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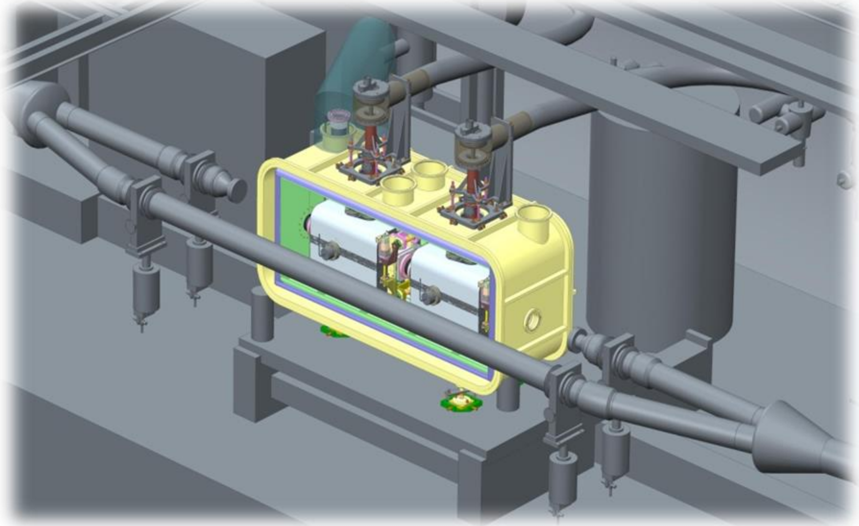

Cryomodule for Crab Cavity Tests with SPS

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3rd Annual Hi-Lumi Meeting Nov 11-15, 2013, Daresbury

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Acknowledgements

This presentation is on behalf of the members of the Global WP4 team

STFC	ASTeC, Technology, University of Lancaster
CERN	Various Departments
LARP	ODU+SLAC, BNL, FNAL

Contents

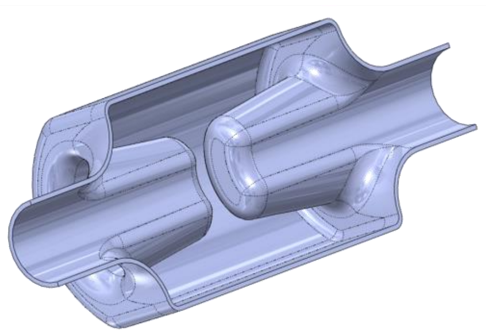
- Factors Influencing Design Requirements
- Achievements so far …

  Concept designs for Helium Vessel and Cryomodule
- Work in Progress
- Future Plans
- Conclusion

Requirements

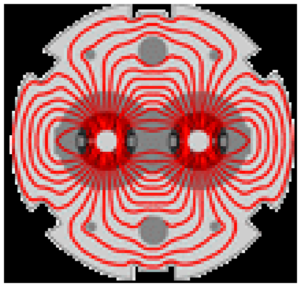
Requirements for the **cryomodule** are influenced by various Factors

1. Cavity



- Operating Temperature
- Magnetic shielding
- Helium Vessel
- Couplers and Interfaces
- Tuner mechanism
- Dynamic Heat Load
- ….

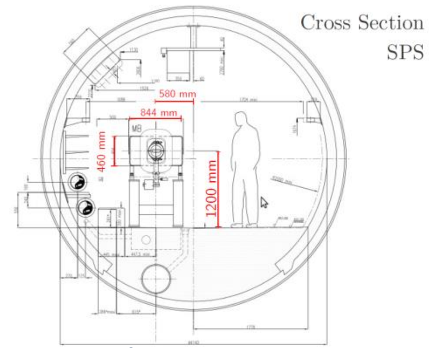
2. LHC



- Two beam pipes
- Heat load due to beams
- Helium Vessel Geometry
- Internal Layout
- ….

Talk # 92 by Rama Calaga
and # 95 Alex Ratti

3. SPS Layout



- External Geometry
- Third beam pipe (SPS Bypass)
- Coupler Orientations
- Integration with Infrastructure
- Operation

Talk # 100 by Alick Mcpherson
106 by Ofelia Capatina

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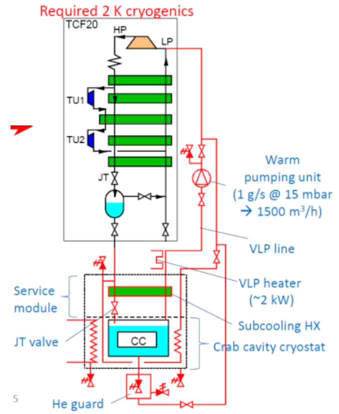
Requirements *continued*

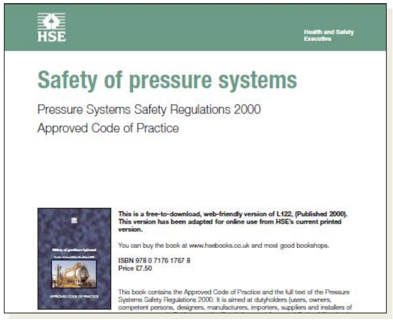
4. Cryogenic Services



- Cooling Capacity at various temperatures
- Cooling Processes
- Ports and Interfaces
- Operating modes

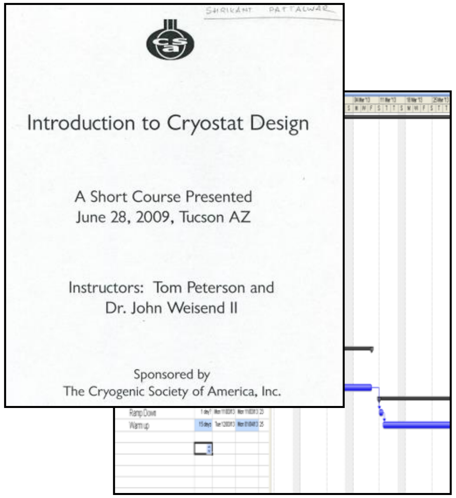
Talk # 102 by Laurent Tavian

5. Regulations and directives



- Mechanical Design
- Safety and Pressure Relief
- Volumes, pipe sizes
- Methods of QC/QA

6. Other



- Intermediate Tests (SM18)
- Assembly Procedures
- Instrumentation
- Cost
- R&D needs

Talk # 105 by Ofelia Capatina

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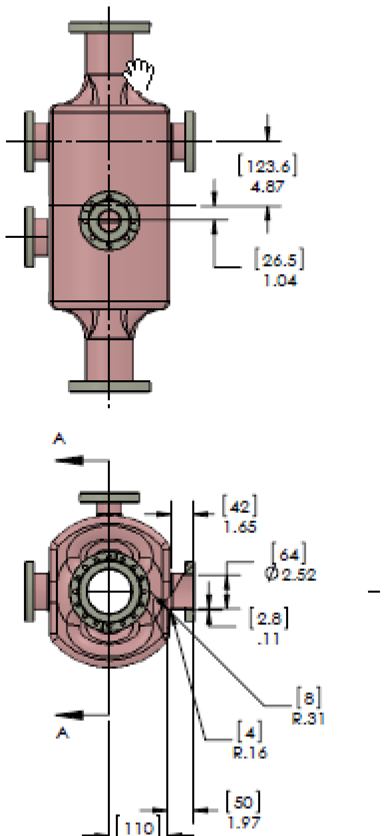
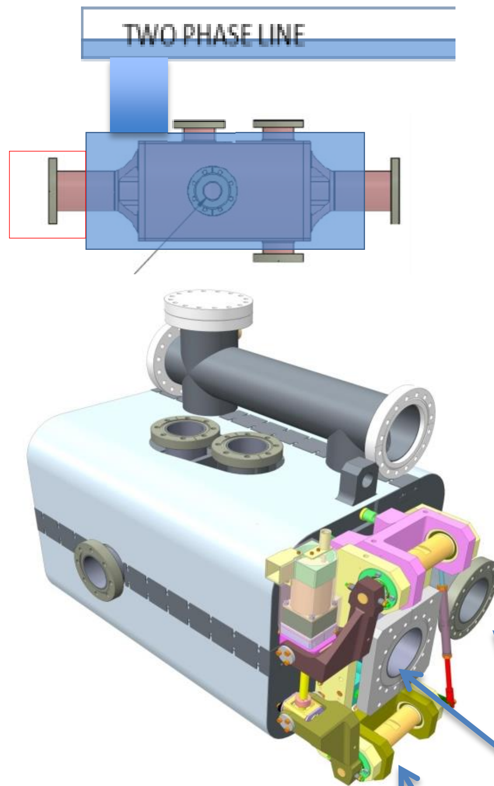
Helium Vessel

