

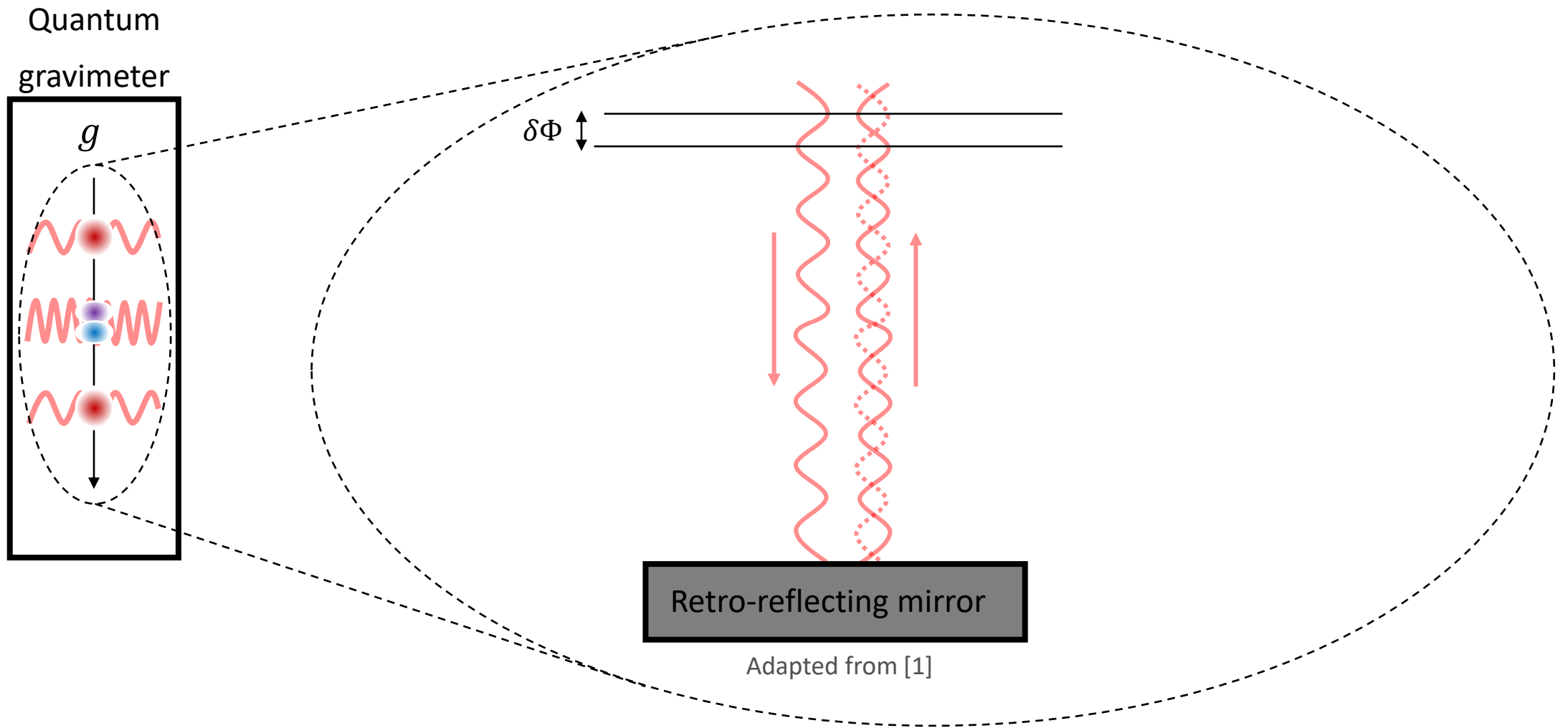
# High resolution compact vertical inertial sensor for atomic quantum gravimeter hybridizing

Anthony Amorosi, Amez-Droz Loïc, Christophe Collette (supervisor)

2nd year PhD at ULiège & ULB (Belgium)

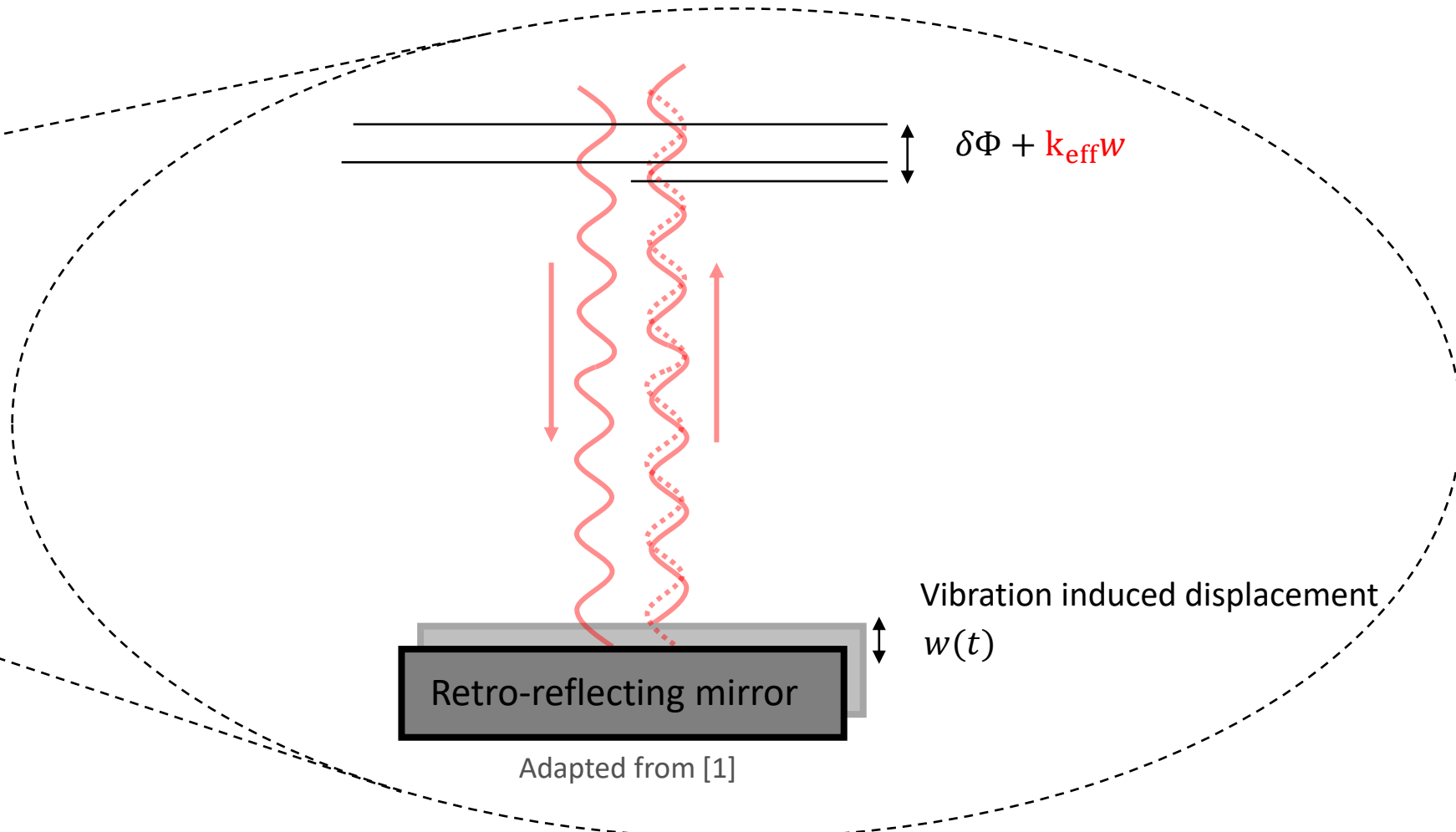
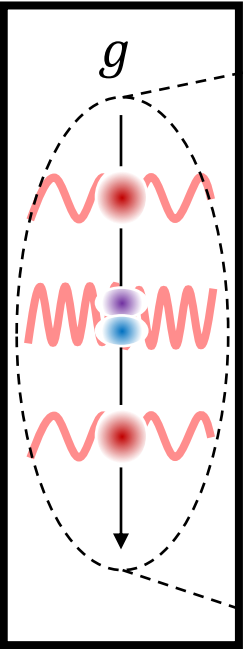
November 18, 2022

# Quantum gravimeter



# Quantum gravimeter

Quantum gravimeter

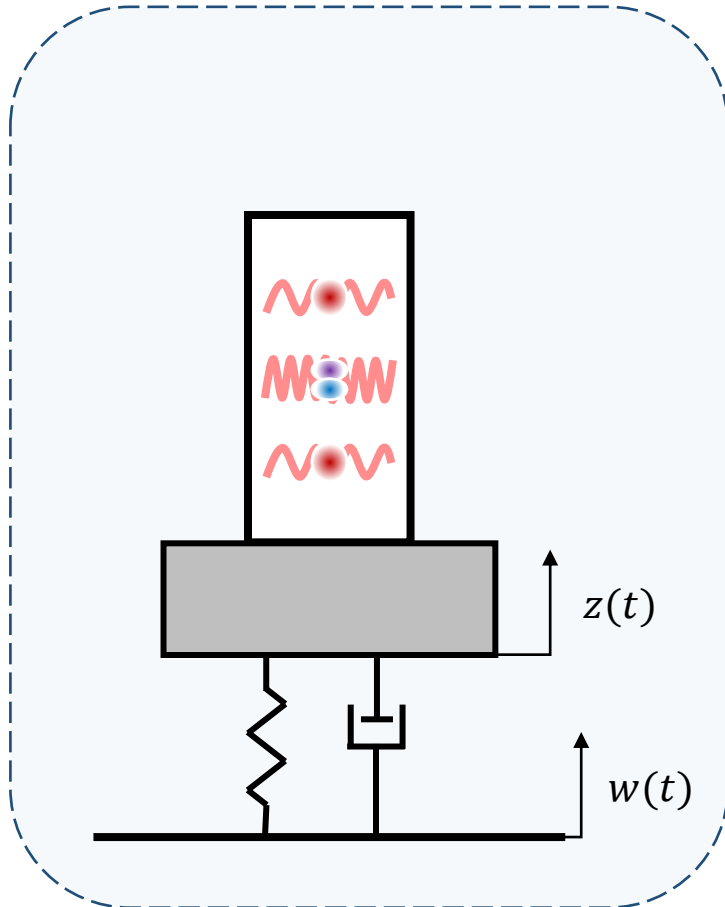


Retro-reflecting mirror

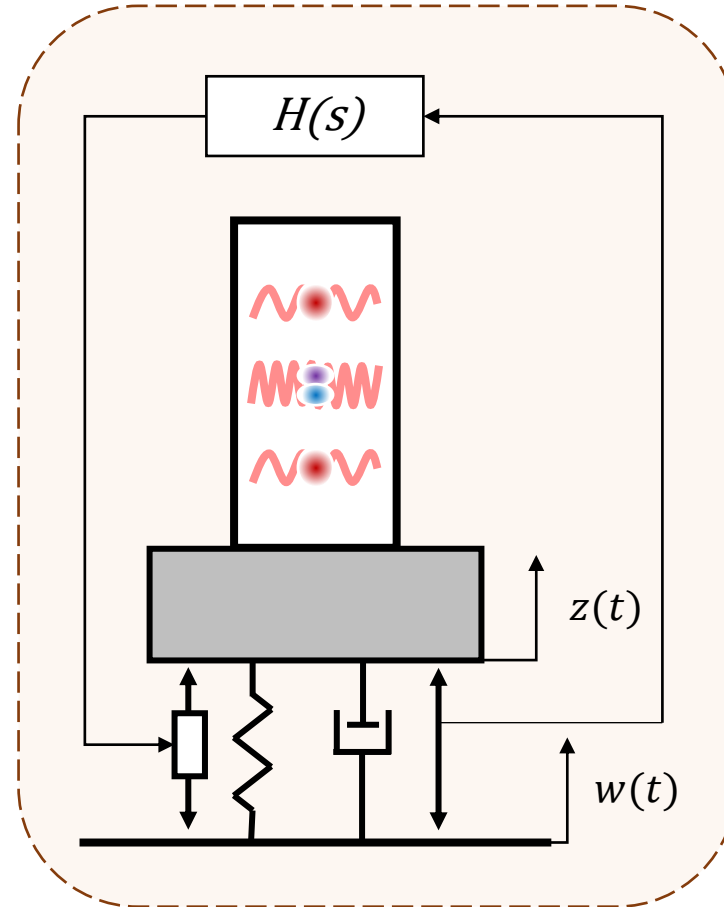
Adapted from [1]

