

Development of a hybrid superconducting dipole magnet with the magnetic field beyond 14 T

Several high-field dipole magnets have been developed at the Institute of High Energy Physics, Chinese Academy of Sciences (IHEP, CAS) for preliminary research on next-generation high-energy colliders such as the Super Proton-Proton Collider (SPPC), Future Circular Collider (FCC), and others. Following the achievement of a 12.47-T main field at 4.2 K by the LPF1-U magnet in 2021, IHEP is currently involved in the production of a hybrid magnet, LPF3, with a magnetic field strength towards 16 T. LPF3 consists of six racetrack Nb₃Sn coils on the exterior, designed to generate a 10-T main field within two 75-mm apertures, with additional HTS coils inserted to boost the field strength to 16 T. Graded common-coil configuration was implemented during the fabrication of the six Nb₃Sn coils. Additionally, internal-joint soldering technology was explored to manufacture the innermost two 2-in-1 Nb₃Sn coils, effectively enhancing the magnet's efficiency. A shell-based support structure with dedicated hydraulic pistons was employed to replace traditional bladders for applying pre-stress during assembly. Resistive strain gauges, along with fiber optic sensors, were utilized to monitor stress distribution during the three loading steps from assembly to energization. The magnet was subjected to testing at 4.2 K, successfully achieving a main field strength of 9.8 T through two 75-mm apertures during the initial training tests. In order to maximize its higher current-carrying capacity, the inserted ReBCO coils were configured in a racetrack design, aligning the wide surfaces of the tapes with the magnetic flux. These advancements enabled the HTS insert coil in the LPF3 to achieve a peak dipole magnetic field of 7.66 T, setting a new world record. Details about the development of Nb₃Sn coils and HTS coils will be presented.

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