Optimum cryomodule length at the ESS

2012-11-07 TTC meeting JLab

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# Accelerator Components

## FDSL_2012_10_02

![Diagram of accelerator components](image)

<table>
<thead>
<tr>
<th>Section</th>
<th>Number of modules</th>
<th>Frequency (MHz)</th>
<th>Input energy (MeV)</th>
<th>Cavities per module</th>
<th>Cavity per sector</th>
<th>Module length (m)</th>
<th>Sector length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spoke</td>
<td>14</td>
<td>352.21</td>
<td>79</td>
<td>2</td>
<td>28</td>
<td>2.9</td>
<td>58.5</td>
</tr>
<tr>
<td>Medium-beta</td>
<td>15</td>
<td>704.42</td>
<td>201</td>
<td>4</td>
<td>60</td>
<td>5.6</td>
<td>113.8</td>
</tr>
<tr>
<td>High-beta</td>
<td>30</td>
<td>704.42</td>
<td>623</td>
<td>4</td>
<td>120</td>
<td>6.7</td>
<td>227.9</td>
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<tr>
<td>Total</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td>208</td>
<td></td>
<td>400.16</td>
</tr>
</tbody>
</table>
High-beta Cryomodule

2011 design: 8 cavities

2012 design: 4 cavities

- concept, design & engineering done by IPN Orsay
- based on SNS type space frame

add. beam line valves:
4-cavity design based on SNS type is more conservative, requires less design effort and presents less risk to scope, cost and schedule.

Availability of infrastructure drives schedule:

- 8-cavity cryomodules need very large clean rooms: class 10 /100 (100 m$^2$) + class 1000 (5 worldwide ?)
- access to DESY or CERN clean rooms is questionable due to overlap of ESS’ schedule with XFEL’s and LHC’s

A relatively short machine & small number of CMs results in higher prototyping cost per CM, which should be minimized - and - a very tight schedule demands quick prototyping: only solution is a conservative design.
4 cavity design

- It presents a higher heat load because of the additional cold-warm transitions and additional valve boxes & jumper connections. For ESS there is a 10% increase in total heat load.
- It induces higher costs for the helium distribution system (valve boxes & jumper connections)
- It results in a longer linac. For ESS there is a 14 m increase of the high-β section.
- It requires twice the number of units, which might increase production time (not confirmed).
- It reduces both technical and project risk.
- It is better understood and reduces time for prototyping and pre-series. For ESS there is a projected gain of 2 yrs.
Like in the SNS design, a spaceframe supports the cold mass inside the vacuum vessel.
Each cavity is supported by 2 sets of 4 cross rods to keep the cavity axis aligned with the beam axis and by 2 sets of 2 axial rods for longitudinal positioning.
Conclusions

• ESS will build a high-power proton linac by 2019
• our high-β cryomodules will have 4 cavities each – there are downsides (heat load, space)
• but the reduction in risk & gain in schedule by extrapolating from a tested design makes this by far the preferred solution
• Choice concurred by ESS TAC:

“The Committee supports the decision of having only 4 high beta cavities per cryomodule.”