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HOST:

Exactly Constrained, High Heat Load Design for SABIA'S First Mirror*

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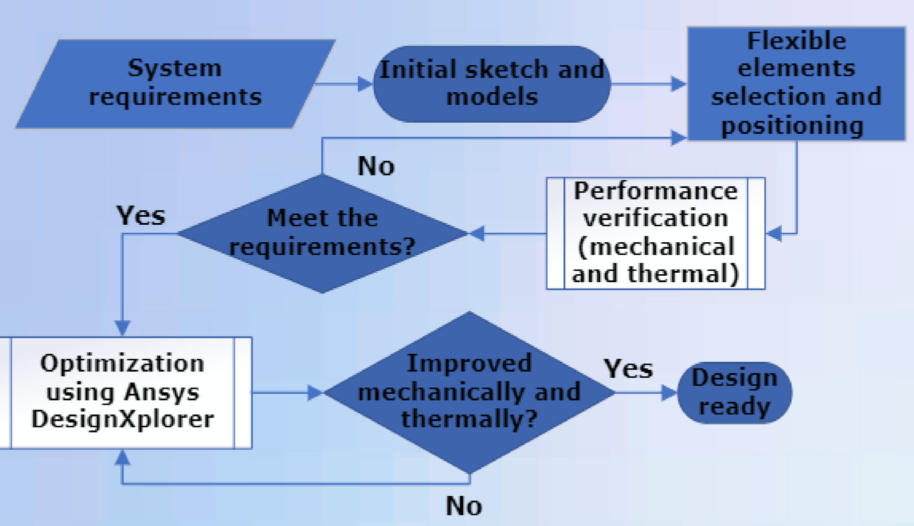
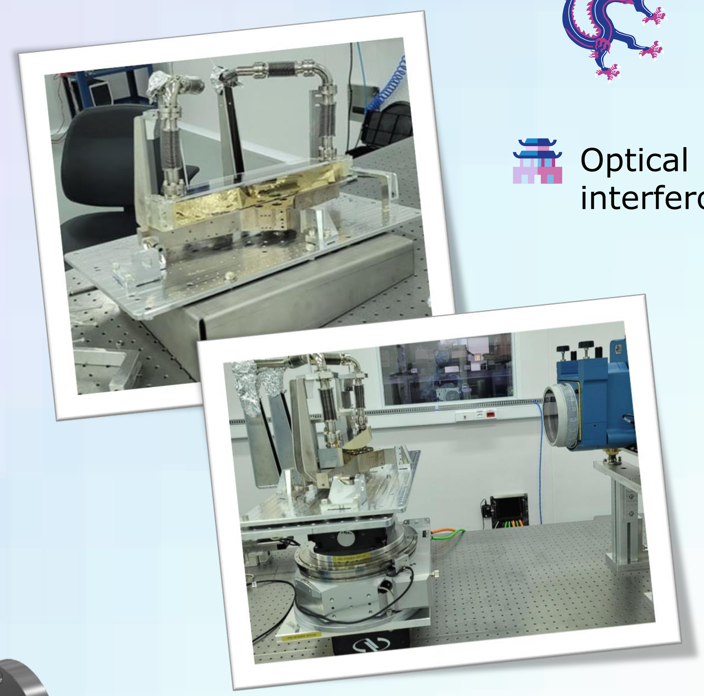
Abstract

The SABIA beamline (Soft x-ray ABsorption spectroscopy and ImAging) will operate in a range of 100 to 2000 eV and will perform XPS, PEEM and XMCD techniques at SIRIUS/LNLS. Thermal management on these soft x-ray beamlines is particularly challenging due to the high heat loads. SABIA's first mirror (M1) absorbs about 360 W, with a maximum power density of 0.52W/mm², and a water-cooled mirror was designed to handle this substantial heat load. To prolong the mirror operation lifetime, often shortened on soft X-ray beamlines due to carbon deposition on the mirror optical surface, a procedure was adopted using high partial pressure of O2 into the vacuum chamber during the commissioning phase. The internal mechanism was designed to be exactly constrained using folded leaf springs. It presents one degree of freedom for control and alignment: a rotation around the vertical axis with a motion range of about ±0.6 mrad , provided by a piezoelectric actuator and measured using vacuum compatible linear encoders. This work describes the SABIA's M1 exactly constrained, high heat absorbent design, its safety particularities compared to SIRIUS typical mirrors, and validation tests results.