UK 4-Rod Cavity

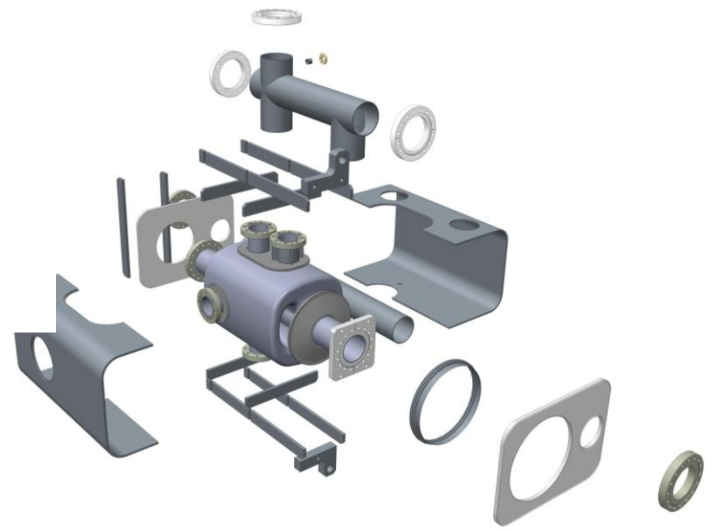


Courtesy : Graeme Burt and Ben Hall, ULAN

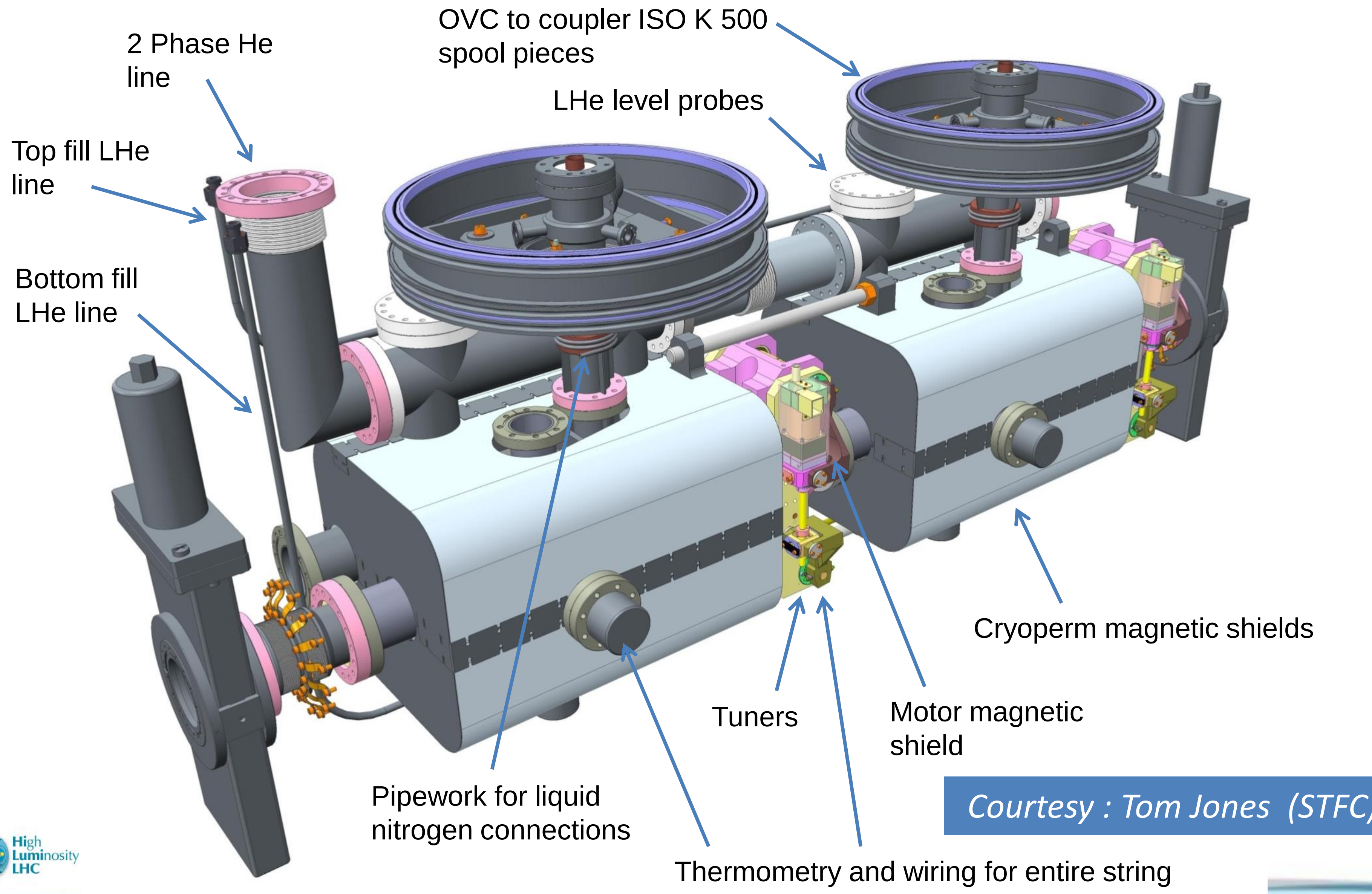
Cavity in He Vessel



Parts of the Vessel



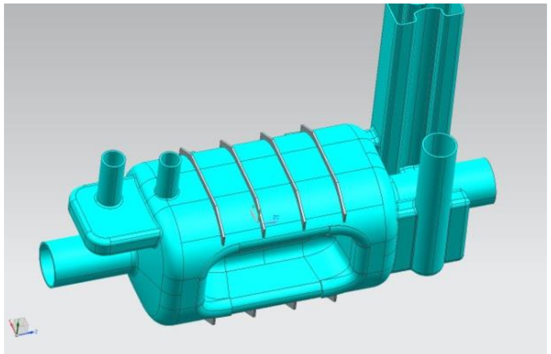
Fully Assembled Cavity String (4R)

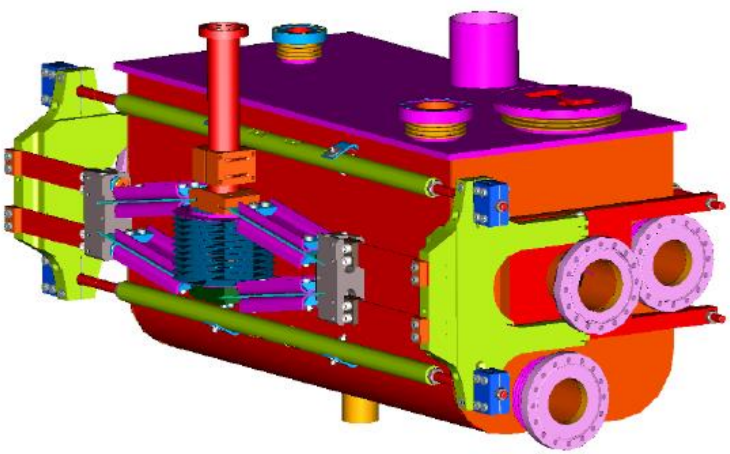


Courtesy : Tom Jones (STFC)

Helium Vessel

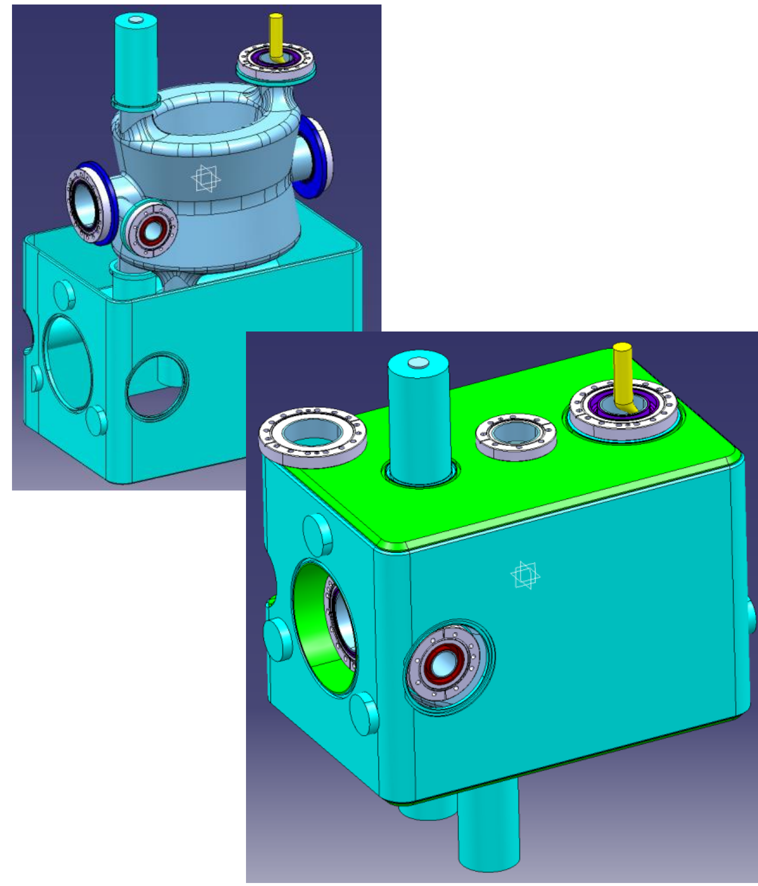
ODU Dipole cavity





Courtesy : HyeKyoung Park (ODU)

