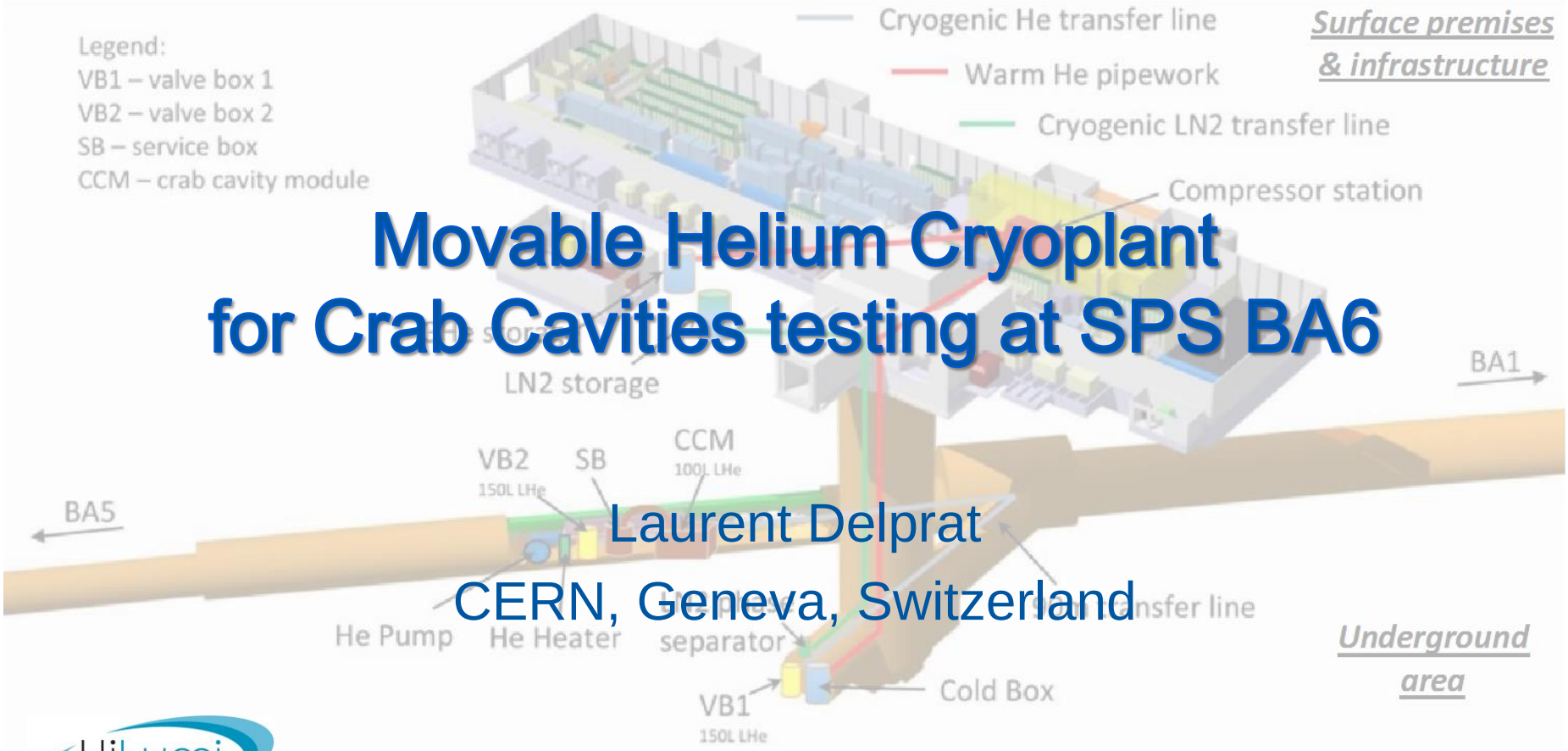

Movable Helium Cryoplant for Crab Cavities testing at SPS BA6

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Research supported by the High Luminosity LHC project

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OUTLOOK

- Introduction to High-Luminosity LHC project – HL-LHC
- Design principles and key features
- Timeline of procurement and installation
- Commissioning and operation
- Conclusions and perspectives

