Development of the agnostic global PID for ND280 near detector

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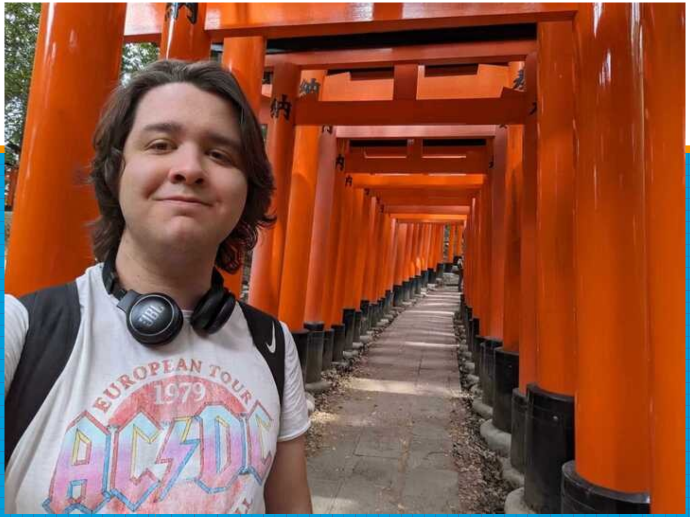


T2K Experiment

- T2K is a long baseline neutrino experiment stationed in Japan, with the beam stretching 295km
- The beam originates at J-PARC, passing through the near detector suites, located 280m downstream, before reaching Super-K

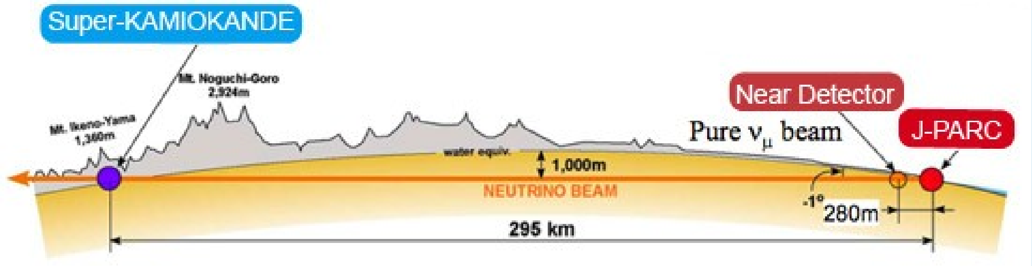


Diagram of the T2K experiment

- The experiment investigates neutrino oscillations, measurement of oscillation parameters, and measurement of neutrino interaction cross section
- The ND280 near detector is an off axis detector that constrains and measures the neutrino flux to simulate what we see at Super-K, with the Fine grained detector (FGD) serving as the target mass
- The upgrade introduces three new sub-detectors:
  - Super-FGD: a larger target mass, capable of reconstructing short tracks near the interaction vertex and neutrons
  - High angle TPC: provides larger angular acceptance
  - Time of flight planes: reconstruction of direction

