

Experimental investigation of 1,300 liter zero-boil-off (ZBO) liquid hydrogen storage tank

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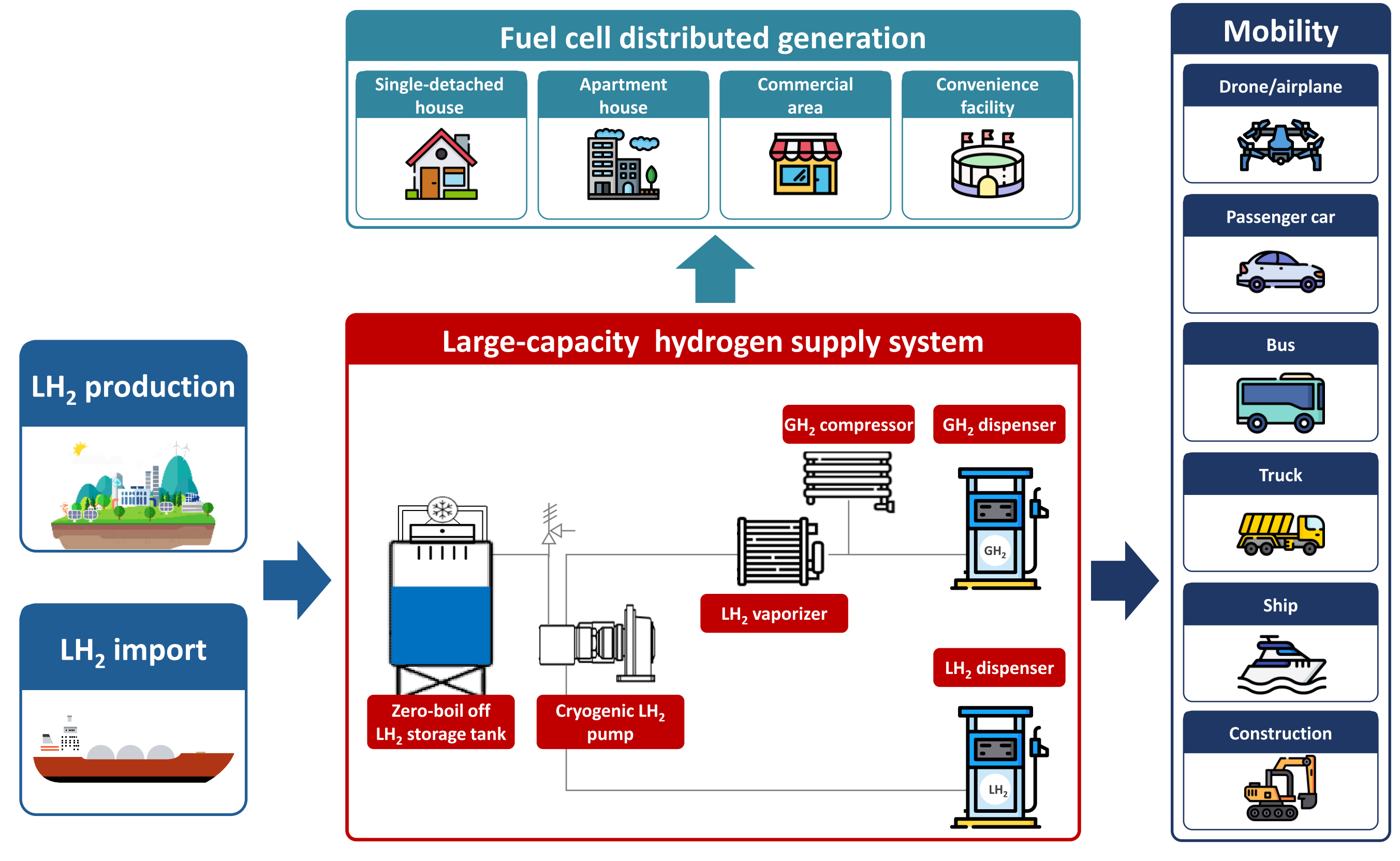
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I Introduction

Background & Motivation

- Development of core equipment for large-scale hydrogen supply system
 - ZBO LH₂ storage tank ▶ LH₂ pump ▶ LH₂ vaporizer ▶ gas utilization
 - ZBO LH₂ storage tank ▶ LH₂ pump ▶ liquid utilization



