Measurement of π/K Production Ratios on Carbon Target

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MINOS Beam Systematics Meeting

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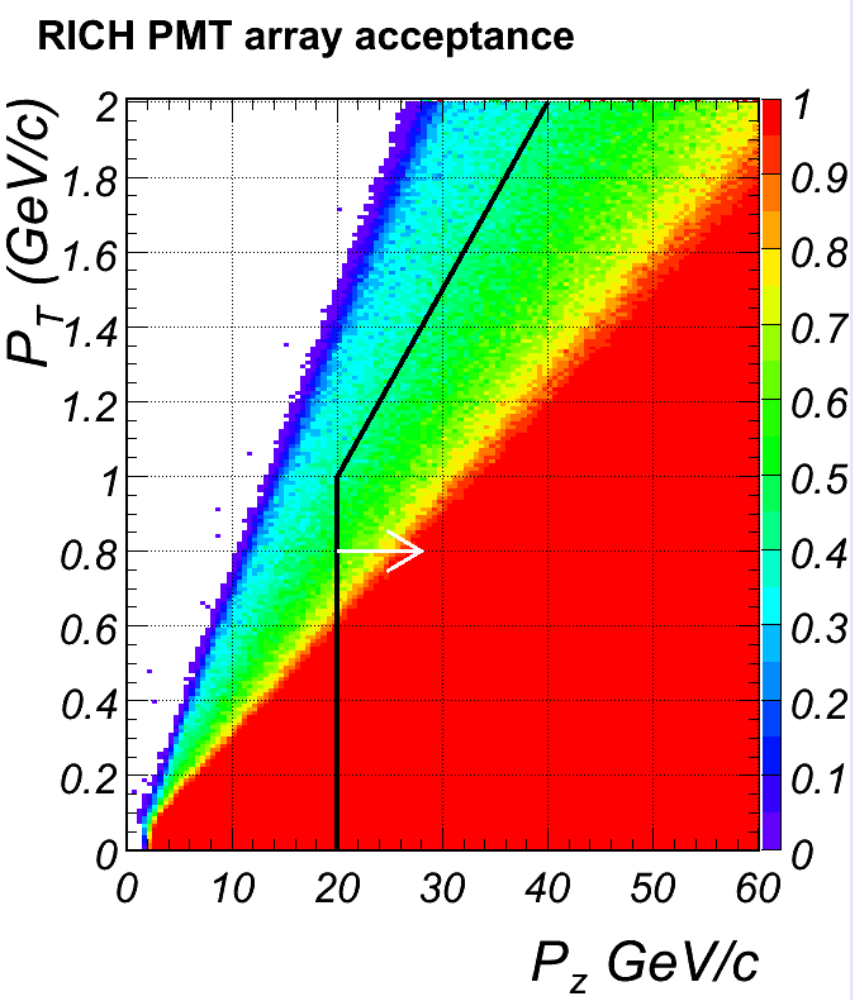
Overview

- I present measurement of pion and kaon production on 2% interaction length carbon target by 120 GeV/c protons in 24 bins in p_z and p_T
- Particle ID comes from the RICH
  - Minimum p_z 20 GeV/c as kaon threshold is at ~17 GeV/c
- Results are ratios of like charges and like species

