Precise absolute gravimeter for inertial control and gravity measurements

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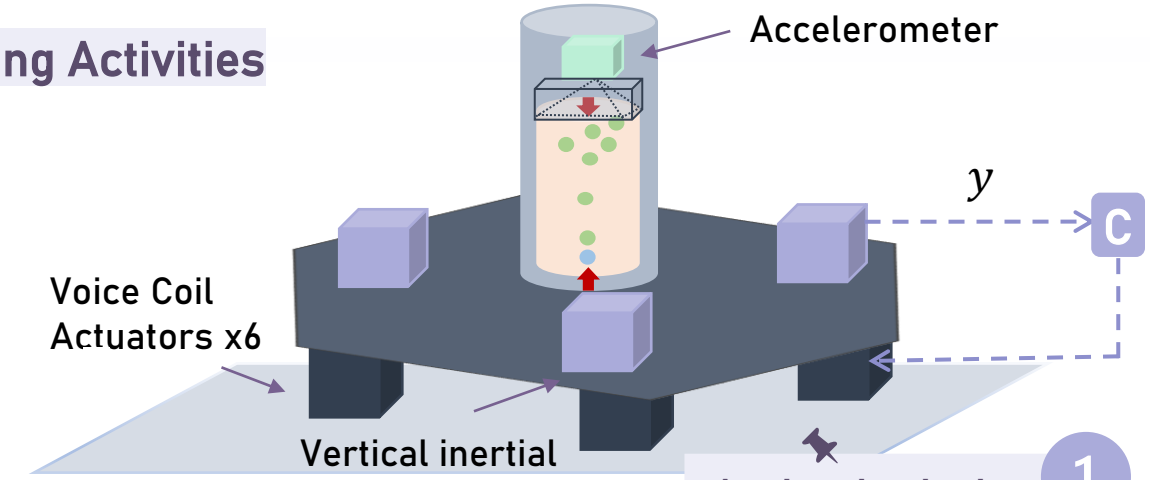
Supervisor: Pr. Christophe Collette

AQG operator meeting - Leibnitz University Hannover

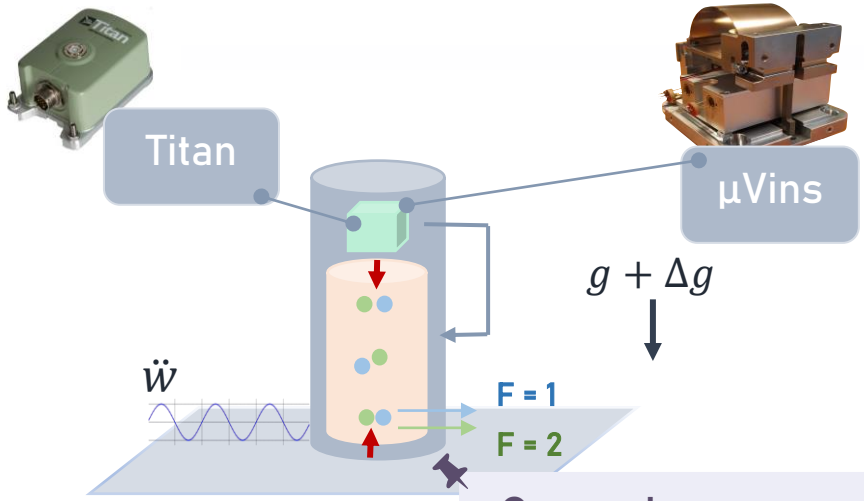
24 - 25 January 2024

Ongoing Activity & Applications

Ongoing Activities

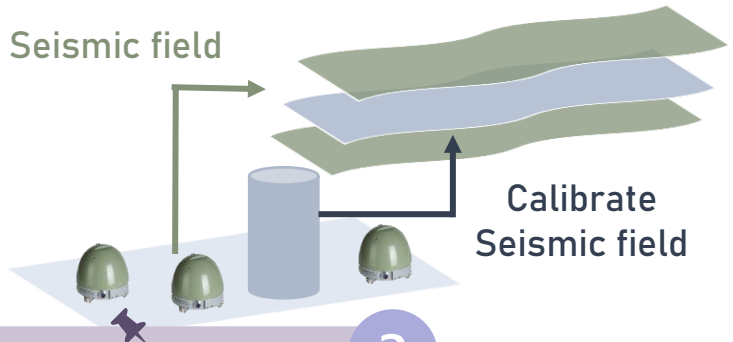


1 Active Isolation of the AQG

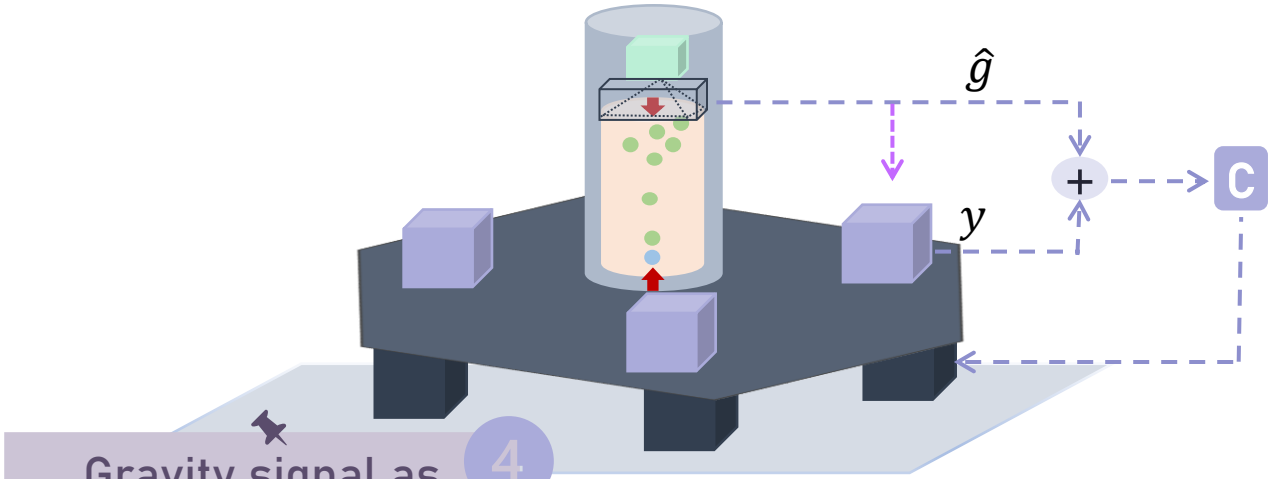


2 Ground compensation with homemade sensor

Applications



3 Seismic Newtonian Noise calibration



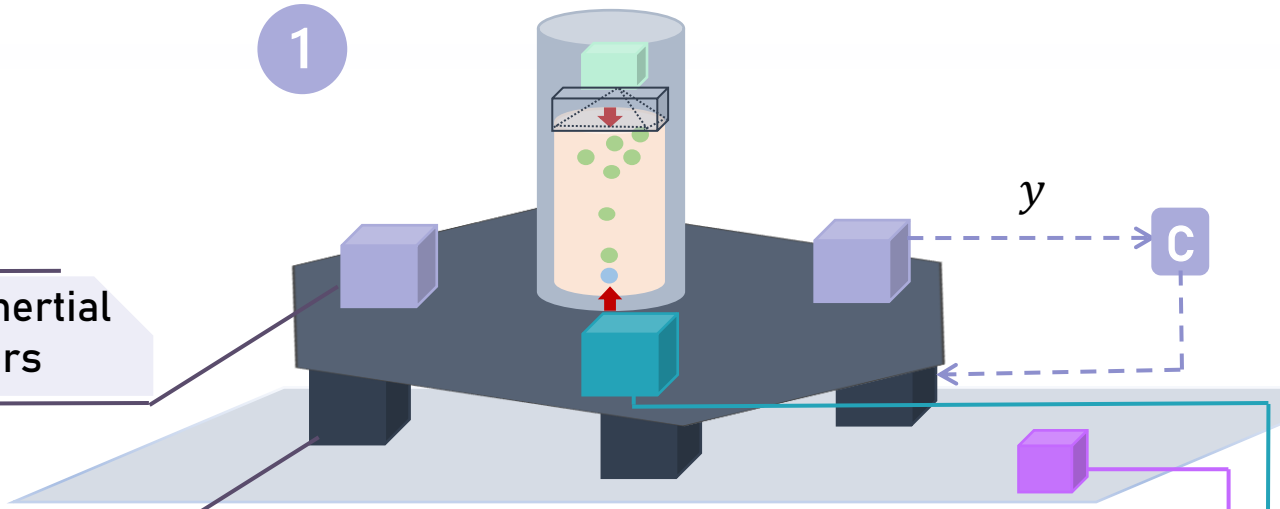
4 Gravity signal as control input to the active platform

