
Low-Frequency Isolation and Alignment for Advanced LIGO

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LIGO-G010165-00-D



Motivation for an External Stage

- Isolation
 - The micro-seismic peak
- Alignment
 - Seasonal Temperature Changes
- Control Reallocation
 - Reduce control effort / noise from inner stages

Performance Requirements

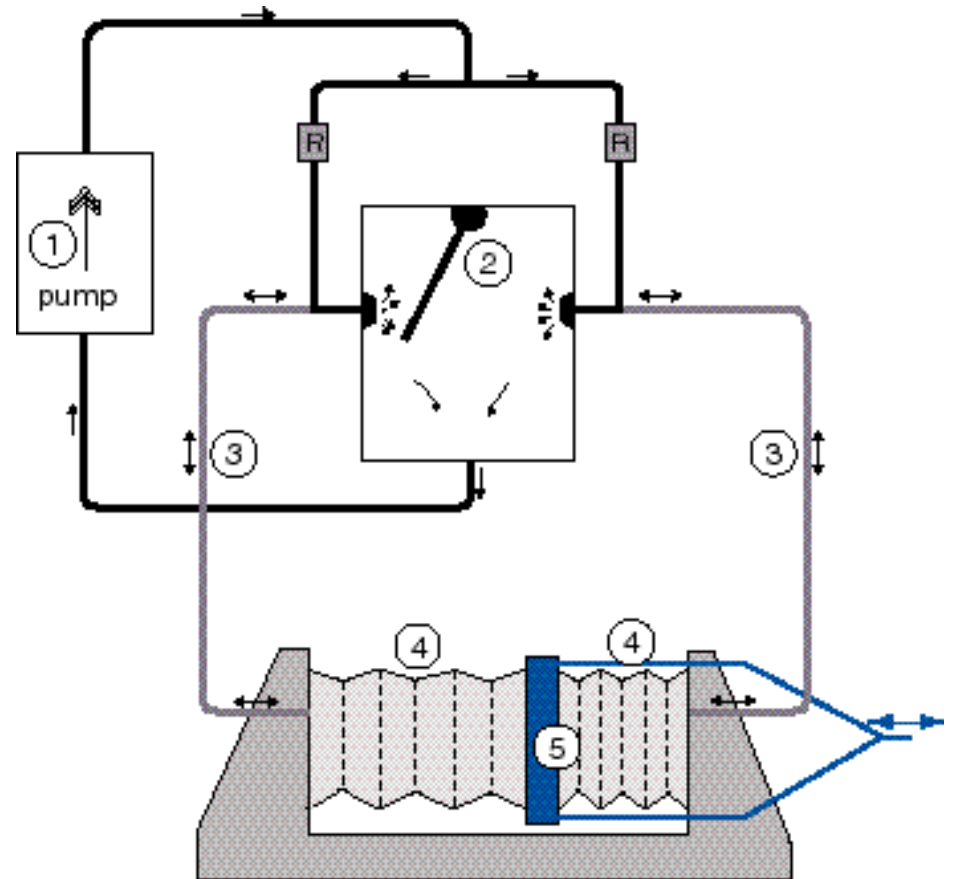
- Range of Motion
 - Mechanical Adjustment: 5 mm.
 - Active Control: +/- 1 mm.
- Response
 - Initial Response: 1 mm. in 10 sec.
 - Bandwidth: .1 - 10 Hz.
- Resolution and Noise
 - 10 nm. rms (10^{-2} to 3 Hz)

