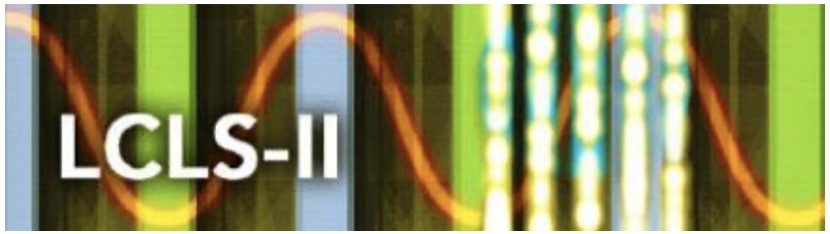


LCLS-II

LCLS-II Linear Accelerator Cool-Down And Pump-Down

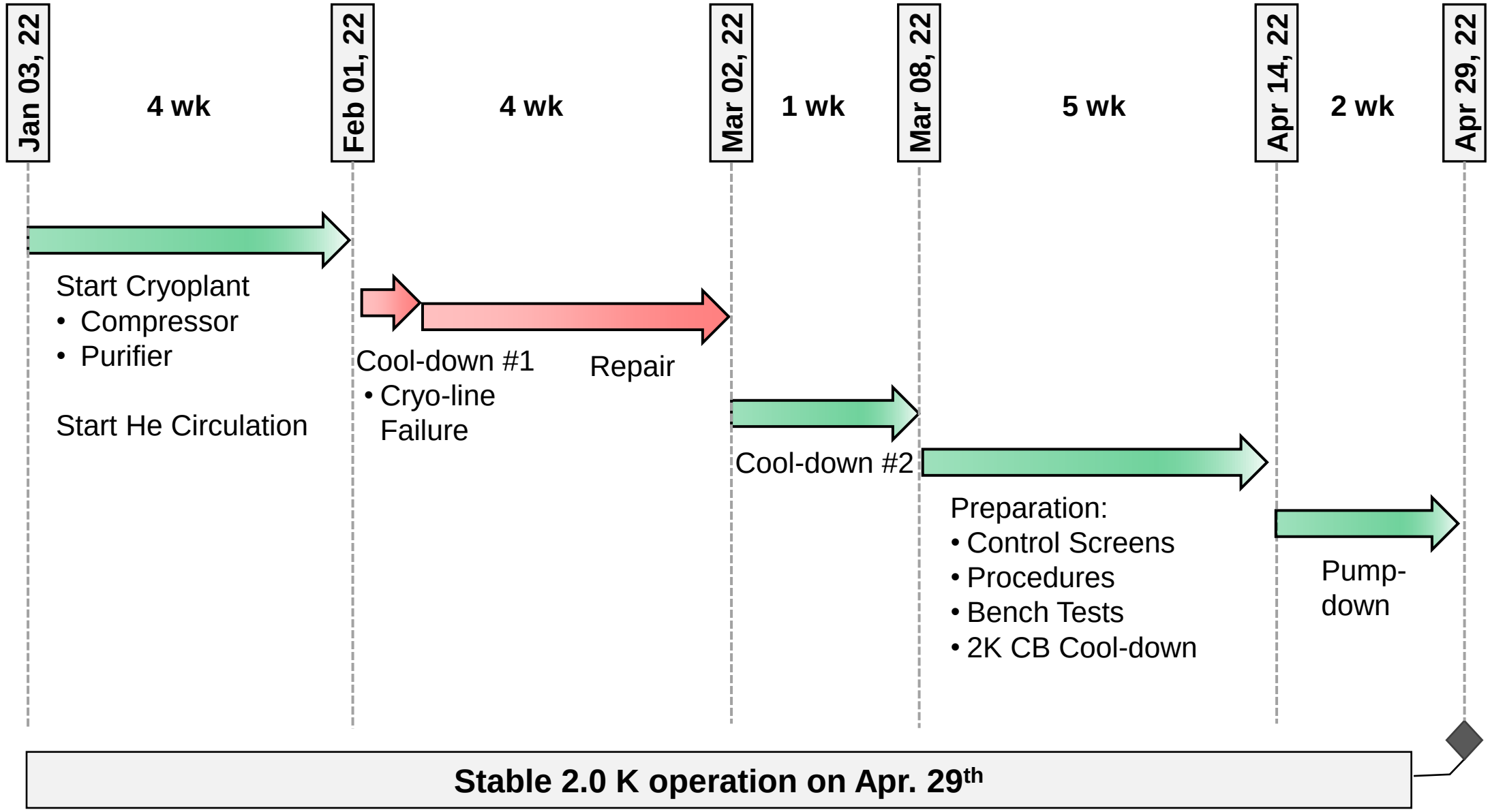
Viswanath Ravindranath
LCLS-II Process Group Leader

