CERN

JOURNÉES DES LIQUÉFACTEURS ET RÉFRIGÉRATEURS HÉLIUM

CERN

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ÉVOLUTIONS DU CRYOPLANT SM18

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on behalf of TE-CRG

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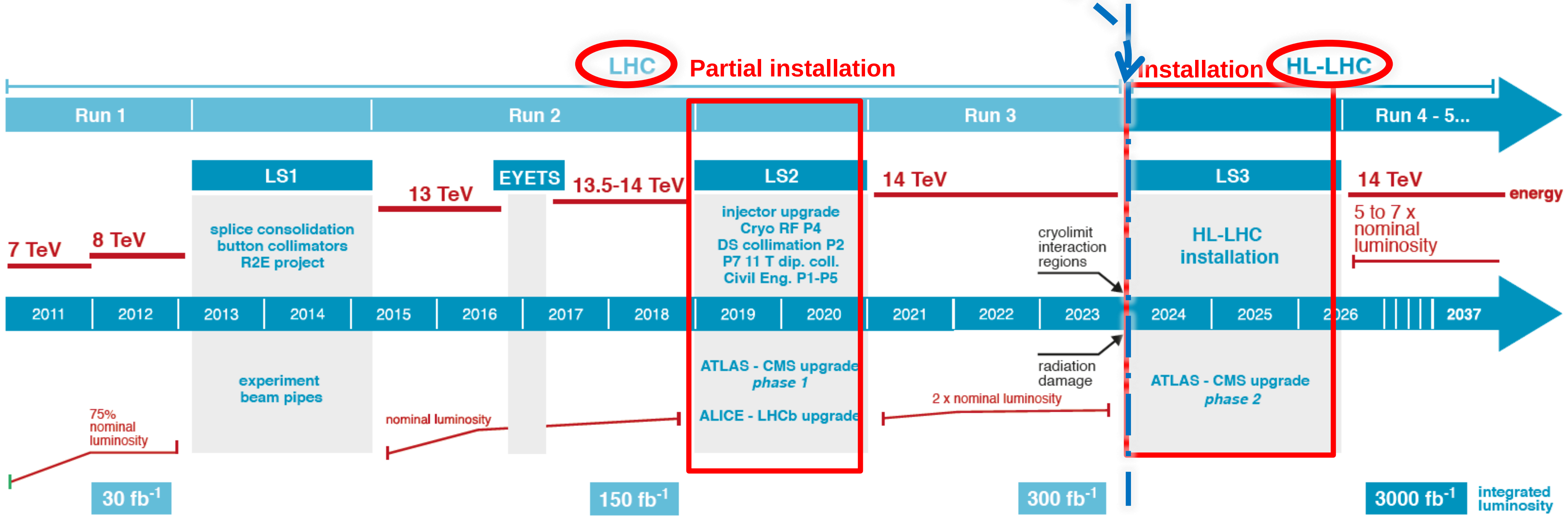
OUTLOOK

SM18 : CERN main facility for testing SC accelerator magnets and SC RF cavities

SM18 cryo infrastructure is being significantly upgraded (starting in 2019) to meet requirements for :

- **LHC High Luminosity project (HL LHC)**
- **R&D program for SC magnets**
- **RF equipment until 2023 and beyond**



SOME OF THE SYSTEMS CURRENTLY IN OPERATION IN SM18

- **5 vertical magnet cryostats :**
  HFM, CLUSTER D, SIEGTAL,
  LONG, DIODES (80K, 4.5 K, 1.9 K)

- **10 Horizontal test benches for magnets** (80K, 4.5 K, 1.9 K)

- **1 test bench for SC Link :**
  (30 - 4.5 K, 2 ~ 15g/s)

- **4 test benches for RF cavities :** V3, V4, V5, V6
  (4.5 K, 1.9 K)

- **2 test benches for Cryomodules :** M7, M9
  (80K, 4.5 K, 1.9 K)

- **1 independent test Bench :**
  Eu HIT GReC (10 - 4.5K)


Vertical magnet tests


Hor. Magn, feed box


Horizontal magnet test benches


Vertical magnet tests


SC links tests


RF cavities & CM tests

SOME DEVICE OF THE CRYOGENIC INFRASTRUCTURE CURRENTLY IN OPERATION

6kW Linde Cold Box

27g/s (~700L/h) @4.5K

Purification units

3 x 130 Nm3/h Burckardt recovery compressors +
2 Purifiers with 200 Nm^3/h total at 180 bars
+ 5 balloons