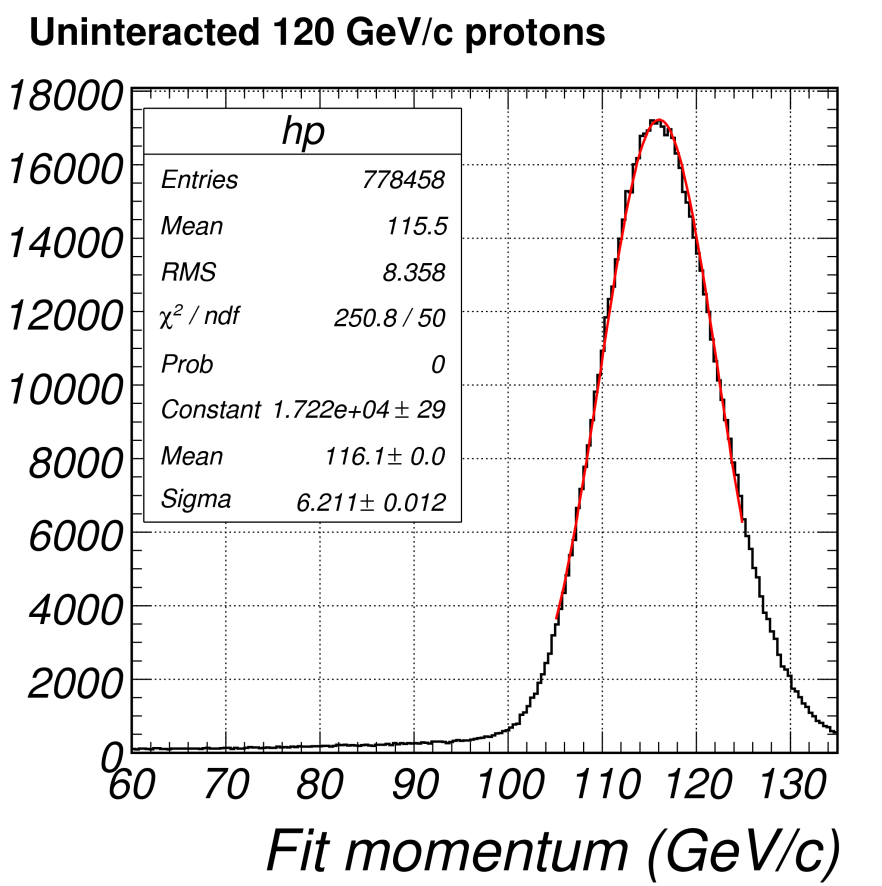
Geometric Acceptance



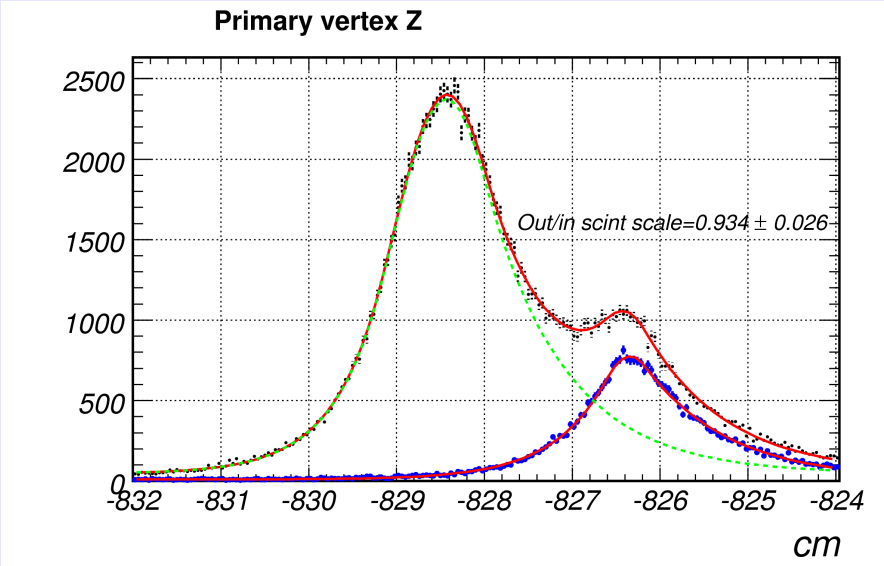
- Acceptance is not perfect
  - Better in x than in y
- Choose bins in (pz, pT) to avoid regions with <50% acceptance
- p_z bin boundaries (GeV/c)
  - 20, 24, 31, 42, 60, 90
- p_T bin boundaries (GeV/c)
  - 0.2, 0.4, 0.6, 1.0, $0.05p_{z,min}$

Momentum Measurement

- Track fits measure 119.7 GeV/c MI protons as 116.1 GeV/c
  - Source is chamber alignment
  - Not present in Monte Carlo
- Assume (conservative) 3% systematic momentum uncertainty and 5.3% momentum resolution everywhere
- Long tails come from scattering

