Electron-Ion Collider, Thomas Jefferson National Accelerator Facility			
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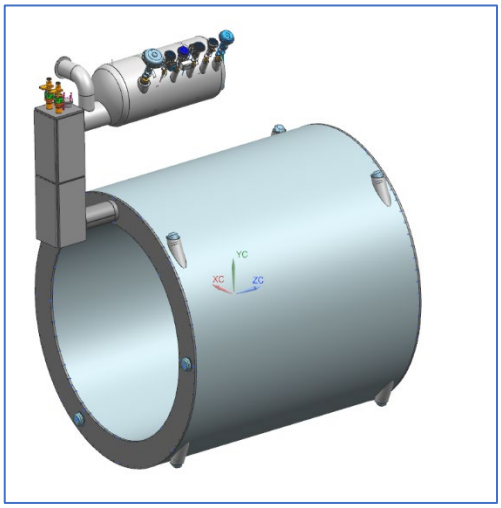
STATEMENT OF WORK- ELECTRON ION COLLIDER (EIC) DETECTOR SOLENOID SUPERCONDUCTING MAGNET



Author:

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Revision History

1	Updated	Document revised after final design	Renuka	Rolf	Elke		12/10/2024
0	Initial Release	Detector Solenoid Superconducting magnet	Renuka	Rolf	Elke		02/13/2023
REV.	ECO#	DESCRIPTION	BY	CHK.	APP.	APP.	DATE
SUMMARY OF CHANGES FROM PREVIOUS REVISION:							

MARCO Magnet Design Team

- **JLab**
  - Team Lead: Renuka Rajput-Ghoshal
  - Design Team Members: Probir Ghoshal, Sandesh Gopinath, Eric Sun, and Dan Young
- **CEA, Saclay**
  - Team Lead: Valerio Calvelli
  - Design Team Members: Christophe Berriaud, Jean-Pierre Lottin, Hugo Reymond, Michel Segreti, Damien Simon, and Francesco Stacchi
- **BNL**
  - Team Members: Rahul Sharma, Roland Wimmer and Roberto Than

Contents

LIST OF ACRONYMS

BNL	Brookhaven National Laboratory
EIC	Electron-Ion Collider
ESR	Electron Storage Ring
JLAB	Thomas Jefferson National Accelerator Facility (Jefferson Lab)
QA	Quality Assurance
RCS	Rapid Cycling Synchrotron
RFI	Request for Information
RFP	Request for Proposal
RHIC	Relativistic Heavy Ion Collider
SOW	Statement of Work
IR	Interaction Region
TJNAF	Thomas Jefferson National Accelerator Facility (JLab)
IP	Interaction Point
RICH	Ring-Imaging Cherenkov
HCal	Hadronic Calorimeter
SC	Superconducting

1. *DEFINITIONS*

Customer	Jefferson Lab
Vendor	Selected magnet vendor
Subcontractor or manufacturer	Subcontractor to vendor
Supplier	Supplier to vendor
Braze makers or Braze Operators	Vendor's braze technicians
JLab/BNL Technical Representative (TR)	Jefferson Lab's designated technical contact (for all technical enquiries)
JLab/BNL Procurement Officer (PO)	Jefferson Lab's designated procurement contact (for all contractual enquiries)

2. *Introduction*

The Electron Ion Collider is a partnership between Thomas Jefferson National Accelerator Facility (TJNAF) and Brookhaven National Laboratory (BNL). It will be a new physics research facility to be constructed at Brookhaven National Laboratory (BNL) based on the existing Relativistic Heavy Ion Collider (RHIC) facility. The EIC will use the existing RHIC accelerator to produce hadrons with maximum proton energies up to 275 GeV. The hadrons will be collided with electrons produced in an all-new electron facility capable

producing up to 18 GeV in energy. A detector is also being constructed to evaluate the particles scattered by these collisions.

