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# Development of an agnostic global particle identification tool for the upgraded ND280 near detector

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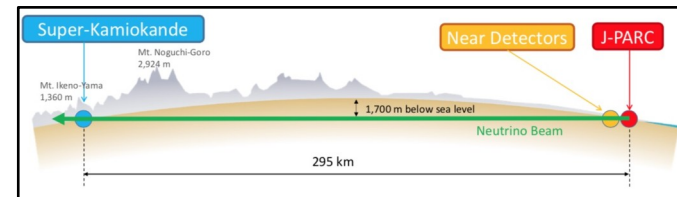
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# T2K Experiment

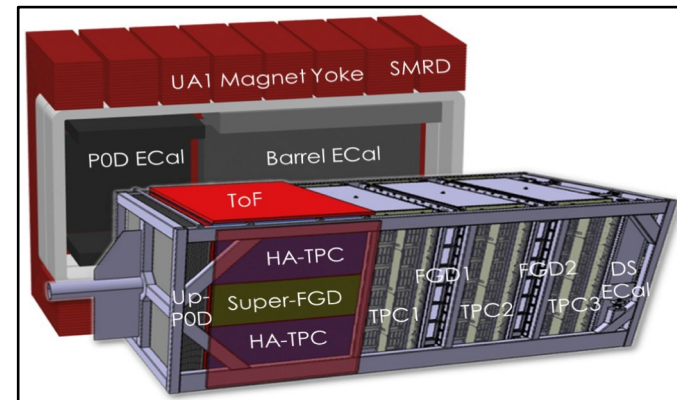
## T2K:

- Tokai-to-Kamioka (**T2K**) is a long baseline neutrino experiment stationed in Japan, stretching 295 km. T2K is composed of the Japan Proton Accelerator Research Complex (**J-PARC**) neutrino beam, the near detector suite and Super-Kamiokande (**Super-K**).



## ND280:

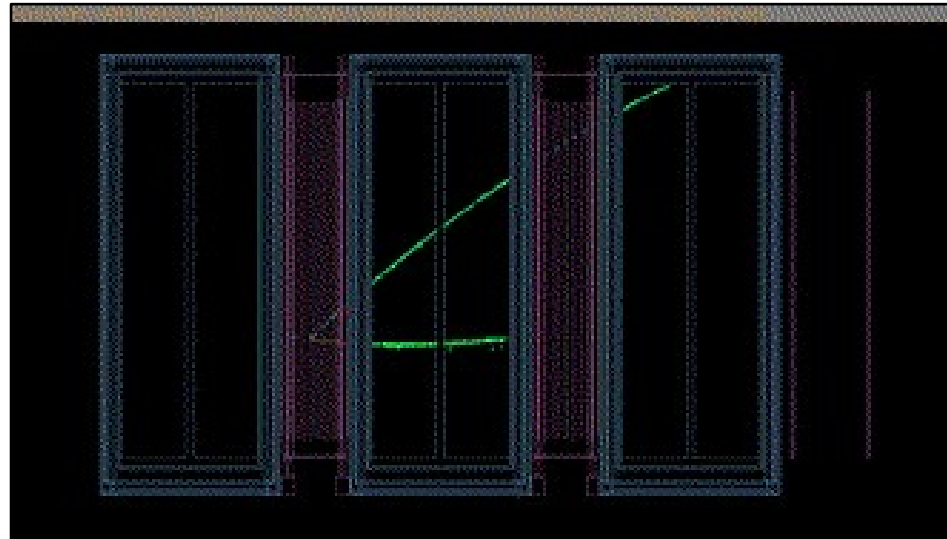
- A near detector, ND280 is located 280m downstream and 2.5° off axis from the beam source.
- Samples the neutrino beam before oscillation occurs, and constrains both the oscillation fits and the neutrino nucleus interaction cross sections.
- ND280 sub-detectors:
  - Two Fine Grained Detectors (**FGD**)
  - Two Time Projection Chambers (**TPC**)
  - Electromagnetic Calorimeter (**ECAL**)
  - UA1 magnet yoke
  - Side Muon Range Detector (**SMRD**)
  - Super Fine Grained Detector (**SFGD**)
  - Time Of Flight (**TOF**) planes
  - Two High Angle Time Projection Chambers (**HATPC**)



# Particle Identification in the ND280 near detector

## Current PID methods:

- Particle Identification is typically carried as a user-defined sequence of cuts on a track.
- In neutrino induced charged current pion production there can be a misidentification of a negative (positive) pion as the leading (anti) muon due to a wrong signed background from contamination in the beam.
- There is room for improvement through machine learning methods.

