

E-TEST as a possible be-aware-of for lunar-like experiments

A facility to test heavy suspension

And cryo science

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LGWA Catania 2023



What's on stage

- E-TEST: what it is and its state-of-the-art
- Key features of E-TEST
 - Suspension
 - Cryostat
 - Sensors
 - State-of-the-art
- Possible points of interest for LGWA

Please read more about E-TEST via our recent presentations @:

- ET Symposium 2023
- LVK September 2023
- GWADW May 2023

Useful links:

TDR

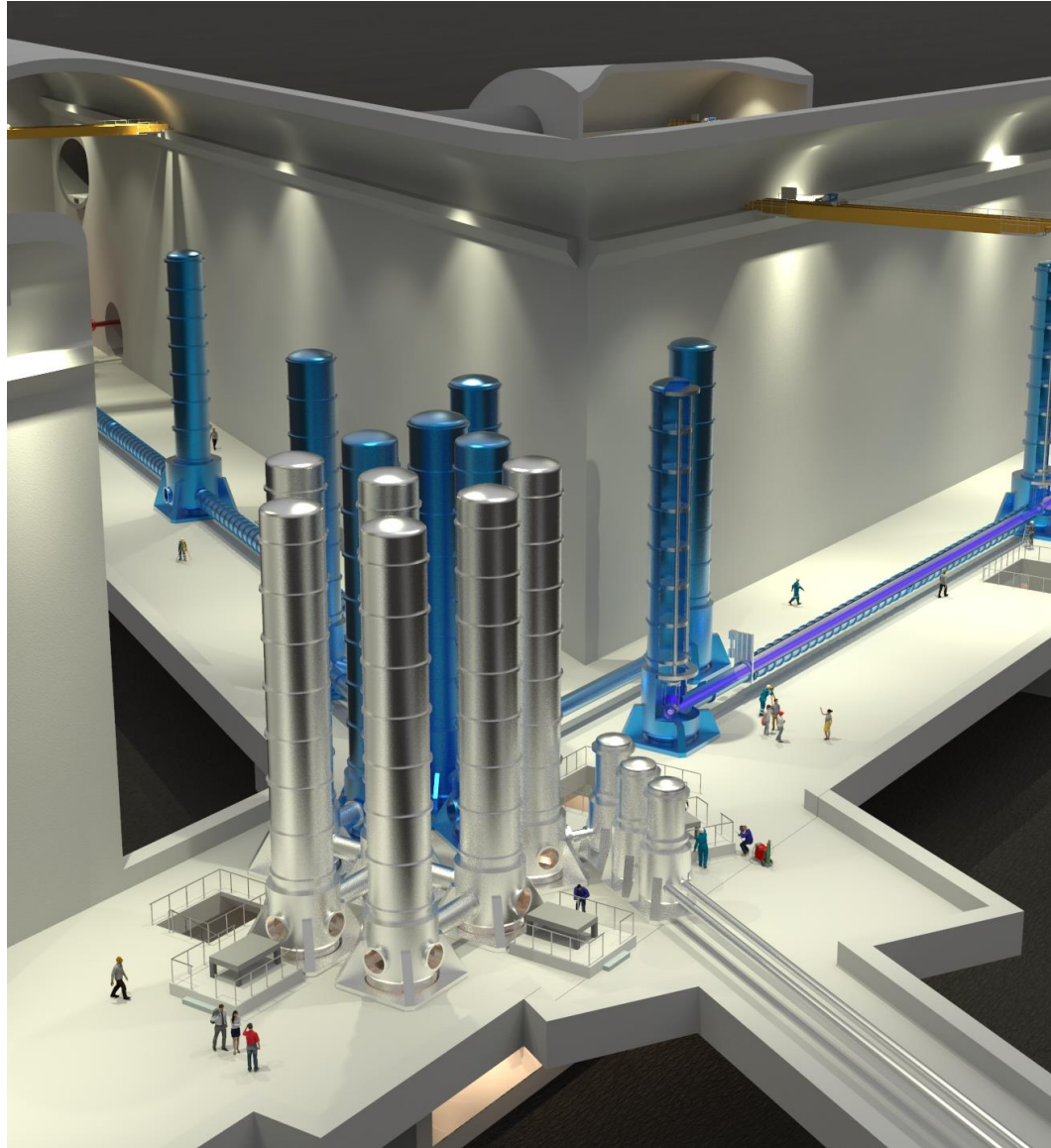
<https://arxiv.org/abs/2212.10083>

E-TEST Project website

<https://www.etest-emr.eu/>

PML website

<http://www.pmlab.be/>



E-TEST objectives

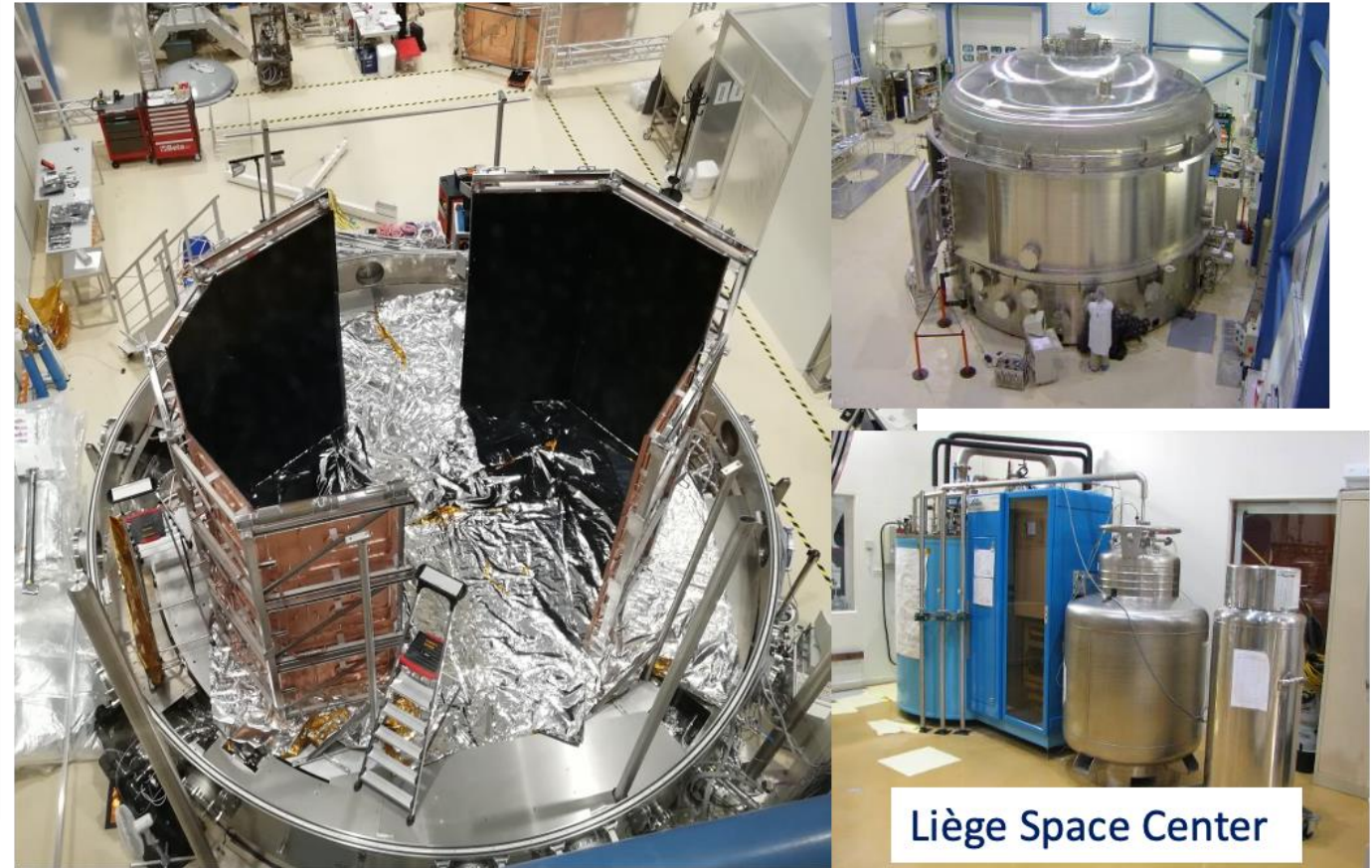
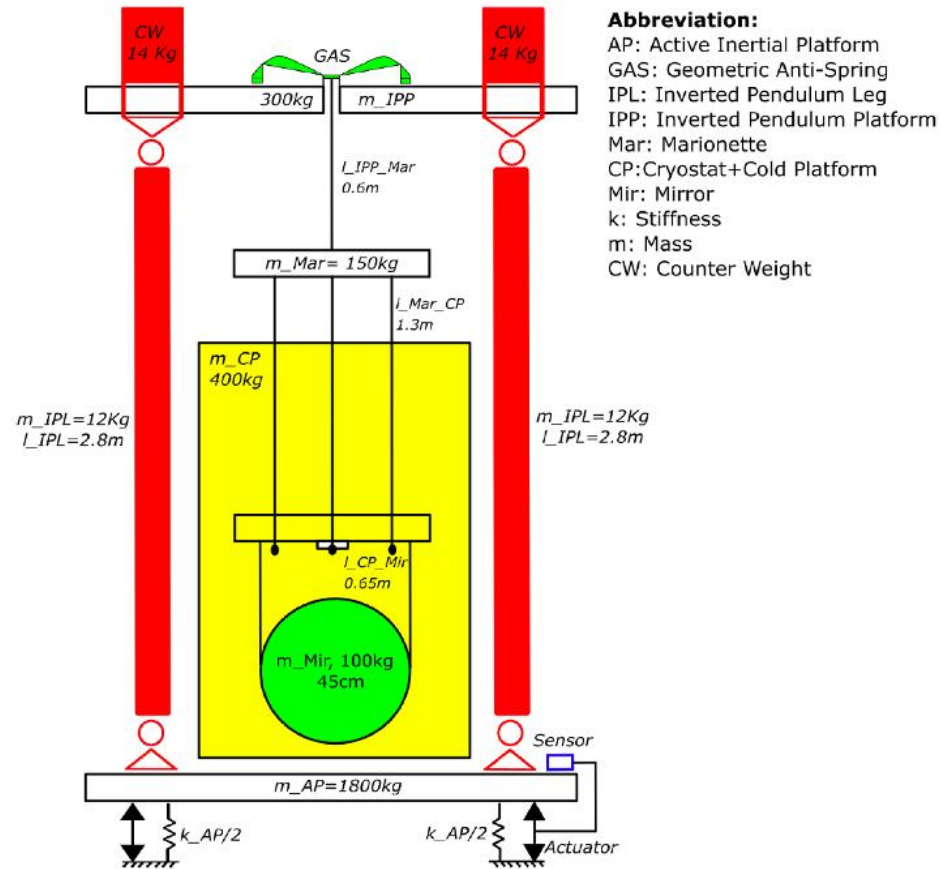
- Large mirror (100 Kg)
- Cryogenic temperature (around 25 K)
- Isolated at low frequency (0.1-10 Hz)
- Compact suspension (4.5 meters)

