CHARACTERIZATION OF ENVIRONMENTAL AND INPUT BEAM NOISE INPUTS

Director's Review, May 1, 2000
Daniel Sigg

Seismic Displacement Noise
Fred R., Eric M., Robert S., control room staff

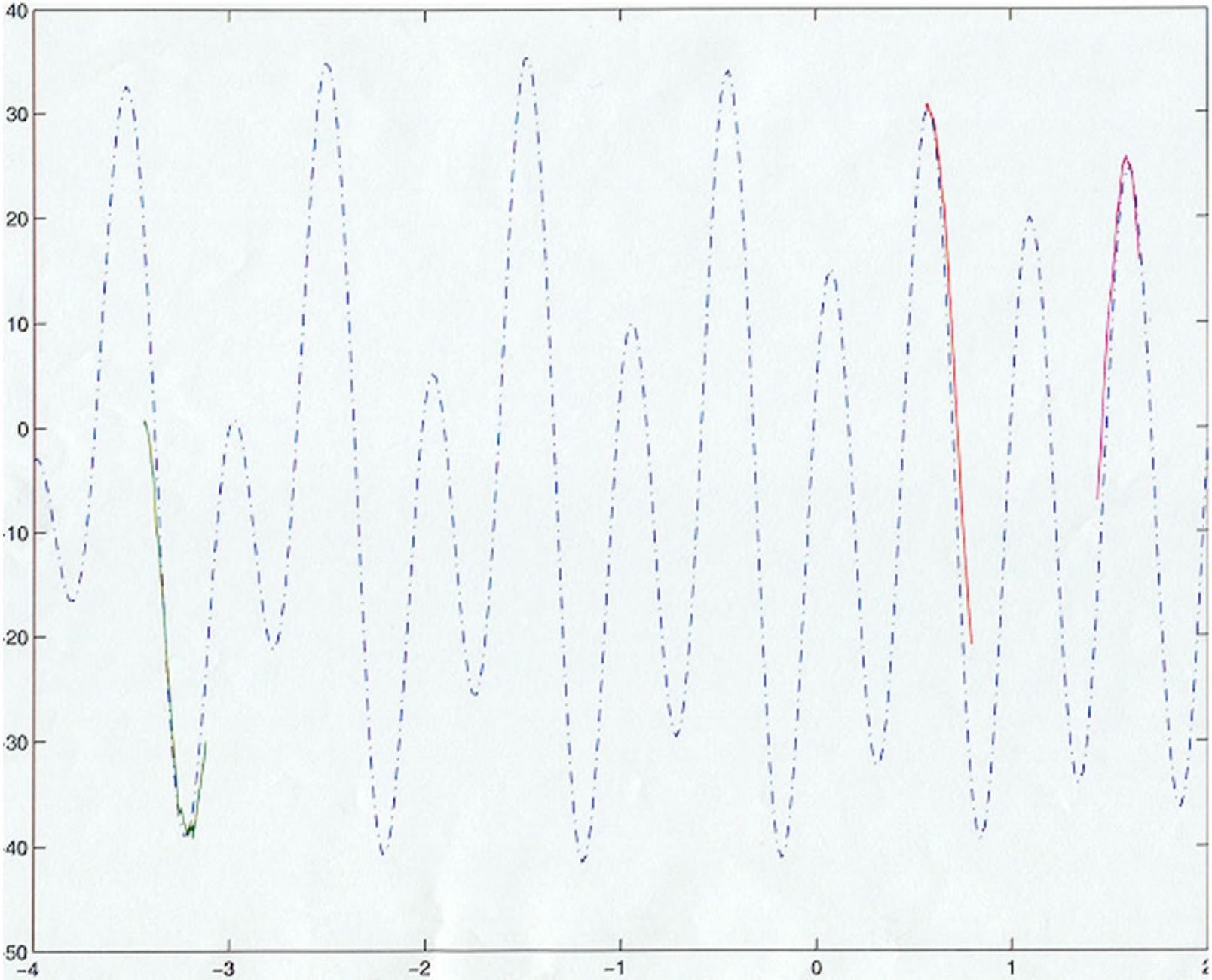
Frequency Noise of Light after Mode Cleaner
Nergis M., Peter F., Haisheng R., Dale O., Dick G.

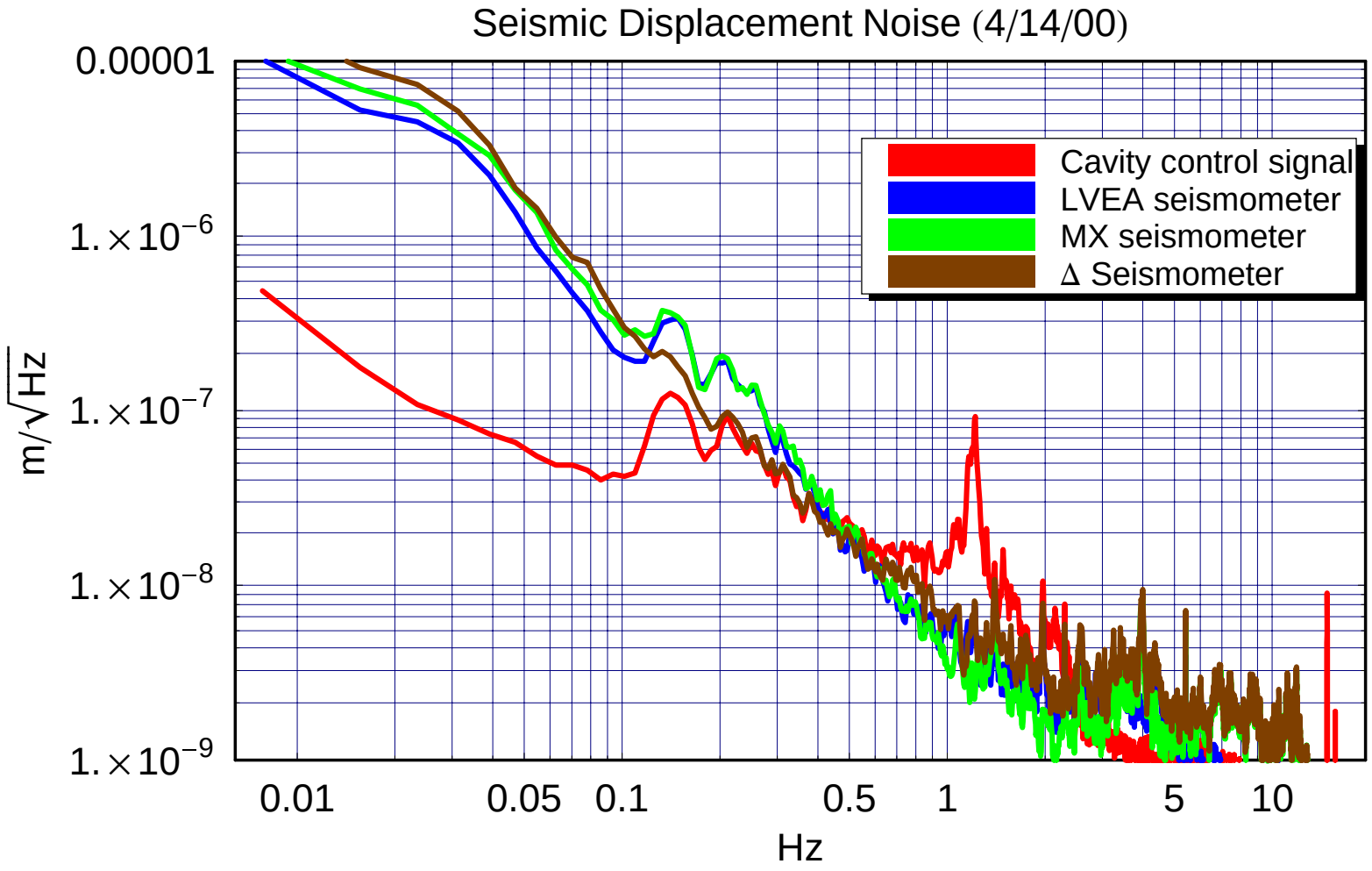
Angular Fluctuations of Optics
Rolf B., Bill K., Luca M., Rana A., David S., Rai W., Tom N.,...

