Ultra-slow muon production at the RIKEN-RAL muon facility based on muonium emission from silica aerogel

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Positive muons having an energy of a few eV, the so-called ultra-slow muons, are generated by laser ionization of thermal muonium atoms (Mu) in vacuum. By accelerating them through an electrostatic field, a variable-energy muon beam with an extraordinarily small energy spread can be realized[1,2]. This technique has therefore attracted attention for advanced μSR studies and for measurement of the muon anomalous magnetic moment, g-2, and electric dipole moment at J-PARC[3].

One of the key issues with ultra-slow muon production is how to generate more Mu in vacuum. Recently, we successfully observed Mu emission into vacuum from a silica aerogel with a uniform surface[4], and subsequently realized that a silica aerogel having a non-uniform structure with hole-like regions created by laser ablation leads to an emission that is higher than that for uniform one by one order of magnitude[5]. Compared to the conventional tungsten heated to 2300 K[1,2], this room-temperature silica-aerogel has significant advantages: it is easy to handle because of no significant heat radiation; its lower Mu energy distribution leads to a smaller emittance of the ionized source; its smaller spatial spread and smaller Doppler broadening results in more efficient use of the available laser power.

As the next step, we will perform a demonstration and R&D study of the actual ultra-slow muon production using a silica-aerogel target at the RIKEN-RAL muon facility (Port 3). The new experimental setup is shown in Fig. 1. Ultra-slow muons will be extracted at an angle of 45-degrees to avoid a straight beam background with a rotationally-symmetric electrostatic field (SOA lens); these muons will be detected by a Micro-Channel Plate (MCP) detector with a slit system to evaluate the beam characteristics. The Mu spin is controlled using three-axis Helmholtz coils. A μSR counter set is used for measurement of the Mu production rate, control of Mu spin and optimization of stopping.

Commissioning runs without the laser system were peformed in September and December 2015. After installing the laser system in early 2016, we plan to produce the first ultra-slow muon beam with an aerogel target. Then, we hope to start optimization towards a higher yield with the shape of the structured aerogel target and by efficiently increasing the Lyman-α irradiation using reflection mirrors installed near the target.

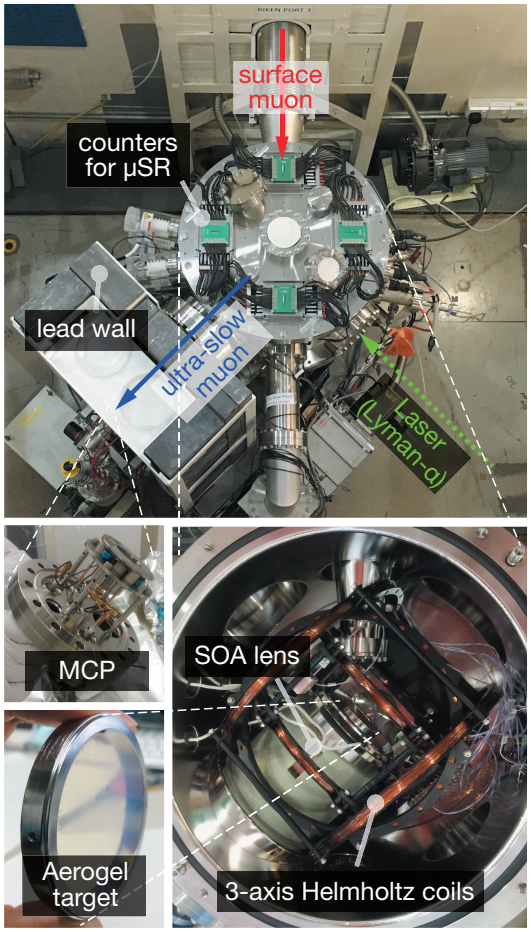

Fig. 1. New experimental setup at the Port 3 beam line of the RIKEN-RAL muon facility for ultra-slow muon study based on muonium emission from a silica aerogel target.

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