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E-TEST: Einstein Telescope EMR Site

Mayana Teloi on behalf of the Precision Mechatronics Laboratory – Uliege

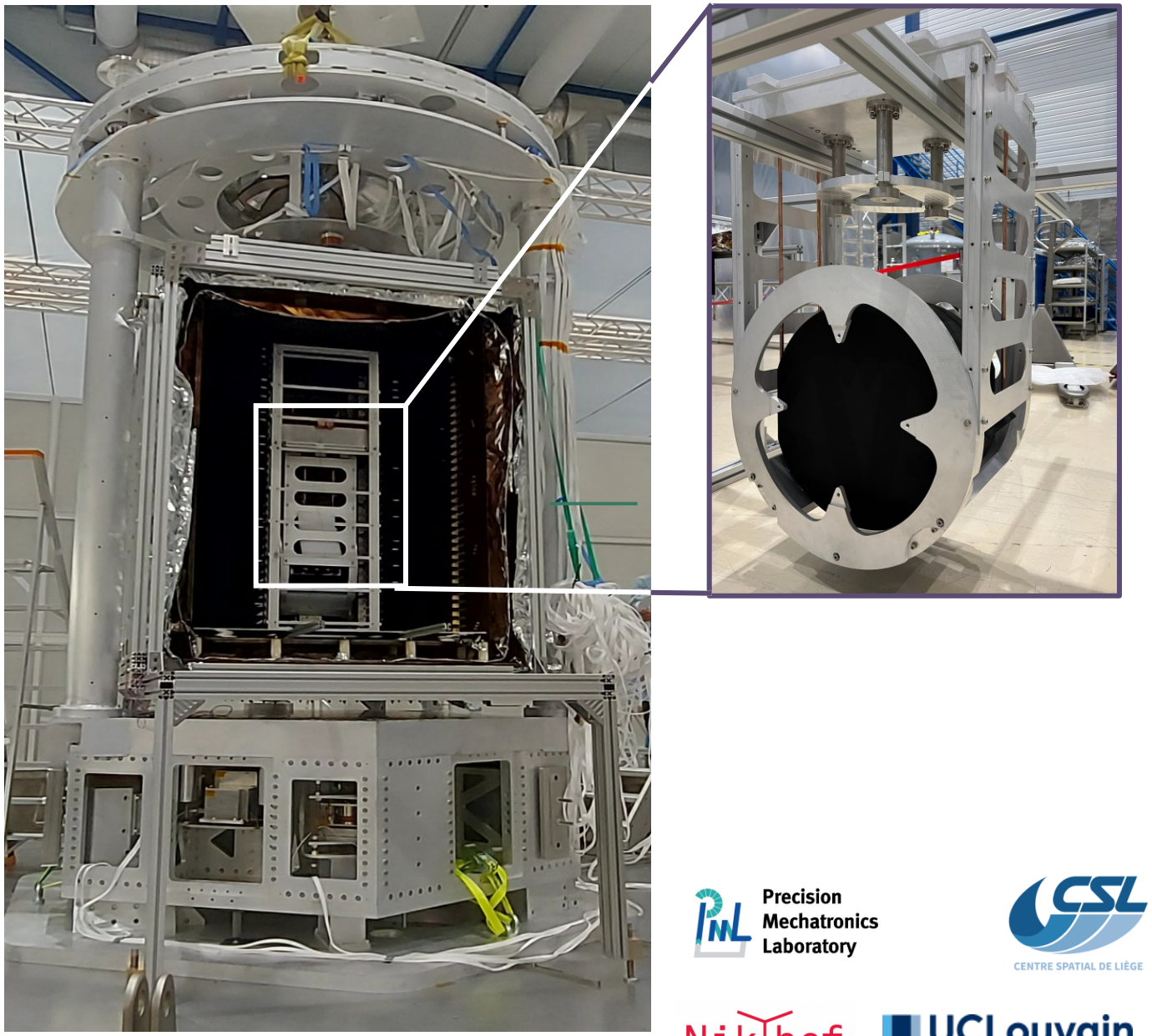
LGWA – 17/09/2025

E-TEST Einstein Telescope EMR Site & Technology

Interreg Euregio Meuse-Rhine European Regional Development Fund

EUROPEAN UNION

E-Test



- Large mirror (100 Kg)
- Radiative cooling
- Cryogenic temperature (20 K)
- Isolated at low frequency (0.01-10 Hz)
- Compact suspension (4.5 meters)

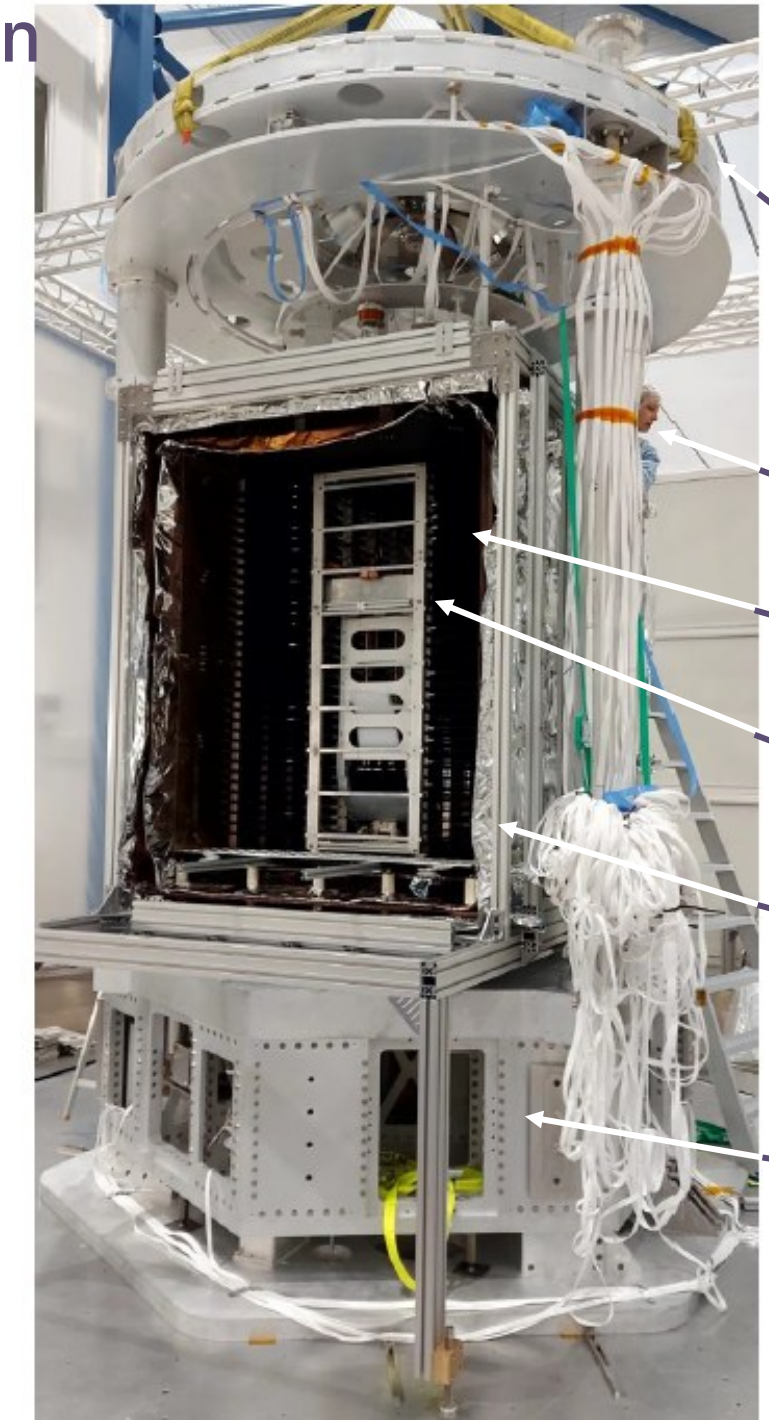
E-TEST feasibility strategy

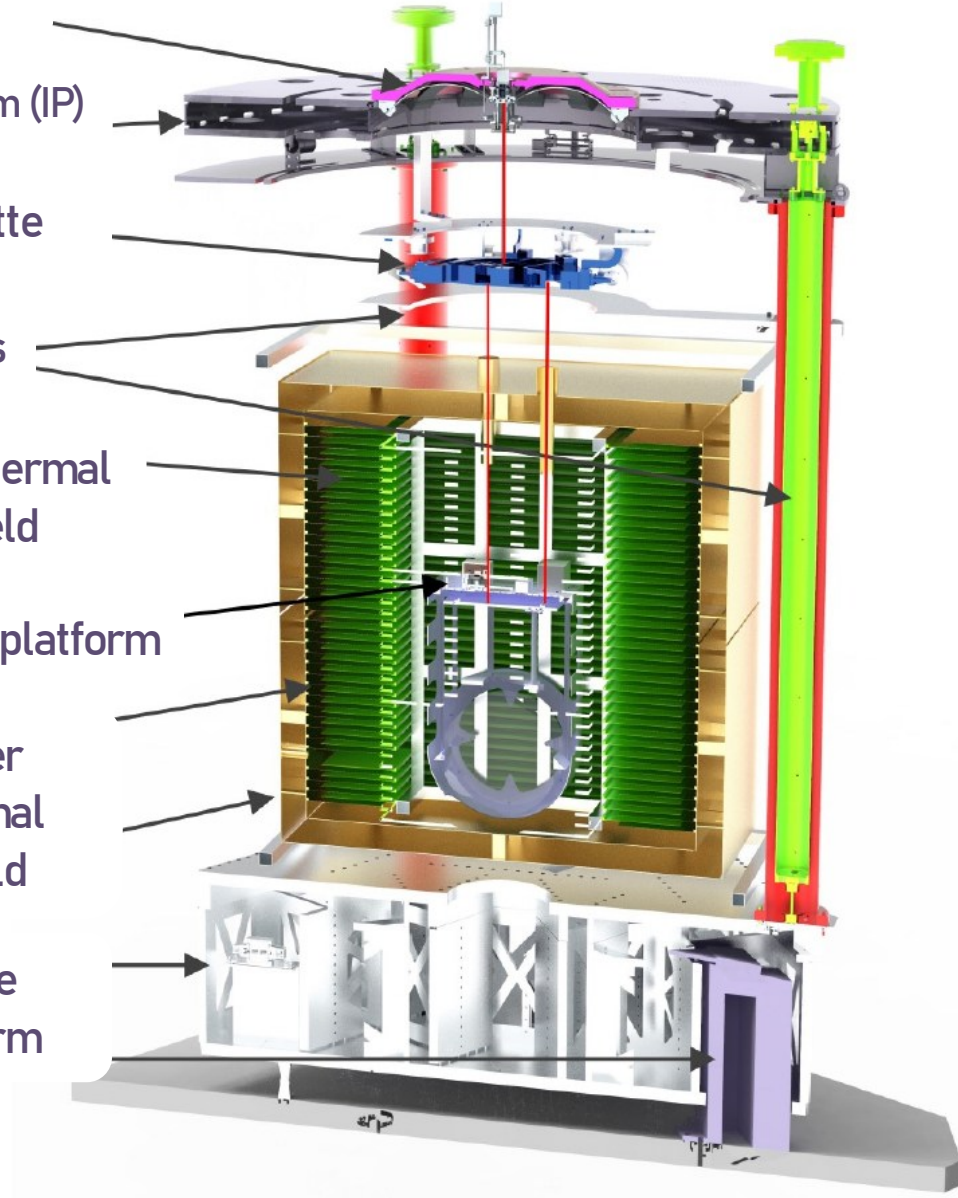
E-TEST is a project funded by the Interreg Euregio Meuse-Rhine and ET2SME consortium, which allow us to capitalize on existing infrastructure at Centre Spatial Liège (CSL) for the construction of the facility.