2 x Very Low Pressure unit (called WPU)

Values per WPU unit :
6 g/s @ 10 mbar
12 g/s @ 20 mbar
18 g/s @ 30 mbar (max)

Cool down - warm up unit (CWU)

2 x CWU 80g/s –
2 x 120kW @80K

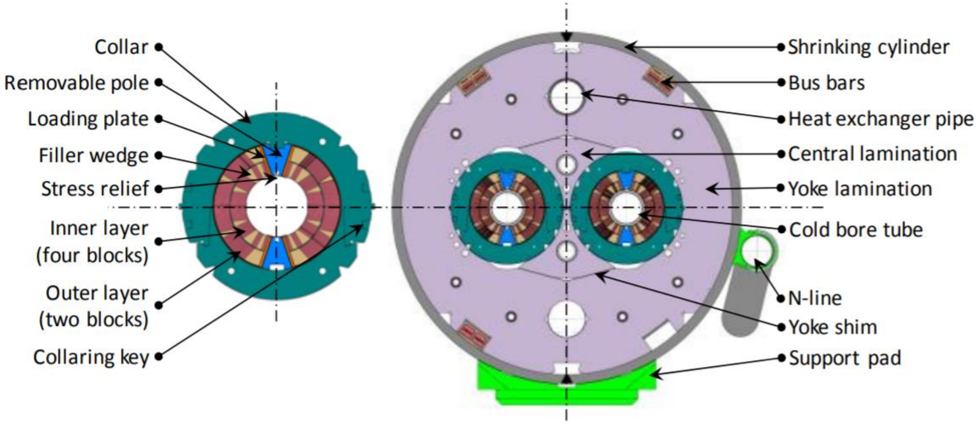
With 3 Kaesers compressors

New SC devices for the HL-LHC project require the SM18 cryostructure upgrade

- Crab RF cavities
- Standalone magnets
- Dipole magnets :

LHC ⇒ long 8.3 Tesla Dipole magnets
14.3 m long 8.3T NbTi supercond. Main Bending dipole (MB),
Contain 2 beam channels in a common structure,
Produce the magnetic field to deflect 7 TeV protons along a circular trajectory

HiLumi LHC ⇒ short 11 Tesla Dipole magnets
Upgrade of the LHC includes additional collimators in the LHC lattice.
The longitudinal space for the collimators will be obtained by replacing some LHC main dipoles with shorter but stronger dipoles,
leading to development of 5.5 m long 11T Nb3Sn dipole (MBH)



- Superconducting link (Cables & current leads)

