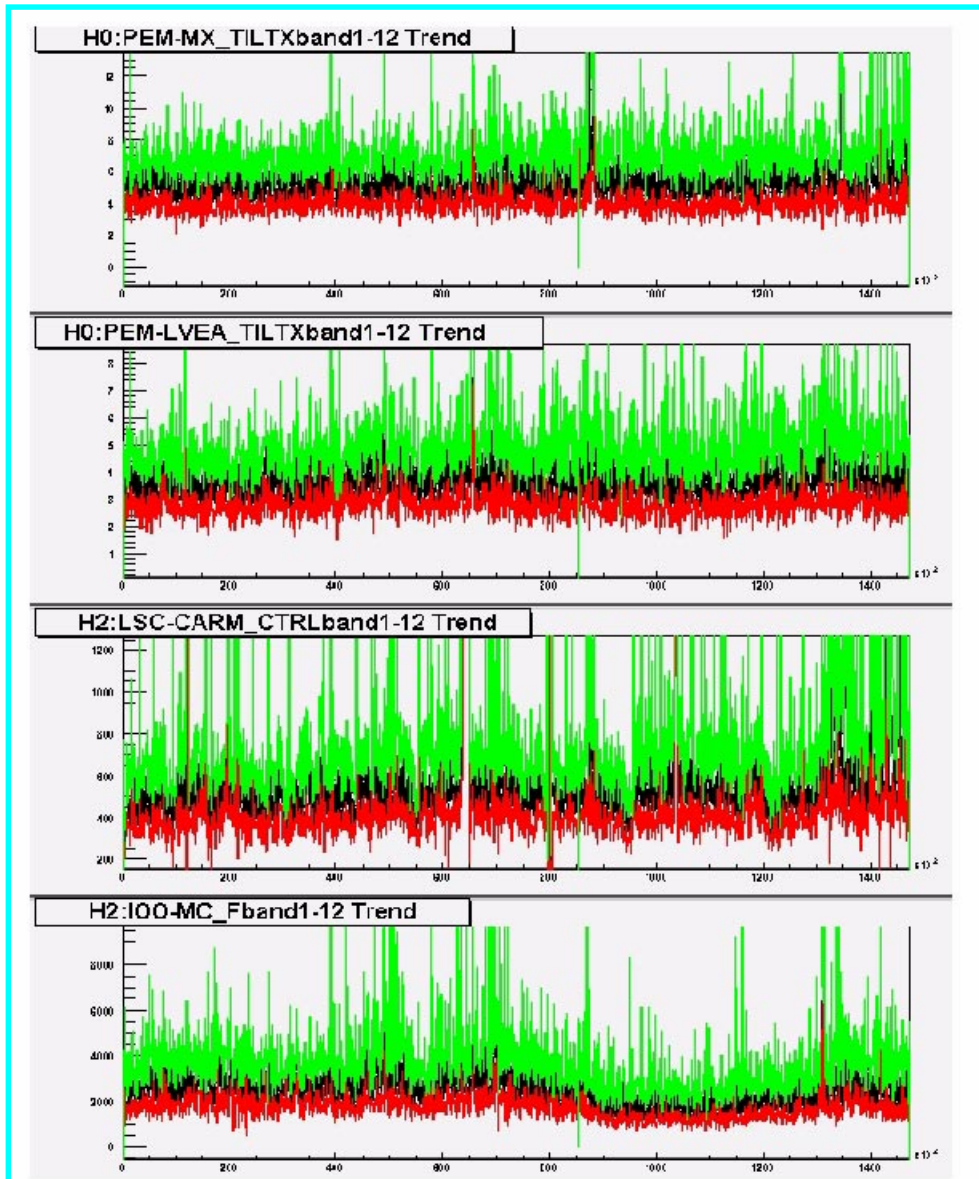


After:



People at Mid-X Seem to Increase Low Frequency Noise in Arm-Control Signal

Visit evident in control signal for arm but not for mode cleaner:



About 42 Hours Shown, visit to Mid-X is at about 875×10^2 seconds

Doubling the RMS of the Gravitational Wave Channel

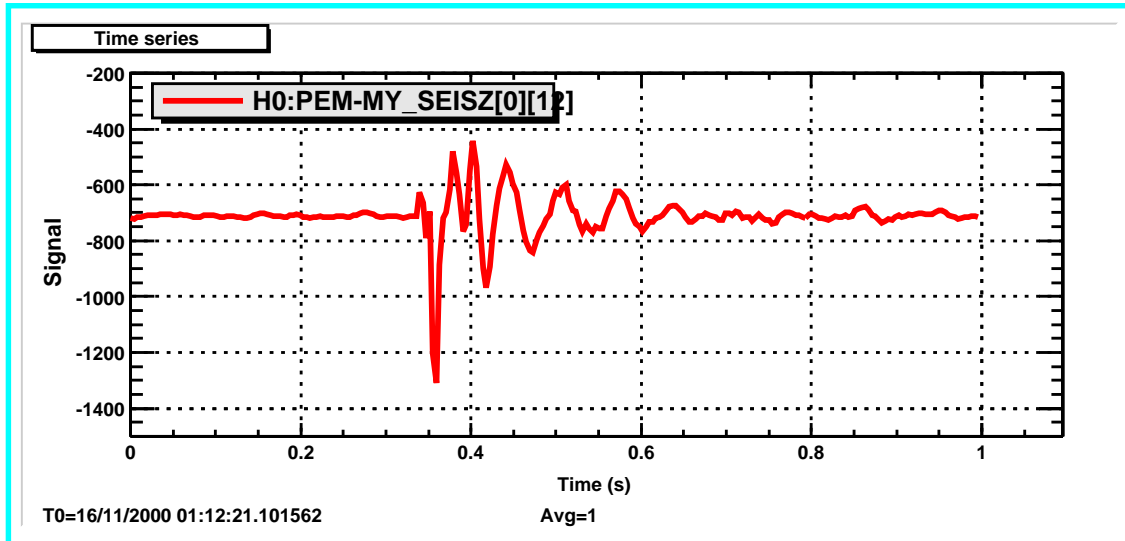
- Stomped hard in hall outside control room
- Jumped in changing room
- Stomped hard on access road outside Mid-Y station
- Drove site truck across “Otto’s bump” at 20 MPH

“Otto’s bump”:

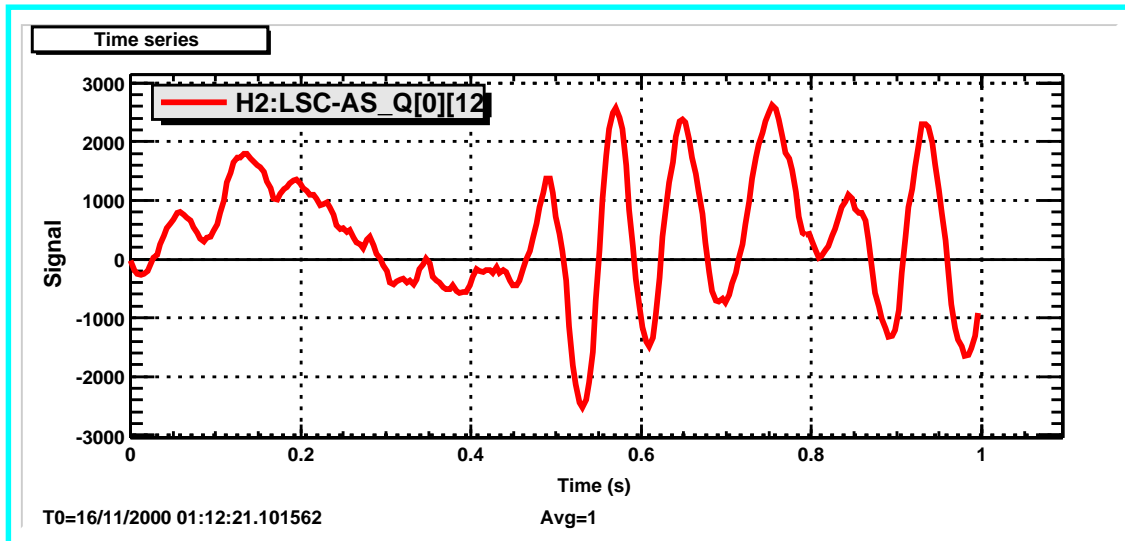


A Stomp at Mid-Y

Seismic channel:



Gravitational wave channel:

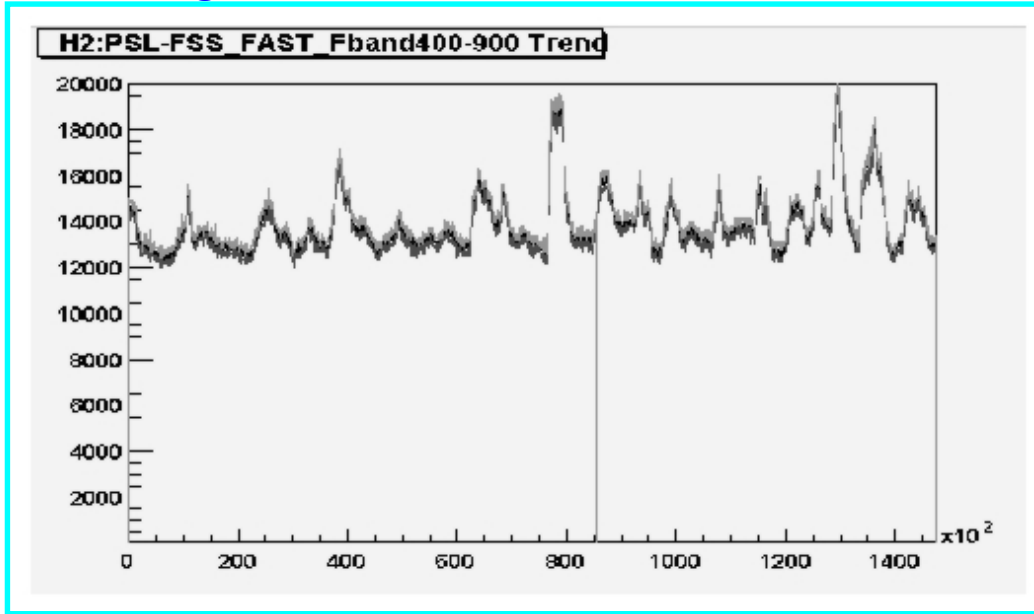


Consistent with the BSC 10.3 Hz vertical mode.

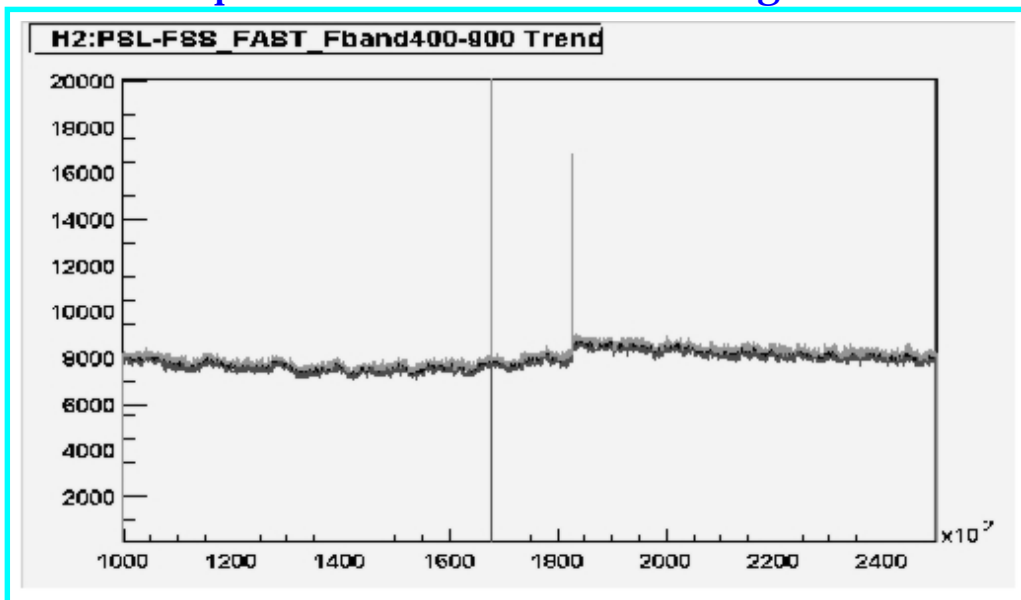
No evidence of stomp in G.W. channel above 20 Hz.

Non-Stationary Frequency Noise in the Pre-Stablized Laser

42 hours during E2:

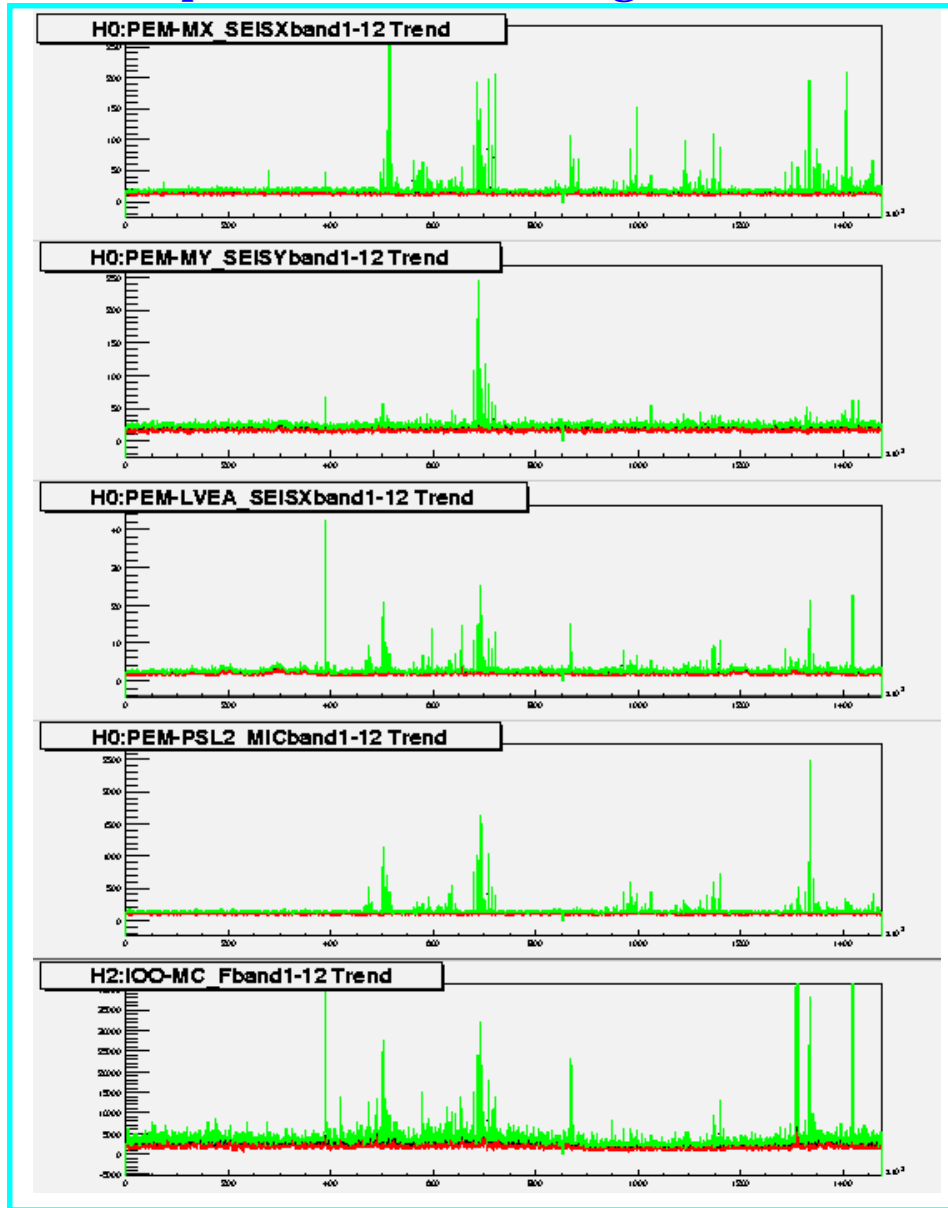


After R. Savage cut flow of PA cooling water to MO, optimized pump diode temperatures and MO to PA alignment:



Possible Tank Fire at Y.F.C.

Seismic, microphone and MC_F signals:



About 42 hours of data shown, tank signal prominent at 500×10^2 and 700×10^2 seconds

Between-station time delays suggest acoustic propagation from Y.F.C.