The detector solenoid for the EIC is a large size superconducting magnet. Most of the detector magnets are one-off magnets. This magnet is a 2T magnet and will be wound using copper cladded Rutherford cable, 22 strands of 0.85 mm diameter NbTi superconductor will be used to make the Rutherford cable of 8.85 mm x 1.49 mm size. This Rutherford cable will then be soldered into a copper channel. The overall size of the copper cladded conductor is 11.4 mm x 4.6 mm. The magnet will be indirectly cooled using a thermosiphon method. The coils will be wound internally to a brass mandrel. The coil is divided in 3 modules and each module has six layers. The magnet will be installed at BNL. The schematic cross-section of the coil and the mandrel is shown in figure 1. The overall magnet cryostat dimensions are shown in figure 2. Figure 3 shows the overall dimensions of the cryostat and the phase separator. There will be a number of detectors in and around the magnet. The details of the detectors relevant for magnet design are given in the magnet design report.

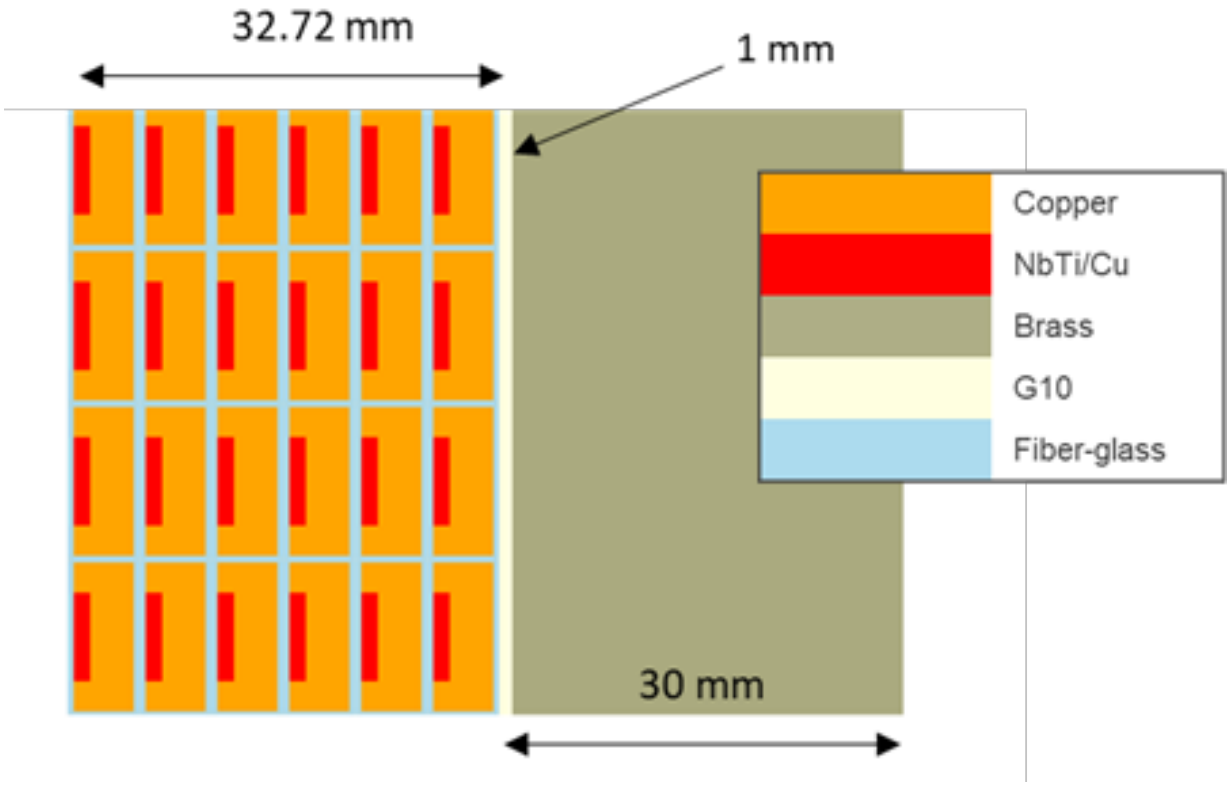

Figure 1: Schematic cross-section of the coil and the mandrel

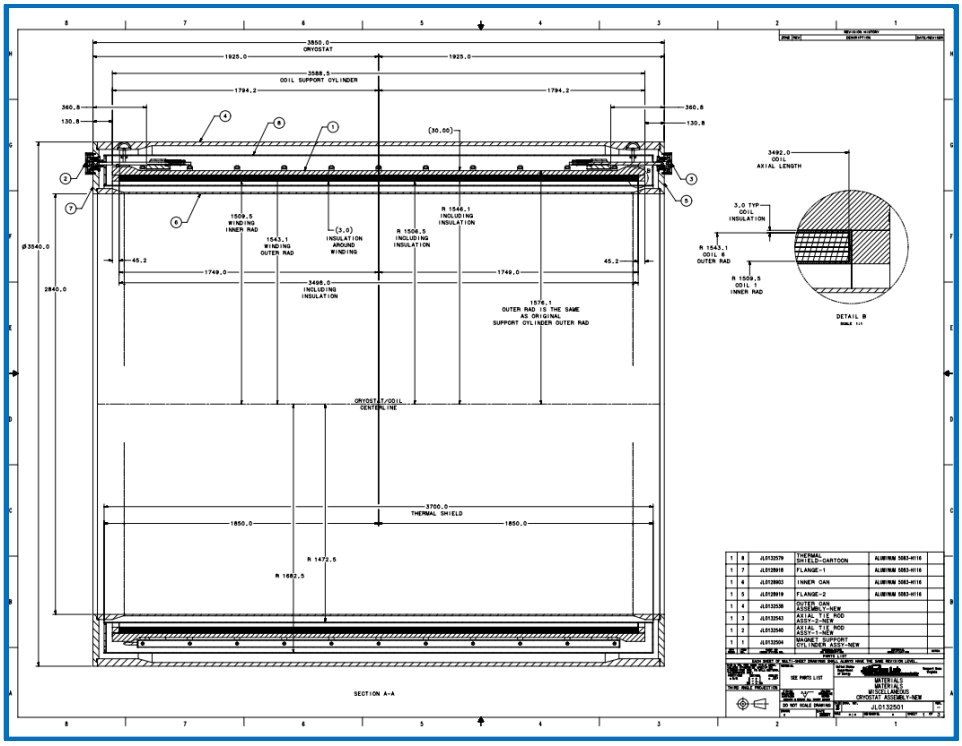

Figure 2: Magnet Cryostat Dimensions

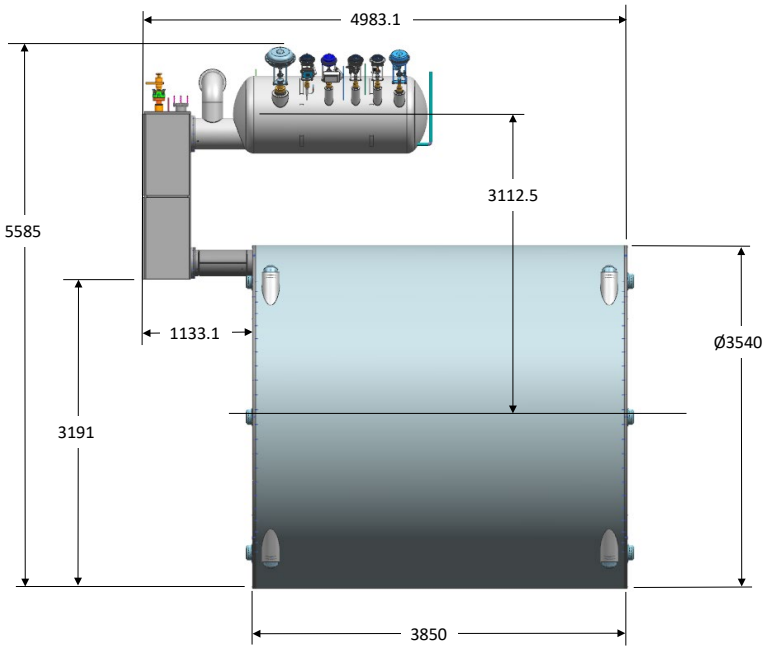

Figure 3: Overall Dimensions of the Cryostat and Phase Separator

3. *SCOPE*

This Statement of Work (SOW) defines:

i. Magnet performance requirements: field strength and field accuracy, coil and cryostat cross- sections.
ii. The magnet design functional requirements, detailed design of the magnet and the conductor
iii. The magnet fabrication functional requirements: materials – coil and cryostat, manufacturing requirements, quality assurance, inspection, contractor QA inspection and tests, and EIC QA, tests, and magnetic measurement(s).
iv. The method of procurement, and anticipated delivery schedule.

This document outlines the Contractor's responsibilities and obligations necessary for completing the requirements as set forth herein.

4. *Procurement Officer's Technical Representative (TR)*

The TR is a TJNAF employee assigned to interface with the Subcontractor on technical matters after subcontract award. The TR is only authorized to provide technical direction within the scope of the subcontract. Any modification to the scope or terms of the subcontract must be approved in advance by the TJNAF Subcontracting Officer.

After subcontract award, the TR will assist the Subcontractor in the interpretation of technical requirements as outlined in the contract. Any clarification provided by the TR concerning the work to be performed shall not be construed as a change to the subcontract. Only the TJNAF PO is authorized to accept nonconforming work; waive any requirement of this subcontract; or modify any term or condition of this subcontract.

All direction from the TR and the Procurement Officer shall be provided in writing.

TR Name: Renuka Rajput-Ghoshal
TR Phone: 757 – 269 (5992)
TR Email: renuka@jlab.org

5. *Magnet Functional Specifications*

The magnet functional specification and design details are given in the "EIC Design Report: MARCO Magnet"- "EIC-SHC-TN-005" and "EIC-EPIC Detector Superconducting Magnet Specifications"- "EIC-DMG-TN-003".

6. *Documents Provided by TJNAF*

The following table lists all the technical documents provided by TJNAF:

Table 1: List of Documents

Document Name	Document Number	Rev
EIC Design Report: MARCO Magnet	EIC-SHC-TN-24-005	0
EIC- EPIC Detector Superconducting Magnet Specifications	EIC-DMG-TN-003	2

7. *Deliverables*

The following are to be delivered by the vendor:

- Fully functional magnet in vacuum vessel
- Fully functional phase separator
- Magnet chimney with vapor cooled installed
- All the required instrumentation
- Instrumentation racks

8. *Quality Assurance AND Standards, Contractor Required Testing*

8.1. *Quality System*

The Contractor shall maintain a documented quality assurance (QA) system, which provides the processes to ensure that the magnet produced for acceptance conforms to the requirements of the applicable technical specifications. QA system shall meet the requirements of ISO-9001. The Contractor shall create and maintain a system of travelers for the magnet manufacturing, materials certifications, testing, and inspection. These records shall be part of certificate of conformance provided with the magnet.

Where applicable, the power supplies must conform to the following standards or codes:

a. ASME compliant
b. American Society of Testing Materials
c. American Standards Association, Inc.
d. Institute of Electrical and Electronics Engineers [IEEE]
e. International Electro-technical Commission [IEC]
f. National Electrical Manufacturers Associations [NEMA]
g. Underwriter’s Laboratories, Inc. [UL]
h. National Electrical Code [NEC]

8.2. *JLAB Standard:*

Maximum Allowable Working Pressure: 150 PSIG

Jefferson Lab requires measures to be implemented for pressure safety, e.g., the power supplies may include water-cooled systems that will be pressurized beyond 15 PSIG the following sections shall apply to the manufacture, testing, etc. of equipment supplied under this procurement.

