Measurement of the p_{T} Spectra of Identified Hadrons in Pb-Pb Collisions at $\sqrt{s} = 2.76$ TeV in the ALICE Detector

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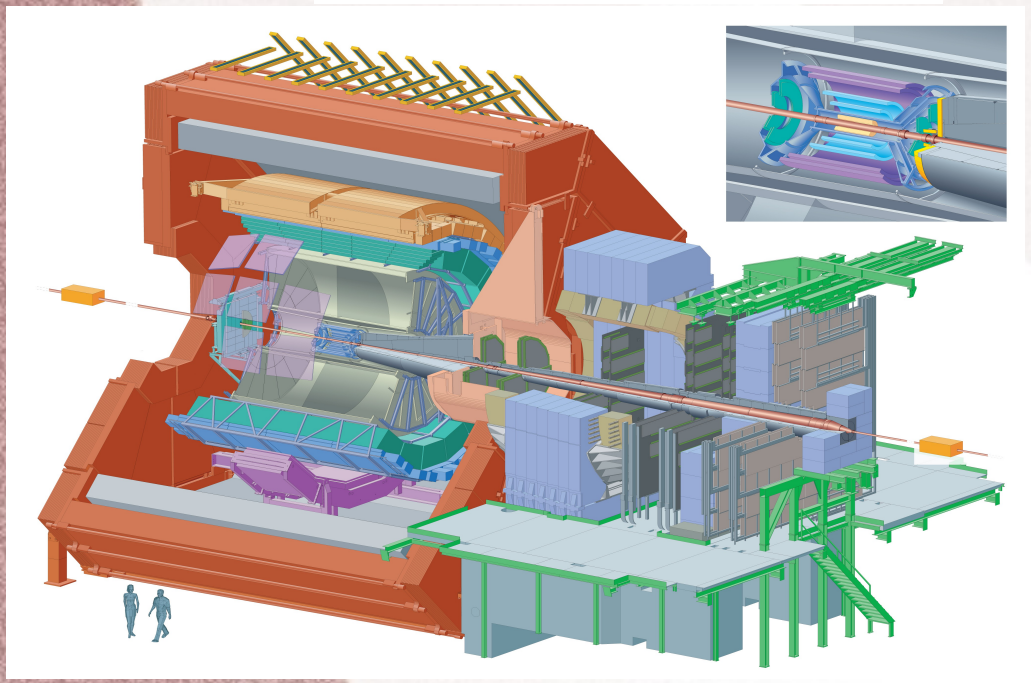
Motivation

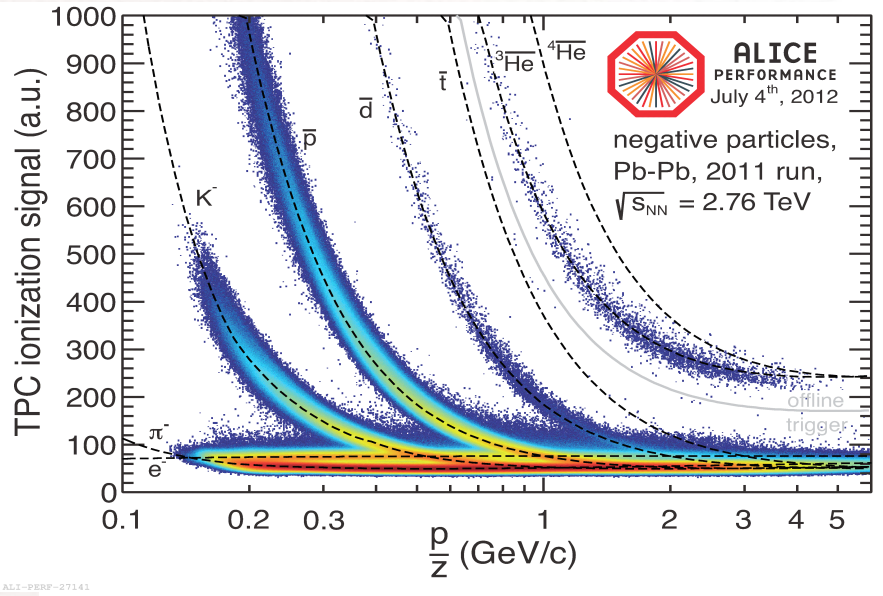
- Main goal of ALICE: study properties of the QGP
  - QGP → state of matter where quarks no longer confined to hadrons
  - QGP created in Pb-Pb collisions in LHC
    - quarks and gluons thermalized, expand rapidly
    - recombine into hadrons before reaching detector
    - Vast majority are pions (~80%), kaons (~15%), and protons (~5%)
- Measuring inclusive spectra gives information on hydrodynamic properties of the expanding QGP
  - Expansion velocity, etc
  - Parameters can be extracted from fits to theoretical models

