CFH COOLING AGENT REPLACEMENT

Prototype tests with LN2 container

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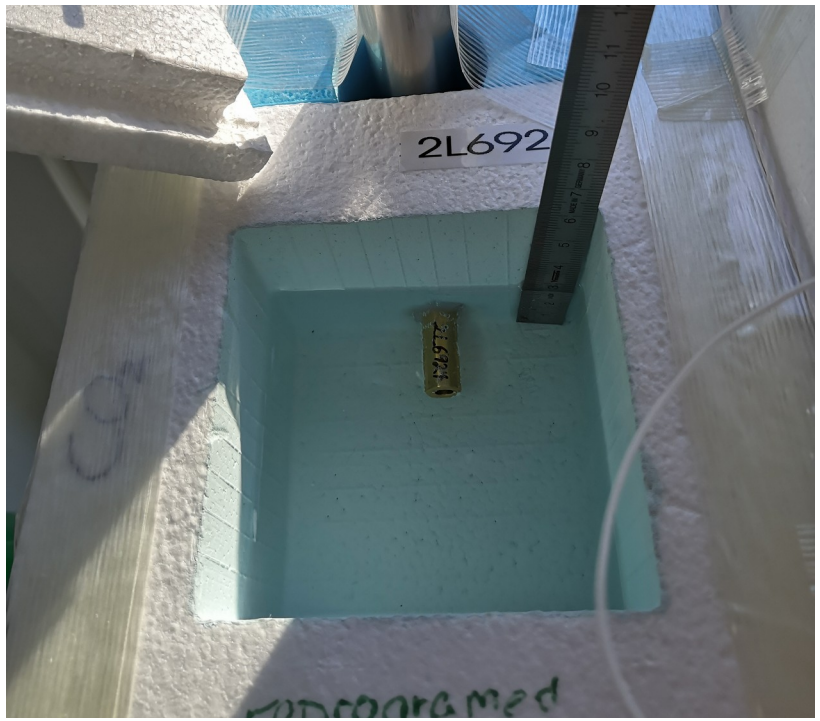
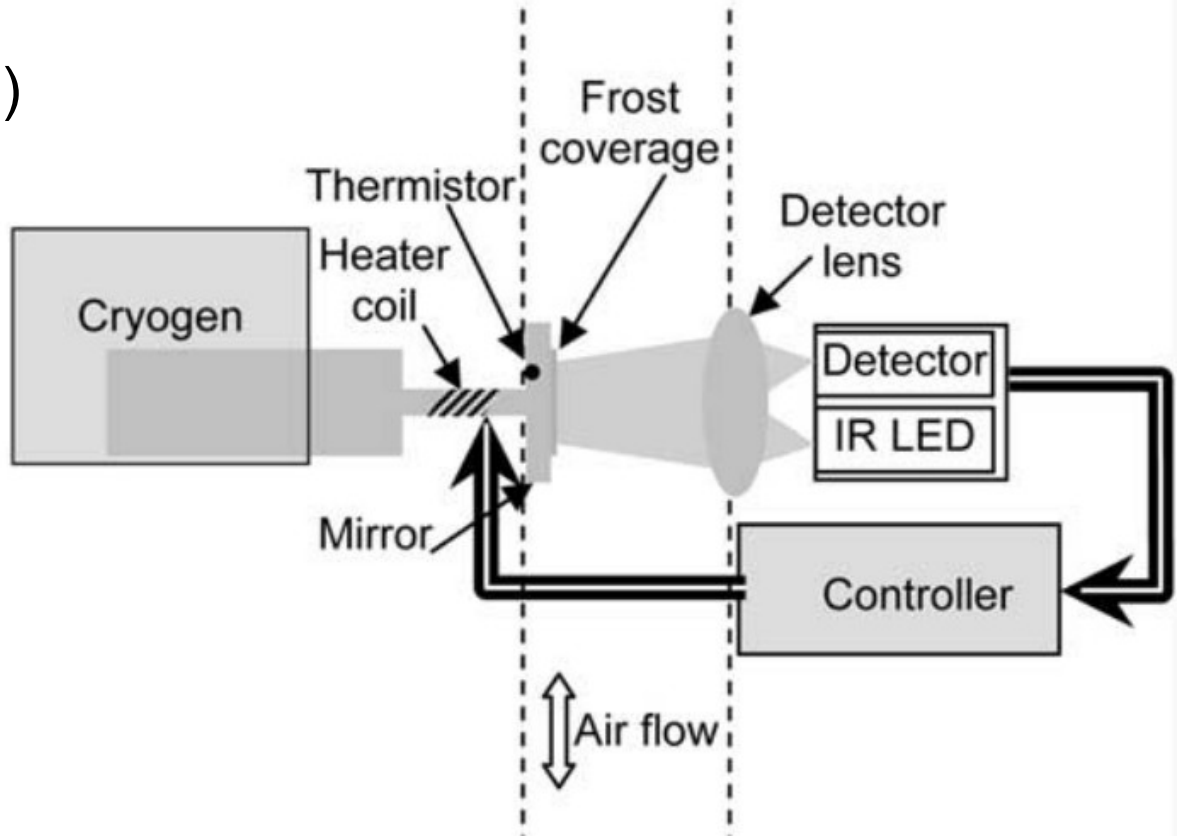
CRYOGENIC FROSTPOINT HYGROMETER (CFH)

- Mirror temperature is controlled by heating against a cold sink (fast response)
- Cold sink by cryogenic vessel with R23 (HFC-23)





