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A new cryogenic test facility for large superconducting devices at CERN

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Acknowledgements: all people of the S-FRS test project at CERN and at GSI Helmholtz Center for Heavy Ion Research

Outline

Introduction

Description of the cryogenic system of the new test facility

Current project status and conclusions

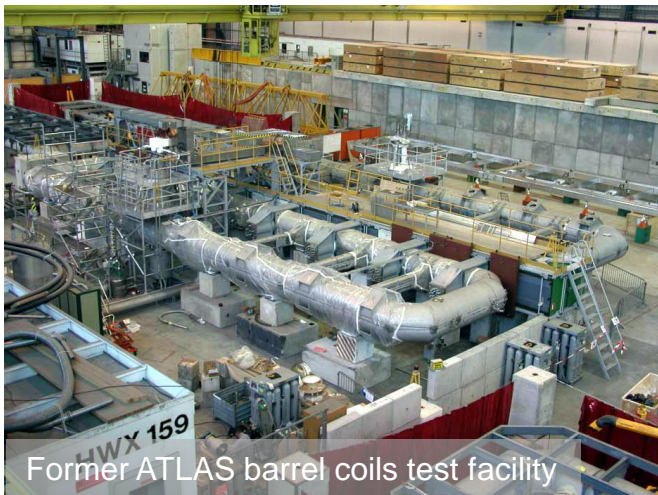
A new facility for large devices?

Several cryogenic test facilities exist at CERN for testing superconducting magnets and cavities. Up to sizes like LHC dipoles (15 m long, 30 ton).

For even larger devices?

For the LHC detector magnets, dedicated facilities were created.

Their cryogenic systems are now either used for production or unavailable because of the end of lifetime of some of their components.



FAIR S-FRS magnets tests at CERN

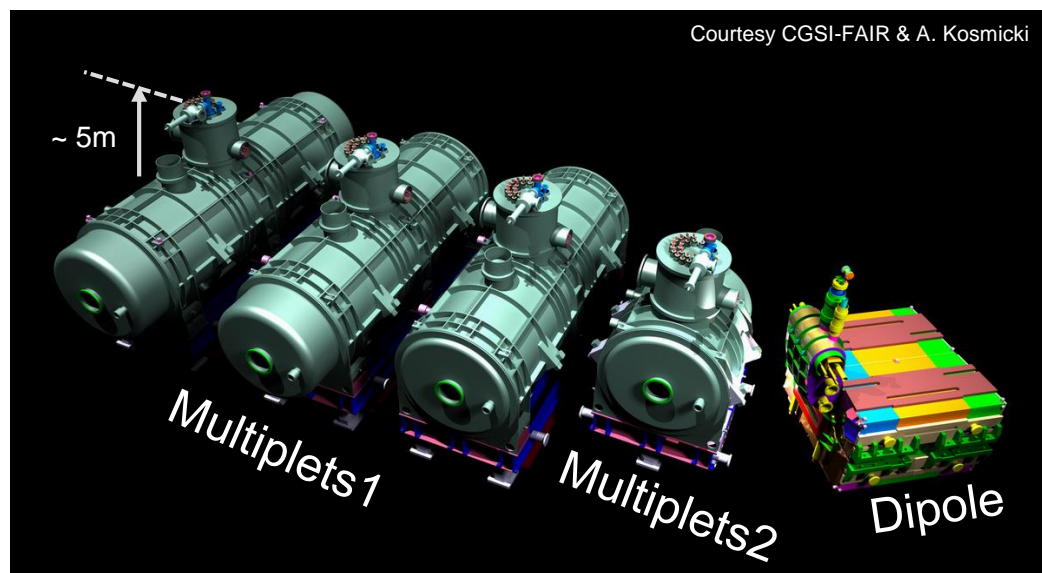
In the framework of a collaboration agreement between CERN and GSI-FAIR, **57 S-FRS magnets will be tested at CERN at 4.5K**: 48 multiplets and 9 dipoles.

