

S5 Environmental Disturbances: To March 07

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LHO, Erik Katsavounidis, Laura Cadonati, MIT, Mike Viles, BPA

I. Understanding environmental coupling: S5 PEM injections

II. Reducing coupling during S5

- a. Isolating the 4k dark port with servoed pneumatic legs
- b. Backscattering reduction from end stations
- c. Microseismic peak servo

III. Local (self-inflicted) sources in S5

- a. Dewar insulation working
- b. Noise reduced by extra rack cooling
- c. Magnetic noise from laser chillers
- d. Motors at the crab pulsar frequency
- e. Update on reduction of inspiral range from building temperature control fans

IV. External sources discovered during S5

- a. H1 H2 coincidences from power grid events
- b. Inspiral range limited by McNary dam
- c. H1 60 Hz peak partly from power transmission lines

S5 PEM Injections

Location	LHO	LLO
Round 1:	Nov.-Dec. 2005	Dec. 2005
Round 2:	April-May 2006	Aug. 2006
Round 3 (planned):	Near end of run	Near end of run



Acoustic/in-band seismic

LHO

4x lower than S4. Ambient sound contribution is 1/10 to 1/100 of displacement noise floor, except at certain frequencies such as 280 Hz. Coupling levels the same for both rounds except: H1 was much higher in round 2 due to damaged dark port diode, and high level at end stations until back scattering fix.

LLO

~4x lower than S4, coupling the same for both rounds, ambient sound contribution is generally 1/10 to 1/100 of noise floor.

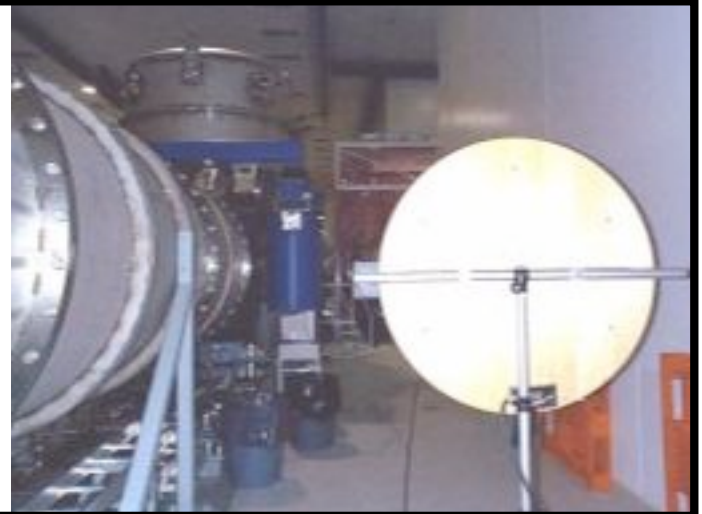
Magnetic

LHO

Same as S4, same both rounds, less than 1/10th of the displacement noise floor except at 60 Hz harmonics. The ambient 60 Hz field is substantial or dominant contributor to 60 Hz peak in gravitational wave channel.

LLO

Roughly the same as LHO, same as S4, pulsed heating turned off. Magnetic transients interfere with Crab.



Low frequency seismic upconversion

LHO

Same at all stations, both interferometers, same both rounds.

Radio Frequency

LHO

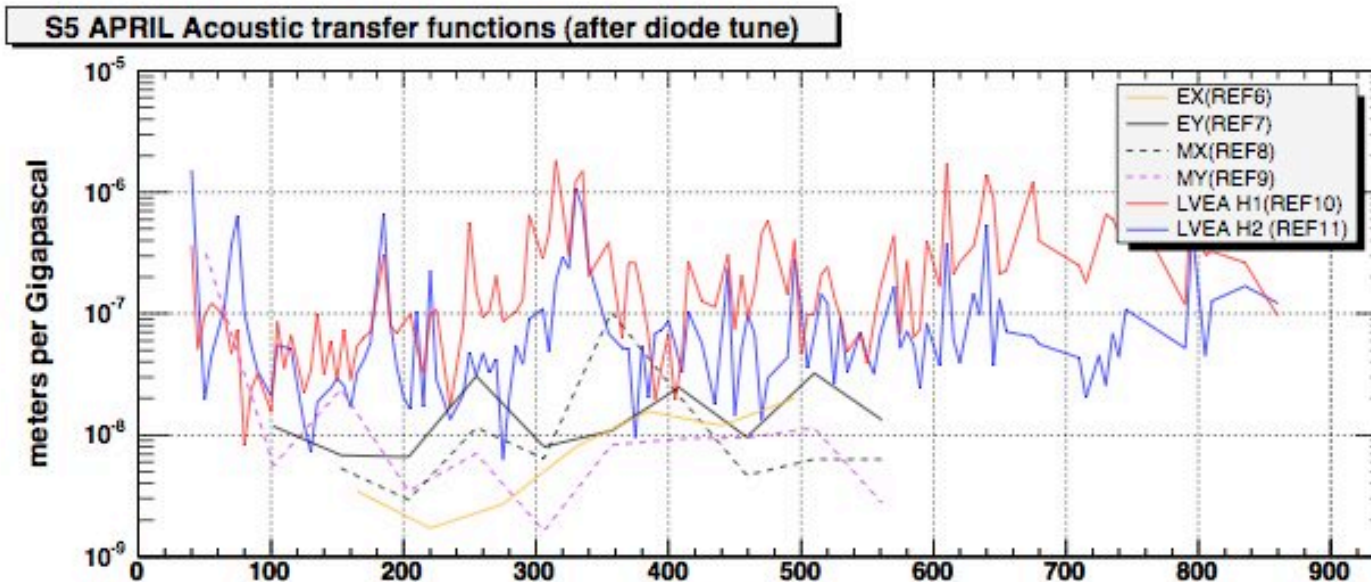
Coupling unchanged since S4. Normal background contributes less than 1/100 to the noise floor.

LLO

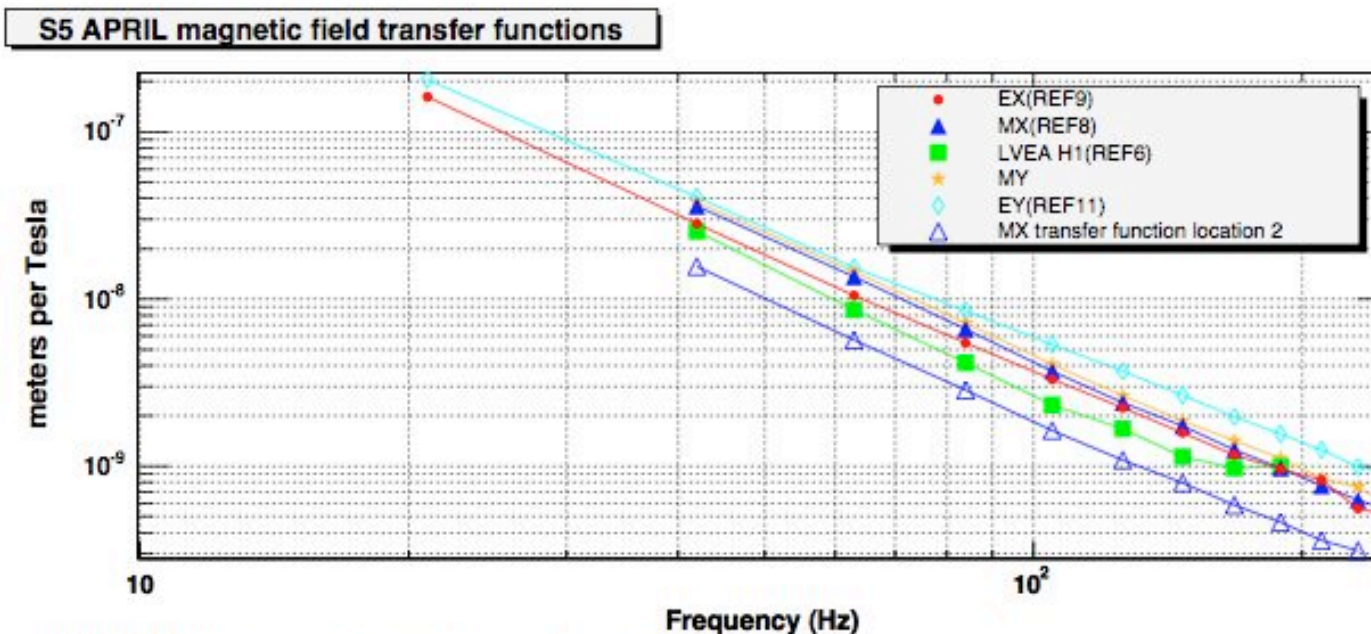
Coupling roughly the same as S4 and LHO. Automatic Link Establishment signals could be seen on the gravitational wave channel if they pass through the 24 MHz main modulation frequency.

