VLENF MIND Status and Planning

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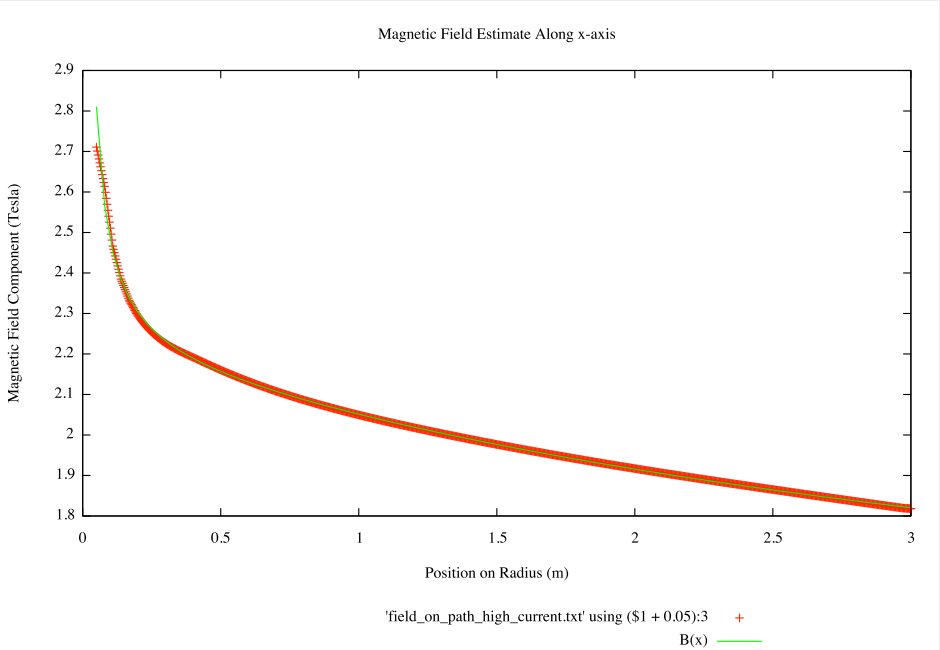
Outline

Magnetic Field

Fitting to high current field.



- Bob Wands provided field simulation for a 1 cm thick 6 m diameter steel disk with 270 kA(?) SCTL current.

Used a model:

$$B(r) = B_0 + \frac{B_1}{r} + B_2 \exp(-Hr)$$

Fit produced $B_0 = 1.53$, $B_1 = 0.032$, $B_2 = 0.64$, and $H = 0.28$

- A new field map can be used in existing code.

Track Selection based on Existing Cuts

- Generated 1×10^6 ν_μ and $\bar{\nu}_\mu$ CC events and 3×10^6 ν_μ and $\bar{\nu}_\mu$ NC events in μ^+ focusing field.
- Will start by considering existing analysis for cuboid MIND in 25 GeV ν beam.

Cuts for 25 GeV NF not applicable to 2 GeV VLENF

- Levels on cuts need to be re-evaluated (probably also true for Octagonal geometry).
- Cuts will have to be scaled down or generally re-evaluated.
  - Does the cut depend on geometry?
  - Does the cut depend on momentum?

Basic Optimization

- Consists of inspecting plots of each variable.
- Adjust cuts to remove background rather than signal.

