

# HEPI S4 PERFORMANCE

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## **CURRENT HEPI STATUS:**

- BSC's:

Position sensors and geophones blended at  $\sim 0.5\text{Hz}$  in X, Y, Z, and RZ directions.  $\rightarrow$  Gives isolation from 1 to 10Hz.

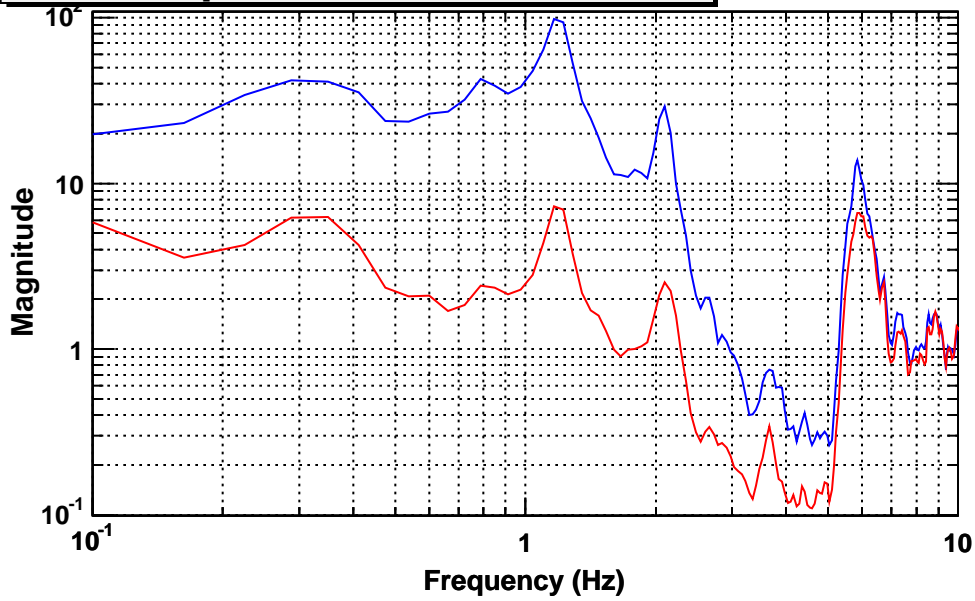
Sensor correction in X, Y, and Z directions.  $\rightarrow$  Gives isolation from around 0.1Hz to 1~2Hz.

Position sensor loops only in RX and RY.

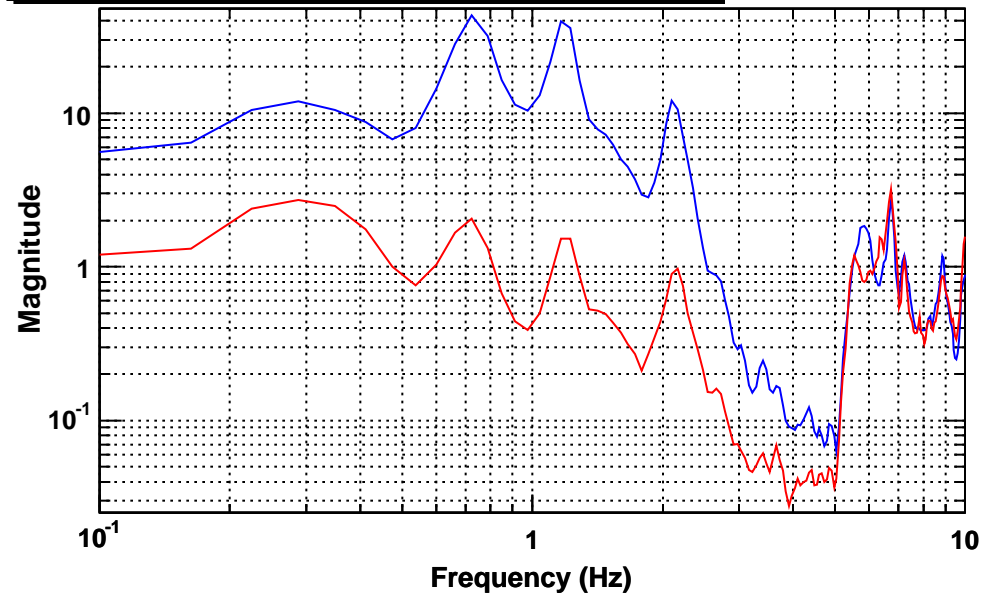
Factor of few to ten overall noise (power) reduction from 0.1 to 10Hz .

Performance  $ETM > ITM \sim BS$ ,  $Z > X \sim Y$ .

