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Sun-Mo-PL1-01: The role of high temperature superconductors for a 10 TeV muon collider

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The international particle physics community, among different options for the development of future high-energy particle colliders and fundamental interactions exploration, considers Muon Colliders (MC) as a great opportunity to achieve high discovery potential and integrated luminosity compatible with a compact and cost-effective accelerator machine. An international muon collider collaboration (IMCC) has recently been set up, following the recommendations of the European Strategy for Particle Physics (ESPP), to produce a conceptual design of a Muon Collider with a 10 TeV center-of-mass energy.
From the analysis of the collider's various magnetic components, large stored energies for the capture and cooling solenoids, very high magnetic fields up to 40 T for the final cooling solenoids, and large bore (up to 140 mm) and high field combined function magnets for the accelerator and collider rings are required. High-temperature superconductors (HTS) result the enabling technology to address these challenges and achieve the required collider performances. Given the peculiar accelerator stages of the muon collider, most superconducting magnets are required to operate in steady-state mode, with normal-conducting dipoles handling rapid acceleration and fast field variations, allowing the use of HTS coated conductors to increment magnet performances compared to low temperature superconductors (LTS) technology. This aspect is also fundamental in advancing the energy efficiency and sustainability goals of next-generation accelerator facilities for high-energy physics. By enabling magnet operation at temperatures above liquid helium, HTS offer the potential to significantly reduce the energy consumption of entire accelerator complexes. This energy-saving capability must be increasingly prioritized in magnet design strategies with different impacts on the collider performance, cost and feasibility.
In this paper we elaborate on the above aspects, discussing the technological challenges for the 10 TeV muon collider configuration and how HTS will make them viable and efficient to pave the way to new compact and high-performance particle collider machines capable to overcome the current energy frontier.

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