SPINE Reconstruction in the 2x2 ND Prototype

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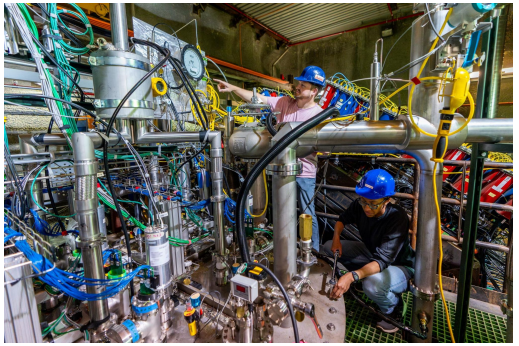
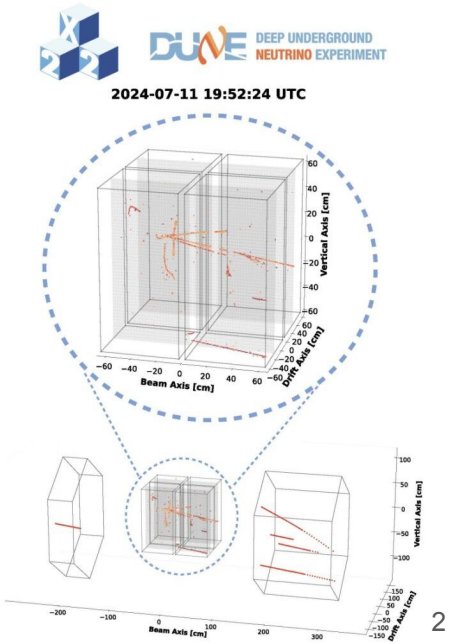
Overview

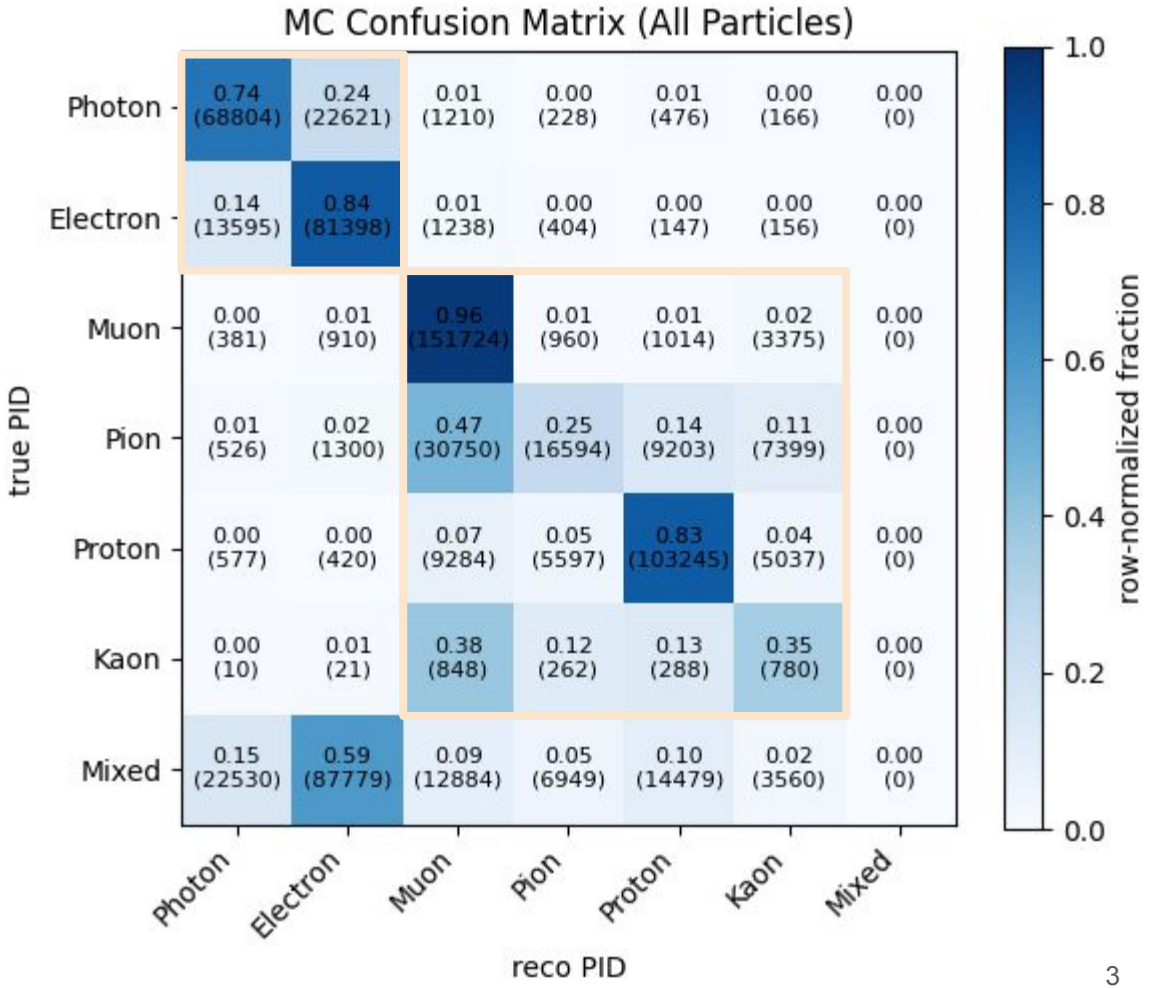
- Goals:
  - Evaluate the performance of SPINE on 2x2 data (real and simulated/MC)
    - Find where SPINE performs well and poorly
    - Look for methods to obtain purer samples in 2x2 data
- Info:
  - MC (~175,000 spills): Simulated NuMI beam in 2x2 detector geometry (MiniRun 6.5)
    - Using reco-to-truth matching: one instance of each reco particle
  - Data (~240,000 spills): 4 days of data from July 2024