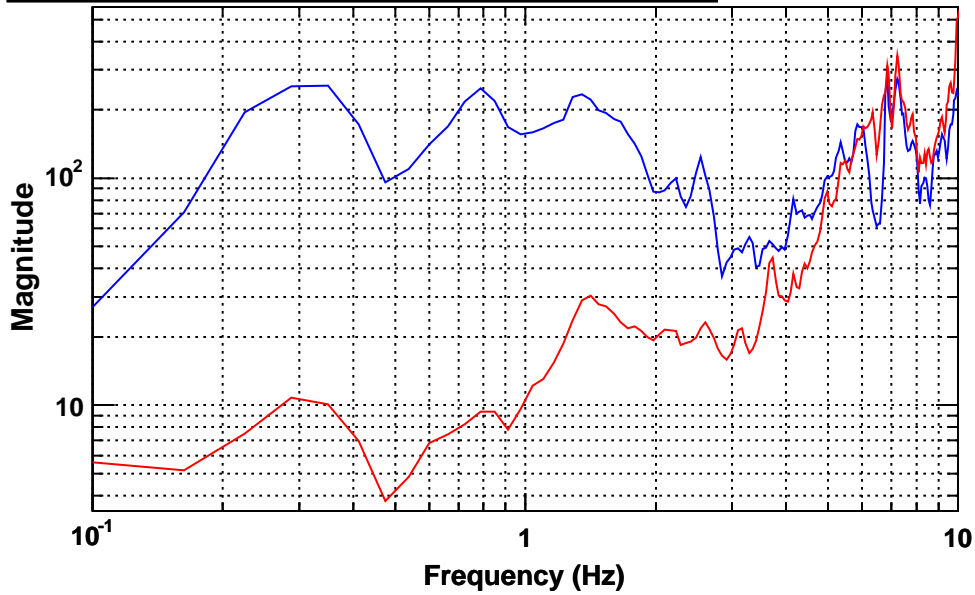
**Power spectrum, ETMX SUS X**



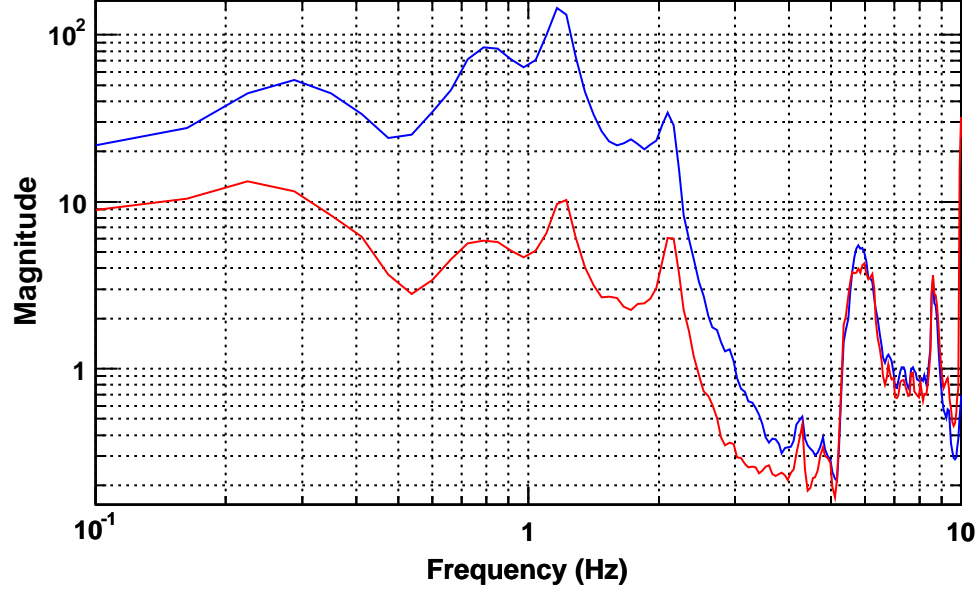
**Power spectrum, ETMX SUS Y**



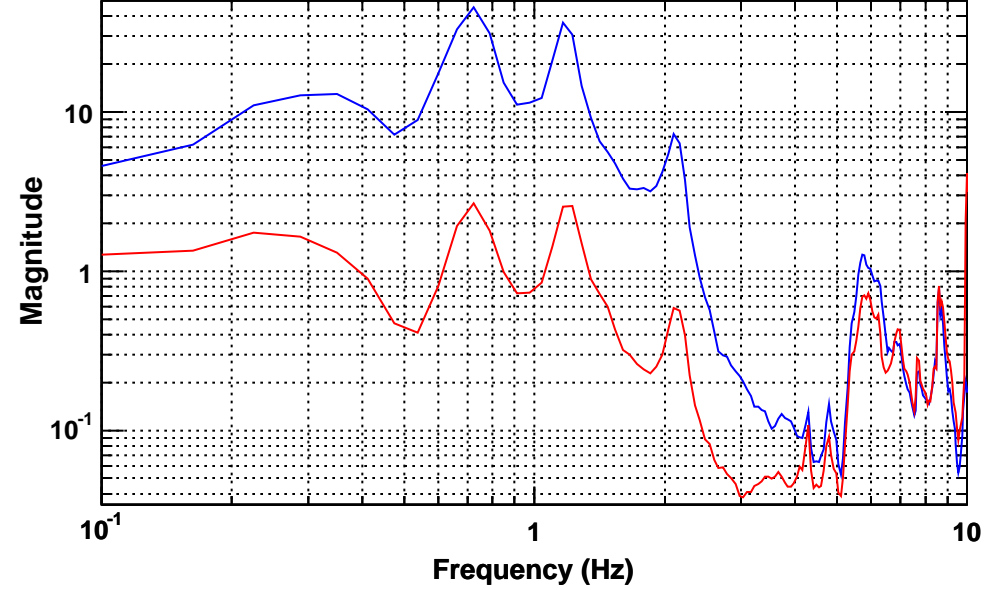
**Power spectrum, ETMX GEO Z**



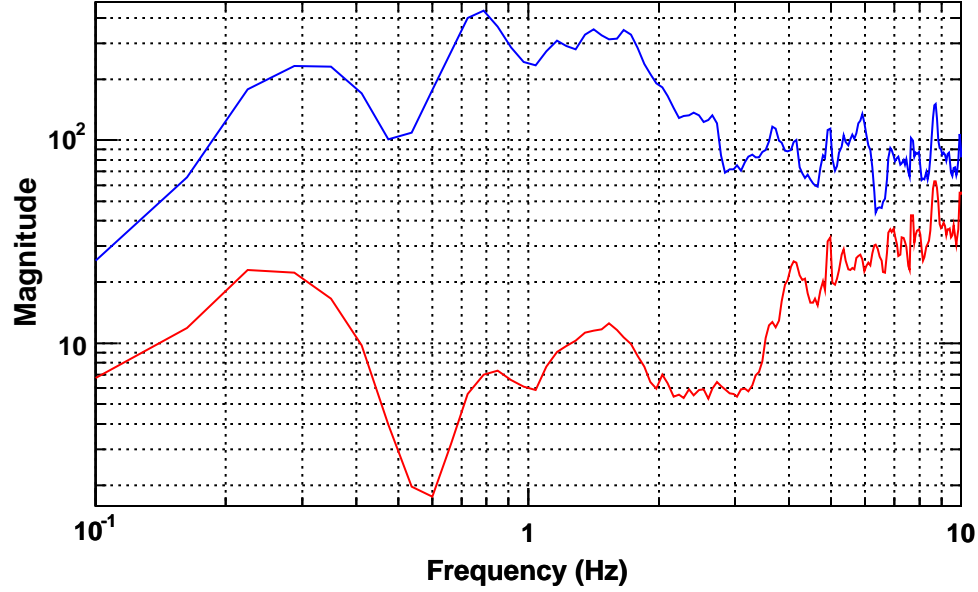
**Power spectrum, ETMY SUS Y**



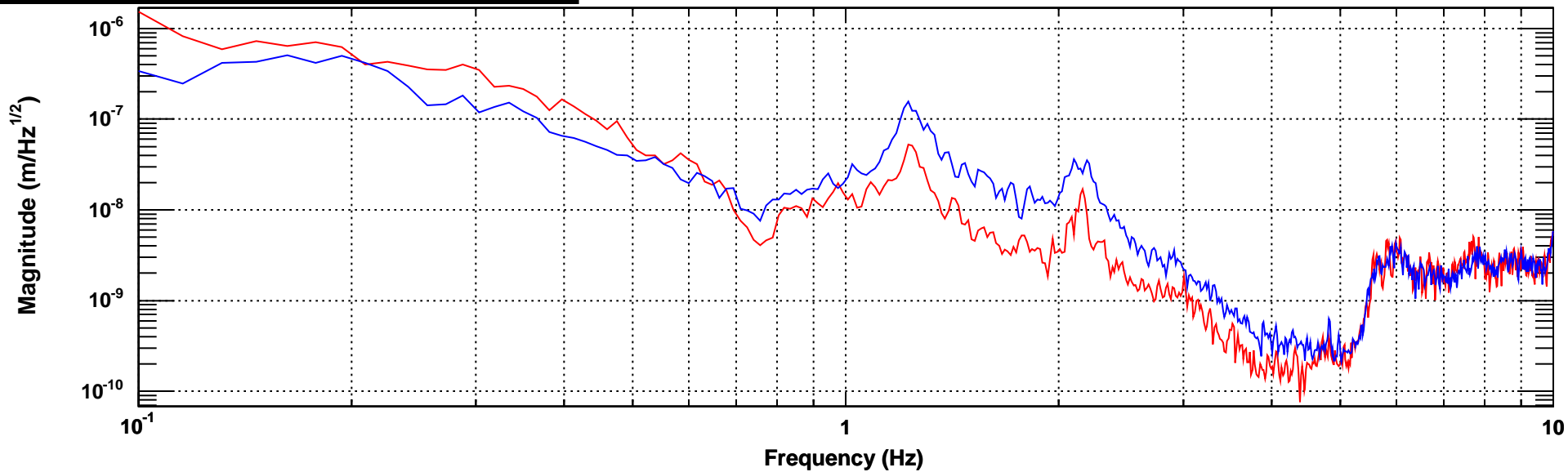
**Power spectrum, ETMY SUS X**



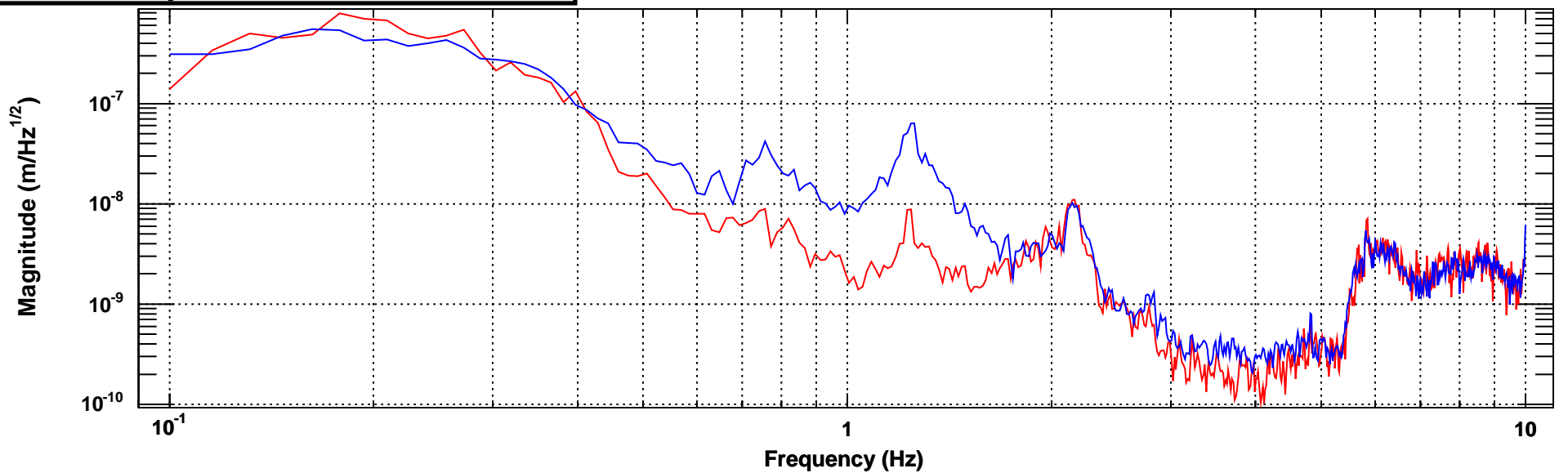
**Power spectrum, ETMY GEO Z**



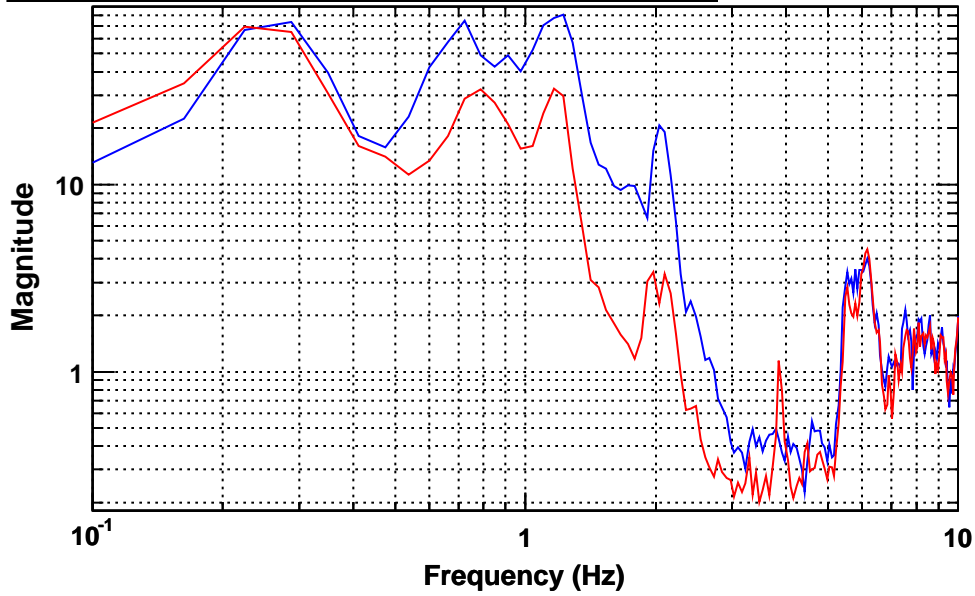
**Power spectrum, ITMX SUS X**



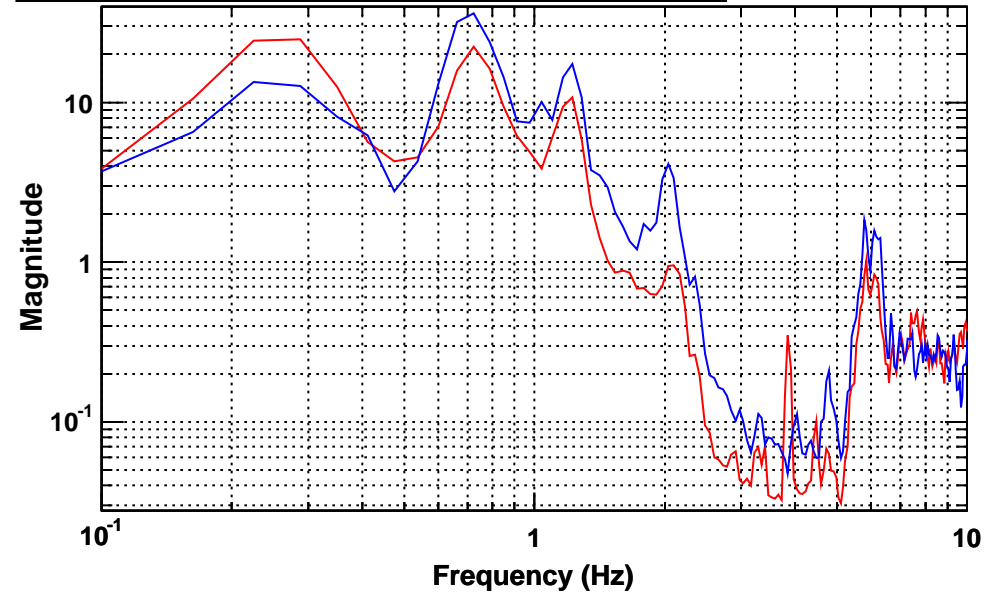
**Power spectrum, ITMX SUS Y**



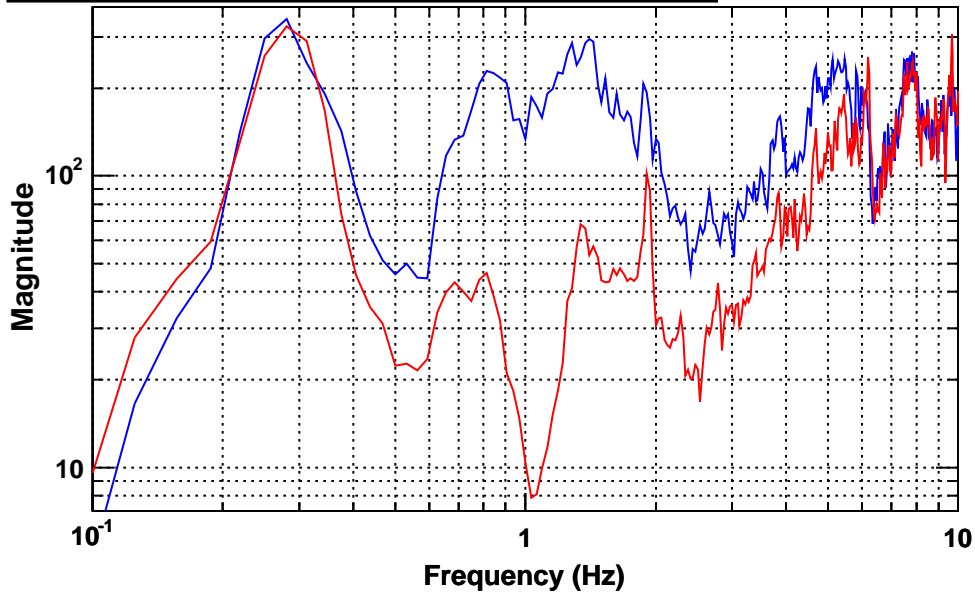
**Power spectrum, ITMY SUS Y**



**Power spectrum, ITMY SUS X**



**Power spectrum, ITMY GEO Z**



- HAM1~HAM4:

Position sensor loops + Sensor correction in X, Y, and Z directions.

Position sensor loops only in RX, RY, and RZ.

Performance is very close among tanks, typically factor of few to ten reduction from 0.1 to 1~2Hz.



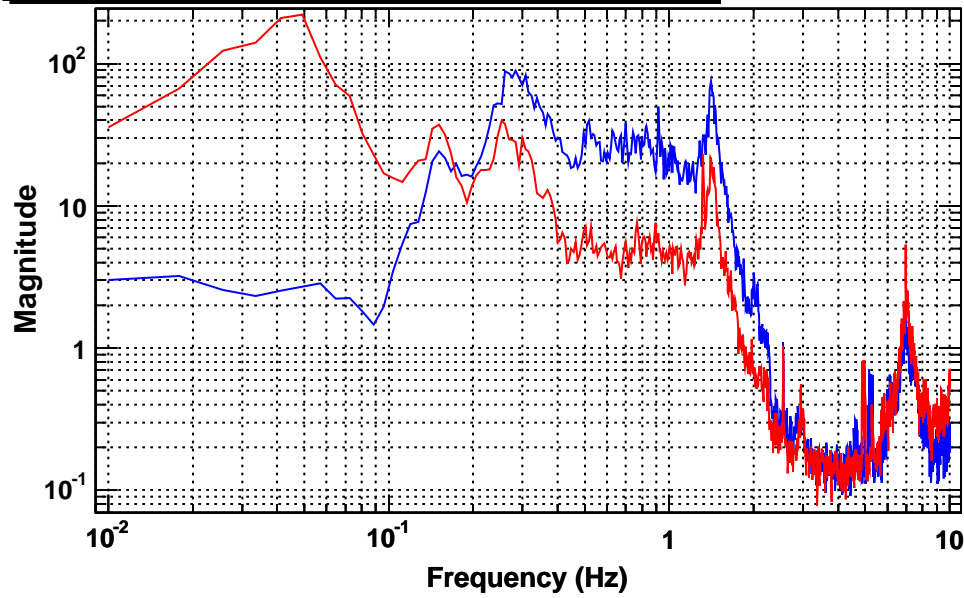
It is well known that performance among directions:

$Z > Y \gg X$ . ( $Z > X \gg Y$  for HAM4).