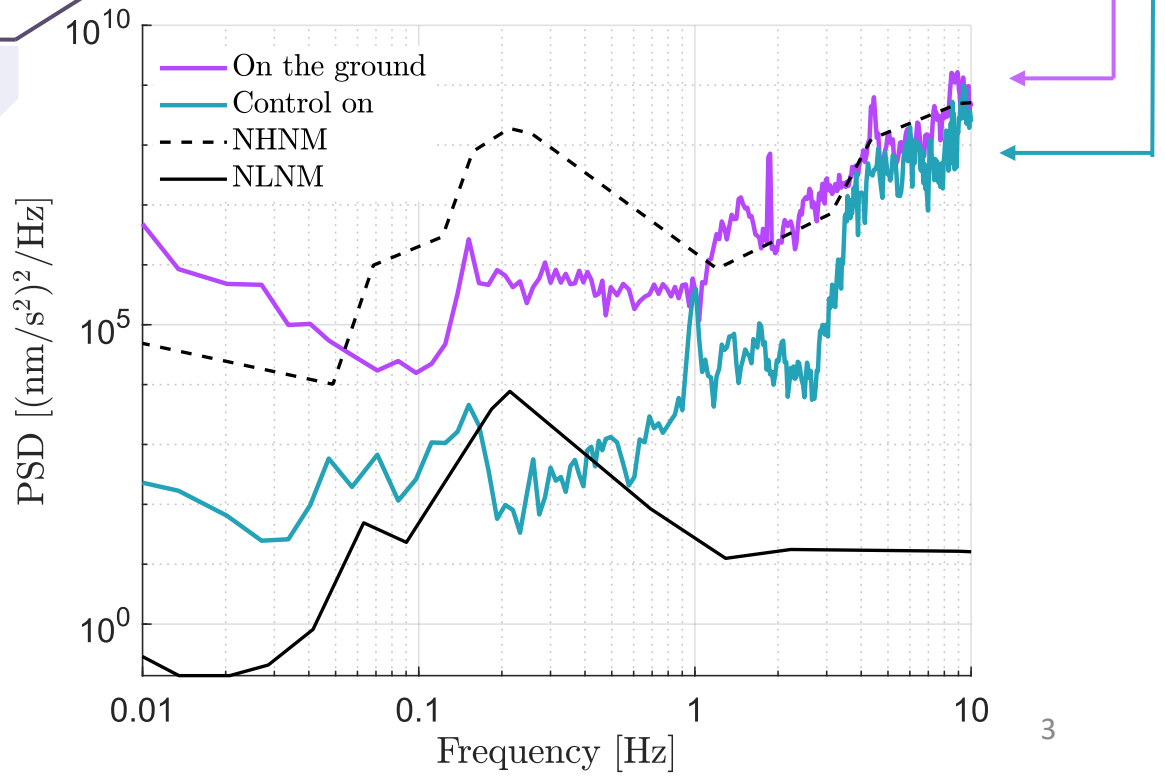
Active Isolation of the AQG

Mouhamad Haidar Lakkis

Vertical inertial sensors

Voice Coil Actuators





Active isolation in 0.1 – 10 Hz frequency range

Active Isolation of the AQG

Motivation

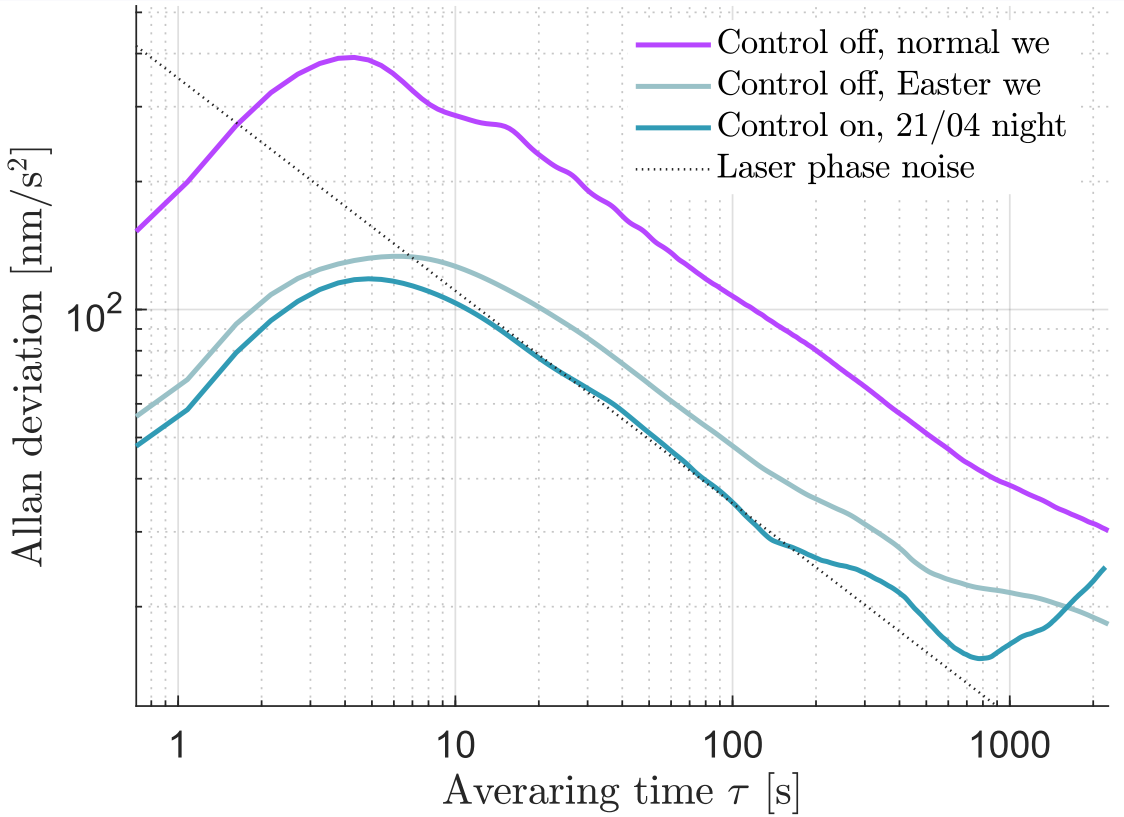
- Which part of ground motion is impacting gravity ?
- What kind of sensitivity can we reach ?

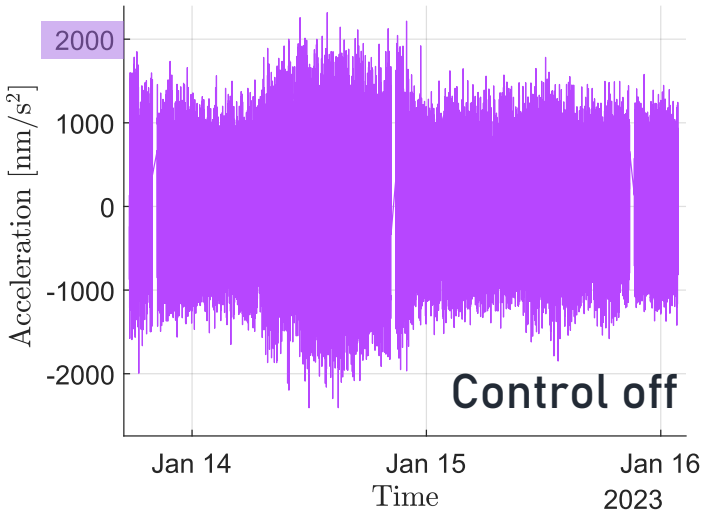
Result

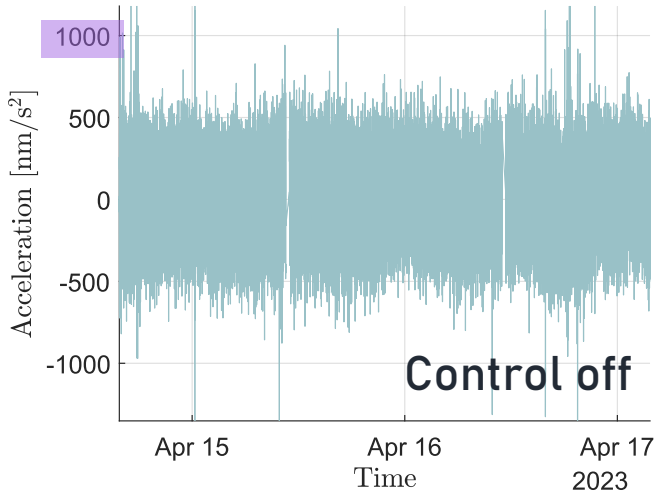
→ Reaching the intrinsic noise of the gravimeter with active control: $350\ \tau^{-1/2}\ \mathrm{nm/s^2}$

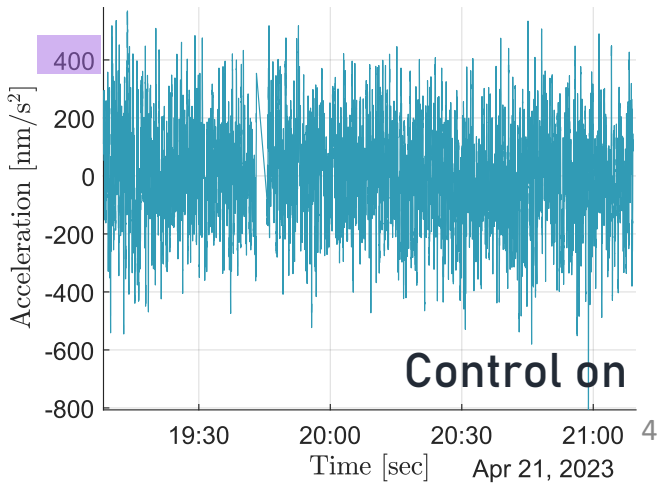
→ Titan noise, Acquisition noise are not limiting the AQG