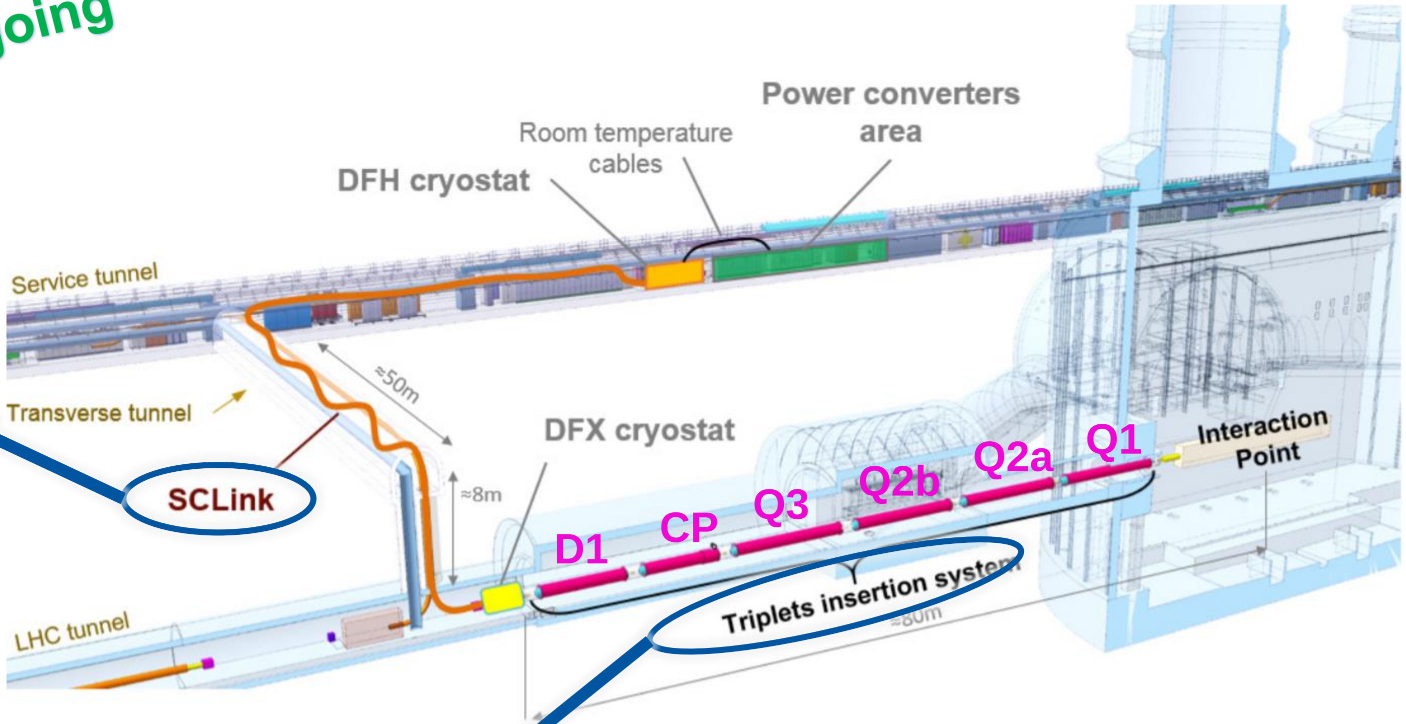
On going

''Conceptual study of the cryostats for the cold powering system for the triplets of the High Luminosity LHC'', A . Ballarino (CERN)

New SC lines for the feeding of magnets :
Power converters in surface and transfer of the current from the surface to the tunnel will bemade *via* SC links

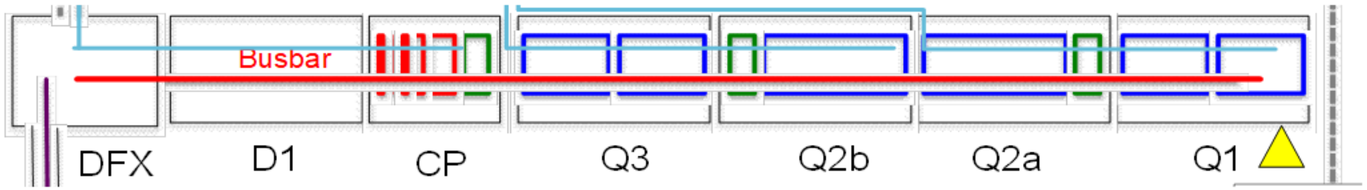
SC links contain tens of cables feeding different circuits and transferring more than 150 kA

MgB2 cables and high temperature SC



- Inner Triplet magnets **Project**

Nb3Sn technology - peak field of 11.4 T
2 outer quadrupoles, Q1 & Q3 +
central one divided into 2 identical magnets, Q2a and Q2b

