Development of a Cylindrical Rotation Sensor for LIGO

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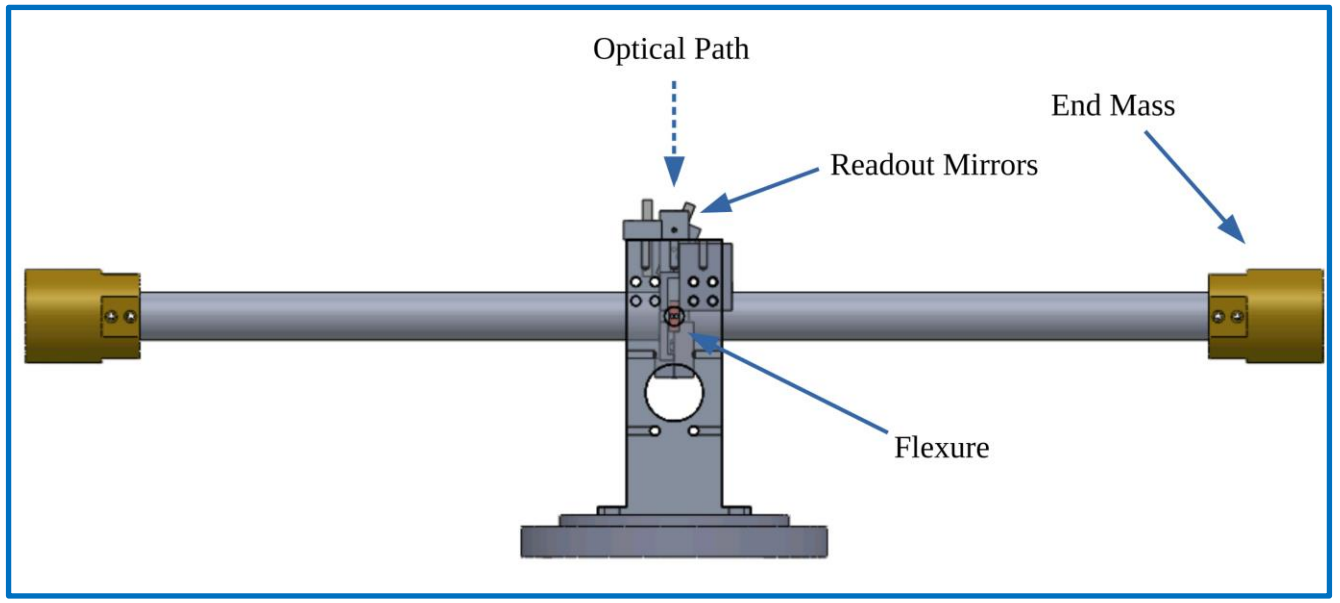
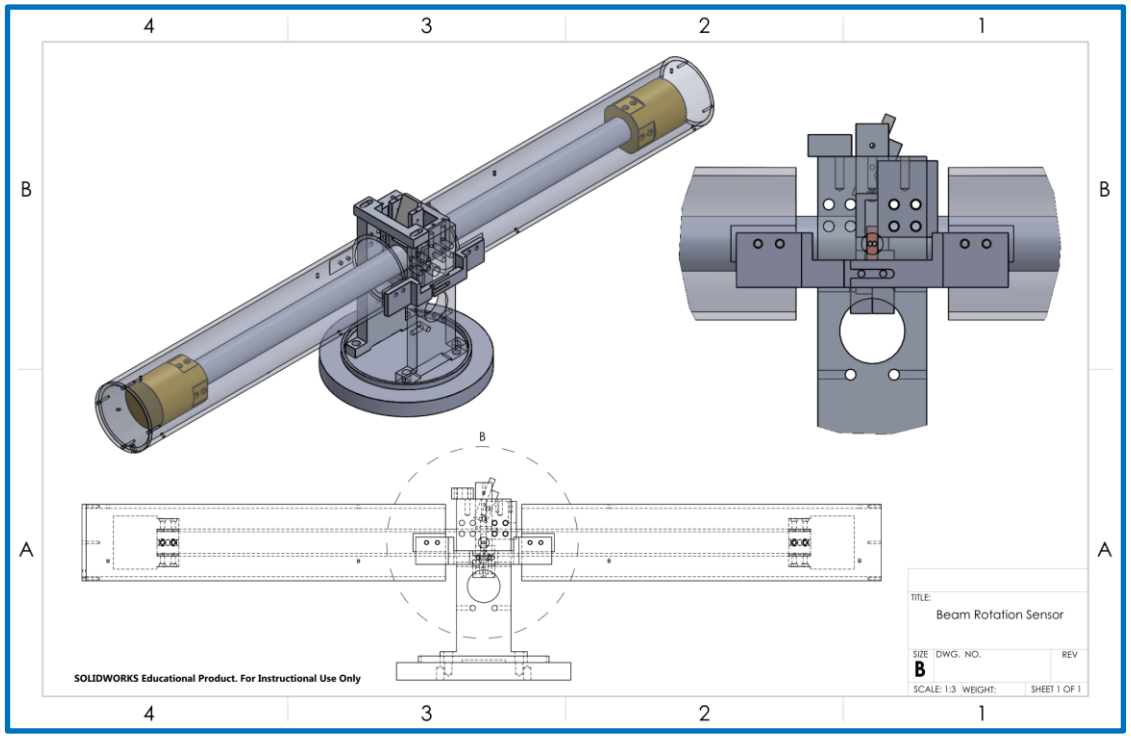
Tilt in Gravity Wave Detectors

