# Status of CIEMAT Activities in the Development of Particle Accelerators

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Department of Technology

CIEMAT

# The Electrical Engineering Division at CIEMAT

## STRUCTURE

ELECTRIC ENGINEERING DIVISION

- ACCELERATOR TECHNOLOGY UNIT
- ELECTROMECHANICAL TECHNOLOGY UNIT
- POWER SYSTEMS UNIT

## FACILITIES

Main Offices (Moncloa)

Energy & Superconductivity (J. Camarillo)

Assembly Hall (J. Camarillo)

# Ongoing Projects and Collaborations

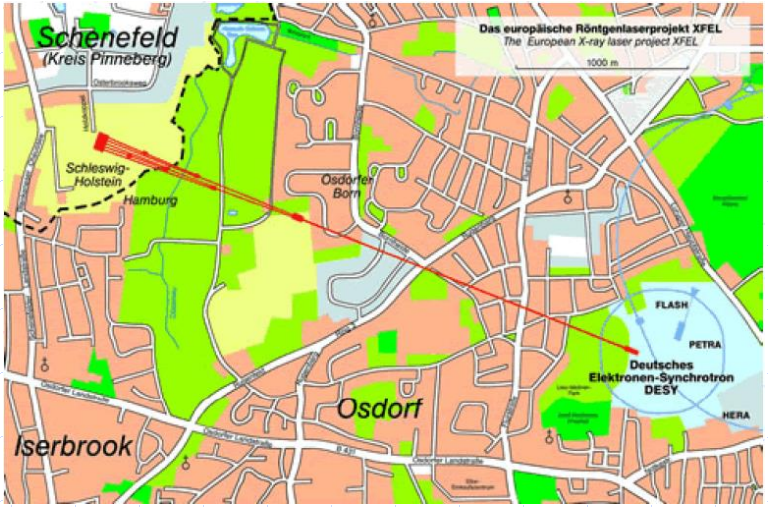
| ACCELERATORS | POWER SYSTEMS |
|---|---|
| **Large Facilities ↓** | **Storage ↓** |
| **E-XFEL** | SA$^2$VE |
| FAIR | ACEBO |
| LHC Hi-Lumi (CERN) | ADIF/CETRAF |
| CTF3/CLIC (CERN) | TRAIN2CAR |
| FCC (CERN) | |
| ILC | |
| IFMIF | **Generation ↓** |
| TIARA | SUPERTURBINES |
| **Small Accelerators ↓** | UNDIGEN |
| AMIT CYCLOTRON | SEA-WEDGE |
| UPC MICROTRON | IISIS |

# *The XFEL Contribution*

# The E-XFEL Facility

XFEL

E-XFEL (European X-Ray Free Electron Laser) is a 100 ns pulse laser source working in the band from 0.085 to 6 nm. It will be located inside DESY facilities in Hamburg.
It consists of a Superconducting LINAC (cavities & magnets) up to 17GeV and an array of undulators based on permanent magnets.

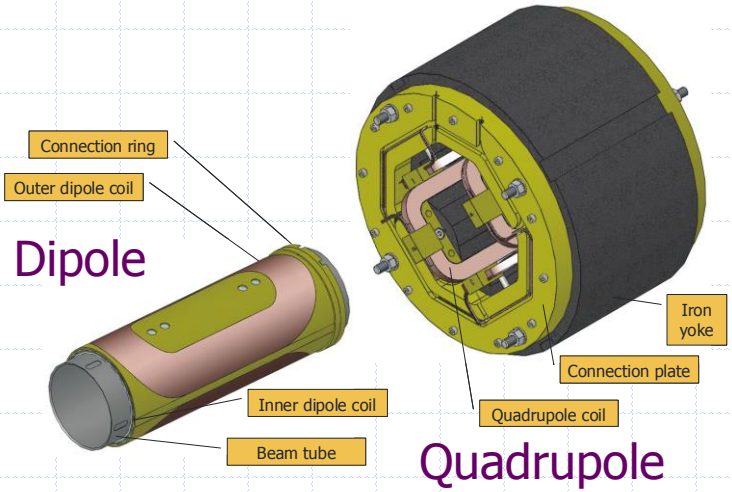


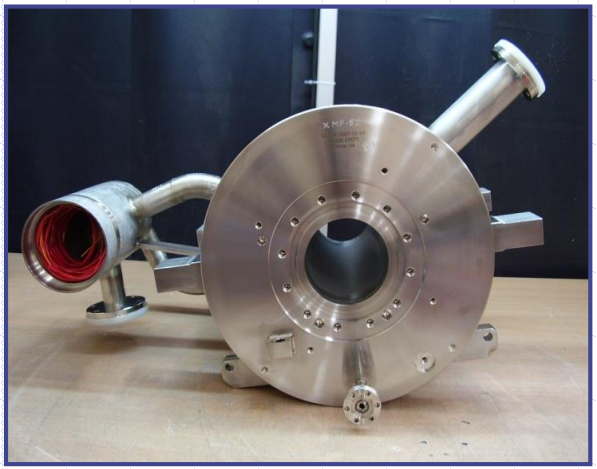

| Present CIEMAT contribution to E-XFEL | | |
|---|---|---|
| **COMPONENT** | **TYPE** | **QUANTITY** |
| Superconducting Combined Magnets | SC Magnet | 103 |
| Moving Tables (Movers) | Mechanics | 101 |
| Electronic Control Racks | Electronics & Instrum. | 101 |
| Phase Shifter Magnets | Special Magnet | Contrib. Failed |
| **NON- CIEMAT contribution to E-XFEL** | | |
| Superconducting Magnets Power Supplies | Electronics & Instrum | 240 |

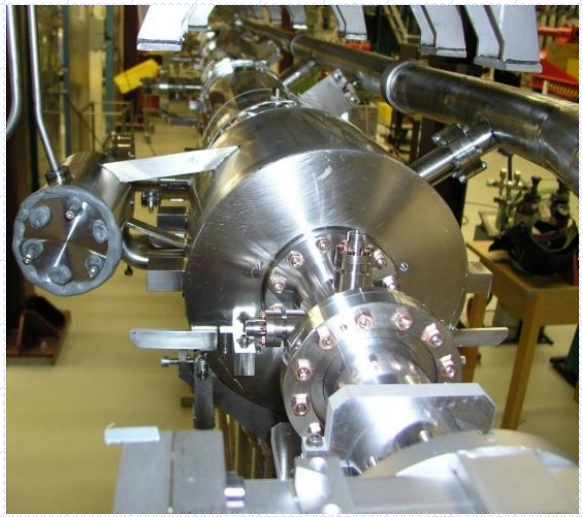
CIEMAT Contribution to E-XFEL

SC MAGNETS

# Superconducting Magnet for E-XFEL for the Main LINAC





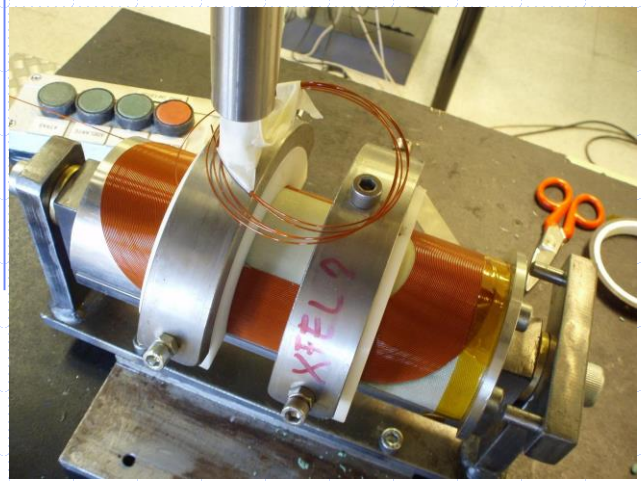
| Type: Combined | Quadrupole | Dipole (2) |
|---|---|---|
| Integrated Field | 5.97 T | 0.75E-3 Tm |
| Inner Diameter | 94.4 mm | 83.6 mm |
| Op. Current | 50 A | |
| Technology | NbTi Superferric | |
| Industrialization | YES: Different prototypes at CIEMAT & Industry<br>Series manufactured at Industry | |

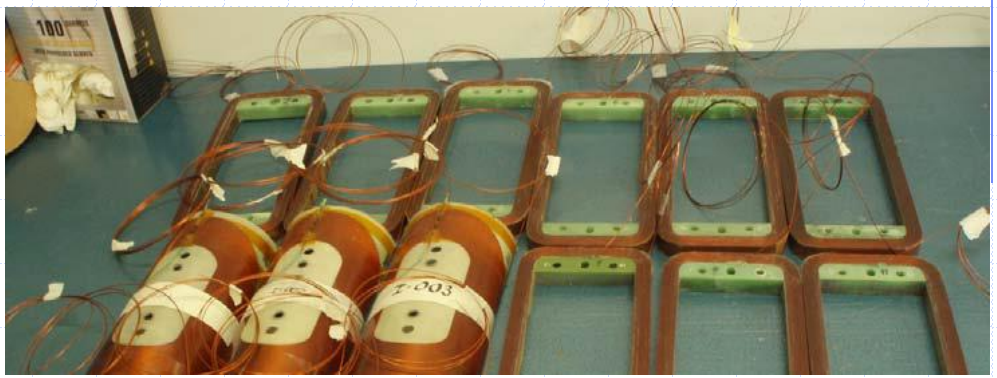
CIEMAT Contribution to E-XFEL

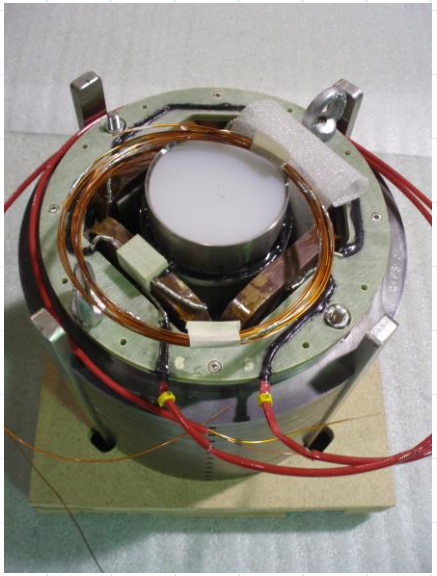
SC MAGNETS

# Superconducting Magnets for E-XFEL for the Main LINAC

## *Fabrication Process*



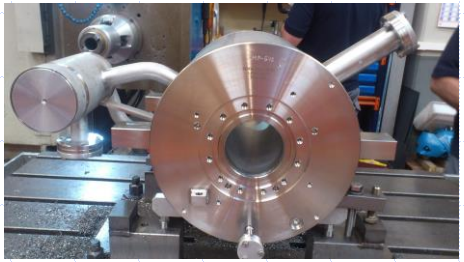





SC MAGNETS

## CIEMAT Contribution to E-XFEL

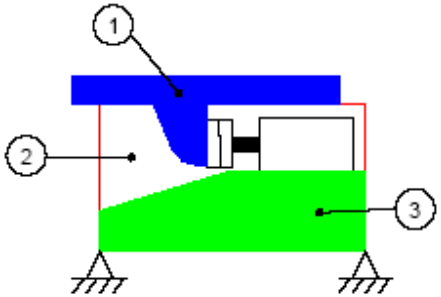
# Superconducting Magnets for E-XFEL for the Main LINAC

