VLENF SuperBIND Analysis Update

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MIND Reconstruction Update

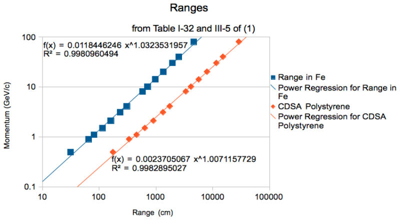
- Reconstruction updated to use a dE/dx map.
  - Before all particles were assumed to be minimum ionizing.
  - This updates the Energy loss at each node as a function of energy.
- Corrected some bugs at the same time.
  - Linear extrapolation for the momentum range was wrong.
  - Resulted in negative momenta for ranges below 1 metre.
  - Power law is correct for momentum range calculation.
- Also altered the Charge estimate from the "momentum_from_range" subroutine.
  - Look for deviation between linear extrapolation between starting and endpoint and the true path.

Details of dE/dx Map

- Contains an array of 28 measurements of dE/dx matched to momenta; $p \in \{0, 5 \,\mathrm{GeV/c}\}$
- dE/dx for muons and electrons are listed separately.
- Energy loss for muons, protons, pions, and kaons are defined by scaling the muon dE/dx.
- If momentum is larger than any listed bin the energy loss is that of the largest momentum bin listed— otherwise eloss is that of the matching bin.
- Implication is that radiative losses will be treated separately from ionization losses.

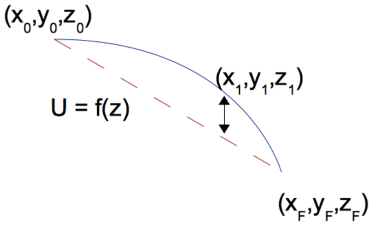
Details of Momentum Range Calculation

- Attempted to make the momentum seed calculation reliable.
- Found persistant, incorrect charge for low momenta.
- Reviewed range tables — Found a bias with respect to the assumed linear extrapolation — much more clear on log-log plot.
- Much better fit using a power law.



Correction to Charge Estimate

- Charge estimate assumed that initial momentum was in $\hat{z}$ direction.
- Define $u_i = \vec{r}_i \cdot (\hat{z} \times \vec{B}_i)$
- Was: the sum of $\Delta u_i = u_i - u_{i-1} < 0$ then charge is negative. Problem — fluctuations can have an impact.
- Make this more like how eye would judge charge.
- NB: Polynomial fit not used because of changing $\vec{B}$.



- Define a straight line

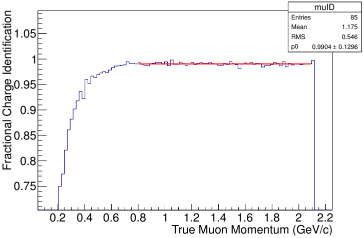
$$f(z) = \frac{u_F - u_0}{z_F - z_0}(z - z_0) + u_0$$

- Charge defined as: $q = +1$ if $\sum_{i=0}^{F}(f(z_i) - u_i) > 0$, $q = -1$ if $\sum_{i=0}^{F}(f(z_i) - u_i) < 0$.
- Exceptions exist if track passes axis.

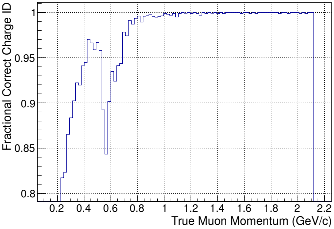
Changes in Momentum Dependent Efficiency

- Charge ID efficency very different after above changes.
- Dip at 0.5 GeV/c disappears in new reconstruction.
- Charge ID efficiency dropped to 0.99 on plateau.