# Vibration compensation techniques

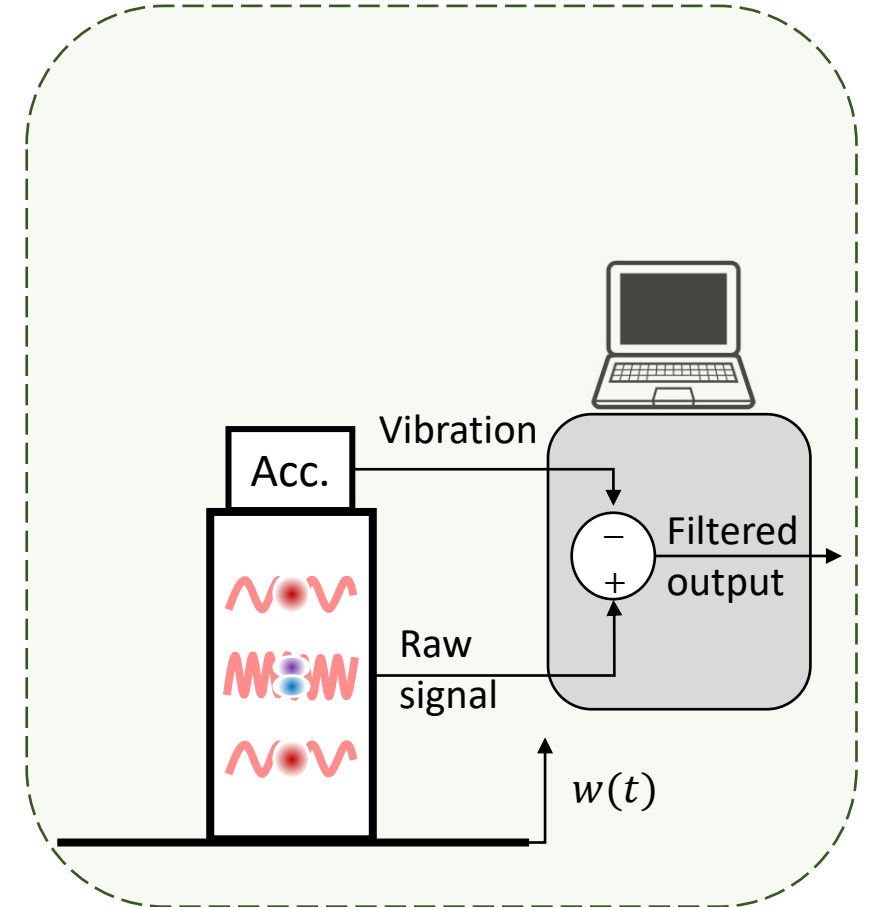
Passive vibration isolation



Active vibration isolation

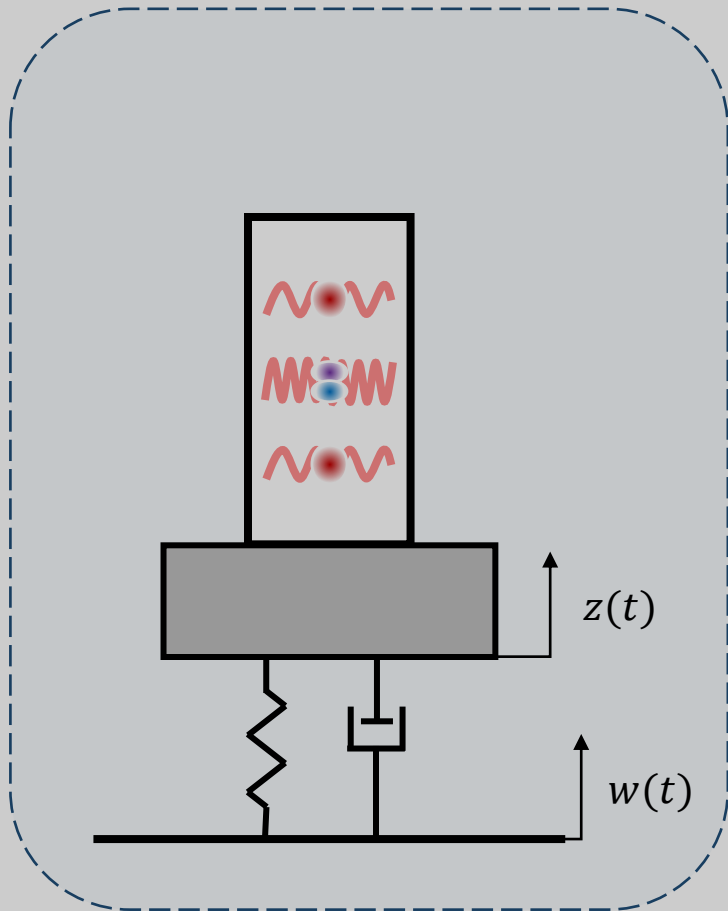


Software rejection

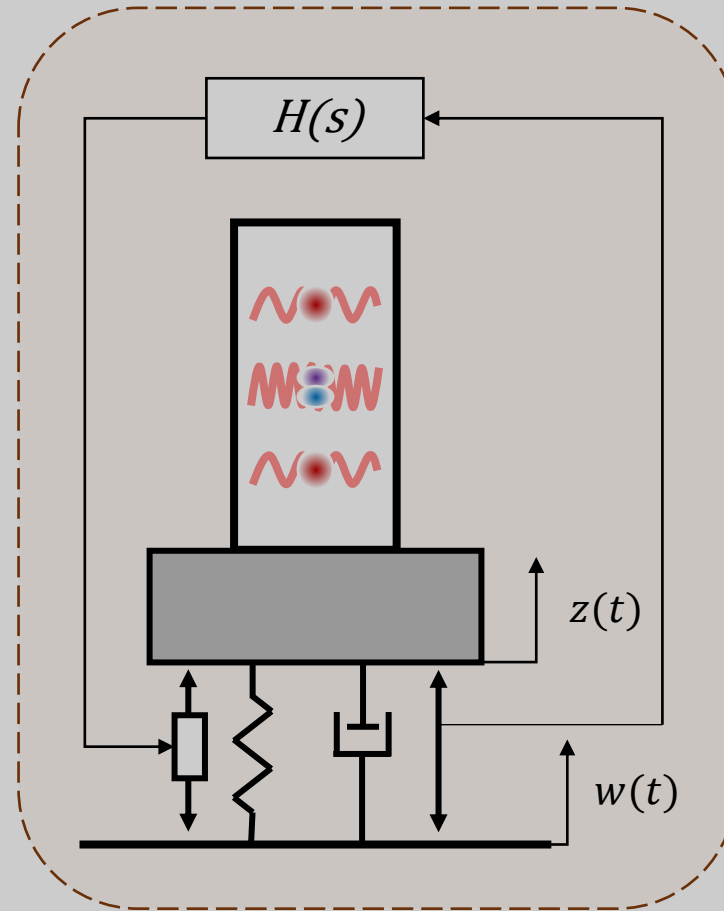


# Vibration compensation techniques

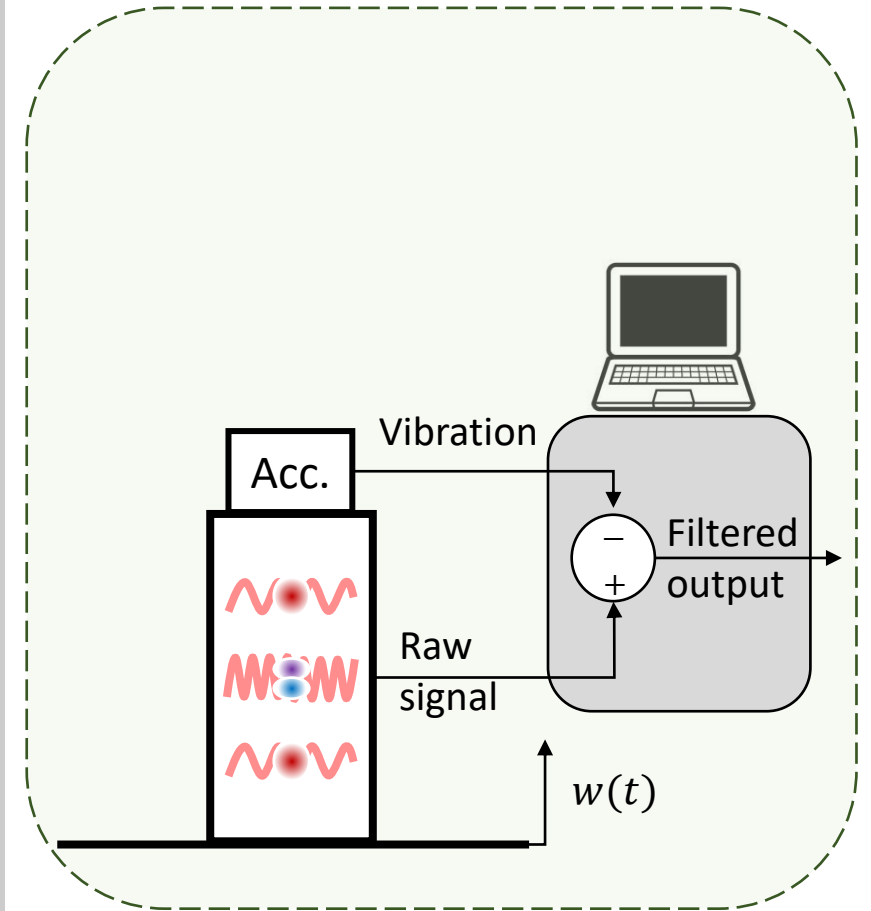
Passive vibration isolation



Active vibration isolation



Software rejection



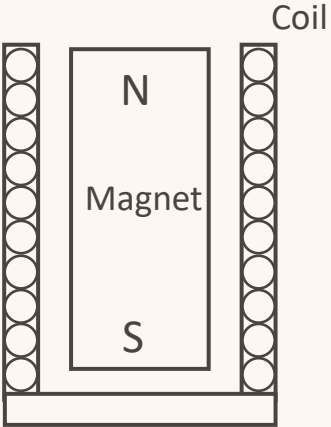
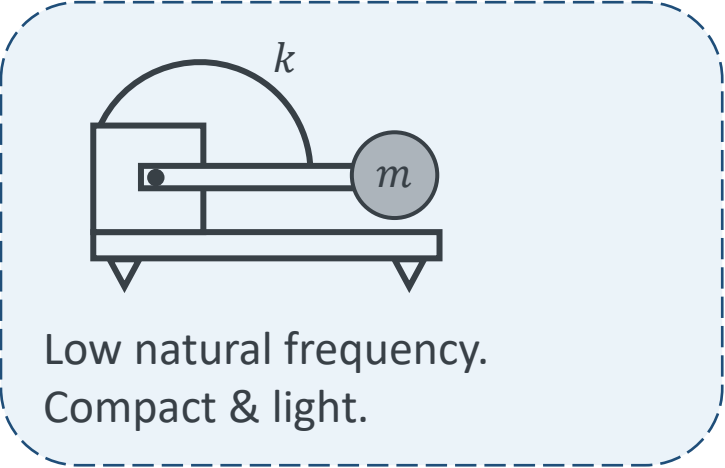
# Outline

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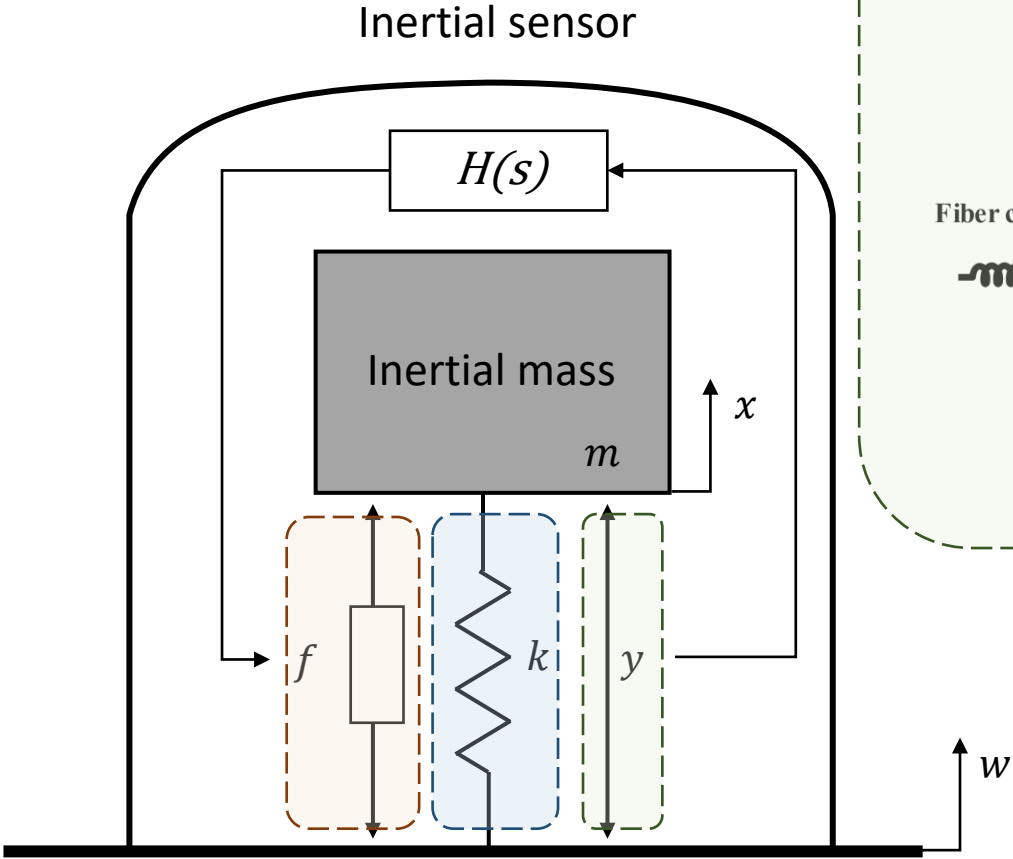
- Gravimeters and effects of ground vibrations
- Compact Vertical INterferometric Sensor ( $\mu$ VINS)
- Conclusion and future work

# Vertical inertial sensor

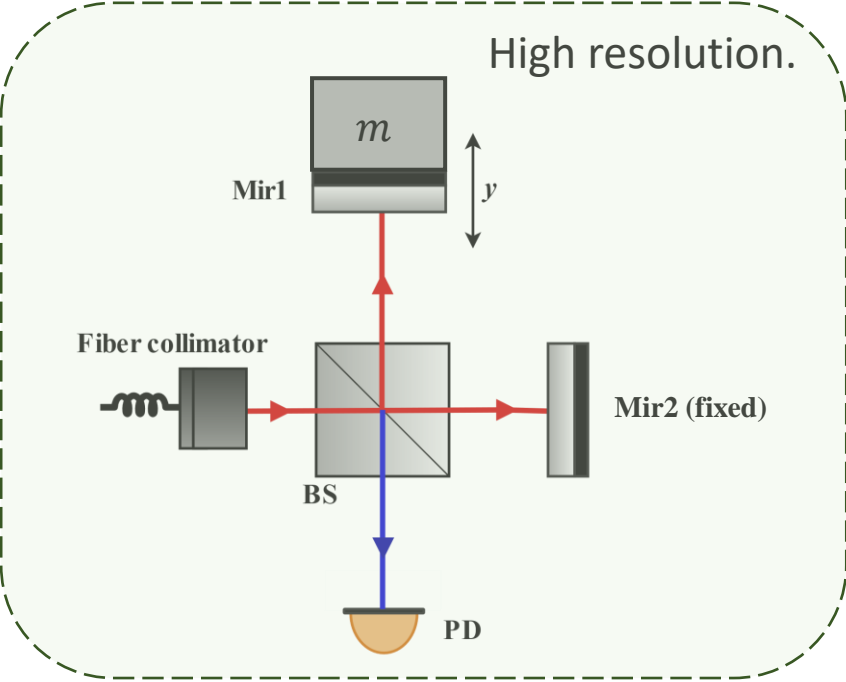
Low stiffness mechanics and guidance



Low noise injection.  
Improved linearity and bandwidth.



