

Three DOF Active Isolation Of Microseismic Peaks

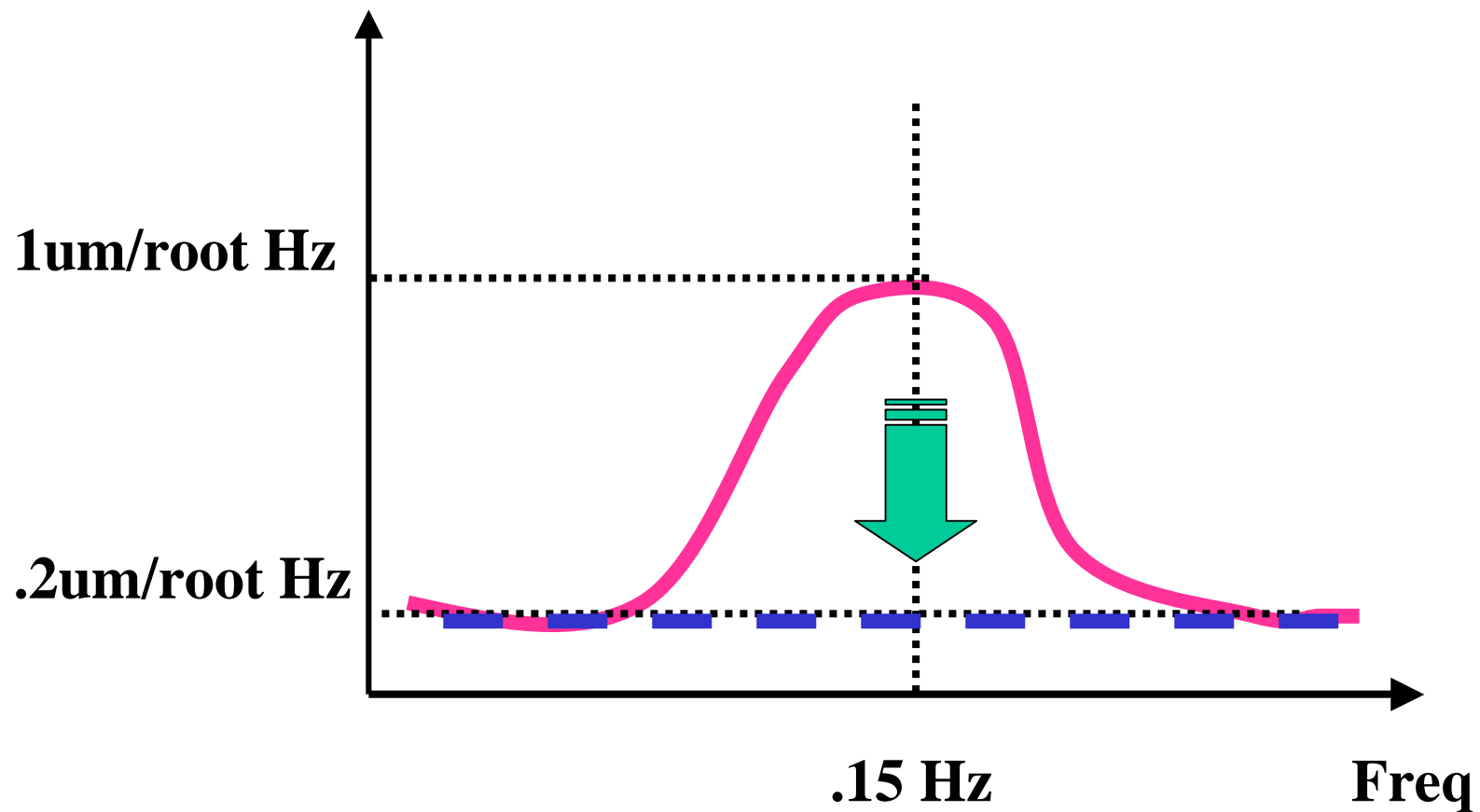
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DeBra, Corwin Hardham, Norna Robertson, Sam
Richman, Richard Mittleman

LIGO-G030208-00-Z

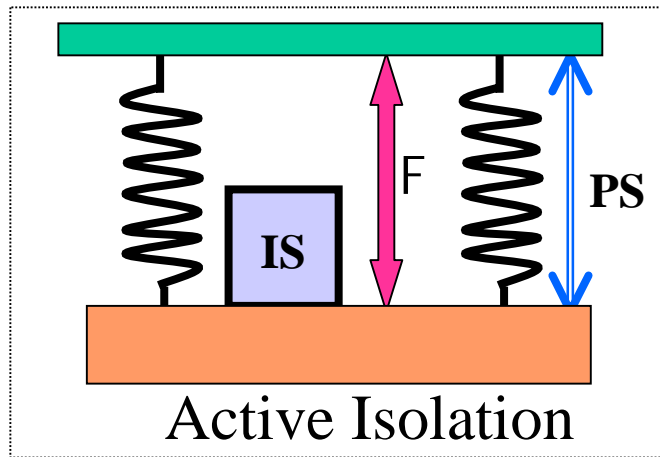
Outline

- Requirement
- Challenging Part: Tilt Horizontal Coupling.
- Solution : Sensor Correction.

Target: Factor of 5 Isolation on Microseismic Peaks



Active Isolation Platform



Inertial Sensors (IS) :