Precision Mechatronics Laboratory · CSL Centre Spatial de Liège · RWTH Aachen University · E-TEST · Interreg Euregio Meuse-Rhine · Nikhef · UCLouvain · micas KU Leuven · Fraunhofer ILT · KU Leuven

From a design concept to technical drawings

- Large mirror (100 Kg)
- Radiative cooling
- Cryogenic temperature (20 K)
- Isolated at low frequency (0.01-10 Hz)
- Compact suspension (4.5 meters)

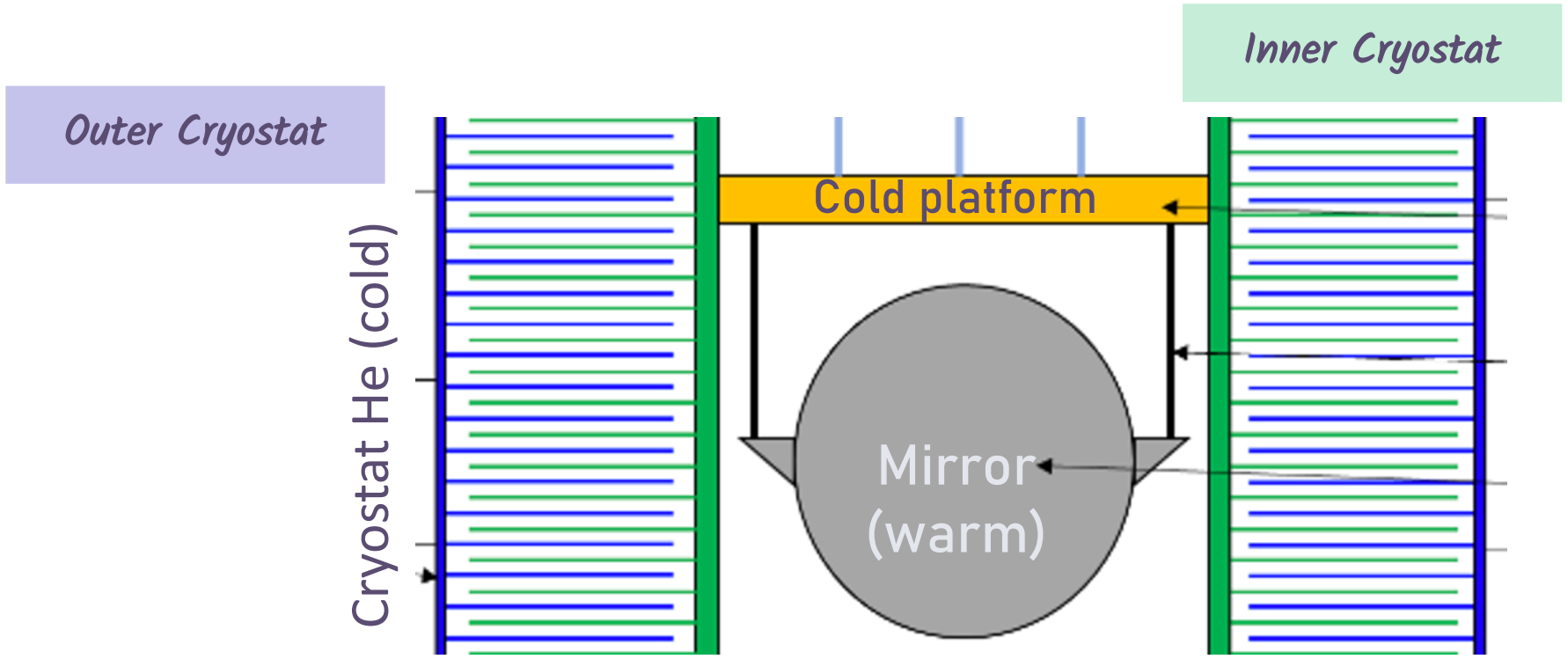




Radiative Cooling

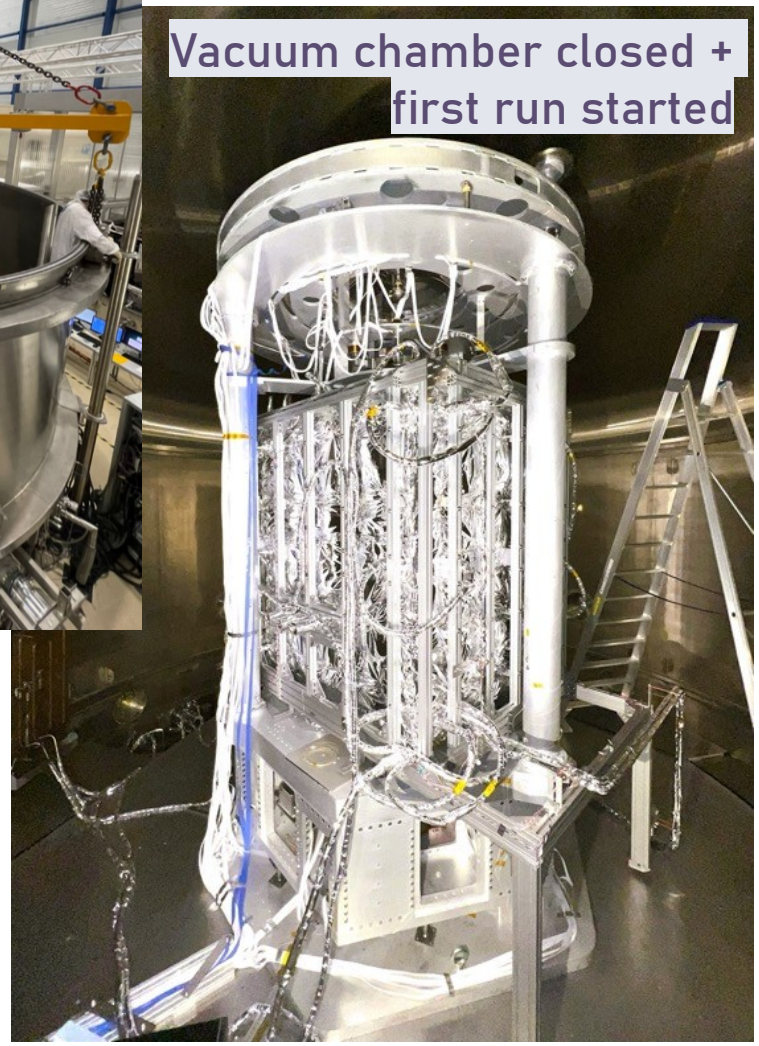
Contact: Lionel Jacques (CSL)
ljacques@uliege.be

- Interlacing fins to increase the radiative heat exchange area (80m² for E-TEST, ~500m² for ET).
- Inner cryostat linked to Si mirror, outer cryostat connected to the vacuum chamber
- Emissivity enhancement at low temperature (coating)



Cryogenic Temperature (20K)

Assembly of the prototype was finished by the end of November 2023



Vacuum chamber closed + first run started

Contact :Cédric Lenaerts (CSL)
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Lionel Jacques (CSL)
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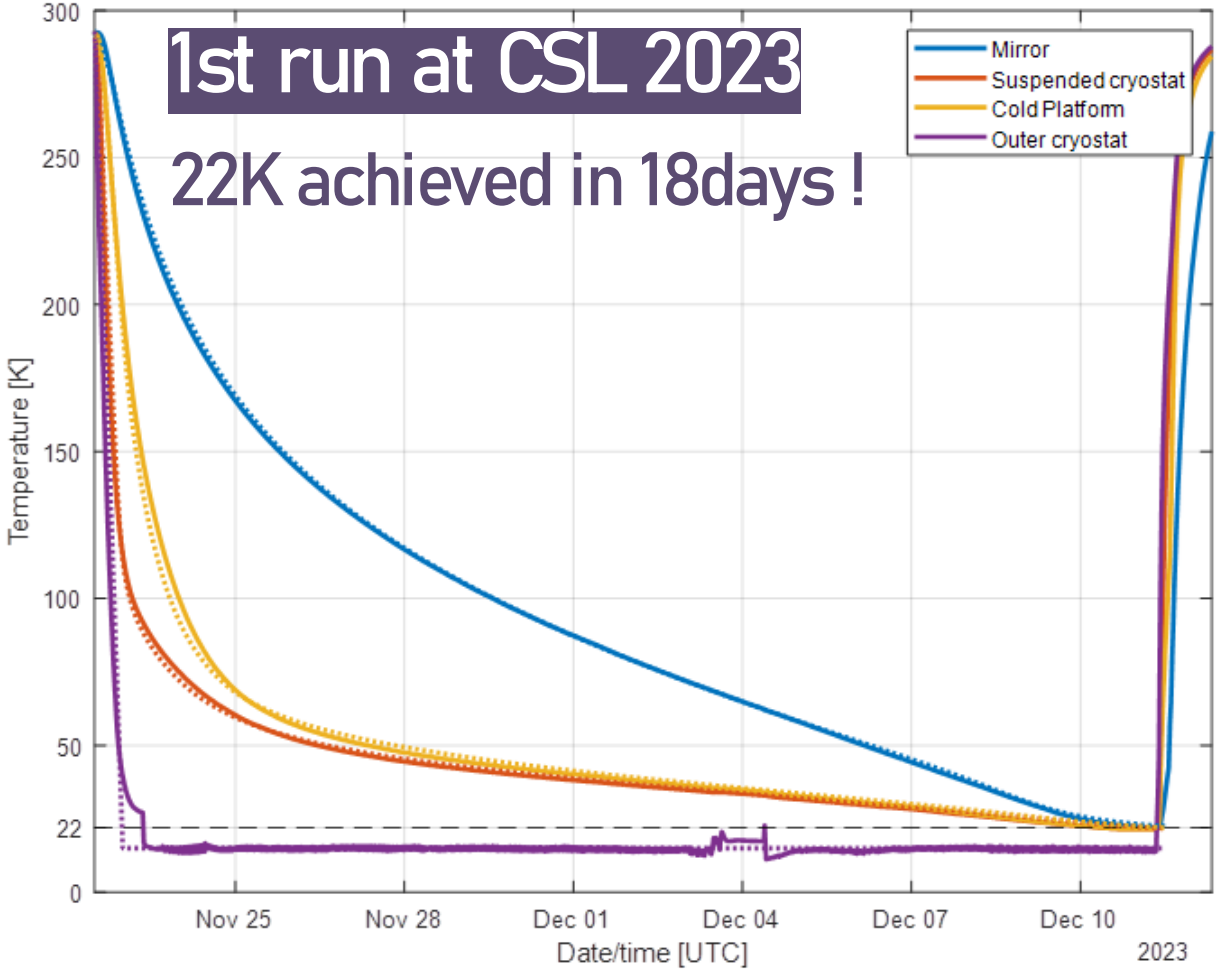
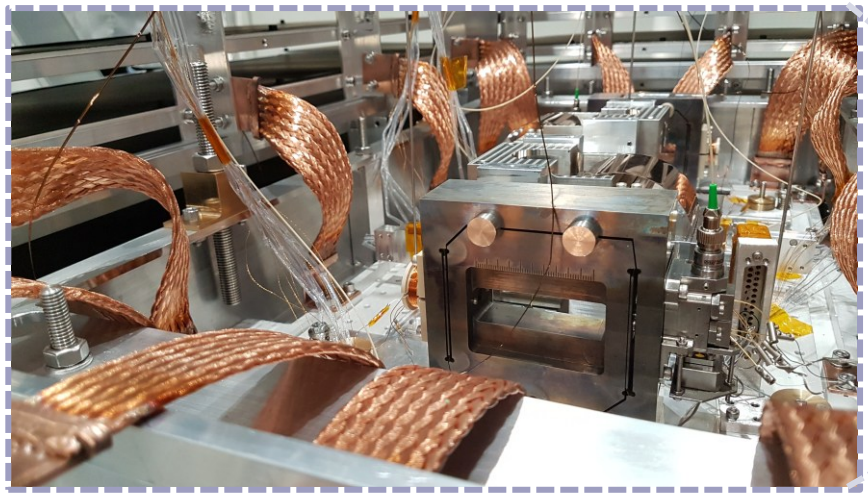
CENTRE SPATIAL DE LIÈGE

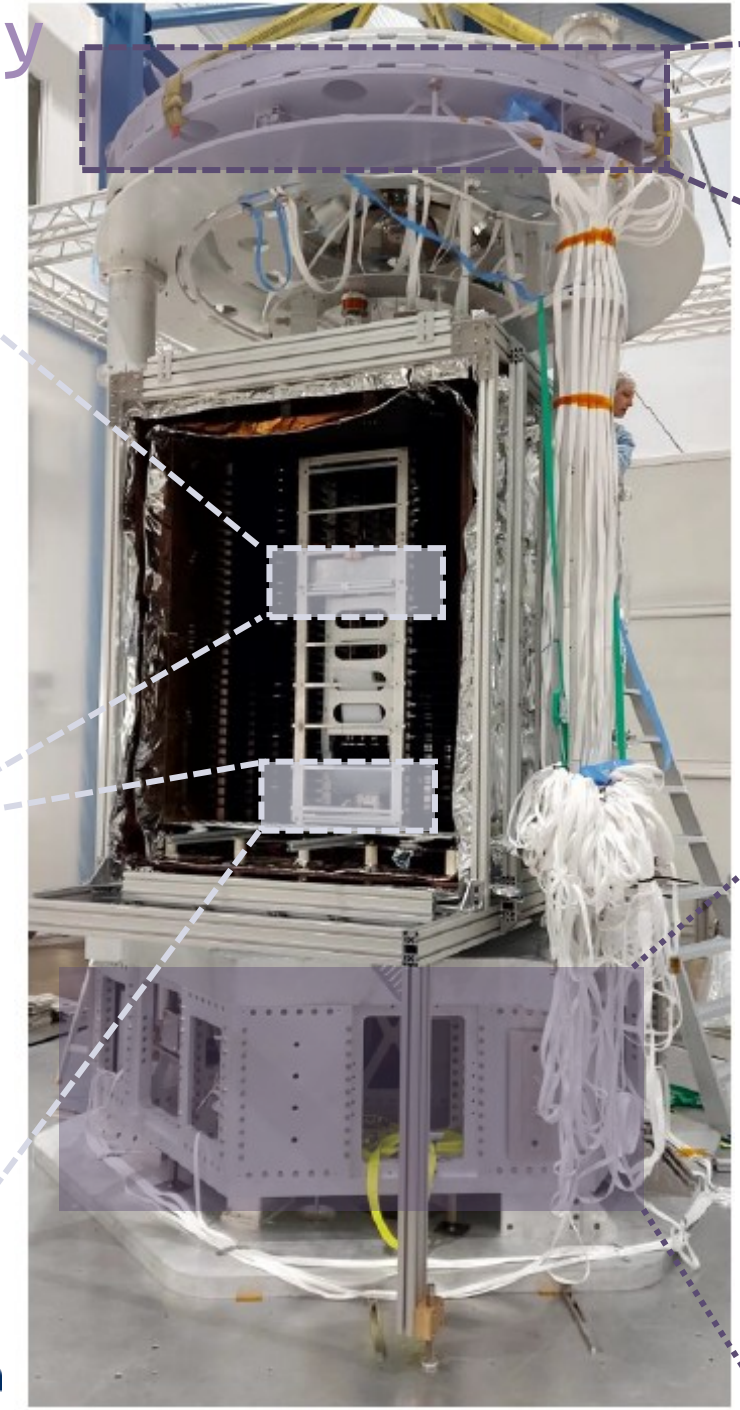


→ Perfect environment to validate technologies for lunar missions !