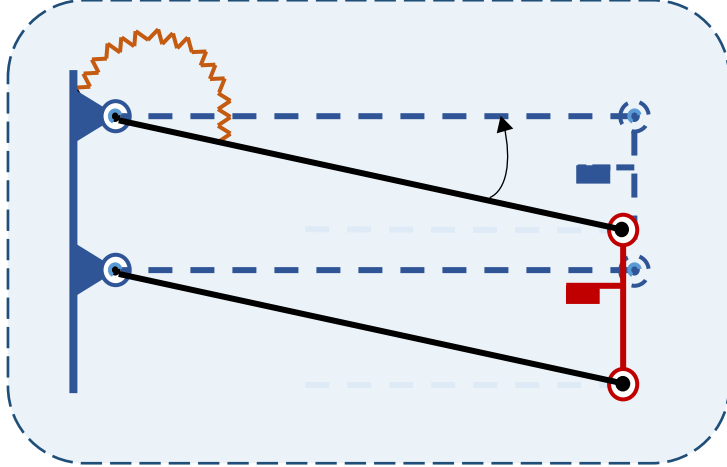
Contactless actuation



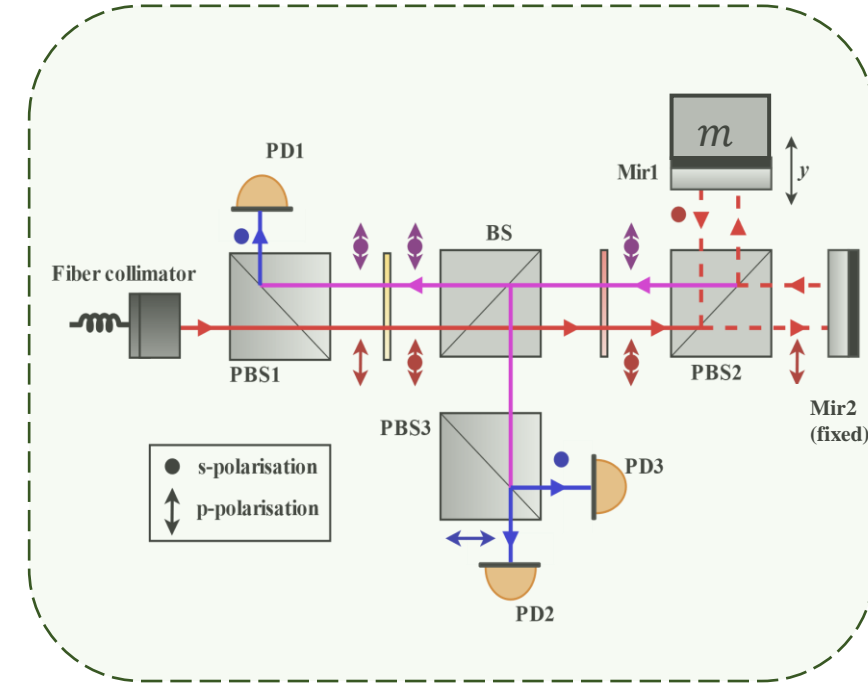
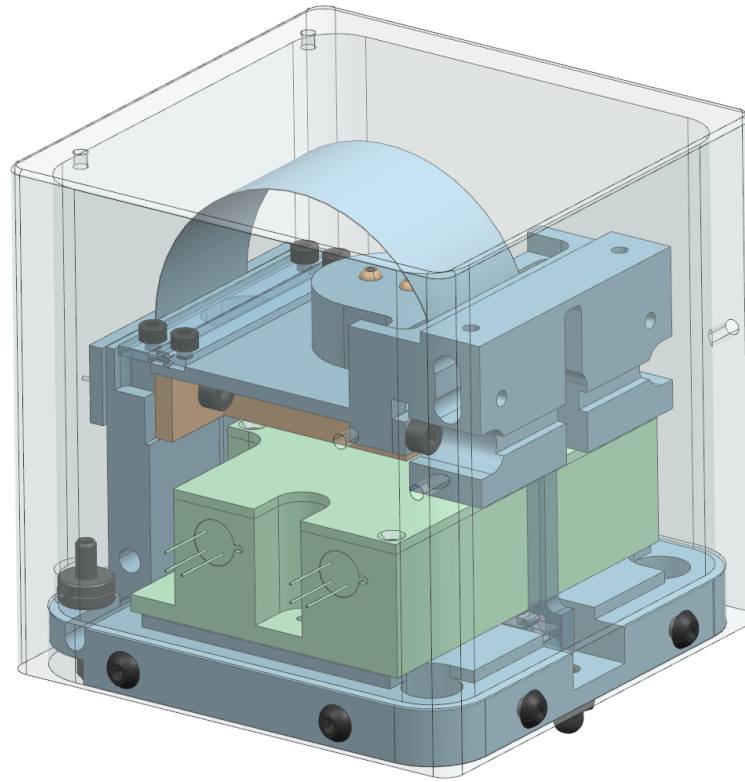
Contactless readout

# $\mu$ - Vertical INterferometric inertial Sensor

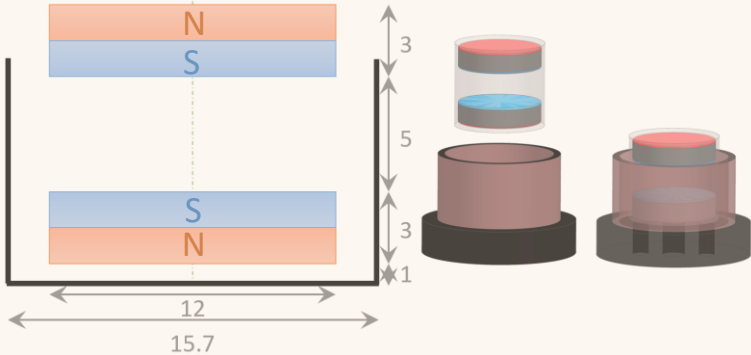
Low stiffness mechanics and guidance



$\mu$ VINS



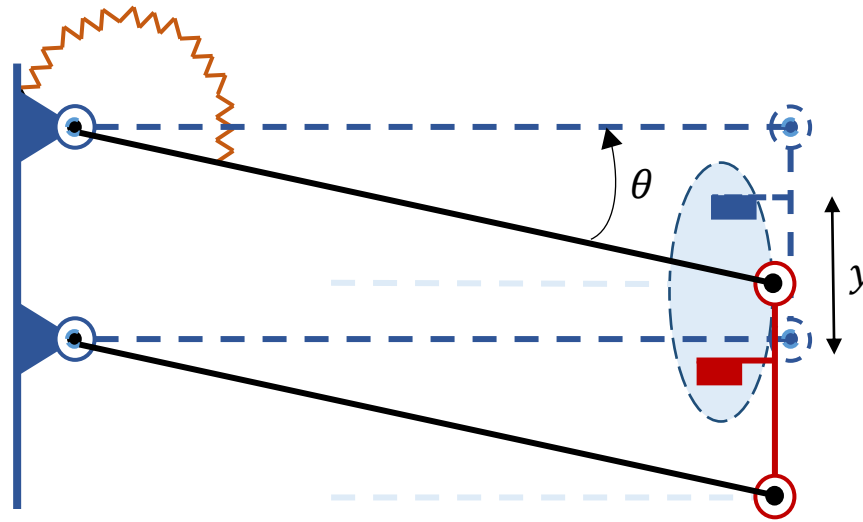
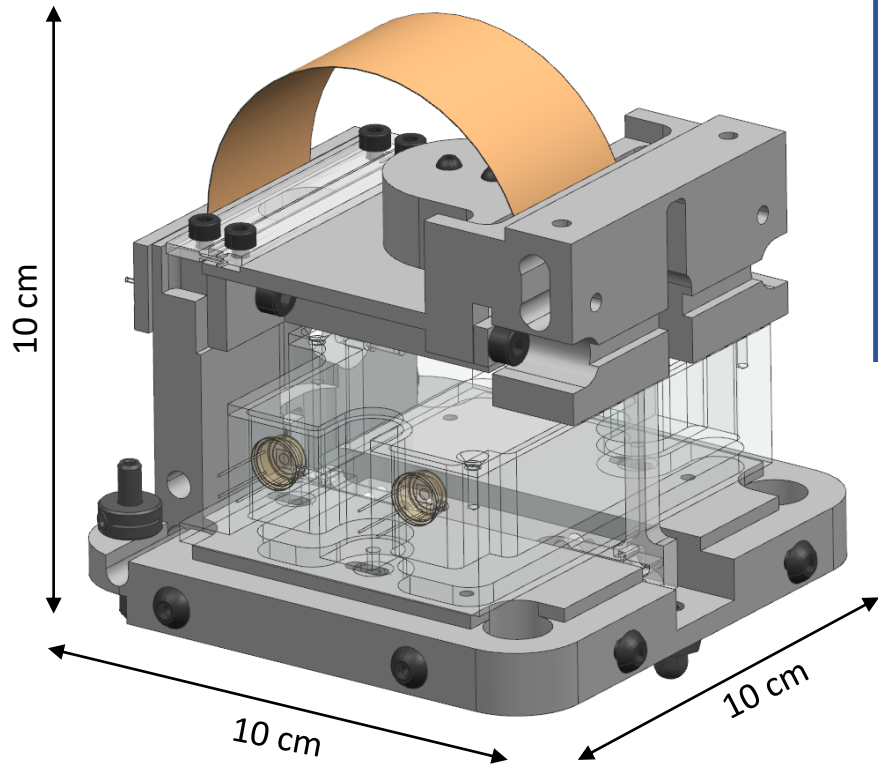
Contactless readout



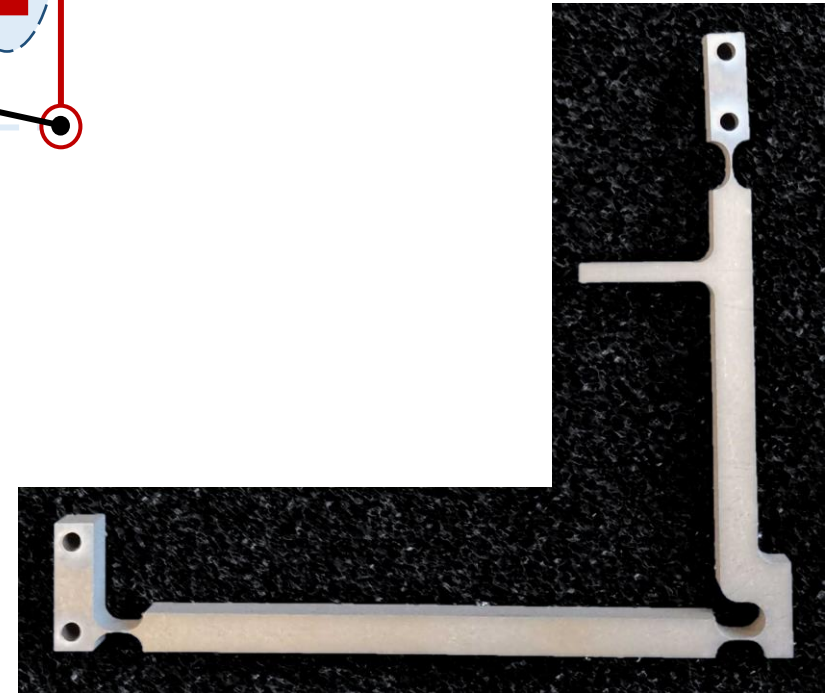
Contactless actuation



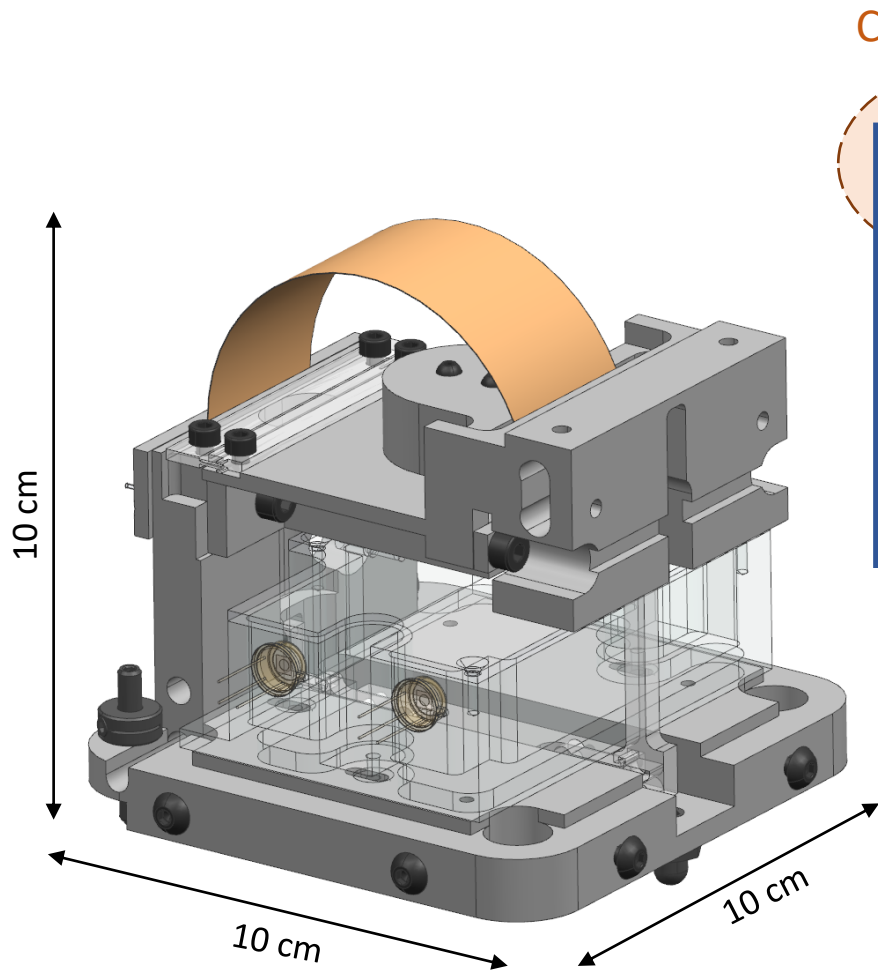
# Low stiffness mechanical guide



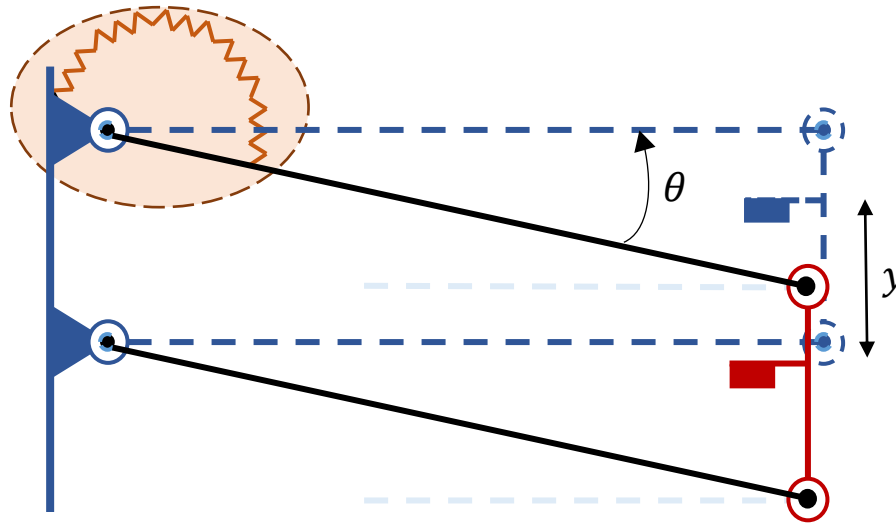
Linear, angle-maintaining,  
motion of the mirror.



