



ESAC Review February 2013

CEA Saclay

Fresca2 Dipole
Reaction, Instrumentation, Impregnation
RMC project status

J.C Perez
on behalf of Fresca2 collaboration team

3rd ESAC Review, 27th February to 1st March 2013, CEA Saclay





Outline

Fresca2

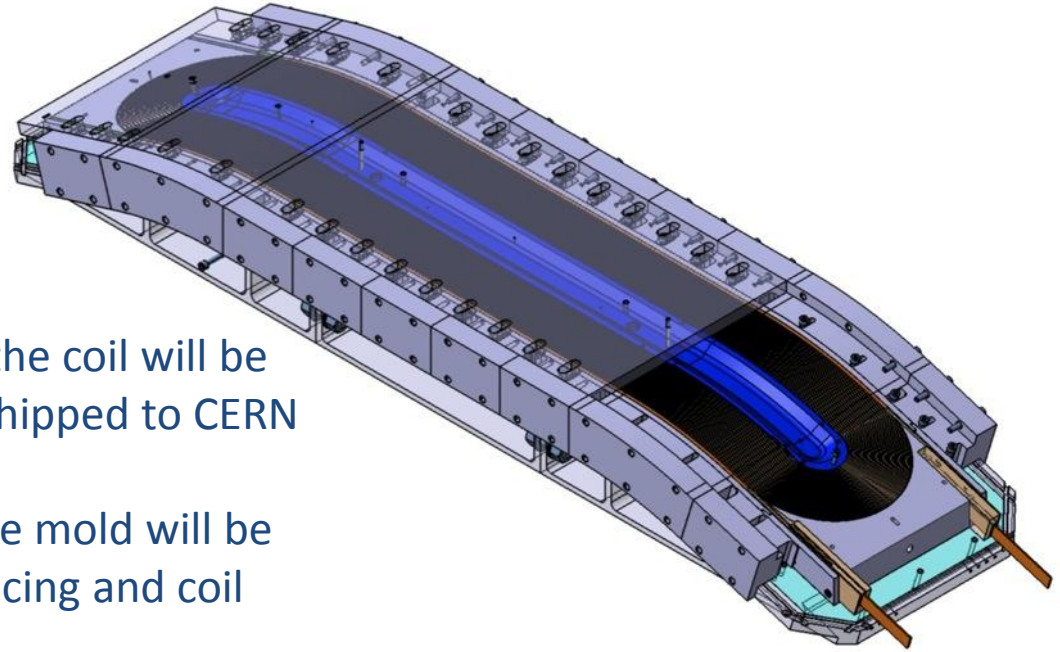
- Heat treatment mold and reaction furnace
- Splicing and instrumentation
- Impregnation mold and impregnation system
- Coil assembly procedure and tooling
- Coils interconnection
- Conclusions

RMC

- RMC project overview
- Conclusions



Fresca2 heat treatment mold



- After winding operation @ CEA the coil will be closed in its reaction mold and shipped to CERN for heat treatment.
- After reaction, the top part of the mold will be opened to allow Nb₃Sn/NbTi splicing and coil instrumentation.
- The instrumented coil will be moved to its impregnation mold*.

*Reaction and impregnation molds have been design to have inter-exchangeable parts.

Heat treatment furnace

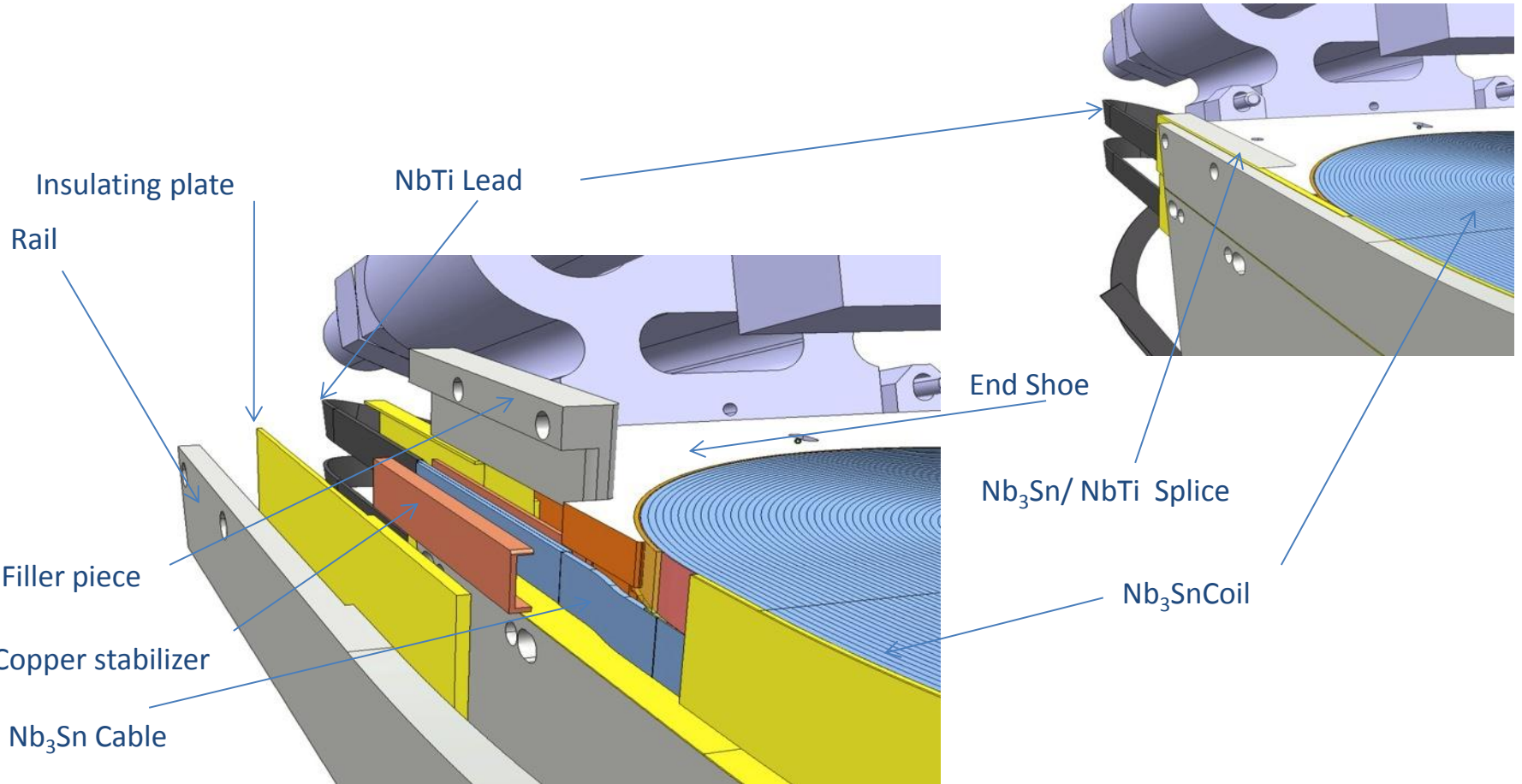


- The heat treatment furnace ordered to GERO has been fully commissioned at CERN
- Several runs have been performed using Cu coils to precisely tune the temperature over-shoot and the time of the plateau
- The first layer 3-4 copper coil will be used to setup the oven parameters to treat RRP as well as PIT conductor



Fresca2 splices

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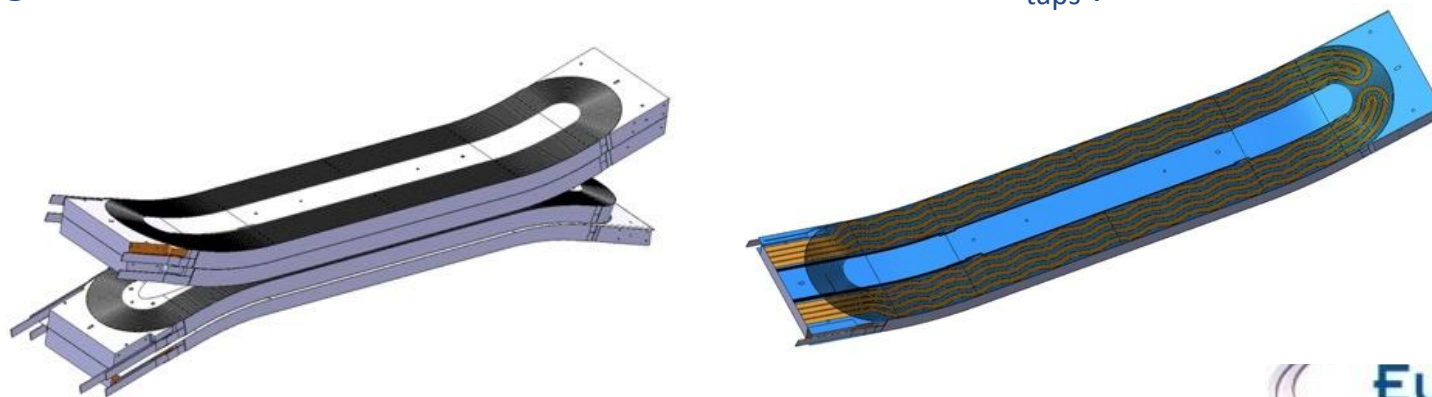
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Fresca2 instrumentation

