





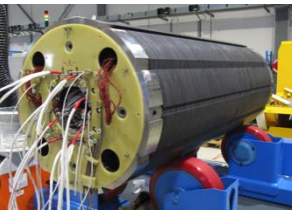

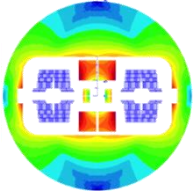
# Status of CIEMAT Contribution to the HL-LHC Collaboration and the FCC Project in the framework of the PRISMAC Agreement

Luis García-Tabarés, José Manuel Pérez & Fernando Toral  
on Behalf of CIEMAT

# What is PRISMAC ?

## (PRograma Imanes Superconductores de Muy Alto Campo)

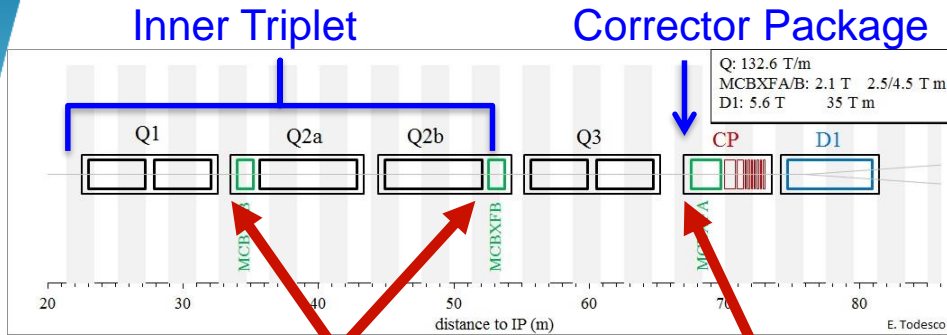
**PRISMAC:** A CIEMAT-CDTI Collaboration Program for Research on High Field Magnets, Supported by SGI/MCI & CERN

		 Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas		 GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN  SECRETARIA GENERAL DE INVESTIGACIÓN	
HL-LHC MCBXF Magnets In-Kind Contribution	<ul style="list-style-type: none"> <li>• Training &amp; Support on magnets and facilities</li> <li>• Use of Facilities during the set-up of CIEMAT Laboratory</li> </ul>	<ul style="list-style-type: none"> <li>• Providing a team, facilities and economical resources to all the activities</li> <li>• Prototype Development</li> </ul>	<ul style="list-style-type: none"> <li>• Project Funding</li> <li>• Industrial exploitation of the associated technologies (Early Alert)</li> </ul>	<ul style="list-style-type: none"> <li>• Funding the series production, components and new personnel</li> </ul>	
Facility for very high field superconducting magnet prototypes	<ul style="list-style-type: none"> <li>• Qualification of CIEMAT as a Technological Partner</li> </ul>	<ul style="list-style-type: none"> <li>• Series Fabrication Follow-up</li> </ul>	<ul style="list-style-type: none"> <li>• Dissemination of the developed technologies to other fields (i.e. Space, Fusion, Light Sources, Energy..)</li> </ul>	<ul style="list-style-type: none"> <li>• Supporting the Spanish Traineeship Program (FTEC)</li> </ul>	
Development of FCC model magnets		<ul style="list-style-type: none"> <li>• Qualification of Industry as Industrial Partners</li> <li>• Management of IK contribution to CERN</li> </ul>		<ul style="list-style-type: none"> <li>• Supporting the R&amp;D Program on Key Technologies</li> </ul>	