Candidate Actuators

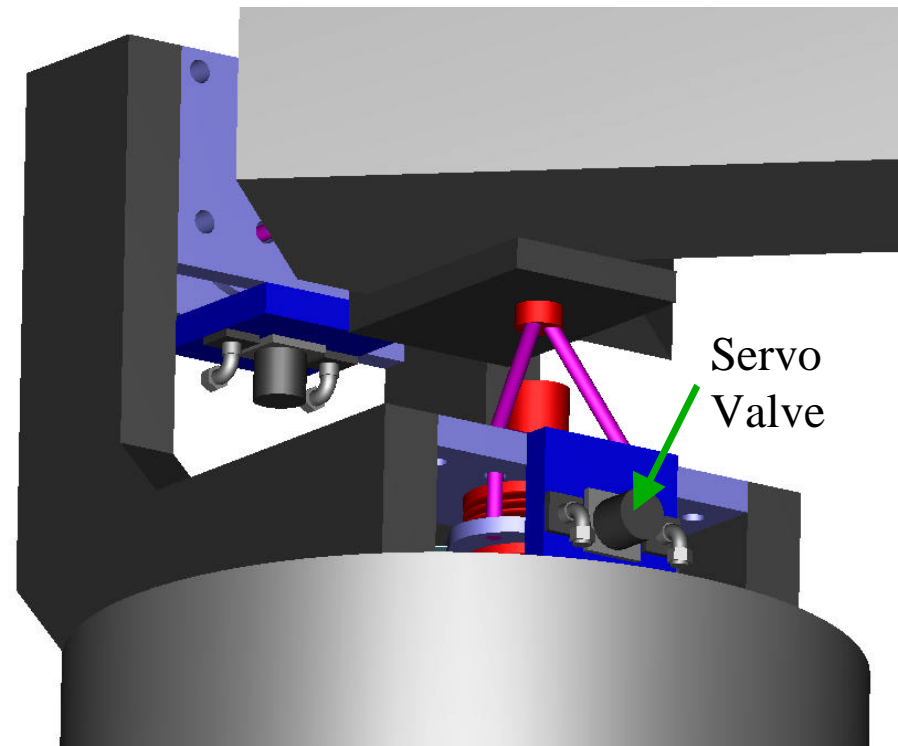
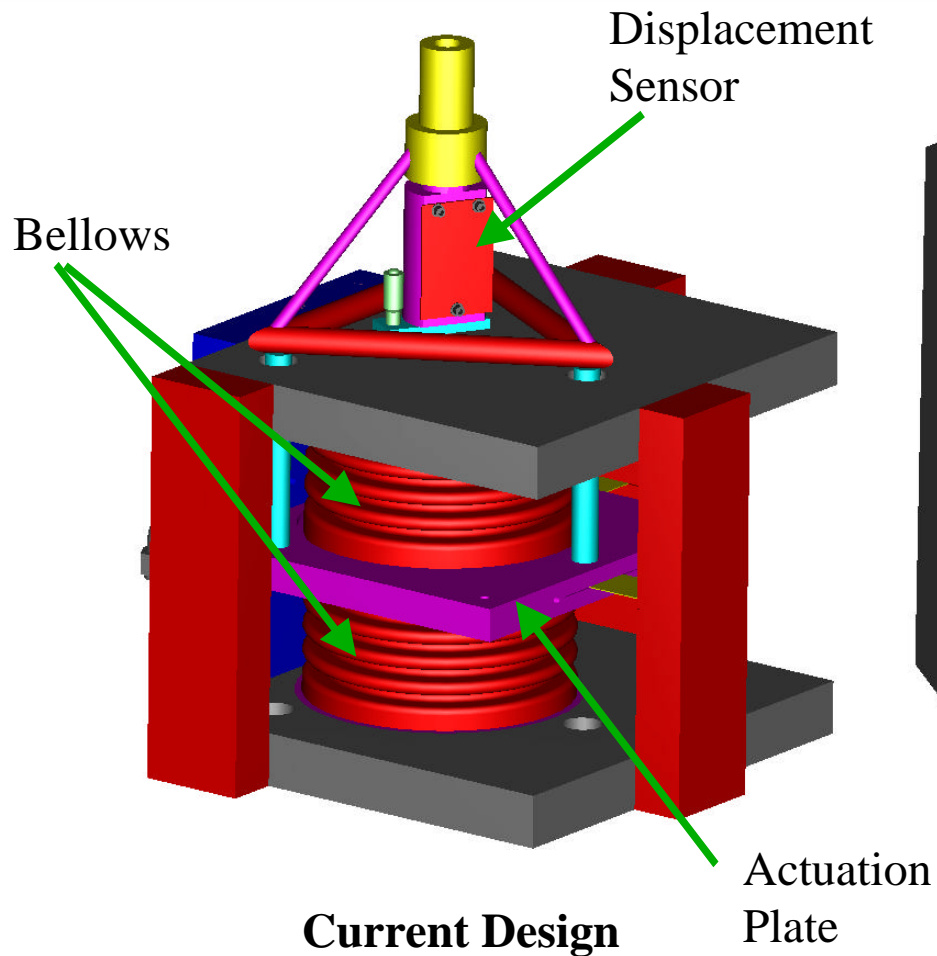
	Force	Velocity	Stiffness	Displacement	Stiction	Hysteresis	Mechanical Noise
• Hydraulic	High	Low	Med	Med	Low	Low	Low
• Ball Screw	High	Low	High	High	High	Low	High
• Linear Motor	High	High	Low	High	Low	Low	Low
• Piezo or Magnetostriction	Med	High	High	Low	Low	High	Low

Differential Bellows for Quiet Actuator

- 1) Pump
- 2) Differential Flapper Valve
- 3) Bellows Supply
- 4) Differential Bellows
- 5) Actuation Plate

