Electron neutrino Energy Estimation for the NOvA 3 Flavor Analysis

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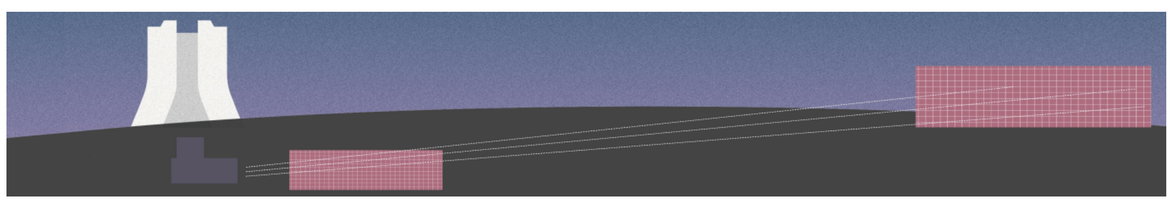
The NOvA Experiment

NOvA is the long-baseline accelerator neutrino experiment

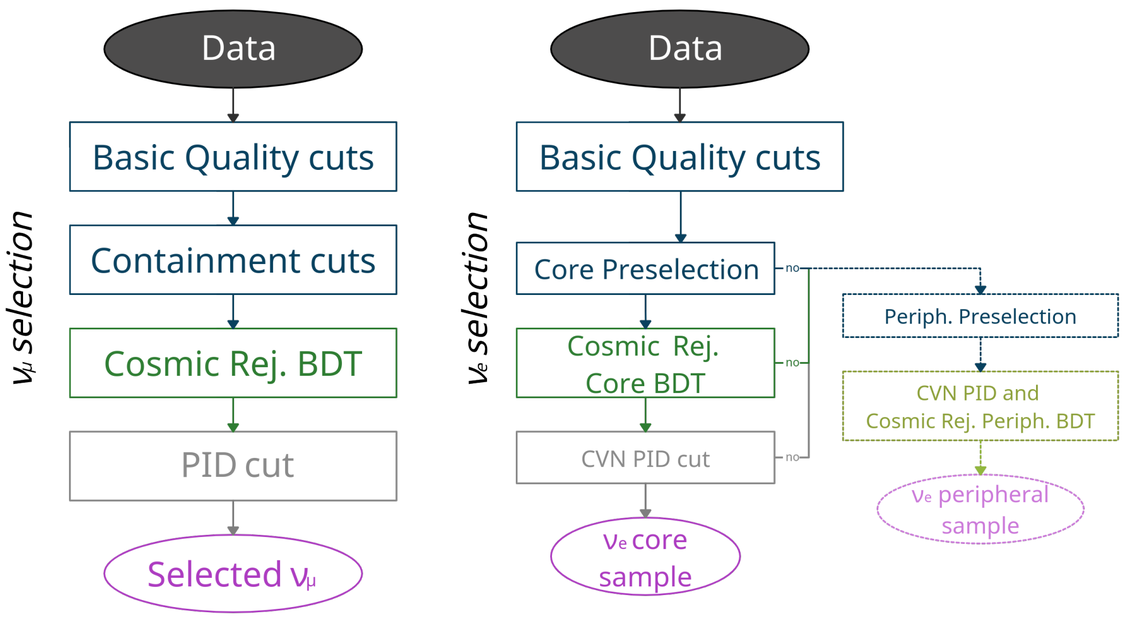
- two functionally identical tracking calorimeter detectors with 810 km baseline;
- both detectors sit 14.6 mrad off;
- ν_μ or $\bar{\nu}_\mu$ dominated flux, peaked around 2 GeV;

NOvA is sensitive to θ_{23}, Δm^2_{23}, neutrino mass ordering etc.



NOvA's Event Selection

There are two conceptually different event selection chains:

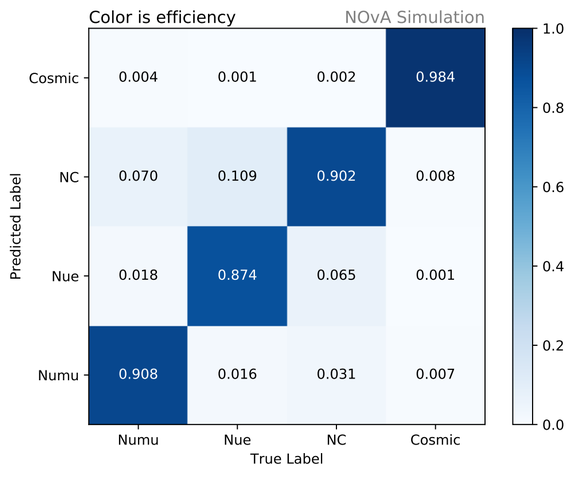


Event Classifier

Convolution Visual Network [1] was developed for classification of neutrino events by 4 categories: ν_μ CC, ν_e CC, NC, or cosmic.

