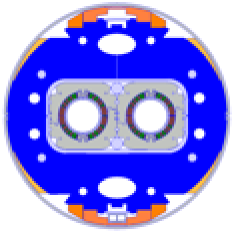


Status of D2 (LMBRD) documentation and cold mass integration

Arnaud Foussat

CERN TE Department - Superconducting Magnet Group, LMF section

Acknowledgments to H. Prin, T. Sahner, O. Id'Bahmane, J. Petrik, L. Grand Clement, D. Ramos, E. Todesco, A. Van de Craen, R. Principe, O Housiaux, B, Almeida, I. Bejar Alonso, L. Favier, M. Guinchard, A. Perin, F. Mangiarotti, P. Freijedo, O. Sacristan de Frutos (CERN), Ph. Perret, E. Chaudet, L. Favre (Kraftanlagen) & INFN_Ge D2 collaboration team

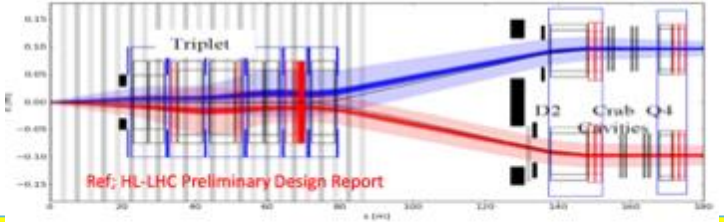
17th Oct. 2018, **8th HL-LHC Collaboration Meeting, CERN.**

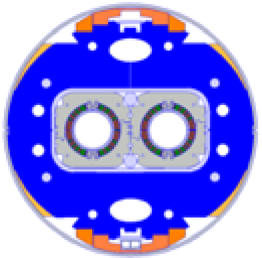
Outline

- Cold mass scope of supply
- LMBRDP design status
- Components status
- Interfaces status
  - Integration layout
  - Cryogenics, instrumentation, busbars & splices, assembly
- Documentation
- Manufacture integrated schedule, HSE approval
- Summary

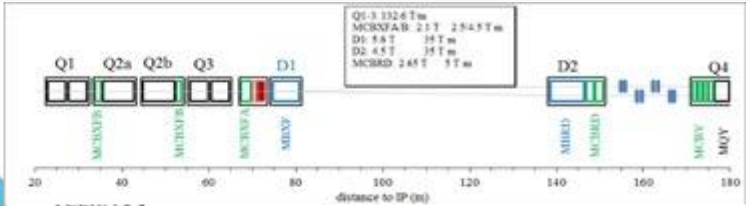
Scope of D2 cold mass procurement

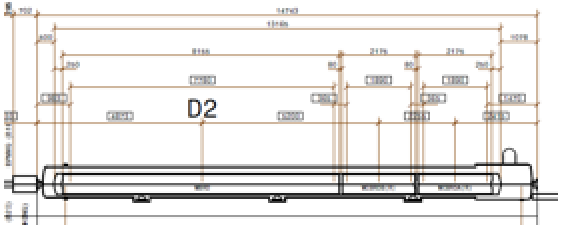
- *New Nb-Ti D2 recombination Dipole to be built for IR1 and IR5 under WP3 responsibility*





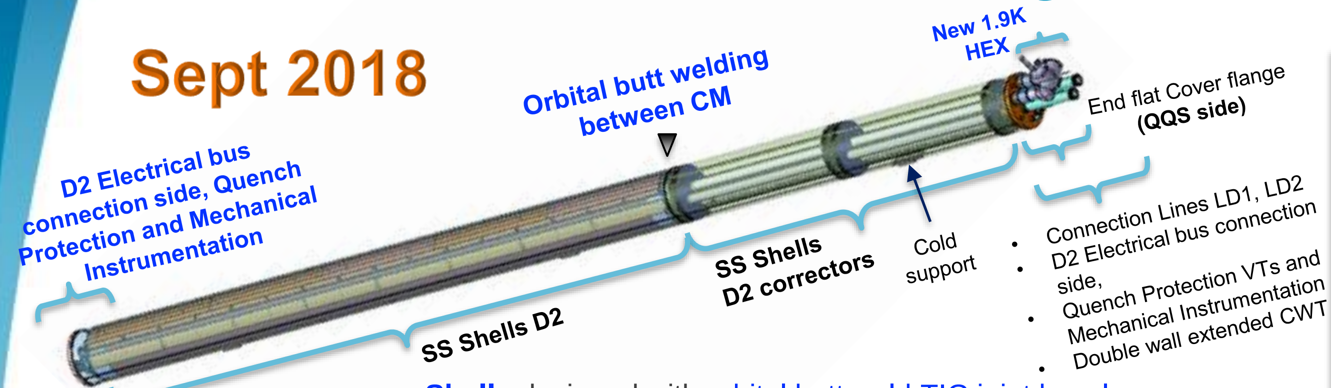
- ***Short Model under construction at ASG, 1 unit, 105 mm, 4.5 T, 1.6 m long planned for test at SM18 from Dec 2018, early 2019.***
- ***Prototype MBRDP (D2): 1 unit, 105 mm, 4.5 T, 35 T.m , 7.8 m***
- ***Series MBRD (D2): 4 units + 2 spares, 105 mm, 4.5 T, 7.8 m***
- ***Double aperture correctors MCBRD: 8+2 spares, 105 mm, 2.2 T, 1.9 m***
- ***<u>Integrated cold masses LMBRD length</u>: 13 165 mm, built at CERN (1p+6s), all cold tested in SM18 at CERN***





LMBRDP design status

Sept 2018



Design completed by Oct. 2018

- **Shells** designed with orbital butt weld TIG joint bevel
- Two **End flat covers** common design with MQXF, forgings manufacture, under order.
- **Cryo supports** complete under procurement, position approved
- Cryostating interfaces definition done
- **Instrumentation Flange System (IFS)** designed for **prototype and series cold mass**
- **Prototype busbar fixed point** proof load tested up at 14kN (no damage)
- **QQS connection** integrated piping model done (CMI)
- **Interface with new 1.9K HEX** done (CRG, CEA Gre)
- **Connection lines to the CFB test station** on going (TF)
- **LV Instrumentation prototype pots with vacuum guard** design done (LMF)
- **DMOS complete** of **orbital automatic TIG welding**

On going / next

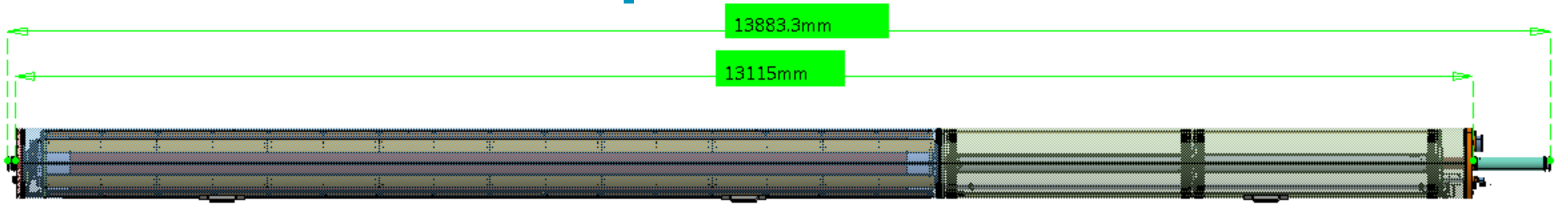
- Fabrication **drawings for all CM subcomponents** - Target completion by Feb 2019

- **IFS system components drawings**, and prototypes
- Insertion **centering jig for cold tube**
- **Wires routing** optimisation

Next:

- **Qualification of longitudinal TIG/MIG welding**
- Specific supply pipes procurement
- **Assembly sequence, dedicated tooling drawings**
- **Pressure test bench** connections layout

Components status



Ordered/Delivered

Shells: 2 for w48
End covers: from w50
Supports: To be delivered
Heat exchanger : shall be manufactured commissioned at CEA Grenoble, tested in cold mass at CERN
Supply pipe: to be procured
IFS : prototype to be manufactured,

Components to be ordered,

Cold bore tube: nominal dimension agreed, insulation thinner, to be ordered, production time 12 months, from W44

IFS LV prototype : **to be procured, qualified** (LMF)
Flexible adaptation lines: to be done (SM18)
Busbar & Splices : Pending design of 13kA DFM link bus, Internal main busbar for prototype

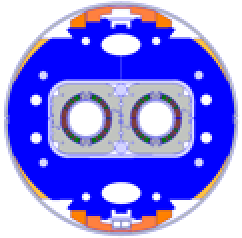
Tooling

Orbital welding machine **to be upgraded, welder qualification, cross weld samples qualification, [10/2018 - 04/2019]**

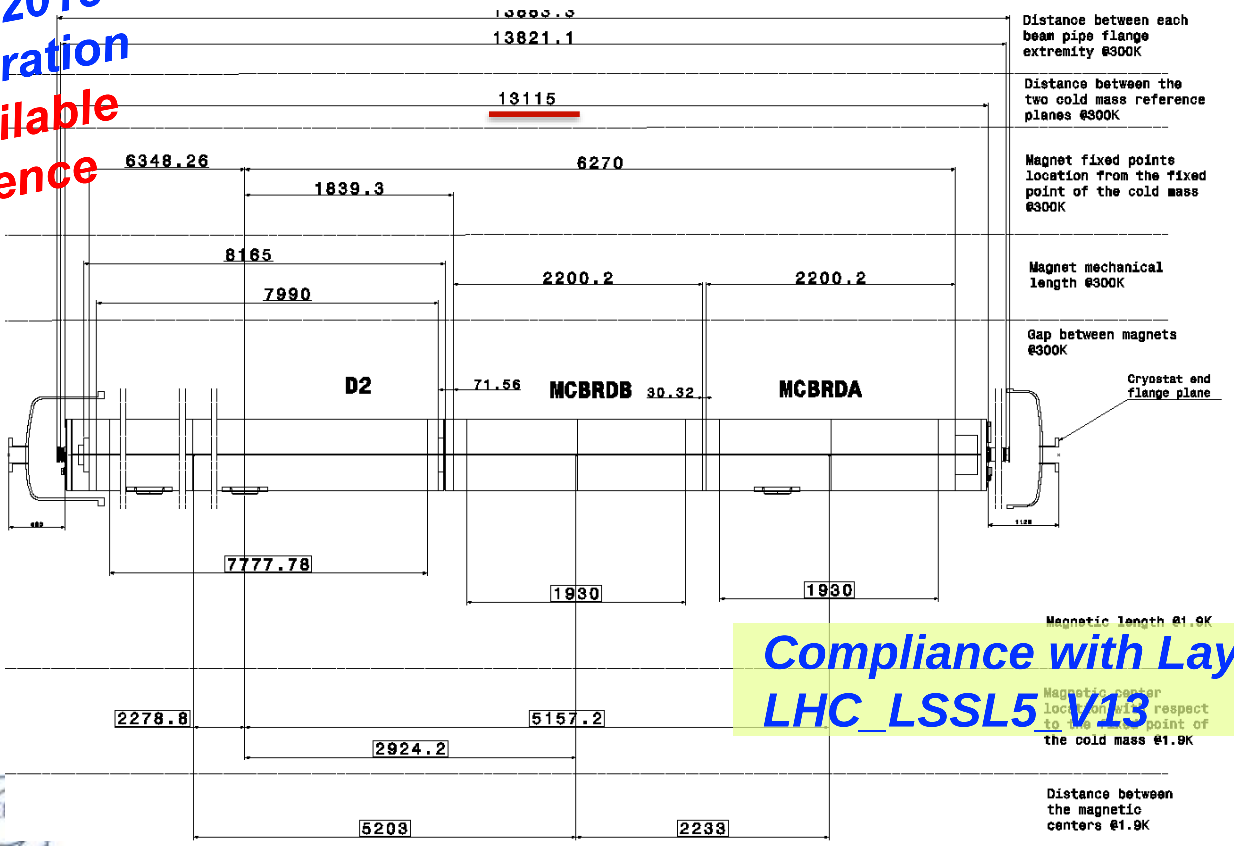
Alignment support bench: **to be designed**
Lifting beam: **✓ commissionned**
Welding press: **✓ longitudinal welding process under common development,**

Cradles for welding : Under procurement, W06
Laser tracker: ✓
Magnetic mole: **Under fabrication**
Finishing bench tooling: **To be designed, procured**
Pressure/test bench: **Pending studies for terminal connection**

Integration layout

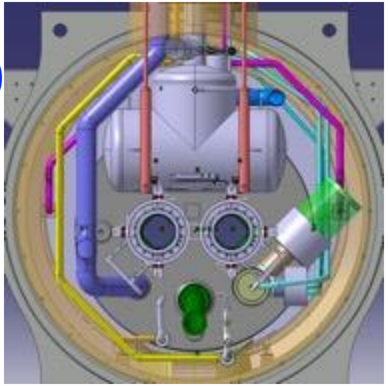


September 2018 model integration layout available for reference



Compliance with Layout Dwg LHC_LSSL5_V13

Cryogenic supply side interface



- Successful integration of new finned tube 1.9K HEX (CRG) in Cryogenic service module, welded flanges to cold mass.
- CCT feedthroughs IFS design complete, main 13kA bus compensation lyra, LHe feed lines (LD1, LD2)
- Design of prototype and series cryostat finalized by CMI, cold supports locations approved, start of VV procurement.

