

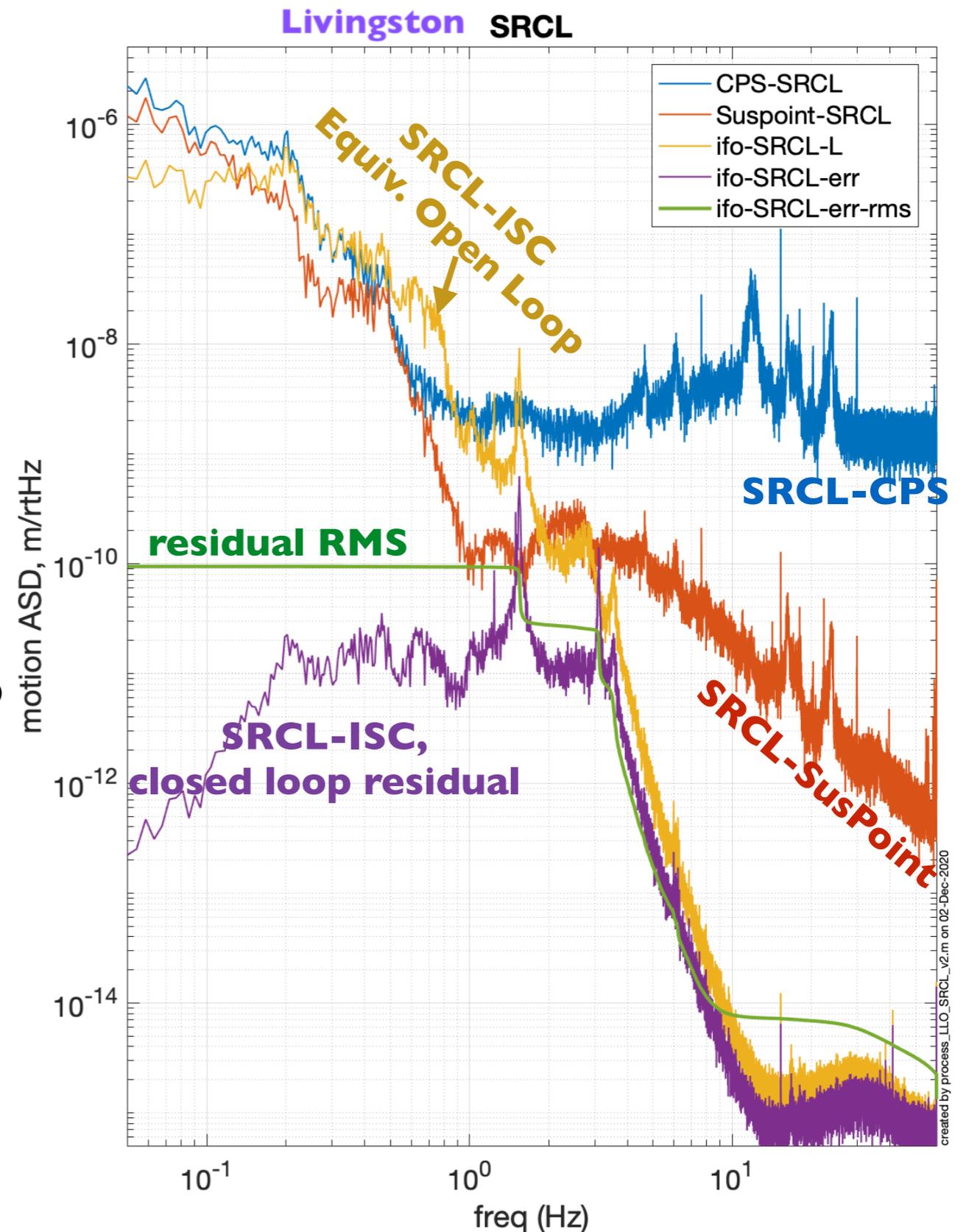
Thoughts on Low Frequency Tilt Coupling

Brian Lantz, April 7, 2021, G2100764

- Residual differential motion is about to be important for SRCL loops (and probably PRCL & MICH).
- Differential-Horizontal motion likely caused by vertical drive -> platform tilt -> platform horizontal motion
 - Even though we've tuned for this, we are hoping to do more tuning before O4
 - The CPS-differential control helps, but it's limited by CPS noise
 - The tilt sensors and SPI sensors are good / complementary ways to address tilt-driven differential motion
- The resulting ISC length motions are highly correlated with the angular motion of the optics

