Improving Particle Identification in SFGD for ND280 in T2K Using Neural Networks
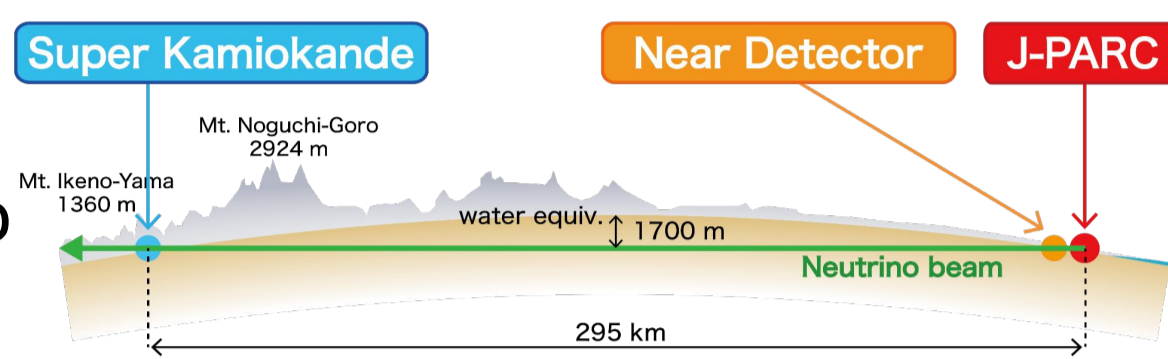
Enhancing neutrino interaction studies through modern Machine Learning methods.

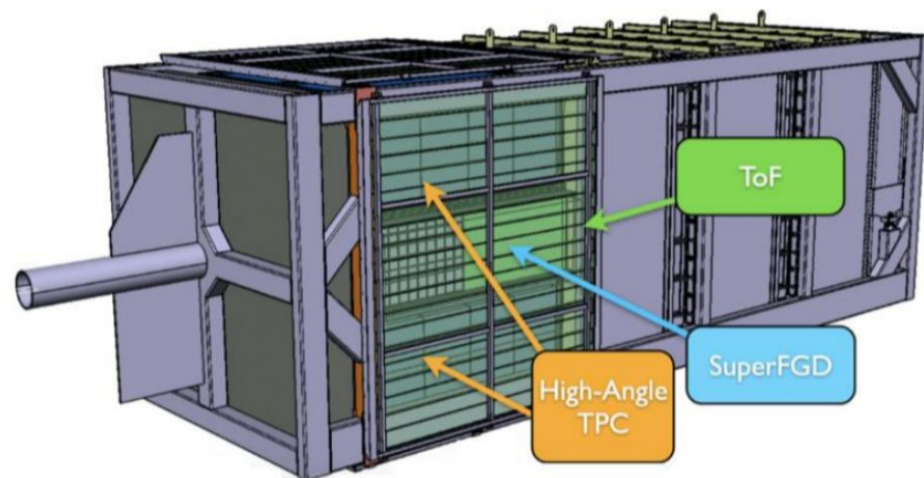**V. Kiseeva on behalf of the JINR T2K group**

Problem Statement

The **T2K** (Tokai to Kamioka) is a long-baseline neutrino oscillation experiment in Japan.
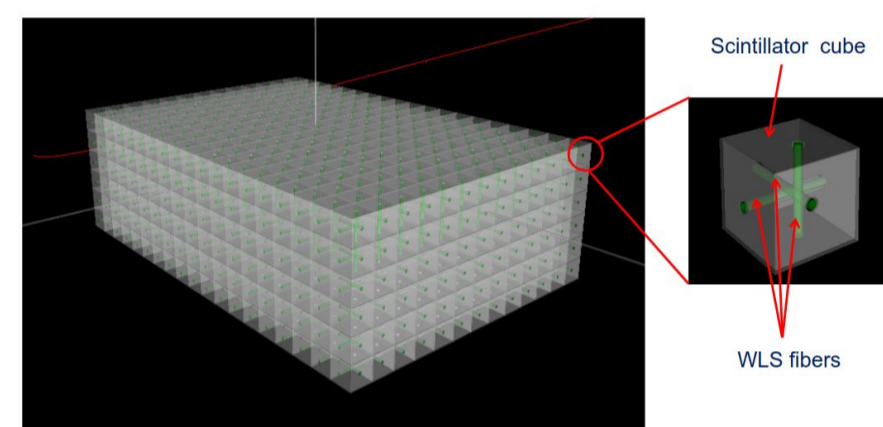

T2K experiment

Its primary objective is study of neutrino oscillations [1].

