MIND Prototype Simulation

Results and Observations

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Single Particle Simulations

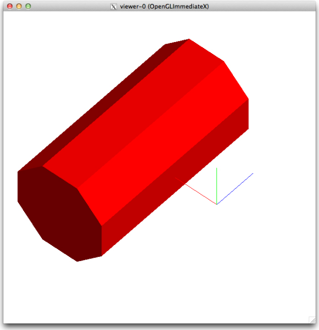
Started considering simulations of single particles in detector.

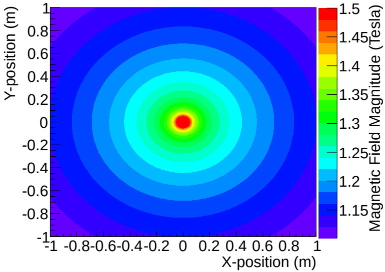
- Not done before because the analysis code was not compatable.
- Necessary for the assessment of the reconstruction efficiency.
  - The MIND reconstruction algorithm does not handle hadronization from neutrino interactions.
  - To understand the track reconstruction must suppress the appearance of mesons in the tracks.
- Required for the assessment of track efficiency in MIND prototype, a MIND near detector, and the full sized detector.

MIND Prototype Simulations

Use a simulation of a 1m×1m×2m detector

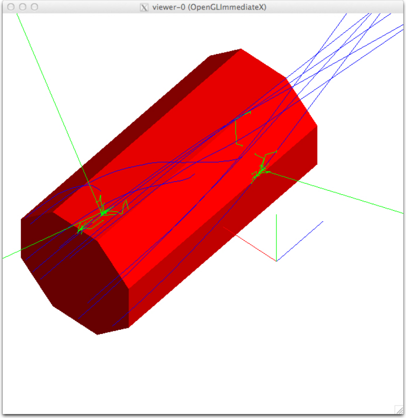
- Alternating 3cm iron plates and 2cm scintillating planes.
- Octagonal geometry used to avoid compatability issues.
- Support ears suppressed.
- Use idealized toroidal magnetic field, assuming 100 kA current.
- Simulation includes 7cm diameter copper STL for scattering.



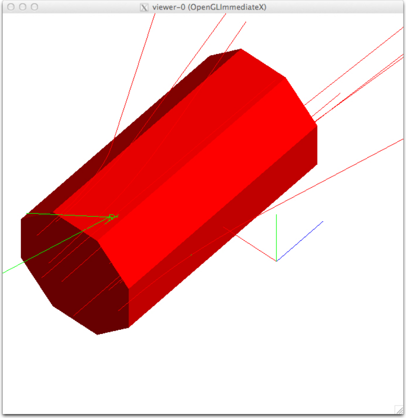


Simulations with Muons

μ^+ Simulation (10 Events)



μ^- Simulation (10 Events)



- Simulations completed using muons and pions.
- Muons generated at random position in $x - y$ plane at $z = -L/2$.
  - L is detector length.
- 1 million events generated for each simulation.

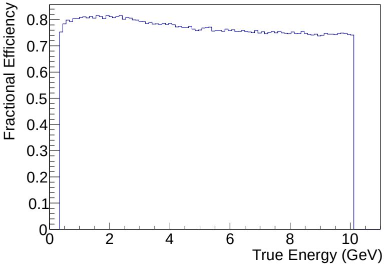
MIND Prototype Efficiencies For μ^+

Only two cuts applied

- Has the track been reconstructed?
- Is the reconstructed charge correct?

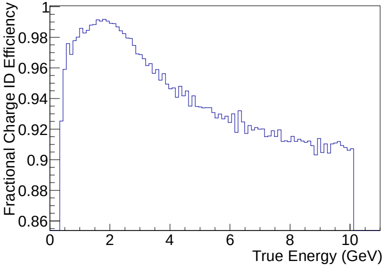
Overall Efficiency

- Number of successful tracks over the total number of tracks.



Charge Identification

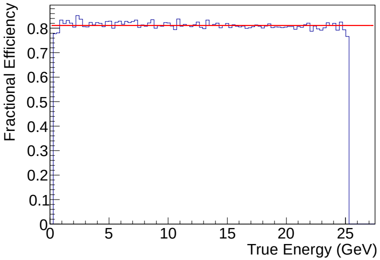
- Number of successful tracks over the number of tracks reconstructed.



