



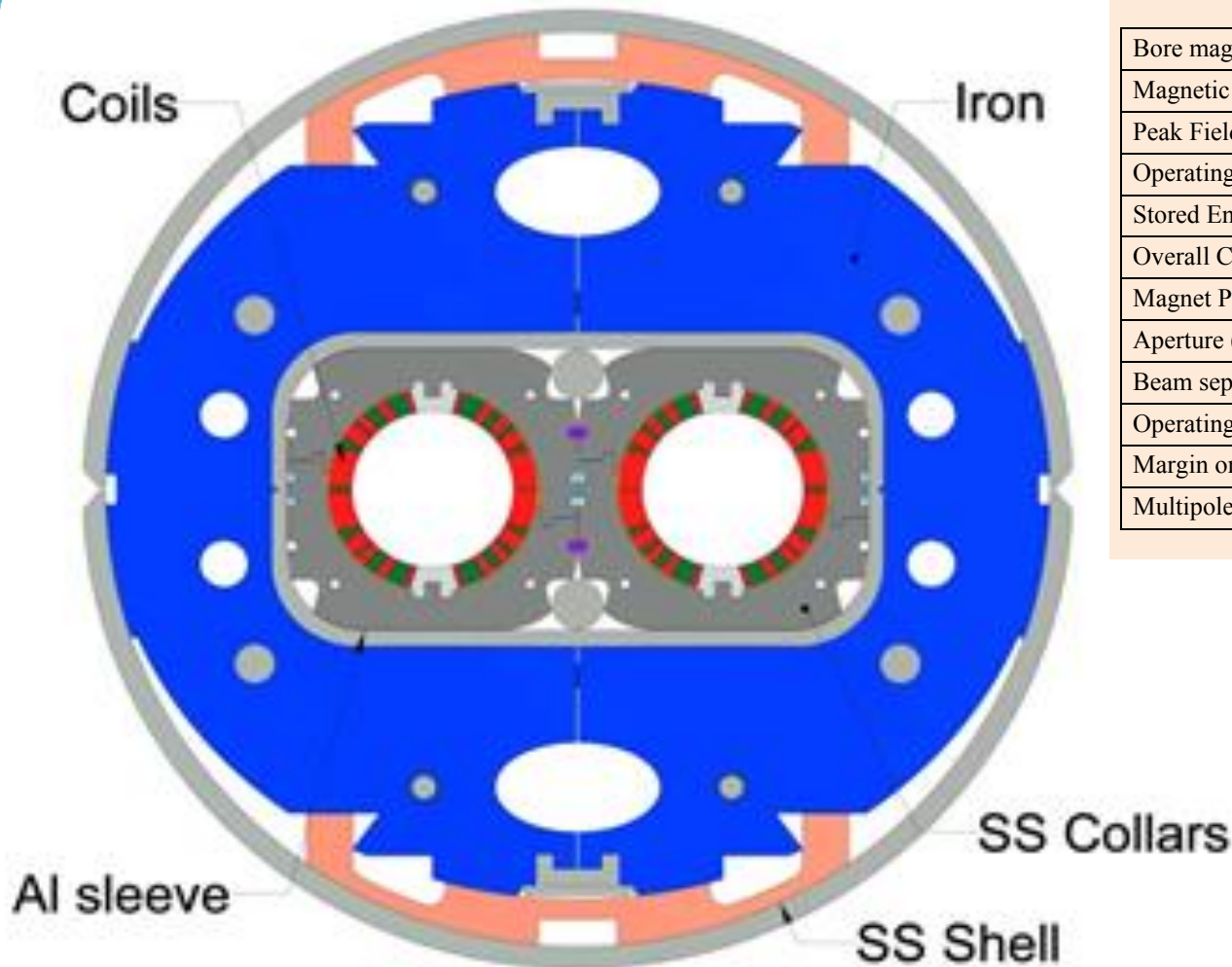
D2 (MBRD) Status Update

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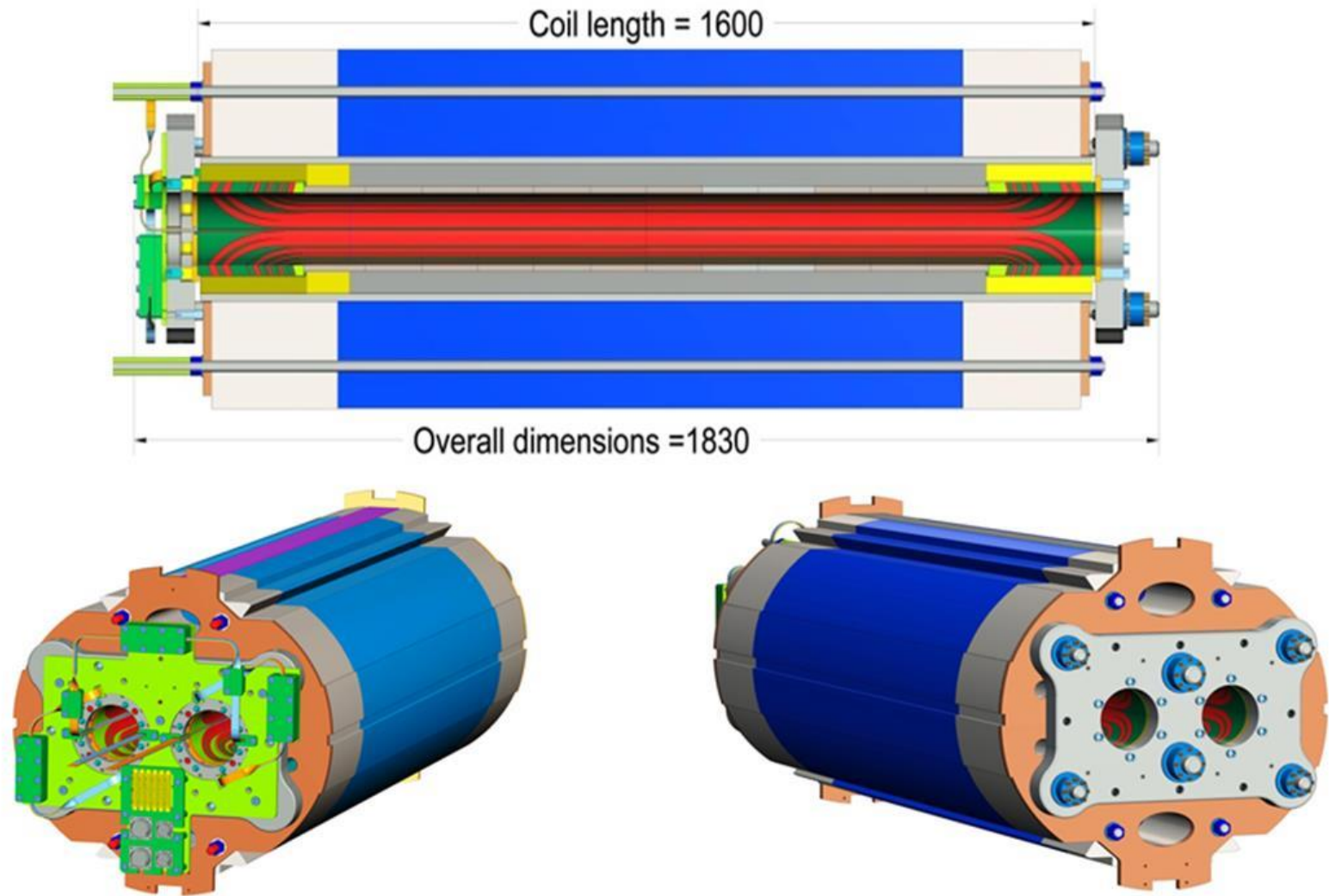
The D2 cross section



Main characteristics of the D2 dipole.

Bore magnetic Field (T)	4.50
Magnetic length (m)	7.78
Peak Field (T)	5.26
Operating current (kA)	12.34
Stored Energy (MJ)	2.28
Overall Current Density (A/mm^2)	443
Magnet Physical Length (m)	8.11
Aperture (mm)	105
Beam separation at cold (mm)	188
Operating temperature (K)	1.9
Margin on load line (%)	33
Multipoles variation due to iron saturation	<10 unit

The INFN/CERN design of the short model



The contract to ASG Superconductors for short model (1.6 m) construction

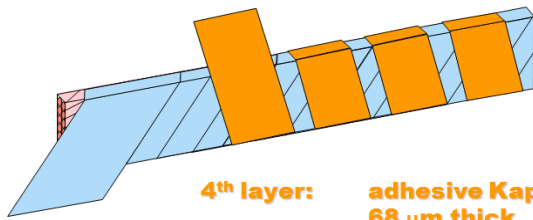
- **The contract:** The contract to ASG Superconductors was awarded on November 30th. The contract is of the type: *To be built under specification*, with frozen magnetic lay-out (coil and iron). The contractual delivery time was 15 months, leading the delivery of short model to Feb 28th 2018. Later on the delivery was moved to May 5th for including in the schedule the construction of coil mock-ups and at least one practice coil.

The need for constructing mock-ups and a practice coil (not included in the short model spec.)

