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COMET Phase-Alpha Experiment to Investigate COMET's New Muon Beamline at J-PARC

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The COMET experiment aims to search for the muon-to-electron conversion process with a sensitivity 10,000 times better than the current best result. The muon-to-electron conversion process violates charged lepton flavor conservation, which is strictly forbidden in the Standard Model. Once discovered, the muon-to-electron conversion process will provide definitive evidence of the existence of new physics beyond the SM.

The key to significantly improving sensitivity lies in providing an intense muon beam. By utilizing the 8 GeV proton beam from the J-PARC facility, the COMET experiment will deliver a muon beam with a world-record intensity. To achieve this, the superconducting pion capture system and muon transportation system play crucial roles. In addition to intensity, the transportation system can select beam particles based on their charge and momentum to ensure the quality of the muon beam, which is essential for precise measurements. To investigate the muon beam and its transportation, the COMET collaboration proposed an experiment known as Phase-α to generate muons in the COMET experimental hall using the transportation system and directly measure the beam.

To measure the muon beam, three detectors were developed for the COMET Phase-α experiment. The first is the Muon Beam Monitor, which utilizes scintillating plastic fibers to measure the position and timing of beam particles. The second is the Straw Tube Tracker, which determines the position and direction of beam particles. The third detector is the Range Counter, consisting of plastic scintillators, absorbers, and targets, capable of counting negative muons in different momentum ranges and identifying positive pion decay chains. To further investigate transportation performance, a beam-masking device was placed in front of the transportation system to precisely control the initial phase space distribution of the injected muon beam. In addition to muon beam measurement, titanium dioxide (TiO_2) sensors were installed for primary proton measurement.

In February and March 2023, the COMET experimental hall received the muon beam for the first time. The COMET Phase-α experiment successfully observed muon beams delivered by the transportation system and collected valuable datasets for in-depth analysis. The ongoing data analysis process will be discussed, including detailed insights into the facility, experiment, detectors, and some preliminary results.

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