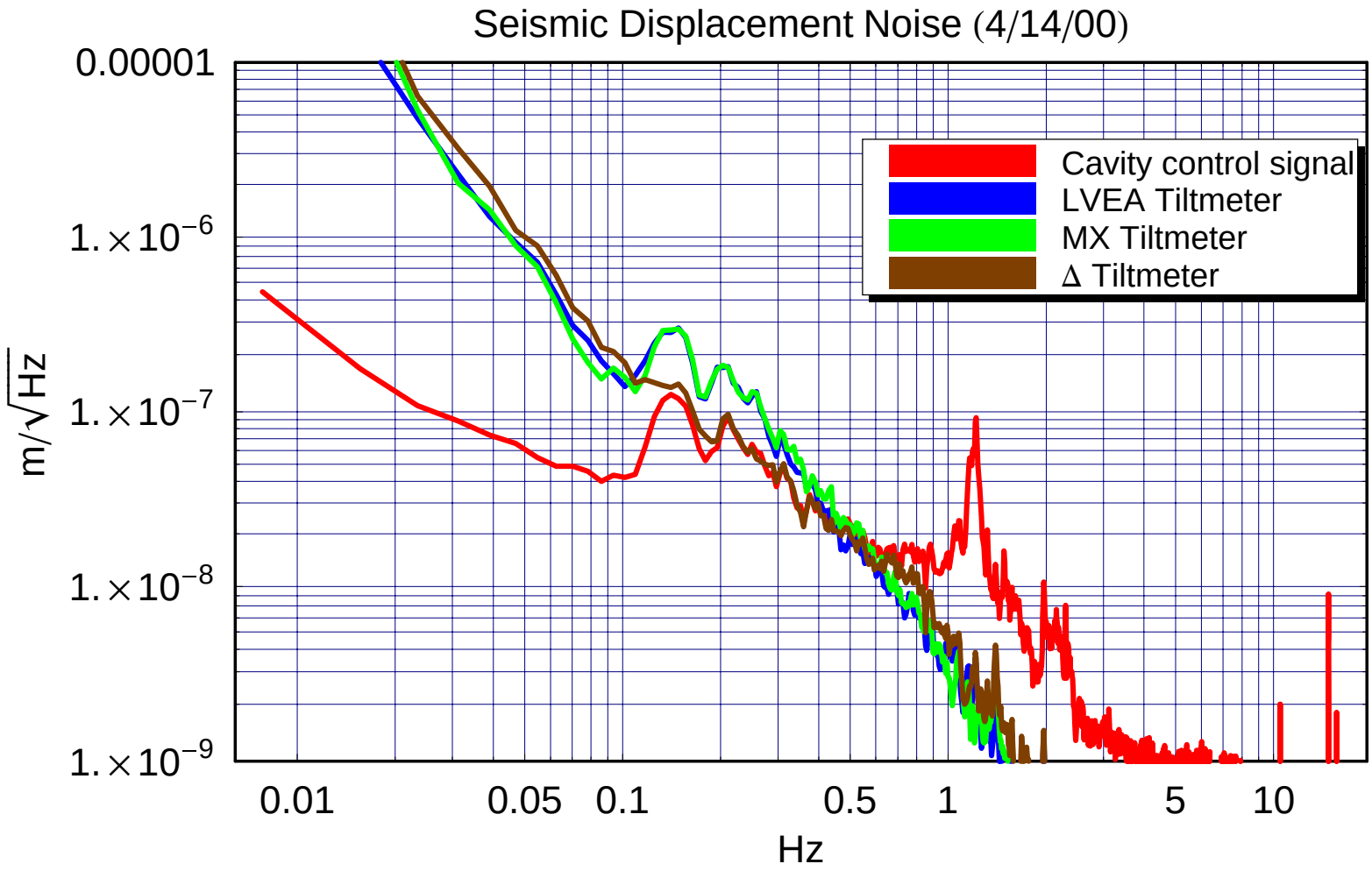
LIGO-G000115-00-D

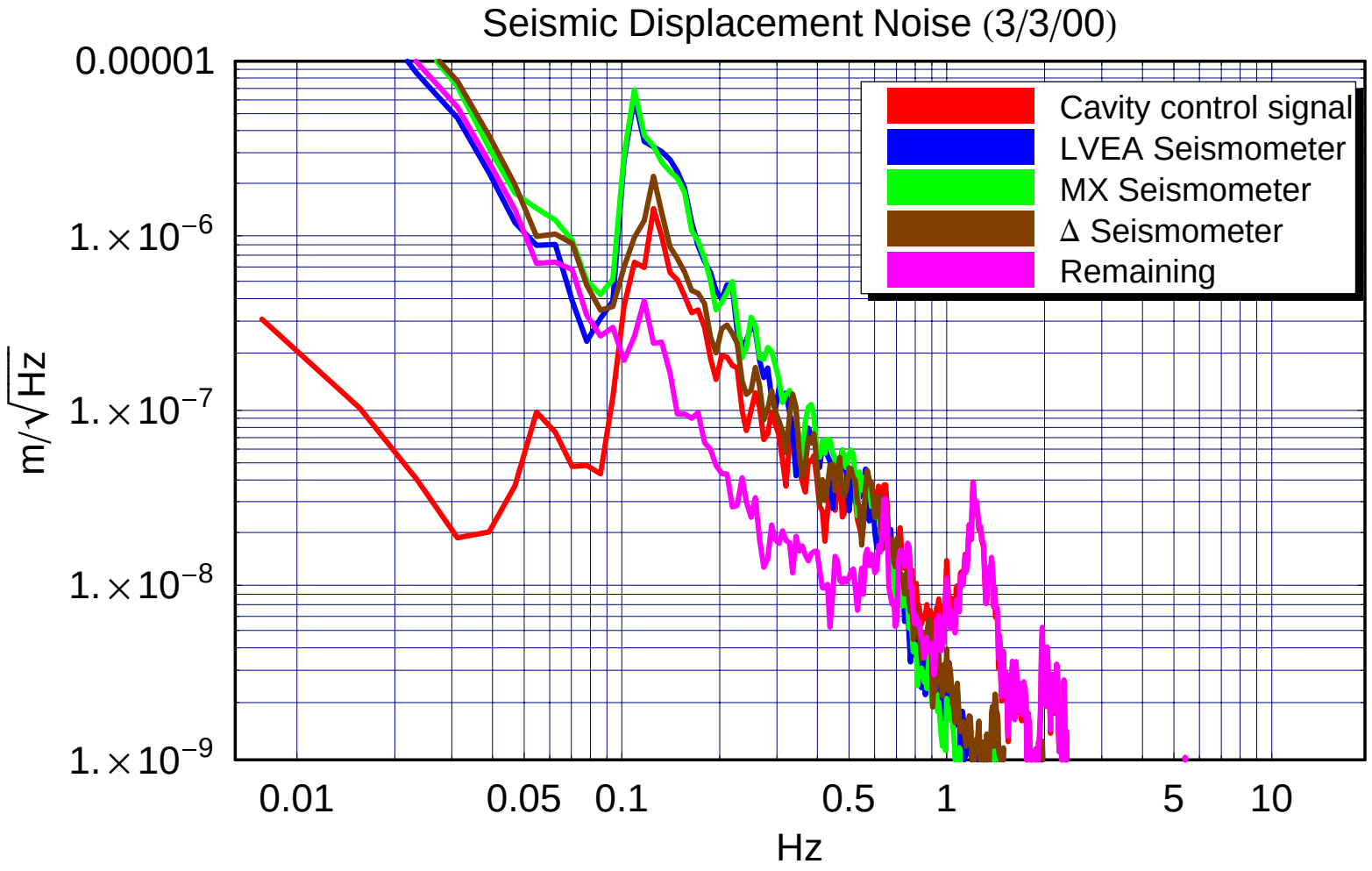
SEISMIC DISPLACEMENT NOISE

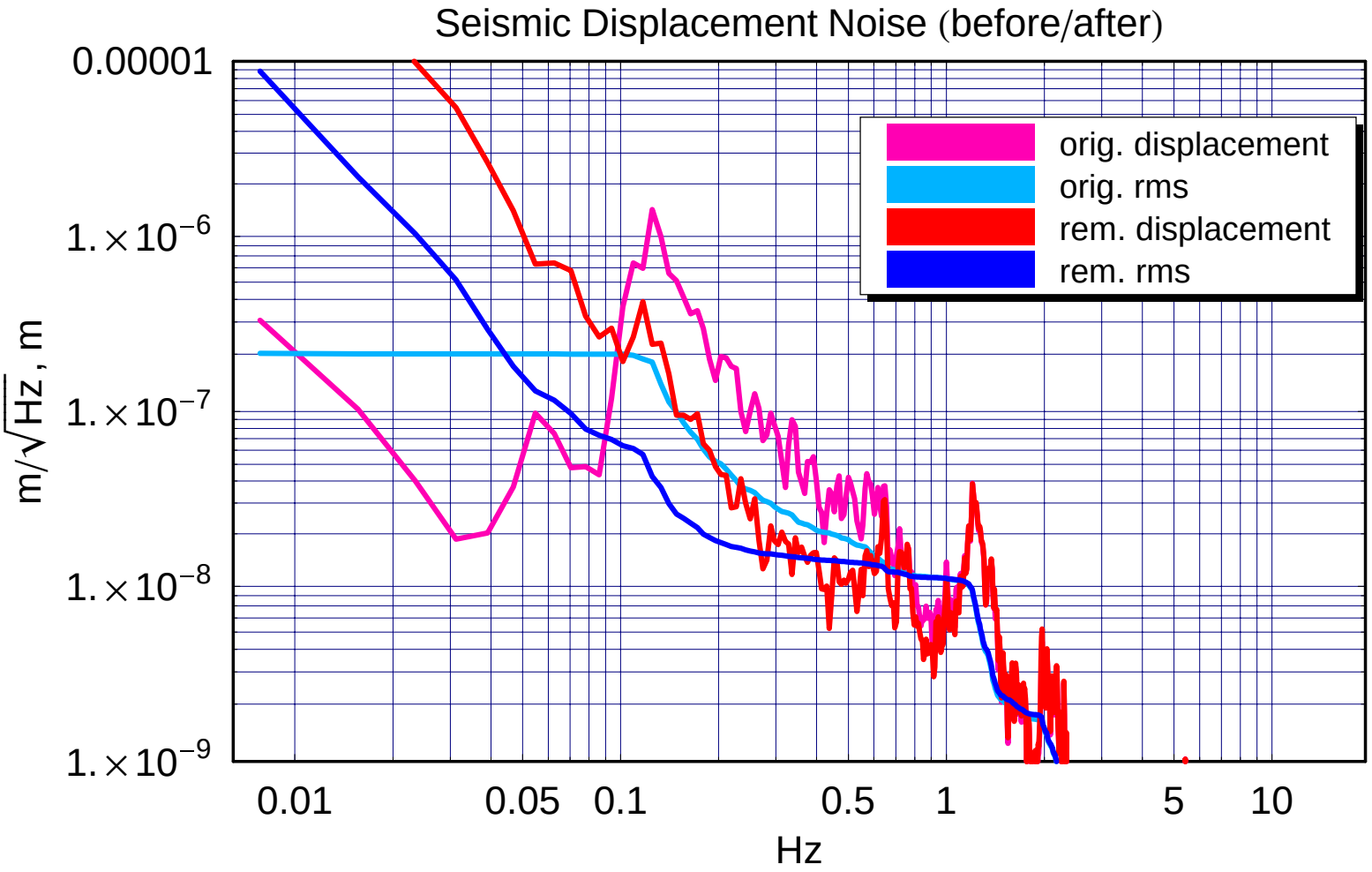
- Micro seismic
- Tidal forces
- Dynamic range of suspension controller
- Average velocities for “locking”
- Thermal actuator (reference cavity)
- Fine actuator
- Dial-in/feed-forward?
- Seismometer/Tiltmeter?