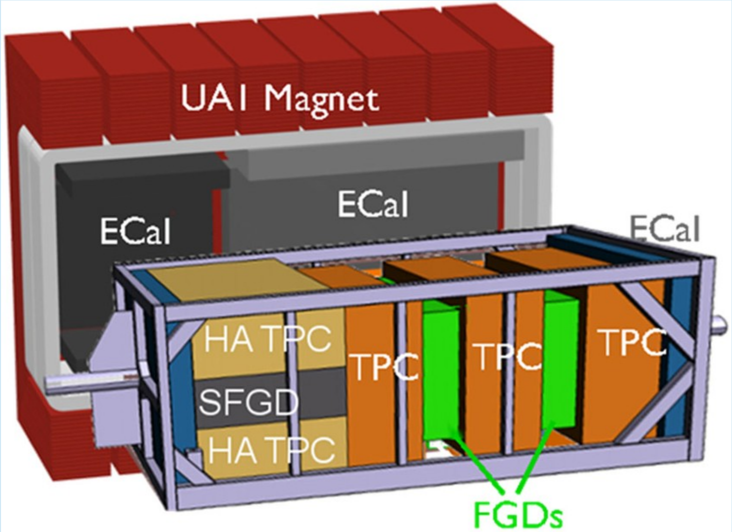
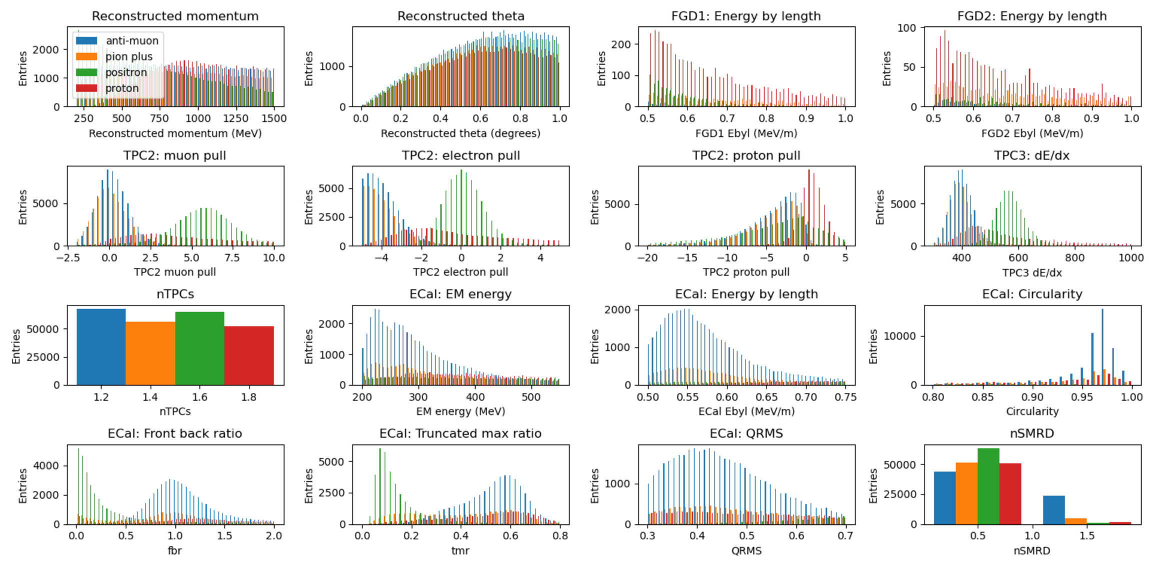


Diagram of the upgraded ND280 near detector

PID selection – set up

- My PID selection utilizes a Boosted Decision Tree (BDT) built using the xgboost package
- Originally I was using the TMVA package, but I moved over to xgboost as it is a more modern multivariate analysis tool
- All my tests used training and testing samples with the old configuration, originate in FGD1 and are all positive tracks

