O4に向けたKAGRA防振系の改良

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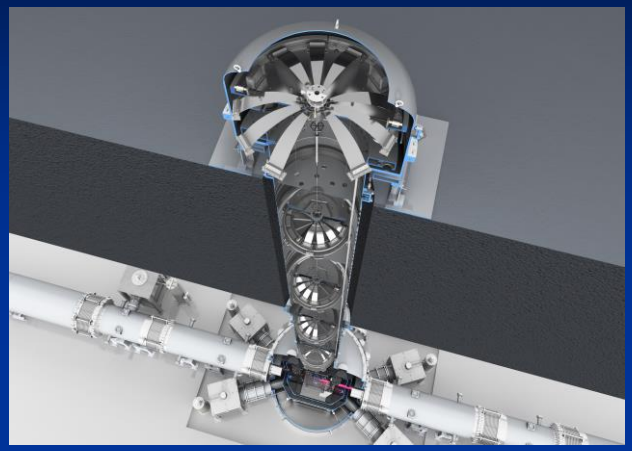
オンライン

Outline

1. Vibration isolation system in KAGRA
2. Improvement of inertial sensors
3. Position sensors
4. Tuning of folded pendulum
5. Comparison of inertial sensors
6. Test at the KAGRA site
7. Summary

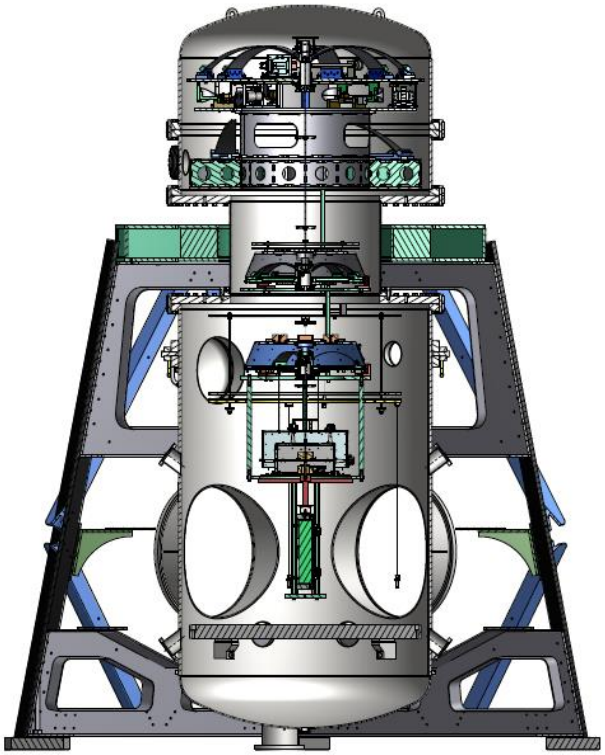
Vibration isolation system in KAGRA

Type-A

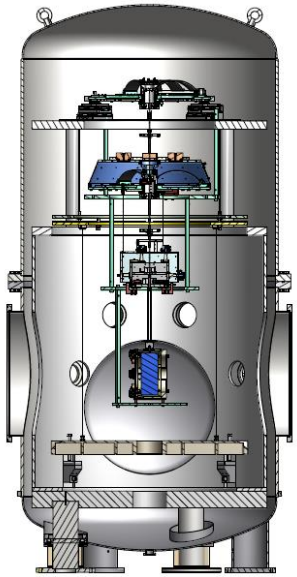


Type-A: for cryogenic mirrors
Type-B: for room temperature mirrors
Type-Bp: simpler Type-B
Type-C: for small optics

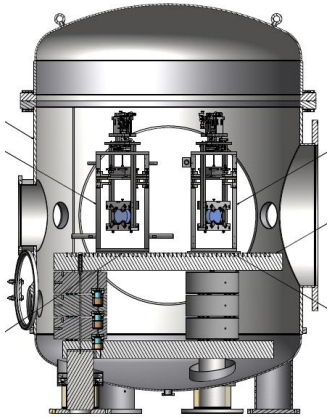
Type-B



Type-Bp

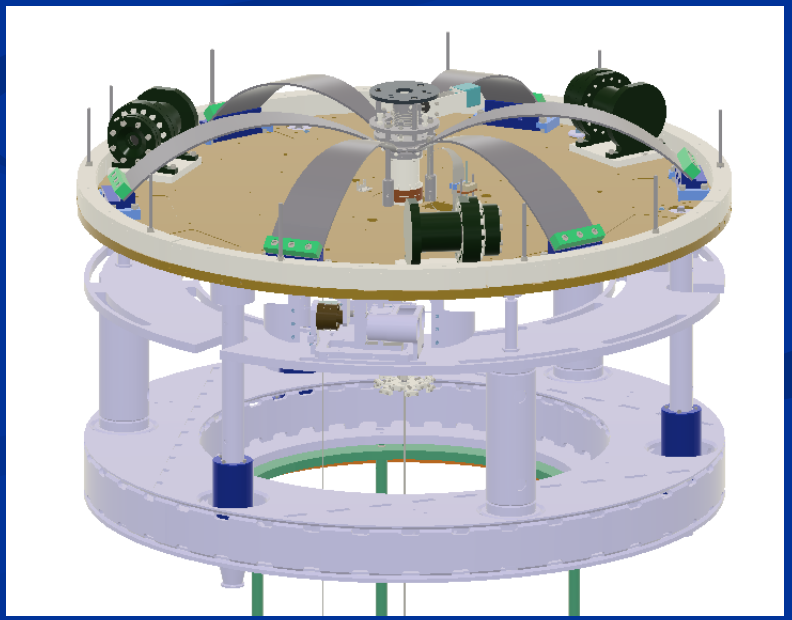


Type-C



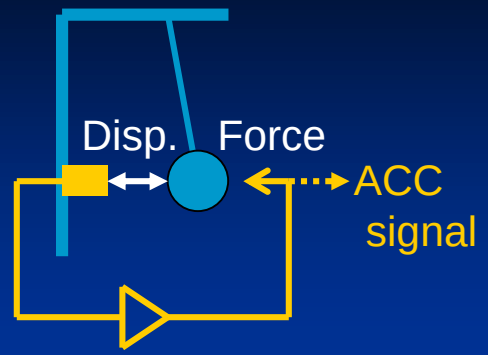
Improvement of inertial sensors for IP control

- The servo type accelerometers (IX, IY) and the commercial geophones (EX, EY) are used as inertial sensors in Type-A towers.
- The sensitivity of present inertial sensors are not good enough to control the IPs around 0.1Hz.
- We plan to replace the inertial sensors to better accelerometers.
  - Replace the position sensor.
  - Tune the folded pendulum.