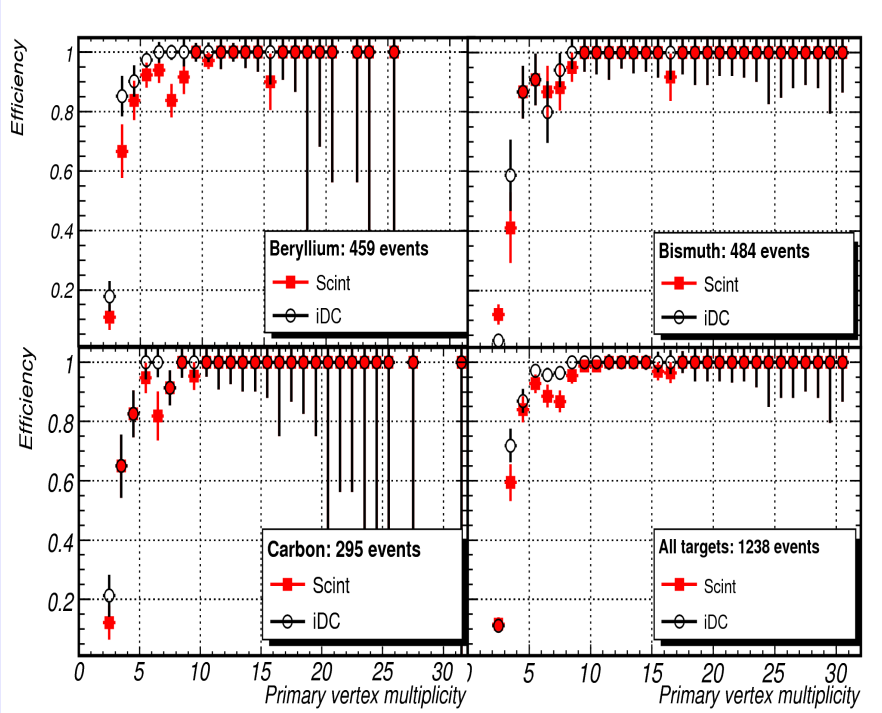


Primary Vertex



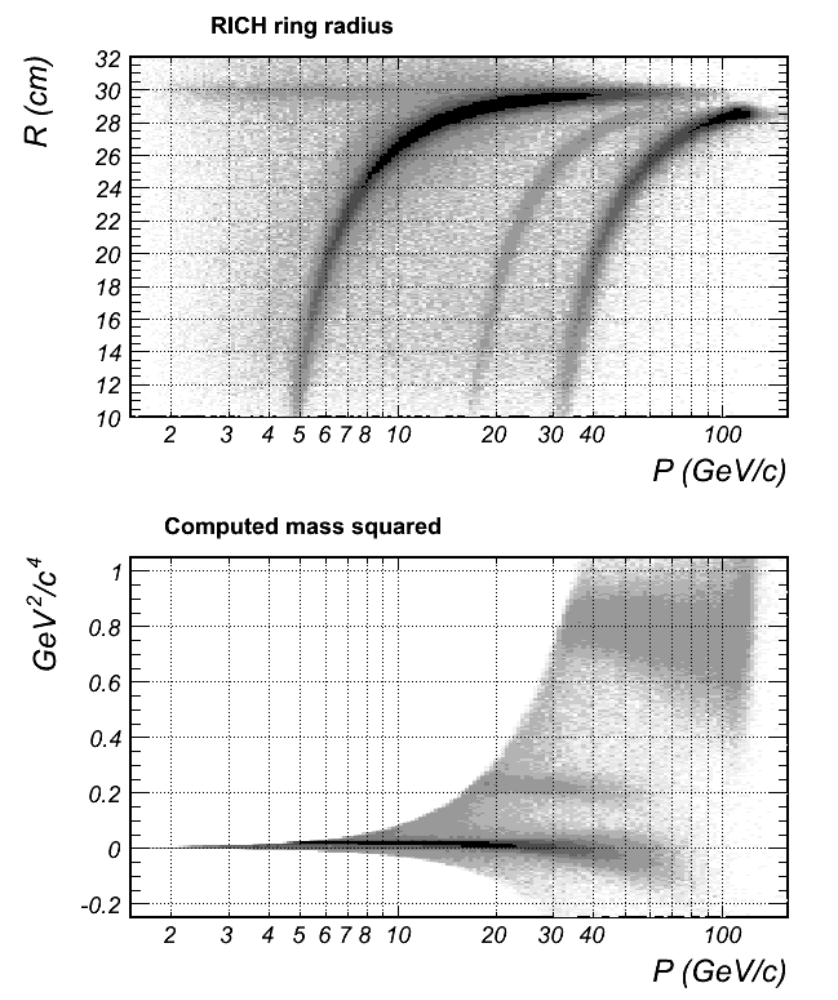
- We want prompt production of hadrons: cut on primary vertex consistent with target
- Vertex z resolution ~6 mm sigma with long tails
- Take -832 < z < -825 and do target out subtraction
- Fit z spectrum to Gaussian with exponential tails

Interaction Trigger



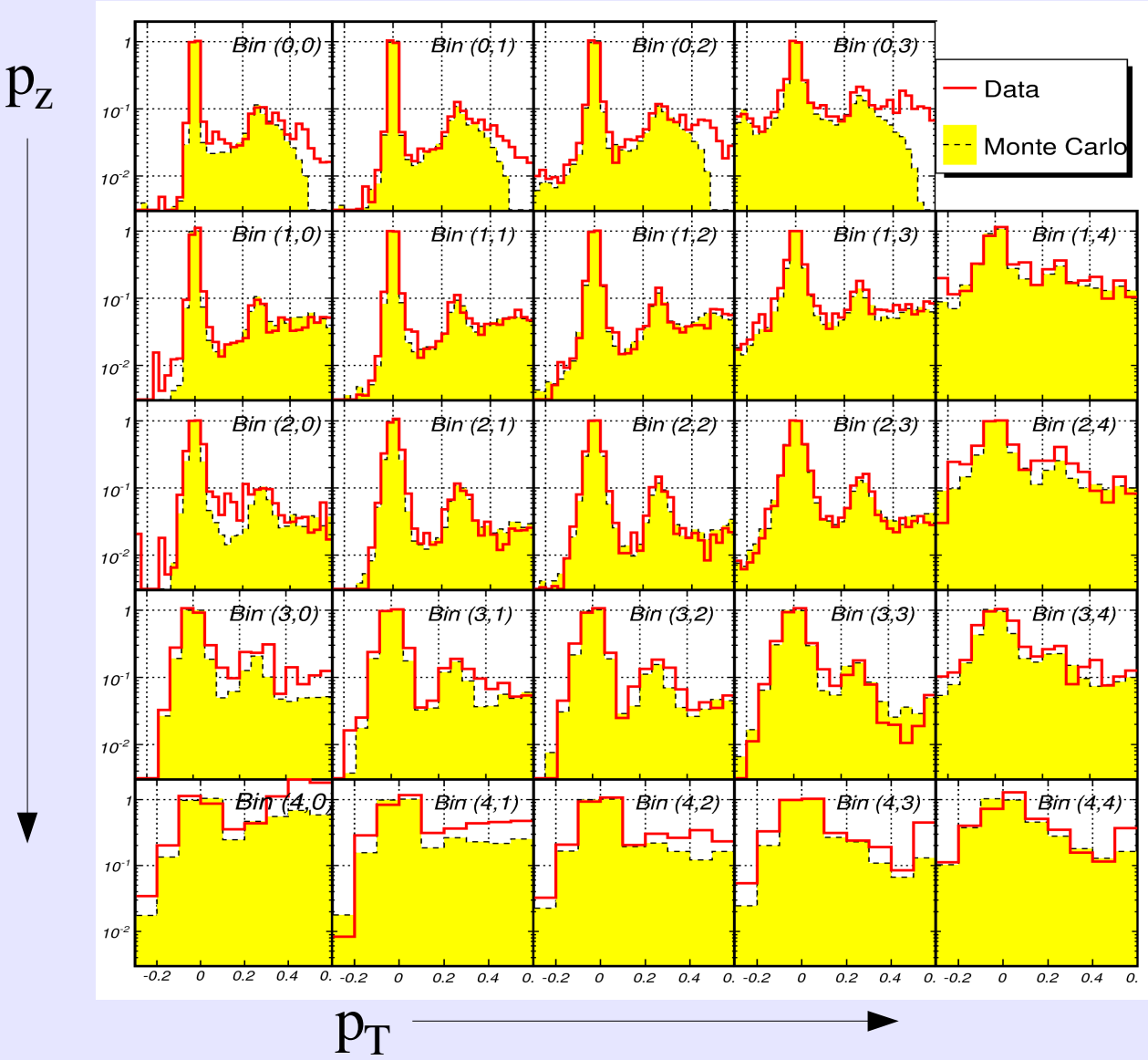
- Interaction trigger efficiency is low for 2-particle final states
- Efficiency measured from minimum bias triggers
- Not a significant source of error on the ratios