Mass **up to 70 tons** and dimensions **up to 5 m high** (see H. Kolmuss et al. C2OrE-05 at this conference).

Test rate approx. 21 units/year. Time on test bench 42 days.

There are three type of magnets:

Type	#	Tot. mass [ton]	Cold mass [ton]
dipole	24	50	2
multiplet 1	24	70	45
multiplet 2	9	25	20



A new test facility for large and heavy devices is needed !

Architecture and dimensioning parameters

The **S-FRS magnets tests** is the **major driver for defining the architecture and dimensioning parameters**. A detailed study of the parameters [is presented at this conference C2PoF-04](#).

The test sequence is planned to last about **42 days for each magnet**.

The required test rate is **21 magnets / year**:

- **three test benches**
- **two cool-down/warm-up**

Dimensioning parameters for performing the test sequence for a multiplet 1 (heaviest magnet)

Test Phase	Requirement
Cool-down 293 K – 90 K	5.6 kW cooling power, 21.4 g/s at 10 bar
Cool-down 90 K – 4.5 K	6.2 m ³ of saturated LHe at 4.5 K
Filling of magnet with LHe	1.4 m ³ of saturated LHe at 4.5 K
Cold tests heat loads	30 W static at 4.5 K + 35 W dynamic during 10 minutes, 160 W at 60 K – 90 K (screen) 1.6 g/s at 4.5 K – 300 K (liquefaction load)
Warm-up 90 K – 293 K	5.4 kW heating, 20 g/s at 10 bar

Requirements for the new facility

- Provide the functionalities to perform the tests of the S-FRS magnets
- Possibility to add one test station easily for future detector magnets tests
- Re-use, when possible, existing systems that were used for the tests of the magnet system of the ATLAS LHC experiment.



- Facility located in the same location as ATLAS magnet tests (B180)
- For cryogenics
 - Re-use existing Sulzer (Linde) TCF200 cold box
 - Re-use existing distribution valve box and cool-down unit



The new test facility

In B180 (very large building)
Previously used for the ATLAS
magnet tests.

Devices that can be tested:

Up to **55 ton 7 m** high max

Up to **89 ton 5 m** high max

1400 m² reserved for facility

40 m x 30 m

Facility will include:

