Identified hadrons in pp and Pb-Pb collisions at LHC with ALICE detector

presented at 'ICFP2012', 10-16 June 2012,
Kolymbari, Creta, Greece

Martha Spyropoulou-Stassinaki
Physics Department
University of Athens
for the ALICE Collaboration

- INTRODUCTION

- ALICE Detector and **PID** (**P**article **ID**entification)

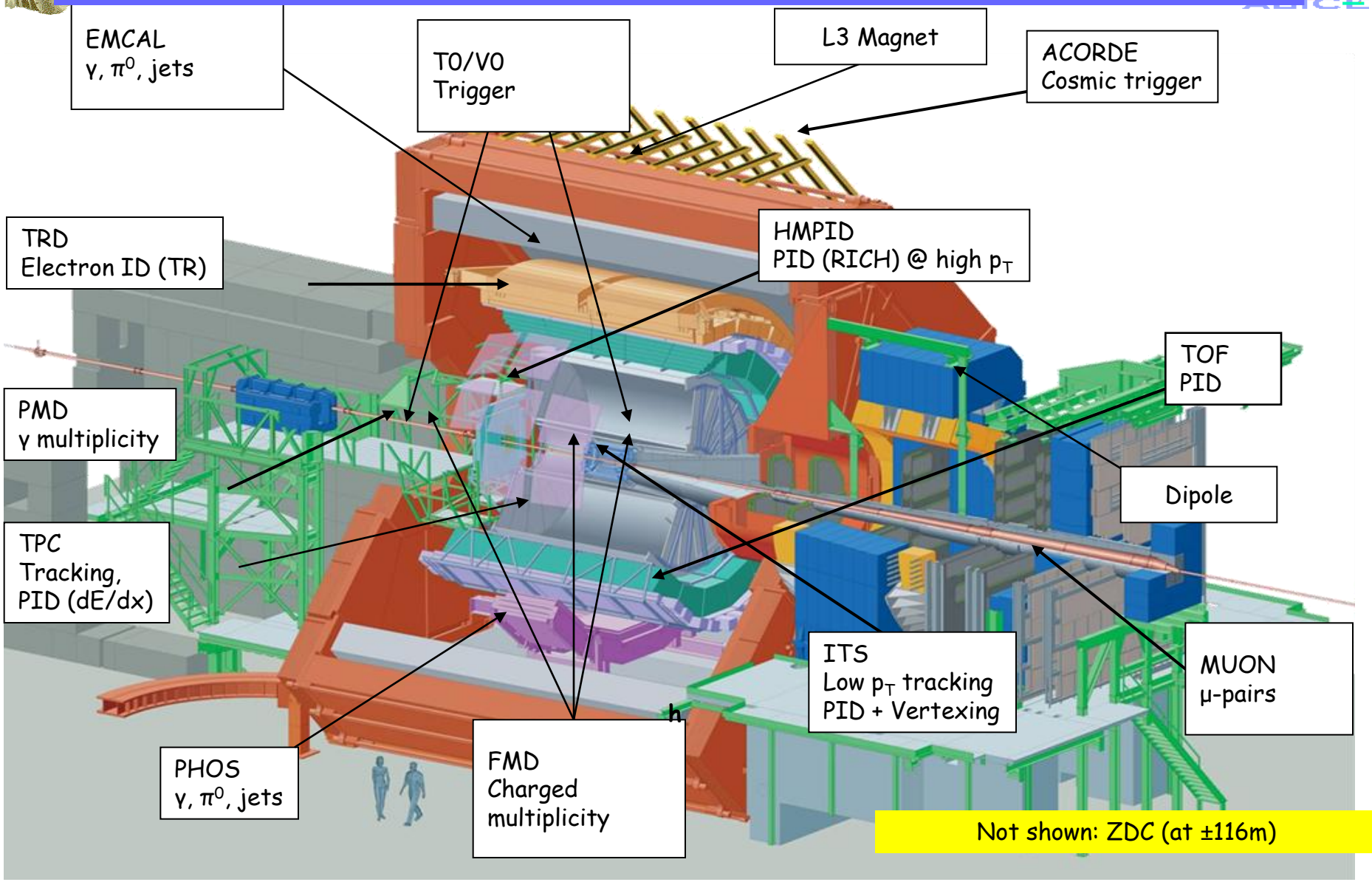
- Detectors signals and identification of hadrons

- Spectra results of identified hadrons in pp and Pb-Pb collisions

- SUMMARY

ALICE: A Large Ion Collider Experiment at CERN-LHC

Size 16x26 m, weight 10.000 tonnes



ALICE detector at the CERN-LHC

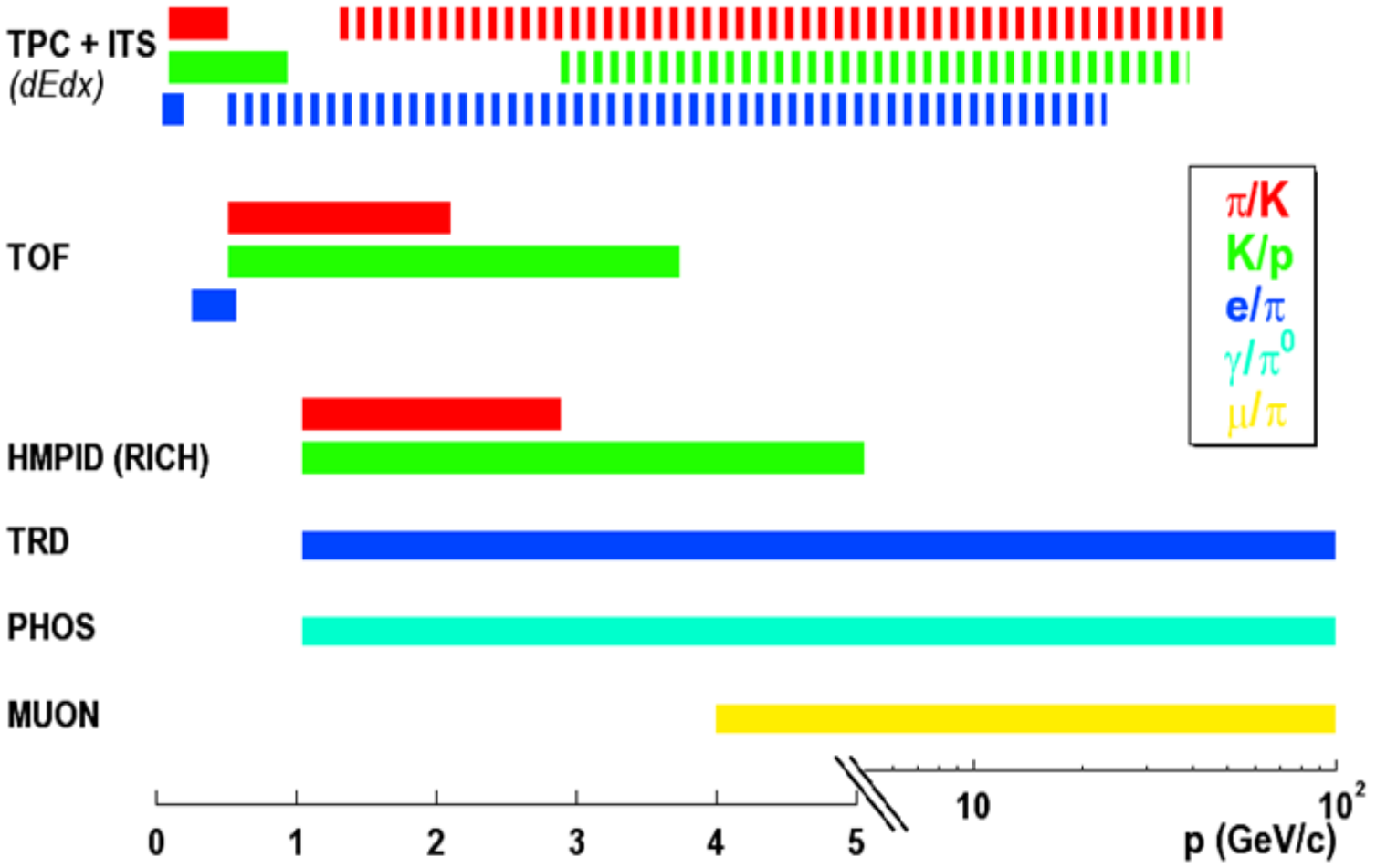
• Unique PID capabilities. Almost all known techniques are exploited:
dE/dx measurements
Time-of-flight measurements,
Cherenkov radiation,
Transition radiation,
Calorimetry,
Decay topologies (V0, cascades, kinks)

• Central region with small material budget

Inner Tracking System– ITS: Primary vertex, PID via dE/dx
Time Projection Chamber–TPC: Global tracking, PID via dE/dx
Time Of Flight system–TOF:PID via **T**ime-**O**f-**F**light measurement are used in this analysis

PID in ALICE

ALICE PPR CERN/LHCC 2003-049



Particle Identification in pp collisions

Production of pions, kaons and protons in pp collisions at $\sqrt{s} = 900$ GeV with ALICE at the LHC

Eur. Phys. J. C (2011) 71:1655
DOI 10.1140/epjc/s10052-011-1655-9

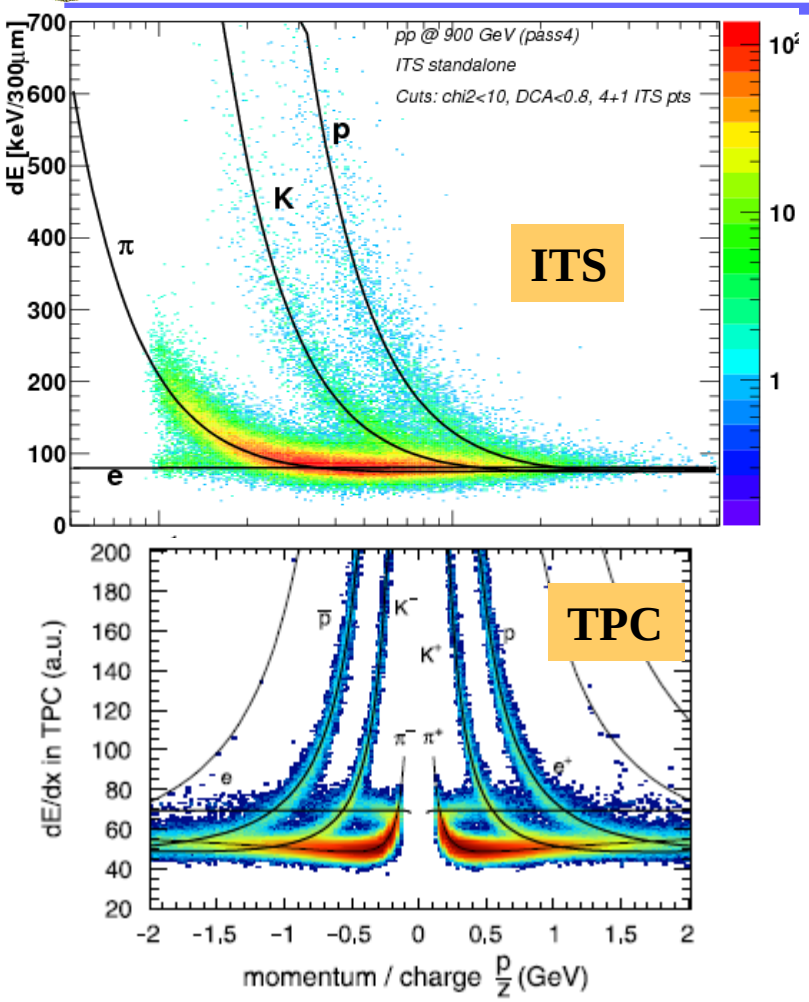


Fig. 4 (Color online) Specific energy loss dE/dx vs. momentum for tracks measured with the ALICE TPC. The *solid lines* are a parametrization of the Bethe–Bloch curve [25]