Extracting RICH PID



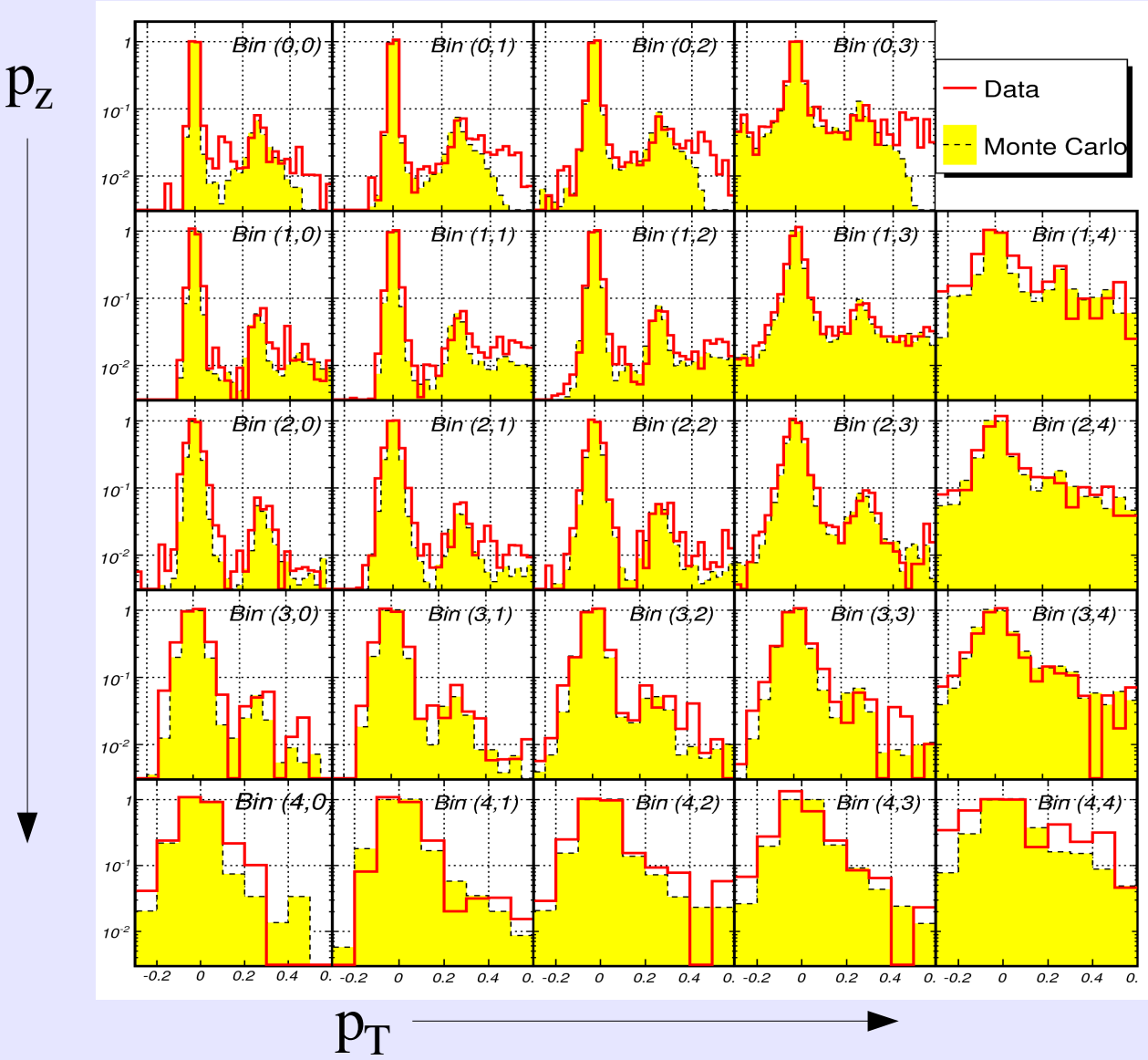
- RICH ring radius is fit for each track using predicted ring center and sharing hits among multiple rings
- Convert ring radius into m^2 using particle momentum
- m^2 converted to PID variable because m^2 varies with p_z, p_T
  - $0 \equiv \pi$, $1 \equiv p$, $K=0.265$

Data-MC comparison: positives



- PID variable distributions for data and MC are normalized to pion peak
- Agreement is generally good
- MC width is smaller than data