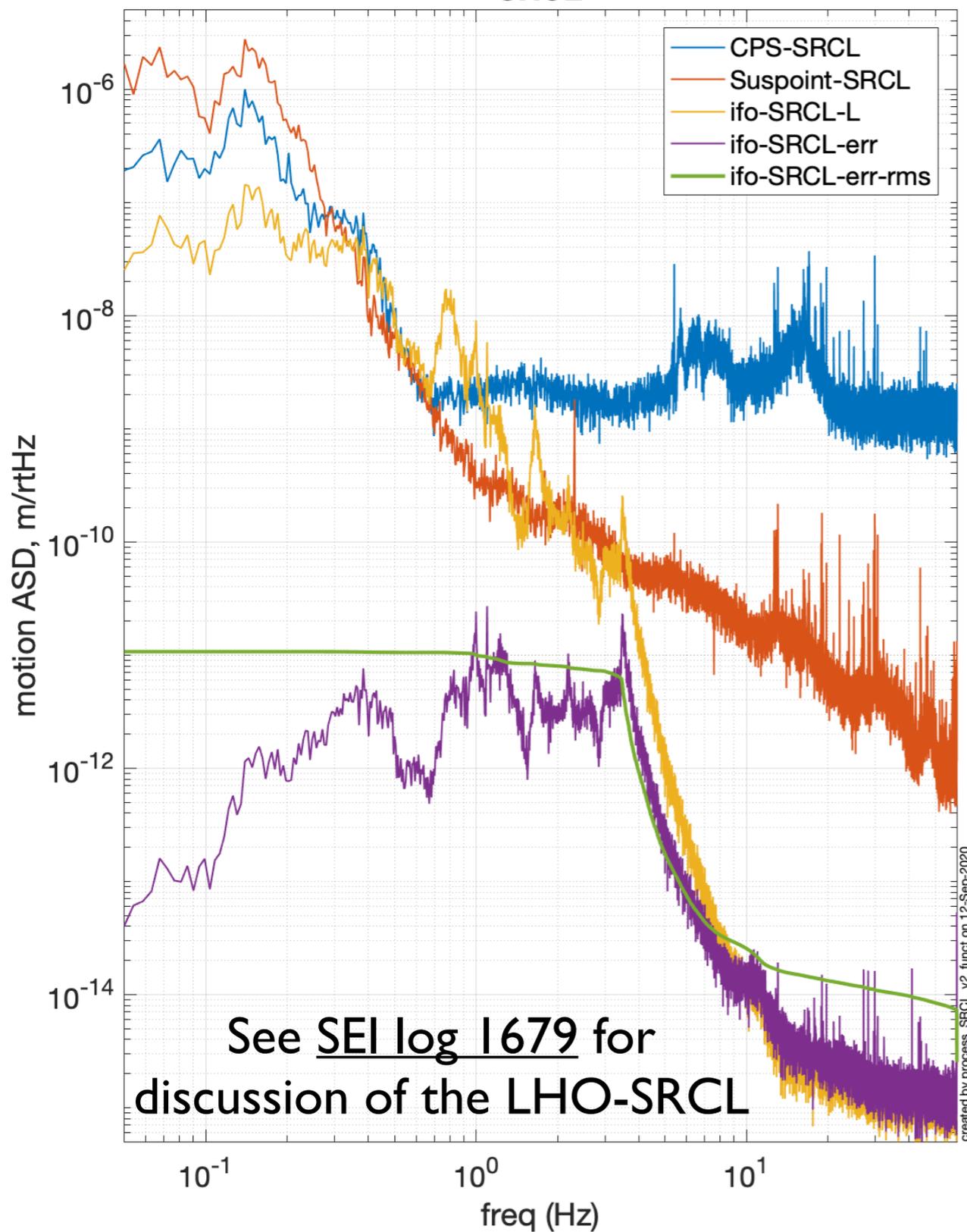
- 3 measures of SRCL (ISI-CPS, ISI-GS-13, and SRCL IFO signals) are reasonable consistent, so the calibration is not crazy.
- How can we reduce the bandwidth of the SRCL loop?
- RMS now dominated by:
 - SRC optic OSEM noise from 4-10 Hz
 - Peaks at 1.55, 3.11, & 3.53 Hz.
 - LF motion (from ISI) suppressed by loop less bandwidth would change this
- Motion below 10 Hz is real motion, so SRCL loop gain here is good.

Data from Feb 2020, see [SEI log 1692](#) for details
 Anamaria has recently updated the ISC calibration by ~15%, not reflected here.