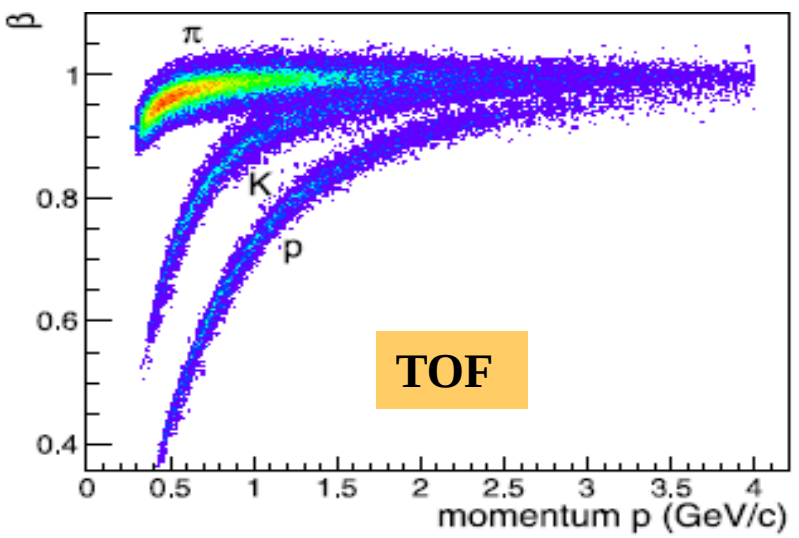


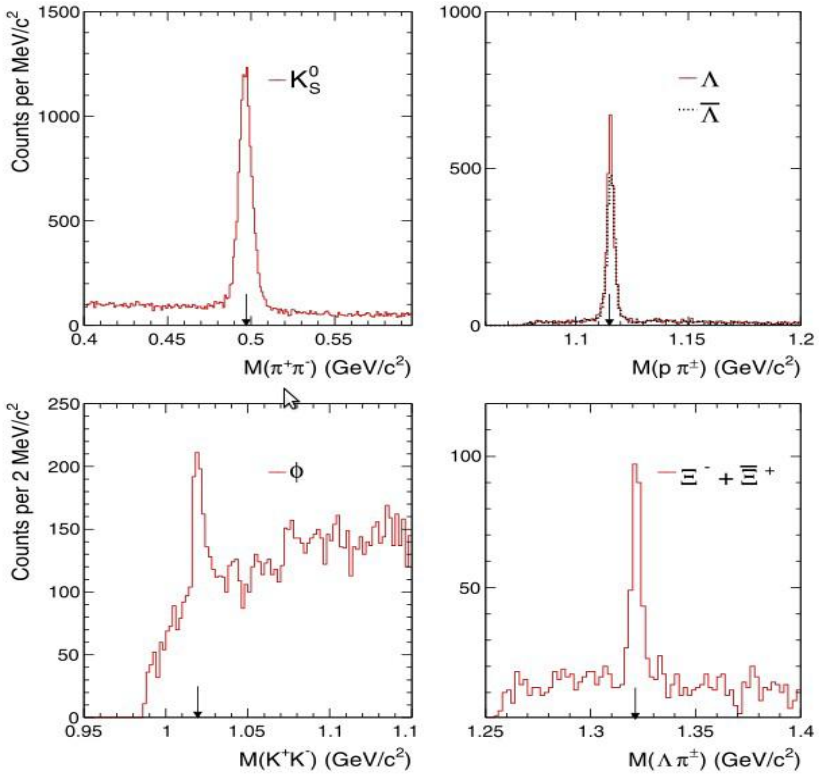
Fig. 7 (Color online) β of tracks of particles measured by TOF vs. their momentum

Charged hadron ID in ALICE:

- dE/dx in ITS and TPC
- TOF
- V^0 topology (Λ, K)
- Kink topology in TPC

Topological Identification in ALICE pp data at 900 GeV/c

	Particles	Charged decay	B.R. (%)
Mesons	K^0_S	$K^0_S \to \pi^+ + \pi^-$	69.2
	$\phi\ (s\bar{s})$	$\phi \to K^+ + K^-$	49.2
Baryons	$\Lambda\ (uds)$ and $\overline{\Lambda}\ (\overline{uds})$	$\Lambda \to p + \pi^-$ and $\overline{\Lambda} \to \bar{p} + \pi^+$	63.9
	$\Xi^-\ (dss)$ and $\overline{\Xi}^+\ (\overline{dss})$	$\Xi^- \to \Lambda + \pi^-$ and $\overline{\Xi}^+ \to \overline{\Lambda} + \pi^+$	99.9



ALICE Collaboration, Eur. Phys. J. C **71(3), 1594 (2011)**

E.g. Kaons are identified by three different methods:
• direct PID: K± , • V0s: K0 → π+π-, • Kinks: K± → μ± ν

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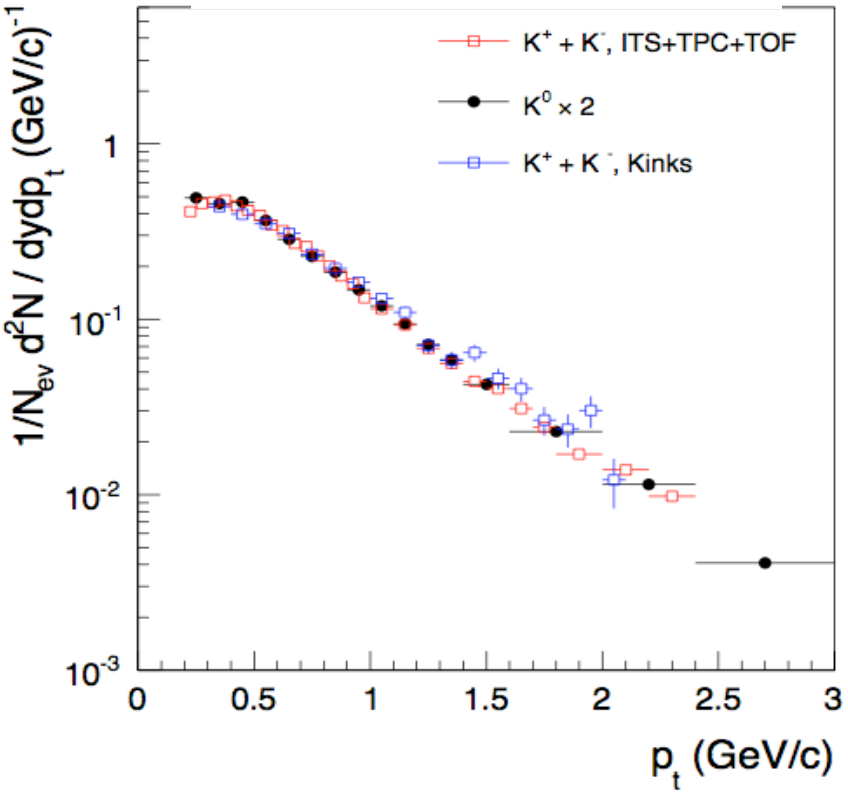
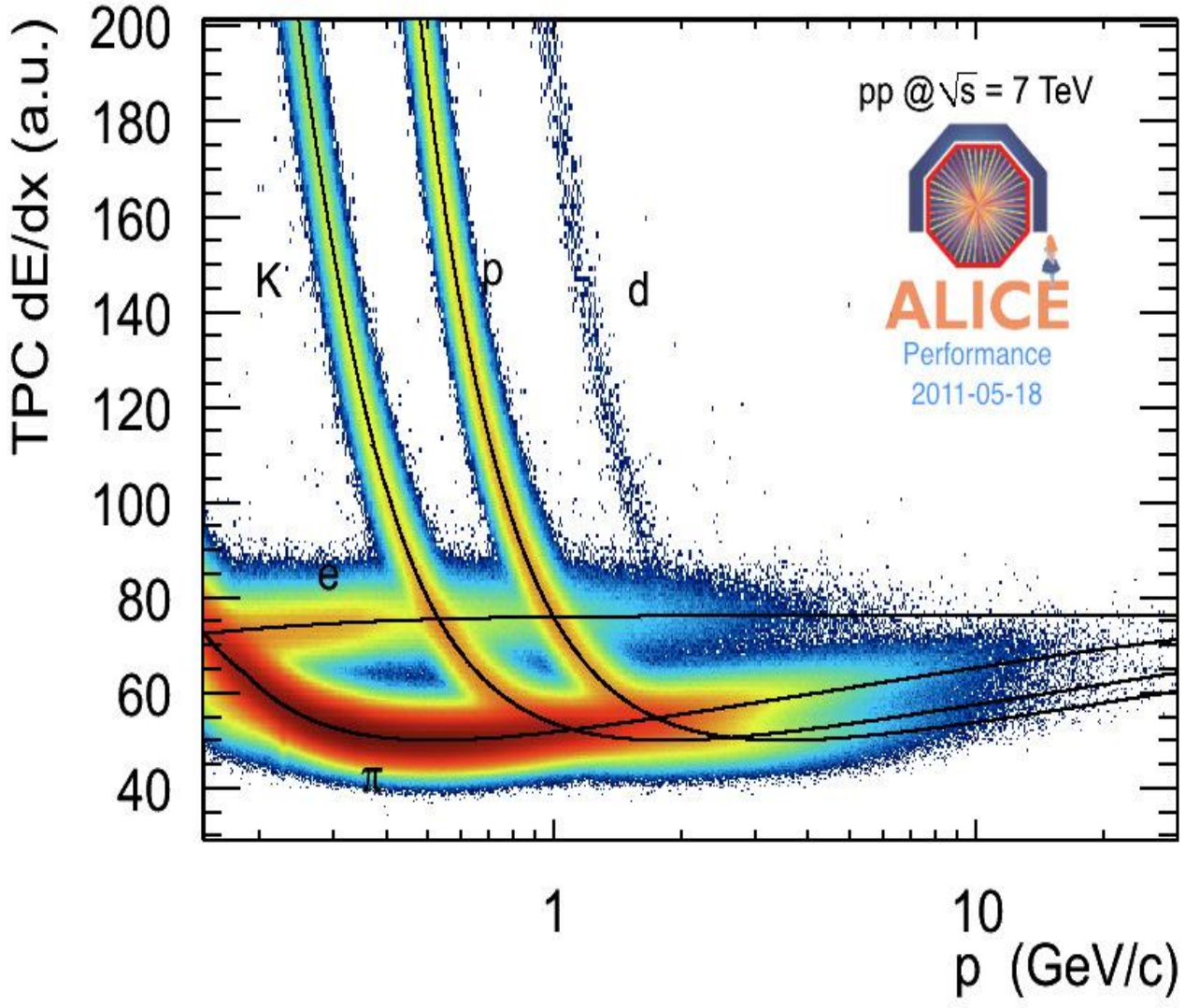
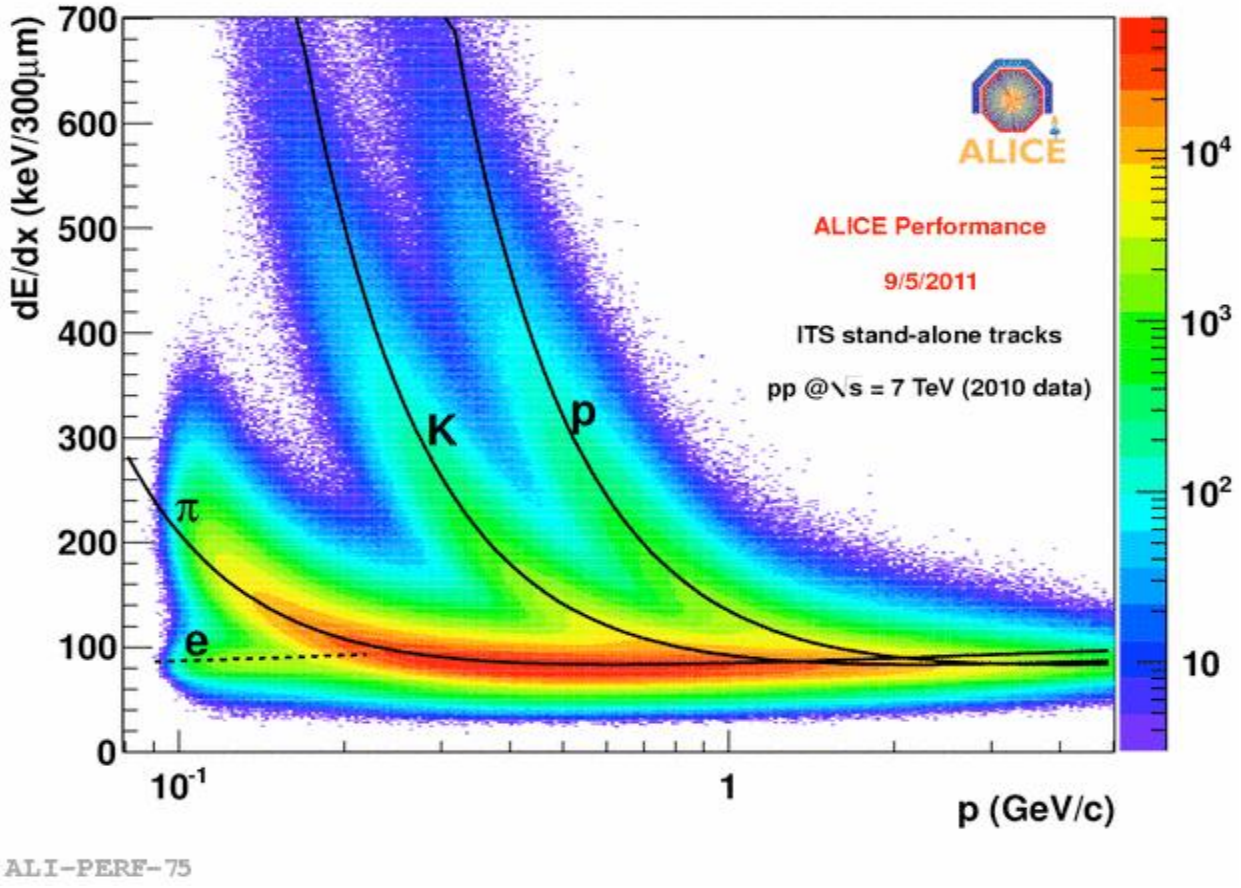


