16 T magnet R&D overview

Davide Tommasini

On behalf of the EuroCirCol WP5
Content

The talk summarizes the activity performed within EuroCirCol on the 16 T magnets, and will be composed of two parts.

The first part provides a general overview of the 16 T magnets programs and recall the related achievements of the EuroCirCol initiative, including new initiatives coming as a direct consequence of the program.

The second part, presented by Bernardo Bordini, will summarize the evolution and results of the EuroCirCol conductor program.
Content

- Overview of 16 T magnet R&D
- EuroCirCol WP5
  - Impact in the magnets community
  - Contribution to the FCC CDR
  - Deliverable 5.4: a special contribution of the US Labs (US MDP) as EuroCirCol Partners
- Recent initiatives
  - Model magnets with CEA-CIEMAT-INFN
  - Chart-2
- Latest news
  - FCC 16 T program
  - US-MDP
- Evolution and results of the EuroCirCol Conductor Program (Bernardo Bordini)
Overview of 16 T magnet R&D

EuroCirCol WP5 (CEA, CERN, CIEMAT, UNIGE\textsubscript{neva}, KEK, INFN, Tampere\textsubscript{U}, UT\textsubscript{wente})
Feed the FCC CDR with design and cost model of 16 T magnets

FCC 16 T Magnet Development, supporting:
• conductor development & procurement
• R&D magnets and associated development
• model magnets

US Magnet Development Program (ASC/NHMFL, BNL, FNAL, LBNL)
• 14-15 T cosine-theta magnet (2017-2019)
• Design, manufacture, and test of a 2-layer 10 T CCT magnet
• Novel diagnostics and advanced modeling techniques
EuroCirCol WP5 : impact in the community

• The program has set the parameters for conductor and magnets which are being used as a common reference worldwide. This has allowed/motivated different laboratories to work on the same basis.

• The existence of common targets has facilitated the promotion and development of parallel programs (in particular the US MDP, for both the conductor and the magnets).

• The choice of identifying certain strategic packages as a general support for the whole community (analysis tools, conductor characteristics, quench protection) has favoured interchange between labs.

• The existence of a reference framework has promoted and facilitated sharing of information, with an avalanche and contagious effect across generations, from students to senior scientists.

• A considerable effort has been put in place, by all parts, in cultivating this spirit through the whole duration of the program. In addition to meetings in persons, visits to labs, conferences and workshops, the EuroCirCol WP5 has organized about 40 collaboration video-meetings and about 30 topical meetings, many of them with the enlarged participation of the US labs engaged in the US MDP.
Collider Technical Systems

Chapter 3

Overview
This chapter provides details of those technical systems that are required for the magnet R&D. It is shown that the R&D will proceed in parallel with the studies of the nine technical systems that are required, namely, magnets, water cooling, helium systems, radio frequency, cryogenics, R&D, project management, and engineering. All these technical systems will be described and are presented here.

Overview of the R&D

2.3.2. Magnet R&D

The main driver of the R&D is the FCC magnet, a superconducting magnet with a length of 17 m and a maximum field of 16 T. It is installed in a cryostat structure composed of a main vessel and a thermal screen and vacuum vessel. The cryostat is produced by the Istituto Nazionale di Fisica della Materia (INFN) and is the main technical system that is required for the R&D. The cryostat is produced by the INFN and is the main technical system that is required for the R&D.
Davide Tommasini

16 T magnet R&D overview

FCC Week 2019
Davide Tommasini

16 T magnet R&D overview

FCC CDR - 3

FCC Week 2019
DELIVERABLE REPORT

MANUFACTURING FOLDER FOR REFERENCE DESIGN DIPOLE SHORT MODEL

Abstract:
Manufacturing folder for a novel high-field dipoles model magnet, suitable for the hadron collider designed in the scope of the EuroCerCol project, which is part of the international Future Circular Collider study.

