Recent Work to Damp the Frame of the Quadruple pendulum at the Stanford Engineering Test Facility

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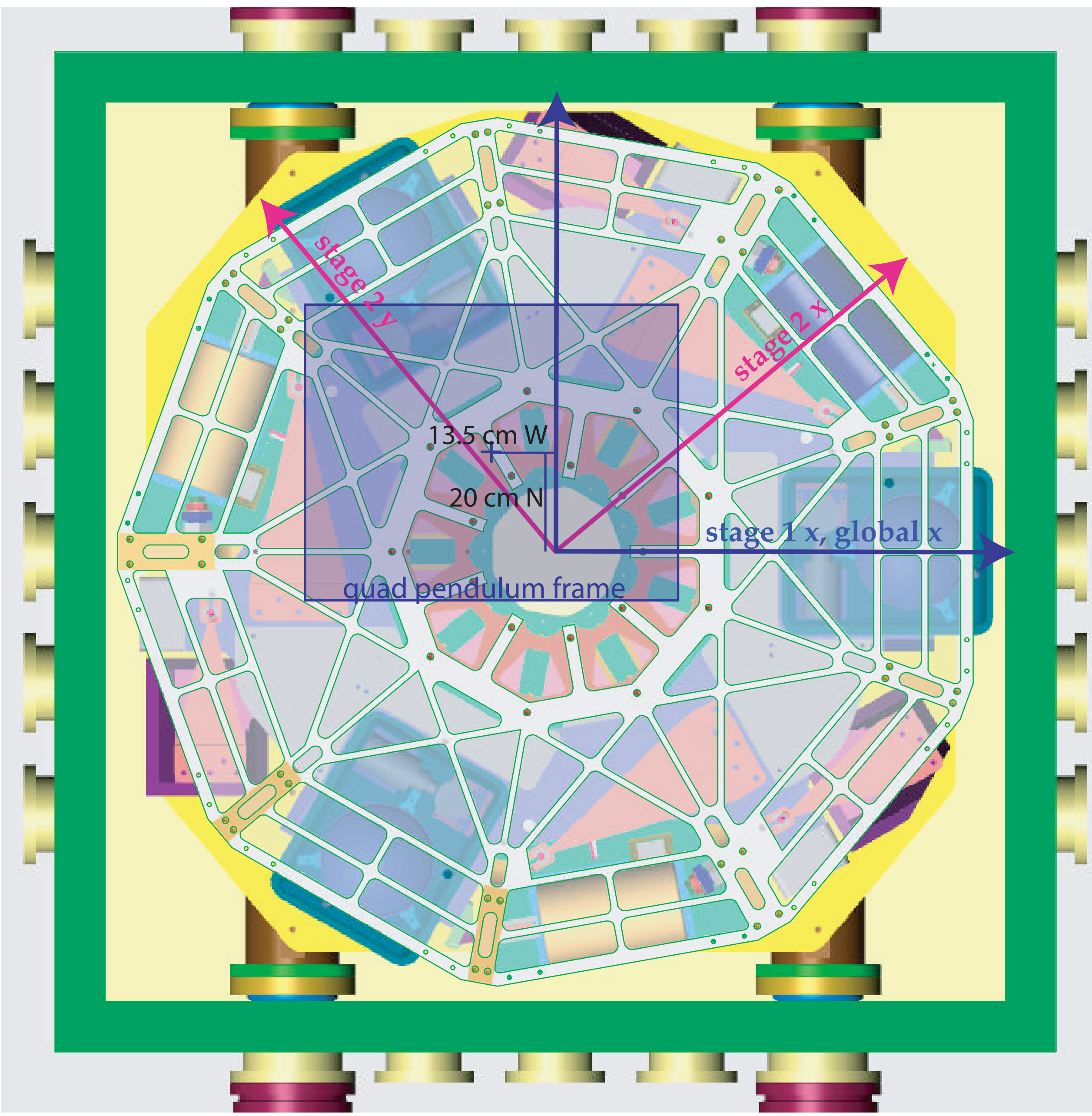
Quad Pendulum Frame

- Received a frame from Caltech
- Install on the Tech Demo
- Study the impact of frame resonances on the system
  - Not so great
- Try to improve the interaction
  - Electronic damping (OK)
  - Passive "Constrained Layer" damping (Great)

