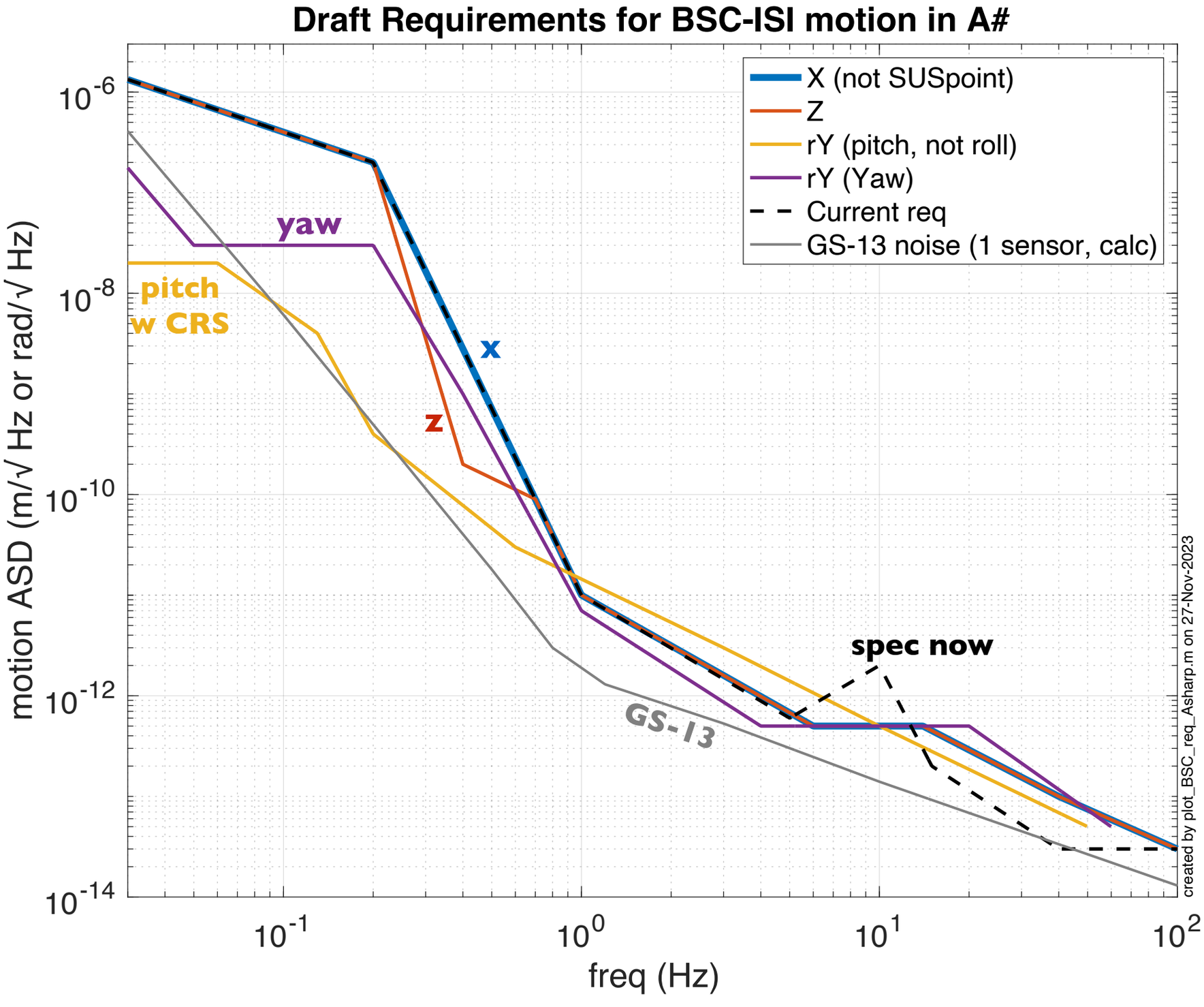
Motion estimates for the BSC-ISI during A#

G2302230, B. Lantz, Nov 28,2023

Tweak the BSC requirement a bit:

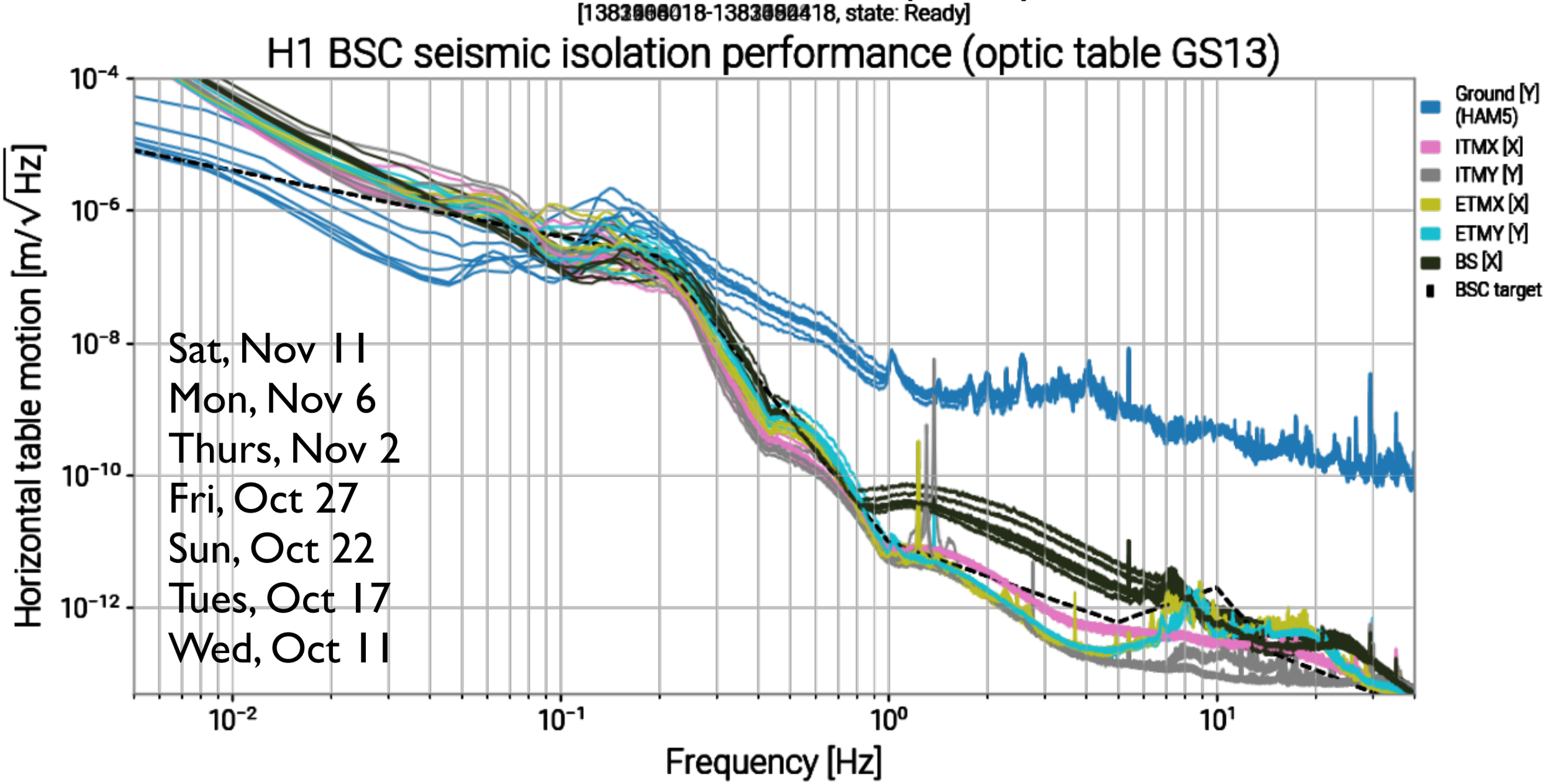
- Set the SUSpoint Length & Vertical requirement to 5e-13 m/√Hz at 10 Hz
  (Not all the ISIs reach this now, a few do better,.
  My target is 2e-13 for all the tables,
  but not confident we can do that everywhere all the time)
- Leave the current req for horizontal & vertical microseism.
  (but we can probably do better, requires some thought)
- Set the 0.4 Hz vertical to 2e-11 m/√Hz.
  Impacts vertical calculations (I think?)
- Improve req for low frequency pitch motion.
  Assume a good rotation sensor, impacts the pitch calculations
  Roll doesn't get this improvement.

TL; DR


Draft Requirements for BSC-ISI motion in A#
X (not SUSpoint)
Z
rY (pitch, not roll)
rY (Yaw)
Current req
GS-13 noise (1 sensor, calc)
yaw
pitch
w CRS
x
z
spec now
GS-13
motion ASD (m/√ Hz or rad/√ Hz)
freq (Hz)
created by plot_BSC_req_Asharp.m on 27-Nov-2023

Motion now - LHO

Ground motion and table motion is very consistent above 1 Hz
(5 tables, 7 different times)
Table motion at 1 Hz is limited by sensor noise and blend filters
Table motion at 10 Hz is set by UGF, Feedforward tuning, and sensor noise
table motion at 10 Hz is not a priority for O4.