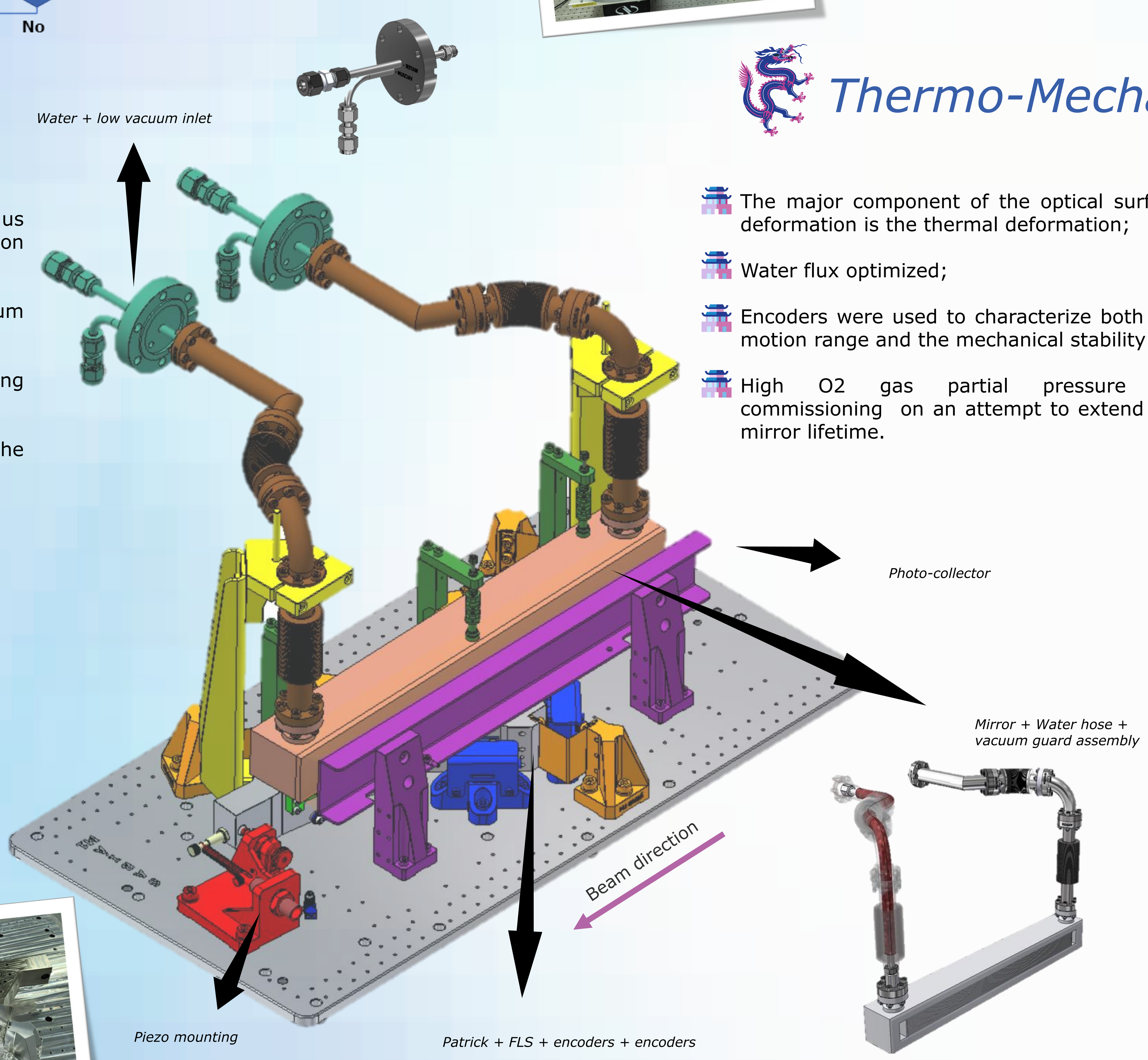
Optimization Methodology

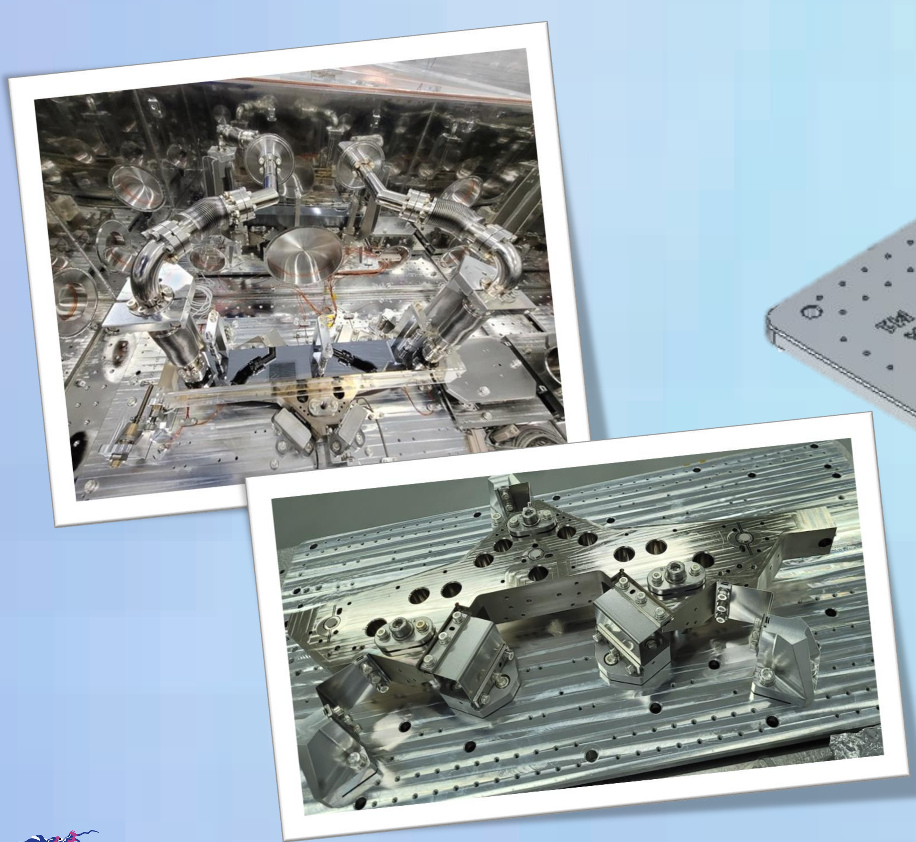


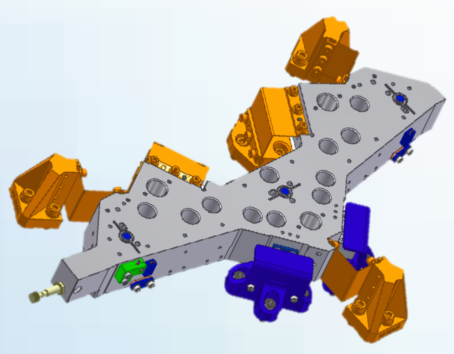


Water Hose

- By utilizing a flexible water hose allowed us to maintain continuous mirror rotation around the vertical axis;
- The hose is safeguarded by a vacuum enclosure;
- Pressure monitoring to detect leaks, ensuring electronics and vacuum protection;
- Parasitic forces minimized by anchoring the hose vacuum guard on the frame.

