MIND Optimization with 10 GeV NF

For Large θ_{13}

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on behalf of the IDS-NF collaboration

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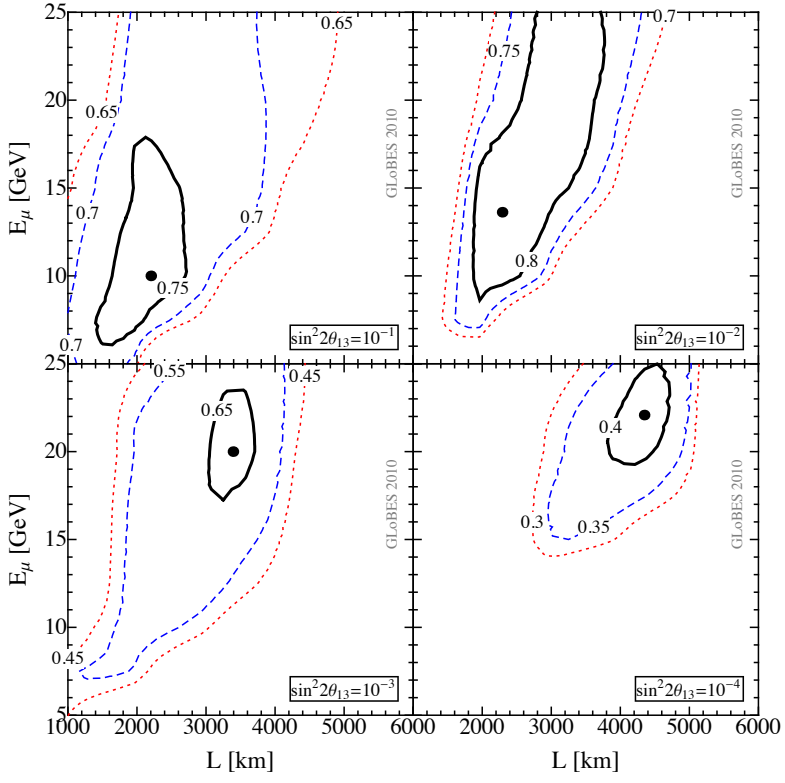
Consequences of Large θ_{13} on Neutrino Factory

- Re-optimization of baseline and beam energy required
- Best sensitivity to δ_{CP} achieved with
  - 2000 km baseline.
  - 10 GeV stored μ energy.

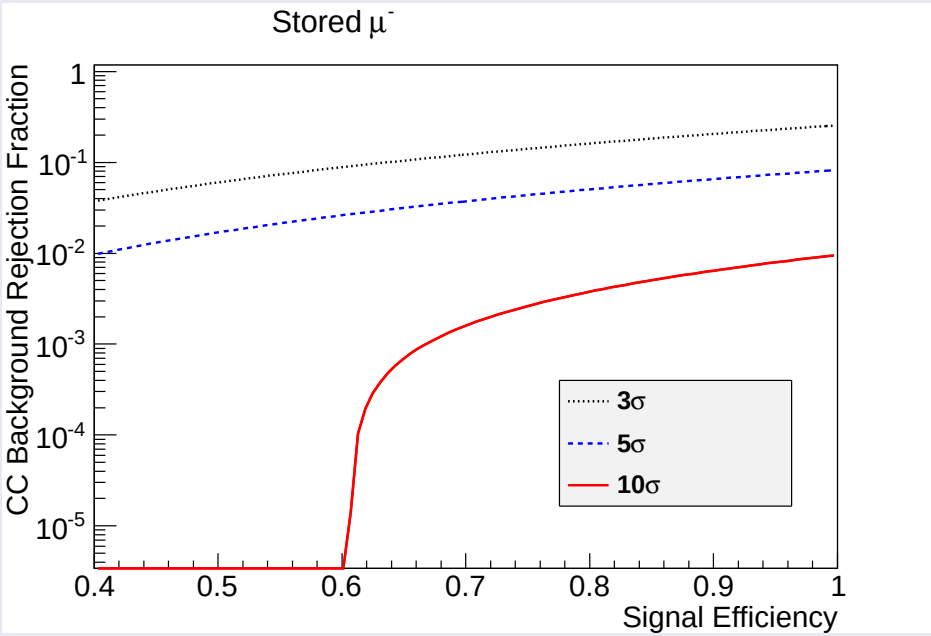


- MIND simulation used to examine sensitivities with these specifications.