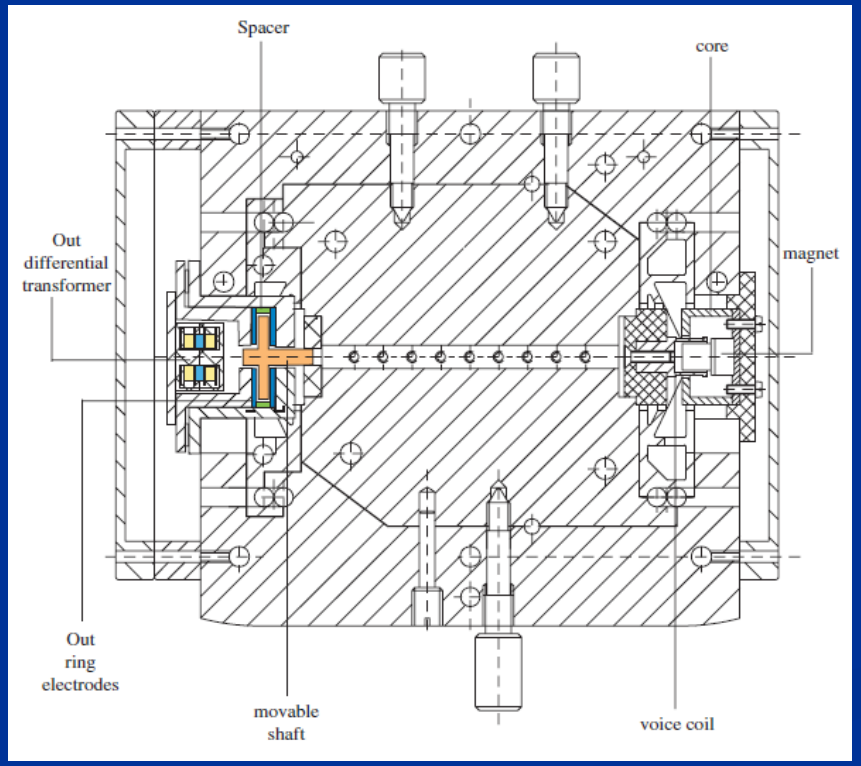


Present accelerometers for IP control

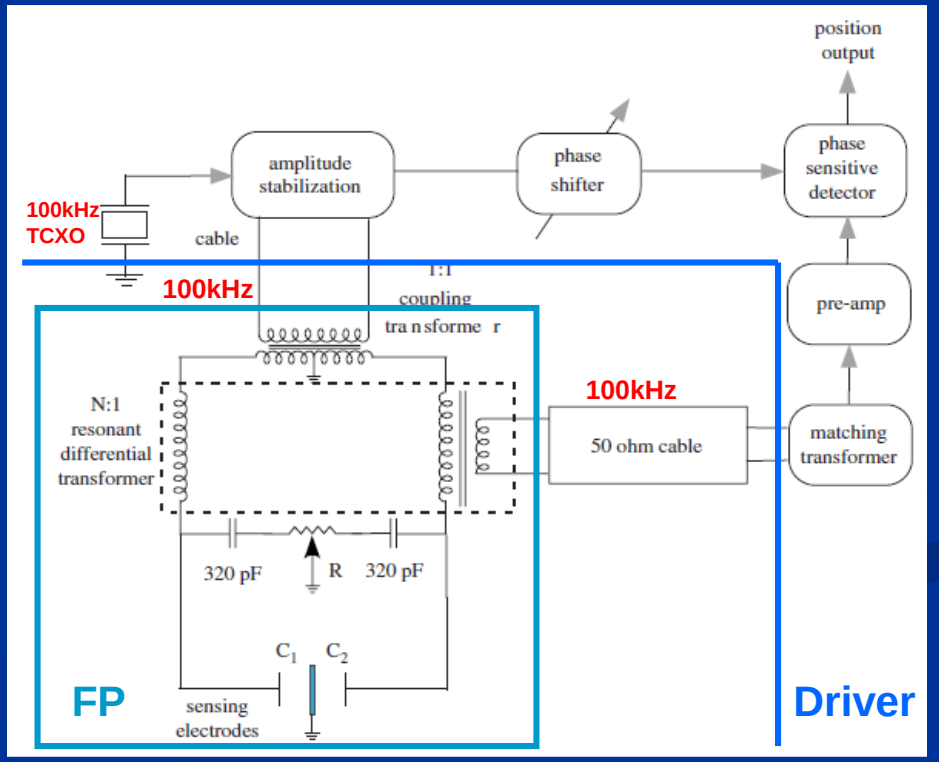
- Servo type accelerometer.
- Proof mass is suspended by a folded pendulum (0.4Hz).
- Displacement is red by a capacitance sensor using resonant differential transformer.
- Signal of 100kHz is demodulated at the driver.



