Study for cryogenic testing the Super-FRS magnets of FAIR in a new test facility at CERN

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Introduction

The Super-FRS magnets of the international Facility for Antiproton and Ion Research (FAIR) being built at GSI Germany will be tested at CERN in a new test facility currently under development. A study performed to determine the operational parameters required for testing these magnets is presented.

Super-FRS magnets

The Super-FRS magnets are iron dominated superconducting magnets located in a vacuum insulated cryostat with an actively cooled thermal shield.
In total 57 Super-FRS magnets will be tested of three different types:

Type	Quantity	Mass [kg]	Cold mass [kg]	LHe volume [L]	Nominal heat load [W]	Shield heat load [W]	Stored energy [MJ]	Pole field [T]
Dipole	24	50'000	2'000	25	4	35	0.5	1.6
Multiplet 1	24	70'000	45'000	1350	30	160	2.7	2.5
Multiplet 2	9	25'000	20'000	900	30	160	1.2	2.5

Test requirements

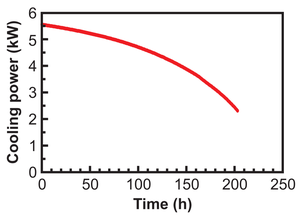
Nominal operating temperature: 4.5 K
Maximum cool down / warm-up rate 293 - 90 K: 1 K/h
Maximum temperature difference over the magnet: 50 K

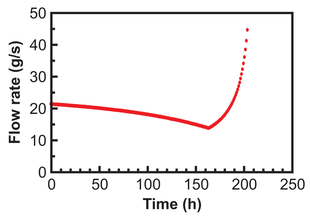
Operational parameters

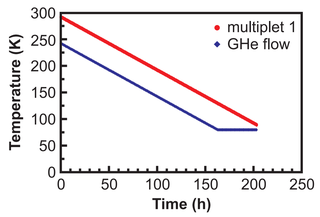
Pre-cooling multiplet 1

Pre-cooling from 293 K to 90 K
CWU provides GHe flow at 10 bar; max. 50 g/s
Thermal shield and cold mass in series

Cool-down rate: 1 K/h
Amount of LN_2: 13 m^3
Time: 8.5 days



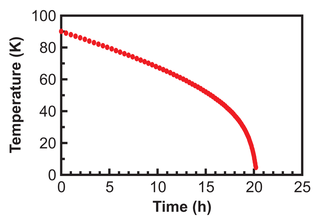


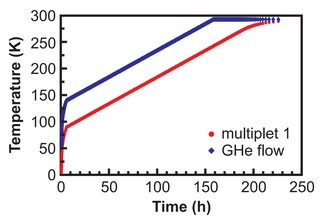


Cooling & filling multiplet 1

Energy to extract: 241 MJ
Amount of LHe: 6.2 m^3 (min)
Flow rate: 10 g/s
Cool-down time: 20 hr

Fill speed: 20 g/s
Fill time: 2.5 h

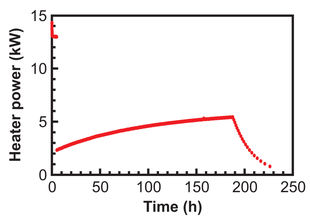


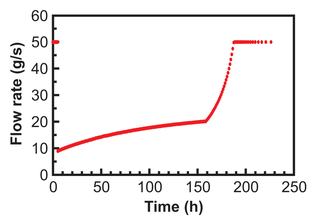


Warming up multiplet 1

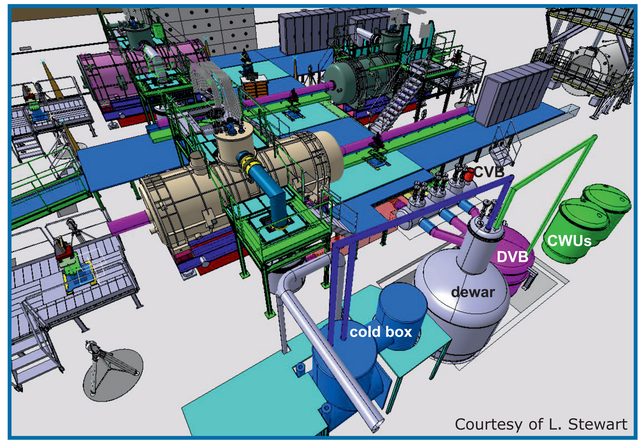
Evaporating LHe done with 300 W heater in ~3 h
CWU provides GHe flow at 10 bar; max. 50 g/s
Thermal shield and cold mass in series

Warm-up rate: 1 K/h
Heater power: 14 kW (max)
Time: 8.5 days

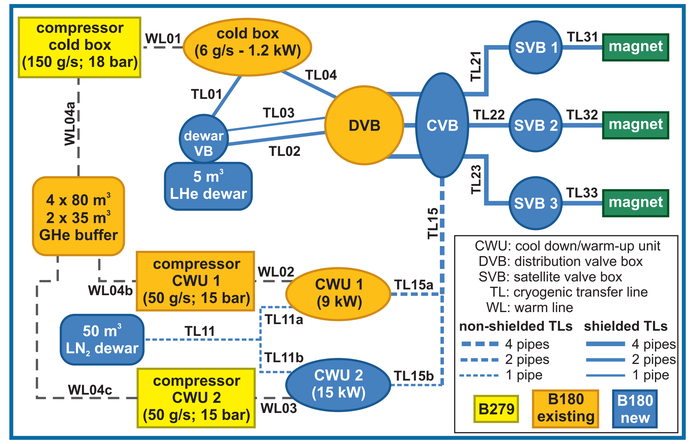




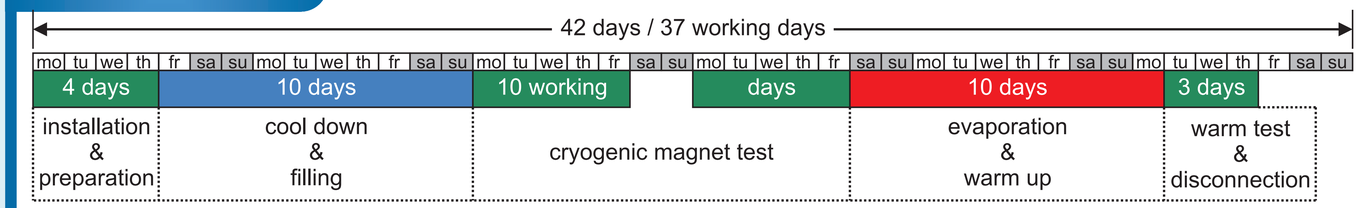
Layout of the test facility



Courtesy of L. Stewart



Test schedule



Required: maximum one magnet in cool down, one in warm up and one in magnet test phase at a time.

Available testing time per year: 46 weeks (4 weeks maintenance, 2 weeks annual closure)
Testing capacity: 21 magnets per year
Total testing period: 3 years

Conclusions

The 57 Super-FRS magnets will be tested over a period of 3 years.

The planned test facility at CERN fulfills the cryogenic requirements for testing the Super-FRS magnets for the cool down and the testing phase.

During the warm up phase, above a magnet cold mass temperature of 273 K, breakage of the vacuum with dry nitrogen gas will increase the warm-up speed.

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