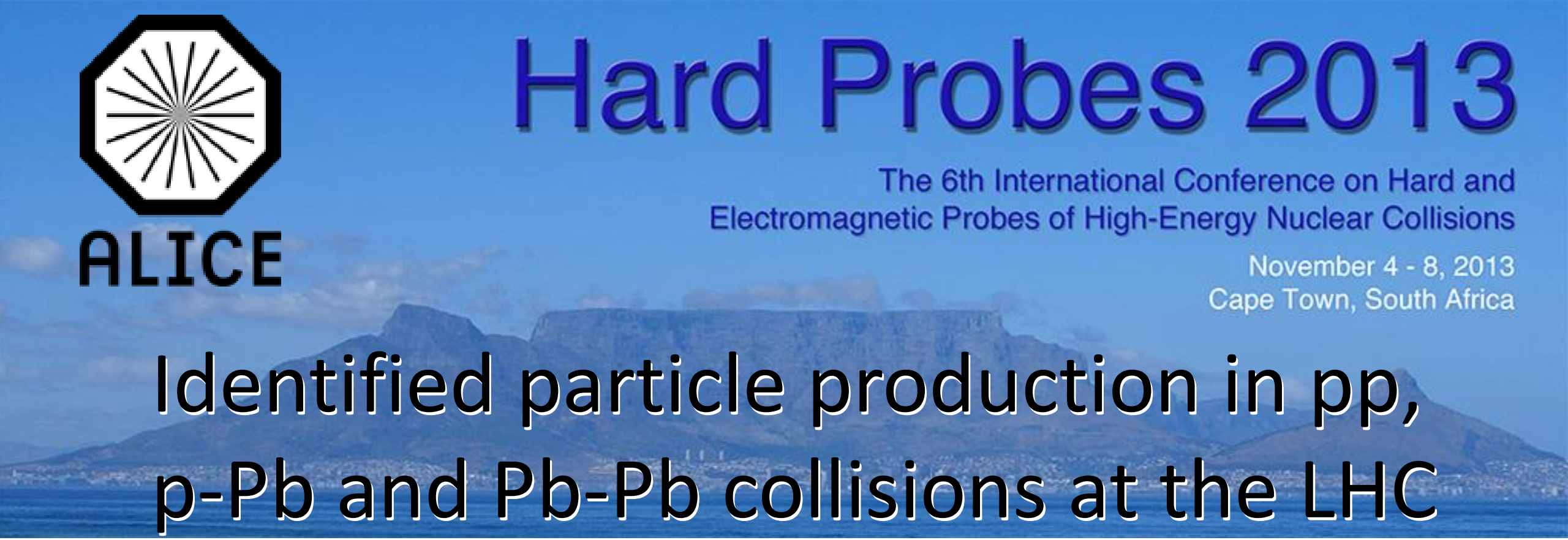


Identified particle production in pp, p-Pb and Pb-Pb collisions at the LHC

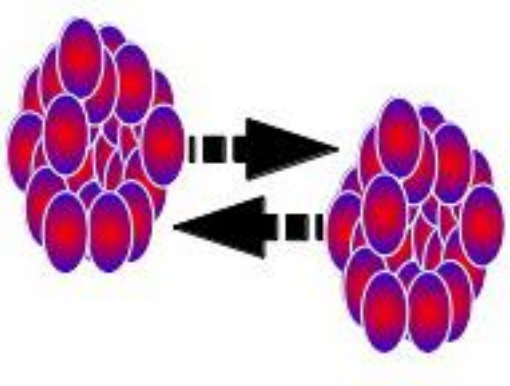
Antonio Ortiz Velasquez
for the ALICE Collaboration

Outline

- Motivation.
- Particle identification with ALICE detectors.
- Spectra and R_{AA} in Pb-Pb collisions.
- Spectra and particle ratios as a function of multiplicity in p-Pb collisions.

  New results, identification of π/K/p at high p_T, up to 15 GeV/c.
- Similarities and differences among: pp, p-Pb and Pb-Pb collisions.
- Summary.

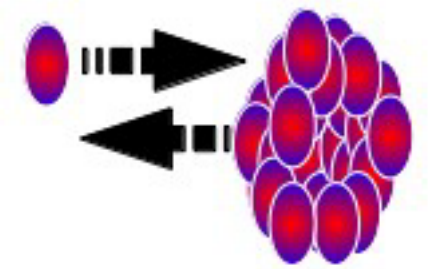
Motivation



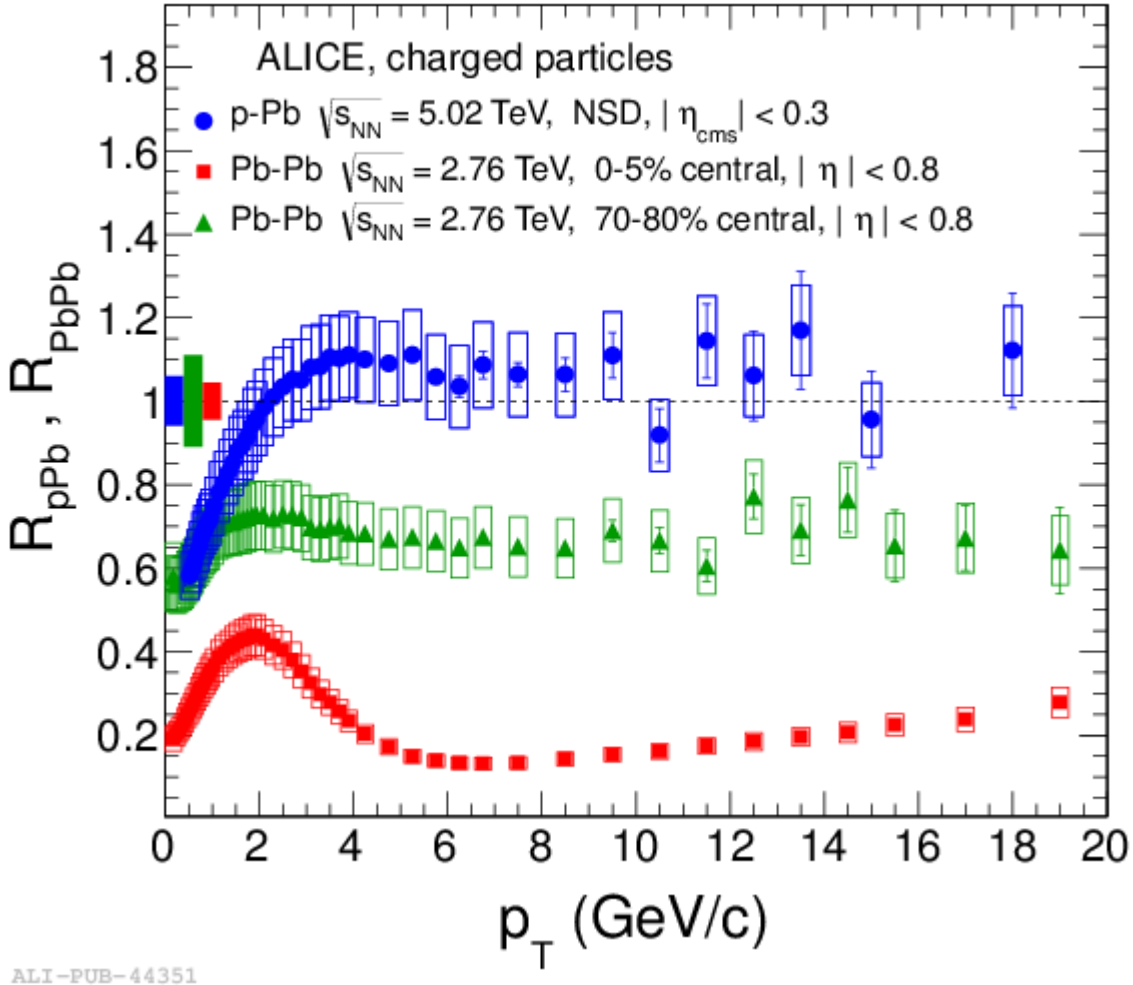
Pb-Pb collisions produce a hot and dense medium, QGP,

$$R_{\mathrm{AA}} = \frac{\mathrm{d}^2 N^{\mathrm{AA}}/\mathrm{d}p_{\mathrm{T}}d\eta}{\langle T_{\mathrm{AA}}\rangle \mathrm{d}^2\sigma^{\mathrm{pp}}/\mathrm{d}p_{\mathrm{T}}d\eta}$$

$$\langle T_{\mathrm{AA}}\rangle \sigma^{\mathrm{pp}} = \langle N_{\mathrm{coll}}\rangle$$



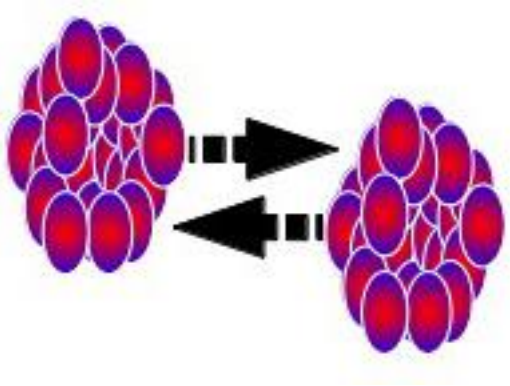
p-Pb collisions allow one to study cold nuclear matter effects which are present also in Pb-Pb collisions.



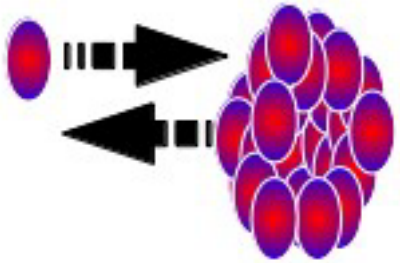
Phys. Rev. Lett. 110, 082302 (2013)

Motivation

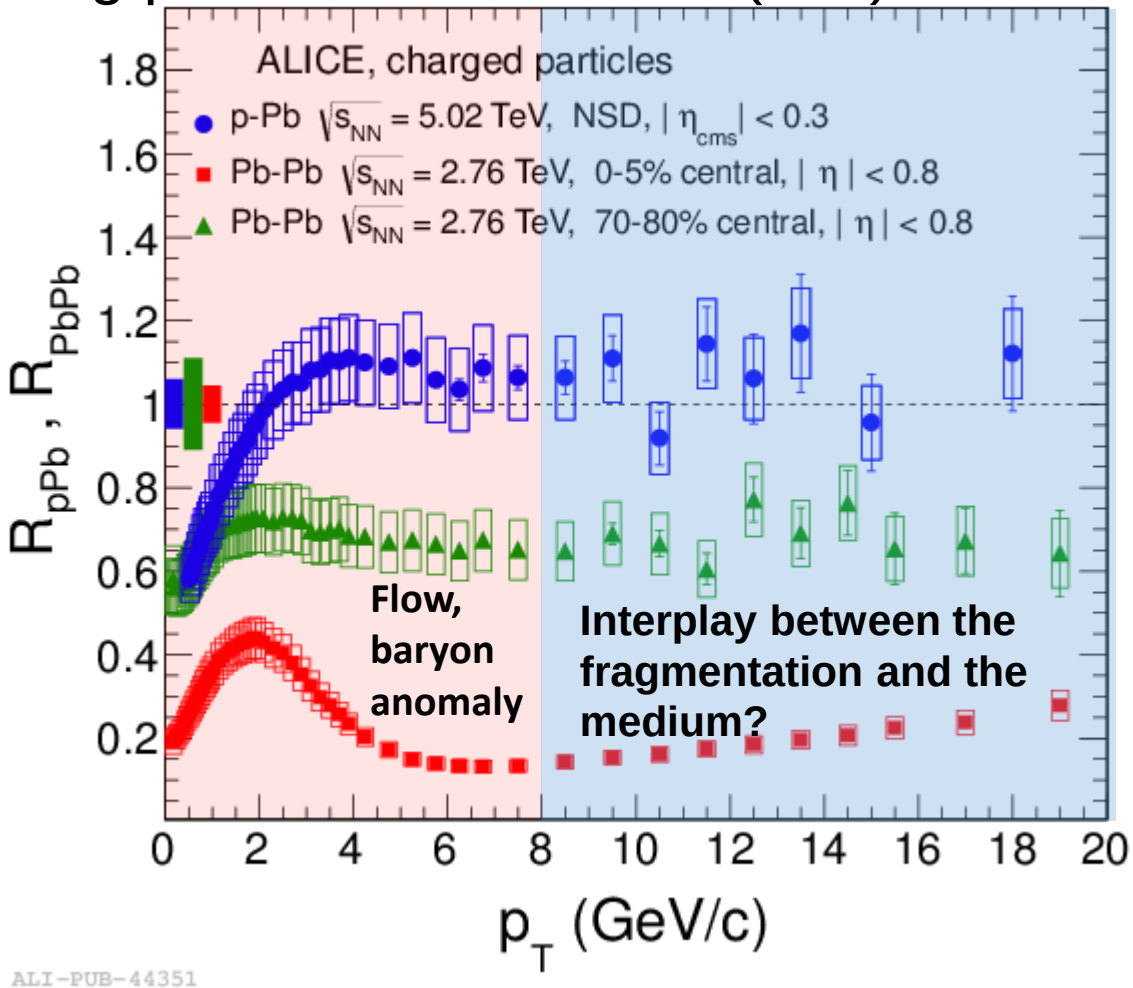
We can extract more information using particle identification (PID).



Pb-Pb collisions produce a hot and dense medium, QGP, where effects due to collective expansion, quark recombination and jet quenching could be observed.



p-Pb collisions allow one to study cold nuclear matter effects which are present also in Pb-Pb collisions.



Phys. Rev. Lett. 110, 082302 (2013)

ALICE detectors

Trigger and centrality (multiplicity) in Pb-Pb (p-Pb) collisions:

V0

Particle identification:

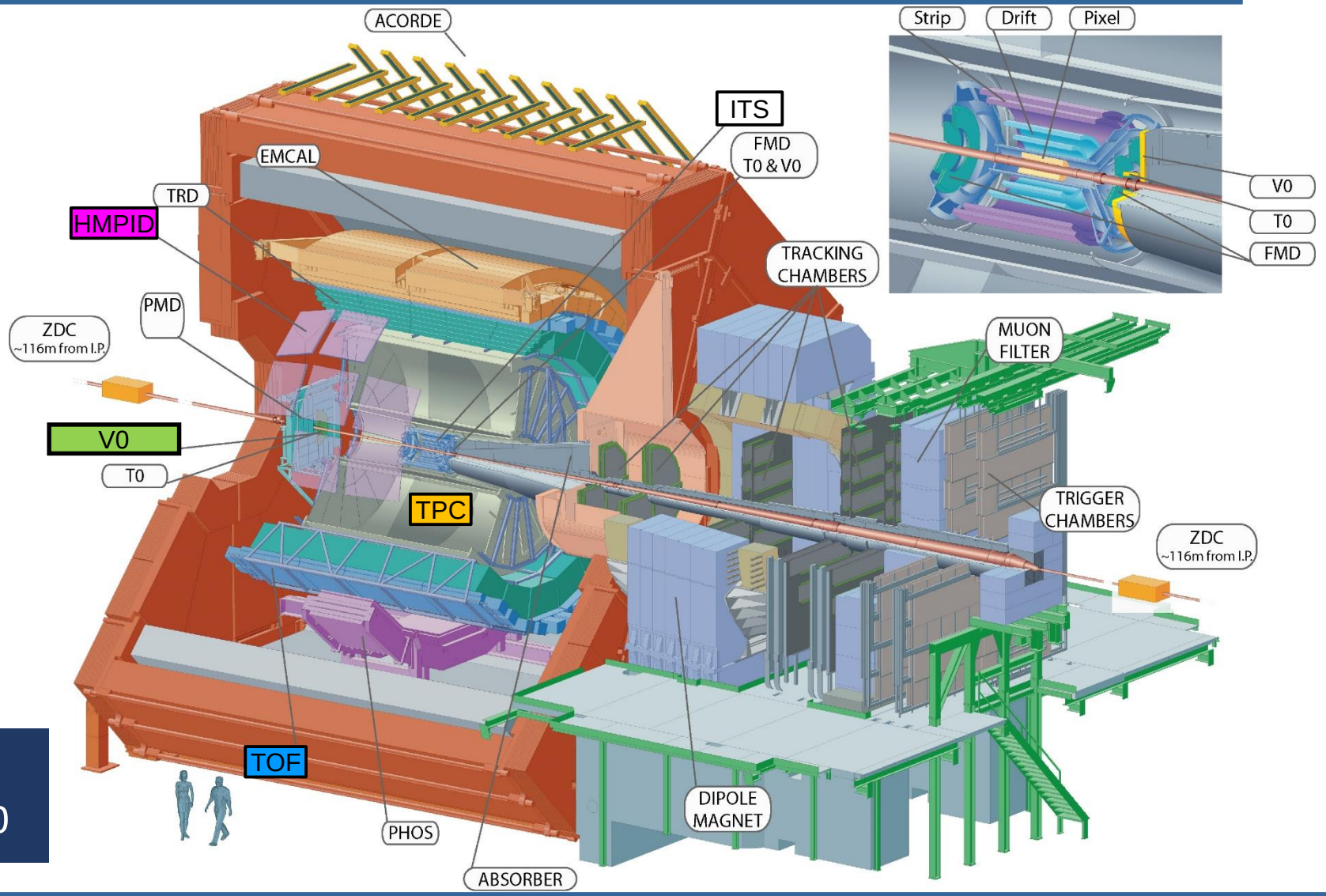
TPC

ITS

TOF

HMPID

See talk of F. Prino
04/Nov/2013, 09:30



PID in ALICE

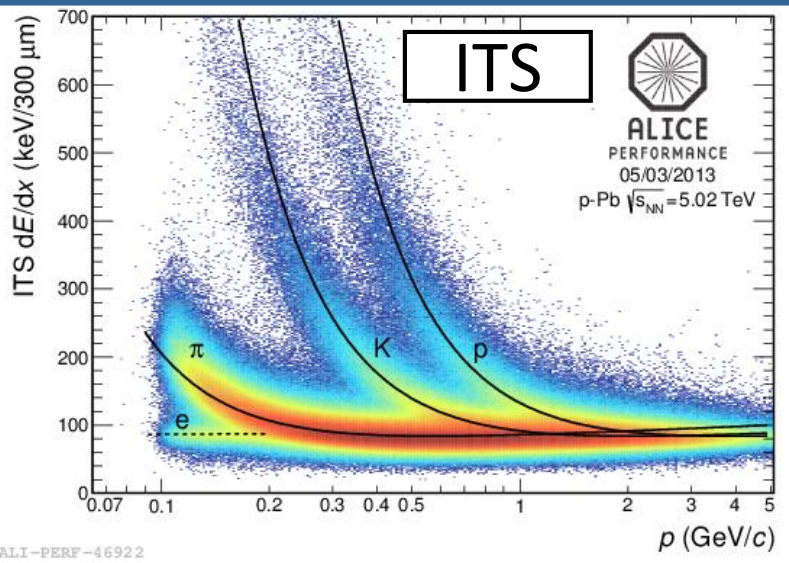
Particle identification:

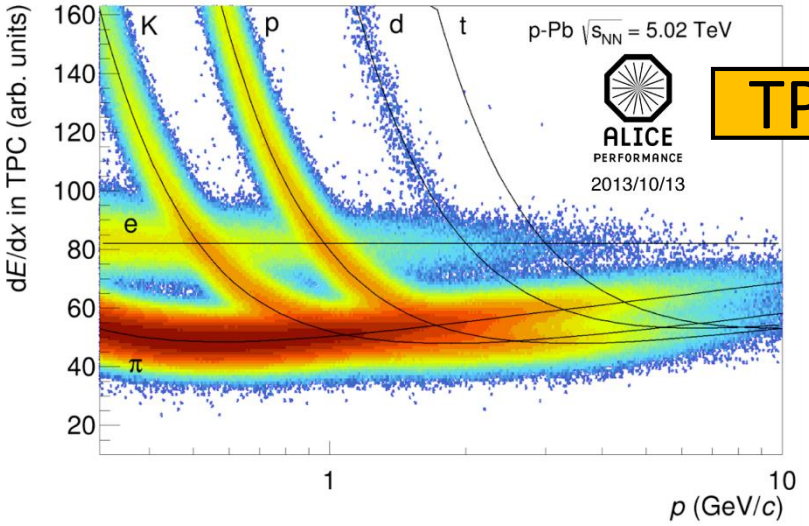
TPC

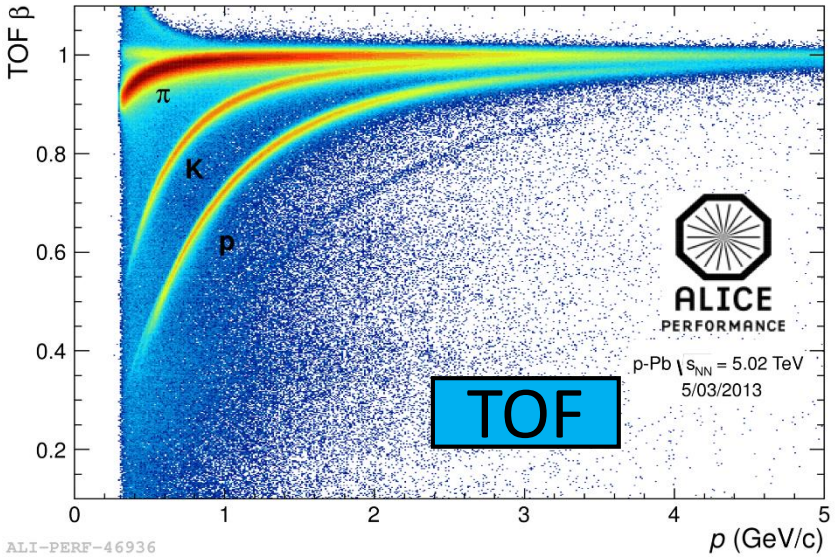
ITS

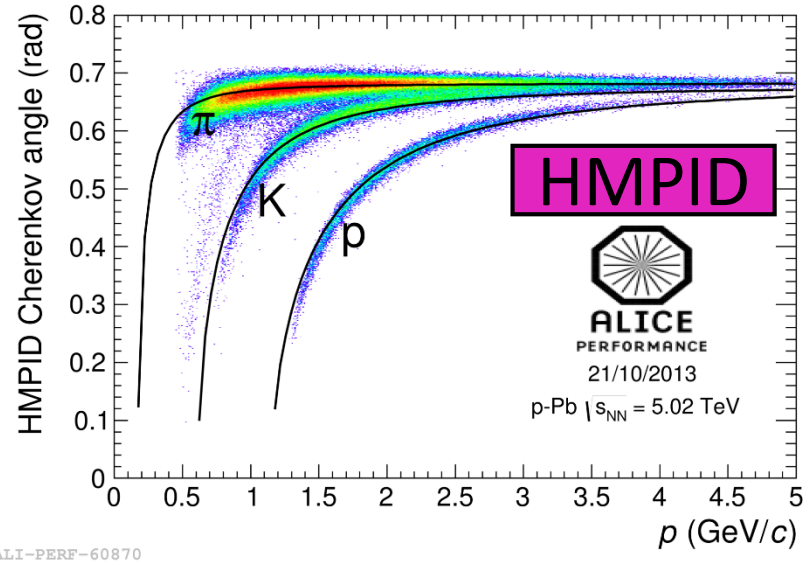
TOF

HMPID









PID in ALICE

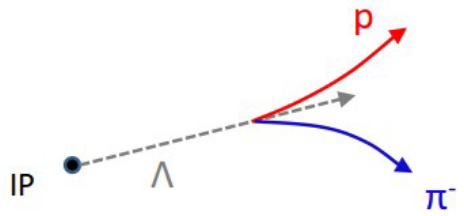
Topological PID:

