

ET-CRISTAL: a full-scale prototype of ET-LF seismic isolation

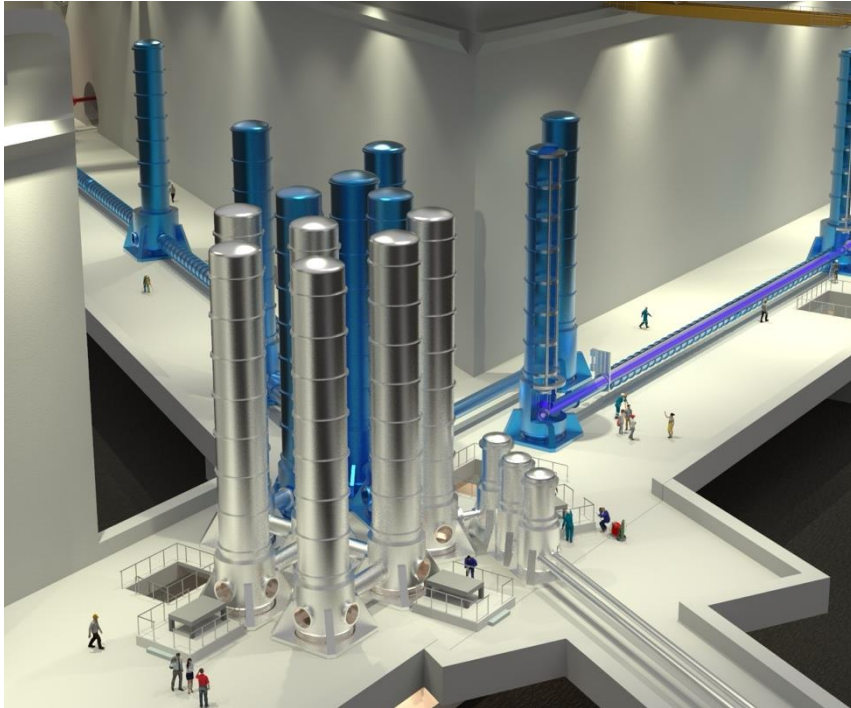
Thomas Giordano

On behalf on

Precision Mechatronics Laboratory

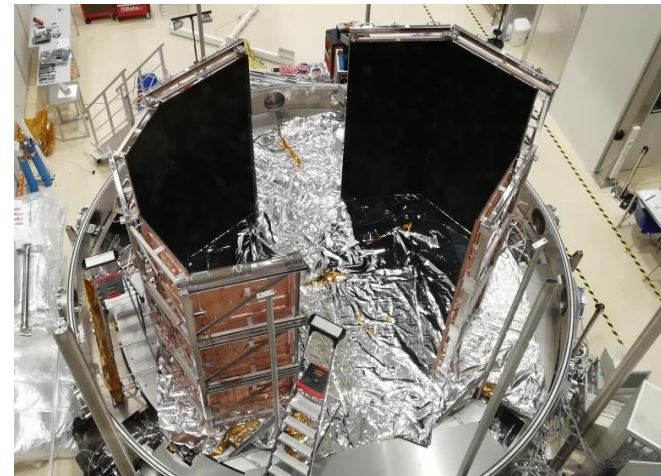
Belgian-Dutch GW Meeting - October 9, 2026