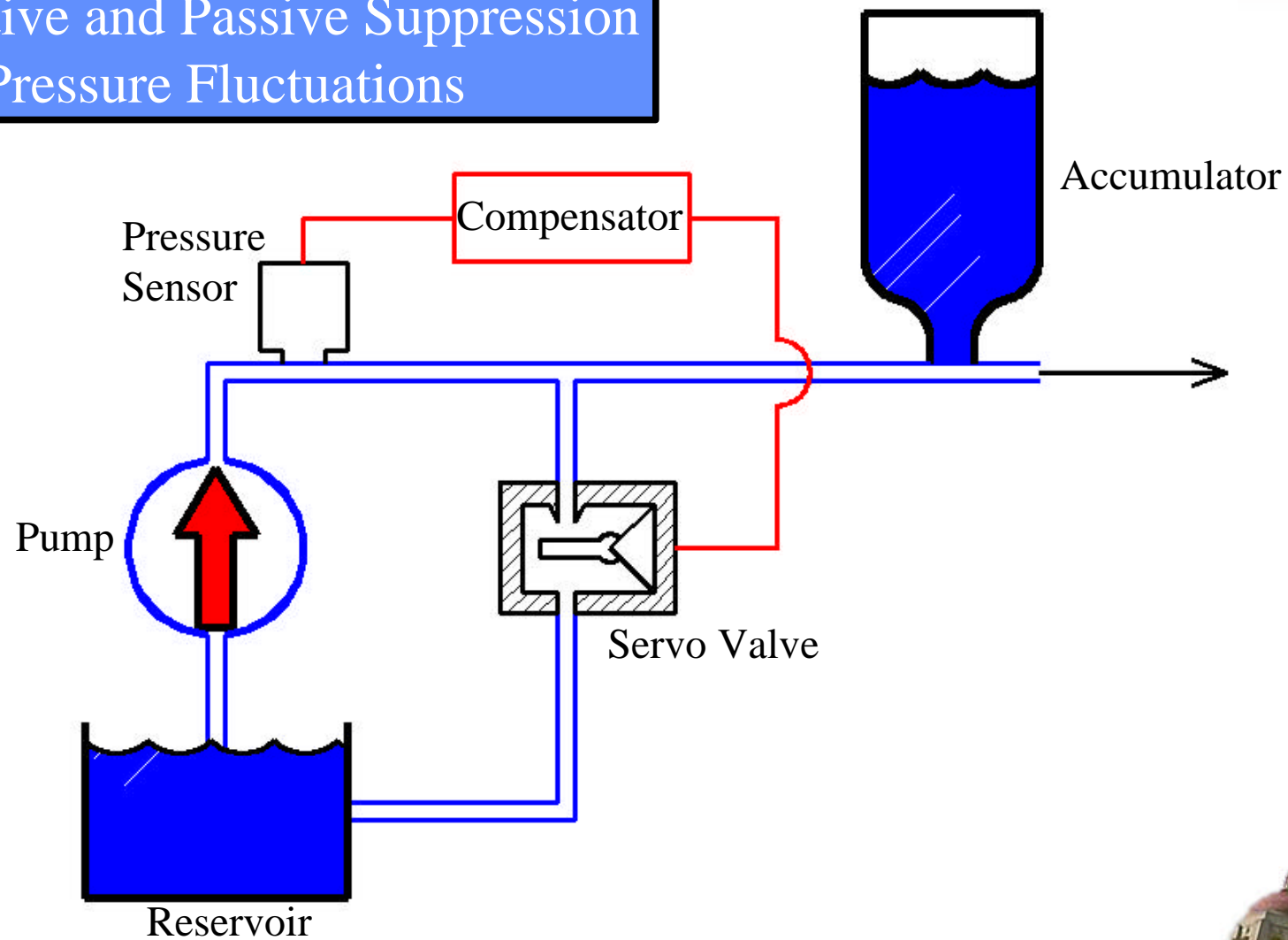


The Quiet Hydraulic Actuator

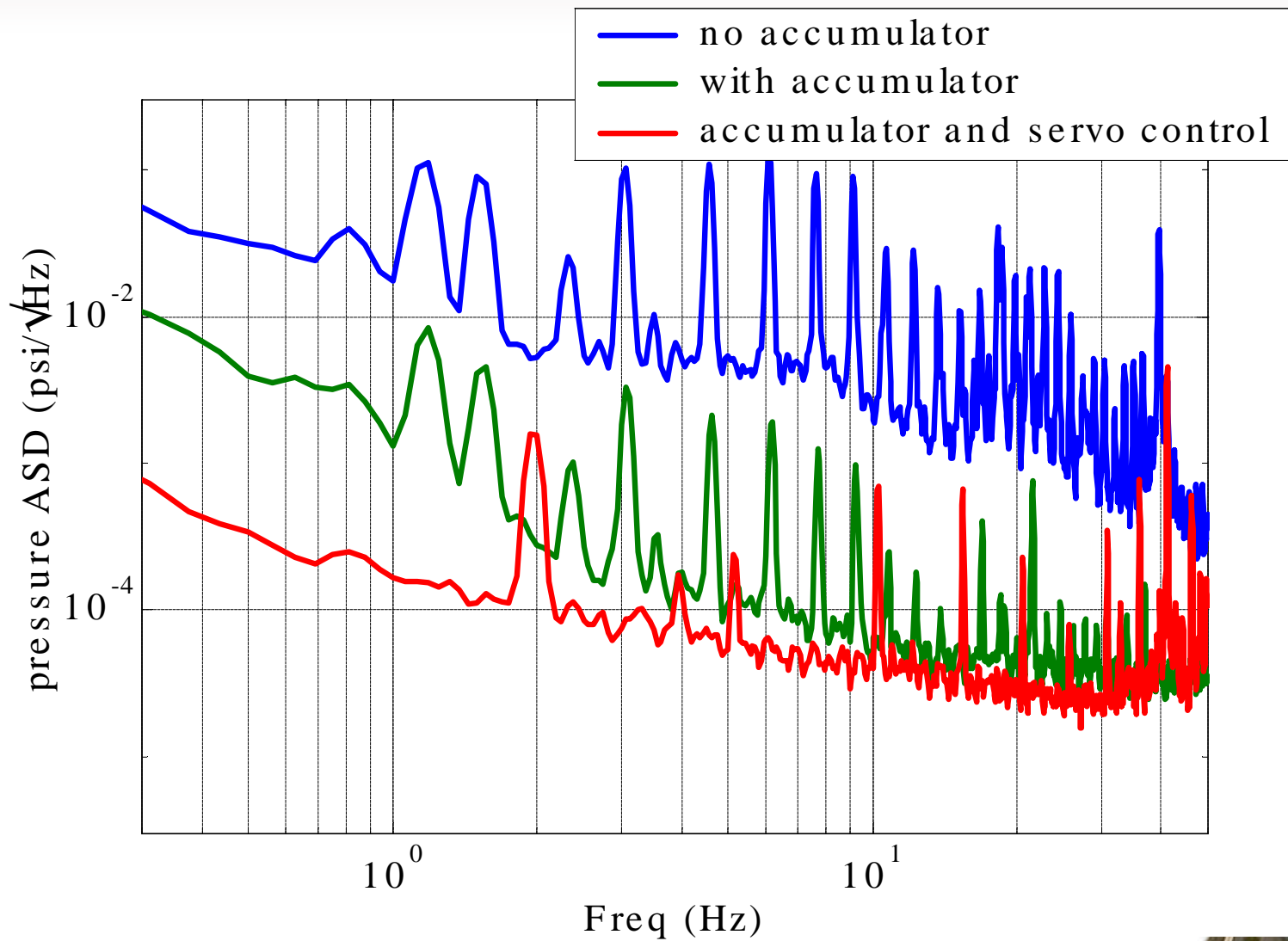


