MIPP

Main Injector Particle Production Experiment

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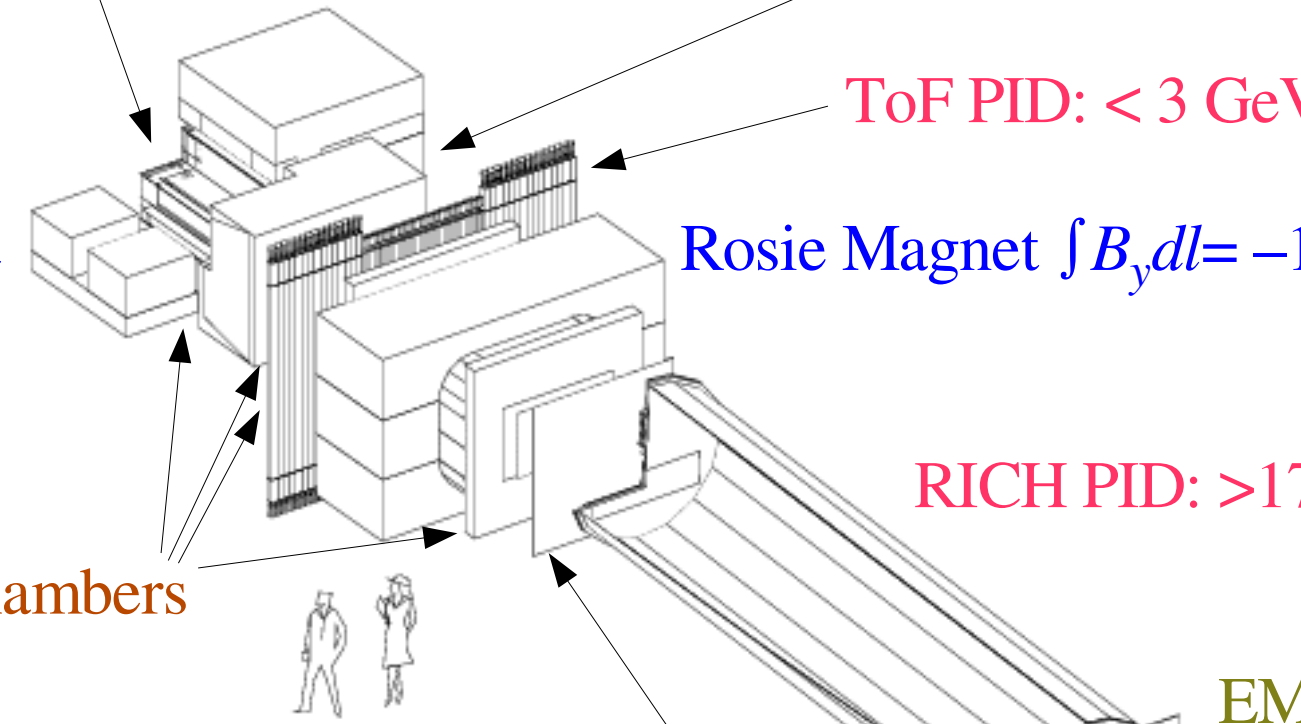
Overview

