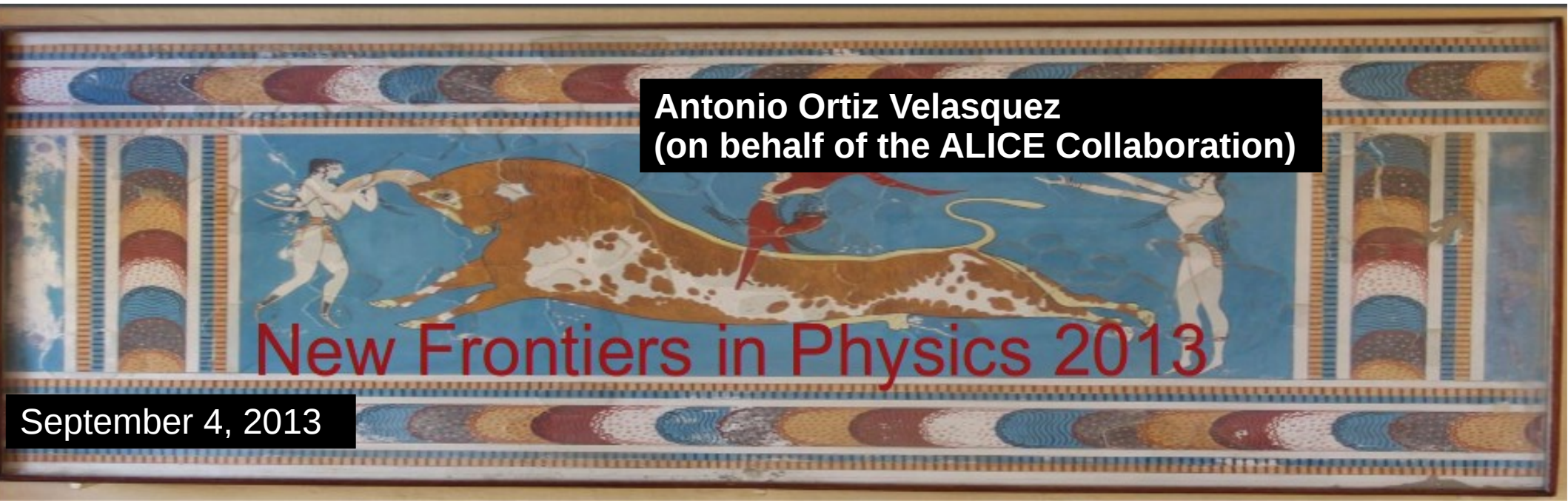
Results on identified particle production in pp, p-Pb and Pb-Pb collisions measured with ALICE at the LHC

Antonio Ortiz Velasquez
(on behalf of the ALICE Collaboration)

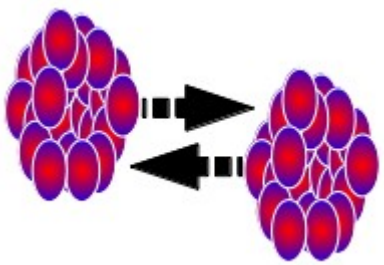


September 4, 2013

Outline

- Introduction.
- Particle identification with ALICE detectors.
- Spectra, particle ratios and R_{AA} in Pb-Pb collisions.
- Results on p-Pb collisions.
- Similarities and differences among: pp, p-Pb and Pb-Pb collisions.
- Conclusions.

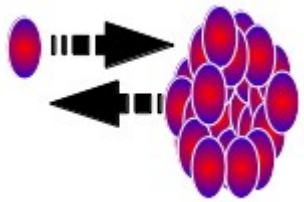
What can be observed from the transverse momentum, p_T, spectra of identified particles measured in different systems, pp, p-Pb and Pb-Pb?



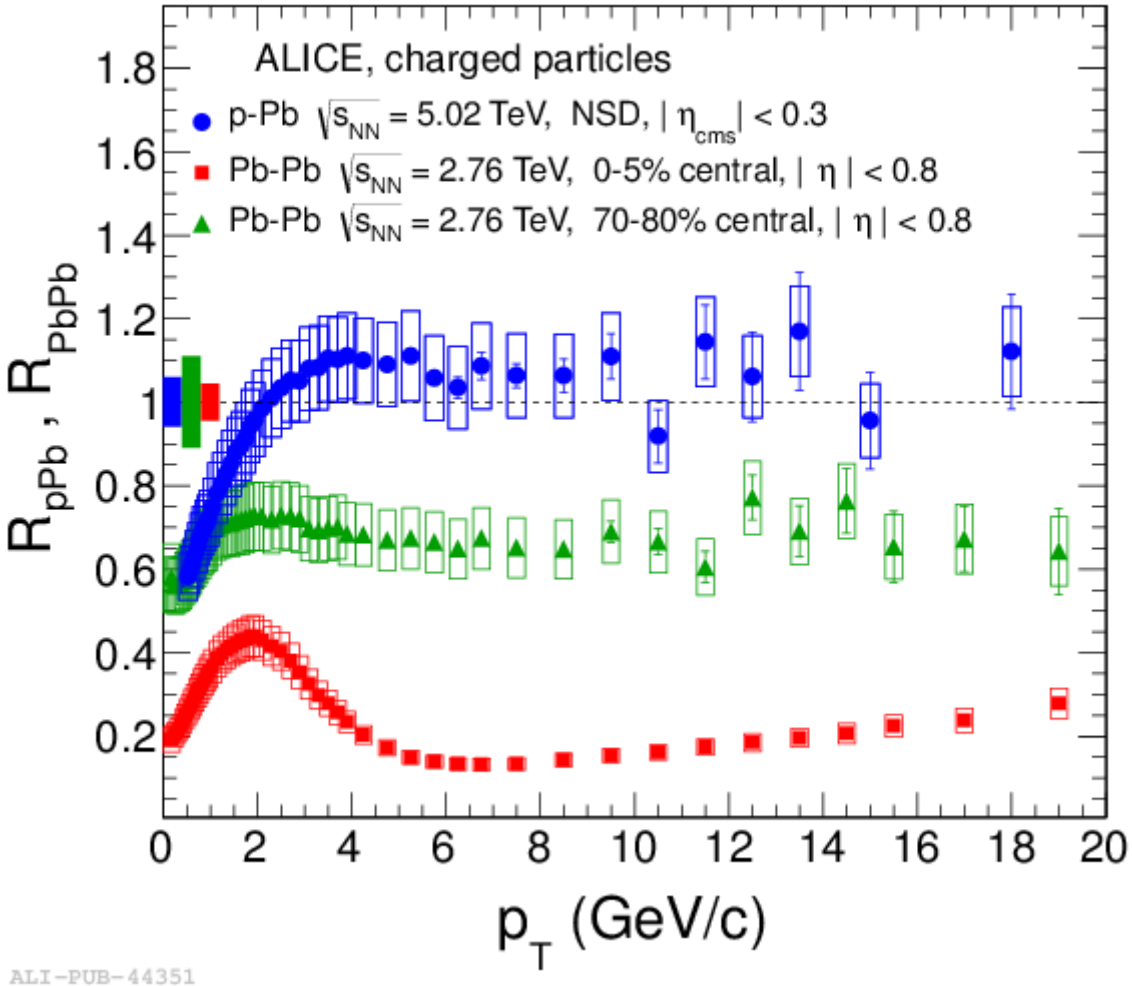
Pb-Pb collisions produce a hot and dense medium, QGP,

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

$\langle T_{AA}\rangle \sigma^{pp} = \langle N_{coll}\rangle$
N_{coll} is the number of binary collisions

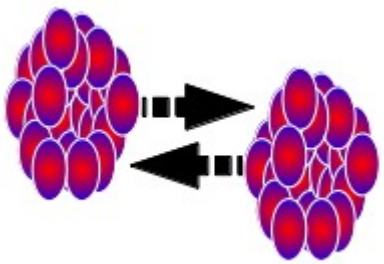


p-Pb collisions allow one to study cold nuclear matter effects which are present also in Pb-Pb collisions.

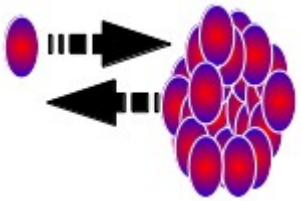


Phys. Rev. Lett. 110, 082302 (2013)

What can be observed from the transverse momentum, p_T, spectra of identified particles measured in different systems, pp, p-Pb and Pb-Pb?



