

A cold ejector-supported krypton system for future highly irradiated detectors



Luca Contiero^{1,2}, Armin Hafner¹, Bart Verlaat², Paolo Petagna²

¹Norwegian University of Science and Technology, Trondheim

²CERN, Experimental Physics – Detector technology, Meryin, Switzerland

Introduction

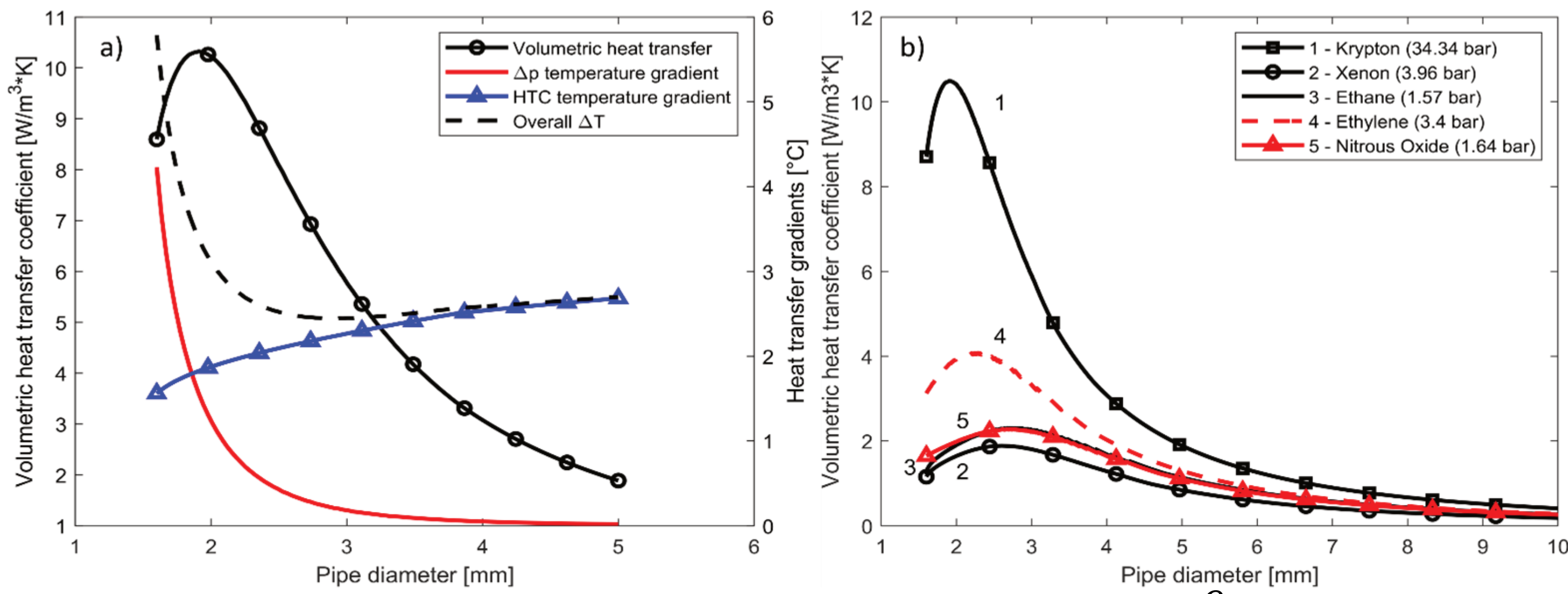
A future upgrade of the Large Hadron Collider (LHC) at CERN will expose silicon-based particle detectors to higher radiation levels requiring temperature levels below than what is currently attainable with the CO₂ cooling system (2PACL). Krypton appears to be a promising fluid for thermal management of detectors and according to its thermos physical properties a new cooling cycle has been developed.

