Toward better understanding of MINOS neutrino flux with MIPP hadronic production data

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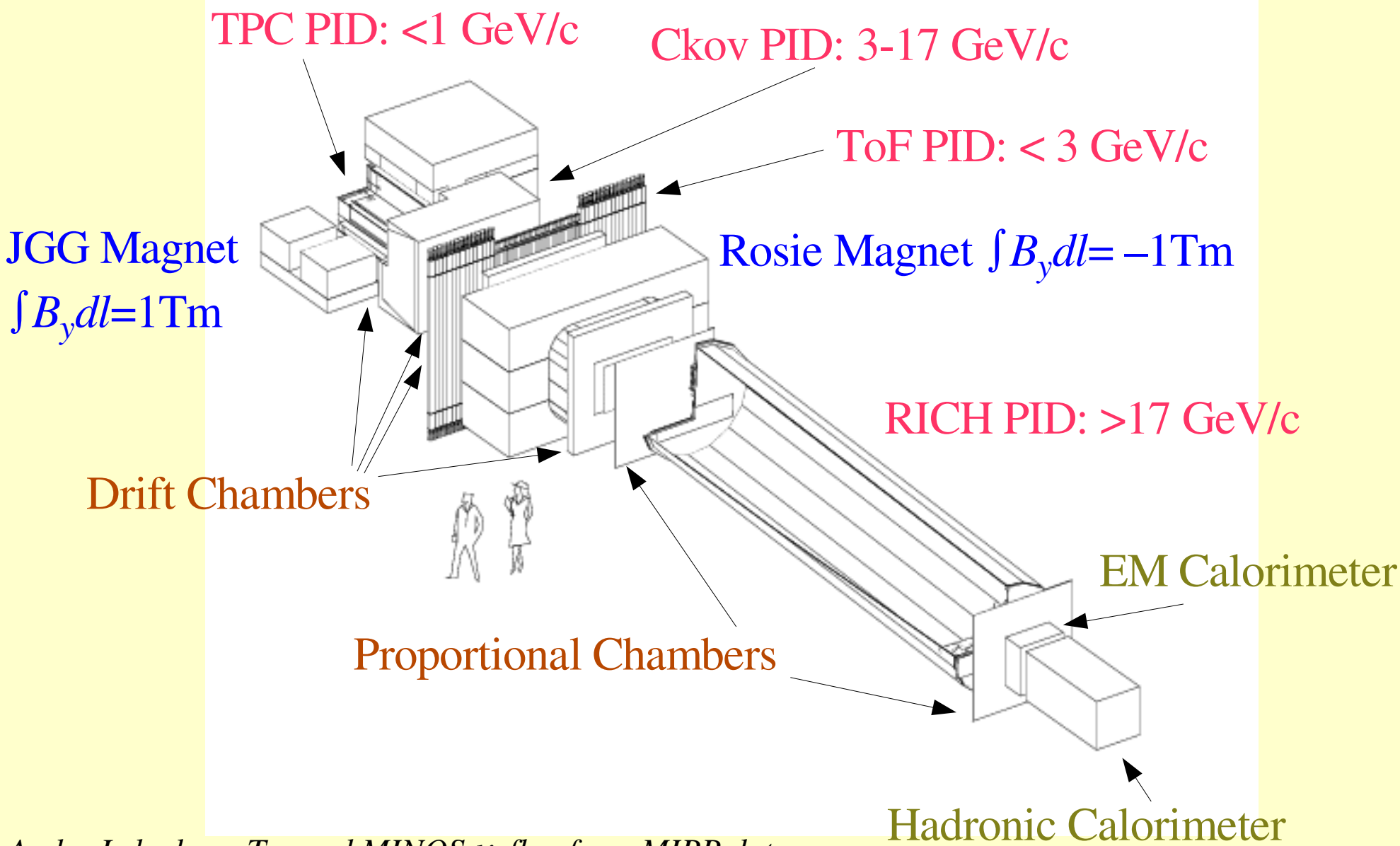
MIPP Collaboration:
Colorado, Fermilab, Harvard, IIT,
Iowa, Indiana, Livermore,
Michigan, South Carolina, Virginia

What is MIPP?

