PEM update, September 2013

Robert Schofield,
Vinny Roma, Terra Hardwick (Oregon)
Emily Maaske (Seattle Pacific),
Dominick Ghirado(Notre Dame)
Brian Dawes (Columbia),
Anamaria Effler (LSU),
Tristan Shoemaker (Boston),
David Shoemaker (MIT),
Thomas Vo, Richard McCarthy (LHO)
Stefan Ballmer (Syracuse)

LIGO-G1301067

2013 Summer PEM Crew

Emily Maaske
Terra Hardwick
Vinny Roma
Dominick Ghirardo
Brian Dawes
Tristan Shoemaker
David Shoemaker
Anamaria Effler
Robert Schofield




Installing sensors

Emily epoxies accelerometer on beam tube, Vinny installs microphone on HAM

Installing sensors

Terra and Vinny install accelerometers on PSL table

Pulling cables

Terra pulling and guiding in e-bay

Brian guiding in LVEA

Cross-talk studies of new channels

Emily Maaske, Seattle Pacific

Channel	Orders of magnitude of attenuation of cross talk	Channel	Orders of magnitude of attenuation of cross talk
Anti-Aliasing Chassis 2 Channel 1	3.5	Anti-Aliasing Chassis 2 Channel 17	3
Anti-Aliasing Chassis 2 Channel 2	3.5	Anti-Aliasing Chassis 2 Channel 18	3.5
Anti-Aliasing Chassis 2 Channel 3	3.5	Anti-Aliasing Chassis 2 Channel 19	3.5
Anti-Aliasing Chassis 2 Channel 4	4	Anti-Aliasing Chassis 2 Channel 20	3.5

Channel	Orders of magnitude of attenuation of cross talk	Channel	Orders of magnitude of attenuation of cross talk
Endevco 1 Channel 1	4	Endevco 1 Channel 9	3
Endevco 1 Channel 2	3	Endevco 1 Channel 10	3
Endevco 1 Channel 3	2.5	Endevco 1 Channel 11	2.5
Endevco 1 Channel 4	2.5	Endevco 1 Channel 12	3
Endevco 1 Channel 5	4	Endevco 1 Channel 13	3.5
Endevco 1 Channel 6	4	Endevco 1 Channel 14	4
Endevco 1 Channel 7	2	Endevco 1 Channel 15	4
Endevco 1 Channel 8	2	Endevco 1 Channel 16	4

Channel	Orders of magnitude of attenuation of cross talk
Endevco 2 Channel 6	1.5
Endevco 2 Channel 7	1.5
Endevco 2 Channel 8	1.5
Endevco 2 Channel 9	1
Endevco 2 Channel 10	1.5
Endevco 2 Channel 11	1.5
Endevco 2 Channel 12	0.5
Endevco 2 Channel 13	1
Endevco 2 Channel 14	1.5
Endevco 2 Channel 15	1
Endevco 2 Channel 16	1

This Endevco multi-accelerometer signal conditioner was so bad we replaced it

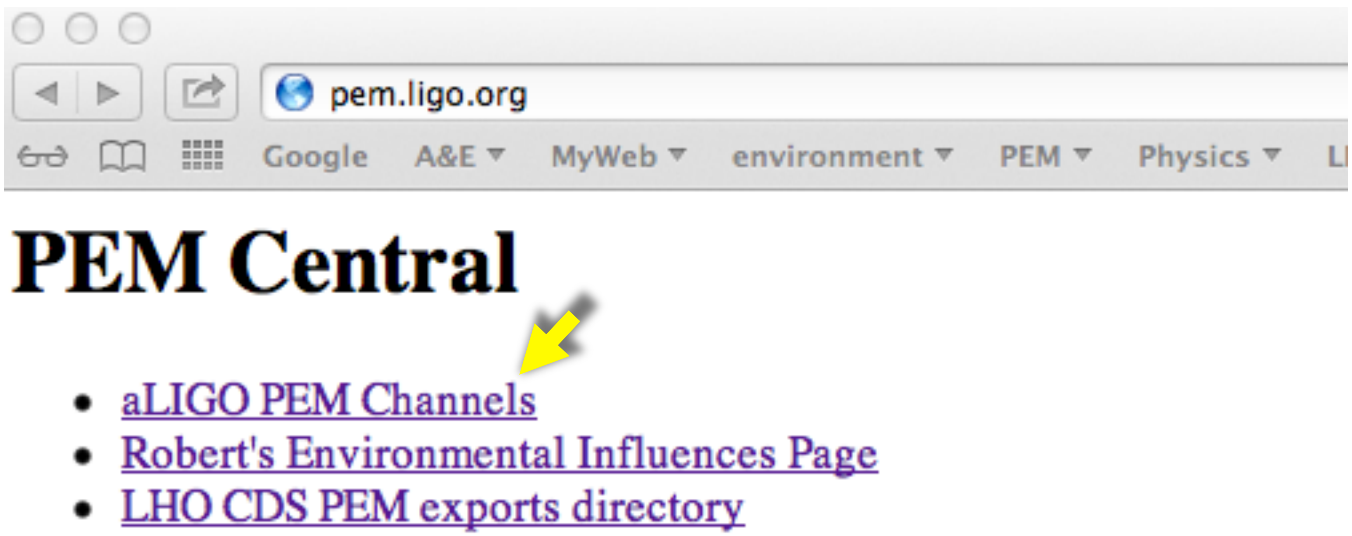
Monitoring all the new PEM channels

Development of LIGOCAM (Dipongkar Talukder, U of O)

LigoCAM

Band (Hz) / Channel	0.03 - 0.1	0.1 - 0.3	0.3 - 1	1 - 3	3 - 10	10 - 30	30 - 100	100 - 300	300 - 1000	1000 - 3000	3000 - 10000	Excess	Comb-like	Disconnect	Status	Image
H1:PEM-VAULT_SEIS_1030X195Y_STS2_Z_DQ	-1.000	-1.000	-0.953	-0.532	-0.557	-0.696	0.007	-0.204	0.390	0.000	0.000	Yes	Yes	No	Alert	PSD, TS
H1:PEM-VAULT_MAG_1030X195Y_COIL_X_DQ	-1.000	-1.000	-0.730	0.136	0.018	-0.228	0.003	0.008	-0.032	0.001	0.000	Yes	Yes	No	Alert	PSD, TS
H1:PEM-VAULT_SEIS_1030X195Y_STS2_Y_DQ	-1.000	-1.000	-0.789	-0.005	-0.775	-0.694	0.141	-0.037	0.528	0.000	0.000	Yes	Yes	No	Alert	PSD, TS
H1:PEM-MX_SEIS_VEA_FLOOR_QUAD_SUM_DQ	-1.000	-1.000	-0.964	-0.587	-0.709	-0.210	0.328	-0.145	-0.007	0.000	0.000	Yes	Yes	No	Alert	PSD, TS
H1:PEM-CS_MAG_LVEA_VERTEX_X_DQ	-0.993	-0.996	-0.999	-0.997	-0.999	-1.000	-1.000	-1.000	-1.000	-1.000	0.000	Yes	No	Yes	Alert	PSD, TS
H1:PEM-CS_ACC_FLOOR_YCRYO_Z_DQ	0.951	0.889	0.716	-0.152	-0.995	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	Yes	No	Yes	Alert	PSD, TS
H1:PEM-CS_MAG_EBAY_SEIRACK_QUAD_SUM_DQ	-0.738	-0.910	-0.149	-0.174	-0.149	-0.013	0.523	0.057	-0.010	0.115	0.000	Yes	No	No	Alert	PSD, TS
H1:PEM-CS_MIC_EBAY_RACKS_DQ	0.232	-0.044	-0.080	0.392	-0.038	-0.062	-0.289	-0.087	-0.342	-0.172	-0.168	No	No	No	Ok	PSD, TS
H1:PEM-CS_ACC_BSC1_ITMY_X_DQ	-0.352	0.015	0.030	-0.061	-0.455	-0.378	-0.134	-0.144	-0.090	-0.058	-0.097	No	No	No	Ok	PSD, TS
H1:PEM-CS_ACC_OPLEV_ITMY_X_DQ	0.008	0.053	0.014	0.168	-0.001	-0.098	-0.059	-0.123	-0.323	-0.181	-0.198	No	No	No	Ok	PSD, TS
H1:PEM-CS_ACC_BEAMTUBE_YMAN_Z_DQ	0.140	-0.241	-0.018	-0.015	0.048	-0.015	-0.101	0.031	-0.002	0.014	0.005	No	No	No	Ok	PSD, TS
H1:PEM-CS_MIC_LVEA_VERTEX_DQ	-0.159	-0.115	-0.090	-0.016	0.007	-0.030	-0.306	-0.185	-0.197	-0.152	-0.175	No	No	No	Ok	PSD, TS

Populating PEM web page



[Link]

PEM Channel Info

Home | LHO | LLO | Database | Contact

Channel Lookup

hide ▲

(Sensor for selected channel will flash on map.)

Paste a channel name:

[ ] Go

OR

Select a channel:

[ ] Search LHO

[ ] Search LLO

OR

Click on a sensor on the map:

[ ]

Welcome to the PEM Channel Information Lookup Page

To start, use the search bar on the left to look up a channel, or search using sensor locations by choosing a map (LHO or LLO) in the navigation bar.

Channel Naming

Channels are named according to this convention:

site:system-building_sensor_location_descriptor(_axis, units)(_`BLRMS`_band)

More information here.

Sensor Information

These are the different sensors used:

Seismometers: Guralp model CMG-40T
Tiltmeters: Applied Geomechanics model 520 Biaxial Clinometers
Accelerometers: Endevco model 7754-1000 Isotron Accelerometer
Microphones: Bruel & Kjaer model 4130 with preamp model 2642 and dual microphone power supply model 2810
Magnetometers: Bartington Model MAG-03MC three axis fluxgate magnetometers

More information here.

Grid Locations

The grid locations for sensors are based on global LIGO coordinates, and measurements are all given in mm.

Created by Maggie Tse   Last Updated: Jan 27, 2013   Instructions for editing website

PEM Channel Info

Home | LHO | LLO | Database | Contact

Channel Lookup

hide ▲

(Sensor for selected channel will flash on map.)

Paste a channel name:

[ ] Go

OR

Select a channel:

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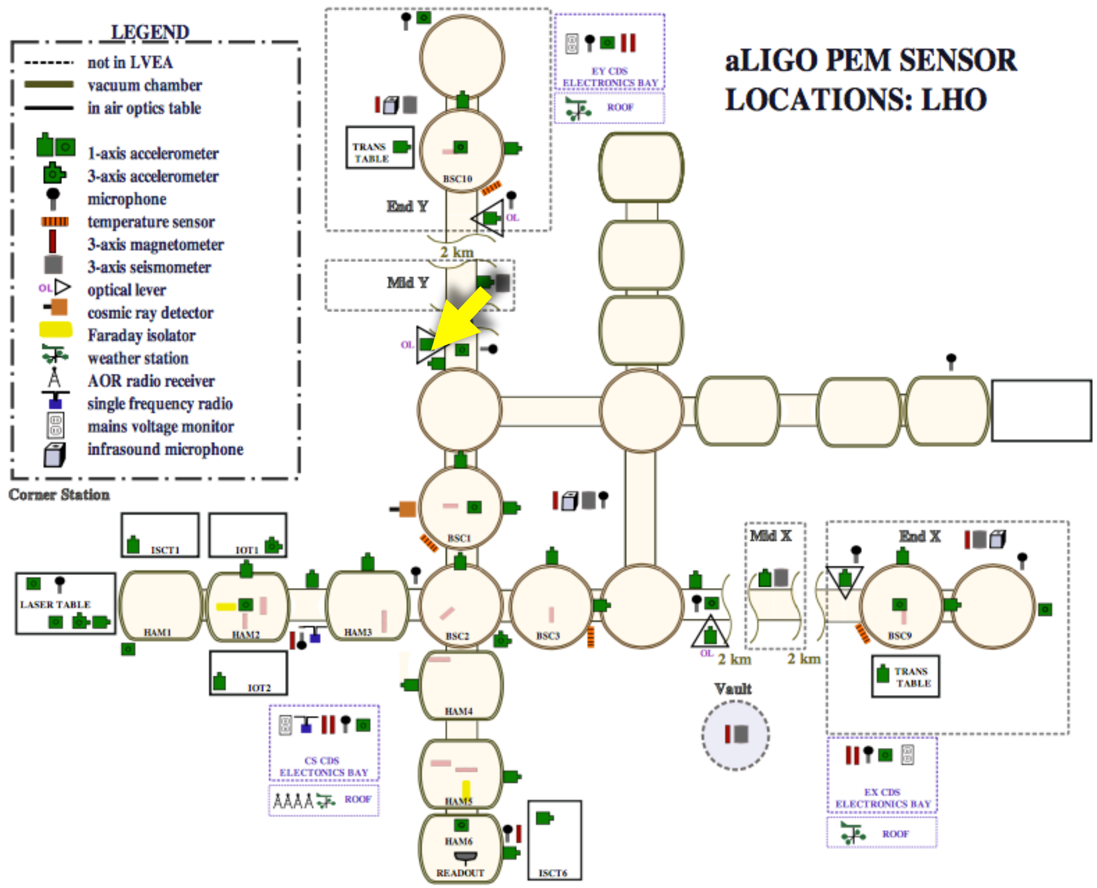
Click on a sensor on the map:

[ ]



Created by Maggie Tse | Last Updated: Jan 27, 2013 | Instructions for editing website

PEM Channel Info

Home | LHO | LLO | Database | Contact

H1:PEM-CS_ACC_OPLEV_ITMY_X

Calibration:

- *Factor:* 6.2 um/s2 per ADC count
- *Calulation:* ((10 m/s2) / 100 V) * (4 V / 65536 counts)
- *Range:* 1 - 900 Hz
- *Amplitude Error:* 7%
- *Phase Error:* Not reported
- *Date Calibrated:* 2013-08-23

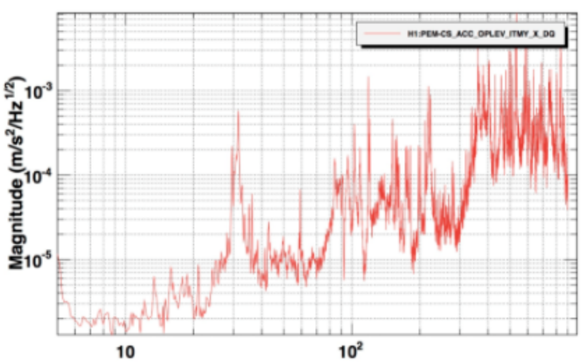
Sample rate: 8192

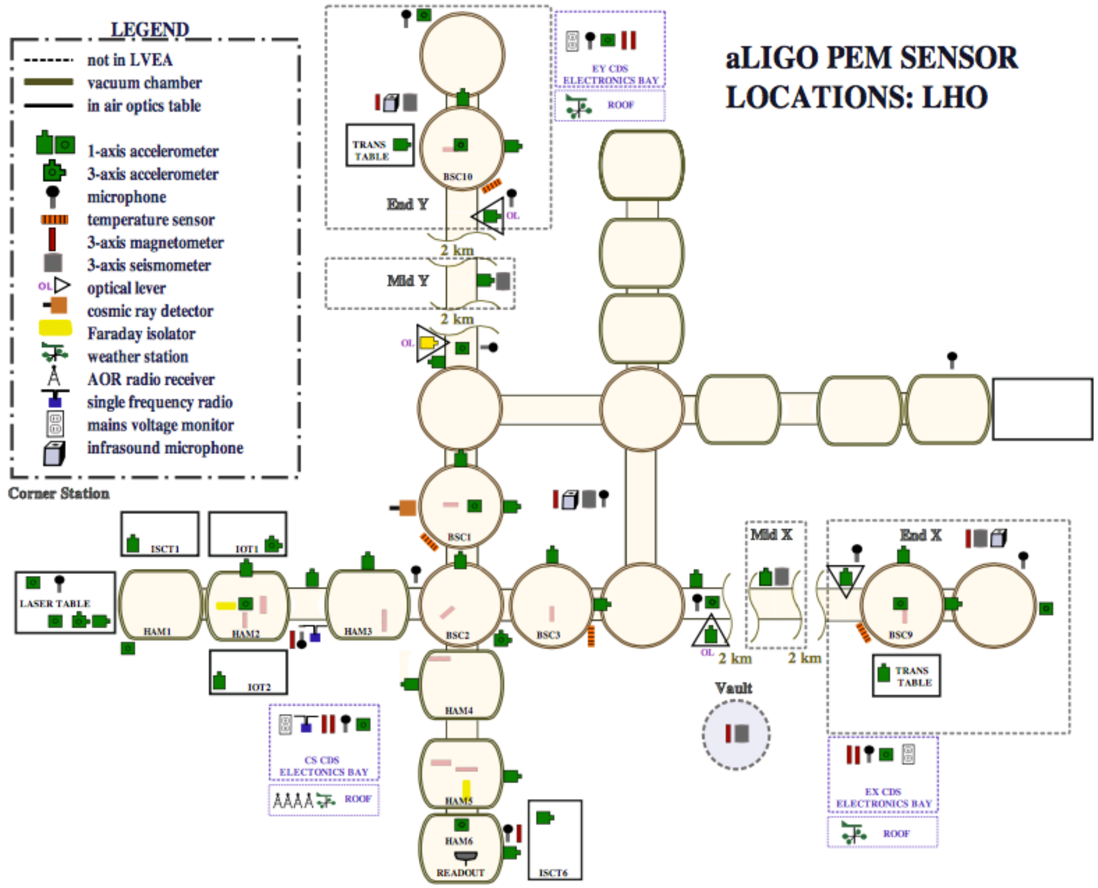
Grid location (x, y, z) (mm): (850, 11428, 2420)

Date Tested: 2013-08-23

Sample spectrum:

Power spectrum





Last Updated: Jan 27, 2013

Instructions for editing website

PEM Channel Info

Home | LHO | LLO | Database | Contact

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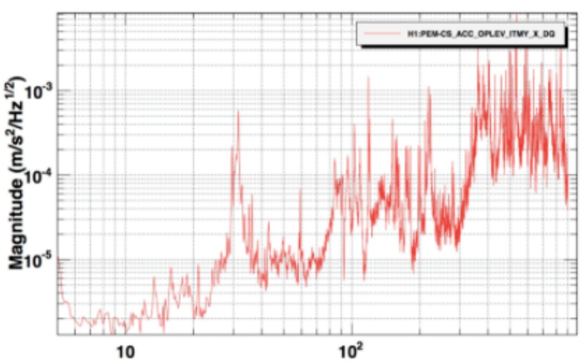

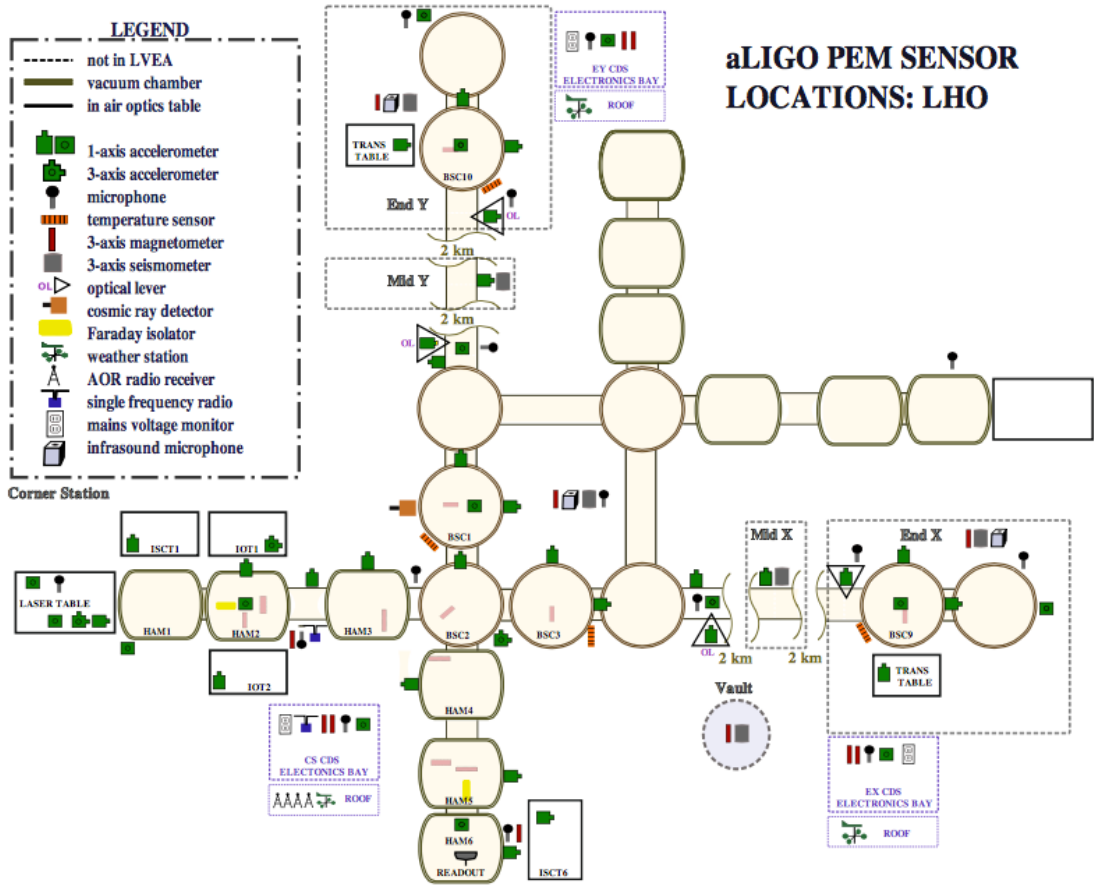

Last Updated: Jan 27, 2013

Instructions for editing website

Calibration

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Sample rate: 8192

Grid location (x, y, z) (mm): (850, 11428, 2420)

Date Tested: 2013-08-23

- **Accelerometers calibrated to match LVEA seismometer**
- **Microphones calibrated with pressure piston**
- **Factory calibration given if not calibrated through DAQ**

Grid location

H1:PEM-CS_ACC_OPLEV_ITMY_X

Calibration:

- *Factor:* 6.2 um/s2 per ADC count
- *Calulation:* ((10 m/s2) / 100 V) * (4 V / 65536 counts)
- *Range:* 1 - 900 Hz
- *Amplitude Error:* 7%
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- *Date Calibrated:* 2013-08-23

Sample rate: 8192

Grid location (x, y, z) (mm): (850, 11428, 2420)

Date Tested: 2013-08-23

Grid location gives distance from the projection of the vertex onto the LVEA floor. Useful for source pointing and propagation velocities.