Cryogenic system

Power converters

Magnetic measurements

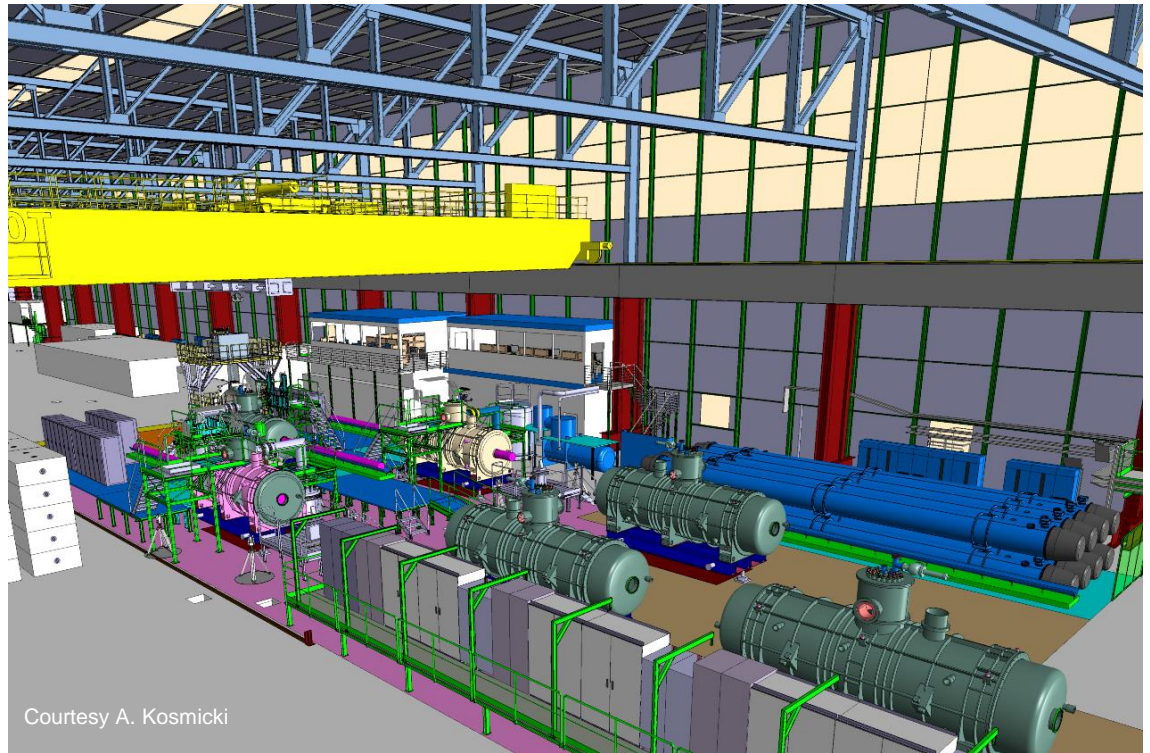
Quench protection

Two buildings:

B279: compressors

- Noise protection
- Oil spillage protection

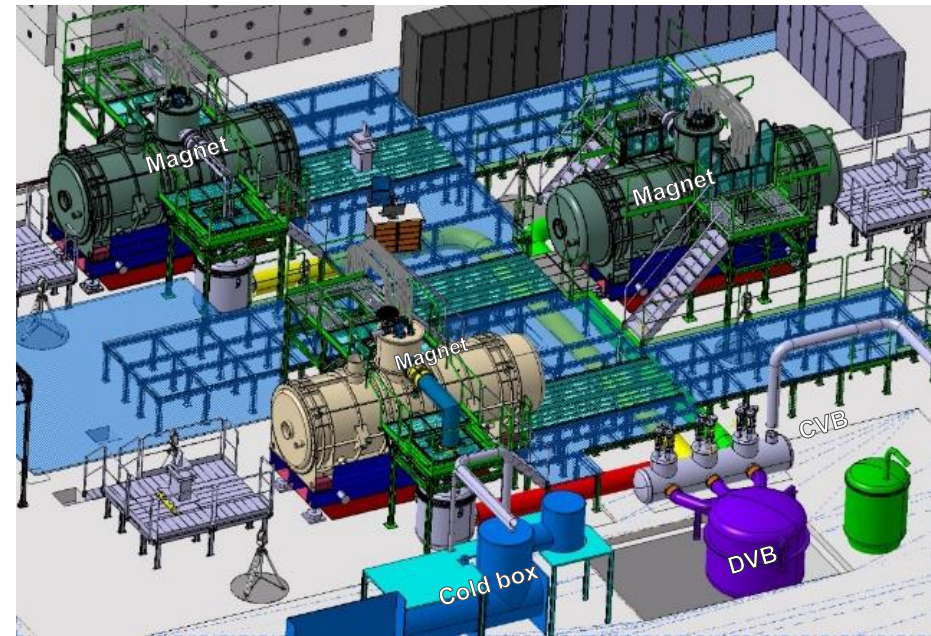
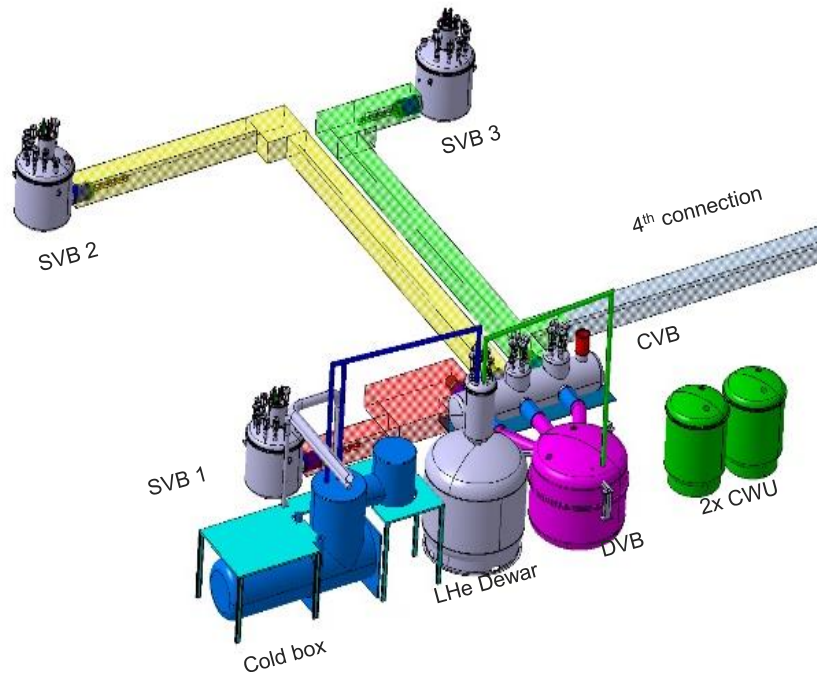
B180: cryogenics and tests



