Contribution ID: **52**   Type: **Flash Plenary Talk**

Prospects for true muonium observation at existing beamlines and colliders

Thursday, 29 May 2025 14:40 (8 minutes)

True muonium (TM), the bound state of a muon and an antimuon, remains unobserved due to its short lifetime and production cross-sections, together with its extremely high ($13Z^2$) dissociation cross-section in matter. Recent theoretical and experimental studies have, however, identified feasible pathways to its discovery at current high-energy physics facilities.

At the LHCb experiment, the production of the vector 1S TM state via $\eta \to \gamma TM$ with subsequent $TM \to e^+e^-$ decay has been proposed in 2019. Preliminary studies suggested that a displaced e^+e^- vertex search could achieve a significance exceeding five standard deviations thanks to the large LHC-Run3 statistics.

In 2024 a resonant search for true muonium via $e^+e^- \to TM \to e^+e^-$ interactions has been proposed, using a 43.7 GeV positron beam at the CERN Super Proton Synchrotron (SPS) North-Area H4A beam facility. Simulations indicate that the spin-1 TM state could be observed with high significance with about 10^{12} positrons impinging on an assembly of multiple thin lithium targets by searching for displaced e^+e^- vertices, thanks to its large decay-in-flight distance of about 11 cm.

Another method to observe true muonium using e^+e^- interactions, proposed in early 2025, employs photon-photon fusion into the spin-0 TM state (para-TM), decaying into two photons. Thanks to its high integrated luminosity and to the presence of triggers dedicated to photons, the Belle-II experiment, featuring a 10.58 GeV center-of-mass energy, is a very good candidate for this measurement. Monte Carlo simulations incorporating trigger, detector efficiencies and resolutions and background processes suggest that para-TM production via photon-photon fusion is feasible. Applying machine learning techniques, such as extremely randomized trees, to simulated events indicates that the TM signal can be distinguished from background, with projected statistical significances reaching discovery level, using the current dataset of about 400 fb-1 already collected at Belle-II.

Muon dipole moments (magnetic and electric): theory, experiments and future perspectives

Charged lepton flavor violation: theory, experiment and future perspectives

New Physics opportunities with low and high energy muon beams

Neutrino physics with muon beams: theory, experiments and future perspectives

Muons beams technologies: production, cooling and acceleration at different energy

Advancements in Muon-based Facilities and Broader Applications

Muons in other fields: muography, muon spin spectroscopy, muon-catalyzed fusion

none

Primary author: GARGIULO, Ruben (Istituto Nazionale di Fisica Nucleare)

Presenter: GARGIULO, Ruben (Istituto Nazionale di Fisica Nucleare)

Session Classification: New Physics oppportunities with low and high energy muon beams