Installation

- installed 12/16/05
- Upside down



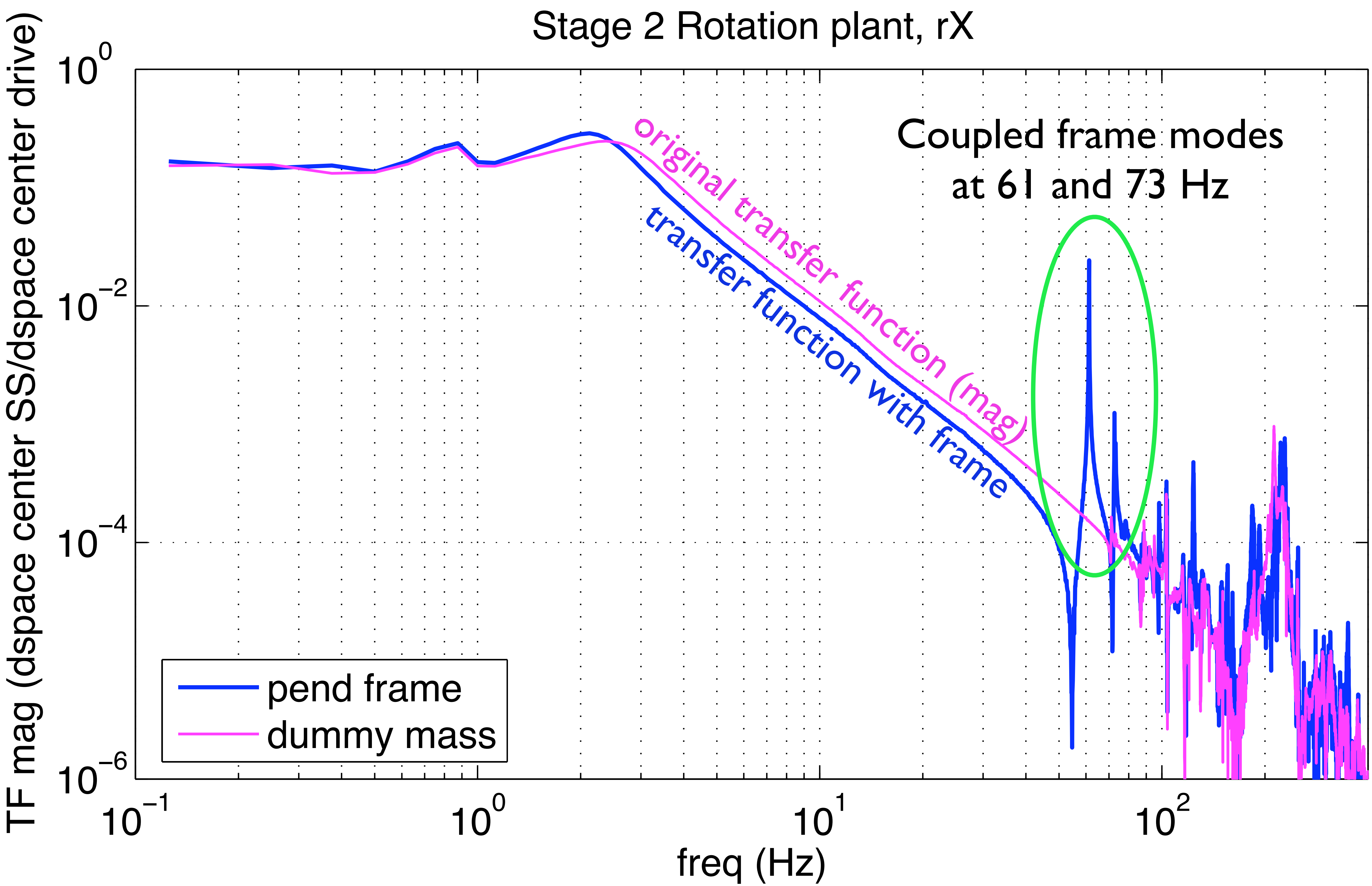
top view of frame installation

Interaction Performance Tests

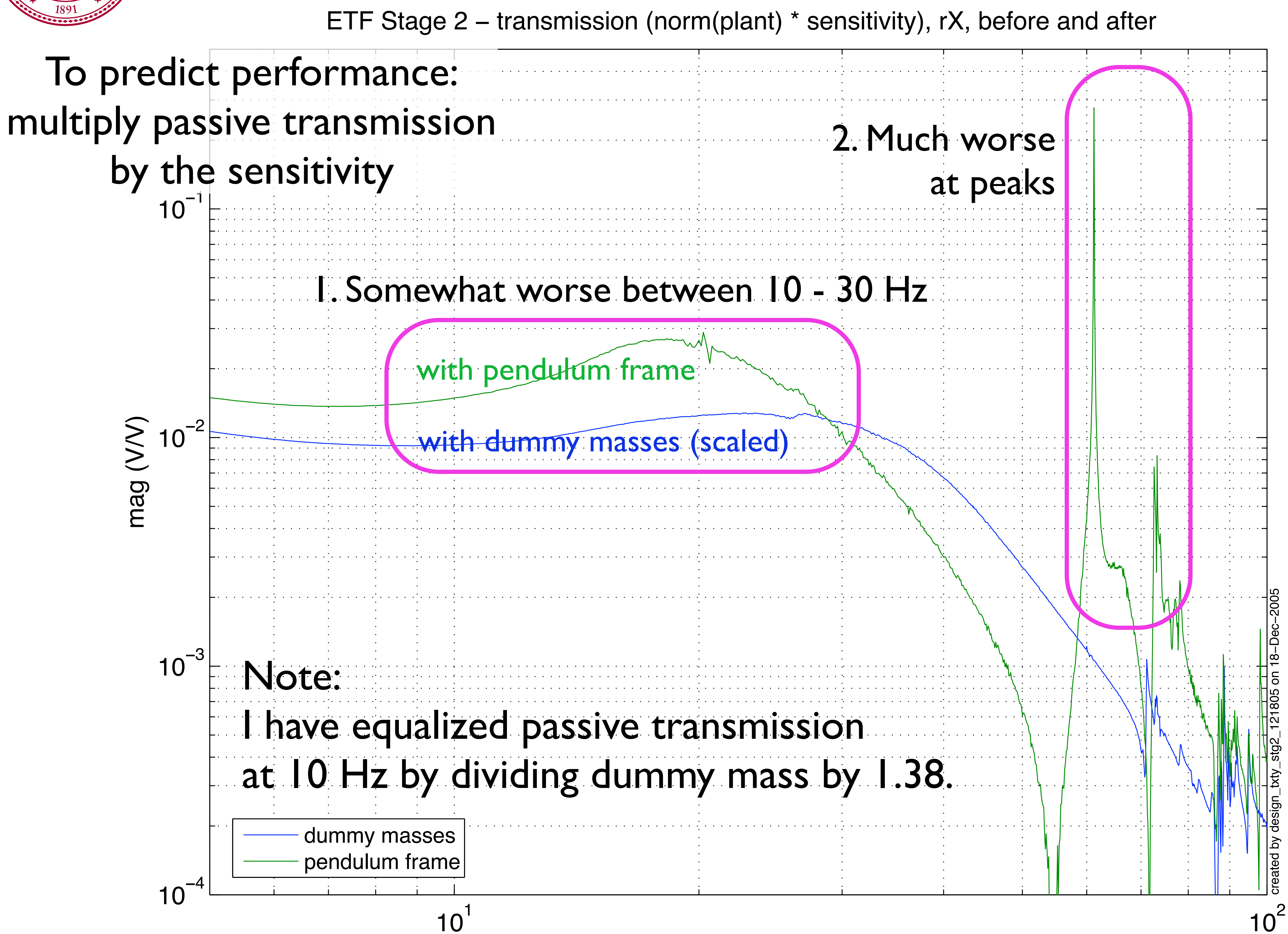
- Goal: Try to understand the impact of the frame vibrations on the system performance.
- But: Testing in air makes performance measures difficult.
- So: Predict performance by:
  - Measuring mechanical transfer function of stage, and
  - Multiplying by calculated suppression of the isolation loop.

- We see that:
  - Mechanical transfer function is worse.
  - Control loop performance is worse.

Largest Coupling to rX & rY



Performance Impact of resonances

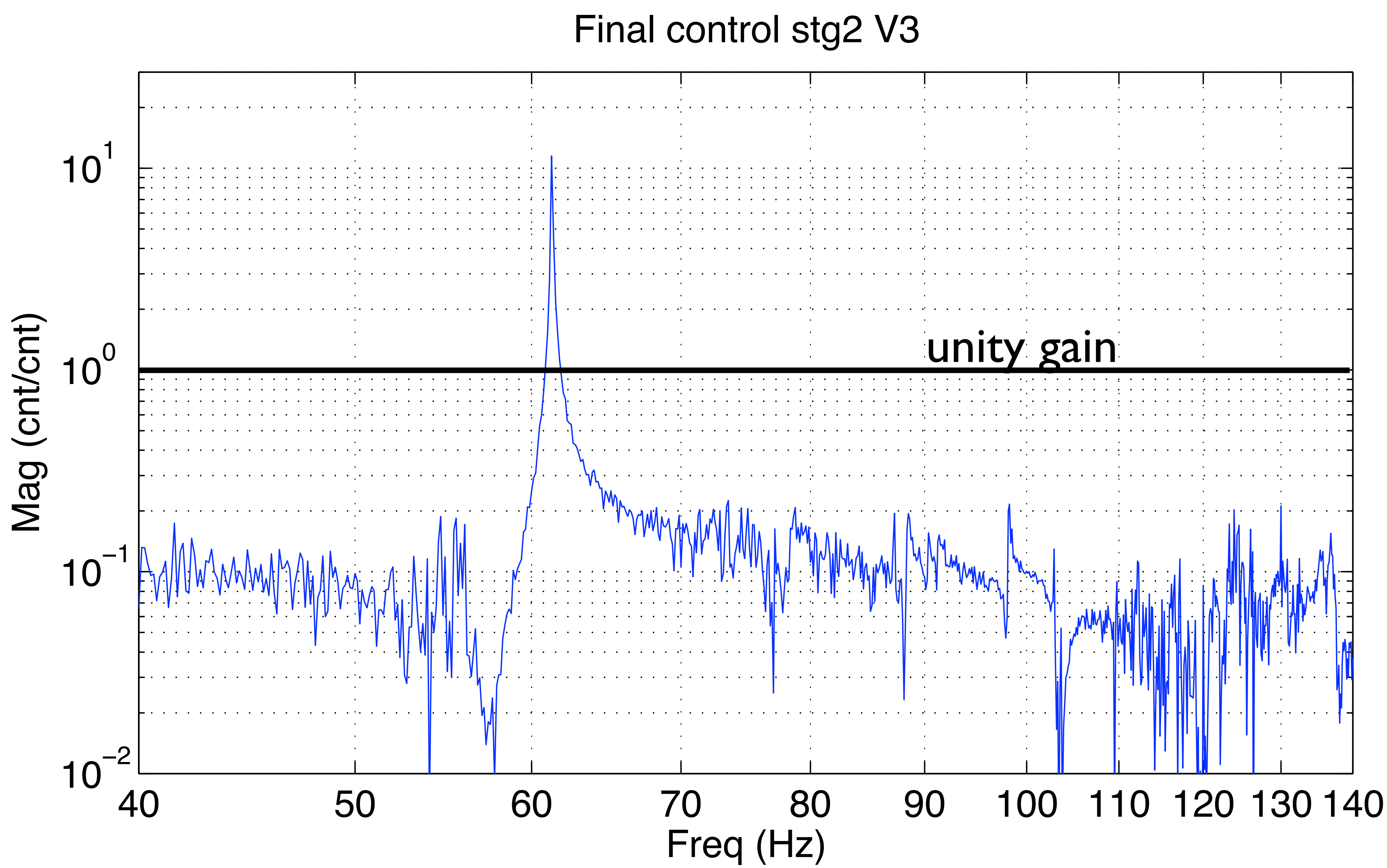


What to do?

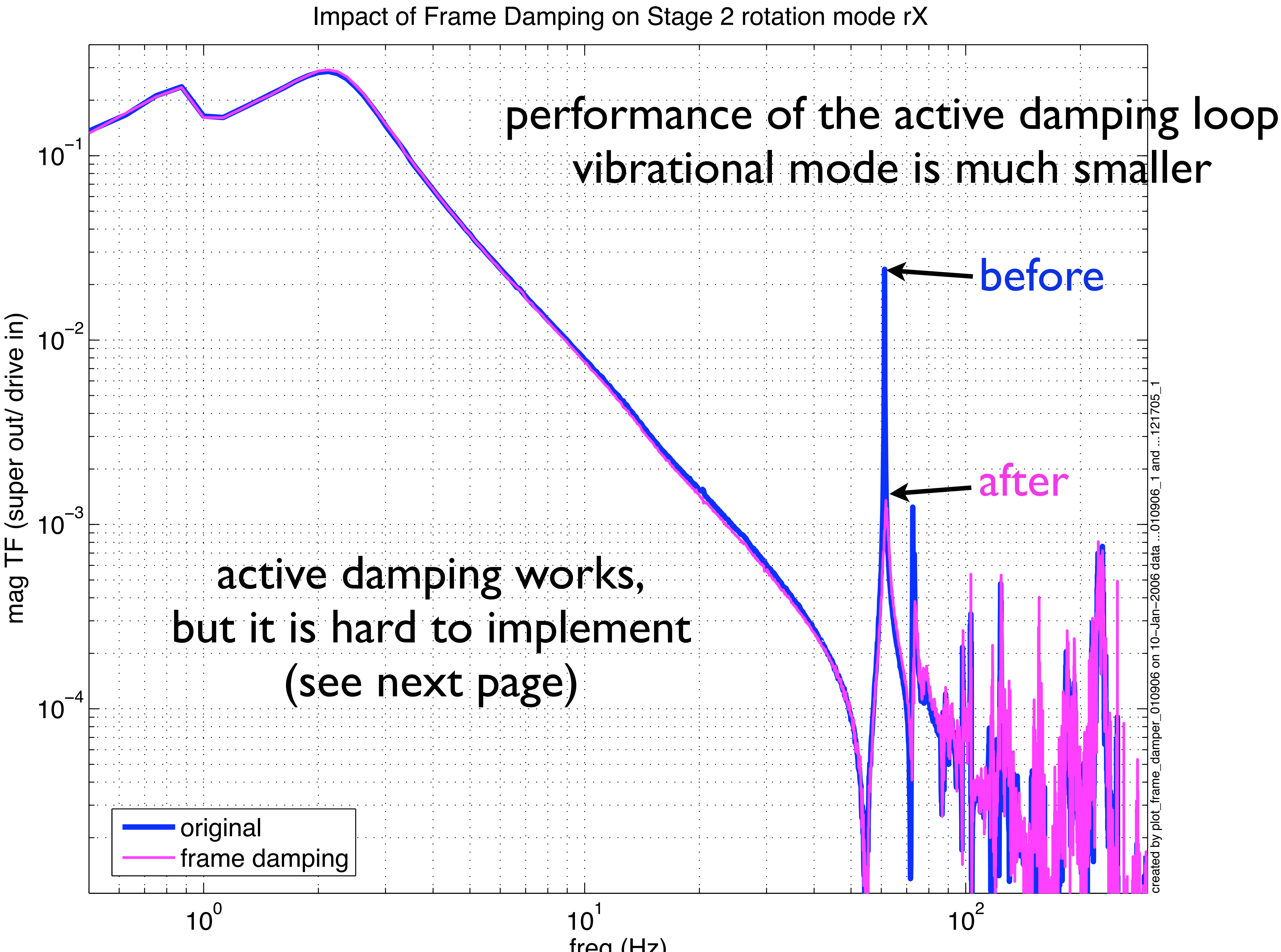
- Frame Designers - Increase the frequency of the modes
- Damp the modes:
  - Actively, using existing sensors, or using new sensors
  - Passively with constrained layer damping