- Each double pancake will be equipped with 2 traces
- Dedicated traces have been designed and are being produced at CERN (first pair to be installed on the copper coil in March 2013)
 - 50 μm thick Kapton[®] sheets
 - Heater strip 25 μm thick
 - Wiggling geometry: 12 mm width X 3.1 m long (370 cm^2)
 - $R \approx 5.2 \Omega$, $I \approx 60 \text{ A}$, $V \approx 310 \text{ V} \rightarrow$ Power deposition 50 W/cm^2 (125 W/mm^3)
 - Capacitor of 10 mF, discharge 480 J with $\tau = 52 \text{ ms} \rightarrow$ 60 K in 1 ms (adiabatic approximation)
- Each coil layer will be protected by 2 independent quench-heater circuits
- Voltages across the coil will be monitored thanks to 10 V_{taps} per side



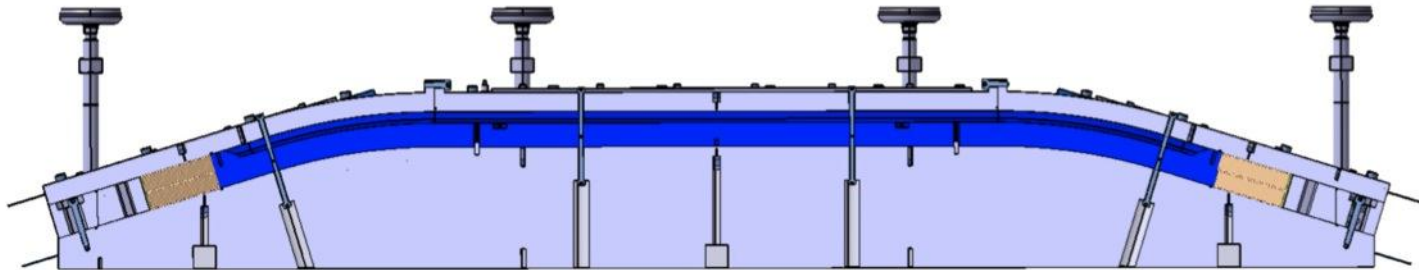
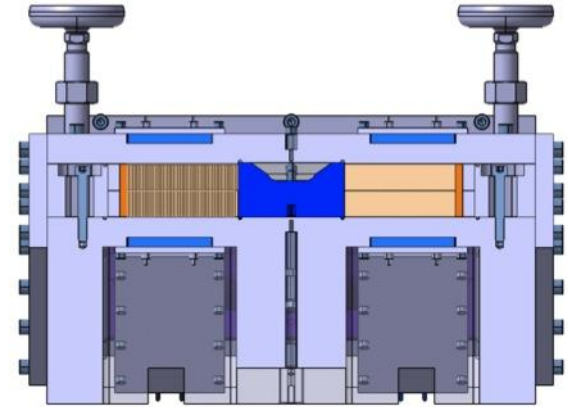
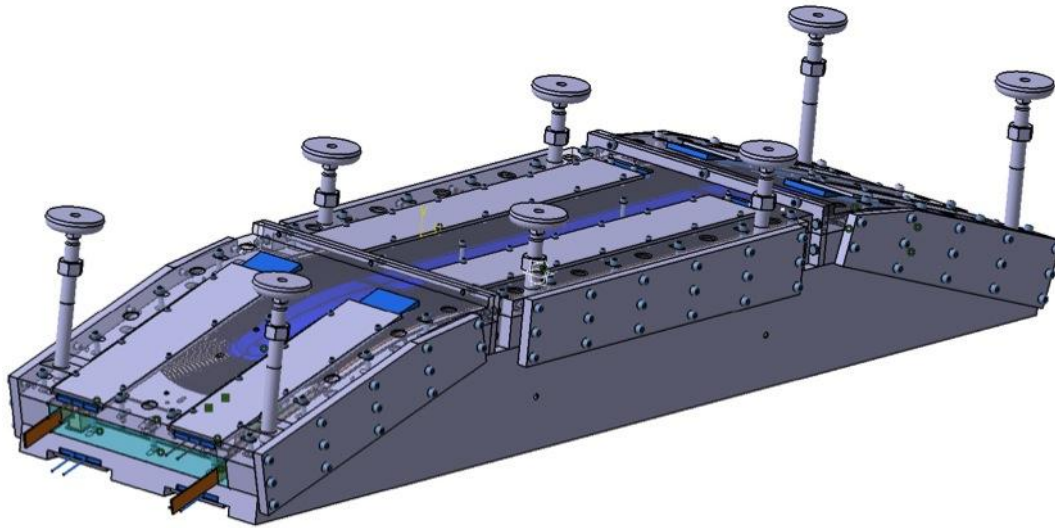
Impregnation system

- The acceptance tests for the new vacuum impregnation tank has been held in Spain in January 2013
- The system is being installed in 927 laboratory and the commissioning @ CERN will start on second week of March 2013





Impregnation mold



Lorenz Carlier, Damien TE-MSC

The order to fabricate the mold for layer 3-4, has been placed.
Delivery scheduled for April 2013.

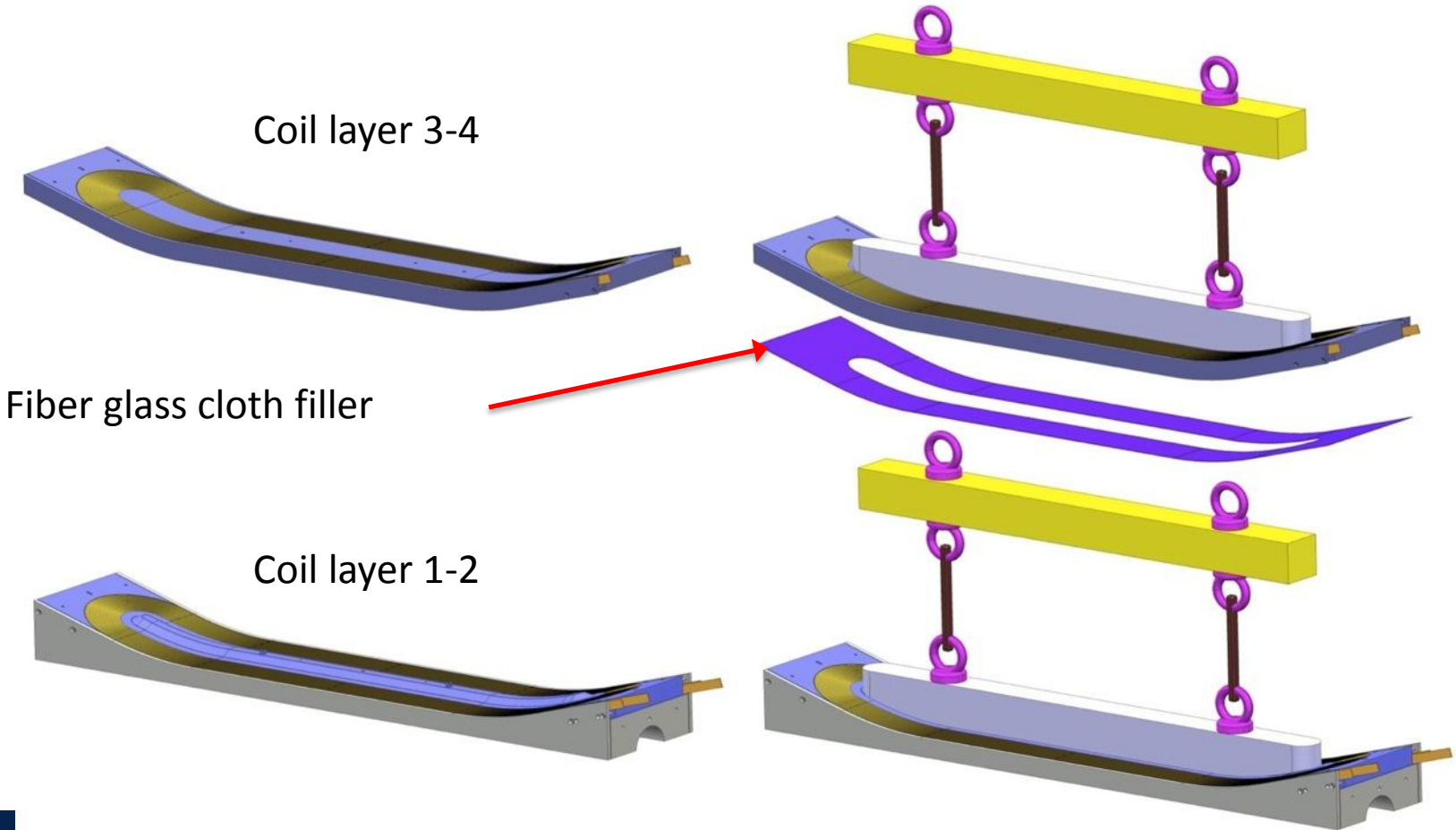
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Coils Assembly procedure

