ePIC MuID capabilities

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- work performed by Andrew Hurley (Umass Amherst) -

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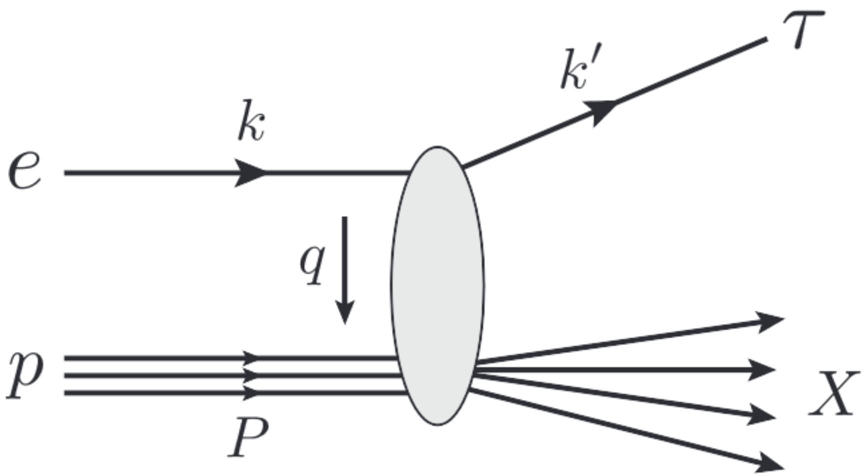
Motivation: CLVF

- The e -> tau constraints currently still allow for the EIC to probe new phase space
- Initial interest in the e -> tau conversions was on the three-pion decay mode due to its topological signature
  - Studies done by Jinlong Zhang indicate that this channel alone could increase the limits set by HERA by a factor of 2 (at 100 fb^{-1}) and comparable to limits set by BABAR



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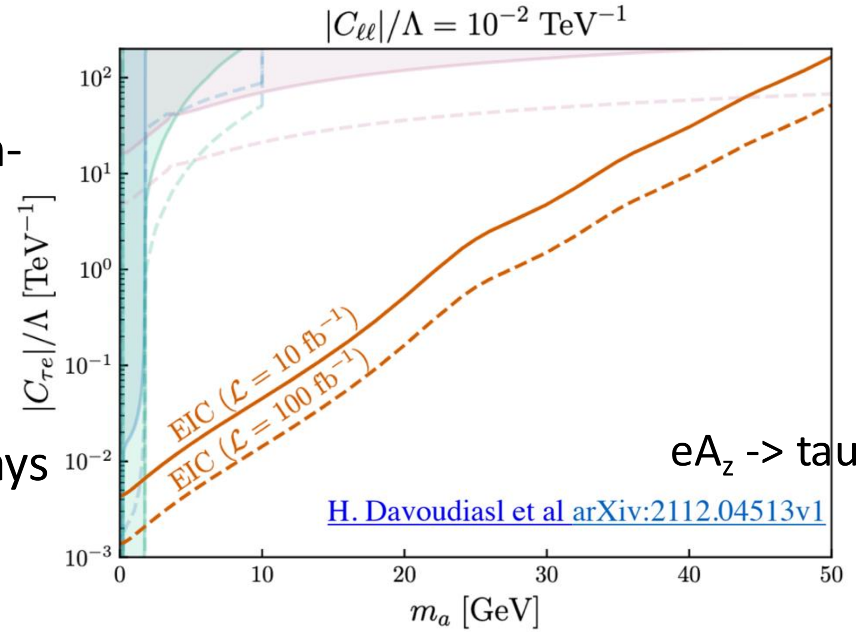
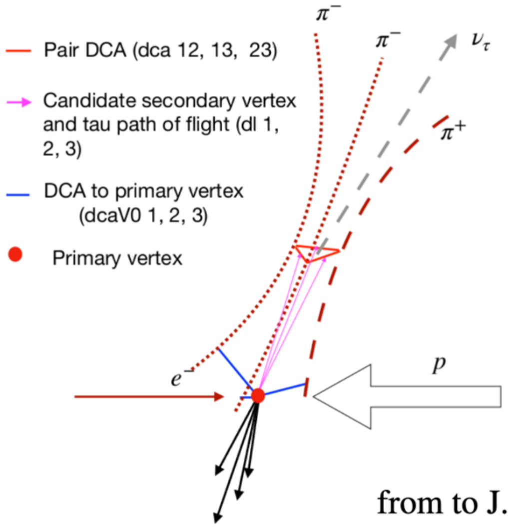
https://arxiv.org/pdf/2102.06176.pdf