1. INTRODUCTION
The specifications and parameters set by the EuroCerCol WP1 have been implemented in the engineering design of a cos-theta dipole model magnet developed for Fermilab in the framework of the US Magnet Development Program (MDP), which includes Fermilab, LBNL, NDRL, and recently FNAL. The magnet design and manufacturing has been in part adapted to the tuning tool for the 11 T dipole for the HC-LHC upgrade project, which was available at FNAL when the activity started. The status of advancement of the model magnet is well beyond the initial goal of EuroCerCol, going beyond the delivery of a manufacturing folder. At the time of the writing of this report all magnets have been manufactured and the magnet is assembled and ready for testing (Fig. 1).

2. MAGNET PARAMETERS
The magnet is based on a 4-layer graded cos-theta coil with 40 mm aperture and cold iron yoke. To compensate the large Lorentz forces, a novel mechanical structure based on a vertically split iron yoke, inclined by 15º at a 1-mm gluing plane, has been developed at FNAL.

The main magnet parameters are summarised in Table 1.

3. MANUFACTURING FOLDER
The manufacturing folder is composed of the following drawings:
- F0000781_U1_Awesky
- F0000871_L_clamp
- F0000321_Iron_Laminaton
- F0000784_Coil assembly
- F0000572_Coil_L1-L1
- F0000752_Coil_L4-L4
- F0000861_L1 Pole LE
- F0000864_L1 Pole RE
- F0000894_L2 Pole LE
- F0000908_L2 Pole RE
- F0000487_L3 Splices Block
- F0000482_L3 Splices Block
- F0000316_L1 Wedge
- F0000385_L2 Wedge
- F0000761_L1 Spacer LE
- F0000763_L1 Spacer RE
- F0000761_L2 Spacer LE
- F0000763_L2 Spacer RE
- F0000764_L1 Spacer LE
- F0000764_L1 Spacer RE
- F0000841_L2 Spacer LE
- F0000908_L2 Spacer RE
- F0000901_L2 Spacer LE
- F0000901_L2 Spacer RE

Fig.1: The cos-theta dipole model magnet with project leader A.V. Zobin and his team (FNAL).
Recent initiatives: model magnets

As a spin-off of EuroCirCol, the work developed in WP5 will continued and exploited in the design, manufacture and test of model magnets. The activity is supported by National Institutes and by the CERN FCC 16 T program.

Thursday 15:30-17:00
High-field magnet R&D
The CEA dipole model for the FCC (Etienne Rochepault)

Thursday 15:30-17:00
High-field magnet R&D
The INFN dipole model for the FCC (Riccardo Valente)

Just signed
Recent initiatives: Chart-II, 2019-2023

Mission:
- Develop a Swiss-based expertise in applied superconductivity and superconducting magnets for HEP, in view of a possible FCC-hh or HE-LHC.

Focus on:
- High field magnets R&D (both LTS and HTS)
- Particle collider design (beam dynamics, collimation, materials at extreme conditions)
- Advanced acceleration methods (high gradient THz Laser Acceleration)

High-field magnets:
- Establish the infrastructure needed to build and test SC accelerator magnets
- Design, build, and test superconducting-magnet models according to needs of the FCC design study:
  - explore CCT technology for Nb$_3$Sn 16-T dipoles,
  - develop up to 2-m-long high-field prototypes – not necessarily of CCT type
  - contribute to HTS accelerator-magnet R&D constructing technology models

Other HTS magnets:
- Design, build, and test a HTS variant of the SLS 2.0 super-bend magnet.
- Design, build, and test several periods of an HTS undulator magnet.
FCC 16 T Magnet Development: latest news

eRMC magnet structure was assembled using instrumented aluminium dummy coils

Two thermal cycles, using 2 different interference level, were used to characterise the mechanical structure behaviour at cryogenic temperature

Three coils were produced and are ready for assembly

The magnet will be assembled using 2 coils and the first cold powering tests are scheduled before end 2019
US MDP: latest news

Thursday 15:30-17:00: High-field magnet R&D
The US-MDP program (S.Prestemon)
The US-MDP costheta model (A.V.Zlobin)
Evolution and results of the EuroCirCol Conductor Program
Thank you for your attention