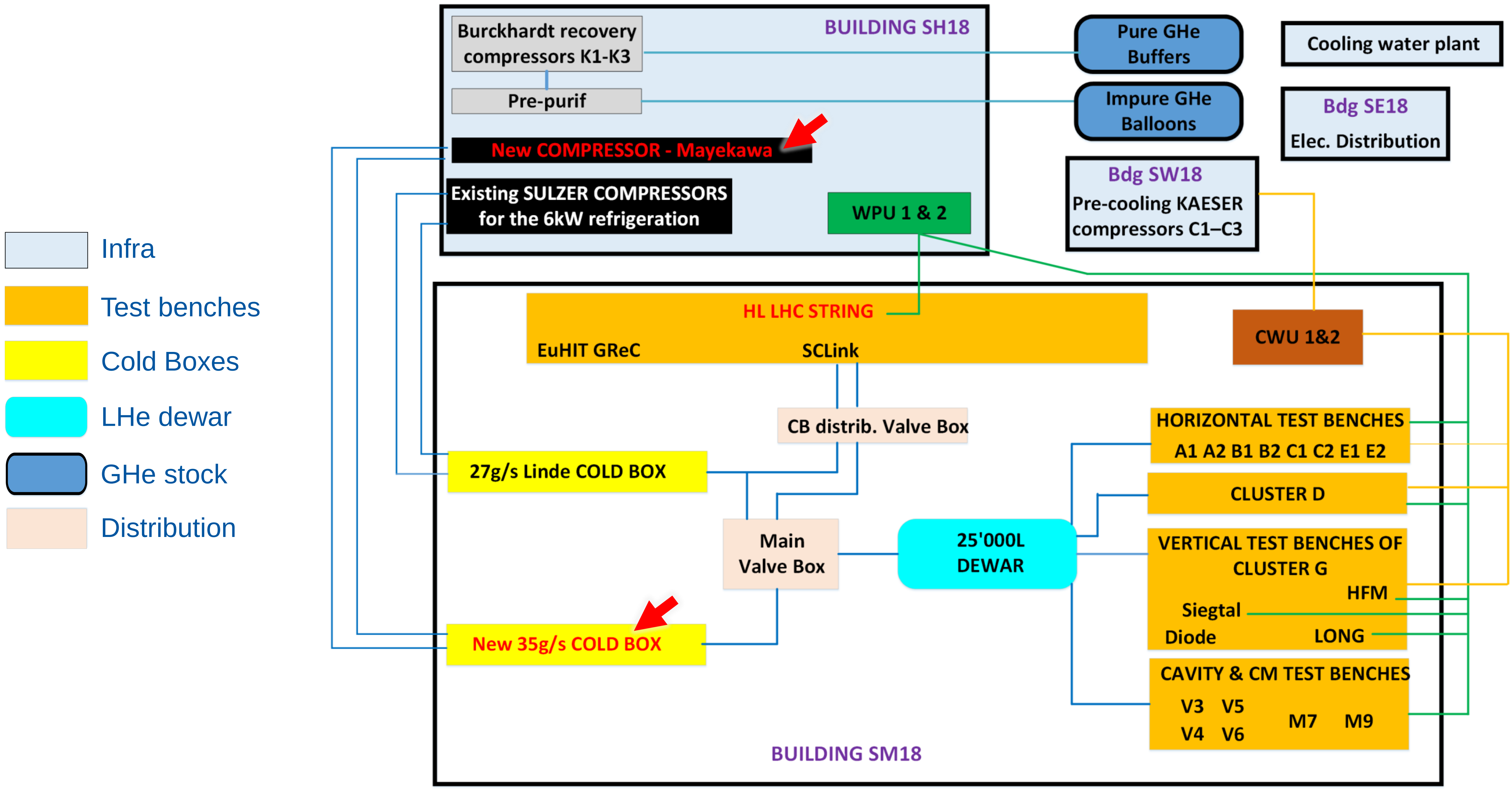


HL LHC String will be a new test stand to validate the collective behaviour of a structure including IT magnets