S5 PEM Injections: sample coupling functions

Acoustic



Magnetic



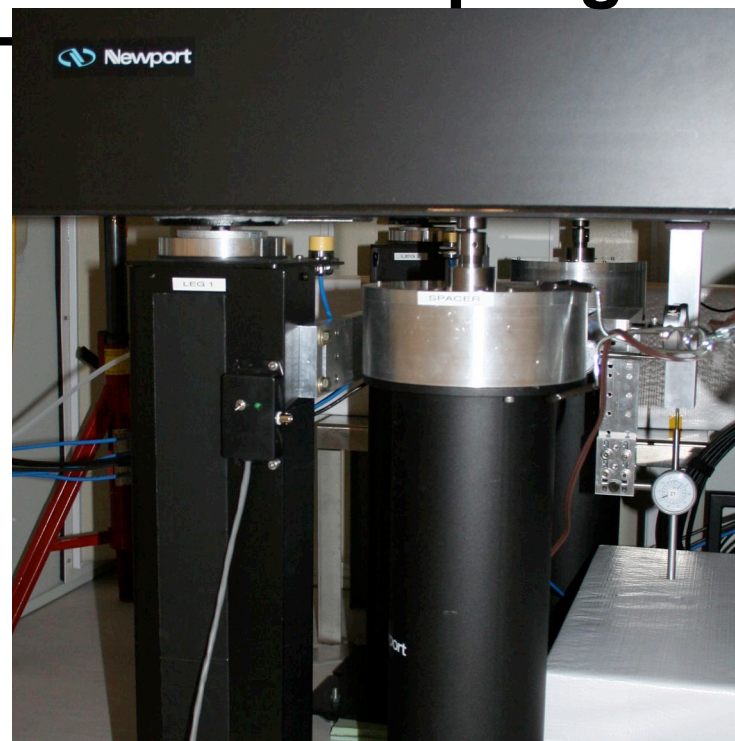
S5 efforts to reduce environmental coupling

Just Pre-S5

- 1) Acoustic enclosures on reflected ports (similar to enclosures already on dark ports).
- 2) Experimental seismic isolation (servoed pneumatic legs) of 2k dark port.

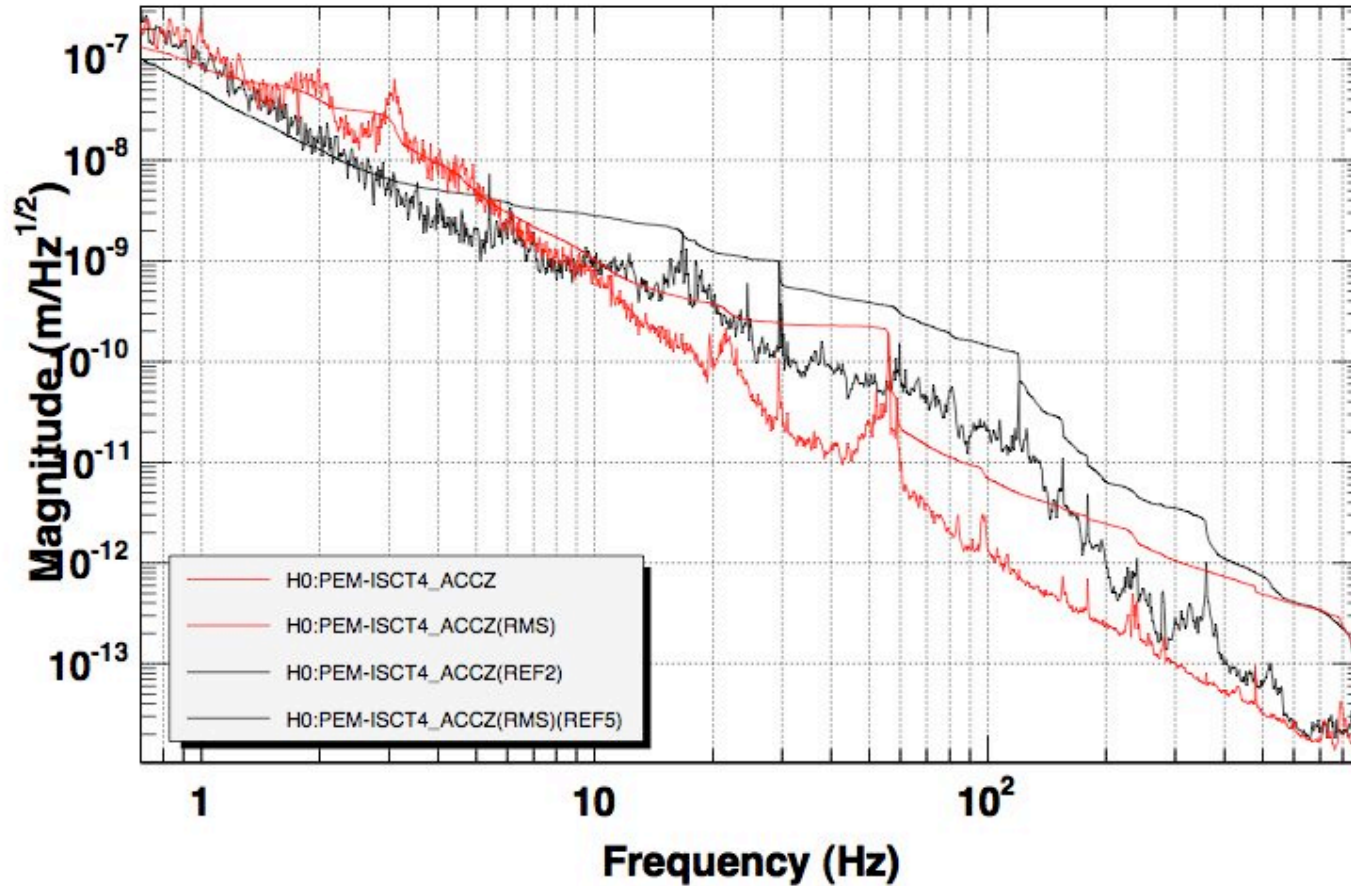
During S5

- 1) Backscattering reduction at end stations (Keita K. and Sam W.).
- 2) Tuning position of beam on dark port diodes to minimize acoustic coupling.
- 3) Update of microseismic servo to minimize low frequency seismic upconversion (Mike. L., Keita. K., Richard. M., Hugh. R., Robert. S.)
- 4) Seismic isolation (servoed pneumatic legs) of 4k dark port. (Doug. C., Robert. S.)



Reduction of in-band motion of 4k dark port with “floating”

Z-axis, Black: damped tripod legs, Red: servoed pneumatic legs



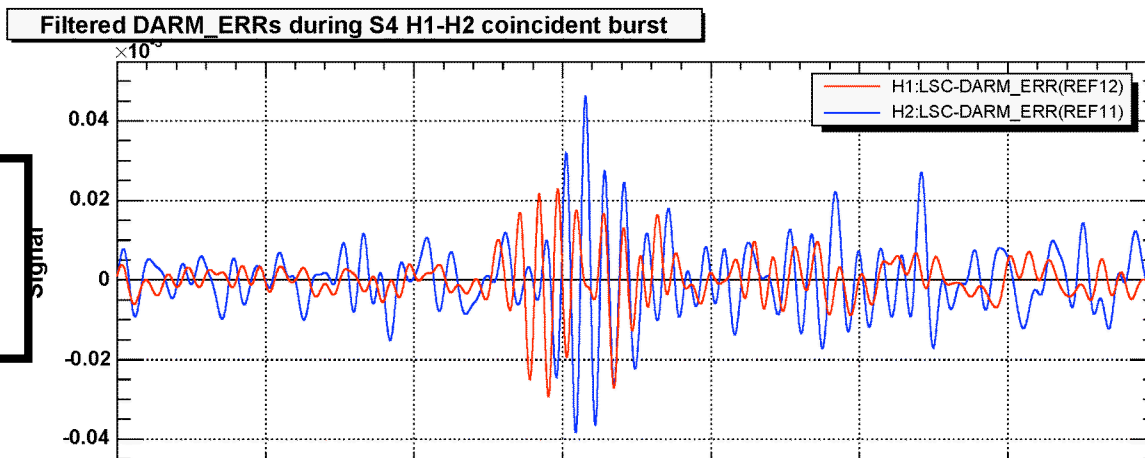
*T0=11/11/2006 10:40:16

Avg=4/Bin=50L

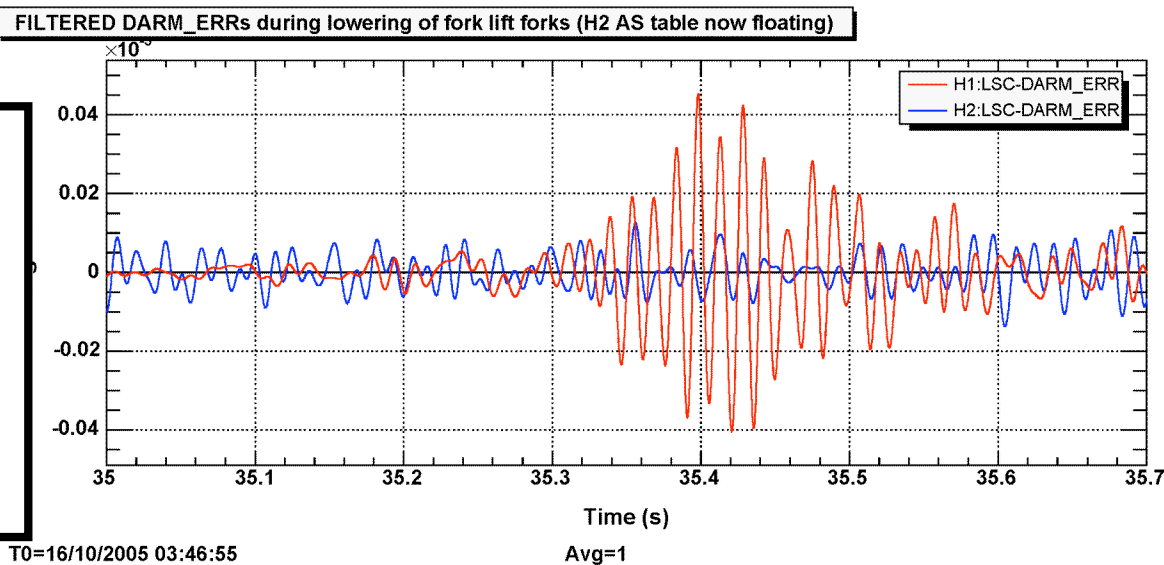
BW=0.0117178

“Floating” dark ports should reduce H1-H2 coincidences

H1 DARM, H2
DARM during S4
event



H1 DARM, H2
DARM during
forklift event:
with floating H2
dark port, very
little signal is
seen on H2