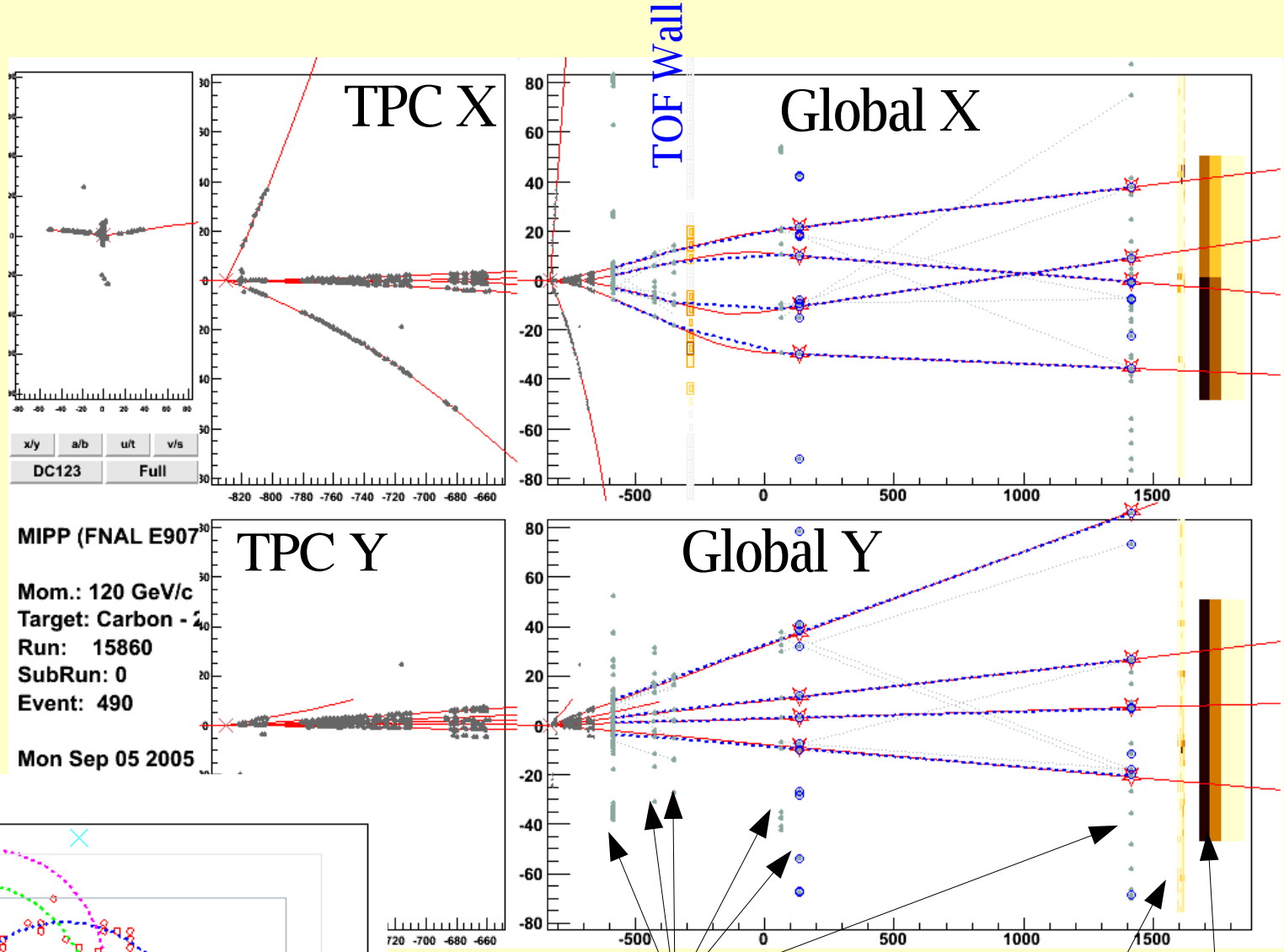
Main Injector Particle Production Experiment