BNL Double QW cavity



Courtesy : Ofelia capatina (CERN)

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Cryomodule Schematic (P&ID)

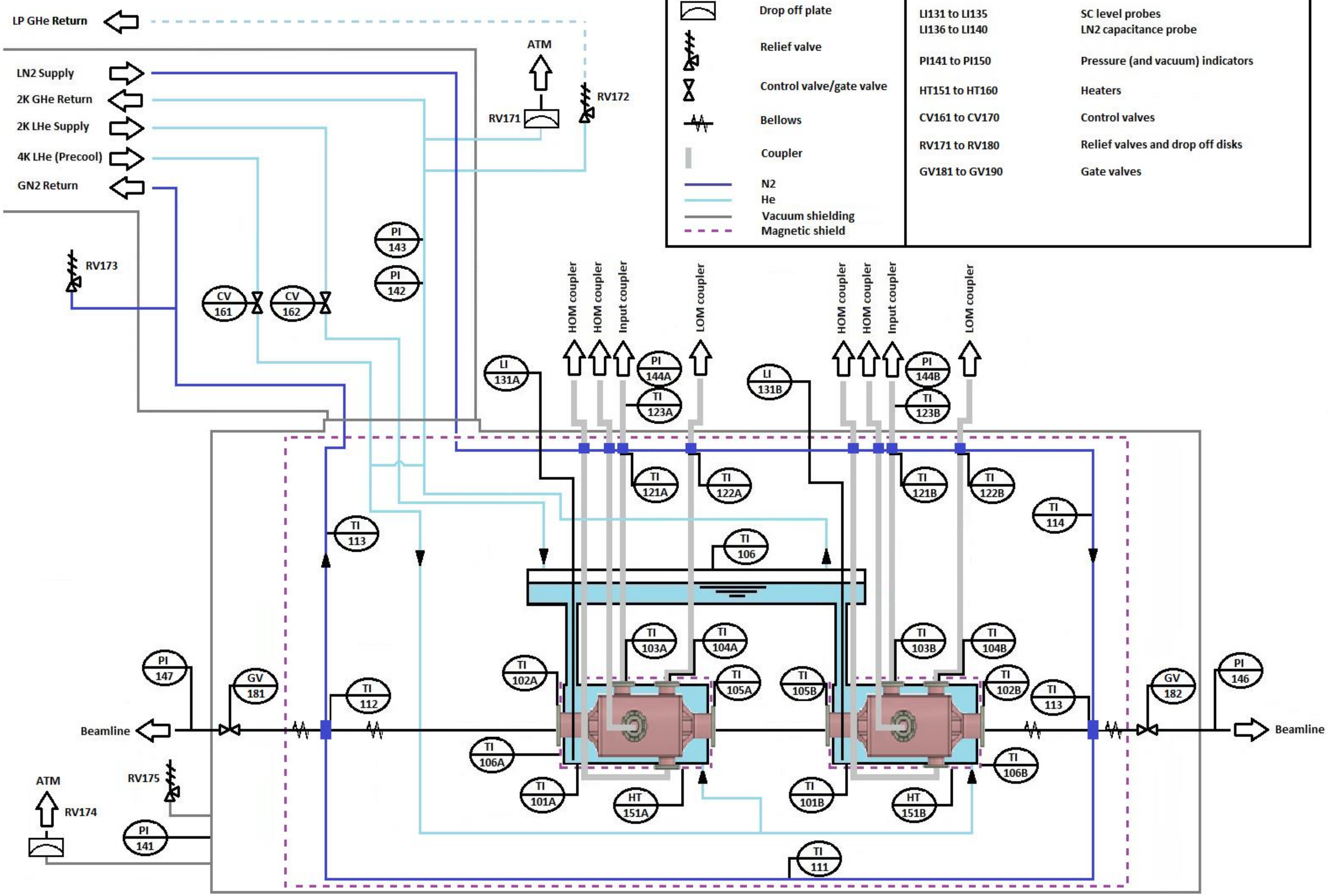
Piping and Instrumentation diagram for LHC Crab Cavity Cryogenics System

Courtesy : Andy May (ASTeC)

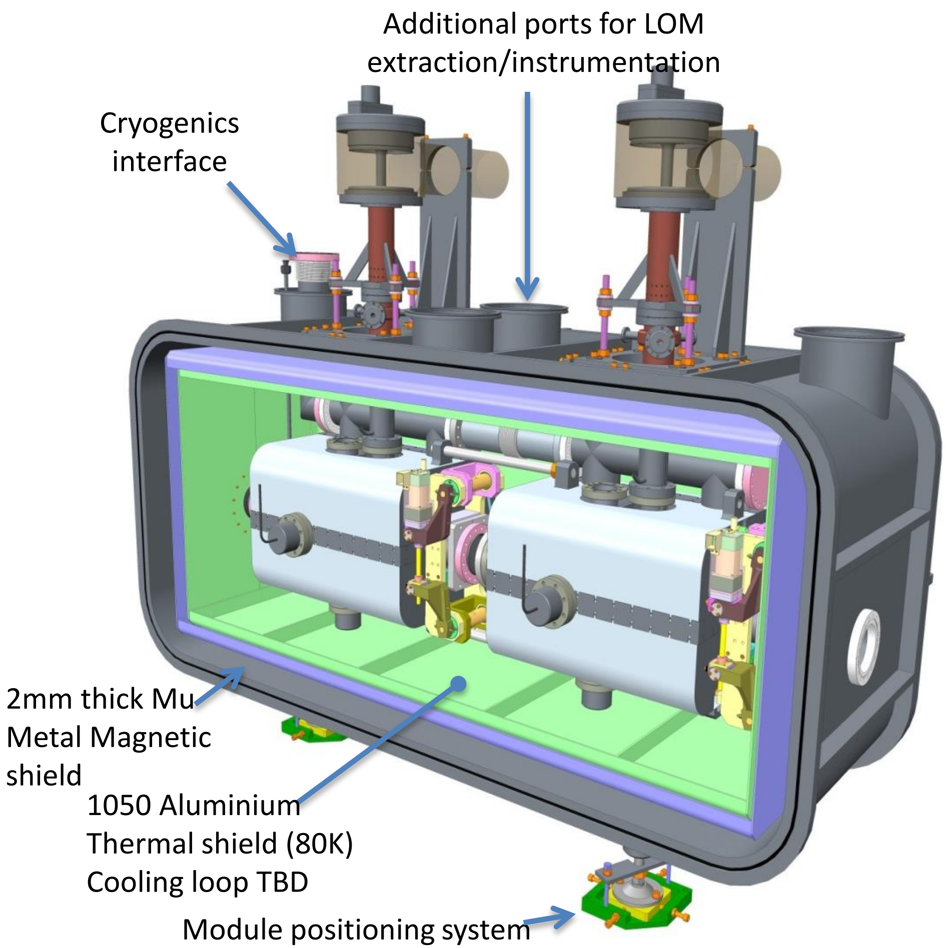
Legend

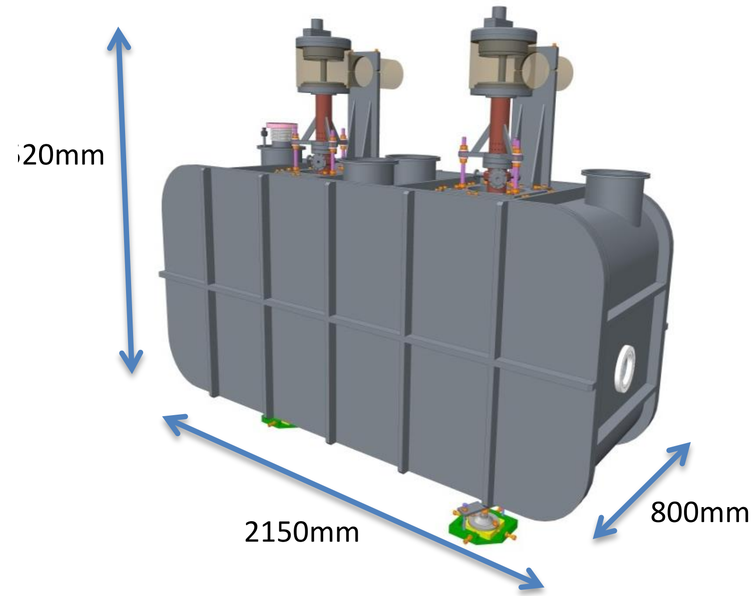
Symbol	Meaning
Indicator	
External connection	
Drop off plate	
Relief valve	
Control valve/gate valve	
Bellows	
Coupler	
N2	
He	
Vacuum shielding	
Magnetic shield	