# Activities to perform in PRISMAT

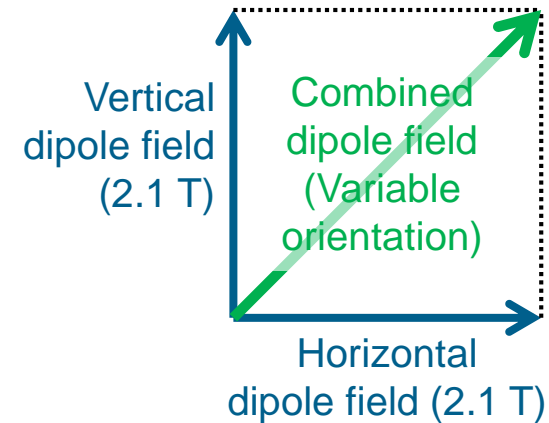
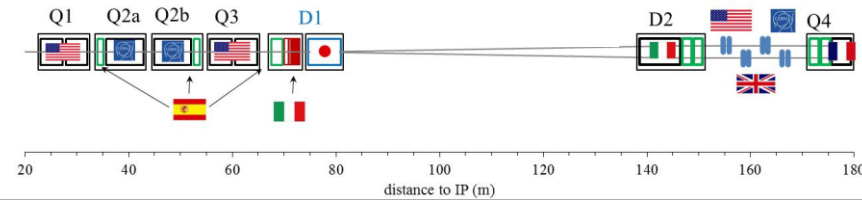
ACTIVITY 1	MCBXFB & MCBXFA series production for the HL-LHC	The agreement includes the procurement of 1+6 MCBXFA (long) magnets plus another 2+12 MCBXFB (short) magnets to be installed in the HL-LHC as Spanish In-Kind Contribution to the Project. Previous to the agreement, an intense prototype development phase took place on the basis of a CERN/CIEMAT Collaboration agreement
ACTIVITY 2	Deployment of a facility for building & testing High Field Magnets	Development of a facility in CIEMAT premises to build and test superconducting magnets based on either NbTi and Nb <sub>3</sub> Sn technology. This facility will include specific systems which are required for the fabrication of those magnets and rely on the experience previously developed by CERN.
ACTIVITY 3	Fabrication of High Field Model Magnets for FCC	Full development of model magnets for FCC based on Nb <sub>3</sub> Sn technology divided in two phases: In the first one RMM model magnets will be fabricated, while in the second one, a short magnet based on EuroCirCol designs will be manufactured.

# ACTIVITY 1: The MCBXF Magnet



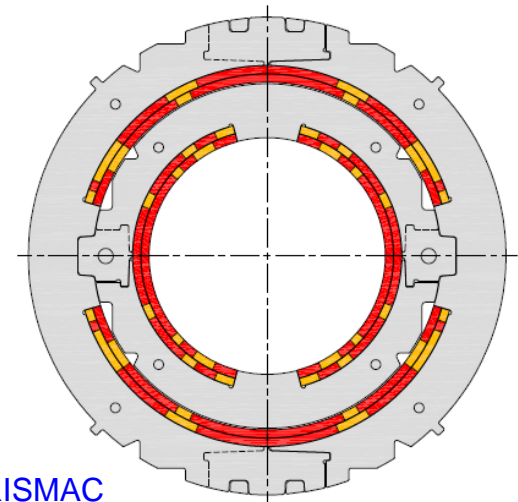
**MCBXFB**  
(2.5 T·m)

**MCBXFA**  
(4.5 T·m)



## MCBXFB Technical specifications

<b>Magnet configuration</b>	Combined dipole (Operation in X-Y square)
<b>Integrated field</b>	2.5 Tm
<b>Minimum free aperture</b>	150 mm
<b>Nominal current</b>	< 2500 A
<b>Radiation resistance</b>	40 MGy
<b>Physical length</b>	< 1.505 m
<b>Working temperature</b>	1.9 K
<b>Iron geometry</b>	MQXF iron holes
<b>Field quality</b>	< 10 units (1E-4)
<b>Fringe field</b>	< 40 mT (Out of the Cryostat)



