Q2 cold mass: status and plan

H. Prin

With contribution from D. Duarte Ramos, C. Eymin, A. Foussat, L. Grand-Clement, M. Mentink, J. L. Rudeiros Fernandez, A. Temporal, E. Todesco

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Outline

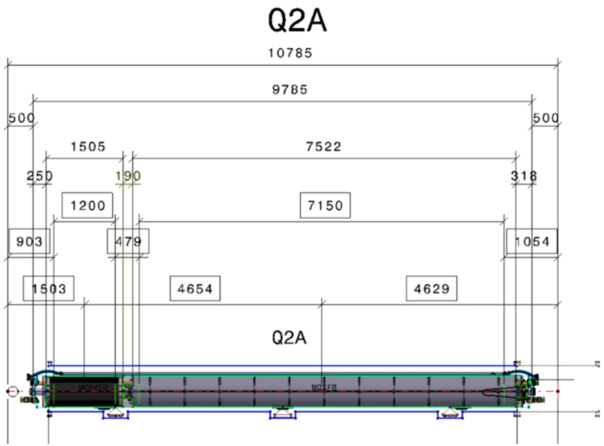
- Cold Mass Layout and Structure
  - Composition and Components
  - Supporting system
  - Extremities
- Electrical Scheme
  - Global scheme
  - Electrical connections and routing inside the cold masses
  - Expansion loops
- Instrumentation Scheme
- On going developments
- Tooling
- Workshop Layout

Cold Mass Definition and Naming

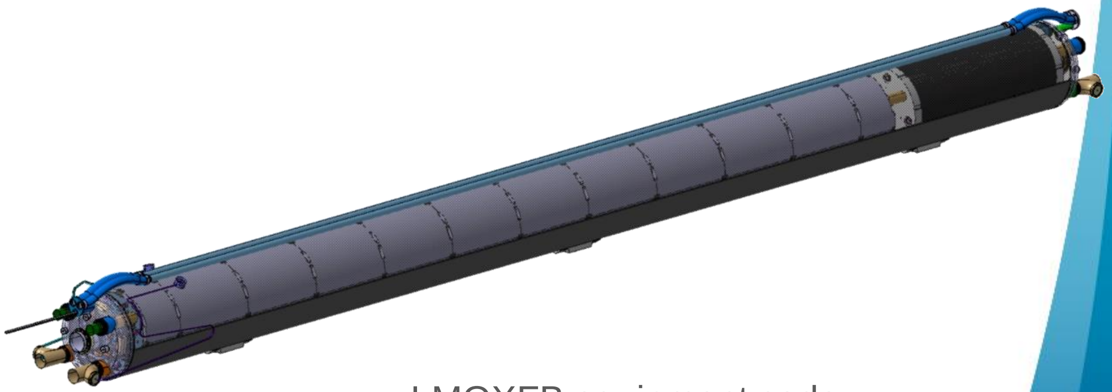
- **Cold Mass:**

  Leak tight envelope surrounding one or more superconducting magnets which acts as a helium pressure vessel and provide the mechanical rigidity to align the magnetic element(s). It can be composed of two welded half-shells (main dipoles, insertion cold masses...) or by an "inertia tube" (arc SSS) closed by two end covers in the extremities.