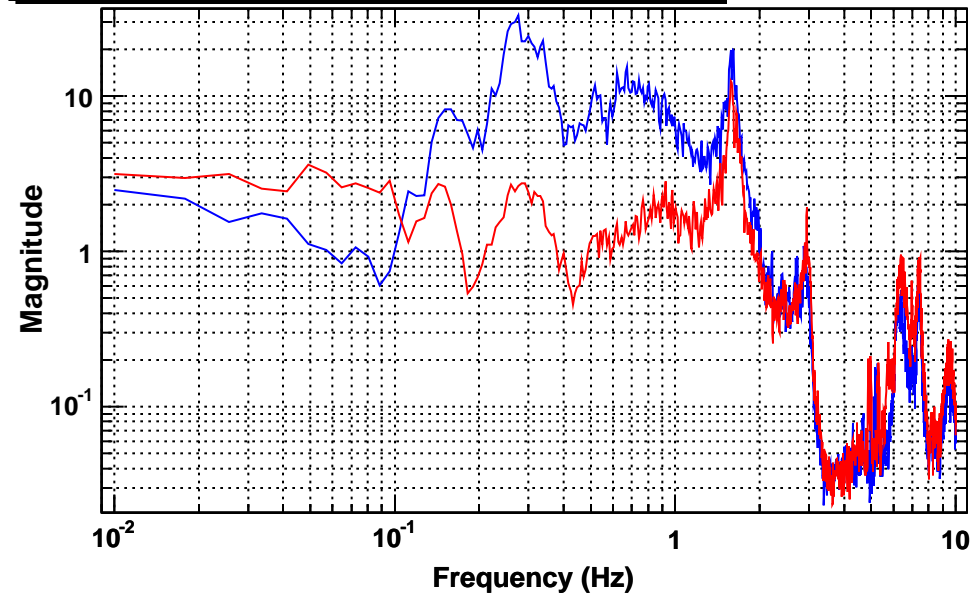
X (or Y for HAM4) needs to be reworked.

In the very long term, re-designing the cross-beam (gull wing) may be necessary.

