Event reconstruction of atmospheric neutrinos using Machine Learning-based method in JUNO

Wing Yan Ma[1], Fanrui Zeng[1], Jiaxi Liu[2], Xinhai He[2], Zhen Liu[2], Wuming Luo[2], Hongye Duyang[1], Teng Li[1], Yongpeng Zhang[2]

[1] Shandong University

[2] Institute of High Energy Physics, CAS

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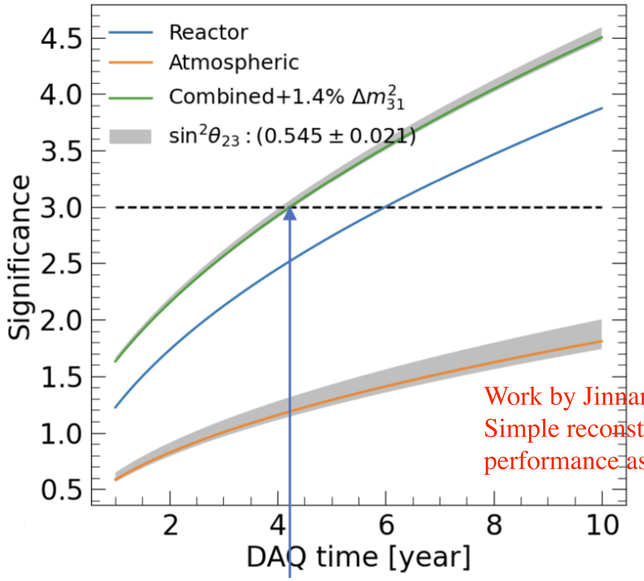
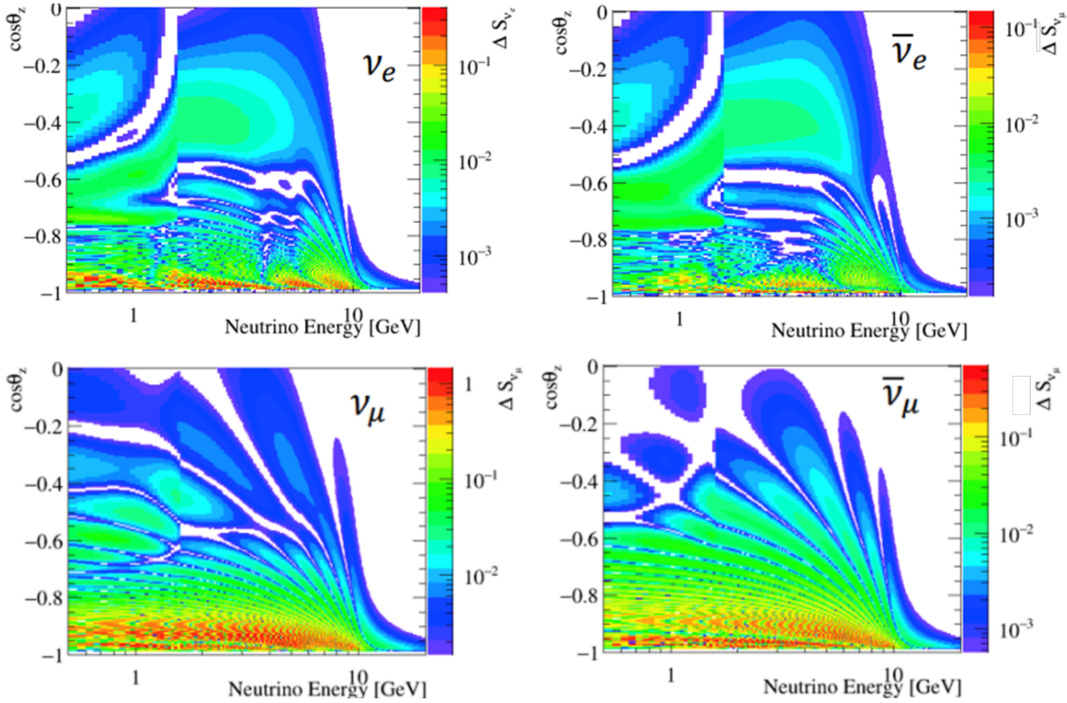
Overview

- NMO sensitivity can be enhanced by studying ν_{atm} oscillations in GeV region
- Oscillation probabilities depends on E, L, different neutrino flavor exhibits different oscillation probabilities depending on Mass Ordering
- Precise **energy, direction, particle identification (PID)** reconstructions are crucial
- We present a novel, **multi-purpose reconstruction method** based on ML algorithms