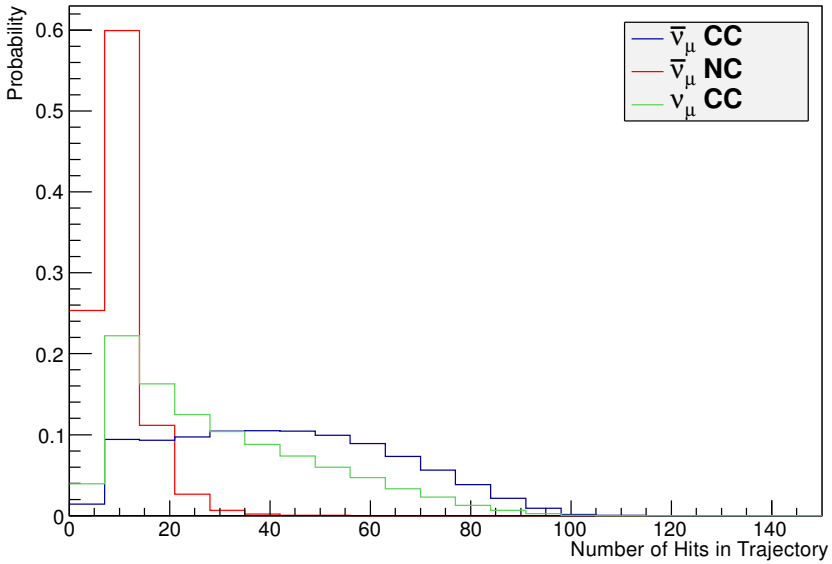
List of Cuts

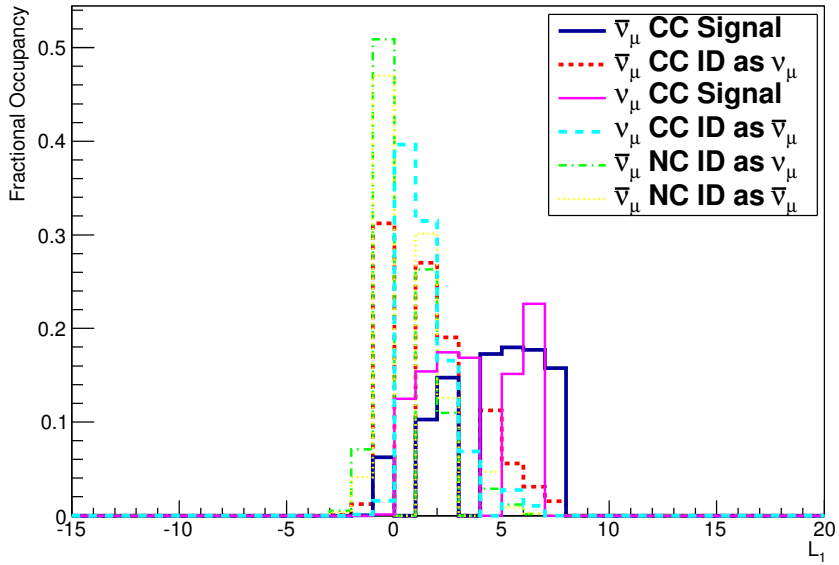
Cut Name	25 GeV Cut	2 GeV Cut	Explanation
Fiducial	$z1 \leq 18000$ mm	$z1 \leq 9000$ m	20 m Detector
Max Momentum	$P_\mu < 40$ GeV	$P_\mu < 3.2$ GeV	ν momentum
Fitted Proportion	$N_{fit}/N_h \geq 0.6$	$N_{fit}/N_h \geq 0.6$	No Change
Track Quality	$\mathcal{L}_{q/p} < -0.5$	$\mathcal{L}_{q/p} < 0$	By Inspection
Displacement	$\frac{dispR}{dispZ} > 0.18 - 0.0026N_h$, $dispZ > 6000$ mm or $P_\mu \leq 3dispZ$	$\frac{dispR}{dispZ} > 0.75 - 0.026N_h$, $dispZ > 400$ mm	By Inspection By Inspection
Quadratic Fit	$qp_{par} < -1.0$ or $qp_{par} > 0.0$	$qp_{par} < -1.0$ or $qp_{par} > 0.0$	Radial Curve
CC Selection	$\mathcal{L}_1 > 1.0$	$\mathcal{L}_1 > 2.0$	By Inspection
Kinematic	$E_{rec} \leq 5$ GeV or $Q_t > 0.25$, $E_{rec} \leq 7$ GeV or $P_\mu > 0.3E_{rec}$	$E_{rec} \leq 1$ GeV or $Q_t > 0.025$, $E_{rec} \leq 0.1$ GeV or $P_\mu > 0.3E_{rec}$	By Inspection