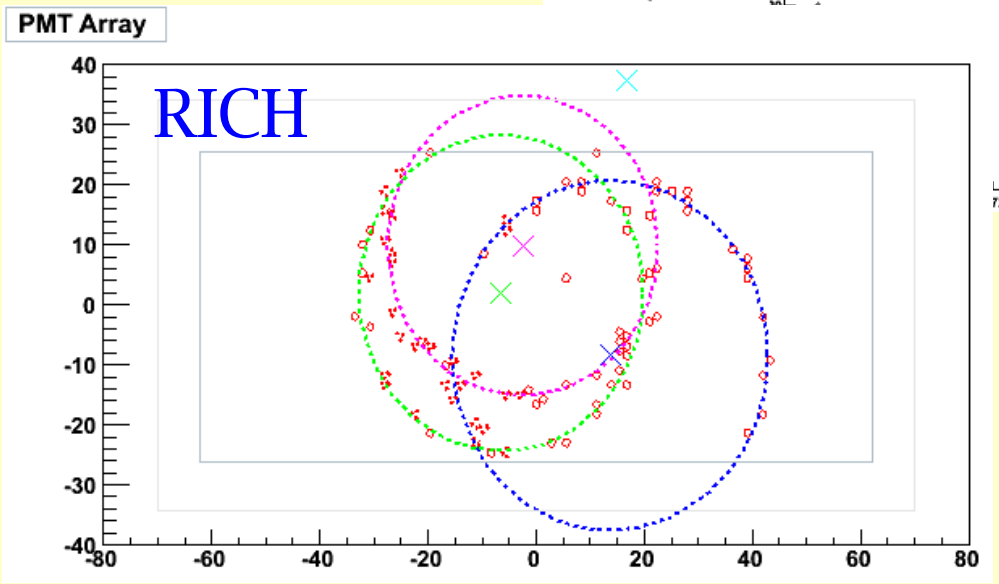
- (FNAL-E907) is a large acceptance spectrometer to measure hadronic particle production
  - TPC and wire chambers to measure track parameters
  - TPC dE/dx, ToF, differential Cherenkov and ring imaging Cherenkov give π/K/p separation up to 100 GeV/c
- Primary 120 GeV/c beam from the Main Injector
- Secondary beam of tagged $\pi^{\pm}$, $K^{\pm}$, $p^{\pm}$ from 5 to 85 GeV/c
- Collected 20M triggers on cryogenic H_2, Be, C, Bi, U, and NuMI target