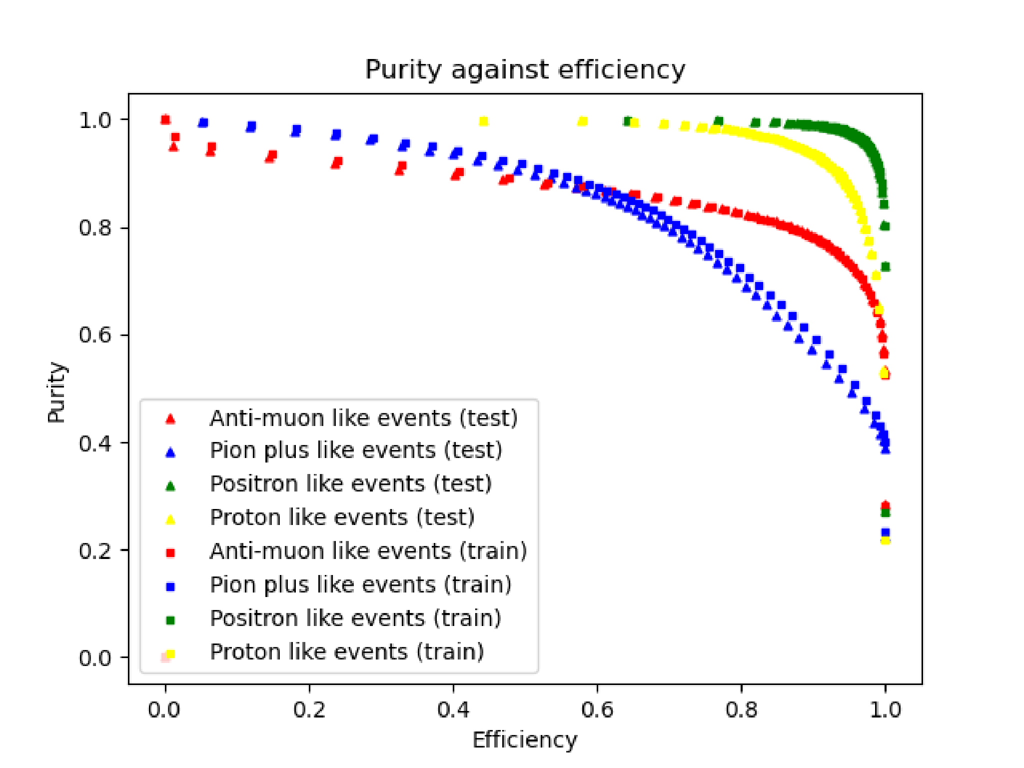


All input variables used in my PID selection: blue are muons, orange are pions, green are positron and red is proton

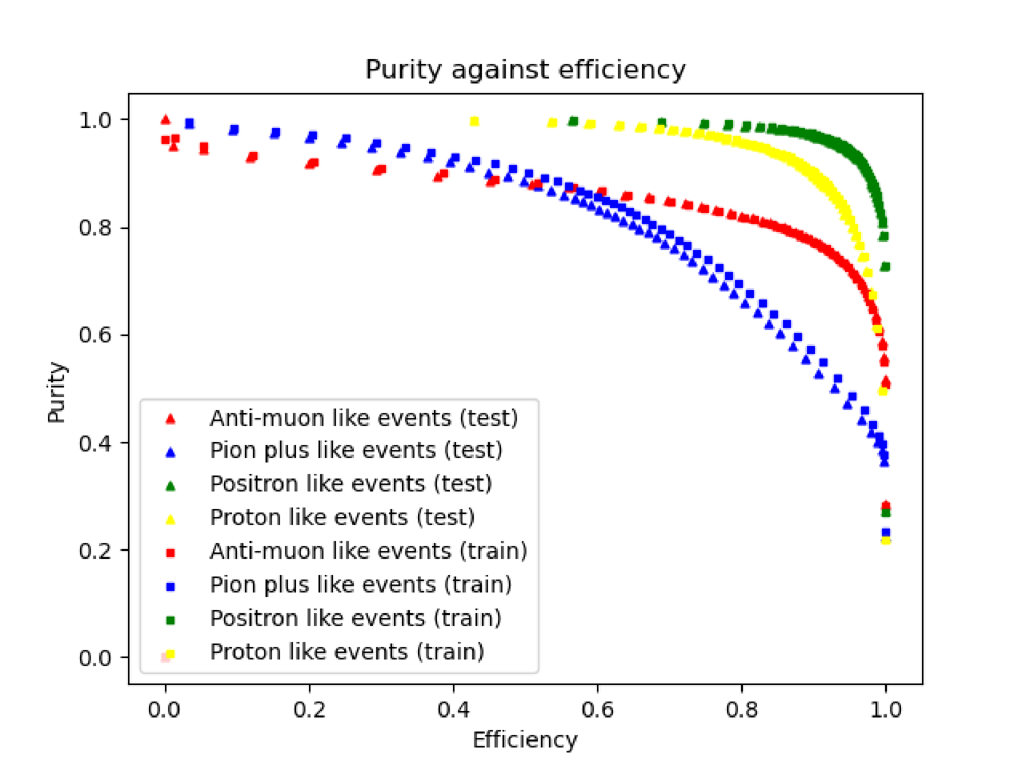
PID selection - implementation

- The standard method of PID is to carry out PID at each individual sub-detector
- The BDT can carry out PID using information from multiple sub-detectors, which takes advantage of and utilizes as much information as possible
- Tests were run to see what effects removing certain input variables, such dE/dx from TPC3, would have on overtraining
  - The lack of TPC3 dE/dx did not affect overtraining