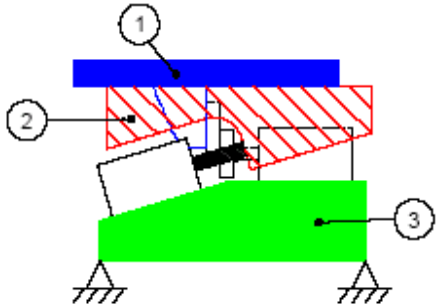


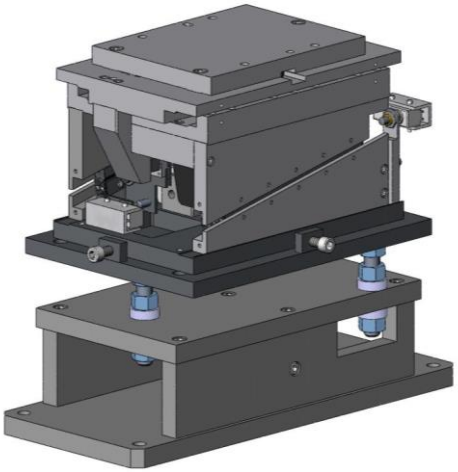
| | |
|---|---|
| *CIEMAT Contribution* | 103 Combined Superconducting Magnets (CSM) for the Main LINAC |
| *E-XFEL Contribution* | Warm & Cold magnetic measurements. Quench Tests |
| *Recognized Contribution Value* | 2.129.100 € (Prices corresponding to 2005) |
| *Present Status* | Contribution finished |
| *Prototyping Phase* | CIEMAT **5 CSM** (2004-2010) // CIEMAT-Industry **3 CSM** |
| *Tendering Process* | After Technical Specs. & Documents were issued by CIEMAT and approved by DESY, a tendering process was launched, 3 companies competed, being Trinos Vacuum Projects (subcontracting ANTEC) selected. |
| *Fabrication at Industry* | Fabrication started 2011/08 for a period of 26 months |
| *Delivery Schedule* | 2012 **15 CSM** //2013 **55 CSM** //2014 **32 CSM** (**5 CSM** per month) //2015 **1CSM** |
| *Quality Assessment Plan* | Done by TUEV-Nord (Cryostats) . Rest at the companies, revised by CIEMAT |
| *Testing* | Partial testing & dimensional control at the company. Magnetic testing at DESY |
| *Installation & Commissioning* | Fully done by DESY |

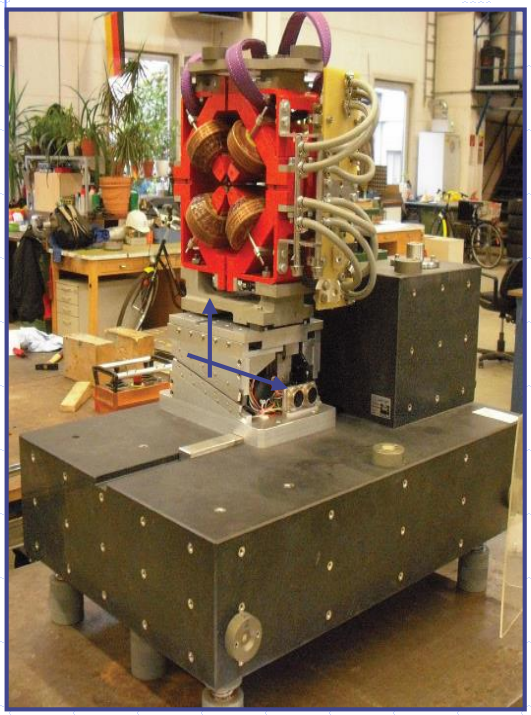
MECHANICS

# Moving Tables for E-XFEL



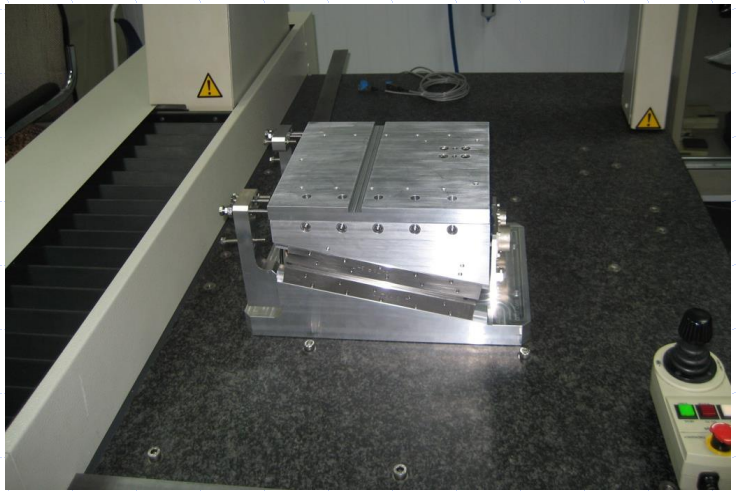





| Type | 2-axes Quadrupole Positioning Table |
|---|---|
| Range | ±1.5mm |
| Repetitivity | ≤1μm |
| Max Load to move | 70 kg |
| Technology | St.Steel & Aluminium. Closed Loop |
| Industrialization | YES: Different prototypes at CIEMAT & Industry<br>Series manufactured at Industry in two different batches. |

MECHANICS

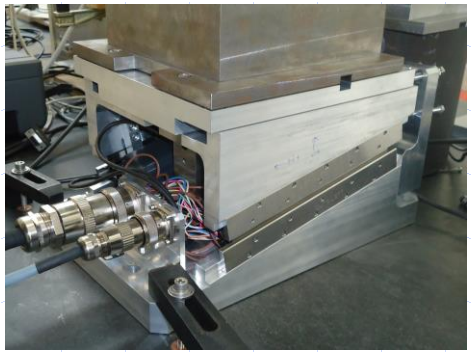
# Moving Tables for E-XFEL



CIEMAT Contribution to E-XFEL

MECHANICS

# Moving Tables for E-XFEL



| | |
|---|---|
| *CIEMAT Contribution* | 97 Quadrupole Moving Tables (**QMT**) for Intersections |
| *E-XFEL Contribution* | 4 QMT directly bought to the selected Spanish companies |
| *Recognized Contribution Value* | 2.433.300 € including QMTs & ICRs (Prices corresponding to 2005) |
| *Present Status* | Contribution finished |
| *Prototyping Phase* | 2 Prototypes built at CIEMAT with industrial collaboration. 5 Prototypes built at industry for pre-qualification > Improvements in the design & control system |
| *Tendering Process* | After Technical Specs. & Documents were issued by CIEMAT and approved by DESY , two tendering processes were launched. Production was split in two equal batches to reduce delivery time. One was awarded to RAMEN and the other to HTS. |
| *Fabrication at Industry* | Fabrication started May 2013 for a period of 24 months |
| *Delivery Schedule* | 2013 **10 QMT** //2014 **30 QMT** //2015 **9 QMT** (up to **4 QMT** per month) |
| *Quality Assessment Plan* | Done at the company and supervised by CIEMAT. |
| *Testing* | At the company using Tests Benches built by CIEMAT |
| *Installation & Commissioning* | Commissioned by CIEMAT @ Hamburg and installed by DESY |

# ICR for E-XFEL


| Type | Intersection Control Rack |
|---|---|
| Description | Control electronics for the Quadrupole Moving Tables and the Phase Shifter. |
| Dimensions | 1000 x 500 x 500 mm |
| Technology | Forced air cooling and high security cabling. Based on Beckhoff Modules. |
| Industrialization | YES Different prototypes at CIEMAT & Industry Series manufactured at Industry. |

