Design of a magnetic refrigeration for future particle accelerators

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PhD may follow: Yes

Summary :

Bending and focusing magnets or accelerating cavities of particle accelerators use superconducting materials and require significant cryogenic capacities (kW range at 1.8 K for LHC). The refrigeration cooling power is presently produced by "traditional" compression/expansion helium refrigeration cycles with reduced overall efficiencies (â€¹ 20%). For the next generation of accelerators (Future Circular Collider â€“FCC- being studied at CERN), the needs of greater cooling (10 kW/sector) and colder temperatures (â€¹ 1.8K) are considered. A potentially attractive alternative for this refrigeration below 4.2 K (boiling temperature of helium at normal atmospheric pressure) is magnetic refrigeration (or adiabatic demagnetization) that would avoid the use of sub-atmospheric compression source of complexity in existing systems and that would improve the overall efficiency of the cooling system. Magnetic refrigeration applies cyclically an external magnetic field on paramagnetic materials to reduce entropy and then to produce cooling. This technique of adiabatic demagnetization is currently used in our Low Temperature Laboratory (SBT) for space activities to reach temperatures կ K at low heat load (a few mW). SBT offers today to study magnetic refrigeration around 1.5 K for large cooling powers of the order of kilowatts. Based on a preliminary conceptual design of a magnetic refrigeration unit able to fulfill the ambitious requirements of FCC project (10kW to 1.5K), the trainee will first review the state of the art of other alternative designs and then perform a detailed design of the selected solution including the study of the paramagnetic material configuration to improve heat exchange.

Requested skills :

Basic knowledge in thermal, mechanics and magnetism