CEC-ICMC23

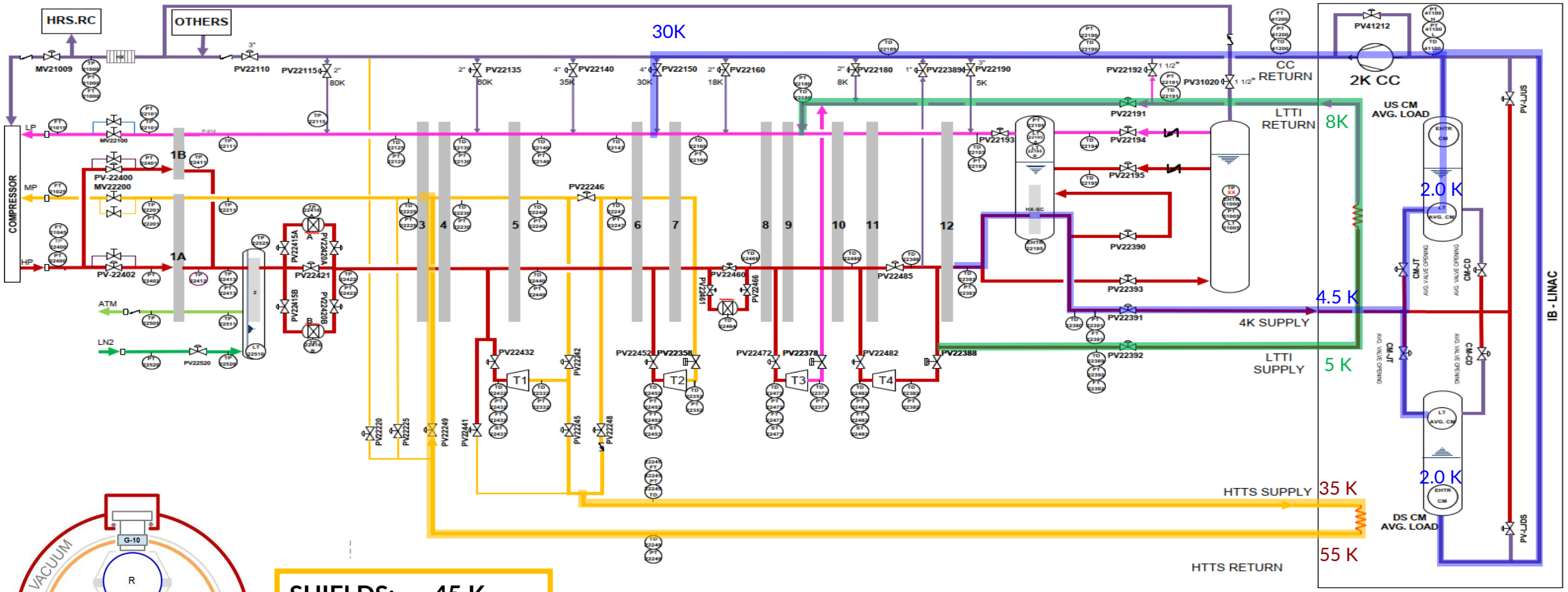
Outline

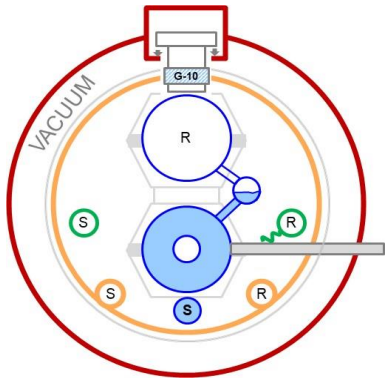
- Overview
  - Timeline: Cool-down and Pump-down
- Cool-Down (4.5 K)
  - Scope
  - Strategy
  - Results
  - Challenges
- Pump-Down (2.0 K)
  - Scope
  - Strategy
  - Results
- Summary

Timeline: Cool-Down and Pump-Down



Scope: 4K System





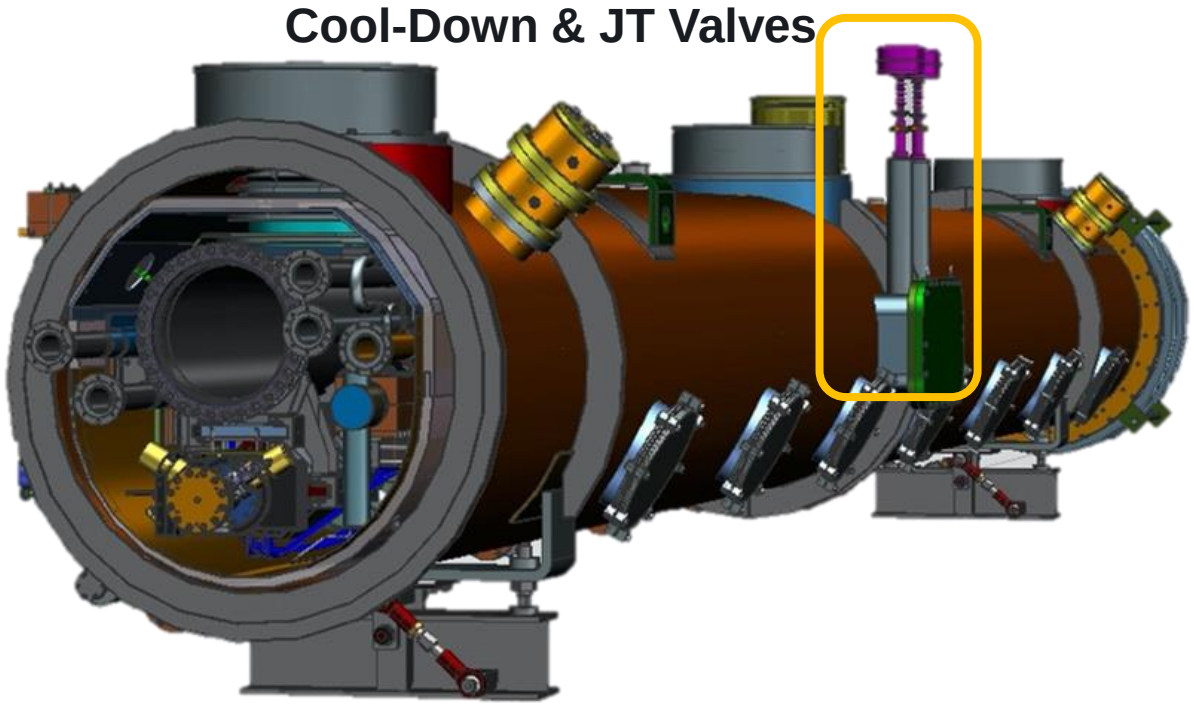
SHIELDS: 45 K

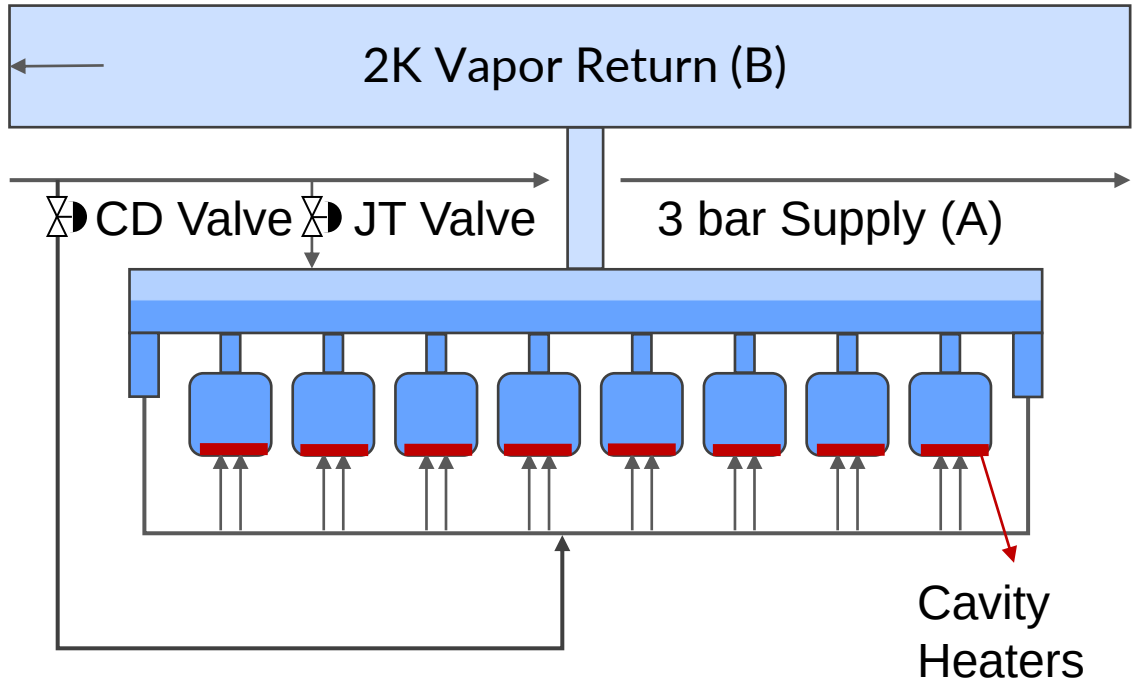
INTERCEPT: 5 K

CAVITIES: 2 K

- Simultaneous cool-down of Cryoplant and LINAC
- Adequate cryoplant cooling capacity:
  - Cavities flow: 100 g/s
  - Shield flow: 100 g/s
  - Intercept: 30 g/s
  - Cool-down time: 1 week