Example: CC Selection

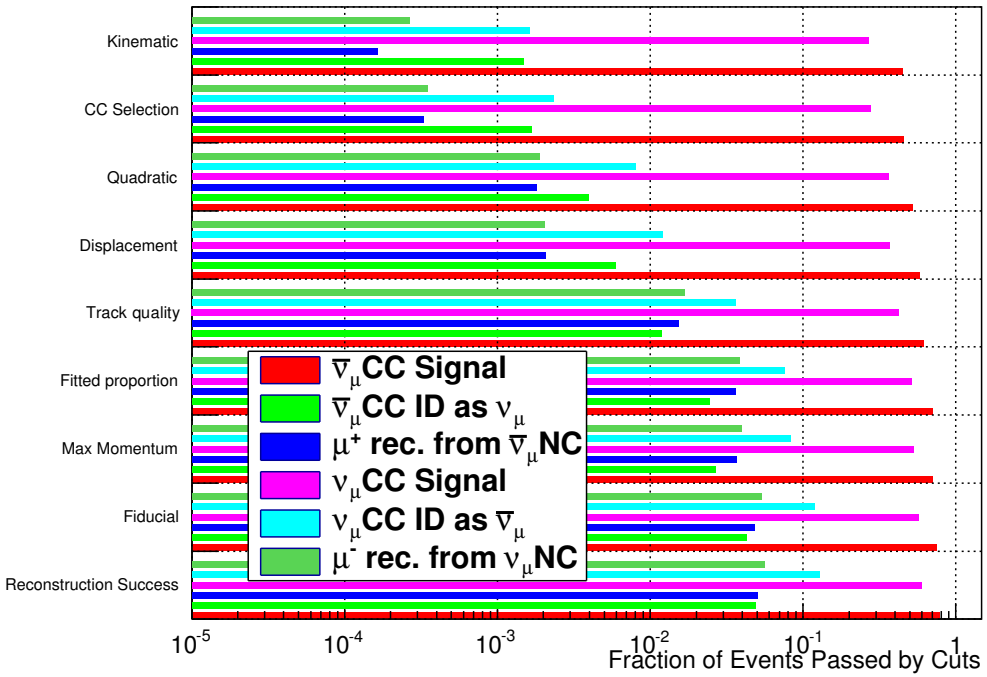
Charge current selection uses the distribution of hits in trajectory in a log likelihood selection algorithm i.e. $L_1 = \log(I_{hit}^{CC}/I_{hit}^{NC}$.

- Strongly momentum dependent. Dictated by muon range.
- Mean and Variation in Energy Deposition also available.
- No improvement in signal to background ratio with other variables.





Current State of Analysis



- Signal/Background for ν_μ: 180
- Signal/Background for $\bar{\nu}_\mu$:280

- Problem is charge discrimination.
- Neutral current identification almost good enough.
- Further analysis optimization questionable.
- Reconstruction improvements are critical.

