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Machine Learning in the JUNO Experiment: An Overview

The Jiangmen Underground Neutrino Observatory (JUNO) is a neutrino experiment located in China with a broad physics program. Following nearly a decade of construction, JUNO began physics data-taking on August 26, 2025. The primary goals of the experiment are the determination of the neutrino mass ordering and the high-precision measurement of neutrino oscillation parameters. JUNO's central detector is an acrylic sphere 35.4 meters in diameter filled with 20 kt of liquid scintillator. The detector is equipped with photomultiplier tubes (PMTs) of two types: 17,596 20-inch PMTs and 25,587 3-inch PMTs, which record the intensity and timing of scintillation light.

Due to the detector's large size and complexity, JUNO is expected to benefit from machine learning (ML) techniques in meeting its strict performance requirements. This talk will review various ML developments within the experiment. Specifically, in the MeV regime, I will cover ML models developed for waveform, vertex, and energy reconstruction, alongside selection algorithms for inverse beta decay events. For atmospheric neutrinos, neural network applications to perform particle identification, event directionality, and energy reconstruction will be discussed. Additionally, I will report on JUNO's efforts regarding ML-based muon track reconstruction, which enhances cosmic background veto efficiency. Finally, I will discuss the application of simulation-based inference for detector energy response parameter tuning.

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