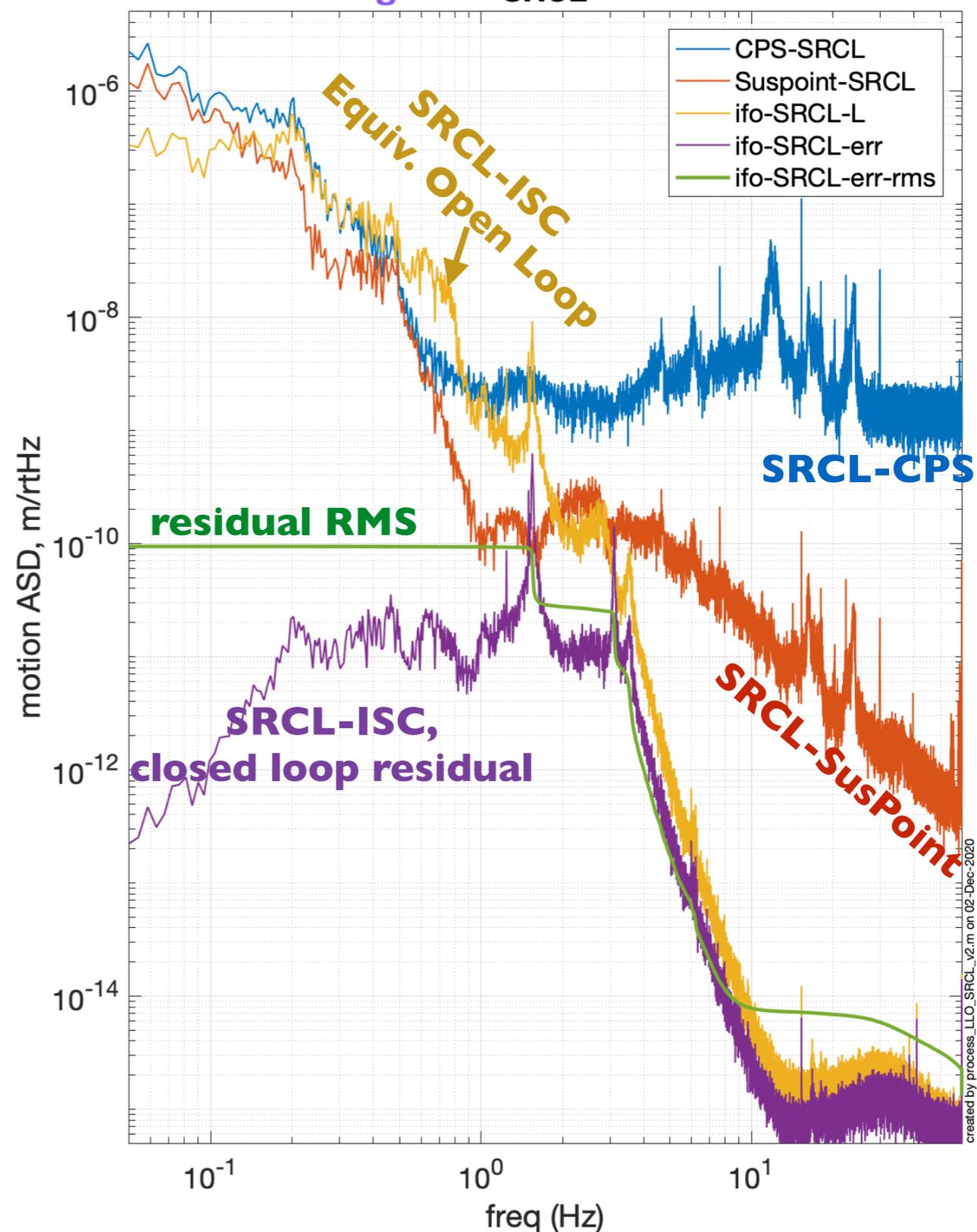


LHO is ~similar

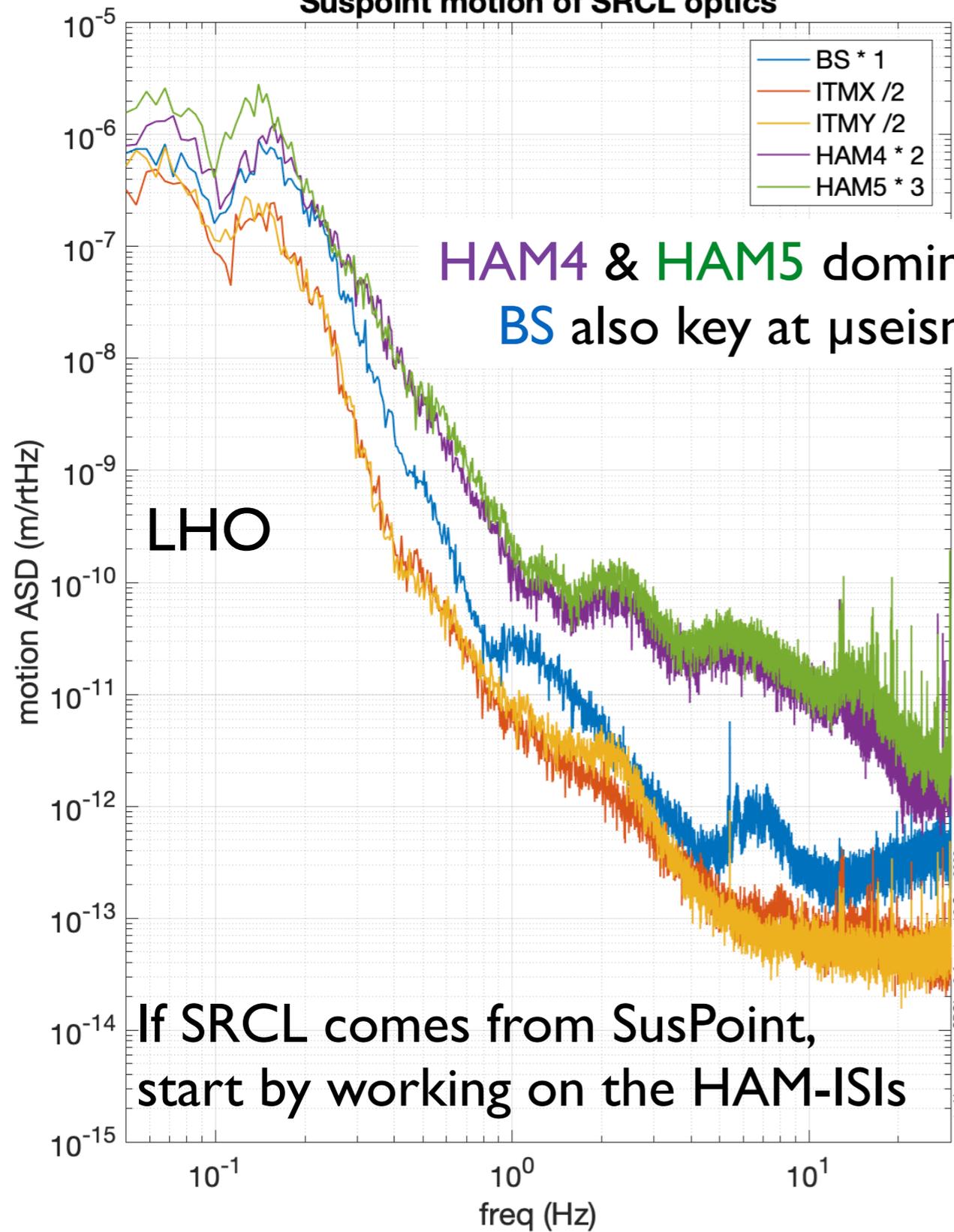
Hanford SRCL



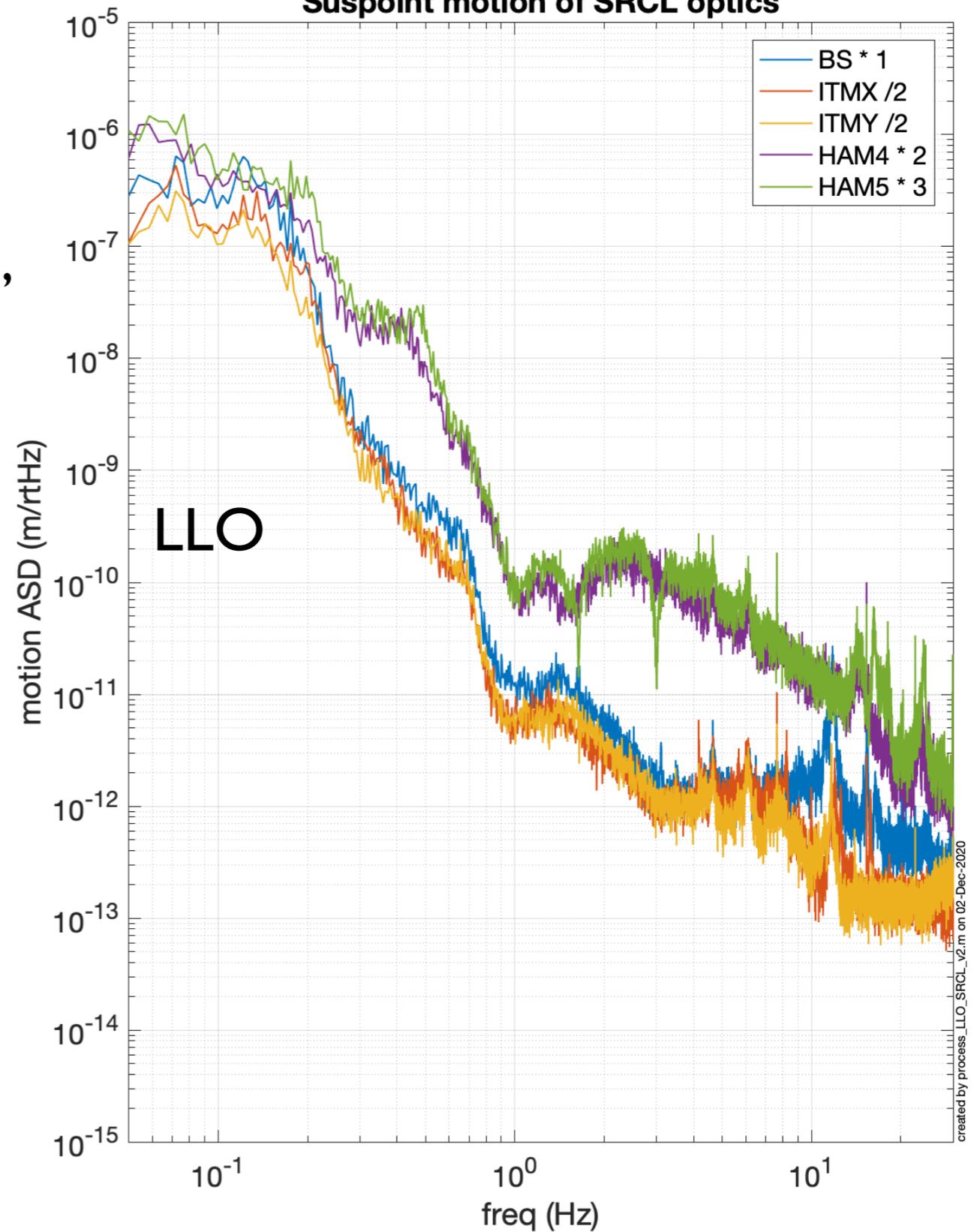
Livingston SRCL



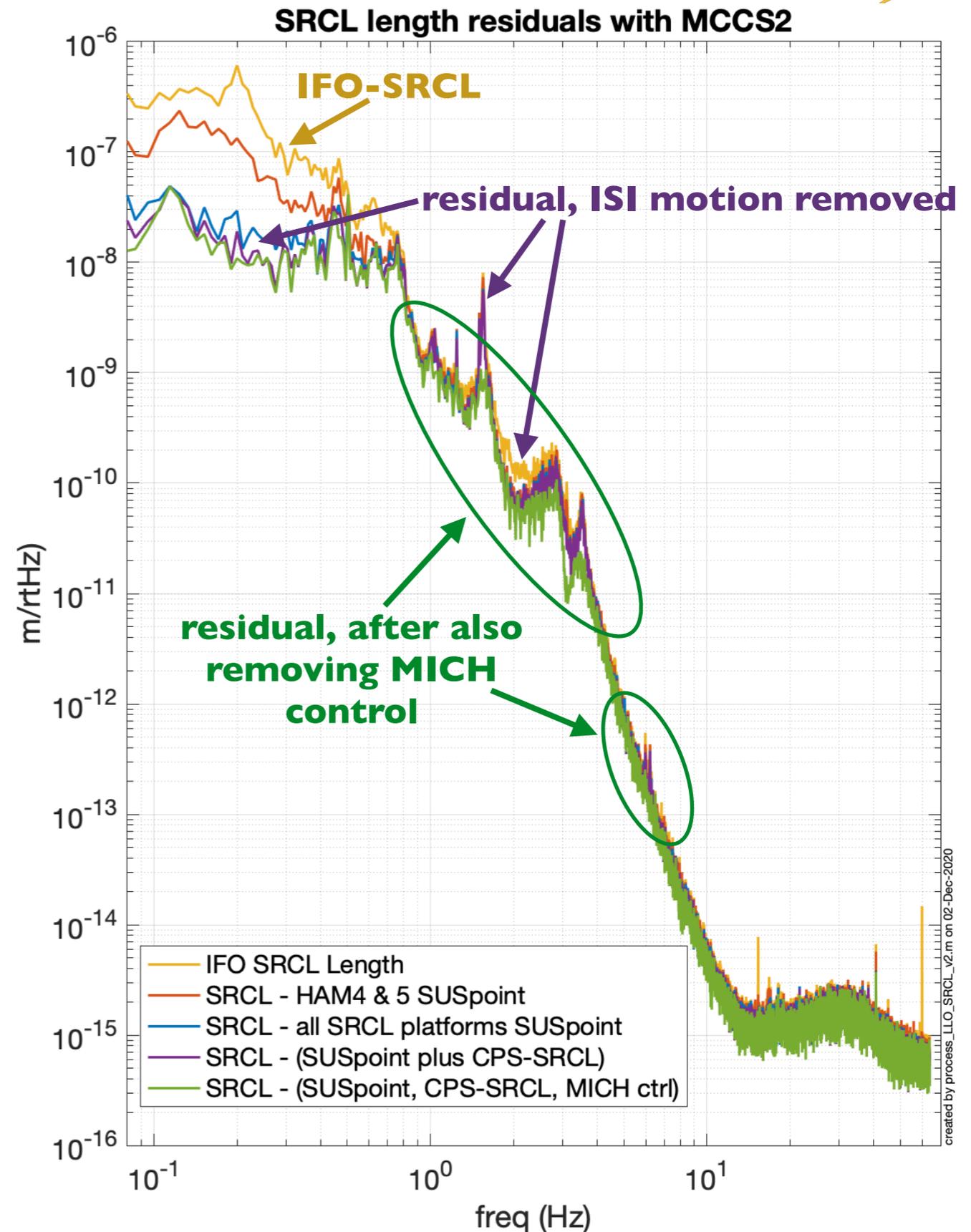
Suspoint motion of SRCL optics