Active damping control loop

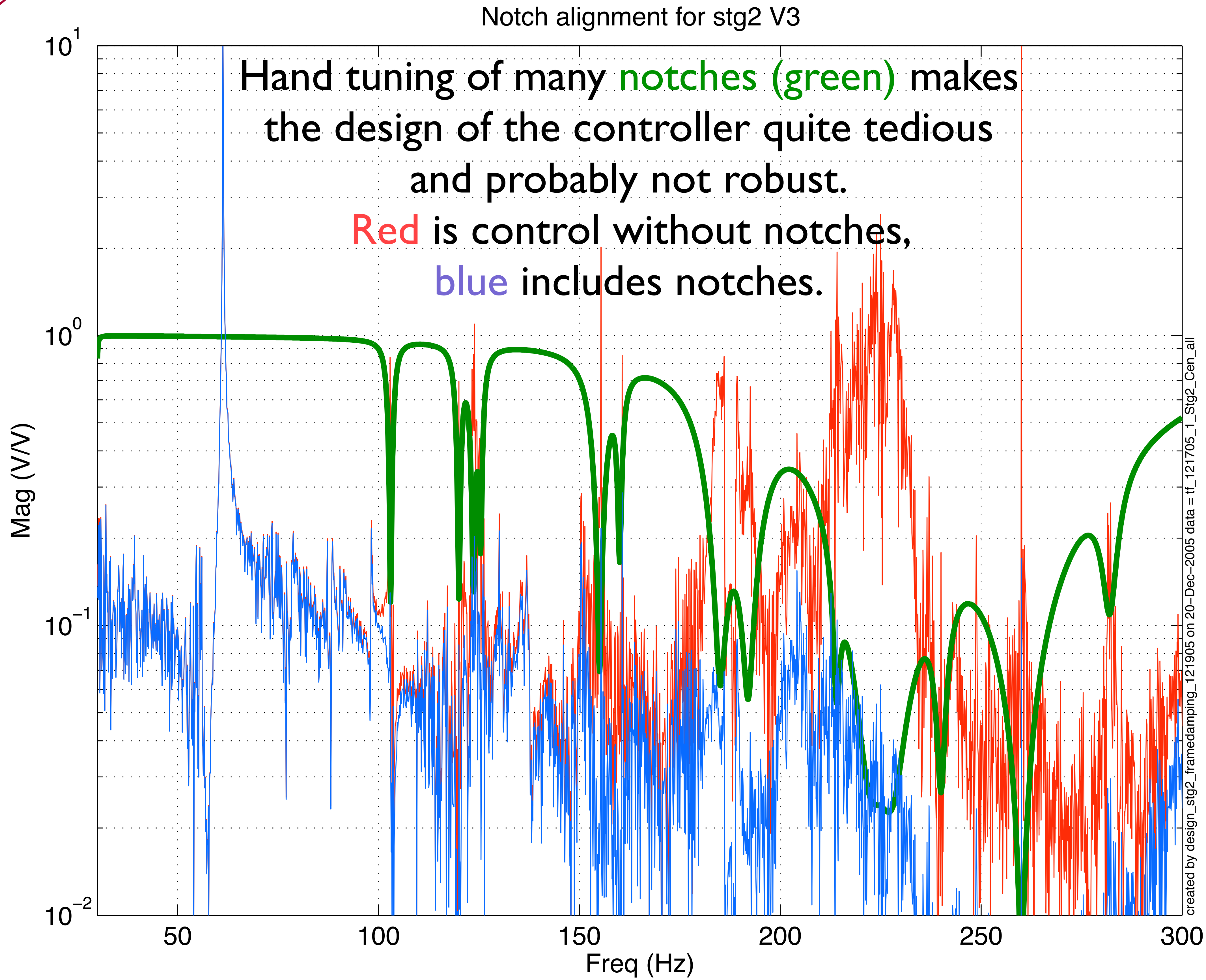
open loop transfer function of a damping controller
61 Hz mode will be damped