Implementation of the BDT – Testing PID with no TPC3 dE/dx input

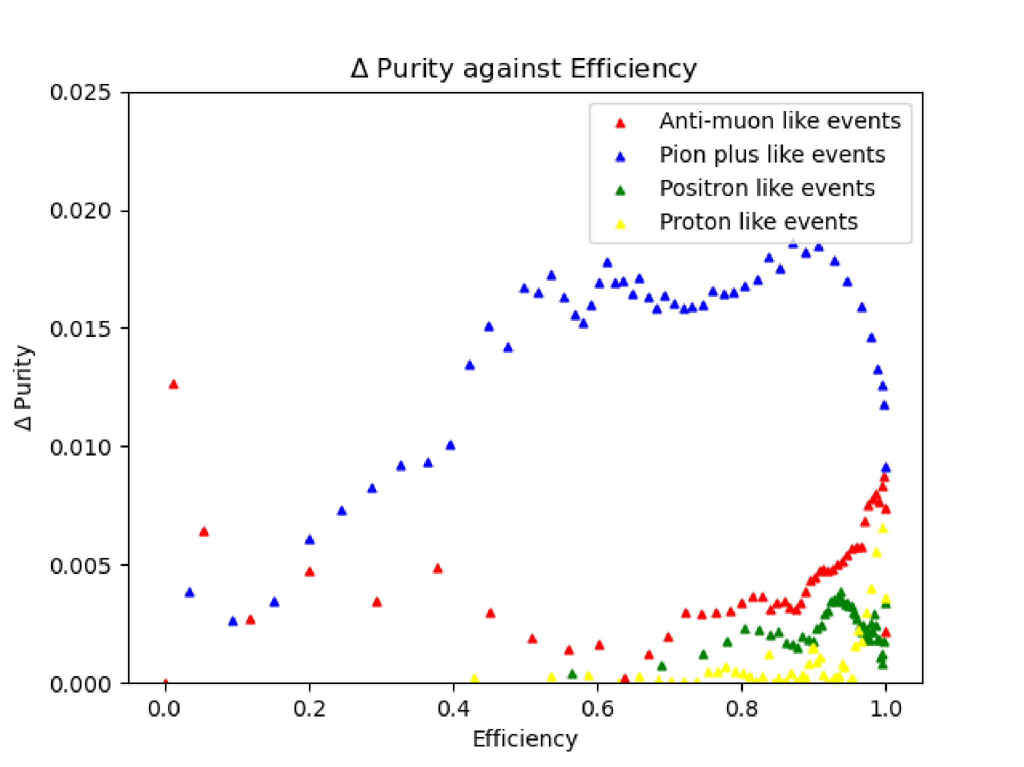


Purity against efficiency – all input variables

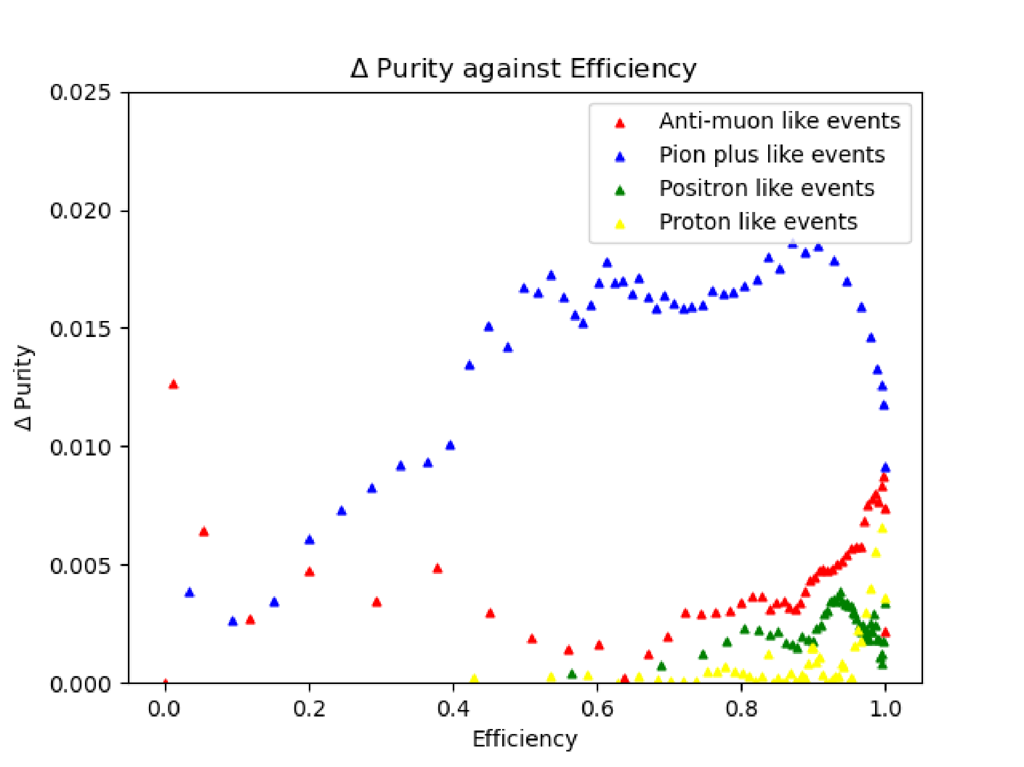


Purity against efficiency – no TPC3 dE/dx input

