

# Sigmaphi presentation

## Summary

- Companies
- Markets
- Products



# Sigmaphi

- For more than **40 years**, Sigmaphi team has been dedicated to **Particle Accelerator Technologies and Superconducting Magnets**
- Combining the best of **industrial world and research labs** to offer cost efficiency, reliability and high technology

# Group companies



- **Sigmaphi Magnets** :  
95% exported, 120 people, based in Vannes (Bretagne, France)



- **Sigmaphi China** :  
18 people, 100% Sigmaphi owned, based in Beijing; same quality and management as in our French facilities



- **Sigmaphi Japan** :  
sales branch in Tokyo (Japan)



# Our markets

## Physics research labs



CERN-LHC



Jefferson Lab



ESRF

## Hadrontherapy centers manufacturers



## Other industries

Ion implantation

Isotope production

Ion beam analysis

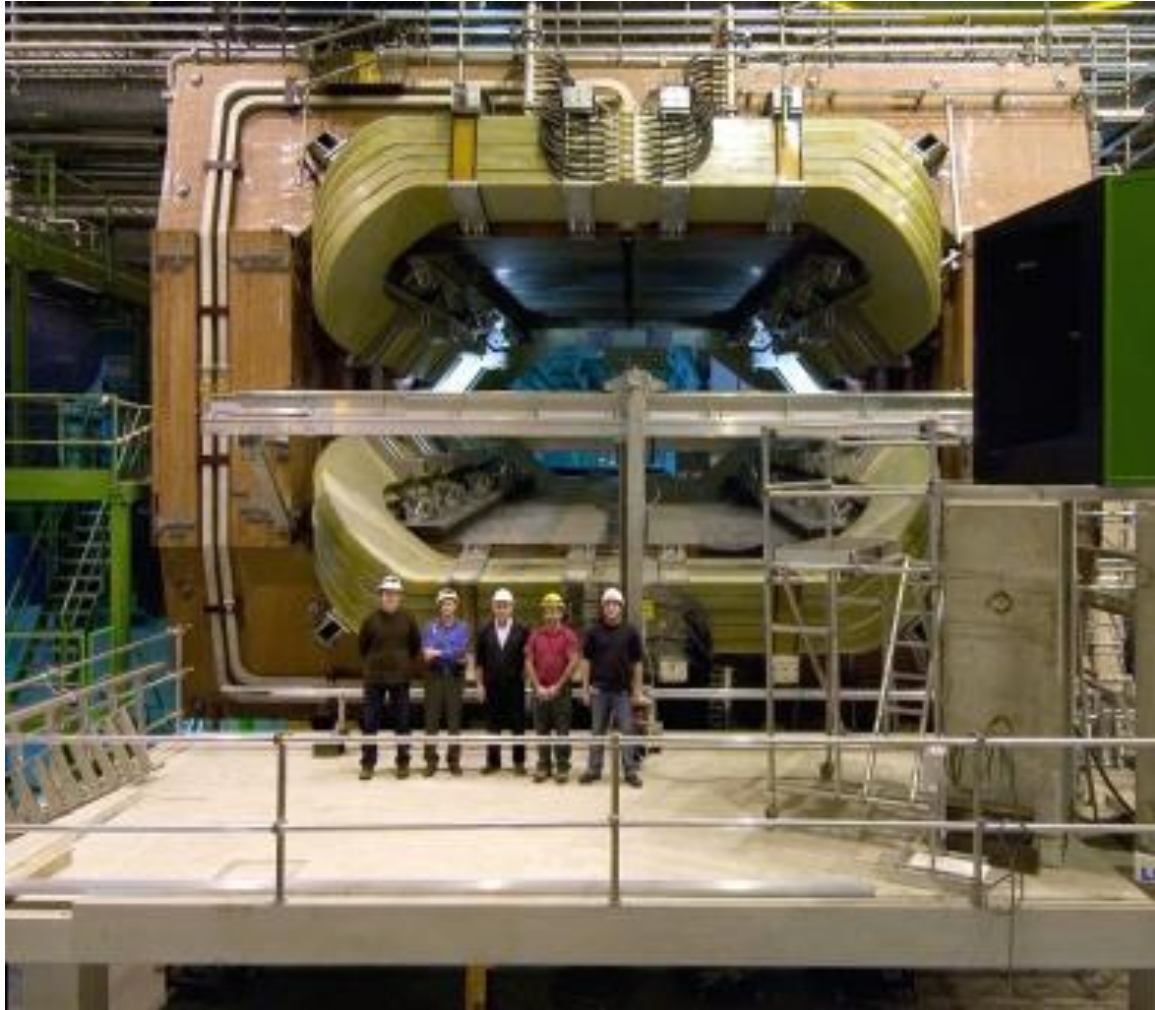
# Our products :

## Beamlines and equipments for particle accelerators

- **Resistive magnets**
- **Beamlines – turnkey systems**
- **Injection/extraction systems**
- **Permanent magnets**
- **Superconducting magnets**



# Resistive Magnets



**Sigmaphi team designs, manufactures, measures and installs any type of magnet**

- Dipoles, multipoles, solenoids, kicker, septum
- DC, AC, scanning magnets
- From 20kg to more than 100 tons
- With solid steel or laminated steel yoke (1mm, 0.5mm, 0.35mm, 0.23mm...)
- With plain enameled or hollow copper conductor (including oversized cross sections)
- Extreme environments resistant (heat, vacuum, radiations...)

# Resistive magnets



Quadrupoles – Elettra synchrotron (Trieste, Italy)



HESR Dipole FAIR (Germany)



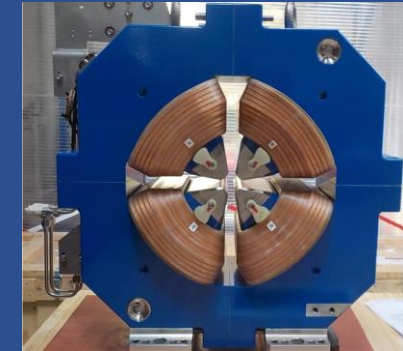
Sextupole – synchrotron SOLEIL (France)



Dipole – Carbon Therapy (CNAO, Italy)



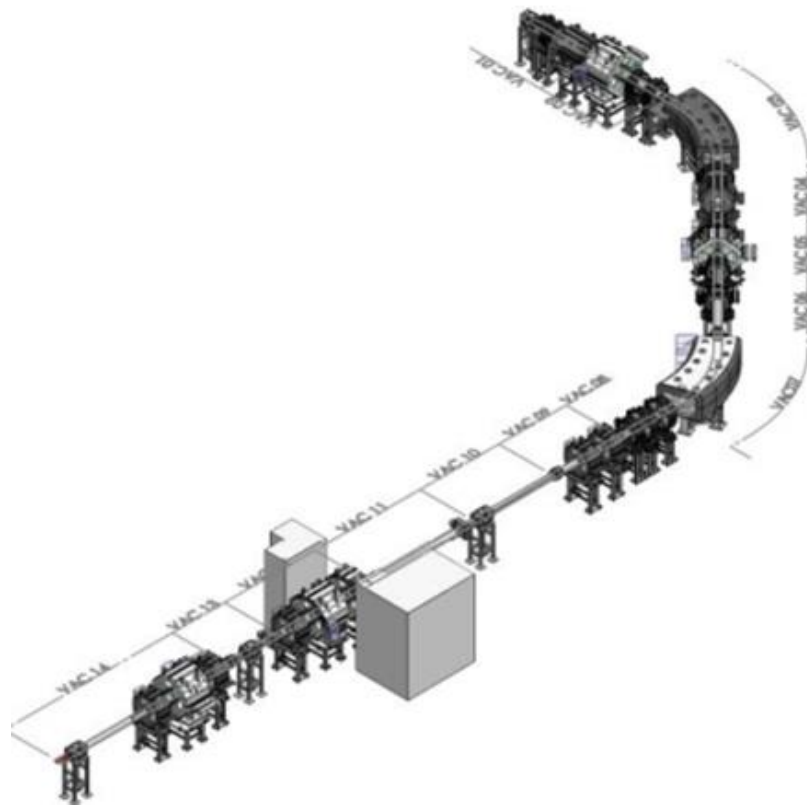
90° Dipole - MedAustron Protontherapy center (Austria)