→ Ground compensation strategy is not fully subtracting ground signal

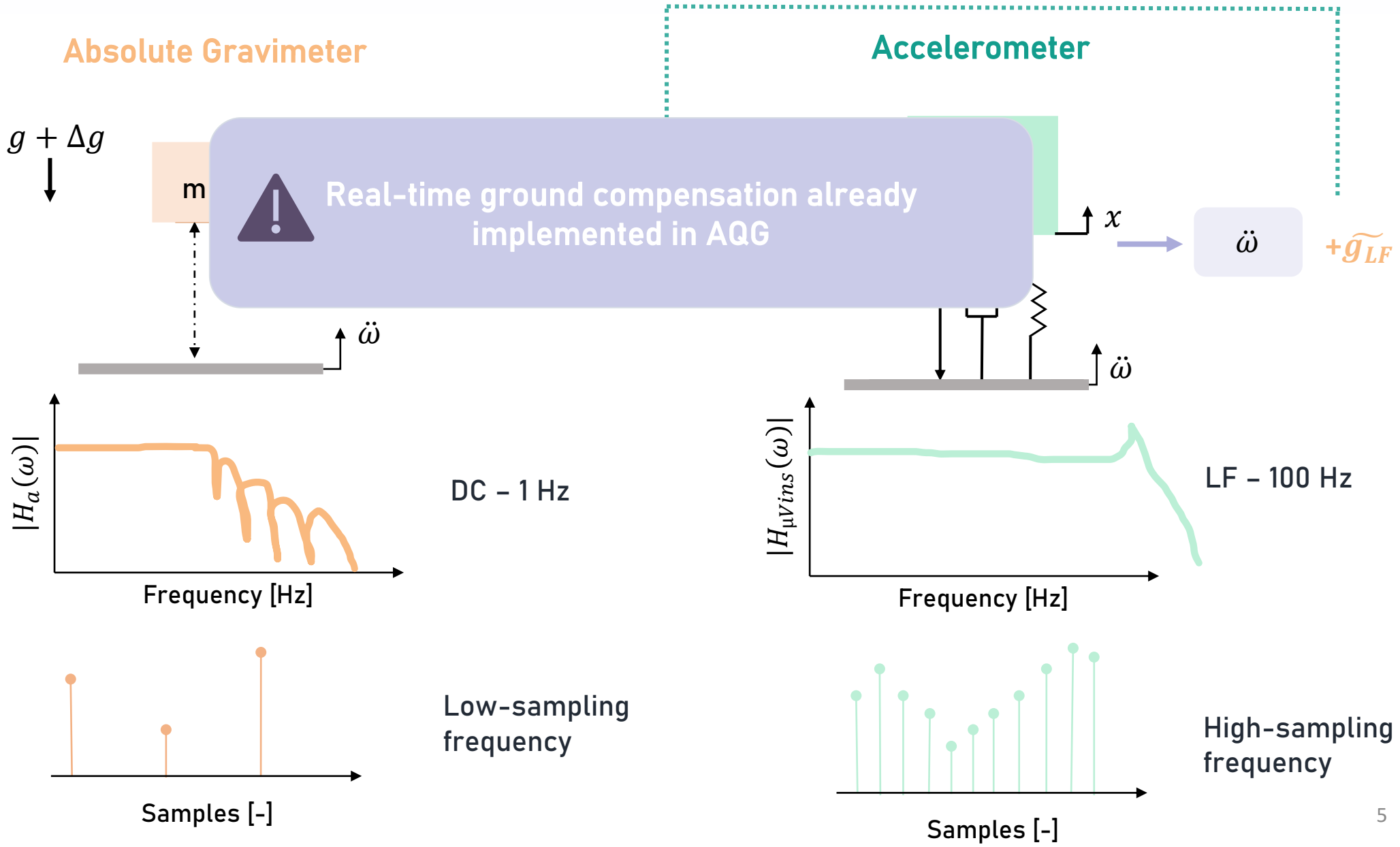




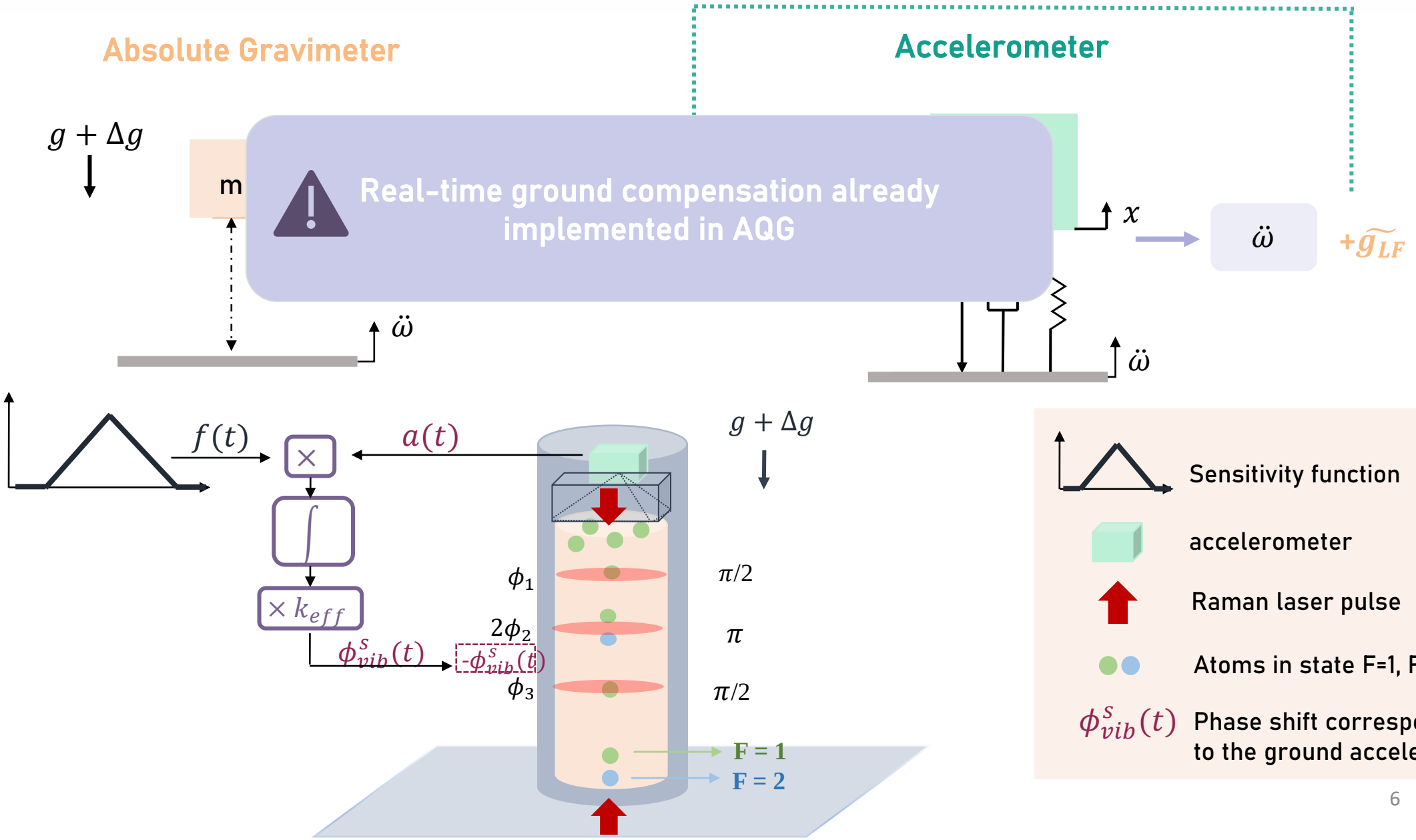




Ground compensation with homemade sensor



Ground compensation with homemade sensor



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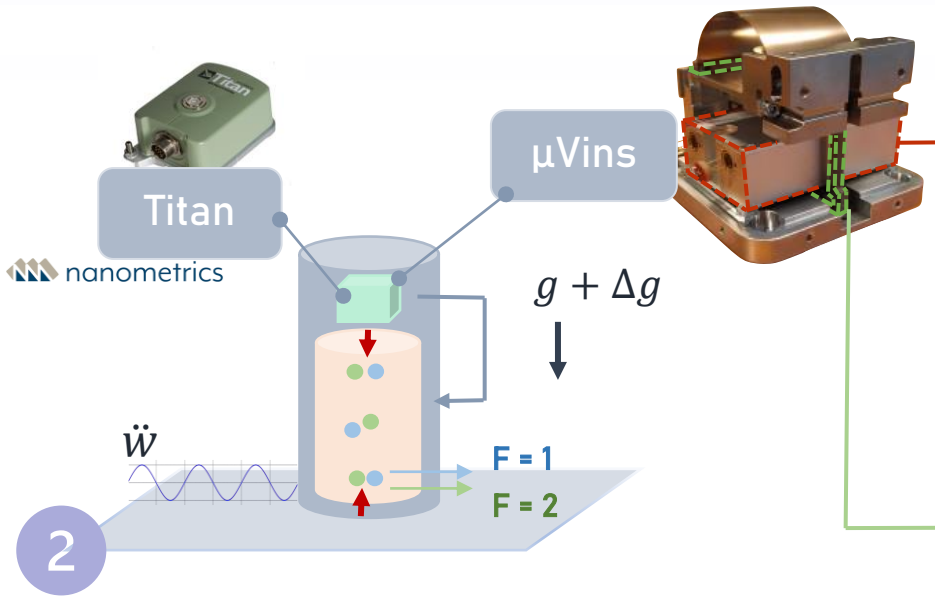

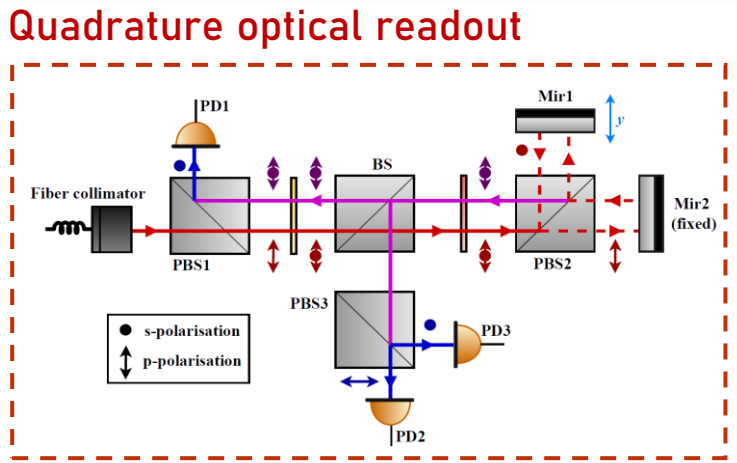

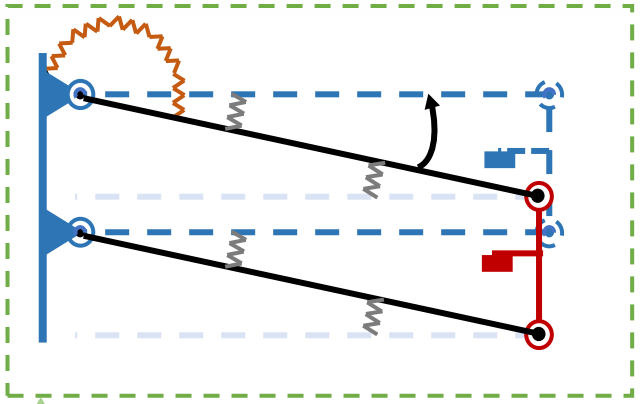

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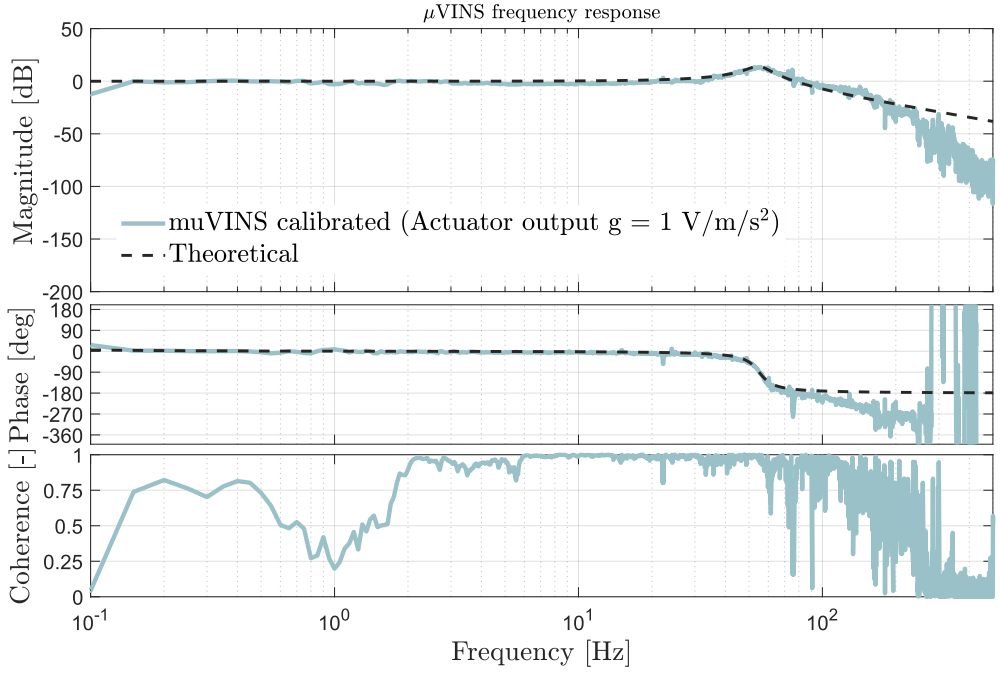
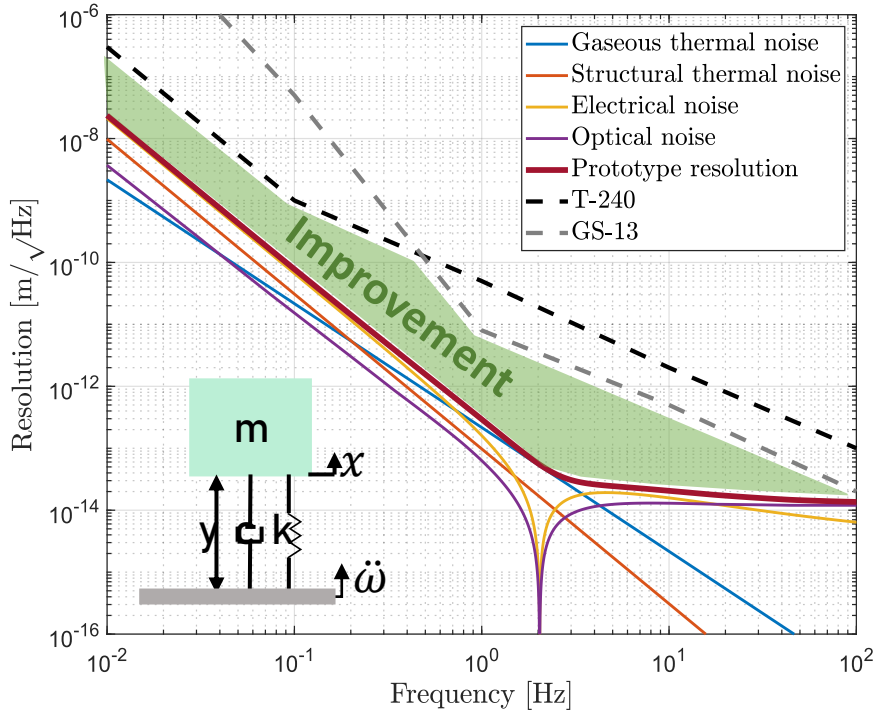