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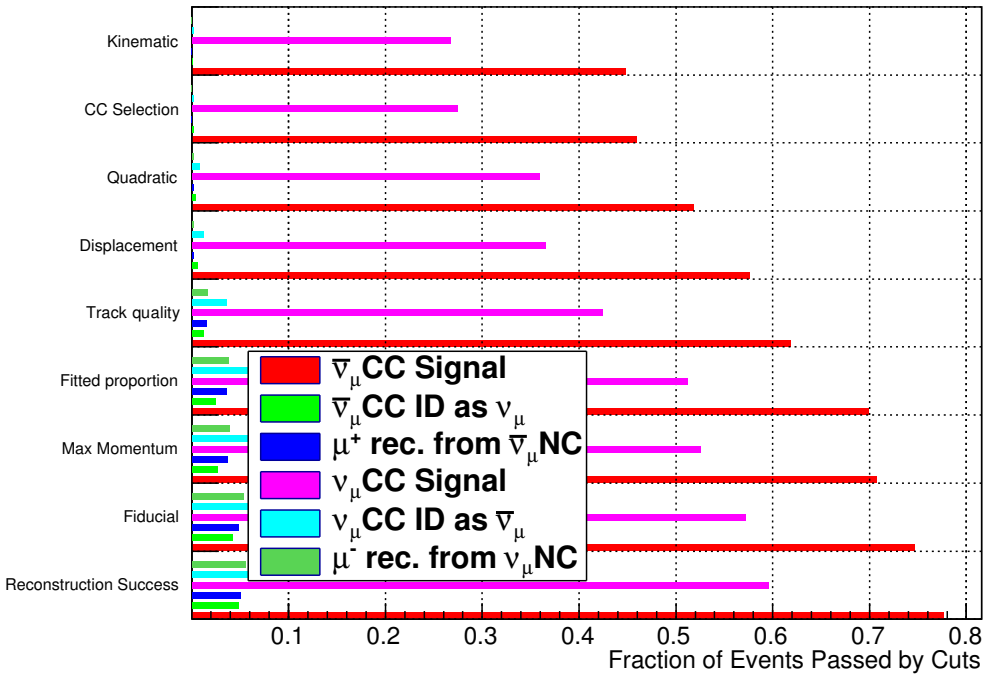

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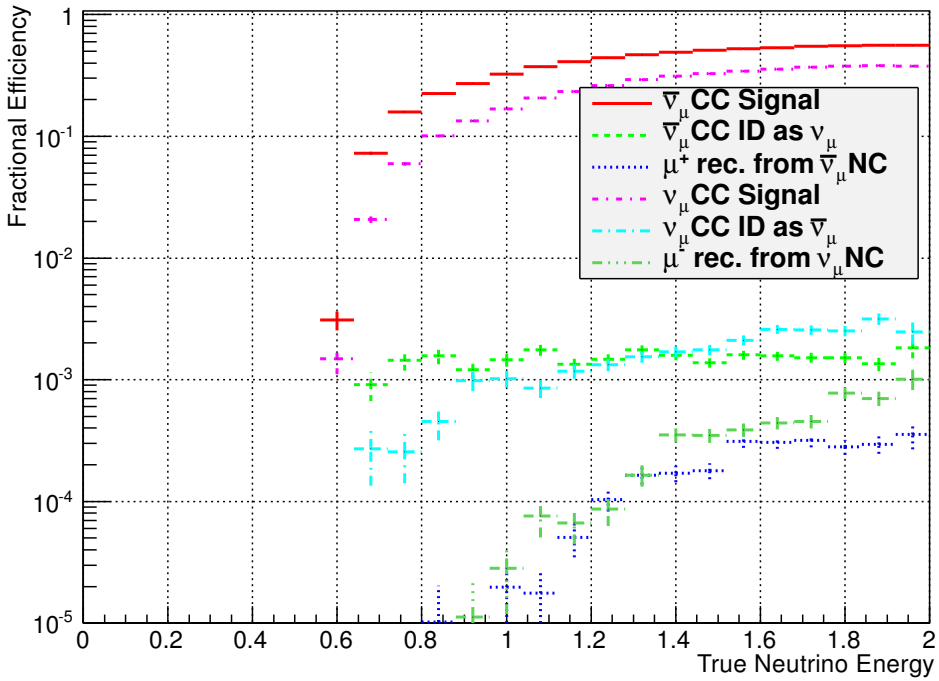

