VLENF SuperBIND Analysis Update

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Outline

1. Further Changes to Cuts based Analysis
2. Reversing the Magnetic Field for Super-BIND

Outstanding VLENF Studies

Why is there a difference between ν and $\bar{\nu}$?

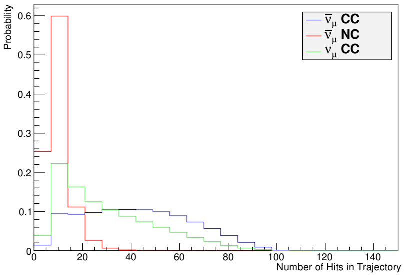
- Need to look at difference in signal efficiencies from reversed magnetic field.
- Alan suggested that there may be a radial relationship.
  - Suggested that a subset of the events based on radial position
- Possibly due to a definite difference in physics.
  - Evidence in the difference between the trHit distributions

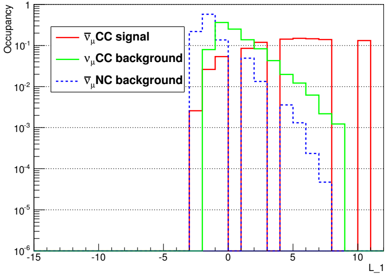
Can the Signal/Background ratio be Improved?

- Can the signal be boosted with better background rejection?
- Will need better discriminating variable.
- Need to find out cause of wrong charge fits.
- Need to improve reconstruction to correct for such fits.

Why is there a difference between ν and $\bar{\nu}$?

- Smoking gun is in the distribution of hits in track
- ν_μ distribution qualitatively different from $\bar{\nu}_\mu$.
- Suggests that μ^+ tracks are longer than μ^- tracks.
- NC and mis-id CC interactions can be removed with CC Selection.





Suggested Changes To Cuts Based Analysis

List of Poorly Justified/Ineffective Cuts

- The Kinematic cuts
- The Displacement cuts
- The Quadratic cut

These cuts have been removed or all values were set to zero.

Track Quality Cut and CC Selection are most Effective

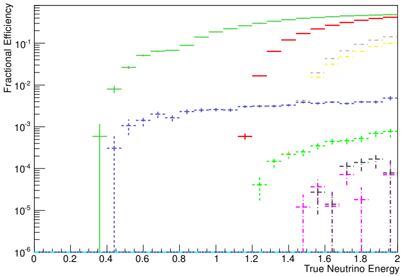
- Loosen all other cuts as much as reasonable.
  - remove cuts as noted above.
  - Lower Fitted proportion cut to 0.6
  - Increased maximum momentum to 10 GeV/c.
- Again optimize signal using the two likelihood selections.
- Can achieve a $\bar{\nu}_\mu$CC Signal/Background ratio of 1.22×10^4
  - Integrated $\bar{\nu}_\mu$CC Efficiency is 0.14
  - Not optimum for ν_μCC signal ($\mathcal{E} = 0.015$, $S/B = 6.5$)

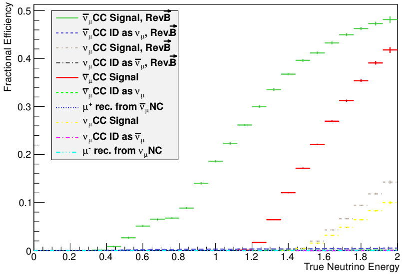
Magnetic Field Reversal

- Polarity reversal does not switch behaviour of charge states.
- Interactions are responsible for the difference.

Defocusing $\vec{B}$ Field Performance

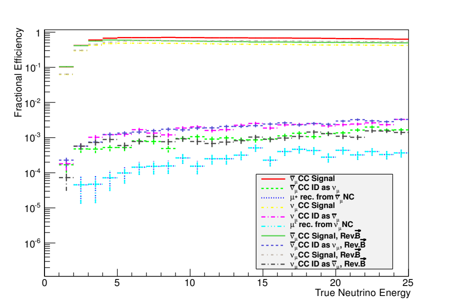
- Integrated signal efficiency for $\bar{\nu}_\mu$ is 0.334.
- NC background completely rejected.
- Integrated CC background is 2.67×10^{-5}.
- $S/B = 1.25 \times 10^4$.

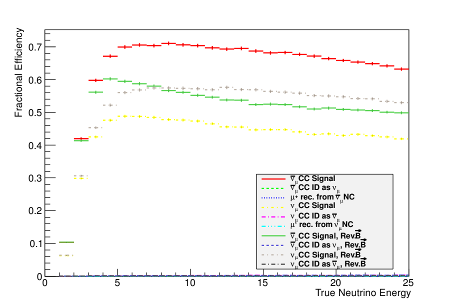




Comparison between MIND and Super-BIND

Efficiencies from MIND in 25 GeV ν Beam





- Focusing field produces better efficiencies over the majority of the energy range
- Efficiency of $\bar{\nu}_\mu$CC selection similar to cuboid geometry.
- Clear that optimal experimental configuration is focusing magnetic field
- Still not optimized for background rejection.

Multi-variate Analysis

- Trained with $\bar{\nu}_\mu$CC (signal) and $\bar{\nu}_\mu$NC or ν_μCC (background).

