Design, procurement, installation and commissioning of the cryogenic infrastructure for a new superconducting RF test facility with beam at CERN

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Introduction. The High-Luminosity LHC project – HL-LHC aiming at peak luminosity above $5.0.10^{34}$ $cm^{-2}.s^{-1}$ consists in replacing the matching sections on both sides of the ATLAS and CMS experiments. To complement new focusing quadrupoles, this upgrade considers using crab cavities, never operated with protons. New cryogenic infrastructure was thus initiated and recently installed at CERN SPS accelerator in 2018. This poster describes the main cryogenic requirements of this infrastructure, its design challenges, procurement, installation, and commissioning up to stable operation of the crab cavities module in superfluid helium at 2 K.

Design principles and key features

Cryogenic distribution system

- **2 valve boxes** – VB1 as interface to the cold box, VB2 to the Service Box
- **Sub-cooler in VB1 phase separator** to recondition supercritical helium supply stream
- **80 m long distribution line** (TL): supercritical He for the supply and thermal shielding to minimize the losses
- Liquid helium produced at VB2 then sent to the Service Box

Service Box

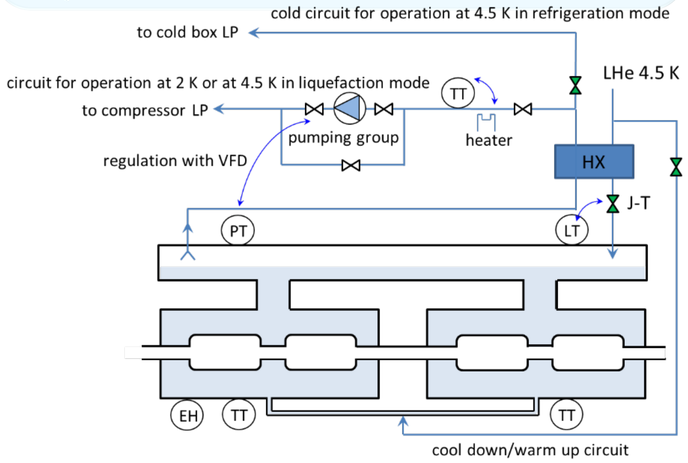
- Main function: provide **adapted interfaces** between 4.5 K distribution, client cryostat and helium pumping system
- **Integrated subcooling heat exchanger** for supply helium stream precooling

Helium pumping system

- Water bath heater, installed power 10 kW
- 2 Roots pumping units, total 2.3 g/s at 20 mbar abs