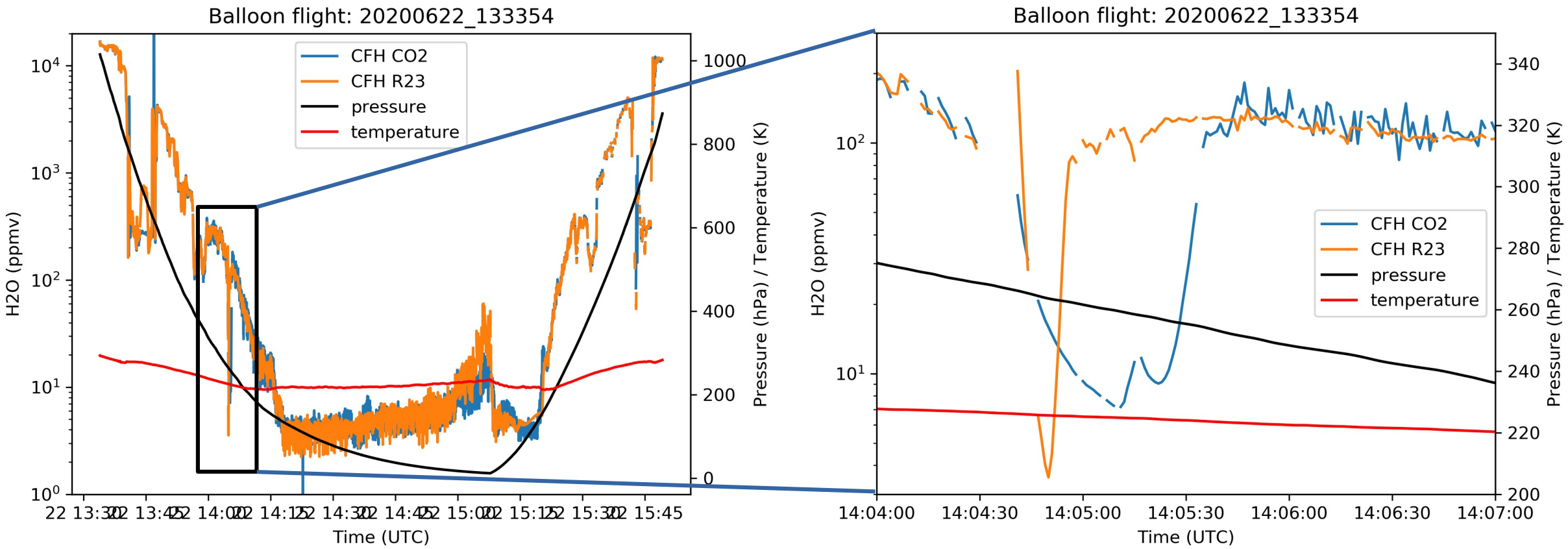
Vömel et al, JGR, 2007

COOLING ALTERNATIVES

- **Criteria**
- Environmental friendly, low cost, easy provision, harmless, and good heat conduction (liquid)

	R23	Liquid Nitrogen	CO2 (dry ice)
Boiling Temperature	-82,2 °C	-196 °C	-78,5 °C
ΔH_v enthalpy of evaporation	17,03 kJ/mol	5,59 kJ/mol	23,2 kJ/mol

TEST FLIGHT WITH ETHANOL DRY ICE MIXTURE

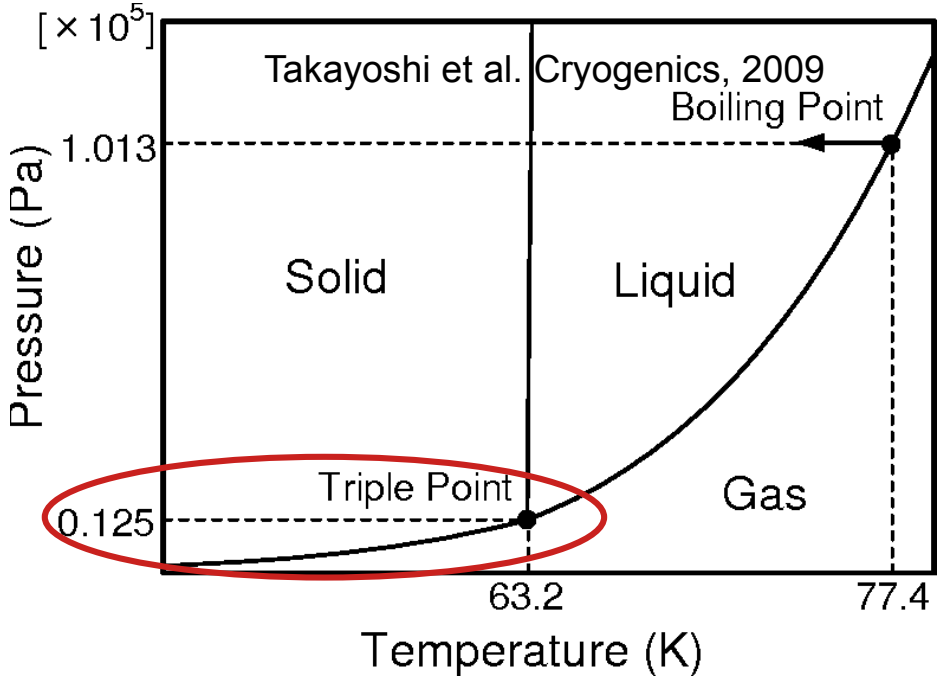


Cooling efficiency lower and gernal warmer cooling bath temperatures

→ **Not suitable for measurements at the cold tropical tropopause**

LIQUID NITROGEN (LN_2) AS REPLACEMENT

Properties



	R23	Liquid Nitrogen
Boiling Temperature	-82,2 °C	-196 °C
ΔH_v enthalpy of evaporation	17,03 kJ/mol	5,59 kJ/mol

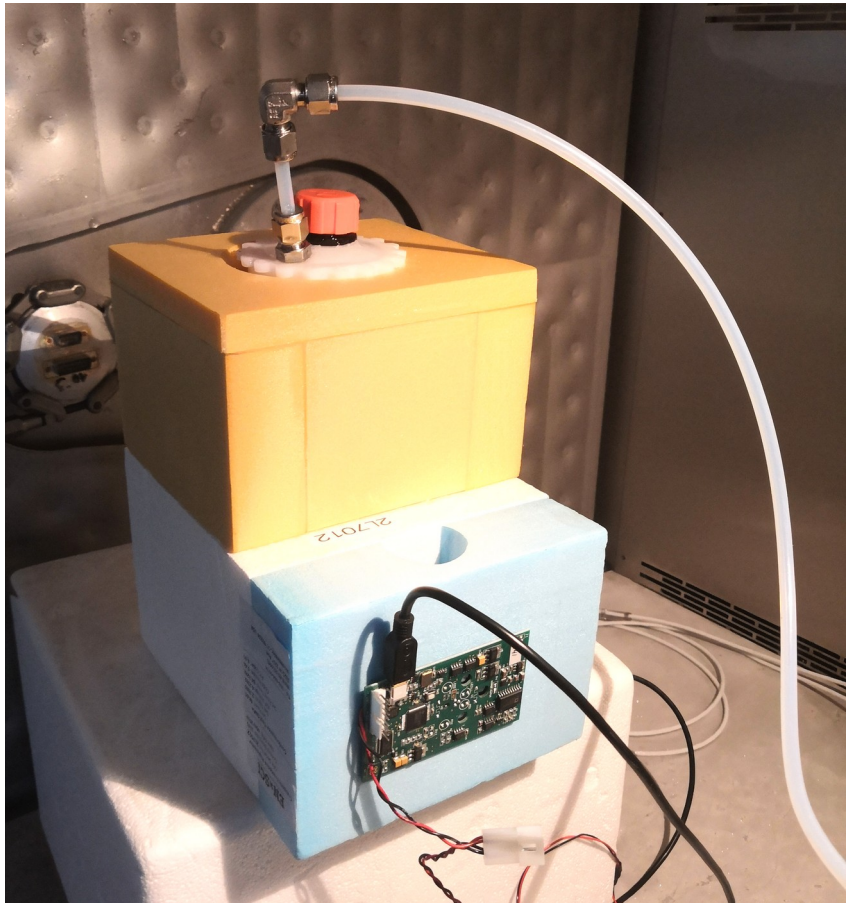
- Liquid nitrogen gets solid at pressures < 125hPa
- **Need for pressure vessel to keep pressure always > 125hPa during balloon sounding**
- Small value of evaporation enthalpy
- **Amount of LN_2 must be larger, compared to R23 (~0,7 L)**