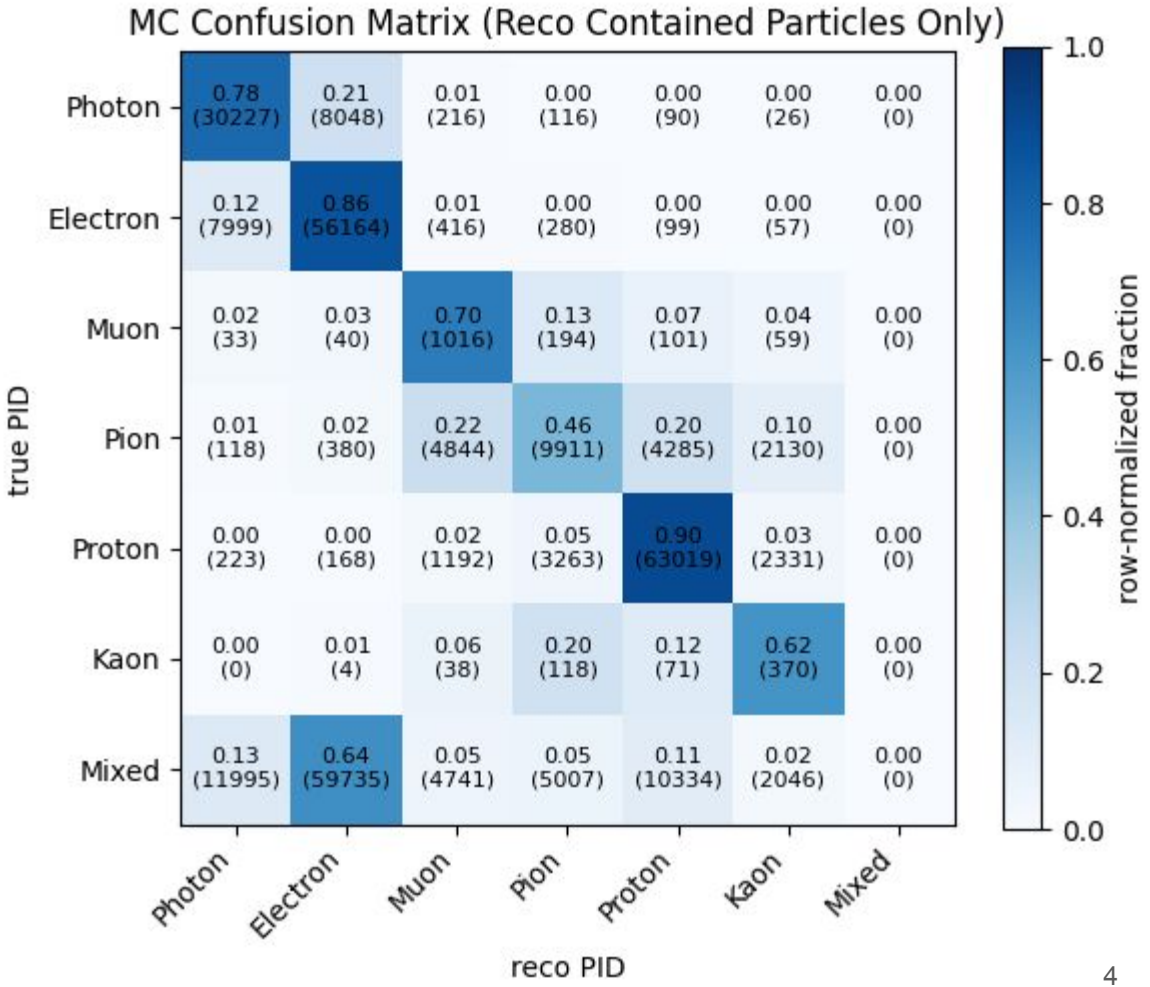
MC Confusion Matrix

- SPINE differentiates showers and tracks well
  - Struggles within those bounds, especially pions and kaons
  - Quite good at labeling muons and protons