Krypton as cooling agent

The first task is to identify a new cooling fluid that fulfills the requirements of silicon detector trackers:

- **Mass minimization** (small cooling lines)
- **Low TFM** (high heat transfer coefficients, low temperature drops)

Indicator of thermal performance is the critical T - p

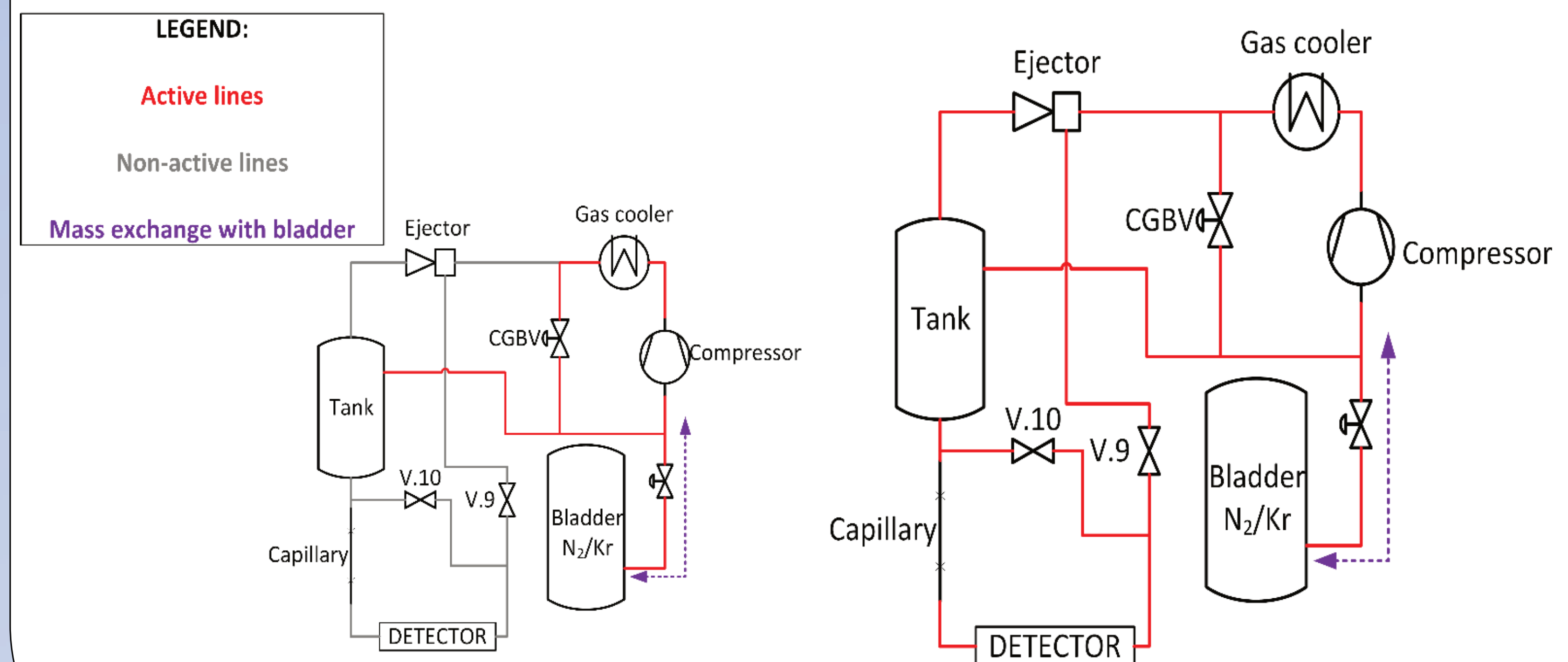


$$\text{Volumetric heat transfer coefficient (VHTC)} = \frac{Q}{\text{Volume} * (\Delta T(\text{HTC}) + \Delta T(\text{DP}))}$$