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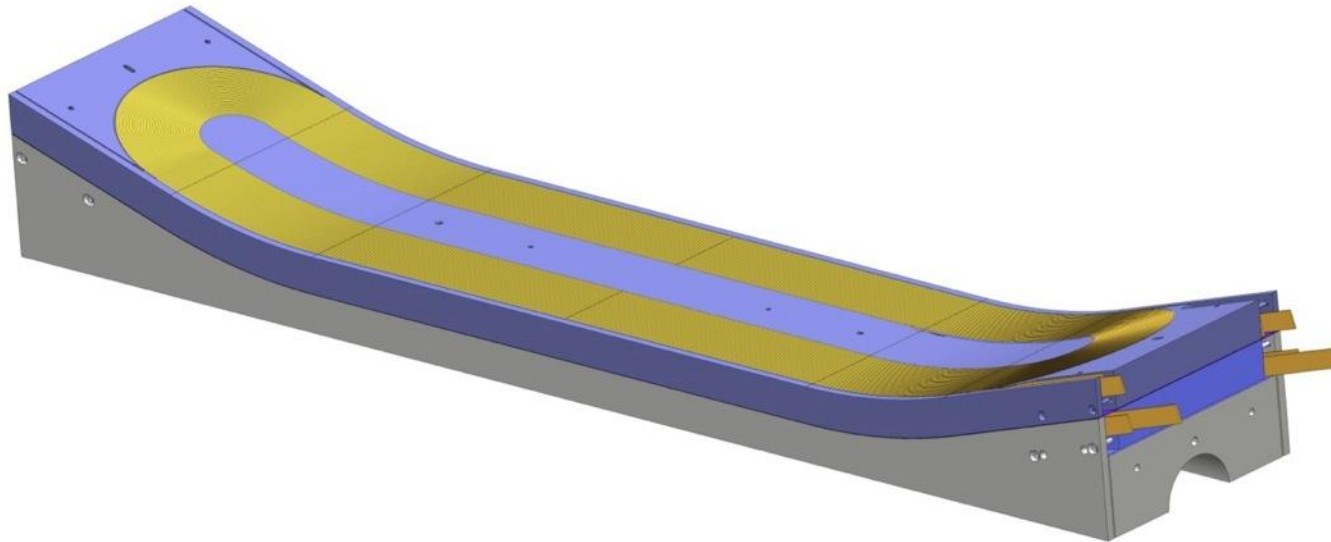
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Gap impregnation (1/2)

- 2 facing surfaces of the coils will be mold released
- Gap between coils will be filled with 0.9 mm fiber glass cloth
- Impregnation of the fiber glass using the coils as cavity
- This will guarantee a perfect contact between the 2 coils
- This technique will allow to separate the coils in case of failure of one coil



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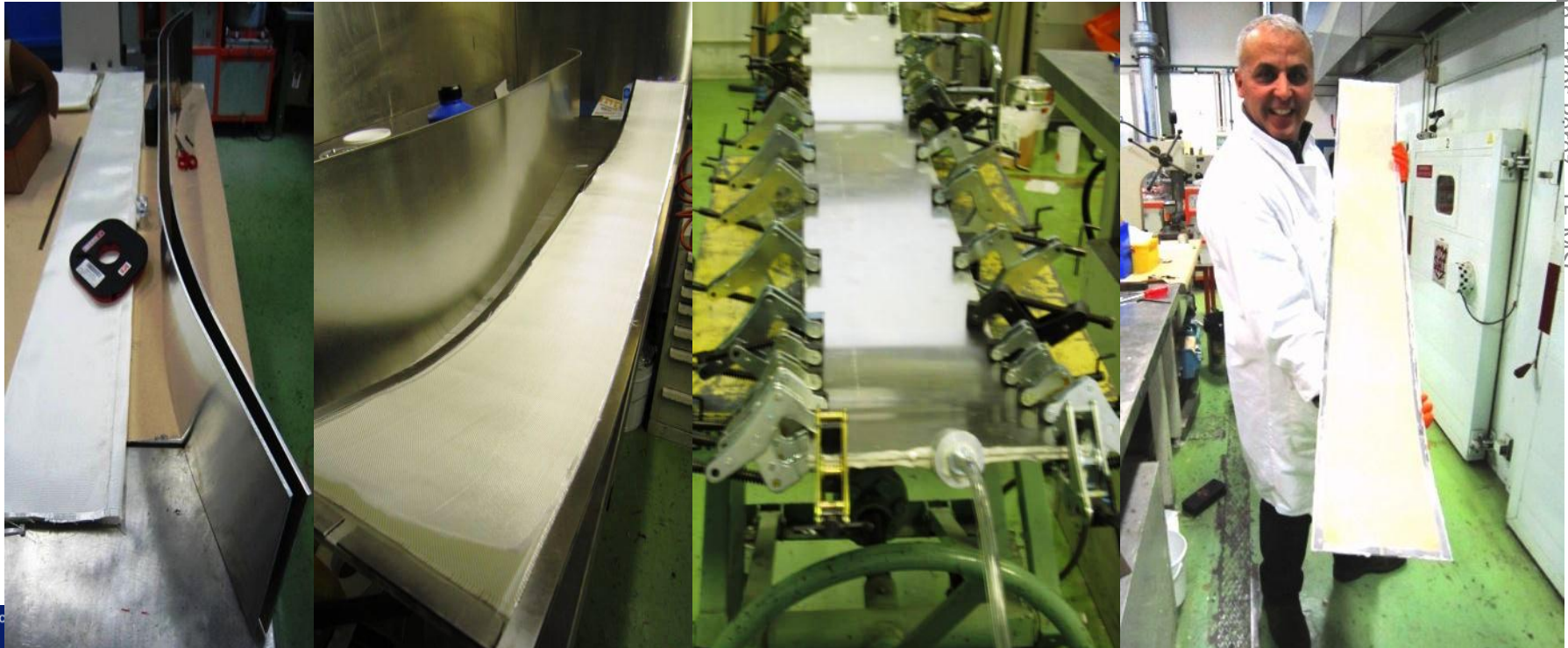
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Gap impregnation (2/2)

- Impregnation tests using a fake mold with 1 mm gap have been performed (as recommended by the committee during the last review)
- Gap between plates filled with 3 sheets 0.25 mm thick fiber glass cloth
- Impregnation of the fiber glass using MY 750 & Jeffamine D400
- Tests performed at CERN polymer laboratory confirm the feasibility



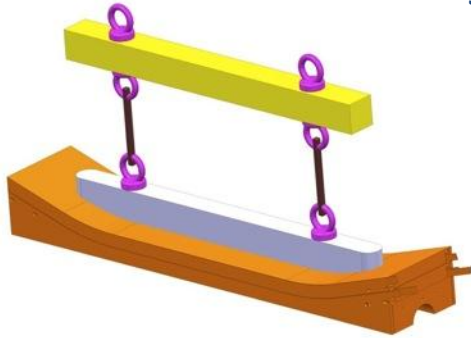
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Juan Carlos Davila TE MSC