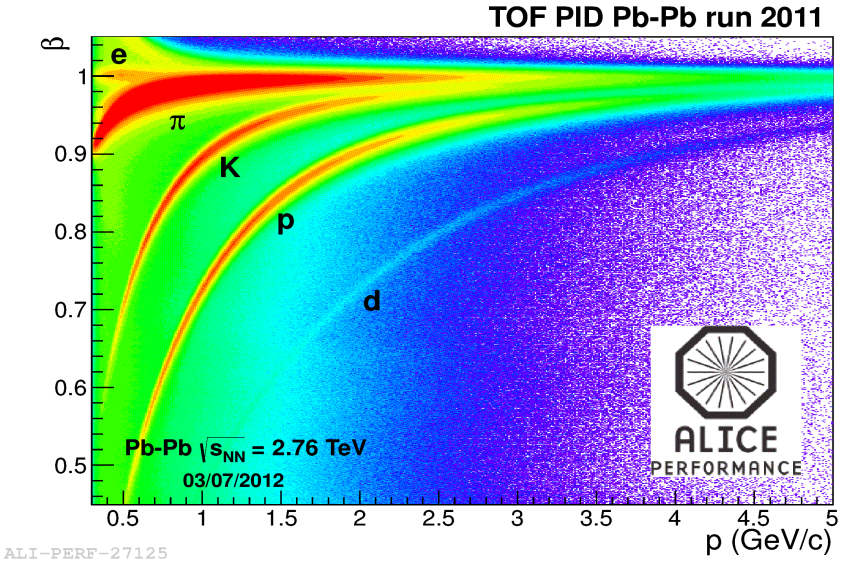
Particle Identification Strategy

- TPC (Timing Projection Chamber)
  - Gas detector
  - 6.5% dE/dx resolution (central Pb-Pb)
- TOF (Time Of Flight)
  - Multi-gap resistive plate chambers
  - Resolution of 85 ps
  - Hits matched to tracks in TPC
- Particle Identification done with combined TPC and TOF signal:

$$\sigma_{TPC+TOF} = \frac{\sqrt{\sigma_{TPC}^2 + \sigma_{TOF}^2}}{\sqrt{2}}$$







Previous Work

- 2 data formats in ALICE:
  - ESD (Event Summary Data)
    - Contain full details of reconstruction
    - Appropriate for analysis where statistics is not an issue
  - AOD (Analysis Oriented Data)
    - Contain only high-level information
- p_T spectra already measured using ESDs
- Re-measuring using AODs
  - Streamline the analysis for large samples
  - Allows for more differential analyses (i.e. of different event classes)