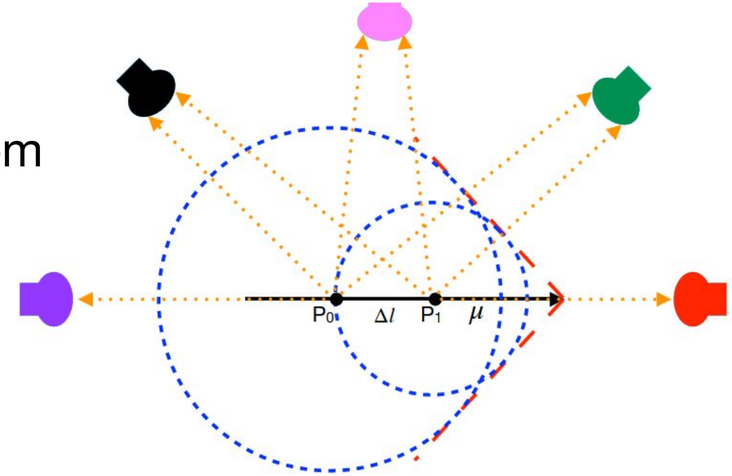


Work by Jinnan Zhang
Simple reconstruction performance assumed

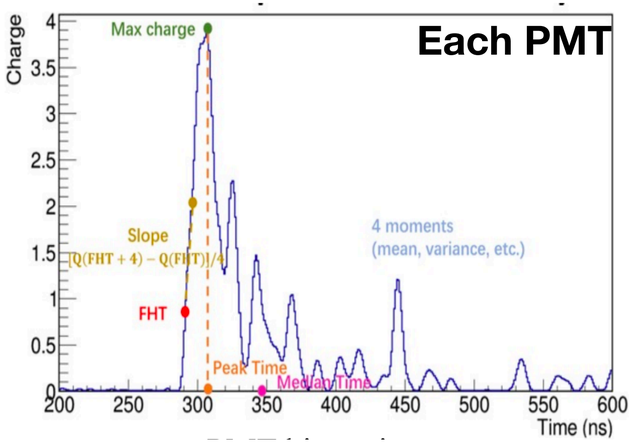


Methodology

- Light seen by PMTs of an LS detector is a superposition of light generated from many points along the track
  - Shape of light curve received by each PMT depends on :
    - Angle w.r.t. track direction θ
    - Track starting and stopping position
    - Particle type - different dE/dx

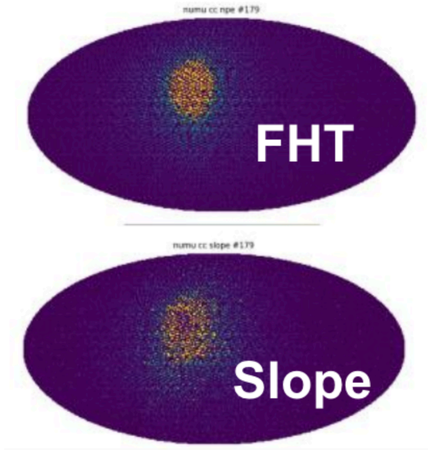


- Features extracted from each PMT's waveform reflect the event's topological structure and carry information about the event's direction, energy and flavor types: **multi-purpose reconstruction**



PMT waveforms

Combining all PMTs



Pictures of PMT features

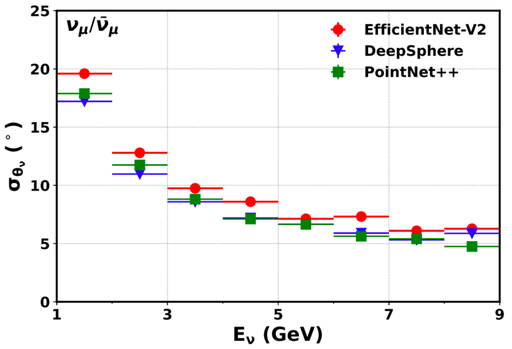
ML models (Energy)

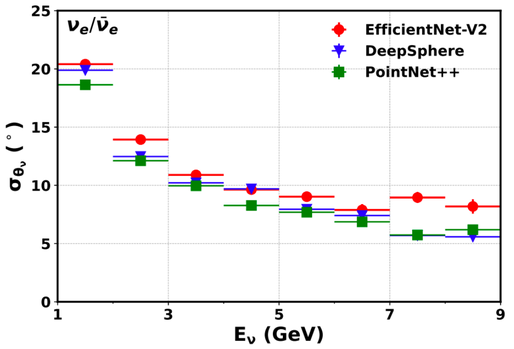
ML models (Direction)

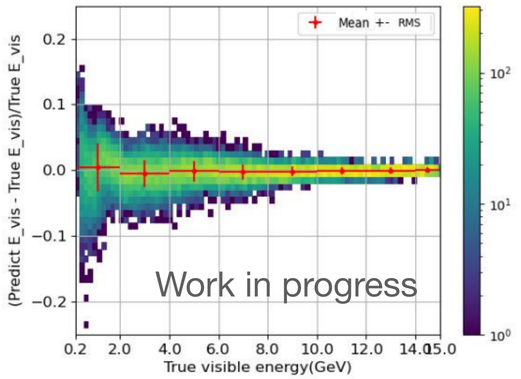
ML models (PID)

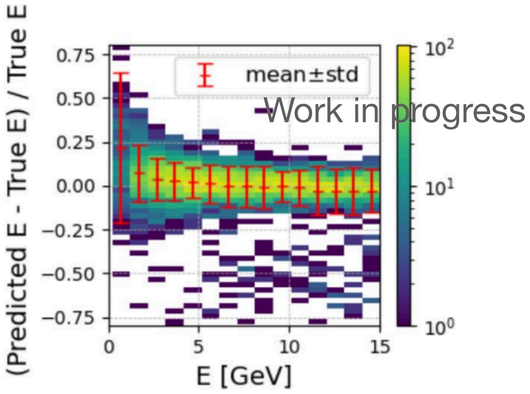
Performances: Energy, Direction

- Different types of machine learning models were developed to cross validate the method:
  - Planar Model: EfficientNetV2, Spherical CNN: DeepSphere, 3D point cloud: PointNet++
- Good resolutions achieved for both energy/directional reconstructions
  - Can reconstruct both E_{vis}/E_{ν} with good resolution
- Paper published on PRD: arxiv:2310.06281
- **First demonstration in reconstructing ν_{atm} direction in a LS detector with MC**









Performances: PID

- Can utilise neutron capture events producing delayed signal to aid $\nu/\bar{\nu}$ separation
- Efficiencies and purities can be tuned to obtain an optimised sample for NMO analysis
- Please come and see our poster for more details! (**4-11**)