The **Super-Fine-Grained Detector** (SFGD) in the T2K experiment identifies particles such as protons, muons and pions [2].
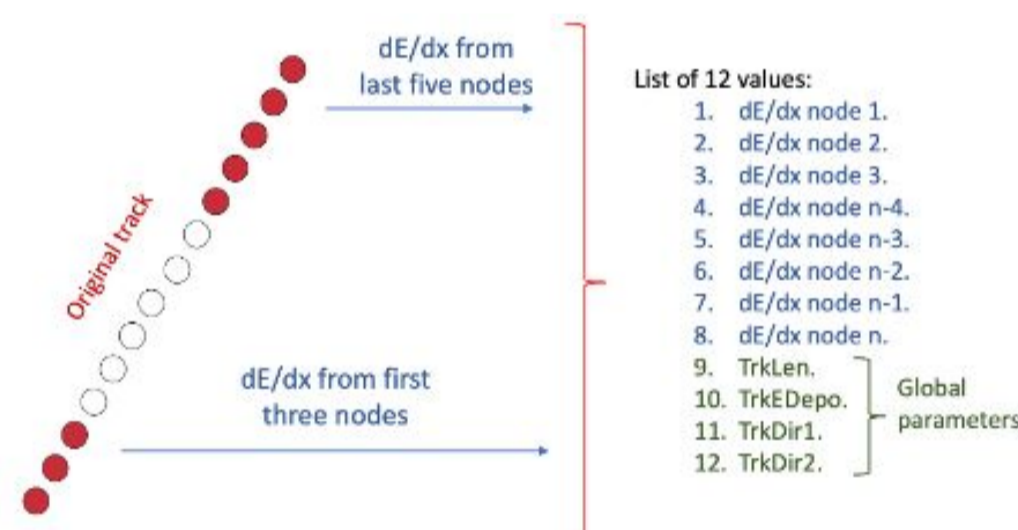

Upgraded ND280   **Upgraded SFGD**

Accurate PID is critical for improving neutrino oscillation measurements.
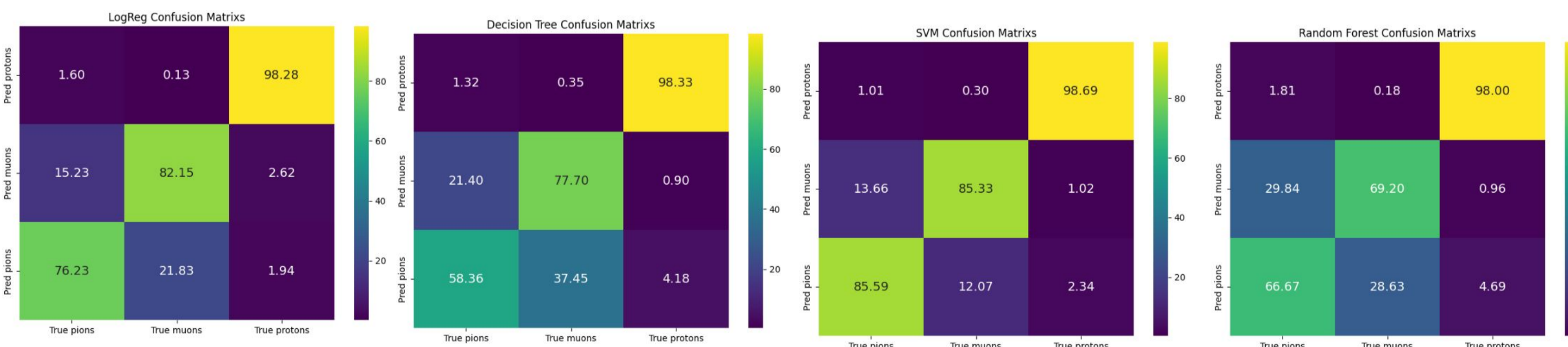
Data Preprocessing

A more robust but straightforward way is to keep the information of only a few nodes of each track [4].