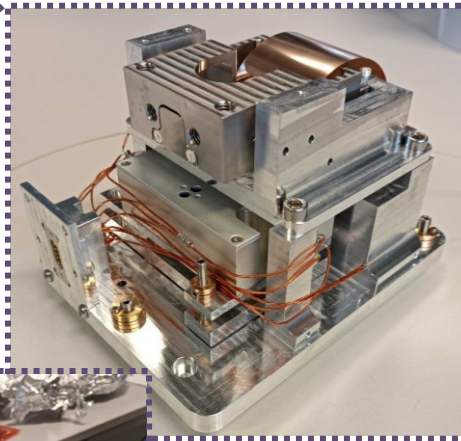
Isolated at low frequency (0.01-10 Hz)

*The interferometer remained aligned from room temperature to **22K!***

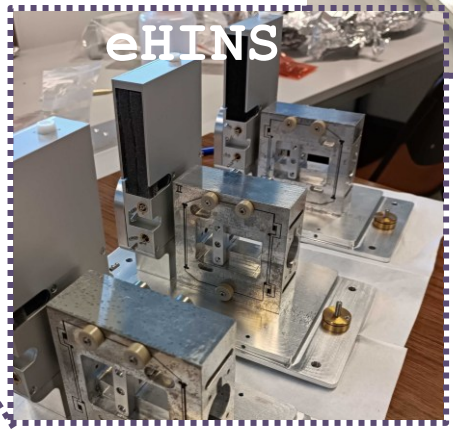


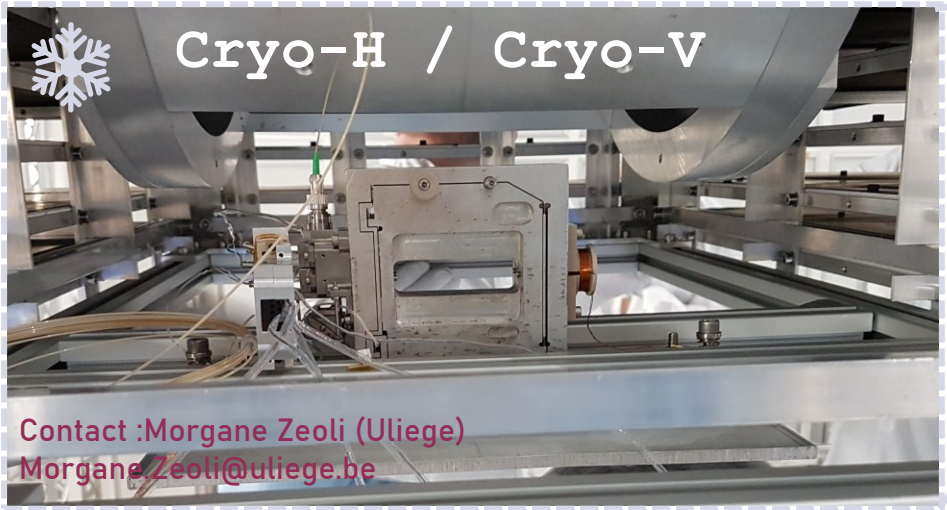


Long-range interferometric readout
+ LVDT reading



+BOSEMs
eVINS





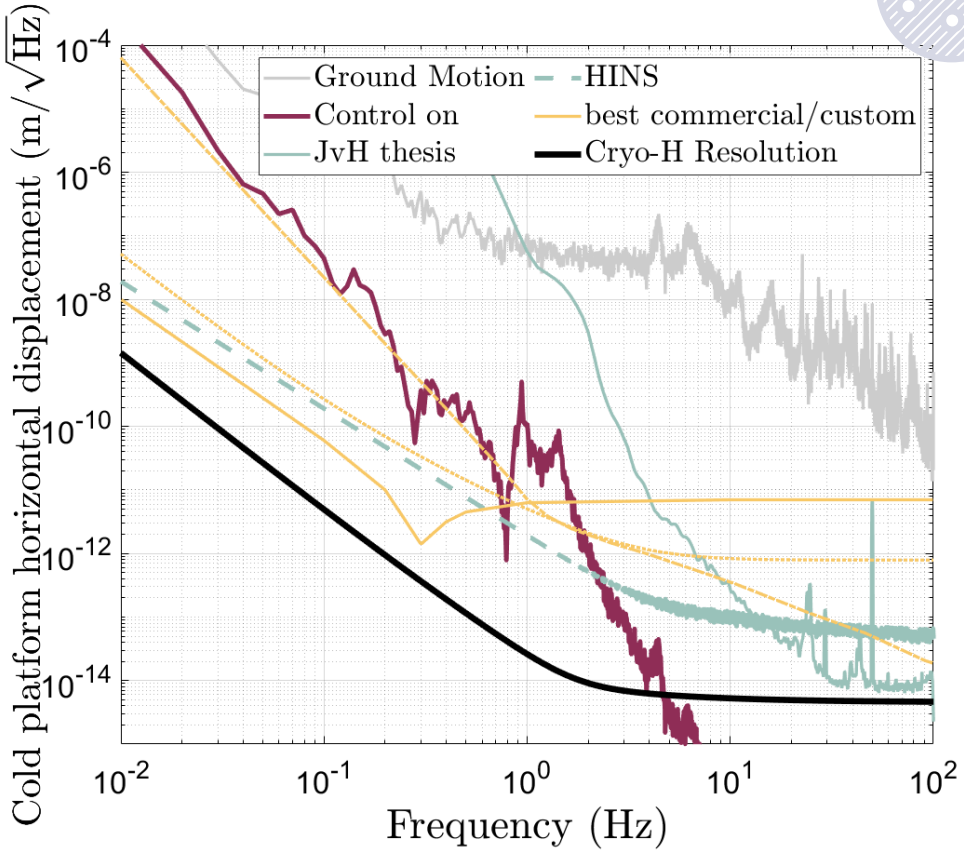
Contact :Morgane Zeoli (Uliege)
Morgane.Zeoli@uliege.be

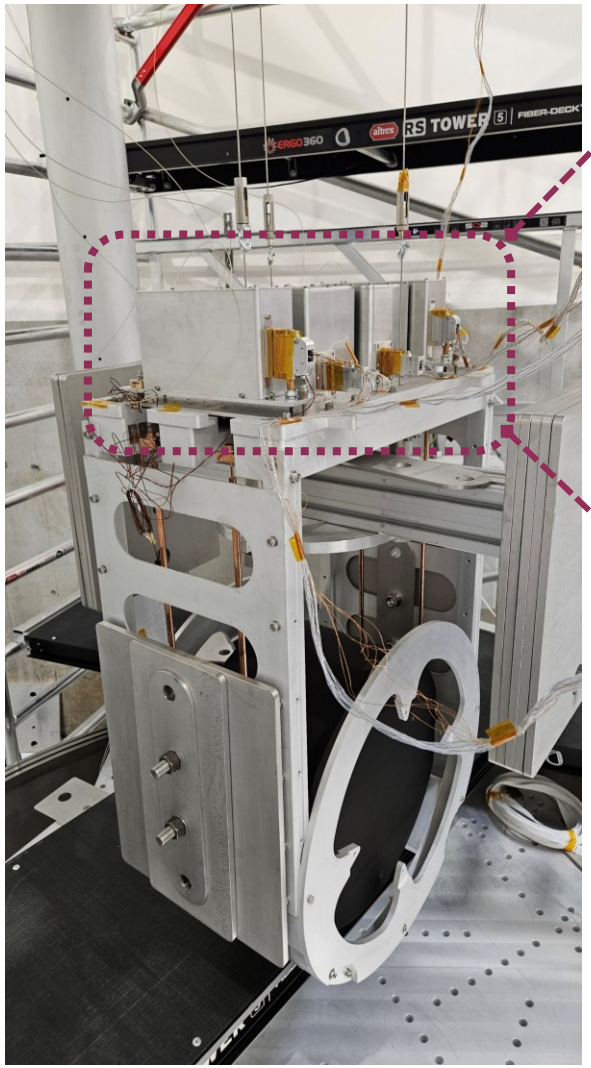
Anthony Amorosi (Uliege)
Anthony.Amorosi@uliege.be

RWTH AACHEN UNIVERSITY UCLouvain

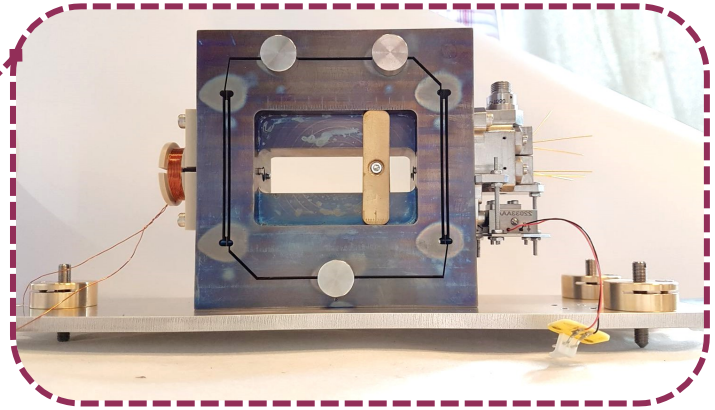
Cryogenic highly sensitive inertial sensors

Develop and validate cryogenic compatible inertial sensors with a sensitivity of 1×10^{-14} **m/√Hz from 1Hz at 20K**



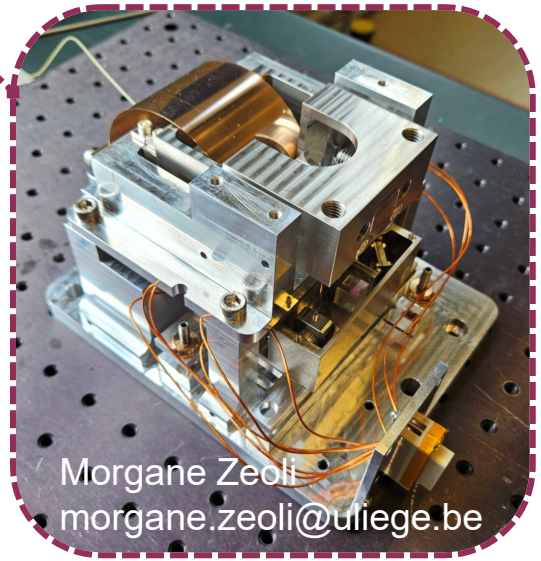


Cryo-H



Closed-loop homodyne interf. readout

Cryo-V



Open-loop homodyne quadrature interf. readout

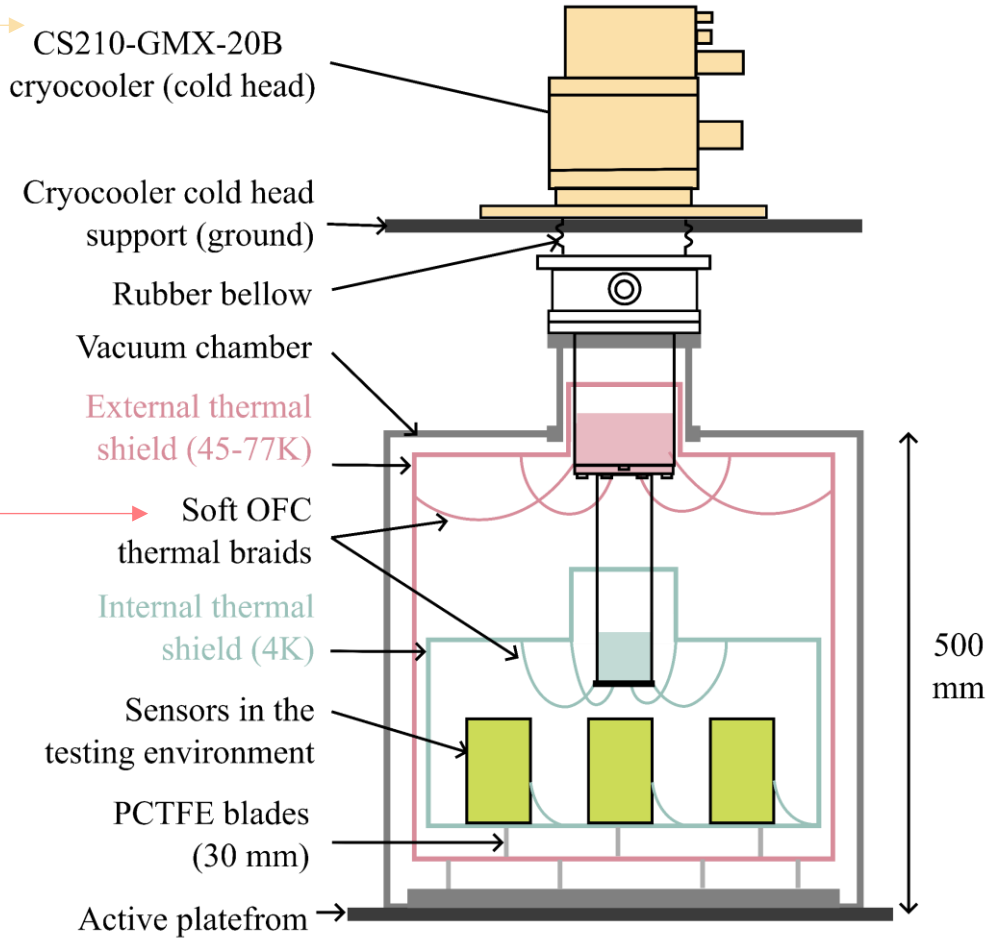
Morgane Zeoli
morgane.zeoli@uliege.be

Low-vibration cryogenic testbench

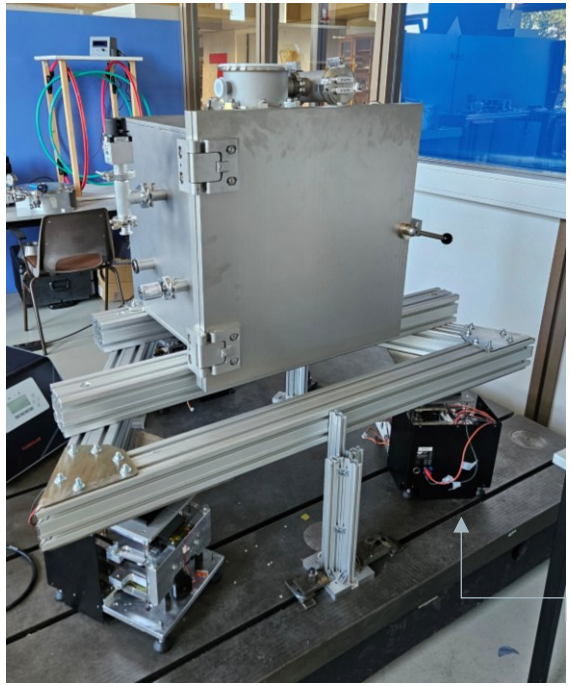
Target temperature	10 – 20 K
Cooling power	1 W at 4 K
Vibration level	– 10 nm RMS in [0.01–10] Hz – 10 nm/√Hz from 0.1 Hz – pm/√Hz level from 3 Hz
Volume	Host 3 sensors (20x20x20cm)

