Contribution ID: **76** Type: **Oral contribution**

Separating Muons from Pions in LArTPC Data Using Optimal Transport for BSM Dimuon Searches

Tuesday, September 1, 2026 4:35 PM (25 minutes)

Searches for beyond the Standard Model (BSM) massive long-lived particles decaying to muon pairs face severe irreducible backgrounds in Liquid Argon Time Projection Chambers (LArTPCs). Standard neutrino interactions regularly produce a muon and a pion in the final state, which are currently indistinguishable in LArTPC data. We address this ambiguity using a novel machine-learning method based on the Optimal Transport (OT) algorithm, adapted from LHC jet-classification techniques. By analyzing full 3D track trajectories, our method exploits distinct event topologies at track ends, where muon/pion decays and nuclear captures diverge. We demonstrate the algorithm' s performance using publicly available MicroBooNE simulation data. The classifier is optimized for high-purity muon identification to ensure robust confidence in potential BSM discoveries. The efficiency gains in muon selection evaluated at a 90% accuracy will be reported.

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Session Classification: WG5 —Searches Beyond PMNS

Track Classification: WG5: Neutrinos Beyond PMNS