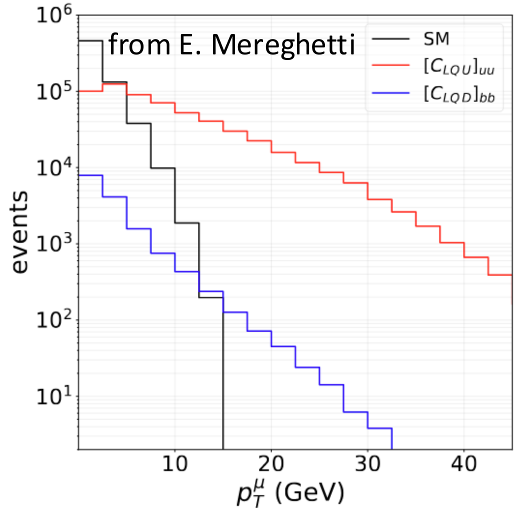
- Sensitivity to axion-like particles has been shown to be quite high for the EIC in eA collisions through similar measurements (where nucleus stays intact)



eA_z -> tau A_z



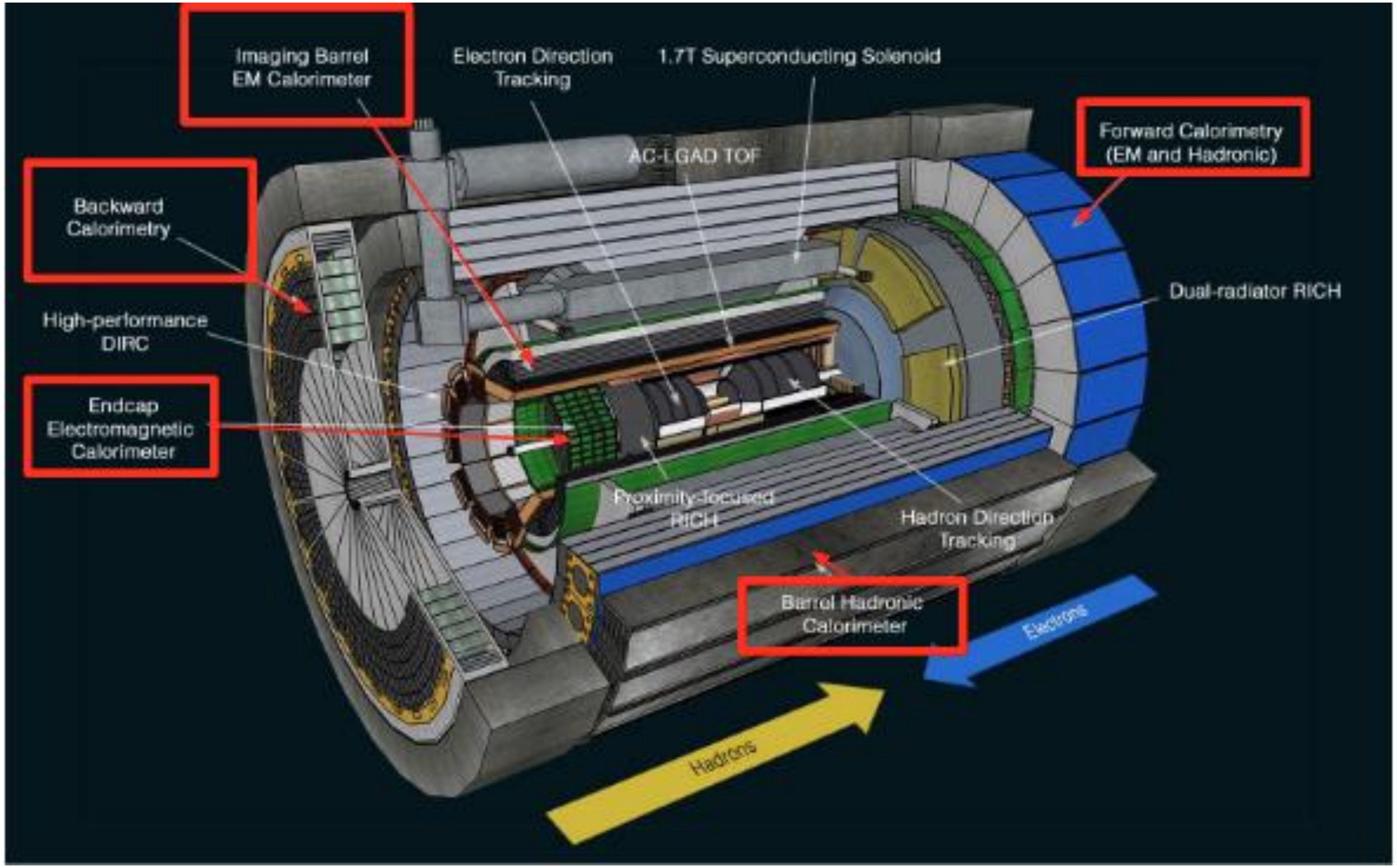
from to J. Zhang



- Two decay modes offer different advantages

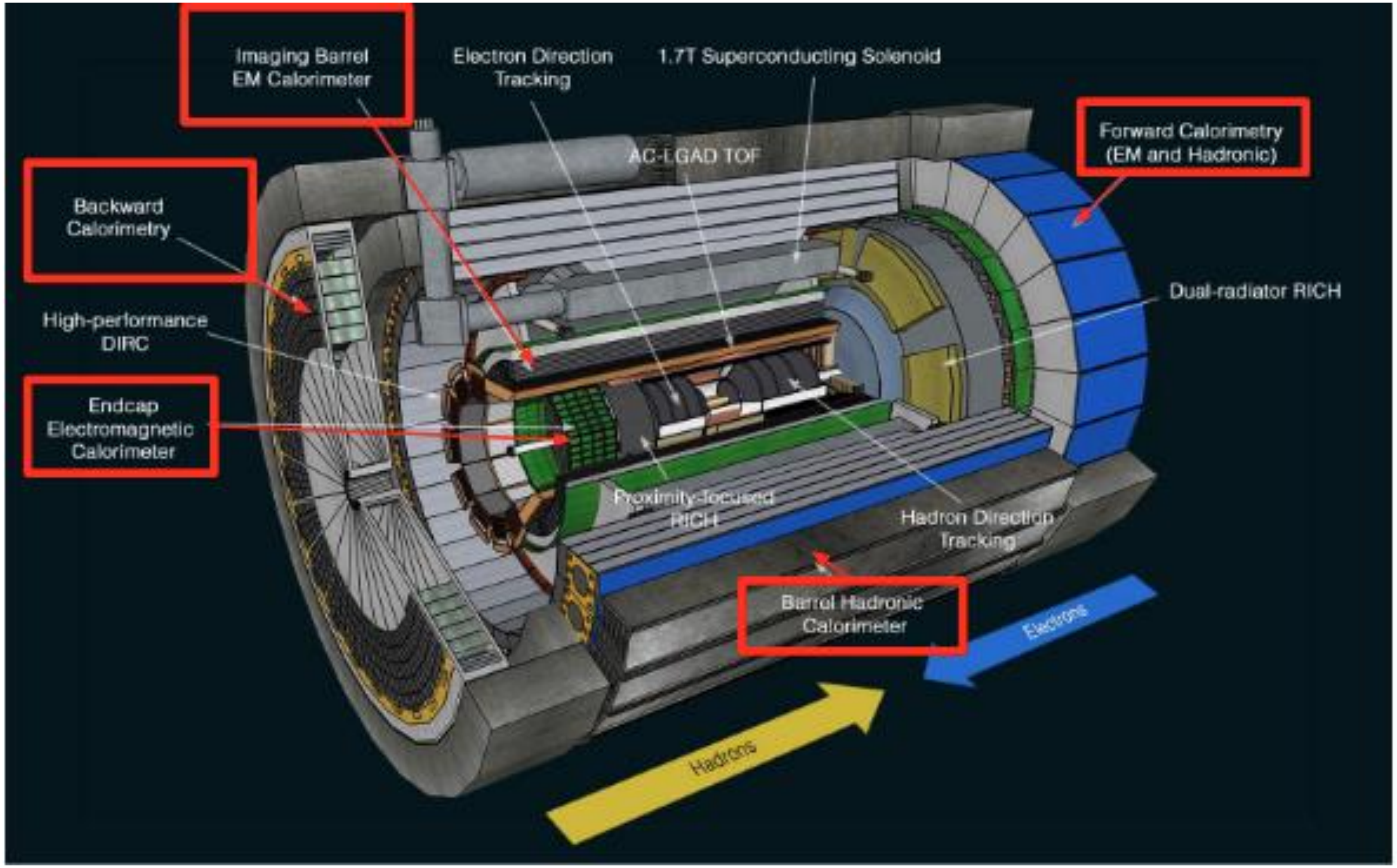