Close view of the architecture of the test facility



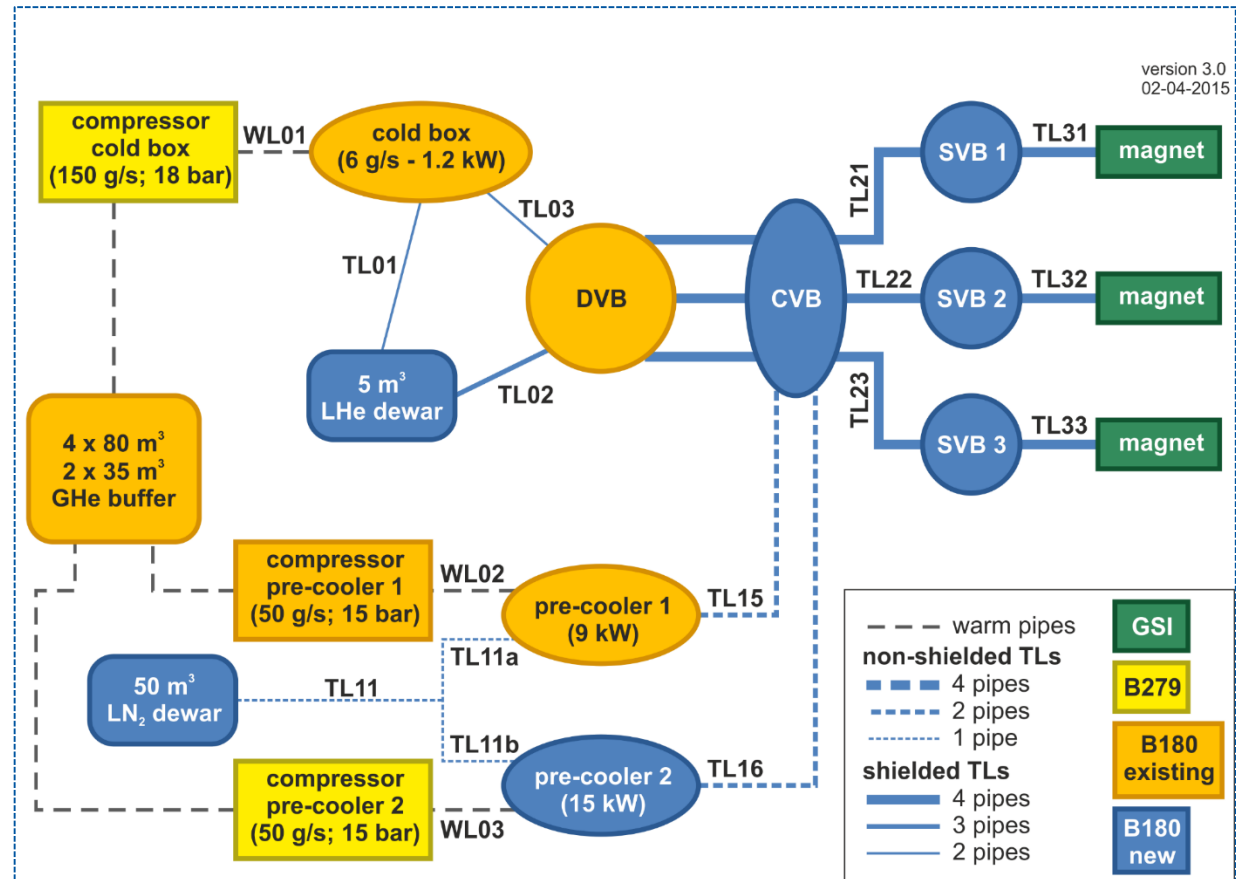
Layout of the cryogenic system



- 1 cold box (existing TCF200)
- 2 LN2 cool-down/warm-up units (CWU) (1 existing, 1 new)
- A 5 m³ LHe dewar
- A cryogenic distribution system:
 - 3 test benches with satellite valve boxes (SVB) next to the magnets
 - A LHe/SCHe distribution valve box (DVB)
 - A connection valve box (CVB) to connect the CWUs

Configuration of the cryogenic system

- 1 cold box (existing TCF200)
- 2 LN2 cool-down/warm-up units (CWU) (1 existing, 1 new)
- A 5 m³ LHe dewar