- Problem: During high winds, the seismometers pick up ground tilt and inject additional noise into the measurements
- Solution: Have a separate device that can detect when the ground is tilting and subtract that out of the seismometer reading
- Currently have sensors installed in LIGO





Requirements for CRS

- Want to make compact version that can go on the Seismic isolation platform
- Must be small enough to fit on the platform(30cm)
- Must be vacuum compatible
- Needs to be able to operated remotely

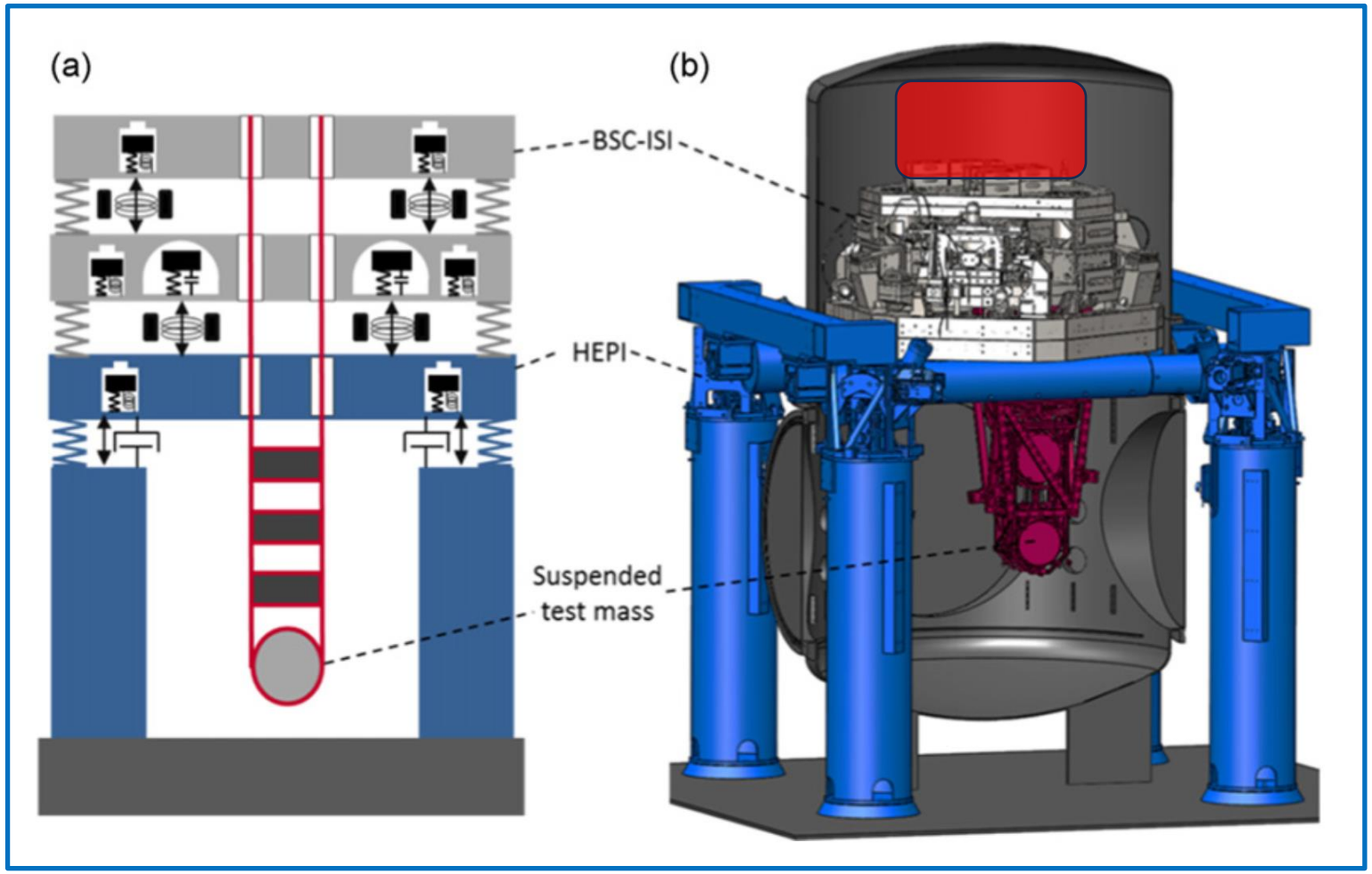
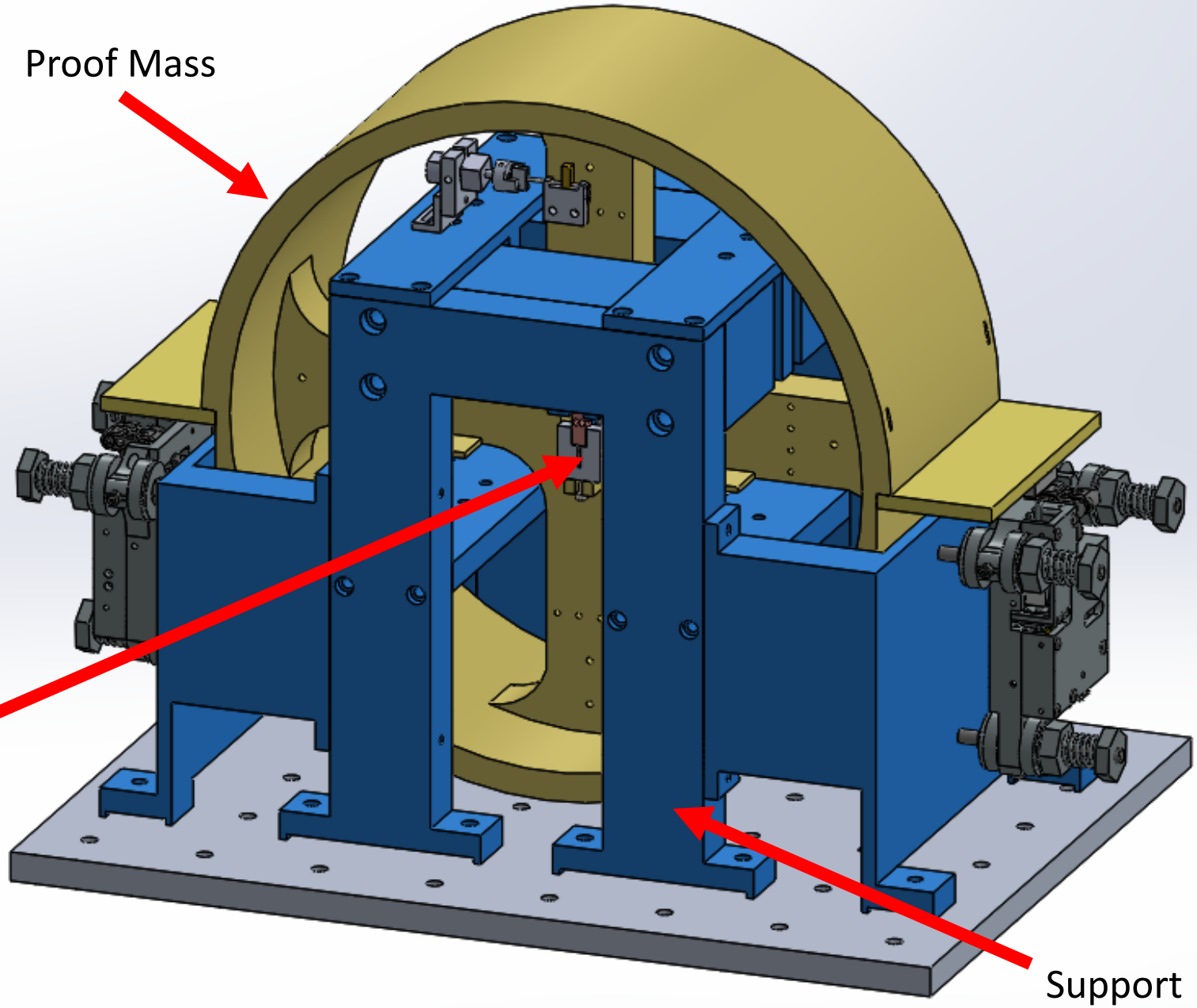