Implementation of the BDT – Testing PID with no TPC3 dE/dx input

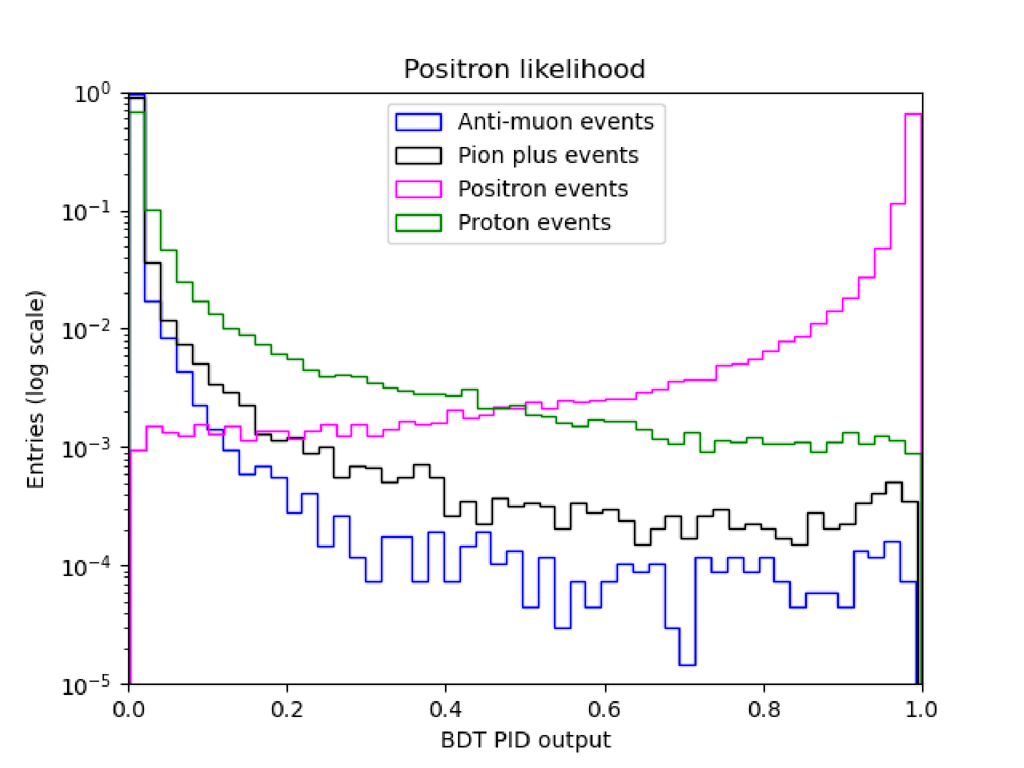


Difference between the training and testing sample purity against efficiency – all input variables