Spectrometer Geometry



Reconstructed Proton-Carbon at 120 GeV/c Event

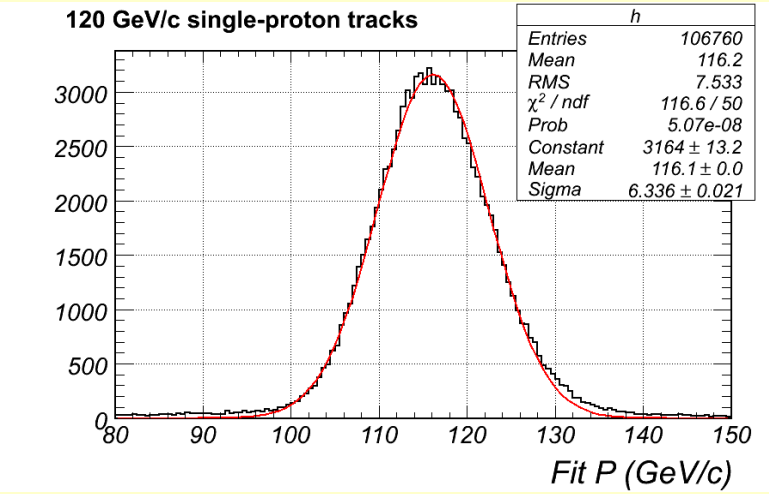


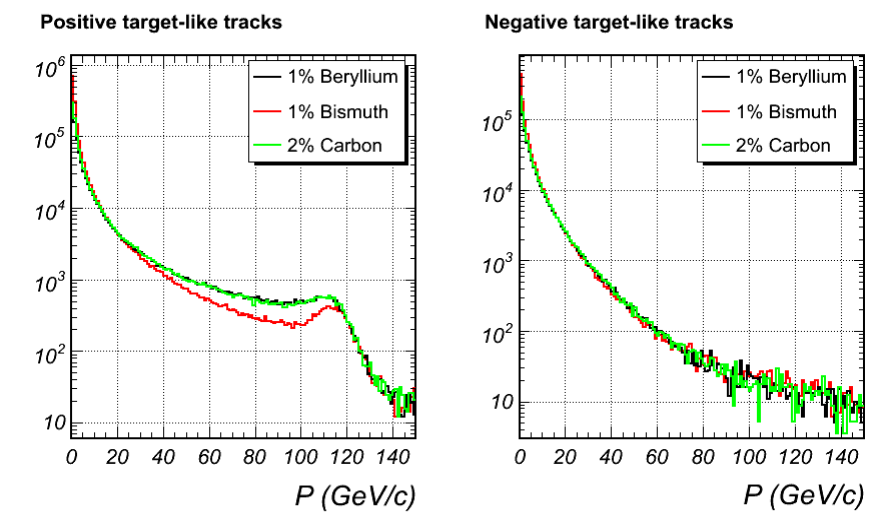


Track Reconstruction

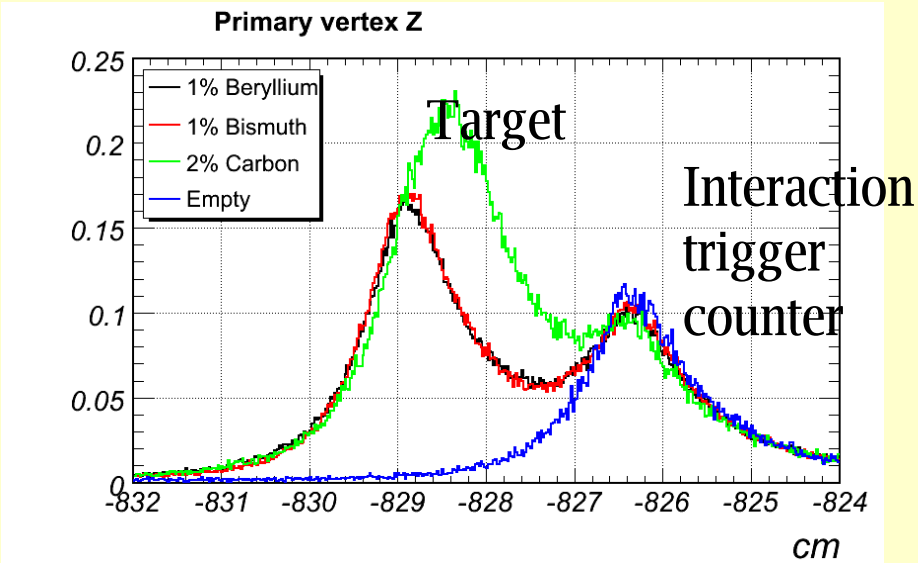
Plots from 120 GeV/c proton data

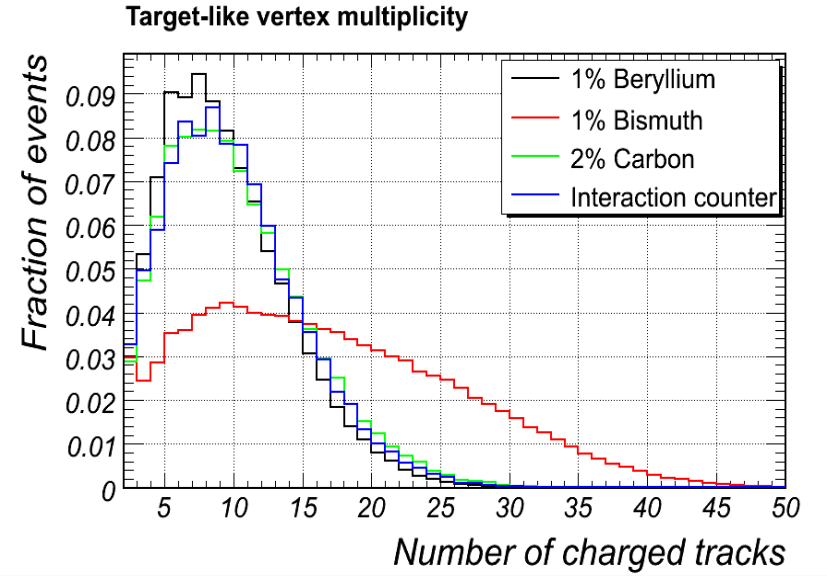
- TPC tracks are fitted to helices
  - Non-uniform B-field complicates the task
- Matched to chamber wires to form global tracks
  - Fit using track templates
- Momentum resolution 5.5% at 120 GeV/c
  - Drift times are not yet used