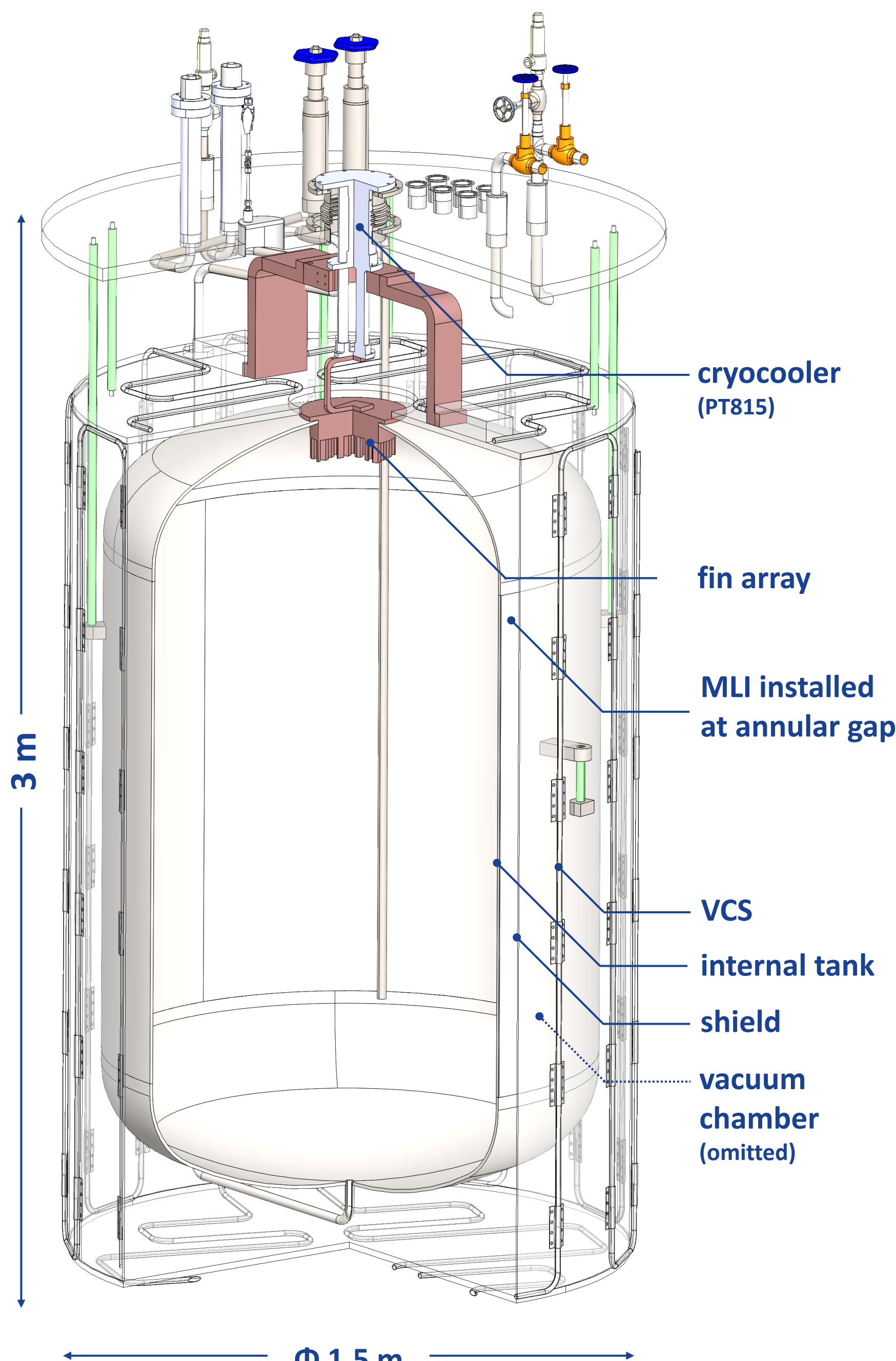
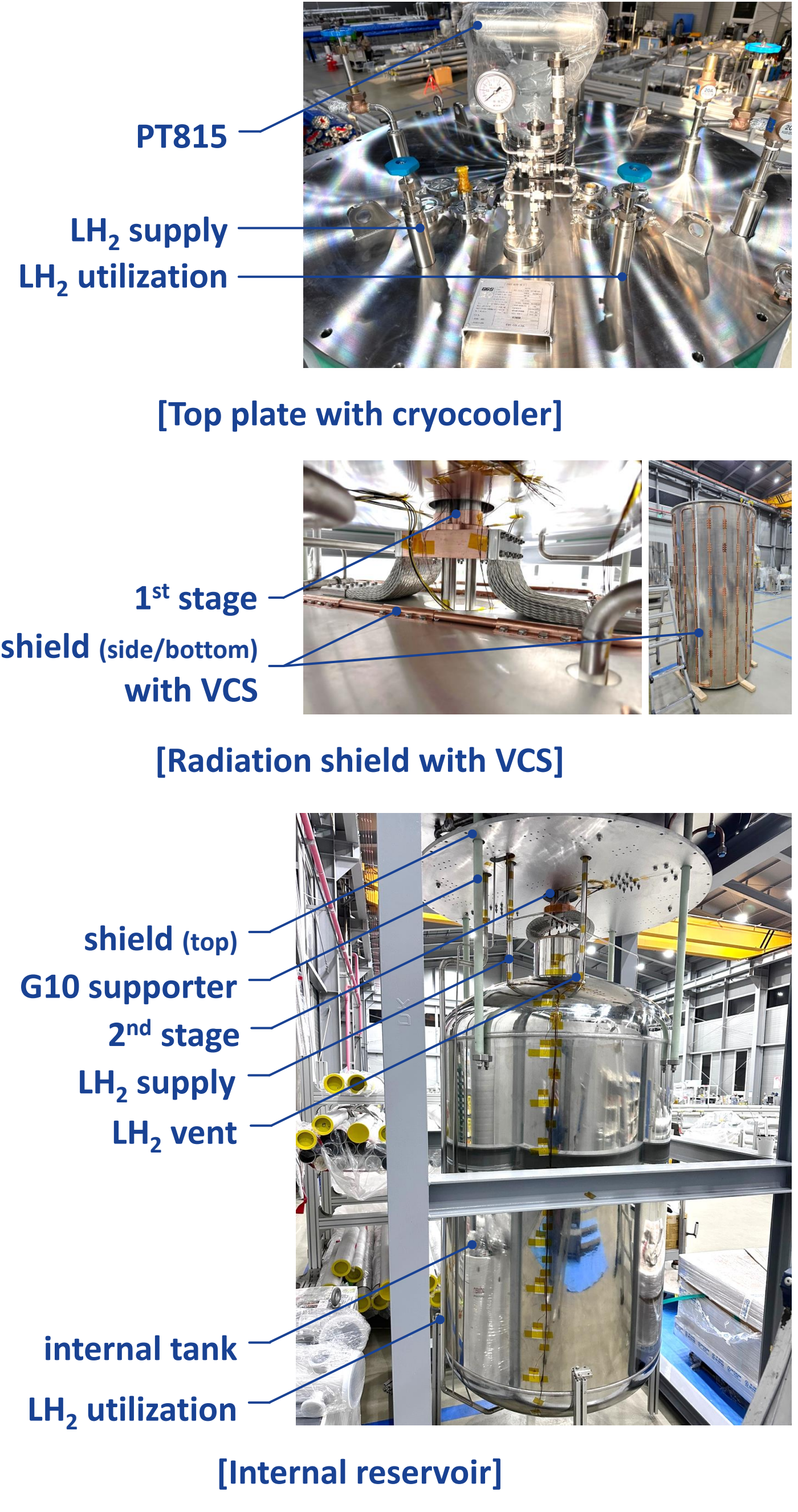
Development of a 1,300-liter ZBO LH₂ storage tank