https://espace.cern.ch/HiLumi/TCC/SiteAssets/LHC_Glossary_high_resolution.pdf

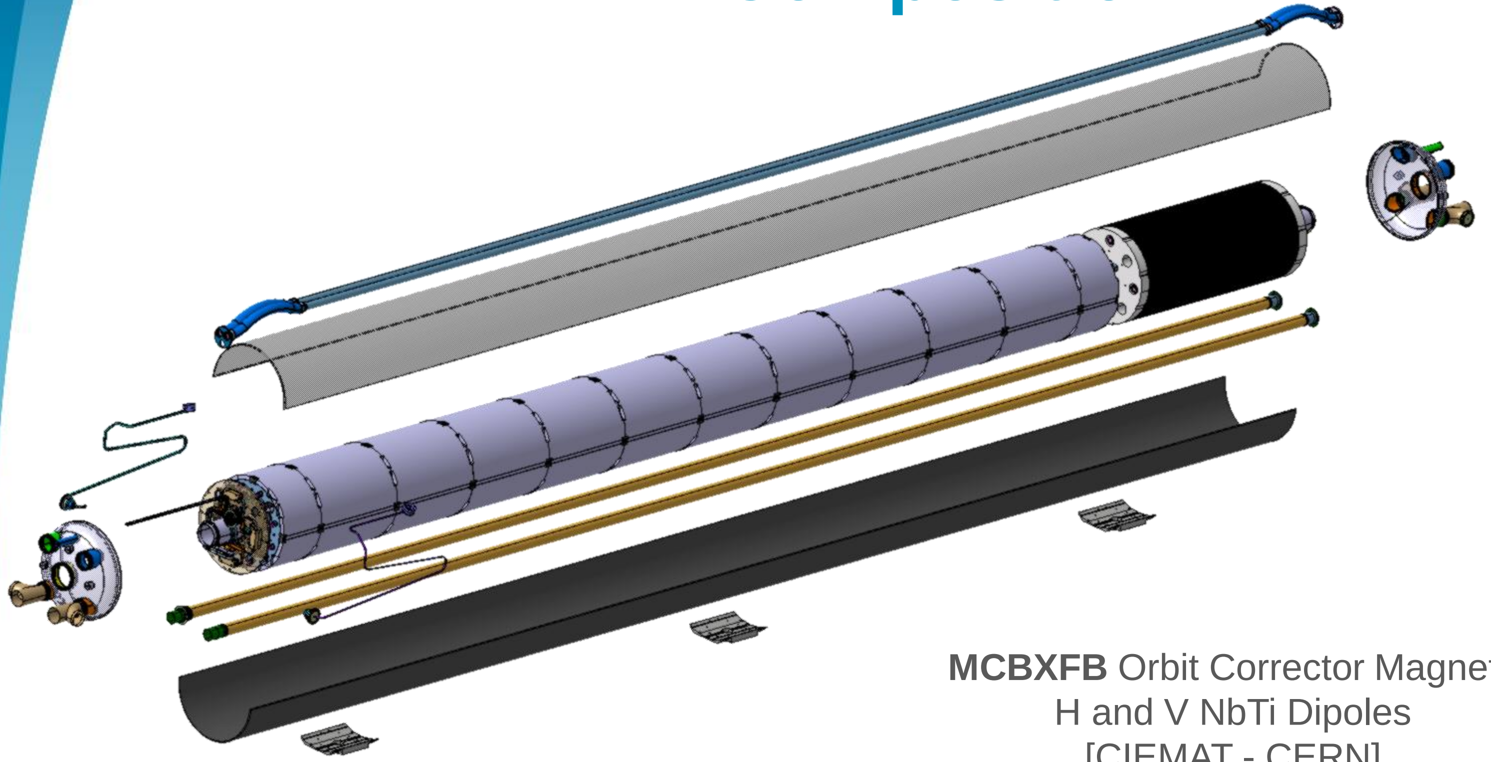


Source for the design:
Mechanical Layouts LHCLSXH_%



LMQXFB equipment code

LMQFXB Cold Mass Layout Composition



- Half shells
- Cold bore tube
- End covers
- Heat Exchangers
- Busbars
- Supports
- Instrumentation feedthroughs
- CLIQ feedthroughs
- Auxiliary lines

MCBXFB Orbit Corrector Magnets
H and V NbTi Dipoles
[CIEMAT - CERN]

MQXFB Quadrupole Magnet
[CERN]

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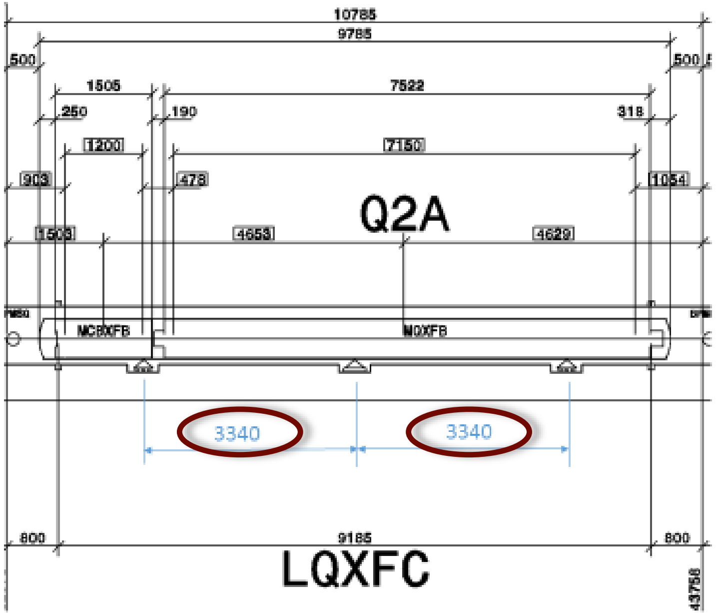
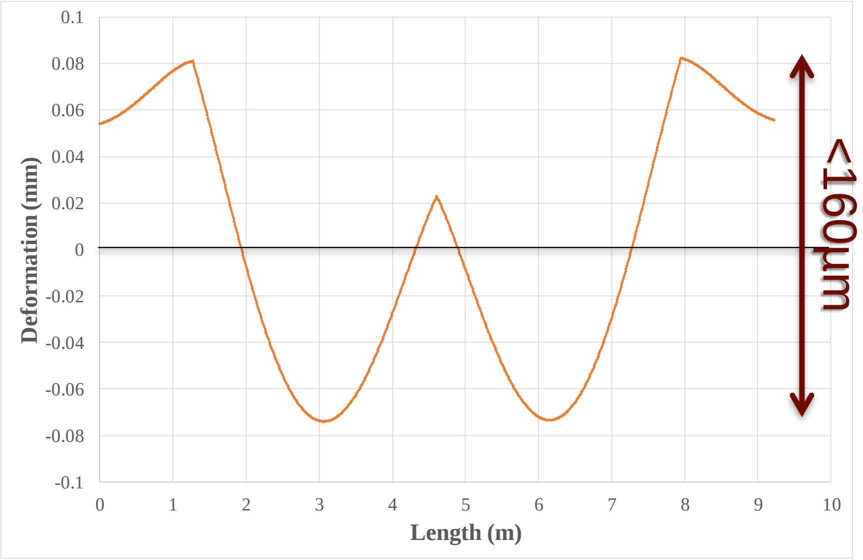
CERN

LMQFXB Cold Mass Layout Supporting System

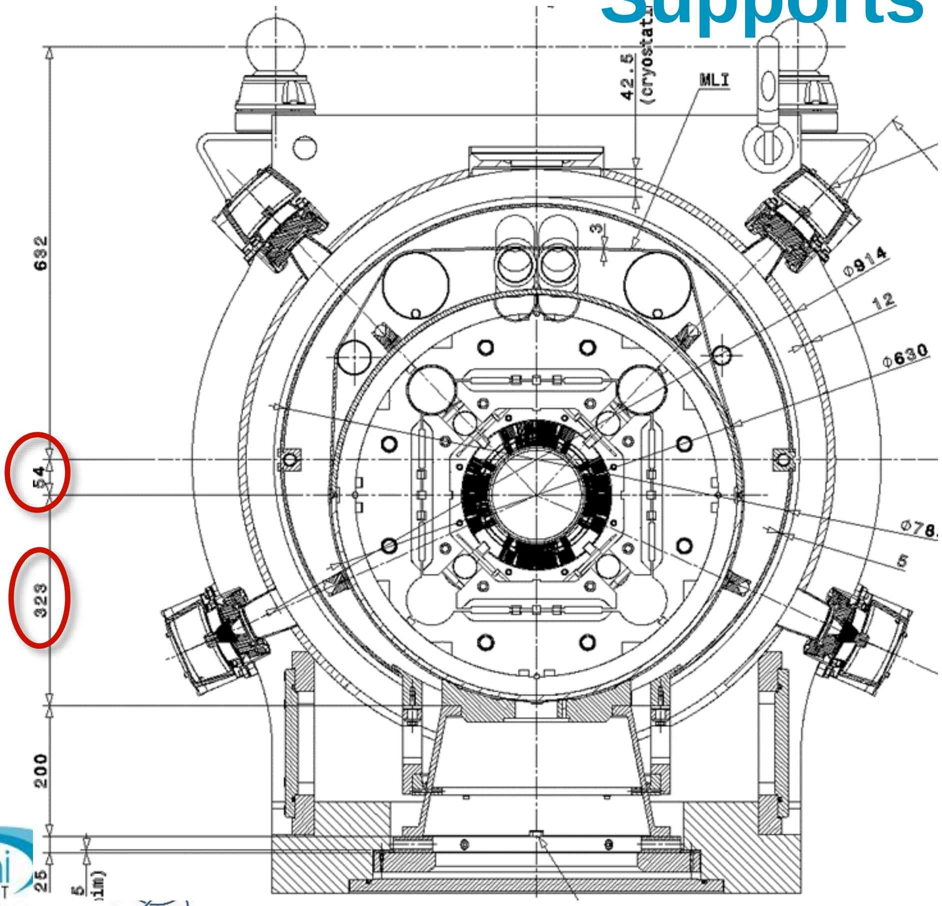
Identical supporting configuration used for Q1/Q3 and Q2A/B





