Lessons from the ETF Technology Demonstrator

presented by Brian Lantz, May 25, 2005

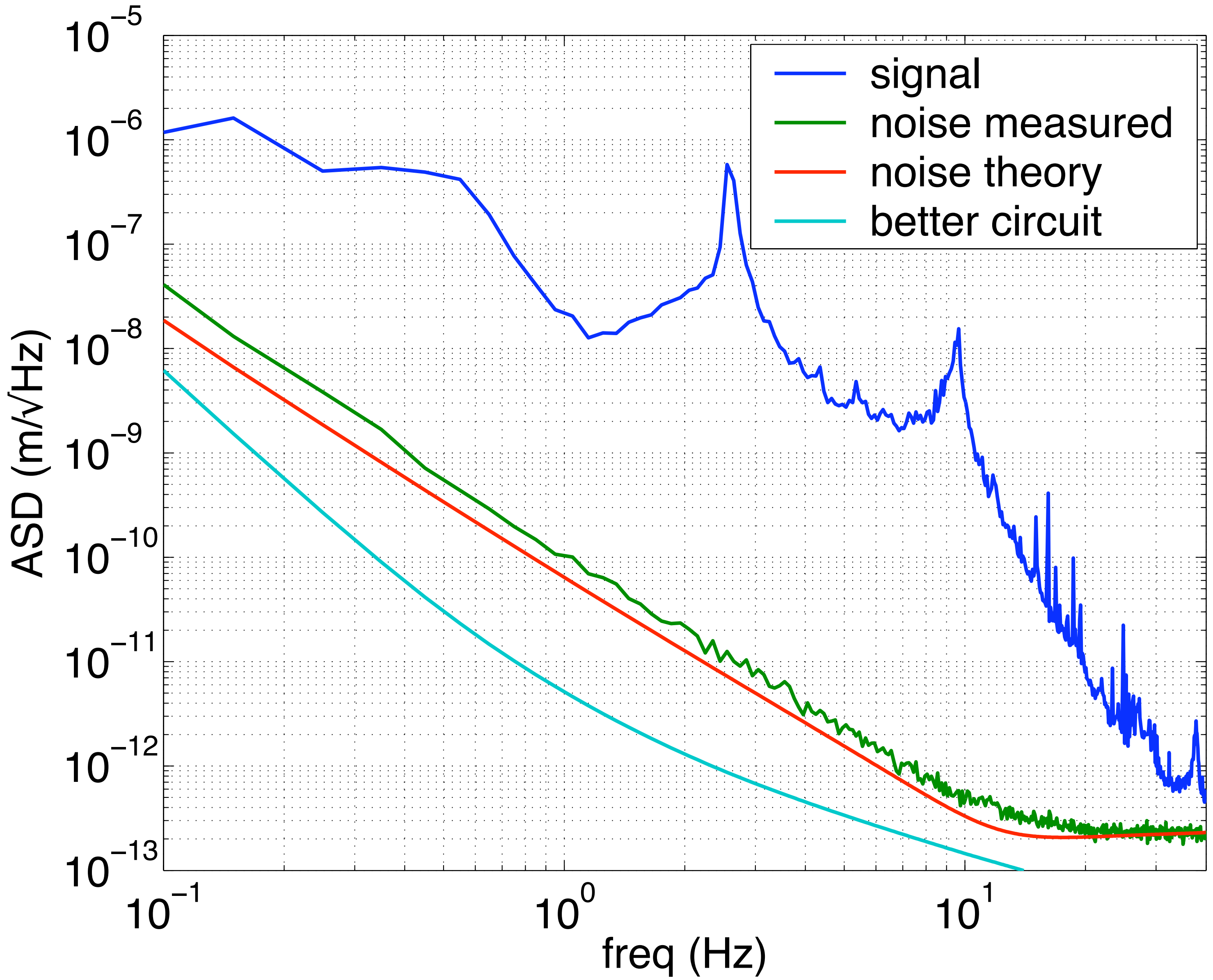
G050271-00-R

Since last time...

- Modeling noise of the GS-13.
- Improved 10 Hz performance of Tech Demo
- Modeling behavior of the Tech Demo.
- Explain the motion of stage 2.
- Thinking about softer stage 1 springs.

GS-13 noise performance

- Noise performance not up to spec
- We have a lower-noise design for pre-amp.
- Jay will be making new pre-amps, tested at ETF.



Original circuit is a negative resistor with readout, limited by current noise.

Quieter circuit could be either
- lower the current noise
  with a better op-amp
- use a "classic" readout

The calculations are written up in "Noise calcs for GS-13.pdf" at http://ligo.phys.lsu.edu:8080/SEI/445

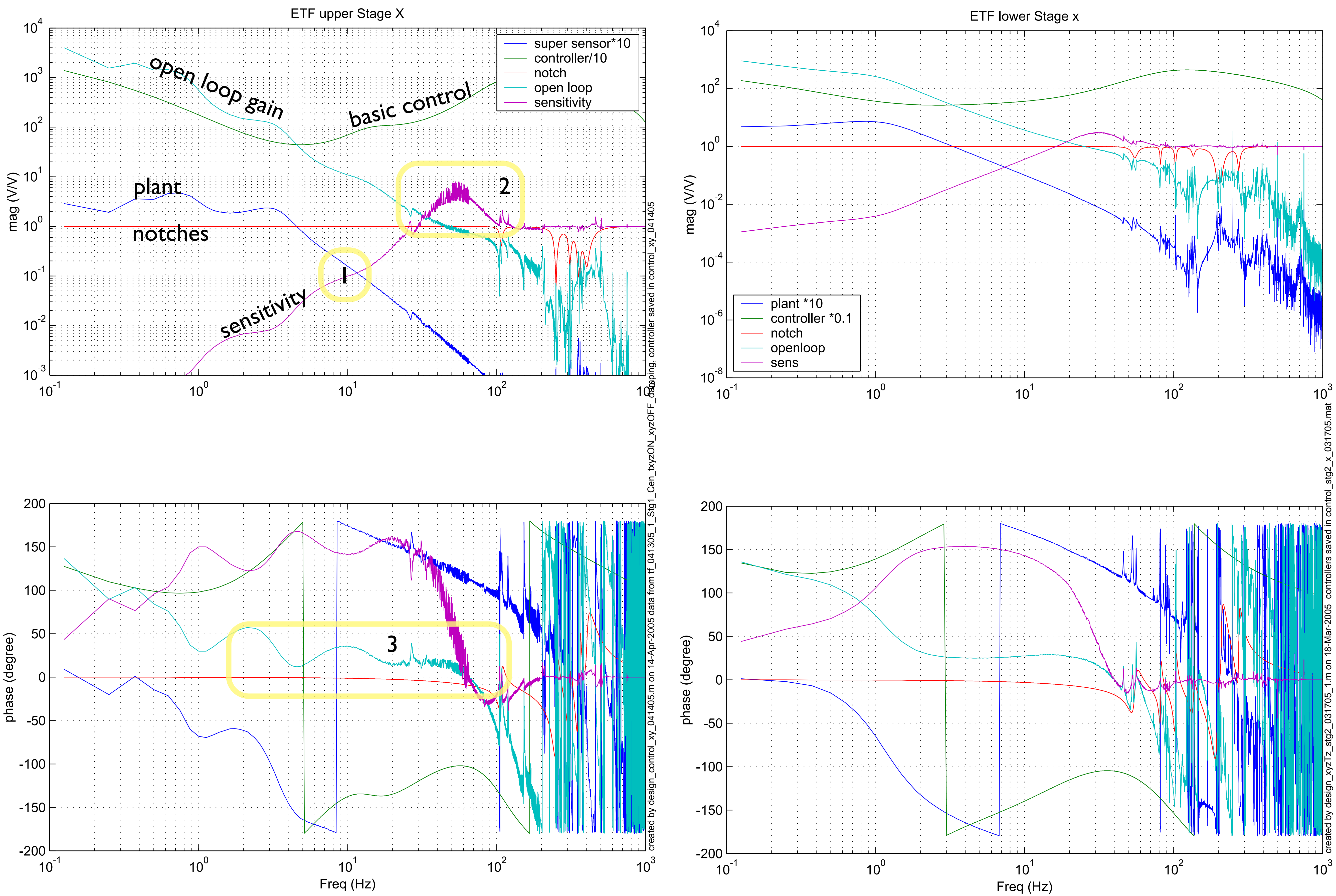
Understanding the Tech Demo Performance

- Using measured TF models to calculate noise coupling (.1 Hz to 10 Hz)
- Updated the dynamic model with Tech Demo parameters:
  - Vertical transmission too high at 10 Hz.
  - Tilt coupling causes translation.
- Not yet analyzed proposed BSC system. (but the stage 1 vertical springs are too stiff)