Ground motion and table motion is very consistent above 5 Hz
Table motion at 1 Hz is limited by sensor noise and blend filters
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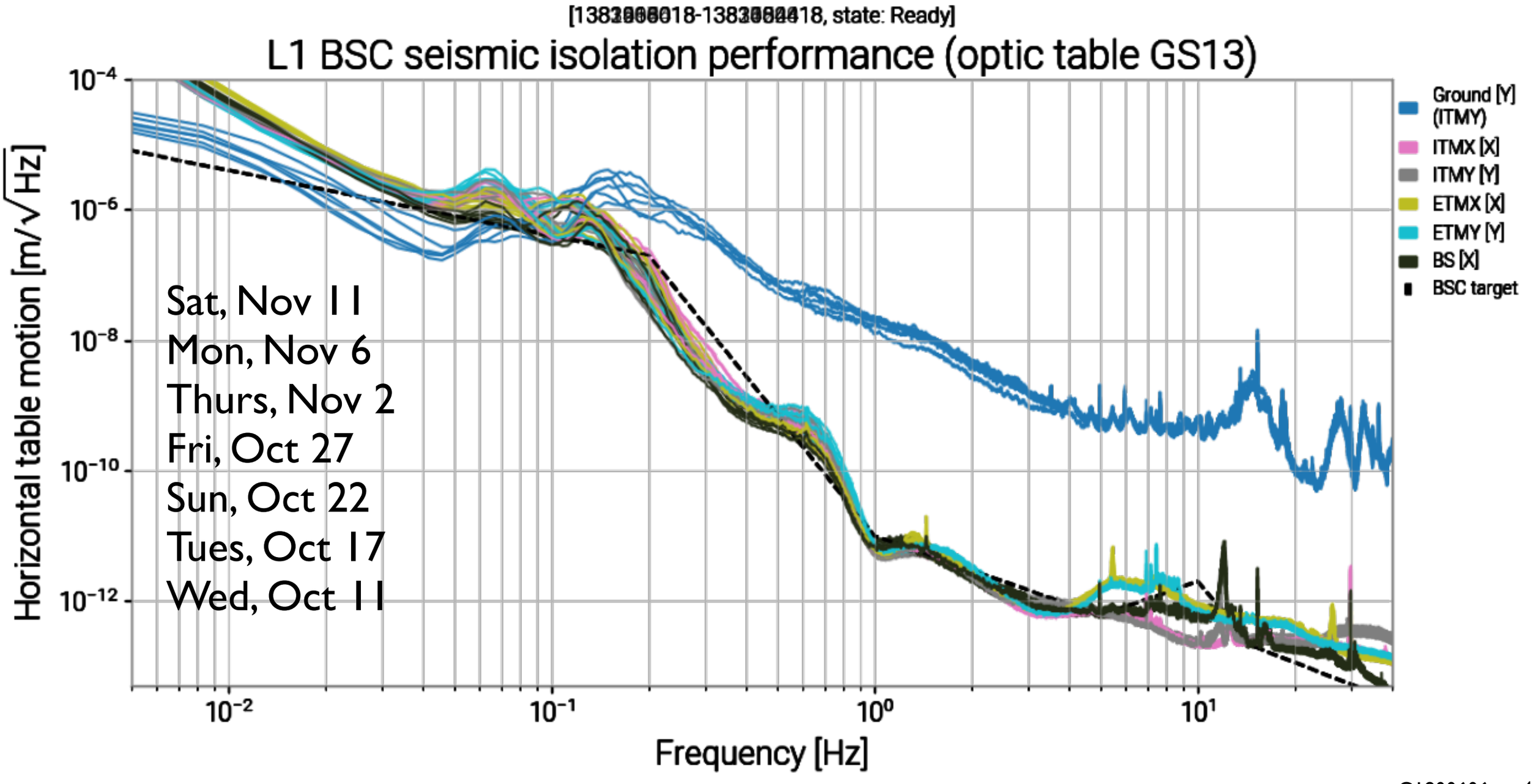