After contract start we changed the insulation lay-out moving from the known scheme used by us in the SIS300 dipole to a new scheme.

- Why? Two rised issues : The 25 μm tape and the overlapping 2/3 are critical

1st 3 layers: Kapton HN
25 μm thick
11 mm wide
wound 2/3 overlapped

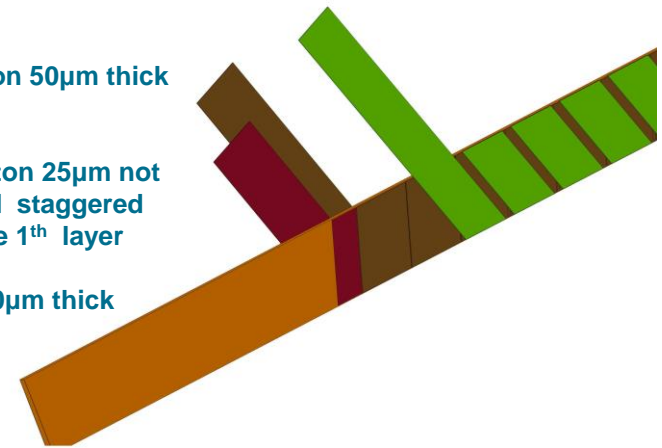


4th layer: adhesive Kapton HN
68 μm thick
9 mm wide
wound with 2 mm gap

1th layer: Kapton 50 μm thick
not overlapped

2nd layer: Kapton 25 μm not overlapped and staggered with respect the 1th layer

3rd layer: 68 50 μm thick with adhesive



From SIS300 scheme



To a new scheme for D2

In principle the expected insulation thickness after curing should be the same (about 100 μm) , but ...after many discussions it was agreed to proceed with two construction and tests of two mock-ups, practice coil and more extensive stack tests

Conductor stacks (12 cables)



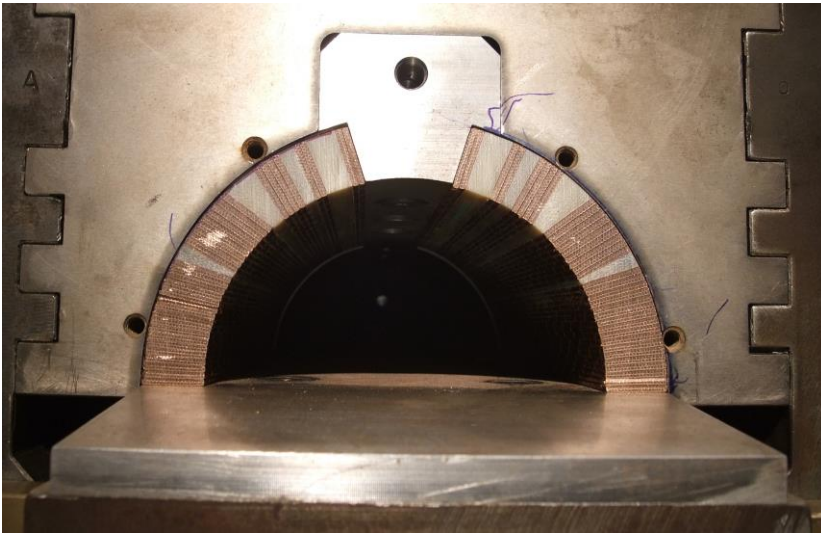
The stack test campaign is started

We are waiting for two information:

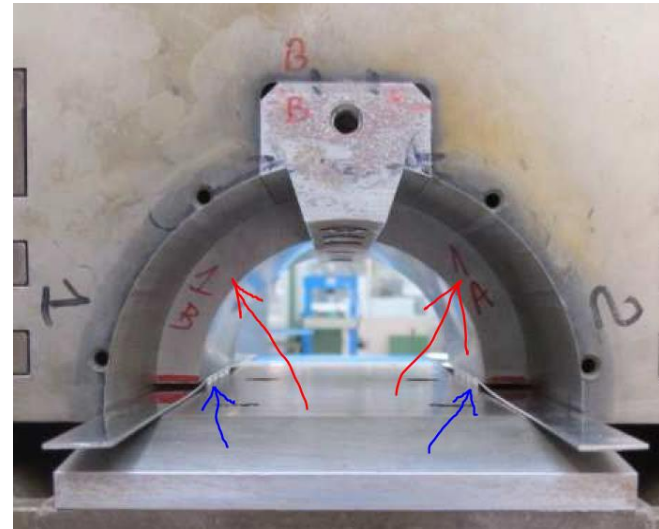
- 1) Dimensions of the conductor insulation after curing
- 2) Stress-strain curve (loading and unloading) of the conductor



Mock-up (Arc piled conductors+wedges)



Example- SIS300



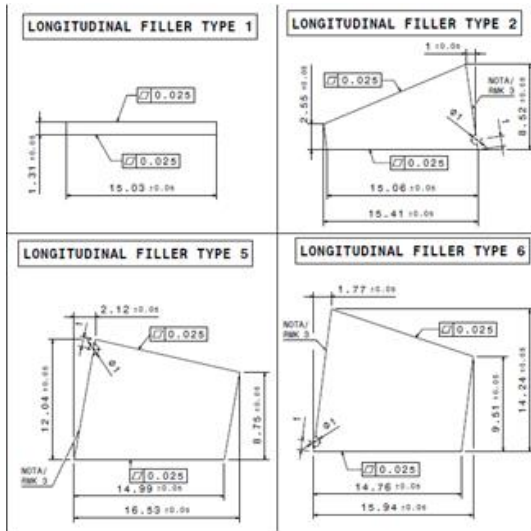
The tool is ready

- As soon as the wedges will be available the mock-ups will be constructed and tested proving the input for parameters of the coil curing

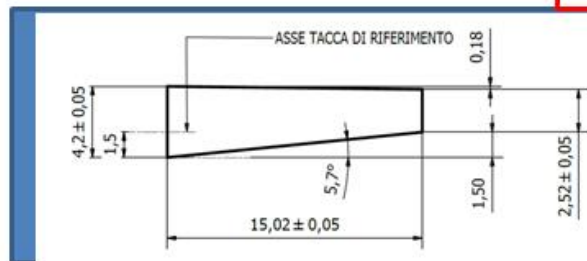
Longitudinal wedges: From G11 to Copper

- **Design modification:** After a remark by our collaboration that G11 (used in SIS300) can have, on long time, a degradation of mechanical properties, the risk to involve this material in D2 was considered too high and a decision to move to “classical” copper wedges (with poly-imide insulation) was taken (March 2017).
- **Issue:** The sub-supplier of ASG Superconductor provided wedges (done by machining) out of specification (tolerance on thickness) .
- **Solution found:** Involving a new sub-supplier using a different technique.
- **Consequences:** The schedule is moving forward of some months.

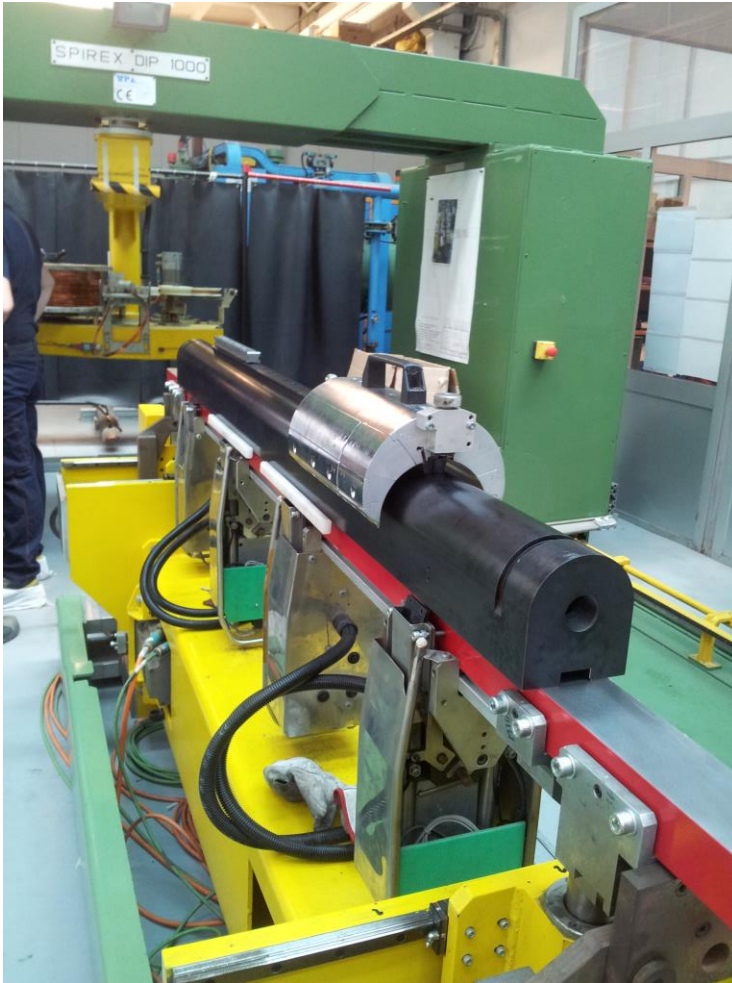
Copper wedges - 10 different types – After failure of first sub-supplier 4 companies with different techniques involved. Two were qualified



