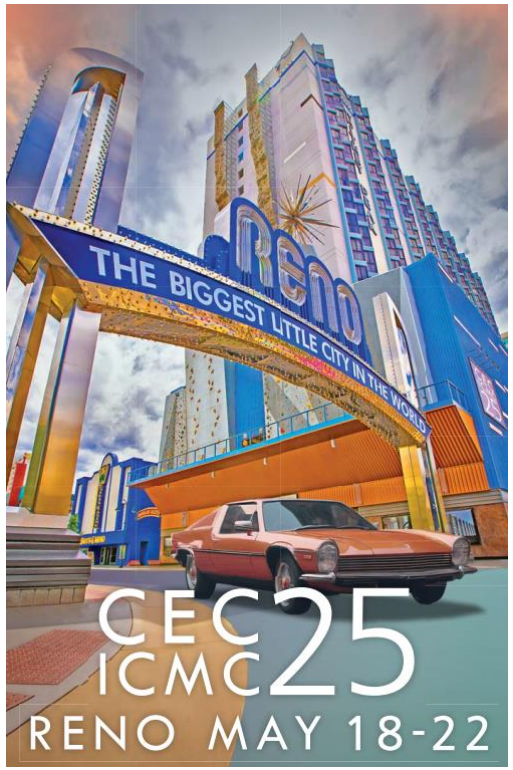
CEC/ICMC - 2025 – Reno (Nevada, USA)

[C3Or4B-01] Large-Scale: Systems, Facilities, and Testing



Operation of CERN's major tests facility with upgraded cryogenic infrastructure for superconducting magnets, power links, inner triplets String and radio-frequency cavities for HL-LHC

T. Barbe, T. Dupont, F. Ferrand, V. Gahier, J. Gery, N. Guillotin, R. Mauny, A. Perin, A. Onufrena, O. Pirotte.

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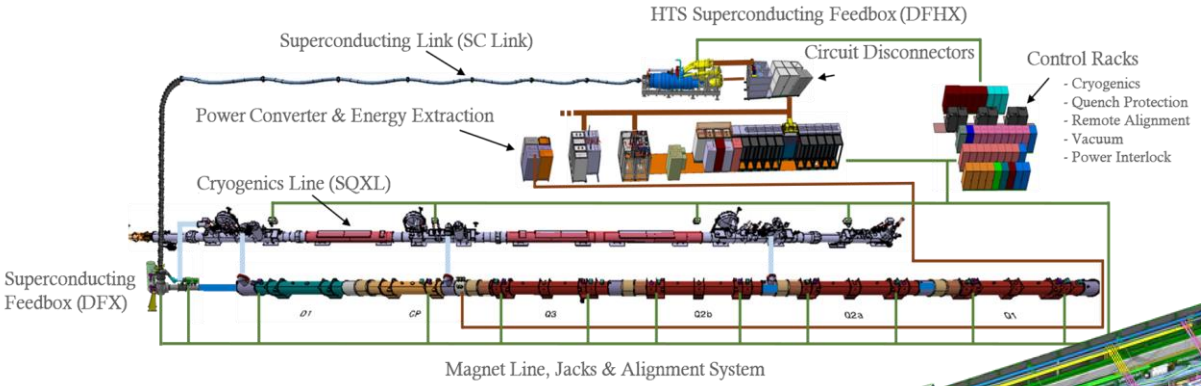
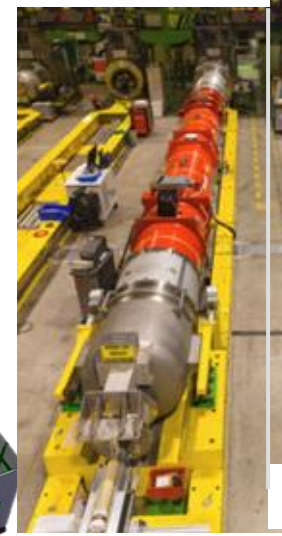
SM18 presentation

SM18: CERN's major test facility for superconducting magnets, power links, and radio-frequency cavities



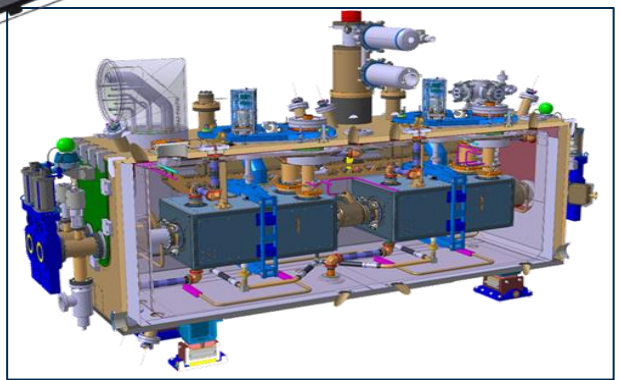
*(**I**nner **T**riplet)* IT-STRING test bench

*(**I**nner **T**riplet)* **IT** Magnet



Power Link

Cryogenics plants

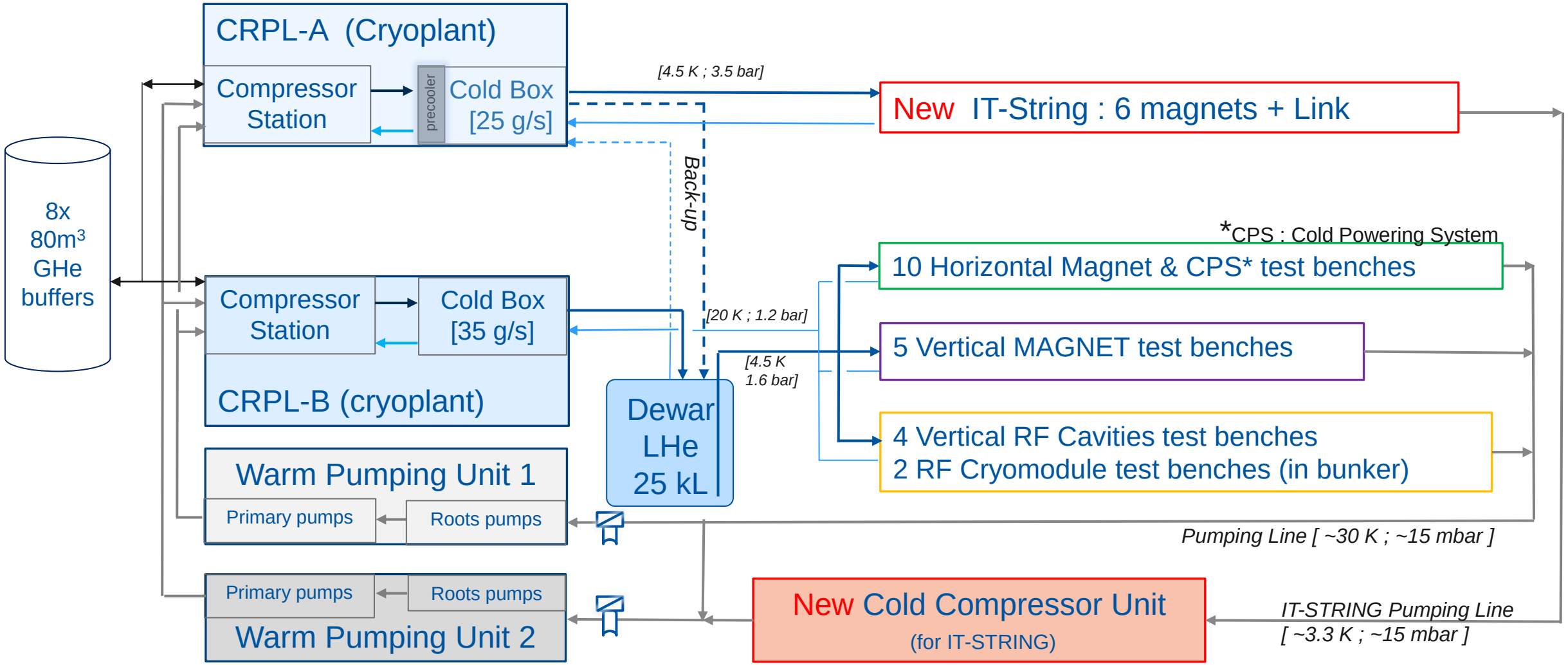


RF Crab Cavities Cryo-Module

SM18 hall surface : 7200 m^2

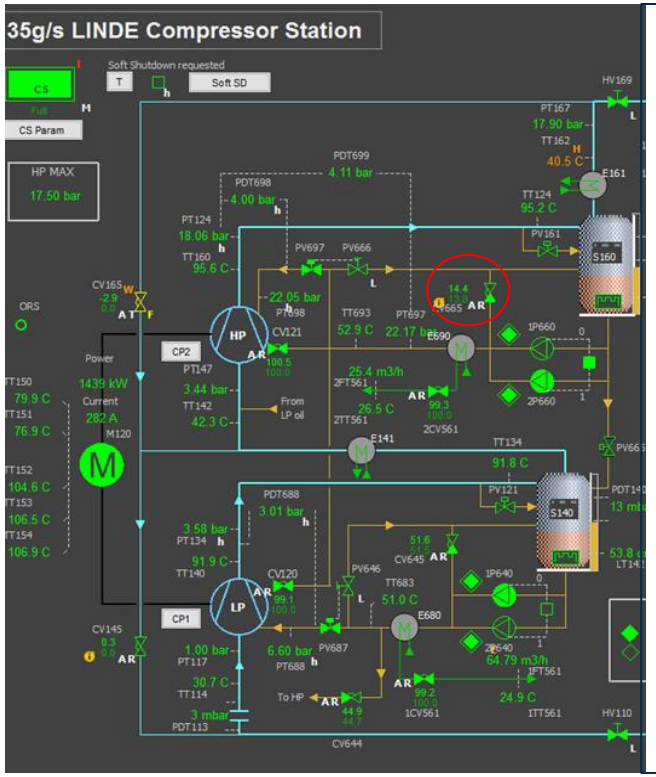
SM18 Cryogenics infrastructure

SM18: CERN's major test facility for superconducting magnets, power links, and radio-frequency cavities



SM18 Cryogenics infrastructure - issues

NEW COMPRESSOR STATION (CS-B)



CS - HP oil injection issue :

Observation : HP oil bypass valve (CV665) kept going out of adjustment during starting up process.