LLO

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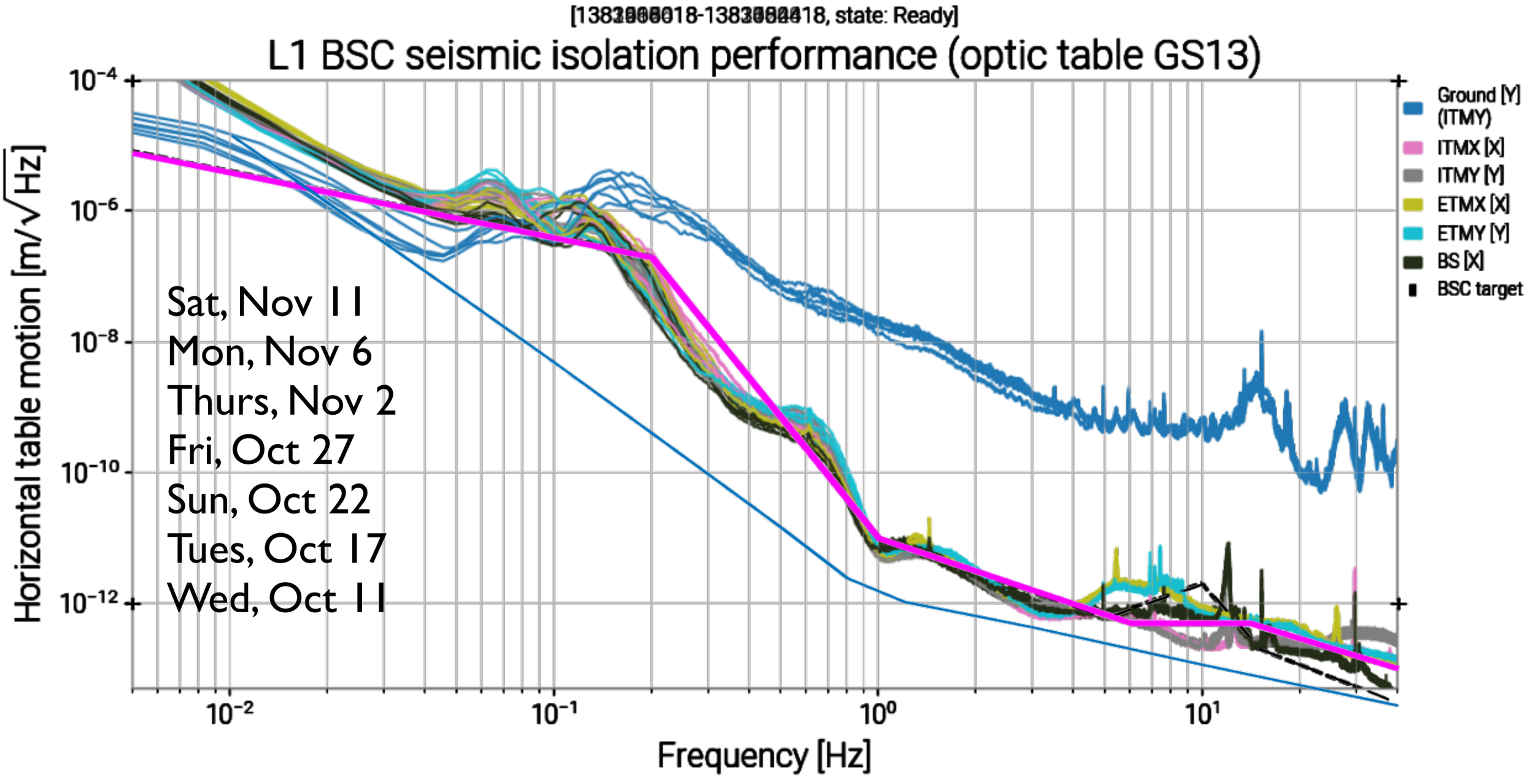
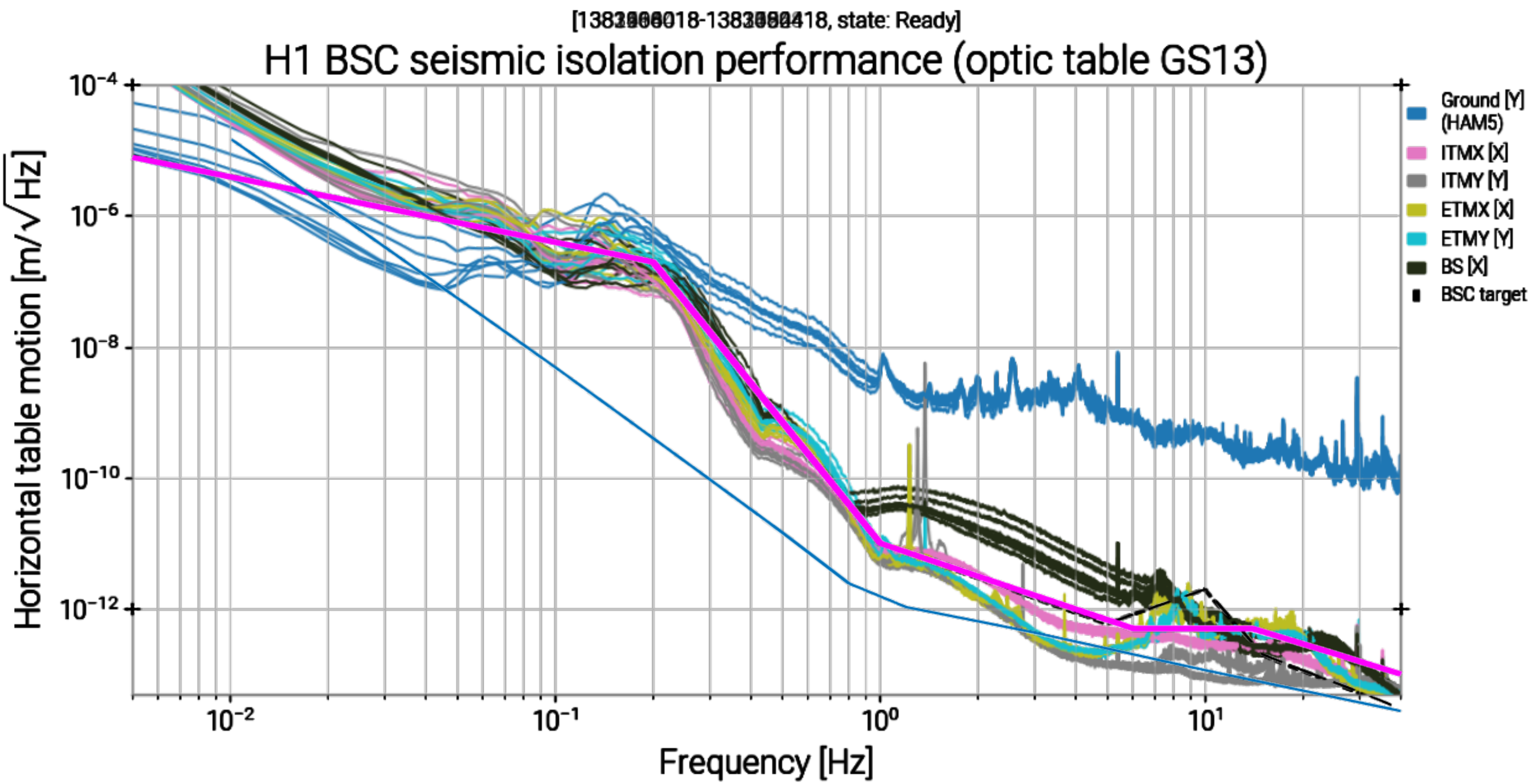
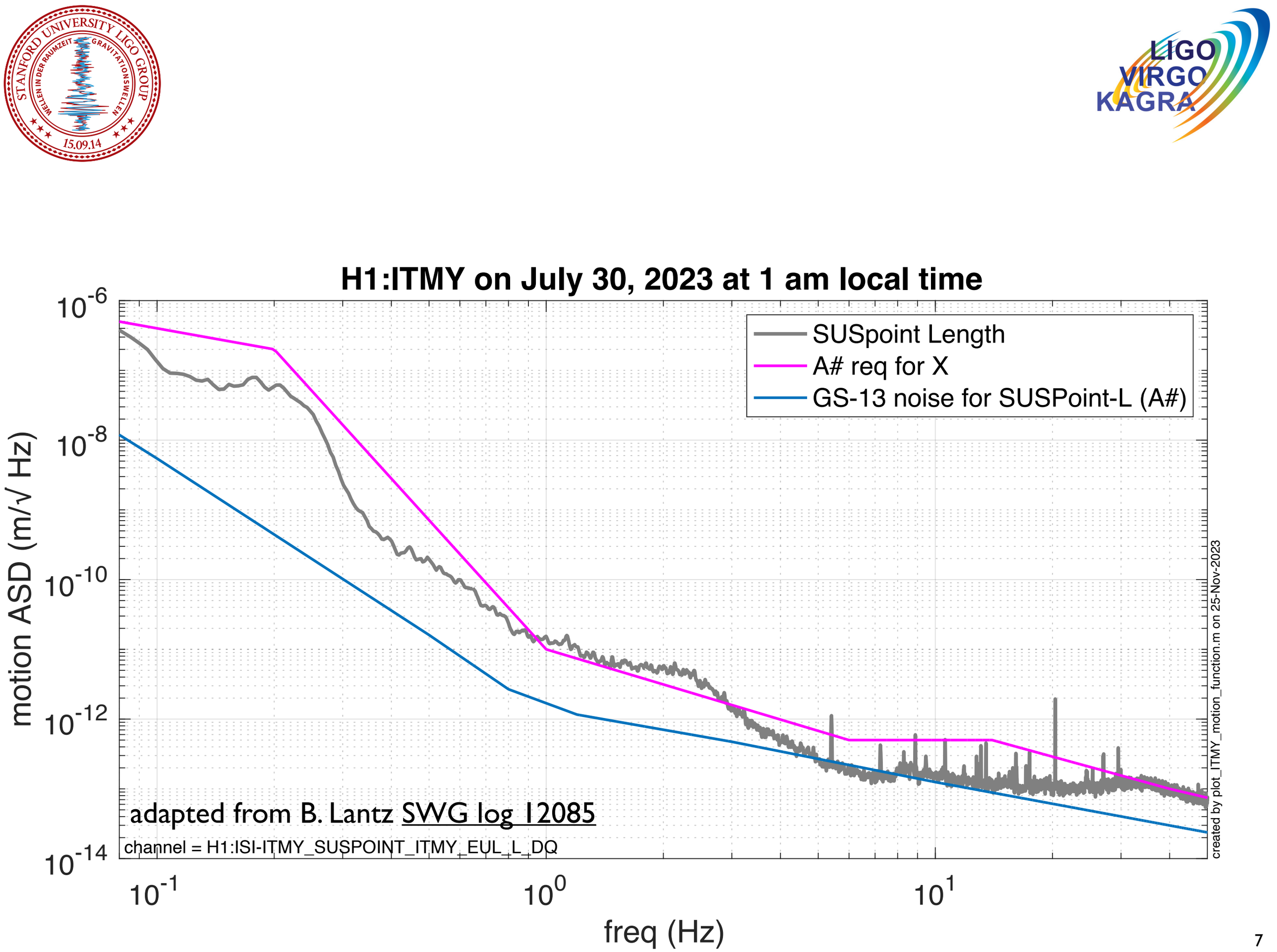
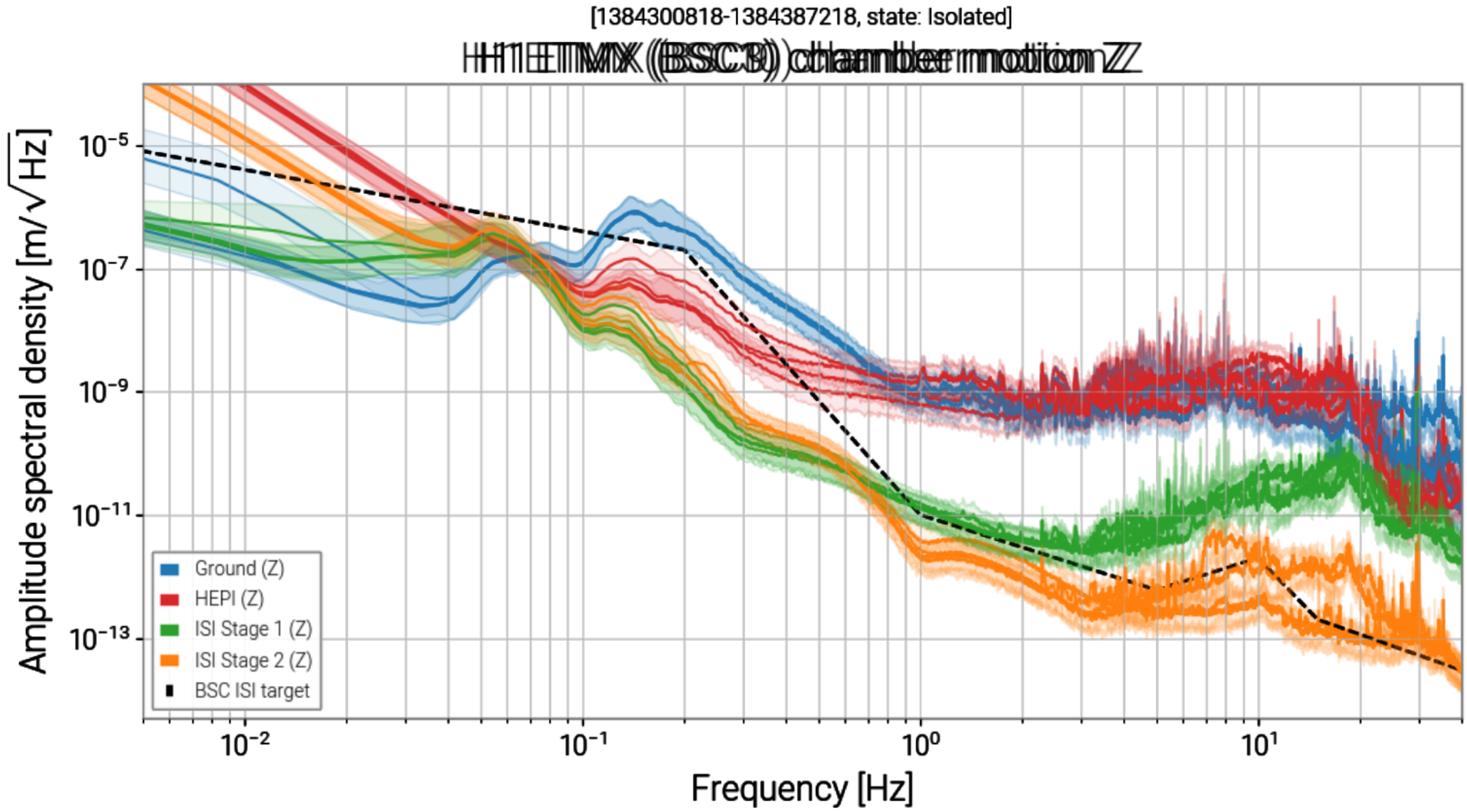