Jefferson Lab has determined that national consensus codes are not applicable. However, vendors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME (B31.xx, vendor to decide applicable code) These measures must include the following:

i. Design drawings, sketches, and calculations must be reviewed and approved by a qualified independent design professional (i.e., professional engineer or equivalent). The results of the analysis must be provided to JLAB.

ii. Qualified personnel must be used to perform examinations and inspections of materials, in-process fabrications, nondestructive tests, and acceptance test.

iii. Documentation, traceability, and accountability must be maintained for each unique pressure vessel or system, including descriptions of design, pressure conditions, testing, inspection, operation, repair, and maintenance.

iv. Vendors shall include in their proposals measures/procedures that demonstrate compliance with these requirements.

v. Documentation supporting these requirements shall be included with each equipment (magnet system, other accessories separate) shipped

Brazing and welding - Braze Joint Samples for the Proposal, As JLab considers this brazing critical to the success of the project, vendors are requested to provide ASME BPVC, Section IX-qualified Brazing Procedure Specification (BPS), supporting Procedure Qualification Record (PQR), Brazing Performance Qualifications (BPQ) of brazers and brazing operators in accordance with Subsection 328.2. Requirements in B31.3 Section 333 that are applicable to brazing must be followed.

Welding - The coil vendor must be on the Jefferson Lab approved vendors list for welding fabrication. In order to qualify to be put on the Jefferson Lab approved vendors list for welding fabrication.

8.3. *Responsibility for Conformance*

The quality requirements set forth in a future purchase order shall become part of the Contractors overall inspection/test program. Acceptance of article under the test provision shall not relieve the Contractor of the responsibility of ensuring that the magnet meet the design requirements and comply with all requirements of the contract or purchase order.

8.4. *Configuration Management*

The Contractor shall establish and maintain a system to assure that the magnet is of the proper configuration, and that all approved configuration changes are documented and incorporated at the specified affected points.

8.5. *Measuring and Test Equipment (M&TE) Calibration*

The Contractor shall calibrate any M&TE used for the fabrication, testing, or inspection of the magnets that are traceable to national standards such as the National Institute of Standards and Technology (NIST or equivalent).

8.6. *Responsibility for Inspections and Tests*

The Contractor shall be responsible for inspections and tests listed herein using their own equipment and facilities. JLab may repeat some of these inspections and/or tests after delivery to assure that the magnets meet the requirements at no cost to the Contractor. The JLab will also perform magnetic measurements to assure that the magnets meet EIC requirements at no cost to the vendor.

8.7. *Contractor Acceptance Tests*

The following acceptance tests and inspections shall be performed at the Contractor's facility prior to shipping the magnet to verify that they meet the EIC requirements. The tests shall be documented in the Contractor traveler system:

i. Coil dimensional measurement and visual inspection to confirm the coil cross-section, the coil turns, overall cured coil size, and the coil lead location meet the drawing requirements within specified tolerances.
ii. Coil ground insulation test after epoxy infusion and cure. The magnet coils shall be tested to 1000 V (min) between the bus and the outer epoxy insulated surface.
iii. Coil turn-to-turn insulation test should be performed, test method should be discussed in the quality plan.
iv. Tests - mechanical, structural, electrical (e.g., resistance, inductance, Hi-pot, etc.)
v. Coil resistance verification from lead end to lead end.
vi. Ground insulation check: the assembled magnet coil circuit with jumpers shall be tested to 1000 V with the magnet as ground.
vii. Ohmic resistance and inductance of the completed magnet coil circuit.
viii. JLAB inspection/witness - JLab technical and/or procurement representatives shall be allowed to witness any or all manufacturing, tests and inspections upon notification by JLab team.
ix. Shipment – The whole magnet shall be crated or palletized for shipment. The packaging shall protect the unit from damage in transit and from weather during transit.

9. *Contractor Responsibility, Planning and Reports*

The Contractor shall furnish all equipment, materials, tools, inspection equipment, facilities and labor to perform the work necessary to manufacture, inspect, test, and ship the magnet assembly.