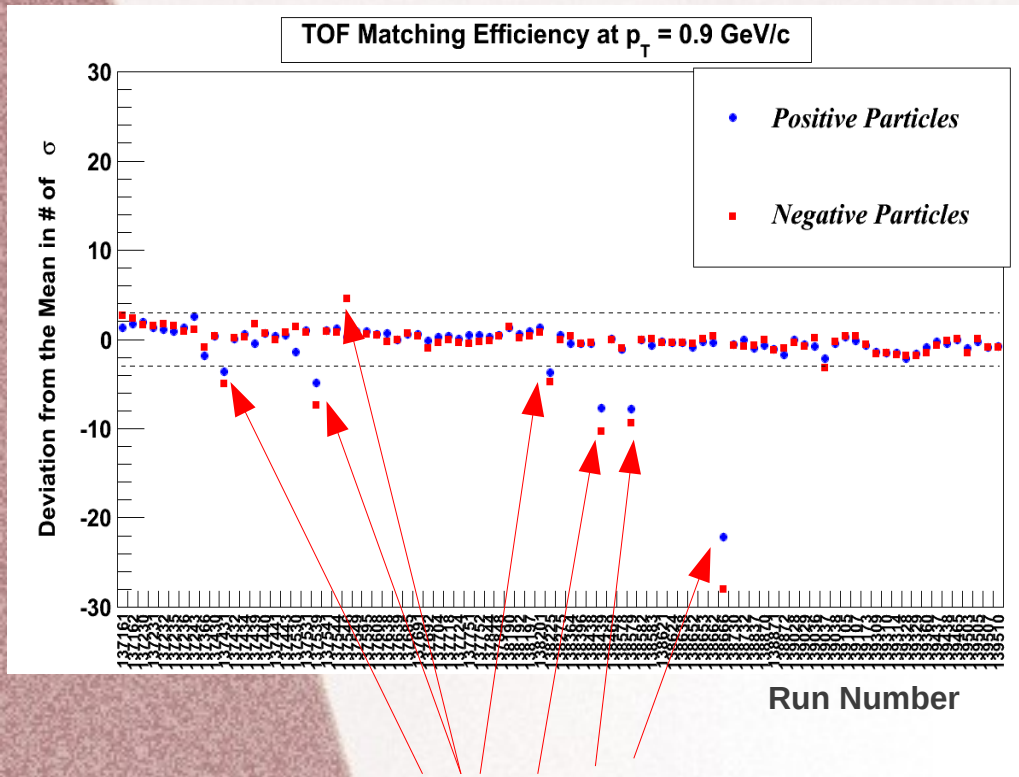
Quality Assurance on LHC10h AODs

- A high-level QA on AODs is necessary
  - Not previously done for 2010 Pb-Pb data
- Method:
  - Choose several quantities that should be stable as a function of the run number
    - TOF Matching Efficiency
    - Monte Carlo Correction Factor
    - Raw Yield
    - Positions and widths of normalized signal distributions from the TPC and TOF
  - Outliers > 3σ from the mean value require further investigation

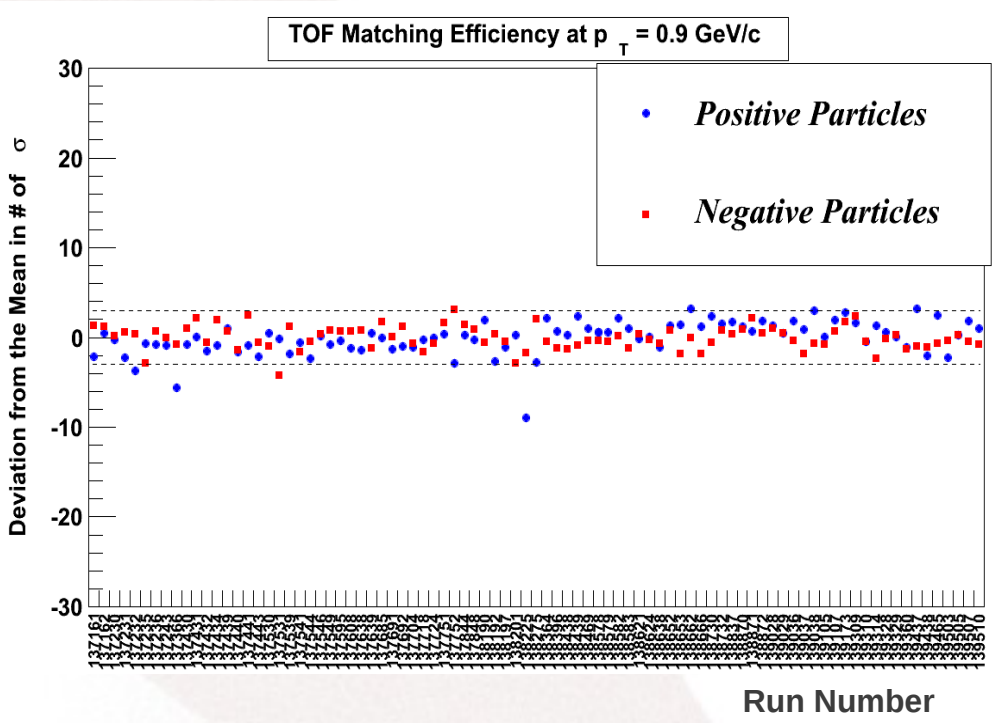
Example Check – TOF Matching Efficiency

TOF Matching Efficiency = % of tracks in TPC matched to tracks in TOF

Data



Monte Carlo



Several large outliers that are not reproduced in the Monte Carlo. Reported to TOF experts. Excluded from analysis.