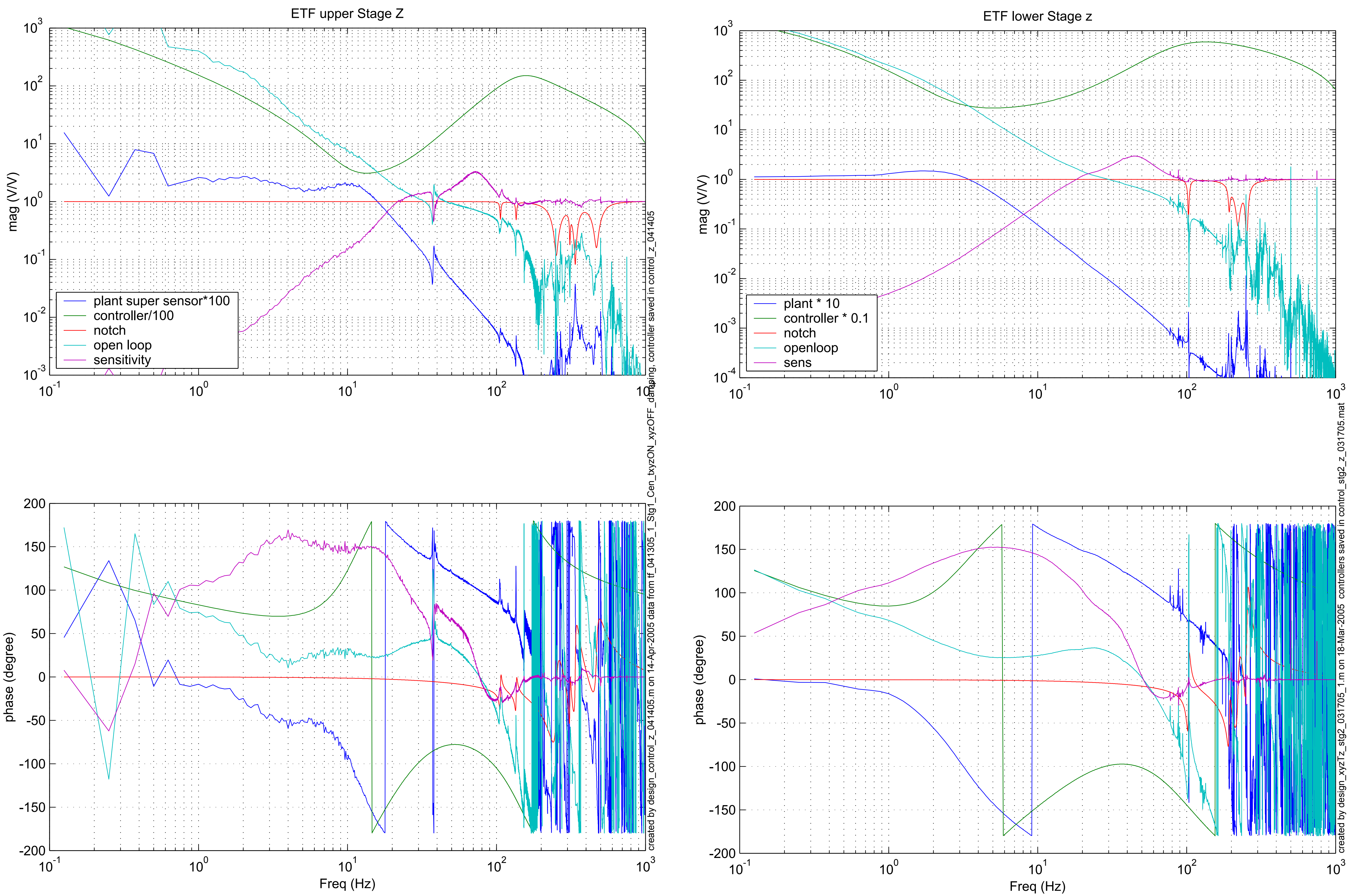
Improved performance

- Increased loop gain at 10 Hz.
- Still within limits of reasonable, unconditionally stable servos. Upper unity gain ~30-40 Hz.
- 1 Hz reduced by >100, now limited by sensor noise.
- 10 Hz in trouble.

