

# Charged pion identification at high $p_T$ in ALICE using the TPC $dE/dx$



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# Outline

## The ALICE TPC

Design

Performance

## PID on the relativistic rise

Motivation

Performance

## Conclusions



# The ALICE Experiment



## TPC

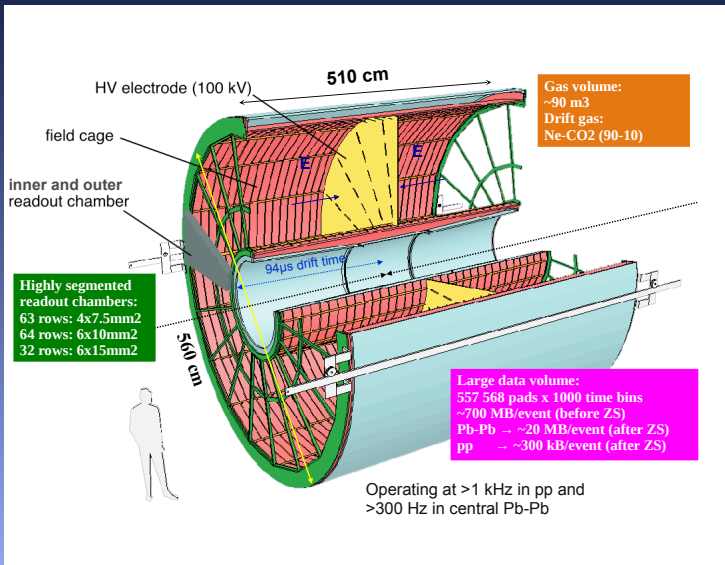
Tracking

Momentum measurement

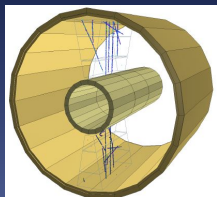
Particle identification via  $dE/dx$

$|\eta| < 0.9$  for full track length

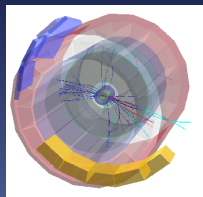
# The ALICE TPC



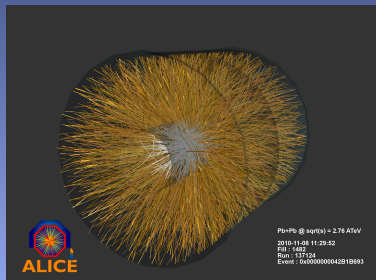
# Events in ALICE: tracks reconstructed using TPC data



(a) Cosmic rays



(b) pp event



(c) Pb-Pb event

# TPC momentum resolution

## Method:

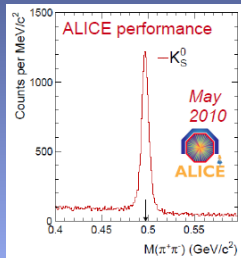
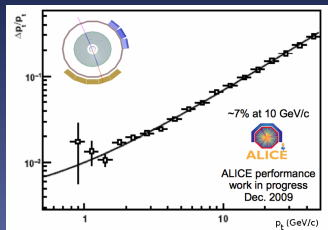
- High momentum tracks
  - Cosmic muon tracks treated independently in two halves of TPC
  - Comparison of  $p_T$  at vertex gives resolution
  - Statistics:  $\sim 5 \times 10^6$  events
- Low momentum tracks
  - Deduced from the width of  $K_S^0$  mass peak

Status (end of 2010, combined TPC-ITS tracks):

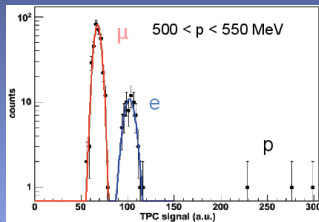
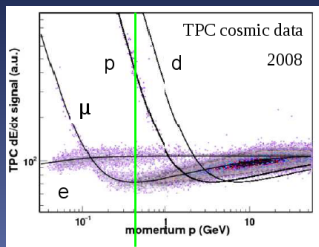
$$(\sigma_{p_T}/p_T)^2 = (0.01)^2 + (0.0045 p_T)^2$$

