

CEPC Detector R&D Project

5.1 LTS solenoid magnet

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Change history

Revision	When	What changed and why
1	12/12/2019	First draft
		< Add further lines to table as required >

Readme first

- i. Please do not delete or modify this section or its structure.
- ii. Only change text enclosed by (and including) angled brackets "< ... >".
- iii. Don't change field directly, instead modify the document options, under File → Properties (or similar)
 - o Enter name of person that wrote the document in Document:Summary: Author
 - o The project ID number, should follow the rules provided to you earlier. The number should be changed in Document:Custom: PBS.
 - o The project name should be changed in Document:Summary: Subject.
- iv. In Section [Project Objectives](#) provide a brief description of the project goals, i.e. why and what is being produced, for PBS item **1.1 Vertex Prototype**. If this project includes identifiable sub-projects you can indicate them in the [Sub-projects Description](#) Section, otherwise submit a separate document for each of them. The sub-project IDs are free for you to define.
- v. Finally, remember to update the [Change History](#).

5.1 LTS solenoid magnet: Project Objectives

The proposed 3 tesla solenoid with a 6.8 m diameter bore for CEPC detector magnet, can be reached by adopt a self-supporting aluminum stabilized low temperature NbTi superconductor.

During the past three years, we have developed a 1.5 km long superconducting Rutherford cable with 16 strands of NbTi wire embedded in pure aluminum stabilizer, which has achieve a critical current 50 kA at 3 tesla background magnetic field. The final conductor for CEPC detector magnet is a 32 strands of NbTi wire Rutherford cable inserted in pure aluminum stabilizer and together with aluminum alloy reinforcement, with critical current of 60 kA at 4 tesla background field and residual resistance ratio (RRR) of 400. Meanwhile the measurement of the material properties and the tensile stress of the cable will be a necessary part for the structural simulation of the solenoid coil and the conductor development. The total required cable length of the detector solenoid is around 30 km. We will built a winding model by using dummy conductor to study the inner winding technique of large diameter solenoid, and to improve its automation performance. A 1:10 scale superconducting model is necessary for the thermosyphon cooling, quench behavior study, and study of the electrical connecting between the several coil segments.

We also analyze iron yoke structure configuration that will be needed in order to optimize the overall detector design and MDI design.

The objectives of the detector magnet R&D projects are relative to the four different tasks listed as follows.

5.1 LTS solenoid magnet: Sub-projects Description

Sub-project ID	Title	Description
5.1.1	Development of special low temperature superconductor	A 32 strands of NbTi wire Rutherford cable inserted in pure aluminum stabilizer and together with aluminum alloy reinforcement, $I_c > 60 \text{ kA@4T}$
5.1.2	Study of thermosyphon cooling method for large size solenoid magnet	Thermosyphon principle is used to cool CEPC detector superconducting magnet by the U-shaped circuit configuration carrying LHe on the outer surfaces of the coil supporting cylinders. The thermosyphon circuit consists of helium phase separator located in an elevated position and the cooling tubes. In order to study the phase transition process of helium in the circuit, the changes of the temperature distribution and the density distribution over the time, a 1:10 scale thermosyphon circuit will be established for simulation and experiment.
5.1.3	Study of large size coil winding	The model study is necessary for the large detector magnet, to develop the inner winding technique and to improve automatic performance for the 6.8 m coil

	techniques	of inner diameter by using dummy conductor.
5.1.4	Construction of superconducting coil prototype	A 1:10 prototype built to study the coil cryogenics and quench protection, the electrical joint of the cable, and verify the electromagnetic structure and force inside the coil.
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5.1 LTS solenoid magnet: CEPC Relationship

All four activities are strictly (almost exclusively) related to the design of the solenoid magnet of the CEPC detector.

5.1 LTS solenoid magnet: Project Schedule

Project 5.1.1 got funding from the IHEP innovation fund for LTS conductor development which should be completed by the end of 2021.

Project 5.1.2 and 5.1.3 has received funding from CAS Center for Excellence in Particle Physics for the design of large diameter superconducting coil, which should be completed by the end of 2021.

Project 5.1.4 is being requesting funds, activity is expected to start in 2022. We expect completion of the project by the end of 2025.

5.1 LTS solenoid magnet: Funding Availability

We have received from CAS Center for Excellence in Particle Physics 3M CNY for the first phase of this project, and another 1.5M CNY from the IHEP innovation fund for key technology of large diameter superconducting coil, part of the fund is for HTS conductor development and part for LTS conductor development.

We are missing the funds needed for the construction of the 1/10 scale prototype of the superconducting coil described in the fourth step of project 5.1.4.

5.1 LTS solenoid magnet: Leadership Arrangement

Leading institute for the LTS solenoid magnet project will be Institute of High Energy Physics, CAS (coordinated by Zhao Ling).

Significant support will be given by the industrial companies, Toly Electric Works Co. LTD at Wuxi (coordinated by Liao He'an) for what concerns aluminum stabilized superconductor, and by Fubin Vacuum Equipment Co. Ltd at Beijing (coordinated by Li Wenqin) for what concerns liquid helium thermosyphon cooling, and by Keye Company at Hefei (coordinated by Zhu Zhiliang) for what concerns industrialization of the large size coil windings.

5.1 LTS solenoid magnet: Manpower Resources

Type	Average FTE Expected
5 Faculty	2.5
1 Postdoc	0.5
4 Students	2
1 Engineer	0.5