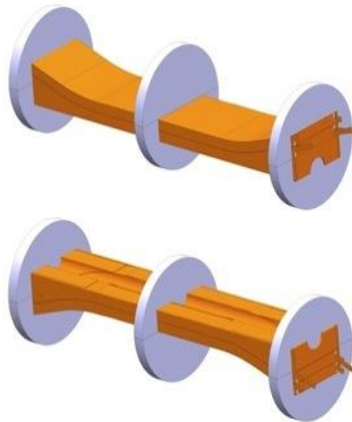


Coil pack assembly steps

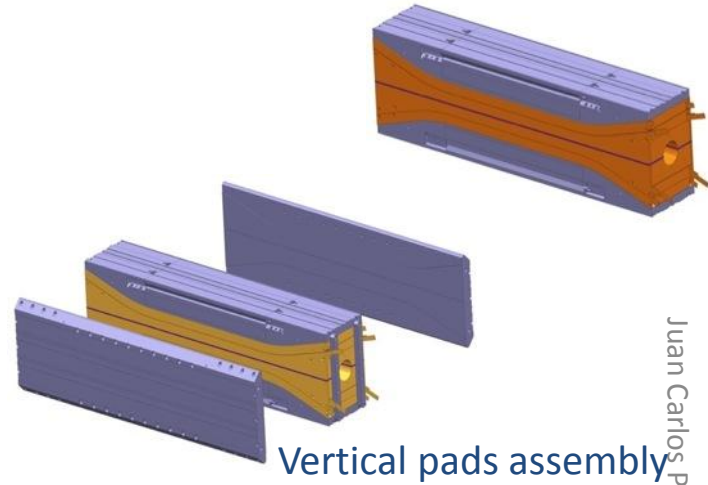
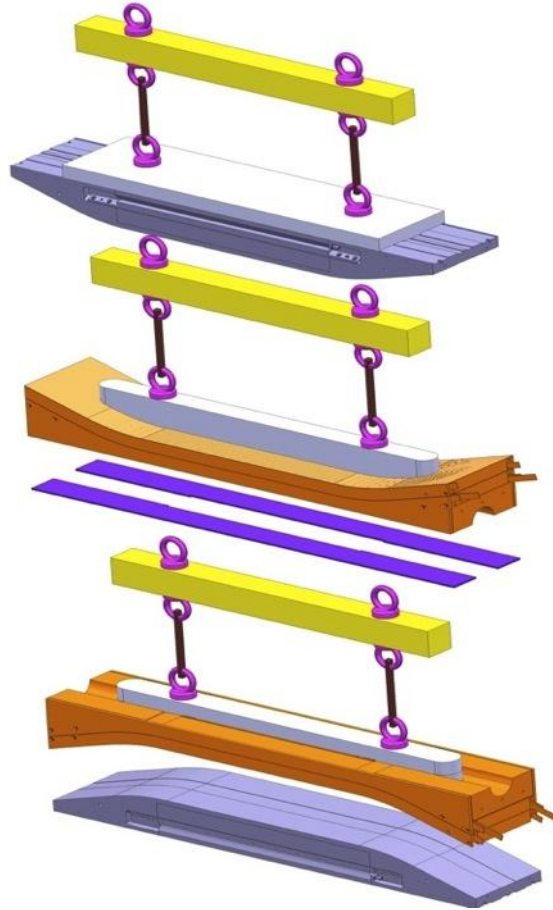
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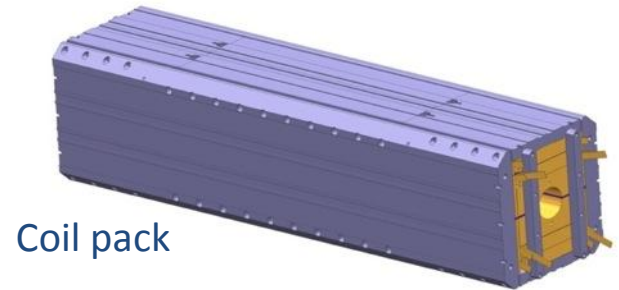
Coil lifting and rotation



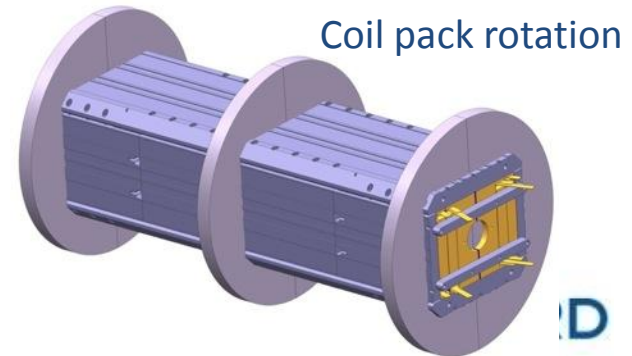
Stacking coils and horizontal pads



Vertical pads assembly



Coil pack



Coil pack rotation

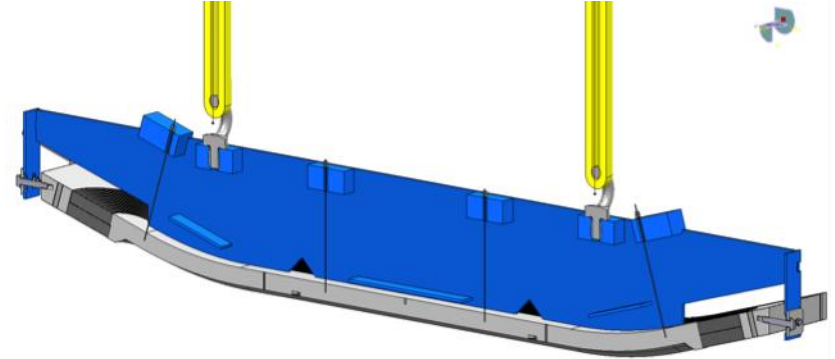
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Rotation tooling still to be defined and produced

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Lifting tools for coil handling

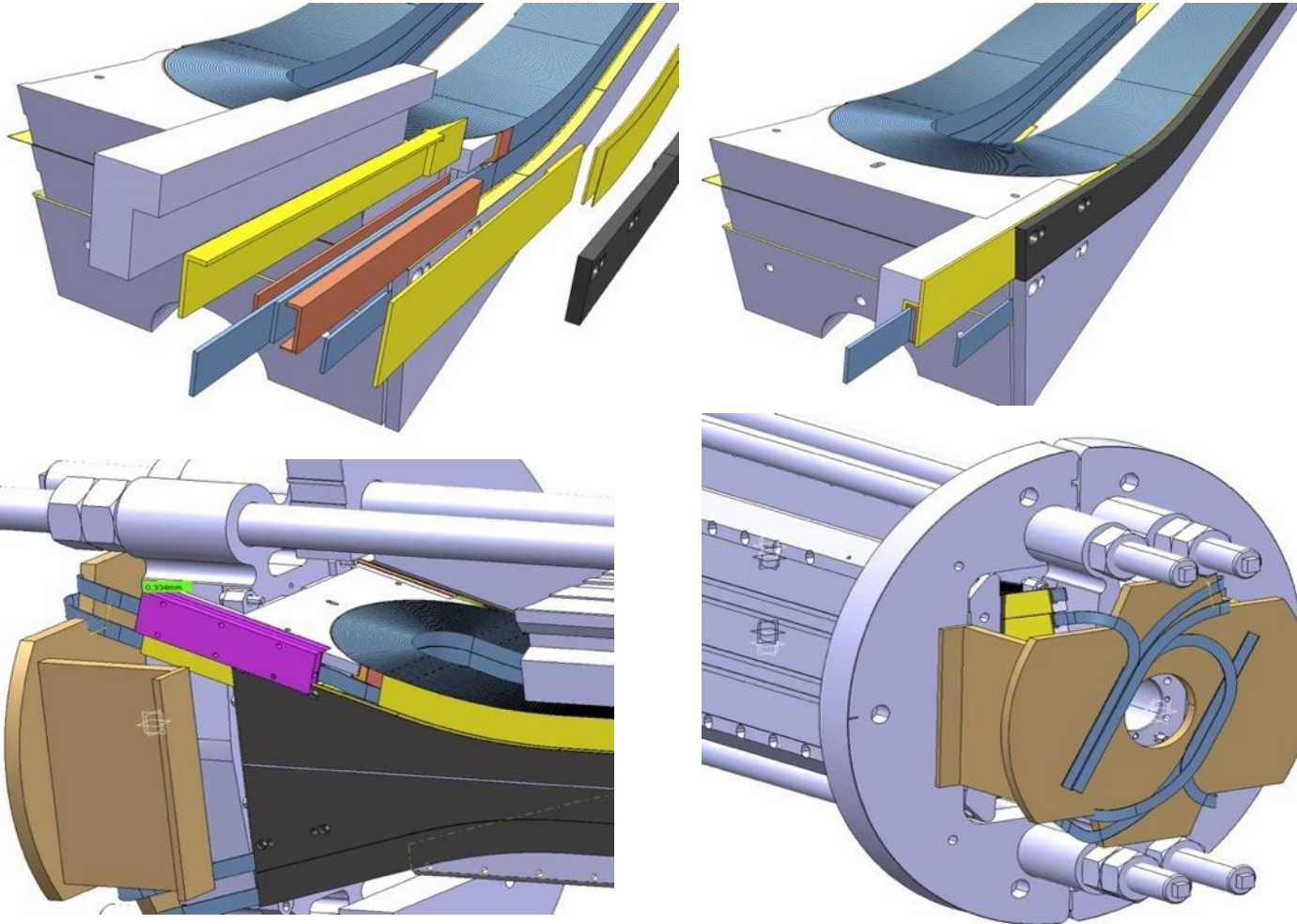


- The fabrication of the lifting tools has been out-sourced to a French company
- The delivery of all remaining lifting tooling, CE certified, is expected in March 2013