LN_2 AS CFH COOLING AGENT

Specifications

- Frost safe over pressure valve
- Cooling power: 10-15 Watt
- Operation endurance: 3 hours
- Weight of the system: < 2 kg
- Integration into the CFH, with thermal connection to the cold finger
- Ready for testing 1. quarter of 2022

CFH MODIFICATION: PROTOTYPE



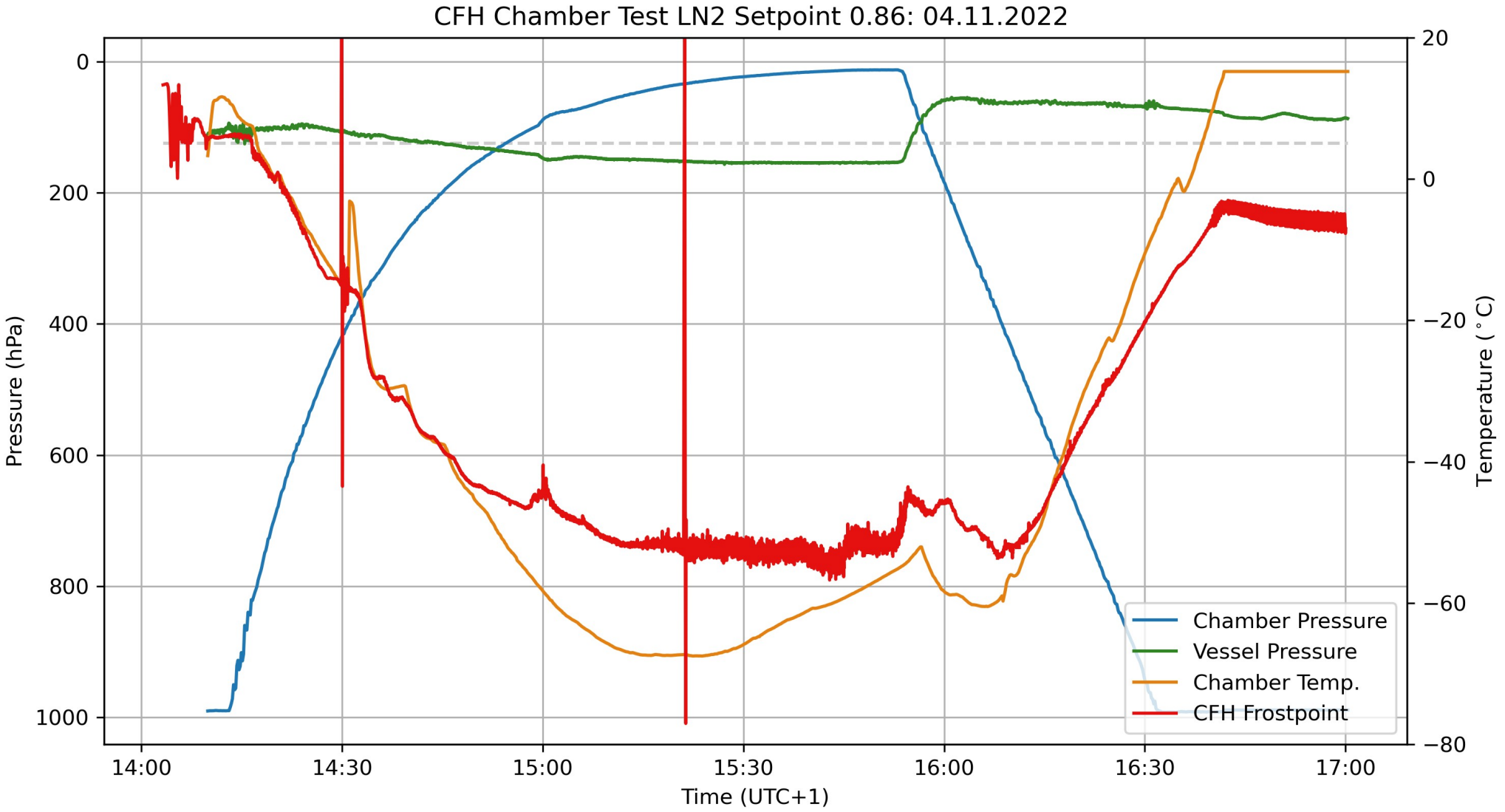
- Shorten cold finger to half size
- Plastic container is glued with Epoxy glue onto the cold finger
- Addition isolation with silicon around cold finger
- Housing for LN2 container to avoid heat exchange with the outer air.
- **Reduction of LN2 consumption and lowering duty cycle**