Ground compensation with homemade sensor

Anthony Amororsi

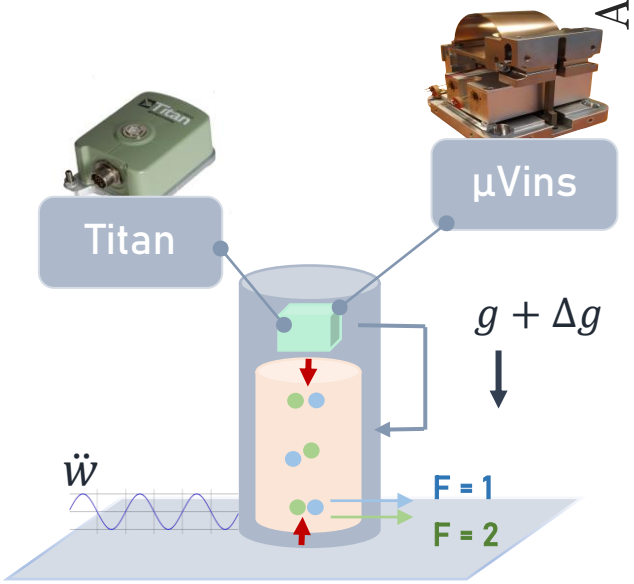
Procedure

Signals of Titan & µVins are acquired through the acquisition system of the AQG

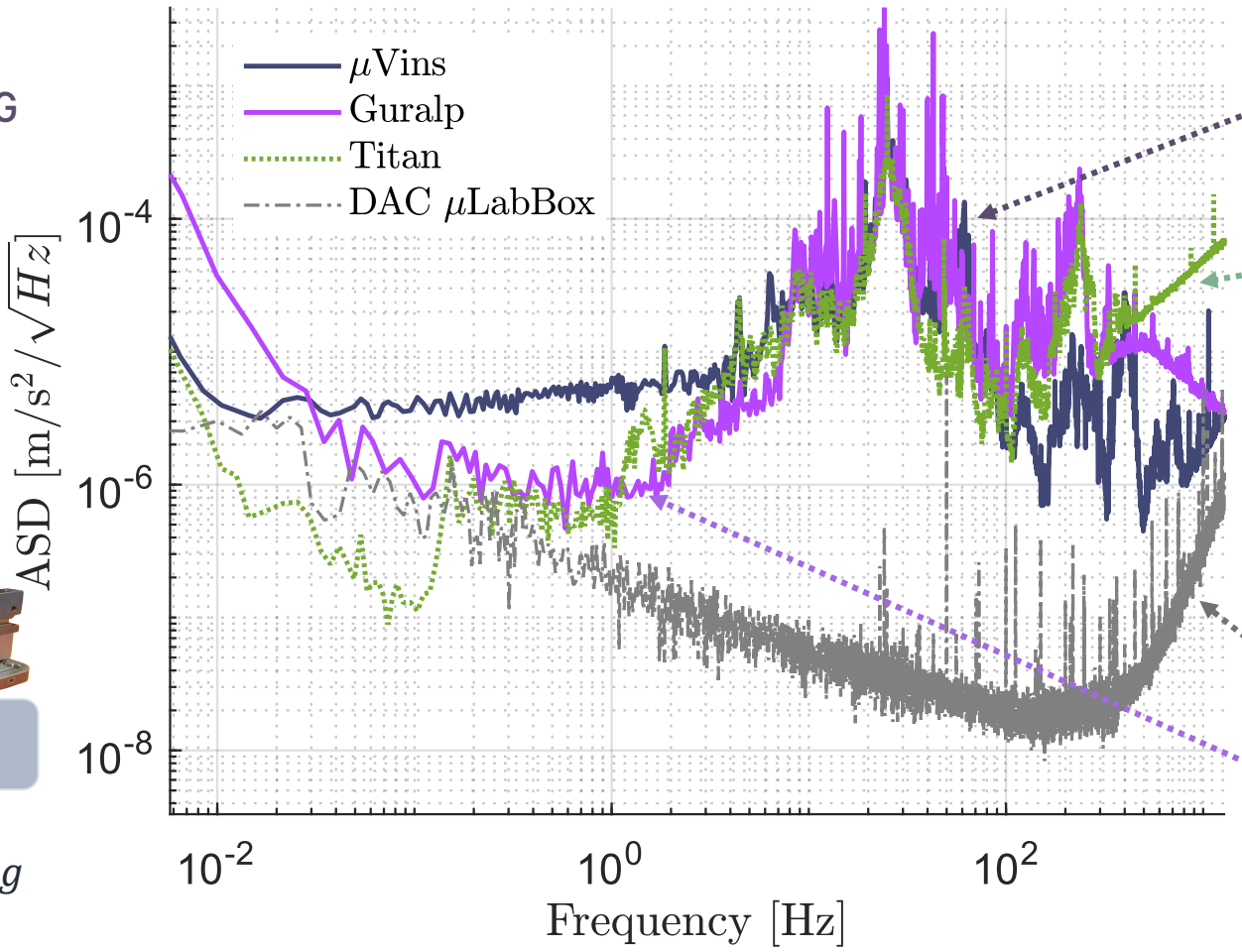
Noise below 4 Hz

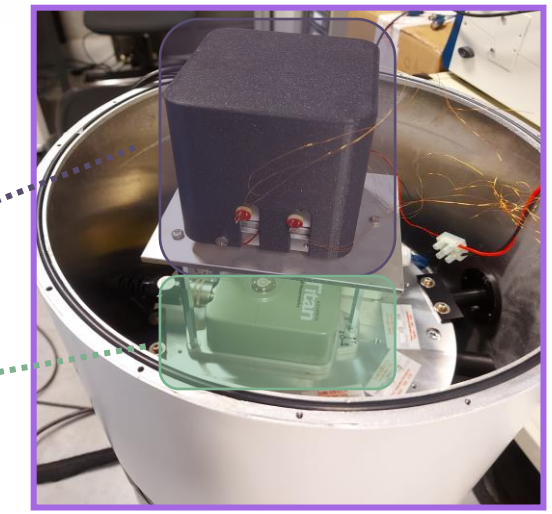
→ influence of internal magnetic field

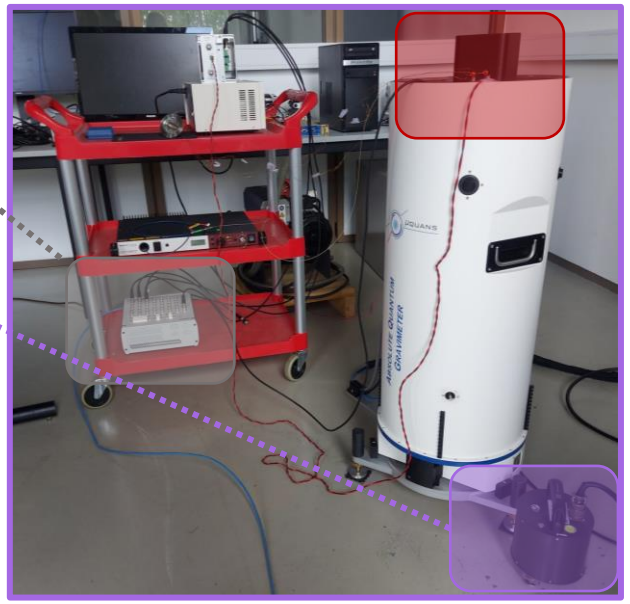
→ AQG acquisition card



Preliminary result







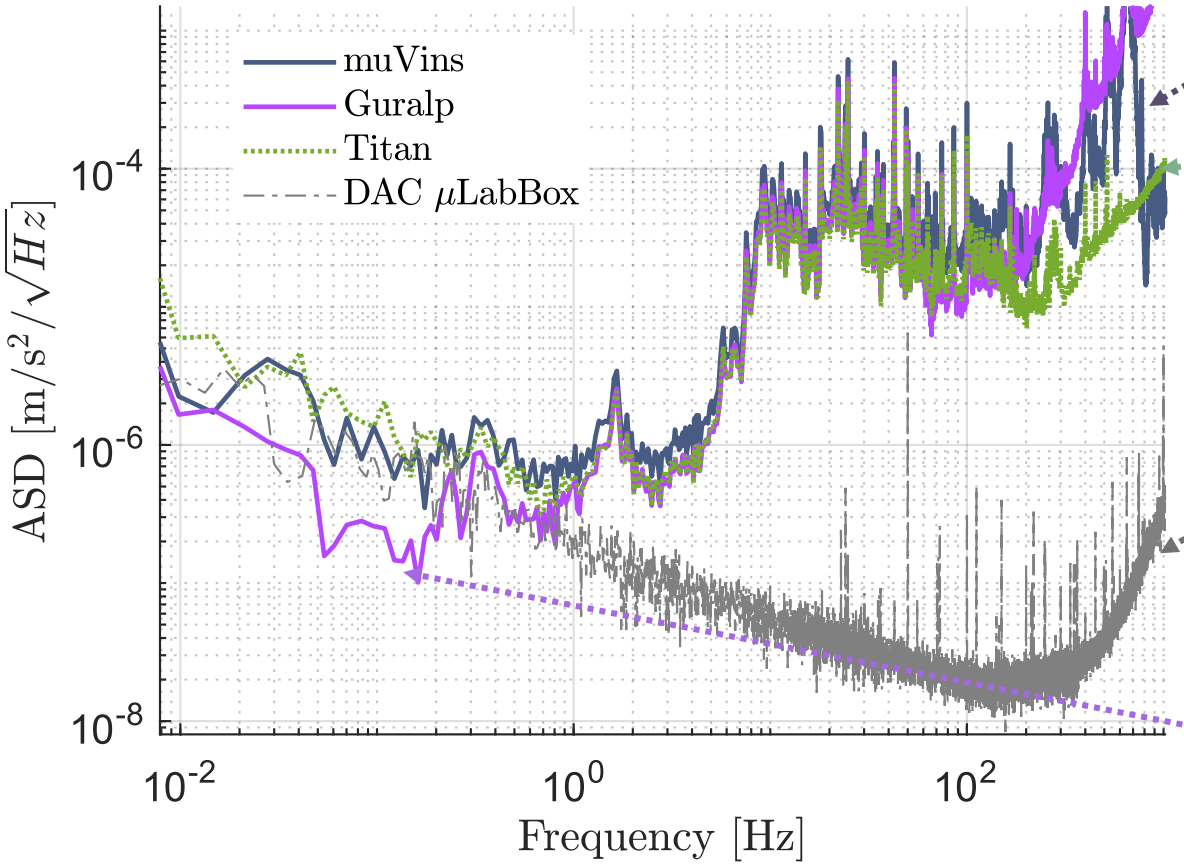
Ground compensation with homemade sensor

