Improving DARM
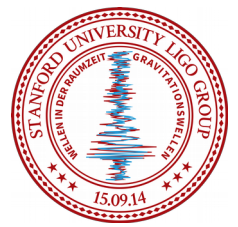# with ISI→ SUS feedforward
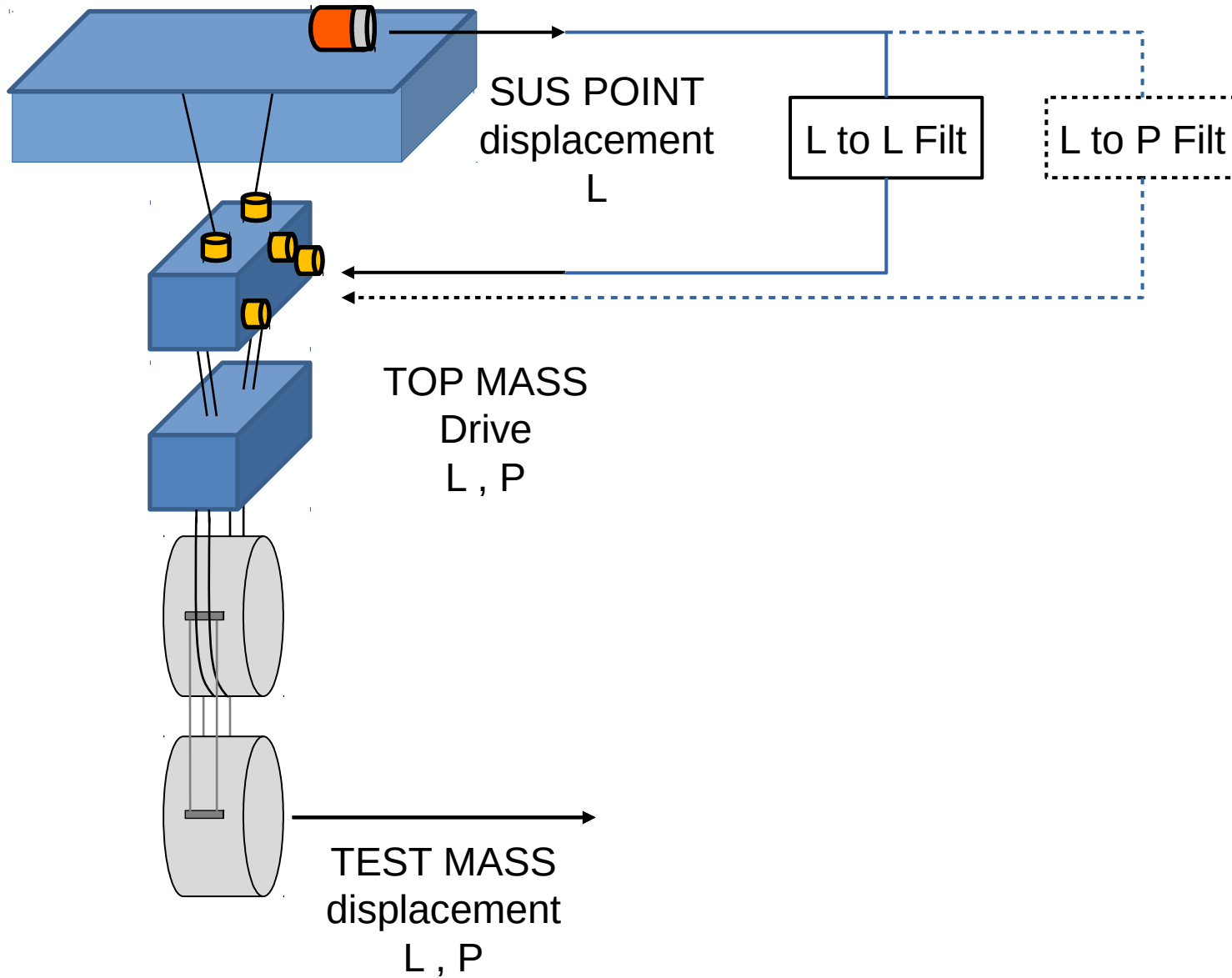# (Status Update)

Outline

- Motivation / Overview

- Progress on ISI to Test Mass <u>Pitch only</u> feedforward at LHO.