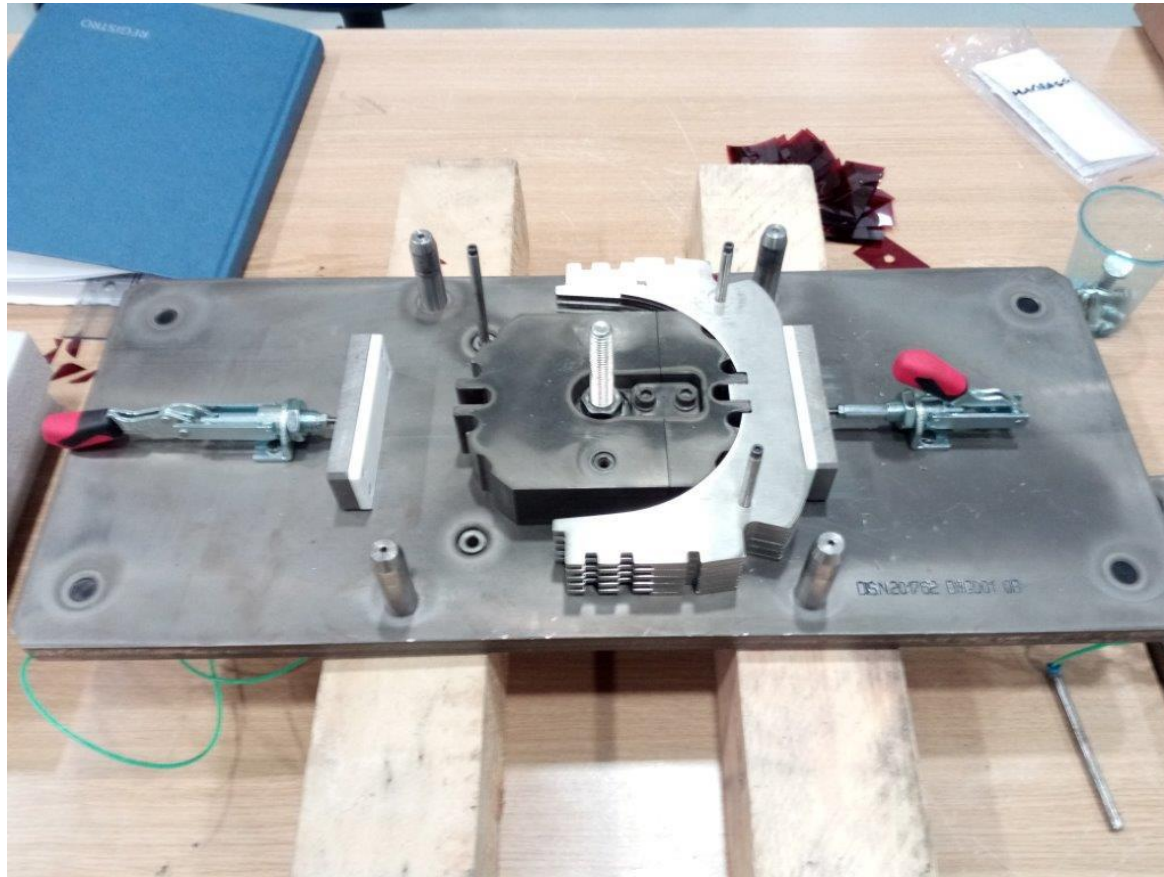
Technique	Firm involved	Tolerances (mm)	Delivery time (weeks)	Unit Length (m)
Machining	FIRM 1 (I – Genova)	± 0.05	?	0.500
Spark Erosion	FIRM 2 (I – Genova)	± 0.05	12	0.200
				0.400
Estrusion	FIRM 3 (CH)	± 0.1	16	1.2
Lamination	MEPLA (I – Udine)	± 0.05	6+3	>1.2



Winding test done using 3D printed wedges and end spacers



The collars for short model are done through laser cut + machining.
For prototype only fine blanking



Dimensional checks have given excellent results

Short Model Test at CERN

The test of the Short Model is under discussion since the «D2 Short model Cryogenic test interface meeting #01” held at CERN on June this year.

One important point is related to the type and number of sensors to be integrated into the short model. A complete list has been decided as well as the sharing CERN-ASG-INFN

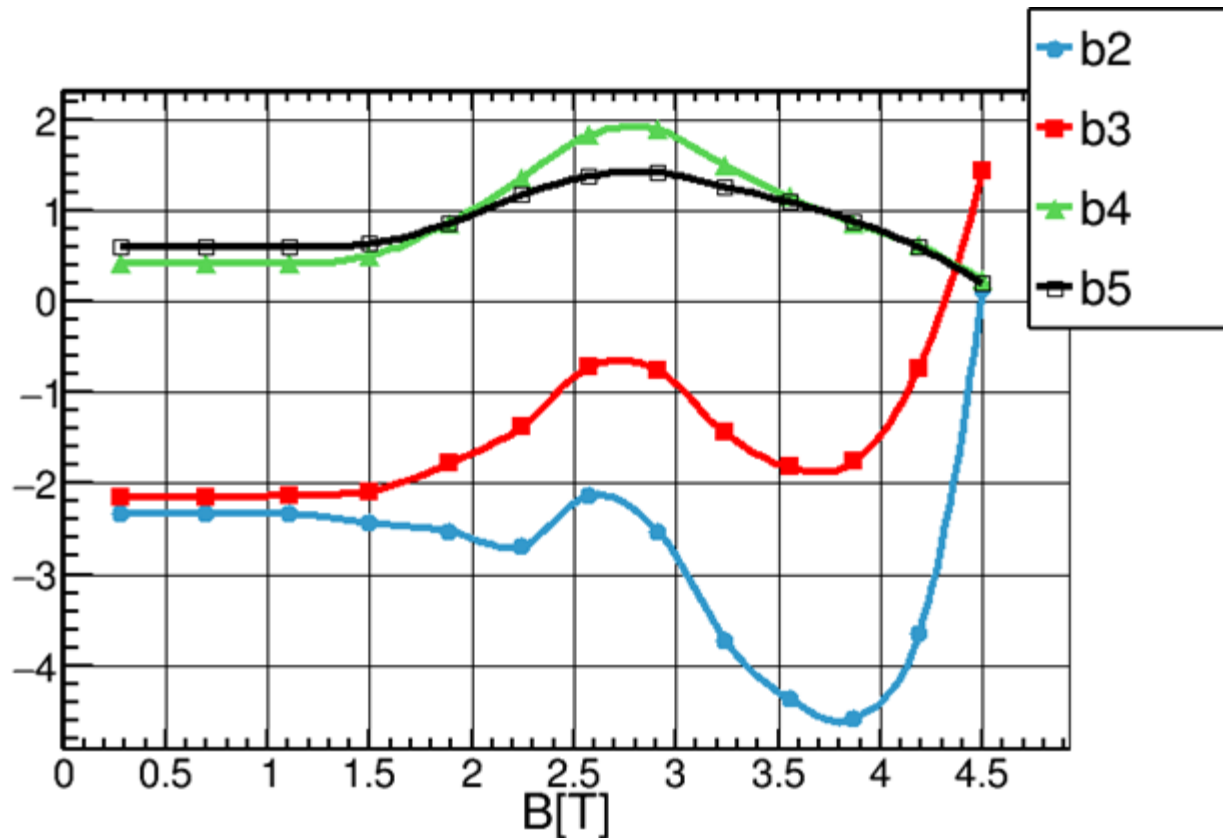
Instrumentation groups	Location	# sensors	# wires	Insert Connector	Pins used	wire type
Voltage taps	Lower Right Coil	8	8	A/RA8	8/8	HH 2619 - LH
	Upper Right Coil	8	8	A/RB8	8/8	HH 2619 - LH
	Lower Left Coil	8	8	A/RC8	8/8	HH 2619 - LH
	Upper Left Coil	8	8	A/RD8	8/8	HH 2619 - LH
Quench heaters	Lower Right Coil	2	4	A/RK8	8/8	HH 1819 - LH
	Upper Right Coil	2	4			HH 1819 - LH
	Lower Left Coil	2	4	A/RL8	8/8	HH 1819 - LH
	Upper Left Coil	2	4			HH 1819 - LH
Temperature sensors	Right aperture	2	8	B/RA40	16/40	HT 3007 H4 - LH
	Left aperture	2	8			HT 3007 H4 - LH
Strain sensors	Rings	9	36	B/RB40	36/40	?
	bullet gauges	32	96	B/RC40	36/40	
				B/RD40	36/40	
				B/RE40	24/40	
	Tie Rods	12	36	B/RF40	36/40	
	Collars	24	96	A/RD40	32/40	
				A/RE40	32/40	
A/RF40	32/40					
Fiber optics	Magnet structure	10	0	FOS 1--4		
Cryogenics	Cryostat and magnet			A/RA40		
				A/RB40		
				A/RC40		