Trained MVA on subset of events where

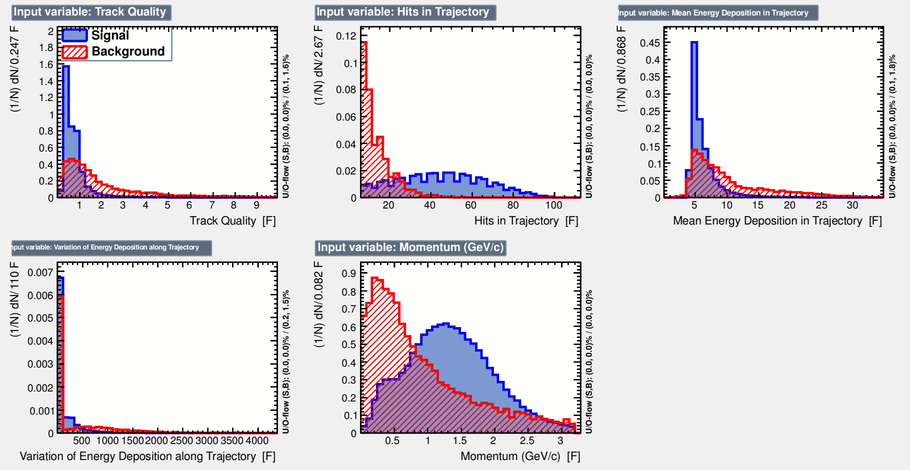
- Event is reconstructed with a charge of 1.
- Event vertex before 8500 mm.
- Reconstructed Momentum $<$ 3.2 GeV/c.
- Fraction of hits in final fit $>$ 0.6.

Variables used by Multi-variate analysis

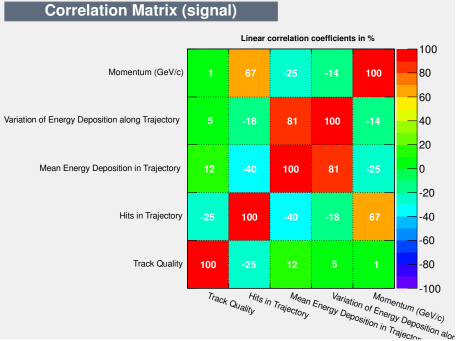
- Scaled error in curvature $\sigma_{q/p}/(q/p)$.
- Number of hits in muon track.
- Mean energy deposition in trajectory.
- Variation in the energy deposition along trajectory
- Reconstructed momentum.
- N.B. Minos also includes “transverse energy deposition profile”.

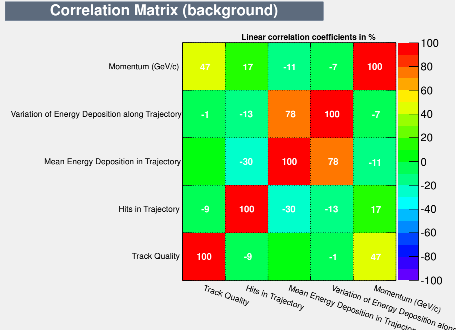
Distributions of Discriminating Variables

- Consider training between $\bar{\nu}_\mu$CC and ν_μCC μ^+ tracks.



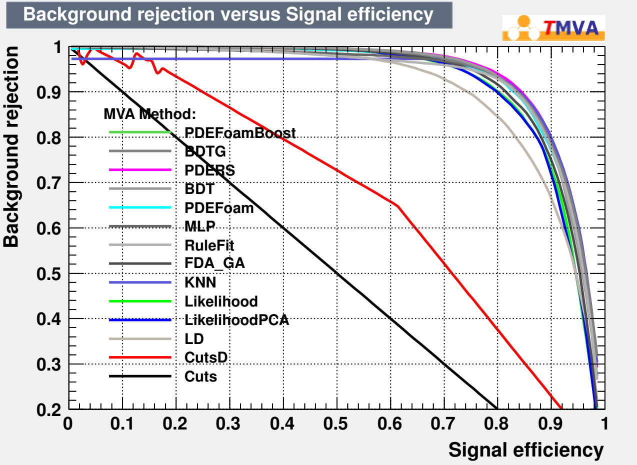
- 100000 signal and background events were used for training and testing.



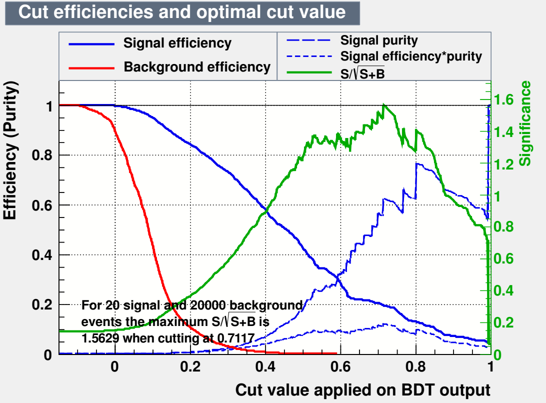


- Demonstrates the inter-relation of the Mean EDep, the EDep Var and the number of track hits.

Potential Background Rejection Versus Efficiency



Efficiency Plot from Best Case



- BDT method provides the best discrimination (so far).
- Need to train the analysis using larger sample.

Conclusions

- Can achieve high degree of background rejection with simplified analysis.
- $\bar{\nu}_\mu$ signal yields better sensitivity than ν_μ signal because of material interactions.
- μ^+ defocusing $\vec{B}$ yields higher signal efficiency than focusing $\vec{B}$.
    - Only true for VLENF.
    - At neutrino factory energies defocused μ leave detector volume.
- Attempted MVA, but still needs work.
    - Currently reviewing MINOS methods.