- Direct cooling method by GM-type pulse tube refrigerator

II Construction



[Constructed ZBO LH₂ storage tank]

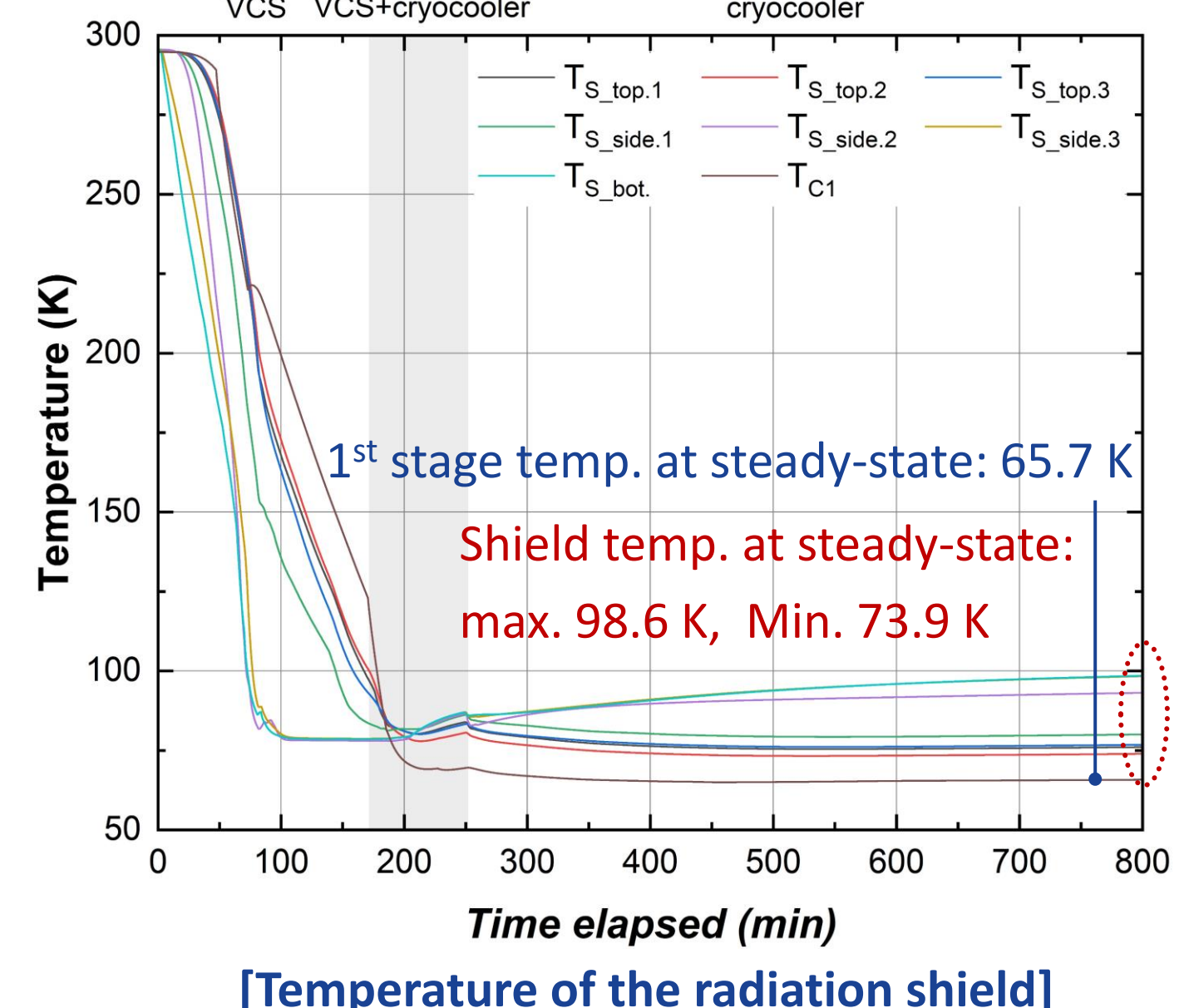


[3D drawing of ZBO LH₂ storage tank]