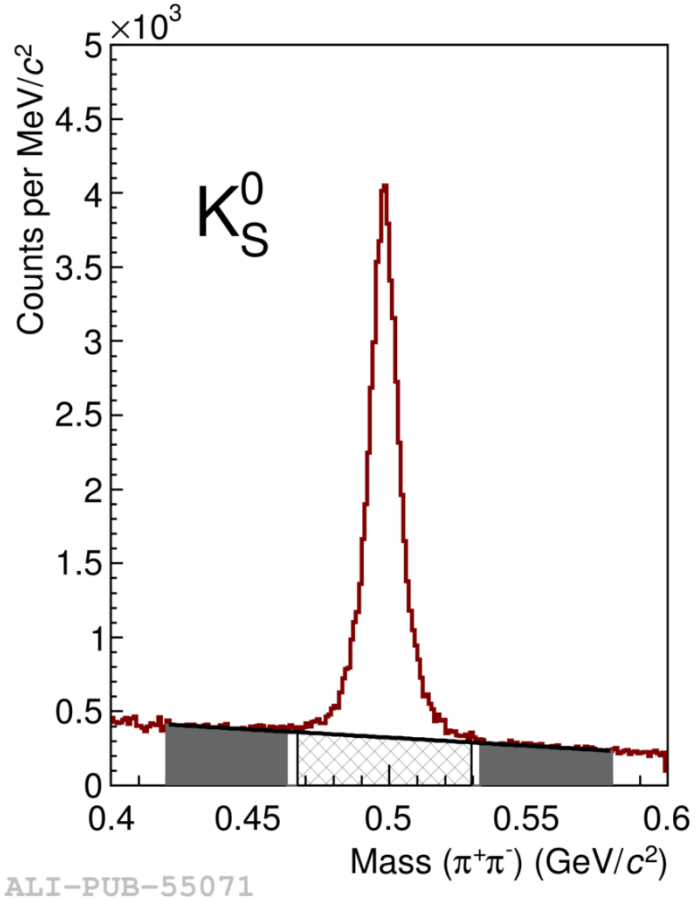
$K_S^0 \longrightarrow \pi^+ + \pi^-,$

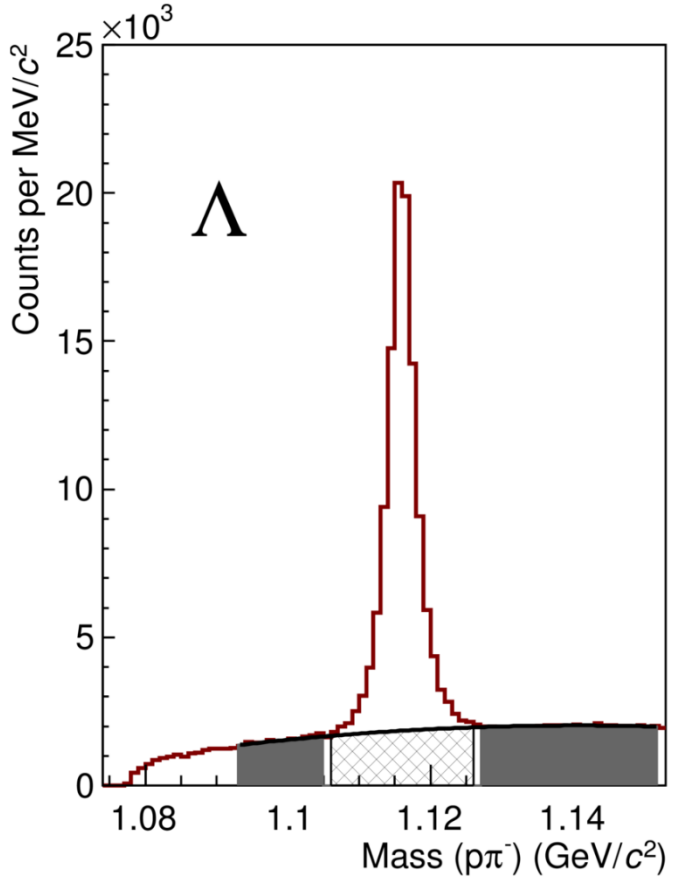
$\Lambda \longrightarrow p + \pi$

Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV, $|y|<0.5$

$3.0<p_T<3.2$ GeV/c, 0-5% centrality

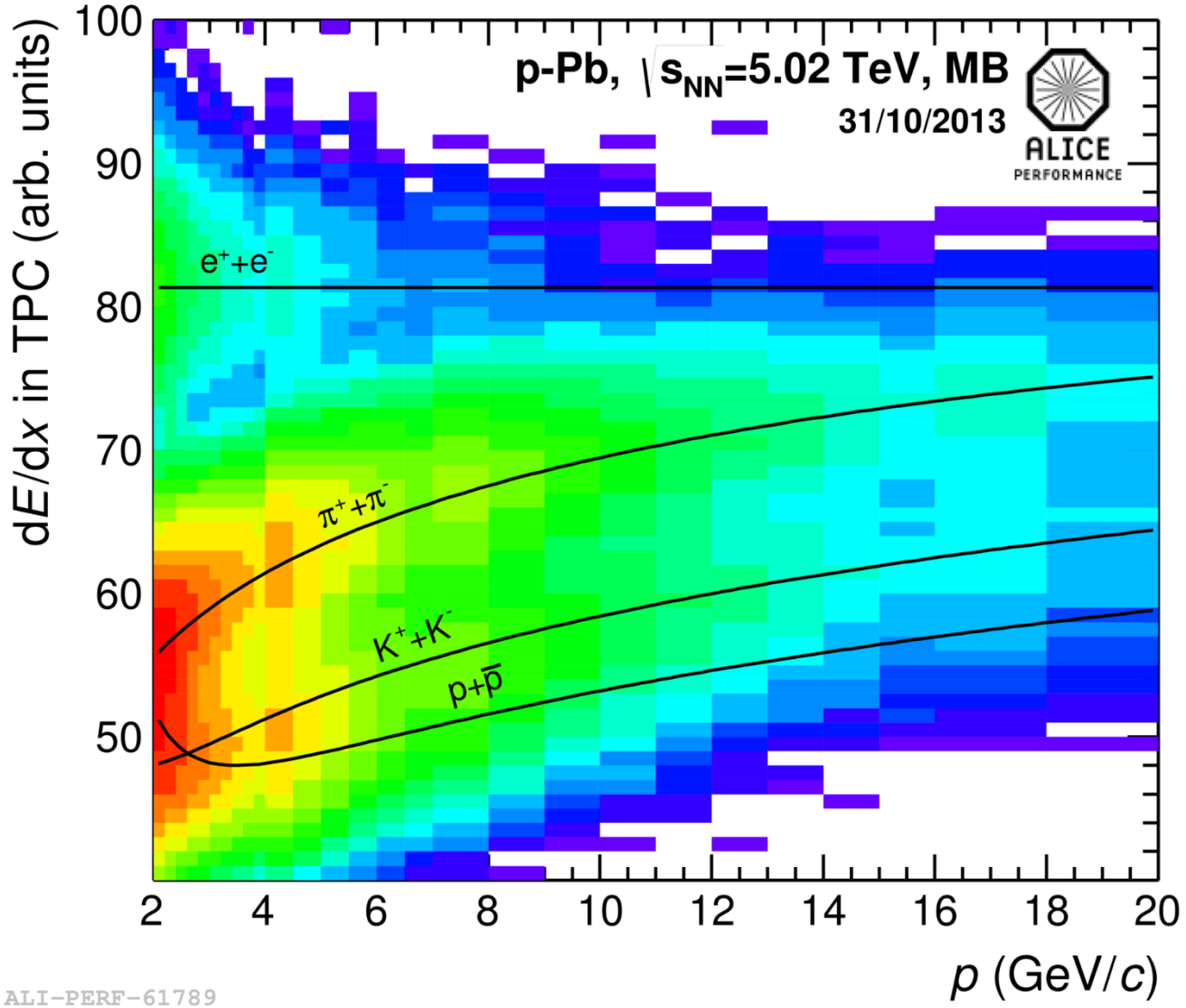






ALI-PUB-55071

Statistical PID at high p_T

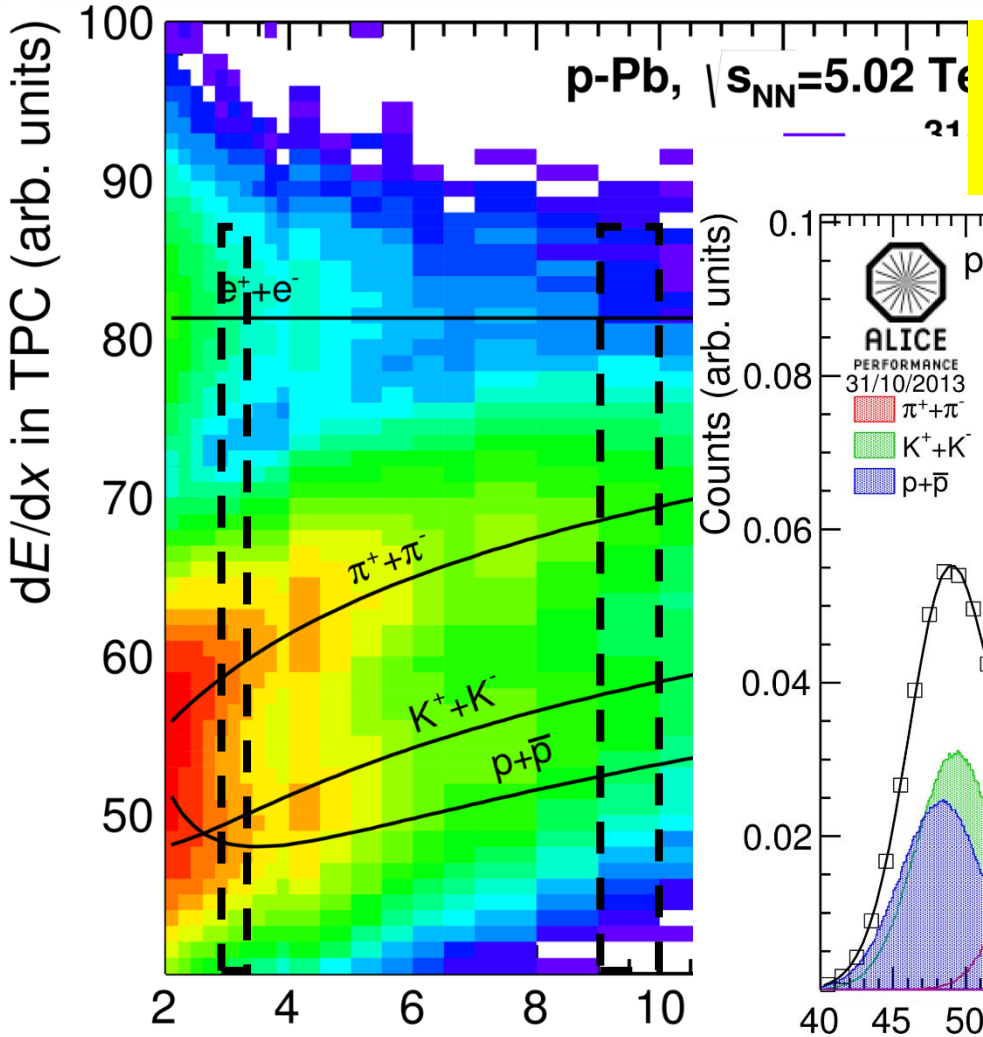


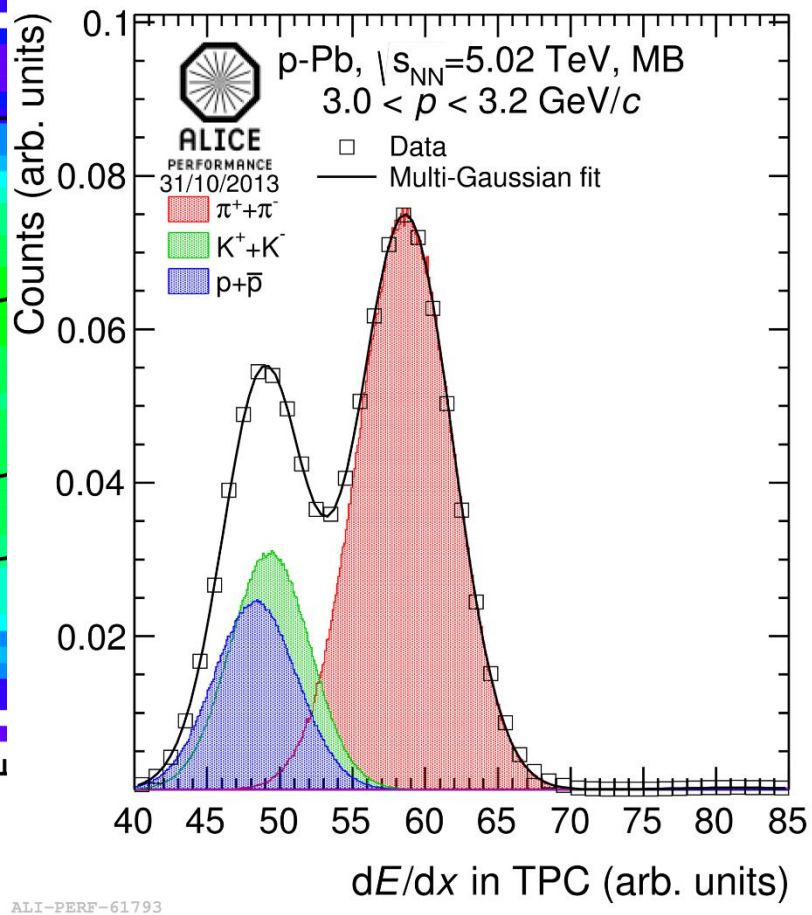
This is done in the relativistic rise regime of the Bethe-Bloch curve, where the <d*E*/d*x*> separation between particles with different masses is nearly constant.

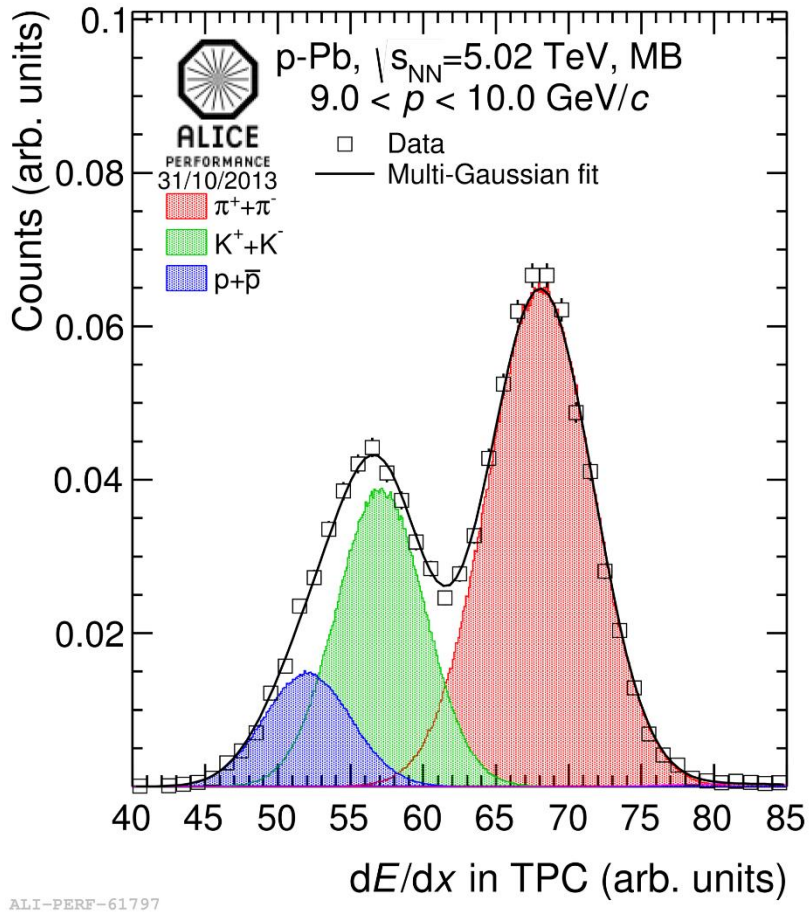
The parametrization of the Bethe-Bloch and resolution uses clean samples of identified particles.

Statistical PID at high p_T

Examples of multi-Gaussian fits to d*E*/d*x* signals in two *p* intervals.

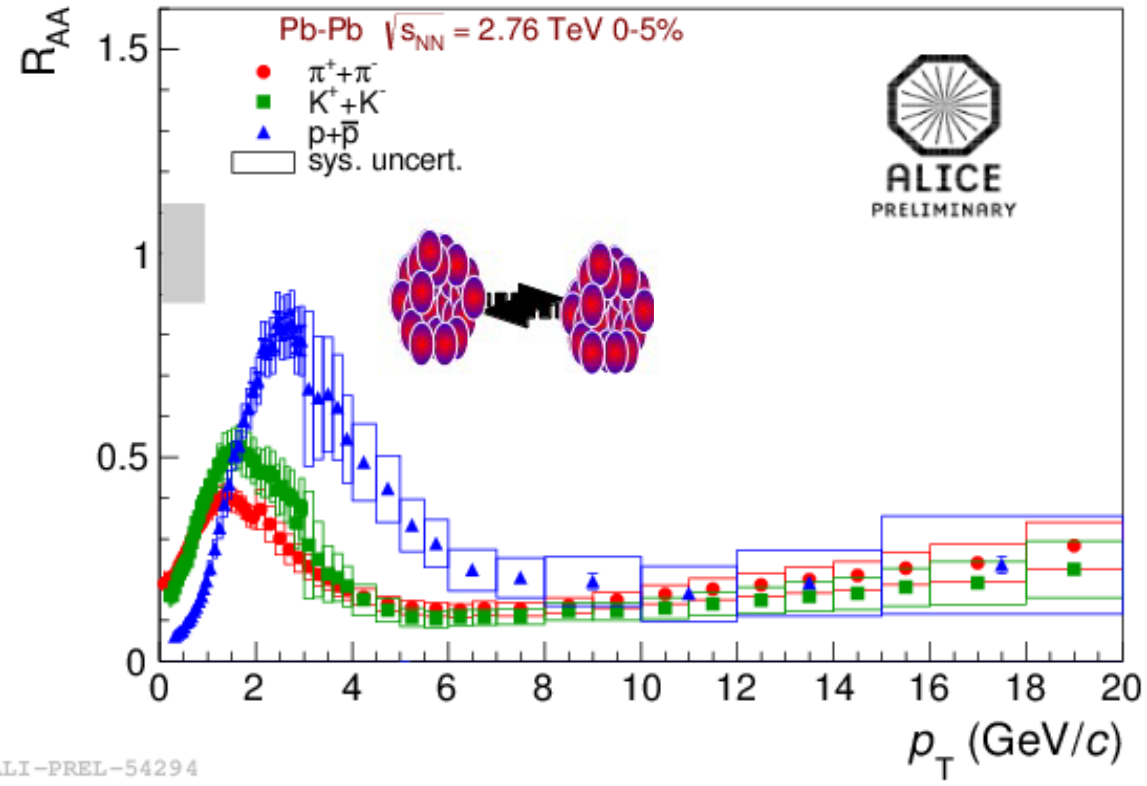


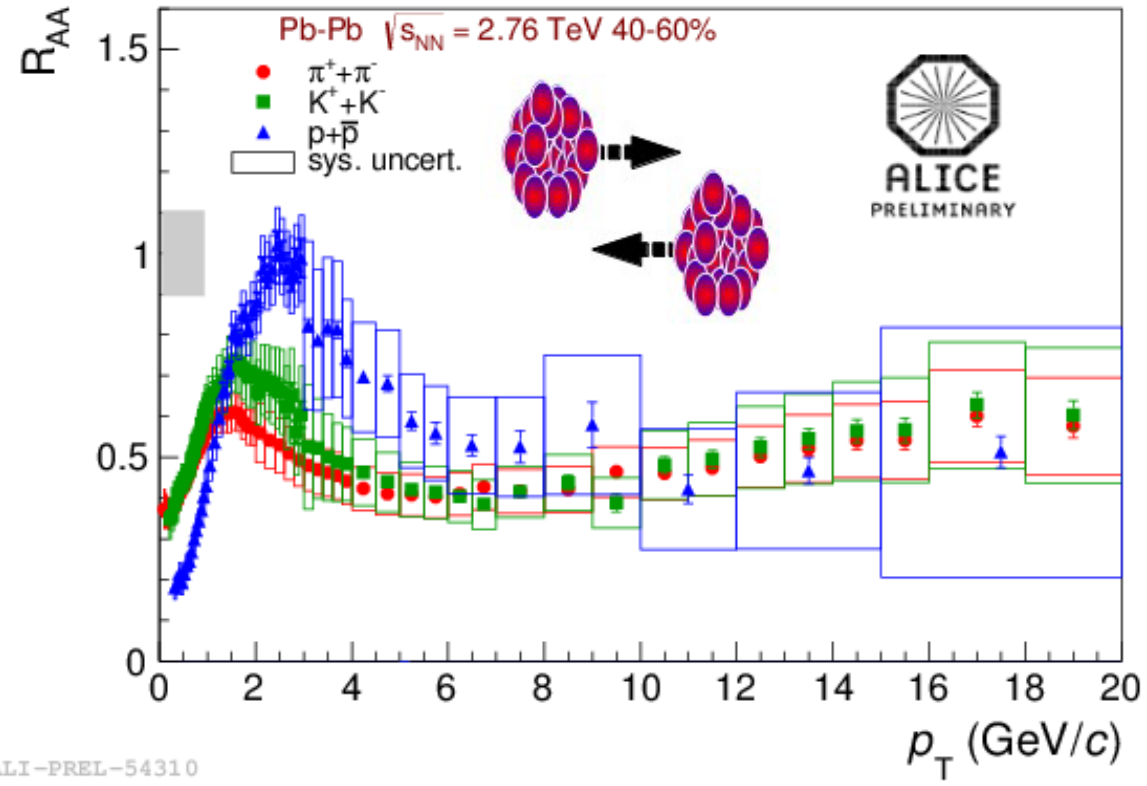




High p_T production

At high p_T (>8 GeV/c), within the systematic uncertainties pions, kaons and protons are equally suppressed.