E-TEST feasibility strategy

E-TEST (Einstein Telescope Euregio-Meuse-Rhin Site and Technology) is a project funded by the Interreg Euregio Meuse-Rhine and ET2SME consortium, which allow us to capitalize on existing infrastructure at Centre Spatial Liège (CSL) for the construction of the facility.



E-TEST concept



Hybrid (active + passive) isolation
 Radiative cooling



Submitted: 12/2021
 Revised: 03/2022

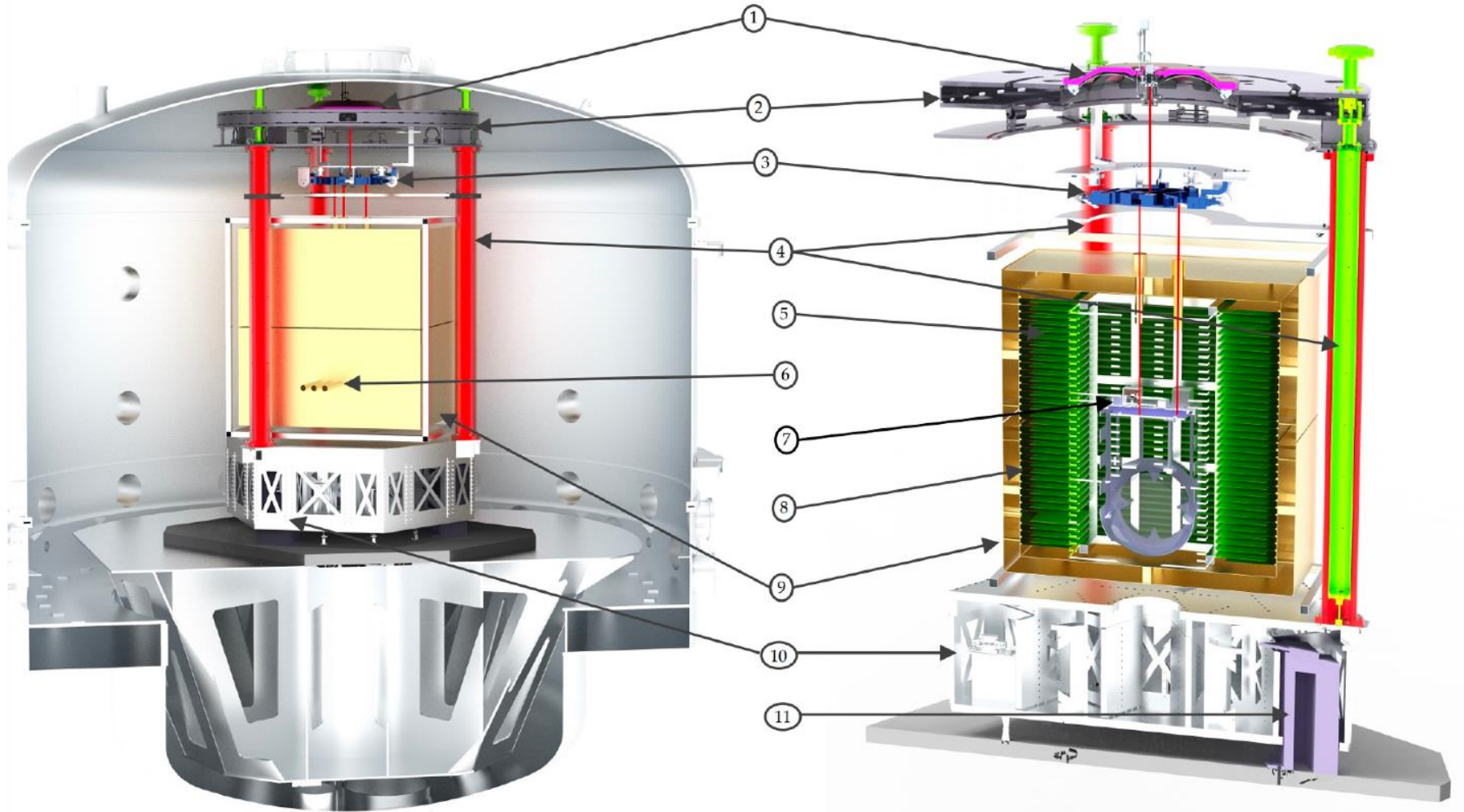
<https://arxiv.org/abs/2212.10083>

Vibration isolator

- 1) GAS filter
- 2) Inverted Pendulum (IP) platform
- 3) Marionette
- 4) IP legs
- 10) Active platform