[1383000018-1383000418, state: Ready]
H1 BSC seismic isolation performance (optic table GS13)
Horizontal table motion [m/√Hz]
Frequency [Hz]
10⁻⁴
10⁻⁶
10⁻⁸
10⁻¹⁰
10⁻¹²
10⁻²
10⁻¹
10⁰
10¹
Ground [Y] (HAM5)
ITMX [X]
ITMY [Y]
ETMX [X]
ETMY [Y]
BS [X]
BSC target


H1:ITMY on July 30, 2023 at 1 am local time
SUSpoint Length
A# req for X
GS-13 noise for SUSPoint-L (A#)
motion ASD (m/√ Hz)
freq (Hz)
adapted from B. Lantz SWG log 12085
channel = H1:ISI-ITMY_SUSPOINT_ITMY_EUL_L_DQ
created by plot_ITMY_motion_function.m on 25-Nov-2023

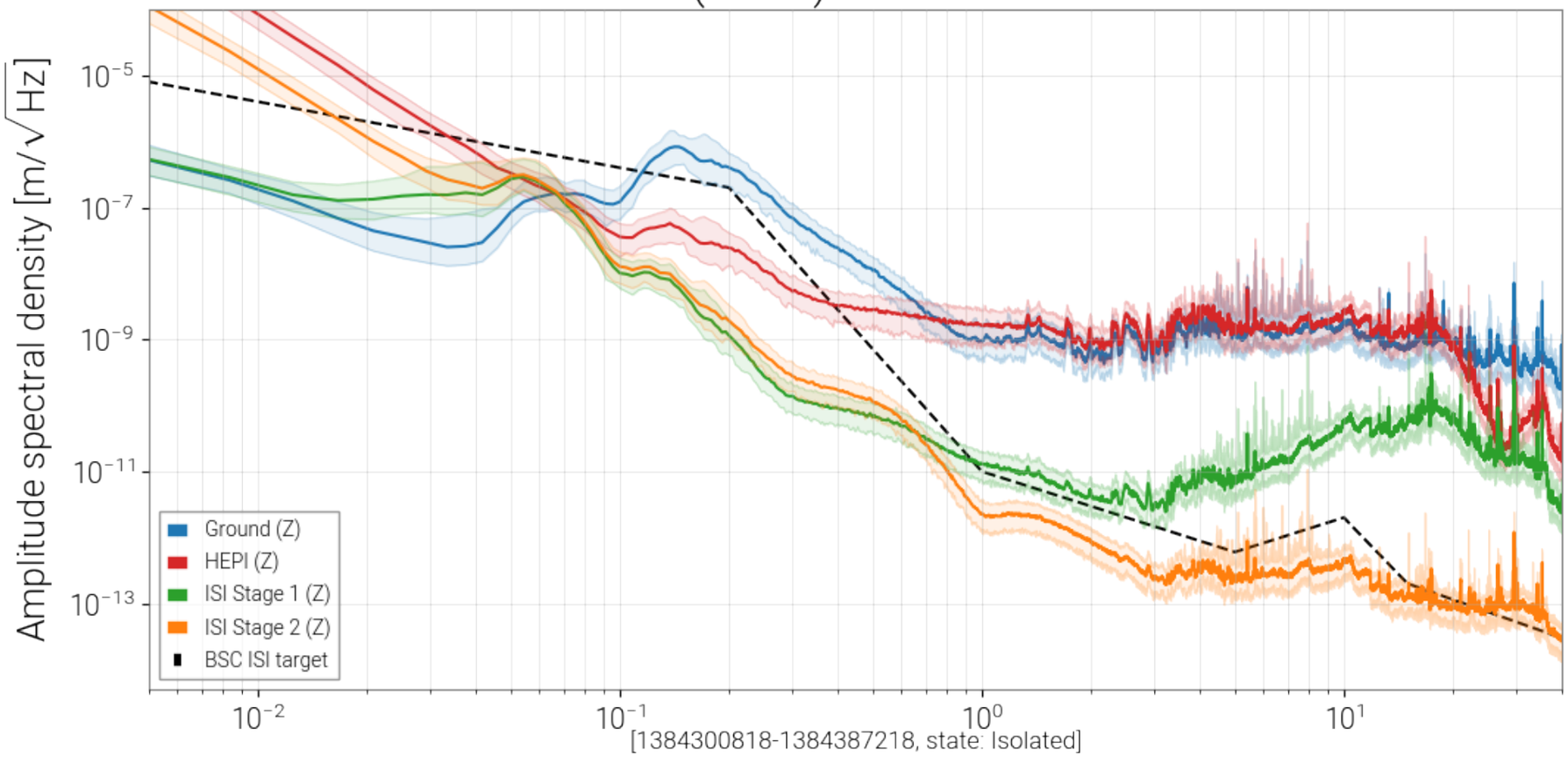
Z motion

Z motion, LHO, Nov 18, 2023, 4 test mass chambers
10 Hz is typically pretty stable (unlike microseism)
Feedforward tuning important to get best performance,

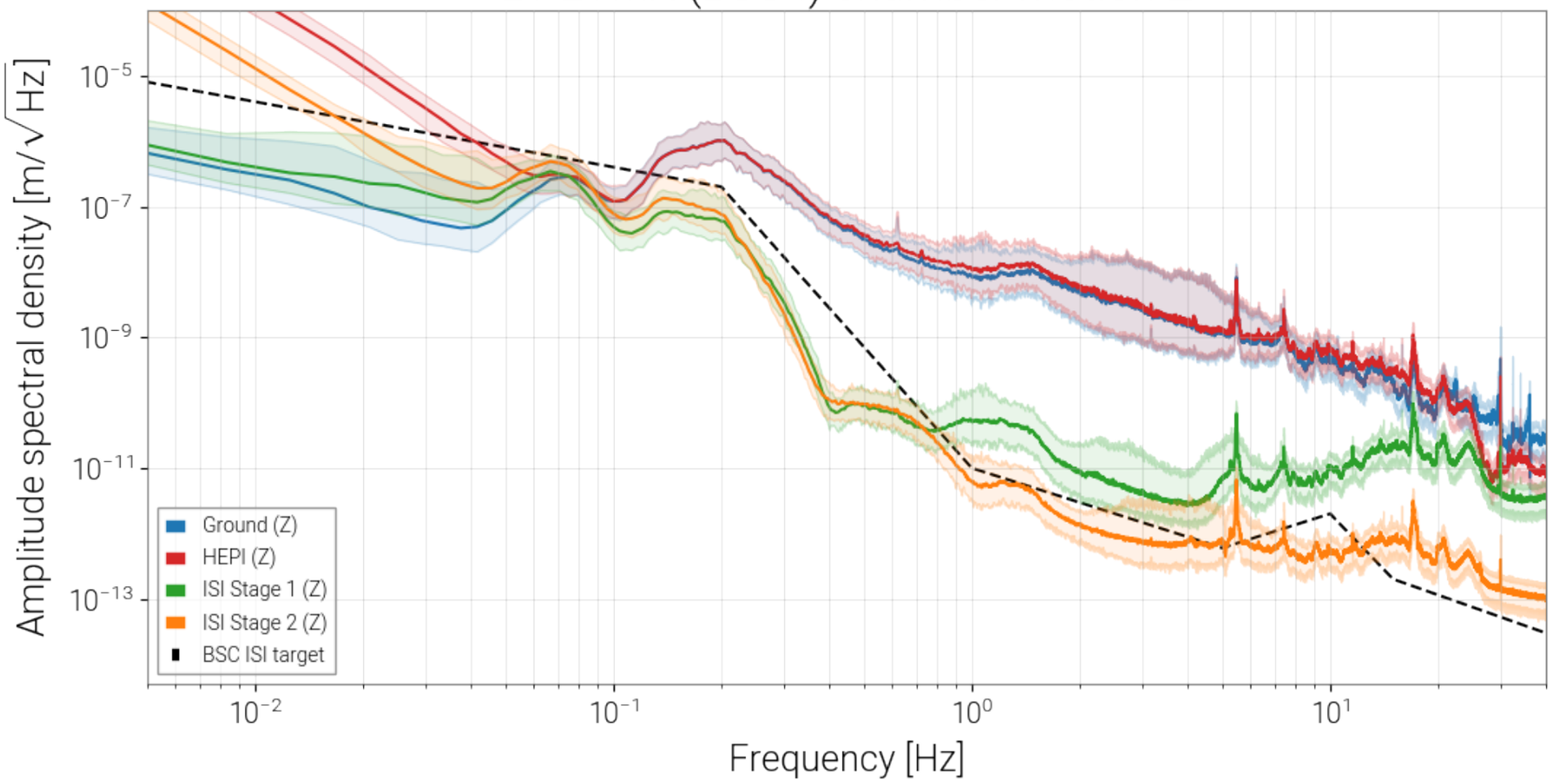


[1384300818-1384387218, state: Isolated]