Yakima Firing Center

Tank area just over ridge beyond tip of lightning rod

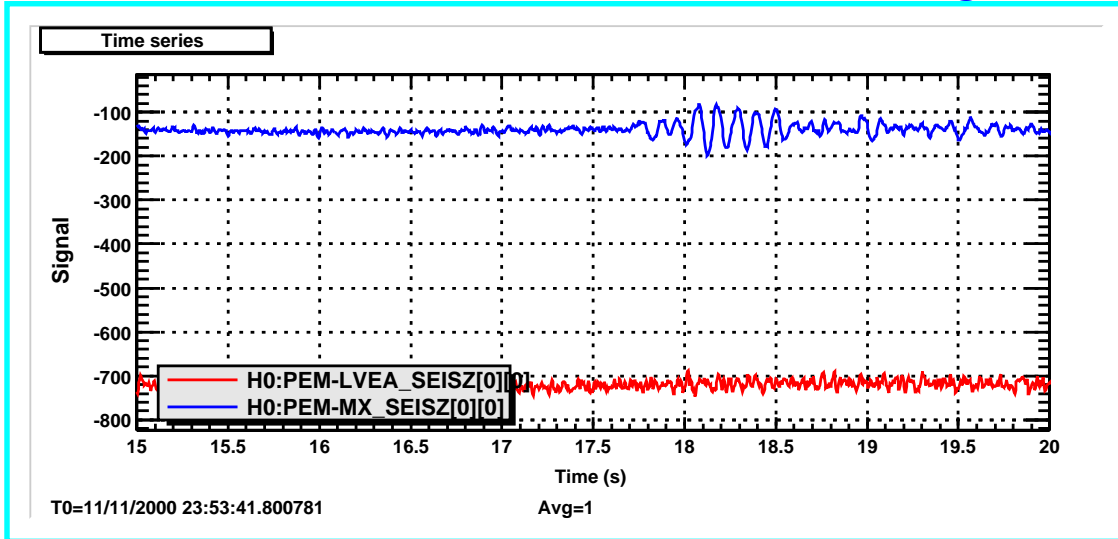


Y.F.C. and LIGO

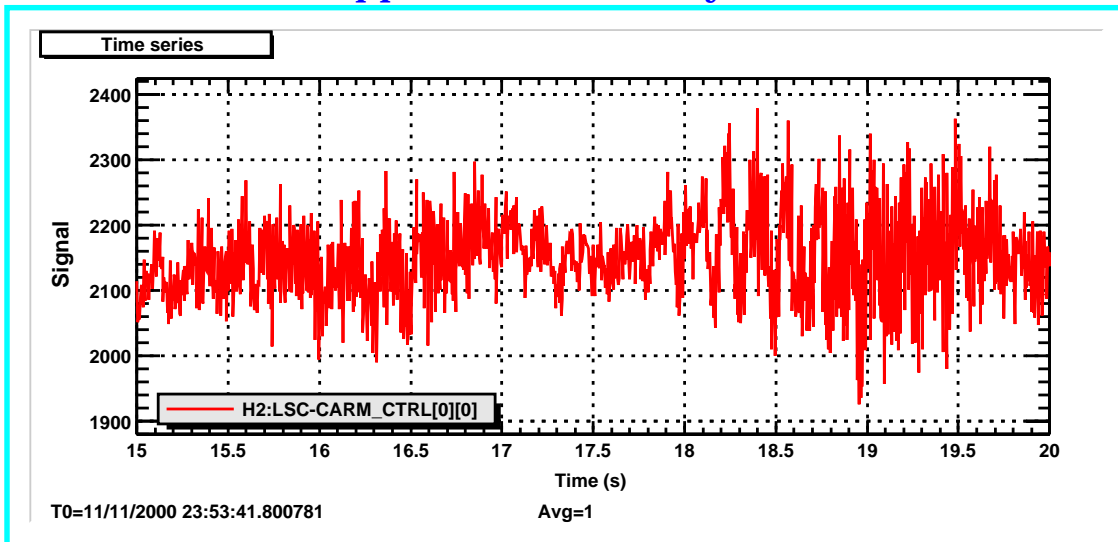


Tank Shots Seem to Couple to Arm Control at All Stations

10 Hz seismic transient at Mid-X, 6s before reaching LVEA:



Transient seems to appear concurrently in arm control:



That Breathing Sound During E2

- AS_Q modulation of about 0.85 Hz
 - Audibility was not due to distortion in the audio system
 - Modulation frequency seems to low for $2f$, at $1f$ it could be small optic angular (0.79 & 0.85 Hz)
 - Modulation extends up to about 1kHz
 - Consistent with side bands seen on calibration peaks
 - Observations consistent with modulation of audible frequency noise by alignment variation
-

Summary

- Band limited rms trending is working well continuously.
 - Intermittent peaks in frequency noise are produced by chiller-pad air compressors at 72 & 55 Hz.
 - Intermittent peaks are also produced by the 12 water-chiller compressors at 57-60 Hz.
 - The gravitational wave channel registers “normal” human activity at frequencies under 20 Hz, peaking at about 10Hz.
 - Cooling water re-routing and laser tune up reduced and stabilized noise in the frequency stabilization servo.
 - Tanks firing at the Y.F.C. apparently produced low frequency transients in control signals, which couple at all stations also at about 10Hz.
 - Modulation of gravitational wave channel noise at audible frequencies seemed consistent with alignment variation
-