Result of active damping



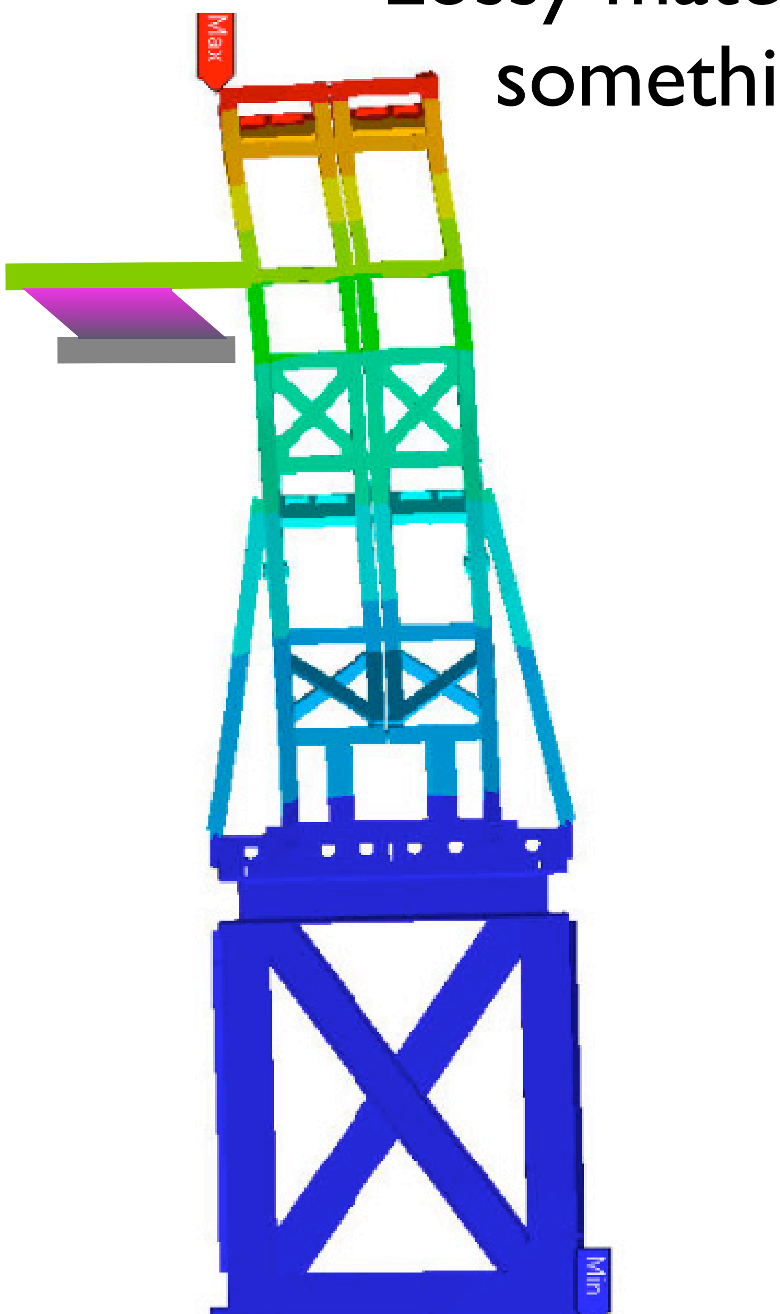
Requires many irritating notches



Passive damping of frame mode

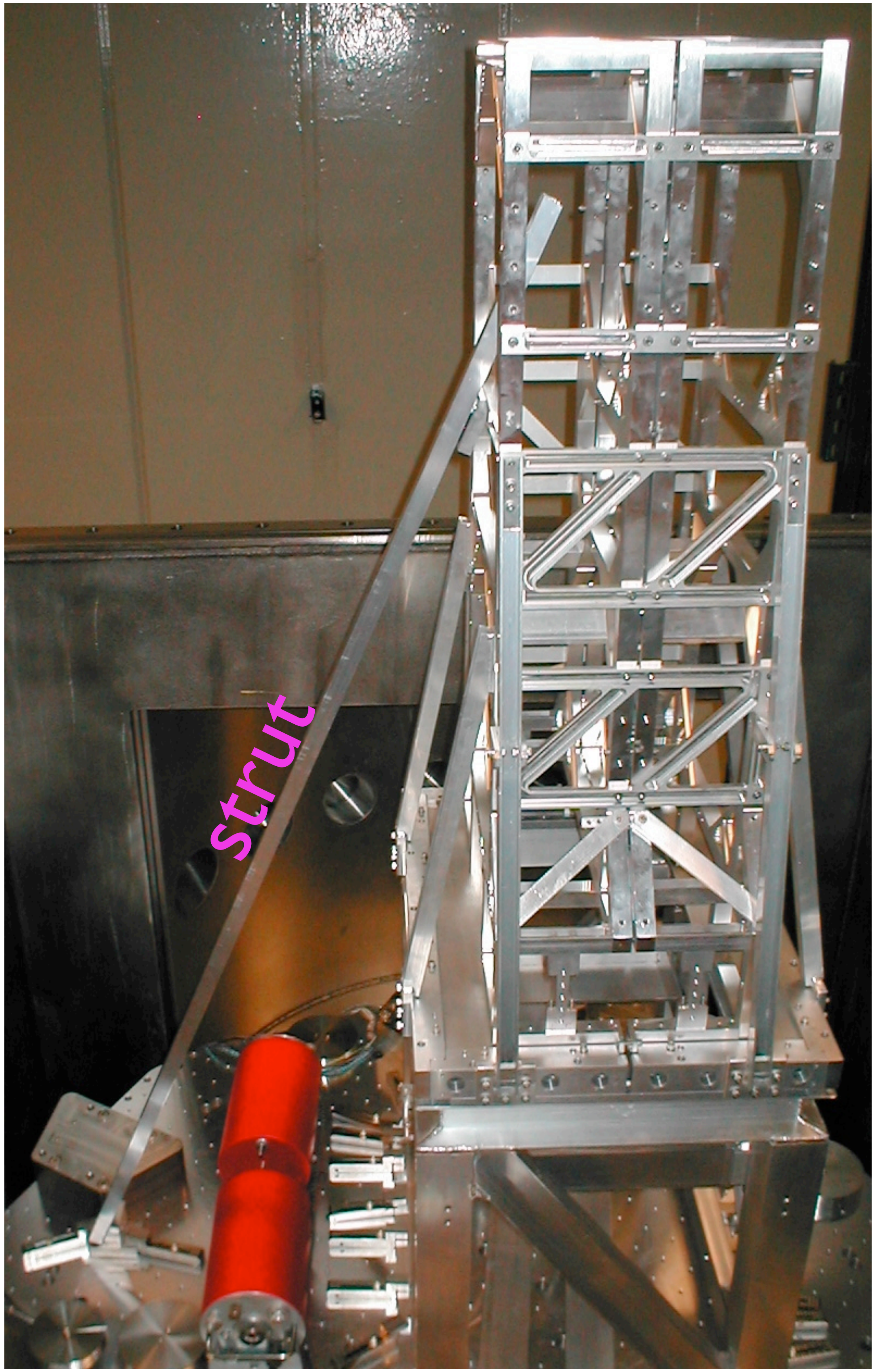
Use vibrational motion to create to create shear in a lossy material (Dyad 601 by SoundCoat)

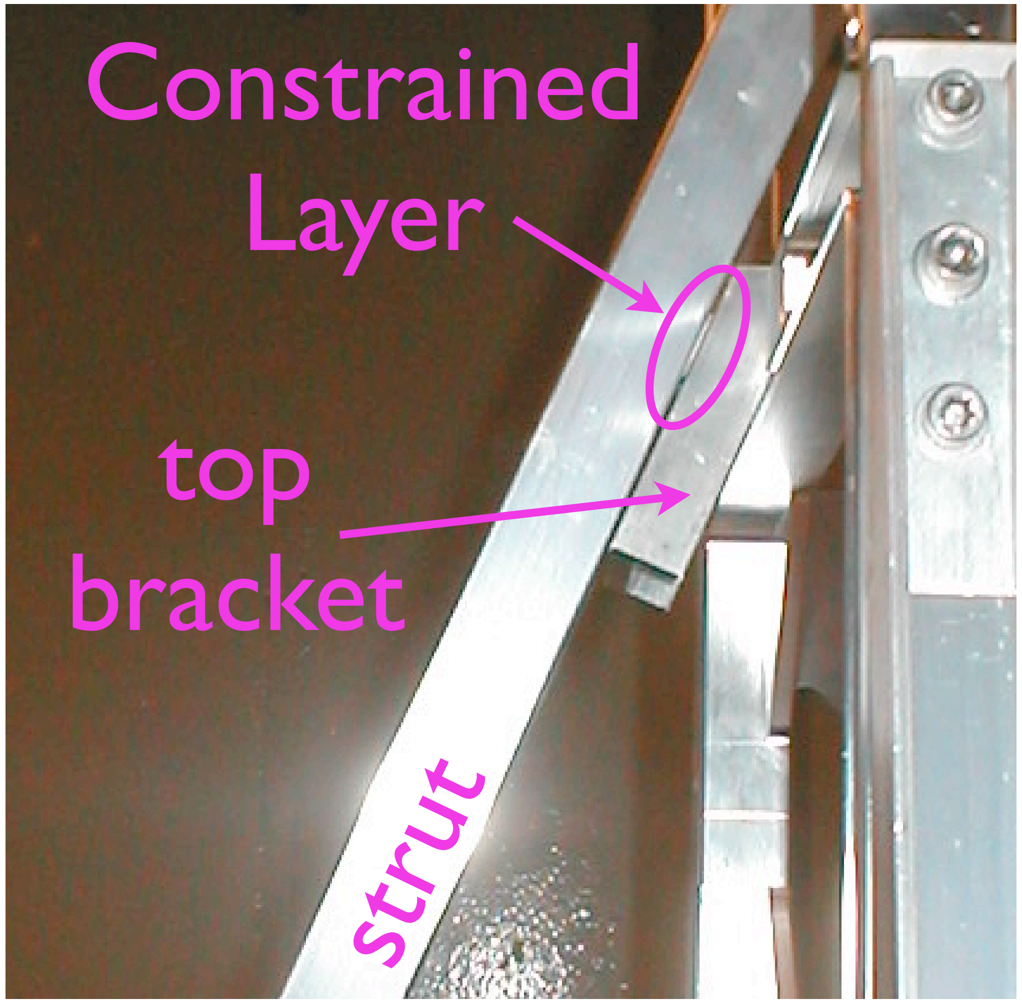
Lossy material placed between frame and something which moves differently.