- Progress on full L and P feedforward.
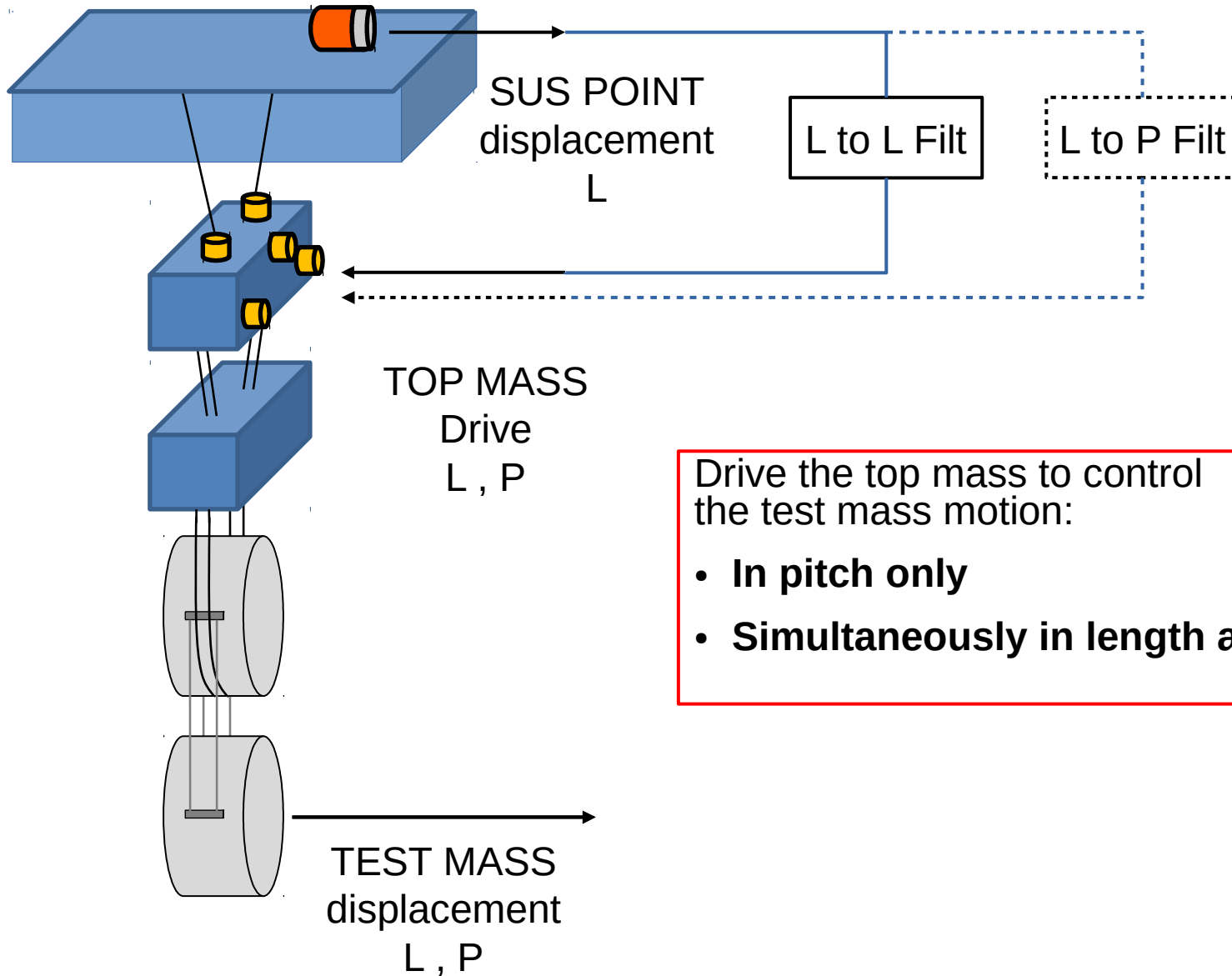
- Conclusion / Next Steps

Motivation

- An analysis showed high coherence between DARM and the suspension point motion of the QUADs in the microseismic band.[1]