First pp data at 900 GeV

Particle identificaton with Time Projection Chamber for pp at 7 TeV with a dE/dx resolution of 5%

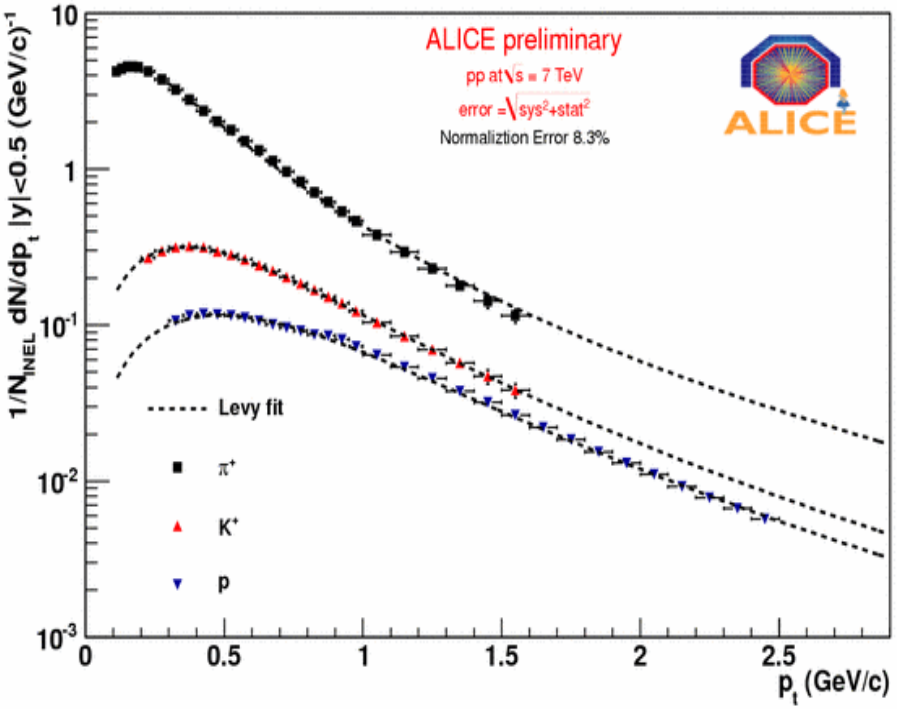


Drift and strip detectors have analog read-out for up to 4 samples of specific energy loss with $\sigma \approx 10\text{-}15\%$.



pp at 7 TeV

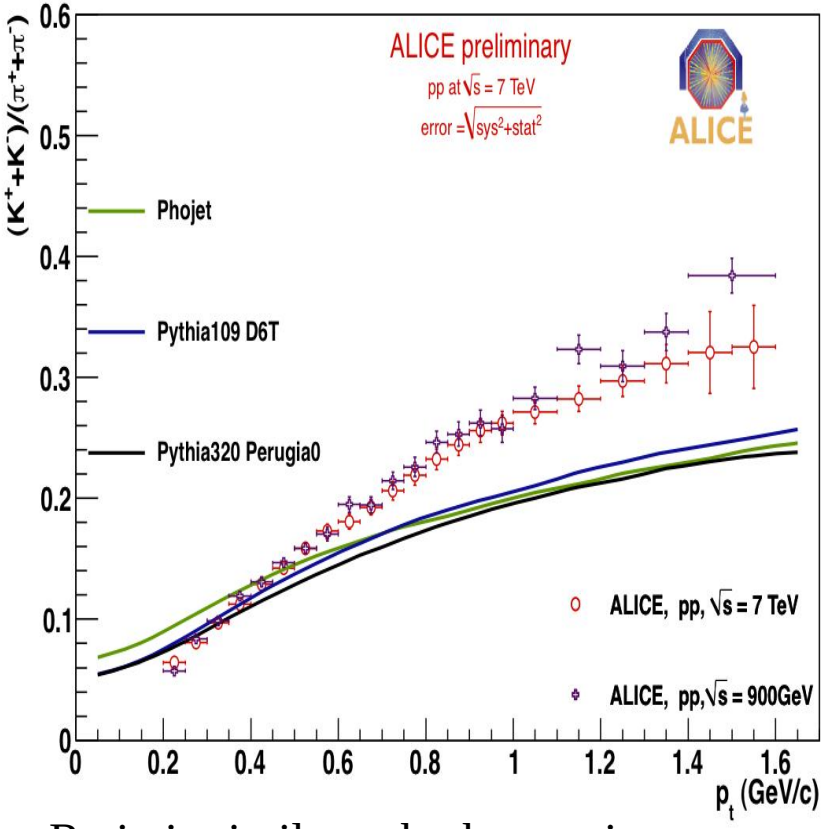
Levy fits for 7 TeV spectra



Different techniques used

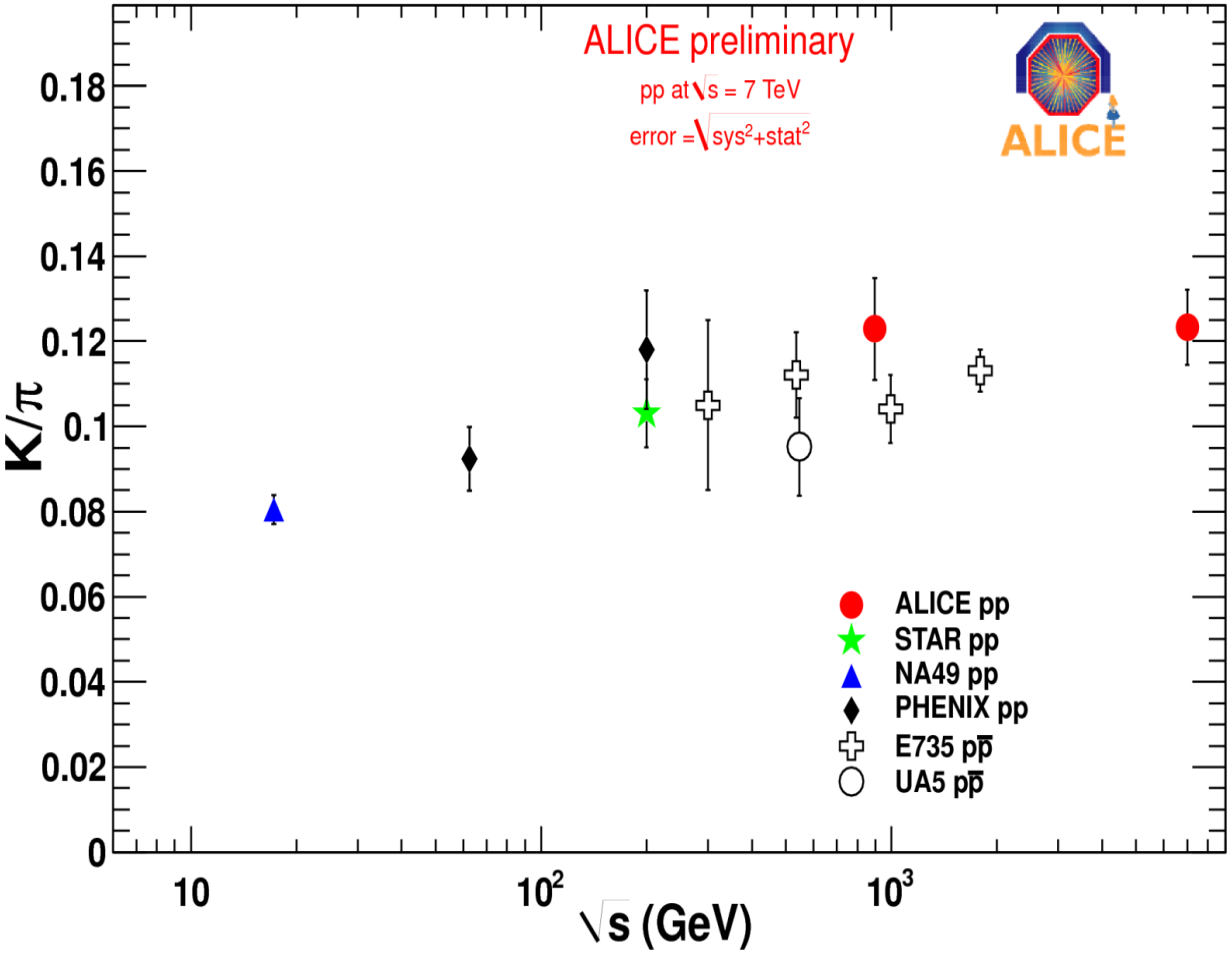
Minimun p_t = 0.1 / 0.2 / 0.3 GeV /c for π/K/p

K/π vs p_t



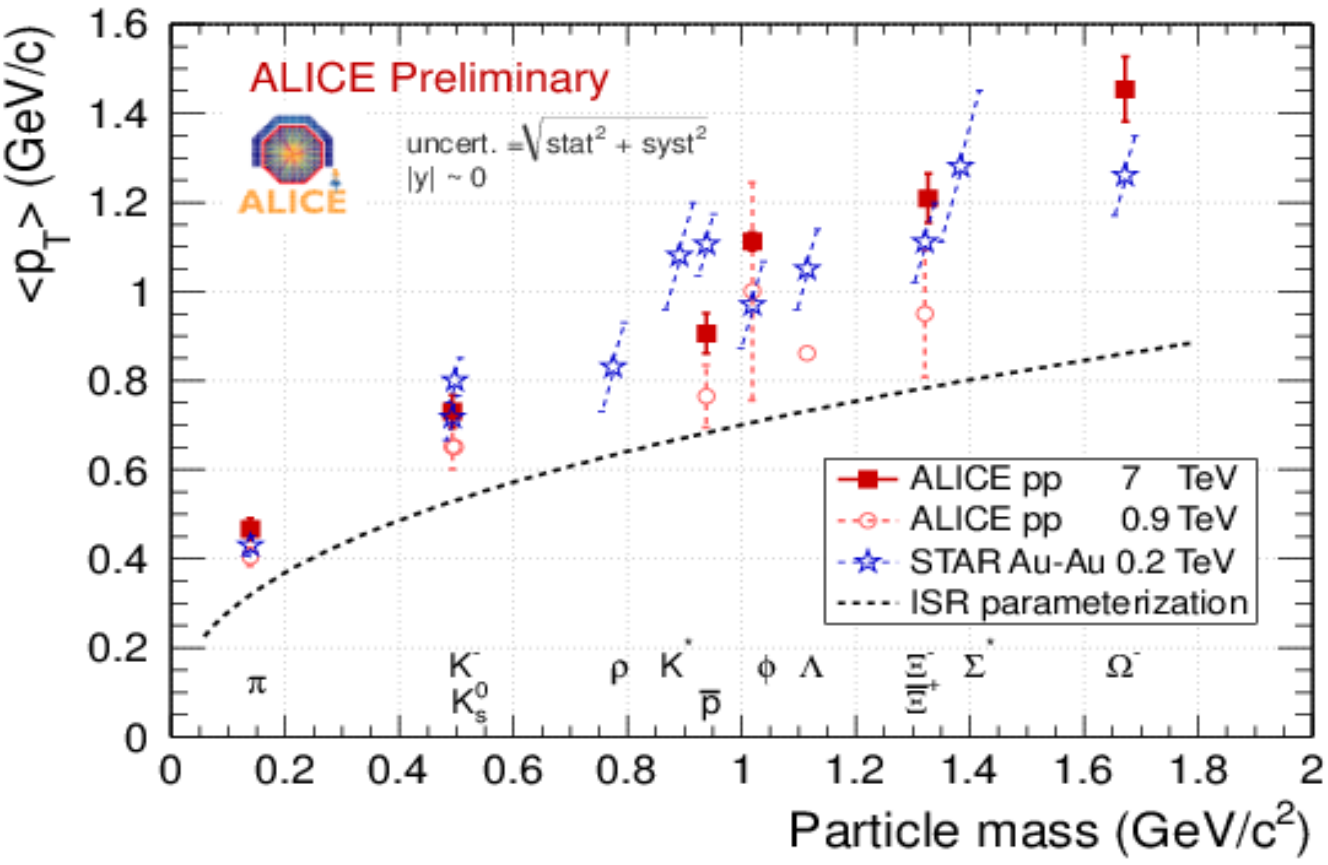
- Ratio is similar at both energies
- Ratio is not described by MC models for $p_t > 0.6$ GeV/c