Folded pendulum

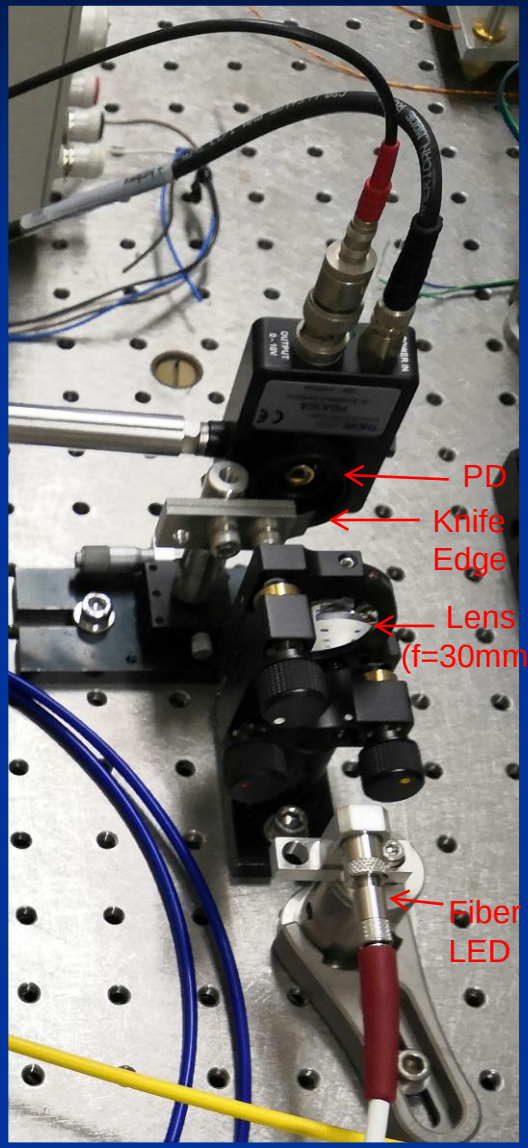


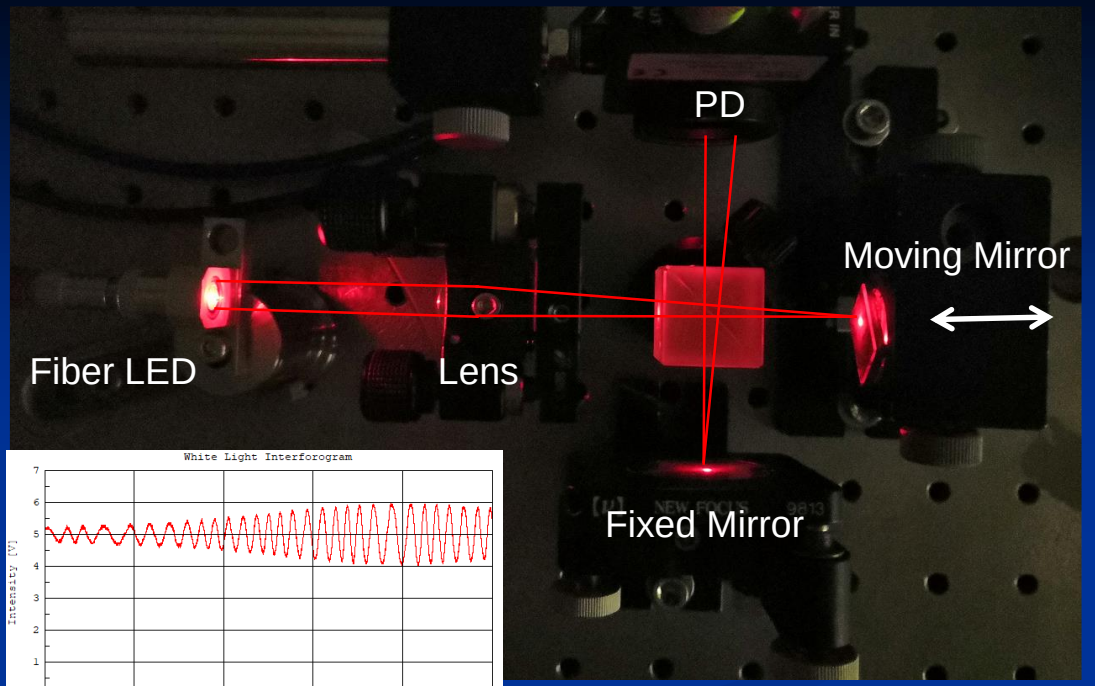
Differential capacitance bridge



A. Bertolini *et al.*, NIM A564, 579, 2006)

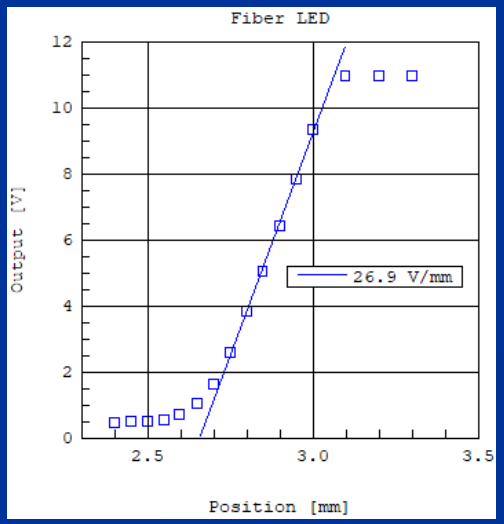
Position sensors



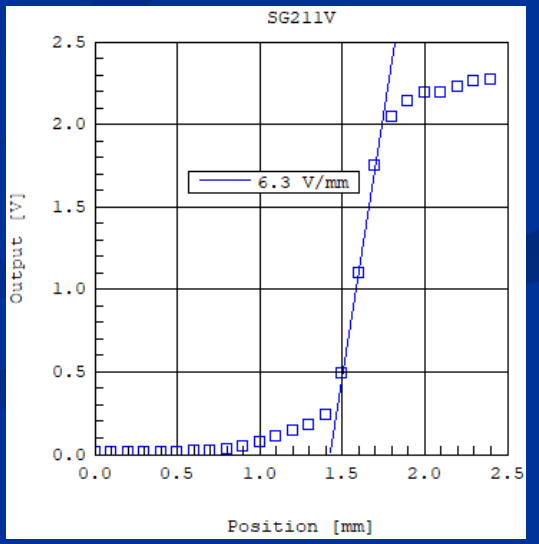


White Light Interferogram

Focused Fiber LED

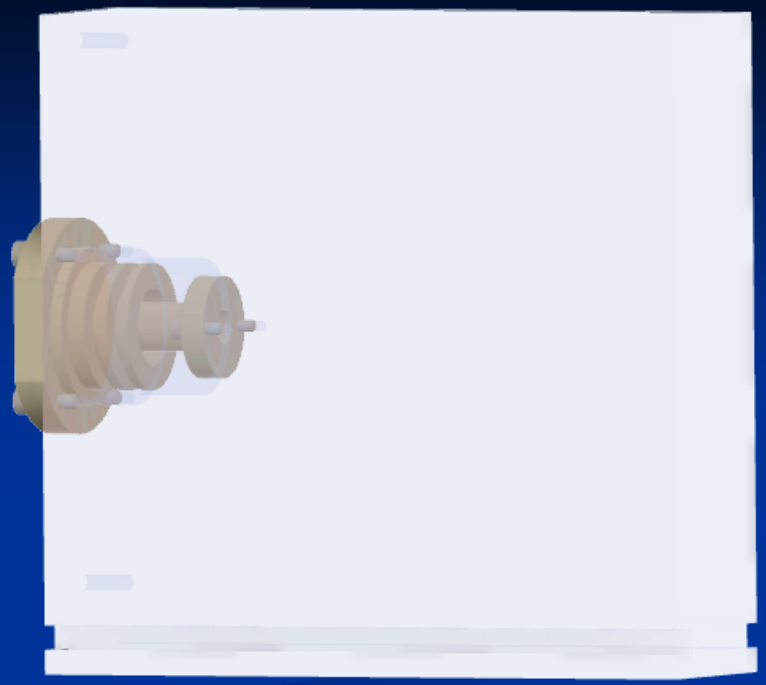