- The ASC control output budget analysis suggests that the ISI longitudinal residual motion dominates the total rms. Which mostly accumulates around 0.2 Hz due to the microseism.[2]

[1] SEI log 1237.   [2] LHO log 42751

ISI-SUS Feedforward*

SUS POINT displacement L

L to L Filt

L to P Filt

TOP MASS Drive L , P

TEST MASS displacement L , P

= GS13

= Top Mass OSEM

[*] More info: T1800301

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ISI-SUS Feedforward*

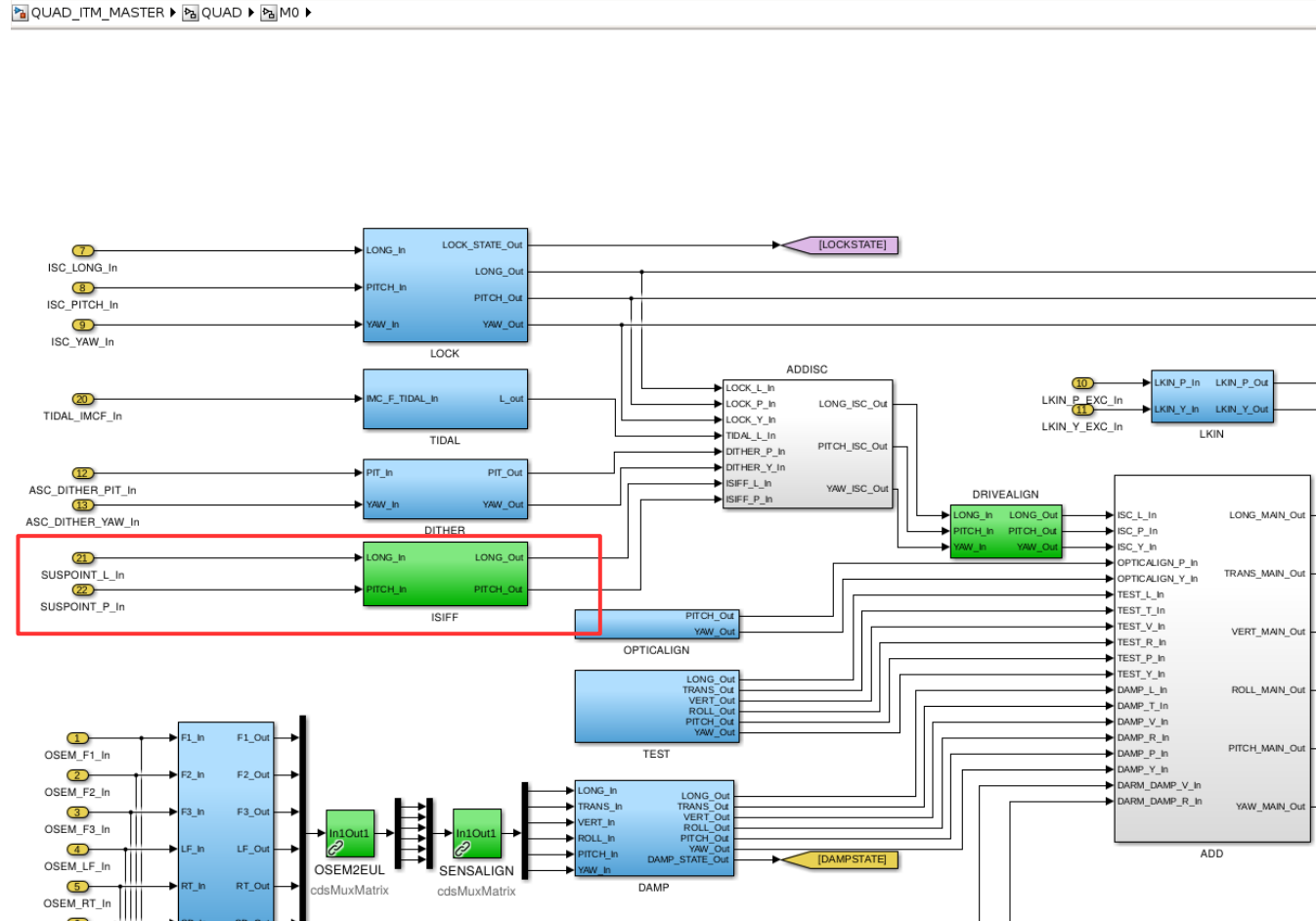SUS POINT displacement L

L to L Filt

L to P Filt

TOP MASS Drive L , P

Drive the top mass to control the test mass motion:

- **In pitch only**
- **Simultaneously in length and pitch**

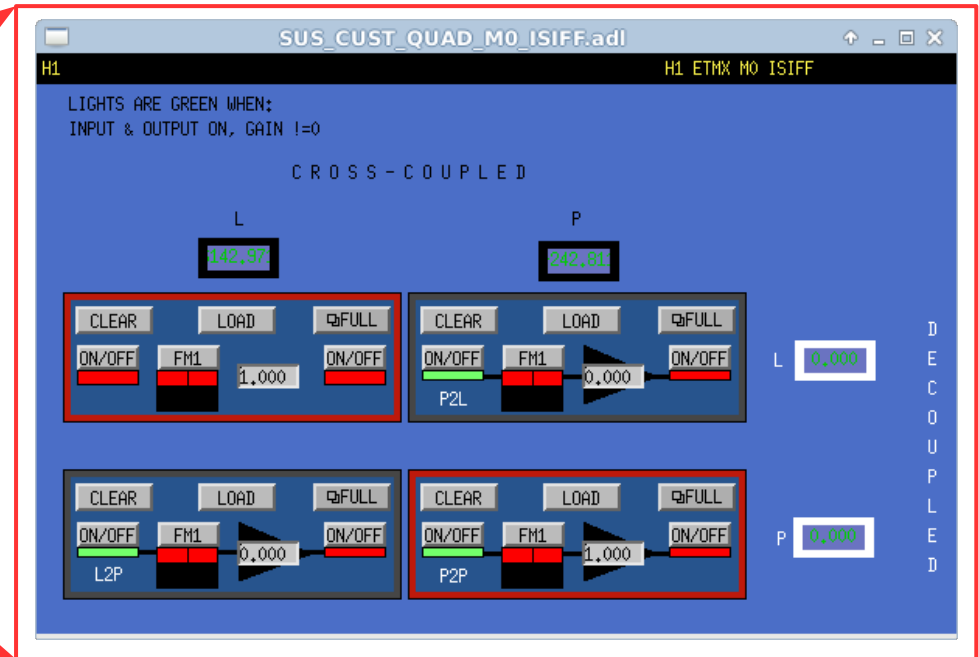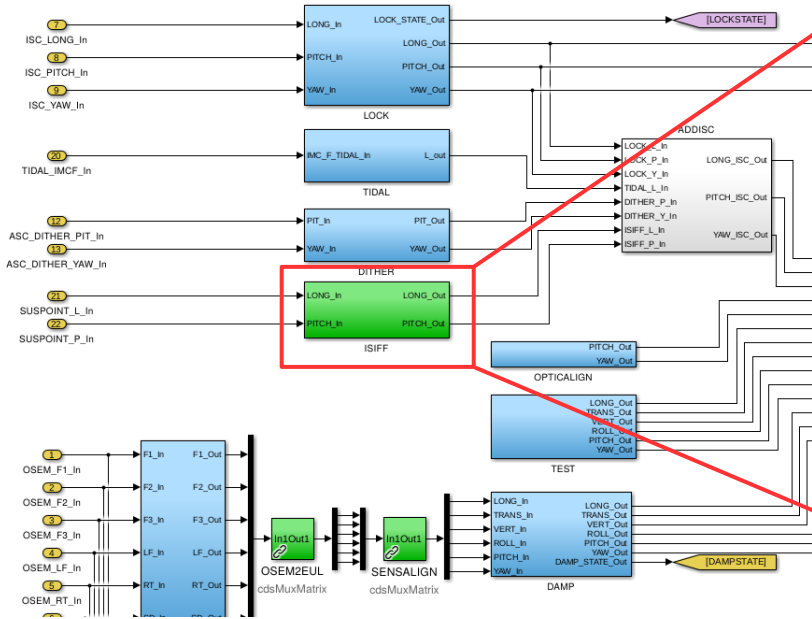TEST MASS displacement L , P