40
30
20
10
0
-10
-20
-30
-40
-50
-4
-3
-2
-1
0
1

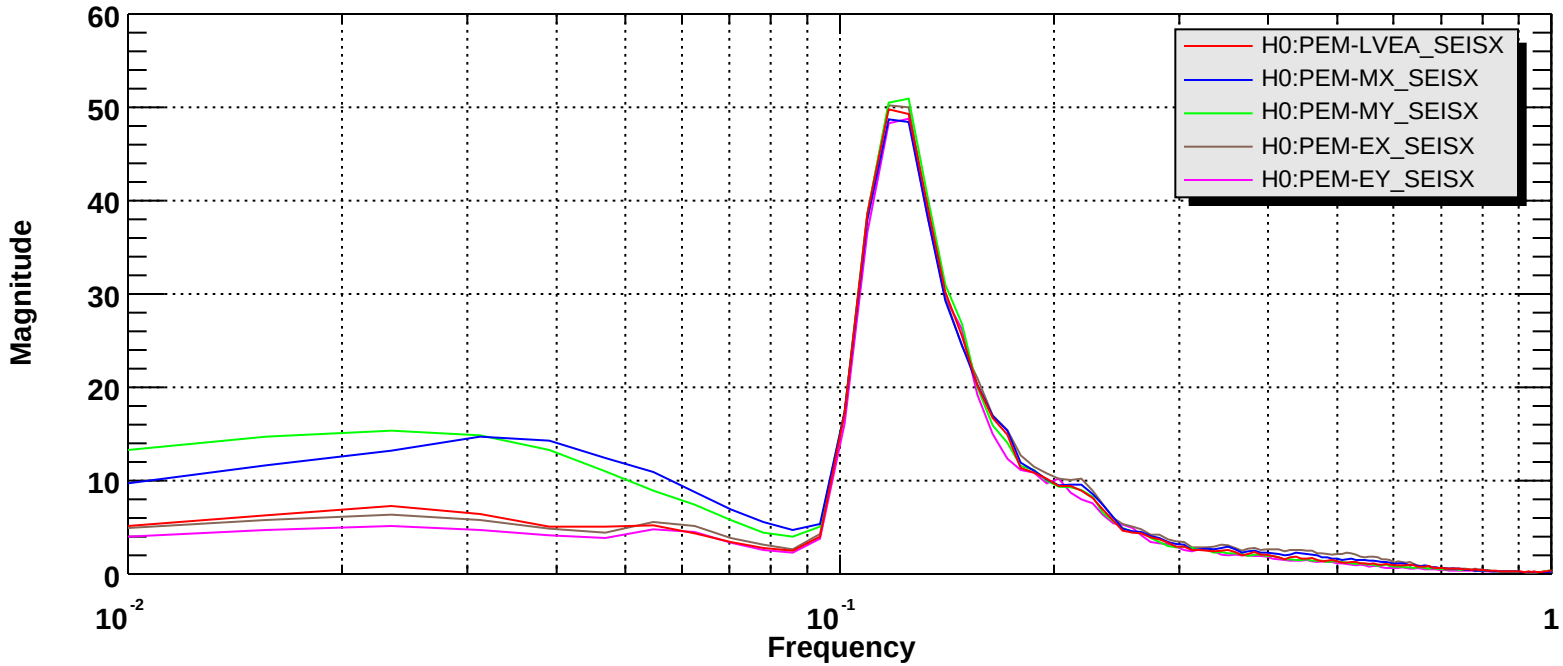

Seismic Displacement Noise (4/14/00)
0.00001
1.×10−6
1.×10−7
1.×10−8
1.×10−9
m/√Hz
0.01
0.05
0.1
0.5
1
5
10
Hz
Cavity control signal
LVEA seismometer
MX seismometer
Δ Seismometer


Seismic Displacement Noise (4/14/00)
0.00001
1.×10−6
1.×10−7
1.×10−8
1.×10−9
m/√Hz
0.01
0.05
0.1
0.5
1
5
10
Hz
Cavity control signal
LVEA Tiltmeter
MX Tiltmeter
Δ Tiltmeter

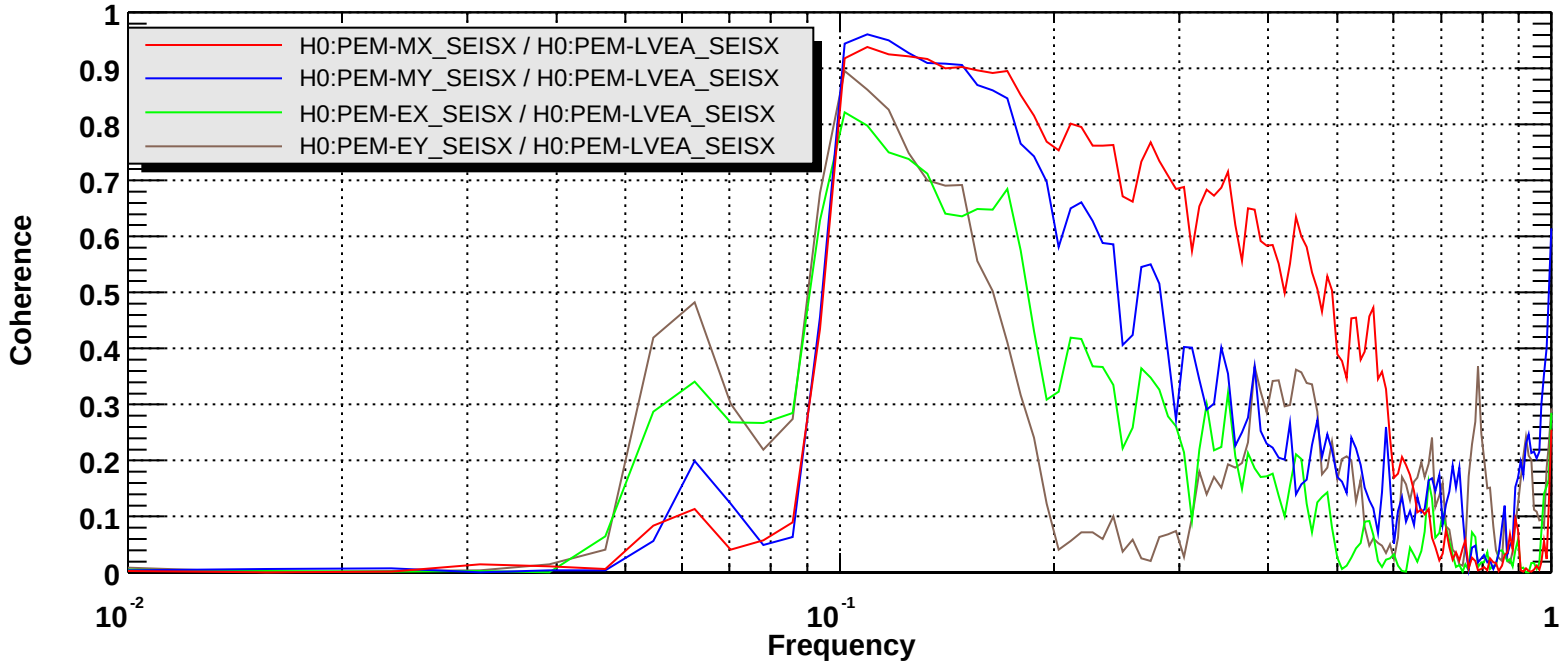

Seismic Displacement Noise (3/3/00)
0.00001
1.×10−6
1.×10−7
1.×10−8
1.×10−9
m/√Hz
0.01
0.05
0.1
0.5
1
5
10
Hz
Cavity control signal
LVEA Seismometer
MX Seismometer
Δ Seismometer
Remaining


Seismic Displacement Noise (before/after)
0.00001
1.×10−6
1.×10−7
1.×10−8
1.×10−9
m/√Hz, m
0.01
0.05
0.1
0.5
1
5
10
Hz
orig. displacement
orig. rms
rem. displacement
rem. rms