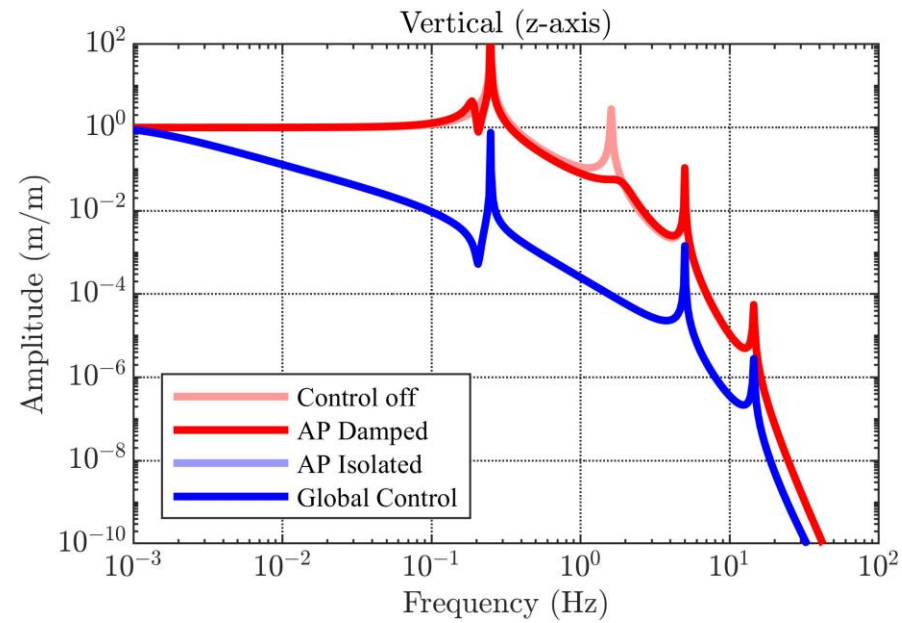
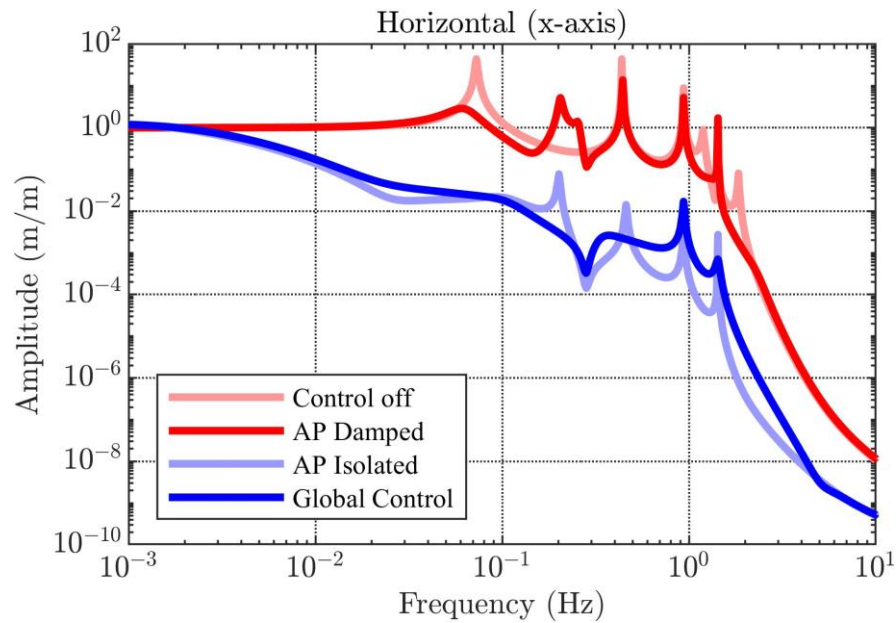
Cryogenic payload

- 5) Heat exchanger and cold platform
- 7) 25K inner thermal shield
- 8) 80K outer thermal shield

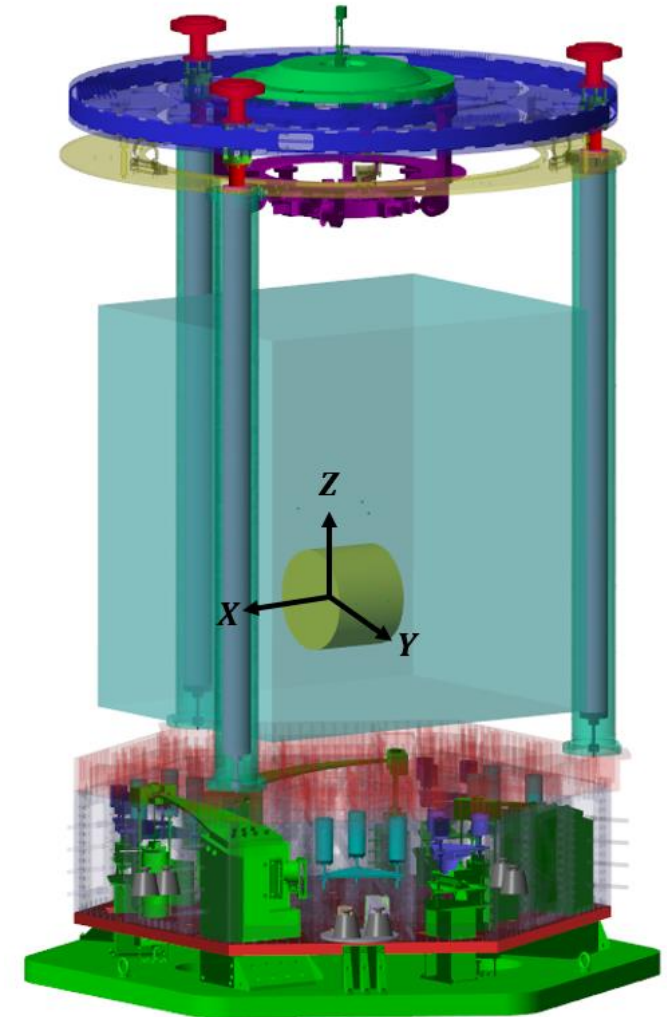


Finalizing the multi-body model and applying the first control strategy

Transmissibility (Mirror/ground)



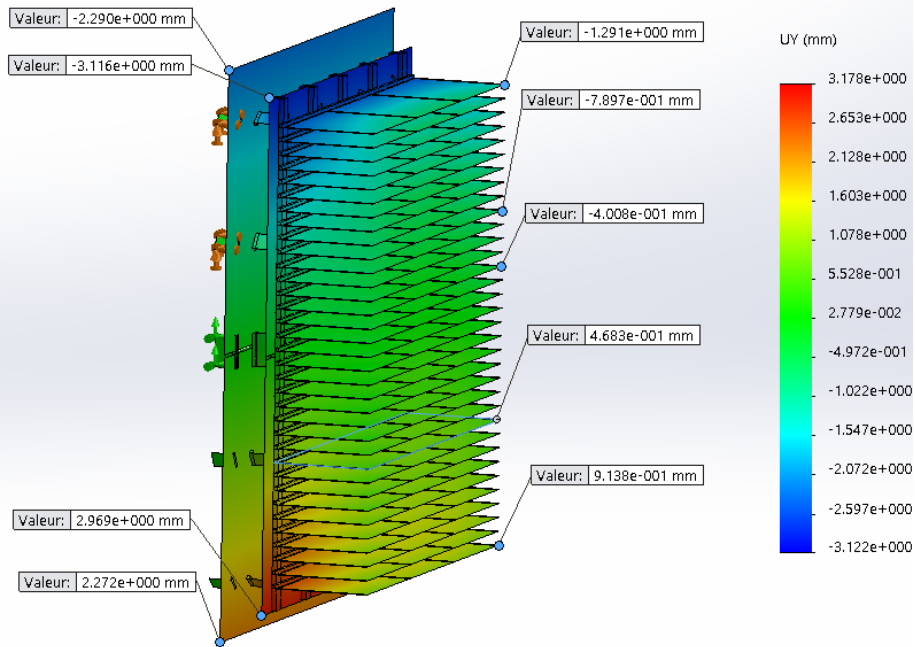
E-TEST Simscape model



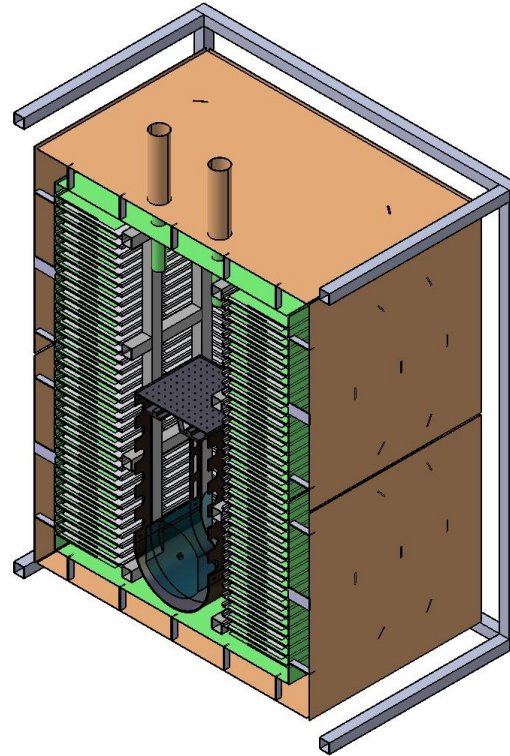
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Cryostat development

