Simulations of a gas-filled helical muon beam cooling channel

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Abstract
A helical cooling channel (HCC) has been proposed to quickly reduce the six-dimensional phase space of muon beams for muon colliders, neutrino factories, and intense muon sources. The HCC is composed of a series of RF cavities filled with dense hydrogen gas that acts as the energy absorber for ionization cooling and suppresses RF breakdown in the cavities. Magnetic solenoidal, helical dipole, and helical quadrupole coils outside of the RF cavities provide the focusing and dispersion needed for the emittance exchange for the beam as it follows a helical equilibrium orbit down the HCC. In the work presented here, two Monte Carlo programs have been developed to simulate a HCC to compare with the analytic predictions and to begin the process of optimizing practical designs that could be built in the near future. We discuss the programs, the comparisons with the analytical theory, and the prospects for a HCC design with the capability to reduce the six-dimensional phase space emittance of a muon beam by a factor of over five orders of magnitude in a linear channel less than 100 meters long.

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