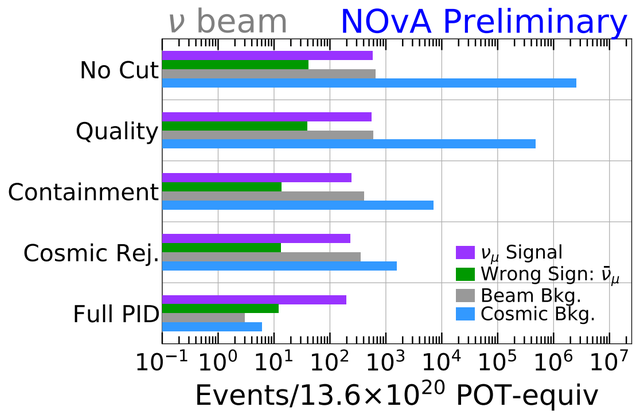
Improvements:

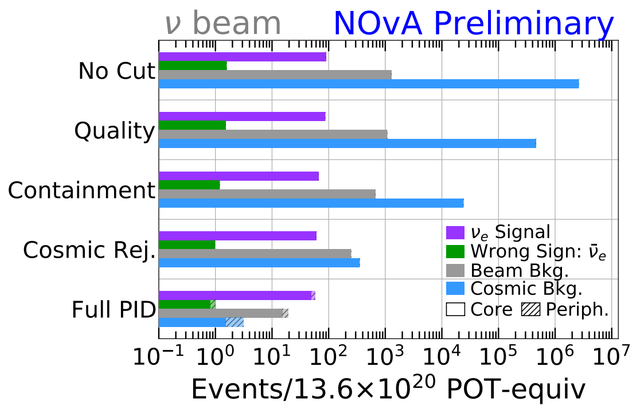
- training by Tensorflow
- efficiency of over 90%
- faster



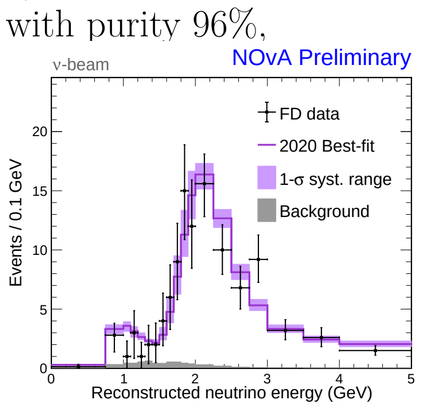
Selection efficiency

Working with *neutrino beam* the efficiency to select:

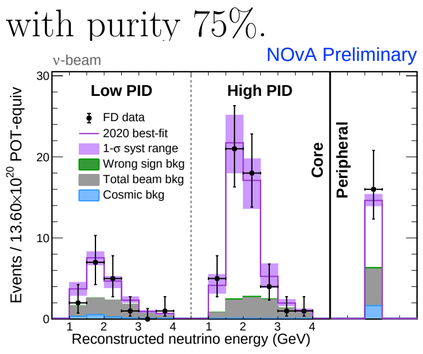




- ν_μ signal events is about 33% with purity 96%,



- ν_e signal events is about 55% with purity 75%.



ν_e Energy Estimators

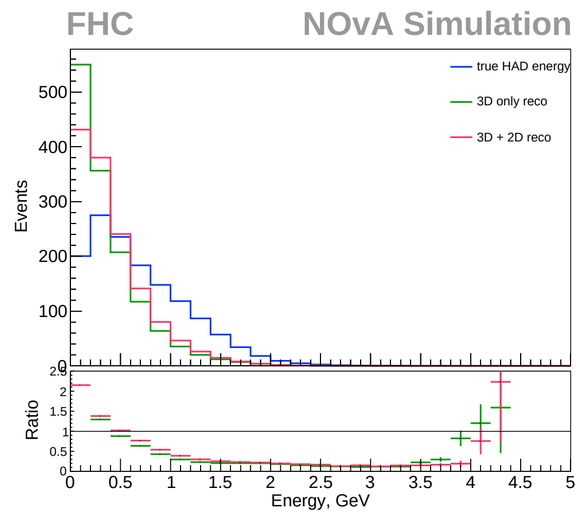
The event is broken up into hadronic (HAD) and electromagnetic (EM) clusters using a CNN [2]. The energy of the event is estimated using a fit to the energy deposited from its HAD and EM parts.

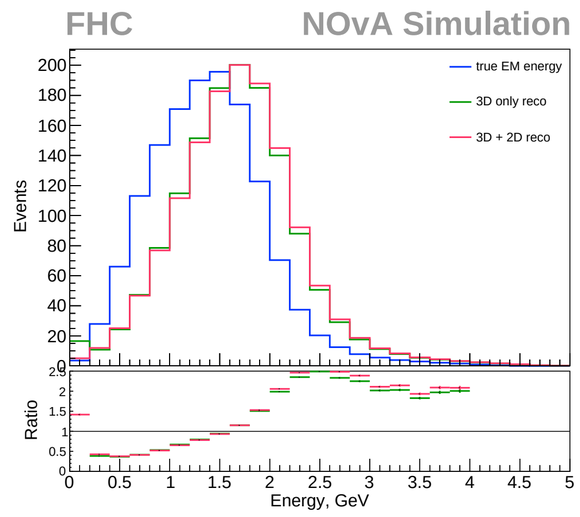
Monte Carlo dataset was divided into to halves for "Training" and "Testing".