- ✓ overall dimensions: 1.8 x 1.6 x 2 m³
- ✓ conventional radiator design with **horizontal fins** (25K)
- ✓ three 30-mm diameter optical feedthroughs towards the mirror

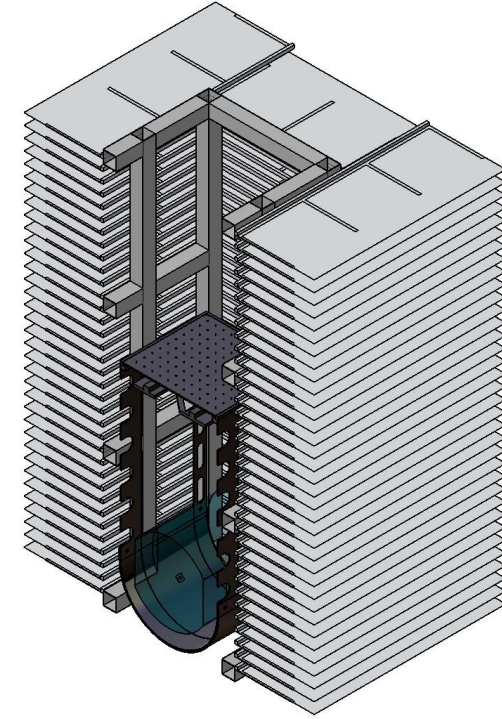


radiation heat transfer for
mirror cooling



Outer cryostat
(connected to the vacuum chamber):

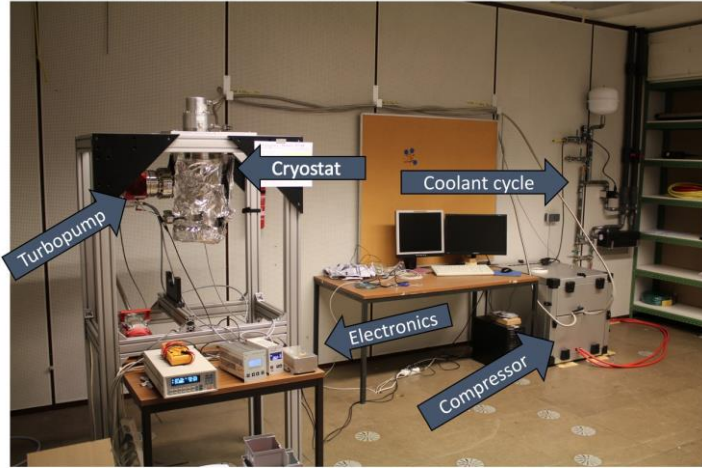
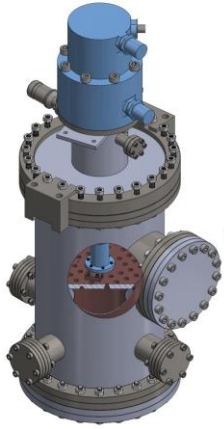
- 80K LN2 shield (brown)
- 25K He panels (green)



Inner cryostat
suspended and
conductively linked to
the silicon mirror

Contact: Cedric Lenaerts (CSL)
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Cryogenic test bench



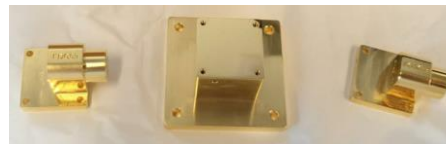
- Closed-cycle cryostat providing up to 1W cooling power at 10K
- Vacuum level: better than 10^{-9} mbar
- Usable volume: cylindrical 15x15cm
- Fast turnaround and low running costs
- Useful for testing materials, components and assemblies

Contacts: Robert Joppe

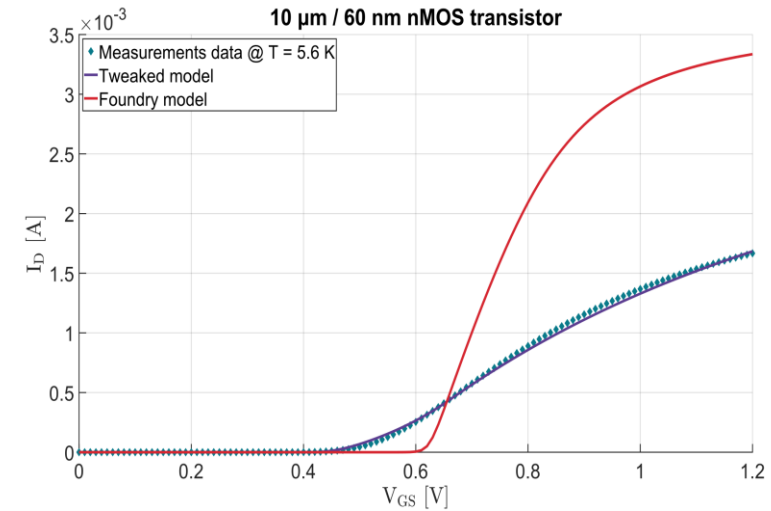
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Custom CMOS chips for sensor signal conditioning at low temperature



- Major achievement in cryogenic CMOS structures modeling: faithful representation over the full range of gate-channel geometries
- Custom Au-plated parts for photodiode test setup received

FOUNDRY MODEL **OUR CRYO-MODEL (SO FAR)**

Error* up to 65 %

Error* < 5.7 %

*Maximum current error in saturation and linear region of operation

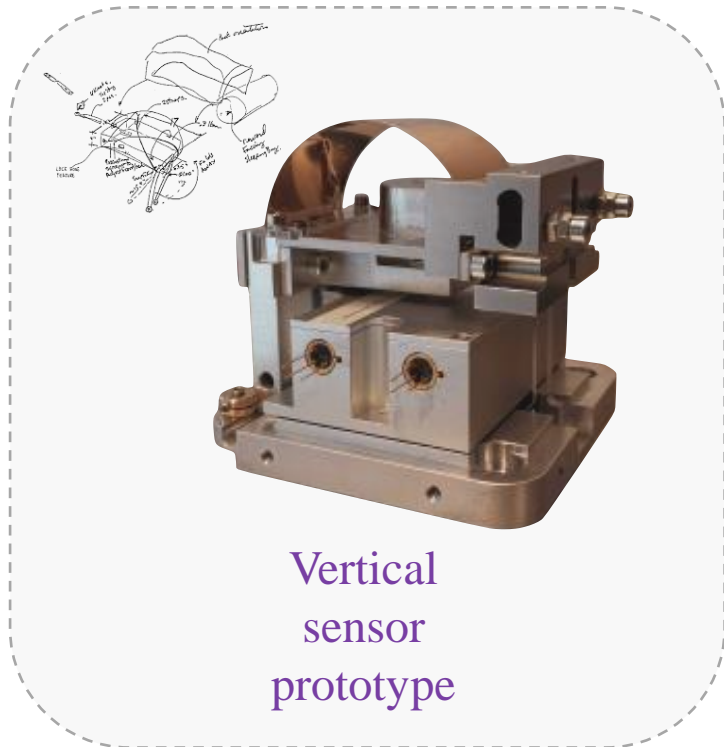
Contact: Alberto Gatti

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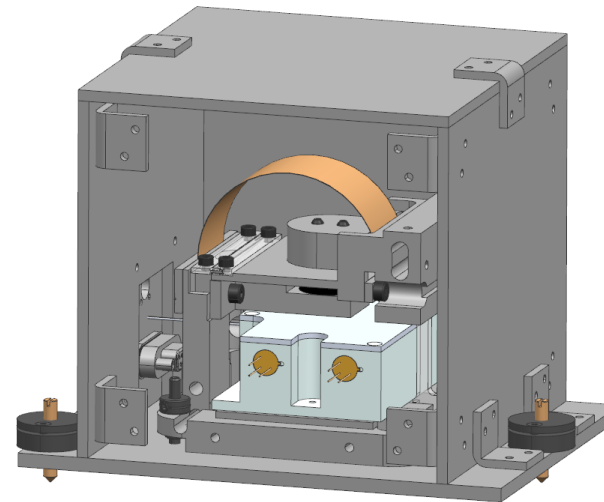
Ultra-cold vibration control

