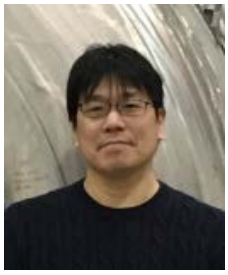
【Grant-in-Aid for Specially Promoted Research】

Science and Engineering



Title of Project： Super high precision measurements of anomalous magnetic moment and electric dipole moment of muon

MIBE Tsutomu
(High Energy Accelerator Research Organization, Institution of Particle and Nuclear Science, Associate Professor)

Research Project Number: 20H05625 Researcher Number：80536938
Keyword：muon, anomalous magnetic moment, electric dipole moment, high precision

【Purpose and Background of the Research】

The standard model of particle physics is a successful theory to quantitatively describe varieties of phenomena in particle physics. However, new laws of physics beyond the SM (new physics) are strongly required as this theory is not able to explain recent observations such as origin of neutrino masses, mass hierarchy of quarks and leptons, origin of dark matter and matter-dominant universe.

The anomalous magnetic moment g-2 (or a_μ) of muon has been known for its sensitivity to prove new physics. It was measured at BNL with a relative precision of 540 ppb (parts-per-billion, 10^{-9}). This is more than three standard deviations larger than the SM prediction (Fig. 1). Inputs to the SM calculation have been given by the large number of experiments. It is not meaningful to blame the SM calculation without allowing inconsistencies elsewhere. On the other hand, there is no other experimental measurement of g-2 with precision of the BNL experiment so far.

In this research proposal, we employ a completely different experimental technique to precisely measure the g-2 and electric dipole moment (EDM) of muon. Our experiment naturally has a different source of systematic uncertainty. Therefore, the scientific value of the research will remain unchanged even after the release of the Fermilab experiment, a successor of the BNL experiment. The objectives of this research are to obtain a decisive conclusion on the question whether the g-2 value is indeed larger than in the SM, and to carry out a search for muon EDM with the best sensitivity ever achieved.

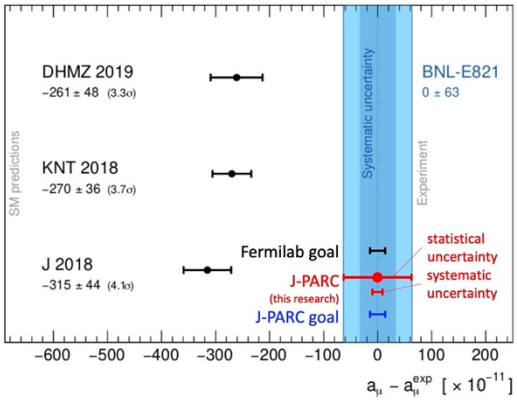


Figure 1 Difference between theory predictions and measurements of muon g-2

【Research Methods】

In our reseach methods, we emphasise importance of beam emittance. A muon beam is in general produced in two steps. First, a proton beam hits a pion production target to generate pions through nuclear reactions. Next, a pion decays into a muon and a muon neutrino. At these steps, the beam emittance (phase space volume of the beam) inevitably inflates. A typical value of emittance is ~1,000π mm·mrad. We plan to reduce the emittance by three orders of magnitude, i.e. ~1π mm·mrad by a cooling followed by acceleration. This allows to use much more efficient beam injection, a compact storage ring with a better controlled magnetic field distribution, large coverage of the decay-positron tracking detector. Our approach is immune to all major systematics of the BNL and Fermilab experiments.

【Expected Research Achievements and Scientific Significance】

The expected research achievements are to start data taking of the experiment to measure the muon g-2 and EDM with completely different technique in the period of this research. After construction of experimental apparatus and its commissioning, data taking will follow. The target precision of g-2 is a 450 ppb statistical uncertainty (similar to the BNL result) with a systematic uncertainty less than 70 ppb (four times better than BNL, similar to the Fermilab goal). The same data will be used to search for muon EDM with a sensitivity of 1.5×10^{-21} e ·cm (100 times better than the BNL limit).

【Publications Relevant to the Project】

· M. Abe, et al., Prog. Theor. Exp. Phys. 2019, 053C02 (2019).
· T. Aoyama, et al., arXiv:2006.04822 (KEK Preprint 2020-5) (2020).

【Term of Project】

FY2020-2025

【Budget Allocation】

489,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://g-2.kek.jp
tsutomu.mibe@kek.jp