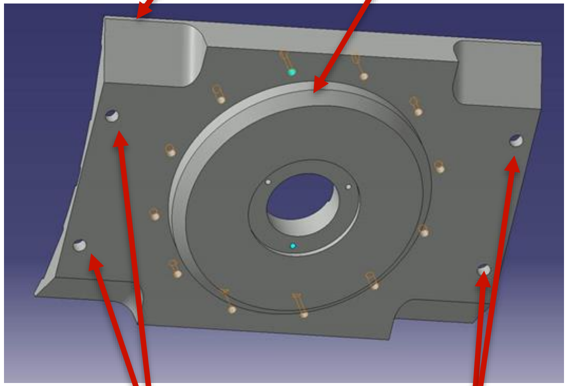
Courtesy of Massimiliano Moretti

LMQFXB Cold Mass Layout Supports



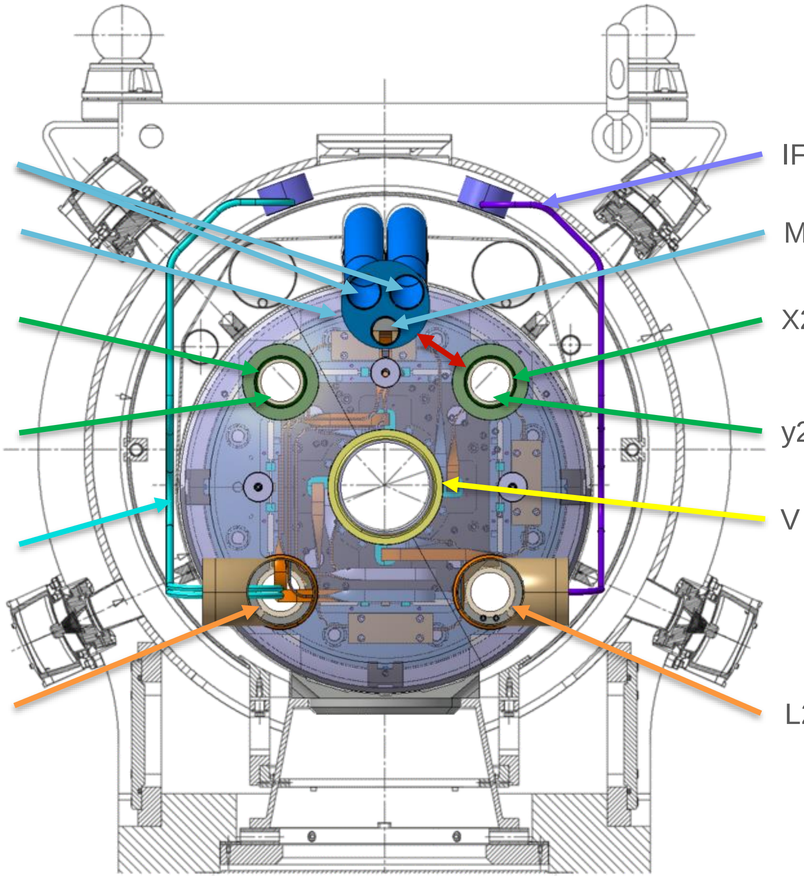
Welding interface

Ø232g6



4 x 12H7
(Fiducialisation)

LMQFXB Cold Mass Layout Extremities



N1 & N2	Auxilary lines for Trim and Correctors Busbars
M	Aperture for the cold mass busbars
MN	Busbars Interconnection line
X1 & X2	Heat exchanger tubes
y1 & y2	Helium inlets
V	Beam pipe
L1 & L2	Conduction path for HeII (2x75cm^2)
IFS	Instrumentation feethroughs capillary
CLIQ	CLIQ feedthroughs current leads

Cold Masses Extremities Structural Analysis

Courtesy of J. L. Rudeiros Fernandez

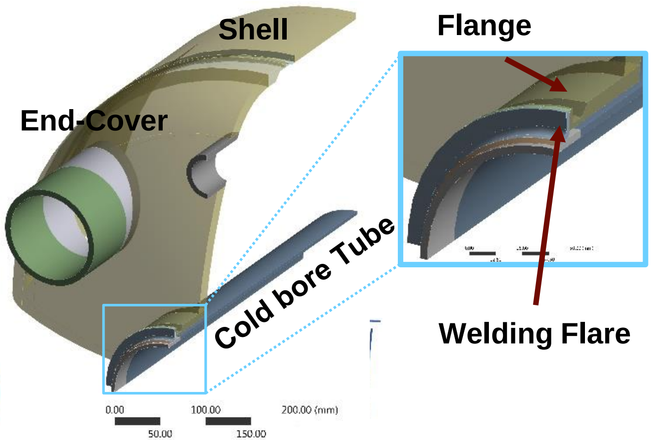
The Q2 A/B cold mass must safely withstand the internal helium pressure in all operating conditions.