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



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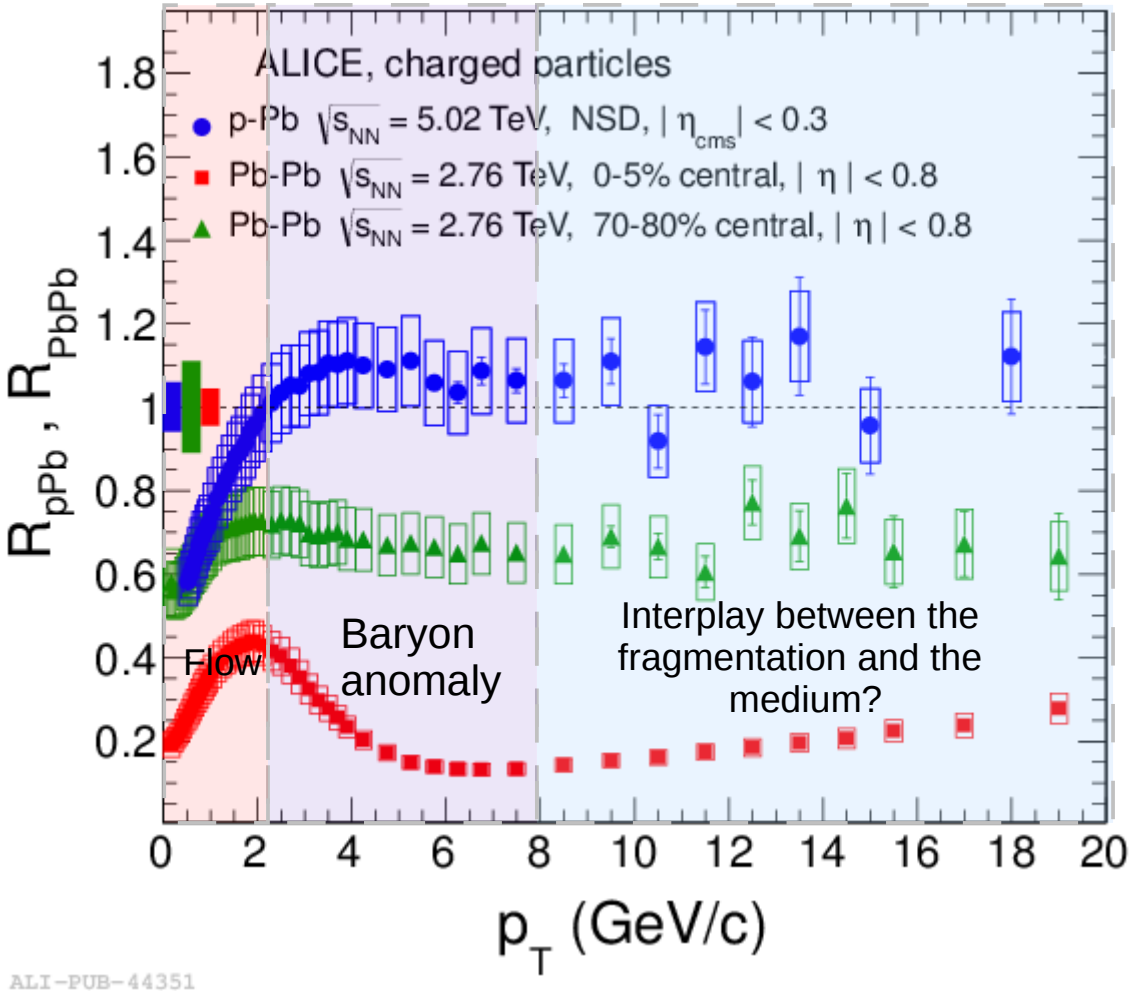
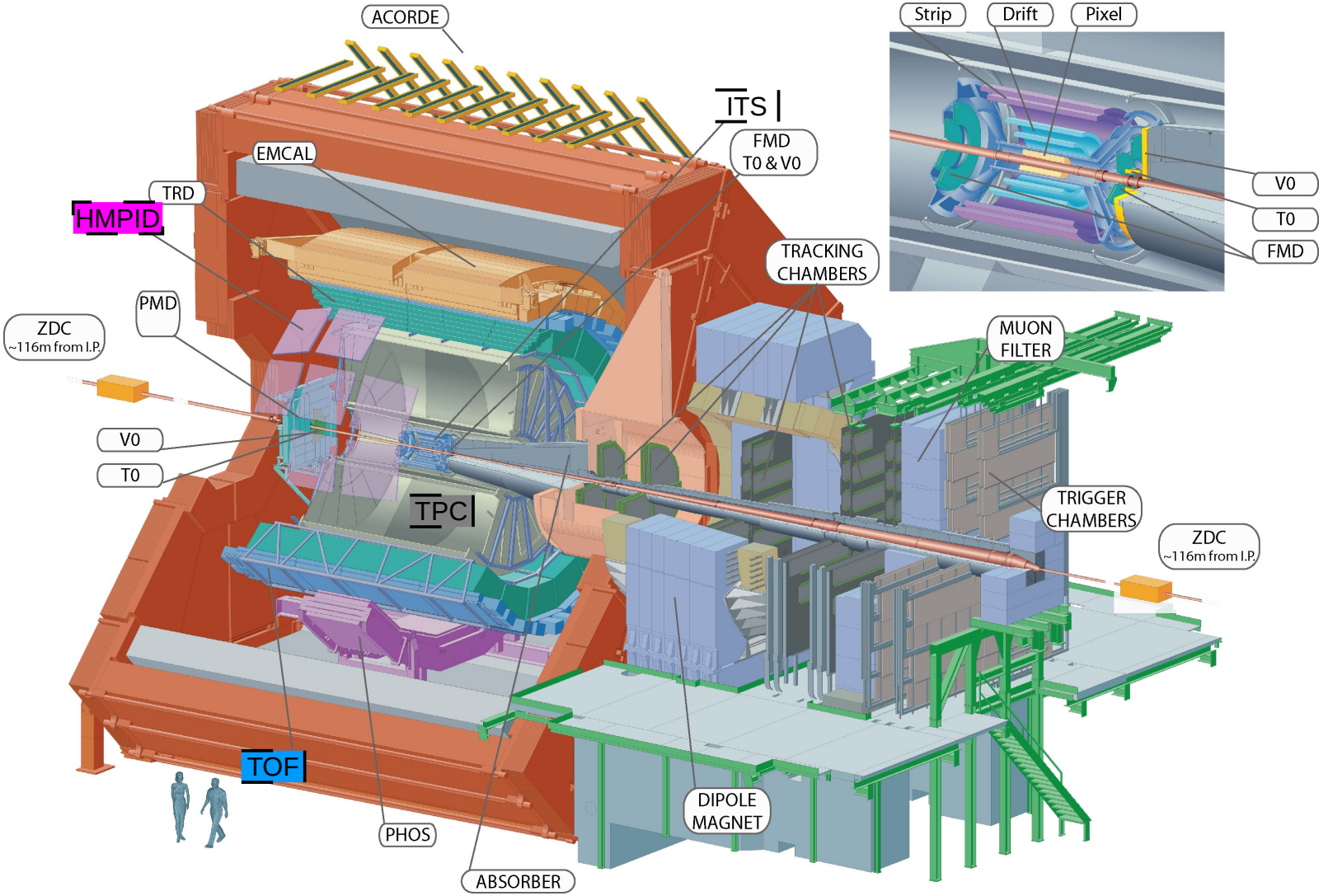


Phys. Rev. Lett. 110, 082302 (2013)

Particle identification, PID, with ALICE detectors



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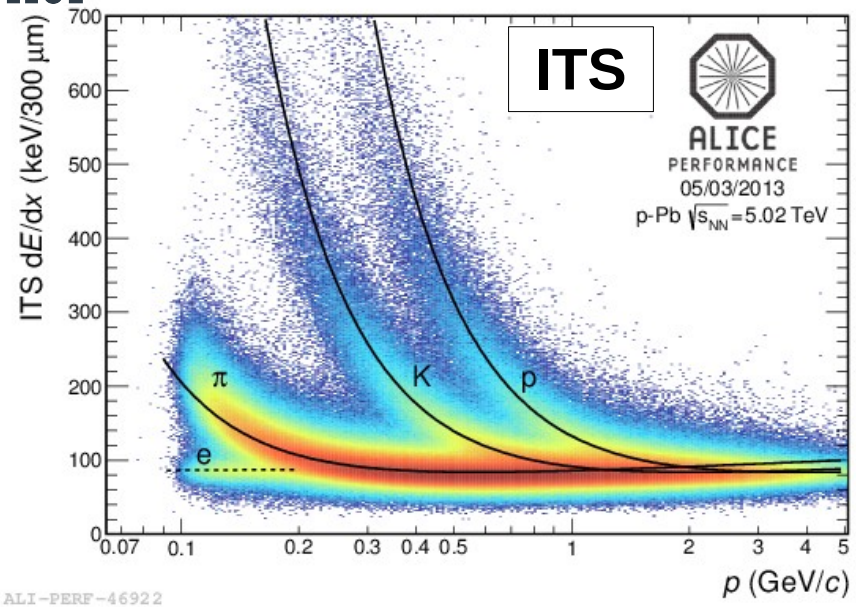
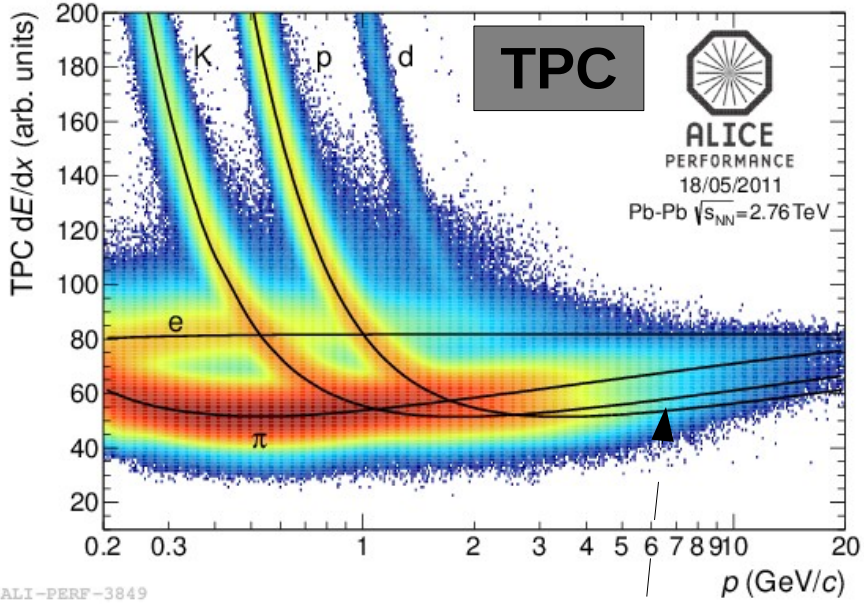
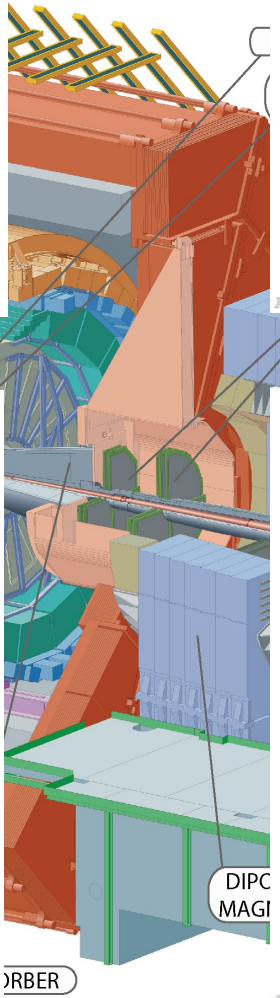
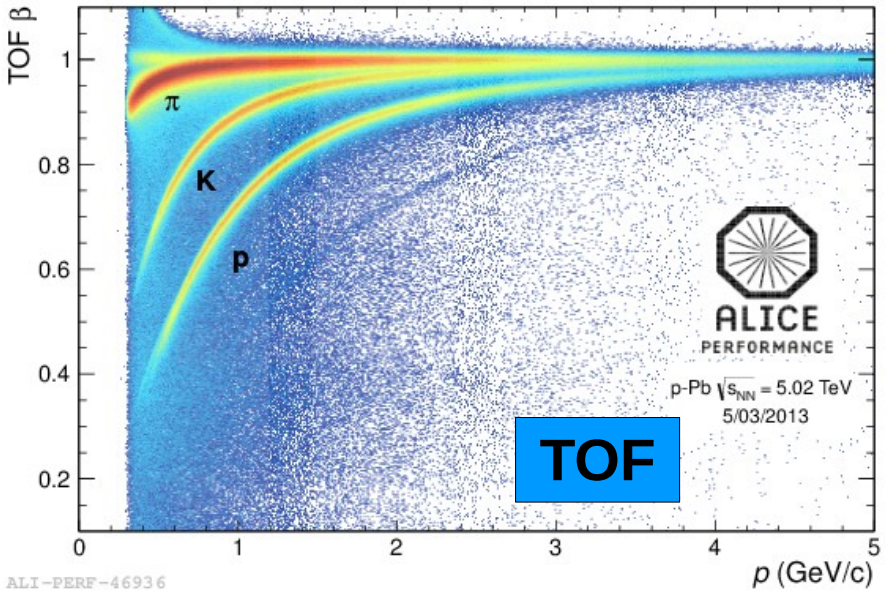
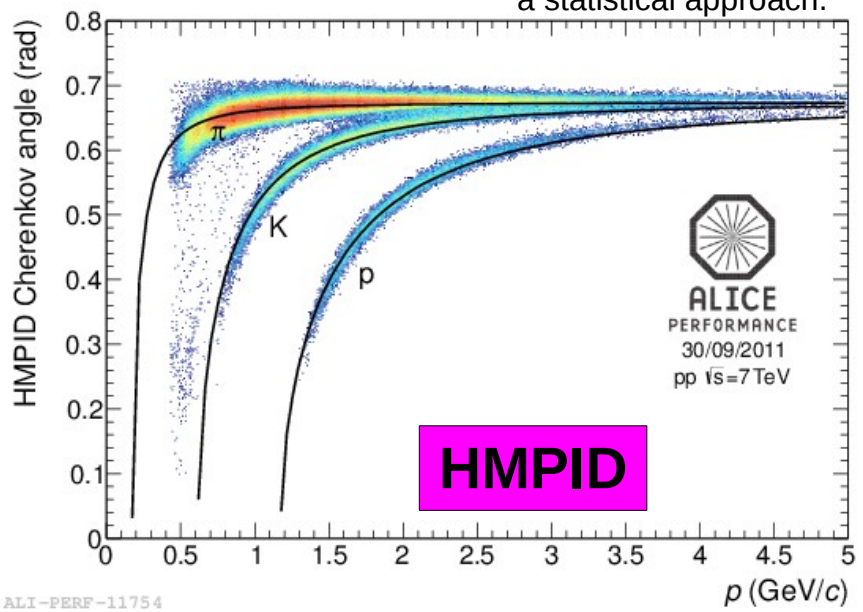






PID is extended from 2-3 GeV/c up to 20 GeV/c using a statistical approach.