Power spectrum



Coherence



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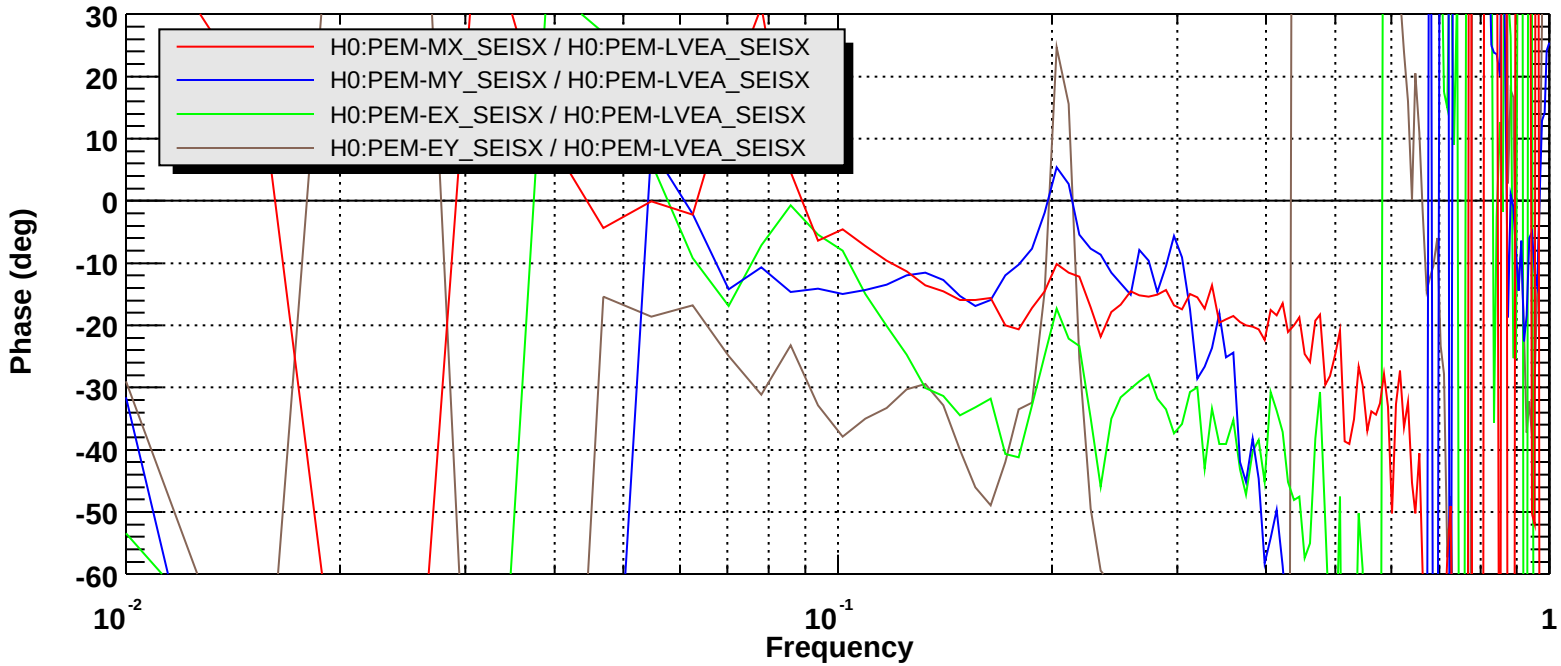
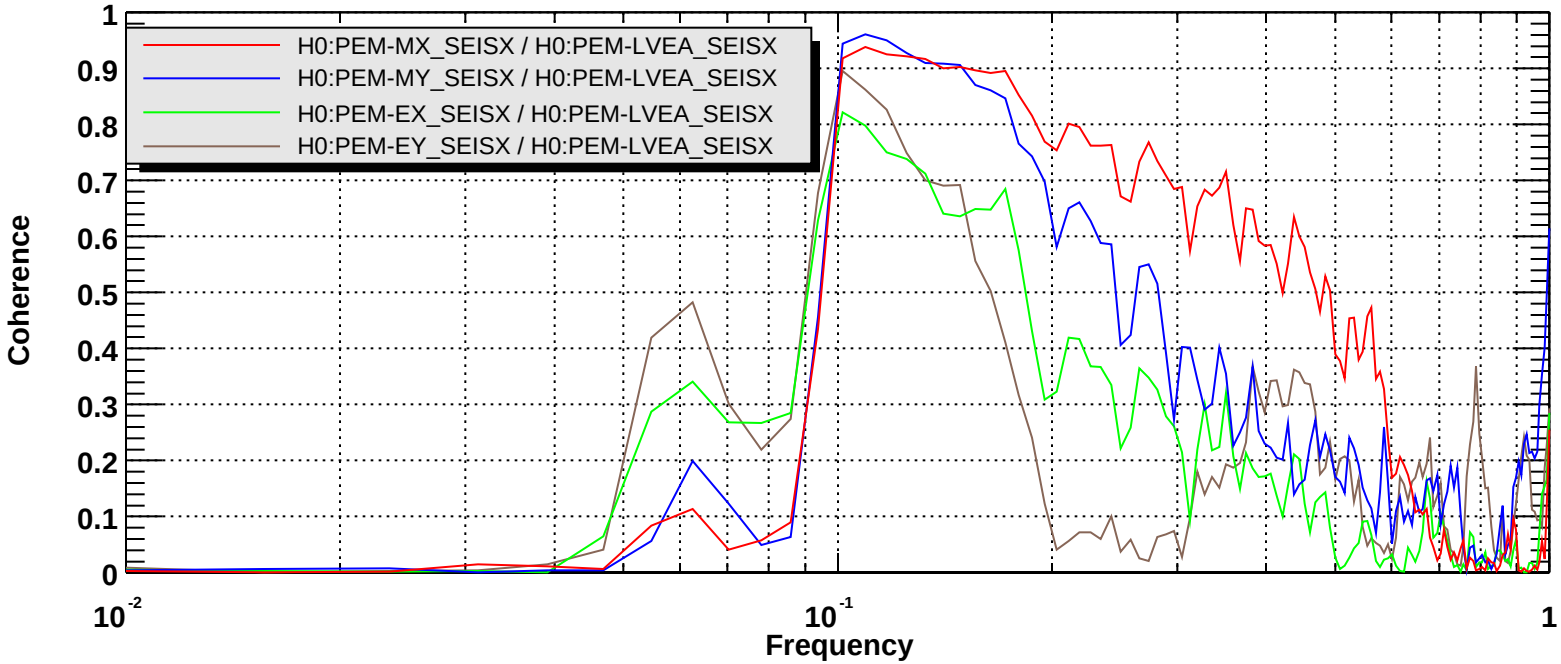
Cross power spectrum



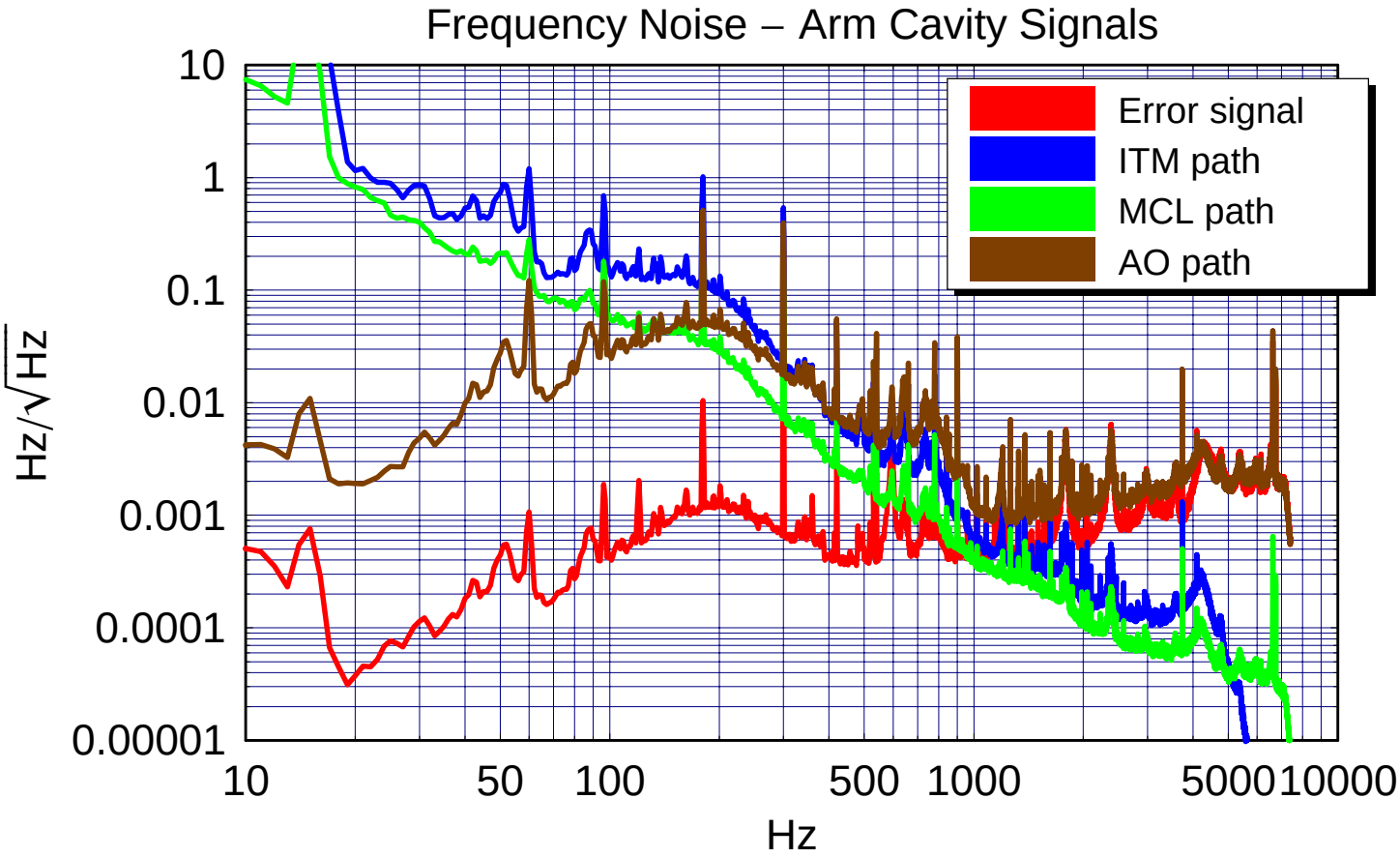
Coherence



T0=03/03/2000 09:00:00 Avg=99 BW=0.0117187

FREQUENCY NOISE

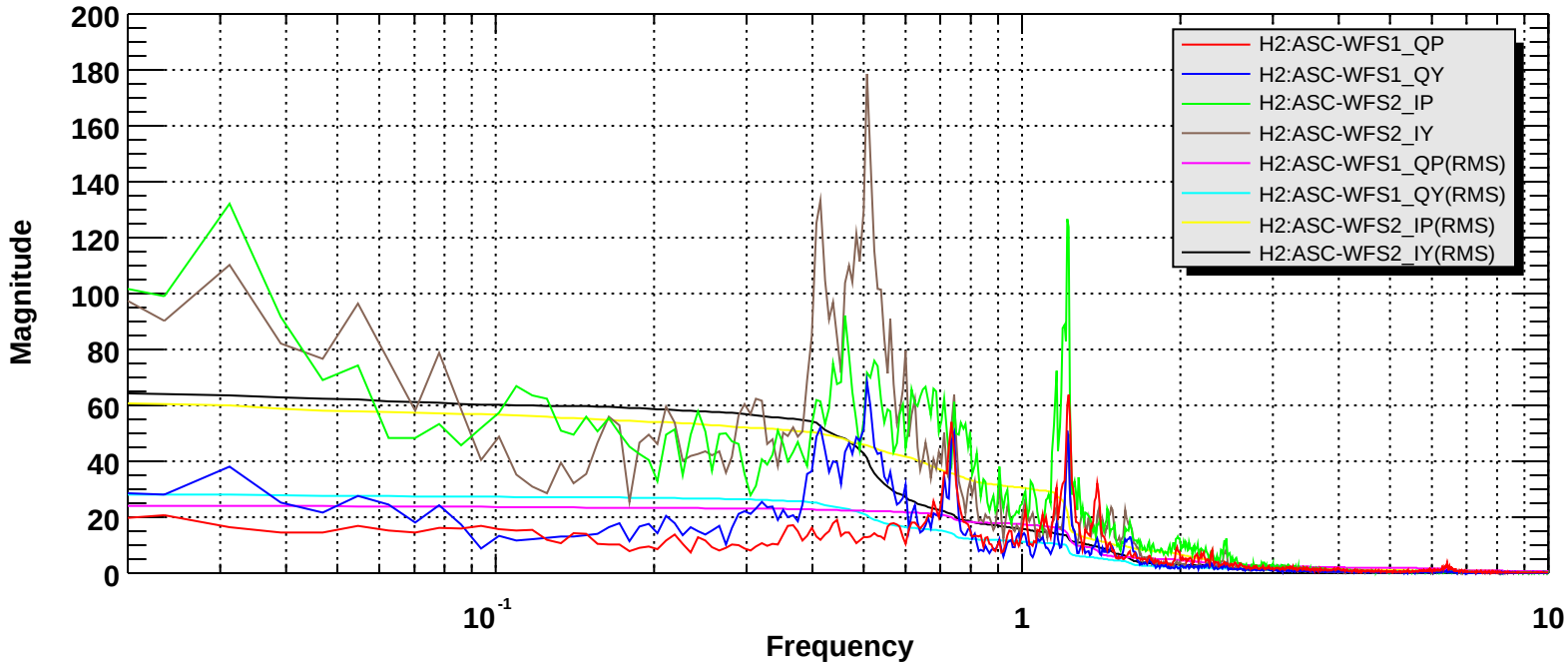
- After Mode cleaner:
  Measured with arm cavity control signals
  - ITMX path
  - MCL path
  - AO path
- Remaining frequency suppression at RM
  Measured with arm cavity error signal