Results from MIND Far Detector

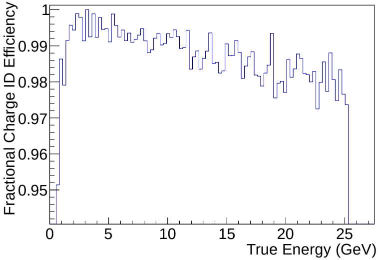
Important to put above results in context

Overall Efficiency



- Efficiency is flat throughout test range.
- Average efficiency of 81%

Charge Identification



- Efficiency peaks at low energies
- Charge identification better than 98%

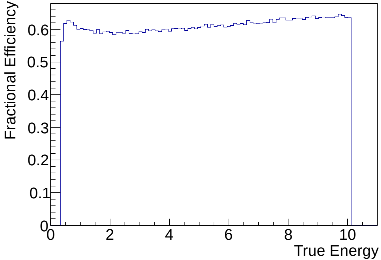
Comparison of the Far Detector and Prototype

- Prototype has a lower charge identification efficiency than far detector.
  - Likely due to small proportion of bending contained in detector.
- Low momentum (better contained) tracks are more likely reconstructed
- Limited by seeding algorithm.
  - Kalman filter seeding based on track range if contained in detector, and estimated from curvature otherwise.
- Efficiency is higher at low momentum for both detectors here compared to Golden channel analysis.
  - some cuts preferentially remove low momentum and large angle tracks: e.g. Track Proportion cut.
  - All muons in this study start parallel to detector axis.
  - Should consider tracks at range of longitudinal angles.
  - Must test effect of track quality cuts on single particle samples.

μ^- Samples in Prototype MIND

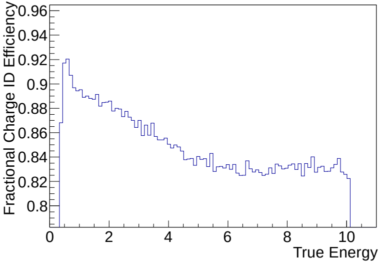
- Reconstruction of defocussed species must be considered

Overall Efficiency



- Efficiency 10% lower than for μ^+.
- More track contained in detector for tracks with large E_μ.

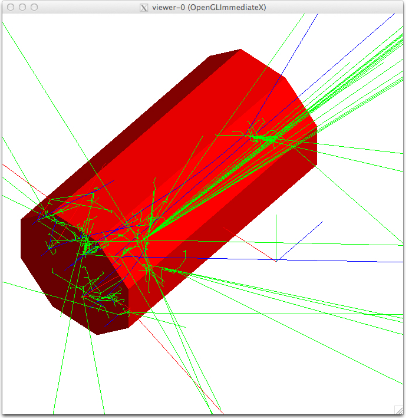
Charge Identification



- Hurt by the lack of contained tracks.
- Much lower efficiency than μ^+ reconstruction.

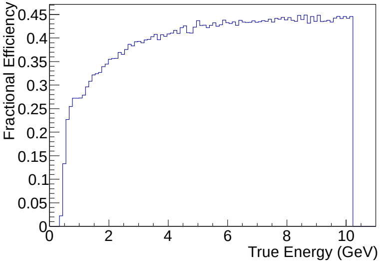
Pion Simulations

- Hadron shower makes identification of track difficult.
- Kalman filter seeding optimized for muons.



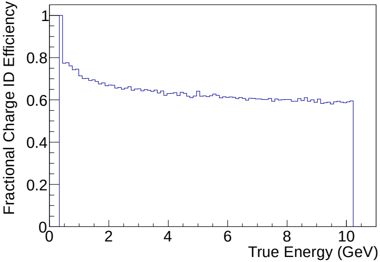
π^+ Samples in Prototype MIND

Overall Efficiency



- Reconstruction much better at high momentum.
- Less probablility of scattering before stopping?

Charge Identification

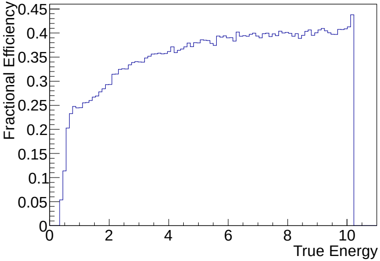


- Like μ^+, better charge ID at low momentum.
- Competes with reconstruction efficiency.

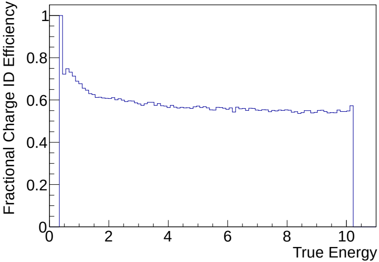
π^- Samples in Prototype MIND

- Reconstruction hampered by both field defocussing and hadron showering.

Overall Efficiency



Charge Identification



- Both efficiencies are smaller ($\sim$ 2%) than the focussing case.

Conclusions

- Muon reconstruction efficiency $> 70\%$ with prototype design.
  - Far detector design efficiency is 81%.
- Reconstruction efficiency less for defocussing magnetic field.
- Charge identification efficiency better than 90%
  - Charge ID $> 98\%$ for far detector design.
- Detector is much less efficient for pions
  - Reconstruction still does not handle hadron (or electron) showers.
  - Scattering much greater effect.
  - Kalman filter seeding optimized for muon detection.
    - Based on a range calculation.
- Pion Reconstruction efficiency $< 45\%$
  - Charge identification $> 60\%$
  - Field defocussing does not strongly impact the result.