Consolidation:

- HP sensor added
- Starting up sequence to start HP oil pump revised
- Synchronisation between PV697 & PV666 optimized
- DPT(Oil/He) Setpoint decreased from 4 bar to 3 bar.

NEW COLD BOX (CB-B)

Cold Box - Issue:

inlet & outlet valves of Adsorbers 80 K not tight in line after 1 thermal cycle.
Manufacturer intervention to replace valve heads

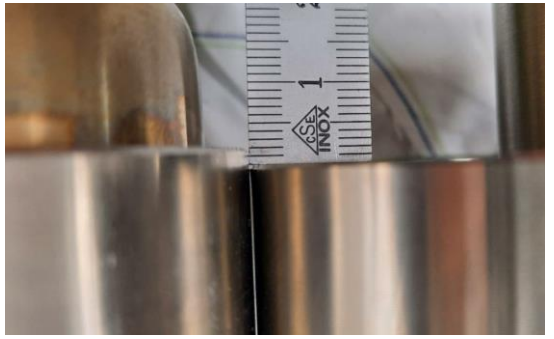
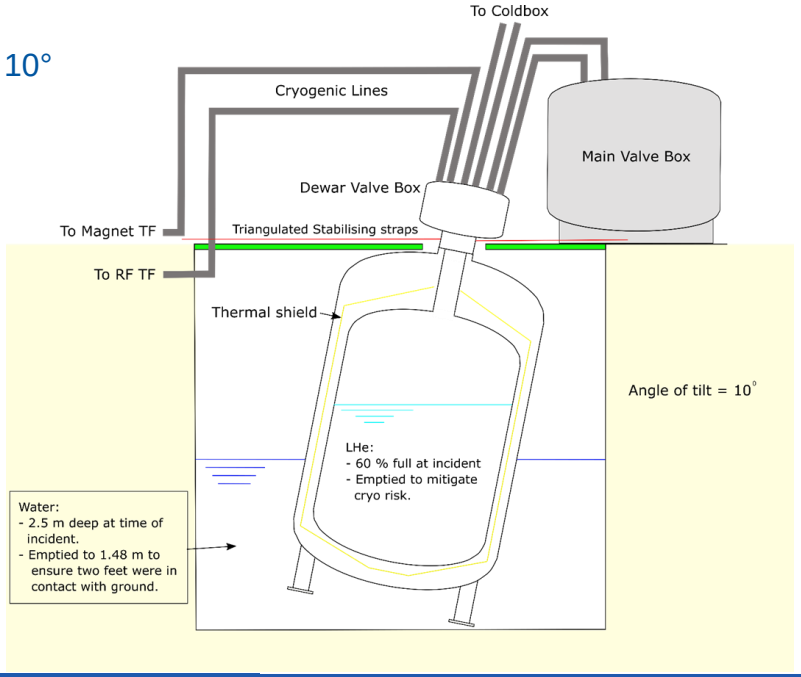


Photo 1 : Comparison old vs. new valve head

25 kL Dewar – Issue (2021):

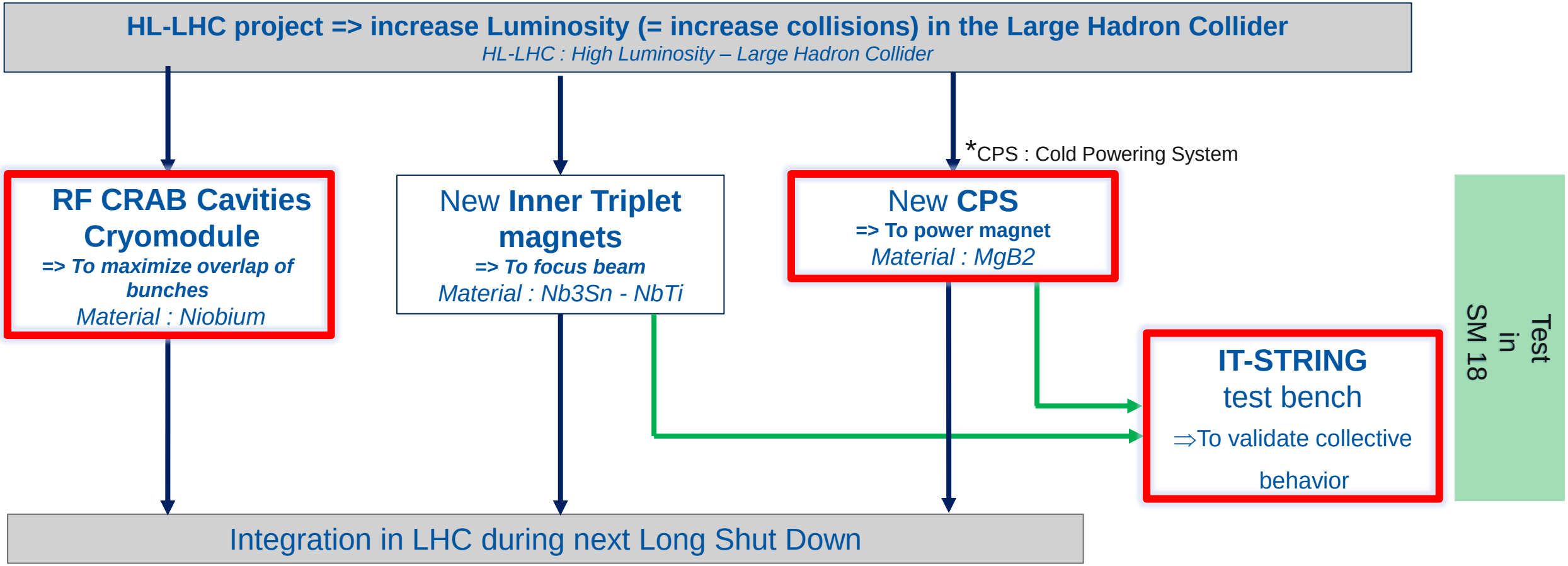
Flooding in the pit – Dewar tilted by 10°

MAIN LHE STORAGE

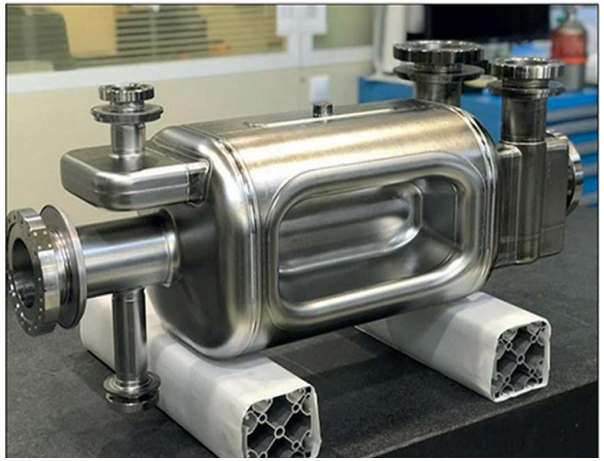


Test Benches upgrade - CONTEXT

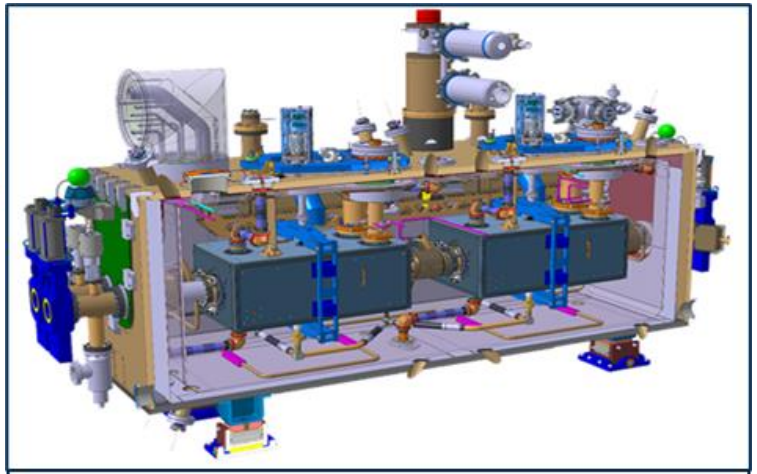
SM18: CERN's major test facility for superconducting magnets, power links, and radio-frequency cavities



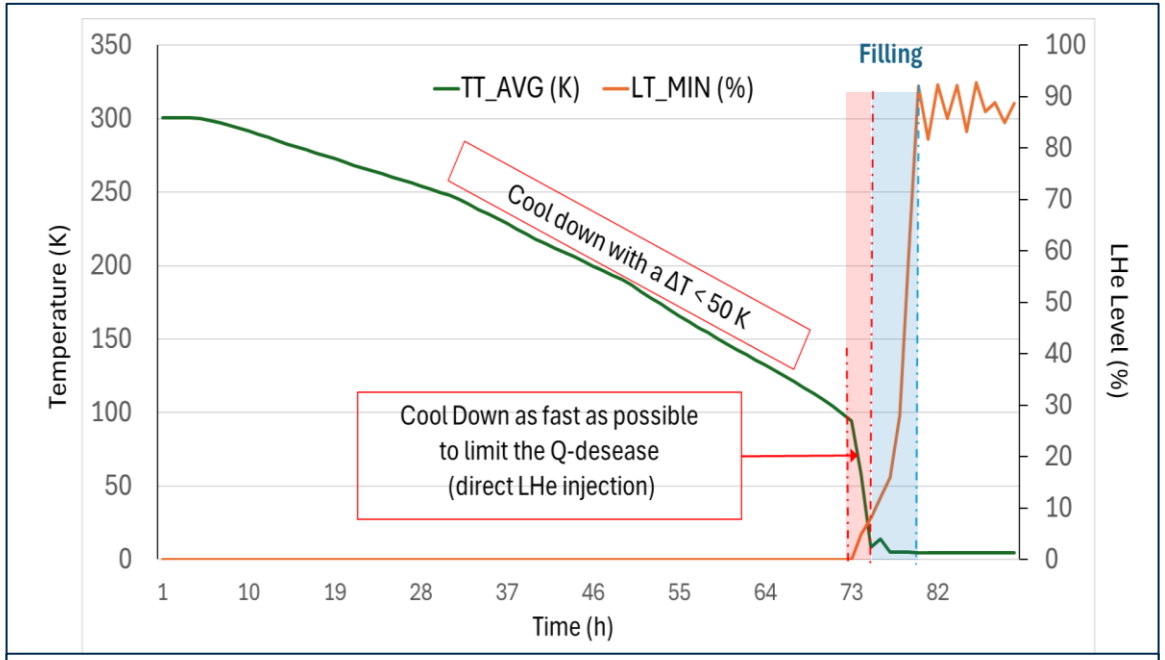
1. Radio Frequency (RF) Crab Cavities – Test benches upgrades