Pulse-tube + gHe heat exchanger

Decoupling



Currently being build



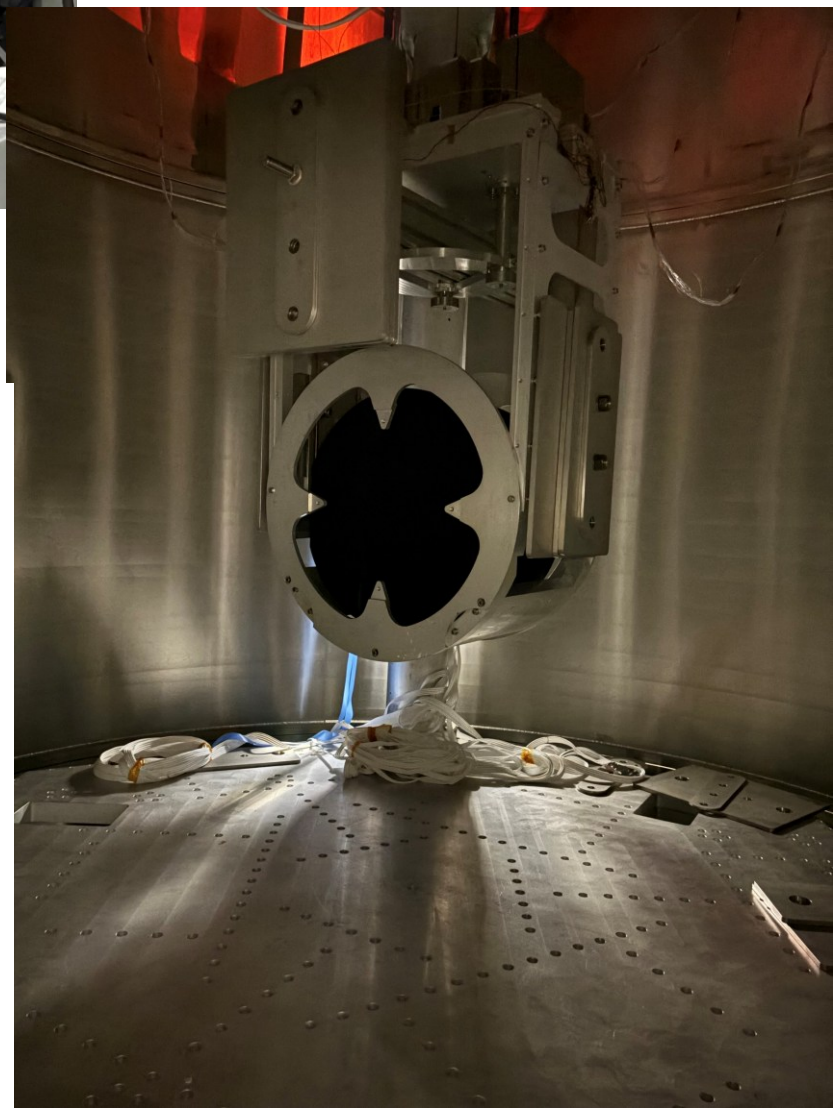
Active isolation from ground disturbances

Morgane Zeoli
morgane.zeoli@uliege.be

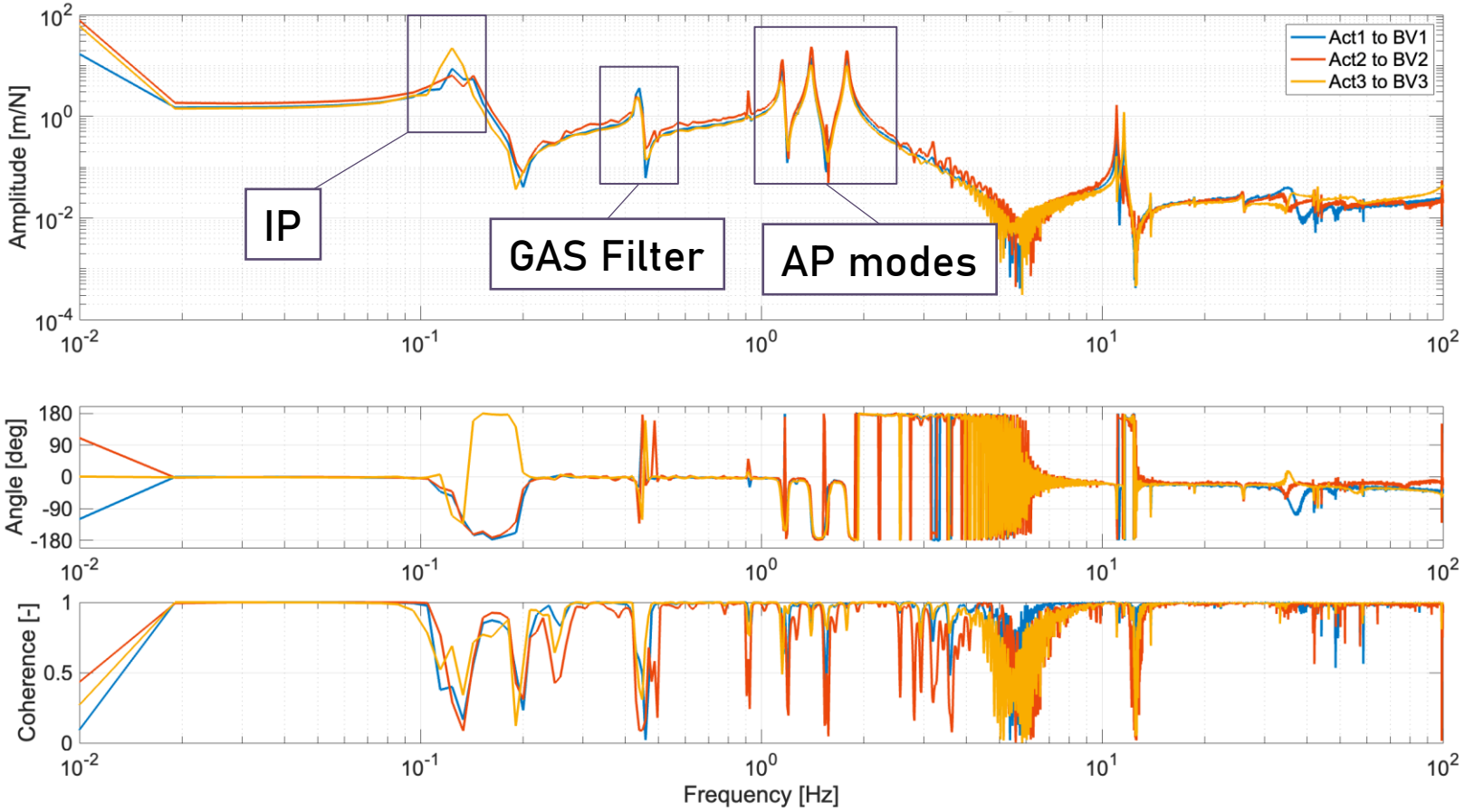
Isolated at low frequency (0.01-10 Hz)

Full prototype Active vibration isolation testing

In vacuum at $1{,}96 \times 10^{-6}\ mbar$



Open loop transfer function from vertical actuators to collocated vertical BOSEMs



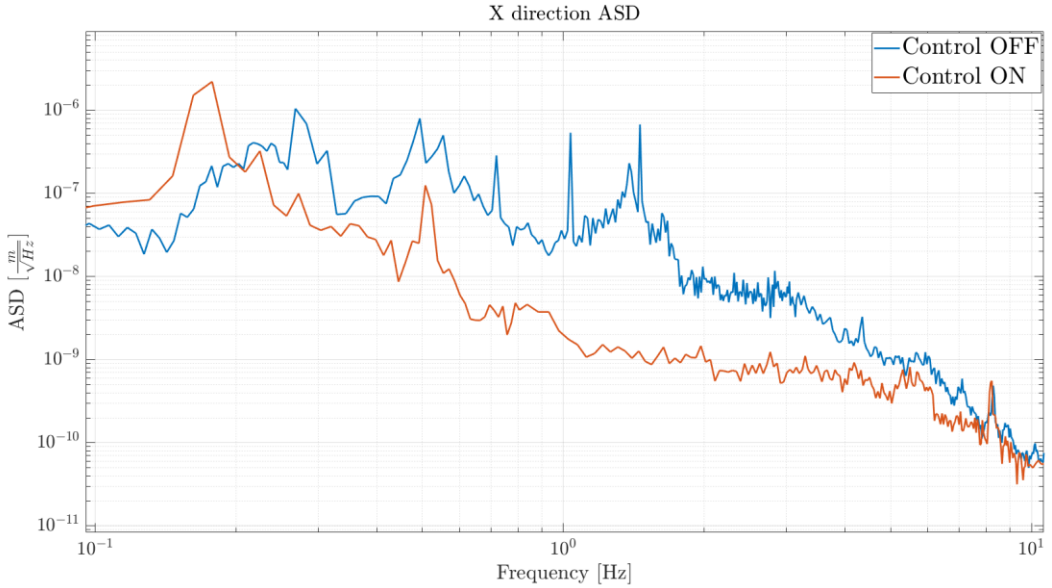
Contact : Haidar Lakkis (ULiege)
mhlakkis@uliege.be