Conditioning a Pressure Source

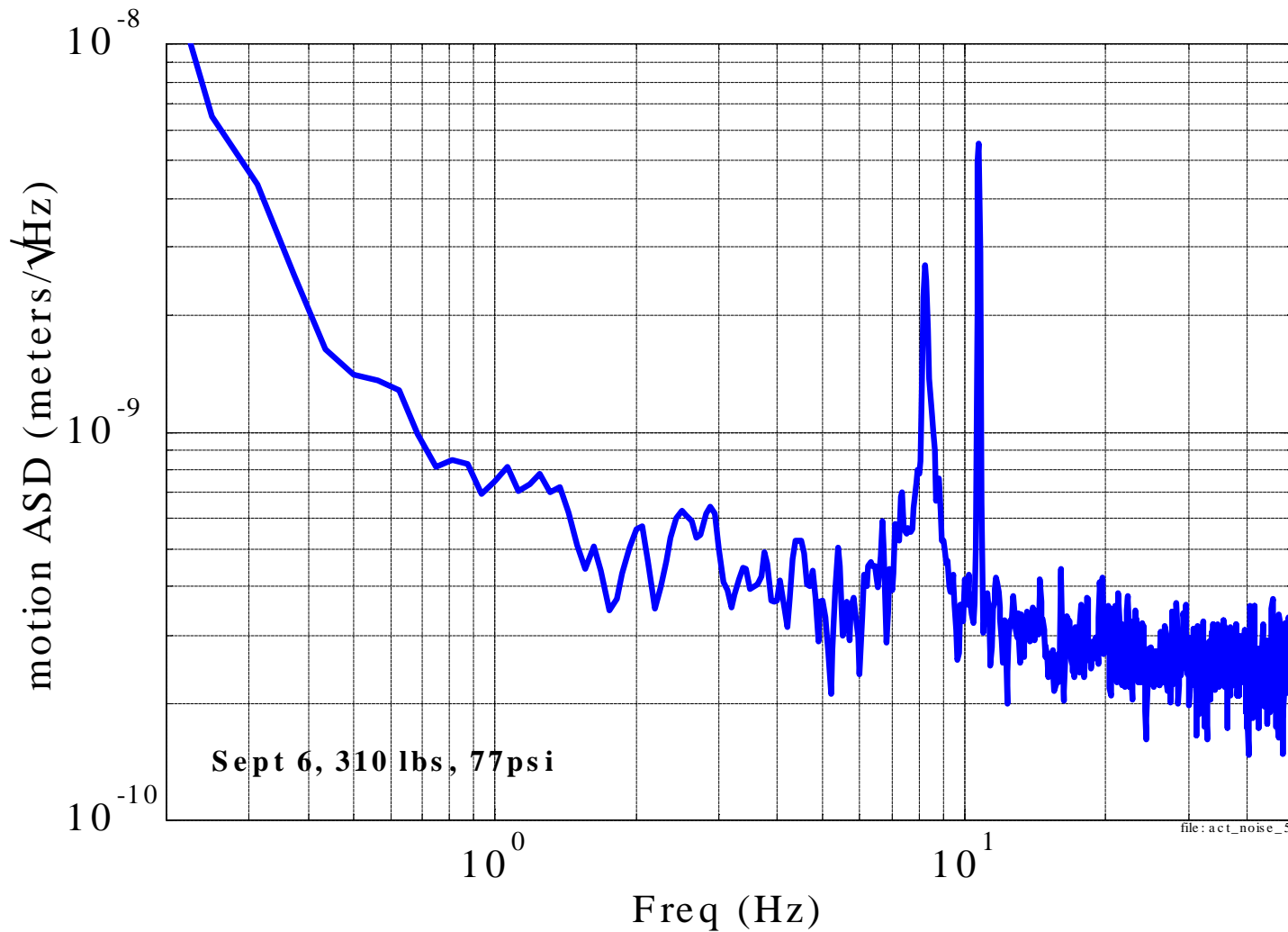
Active and Passive Suppression
of Pressure Fluctuations