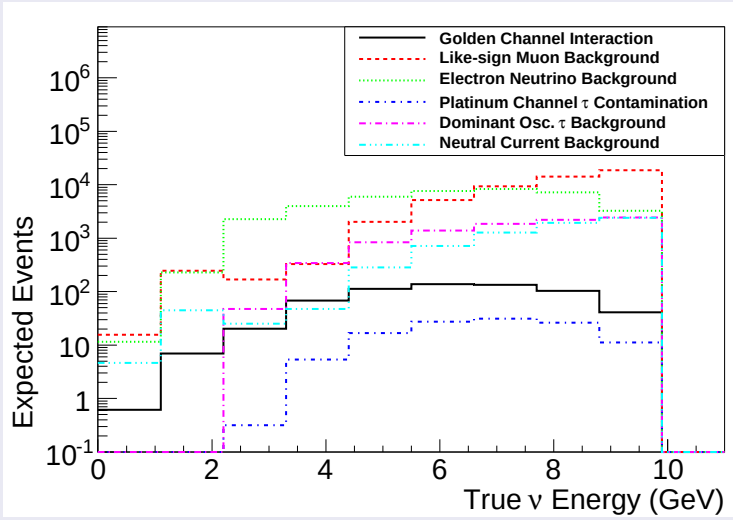
Expected Neutrino Rates At Detector

- Rates calculated with GENIE and the NeUtrino Tool Suite (NUTS).
  - Single 50 kTon MIND.
  - Collected 10^{21} μ^- and μ^+ decays over 5 years.