- Most fragmented tracks are reconstructed as showers
- “Mixed”: reconstructed particles that are fragments of true particles (overlap < 0.5)



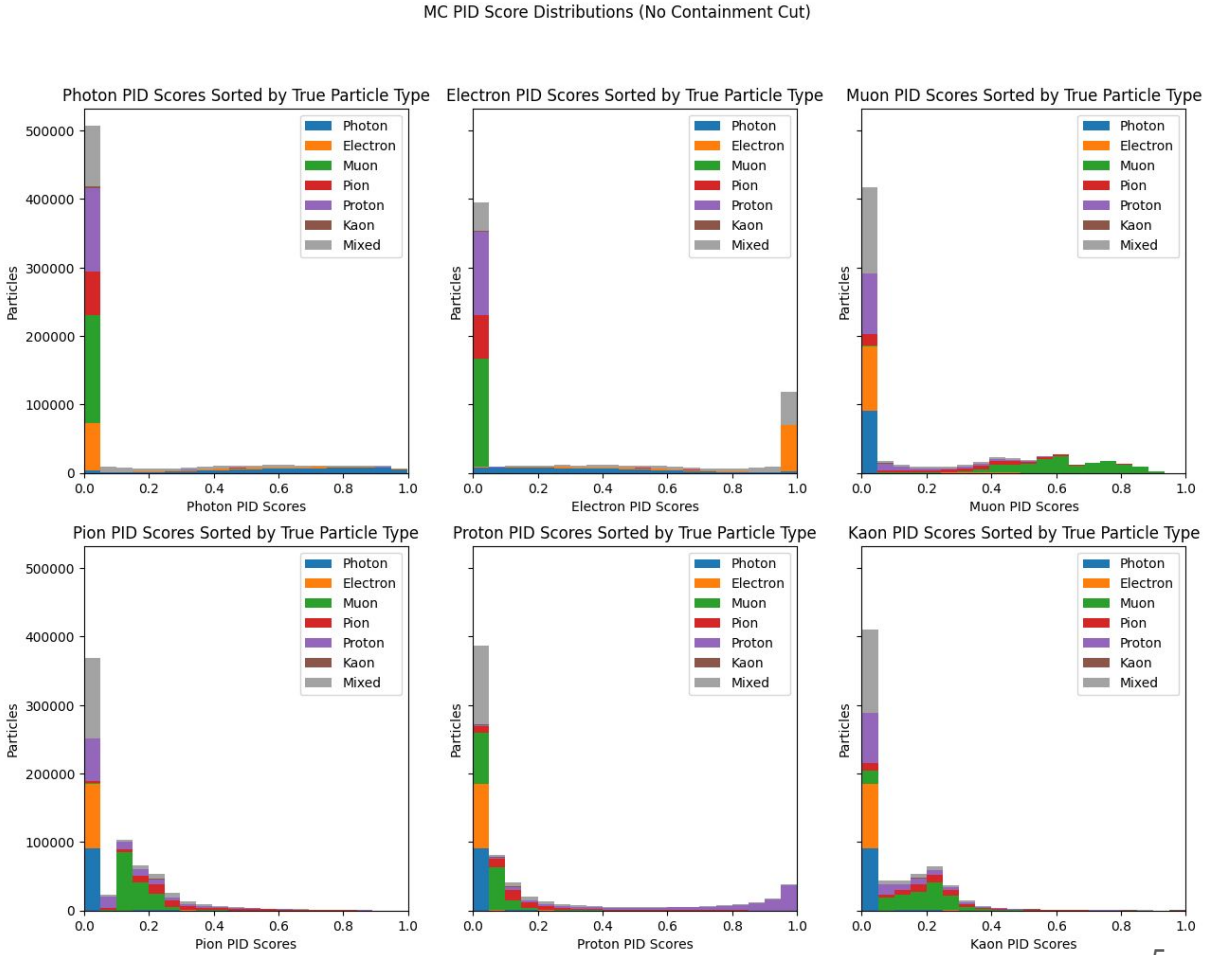
MC Confusion Matrix (Contained)