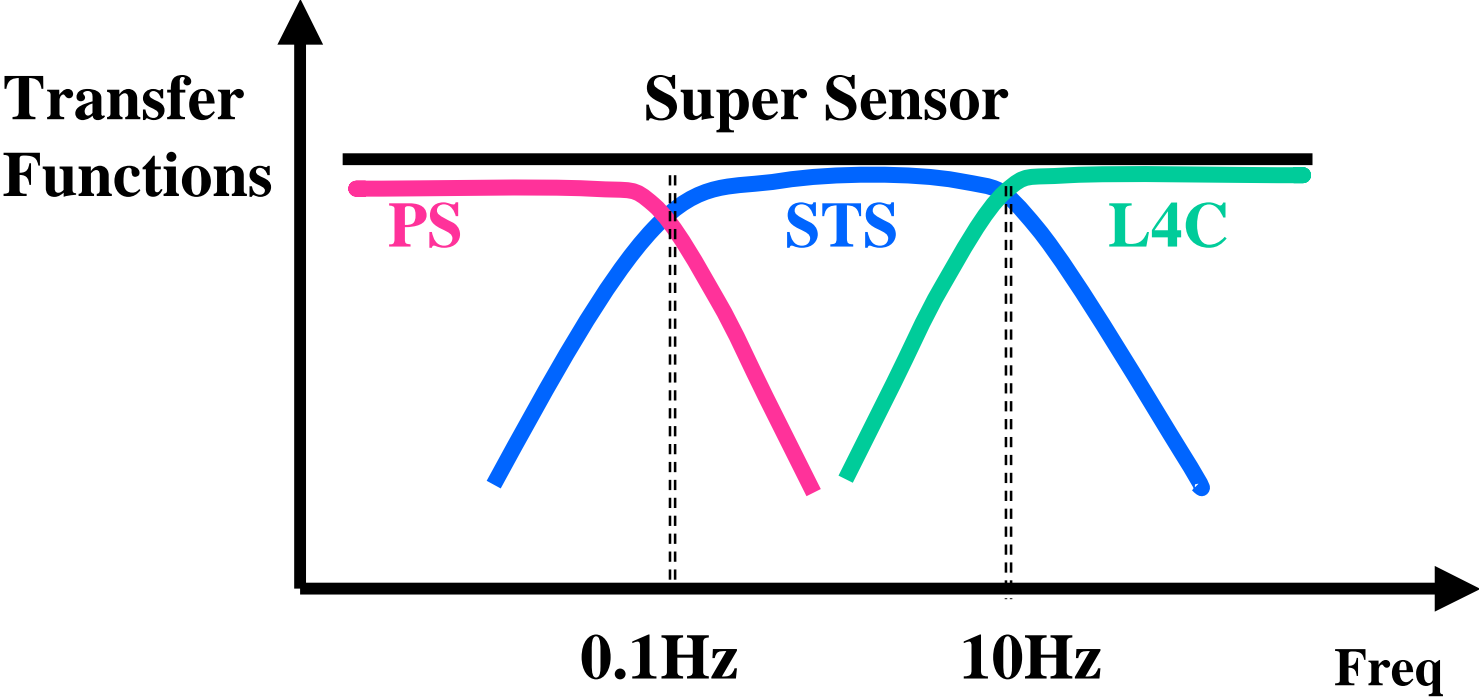
Streckeisen STS-2: 10mHz to 70Hz

L4C: 1Hz to 500Hz

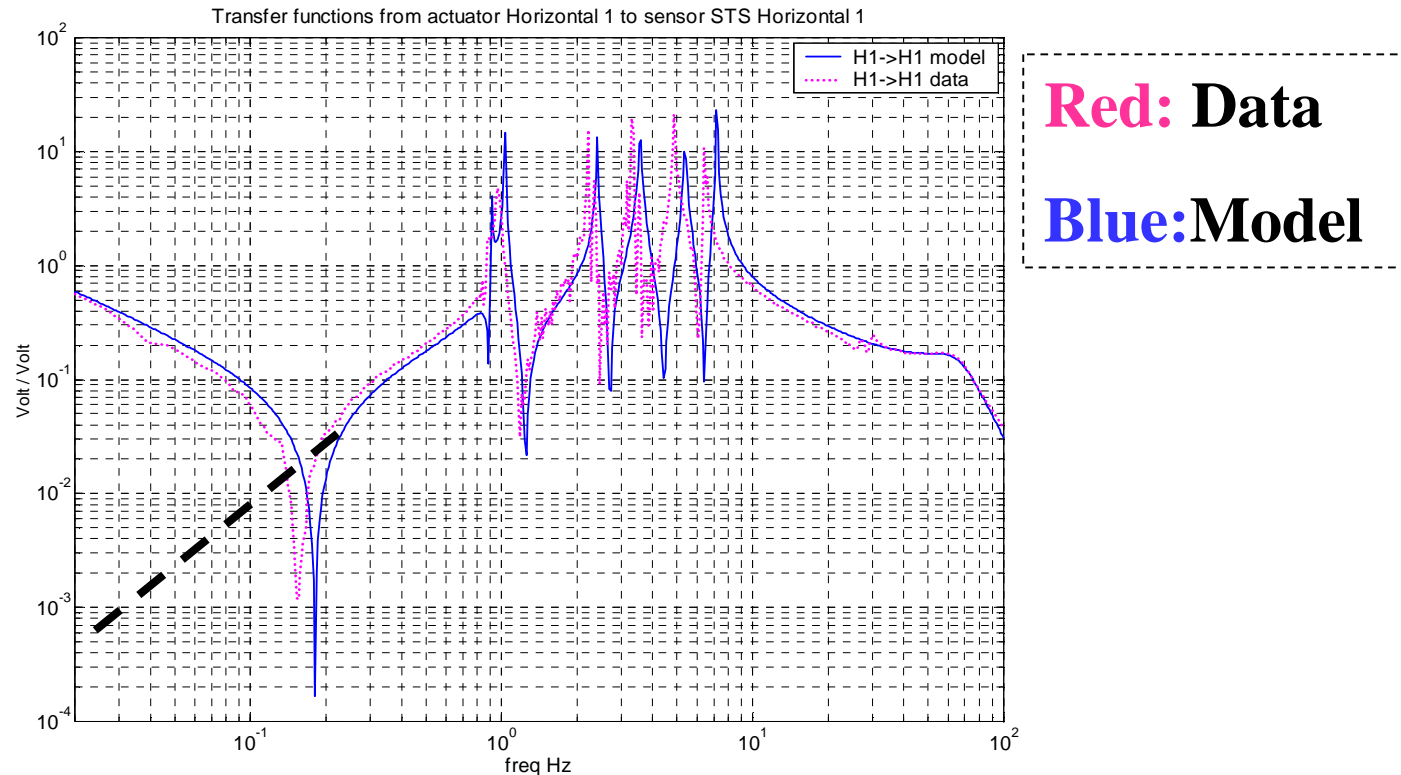
Position Sensor (PS) : from DC



Sensor Blending

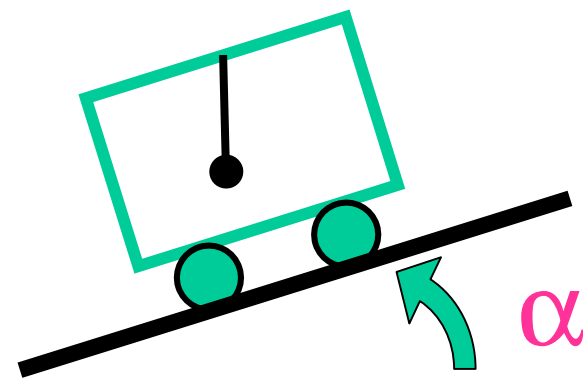
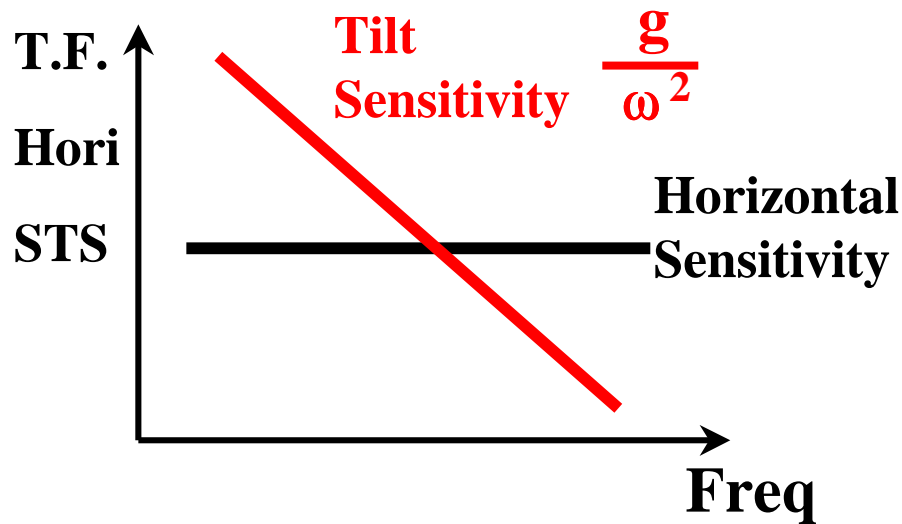
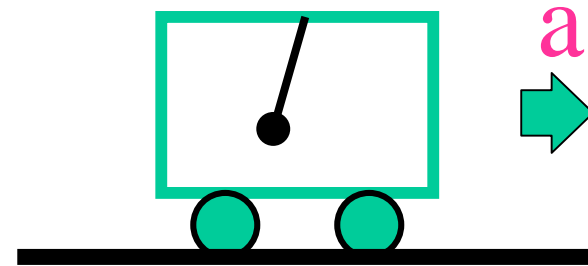
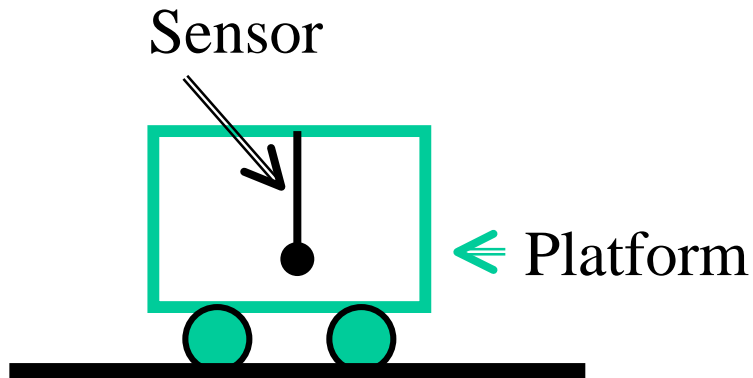