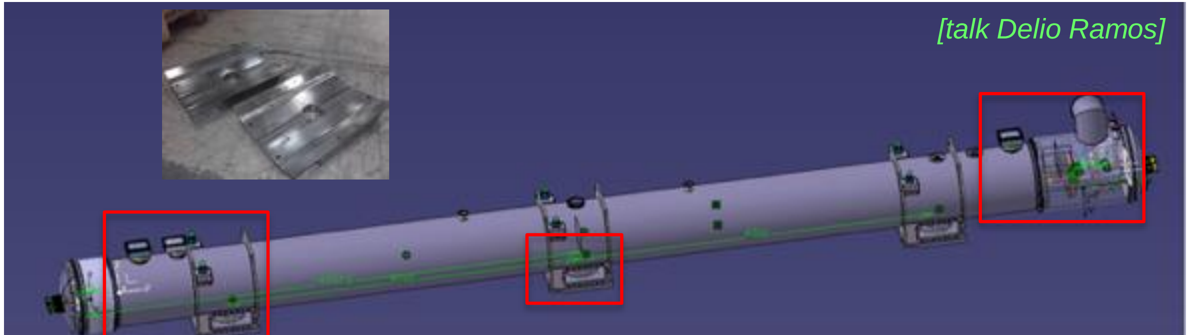


Fig 1. view of integrated D2 cryostat

Courtesy A Van de Craen

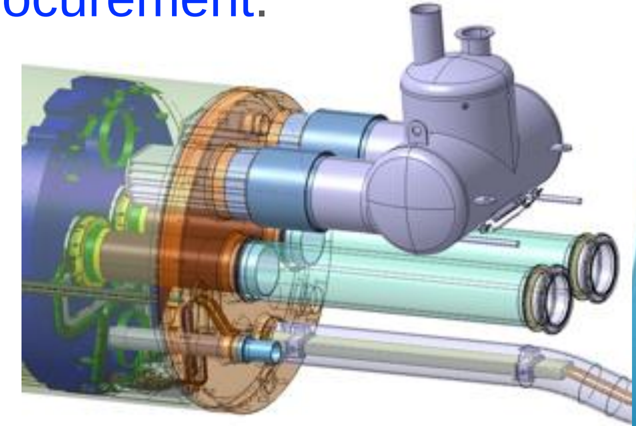
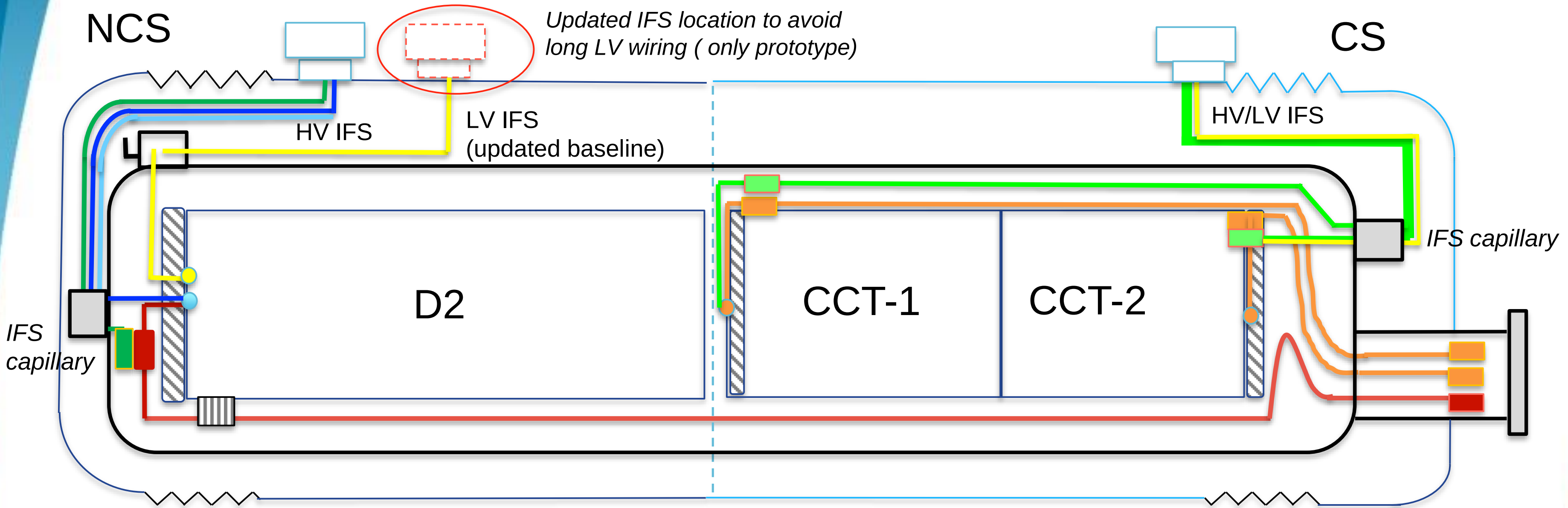


Fig 2. Cold mass connection side integration

LMBRDP Instrumentation synopsis



D2 — **13kA**

D2 correctors — **0.6kA**

Internal busbars

	4
	2

Voltage taps

	16
	48

Quench heaters
Cryo heaters

	16
	4

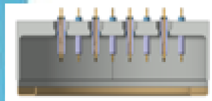
LV signal (SG, TempS) *

	178 (D2)
	8 (CCTs)

* Inside insulation vacuum (only prototype)

Instrumentation budget on LMBRDP

- **Instrumentation for D2 prototype and series is finalized,**
- Design **drawings of Instrumentation flange system (IFS)** under completion,
- Wires routing in progress, up to **178 LV wires and 48 HV in prototype** (Oct 2018)
- **LV IFS prototyping** procurement, testing from Dec 2018 - May 2019.



IFS D2 Series:
- *32 HV*
- *4 LV (Temperature sensor)*
- *2 LV (cryoheater)*

IFS D2 Proto:
- *48 HV*
- *4 LV (Temperature sensor) - in HV IFS*
- *2 LV (cryoheater) - in HV IFS*
- *200 LV pins for strain gauges – separate LV IFS*

Correctors (the same for proto and for series):
- *48HV*
- *8 LV (2x temperature sensor - one per magnet)*
- *2 LV (cryoheater)*

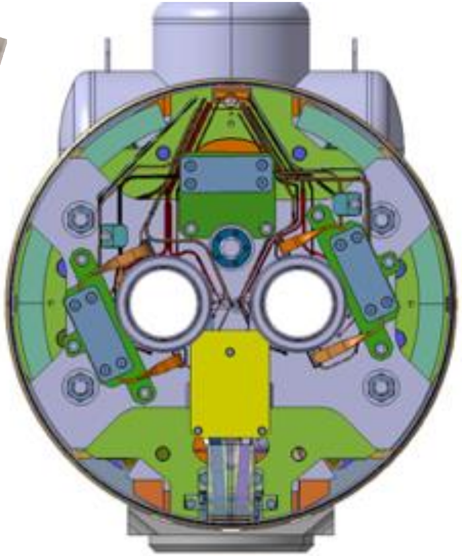
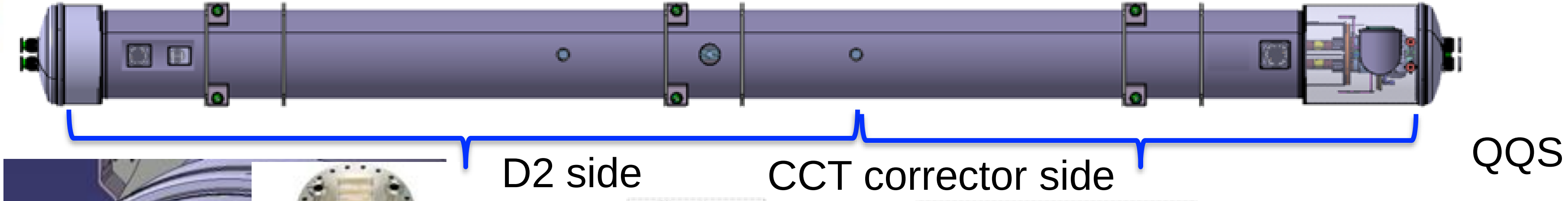


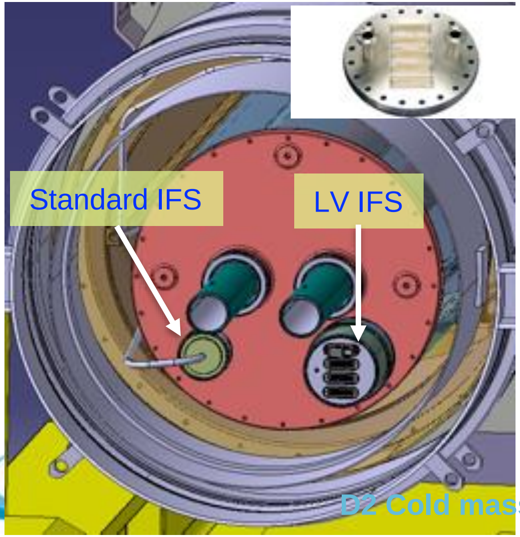
Fig.1 Wires, cable routing on going, integration by CERN, Courtesy from O. Id' Bahmane