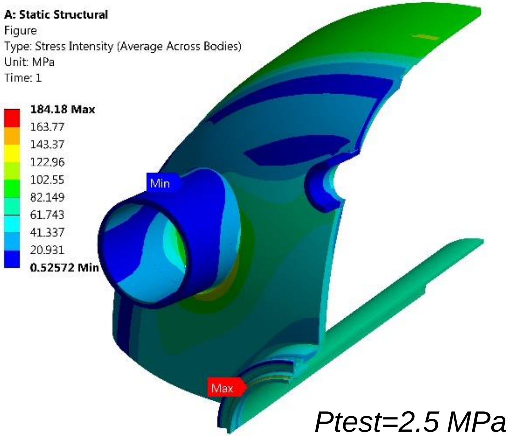
Maximum allowed values of the nominal design stress – EN 13445

Load cases	Allowable stress (MPa)
Normal operating load cases: *Normal quench pressure design (PS=2 MPa)*	$f_d = max\left[\left(\frac{R_{p1.0/T}}{1.5}\right); min\left(\frac{R_{p1.0/T}}{1.2}; \frac{R_{m/T}}{3}\right)\right]$= 213
Testing and exceptional load cases: *Proof operation (Ptest=2.5 MPa)*	$f_{test} = max\left[\left(\frac{R_{p1.0/T}}{1.05}\right); \left(\frac{R_{m/T}}{2}\right)\right]$= 304

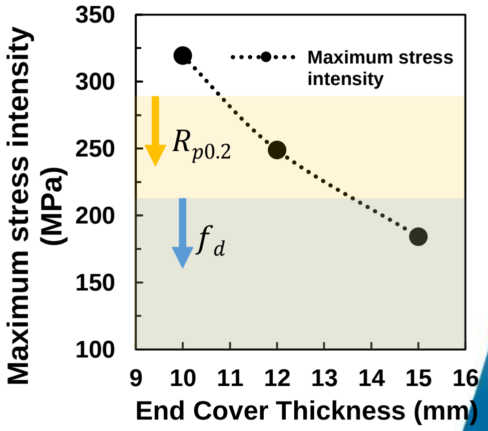
Mechanical properties considered for 316LN

Property	Symbol	Min. value
0.2% proof strength (from EN 10028-7)	$R_{p0.2}$	280 MPa
1.0% proof strength (from EN 10028-7)	$R_{p1.0}$	320 MPa
Minimum tensile strength (from CERN specifications)	$R_{m,min}$	590 MPa