RF Dipole Crab cavity
made in pure Niobium



RF Crab Cavities Cryo-Module



Proto RFD C3M cool down in M7 bunker in August 2024

- **300 K – 130 K :**
  Sensitive to mechanical stress during thermal transition
  => **ΔT = 50 K max**

- **130 K – 4.5 K :**
  Must limit Q-Disease => **Cool Down as fast as possible**

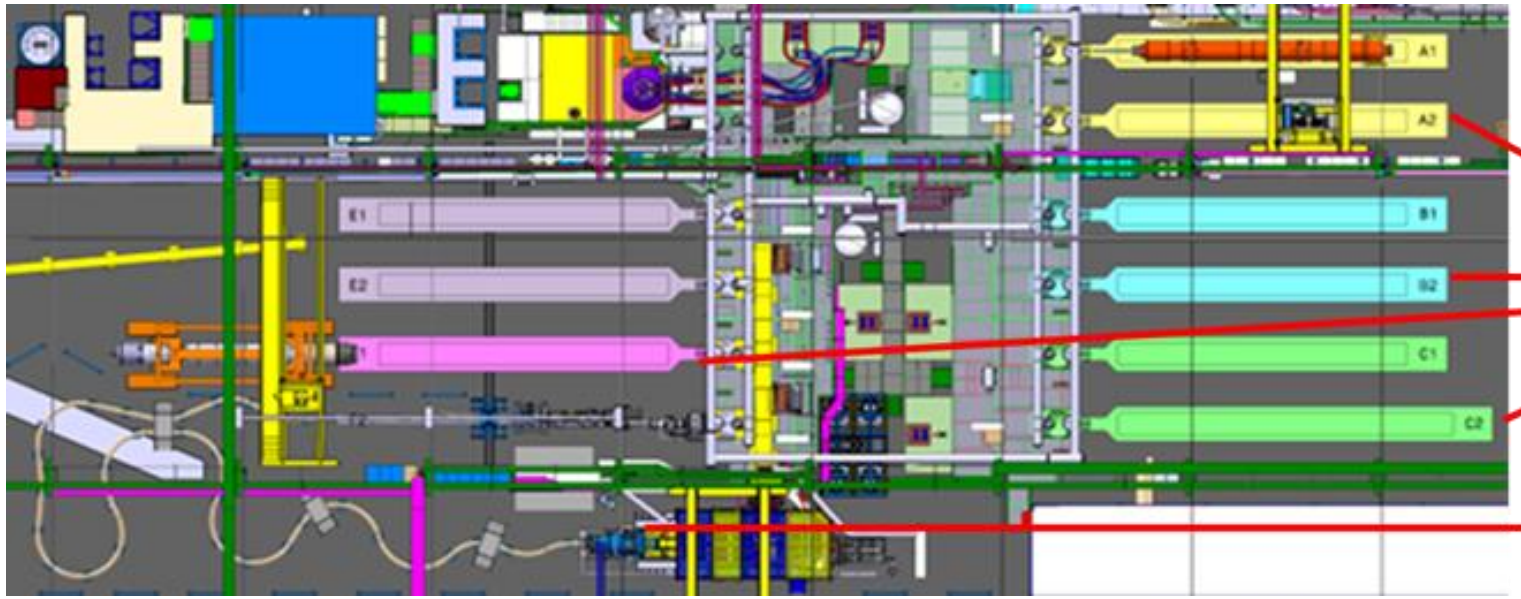
Nominal operation : 2 K

RF Test benches upgraded to fulfill with requirements ✓

Cryogenics process improved ✓

Ready to test RF Crab cavities series ✓

2. Magnet test benches upgrades for Magnets & CPS (Sc-link)

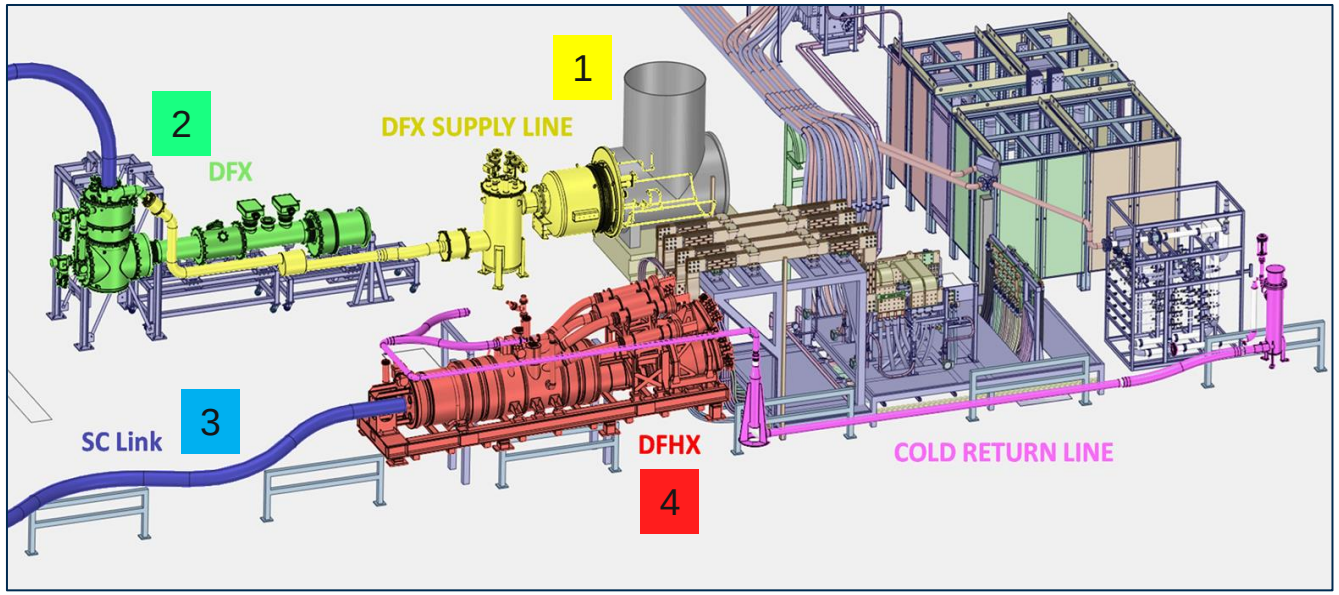


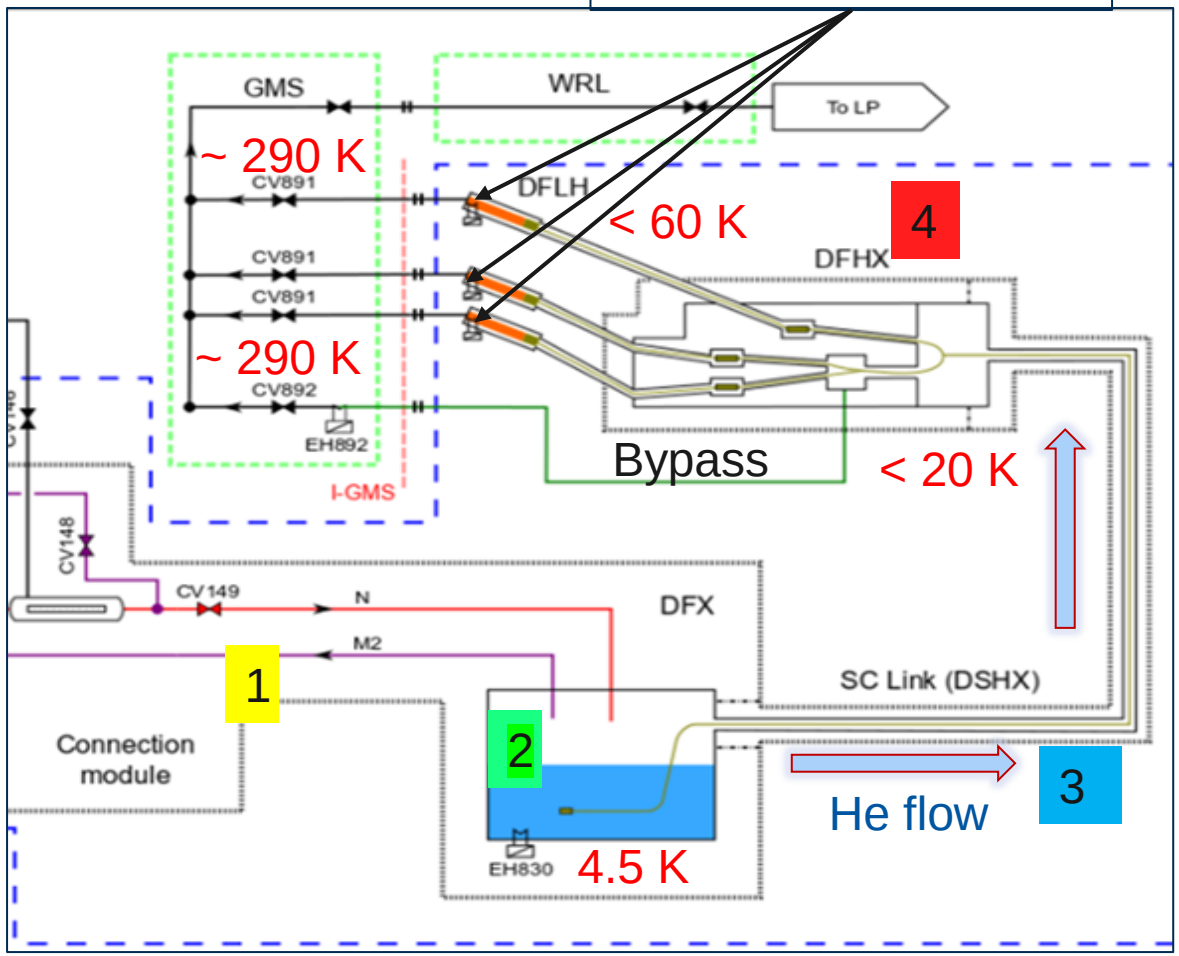
5 Horizontal test benches upgraded to test new IT magnets + SC-Link