- MIPP (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



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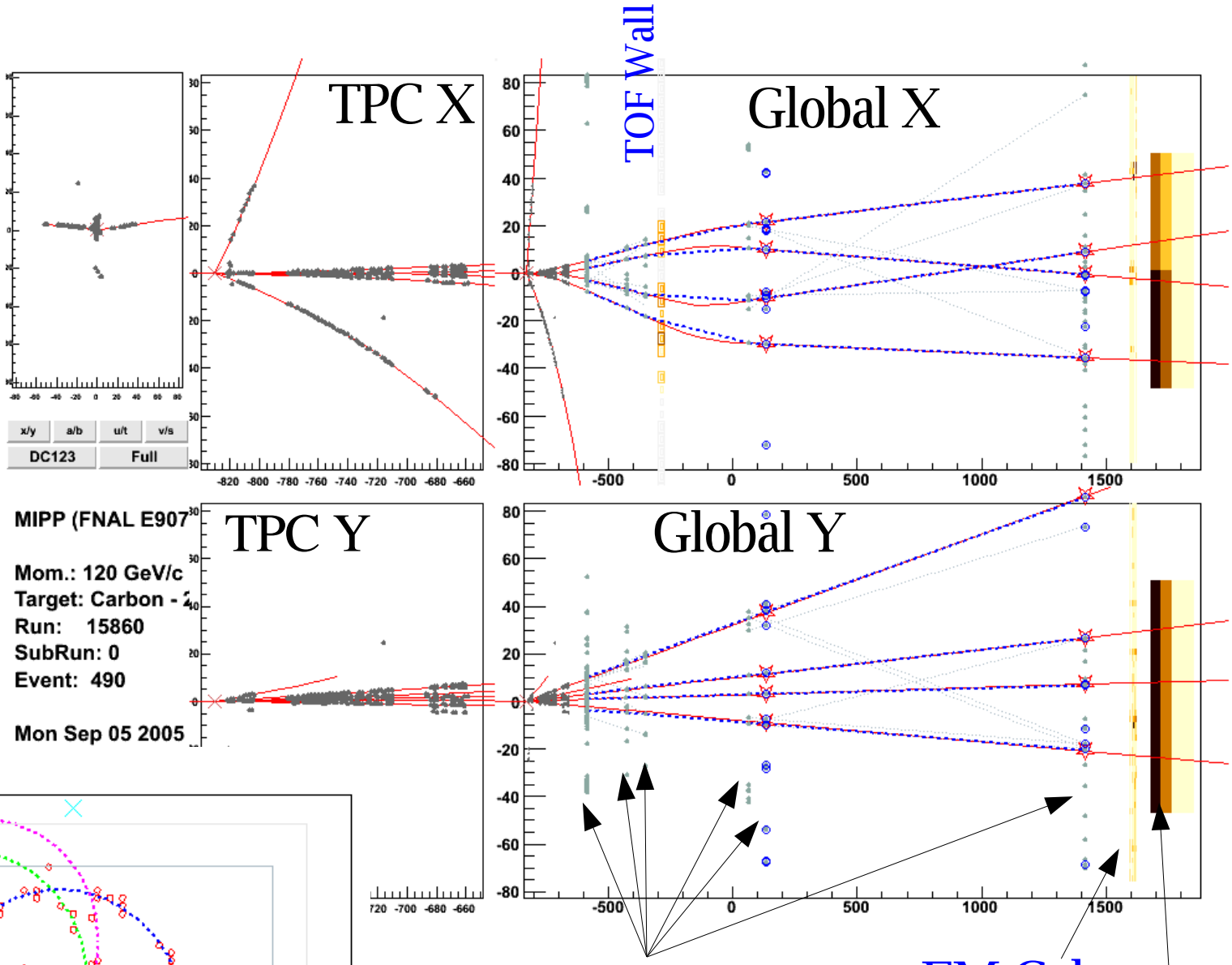
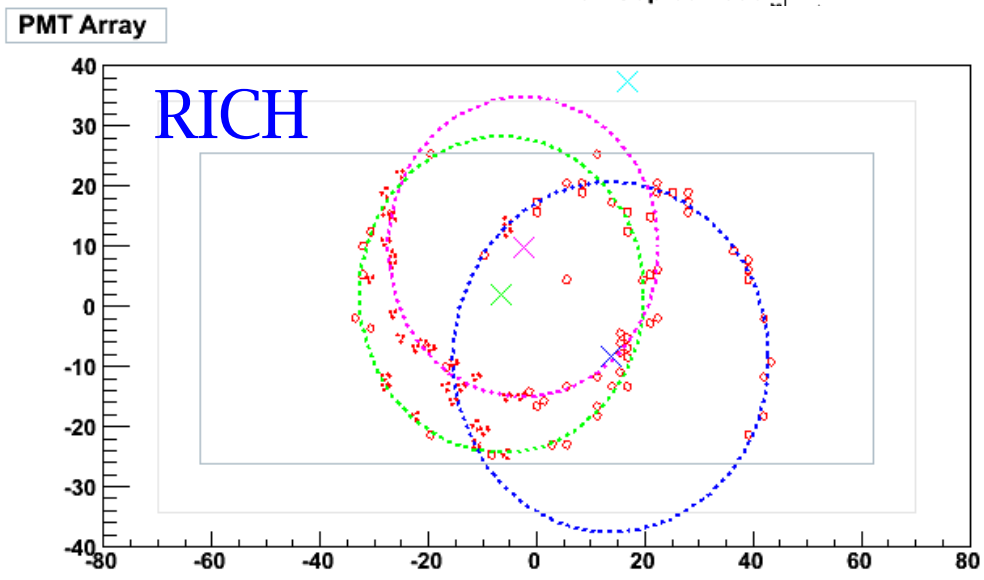
MIPP Physics

- Hadronic production cross section measurements
  - Improve hadron shower models in Fluka, Geant4, MARS
- Non-perturbative QCD
  - Particle fragmentation scaling laws can be probed in 36 reactions
- Service measurements
  - Proton radiography, stockpile stewardship
  - Particle flux from NuMI target
    - Reduce uncertainty of MINOS neutrino flux prediction