Photointerrupter (SG211V)



Position sensor (LVDT)

- Virgo accelerometers employ the LVDT as the position sensor.
- The LVDT drivers and the digital system in KAGRA can be used to make the servo system.

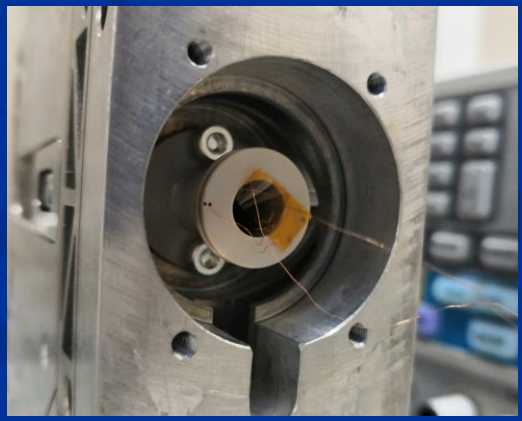


Assembly in 3D model

LVDT coils

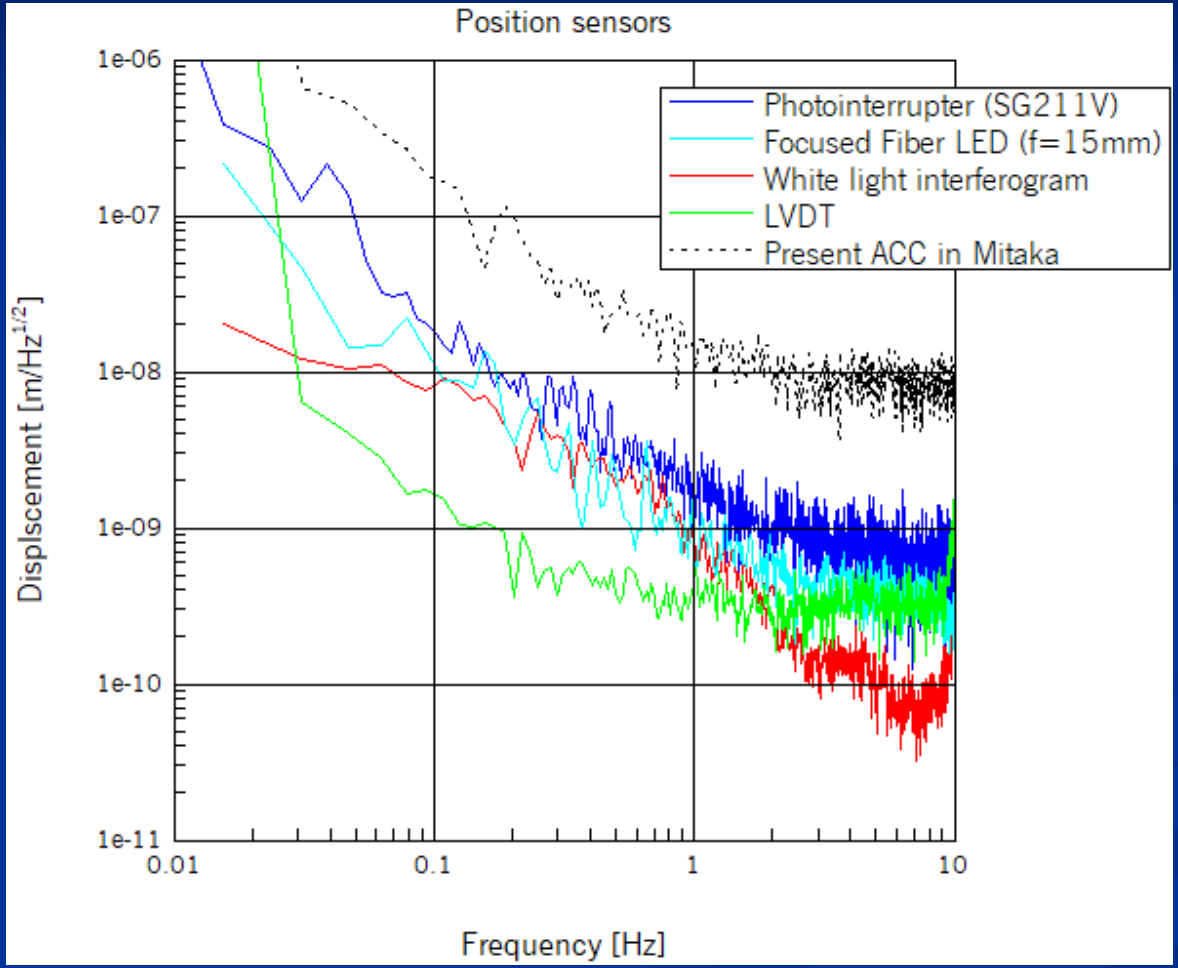
[Primary]
AWG 46 (OD: 0.05mm)
68 turn, 28.6 Ω