Vertex Reconstruction

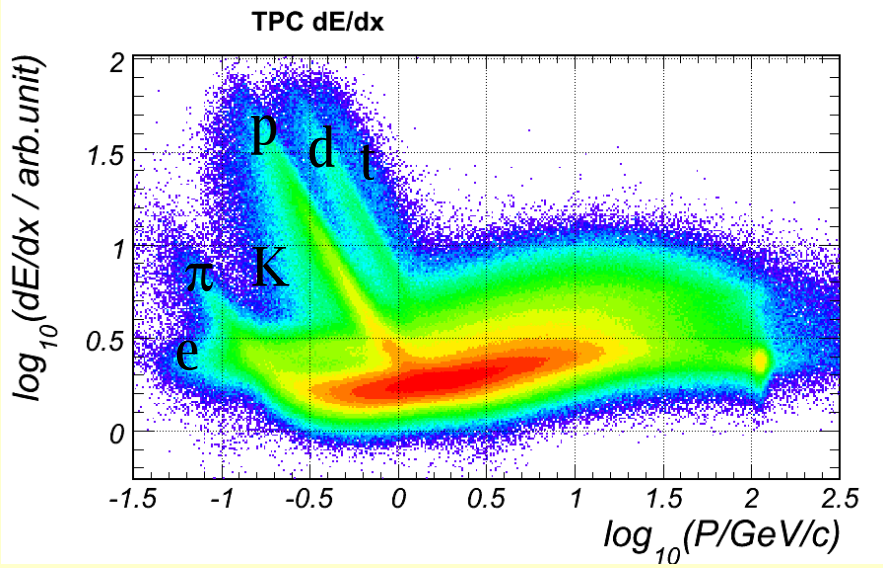


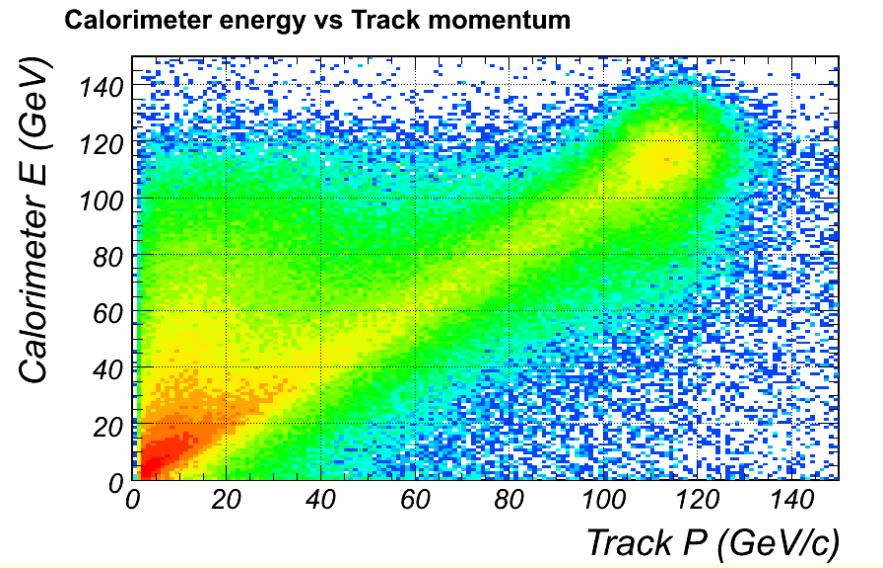


- Vertex finding is done with deterministic annealing filter
- Vertex-constrained fit done with track templates
  - 6mm vertex Z resolution
  - X,Y resolution < 1mm