Quadrupole doublet - ANL (USA)



# Particle beamlines / Turnkey systems



- Magnets
- Power supplies
- Vacuum
- Diagnostics and control
- Installation



ACCULINA (JINR) 70m heavy ion beamline



# Other beamlines



Protontherapy short beamline



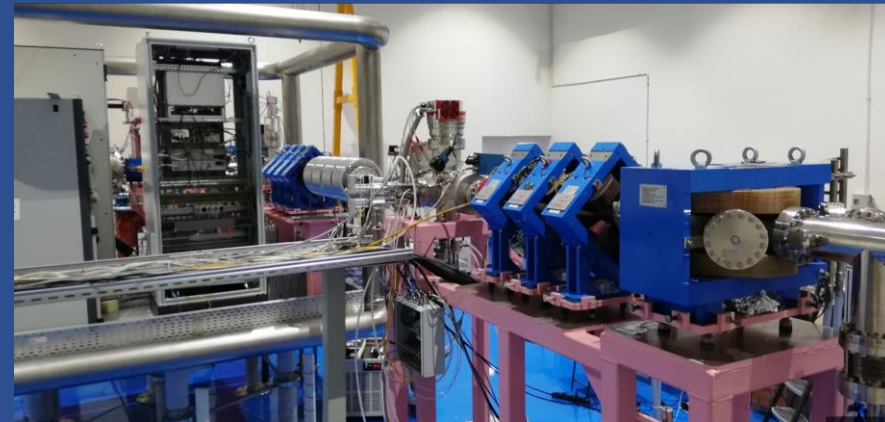
ELI energy selection system



JINR (Russia) He gas filled separator GFS-II



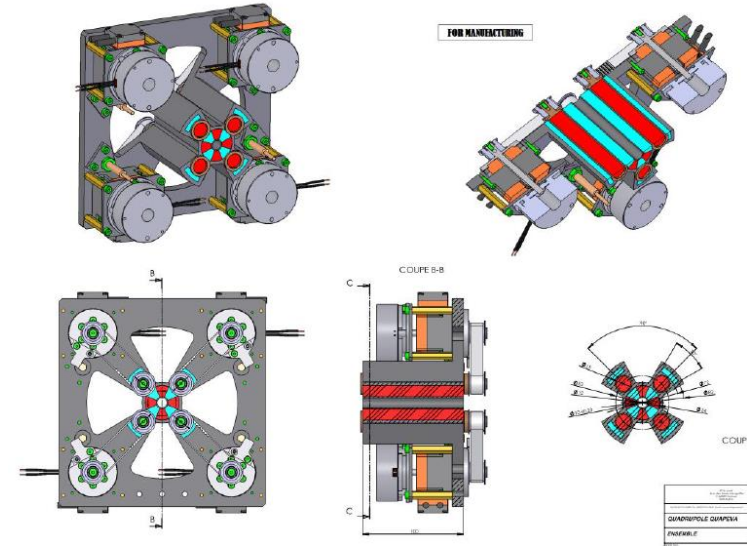
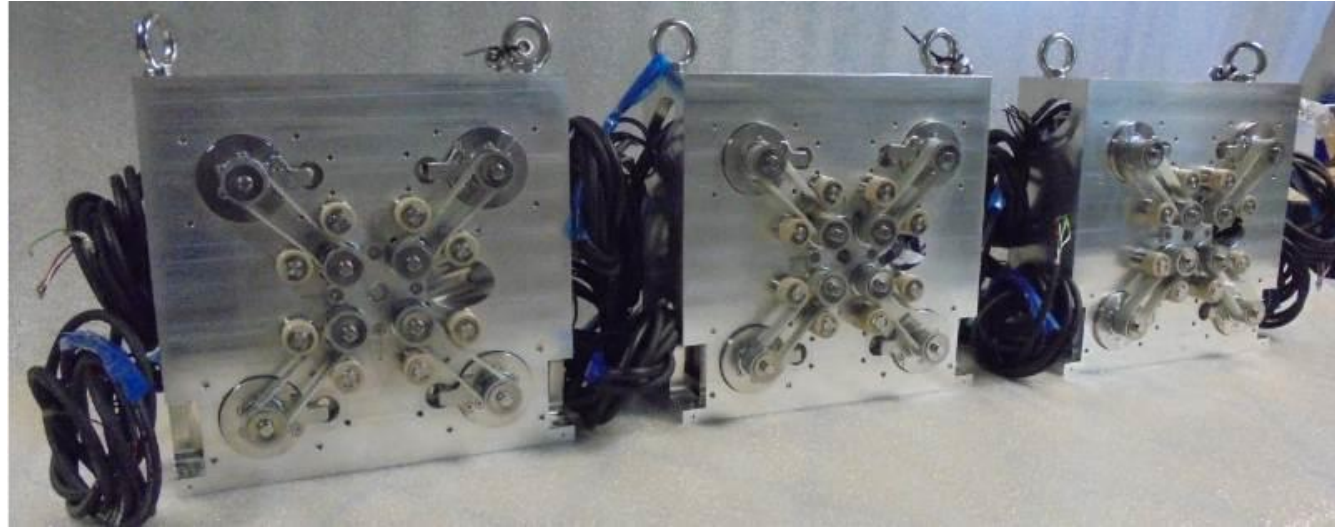
R&D beamline, Manchester Hospital (UK)



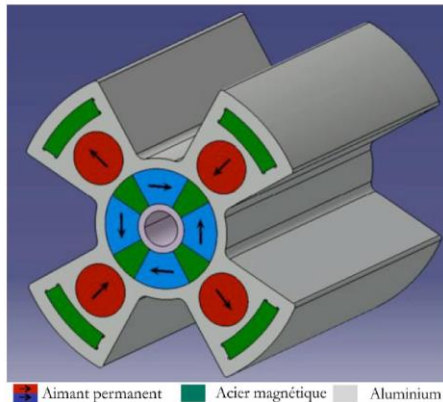
Institute for Plasma Research (India) 300 kV HV deck & beamline