TESTING FACILITY: CLIMATE CHAMBER

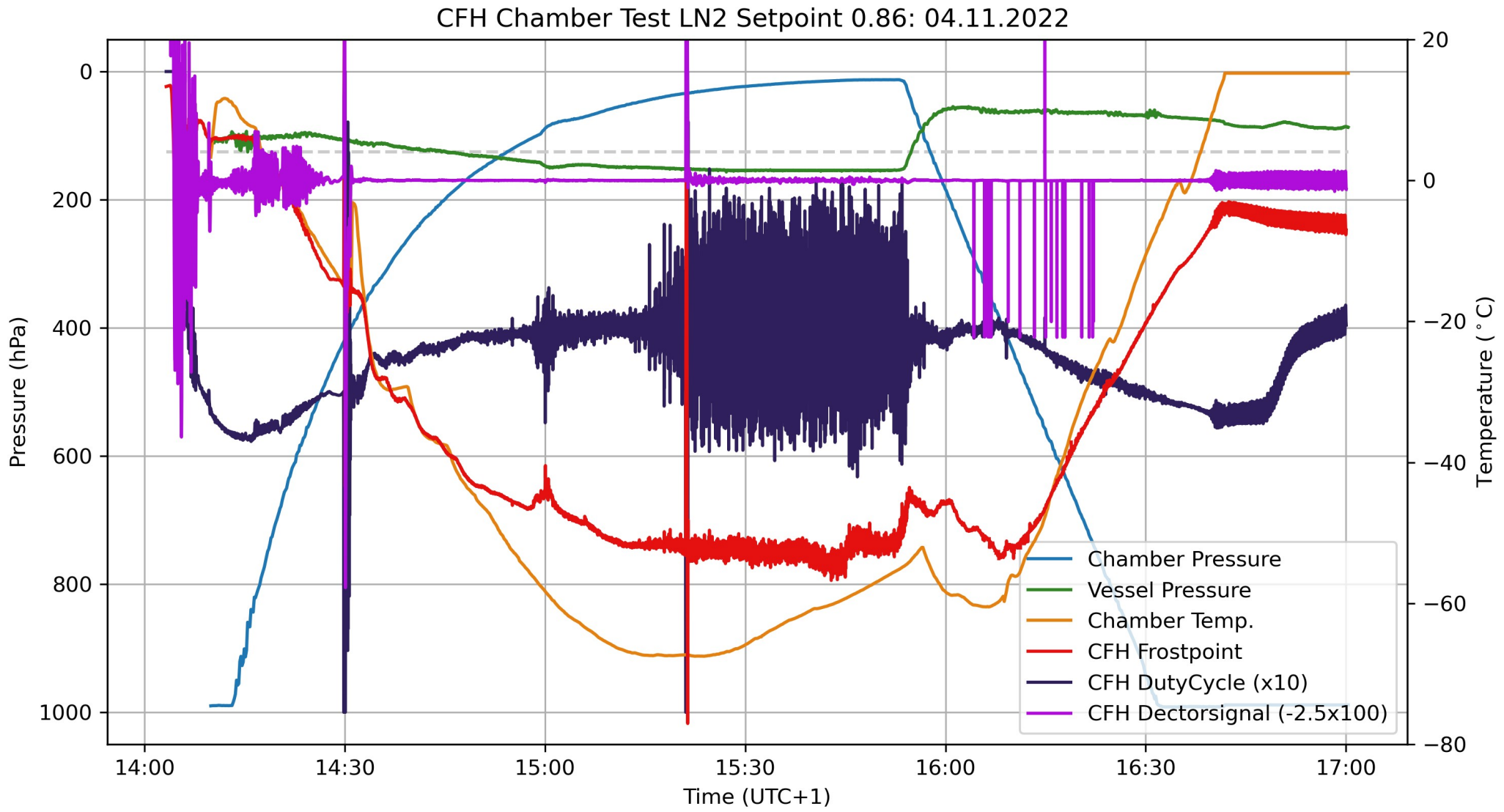
- Dimensions: 770mm × 750mm × 750mm
- Temperature range: -90 to 100°C
- Pressure range: 1000 – 10 hPa