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Fresca2 Interconnection



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14





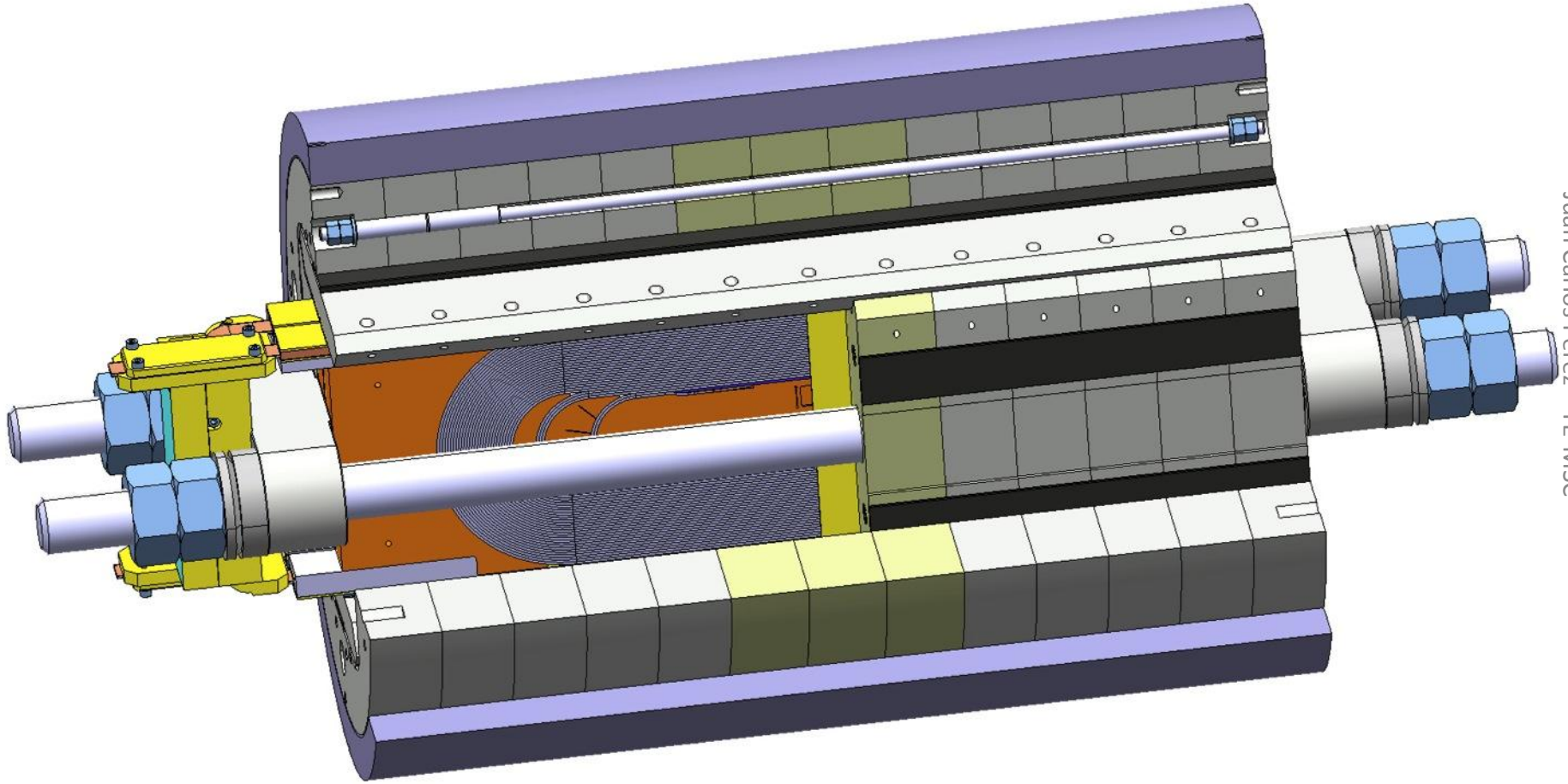
Conclusions

- The reaction furnace is operational
- The vacuum impregnation system will be commissioned in March
- Impregnation mold has been ordered. Delivery due for April 2013
- The first prototypes of traces will be delivered in March 2013
- All dedicated lifting tools to handle the coils will be operational in April
- The copper coil will be used to validate all fabrication steps





RMC



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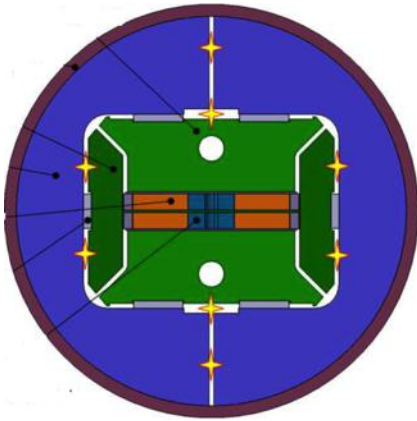
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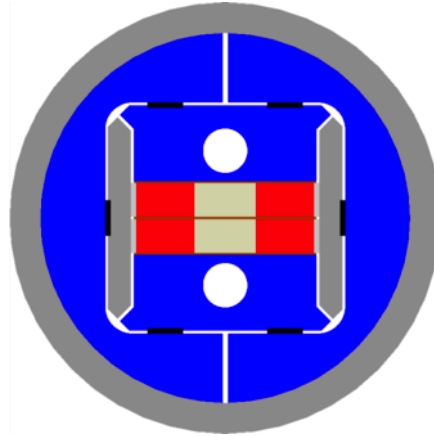


From SMC to RMC towards FRESCA2

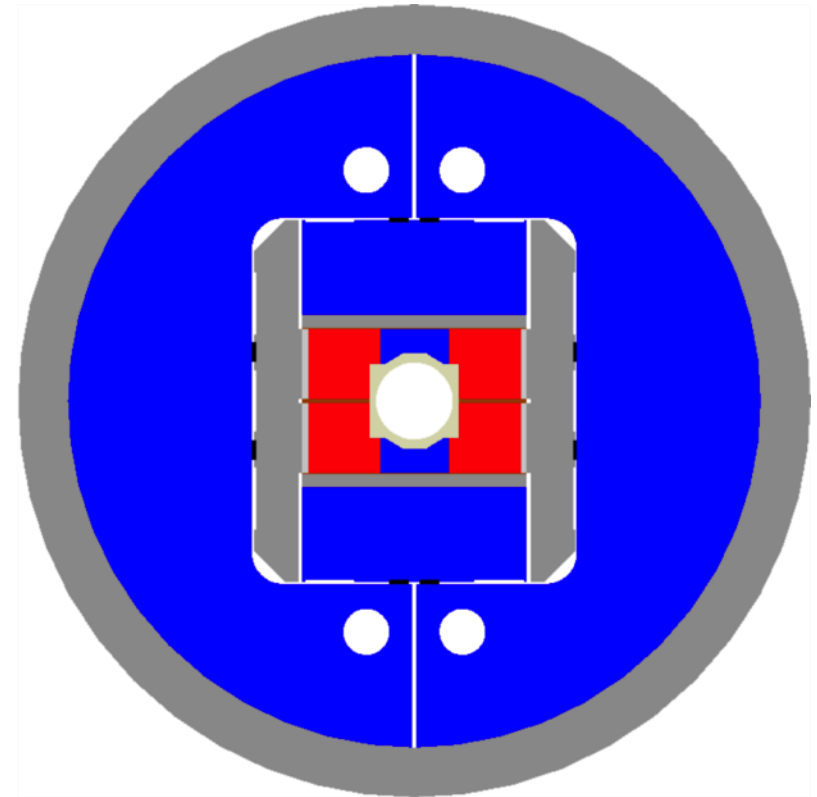
SMC



RMC



FRESCA2



- **RMC goals:** test FRESCA2 cable and FRESCA2-type coils in realistic cond.
- Constraints
 1. Layer jump similar to FRESCA2
 2. Power supply limit ~20 kA
 3. Magnet OD: 570 mm