Introduction

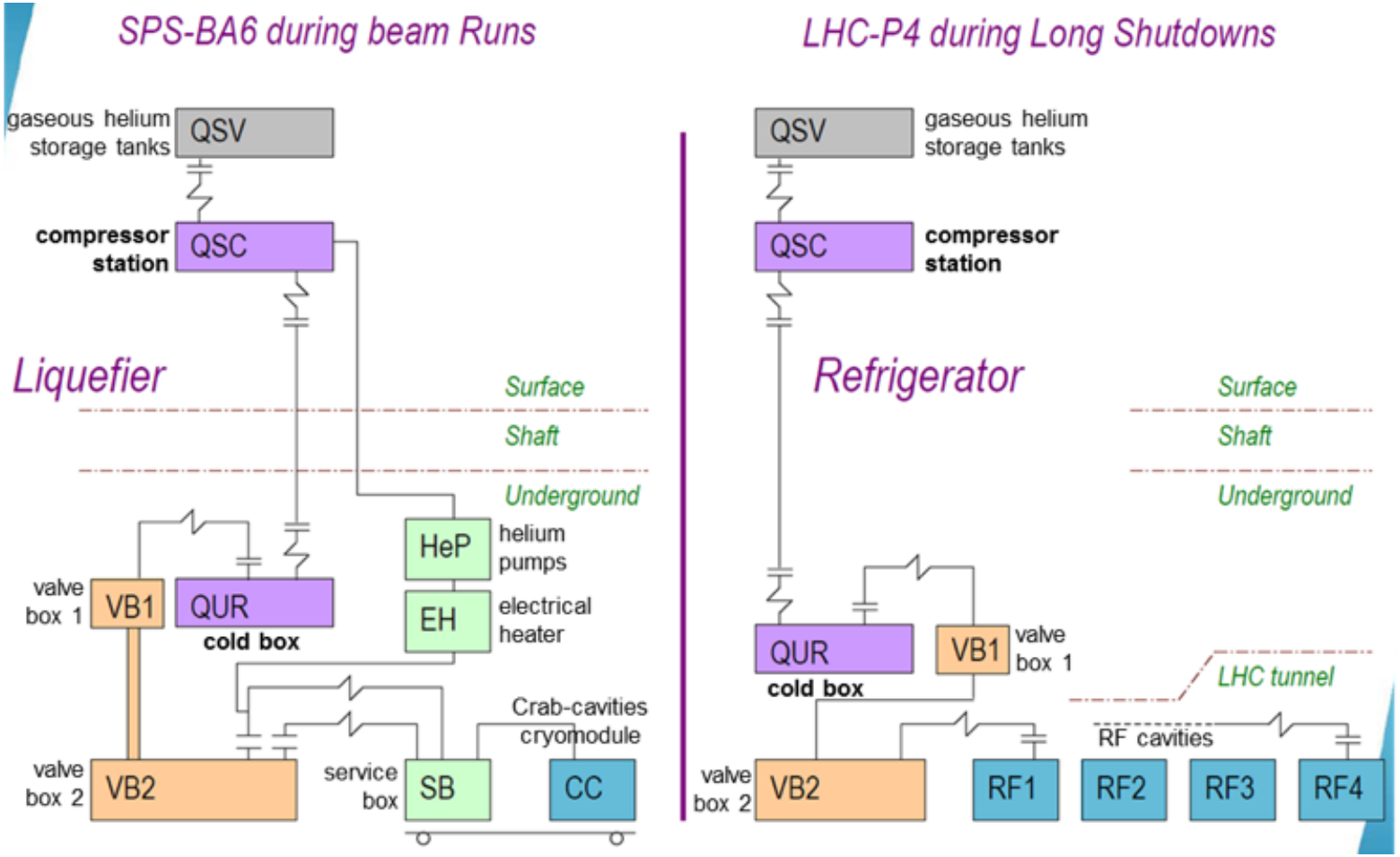
- Goal of peak luminosity above $5.0.10^{34}$ $cm^{-2}.s^{-1}$
- Replacing the matching sections on both sides of ATLAS and CMS experiments
- New focusing quadrupoles
- Use of superconducting crab cavities

Need for a new cryogenic infrastructure

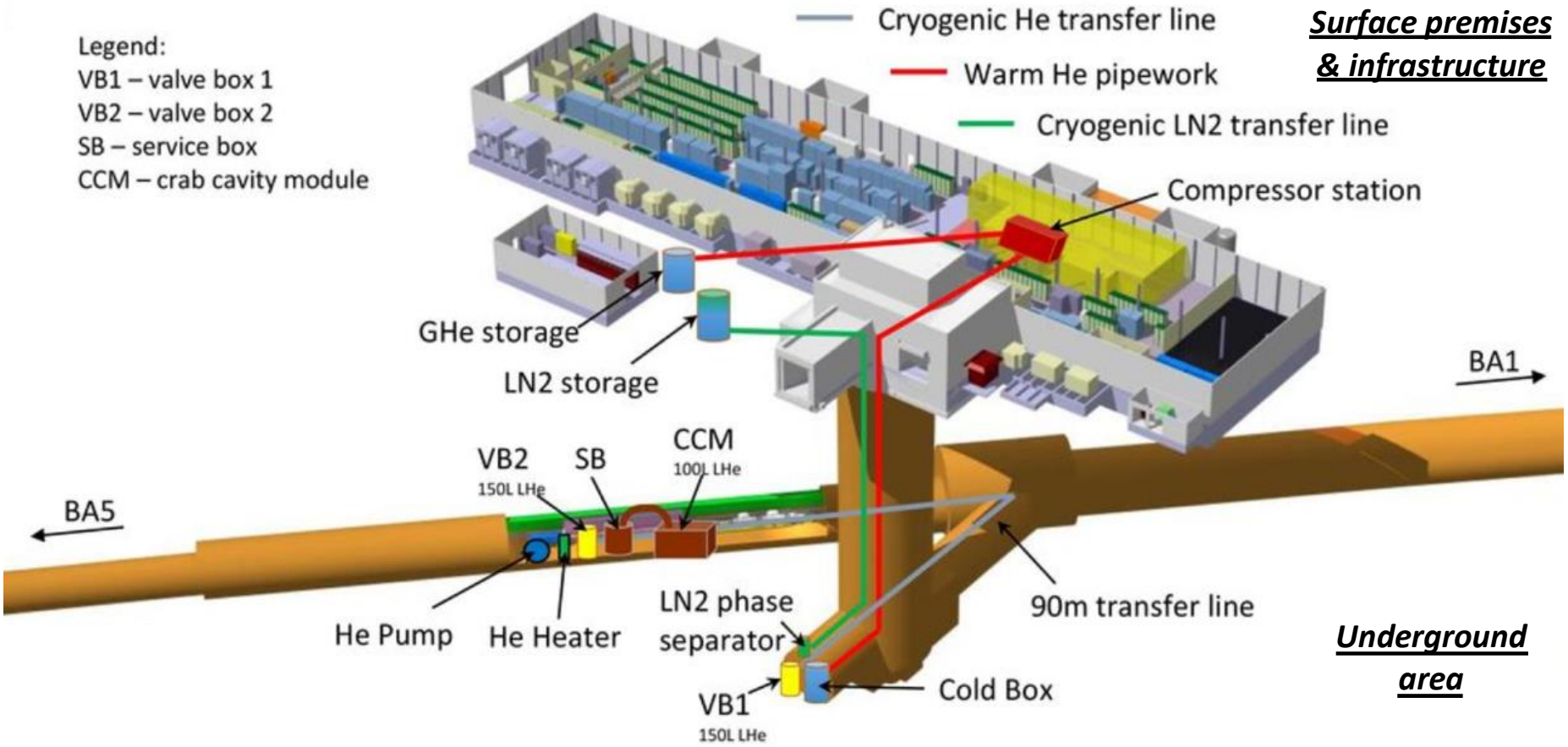
for a superconducting RF test facility with proton beams