''HL-LHC IT STRING TEST'', M. Bajko,
LHC Performance Workshop 2018 Chamonix

OUTLOOK

SCHEMATIC LAYOUT OF THE SM18 CRYO INFRASTRUCTURE AFTER UPGRADE



SM18 NEW COLD BOX & MAYEKAWA COMPRESSOR

Mechanical Integration, Elec & Control System held at Linde Kryotechnik AG

Transport and arrival at the SM18
2019 MAY, 14

Cold Box installed
2019 MAY, 15

Mayekawa CP reception March, 26

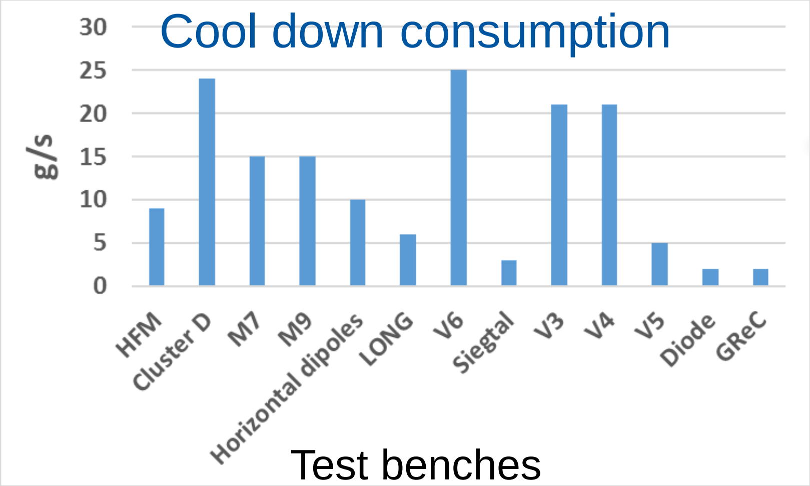
Mayekawa in SH18

OUTLOOK

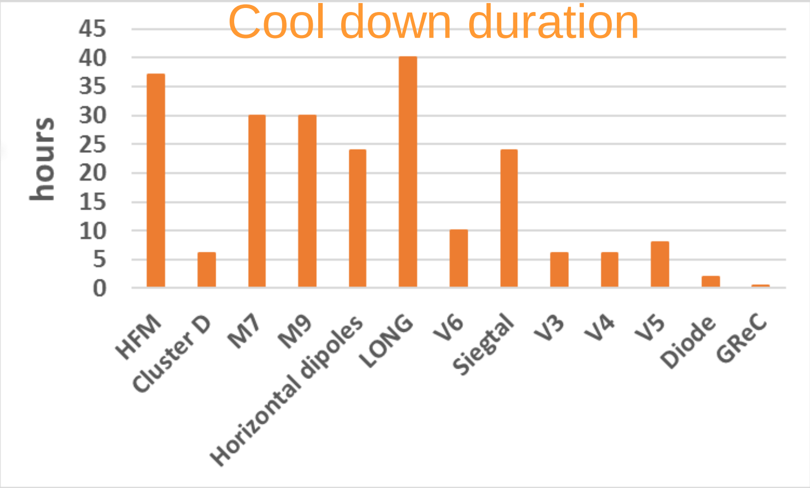
SM18 CRYOPLANT GENERAL KEY FIGURES : AFTER UPGRADE

Sytem	Characteristics
EXISTING 6kW CB – ''LINDE A''	27g/s *(~700L/h) @4.5K*
NEW Linde CB – ''LINDE B''	**35g/s *(~1000L/h)*** *@4.5K*
Process compression station	3 Stal He compressors (350 g/s @19 bar), 1.6 MW elec. power + ORS **+ new MAYEKAWA compressor (main drive motor of 1.4 MW)**
Very Low Pressure Pumping (WPU)	2 warm pumping units, each one : 6 g/s @ 10 mbar 12 g/s @ 20 mbar 18 g/s @ 30 mbar (max) To each WPU is dedicated a very low pressure heater of 32 kW (20g/s)
Pre-cooling to 80K	2 x CWU (80g/s - 2 x 120kW @80K) - With 3 Kaesers compressors
GHe Purification	5 x 80 m^3 Balloons at 1 bar (3 Burckardt recovery compressors + 2 Purifiers 200 Nm^3/h at 180 bars)
Pure GHe storage	8 x 75m3 @18 bars
LHe storage	1 x 25 m^3 LHe storage at 1.6 bar (+ 1x 10 m^3 mobile)
LN2 storage	50'000L Dewar