- A cryogenic distribution system:
 - 3 test benches with satellite valve boxes (SVB) next to the magnets
 - A LHe/SCHe distribution valve box (DVB)
 - A connection valve box (CVB) to connect the CWUs
- GHe buffers
- 3 Compressor stations
- 50m3 LN2 dewar



Existing Sulzer (Linde) TCF 200 cold box

Compression & GHe input

Supply pressure: 18 bar
Input flow: 150 g/s
Specified max
Electrical power 700 kW

Refrigeration at 4.5 K / liquefaction

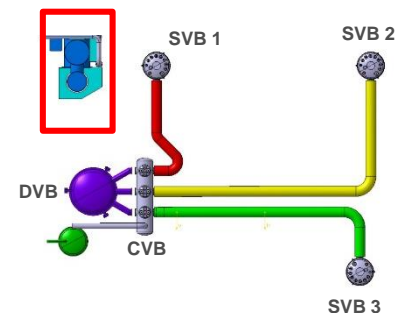
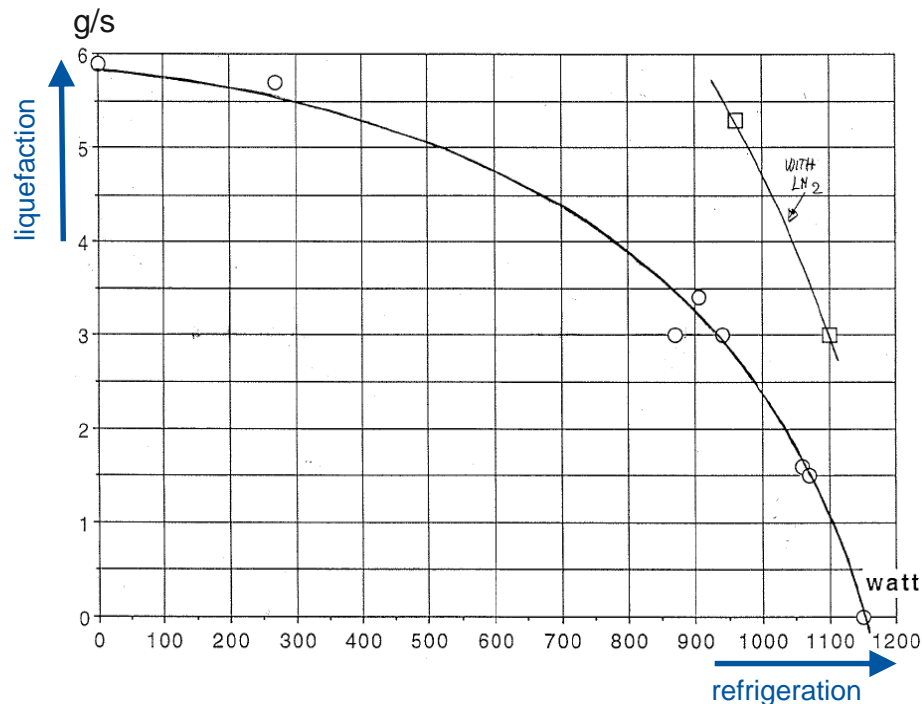
1100 W at 4.5 K and/or 5.6 g/s
liquefaction (see graph)