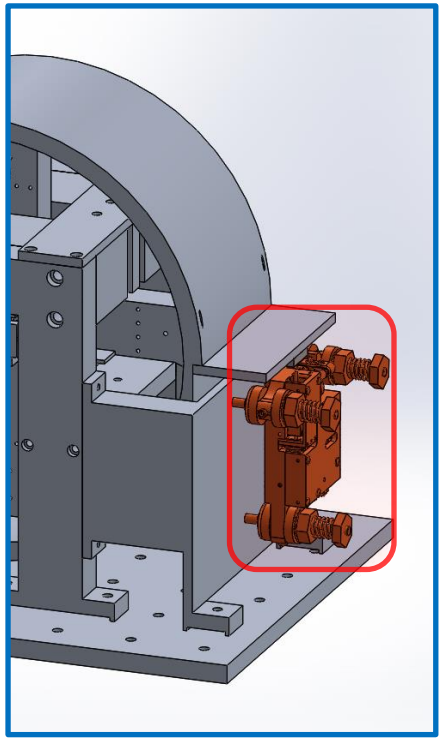
Image credit: F Matichard *et al* 2015 *Class. Quantum Grav.* **32** 185003

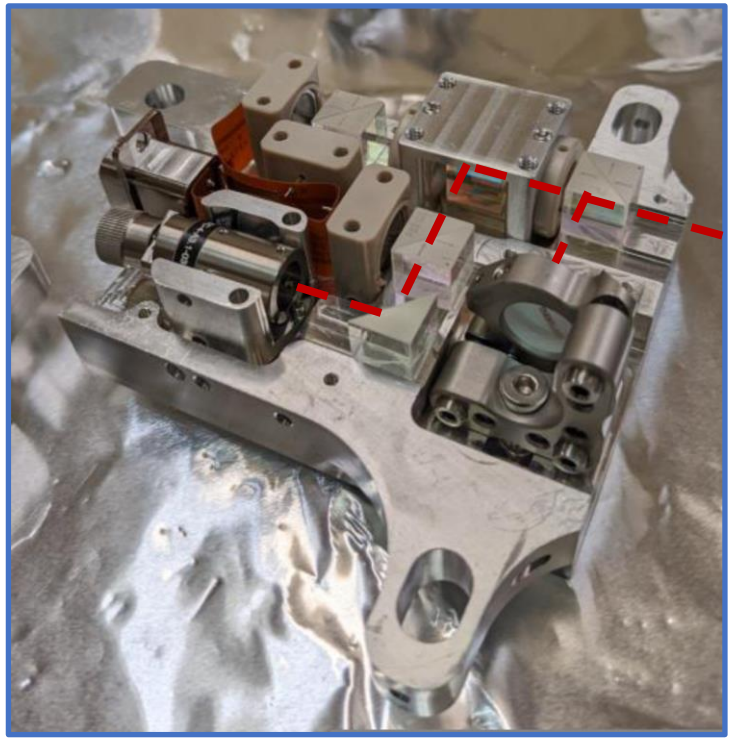
CRS Design

- A proof mass supported by two flexures
  - rotationally isolated from supports
- Interferometers detect how far each “wing” is from ground to calculate the tilt angle