at CERN SPS accelerator

Design principles and key features



Design principles and key features



Design principles and key features

Movable helium cryoplant @ 4.5 K

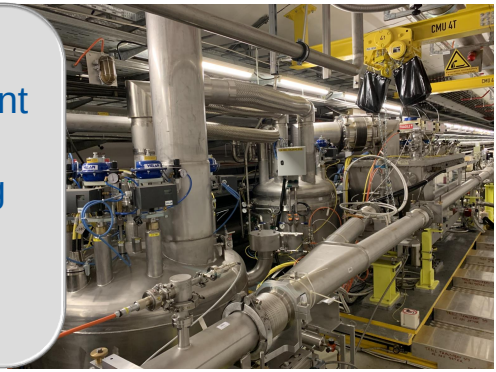
- 4 major **constraints**: timeframe of the supply, guarantee of the required performances, accessibility of installation location, **movability** requirement
- **Liquefaction** mode: **7 g/s of LHe @ 4.5 K + 750 W shielding @ 50 – 80 K**
- **Refrigeration** mode: **700 W @ 4.5 K + 300 W shielding @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

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

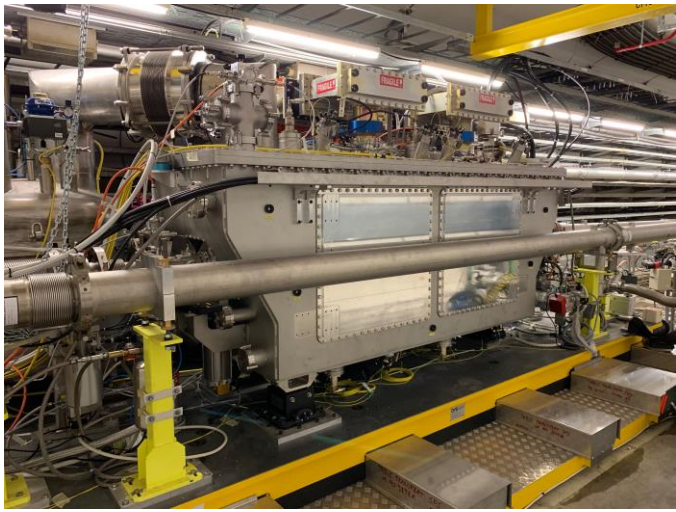
- Main function: provide **adapted interfaces** between 4.5 K distribution, client cryostat and helium pumping system
- **Integrated subcooling heat exchanger** for supply helium stream precooling



Design principles and key features

Crab cavities cryomodule

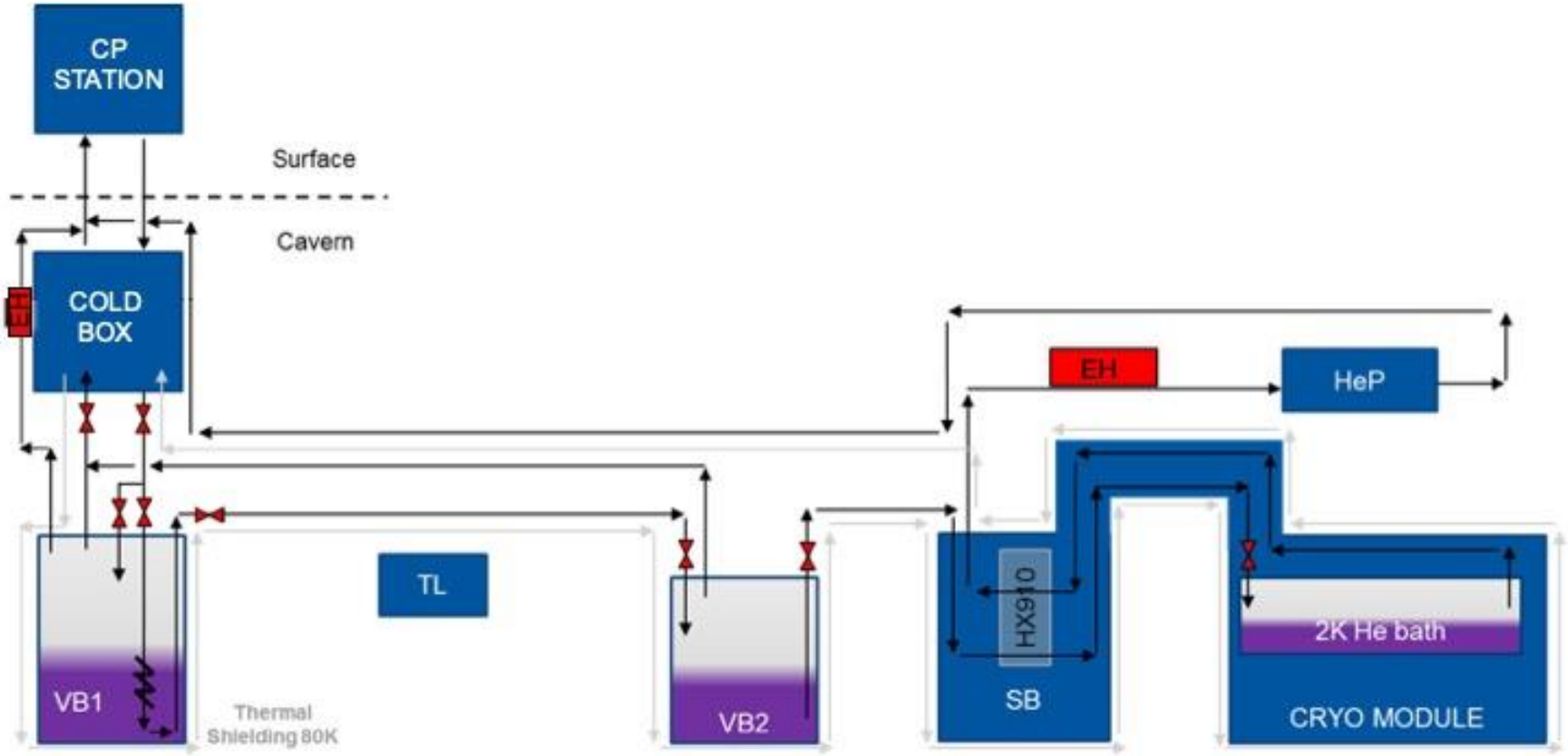
- 4.5 K LHe sat and 2 K – 30 mbar abs operation
- 18 W (static) and expected 13 W (dynamic) @ 2 K
- **Integration in SPS** (same proton beams as in LHC)
- **Mobile platform to bypass it** when SPS serves as LHC injector



