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Commissioning and performance of the cryogenic system of the new test facility for large superconducting devices at CERN

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On behalf of all people of the project team at CERN and GSI Research Center

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Outline

Introduction

Description of the cryogenic system

Commissioning and performance

Compression building refurbishment

Conclusions with project status

GSI-FAIR Super-FRS magnet tests at CERN

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

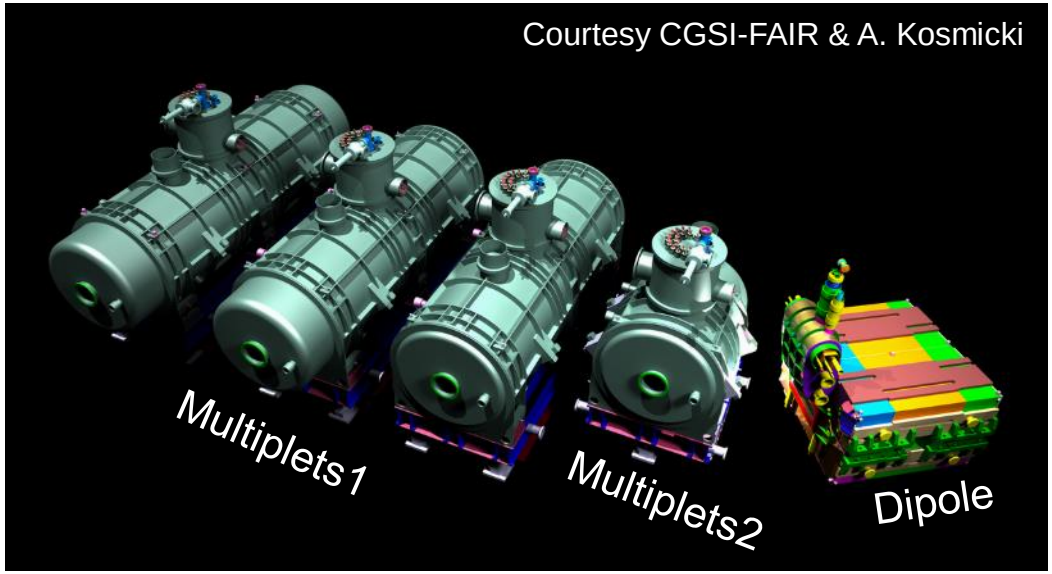
Mass up to **70 tons** and dimensions up to **5 m** high

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

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

The super-FRS magnet tests are the main driver for the architecture of the new test facility

Type	#	Total mass [kg]	Cold mass [kg]
dipole	24	50’000	2’000
multiplet 1	24	70’000	45’000
multiplet 2	9	25’000	20’000



See also:
A. Perin et al. CEC 2015, Mat. Sci. Eng. **101** p. 012185
J.H. Derking et al. CEC 2015, Mat. Sci. Eng. **101** p. 012104

The new test facility for large devices

Located in 2 buildings:

B279: compression stations

B180: 1400 m^2 for cryogenics and tests

The facility can accommodate devices:

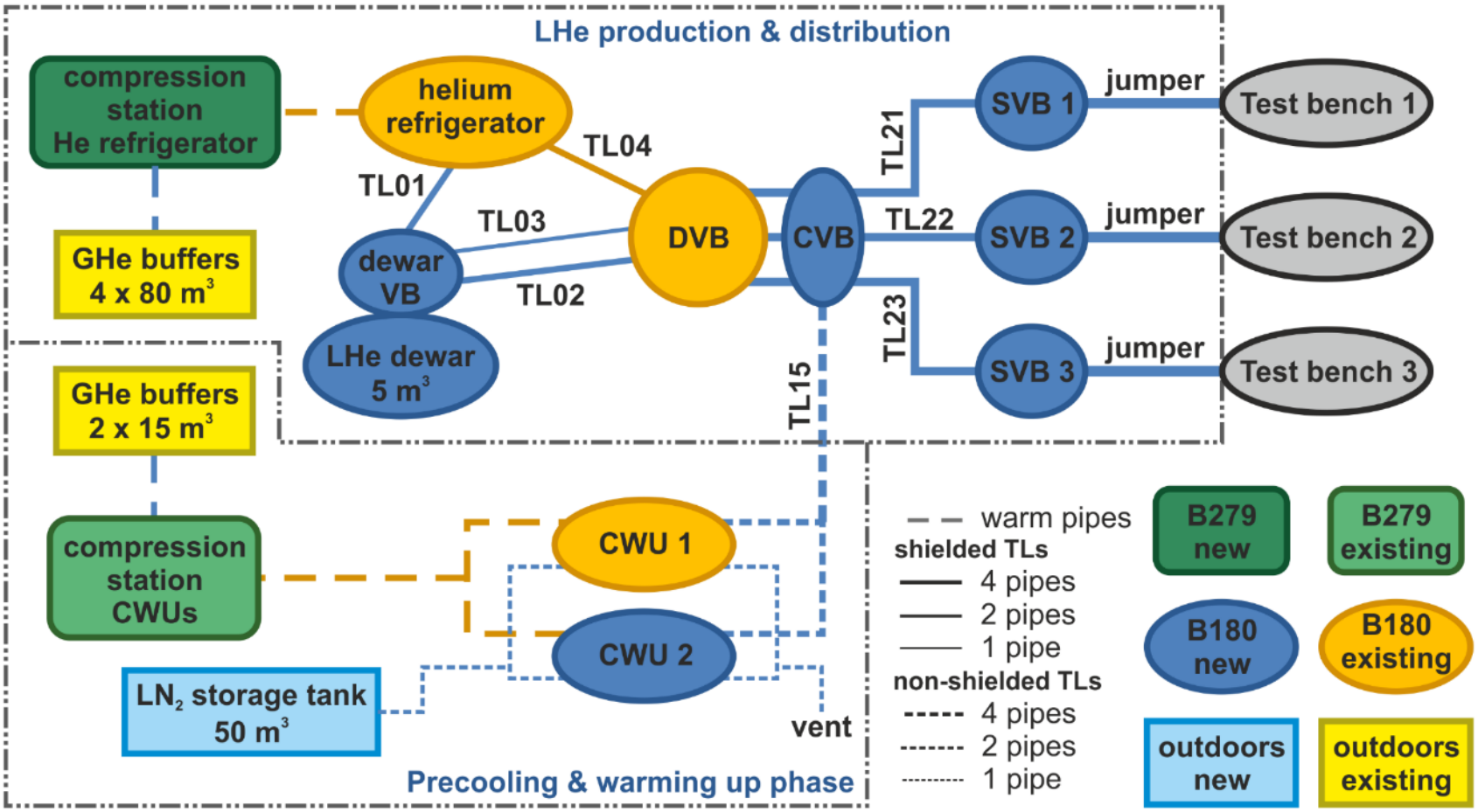
- Up to **55 tons, 7 m** high max
- Up to **89 tons, 5 m** high max

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	1.7 m^3 of saturated LHe at 4.5 K
Cold tests heat loads	30 W static at 4.5 K + 35 W dynamic during10 minutes 160 W at 60 K – 70 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

3D overview of test facility

Configuration of cryogenic system



DVB: Distribution Valve Box

SVB: Satellite Valve Box

CVB: Connection Valve Box

CWU: Cool down / Warm up Unit













LHe production & distribution
compression station He refrigerator
helium refrigerator
TL04
TL01
TL03
TL02
dewar VB
LHe dewar 5 m³
DVB
CVB
TL15
TL21
TL22
TL23
SVB 1
SVB 2
SVB 3
jumper
jumper
jumper
Test bench 1
Test bench 2
Test bench 3
GHe buffers 4 x 80 m³
GHe buffers 2 x 15 m³
compression station CWUs
CWU 1
CWU 2
LN₂ storage tank 50 m³
vent
Precooling & warming up phase
warm pipes
shielded TLs
4 pipes
2 pipes
1 pipe
non-shielded TLs
4 pipes
2 pipes
1 pipe
B279 new
B279 existing
B180 new
B180 existing
outdoors new
outdoors existing

Contracts

Helium refrigerator

Linde Kryotechnik

Cryo distribution

Kriosystem

Compression station refrigerator

Mayekawa Italy SRL

9 major contracts

in 7 member states

LHe dewar: *Cryoworld BV*

LN_2 distribution: *Demaco Holland BV*

Cool down / warm up unit

AS Scientific Products

Cryogenic valves: *Flowserve*

Warm control valves: *Stohr Armaturen*

LN_2 storage tank

Cryocan

B180 test facility: overview

Before: January 2015

After: August 2018

Helium refrigerator

An existing **Sulzer TCF200** helium refrigerator of 1979 was fully refurbished by *Linde Kryotechnik* in 2016.