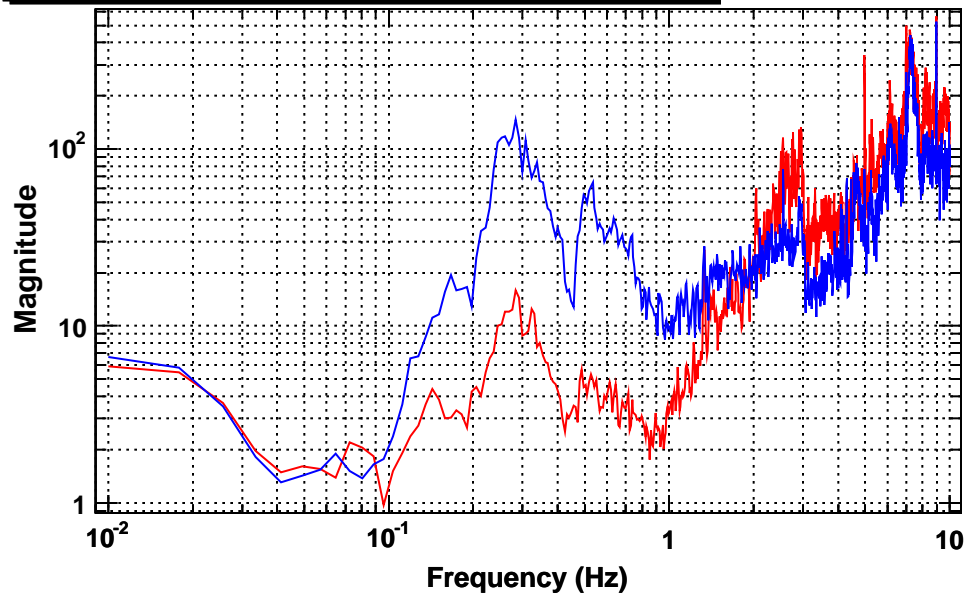
**Power spectrum, MMT3 SUS X**



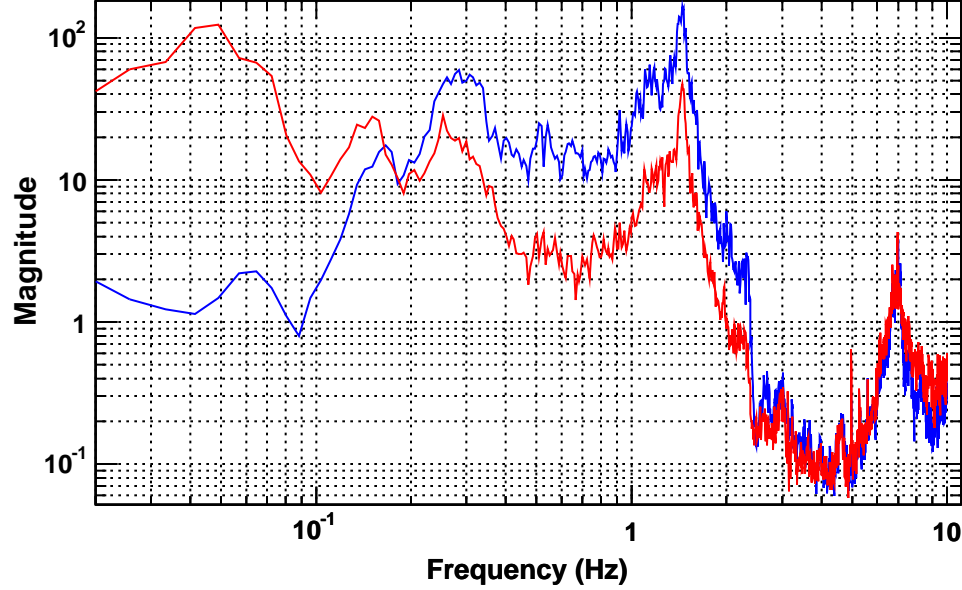
**Power spectrum, MMT3 SUS Y**



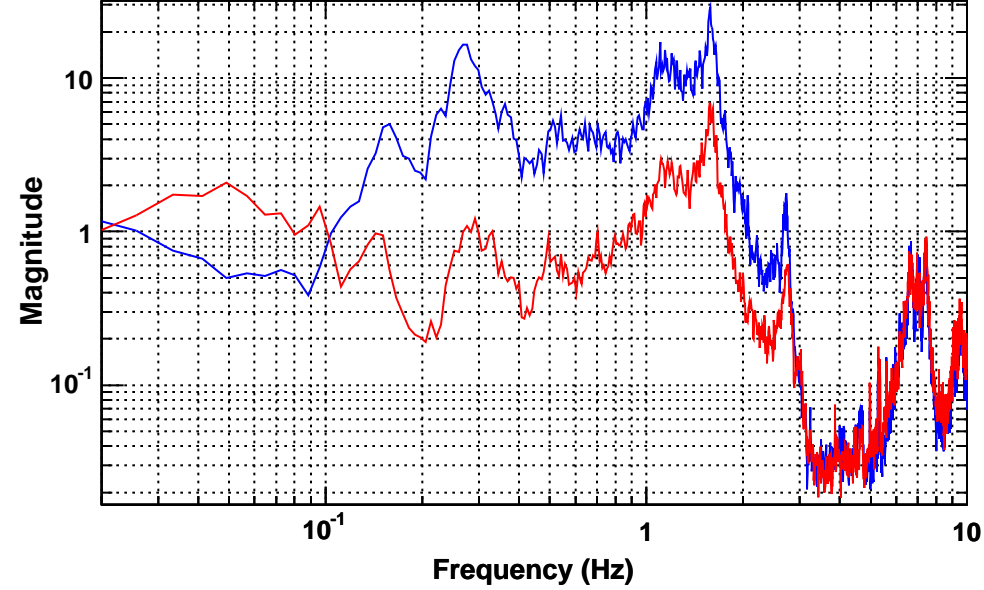
**Power spectrum, HAM1 GEO Z**



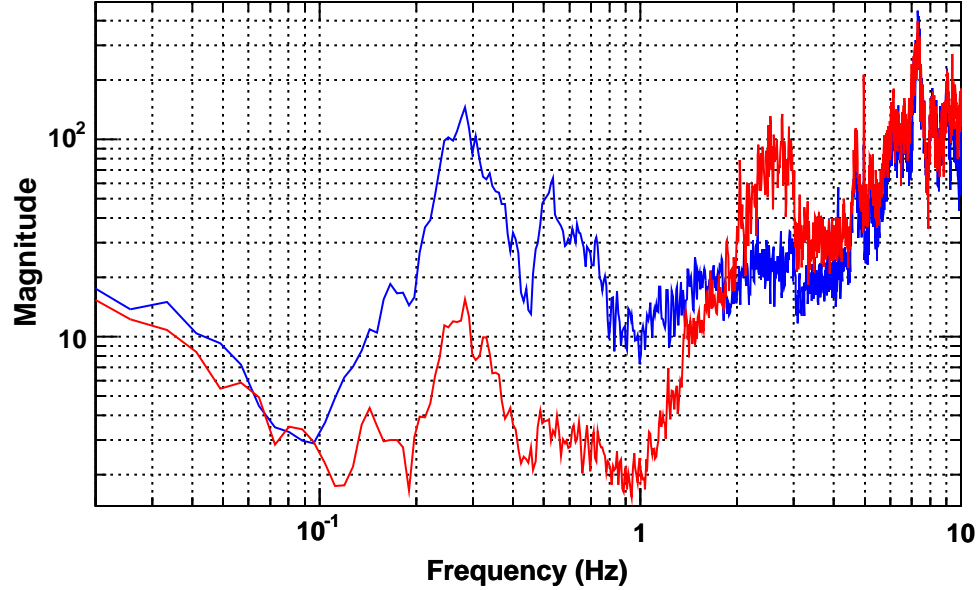
**Power spectrum, MMT2 SUS X**



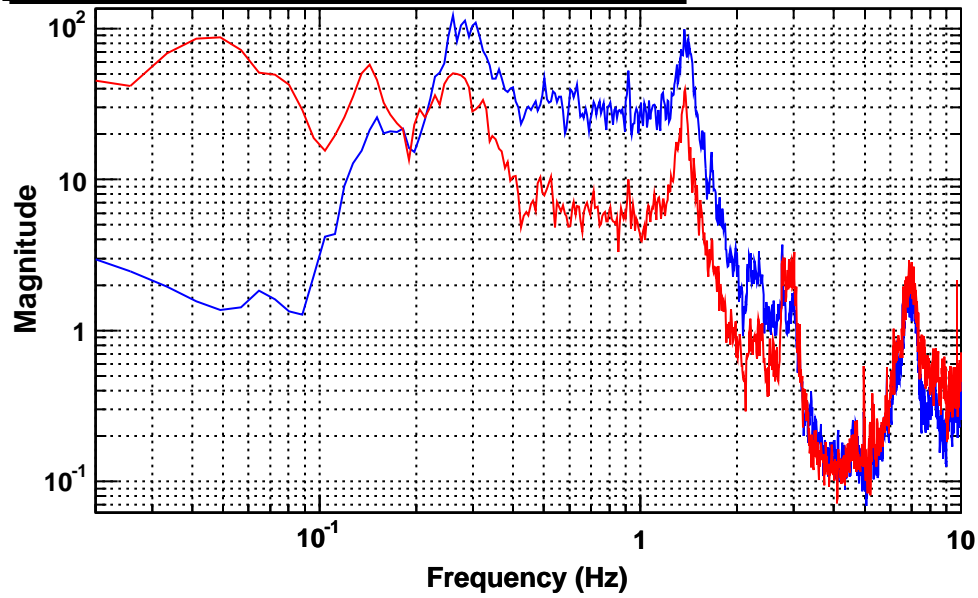
**Power spectrum, MMT2 SUS Y**



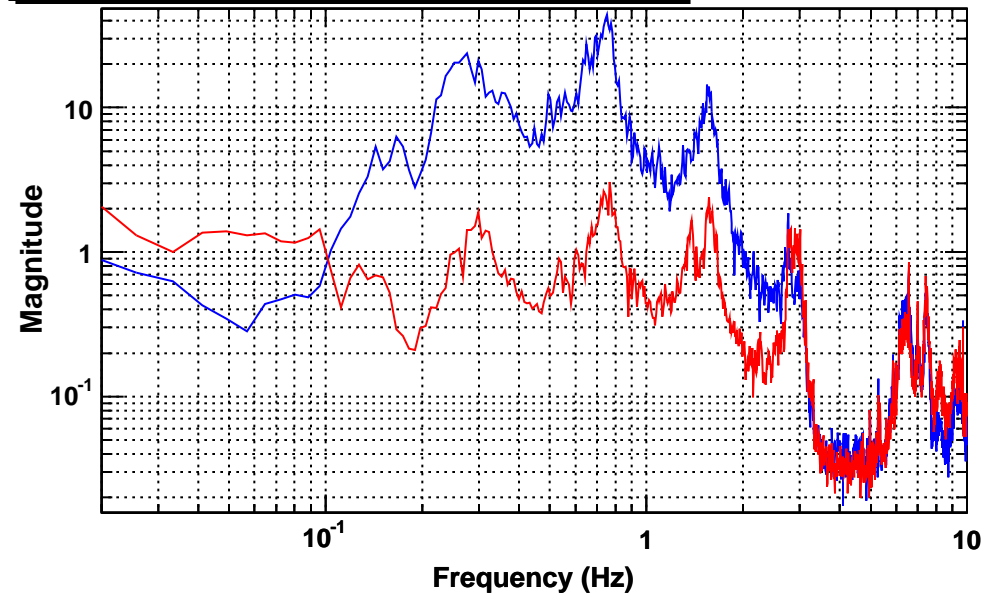
**Power spectrum, HAM2 GEO Z**



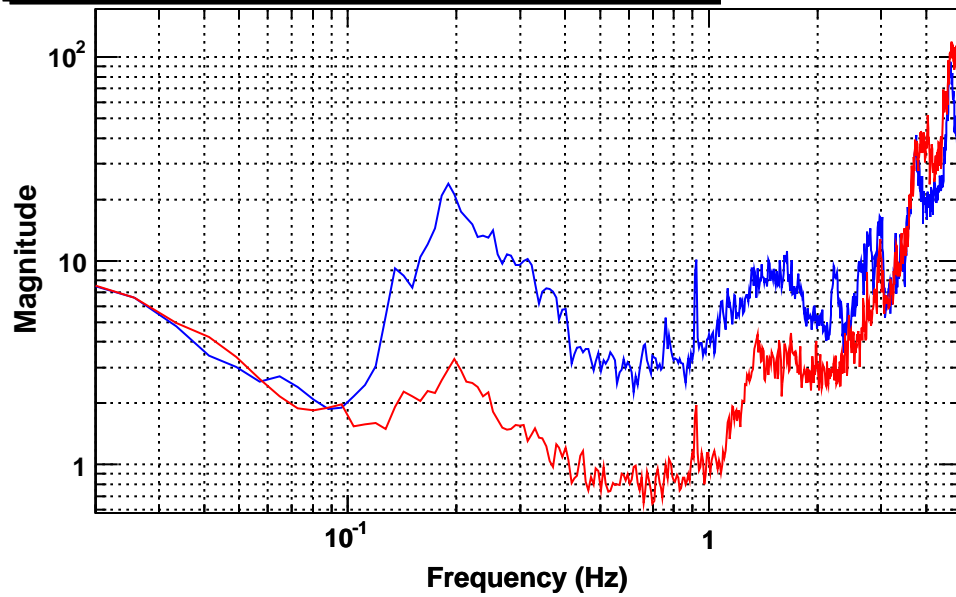
**Power spectrum, RM SUS X**



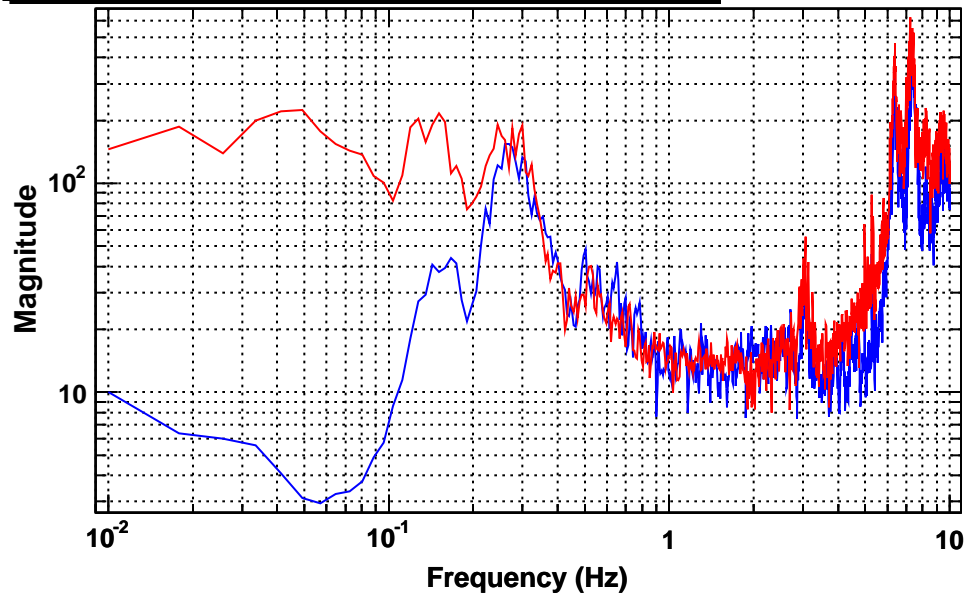