- **Simulation of a balloon flight profile including ascent and descent phase**

PROTOTYPE: FLIGHT SIMULATION 04.11.22

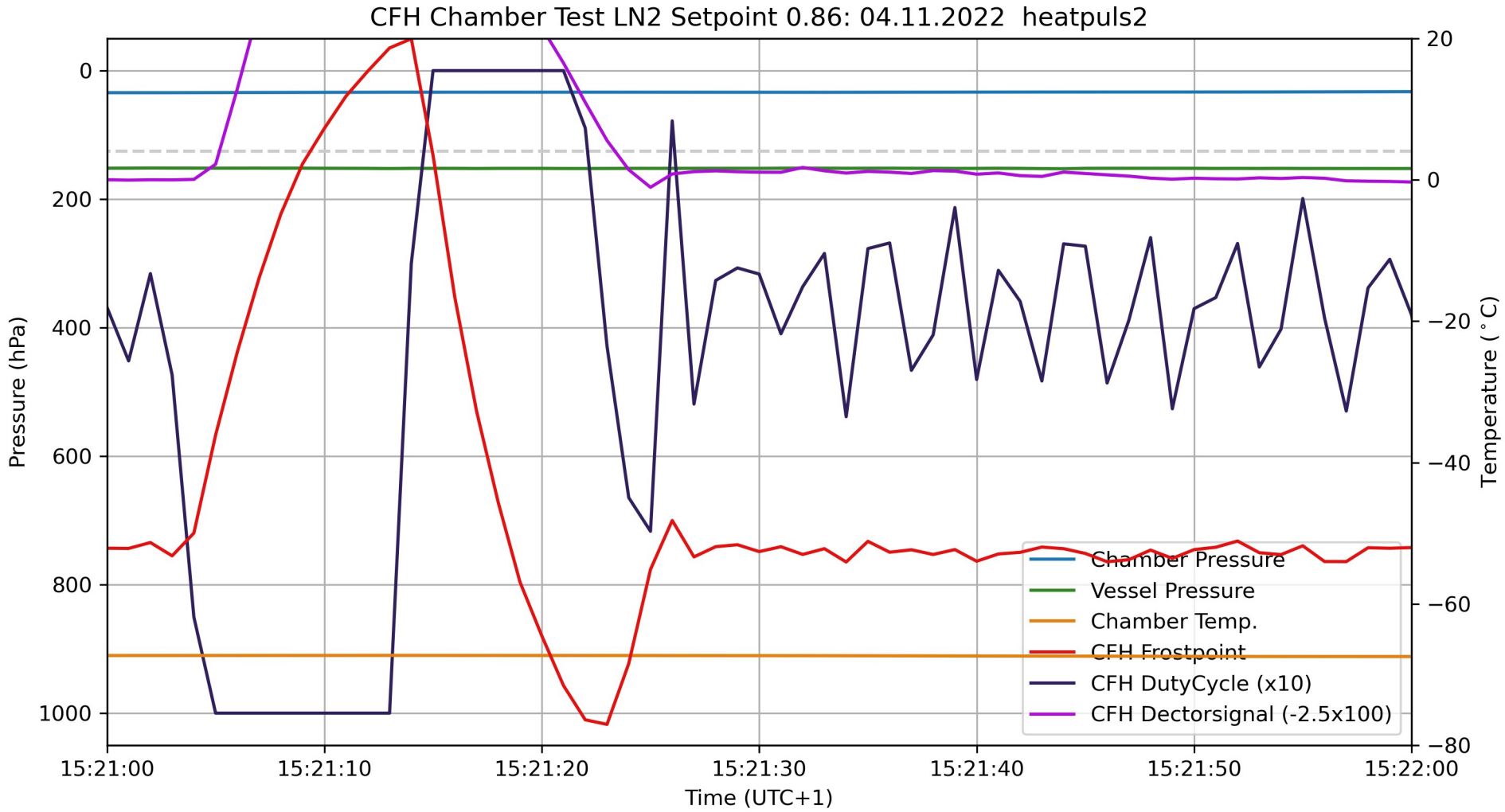


PROTOTYPE: FLIGHT SIMULATION 04.11.22



PROTOTYPE: FLIGHT SIMULATION 04.11.22

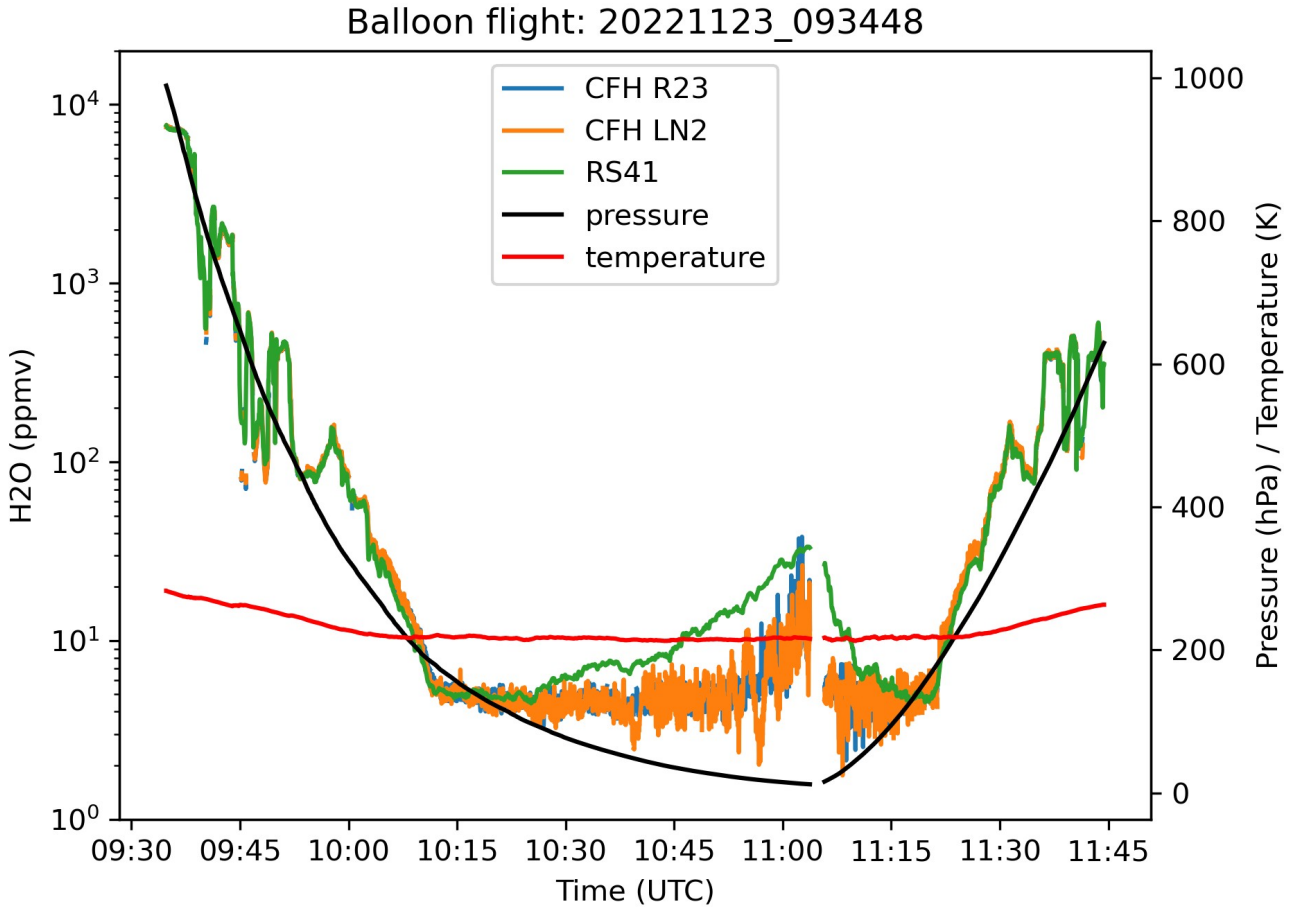
HEAT PULSE 2 @ -35°C

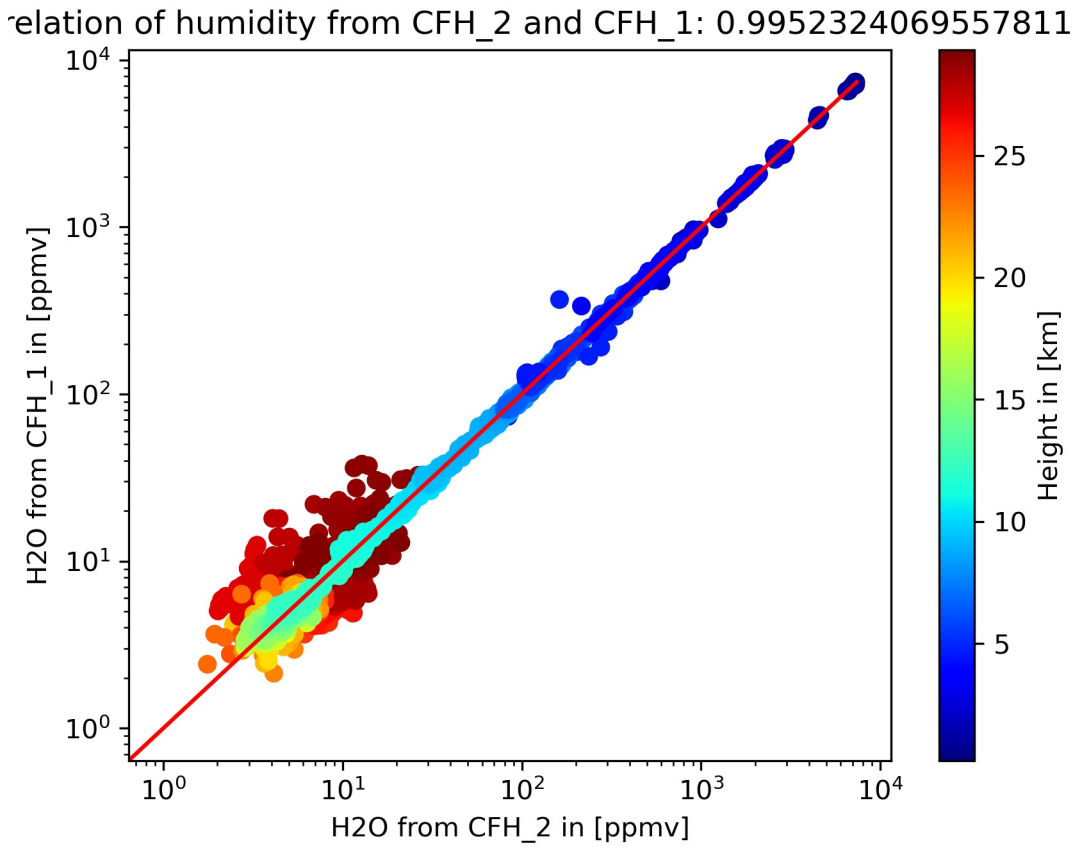


TEST FLIGHT OF PROTOTYPE (23.11.22)