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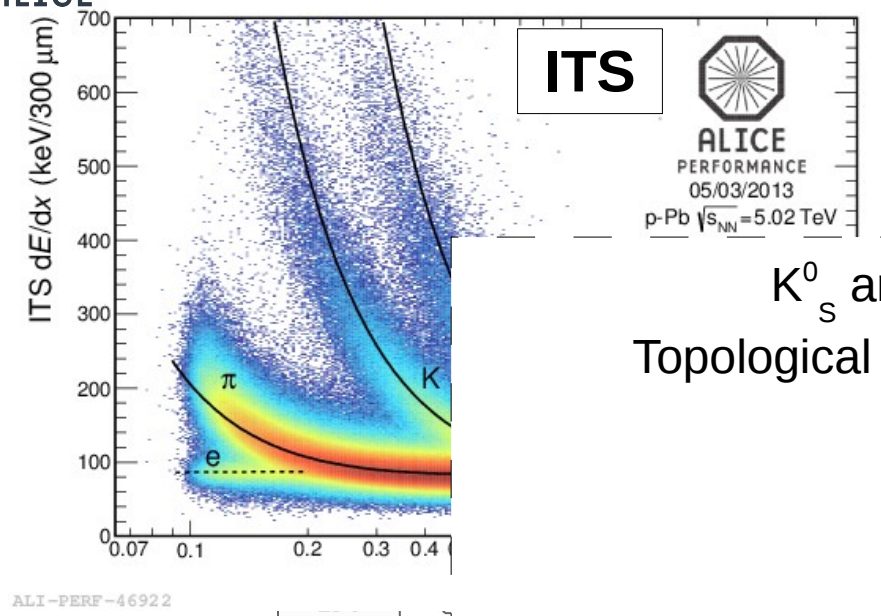
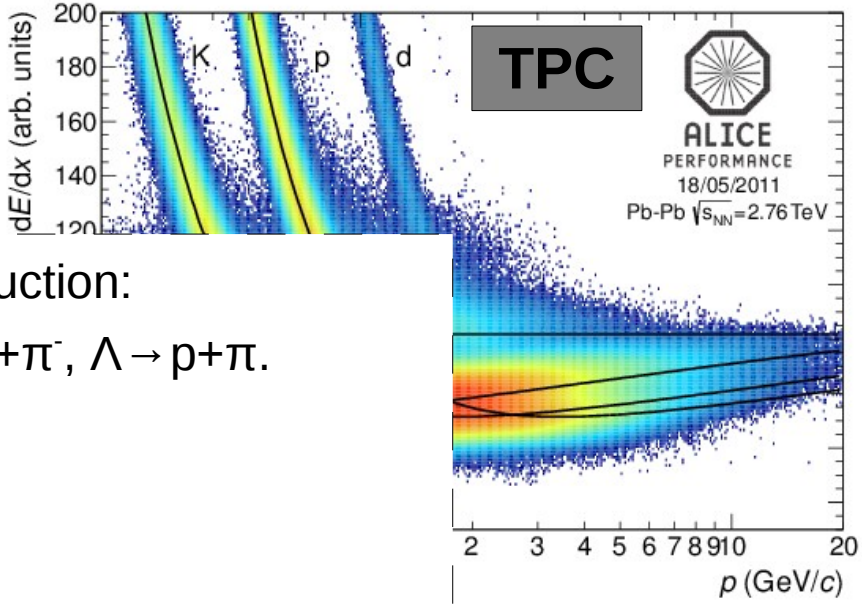
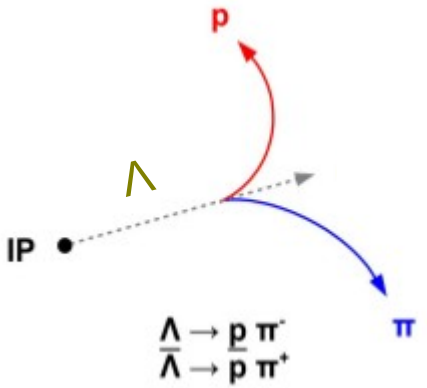


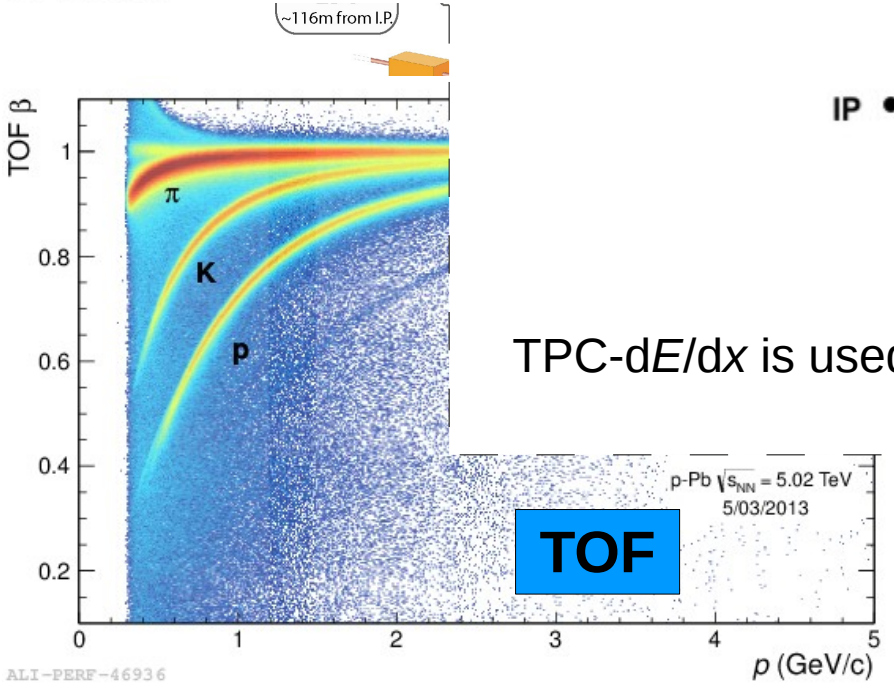


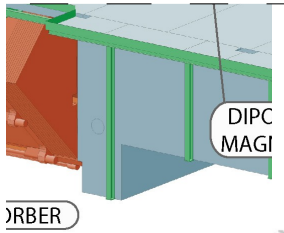
K^0_s and Λ reconstruction:

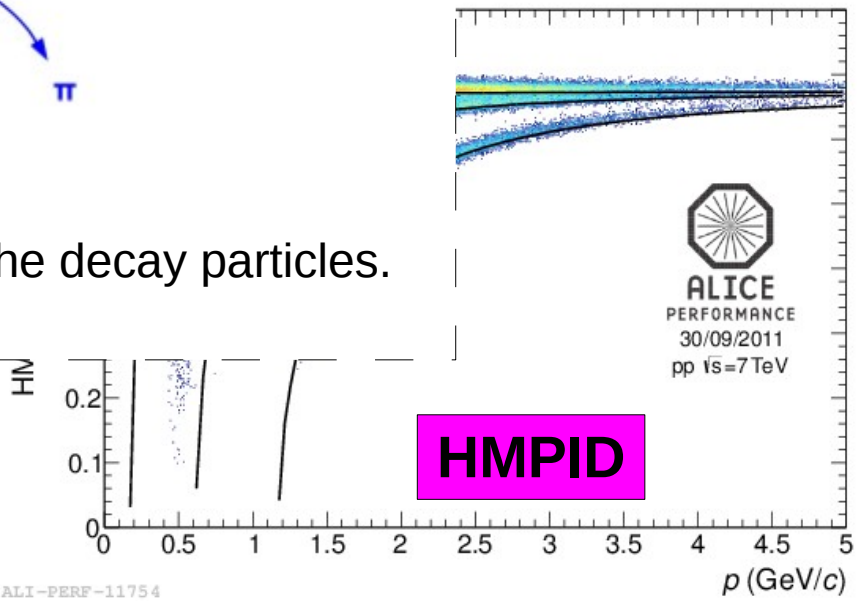
Topological PID: $K^0_s \rightarrow \pi^+ + \pi^-$, $\Lambda \rightarrow p + \pi$.



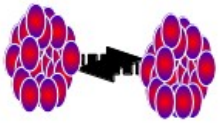
TPC-d*E*/d*x* is used to identify the decay particles.