Numerical model as virtual test bench

Modelica software used for testing control strategies

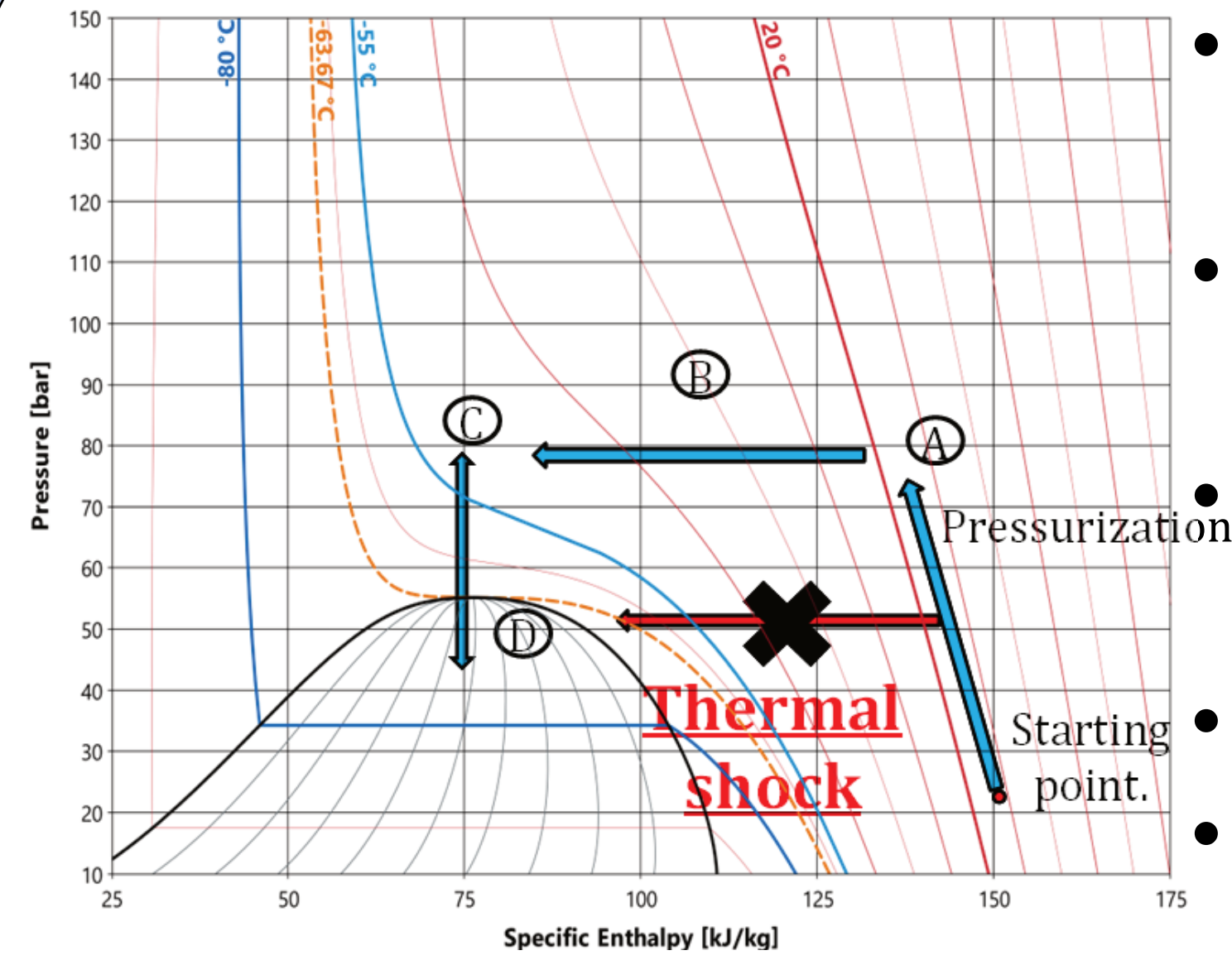