Optics





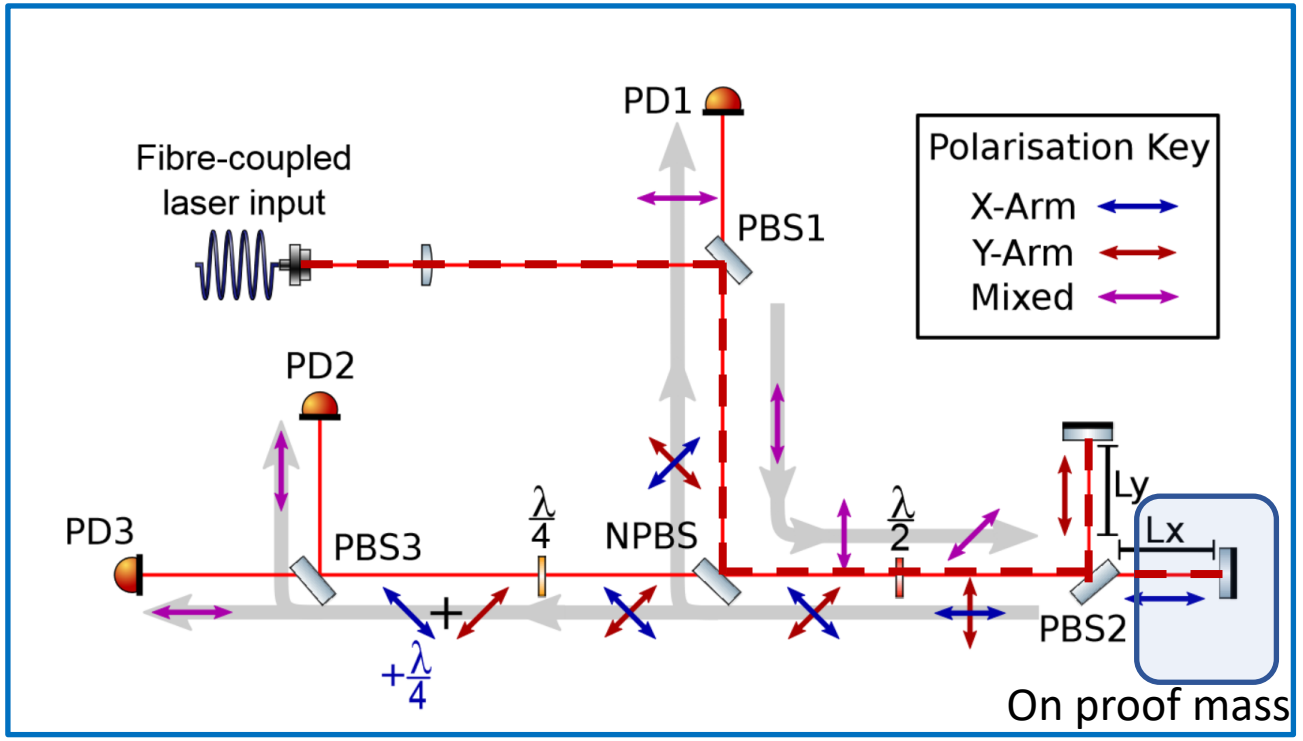
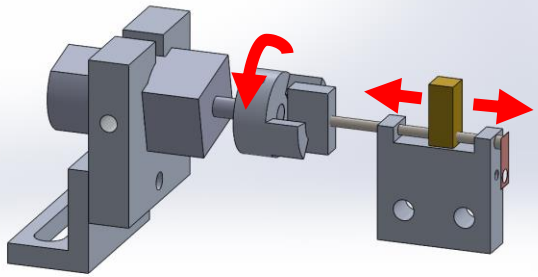


Image credit: S J Cooper *et al* 2018 *Class. Quantum Grav.* **35** 095007

- Homodyne Quadrature Interferometer
- Developed by group at Vrije Universiteit Amsterdam & University of Birmingham
- Mirrors on wings reflect beam to give a distance readout