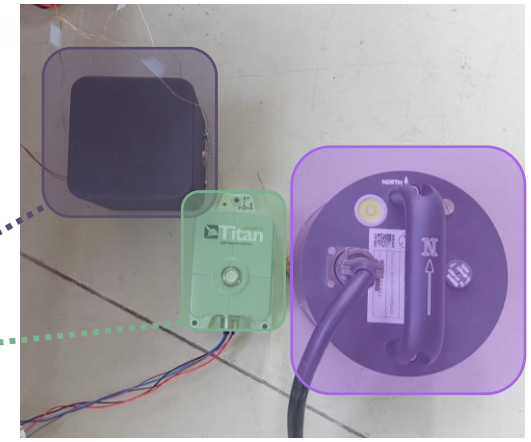
→ **influence of internal magnetic field**

µVins placed on the floor works slightly better than placed on the AQG

→ **AQG acquisition card**

µVins signal recorded through an external acquisition system works as the AQG in-build accelerometer



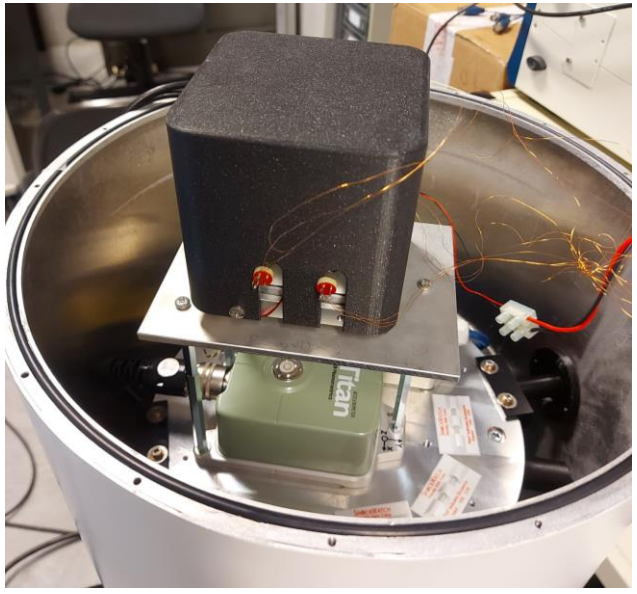


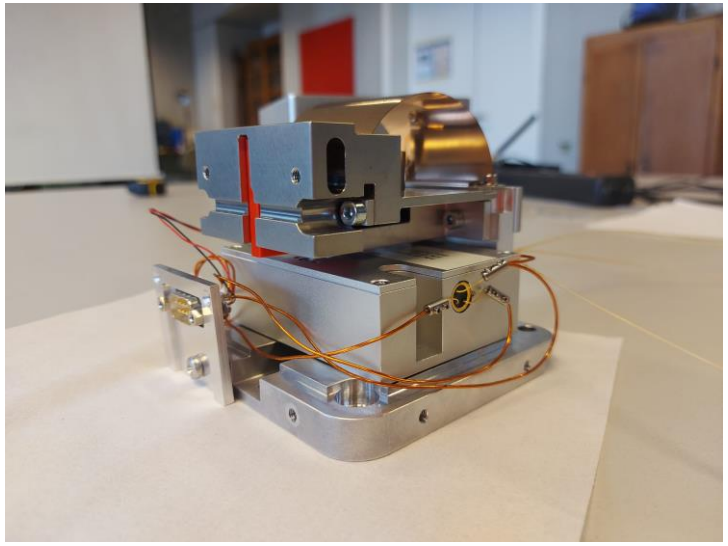
- Better casing
- Proper cabling

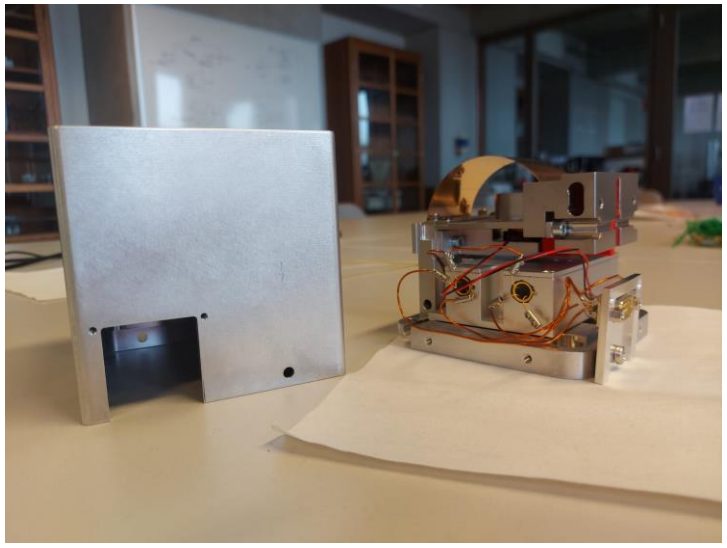
Ground compensation with homemade sensor

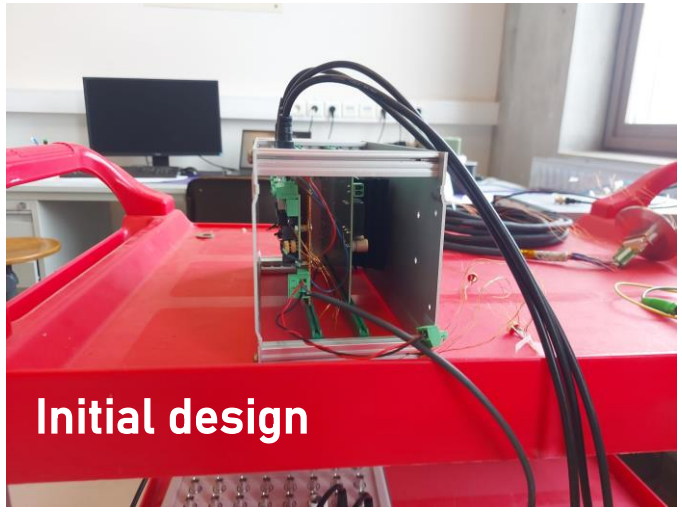
→ influence of internal magnetic field

- Better casing
- Proper cabling

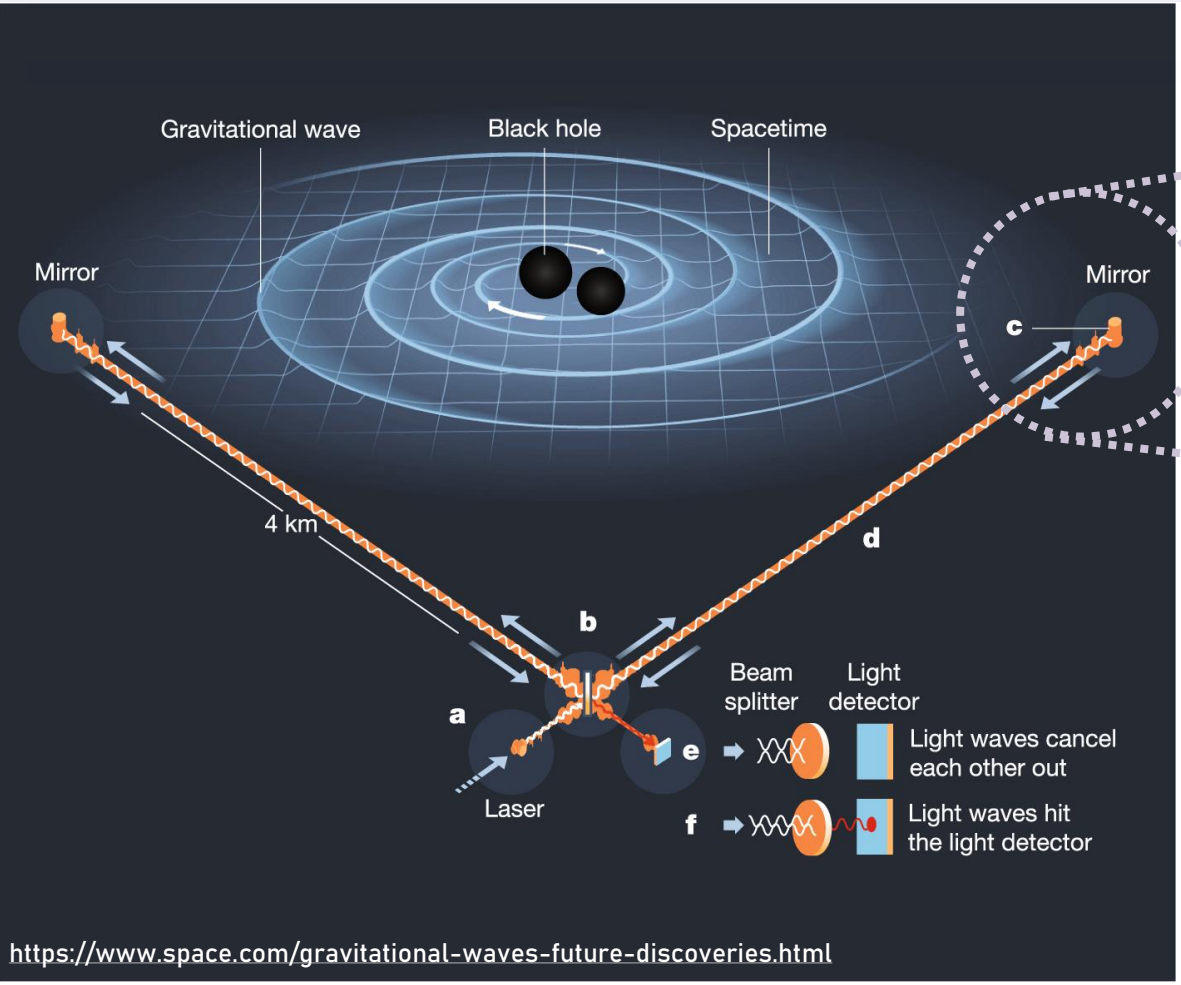


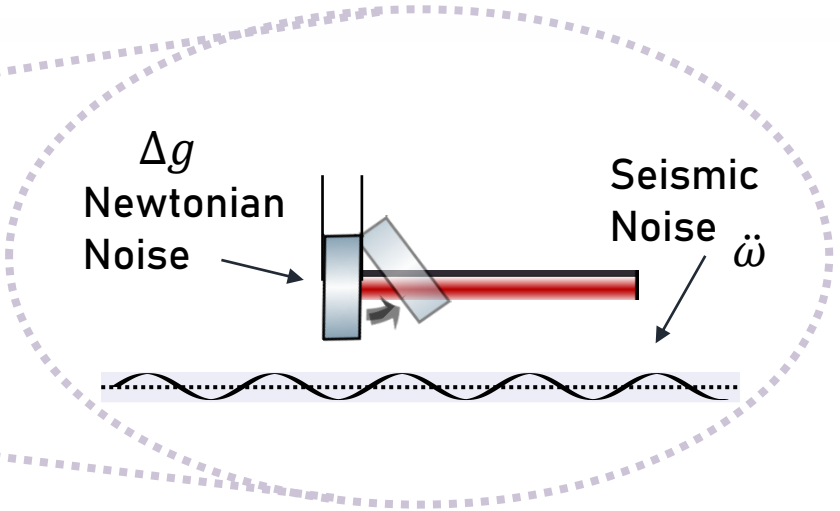




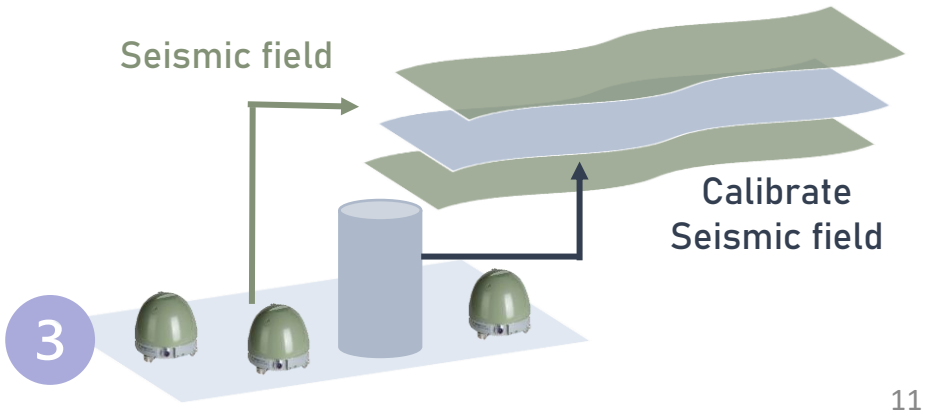


Seismic Newtonian Noise calibration





Using the gravity signal from the Absolute Quantum Gravimeter to model the Newtonian Noise and achieve better isolation