Data-MC comparison: negatives



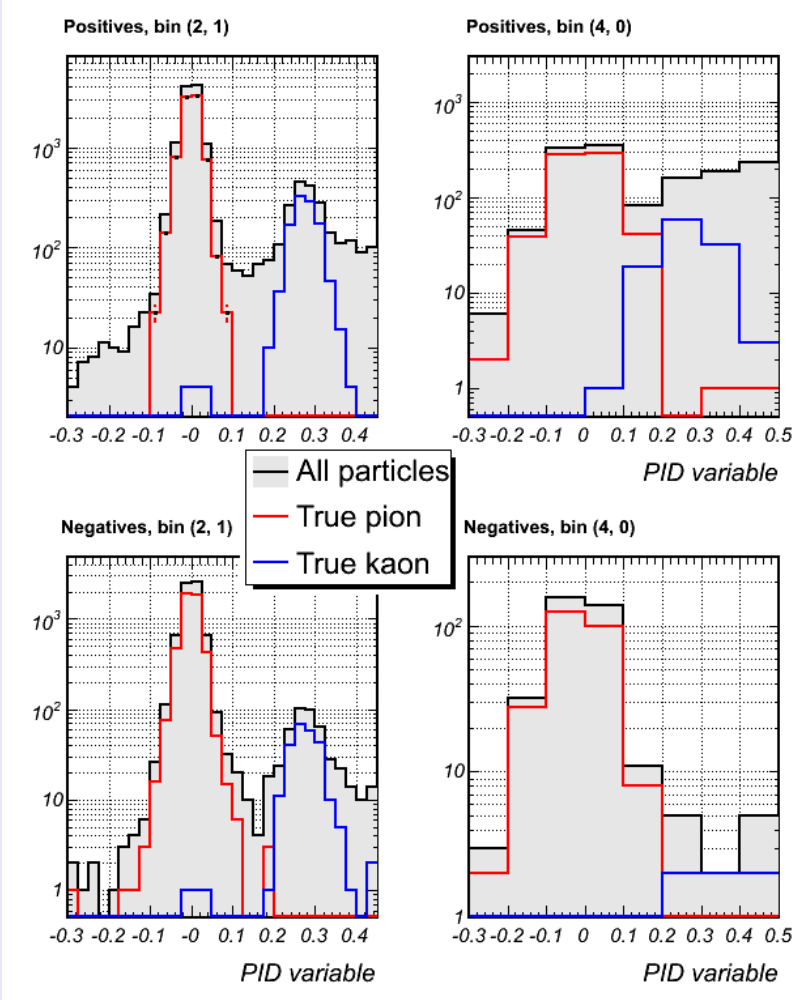
- Background in negatives is smaller because there are much fewer anti-protons than protons

Background Modeling

- Monte Carlo consists of
  - FLUKA-06 for pC interactions
  - GEANT-3.21 for particle transport
- Important effects
  - Interactions in the spectrometer
    - ~10% interact before the RICH, ~10% more if particle does not go through the RICH window
  - Decay in flight (~10% kaons at 20 GeV/c)
  - Multiple scattering

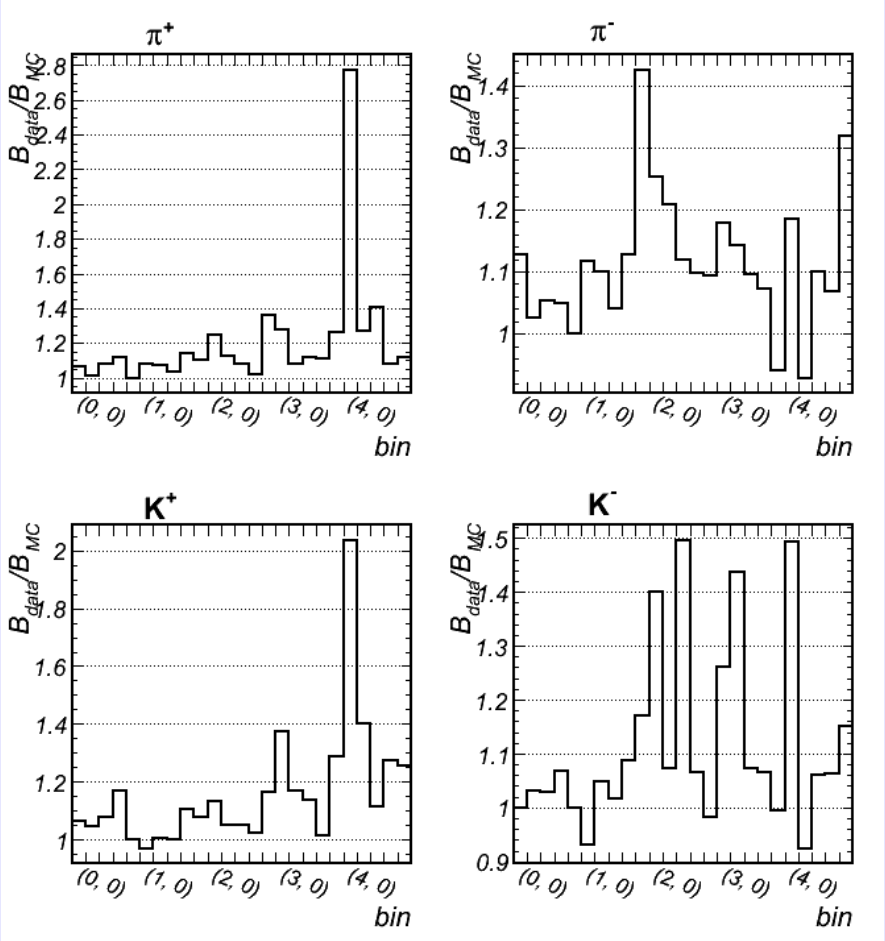
Background (cont.)