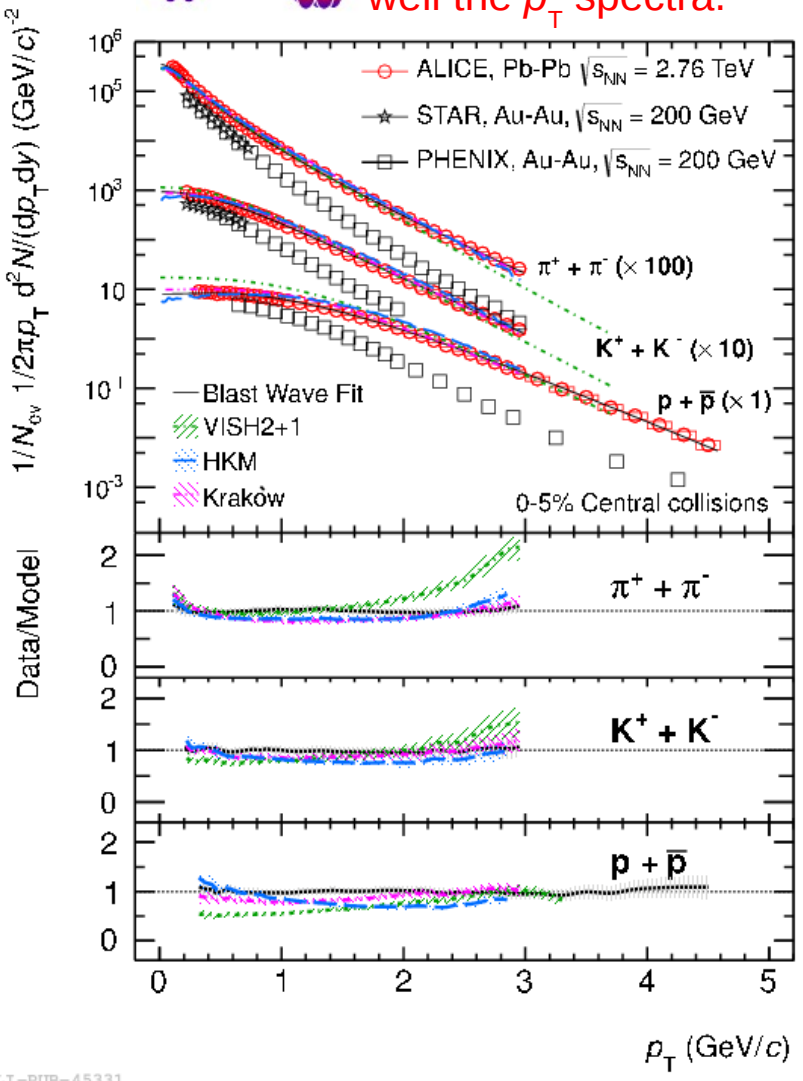




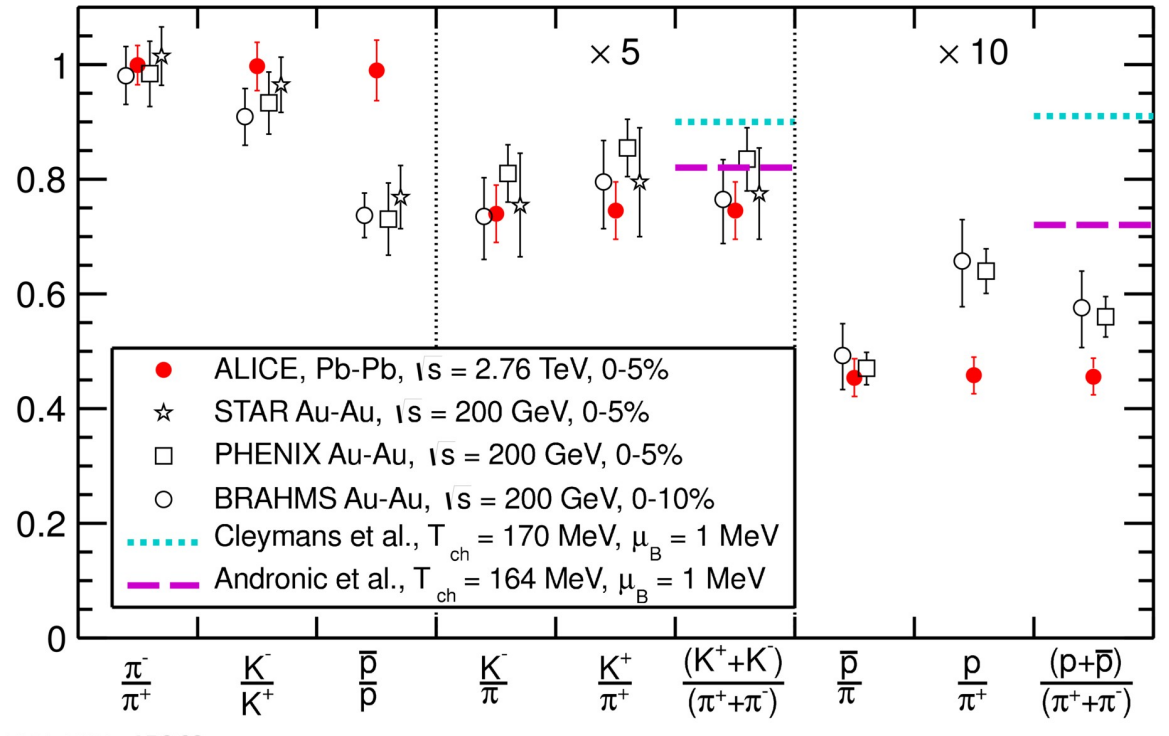
Low p_T production in Pb-Pb



Hydrodynamics describes well the p_T spectra.



ALI-PUB-45331



ALI-PUB-45363

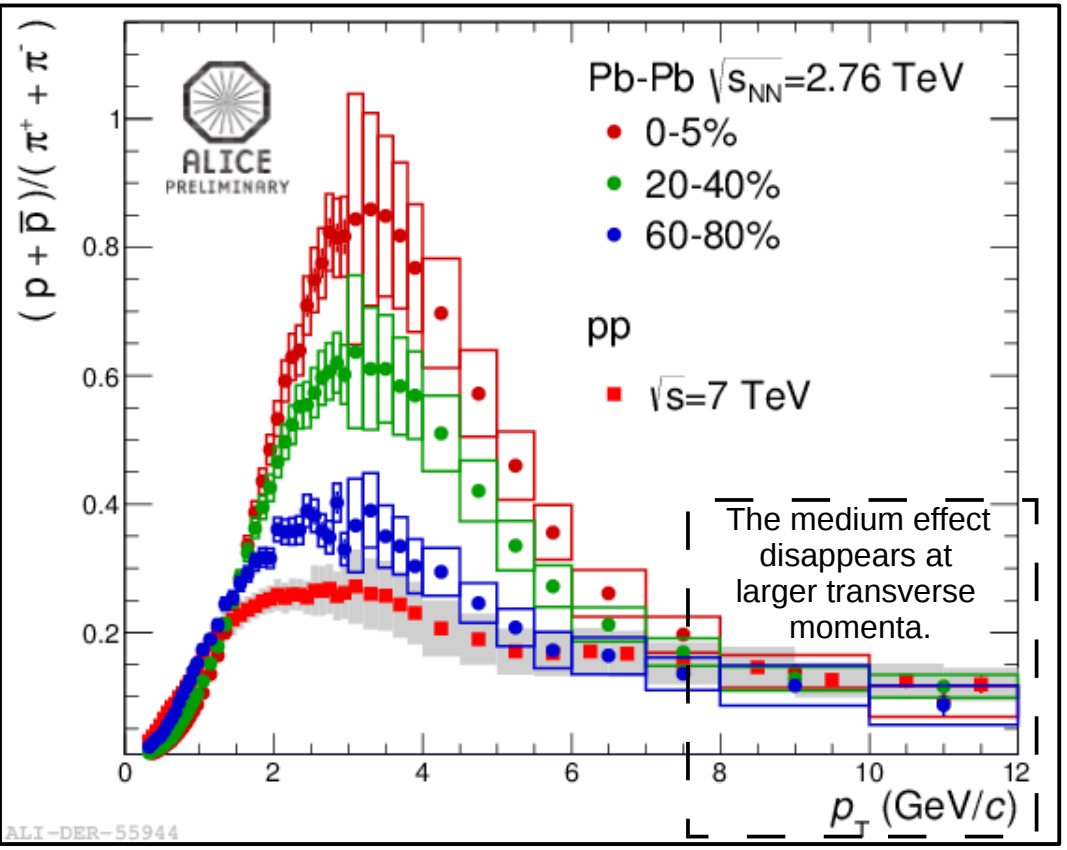
Phys. Rev. Lett. 109, 252301 (2012)

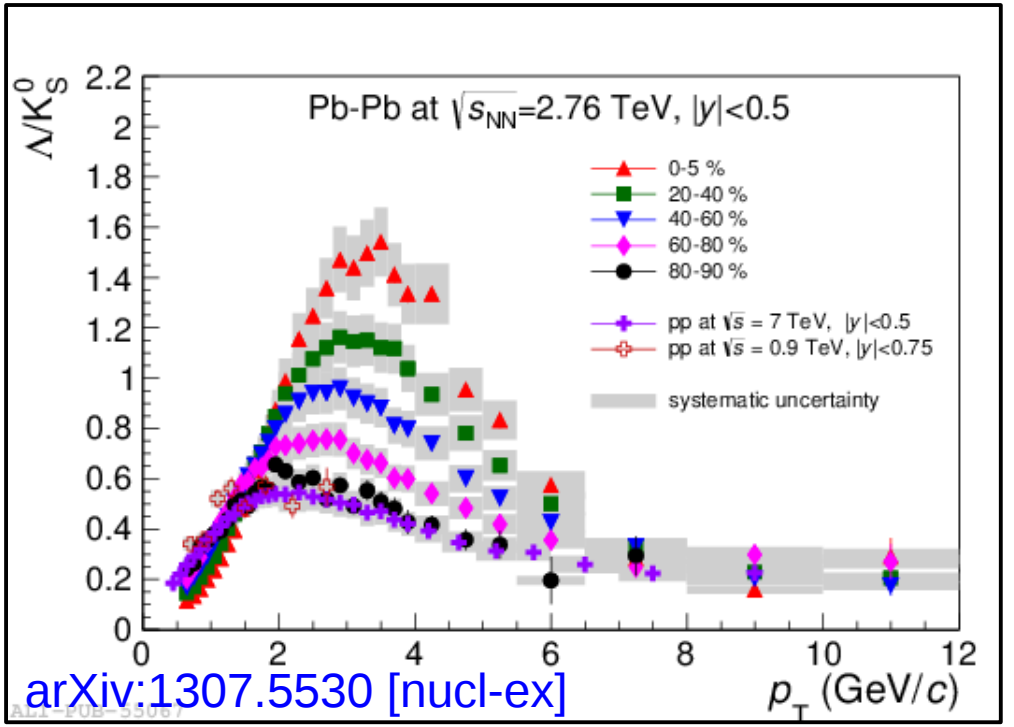
Most of the ratios are well described by statistical models. Disagreement for p/π might indicate:

- 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).

Intermediate p_T production

The sizes of the enhancements are compatible to those measured in Au-Au collisions at 200 GeV (arXiv:1304.3410)



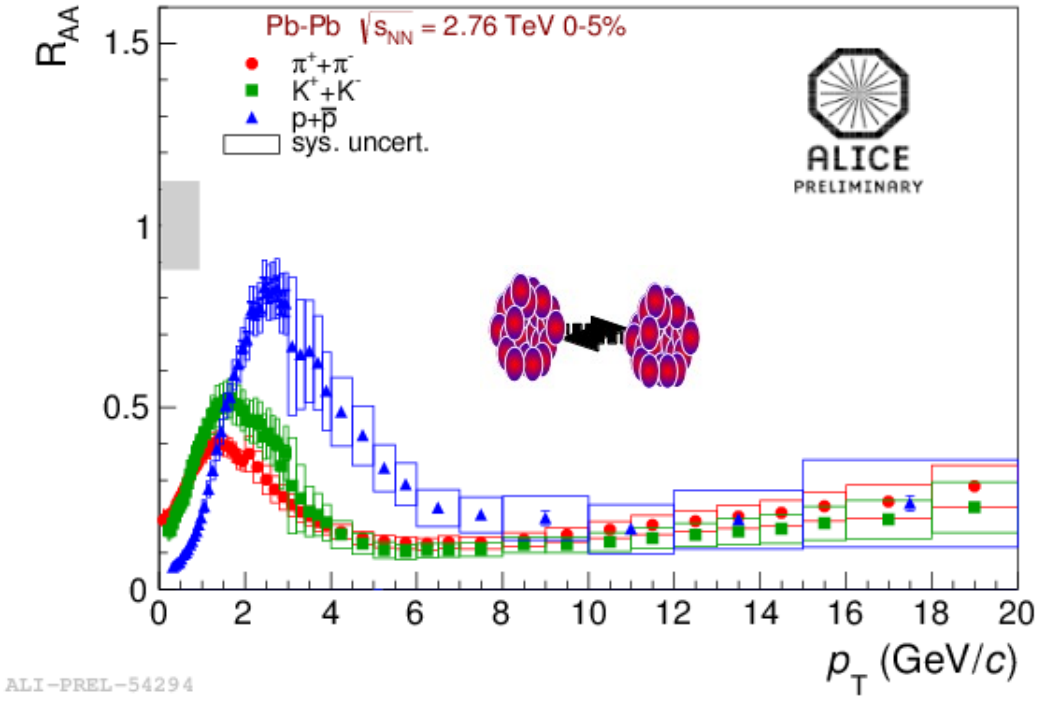


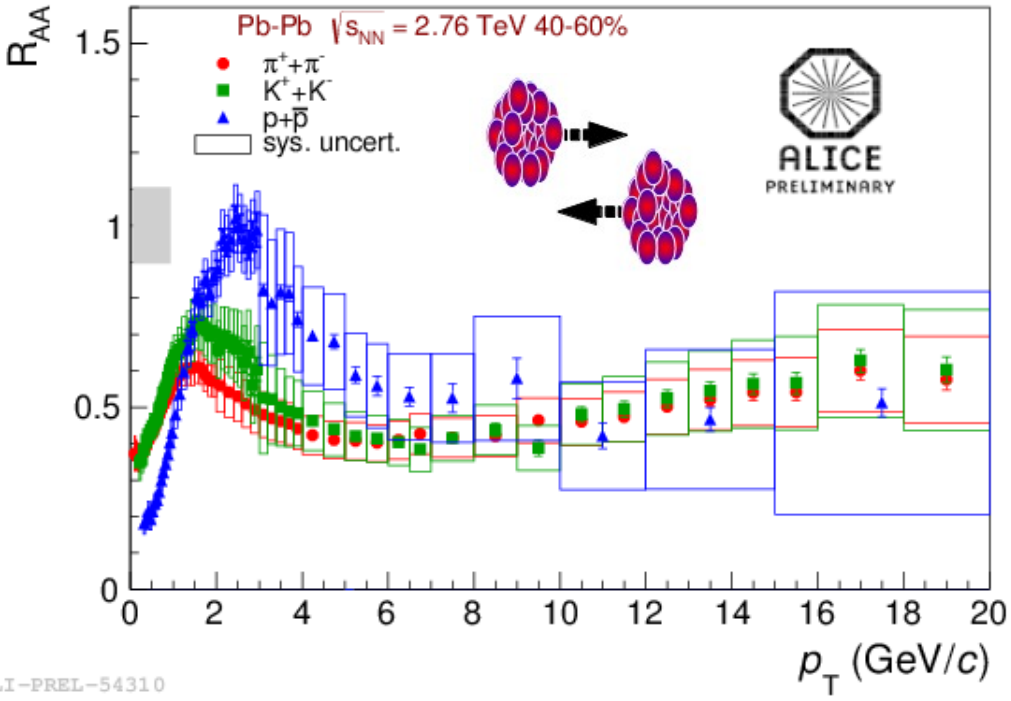
arXiv:1307.5530 [nucl-ex]

At low to intermediate p_T (<8 GeV/c) both baryon to meson ratios exhibit the same centrality dependence: the position of the peak moves to higher p_T when multiplicity increases.