→ Extend detection at low frequency

→ Detect more massive stellar objects

→ Detect GW earlier

Seismic Newtonian Noise calibration

Motivation

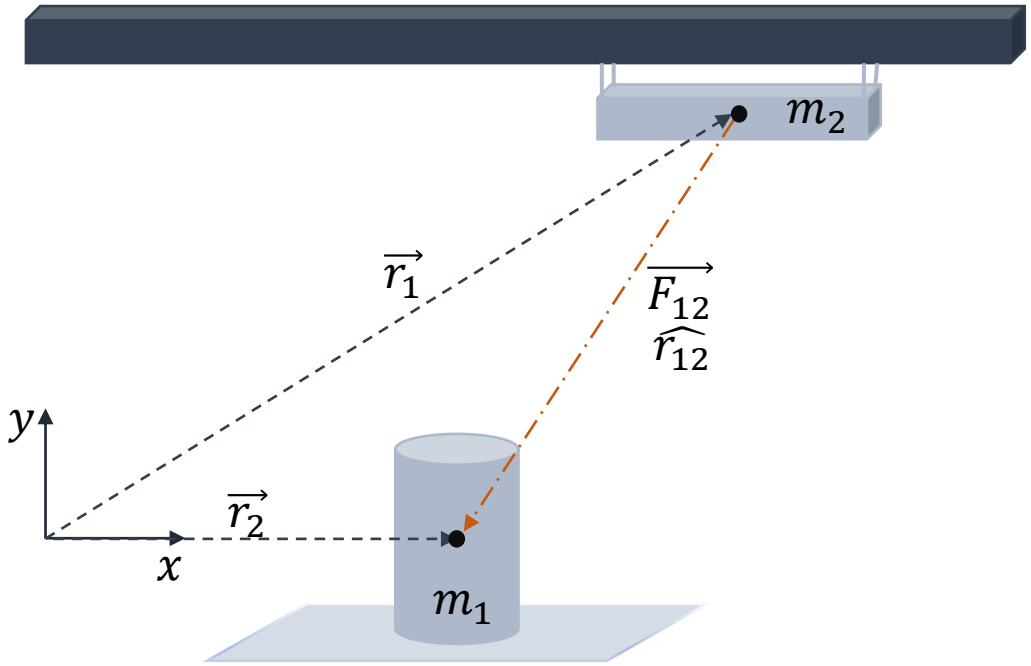
Induce known gravity variation and relate it to the AQG output

Procedure

$$\overrightarrow{F_{12}} = -\frac{G m_1 m_2}{|\overrightarrow{r_{12}}|^2}\widehat{r_{12}}$$

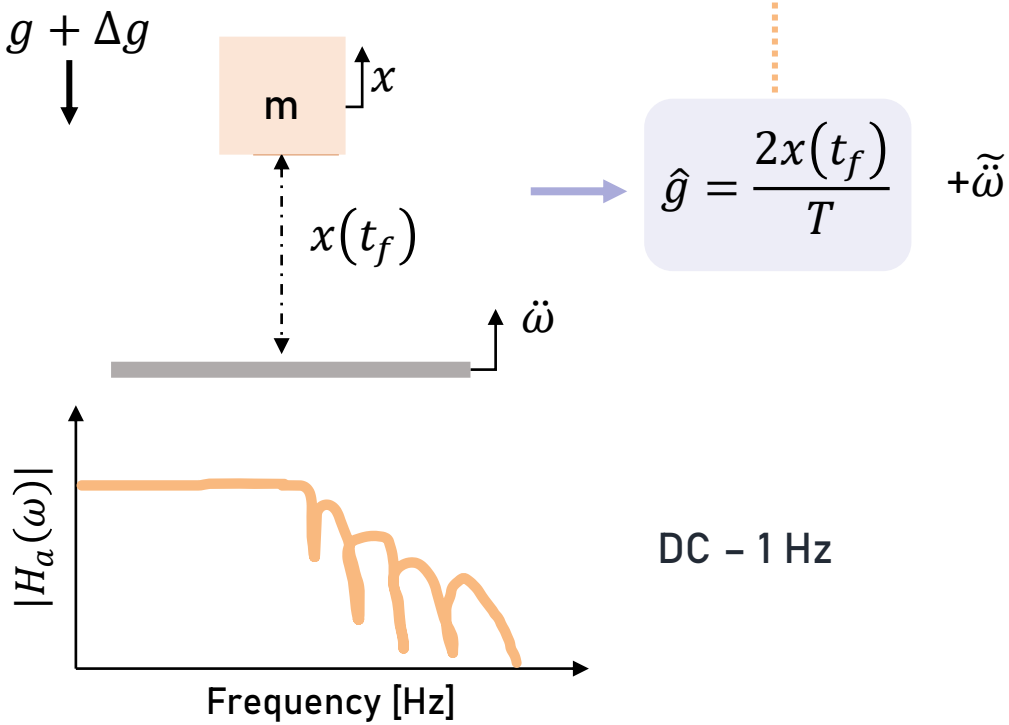
Expected results

$\Delta g = 40\ \mathrm{nm/s^2}$



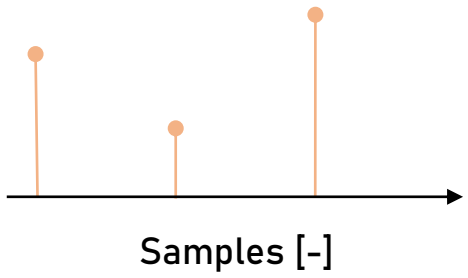
Gravity signal as control input

Absolute Gravimeter



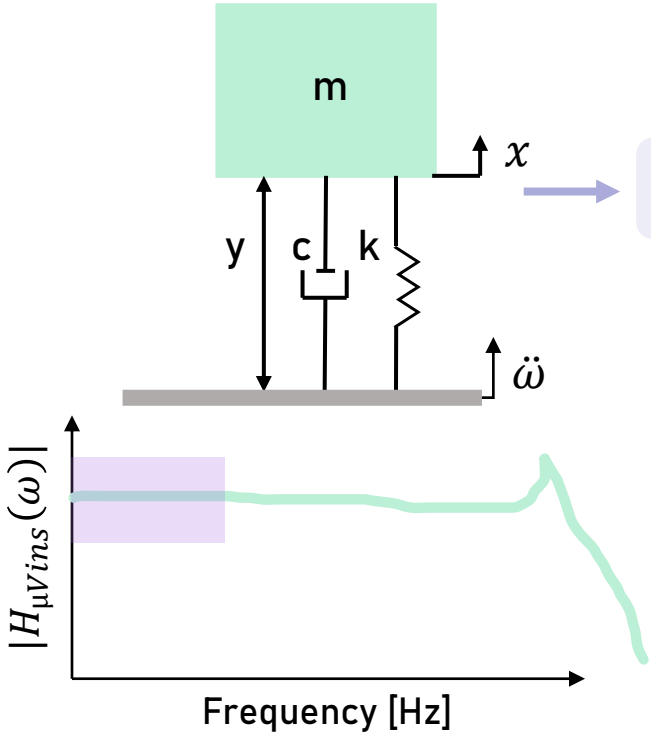
$$\hat{g} = \frac{2x(t_f)}{T} + \tilde{\ddot{\omega}}$$

DC – 1 Hz



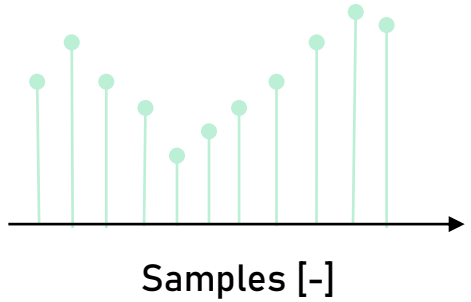
Low-sampling frequency

Accelerometer



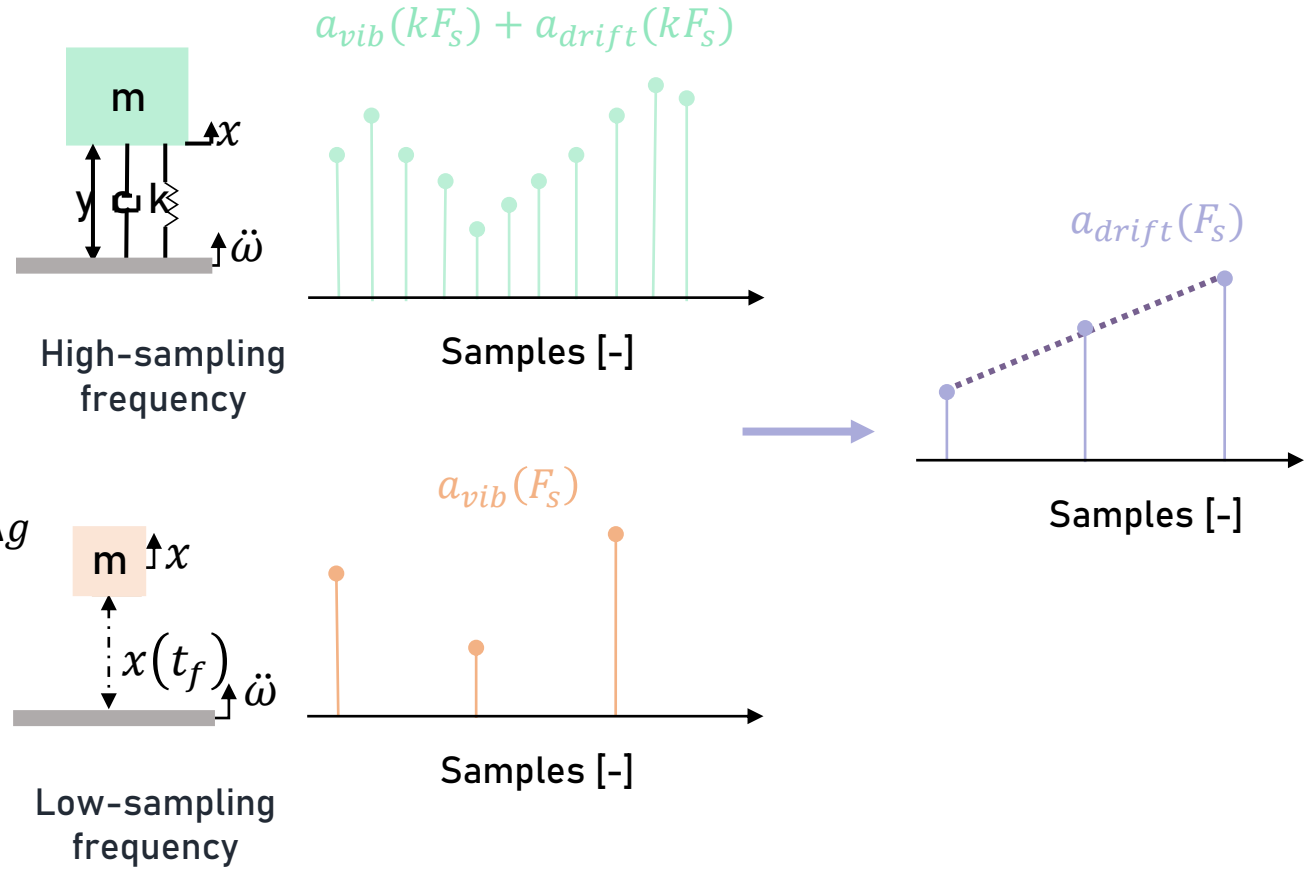
$$\ddot{\omega} + \widetilde{g_{LF}} + a_{drift}$$