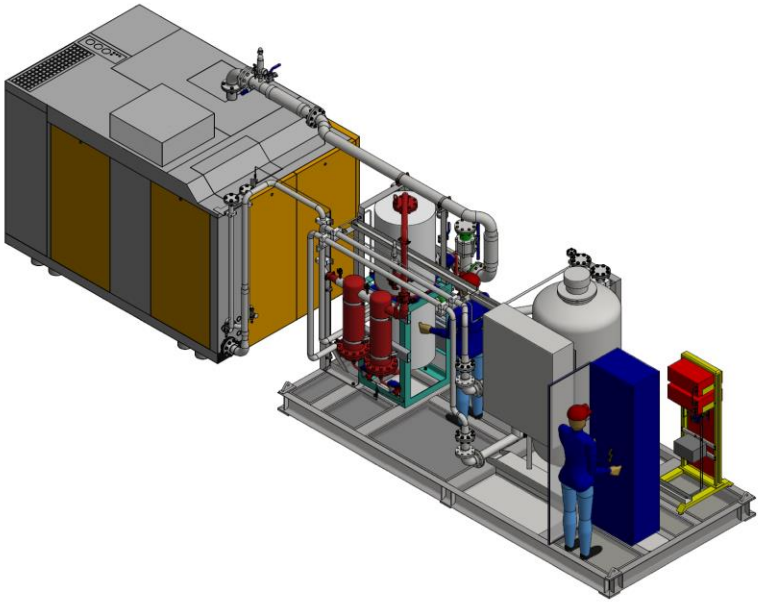
Helium pumping system

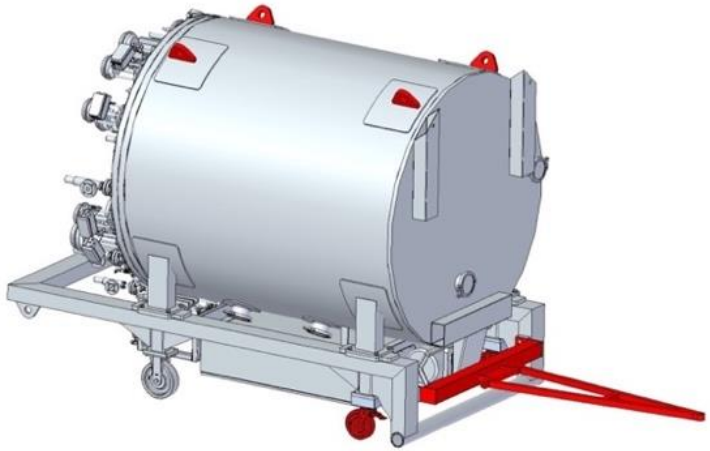
- Water bath heater, installed power 10 kW
- 2 Roots pumping units, total 2.3 g/s at 20 mbar abs