Suspoint motion of SRCL optics

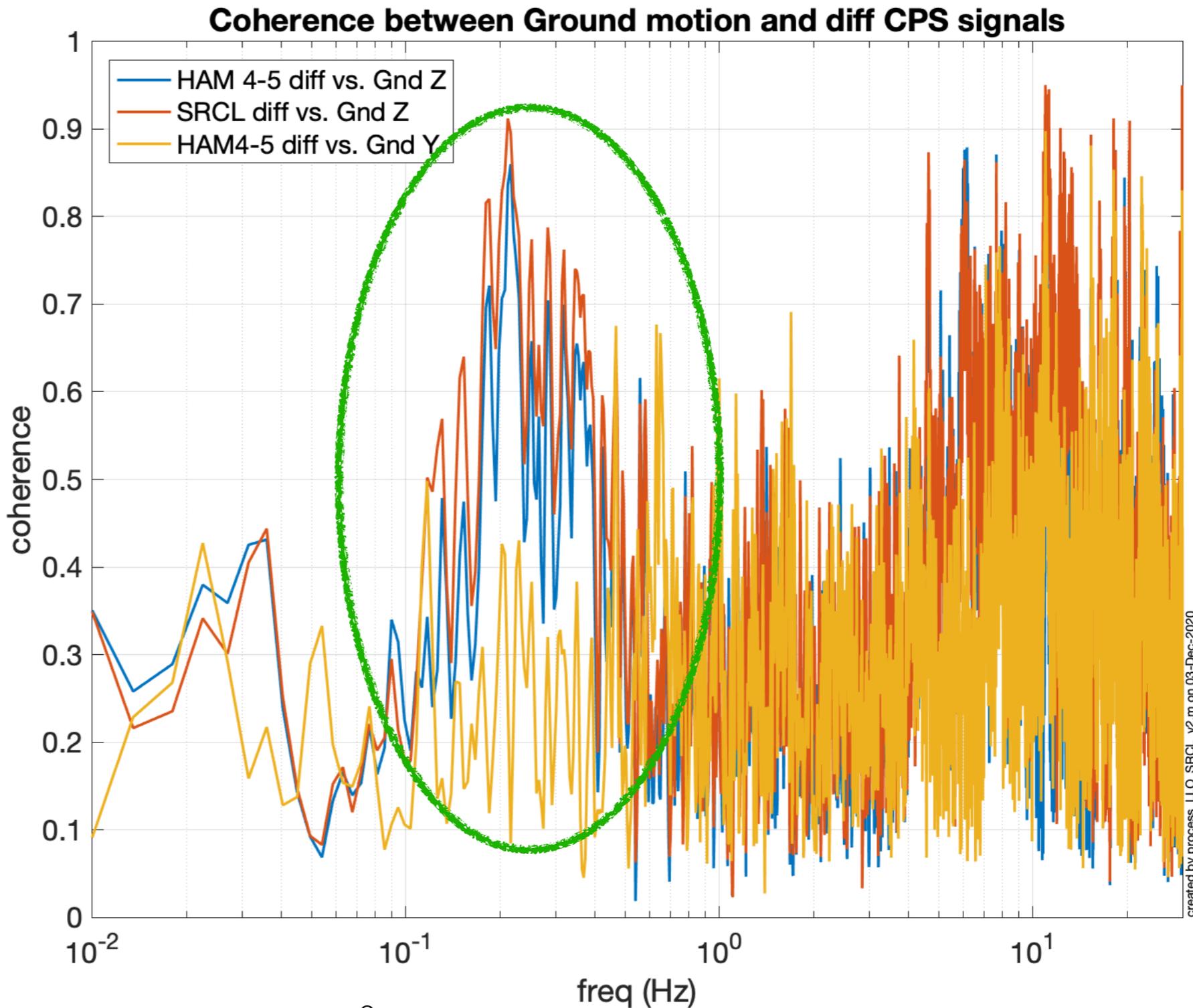


- Look at the equiv. open loop SRCL, remove various signals w/ MCCS2 and look at what's left.
- Compare yellow to Purple, Removing ISI motion helps below 0.7 Hz, and around 2 Hz.
- ISI removal doesn't help the 1-4 Hz peaks
- Purple to Green
- also remove MICH control,
- Notice peaks at 1.55, 3.11, & 3.53 Hz



Around the microseism, Differential platform motion is more correlated with vertical ground motion than horizontal ground motion

LLO, see [SEI log 1694](#)



Just a recent example,
not a new discovery

During earthquakes, using the EQ mode, Eyal found that the differential arm motion of the ISI stage 1 sensors needed a large vertical drive term to explain the motion

Tilt is probably limiting earthquake performance.