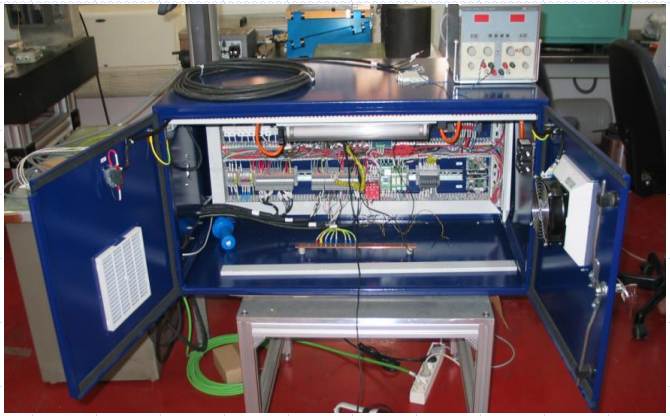
CIEMAT Contribution to E-XFEL

ELECTRONICS & INSTRUMENTATION

# ICR for E-XFEL

## CIEMAT Contribution to E-XFEL

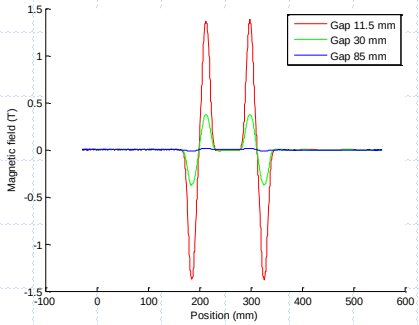
# ICR for E-XFEL

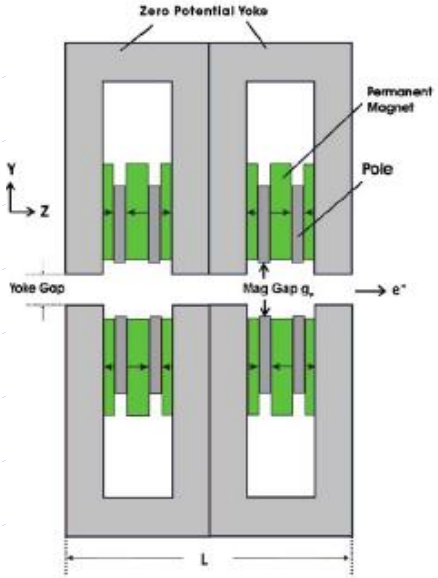


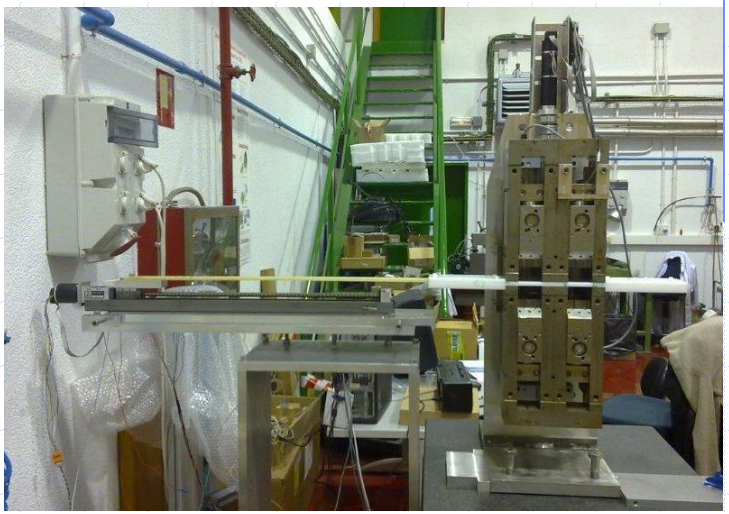

| | |
|---|---|
| *CIEMAT Contribution* | 97 Intersection Control Racks (**ICR**) for Intersections |
| *E-XFEL Contribution* | 4 ICRs directly purchased to the selected Spanish companies |
| *Recognized Contribution Value* | 2.433.300 € including QMTs & ICRs (Prices corresponding to 2005) |
| *Present Status* | Contribution finished |
| *Prototyping Phase* | During 2012, 4 Prototypes were built at industry to qualify companies > Improvements in the design & control system |
| *Tendering Process* | After Technical Specs. & Documents were issued by CIEMAT and approved by DESY , a tendering processes was launched. Contract was awarded to PINE. |
| *Fabrication at Industry* | Fabrication started January 2014 for a period of 13 months |
| *Delivery Schedule* | 2013 **2 ICR** //2014 **92 ICR** //2015 **4 QMT** (up to 8 **ICR** per month) |
| *Quality Assessment Plan* | Done at the company and supervised by CIEMAT. |
| *Testing* | At the company using a Test Bench built by CIEMAT |
| *Installation & Commissioning* | Commissioned by CIEMAT @ Hamburg and installed by DESY |

SPECIAL MAGNETS

# Phase Shifters for E-XFEL

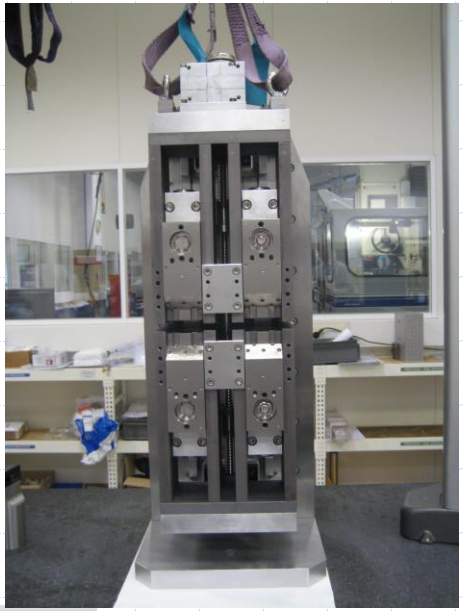


| Type | Rare Earth Permanent Magnet |
|---|---|
| First Field Integral | ≤0.004 Tmm |
| Second Field Integral | ≤0.67 Tmm$^2$ |
| Gap | 10.5 ÷ 100 mm |
| Technology | NbFeB Magnets + Pure Iron Yoke. Controlled air gap with stepping motors |
| Industrialization | YES: Different prototypes at CIEMAT & Industry |

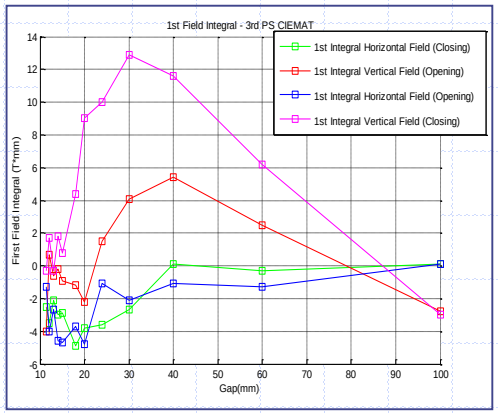
# Phase Shifters for E-XFEL



ELECTRONICS & INSTRUMENTATION

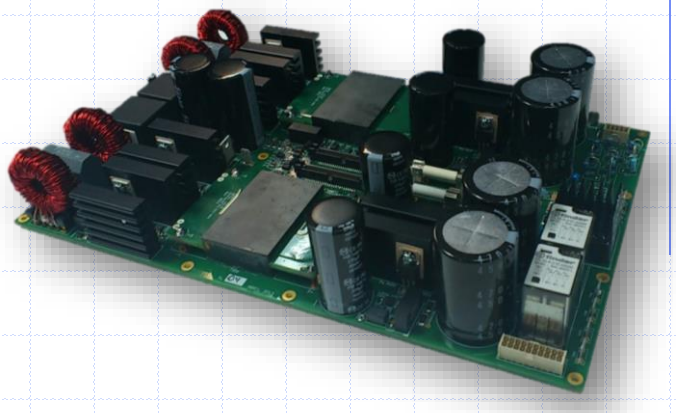
## CIEMAT Contribution to E-XFEL

# Phase-Sifters for E-XFEL




| | |
|---|---|
| *CIEMAT Contribution* | Initially 91 Phase Sifter Magnets (**PSM**). Finally 3 Protptypes done & intense R&D Activities |
| *E-XFEL Contribution* | None |
| *Recognized Contribution Value* | 510.000 € (for the partial contribution) |
| *Present Status* | Contribution failed |
| *Prototyping Phase* | 3 **PSM** Prototypes were made before 2010 at CIEMAT & Industry > Best results for the 1st Integral were above 6 mTmm. In 2011 XFEL imposed a Panel review to analyse the situation since there was a significant delay in the initial schedule, and specifications could not be achieved. Panel suggested XFEL to relax specifications since they seemed to be clearly beyond a reasonable state of the art. The recommendation was only partially admitted by them. Finally CIEMAT committed to supply **PSM**s with a 1st Field Integral above 10 mTmm for a series production and this was rejected by XFEL, being the end of the contribution. |

# Power Supplies for the Superconducting Combined Magnets

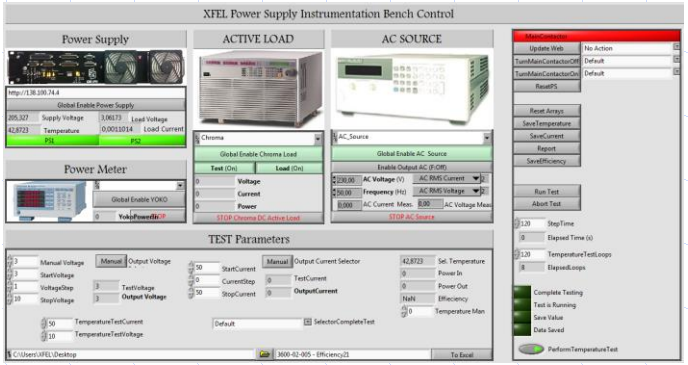
The Centro de Electronica Industrial (CEI) from the UPM is also contributing to E-XFEL with the following delivery

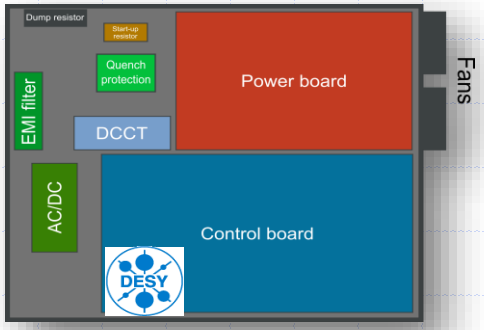
| Type | Bipolar Power Supply |
|---|---|
| Output voltage | ± 10 V |
| Output Current | ± 50 A |
| Technology | Switch-Mode MOSFET-based Converters @ variable commutation frequency & PBC transformer |
| Industrialization | YES Different prototypes at UPM (CEI) & Industry Series manufactured at Industry |

ELECTRONICS & INSTRUMENTATION

## Universidad Politécnica de Madrid Contribution to E-XFEL

# Power Supplies for the Superconducting Combined Magnets



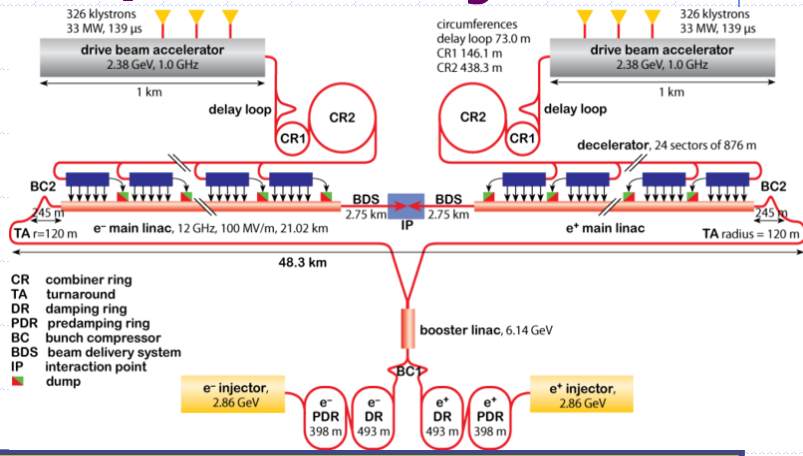

| | |
|---|---|
| *UPM Contribution* | 240 Power Supplies (**PS**) for the SC Combined Magnets |
| *E-XFEL/DESY Contribution* | 240 Control Boards to be integrated in the Power Supplies |
| *Recognized Contribution* | 1.448.000 € (Prices corresponding to 2005) |
| *Present Status* | 20 Prototypes **PS** for evaluation to be done at CEI |
| *Prototyping Phase* | 5 Prototypes already built at the CEI |
| *Tendering Process* | After Technical Specs. & Documents were isssued by CEI, a tendering process was launched, 4 companies competed, being BTESA selected. |
| *Fabrication at Industry* | 250 (240 + 10 spares) Units to be built at BETESA under supervision of CEI. |
| *Delivery Schedule* | 2015/07 **Quality Plan** // 2015/10 **20 PS** //2015/12 **80 PS** //2016/02 **150 PS** |
| *Quality Assesment Plan* | Defined by CEI, developed by BTESA, followed-up by CEI |
| *Testing* | Critical component testing & complete Power Supply testing @ BTESA. Test bench developed by CEI |
| *Installation & Commissioning* | Commissioning @ XFEL by CEI. Final Installation including magnet connection by DESY |