ET-CRISTAL Objectives

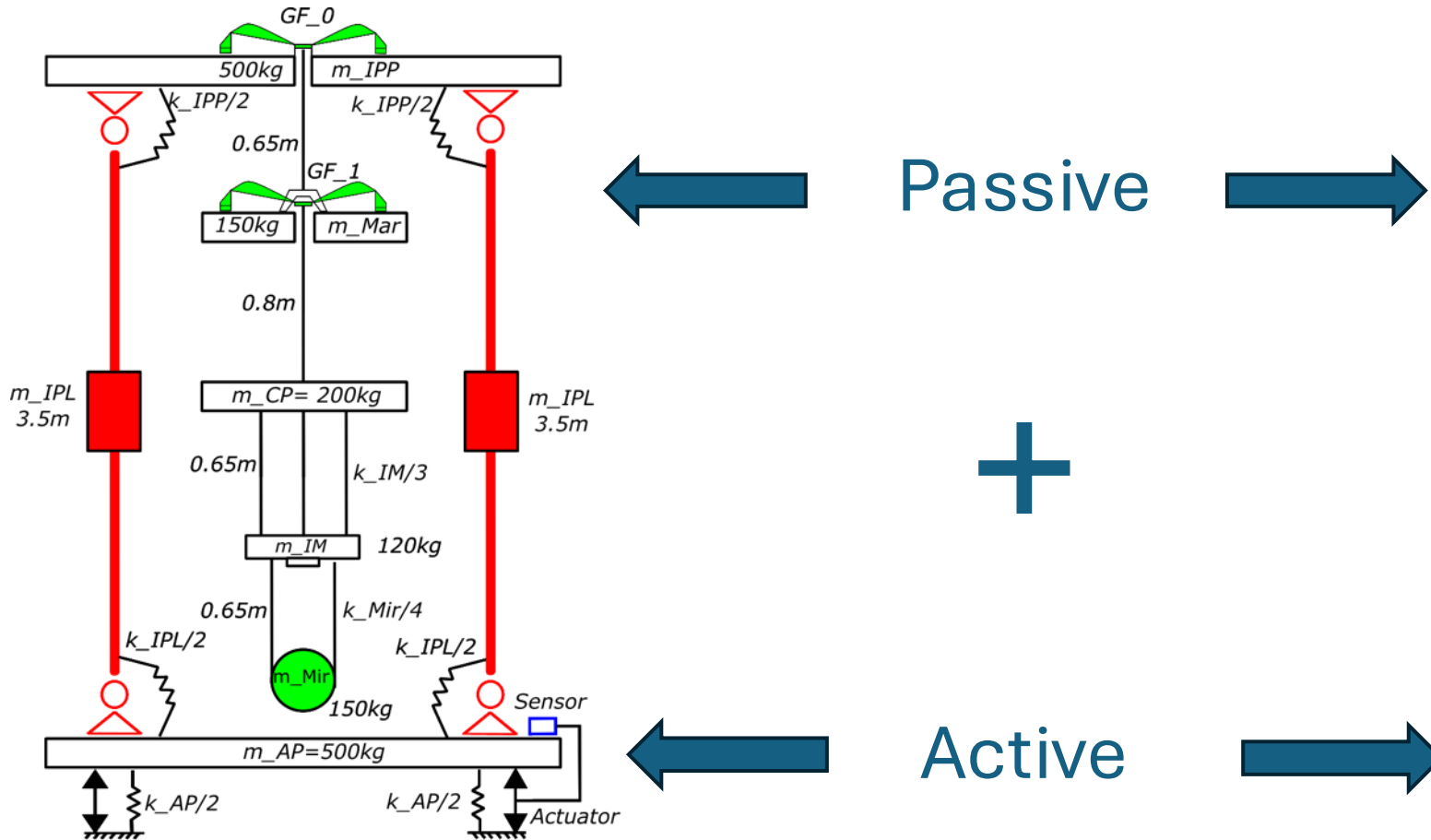


- Large mirror (100 Kg)
- Cryogenic temperature (20 K)
- Radiative cooling
- Isolated at low frequency (0.01-10 Hz)
- Compact suspension (4.5 meters)

Partners



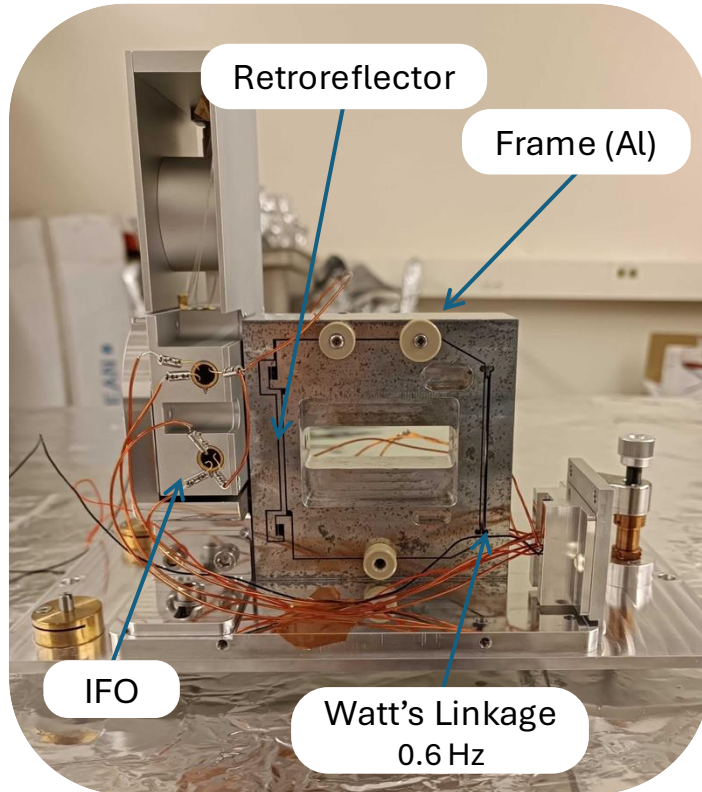
Low-Frequency seismic isolation



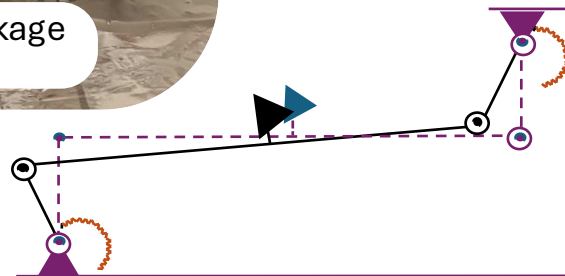
E-TEST: a compact low-frequency isolator for a large cryogenic mirror

A Sider et al 2023 *Class. Quantum Grav.* **40** 165002

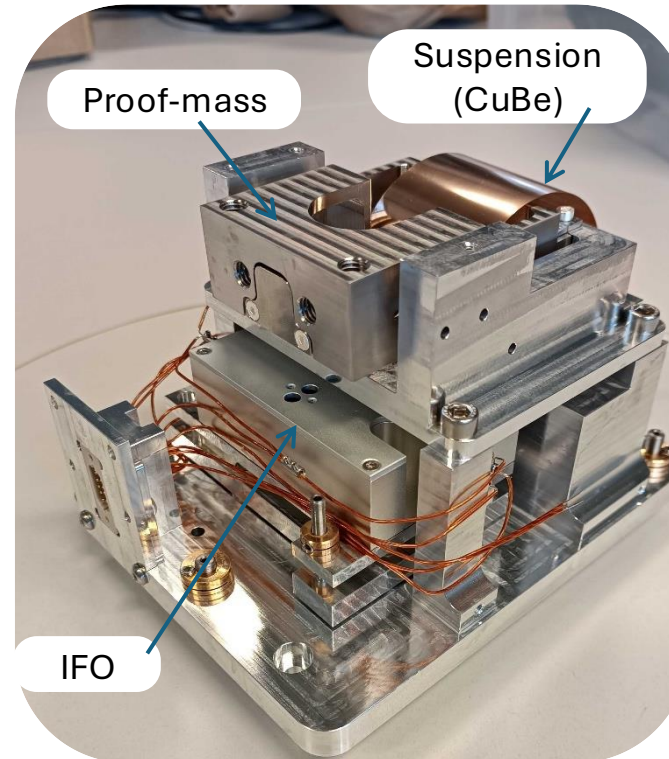
Horizontal sensing



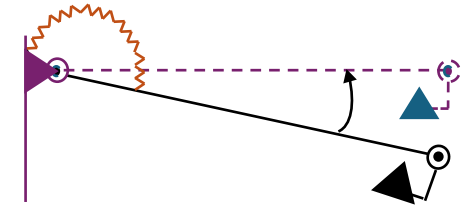
- 0.5 Hz Watt's linkage.
- Long-range readout.
- Open-loop operation.
- Resolution: 1 pm/rtHz above 1 Hz