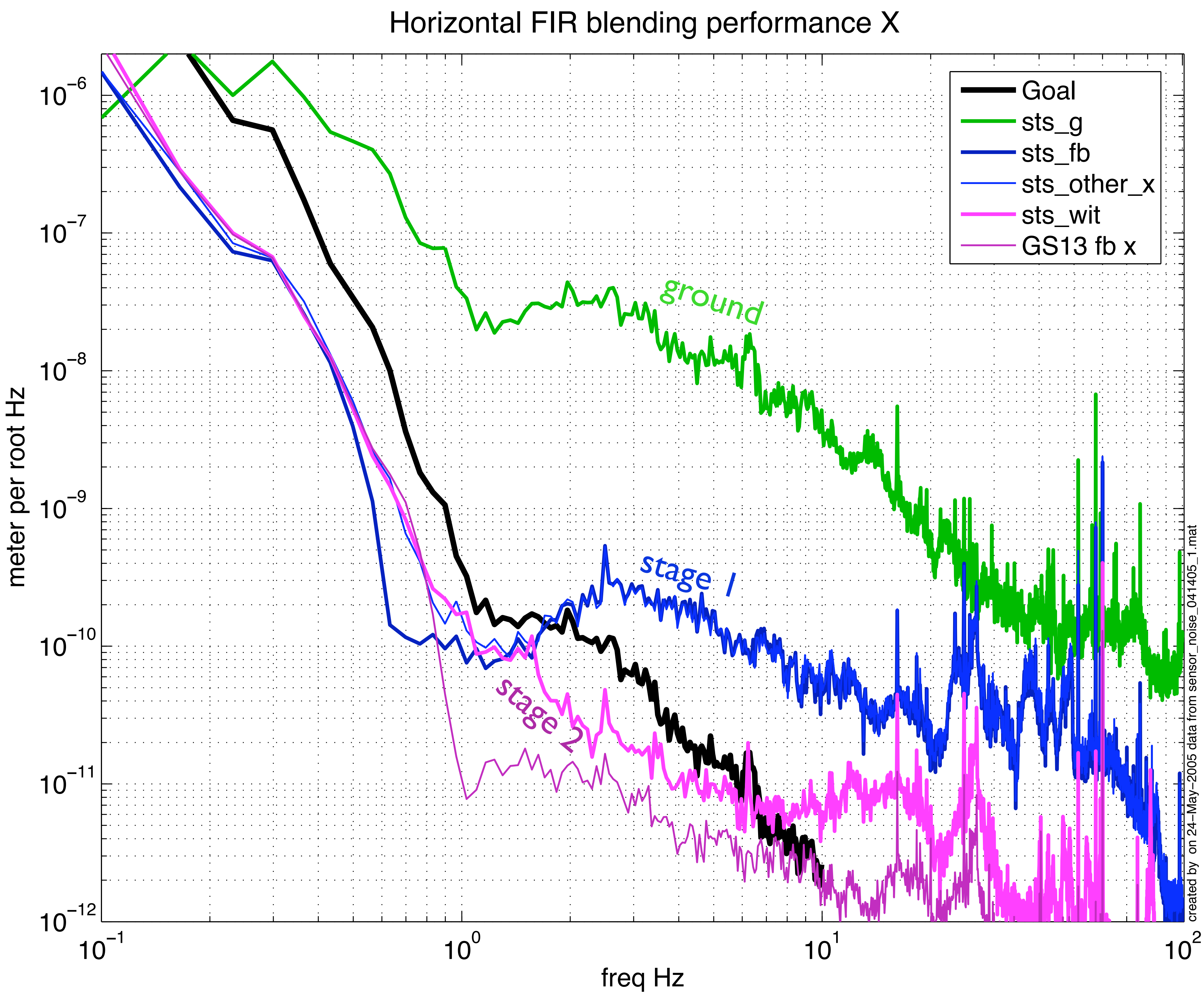
Controllers for X



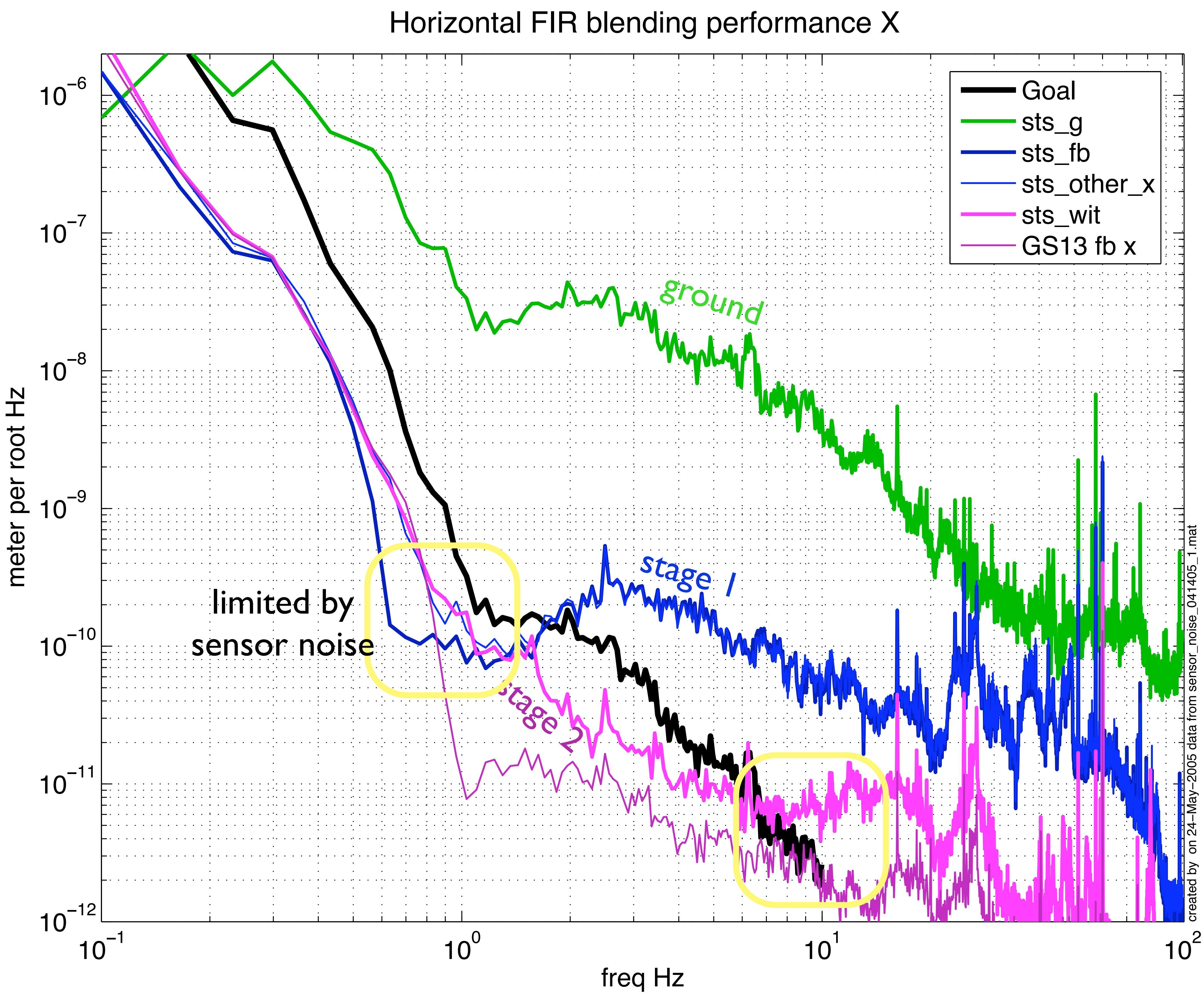
Controllers for Z



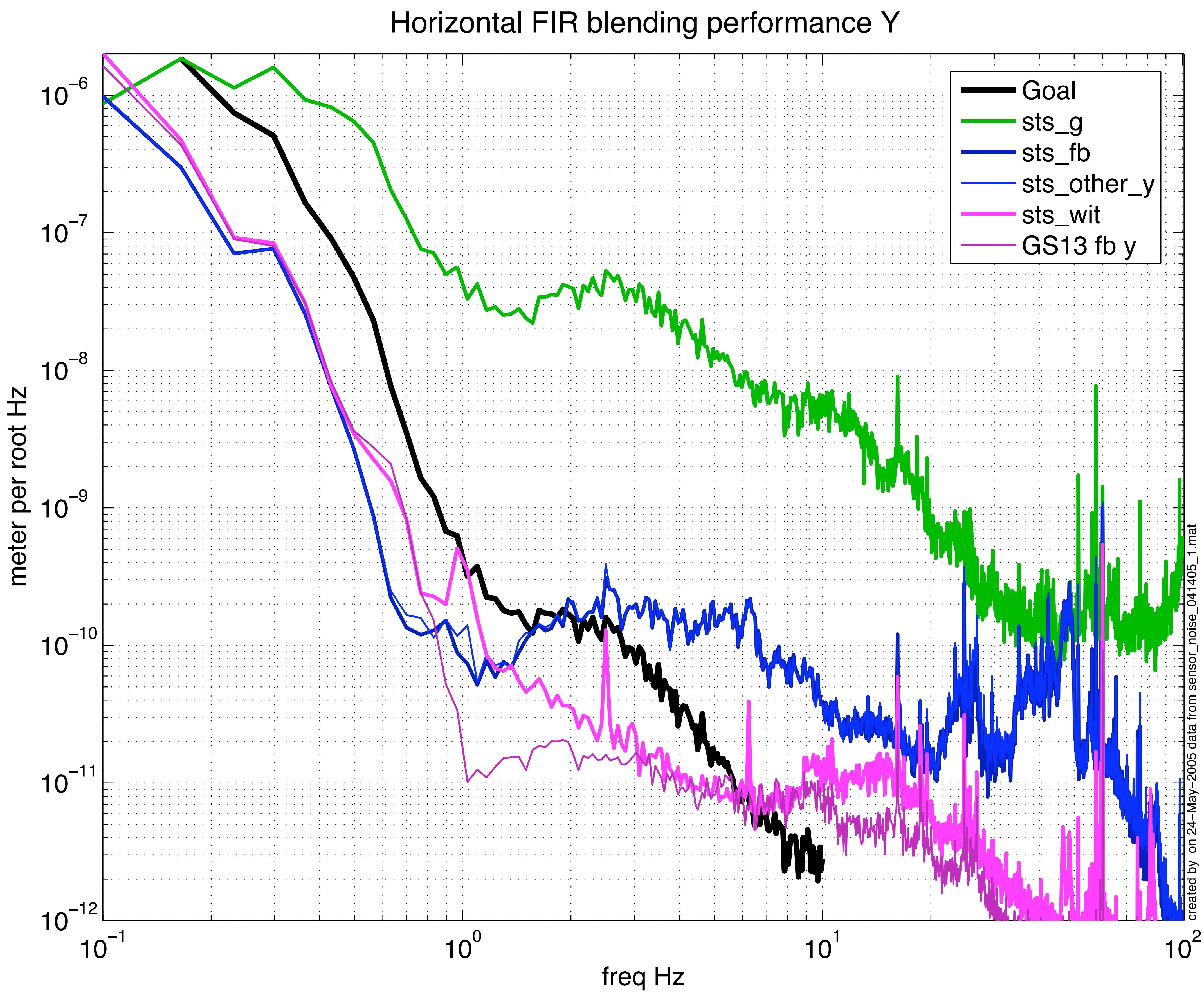
Performance X



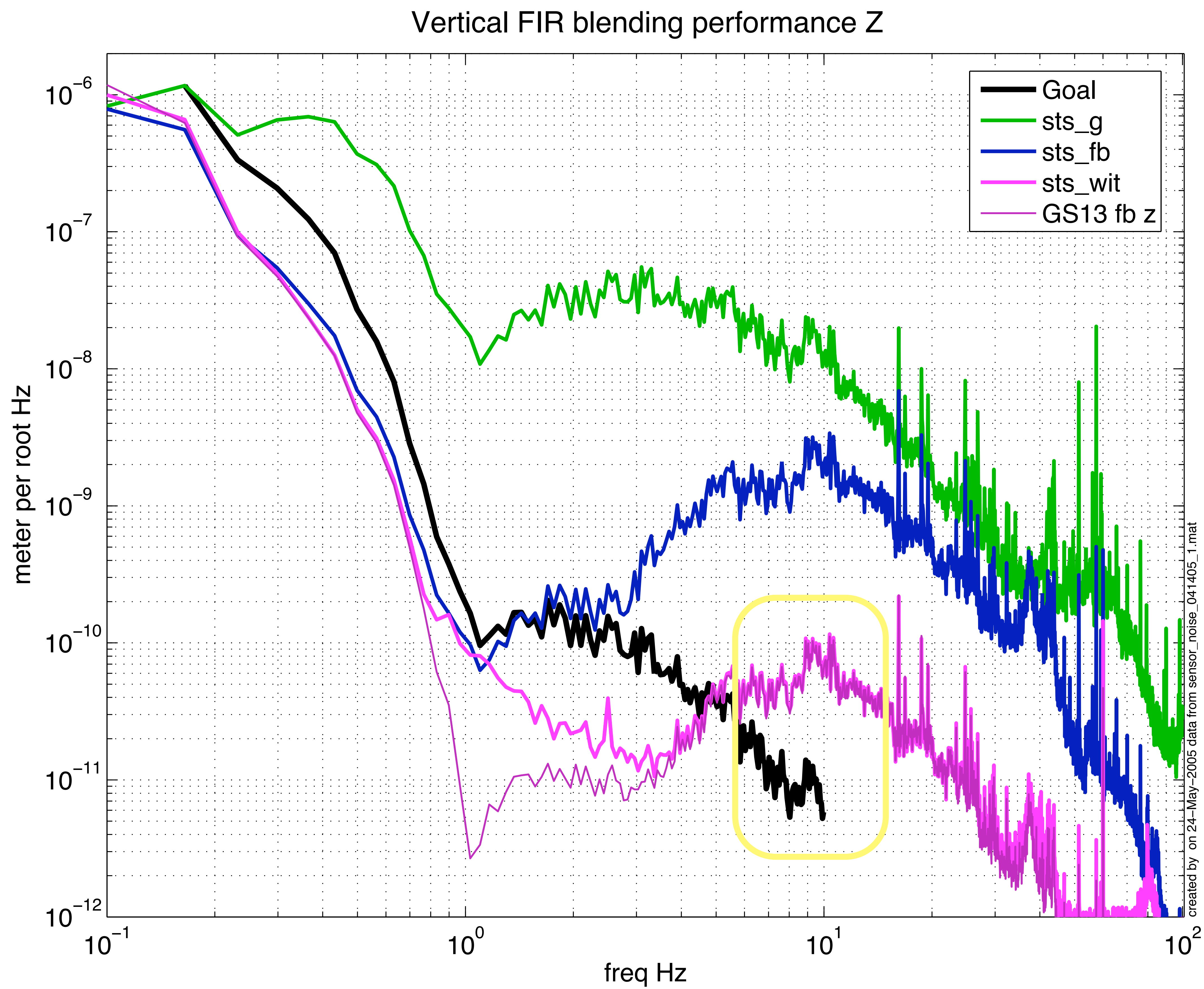
Performance X



Performance Y



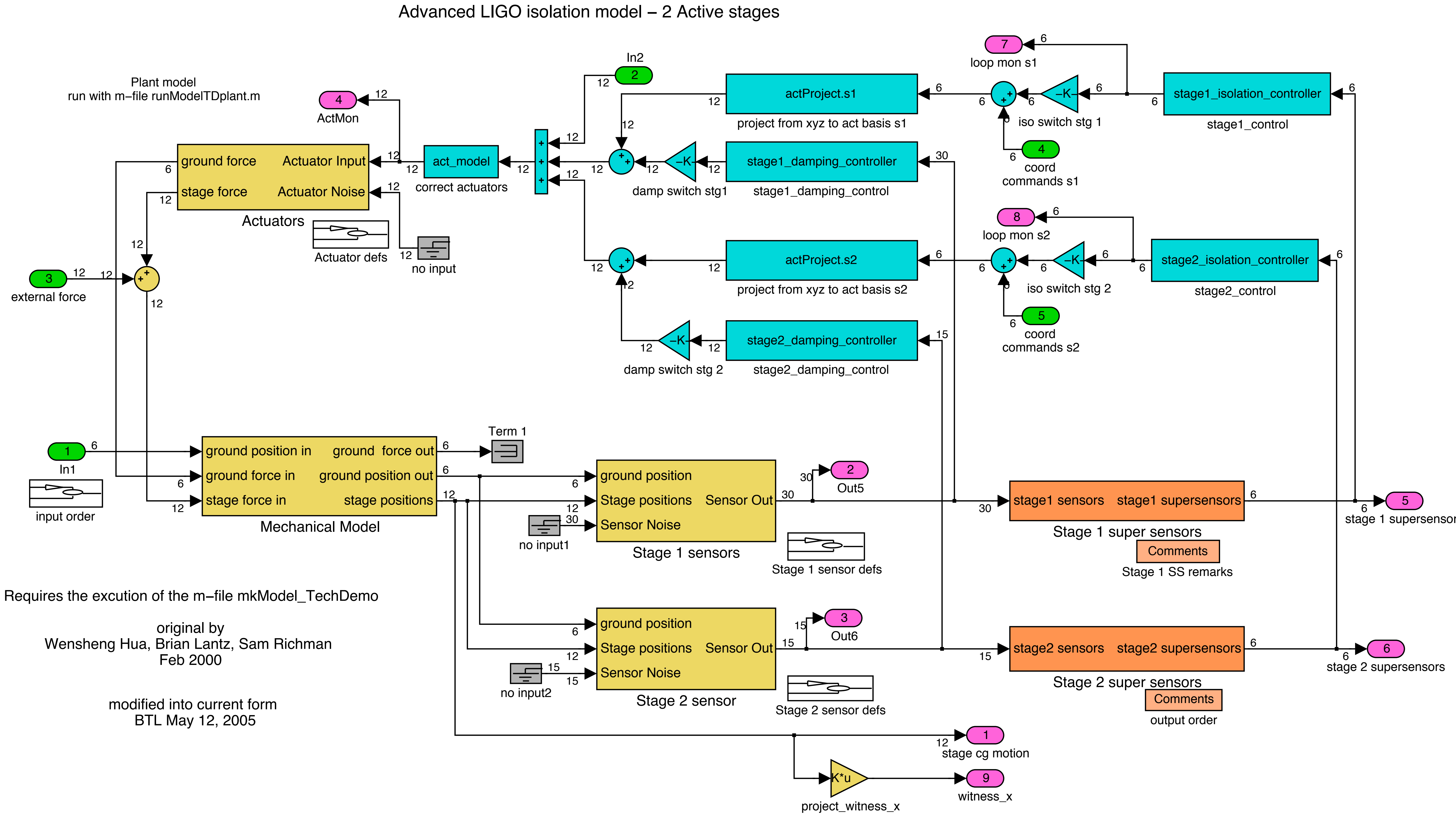
Performance Z



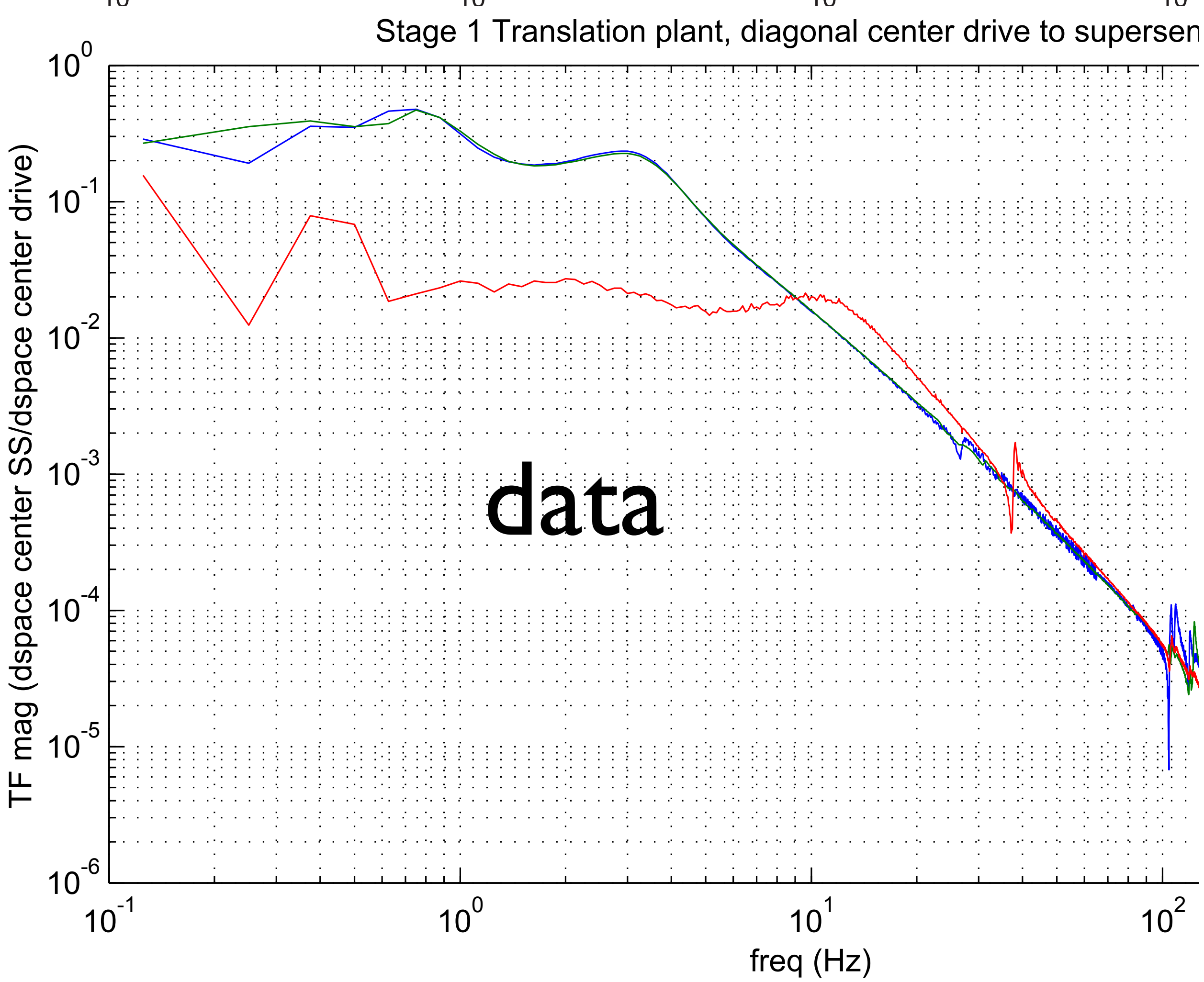
Dynamic Model

- Created by W. Hua (about 5 years ago)
- uses simple masses, springs and 6 DOF projections to build a mechanical system
- pieces hooked together in Simulink
- populate stages with sensors and actuators
- accurately captures dynamics up to ~30 Hz
- copy in the controllers used on the Tech Demo
- don't use FIR blending for stage 1 X & Y