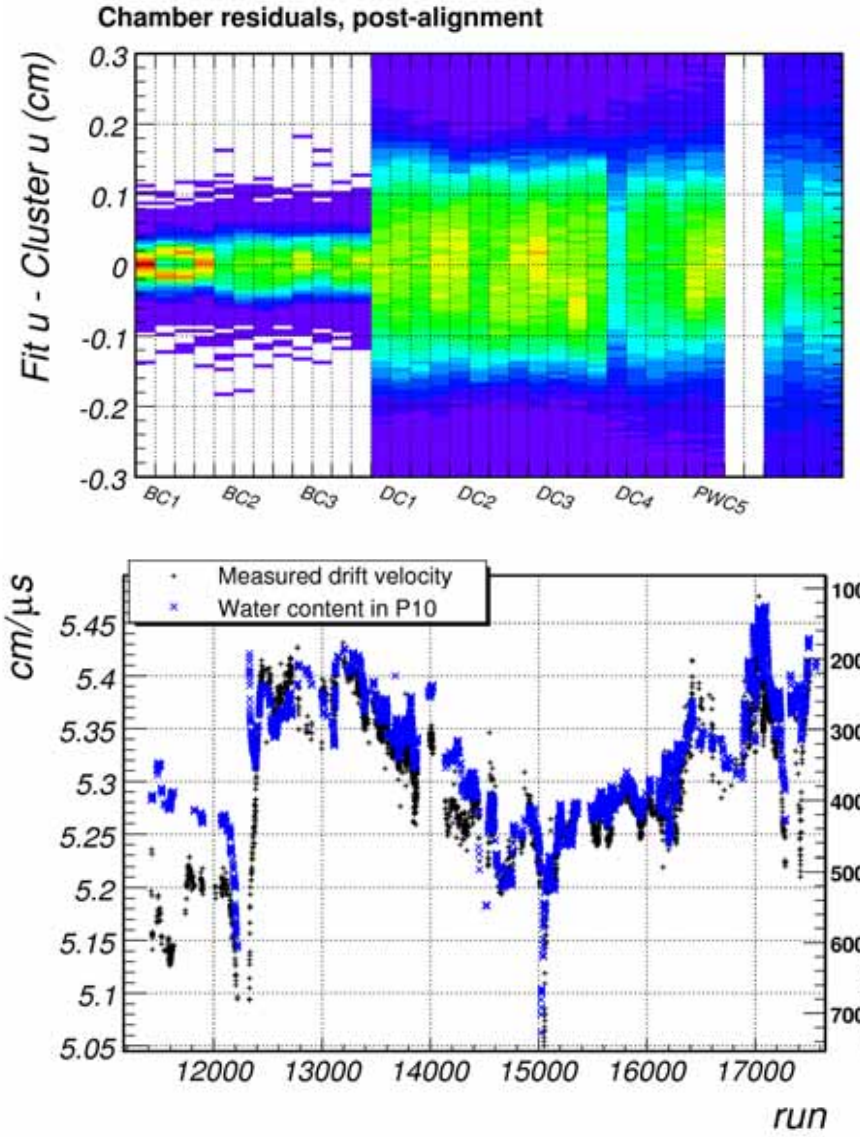
Reconstructed Proton-Carbon at 120 GeV/c Event





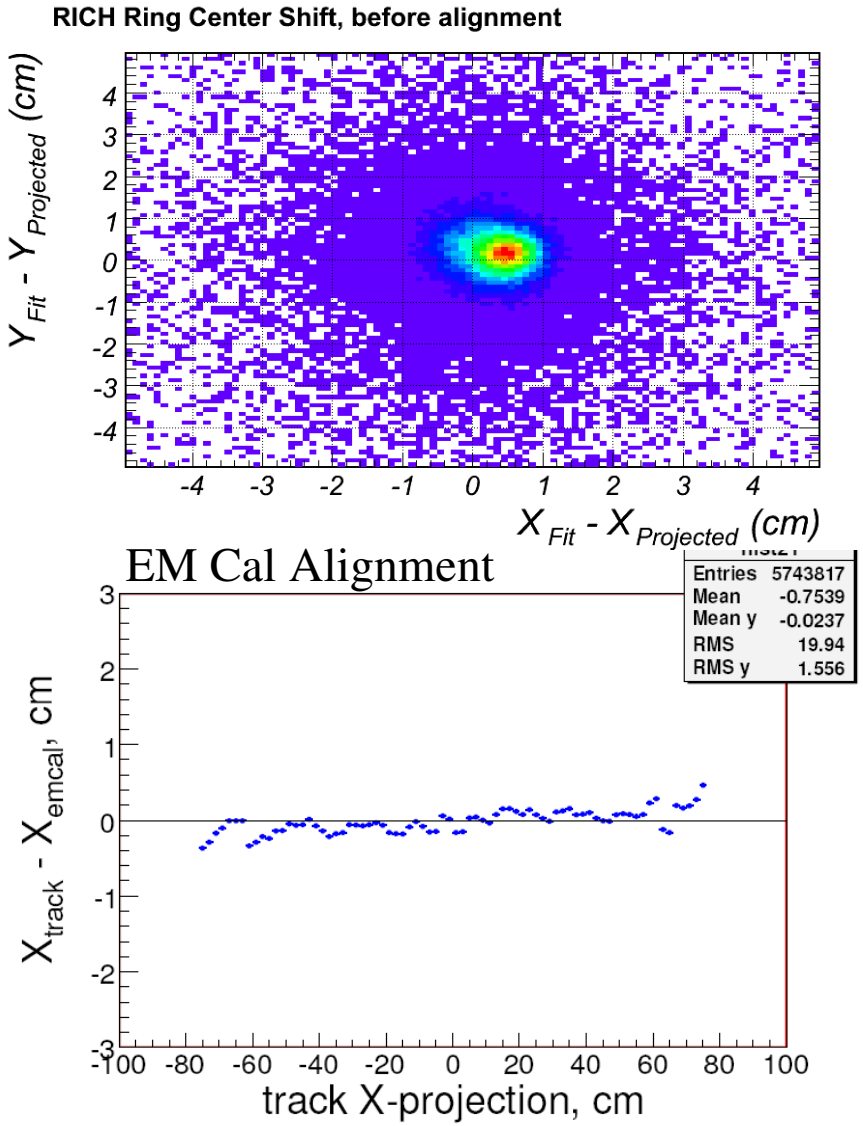
Spectrometer Calibration

- Chamber alignment done for every run
  - Helped to find bugs in geometry description and refine magnetic field maps
- TPC electron drift velocity measured for every run
  - Strong correlation with water vapor contamination



Calibration (cont.)

