

Plenary | Plenary Session

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[PL4] Plenary 4

Chair: Toru Ogitsu(KEK)

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REBCO Requirements for Next-Generation HEP High-Field Magnets — Insights from Recent Muon Collider Design Studies

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Abstract

REBCO-coated conductors have reached performance levels that make them strong candidates for the next generation of High-Energy Physics (HEP) high-field (>12 T) magnets. HEP circular colliders impose simultaneous requirements on field reach, operating temperature, tolerance to radiation and dynamic heat loads, mechanical robustness, quench protection, and cost per meter. Muon Collider (MC) concepts—one of the leading options under study for the next energy-frontier collider—are particularly demanding, calling for 10–20 T dipole and quadrupole magnets and a broad suite of solenoids ranging from ~ 20 T with meter-scale bores to >40 T ultra-high-field final-cooling coils. Operating at 15–20 K is a key lever for sustainable facilities, enabling multi-fold improvements in cryogenic efficiency ($\sim 4\times$ lower electric power at the cold end vs. 4.2 K) and a $\sim 3\times$ reduction in helium inventory, while preserving margin at high field. Recent non-insulated (NI) winding advances demonstrate coil-average current densities in REBCO solenoids that surpass LTS benchmarks (e.g., 45.5 T with ~ 1.4 kA/mm² in small-scale coils), and conceptual studies indicate feasible 16–24 T REBCO-based dipoles operating near 20 K. Building on these results, we outline the integration needs for HEP: conductor architectures compatible with accelerator cabling and winding; engineered inter-turn resistance (for stability and protection); mechanical design to manage strain and mitigate delamination and other failure modes under high Lorentz forces ($J \times B$); protection strategies at very high operating current densities; radiation-tolerant insulation and cooling (including forced-flow options); and cost/supply-chain pathways to series production. We conclude with an R&D roadmap linking near-term magnet demonstrators to the specific field/temperature/availability targets of the MC and future colliders.

Keywords: ReBCO, HEP, Muon Collider, High Field Magnets