Dynamic Model

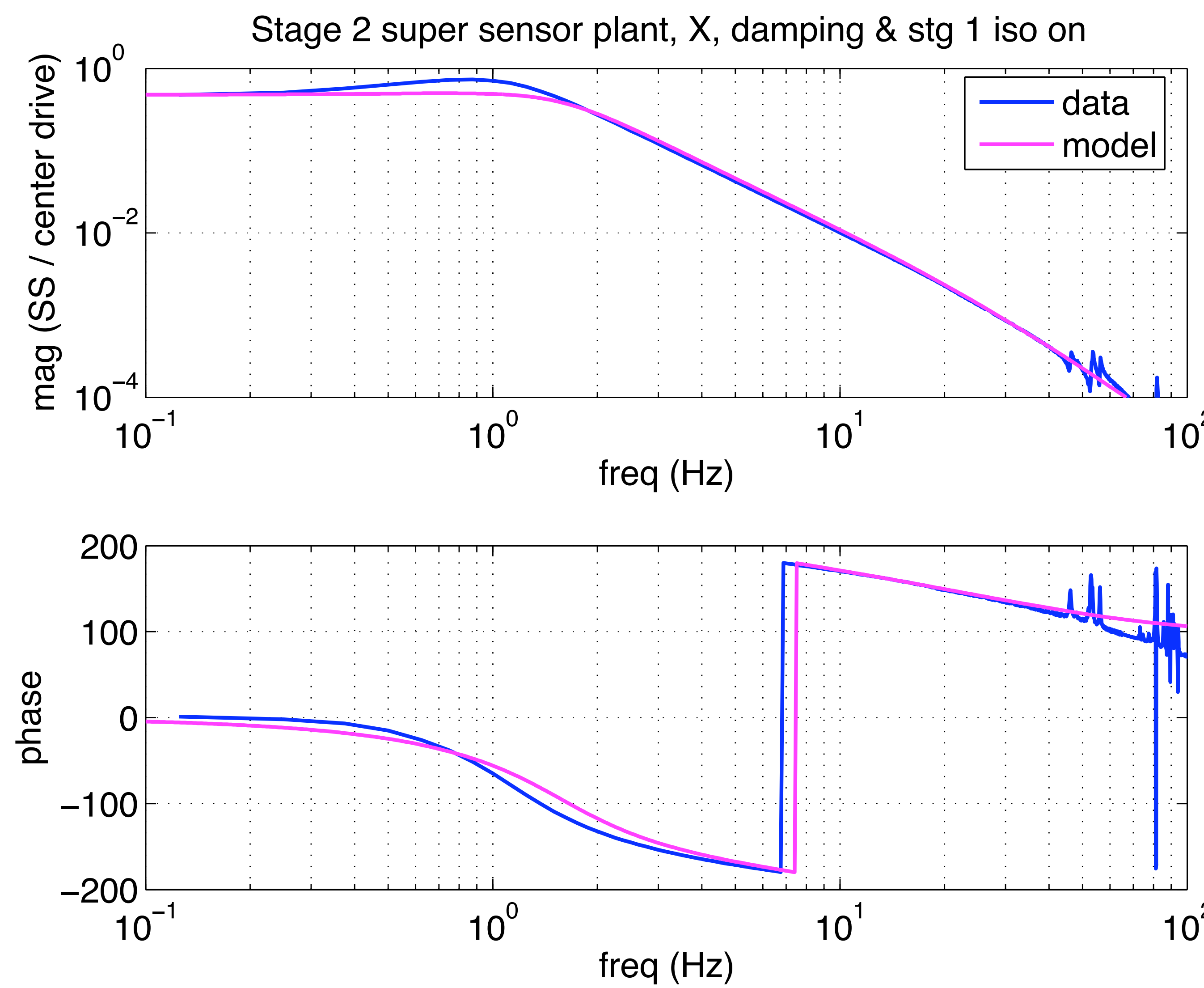


Stage 1 Supersensor Modal Plant

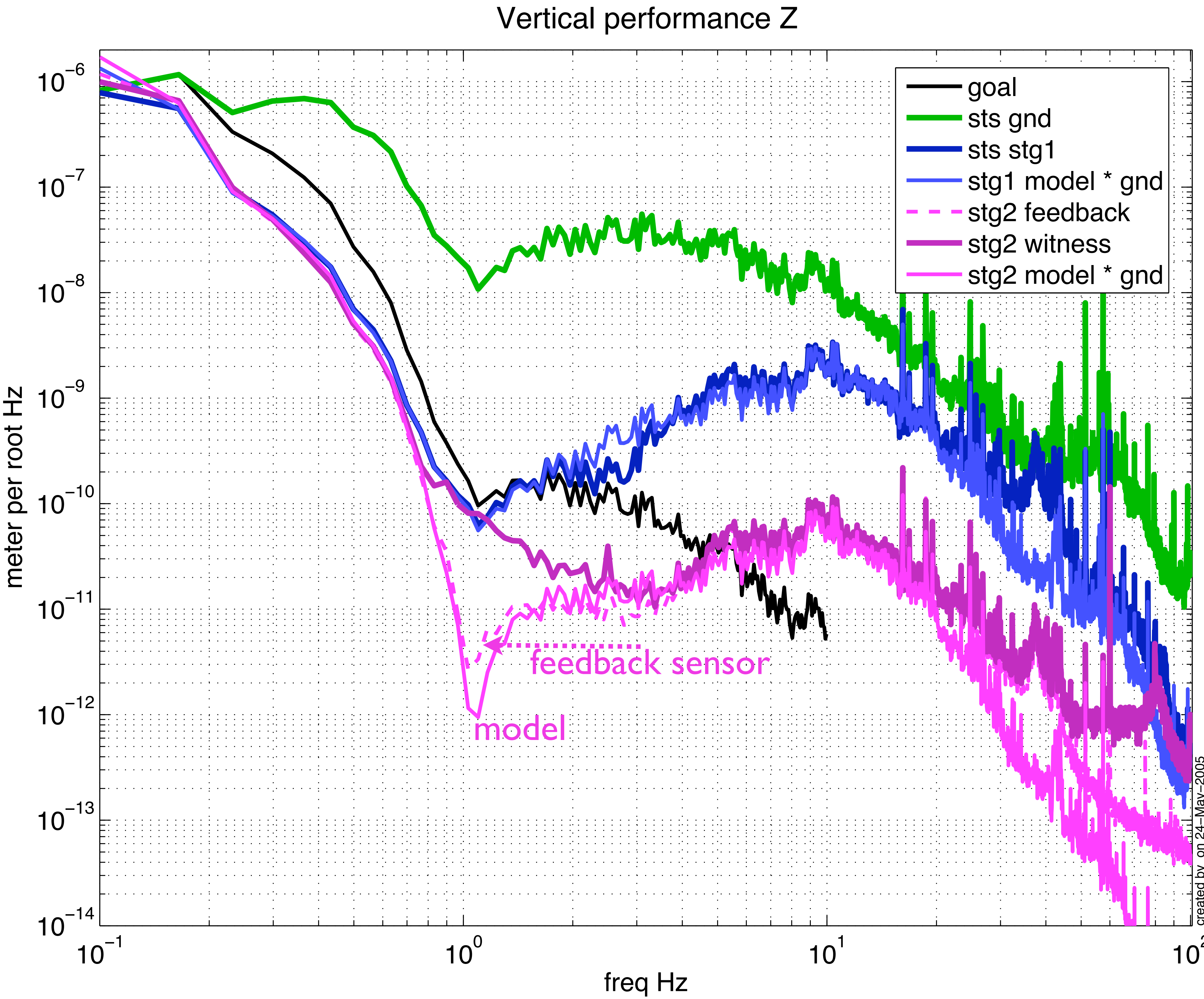


Fidelity?

Stage 2 Supersensor Modal Plant



Noise coupling to stage 2, Z



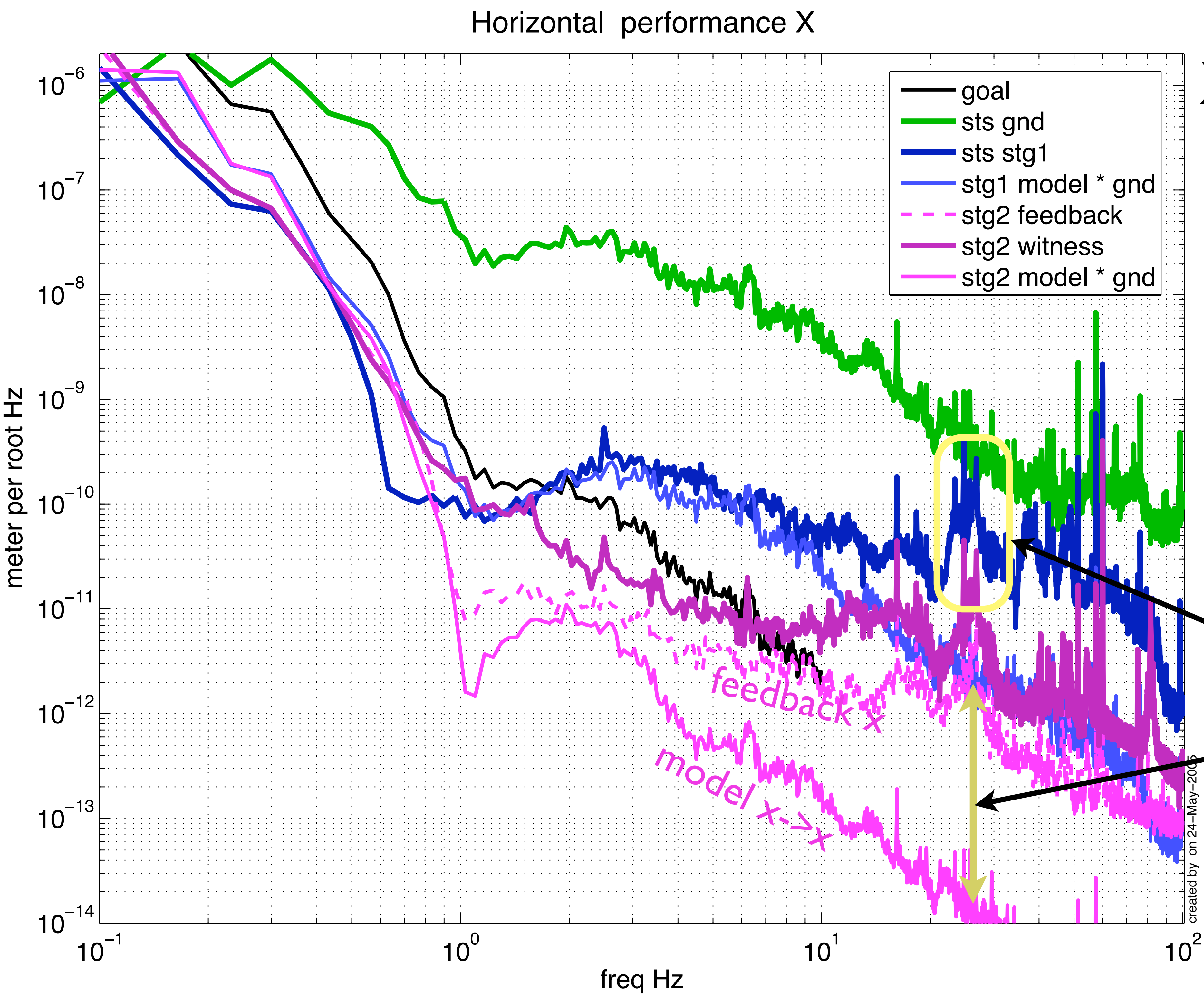
Model matches well

Issues:

1) 1 Hz Sensor noise

2) miss 10 Hz goal

