Contribution ID: **127** Type: **Oral**

muCool: A novel low-energy muon beam for future precision experiments

Friday 25 October 2019 10:20 (20 minutes)

Experiments with muons (μ^+) and muonium atoms (μ^+e^-) offer several promising possibilities for testing fundamental symmetries of particle physics with high precision. Examples of such tests include the search for the muon electric dipole moment, measurement of the muon $g-2$ and muonium laser spectroscopy. These experiments could benefit from a high-quality muon beam at low energy with small transverse size and high intensity.

At the Paul Scherrer Institute, we are developing a novel device (muCool) that produces such a high-quality muon beam, reducing the phase space of a standard μ^+ beam by 10 orders of magnitude with 10^{-3} efficiency. The phase space compression is achieved by stopping a standard μ^+ beam in a cryogenic helium gas and subsequently manipulating the stopped μ^+ into a small spot using complex electric and magnetic fields in combination with gas density gradients. Finally, muons are extracted through a small orifice into the vacuum and into a field-free region. The whole process takes less than 10 μs, which is essential due to a short muon lifetime of 2.2 μs. Various aspects of this compression scheme have been demonstrated in the last few years. Comparison of the measurements with GEANT4 simulations confirms that the proposed efficiency can be achieved.

In this talk, I will explain the working principle of the muCool device and present the most recent measurements and current developments.

This work is supported by SNF grant 200020_172639.

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Session Classification: Session