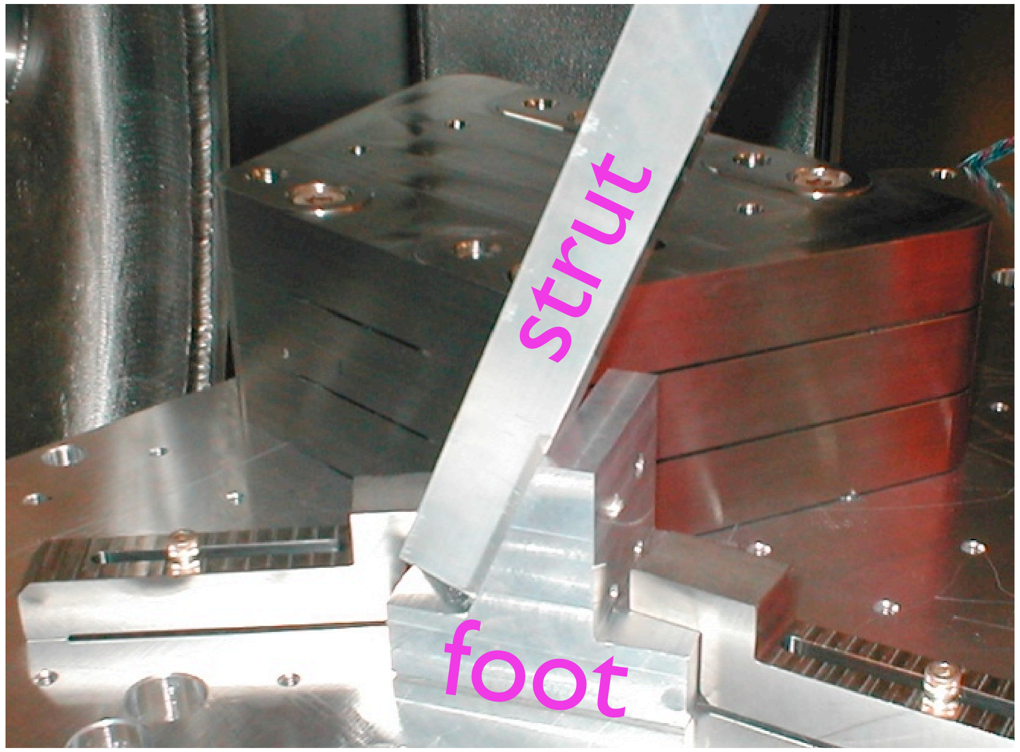


FEA modeling courtesy of Tim Haylor at Rutherford Labs

Test setup

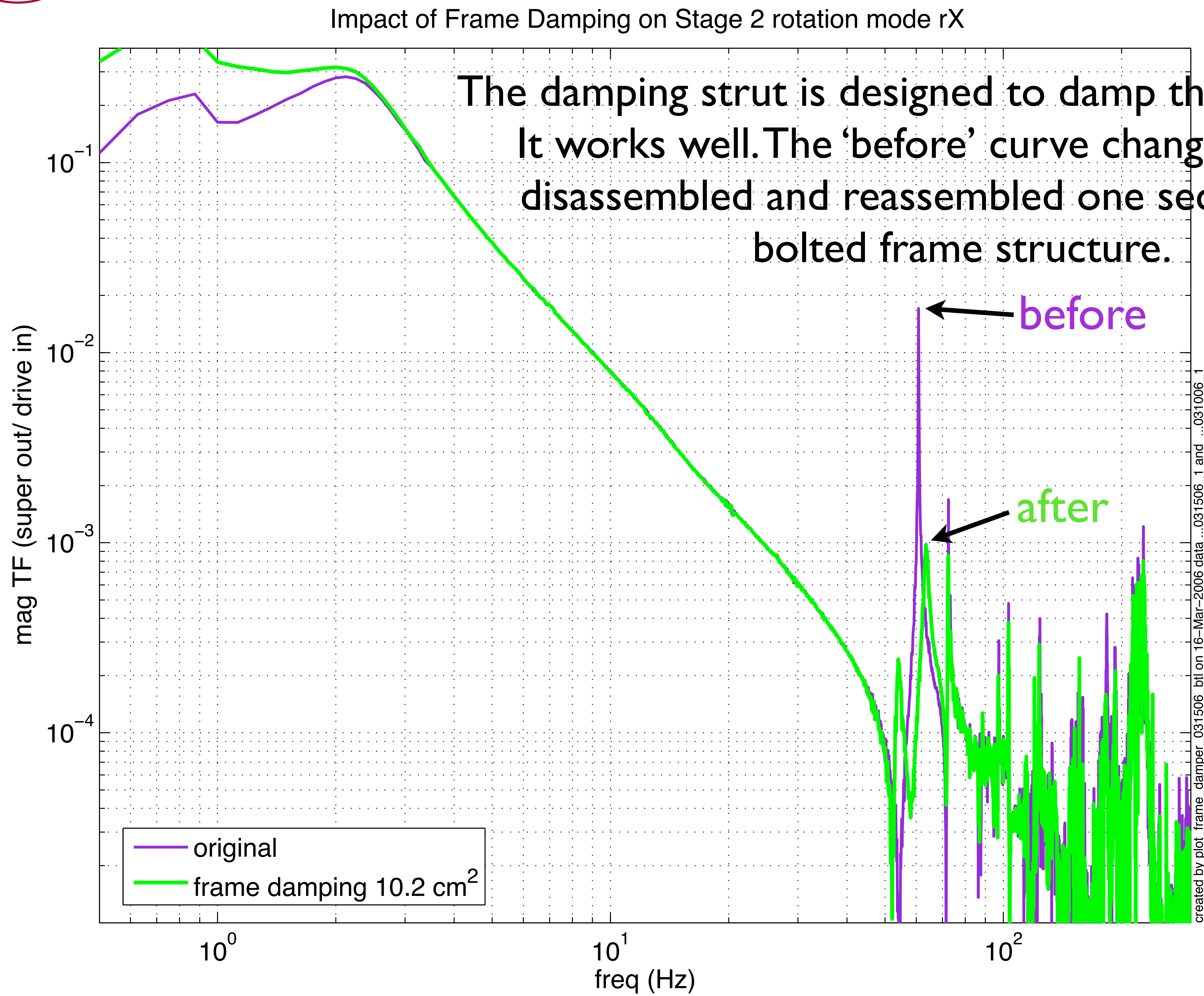




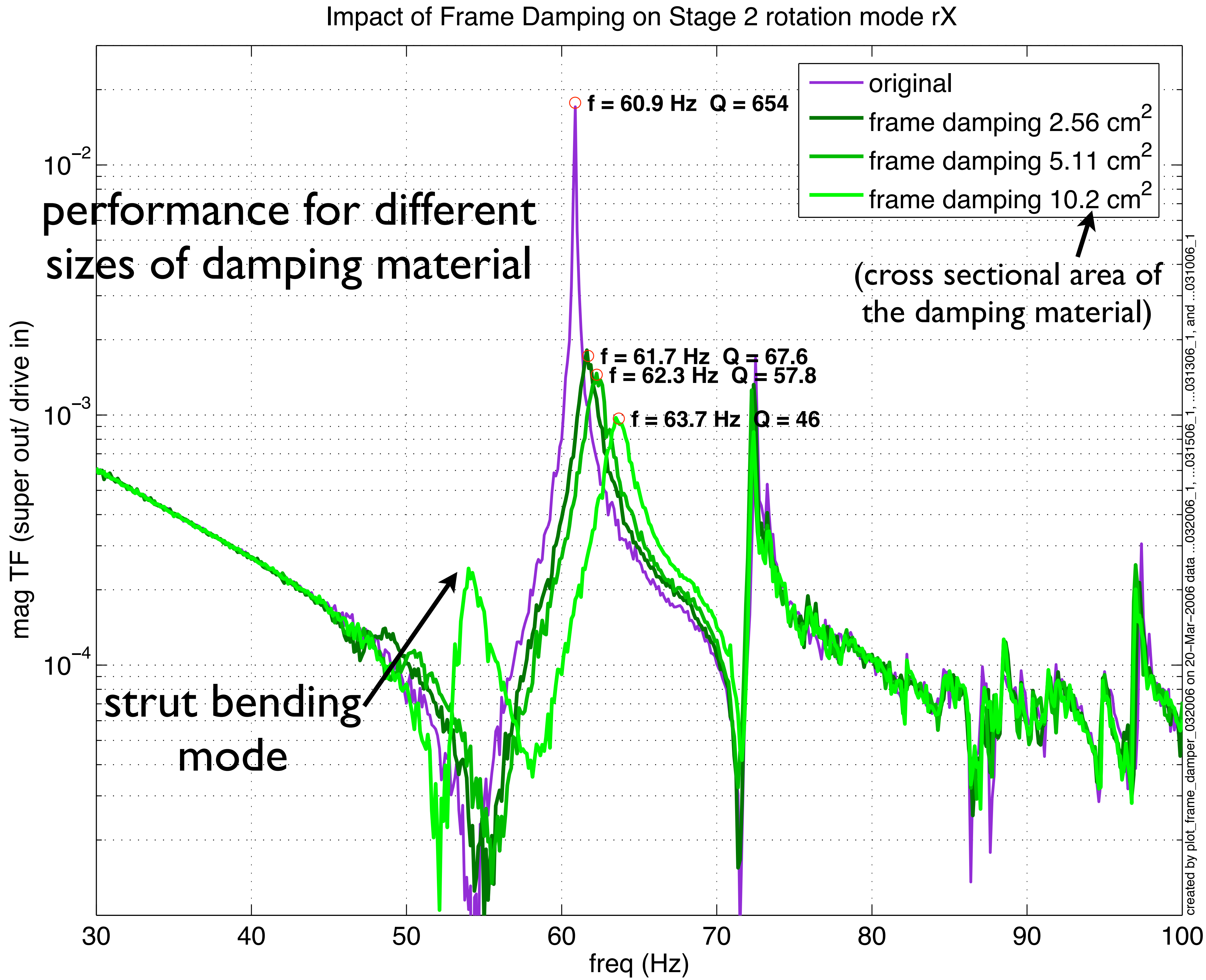


Damping strut performance

The damping strut is designed to damp the 61 Hz mode. It works well. The 'before' curve changed after we disassembled and reassembled one section of the bolted frame structure.