Pressure Noise at the Actuator

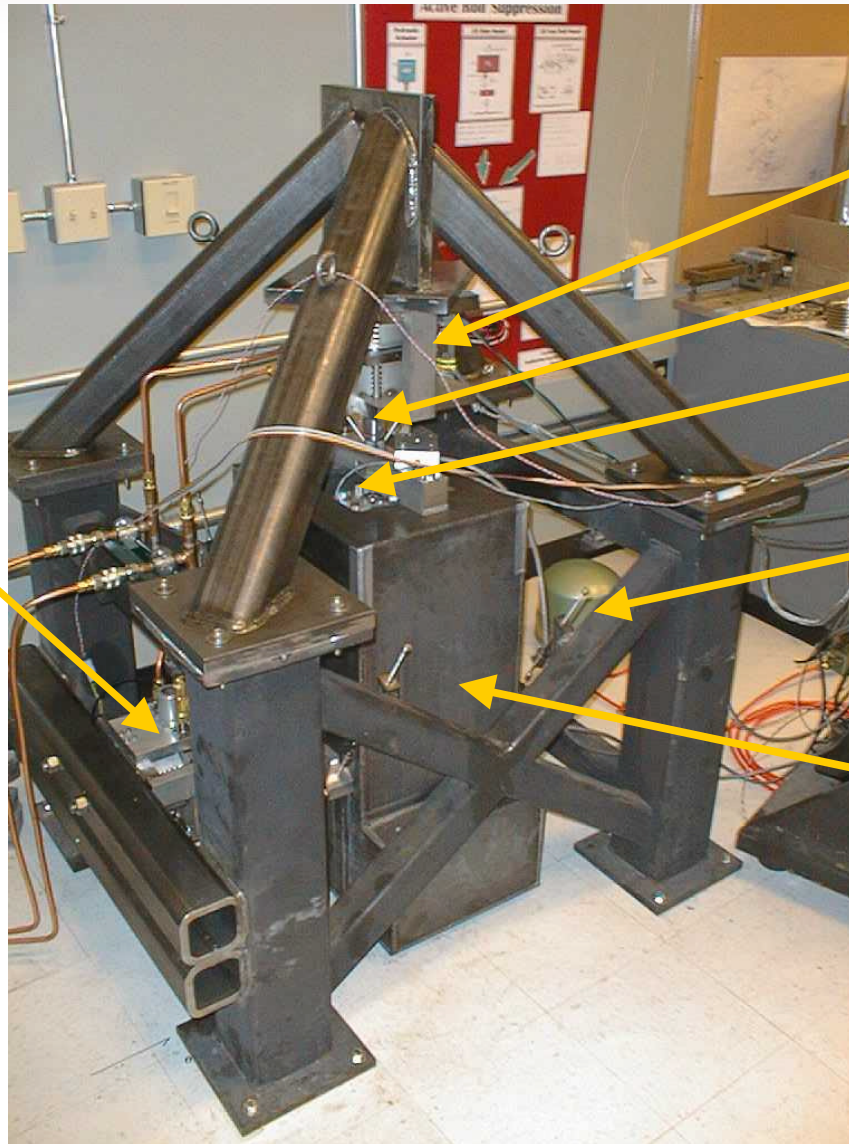


Motion of the Actuator



The Test Platform at Stanford