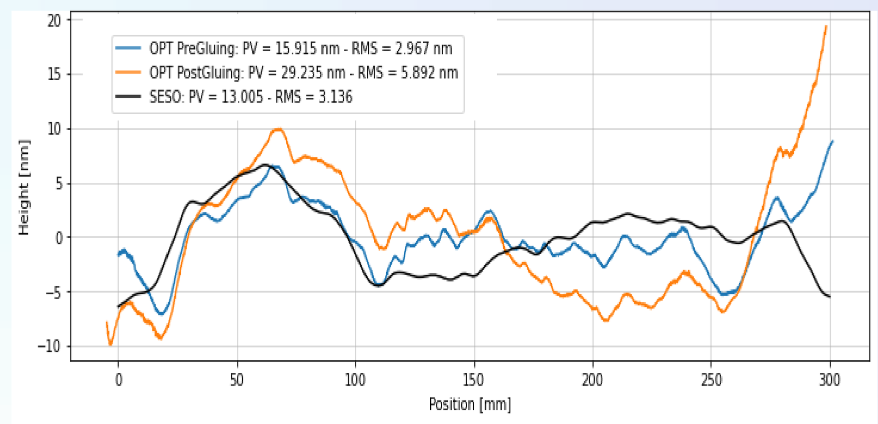






Optical Face Deformation Measurements

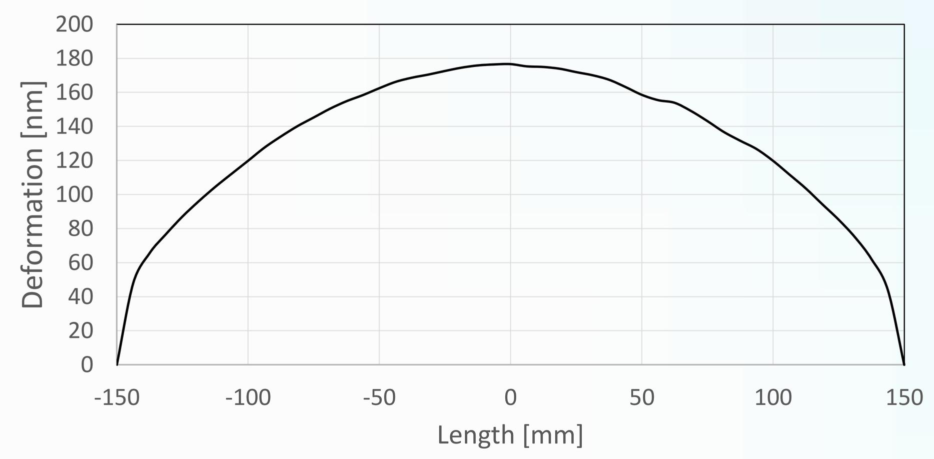
- Optical face measured using a Fizeau interferometer.



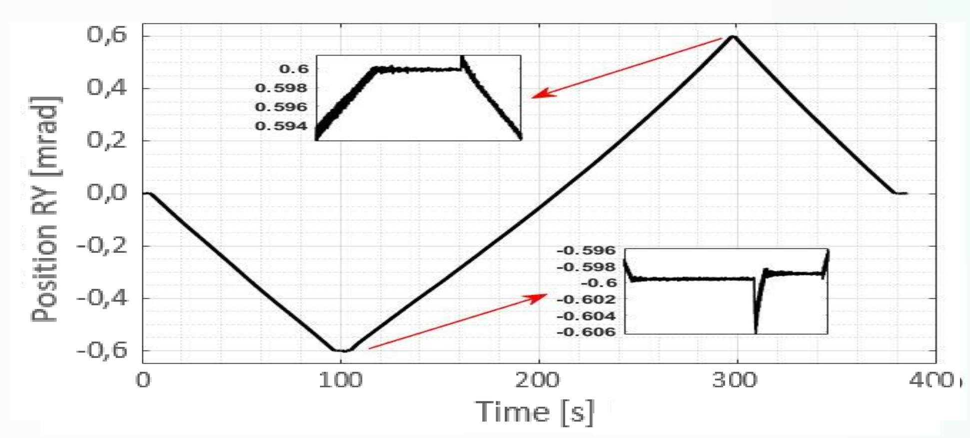
Heigh-error before and after the glue dried out.