From Short Model to Prototype

Activity	Planned
TDR and SPECS ready	October 31 2017
Request for tender to INFN	December 2017
Request for quotation	January 15 2018
Evaluation of offers	March 15 2018
Approval of tender	April 15 2018
Contract start	May 30 2018
Prototype delivery to CERN	October 2019 (agreed deadline CERN-INFN)

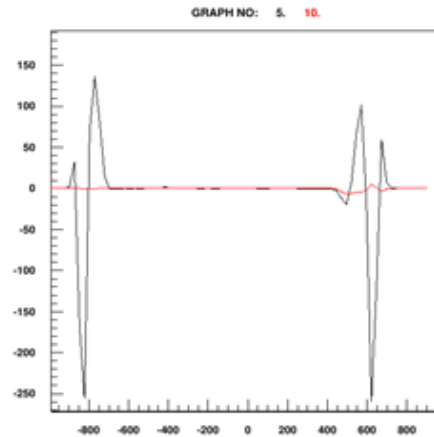
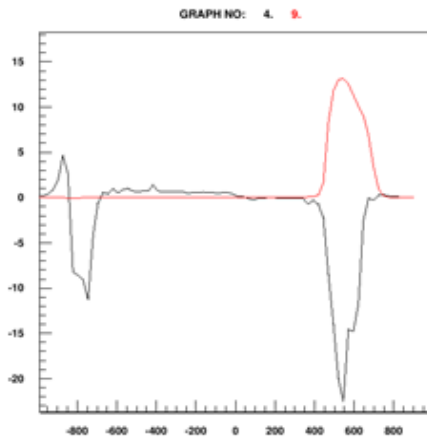
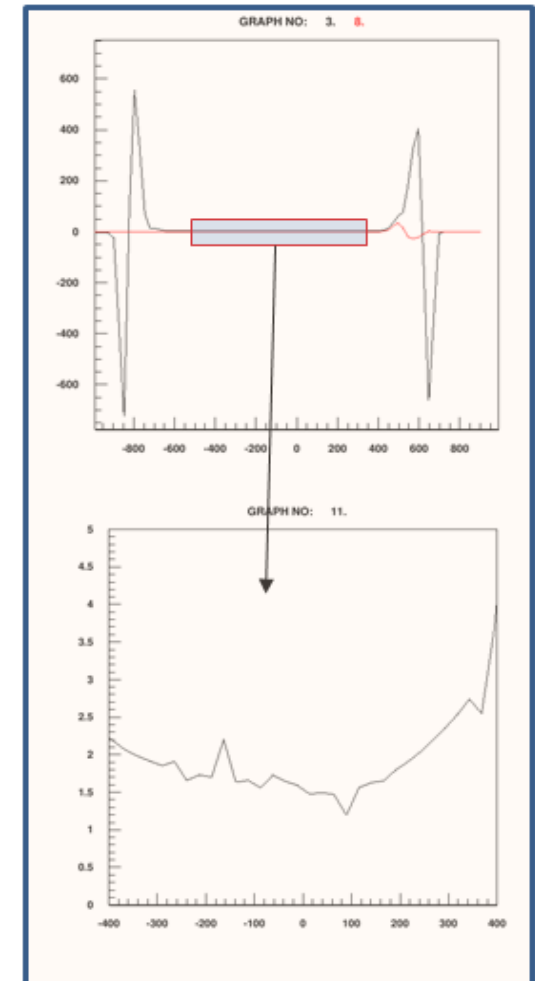
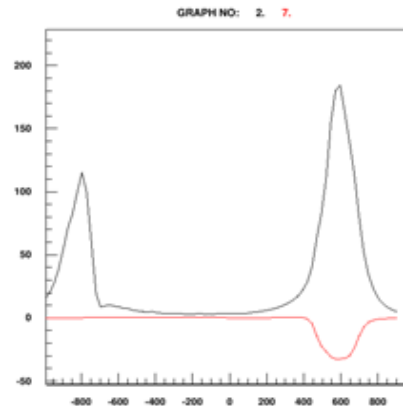
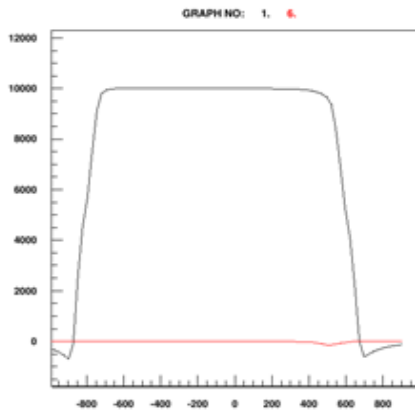
- The TDR is a document with full description of prototype including drawings and design analyses (magnetics, mechanics, quench, interface). It is close to be finalised.
- Since some information will be available after mock-up and practice coil construction we are finalising TDR and SPEC within November end, with a temporary cross section
- At the contract start we will provide the final information (see following slides)

Fine tuning: short model – 2D Field quality – Magnetic model



B	b2	b3	b4	b5
4.5	0.13	1.4	0.23	0.18

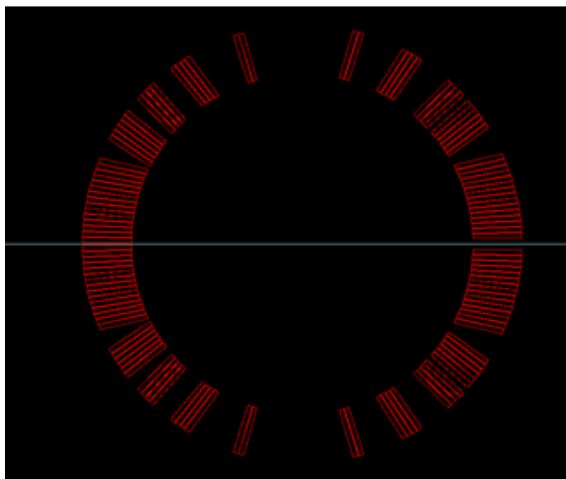
Short Model 3D Magnetic Field



We know that the 2D block lay-out shall be modified for accounting the coil end effects → Small modifications of the block angles

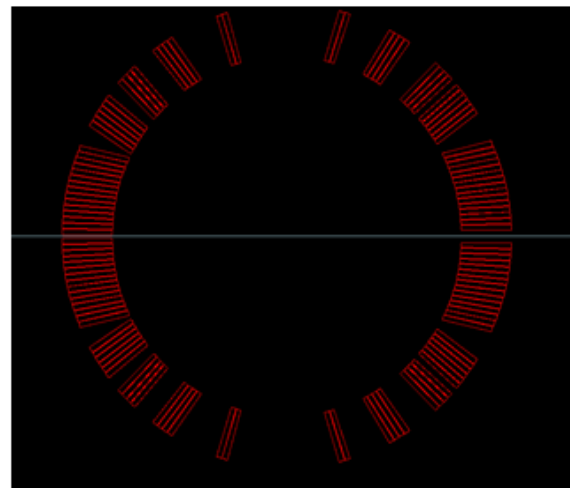
Design modifications from short model to prototype

Short model



no	type	nco	radius	phi	alpha
1	1	15	52.5	1.9564	0
2	1	6	52.5	30.7	36.227
3	1	4	52.5	42.886	41.6
4	1	4	52.5	57.502	54.629
5	1	2	52.5	74.239	71.053
6	1	15	52.5	0.47	0
7	1	6	52.5	27.055	33.537
8	1	4	52.5	40.292	45.218
9	1	4	52.5	54.002	50.549
10	1	2	52.5	71.457	72.573