# Permanent magnets



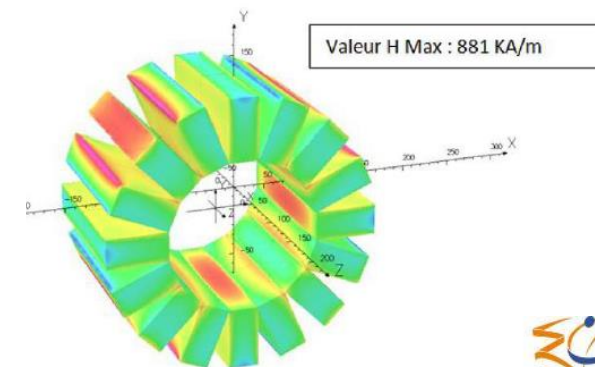
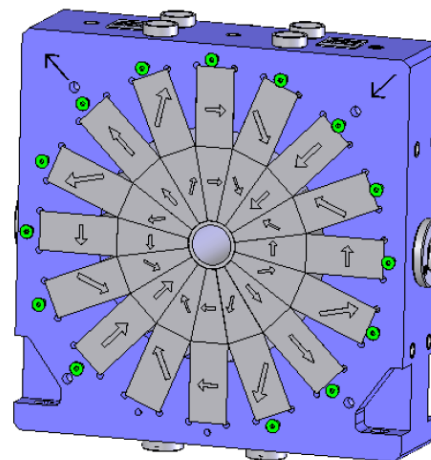
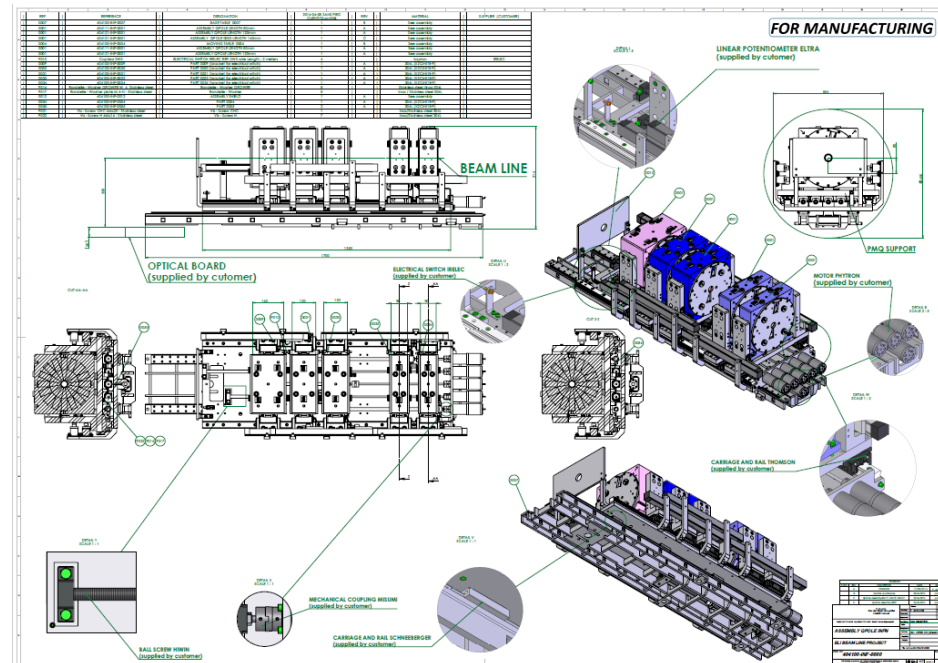
In vacuum Permanent Quadrupole with adjustable gradient for  
**SYNCHROTRON SOLEIL**  
 Gradient 100 T/m - 200 T/m – Bore 6 mm



# Permanent magnets



In vacuum Permanent Quadrupoles with displacement system for INFN ELI Gradient 100 T/m- Bore 36 mm





# Kicker magnets for FAIR - CRYRING

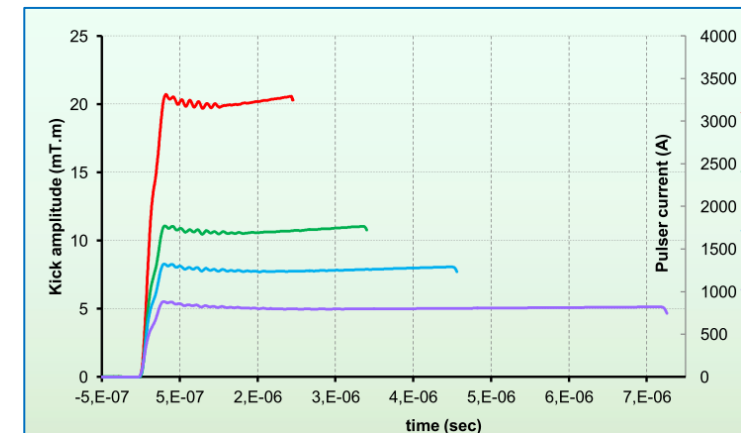
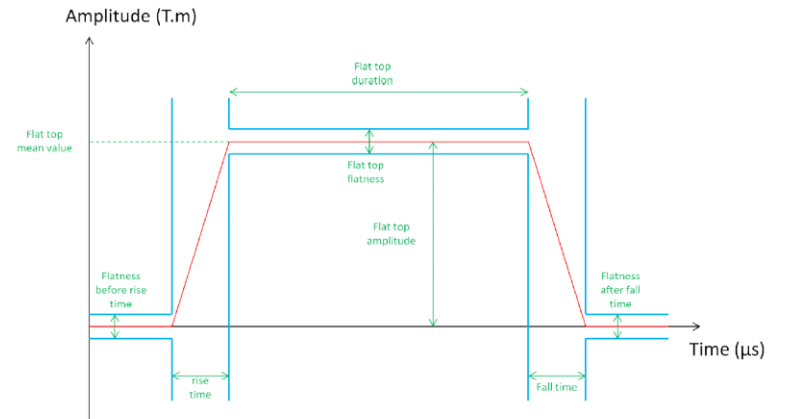
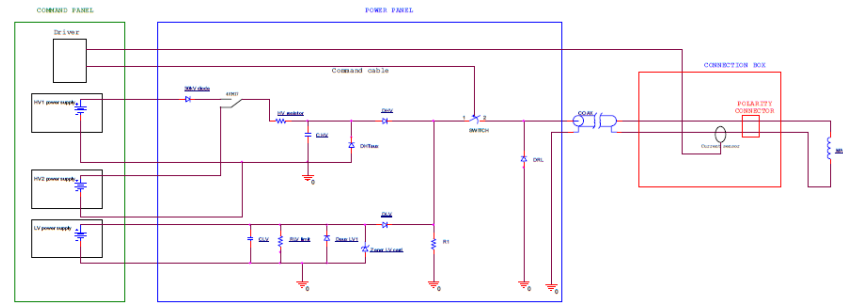
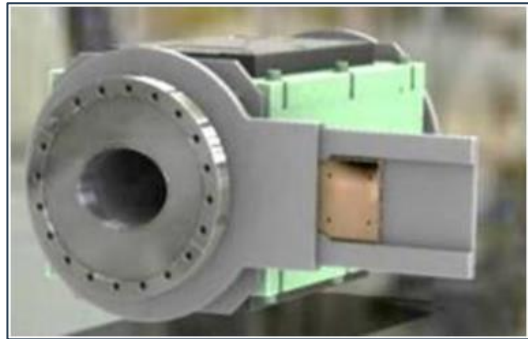


## Injection & Extraction Kicker magnets for FAIR - CRYRING

Field 0,046 T - Leff 436mm- Rise / Fall time <280ns – Flat top adjustable 1,6  $\mu$ s to 16,3  $\mu$ s

