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Development of a 3D magnetic-field scanner system for the MAGDEM of the ISOLDE Superconducting Recoil Separator (ISRS)

The ISOLDE Superconducting Recoil Separator (ISRS)[1] is an ambitious R&D initiative at CERN aiming to realize an advanced, high-resolution recoil spectrometer based on superconducting Canted Cosine Theta (CCT) magnet technology. Achieving the required field homogeneity, stability, and harmonic control in these magnets is essential to guarantee precise mass separation and time-of-flight measurements. In this context, an accurate experimental characterization of the magnetic field is a critical validation step before integrating the first MAGDEM prototype into the ISRS Ion Test Bench.
To meet this need, a fully automated Magnetic Field Scanner System (MFSS) has been developed to perform precision mapping of the MAGDEM magnet—a cryogen-free, combined dipole–quadrupole CCT superconducting prototype. The MFSS delivers three-dimensional field measurements with sub-millimeter spatial resolution (1 mm step, 0.05 mm precision) and magnetic sensitivity better than 100 μT. It integrates a computer-controlled positioning platform and a HallinSight® 32×2-pixel 3D Hall sensor array, supported by a dedicated software suite for automated scanning, data acquisition, visualization, and direct comparison with simulated field maps. The system achieves alignment precision better than 1.9 mrad, calibration accuracy of 0.2% for a 15 mT reference field, and RMS magnetic noise below 44 μT.
Initial field maps show excellent agreement with COMSOL-based electromagnetic simulations, validating the harmonic purity, field homogeneity, and quench-protection design of MAGDEM. Constructed entirely from non-magnetic materials, the MFSS constitutes a key diagnostic and quality-assurance instrument for MAGDEM and future ISRS superconducting ring magnets, ensuring compliance with the stringent field uniformity and stability requirements of next-generation recoil separators.

References

[1] ISRS website: http://www.uhu.es/isrs

Abstract

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