pp at 7 TeV, K/π vs energy



K/π ratio is constant between 900 GeV and 7 TeV

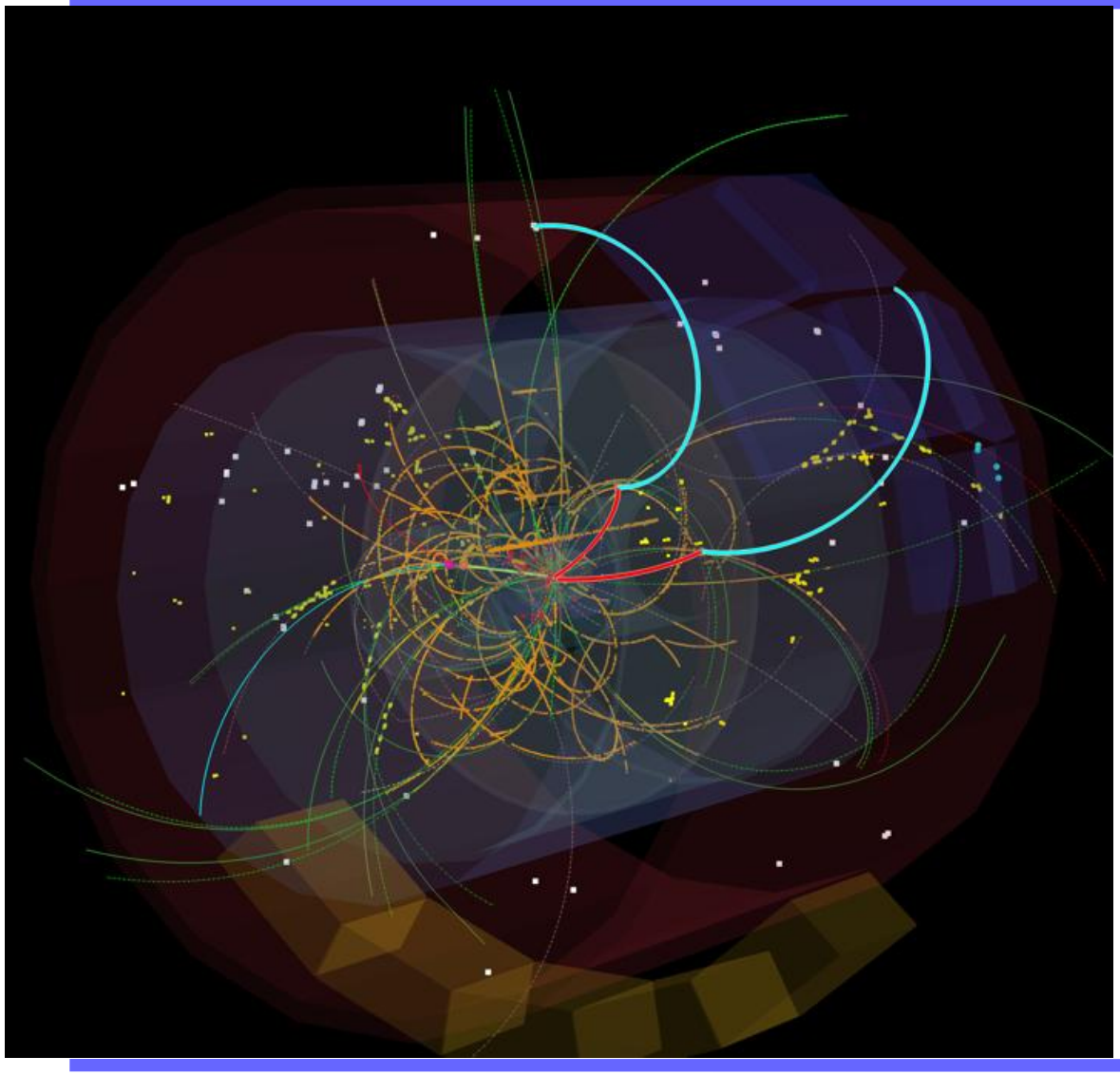
$< p_t >$ of identified particles as a function of energy



STAR: Central collisions

- Linear increase of $< p_t >$ with mass
- Increase of the $< p_t >$ with collision energy

Kaon/pion 'identification' from their weak decay inside the ALICE TPC detector



K- kinks

$K \rightarrow \mu\nu$ 63.43%

$K \rightarrow \pi\pi^0$ 21.13%

$K \rightarrow e\pi^0\nu$ 4.87%

$K \rightarrow \mu\pi^0\nu$ 3.27%

$K \rightarrow \pi\pi^0\pi^0$ 1.73%

π- kinks

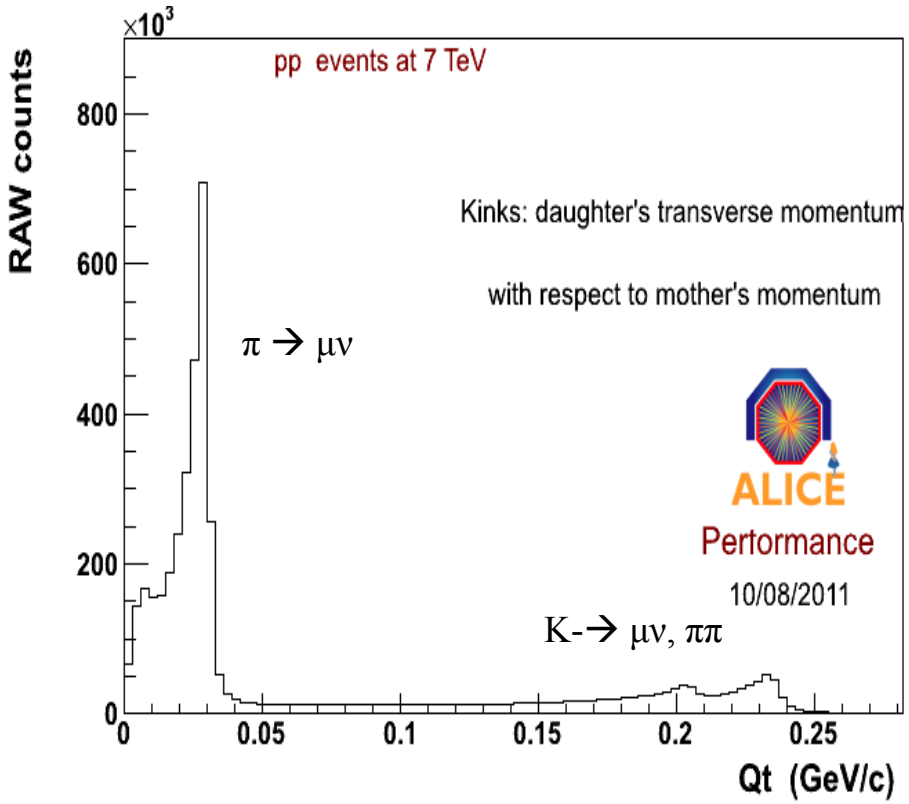
$\pi \rightarrow \mu\nu$ 99%

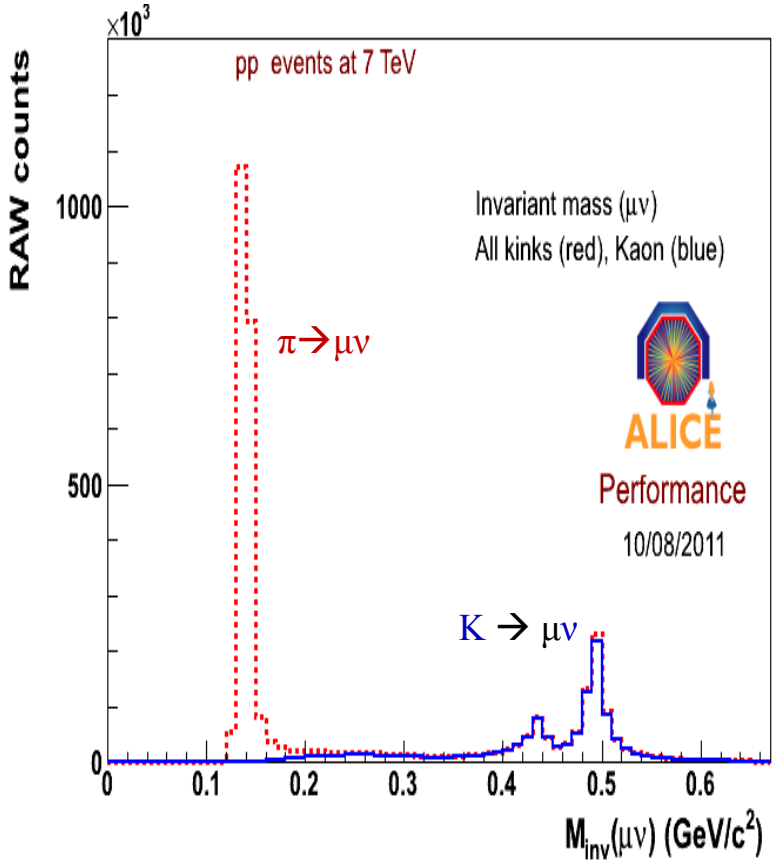
(K+->π+π+π-, 5.6%)

pp collisions at 7 TeV, kinks study, ~22 M Minimum Bias events

The two body-decay kinematics are used for the decay K-> μν and π->μν.

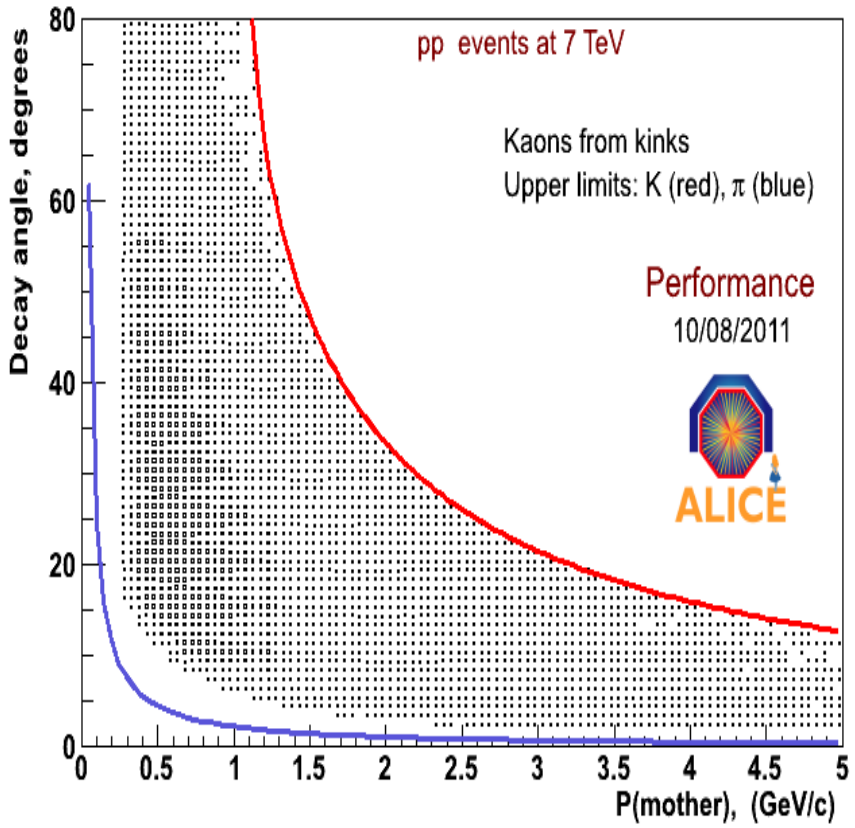
The kink vertex inside the radius 120-210 cm, with p_t (mother) >250 MeV/c, |y(K)| <0.7





pp collisions at 7 TeV, kinks study inside TPC radius 120-210 cm

The two dimentional plot vs P shows the 'identified' Kaons after Q_t>120 MeV/c, Minv(μν) and maximum angle cuts

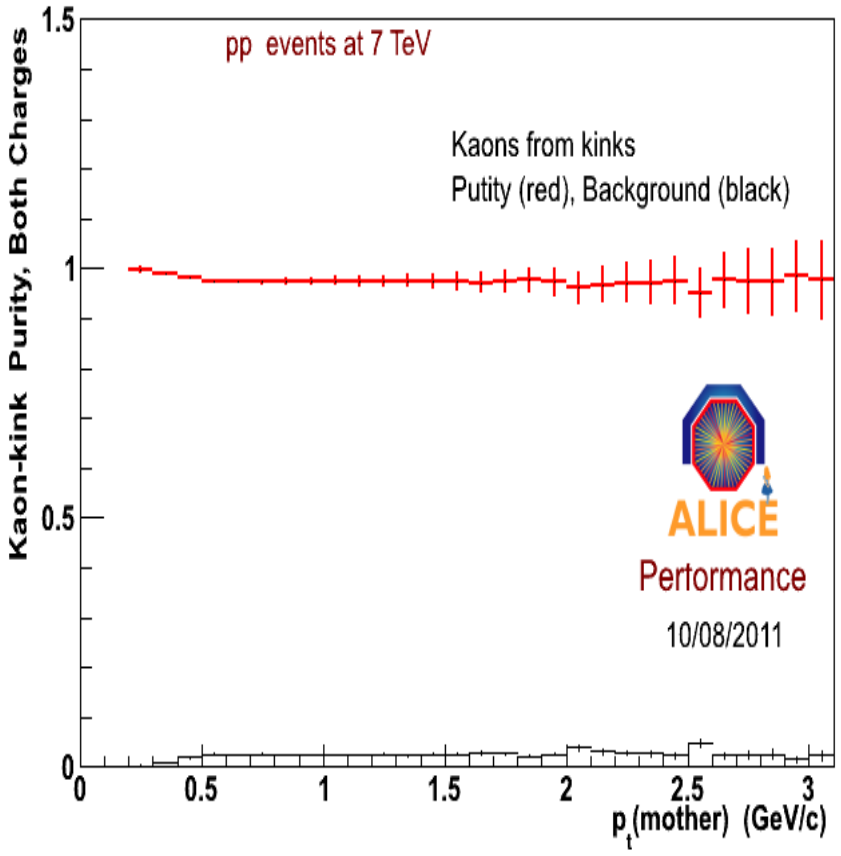


The sample of the 'identified' Kaons in MC studies has a measurement of dE/dx inside TPC consistent with Kaon , with a background ~5% . A large fraction of it has been removed with a 3.5σ cut around the Bethe-Bloch curve of Kaon.