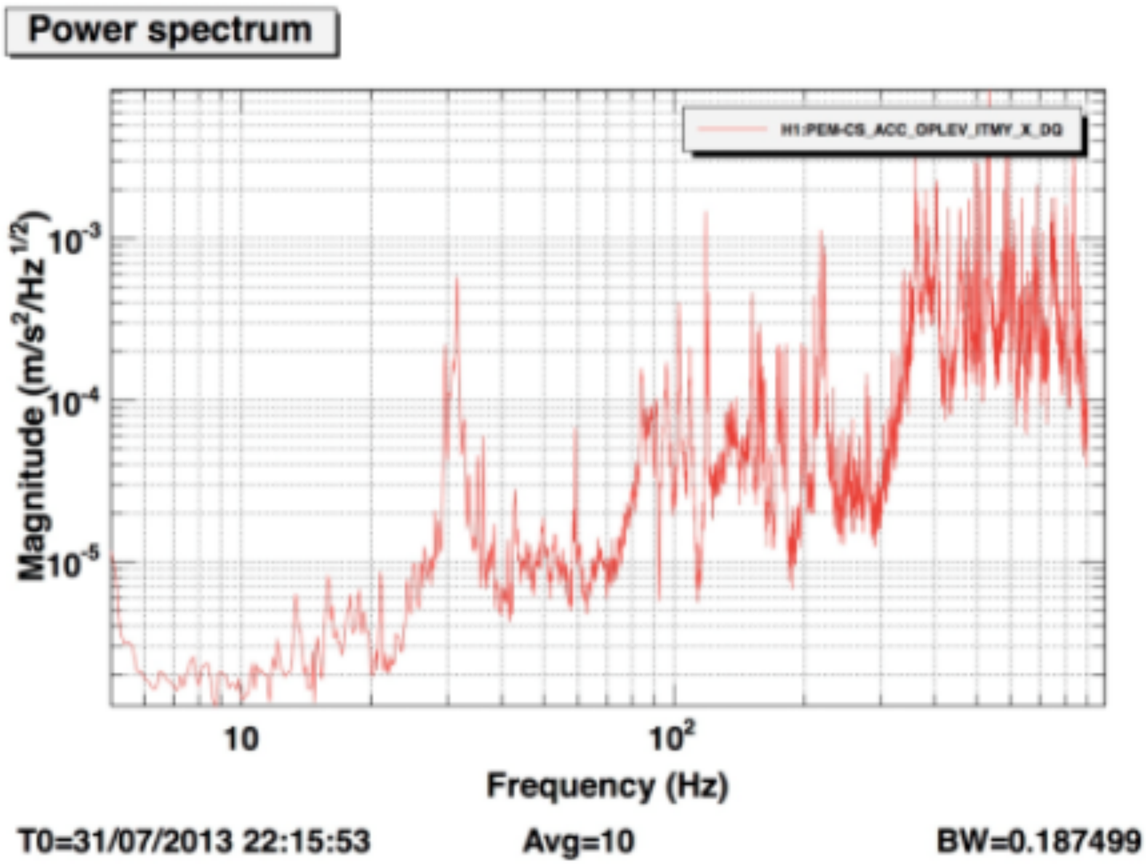
Trilateration of sensor location

Vinny and Tristan using monuments and laser distance finder

Picture

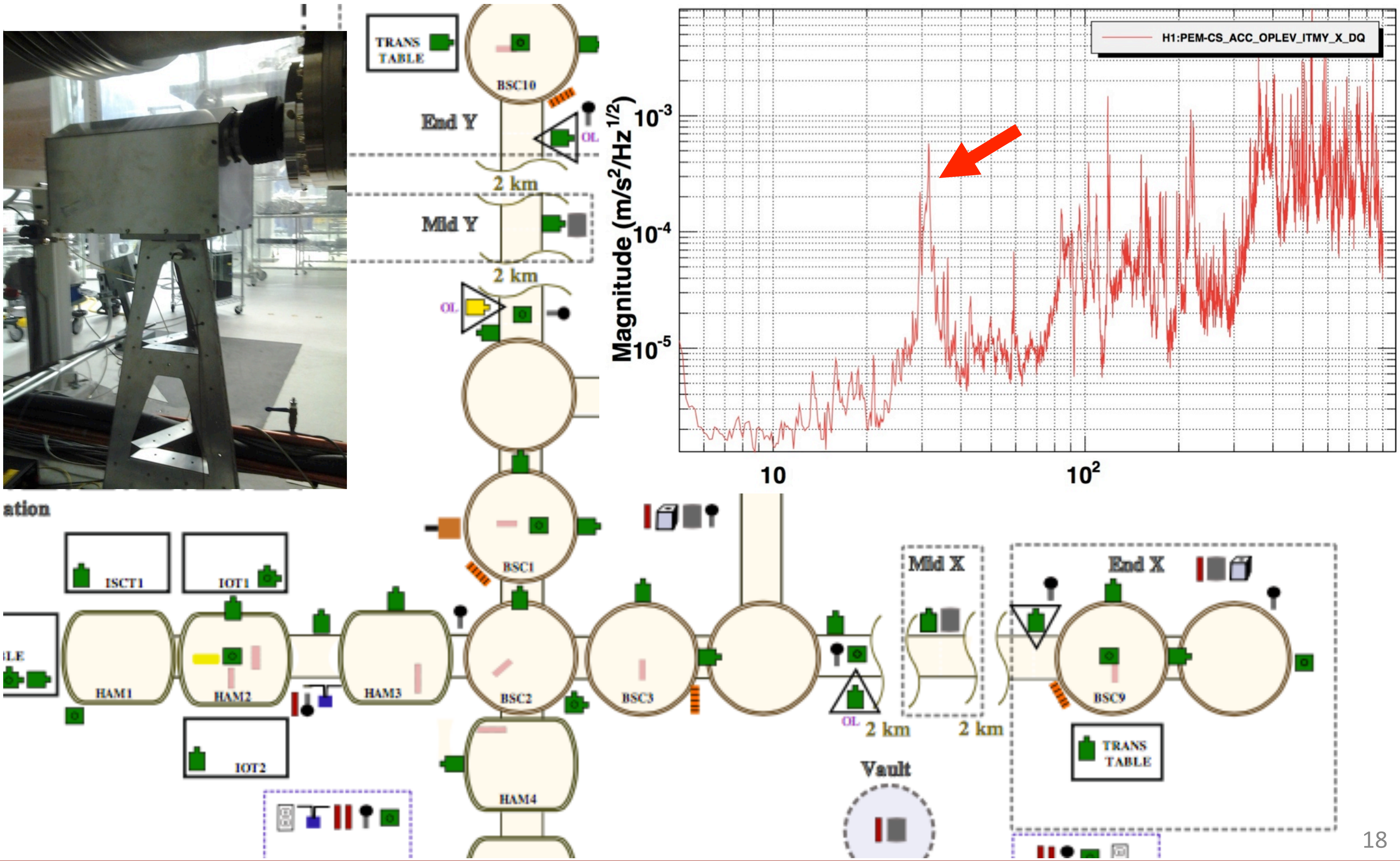
Calibrated spectrum

Sample spectrum:



Early investigations with the new PEM system

Web page spectrum suggest op-lev transmitter pier resonances may be too low

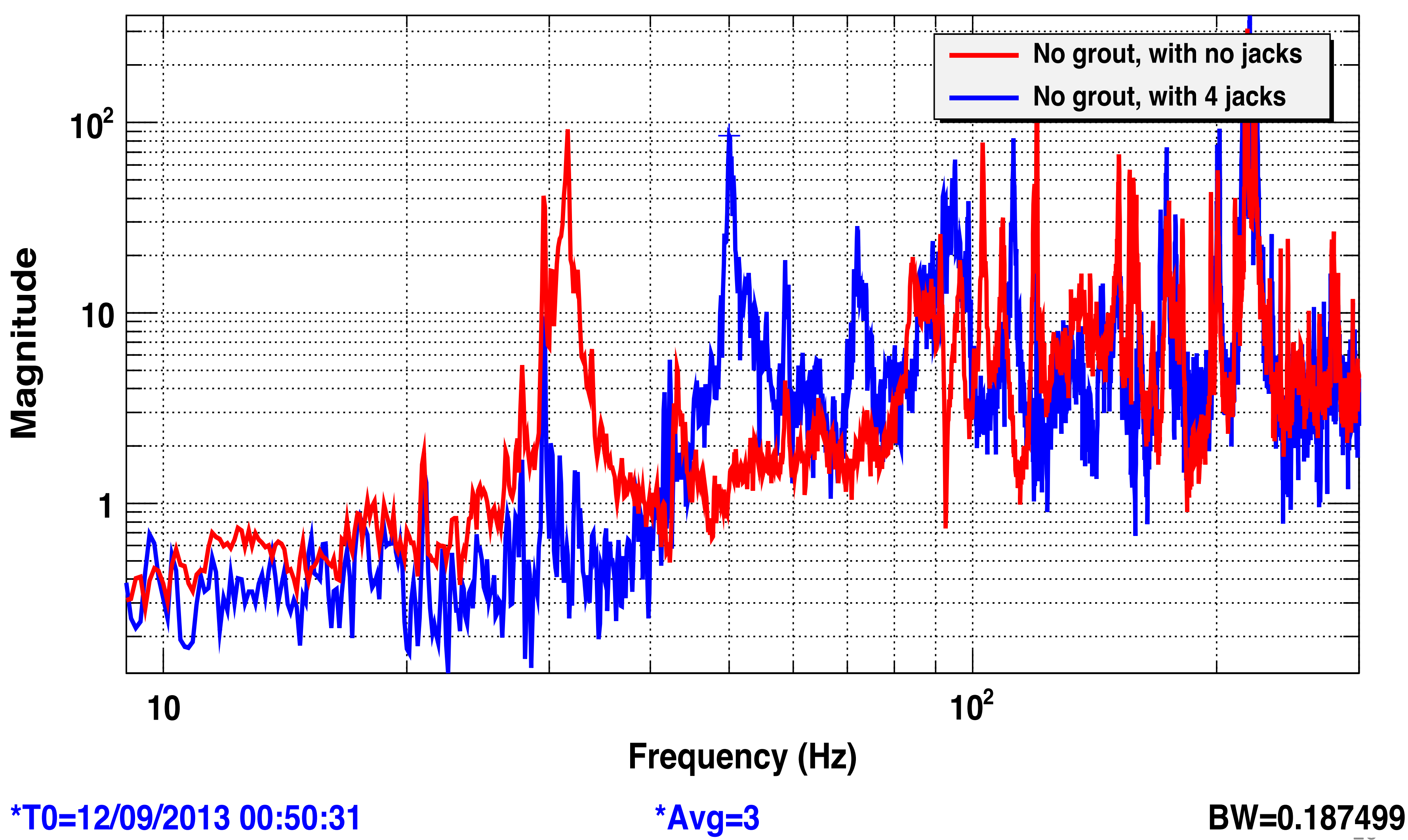


Test to see if grouting will help

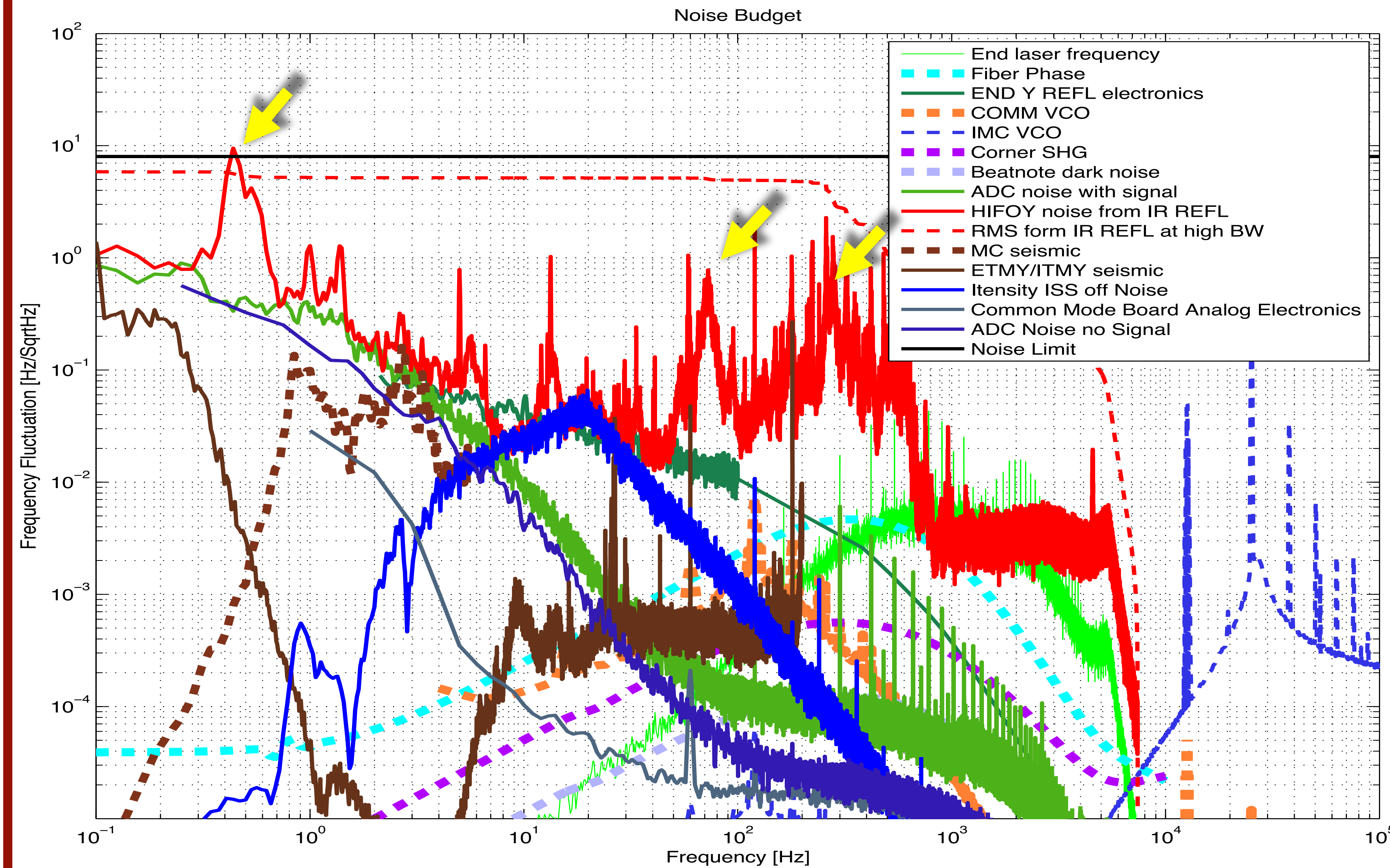
Added machine jacks stiffen floor connection (with T. Vo)