Tilt Horizontal Coupling

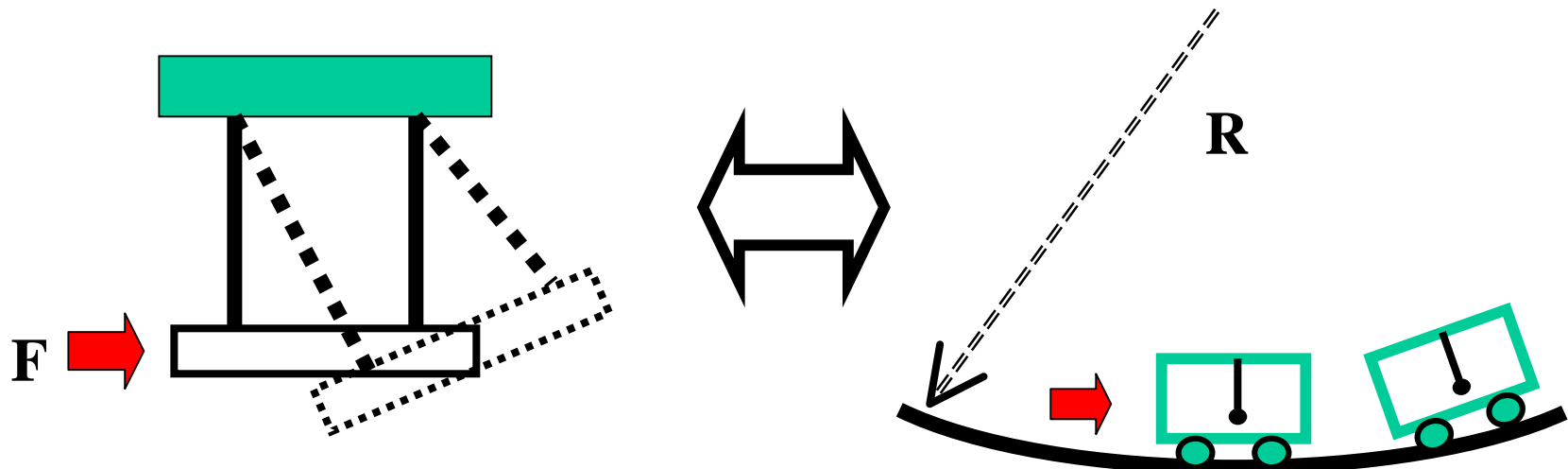


A typical transfer function from horizontal voice coil to horizontal STS.

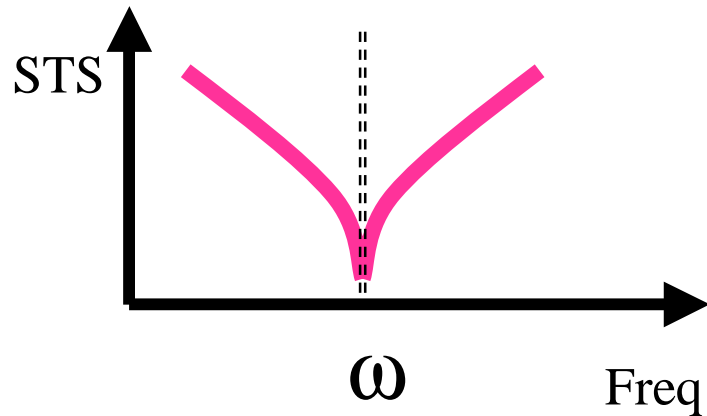
Inertial Sensor **Can Not** Distinguish Acceleration and Gravitation Field Change Locally



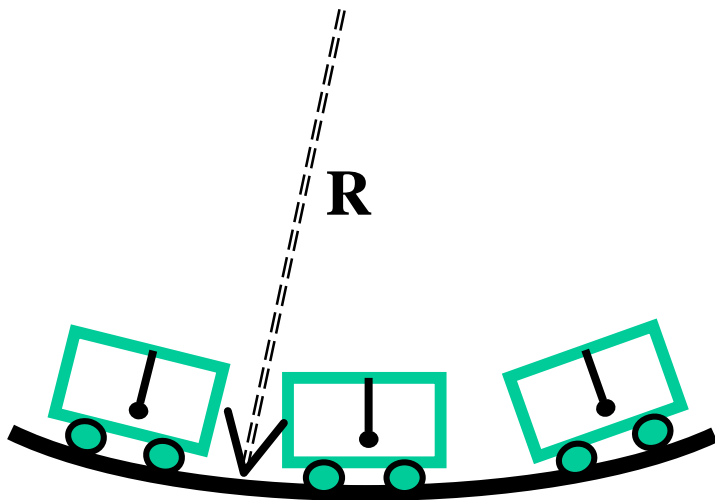
Horizontal Actuator Generates Tilt Motion



Big Zero



$$R = \frac{g}{\omega^2}$$



Freq = 1Hz R = .25 meter

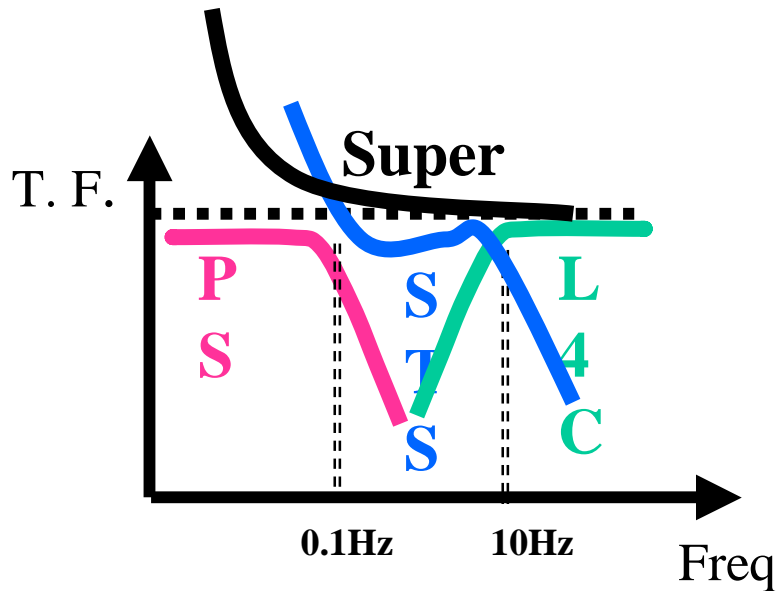
Freq = .1Hz R = 25 meter

Freq = .01Hz R = 2500 meter

Problems Generated by Tilt Horizontal coupling

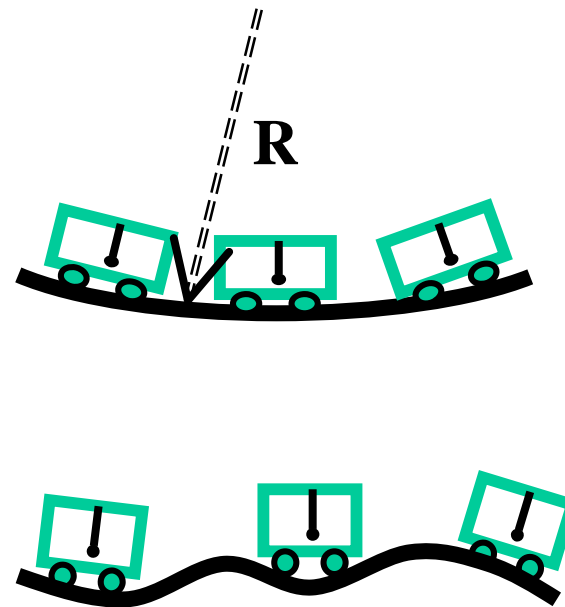
1. Stability:

Control loop on super sensor is not Stable.



