Development for the precise microwave spectroscopy of muonium with a high magnetic field

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on behalf of the MuSEUM collaboration

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The MuSEUM collaboretion is planned at J-PARC to measure the hyperfine structure of muonium (Mu HFS) at high magnetic field (1.7 T). The goal is to presicely test the Standard Model and determine the fondamental constants.

The MuSEUM collaboration aims to measure the Mu HFS transition energy with an accuracy of 1.2 ppb and determine the magnetic moment ratio of the muon proton with an accuracy of 12 ppb, resulting in an order of magnitude improvement compared to the previous experiment [1]. In 2023, we perform the first measurement with a high magnetic field at high intensity pulsed muon beamline (H-line). In this measurement, the transition frequency depends on the magnetic field because the measurement is based on the Zeeman splitting produced by the magnetic field (see Fig.1). Whereas, this measurment requires a very uniform magnetic field (0.2 ppm, peak-to-peak) in a large spectroscopy volume (ϕ 20 cm and L 30 cm). To overcome this challenge, we are developing a magnetic field distribution measurement system with a resolution smaller than 10 ppb using a CW (Continuous Wave)-NMR probe [2], and passive shiumming technique. We are developing a magnetic field measurement system (see Fig.2) in which multiple CW-NMR probes are arranged in a semicircle circumference to enable measurement in a short time. In this poster, various key technologies of contorolling the magnetic field are presented.

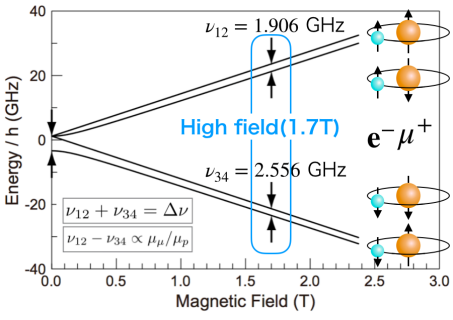

Figure 1: The energy levels of muonium under a magnetic field.

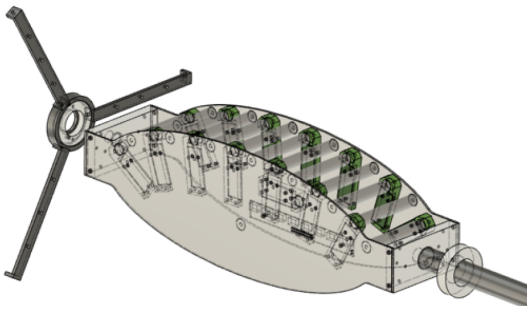

Figure 2: Magnetic field measurement system

[1] W. Liu *et al.*, Phys. Rev. Lett. **82**, 711-714.
[2] H. Tada *et al.*, IEEE Trans. Appl. Supercond. **32**, 6.