Peak moves up

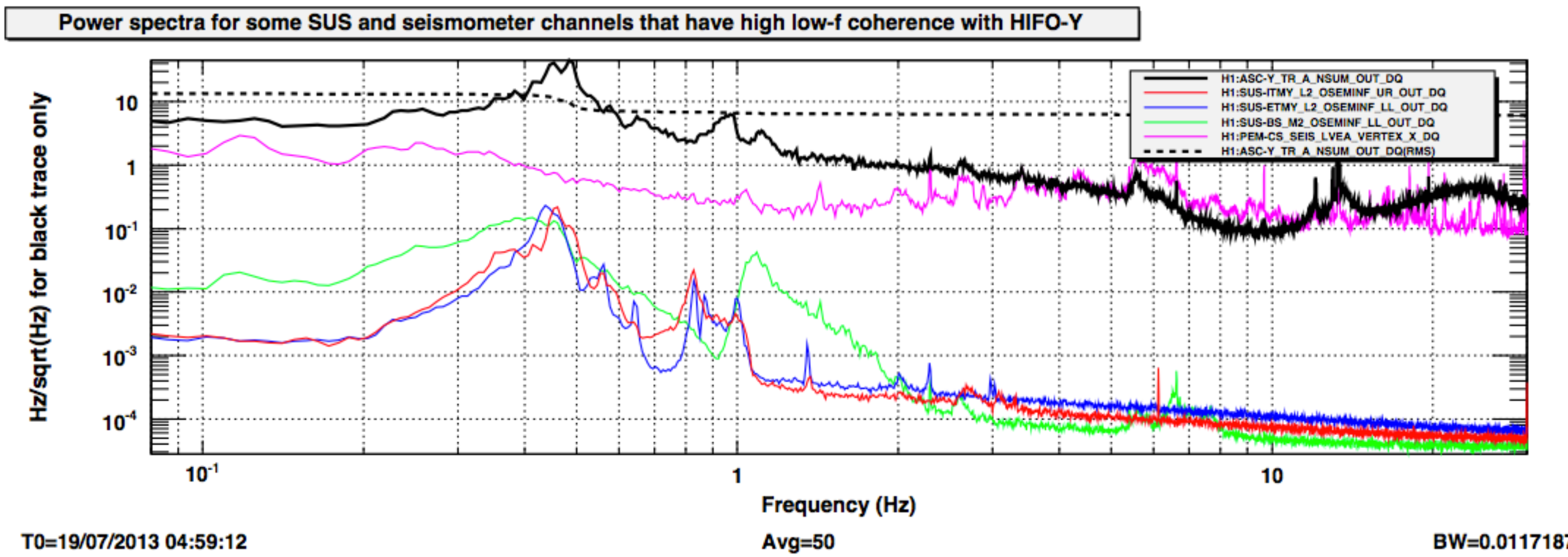
Resonance given by connection to floor, so grouting should help