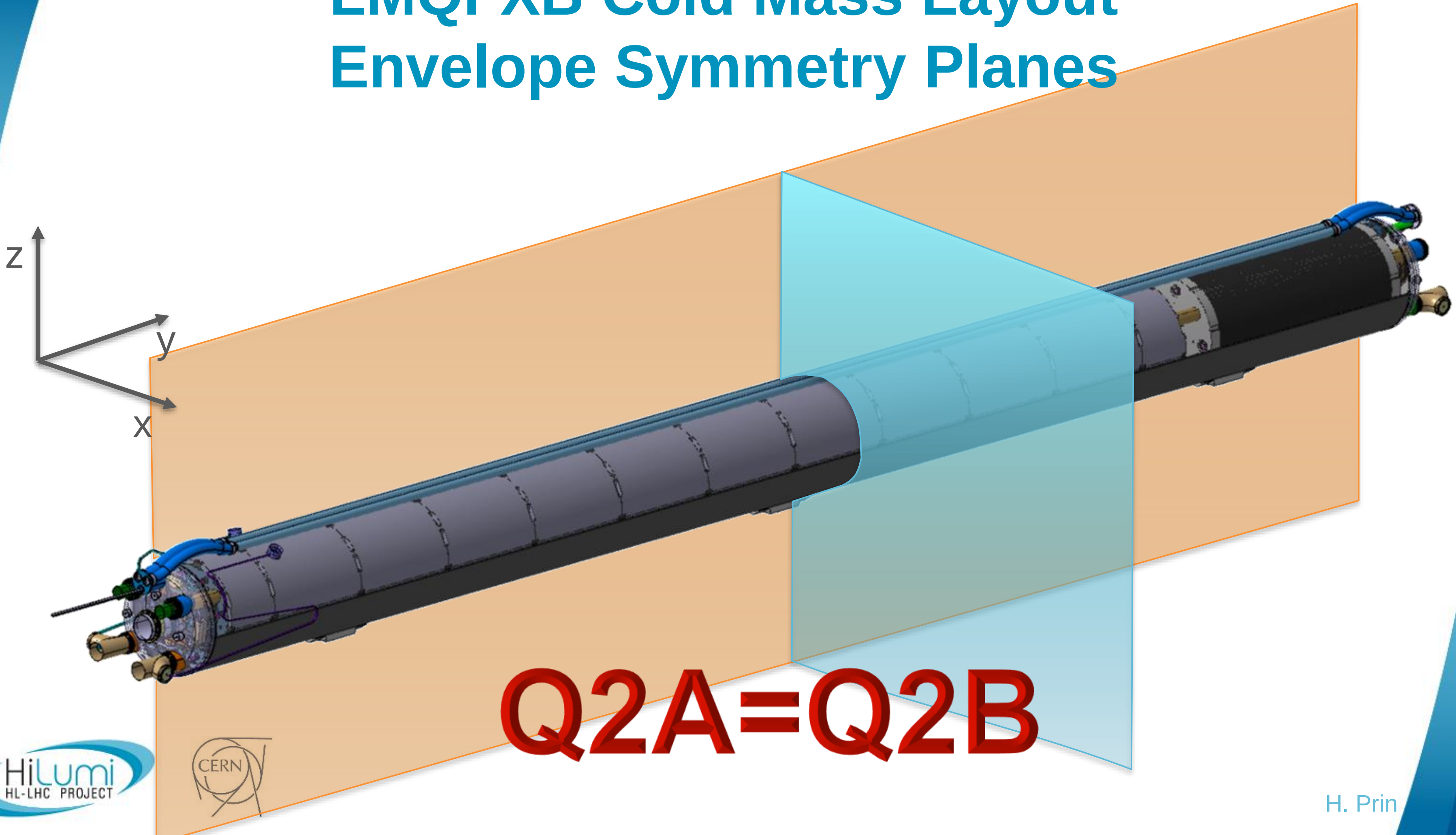




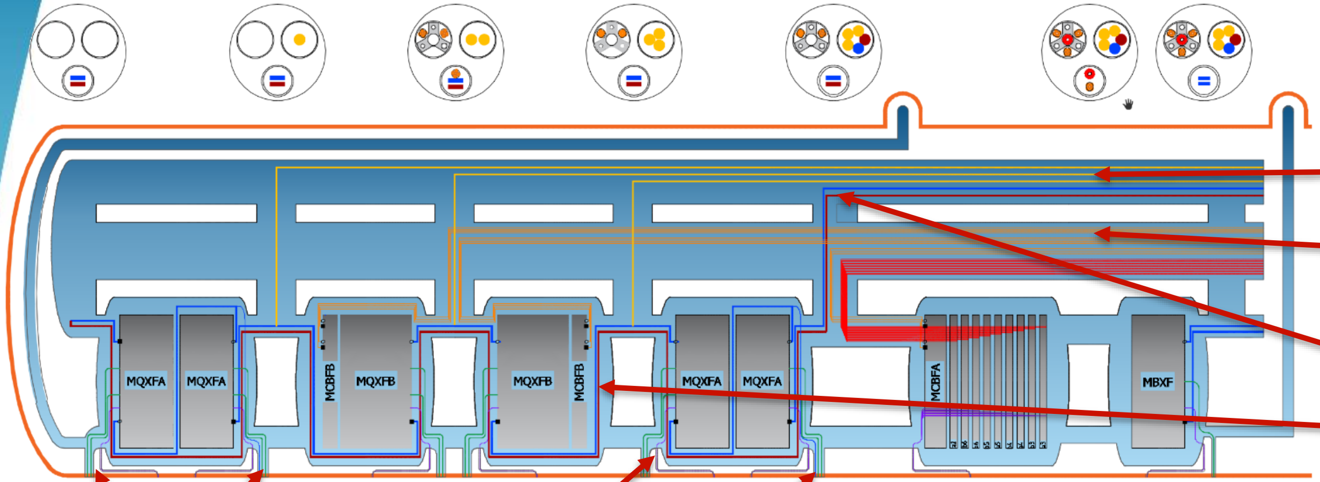
Ptest=2.5 MPa



LMQFXB Cold Mass Layout
Envelope Symmetry Planes



Electrical Scheme



Trim busbars

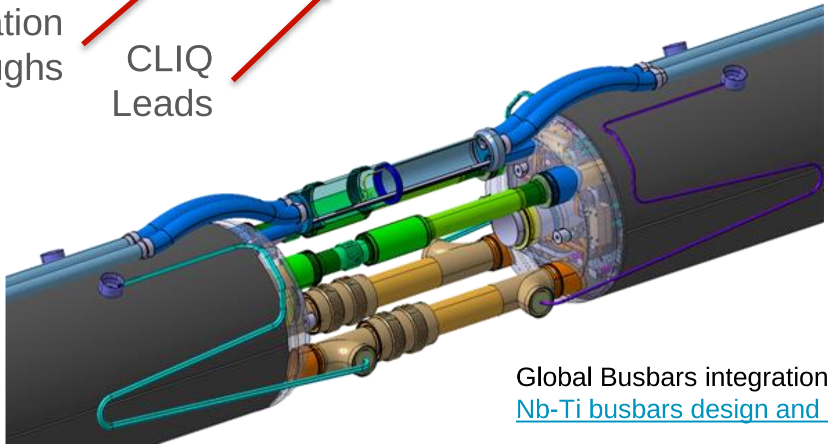
Orbit corrector busbars

18kA busbars
- round cable
- Flat cable

Instrumentation Feedthroughs

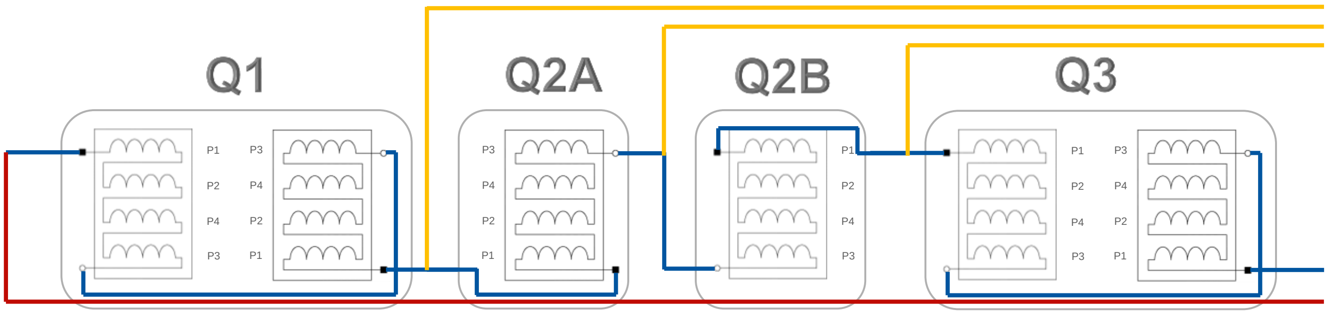
CLIQ Leads

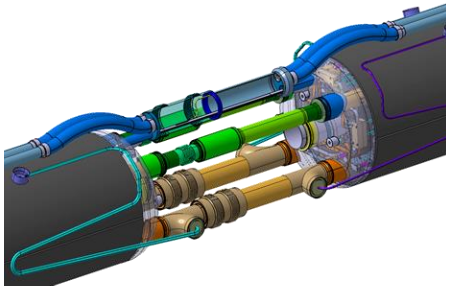
35A Trim for Q1A Leads



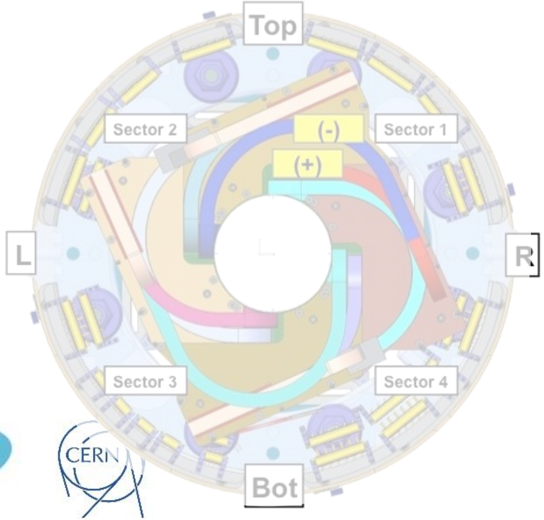
Global Busbars integration presented in [Nb-Ti busbars design and interfaces]