From 2022, 5 Horizontal benches for magnets upgraded :

- 4 with a shuffling module to test new Inner Triplet magnets
- **1 to test the new HL-LHC Cold Powering System (72 m long)**

2. Cold Powering System - test bench

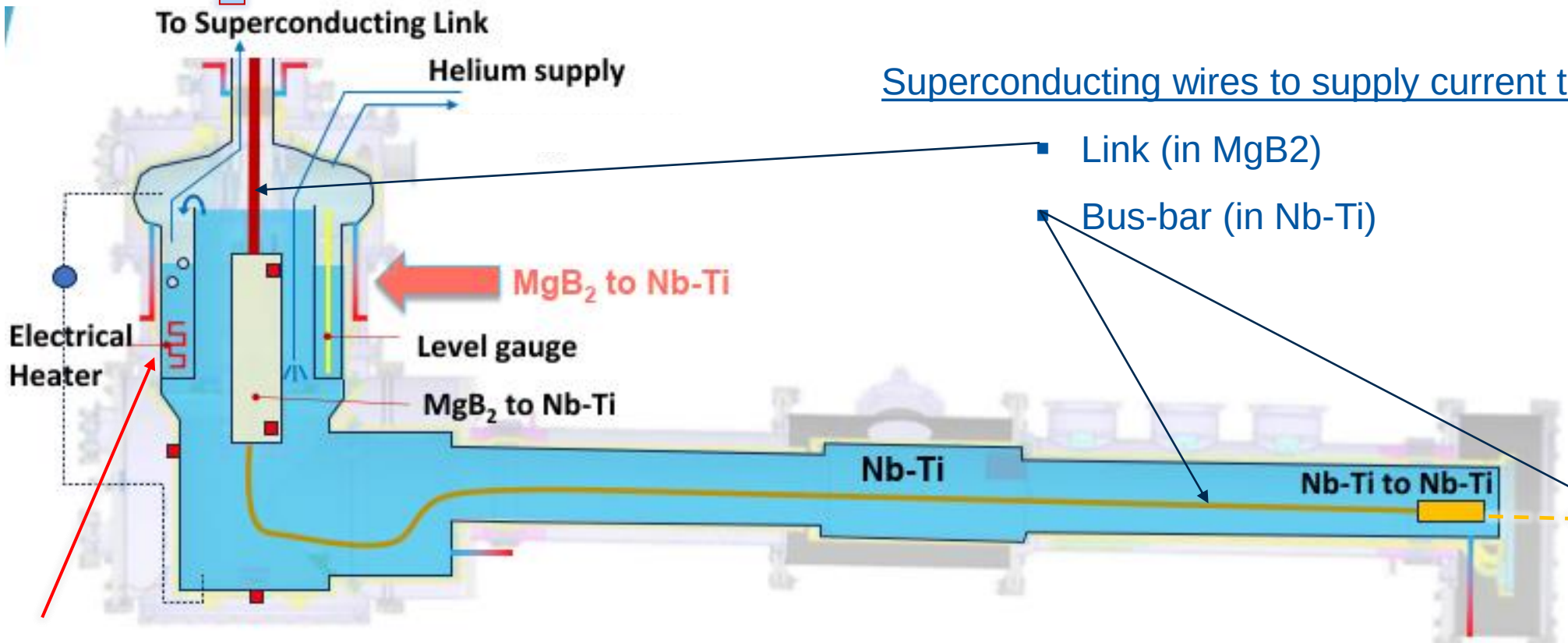




1. In Yellow : upgrade added to the original Magnet test bench
2. In green : Distribution Feed Box (DFX) : at 4.5 K – it's where the Link ends-up with connections (splice) between the link in MgB2 to the busbars in Nb-Ti
3. In Blue : Superconducting (SC) Link; ~72 m ; 19 cables in MgB2
4. In red : Distribution feed box high (DFHX): where the link starts up with splices MgB2 / HTS < 20 K + 19 Current Leads HTS/Copper

2. Cold Powering System – DFX & Results

Cold He flow generated by Heater : 6 g/s



Superconducting wires to supply current to magnets :

- Link (in MgB2)
- Bus-bar (in Nb-Ti)

MAGNETS

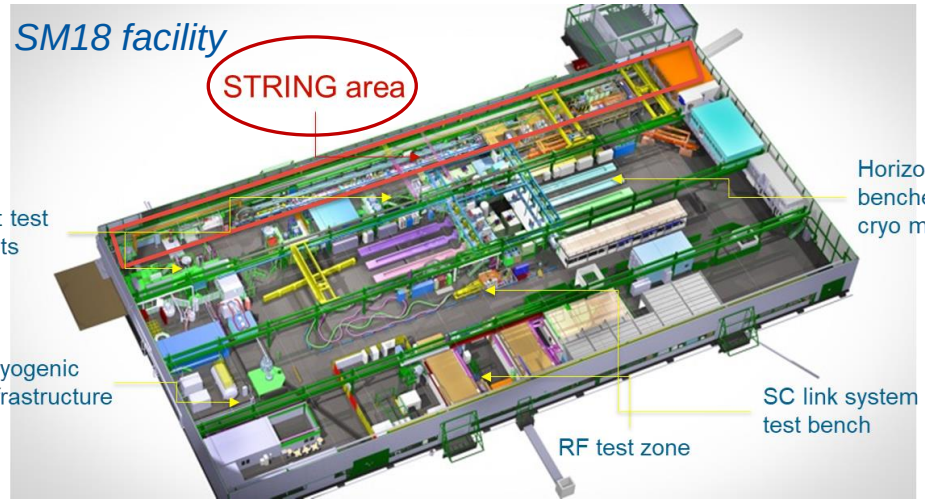
(theoretical position)

Lesson learnt:
15 W permanently

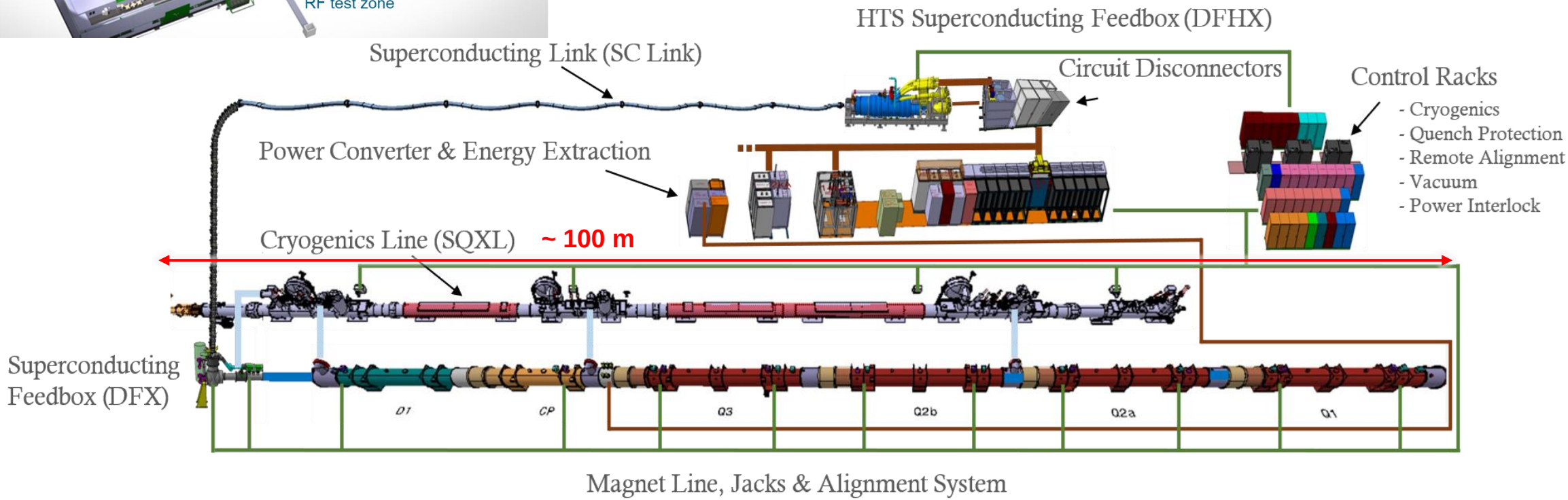
a DFX drawing with the 2 Helium bath in cascade

- **Constant generated flow of 6 g/s with and without current.** ✓
- **Cryogenic conditions OK with powering up to 94 kA !** ✓