- SPINE performs better on contained particles
  - Muons are the exception; most were cut
- Pions are still a problem



MC PID Scores

- SPINE trends:
  - Rarely confident with pions and kaons
  - Generally quite confident with electrons and protons
  - Muons are more spread, but rarely get high scores for other PIDs
- Potential for more nuanced cuts, purer samples
  - Ex: Many pions have low but non-zero proton scores



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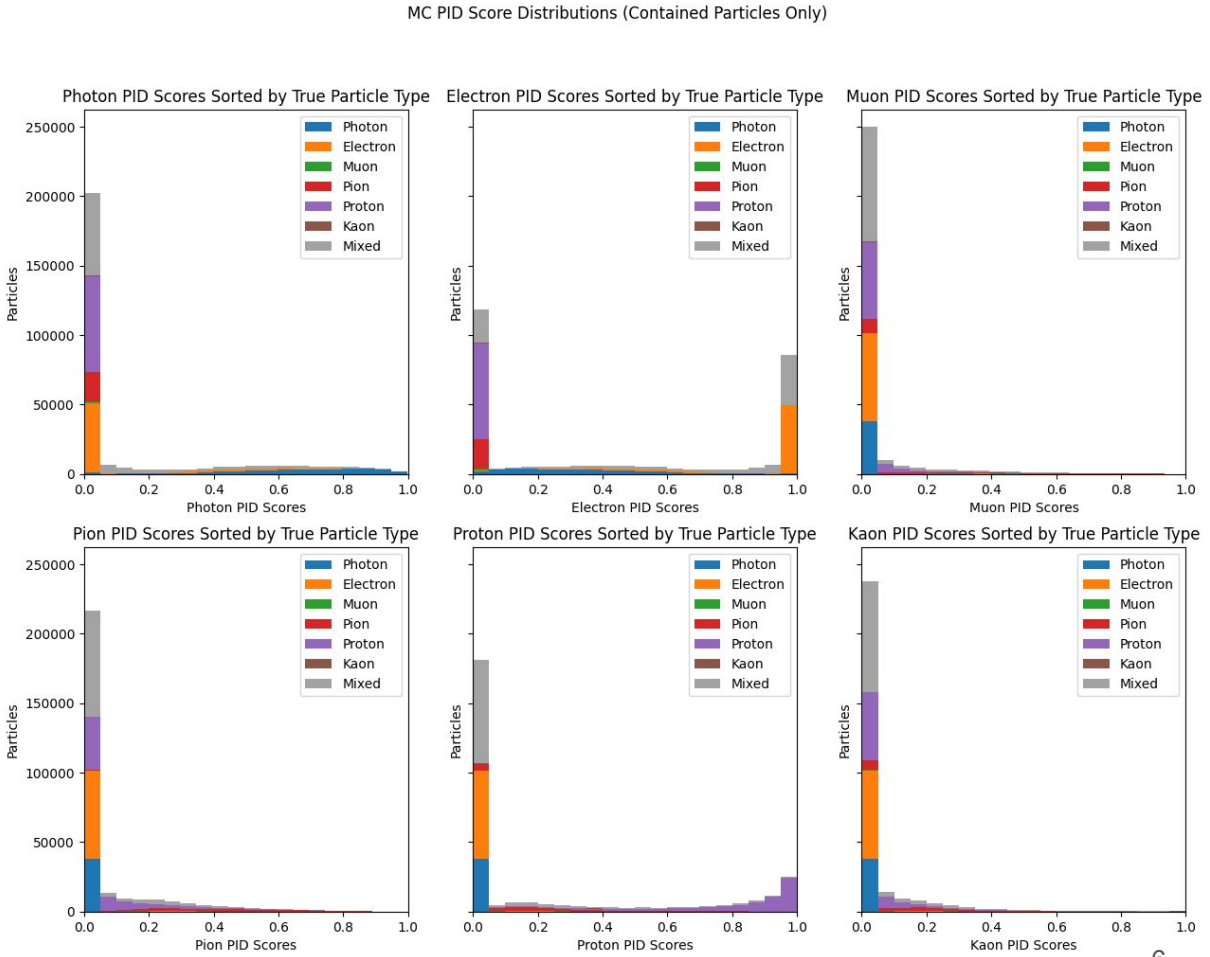
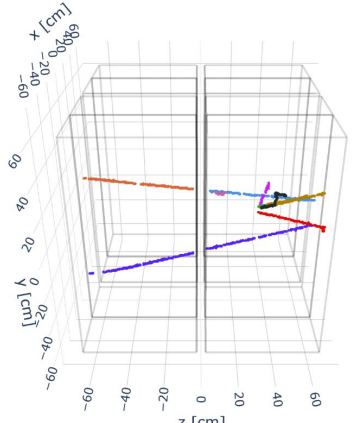
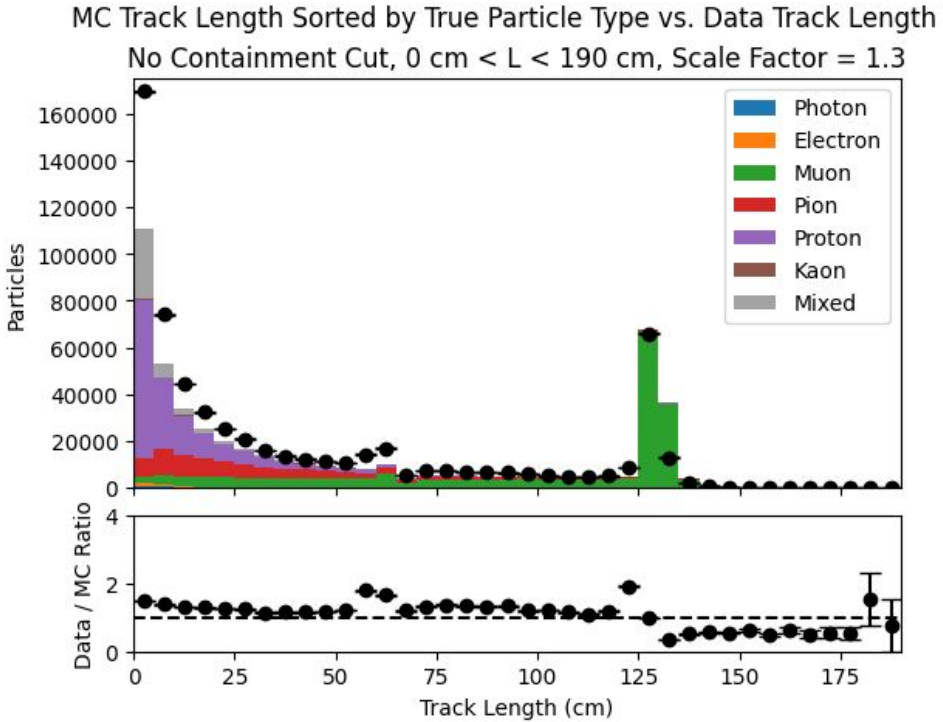