System startup



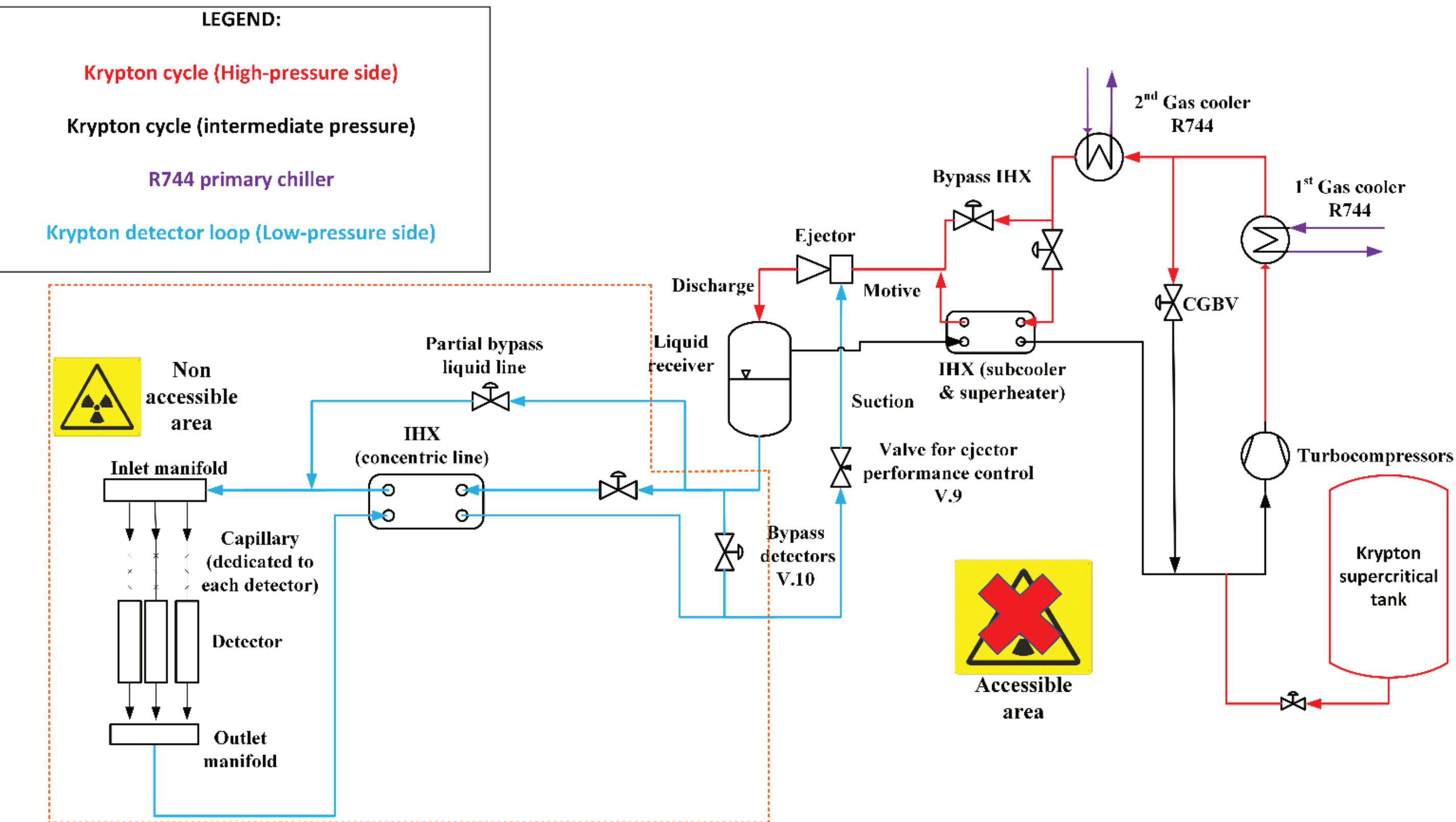
System cooldown is governed by primary chiller