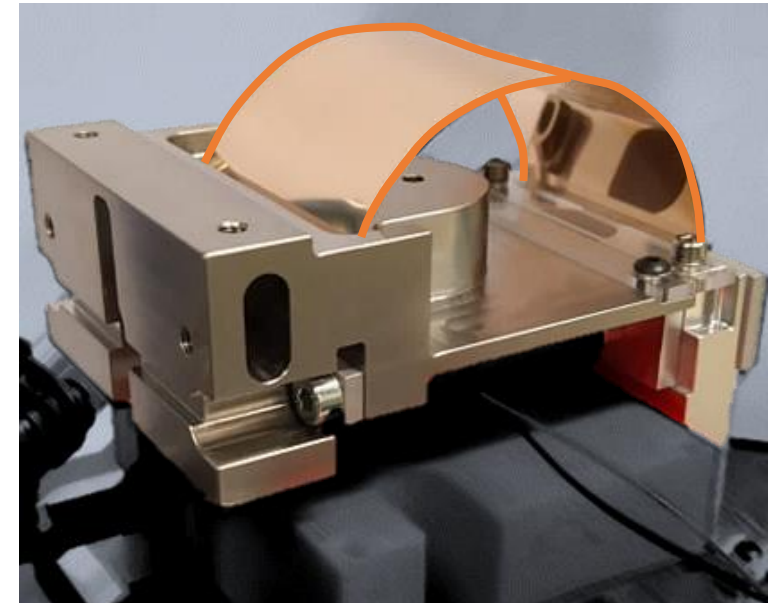
# Low stiffness mechanical guide



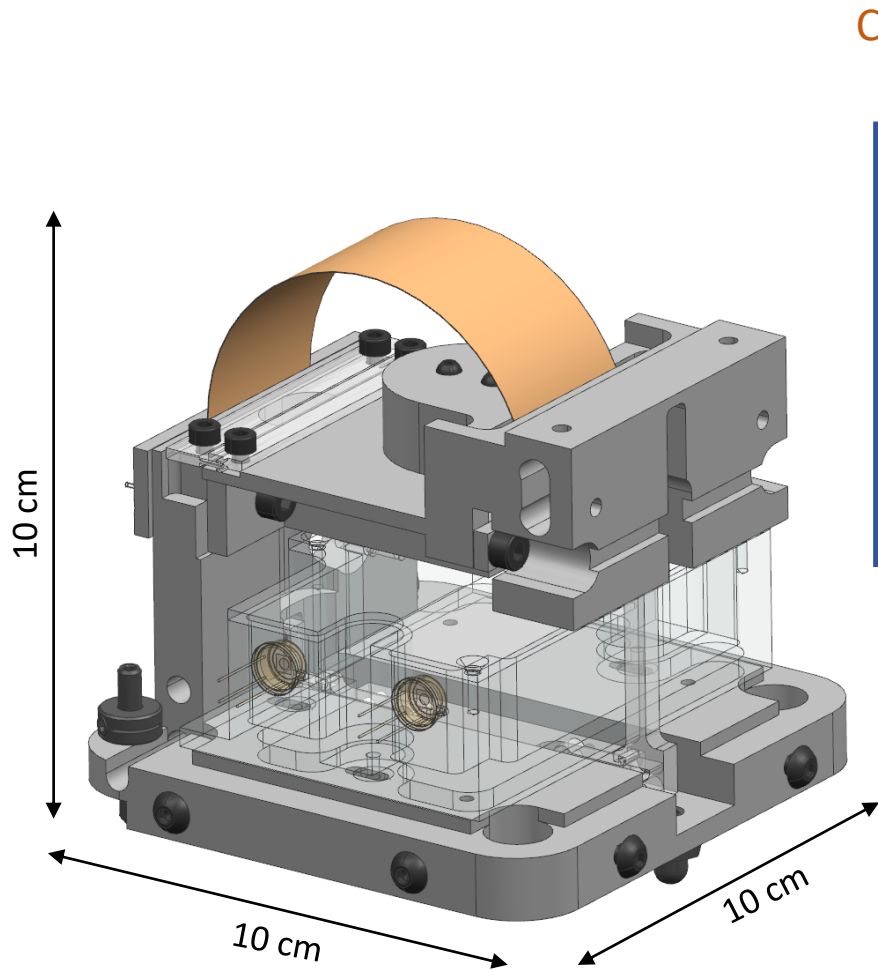
CuBe leaf-spring



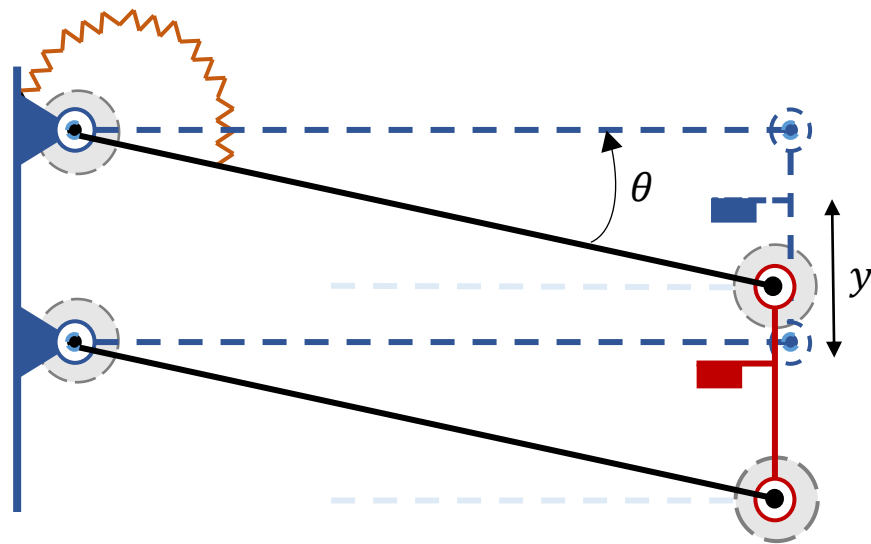
2.8 Hz natural frequency suspension.



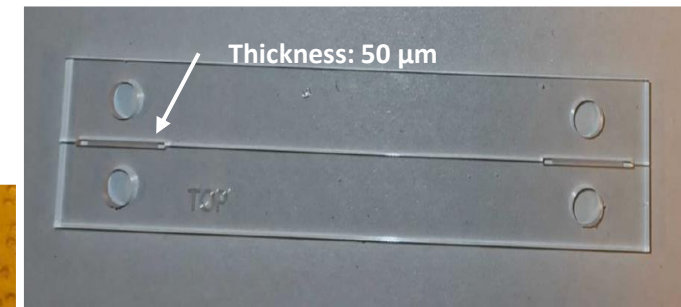
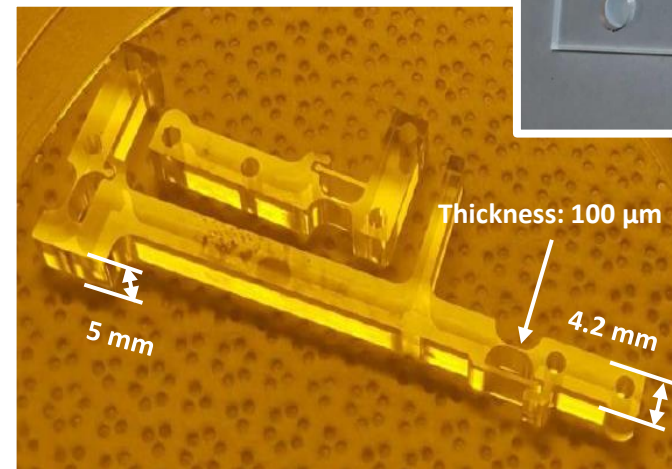
# Low stiffness mechanical guide



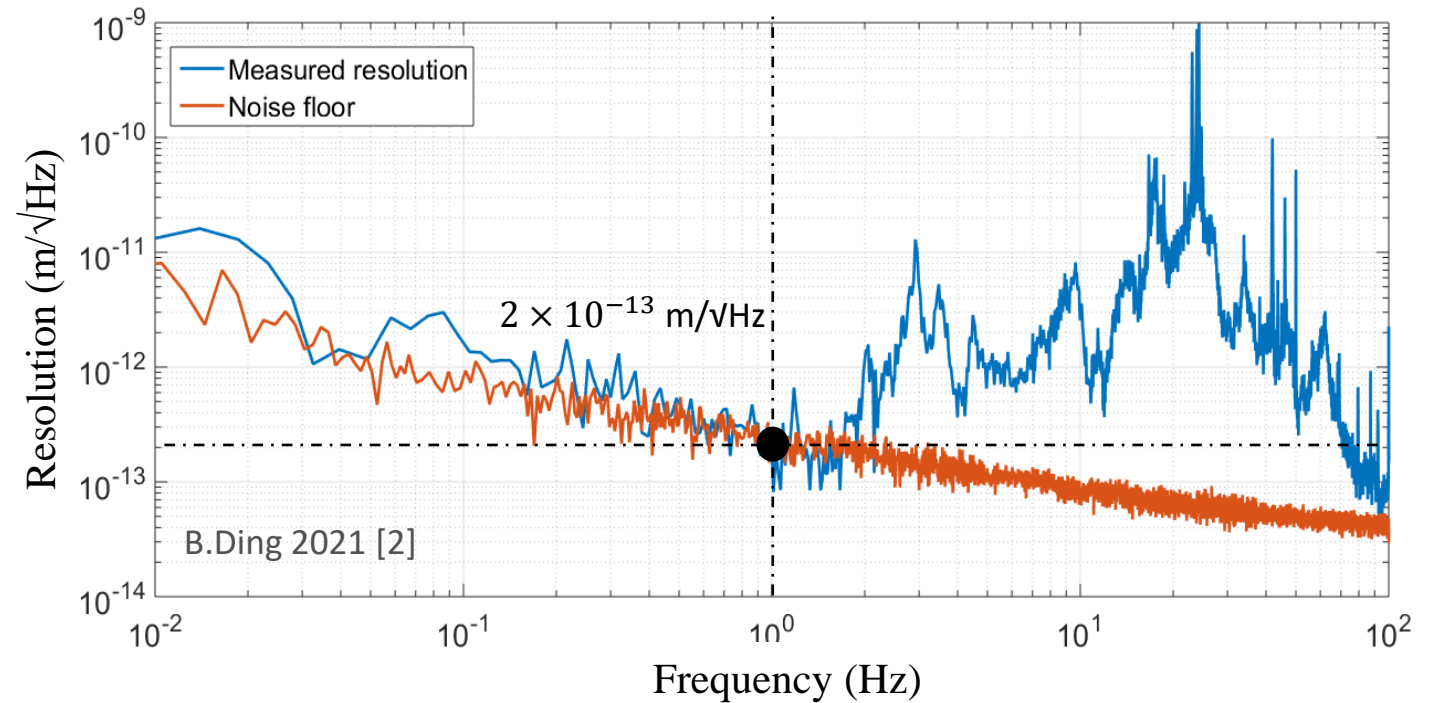
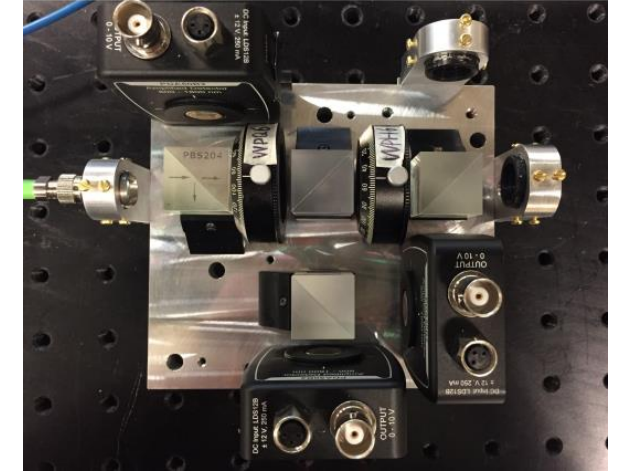
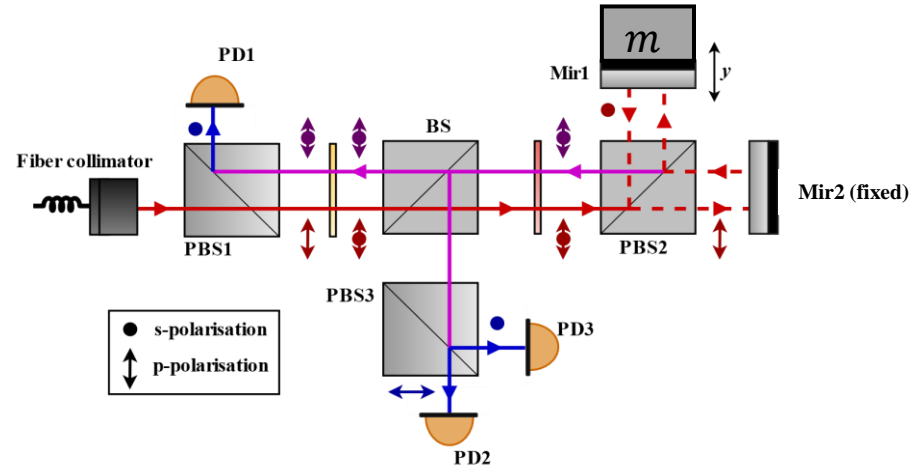
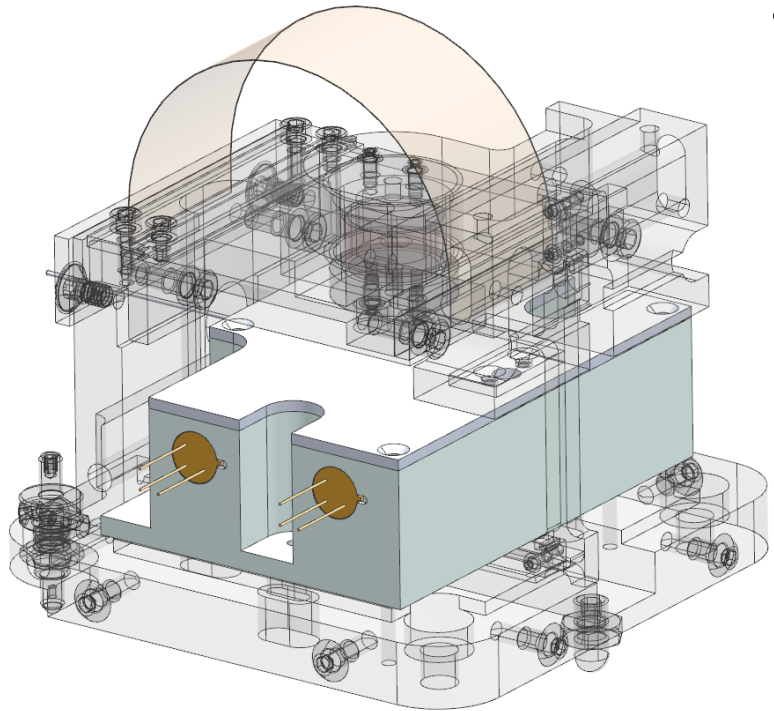
CuBe leaf-spring