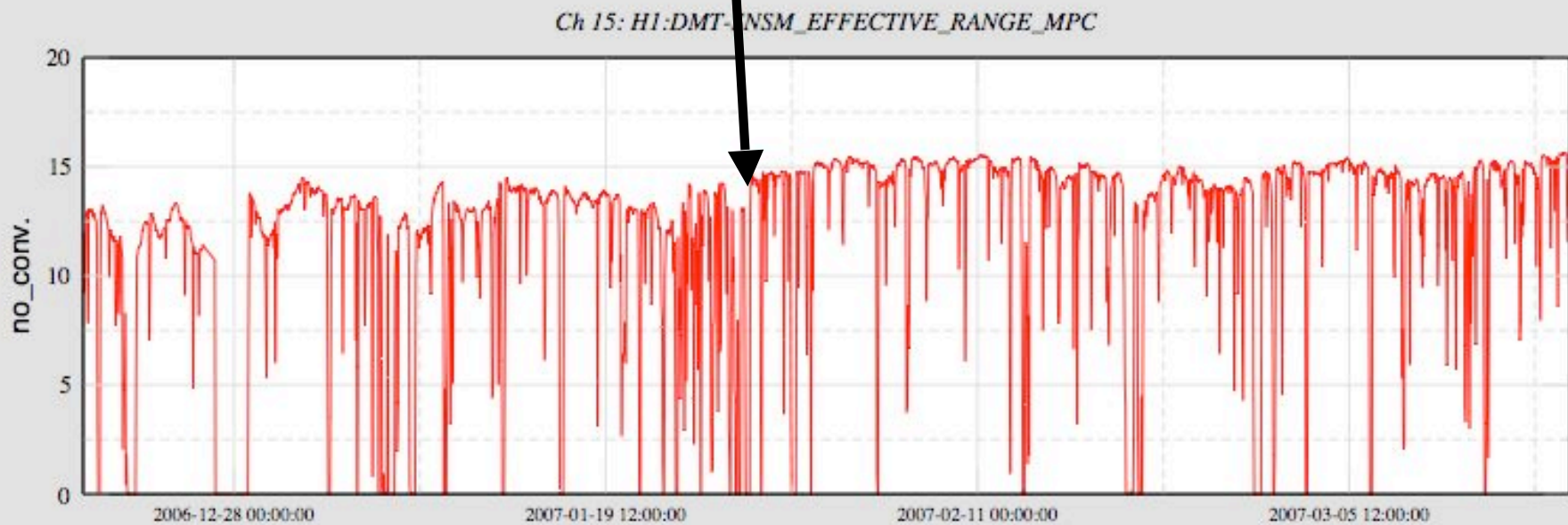
T0=16/10/2005 03:46:55

Avg=1



Improvement in range with reduction of coupling of microseismic peak

Microseismic peak servo



Local (self-inflicted) S5 sources: update on LN2 dewar induced seismic events

(Emelie Harstad, U of O)

Original



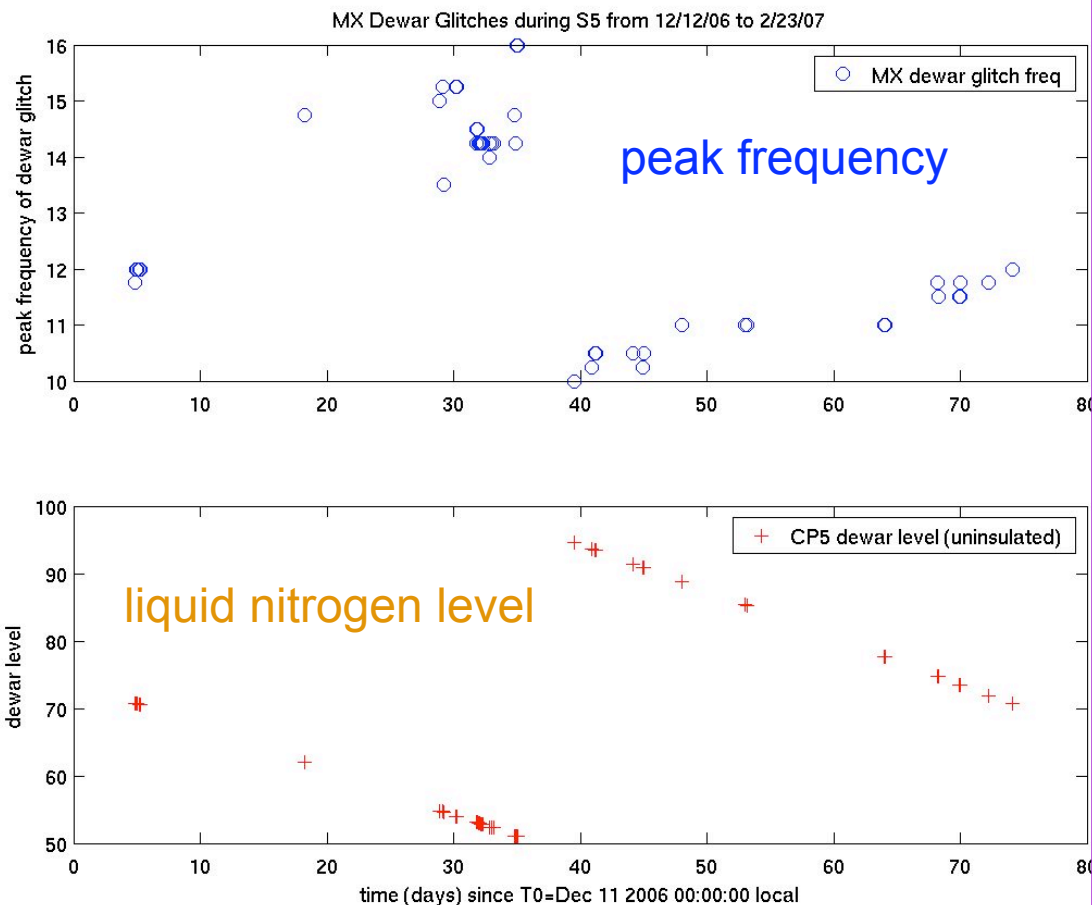
Thermally insulated



1) Mid-X dewar events down by ~10 since insulation (between S4 and S5).

2) Most of the remaining glitches from non-insulated dewar.

3) Peak frequency of glitch increases as dewar empties.

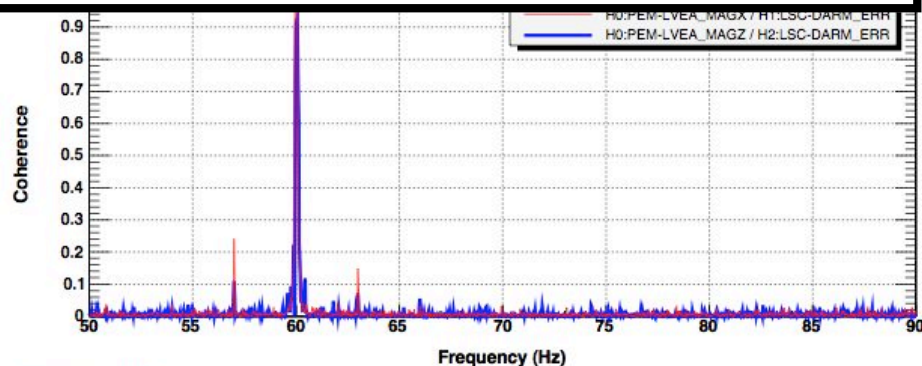


Local S5 sources of environmental noise:

Seismic: Kyle Ryan improves the seismic isolation of the office area air handler, which has been running at 59.6 Hz, the GW frequency for the Crab pulsar.