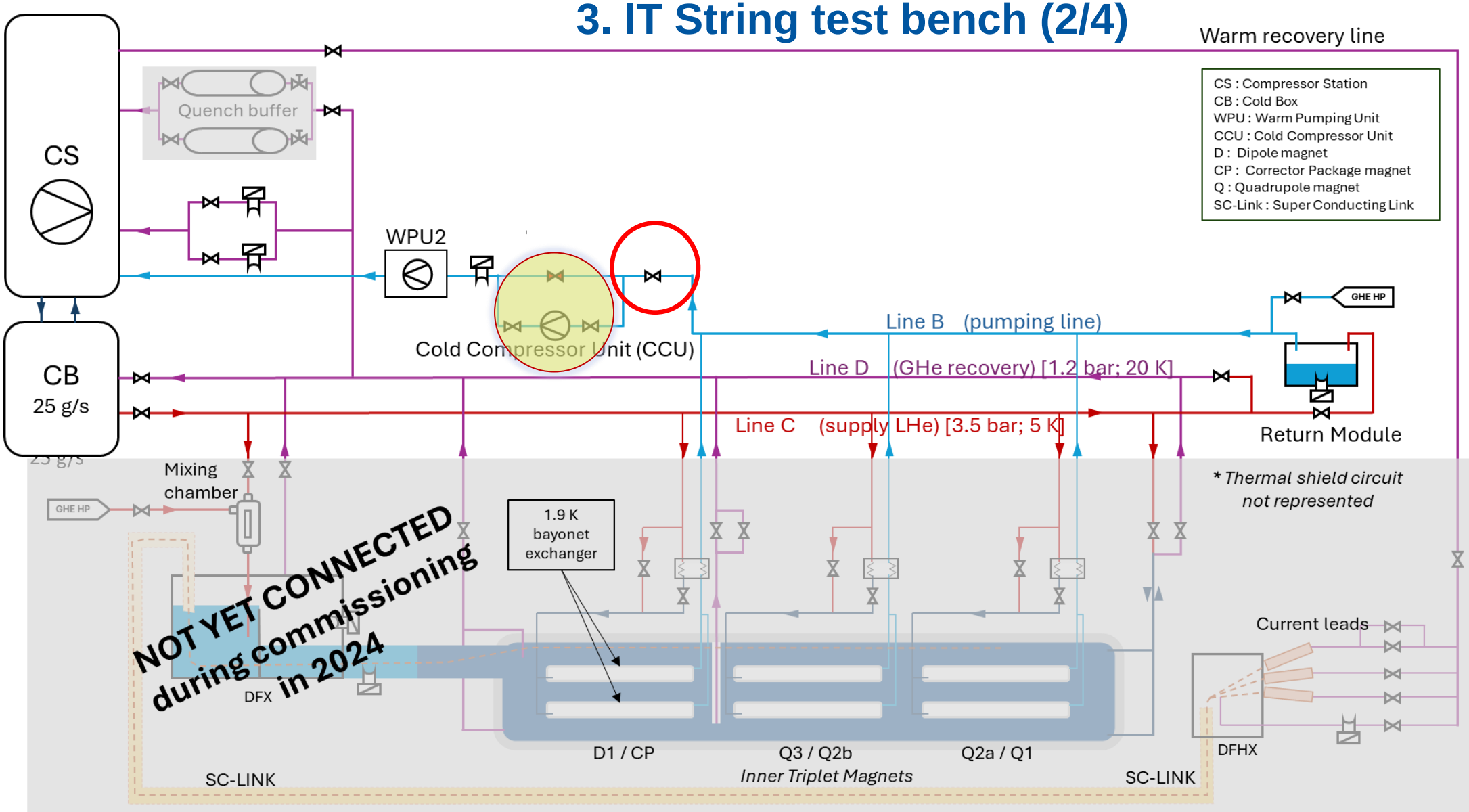
3. IT String test bench (1/4)



to **STUDY and VALIDATE the COLLECTIVE BEHAVIOUR** of a string if inner triplet magnets with their powering system. (+ other non-cryogenics systems).



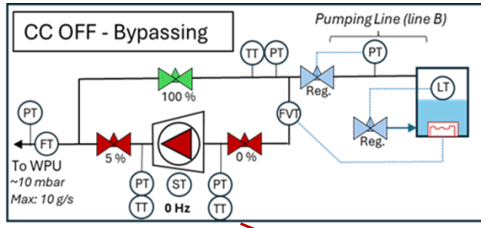
3. IT String test bench (2/4)

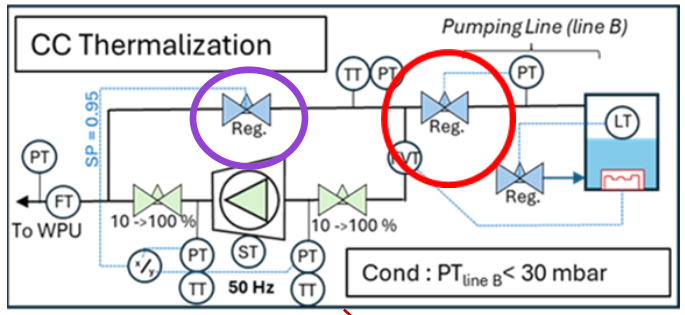


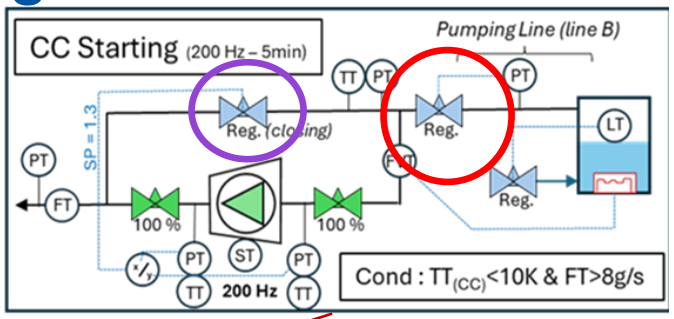
3 cool down done for :

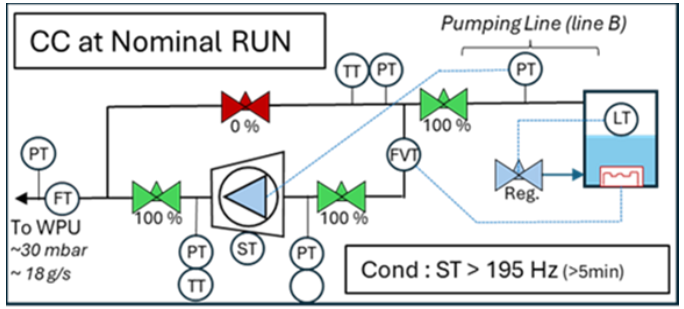
- SQXL validation ✓
- Cooldown procedure ✓
- Heat load check ✓
- New CCU operation