- Define occupancy as the fraction of true pion/kaon with fit momentum within 4σ of true momentum
- At lower momenta, the peaks are well separated
- At higher momenta we are dependent on FLUKA/GEANT



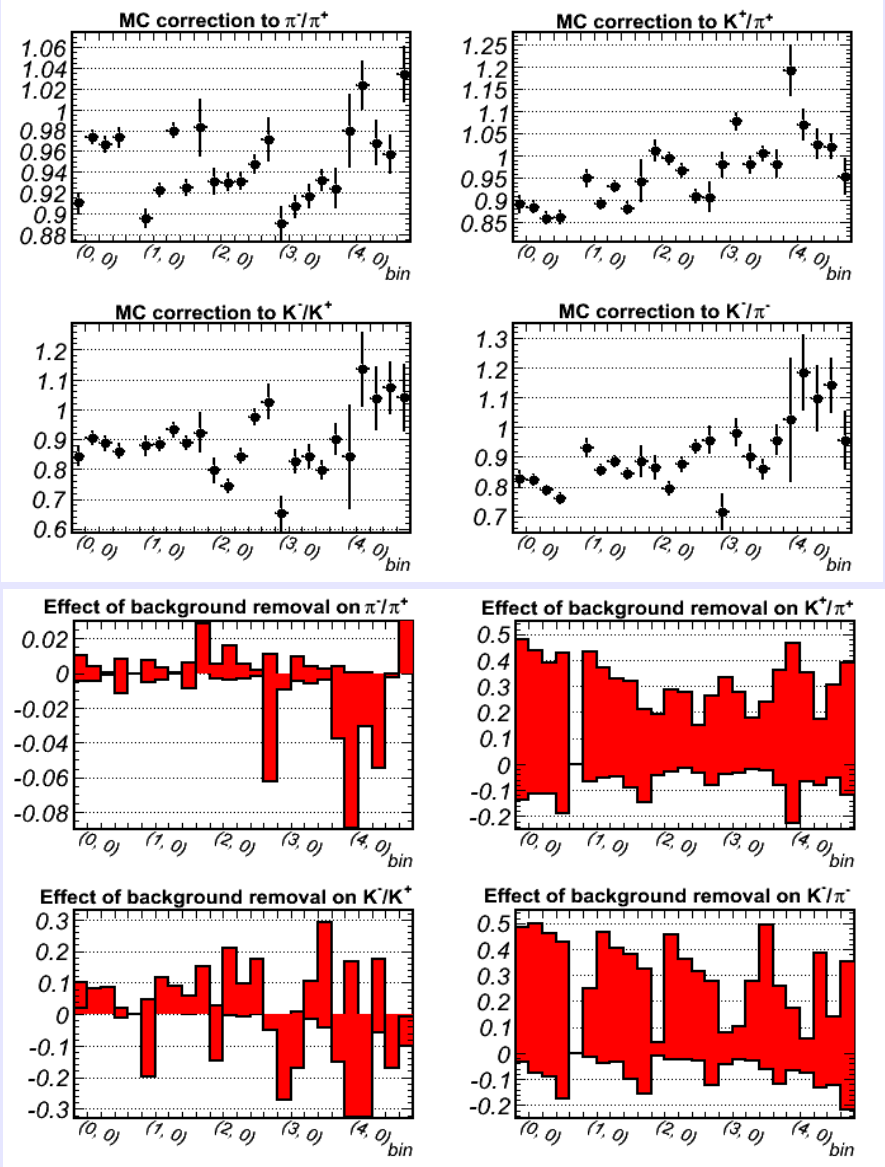
Data vs MC Background

- To get a feel for how close MC/data is, we compute background in bins with non-zero occupancy
- Increase and decrease background by the data/MC ratio or at least 1.1 (average over all bins)