Vertical sensing

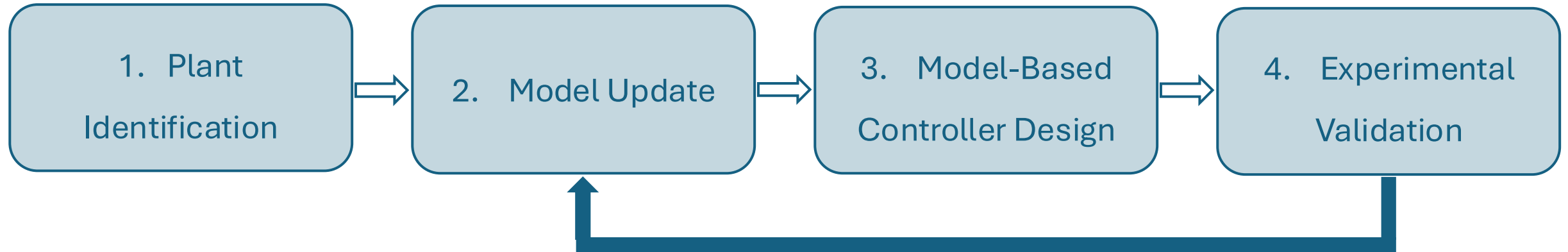


- 1.1 Hz leaf-spring suspension
- Long-range readout.
- Open-loop operation.
- Resolution: 1 pm/rtHz above 1 Hz

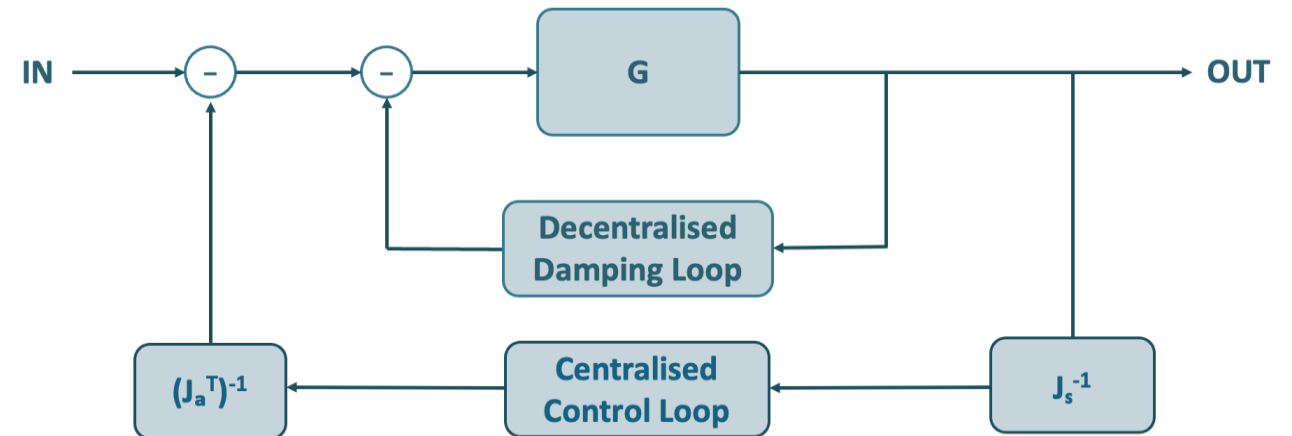


Active Isolation: Full Prototype

Methodology

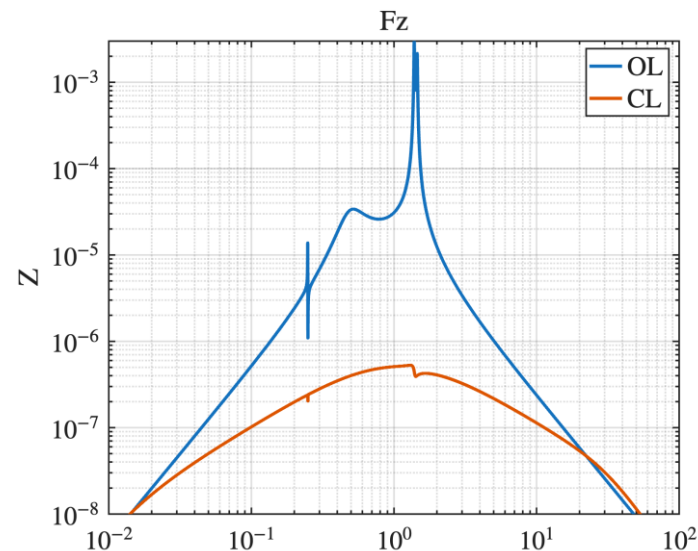


Control Scheme:



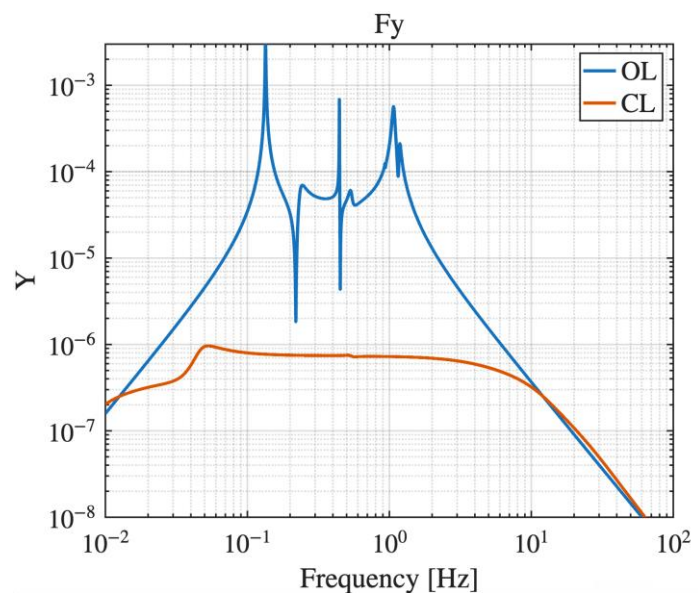
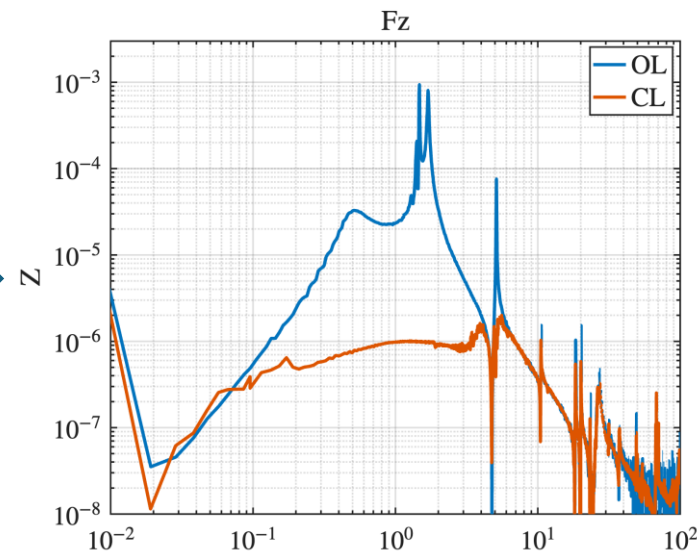
Active Isolation: Full Prototype

Model objectives

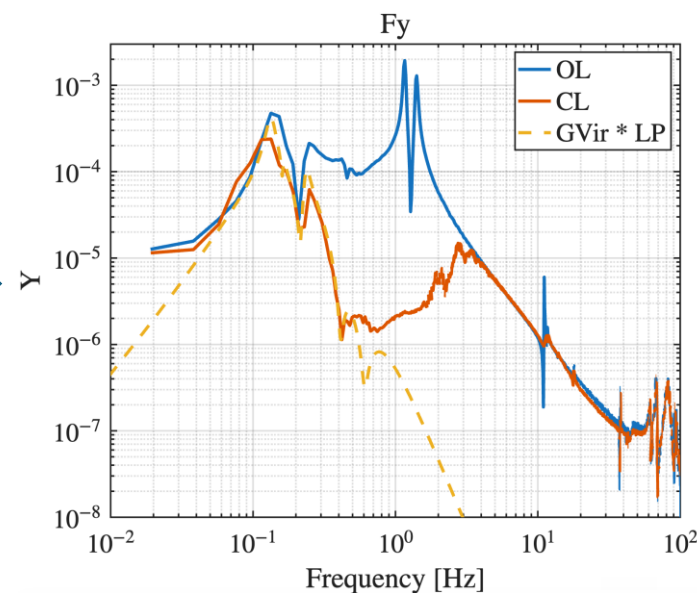


Vertical
(Without VSF)

Experimental results



Horizontal
(With VSF)



Radiative Cooling Strategy



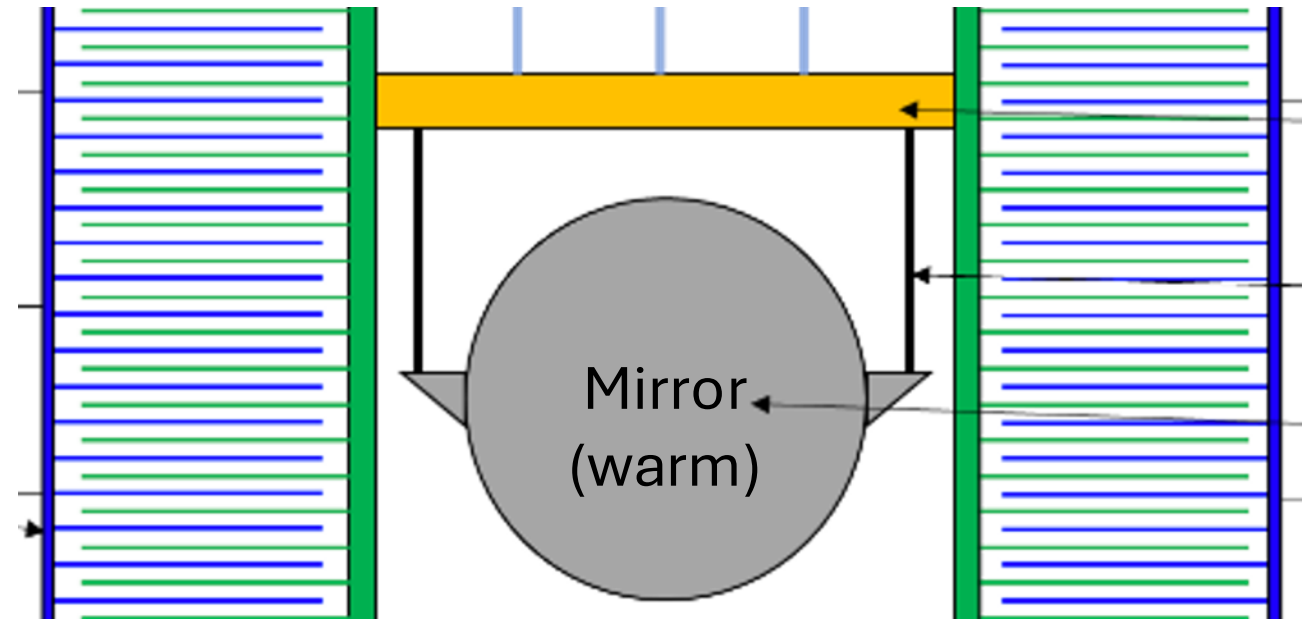
- Interlacing fins to increase the radiative heat exchange area (80m^2 for E-TEST, $\sim 500\text{m}^2$ for ET).
- Thermo-mech. topology optimisation of fin geometry with radiation
- Emissivity enhancement at low temperature (coating)
- Cryogenic heat pipes