ePIC detectors used in analysis

- The calorimeters are the clear starting point for a muon identification
  - both calorimeters are needed for the best results
- The barrel region was the focus of Andrew's analysis
  - a FWD and BWD analysis would be very useful in the future



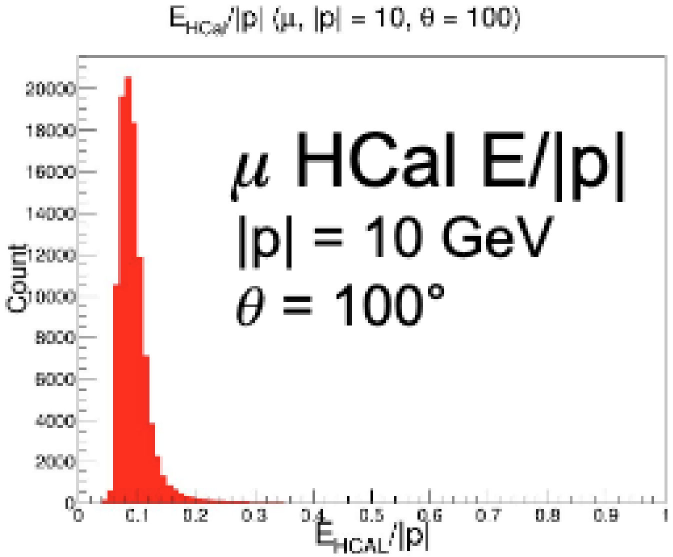
ePIC simulations