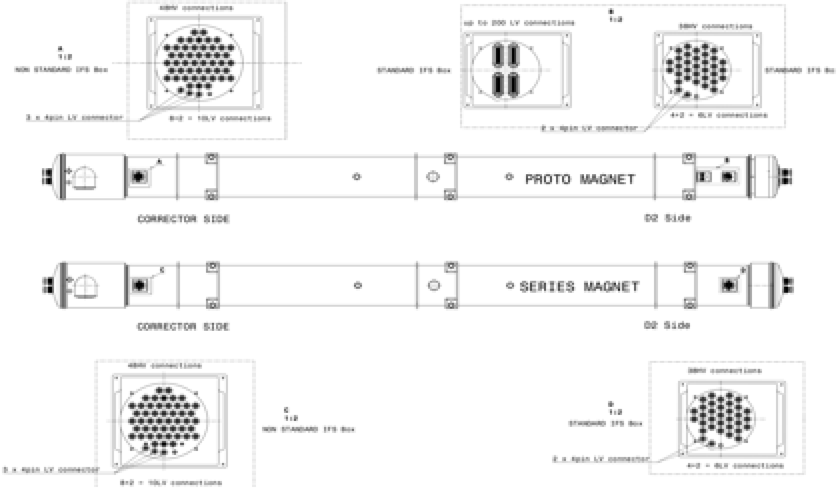
Instrumentation groups	Location	Type	Wires per Instrumentation	HV?	Prototype # sensors	Prototype # wires	Prototype # HV wires	Series # sensors	Series # wires	Series # HV wires	Wire type	Wire Size	diameter[mm] including insulation	Wire crosssection [mm^2] including insulation
D2 IFS														
MBRD Dipole	MBRD Dipole													
Voltage taps	ght aperture inter pole leads	Differential Voltage Tap	2	1	2	4	4	2	4	4	HH 2619 LH	AWG26	0.95	0.71
	eft aperture inter pole leads	Differential Voltage Tap	2	1	2	4	4	2	4	4	HH 2619 LH	AWG26	0.95	0.71
	Inter aperture lead	Differential Voltage Tap	2	1	2	4	4	2	4	4	HH 2619 LH	AWG26	0.95	0.71
	ext leads	Differential Voltage Tap	2	1	2	4	4	2	4	4	HH 2619 LH	AWG26	0.95	0.71
	Internal coils turns VTs	Differential Voltage Tap	2	1	8	16	16	0	0	0	HH 2619 LH	AWG26	0.95	0.71
Quench heaters	Lower Right Coil	Resistive Element	2	1	2	4	4	2	4	4	HH 1819 LH	AWG18	1.70	2.27
	Upper Right Coil	Resistive Element	2	1	2	4	4	2	4	4	HH 1819 LH	AWG18	1.70	2.27
	Lower Left Coil	Resistive Element	2	1	2	4	4	2	4	4	HH 1819 LH	AWG18	1.70	2.27
	Upper Left Coil	Resistive Element	2	1	2	4	4	2	4	4	HH 1819 LH	AWG18	1.70	2.27
Temperature sensors		4 Wire RTD	4	0	1	4	0	1	4	0	T 007 H4 LH	AWG30	1.70	2.27
Strain sensors	Rings/sleeves	QB	4	0	2	8	0	0	0	0	T 007 H4 LH	AWG30	TBD	
	bullet gauges	FB	6	0	16	96	0	0	0	0	T 007 H4 LH	AWG30	TBD	
	Tie Rods	FB	6	0	6	36	0	0	0	0	T 007 H4 LH	AWG30	TBD	
	Poles	QB	4	0	6	24	0	0	0	0	T 007 H4 LH	AWG30	TBD	
	C clamps	HB	5	0	2	10	0	0	0	0	T 007 H4 LH	AWG30	TBD	
			Number of SG		32	174								
# LV MBRD Wires					178			4						
# HV MBRD Wires					48			32						
# Total MBRD Wires					226			36						
Fiber optics	Fiber optics													
Optical Strain Sensor			1	0	4	4	0	0	0	0				
# Total Optical Fibres					4			0						
Cryogenics	Cryogenics													
Cryo heaters		Vishay RH50 RE3 100R 5% R7	2	0	2	4	0	2	4	0	HH 2619 LH	AWG26	0.95	0.71
# LV Cryogenics Wires					4			4						
# HV Cryogenics Wires					0			0						
# Total Cryogenics Wires					4			4						
Corrector IFS														
MCBRDA corrector	MCBRDA corrector													
Voltage taps	Left Apperture	Single Voltage Tap	1	1	12	12	12	12	12	12	HH 2619 LH	AWG26	0.95	0.71
	Right Apperture	Single Voltage Tap	1	1	12	12	12	12	12	12	HH 2619 LH	AWG26	0.95	0.71
Temperature sensors		4 Wire RTD	4	0	1	4	0	1	4	0	T 007 H4 LH	AWG30	1.70	2.27
# LV MCBRDA Wires					4			4						
# HV MCBRDA Wires					24			24						
# Total MCBRDA Wires					28			28						
MCBRDB corrector	MCBRDB corrector													
Voltage taps	Left Apperture	Single Voltage Tap	1	1	12	12	12	12	12	12	HH 2619 LH	AWG26	0.95	0.71
	Right Apperture	Single Voltage Tap	1	1	12	12	12	12	12	12	HH 2619 LH	AWG26	0.95	0.71
Temperature sensors		4 Wire RTD	4	0	1	4	0	1	4	0	T 007 H4 LH	AWG30	1.70	2.27
# LV MCBRDB Wires					4			4						
# HV MCBRDB Wires					24			24						
# Total MCBRDB Wires					28			28						

Instrumentation Flange System (IFS)

- Last optimization of feedthrough IFSs location to **minimize wires integration lengths**, **standardization of cryostats types**.
- Dimensioning done, specific choice of weldable sub-D connectors with vacuum guard (10^{-4} mb) for LV instrumentation cables (detailed drawings on going)

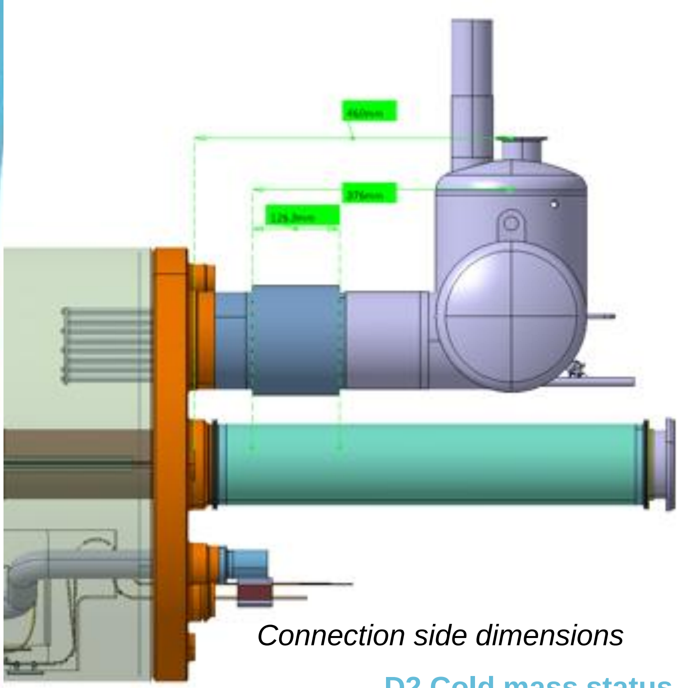




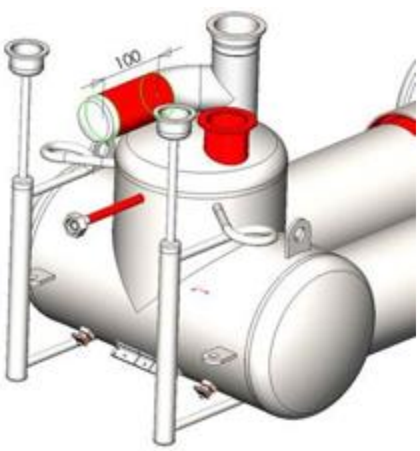


Finned Cu tubes 1.9K HEX interface

- Assembly flanges to new 1.9K designed, interface drawing under progress
- HEX assembly to be done at cryostating with dedicated assembly tooling due its size, including final pressure test at 2.5 MPa.

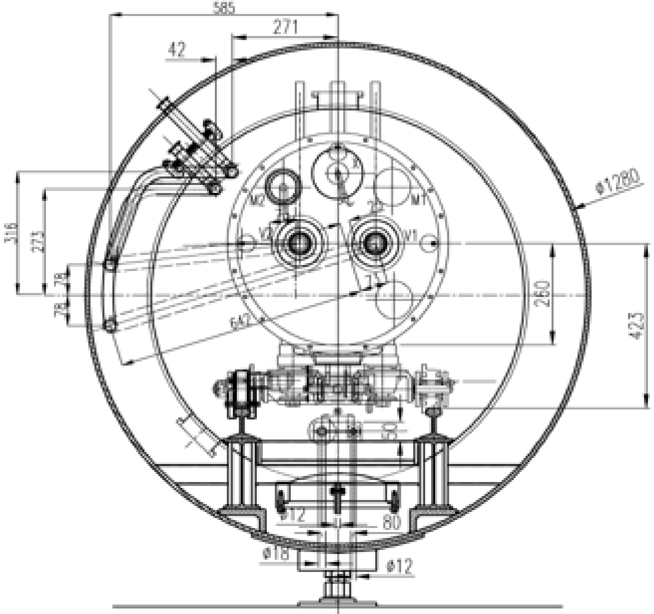


Connection side dimensions



courtesy from CEA Gre.

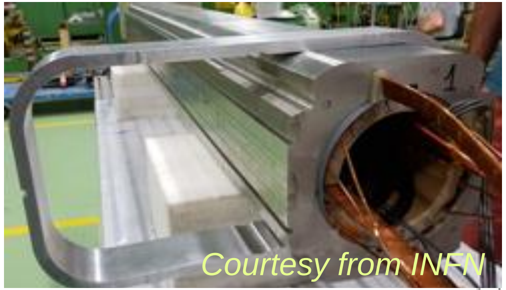
[talk Antonio Perin]

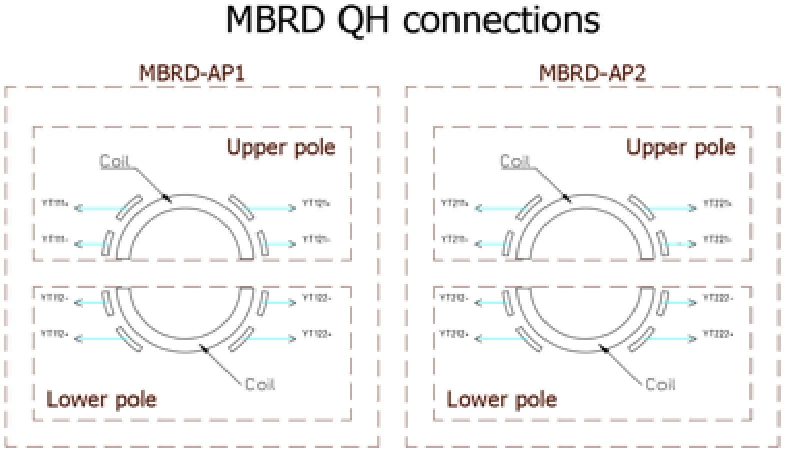


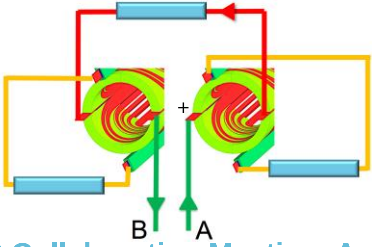
Pressure test bench Ref Dwg: LHCLMQ_T0114

Electric internal circuit interface

- D2 quench protection (PHs) and detection (VTs) **circuit diagram ready** with allocated pins number.
- LV IFS **prototype fabrication planned [from 12/2018],** dedicated mechanical instrumentation diagram to be confirmed with INFN Ge.







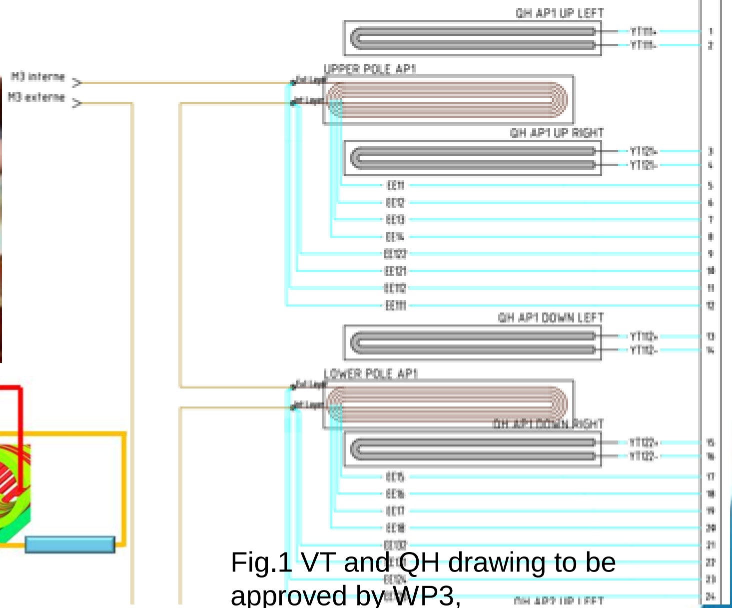
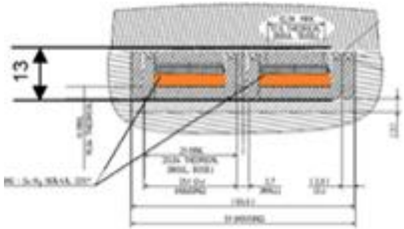
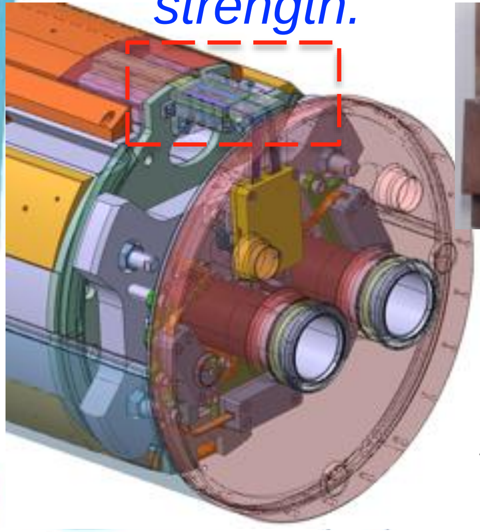