New cooling technology

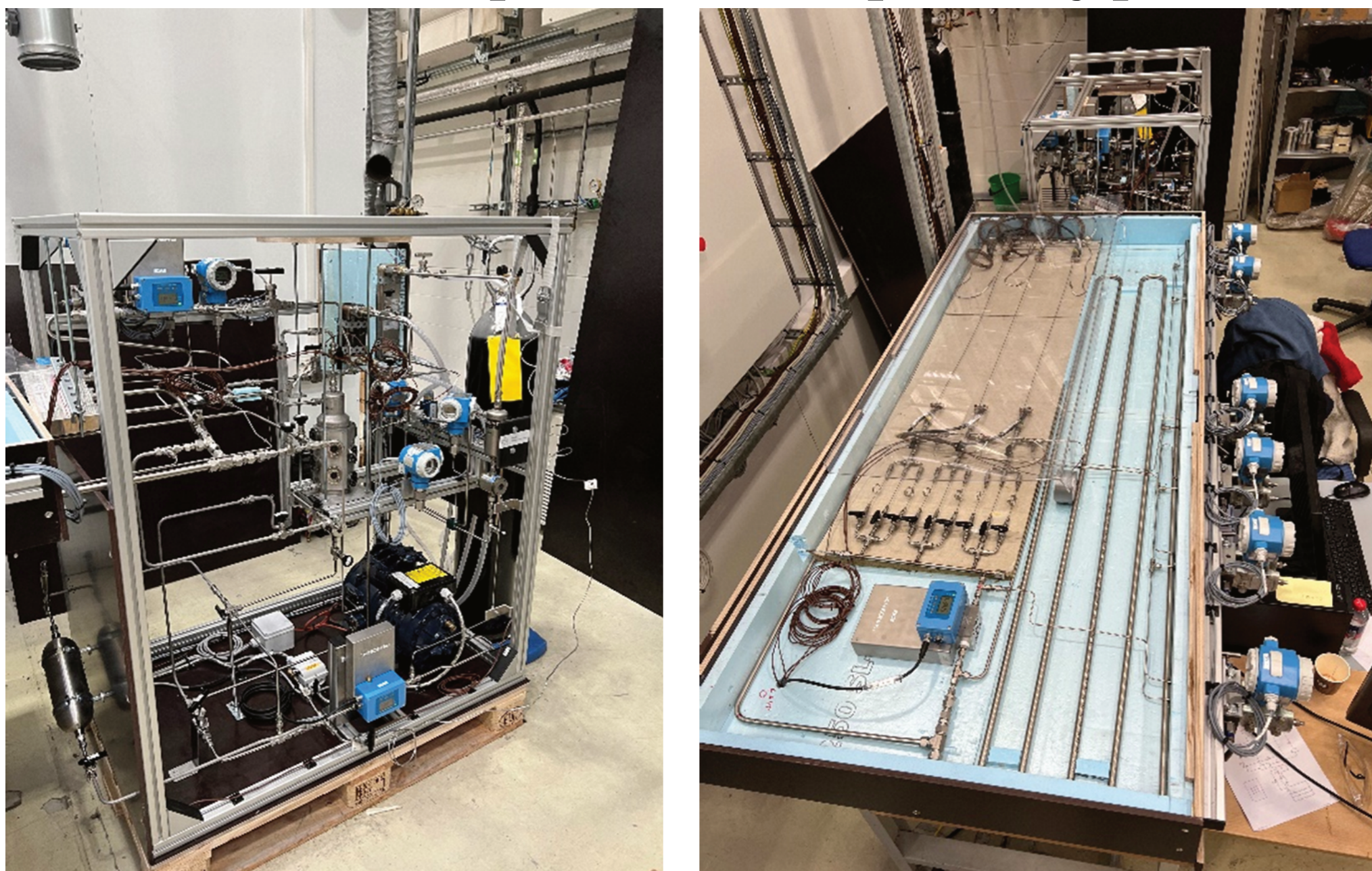
(T_{crit} ≈ -64°C, p_{crit} ≈ 55 bar)