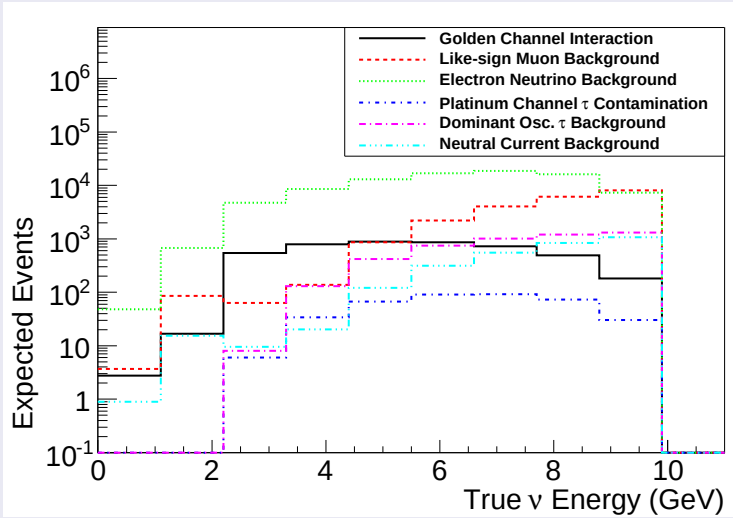
Signal Significance



Stored μ^-



Stored μ^+



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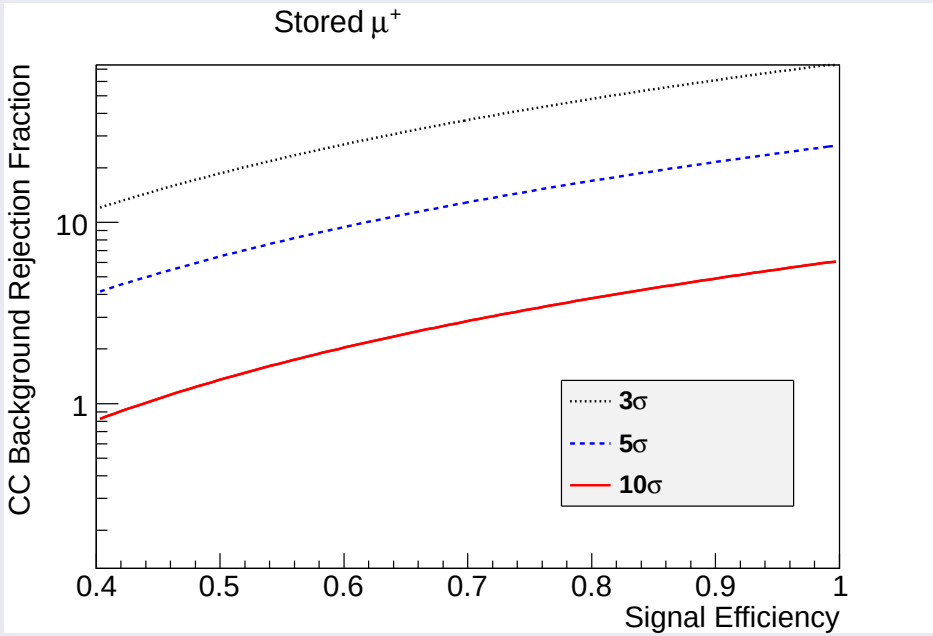