Test flight with **CFH (R23)** and Prototype **CFH (LN2)**

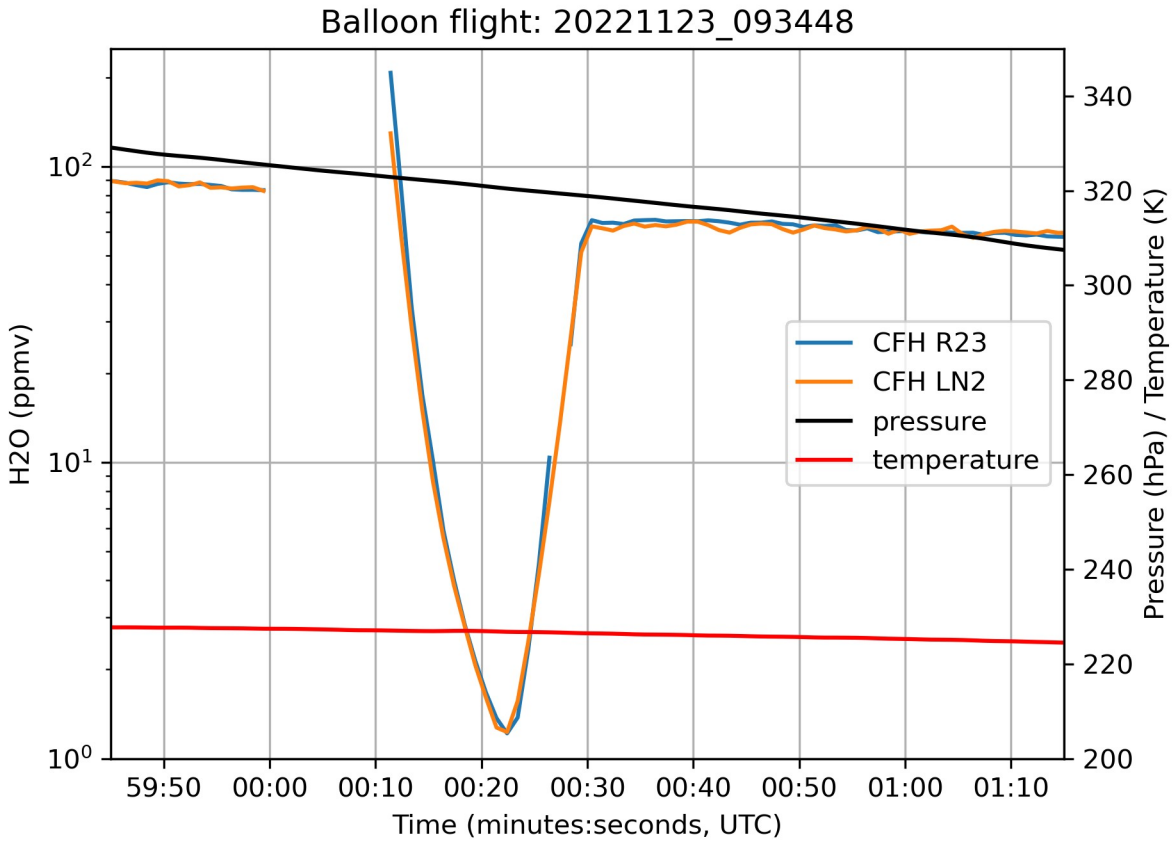
TEST FLIGHT OF PROTOTYPE (23.11.22)

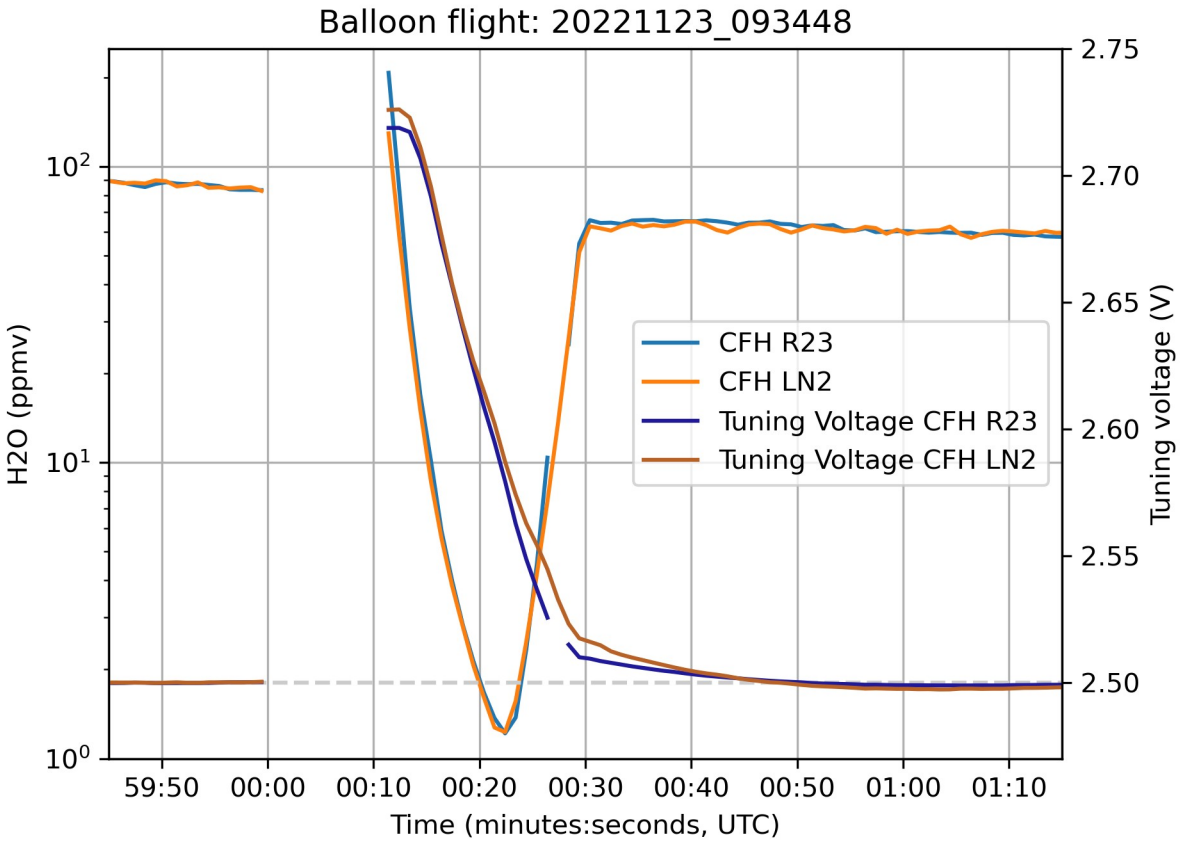




- No obvious bias of CFH (LN2) in comparison to CFH (R23)
- Slight more noise above 20 km