TI101 to TI110	1.5K < T < 40K	CERNOX or Si diode
TI111 to TI120	40K < T	PT100 allocated to thermal shield
TI121 to TI130	40K < T	PT100 allocated to couplers and intercepts
LI131 to LI135		SC level probes
LI136 to LI140		LN2 capacitance probe
PI141 to PI150		Pressure (and vacuum) indicators
HT151 to HT160		Heaters
CV161 to CV170		Control valves
RV171 to RV180		Relief valves and drop off disks
GV181 to GV190		Gate valves



Cryomodule Concept





Design features

- *simplifies the assembly procedures*
- *provides sufficient access to internal components during assembly and after installation*
- *FPC is used as the main support for the cavity string.*

More details in - Conceptual design of a Cryomodule for Crab Cavities for HiLumi-LHC
S. Pattalwar, et al, MOP 087, SRF 2013, Paris

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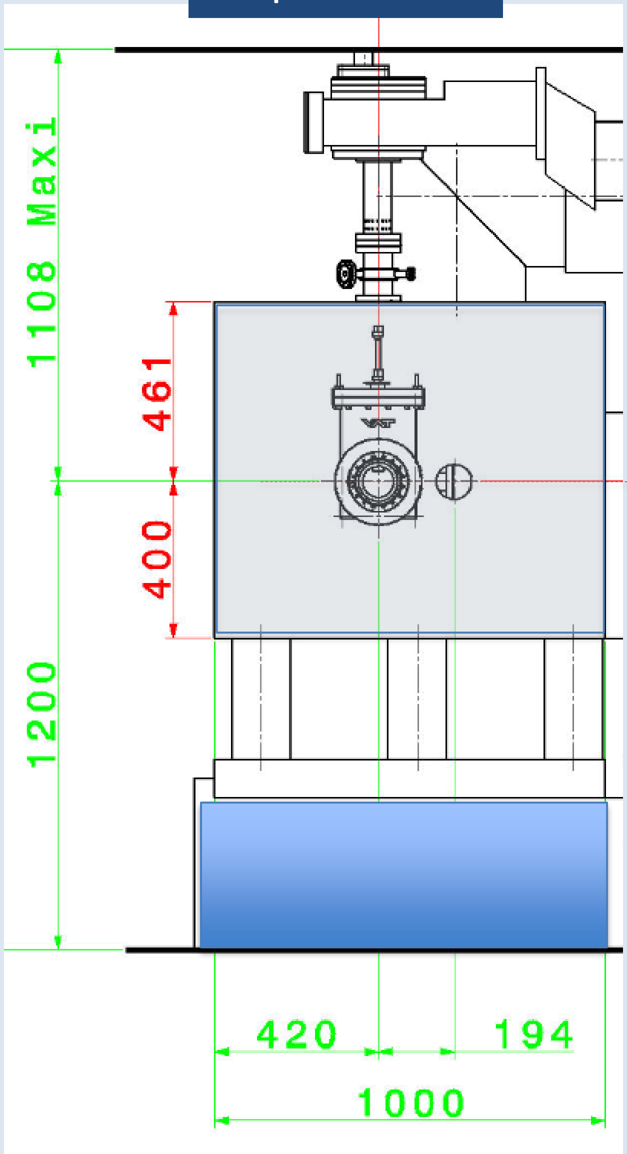
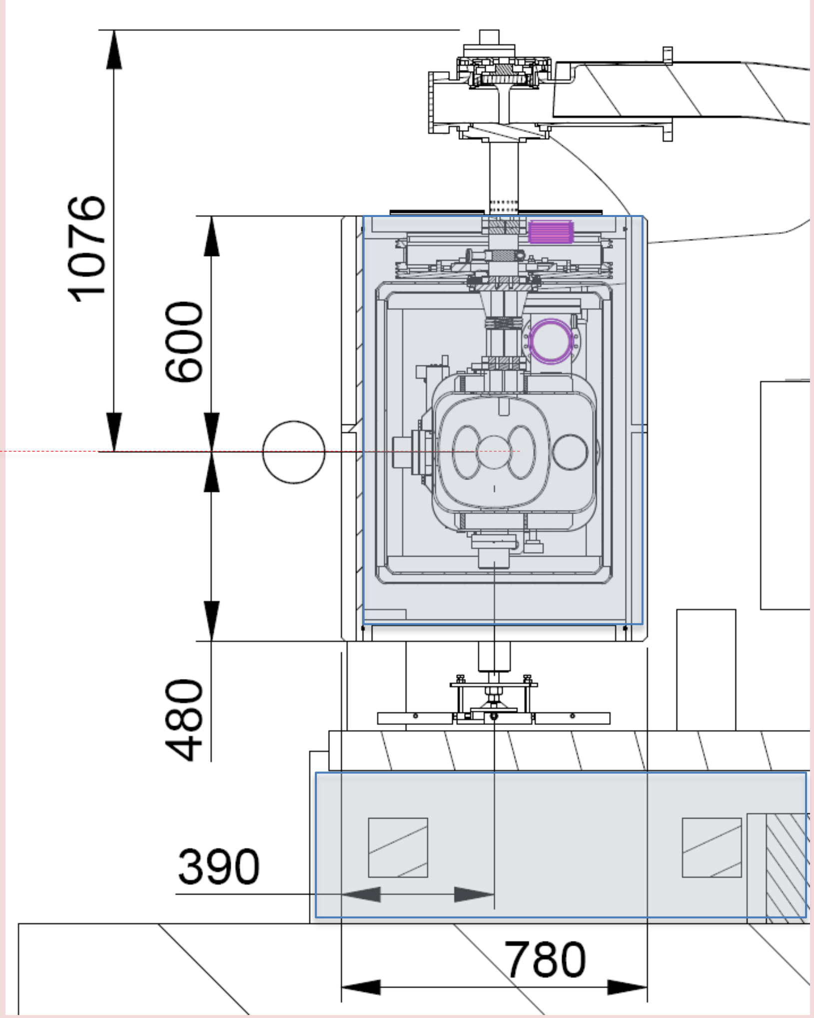
Compatibility with SPS Infrastructure

Requirements



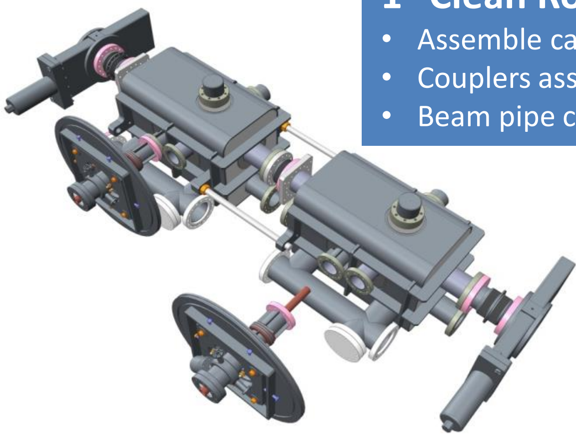
Concept Design



Assembly Sequence – Proposal 1 (Side Loading)

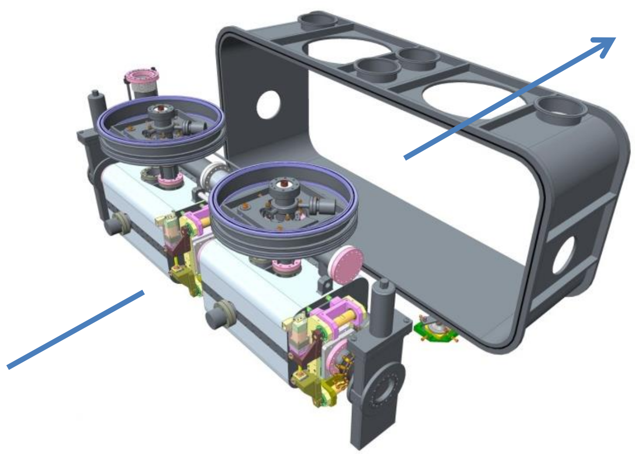
1 Clean Room Operations

- Assemble cavity string
- Couplers assembled at 90°
- Beam pipe closed with gate Valves