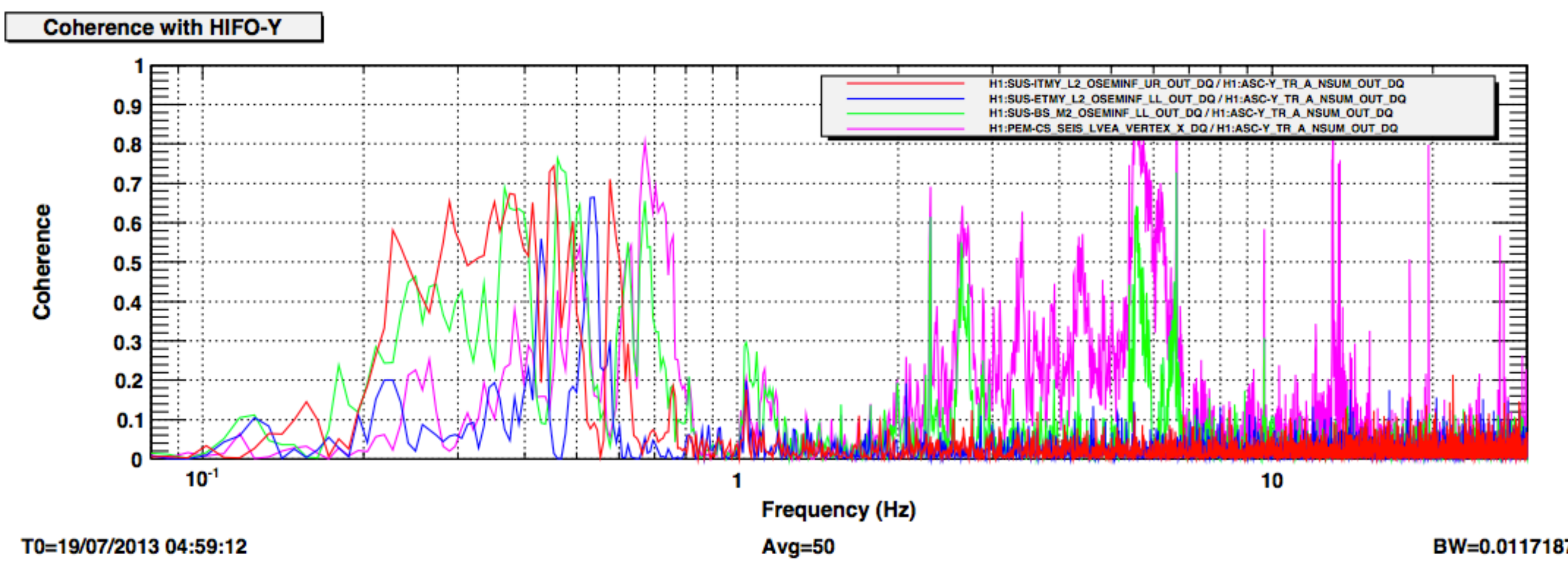


Excess noise in HIFO-Y ALS test

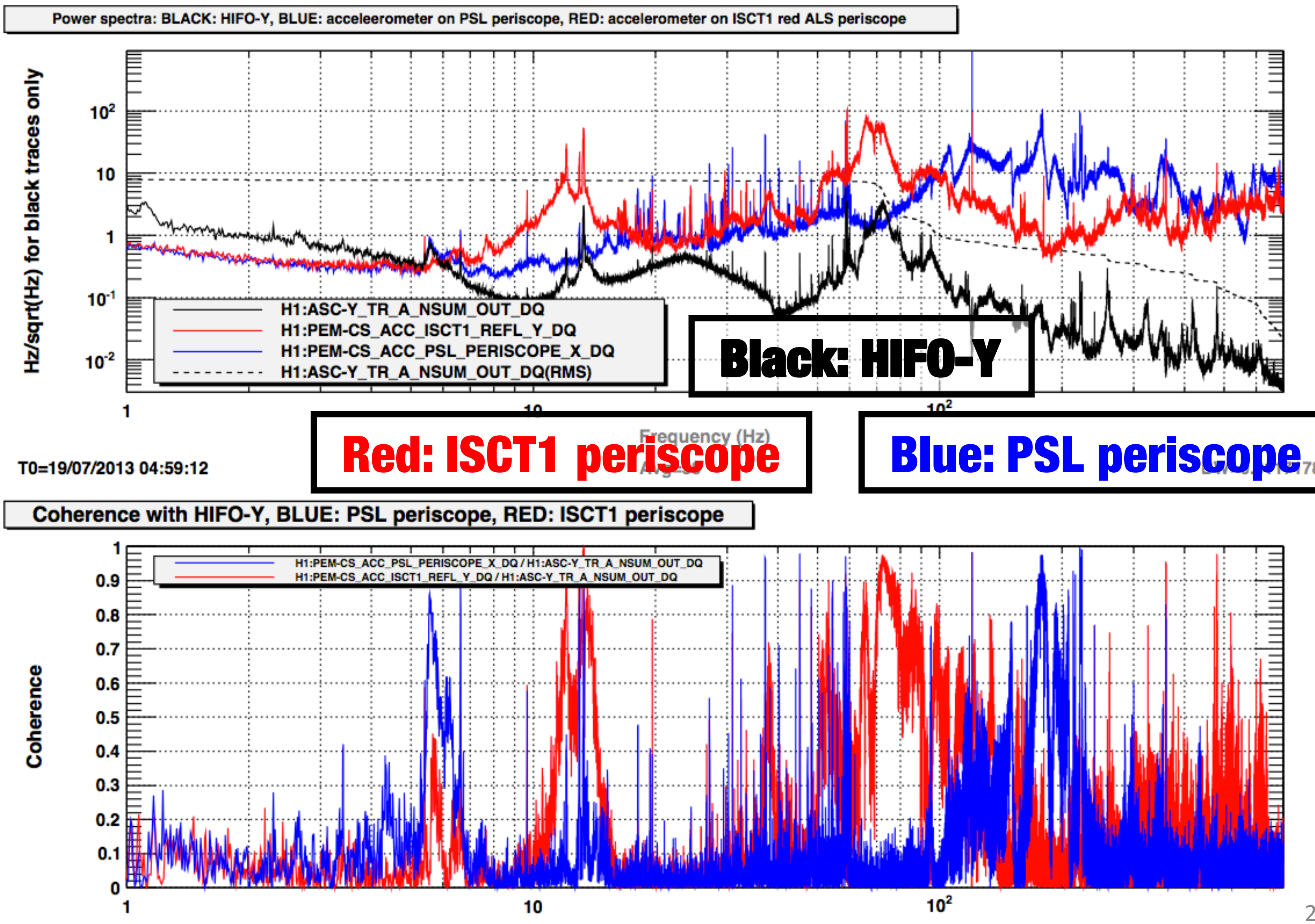


Low-f coherence with seismic and OSEMs





Accelerometer coherence at higher f



ISCT1 ALS periscopes

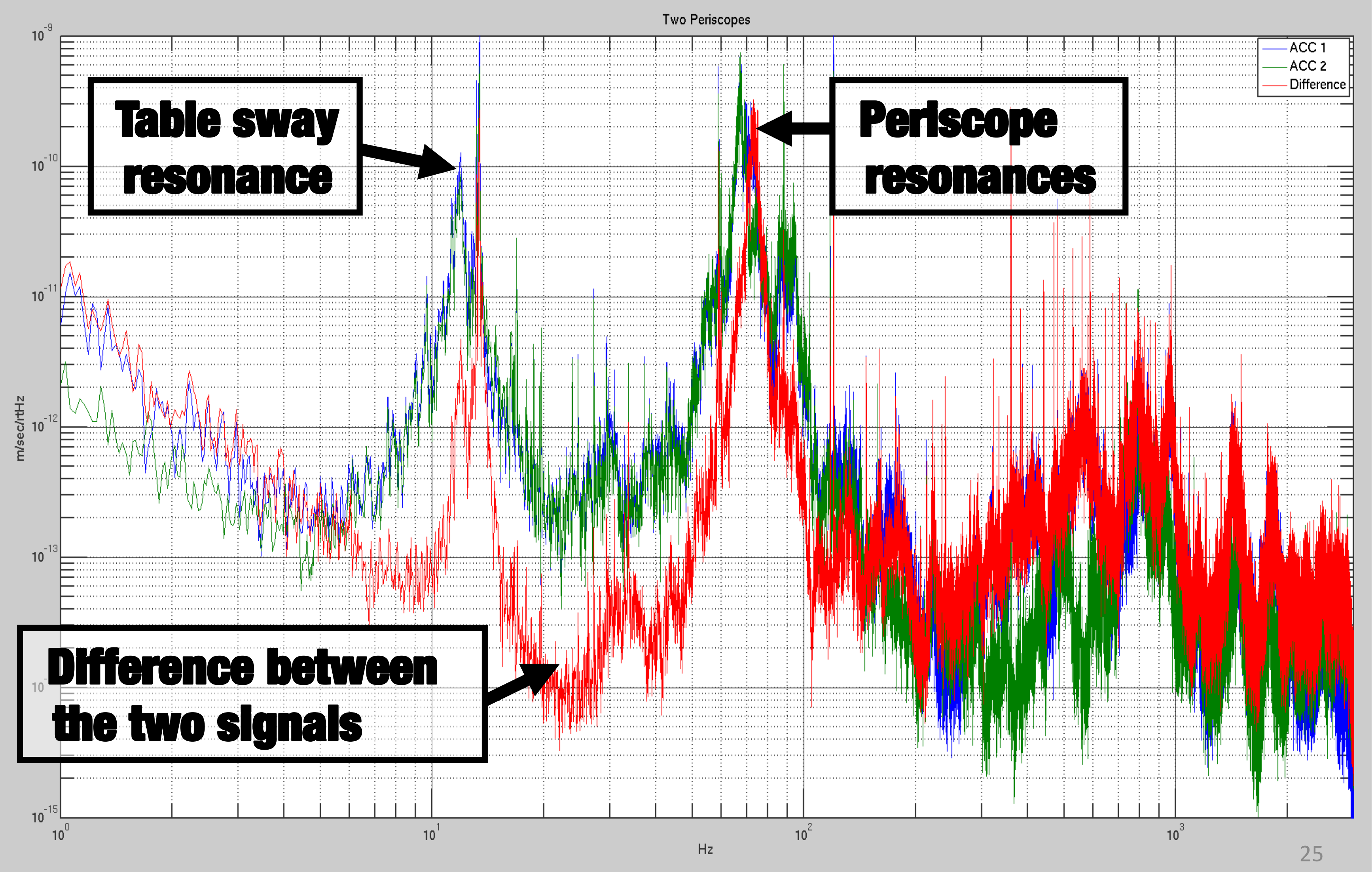
Green light from Y-end

Infra-red light from PSL

Red doubled and beat against green – differential path length changes show up in beat note

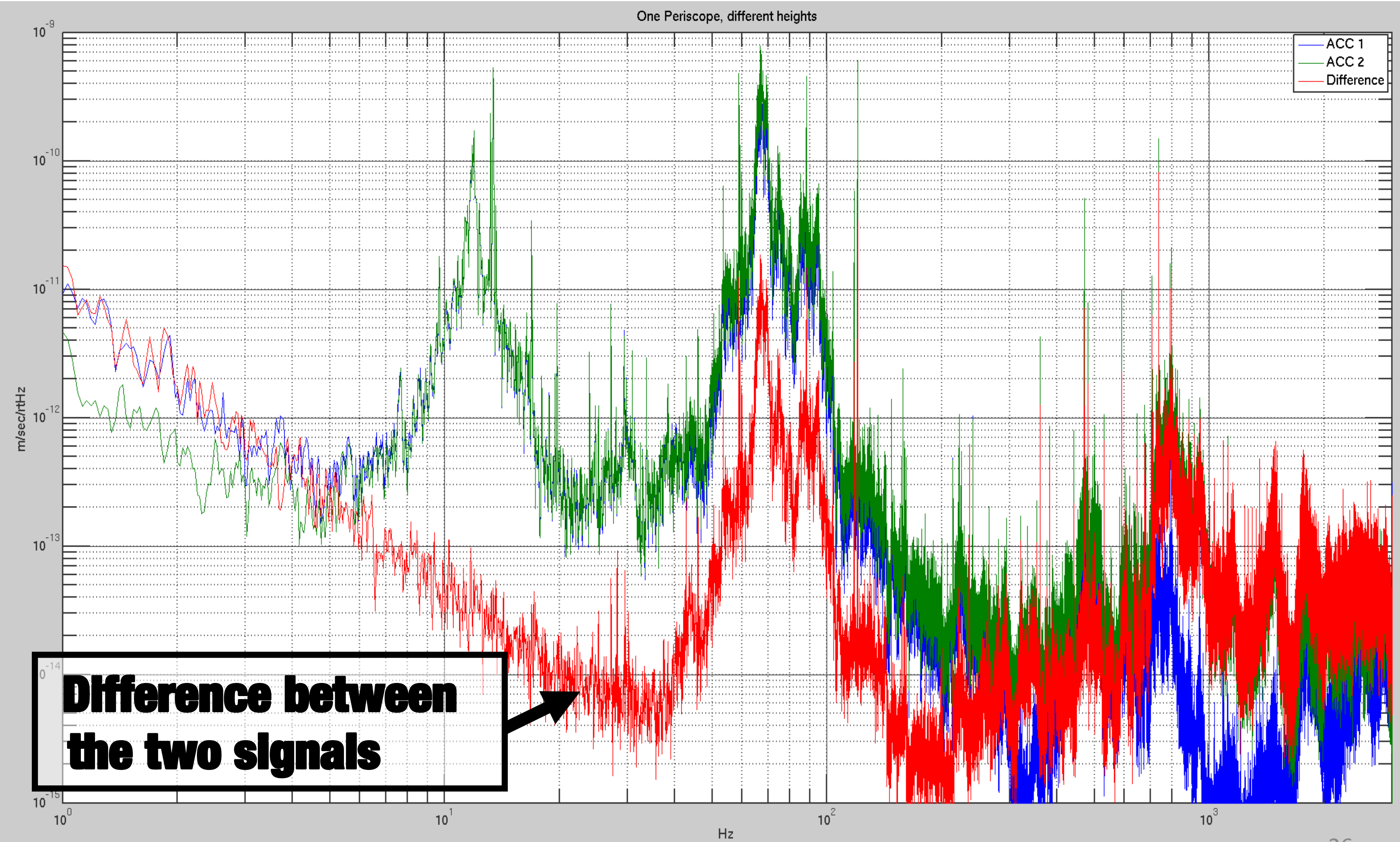
Differential motion between periscopes

Accelerometer on each periscope



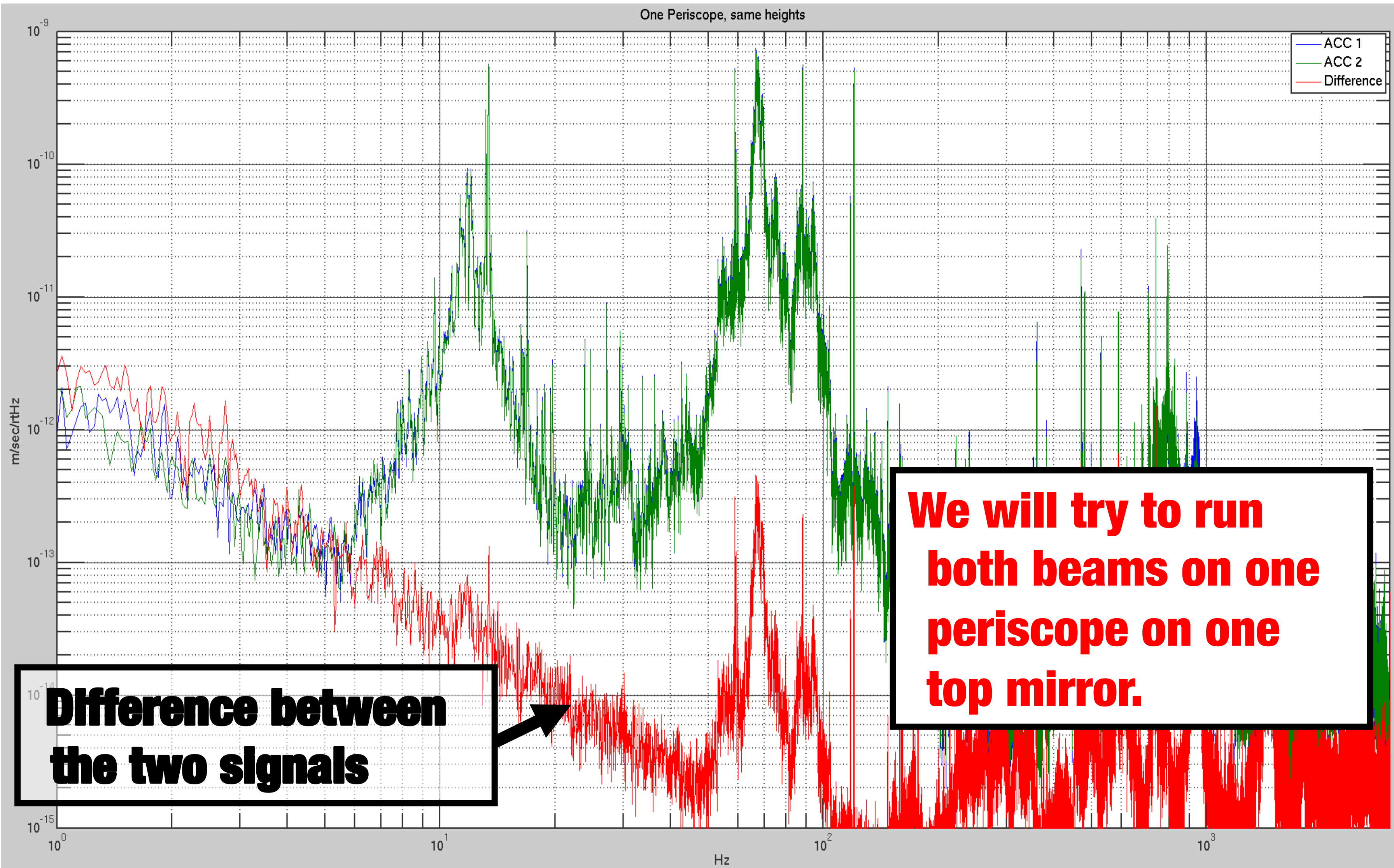
Differential motion same periscope

accelerometers at different heights - potential location of mirrors



Differential motion same periscope

Accelerometers at same height as if on one mirror



More PEM updates: PEM Projects on web page

Link

PEM Hardware Projects

RF

1) **Power meters for roof radio monitors.** Monitor RF in modulation frequency bands (e.g. 9MHz 45MHz) etc. A unit would monitor 6 frequencies at once and output 6 analog signals proportional to the power in the band.

✔ 2) **RF monitors at the main modulation frequencies for inside the LVEA (Richard @ LHO).** These would use signals from the RF distribution system as the local oscillators. They would be attached to lamda/2 antennas in the LVEA.

✔ 3) **An RF spectrum monitoring system that sweeps from a few KHz to a couple of GHz (U of O).** It would monitor the RF environment and output spectrograms using a spectrum analyzer and a laptop. The motivation for this is that coupling can occur at frequencies outside our 100kHz bands (e.g. 10 MHz).

4) **An audio frequency RF system (1 Hz to 10,000 Hz).** Would use a Marconi antenna and audio amp into the DAQ system.

