The ESS cryogenic system

ESS: a spallation source, using a 5 MW proton beam to produce long pulse neutrons for research

Cryo clients:
• accelerator: 146 SRF cavities at 2K
• target: two supercritical H₂ moderators
• instruments: consumers of LHe & LN₂
• test stand: testing 30 accelerator cryomodules

<table>
<thead>
<tr>
<th>cryo concept</th>
<th>CDR</th>
<th>TDR</th>
<th>specifications</th>
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<tr>
<td>2010 - 2011</td>
<td>2012 - 2013</td>
<td>2014 - 2015</td>
<td></td>
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</tbody>
</table>
First Concept 2011: overview

ACCP: 13.4 kW @4.5Keq

TMCP: 11 kW @4.5Keq

TICP: 31 l/h

LN2 dewar

ACCP coldbox

ACCP compressors

MP gas storage

TMCP + TICP coldboxes

TMCP + TICP compressors

Access road

Vacuum workshop building

Vacuum storage
Second Concept 2012

ACCP: 14 kW @4.5Keq

TMCP: (11 kW @4.5Keq)

TICP: 45 l/h

ACCP coldboxes

TMCP + TICP compressors

LN2 dewars

MP gas storage
Third Concept 2014

- **ACCP:**
  - 2.9 kW @ 2 K
  - 7.9 kW @ 40 K
  - 7.2 g/s liq.

- **TMCP:**
  - 25 kW @ 16 K

- **TICP:**
  - 50 l/h

- **MP gas storage**
- **TMCP + TICP compressors**
- **ACCP compressors**

**coldbox building**
Current Layout 2015

ACCP:
3.06 kW @ 2 K
11.4 kW @ 43 K
9.0 g/s liq.

TMCP:
32 kW @ 15 K
LN2 dewars

TICP:
50 l/h

coldbox building

MP gas storage

ACCP compressors

TMCP + TICP compressors
## Evolution of Heat Loads

<table>
<thead>
<tr>
<th>source</th>
<th>date</th>
<th>accelerator cryoplant capacity</th>
<th>target cryoplant capacity</th>
<th>liquid helium yield</th>
</tr>
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<tbody>
<tr>
<td>technical note</td>
<td>May 2011</td>
<td>13.4 kW @4.5Keq.</td>
<td>11 kW @4.5Keq.</td>
<td>31 l/h</td>
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<tr>
<td>CDR</td>
<td>Feb. 2012</td>
<td>14.0 kW @4.5Keq.</td>
<td>-</td>
<td>45 l/h</td>
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<tr>
<td>TDR</td>
<td>Apr. 2013</td>
<td>1.7 kW @ 2 K + 1.2 kW @ 5-8 K + 7.9 kW @ 40 K + 7.2 g/s liquefaction</td>
<td>25 kW @ 16 K (no contingency)</td>
<td>50 l/h</td>
</tr>
<tr>
<td>technical specifications</td>
<td>Jun. 2015</td>
<td>2.23 kW @ 2 K + 0.83 kW @ 2-4 K + 11.4 kW @ 33-53 K + 9.0 g/s liquefaction</td>
<td>32 kW @ 15 K</td>
<td>50 l/h</td>
</tr>
</tbody>
</table>
Compromises

• parallel design of cryo system and buildings/utilities
• necessary for schedule
• requires very close communication
• requires a healthy set of margins
Lessons learned

• location of TMCP was placed too far from target
• target H2 system not in cryo group’s control
• procurement of ACCP should have been ‘competitive dialog’
• requirements for buildings should have been defended better
Future

• ACCP: specified and ordered, design ongoing, plant ready in 2018
• TMCP: being specified, procurement in 2015, plant ready in 2018
• TICP: specified, procurement started, order in 2015, plant ready in 2017
• CDS: specified and ordered, design ongoing, ready in 2018