# ACTIVITY 1: Status of the MCBXFB Prototype

PHASE	MILESTONES	STATUS	
Magnetic, Mechanical & Quench Calculations	<ul style="list-style-type: none"> <li>✓ Field Quality</li> <li>✓ Mechanical Stresses</li> <li>✓ Voltages &amp; Temperature</li> </ul>	DONE	 
Short Mechanical Models	<ul style="list-style-type: none"> <li>✓ Coil Mechanical Properties</li> <li>✓ Collar Assembly Testing</li> <li>✓ Stress Measurement at Warm &amp; Cold</li> </ul>	DONE	 
Magnet & Tooling Design	<ul style="list-style-type: none"> <li>✓ Coil &amp; Magnet Drawings</li> <li>✓ Winding Tooling</li> <li>✓ Binder &amp; Impregnation Tooling</li> <li>✓ Assembly Tooling</li> </ul>	DONE	
Magnet Components & Tooling Fabrication	<ul style="list-style-type: none"> <li>✓ Spacers &amp; End Spacers</li> <li>✓ Collars &amp; Iron Yoke</li> <li>✓ Winding Table, Spools &amp; Brakes</li> <li>✓ Binder &amp; Impregnation Tooling</li> </ul>	DONE	 
Coil Fabrication	<ul style="list-style-type: none"> <li>✓ ID Coil Winding &amp; Binding</li> <li>✓ ID Coil Curing</li> <li>✓ OD Coil Winding &amp; Binding</li> <li>✓ OD Coil Curing</li> </ul>	DONE	
Magnet Assembly	<ul style="list-style-type: none"> <li>✓ ID Coil Collaring &amp; Assembly</li> <li>✓ Magnet Testing with only ID Coils</li> <li>✓ OD Coil Collaring &amp; Assembly</li> <li>✓ Full Magnet Testing</li> </ul>	DONE	

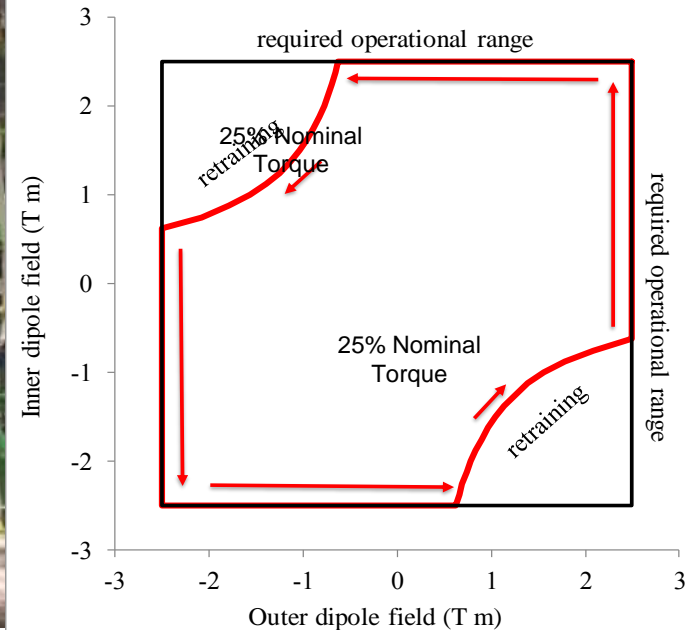
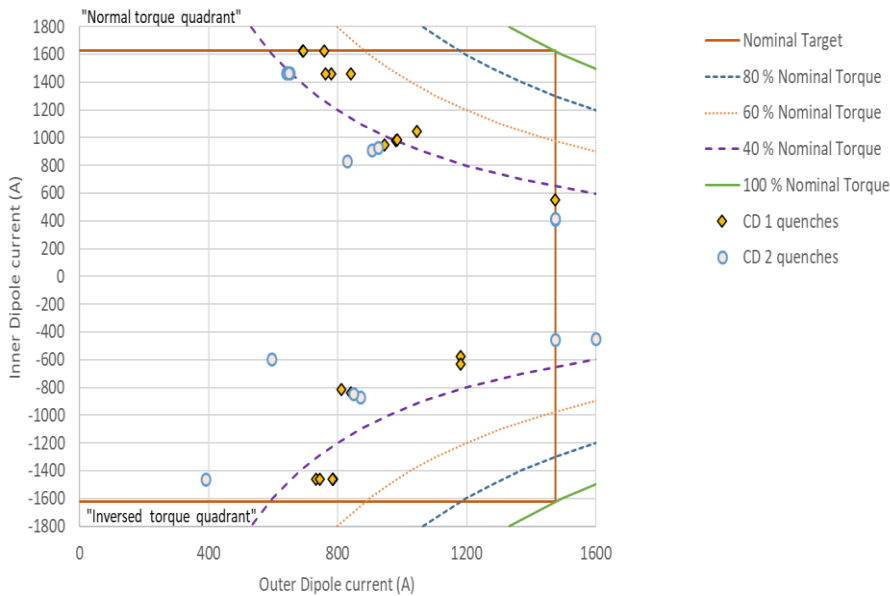
- ✓ Finish
- Pending
- Main Present Activity