2. Observability:

The Platform is moving, but we do not know.



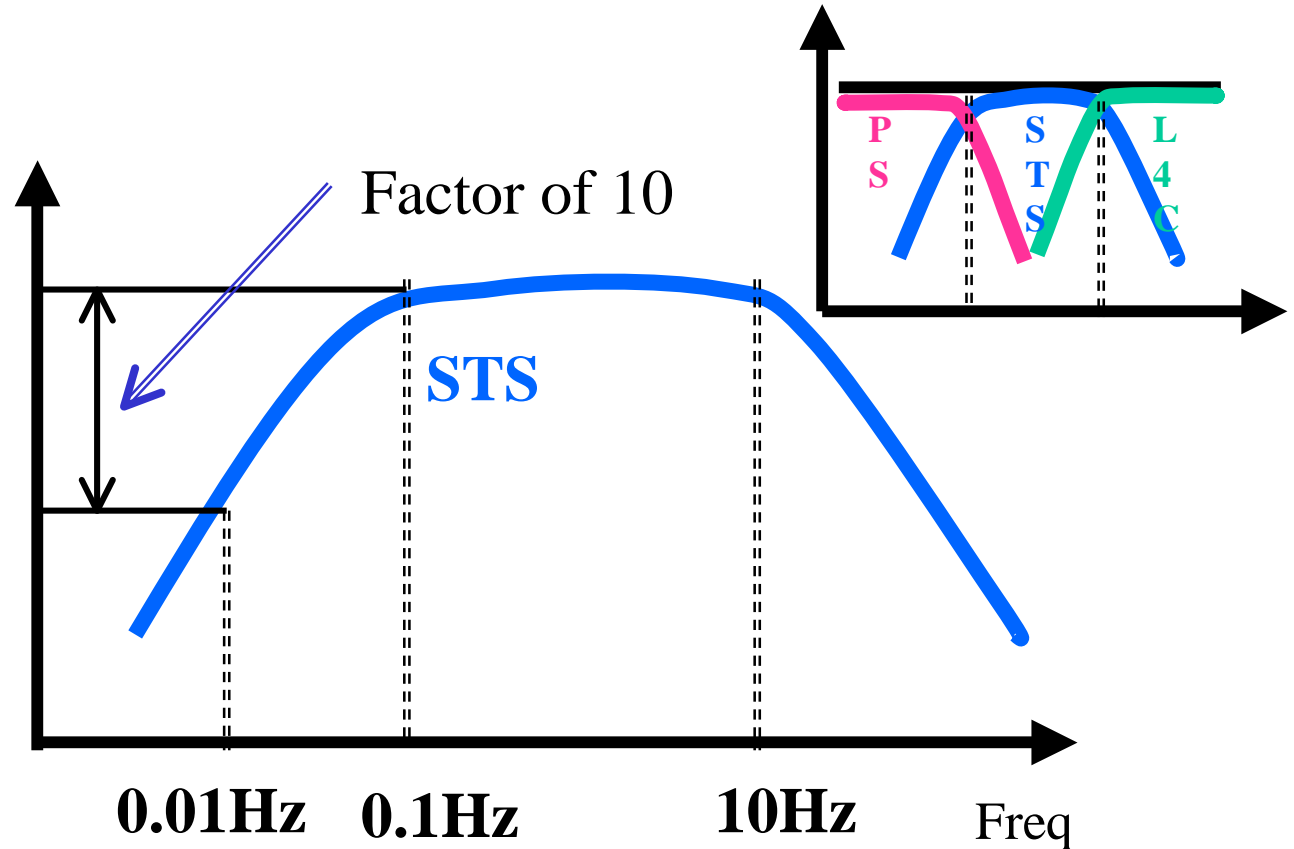
How Much Tilt is Acceptable?

Target total
RMS motion:
1 μ m

R at .01 Hz:
2500 meter

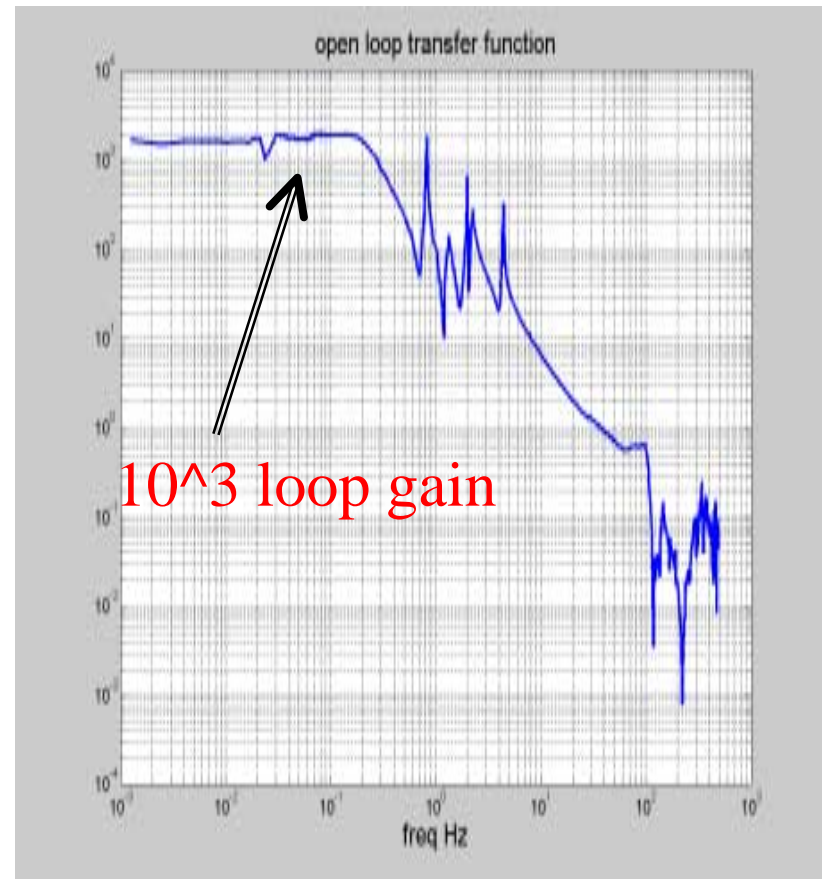
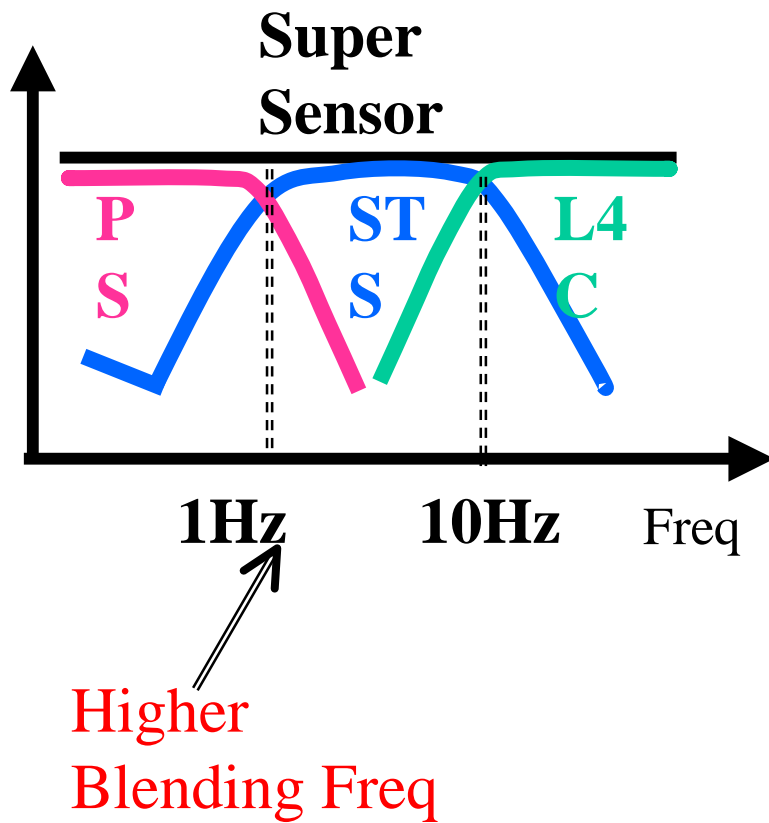
Tilt angle can
bring us trouble.:
 $1e-6/2500*10 =$