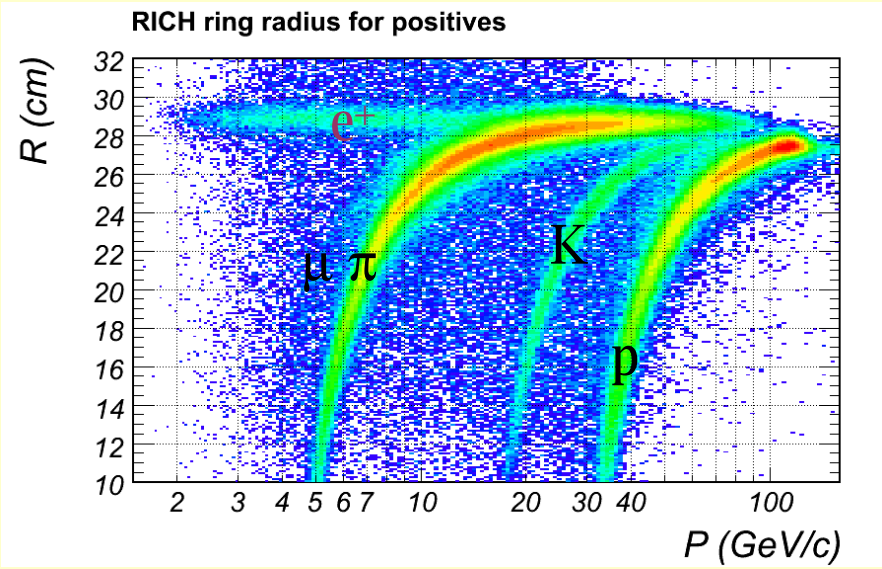
Particle Identification

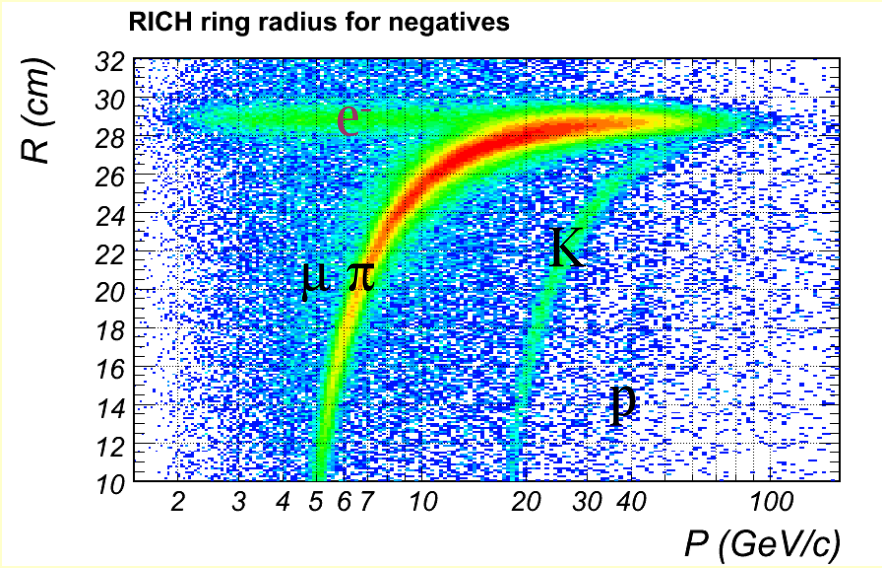
- Normalized TPC dE/dx is computed
  - Complicated by dead sections of the chamber
- Tracks are matched to calorimeter showers
  - Energy scale is calibrated
- Tracks are matched to time of flight wall and differential Cherenkov
  - Calibration in progress





Particle ID (cont.)