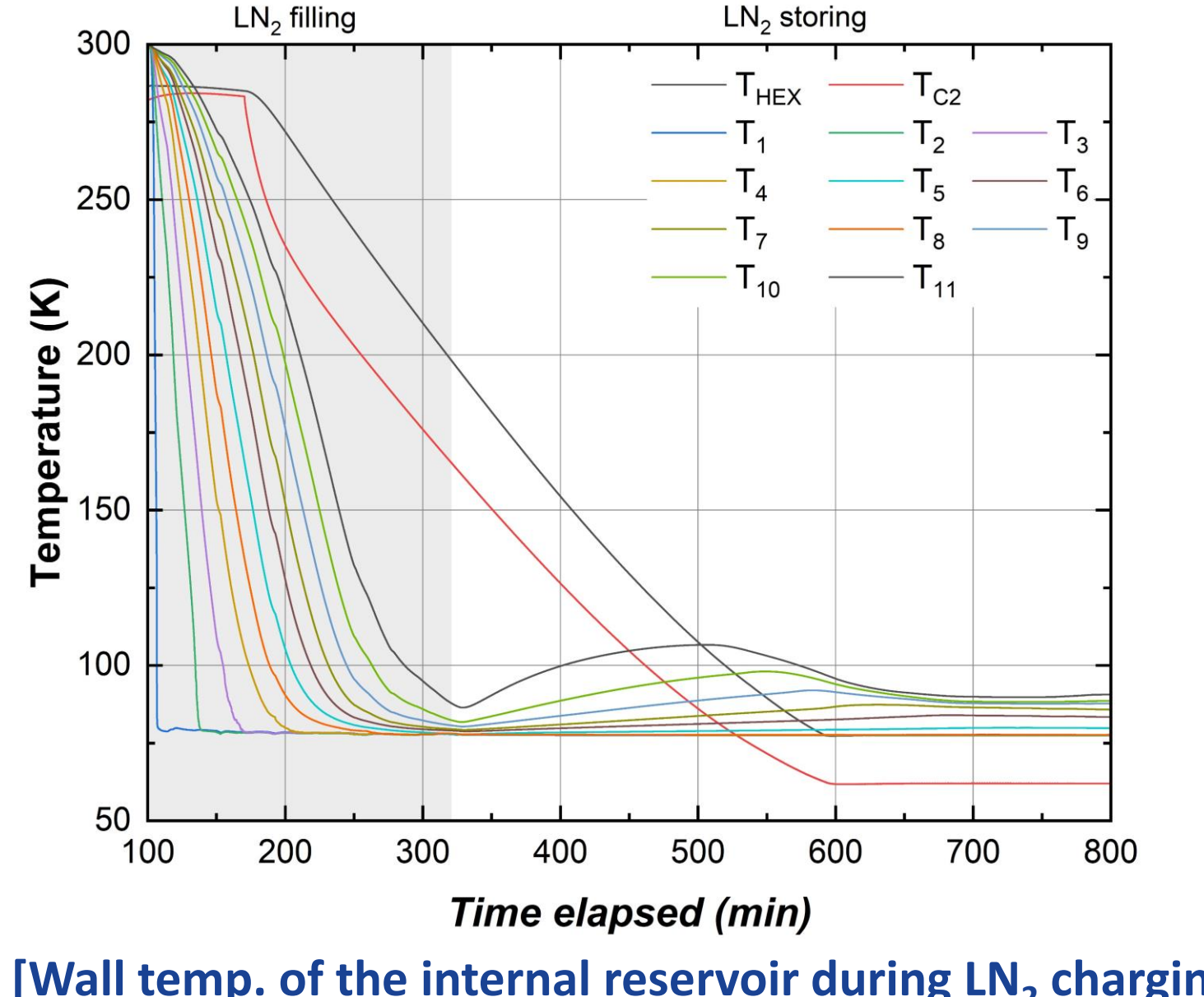
III Experiments

Cooling procedure

- Radiation shield cooling
 - VCS only for initial cooling
 - VCS and cryocooler to shield's temperature (T_s) below 100 K
 - cryocooler only when the temperature of cryocooler's 1st stage (T_{C1}) below 130 K
- LN₂ supply to internal reservoir
 - 38% filling level



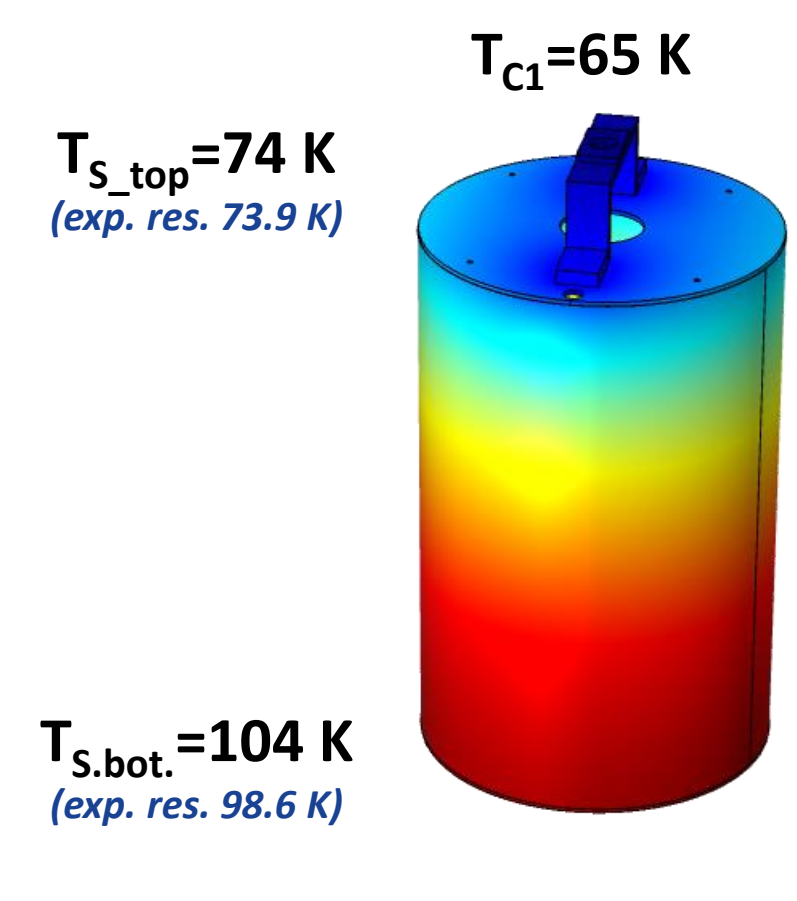
[Temperature of the radiation shield]