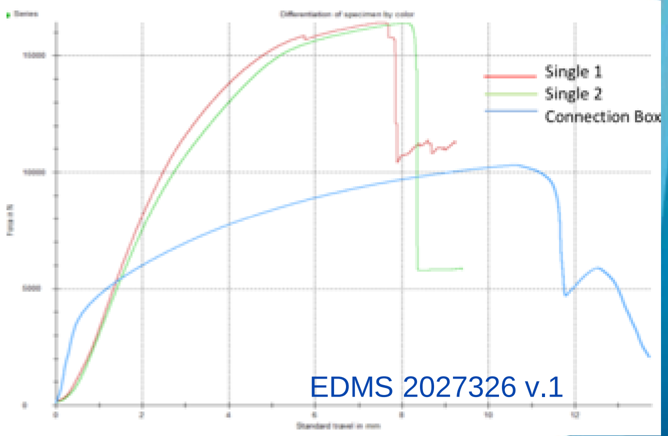
Fig.1 VT and QH drawing to be approved by WP3,

Busbar design, prototype

- ***Fixed point prototype*** *on internal 13 kA OFE copper stabilised 13 m long busbar made by successive brazing method by Silfos Cu-Ag (~ 600 °C melting) then Sn90Ag40 (183 °C)*
- ***Tensile loading tests completed*** *on both SC bus samples and Ryton® insulation box, more than 5 kN strength.*





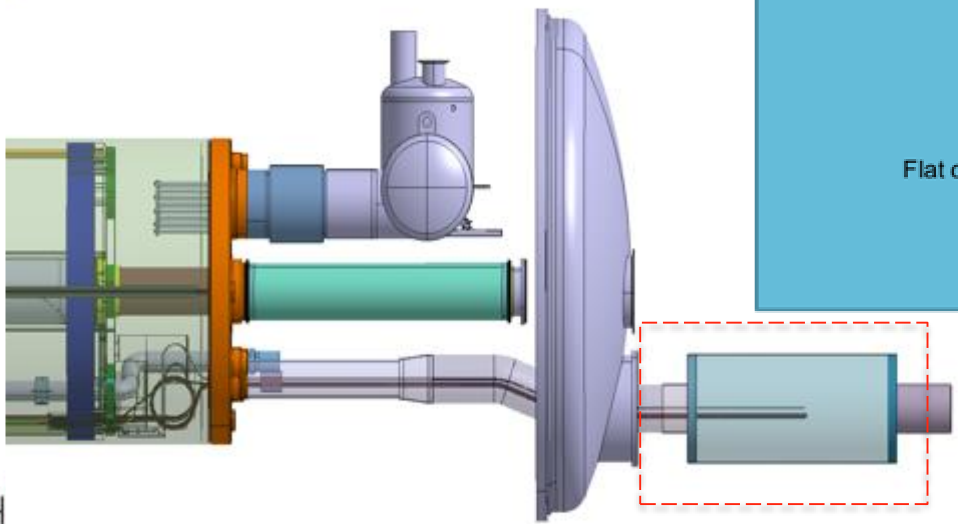


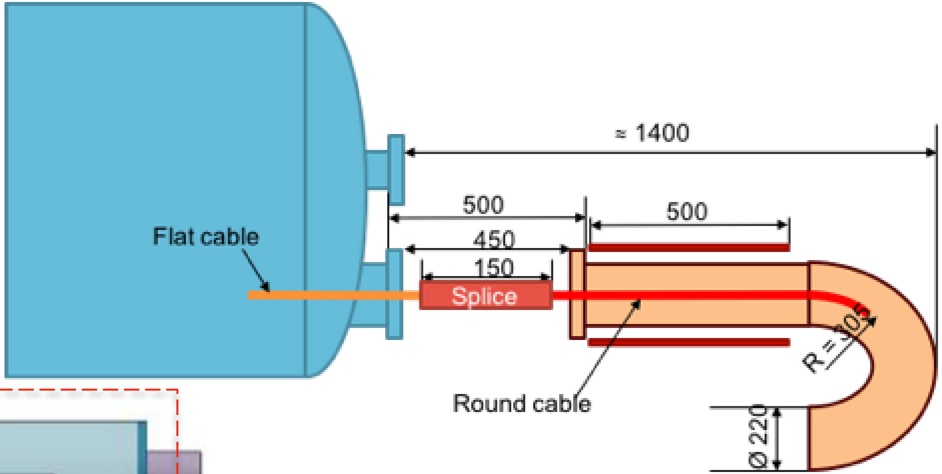
EDMS 2027326 v.1

Fig 1. Fixed point location on cold mass NCS
Fig 2.a,b prototype test samples, results

D2-DFM Link busbar splice

- CAD layout interface design of 13kA splice to DFM link NbTi busbar done, check by integration
- Next, WP3 to confirm the specifications of DFM link 13kA round busbar to start detailed design of splice [Dec 2018 – Feb 2019]



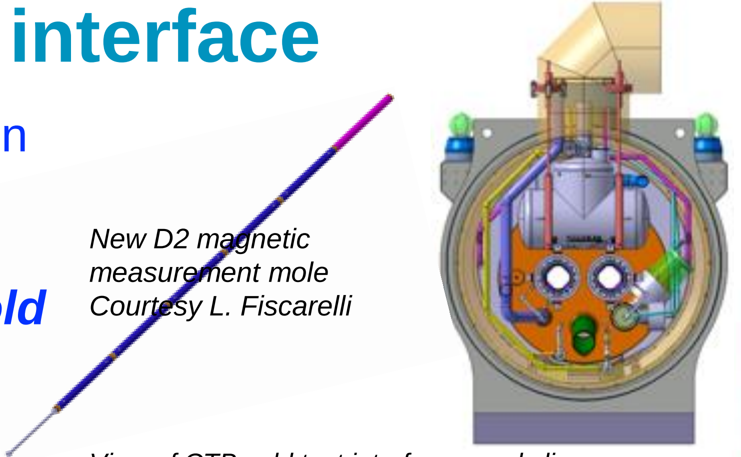


Courtesy V. Parma

Fig.1 Layout and design views of splicing region to DFM link bus

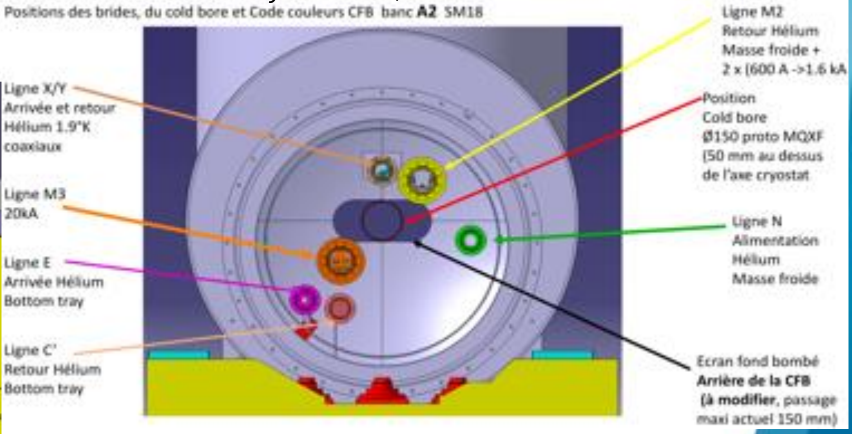
SM18 Cold test interface

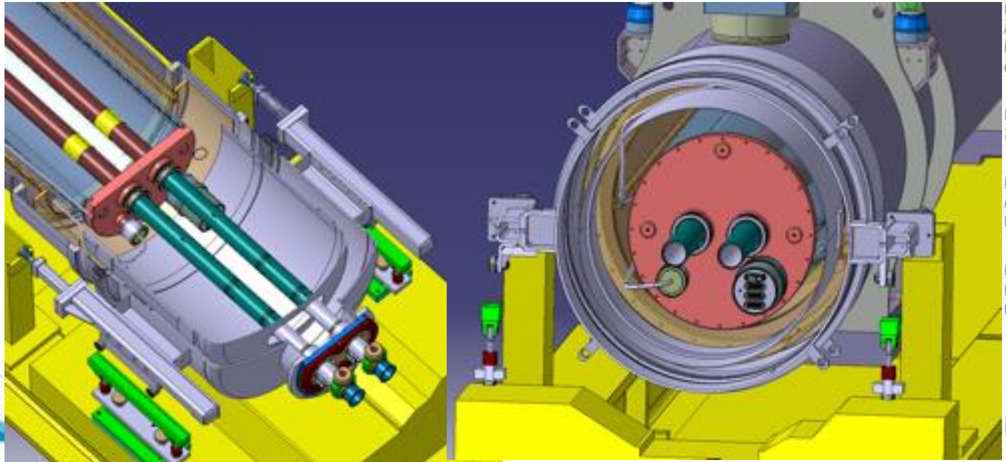
- On going CAD integration study of D2 prototype in SM18 test cryostat, interface to CFB, compatible with cold test of 1.9K HEX.
- ***Design of internal connection routing from cold mass exits lines to CFB M2/3, N, C', E.***
- Magnetic measurement to check mid plane tilt at warm, operation on cold test in anticryostat (under design by CMI).



New D2 magnetic measurement mole Courtesy L. Fiscarelli

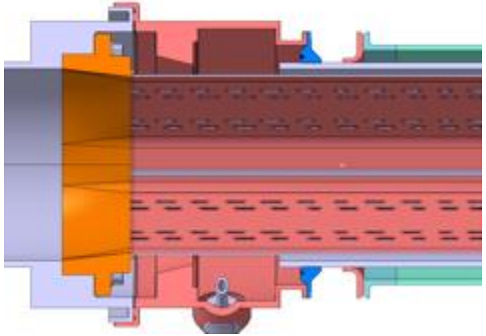
View of CTB cold test interface supply lines Courtesy P. Perret, reference 29-06-2017



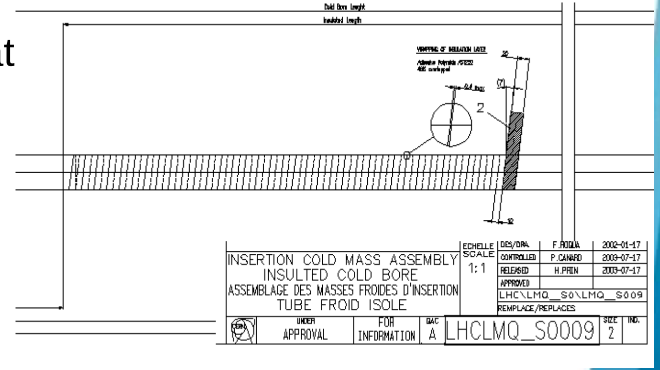


Cold bore tube integration

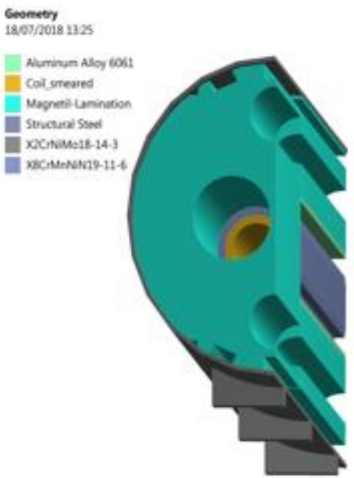
- The baseline of **13 m long cold bore tube (CBT),** OD100 mm requires an **insertion from the side** of the D2 cold mass once assembled (Drawing LHCVSCSC0001) similarly to SSS arcs LHC cold mass

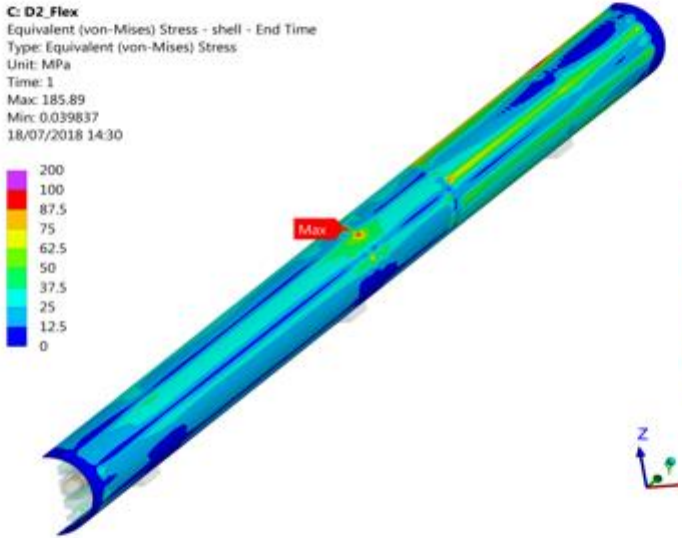


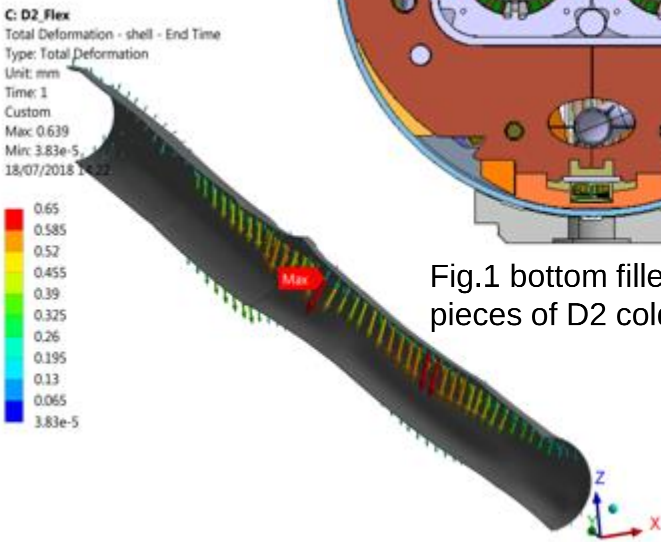
- **Past SSS experience** with a **1,5 mm gap side insertion** in Ø 56 mm aperture, 120 µm insulation thickness(LMQ_S0009), **no internal supports.**
- The **D2 CBT insulation system is designed with minimum thickness of 0.3 mm (2 polyimide layers, isopreg)** with no intermediate support giving a minimum clearance of 1.5 mm at radius.
- Expected sagging of 1.5 mm over 4 m support span.
- Design change on prototype accepted by INFN **to avoid protruding of collar nose**
- *Note:* Coils collaring on tube is not an option at moment as would require butt welding development not permitted so far.