= GS13

= Top Mass OSEM

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[*] More info: T1800301

Progress:

The ISI -SUS feedforward paths were installed in the QUAD master models in July 10, 2018[3]
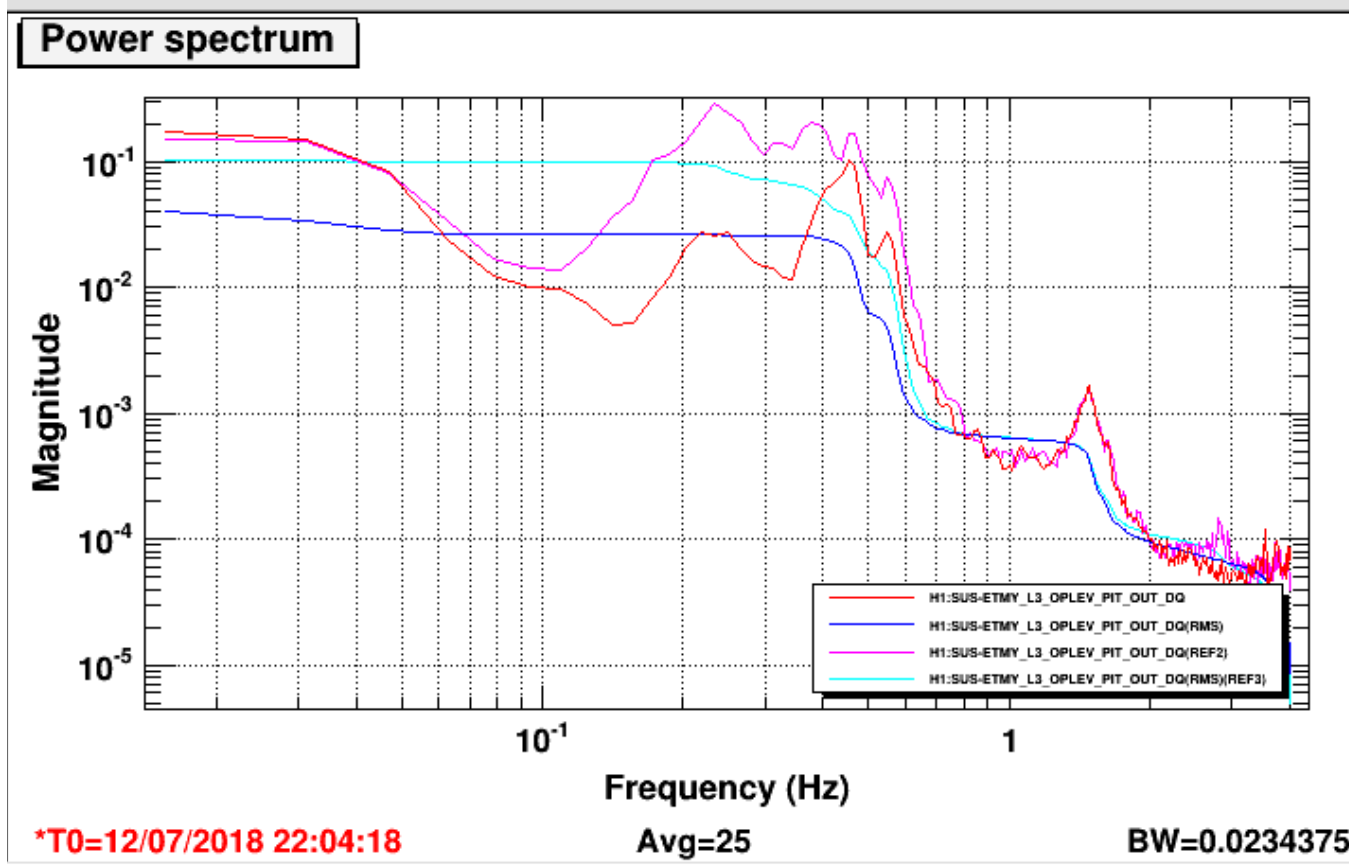
[3] LHO log 42851

Progress:

The ISI -SUS feedforward paths were installed in the QUAD master models in July 10, 2018

[3] LHO log 42851

Progress:
Pitch Only FF

ISIFF Effect on L3P

— No ISIFF

— ISIFF

Pitch RMS was reduced by a factor of 2.5

Results of the first test of the Pitch only feedforward by Hang Yu at LHO ETMY.[4]
- They show a broadband reduction of the pitch motion for the test mass.
- Similar results were later obtained for ITMY, ETMX[5] and ITMX. [6]

[4] LHO log 42875.   [5] LHO log 42906.   [6] LHO log 43466.