High p_T production

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

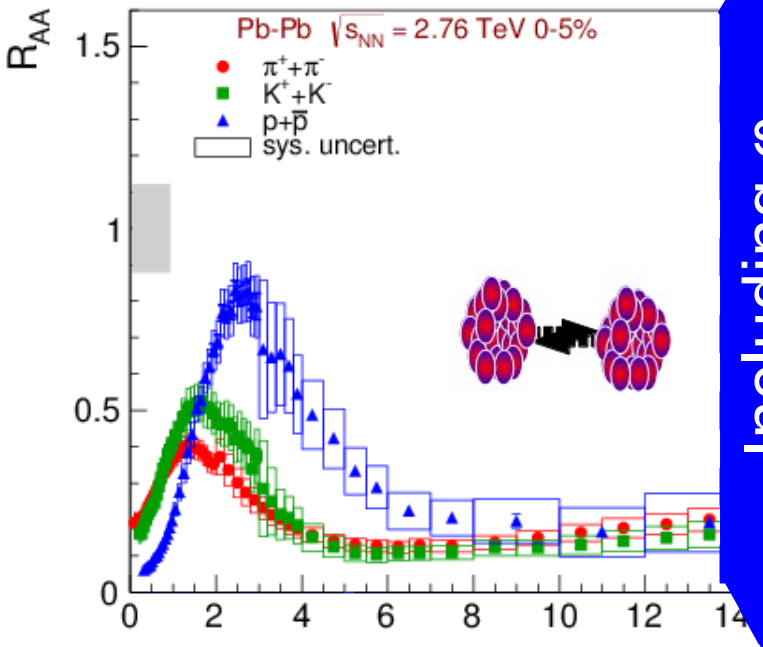




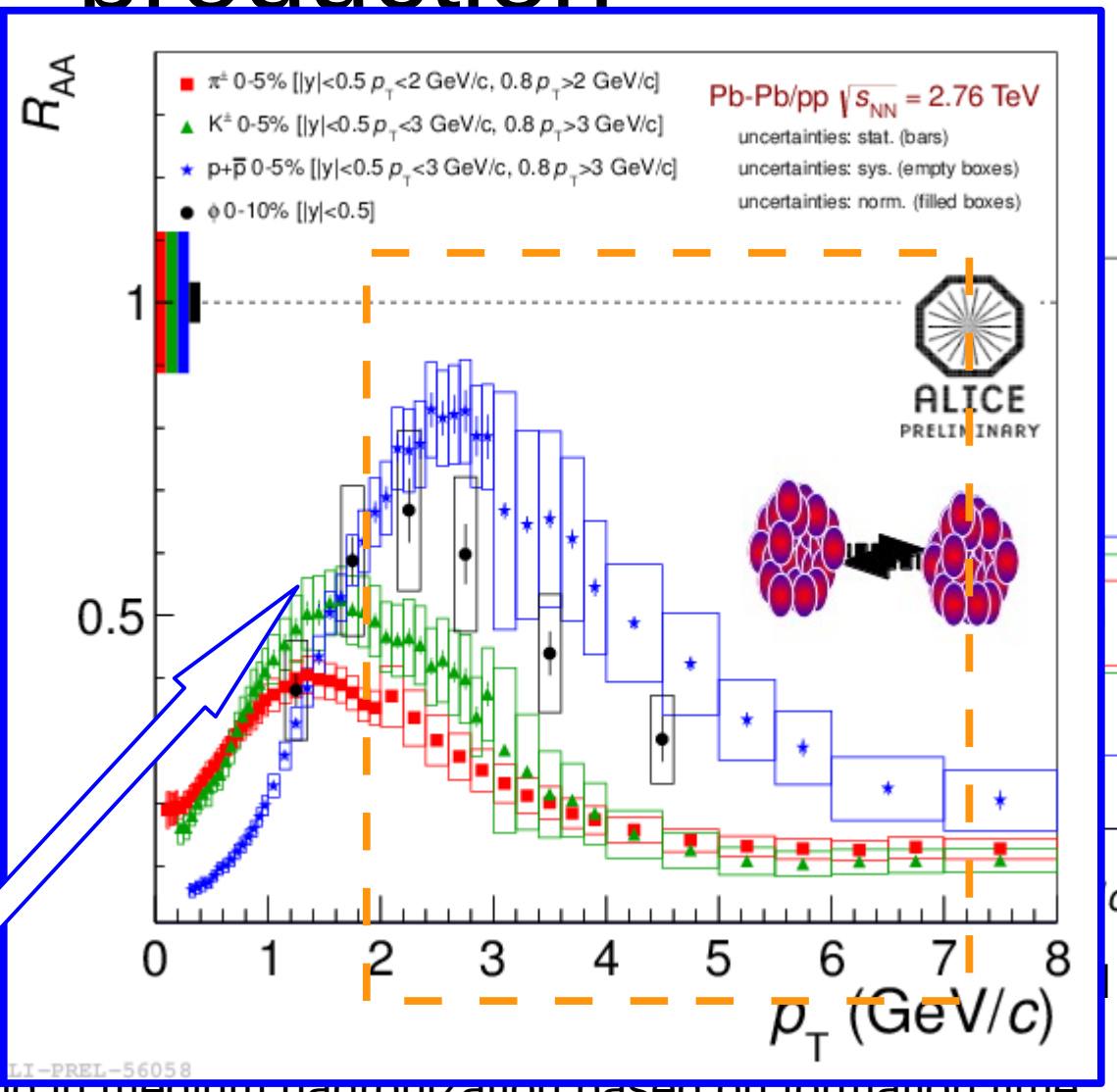
These results contradict the prediction for medium modified jets via enhanced parton splitting functions: Eur. Phys. J. C 55, 293 (2008).
They also contradict the predictions assuming in-medium hadronization based on formation time: Phys. Lett. B 691, 208 (2010).

High p_T production

At high p_T (>8 GeV/c), within the
equally suppressed.



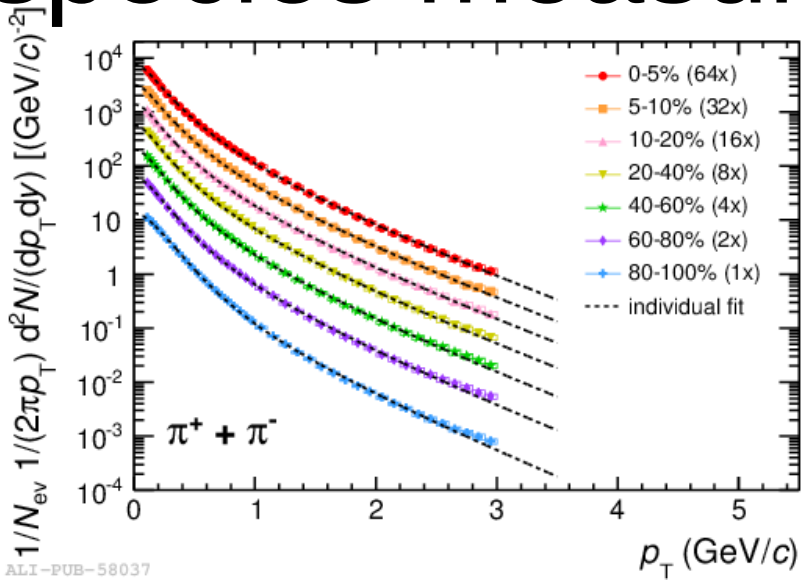
Including φ

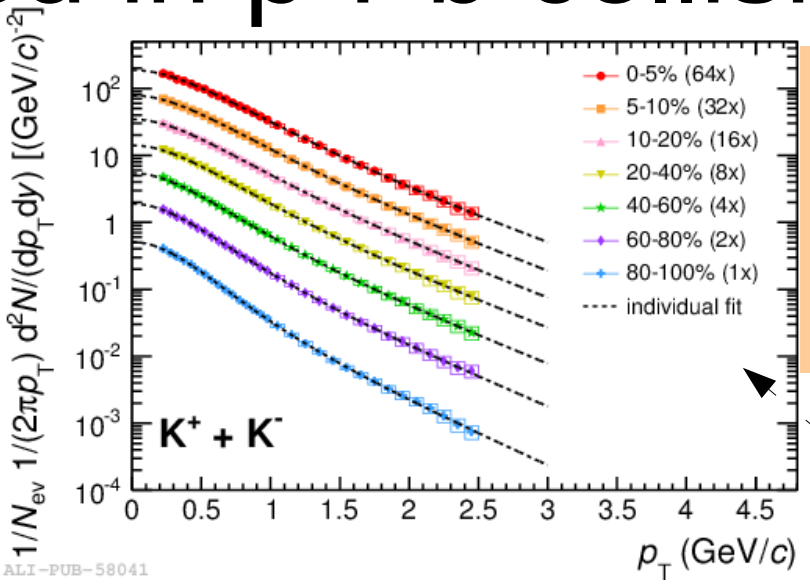


At low p_T (<2 GeV/*c*) R_{AA} for φ and p follow the same curve, this is interesting because here we expect hydrodynamic effects.

suming in medium hadronization based on formation time:
208 (2010).

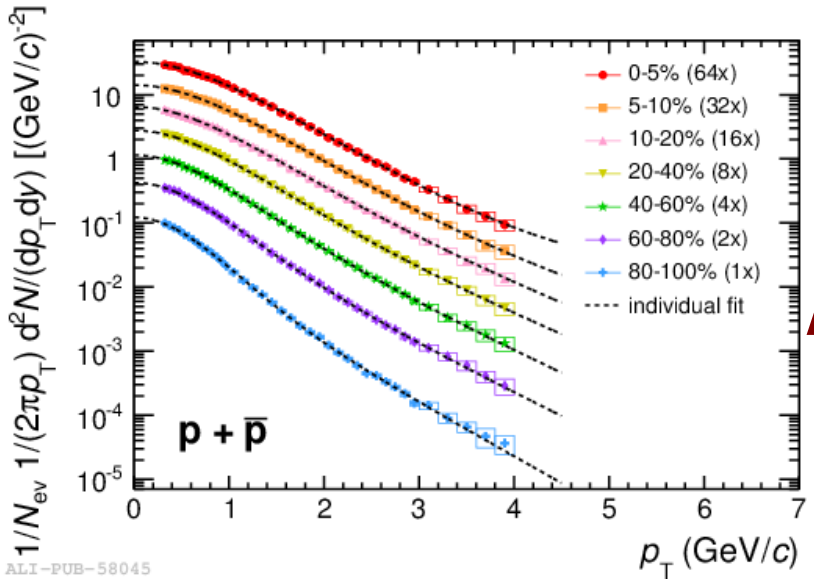
p_T spectra of different particle species measured in p-Pb collisions





Asymmetric energy/nucleon. CMS moves with y_{lab} = 0.468 (p direction) **Measurement $0<y_{cms}<0.5$**

Individual fit to Blast-wave function.

