



Contribution ID: 71

Type: **Oral contribution**

COMET Phase- α : Validation of the Muon Transport System for a Muon-to-Electron Conversion Search at J-PARC

The COMET experiment at J-PARC searches for the charged-lepton-flavour-violating process of coherent muon-to-electron conversion in a muonic atom, $\mu^- N \rightarrow e^- N$, with a target single-event sensitivity of $O(10^{-17})$. Its beamline is designed to transport low-energy negative muons produced by a high-intensity proton beam with high efficiency and to maximise the number of stopped muons in the downstream stopping target. A key element of this system is the Muon Transport Solenoid (MTS), a curved superconducting solenoid that provides charge and momentum selection while guiding the selected negative muons to the experimental area.

COMET Phase- α was carried out in 2023 as the first proton-beam commissioning campaign of the COMET facility. In this campaign, proton-beam injection and secondary-particle transport were commissioned. In particular, negative-muon transport through the MTS was demonstrated for the first time at the facility. This talk reports the validation of the muon transport system, focusing on measurements of the negative-muon beam in the downstream experimental area using a Range Counter (RC).

The RC measures decay electrons from negative muons stopped in a copper plate installed inside the detector, and reconstructs the number of stopped muons from the decay-time distribution. By varying the thickness of graphite degraders placed upstream of the RC, the incident momentum acceptance for stopped muons was changed, allowing the negative-muon momentum spectrum to be reconstructed from data taken under multiple conditions. In addition, position-scan measurements were performed to evaluate the spatial distribution of the beam in the experimental area.

The measured momentum spectrum was broadly consistent with the shape expected from the MTS configuration. The position scan showed an asymmetric beam profile, interpreted as a characteristic effect of transport through the curved solenoid. Comparisons with Geant4-based simulations, including backward muon production, transport, and detection, showed agreement with the main features of both the momentum spectrum and the spatial distribution at the present level of precision.

These results demonstrate successful proton-beam injection into the COMET facility and negative-muon transport through the MTS, marking an important milestone toward the physics search phase of the COMET experiment.

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Track Classification: WG3: Accelerator Physics