A Study of the Performance of the Tracker and Calorimeter for the COMET Experiment

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Any observation of charged-lepton-flavor violating processes gives a significant impact on physics beyond the standard model (BSM). The COMET experiment will search for the muon-to-electron ($\mu - e$) conversion in aluminum at J-PARC in Japan with high-intensity pulsed proton beams [1]. If it exists, the signal is an electron having monochromatic energy of 105 MeV. Since the standard model, even including the neutrino oscillation, suppresses its branching ratio down to an unobservable level of $< O(10^{-50})$, detection of the signal is clear evidence of new physics. The experiment will be performed separately in Phase-I and Phase-II, by extending the facility and by changing the detector, and aims to finally improve the single event sensitivity by 10,000 times more than the latest upper limit $\sim O(10^{-13})$ set by the SIMDRUM-II experiment [2]. The detector for the Phase-I is a cylindrical drift chamber, although, in the Phase-II, a pair of a gaseous tracker using low-material straw tubes and electromagnetic calorimeter (ECAL) of LYSO scintillating crystals will measure the signal electrons and is called StrECAL. The single straw tube must have a spatial resolution less than 200 μm to realize a momentum resolution of 200 keV/c for electrons at 105 MeV. The ECAL also plays a role of the trigger detector and is required to have energy resolution $< 5\%$, position resolution < 10 mm, and time resolution < 1 nsec for the signal electrons. The StrECAL also will work in the Phase-I to investigate the property of the muon beam and beam-origin backgrounds and hence must be able to distinguish kinds of beam particles, mainly electrons, muons, and pions. We have been developing several prototypes and constructed the final one combining both the tracker and ECAL prototypes. In 2017, a test-beam experiment was carried out to evaluate their performance by using electron beams with several momenta around 105 MeV/c at Research Center for Electron Photon Science in Tohoku University, Japan. As a result, both the prototype detectors accomplished all the requirements. In the term of the particle identification, we recorded real responses of the ECAL against electrons, muons, and pions at Paul Scherrer Institut in Switzerland in 2015. Our simulation study combining those data estimated that the StrECAL would have PID efficiencies better than 90% for each of the three particle kinds. This poster reports all the detail of the performance studies of the StrECAL prototypes.

References

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