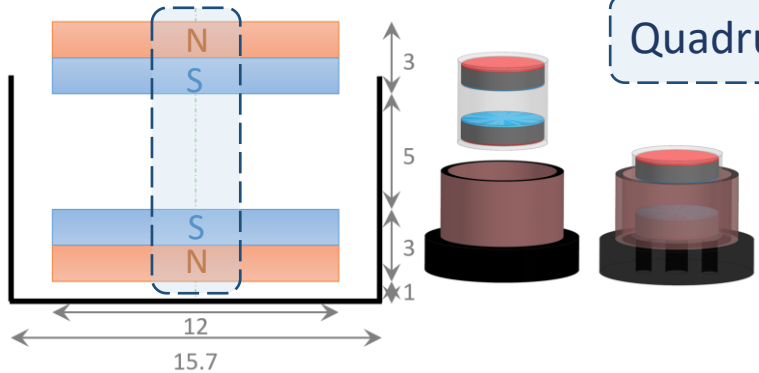
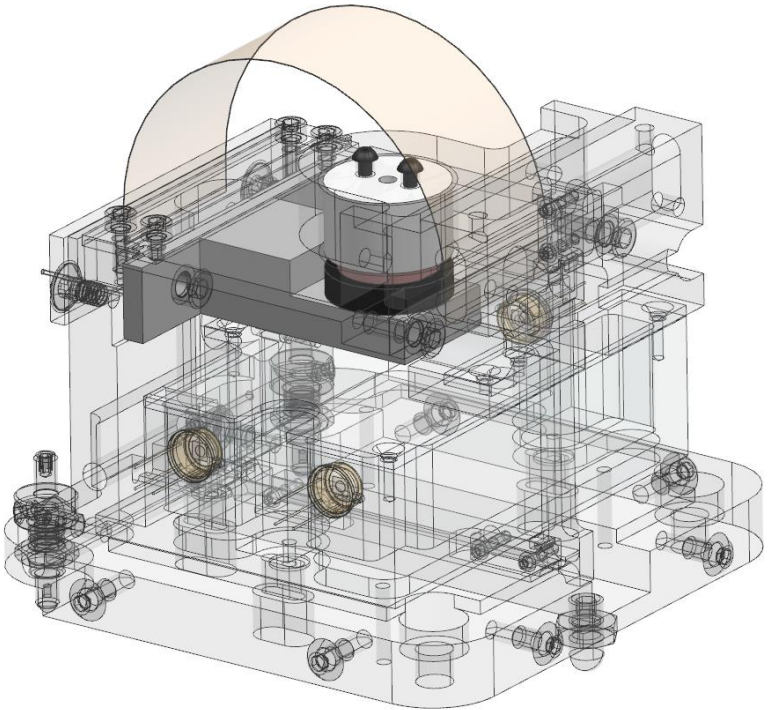
Low dissipation fused-silica joints.



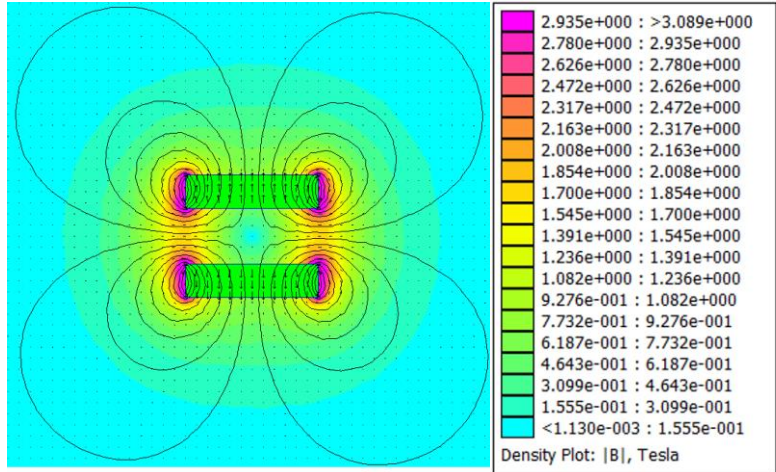
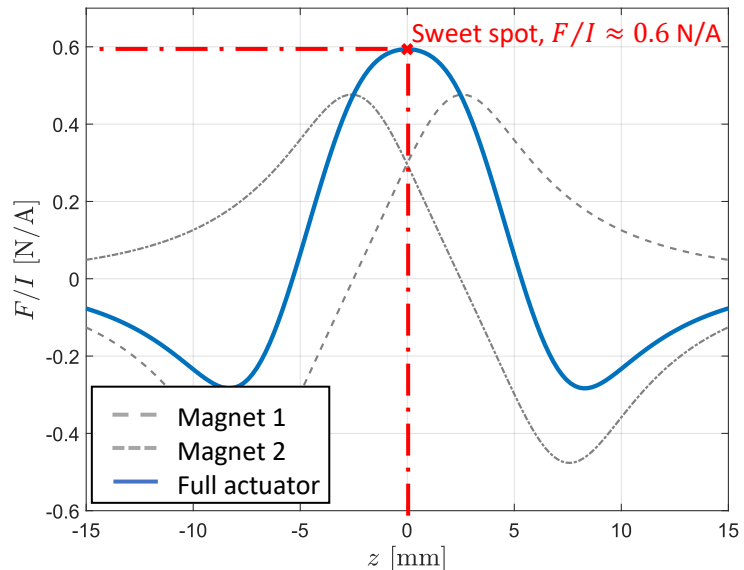
# Interferometric readout



# Quadrupole voice-coil actuator

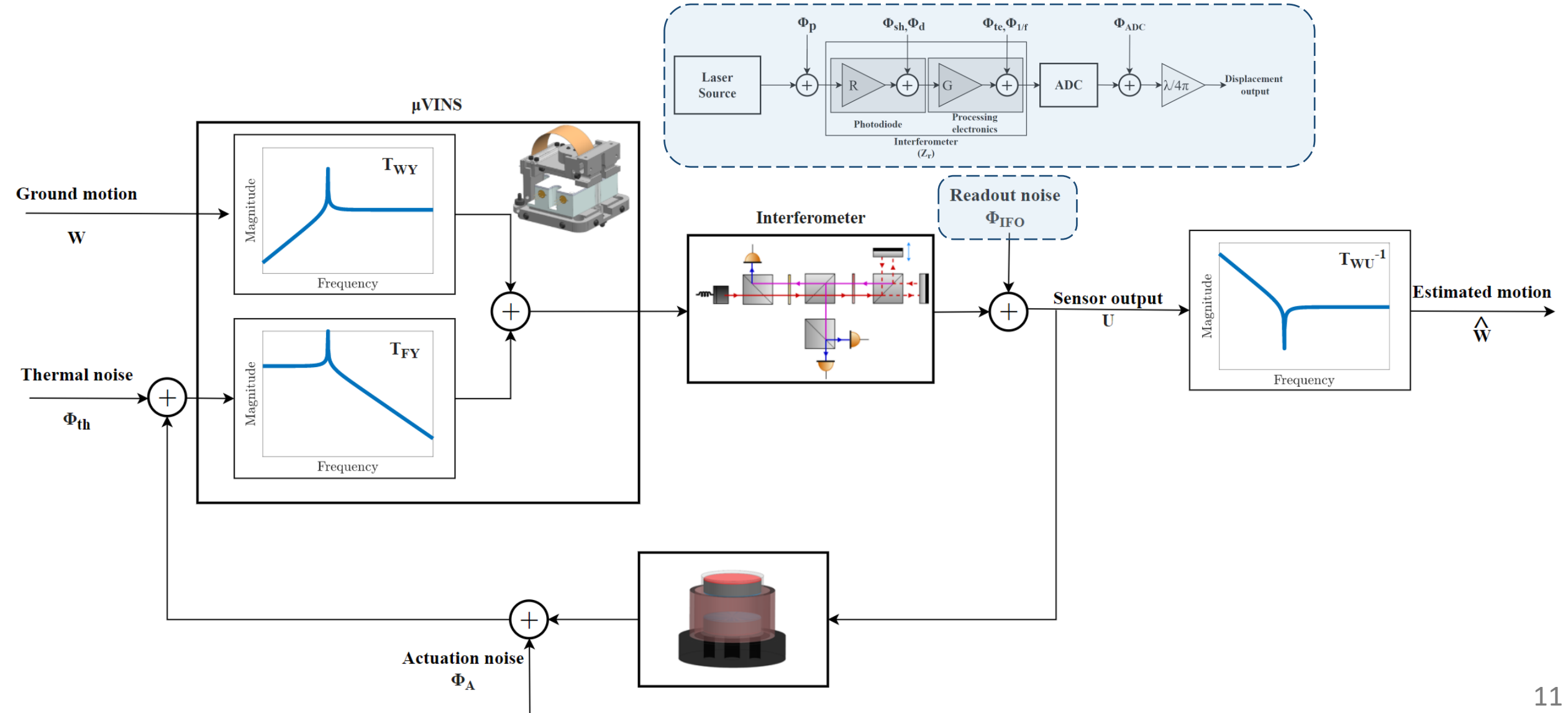


Quadrupole, selfshielded, magnet.

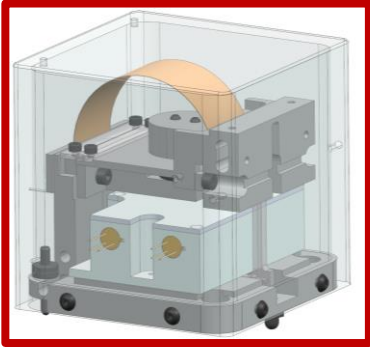


Numerical optimization of the geometry.

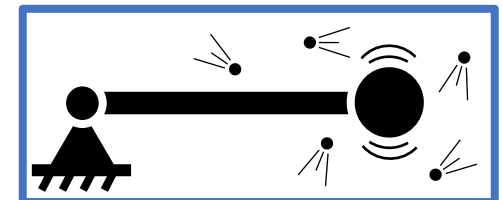
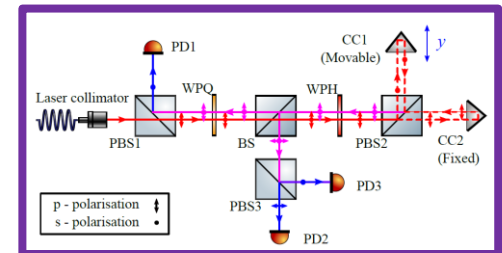
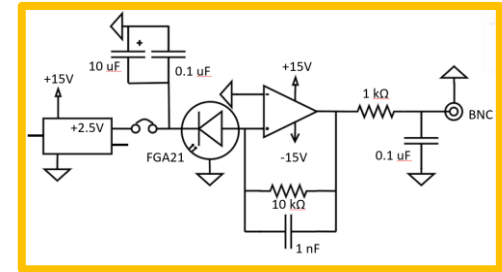
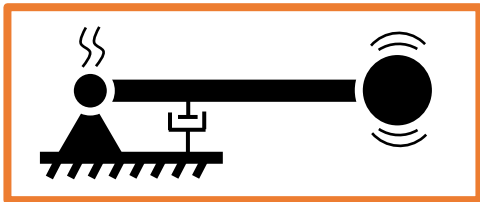
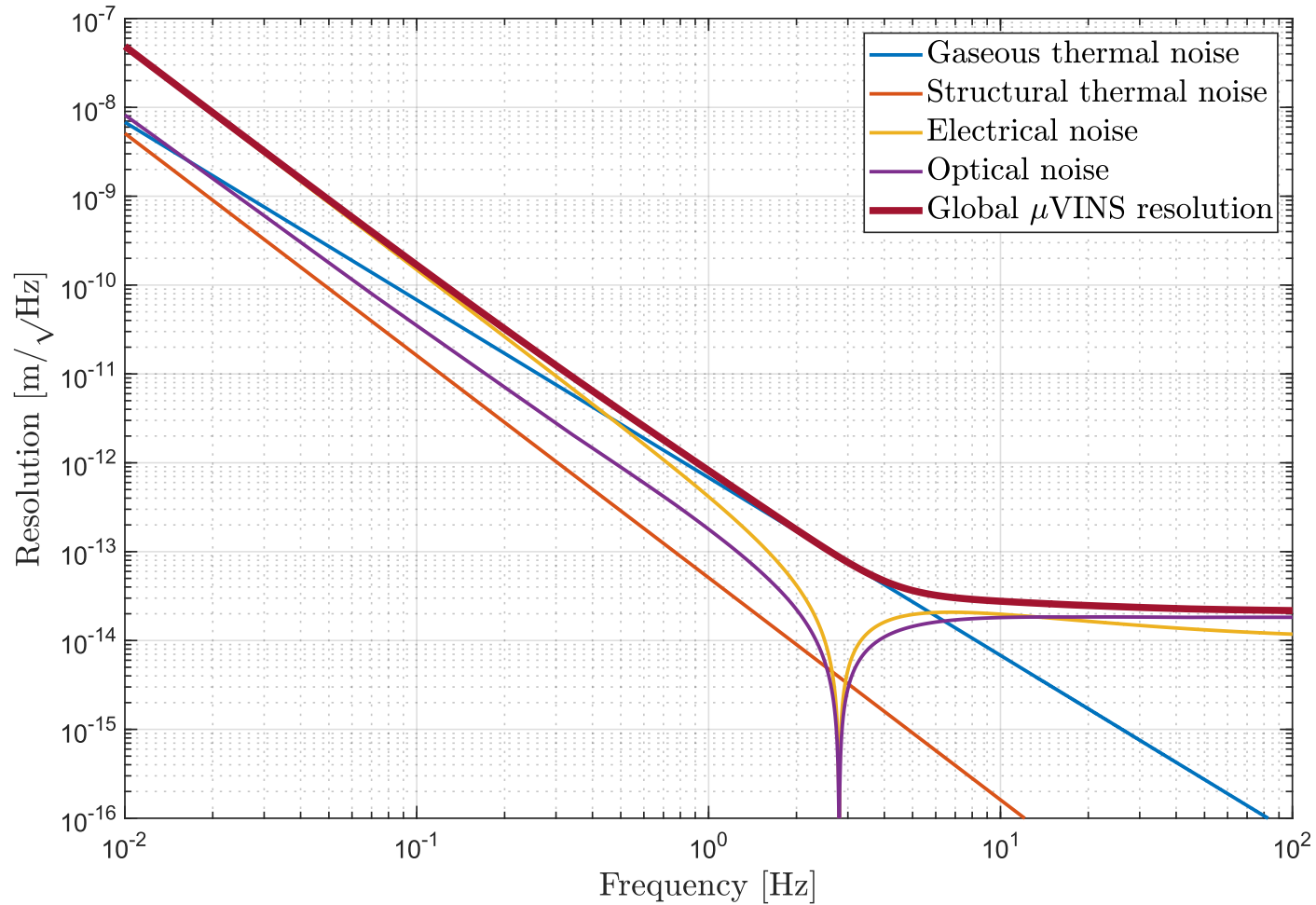
# Noise budgeting