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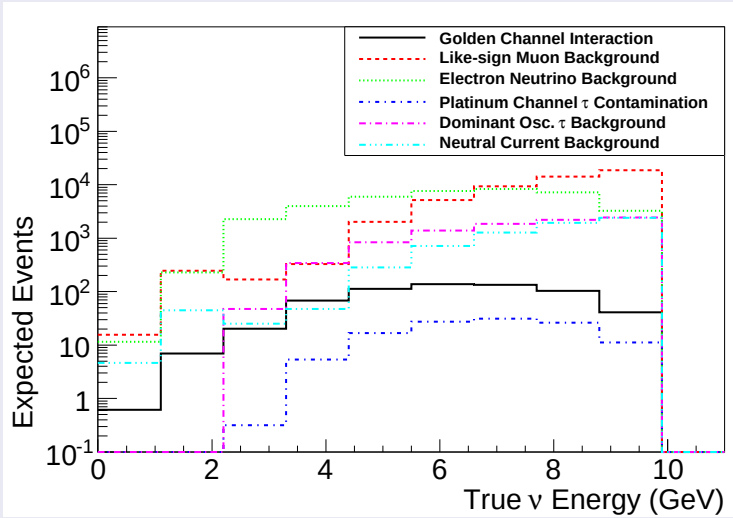
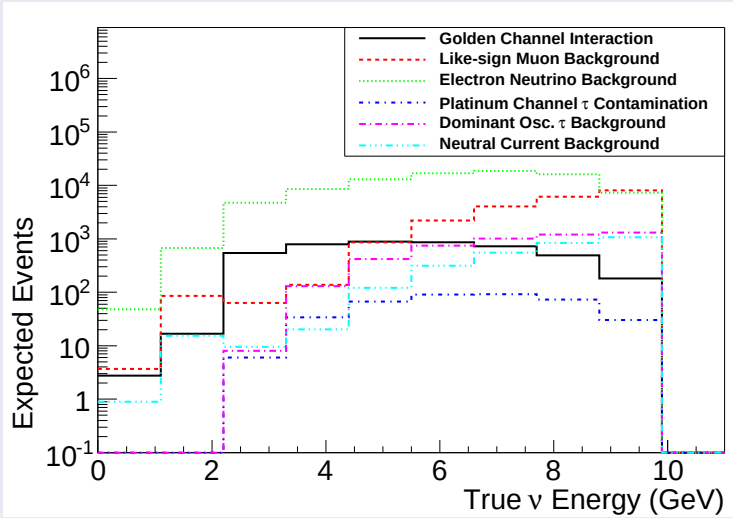
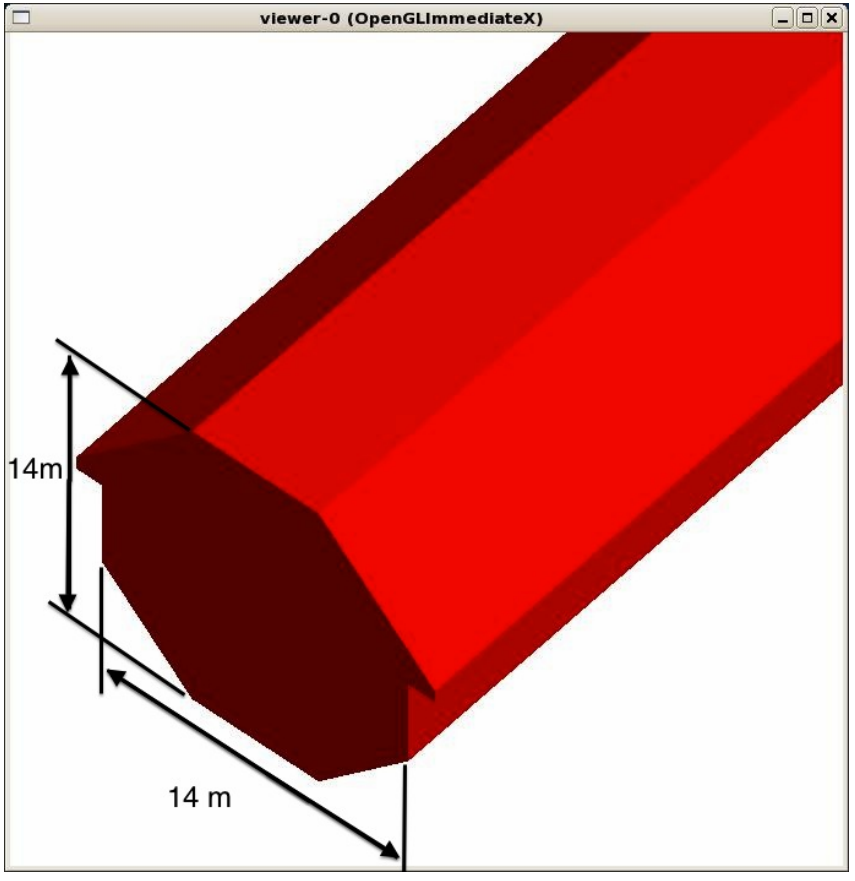


Stored μ^+



MIND Simulation in Review

- Simulation implemented in GEANT4.
- Detector is layered 3 cm iron plates and 2 cm scintillator
  - Octagonal cross section
  - Detector
    14 m$\times$14 m$\times$60 m
  - Each scintillator plane gives readouts in x and y
- Neutrino interactions sampled from GENIE.
- Used magnetic field map provided by Bob Wands for simulation and reconstruction.



MIND Reconstruction

- This is the focus of development for MIND

Operation Summary

- Digitized detector space points passed to reconstruction.
- Events are sorted into tracks using either Kalman filter or cellular automaton methods.
- Selected tracks are fit using Kalman fitter.

- Reconstruction supported and maintained by IFIC group.
- Details of recent development to be given in talk by Tapasi Ghosh.