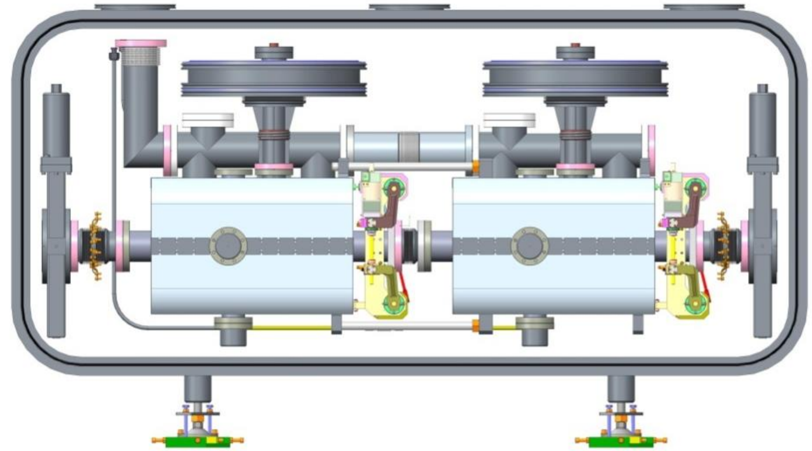
2 Outside the clean Room

- Load the cavity String from Side



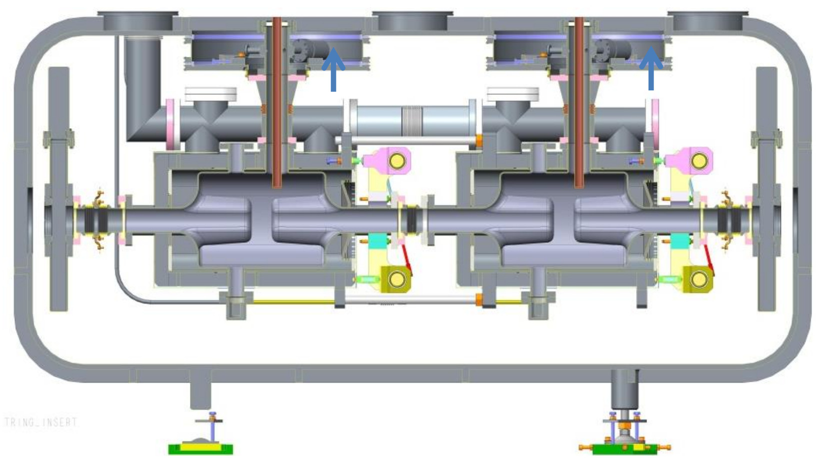
3 Align the string

with the vacuum chamber



4. Lift and assemble

with top plate of the vacuum chamber



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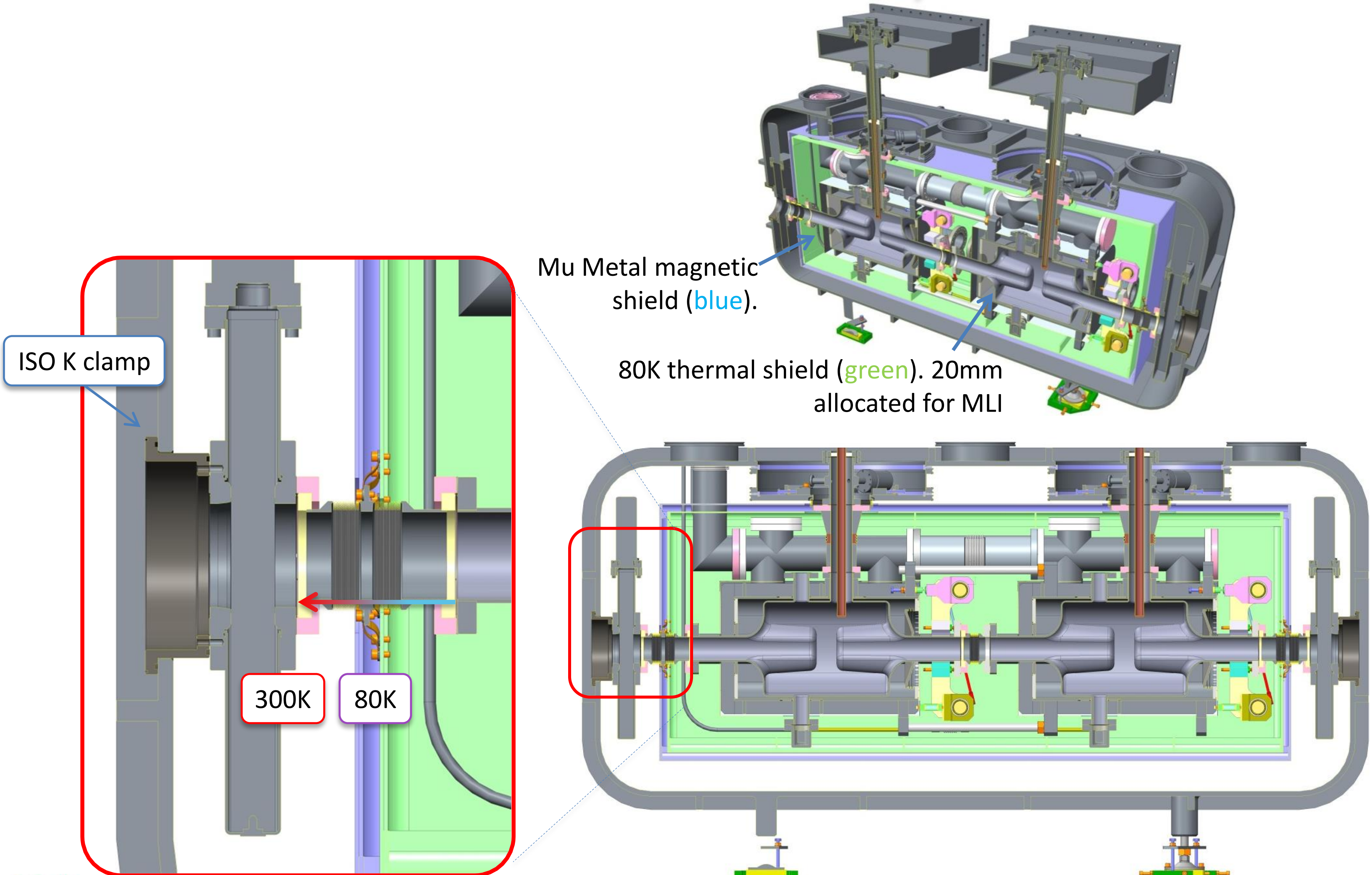
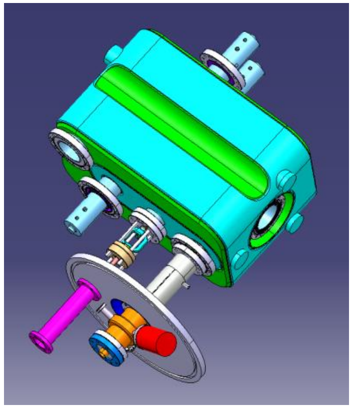
Final Assembly

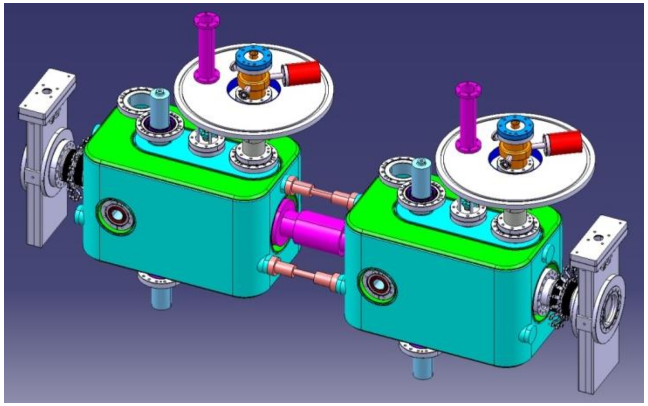


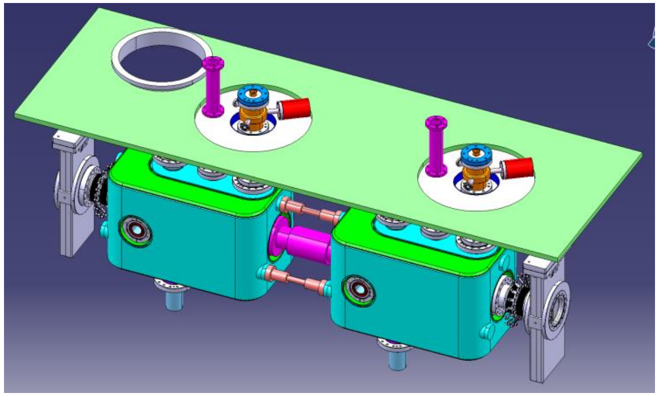
Assembly Sequence – Proposal 2 (Top Loading