Inertial sensors development for active seismic attenuation at low frequency

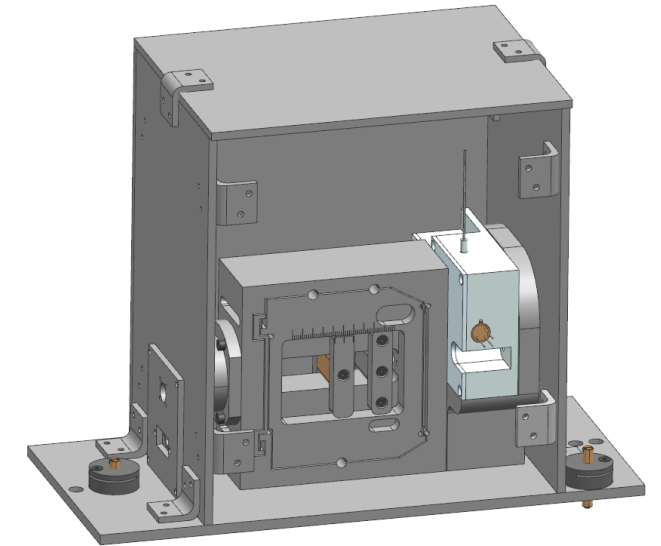
- Laboratory prototype is getting turned into its final assembling



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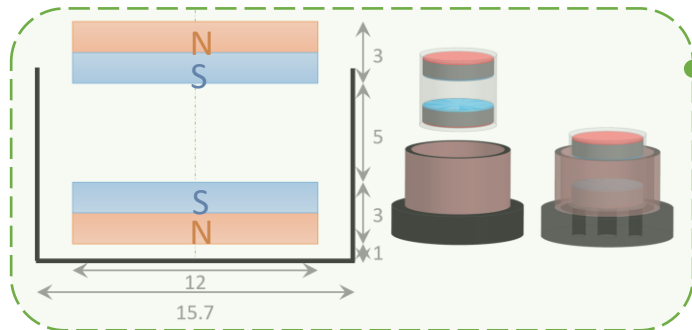


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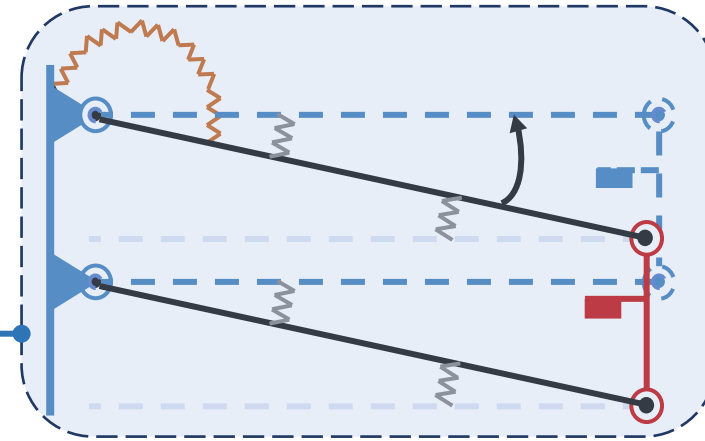
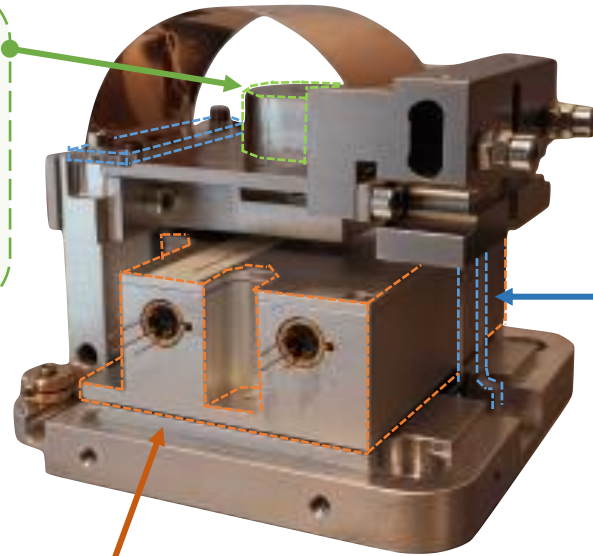
Morgane Zeoli (PML, UCL)
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High resolution long-period accelerometer



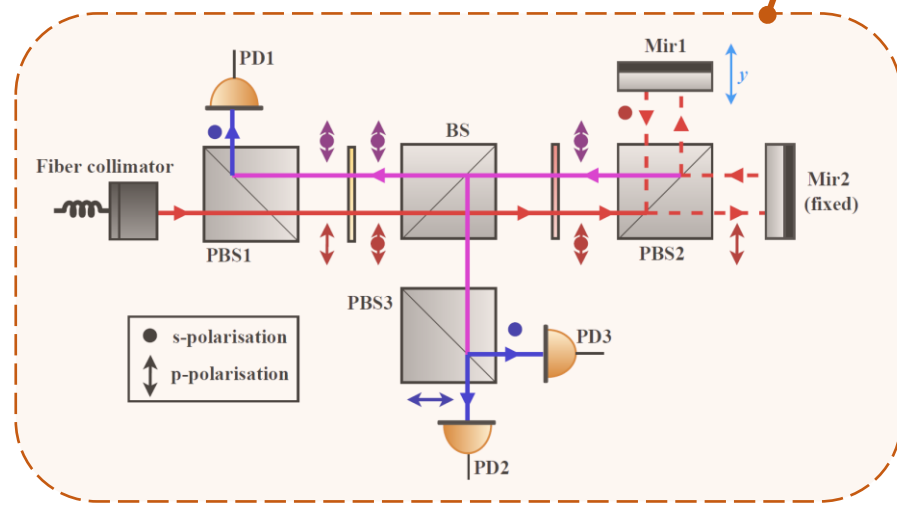
Feedback actuator:

- Moving magnet VCA.
- Self-shielded quadrupole magnet.



