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HL-LHC PROJECT

Status and plan of MQXFB cold mass and cryostat

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HL-LHC Collaboration Meeting, 16.10.2018

CERN

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D. Ramos

- **Cryostat**
  - Breakdown structure
  - Status of standard sections design and procurement
    - Vacuum vessels
    - Thermal shields
    - Support posts
  - Service modules
  - Interconnects
  - Tooling
  - Test cryostat for MQXF proto 1

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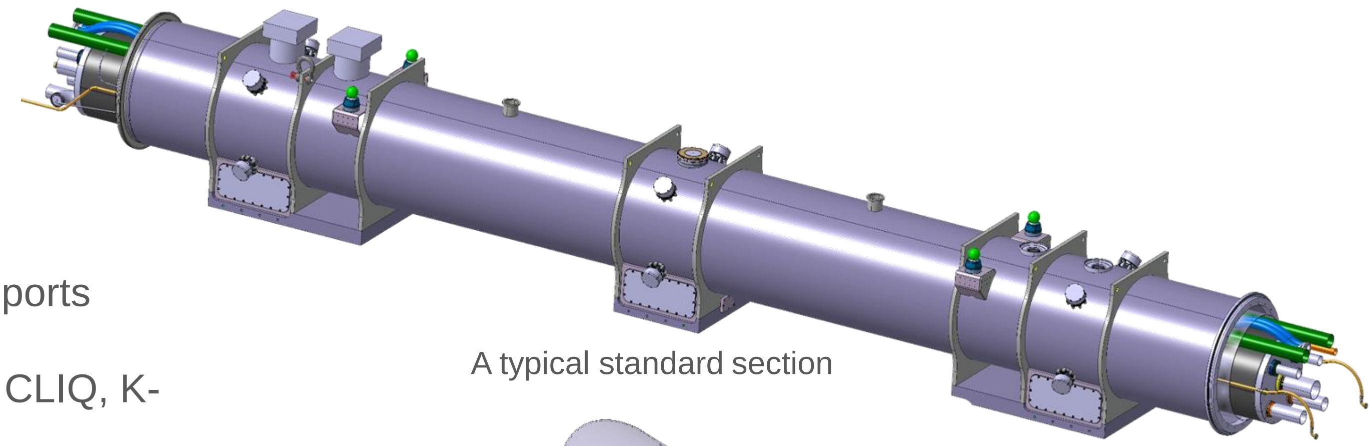
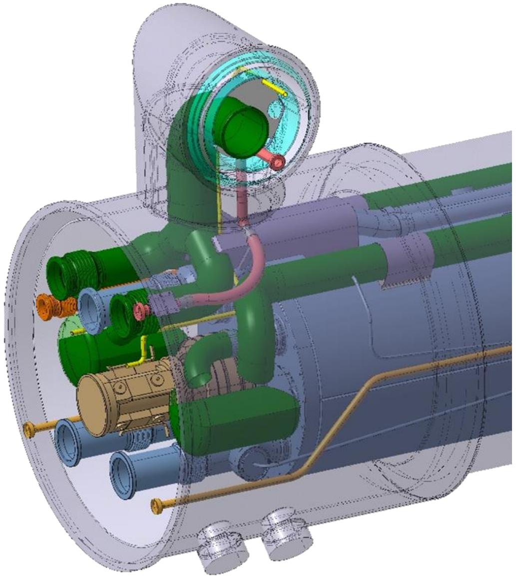
Cryostat breakdown structure

- Standard section
  - Vacuum vessel
  - Thermal shield
  - MLI
  - Support posts
  - Piping and pipe supports
  - Cold mass
  - Feedthroughs (IFS, CLIQ, K-modulation)
- Service module: design depends on location
  - Vacuum vessel
  - Thermal shield
  - MLI
  - Phase separators
  - Piping and supports
  - Expansion joints
  - BPM and cables
  - Vacuum pumping port



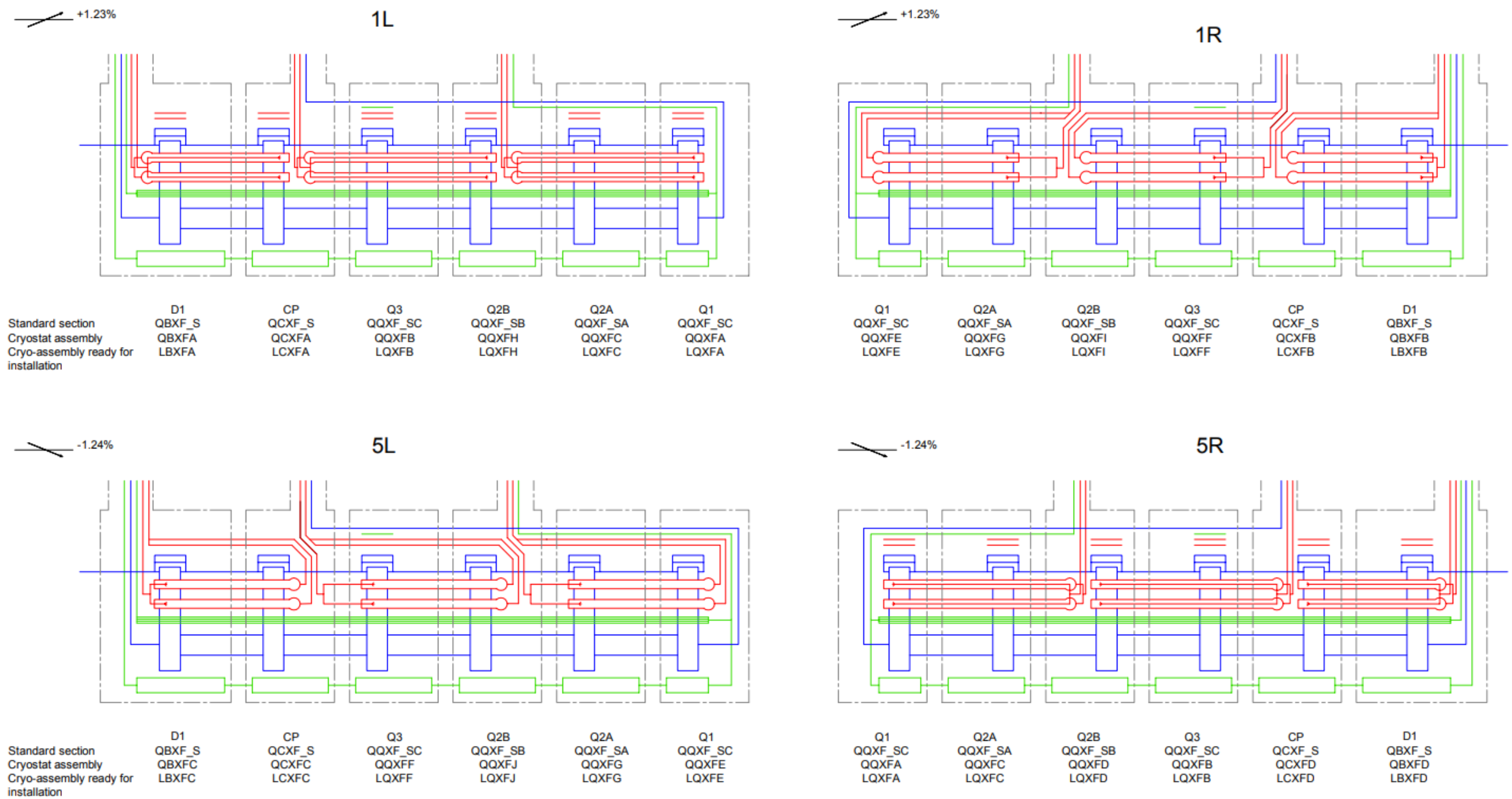
A typical standard section



Service module: many variants depending on cryogenics functional requirements. May include a connection (jumper) to the cryogenic distribution line

Types of assemblies

EDMS 1964233



He II saturated
He II pressurized
60-80 K

See EDMS 1963716 for cryogenic diagram.

Magnet cold testing is performed before assembly of the service module, i.e. in standard section configuration. Q1/3 are shipped to CERN as standard section only.

All service module operations performed at CERN SMI2.

