THPAB121

PLASMA MUON BEAM COOLING FOR HEP

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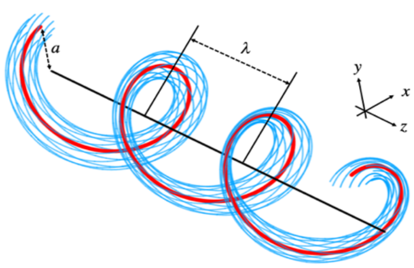
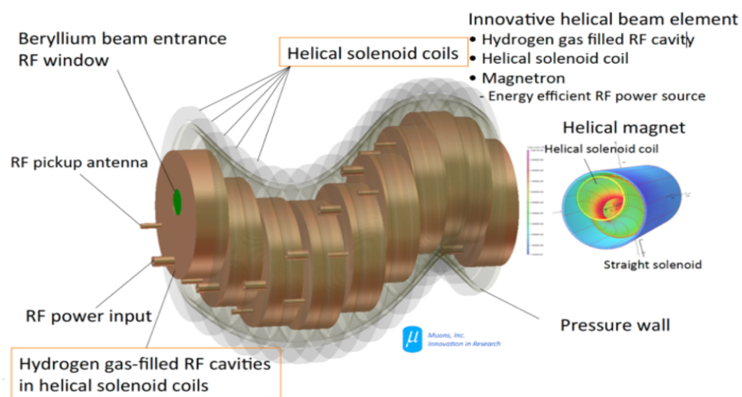
Abstract

Ionization cooling has the potential to shrink the phase space of a muon beam by a factor of 10^6 within the muons short lifetime (2.2 μs) because the collision frequency in a cooling medium is extremely high compared to conventional beam cooling methods. Ionization cooling inherently produces a plasma of free electrons inside the absorber material, and this plasma can have an important effect on the muon beam. Under the right circumstances, it can both improve the rate of cooling and reduce the equilibrium emittance of the beam. This can improve the performance of muon facilities based on muon cooling; in particular a future muon collider. We describe how plasma muon beam cooling can be applied to both the basic Helical Cooling Channel (HCC) and extreme Parametric-resonance Ionization Cooling (PIC) techniques. This new approach to muon cooling can achieve significantly reduced muon beam emittance.

HELICAL COOLING CHANNEL

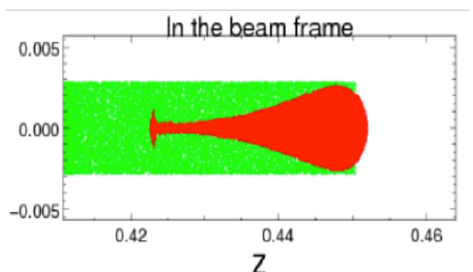


Typical beam paths in a HCC (blue), around a design reference orbit (red).

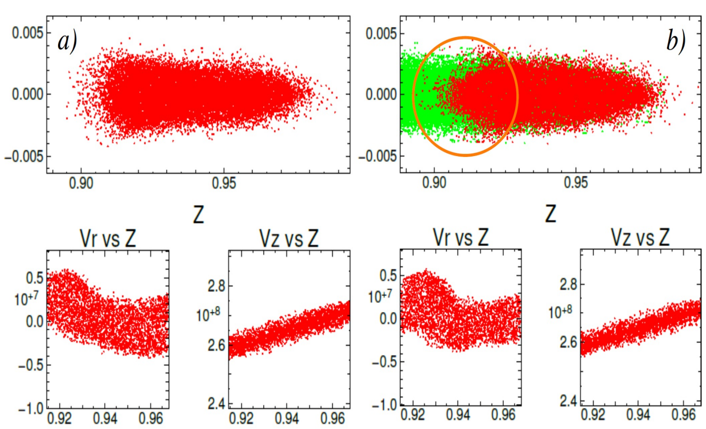


Pictorial drawing of an HCC channel

BEAM-INDUCED PLASMA FOCUSING

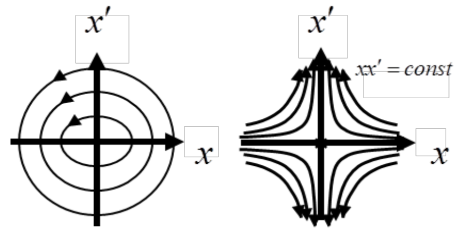


Muons (red) passing through hydrogen gas leave a beam-induced plasma trail (green)

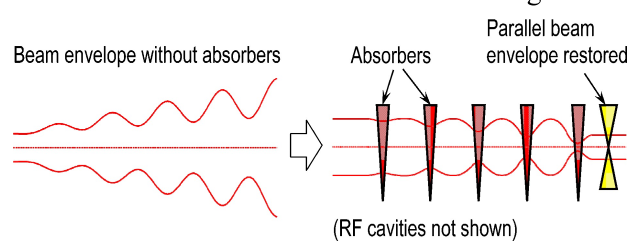


WARP simulations show the plasma lens effect without gas (a) and with gas (b). A red point is an incident particle and a green one is an ionization electron. Only a straight solenoidal magnetic field and RF field are applied, with no dispersion in this simulation. The orange circle shows that the beam is focused by the plasma lens.

PARAMETRIC-RESONANCE IONIZATION COOLING OF PLASMA COOLED BEAMS



Parametric-resonance Ionization Cooling



Stabilizing effect of ionization cooling energy absorbers in a channel with a half-integer resonance. Plasma cooling would reduce aberration and beam size and would greatly help compensation.

Plasma cooling is an important aspect of muon beam cooling. The challenges in performing accurate and realistic simulations arises from it combining multiple physics processes in a unique way:

1. A muon beam propagating in a magnetic lattice consisting of dipoles, quadrupoles, and higher-multipole magnets.
2. A muon beam being accelerated in RF cavities.
3. A muon beam interacting with the matter in the absorbers.
4. The electron plasma generated by #3 being affected by the magnets, the RF cavities, and the muon beam.
5. The muon beam being affected by the electron