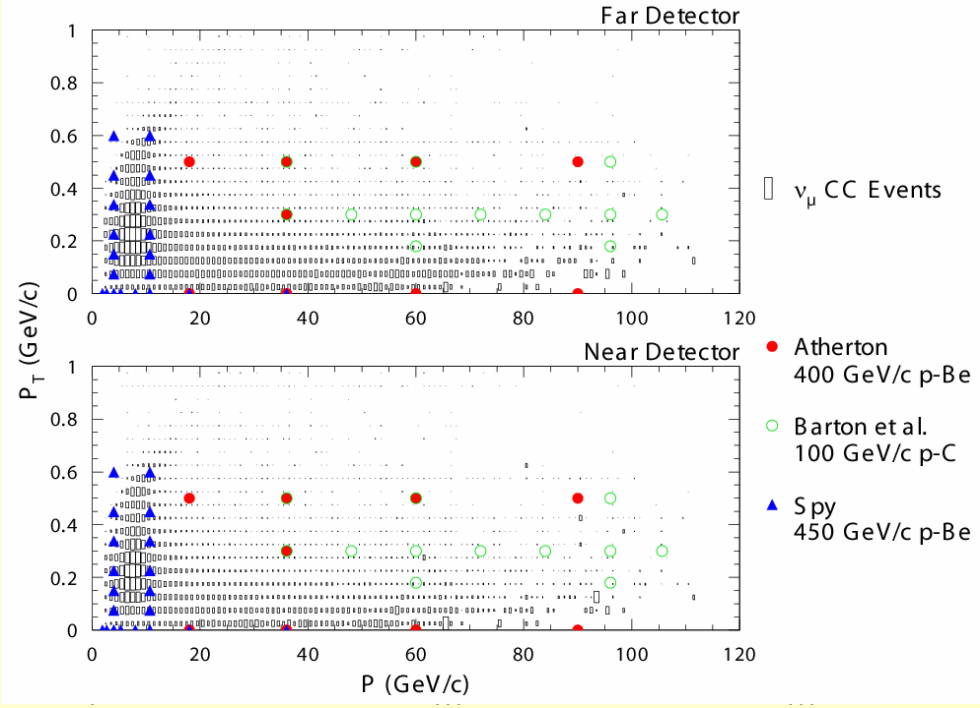


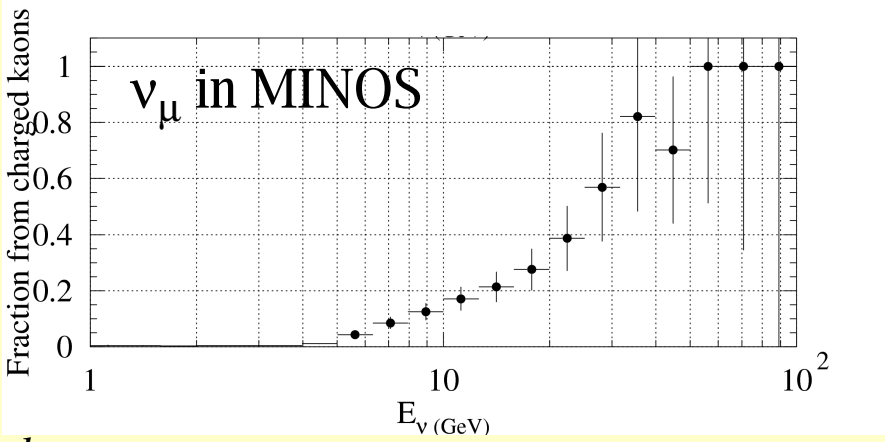


- RICH ring radius gives very good particle ID within acceptance
  - e/μ/π to 12 GeV/c
  - π/K/p to 100 GeV/c
- Detector is calibrated and well understood

Can MIPP help MINOS?

- Inclusive π/K/p production data is scarce
  - Large discrepancies in hadron production simulations
  - NA49 published pion flux from pC at 158 GeV/c
- Neutrino spectrum at the two MINOS detectors is somewhat different
  - Need to know π, K flux