Shield cooling

Available: 1000 W at 60 K – 70 K

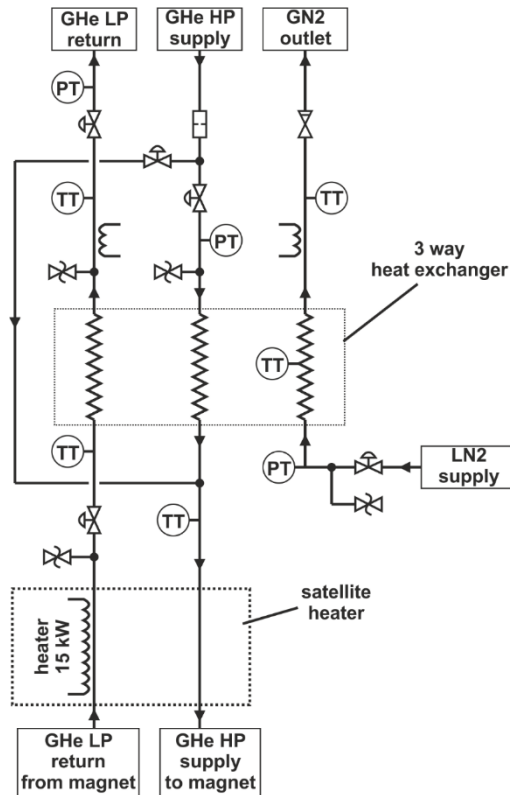
The cold box will be completely refurbished.

A new compression station is being purchased.