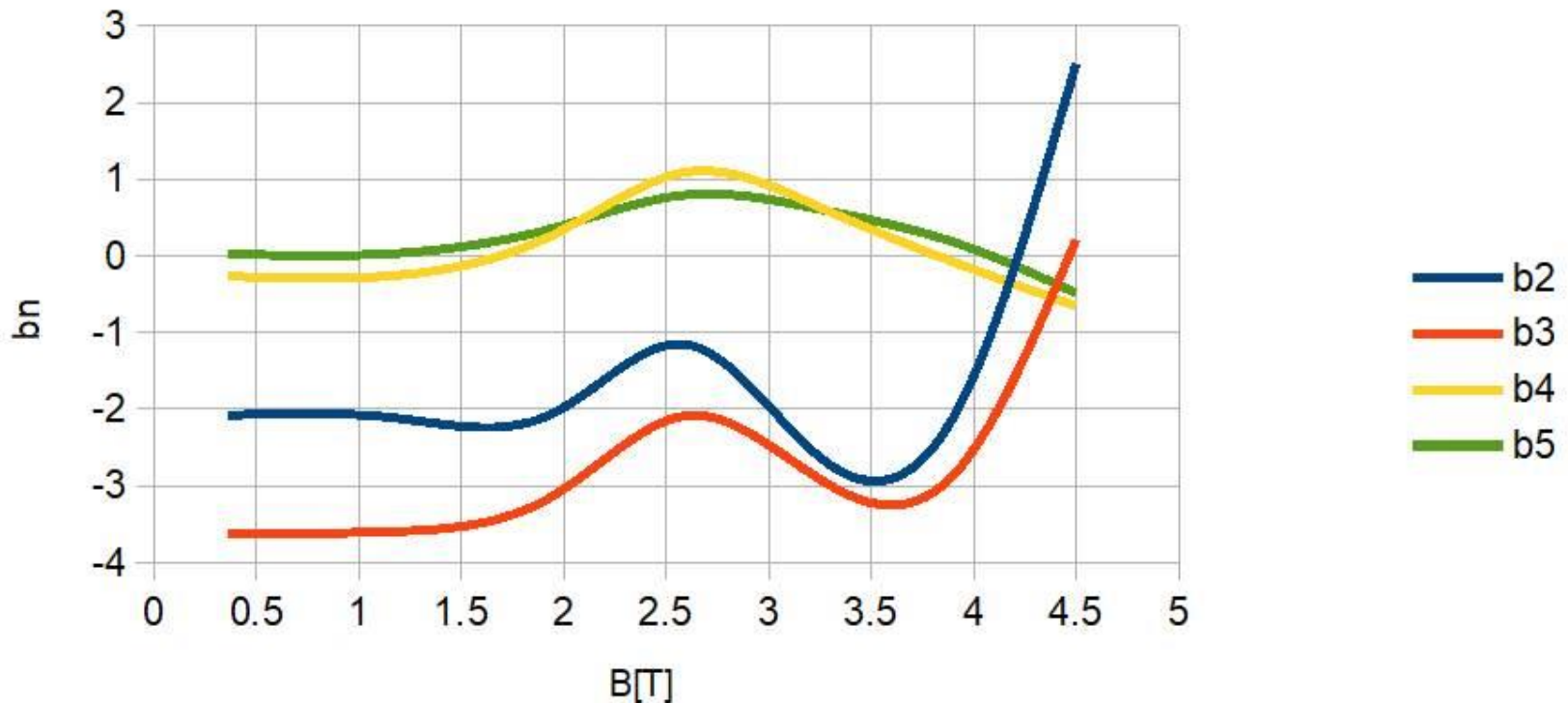
D2 updated design



no	type	nco	radius	phi	alpha
1	1	15	52.5	1.9777	0
2	1	6	52.5	30.815	35.787
3	1	4	52.5	42.903	41.589
4	1	4	52.5	57.589	54.566
5	1	2	52.5	74.125	72.013
6	1	15	52.5	0.45855	0
7	1	6	52.5	26.991	33.787
8	1	4	52.5	40.248	45.336
9	1	4	52.5	53.987	50.033
10	1	2	52.5	71.389	72.417

Prototype – Integrated field quality

Magnetic design considering coil end effects



- All fine! But ... the mechanical deformation modifies the cross section as well →

Short model cross section modifications due to mechanical effects

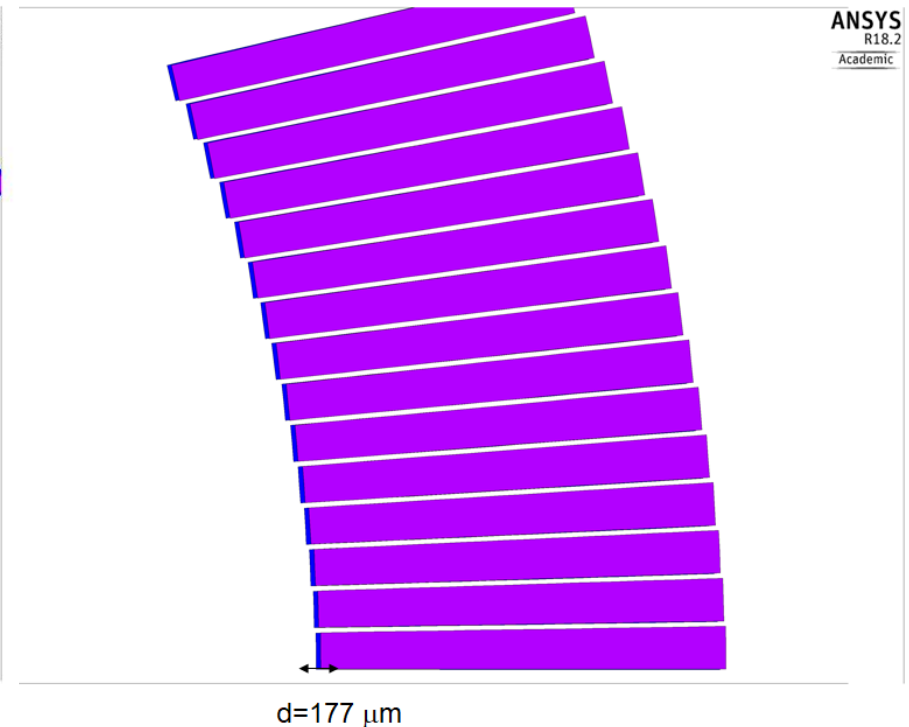
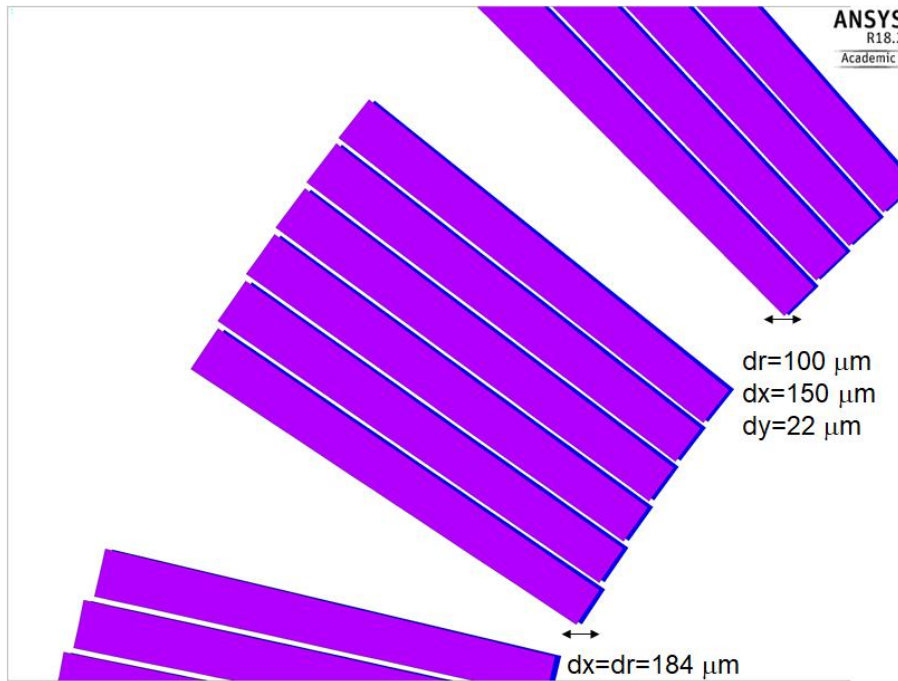
Roxie – magnetic model
ANSYS - mechanics

ANSYS
R18.2
Academic



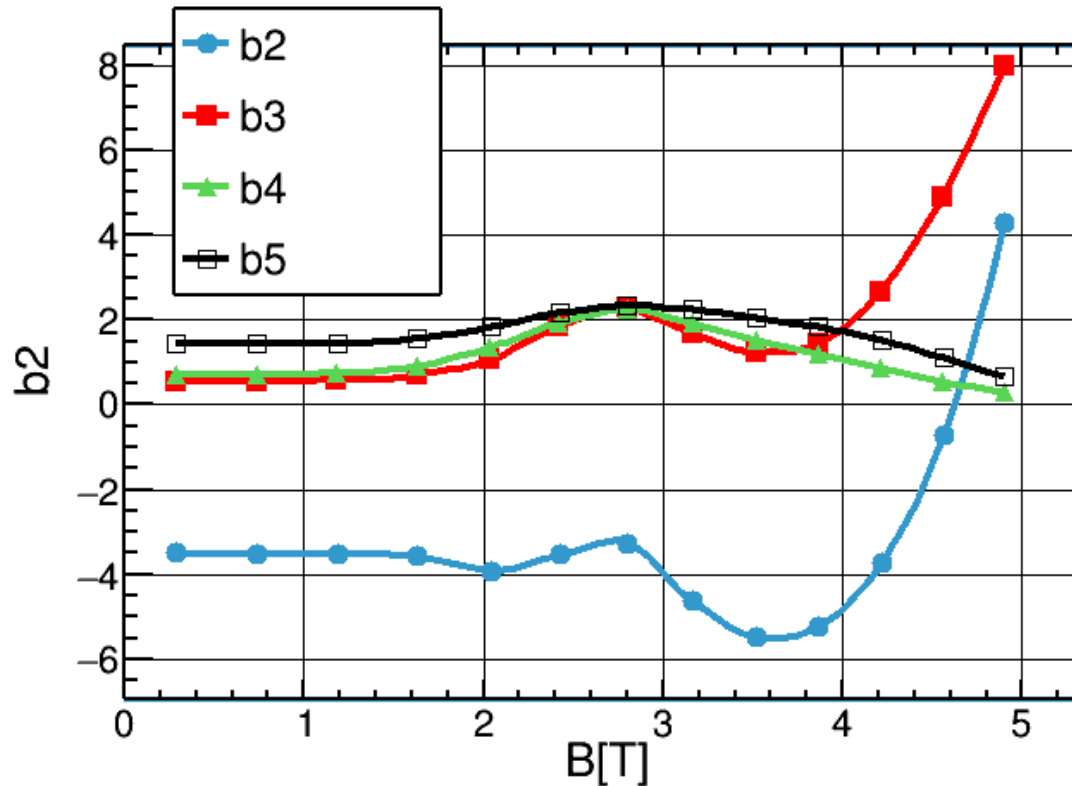
A more close view shows local modifications up to $\sim 200 \mu\text{m}$