- Global tracking is used to
  - Align the RICH
  - Align EM calorimeter
  - Compute drift attenuation in the TPC
  - Compute ToF cable delays
  - Calibrate Ckov light output
  - Calibrate RICH index of refraction
- Calibration to be completed within 2 weeks



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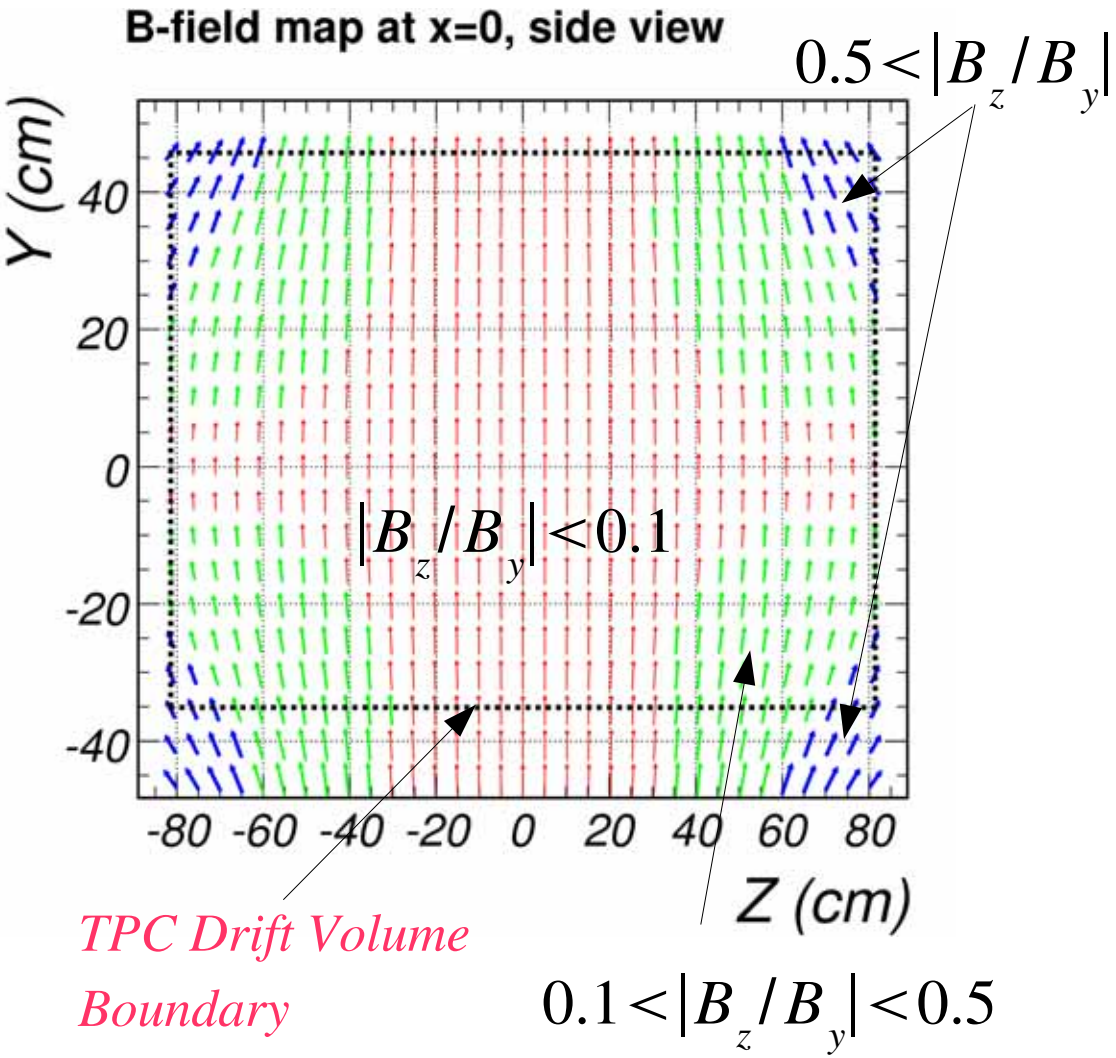
Event Reconstruction Summary

- Track reconstruction
  - Form hits in TPC, find tracks and fit to helices
  - Match TPC tracks to chamber hits, fit using track template method
- Vertex reconstruction
  - Find vertices using Deterministic Annealing Filter (DAF)
  - Make vertex constrained fits using track templates
- Particle identification
  - Compute TPC dE/dX, track ToF, Cherenkov likelihood
  - Match tracks to RICH rings and compute likelihoods
  - Match tracks to calorimeter showers