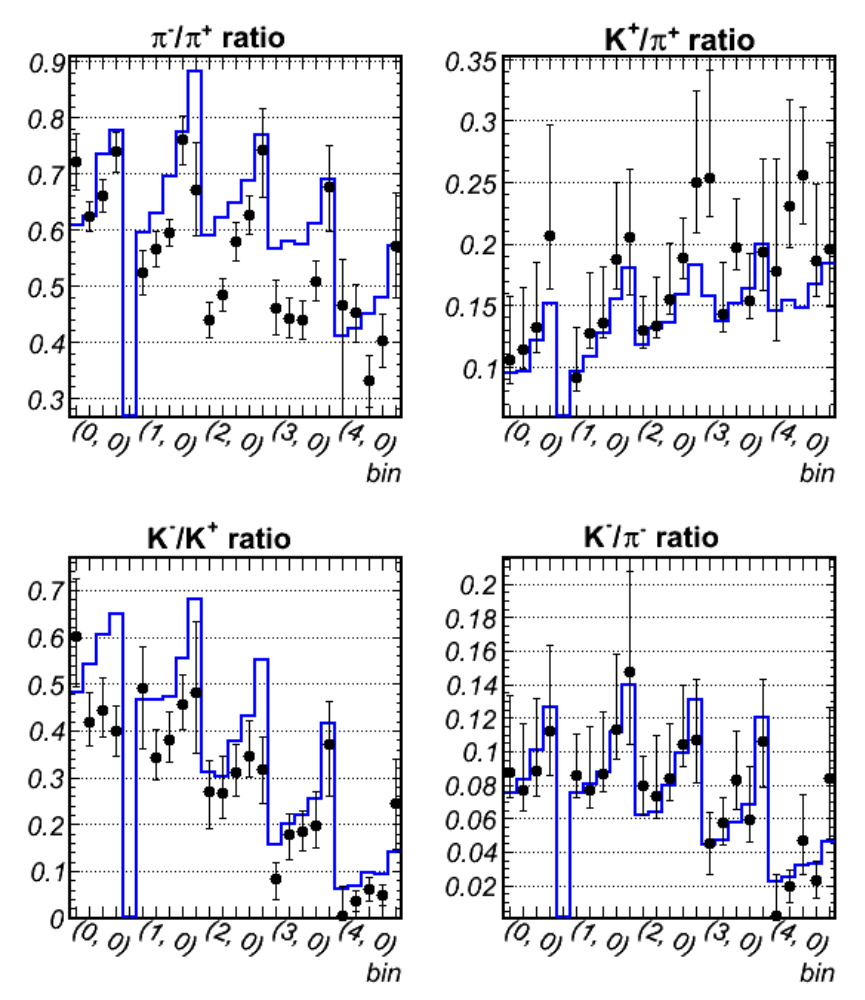
MC & Background Error

- The error from MC is 50% of the correction from reconstructed MC-true MC comparison
- The errors on background modeling are obtained from data
- Errors are asymmetric as it's easy to pick up extra kaons

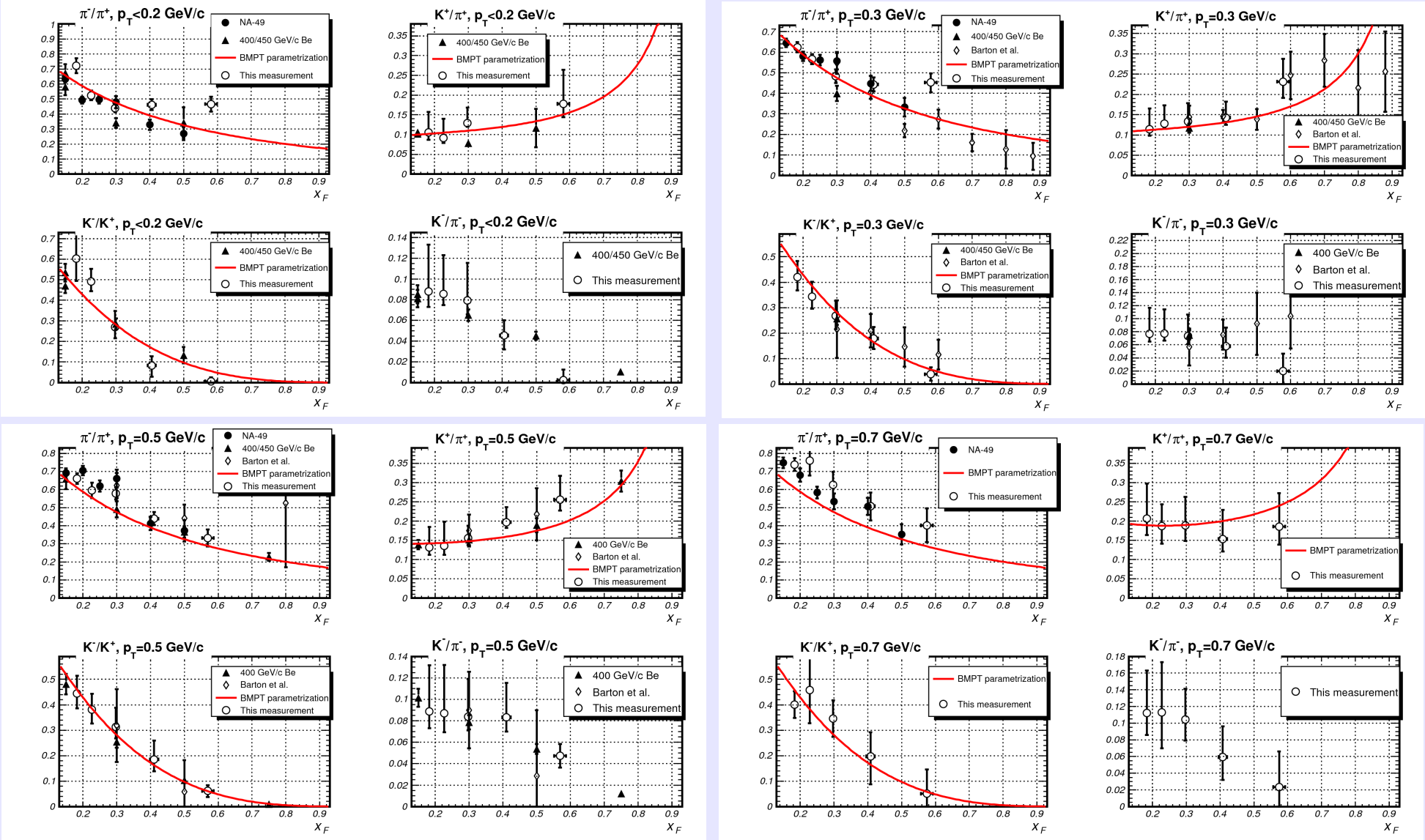


Measurement vs FLUKA

- I consistently put majority particle into denominator so all ratios are <1
- Ok agreement with FLUKA on like charges
- Not so good on like species