Measuring the p_T Spectra

Correction for known problem with Geant transport code for antiprotons and kaons

$$Spectra = \frac{Raw\ Spectra \times \Lambda_{GF}}{\epsilon_{MC} \times \epsilon_{PID} \times \epsilon_{TOF} \times \alpha_{cont} \times \beta_{sec}}$$

Tracking Efficiency:
% of generated particles with tracks

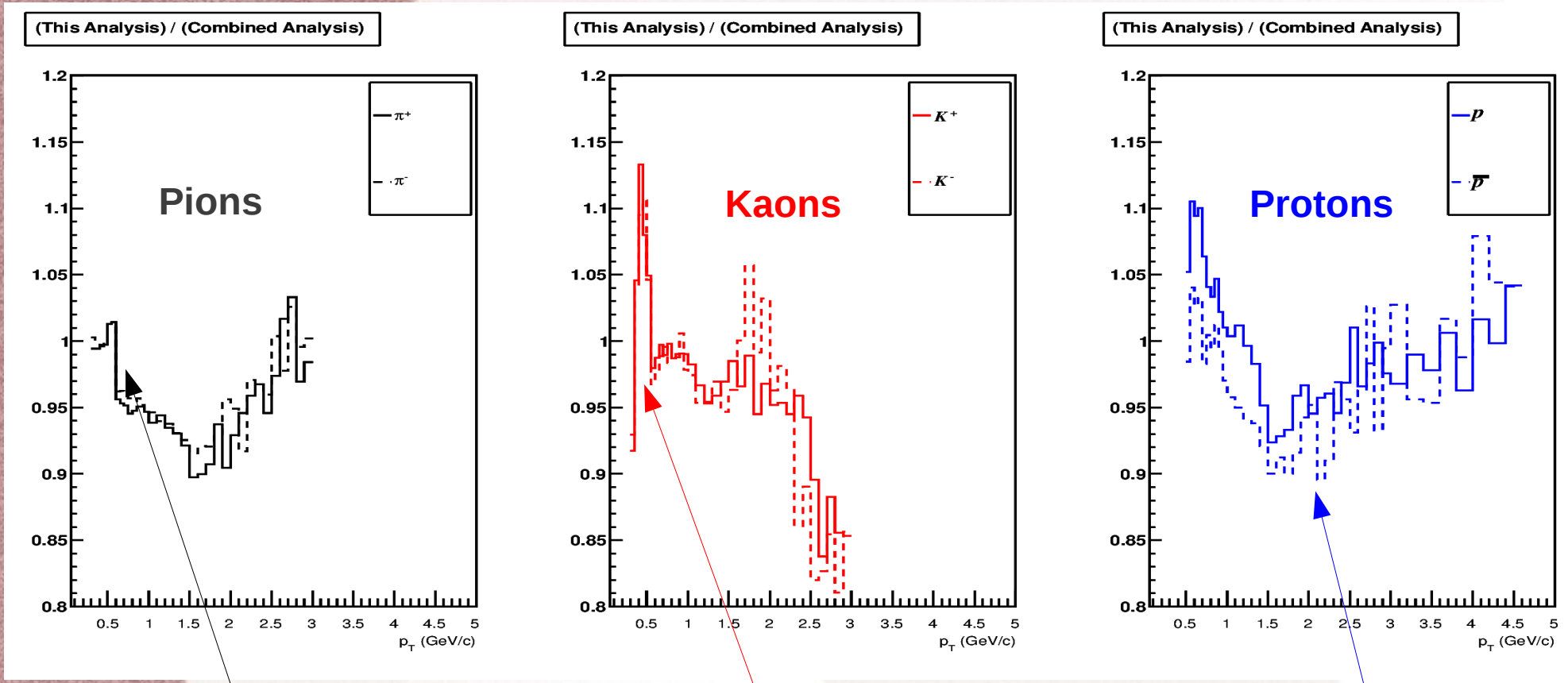
PID Efficiency:
accepted by PID
(see slide 8)