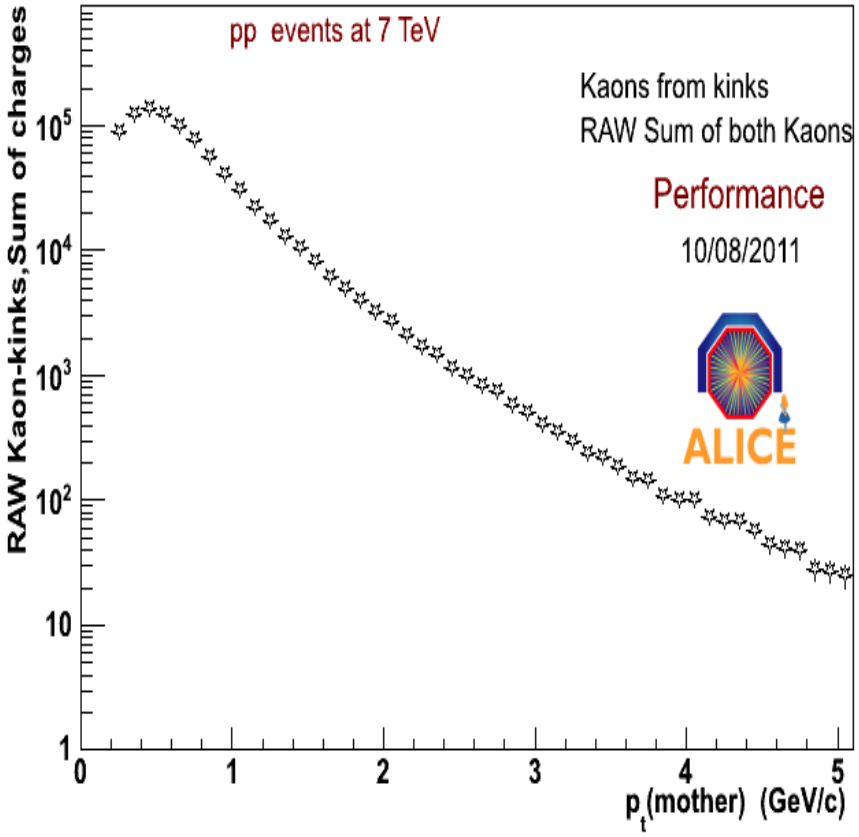
The remaining background (~2%) is mainly random association of primary and secondary tracks.

pp collisions at 7 TeV, kinks study, ~22 M Min. Bias events

MC calculation of the Kaon purity



The RAW p_t distribution of both charges, shows that the method allows for K- identification at intermediate p_t