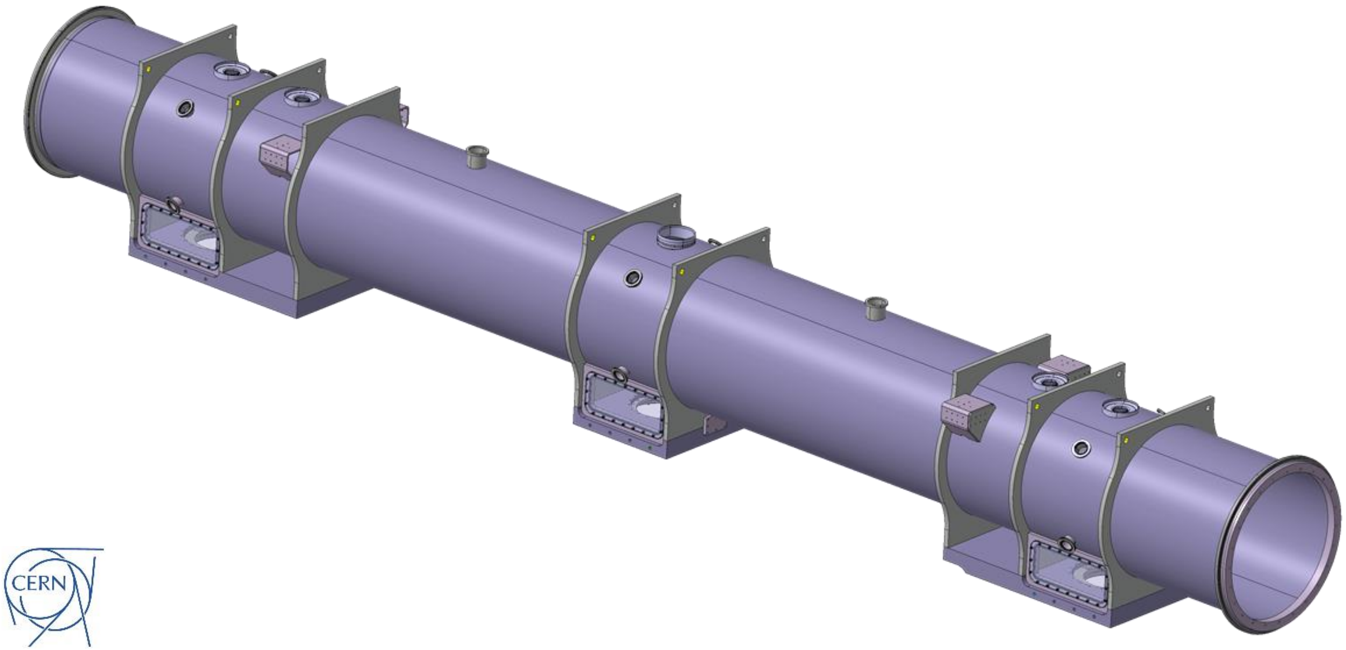
To be decided if the beam screen is to be assembled after the service module assembly (as in the LHC) or before the service module assembly.

PIPING DIAGRAM AND TYPES OF ASSEMBLIES FOR THE HL-LHC INSERTION REGION CONTINUOUS CRYOSTAT Q1 TO D1

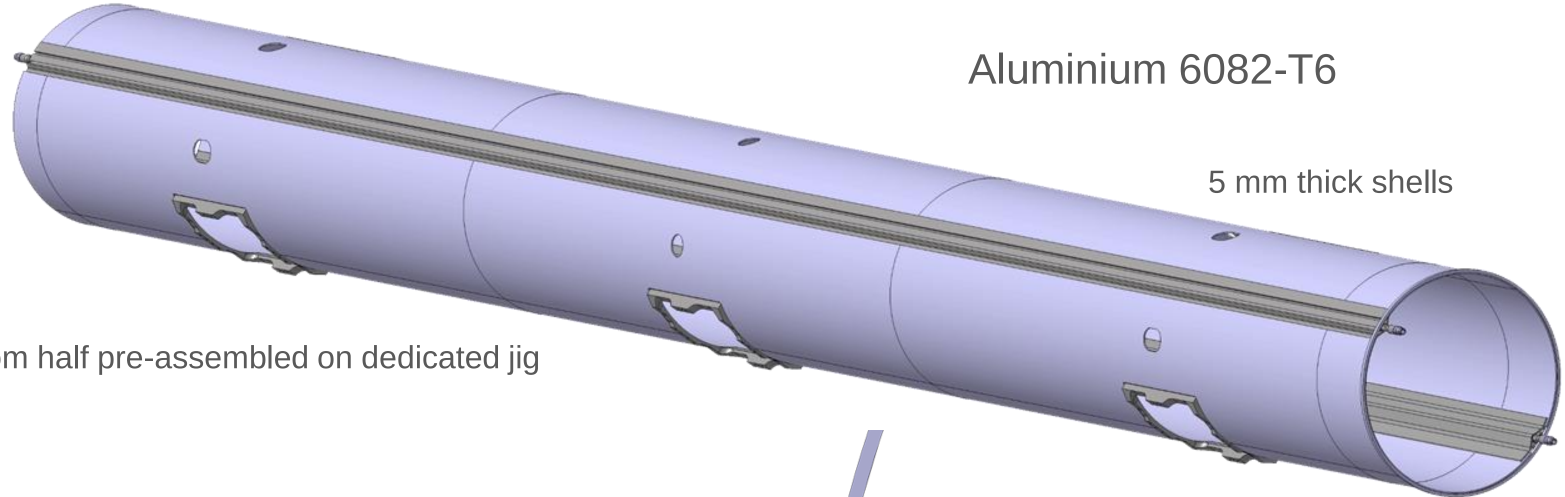
EDMS No.:	1964233	Version: 0.3		Date:	2018-04-12
Prepared by:	D. Ramos				

Standard sections: Vacuum vessels

Contract	Scope	Dates
1. For QXF protos	2 proto units: 1xProto 1 Q1/3 1xProto 2 Q2	Purchase order (CA7409153): Sep 2018 Delivery Q1/3: Jan 2019 Delivery Q2: Feb 2019
2. For all other protos and series	41 units: 10xQ1/3 11xQ2a/b 6xCP 7xD1 7xD2	MS done IT out by: Dec 2018 Finance Committee: June 2019 Purchase order: July 2019 First units delivered: Feb 2020 Production over 14 to 20 months (2 to 3 un./mo) (First units needed Q1/3, Q2, CP, D2: May 2020)



Standard sections: Thermal shields



Aluminium 6082-T6

5 mm thick shells

Bottom half pre-assembled on dedicated jig

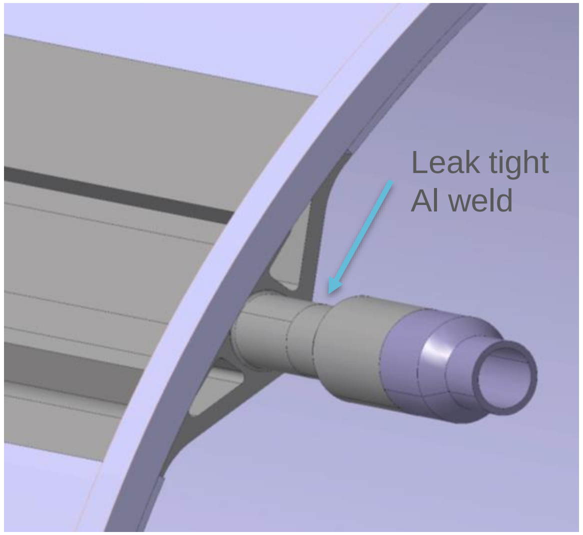
Machined structural
support craddle

Weld #2

Weld #1

Line of rivets

Pipe extrusion with
positioning dove tail and
reinforcement wings



Leak tight
Al weld

Aluminium to stainless steel
transition

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Standard section: support posts

- On-going contract for the supply of 140 units
- Contractor finishing the design file
- Raw materials have been approved and ordered
- Tooling being manufactured
- Samples for material testing will be prepared soon
- 100% load tested and ultrasound tested
- Delivery of 10 units pre-series by January 2019
- Delivery of series in 3 batches up to January 2020