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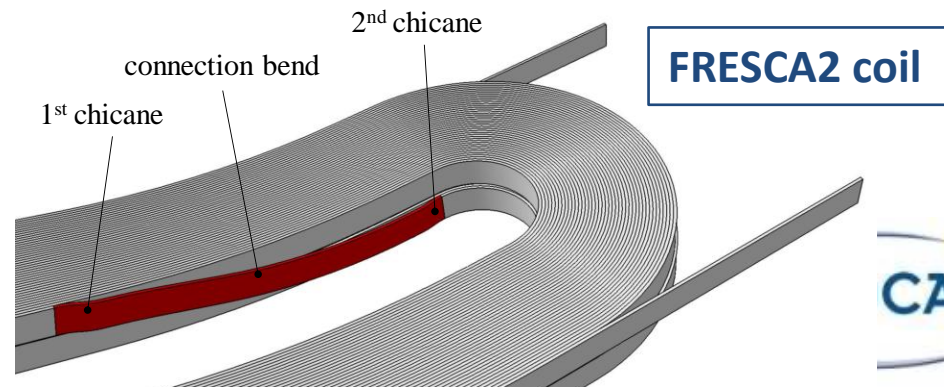
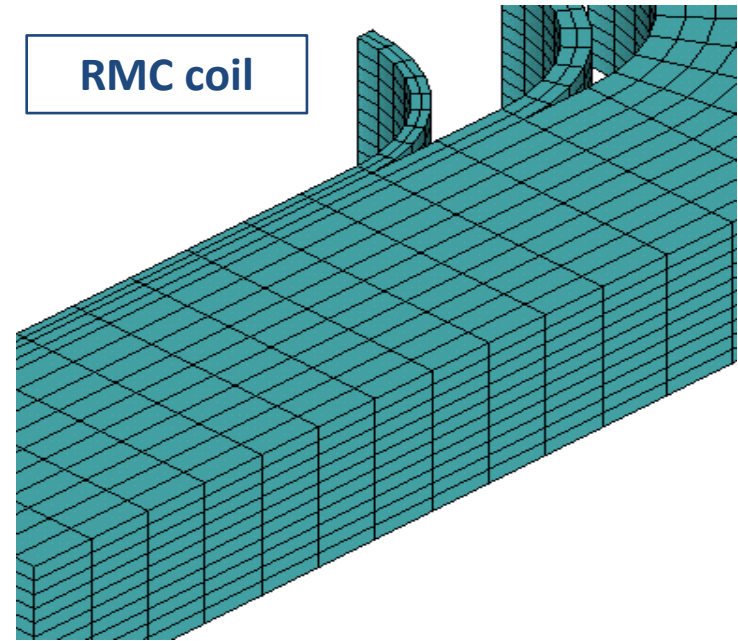
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RMC coil design

- Same design as SMC
 - 2 end spacers
 - 33 turns (like FRESCA2)
- FRESCA2-type layer jump
- As a result
 - Straight section: 300 mm
 - 150 mm in SMC
 - Coil length: 820 mm
 - 500 mm in SMC
 - 96 m of cable per coil
 - 4.0 km of strand



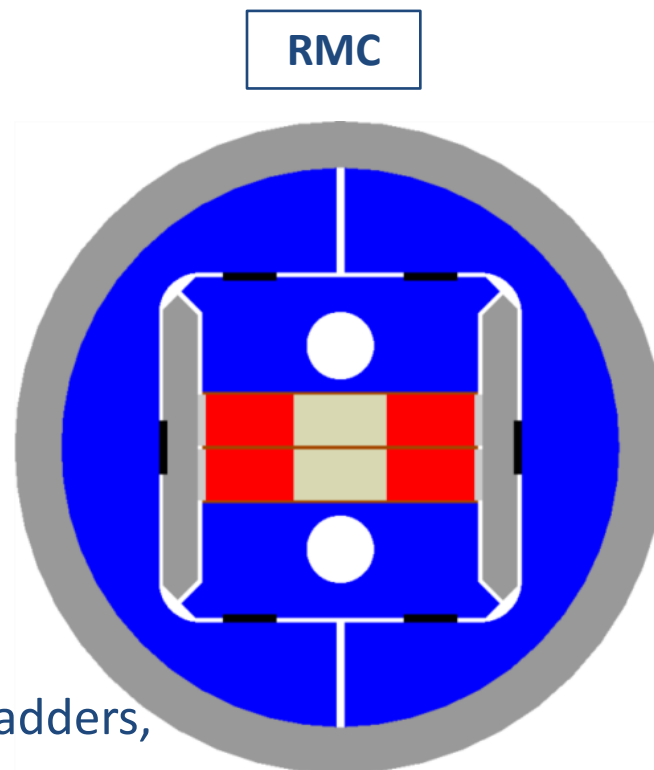


RMC magnet design

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RMC configuration

- 2 RMC coils
 - I_{ss} (1.9 K) = 18.3 kA
 - Below power supply limit
 - $B_{peak} = 16.0$ T
- Significantly higher forces
 - From 2.2 MN/m in SMC to 5.4 MN/m
- New structure required
 - Thicker shell, new yoke design, larger bladders, larger axial rods



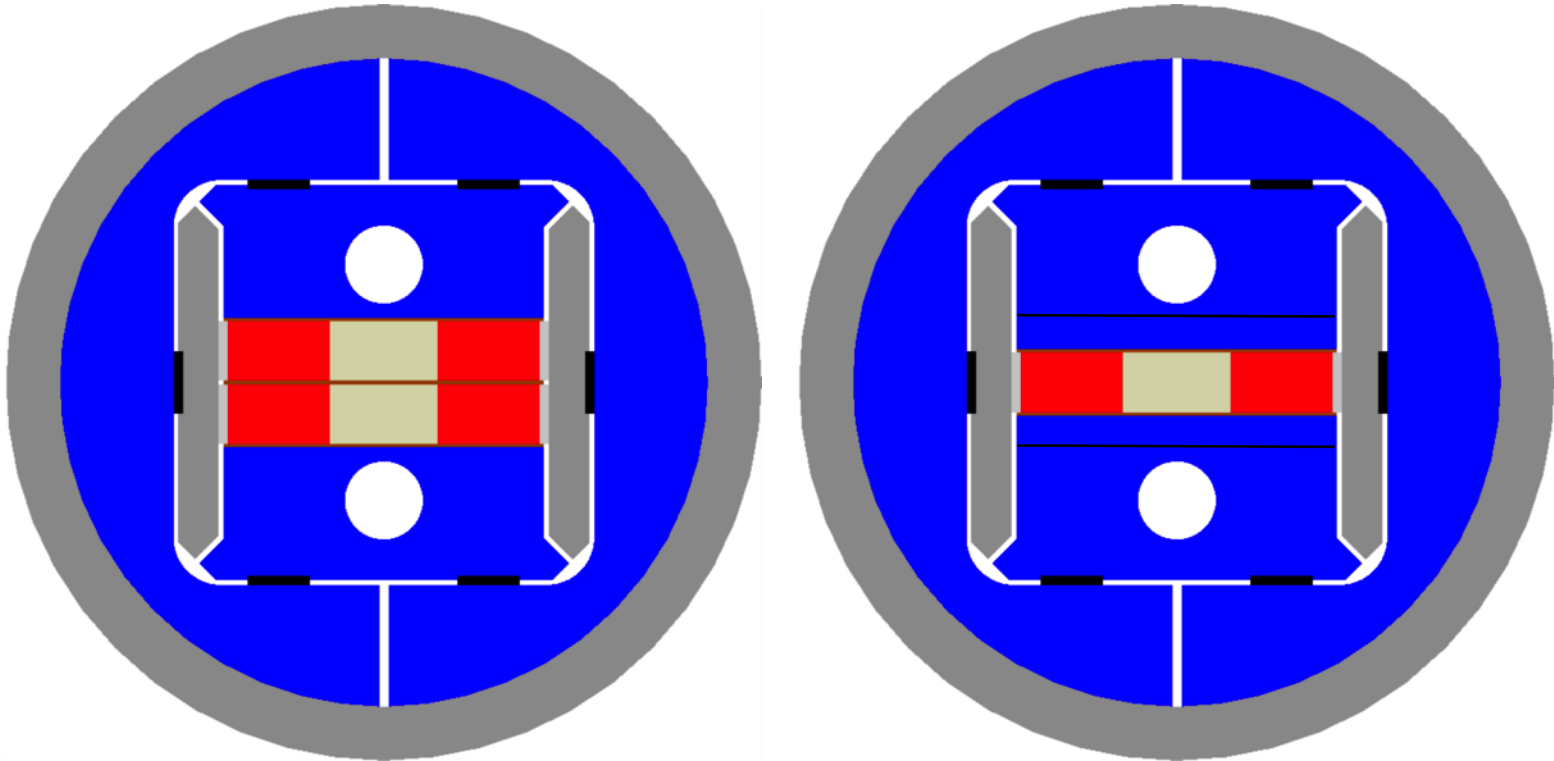
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RMC

1 double pancake VS. 2 double pancakes

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- Still possible to test individual coils up to 20 kA
 - Corresponding to about 93% of I_{ss} @ 4.2 K