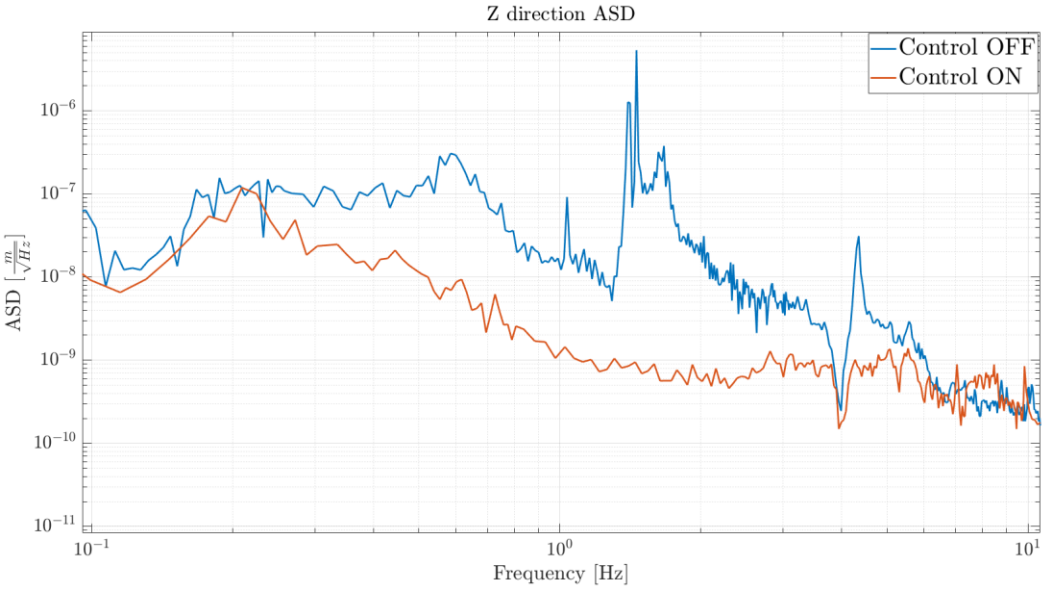
Precision Mechatronics Laboratory

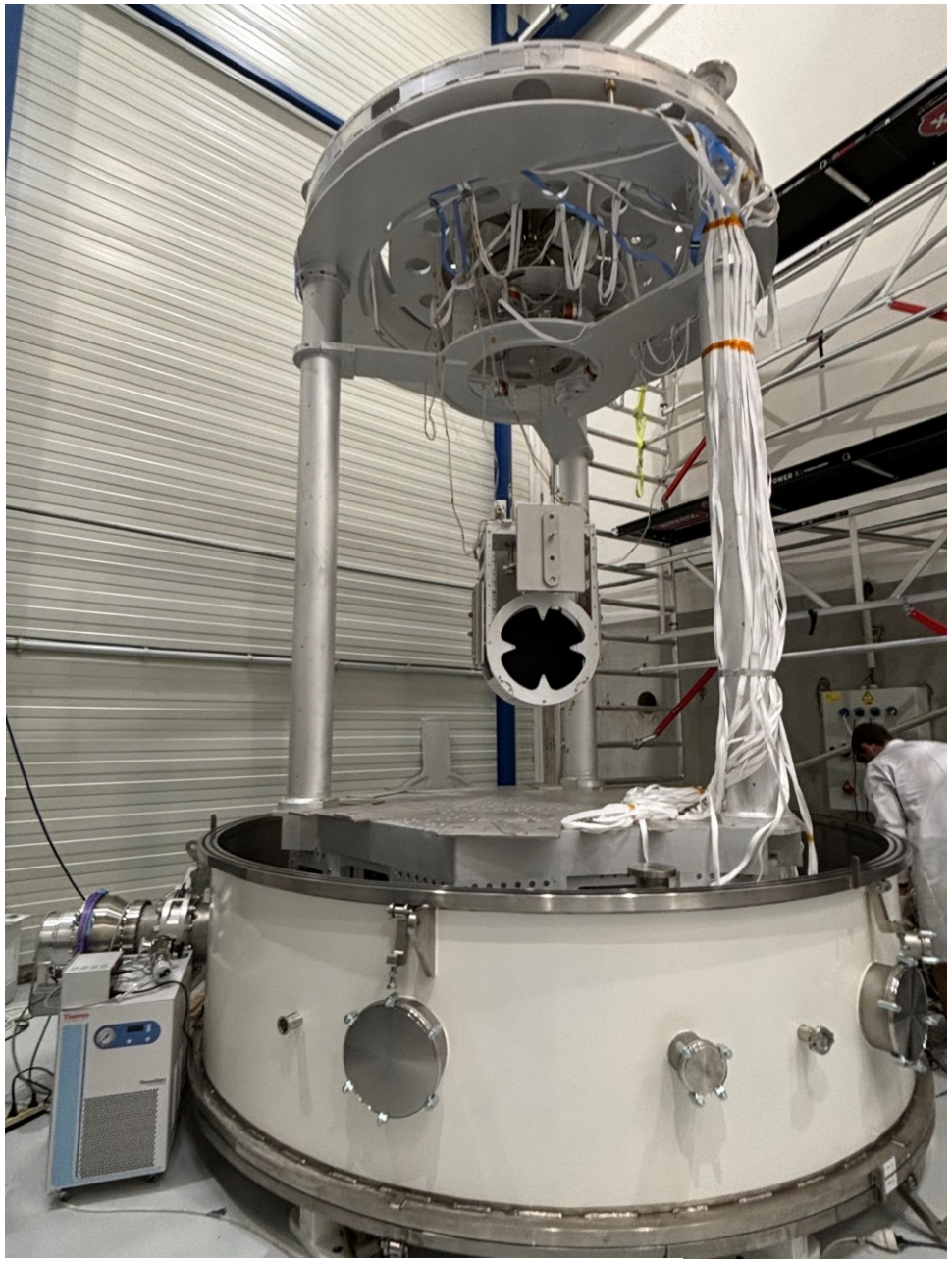
Isolated at low frequency (0.01-10 Hz)

Full prototype Active vibration isolation testing

In air results: Closing control loops from AP inertial sensors to Voice coil actuators in the three translational directions







Contact : Thomas Giordano (ULiege)
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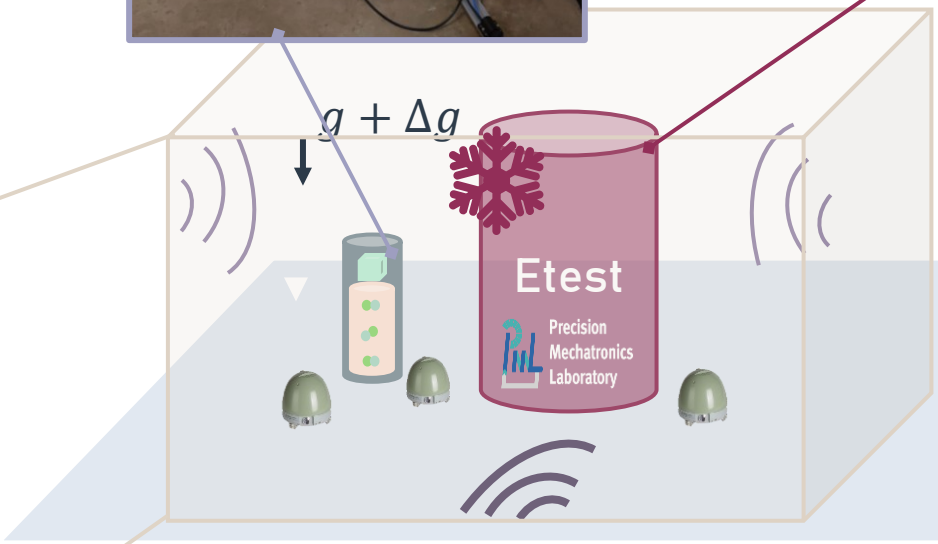
Contact : Haidar Lakkis (ULiege)
mhlakkis@uliege.be

E-Test: Experimental facility RoadMap

☑ 2023, prototype assembled and tested:

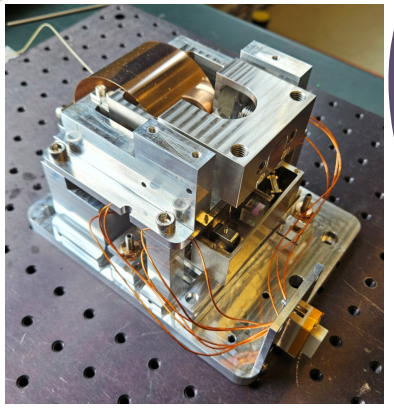
- Suspension for 100 kg
- Instrumentation developed
- Radiative cooling validated

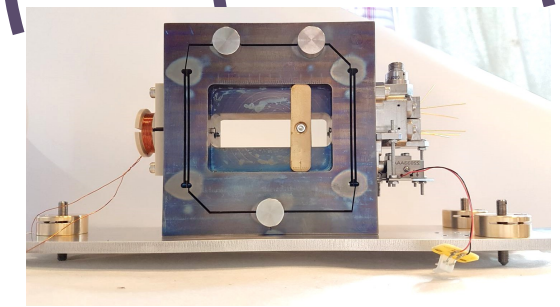
❑ 2025: installation at CSL



❑ 2026: R&D @ **cryogenic temperature**

- **Active Isolation & control development**
- **Inertial sensors development**
- **Newtonian Noise subtraction techniques**





ULB UNIVERSITÉ LIBRE DE BRUXELLES

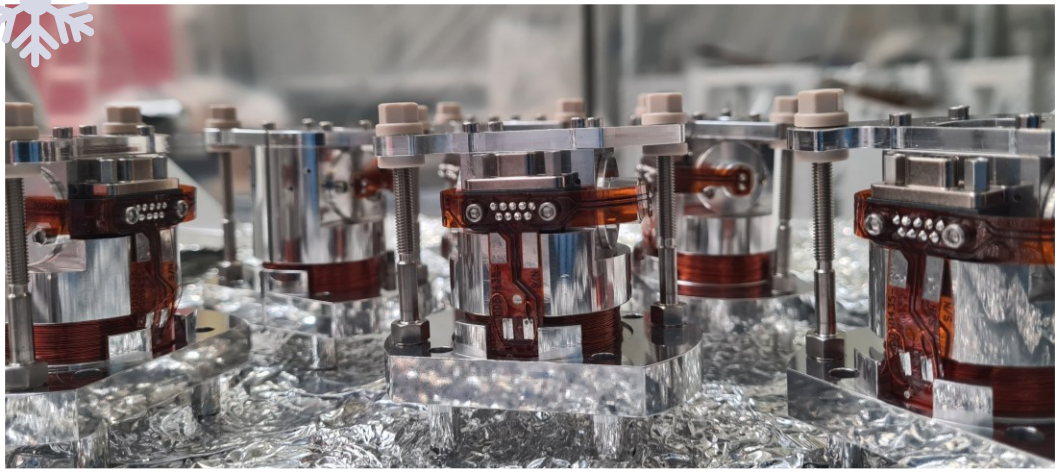
E-TEST

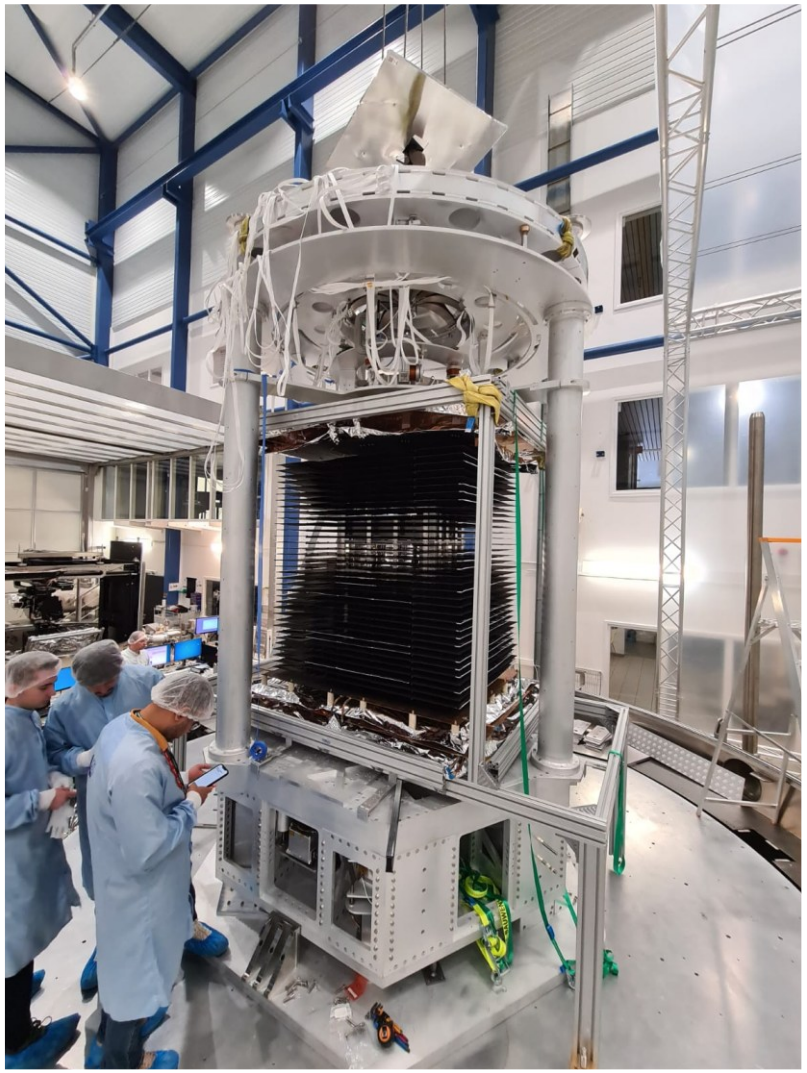
PNL Precision Mechatronics Laboratory

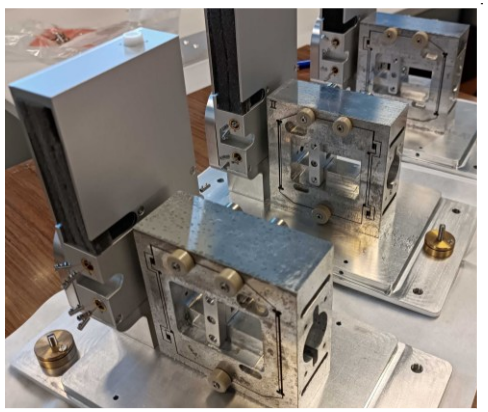
erc

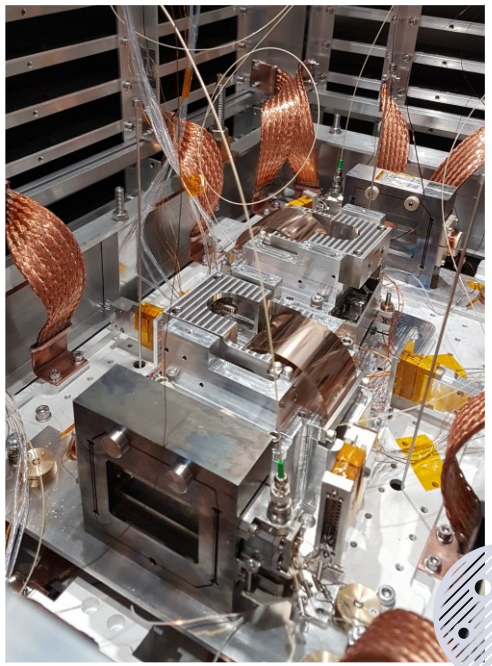
LIÈGE université

Thank you for your attention!