TOF matching efficiency:
% of tracks in TPC matched to tracks in TOF

PID Accuracy:
% correctly identified with PID

Correction for secondaries:
% of reconstructed particles that are primaries

Comparison with Previous Results



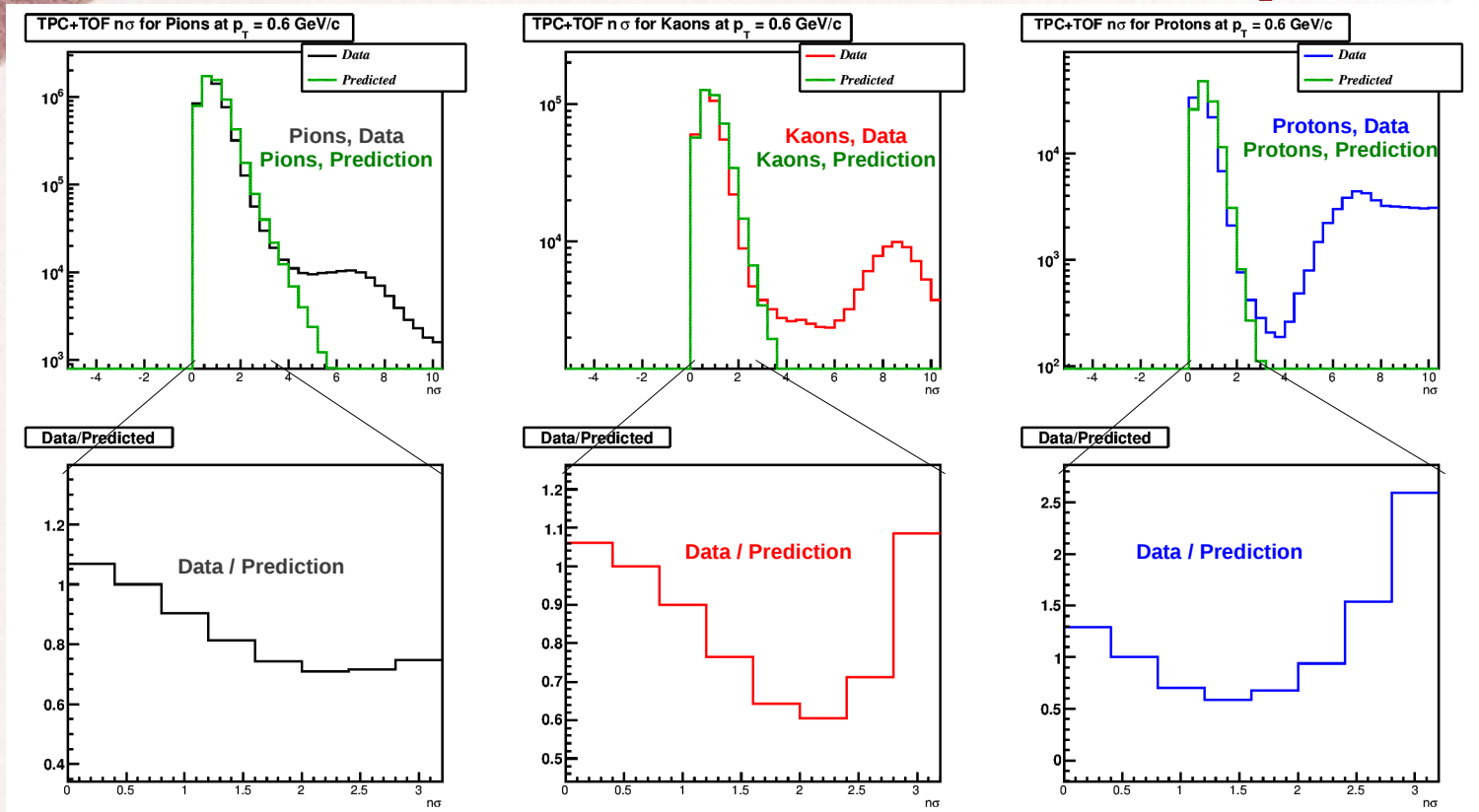
Discontinuity at pT = 0.6 GeV/c – lower boundary of TOF acceptance. TOF matching efficiency? PID efficiency?

Known problem of contamination from electrons. Possible remedies might include using information from other detectors. This ratio should also improve after implementing a tighter PID cut.

Data-driven correction for secondary particles from weak decays and detector interaction still to be applied. Known issue.