3. IT String test bench 3/4

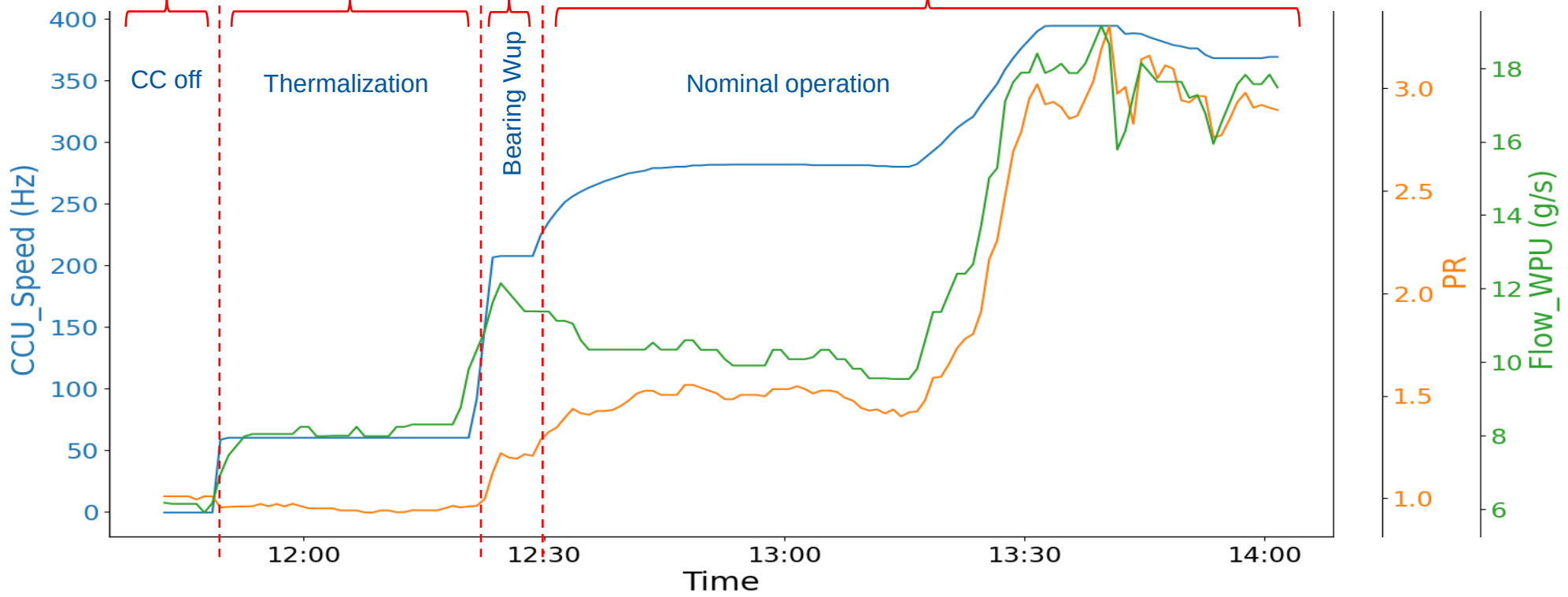








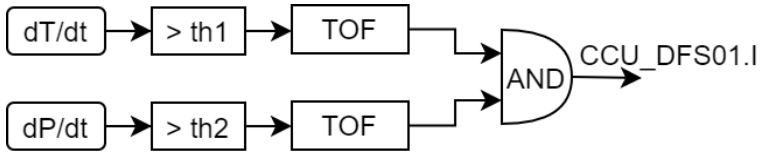
Cold Compressor

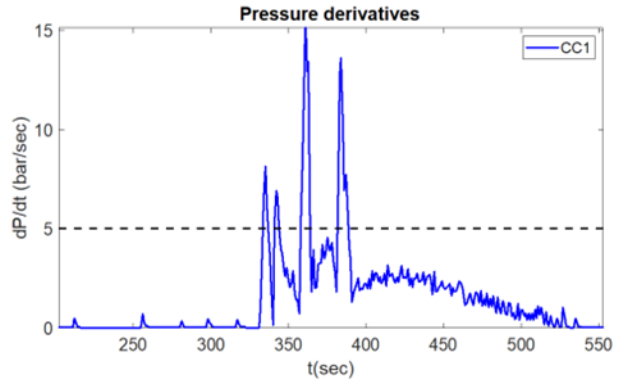


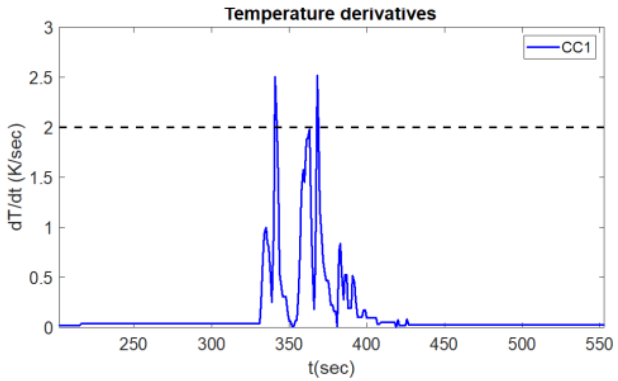
3. IT String test bench 4/4

Surge detection

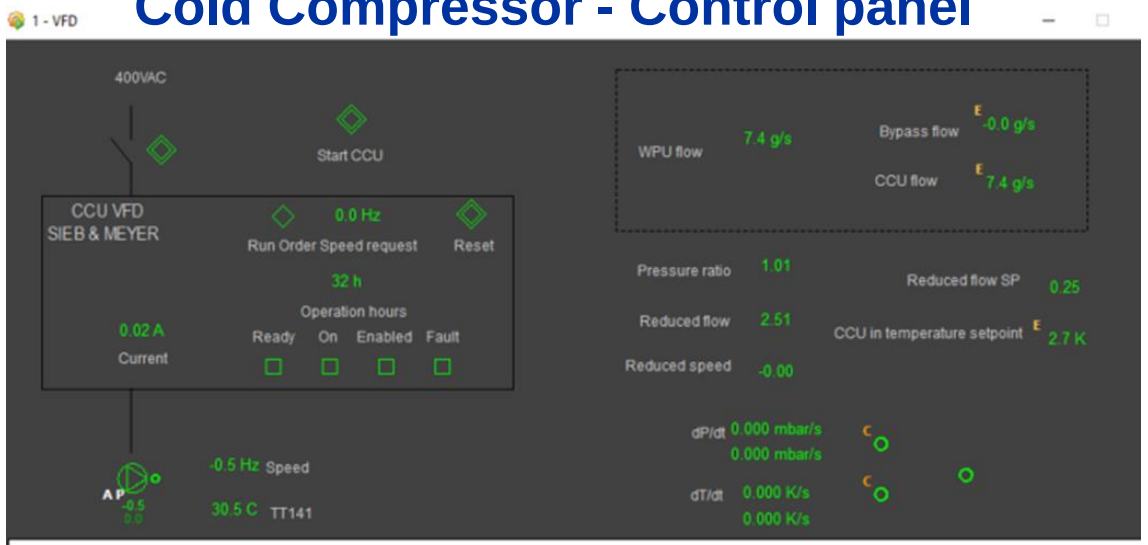
Interlock :

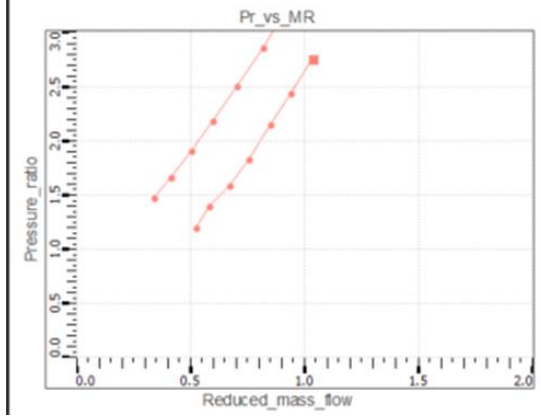


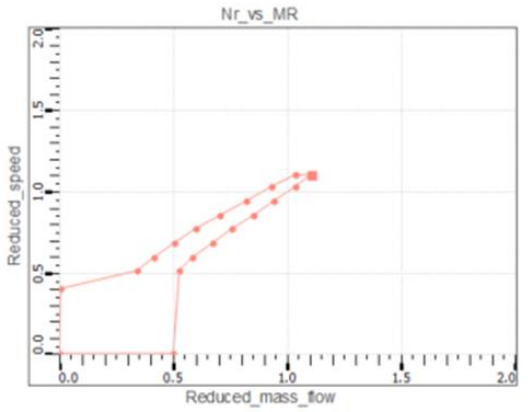




Cold Compressor - Control panel





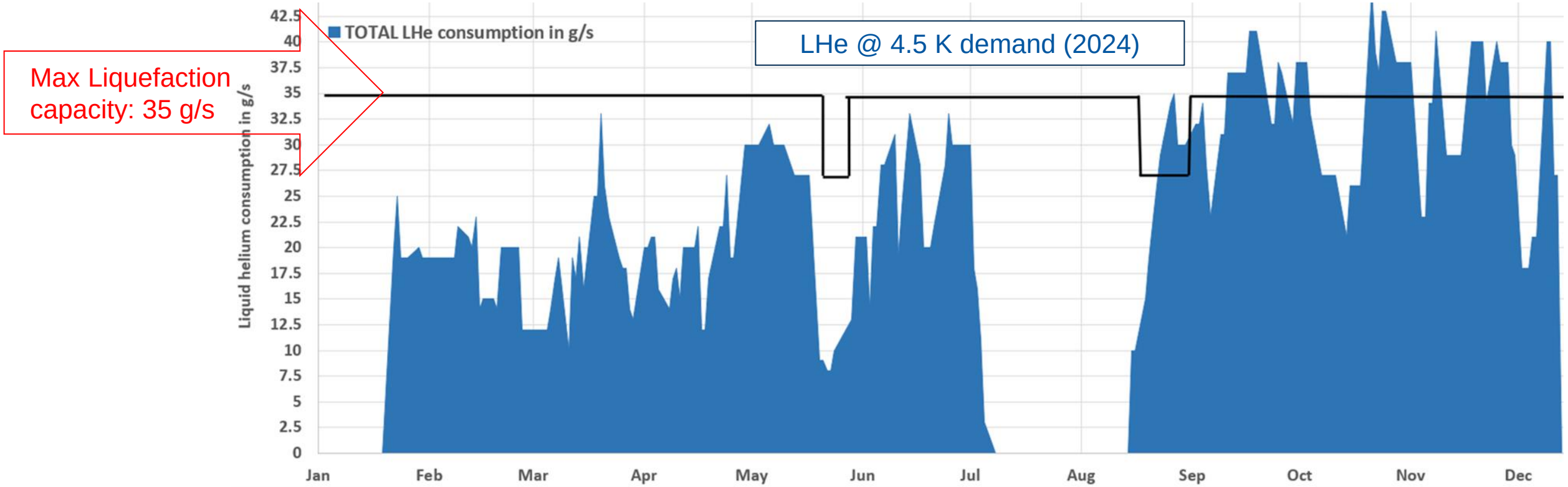


Cold Compressor operation & control system ✓

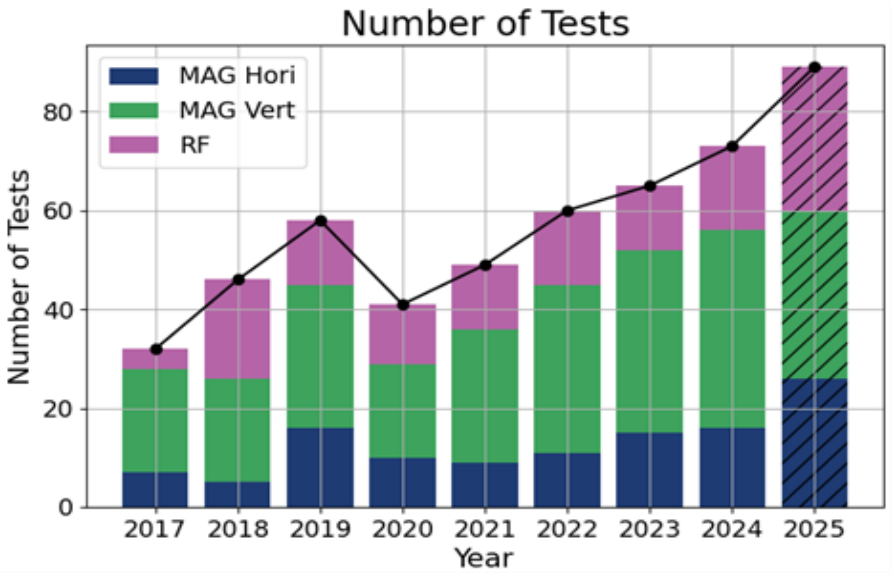
CONCLUSION 1/2

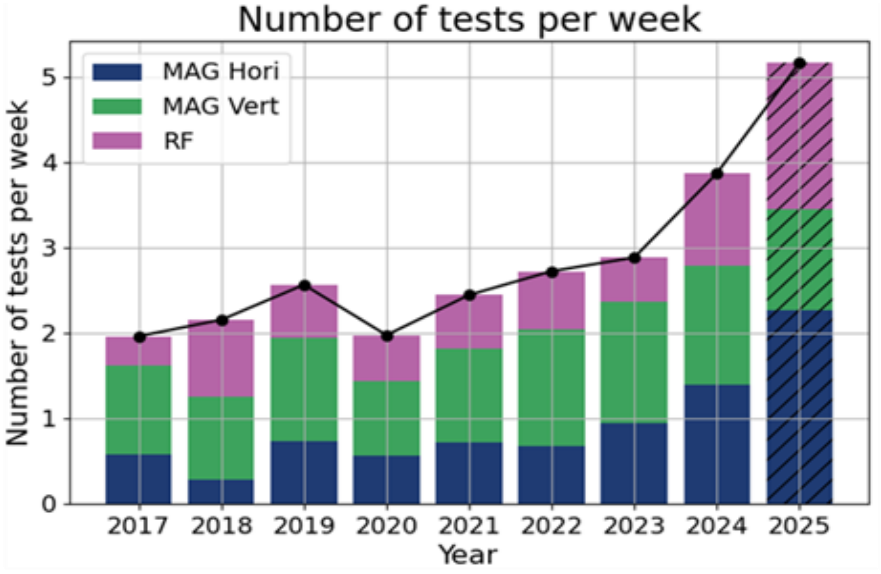
Today status :