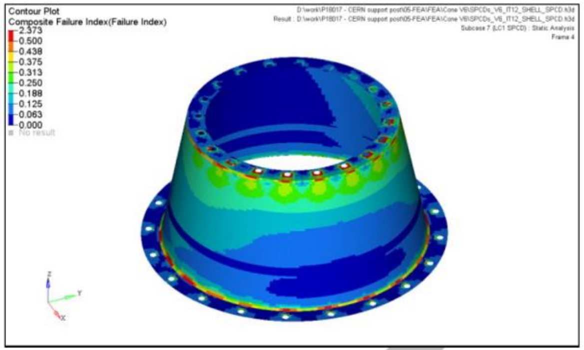


Figure 21 – Failure index – I

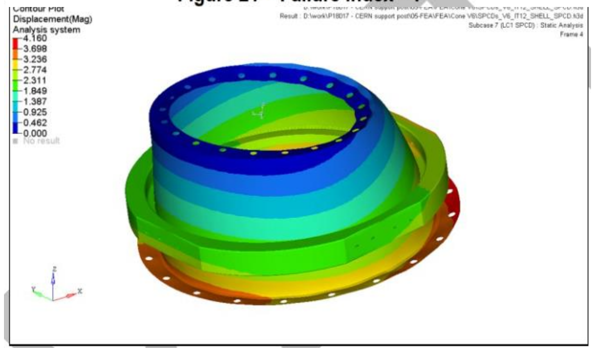


Figure 19 – Displacement amplified x20 – I

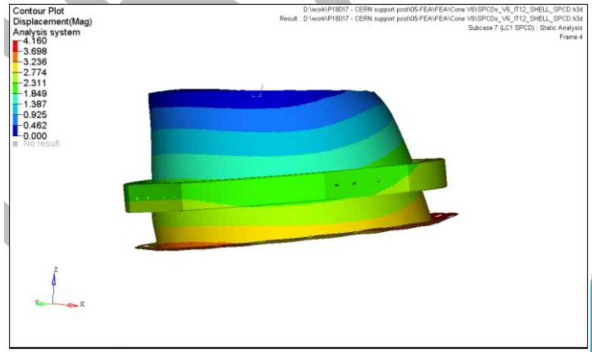
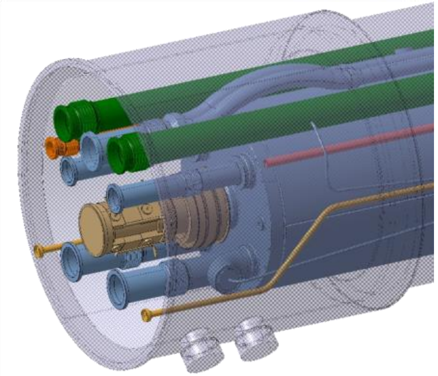
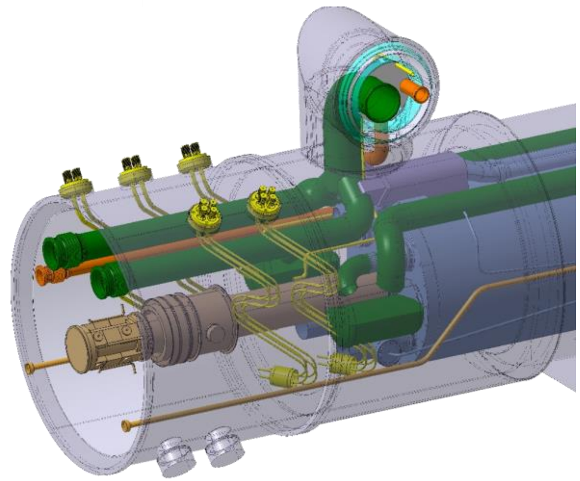


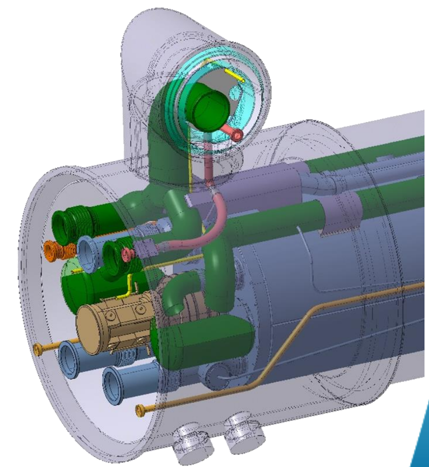
Figure 20 – Displacement amplified x20 – I

Service modules

- Service module assembly
  - Assembled **after** cold test for Q1, Q2, Q3, D1
  - Assembled **before** cold test for D2 because the **heat exchanger** is required for testing
  - Corrector package: Must be assembled **after** cold testing if magnets powered through the **local leads**
- Component design and development of detailed assembly procedures starting now
- Accessibility for installation of the **beamscreen and BPM** are critical
  - But compromises are needed due to boundary conditions that are more demanding than in the past LHC experience
  - Discussions **on-going** to define the best step in the **assembly sequence** on which to install the beamscreen







Interconnect expansion joints

Role:

- Absorb thermal expansion/contraction during transients
- Ensure assembly and alignment flexibility

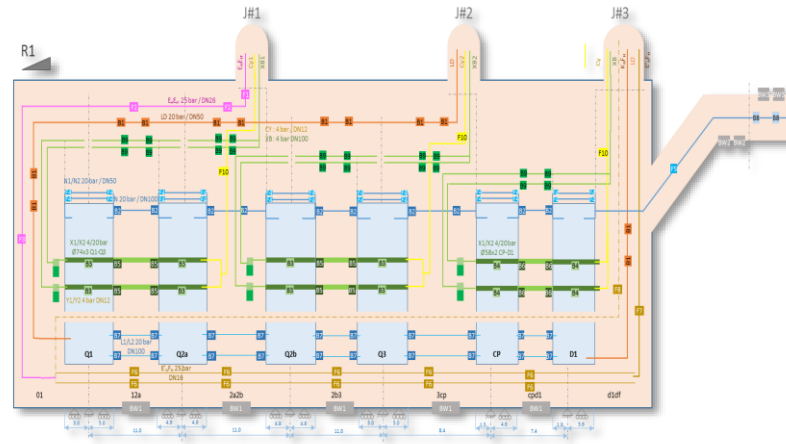
Design sequence:

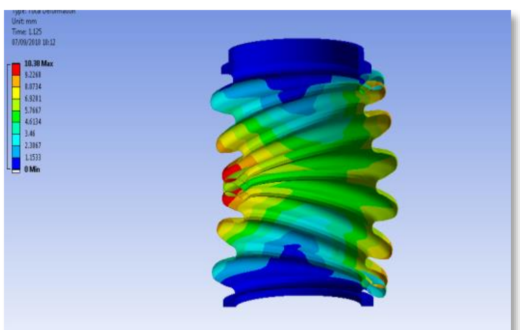
- Study cryogenic layout and transient procedures : Completed
- Define fixed points, bellows positions: Completed
- Studies for bellows operation validation: in progress
- Pre-design bellows: 75% completed
- Integrate pre-designed bellows : in progress

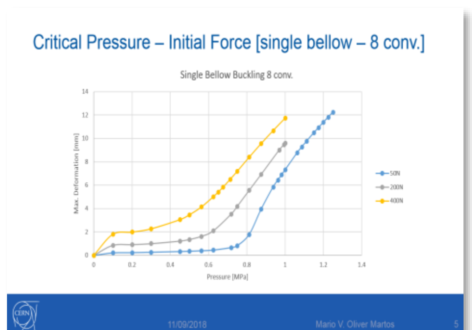
Progress status:

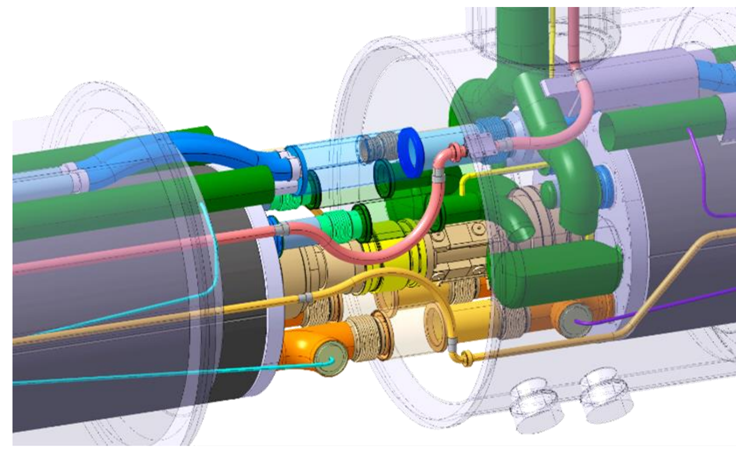
- Market Survey for 600 bellows out in October 18
- Contract placement 1st semester 19

5L bellows and fixed point layout









Design parameters	
Pressure	Int: 25 bar / Ext: 20 bar
Stroke	Up to 34 mm
Internal diameter	40 to 120 mm
Temperature	1.9K to 350K

Supply requirements
Standards: EN14917 / EN13445 / PED
Nb of bellows: 5L x90 / 5R x80
HL-LHC QA requirements
CE certification

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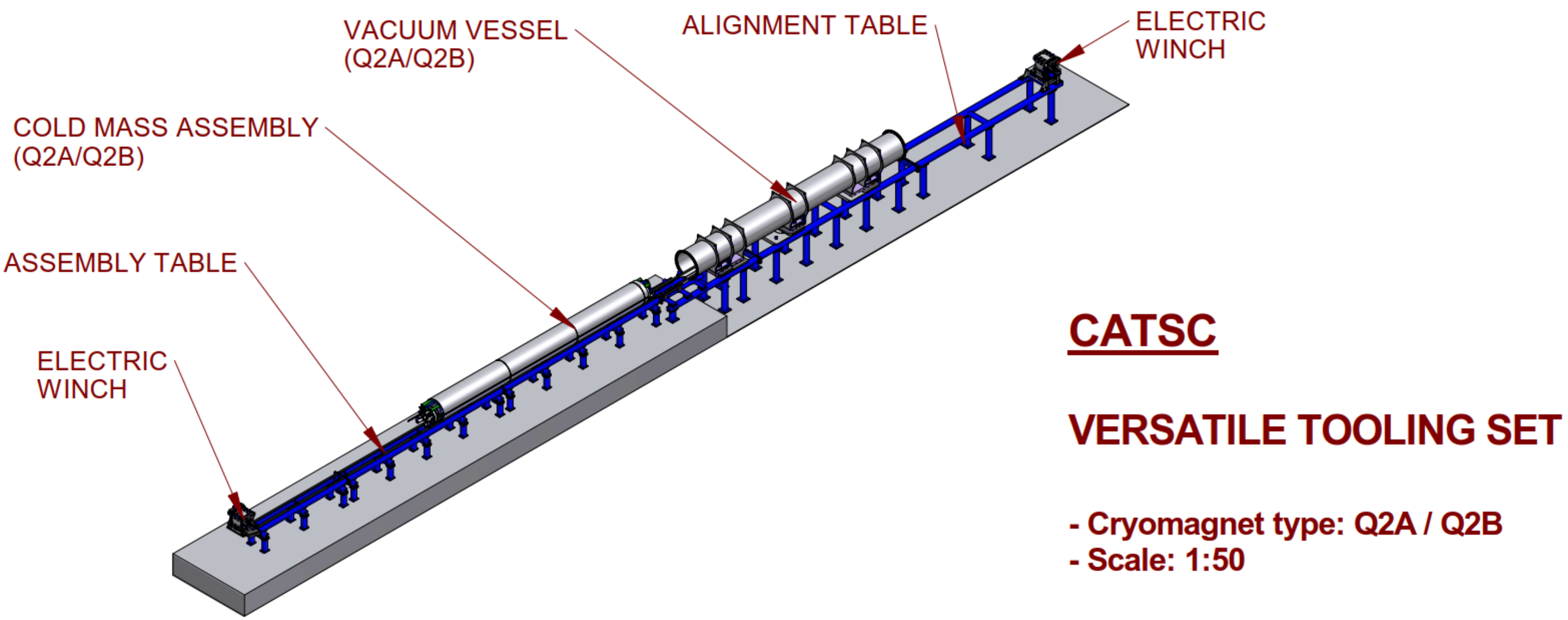
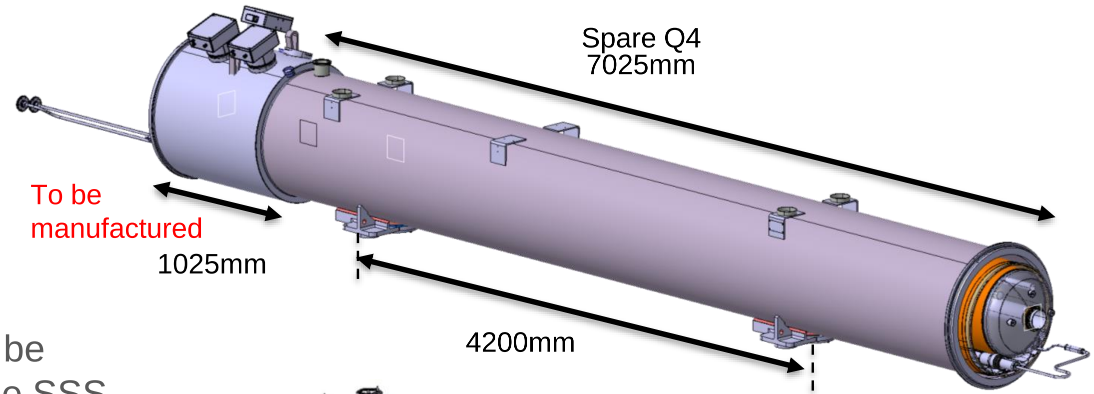
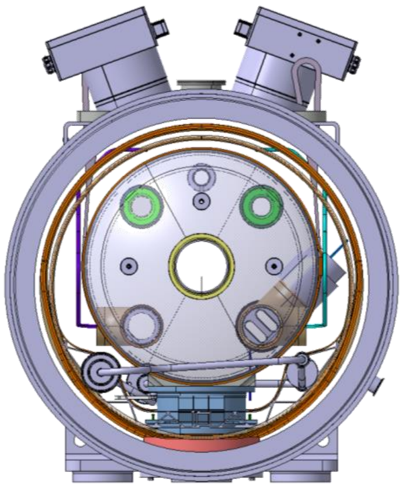
Cryostating tooling

- Contract running. Design almost finished, manufacturing starting soon.
- Contractual installation schedule:
  - at CERN: March 2019
  - at Fermilab: May 2019

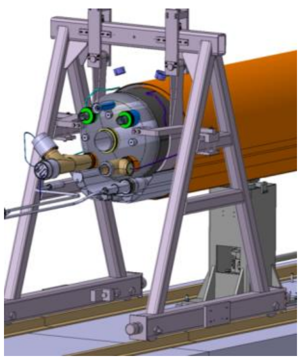


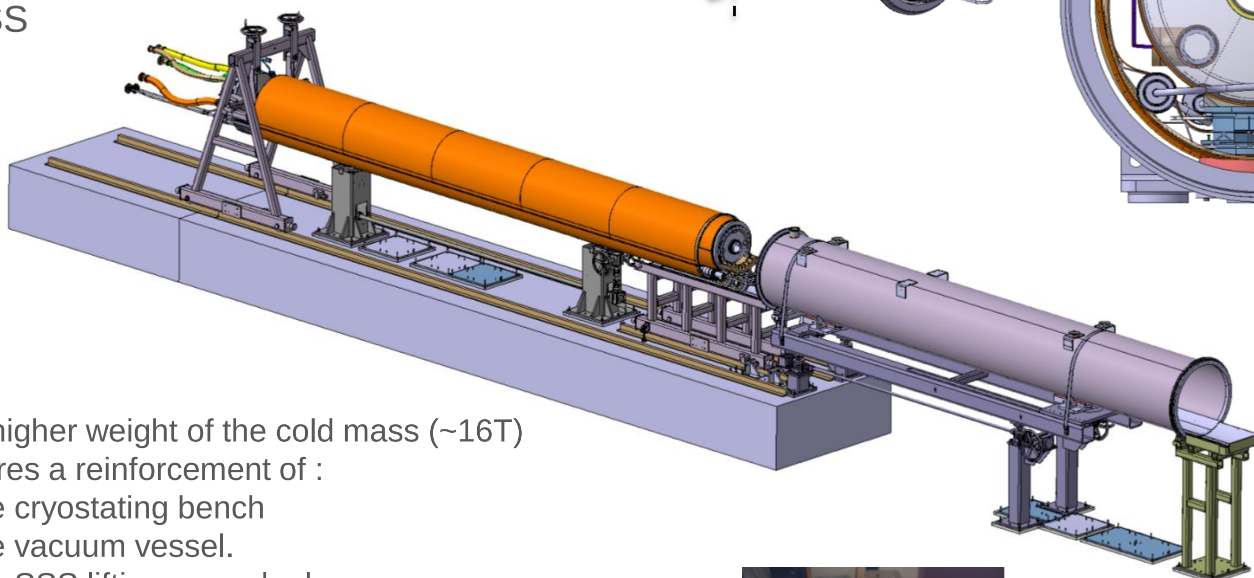
Test cryostat for MQXFB 8.1 m cold mass





The cold mass will be cryostated using the SSS cryostating bench :





