Cryogenics in high-energy particle accelerators

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Applied superconductivity has become a key technology for high-energy particle accelerators, allowing to reach higher beam energy while containing size, capital expenditure and operating costs. Large and powerful cryogenic systems are therefore ancillary to low-temperature superconducting accelerator devices – magnets and RF cavities – distributed over multi-kilometer distances and operating generally close to the normal boiling point of helium, but also above 4.2 K in supercritical and down to below 2 K in superfluid. Additionally, low-temperature operation in accelerators may also be required by considerations of ultra-high vacuum, limited stored energy and beam stability. We discuss the rationale for cryogenics in high-energy particle accelerators, review its development over the past half-century and present its outlook in future large projects, with reference to the main engineering domains of cryostat design and management of heat loads, cooling schemes, efficient power refrigeration, specific instrumentation and process control.