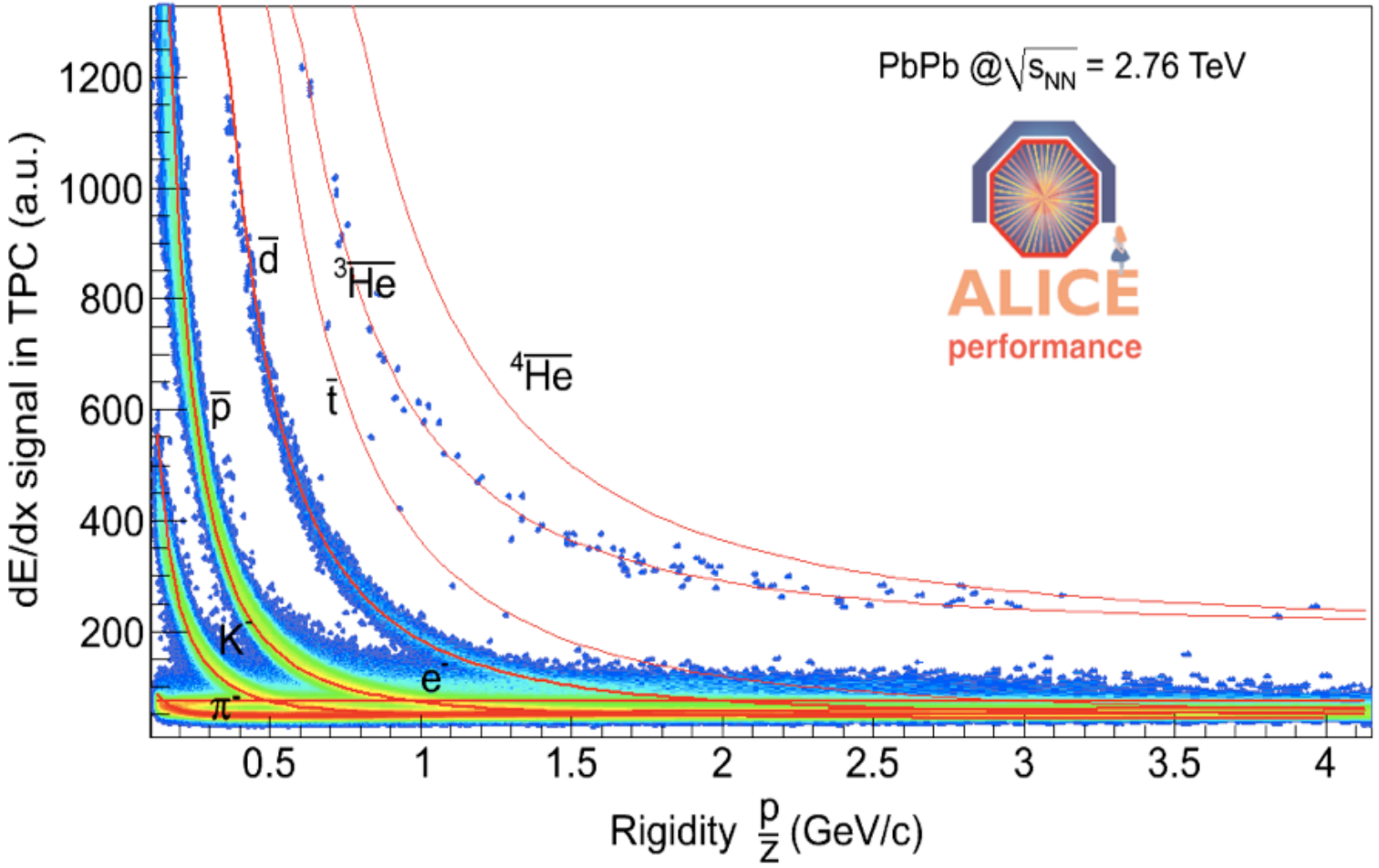


The contamination is smaller than 3% in the measured momentum range

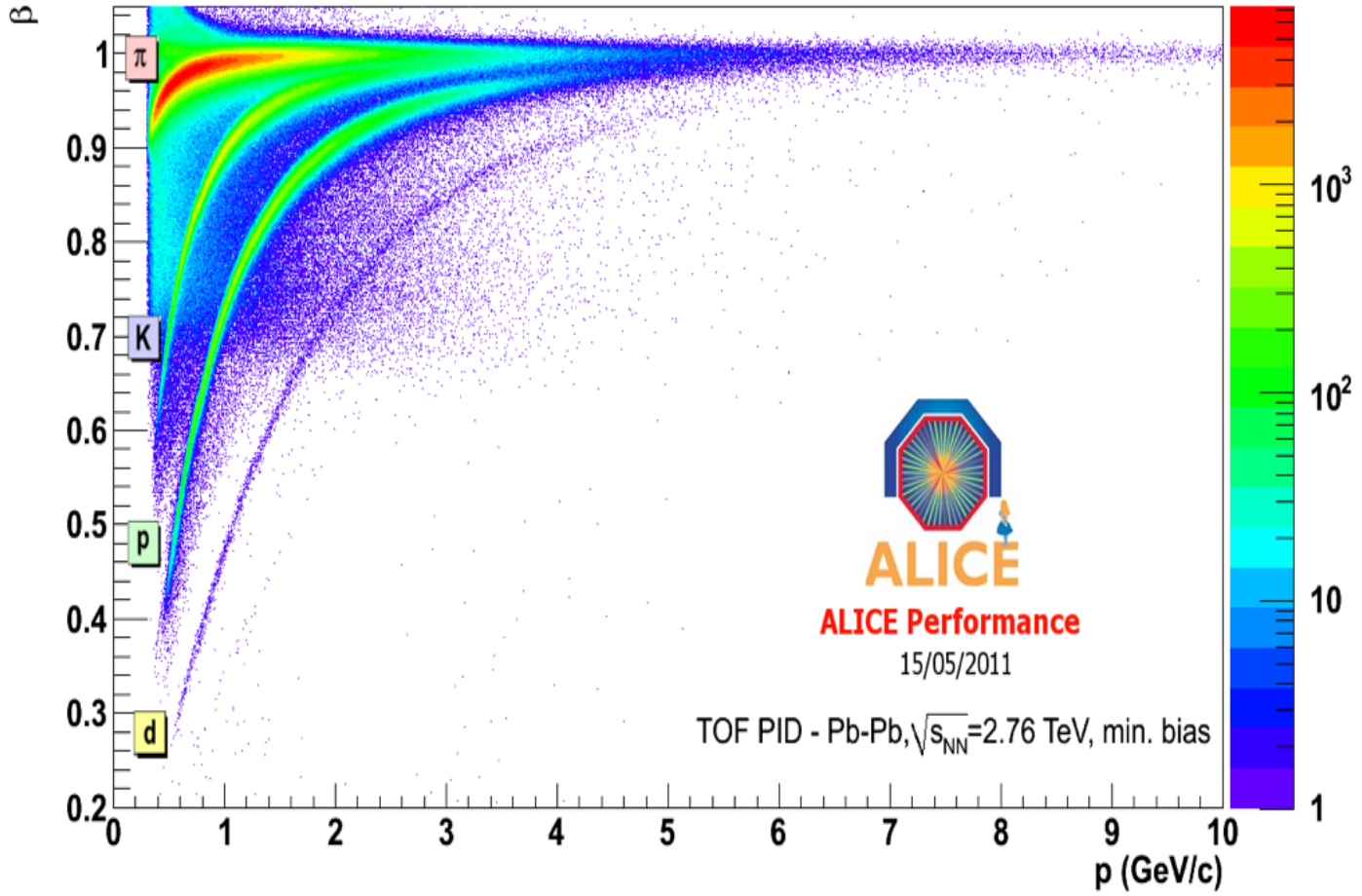
Particle spectra in Pb-Pb collisions

dE/dx measurement in TPC in Pb-Pb collisions

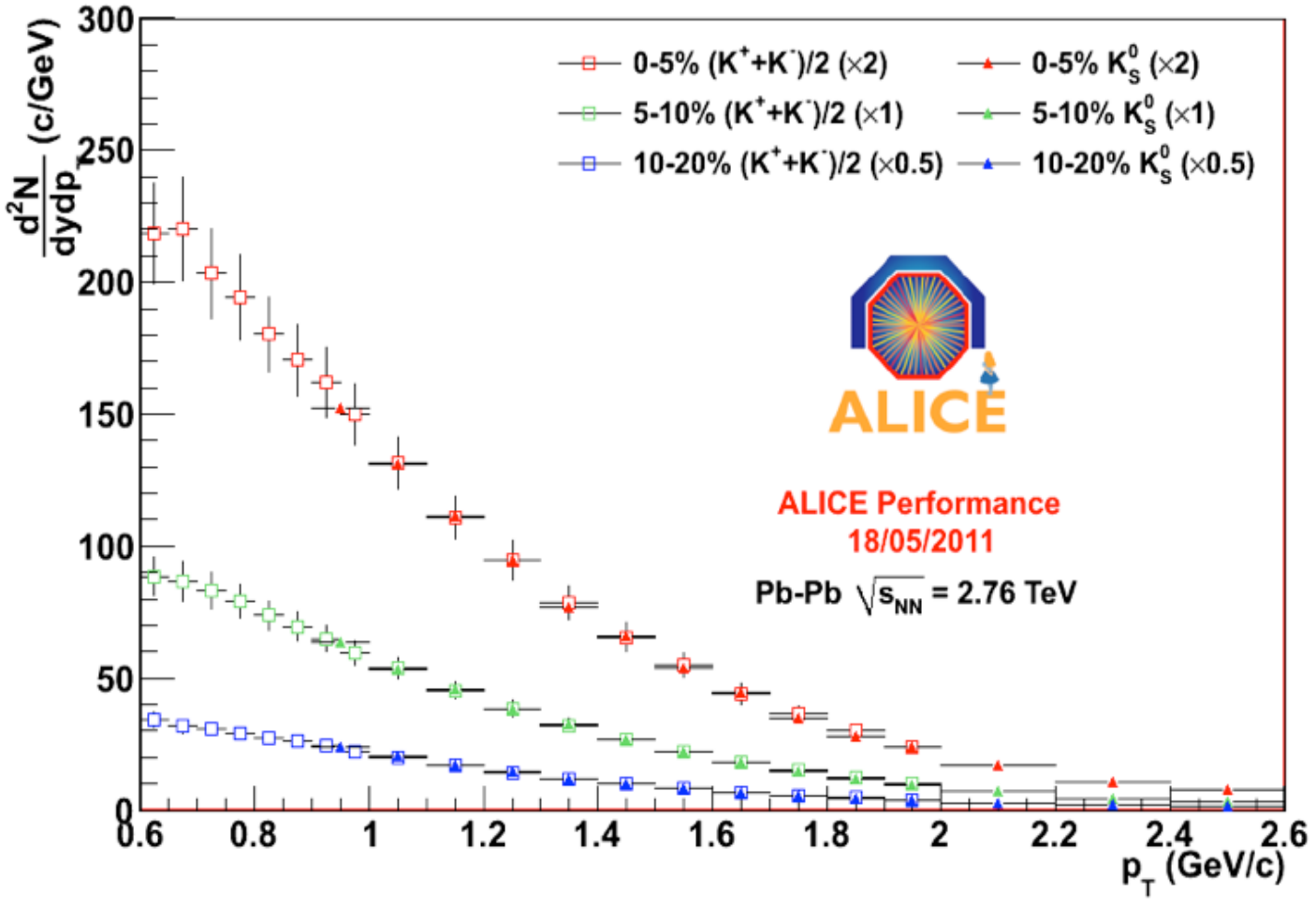
Very large dynamic range(up to 26x min. ionizing) allows one to identify light nuclei and separate their charge.



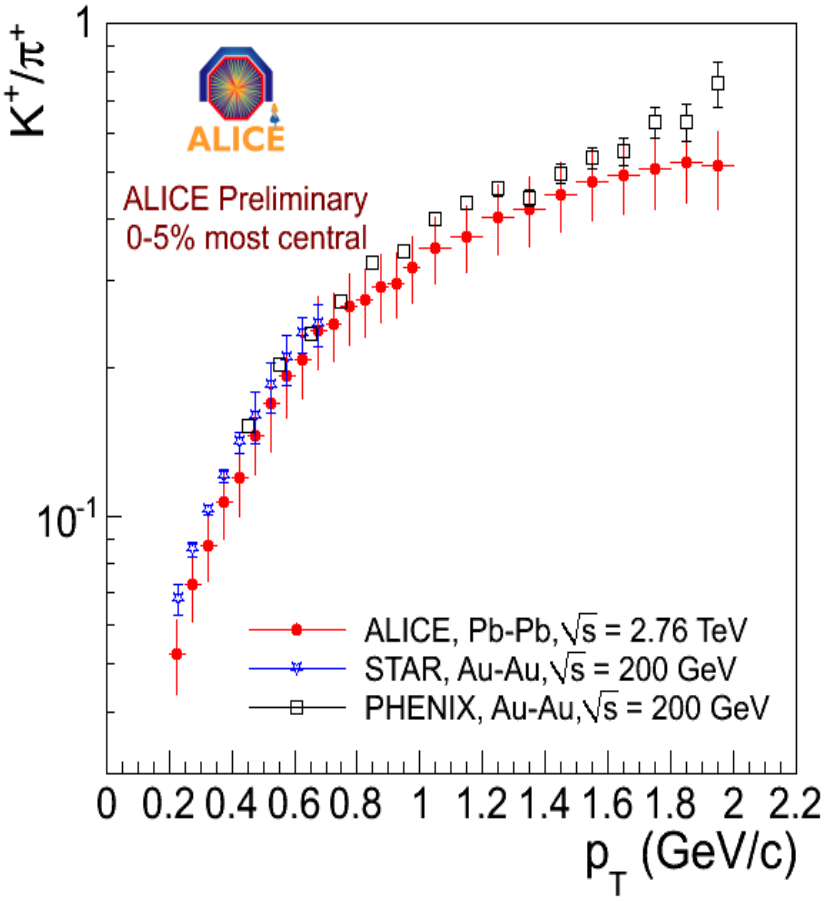
Time of Flight (TOF) *in Pb-Pb collisions*

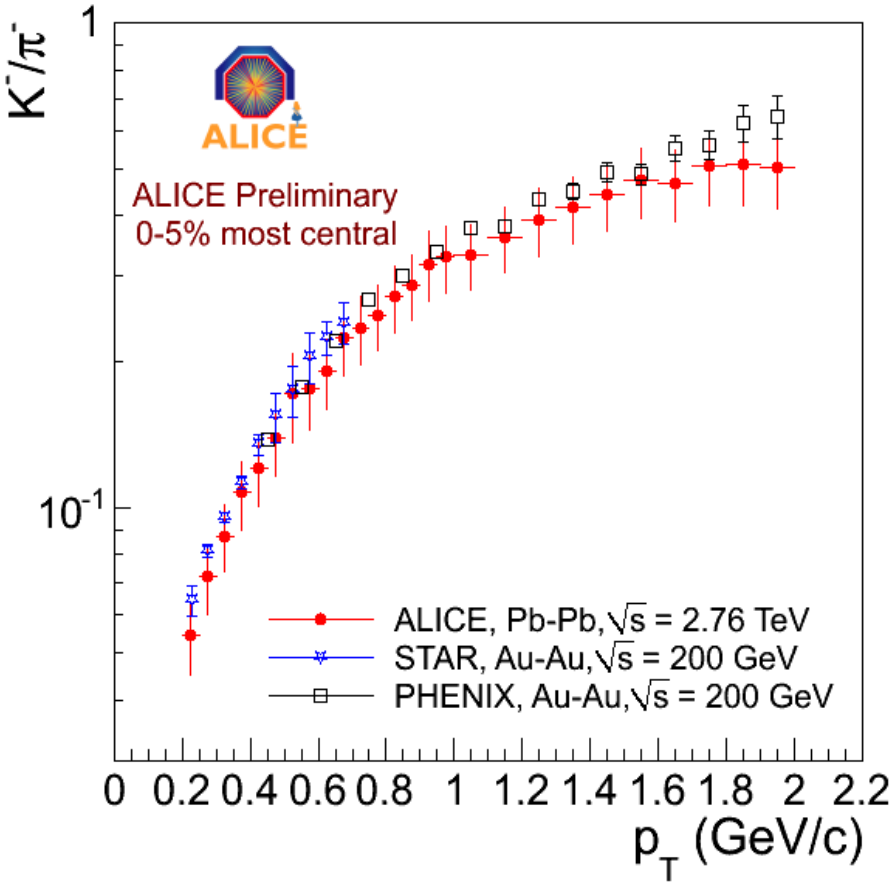


Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. Agreement of charged kaons and K^0_s in 3 centrality bins

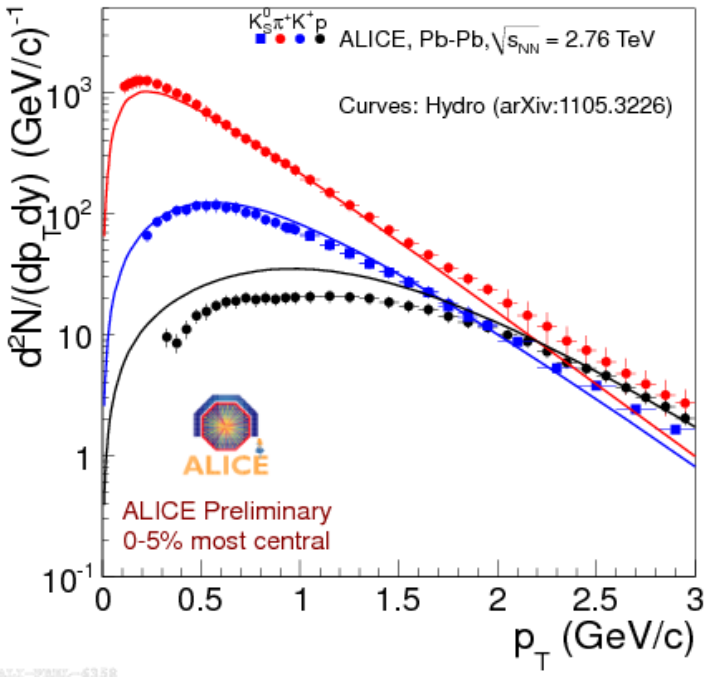


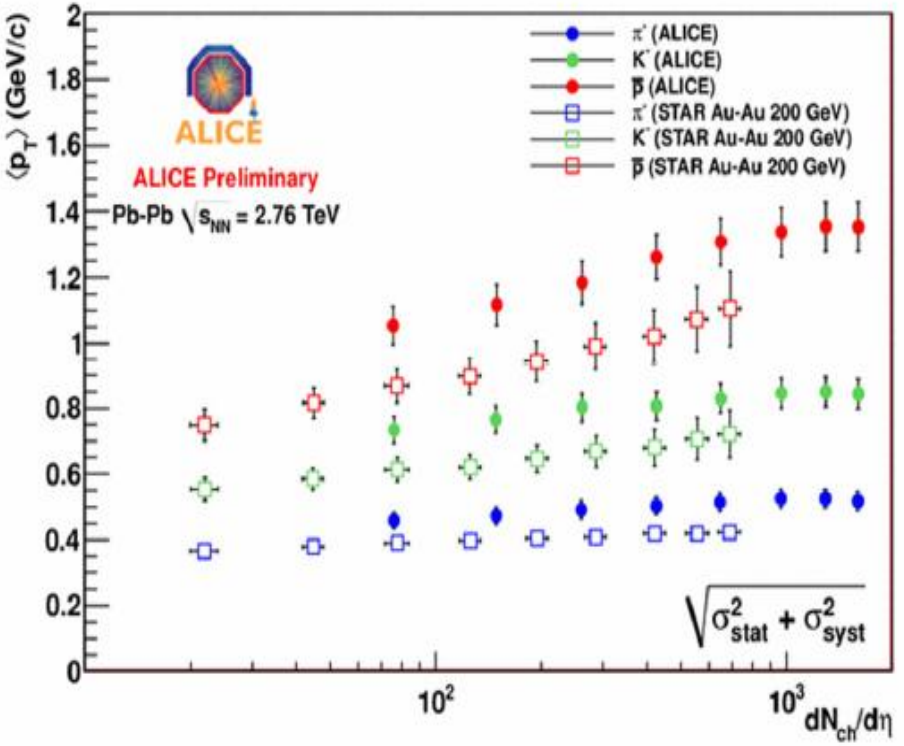
Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV.
K/π ratios are similar at RHIC and LHC energies





Positive K/π , p and K^0 spectra in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV together with hydro predictions