**Power spectrum, RM SUS Y**



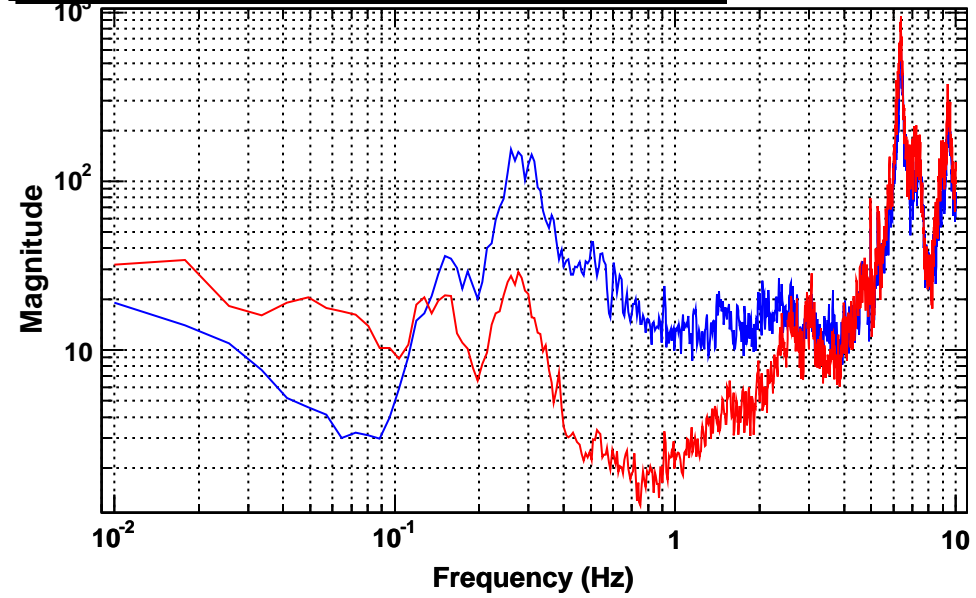
**Power spectrum, HAM3 GEO Z**



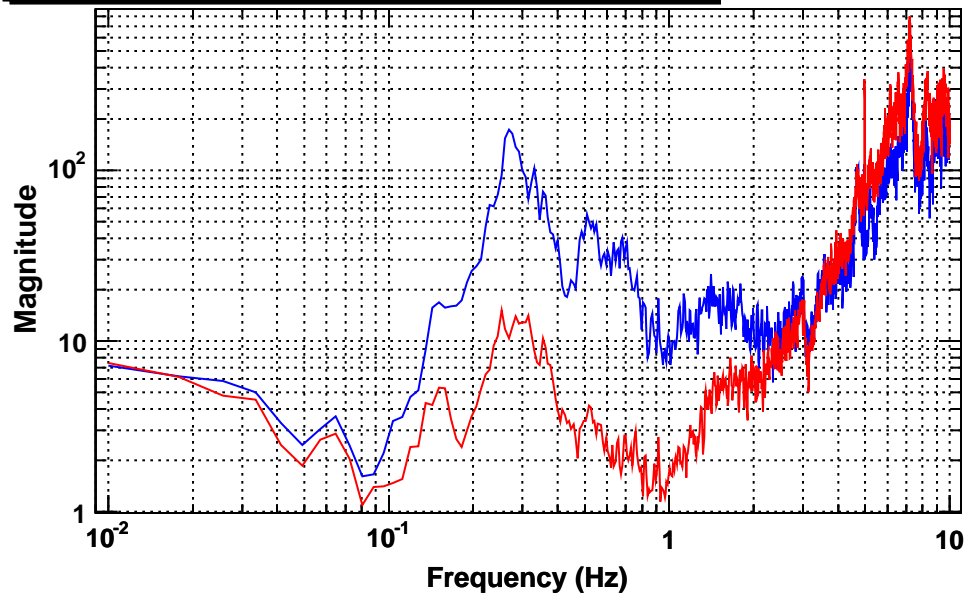
**Power spectrum, HAM4 GEO Y**



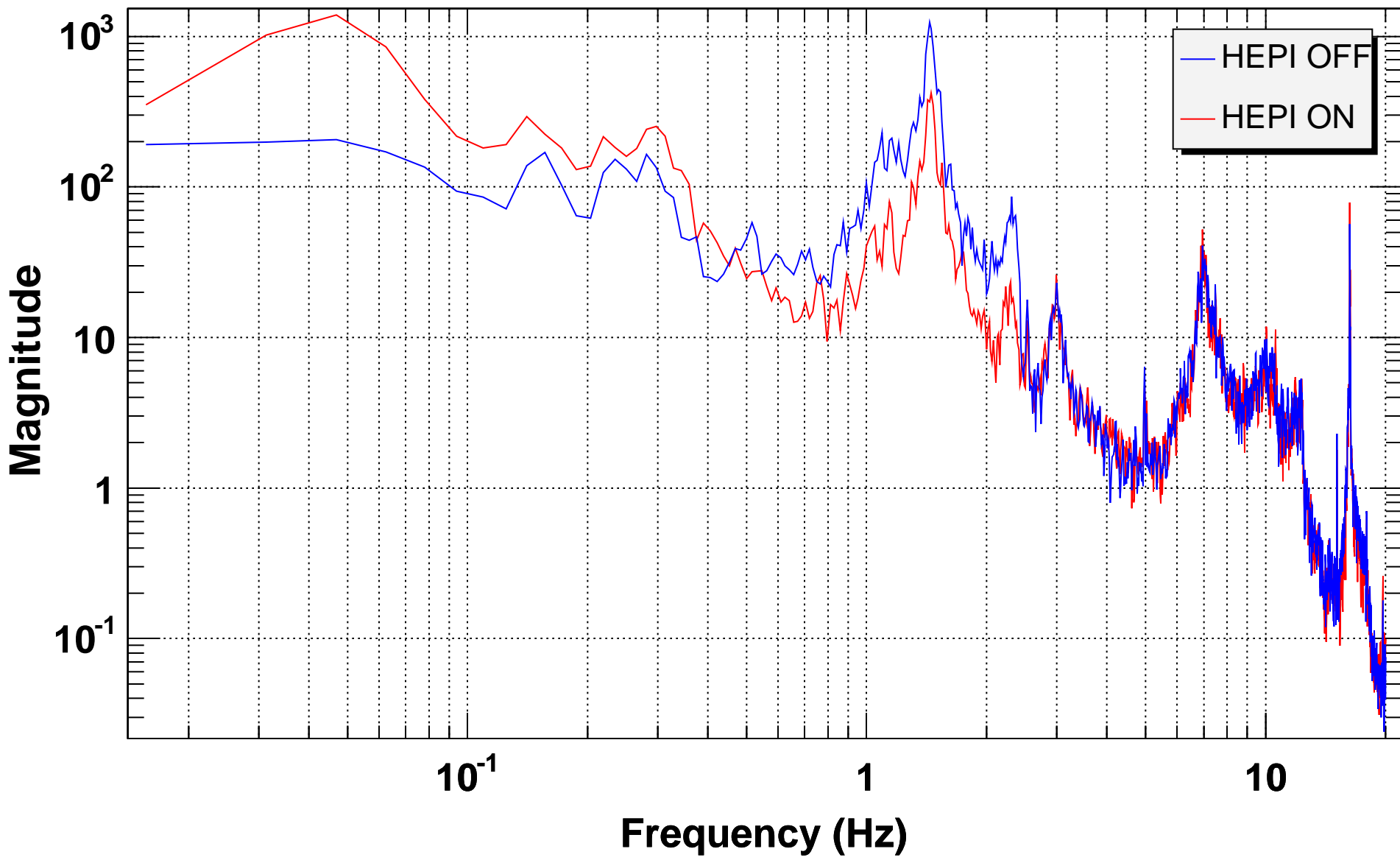
**Power spectrum, HAM4 GEO X**



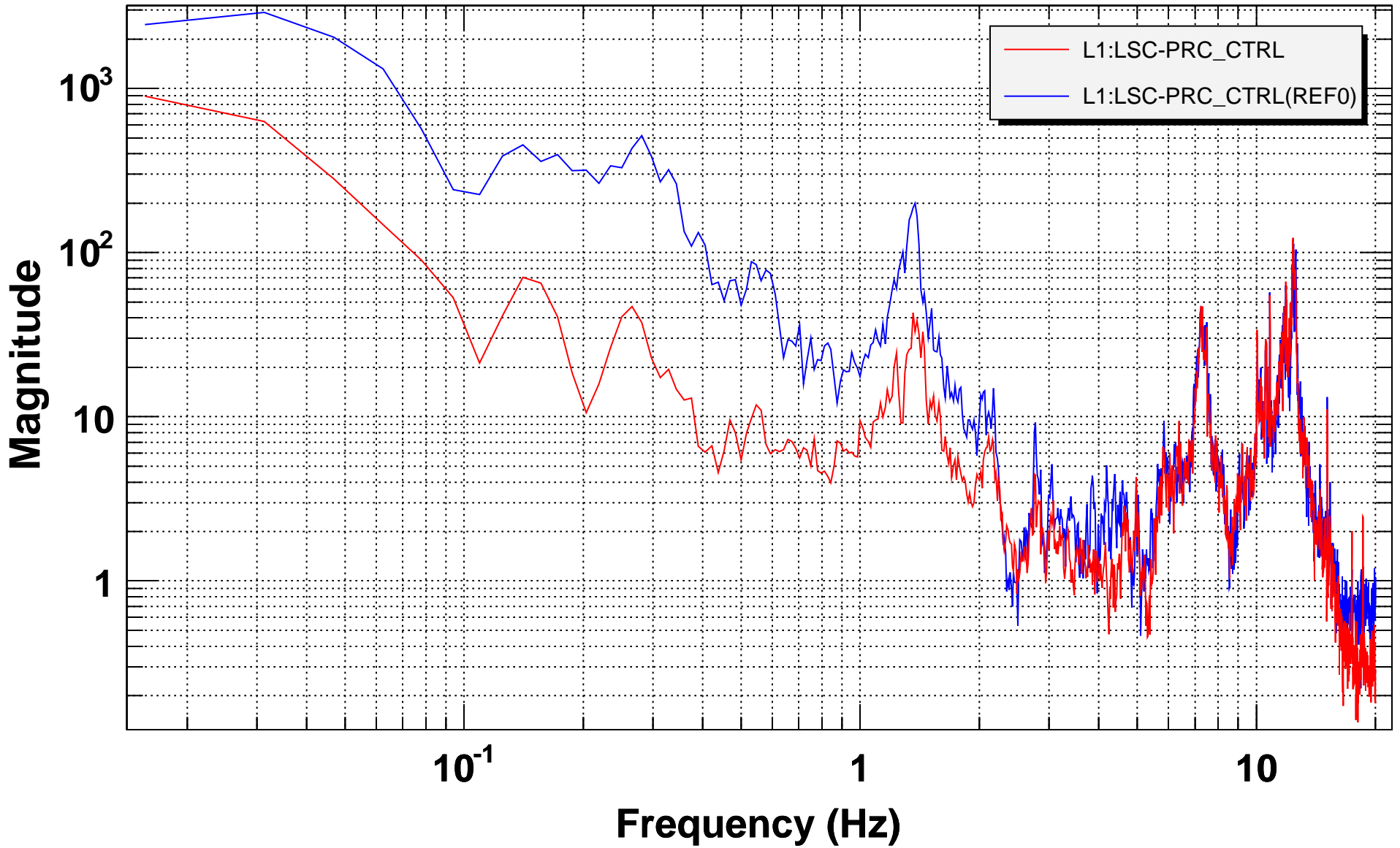
**Power spectrum, HAM4 GEO Z**



**Power spectrum, MC\_L**



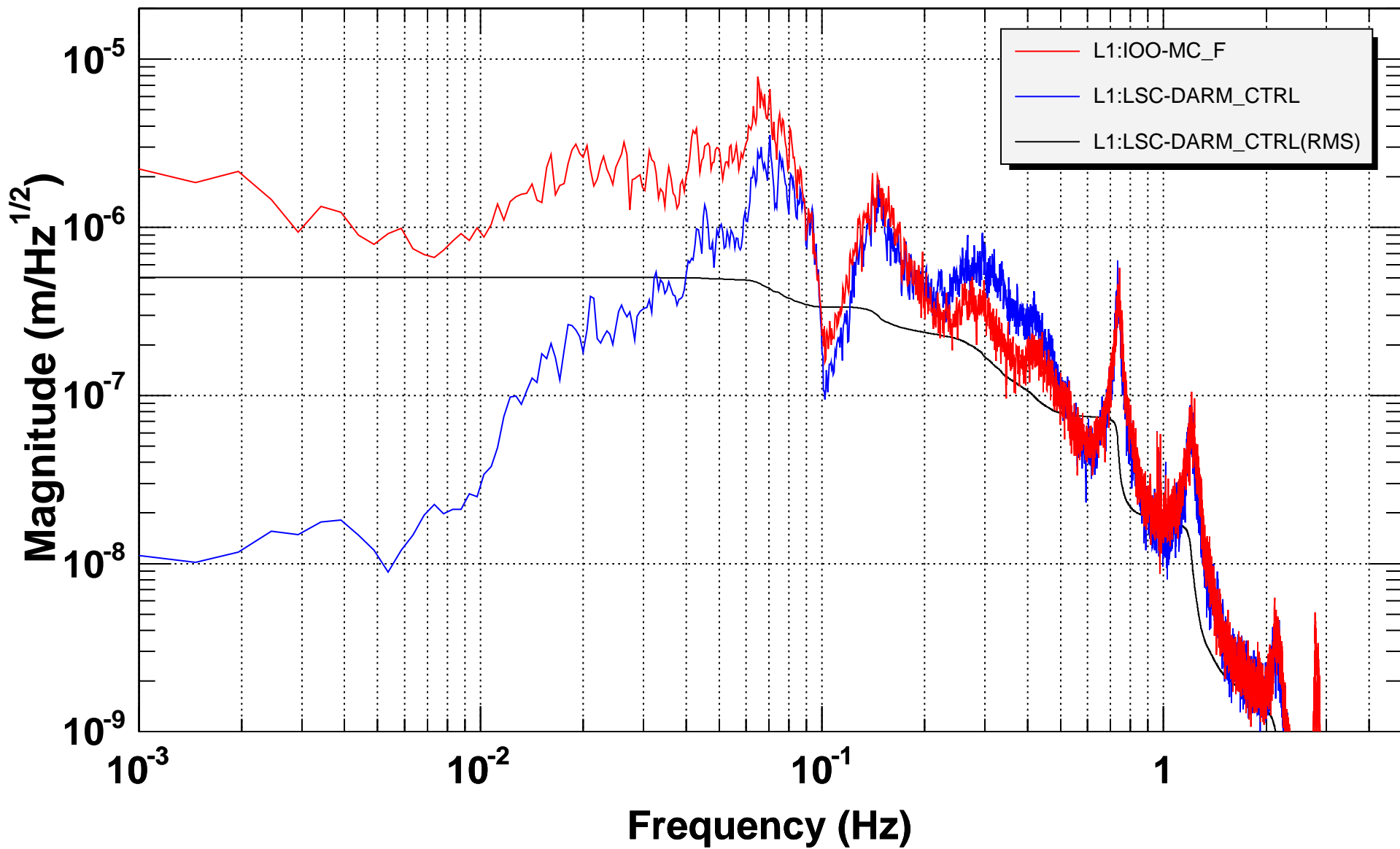
# Power spectrum



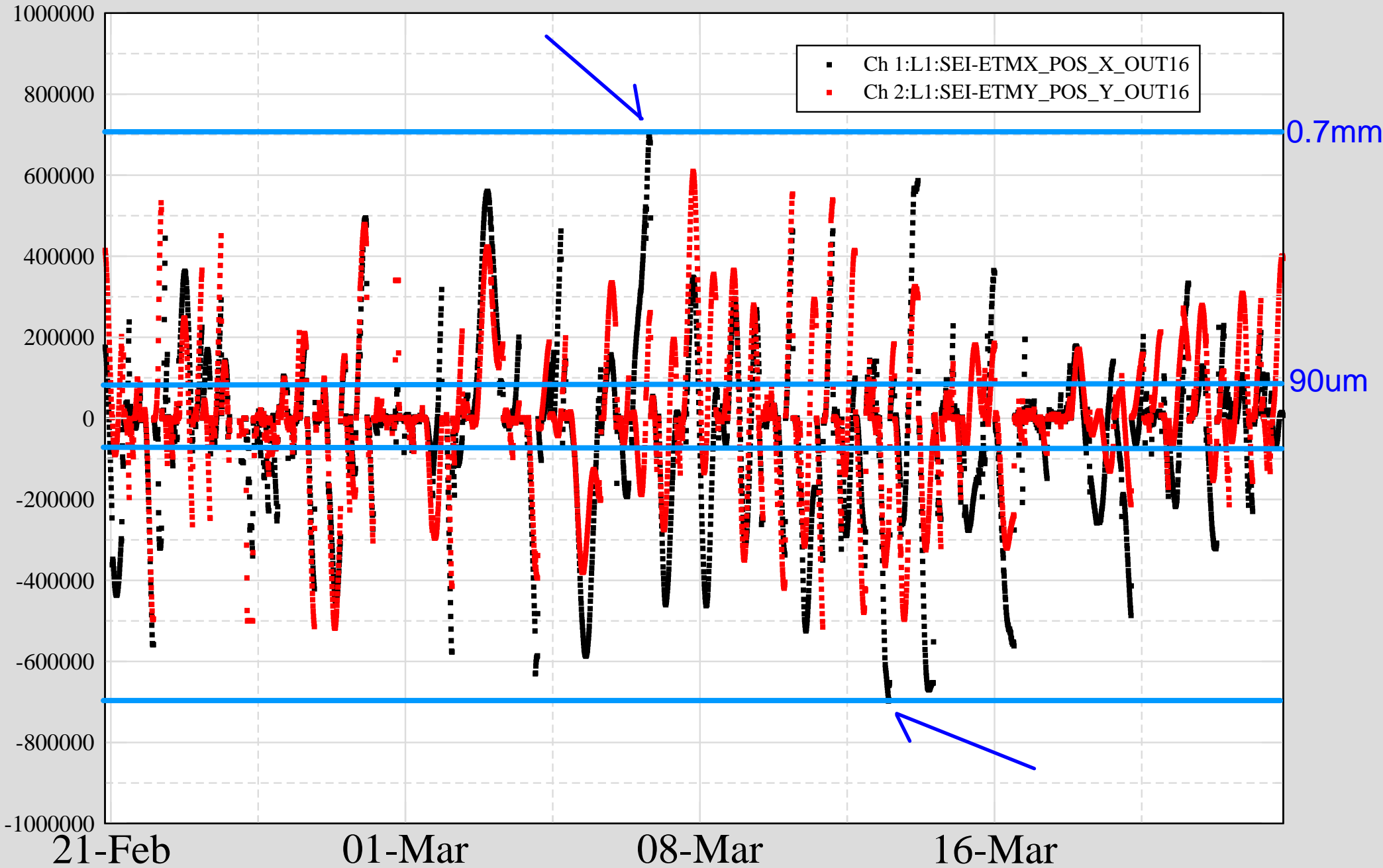
- Length Sensing Control (LSC) Feedback in common and differential modes. Tidal feedback on ETMX and ETMY. (Matt Evans & Rana Adhikari et al.)