Major improvement from not driving the vertical so hard

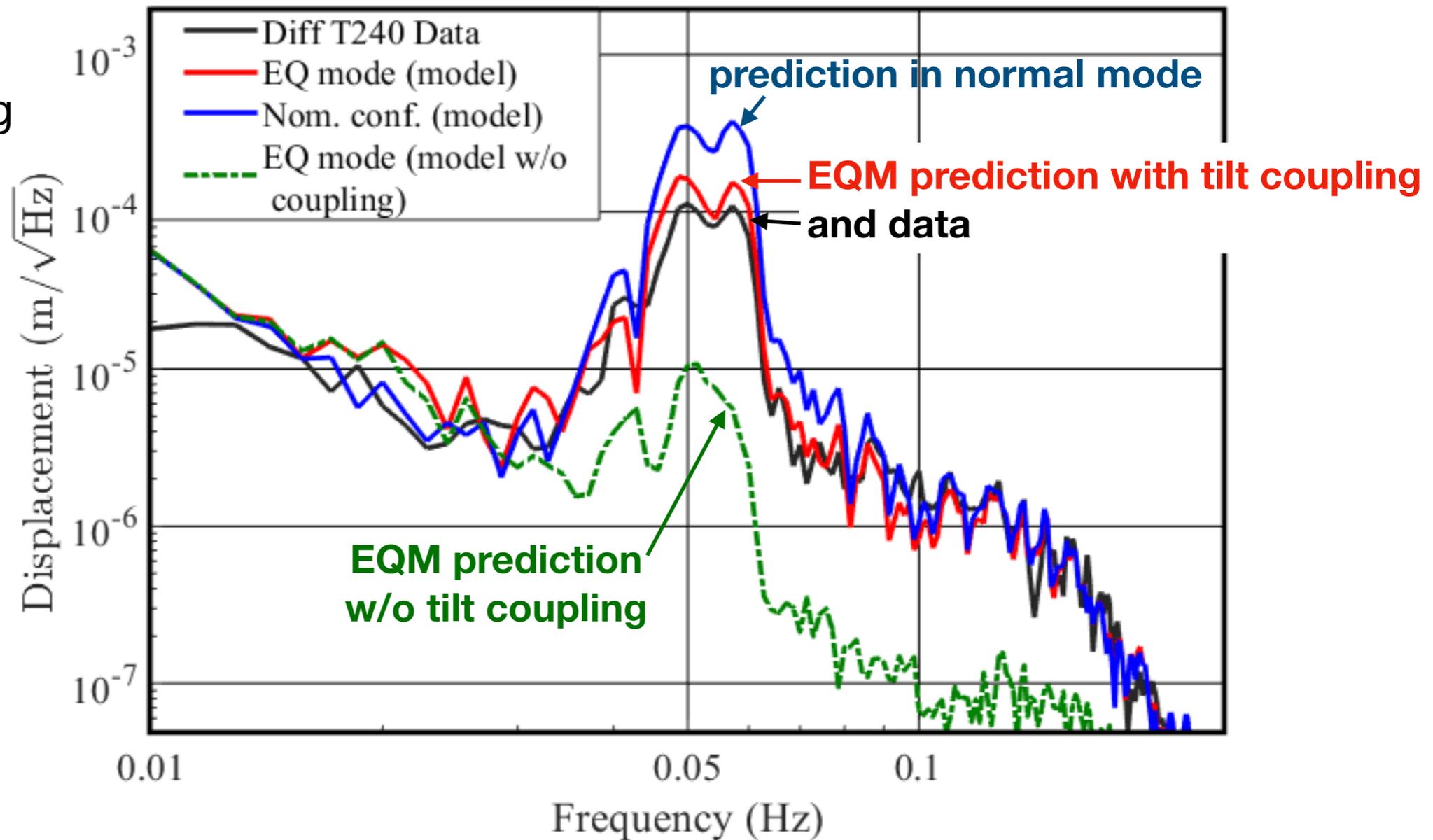
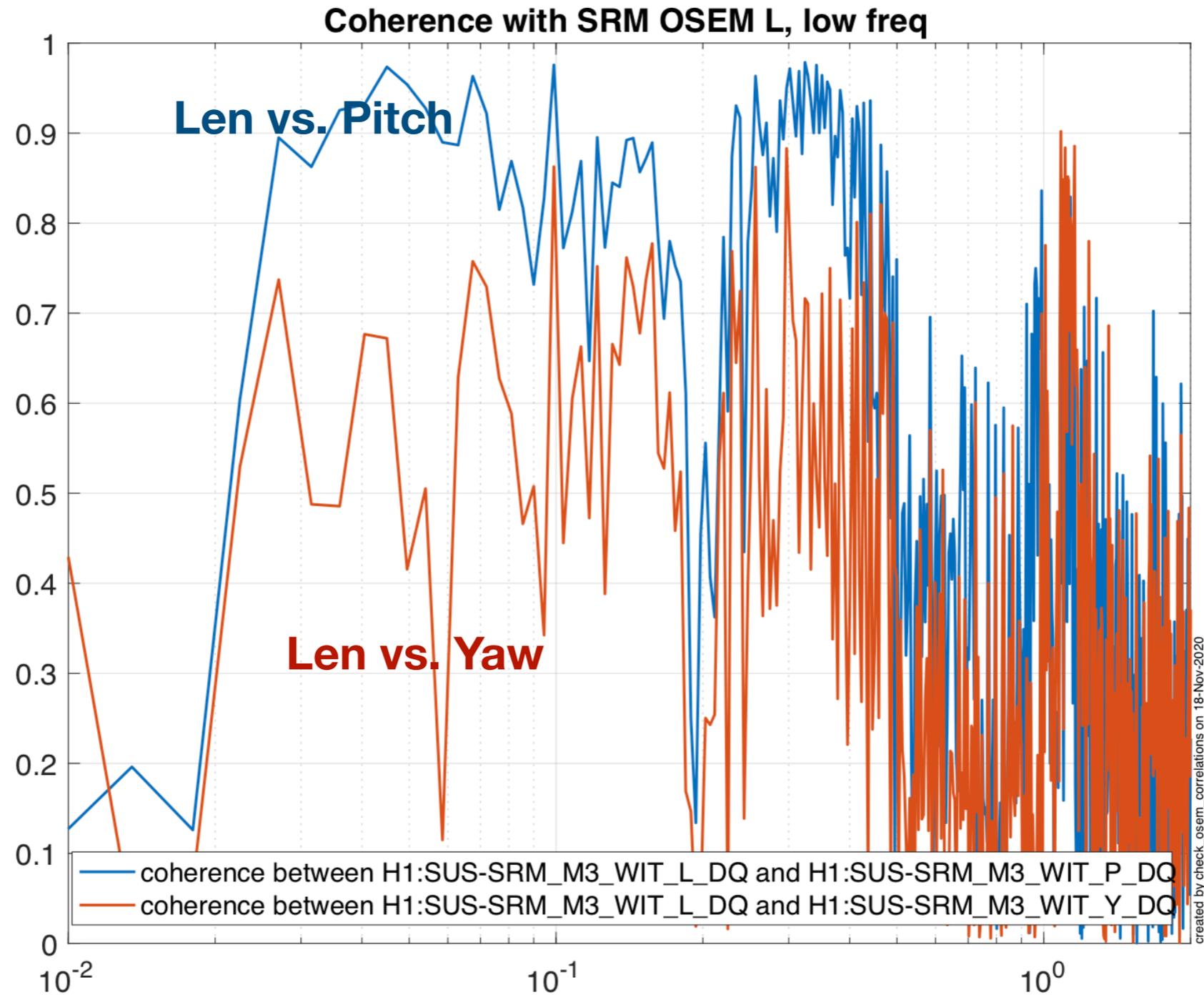


Figure 8: Predicted differential ST1 platform motion for Nominal (blue) and *EQ mode* (red) during an earthquake.

Witness OSEMs on the SRM optic (driven by SRCL) have high coherence
Again, not inconsistent with L2A coupling in the triple



Final Thoughts

- SRCL measurements show that differential ISI motion will probably be a limit to reducing the bandwidth of the SRCL loops (and probably PRCL & MICH).
- The Differential-Horizontal motion is likely caused by vertical drive -> platform tilt -> platform horizontal motion
 - we are hoping to do more tuning before O4
 - The tilt sensors and SPI sensors are good / complementary ways to address tilt-driven differential motion
- These plots suggest a logical path from better differential motion of the ISIs to lower excitation of ASC SRCL .
- This only shows a hints, not proof, but hopefully prompt followup

Coherence of ISI motion and SRCL-interferometer signal

Red and yellow are IFO signals vs. ISI signals. These show significant coherence below about 0.7 Hz