Yields and spectra of π and K are in good agreement with hydro predictions

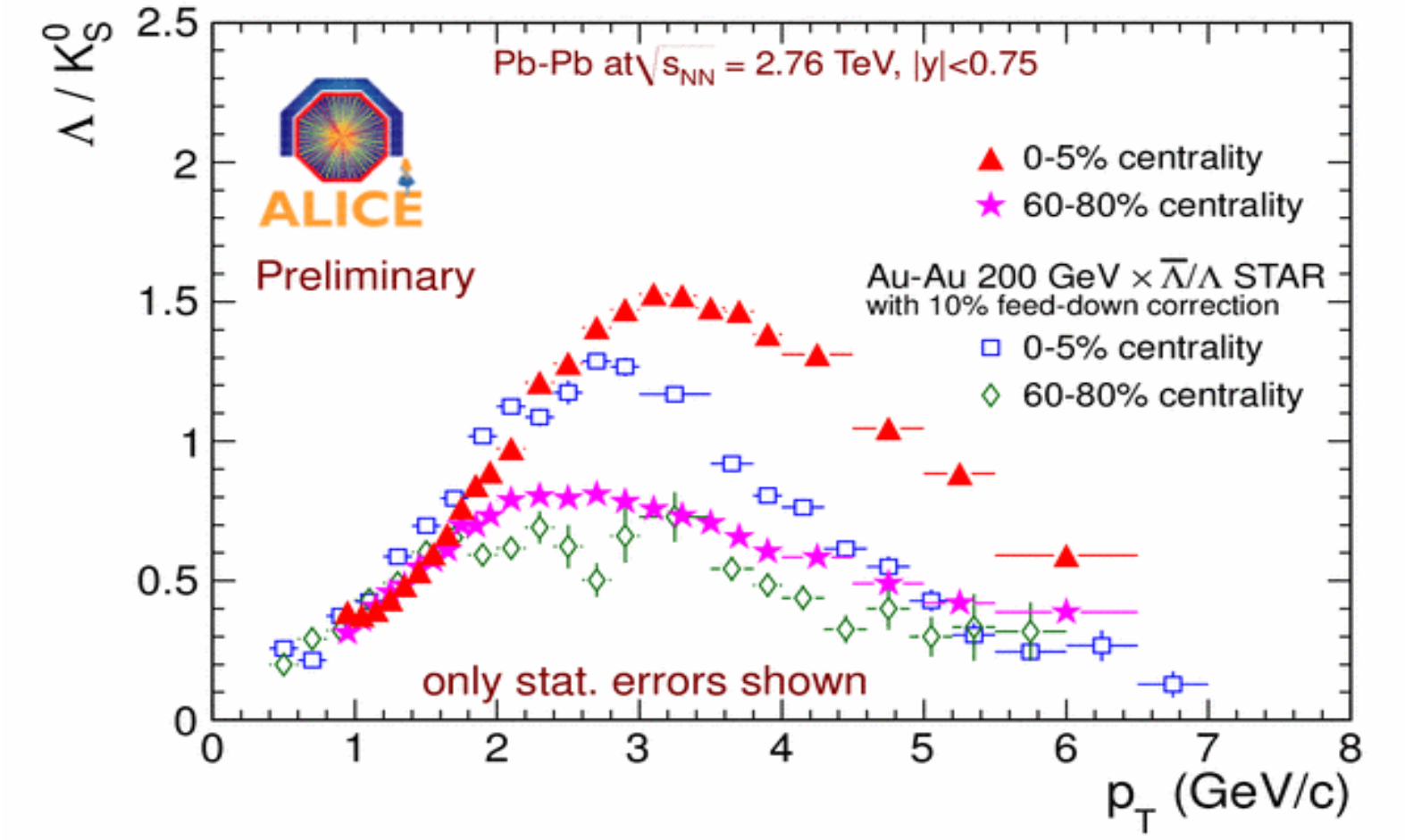
Harder spectra and flatter protons than at RHIC

$< p_t >$ increases with $dN_{ch}/d\eta$

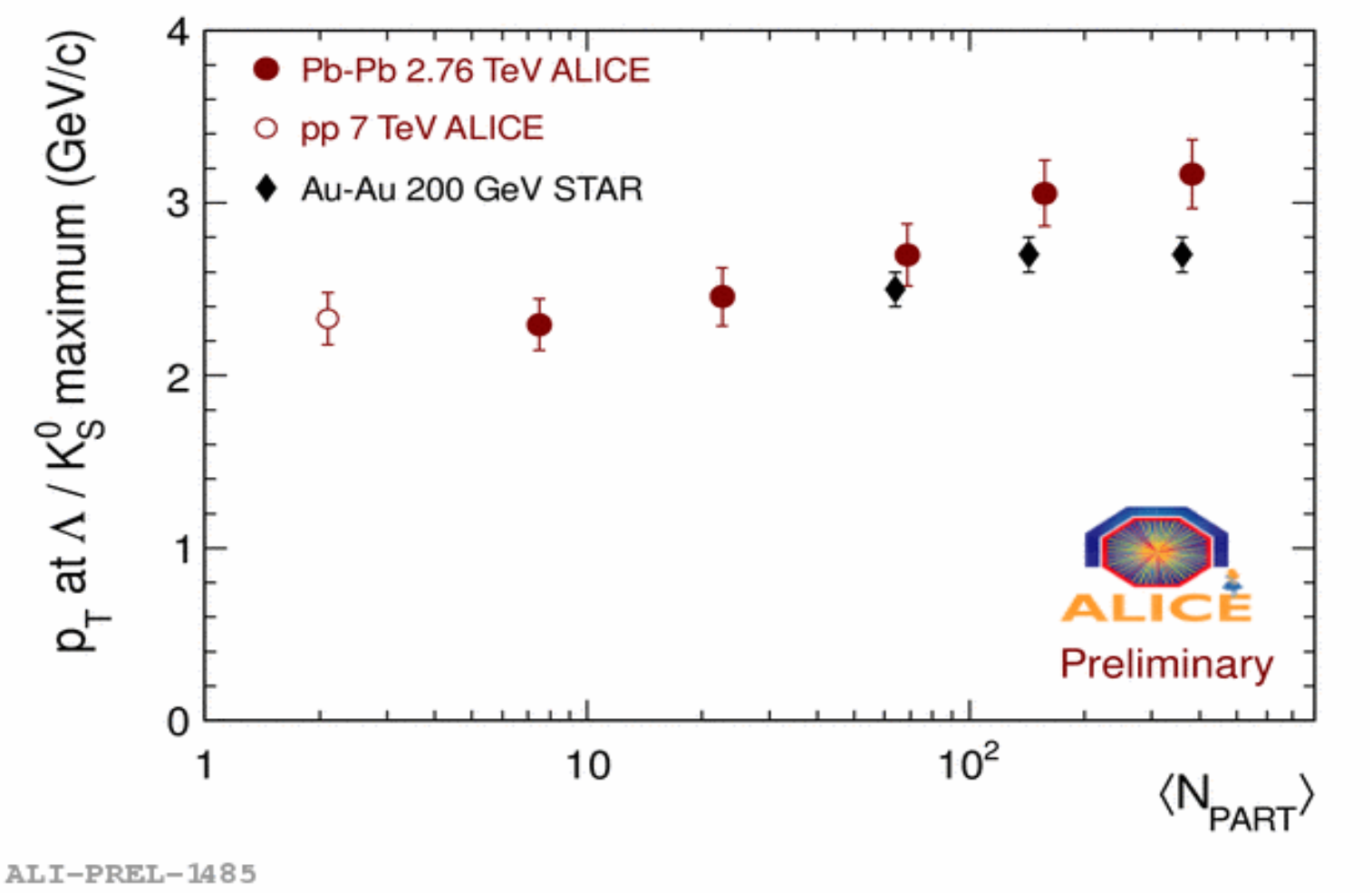
$< p_t >$ is higher than at RHIC for similar $dN_{ch}/d\eta$

Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV.

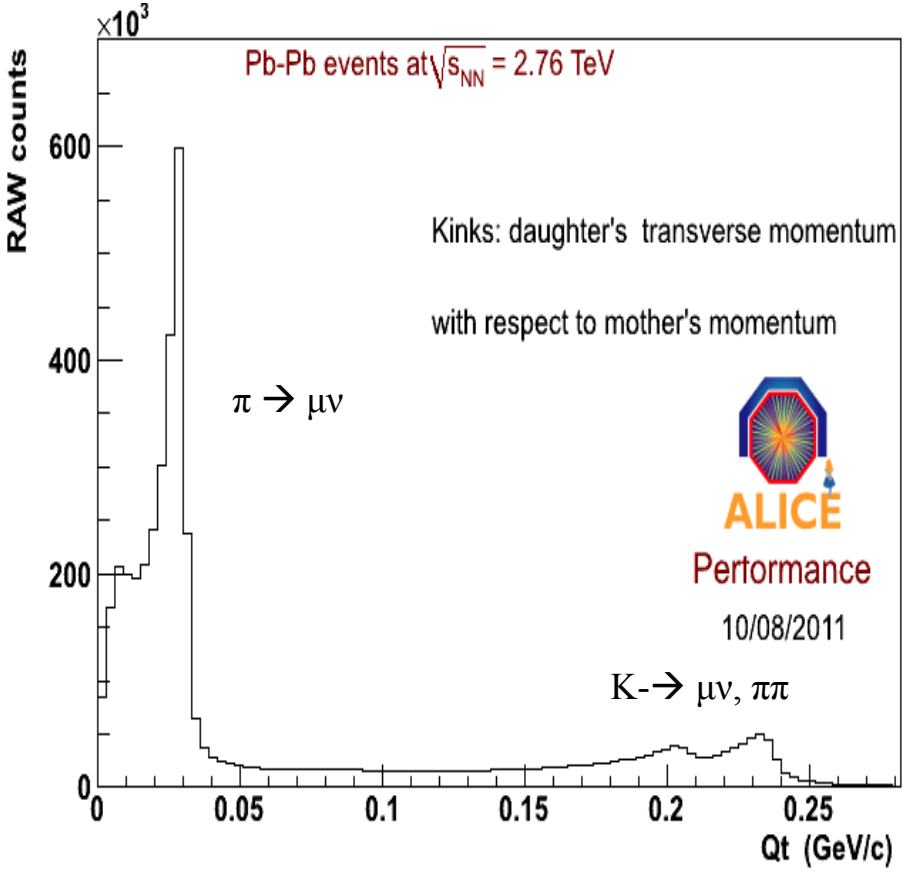
The production of Λ is enhanced compared with the production of K^0_S

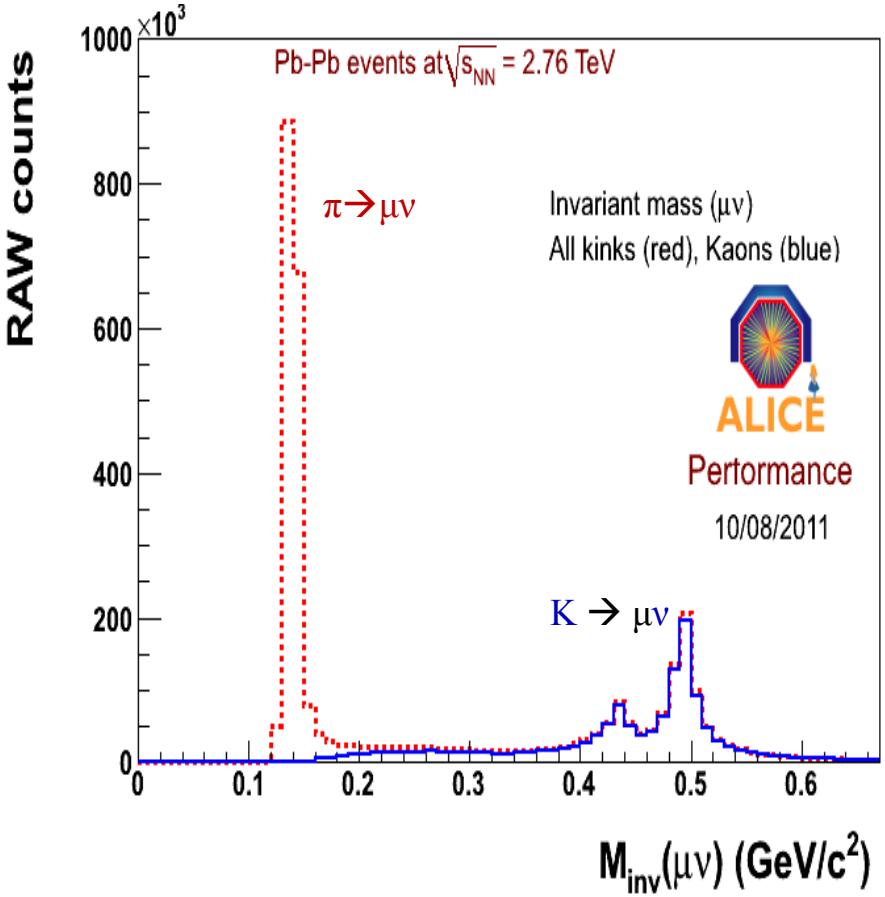


The position of the maximum value of the Λ/K ratio measured by ALICE is higher than that observed by STAR at RHIC.