# *The CLIC Project*

# The CLIC/CTF3 Project

CLIC/CTF3

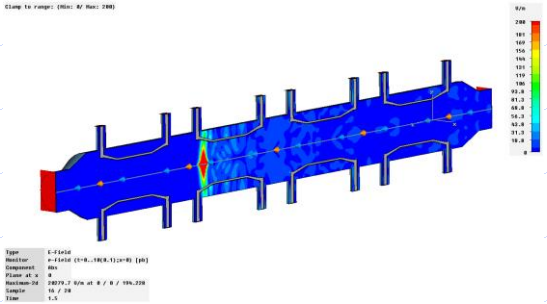
CLIC is a proposal for an up to 3TeV Linear Collider, which is based on a two beam scheme to achieve the required accelerating gradients. It uses non superconducting radiofrequency components which are called PETS for the drive beam and Accelerating Structures for the main beam. A validating test facility called CTF3 has already been successfully operated.

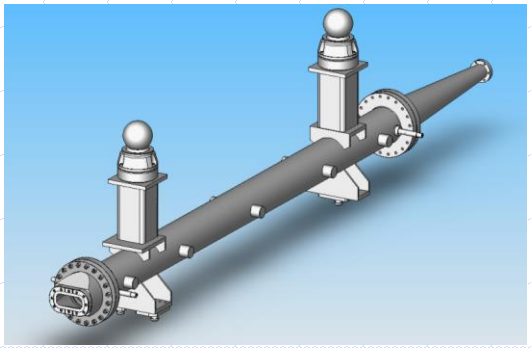


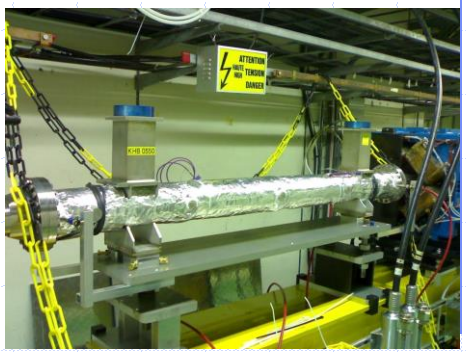

| Present CIEMAT contribution to CTF3/CLIC | | |
|---|---|---|
| **COMPONENT** | **TYPE** | **QUANTITY** |
| Septa Extraction Magnets | Resistive Magnet | 2 |
| Corrector Window-Frame Dipole | Resistive Magnet | 15 |
| Moving Tables (Movers) | Mechanics | 15 |
| Tail Clipper Kicker & Fast Kicker | Special Magnet | 1+1 |
| Kicker for CLIC Damping Ring | Special Magnet | 1 |
| Power Extraction Transfer Structures (PETS) for TBL | RF | 12 (Partial Contrib.) |
| Double Length PETS for CLIC | RF | 1 |
| **Future CIEMAT contribution to CLIC** | | |
| Accelerating Structures | RF | TBD |
| Longitudinally Variable Field Dipole | Hybrid Magnet | TBD |

SPECIAL MAGNETS

# Kickers for CTF3







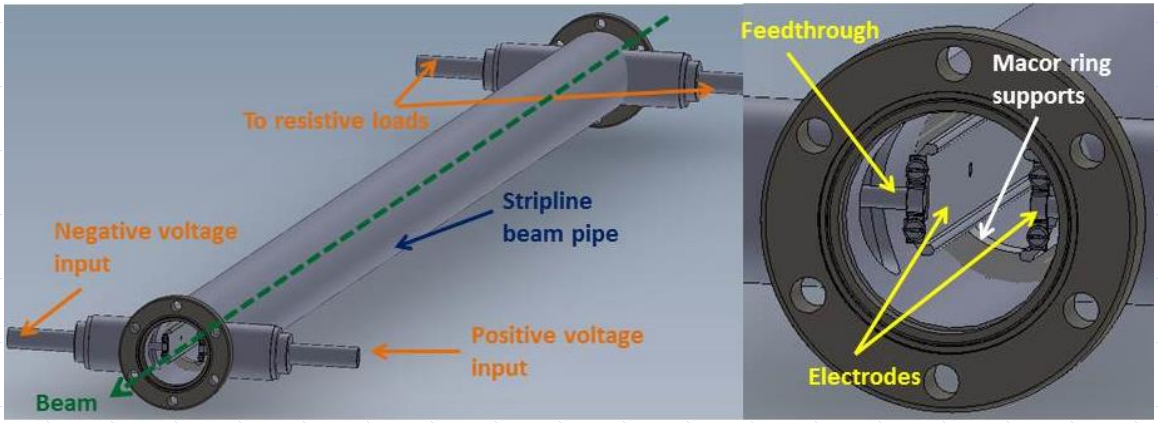
Extraction kicker

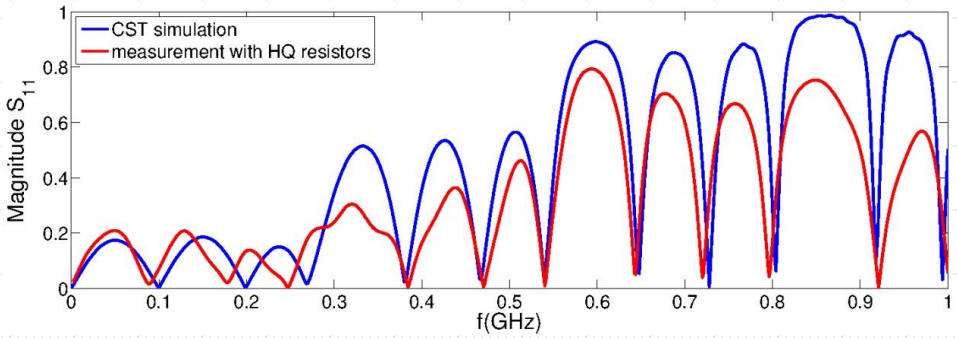
Tail Clipper

| Type | Strip-Line Extraction kicker | Strip-Line Tail Clipper |
|---|---|---|
| Nº of Modules | 1 | 4 |
| Deflection | 5 mrad | 1.2 mrad |
| Rise time | ≤70 ns | ≤5ns |
| Length | 2000 mm | 4 x 1625 mm |
| Op. Voltage | 14.4 kV | 4 x 2 kV |
| Technology | Full Stainless Steel Tapered Ends Transmission Line | |
| Industrialization | YES: Prototypes partially made at Industry | |

SPECIAL MAGNETS

# Kickers for CLIC Damping Rings (in collaboration with IFIC)

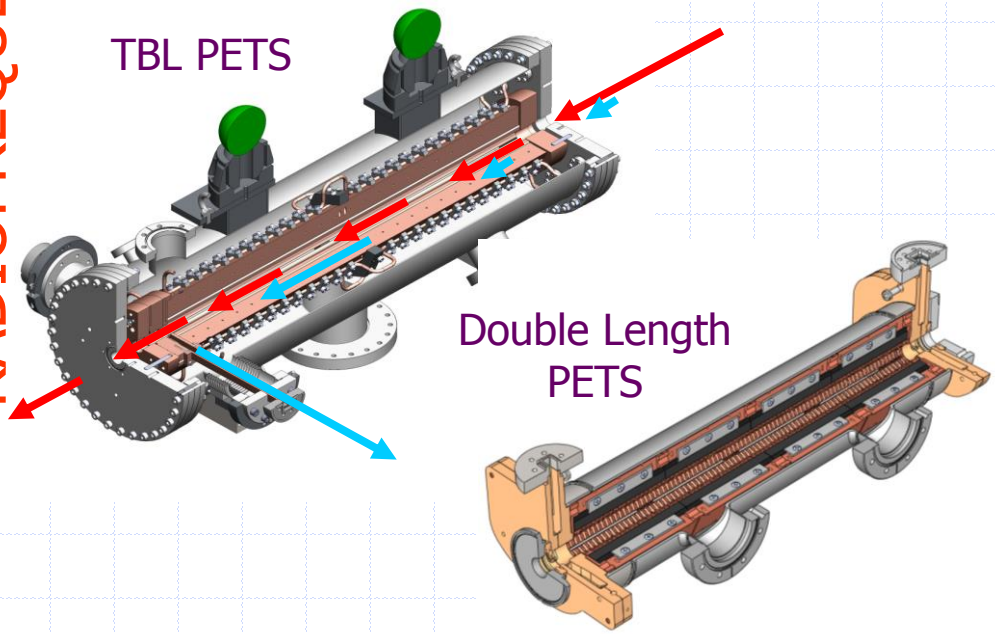


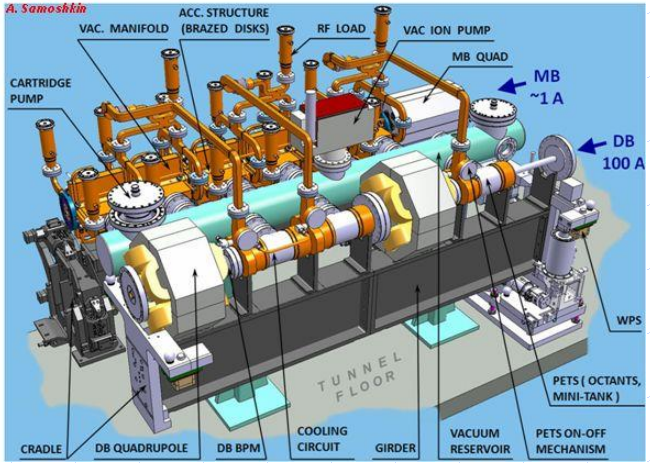




| Type | Damping Ring |
|---|---|
| Nº of Modules | 1 |
| Deflection | 1.5 mrad |
| Rise time | ≤560 ns |
| Effective length | 1700 mm |
| Op. Voltage | ±12.5 kV |
| Technology | Stripline |
| Industrialization | YES: Prototype made at Industry |