Simplified flow diagram

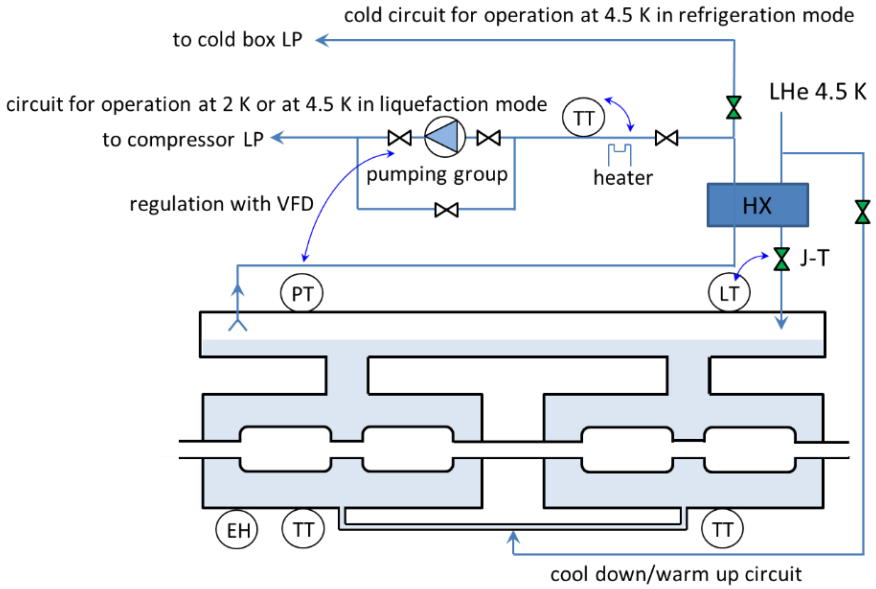


Design of the 4.5 K cryoplant





Principle of 2 K cooling system of the cavity



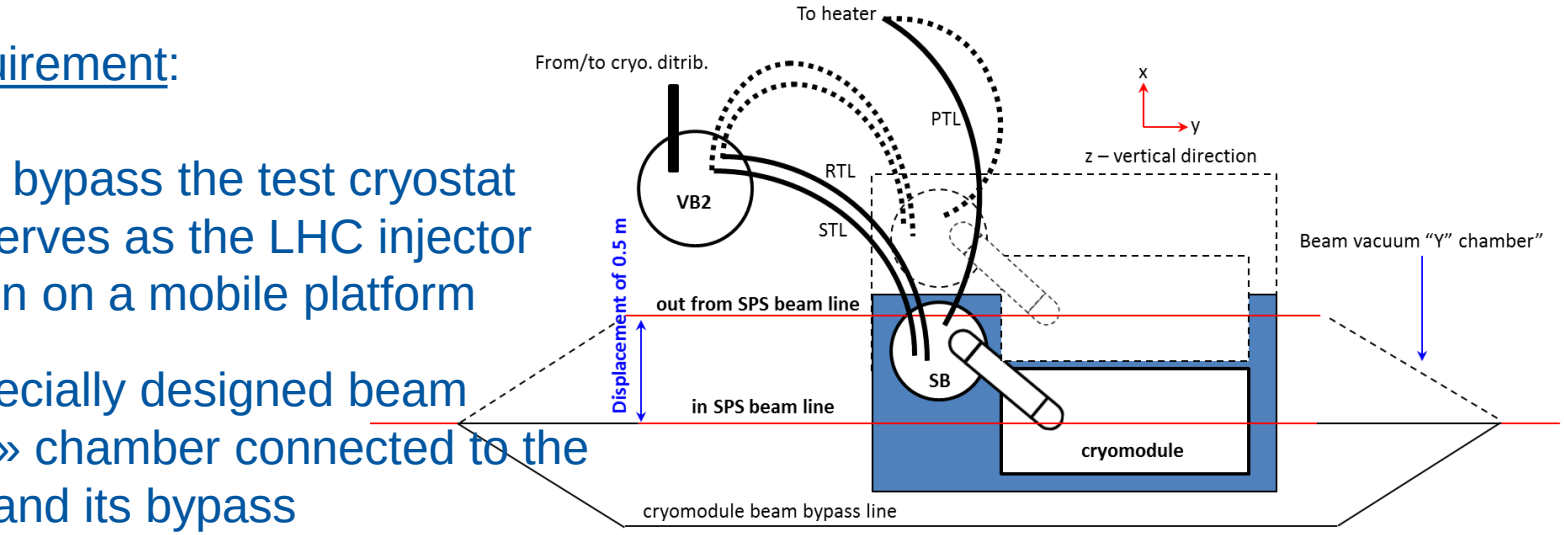
2 K operation:

- Saturated superfluid helium bath
- Integrated subcooling heat exchanger
- Water bath heater – installed power of 10 kW
- Helium pumping system – 2.3 g/s at 20 mbar abs