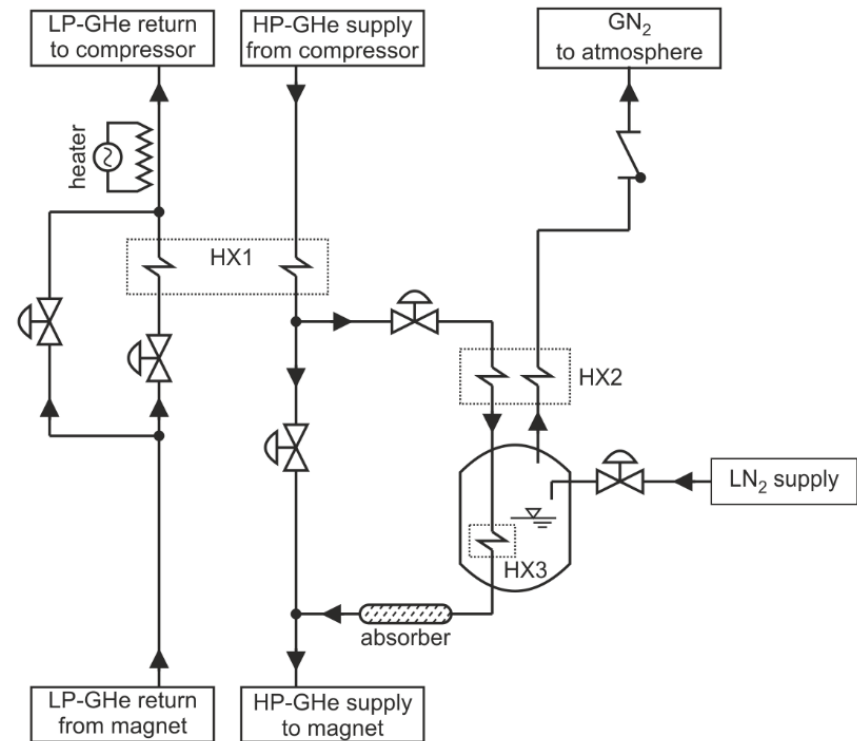
The cool-down / warm-up units

CWU 1 (existing)



50 g/s GHe circulation at 10 bar
 9 kW cooling capacity with ΔT of 50 K
 15 KW heater to be added
 18 m³ of LN₂ for 293K-90 K for 45 T magnet

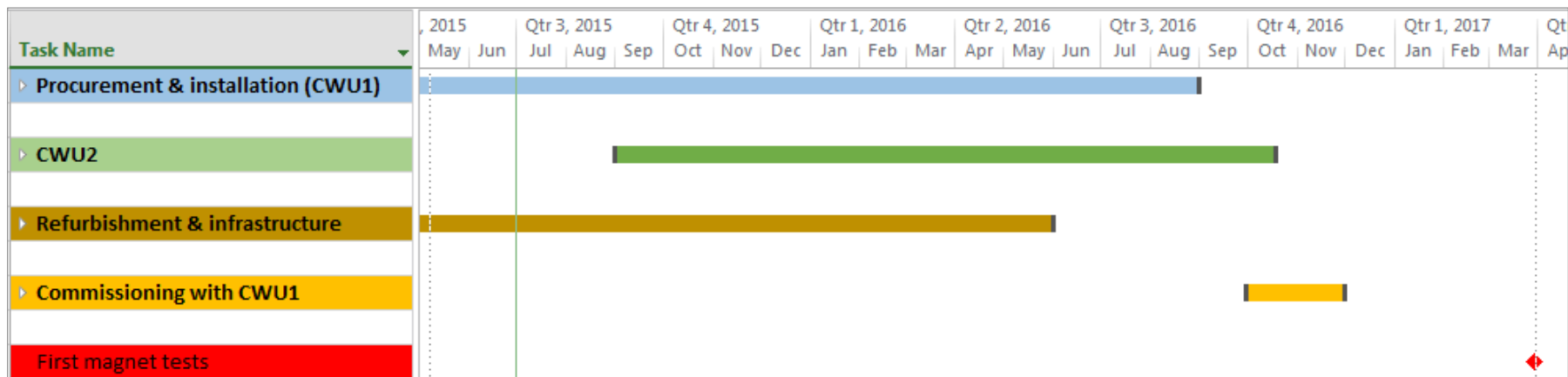
CWU 2 (new)



50 g/s GHe circulation at 10 bar
 15 kW cooling capacity with ΔT of 50 K
 15 KW heater to be added
 13 m³ of LN₂ for 293K-90 K for 45 T magnet

Schedule and status

Schedule



- First stage of operation with only CWU1: commissioning Oct-Nov 2016
- First magnet test (Dipole pre-series): April 2017
- Series tests: June 2018 – June 2021

Status

- Procurement of main items in tendering phase

Conclusions

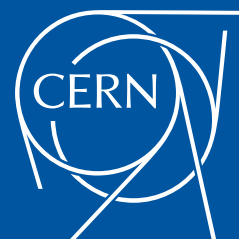
A new test facility for large and heavy superconducting devices is under construction at CERN. It will provide unique testing capabilities and it will be used to test the FAIR S-FRS magnets starting from the second quarter of 2017.