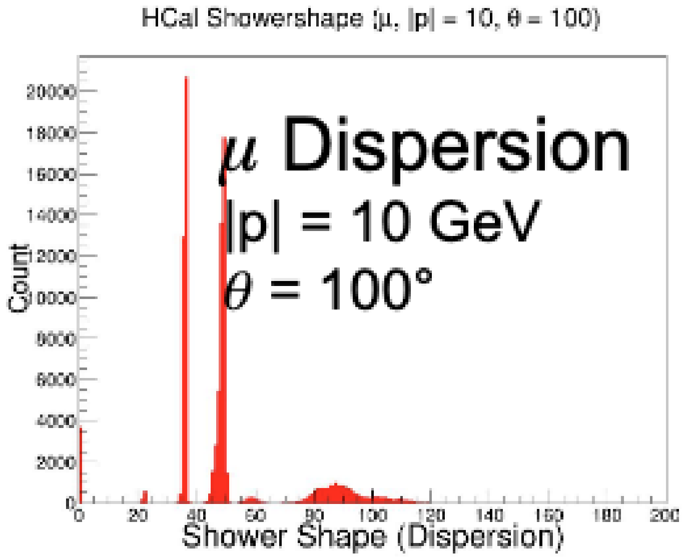
- Only single particle simulations were used to determine the base identification algorithm
- The main "background" are pions
- 100k mu & pi single particle sims were run with the ddsim setup of ePIC
  - momentum between 1 and 15 GeV (1 GeV steps)
  - theta 90º to 150º (10º steps)
- EICrecon used for reconstructed variables