4nrad

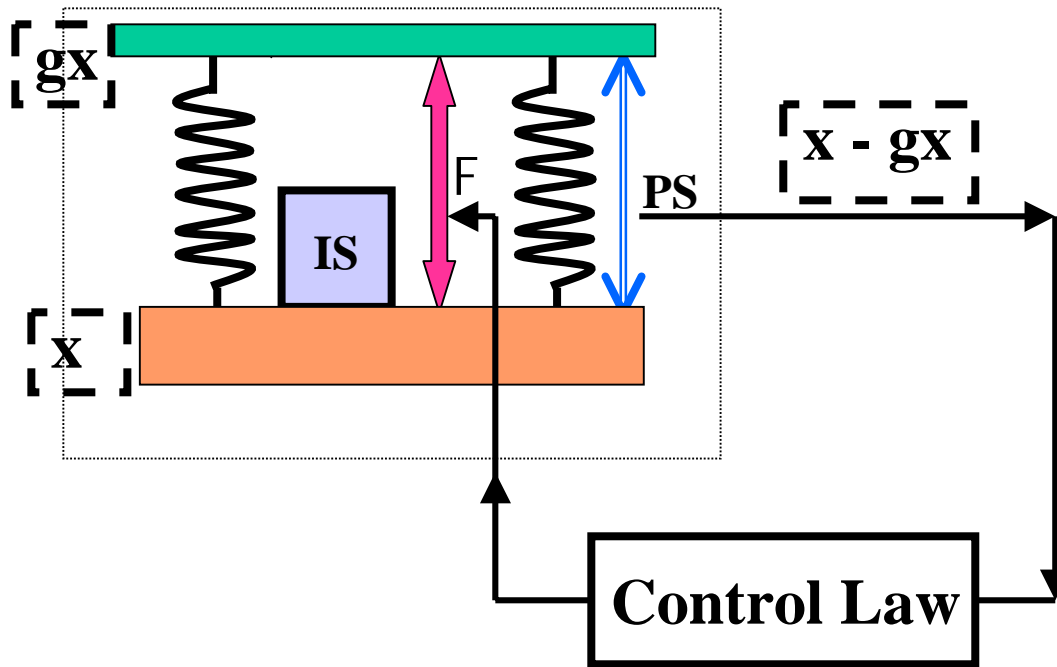


Realistic Blending Filter

Move Blending Freq from 0.1Hz to 1 Hz



“Clamp Up” the Platform



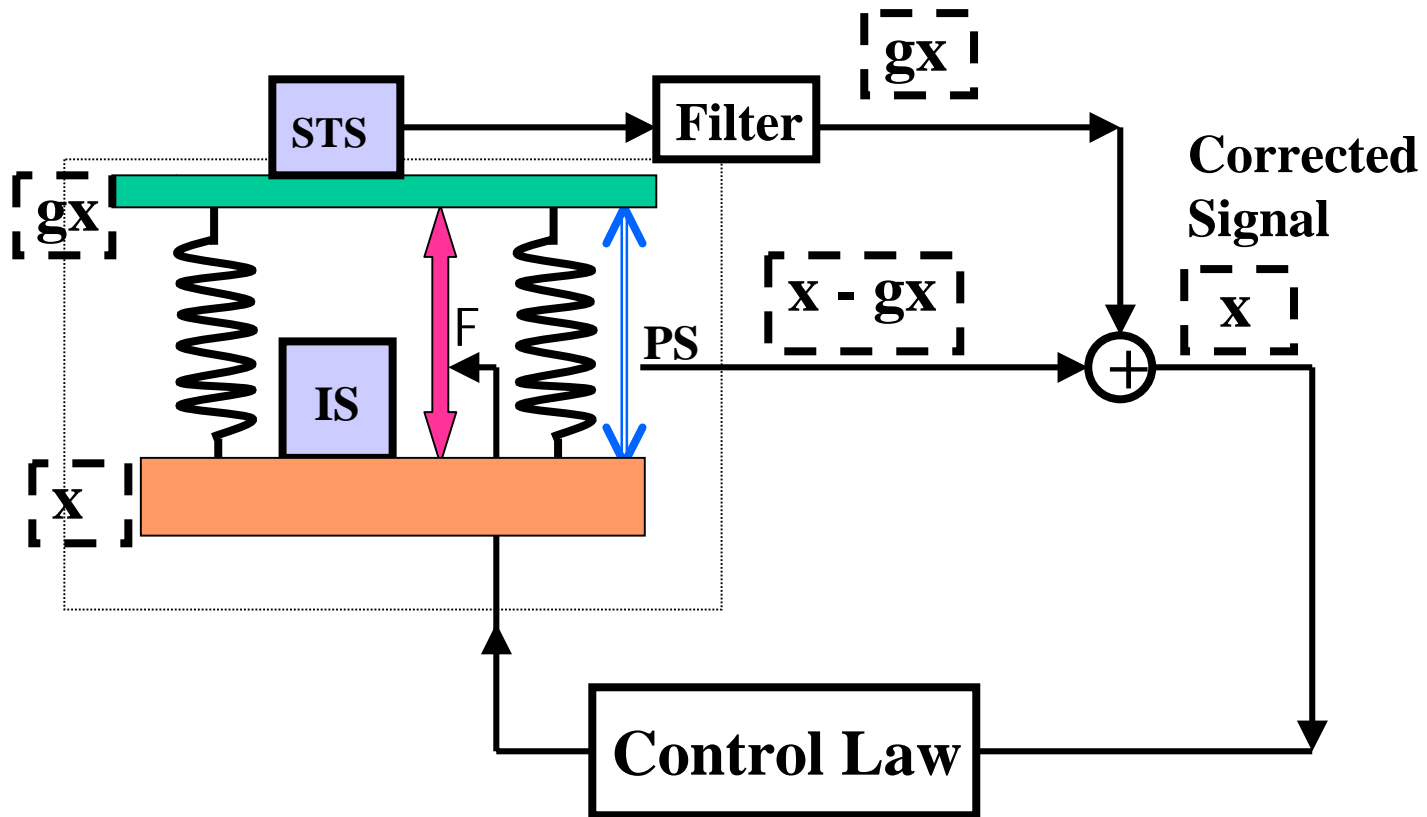
If loop gain $\gg 1$,