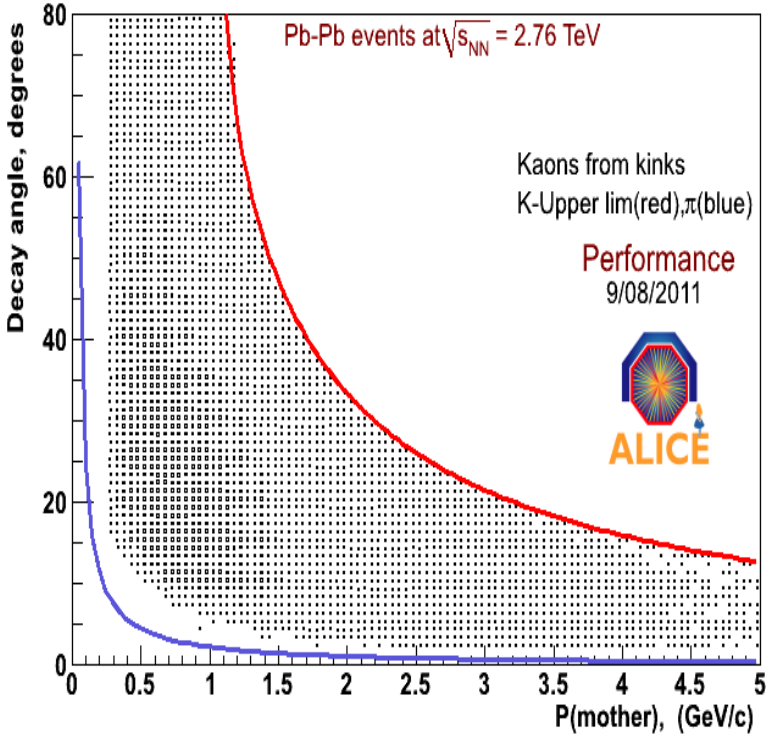
Pb-Pb collisions at 2.76 TeV, kinks study, 560k events

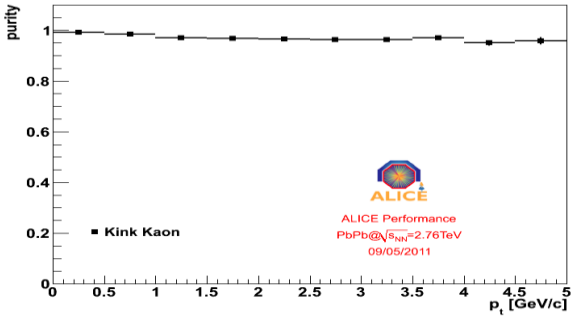




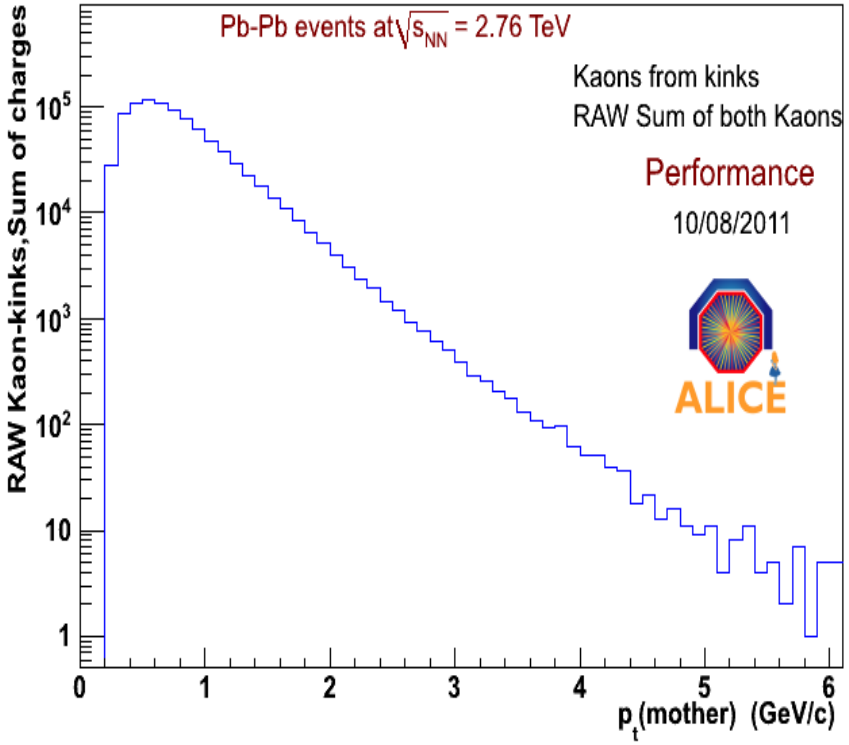
Pb-Pb collisions at 2.76 TeV, kinks study, 560k events

Clean sample. Background ~2%





The RAW pt distribution of both charges, shows that the method allows the K- identification at intermediate p_t up, at least, 10 GeV/c



SUMMARY I

ALICE has very good capabilities for the measurement of identified particles

• Particle spectra of various identified spectra have been extracted, e.g. charged pions, kaons, protons, neutral K, Λ , Ξ , Ω ,resonances.
The identified particles are used in many signatures in exploring the hot dense medium created in HI collisions
• Various internal cross-checks between different detectors and identification techniques show consistent results., e.g. detectors signals and topological identification.

The kink topology can be used for Kaon identification in a p_t range 0-10GeV/c (at least, slides 17 and 27) on **a track by track** level with purity ~98%, both in pp and Pb-Pb collisions.
At intermediate transverse momentum, togerher with dE/dx studies in ALICE, will provide a useful tool in signatures using the relativistic rise region (e.g K/π ratio).

SUMMARY II

For pp collisions, as the energy increases from 900 GeV to 7 TeV :

--- spectra become harder (increase of $< p_t >$)

--- K/π ratios as function of p_t are similar

---ratios (dN/dy) K/π, remain constant

In Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV :

---Yields and spectra of π and K are in good agreement with hydro predictions

---Harder spectra and flatter protons than at RHIC

--- $< p_t >$ increases with $dN_{ch}/d\eta$

--- $< p_t >$ is higher than at RHIC for similar $dN_{ch}/d\eta$

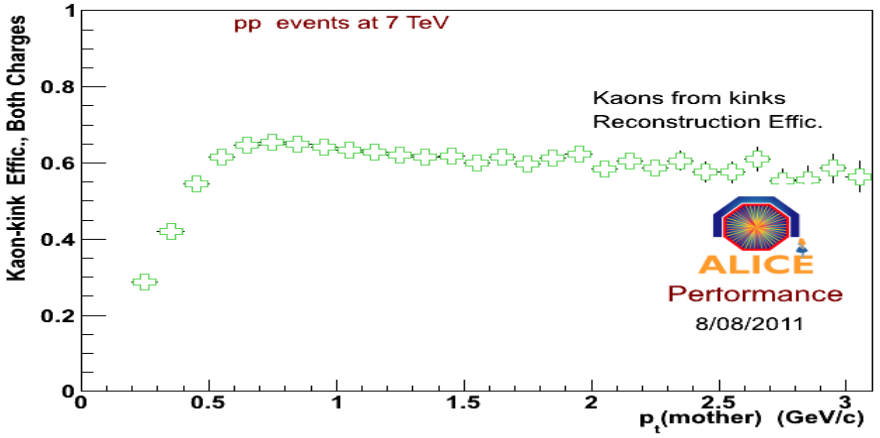
--- K/π ratios are similar at RHIC and LHC energies

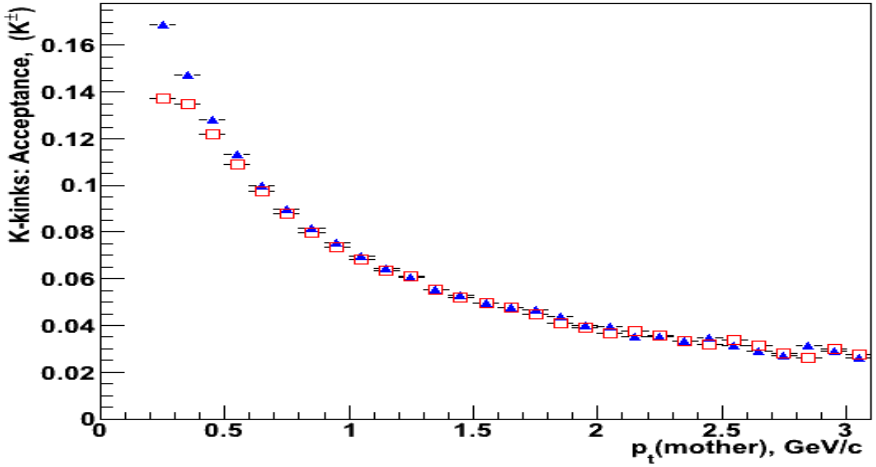
---At intermediate p_t, the production of Λ is enhanced compared with the production of K^0_S. The magnitude of this enhancement increases with the collision centrality

BACKUP

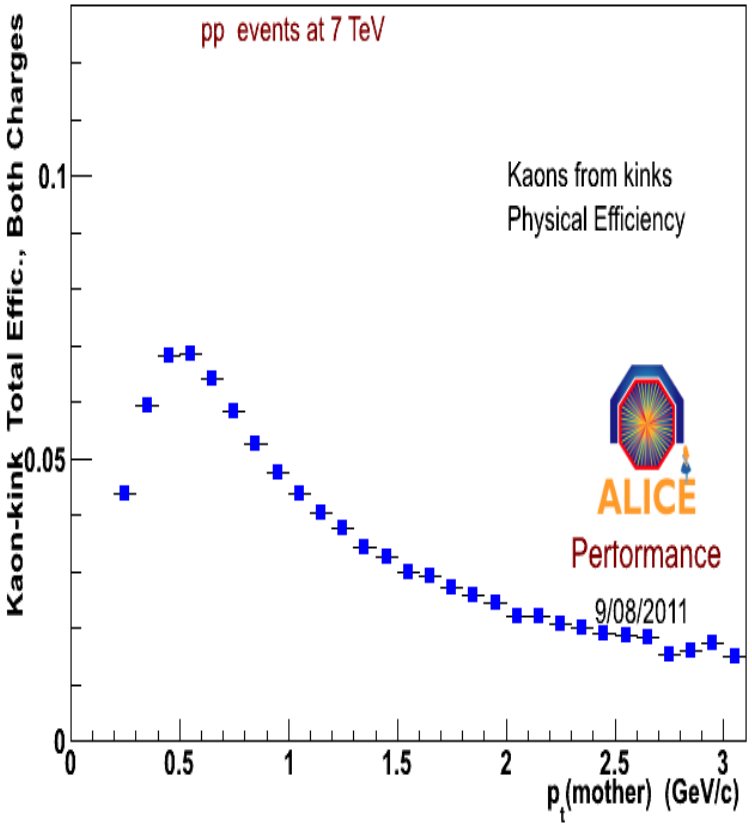
p-p collisions at 7 TeV, kinks study

Reconstruction efficiency



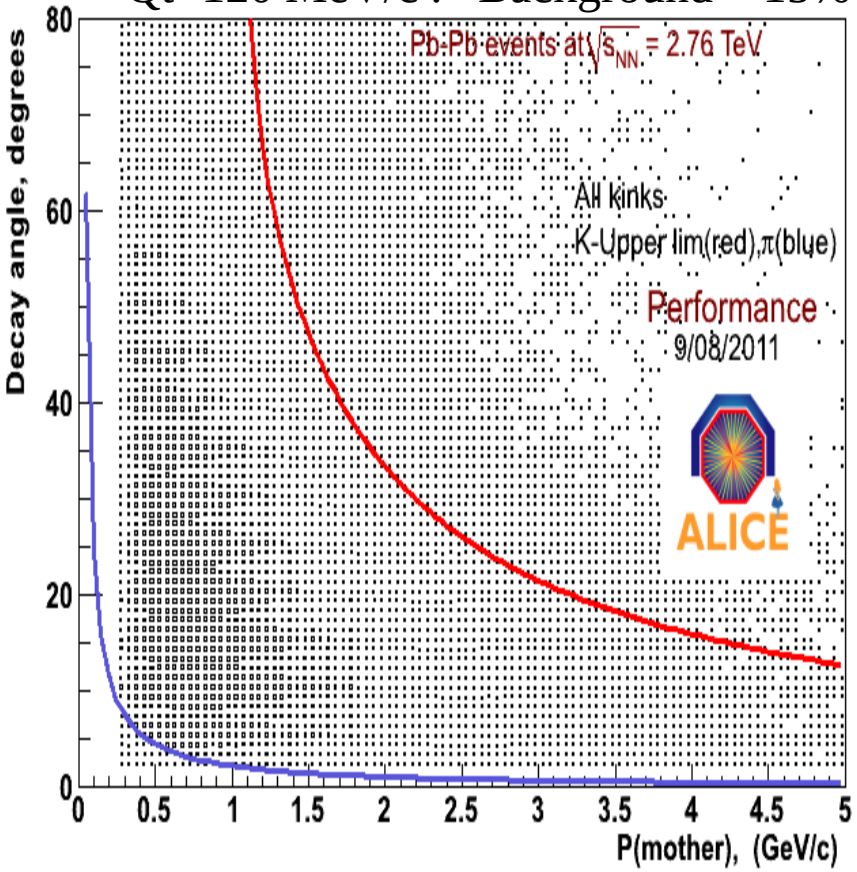


Total correction factor



ALICE Pb-Pb interactions at 2.76 TeV, RAW kaons from kinks

The two dimentional plot θ vs P shows the 'identified' Kaons ONLY after the Qt>120 MeV/c . Background ~ 15%



Kinematics of kink K/π to μν decays, ALICE_INT-2006-012

The momentum of the daughter muon in the K/π rest frame is 236 and 30 MeV/c respectively.

This is the maximum Qt value of the muon in the Lab frame.

The muon decay angle in the parent rest frame and in the lab system are connected as:

$$\tan\theta_{lab} = \frac{p_{rest}\sin\theta_{rest}}{\gamma^{*}p_{rest}\cos\theta_{rest} + \beta^{*}\gamma^{*}E_{rest}}$$

The maximum Lab. Decay angle is :

$$(\tan\theta_{lab})_{\max} = \frac{p_{rest}}{\gamma^{*}E_{rest}}\frac{1}{\sqrt{\beta^{*2} - p^{2}_{rest}/E^{2}_{rest}}}$$