PEM Hardware Projects

Non-RF

1) 6 more coil magnetometers. One in each building, would reproduce design of vault coil magnetometers.

✔ 2) Eotvos infrasound microphones.

✔ 3) A temporary monitor for electrostatic fields inside the BSCs (U of O). Would be connected to a dead-end wire that goes into the BSC.

✔ 4) Develop mounting system for chamber accelerometers.

PEM Software Projects

- ✔ 1) Dead channel monitor and more sophisticated band change monitor / coherence monitor (Dipongkar Talukder, U of O)
- ✔ 2) Modify DAQ system to produce channels containing the sum in quadrature for all 3-axis sensors. The quadrature channels would each replace 3 single-axis channels in the RDS.
- ✔ 3) Channel location documentation web page. Enter channel name to light up sensor location on sensor map, also shows photos of sensor in its location.
- ✔ 4) Channel calibration documentation
- ✔ 5) Direction to source finder (V Roma, U of O). Uses propagation delays to point in source direction
- 6) Serving PEM calibrations to glitch detectors

PEM Software Projects

With emphasis on stochastic and CW searches

9) Search for pulsars in selected auxiliary channels with modified all-sky and/or specific pulsar search code.

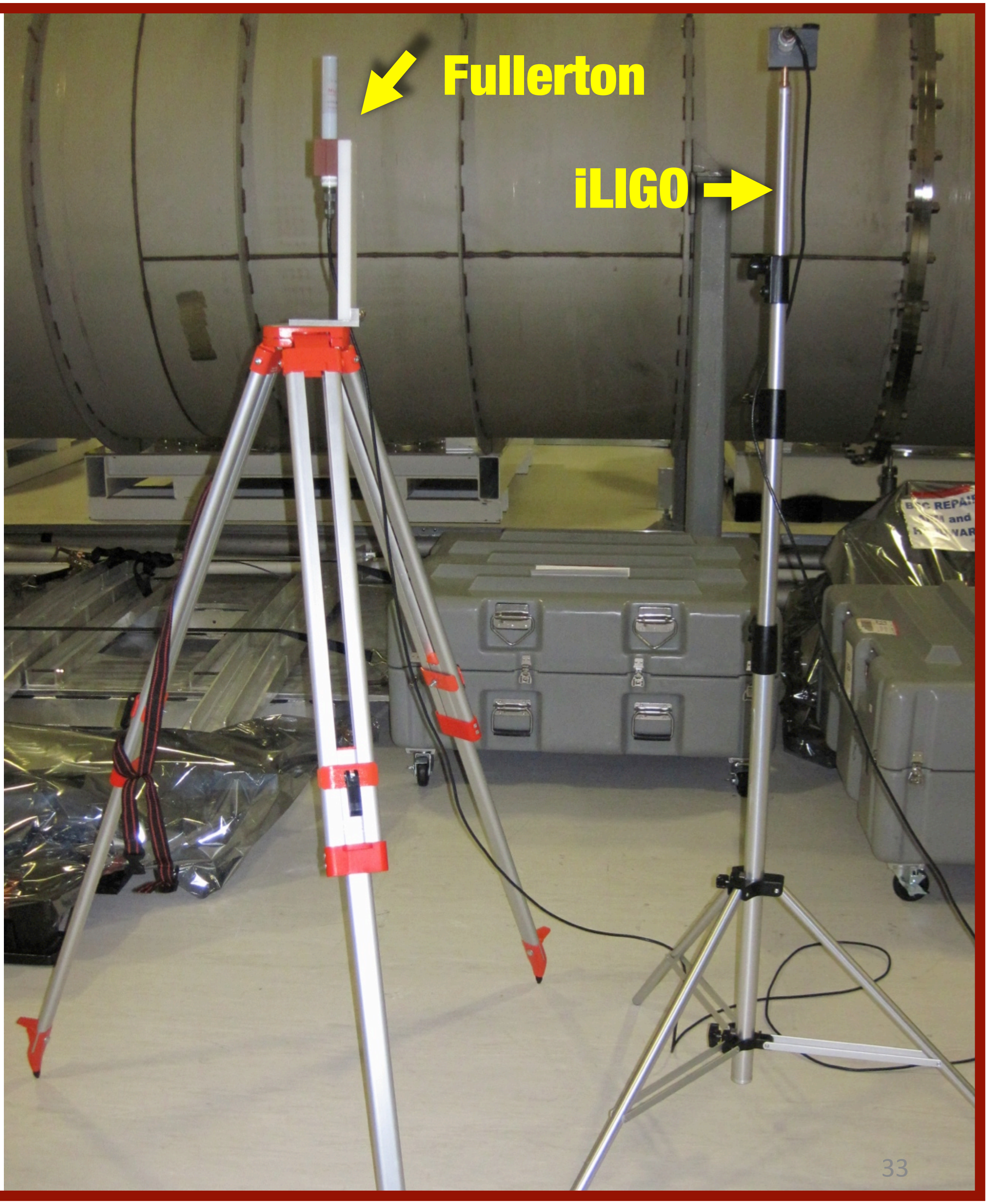
✔ 10) Modify stochastic code to search for signal between aux channels (Violet Poole, WSU). Compare empty channels between sites, coil magnetometer channels, and other aux channels.

✔ 11) Add significance FOM to Carleton DARM-aux coherence line monitor (Greg Mendell, LHO).

✔ 12) Modify coherence code to look between auxiliary channels instead of just DARM-aux (U of O).

✔ 13) 1Hz (and other) comb monitor (Ryan Magee, WSU, Greg Mendell, LHO). Searches for combs in DARM and auxiliary channels and monitors f-dependent amplitude.

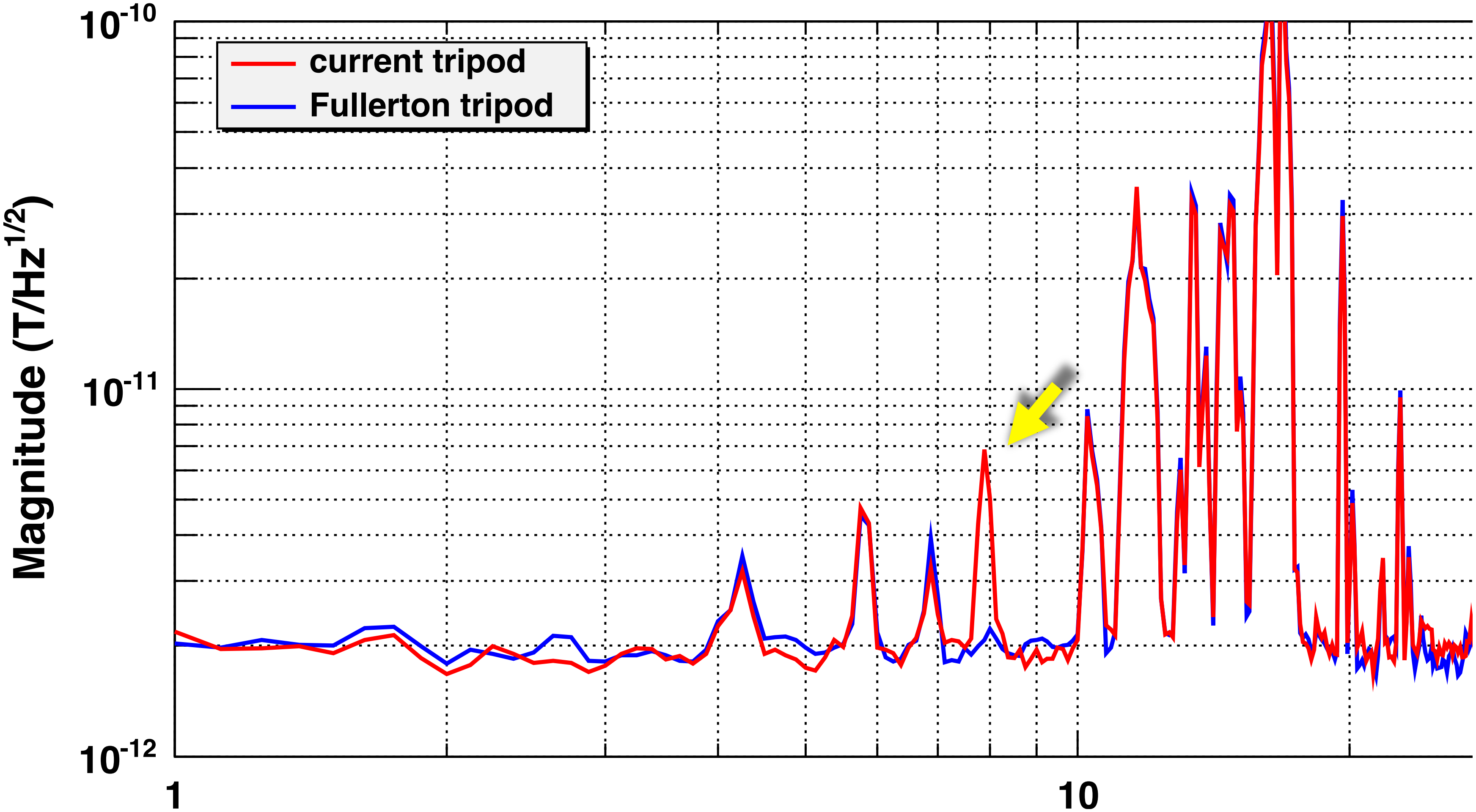
Test of Fullerton magnetometer mount and surveyors tripod



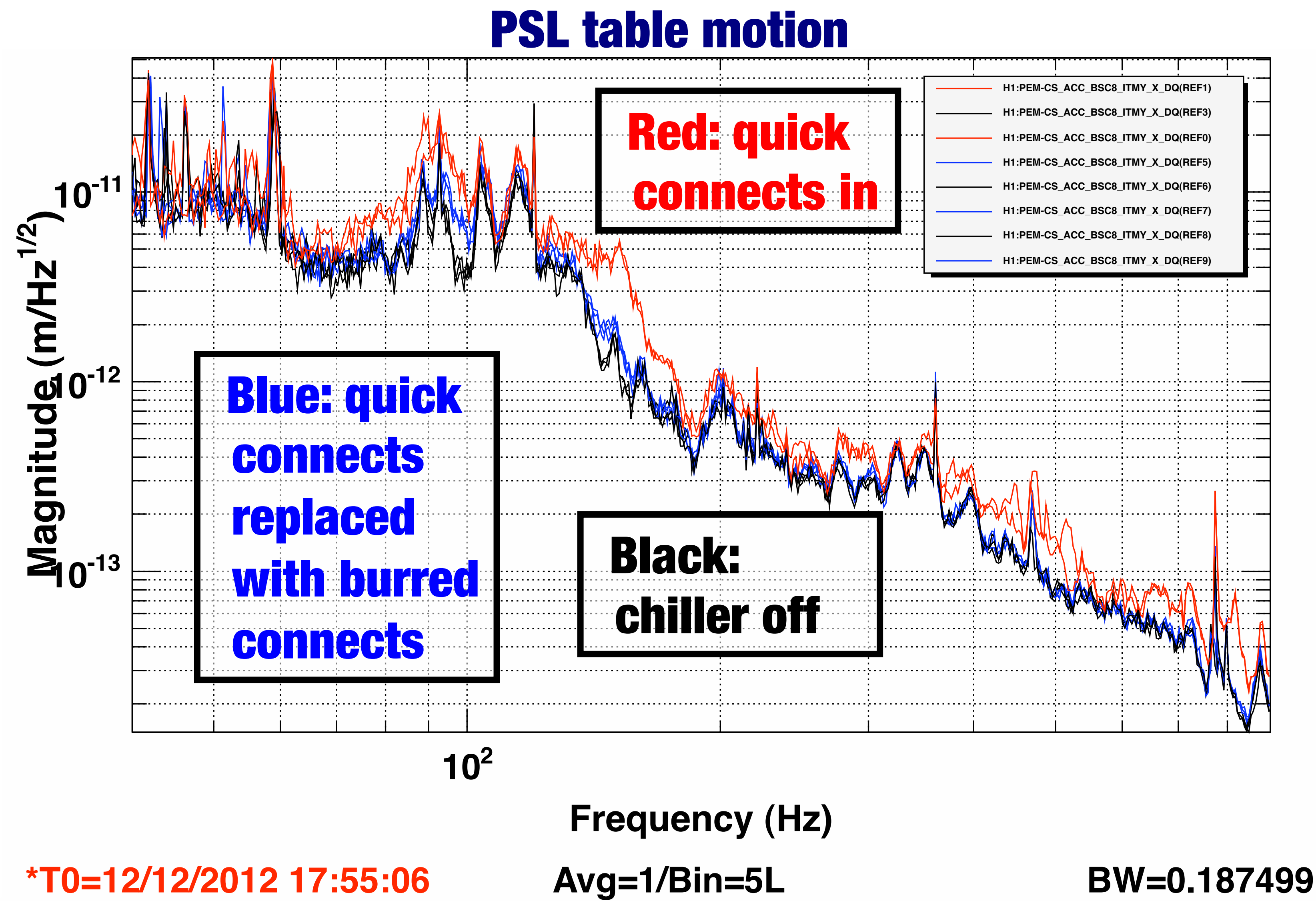
Design: Gabe Islas

Tripod resonance gone

Magnetometers read about the same except that LHO iLIGO one has extra peak (flagpole resonance)