- Starting conditions in gas phase
- Oil free vapor compression cycle
- Ejector for flow circulation through the detectors
- Passive detector loop
- Coupled with a CO₂ chiller



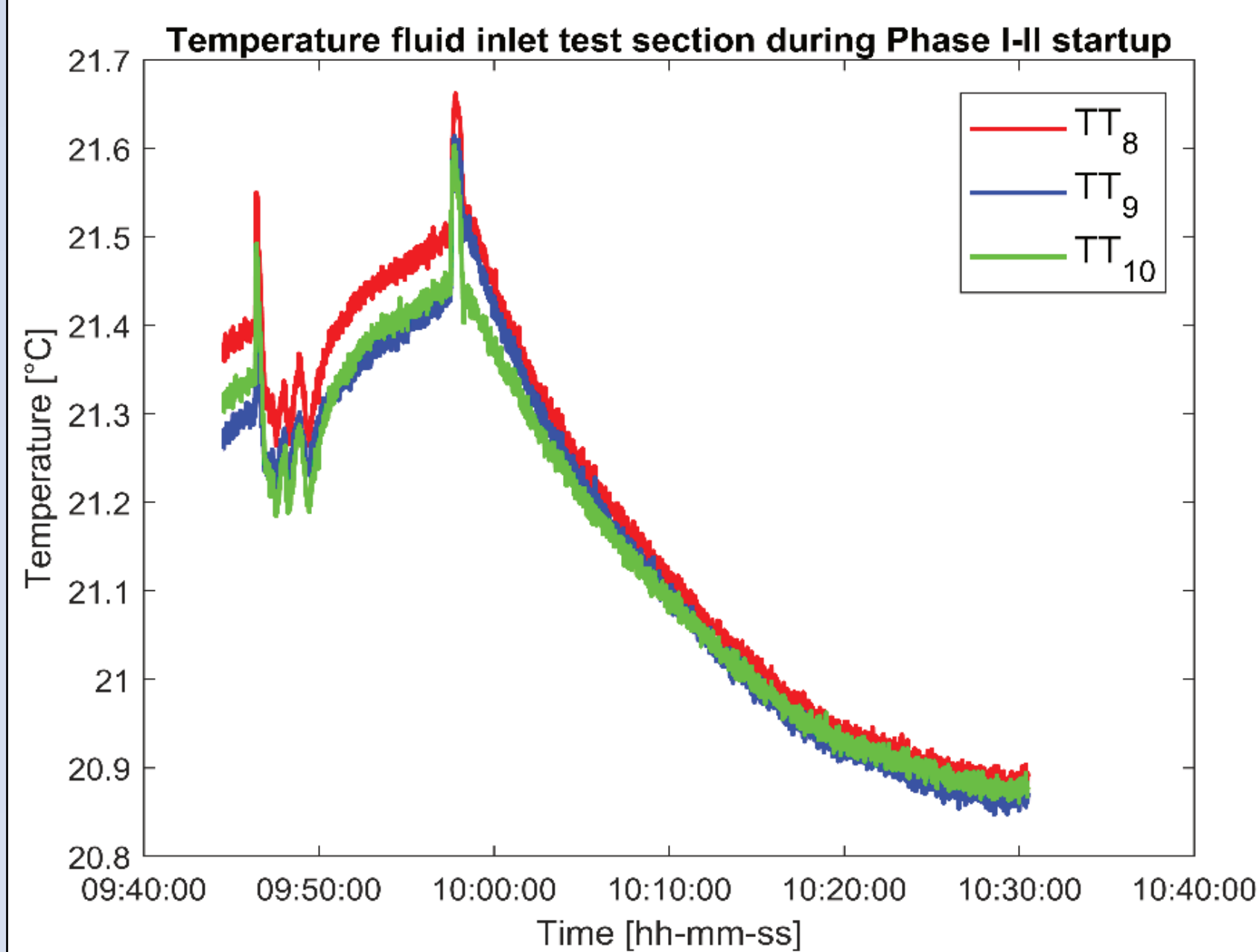
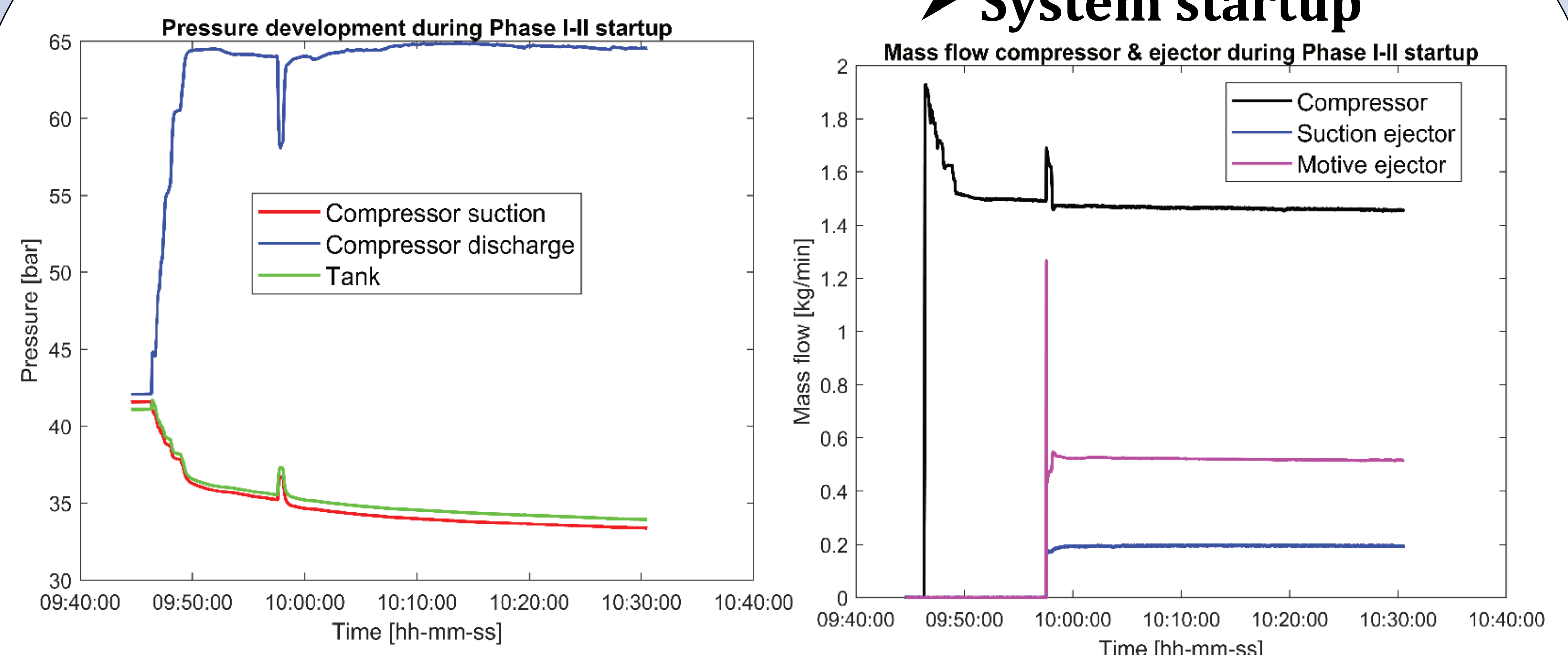
Experimental prototype