Horizontal
Actuator



Vertical Actuator

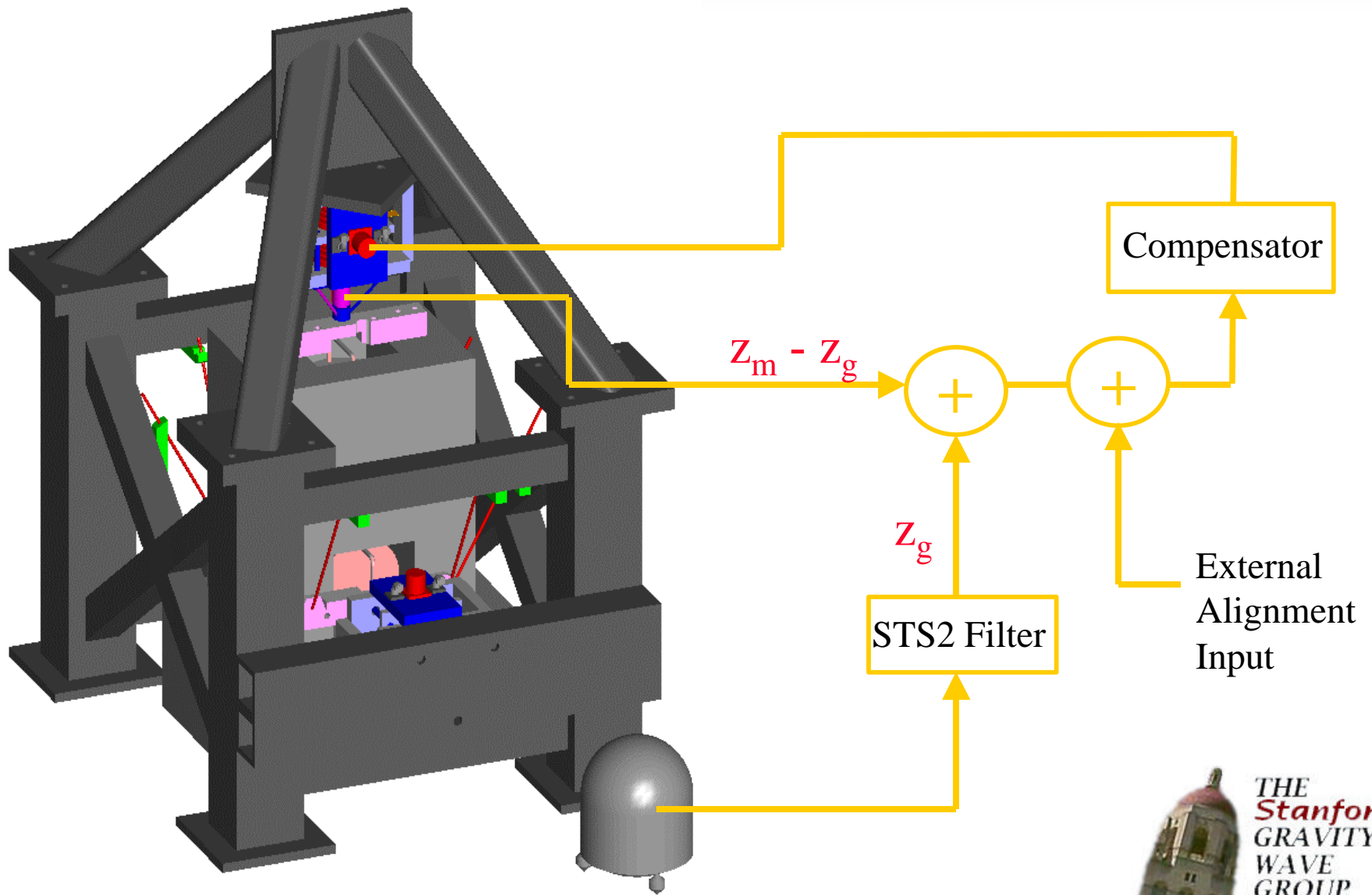
Displacement Sensor