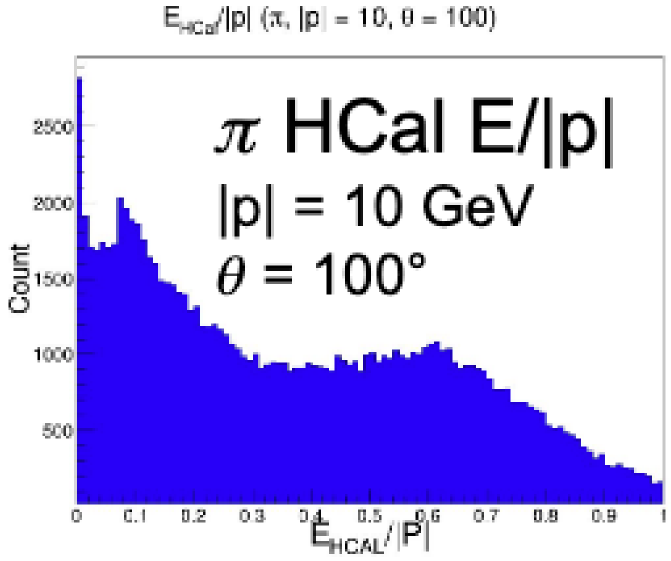


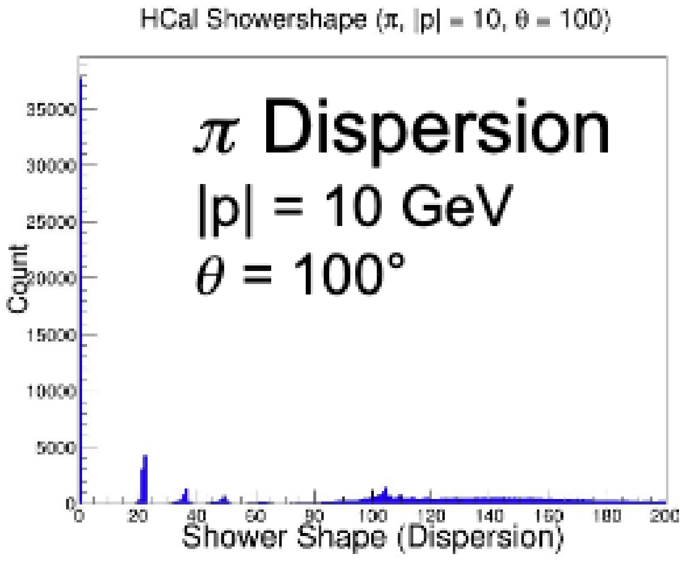
EICrecon

- The calorimeter information has the most discrimination power
  - E/p is used in line with the electron ID efforts
- Energy weighted radius (dispersion or shower shape) provides additional information that we can use