H1 ITMY (BSC1) chamber motion Z

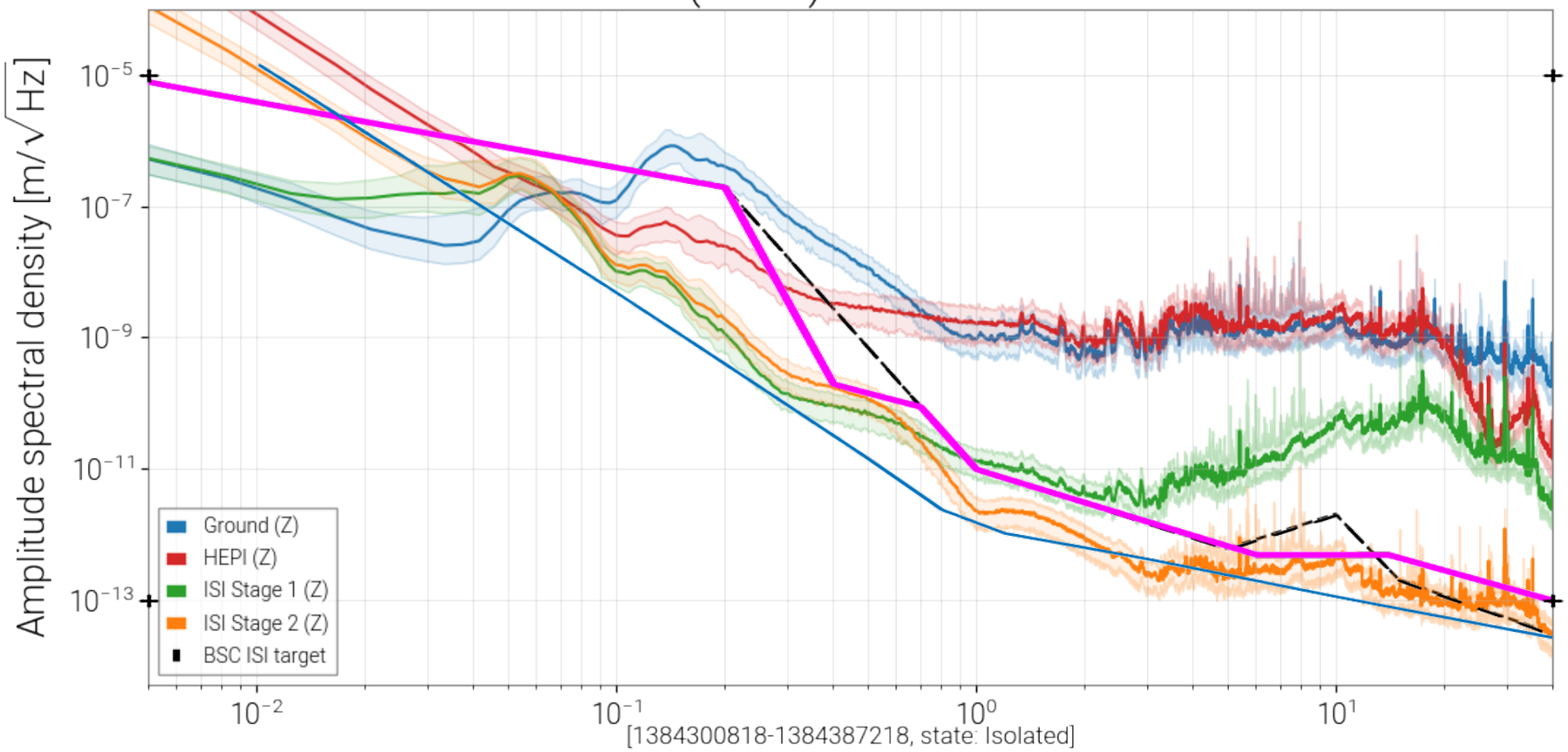


L1 ETMX (BSC4) chamber motion Z

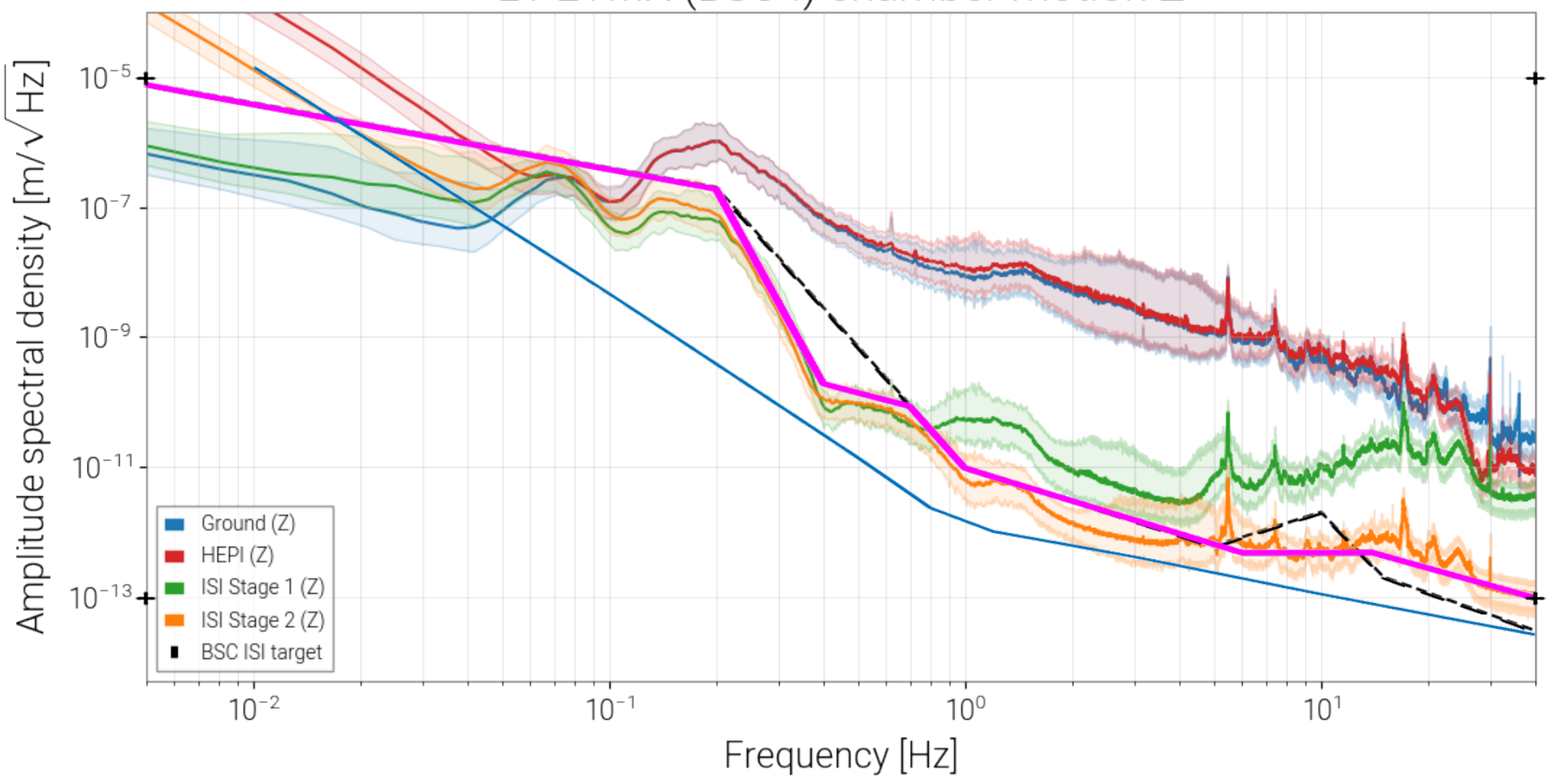


[1384300818-1384387218, state: Isolated]