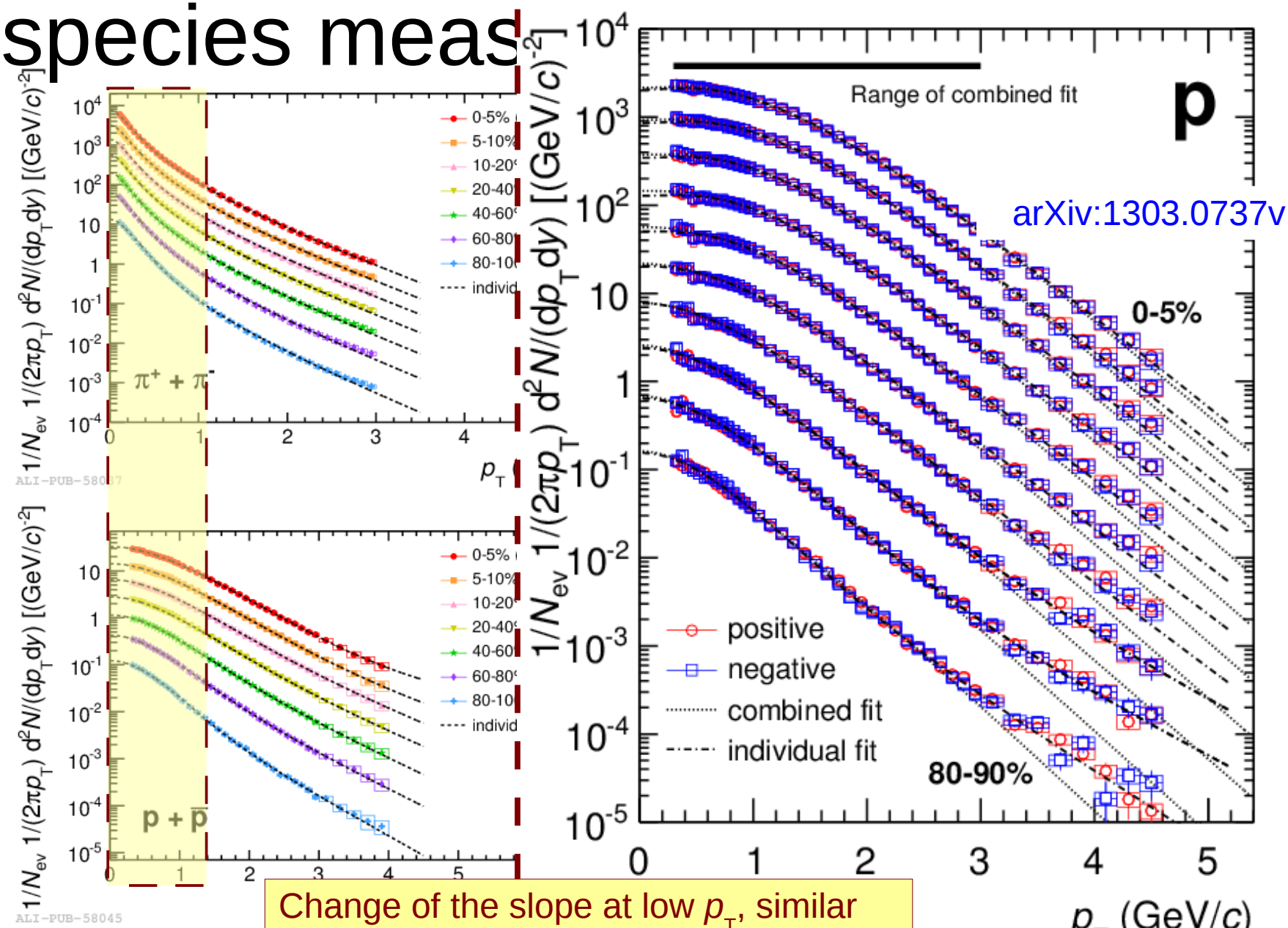


The spectra become harder with increasing multiplicity

arXiv:1307.6796v1 [nucl-ex]

Centrality in p-Pb:
In p-Pb, the correlation between geometry and multiplicity is not as straightforward as in Pb-Pb. 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 $2.8<\eta_{lab}<5.1$).

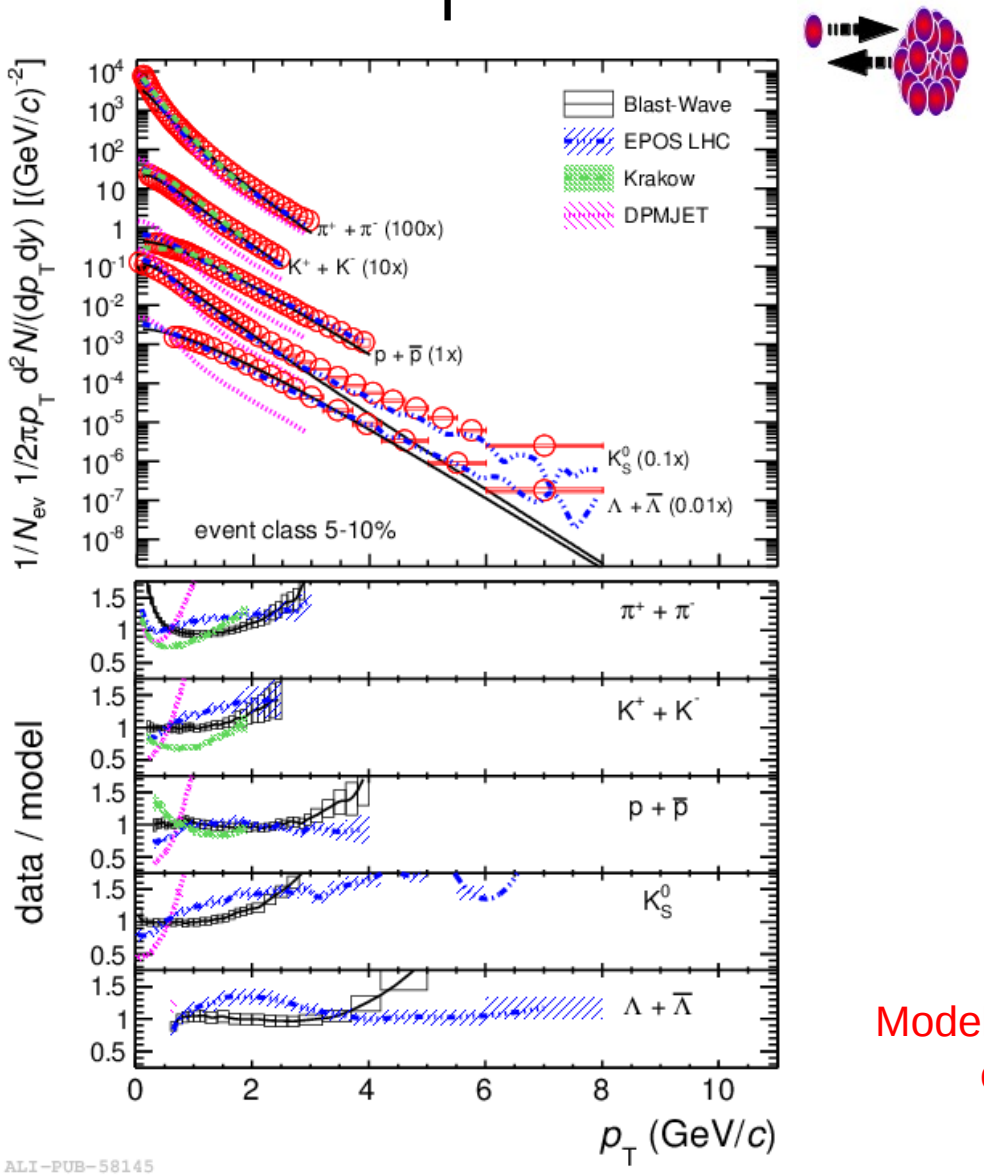
p_T spectra of different particle species measured



Change of the slope at low p_T, similar behavior is seen in Pb-Pb collisions.

arXiv:1303.0737v1 [hep-ex]

Low p_T, comparison to models



Blast-Wave fit:

Schnedermann, 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, arXiv:1306.0121 [hep-ph]

➢ hard/soft scattering contribute to jet/bulk

➢ bulk matter described with hydro

Kraków:

Bozek, PRC 85, 014911 (2012)

➢ initial conditions from Glauber MC

➢ viscous hydrodynamic expansion

➢ statistical hadronization at freeze-out

DPMJET:

Roesler, arXiv:hep-ph/0012252

➢ QCD-inspired model

➢ reproduces $dN_{ch}/d\eta$ in NSD p-Pb.

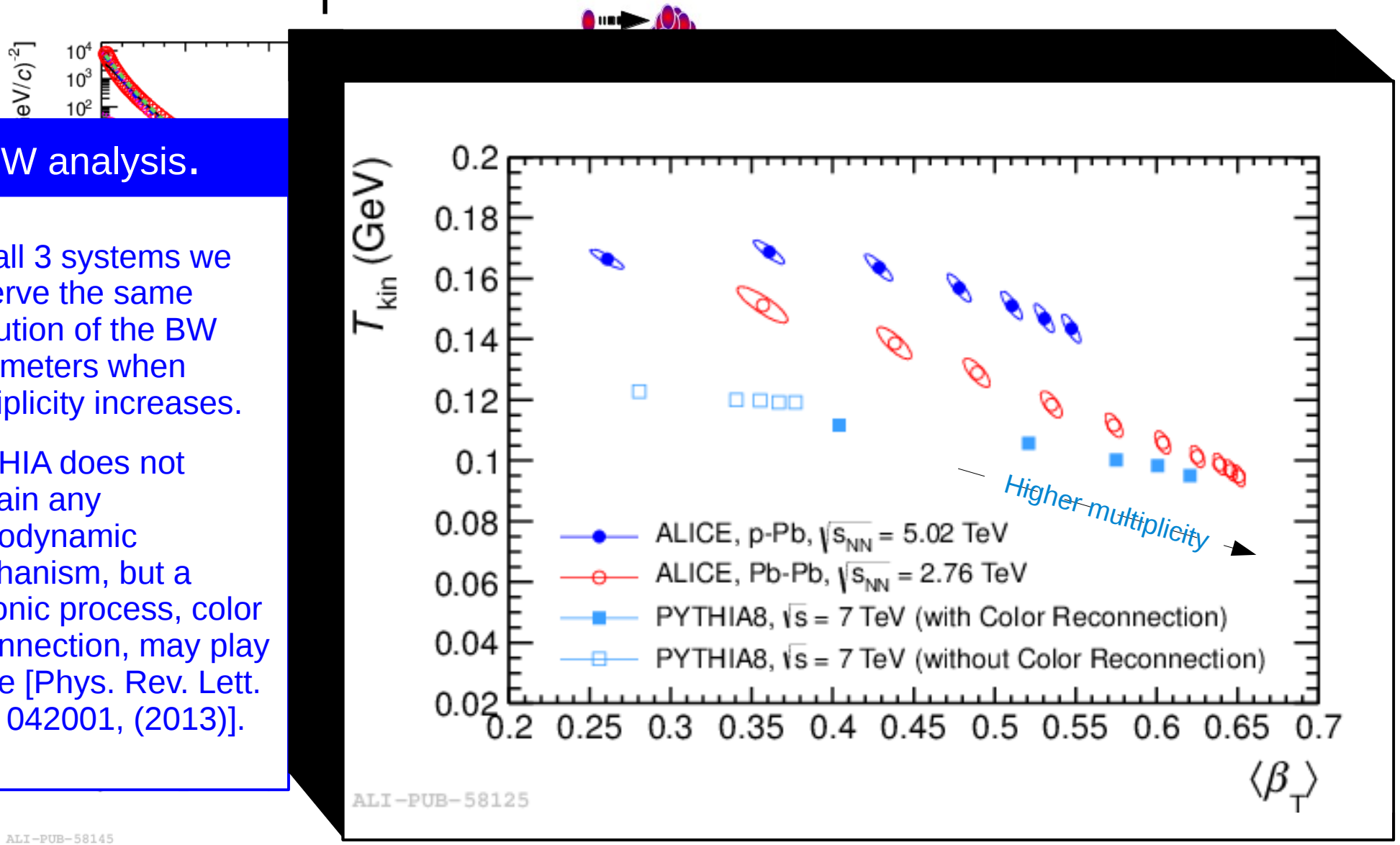
Models including hydro give an overall good description of data, this is particularly interesting in p-Pb.

arXiv:1307.6796v1 [nucl-ex]

Low p_T, comparison to models

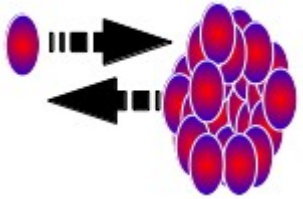
BW analysis.

