FAIR Cryogenic System

Holger Kollmus

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Outline

- Introduction
- Cryogenic topology
- FAIR machines
  - SIS 100
  - SuperFRS
- Refrigerator
- Summary & Outlook
FAIR – Facility for Antiproton and Ion Research

**GSI-Today**
- Protons to Uranium
- max 1 GeV/u Uranium and 2 GeV/u for Neon

**GSI in future / FAIR**
- Rare isotopic beams
- Anti protons
- Higher Beam Current
- At higher energies

GSI Helmholtzzentrum für Schwerionenforschung GmbH
- founded 1969
- 90 % German Federal Government
- 1350 employees
- 2 superconducting detectors: ~300 W@4.4K

FAIR GmbH
- founded 2010
- 9 countries signed
- ~75 % stake holder GSI
- large superconducting facility: ~25 kW@4.4K
FAIR – machines and experiments

- APPA
- HEDgeHOB
- HESR (FZJ)
- CR (BINP)
- Super-FRS
- CBM
- SIS 100
- NuSTAR
Cryogenic topology

- CRYO plant: CRYO2
- common compressor station
- Cool down/Warm up Unit
- CWU
- SIS 100 (SIS 300)
- CBM
- SuperFRS
- (Panda)
- APPA
- R3B
Challenges for the cryogenic supply of SIS100 and SuperFRS

Stand: Jan 15 (WrUT values)

SIS100

Cold mass: 400 t
Helium inventory: 1.3 t

SuperFRS

<table>
<thead>
<tr>
<th>Static heat loss</th>
<th>4.5 K [W]</th>
<th>50 K to 80 K [W]</th>
<th>Liquefaction [g/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet cryostats</td>
<td>579.3</td>
<td>5487</td>
<td>6.20</td>
</tr>
<tr>
<td>Local cryogenics</td>
<td>593.1</td>
<td>4826</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1172</td>
<td>10313</td>
<td></td>
</tr>
</tbody>
</table>

4K equivalent ~3000 W
Transfer line DB3 <-> DB2 300 W
LEB 700 W
Sum 4000 W

Cold mass: 1300 t
Helium inventory: 5.9 t

Mixed cycles will cover the full range

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FAIR – SIS100- Magnets

Iron dominated magnet design:
dipole: \(1.9\ T, 4\ \text{T/s} @ 1\ \text{Hz}; 109\ \text{pcs.}\)

quadrupole module: \(27\ \text{T/m}; 84\ \text{pcs.}\)

Single cable (13 kA)

Helium – CuNi tube
Superconductor
NiCr wire
Kapton foil
Glass fiber tape

Bus bars

Supply
Return

Details: FAIR – Technical Design Report, July 08

T-s diagram for helium flow in coil

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FAIR – SIS100- supply system

Supply line
Return line
shield cooling
Helium transfer lines
Cold electrical connection
Warm electrical connection

4.4 K
50-80 K
300 K

Feed box
Current lead box
Damp resistor

Compressor
Refrigerator Cryo 2
Distribution box 3
Damp resistor

Distribution box 4

End box

Talk by Th. Eisel

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FAIR – SuperFRS- Magnets

iron dominated magnet design:
dipole: 0.15 - 1.6 T; 21 pcs.
quadrupole: 1-10 T/m; 80 pcs.

multiplet:
Total mass: > 50t
cold mass: ~ 37t
current: ~250 A
Helium inventory: ~ 1500 l
heat load: ~ 30 W
no ramping

31 pcs.

Details: FAIR – Technical Design Report, July 08

up to 9 pair of current leads
Refrigerator Options with 25 kW Overall Capacity

- Planned cooling capacity for first cryo plant approx. 25 kW@4.4K
- Pre-cooling by additional 80K circuit. (LN\textsubscript{2}; Brayton machine)
- Without additional cooling: approx. 23 kW
FAIR Cryo 2 – CWU Interaction

Normal operation

SIS 100
CRYO
SFRS Magnets

SIS 100
CRYO
SFRS Magnets

SIS 100
CRYO
SFRS Magnets

SIS 100
CRYO
SFRS Magnets

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Series Test Facilities, Linde KT

- 700 W@4.4K; 6g/s; 2000W@50K
- Ready for magnet testing
- SIS 100 dipoles, quadrupoles and SuperFRS Magnets can be tested
HeSu in Operation

- Liquefaction rate ~ 20+ l/h
- 3000 l LHe storage
- Commissioning (SAT) done
Summary & Outlook

Significant steps in cryogenic infrastructure for testing components
Foundation finished: 1500 concrete pillars
Start of construction for buildings next year
Start of series magnet testing in 2016
First experiments in 2021