[Secondary]
AWG 36 (OD: 0.15mm)
300 turn x2, 38.4Ω



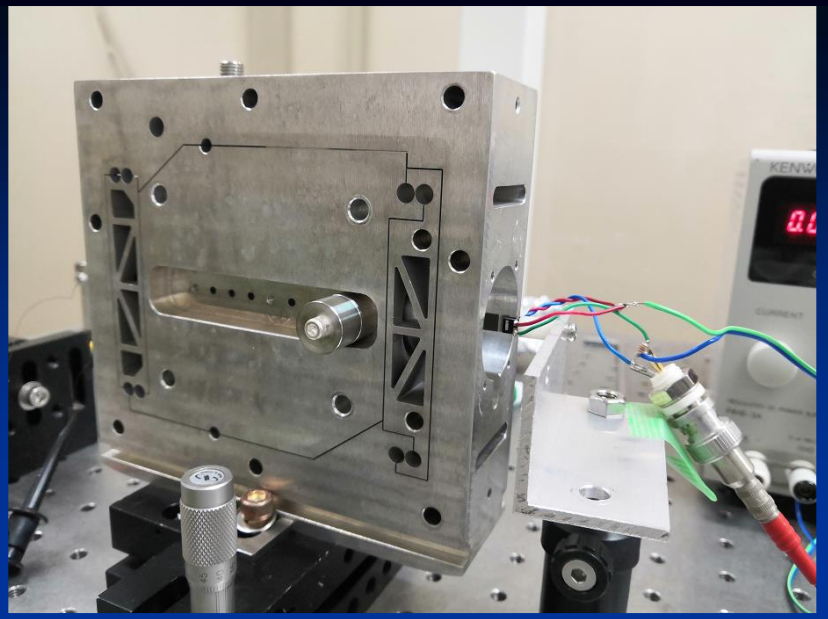
Primary coil on proof mass

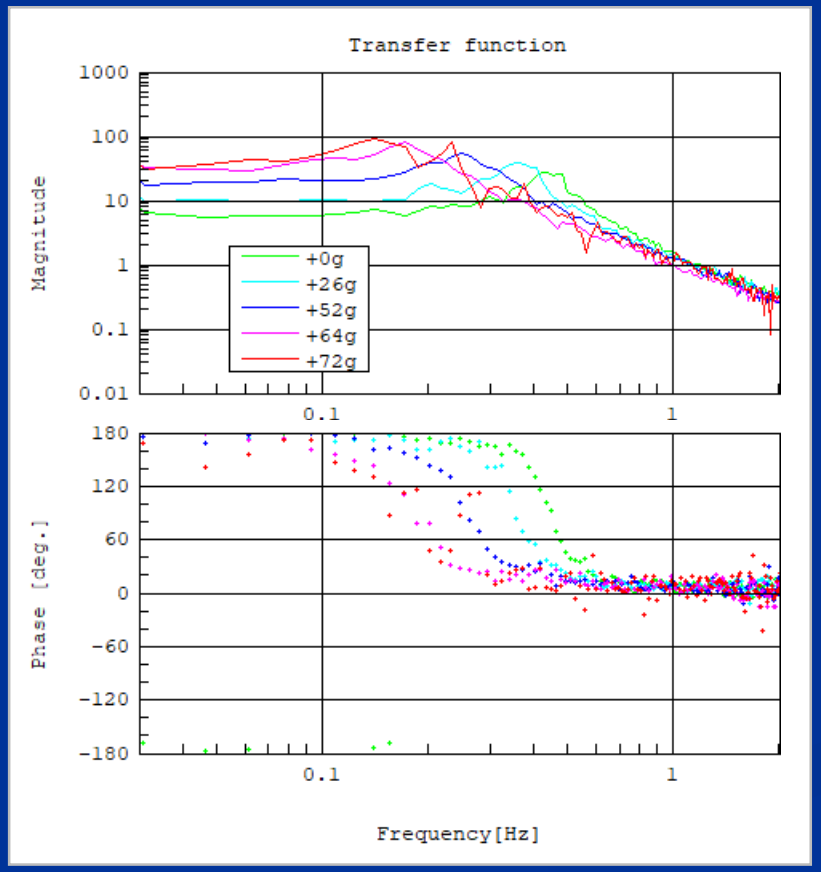
Displacement sensitivity of position sensors