$$x - gx = 0,$$

$$x = gx,$$

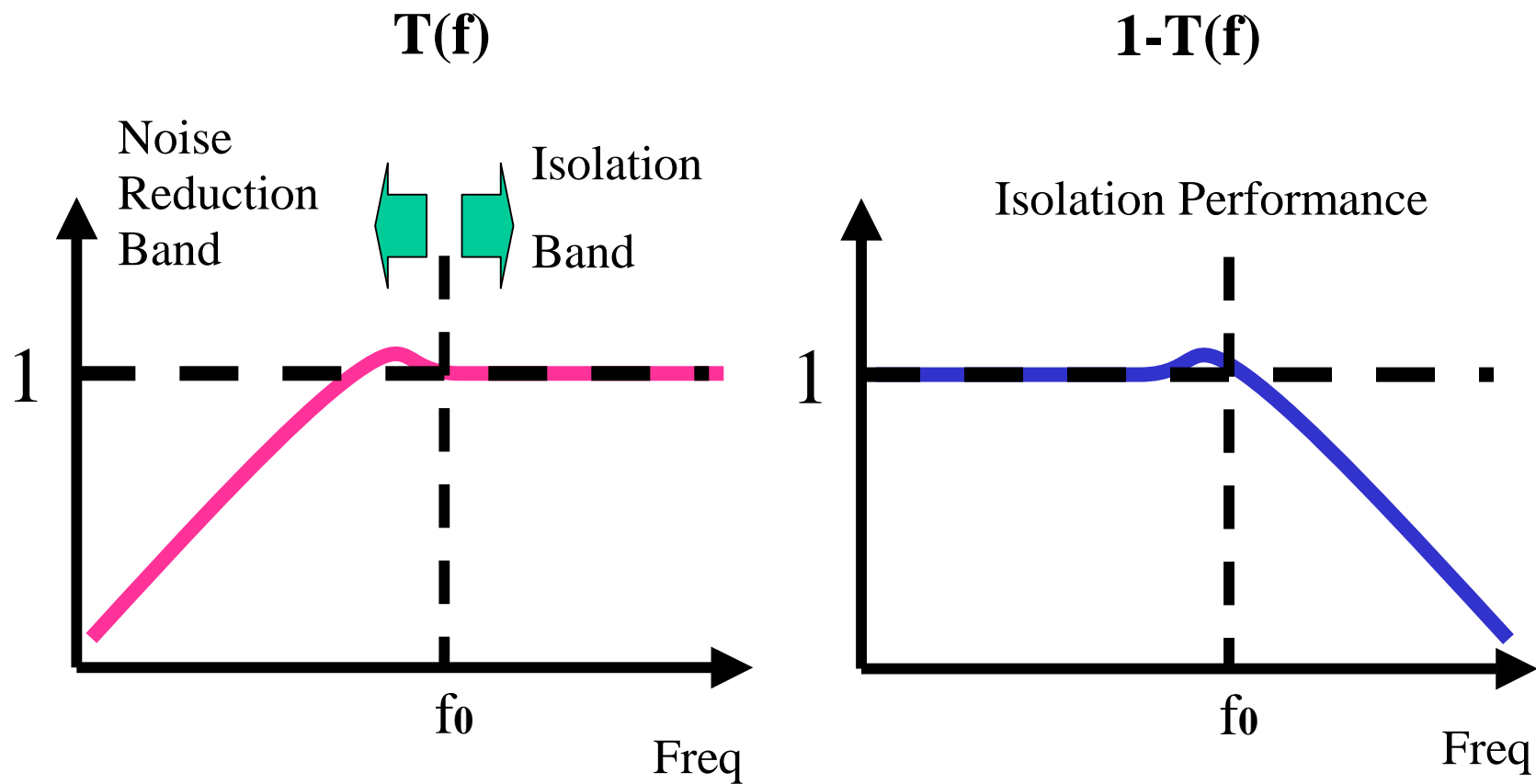
platform is
‘clamped up’ to
the ground.

Sensor Correction

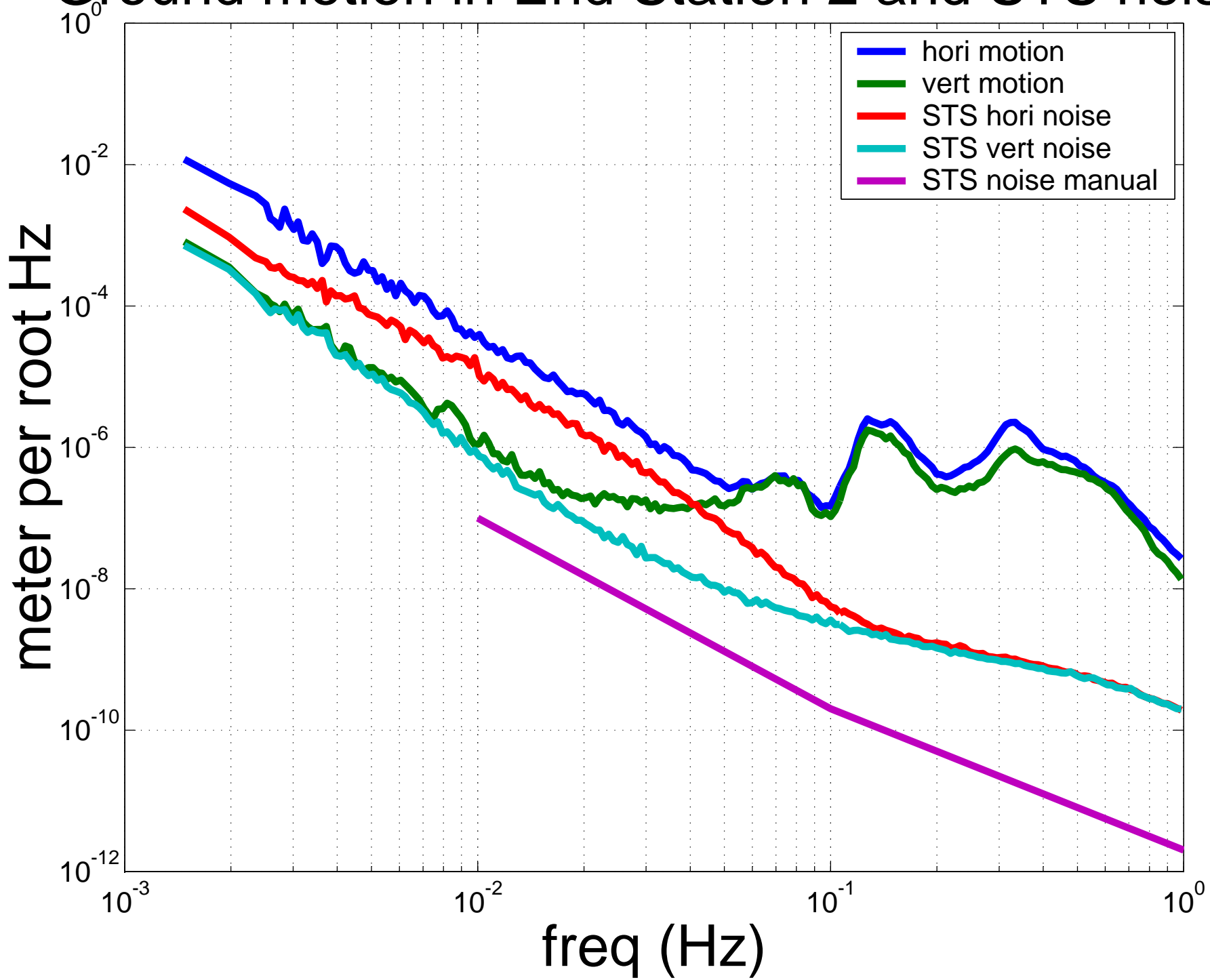


If loop gain $\gg 1$, $x = 0$, we have isolation !