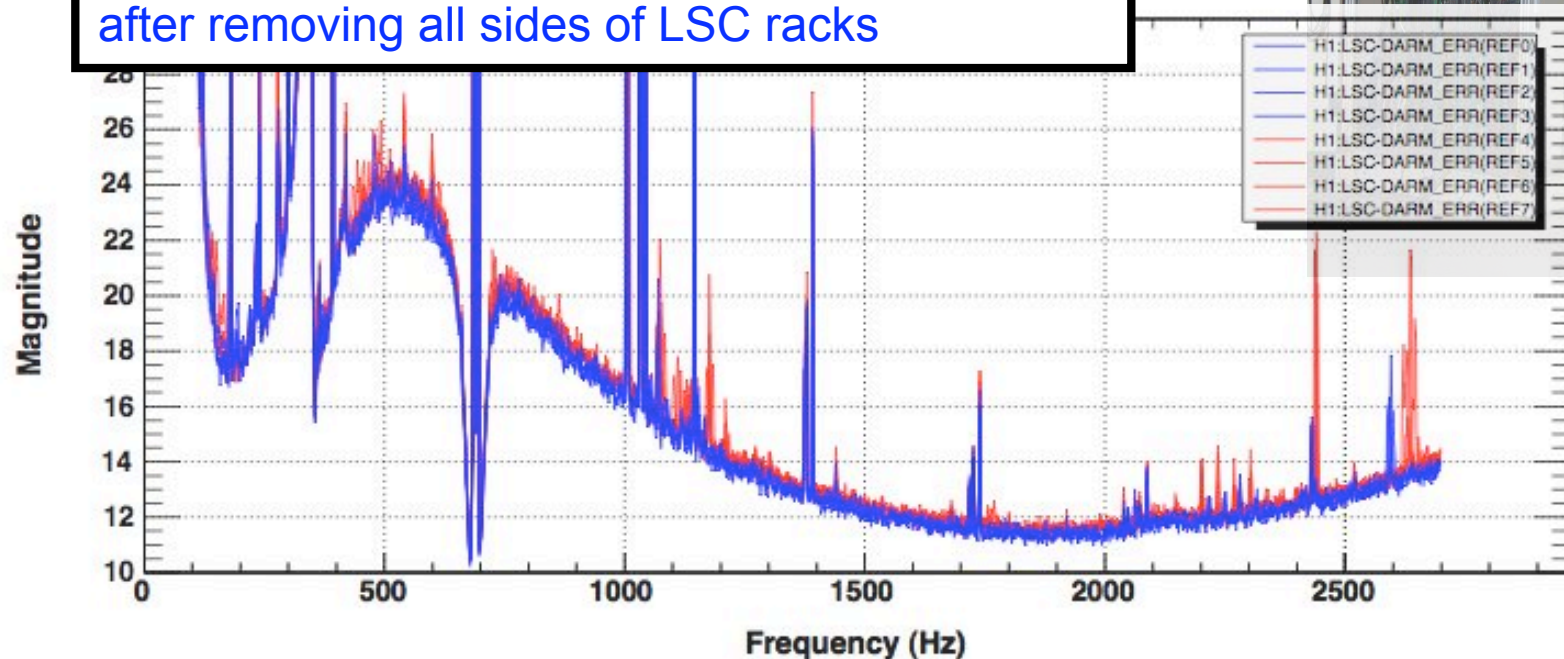
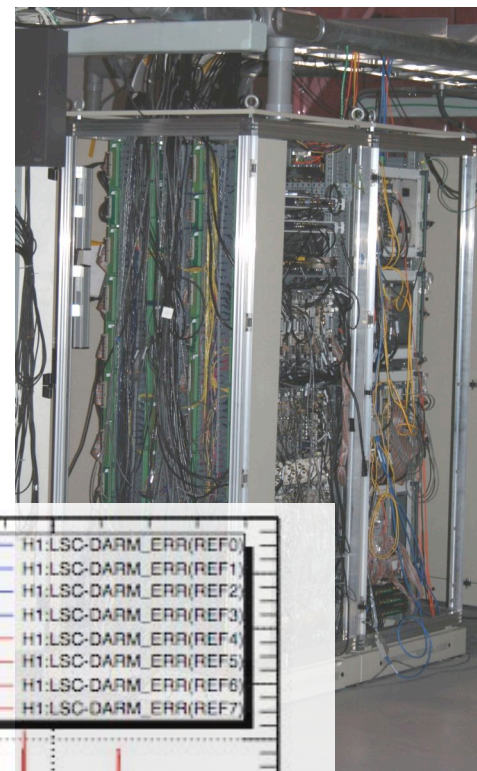
Magnetic: 3 Hz side bands on 60 Hz peak in gravitational wave channel found to be from laser chillers, probably 3 Hz pulsed heating.



Local S5 sources of environmental noise:

Temperature: a number of wandering lines were removed from the gravitational wave channel by extra cooling of certain electronics racks.

Gravitational wave channel: Red: before; Blue: after removing all sides of LSC racks



*T0=26/01/2007 08:00:00

Avg=50/Bin=63

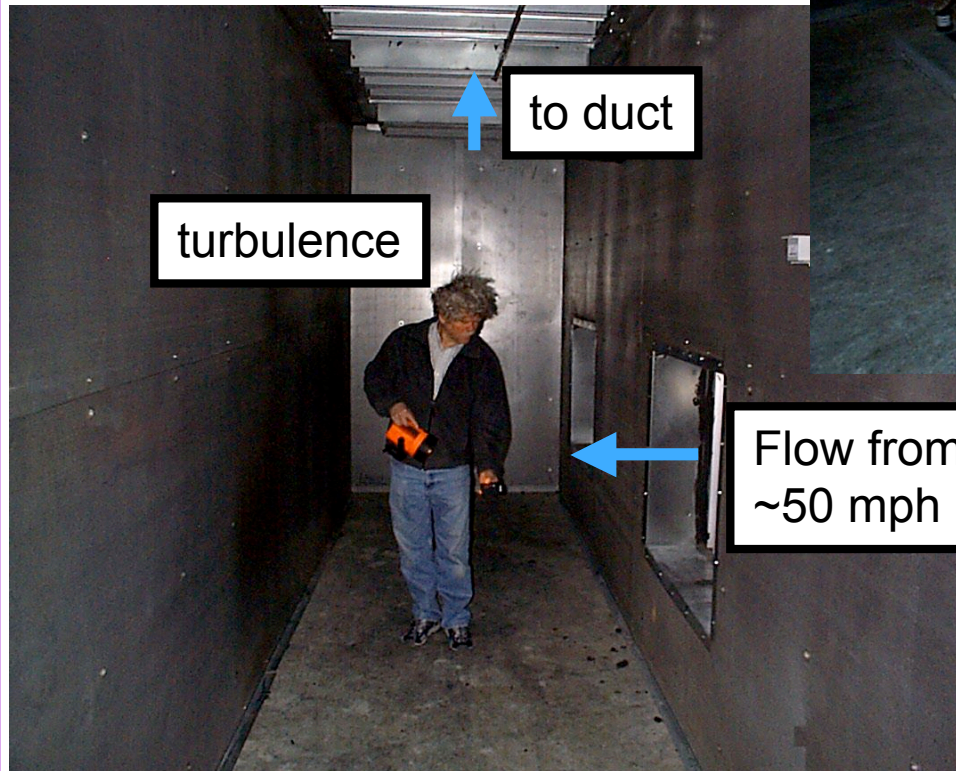
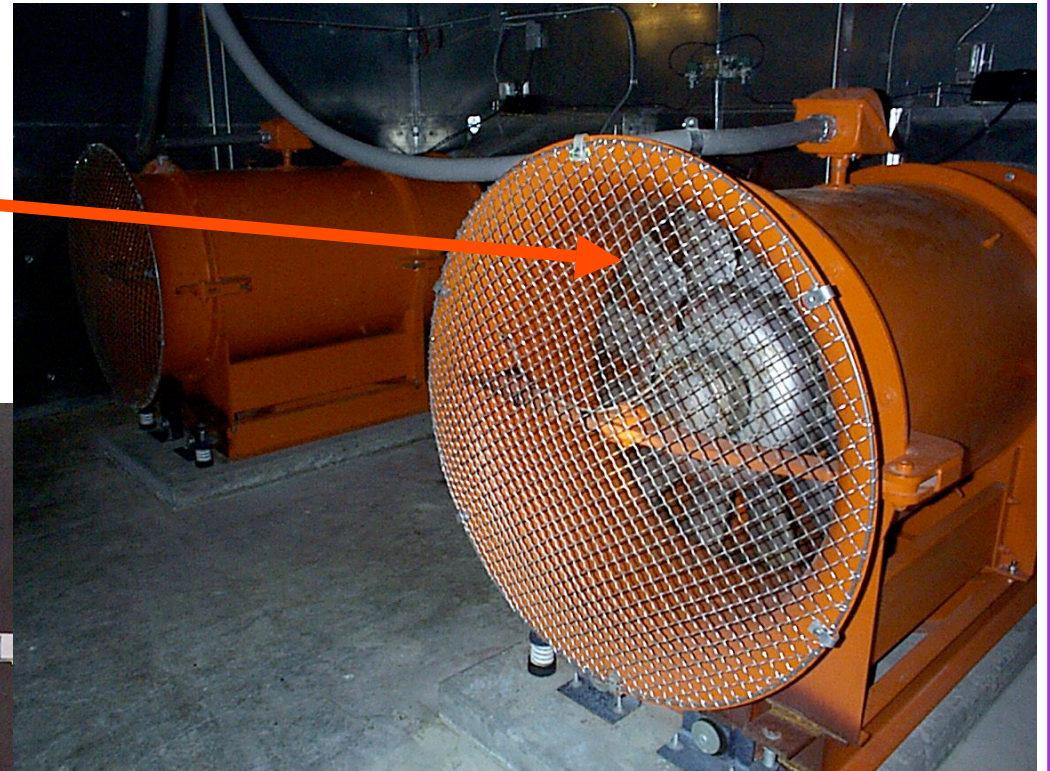
BW=0.0468711