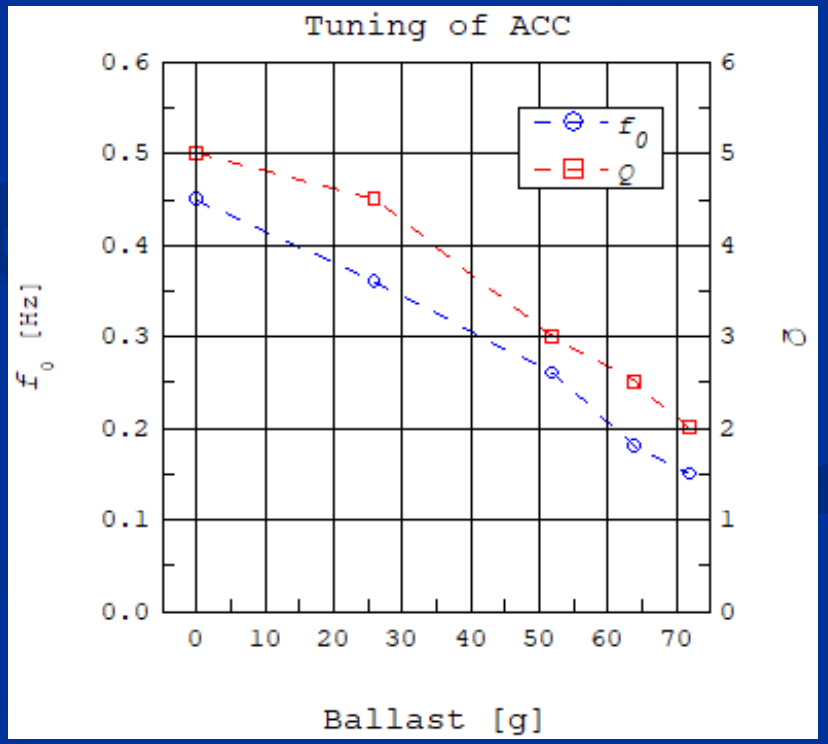


Tuning of folded pendulum

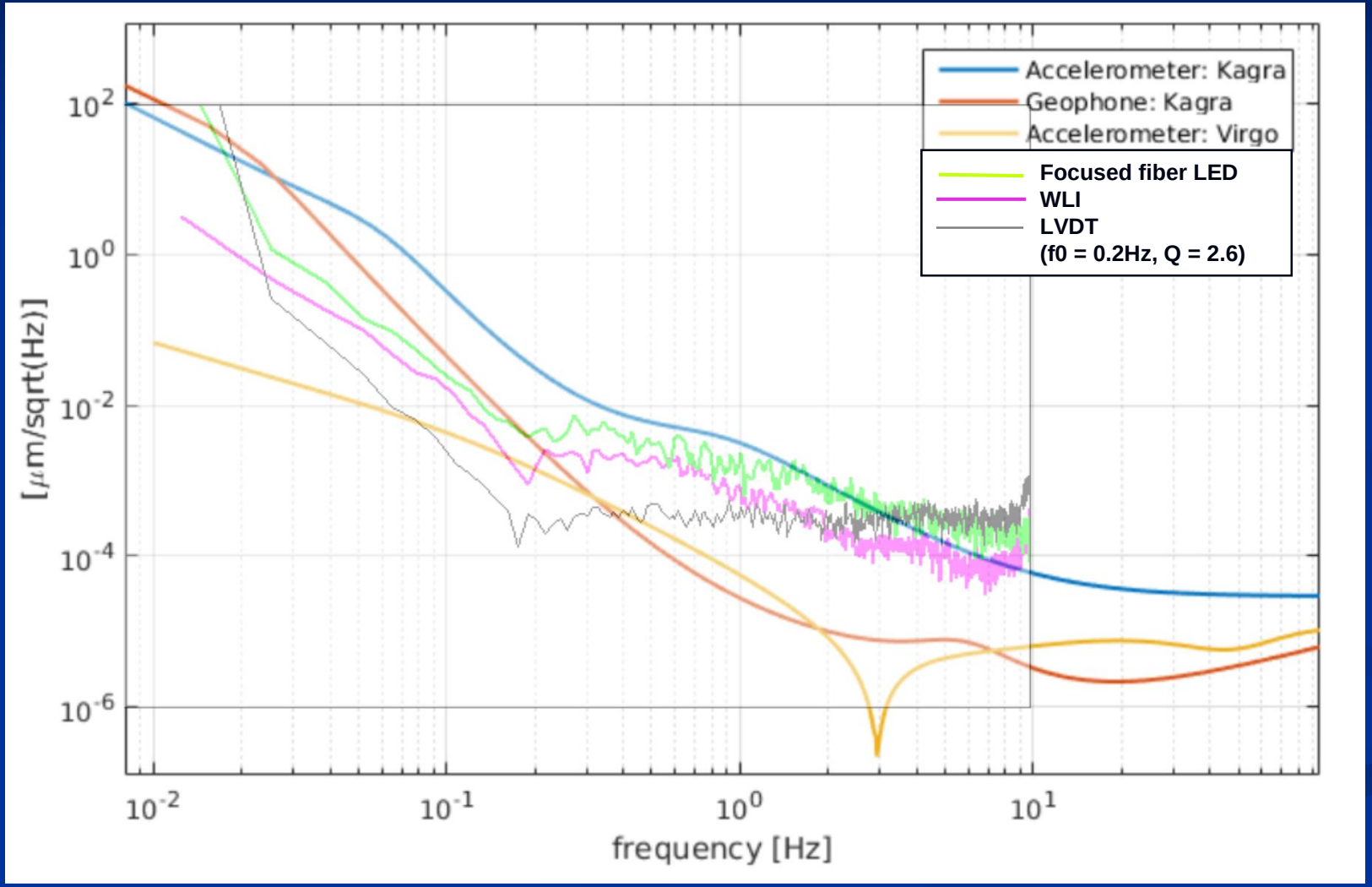
- Default resonant frequency is 0.4Hz.
- Adding the ballast masses at the IP side, the frequency is decleased.
- Q is also decreased.
- We can tune the frequency to be lower than 0.2Hz.