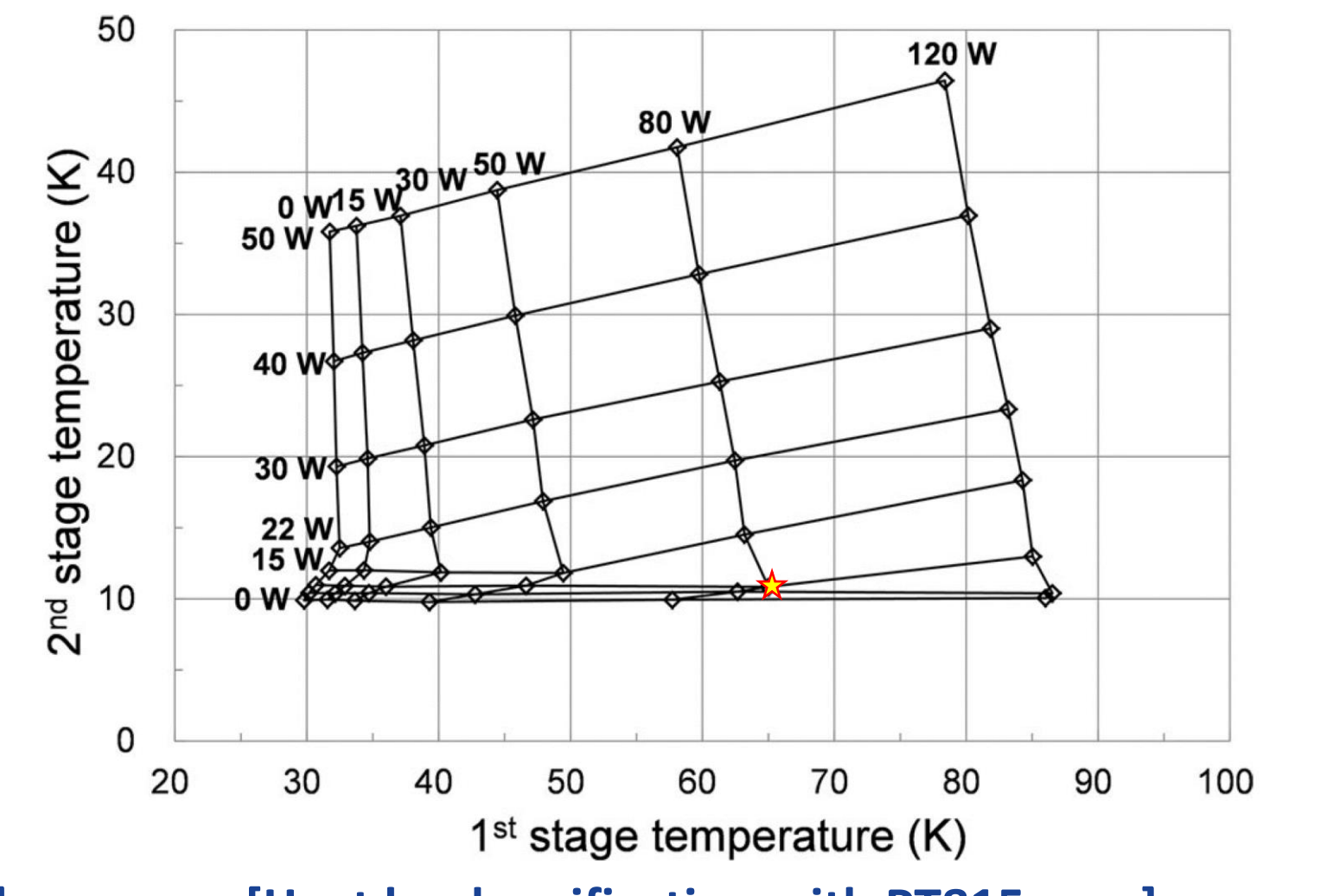
[Wall temp. of the internal reservoir during LN₂ charging]

Heat load analysis

- 40.7 W-heat load at the 1st stage ▶ 1st stage temp. of 65.7 K
- temperature gradient comparison: simulation vs. experiment
- heat load on the 1st stage of the cryocooler: 39.3 W (simulated result: 37.7 W)