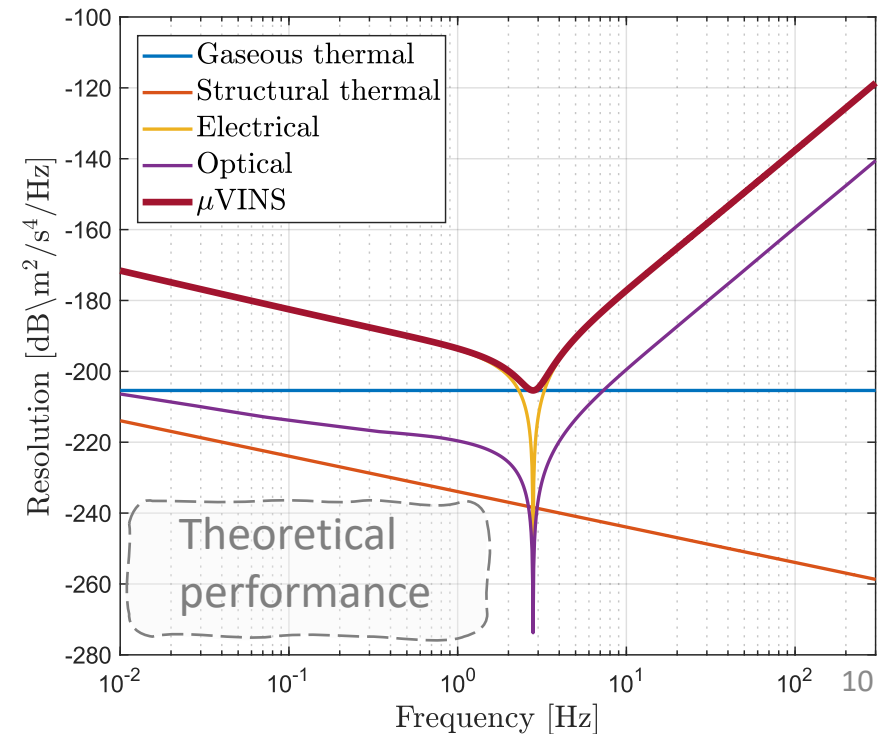
Mechanics

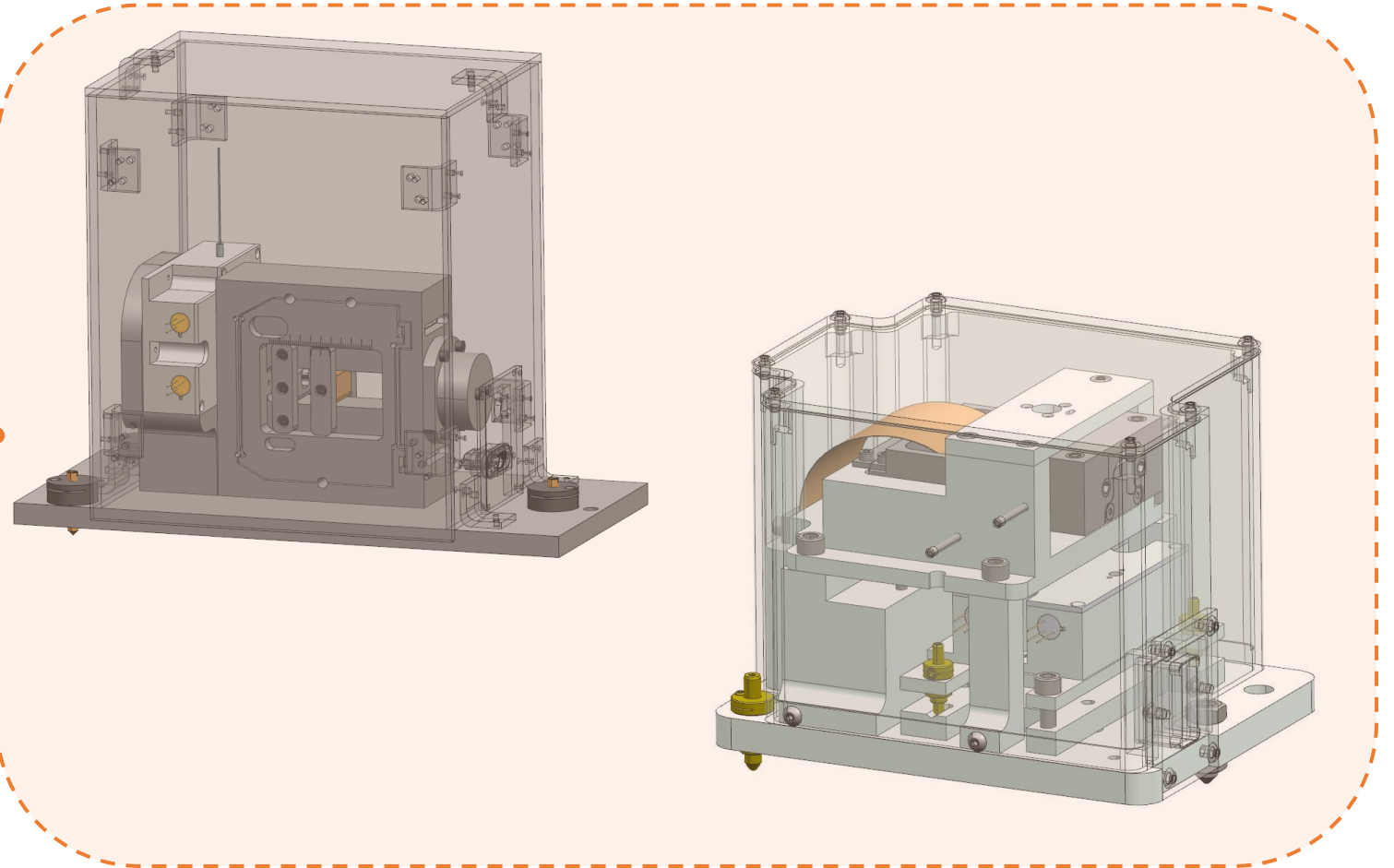
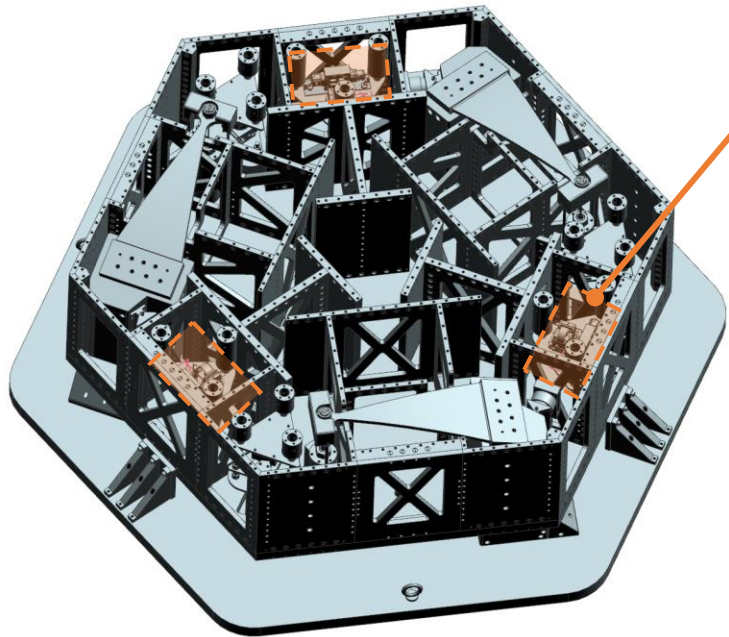
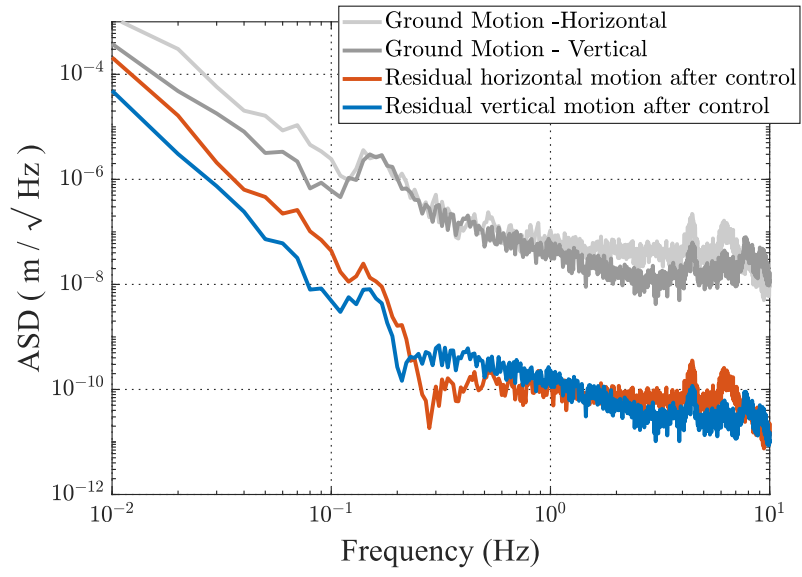
- Long period: $f_0 = 2$ Hz
- Low loss fused-silica flexures.
- Linear mechanical guide for the optical readout.



Quadrature Michelson interferometer

- High dynamic range.
- High resolution: 2×10^{-13} m/ $\sqrt{\text{Hz}}$.





