Contribution ID: **115** Type: **Late poster**

muCool: High brightness ultra-cold positive muon beam

Monday 8 July 2024 16:52 (2 minutes)

The muCool project aims to develop an innovative device for generating low-energy, high-intensity, and high-quality muon beams for future high-precision experiments such as muon g-2 measurements, muonium spectroscopy, and muonium gravity studies. These experiments, involving muons and muonium atoms, hold significant potential for testing theoretical predictions of the Standard Model within a purely leptonic system.

The muCool device is designed to reduce the phase space of a standard positive muons beam by a factor of 10ˆ10 with an efficiency of 10ˆ-3 [1]. The muCool device is a cryogenic helium gas target with a complex electric field geometry inside the active volume, placed in a homogeneous magnetic field of 5T. Muons are transversely compressed by a combination of ExB drift and drift resulting from collisions with helium gas, as the collision frequency changes vertically due to the gas density gradient. Longitudinal compression is achieved through an electric potential minimum along the length of the muCool device. Combined transverse and longitudinal compression of the muon beam to sub-millimeter size and cooling to eV energies have been demonstrated recently [2]. To make the muCool device compatible with future muon experiments, the muon beam must be extracted from the target volume through an orifice. The extraction step poses a significant technical challenge in maintaining the helium gas density profile inside the muCool target while transitioning from a closed to open volume design. The upgraded design concept and simulation results for muon beam extraction will be presented.

[1] Belosevic, I., Antognini, A., Bao, Y. et al. “muCool: a next step towards efficient muon beam compression”. Eur. Phys. J. C 79, 430 (2019). https://doi.org/10.1140/epjc/s10052-019-6932-z
[2] A. Antognini, N.J. Ayres, I. Belosevic et al. “Demonstration of Muon-Beam Transverse Phase-Space Compression”. Phys. Rev. Lett. 125, 164802(2020). https://doi.org/10.1103/PhysRevLett.125.164802

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Session Classification: Poster session

Track Classification: Antimatter