The higher weight of the cold mass (~16T) requires a reinforcement of :

- the cryostating bench
- the vacuum vessel.
- the SSS lifting spreader beam

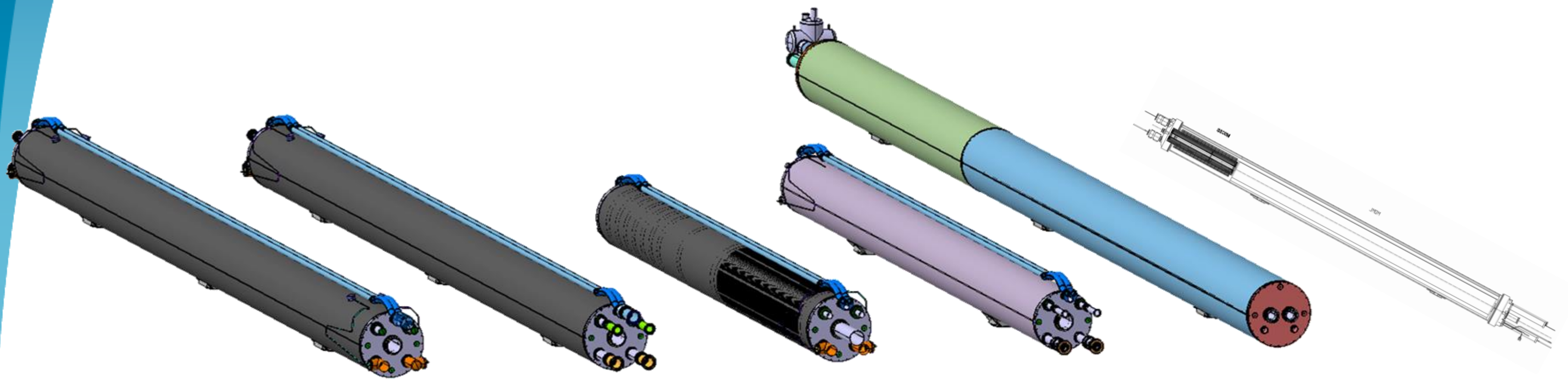
Procurement of components finished by January 2019

Custom made GFRE support posts in collaboration with **EP-DT**

- **Cold mass**
  - Status of design
  - Status of procurement
  - Heat exchangers
  - Extremities and expansion loops integration
  - End covers
  - Instrumentation

H. Prin

Cold Masses Catalogue and Design Status

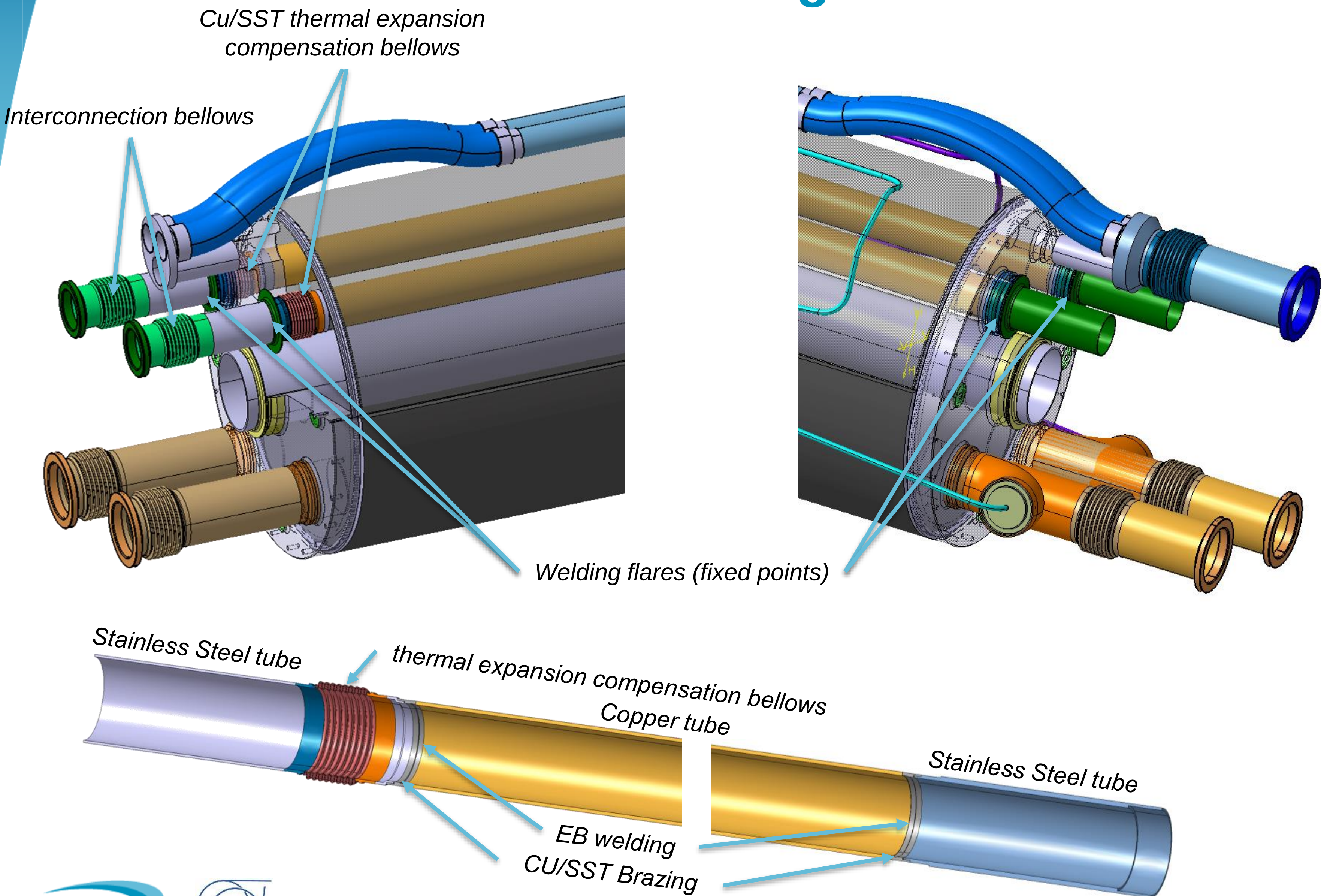


	Q1/Q3	Q2A/B	CP	D1	D2	Q10
Envelope	✓	✓	✓	✓	✓	✓
End covers	✓	✓	✓	Proposal to avoid trans. rings	✓	✓
Supports	✓	✓	✓	Proposal to fit std interfaces	✓	✓
Bus work	Ongoing Expansion loops	Ongoing	TBD	TBD (2 leads, no internal busbars)	✓	✓
Extremities	Bellows, IFS, CLIQ leads and k-mod under definition	Bellows, IFS, CLIQ leads under definition	Beam pipe pumping Cond. Cooled leads interfaces TBD	Bellows, IFS TBD No CLIQ	✓	MS connections to N-Line under study
Heat exch.	✓	✓	✓	✓	✓	✓
Instrumentation	✓ to be refined	✓ to be refined	TBD (11 magnets)	TBD	Ongoing	✓
Remark			*HO corrector centering system ongoing*			*MSCBB corrector centering system ongoing*