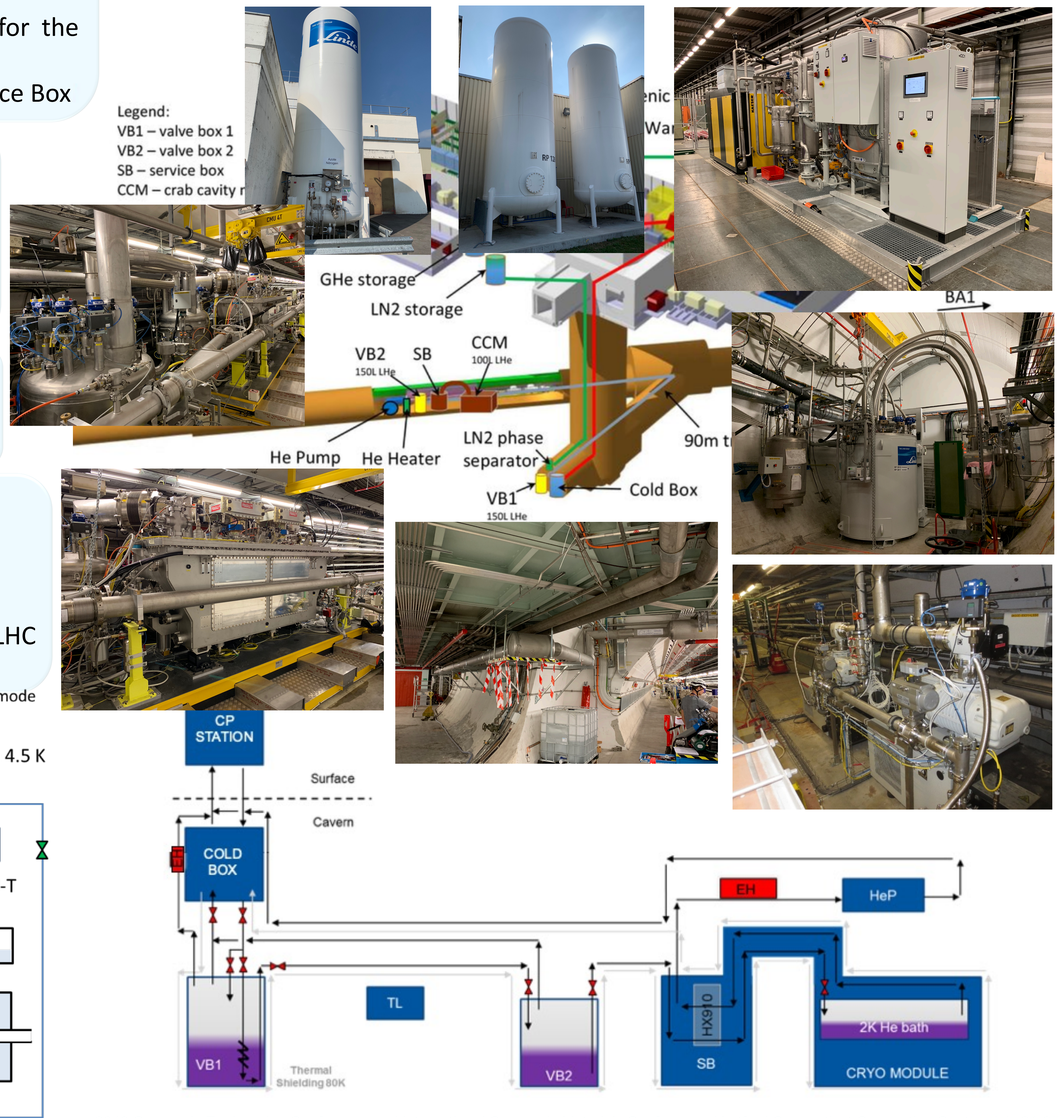
Crab cavities cryomodule

- 4.5 K LHe sat and 2 K – 30 mbar abs operation
- 18 W (static) and expected 13 W (dynamic) @ 2 K
- **Integration in SPS** (same proton beams as in LHC)
- **Mobile platform to bypass it** when SPS serves as LHC injector



Movable helium cryoplant @ 4.5 K

- 4 major **constraints**: timeframe of the supply, guarantee of the required performances, accessibility of installation location, **movability** requirement
- **Liquefaction** mode: **7 g/s of LHe @ 4.5 K + 750 W shielding @ 50 – 80 K**
- **Refrigeration** mode: **700 W @ 4.5 K + 300 W shielding @ 50 – 80 K**
- **LN_2 precooling** in both modes
- **LR280** from Linde Kryotechnik AG® with liquefaction and refrigeration turbines



Procurement timeline

Package	Phase	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Q2	2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4	2020 Q1	2020 Q2	2020 Q3	2020 Q4
Infrastructure (warm piping / GHe / LN2)	Studies & Requirements																				
	Tendering																				
	Engineering & Fabrication																				
	Installation																				
	Comissioning																				
	Operation																		Tentative		
	Consolidation																				
Movable helium cryoplant	Studies & Requirements																				
	Tendering																				
	Engineering & Fabrication													LONG							
	Installation																				
	Comissioning																				
	Operation													SHUT-					Tentative		
	Consolidation																				
Cryogenic distribution	Studies & Requirements																				
	Tendering													DOWN							
	Engineering & Fabrication		Transfer Line				Valve Boxes														
	Installation					Phase 1				Phase 2				2							
	Comissioning																				
	Operation																		Tentative		
	Consolidation																				
2 K cryogenic sub-system	Studies & Requirements																				
	Tendering																				
	Engineering & Fabrication																				
	Installation								Phase 1	Phase 2											
	Comissioning								SM18	SPS											
	Operation																		Tentative		
	Consolidation																				

Commissioning and operation