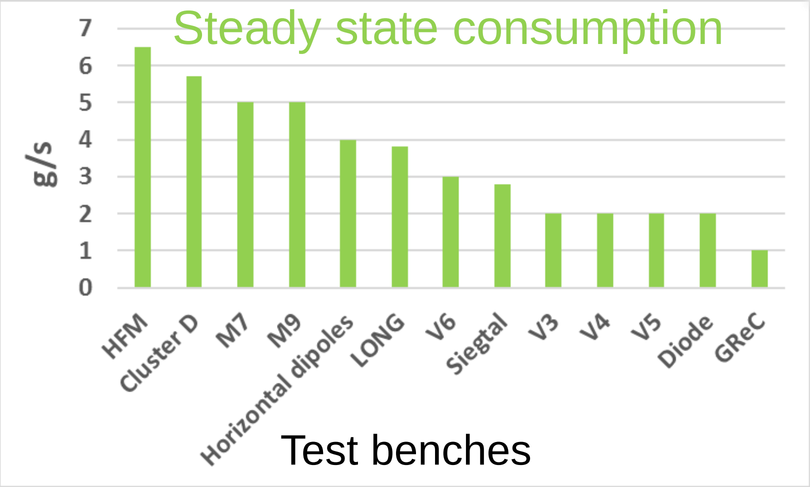
LHe CONSUMPTION



The cool down



The steady states

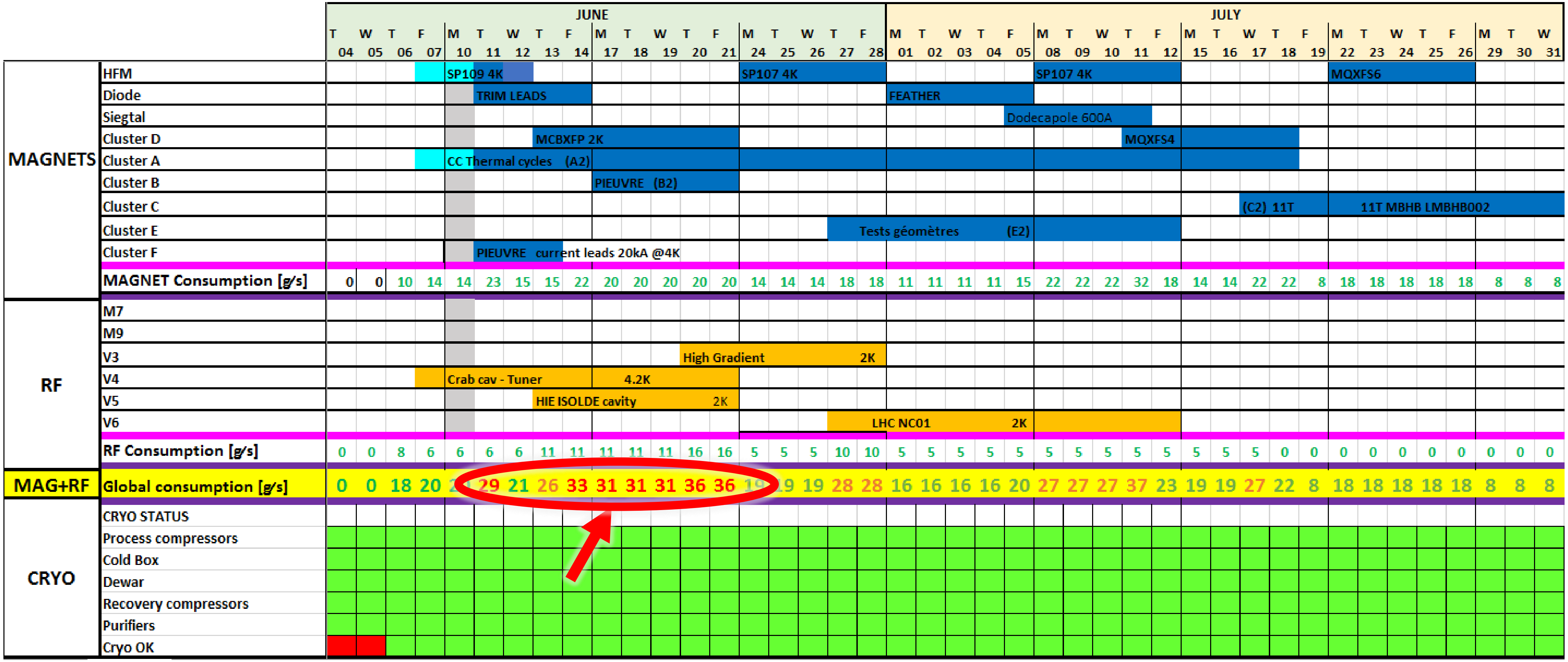


The Quench recovery

- **New 35g/s CB will significantly increase LHe capacity**
- The 27g/s CB will be dedicated to **HL LHC String** and could complement the **Dewar** for other test benches

EQUIPMENT	LHe FLOW FOR QUENCH RECOVERY [g/s]	QUENCH RECOVERY TIME [h]
HFM	12	4
Cluster D	12	4
Horizontal dipoles	14	2.25
LONG	6.8	2

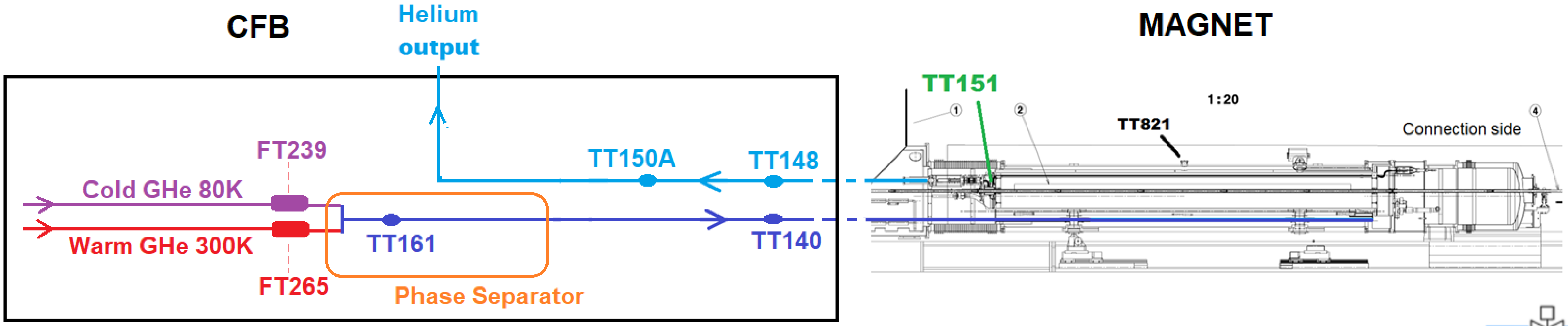
SM18 TYPICAL CURRENT PLANNING : LHe DISTRIBUTION FOR THE TESTS