Comparing to Data: Track Length

- Scaling MC counts up by difference in exposure (x1.3)
- Muon tracks are long, protons are short
- Spikes in MC and data at 60cm and 125cm; likely due to detector geometry
    - SPINE weak spot: splitting tracks at module boundaries

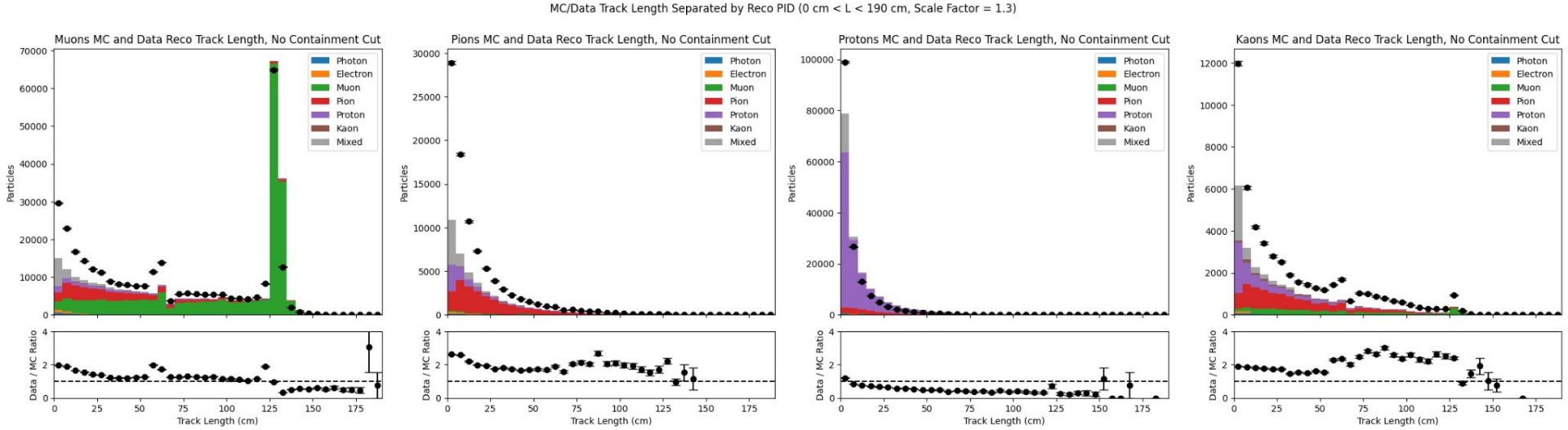




*Reco length > 0

Comparing to Data: Track Length by PID

- For all particles, data has more near-0-length tracks
- Muons make up the bulk of the spikes
- Reco kaons far outnumber true kaons, and have longer track lengths
- Protons appear in data at a lower relative rate than other track-like particles



What's Next?

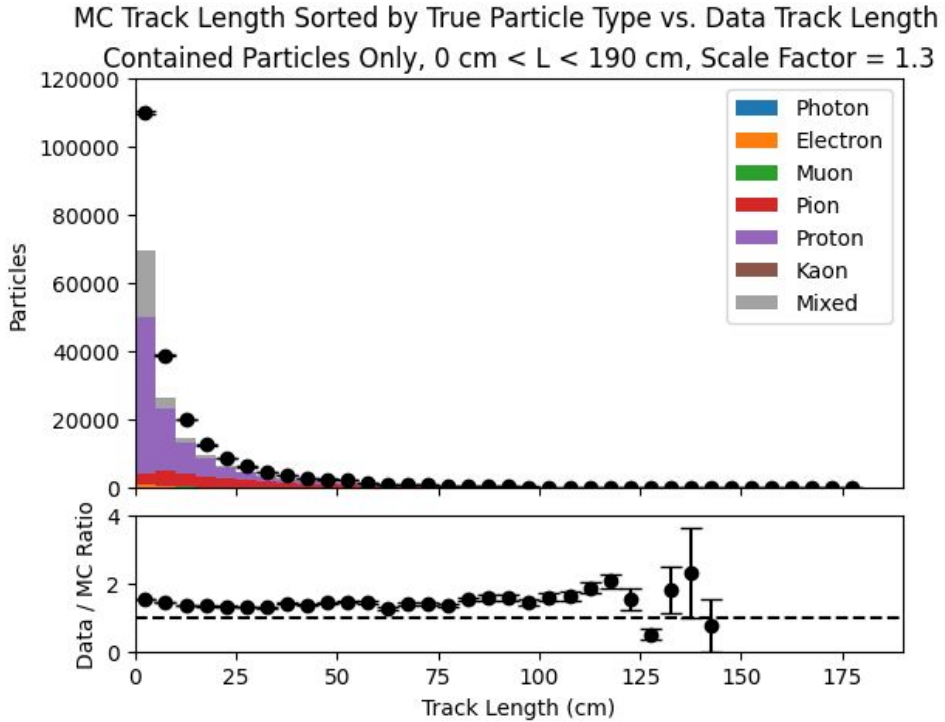
- Investigate methods to get pure samples from real data based on trends we see in MC
- Look into some strange reconstruction habits SPINE has
  - e.g. split muon tracks and reverse-split muons
- Develop and test hypotheses for noticeable disagreements between MC and data
  - e.g. 0-length and near-0-length particles

Questions?

Thank you!

Comparing to Data: Track Length (Contained)

- Most muons removed
- Spikes disappeared, replaced with slight dips
  - Few contained particles run from one end of module/detector to the other



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Comparing to Data: Track Length by PID (Contained)

- Same trend with near-0-length tracks, relative proton undercounting in data
- We see the dip where we saw the spike earlier (muons, kaons)