The architecture and performance of the cryogenic system has been defined.

The performance of the cryogenic system will be compatible with the test of 21 S-FRS magnets per year (with operational margin).

The main items of the cryogenic system are in tendering phase.

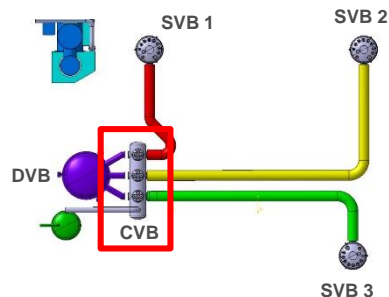
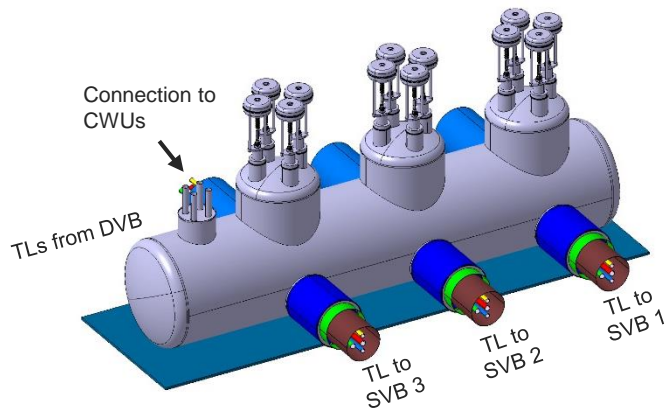
Commissioning is planned for autumn 2016, first magnet tests for April 2017.



The cryogenic distribution system

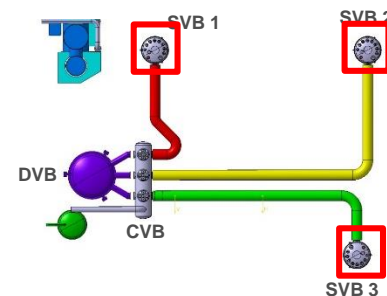
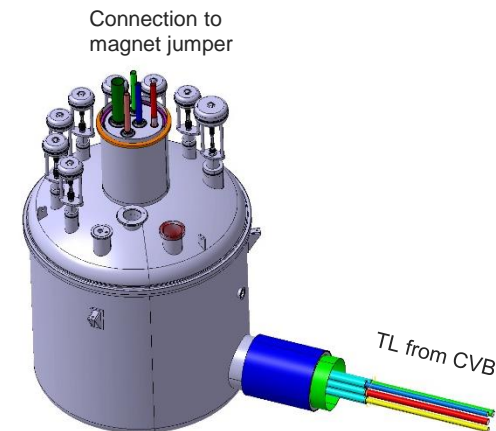
The connection valve box

- Connection of the CWUs
- Allows parallel cool-down and warm-up of the test benches



The satellite valve boxes

- Interface to the magnet jumper (identical for all magnets)
- Located next to magnet so the transfer lines act as buffer during exchange of magnets



Configuration of the cryogenic system

- 1 cold box: existing Sulzer TCF200, 1.3 kW at 4.5 K or 5.6 g/s liquefaction with a new compression station 150 g/s at 18 bar
- 2 LN2 cool-down/warm-up units (CWU) (1 existing, 1 new)
- A 5 m³ LHe dewar
- A cryogenic distribution system:
 - 3 test benches that can be operated independently equipped with satellite valve boxes (SVB) next to the magnets
 - A LHe/SCHe distribution valve box (DVB)
 - A connection valve box (CVB) to connect the CWUs