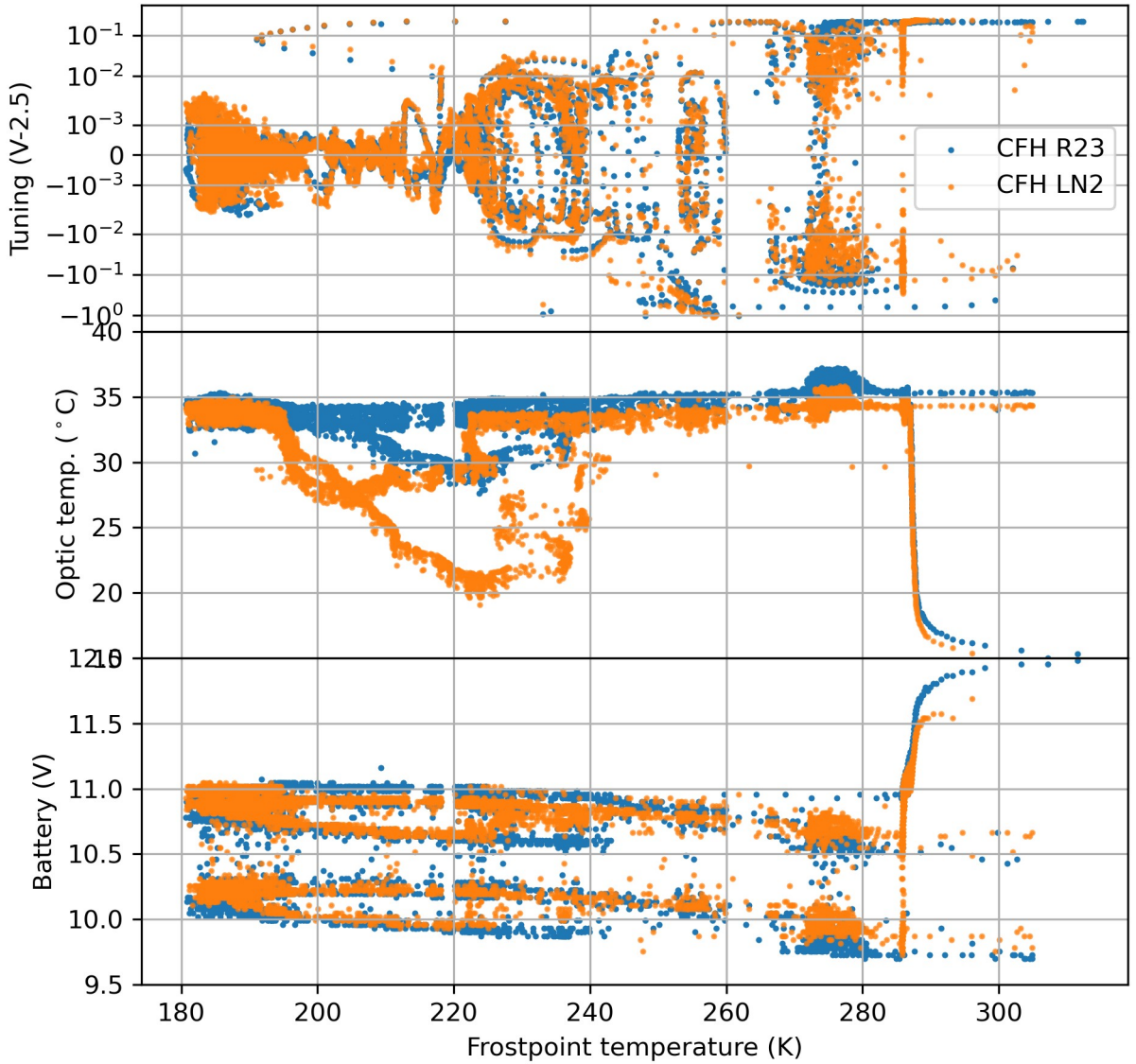
HEAT PULSE @-35°C DURING TEST FLIGHT

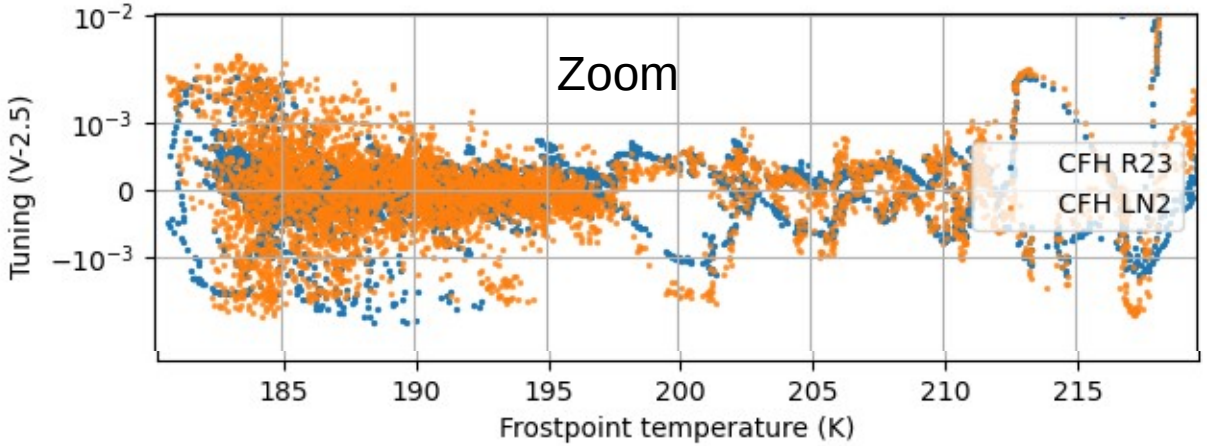




LN2 cooling is similar as for R23, same time resolution of LN2 CFH expected

CFH PERFORMANCE DURING TEST FLIGHT





- Detector signal / Tuning voltage for both CFH similar
- Optic temperature for LN2 partly ~10°C lower
- Battery performance similar (no critical issue can be detected)