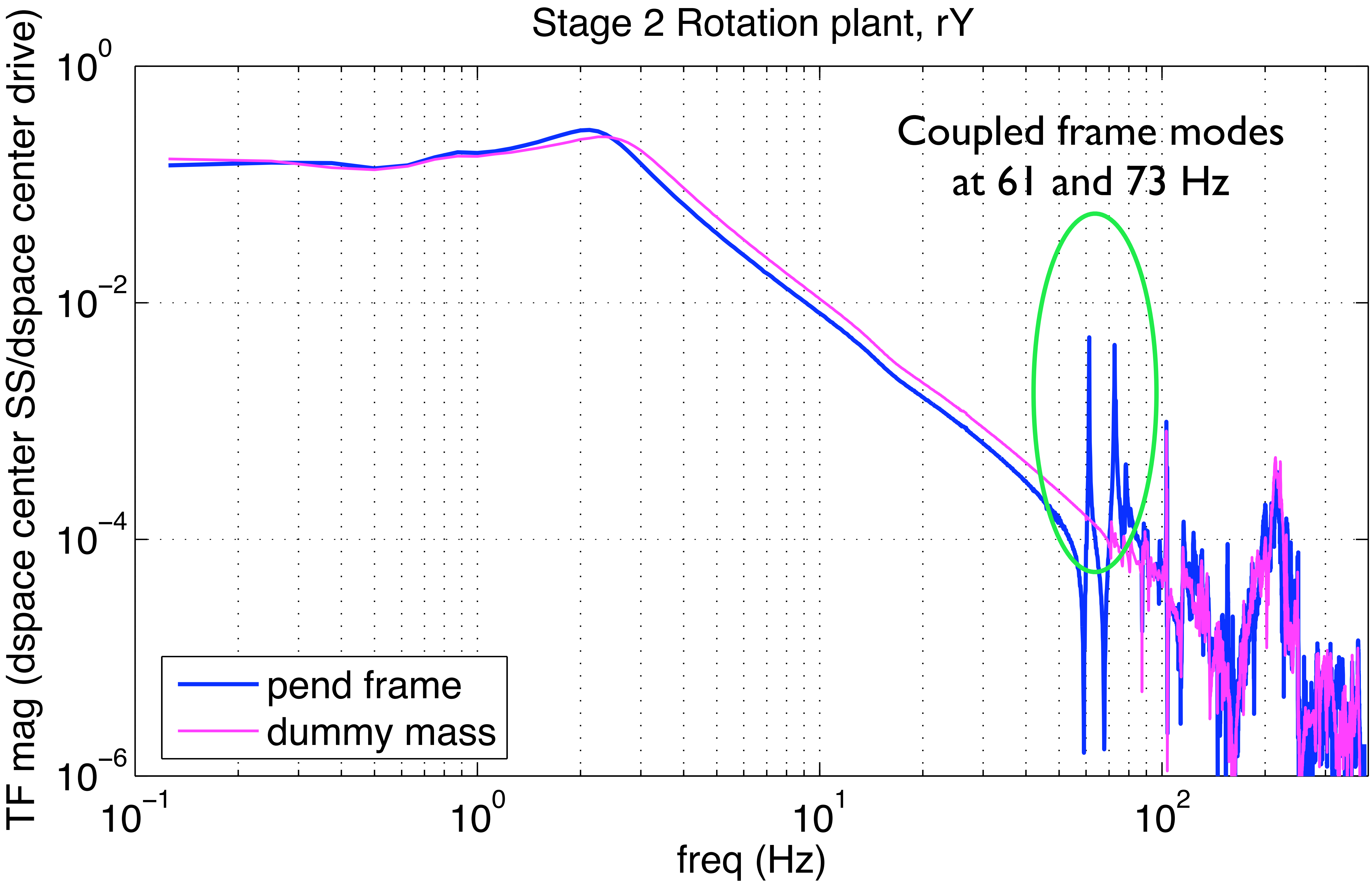
Optimizing the layer



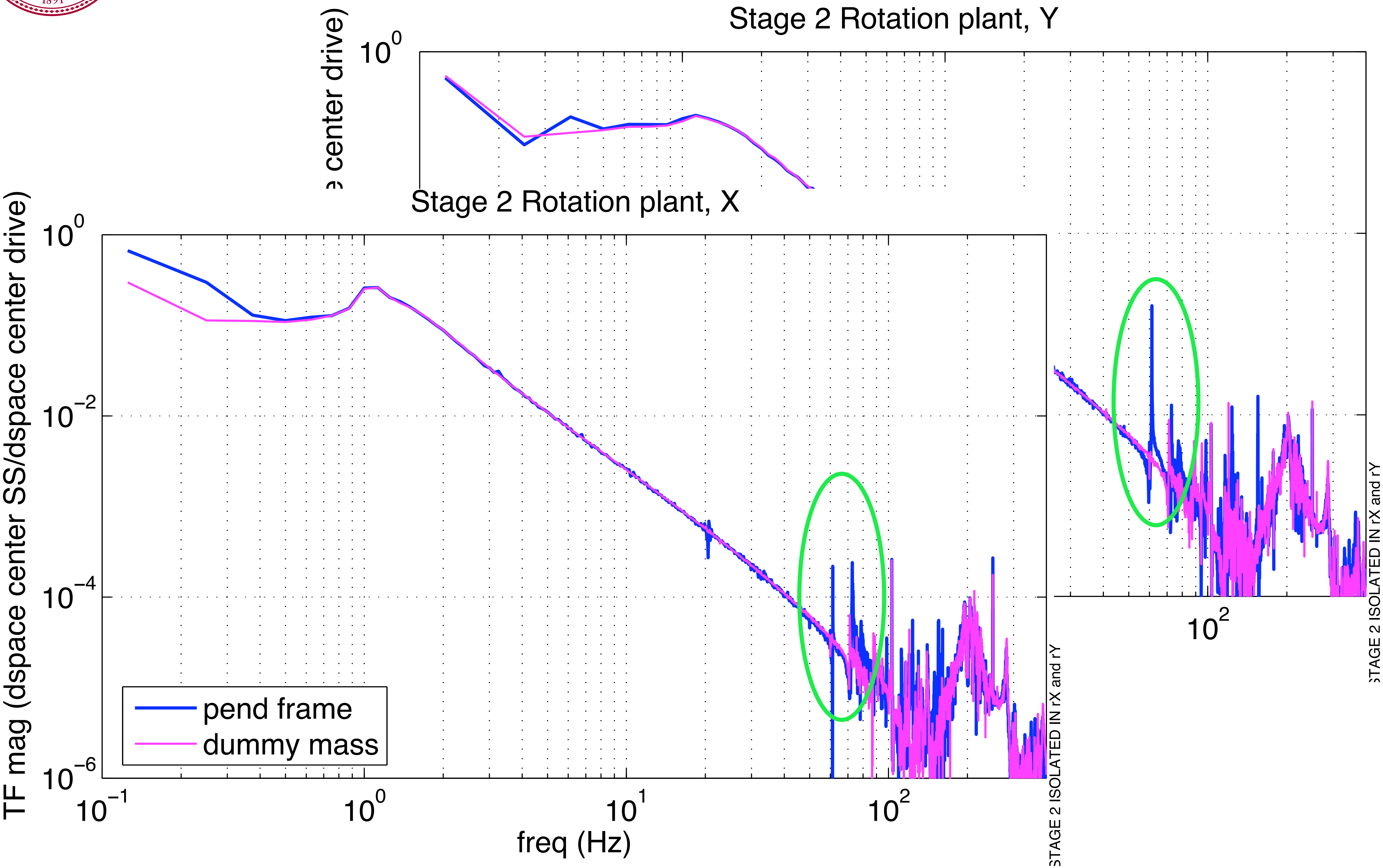
Conclusions

- System works with the quad pendulum frame.
- It will work better if the peaks are smaller amplitude and higher frequency.
- Demonstrated 2 ways to improve the damping.
- We prefer the constrained layer: much easier for Advance LIGO operations.
  Eager to help the SUS team get it working in vacuum.
- Making good progress dealing with the issues identified at the last set of reviews.