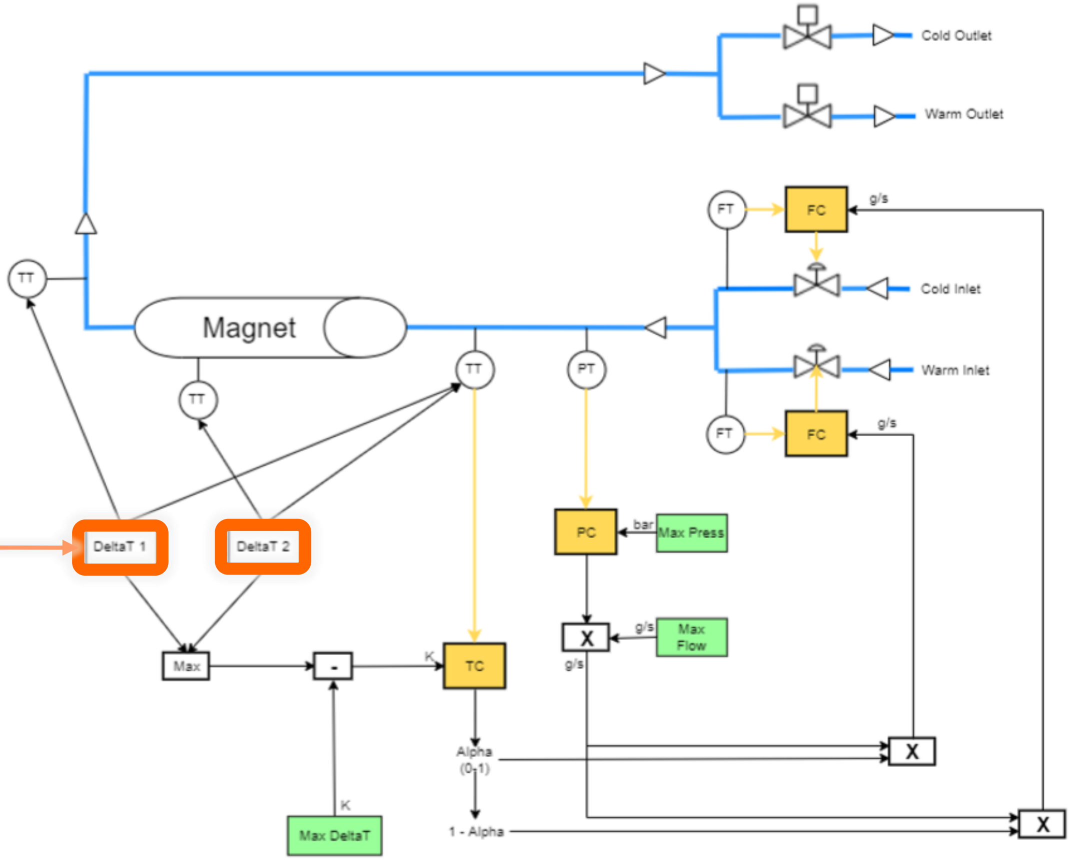
A priority management is currently essential for the cool down organisation (capacity limited to 27 g/s)