CO₂ components are used

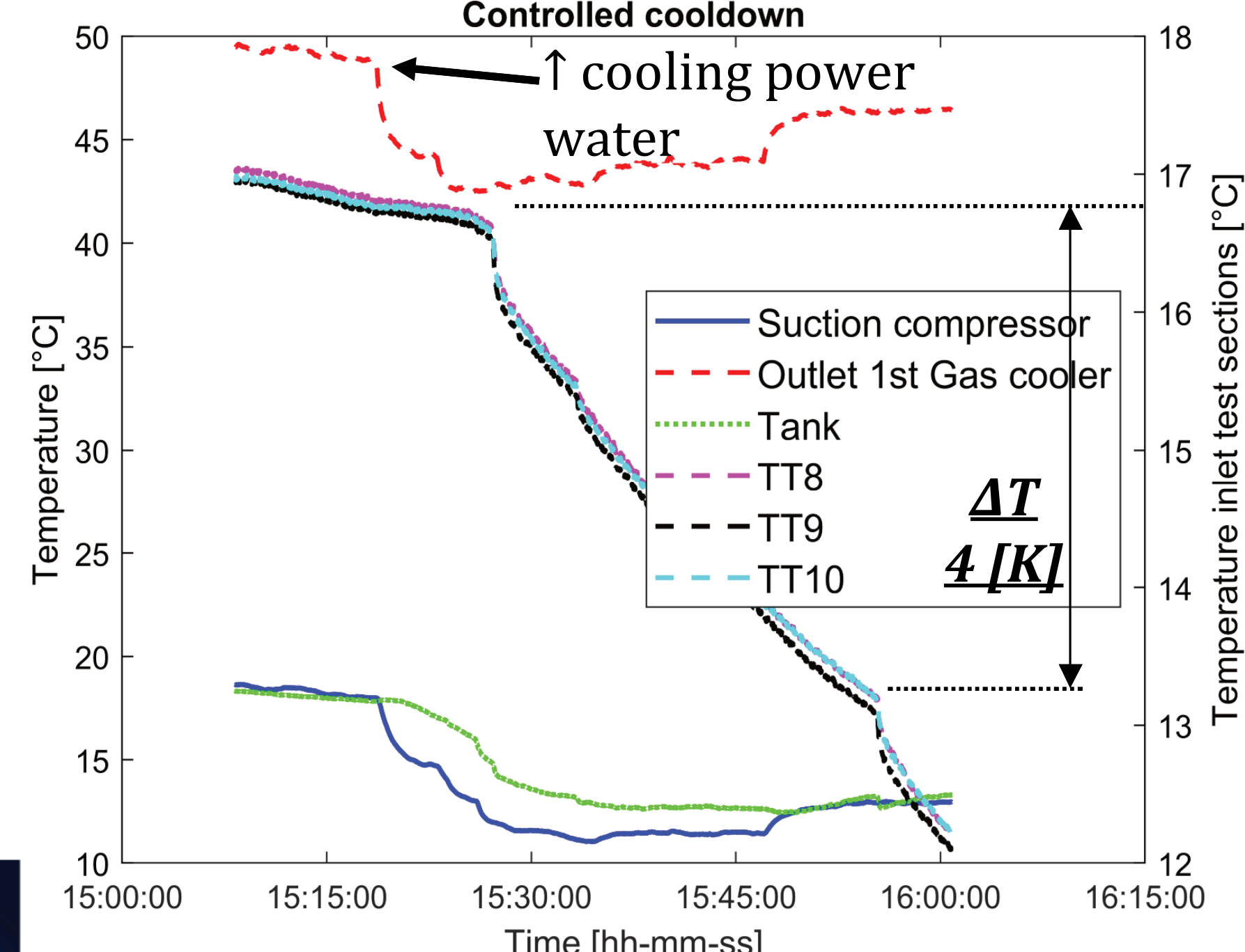
Preliminary experimental test with CO₂

System startup



- No thermal shocks when compressor start
- Detector is pressurized with tiny flow
- Capability of boosting cooling capacity via ejector

System cooldown



- Cooling speed under control (4 K in ≈ 30 mins)
- Cooldown rate faster by reducing bypassed flow or increasing ejector capacity