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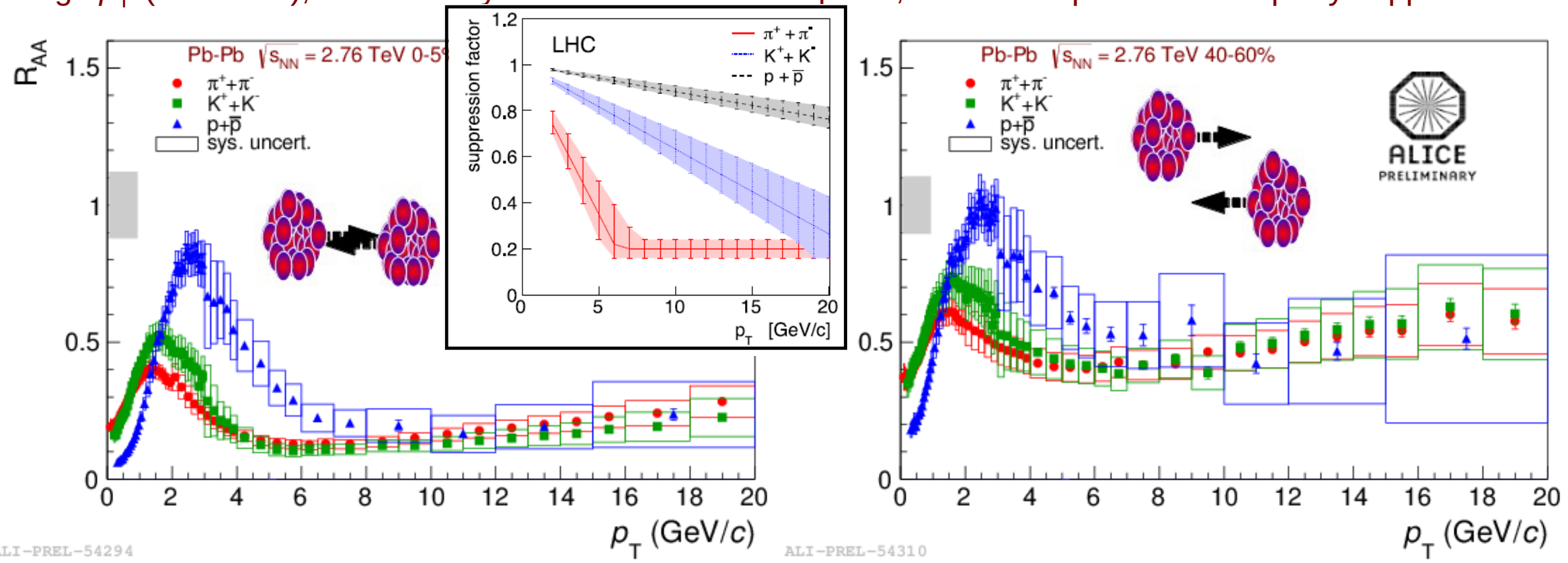
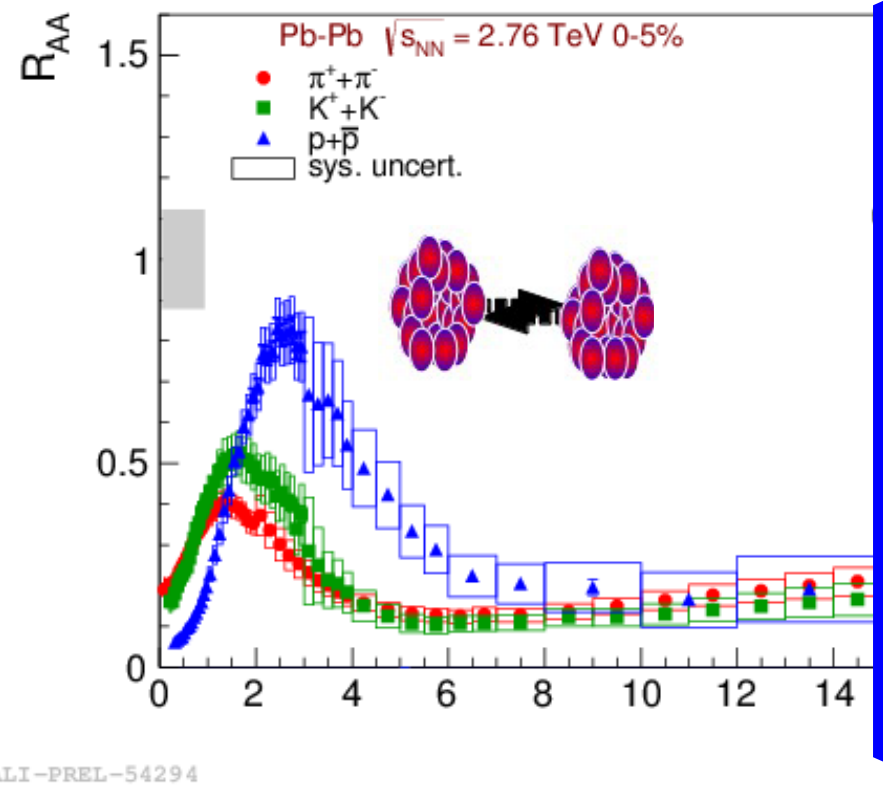
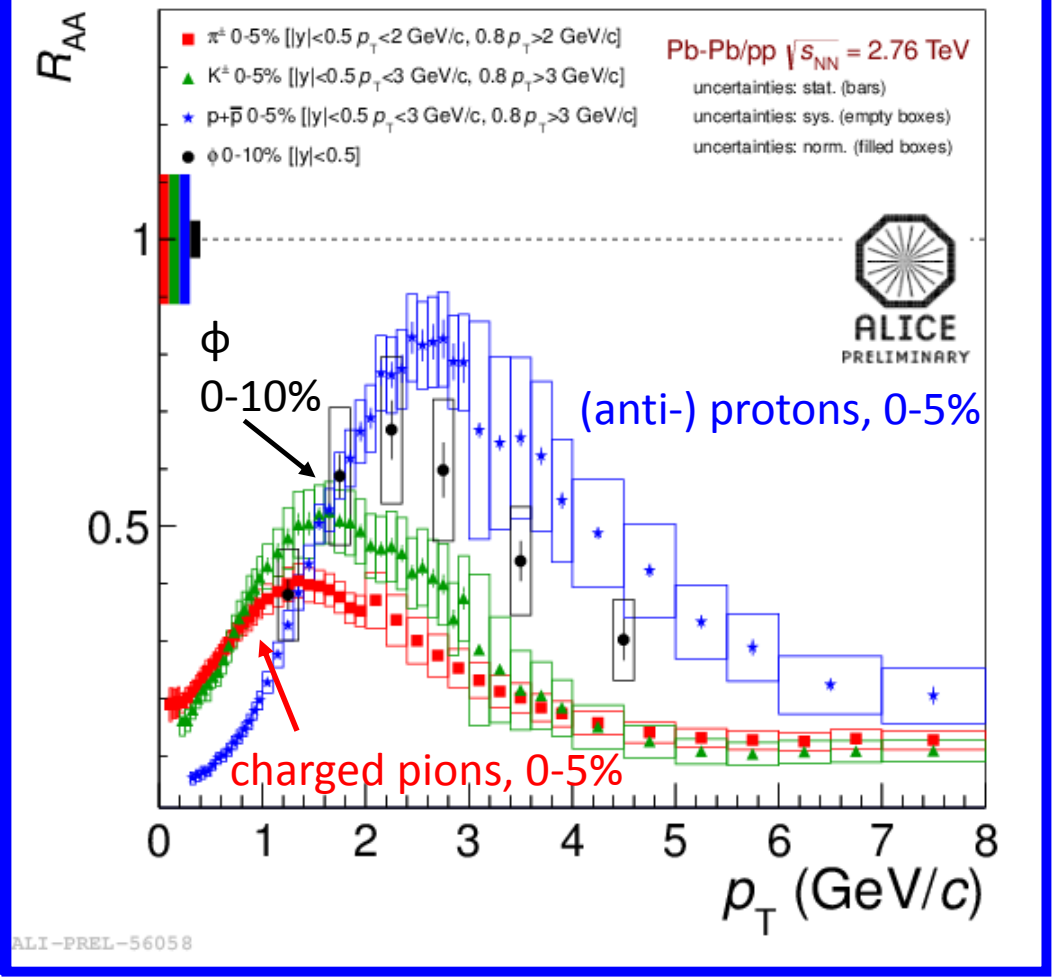


In some models $R_{AA}^{p} > R_{AA}^{K} > R_{AA}^{\pi}$, for example assuming in-medium hadronization based on formation time: Phys. Lett. B 691, 208 (2010).

High p_T production



R_{AA} of φ

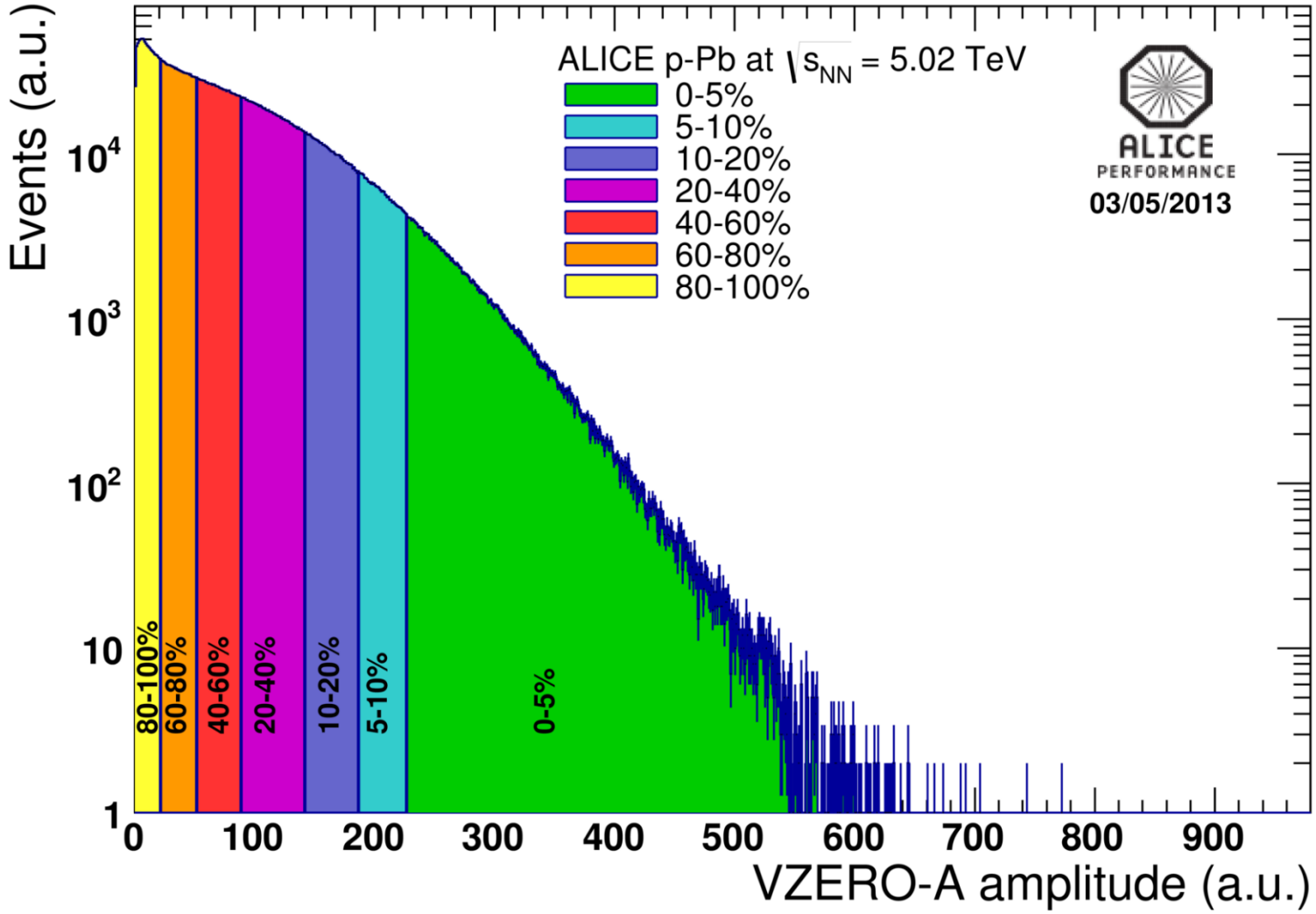


At low p_T (<2 GeV/*c*) R_{AA} for φ and p follow the same curve, this is interesting because here we expect hydrodynamic effects.

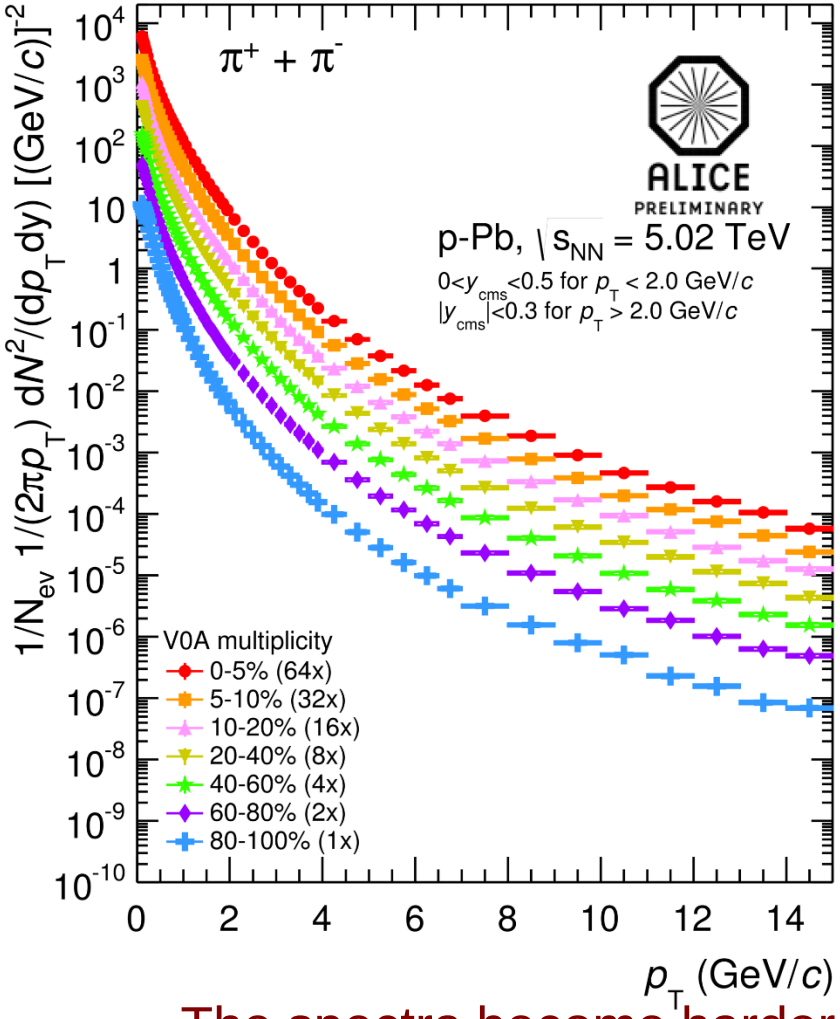
Analysis of p-Pb data

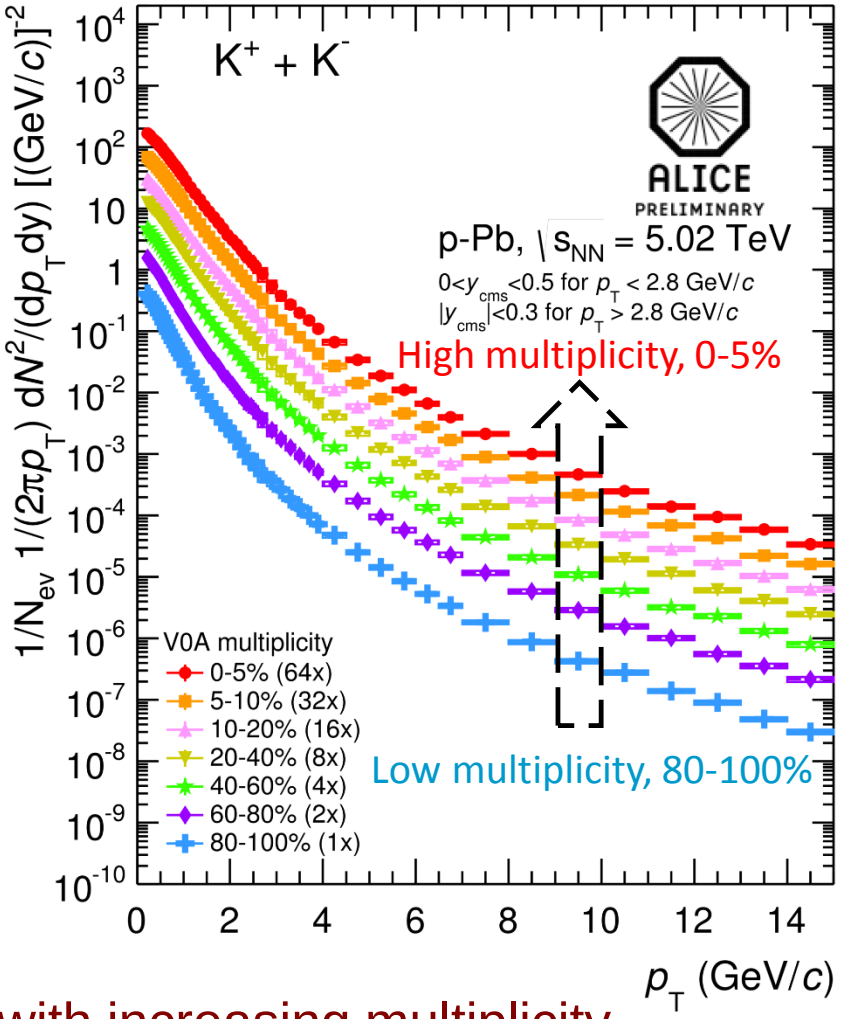
Centrality in p-Pb:
In p-Pb, the correlation between geometry and multiplicity is very weak. Therefore the results are presented in multiplicity event classes based on the amplitude of the signal of V0A detector (proportional to the charged particle multiplicity in $2.8<\eta_{lab}<5.1$).