Electrical Connections and routing inside the cold masses

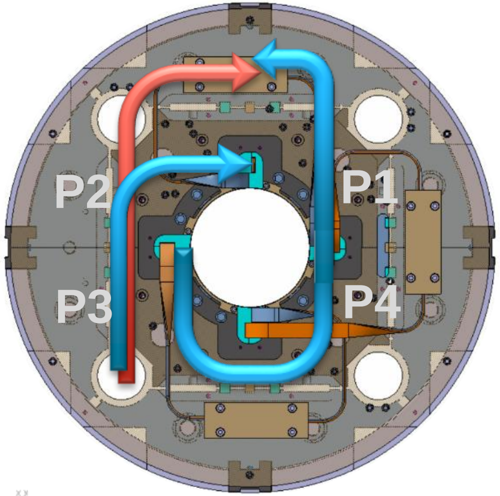


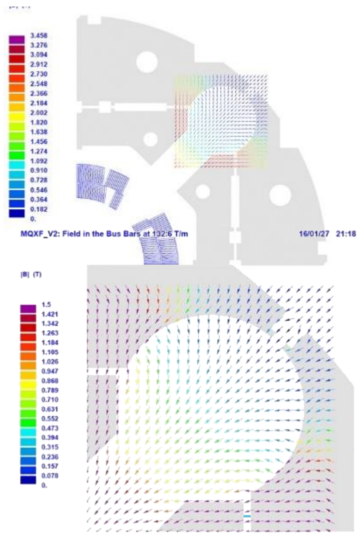


MQXFA



MQXFB

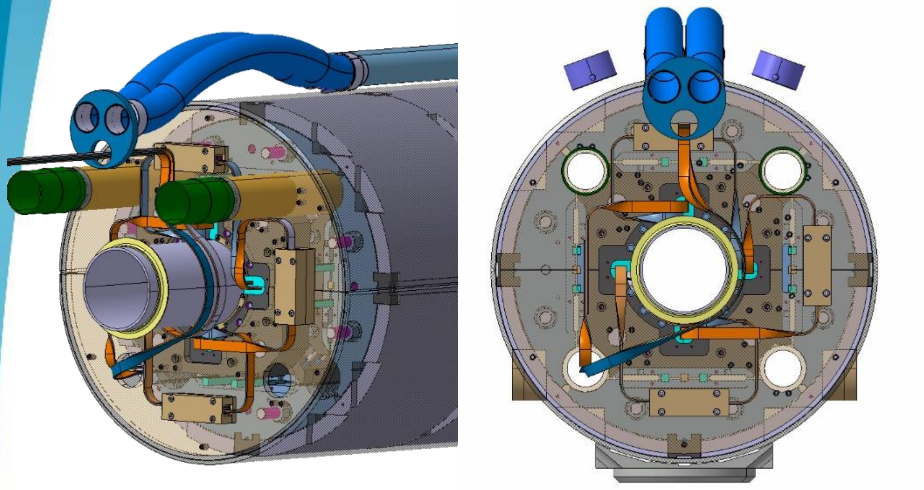




Courtesy of S. Izquierdo Bermudez

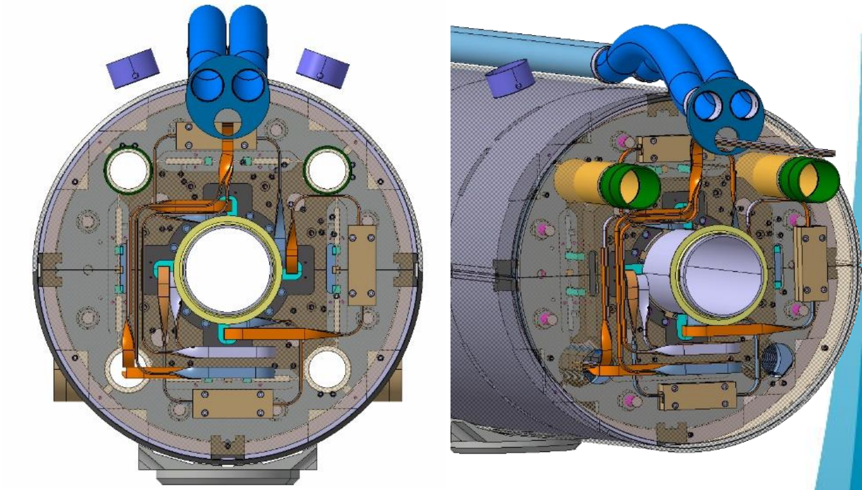
Expansion Loops Design (on going work)

Pig tail Option



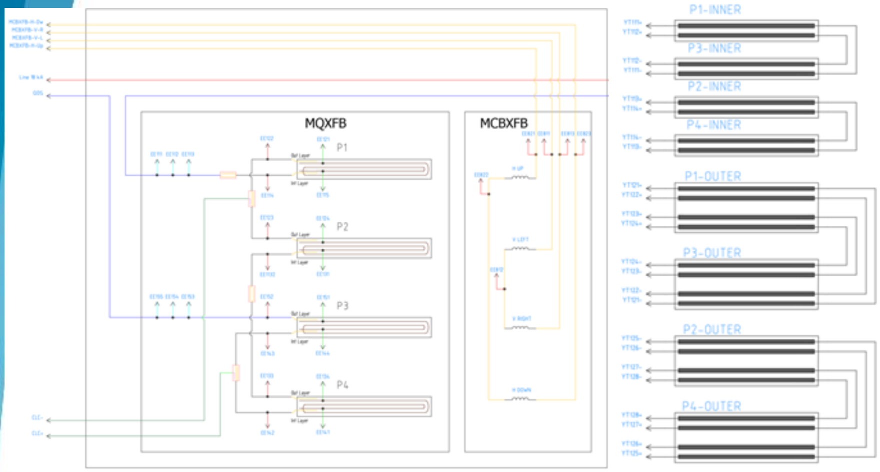
- ☺ Integration
- ☺ Fewer longitudinal space
- 😐 Supporting and guiding
- 😐 Stabilisation along the path ?

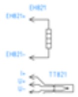
Lyra Option

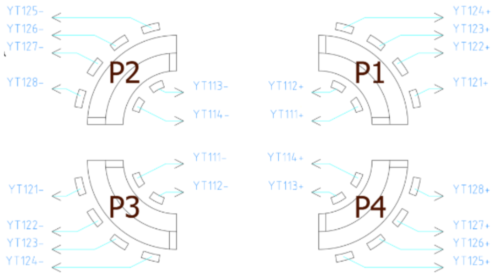


- ☺ Well known at CERN
- ☺ Minimum inertia for bending
- ☺ Stabilisation
- 😐 Routing