Baseline Models

Logistic Regression, Decision Trees, Random Forest and Support Vector Machine are used to establish baseline performance.

Previous Approach

Boosted Decision Trees used for classification and momentum reconstruction [3].
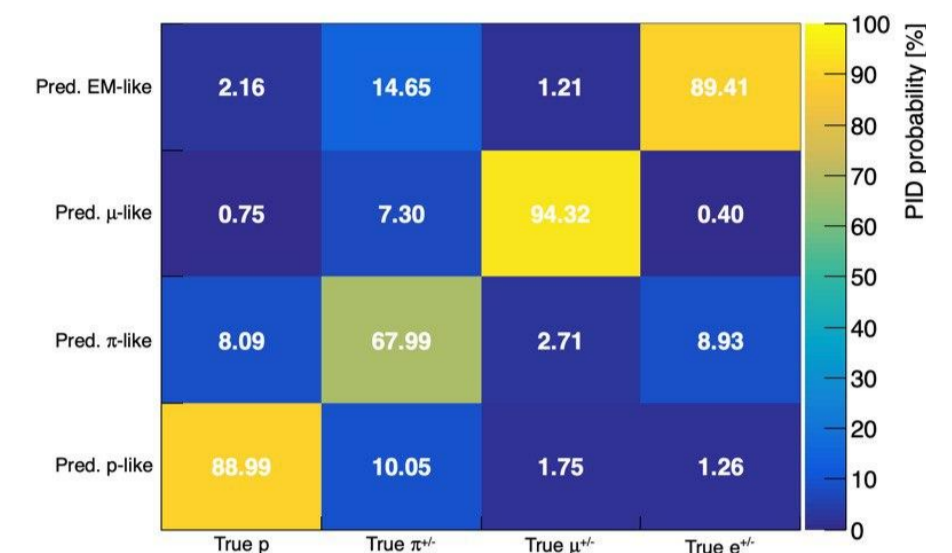
Proposed Method

Neural Networks are highly effective to solve problems of this type as they can model complex, non-linear relationships between input features.

Input Data

- code for PID
- momentum in MeV
- number of nodes
- order of the nodes
- coordinates of the nodes X,Y,Z-axis
- timestamps
- energy deposits of nodes
- length of the track
- energy deposition
- track direction, polar/azimuth angle

Neutrino interaction ND280

Data Visualization

Future Steps

1. Feature engineering
2. Neural Network Architecture Design
3. Training and Optimization
4. Apply custom tool to compare performance