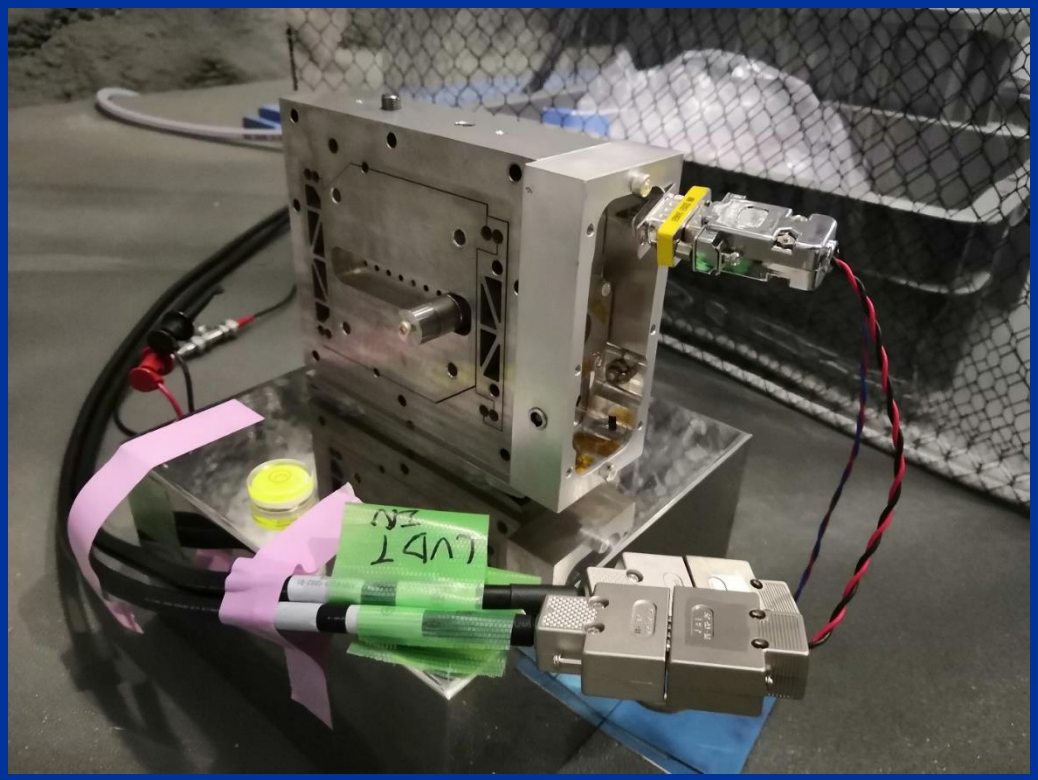
Comparison of inertial sensors



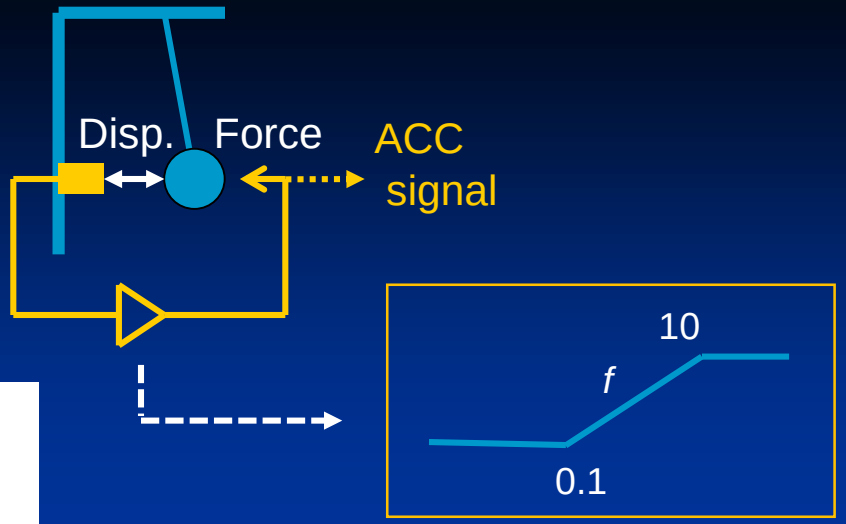
(Original graph by L. Trozzo)

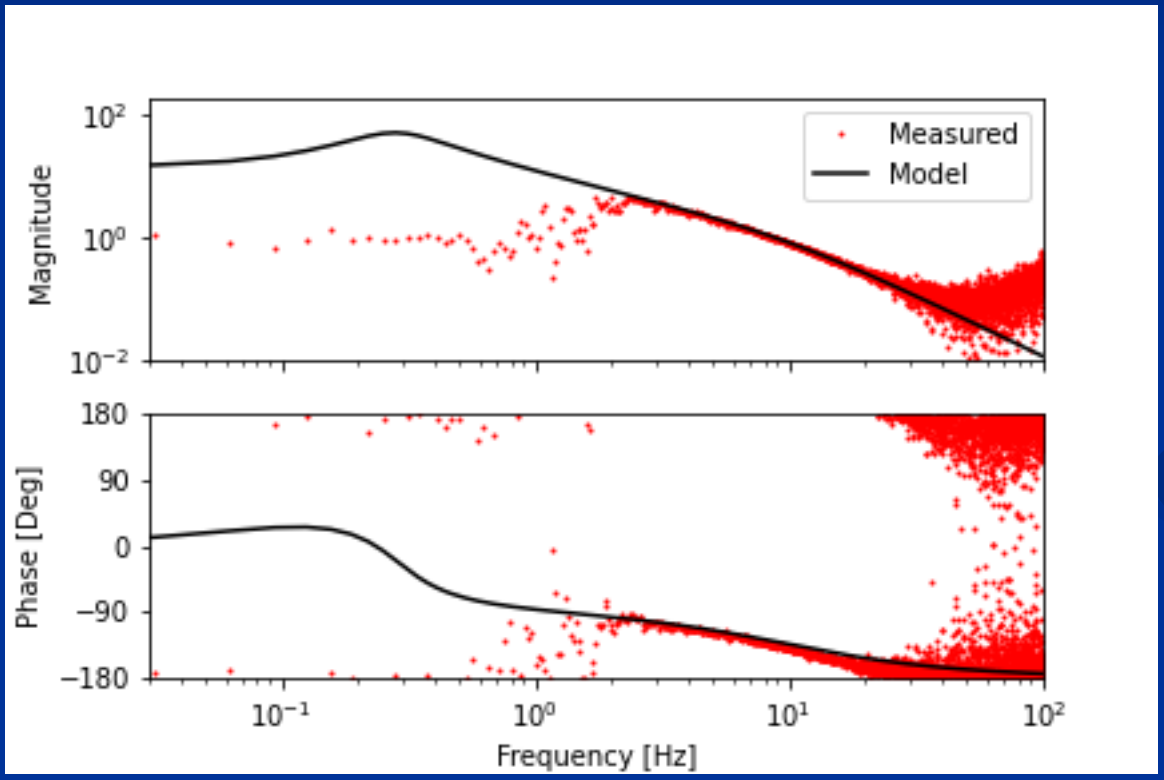
Test at the KAGRA site

- The ACC prototype with LVDT was set on the 30-kg SUS block in IY.
- The resonant frequency was tuned to 0.24Hz.
- The ACC was covered by the boxes to avoid air flow.
- Servo filter consist of the digital system with the high-power coil driver.
- Spectra were compared with the seismometer in IX.

