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Precise measurement of the hyperfine splitting in muonium with a high intensity pulsed muon beam at J-PARC

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A muonium is a purely leptonic bound system of a positive muon and an electron.
Fundamental properties of such a system can be precisely predicted by the QED, whereas ordinal atoms require to calculate hadronic interactions.

At J-PARC, the MuSEUM (Muonium Spectroscopy Experiment Using Microwave) collaboration aims to precisely measure the ground-state hyperfine splitting of muonium atoms, arising from spins of the muon and electron.
The pulsed muon beam is stopped in a krypton gas cell to form the muonium atoms.
The transitions of spin states are induced with a microwave cavity, which is then measured by positron counters.

In previously performed measurement with a nearly-zero magnetic field [1,2], the resonance of the hyperfine transition was successfully observed with a relative precision of 160 ppb.
As a next step, we plan to perform the measurements with strong magnetic fields, so that the different frequency shifts by Zeeman splitting allow us to more precisely determine the transition rate down to 1.2 ppb.
This unprecedented precision will be achieved by upgrading several components of the experimental setup, including a new high intensity muon beamline which is currently commissioned at J-PARC.
Performing measurements at various magnetic field strengths requires to replace the current cylindrical microwave cavity with a new boxed-shaped cavity.

In this presentation, the general scheme of our experiment and status of the upgrades for the new measurement are reported.

[1] S. Kanda et al., Phys. Lett. B 815, 136154 (2021).
[2] S. Nishimura et al., Phys. Rev. A 104, L020801 (2021).

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