FORESEEN MARCH 2019  
FINISHED AUGUST 2019



# ACTIVITY 1: Powering Tests of the MCBXFB Prototype

- The first power test (w/o outer dipole) allowed to **validate** the innovative coil fabrication techniques.
- Three power tests were necessary to **reach nominal torque** at combined operation.
- Few training quenches are needed to reach again nominal operation current
- The first prototype reaches performance on 80% of required operational range.
- Additional shimming will be added at the coil ends in the ongoing **second prototype**.



Torque reached at second test (Assembly b)  
(G. Willering, J. C. Perez, F. Toral, et al.)

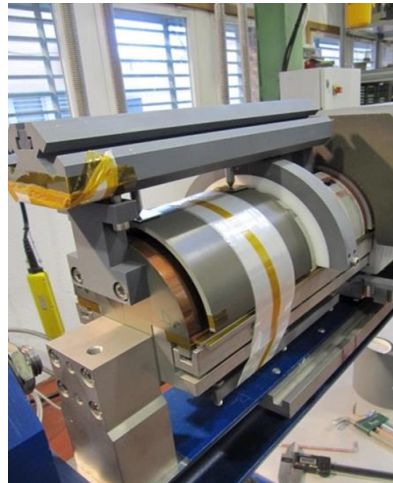
Operational cycle performed without quenches after training (in red) at last assembly (d) (G. Willering, J. C. Perez, F. Toral, et al.)

# ACTIVITY 1: Status of the 2<sup>nd</sup> MCBXFB Prototype

- 3 coils fabricated: 2 inner dipole coils and 1 outer dipole coil.
- 1 outer dipole coil is being impregnated.
- Components for Second Prototype in the last stage of fabrication (spacers, iron yoke, collars, end plates..).
- Collaring of the Inner Dipole at CERN foreseen by March 2020.
- Final assembly at CERN foreseen by June 2020.



Winding Process



Binding Process



Closing the Impregnation Mould

# ACTIVITY1: Status of the MCBXFA1 Prototype

- Magnet design phase almost finished (drawings under validation).
- Tooling design phase on going (80% drawn, 50% released)
- Inner dipole tooling fabricated.
- Magnet start fabrication foreseen in September 2020.
- Final assembly at CERN foreseen in July 2021 \*.