Noise coupling to stage 2, X

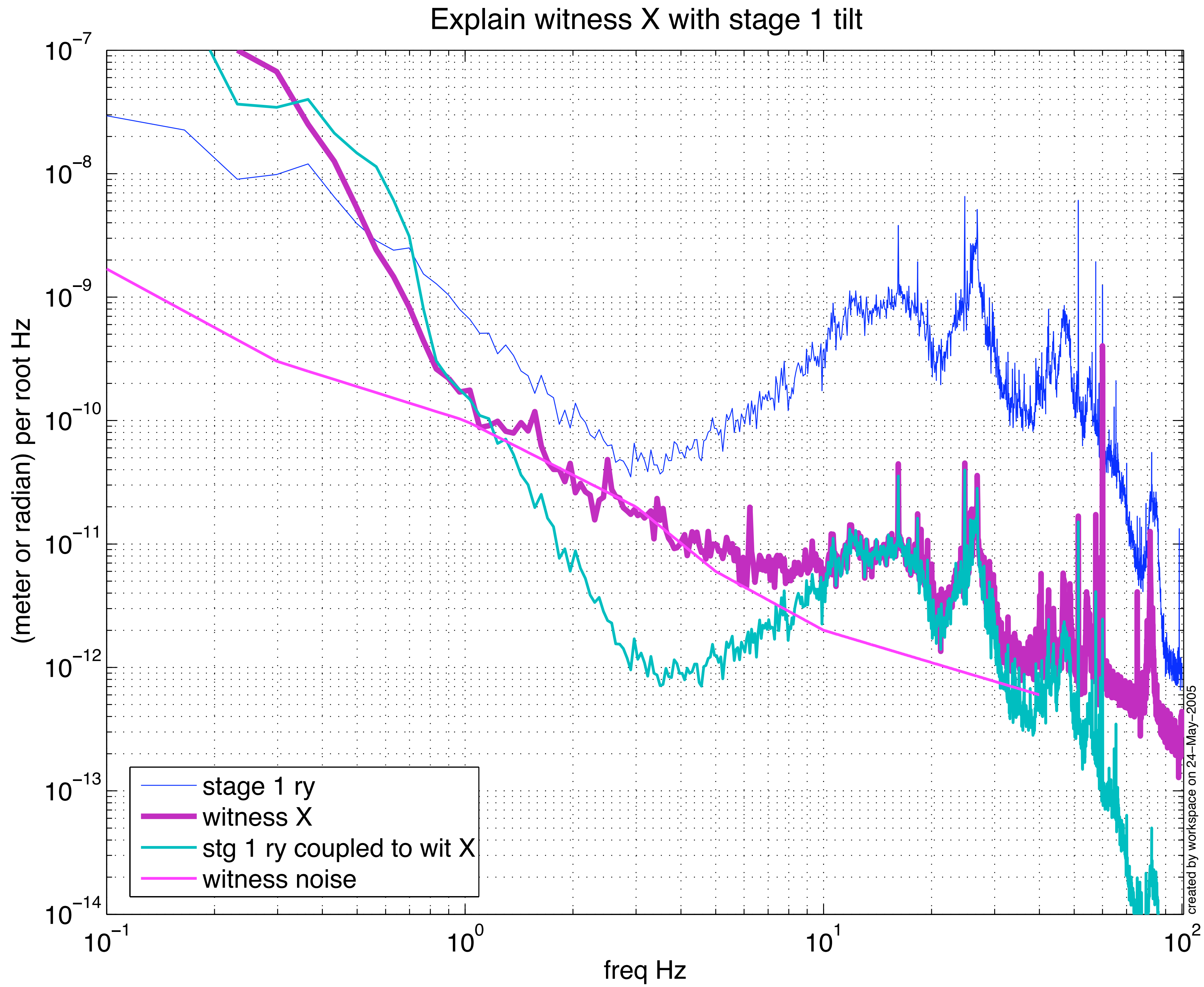


X motion of witness not caused by X motion of ground

Where's my isolation factor? get ~6, expect ~100

Tilt, tilt, tilt

Tilt about the center of the stage causes translations at the witness sensor location (0.5 meters away)



Can we get from 1e-11 to 2e-13?

