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Status of the COMET experiment

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The COMET experiment aims to search for the neutrinoless coherent transition of a muon to an electron in the field of an aluminum nucleus, which violates the lepton flavor conservation and has never been observed yet thus far. The experiment takes place at J-PARC with single event sensitivities of orders of 10^{-15} and 10^{-17} in the Phase-I and Phase-II, respectively. The ambitious goals of the COMET experiment are achieved by realizing a high-quality pulsed beam and unprecedentedly powerful muon source. The construction of a new beamline, superconducting magnets, detectors and electronics is intensively in progress towards the forthcoming Phase-I measurement. An overview and recent status of the COMET experiment are presented.

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Among a lot of experiments to search for physics beyond the Standard Model, observation of charged lepton flavor violation (CLFV) would be one of the most definite evidence. We know that the lepton flavor is no longer conserved since the discovery of the neutrino oscillation. However, taking into account the neutrino oscillation effect, brunching ratios of CLFV processes are negligibly small such as an order of 10^{-54}. On the other hand, most of well-motivated theoretical models predict larger brunching ratios within the reach of experimental sensitivities in near future [1, 2]. Hence experimental plans for next-generation CLFV search are attracting a great deal of attention.

The COMET experiment aims to search for the muon-to-electron conversion, $\mu^- N \to e^- N$, in a muonic atom [3, 4]. The experimental sensitivities are the levels of 10^{-15} and 10^{-17} in the Phase-I and Phase-II, respectively, which are 2 and 4 orders of magnitudes better than the current limit of 7×10^{-13} [5]. The experiment utilizes a dedicated 8-GeV proton beam slowly extracted from the J-PARC Main Ring with 3.2 (56) kW beam power in the Phase-I (II). The primary beam is delivered through a newly-constructed beamline to the COMET experimental hall with keeping the bunch structure of 1.17-μs intervals. The important requirement for the pulsed beam is the number of protons leaking in between bunches, so called extinction, which must be less than 10^{-10} in order to suppress beam-related prompt backgrounds. Recently we have performed an extinction measurement using the slow extraction of the 8-GeV proton beam for the first time, and confirmed that the required extinction was achievable [6].

To construct unprecedentedly powerful muon source, a long production target is placed at the center of a superconducting magnet, and backward-generated low-energy pions are captured by a solenoidal magnetic field of 5 T. Low-energy muons generated by the pion decay in flight are transported through a curved solenoidal beamline in which the negative charged particles and the momentum around 60 MeV/c are selected. Negative muons are stopped in aluminum target discs and form muonic atoms. If the muon-to-electron conversion happens, a 105-MeV monochromatic electron is emitted. The momentum of the signal electrons is measured by a cylindrical drift chamber (CDC) together with trigger hodoscopes in the Phase-I. The construction of the CDC and readout electronics was completed and performance tests are well in progress. Another role of the Phase-I is a measurement of the muon beam quality to understand the beam-related backgrounds in detail. In the beam measurement, we install straw tube trackers and electromagnetic calorimeters which are also used in the Phase-II physics measurement.

The target sensitivity is achievable in 150-days (1-year) operation in the Phase-I (II). Owing to good beam quality and detector performance, the background is expected to be as small as 0.3 events in the Phase-I. Based on results from the Phase-I measurement, the sensitivity and background in the Phase-II are able to improve with high reliability.

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