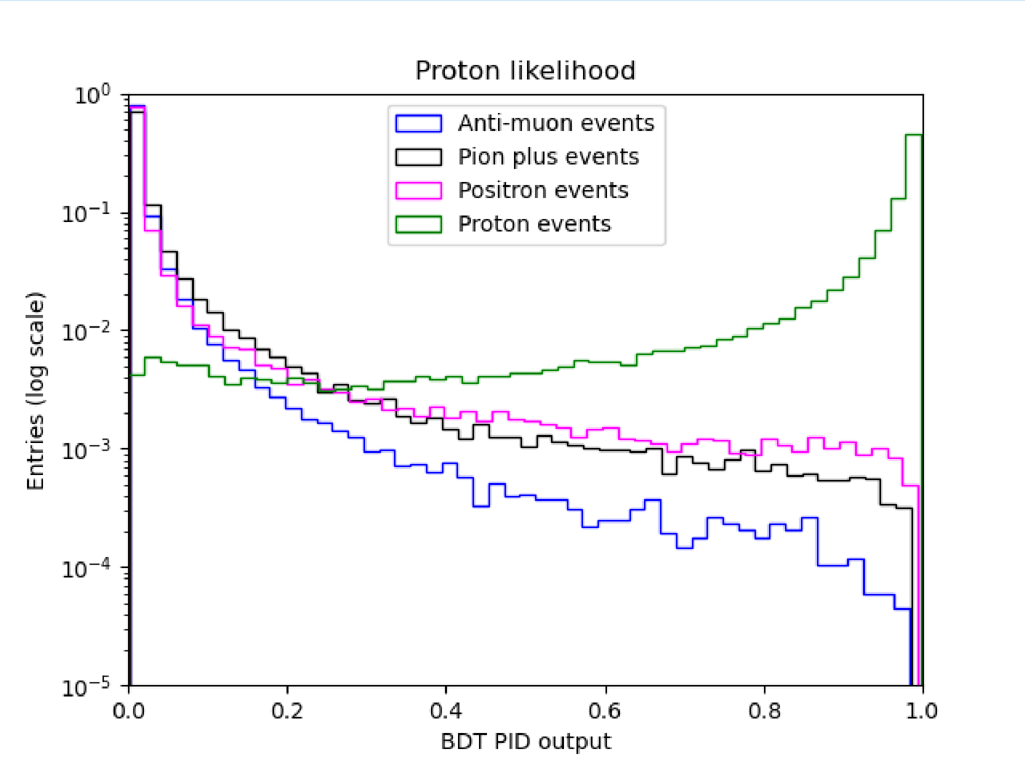


Difference between the training and testing sample purity against efficiency – no TPC3 dE/dx input