H1 ITMY (BSC1) chamber motion Z



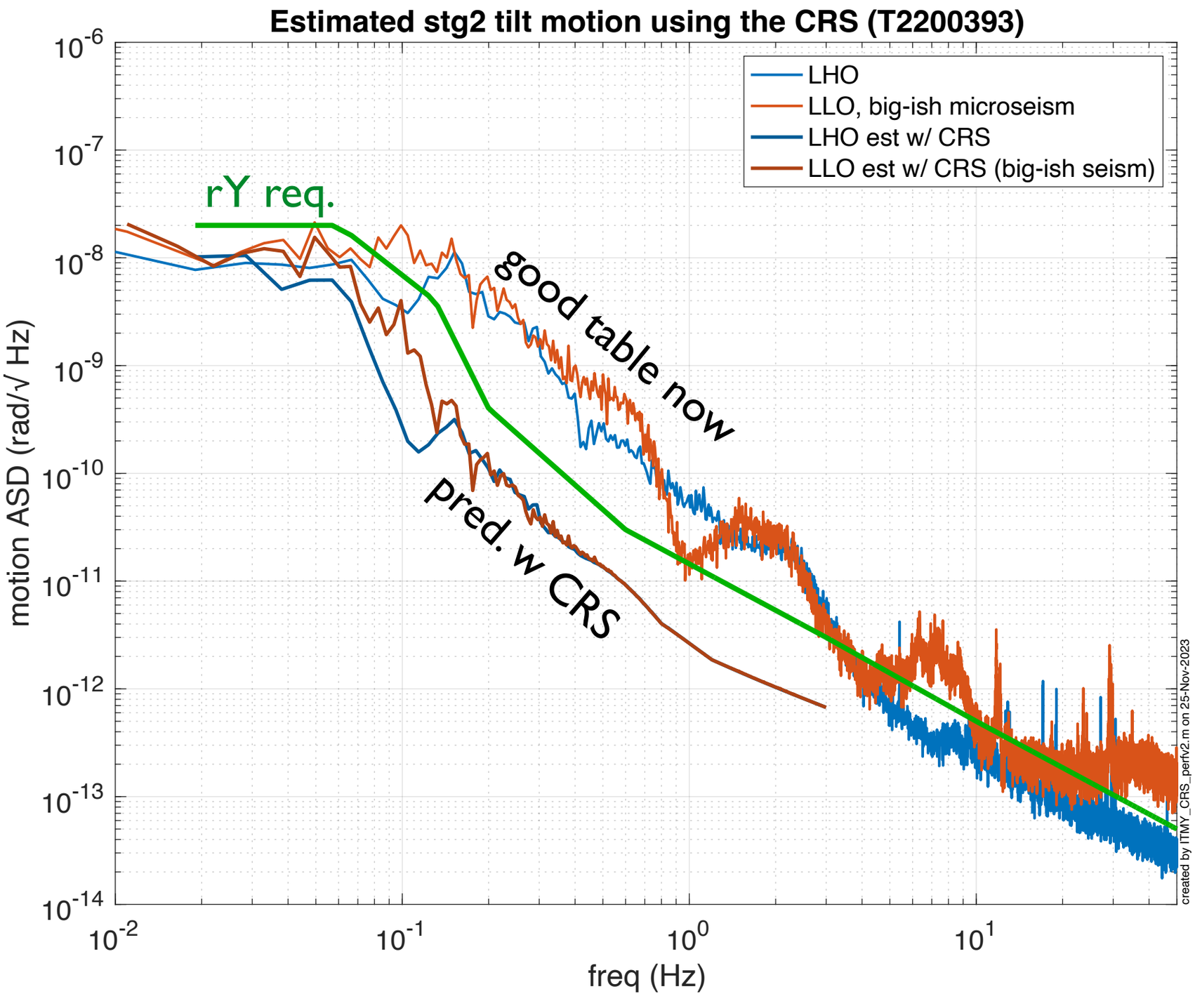
L1 ETMX (BSC4) chamber motion Z



tilt prediction

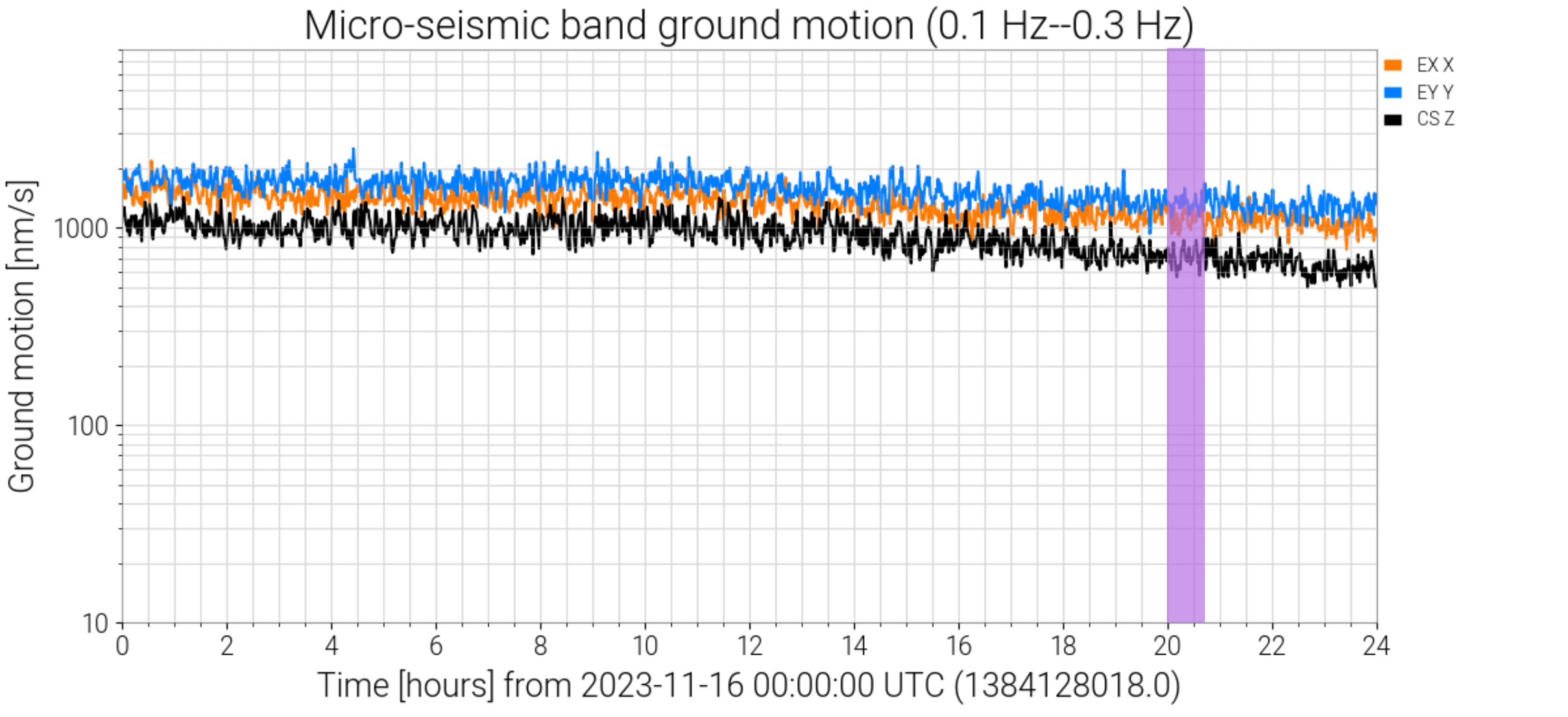
blends developed in T2200393

this curve uses theory curve for CRS, and leaves some margin



LLO tilt data set

data taken at
Nov 16, 2023 20:00:00 UTC
Nov 16, 2023 14:00:00 CST
GPS Time = 1384200018
very low wind, no earthquake
microseism so big the IFO wouldn't lock



Yaw (RZ) motion

Also look at the RZ motion of ITMY at LLO and LHO at this time (because I have most of the data already)

RZ motion of the ground is expected to be quite small at the microseism, but we don't have a good measure of this.

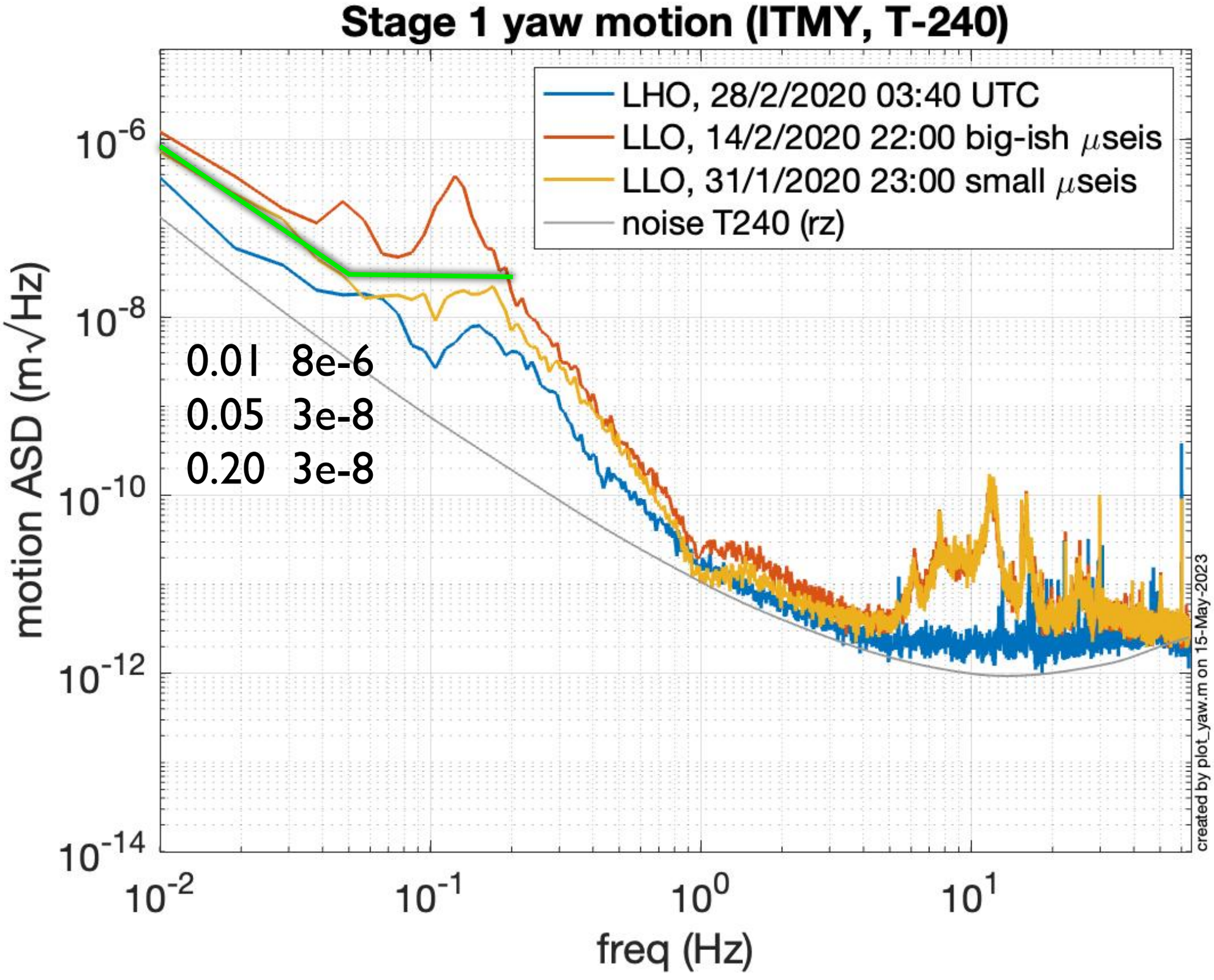
Note - laser ring gyros do have some measures of this which we should look at. They claim RZ can be calculated with the derivative of the shear waves moving through (we should really do this calculation).