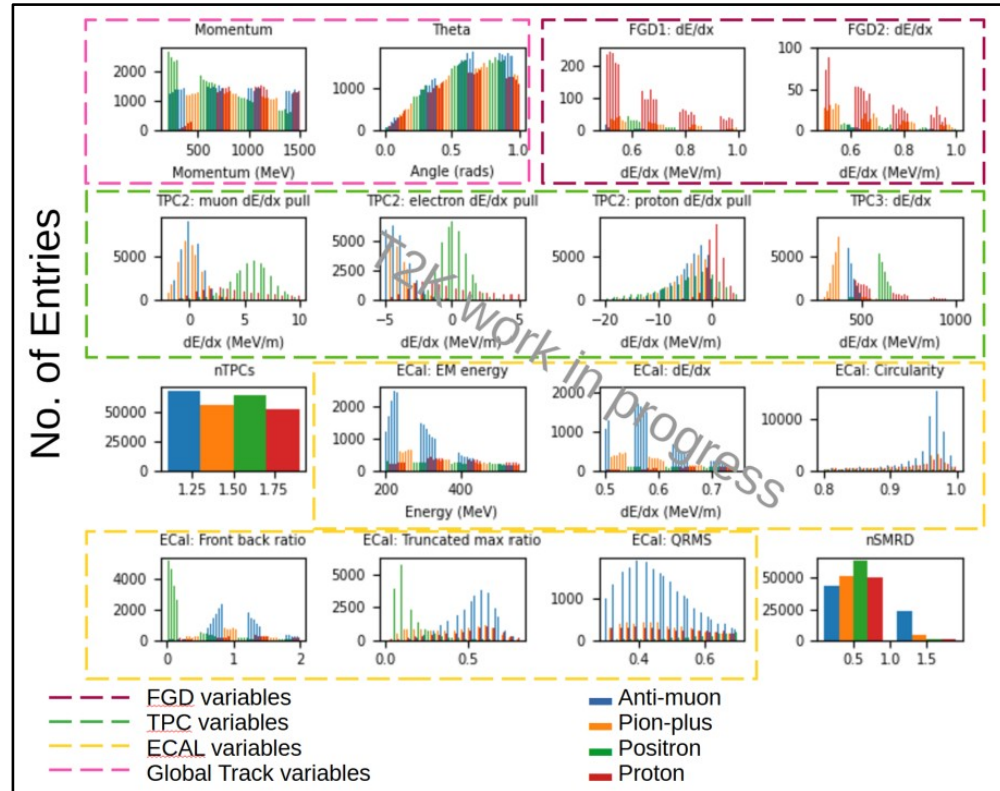


ND280 event display showing a clean charged current interaction in FGD1

# Improving particle identification for ND280

## Investigating machine learning:

- We train a Boosted Decision Tree (BDT), on flat prior distributions of momentum and direction as a general and agnostic Particle Identification tool.
  - BDT from XGBoost package
  - Trained with particle gun simulation with events starting in the FGD1.
- Multiple event variables were considered as candidates, 16 were chosen via an N-1 study.



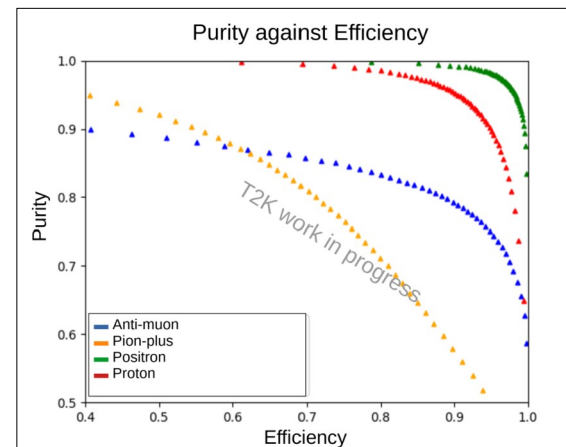
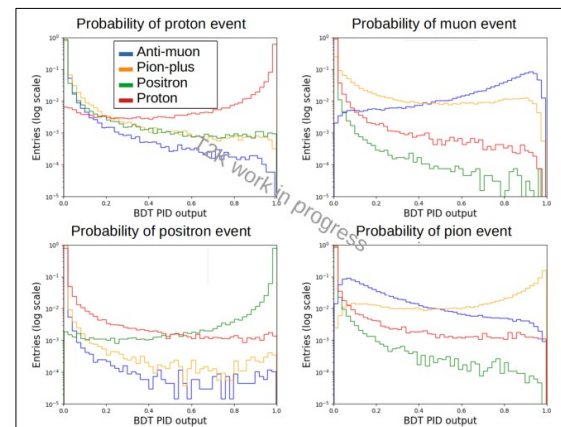
# Performance of the BDT and Future plans

## Results:

- Results are from an agnostic basis.
- The BDT probability outputs have clear separation for positron and proton events.
- The muon and pion separation is weaker when compared to the other events.
- At 90% efficiency the purity is: 57% for pion, 84% for muon, 96% for proton and 98% for positron.

## Future plans:

- Work is underway to extend the PID to include the upgrade detectors alongside the tracker.
- This new approach has the potential to significantly improve the PID and measurements from ND280, increasing efficiency and reducing background.
- Systematics underway – non-trivial as all variable systematics must be propagated.



Thank you for listening!