Current adjustable 200A -3600A – 2kV - 19 kV max. – Rep. rate 0.5 Hz

Magnet in air – Yoke in ferrite – Ceramic Vacuum chamber





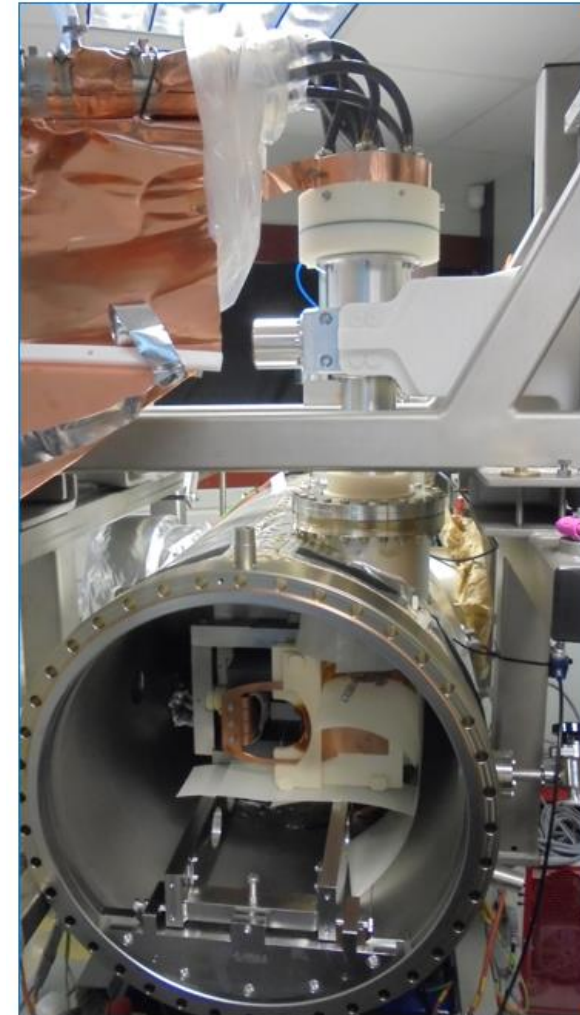
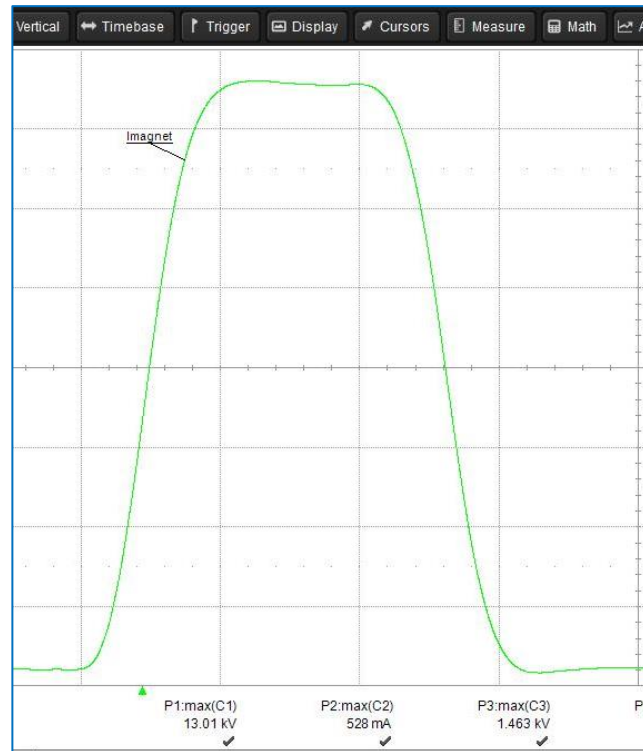
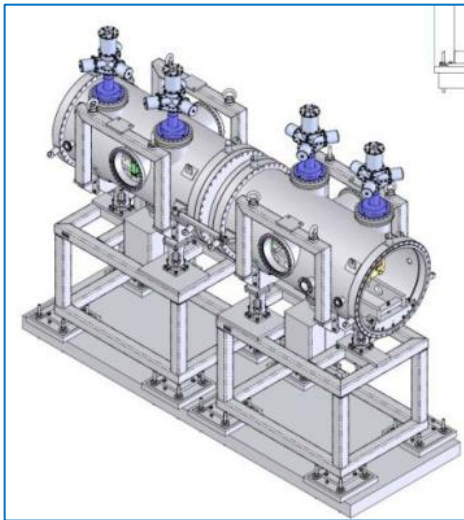
# In vacuum Kicker magnets for FAIR - HESR

## HESR In vacuum Injection kickers system magnets for FAIR - HESR

Field 64 mT per kicker– 220 ns rise time / fall time - flat top 230ns

Solid state pulser 4200 A – 35kV

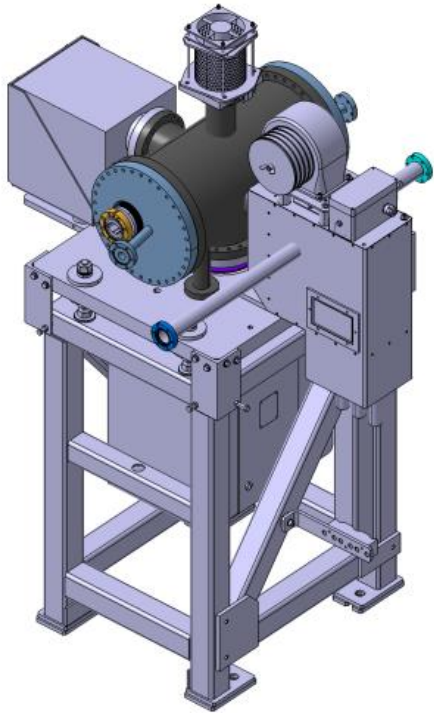
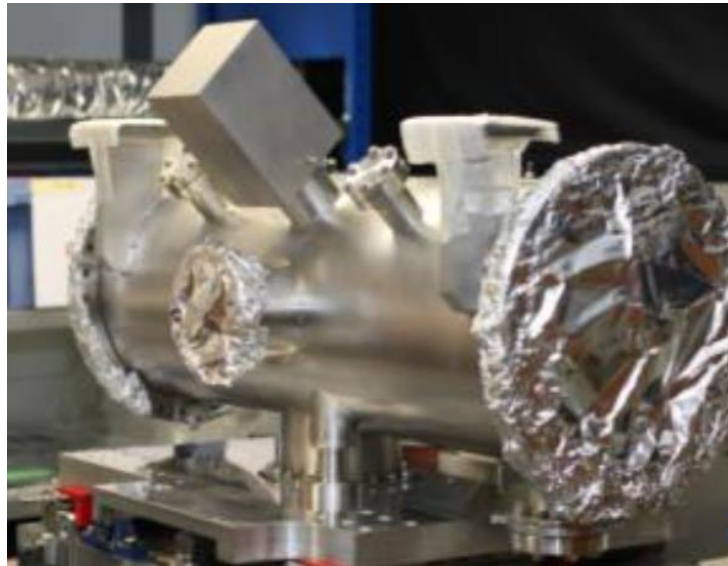
Magnets in vacuum  $5 \cdot 10^{-9}$  mbar – Yoke in ferrite



# Septum & Kicker for SOLEIL - Thom X

## In vacuum septum magnets

Field 135 mT - 1426 A – sinus 130  $\mu$ s – 190V – Rep. Rate 50 Hz  
Magnet in Vacuum  $5 \cdot 10^{-9}$  mbar – Yoke laminated



## Kicker magnet

Field 17,6 mT - Half sinus 120ns – 740 A – 15.5 kV - Rep. Rate 50 Hz  
Magnet in air – Yoke in Ferrite – Vacuum chamber in ceramic