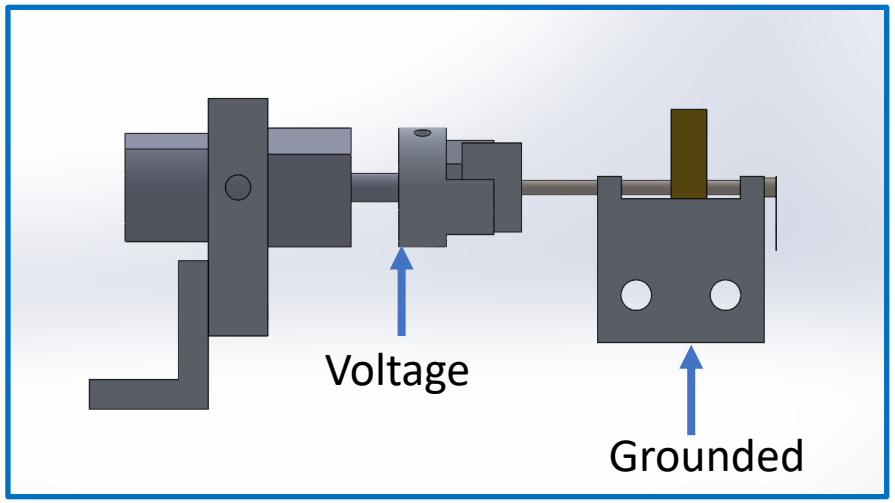
Mass Adjuster

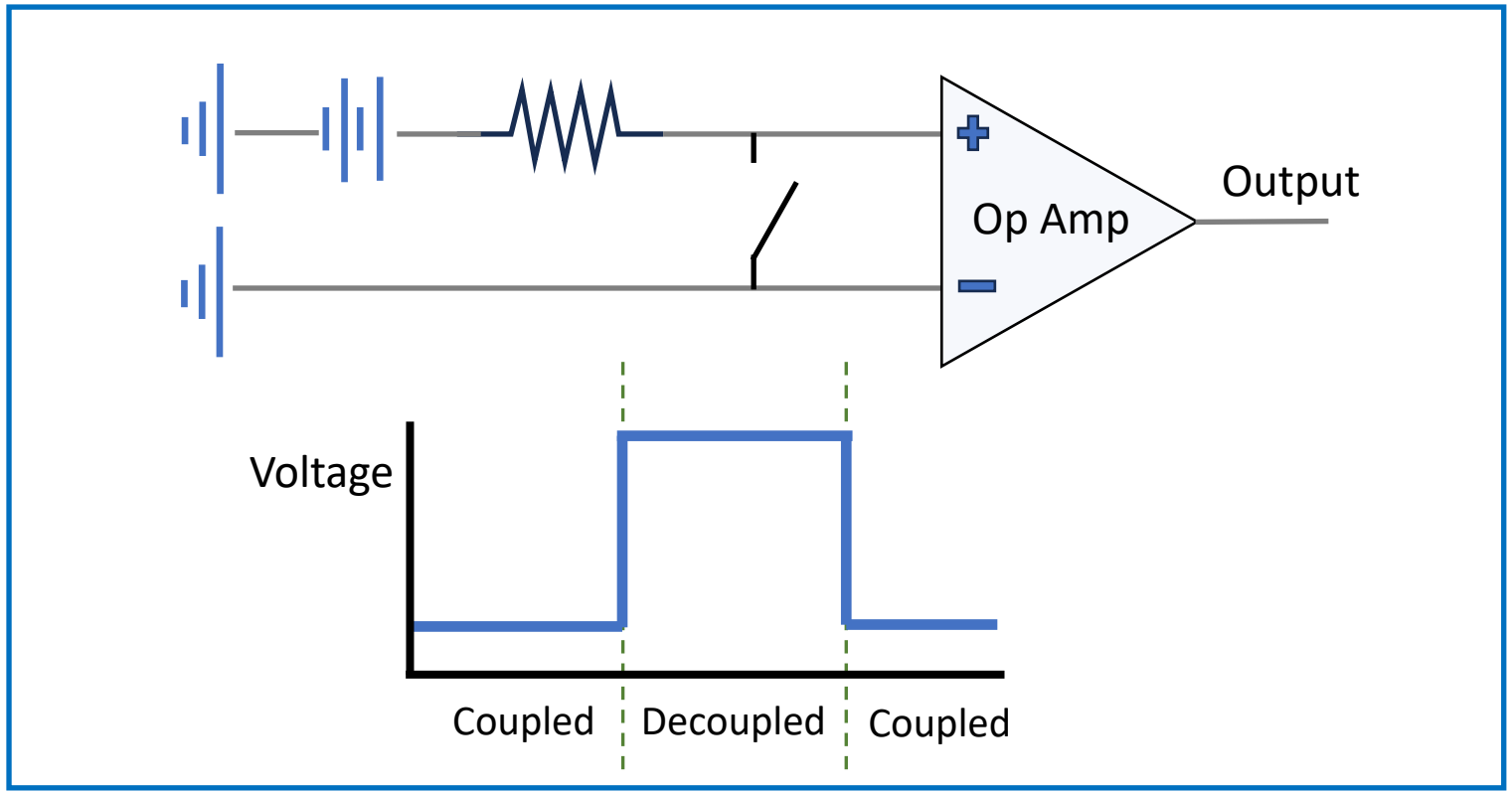


- Center of mass can shift (Temperature, etc.)
- Adjustable mass on proof mass that can be moved via motor
- Can be decoupled by rotating the opposite direction

