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Three-dimensional magnetic field mapping system for large spectrometer magnets utilizing on-fly technology

The Institute of Modern Physics of the Chinese Academy of Sciences is currently building the Cooler-Storage-Ring External-target Experiment (CEE) magnet. The magnet's measurement needs to be conducted online, as depicted in the figure 1. The magnet has a center magnetic field of 0.5T, and the measurement area inside the magnet must cover a volume of 2.0 m × 1.6 m × 1.6 m. Furthermore, it is necessary to measure the edge field and the three-dimensional magnetic field in all the areas to be examined, which presents a significant challenge to the measuring system. Firstly, a large moving area is required. Secondly, a high-precision three-dimensional Hall sensor is needed. The proposed magnetic measurement system utilizes a robotic arm and an aluminum alloy measurement module as the transmission device. The robotic arm is responsible for moving the measurement module to any point in the XOY plane of the coordinate system, with the magnet's center as the origin. Meanwhile, the measurement module continuously drives the Hall sensor to move in the z-direction without pausing. The localization of the sensor in the XOY plane is solely dependent on the robotic arm, while the localization in the z-direction is dependent on the measurement module. The sensor's location in the XOY plane is entirely determined by the robotic arm, whilst its positioning in the z-direction is determined by the measurement module. The alignment of the Hall sensor's location and the magnetic field value depends on the Z-direction motor controller of the measurement module. This controller sends out TTL pulses at regular intervals, which act as trigger signals for capturing the position and magnetic field data. The Kuka KR210 is recommended for use as the robotic arm in the magnetic measuring system. After calibration, the robotic arm can achieve an absolute accuracy of 0.2mm@1000mm. The measurement module is self-customized, with the Z-direction motor utilizing a Beckhoff servo motor known for its repeatability precision of over 0.005mm. The Hall sensors are F3A models from SENIS, and to enhance efficiency, a set of 5 F3A sensors are custom-made as a Hall array. To enhance efficiency, we have developed 5 F3A Hall arrays with a maximum measuring magnetic field of 0.6T and an accuracy of 0.1%. Currently, the system is undergoing debugging.

Primary author: FENG, Wentian (Institute of Modern Physics, Chinese Academy of Sciences)

Co-authors: Mr MEI, Enming (the Institute of Modern Physics, Chinese Academy of Sciences); Ms LU, Jiaqi (the Institute of Modern Physics, Chinese Academy of Sciences); Mr YAO, Qinggao (the Institute of Modern Physics, Chinese Academy of Sciences); Mr WU, Wei (the Institute of Modern Physics, Chinese Academy of Sciences); Mr YOU, Wei (the Institute of Modern Physics, Chinese Academy of Sciences); Mr OU, Xianjin (the Institute of Modern Physics, Chinese Academy of Sciences); Mr TONG, Yujin (the Institute of Modern Physics, Chinese Academy of Sciences); Mr CHEN, Yuquan (the Institute of Modern Physics, Chinese Academy of Sciences)

Presenter: FENG, Wentian (Institute of Modern Physics, Chinese Academy of Sciences)