The PID Correction and its Implications for the Pion Spectra

"Ideal" TPC+TOF Response: Comparison to Data



- PID efficiency correction:
  - randomly sample from TPC and TOF response functions (using parameters from data)
  - use to fill combined TPC+TOF "predicted" response function
- PID Efficiency (TPC+TOF) = (Integral from 0 to 3) / (Integral from 0 to infinity)
- Above: comparison to actual TPC+TOF response function (p_T = 0.6 GeV/c)
- Varying parameters in TPC and TOF response functions by ~20% → change of ~1% in final pion spectra
  - can't account for pion discontinuity at p_T = 0.6 GeV/c

Conclusions and Future Work

- Accomplished:
  - QA analysis pointed out several runs with unusual characteristics – to be excluded from analyses
  - Improved the efficiency calculation for the p_T spectra of identified hadrons
- Still to do:
  - Correct pion discontinuity at p_T = 0.6 GeV/c
  - Correct for electron contamination in kaon spectra
  - Implement a tighter PID cut on kaons

Thanks!

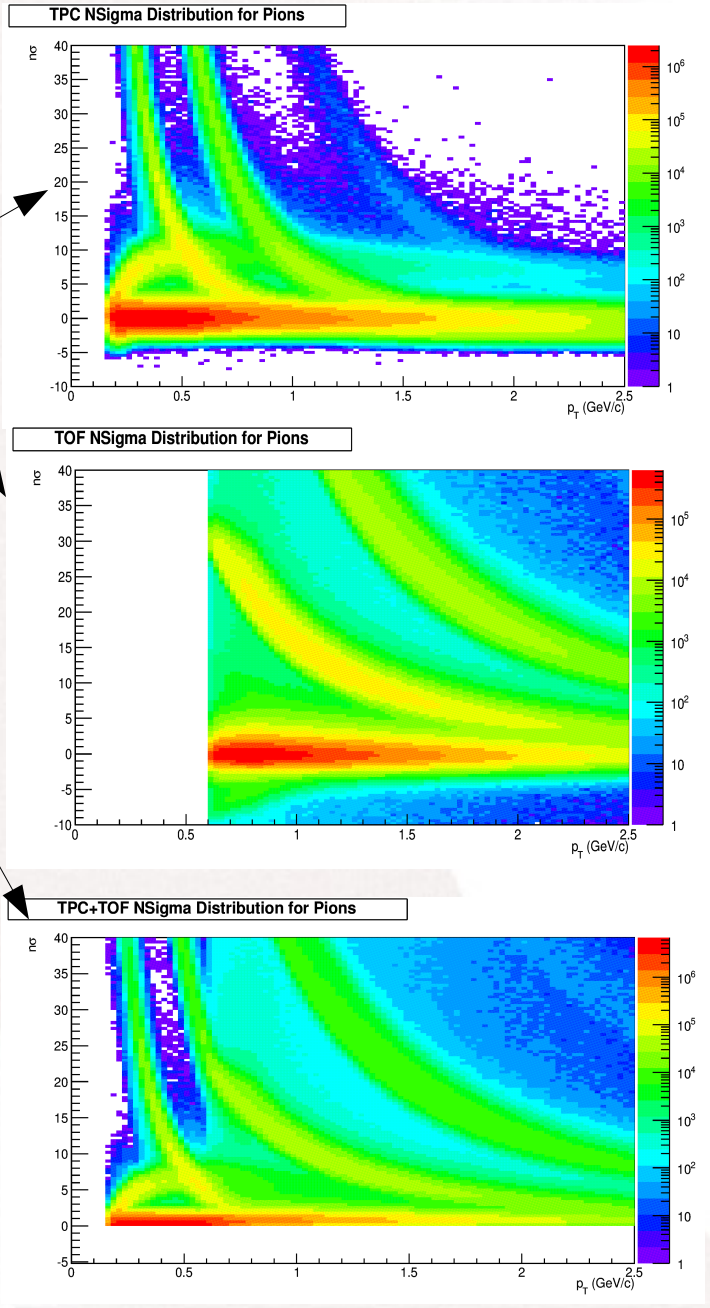
Backup Slides

Particle Identification

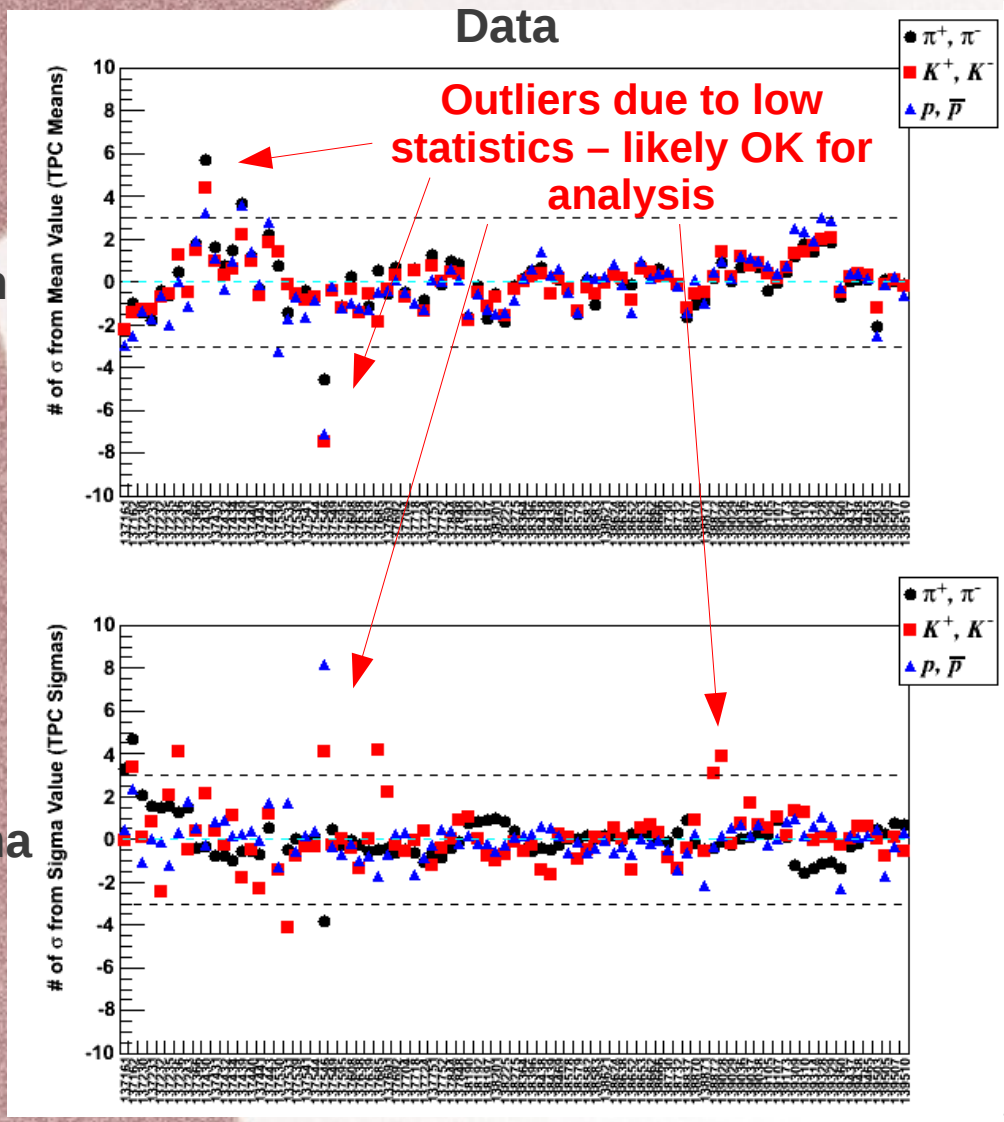
- Use TPC and TOF signal
  - Convert each into # of σ
  - Combine TPC+TOF:

$$\sigma_{TPC+TOF} = \frac{\sqrt{\sigma_{TPC}^2 + \sigma_{TOF}^2}}{\sqrt{2}}$$

  - Particles within 3σ of each peak are identified accordingly

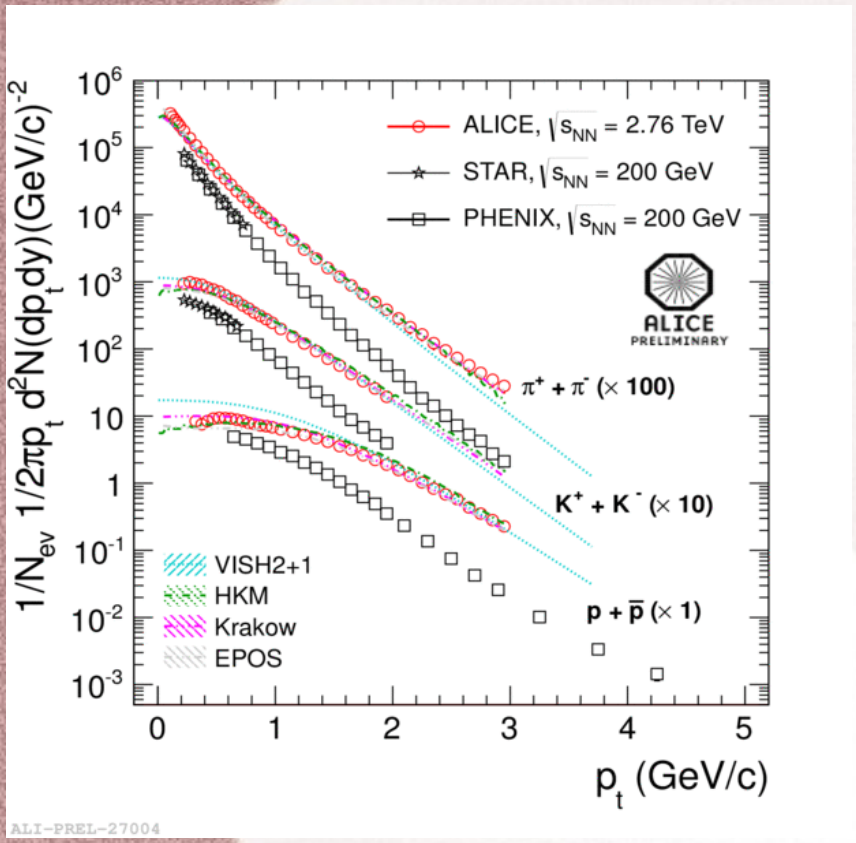
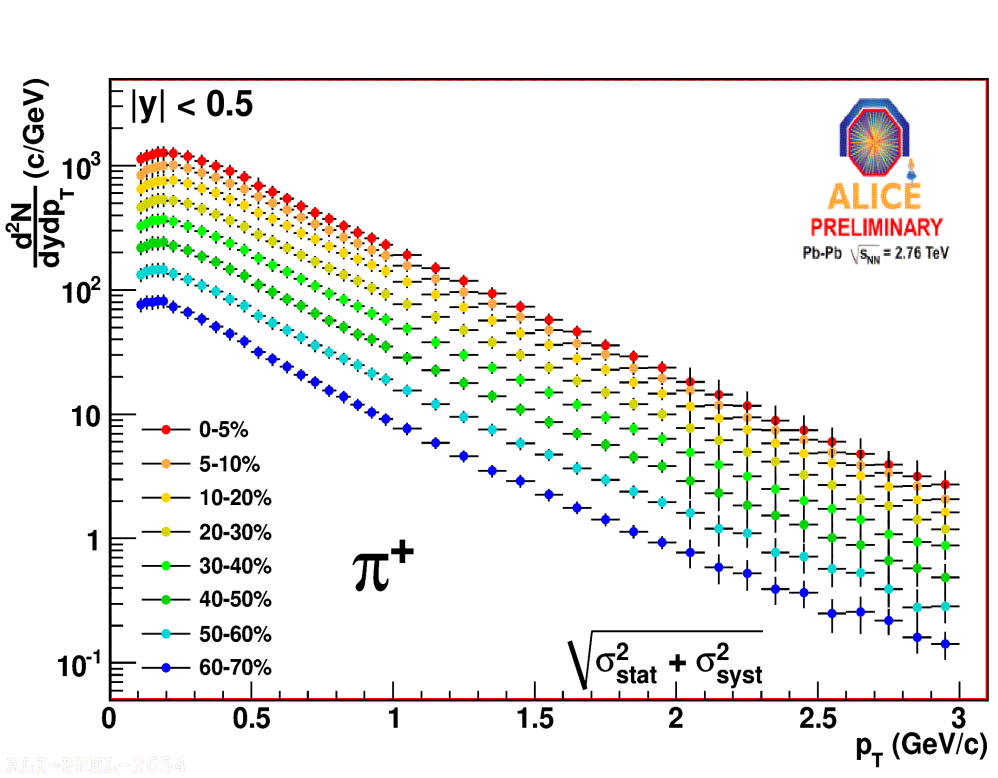


QA Check – Positions and Widths of the Normalized TPC Signal Distribution at p_T = 0.4 GeV/c



Previous (Preliminary) Results

All Particles, 0-5% Centrality



π+ Only, all Centralities