Remote Adjusting

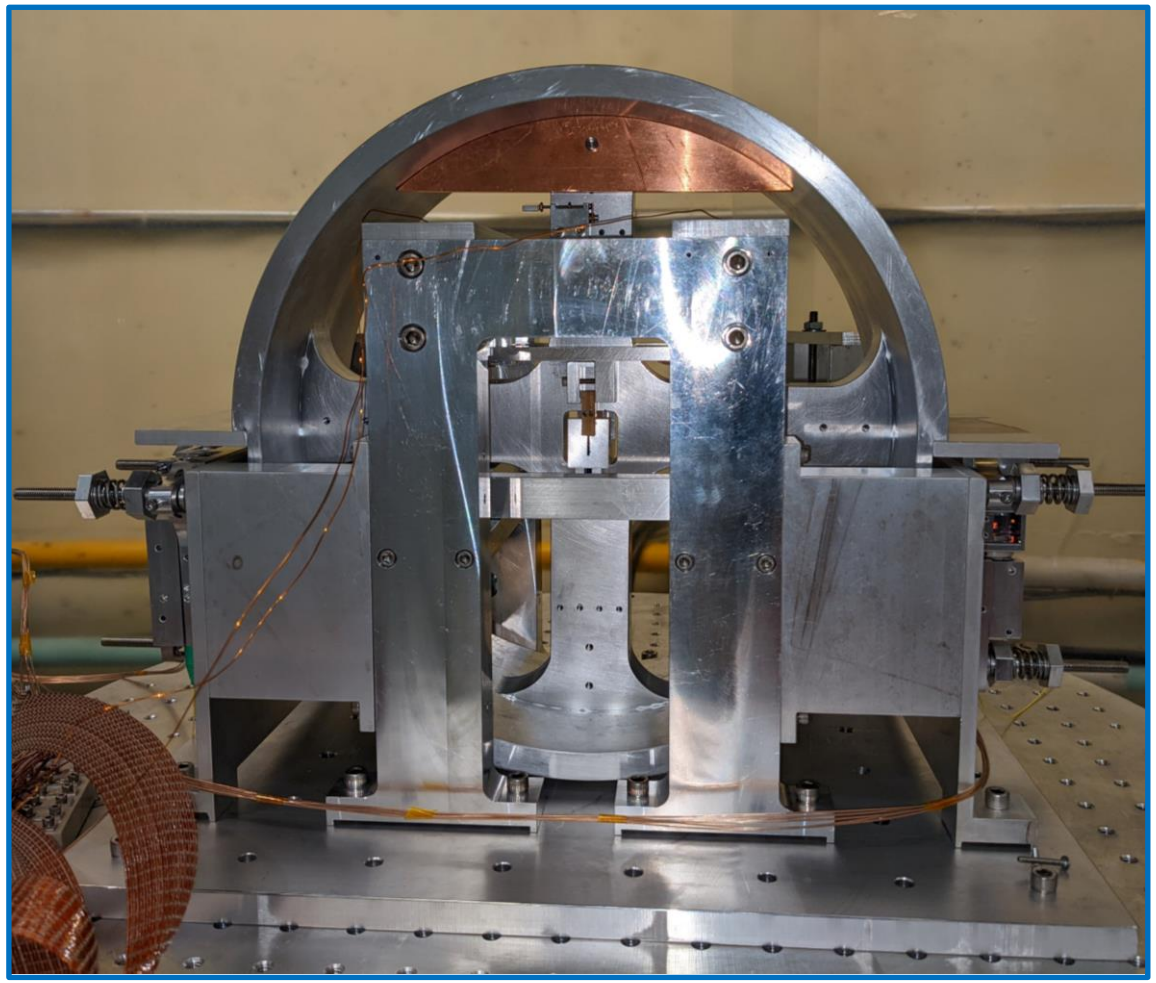
- Need to be able to remotely change CoM while in vacuum without impacting performance
- Motor can couple/decouple itself
- Warning “feelers” at end of track to keep adjuster from breaking itself