S-13 Seismometer

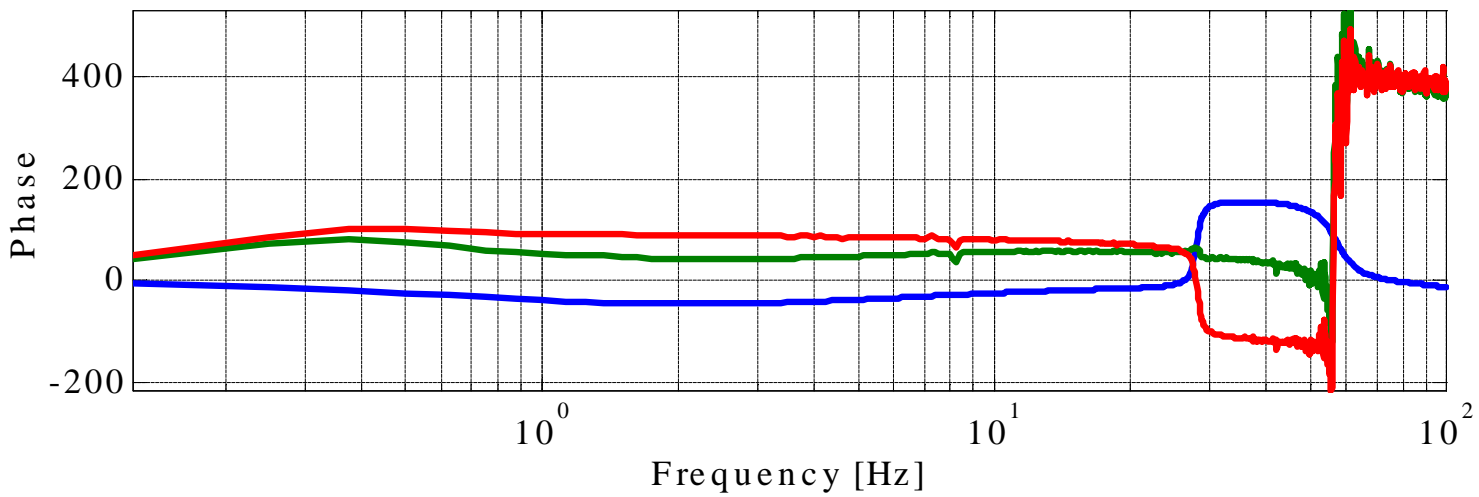
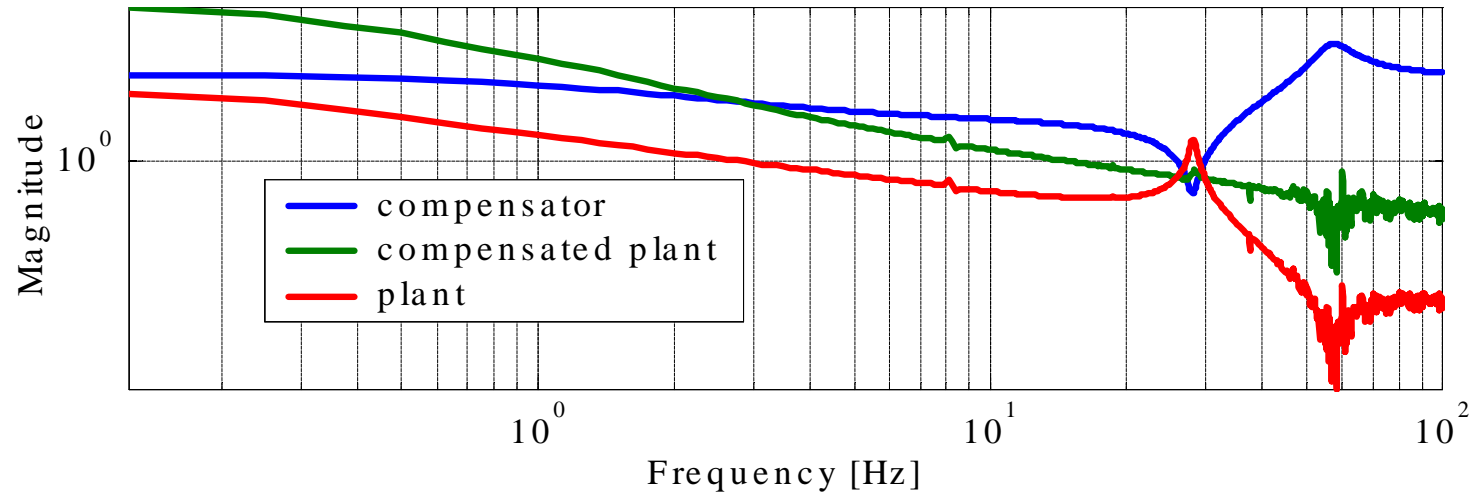
STS2 Seismometer