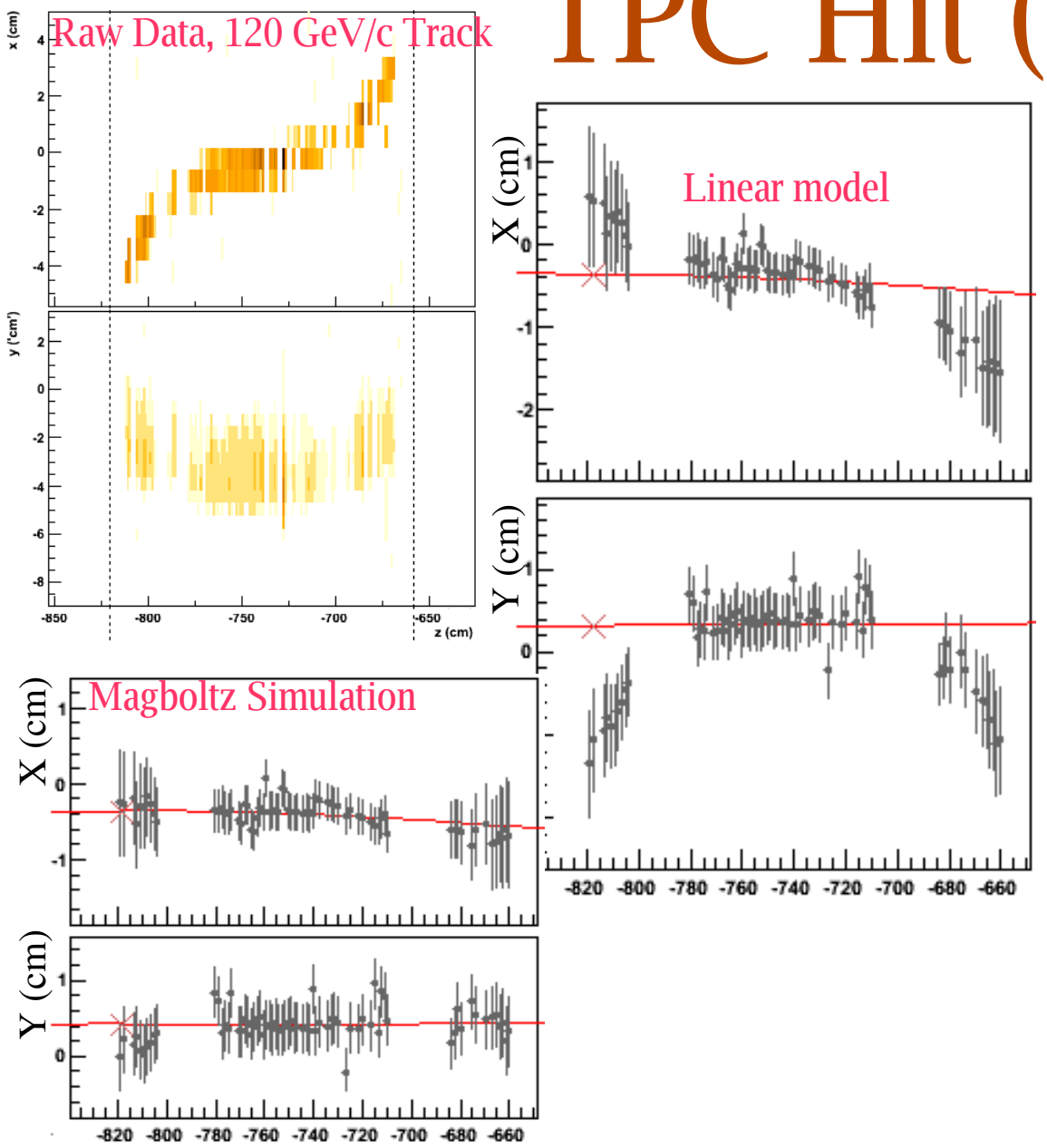
TPC Hit Reconstruction

- JGG field is non-uniform
  - Enormous effect on electron drift in Ar/CH_4
- Previous experiments applied corrections based on steady state solution to linear model

$$m\frac{d\vec{v}}{dt} = e\vec{E} + e\vec{v}\times\vec{B} - \frac{1}{\tau}\vec{v}$$



TPC Hit (cont.)

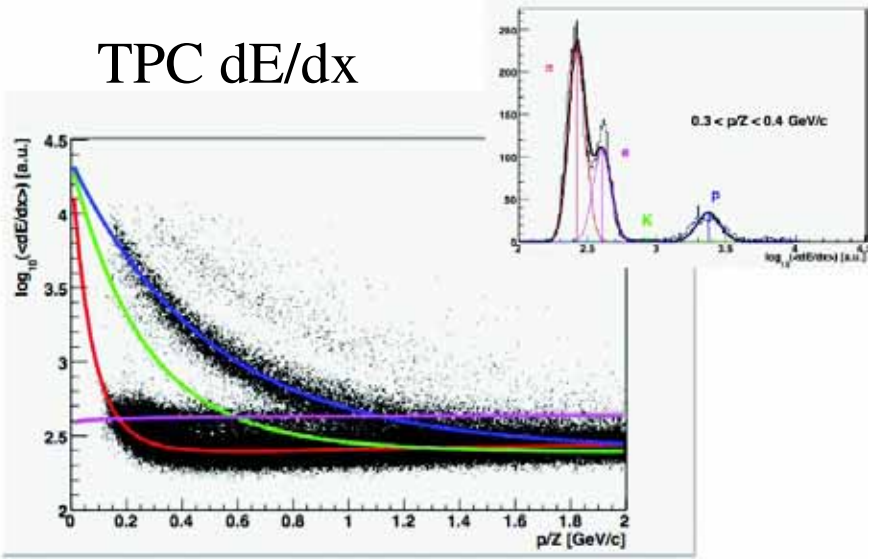


- Linear model fails to describe electron drift
- We use Magboltz simulation to map out drift velocity components as a function of v_0, B-field strength, and angle between E and B-fields
- Good agreement with TPC data