- the training part includes fitting four parameters from the formula:

$$E_{reco} = scale \cdot \{p_1 E_{EM} + p_2 E_{HAD} + p_3 E^2_{EM} + p_4 E^2_{HAD}\}$$

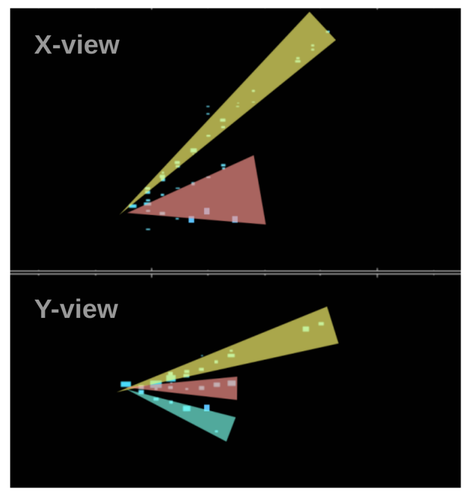
- the testing part is used to compare reconstruction spectra to true energy resolution (see Results).





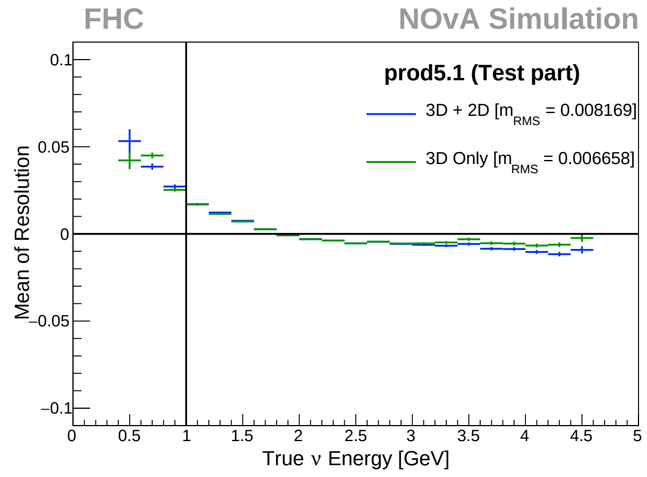
3D only estimators
use 3D prongs CNN to classify EM-like particles

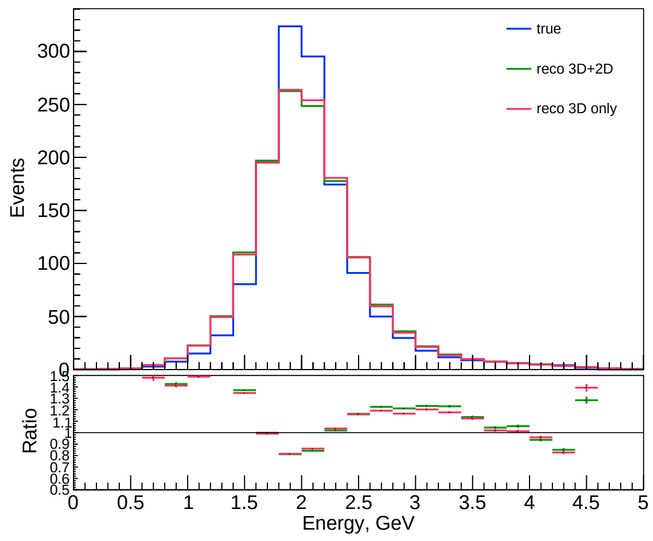
3D + 2D estimators
use both 3D and 2D prongs CNNs to classify particles into EM-like or HAD-like



Results

- Adding the unmatched 2D prongs information improves the EM energy reconstruction.
- The differences between approaches are minor because estimators are highly sensitive to the fit parameters.
- Estimators give similar results for training and testing samples.
- The distributions are quite symmetrical and flat from 1 to 4.5 GeV.





References

[1] A. Aurisano ans A. Radovic, D. Rocco, A. Himmel, M.D. Messier, E. Niner, G. Pawloski, F. Psihas, A. Sousa, , and P. Vahle. A Convolutional Neural Network Neutrino Event Classifier. *JINST*, 11:09001, 2016.

[2] F. Psihas, E. Niner, M. Groh, R. Murphy, A. Aurisano, A. Himmel, K. Lang, M. D. Messier, A. Radovic, and A. Sousa. Context-Enriched Identification of Particles with a Convolutional Network for Neutrino Events. *Phys. Rev. D*, 100(7):073005, 2019.