LMQXFB Instrumentation Scheme







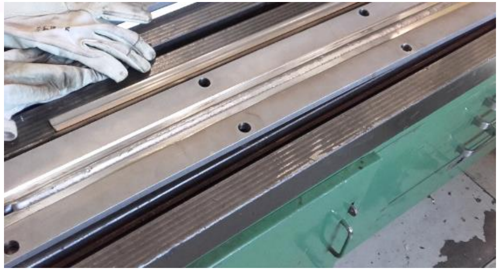
	Wire qtty	Wire type	Remarks
MQXFB	14 V-Taps	AWG26	4 redundant channels comparing poles 2 redundant channels comparing half magnets
	8 V-Taps?	AWG26	NbTi/Nb3Sn splices monitoring
	24 QH leads	AWG18	8 QH in the outer layer high filed area 8 QH in the outer layer low field area 8 QH in the inner layer
	2 CLIQ leads		10mm^2 cross section
MCBXFB	6 V-Taps	AWG26	1 channel per pole using a common lead in the mid point
T. sensor	4 wires	AWG30	Low voltage
Cryo R	2 wires	AWG26	Low voltage

50 wires + 8?
+ 2 CLIQ leads

EEwxy	w: Magnet type	x: V-tap position	y: V-tap increment
	1: MQXFB	1 entry to pole 1	1st Vtap
	8: MCBXFB	2 pole 1 to pole 2	2nd Vtap
		3 pole 2 to pole 4	…
		4 pole 4 to pole 3	
		5 pole 3 to exit	

Global V-Taps integration scheme presented in
Update on circuit protection simulations
by M. Mentink

Welding Developments



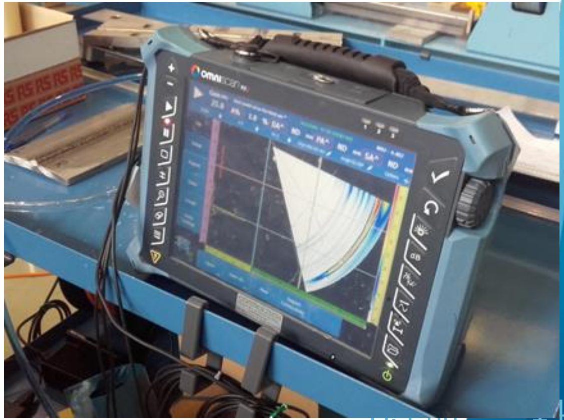
Welding retained parameters:

- 3 MAG passes
- Inerting gas 98%Ar/2%CO_2 (ARCAL™12)

Pass	Wire speed	Welding speed	Trim	Dist. Torch/shell
1st	6m/min	380mm/min	0.83	3mm
2nd	4m/min	380mm/min	0.89	8mm
3rd	4m/min	380mm/min	0.89	8mm

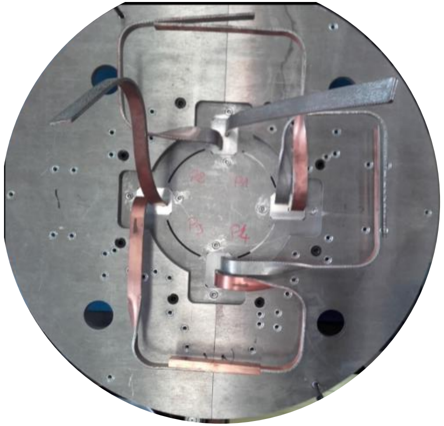
NDT inspection:

Ongoing calibration of the Omniscan phase array detector using the 11T dipole longitudinal welds (15mm thick).



