Sector DC Dipoles Design for the Beam Test Facility Upgrade

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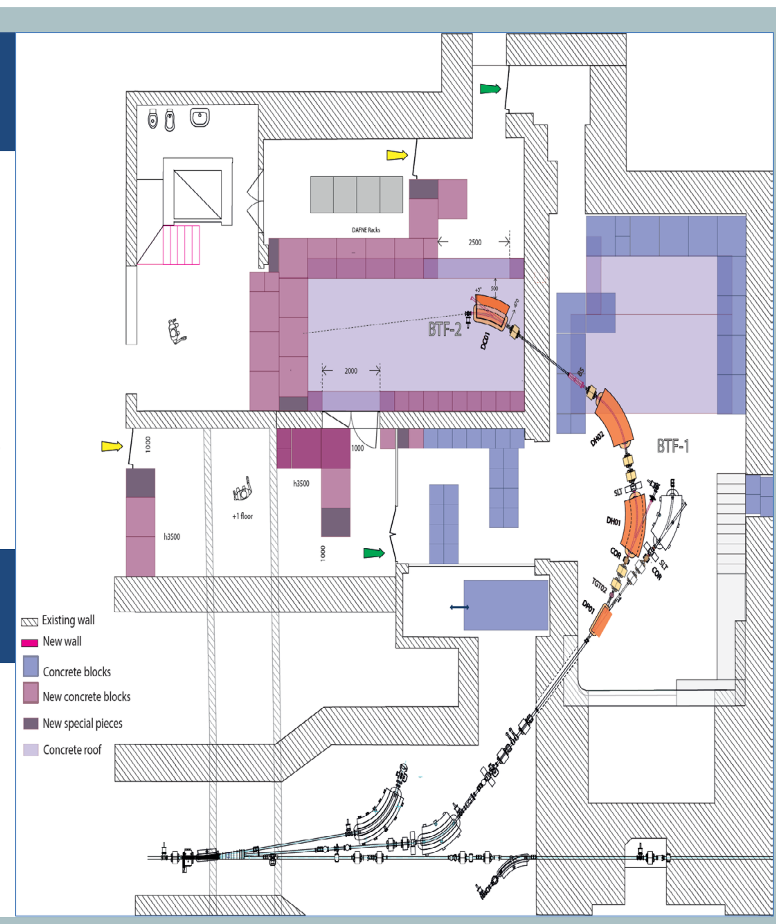
Background

Beam Test Facility (BTF) is part of the DAΦNE accelerators system of INFN Frascati National Laboratory (LNF). The BTF upgrade foresees a new branch of the actual transfer line, in order to have two different beam lines into two separate experimental halls and a beam energy increase from 750 MeV to 920 MeV. For this purpose eleven new magnets will be necessary to finalize the layout: a fast ramped dipole, seven quadrupoles (both shown in the poster [22]), two 45 degrees H-shape sector dipoles, and a 35 degrees C-shape sector dipole operating in DC. The 45 and the 35 degrees bendign dipoles have a full iron yoke and they are characterized by a high flux density, up to 1.7 T, in order to limit the curvature radius to 1.8 m, and to guarantee the required bending angles. This poster describes the design of the two H-shape and of the C-shape sector dipole.



