Cryogenic Systems for Optical Elements Cooling at Sirius/LNLS

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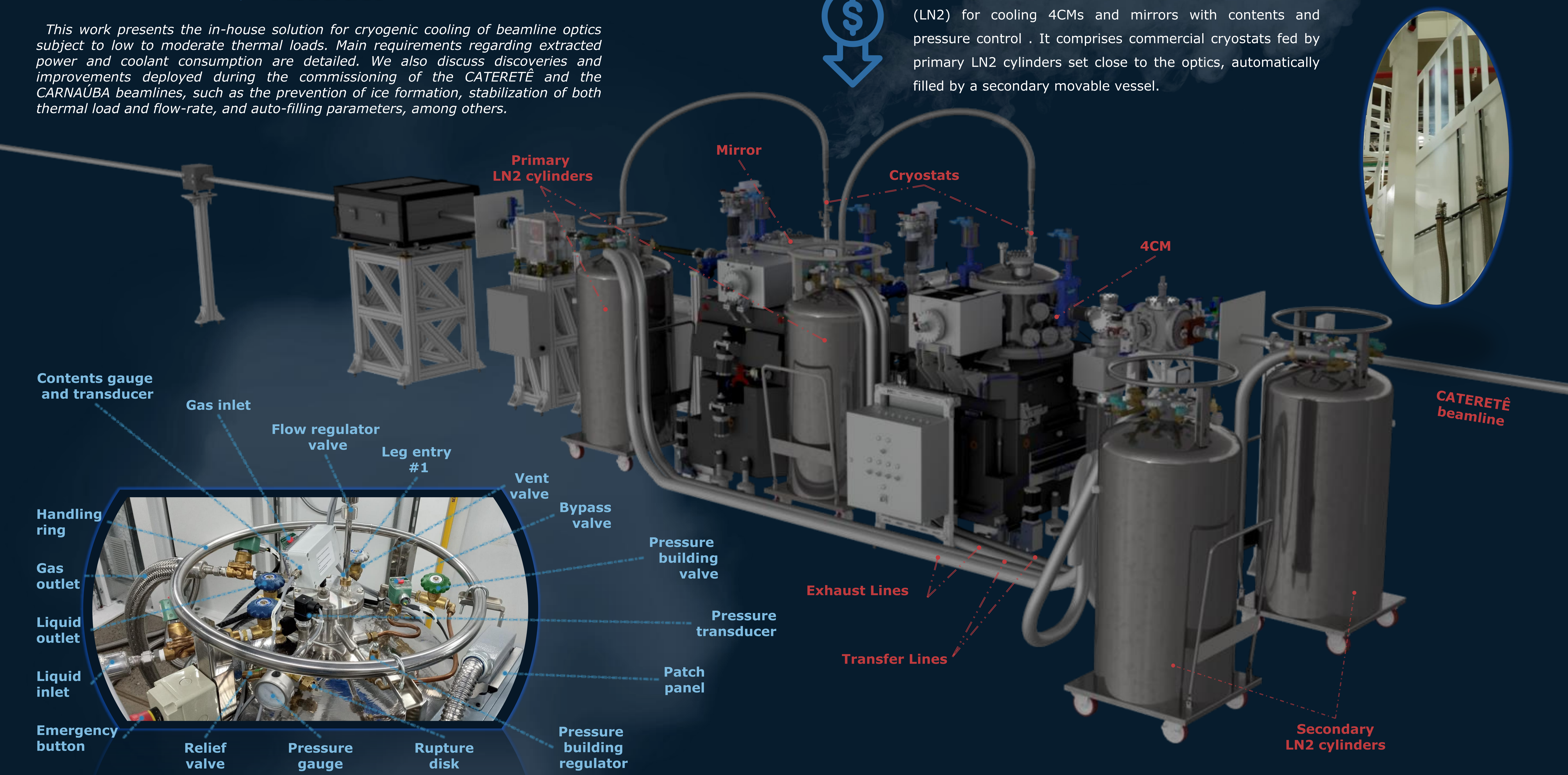
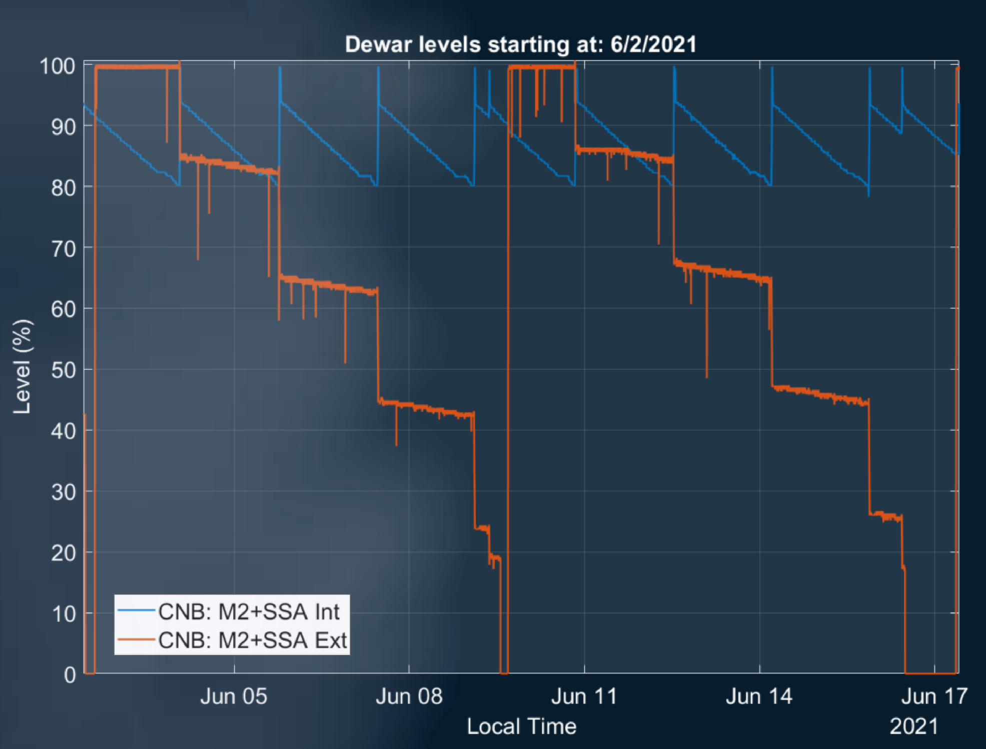
Abstract