HEPI data courtesy of Brian O'Reilly,
not corrected for L-4C dynamics at 1Hz and below

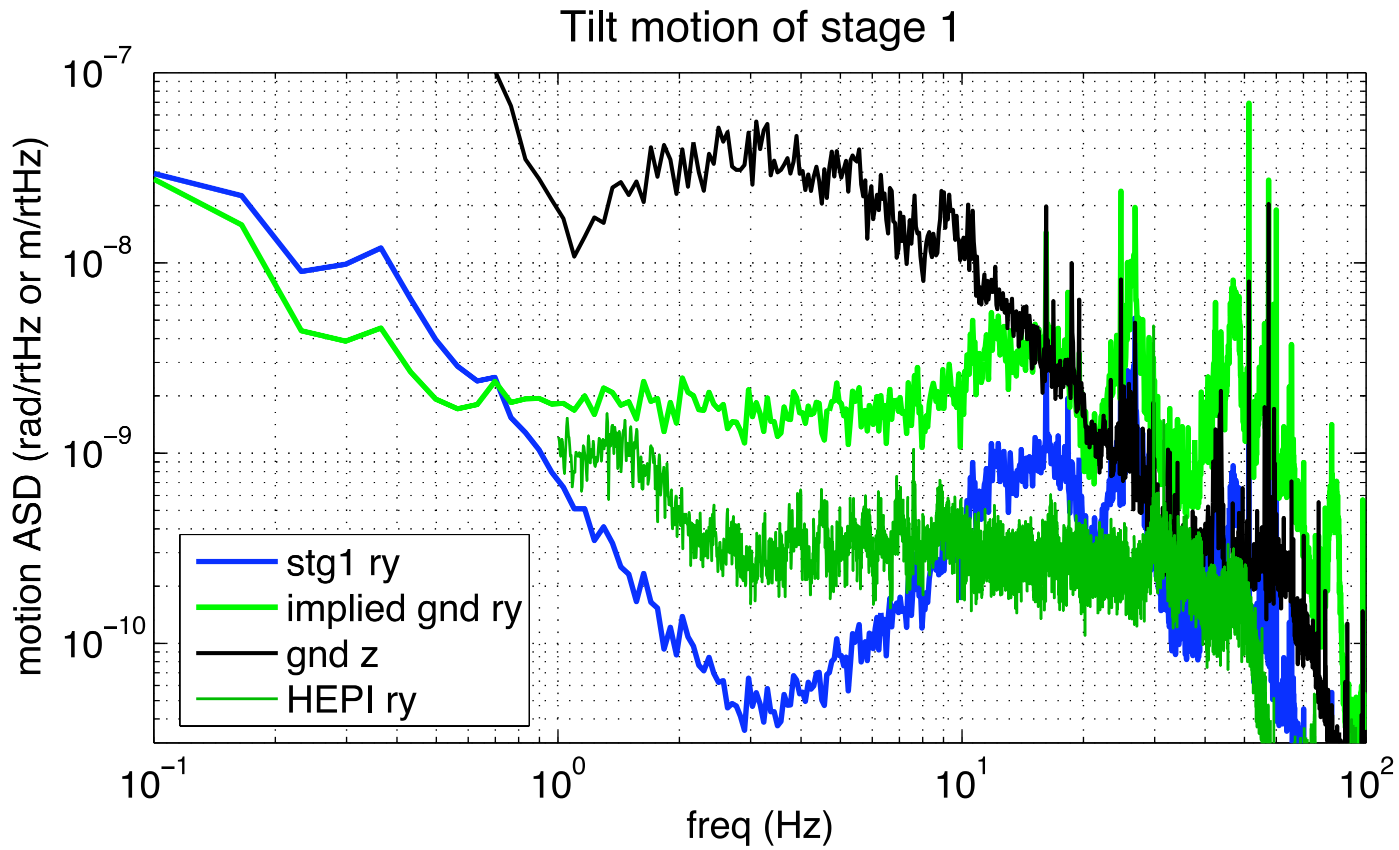
Level of tilt at ETF and LIGO

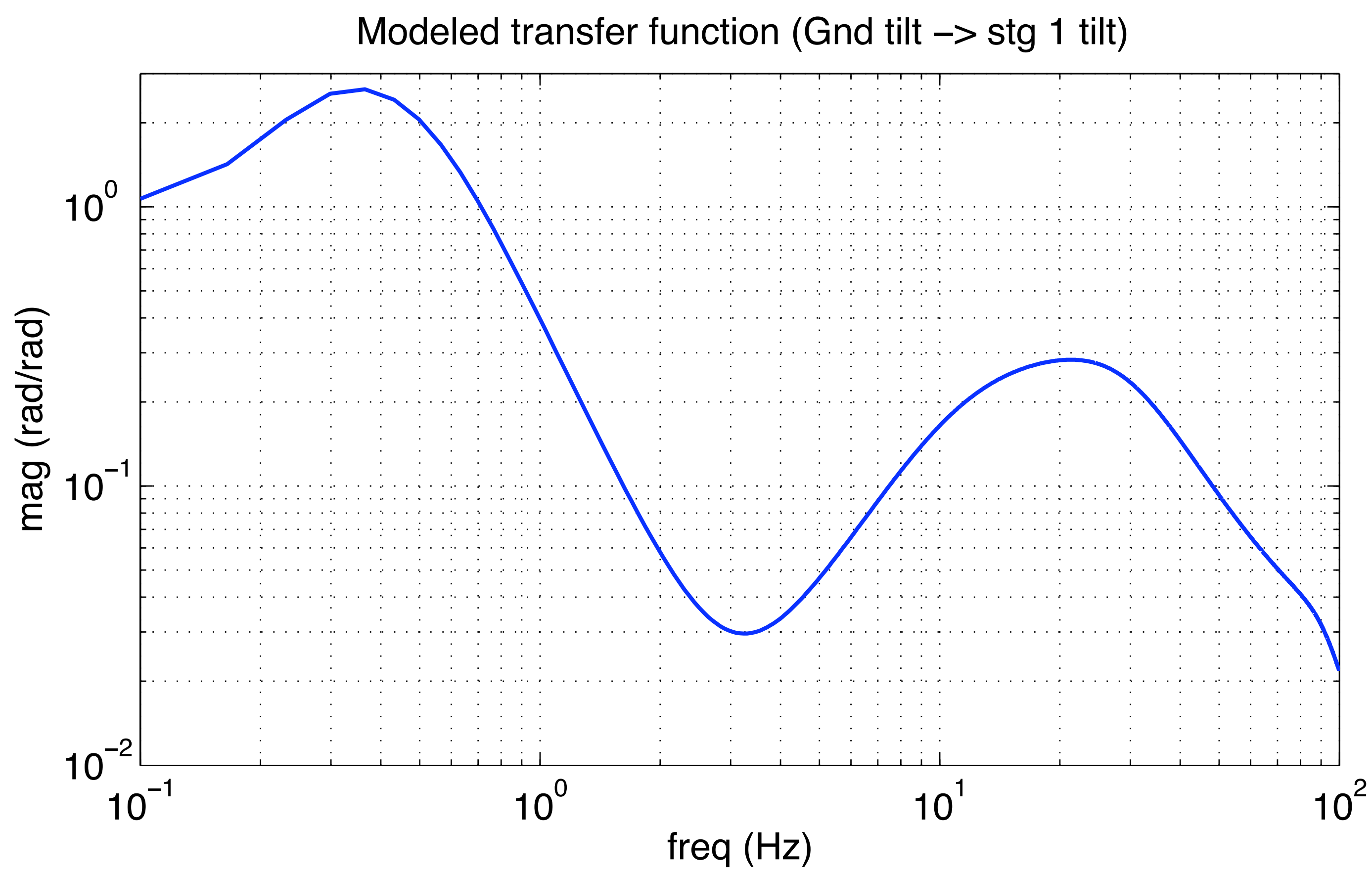
Estimate tilt of support from measured tilt of stage 1

Tilt motion on HEPI about x5-10 smaller than ETF.