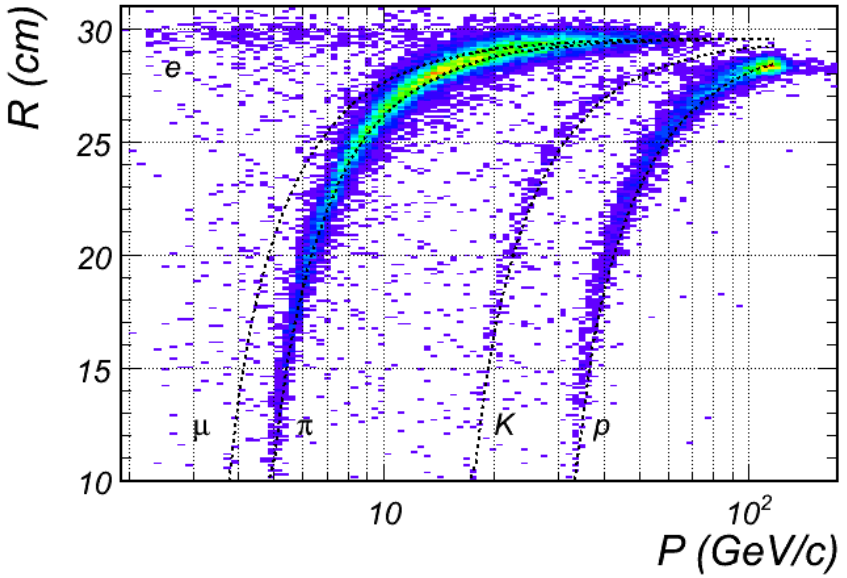
Particle ID status

- TPC dE/dx calibration is in progress,
  - Results to-date are promising
- TOF cable delays to be determined soon
- Cherenkov light calibration is largely done
- RICH calibration and likelihood calculation are nearly complete

TPC dE/dx



RICH ring radii, proton-Carbon at 120 GeV/c



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MIPP Analyses In Progress

- These projects are under way, expect results in 2-3 months
  - Target fragmentation multiplicities
  - HBT effect
  - Soft pion production cross sections
  - π/K production ratio on carbon at 120 GeV/c
  - π/K production ratio on NuMI target
  - K^+ mass (dedicated 17M beam π/K/p triggers)
- Many more projects available: new collaborators are welcome!

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Upgrade Proposal

- Current data rate limitation is ~30 Hz due to TPC electronics
- Upgrade electronics to get 3 kHz data rate
  - TPC with ALICE ALTRO chips – prototype boards in the works
  - New electronics for drift chambers and proportional chambers
- New silicon pixel interaction trigger
- Add recoil detector
- New JGG coils (better field uniformity) – to be delivered in May
- Improve beamline design to get 1-85 GeV/c secondary momenta
- Strong support from FNAL

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Upgrade Physics

- More statistics for existing data sets
- Other neutrino experiment targets
  - NOvA, T2K, ...
- Production cross sections on liquid N_2
  - Atmospheric neutrino and cosmic ray experiments
- Variety of nuclear targets to get uniform coverage in A
- Test beam for calorimeters
  - Minerva, ILC, ...
- Target and beam requests by new collaborators!

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Summary

- MIPP gathered 20M triggers of hadronic interactions
  - Unique data set that covers a range of physics topics
- Collaboration made a lot of progress in understanding our data and the spectrometer
  - Data summaries to be produced shortly
  - Expect first results from analyses in the summer
- Upgraded experiment can improve statistics and cover a broader range of physics topics