Frequency Noise – Arm Cavity Signals
Error signal
ITM path
MCL path
AO path
10
1
0.1
0.01
0.001
0.0001
0.00001
Hz/√Hz
10
50
100
500
1000
5000
10000
Hz

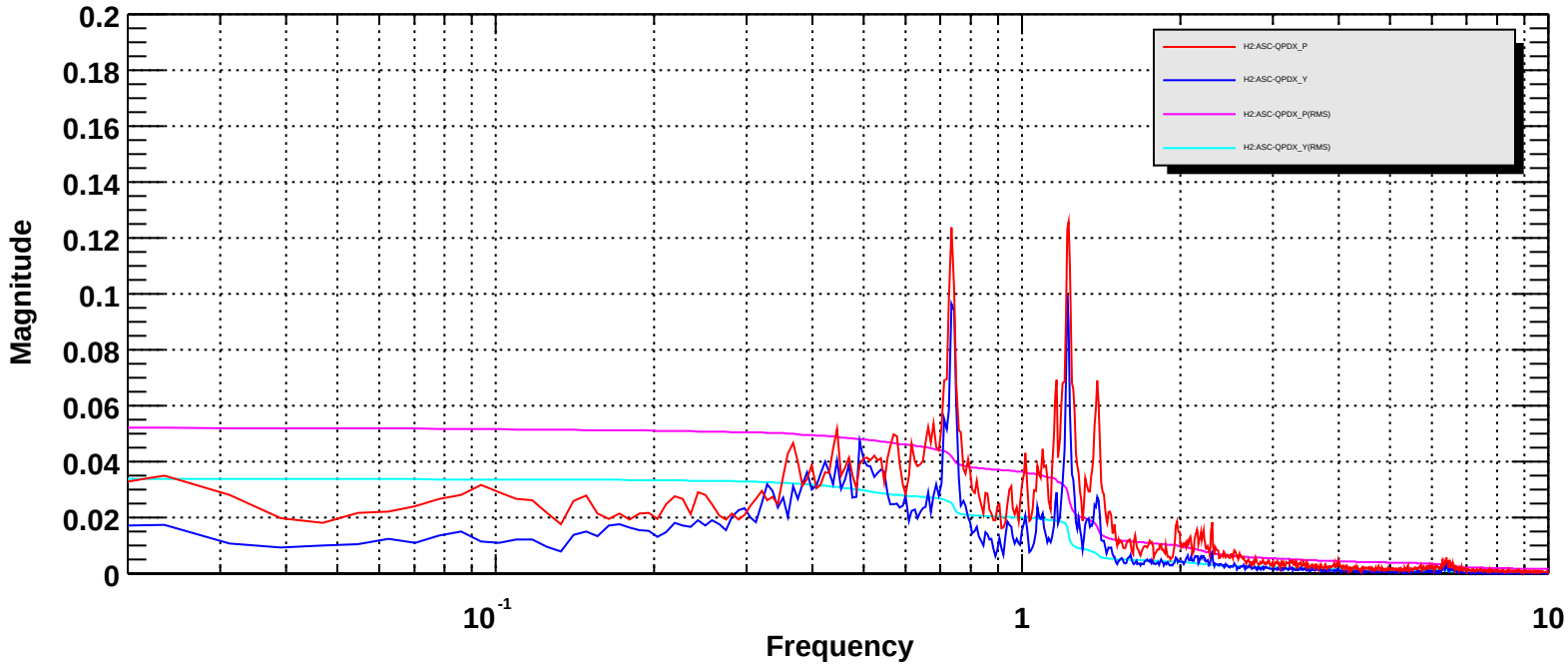
ANGULAR FLUCTUATIONS

- ASC alignment system:
  - Wavefront sensors in reflection
  - Quadrant position sensor in transmission
  - Feedback to beamsplitter, ITMX and ETMX orientations
- Look at error signal with ASC on/off
- Look at control signals when ASC is engaged
- Calibrate with optical levers
- DC readout
- Near/far field differences
- Mode cleaner locking & orientation

Power spectrum



Power spectrum



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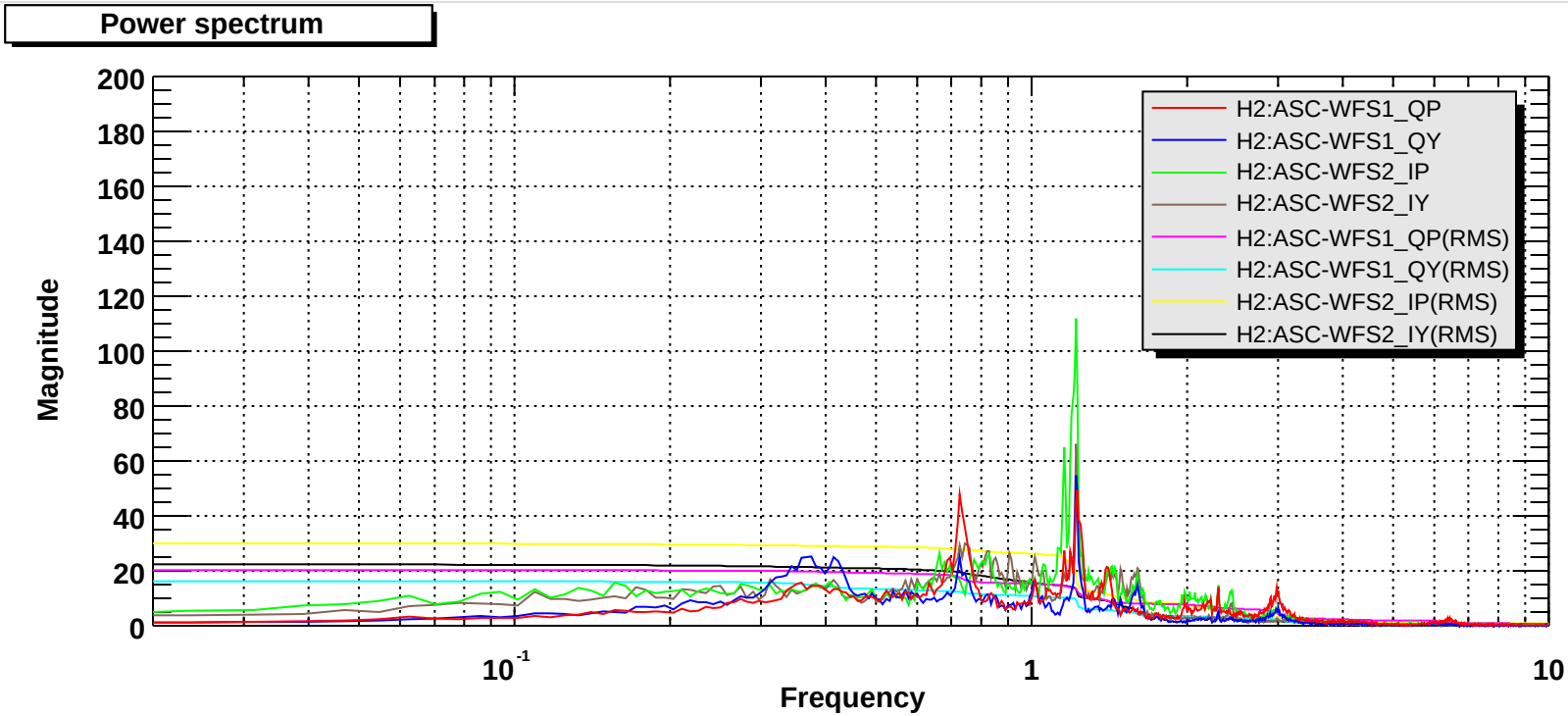