Cold Mass Components Procurement

	Q1/Q3	Q2A/B	D2	CP	D1	Q10
Plates	Mid Jan 2019	IT on going – First delivery in Mar. 2019			KEK	✓
Shells	FNAL	IT on going – First delivery in Jul. 2019			KEK	✓
End covers	Dec. 2019				KEK	✓
Supports	Feb. 2019				KEK	✓
Heat exchangers	Copper tubes delivered Cu/SST transitions to be brazed and welded (mid 2019)		By Sept 2019 (CEA Grenoble)	Copper tubes recovered from LHC spares Half of the Cu/SST transitions to be brazed and welded (mid 2019)		✓
Cold bore tube	First delivery in Apr. 2019 (4)		Nov 2019	First delivery in Oct 2019		✓
Busbars	On going discussion with LARP		From Nov 2019	✓Existing 120A cables		Jun. 2019
Bellows	IT to be launched mid-Nov. 2018					✓
Instrumentation wires	✓Off the shelf components					
CLIQ wires	Dimensioning ongoing					
Ports	✓Off the shelf components					

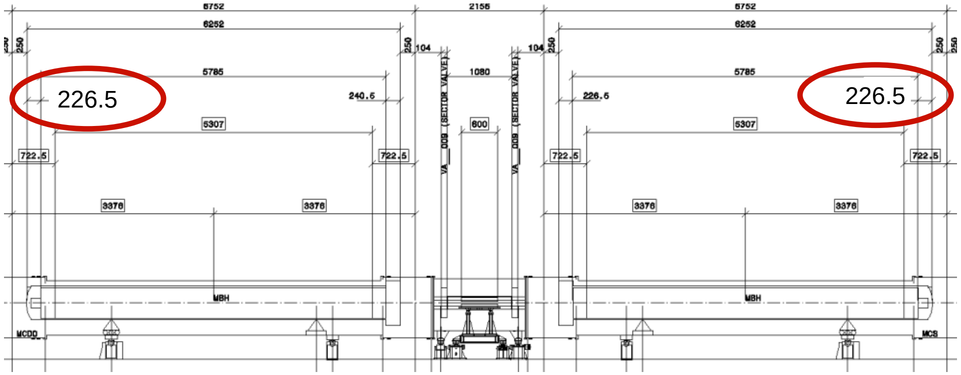
Heat exchangers

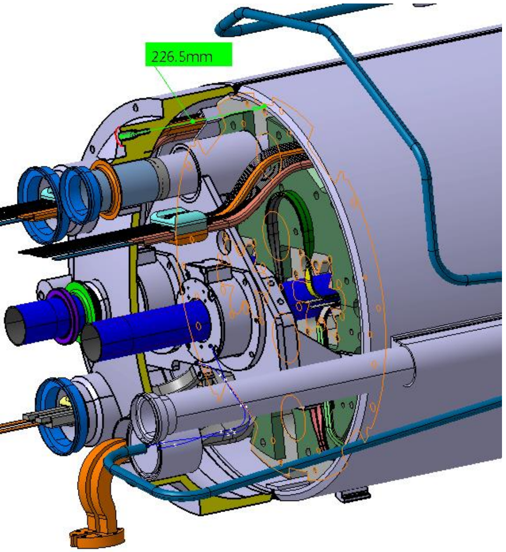


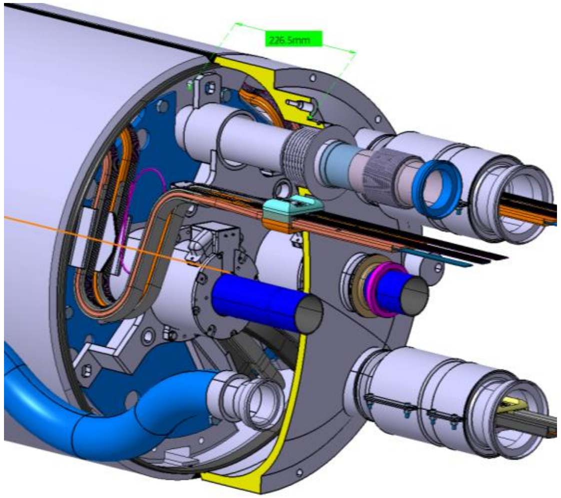
Cold Mass Extremities

11T case

(identical to MB, SSS, SSSS…)