Structural analysis of D2 CM model under gravity







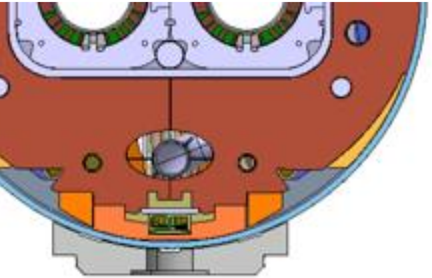
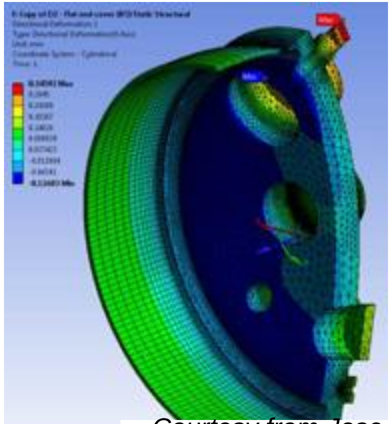


Fig.1 bottom filler SS pieces of D2 cold mass

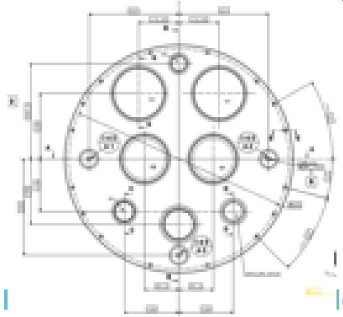
- FEM structural analysis of D2 cold mass under gravity shows 0.6 mm maximum deformation, peak VM stress less than 200 Mpa.
- Local analysis on internal filler support on going (Fig.1).

Pressure vessel structural analysis

- As part of Pressure Equipment Directive (PED) (2014/68/EU) safety files requirements, a structural analysis was performed in pure-elastic analysis, considering *Testing and exceptional load cases* scenario under 2.5 MPa.
  - Examined welds passed both criteria on primary and secondary stresses $(\sigma_{eq})_{Pm} \leq$ 304 MPa, based on stress categorisation. and more conservative value of $(\Delta\sigma_{eq})_{P+Q} \leq 2R_{p1.0/T}$= 640 MPa according to EN 13445-3:2014.
  - Maximum equivalent total strain is kept always well below maximum allowable (i.e. 5 and 7 % for normal operating and testing load cases respectively).



Courtesy from Jose luis Rudeiros



Equivalent Stress (Von-Mises) - Elastic analysis of D2 end plates

Automatic Orbital welding development

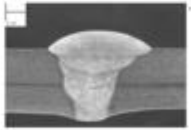
- D2 cold mass assembly relies on successful **Qualification of automatic orbital TIG welding** of two half longitudinally welded CMs. (first DMOS approved by Apave third party last July 18)
- On going procurement of upgraded CERN TIG orbital welding equipment for **next qualification of welder and trial on crossed welds.**
- **Level of NDT inspection clarified** on each weld type per EN:ISO5817 level B standards (see indico 732717). **UT procedures under qualification by EN-MME**

p-DMOS

Fig1. On line dimension survey with Leica laser tracker. 0.3 mm maximum linear deviation

Fig.2 Polycar 60 automatic TIG head installed on guiding rails (OD508, 630mm)

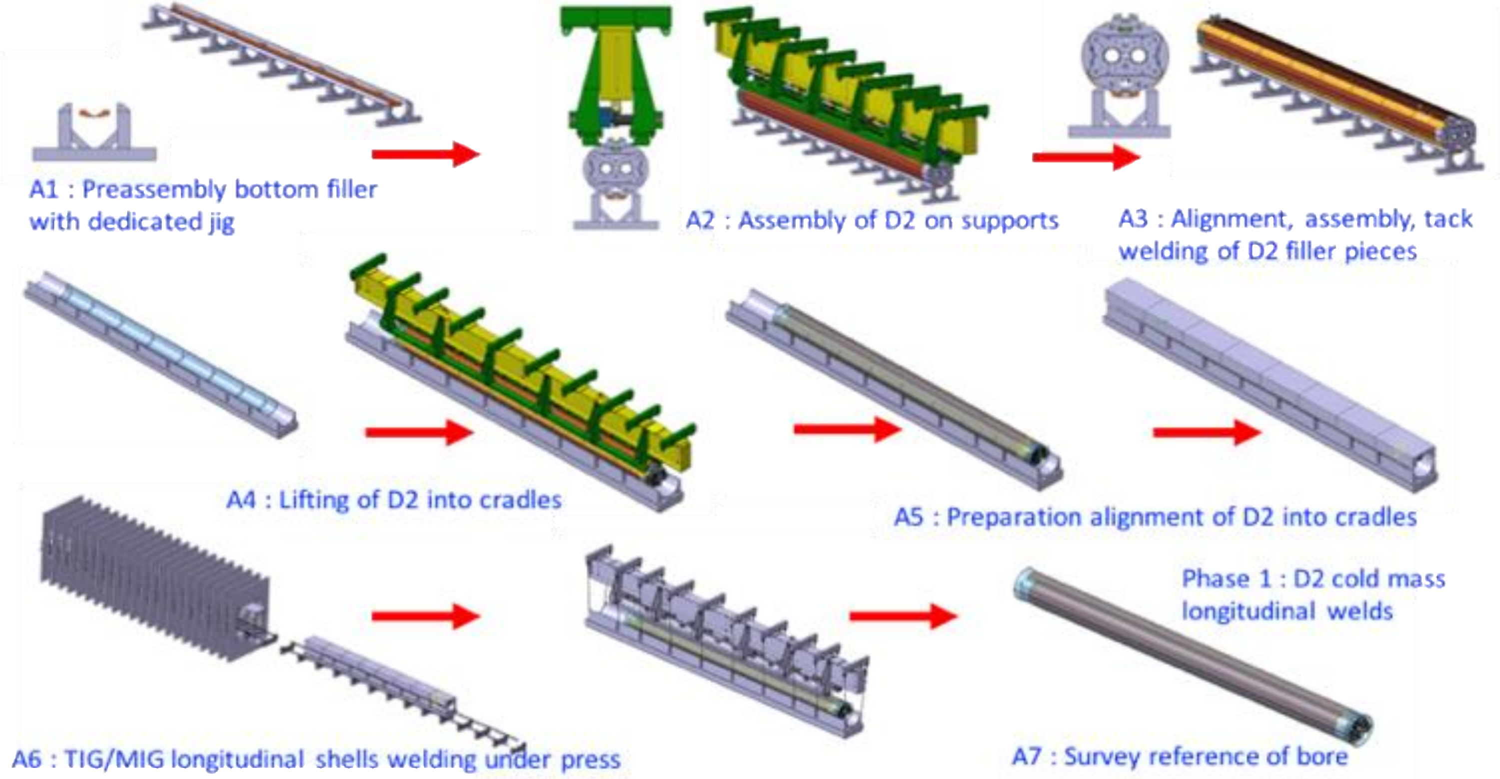
Fifth weld TIG pass



Assembly sequence (Phase I / III) in progress

On going study of assembly sequence to create tooling specification drawings

Universal 30t lifting tool commissioned for D2 and MQXF



Splice box interface for leads and VTs

- **Concept design of 600 A lead and VTs splice box complete (10)** on each CCT with soldered Sn-Ag connections into crimped Alu tube.
- VTs wires routing to CCT instrumentation flange done, exit busbars

