博士論文公聴会の公示 (物理学専攻)

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論文題目: Study of Radiative Muon Capture for COMET Phase-I Experiment
(日本語タイトル) COMET Phase-I 実験における輻射ミュー粒子捕獲反応の研究

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論文要旨:

Recent measurements have proven that neutrinos are massive particles; however, the mass of neutrinos is so small compared to other particles that another process may explain their masses. To explain this, some models introduce at least one Majorana neutrino, which allows for new processes such as $\mu^- + N \rightarrow e^+ + N'$ conversion. Thus, measuring such processes is important to deepen our understanding of neutrinos. The COMET Phase-I experiment aim to improve the limit of this measurement by a factor of 100 from the current upper limit measured by the SINDRUM-II experiment. However, radiative-muon-capture-induced positrons could shadow it.
To account for this, an analysis procedure has been developed to be able to measure the endpoint of the radiative muon capture photons in COMET Phase-I. The analysis is composed of four distinct steps: a hit filtering based on a gradient-boosted decision tree, a track finding algorithm with a circular Hough transform algorithm, a track fitting algorithm based on Kalman filter technique, and a likelihood analysis to fit the theoretical photon spectrum in the reconstructed photon spectrum. A simulation of 10^{11} photons was carried out to test the performance of the analysis procedure thus developed. Through this study, the different acceptances of the COMET Phase-I experiment to the radiative muon capture events have been estimated.
This analysis procedure has been tested on simulation data. As a result, over the course of 100 days of measurement, the COMET Phase-I experiment will be able to reconstruct approximately 16k radiative muon capture events.
The study has shown that the endpoint energy of the radiative muon capture photon spectrum (k_{max}) for an aluminum target could be estimated with the precision of ± 0.82 MeV which is an improvement of a factor of 2 over the previous measurement performed in TRIUMF. Assuming that the mean value of k_{max} in aluminum is 90.1 MeV as measured by the TRIUMF experiment, this improvement of the uncertainty shall reduce the background contribution of radiative muon capture to $\mu^- + N \rightarrow e^+ + N'$ ground state transition by a factor of 10.