$\sim 5\%$  @ 10 GeV/c

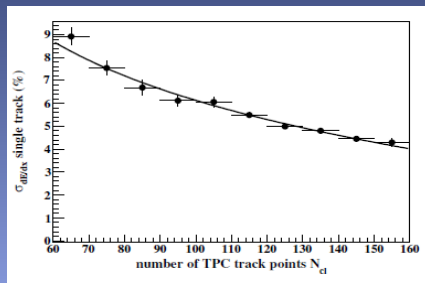
$\sim 1\%$  below 1 GeV/c



# dE/dx resolution

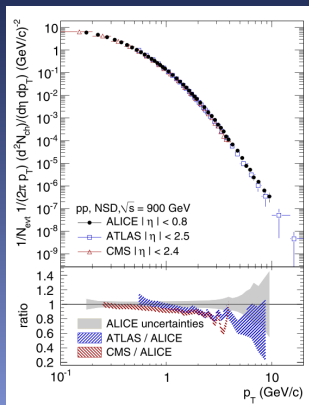


- Measured before LHC start-up
- Cosmic rays:  $8.3 \times 10^6$  tracks in 2008
- Design goal: 5.5%
- Measured: <5%



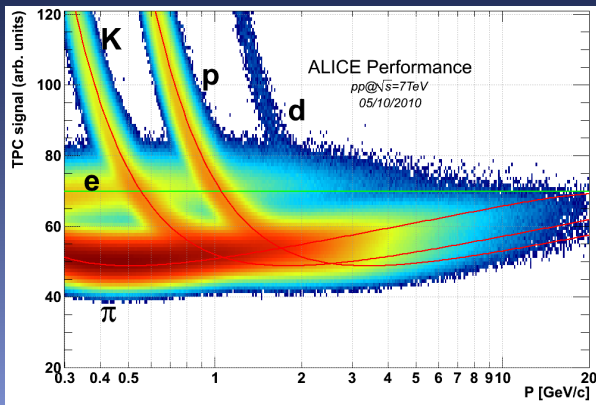
Nucl. Instr. Meth. A622 (2010) 316 (all figures)

# TPC data: pp@900 GeV & 7 TeV



Physics Letters B 693 (2010) 53-68

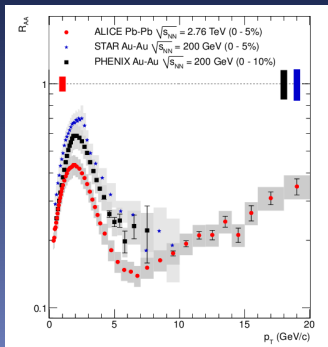
Charged particle spectrum



TPC signal



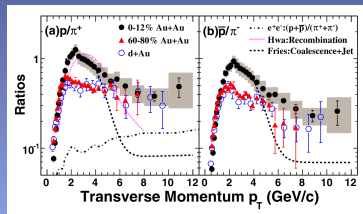
# PID on the relativistic rise: motivation



arXiv:1012.1004v1 [nucl-ex]

- In pp: pQCD comparisons  
⇒ interesting to do PID here!  
Start by confirming detector performance

- Statistical PID is possible on relativistic rise
- In AA:  $R_{AA}$  studies for *identified* particles
- Testing recombination models
- $\rho/\pi$  at  $p_T > 3$  GeV/c holds interesting physics



STAR, Phys. Rev. Lett. 97 (2006) 152301

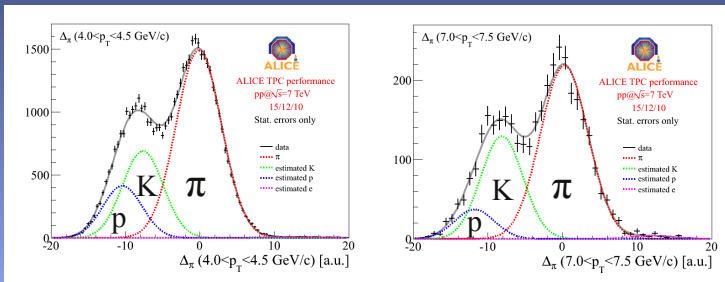


# Particle separation on the relativistic rise

$\Delta_\pi = dE/dx - \langle dE/dx \rangle_{\text{fitted}}(\pi)$  for different  $p_T$

Fitted with 4 Gaussians ( $\pi$ , K, p, e)

Means and widths constrained from Bethe-Bloch fit and MIP resolution, respectively