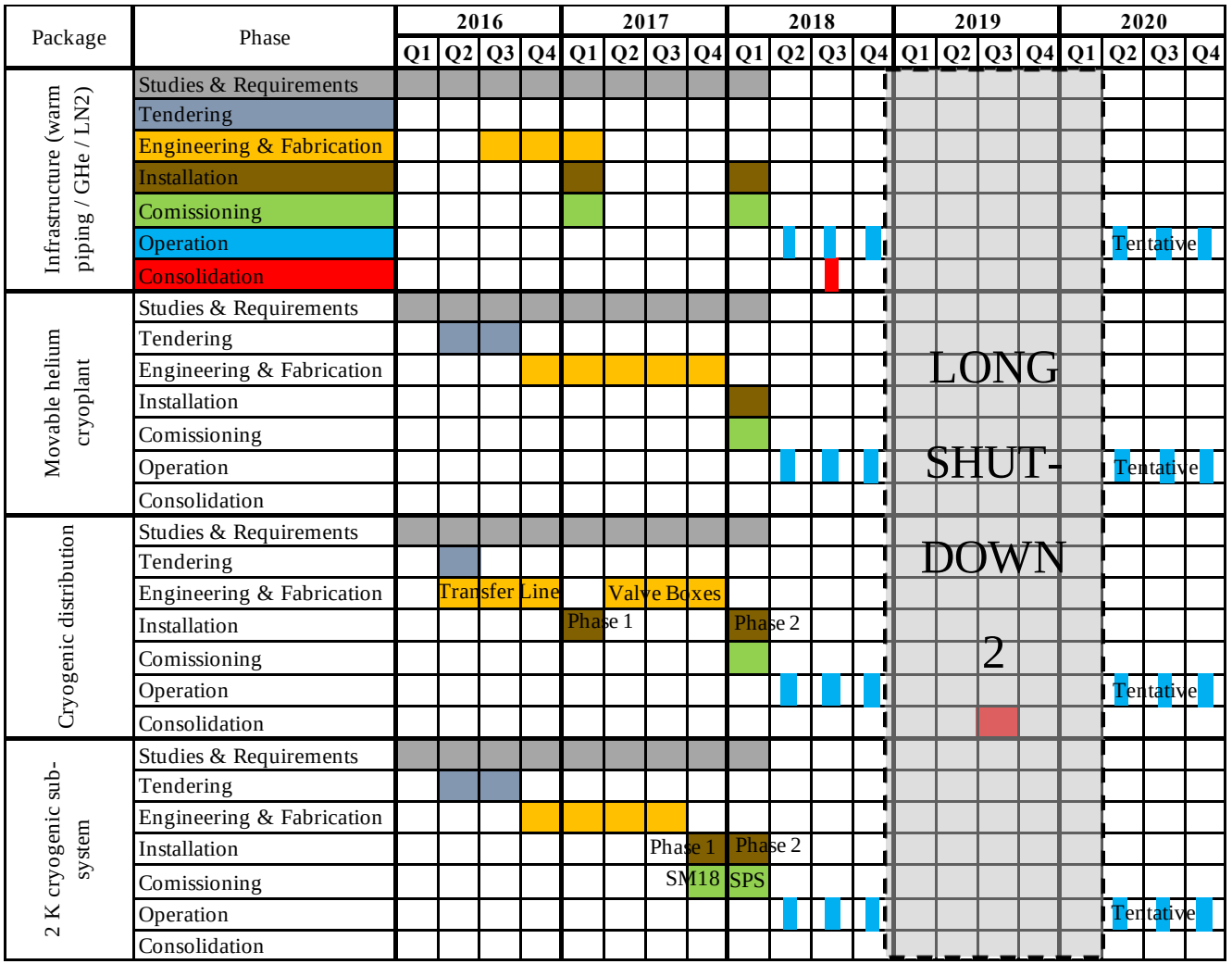
Integration requirement:

- Possibility to bypass the test cryostat when SPS serves as the LHC injector => installation on a mobile platform

  => use of specially designed beam vacuum « Y » chamber connected to the cryomodule and its bypass