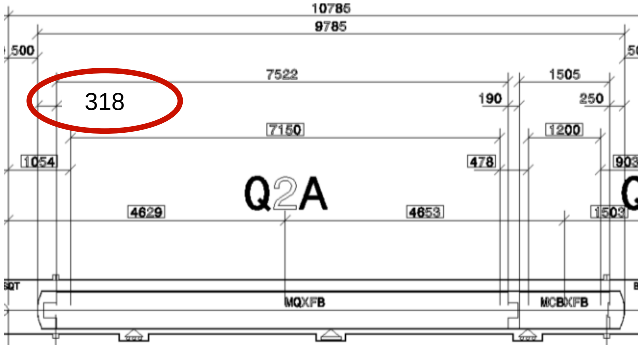


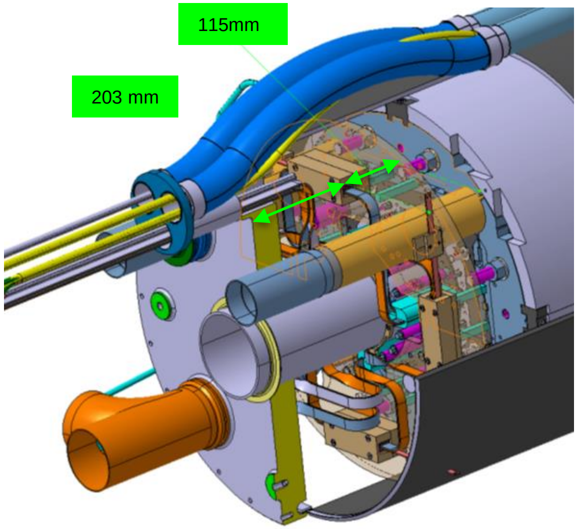




LMQXF

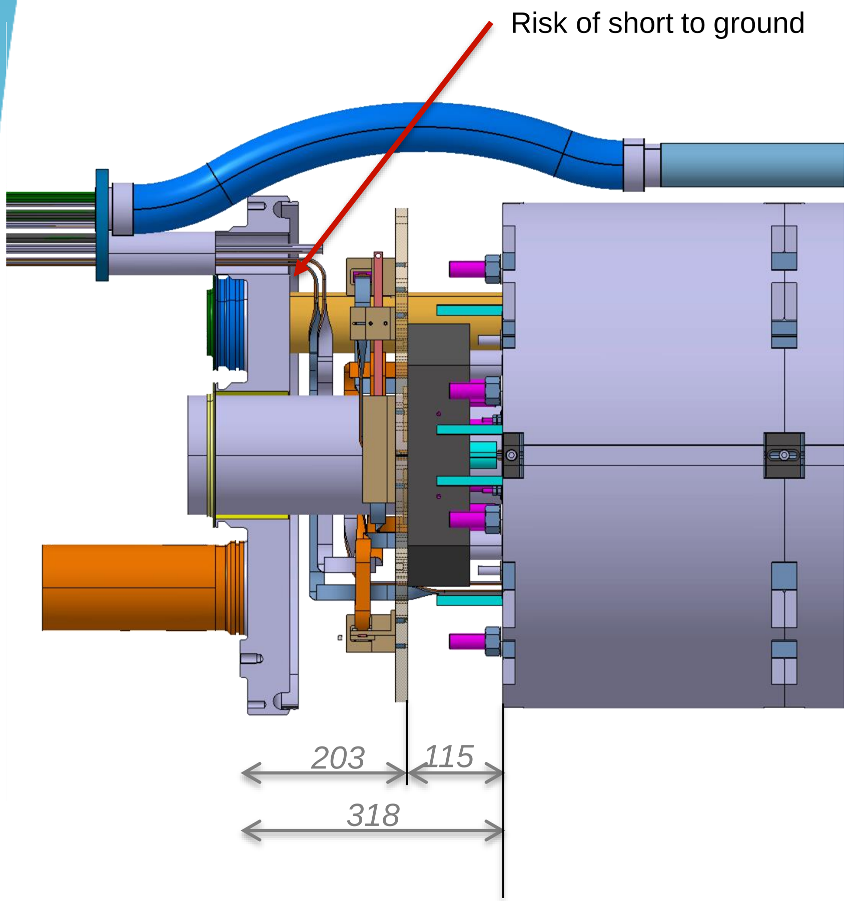
Cold masses with MQXFA or B

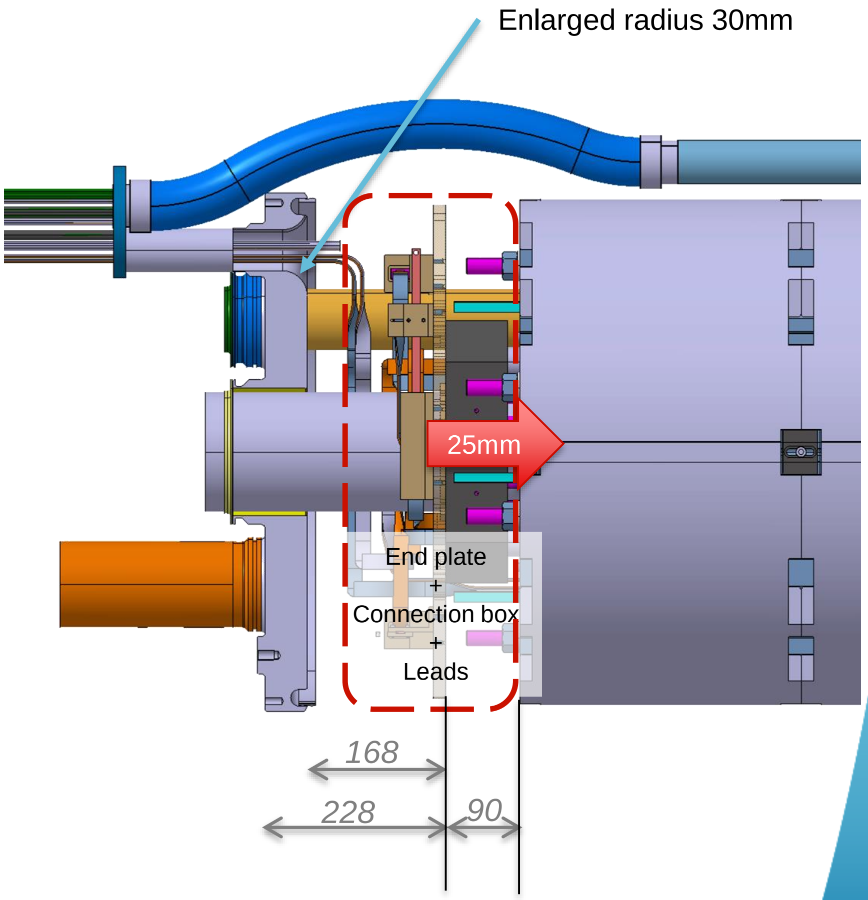




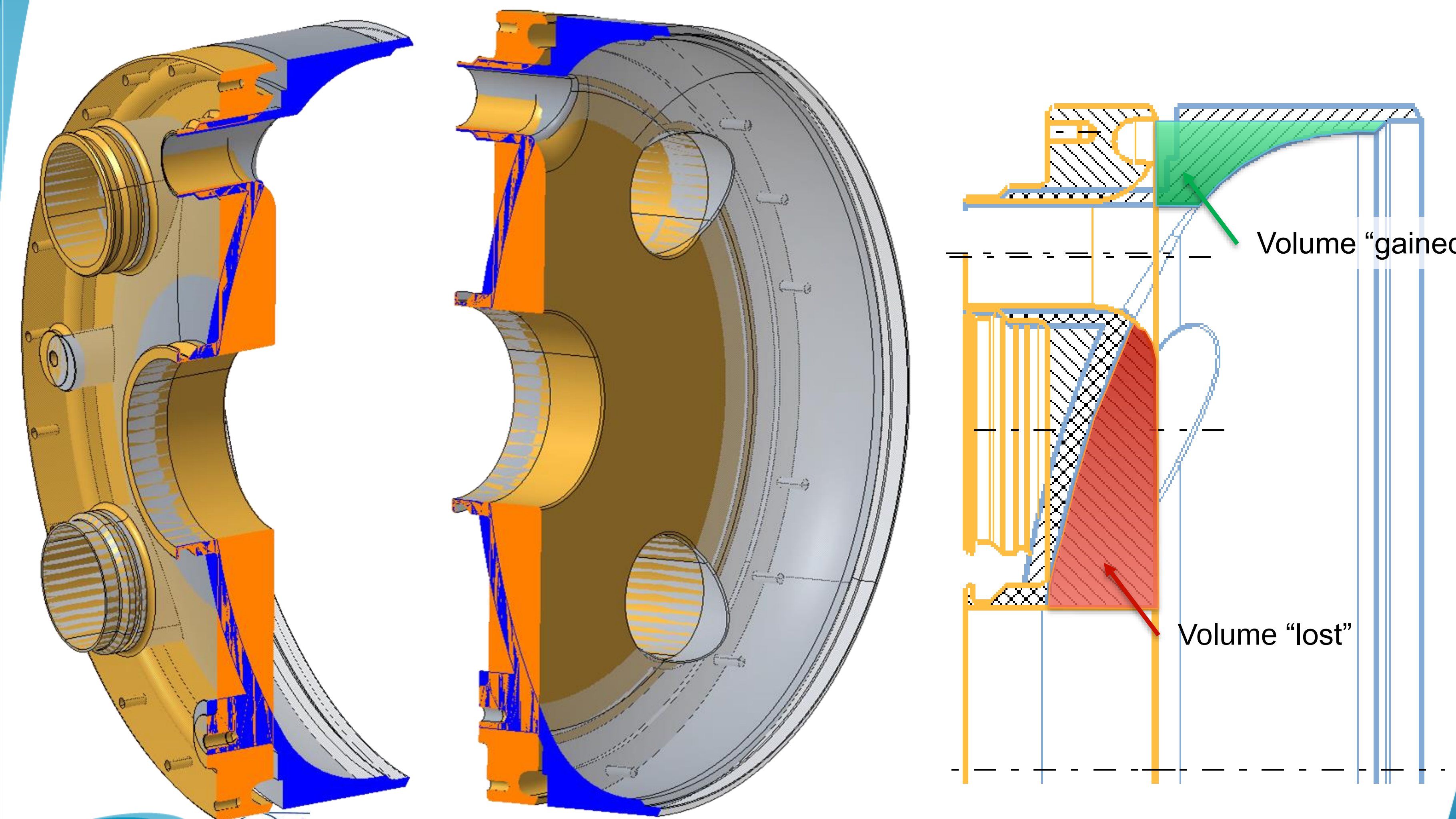
Busbars Expansion loops integration

Proposal to generate additional clearance (agreed on MQXFB)