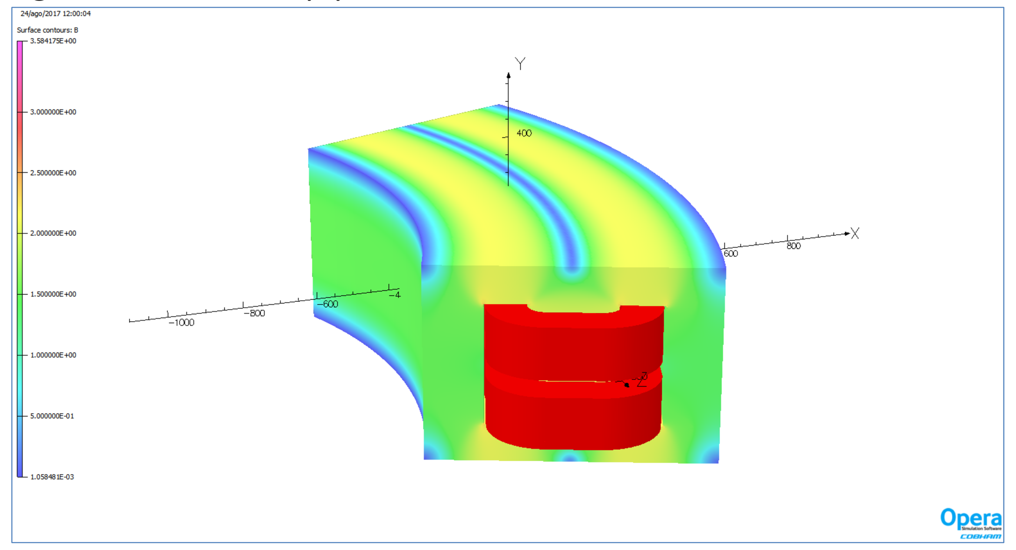
Objectives

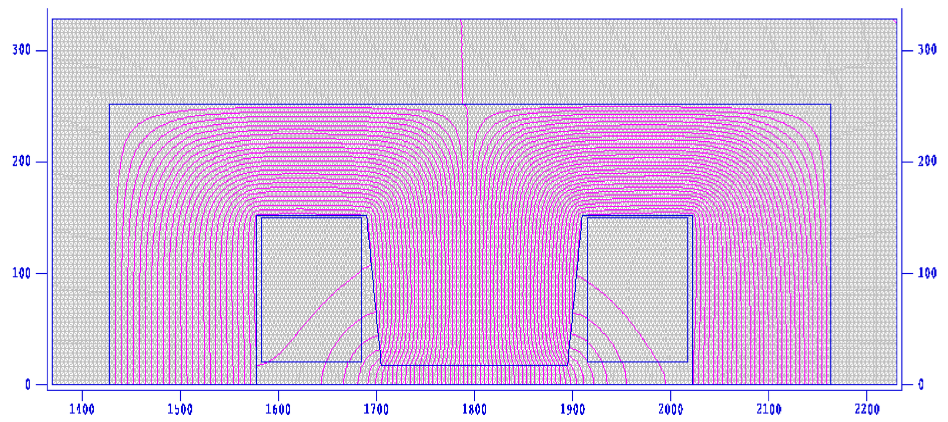
- INFN Staff performed the complete magnet design for the BTF upgrade taking advantage of the long term expertise of Physicists and Engineers of the Accelerator Division and Technical Division of the Frascati National Laboratory, LNF.
- Boost the involvment of local Small and Medium Enterprises in the manufacturing of prototypes and small series of magnets, giving them the occasion of acquiring specific experience in magnet technology.

H-Shape Sector Dipole

Electromagnetic design

The main magnet requirements have been established by Beam Dynamics analysis. Electromagnetic FEA simulations have been performed both with 2D and 3D software in order to define the magnets cross section and the iron length. The pole profile has been optimized in order to reduce the pole saturation by ensuring the required field quality. A hole in the yoke allows the housing of a straight section beam pipe.