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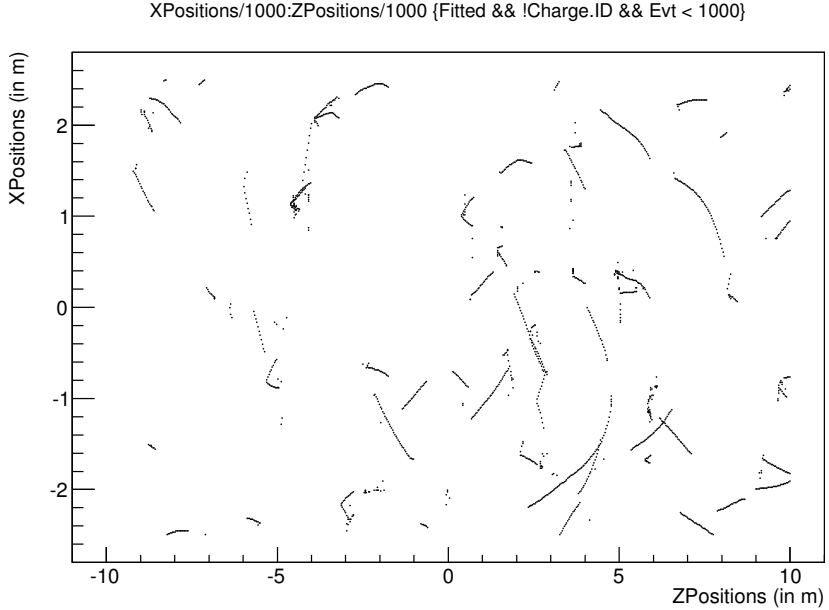
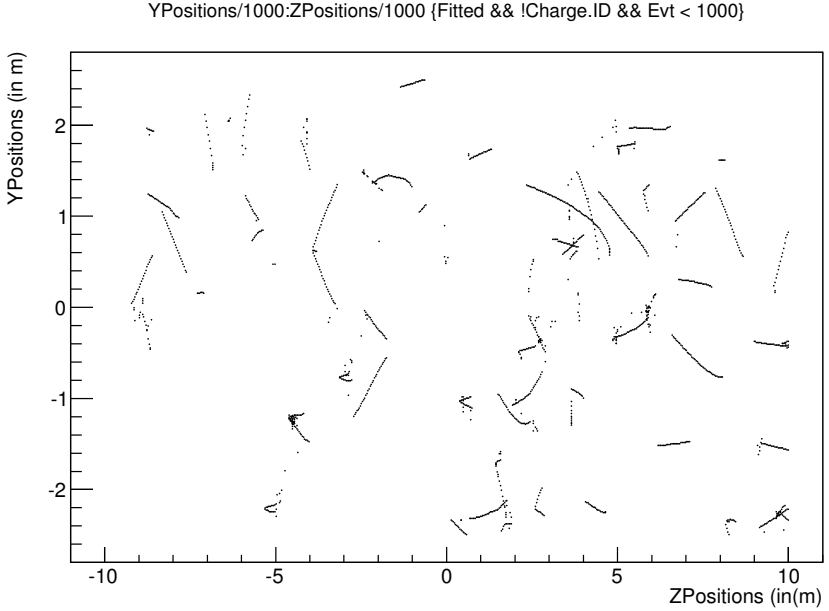
Where Are Improvements Possible

Momentum Seeding for Classification and Fitting

- Charge seed based on assumption that curvature dictates position of final hit relative to first hit.
  - e.g. Last hit of track will be closer to center in focusing case.
  - Not true if muon starts on outbound trajectory or
  - muon ranges out before bending overcomes initial transverse momentum.
- Need to take initial momentum into consideration.