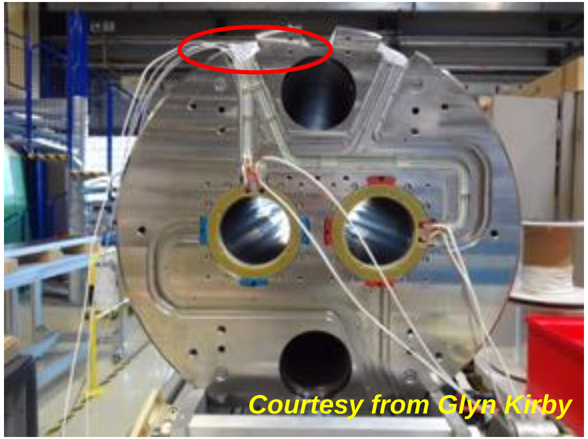


Fig.3 Front view of CCT prototype exit leads

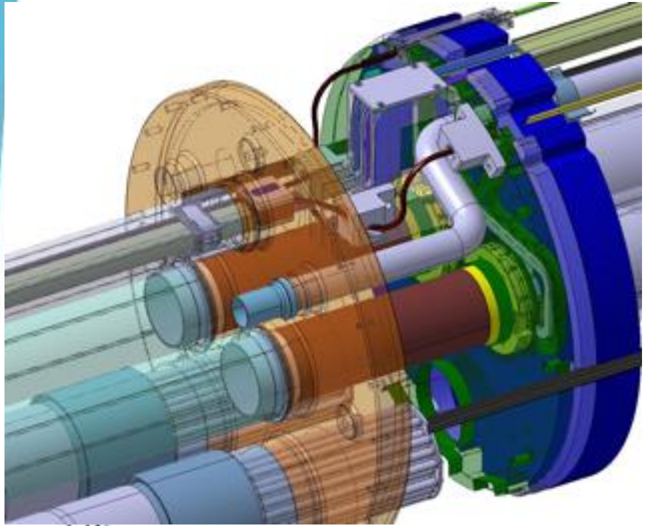


Fig.1 routing of 600 A busbar

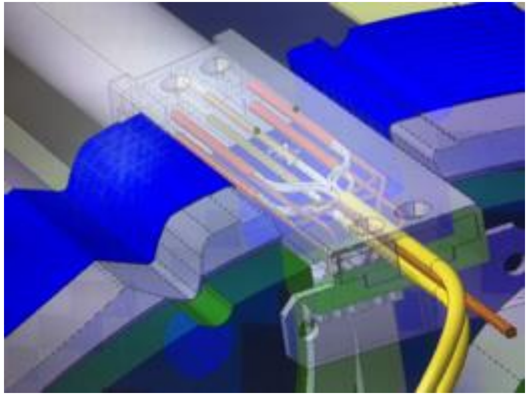


Fig. 2 600 A bus splice with VTs

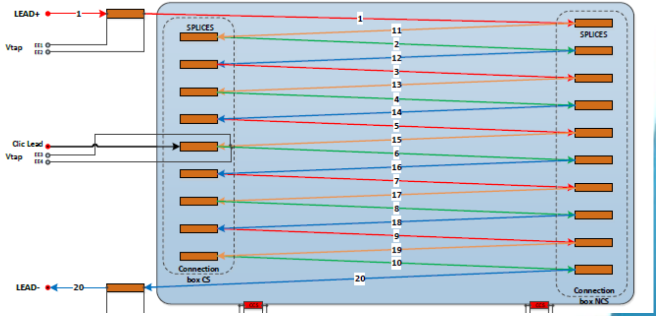
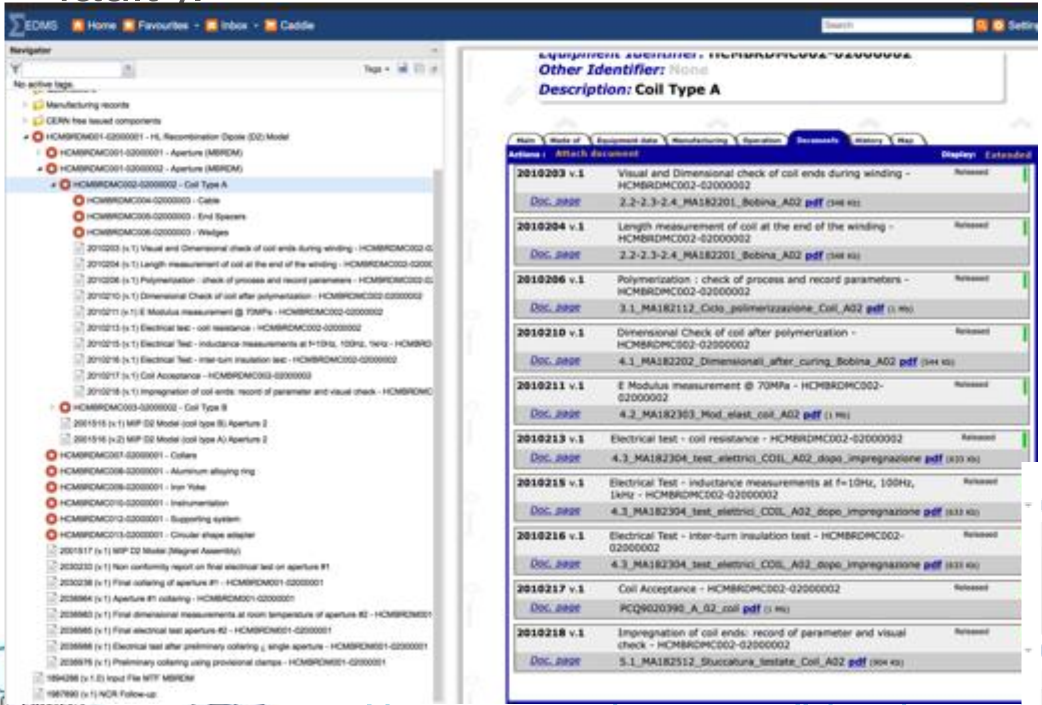


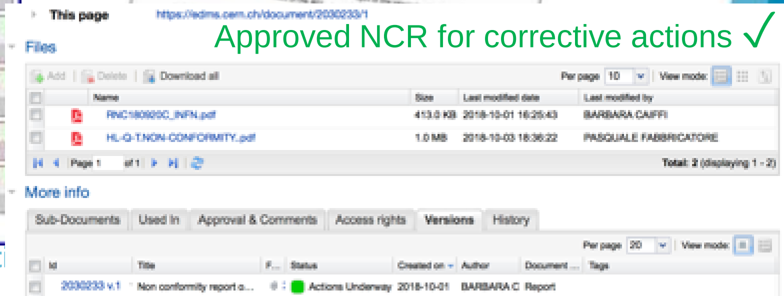
Fig.4 CCT VTs layout

D2 Short model documentation

- Both Short model apertures inspection records are archived and released in MTF by INFN (including last NCR on aperture 1 electrical fault).



Approved NCR for corrective actions ✓



D2 cold mass documents

- Main cold mass **assembly drawings** are created on CDD and currently **under revision**
- *Prototype and series D2* ***cold mass auxiliaries components drawings*** to **be issued by Jan 2019**

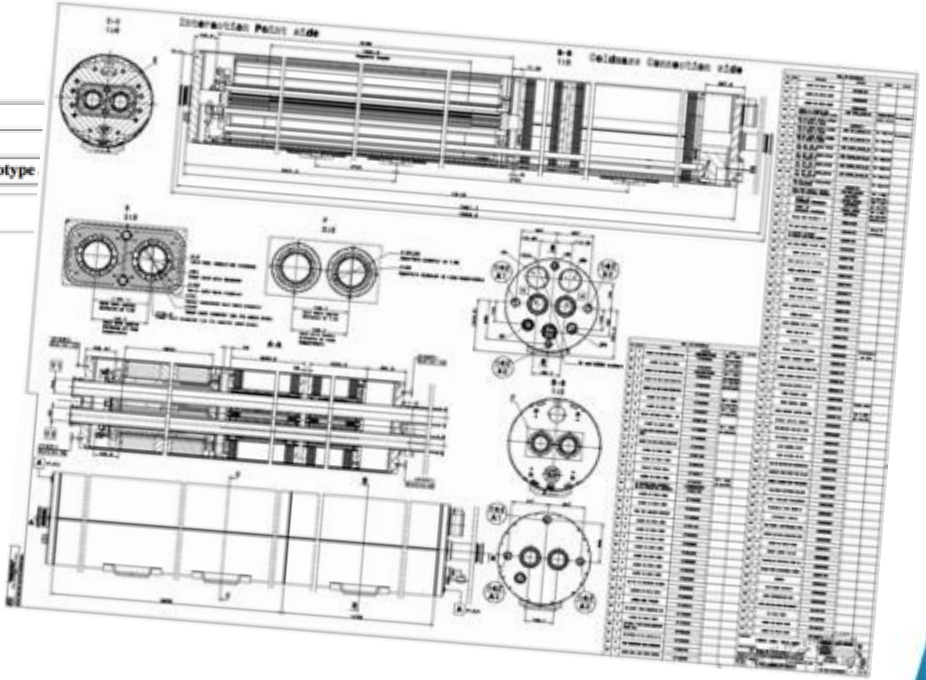
AREA	ACCELERATORS AND MACHINE
PROJECT	
EQUIPMENT	Twin-Aperture (105mm) Recombination Dipole (D2) Cold mass Prototype

✔ Drawing is available ✖ Drawing is cancelled, obsolete or lost

Directly related drawings

Query returned 9 item(s) :

✔ LHCLMBRDP0001	LMBRD (D2) COLD MASS D2 Magnet assembly Layout
✔ LHCLMBRDP0002	LMBRD COLD MASS PROTOTYPE - LMBRD COLD MASS PROTO
✔ LHCLMBRDP0003	LMBRD COLD MASS - D2 BUSBARS
✔ LHCLMBRDP0004	LMDRB COLD MASS PROTOTYPE - COLD MASS INSTRUMENTATION
✔ LHCLMBRDP0005	AVAILABLE DISPONIBLE
✔ LHCLMBRDP0006	DISHED HEAD CONNECTION SIDE
✔ LHCLMBRDP0007	D2 LMBRD COLD MASS PROTO LAYOUT
✔ LHCLMBRDP0008	LMBRD (D2) COLD MASS Welding numbering of LMBRD (D2) cold mass
✔ LHCLMBRDP0009	LMBRD D2 COLD MASS D2 SHELL/YOKE FILLER SUPPORT



Prototype Test plan

- LMBRDP shall follow ***standard NbTi magnet test campaign program*** with additional dedicated tests.

- *Horizontal Magnetic measurement in anticryostat, magnetic cross talk study*
- *Cooling efficiency of D2 1.9K HEX*
- *Mutual magnetic influence of D2 and CCT correctors*
- *Quench Pressure characterization.*

- *Test plan of prototype in progress by 02/2019 based on short model* (https://edms.cern.ch/document/1982344/0.2)

1 Preparation tests at warm up to 3kV to ground

2 Cooldown, RRR measurement

3 Cold powering preparation, HV electrical insulation test up to 2.3 kV to ground

4 Cold powering tests, low current, up to 4kA@ 10 A/s for 300 s, protection QH checks.

5 Cold powering tests, high current at 1.9 K, Training campaign, Holding time (3 h), ramp rate study (up to 200A/s), Magnetic measurements, Transfer function, AC losses (up 100 A/s)

6 Cold powering tests, high current at 4.5 K, check at nominal ramp rate (10 A/s):

7 Final HV electrical insulation tests at cold, up to 590 V to ground

8 Warm up cycle, RRR measurement

9 Cooldown, RRR measurement, Mechanical Strain measurement

10 Cold powering preparation

11 Cold powering tests, low current, check dump and QH circuit

12 Cold powering tests, high current at 1.9 K, dump no heater, check QI (< 15 MA²s), then QH effectiveness by batch

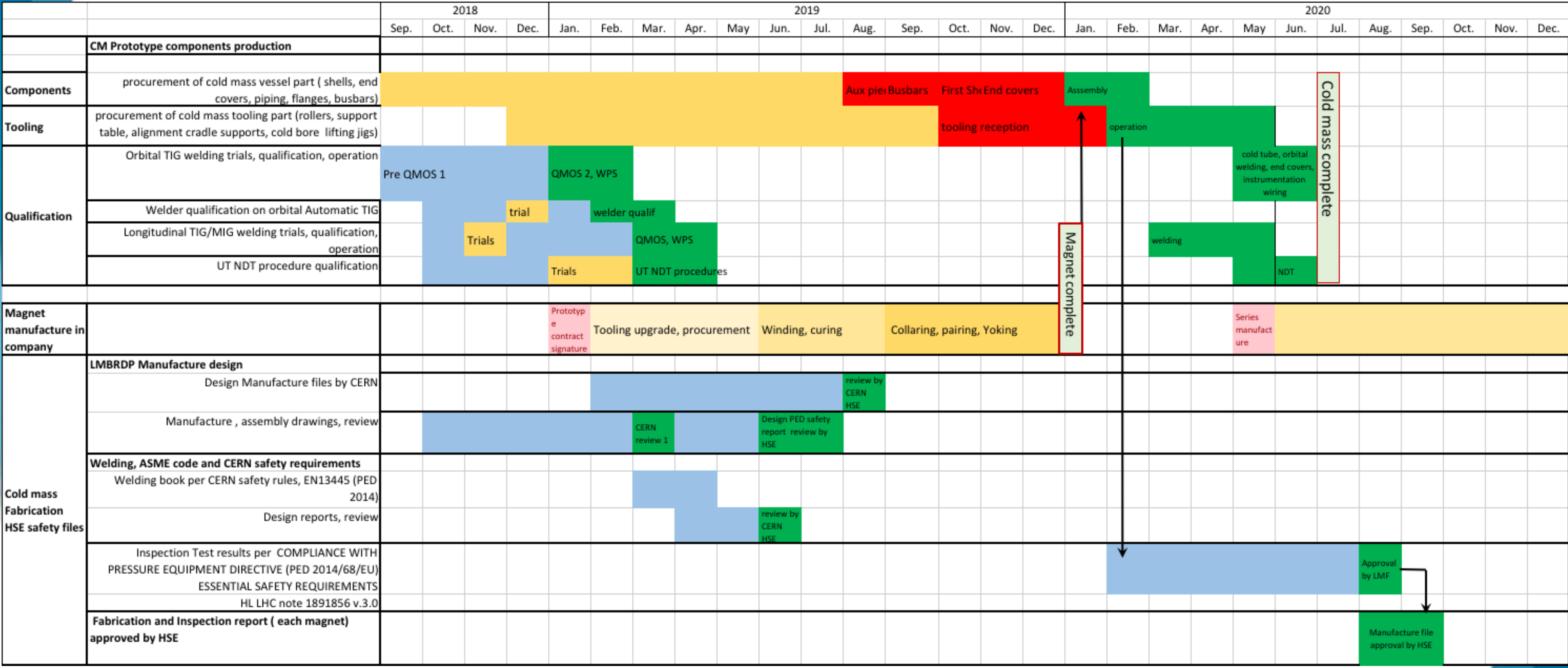
13 Cold powering tests, high current at 4.5 K, training check