UCLouvain

EHP

CRM GROUP

Cryostat He (cold)



GDTECH
engineering



open
engineering

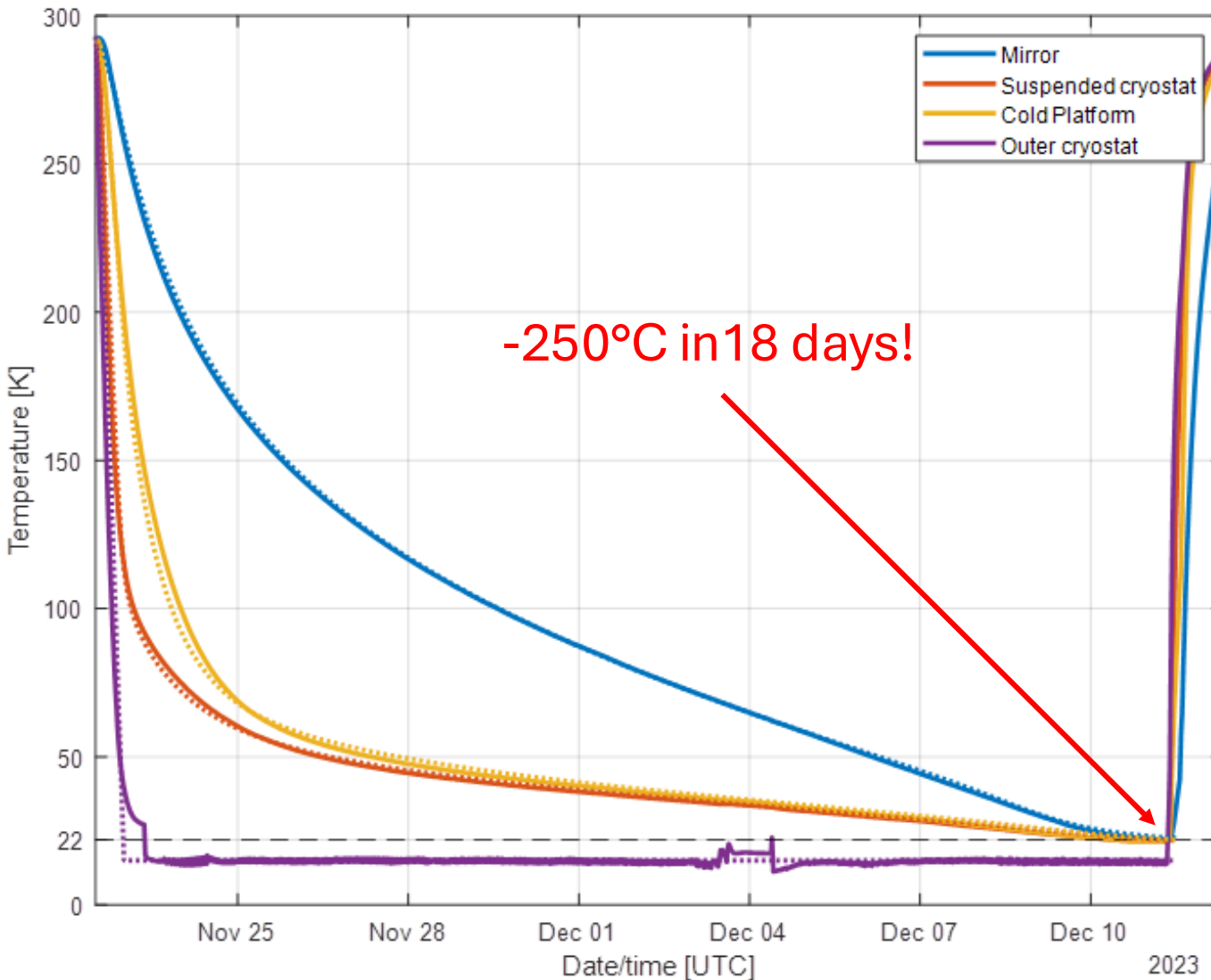


Mecasoft

PIX
COATING

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

1st run @ CSL in 2023



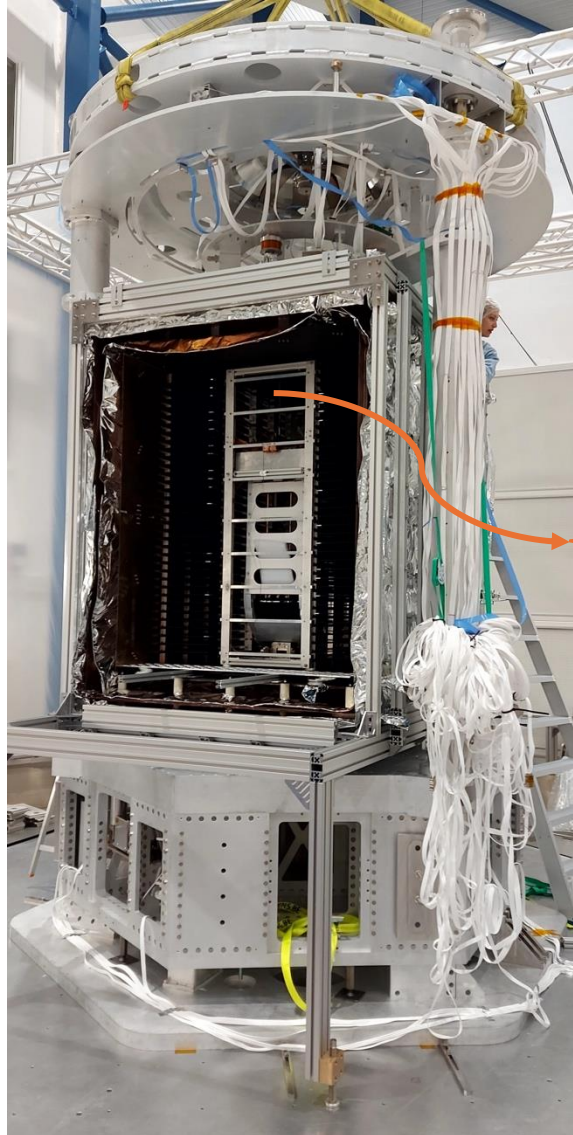
Contact :
Cédric Lenaerts (CLS)
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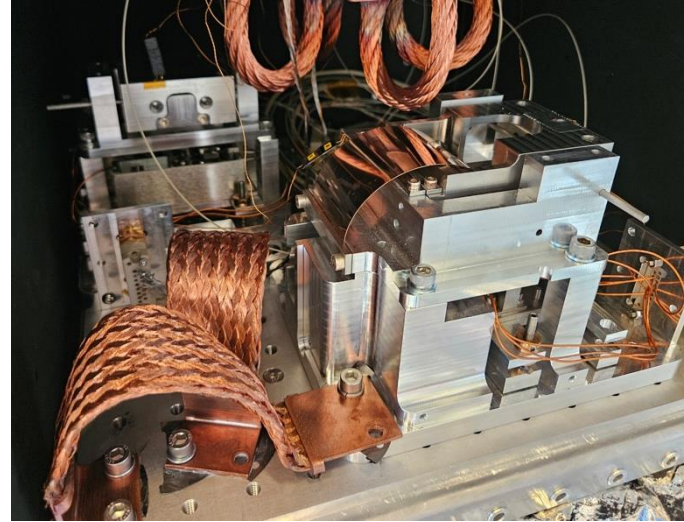