Impregnation closing sheet



Winding Mandrel

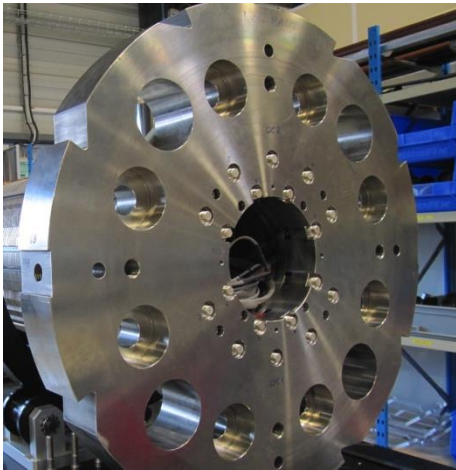
\* A new schedule in which MCBXFA is delayed by 18 months & a MCBXFB 3<sup>rd</sup> Prototype is built by CIEMAT and delivered by Dec 2020, is under consideration



# Spanish Industry Involved in the Procurement Processes (1)

## ■ Components:

- Spacers: Egile
- Collars: Teknicalde, Vacuum Projects, GAZC, Ramem, Inecfi
- Iron Yoke: Teknicalde, GAZC, Finitec
- Connection Plates: Bronymec
- Axial Support: Apteca, Ramem, Jucar Utilajes, Finitec



End Plate



Collars



End Spacers

# Spanish Industry Involved in the Procurement Processes (2)

- **Tooling:**
  - Winding: Ramem, Utillajes Jucar, Apteca
  - Impregnation: FOCS, Egile, Utillajes Jucar, Ramem, Aratz, APM, Vacuum Projects
  - Ground Insulation Bending : Utillajes Jucar, Ramem, Apteca, APM
  - Assembly: Apteca, Ramem, Utillajes Jucar, Aratz
- **Commercials:**
  - Unceta, RS, Sirsa, Tecnovac, Epidor, Isovolta, Royal Diamond, Rubio, Quetersa...



Iron Laminations

Impregnation Mould



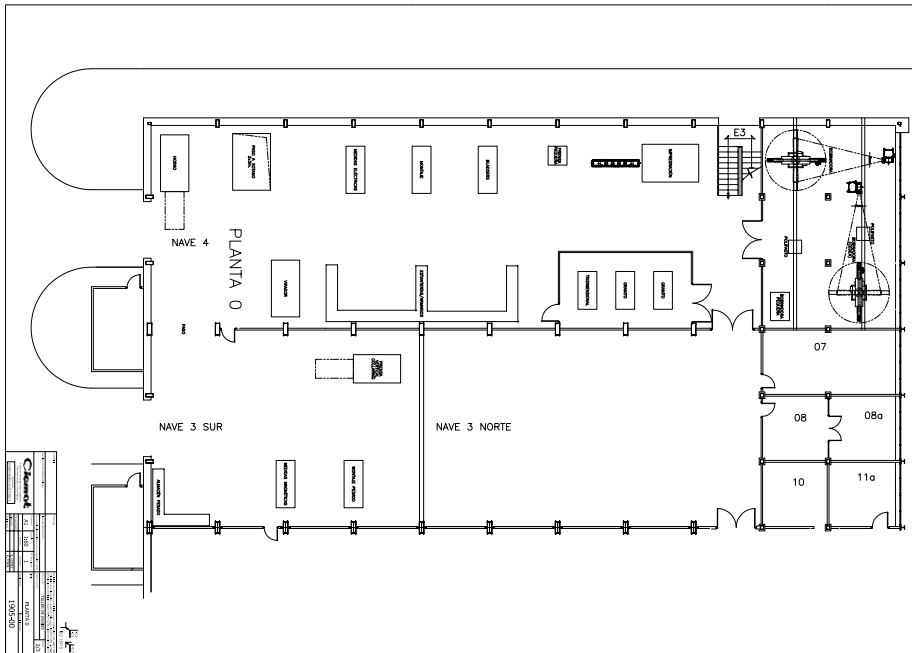
Winding Tooling



# ACTIVITY2: CIEMAT Magnet Laboratory



Building 31 has been finally assigned for the construction of the model magnet laboratory at CIEMAT



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- Building 31 has been finally assigned for the construction of the model magnet laboratory at CIEMAT
- The first project basic study has been completed
- Tendering for the execution of the project has already started
- Construction tender is foreseen on May 2020
- Construction work should start on February 2021 and end in October 2021