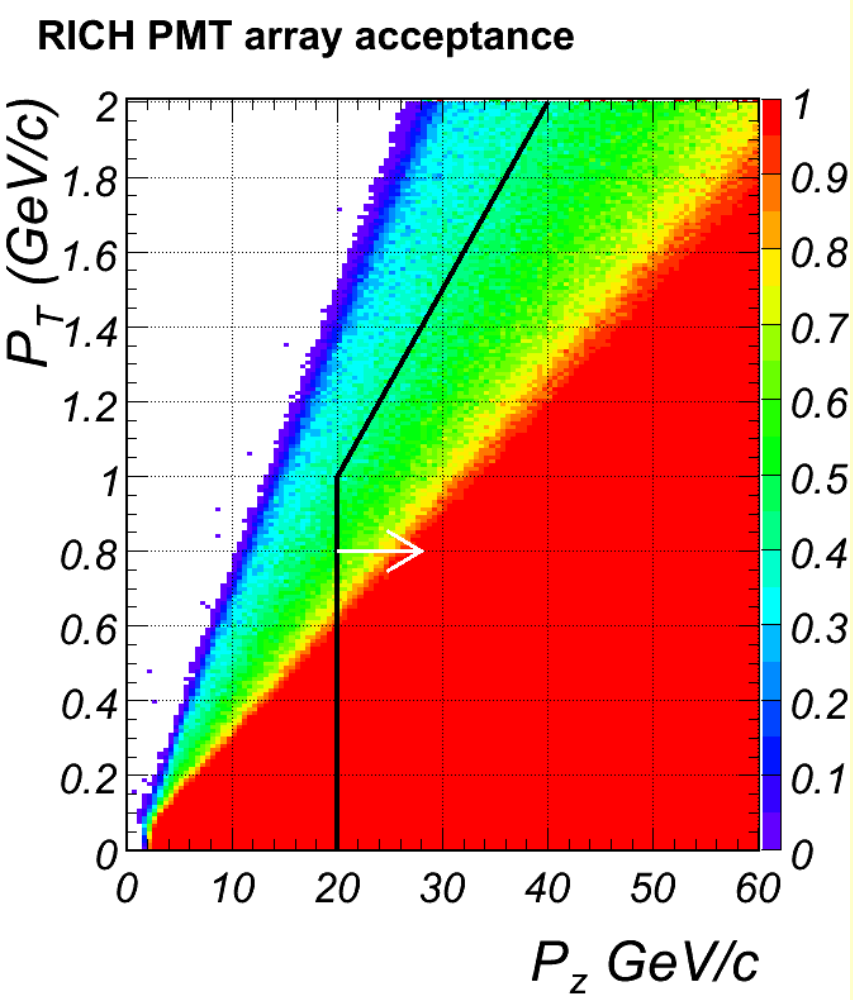


MIPP Carbon Data

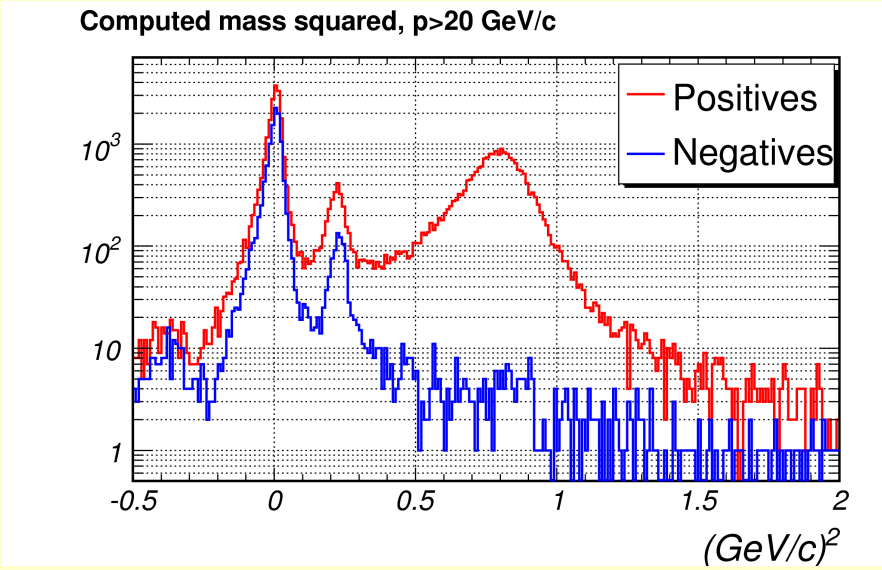
- Thin target: p at 120 GeV/c, π/K/p at 20 and 58 GeV/c
- 2M NuMI target triggers (120 GeV/c proton)
- Objective
  - Measure double differential cross sections from thin target
  - Measure particle fluxes from NuMI target
  - Model secondary and tertiary production off NuMI target using thin target cross sections

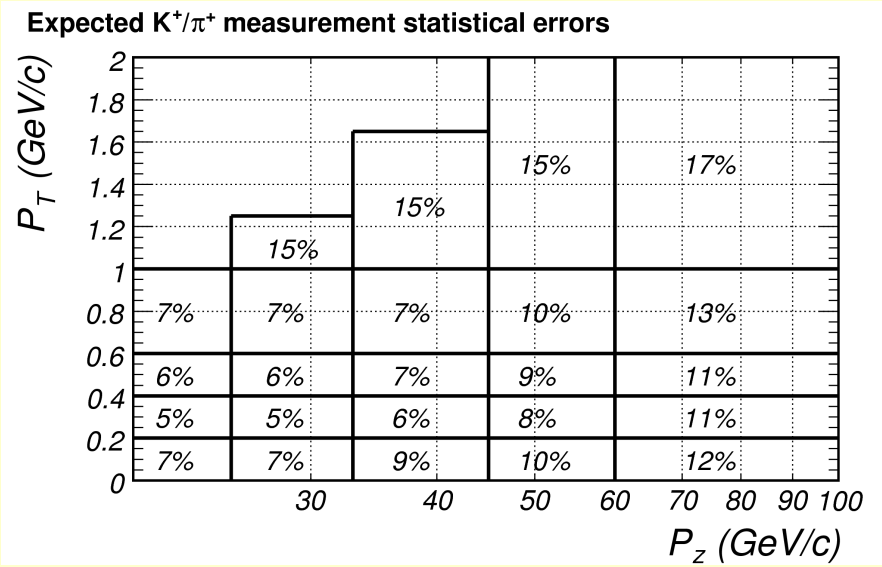
First Analysis in Progress: π/K ratio above 20 GeV/c

- Focus on 120 GeV/c proton-carbon data
- Use RICH for particle ID
  - K threshold at 17 GeV/c
- p_z/p_T bins selected to achieve 5-10% statistical error if possible
  - Require >50% acceptance
- Determine K^+/π^+, K^-/π^-, K^-/K^+, π^-/π^+



How to do the measurement?





- Convert RICH ring radius into mass squared using effective index of refraction
- Compute the number of pions and kaons in each bin
  - Protons are a significant contamination of K^+ peak for p_z>60 GeV/c
- Correct for decay in flight and interactions in the spectrometer with GEANT3

Conclusion

- MIPP experiment recorded 20M hadronic interaction triggers in 2005-2006
- Collaboration made a lot of progress in understanding the spectrometer
- Event reconstruction is in good shape
- First analysis-quality data summaries have been produced
- Time for physics analyses!
  - Particle production ratios (<3 months)
  - Double differential cross sections (~6 months)