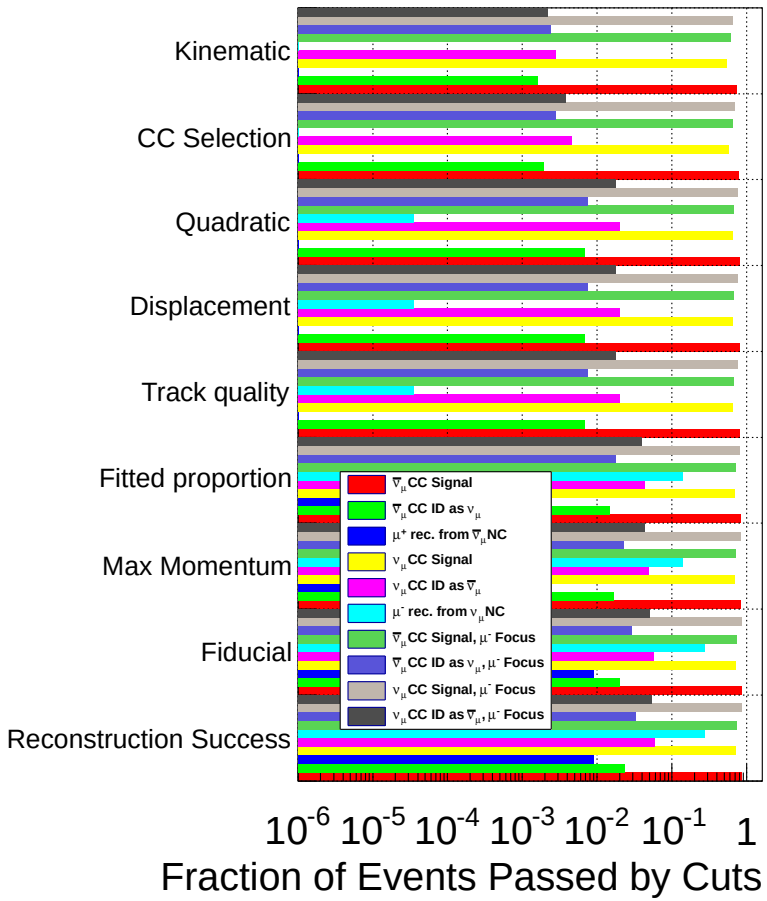
Cuts Based Golden Analysis

Described in detail in IDR.

- Separates NC like from CC like events.
- CC backgrounds are reduced as they are partially NC like.

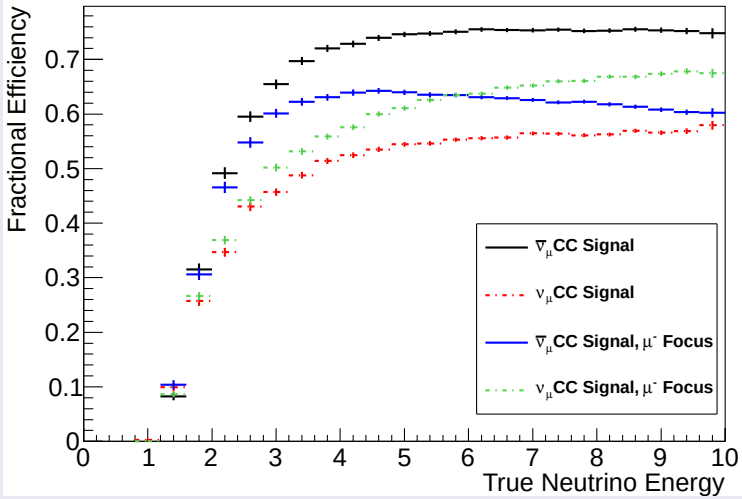
Departures from IDR Analysis

- Quadratic and displacement cuts removed.
- Kinematic cuts replaced by a uniform requirement $Q_t > 0.15$ GeV