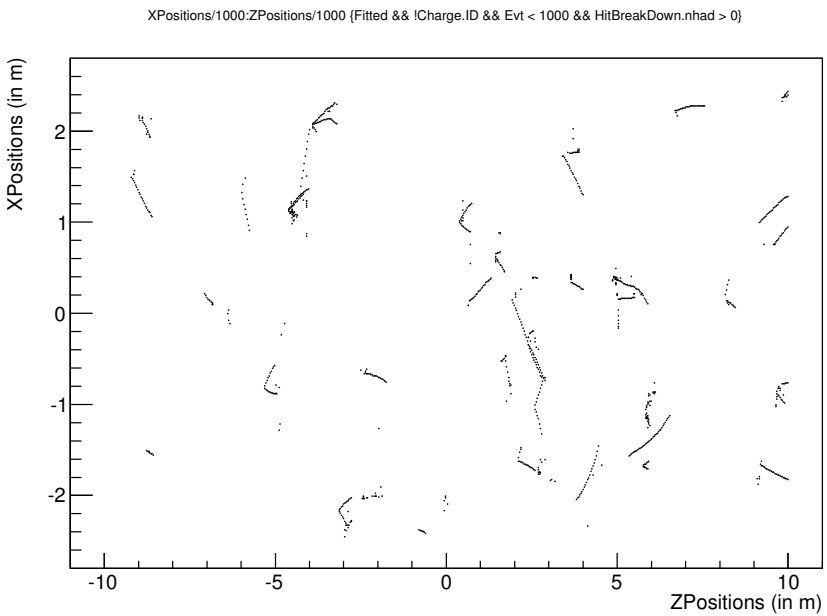


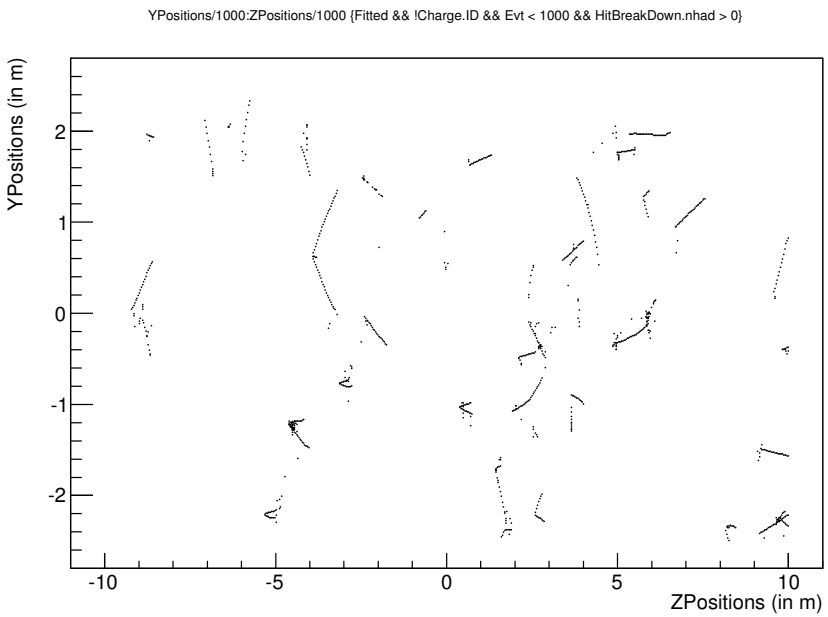


Where Are Improvements Possible

Hadronization

- Important for two points:
  1. Identifying muons from pion decay.
  2. Providing a seed for classification and fitting.
- Have spoken to Tapasi Ghosh at IFIC — she is working on it.





What Else Needs to be Done

Making Simulation More Realistic

- Simulation of scintillator bars.
- Harmonization with reconstruction via digitization.
- Correction to detector cross-section based on engineering.

Derivation of Limits

- Detector response needs to be translated to physics limits.
  - Must agree upon a format.
- Tools for four neutrino oscillation need to be developed/learned.
- Can available tools be used? (I haven't checked yet.)

More Practical Side

- Need to produce a VLENF specific repository.

Conclusions

- Running simulations not rate limiting step.
- “Improvements” to simulation already exist and need to be formalized and benchmarked.
- Current cuts based Golden Channel analysis not sufficient to achieve required precision.
  - Multivariate analysis may be required.
  - Improvements to reconstruction are certainly required
- Partitioning jobs should be possible i.e.
  - Malcolm — Simulation improvements.
  - Chris — Derivation of sensitivities from analysis.
  - Tapasi — Hadron reconstruction.
  - Ryan — track reconstruction.