ACTIVITY	START	DURATION	START (ACTUAL)	DURATION (ACTUAL)	COMPLETED	PERIODS																							
						2020												2021											
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CIVIL CONSTRUCTION PROJECT EDITION	1	3	1		0%	█	█	█																					
PROJECT VISA APPROVAL	4	1			0%			█																					
LICENSE APPLICATION	5	3			0%				█	█	█																		
PROCUREMENT	5	6			0%				█	█	█	█	█																
WORK	11	9			0%									█	█	█	█	█	█	█	█	█							

# ACTIVITY2: CERN support for CIEMAT Magnet Laboratory Infrastructure

CERN shall provide the following material for its use during the project.

- Collaring press
- Curing press refurbished from one existing at CERN
- Pressurized impregnation system for model magnets up to 2.5m length
- Reaction furnace for Nb<sub>3</sub>Sn model magnets up to 2.5m length
- Magnetic measurement system, including one rotating coil



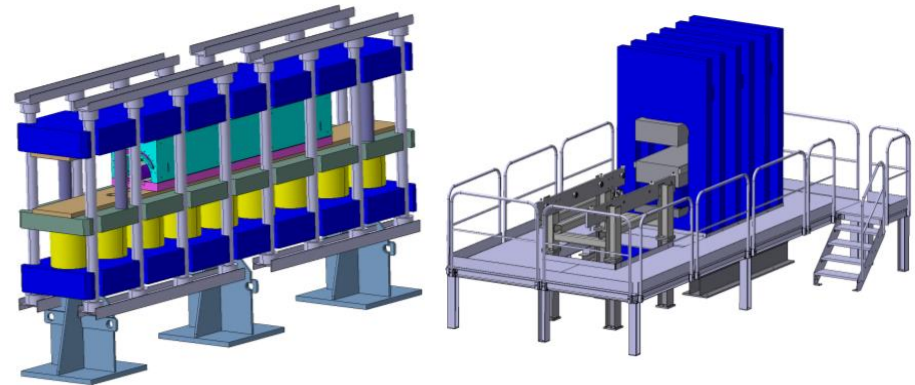
# ACTIVITY2:New Hardware to be delivered by CERN

- **Furnace for Nb<sub>3</sub>Sn coils reaction**
  - Equivalent size than present 927 furnace
  - Retort and control system to be implemented with lessons learned with existing furnaces used in LMF
  - Technical specification under preparation
  - Expected delivery to CIEMAT Q3-2021

- **Collaring and Curing Press**
  - Combination of curing and collaring press in a single machine being considered to minimize the price and save space
  - Modular conceptual design proposed for length capacity increase if needed
  - 3D design and mechanical structure calculations started
  - Expected delivery to CIEMAT Q3-2021

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927 Curing and collaring presses.

# SUMMARY

## ACTIVITY 1

- First short type prototype finished, tested and validated
- Second short type prototype (First magnet of the series) to be finished by June 2020
- First long type prototype to be finished by July 2021\*
- Issue of “Tendering Specifications” for the series production by February 2020

## ACTIVITY 2

- Administrative procedures and preliminary studies for the new model magnet laboratory to be installed at CIEMAT started.
- End of the construction work for CIEMAT magnet facility is foreseen in October 2021
- Technical specifications for tooling to be developed and provided by CERN in progress with help from FTEC crew.
- Tooling commissioning at CIEMAT premises foreseen during second half of 2021

## ACTIVITY 3

- CIEMAT R&D program on Nb<sub>3</sub>Sn has not started yet due to the severe workload for the MCBXF magnet production.
- Detailed R&D program to be agreed during Spring 2020

\* A new schedule in which MCBXFA is delayed by 18 months & a MCBXFB 3<sup>rd</sup> Prototype is built by CIEMAT and delivered by Dic 2020 is under consideration.

# Thank you for your attention