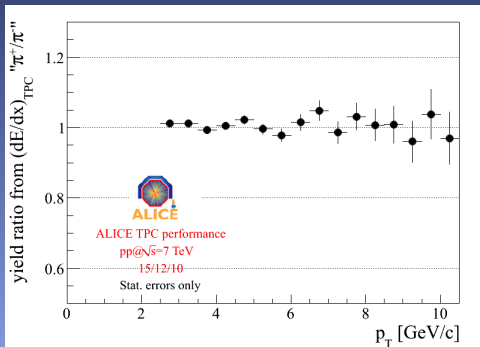


pp,  $\sqrt{s}=7$  TeV



# Particle ratios

We can extract yield ratios from the fit to check the performance of our method



$\pi^+/\pi^-$  close to 1 as expected

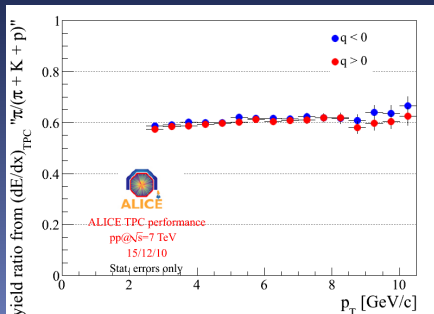


pp,  $\sqrt{s}=7$  TeV



# Particle ratios

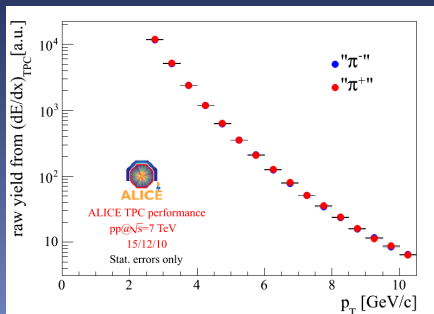
- Stable fit results for pion yields
- Possibility to get pion fraction
- Still needs to be corrected for feed-down protons
- p and K yield extraction needs more work (understand the systematics)
- Good start for Pb-Pb analysis



pp,  $\sqrt{s}=7$  Tev



# $p_T$ spectra



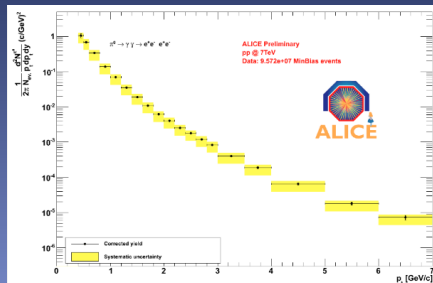
pp,  $\sqrt{s}=7$  TeV

## Uncorrected spectra

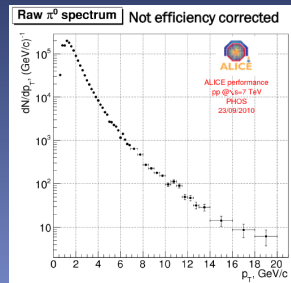
Normalisation and efficiency corrections needed for comparison to other data, work in progress

# Comparable spectra

$\pi^0$  from conversion



$\pi^0$  from PHOS



Same  $p_T$  range for comparison



## Conclusions

- The ALICE TPC is showing very good performance in pp and Pb-Pb collisions
- The performance of the TPC  $dE/dx$  to measure charged particle spectra on the relativistic rise ( $p_T > 3$  GeV/c) has been demonstrated up to 10 GeV/c, and can be extended to higher  $p_T$
- There is interesting physics to be found from PID on the relativistic rise
- We are working on normalisation and corrections to use the results for physics



Thank you





# Back-up



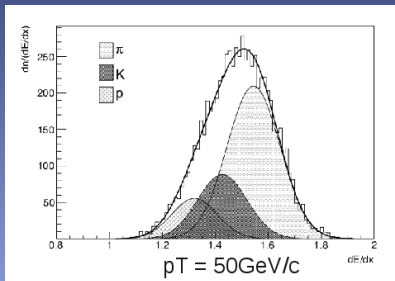
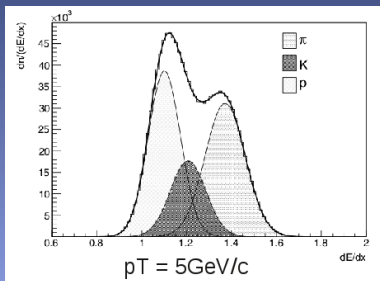
# ALICE publications