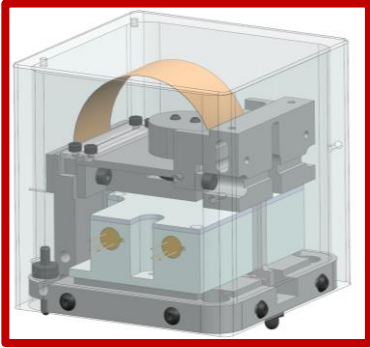
# Noise budget



$\mu$ VINS



# Noise budget



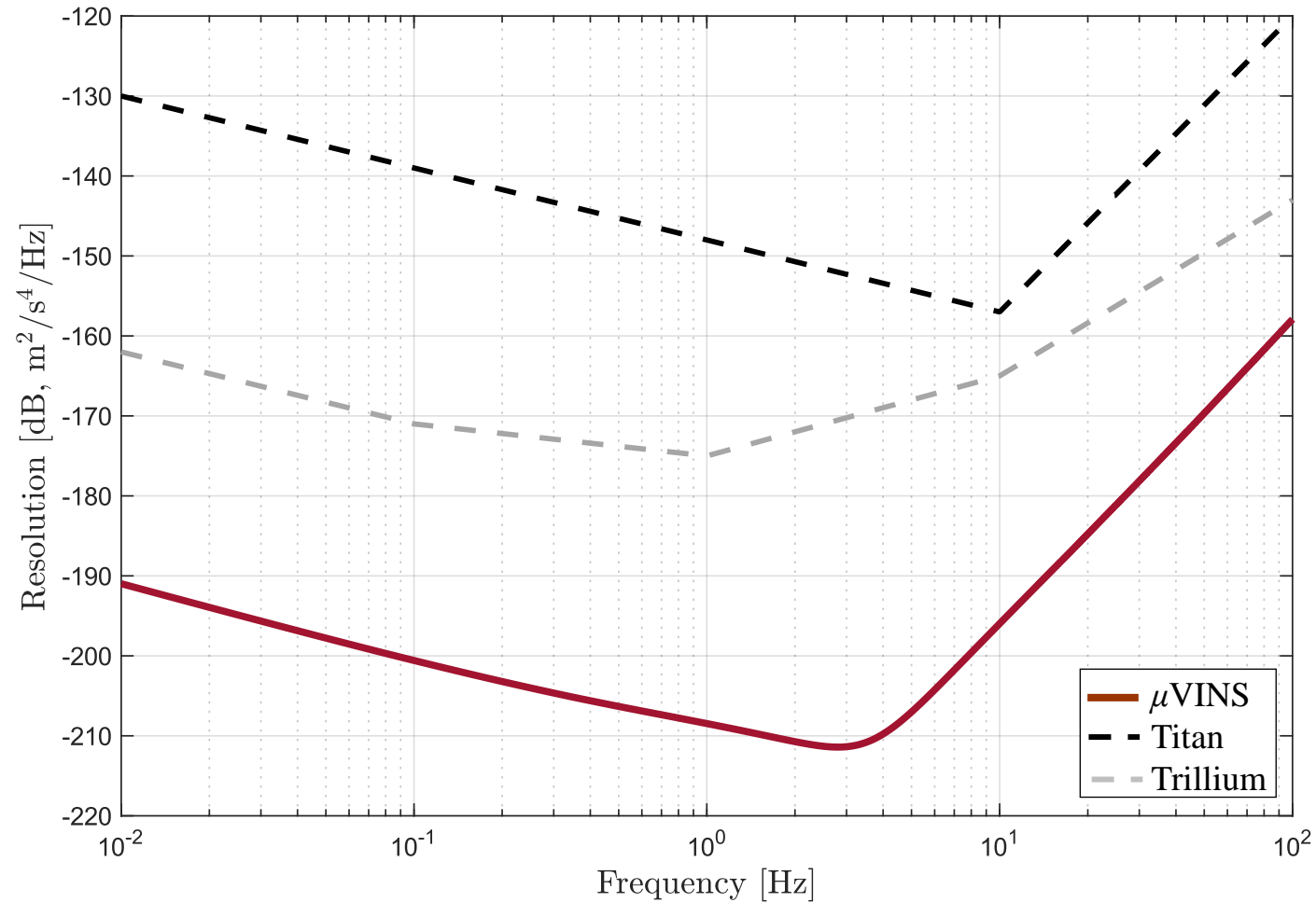
μVINS



Trillium



Titan



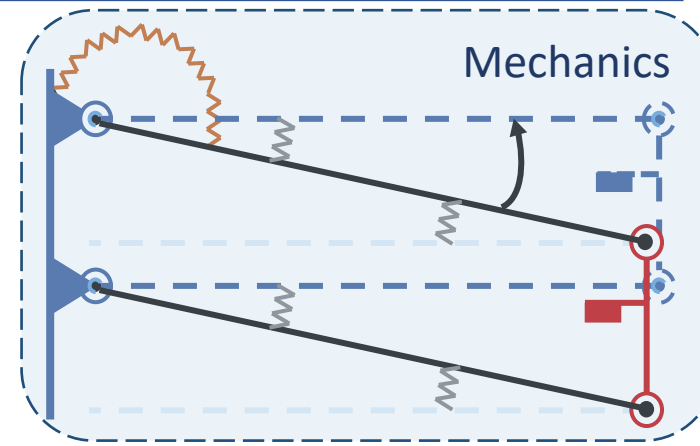
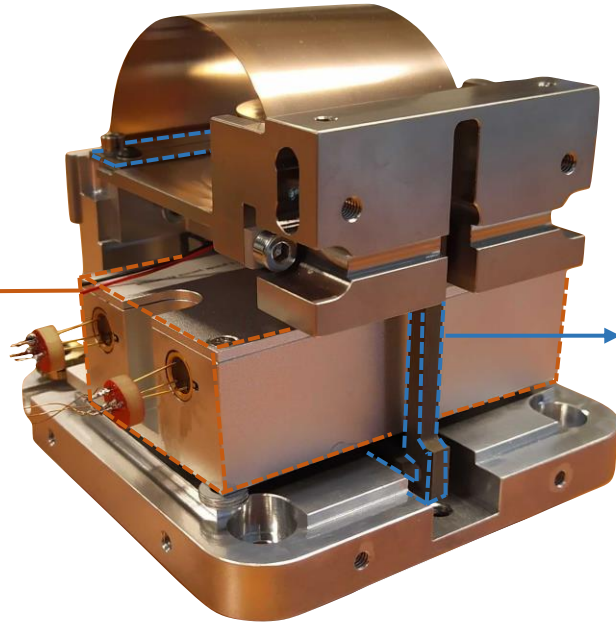


# Outline

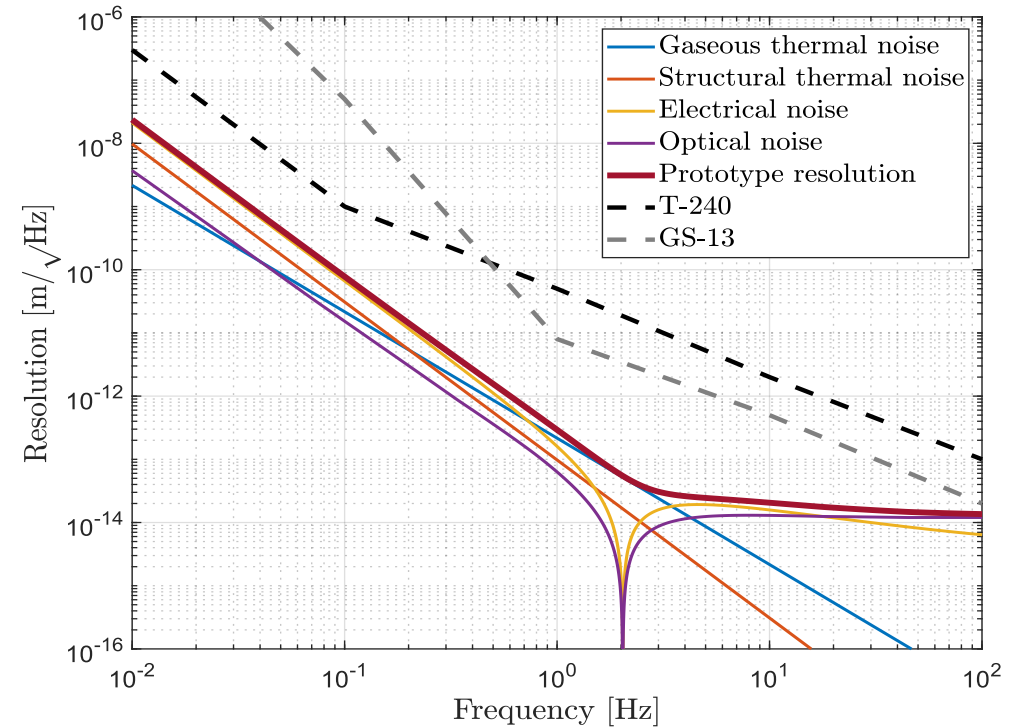
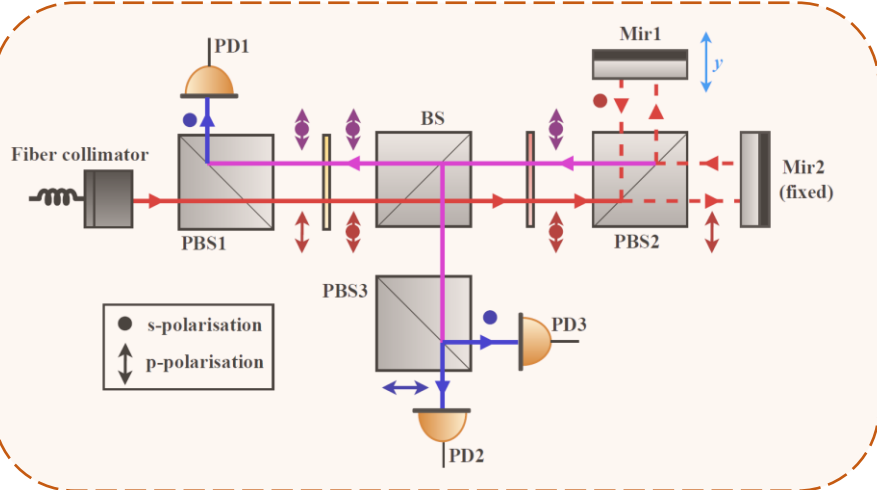
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- Gravimeters and effects of ground vibrations
- Compact Vertical INterferometric Sensor ( $\mu$ VINS)
- Conclusion and future work