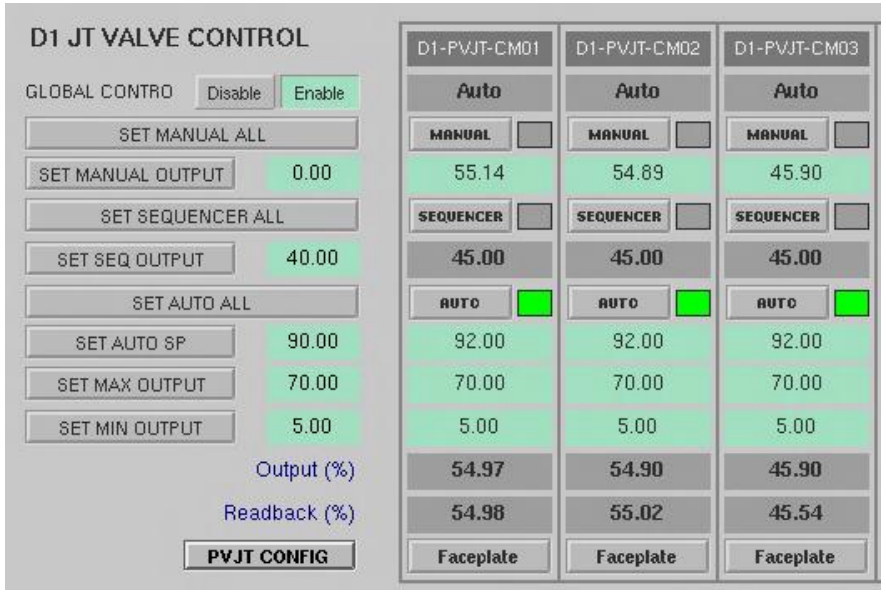
Scope: Cryomodules



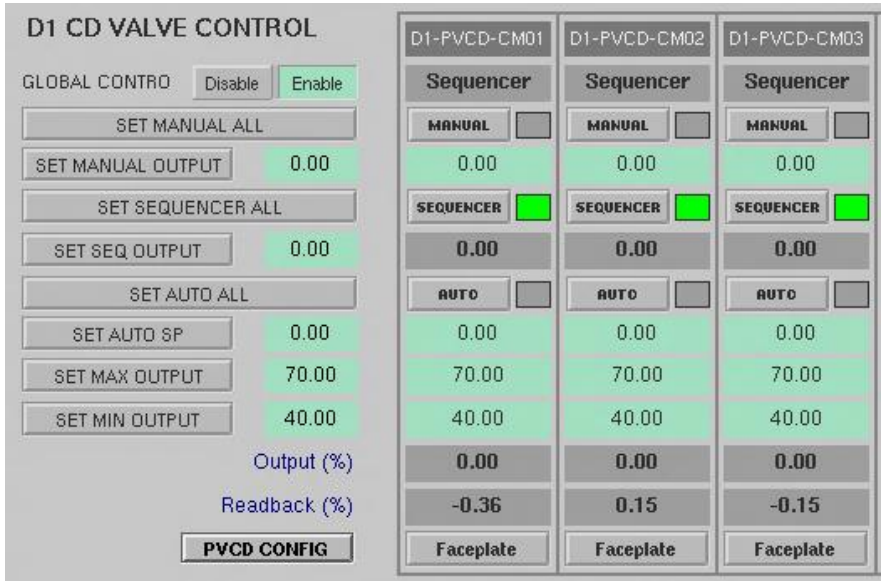


	Function	Quantity
CD Valves	▪ Supplies helium to the bottom of the cryomodule ▪ Used for cryomodule cool-down	37
JT Valves	▪ Supplies helium to the 2-phase pipe ▪ Used for maintaining cryomodule liquid level	37
Cavity Heaters	▪ Installed on cavity helium vessel ▪ Used for Pressure Regulation @ 2.0K	296