- 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)].

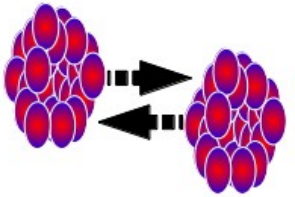


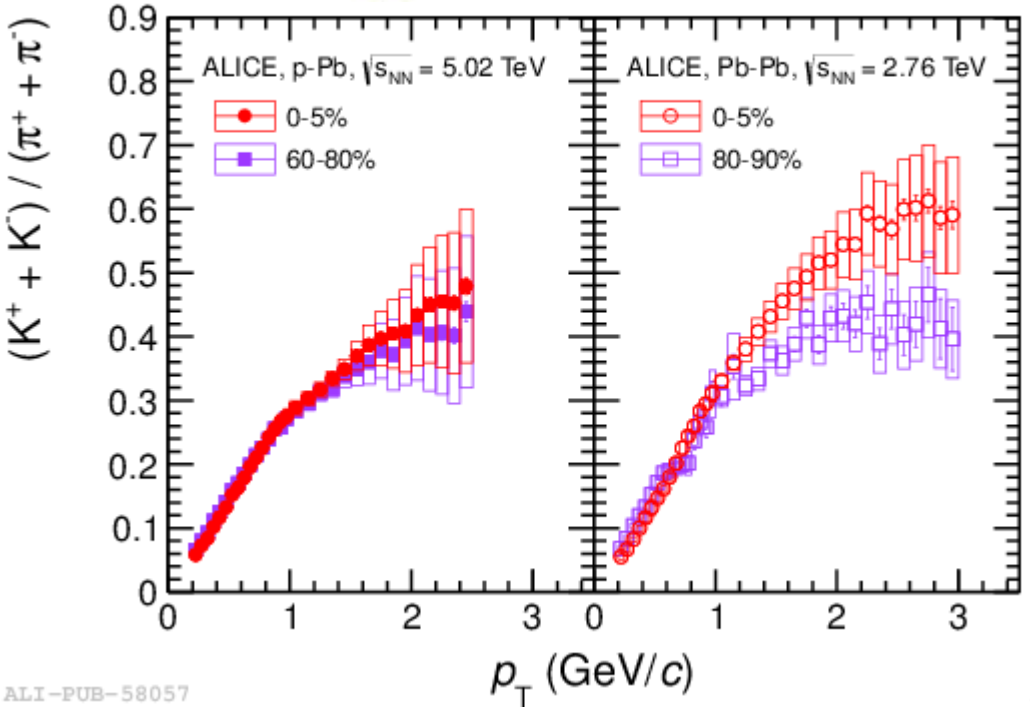
ALI-PUB-58145

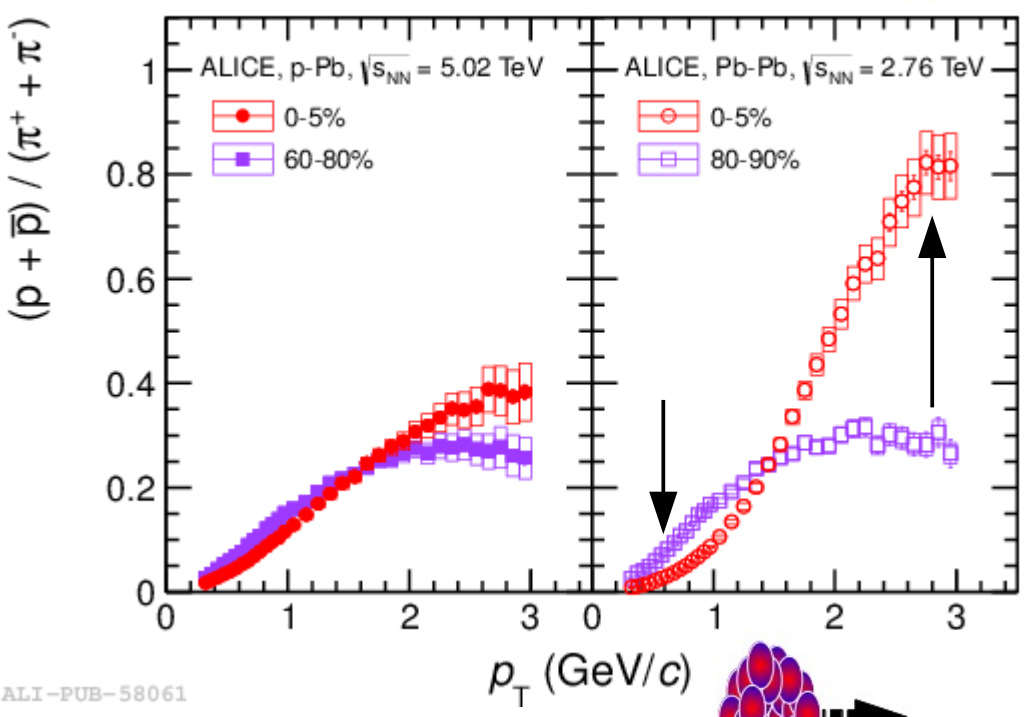
Particle ratios vs p_T



Multiplicity dependence of the particle ratios vs p_T measured in p-Pb *behave similar to those measured in* Pb-Pb *collisions.*

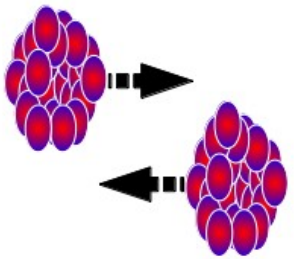




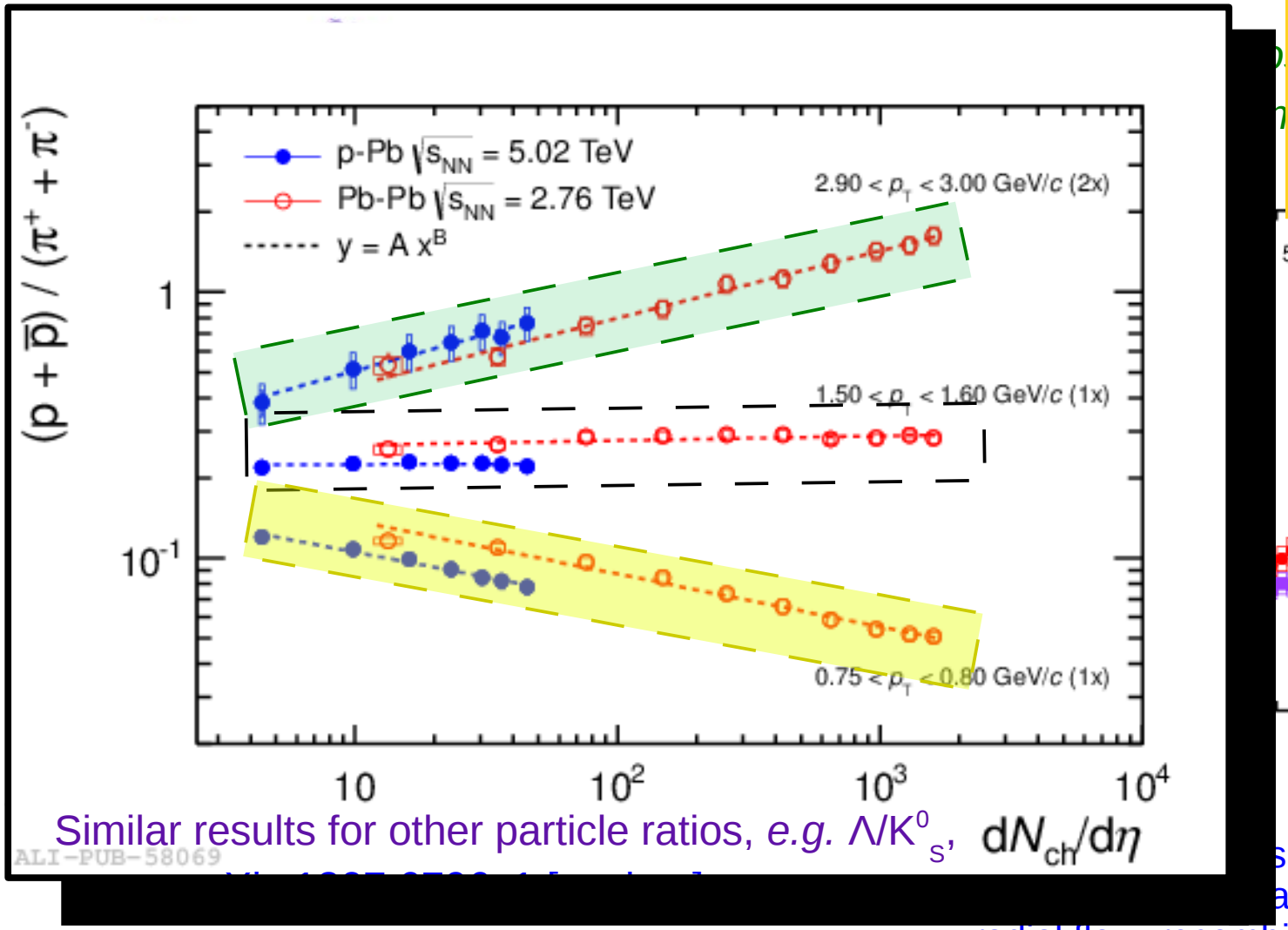


arXiv:1307.6796v1 [nucl-ex]

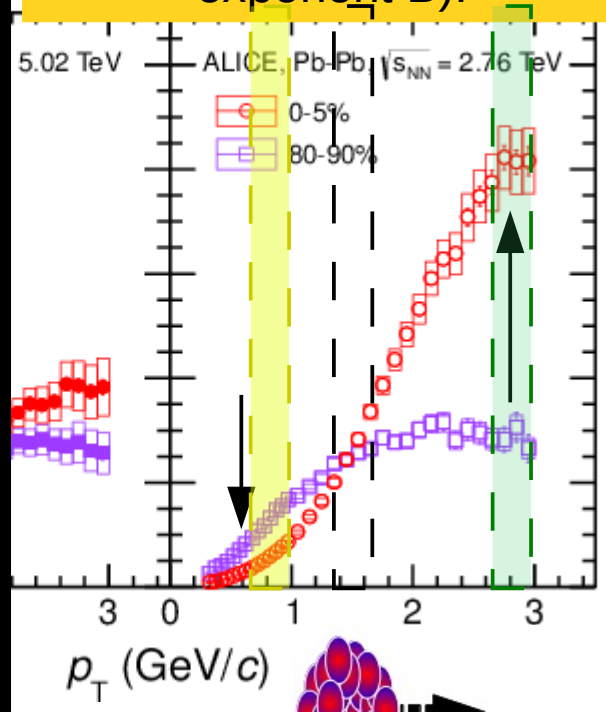
In central Pb-Pb collisions the following mechanisms may play a role: radial flow, recombination.



p/π vs dN_{ch}/dη in three p_T intervals

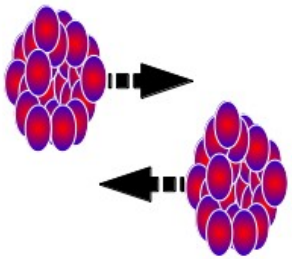


Same multiplicity dependence of the enhancement and depletion (power law with exponent B).



Similar results for other particle ratios, *e.g.* Λ/K^0_S,

s the following
ay a role:
radial flow, recombination.