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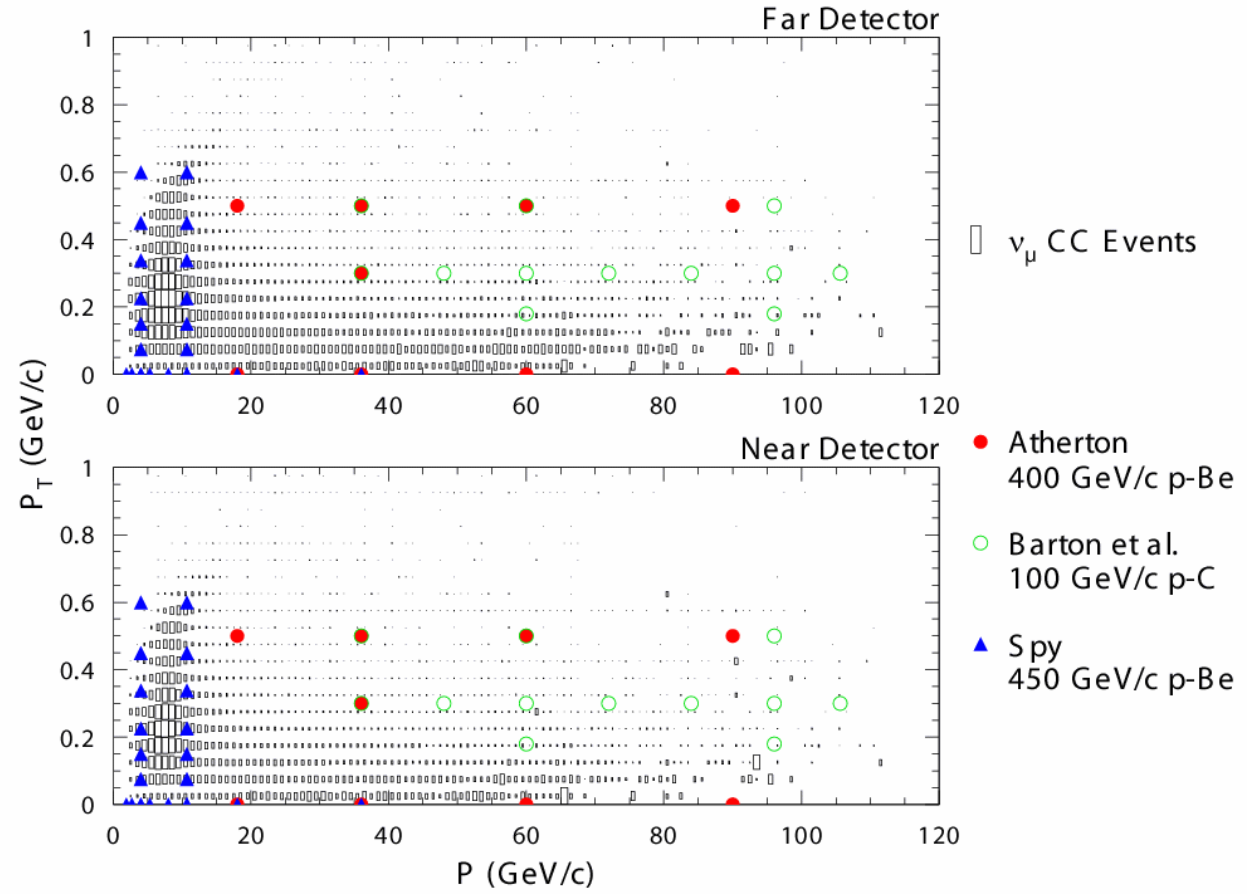
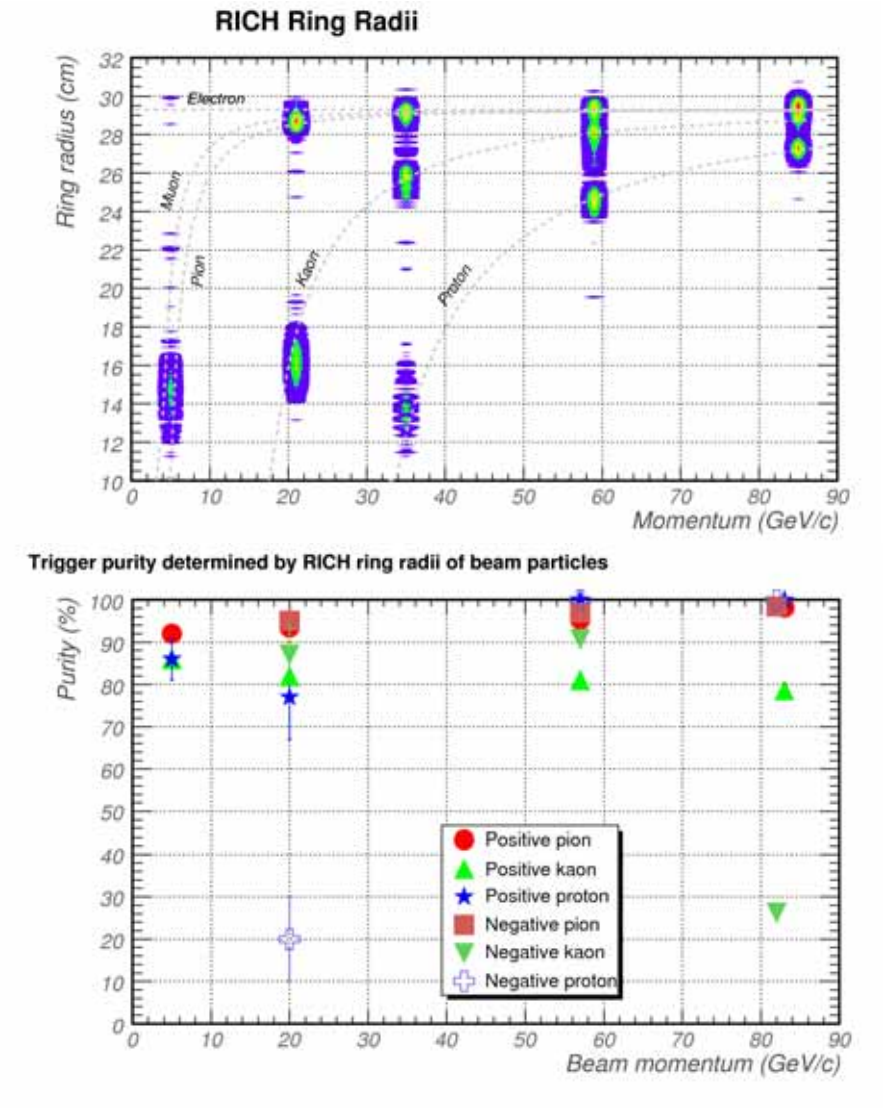
Backup Slides

