Slow μ^- beams: Cooling and a Novel Production Concept

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A μ^- beam of a few keV energy, unique in the world, is presently used at PSI to stop muons in a small hydrogen target at very low density. We show here how it can be extended to obtain muons with energies in the 10 eV range that would stop in the surface atomic layers of solid targets. Such a slow beam would open the field of μ^- investigation of solid surfaces with negative muons. By using existing cooling concepts, the quality of the beam can be strongly improved, and stopping in a small area target with sensitive depth analysis becomes possible.

In terms of intensity however, the existing production scheme, although it uses the world's most intense DC π^- beam, does not provide more than 1000 slow μ^- per second. A novel approach is therefore proposed that should allow a 100–fold increase in beam intensity. It also provides a high quality beam that can be used without further cooling. The basic idea is to induce μ^- stops in helium in such a way that a high quality slow beam of μ^-He^{++} positive ions is extracted. Acceleration to a few MeV leads to a very well timed beam with small emittance. By focusing it on a tiny low Z target, the μ^- are re-emitted at energies around 100 keV. After adequate collection, debunching and deceleration, a timed, high–quality keV beam is formed that can be further decelerated to stop in the surface layers of a solid target.

Two methods for the production of the μ^-He^{++} beam are presented. The first one is an extension of a recently presented new method for slow μ^+ production[1]. The second one relies on the emission of neutral μ^-He$^+$ atoms from a superfluid helium layer followed by laser ionisation.

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[1] D. Taqqu, Phys. Rev. Lett. **97**, 194801 (2006).