9.1. *Contractor Responsibilities*

i. Design validation and suggest changes if necessary
ii. Experience - Please provide evidence of your previous experience of:
    A. Manufacturing Sc magnet/coils
        a. Types and shapes of coils
        b. Conductor cleaning
        c. Using epoxy, conductor and ground wall insulation types
        d. Helium mass spectrometer leak testing capabilities
        e. Static pressure testing capabilities
        f. Pressure testing capabilities
        g. Electrical measurement and testing capabilities
    B. Vacuum Pressure Impregnation process with resin types
iii. Vendor QA plan - This plan shall provide for the tracking of each part/component through the manufacturing process (a traveler system), test and inspection, risk analysis (FMEA), and room temperature test
iv. Manufacturing design and drawing
v. Planning, staff and equipment planning, and all material procurement.
vi. Design and fabrication of manufacturing, inspection, and testing fixtures and tooling.
vii. Status reports (bi-weekly), status meetings, and in process inspection reports.
viii. Inspection and testing.
ix. Packaging of the magnets and traveler/inspection/ test reports to JLab.
x. Magnet will be delivered to BNL.

9.2. *JLab's Responsibilities*

i. Fully developed design and accepted materials.
ii. Conductor procurement - (IMPORTANT NOTE: JLab will supply all the conductor. This conductor will have been received at JLab and the end of each spool will be measured to assure that it locally meets the tolerances conductor designs. This check will only be on the free end of the conductor and it is incumbent upon the vendor to further check the conductor as part of their fabrication/QA process. The vendor must take that amount into account when developing their coil construction process for production coil(s).
iii. Timely response to vendor suggestions, participation in status meetings, on-site vendor meetings, and on-site visits for component and testing witness points.

iv. Timely inspection of parts if needed.
v. Timely inspection, testing, and acceptance upon delivery of magnet.

9.3. *Manufacturing Plan*

The Contractor shall develop and provide a Manufacturing Plan that describes a system of process sheets, shop travelers, or equivalent means to define the sequence of manufacturing, inspection, installation and test activities to be performed. The plan shall include a schedule with milestones that will be tracked with the milestones.

10. *Procurement Plan, Procurement Options*

10.1. *Magnet Procurement Specifications and Drawings*

Magnet procurement for JLab will be through “Vendor Design-Build”, where JLab will provide a Performance Specifications, detailed design and a Statement of Work (SOW) to the vendor who then completes the design, produces their own manufacturing drawings and builds the magnet. The vendor will have an option to validate and modify the design.

The Contractor will be responsible for detailed design by following the magnet specification. The Contractor will be responsible for the manufacturing design and drawings. The contractor has to organize the final design review (if any changes are made to the design), manufacturing readiness review and shipment readiness review. All these reviews should be approved by JLab. The Contractor will submit information and drawings during design reviews for approval by the EIC technical representative.

10.2. *Procurement Plan and Procurement Options*

The SC magnet described herein will be procured with dedicated requests for proposals with supporting technical and contractual procurement packages. All procurements will be for the production quantities after successful technical review and assessment by the EIC Project team (JLAB Magnet Group).

The magnet contract will be based on contract option pricing received during the RFP bid. JLab will request bid pricing based on the production contract and may choose to place production contracts with contractor based on cost and/or schedule. JLab will also be willing to renegotiate costs based on changes in raw material costs, exchange rates, or similar factors.

11. *Reviews*

The vendor will verify the refence design detailed in the design report and organize the following review, all the applicable documents for the review should be provided to TJNAF 3 weeks before the meeting. TJNAF reserve the right to include experts from around the world in these reviews.

- Design verification review
- Manufacturing readiness review
- Shipping review
- Any other intermediate review ad TJNAF deems necessary

12. *Shipping and Delivery*

The complete magnet shall be shipped to BNL, USA. The vendor shall inform TR at least two weeks in advance before shipping the magnet.

TITLE: STATEMENT OF WORK- ELECTRON ION COLLIDER (EIC) DETECTOR SOLENOID SUPERCONDUCTING MAGNET

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