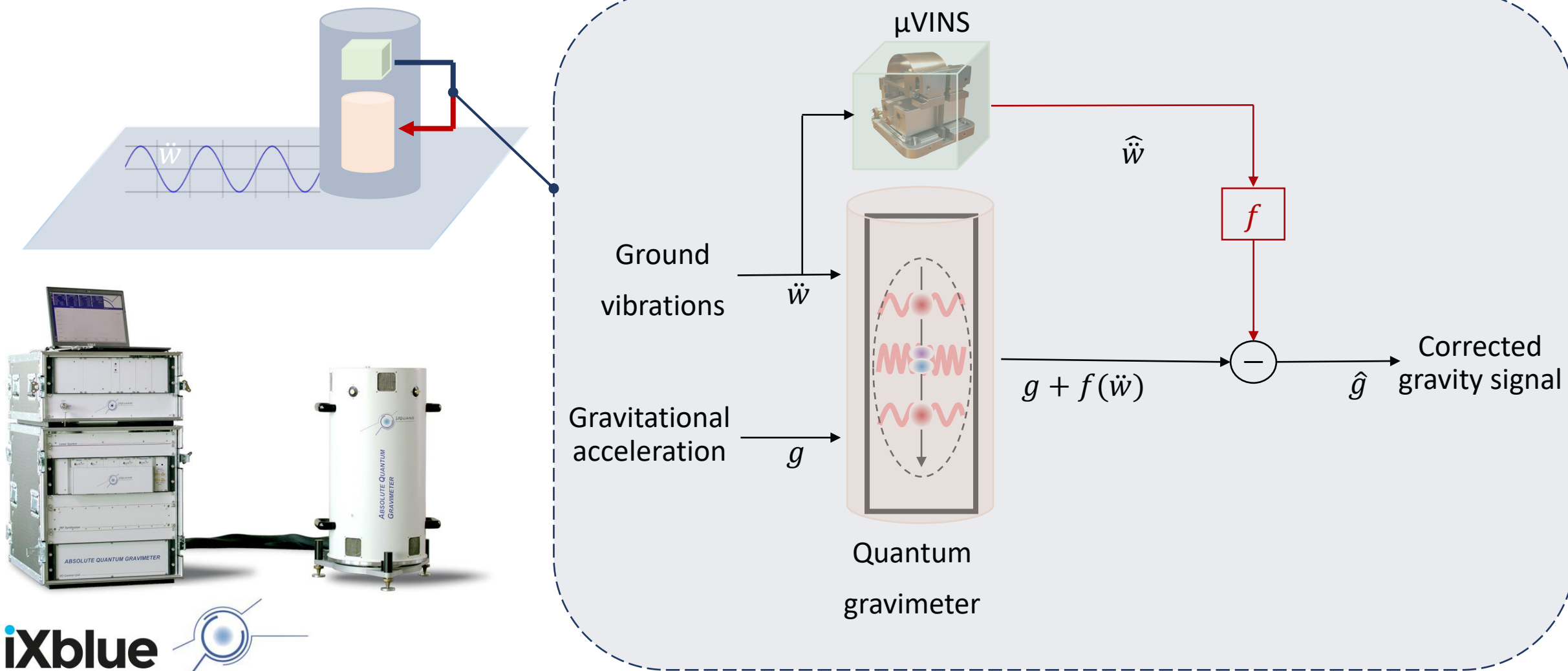
# $\mu$ VINS testing campaign



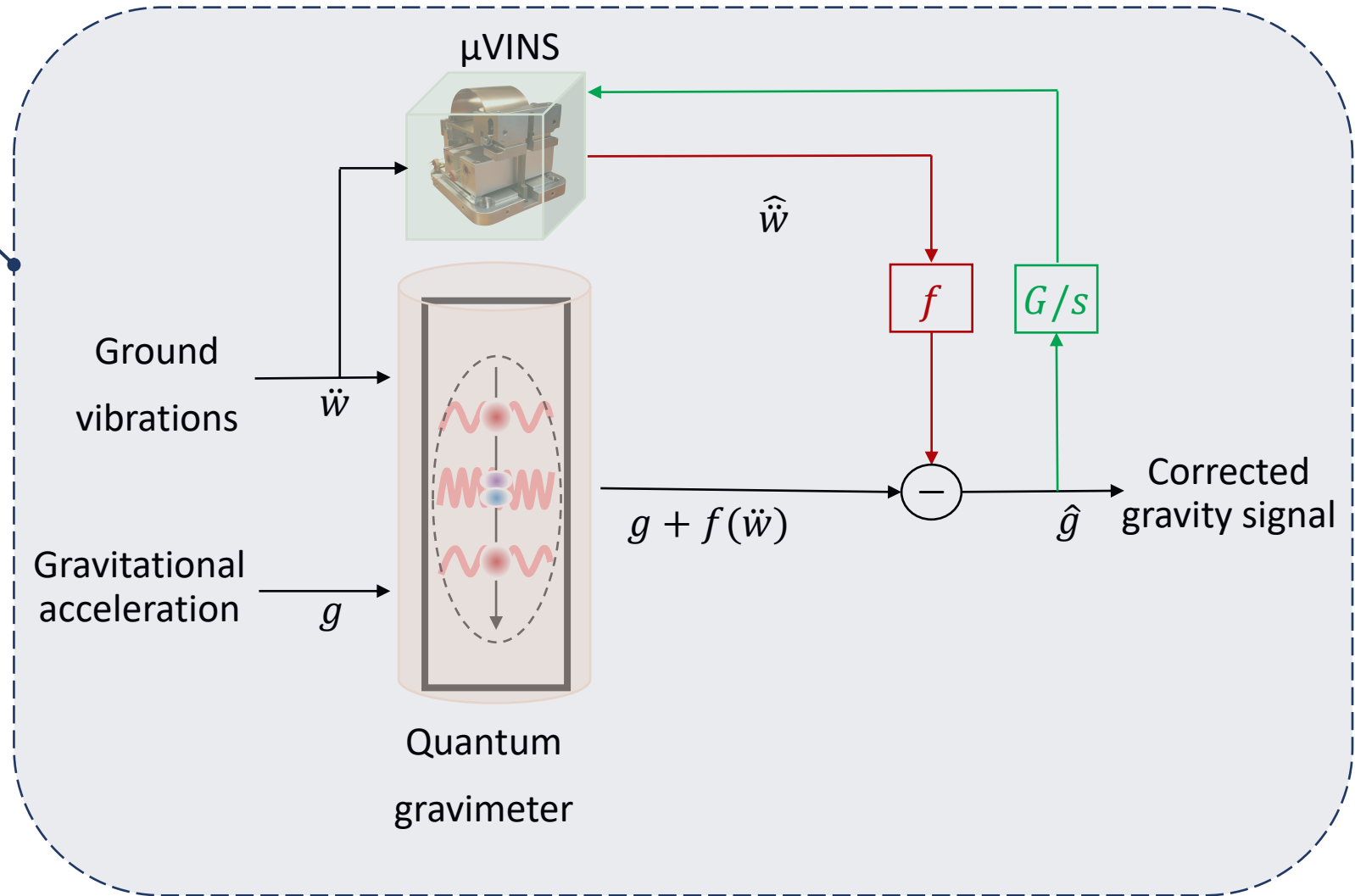
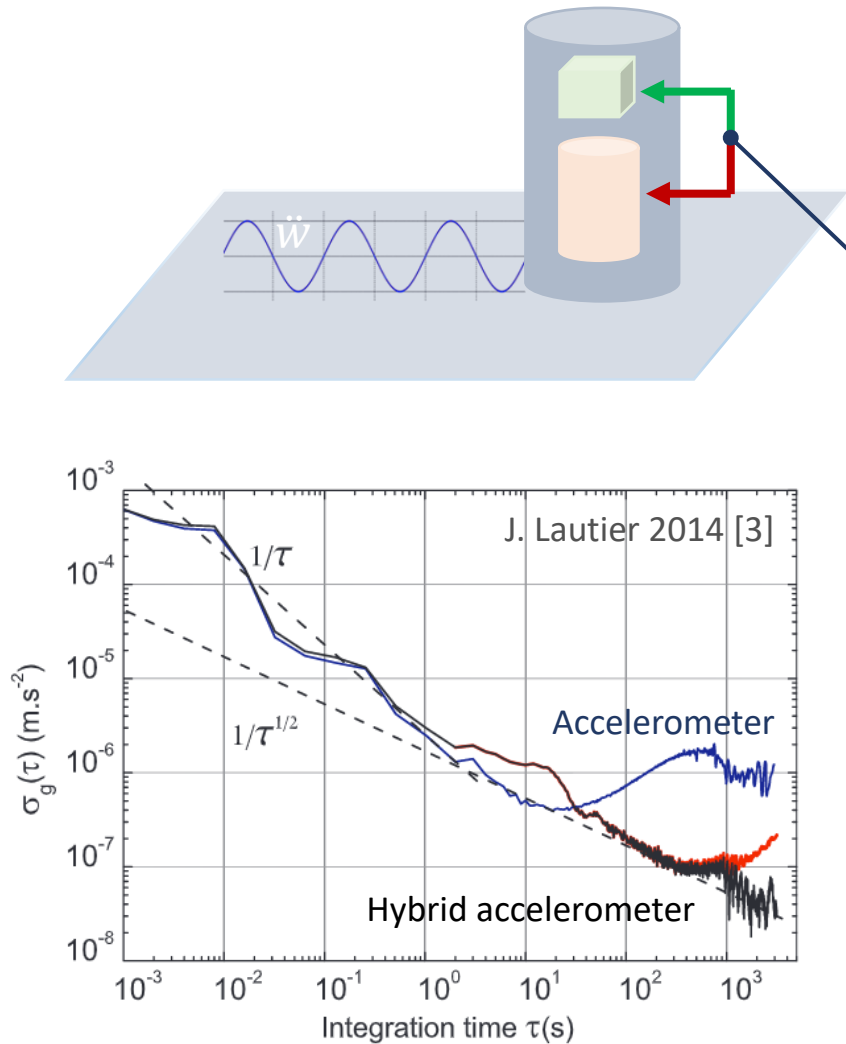
## Quadrature optical readout



