A 3D magnetic field measuring system for the CCT magnet units (MAGDEM) of the ISOLDE Superconducting Recoil Separator

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ISOLDE Superconducting Recoil Separator

Abstract

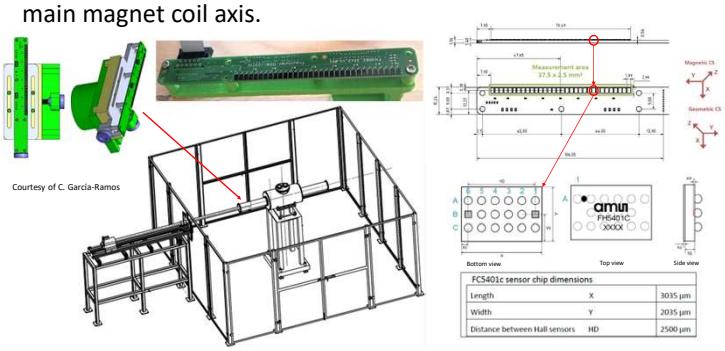
The MAGDEM Magnetic Field Scanner System (MAGDEM-MFSS) is a high-precision solution developed for the ISOLDE Superconducting Recoil Separator (ISRS) project [1]. Designed to accurately measure and monitor magnetic fields in the MAGDEM prototype canted-cosine theta (CCT) magnet [2], it integrates an automated field-mapping machine, Hall sensor array, and advanced software. This system provides critical high-resolution magnetic field measurements essential for the performance and optimization of the ISRS facility [3].

Objectives

- Design and construct a high-precision magnetic field measuring system for MAGDEM units.
- Achieve accurate and detailed measurements of magnetic field distribution.
- Develop software for real-time magnetic field measurement, visualization, and analysis.
- Create a versatile test bench for magnet characterization and validation of computational field models.

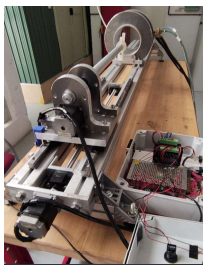
Methodology

- Automated Field Mapping Machine: Multi-axis positioning system with 1 mm step size along z-axis (1.700 mm total length) with 0.05 mm precision and 1° incremental rotation up to 360°.
- Hall Sensor Array: HallinSight® 32x2 pixels sensor array for 3D magnetic field measurements with mT-level accuracy and magnetic resolution of 4 uT.
- Data Acquisition and Control Software: Integrated system for field mapping control, real-time monitoring, and data analysis.
- Non-magnetic Construction: Minimizes disturbances to the magnetic field.
- Precise Alignment: Better than 1.9 mrad with respect to the main magnet coil axis.



Left: Sensor array, security cage and automated field mapping Machine design.
Right: FH5401c sensor contains two 3-D Hall sensors.

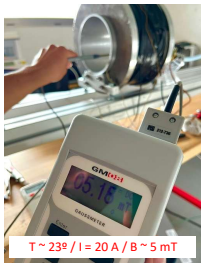
Future Prospects

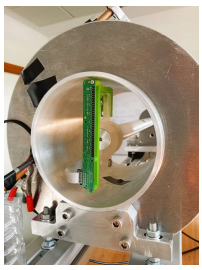


0.4 MFSS Test Bench

- Integration with broader control and data management systems at ISOLDE.
- Integration with large-scale Experimental Facilities and application to other scientific instruments and industrial processes.
- Development of advanced analysis algorithms for magnetic field characterization.
- Investigation of novel sensor technologies for improved sensitivity and resolution.
- Exploration of machine learning techniques for predictive magnetic field modeling.

0.4 Prototype



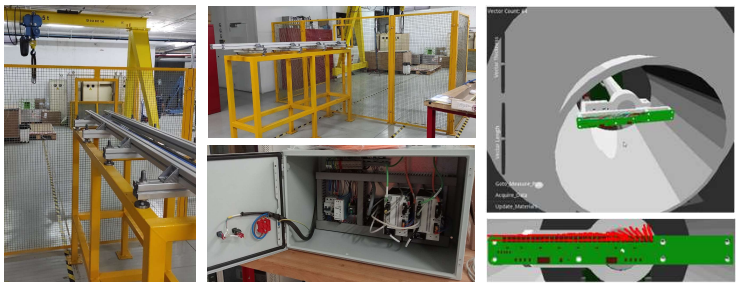


- Advanced Magnetic Field Measurement Technology.
- Precision Robotics and Automation.
- Real-time Data Acquisition and Visualization Software.
- Magnet Characterization and Performance Verification.

Results

Example of magnetic field measurements obtained using Metrolab Software. The sensor was positioned at the midpoint of the solenoid (330 mm).

- Successful commissioning and deployment at the University of Huelva.
- High-precision magnetic flux density measurements with mT-level accuracy.
- Excellent agreement between measured and modeled magnetic field data.
- Real-time detection and response to magnetic field changes.
- Versatile visualization options, including measured field, simulated field, and their difference.



Left and center: Test bench with the control system. **Right:** Array of 3-D Hall sensors displayed in the ACQ Software acquisition.

References

[1] I. Martel et al, Letter of Intent "Design study of a Superconducting Recoil Separator for HIE-ISOLDE", INTC-I-228, 2021.
[2] ISRS project web site, www.uhu.es/isrs/
[3] G. Kirby et al., Design and Optimization of a 4 Tesla 200 mm Aperture Helium-Free Nb-Ti CCT Nested Quadrupole / Dipole Superconducting Magnet. ASC2024 ID 4070214/1LOr1B-07, in press.

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