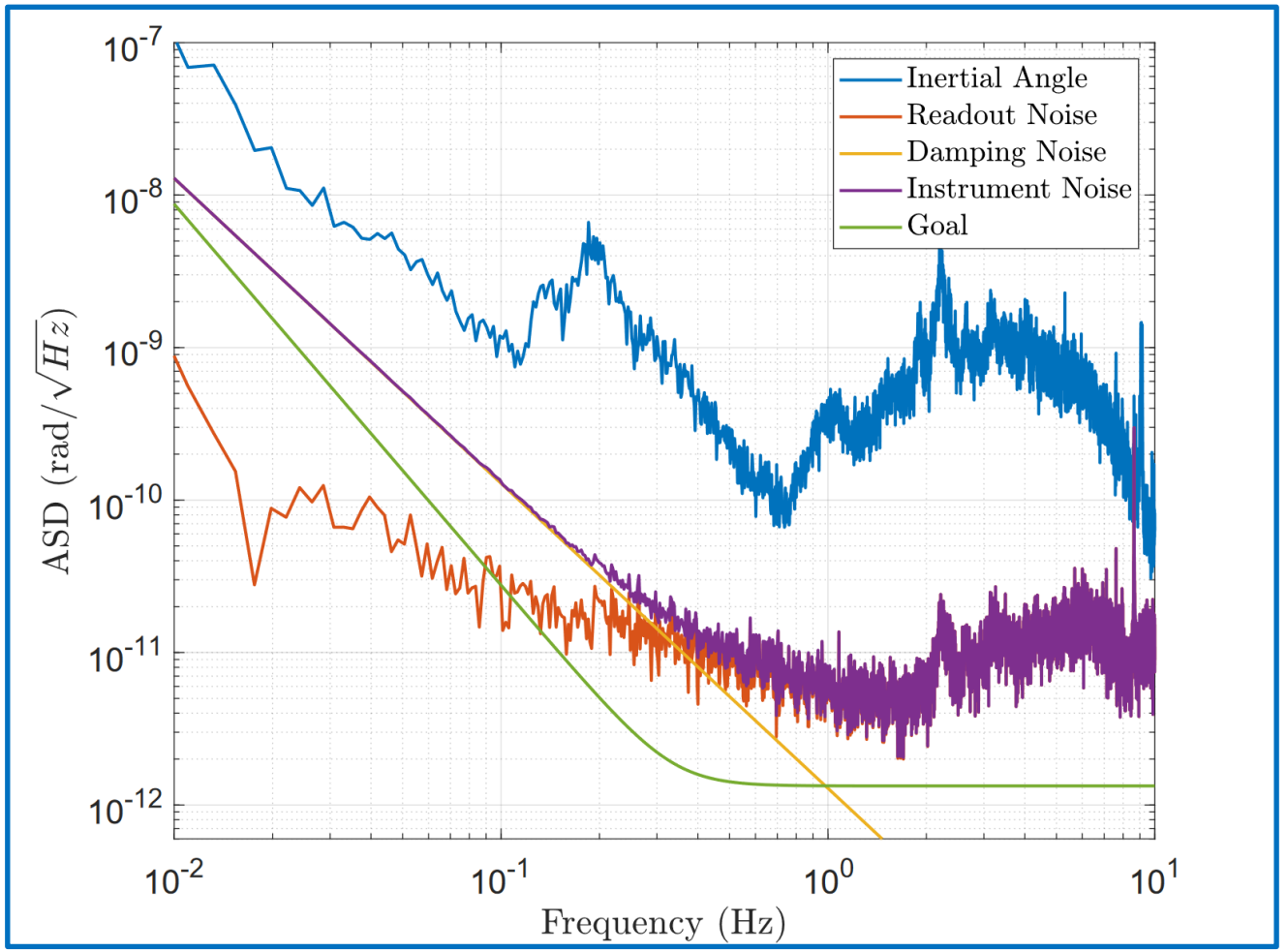




Current Noise Results

- Reaches a sensitivity of ~5 prad/$\sqrt{\text{Hz}}$
- Aim to install CRS for next observing run





Thank You