Largest Coupling to rX & rY

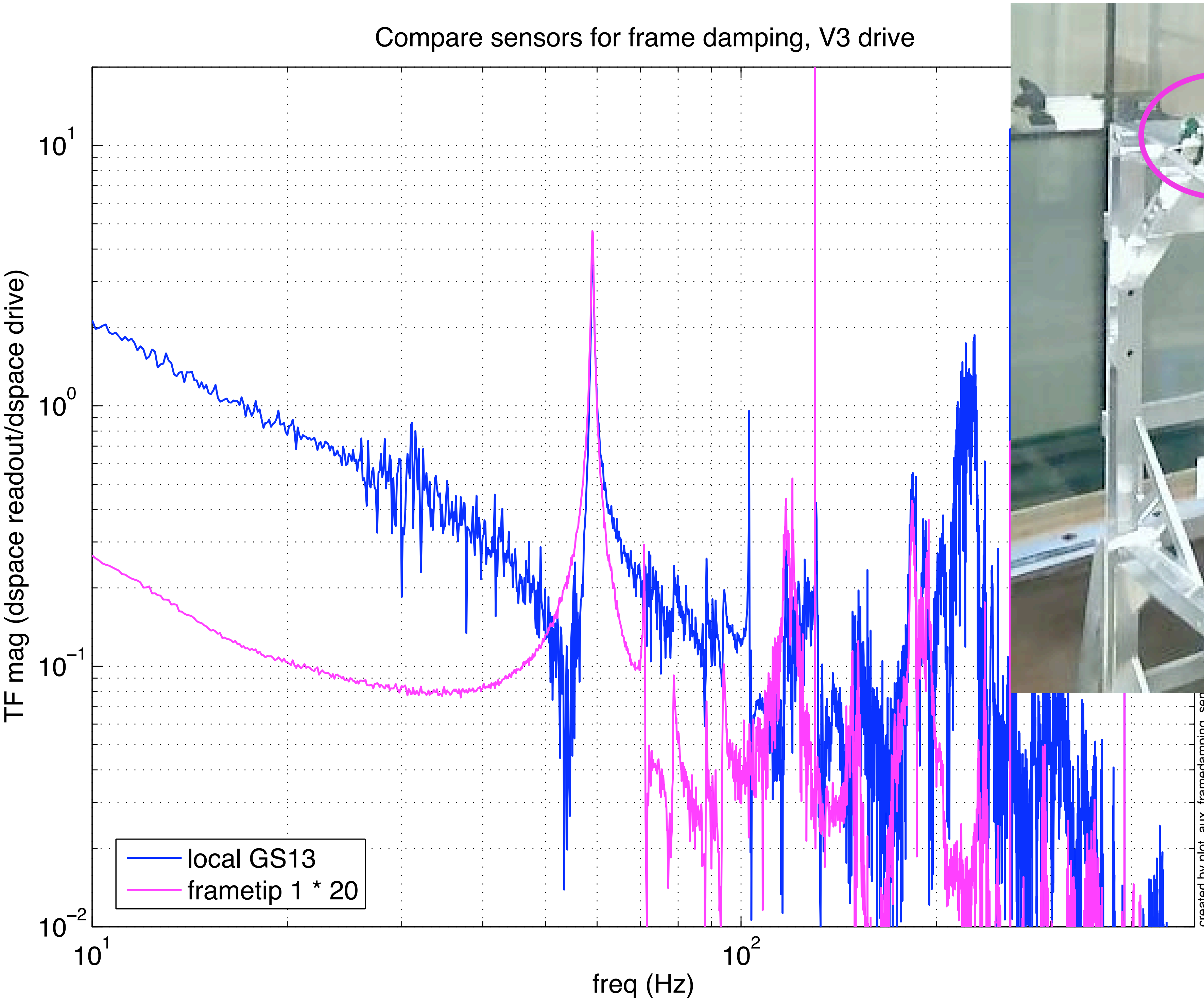


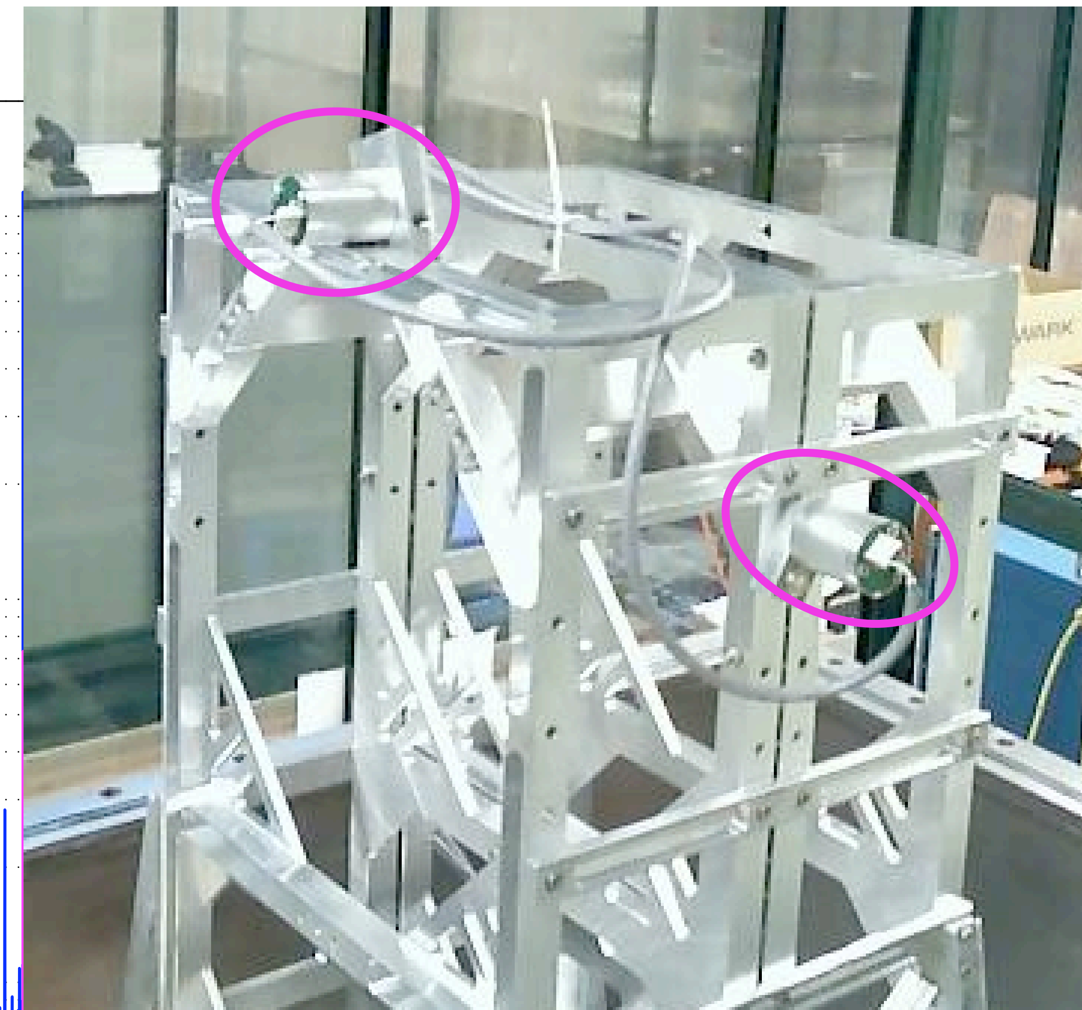
Smaller coupling in other DOF



Improved Active Damping

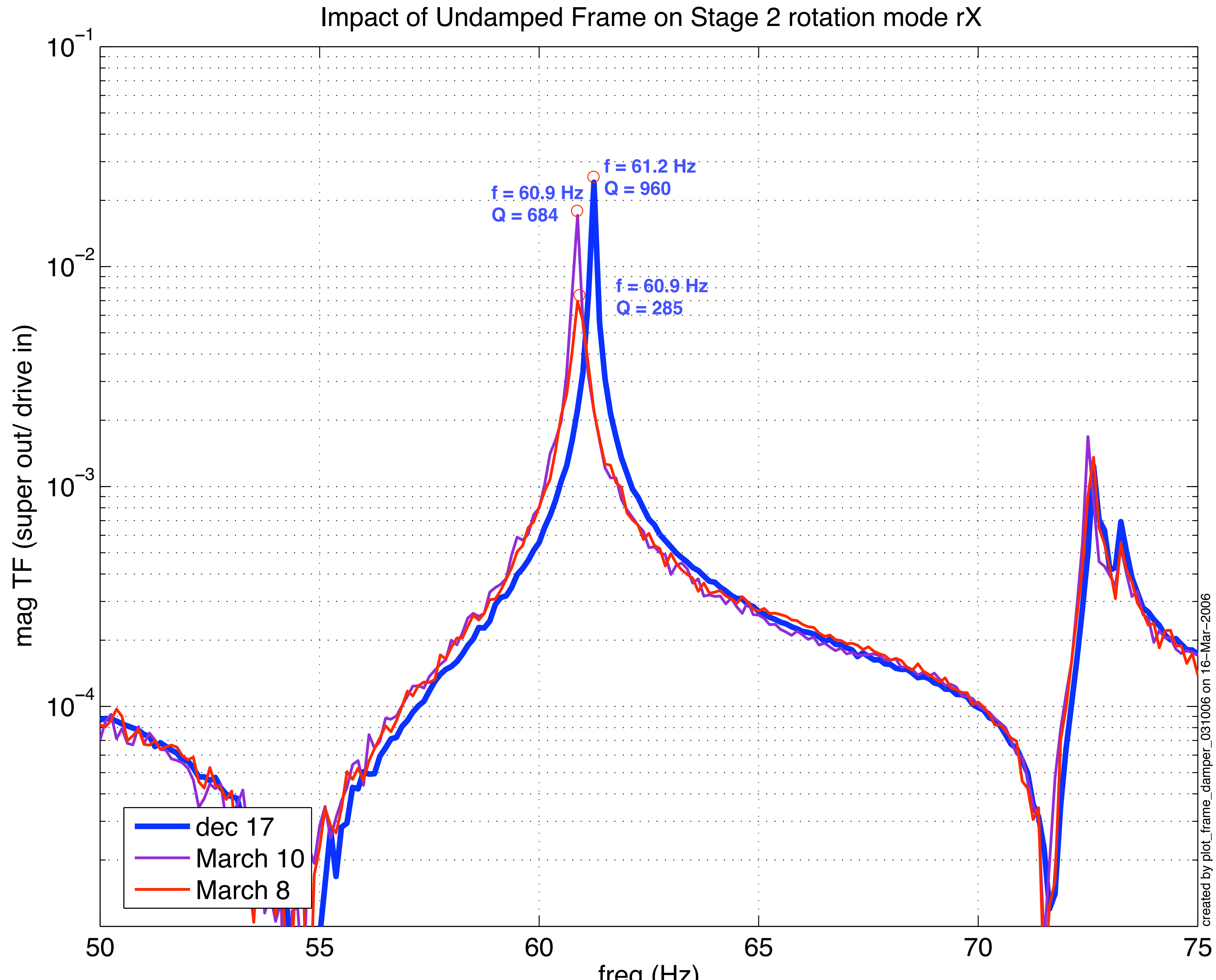
Sensors on the frame tip give better signal for active frame damping