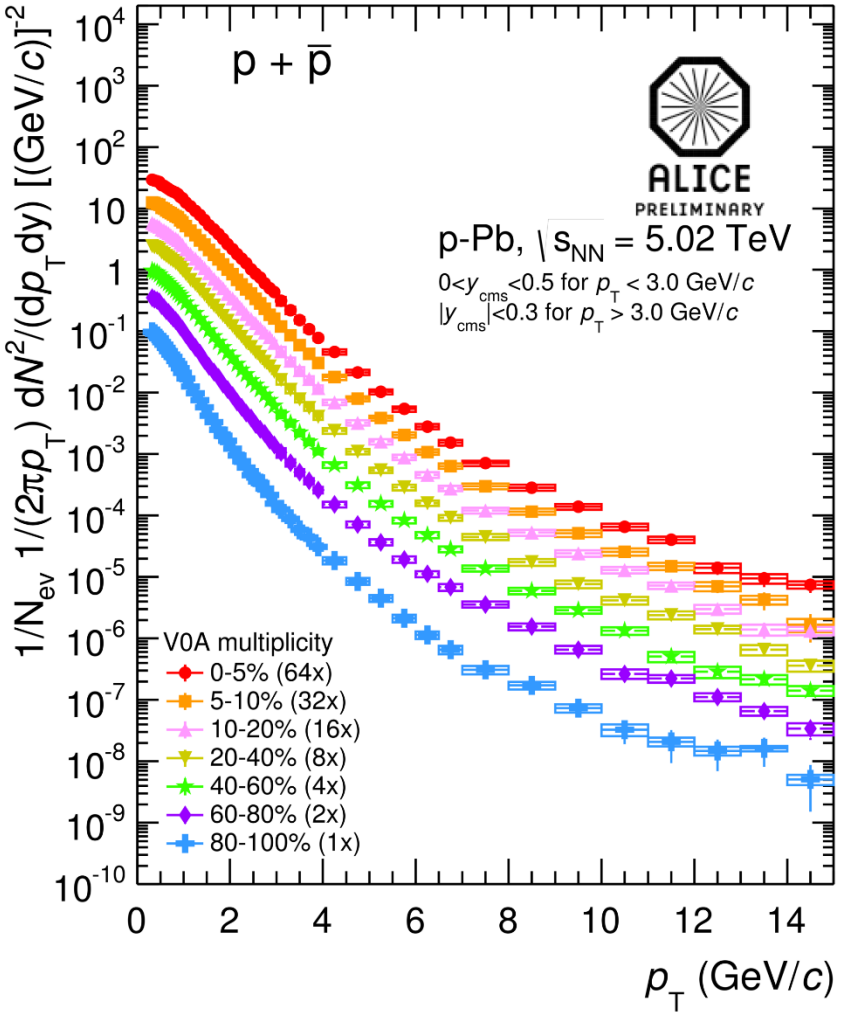
See talk of C. Oppedisano
07/Nov/2013, 13:30



p_T spectra in p-Pb collisions





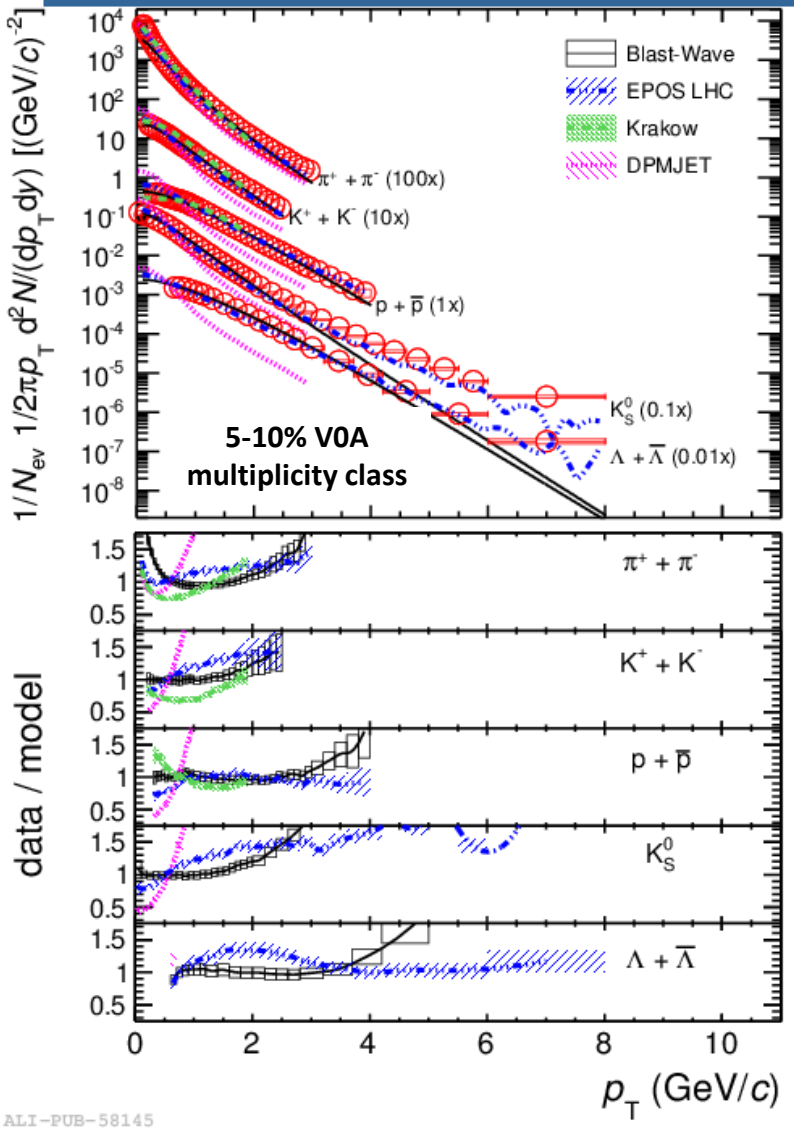


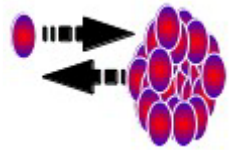
ALI-PREL-60962 ALI-PREL-60970

The spectra become harder with increasing multiplicity.
This effect increases with the mass of the particle.

Results for low p_T: arXiv:1307.6796v1 [nucl-ex]

Low p_T in p-Pb collisions





Blast-Wave fit:

Schnedermann et al., PRC 48, 2462 (1993)

- spectral-shape analysis performed with hydro-inspired model
- allows characterization of ID-spectra with small set of parameters

EPOS LHC:

Pierog et al., arXiv:1306.0121 [hep-ph]

- hard/soft scattering contribute to jet/bulk
- bulk matter described with hydro

Krakow:

Bozek, PRC 85, 014911 (2012)

- initial conditions from Glauber MC
- viscous hydrodynamic expansion
- statistical hadronization at freeze-out

DPMJET:

Roesler et al., arXiv:hep-ph/0012252

- QCD-inspired model
- reproduces dNch/dη in NSD p-Pb.

See talk of J. Otwinowski
05/Nov/2013, 12:00

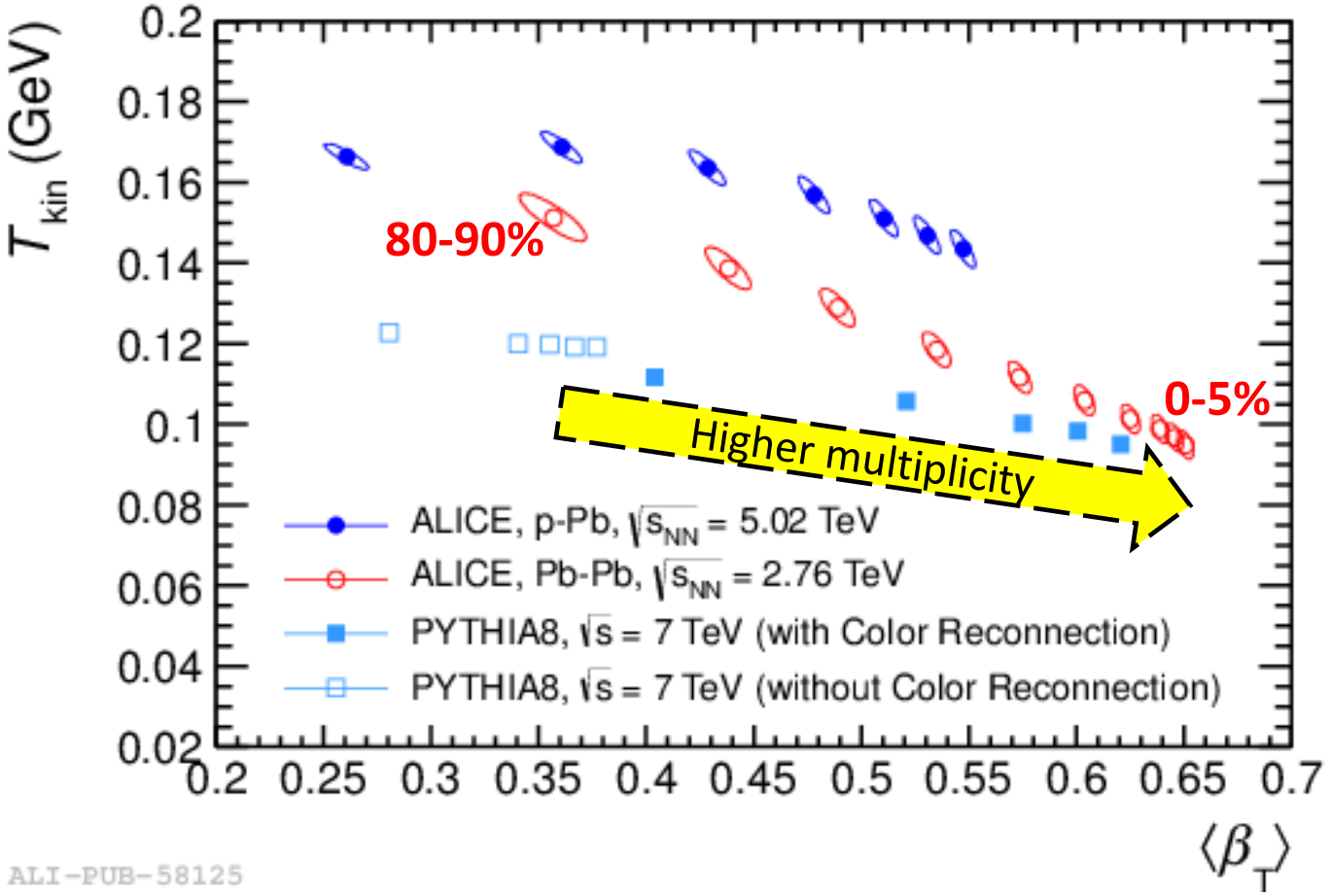
Models including hydro give a good overall description of data, this is particularly interesting in p-Pb.

arXiv:1307.6796v1 [nucl-ex]

Low p_T in p-Pb collisions

BW analysis

- For all 3 systems we observe the same evolution of the BW parameters when multiplicity increases.
- PYTHIA does not contain any hydrodynamic mechanism, but a partonic process, color reconnection, may play a role [Phys. Rev. Lett. 111, 042001, (2013)].



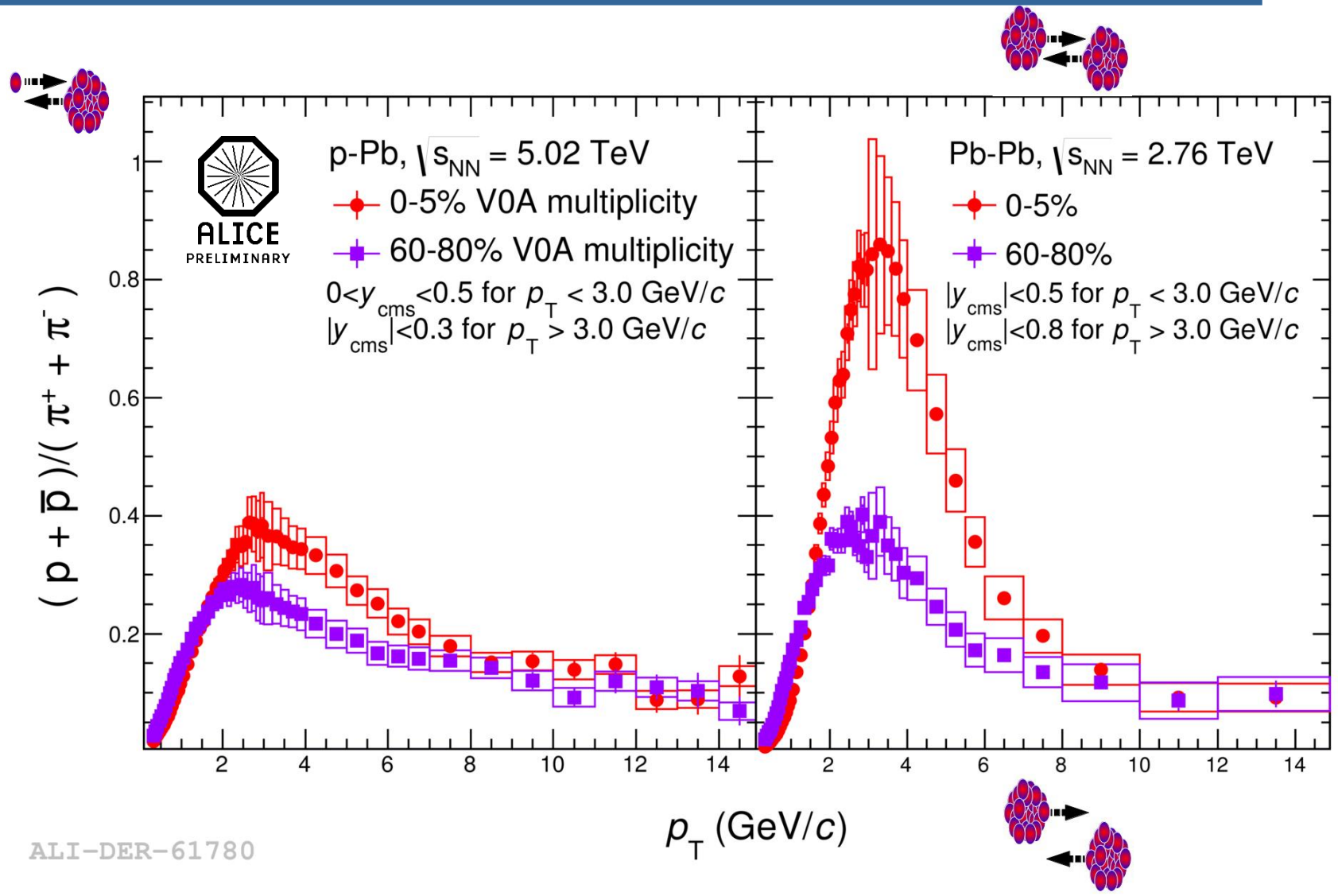
Pb-Pb results: Phys. Rev. C 88, 044910 (2013).

p-Pb results: arXiv:1307.6796v1 [nucl-ex]

Baryon anomaly

Low p_T results:
arXiv:1307.6796v1 [nucl-ex]
Phys. Rev. C 88, 044910 (2013)