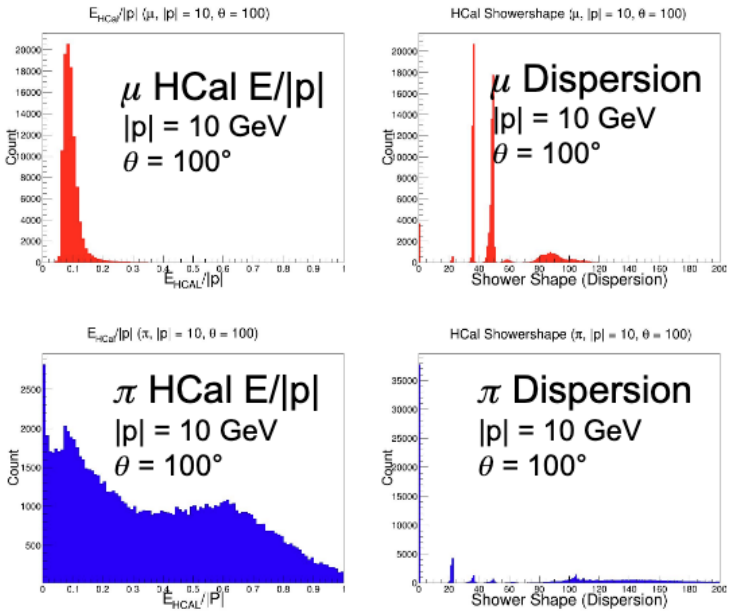






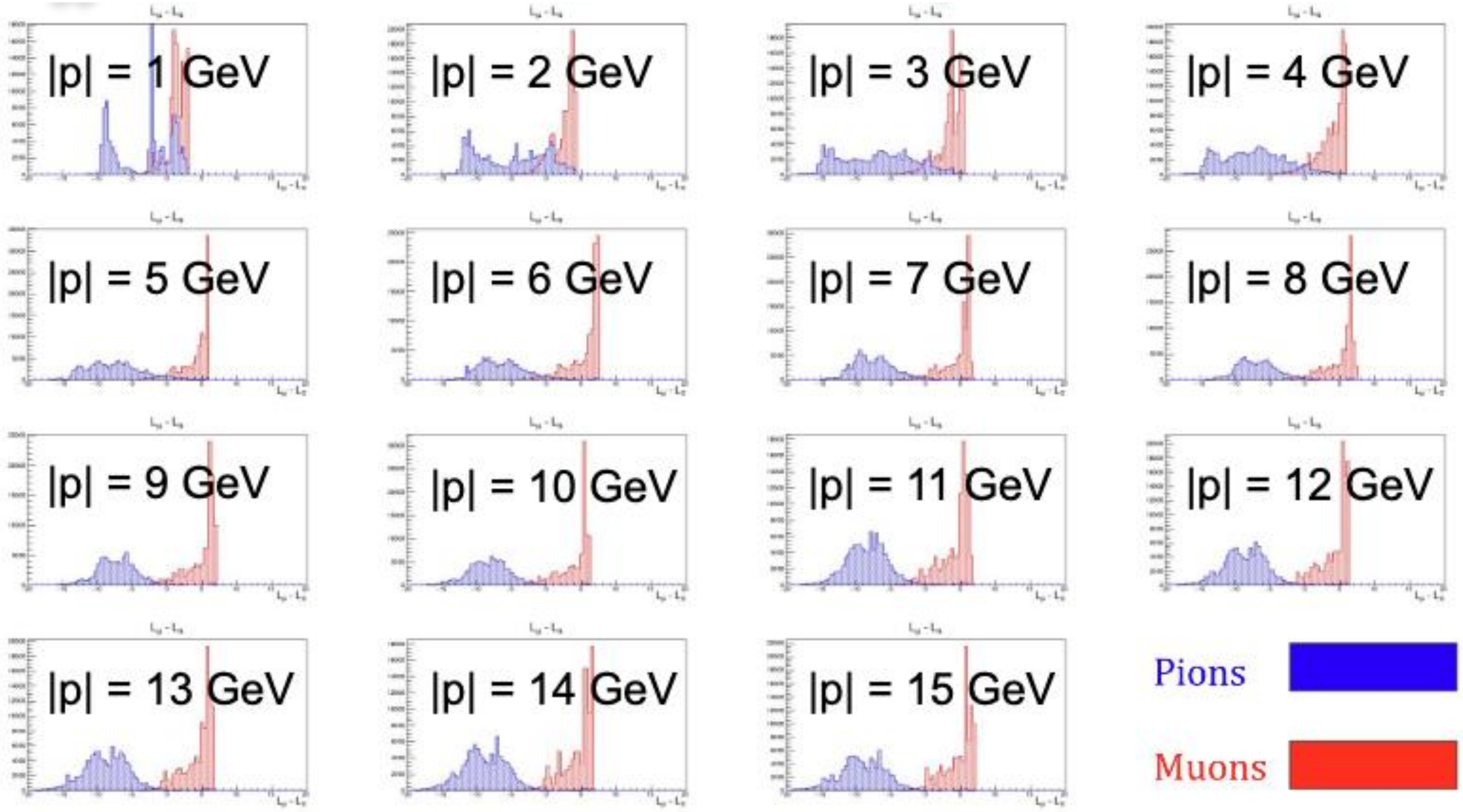
Log-likelihood

- Feed all this information (ECal, HCal, dispersion) into a single variable that can be tuned for each analysis
  - Additional variables are easy to add into the mix
- The cut is on the log-likelihood of the difference between your signal and background