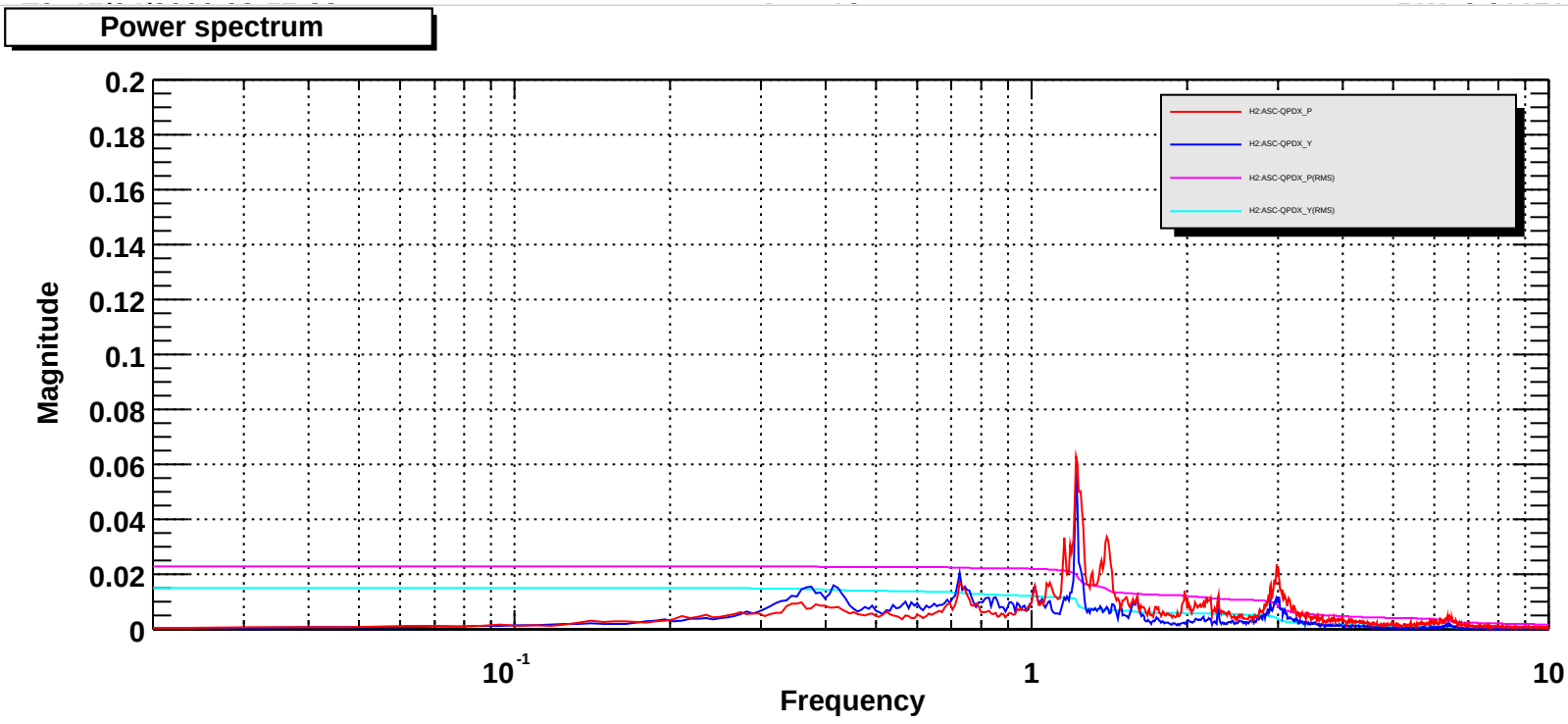

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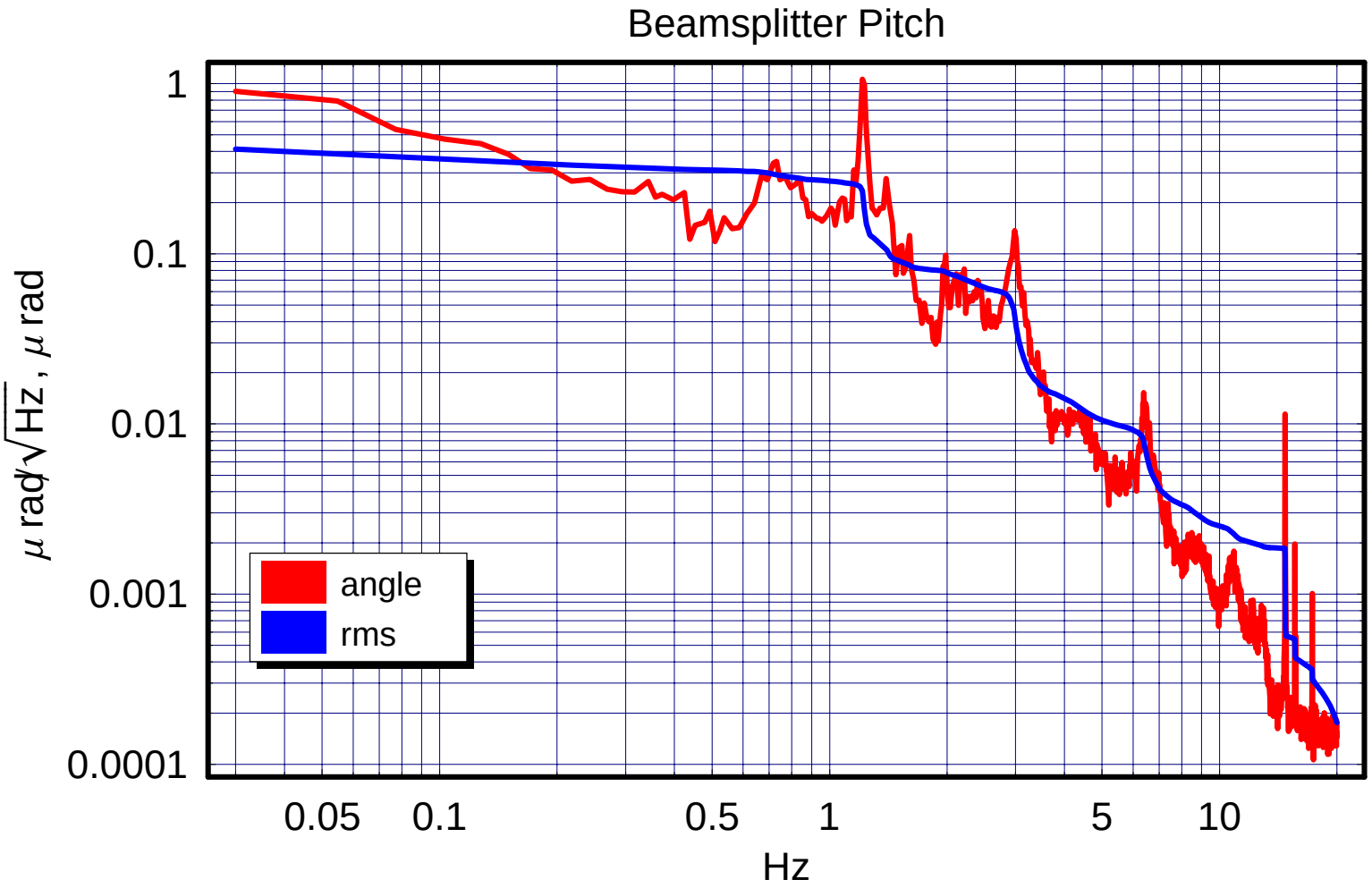
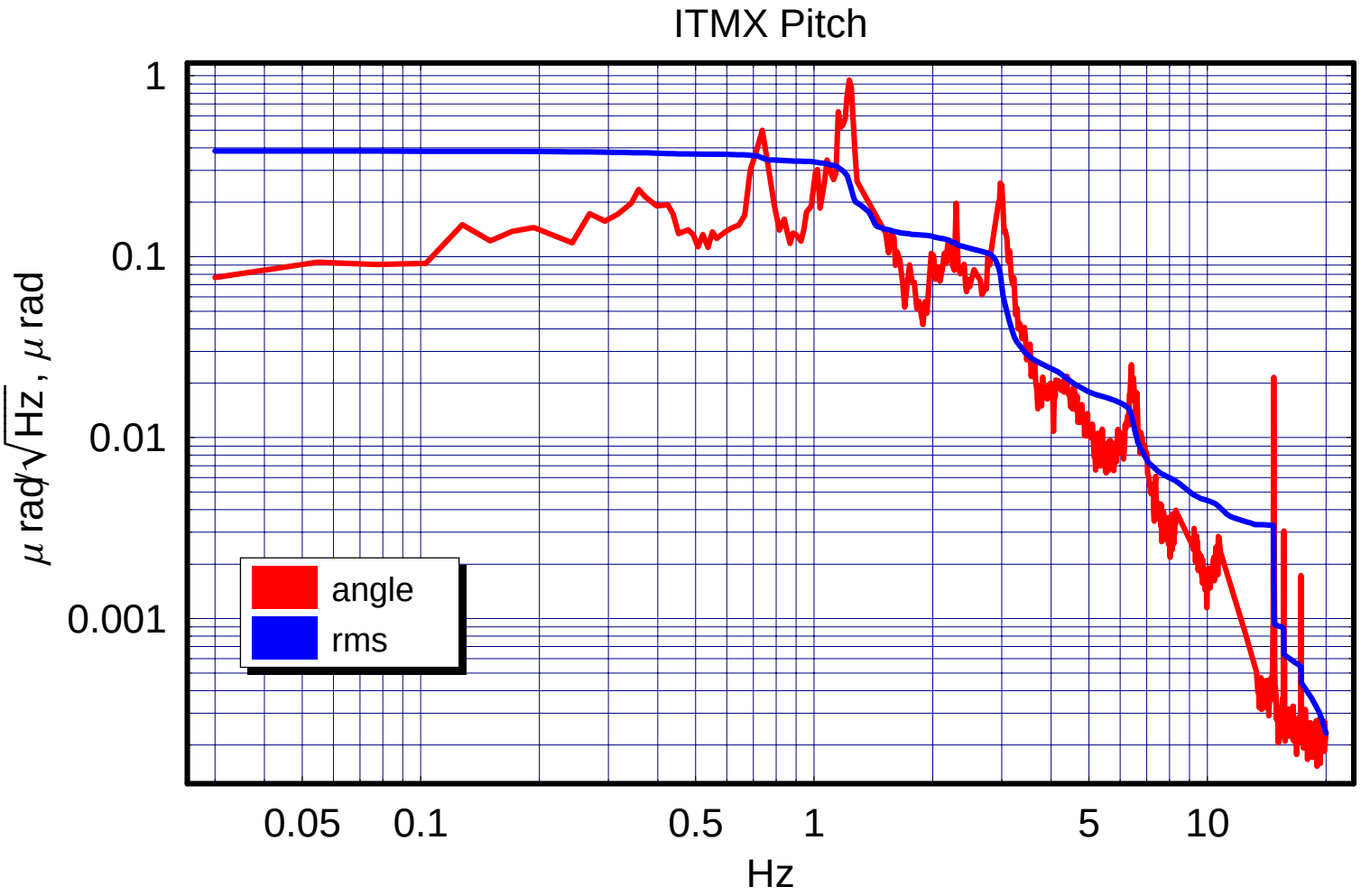