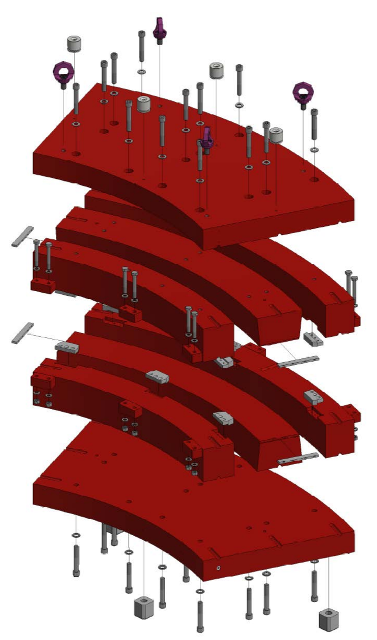


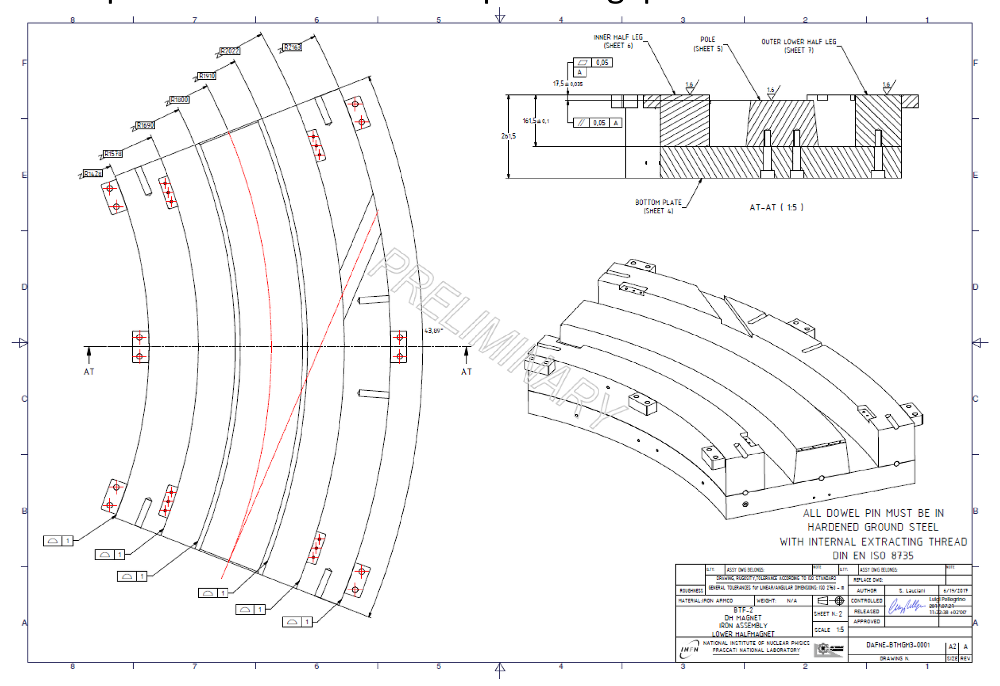


YOKE

The yoke material is AME Iron (equivalent to ARMCO Pure Iron grade 4), in order to achieve the requested high flux denisty.

A yoke assembly (see the picture) is suggested to the manufacturers in order to reduce the size of the single workpiece. This request cames from several local industries specialized in aerospace sector that use to work small pieces with high precision. The single pices tollerances have been defined by the LNF Mechanical Engegneer Service in order to achieve the requested pole faces flatness and aperture gap tolerances.

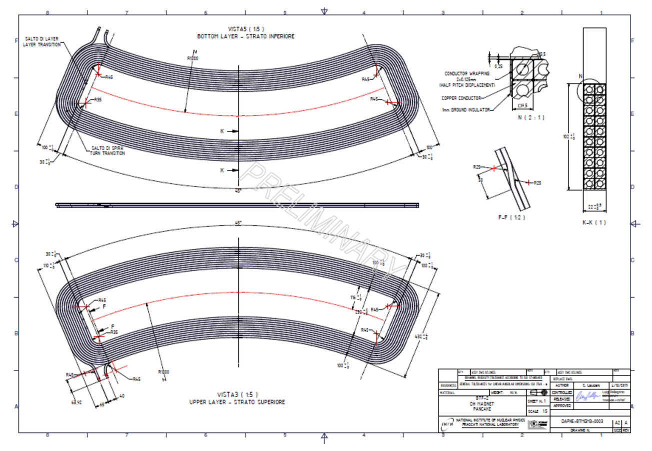




COILS

The Coils are realized by Oxygen Free hollow conductors. The conductor have been sized in order to maintain a low current density (4 A/mm^2) and to have a 3 bar pressure drop compliant with the actual BTF cooling system specifications. Each coil has six cooling circuit.