LF – 100 Hz



High-sampling frequency

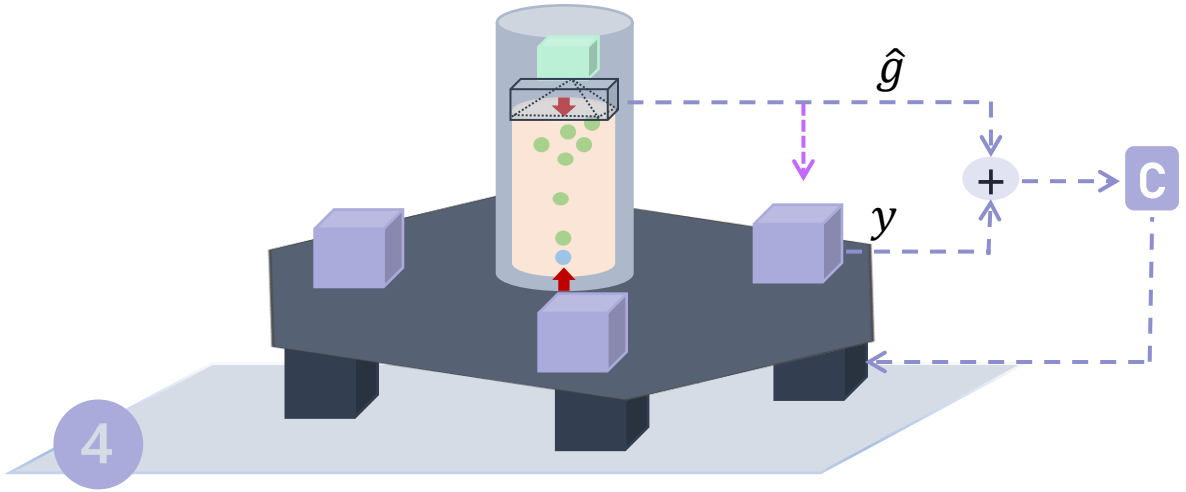
Gravity signal as control input



- Correct drift at low frequency from the inertial sensors on the platform

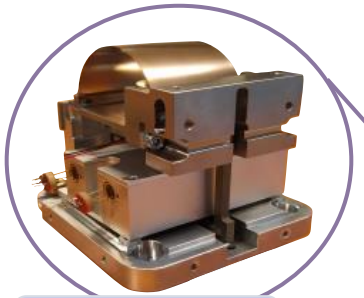
- Gravity signal as control input

→ Improve the isolation



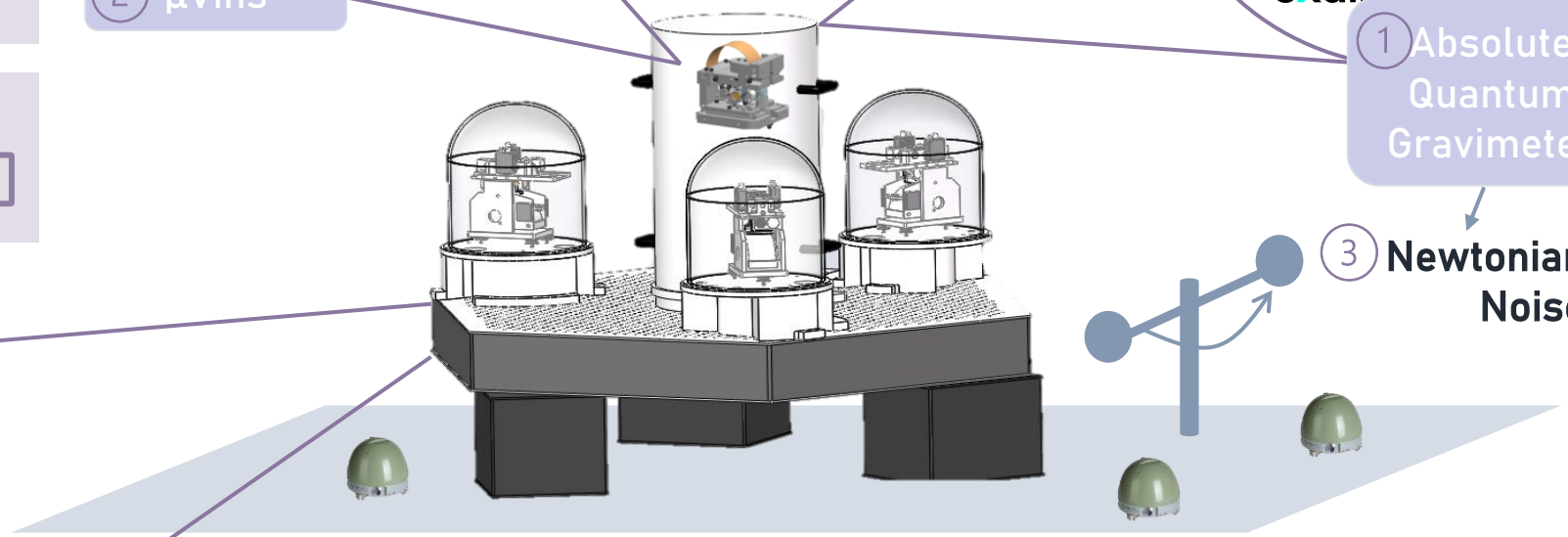
PhD research

1. Isolating the AQG on an actively controlled platform
2. Merging µVins to improve ground compensation
3. Using the signal of the gravimeter with an array of seismometers to model NN
4. Gravity signal to correct drift at low frequency + stabilize the active platform from gravity variation