Sensors & Actuators

4 Optical Sensors

4 Voice coil actuators

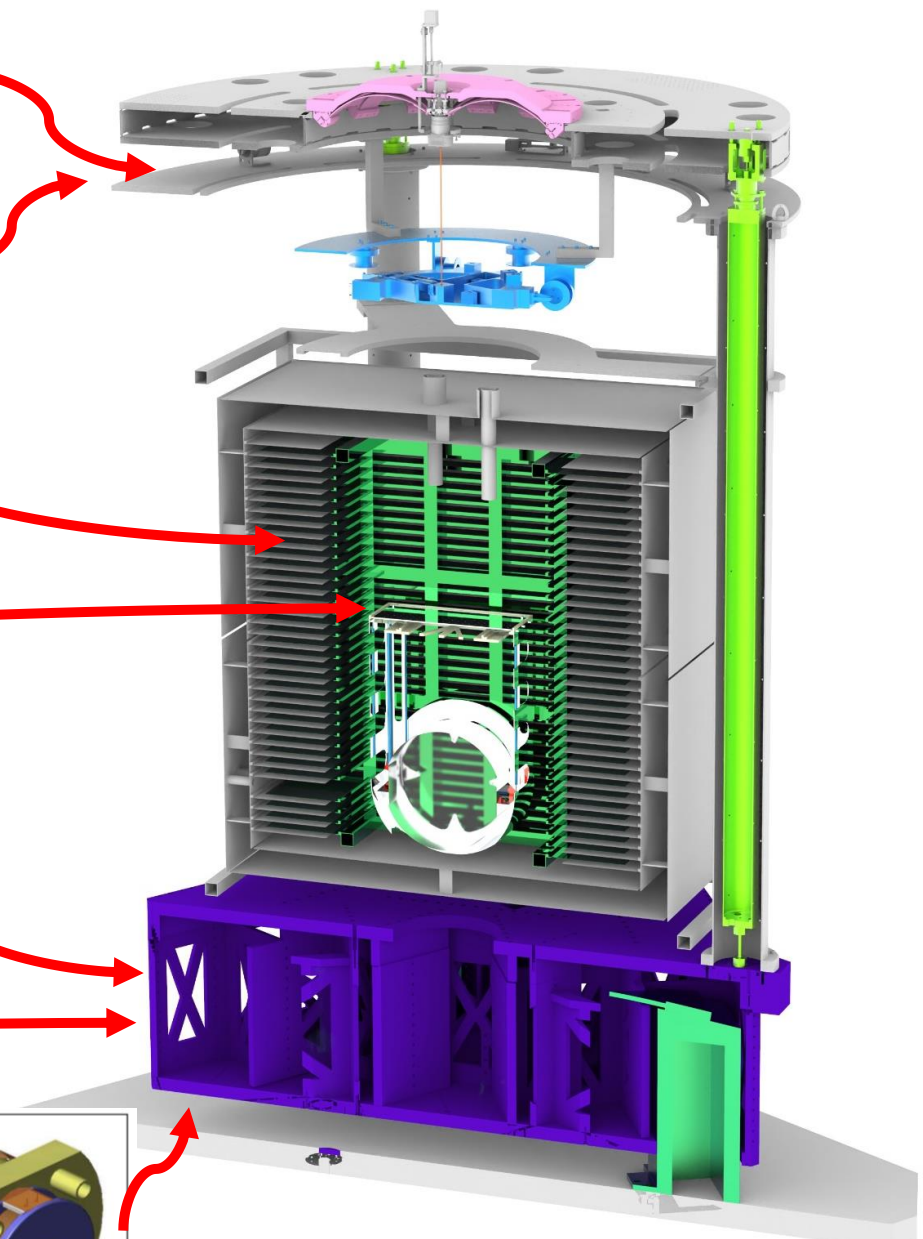
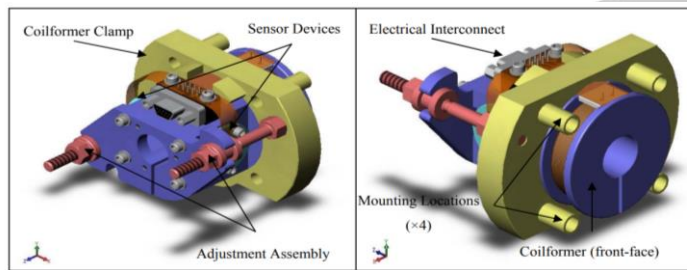
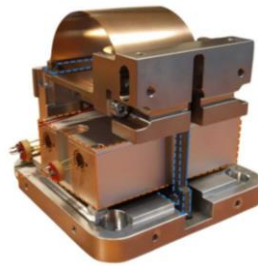
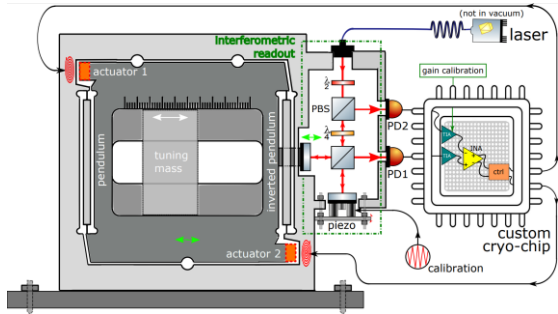
Temperature sensors

5 Cryogenic inertial sensors

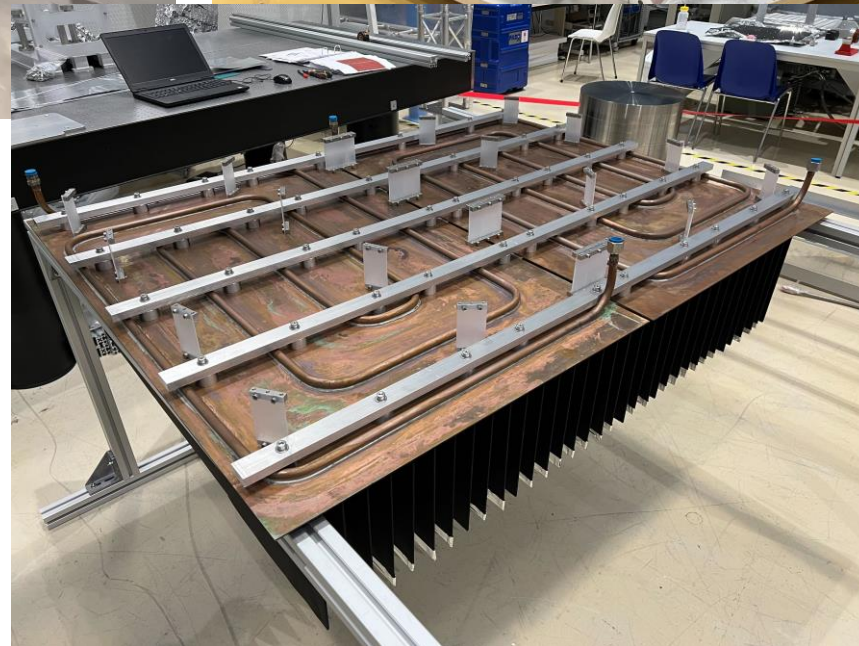
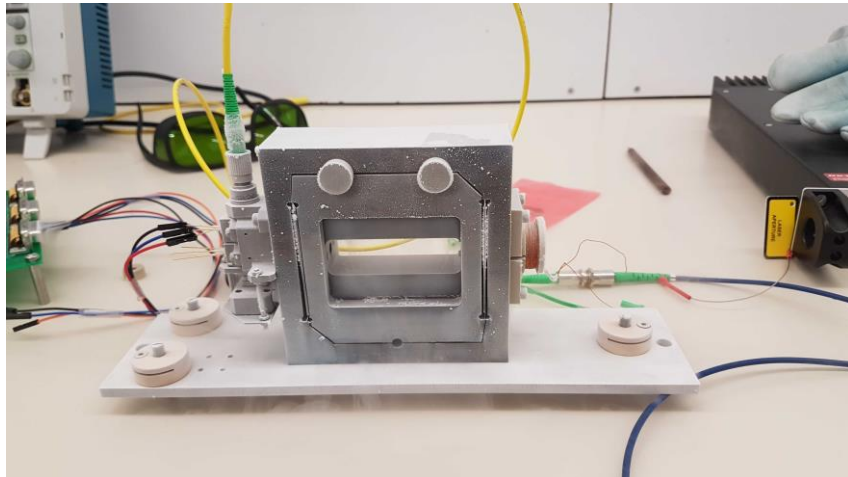
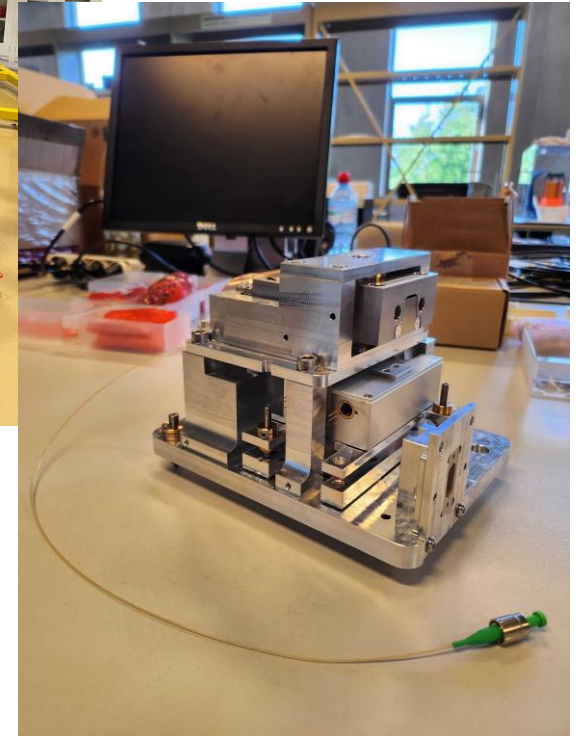
6 Inertial sensors