1 Clean room Operations
Cavity, Coupler and Beam pipe

2 Outside the clean Room
Mounting on the top plate

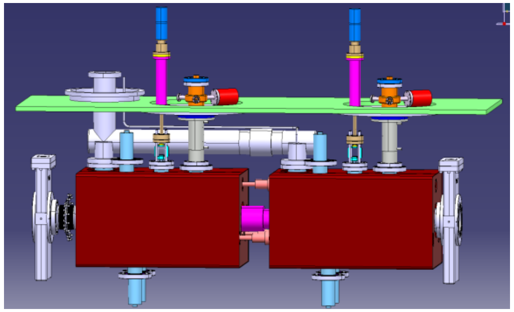


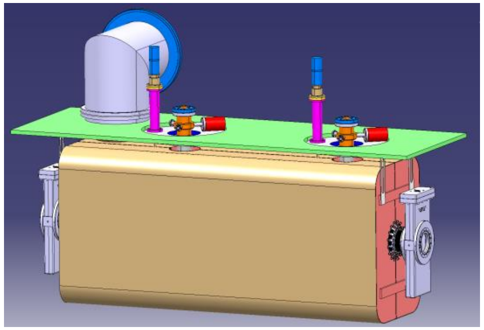


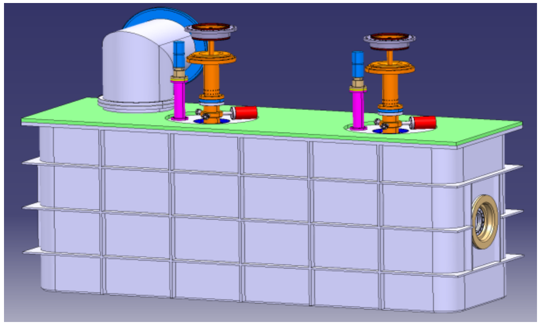


3 Outside the clean Room
Assembly of the cold parts

4 Load from the top into the vacuum chamber







Courtesy : Ofelia capatina (CERN)

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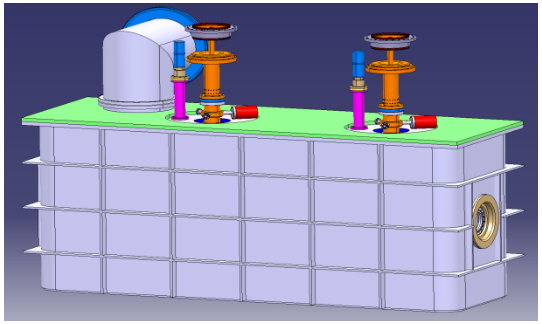
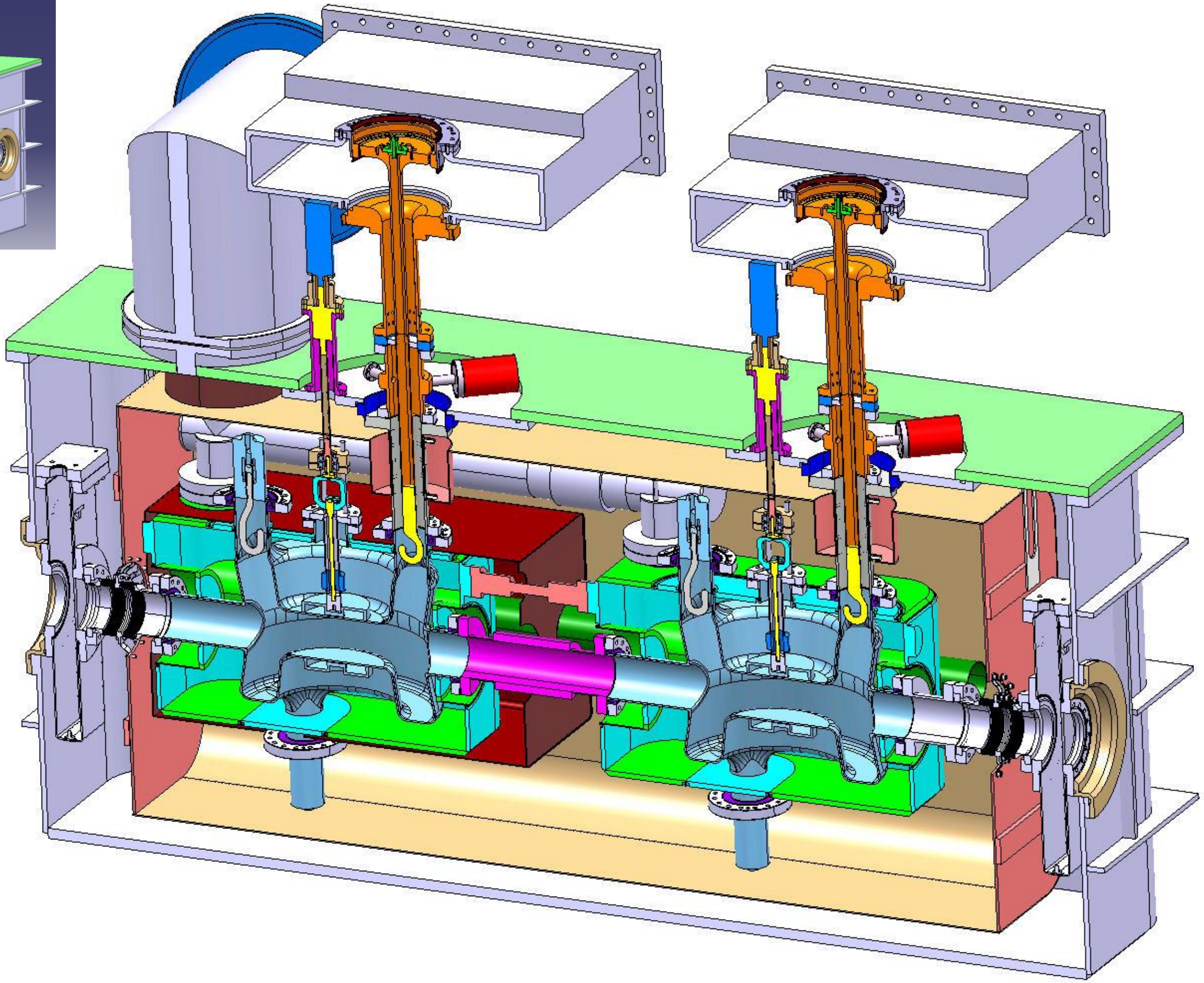
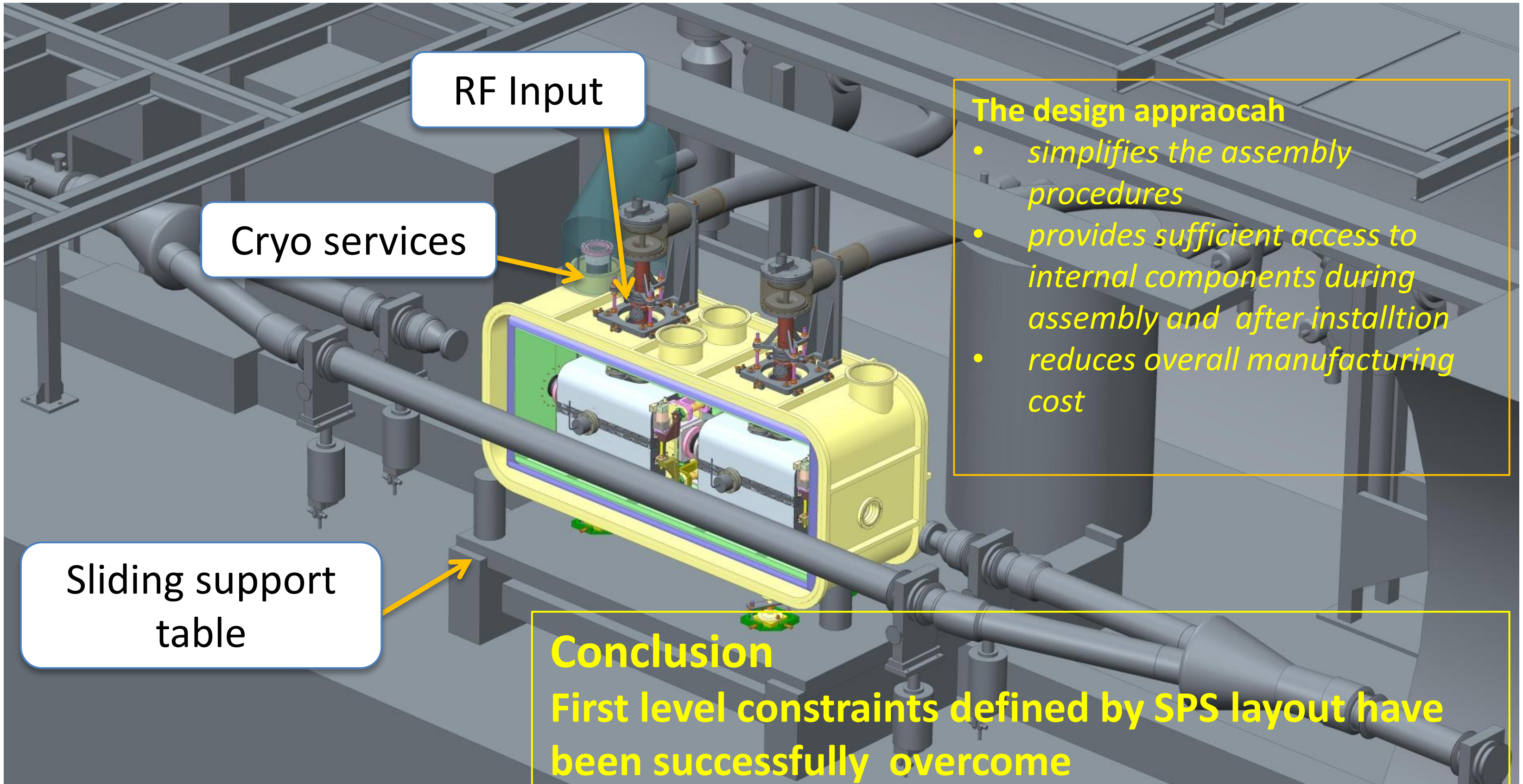
Final Assembly (Top Loading)