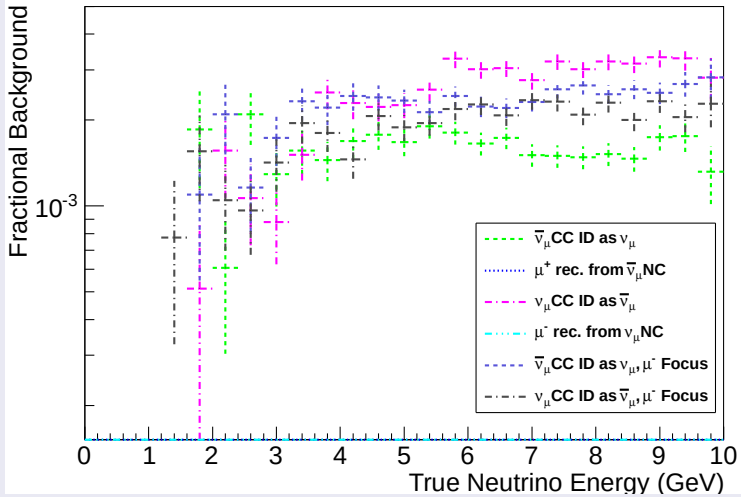


Charge Current Selection Efficiencies

Signal Efficiencies



Background

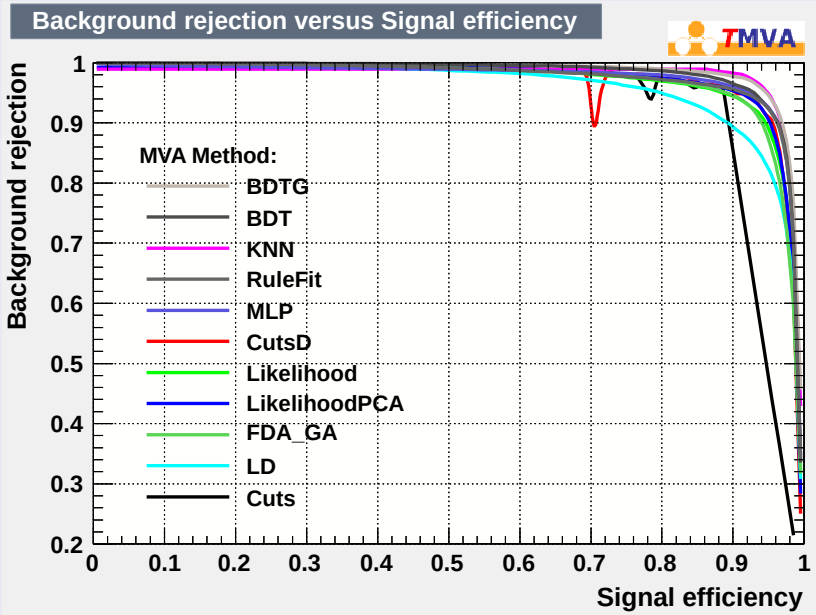


- All reconstruction efficiencies at or above 50%.
- Background suppressed by parts in 10^3.
- NC backgrounds completely suppressed.

