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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 (~4x lower electric power at the cold end vs. 4.2 K) and a ~3x 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 (JxB); 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 (Index Terms)—ReBCO, HEP, Muon Collider, High Field Magnets

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