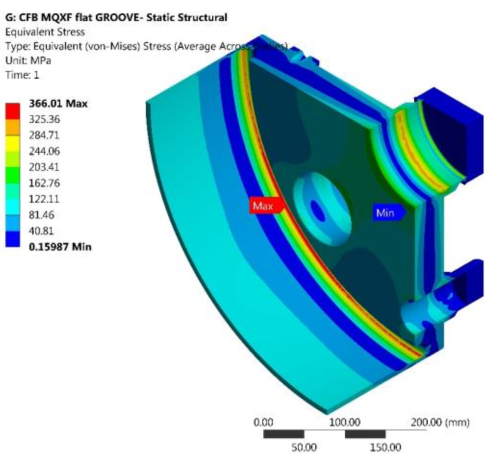
From Dished to Flat End Cover

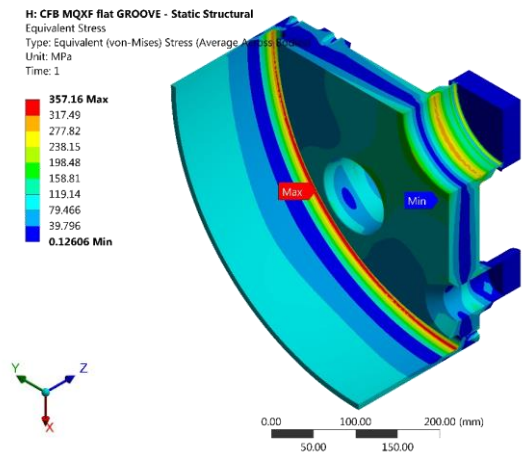


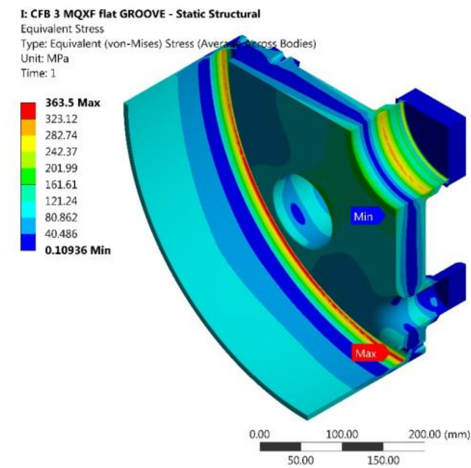
End cover Strustural Analysis

Initial design | 15mm chamfer | 30mm radius

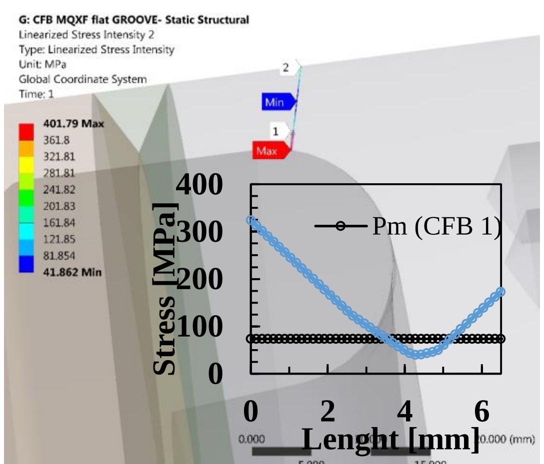
Equivalent Stress (von-Mises) - Elastic

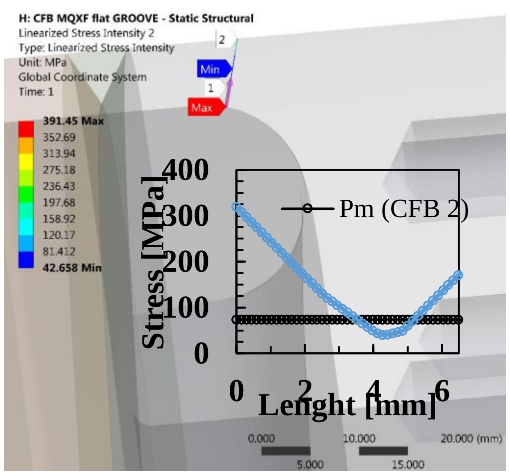


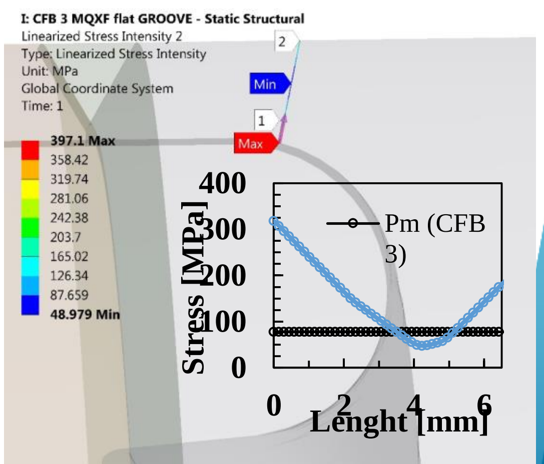




Linearized Stress Intensity (Stress categorisation) according to EN 13445-3 Annex C - Elastic analysis







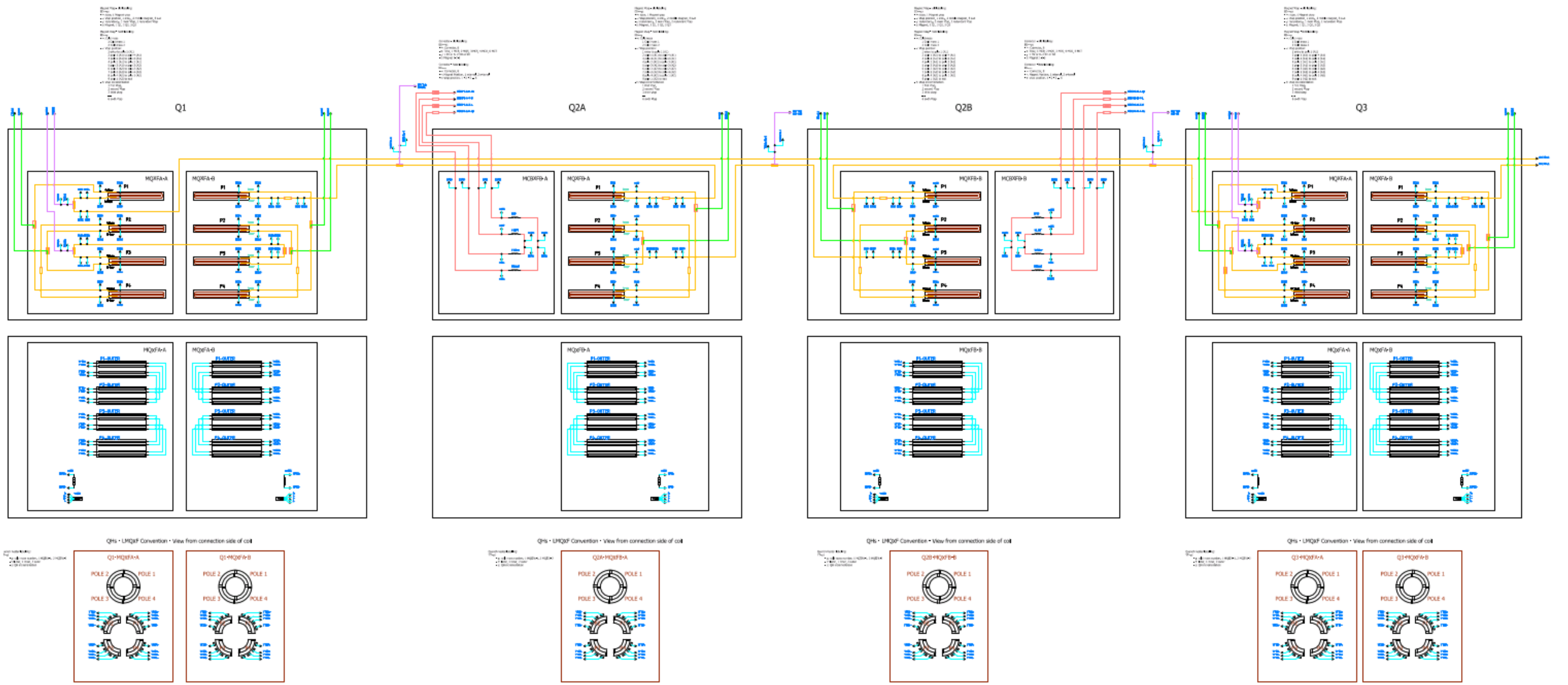
The supporting line segment is established from the node with highest equivalent stress, and approximately normal to the inner surface.

Courtesy of J. L. Rudeiros Fernández

Q1 to Q3 Instrumentation Scheme

V-Taps distribution, QH splicing, Temp. Sensors and Cryogenic Heaters

In collab. with L. Grand-Clement & J. Steckert (V-Taps), M. Valette & Daniel Wollmann (QH), M. Sisti & R. Van Weelderen (Cryo)



Between 56 and 68 feedthroughs per cold mass side to route wires from the cold mass to the IFS

Presented in MCF, LHCLMQXFE0001 ready to be controlled in CDD

Same type of scheme to be done for the CP and D1

Thank you