A more close view shows local modifications up to $\sim 200 \mu\text{m}$



Roxie – magnetic model
ANSYS - mechanics

Short model – 2D Field quality (Roxie) – After mechanical deformation



We are able to modify the 2D cross section for accounting the modifications given by the mechanical deformation. Final decision after more progresses of the short model construction (better knowledge of the coil mechanical properties)

Activities for finalising the contract for the prototype construction

- 1) Technically, we wait for stacking tests and freeze the prototype cross section for TDR and SPEC not including the modifications required for accounting the computed mechanical deformations.
- 2) We need to finalise two further documents:
 - 1) Contract Terms and Conditions (including deposit, guarantee, warranty, penalties, ..);
 - 2) The criteria used for evaluating the offers.
- 3) Together TDR and SPEC, the above documents must be approved by INFN Council and no more amendable
- 4) We will launch the tender phase on January 2018 with the aim to have a formal start of the contract on June 2018.
- 5) We can provide the final cross section at the latest in July 2018 or after the two apertures have been at least integrated into the Al-sleeves



Istituto Nazionale di Fisica Nucleare

ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Genova

INFN/17-XX/GE
Novembre 2017

**TECHNICAL DESIGN REPORT OF THE D2 SUPERCONDUCTING PROTOTYPE
DIPOLE (MBRDP1) FOR THE LUMINOSITY UPGRADE OF LHC AT CERN**

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²*CERN*

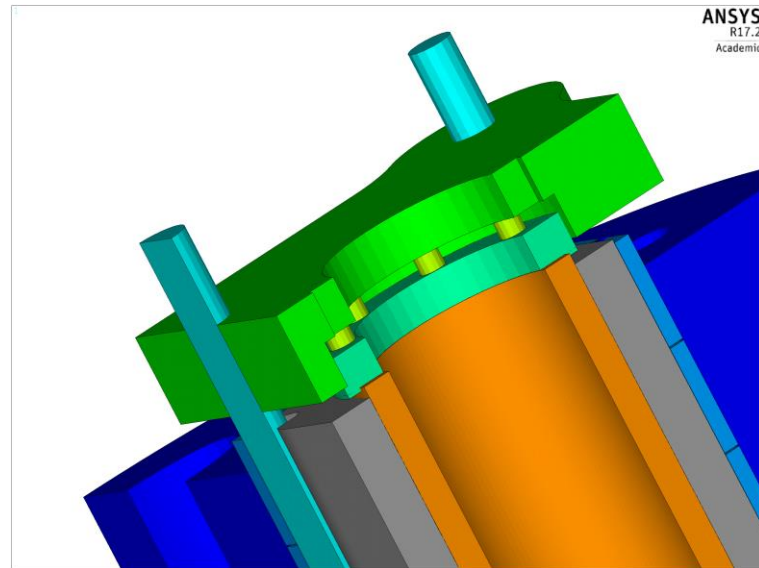
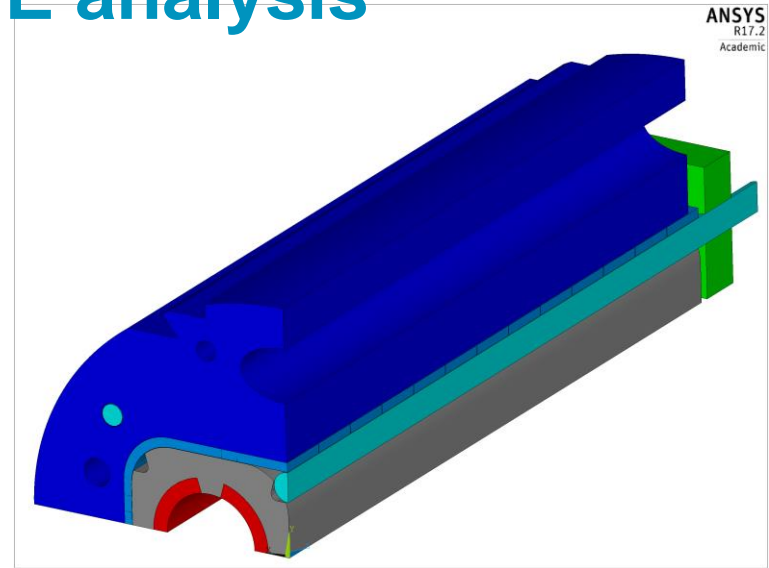
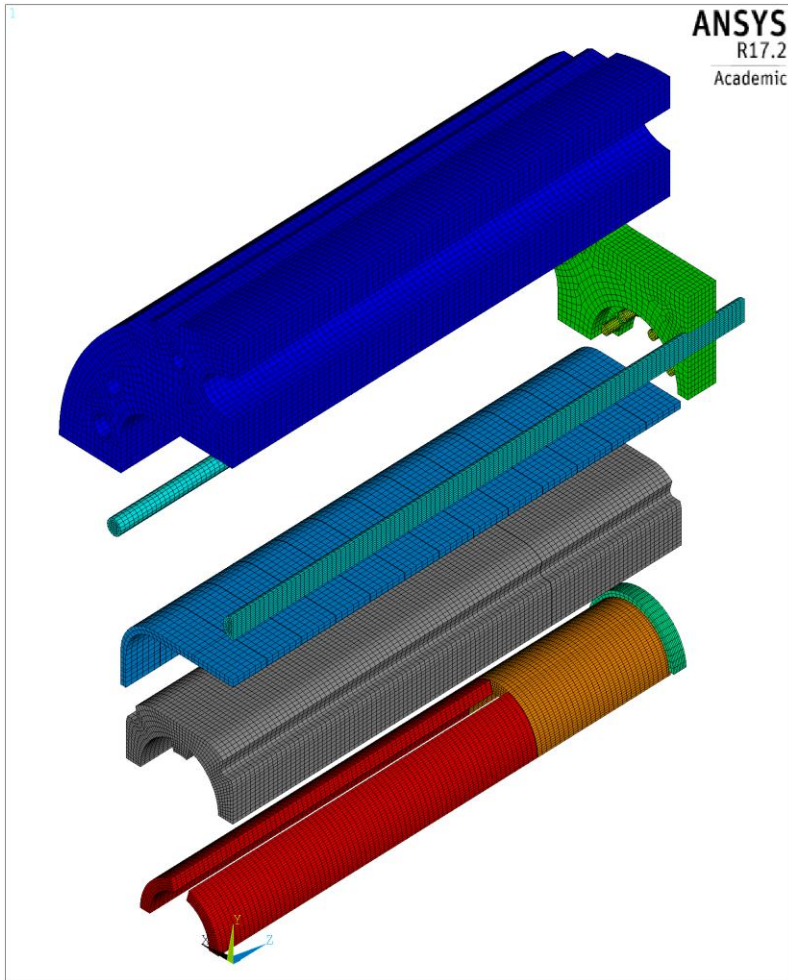
TDR

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Models for FE analysis



Technical Specification

for the Supply of a Prototype of the Superconducting D2Dipole (MBRDP1)
for the High Luminosity Upgrade of LHC (HL-LHC)
 (Author: P.Fabbricatore)