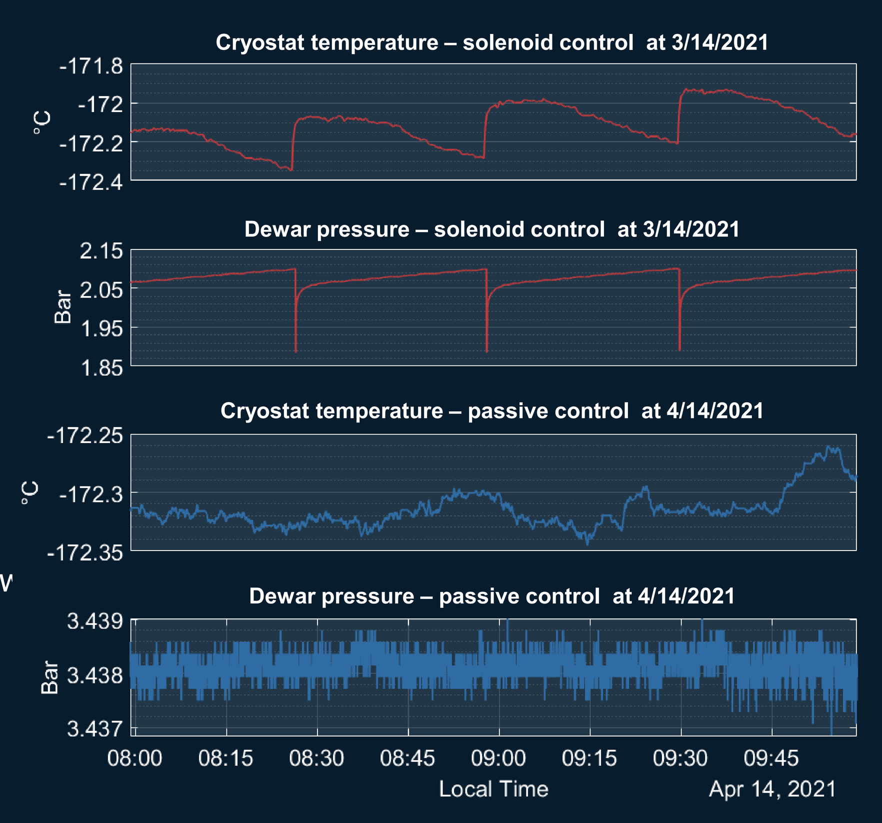
This work presents the in-house solution for cryogenic cooling of beamline optics subject to low to moderate thermal loads. Main requirements regarding extracted power and coolant consumption are detailed. We also discuss discoveries and improvements deployed during the commissioning of the CATERETÊ and the CARNAÚBA beamlines, such as the prevention of ice formation, stabilization of both thermal load and flow-rate, and auto-filling parameters, among others.

A low-cost solution was adopted to supply liquid nitrogen (LN2) for cooling 4CMs and mirrors with contents and pressure control . It comprises commercial cryostats fed by primary LN2 cylinders set close to the optics, automatically filled by a secondary movable vessel.