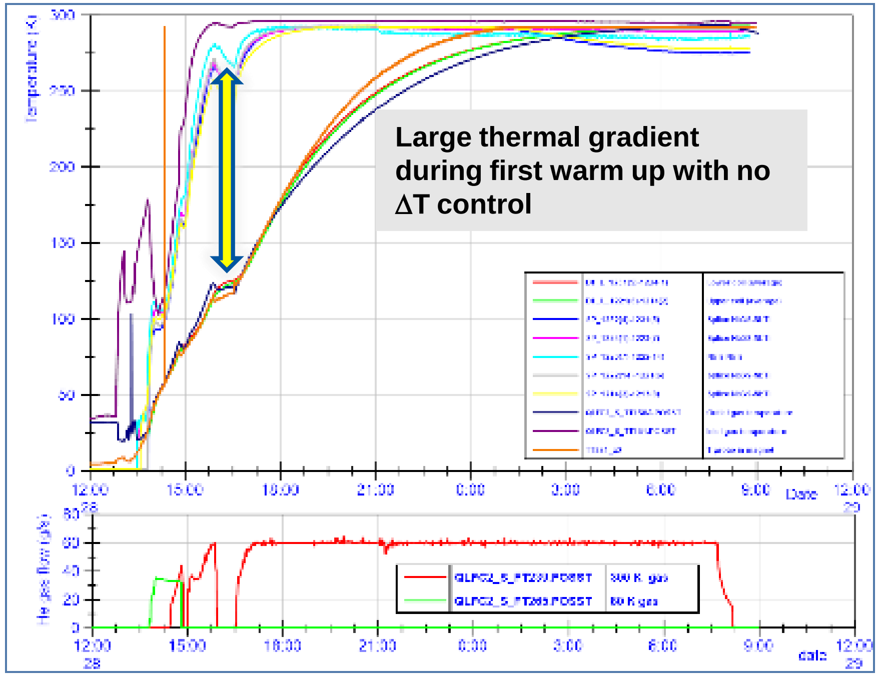
OUTLOOK

AUTOMATED ΔT CONTROL FOR Nb3Sn 11Tesla MAGNETS IN THE 80 – 300K RANGE

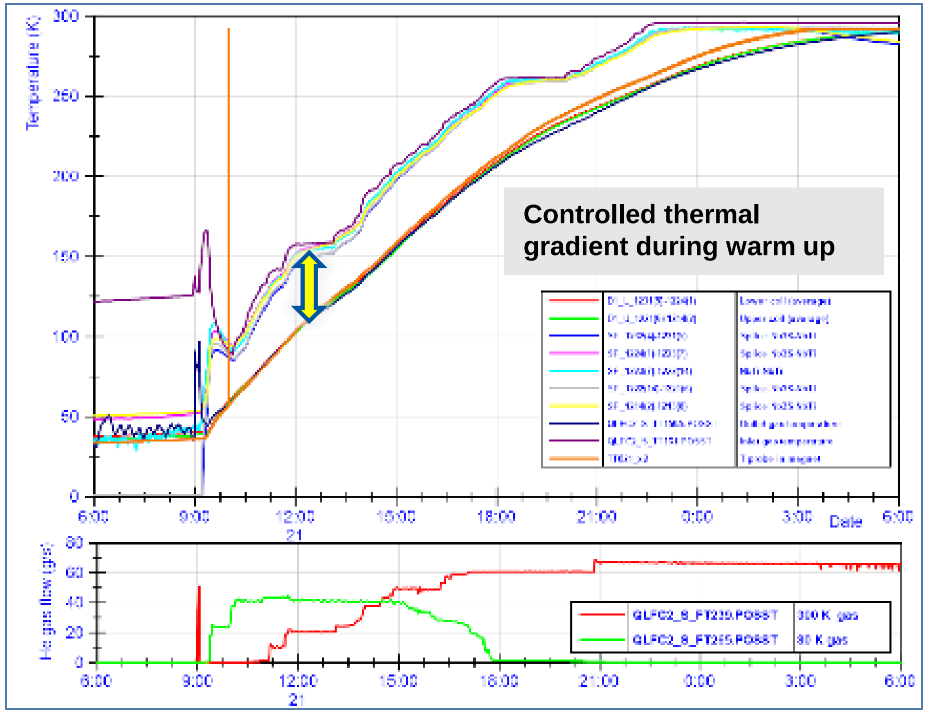


- Installation of a new PT100 (**TT151**) close to the magnet cold mass
- Installation/replacement of TTs by new CERNOX in the CFB
- Upgrade of Flow Transmitters (FT) : calibration & control
- Circulation into the magnet shield to smooth the cool down/warm up
- Continuous regulation of the **ΔT** with regulation loops





Nb3Sn magnet warm up using mainly 300K gas and same process than NbTi magnet



Controlled warm up using mixing 300 and 80 K gas to respect ΔT < 30K on critical points

The ΔT control has been implemented in automated process by TE-CRG and successfully applied for the MBHB-02 11Tesla series magnet early July 2019

OUTLOOK

The upgrade of the cryogenic system at the SM18 gives the possibility to :

- Increase the global LHe capacity for the Magnets and RF cavity tests

- Ease Quenches recovery for Magnet tests

- Allow one CB/Compressor system to be under maintenance while the LHe supply to Dewar can continue

⇒ Operation flexibility & Redudancy in case of major issue

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