# Power spectrum



# Tidal Trend from S4 for LLO



- More things to do:

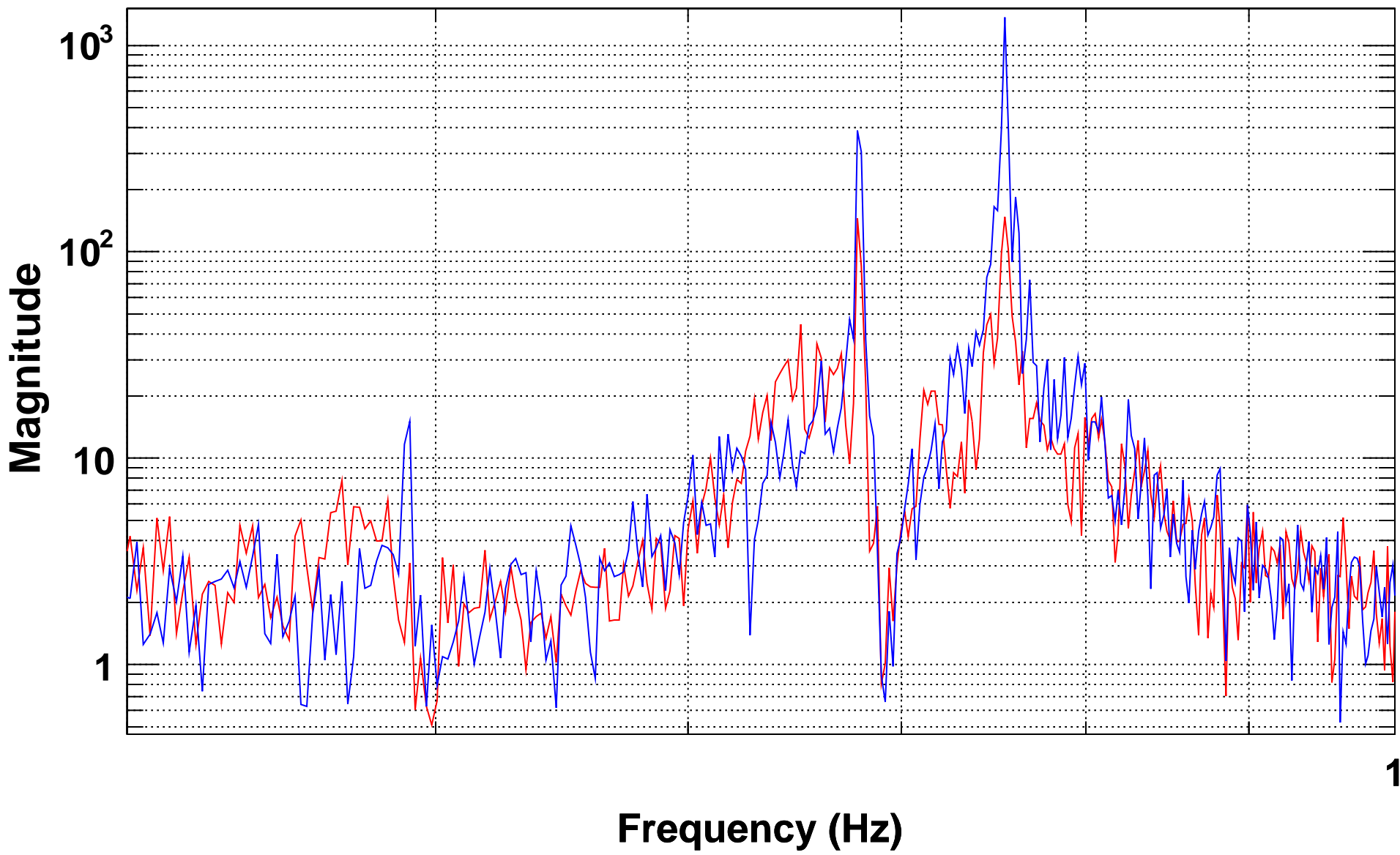
Blended loops on HAM's.

LSC feedback on RM (z direction), BS, HAM1, and HAM2.

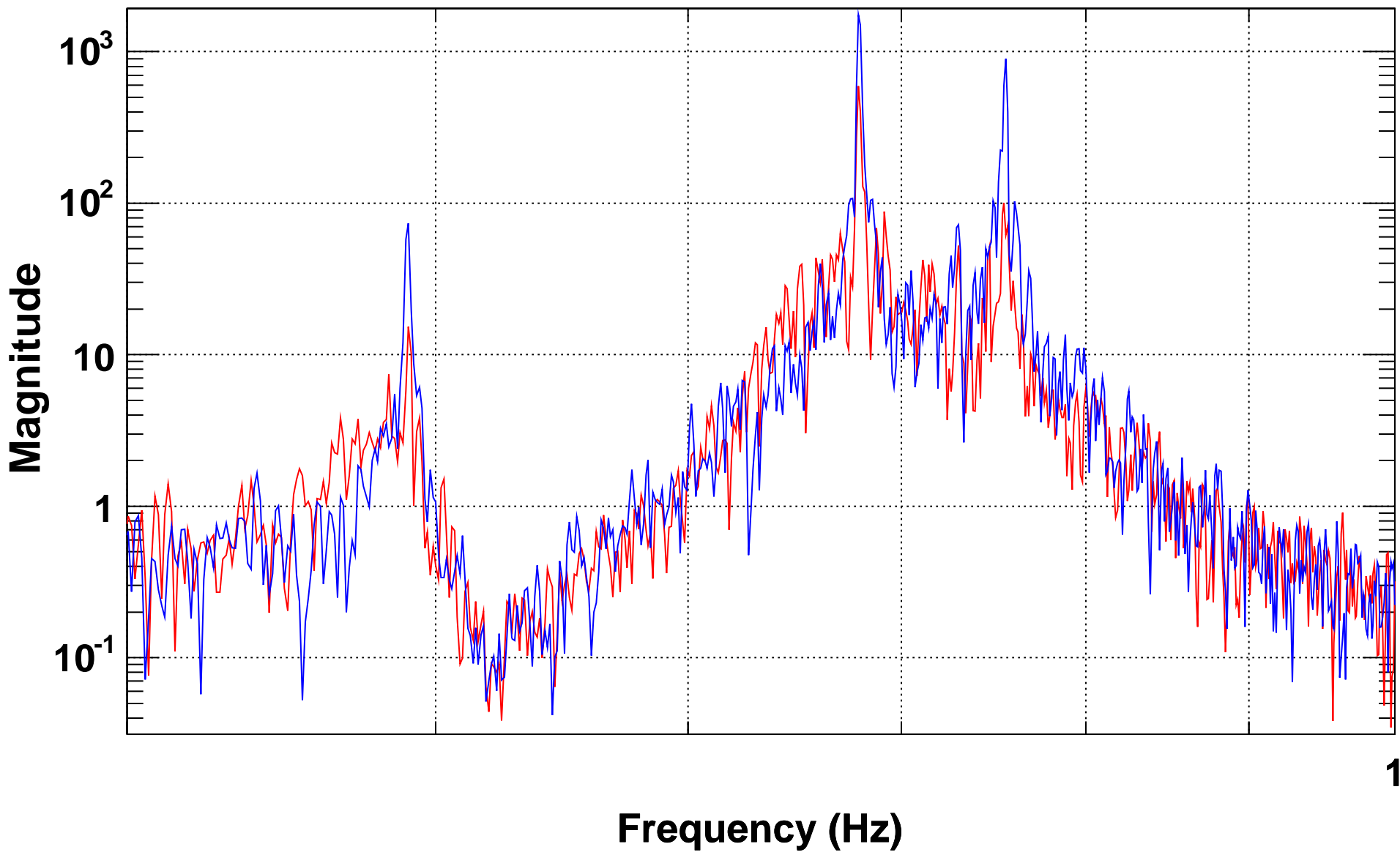
Resonant gain technique on BSC's, and HAM's once they are blended.

This technique has been demonstrated to suppress noise at test mass resonant frequencies, 0.6Hz (pitch), 0.73Hz (side pendulum), 0.76Hz (pendulum), and stack mode 1.2 Hz. Typically factor of few to ten reduction.