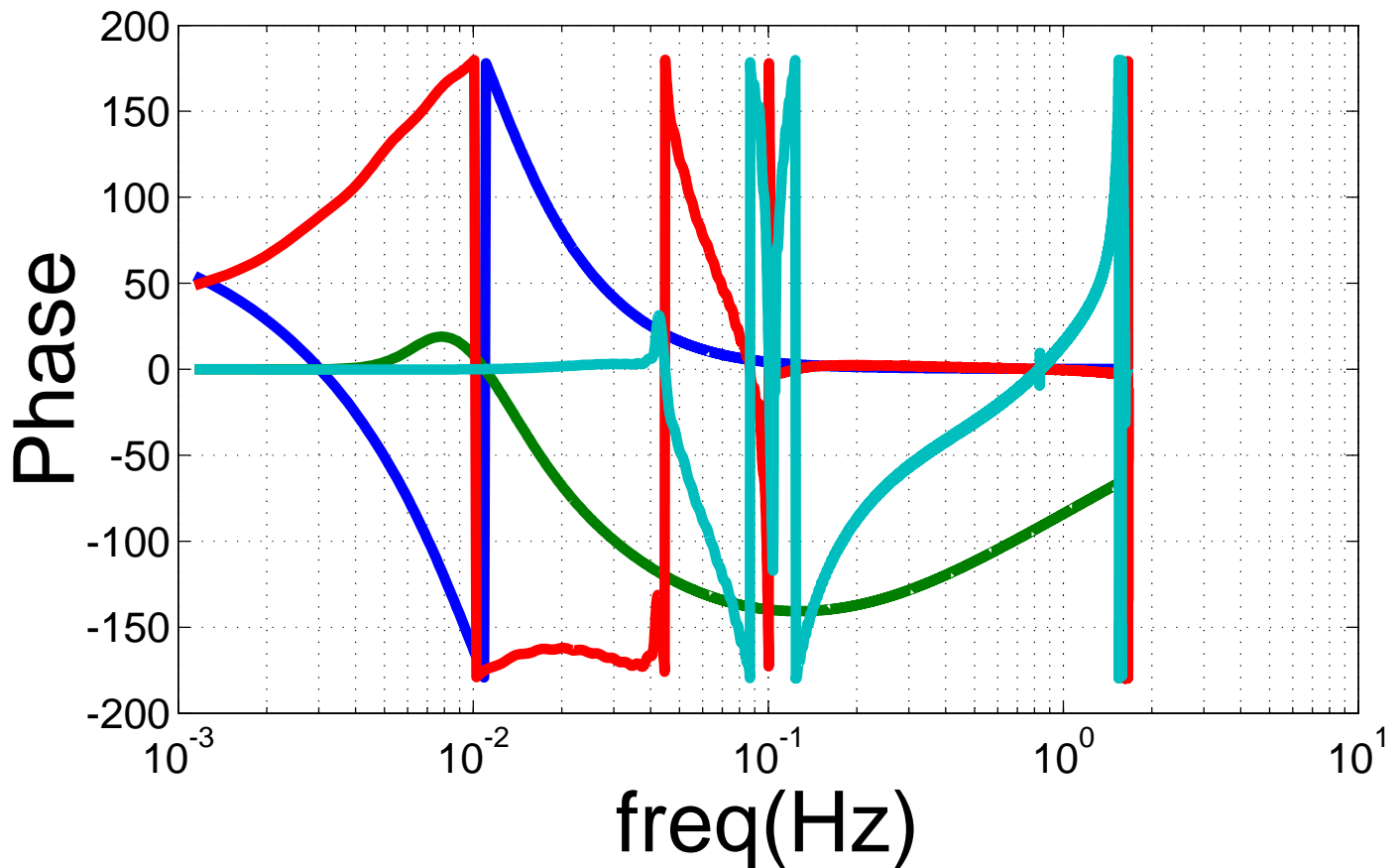
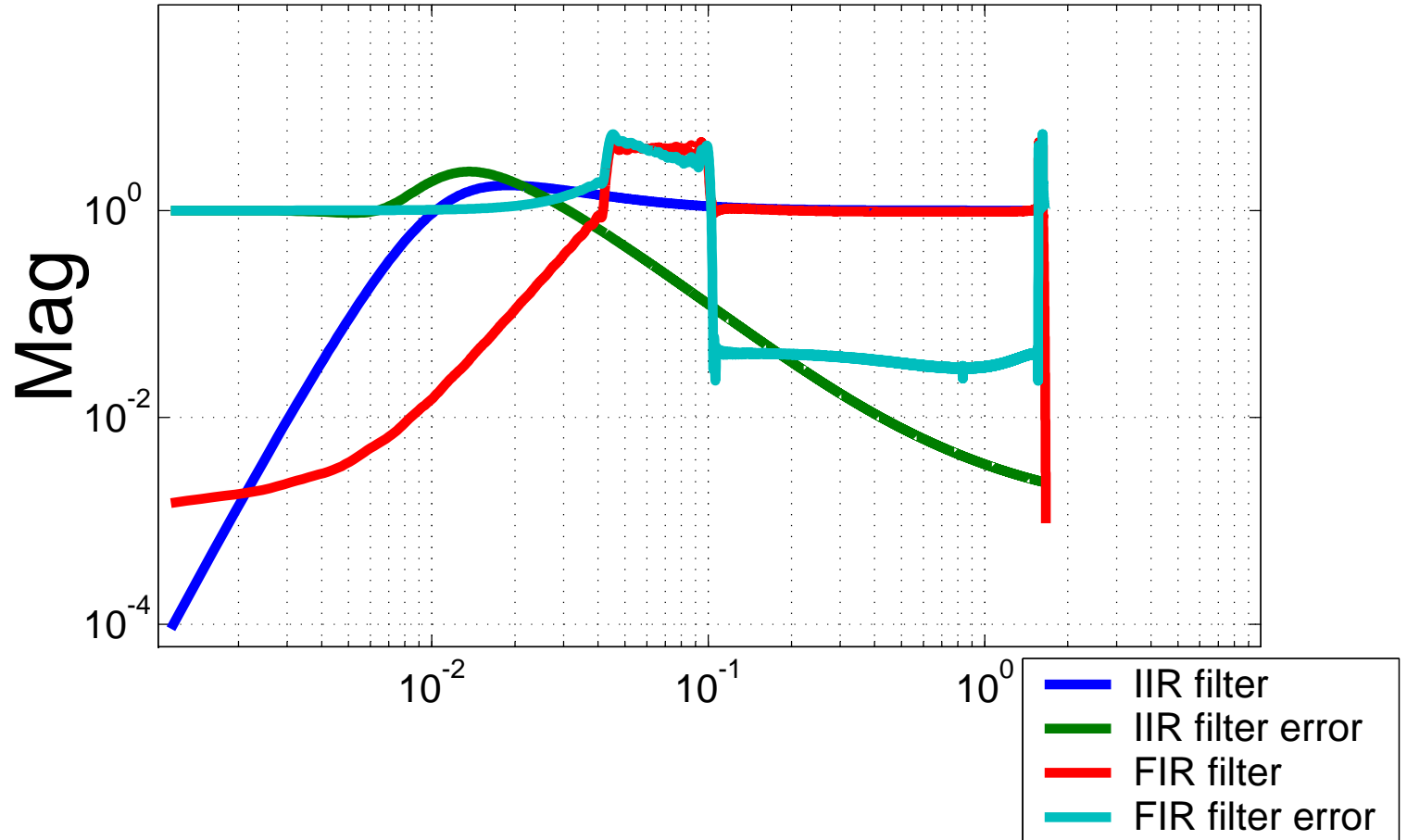
Sensor Correction Filter Design Tradeoffs