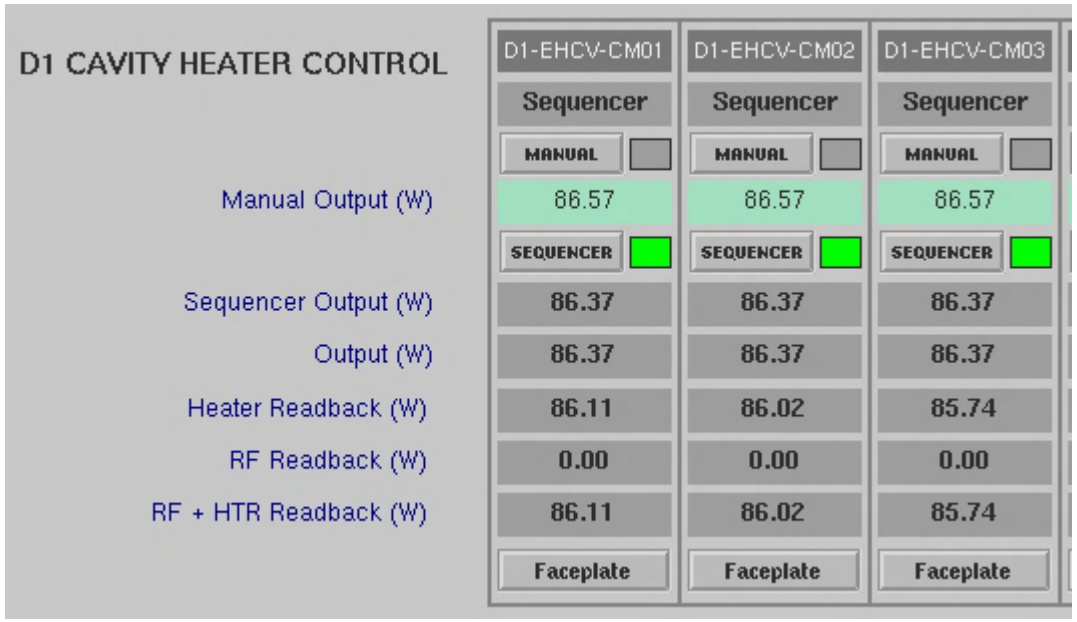
Cool-Down: Strategy – HMI Screens



x37 CM



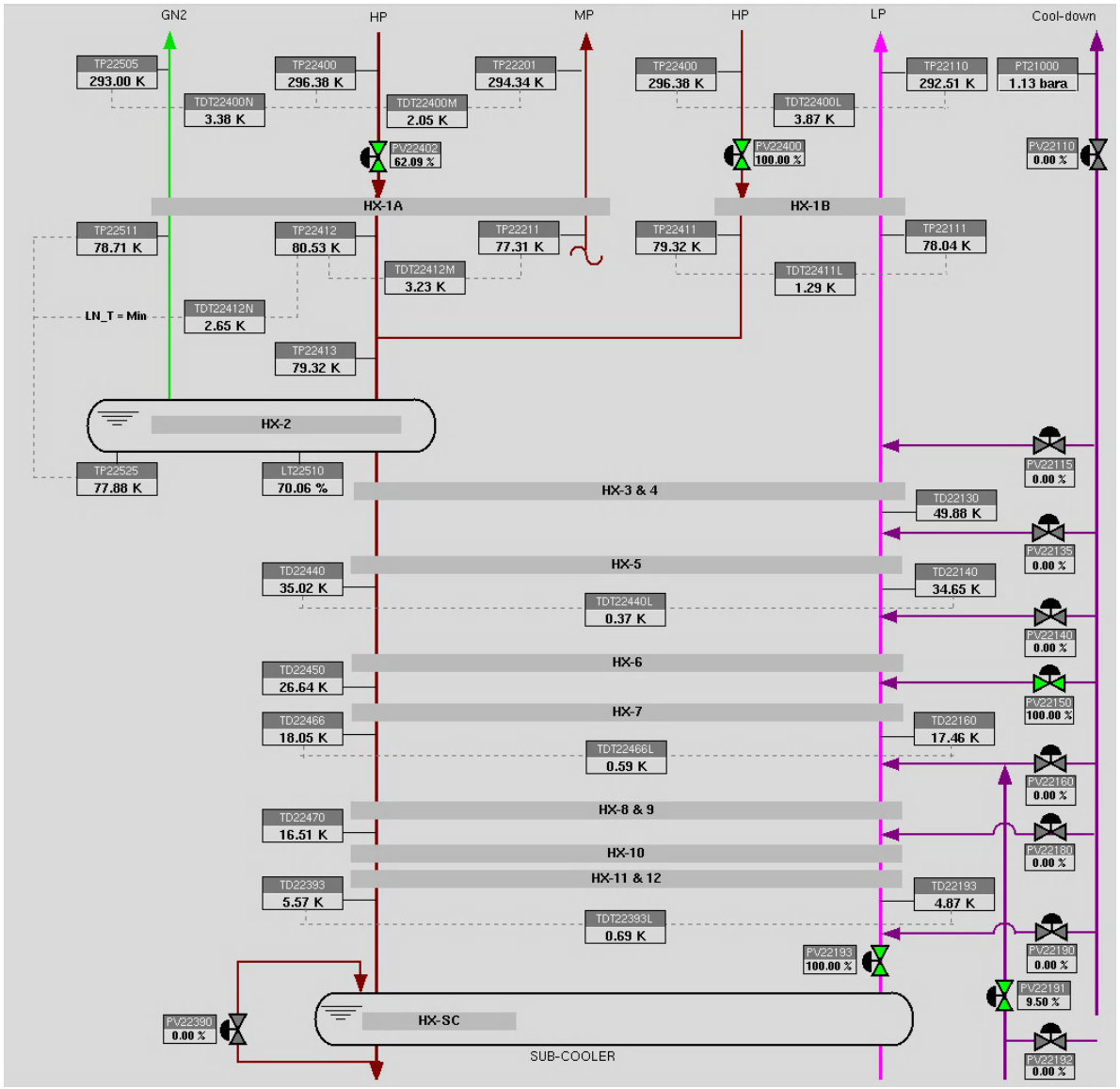
x37 CM



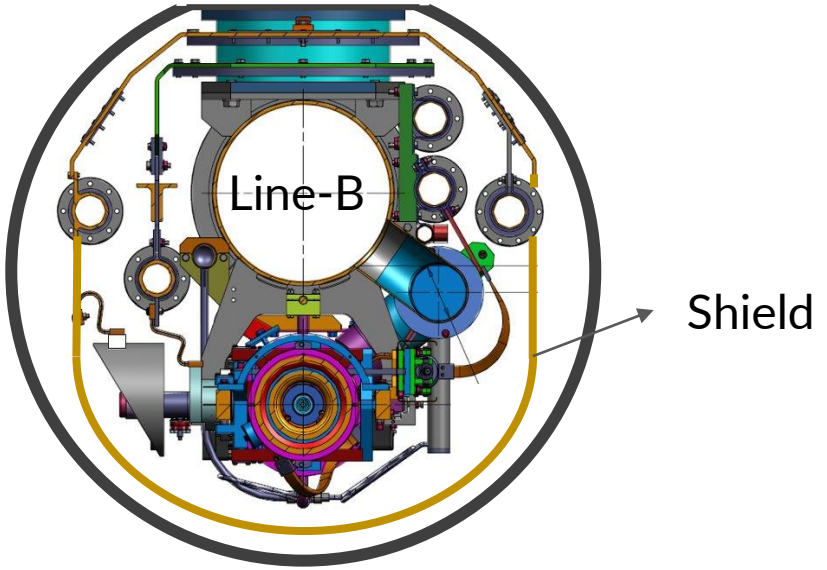
x37 CM

- HMI screen → allows simultaneous control and monitoring of cryomodule valves and heaters

Cool-Down: Strategy - HMI Screens

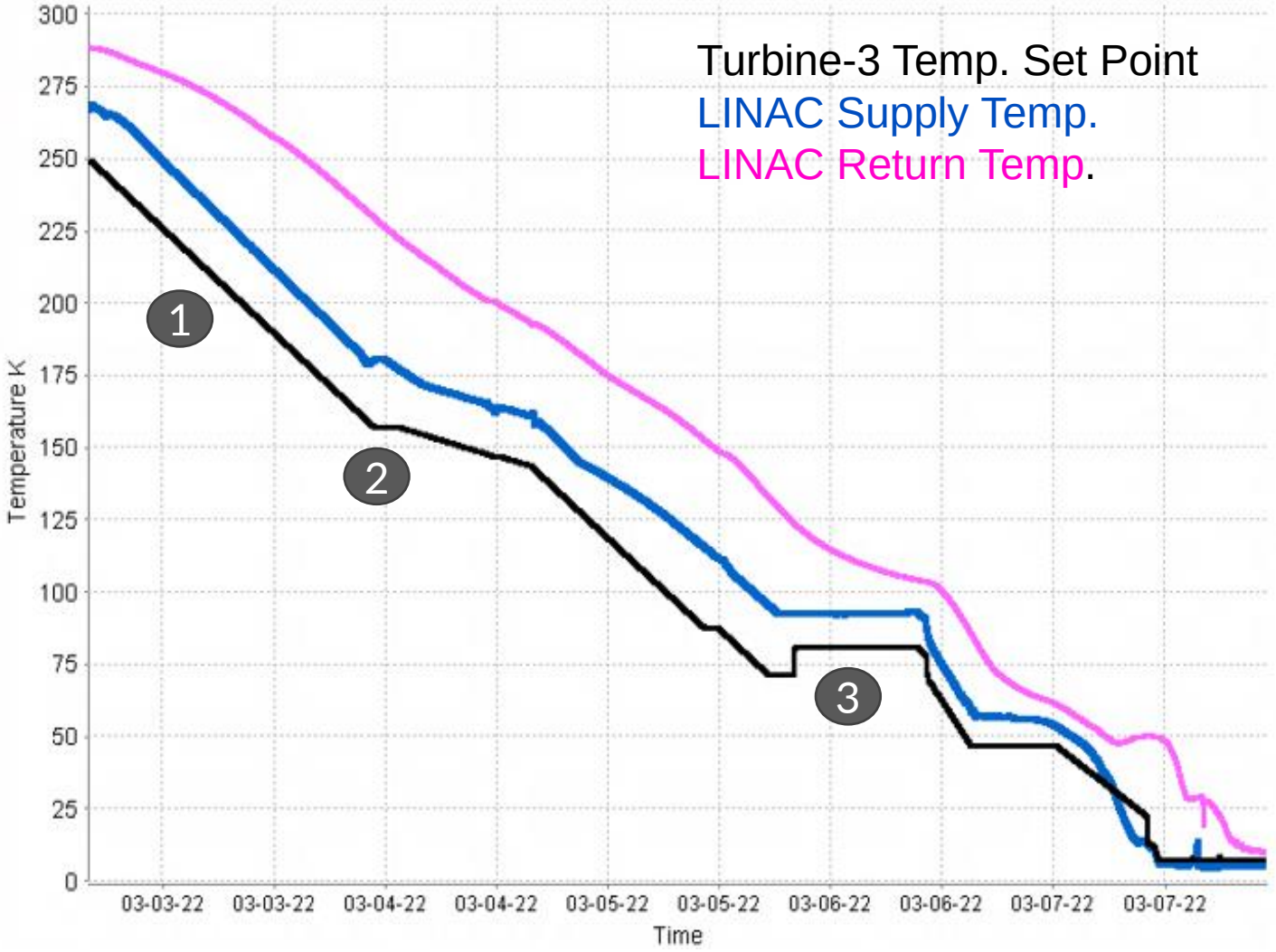


System	Parameters	Spec.
Cryomodule	Line-B Radial DT (within a cryomodule)	< 25 K
	Line-B Long. DT (adjacent cryomodules)	< 70 K
	Shield Long. DT (adjacent cryomodules)	< 70 K
Cryoplant	Brazed Aluminum Heat Exchanger DT	< 50 K



- HMI screens enable monitoring and rapid identification of high DT during LINAC cool-down.

