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Towards Improving the Precision of the Lamb Shift Measurement in Muonium

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Due to its lack of internal structure, Muonium is an excellent candidate to provide stringent tests for bound state QED. Furthermore, Muonium is a sensitive probe for the existence of exotic dark-sector particles, new muonic forces, and hidden dimensions. During the Mu-MASS [1] beamtime in December 2019 at the LEM beamline at PSI, we demonstrated the creation of an intense directed beam of metastable Muonium [2]. This opened up the possibility to measure the Muonium Lamb shift to an uncertainty of 2.5 MHz, which is an improvement of around an order of magnitude upon the last measurements [3]. Additionally, by measuring the isolated $2S_{1/2}, F = 0 \rightarrow 2P_{1/2}, F = 1$ transition for the first time [4], we demonstrated a promising way for an improved determination of the Muonium Lamb shift, provided that the measurement is not limited by statistics anymore. Towards reaching that goal, several improvements are envisioned at the LEM beamline to increase the muon and consequentially the metastable Muonium flux. The experimental setup, the current status and plans for future improvements will be presented.

[1] P. Crivelli, "The Mu-MASS (muonium laser spectroscopy) experiment", Hyperfine Interactions 239, 49 (2018)
[2] G. Janka et al., "Intense beam of metastable Muonium",Eur. Phys. J. C (2020)
[3] B. Ohayon, G. Janka et al., "Precision Measurement of the Lamb Shift in Muonium", Phys. Rev. Lett. 128, 011802 (2022)
[4] G. Janka et al., "Measurement of the transition frequency from $2S_{1/2}, F = 0$ to $2P_{1/2}, F = 1$ states in Muonium", Nat Commun 13, 7273 (2022).

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