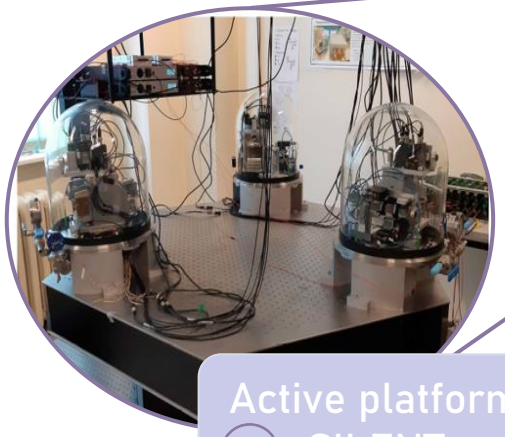


2 µVins

1 Absolute Quantum Gravimeter



3 Newtonian Noise



Active platform
4 SILENT

Active isolation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Thank you for the attention
Any questions ?
erc
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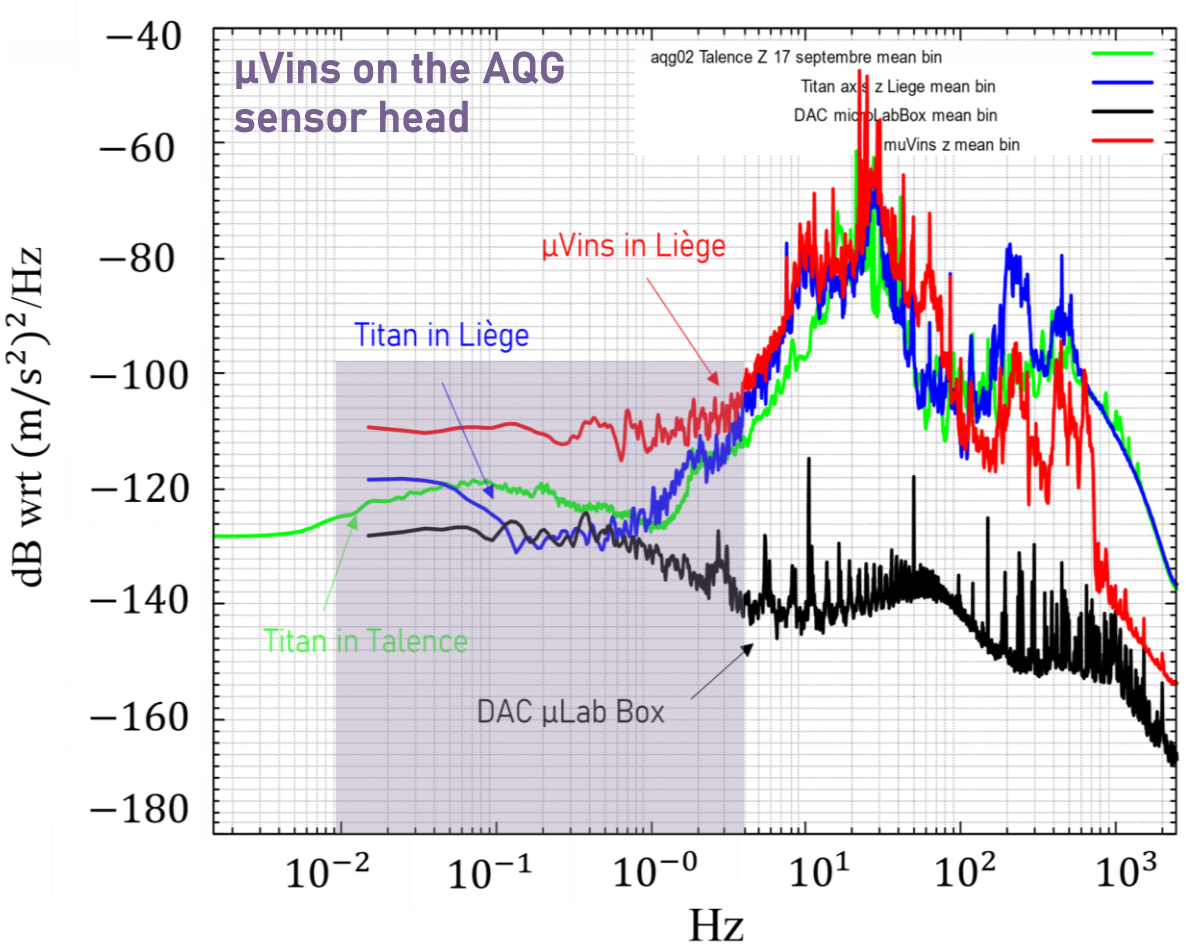
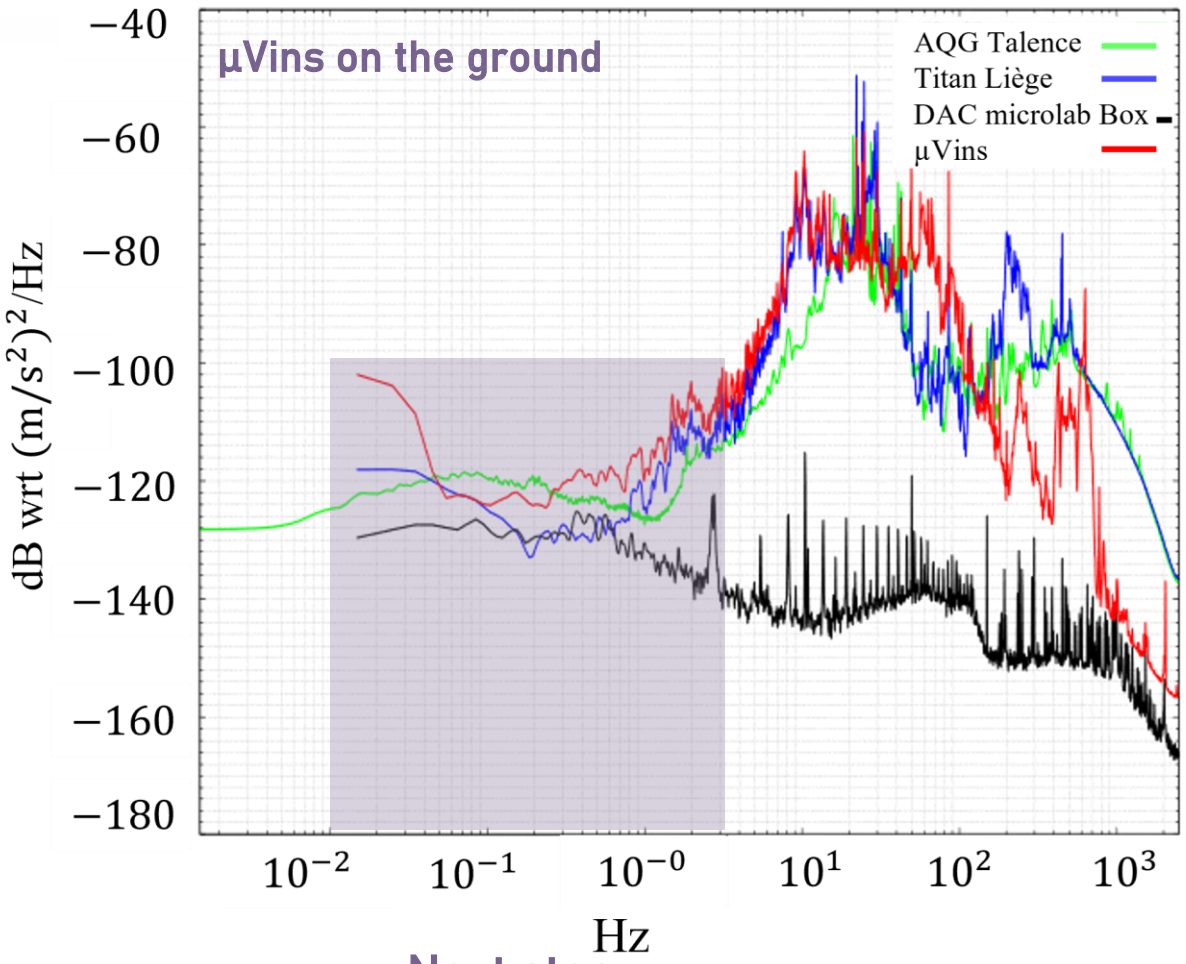
Additional slides





Observation

µVins placed on the floor works better than placed on the AQG.
The DAC signal exhibits a normal shape

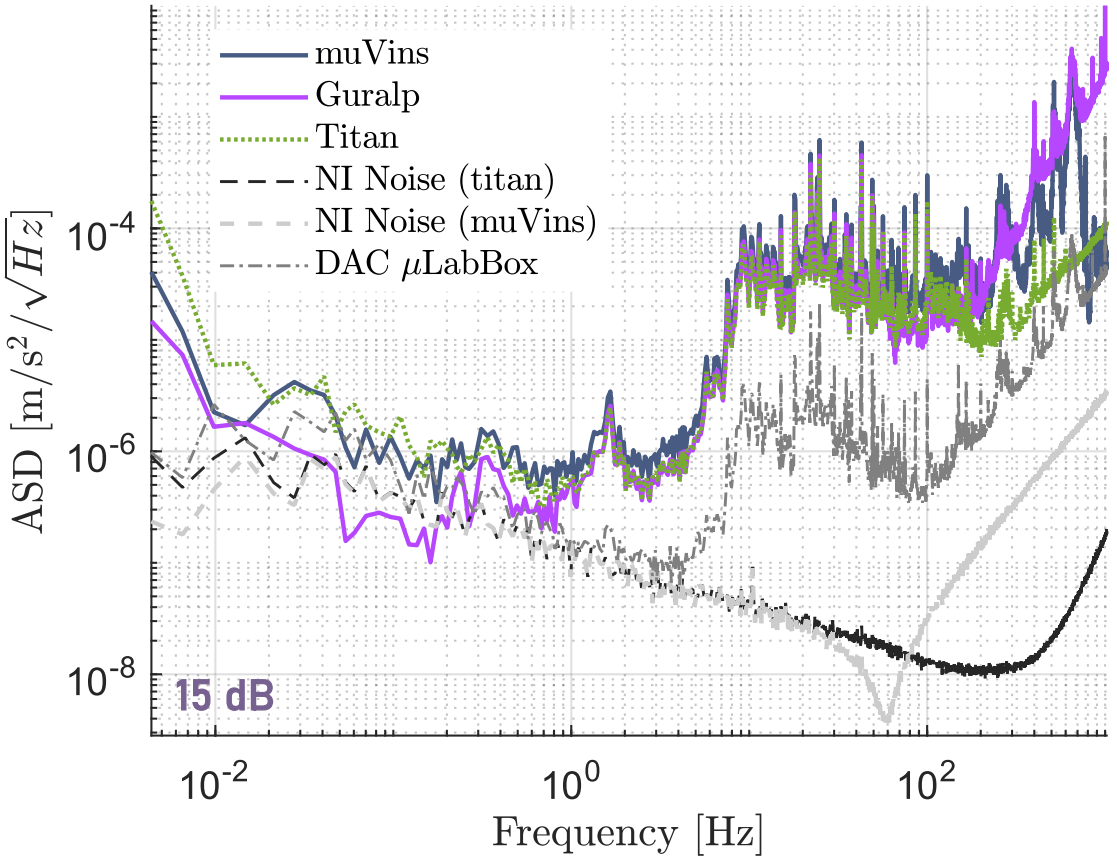
→ Is it really the influence of $\vec{B}_{\mu Vins}$ on $\vec{B}_{AQG}$?
Or something in the acquisition system of the AQG ?

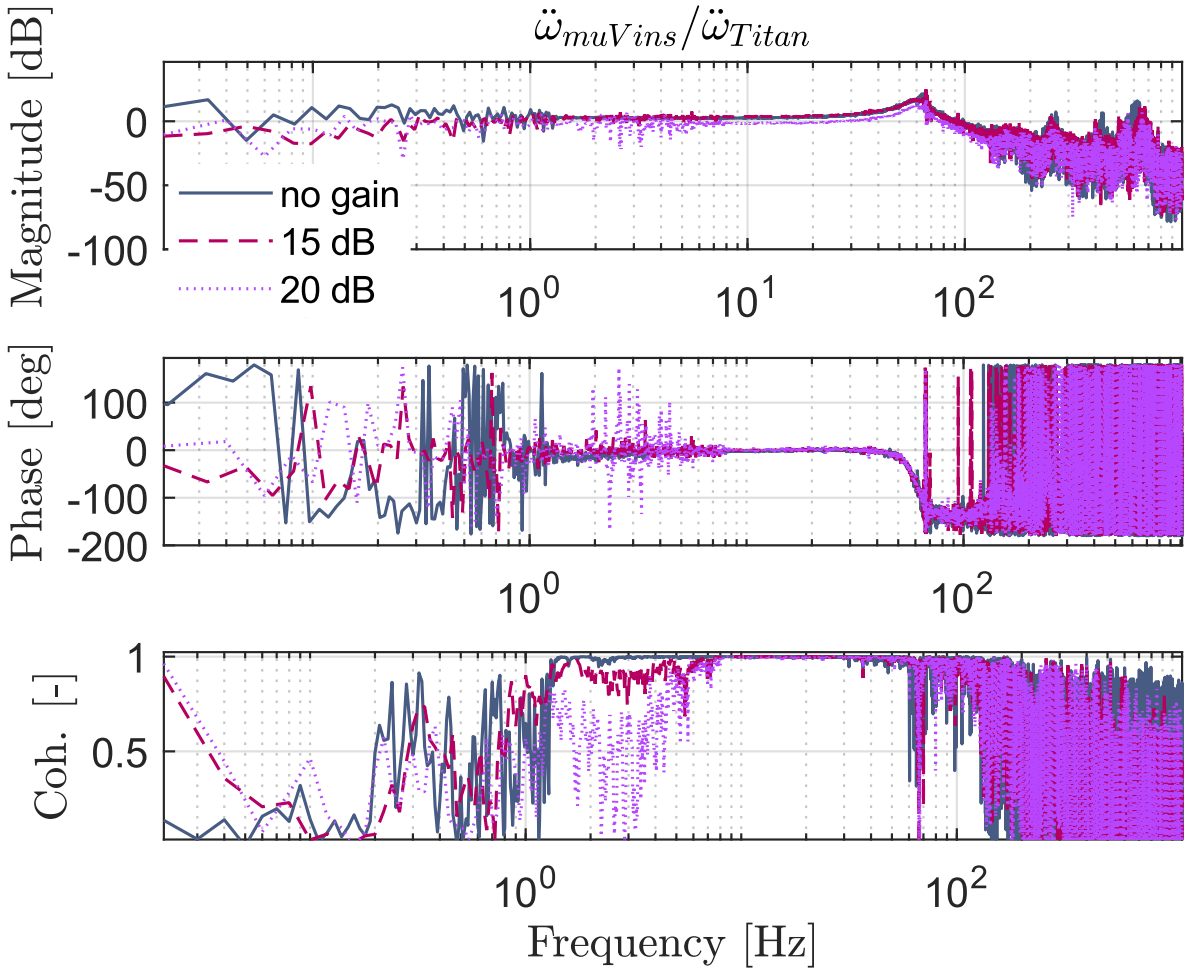
Next step

Record the signal of the µVins via the PXIe from national instrument and compare it to Titan and Guralp

Additional slides

→ **AQG acquisition card**





Additional slides