Cool-Down: Strategy - Automation

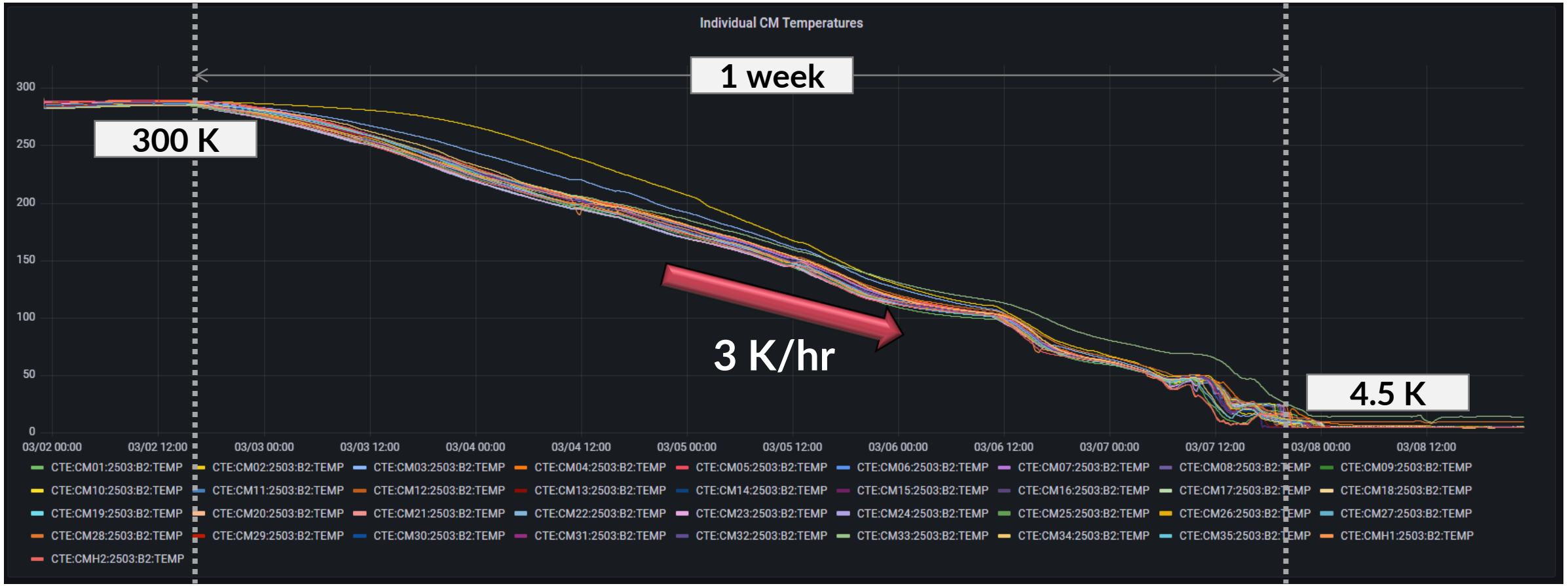


T1, T2 & T3 Cooldown Rate [3.00] k/hr

- Cool-down rate → User Specified
- Cool-down Sequence is automated:
  1. Turbine Temp. SP is ramped down
  2. Turbine Temp. SP is paused if any DT reaches threshold value.
  3. Turbine Ramp can be paused for overnight operation

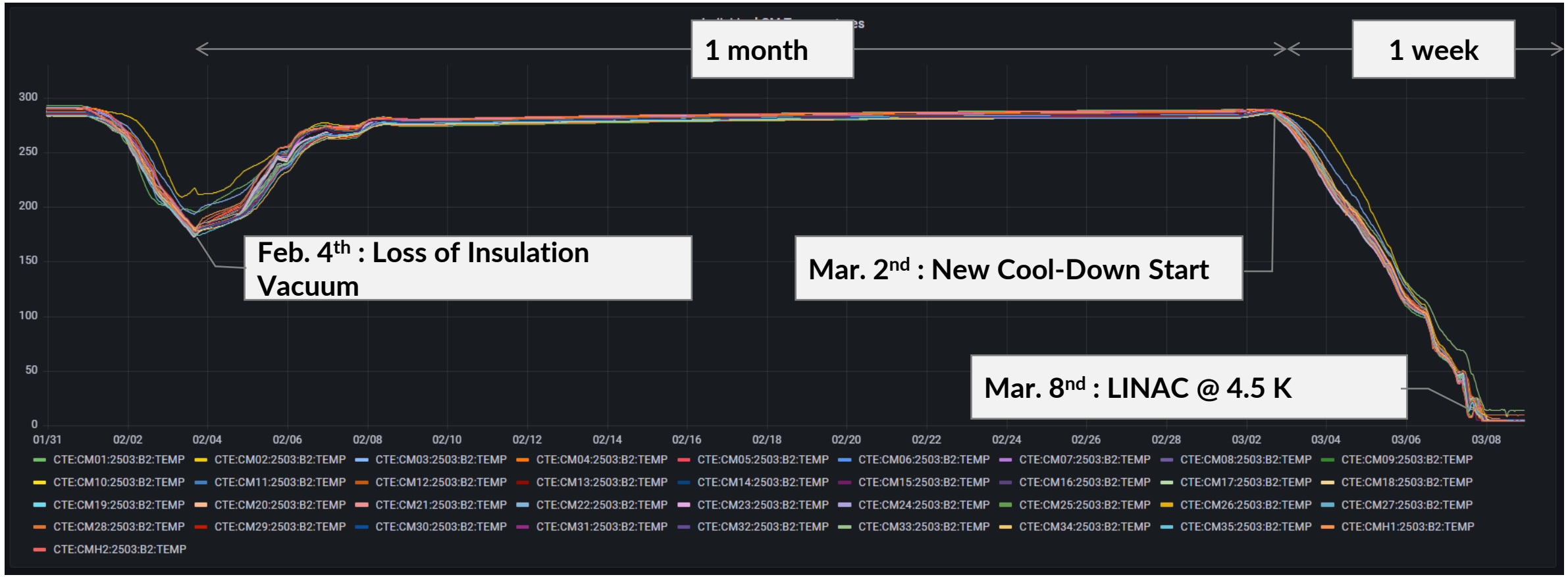
T1, T2 & T3 TIC Ramp: [On] [Off]