The manufacturer will be free to choice a *resin rich* or a *vacuum pressure impregnation* insulation system.



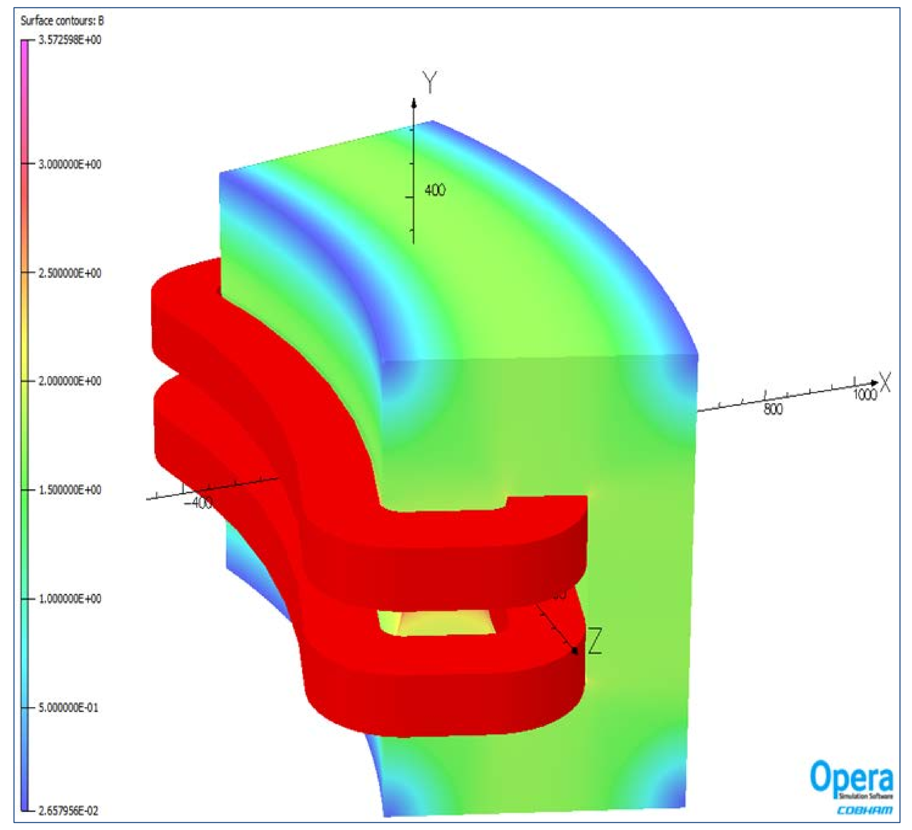
Magnet Specifications

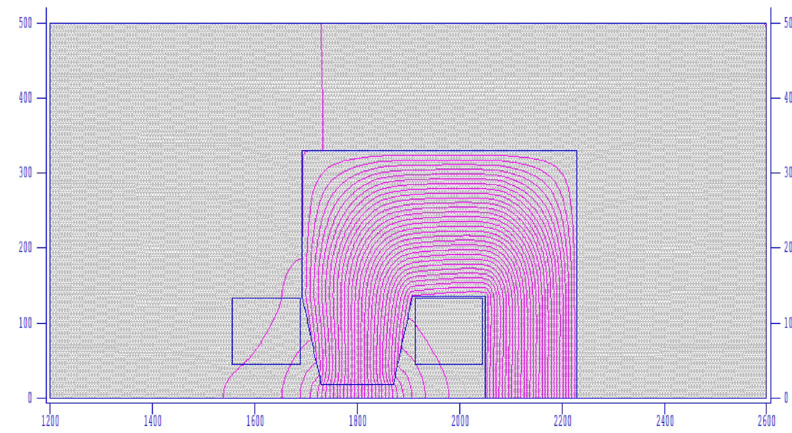
	Unit	Value
Beam Energy	MeV	920
Maximum Field	T	1,7
Bending Radius	mm	1800
Magnet Lenght	mm	1413
Bending Angle	deg	45
Pole Iron Gap	mm	35
Yoke Material		AME Pure Iron
Integrated Field Homogeneity		5*10^{-4} over ±15mm
Number of turns per coil		120
Conductor dimensions	mm	9,5x9x5/ bore 5,5
Nominal Current	A	263
Nominal Voltage	V	85
Coil resistance @60°C	mΩ	280
Inductance	mH	422
Power Complete Magnet	kW	19
Pressure Drop	bar	3
Water Flow	l/min	18