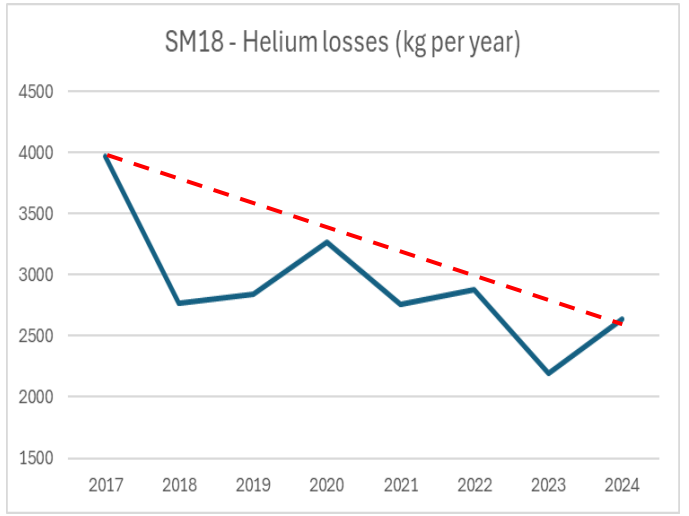
- Test benches upgraded & validated ✓
- Cryogenics infrastructure upgraded ✓
- Cryogenics process optimized ✓



CONCLUSION 2/2







Next challenge :

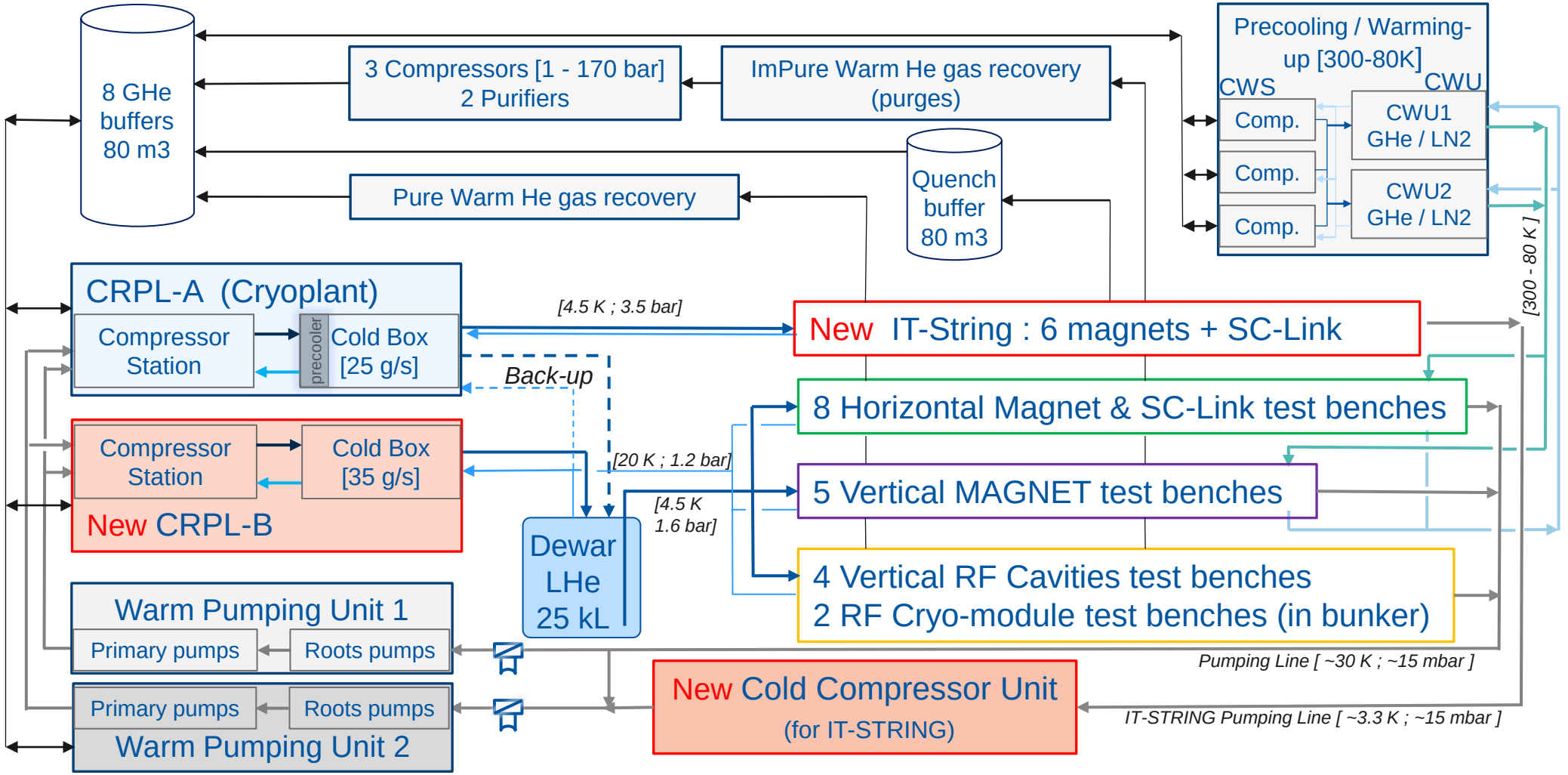
Operation of the IT String test bench with magnets and SC link, scheduled to start in September 2025.

Thank you!

Thank you!

Test Facility building (SM18) – Presentation

SM18: CERN's major test facility for superconducting magnets, power links, and radio-frequency cavities

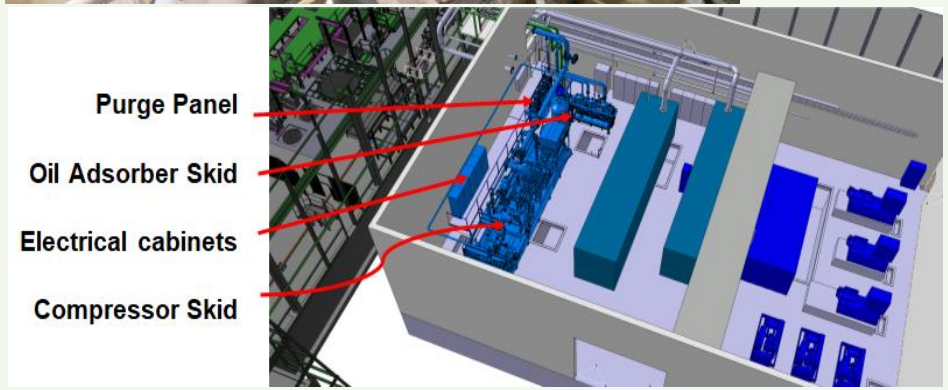


Cryogenics Infrastructure upgrade : new cryogenics plant (Linde B)

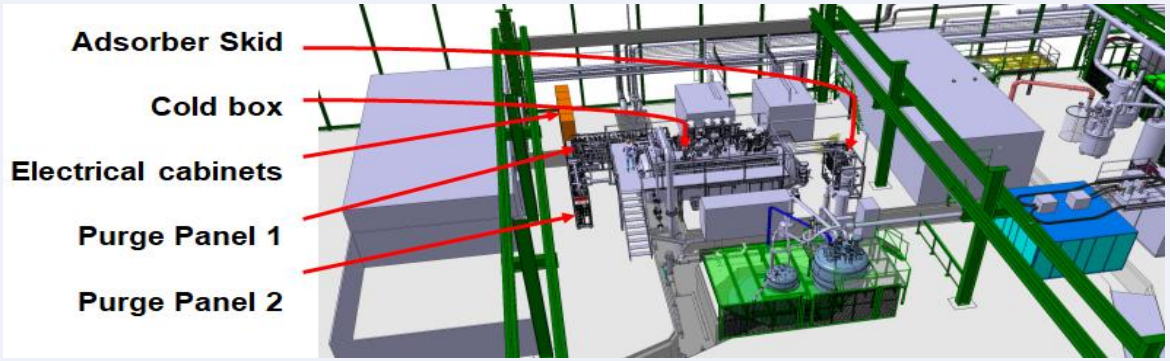
NEW COMPRESSOR STATION (CS-B)

MAIN CARACTERISTICS

1 motor stahl (1.6 MW)
1 double stage compressor Mycom
8 turbines
8 exchangers
2 adsorbers 80 K
1 adsorber 20 K
No precooler LN2
No phase separator
Inlet flow at full capacity : 350 g/s
Liquefaction flow : 35 g/s (Lhe @ 4.5 K, 1.6 bar)



NEW COLD BOX (CB-B)



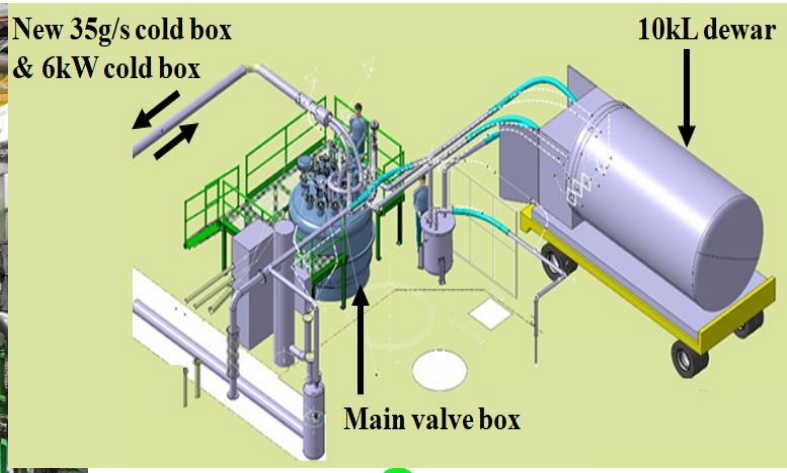
- Installation (Q2 2019 – Q4 2019)
- Commissioning (Q4 2019 – Q3 2020)