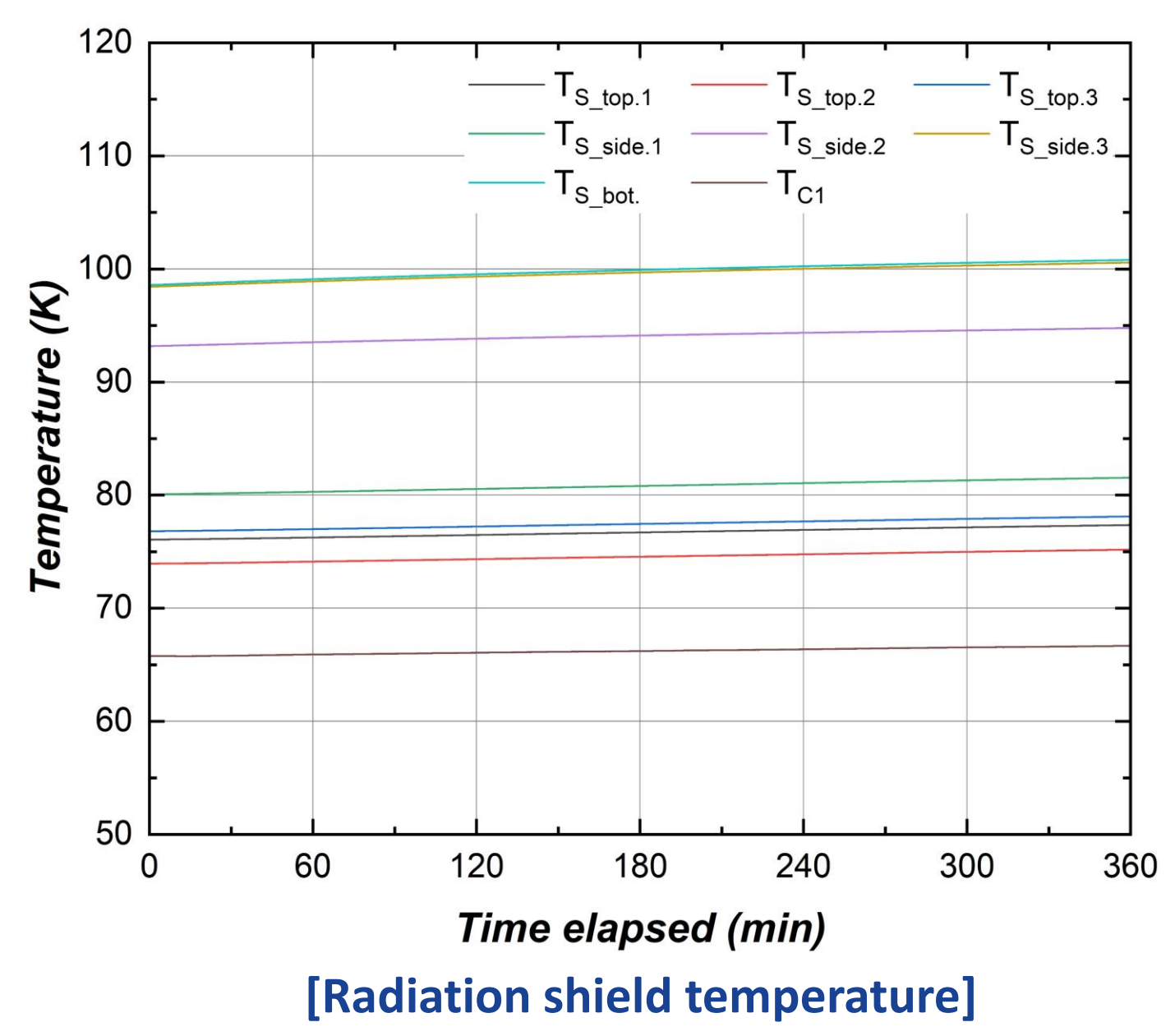
[Radiation shield temp. gradient verification]