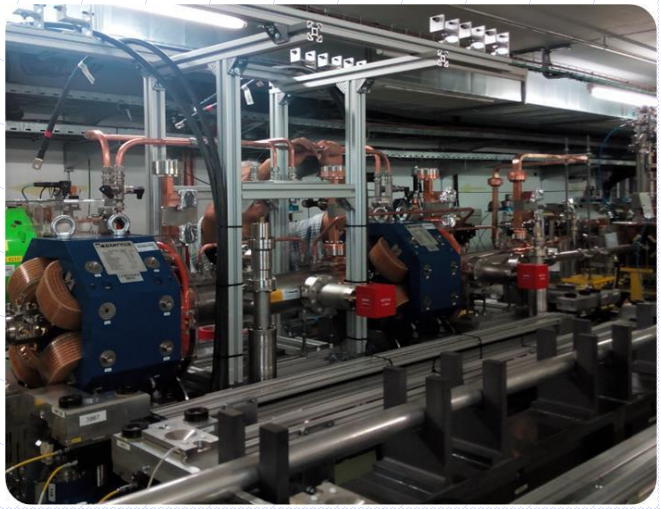
RADIOFREQUENCY

# Power Extraction Transfer Structures (PETS) for CLIC




| Type | TBL PET | Double Length PET |
|---|---|---|
| Op. Frequency | 12 GHz | 12 GHz |
| Length | 4 x CLIC | 2 x CLIC |
| Technology | Warm in Octants | Warm in Octants: Minitank, Integrated Couplers |
| Industrialization | YES: Partial Supplies by Industry | |



# *The LHC Upgrade*

# The LHC Upgrade

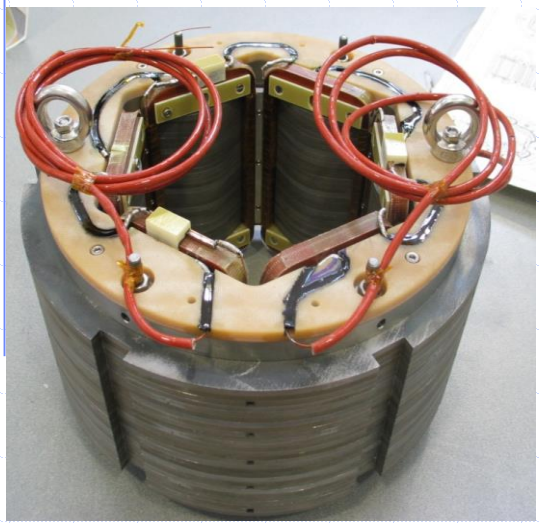
LHC Upgrade

In a first phase, LHC has been working at 8 TeV and 75% of its nominal luminosity. After a 2 year shutdown, luminosity will be increased to 100% and energy to 14 Tev. From 2018 to 2021 it is foreseen to increase the luminosity to 200% and after 2023, it should be increased again by a factor of 5 to 10, after significant changes in the machine.

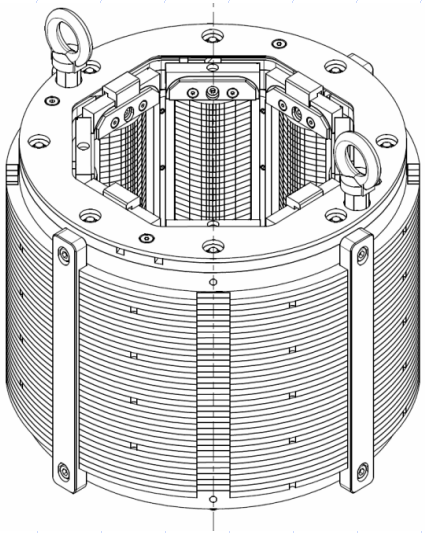

| Present CIEMAT contribution to LHC Upgrade and Hi Lumi LHC | | |
|---|---|---|
| **COMPONENT** | **TYPE** | **QUANTITY** |
| Radiation Resistant SC Sextupole Corrector Magnet | SC Magnet | 1 |
| Radiation Resistant SC Octupole Corrector Magnet | SC Magnet | 1 |
| Participation in the Cabling for the LHC Long Shutdown | Manpower | 8 man-year |
| Development of a Nested Dipole | Superconductor | 1 Prototype |
| Participation in the development of Superconducting Links | HTc Superconductor | Prototyping |
| Participation in the development of a Static VAR Compensator | Solid State | Prototyping |

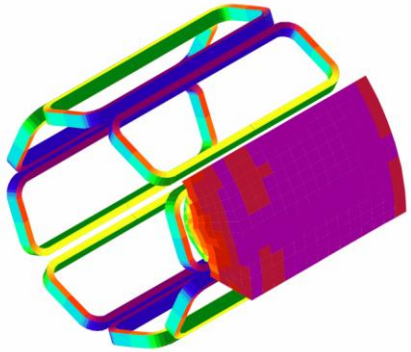
SC MAGNETS

# Superconducting Magnets for LHC Hi-Lumi

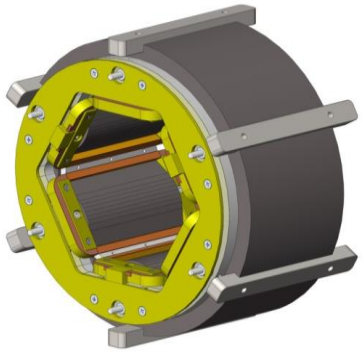


Sextupole





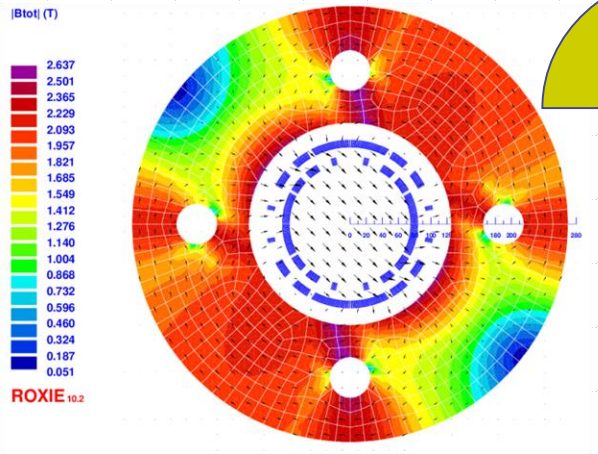
Octupole

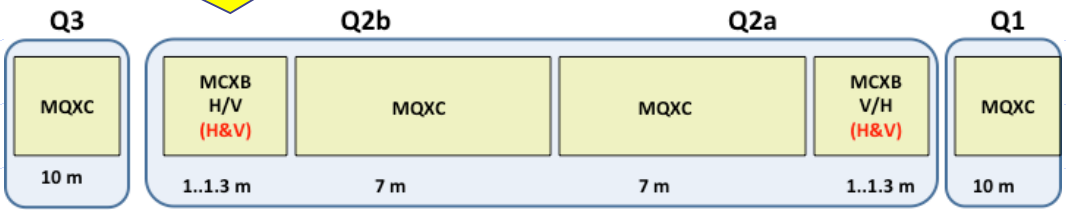


| Type | Sextupole | Octupole |
|---|---|---|
| Integrated Field | 0.055 Tm | 0.035 Tm |
| Physical Length | 160 mm | 160 mm |
| Op. Current | 100 A | 100 A |
| Technology | NbTi Superferric | NbTi Superferric Rad. Resistant |
| Industrialization | HI Lumi LHC Magnets will be based on this development | |

SC MAGNETS

# Superconducting Magnets for LHC Hi-Lumi




## **MCBXS H&V** Combined Corrector Dipole

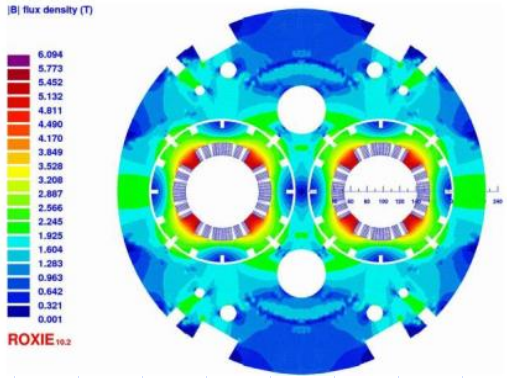
| Type | Combined Corrector Dipole |
|---|---|
| Integrated Field | 2.5 Tm |
| Physical Length | 1200 mm |
| Aperture | 150 mm |
| Technology | Nested NbTi Coils @ 1.9K |
| Industrialization | Yes (TBD) |

| UPDATED MILESTONES | |
|---|---|
| Feb 2015 | Conceptual Desing |
| Sep 2015 | Fabrication Drawings |
| Sep 2016 | 1st Prototype Finished |
| Feb 2017 | Tests @ CERN |
| CERN: 50% Personnel & 100% Materials<br>CIEMAT: 50% Personnel & 100 % Tooling | |

# The QUACO Project

The QUACO project draws together several research infrastructures with similar technical requirements in magnet development, which will allow the avoidance of unnecessary duplication of design effort and reduce overall cost through economies of scale using a **joint procurement process**. By pooling efforts, the partners in QUACO will act as a single buyer group with sufficient momentum for potential suppliers to consider the phased development of the requested magnets. QUACO's goal is to create a paradigm shift in the industrialization of the new generation of superconducting magnets.

QUACO Project is a self-contained and consistent part of the High Luminosity LHC Project, focusing on the design, development and procurement of superconducting magnets.
The final result of the project will be 2 pilot magnets necessary for HI-LUMI LHC.