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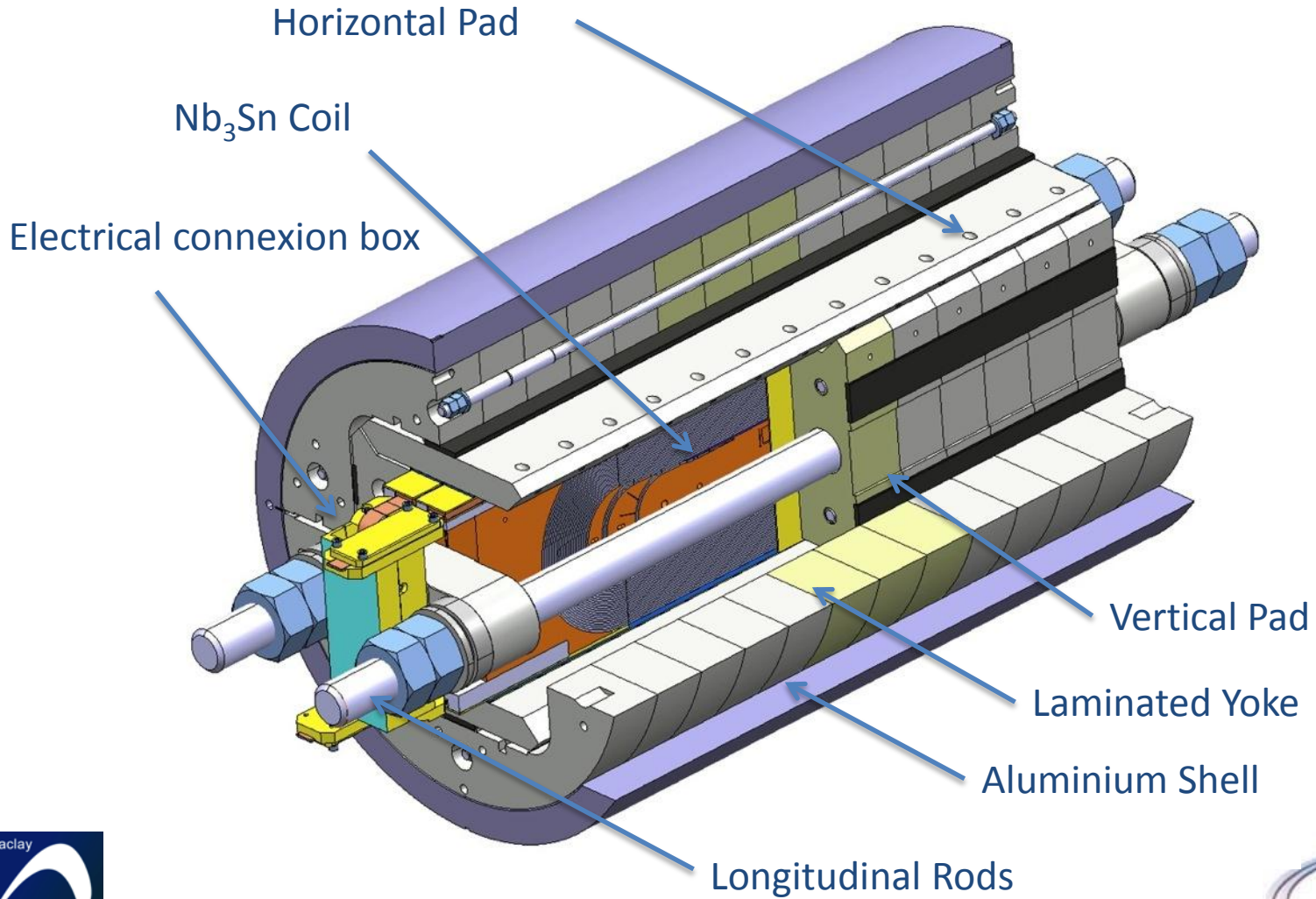
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RMC exploded view



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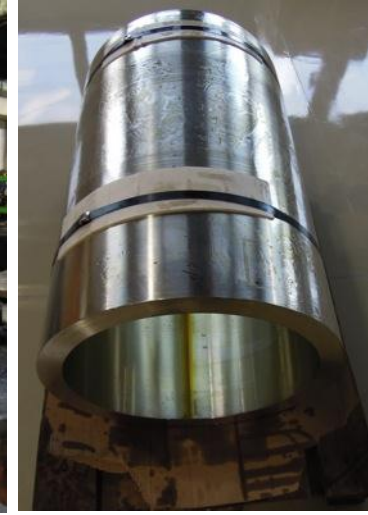


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RMC structure fabrication



Rolled AL 7175 cylinder
production in Fr (Forgital)



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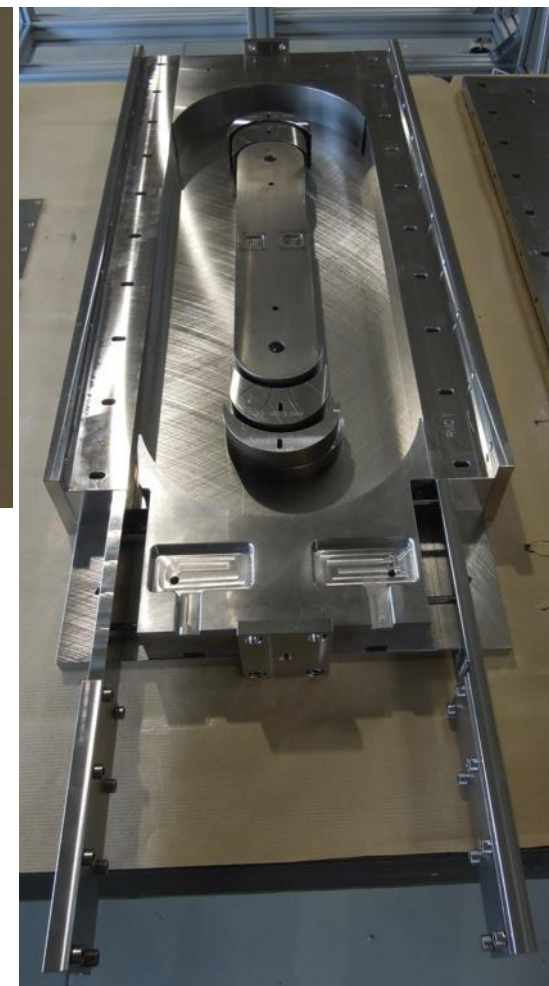


All structure components machined in Spain and delivered at CERN 4th week of February



Coil components and molds

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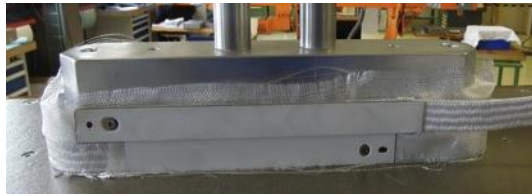
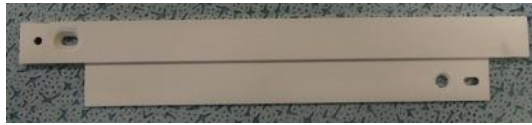


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- Coils components delivered in June 2012
- Plasma coating in July 2012
- Reaction and impregnation molds delivered in August
- First winding in September 2012 using Fresca2 type copper cable with 66 Tex braided insulation

RMC copper coil winding

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RMC copper coil Instrumentation