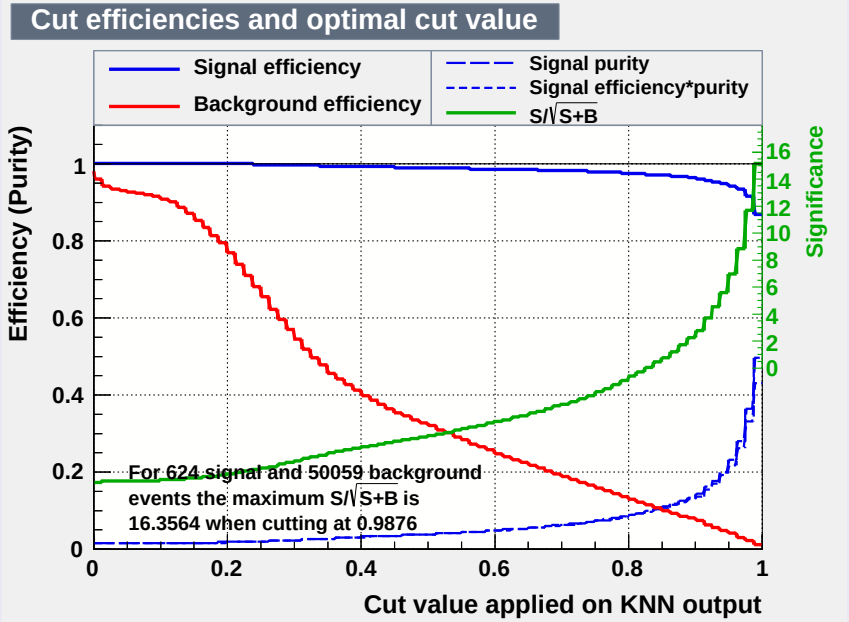
Multi-Variate Analysis

- A full multivariate analysis is under development.
  - Use a set of correlated variables to select CC signal from background.
- Should be able to achieve higher efficiency than existing analysis.
- Still a work in progress.

Variety of Methods Tested



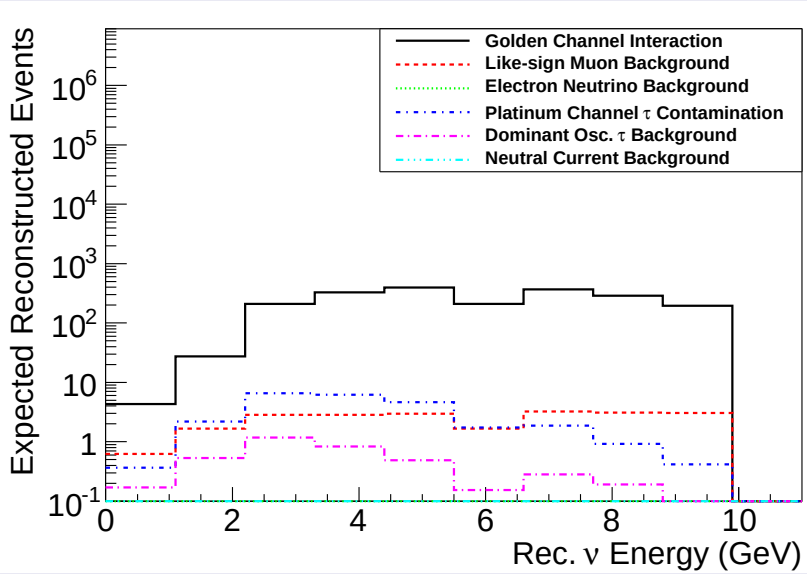
Example KNN Method



Expected Rates at Detector

- Rates after including detector efficiencies.

Stored μ^+



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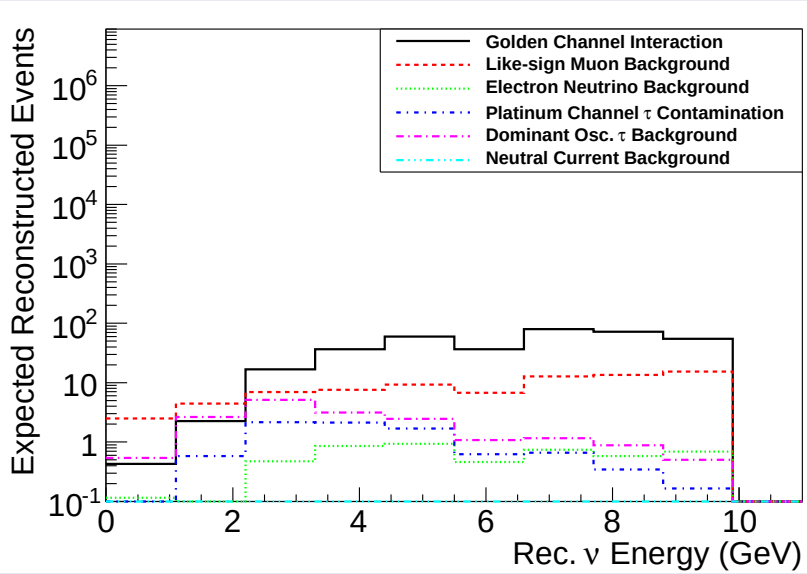