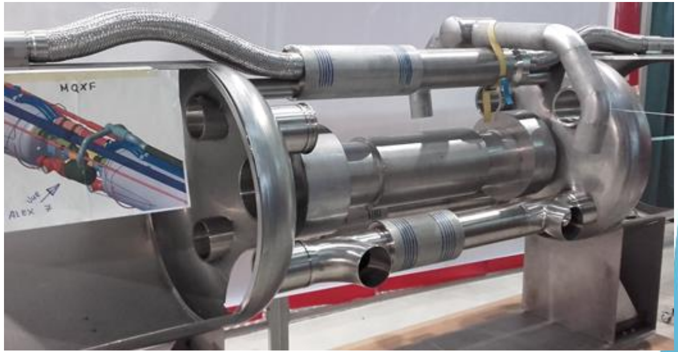
Ongoing and Future Developments

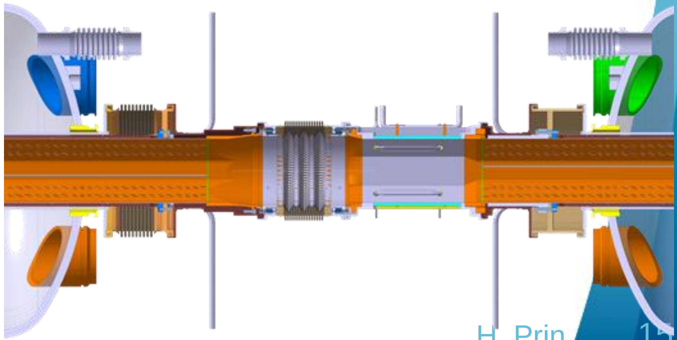
Splices
&
Expansion Loops



Welding test
Stress Measurements

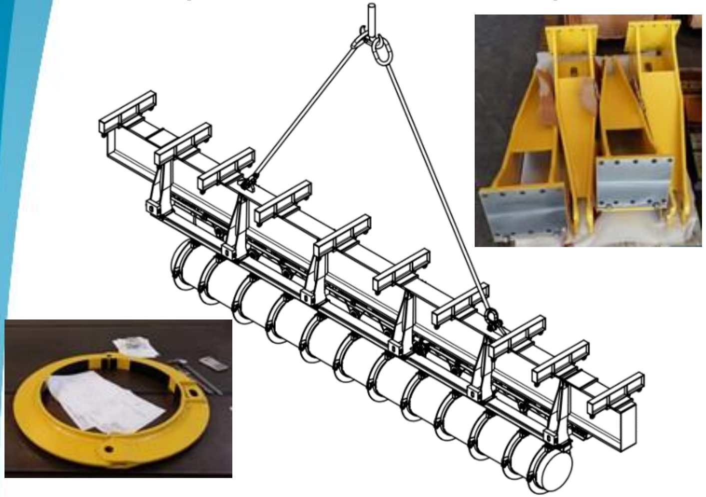
Interconnection Mock-up





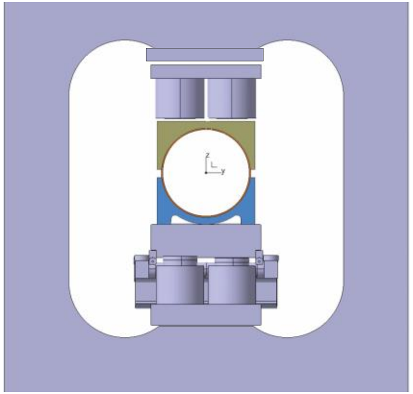
Tooling

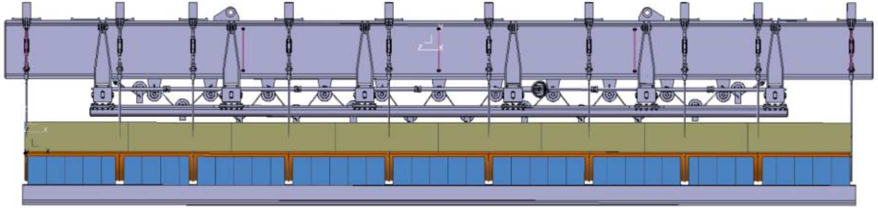
Lifting beam
(in common with D2)



Reception at the manufacturer premises starting from November the 21st

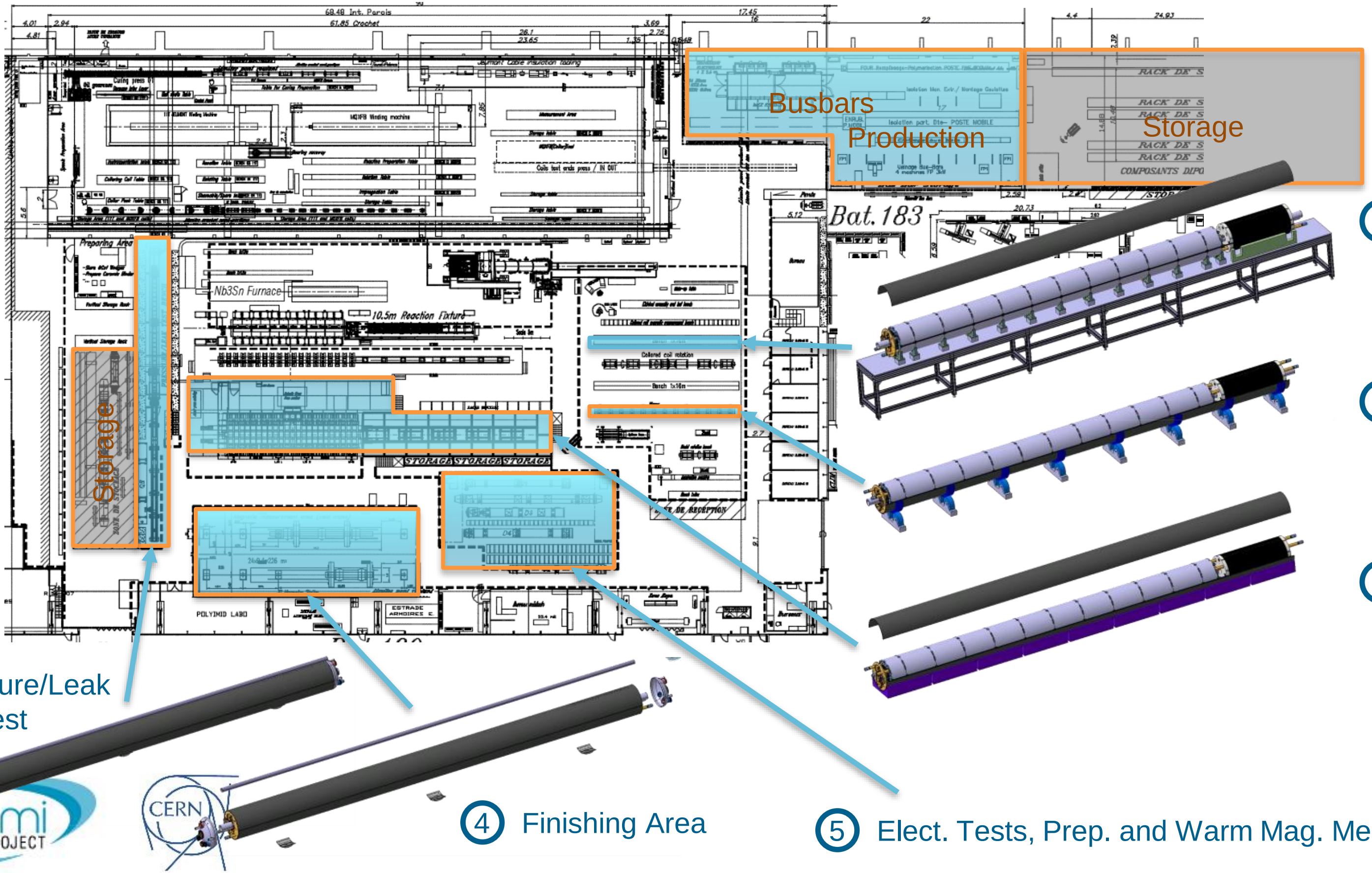
Integration in the welding press and cradles





MQXFB magnet and cold mass Assembly bench

LMF Workshop Layout



1 Magnets Alignment

2 Rotation Bench

3 Welding Press

5 Pressure/Leak Test

4 Finishing Area

5 Elect. Tests, Prep. and Warm Mag. Meas.

Summary

- Cold masses **design is ongoing**, **parameters and interfaces** are increasingly defined with the various **stakeholders**.
- Q2 **standardisation** for A and B slots remains the design principle.
- Electrical scheme and Busbars routing was presented in the international review of the conceptual design of the cold powering system in July 2017:
  - Quadrupole cold masses house the two flat 18kA cables through the magnets,
  - Trim and correctors buses are routed through parallel lines,
  - **Expansion loops and fix points scheme** needs to be designed in **close collaboration** between FNAL and CERN.
- **Design validated** using **real full scale 3D mock-ups.**
- **Instrumentation scheme** is **under discussion** with the Machine Protection (WP7).
- Major components and tooling **procurement** is **ongoing**, assembly steps and benches are straight forward using existing experience and proven technologies.
- A. Foussat had been appointed to certify the **PED** (Pressure Equipment Directive) **compliance requirements** on HL-LHC magnets. Scope and documentation structure are well defined. Most aspects of the design, calculations, production and testing to assess the conformity procedures are taken into account, the EDMS structure is adequate to upload the data. The impact on design resources from the implementation of PED compliance is under assessment.

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Thank you for your attention