Cool-Down: Result



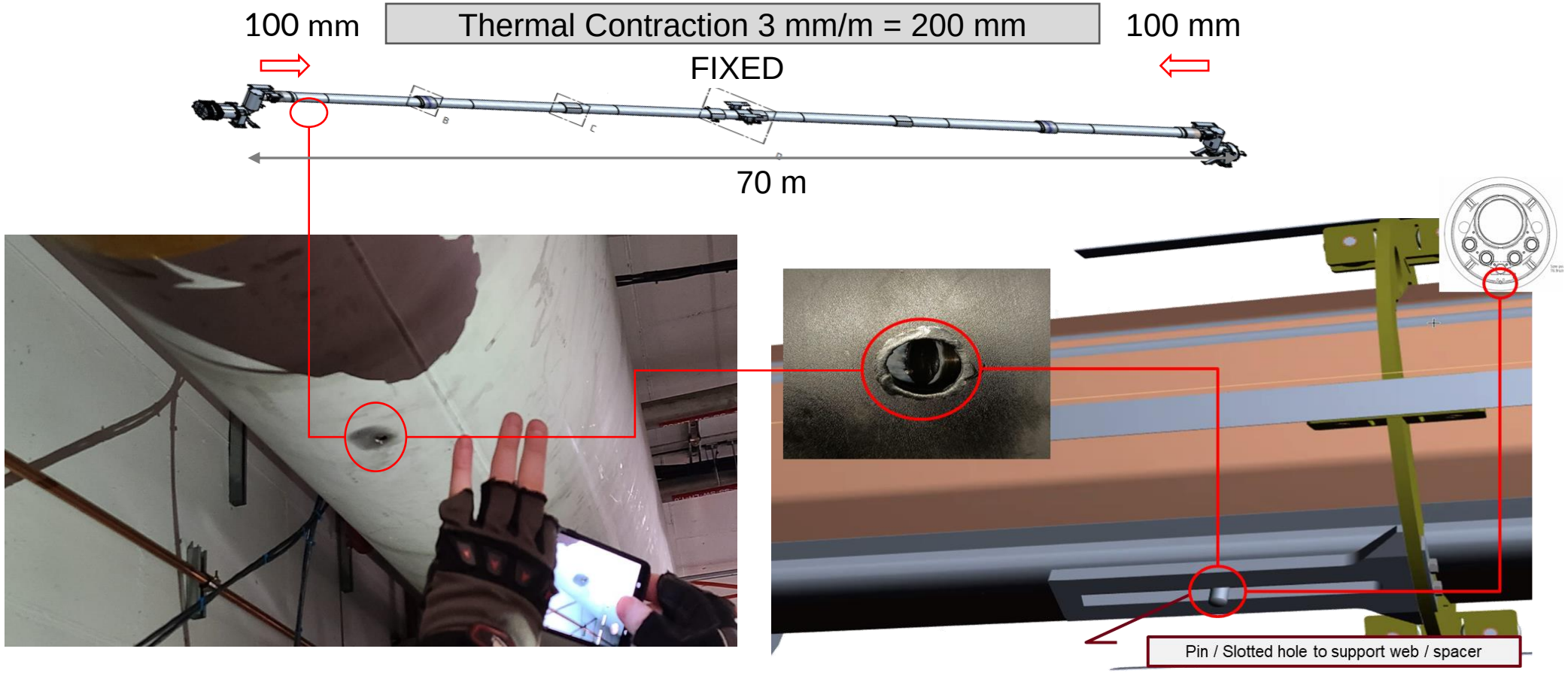
- Successful LINAC cool-down within one week (3K/hr)
- Automation of LINAC cool-down played a pivotal role:
  - Precise temperature control
  - Uniform LINAC and Cryoplant cool-down
  - Safe and efficient operation throughout the cool-down phase

Cool-Down: Challenges



- Loss of insulating vacuum in LINAC cryogenic transfer line during cool-down at ~150 K
- Intense investigation and repair effort: SLAC / Fermilab (FNAL) / DEMACO (vendor)
- Investigation, planning and repair in 1 month
- LINAC cool-down was restarted on Mar. 2nd 2022
- LINAC cool-down completed within a week.