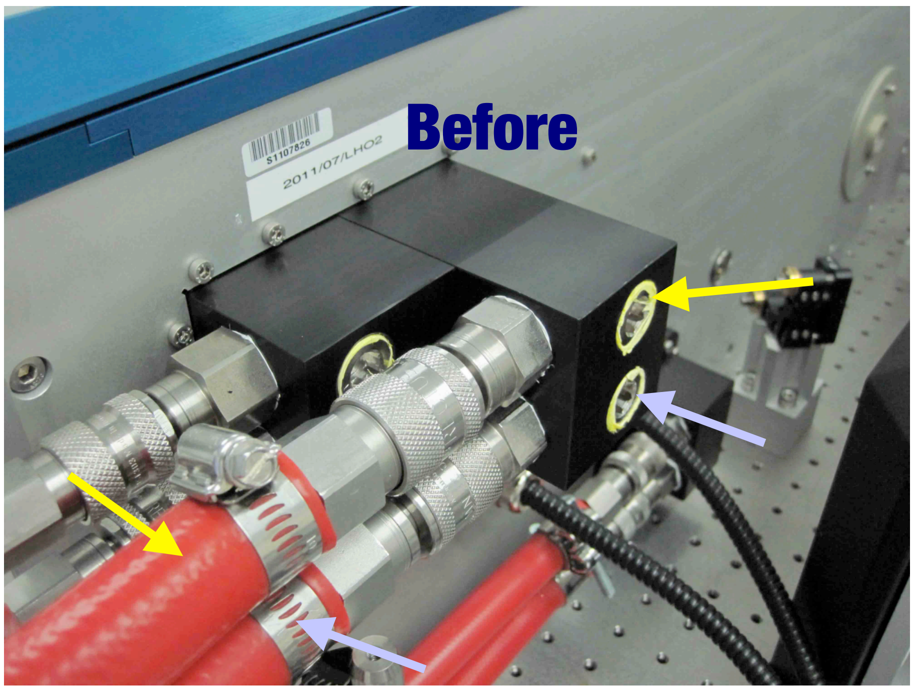


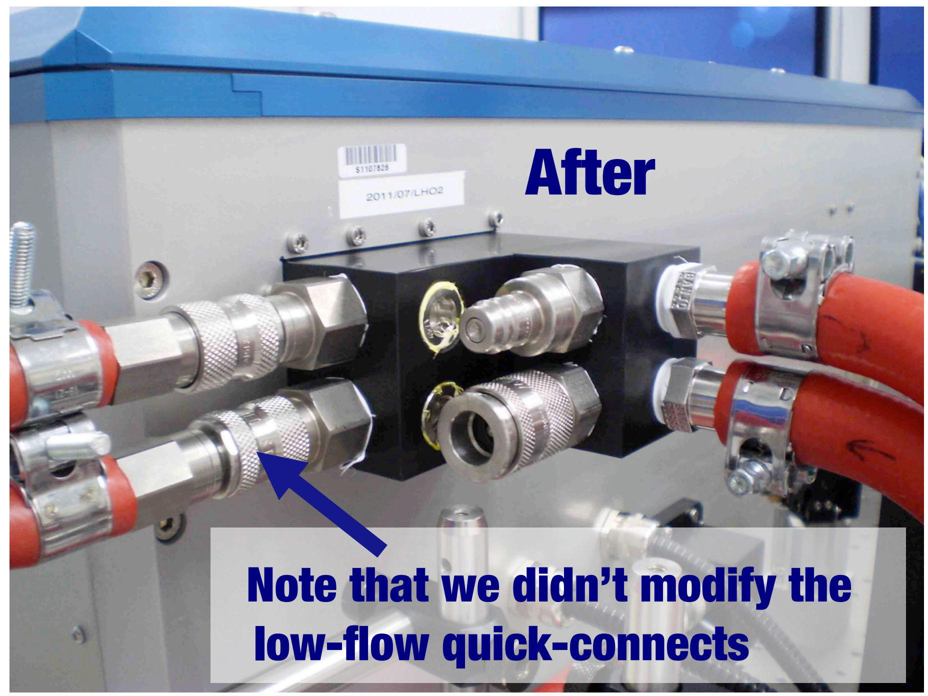
PSL chiller vibration problem solved by removing quick-connects



PSL vibration problem solved

My theory: short term imbalances in the momentum flow on and off the table cause varying forces on the table. Chaotic streams from the quick-connect nozzles cause the imbalance.