Update on HVAC flow rate reduction to improve inspiral range last spring

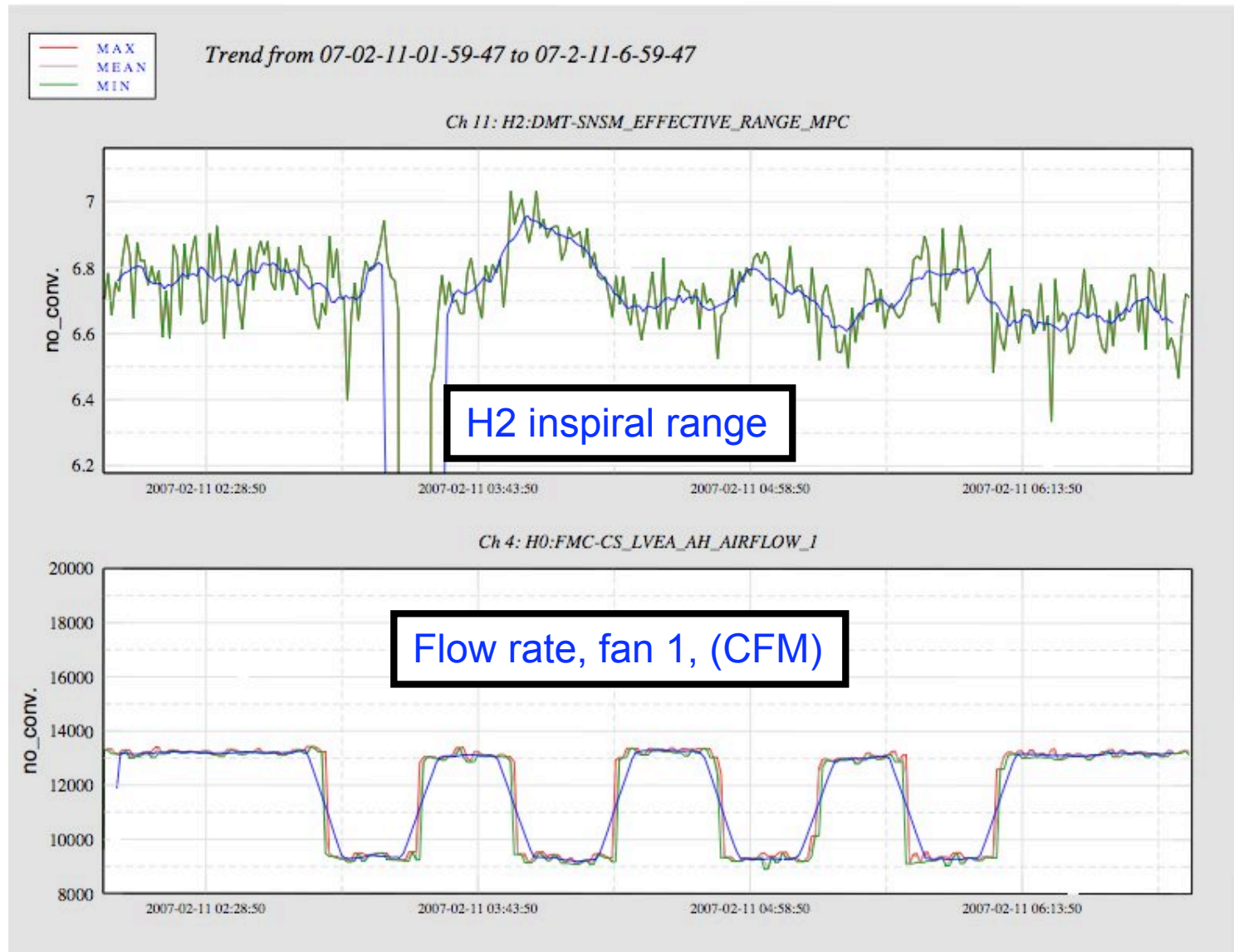
- *Shutting HVAC down improved H1 & H2 range about $\frac{3}{4}$ Mpc.*
- *Influence likely seismic – air flow into LVEA/VEA not needed for range reduction.*
- *Seismic noise likely from turbulence in supply plenum.*
- *DARM noise at 100 Hz is likely from up-conversion of lower frequency HVAC seismic signal instead of direct coupling.*
- *Running at reduced flow rates (about 75%) gave most of the improvement and good temperature control*

Broad-band seismic signal from HVAC possibly produced by plenum turbulence (noise produced without duct flow)

Pitch of blades controls flow rate through turbine



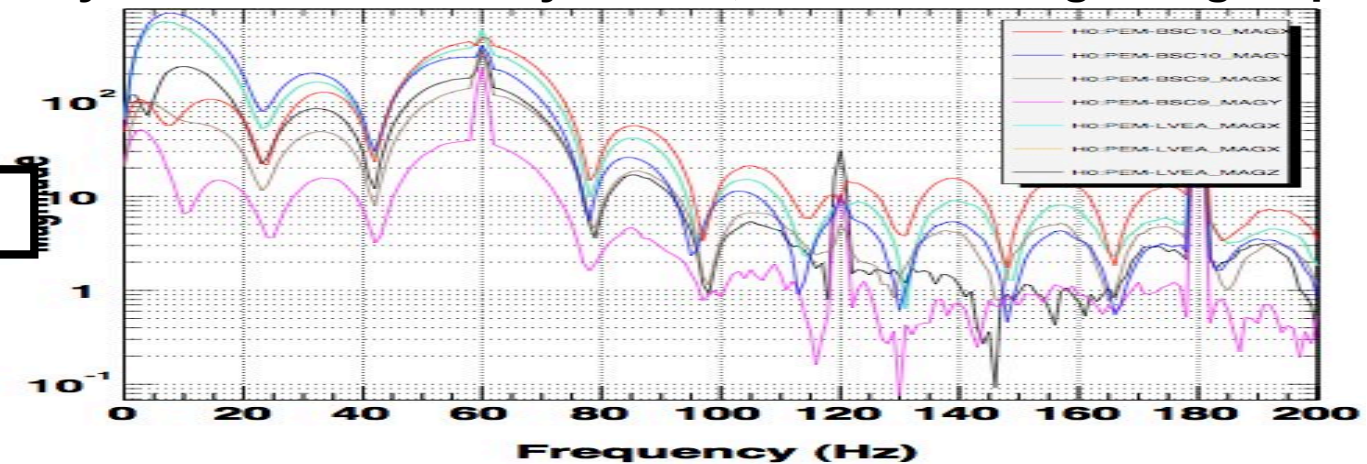
Recent experiment suggested that we were once again limited by HVAC: flow rate was again reduced



External sources: magnetometer/ mains voltage events produce H1 H2 coincidences; where do they come from and how do they couple ?