Cryomodule in SPS

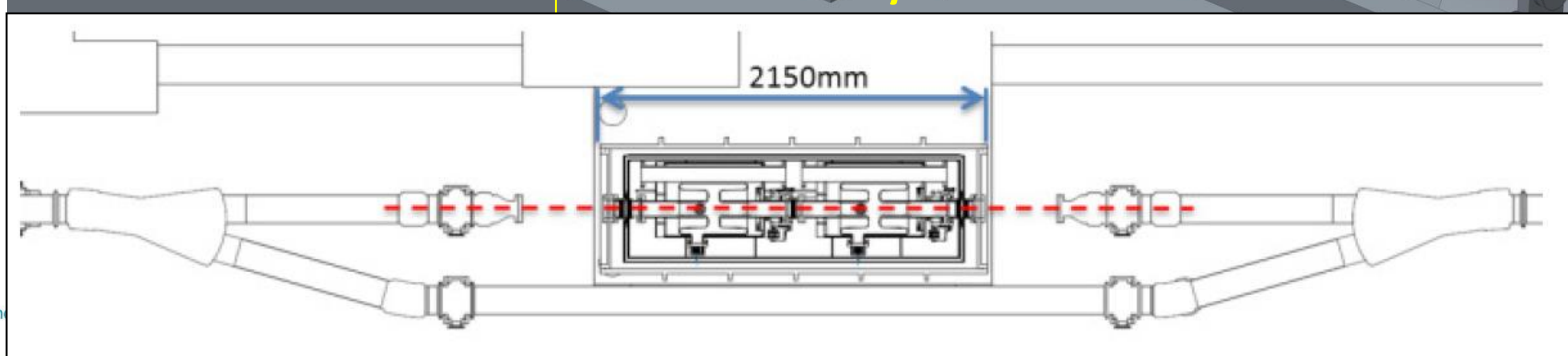


The design appraocah

- *simplifies the assembly procedures*
- *provides sufficient access to internal components during assembly and after installtion*
- *reduces overall manufacturing cost*

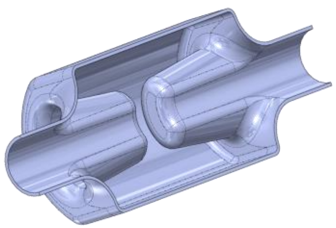
Conclusion

First level constraints defined by SPS layout have been successfully overcome

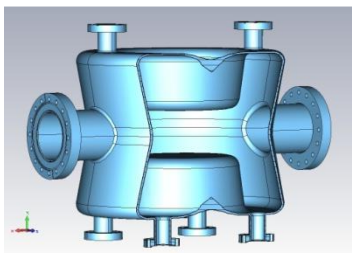


Common Design Approach

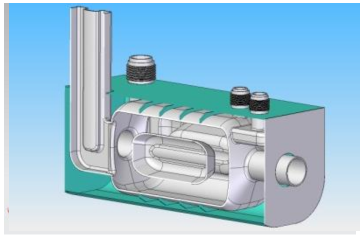
UK 4-Rod

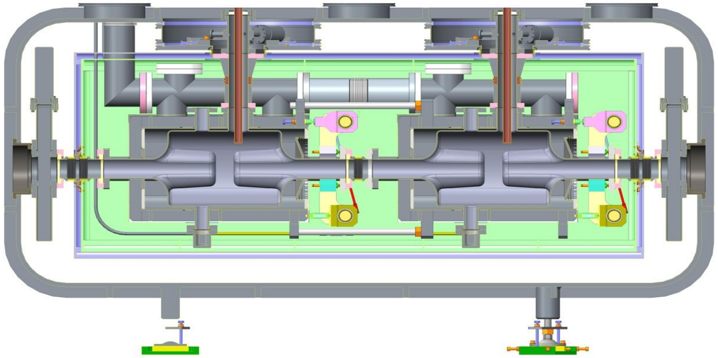


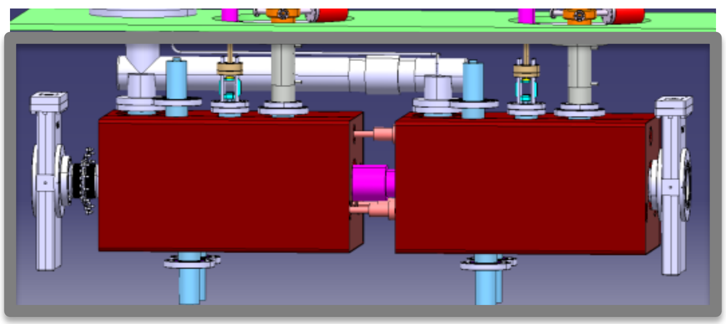
US Double QW

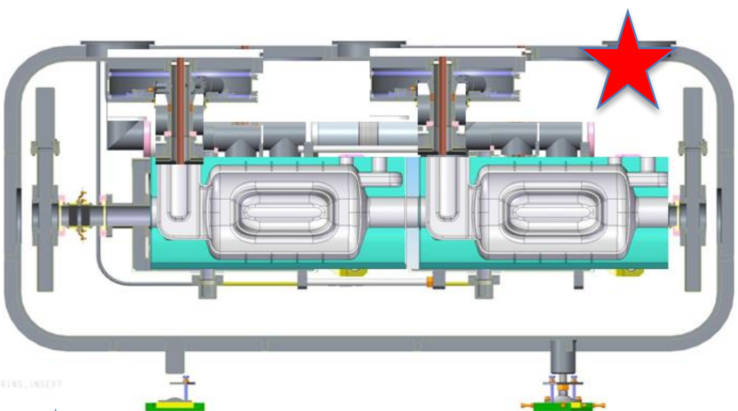


US Dipole









★ *For illustration only*

Conclusion –
A common design approach to accommodate all the 3 cavity designs has been successfully developed.

- *External Envelope*
- *Cryogenic Interface*
- *Cryogenic Process*
- *Alignment (external and Internal)*
- *…….*

Challenges –
Couplers and **Tuners** and their locations for the three designs are different.