L. Jacques et. Al., Cryogenics,
Volume 147, 15 April 2025, 104057

Cryogenic inertial sensors



Cryo-V



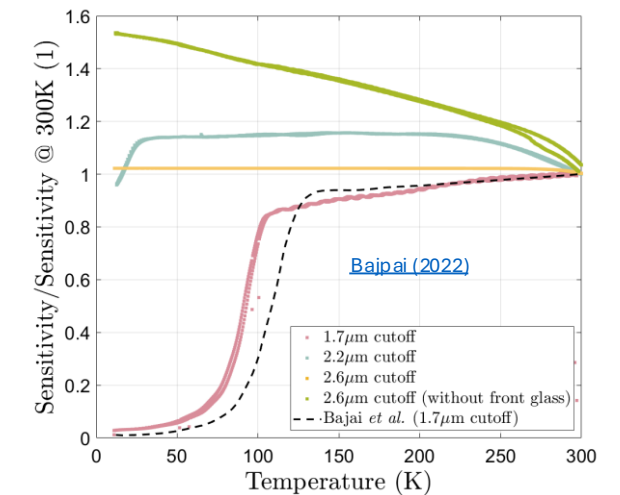
Cryo-H



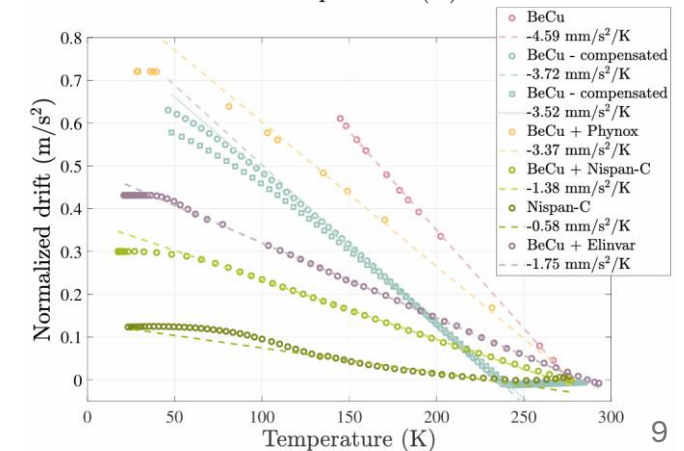
Adaptation to cryogenic conditions of

- a) Optical elements
- b) Thermal effects on suspension
- c) Electrical components