Thermo-Mechanical Design Results

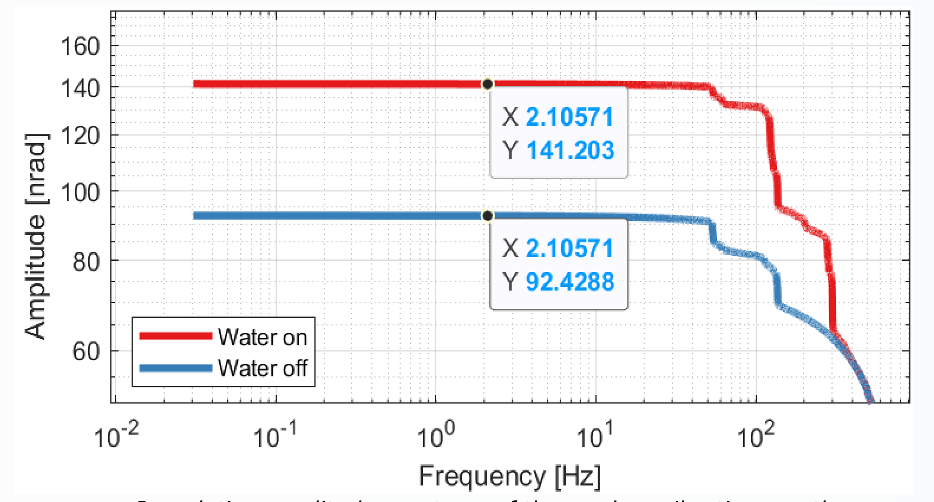
- The major component of the optical surface deformation is the thermal deformation;
- Water flux optimized;
- Encoders were used to characterize both the motion range and the mechanical stability;
- High O2 gas partial pressure on commissioning on an attempt to extend the mirror lifetime.



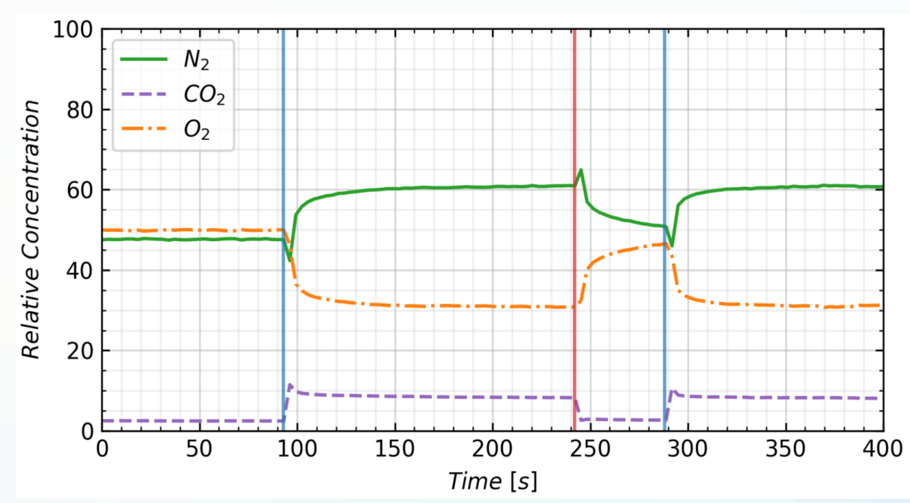
Final deformation of the mirror.



Mechanism motion scan.



Cumulative amplitude spectrum of the random vibrations on the mechanism.



RGA monitoring during the M1 commissioning phase. The blue lines indicate the shutter opening, the red its closing.

Conclusion

The SABIA M1 exactly constrained, high heat absorbent mirror was designed, assembled, and commissioned in 2023. The challenge on this design was to combine an internal water-cooled mirror and the precision engineering concepts. Using a combination stiff actuator and FLS we developed a highly linear and stable mechanism. To protect both vacuum levels and electronics used, a vacuum guard was designed to encapsulate the water hoses used to cool the mirror down during operation.

As it is complex to determine the water flow induced vibration contribution on stability on the water hoses, tests were performed. It shows that water flow is responsible on over 35% of the instabilities. Yet this represent only 2nm increase on linear instabilities when converted to rotation it is about 49nrad.

By using a partial pressure of oxygen gas onto the vacuum chamber we observed possible reactions with carbon-based structures on an attempt to prolong the mirror lifetime, but we need more testing to be certain. In the forthcoming months, the SABIA beamline shall end its technical commissioning and entered the scientific commissioning.

Acknowledgements

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CNPEM Brazilian Center for Research in Energy and Materials

LNLS Brazilian Synchrotron Light Laboratory

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