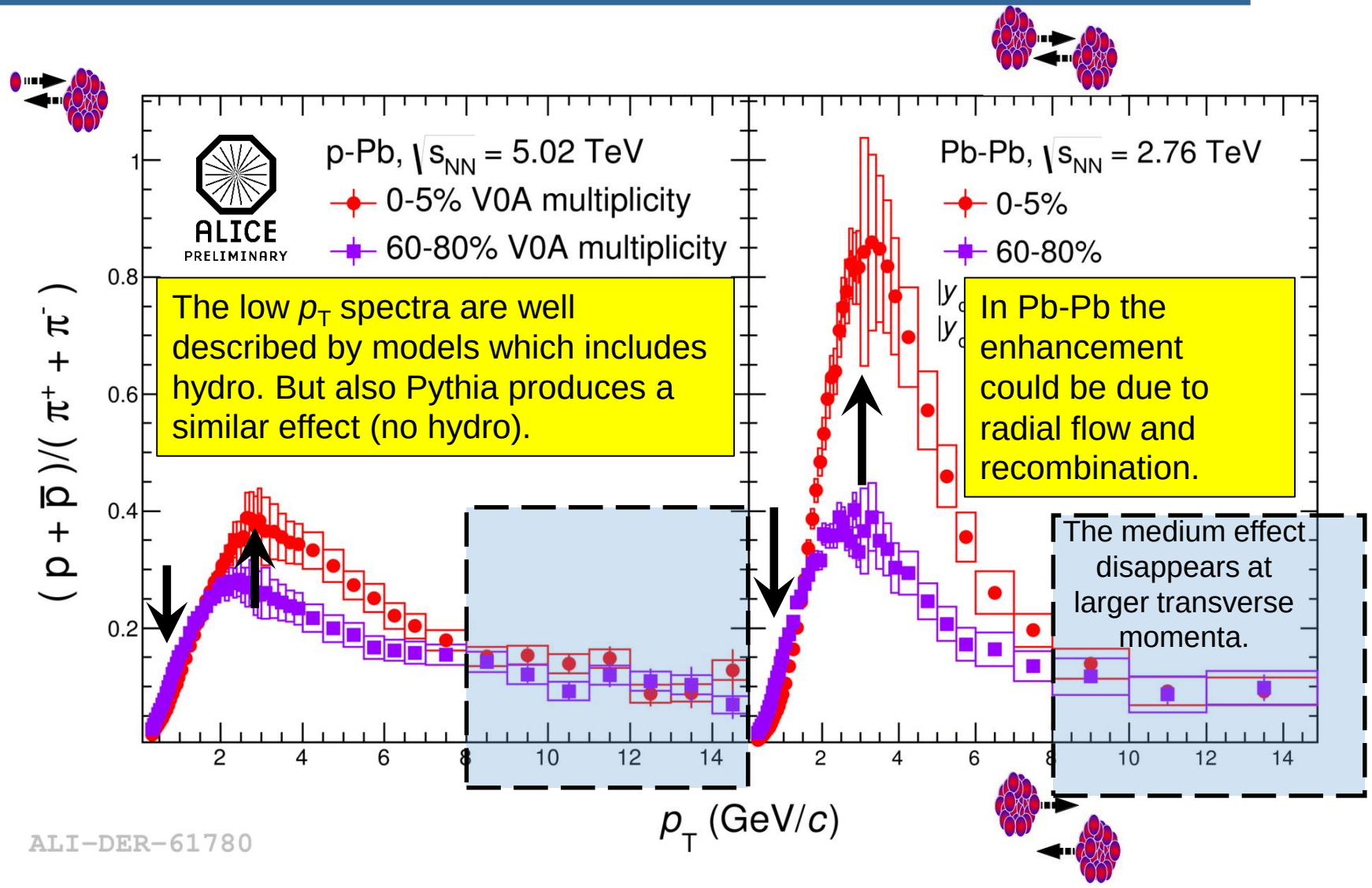
Multiplicity dependence of the particle ratios vs p_T measured in p-Pb *have similar behaviour to that measured in* Pb-Pb *collisions.*



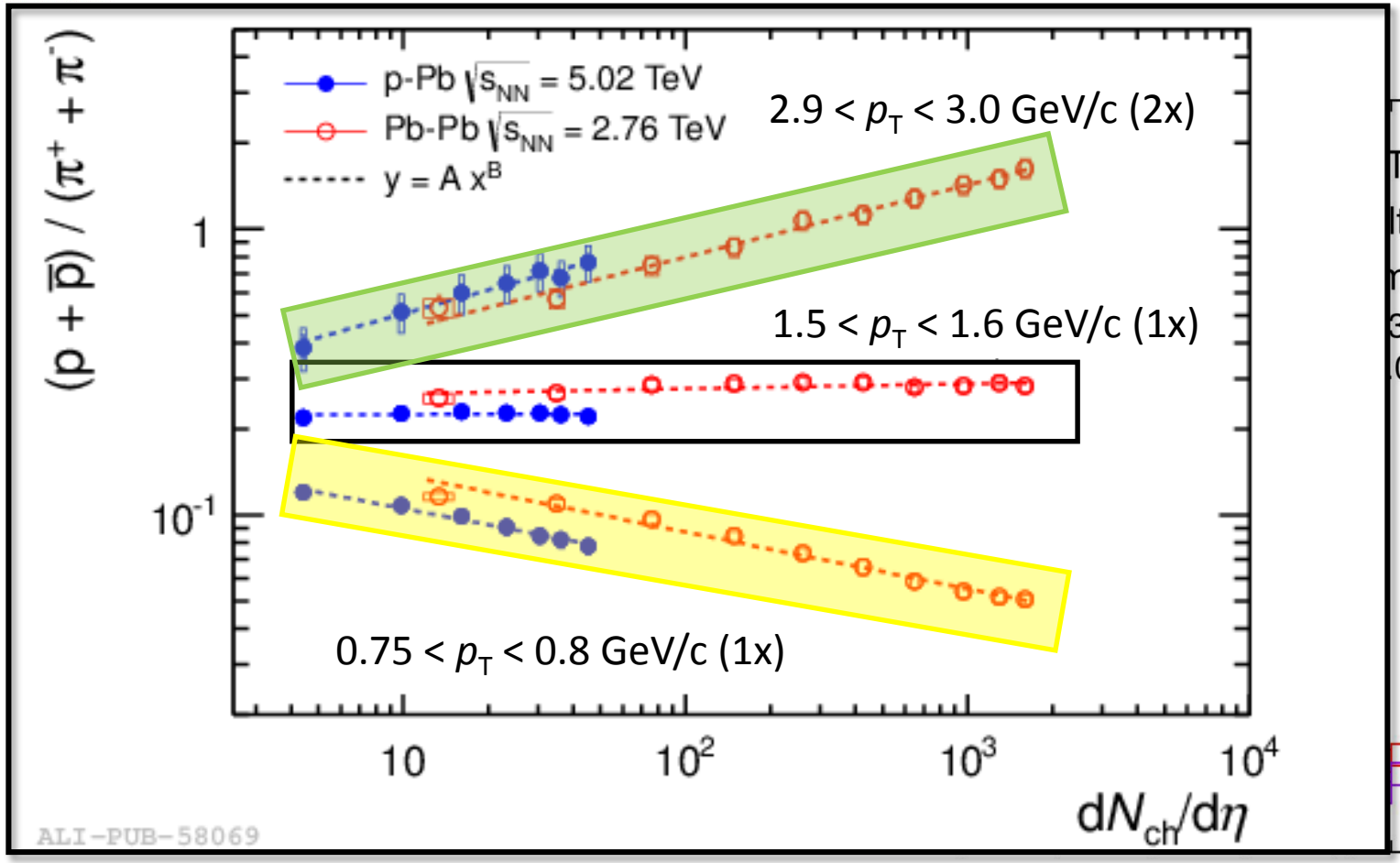
Baryon anomaly

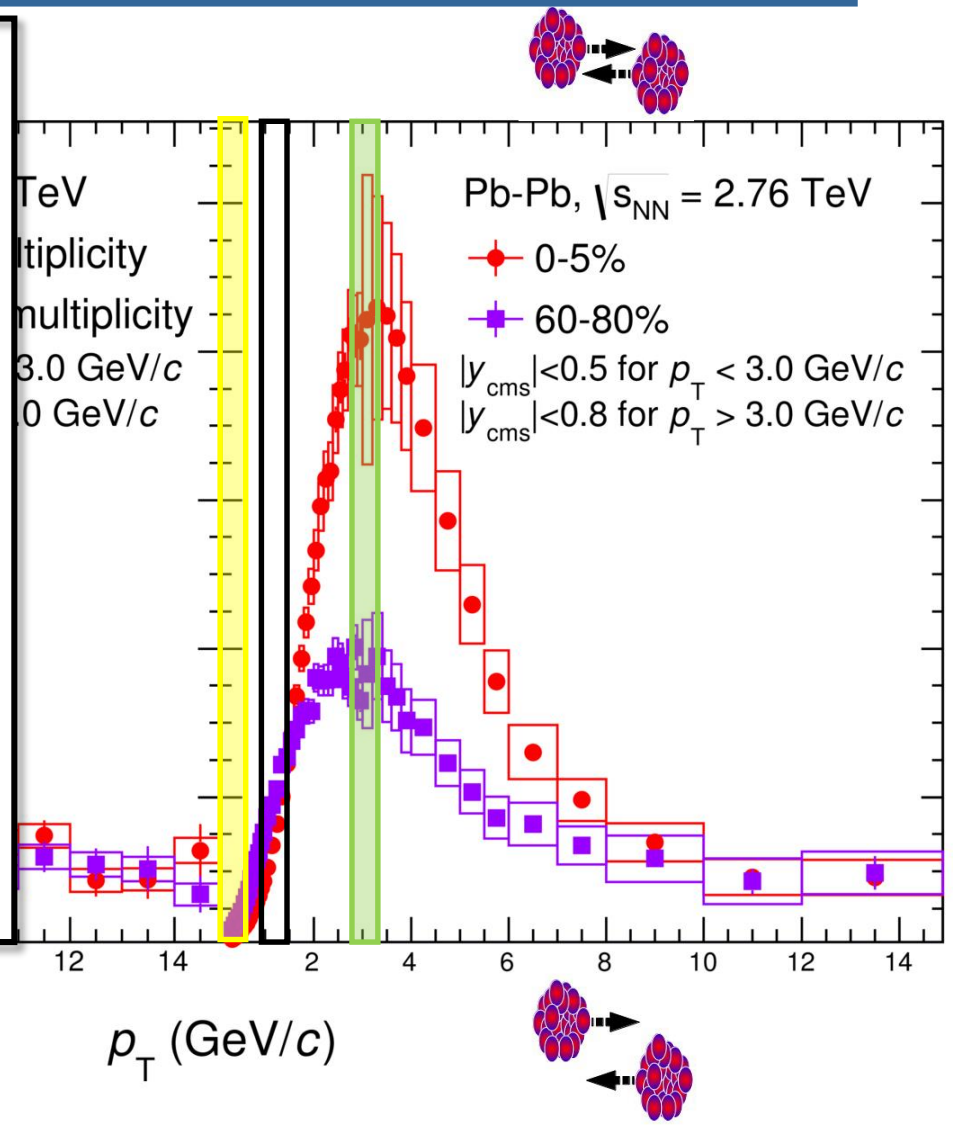
Low p_T results:
arXiv:1307.6796v1 [nucl-ex]
Phys. Rev. C 88, 044910 (2013)

Multiplicity dependence of the particle ratios vs p_T measured in p-Pb *have similar behaviour to that measured in* Pb-Pb *collisions.*



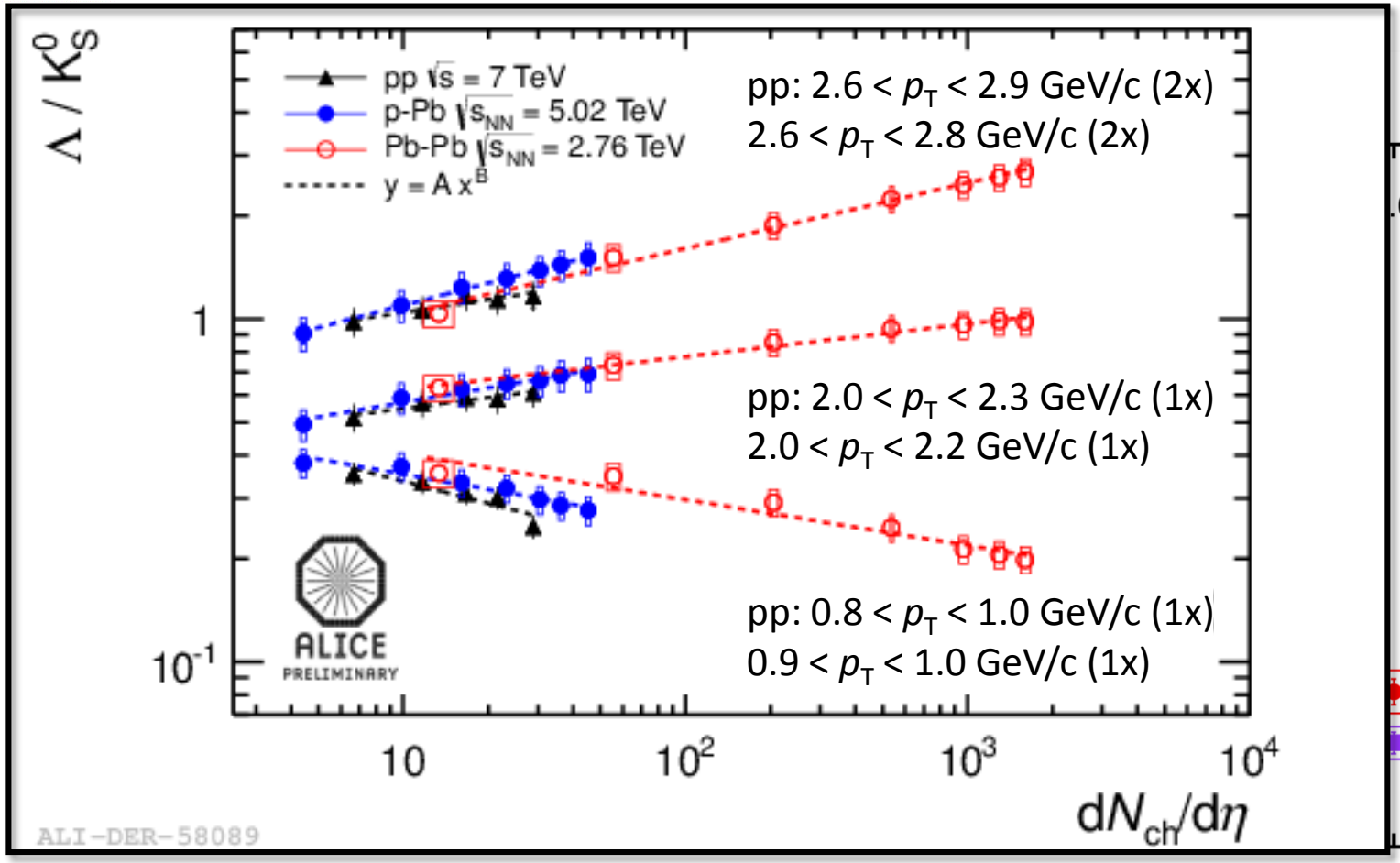
p/π vs dN_{ch}/dη



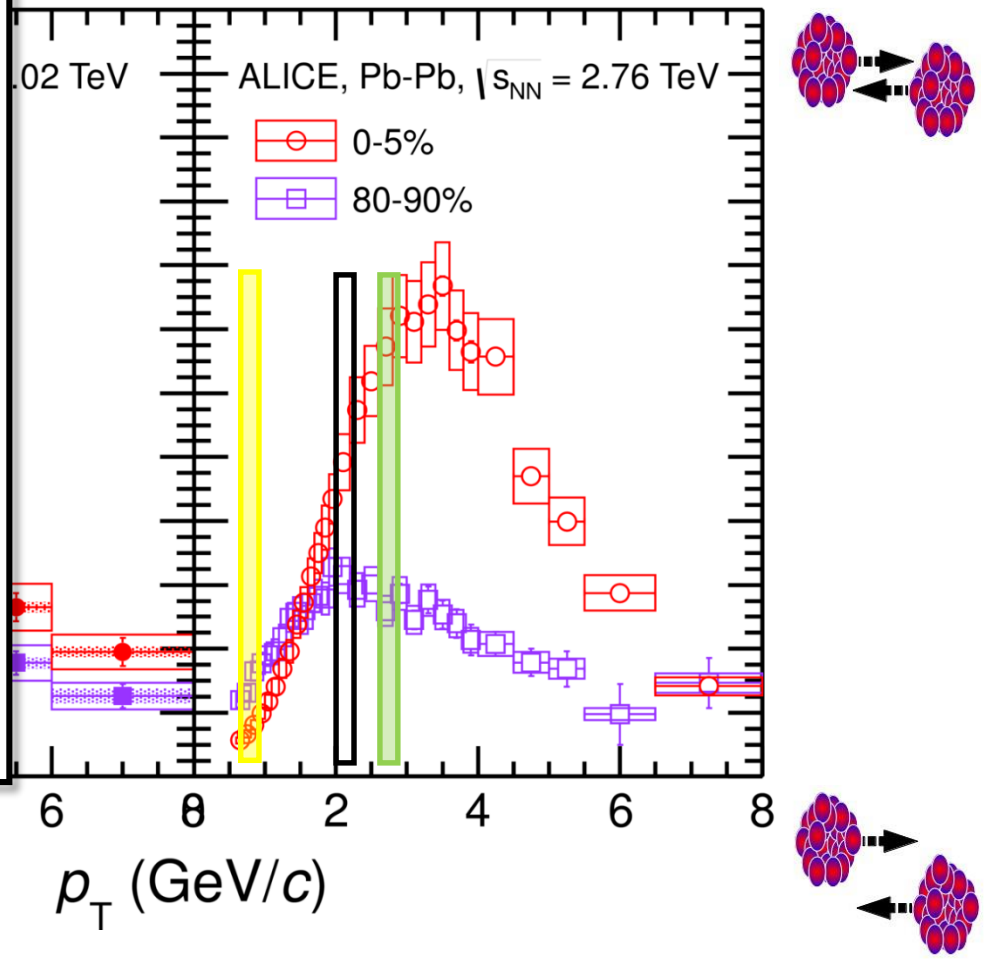


Same multiplicity dependence of the enhancement and depletion (power law with exponent B).