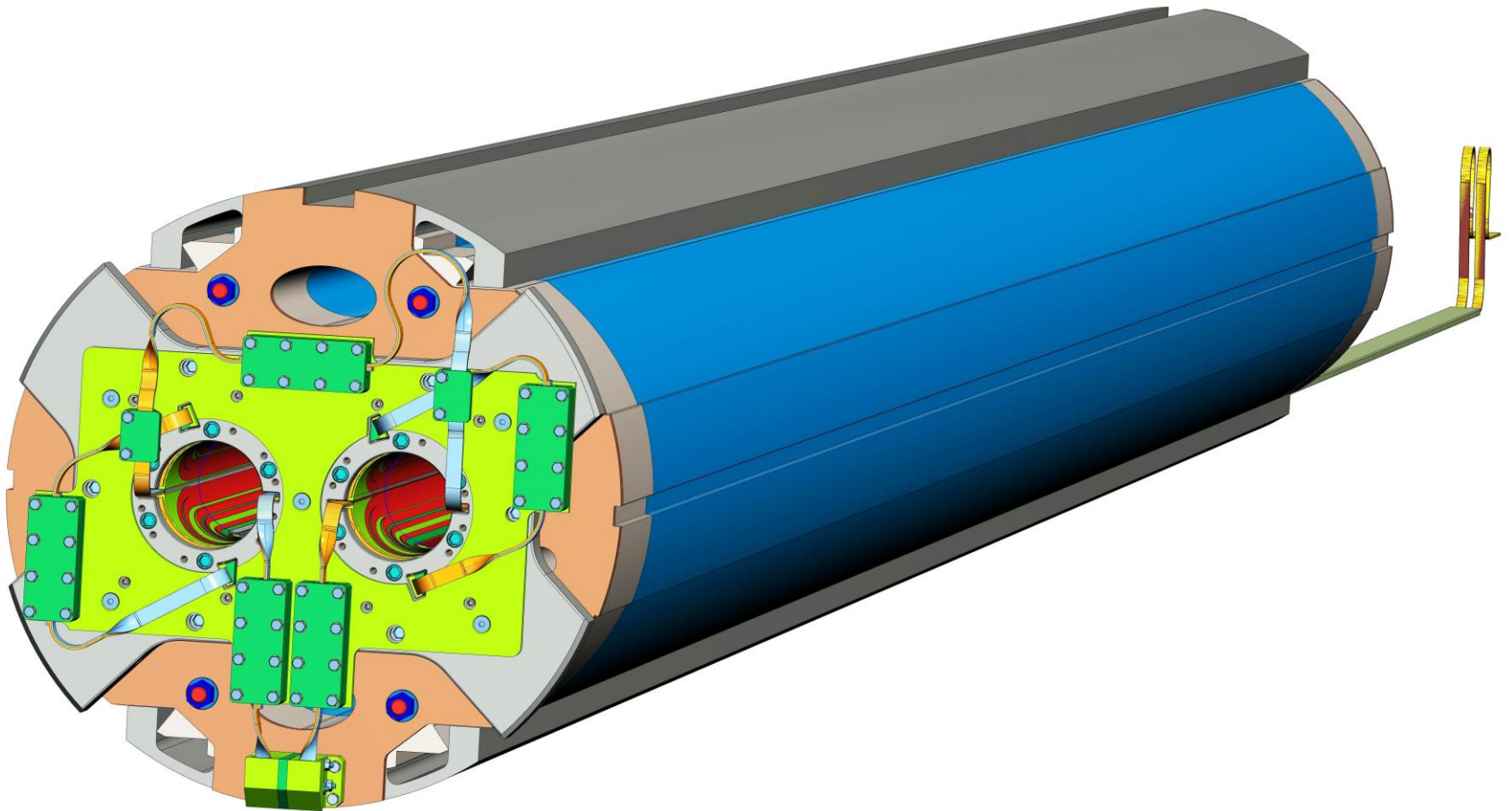
Summary

This technical specification concerns the manufacture of a prototype of the recombination dipole MBRD D2 for the High Luminosity upgrade of the LHC (HL-LHC). It includes all information for allowing selected firms to provide a technical and economical offer.

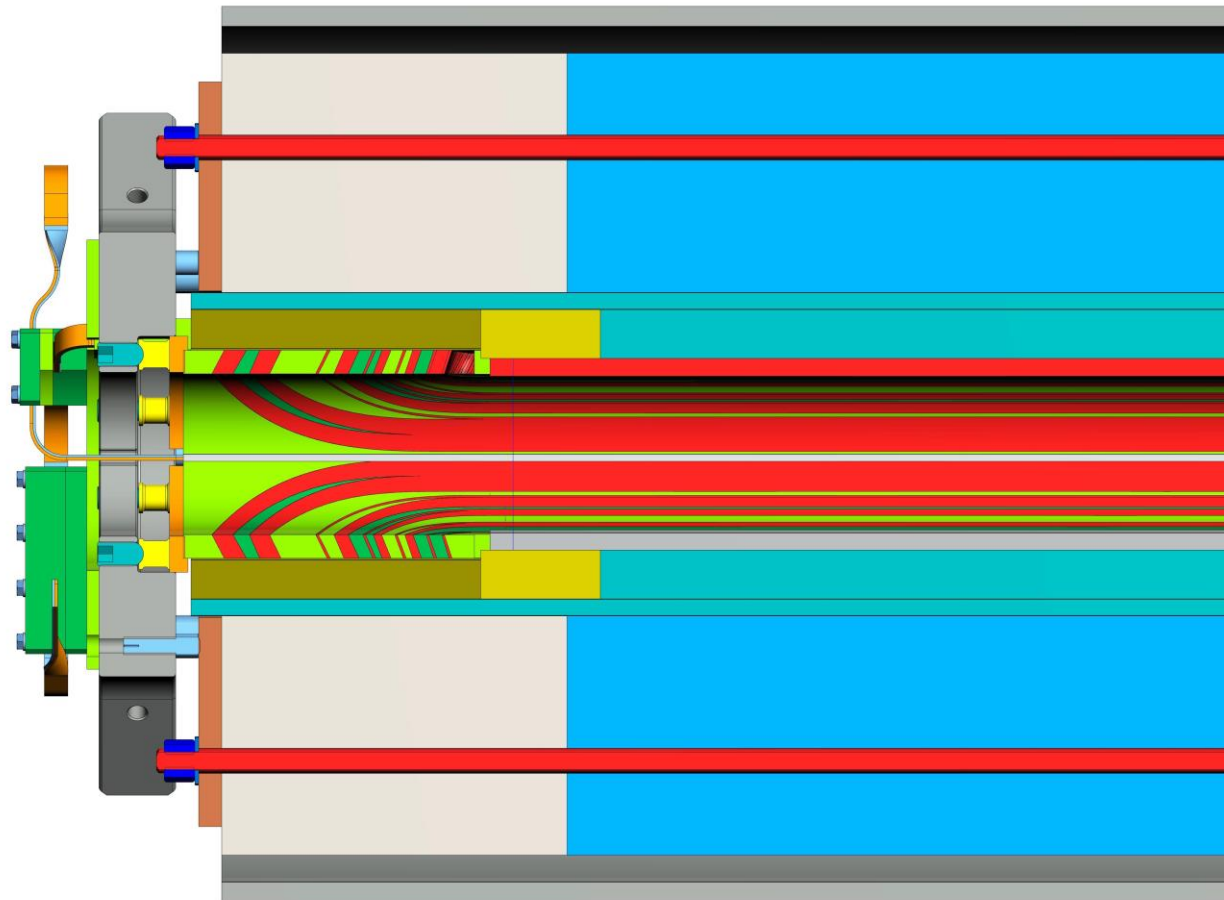
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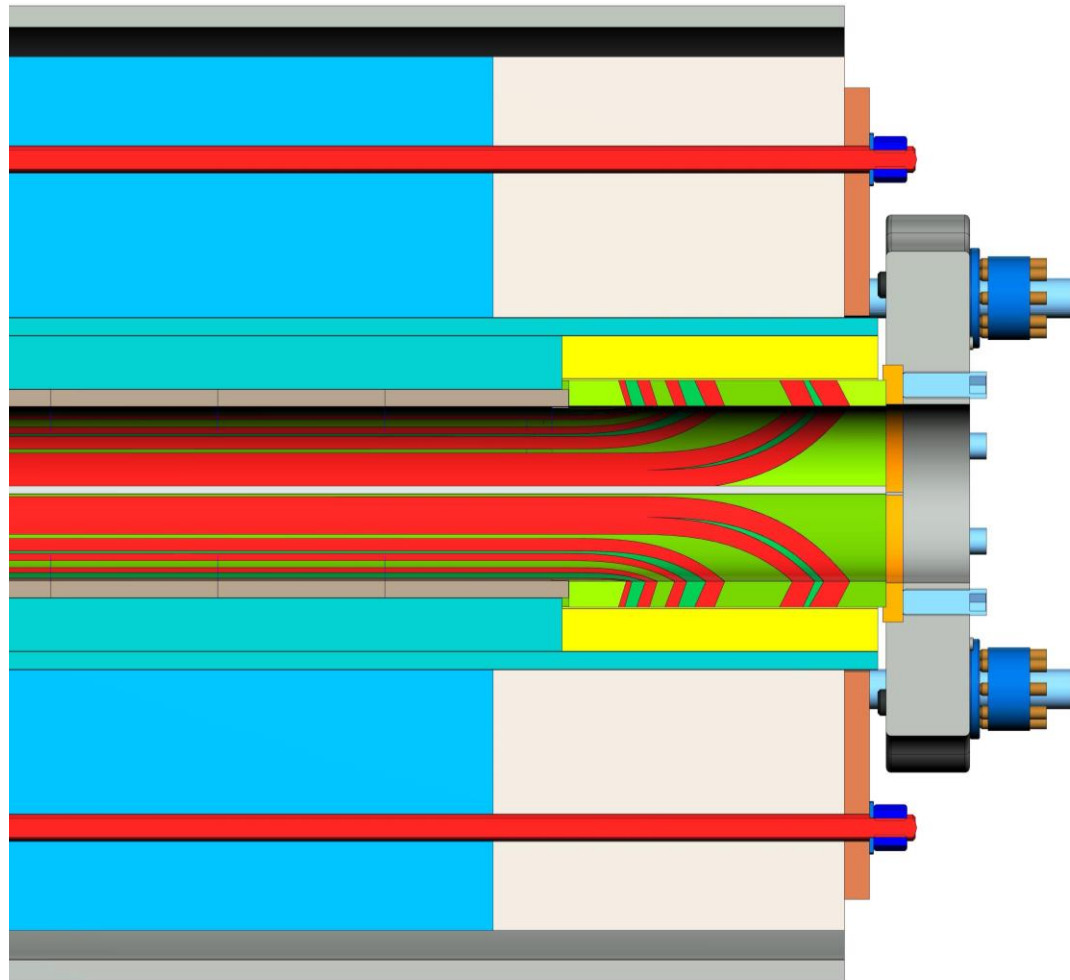
The D2 prototype (MBRDP1)