Brayton cycle with **two** turbines in series. **Third** turbine for boosting performance.

Original performance: 1.2 kW refrigeration or 5.6 g/s liquefaction with 1.0 kW shield between 60 – 90 K.

Main refurbishment work included:

- Adding a GHe return to 300 K;
- New purge and instrumentation rack;
- New cooling water distribution panel and turbine bearing gas supply panel;
- New turbine coolers;
- Maintaining all cryogenic valves;
- Repairing thermometers;
- Repainting the box.

Helium refrigerator before refurbishment

Helium refrigerator after refurbishment

Helium refrigerator compression station

A new compression station from *Mayekawa Italy S.R.L.* is used for driving the helium refrigerator.

Main components:

- Two stage compound screw compressor;
- One 3.3 kV AC electrical motor;
- Oil separation system with oil separator, 3 coalescing filters and a charcoal adsorber.

Design performance:

Supply pressure: 18.7 bar

Suction pressure: 0.9 bar

GHe flow rate: 160 g/s

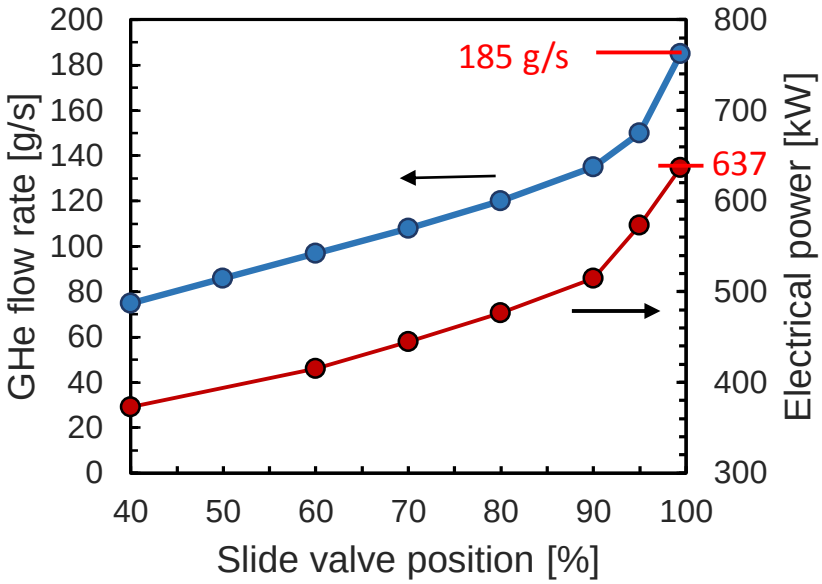
Electrical power: 706 kW

Helium refrigerator compression station

Helium refrigerator oil separation system

Helium refrigerator: commissioning results