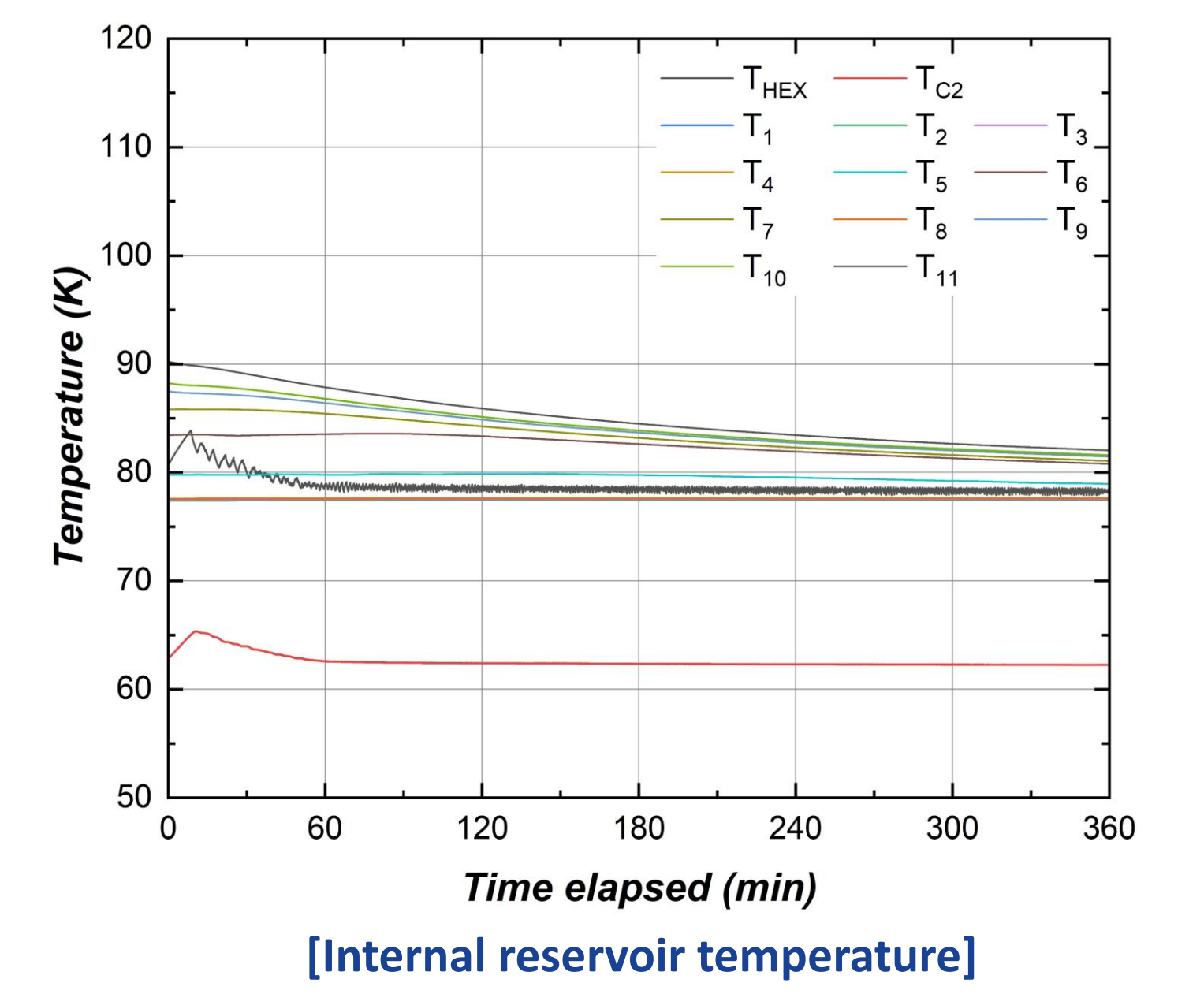
[Heat load verification with PT815 map]

ZBO storage test

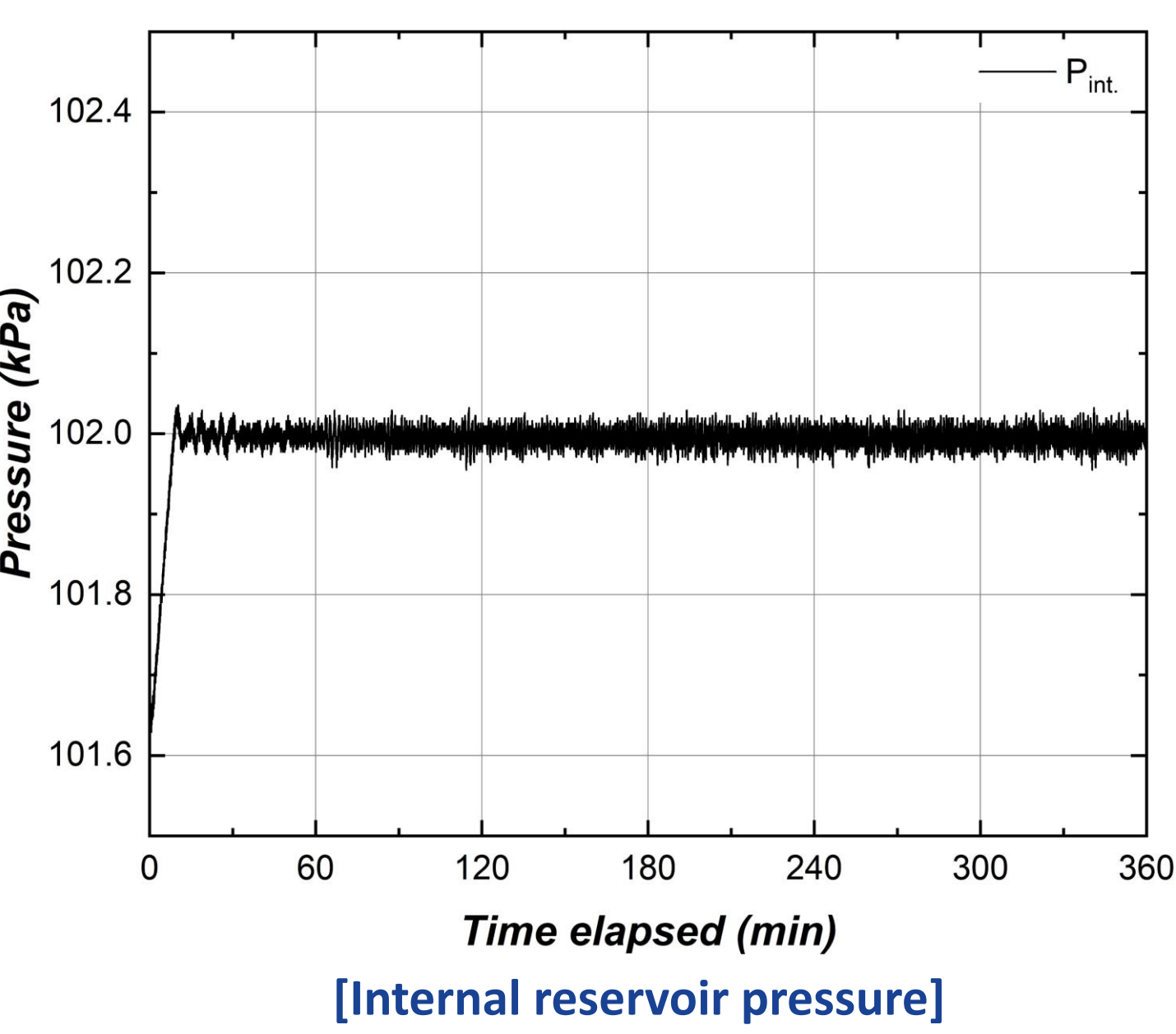
- all the valves closed when the temperatures are stabilized
- 2nd stage heater controlling with the constant internal pressure of 2 kPa(g)
- It is confirmed that the temperature, pressure and level are maintained stably!