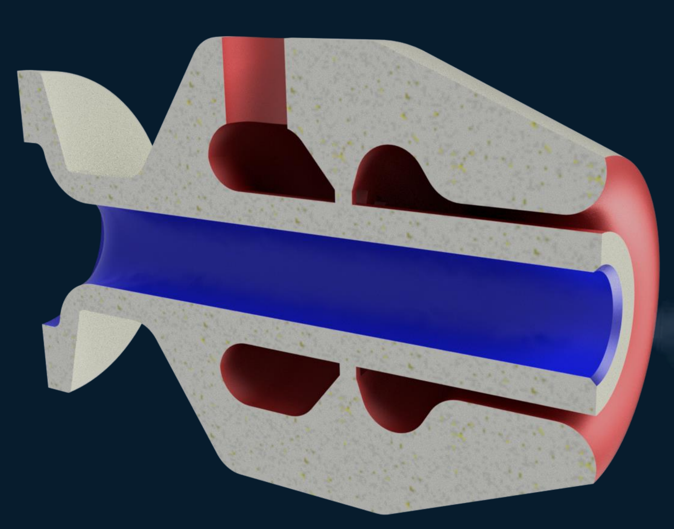


- Solenoid valves for filling control
- Satisfactory results when keeping primary vessel between 80~100%, filled @ 2.5 L/min
- LN2 transfer losses of 3% was observed
- Effectively running for several months

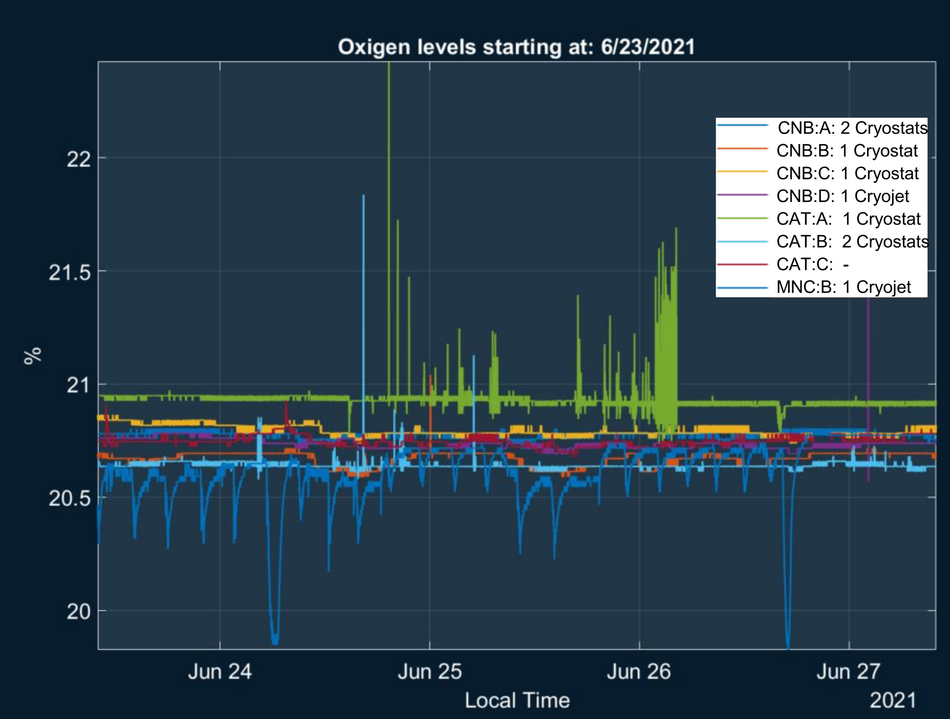


- Active pressure control by solenoids during filling
- Passive pressure control allow temperature and dynamic stability of the optics

For the cryostat outlet, the best insulation performance against condensation was achieved when using a 3D printed part in which the nitrogen flow surrounded by a cylindrical channel through which there is a laminar flow of compressed air.



Optics	Load [W]	Consumption [L/h] Theor.	Primary	Second.
CNB – M1+XDU	60	1.4	1.6	2.0
CNB – M2+SSA	20	0.5	1.1	1.4
CNB – 4CM	26	0.6	0.7	1.1
CAT – M1	16	0.4	1.55	1.64
CAT – 4CM	50	1.1	1.55	1.60
CAT – M2	20	0.5	1.66	1.71



- Oxygen ratio inside the hutches comparable to hutches in which there is no gaseous nitrogen release.

References

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[3] R. R. Geraldes, et al. "The design of exactly-constrained X-Ray mirror systems for Sirius". Presented at MEDSI 2018, Paris
[4] Lena, F. et al. "Copper Braid Heat Conductors for Sirius Cryogenic X-Ray Optics". Presented at MEDSI 2020, Chicago, USA, this conference.
[5] Icons designed by Freepik from Flaticon.com

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