a) InGaAs ++ without front glass



b) Nispan-C



STELLAR cryogenic testbench

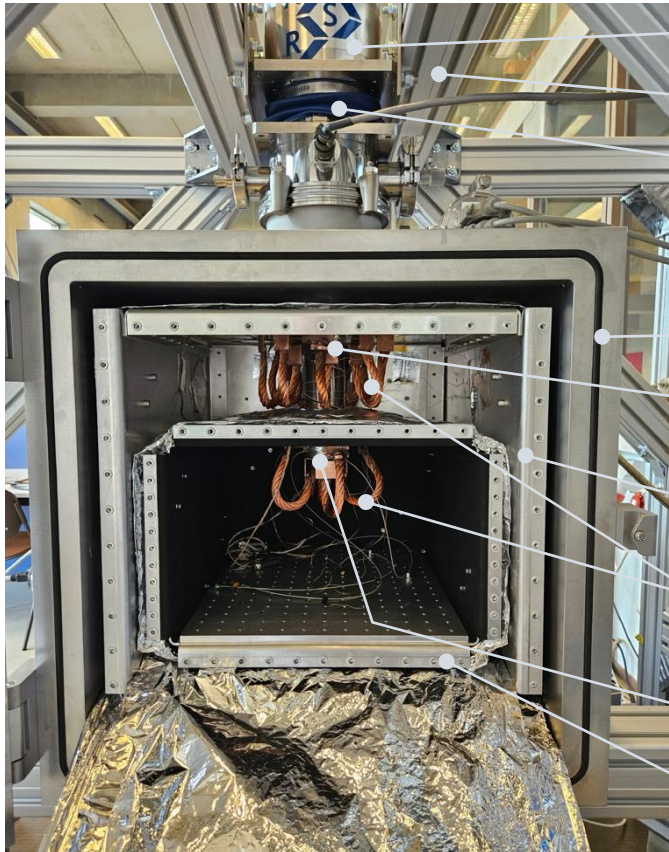


15-20 K

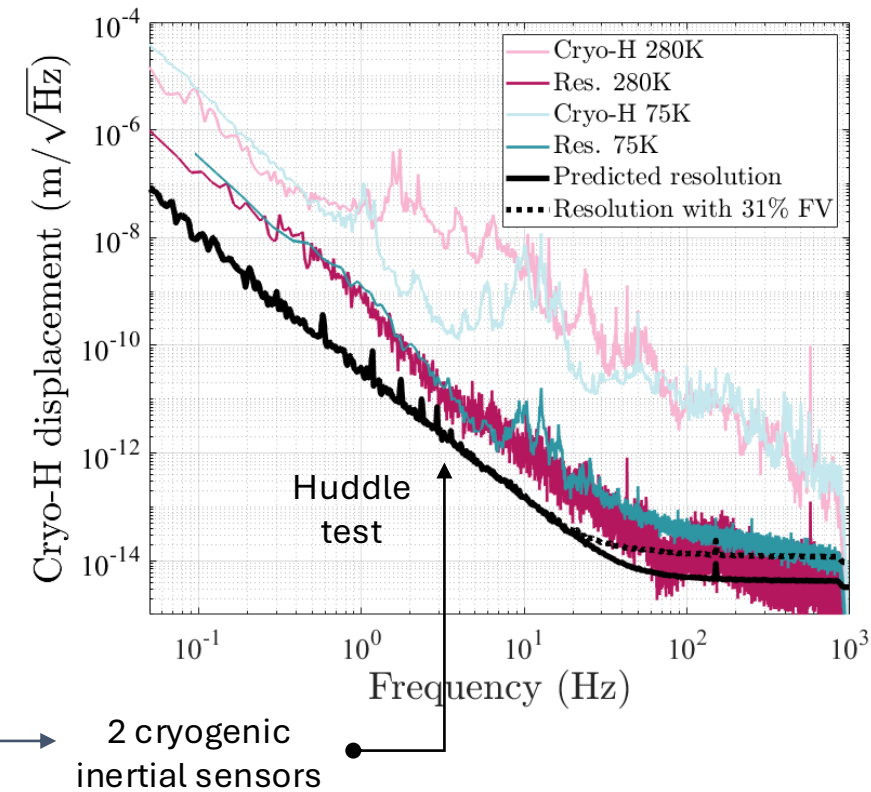
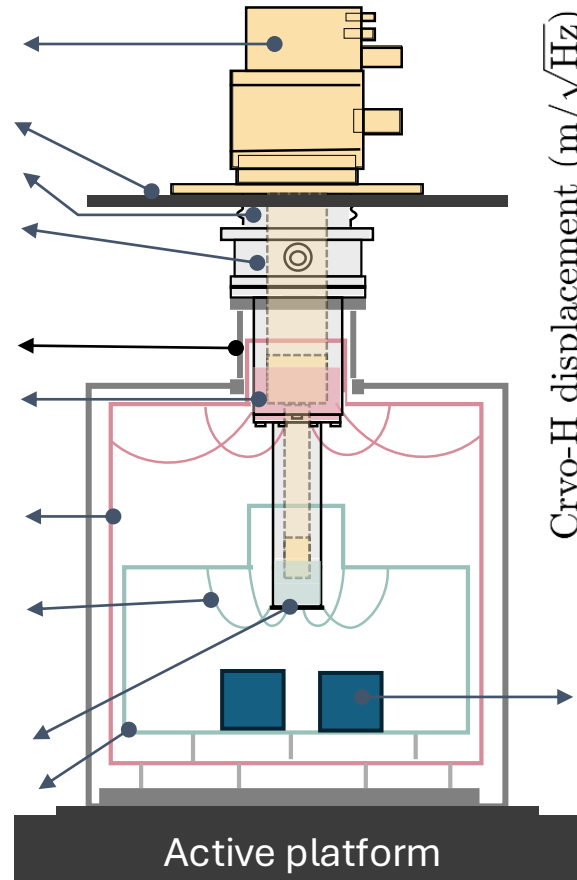