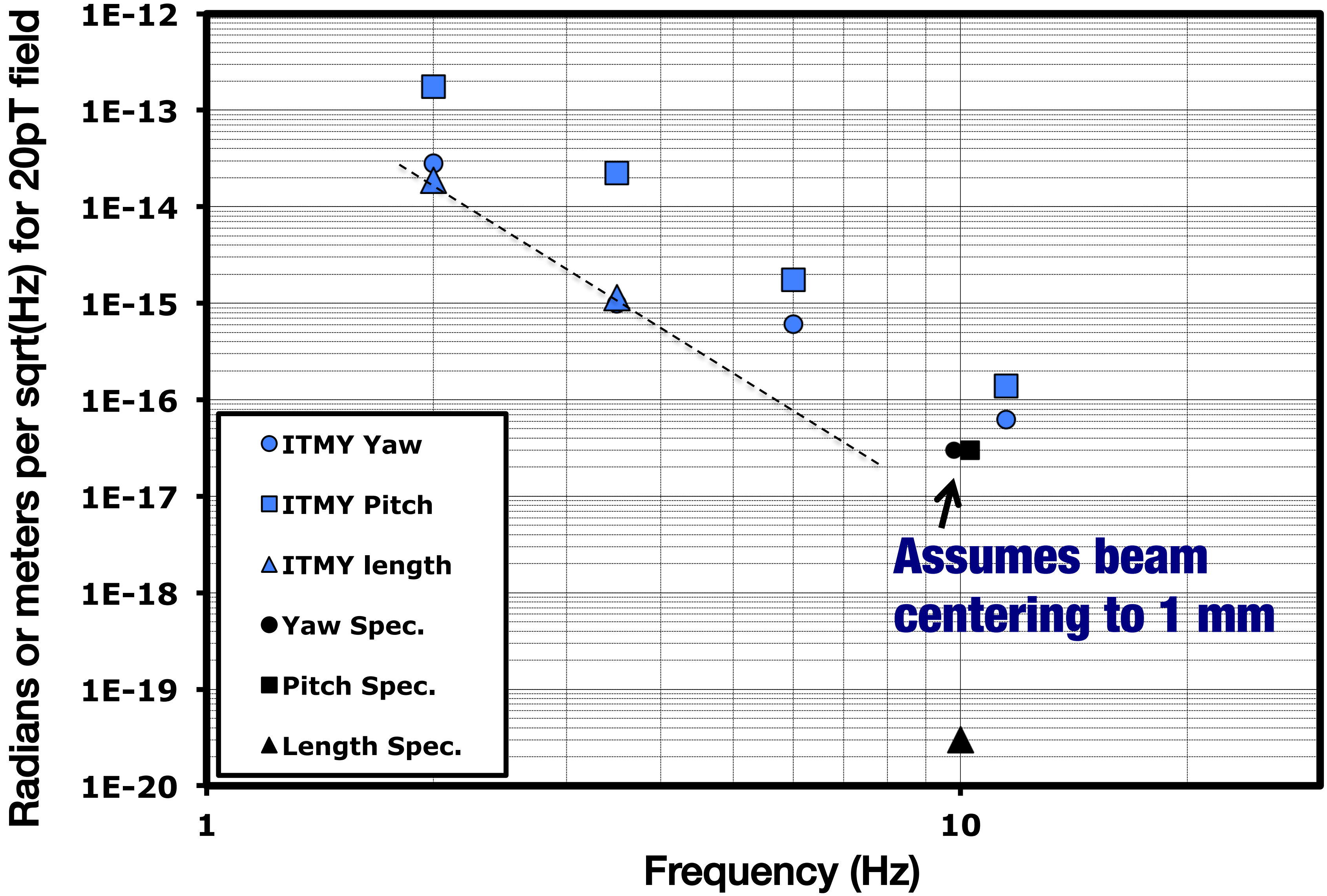


With O. Punken, M. Rodruck and R. Savage

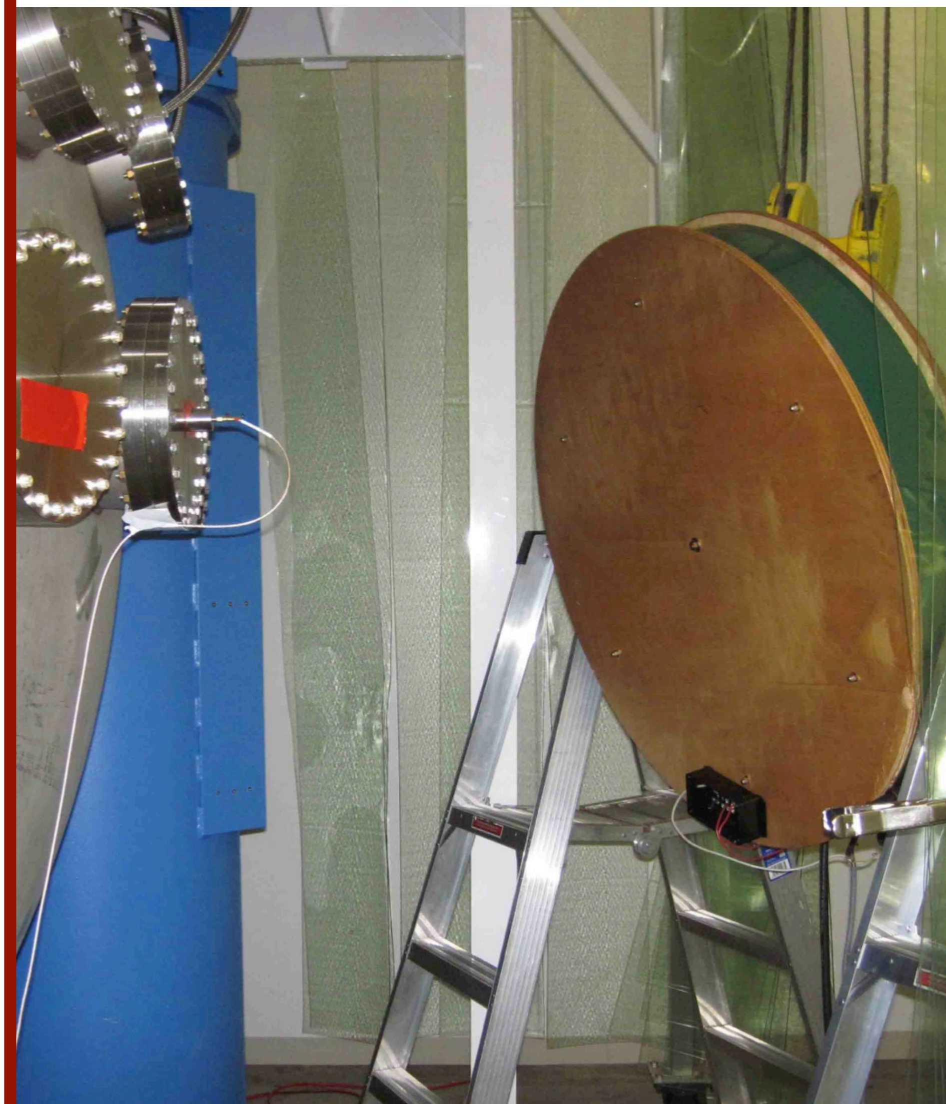
Excess magnetic coupling in OAT

Injection coils at ITMY in pseudo-Helmholtz configuration

First results

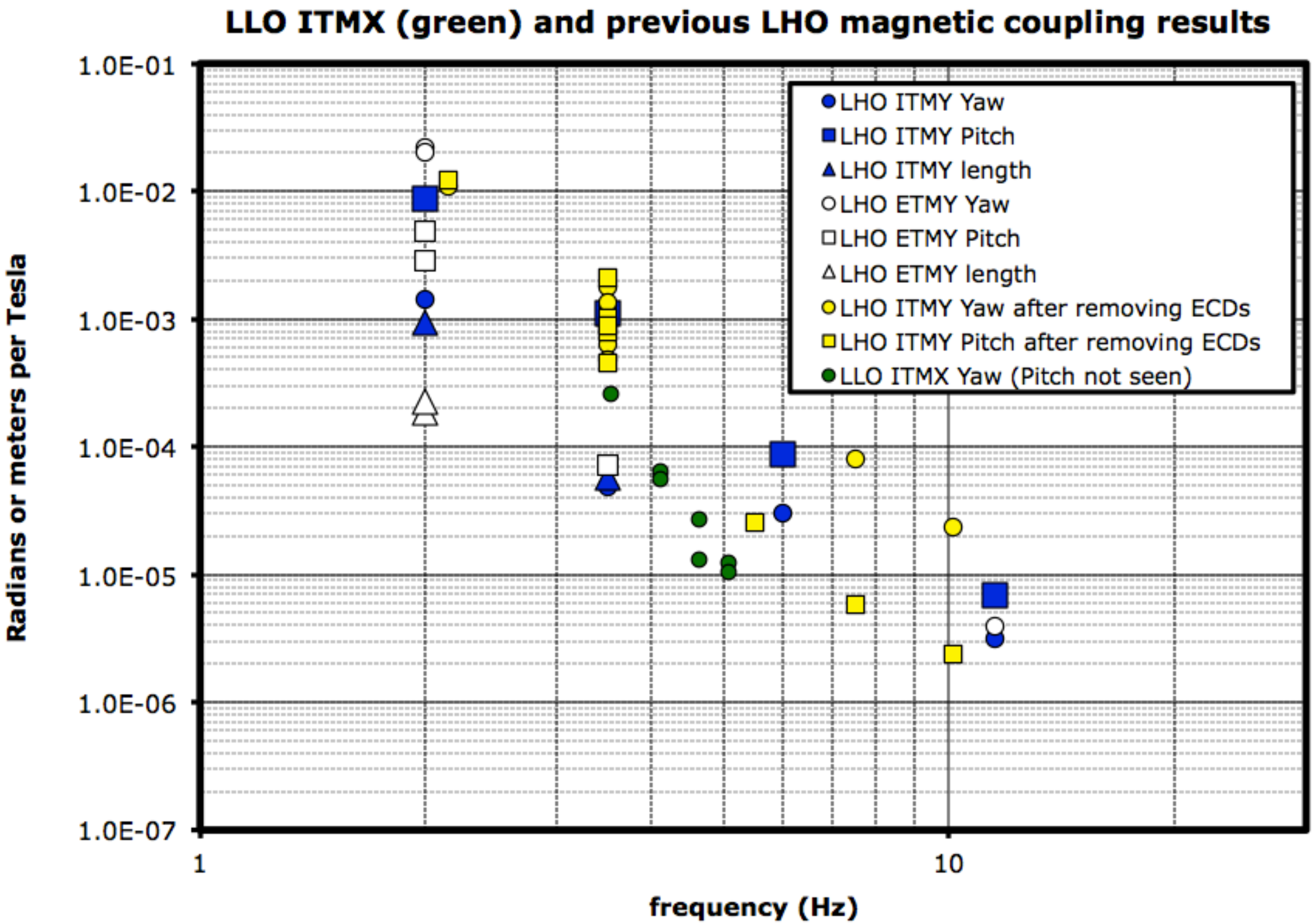


Repeated at ETMY and LLO ITMX



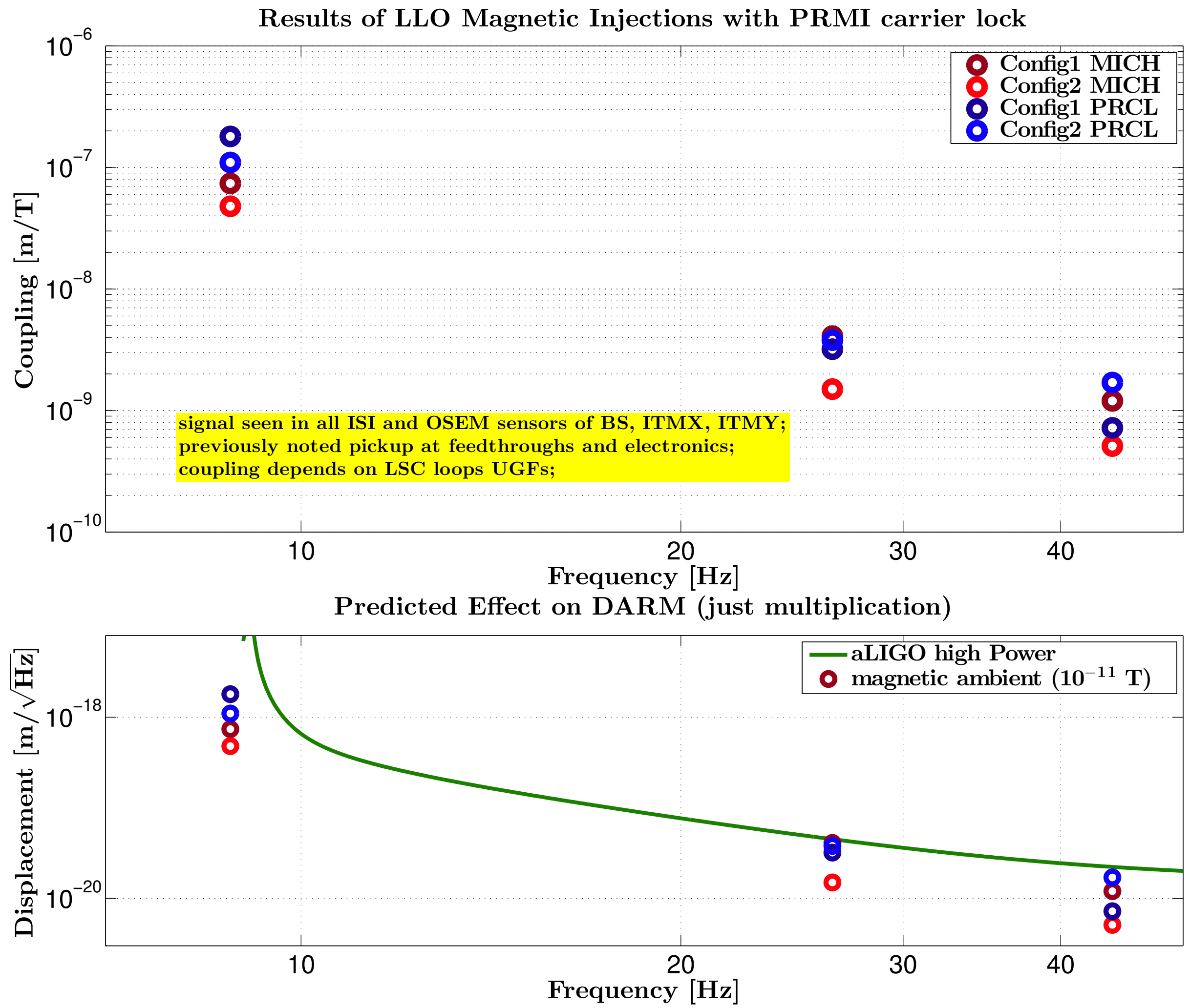
New LLO results with all LHO results

Angular results are for coupling with no SUS actuation



This morning's displacement measurement results from Anamaria

This includes coupling to cables etc.



Summary of magnetic coupling status

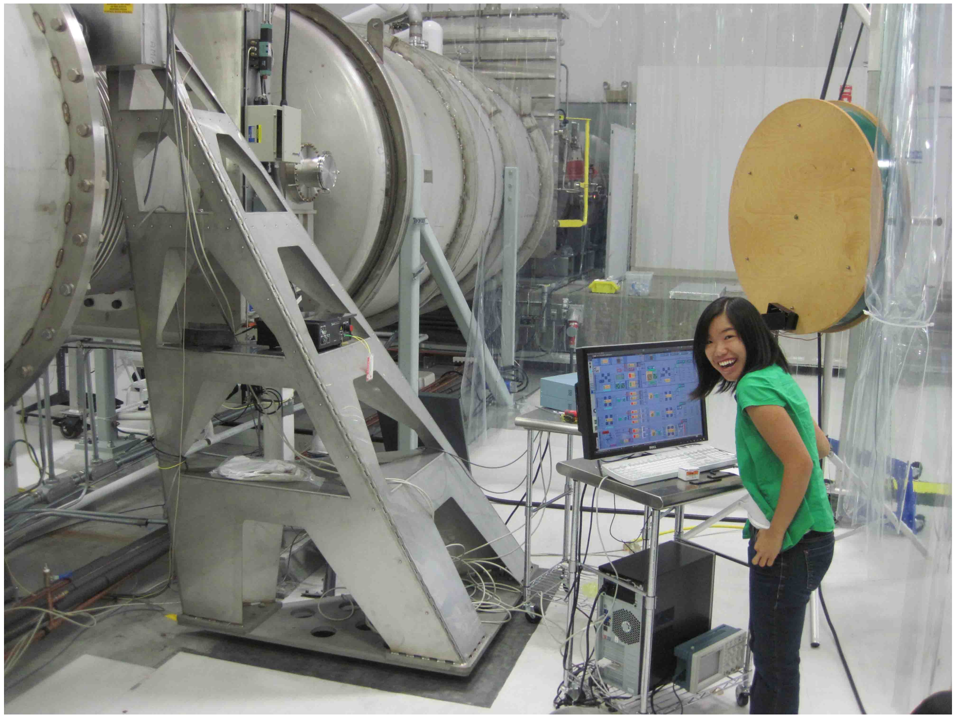
- **The scariest estimate of length noise from magnetic coupling to suspensions is an extrapolation from low-f injections made during OAT. The DRMI is more sensitive and recent LLO results suggests that, in band, coupling is close to the aLIGO noise floor.**
- **Estimates of angular noise from magnetic coupling to suspensions are similar, at about the aLIGO noise floor (and thus 10x spec) except for an anomalous yaw measurement.**
- **Estimates of length coupling from measured moments of the suspension parts are also close to the noise floor.**
- **The worst estimated coupling is to the UIM steel blade springs, not the 304 steel on the UIM and PUMre (2e-19/sqrt(Hz) @ 10 Hz, about 10 x spec. and right at the aLIGO noise floor at 10 Hz)**
- **We need to separate suspension coupling from electronics coupling for length noise measurements.**

Checks

1) Coupling to optical lever? Much higher fields at optical lever and its electronics produced smaller peak in optical lever channel. Signal went away when laser blocked.

2) Linear coupling? Increased field by 2.98 increased motion by 3.00 (would go as B^2 for induced moments).

3) Calibration? In-situ magnetometer calibration



Critical coupling