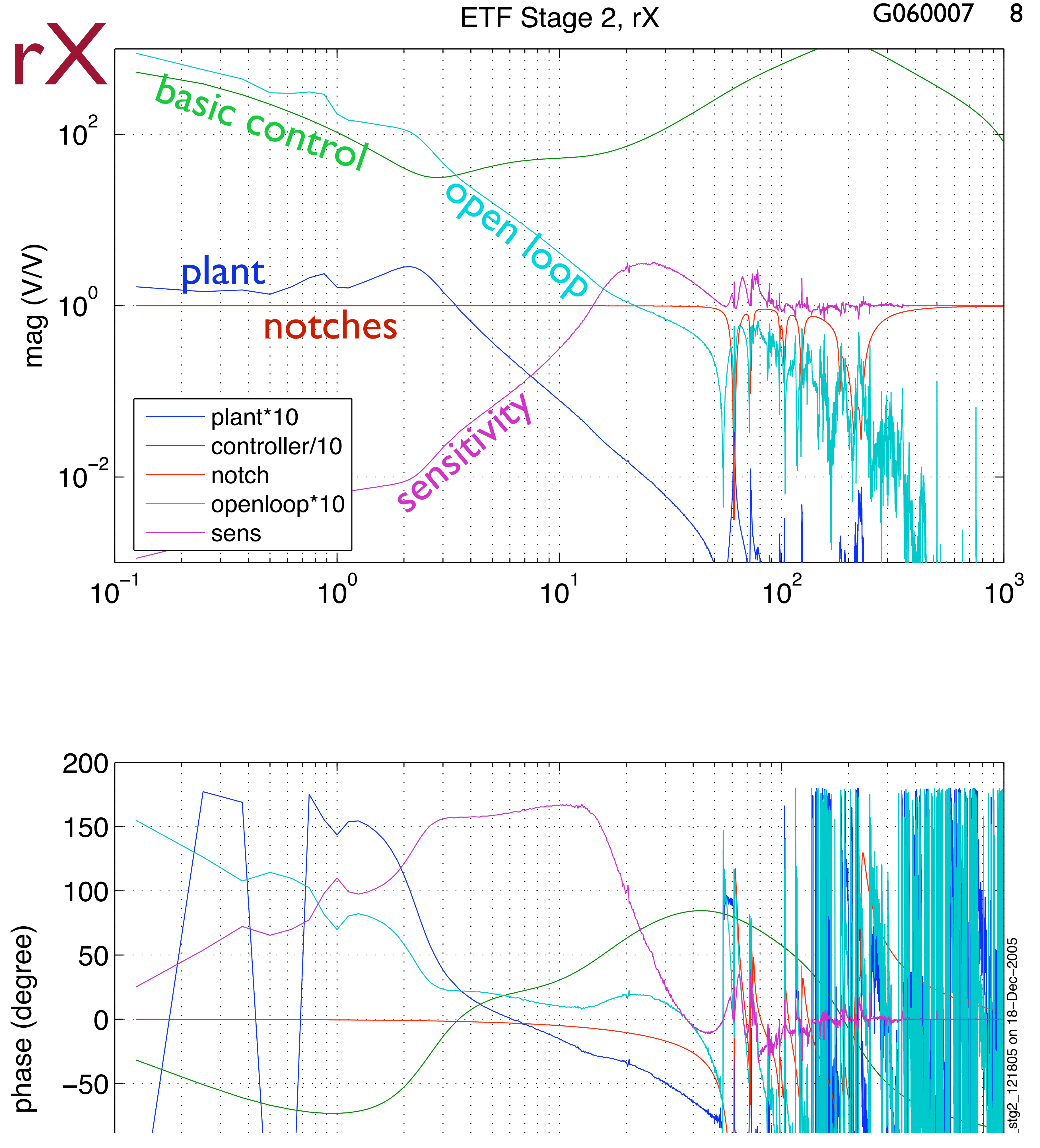


250 grams + preamp +cable + mount + can

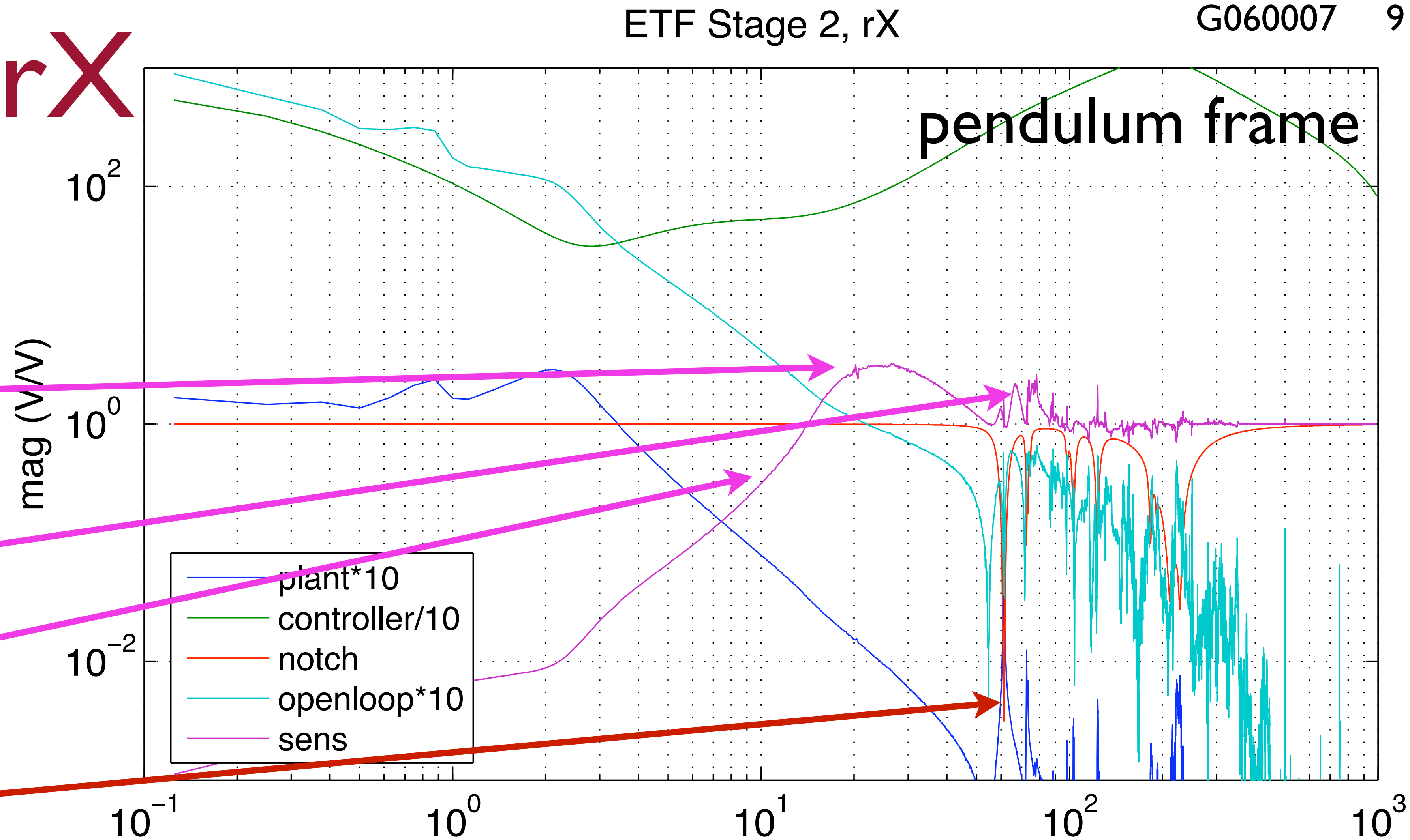
Changing the undamped Frame



Servo for rX

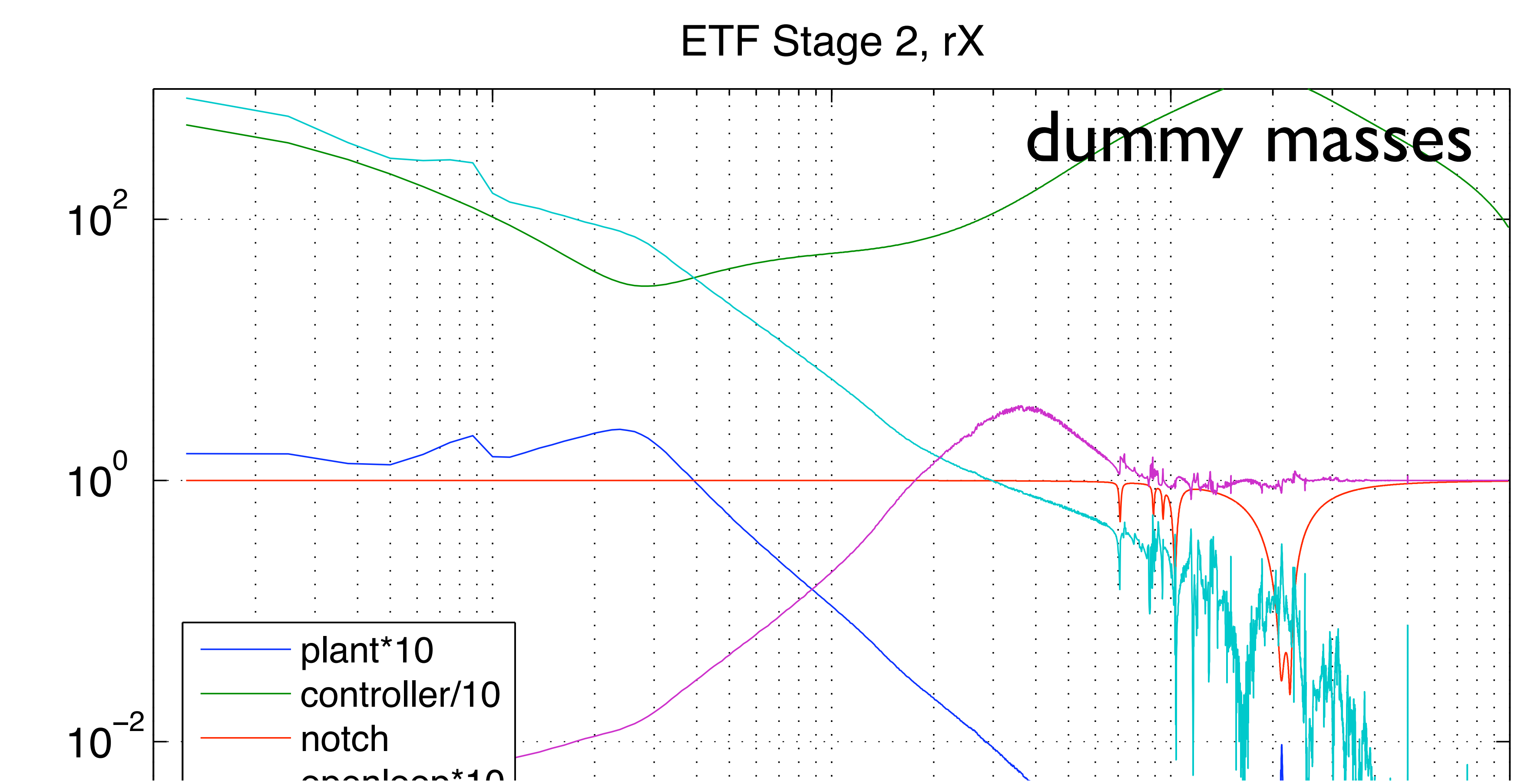

ETF Stage 2, rX
basic control
open loop
plant
notches
sensitivity
mag (V/V)
plant*10
controller/10
notch
openloop*10
sens
phase (degree)
stg2_121805 on 18−Dec−2005

Servo for rX



To notice:

1. Servo amplifies above 13 Hz.
2. 'Hair' about 70 Hz
3. 10 Hz attenuation is modest:
4. Big notches
5. It works.



Dummy mass loop is:

1. Better performance.
2. More robust.
3. Easier to design.