- The ALICE TPC, a large 3-dimensional tracking device with fast readout for ultra-high multiplicity events  
arXiv:1001.1950v1 [physics.ins-det]
- Centrality dependence of the charged-particle multiplicity density at mid-rapidity in Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV  
arXiv:1012.1657v1 [nucl-ex]
- Suppression of Charged Particle Production at Large Transverse Momentum in Central Pb-Pb Collisions at  $\sqrt{s_{NN}} = 2.76$  TeV  
arXiv:1012.1004v1 [nucl-ex]
- Elliptic flow of charged particles in Pb-Pb collisions at 2.76 TeV  
arXiv:1011.3914v1 [nucl-ex]
- Charged-particle multiplicity density at mid-rapidity in central Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV  
arXiv:1011.3916v2 [nucl-ex]
- Transverse momentum spectra of charged particles in proton-proton collisions at  $\sqrt{s}=900$  GeV with ALICE at the LHC  
Physics Letters B 693 (2010) 53–68
- Two-pion Bose-Einstein correlations in pp collisions at  $\sqrt{s}=900$  GeV  
Phys. Rev. D 82, 052001 (2010)
- Midrapidity Antiproton-to-Proton Ratio in pp Collisions at  $\sqrt{s}=0.9$  and 7 TeV Measured by the ALICE Experiment  
Phys Rev Lett Vol.105, No.7, (2010)
- Charged-particle multiplicity measurement in proton-proton collisions at  $\sqrt{s}=7$  TeV with ALICE at LHC  
Eur. Phys. J. C (2010) 68: 345–354
- Charged-particle multiplicity measurement in proton-proton collisions at  $\sqrt{s}=0.9$  and 2.36 TeV with ALICE at LHC  
Eur. Phys. J. C (2010) 68: 89–108
- Alignment of the ALICE Inner Tracking System with cosmic-ray tracks  
J. Instrum. 5, P03003
- First proton-proton collisions at the LHC as observed with the ALICE detector: measurement of the charged-particle pseudorapidity density at  $\sqrt{s}=900$  GeV  
Eur. Phys. J. C (2010) 65: 111–125



# PID method

- Cuts and Calibration
- Parameter constraining
- Fitting
- Normalisation



# Cuts and calibration

## Track selection

- ALICE standard event and track selection
- Acceptance cut for regions near TPC sector boundaries

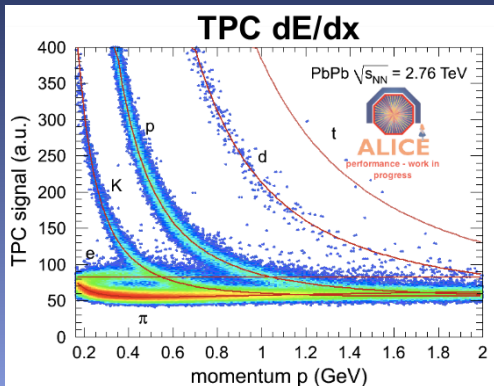
## In the MIP region ( $dE/dx \sim \text{constant}$ )

- Correct Eta dependence
- Evaluate  $\sigma_{dE/dx}$  dependency with Ncl
- Assume MIP behaviour can be extrapolated



# Fit parameter constraints

Mean  $\langle dE/dx \rangle$  fixed from 2D fit on data ( $\sim$ Bethe-Bloch  $\times$  3 Gaussians)



# ALICE design

## Original design:

- TPC tasks
  - track finding with  $dN/dy$  up to 8000  $\Rightarrow$  20 000 tracks in the TPC
  - momentum measurement
  - particle identification:  $0.1 \text{ GeV}/c < p_T < 50 \text{ GeV}/c$ ,  $|\eta| < 0.9$
- Requirements
  - tracking efficiency:  $> 90\%$
  - momentum resolution:  $< 5\%$
  - $dE/dx$  resolution:  $< 5.5\%$
  - two track resolution:  $< 5 \text{ MeV}/c$
  - rate capability: 200 Hz central Pb-Pb (1 kHz pp)

Gas mixture for data used in analysis: Ne-CO<sub>2</sub>-N<sub>2</sub> (85.7-9.5-4.8)