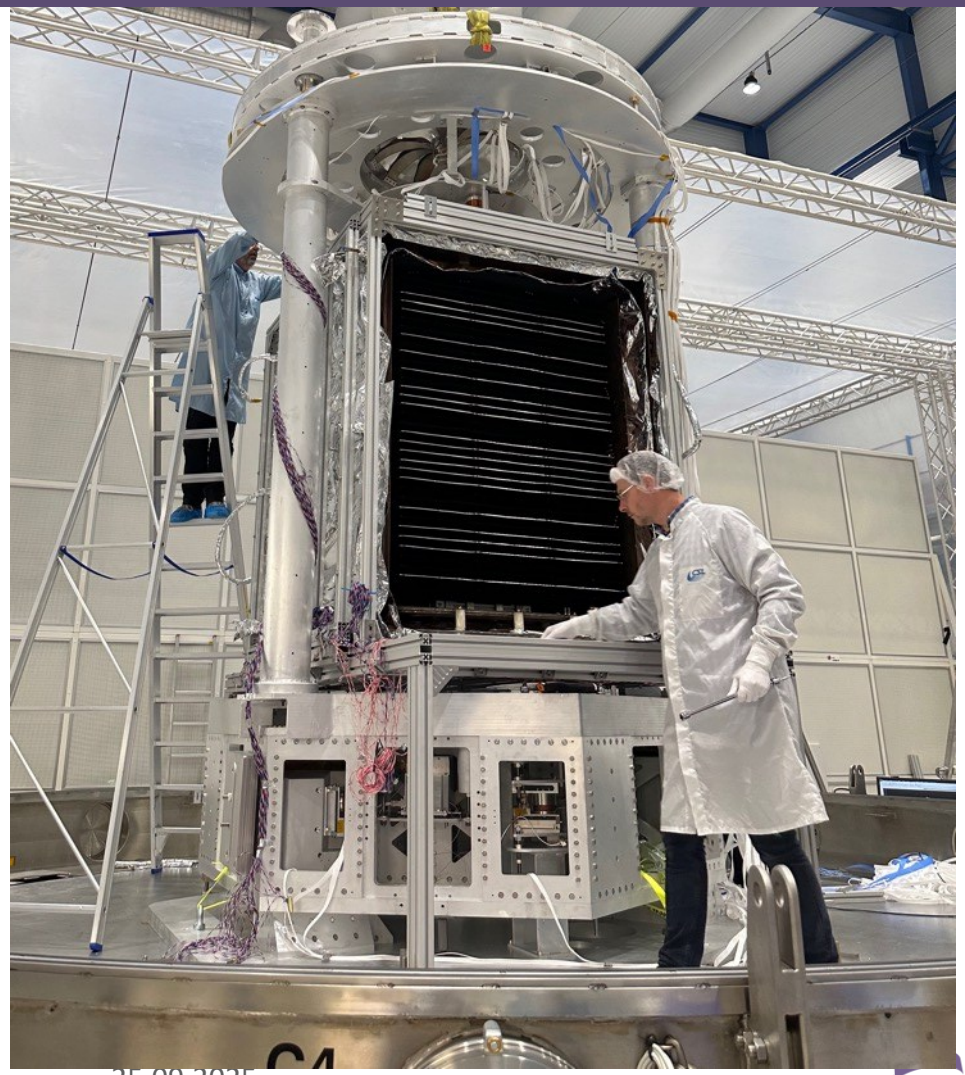


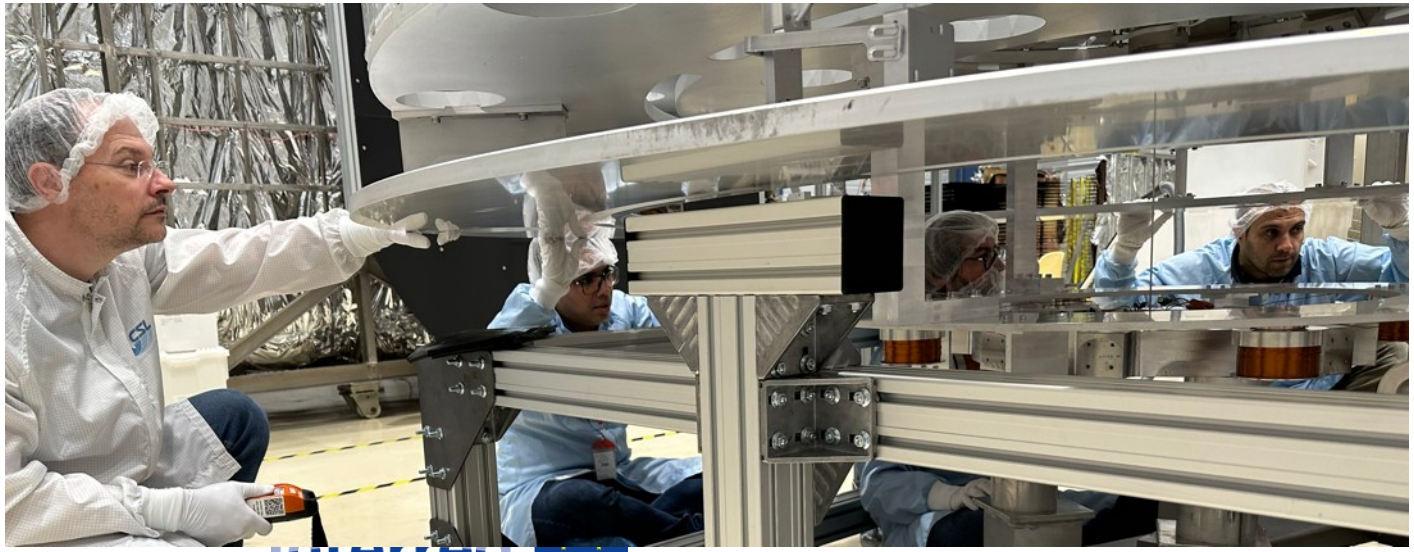




Additional Slides

First run at CSL 12/2023





Contact: Morgane Zeoli
Morgane_zeoli@uliege.be

Horizontal cryogenic inertial sensor

Monolithically suspended Ti6Al4V proof-mass (0.68 kg)

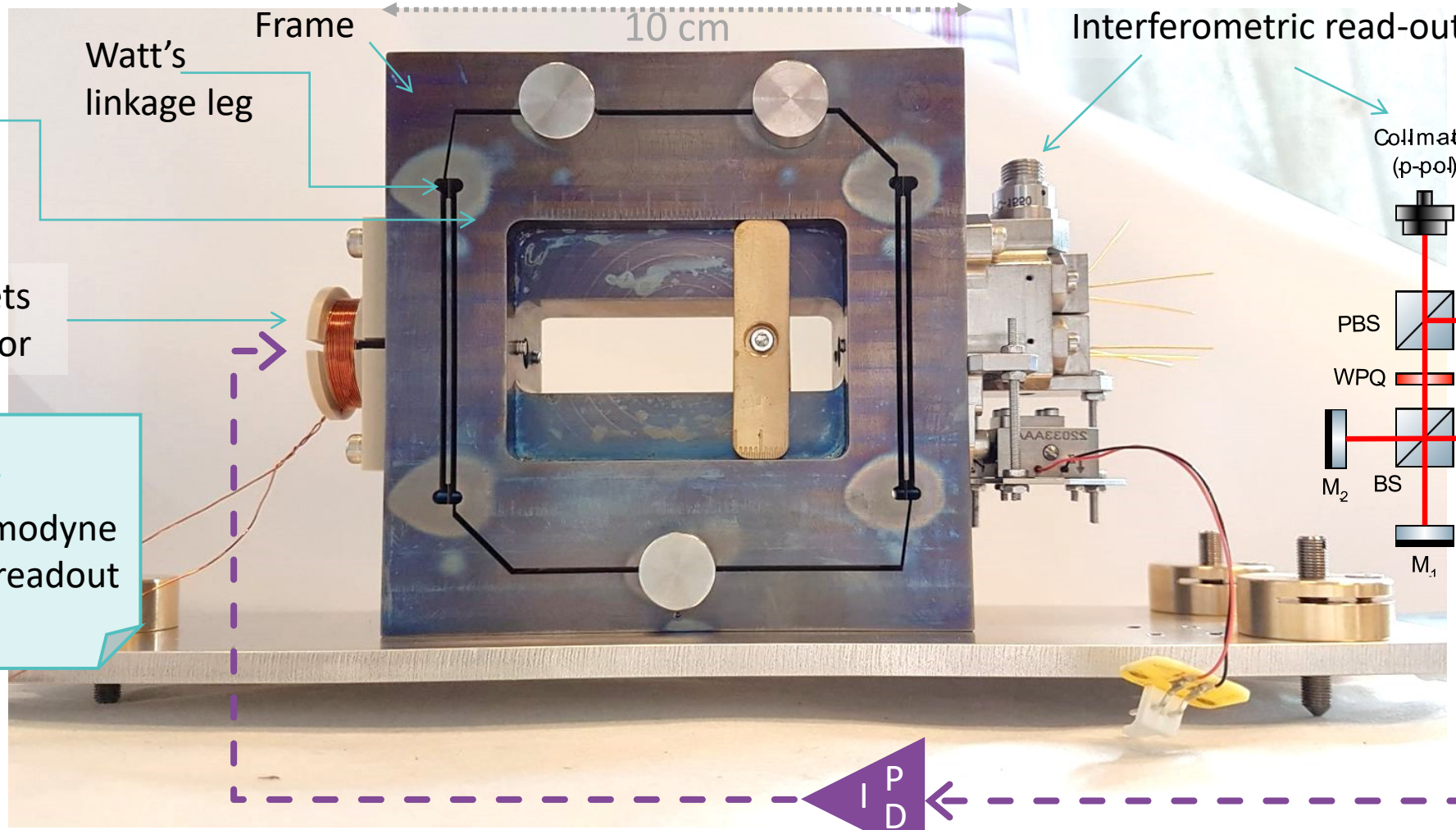
Shielding-magnets voice-coil actuator

Frame

Watt's linkage leg

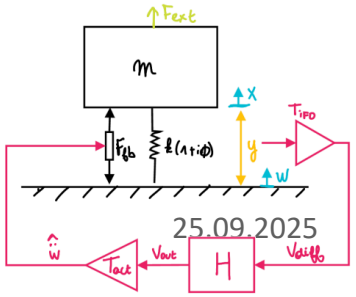
10 cm

Interferometric read-out



Cryo-H

Closed-loop homodyne interferometric readout



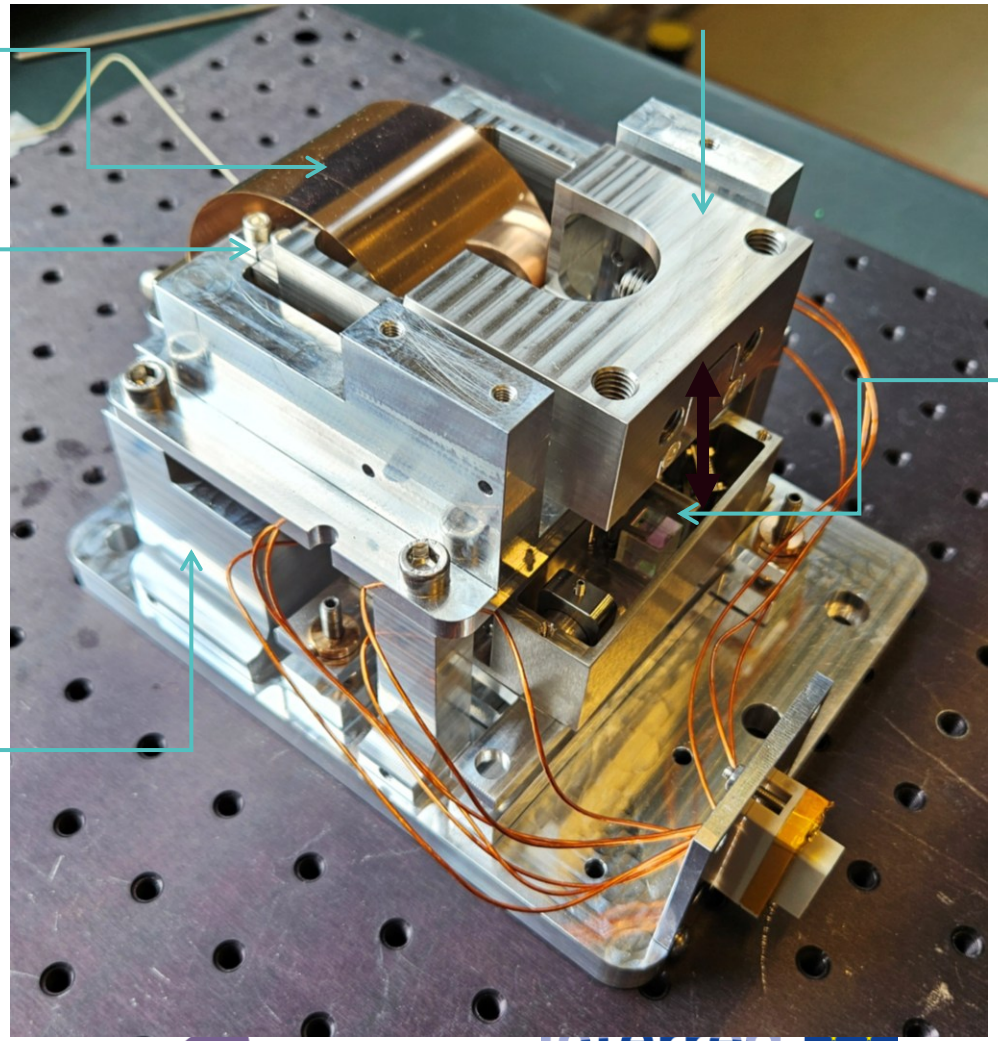
Contact: Morgane Zeoli
Morgane_zeoli@uliege.be

Vertical cryogenic inertial sensor

Inertial mass (AISI)

Leaf-spring suspension (BeCu)

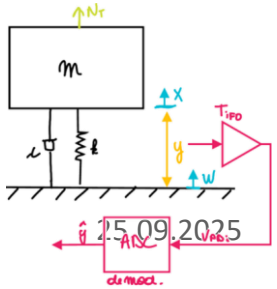
Double-clamped blade hinge (BeCu)

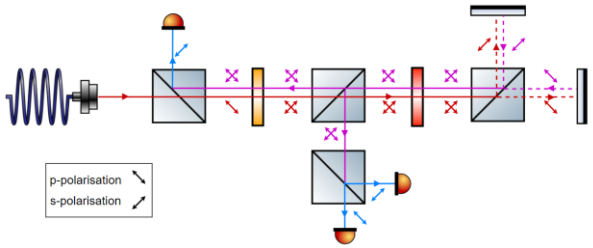


Frame (Al)