Implementation of the BDT – Positron and proton likelihood plots

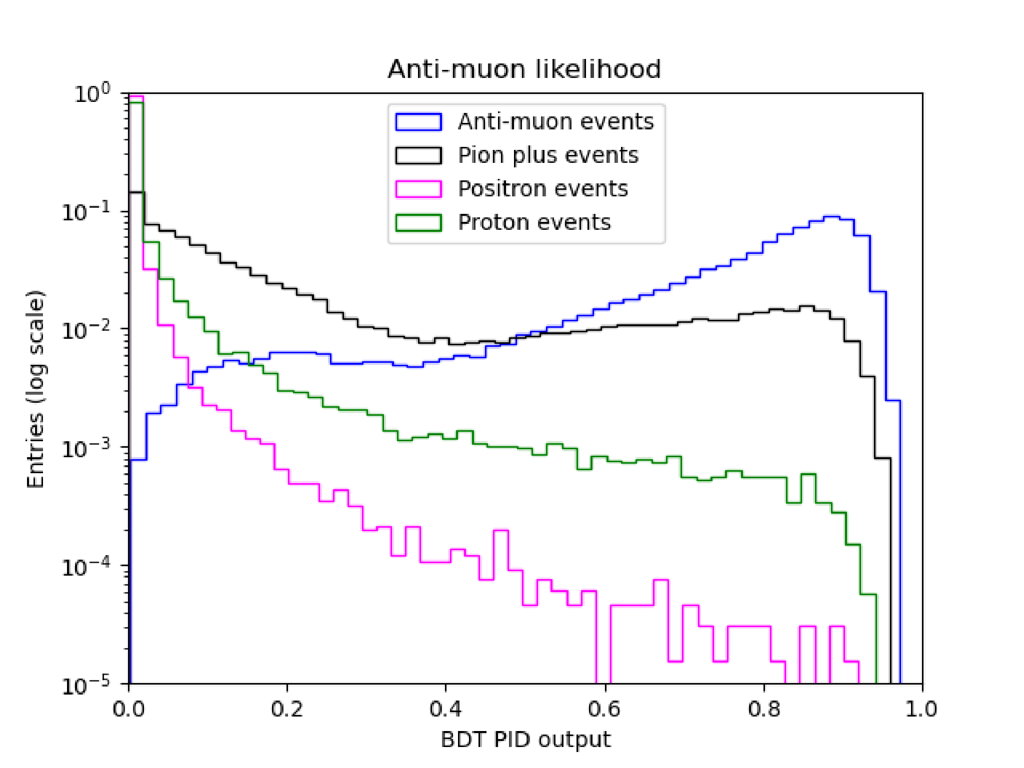


Positron likelihood plot

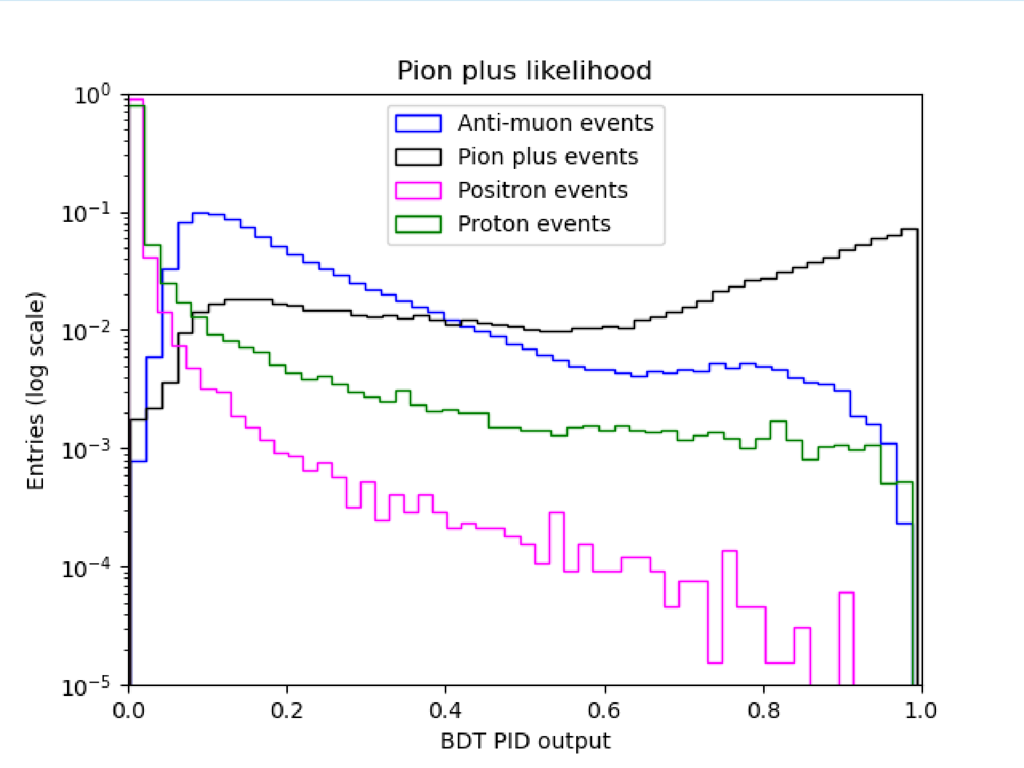


Proton likelihood plot

Implementation of the BDT – Muon and pion likelihood plots



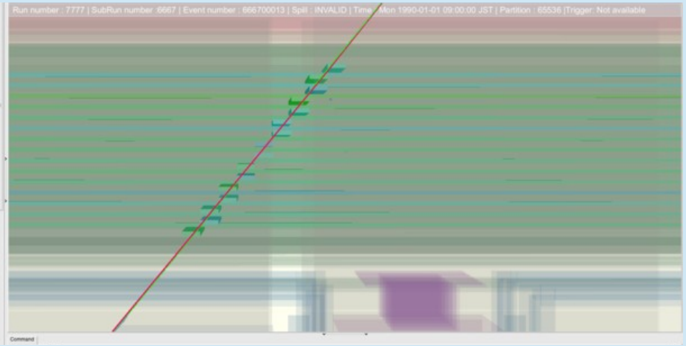
Muon likelihood plot



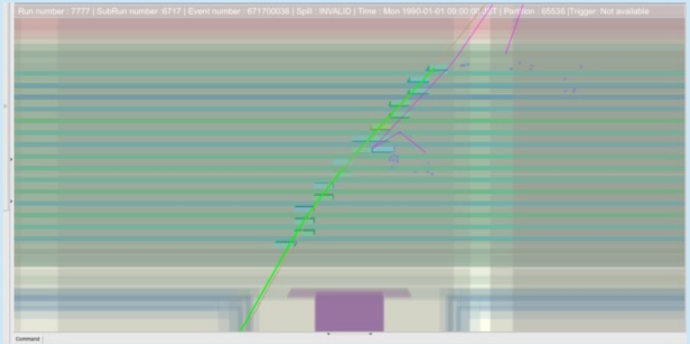
Pion likelihood plot

Measurement of neutrino flux and neutrino interaction cross section

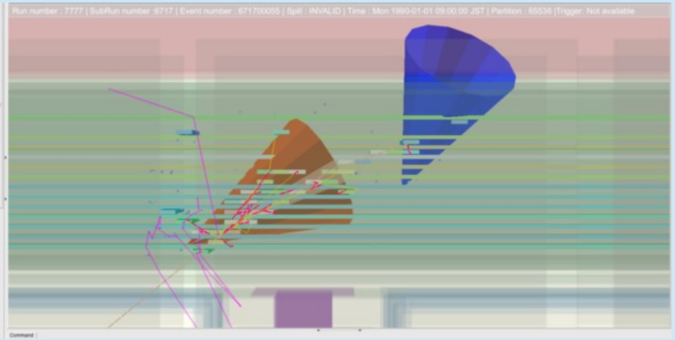
- The likelihood plots show good separation of anti-muons from other particle types
  - Likelihood broader for muons and pions due to the two being indistinguishable if the pion does not shower
- Separation of muon events from other particle events gives us accurate measurement of the neutrino flux
- Accurate measurements of neutrino interaction cross sections improve neutrino-nucleus interaction model



MIP like track passing through the barrel Ecal produced by an anti-muon event



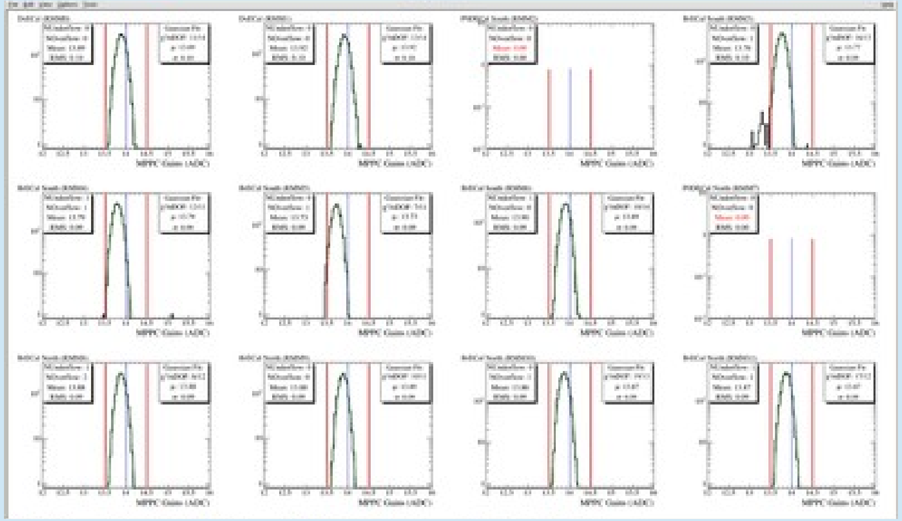
MIP like track passing through the barrel Ecal produced by a positive pion event



Electromagnetic shower seen in the barrel Ecal produced by a positive pion event

LTA – bar to bar calibration and TripT detector expert

- Carrying out bar to bar calibration for the ND280 near detector
  - Helping with the change over to singularity containers
- I am a TripT detector expert:
  - Responsible for the weekly calibration of the SMRD, Ecal and us-ECal
  - Monitoring the cooling lines for the ND280 sub-detectors
  - Dealing with any issues related to calibration and cooling
- Beam starts in a few days and I will be assisting in the start up and carrying out TripT expert work
- Been in Japan for 6 months - back in the UK on the 16th of July



One set of plots, MPPC gains for Ecal, that show the performance of the TripT detectors

Next stage for my analysis

- Developing training and testing samples for the new ND280 configuration that originate in the SFGD
- The new samples allow for analysis for the new configuration, introducing new input variables that can be utilized by my PID
  - PID variables from SFGD, HA-TPC and the TOF
- Implement my analysis into CC1pi cross section measurement and analysis