Progress:
<u>Pitch Only FF</u>

<u>ISIFF Effect on L3P</u>

— No ISIFF

— ISIFF

The coherence between Suspoint and L3P drops from 0.1 to 0.8 Hz

Results of the first test of the Pitch only feedforward by Hang Yu at LHO ETMY.[4]
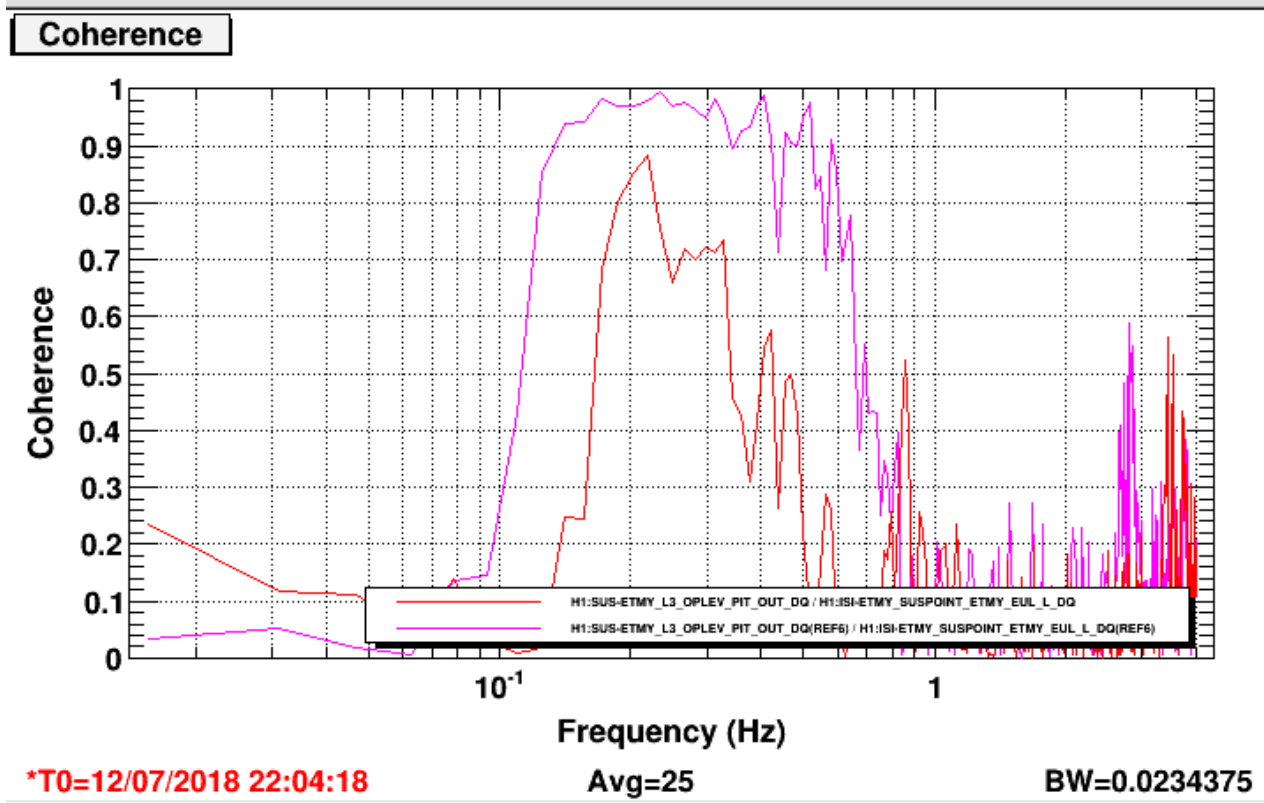
- They show a broadband reduction of the pitch motion for the test mass.
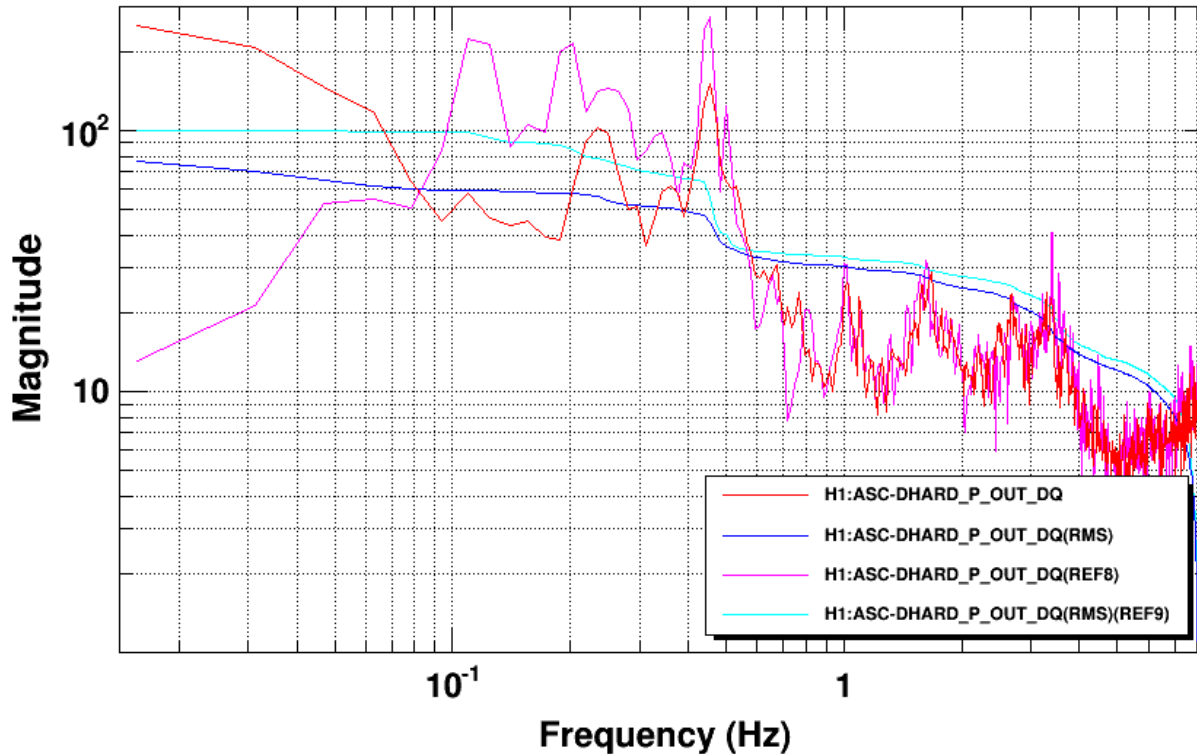- Similar results were later obtained for ITMY, ETMX[5] and ITMX. [6]