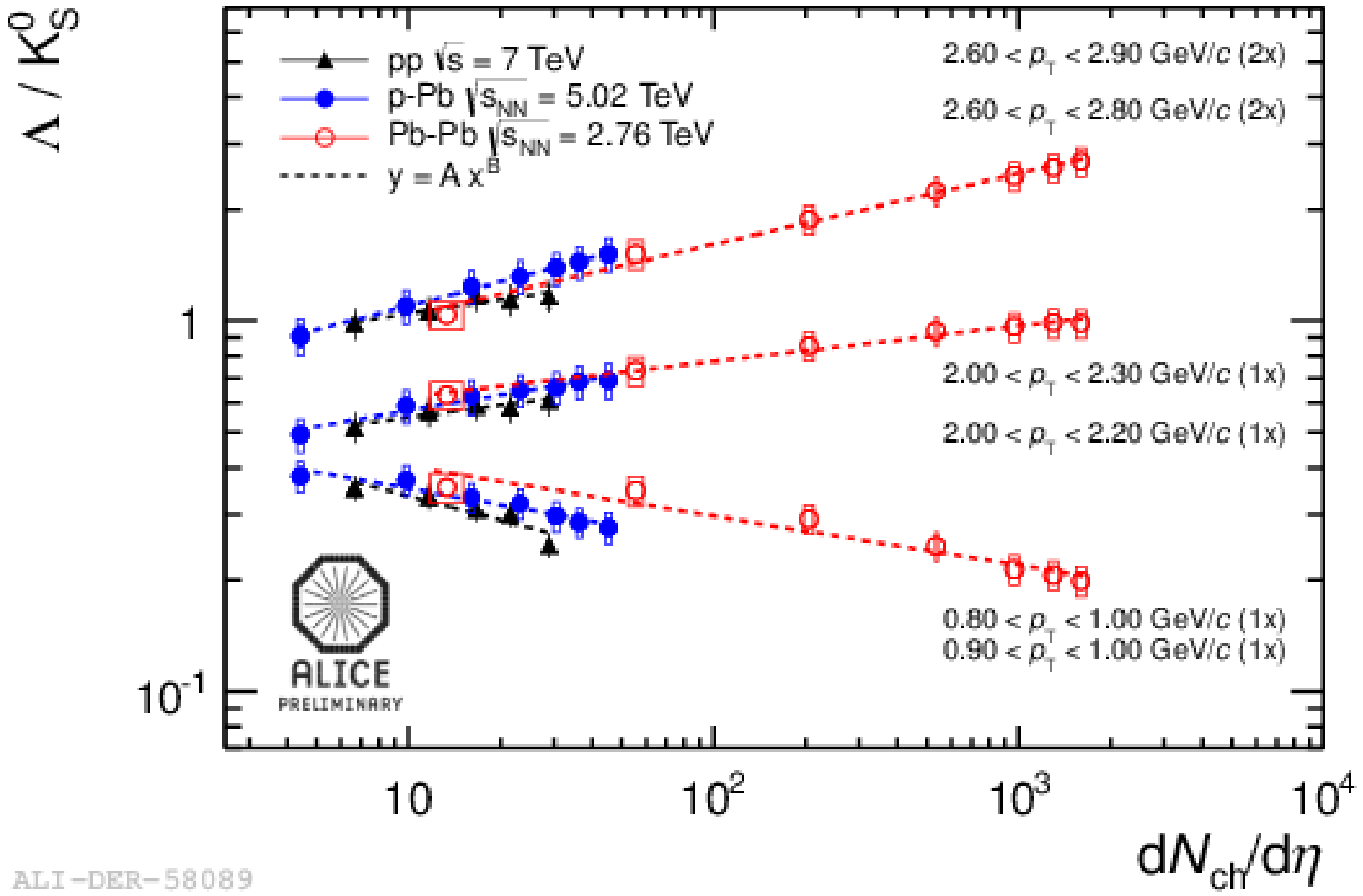


Conclusions

- 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 collisions (even in Pythia where the effect is due to a partonic mechanism, color reconnection, which mimics radial flow).
- At higher p_T (>8 GeV/c), the particle ratios measured in Pb-Pb are consistent to those measured in pp. From the R_{AA} measurement we conclude that π/K/p are equally suppressed at high p_T.

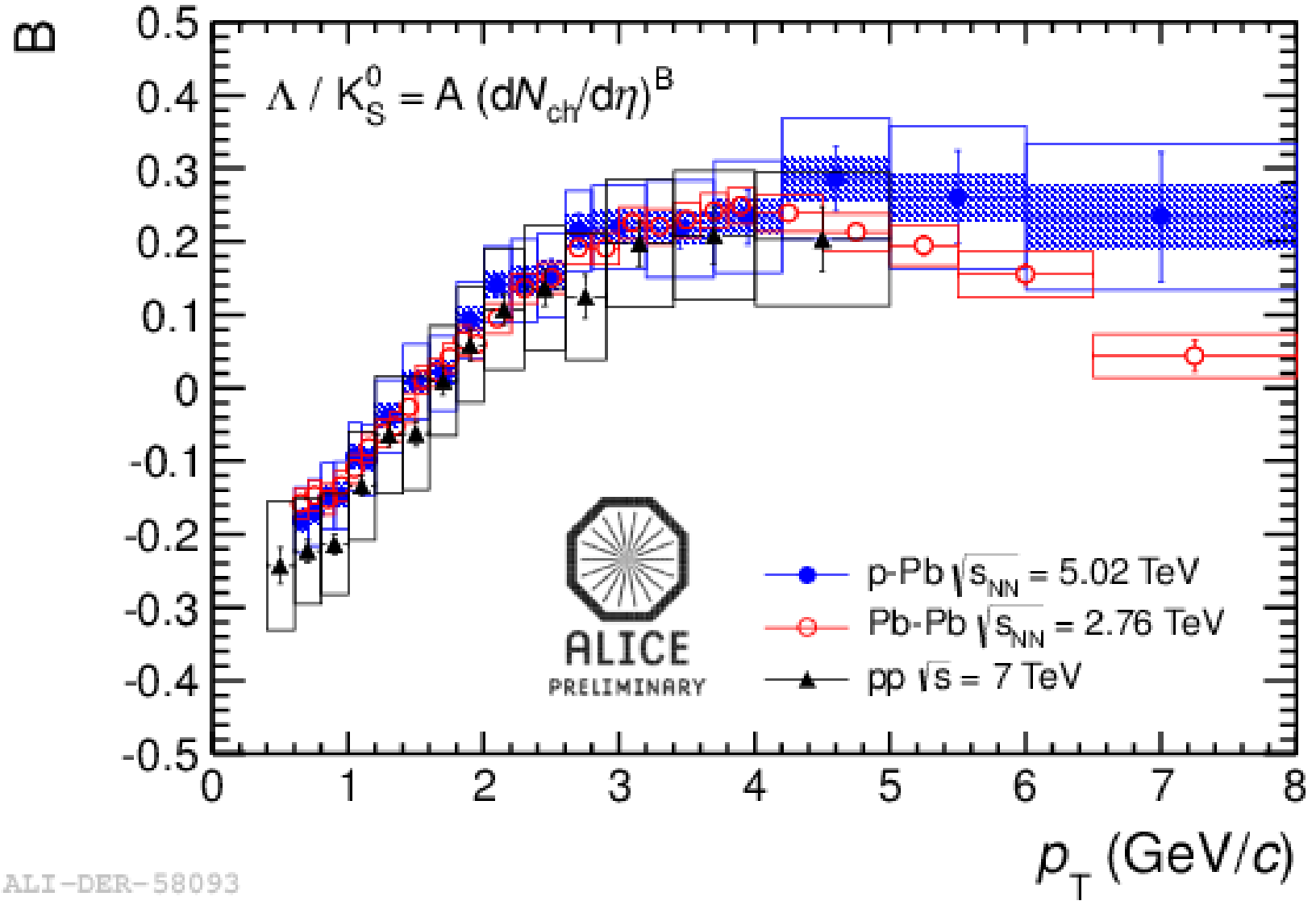
Backup

Λ/K^0_s vs Multiplicity

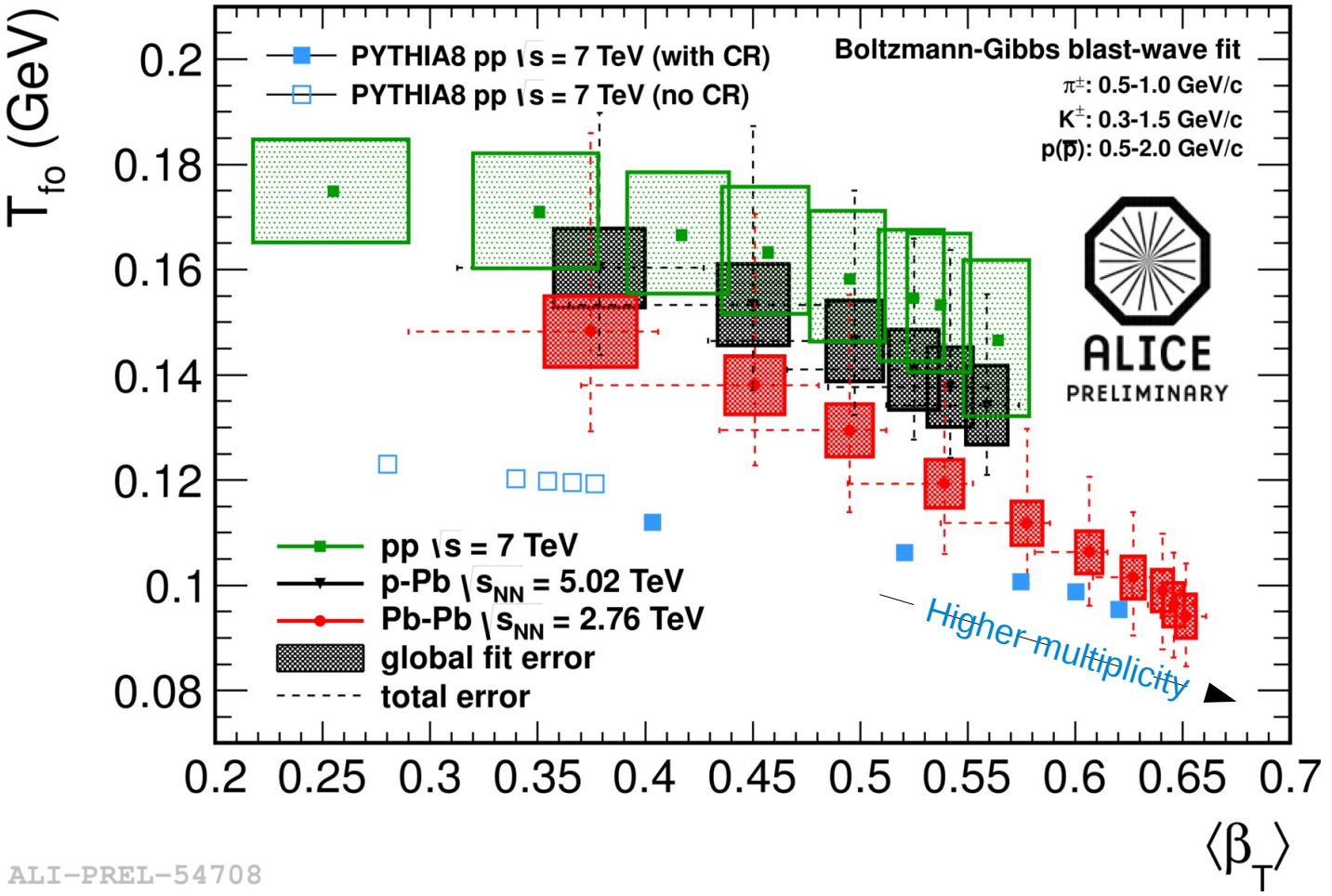


ALI-DER-58089

Scaling exponent vs p_T



- 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)].



ALI-PREL-54708