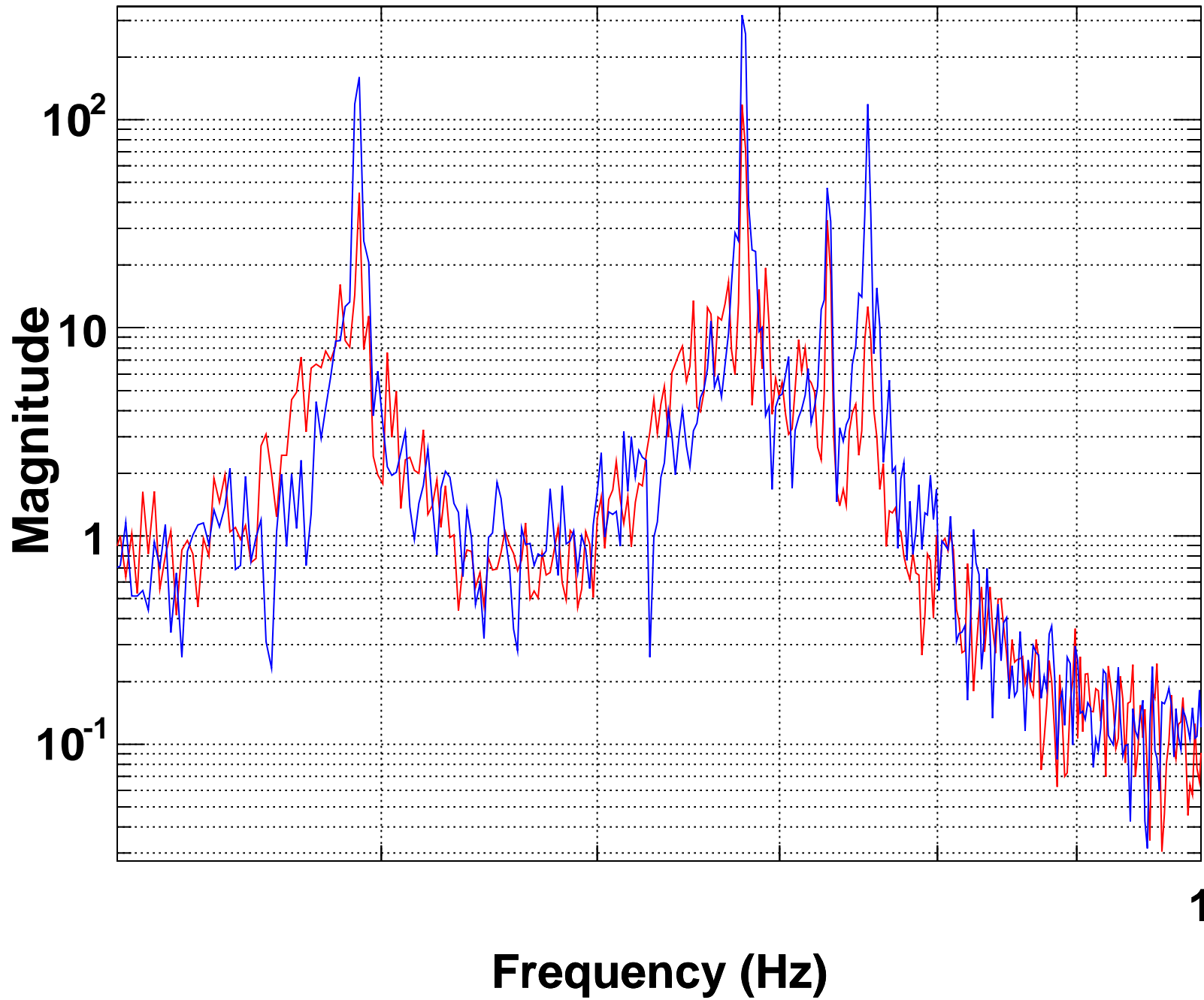
# Power spectrum, Pendulum Mode



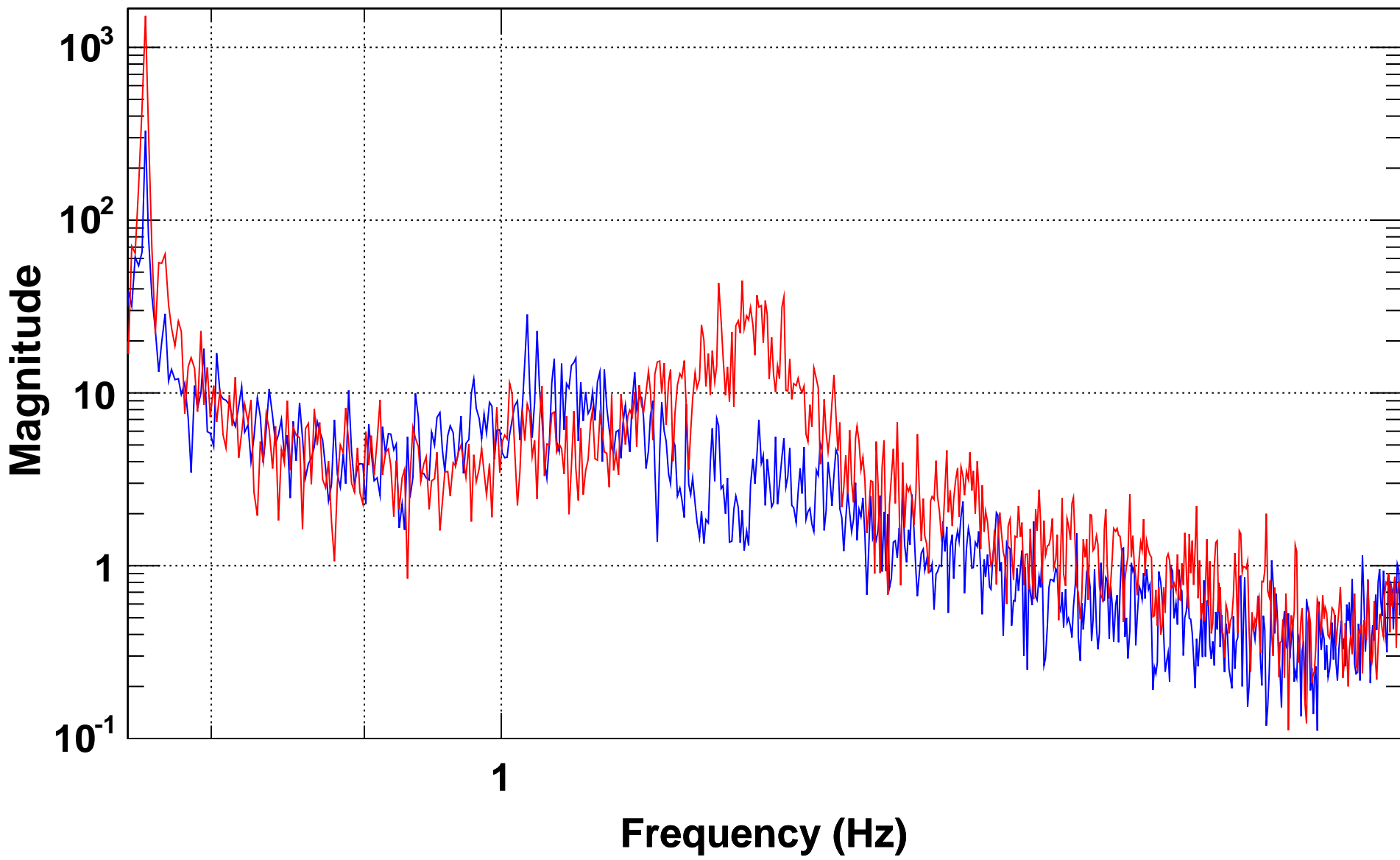
**Power spectrum, Pitch Mode**



# Power spectrum, Yaw Mode



# Power spectrum, Pendulum Mode





We are still haunted by possible channel hopping and valve failure (bad fluid). These are now being investigated.

# **S4 HEPI DUTY CYCLE and VERY LONG TERM DUTY CYCLE**

**Statistics as of March 20:**

**ETMX off time: 2361s      HAM1: 2072s**

**ETMY: 1539s              HAM2: 2836s**

**ITMX: 6371s              HAM3: 2545s**

**ITMY: 5144s              HAM4: 1859s**

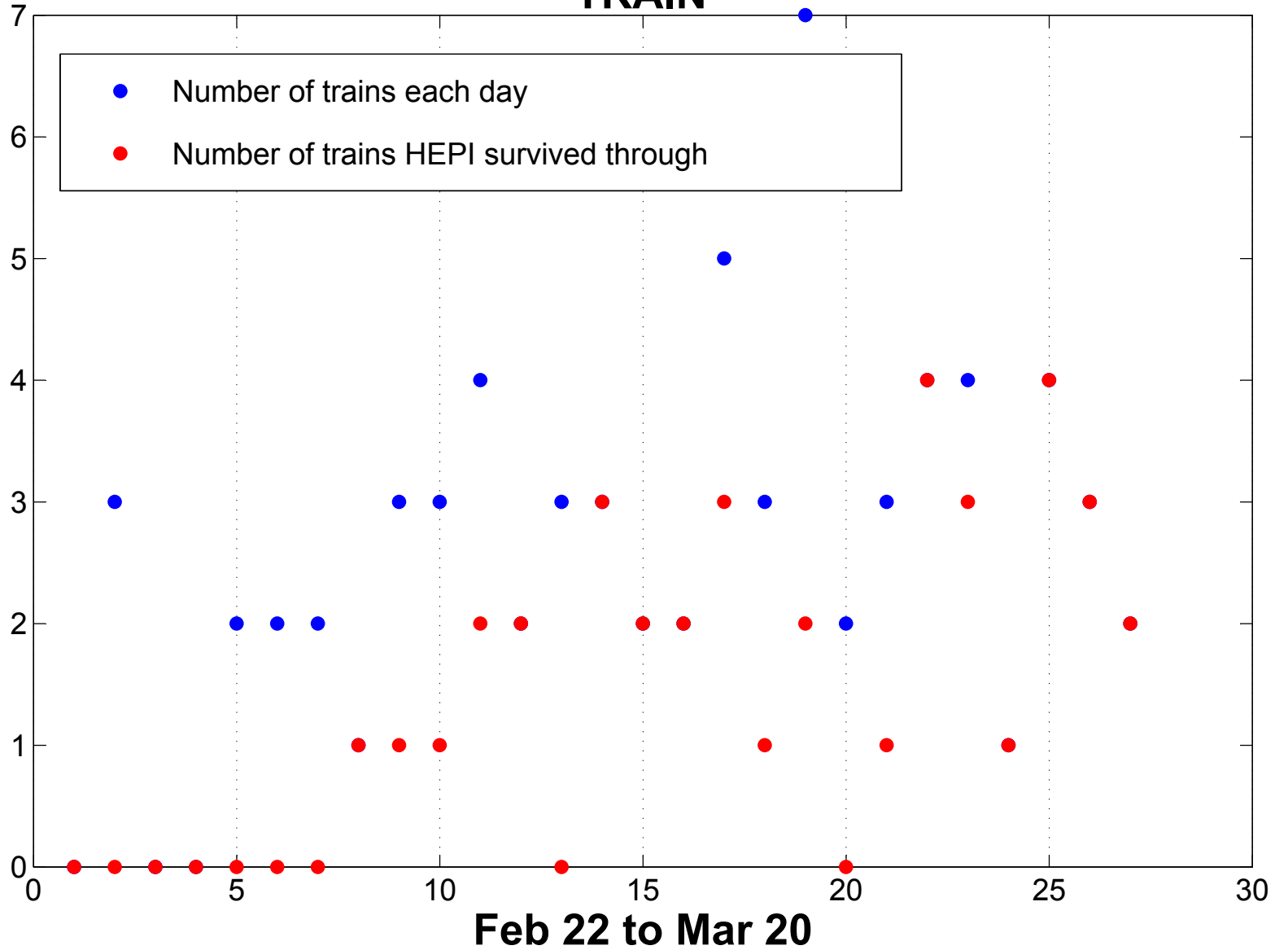
**BS: 2422s**

**Total HEPI on time > 99.7%**

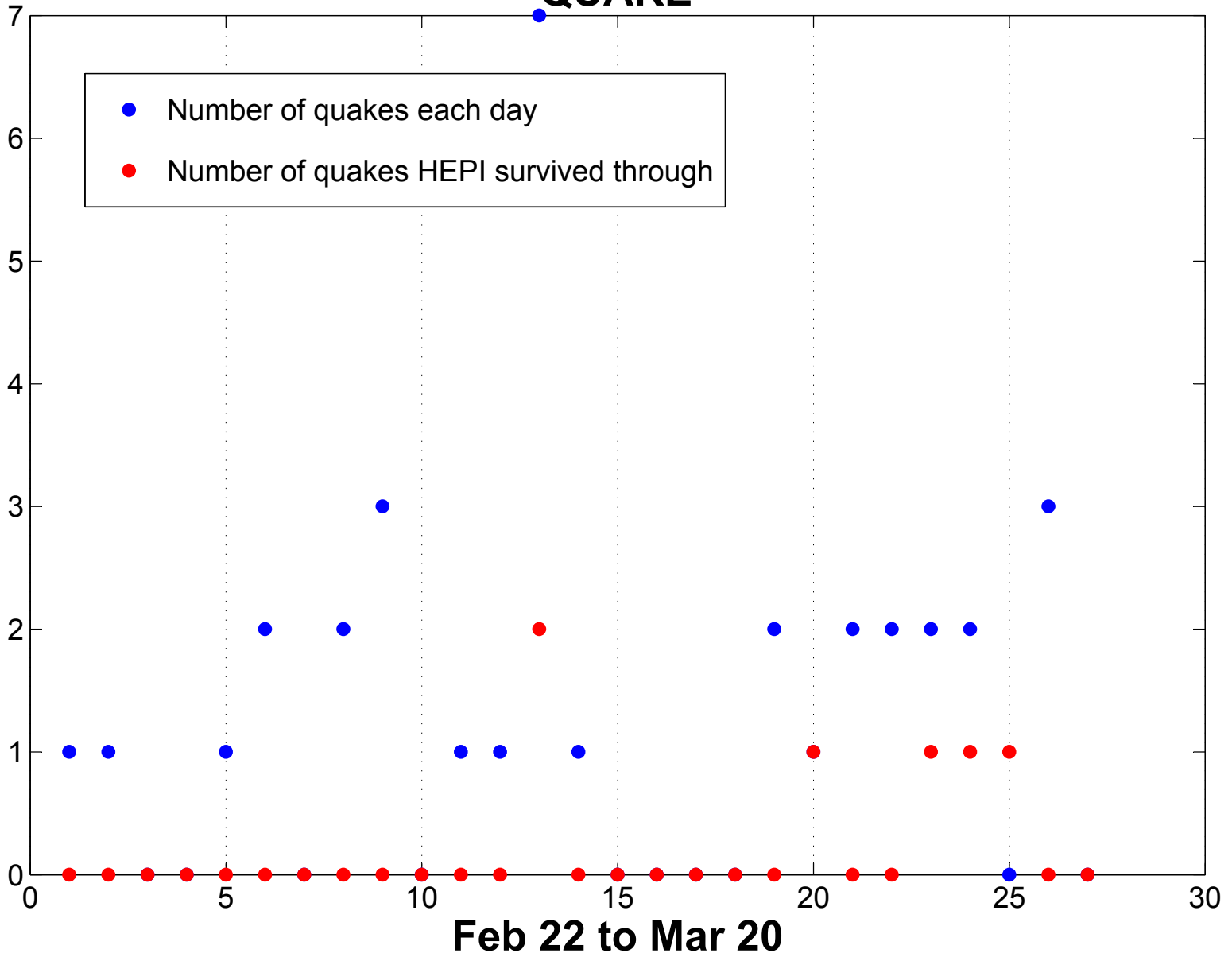
- QUESTION: TRAINS & EARTH QUAKES, CAN WE SURVIVE THROUGH THEM AT ALL?