**Participants:**

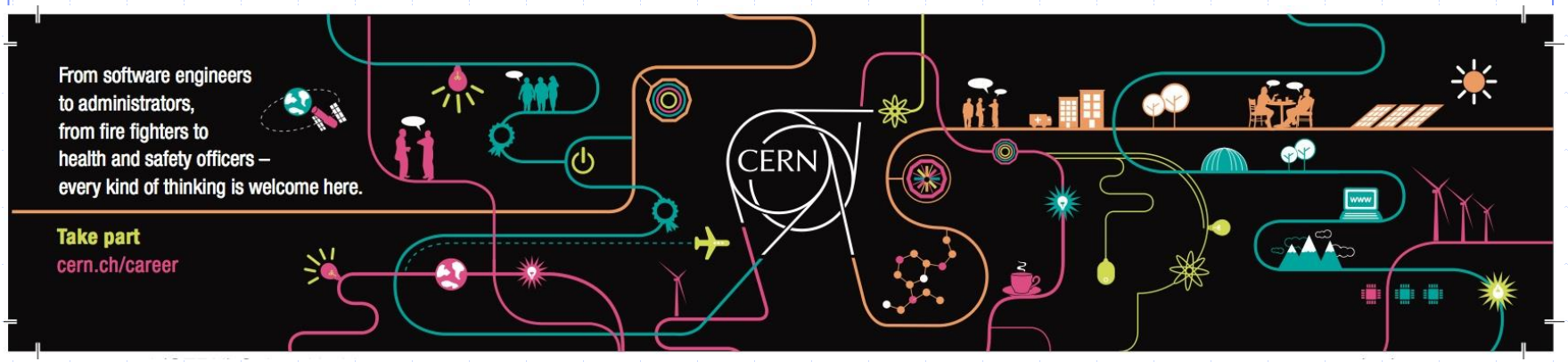
1) The European Organization for Nuclear Research (CERN),
2) Commissariat A L'Energie Atomique Et Aux Energies Alternatives (CEA),
3) Centro de Investigaciones Energéticas, Medioambientales Y Tecnológicas (CIEMAT),
4) Narodowe Centrum Badan Jadrowych (NCBJ).

**Funding:**

Total cost in the proposal 6,647,895.00 €
Maximum grant amount 4,653,523.88 €

# The FTECs Program

The FTEC (Formacion en las TEcnologias del CERN) Trainee Programme has been established through a bilateral agreement between CERN and CIEMAT with the contribution of the SEIDI from the Ministerio de Economía y Competitividad, as well as the CDTI.



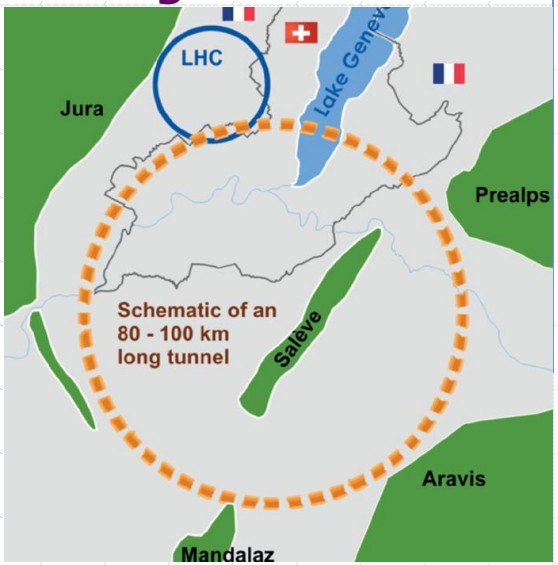

This programme is aimed at recent graduates from university or higher technical institutes seeking further training in a wide area of projects. Selected trainees will join a team working at CERN and have the opportunity to enlarge their knowledge through participation in the hi-tech activities of the laboratory, in fields such superconducting and resistive magnets, power converters and their associated electronics, cryogenics and vacuum technologies and electronics for detectors, including radiation resistance issues, and related activities on infrastructures with a potential industrial return.

# *The FCC Project*

# The FCC Project



CERN has recently launched a feasibility conceptual study for post-LHC particle accelerator options, considering the technology research and development programs that would be required to build a future circular collider in the range of 100 TeV. Among other initiatives, an international collaboration called EuroCirCol has been awarded with a H2020 grant to address the main issues of the future machine.




| Present CIEMAT contribution to the EuroCirCol Project (FCC) | | |
|---|---|---|
| **WorK Package** | **WP Description** | **CIEMAT Contribution** |
| WP1 | Management, Coordination and Implementation | -- |
| WP2 | Arc Design: Conceptual design of the largest fraction of the collider ring | -- |
| WP3 | Design of the experimental insertion regions | -- |
| WP4 | Design of the cryogenic beam vacuum system considering the enormous synchrotron radiation level | 4,5 person·year |
| WP5 | High-Field superconducting magnet design for fields up to 16T | 4,0 person·year |

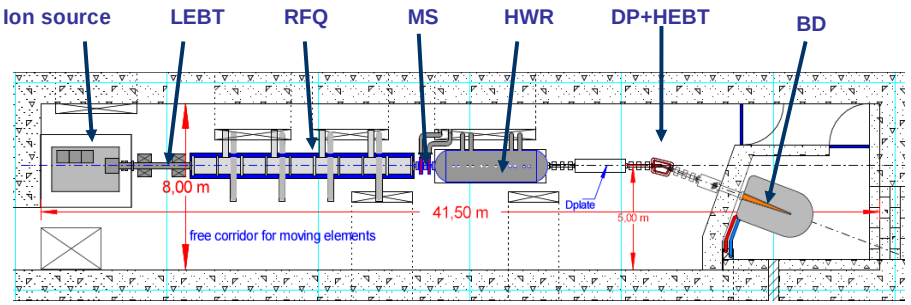
# *The IFMIF Contribution*

# The IFMIF Project

IFMIF

The Division also collaborates in the IFMIF project: a 40 MeV, 125 mA deuteron accelerator acting on a lithium target to generate neutrons to test materials for the first commercial fusion reactor : the DEMO. To validate the IFMIF concept, the so called EVEDA phase has been launched, including a Linear Accelerator (LIPAc) with a current of 125 mA and an energy of 9 MeV.

## IFMIF-EVEDA Accelerator

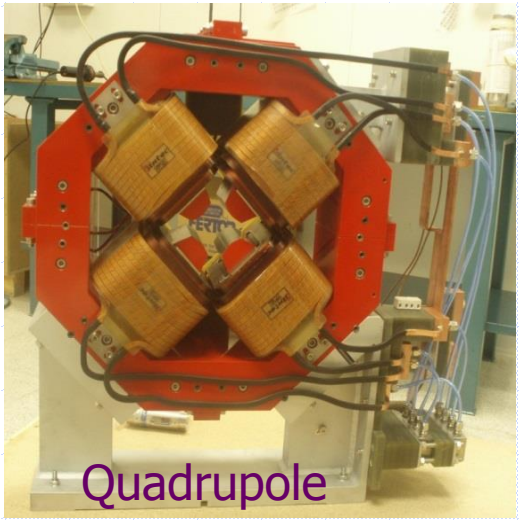


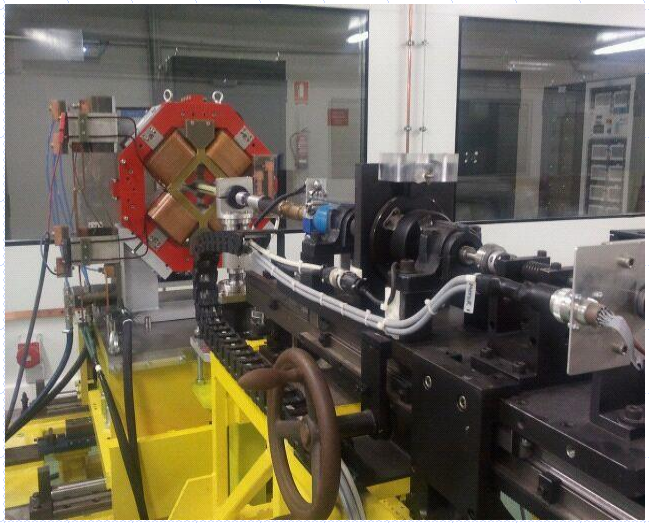

| Present CIEMAT contribution to IFMIF-EVEDA | | |
|---|---|---|
| **COMPONENT** | **TYPE** | **QUANTITY** |
| Solenoid Magnets for the DTL | SC Magnet | 8 |
| Bunchers for the Matching Section | RF | 2 |
| Quadrupoles & Steerers for the MEBT | Resistive Magnets | 13 |
| Scrapers for the MEBT | Mechanics | 2 |
| **Possible Future CIEMAT contribution to IFMIF (Full-Scale)** | | |
| Activities for Future Fusion Accelerators within the TAPIC Project | RF, Simulation, etc. | N/A |

# Resistive Magnets

RESISTIVE MAGNETS

## Resistive Magnet for LIPAc



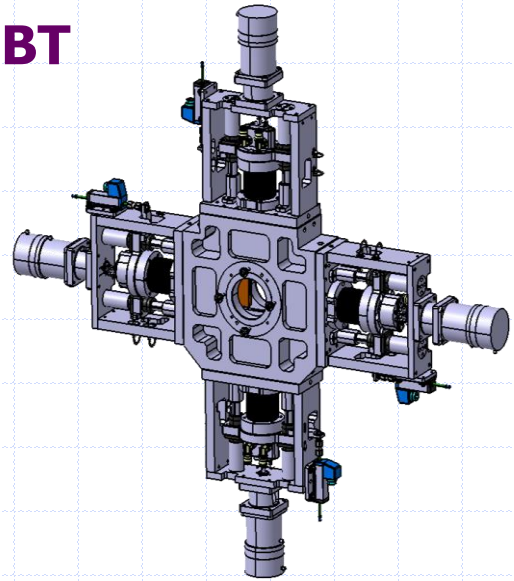



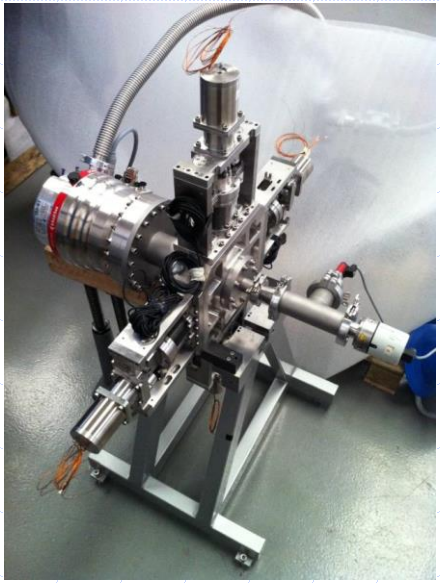
| Type: Combined | Quadrupole | Dipole |
|---|---|---|
| Integrated Field | 0.068 ÷ 0.163 Tm | 3.51 mTm |
| Inner Diameter | 56 ÷ 136 mm | |
| Op. Current | 178 ÷ 313 A | 50 A |
| Technology | Water Cooled<br>Radiation Resistant | Air Cooled<br>Radiation Resistant |
| Industrialization | YES, first 5 units already made by ANTEC | |