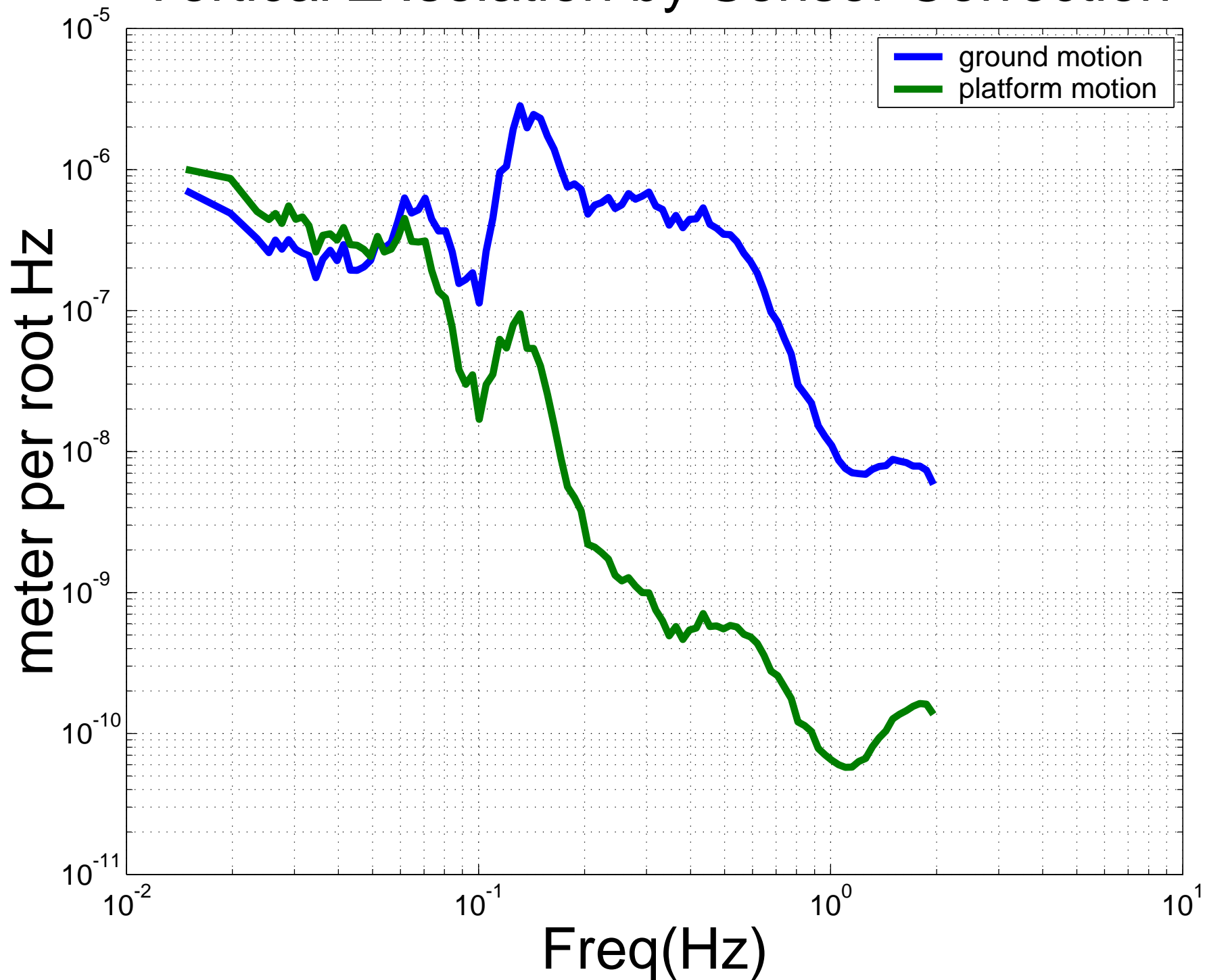
Ground motion in End Station 2 and STS noise



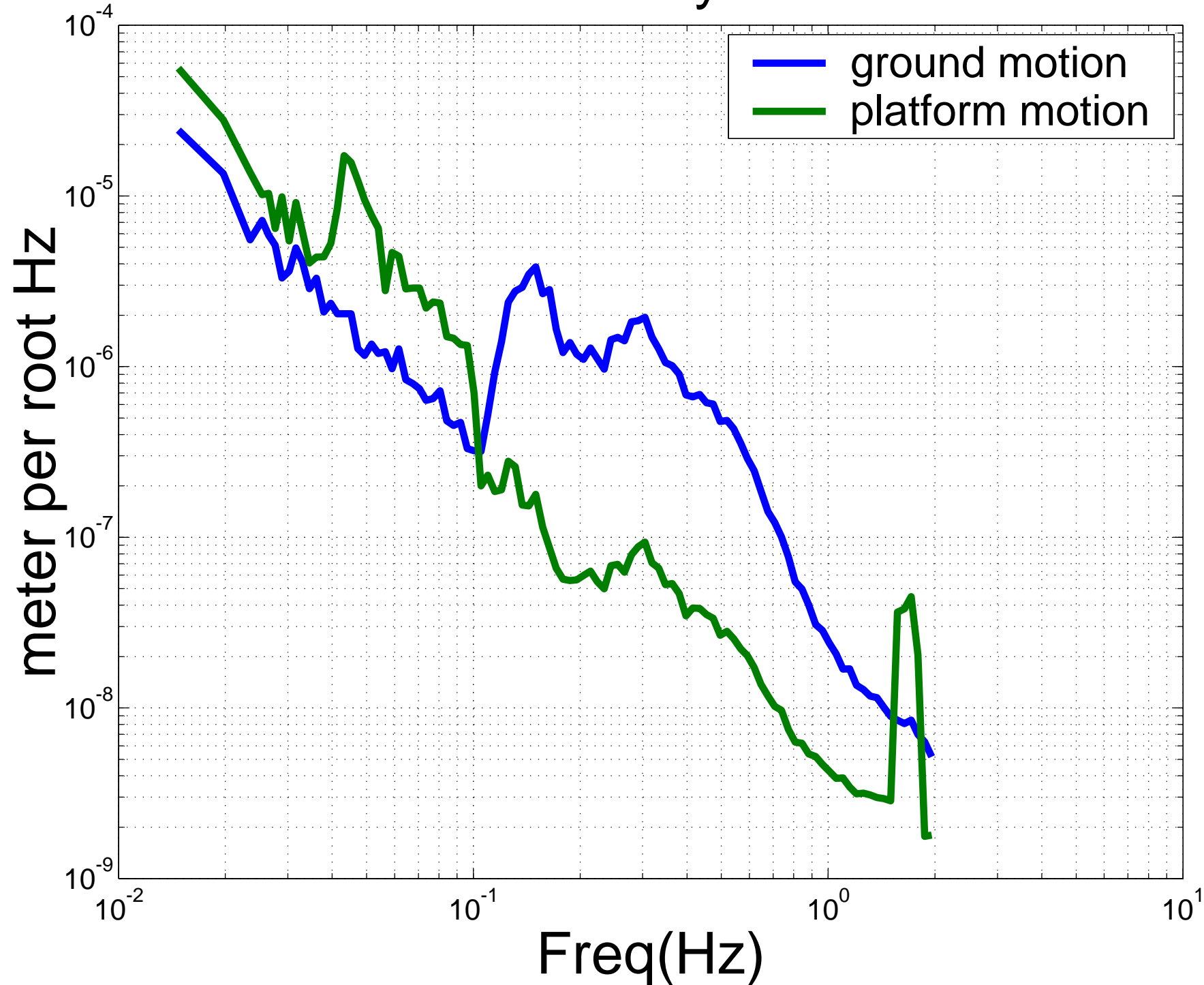
Compare FIR and IIR Filters for Sensor Correction.



Vertical Z Isolation by Sensor Correction



Horizontal X Isolation by Sensor Correction



Current and Future Work

- Design longer FIR filter.
- Find better tilt sensors at low frequencies.
 - **Inertial tilt Sensor with noise $< .2$ nrad/rootHz at 10mHz.**
 - **Relative tilt sensor that does not have horizontal sensitivity.**

Compare FIR and IIR Filters

	FIR	IIR
Design	Convex optimum guaranteed	Non-Convex Try and Fail
Computation Cost	Large	Small
Performance	Great	Ok