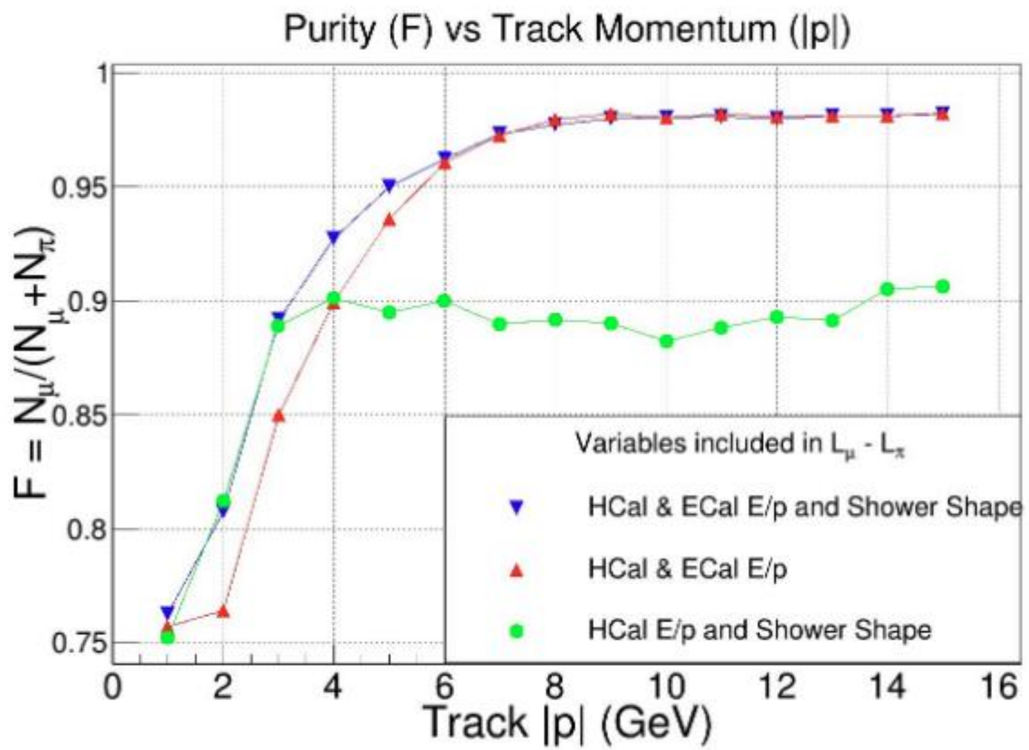


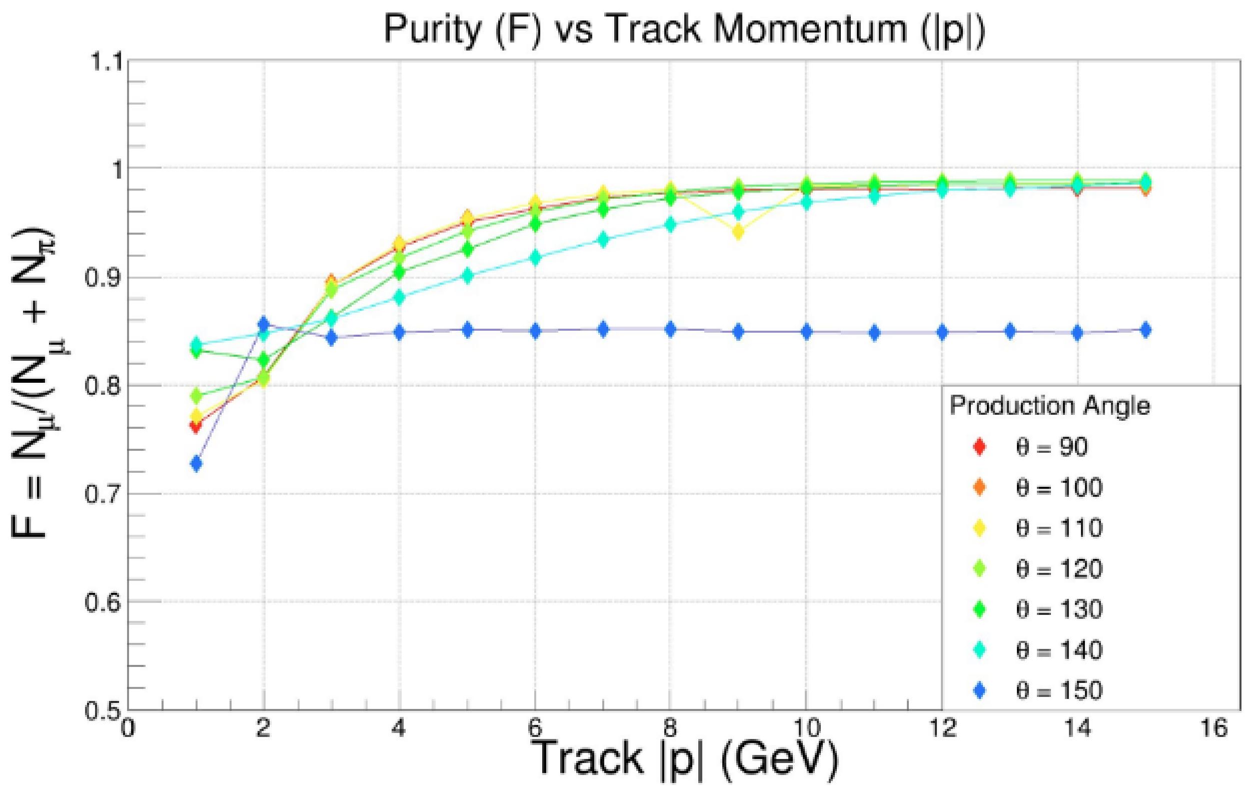
$L_j = \ln(\mathcal{L}_j) = \ln(\Pi_i\, p(q_{ji})) = \Sigma_i \ln(p(q_{ji}))$.
where j is the PID hypothesis (μ or π in this case).
i is each reconstructed value used (e.g. HCal E/|p|).
$p(q_{ji})$ is the probability a track has a value q_{ji} for the given PID hypothesis and reconstructed variable.

Log-likelihood: 90 degree scattering

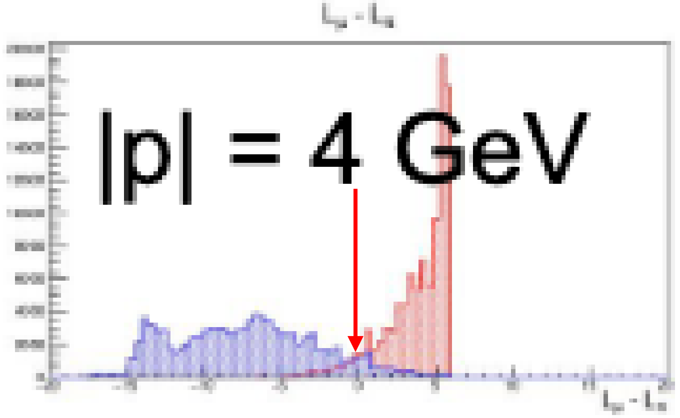


Log-likelihood results





- The L_μ-L_π > 0 cut was used
- We can see that for high enough track mentum we have a reasonable purity of pions
  - we see degradation at larger scattering angles



Conclusions

- Andrew did a great job showing that the current ePIC detector seems to do a reasonable job discriminating between pions and muons in the barrel region
  - Looking at minbias events is needed
  - The CLFV models suggested by Emmanuelle will be well tested by ePIC
- We should extend this to the FWD and BWD going regions
- Any suggestions for additional variables to increase discrimination power are most welcome