Helium refrigerator compression station



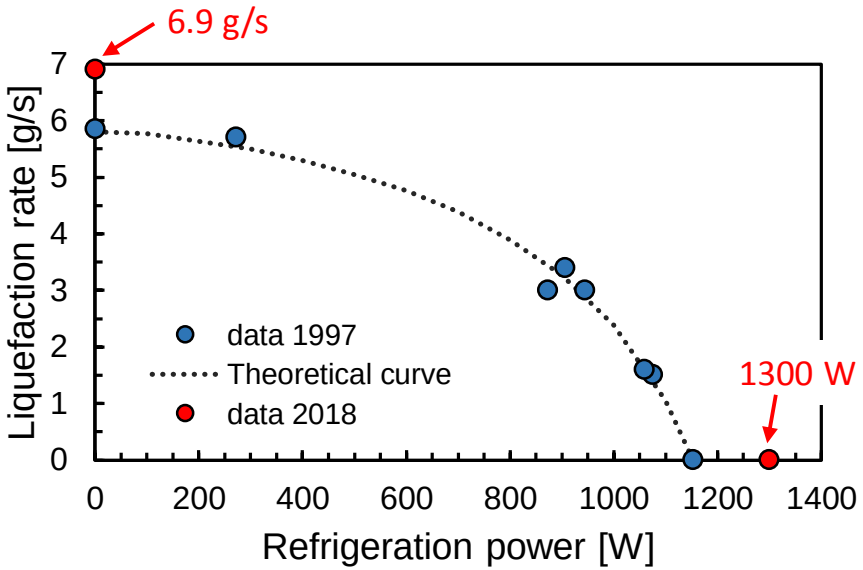
Supply pressure: 17.2 bar

Suction pressure: 1.0 bar

Max flow rate: 185 g/s

Consumed electrical power: 637 kW

Helium refrigerator



Supply pressure: 17.2 bar

Suction pressure: 1.0 bar

Refrigeration power: 1300 W @ 160 g/s

Liquefaction power: 6.9 g/s @ 125 g/s

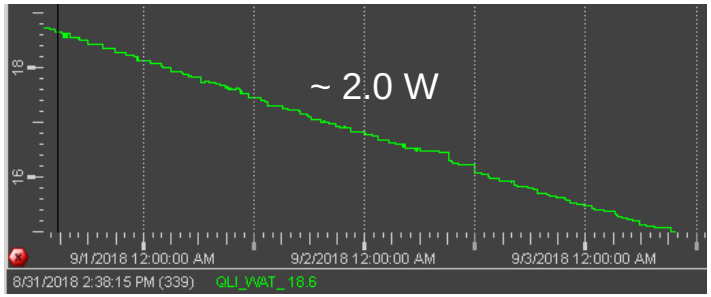
No shield cooling

B180: cryogenic distribution system

5 m^3 LHe dewar delivered by *Cryoworld BV*

Preliminary measured evaporation rate:

~1.4% / day of total capacity or 2.0 W



LHe dewar installation

Cryo distribution installation

Cryodistribution delivered by *Kriosystem*

First cool down in autumn 2017 to test:

- Mechanical integrity
- Leaks
- Vacuum jacket temperature

No major non-conformities found.

Precooling & warming up system

Purpose cool-down / warm up units:

- precool devices to 80 K;
- warm up devices from 4.5 K to room temperature.

50 g/s GHe circulation at 10 bar

15 kW cooling capacity with ΔT of 50 K (LN_2)

15 kW heating capacity

Includes 80 K adsorber to remove gas impurities

50 m^3 LN_2 storage tank

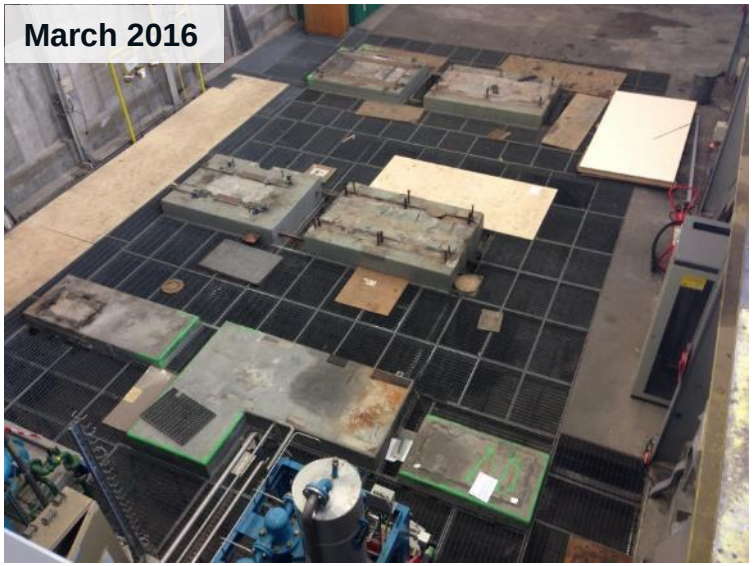
Measured evaporation rate:

0.24%/day of total capacity

CWU1

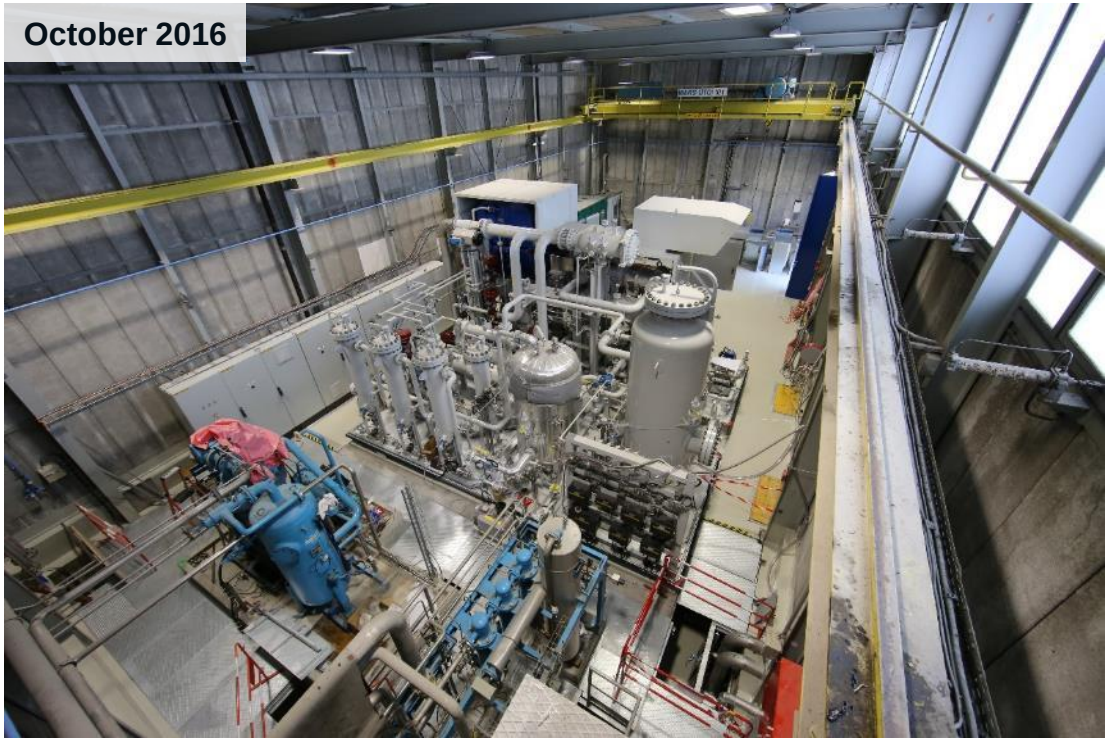
CWU2

Compression station building 279: overview



Compression building B279 was built in 1971.

The building is fully renovated to fulfil current standards with respect to safety and environmental aspects.

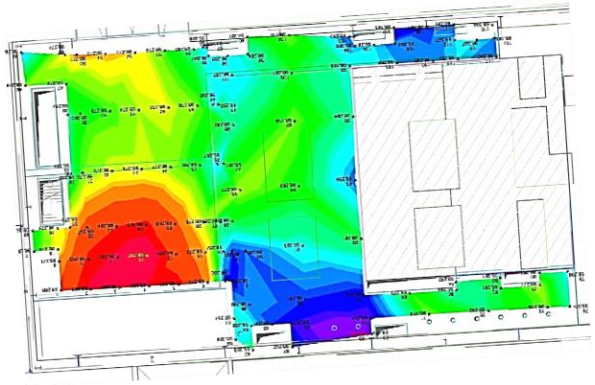


B279: oil spillage measures

Oil spillage measures taken to:

- collect the total amount of oil (2000 L)
- prevent leakage outside the building (through cracks, drainages etc.)

Mapping floor level



Resign on floor

Profiles at corners

Steps at doors and openings

Collector pipe at lowest point of floor

Gutters

Retention tank 1: 1900 L

Retention tank 2: 1900 L

B279: noise measures

Noise **outside** the building needs to stay **below 60 dB(A)** due to proximity of offices.

A study determining the noise damping coefficients showed that we need **below 90 dB(A) inside** the building.

<u>Noise sources:</u>

Helium refrigerator compression station: 98 dB(A)

CWU compression station: 88 dB(A)

<u>Two options:</u>

1) Isolating the building -> complex and costly

2) Noise hood around compressor stages helium refrigerator compression station

Option 2 selected. Noise hood reduces noise to 90 dB(A) at 1 m of compression station.

Noise study

Helium refrigerator compression station

Noise hood

Conclusions

CERN has built a cryogenic test facility for large and heavy superconducting devices. It will be firstly used to test the FAIR Super-FRS magnets.

The LHe production and distribution system were installed and successfully commissioned. The performance corresponds well to the design parameters.

The cool down / warm-up units are installed and commissioning is ongoing.

Test facility is currently in final assembly and commissioning. First magnet prototype arrives in autumn 2018. Series testing in planned to start in autumn 2019.

Thank you for your attention
Questions?

www.cern.ch