The yaw peaks we see at the microseism are almost certainly the results of cross-coupling. Evidence includes:

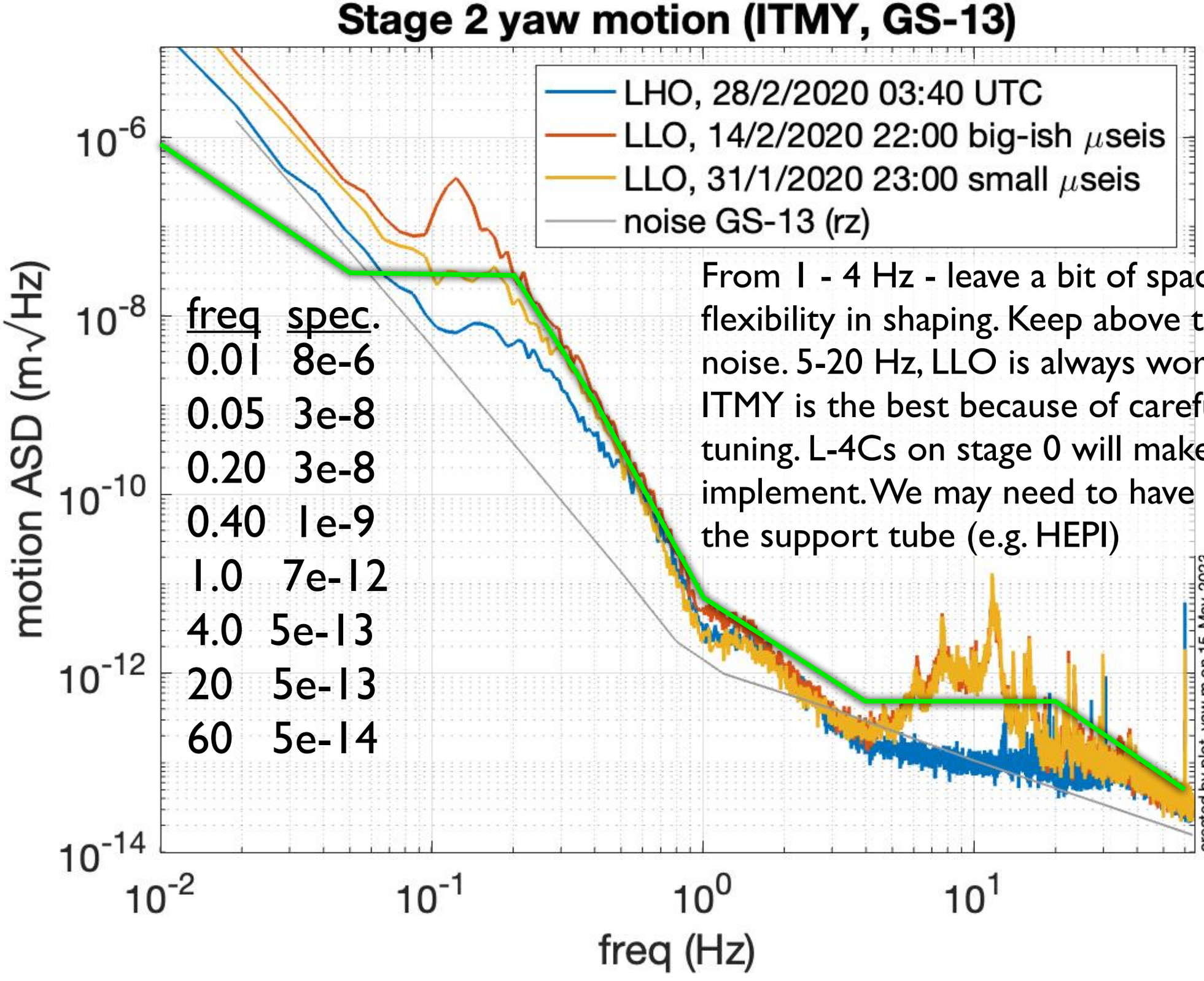
- The ground yaw is less than the table yaw
- The table yaw seen on the 5 platforms is different by 2x
- The T240 and the CPS see very similar signals in yaw

ITMY has the lowest yaw - we'll use that and assume that the tuning will be improved by O5 to match the LLO ITMY yaw motion at low microseism, and be between LHO and LLO at 10 Hz.

stage 1 yaw

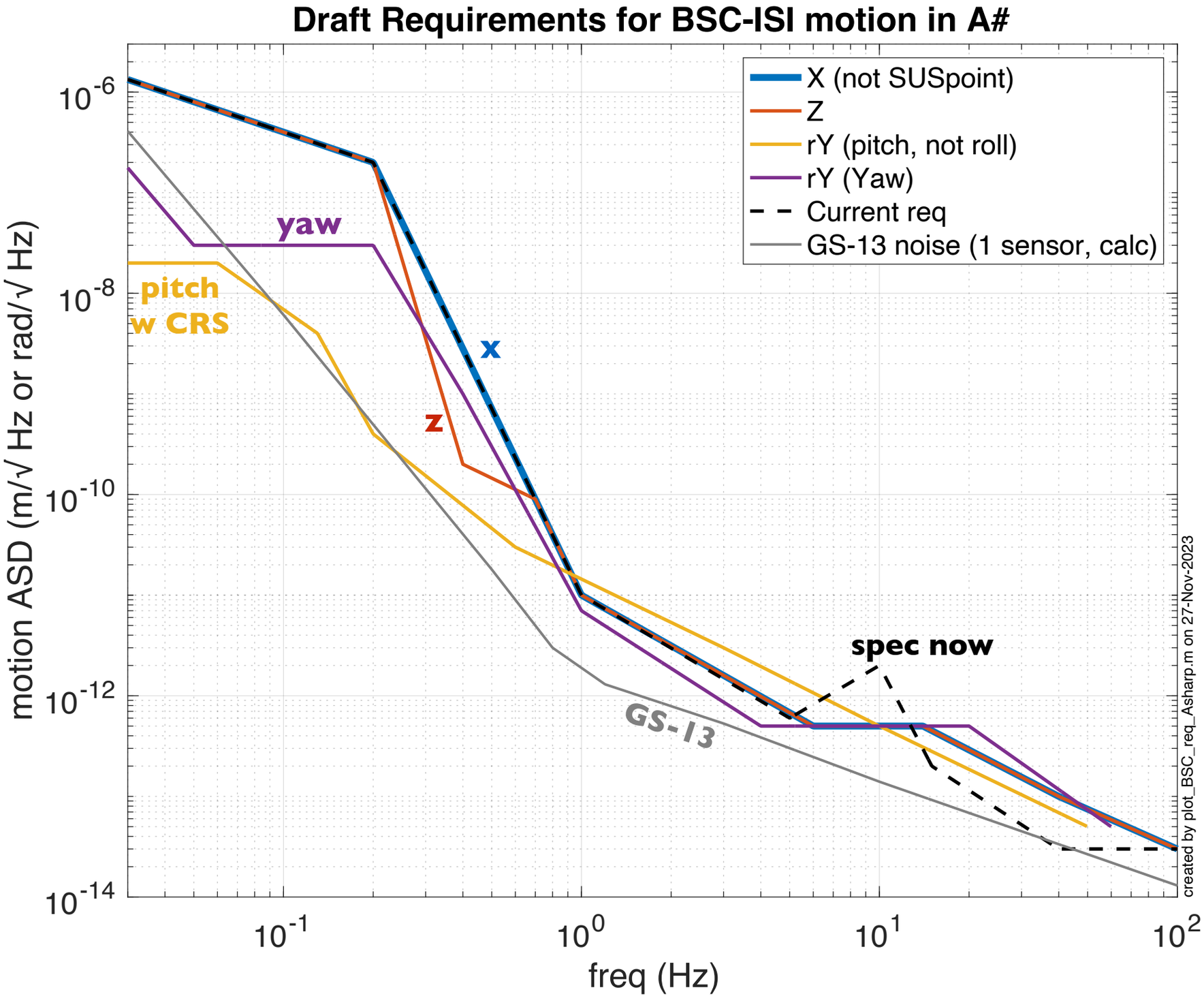

Stage 1 yaw motion (ITMY, T-240)
LHO, 28/2/2020 03:40 UTC
LLO, 14/2/2020 22:00 big-ish μseis
LLO, 31/1/2020 23:00 small μseis
noise T240 (rz)
0.01 8e-6
0.05 3e-8
0.20 3e-8
motion ASD (m√Hz)
freq (Hz)
created by plot_yaw.m on 15-May-2023