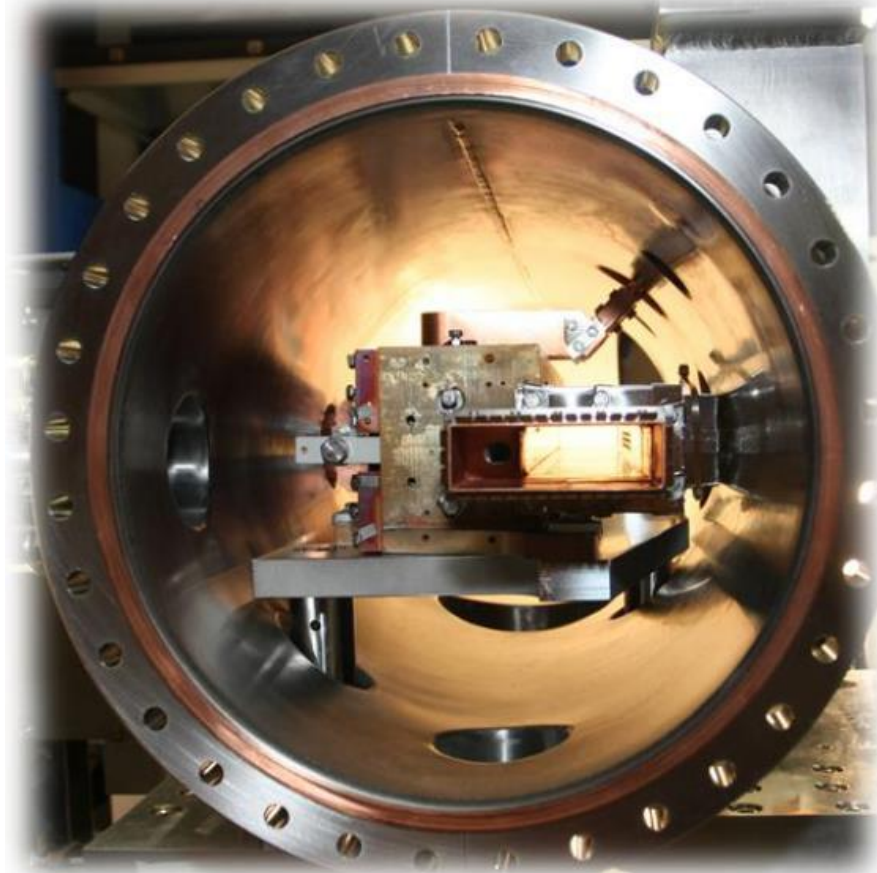
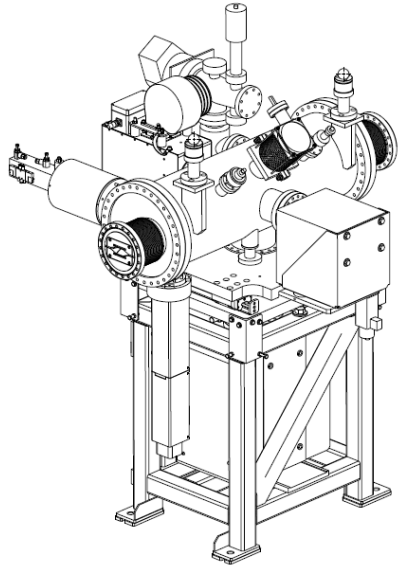


# In vacuum Septum for SOLEIL

Field 0,5 T - Sinus wave 120  $\mu$ s – 5500 A – 1 kV – Rep. rate 3 Hz

Leakage field < 10 ppm (passive septum)

Magnet in vacuum 5. 10<sup>-9</sup> mbar – Yoke laminated



# Superconducting magnets

## ■ NbTi



33 correction dipoles for LHC Dipole for JLAB (4,2T, 4m)

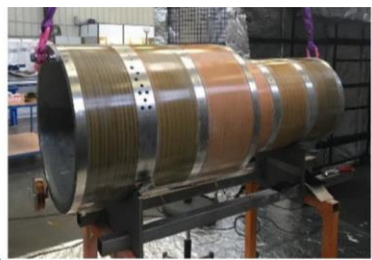
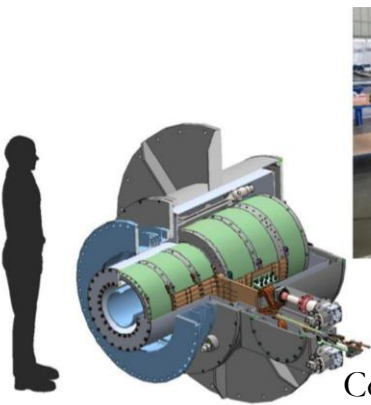
Quad for JLAB (16T/m, 4m)

He free cyclotron magnet

## ■ MgB2



MgB2 coil tested at 460 A



Comet solenoid (KEK)



3D vector magnet WAVE (CEA)

## ■ HTS



SMES



Dipole



Fault current limiter coil



# Workshop for superconducting magnets

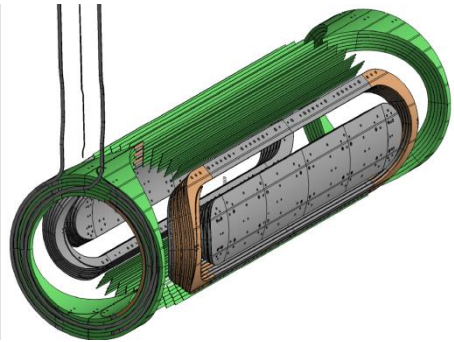
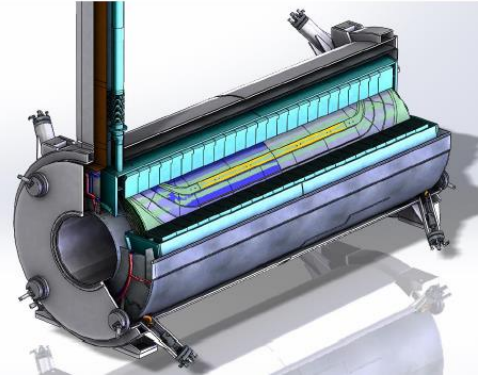




# SHMS Dipole for CEBAF upgrade

24 tons, warm bore 600 mm, 4,25 T, NbTi Liquid helium 4,2K – 3500 A

Jefferson Lab





# Q2 & Q3 Quadrupoles for JLAB CEBAF upgrade

15 tons, warm bore 600 mm, 16T/m, NbTi Liquid helium 4,2K – 4250 A

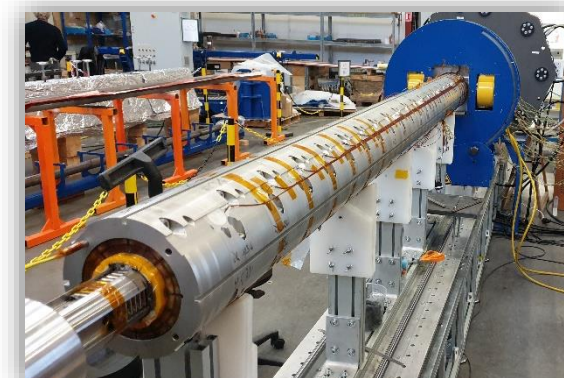
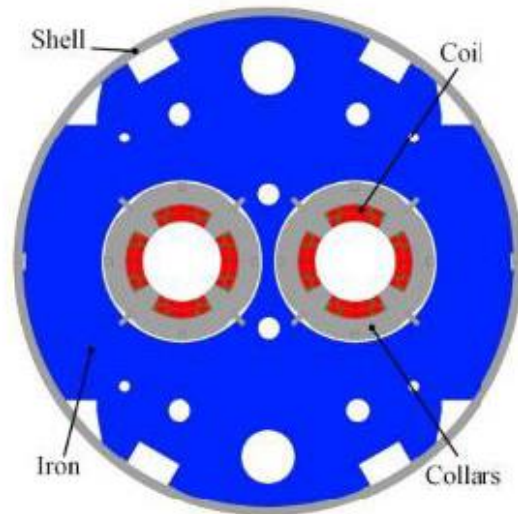
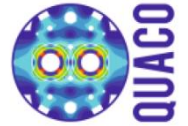
Jefferson Lab