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[4] LHO log 42875.   [5] LHO log 42906.   [6] LHO log 43466.

Progress:
Pitch Only FF

Power spectrum

**ISIFF Effect
on DHARD P control**

—— No ISIFF

—— ISIFF

Pitch RMS was reduced by 20%.[7]

Legend in figure:
- H1:ASC-DHARD_P_OUT_DQ
- H1:ASC-DHARD_P_OUT_DQ(RMS)
- H1:ASC-DHARD_P_OUT_DQ(REF8)
- H1:ASC-DHARD_P_OUT_DQ(RMS)(REF9)

*T0=17/08/2018 00:23:13   Avg=10   BW=0.0234375

- The ISIFF is <u>good above 0.1 Hz</u>, below that it introduces tilt motion into the ASC loops.[8]

- The ISIFF path should be used only after the interferometer is locked.

[7] LHO log 43480.   [8] LHO log 43114.
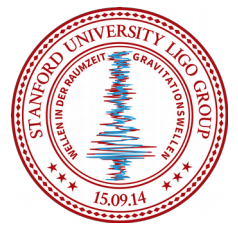
Progress:
Simultaneous L,P FF

- The simultaneous feedforward leads to unstable behavior.[4]
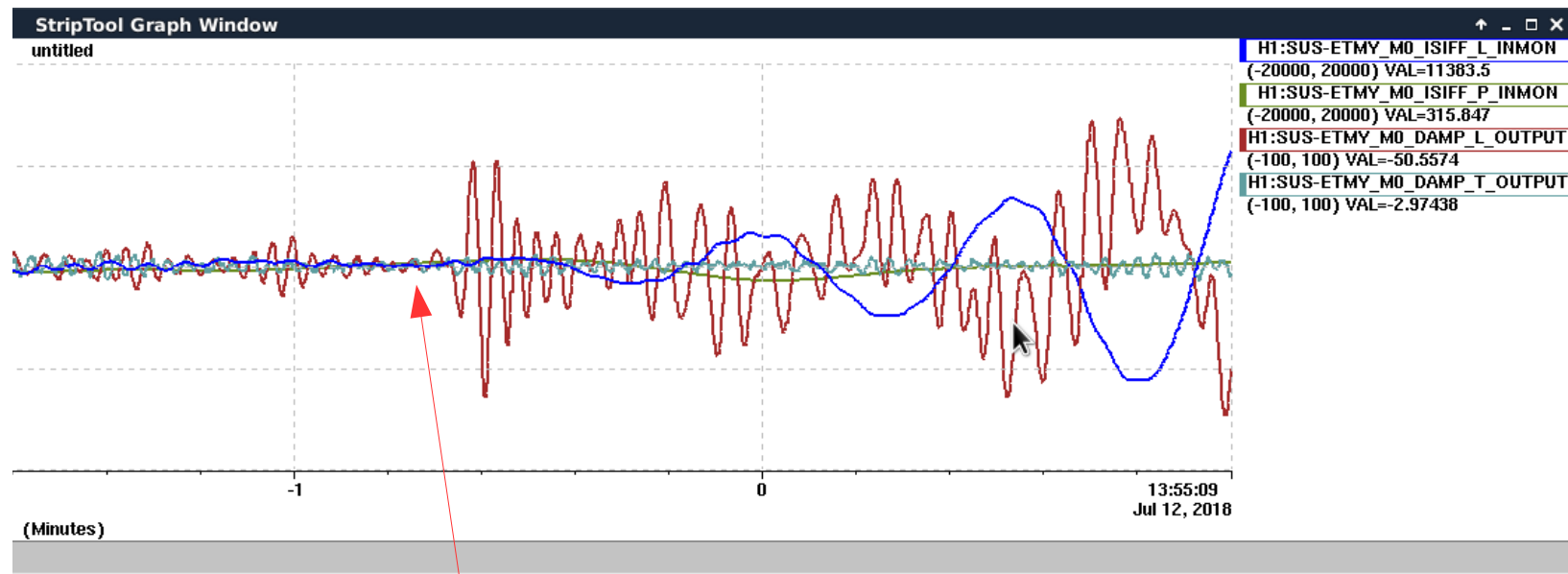
Feedforward Start

[4] LHO log 42875.

Progress:
<u>Simultaneous L,P FF</u>

- The simultaneous feedforward leads to unstable behavior.[4]

- Tests using the RX/RY loops for Stage 2 on the ISI. Suggest that a feedback loop is created with the backreaction of the Top mass actuation.[9]

- Nevertheless, all transfer functions for the Feedforward were taken and the filters are flat at the microseism. [10]

[4] LHO log 42875.   [9] LHO log 43513.   [10] LHO log 43540.

Conclusions

- The Pitch only feedforward has been tested successfully at LHO. We can achieve a 20% reduction of the CHARD control signal with the ISIFF.

- The performance is limited by the injection of tilt motion at low frequencies. There is room for improvement.

- The L-P Simultaneous Feedforward creates unstable behavior that needs to be investigated further.

- The L-P FF can be implemented with constant filters at the microseism.

Next Steps

- Investigate into improving the low frequency performance of the current Pitch only ISIFF. By changing the shape of the bandpass.

- Analyze unstable behavior of the simultaneous FF. To make sure the feedback is happening in the manner we think.

- Systematically test the performance of the simultaneous ISIFF with the ST2 Isolation RX/RY loops on.