Timeline of procurement

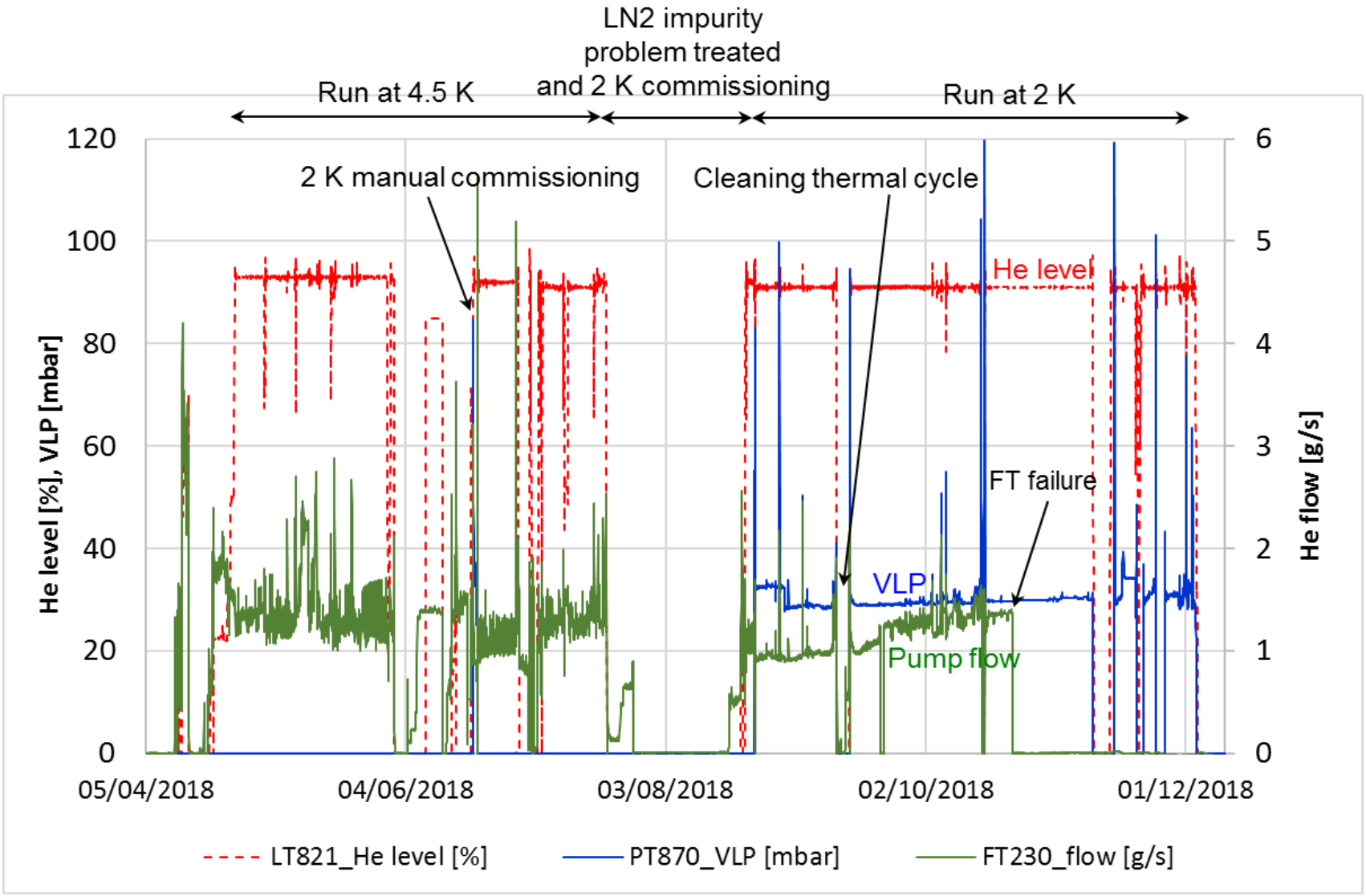


2016: studies and procurements launched

2017: detailed engineering & fabrication

2018: commissioning and operation

Commissioning and operation



Conclusions and perspectives

- The complete 2 K cryogenic infrastructure was **designed and built from scratch between 2016 and beginning of 2018**,
- The **reception test** was conducted **during Q1 of 2018** with direct operation afterwards,
- **First stable operation** of crab cavities in LHe successful in **spring 2018**, in superfluid helium from September 2018,
- **Long Shutdown #2** started with the stop of the cryogenic test facility, allowing for the required maintenance and consolidation,
- **Restart** of the whole facility **in 2020** to allow for completing performance assessment and further testing of the cavities with proton beams in SPS

Thank you for your attention !

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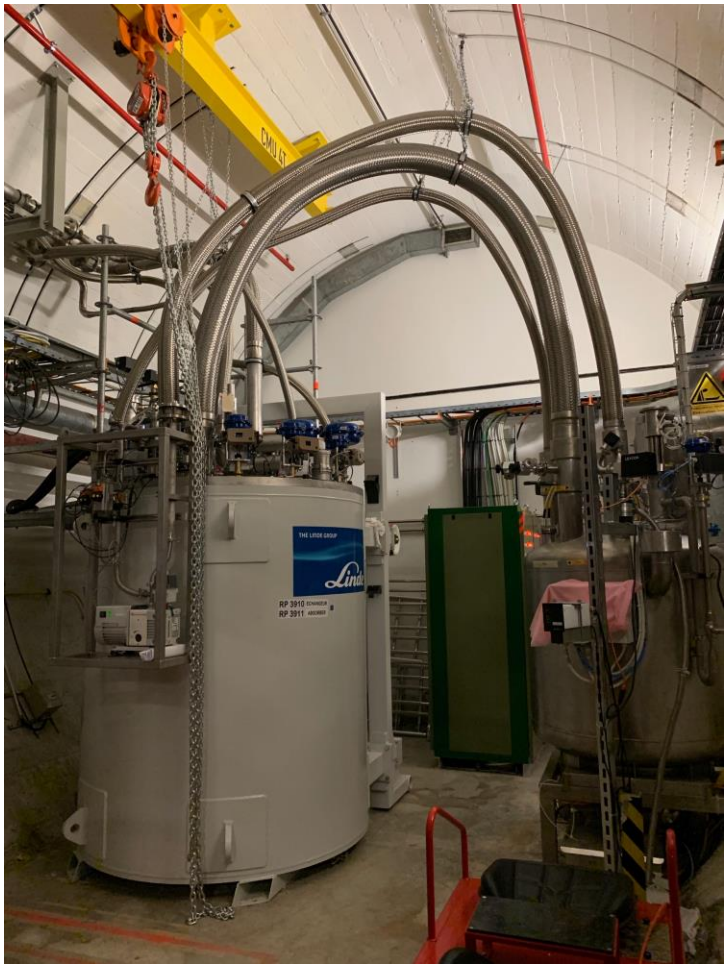
GHe and LN2