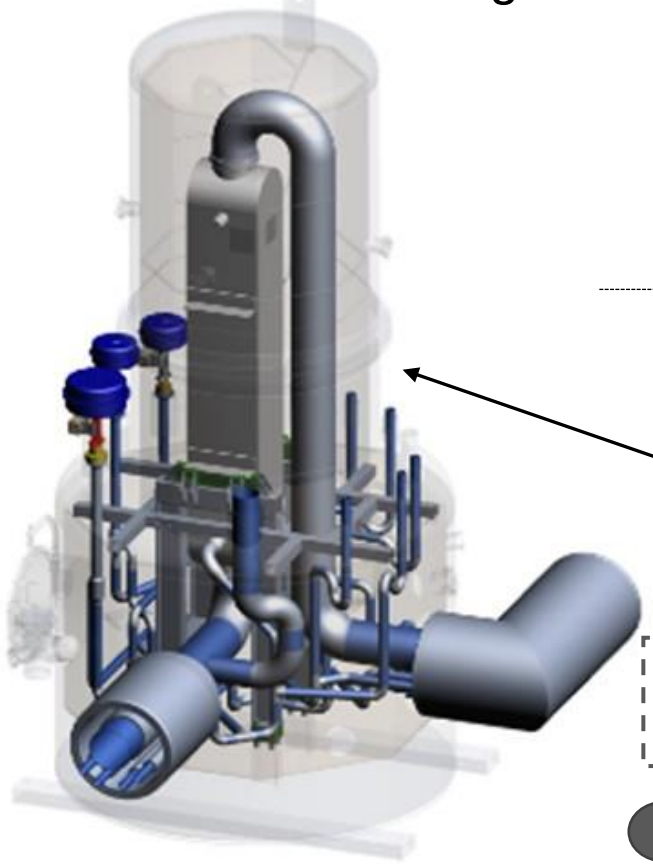
Cool-Down: Challenges

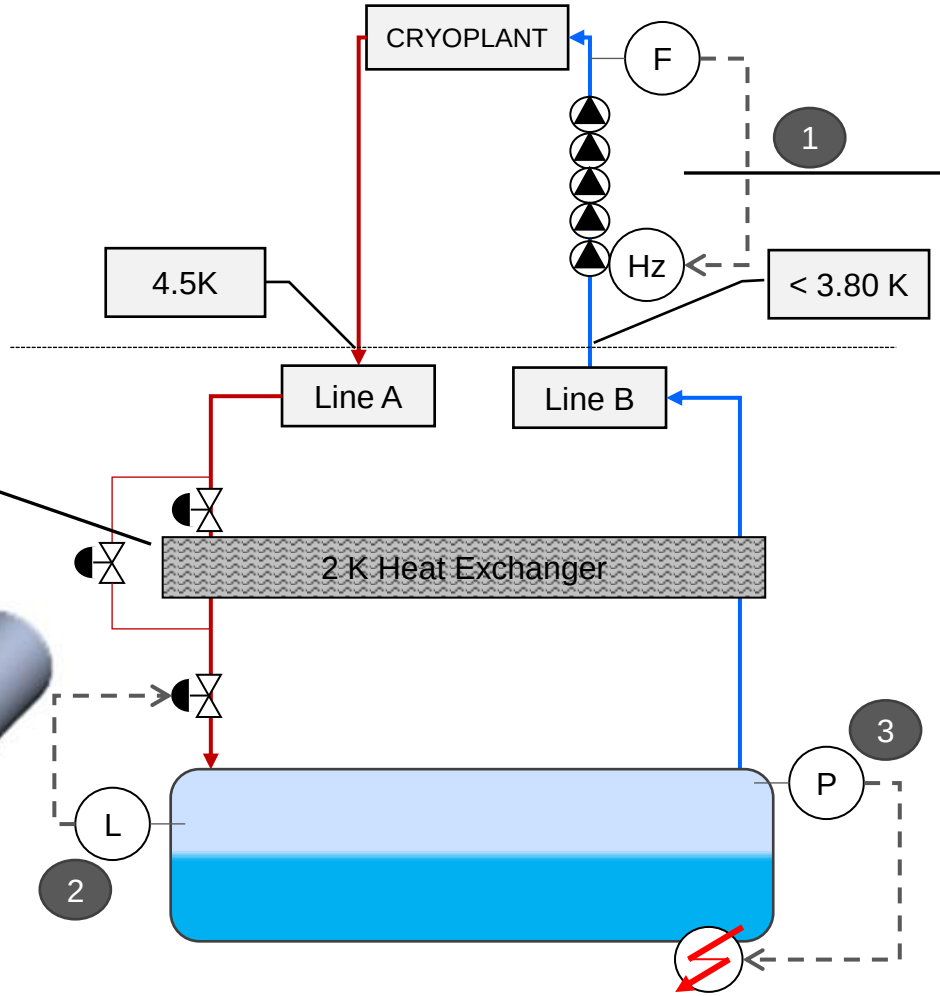


- Linear guide used for blocking rotation of the process pipe bundle → failed.
- Failure caused opening in the vacuum jacket → loss of insulation vacuum.

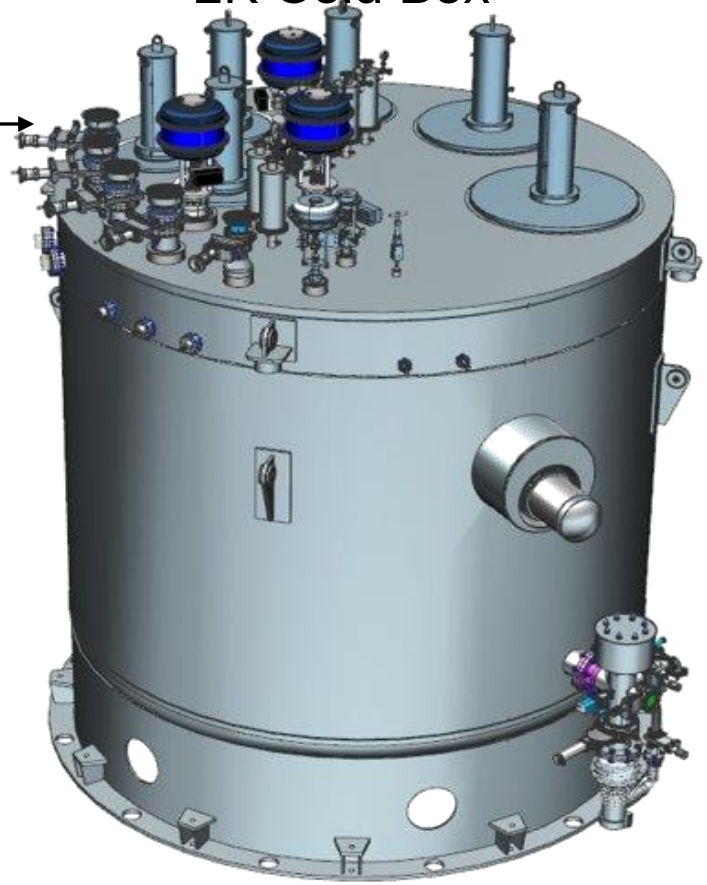
Pump-Down: Scope

2 K Heat Exchanger



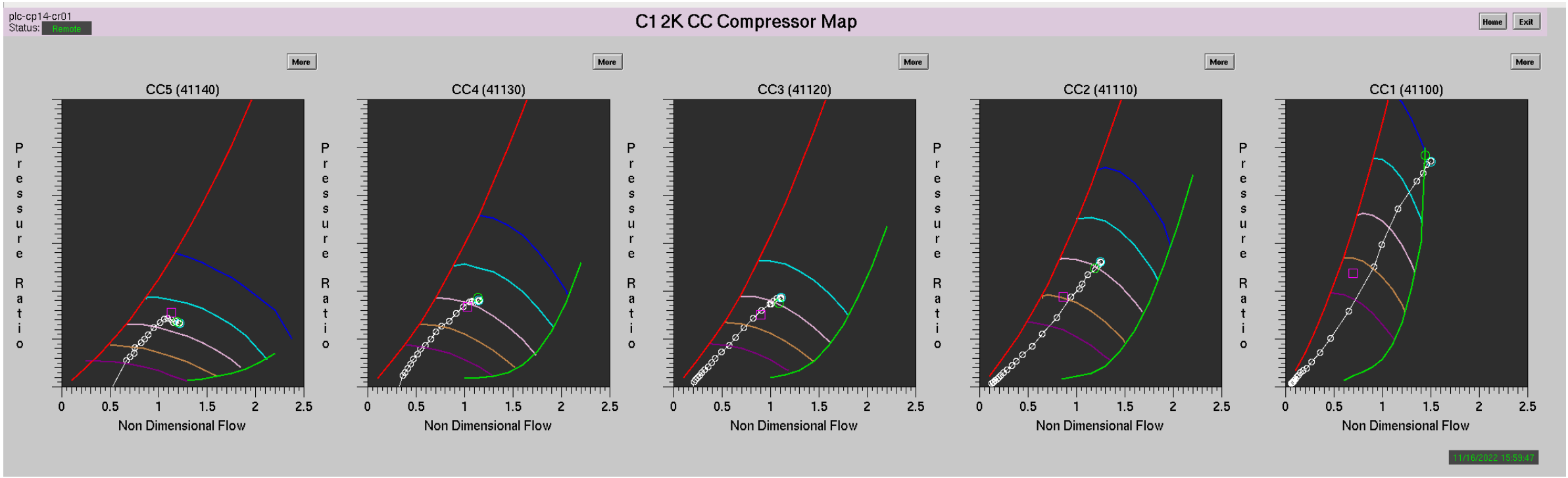


2K Cold Box



1. Cold compressor speed control → Compressor Flow
2. LINAC heater control → LINAC Pressure
3. LINAC JT-valve control → Individual Cryomodules Level