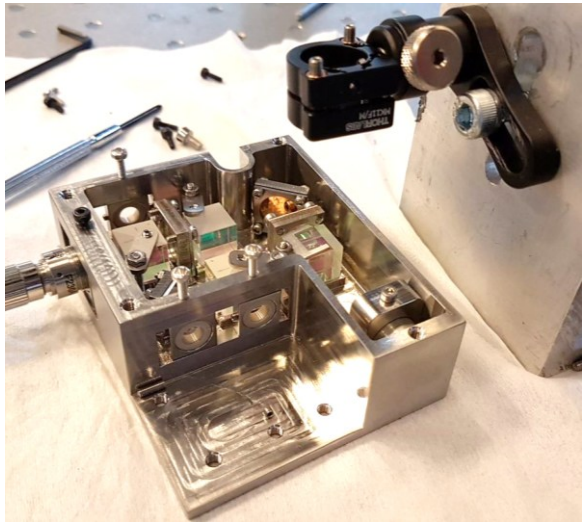
Cryo-V

Open-loop homodyne quadrature interferometric readout





Homodyne quadrature IFO for parallel R&D and comparison with homodyne architecture



Ultra-cold vibration control

Cryogenic inertial sensors

Morgane Zeoli (PML)
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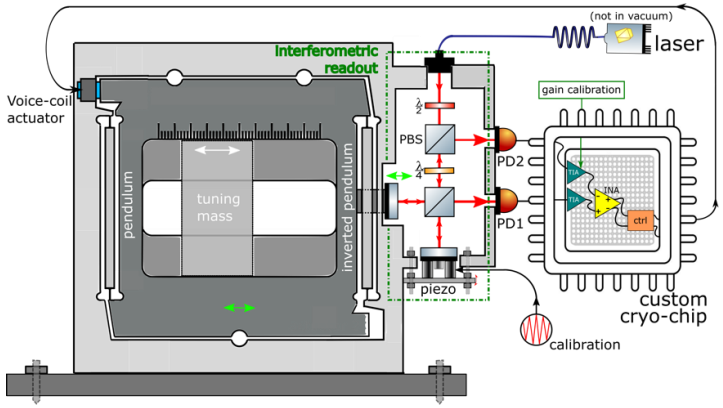
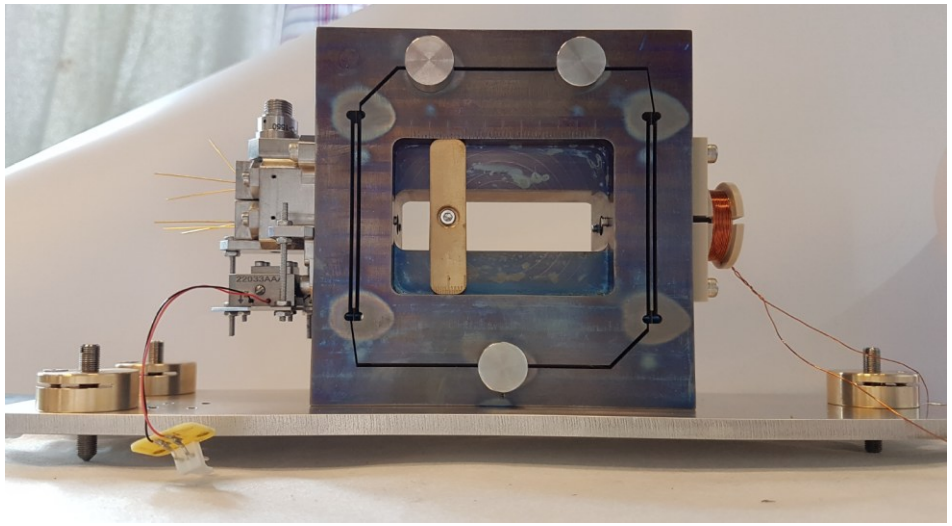
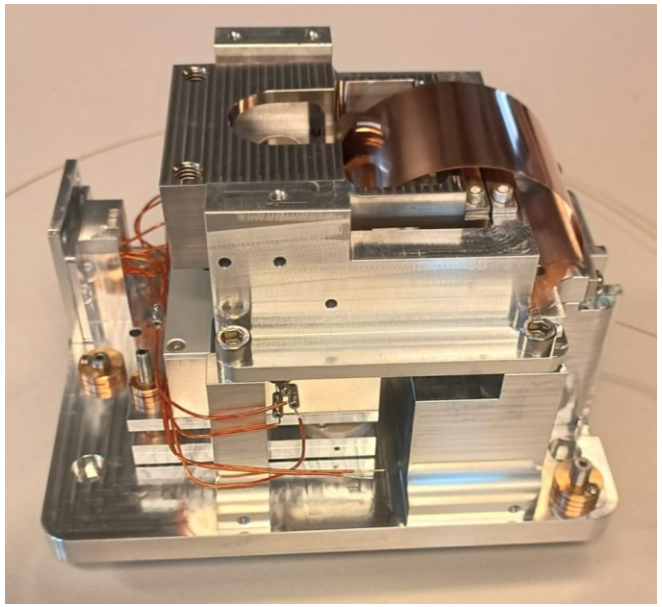
CSIS-H

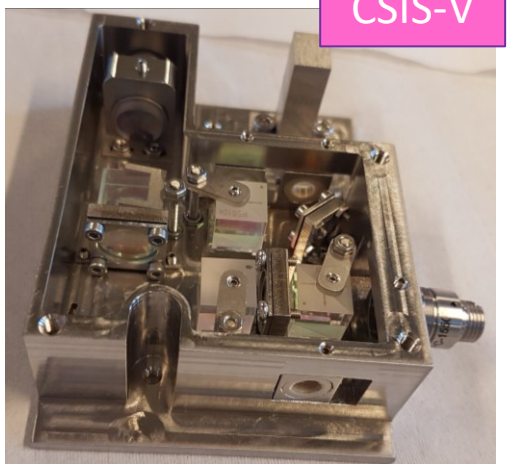




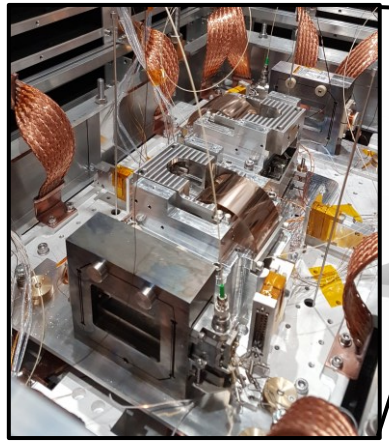
- Sub-Hz resonance frequency.
- fm differential optical readout

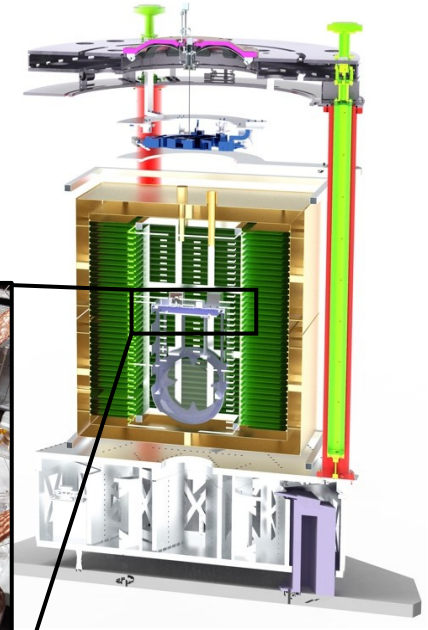
CSIS-V





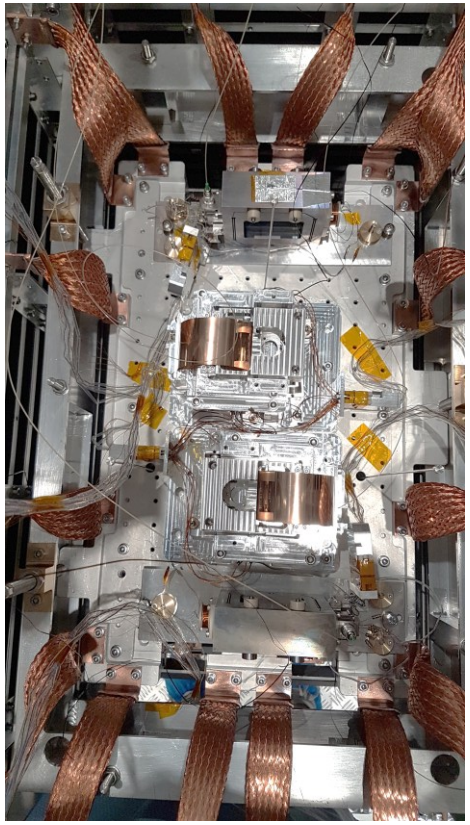
- Approx. 1 Hz leaf-spring resonance frequency.
- Homodyne, fringe-counting, optical readout.





Displacement measurement

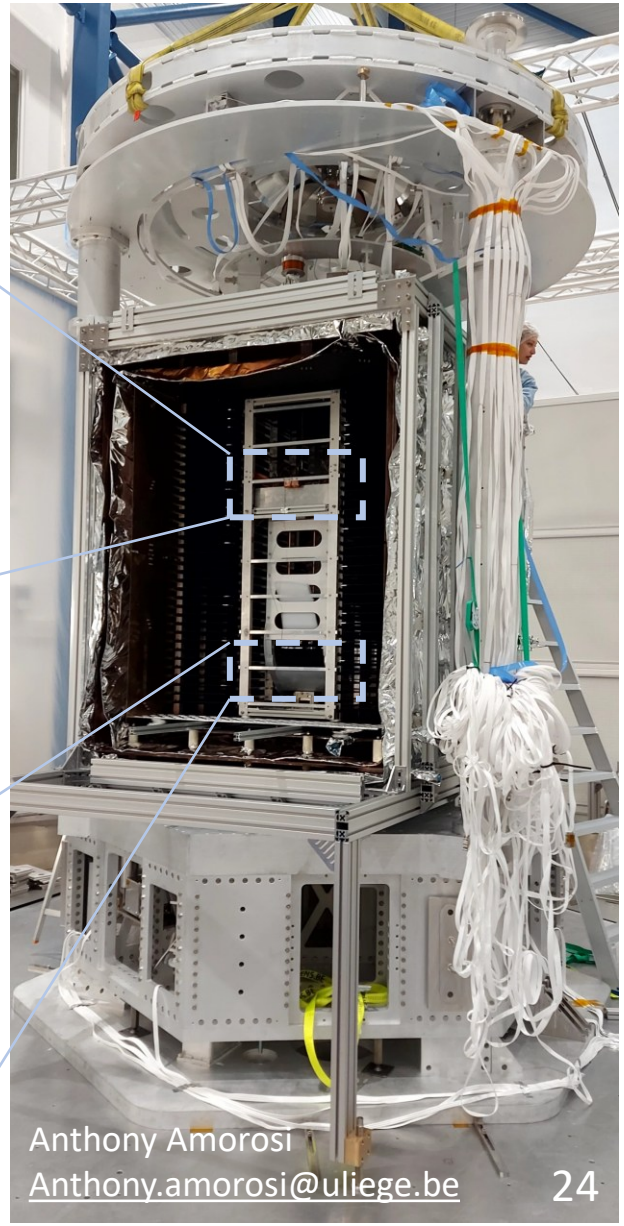
- First test of the horizontal sensor assembly in cryogenic condition with E-TEST
- The interferometer remained aligned from room temperature to 22K!