Event discovery and veto studies by Erik K., Laura C. and glitch group

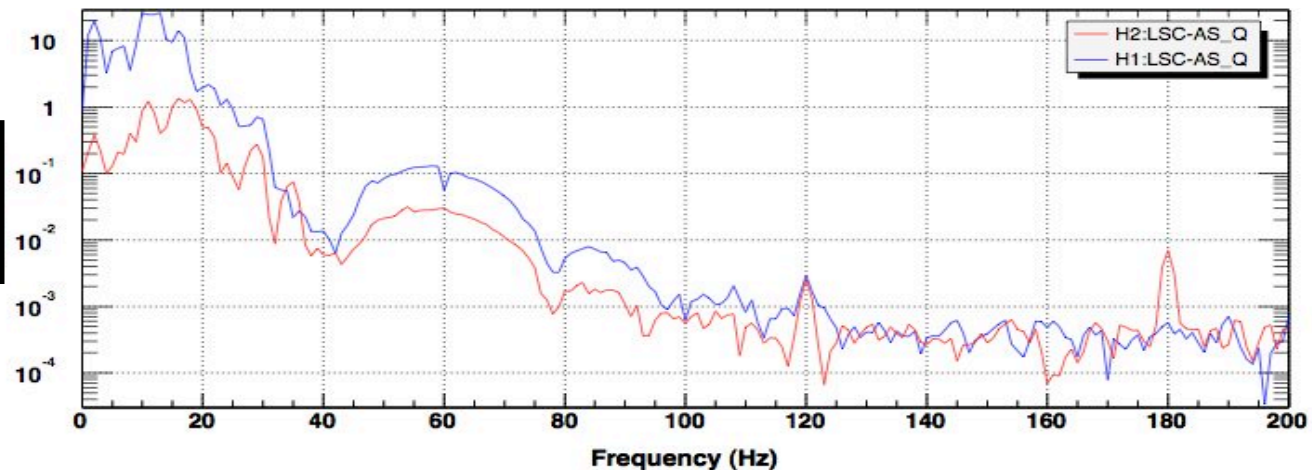
Magnetometers



T0=22/12/2005 03:26:12 Avg=2

BW=1.5

H1 and H2
AS_Q



T0=22/12/2005 03:26:12

Avg=2

BW=1.5

Study of 31 site-wide magnetometer events

magnetic event no.	GPS Time	LocalTime	voltage event?	DARM KW Event?	BPA event (resolution mostly 2s)	Q-scan LVEA_V2 peak f (Hz)	Predicted DARM 70 Hz from mag field	Actual DARM 70 Hz
1	817736343	Dec 04, 2005 04:58:49 PST	Yes		Capacitors in, Benton substation	497		
2	817824114	Dec 05, 2005 05:21:40 PST	Yes		Capacitors in, Benton substation	592	6.00E-08	2.00E-07
3	817911868	Dec 06, 2005 05:44:14 PST	Yes		Capacitors in, Benton substation	631		
4	818073843	Dec 08, 2005 02:43:50 PST	Yes	H1	Capacitors in, Ashe substation	352		
5	818159114	Dec 09, 2005 02:25:00 PST	Yes		Capacitors in, Benton substation	691		
6	818426006	Dec 12, 2005 04:33:12 PST	Yes	H2	Trip, Marion north bus when switching reactor	69		
7	818507471	Dec 13, 2005 03:10:58 PST	Yes		Capacitors in, Benton substation	592	6.00E-08	2.00E-07
8	818511507	Dec 13, 2005 04:18:13 PST	Yes		Capacitors in, Richland substation	417		
9	818515503	Dec 13, 2005 05:24:49 PST	Yes		Capacitors in, Ashe substation	417	6.00E-09	2.00E-07
10	818684261	Dec 15, 2005 04:17:28 PST	Yes		Capacitors in, Ashe substation	417		
11	819002198	Dec 18, 2005 20:36:24 PST	Yes		Capacitors in, Ashe substation	389		
12	819036727	Dec 19, 2005 06:11:54 PST	Yes	H2	Capacitors in, Richland substation	352		
13	819160196	Dec 20, 2005 16:29:42 PST	Yes		Capacitors in, Richland substation	337		
14	819211052	Dec 21, 2005 06:37:18 PST	Yes		Capacitors in, Richland substation	367		
15	819257186	Dec 21, 2005 19:26:12 PST	Yes	H1 And H2	Fault on Ashe-Slatt 500 kV line	68	3.00E-06	4.00E-06
16	819384812	Dec 23, 2005 06:53:18 PST	Yes	H1 And H2	Fault on Slatt-Buckley 500 kV line	95	6.00E-07	6.00E-07
17	819386152	Dec 23, 2005 07:15:39 PST	Yes	H1 And H2	Fault on Benton-Othello 115 kV line	53		
18	819673745	Dec 26, 2005 15:08:52 PST	Yes	H1 And H2	None found	95		
19	820394439	Jan 03, 2006 23:20:25 PST	Yes	H1 And H2	Trip, Ice Harbor-Franklin 115 kV line	68	5.00E-07	3.00E-07
20	820595204	Jan 06, 2006 07:06:31 PST	Yes	H2	Trip, Vantage-Schultz 500 kVline	50		
21	821270678	Jan 14, 2006 02:44:24 PST	Yes	H1 And H2	Trip, Benton-Franklin 230 kV line	53	1.40E-06	2.00E-06
22	821459495	Jan 16, 2006 07:11:22 PST	Yes	H1	Capacitors in, Richland substation	350		
23	823009424	Feb 03, 2006 05:43:31 PST	Yes	H1 And H2	Fault on Lower Monumental-Ashe 500 kV line	53		
24	823355073	Feb 07, 2006 05:44:19 PST	Yes	H1	Capacitors in, Benton substation	592		
25	825082556	Feb 27, 2006 05:35:42 PST	Yes		Capacitors in, Benton substation	691	2.00E-08	6.00E-07
26	825170442	Feb 28, 2006 06:00:28 PST	Yes		Capacitors in, Benton substation	497		
27	826119810	Mar 11, 2006 05:43:16 PST	Yes		Capacitors in, Benton substation	592		
28	827089513	Mar 22, 2006 11:04:59 PST	No		None found	mag at about 10	9.00E-08	2.00E-07
29	827506076	Mar 27, 2006 06:47:42 PST	Yes		Capacitors in, Benton substation	757	3.00E-08	2.00E-07
30	827592239	Mar 28, 2006 06:43:45 PST	Yes	H1	Capacitors in, Benton substation	592		
31	828112266	Apr 03, 2006 08:10:53 PST	No		None found	mag at about 10		

Collaboration with Mike Viles, BPA

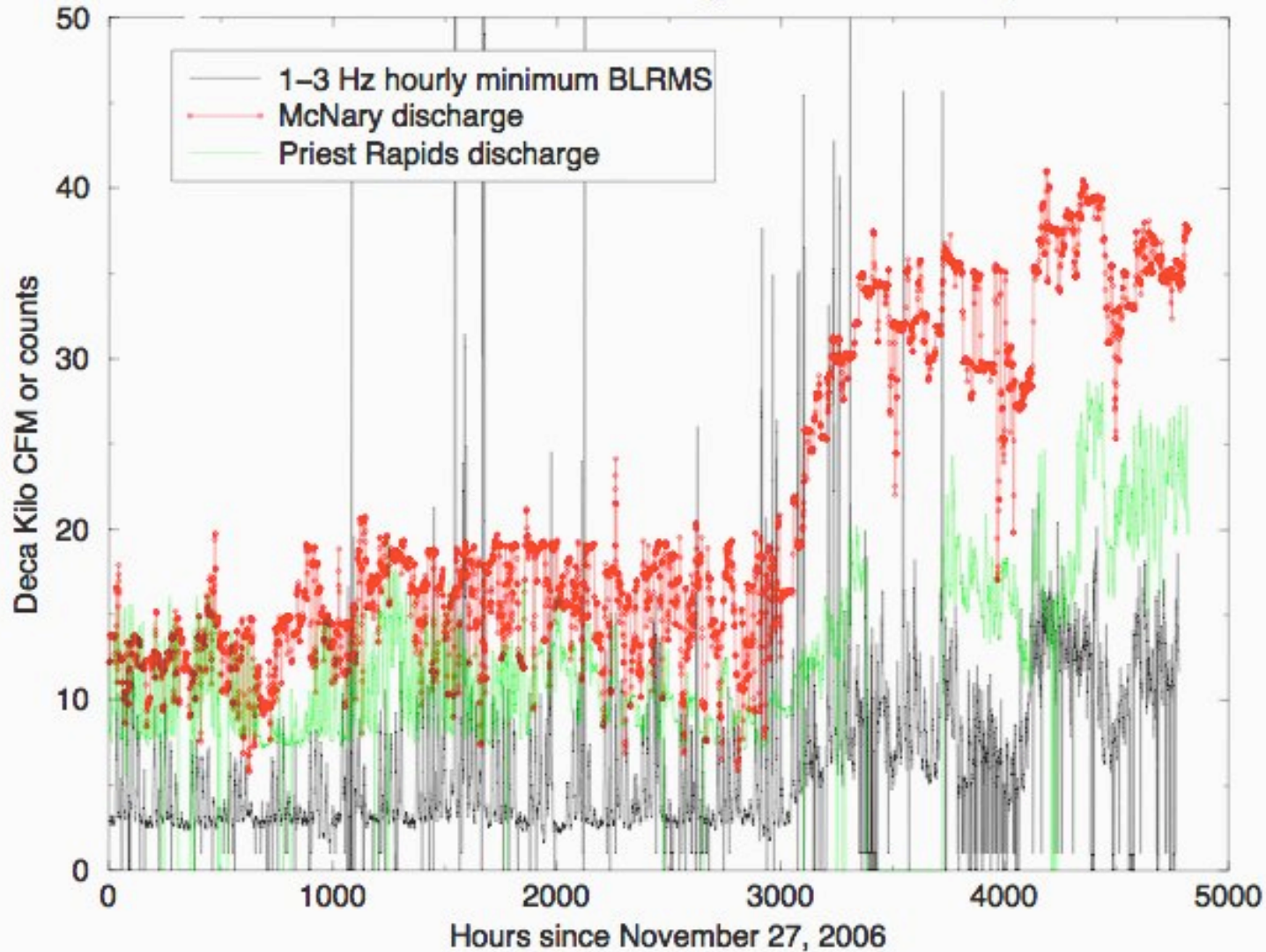
Summary of magnetometer/mains H1 H2 coincidences study

- 1) *BPA events were associated with 28/31 of the large sitewide magnetic events.*
- 2) *The events that affected us the most were line faults and trips; capacitor insertions produced higher frequency transients that are eddy current shielded.*
- 3) *For capacitors, we can tell the originating substation by the peak frequency of the transient.*
- 4) *The effect on the gravitational wave channel is consistent with direct coupling of magnetic fields to TM magnets.*
- 5) *DQ flags have been produced for the first year of S5, based on BPA records of events.*
- 6) *Events were local (tens of miles) except one from central Oregon at the other end of the nearby transmission line.*

