Muon Spin Spectrometer at MLF MUSE U1A: Commissioning results and upgrade plans

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Muons, second-generation charged leptons, have a mass 207 times that of electrons and decay via weak interaction with a lifetime of 2.2 microseconds. The muon spin rotation/relaxation/resonance (μSR) technique leverages the correlation between the muon spin and the angular distribution of decay products to study the time evolution of muon spins in materials. Standard μSR experiments use muon beams with energies around a few MeV, but a low-energy, monochromatic muon beam is essential for studies on thin films or interfaces inside materials. At J-PARC MLF MUSE, the ultra-slow muons (USM) beamline delivers precisely controlled low-energy positive muons with an energy of 30 keV. At the U1A experimental area, a muon spin spectrometer is under commissioning for operations for user programs [1]. The U1A spectrometer is equipped with a helium-flow type cryostat and coils that can apply a magnetic field to the sample along with the beam direction. The apparatus can achieve a lowest temperature of 4.2 K and a maximum magnetic field of 0.1 T. The entire experimental setup is mounted on a high-voltage stage, allowing for controlling the muon energy from nearly zero to 30 keV. Since 2022, the spectrometer has been fully engaged in comprehensive scientific measurements, including sample cooling, magnetic field application, and control of implantation energy. We have been working on the performance evaluation of the apparatus and demonstrating USM-μSR measurements. In this presentation, we will report on the recent results obtained from the pilot experiments and discuss potential upgrades based on simulations.

References

[1] S. Kanda et al., J. Phys.: Conf. Ser., 2462, 012030 (2023).