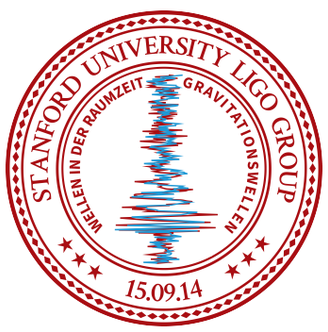
Yaw on stage 2



From 1 - 4 Hz - leave a bit of space to allow flexibility in shaping. Keep above the sensor noise. 5-20 Hz, LLO is always worse than LHO. ITMY is the best because of careful feedforward tuning. L-4Cs on stage 0 will make this easier to implement. We may need to have damping of the support tube (e.g. HEPI)

Back to the plot

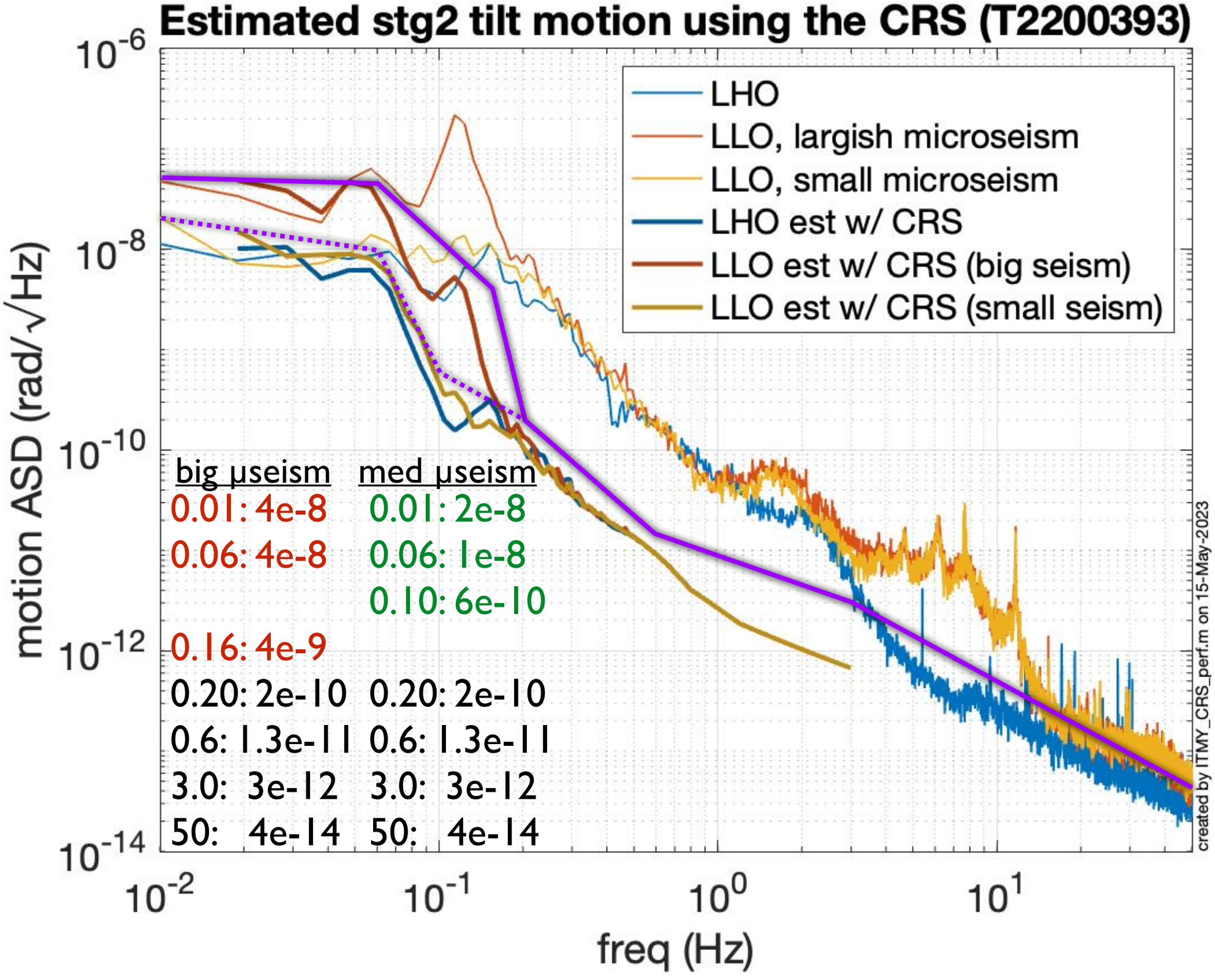



STANFORD UNIVERSITY LIGO GROUP
WELLEN IN DER RAUMZEIT
GRAVITATIONSWELLEN
15.09.14

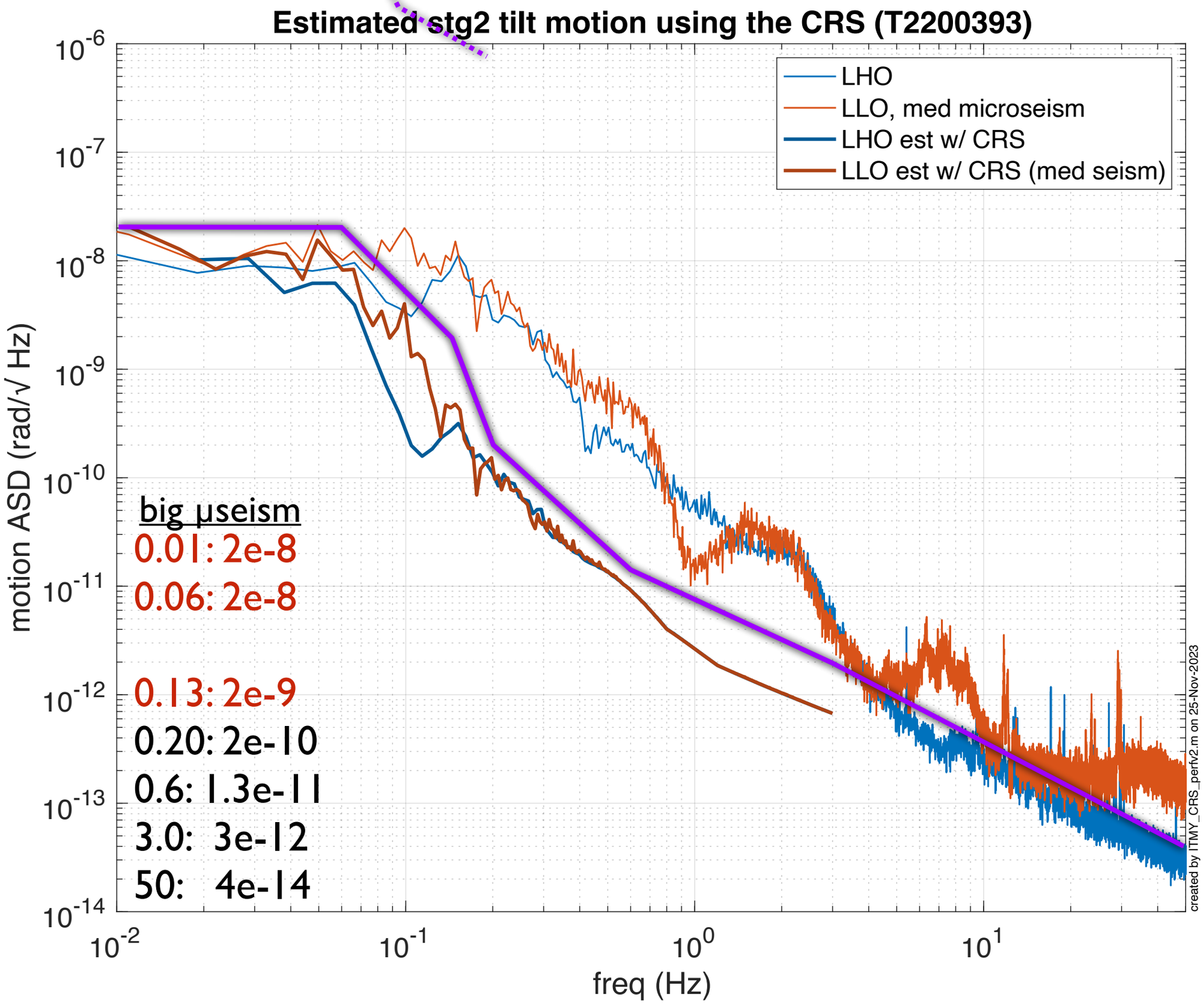
Pitch


LIGO
VIRGO
KAGRA

Tilt stick-line fit



Tilt stick-line fit



- signal on GS-13 for ITMY vs. time - how stationary is it?
- Is it fair to extrapolate ITMY to all chambers?
- ground motion 10-30 Hz - how stationary is it?
- ground motion 10-30 Hz - compare LHO to LLO
- signal on GS-13 vs. motion of platform
- LHO:ITMY vs. other LHO chambers
- LHO vs LLO - how does the ground compare in 10-30 Hz band
- LHO vs LLO -

maybe use 8-20 Hz?
make a ref. spectrum to use
describe how to get all the chambers to this
what are all the peaks in the 8-20 Hz band?
 - many ways that it is not "stiff and well damped"