- Little difference between μ^+ focussing and μ^- focussing

Experiment	Signal	Back.	$S/\sqrt{S+B}$
Stored μ^+	2046	25	45
Stored μ^-	309	81	16

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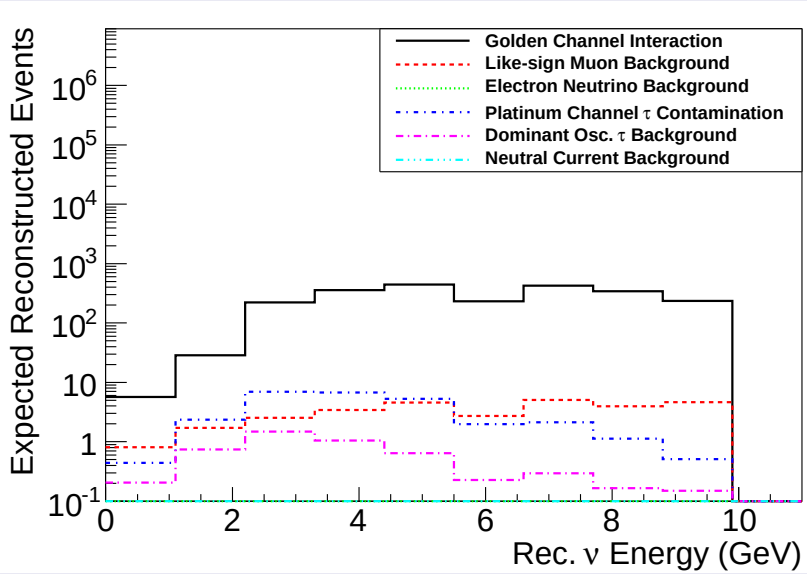

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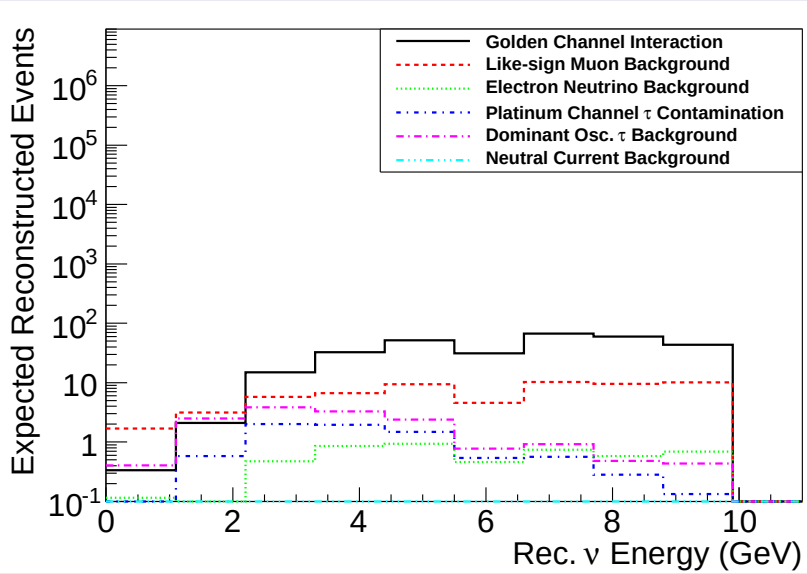

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... To Summarize

- MIND simulation is a
- Much of the effort has been in developing reconstruction and analysis.
- Current analysis can produce a very strong result assuming maximal CP violation.
- Still room for improvement.
  - Nascent multi-variate analysis
  - Reconstruction of low energy tracks.
- Still need to generalize these results to determine δ_{CP} coverage and error.