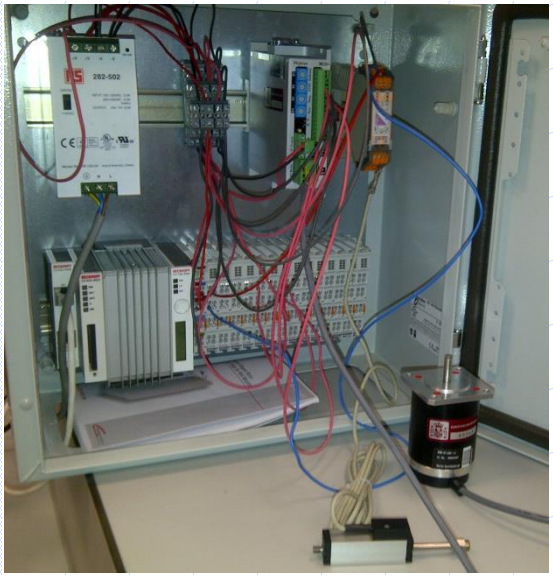
# Mechanics (2)

MECHANICS

## Scrapers for LIPAc MEBT





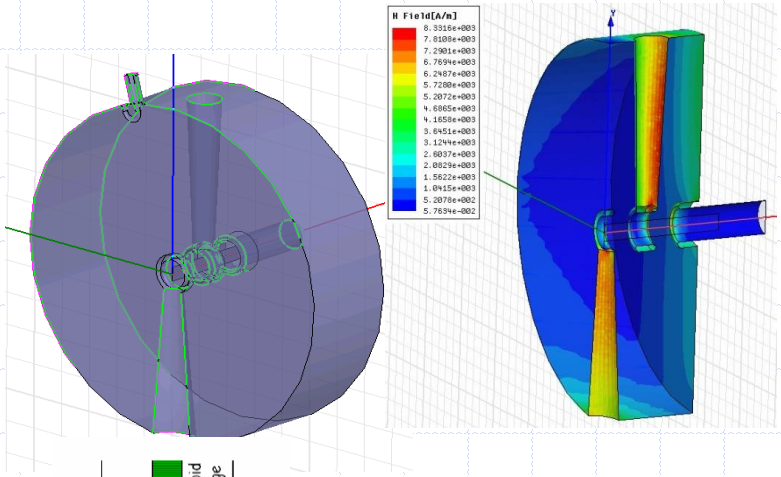


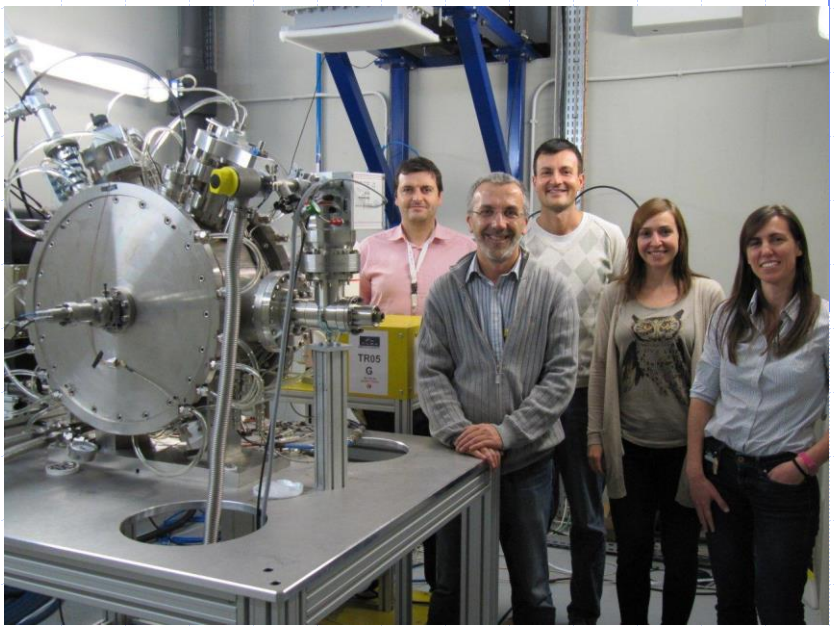
| | |
|---|---|
| Type | 4-Collimator Scraper |
| Displacement Range | 21mm |
| Movement Precision | 20 µm |
| Max Dissip .Power | 4 x 500 W |
| Technology | Water-cooled, Step motor controlled in closed loop |
| Industrialization | YES: First Prototype at AVS finished. The Second one in fabrication |

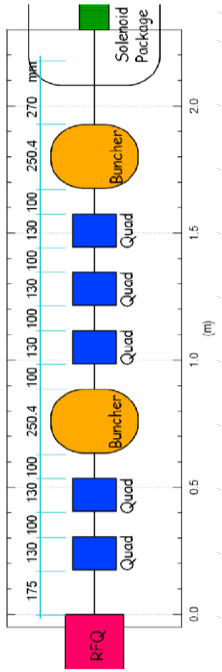
# Radiofrequency (2)

RADIOFREQUENCY

## Buncher for LIPAc






Selected IH-Type Resonator

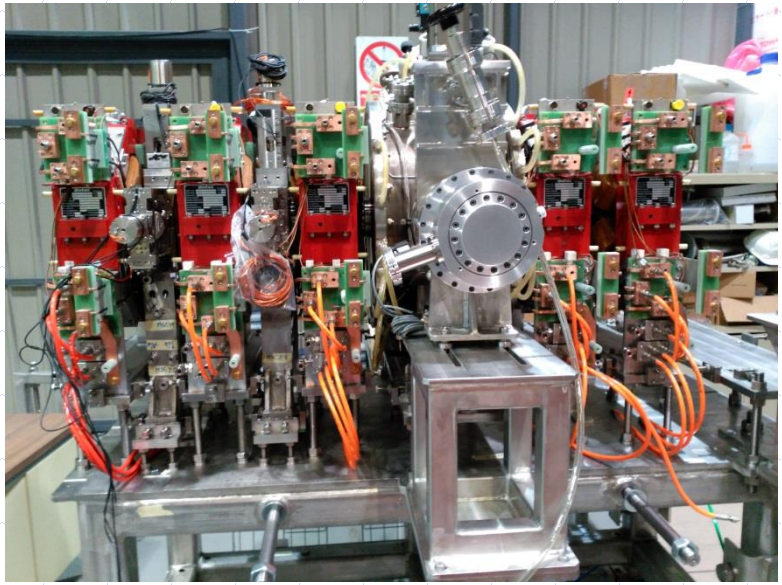
| | |
|---|---|
| Type | IH Resonator, 4 Acceleration gaps |
| Frequency | 175 MHz |
| Peak Electric Field | 24 kV |
| Max Dissip. Power | ≤100 kW |
| Technology | Resistive, Water-cooled, |
| Industrialization | YES: First Prototype already done at DMP |

# Integration Activities

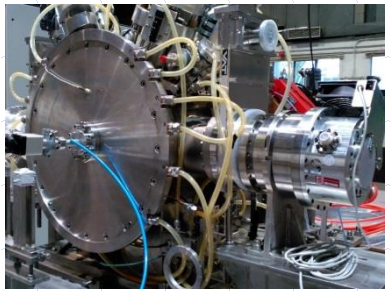
## Medium Energy Beam Transport Line (MEBT):

- Compact transport line between RFQ and cryomodules
- Main components: Five combined magnets, two buncher activities, beam scrapers and beam diagnostics.
- Fully designed by CIEMAT; manufactured by Spanish industry
- **MEBT ready to be sent to Rokkasho: end of January 2016**

***MEBT***

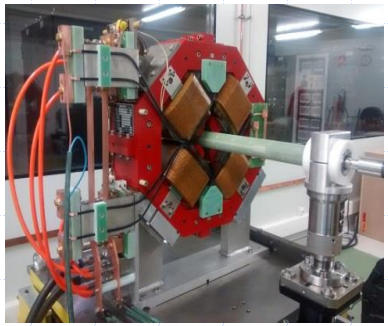


***Buncher cavity***

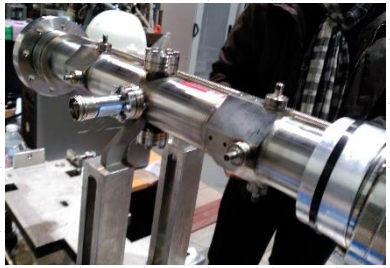


***ZScrapers***

***Combined magnets***



***Beam position monitors***

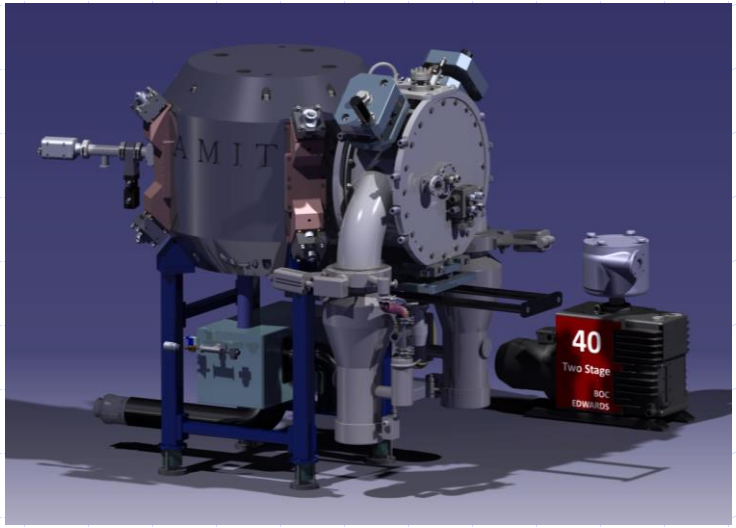


## Other ongoing activities:

- Solenoids for high energy accelerating part of LIPAC
- High Energy beam line: magnets, beam diagnostics, beam dynamics
- DONES accelerator: beam dynamics studies since October 2015

# *The AMIT Project*

# The AMIT Project

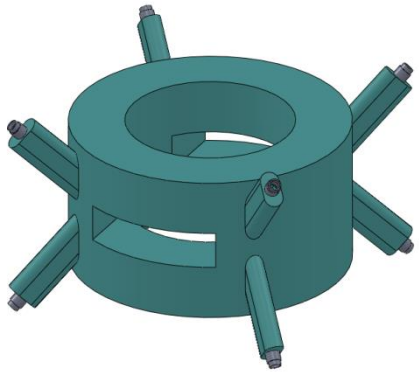


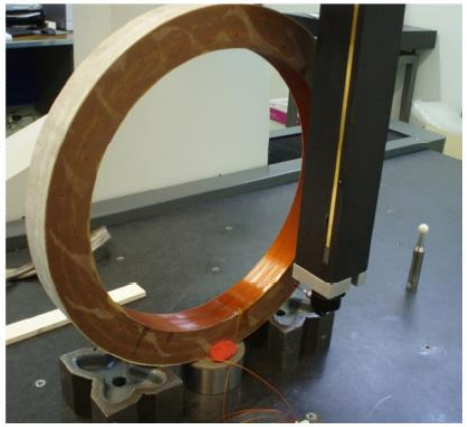

In 2010 the Project AMIT (Advanced Molecular Image Technologies) started. One of the Work Package assigned to CIEMAT consists of the development of a Compact Superconducting 8,5 MeV Cyclotron for $^{11}C$ and $^{18}F$ production. It includes the development and fabrication of the targets and the installation of the facility.