Λ/K^0_S vs $dN_{ch}/d\eta$

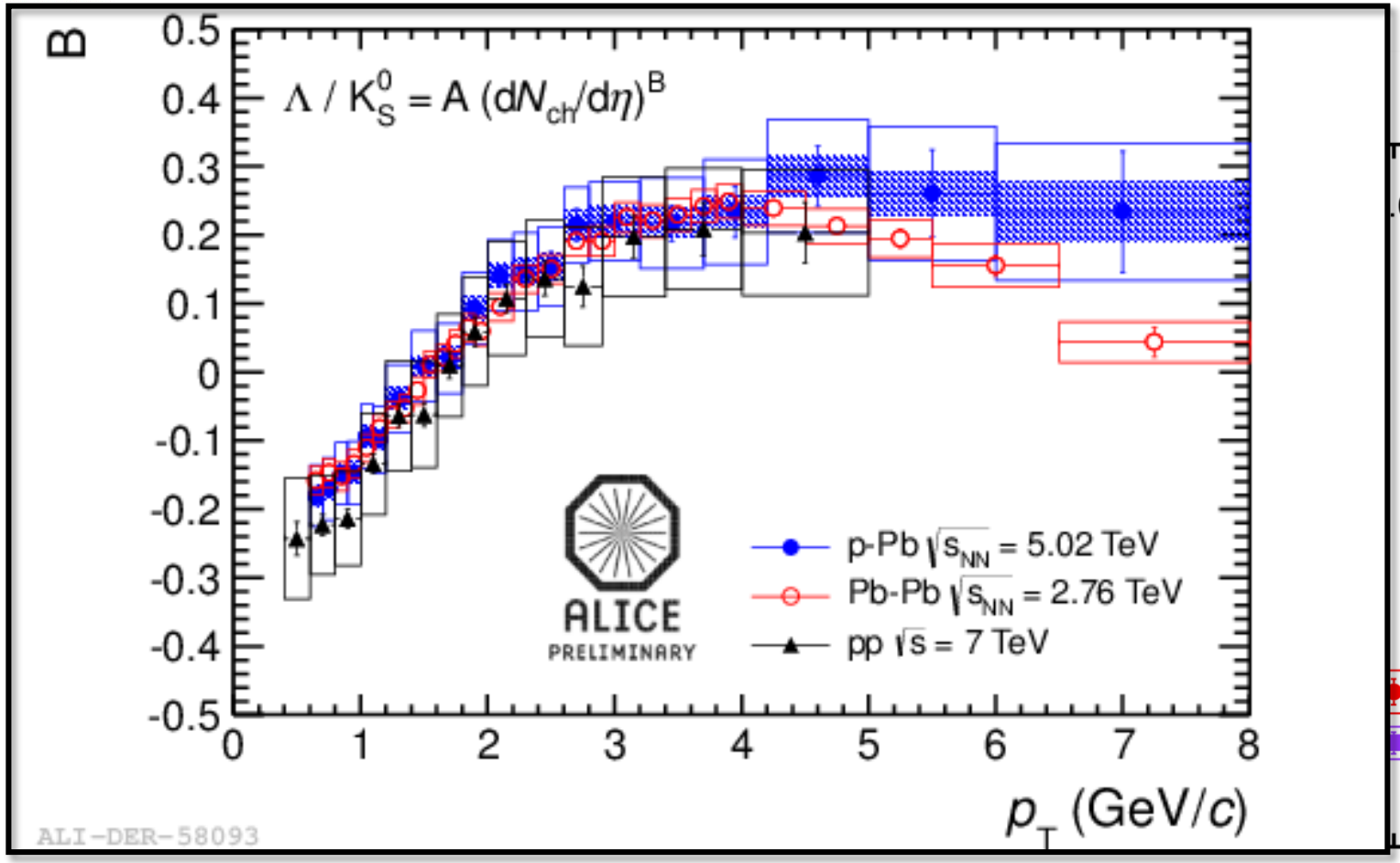


Low p_T results for Λ/K^0_S in Pb-Pb:
arXiv:1307.5530 [nucl-ex] (accepted by PRL)

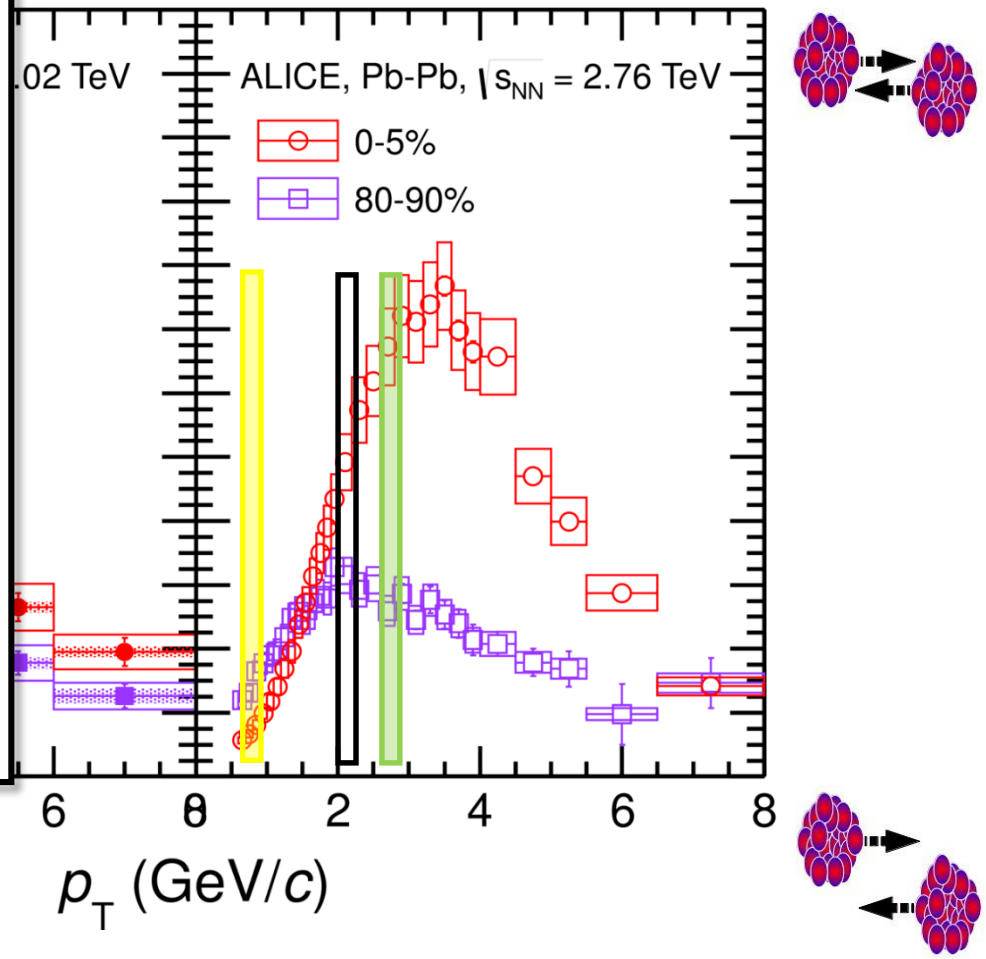


Other particle ratios show a similar effect.
The same multiplicity dependence is observed even in pp collisions.

Λ/K^0_S vs $dN_{ch}/d\eta$



Low p_T results for Λ/K^0_S in Pb-Pb:
arXiv:1307.5530 [nucl-ex] (accepted by PRL)



All systems are described with the same scaling exponent, B.

Summary

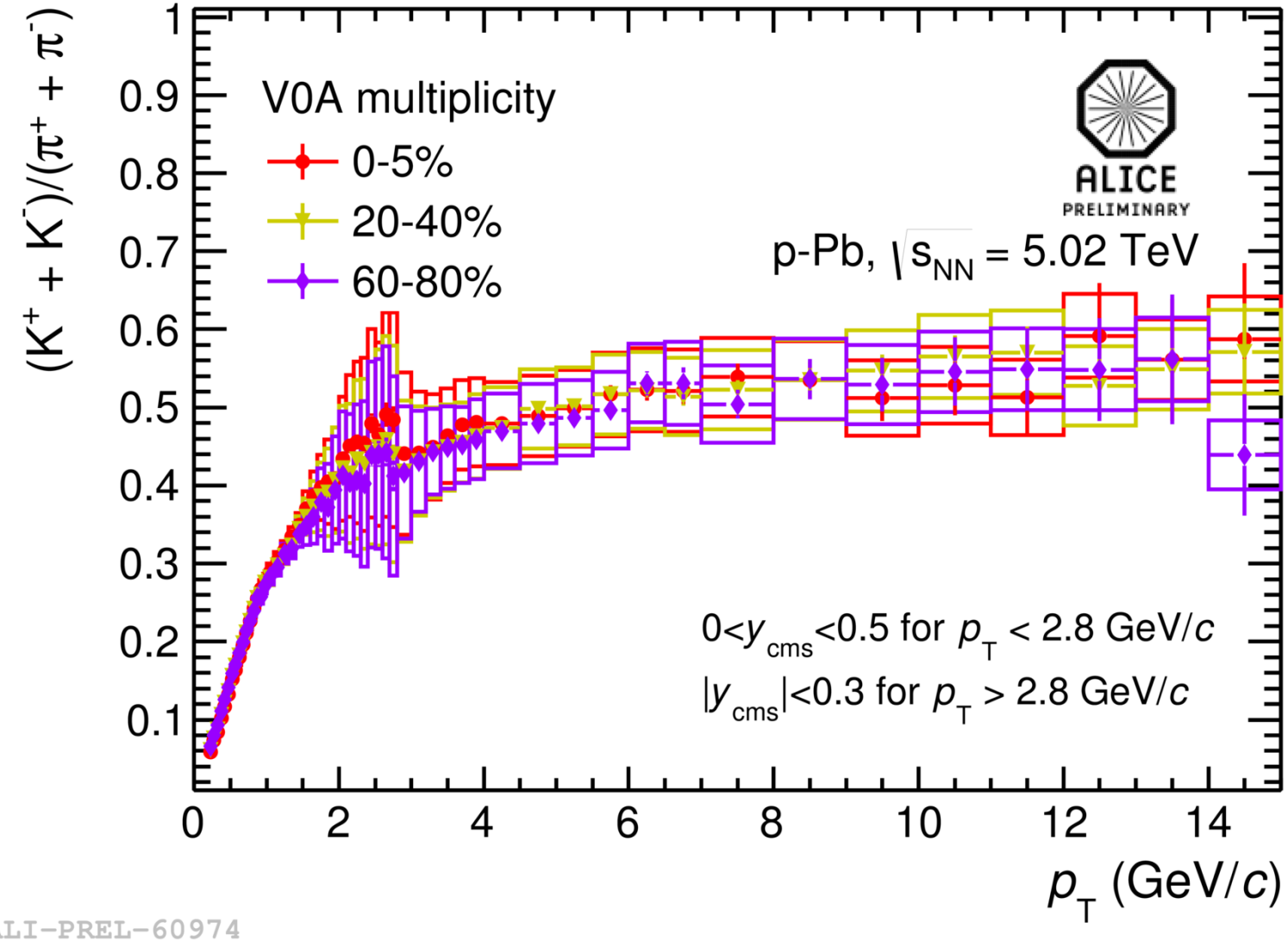
- The evolution of the p_T spectral shapes with multiplicity measured in p-Pb collisions shows similarities to analogous measurements in Pb-Pb collisions. At low p_T (<2 GeV/c), the spectra are well described by models which include hydro.

- At intermediate p_T (2-8 GeV/c) we observe an increase of the baryon to meson ratio with increasing multiplicity. This behavior is seen in p-Pb, Pb-Pb and pp (data and Pythia) collisions.

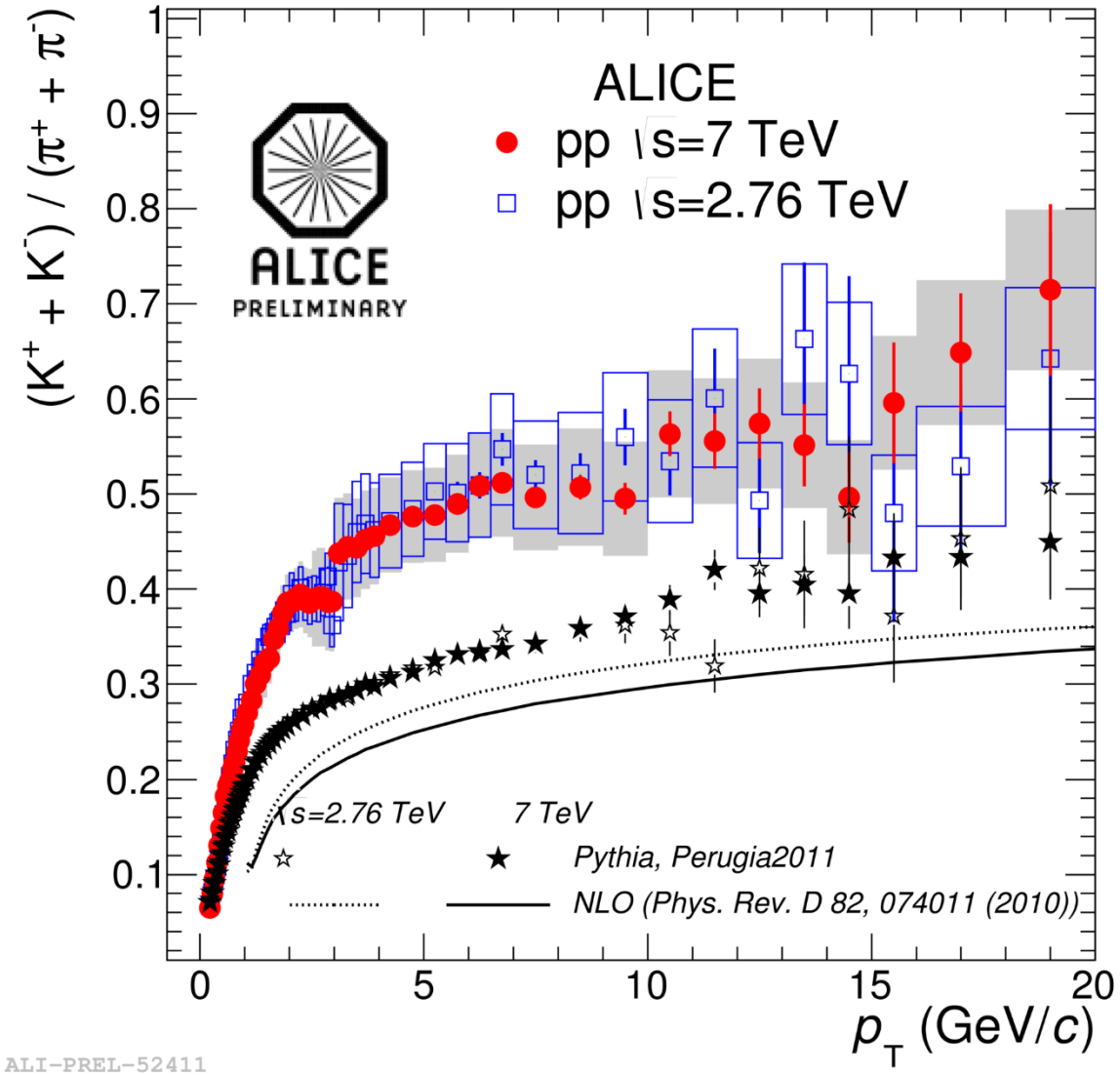
- At higher p_T (>8 GeV/c), the particle ratios measured in Pb-Pb are consistent to those measured in p-Pb and pp. From the R_{AA} measurement we conclude that π/K/p are equally suppressed at high p_T.