14 Final tests at cold, HV electrical insulation test up to 590 V to ground

15 Warm up, RRR measurement, Mechanical Strain measurement

16 Final tests at warm, HV electrical insulation test up to 335 V to ground

Manufacture schedule, HSE approval plan

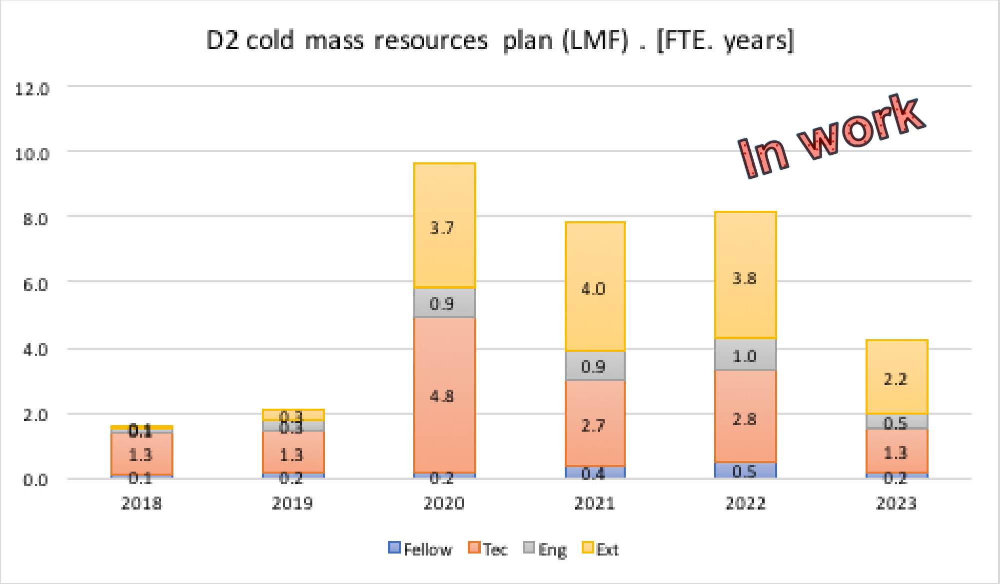


Integrated schedule (in construction)

ID	Task Mode	Task Name	Duration	Start	Finish
63		PROTOTYPE MBRD DIPOLE - MBRD_P	110.8 wks?	Fri 9/14/18	Wed 12/9/20
64		Contract award	0.2 wks?	Tue 1/15/19	Tue 1/15/19
65		Prototype design	1 mon	Wed 1/16/19	Tue 2/12/19
66		Prototype manufacture tooling upgrade	4.5 mons	Wed 1/16/19	Tue 5/21/19
67		Prototype cable insulation @ CERN	18 wks	Fri 9/14/18	Thu 2/7/19
74		Prototype coils fabrication	13.5 wks?	Wed 5/22/19	Fri 8/23/19
102		Prototype collared coils	12 wks	Tue 7/9/19	Mon 9/30/19
103		Practice Coil collaring CCPRAC1	11 wks	Tue 7/9/19	Mon 9/23/19
109		Prototype CCPROT1	7.5 wks	Tue 7/23/19	Thu 9/12/19
115		Prototype CCPROT2	8 wks	Tue 8/6/19	Mon 9/30/19
121		Prototype Magnet assembly MBRDP1 (CCPROT1 + CCPROT2)	12.5 wks	Tue 10/1/19	Thu 1/16/20
128		Prototype Cold mass assembly	26.9 wks?	Thu 1/16/20	Wed 7/22/20
178		Prototype cryostating LMBRD_P1	12 wks	Thu 7/23/20	Wed 10/14/20
180		Prototype horizontal test LMBRD_P1	8 wks	Thu 10/15/20	Wed 12/9/20
182		Specification drawings , tec specs	4 mons	Mon 11/25/19	Fri 4/3/20
183		Bid series	14 wks	Mon 6/1/20	Fri 9/4/20
187		Series MBRD+LMBRD	216.1 wks?	Wed 3/13/19	Wed 7/26/23
188		SERIES COILS Manufacture CONTRACT Signature	0.2 wks?	Mon 12/14/20	Mon 12/14/20
189		Series design	1 mon	Tue 12/15/20	Mon 2/1/21
190		Series tooling adjustments	3 mons	Tue 12/15/20	Mon 3/29/21
191		Cable insulation (@ CERN)	40 wks	Wed 3/13/19	Tue 12/17/19
222		Series coil fabrication	81.1 wks?	Tue 6/22/21	Tue 2/21/23
403		Series Collared coils	61.6 wks	Fri 8/13/21	Tue 11/8/22
482		Series Magnet assembly	59.5 wks	Wed 10/27/21	Fri 1/27/23
519		Packing Transport of magnets	54 wks	Fri 1/14/22	Fri 2/17/23
526		Series cold mass	78.6 wks	Fri 2/4/22	Wed 7/26/23
527		Cold mass assembly LS3 LMBRD__001	23.6 wks	Fri 2/4/22	Wed 7/20/22
536		Cold mass assembly LS3 LMBRD__002	22.2 wks	Fri 5/20/22	Fri 10/21/22
545		Cold mass assembly LS3 LMBRD__003	22.2 wks	Wed 7/27/22	Wed 1/18/23
554		Cold mass assembly LS3 LMBRD__004	22.2 wks	Mon 10/3/22	Mon 3/27/23
563		Cold mass assembly LS3 LMBRD__005	22.4 wks	Thu 12/8/22	Fri 6/2/23
572		Cold mass assembly LS3 LMBRD__006	22.6 wks	Fri 2/17/23	Wed 7/26/23
581		Pressure test station	51.5 wks	Wed 7/20/22	Fri 8/4/23
588		Series cryostating	61.1 wks	Mon 8/1/22	Mon 10/23/23

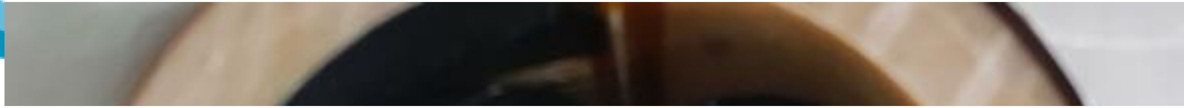
Baseline production schedule

- Integrated magnet and cold mass baseline schedule at CERN including resource load (tooling, personnel) in work progress. D2 prototype cold mass assembly scheduled from 12/2019 with lead time of 27 weeks.
  - On going check for co-activities, common resources, target of 22 weeks / CM.
- The cold mass construction of D2, CCTs magnets involves new tooling and manufacture procedures, **timeline to be validated through prototype**.
- Optional scenario of Series CM assembly by third party under study.

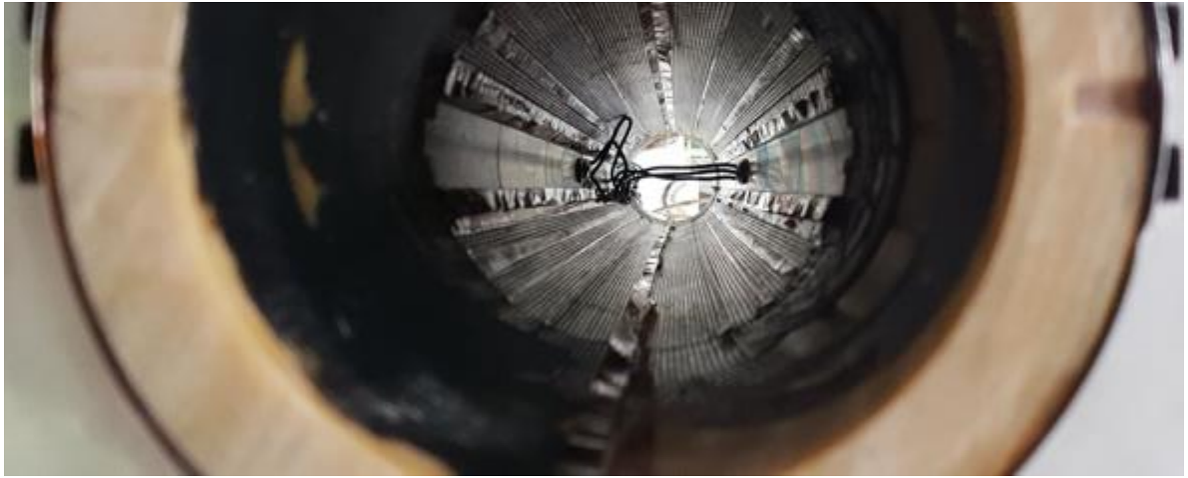


Summary

- LMBRD **cold mass CAD model is complete**, focus to deliver **components drawings** by **Feb 2019.**
- **New assembly welding process** of D2 cold mass requires qualification of welding processes and precise alignment bench design **by 04.2019.**
- **Procurement of final main CM components started**, full swing to manage others **auxiliaries series items procurement** till 10.2019.
- The sequence drawings and manufacture **procedure writing of CM fabrication** to be designed in detail to procure alignment and assembly dedicated jigs **[12.2018 – 08.2019]**
- **Resources for manufacture** to be confirmed, option of partial CM fabrication by magnet contractor under study.
- **Test program of D2 magnet prototype first cold mass** to be integrated with all interfaces test requirements, by **Mar. 2019.**

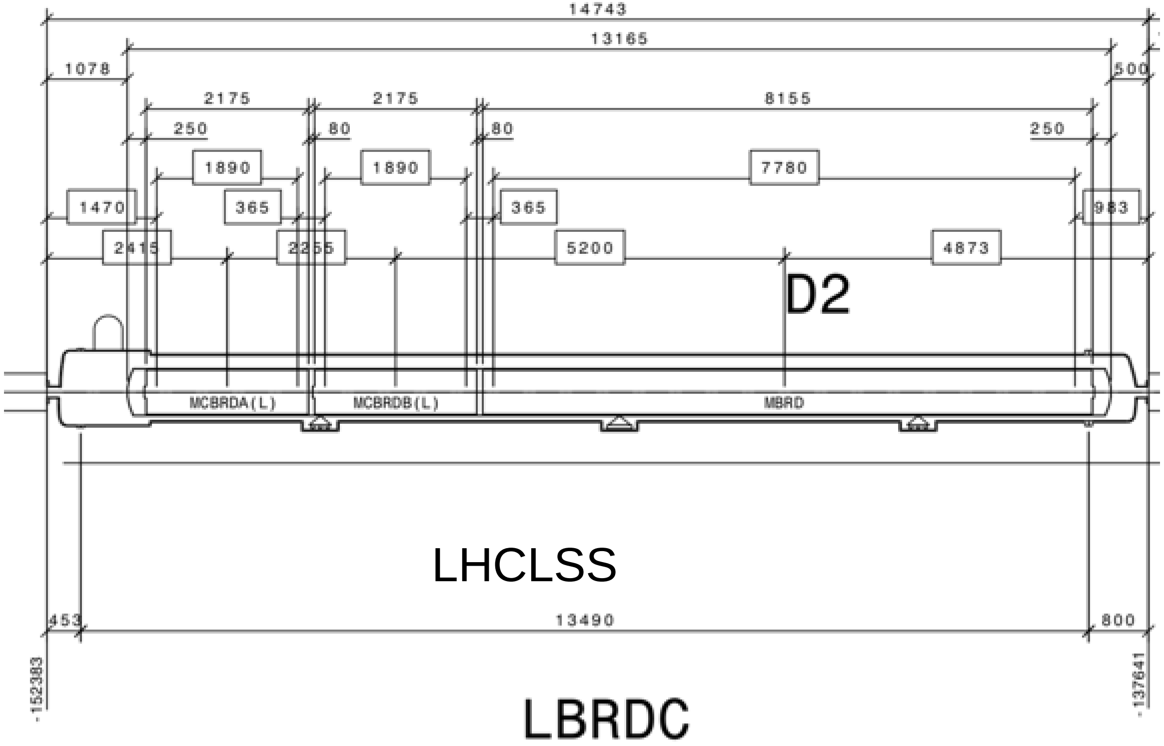


“There must be bright light at the end of the tunnel …“



BACK UP SLIDES

Baseline integration reference drawing



NDT requirements approved. Reference HL-LHC COMPLIANCE with Pressure Equipment Directive (PED 2014/68/EU) EDMS :1891856 v.4.0