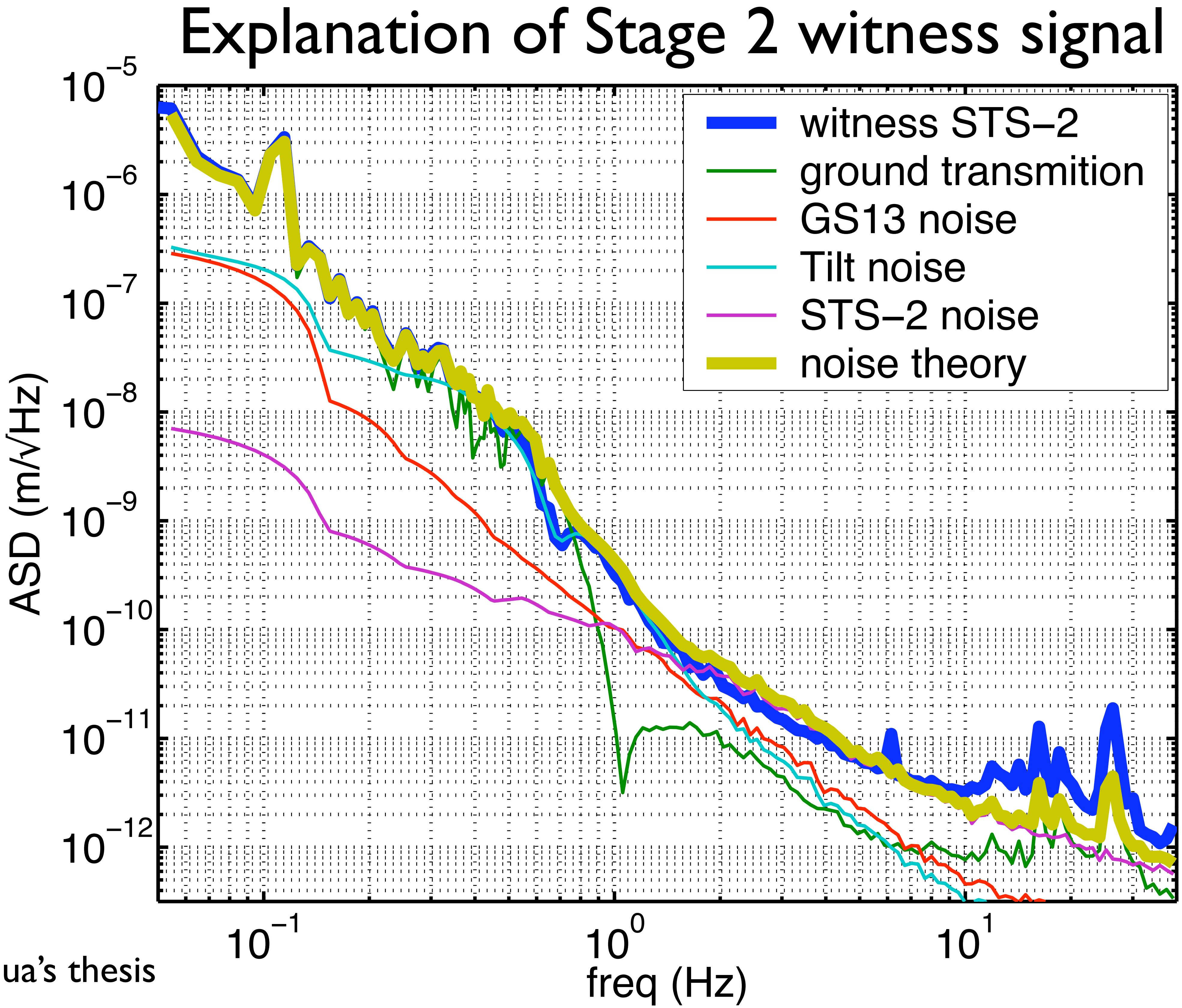
Leaves a factor of 10...

Softer vertical stage 1 springs would help



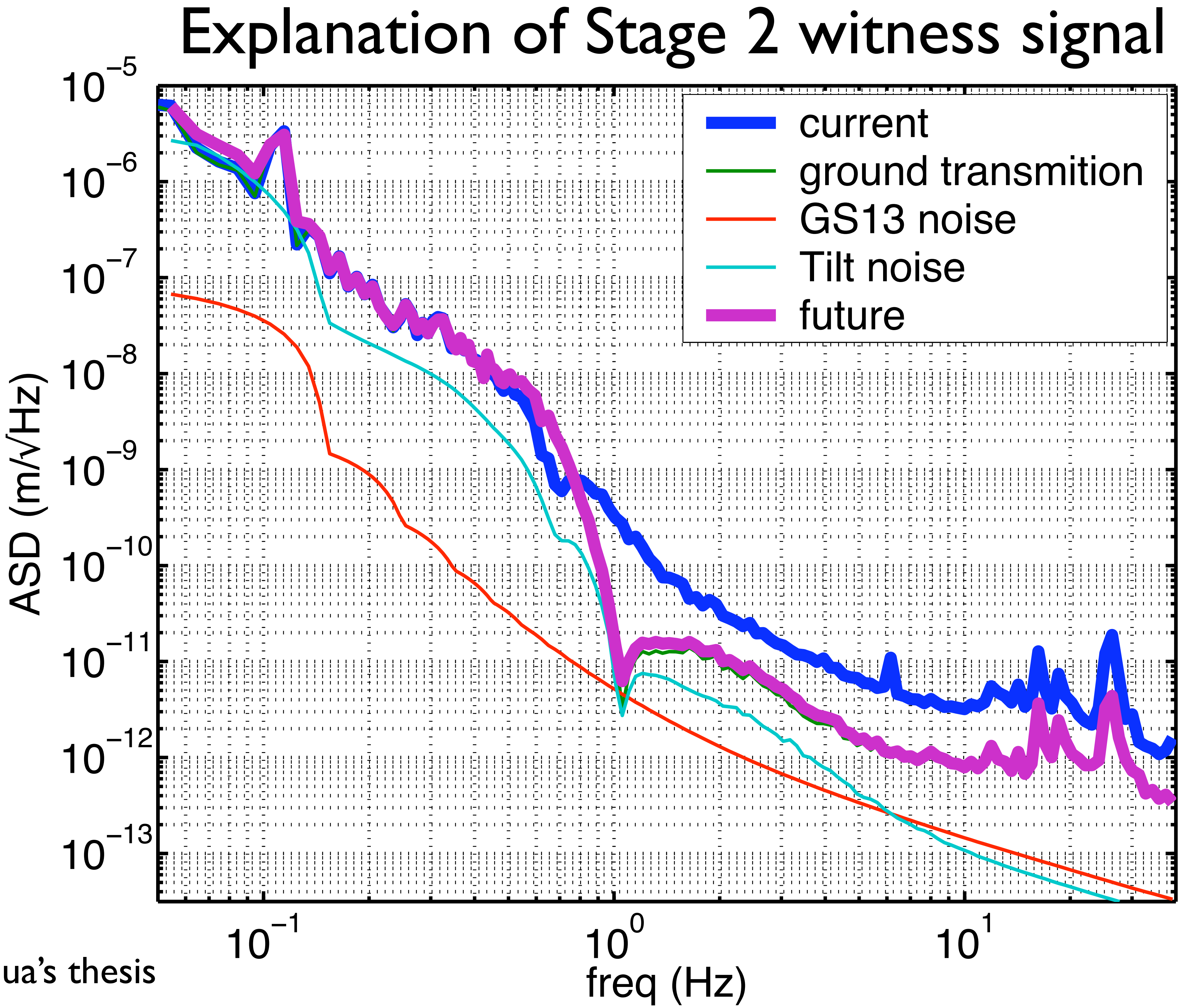


Tilt problems at 1 Hz



from Hua's thesis

Tilt problems at 1 Hz



from Hua's thesis

Conclusions

- We need to modify the GS-13.
- If successful, 1 Hz performance looks OK.
- 10 Hz performance likely to require spring changes, model is ready to study the issue.