6 voice coil Actuators

6 BOSEMs



State of the art of the prototype

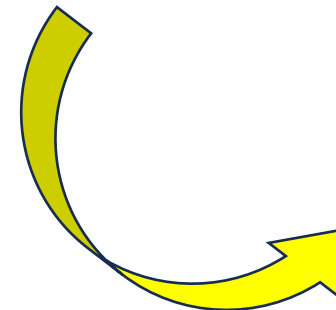


Interest for the LGWA

We will end E-TEST experiments in December, then we will use the facility for validations of further points of interest in science.

E-TEST might be a useful tool to simulate lunar ambient conditions in terms of

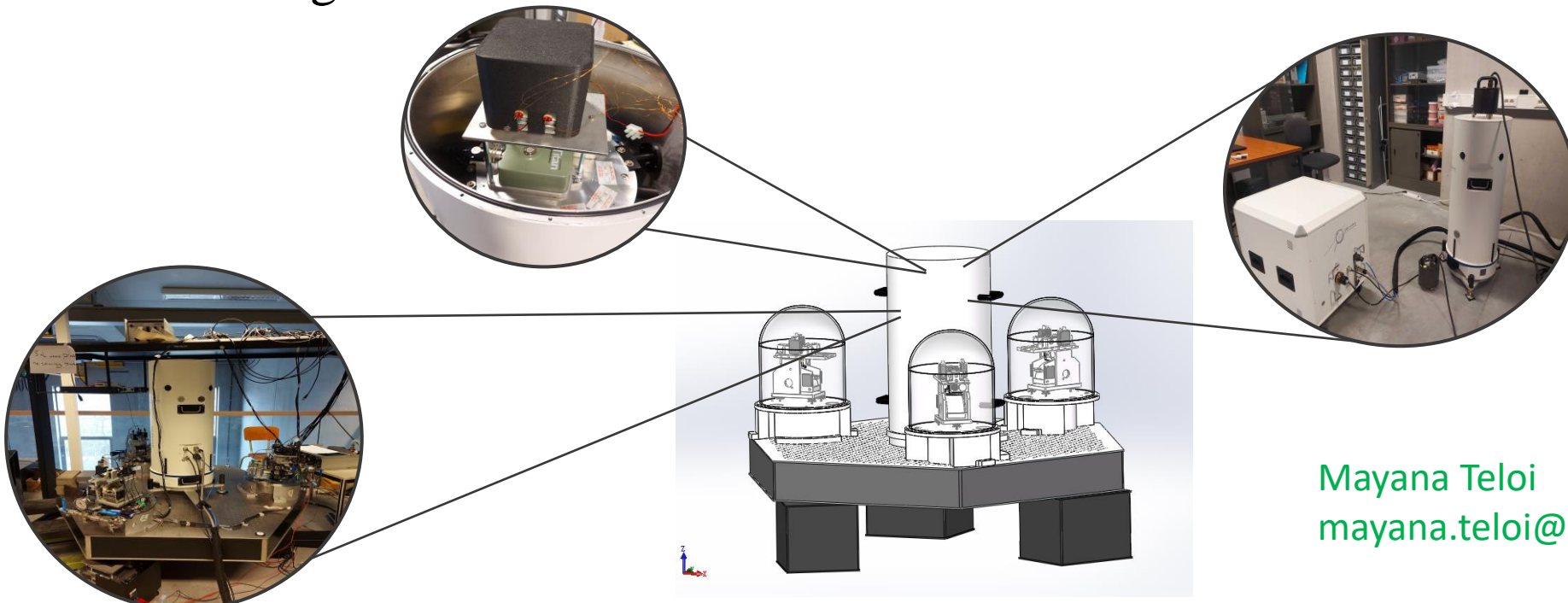
- Gravity
- Seismic isolation
- Temperature
- Atmospheric pressure (vacuum)



Interest for the LGWA

- Gravity and seismic motion

- Smart use of E-TEST for LGWA is to profit from its seismic isolation system to try to reproduce the seismic condition of the Moon, also thanks to the use of an Atomic Quantum Gravimeter that we are developing for Newtonian noise modelling

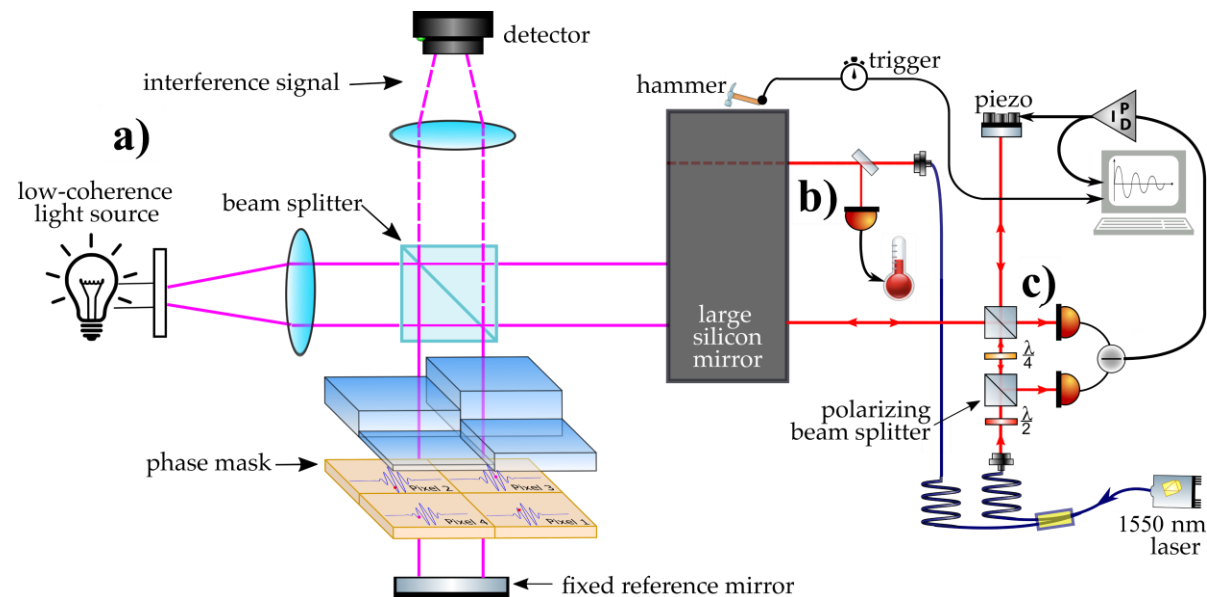


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Interest for the LGWA

- Temperature and pressure

- Thanks to the cryostat (T around 25 K) it would be possible to simulate the temperature conditions present on the Moon. All the setup is placed in vacuum, giving the simulation of atmospheric absence of the Moon.
- Test of sensors, lasers and materials at this temperature conditions can be performed and are already in the design phase





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