- 10 nm RMS in [0.01-10] Hz
- pm/ $\sqrt{\text{Hz}}$ level from 3 Hz

Testbench to measure the sensor resolution in cryogenic conditions



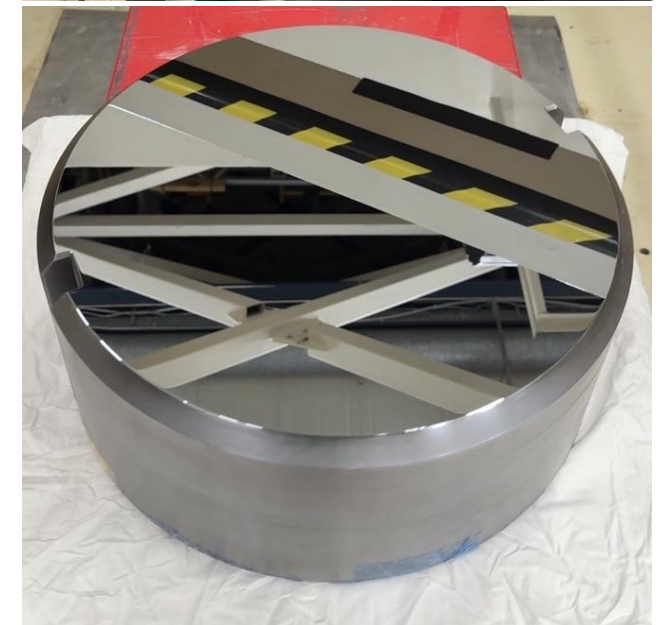
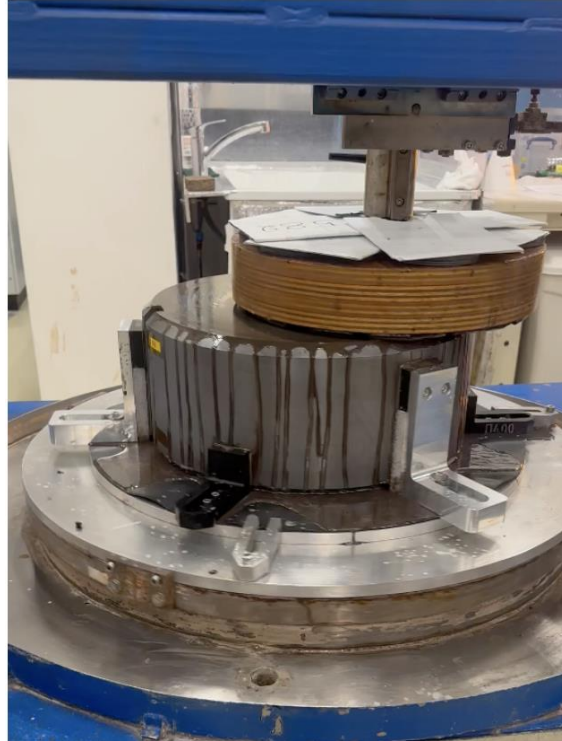
- CS210-GMX-20B cryocooler
- Cryocooler support
- Rubber bellow
- gHe-filled heat exchanger
- Vacuum chamber
- Cryocooler 45K stage
- Intermediate thermal shield
- Soft OFC thermal braids
- Cryocooler 4K stage
- Cold thermal shield



Test Mass Production

Si monocrystalline

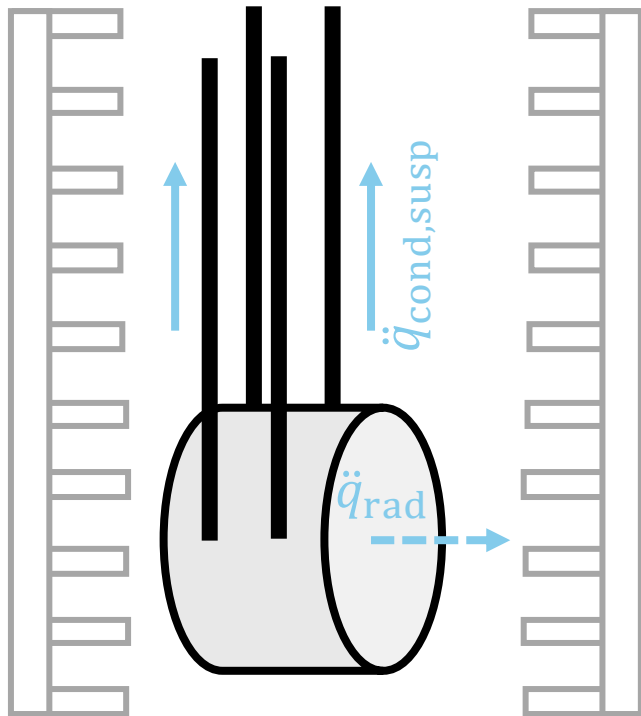
- 45 cm diameter
- < 1 nm residual roughness
- $\lambda/4$ flatness
- 80 kg
- 18 cm thickness



Future suspensions challenges

ET-FIBER project (close collab. with Andrew Spencer and Flavio Travasso)

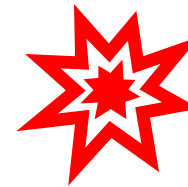
Contact :
Gilles.Magain@uliege.be



Cooling power

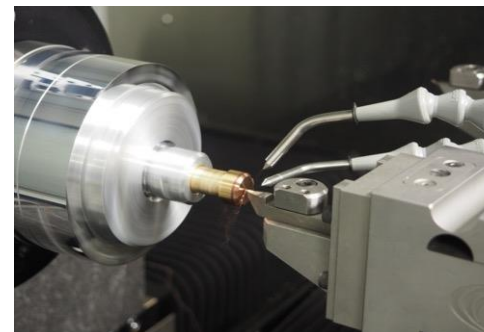
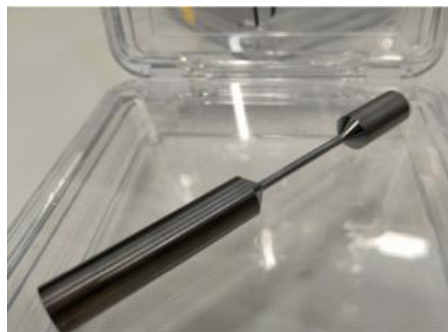
$$P = k \frac{A}{L} \Delta T$$

Short, fat rod
to extract heat from
mirror



Vibration isolation

Long, soft rod
to decrease the
suspension resonances



Newtonian noise experiment

Newtonian Noise estimation and control techniques
Validation experimentally on a full scale prototype



 **UCLouvain**

LAUM

Laboratoire d'Acoustique
Le Mans Université - CNRS - UMR 6613

 **Precision
Mechanics
Laboratory**

 **LIÈGE université**
**Urban & Environmental
Engineering**

 **LIÈGE université**
STAR Institute

- Full-scale prototype addressing ET challenges
 - Large monocrystalline Si mirror
 - Suspension design
 - Seismic isolation for ET-LF
 - Radiative cryogenic cooling
- Open European consortium
- Many opportunities of collaborations with industry:
 - Optics, electronics, mechanics, cryogenics, mechatronics, metrology