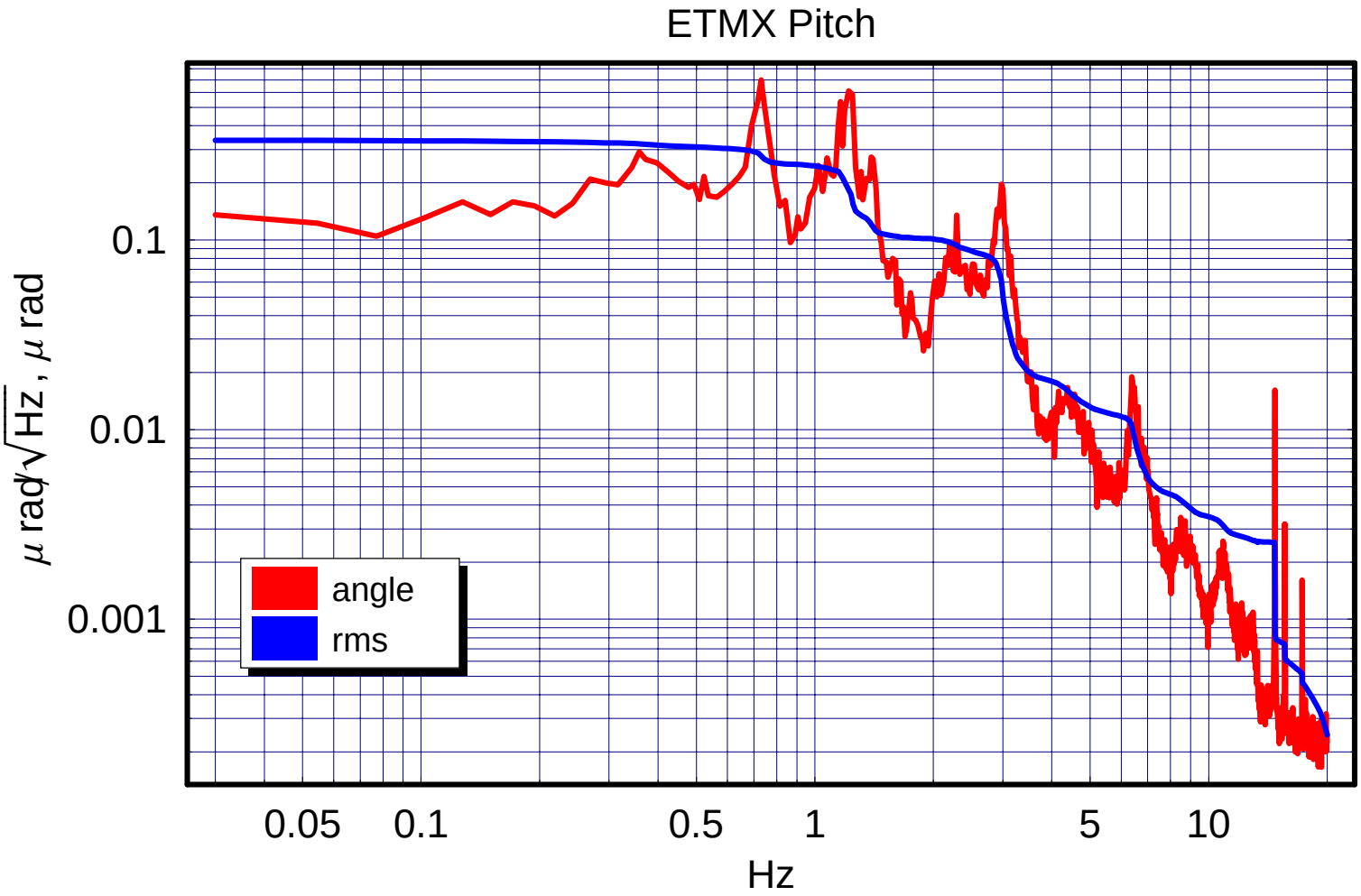
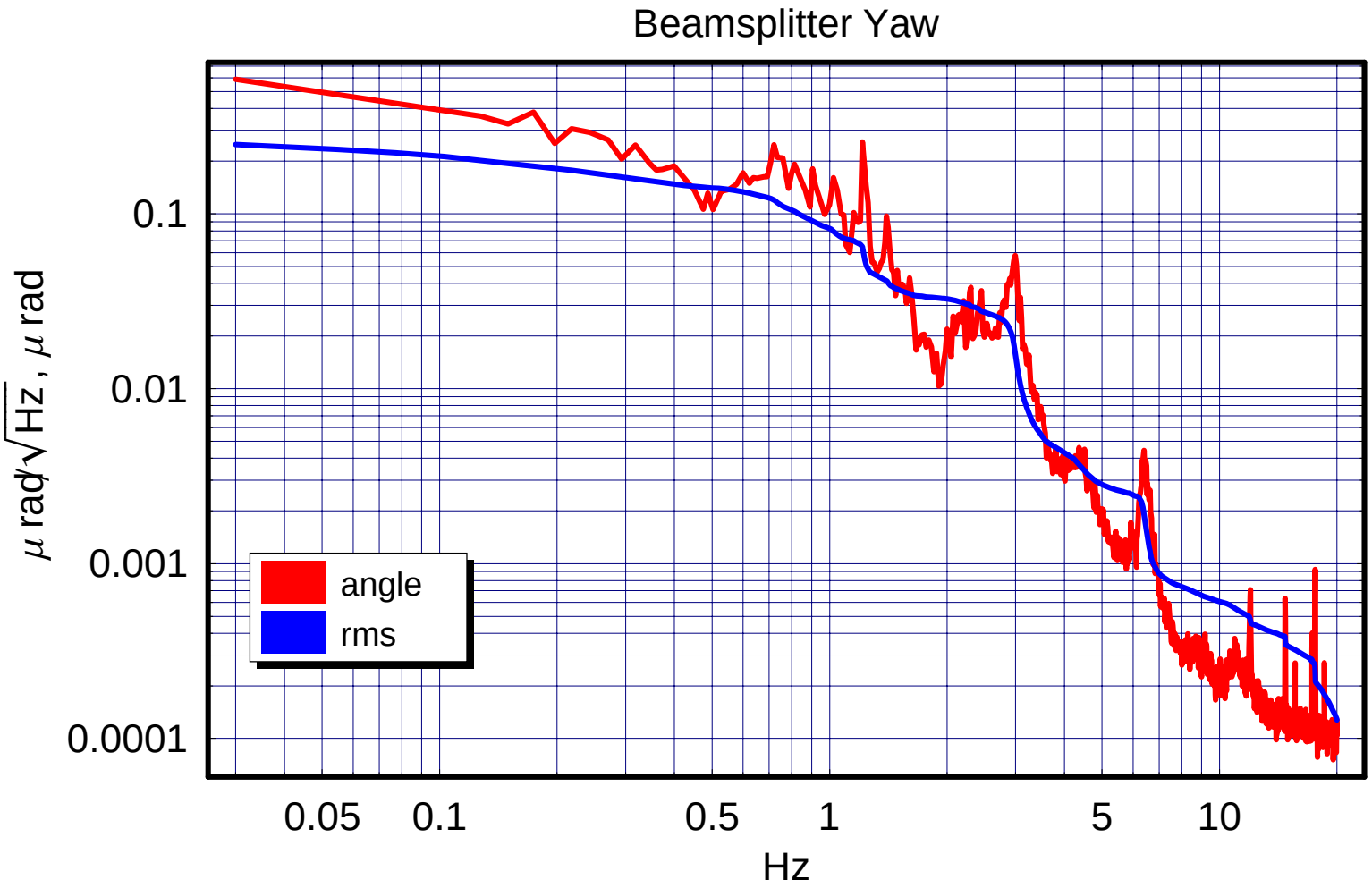
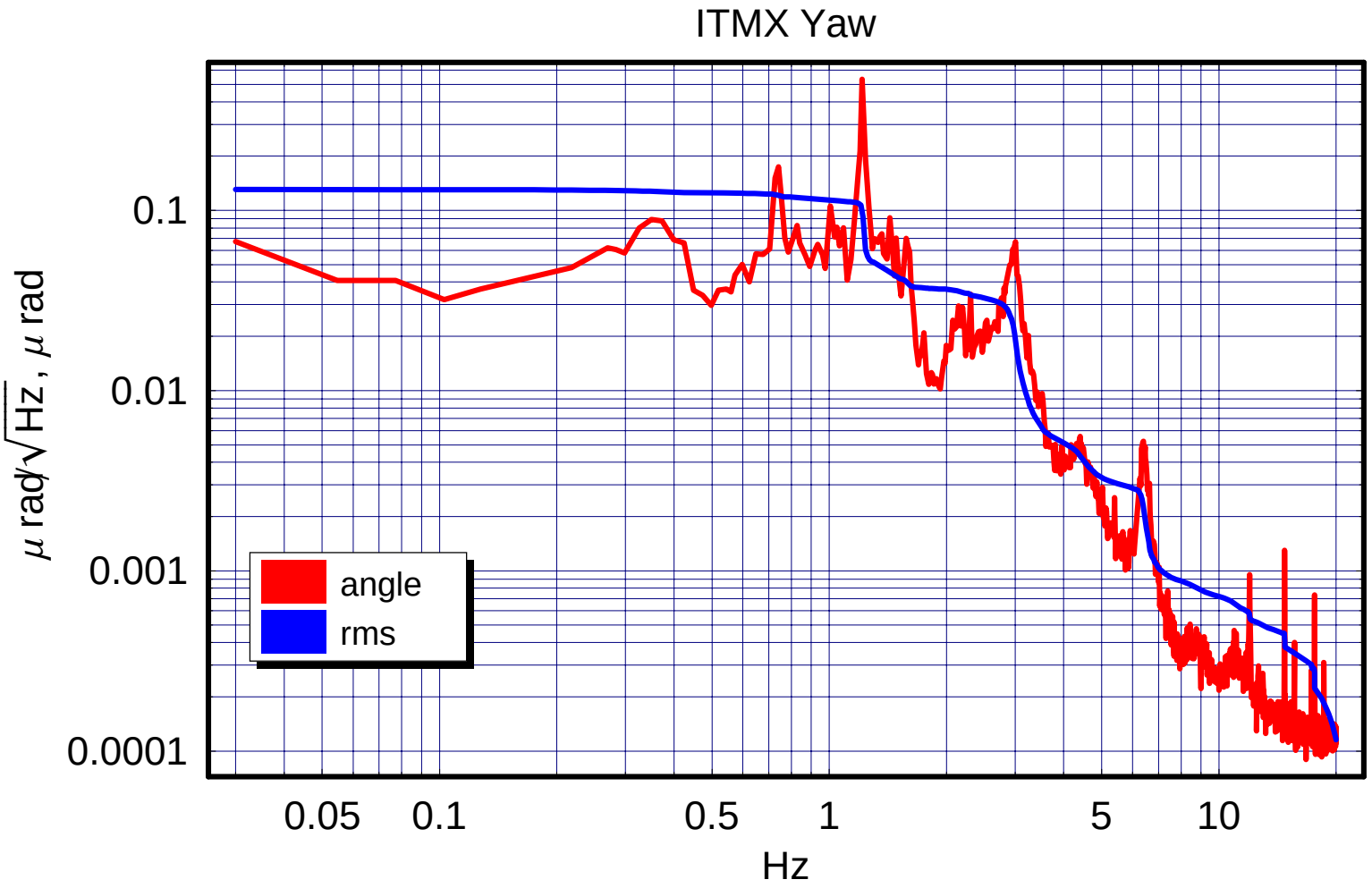
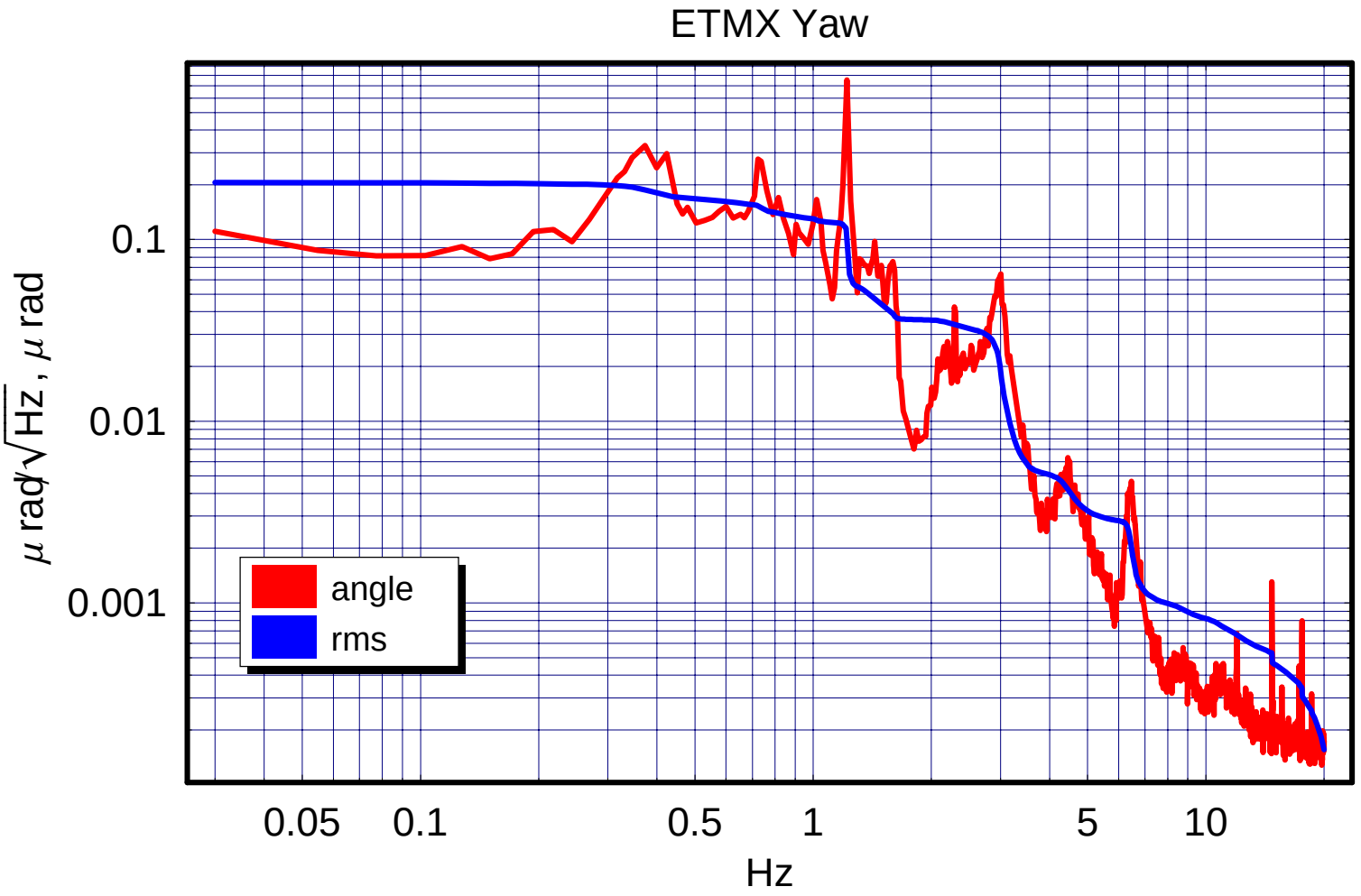

