Status and plan of MQXFB cold mass and cryostat


HL-LHC Collaboration Meeting, 16.10.2018
- **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
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

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

EDMS 1964233

See EDMS 1963715 for cryogenic diagram.

Magnet cold testing is performed before assembly of the service module, i.e. in standard section configuration. Q1/2 are shipped to CERN as standard section only.

All service module operations performed at CERN GM2.

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.

Prepared by: D. Ramos
## Standard sections: Vacuum vessels

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

Pipe extrusion with positioning dove tail and reinforcement wings

Weld #1

Weld #2

Line of rivets

Machined structural support craddle

Bottom half pre-assembled on dedicated jig

5 mm thick shells

Aluminium 6082-T6

Leak tight Al weld

Aluminium to stainless steel transition
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
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

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
Cryostating tooling

- Contractual installation schedule:
  - at CERN: March 2019
  - at Fermilab: May 2019

CATSC
VERSATILE TOOLING SET
- Cryomagnet type: Q2A / Q2B
- Scale: 1:50
Test cryostat for MQXFB 8.1 m cold mass

The higher weight of the cold mass (~16T) requires a reinforcement of:
• the cryostating bench
• the vacuum vessel.
• the SSS lifting spreader beam

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

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
## Cold Masses Catalogue and Design Status

<table>
<thead>
<tr>
<th></th>
<th>Q1/Q3</th>
<th>Q2A/B</th>
<th>CP</th>
<th>D1</th>
<th>D2</th>
<th>Q10</th>
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<tbody>
<tr>
<td>Envelope</td>
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<tr>
<td>End covers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Proposal to avoid trans. rings</td>
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<td>✓</td>
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<tr>
<td>Supports</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Proposal to fit std interfaces</td>
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<td>Bus work</td>
<td>Ongoing Expansion loops</td>
<td>Ongoing</td>
<td>TBD</td>
<td>TBD (2 leads, no internal busbars)</td>
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<td>✓</td>
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<td>Extremities</td>
<td>Bellows, IFS, CLIQ leads and k-mod under definition</td>
<td>Bellows, IFS, CLIQ leads under definition</td>
<td>Beam pipe pumping Cond. Cooled leads interfaces TBD</td>
<td>Bellows, IFS TBD No CLIQ</td>
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<td>MS connections to N-Line under study</td>
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<td>Heat exch.</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>Instrumentation</td>
<td>✓ to be refined</td>
<td>✓ to be refined</td>
<td>TBD (11 magnets)</td>
<td>TBD</td>
<td>Ongoing</td>
<td>✓</td>
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<td>Remark</td>
<td>HO corrector centering system ongoing</td>
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<td>MSCBB corrector centering system ongoing</td>
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<td>Cold Mass Components Procurement</td>
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<td><strong>Plates</strong>&lt;br&gt;Mid Jan 2019</td>
<td>Q2A/B IT on going – First delivery in Mar. 2019</td>
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<td><strong>Heat exchangers</strong>&lt;br&gt;Copper tubes delivered Cu/SST transitions to be brazed and welded (mid 2019)&lt;br&gt;By Sept 2019 (CEA Grenoble)&lt;br&gt;Copper tubes recovered from LHC spares Half of the Cu/SST transitions to be brazed and welded (mid 2019)</td>
<td>Q2A/B KEK</td>
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<td><strong>Cold bore tube</strong>&lt;br&gt;First delivery in Apr. 2019 (4)&lt;br&gt;Nov 2019&lt;br&gt;First delivery in Oct 2019</td>
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<td><strong>Busbars</strong>&lt;br&gt;On going discussion with LARP&lt;br&gt;From Nov 2019&lt;br&gt;Existing 120A cables</td>
<td>Q2A/B Jun. 2019</td>
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<td><strong>Bellows</strong>&lt;br&gt;IT to be launched mid-Nov. 2018</td>
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<td><strong>Instrumentation wires</strong>&lt;br&gt; ✓ Off the shelf components</td>
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<td><strong>Ports</strong>&lt;br&gt; ✓ Off the shelf components</td>
<td>Q2A/B</td>
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Heat exchangers

Cu/SST thermal expansion compensation bellows

Interconnection bellows

Welding flares (fixed points)

Stainless Steel tube

thermal expansion compensation bellows

Copper tube

EB welding

CU/SST Brazing

Stainless Steel tube
Cold Mass Extremities

**11T case**
(identical to MB, SSS, SSSS...)  
226.5  
226.5

**LMQXF**
Cold masses with MQXFA or B  
318

115mm
203 mm
Busbars Expansion loops integration

Proposal to generate additional clearance (agreed on MQXFB)

Risk of short to ground

Enlarged radius 30mm

203 115 318

228 90 168

25mm

End plate
Connection box
Leads
From Dished to Flat End Cover

Volume “lost”

Volume “gained”
End cover Structural Analysis

Equivalent Stress (von-Mises) - Elastic

Initial design 15mm chamfer 30mm radius

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.
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