# Q4 Quadrupole Prototype for CERN HILUMI

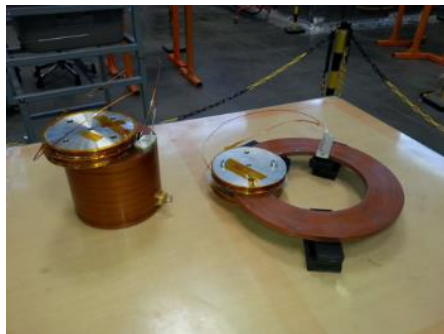
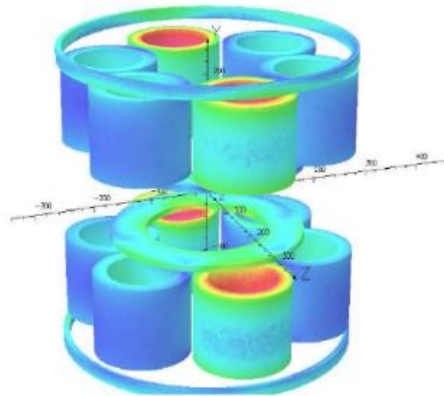
Double aperture quadrupoles ID 90 mm – Gradient 120 T/m (peak field 6,1 T)  
Length 4 meters – NbTi – 1,9K – 4596 A





# Vector Superconducting Magnet for CEA – LLB (WAVE)

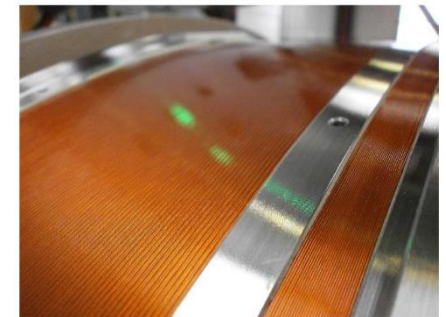
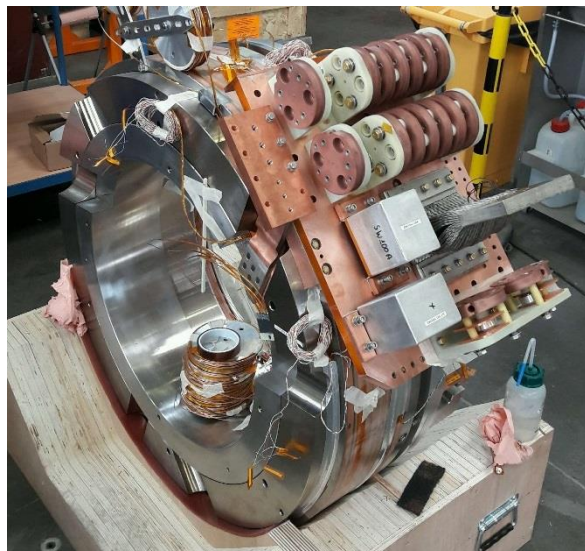
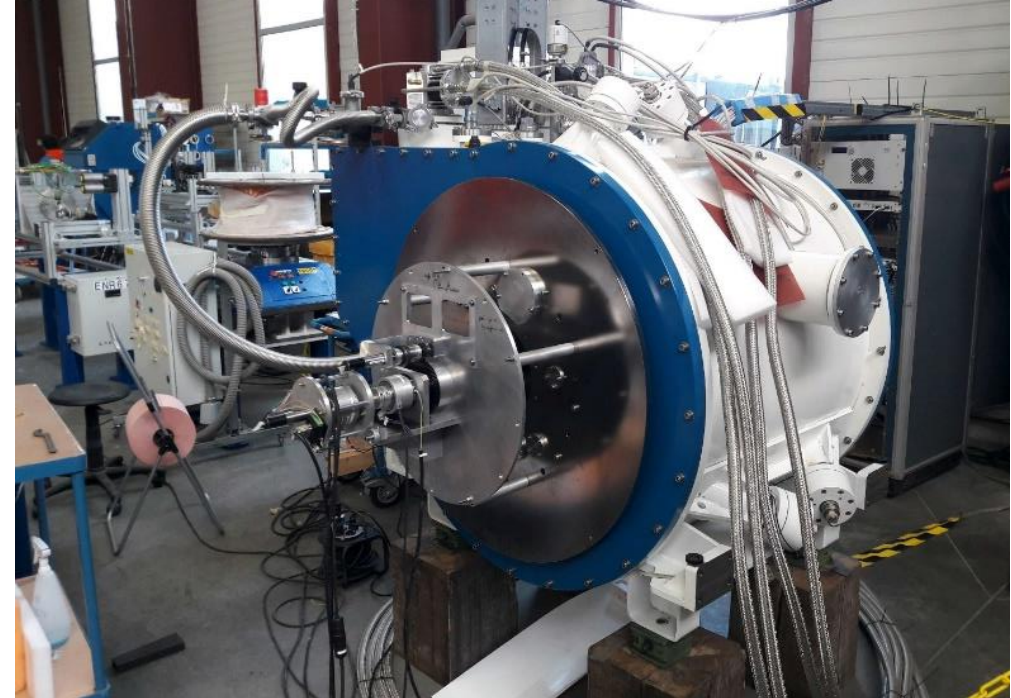
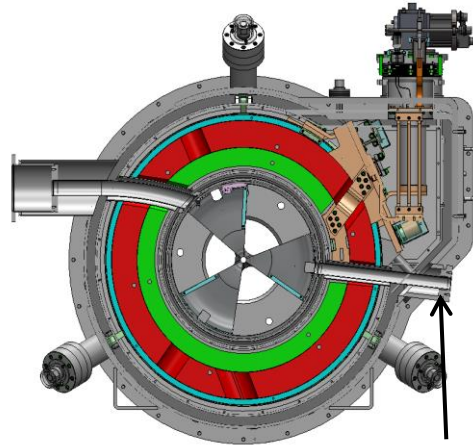
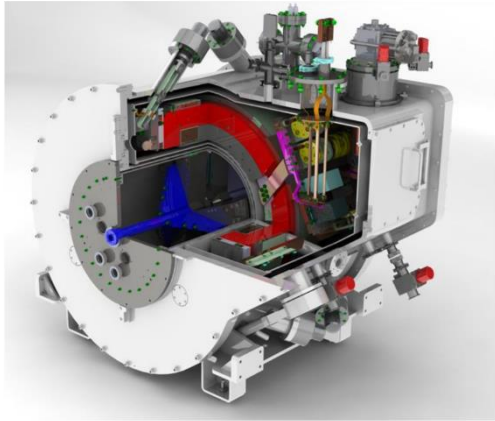
1T/1T/1T Bore diameter 100 mm - NbTi Liquid Helium Zero boil off – 200 A  
High field homogeneity 50 ppm within R5mm – Turn key system delivered with 4 power supplies  
and quench protection system





