FY27 NPP LDRD Type B Pre-Proposal

Time-Resolved Magnetic Field Quality Characterization for Fast-Ramped and Pulsed Accelerator Magnets

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FY27 NPP LDRD Type B Pre-Proposal

Proposal title: **Time-Resolved Magnetic Field Quality Characterization for Fast-Ramped and Pulsed Accelerator Magnets**

Primary Investigator: Anis Ben Yahia

Other Investigators: George Mahler

Indicate if this is a cross-directorate proposal: Yes ___ No_x_

If yes, identify other directorates/organizations:

Proposal Term: From: 10/2026 To: 09/2028

Brookhaven National Laboratory

FY27 NPP LDRD Type B Pre-Proposal

Proposal title: **Time-Resolved Magnetic Field Quality Characterization for Fast-Ramped and Pulsed Accelerator Magnets**

Brief abstract: This project aims to develop and validate a fixed-coil magnetic field measurement system capable of characterizing the field quality of fast-ramped and pulsed accelerator magnets. By enabling direct measurement of transient field quality effects such as eddy currents induced harmonics, and magnetization effects in SC magnets, the work will provide new insight into magnets behavior on timescales previously inaccessible with rotating coil measurements. The resulting measurement capability will support improved beam dynamics modeling, informed magnet design, and reliable operation of next-generation accelerator facilities.

Program: NP, HEP.

Return on Investment: Successful demonstration would position the laboratory to compete for follow-on funding tied to: Accelerator upgrade projects, new facility design efforts requiring validated transient magnet models, and instrumentation and diagnostics R&D calls within NP and HEP.

Broader impact on the activities at the laboratory: A reusable, scalable measurement platform that can be deployed across multiple programs. Direct measurement of transient multipoles provides improved accelerator modeling and operations. Develops critical in-house expertise for accelerator magnets characterization.

Total planned funding: FY27: $250K, FY28: $100K.

Motivation

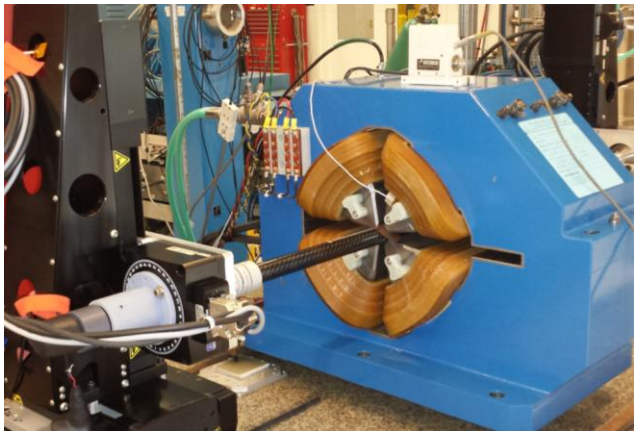
Accelerator performance depends on precise characterization of the magnetic field.

Most commonly measured using rotating coil:

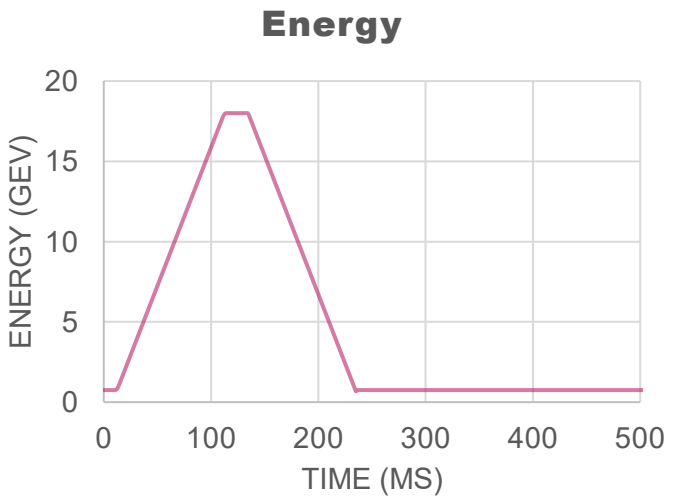
- High precision: measure multipoles at 10^{-5} of the main field.
- Ideally suited for static fields.
- Typical time resolution is in the order of seconds.
- Bandwidth limited by mechanical rotation and vibration

However, many applications require characterization under dynamic conditions:

- Eddy currents induced harmonics.
- Time decay and snapback due to persistent currents.



APS-U rotating coil bench



RCS ramp profile at 18 GeV

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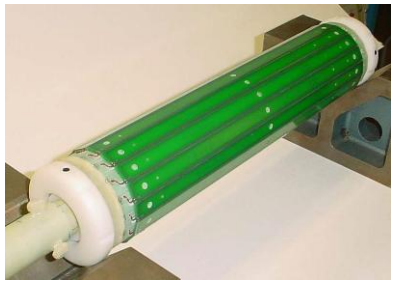
Technical Approach

Fixed-Coil Arrays (Prior Work)

- Simultaneous angular sampling in a single ramp.
- High mechanical, alignment, and DAQ complexity.
- Costly to deploy and difficult to miniaturize for small-aperture magnets.



Tangential coil array (A. Jain, BNL 2005)

Single Fixed-Coil (This Proposal)

- Uses a single fixed coil combined with reproducible magnet current ramps.
- Reconstructs time-resolved field quality from repeated measurements.
- Eliminates multi-coil alignment challenges.
- Simple, compact, scalable to small apertures

Radial coil array (J. Dimarco, FNAL 2008)

Shift from complex fixed-coil arrays to a simplified single fixed-coil methodology designed for scalability.

Deliverables and Resources

Deliverables

- Prototype measurement system.
- Validated fixed-coil measurement methodology.
- Data analysis and field reconstruction software.

Personnel

- Principal Investigator (coil design, measurement methodology, data analysis)
- Engineering and technical support (design, assembly, setup)

Procurements

- PCB based coils: $4k.
- Motion system: $36k.
- DAQ and hardware: $60k.

Summary

- This proposal develops a new magnetic field measurement capability for fast-ramped and pulsed accelerator magnets—an area where existing rotating-coil systems are fundamentally limited.

- By enabling direct measurement of transient field quality effects under realistic operating conditions, the project addresses a critical and growing need for accelerator facilities.

- The work establishes a reusable, scalable diagnostic capability that reduces technical risk in magnet development, improves accelerator modeling accuracy, and lowers cost for future projects.

- Successful demonstration positions the laboratory for follow-on funding in future accelerator upgrades, new facility designs, and advanced magnet instrumentation and diagnostics R&D.