Backup

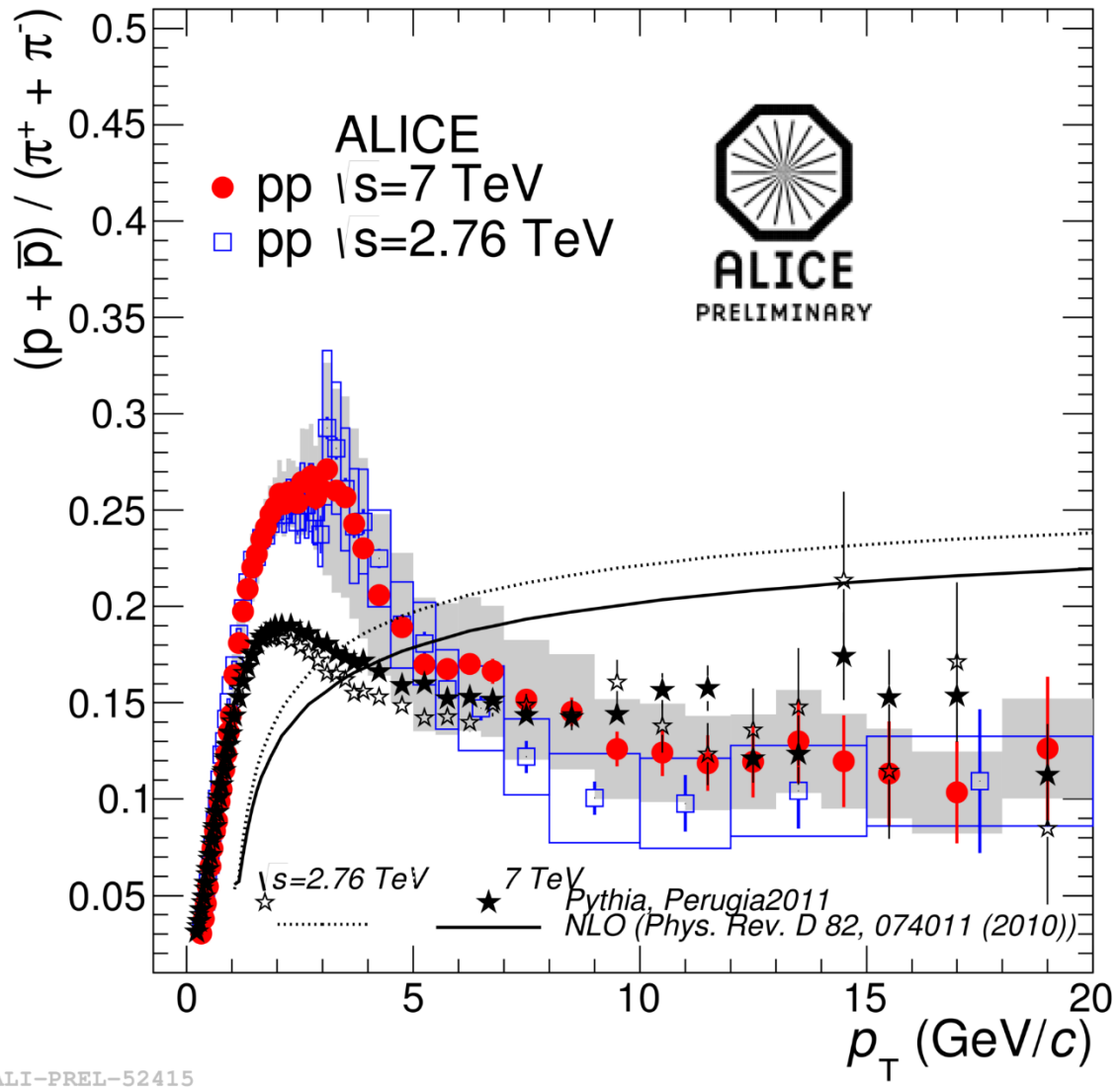
K/π in p-Pb


$(K^+ + K^-)/(\pi^+ + \pi^-)$
V0A multiplicity
0-5%
20-40%
60-80%
ALICE
PRELIMINARY
p-Pb, $\sqrt{s_{NN}}$ = 5.02 TeV
$0<y_{cms}<0.5$ for $p_T < 2.8$ GeV/c
$|y_{cms}|<0.3$ for $p_T > 2.8$ GeV/c
p_T (GeV/c)
ALI-PREL-60974

Particle ratios in pp collisions

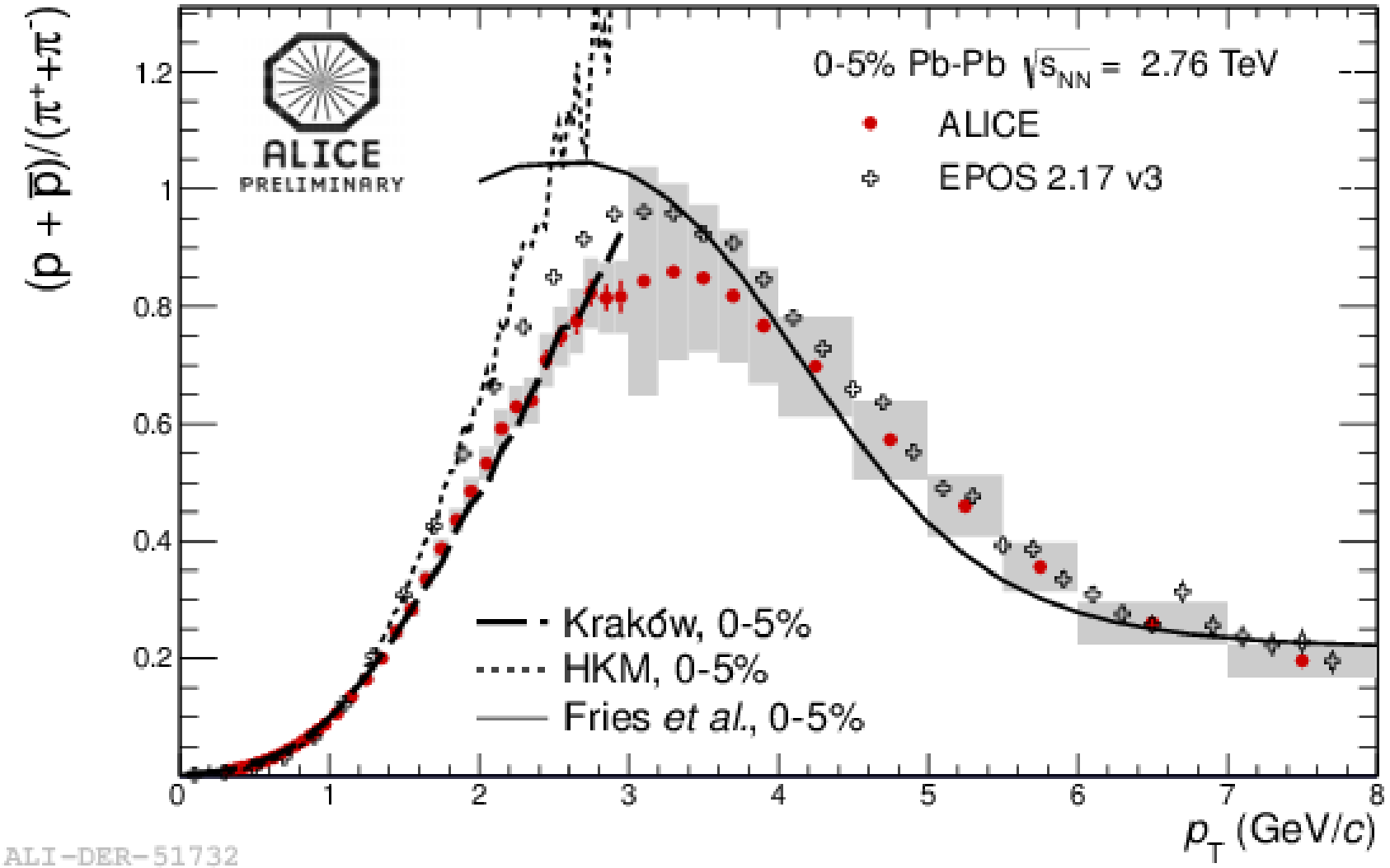


ALI-PREL-52411



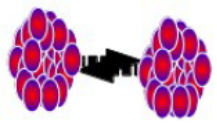
ALI-PREL-52415

p/π vs p_T compared with theory

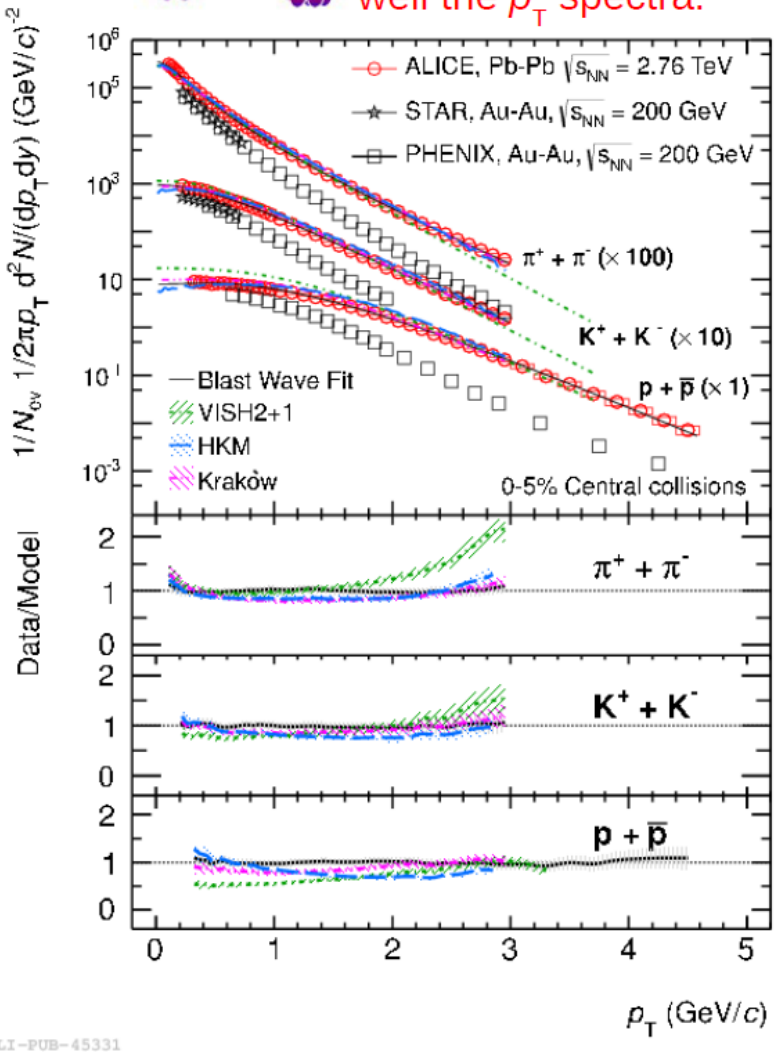


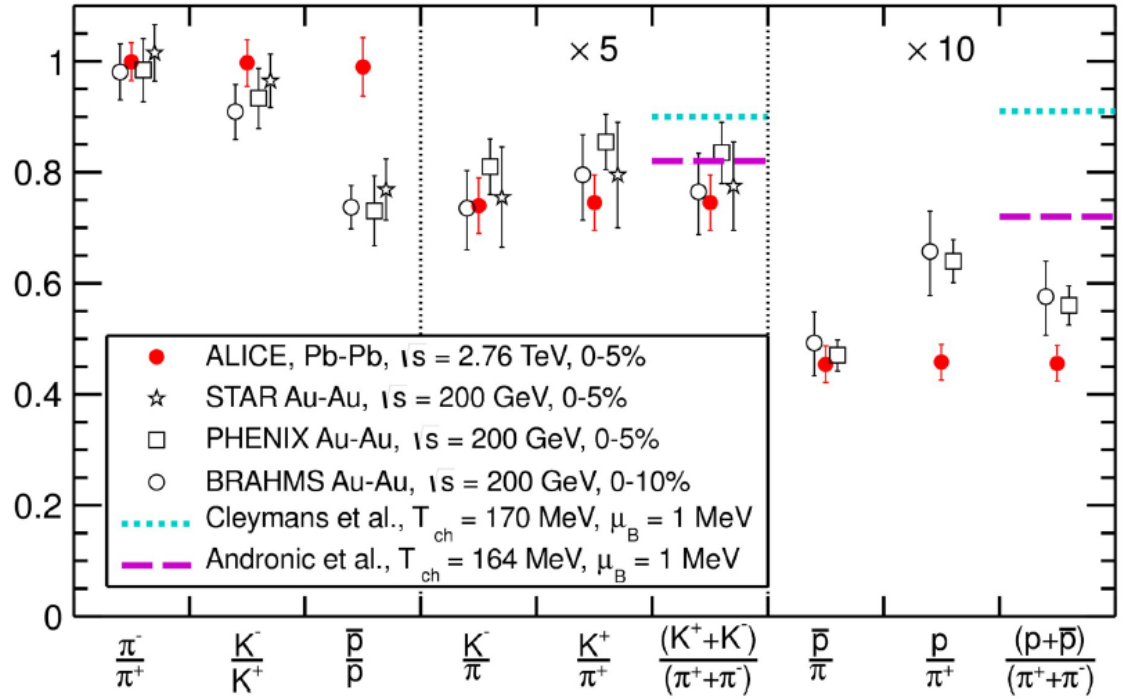
EPOS:
K. Werner,
arXiv:1204.1394
Krakow:
P. Bozek et al.,
ArXiv:1203.6513
HKM:
I. Karpenko
Phys. Rev. C87, 024914 (2013).
Recombination:
R. J. Fries et. al.,
Phys. Rev. Lett. 90, 202303 (2003) and private communication.

Low p_T production in Pb-Pb



Hydrodynamics describes well the p_T spectra.





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Most of the ratios are well described by statistical models.
Disagreement for p/π might indicate:

- non-equilibrium effects: arXiv:1303.2098,
- annihilation in hadronic stage: arXiv:1212.2431,
- or a flavor hierarchy of freeze-out temperatures: PRD 85, 014004 (2012).