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Sun-Mo-PL1-02: Towards 20 T Hybrid Magnets: Perspectives and Challenges

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The aim of providing high collision energy for future particle accelerators relies on the capability to design and demonstrate the feasibility of 20 T dipole magnets. To reach the ambitious goal of a future proton-proton collider, a coordinated effort is required to overcome the current technological limits. The US Magnet Development Program is exploring the hybrid magnets option to reduce the overall design cost. In these magnets, High Temperature Superconductors (HTS) such as Bi-2212 and REBCO coated conductors are used in the high-field portion of the coils and Low Temperature Superconductors (LTS), like Nb3Sn, are used in the lower field region. One of the various designs under development is the cos-theta dipole configuration. The main challenges encountered so far concern the protection of this class of magnets from quench events and the stresses in the mechanical support structure and in the conductors to avoid degradation. To help address the challenge of withstanding the Lorentz forces, a shell-based support structure based on the key-and-bladder technology, which provides azimuthal prestress during room temperature assembly and cooldown to cryogenic temperatures, is being considered. To protect such a high-field magnet from quench events, different quench protection systems are being evaluated for both short prototypes and 15 m long ones. In addition to analyzing the magnetic, mechanical and thermal status of these magnets during room temperature assembly, cooldown to cryogenic temperatures, energization and quenching, the mechanical performance of HTS conductors is under investigation to clarify the load limits that cause irreversible degradation. One of the candidates for the high-field hybrid magnets generation consists of REBCO symmetric tape round (STAR®) wires. However, the mechanical response of STAR® wires has not yet been fully investigated, and studying the behavior of these superconductors is a crucial aspect for the magnet design and potential fabrication improvements. Combining the analysis from multi-physics finite element code with the results of the test campaign is fundamental for designing and building reliable 20 T hybrid magnets. As a stepping stone toward 20 T magnets, the Lawrence Berkeley National Laboratory (LBNL) is planning to test the first 9 T hybrid dipole magnet that combines Bi-2212 and Nb3Sn. The assembly of these magnets has highlighted significant mechanical challenges that need to be considered in the magnet design phase. The results of this test will set the stage for future hybrid magnets in the high-energy particle field.

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