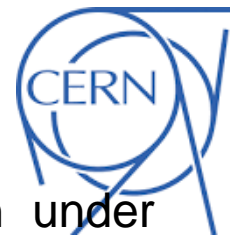
MBRDP1: Detail of the end magnet (connection side)



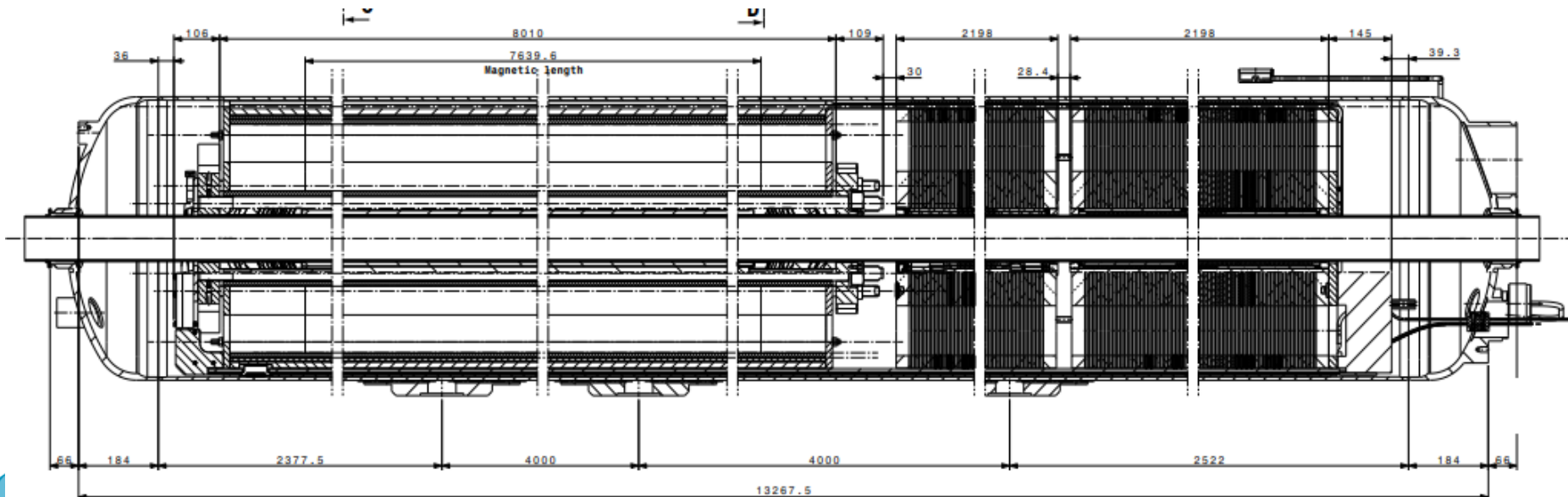
MBRDP1: Detail of the end magnet (opposite connection side)



Short model and LMBRD integration

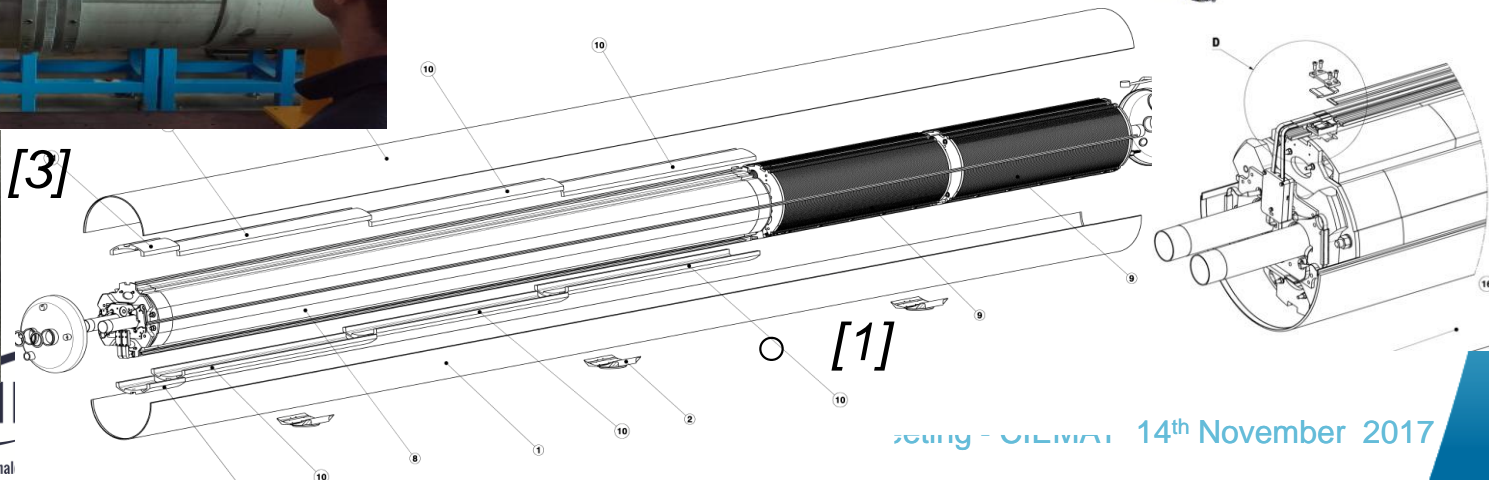
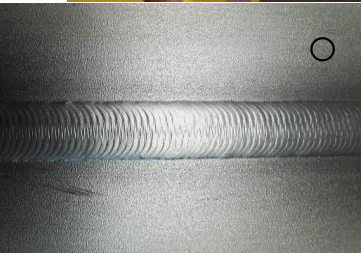
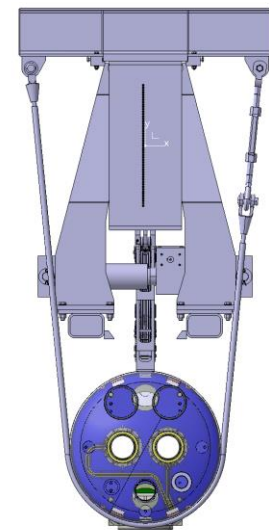
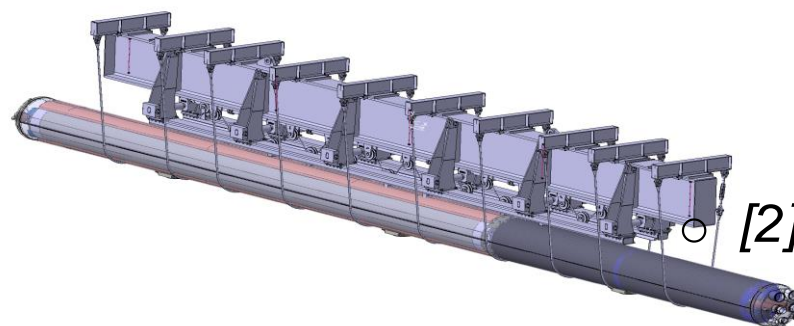


- Short model cold test design in SM18 and instrumentation plan under finalization
- Design assembly drawings of LMBRD cold mass (CM) including MCBRD CCT correctors is complete.
 - *Start procurement of cold mass parts (long shells, end covers) and qualification bus tests from 2018*
 - *Pending interfaces design of in-cryostat cryogenics piping, new heat exchanger.*
 - *Next CM assembly sequence drawings, associated press tooling under study*
 - *Large LMBRD handling tooling under procurement*
- On going design of cold mass welded parts, prototyping tests, inspection plan per EN13445 following PED Directive 2014/68/EU requirements



LMBRD Assembly tooling

- Cold mass assembly sequence drawings under CAD work (MSC-LMF) [1]
- Welding press equipment tooling for OD630 mm under study (common to MQX-F)
- Large LMBRD 30 t handling tooling under procurement (common to MQX-F) by Dec 2017. [2]
- Alternative orbital TIG welding back-up solution to the long 14 m shell recently tested. [3]



[3]

[1]

Conclusions

- The Short Model (MBRDS1) is under construction at ASG Superconductors. The delivery to CERN (May 2018) can shift due to some issues with copper wedges procurement.
- The set-up for test at CERN has been agreed (including instrumentation)
- The documentation for launching tender for prototype (MBRDP1) in January 2018 is under preparation and close to be finalised. Some drawings will be preliminary (final drawings at the contract start)
- The integration of D2 was studied in detail



Thank you for your attention