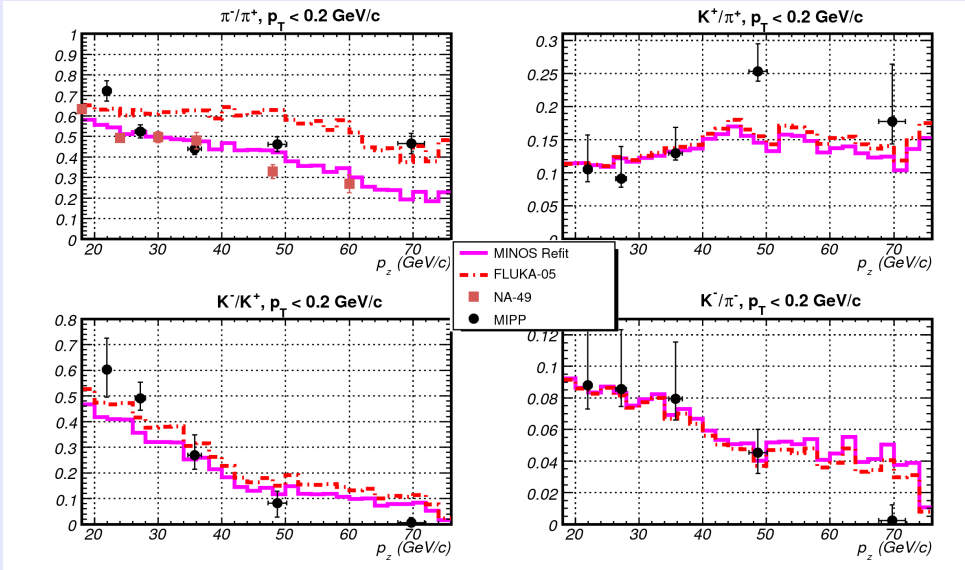


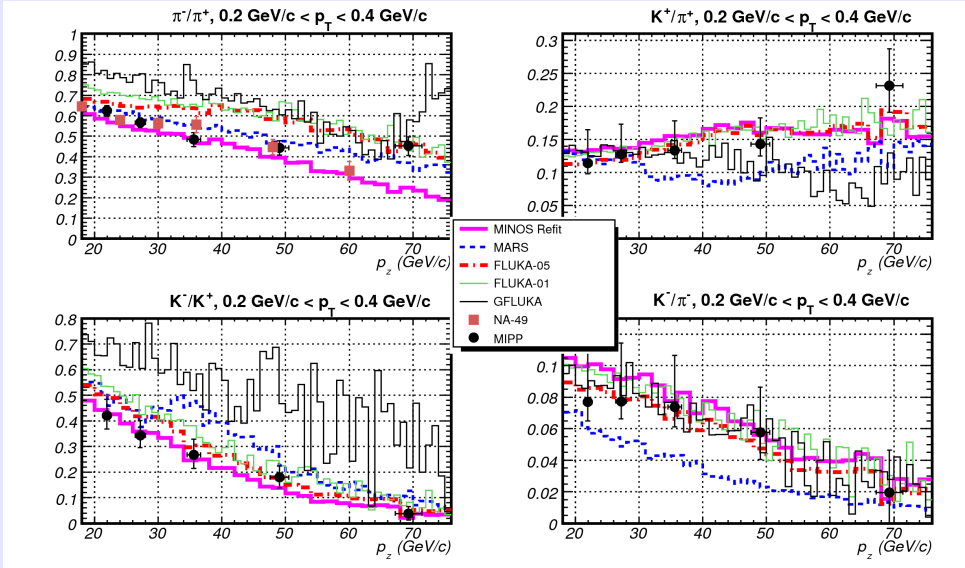
Comparison to existing data



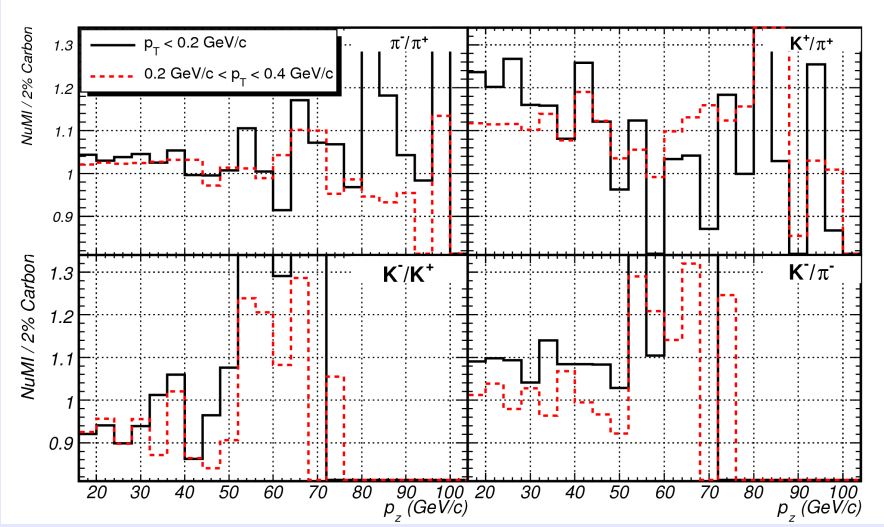
Comparing to MINOS Fits

- Zarko kindly provided ratios from fits and FLUKA-05 for $p_T<0.2$ GeV/c and $0.2<p_T<0.4$ GeV/c





NuMI – FLUKA05
2% - FLUKA06



Summary

- The first measurement using MIPP data!
- Most errors (especially π/π) are dominated by statistics
- Better tuned modeling of the RICH and better understanding of backgrounds will reduce the systematic error on kaon well below statistical errors