Compressor station

Cold Box and LN_2 phase separator



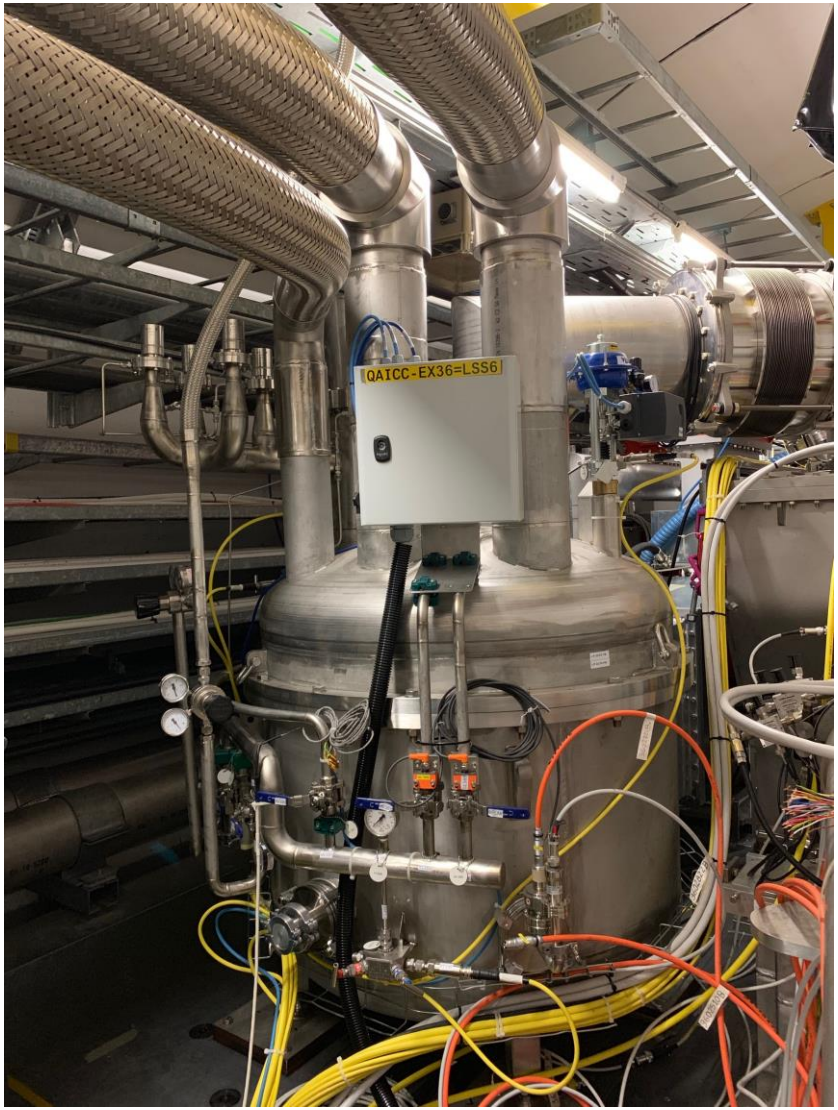
CB, LN_2 φ-sep, VB1

VB1

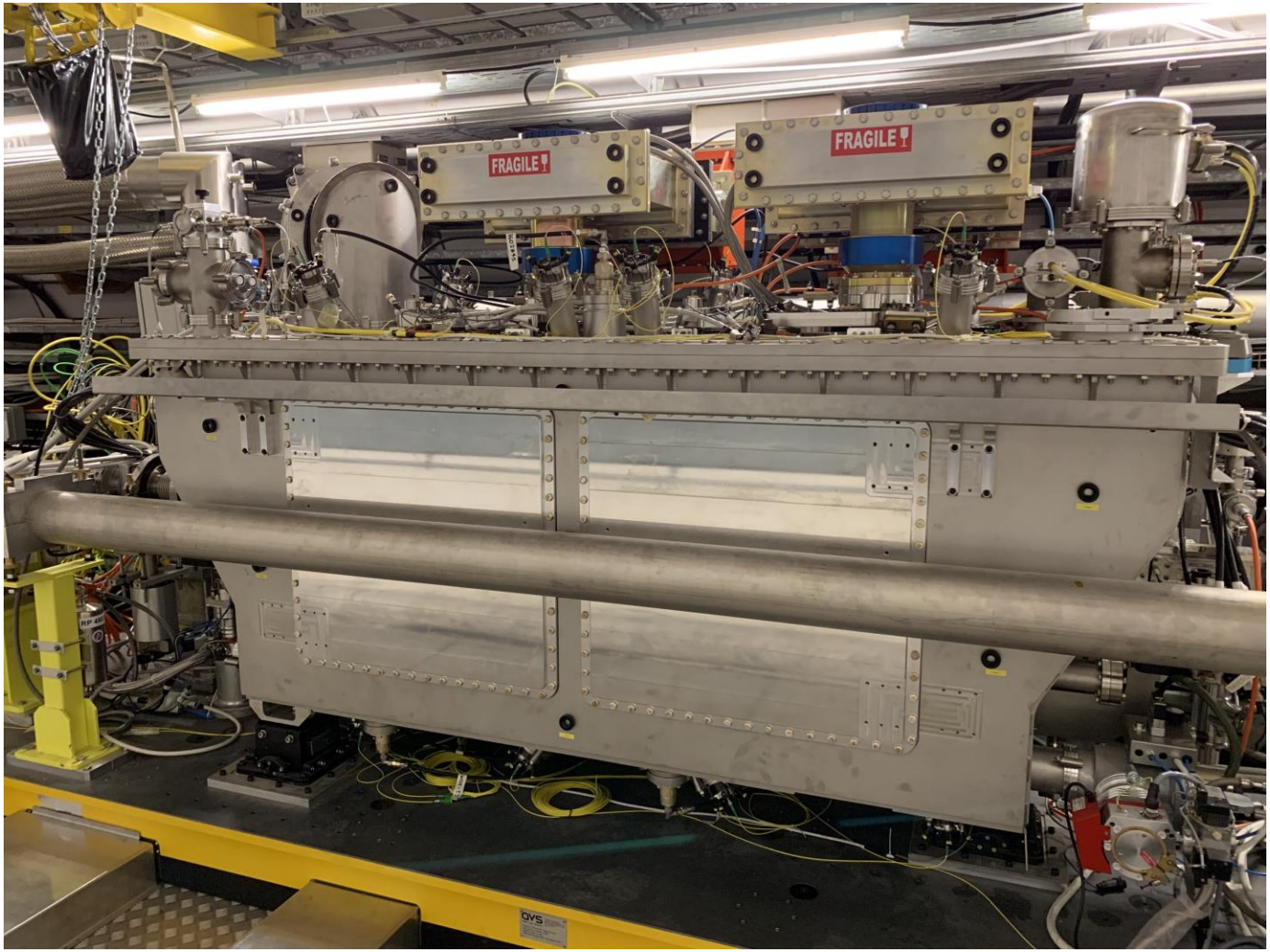
Transfer line

VB2

Service Box



Crab cavities cryomodule



VB2, SB, CM