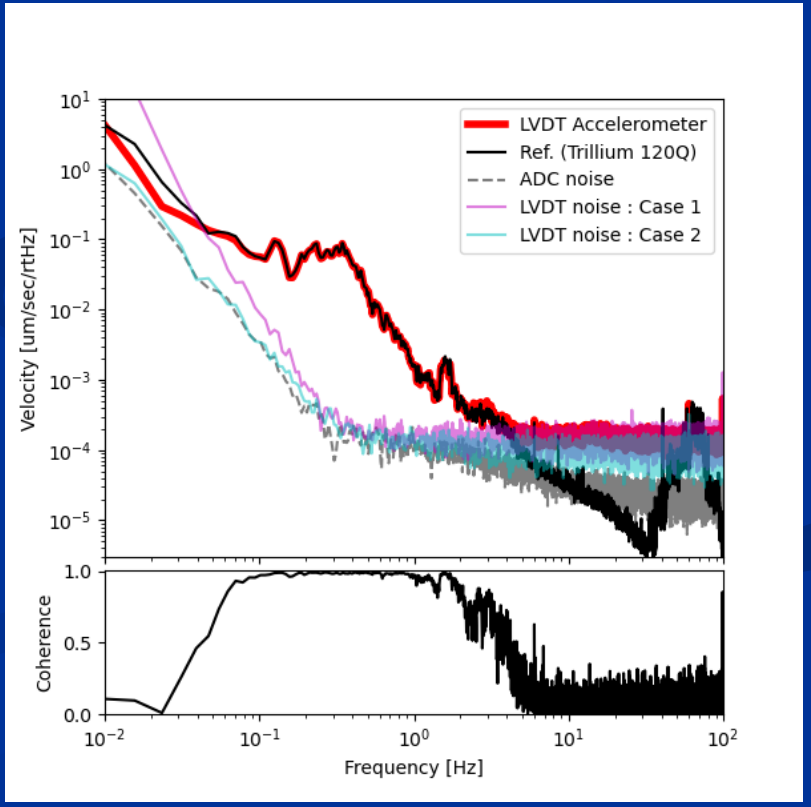


Servo accelerometer using the digital system



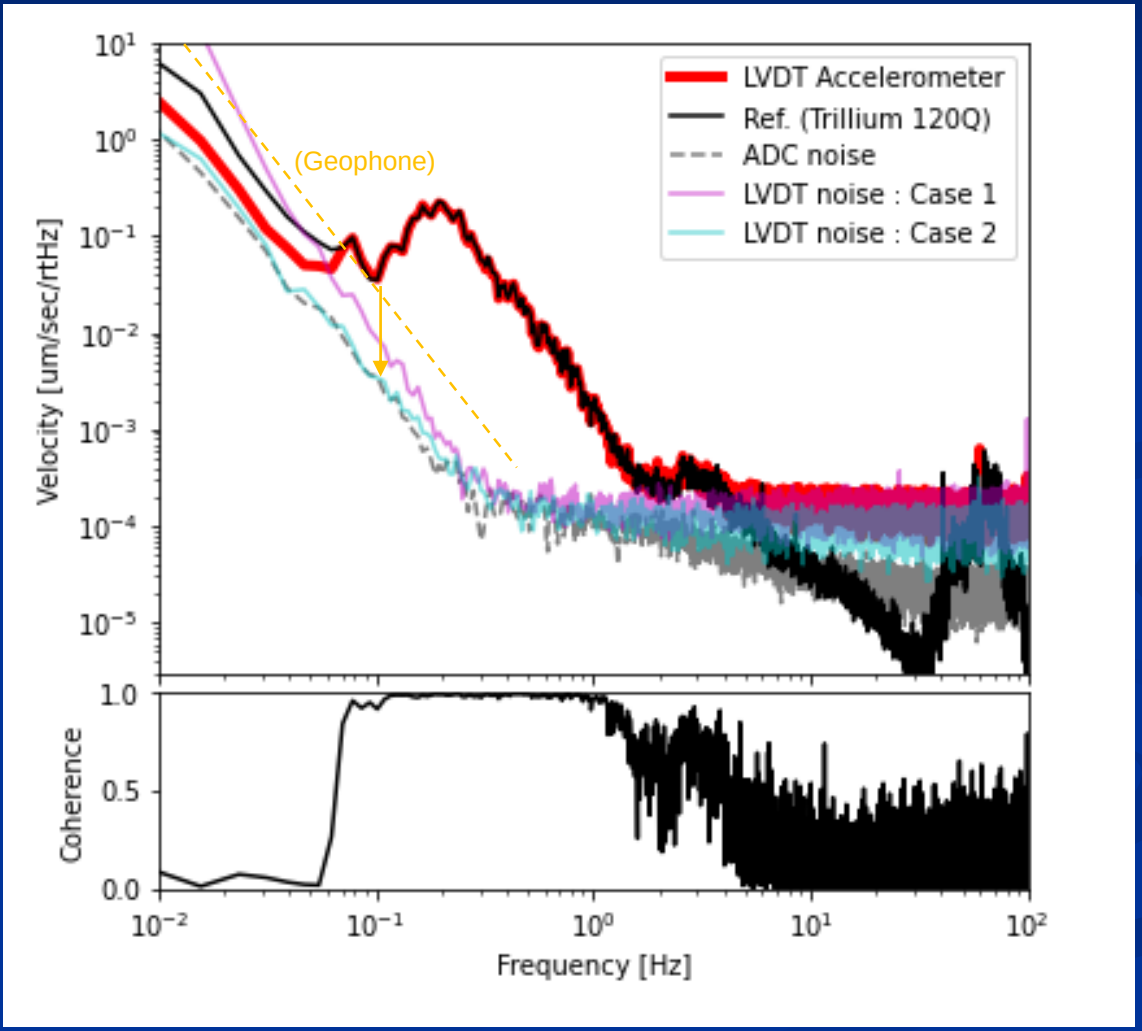


UGF: 9Hz, Phase margin: 60deg.



(Implemented by K. Miyo)

Measured spectra at the KAGRA site



(Measured by K. Miyo)

Summary

- Improvement of inertial sensors for IP control is one of important tasks towards 04.
- The small LVDT has sensitivity better than other kind of position sensors.
- The folded pendulum is the best as proof mass suspension. The resonant frequencies can be tuned lower than 0.2Hz.
- The accelerometer prototype with LVDT was demonstrated at the KAGRA site and showed good performance.