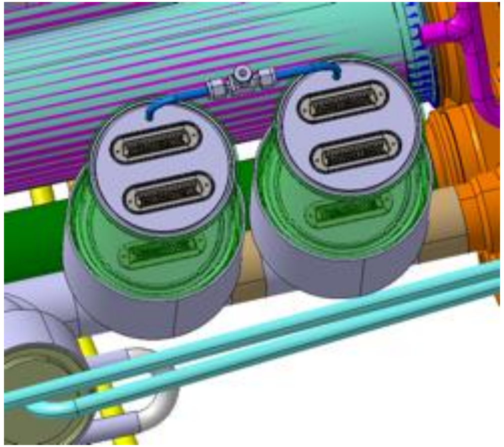
Tests	Standards	Welding Qualification (if necessary)	Production: Weld joint	Production: Test plates /coupons (***)	Acceptance
Non destructive tests					
Visual inspection	EN 17637-2017	100%	100%	100%	EN 5817
Inspection X-ray (film) and/or UT inspection	EN 17636-1 (RT) EN 12668-1/3 (UT) EN 13588 (PAUT) EN583-6 (TOFD UT)	100%	100%	100%	[1] EN 5817 class B (weld efficiency of 1)
Destructive Tests (**)					
Transverse tensile test, 1 required	EN 4136 EN 10002-1	X			[2]
Longitudinal tensile test within the weld bead 1 required	EN 5178	X			[3]
Charpy V-Notch test (4.2 K) 3 required in heat affected zone 3 required in welded metal	ISO 17636-1 EN ISO 148-1 EN 377	X			[4] Energy > 40 J for group 8
Bending test 1 required normal 1 required root	EN 910 ISO 7438	X			[5]
Macrography 1 required	EN 13639	X			[6] EN 5817
Micrograph 1 required	EN 13639	X			[7] EN 5817
Magnetic permeability 1 required		X			[8]
Specific qualification destructive test [9]					
Fracture toughness at RT, 77K, 4.2K (Heat affected zone, weld material) 9 samples required (1 L, 1 T each at each temperature)	ASTM E 399, ASTM E813-89 (or eq. ASME Section VIII Div 3) ASTM E 1820		X		>= 130 MPa.m$^{1/2}$ for weldments at 4K

Specific IFS in insulation vacuum

- For large amount of LV signal wires, use of local evacuated pot with double D-Sub feedthroughs to route wire in insulation vaccum
  - Evacuation line to be added, min ID 10 mm to reach 10^{-4} mbar.
  - Seff = Q/P_{end} ; P_{end}=10^{-5} mb,
  - Assuming a gas leak evolution of Q = 10^{-3} mb.l.s-1, Seff =100 l/s

210-D50-CF100-2

D-Sub Feedthrough, Weld Adapter to be selected
Check for leak rate at cold, < 10^{-9} mb.l.-1 at 1.9K
Tightness under 2.5 Mpa to be checked



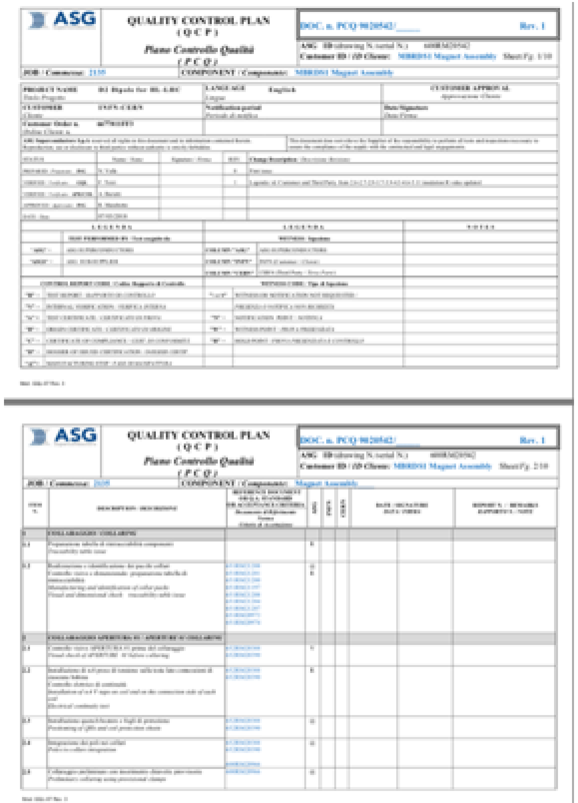
General Specifications Sub-Miniature D

Compliance	DIN 41652, MIL-C-24308
Pin-ø	1.0mm
Pin material	Gold plated NiFe
Seal	Glass Ceramic
Flange	Stainless Steel 316L
Test Voltage	500V DC
Max. Current	5A per pin
Cont. Current	3A per pin, all pins loaded
Temp.	-200°C to 230°C
Leak rate	<$5x10^{-10}$ mar-l/s He

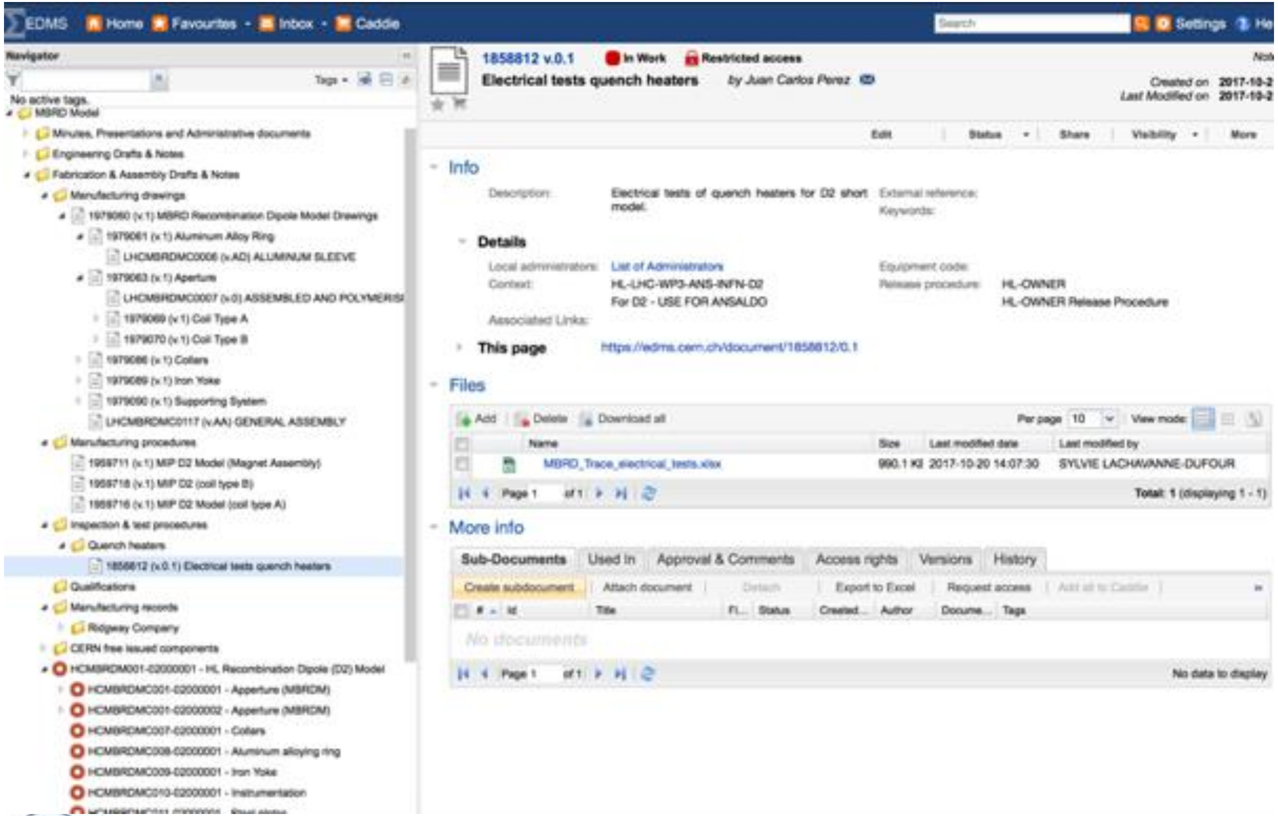
Ref *catalog Allectra*

MIP coils type A-B

- https://edms.cern.ch/document/1959718/1

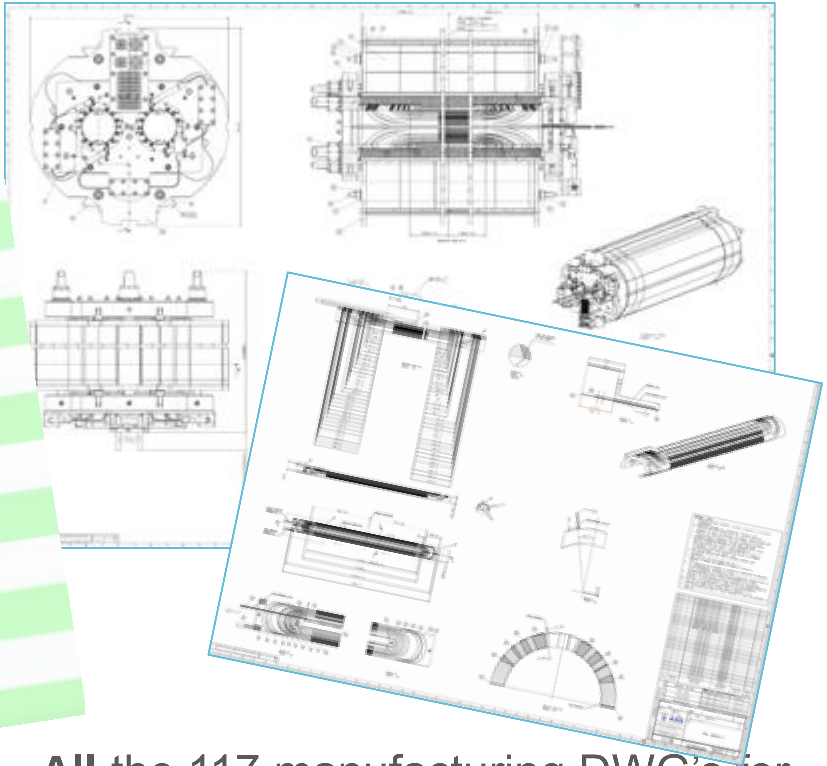


EDMS D2 short model structure



Short model drawings

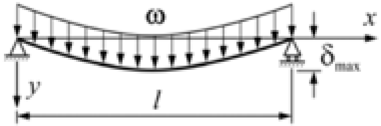
					HALF YOKE ASM
LHCMBRDMC0104	AA	none	A0	IM	ext. ref: 671RM21437 HALF YOKE HEAD
LHCMBRDMC0105	AB	none	A0	IM	ext. ref: 670RM21465 PLATE HEAD YOKE
LHCMBRDMC0106	AA	none	A0	IM	ext. ref: 671RM21576 YOKE PLATE
LHCMBRDMC0107	AB	none	A3	IM	ext. ref: 600RM21574 C-CLAMP
LHCMBRDMC0108	AC	none	A3	IM	ext. ref: 670RM21461 M16 TIE ROD
LHCMBRDMC0109	AA	none	A3	IM	ext. ref: 670RM21462 M24 TIE ROD
LHCMBRDMC0110	AA	none	A3	IM	ext. ref: 670RM21463 M33 TIE ROD
LHCMBRDMC0111	AB	none	A0	IM	ext. ref: 660RM21467 COIL PLATE LC
LHCMBRDMC0112	AA	none	A2	IM	ext. ref: 660RM21621 MEZZELUNE L.C
LHCMBRDMC0113	AA	none	A2	IM	ext. ref: 660RM21622 MEZZELUNE L. O.C
LHCMBRDMC0114	1st	none	A3	IM	ext. ref: 600RM21623 GRANO M16 L50
LHCMBRDMC0115	1st	none	A3	IM	ext. ref: 600RM21624 GRANO M12 L40
LHCMBRDMC0116	1st	none	A3	IM	ext. ref: 600RM21625 GRANO M12 L30
LHCMBRDMC0117	AA	none	A0	IM	ext. ref: 600RM20542 GENERAL ASSEMBLY



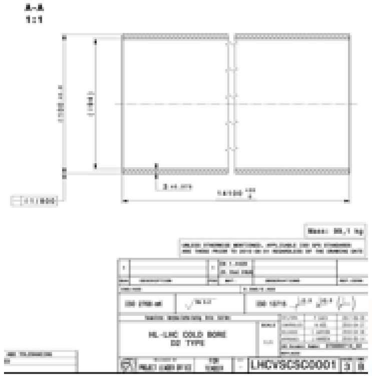
All the 117 manufacturing DWG's for components, coils, magnet are in CDD database

Cold bore tube tolerances

	Value	Unit	Tol. Min	Tol.max
Wall thickness	3		-0.375	0.375
ID	94			
OD	100		-0.8	0.8
straightness			1 /800	
AP maximum opening	105	mm		
AP local collar pole	105	mm		
Insulation thickness	0.3	mm		
cold tube support thickness	0	mm		
Coil aperture envelop deviation	0.3	mm		
Minimum clearance available to aperture (over radius) for BASELINE	1.5	mm	(* not considering in plane elongation of coil aperture)	
E	200	Gpa		
W	100	N/m	note: tube self weight 72N/m	
L range	4	m		
inertia	1076246	mm4		
delta max	1.5E-03	m		



$$\delta_{max} = \frac{5\omega l^4}{384EI}$$



D2 integration site