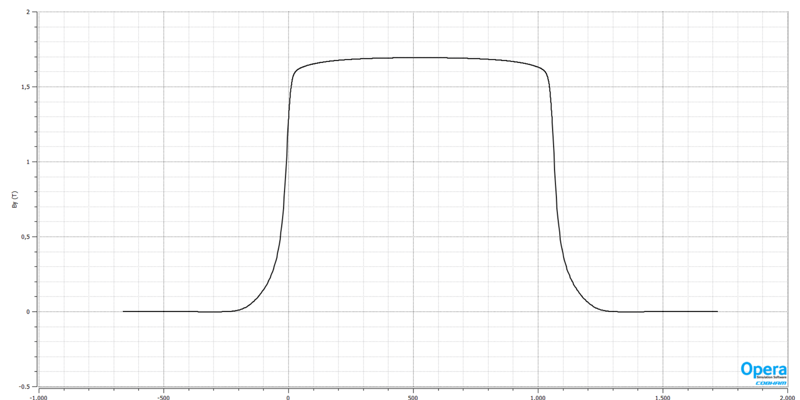
C-Shape Sector Dipole

Electromagnetic design

The 2D and 3D simulations led to the required flux density and magnetic length. As for the H-Shape dipole, the pole profile was optimize in order to reduce the iron saturation by ensuring the required field quality (less than 1E-3 over 15 mm). The yoke material is AME Pure Iron and the coils conductors is the same of the H-Shape Dipole.The CAD design are ongoing.