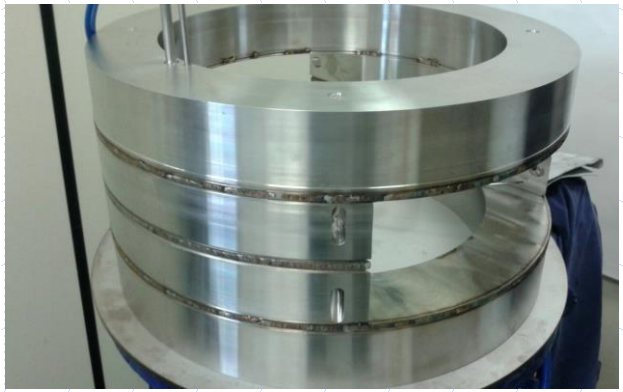
| Present CIEMAT contribution to AMIT | | |
|---|---|---|
| **COMPONENT** | **TYPE** | **QUANTITY** |
| Complete Superconducting Cyclotron Prototype | Accelerator | 1 |
| **Possible Future CIEMAT contribution to AMIT & Other Accelerators for Isotope Production** | | |
| Participation in Cyclotron Industrialization & Commercialization | Industrial Alliance | TBD |
| Participation with CERN in the development of a LINAC | Targets & RF | TBD |

SC MAGNETS

# Superconducting Magnet for AMIT







| | |
|---|---|
| Type: | 2 Solenoid in Hemholtz Coils Config. |
| Central Field | 4.0 T |
| Overall Diameter | 700 mm |
| Op. Current | 110 A |
| Technology | NbTi Wet Impregnation 2 phase helium cooling |
| Industrialization | YES: Prototype made at Industry under CIEMAT supervision |

CRYOGENICS

# Cryogenic Supply System for AMIT

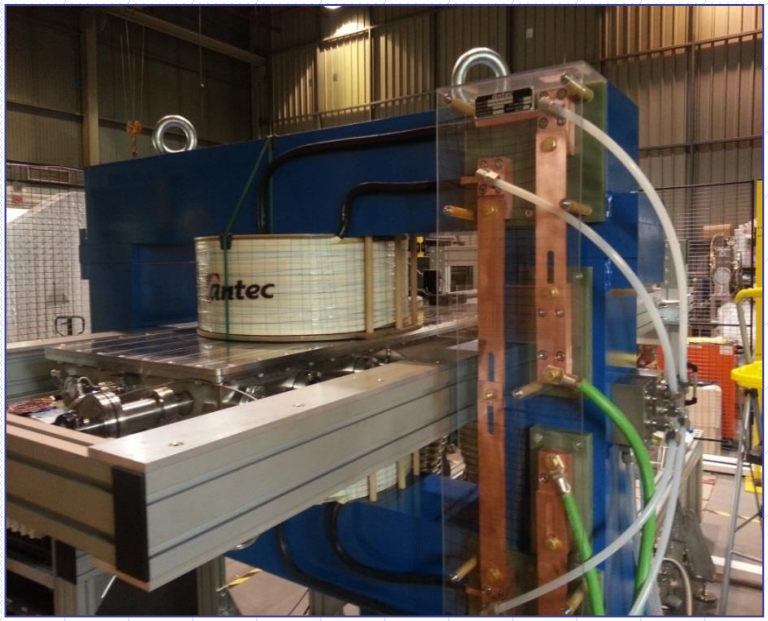
| Type: | Cryogenic Refrigerator for the AMIT Magnet |
|---|---|
| Max. Extracted Power | 1,0 W |
| Refrigeration | Two-Phase Helium @ 4,3K<br>Gas Helium @ 40-70 K |
| Technology | He recirculation in close circuit and re-condensation with a cryocooler |
| Industrialization | YES One prototype built @ CERN as contribution to the AMIT Project and a second prototype under construction at Industry |

# Experimental validation of AMIT cyclotron ion source

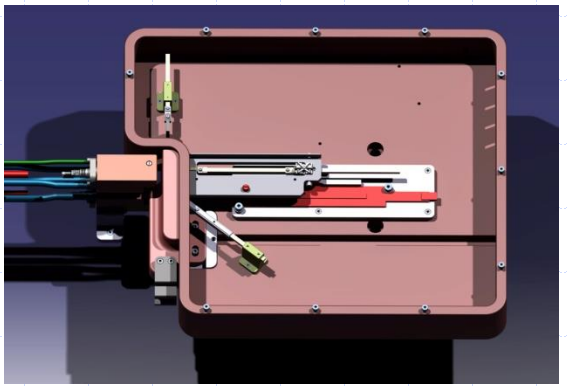
## Goals:

- ❑ To analyze the ion source behavior and improve the design
- ❑ Beam characterization and validation of beam dynamics calculations
- ❑ To reduce AMIT commissioning time (some other cyclotron components can also be tested at IST facility)
- ❑ Future: to provide a future ion source test facility open to external collaborations

Building 75




*Electrical shield box, beam probes, puller and ion source*



- ❖ The ion source is at ground whereas the puller, at positive DC high voltage, will extract the particles.
- ❖ An electrical shield box is installed inside the vacuum chamber. A beam probe, located according to $H^-$ trajectory, will measure the $H^-$ current
- ❖ Beam emittance will be measured with an interceptive method based on slits and wire monitors.

→ **Measurements are on going**

# *Summary of Technology Transfer & Conclusions*

# Summary of Industrial Participation

| COMPANY | SUPPLY | TYPE | QUANTITY |
|---|---|---|---|
| ALDERAN | Intersection Control Rack for E-XFEL | Electronics & Instrum. | 1 (prot.) |
| ANTEC | Combined Magnets for E-XFEL (magnet) | SC Magnet | 103 SERIES |
| ANTEC | Magnet for AMIT (magnet) | SC Magnet | 1 (prot.) |
| ANTEC | Quadrupole for IFMIF | Resistive Magnet | 1 (prot.) |
| APM | Moving Tables for E-XFEL | Mechanics | 1 (prot.) |
| AVS | Scrapers for IFMIF | Mechanics | 1 (prot.) |
| CRYOVAC | Cryostat for E-XFEL Magnet Prototype | Mechanics | 1 (prot.) |
| DMP-HTS | Moving Tables for E-XFEL | Mechanics | 49 SERIES |
| DMP-HTS | Buncher for IFMIF | Radiofrequency | 1 (prot.) |
| DMP-HTS | Phase Sifter for E-XFEL | Special Magnet | 1 (prot.) |
| DMP-HTS | PETS for CLIC/CTF3 | Radiofrequency | 1 (prot.) |
| ELYTT | Combined Magnet for E-XFEL | SC Magnet | 1 (prot.) |
| INABENSA | Intersection Control Rack for E-XFEL | Electronics & Instrum. | 2 (prot.) |
| INDEX | Moving Tables for E-XFEL | Mechanics | 1 (prot.) |
| NOVALTI | Moving Tables for E-XFEL | Mechanics | 1 (prot.) |
| PINE | Intersection Control Rack for E-XFEL | Electronics & Instrum. | 1 (prot.) |
| RAMEM | Moving Tables for E-XFEL | Mechanics | 49 SERIES |
| SINTERSA | Intersection Control Rack for E-XFEL | Electronics & Instrum. | 1 (prot.) |
| Utillajes HUERTA | LINAC for Racetrack Microtron | Radiofrequency | 1 (prot.) |
| Utillajes HUERTA | Moving Tables for E-XFEL | Mechanics | 1 (prot.) |
| Utillajes Huerta | PETS for CLIC/CTF3 | Radiofrequency | 1 (prot.) |
| TRINOS V. P. | Combined Magnets for E-XFEL (vessel) | SC Magnet | 103 SERIES |
| TRINOS V. P. | Magnet for AMIT (vessel) | SC Magnet | 1 (prot.) |
| TRINOS V. P. | Extraction Kickers for CTF3 (CLIC) | Special Magnet | 1 (prot.) |
| TRINOS V. P. | Tail Clipper Kicker for CTF3 (CLIC) | Special Magnet | 1 (prot.) |
| TRINOS V. P. | PETS for CLIC/CTF3 | Radiofrequency | 1 (prot.) |
| TRINOS V. P. | Beam Position Monitors for LIPAc | Mechanics | 4 |

# Conclusions

1.-CIEMAT Department of Technology has developed a significant technological activity in the field of particle accelerators for more than 25 years.

2.-These activities started for the LHC project, mainly focused on superconducting magnets with a clear and fruitful participation of the Spanish Industry.

3.-From 2010 to present days, CIEMAT has undertaken the technical activities of the Spanish contribution to the European XFEL, being in charge of delivering Superconducting Combined Magnets, Quadrupole Moving Tables and Intersection Control Racks in close cooperation with Industry.

4.-This contribution has been complemented with Power Supplies for the Superconducting Combined Magnets, lead by the Polytechnic University of Madrid (Centre for Industrial Electronics).

5.-CIEMAT is also participating in most of the CERN projects for future accelerators like CLIC, LHC Hi Luminosity or the Future Circular Collider

6.-There is also a significant and increasing activity at CIEMAT in the field of small and advanced accelerators.

# Thank you very much for your attention

luis.garcia@ciemat.es