# Superconducting cyclotron magnet – 12 Mev

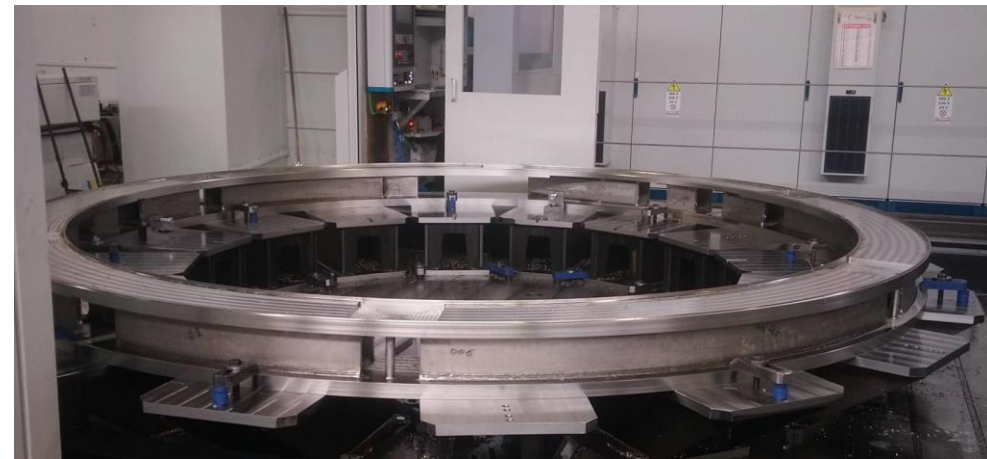
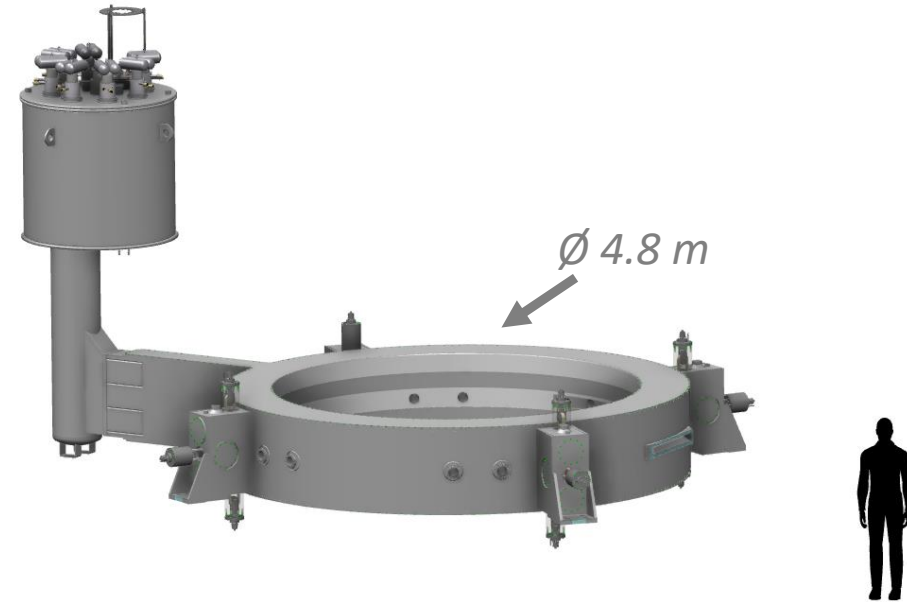
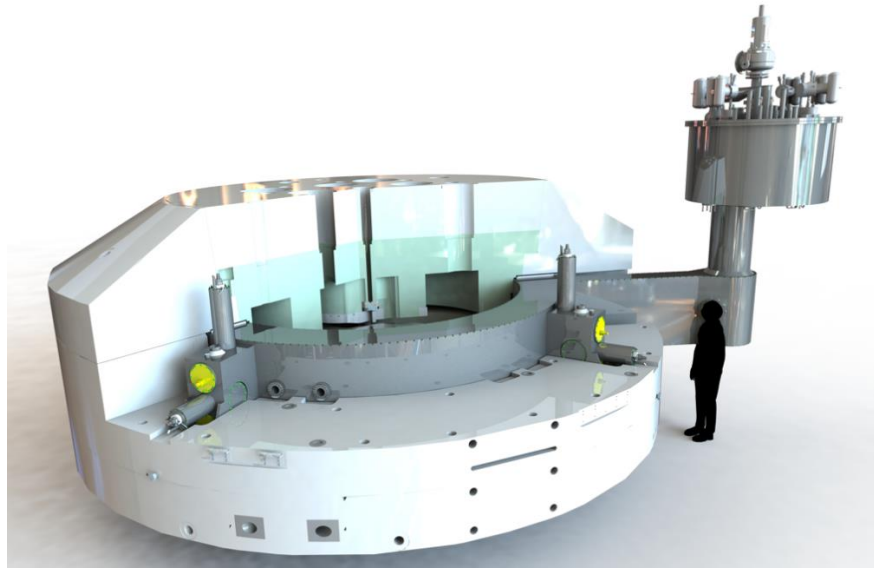
Cyclotron prototype magnet with CEA R&D partnership  
Split coils - warm bore 514 mm – 2,36 T – NbTi Cryogen Free – 100 A





# Superconducting cyclotron magnet – 400 MeV

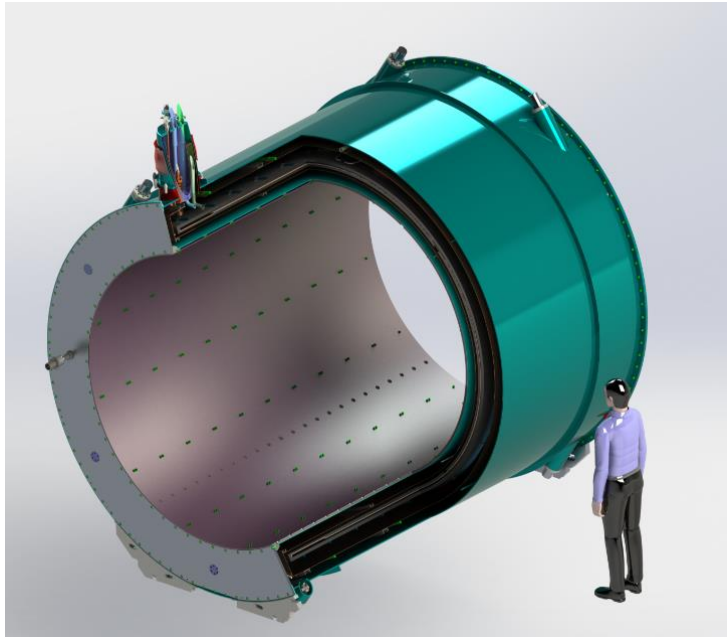
Superconducting Magnetic System – NbTi – 1100 A – 4.5T - Helium bath zero boil off with cryocoolers and quench gas recovery- Coils & cryostat 25 tons (Cyclotron 750 tons )