Motivation for NuMI/MINOS



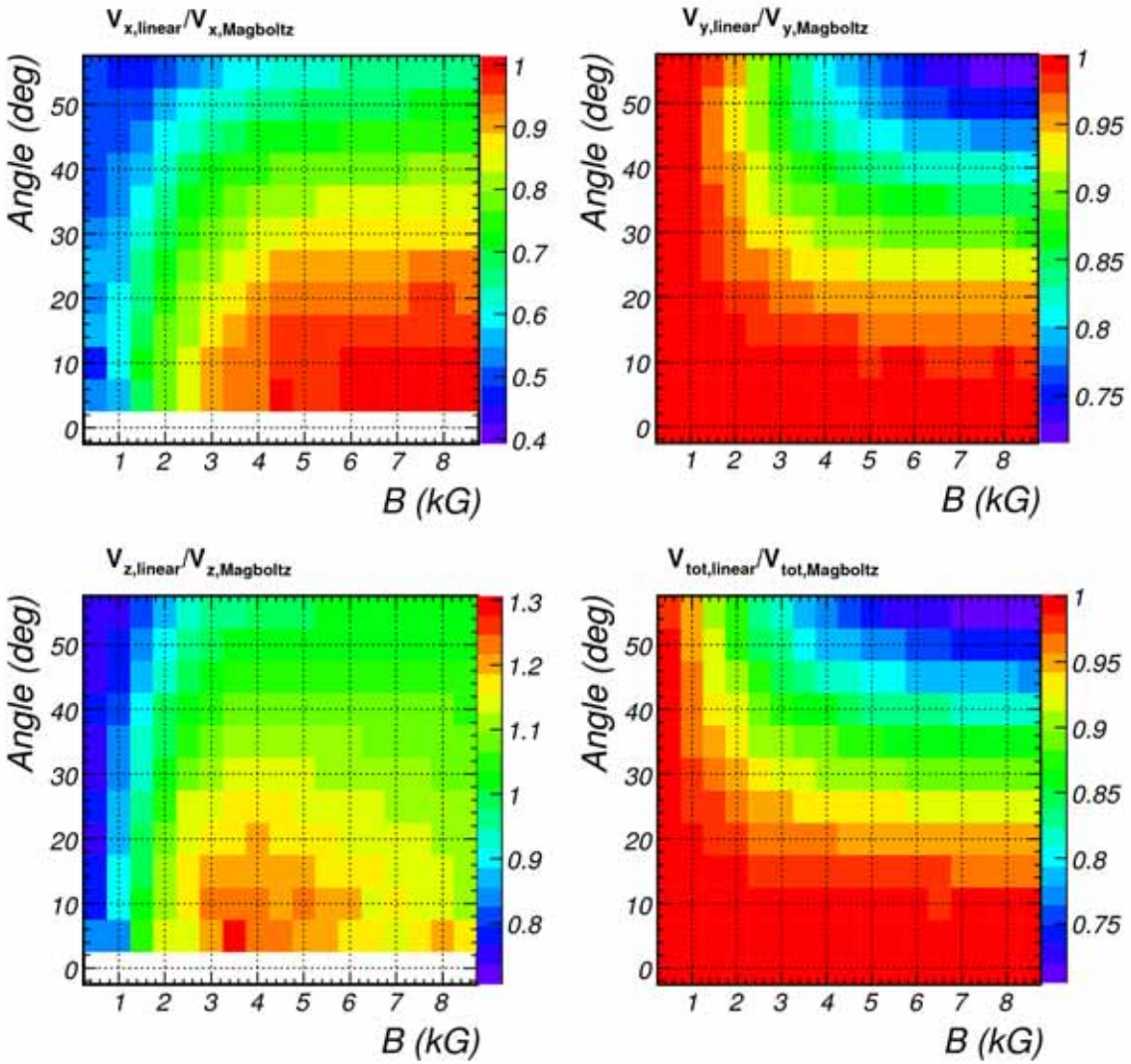
- Single-arm spectrometer data provides spotty coverage of pion production
- NA49 published pC at 158 GeV/c
  - hep-ex/0606028

Secondary Beam Particle ID



- 2 beam Cherenkov threshold counters separate π/K/p from 20 to 90 GeV/c
  - N_2 for momenta above 30 GeV/c
  - C_4F_8O for proton at 20 GeV/c
- Trigger purity measured with the RICH is typically above 80% for minority particle

Linear Drift Model vs Magboltz



- Magnetic field inside the TPC varies from 3.5 to 8 kG
- The angle between E and B fields goes up to 50 degrees
- Difference in drift velocity components reaches 30%
  - With 5 cm correction that's 1.5 cm!