Conclusion

Baseline of neural network method has been analyzed to identify areas for improvement and will be fully implemented in the future.
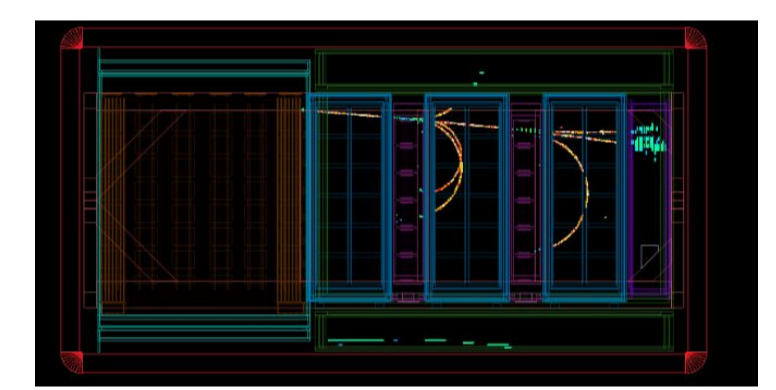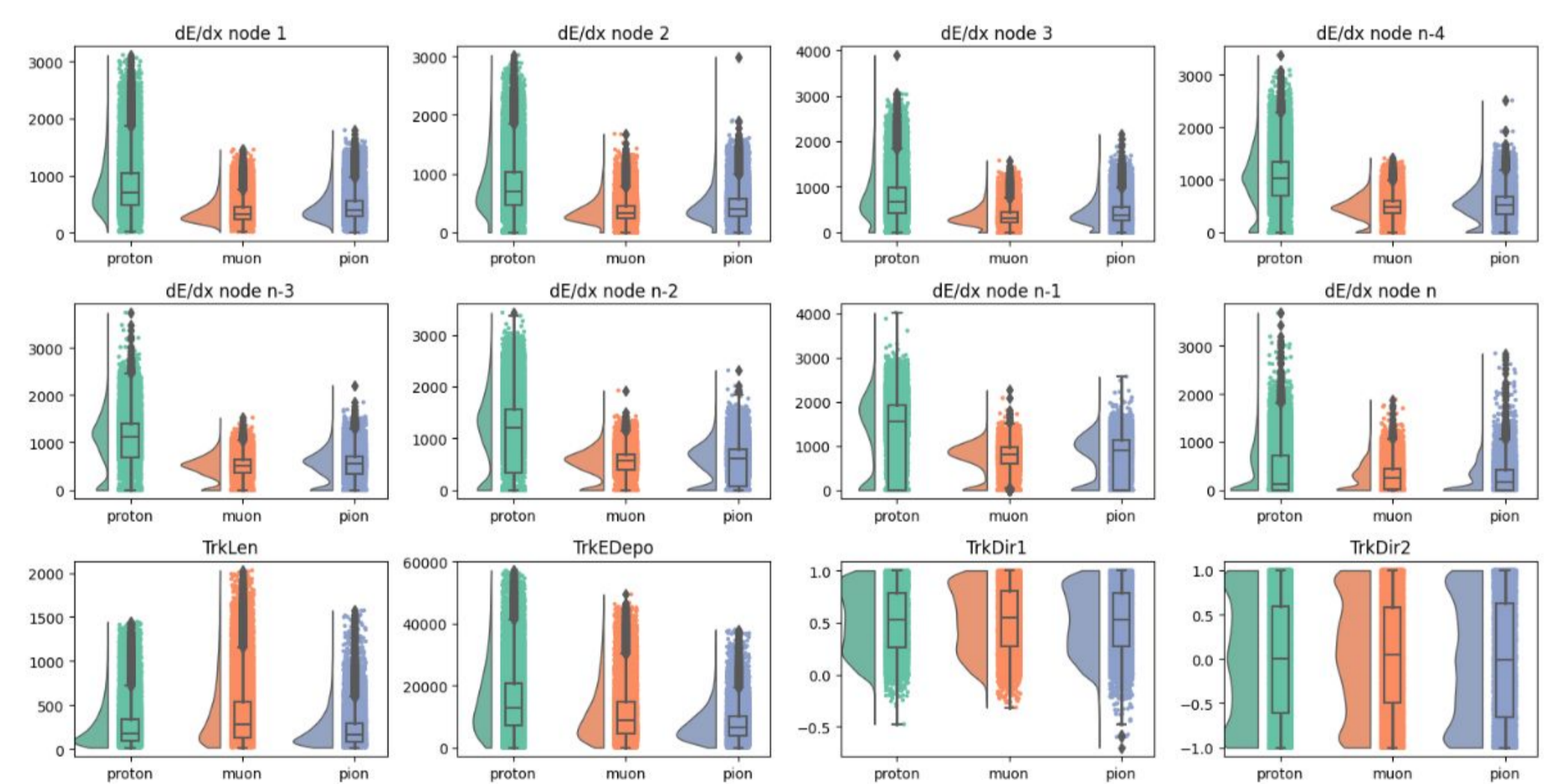
[1] K.Abe et al 2011 Nucl.Instr.Meth.A 659, 106

[2] K.Abe et al., T2K ND280 Upgrade -- Technical Design Report, arXiv:1901.03750 [physics.ins-det], doi: 10.48550/arXiv.1901.03750.

[3] X. Zhao, BDTForTrackPIDAndPrecon, T2K Collaboration, November 1, 2024, https://www.t2k.org/nd280/physics/nd280-ai-ml-working-group/meetings/2024/november-1/BDTForTrackPIDAndPrecon_20241101/view

[4] S. Alonso Monsalve, T2K Masterclass: AI and Machine Learning in Neutrino Experiments, T2K Collaboration, https://t2k.org/young/young-doc/young-masterclass/masterclassAI.