Optimum cryomodule length at the ESS

EUROPEAN SPALLATION SOURCE

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ESS - leader Accelerator Test Stands

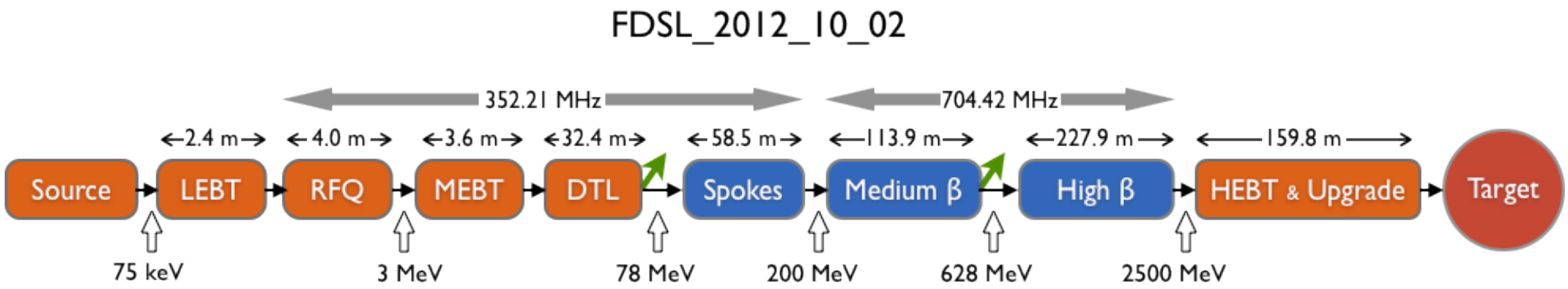
2012-11-07 TTC meeting JLab

The European Spallation Source

Lund, Sweden

accelerator tunnel	target building
klystron gallery	neutron lines
cryoplants	instruments

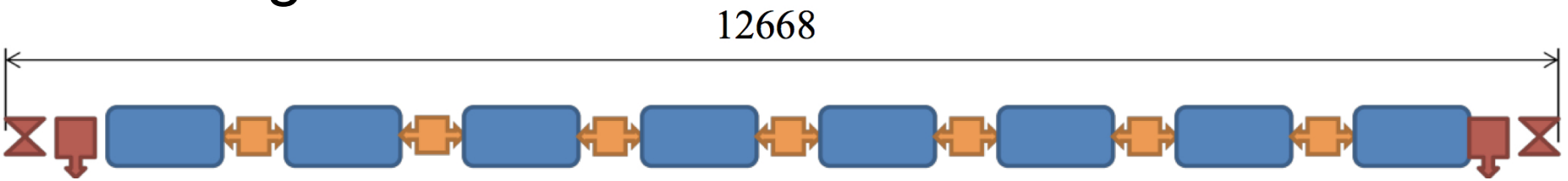
Accelerator Components



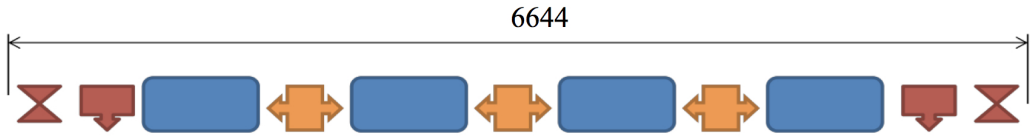
Section	Number of modules	Frequency MHz	Input energy MeV	Cavs. per module	Cavs. per sector	Module length m	Sector length m
Spoke	14	352.21	79	2	28	2.9	58.5
Medium-beta	15	704.42	201	4	60	5.6	113.8
High-beta	30	704.42	623	4	120	6.7	227.9
Total	59				208		400.16

High-beta Cryomodule

2011 design: 8 cavities

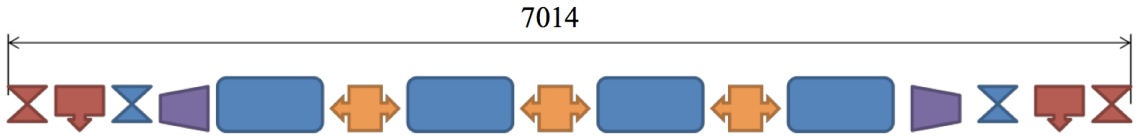


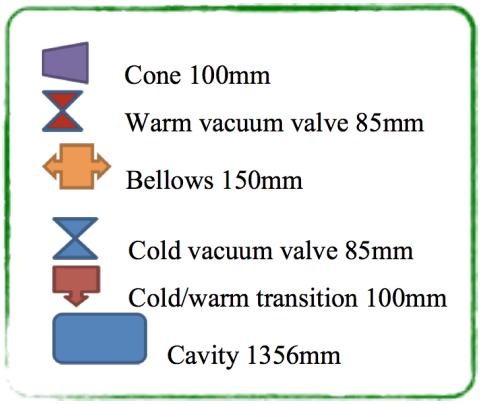
2012 design: 4 cavities



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

add. beam line valves:





Why 4 cavities per CM ?
(and not 8)

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:

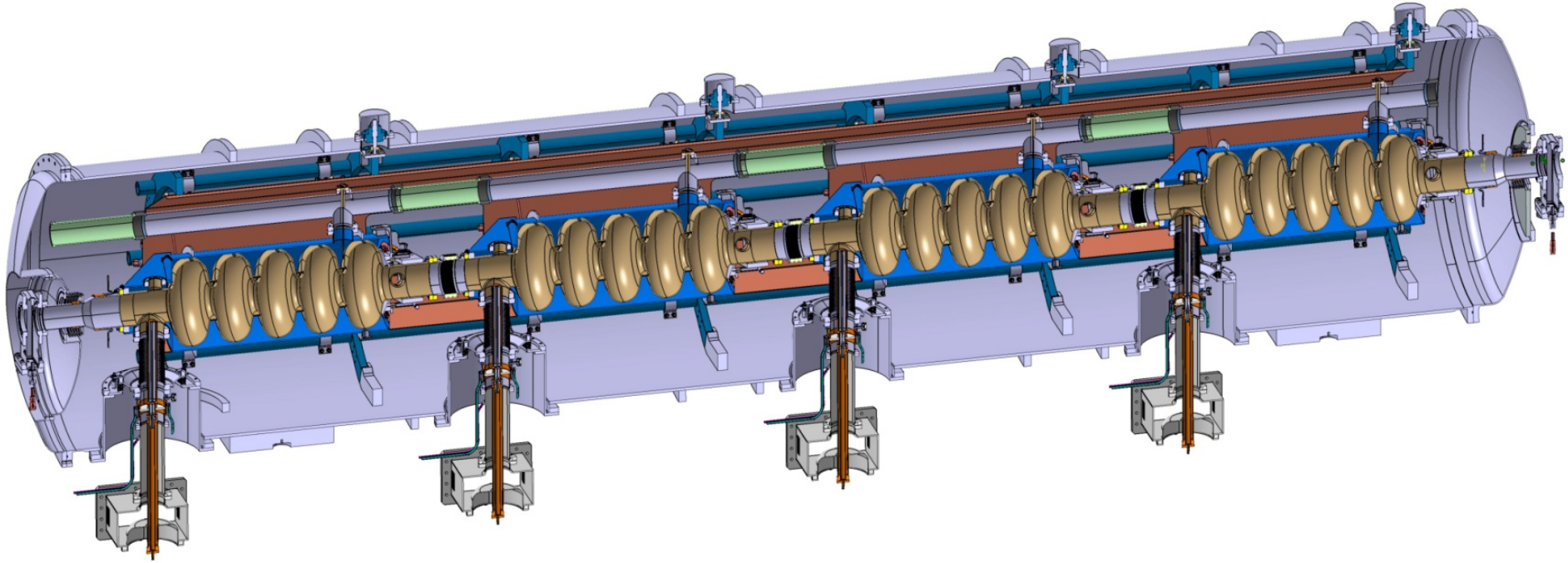
- 8-cavity cryomodules need very large clean rooms: class 10 /100 (100 m^2) + class 1000 (5 world wide ?)
- access to DESY or CERN clean rooms is questionable due to overlap of ESS' schedule with XFEL's and LHC's

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**.