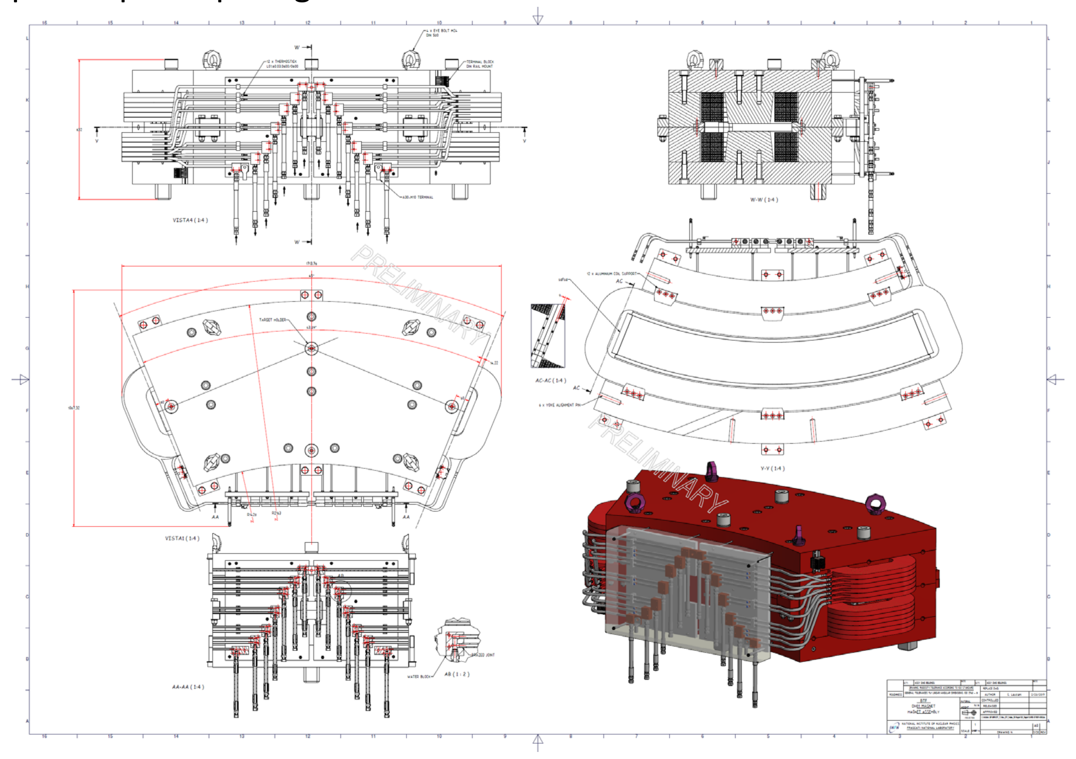
Magnet Specifications

	Unit	Value
Beam Energy	MeV	920
Maximum Field	T	1,7
Bending Radius	mm	1800
Magnet Lenght	mm	1100
Bending Angle	deg	35
Pole Iron Gap	mm	35
Yoke Material		AME Pure Iron
Integrated Field Homogeneity		5,6*10^{-4} over ±15mm
Number of turns per coil		104
Conductor dimensions	mm	9,5x9x5/ bore 5,5
Nominal Current	A	255
Nominal Voltage	V	58
Coil resistance @60°C	mΩ	195
Inductance	mH	348
Power Complete Magnet	kW	13
Pressure Drop	bar	3,15
Water Flow	l/min	12

Mechanical design and Magnetic Measurement

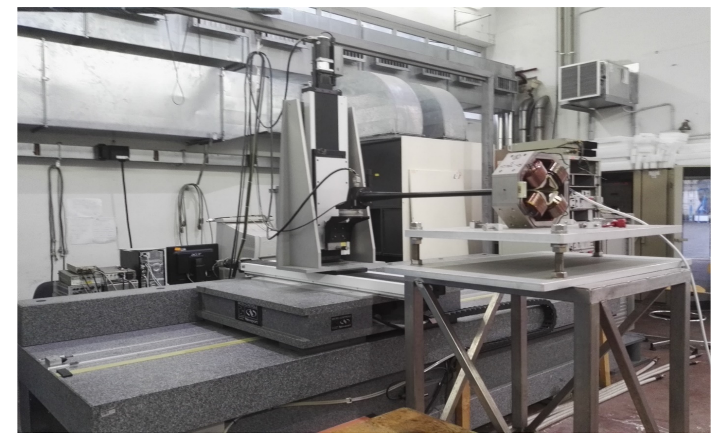
Detailed CAD Drawings

The result of the full design of the magnets is a complete set of CAD drawings. They describe in detail all the features of the magnets, including the yoke, the coils, the electrical and hydraulic connections. All the materials and tolerances have been defined. This work also aims to transfer our specific knowledge in magnet technology to the companies participating to the bid for the construction.



Magnetic Measurements Lab

The magnetic measurements laboratory is equipped with a Hall probe, mounted on a 5 axis movement device



Conclusions

- The design of the magnets has been fully performed at INFN, including eletrcomagnetic, mechanical, thermal and hydraulic aspects.
- The magnet design and CAD Drawings of the H shape sector dipole are completed. The C shape dipole magnet design is finalized and the CAD Drawings are ongoing.
- Power Supplies technical specifications have been completed for both the magnet types.
- Magnetic measurements will be performed at INFN-LNF.
- The installation is and commissioning planned in Spring 2018.

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