Work In Progress

- Coupler designs for HOMs and LOMs and their integration with Infrastructure
- Magnetic Shielding
- Alignment
- Integration with Cryogenics and heat load management
- Switch over with the SPS BY-PASS or with other cryomodule
- Safety , Pressure Vessel Regulations etc.
- Tests at SM-18
- ……………………
- ……………………

Heat Load Budget

HL per cryomodule		HL @2 K [W]	HL @ 80 K (TS)	Comment
Dynamic	Deflecting mode	5.0	-	Confirmed?
	Other Order Modes	TBD	TBD	
	RF Coupler	TBD	TBD	
	Beam Current	**0.5**		Tentative
Static	Radiation (cavity +Phase Sep. Cold surface + Thermal Shield	**0.2**	**6.8**	Rescaling from LHC ○ W/m2 @ cold mass ○ 1.7 W/m2 @ Thermal shield
	CWT	0.557(rad) + 0.892(cond) = 1.5W x 2 = **3.0**	0.625(rad) + 5.926 (cond) = 6.6W x 2 = **12.6**	1 heat intercept @ 80K in the middle
	Supporting System	**1.0**	**3.3**	6 tie rods/cavity
	RF Coupler	0.501(rad) + 0.853(cond) = 1.4W x 2 = **2.7**	0.587(rad) + 5.662 (cond) = 6.3W x2 = **12.6**	1heat intercept @ 80K in the middle
	Cables & Instrumentation	**1.0**	-	Tentative
	Other order modes	TBD	TBD	Design dependent
Totals		~**13.4** + TBD	~**34.9** +TBD	

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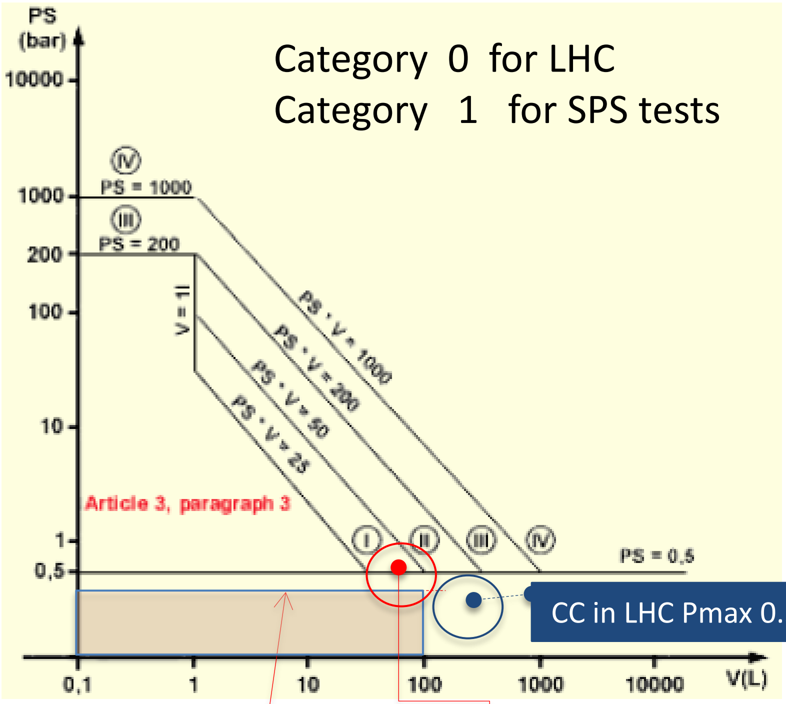
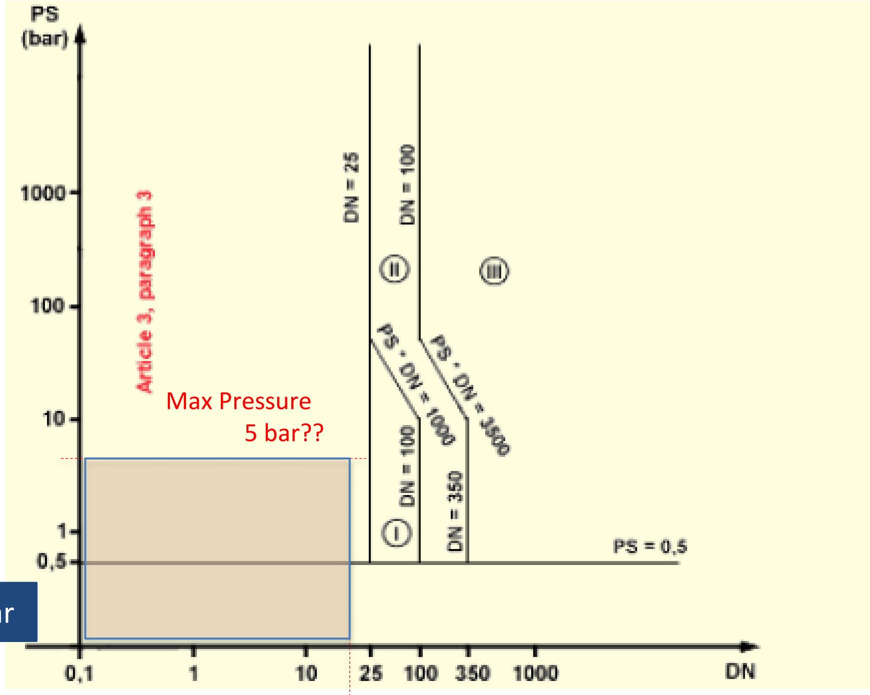
Compliance with Regulations - *PED*



CC in LHC Pmax 0.5 bar

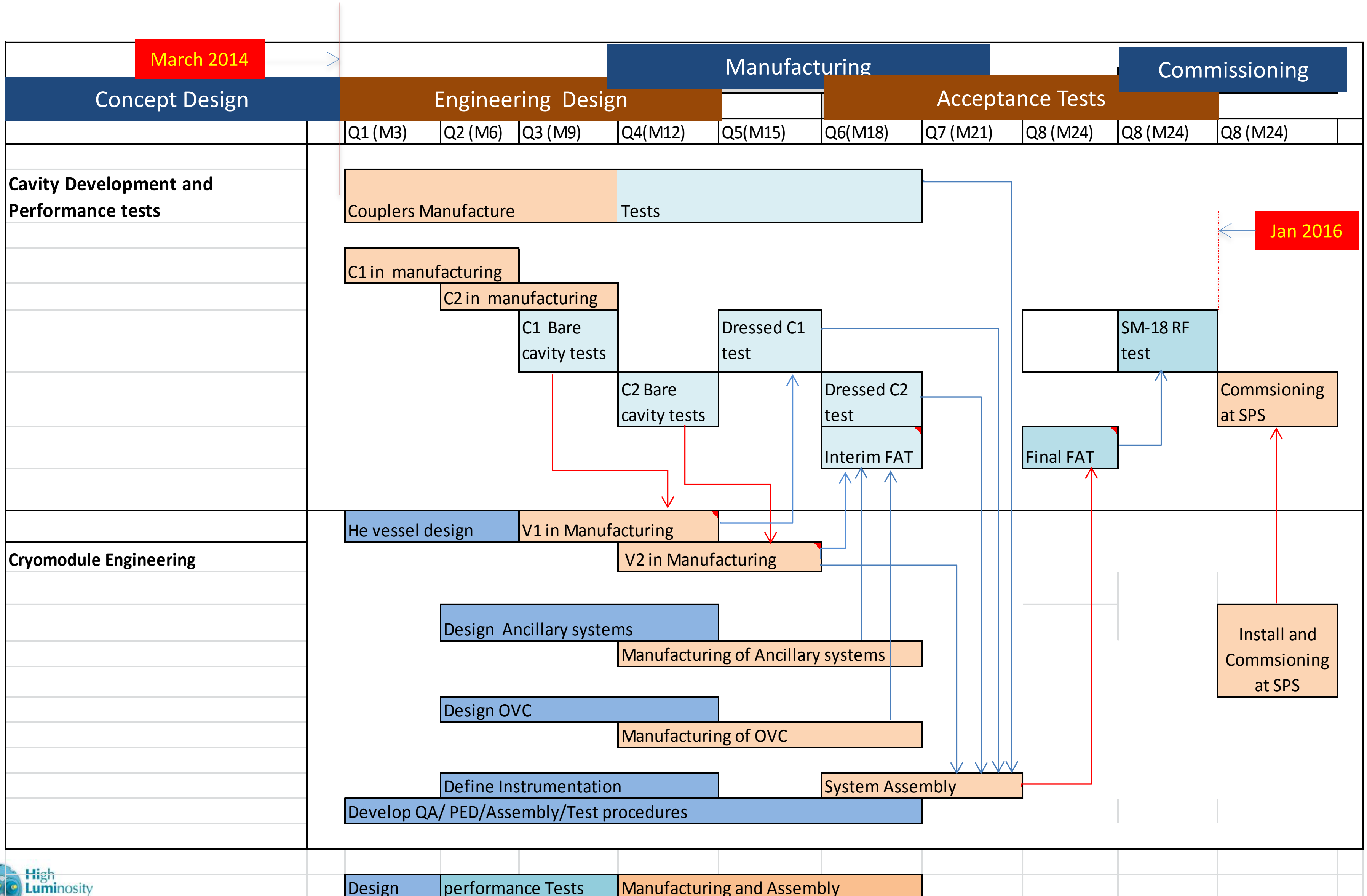


Max He pressure
0.43 barG

Maximum LHe volume < 100 L
Maximum Operating Pressure **0.8 barG**

Max pipe diameter (ID) < 25 mm

Future Plan (Expectations)



Conclusion

1. First level constraints defined by SPS layout have been successfully overcome

2. A common design approach to accommodate any of the 3 cavity designs has been successfully developed

3. Overall design process is at an advance stage .

4. Most of the remaining issues are well understood and solutions are being worked out through collaborative efforts

5. WP4 Global collaboration is working well and advancing in a right direction

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Cryogenics for Superconducting RF Development

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