New Charge ID Efficiency



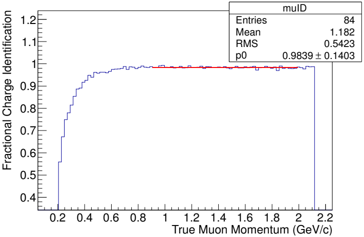
Old Charge ID Efficiency



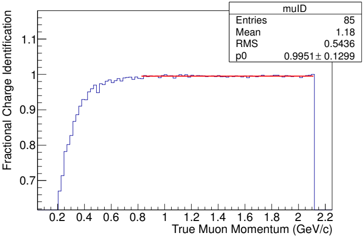
Charge Conjugation in Focusing Fields

- Observed difference in charge ID efficiency in μ^- w.r.t. μ^+.
- Compare the charge ID efficiency for μ^- and μ^+ in simulations with B-fields oriented to focus the μ^+.
- Charge ID efficiency for μ^- in a fucussing field is also shown.

μ^- in a Defocusing Field



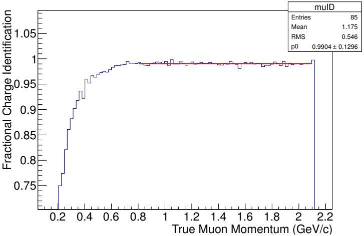
μ^- in a Focusing Field



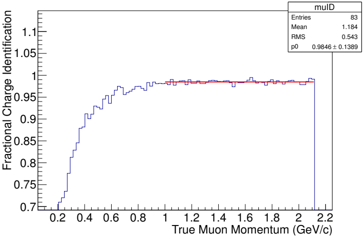
Altering Magnetic Field Strength

- Question asked whether field strength interferes with reconstruction.
  - Does the reconstruction have difficulty if the field changes too fast.
  - This should scale down if the field itself is scaled down.
- Multiplied magnetic field by a factor of 0.75.
- Efficiency reaches plateau later.
- Efficency at platea is smaller — This doesn't improve reconstruction.

μ^+ in Default Field



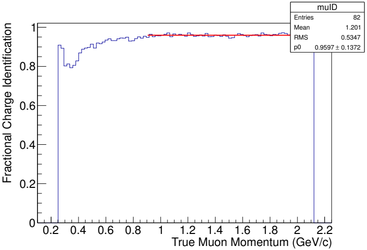
μ^+ in Scaled Field



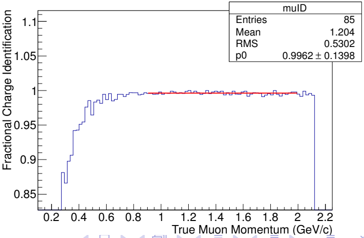
Reconstruction at Large Angles

- One concern not addressed with single particle simulations is the production of muons in an off-axis direction.
- Previous test no longer informative.
- Compare to results with thicker plate to determine if effect is due to geometry or multiple scattering.
- Input either $\cos\theta = 0.5$ or Iron plate thickness of 2 cm.
- Effects are not identical — problem must be due to angle with respect to magnetic field, not multiple scattering.

μ^+ with $\cos\theta_l = 0.5$

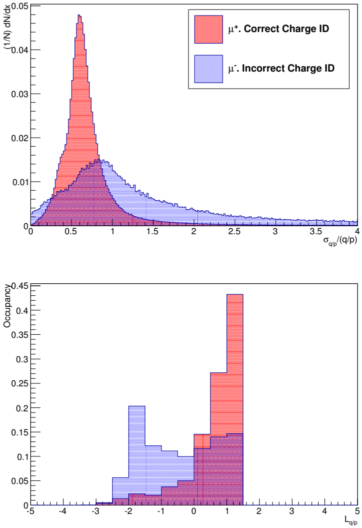


Detector simulated with 2 cm Fe Plate



Consequences of Recent Improvements to CC Selection

- Alters the shape of the $\sigma_{q/p}/(q/p)$ distribution.
  - Makes it "easier" to distinguish signal from background.
  - Does not improve differentiation of background from signal.
- Other distributions used for CC selection not affected.
- Effectively no change in signal efficiency and background rates.



Summary

- Improvements have been made in reconstruction.
- Including dE/dx map, and improved momentum seeding make a difference in the apparent consistency of results.
  - Charge efficiencies consistent between μ^+ and μ^- for example.
- Changes yield minimal improvements to signal and bakcground rates.
  - Best signal to background ratio 1.33×10^4
  - Signal Efficiency: 0.16.
  - Background rate: 1.2×10^{-5}

Incorrect Charge ID Tracks