Dam 60 km away sets maximum inspiral range

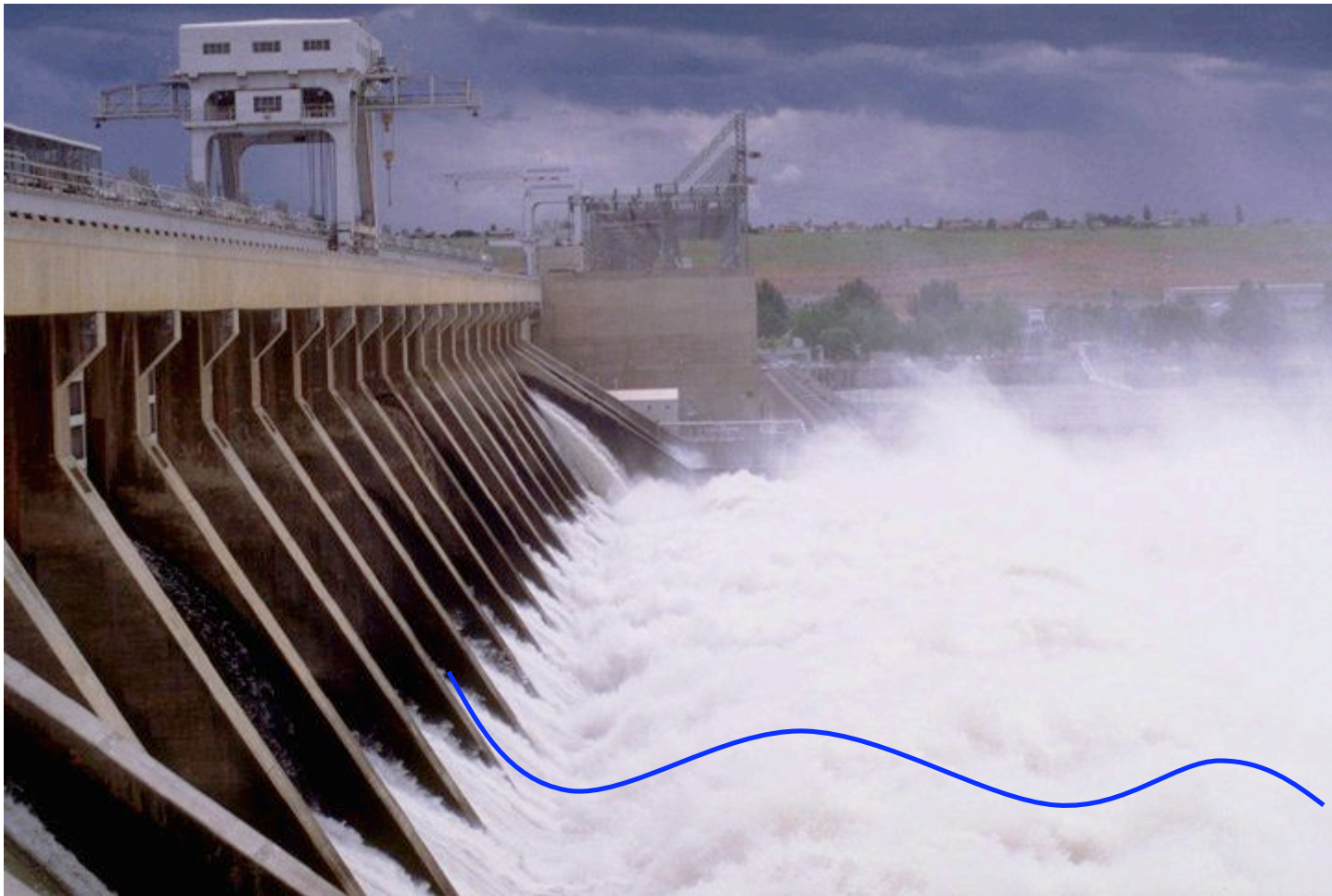
(discovered by Justin Garofoli)

Dam Discharge and 1–3 Hz BLRMS hourly minimum
BLRMS minimum follows McNary better than Priest Rapids



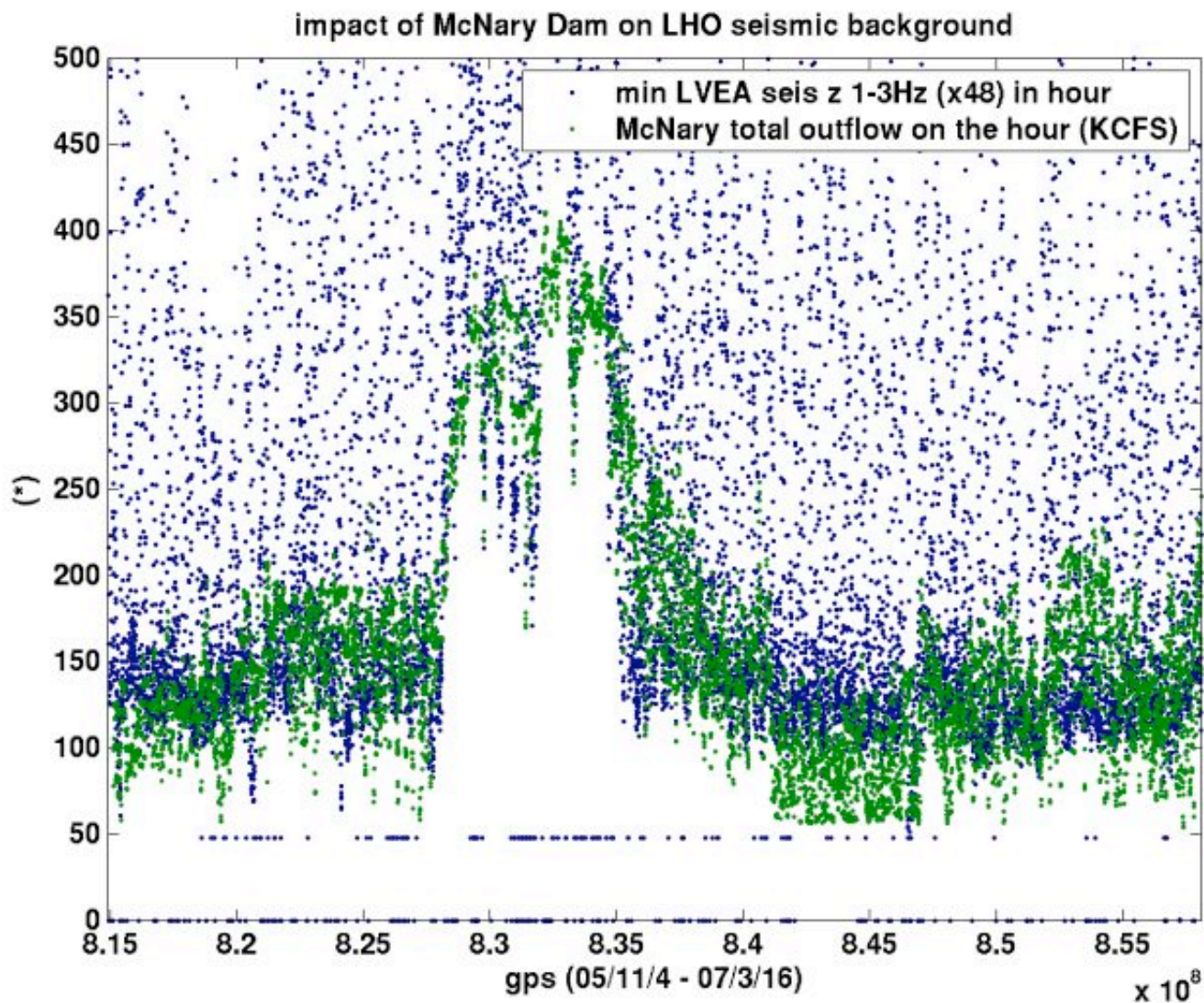
Dam affects inspiral range through upconversion of seismic signal at 1.2 Hz.

“Bounce” of water timed at 1 to 0.3 second.



Large mass bouncing on the ground at our most sensitive frequency

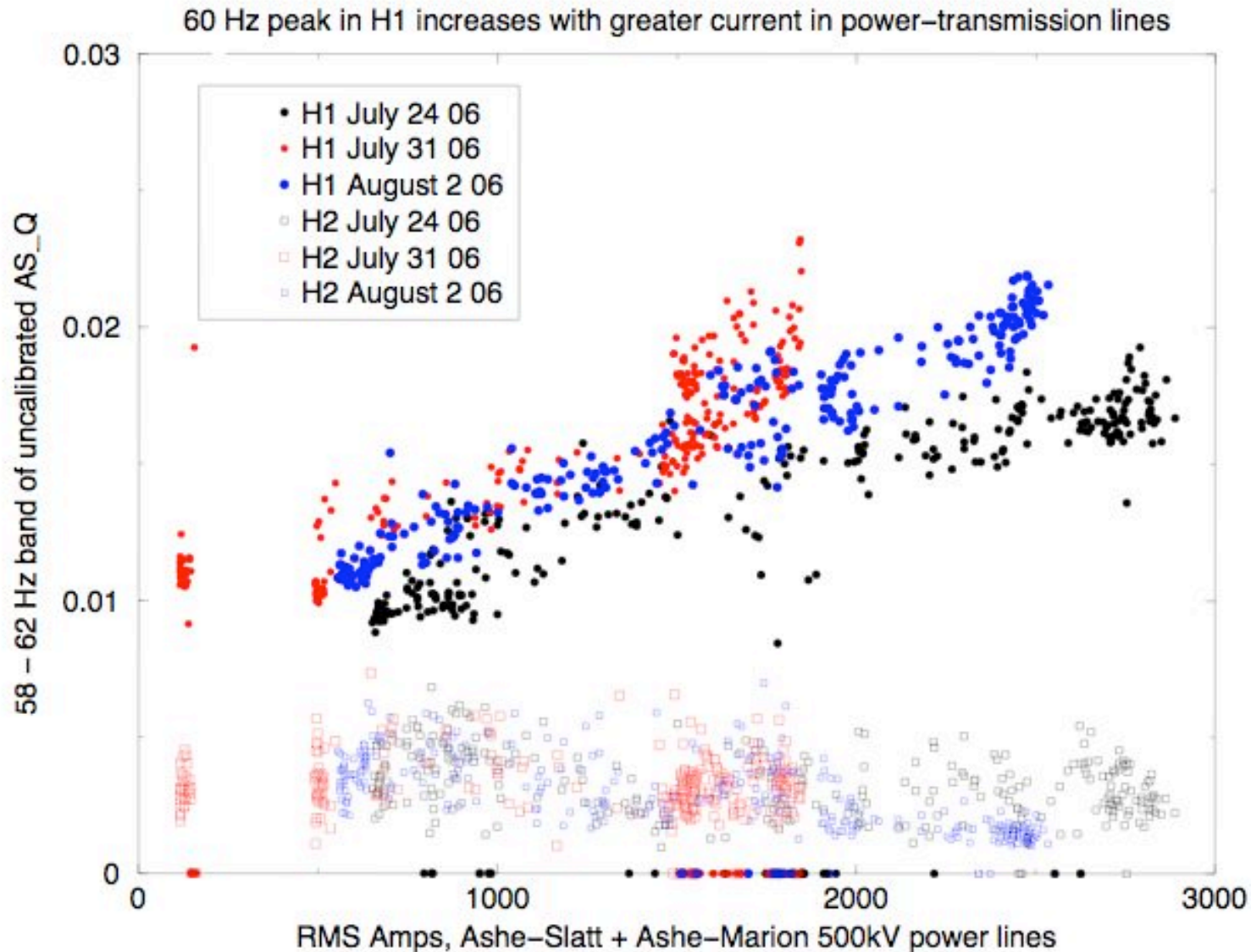
Justins update showing entire run until present: dam has affected us for about 1/4 of the run so far