# Superconducting Solenoid P2 for Gutenberg Univ. Mainz

NbTi – 725 A – 0.7T – Cryostat OD 3309 mm x L 3840 - Aperture 2400 mm

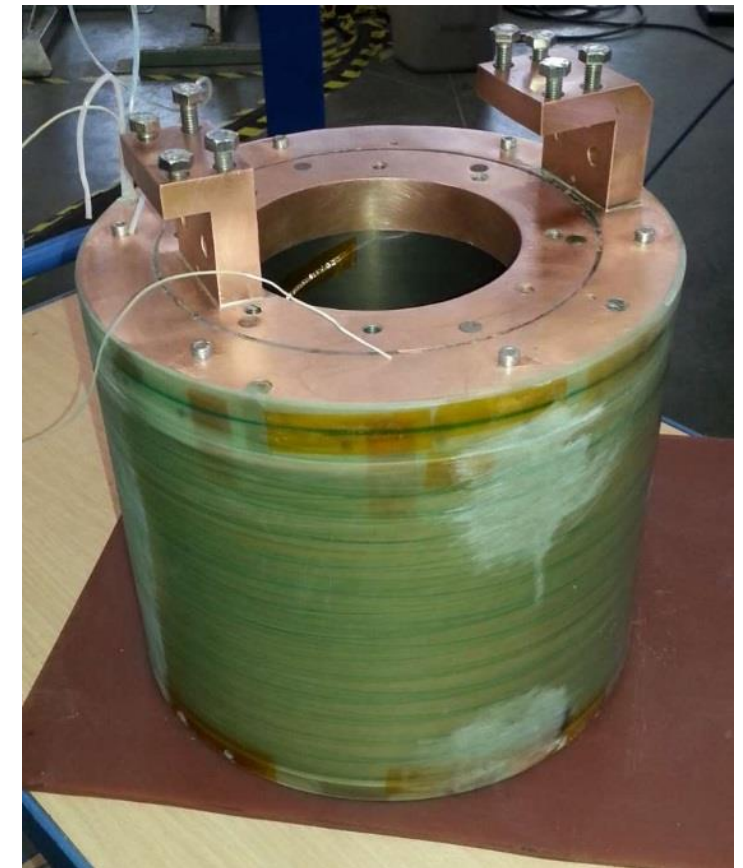
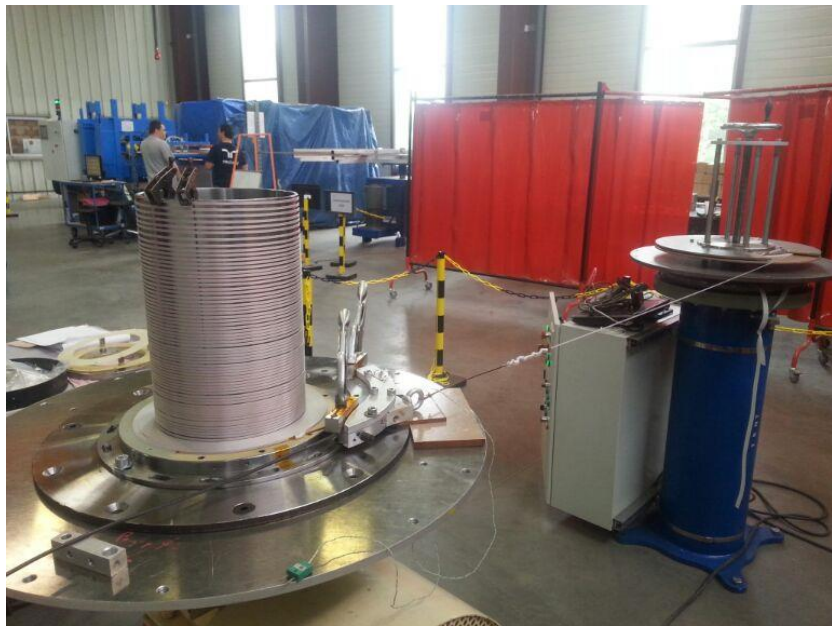
Helium bath - Coils & cryostat weight 15 tons





# MgB<sub>2</sub> coils prototypes

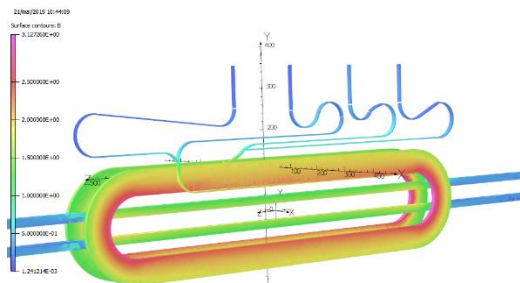
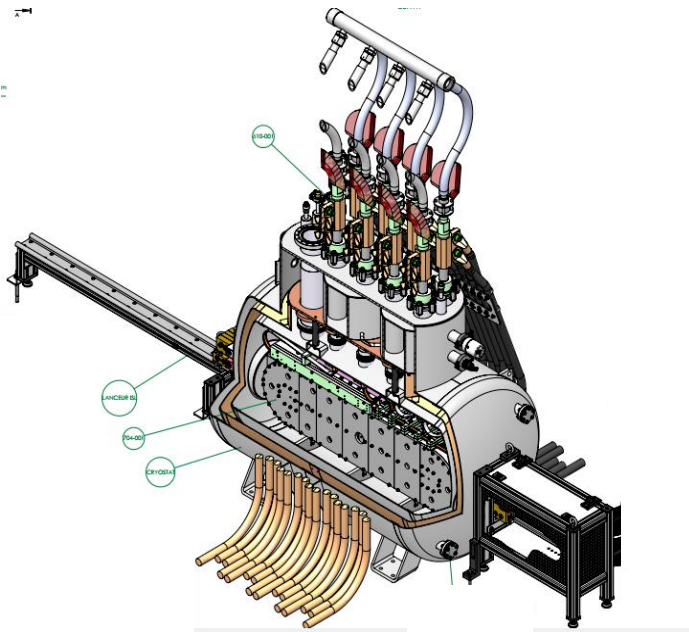
MgB<sub>2</sub> double pancake and solenoid R&D with CEA partnership  
Double pancakes and Solenoid in MgB<sub>2</sub> - 1T in 3T background field  
Conduction cooled



# HTS Dipole

BOSSE Dipole for an electromagnetic launcher in partnership with CNRS for DGA

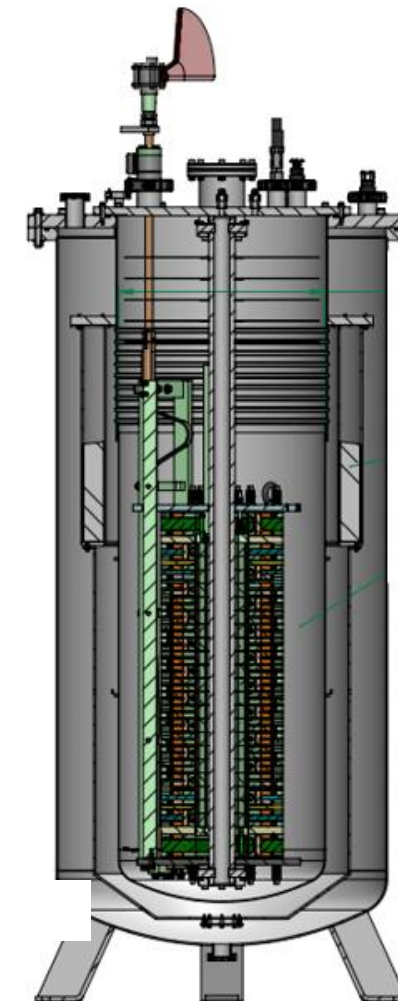
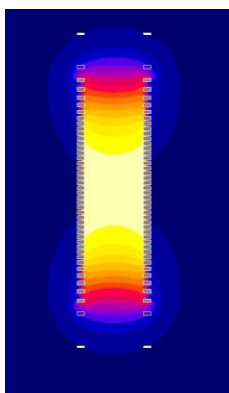
HTS2G (YBCO) dipole – 10 kA – 1,2 T - 100 gr projectile at 100 m/s – 4 stages XRAM concept (current multiplier)





# HTS Solenoid for SMES

BOSSE Solenoid for energy storage in partnership with CNRS for DC  
HTS2G YBCO solenoid – bore 180 mm – 13,1 T – 972A - 1,3MJ



# HTS Fault Current Limiter

## FAULT CURRENT LIMITER FOR SUPERGRID INSTITUTE

Manufacturing of HTS2G (YBCO) windings for a 50 kV Superconducting Fault Current Limiter demonstrator (Fastgrid project) cooled at 65K.

**FastGrid**







Thank you for your attention