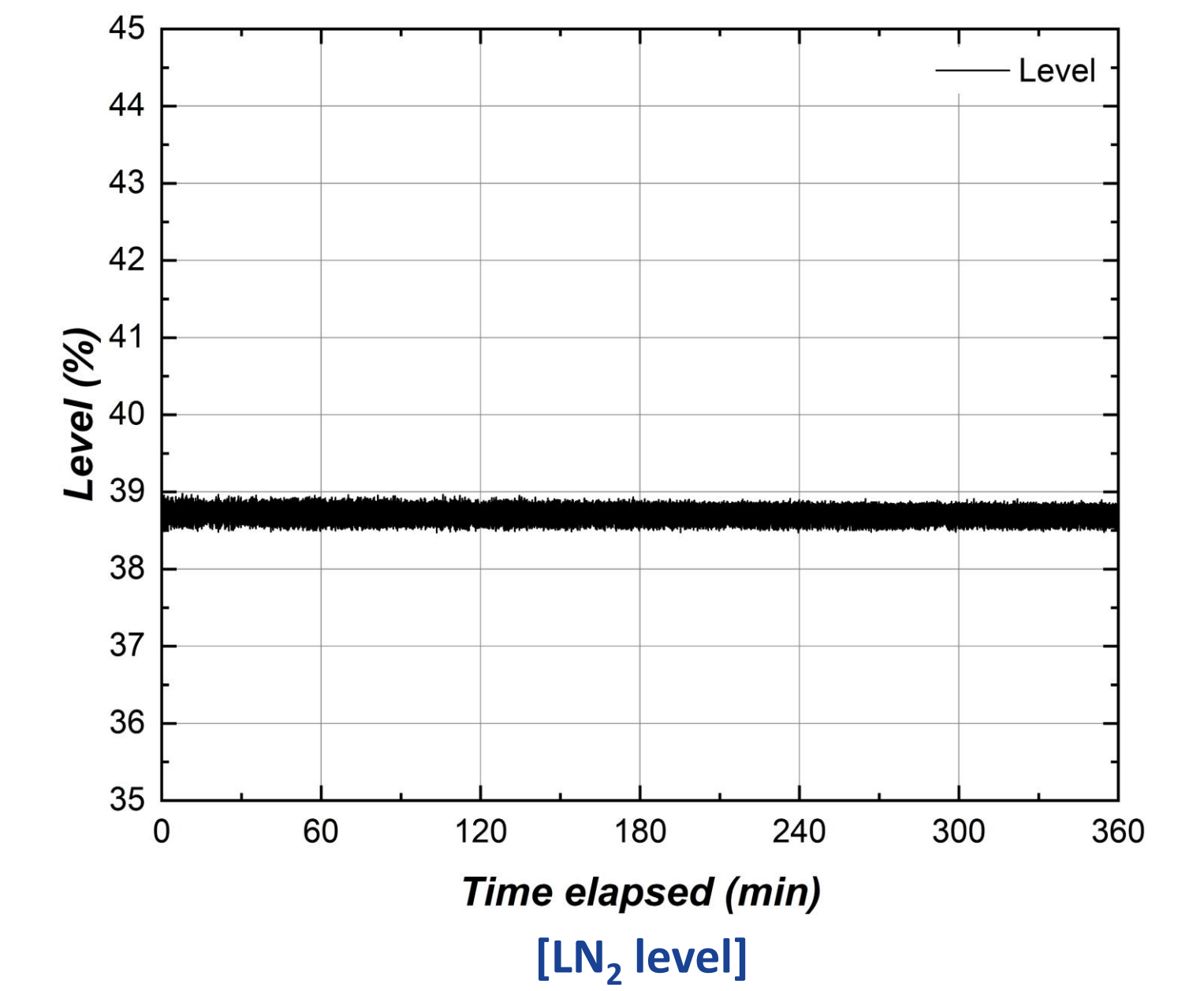
[Radiation shield temperature]



[Internal reservoir temperature]



[Internal reservoir pressure]



[LN₂ level]

IV Conclusion

- A 1,300-liter zero-boil off (ZBO) liquid hydrogen (LH₂) storage tank has been constructed and experimentally tested with liquid nitrogen (LN₂).
- A 7,000-liter ZBO LH₂ storage tank will also be developed and tested with the actual large-capacity hydrogen supply system starting from upcoming year. The 7,000-liter tank will be designed by adopting indirect cooling method.

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