Transmission lines partly responsible for 60Hz peak in H1



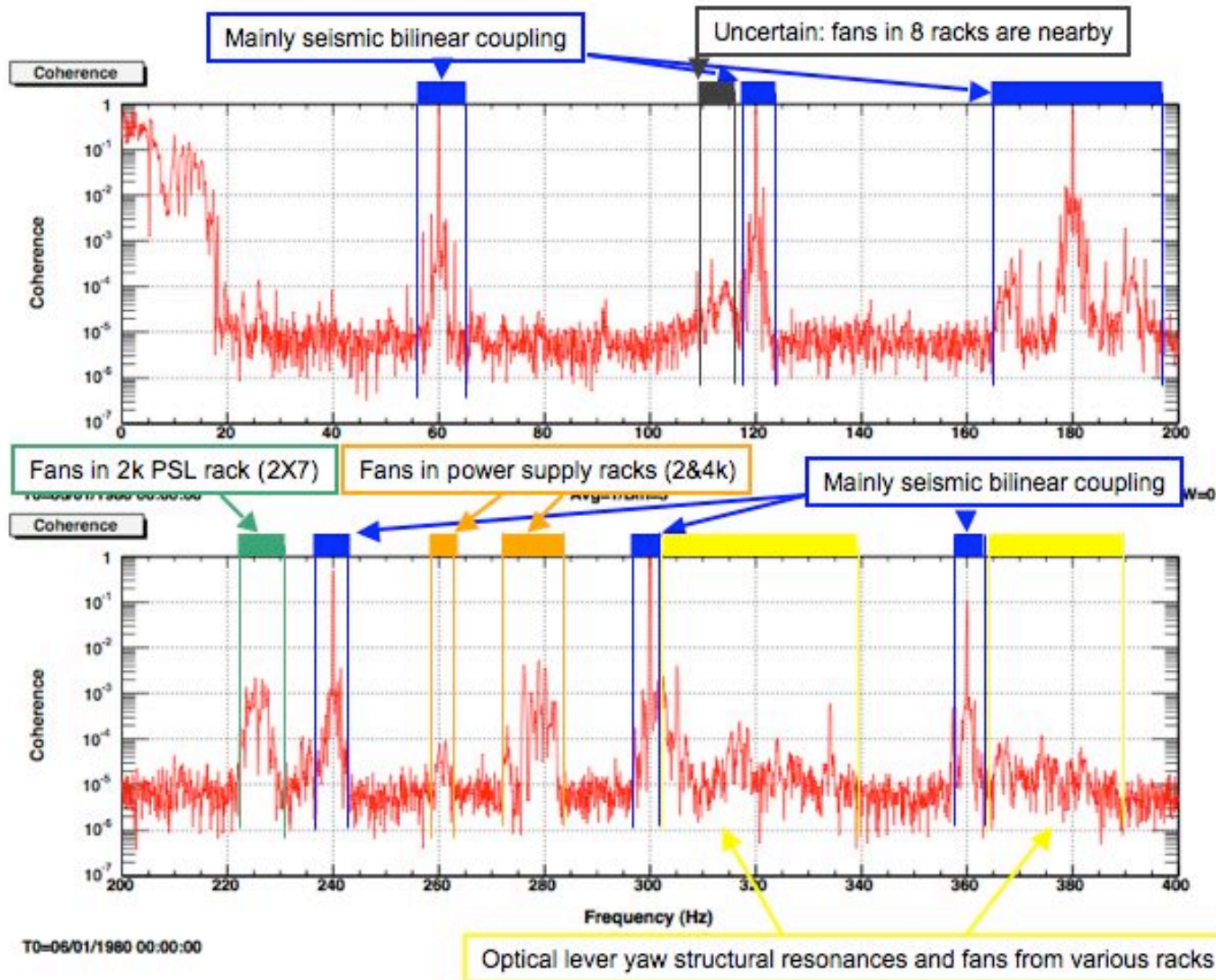
60 Hz peak height in gravitational wave channel as a function of current in transmission lines



Summary of transmission line effect on 60 Hz peak

- 1) *60 Hz magnetic field generated by power transmission lines accounts for 1/2 of 60 Hz peak in H1 gravitational wave channel.*
- 2) *A model of the transmission lines roughly predicts the magnetic field at the end station.*
- 3) *This predicted field can account for the effect on the gravitational wave channel through coupling to the test mass magnets.*
- 4) *The 60 Hz peak in H2 gravitational wave channel is twice as large as H1 and correlation with transmission lines is not evident.*

Main sources of H1 H2 coherence are fans and low frequency seismic motion



Coherence through January 07

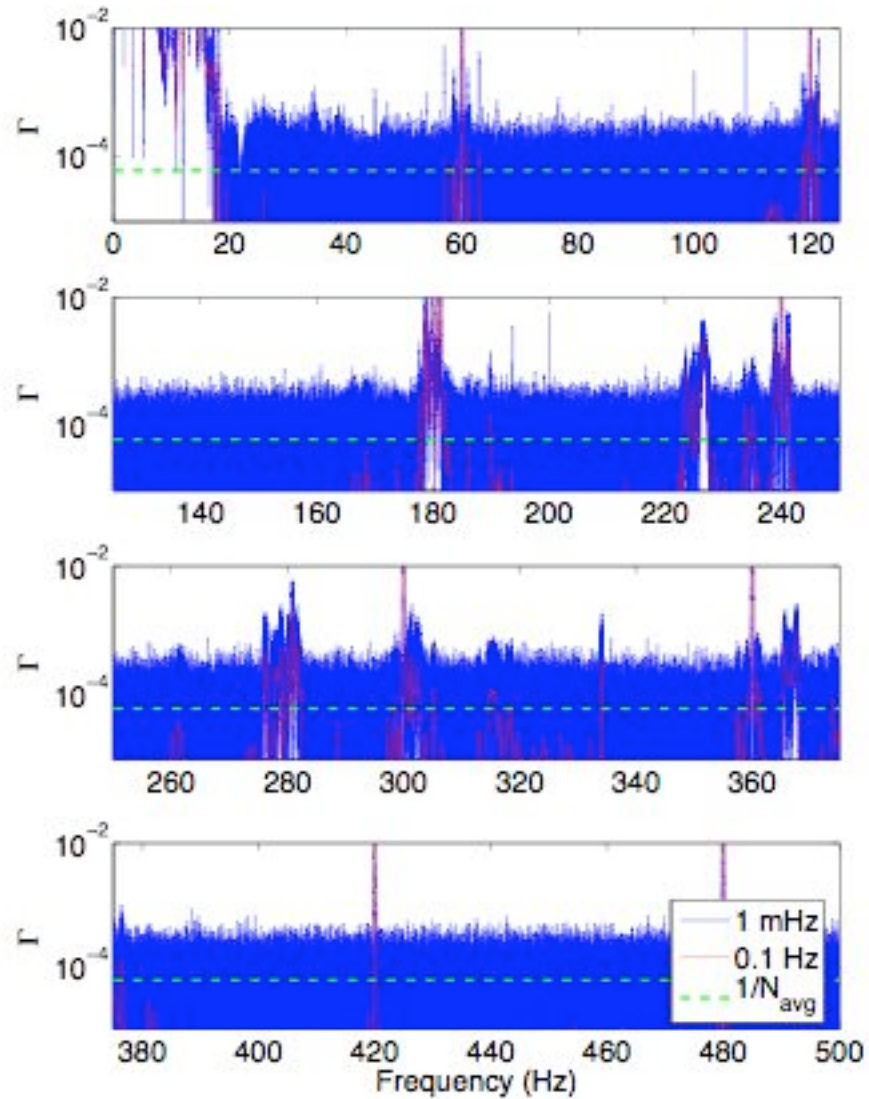


Figure 1: S5 H1H2 coherence using 1 mHz resolution.