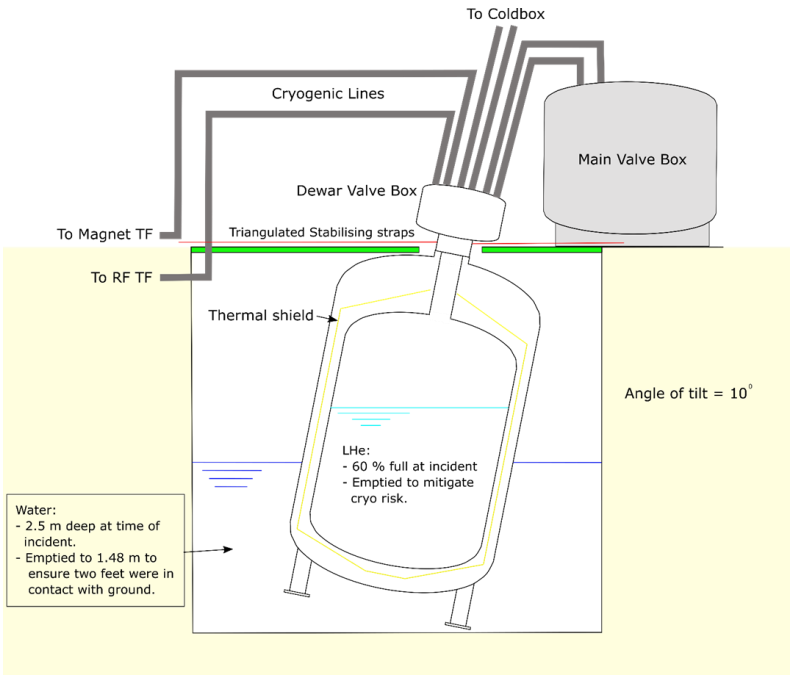
⇨ Operation (Q4 2020 – now)

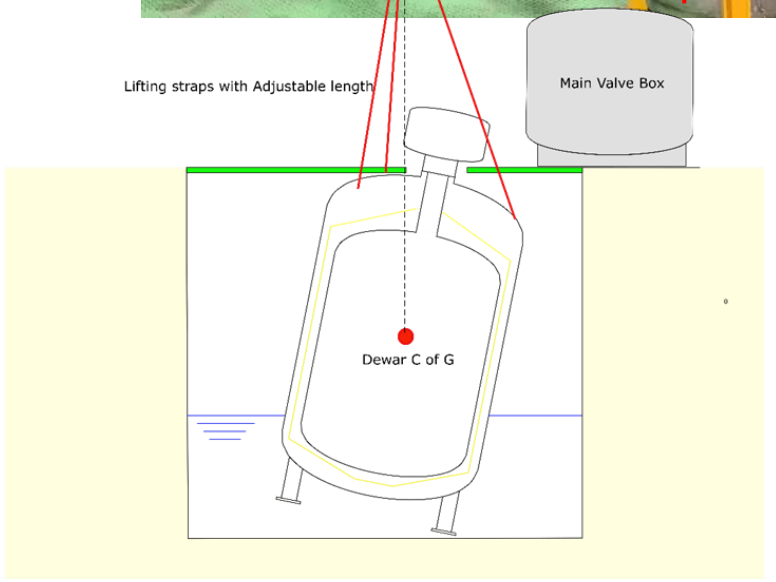
1. Cryogenics Infrastructure upgrade : 25 kl DEWAR ISSUE

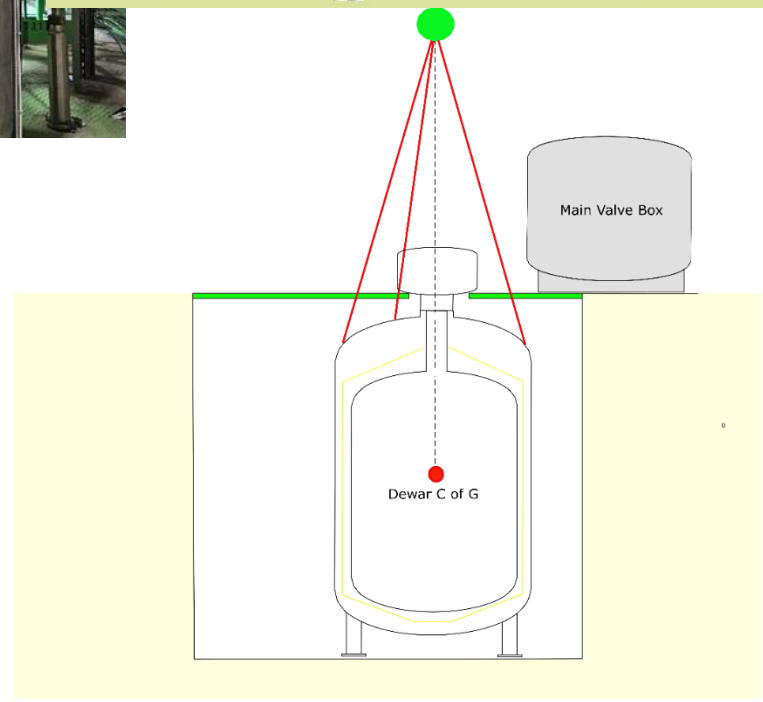
Event (June 2021): Flooding in the pit – Dewar tilted by 10°

1. Emptying
2. Dewar lifted to maintain Center of gravity to avoid swinging.
3. Water drained from the pit.
4. Investigation: dye penetrant test + high resolution 3D laser scan of the neck, endoscopy => experts agreed damage is minor – OK for re-use.
5. Leak test + pressure test
6. Back in service in August 2024

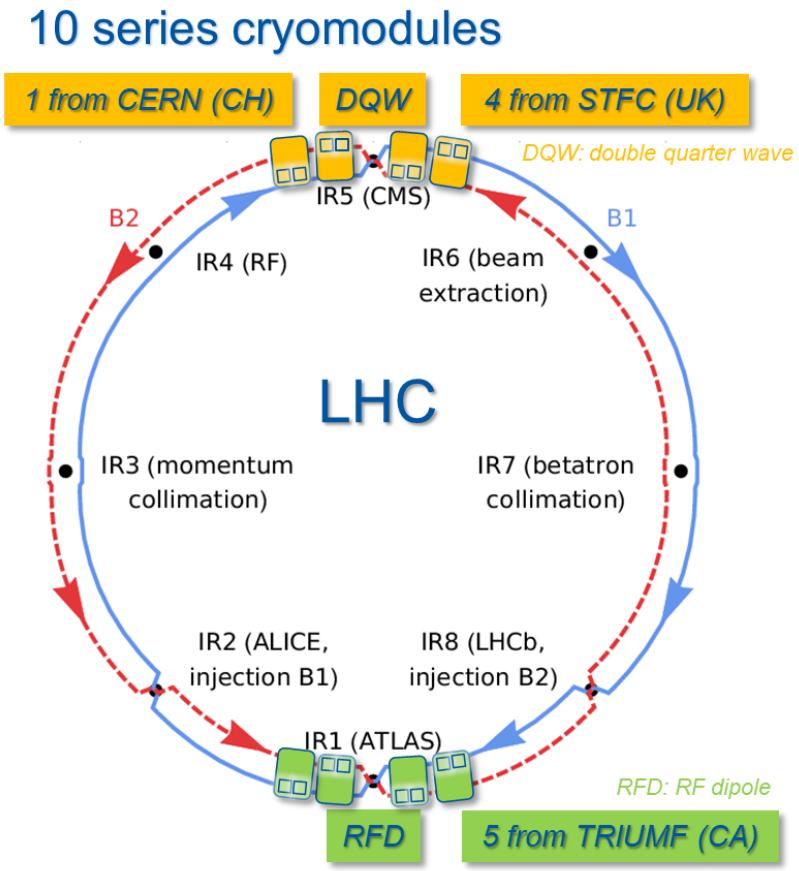




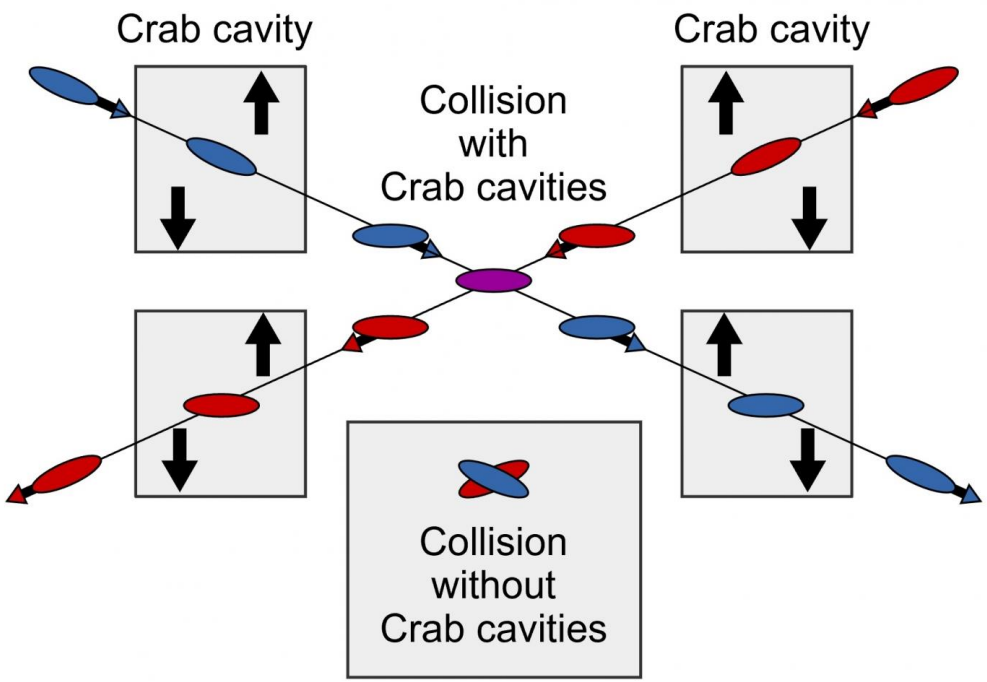




2.0 Radio Frequency (RF) Crab Cavities Cryogenics Module (C3M) upgrade
Introduction & Context



Crab cryo-module cavities location in future LHC



Crab cryo-module cavities' principle