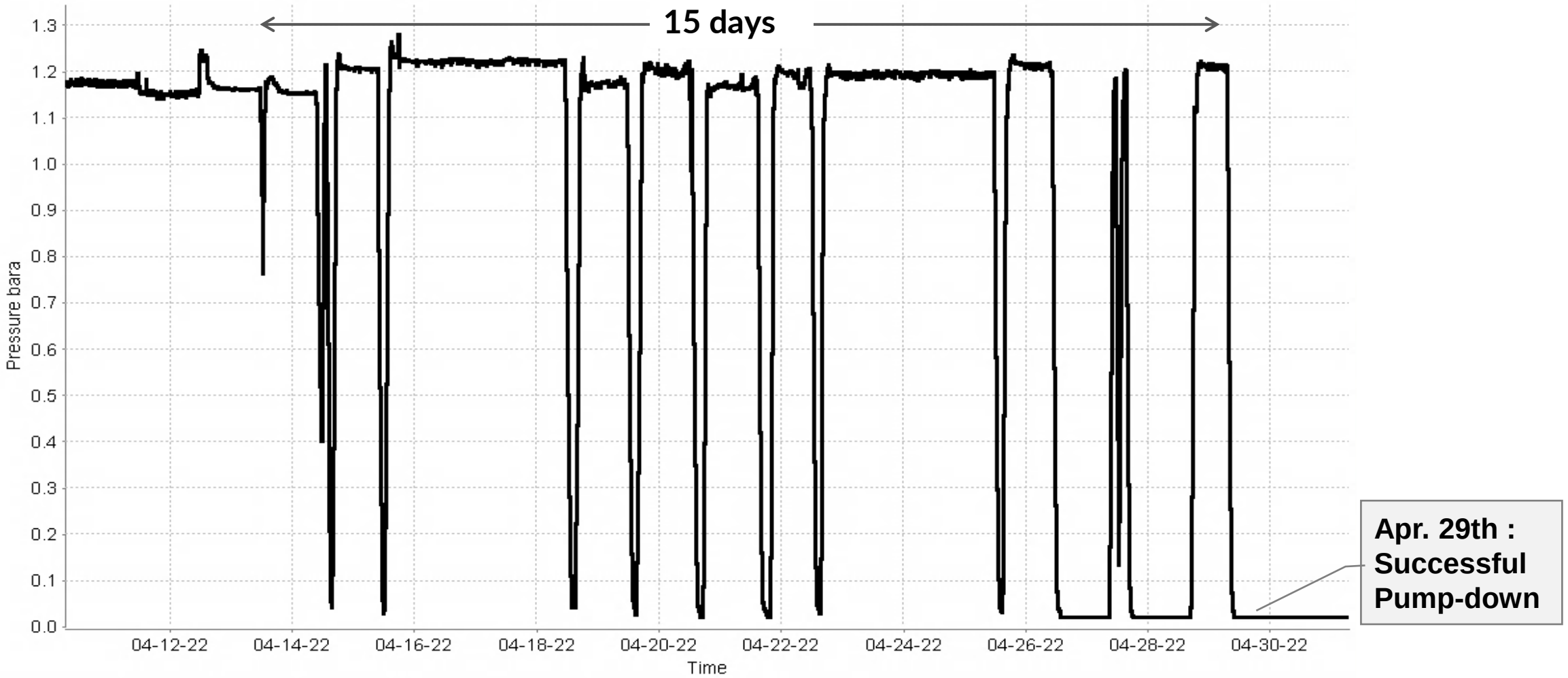
Pump-Down: Strategy



- Cold Compressor Maps HMI Screens:
  - Real time monitoring of cold compressor performance
  - Critical for detecting issues in relationship to the cold compressor thresholds.
  - Efficient tuning of 2K pump-down parameters.

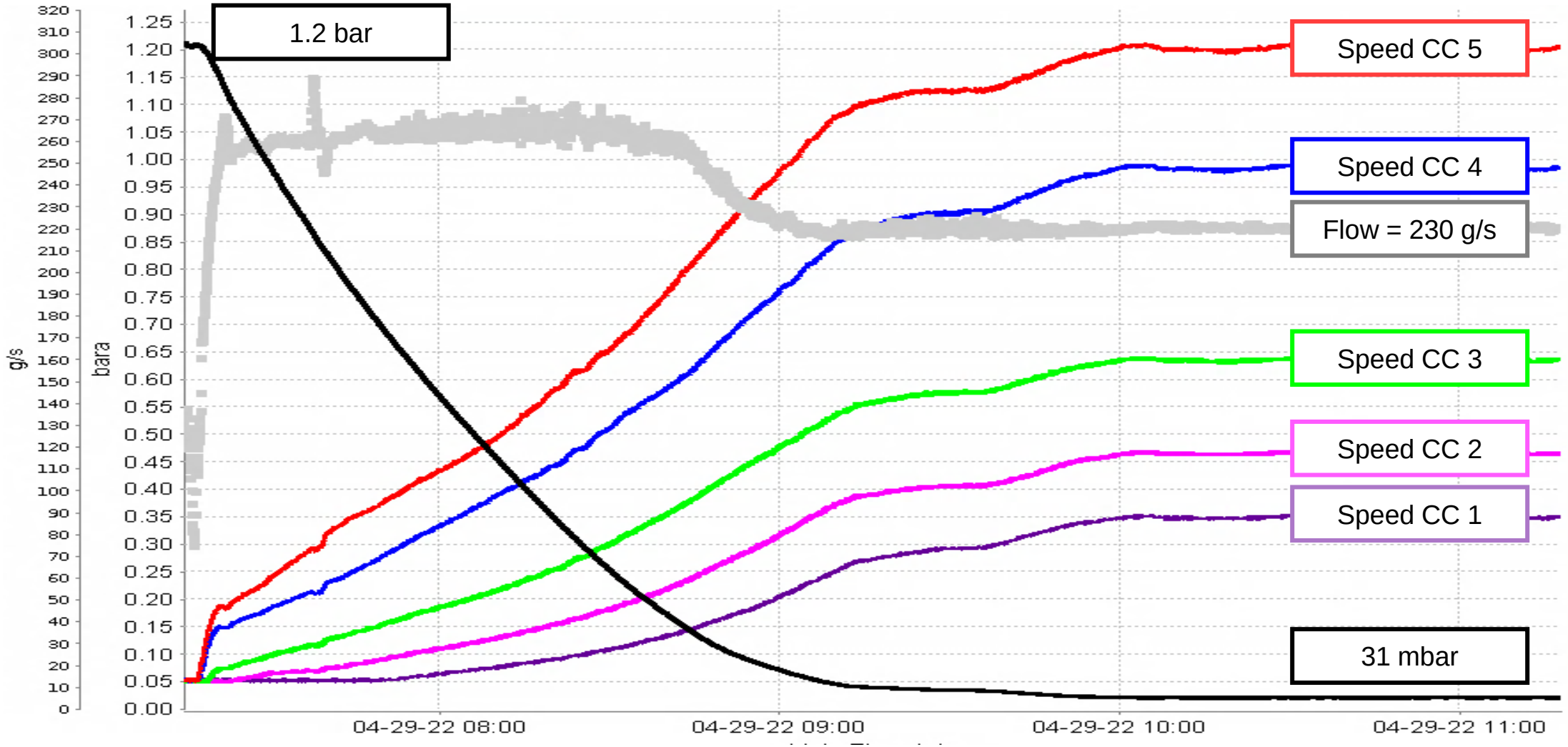
- Pump-down table: Speed vs Suction Pressure
  - Excellent vendor support

Pump-Down: Results



- 10 initial attempts : compressor surge, instrumentation, pressure stability
- Stable operation at 2 K was successfully achieved after 15 days

Pump-Down: Result



- LINAC: Successful PUMP-DOWN: Apr. 29th, in 2.5 hours.
- Code Improvements: have reduced duration to 1.5 hr.

Summary

- Successful LCLS-II LINAC Cool-Down and Pump-Down

- Key aspects for successful commissioning:
  - Detailed documentation describing system behaviour (Functional Analysis)
  - Clear HMI: early detection of issues and improving system response
  - Careful planning supported by thorough Procedures

- LCLS-II cryosystem success was possible thanks to:
  - Vendor: excellent support for commissioning and technical challenges.
  - Strong Technical collaboration with Jefferson Lab
  - Continued discussions with Fermilab, CERN, SNS and BNL.

BERKELEY LAB Fermilab Argonne NATIONAL LABORATORY Jefferson Lab EXPLORING THE NATURE OF MATTER SLAC NATIONAL ACCELERATOR LABORATORY Stanford University U.S. DEPARTMENT OF ENERGY