800 lb Test Mass

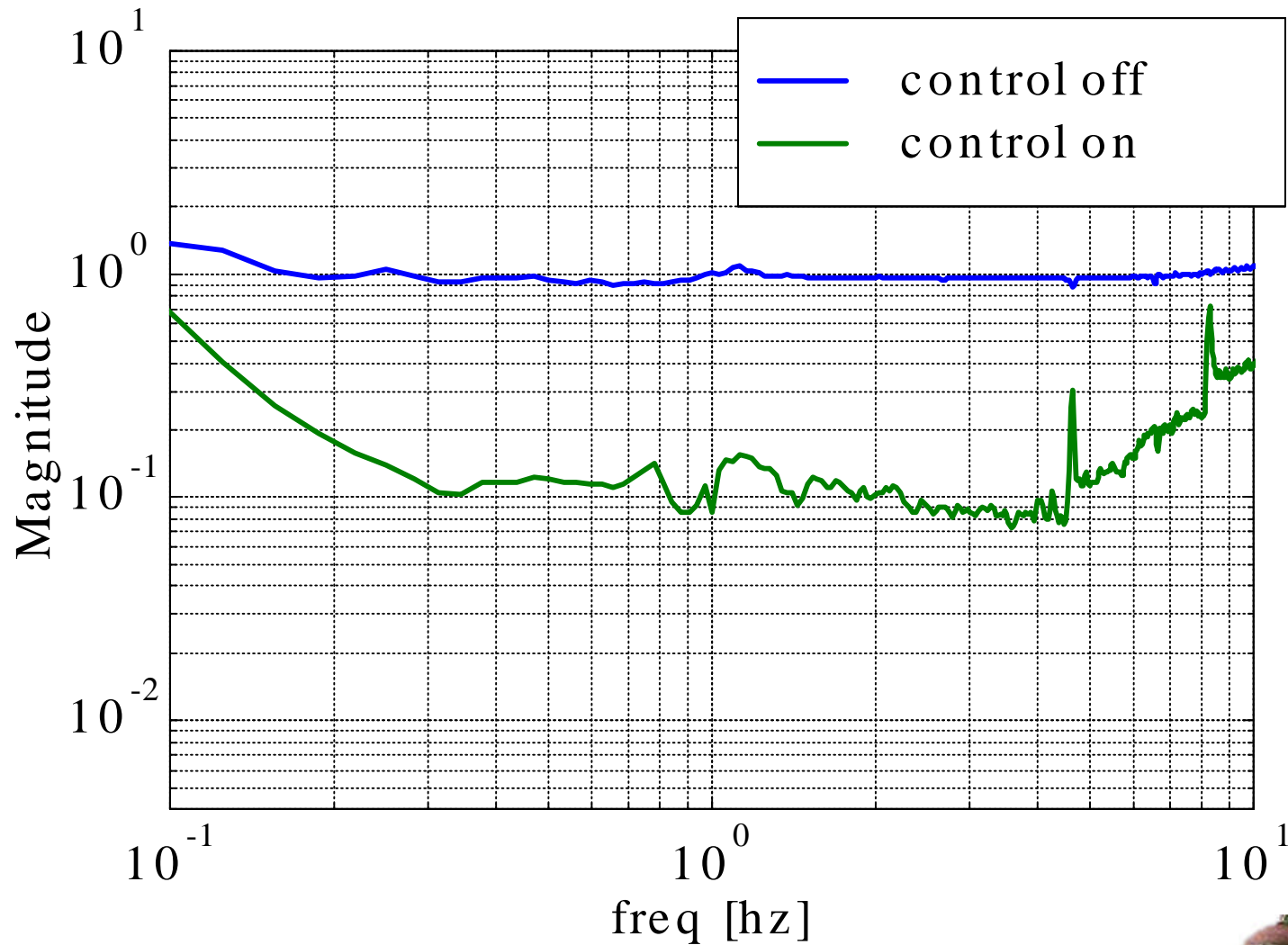
Sensor Correction



Displacement Sensor Compensator



Sensor Correction Performance



Conclusions

- Demonstrated Vertical Performance
 - Actuator meets specification
 - Reduction of the micro-seismic peak
- Improvements to Existing System
 - Horizontal actuator operational
 - Alternative control schemes
- Future Installation at M.I.T.'s LASTI