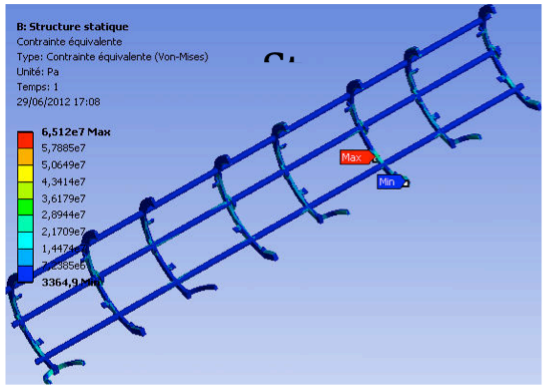
4 cavity design

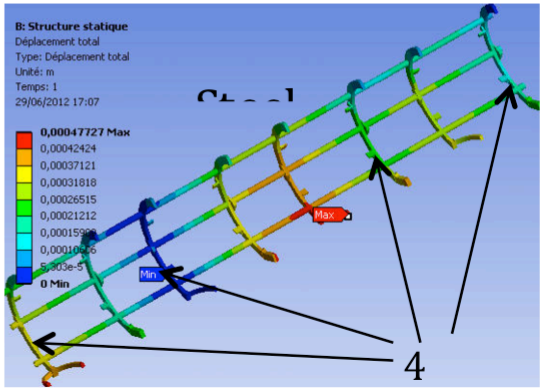
- It presents a higher heat load because of the additional cold-warm transitions and additional valve boxes & jumper connections.
  For ESS there is a 10% increase in total heat load.
- It induces higher costs for the helium distribution system (valve boxes & jumper connections)
- It results in a longer 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**.

ESS High-beta CM design

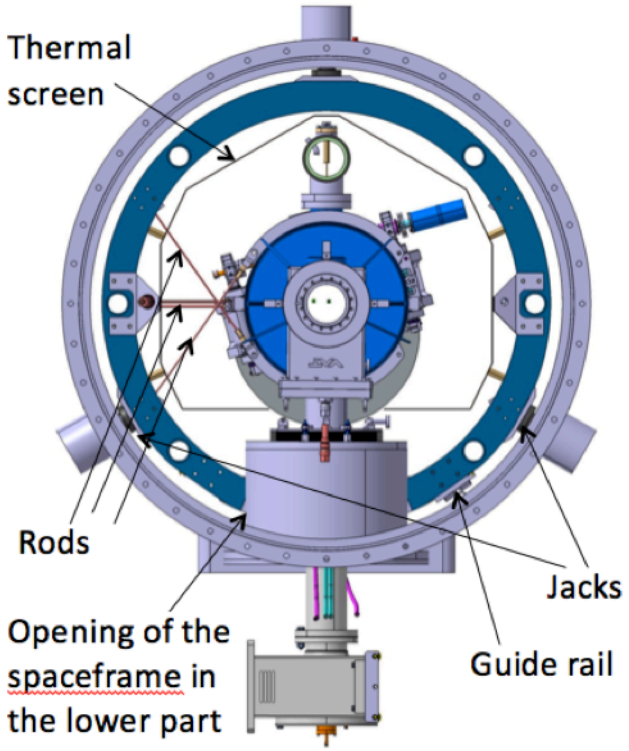


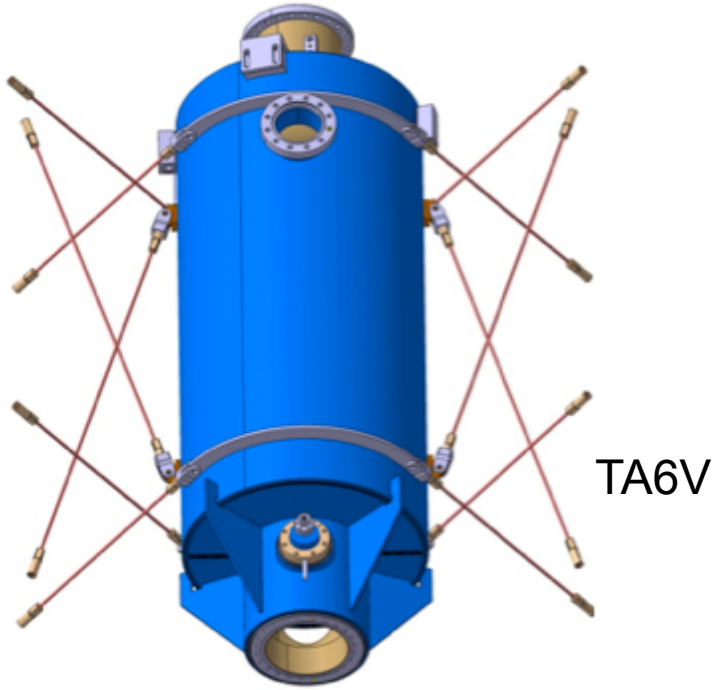
Like in the SNS design, a spaceframe supports the cold mass inside the vacuum vessel.





ESS High-beta CM design





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."

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we will be hiring
cryo-engineers