Experience from S4: Trains that produce  $\sim 0.6 \mu\text{m/s}$  in the 1-3 Hz band does not break lock.

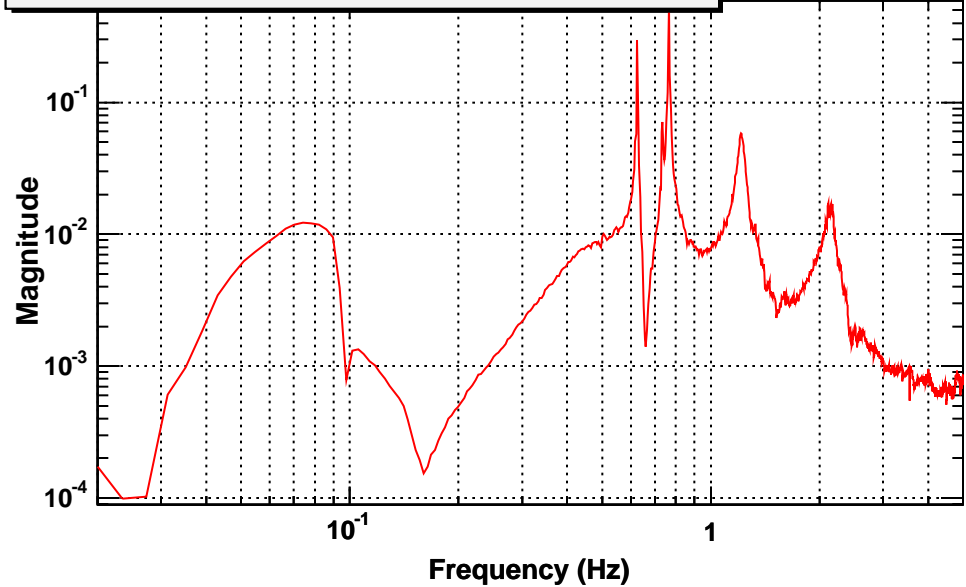
# TRAIN



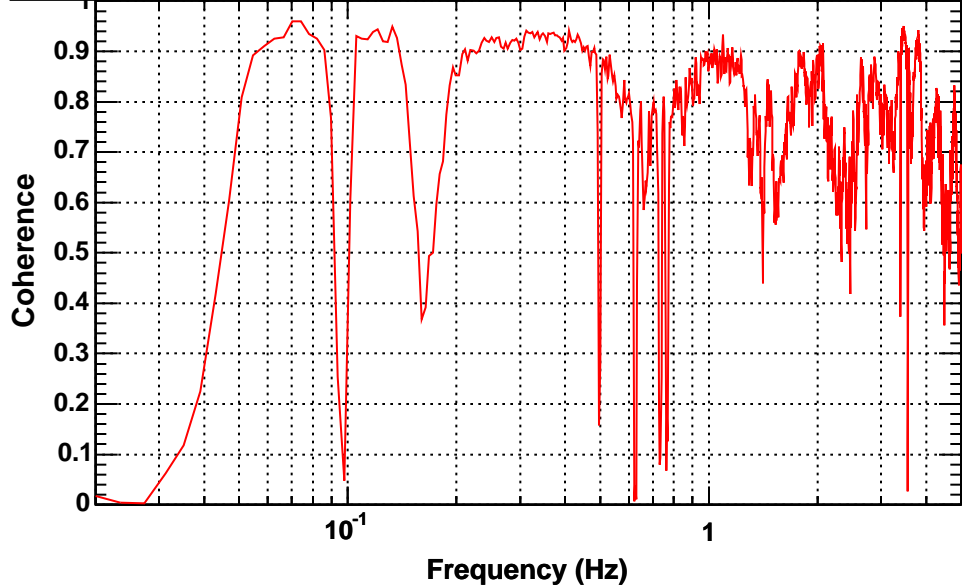
# QUAKE



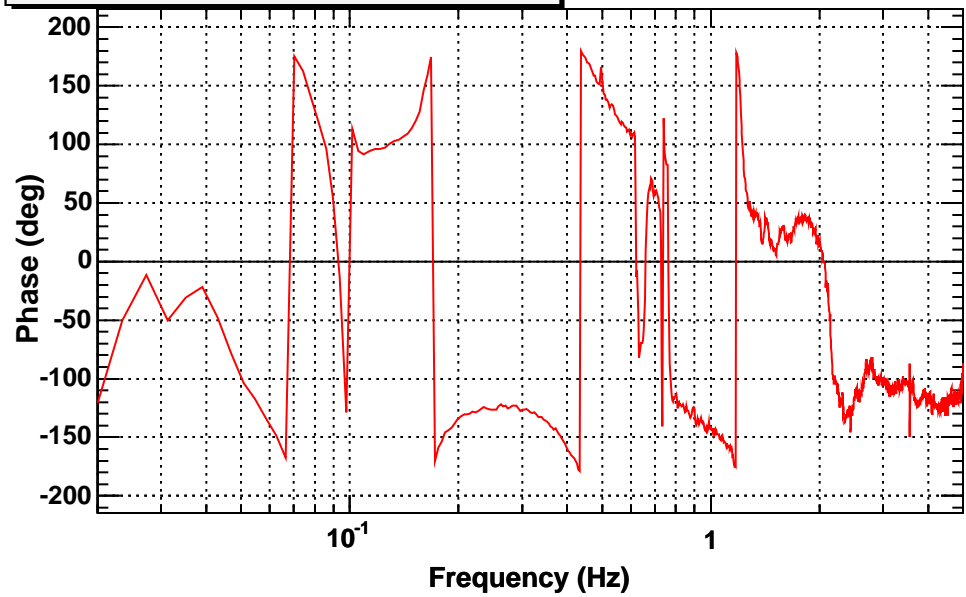
**Transfer function, ETMX STS X to SUS X**



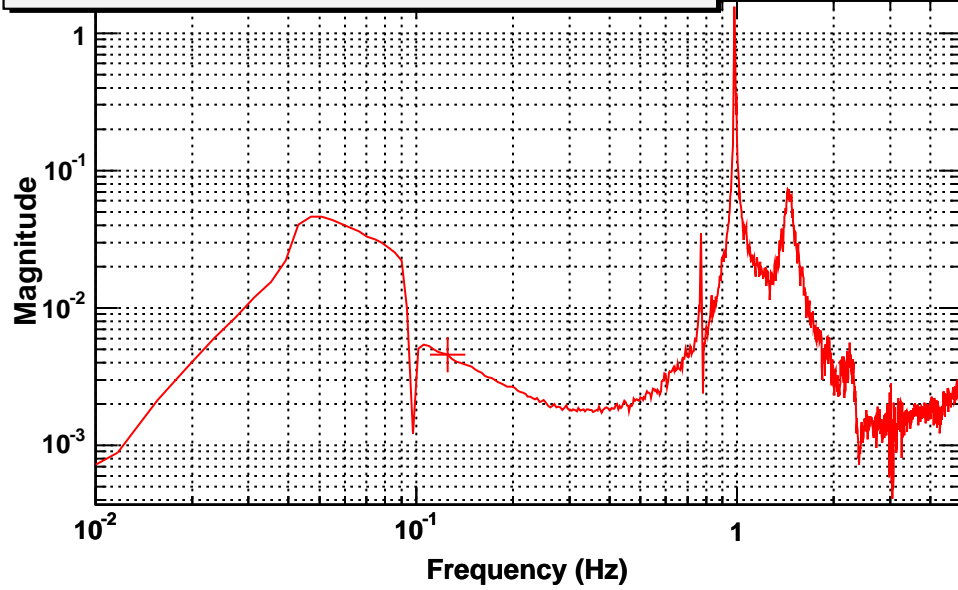
**Coherence**



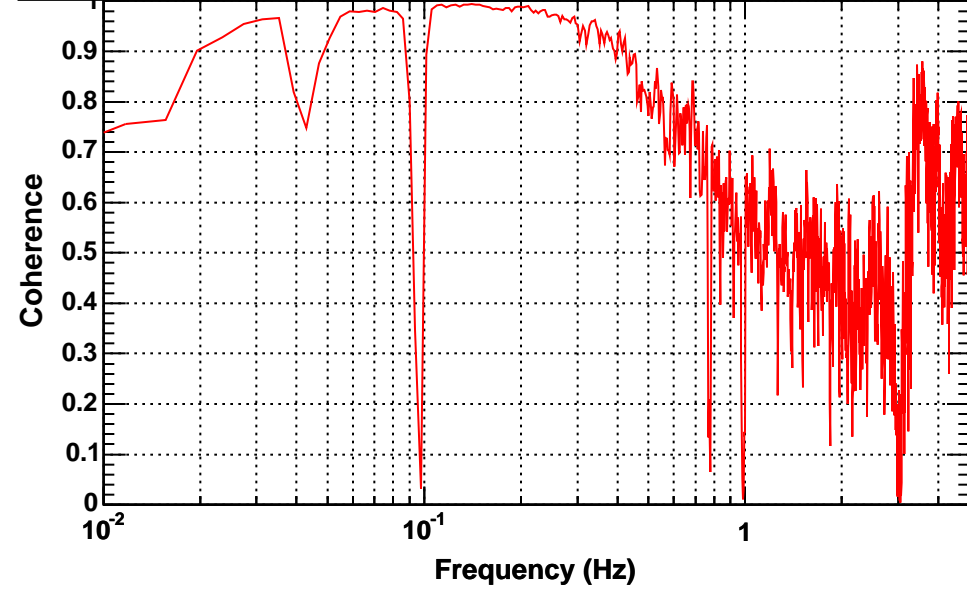
**Transfer function**



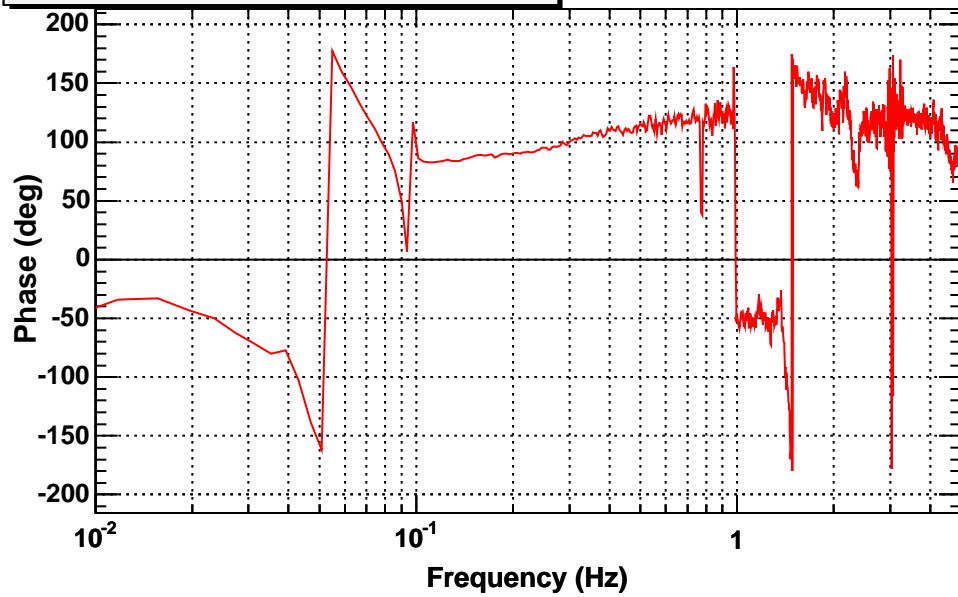
Transfer function, LVEA STS X to MMT2 SUS X



Coherence



Transfer function



- On-going work: Passing through STS signals (S2 and S3 data for example) through these transfer functions, to investigate the actual motion at the optics.



- What one might learn:

- (a) Possibly develop a real-time HEPI performance monitor. (DMT like) Good for operators and commissioners. (I.e., they can tell what went wrong, HEPI or something else?)

- (b) If HEPI ever will be installed at LHO, we can project their HEPI+IFO duty cycle in advance, just by looking at their historical STS data.