Fringe visibility

100K: 88.8% & 88.2%
30K: 87.18% & 88%

100K: 47.5% & 33.29%
30K: 42.64% & 27.57%



Anthony Amorosi
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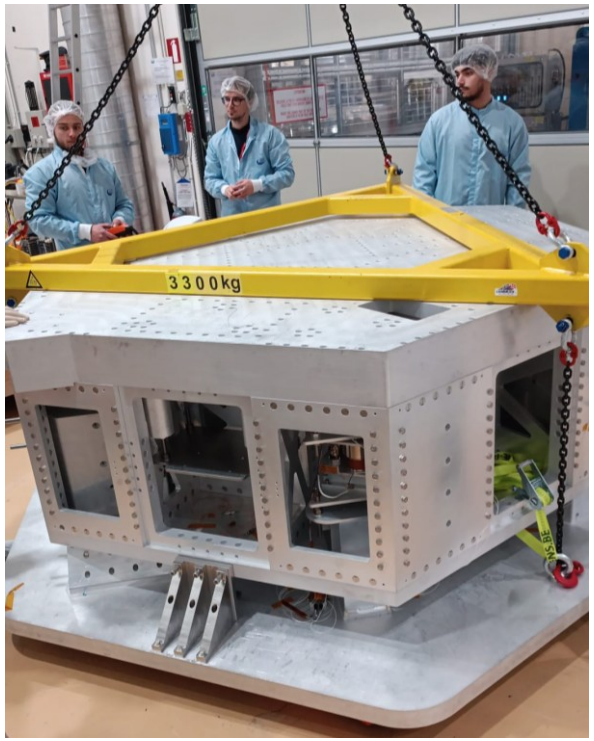
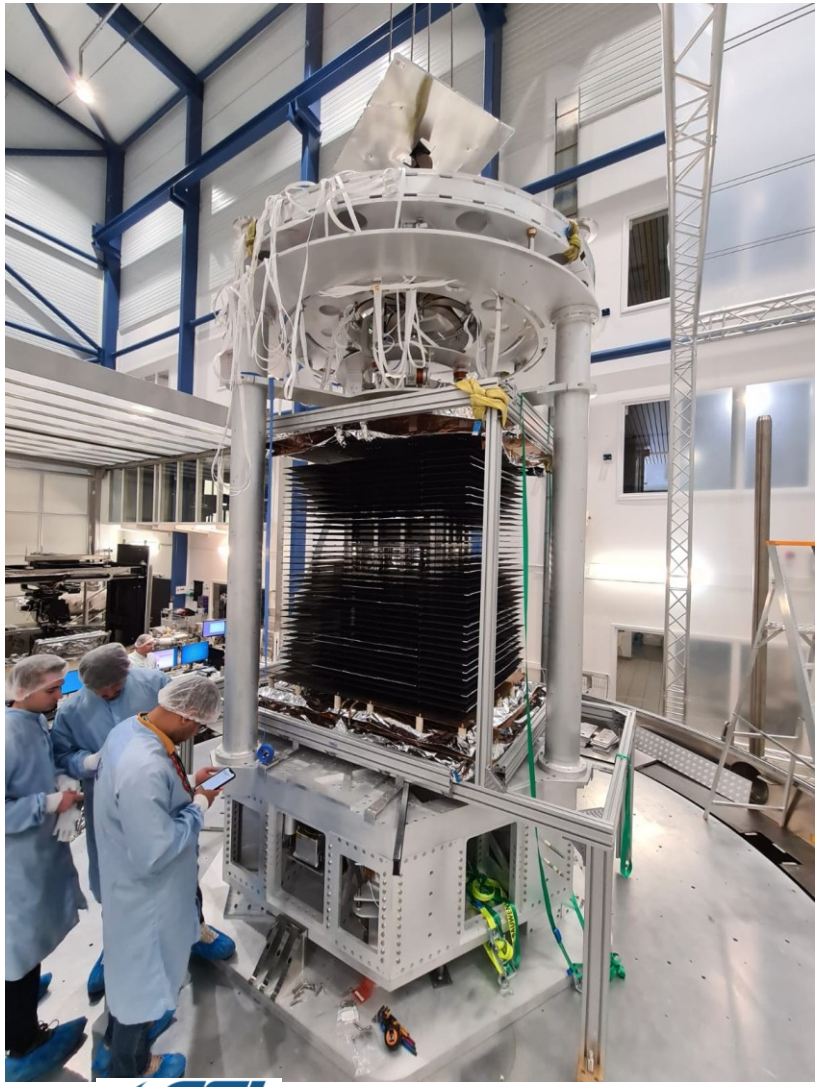
Assembly of the prototype at CSL

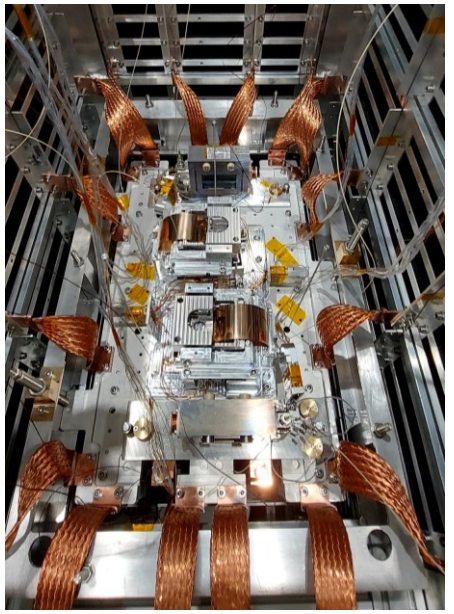
Teamwork makes dreams work!!!

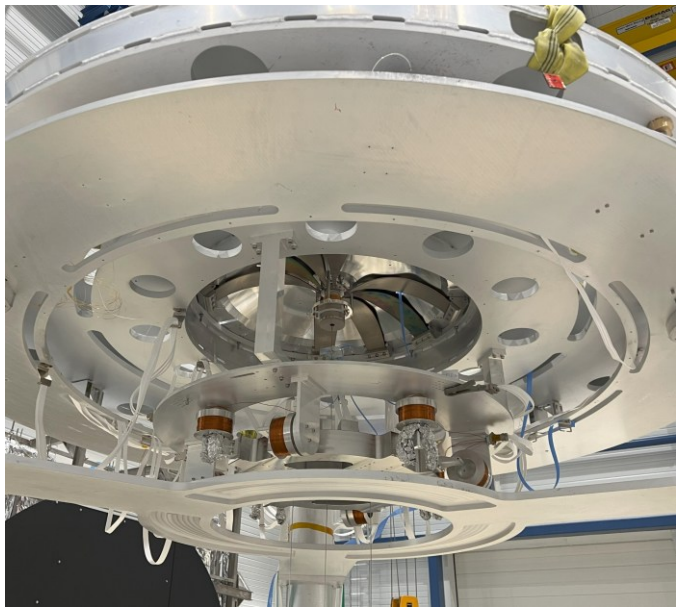
Christophe Collette (PML)
Christophe.Collette@uliege.be

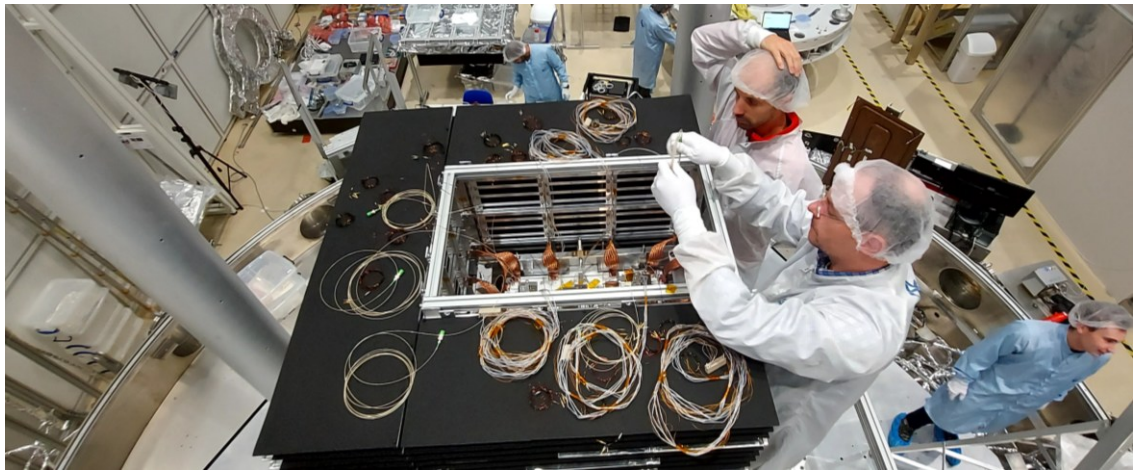
Cédric Lenaerts (CLS)
cedric.lenaerts@uliege.be







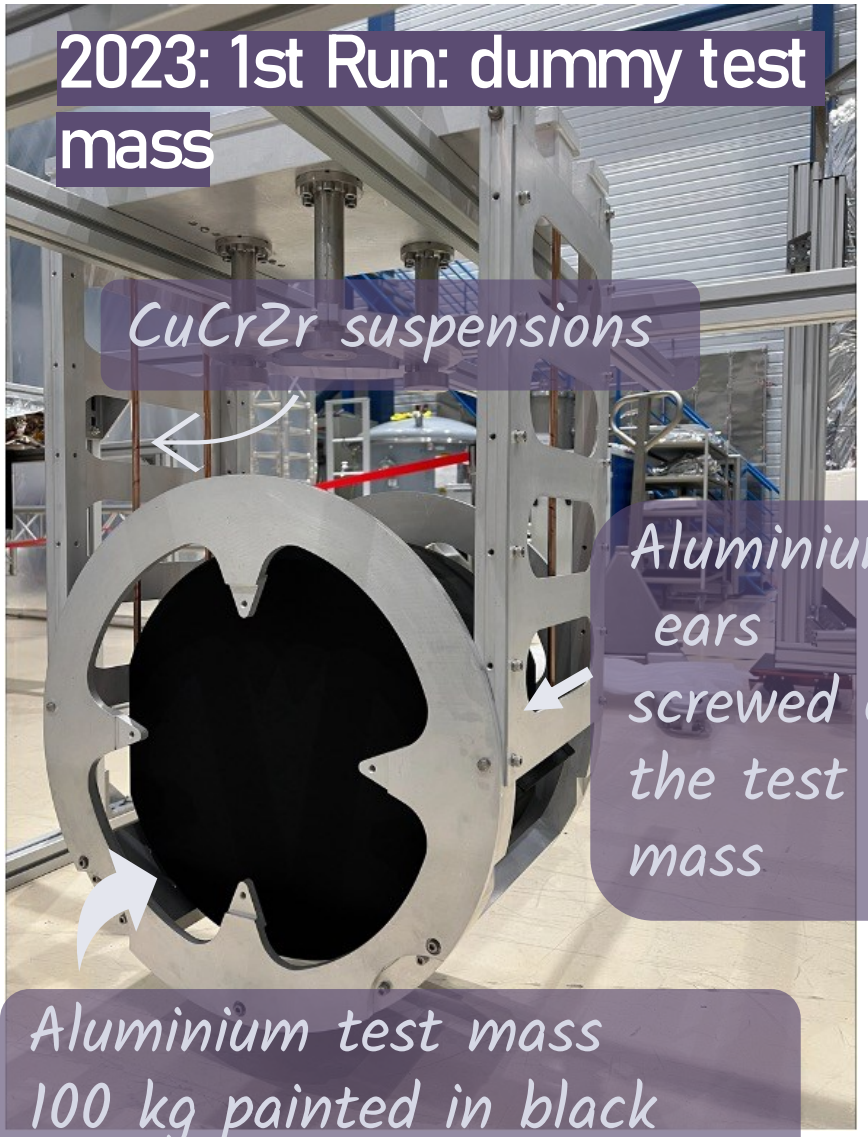




Precision Mechatronics Laboratory

CSL CENTRE SPATIAL DE LIÈGE

Large mirror (100 Kg)

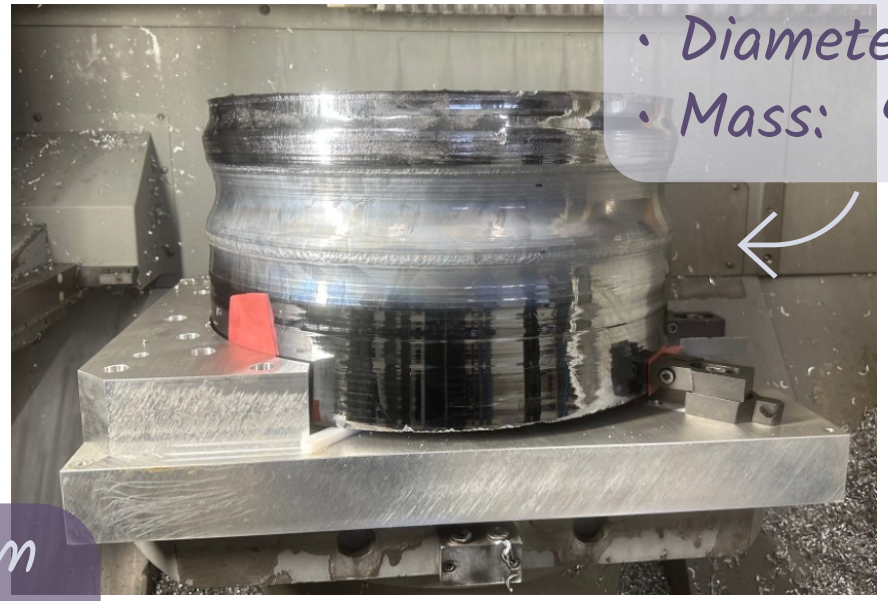


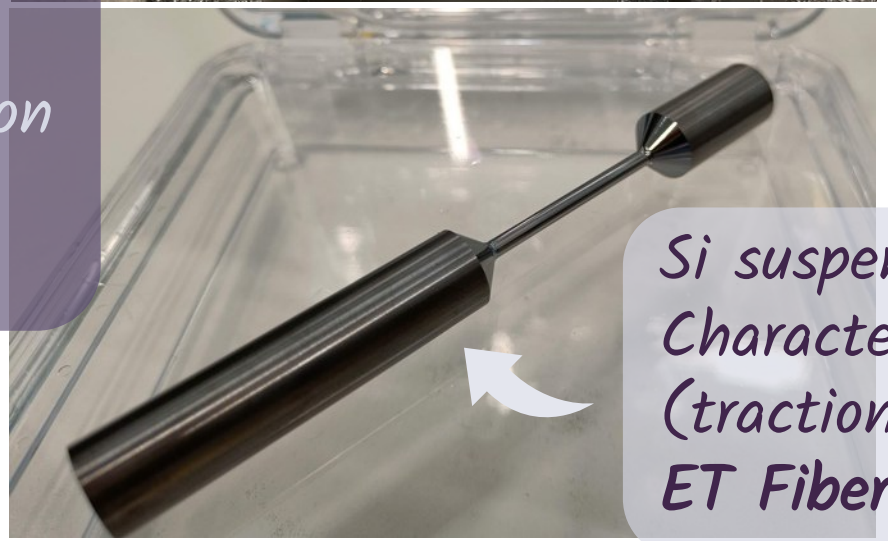
2023: 1st Run: dummy test mass

CuCr2r suspensions

Aluminium ears screwed on the test mass

Aluminium test mass
100 kg painted in black





- Si monocristaline
- Diameter: 45 cm
- Mass: 90 kg

2025: 2nd run

Si suspension + surface treatment
Characterisation
(traction tests + inspection)
ET Fiber project