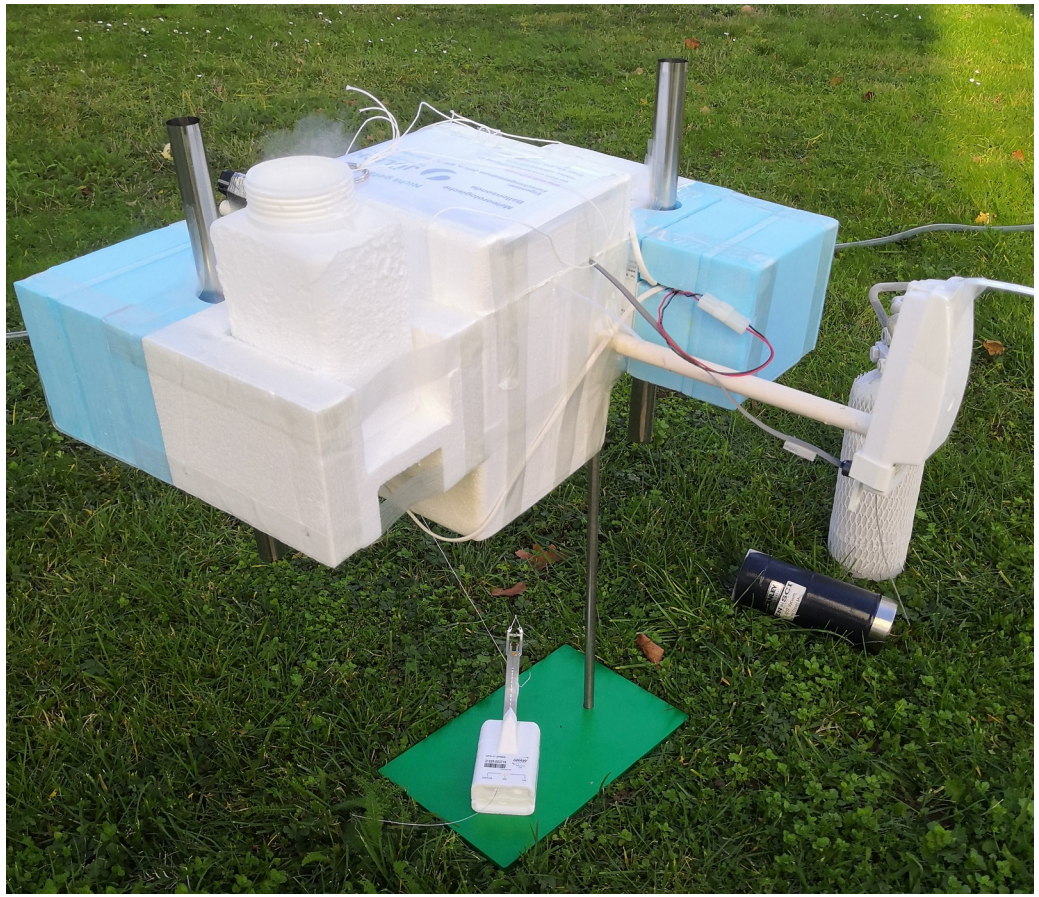
CONCLUSION AND OUTLOOK

Construction of an CFH LN2 Prototype

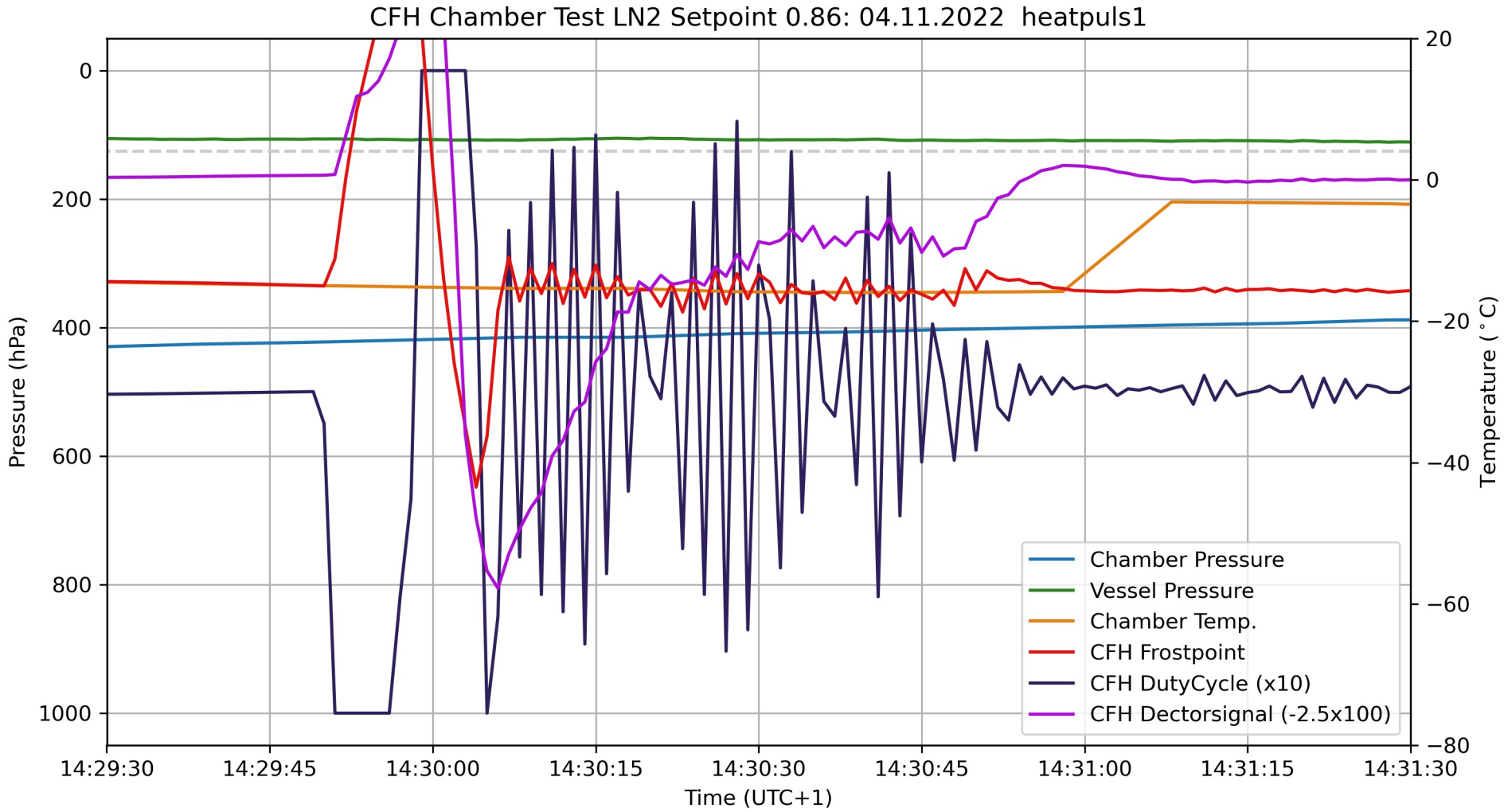
- Vessel pressure prevent LN2 to get solid
- Successful demonstrated performance during chamber tests and ballon flight

Further flights/chamber tests

- Determination of high altitude noise (> 20~km)
- Test flight in Lindenberg



PROTOTYPE V2: FLIGHT SIMULATION 01.09.22
HEAT PULSE 1 @ -15°C



PROTOTYPE V2: FLIGHT SIMULATION 31.08.22