Beamsplitter Pitch
1
0.1
0.01
0.001
0.0001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz

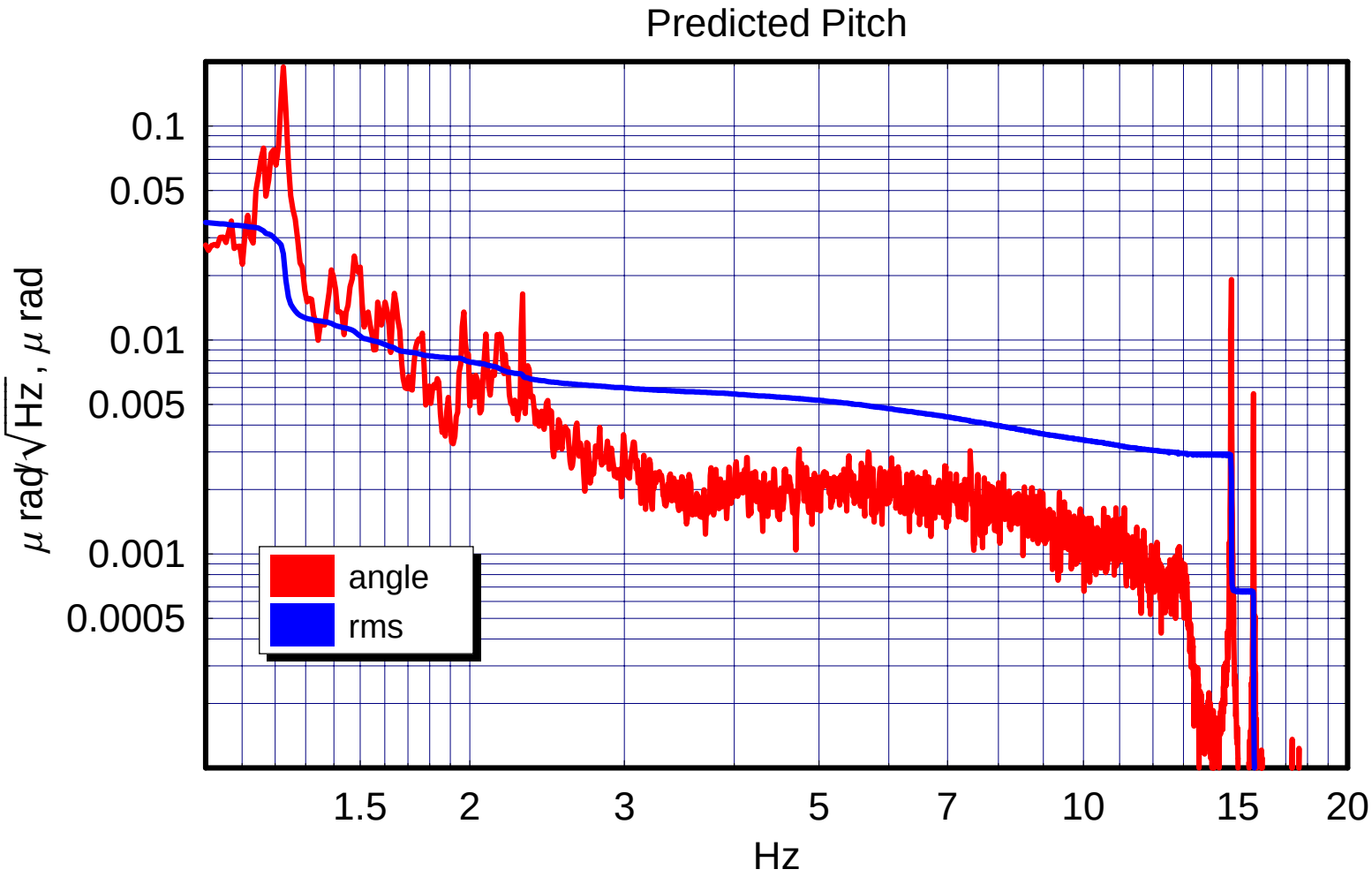

ITMX Pitch
1
0.1
0.01
0.001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz


ETMX Pitch
0.1
0.01
0.001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz


Beamsplitter Yaw
0.1
0.01
0.001
0.0001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz


ITMX Yaw
0.1
0.01
0.001
0.0001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz


ETMX Yaw
0.1
0.01
0.001
μ rad/√Hz , μ rad
angle
rms
0.05
0.1
0.5
1
5
10
Hz


Predicted Pitch
0.1
0.05
0.01
0.005
0.001
0.0005
μ rad/√Hz , μ rad
angle
rms
1.5
2
3
5
7
10
15
20
Hz

CONCLUSIONS

- Did we learn anything about the environment which would significantly impact the current design?
  - Tidal: as expected
  - Micro seismic: better than expected (at least at LHO)
  - Angular fluctuations: larger than expected
    but unclear how much is self-inflicted