# Vibration compensation

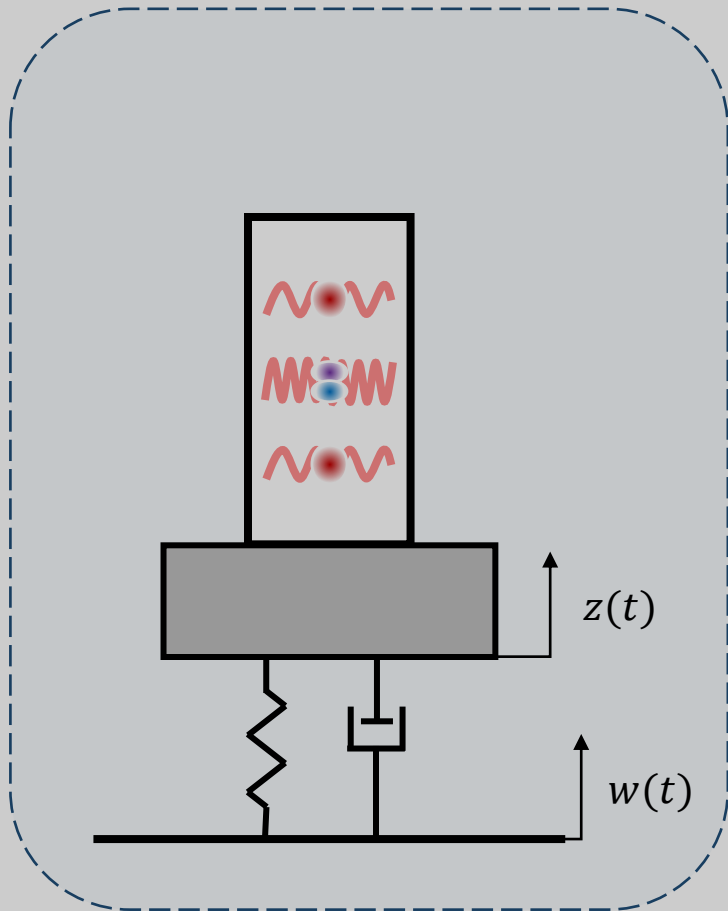


# Full hybridizing

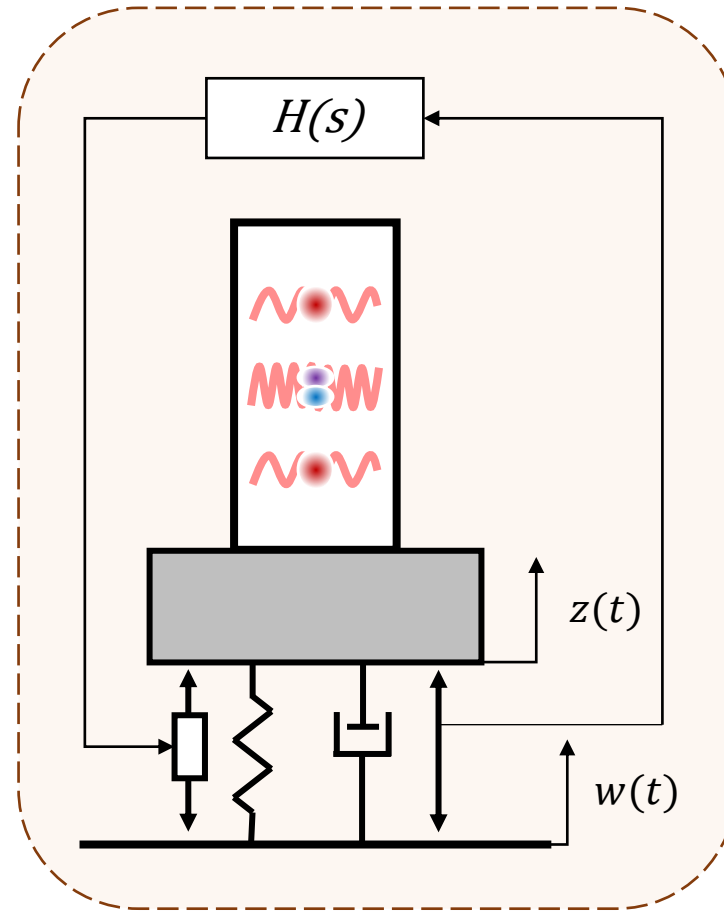


# Vibration compensation techniques

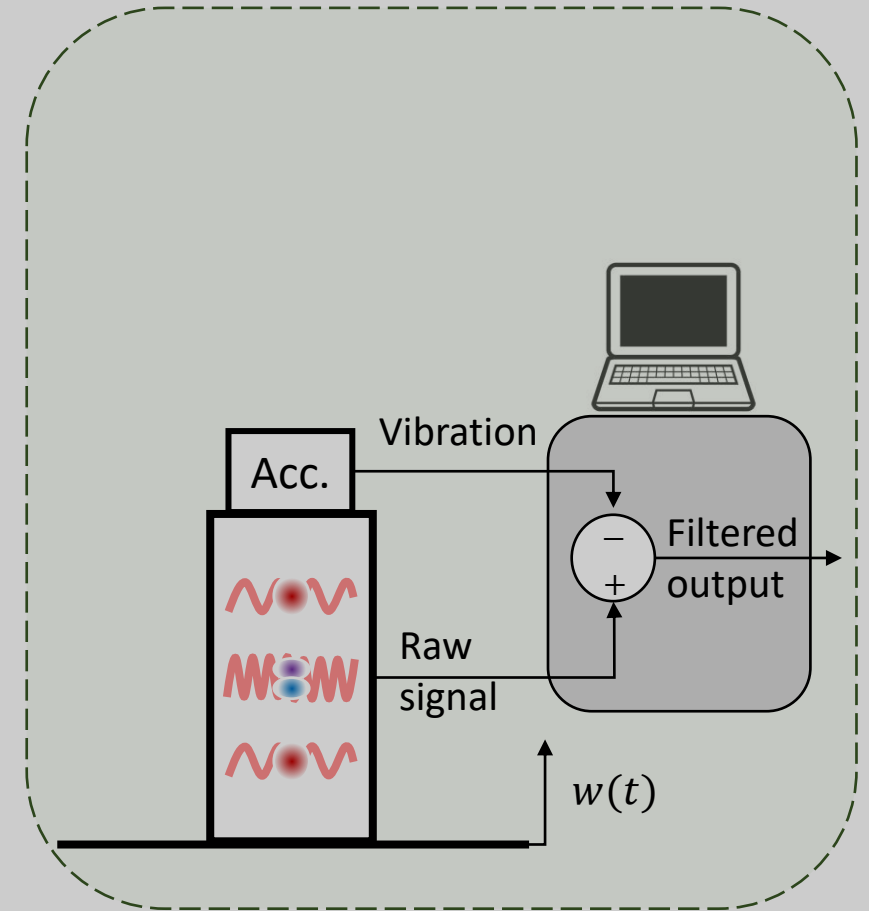
Passive vibration isolation



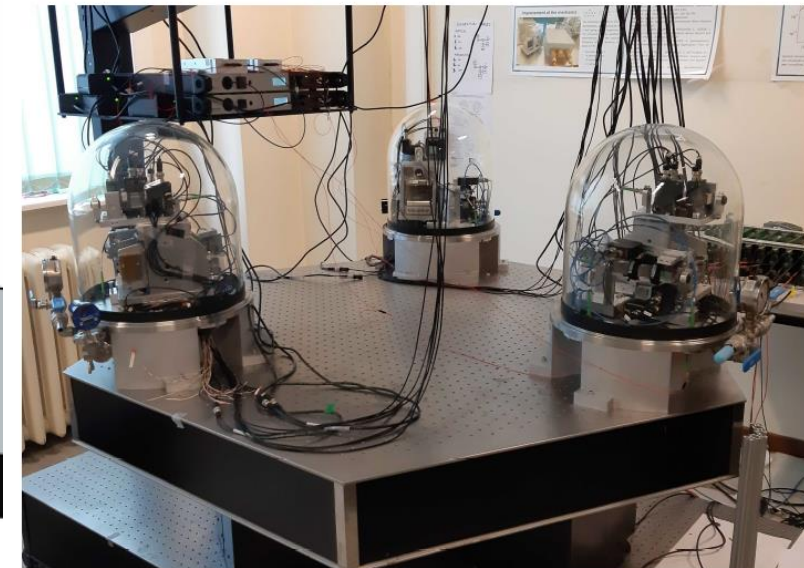
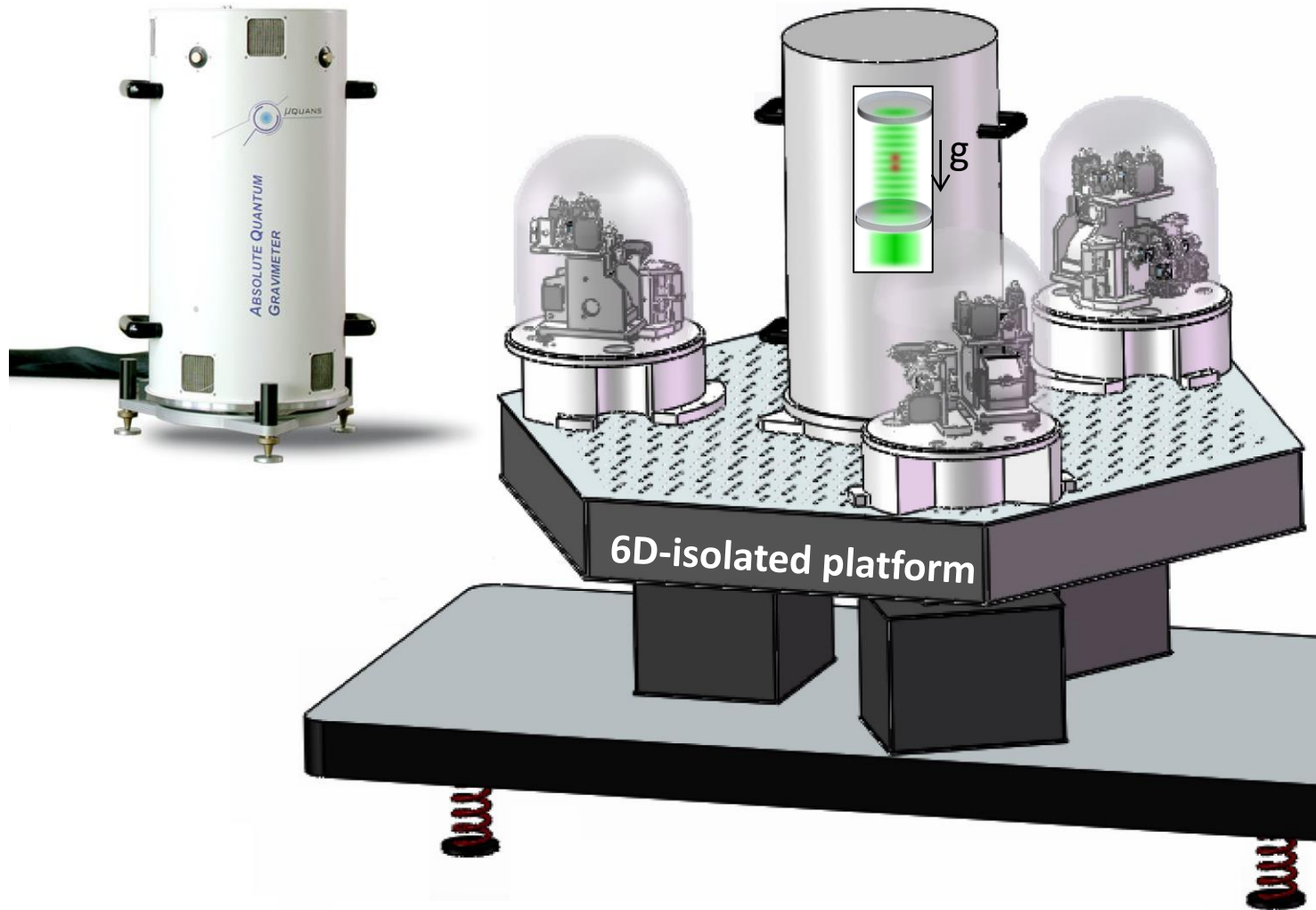
Active vibration isolation



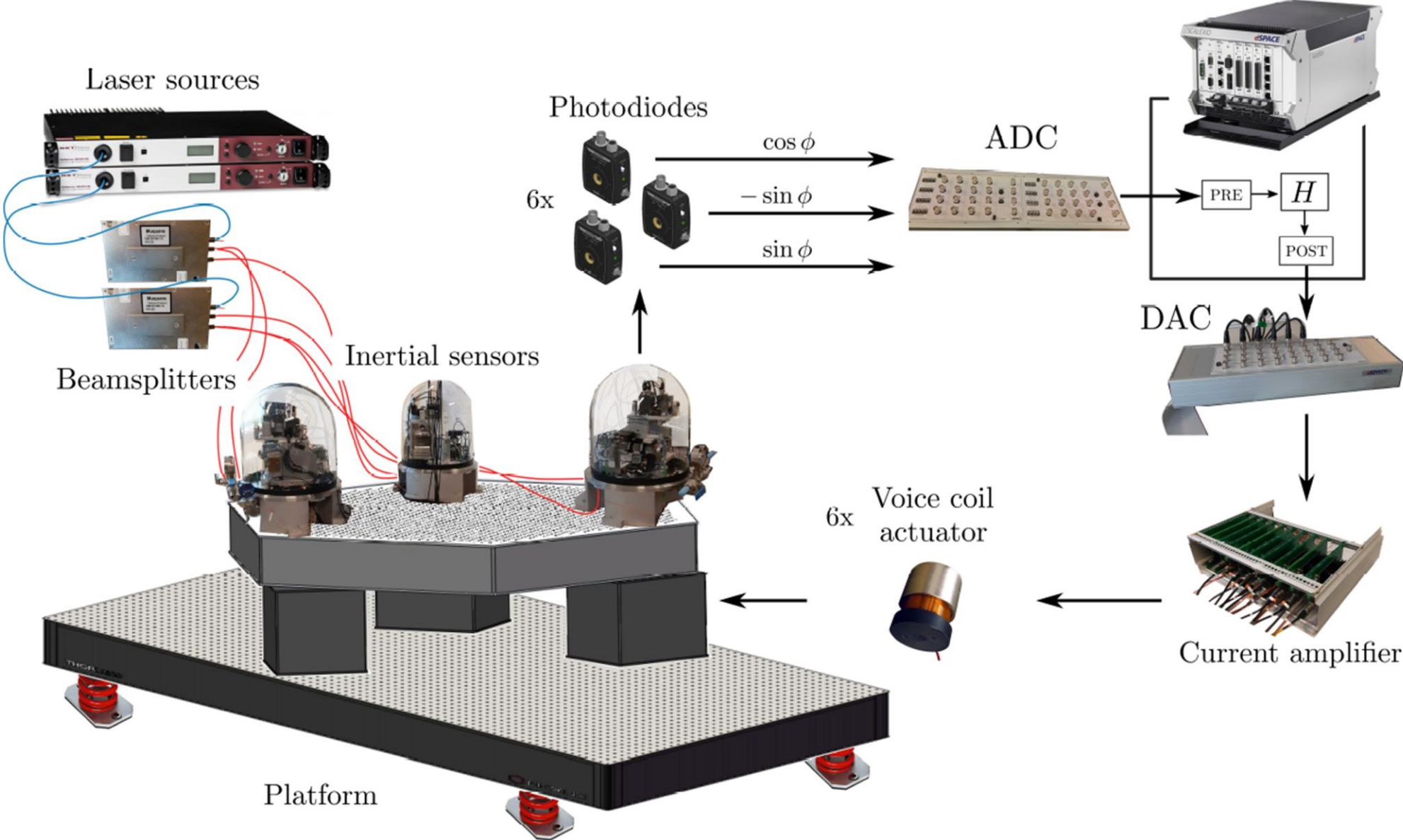
Software rejection



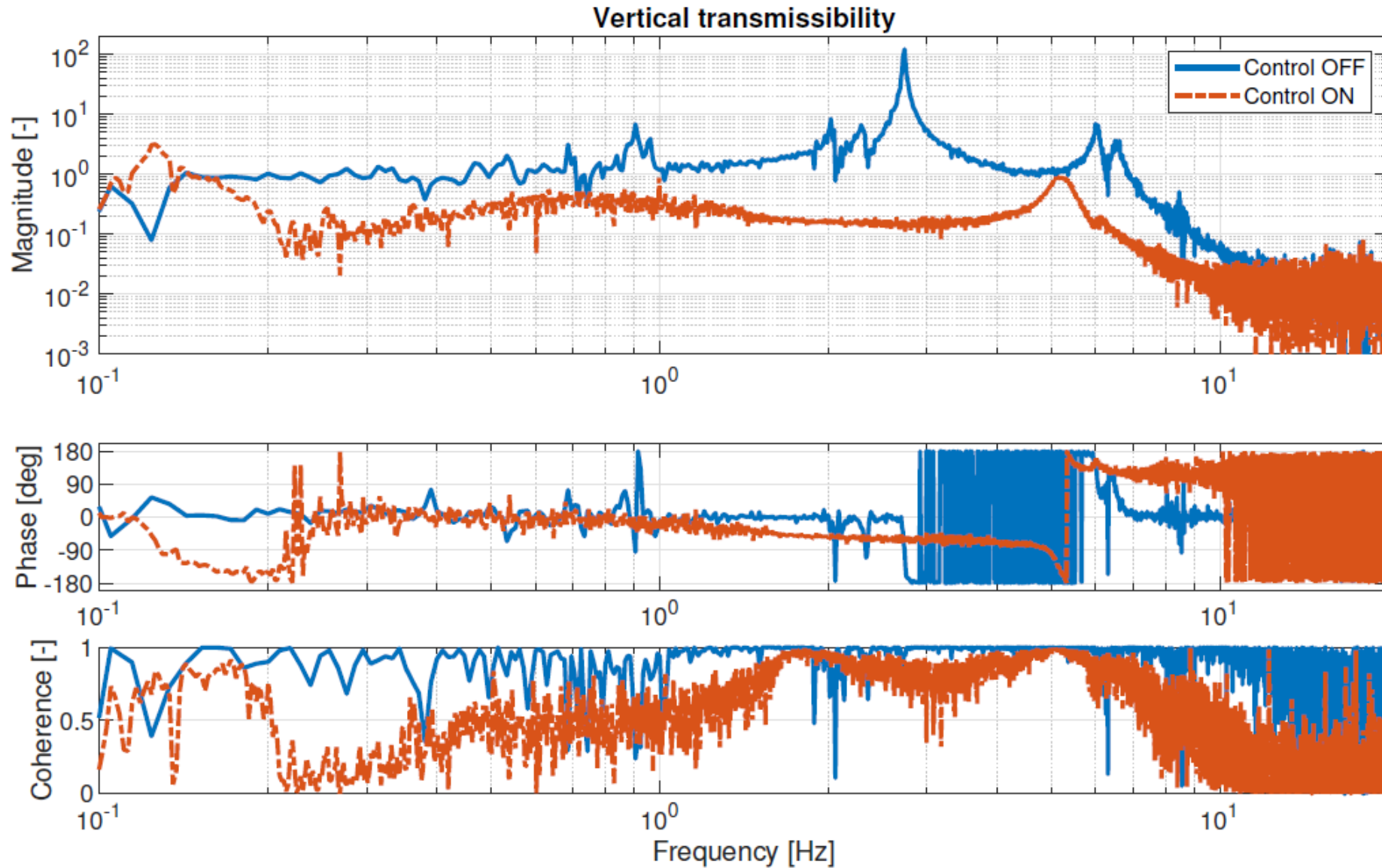
# Active isolation of a quantum gravimeter



# 6-D isolation strategy



# Isolation performances





# References

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[a] <https://www.muquans.com/news/deployment-of-our-quantum-gravimeter-on-mount-etna/>

[b] <https://www.usgs.gov/media/images/changes-earths-gravity-reveal-changes-groundwater-storage-0>

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Sensor mechanics & fused-silica

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Quantum gravimetry and sensor hybridizing

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Control strategies  
Control strategies  
Control strategies

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Supervisor (ULiège, ULB)

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Thank you  
for your attention!