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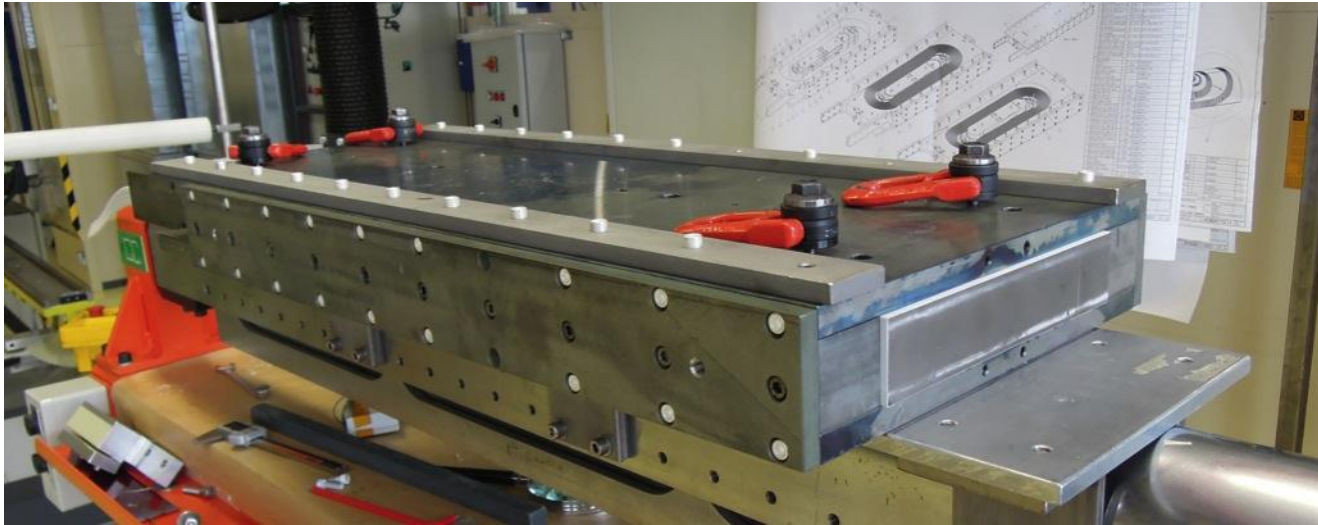
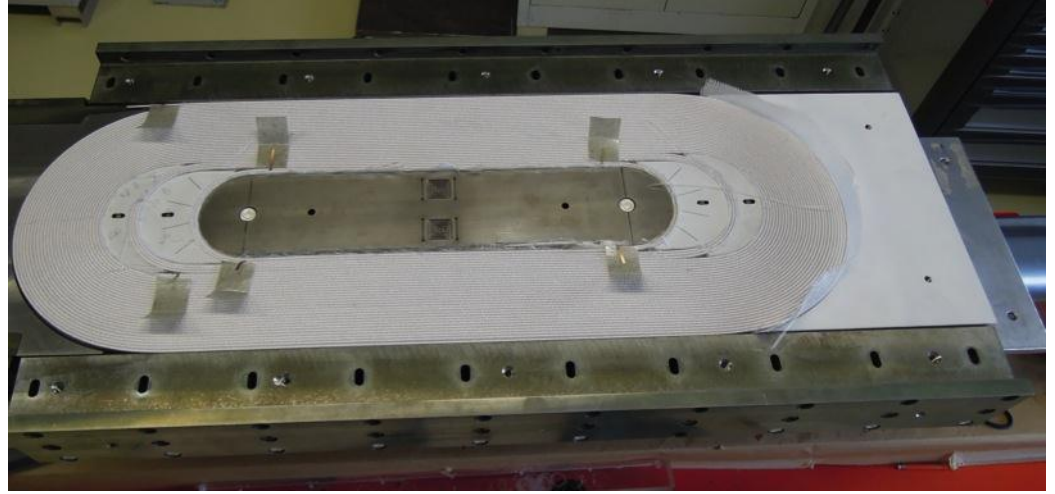
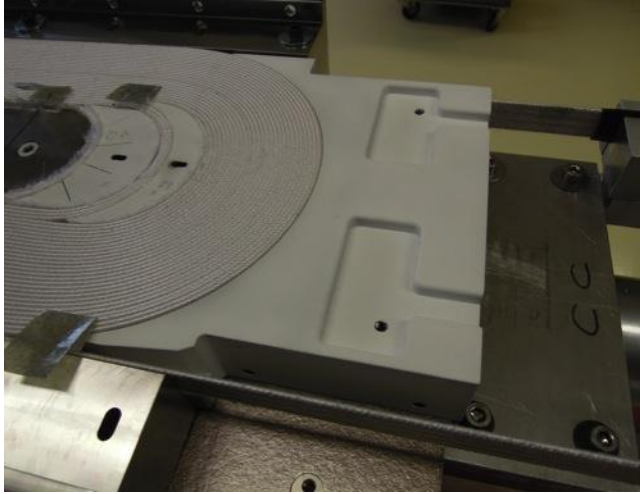
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- The coil has been reacted in November 2012 in the furnace used for SMC coils
- The copper coil will be used to test and validate tooling and procedures
- The coil will be instrumented to validate the traces design
- The splicing procedure, Fresca2 type, will be validated
- The coil will be impregnated in the new vacuum impregnation system



First RMC Nb₃Sn coil winding

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The first Nb₃Sn RMC coil has been wound in January 2013

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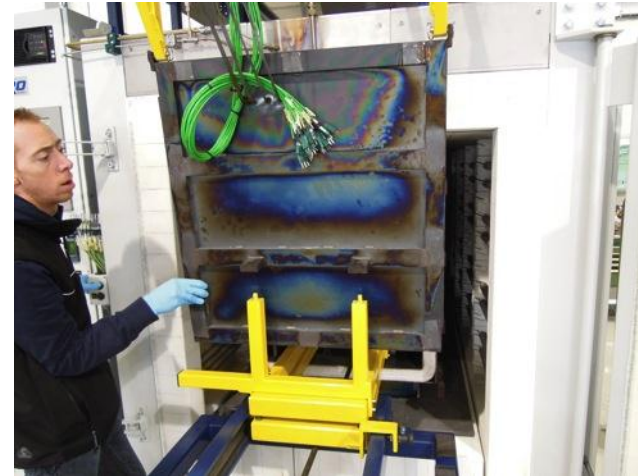
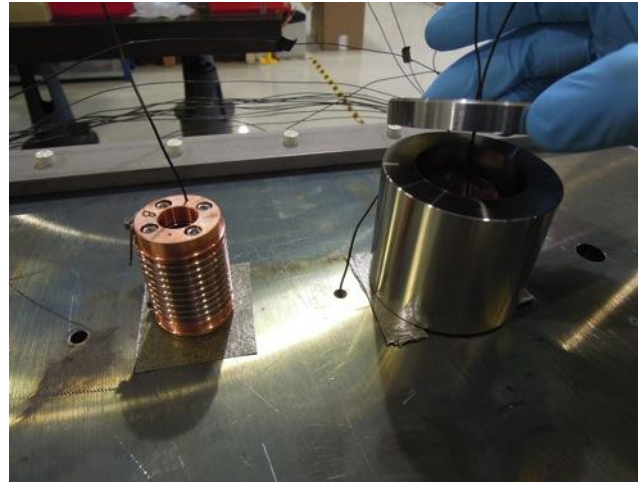


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RMC Nb₃Sn coil reaction



The Nb₃Sn coil will be reacted in the new reaction furnace in March 2013*
* O₂ analyser failure in February (waiting for repair)

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Some relevant dates

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December 2011	<ul style="list-style-type: none">• RMC project presented to ESAC reviewers at CERN
February 2012	<ul style="list-style-type: none">• End of magnetic and mechanical computation and Start design work with drawing office
Mai 2012	<ul style="list-style-type: none">• Launch price enquiry for production of components
June 2012	<ul style="list-style-type: none">• Coil components delivered to CERN and sent for plasma coating
July 2012	<ul style="list-style-type: none">• Reaction and impregnation mold delivered. Order placed for structure components
September 2012	<ul style="list-style-type: none">• Winding of first copper coil
November 2012	<ul style="list-style-type: none">• Heat treatment of first copper coil
January 2013	<ul style="list-style-type: none">• Winding of first Nb₃Sn coil
February 2013	<ul style="list-style-type: none">• Reaction of first Nb₃Sn coil (O₂ analyser failure). Mechanical structure delivery.
March 2013	<ul style="list-style-type: none">• Instrumentation of first Nb₃Sn coil.
April 2013	<ul style="list-style-type: none">• Impregnation of first Nb₃Sn coil. First mechanical assembly using Al dummy coils
July 2013	<ul style="list-style-type: none">• First Magnet assembly with one Nb₃Sn coil
August/September 2013	<ul style="list-style-type: none">• First assembly with single coil configuration to be delivered to SM18

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Conclusion

- Shell, rods and aluminium dummy coils will be instrumented with strain gauges
- First structure mechanical assembly scheduled for April-Mai 2013
- Copper coil will be used to validate coil fabrication procedures
- First Nb3Sn coil expected in May 2013
- Cold powering test expected end of summer 2013 around 18 months after quick-off meeting of the project (limited resources)
- First RMC results will be on time to be used for Fresca2 project



Collaboration team

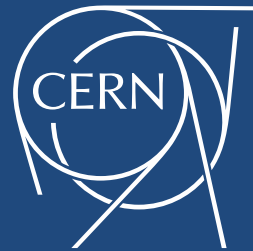
- CEA/Saclay:

M. Devaux, M. Durante, P. Manil, J.F. Millot, J.M. Rifflet, F. Rondeaux

- CERN:

H. Bajas, M. Bajko, S. Clement, P. Ferracin, J. Feuvrier, E. Fornasiere, R. Gauthier, M. Guinchard, G. de Rijk, J. Humbert, A. Milanese, J. E. Muñoz Garcia, L. Oberli, T. Sahner, M. Timmins, G. Villiger , TE/MS-CMDT Section and many others ...

Thanks for your attention



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