LUND UNIVERSITY

Illa da Toxa - Galicia - Spain
8-14 September 2013
IS2013
International Conference on the Initial Stages of High Energy Nuclear Collisions

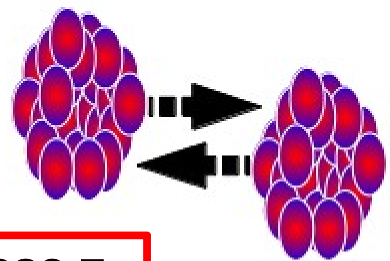
MULTI-PARTON INTERACTIONS, COLOR RECONNECTION AND COLLECTIVE DYNAMICS

Antonio Ortiz Velasquez,
Work done with: P. Christiansen,
G.Paic, E. Cuautle and I. Maldonado.

September 12, 2013

Motivation

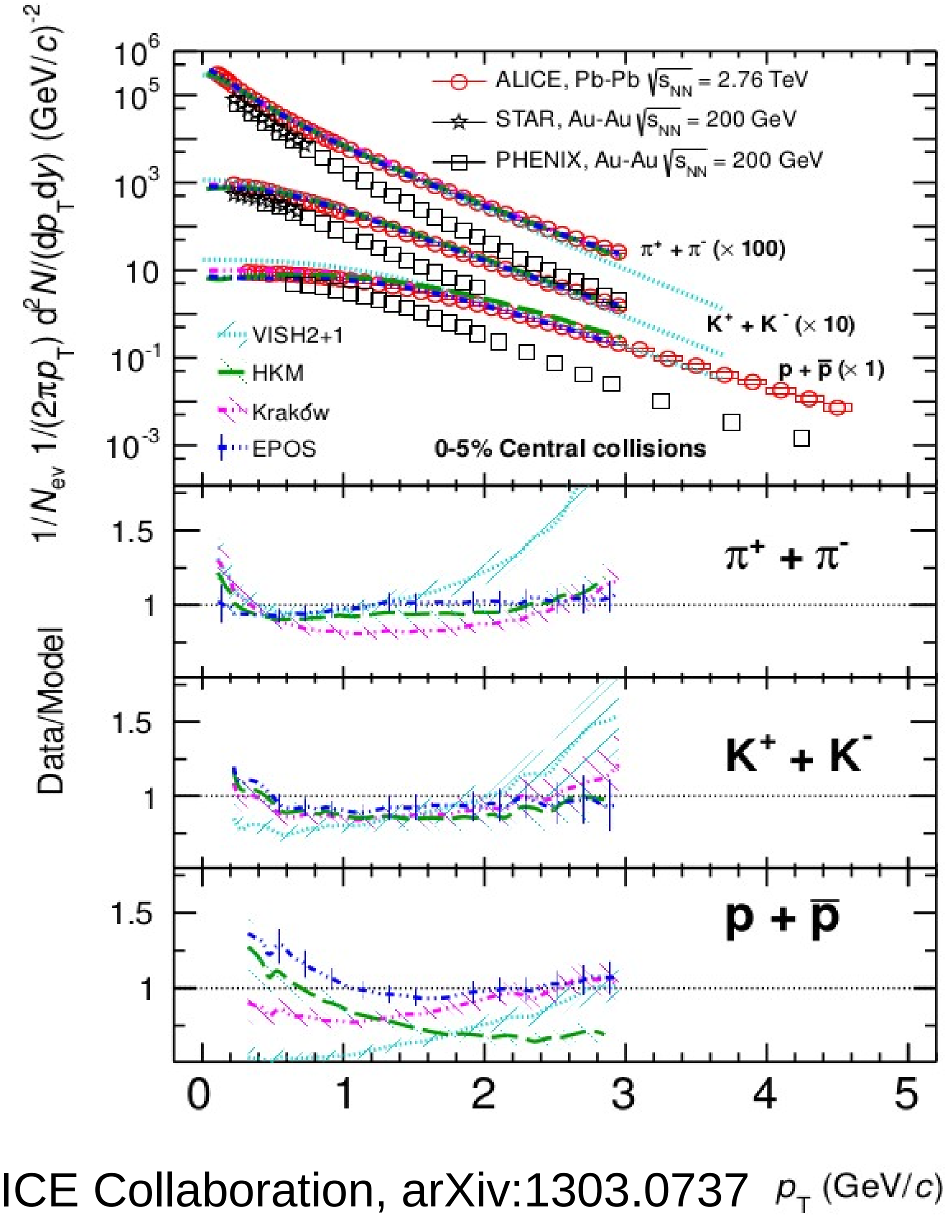
Pb-Pb collisions,
$\sqrt{s_{NN}}$=2.76 TeV
0-5%



$\langle N_{par} \rangle$=282.7

ALICE Collaboration, arXiv:1301.4361

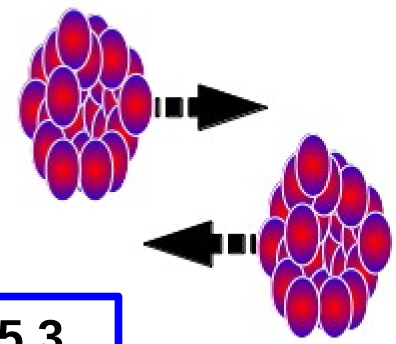
- Hydrodynamics describes quite well the transverse momentum, p_T, spectra of different particle species. This is true in the p_T (< 2 GeV/c) region where collective effects are expected.



ALICE Collaboration, arXiv:1303.0737

Motivation

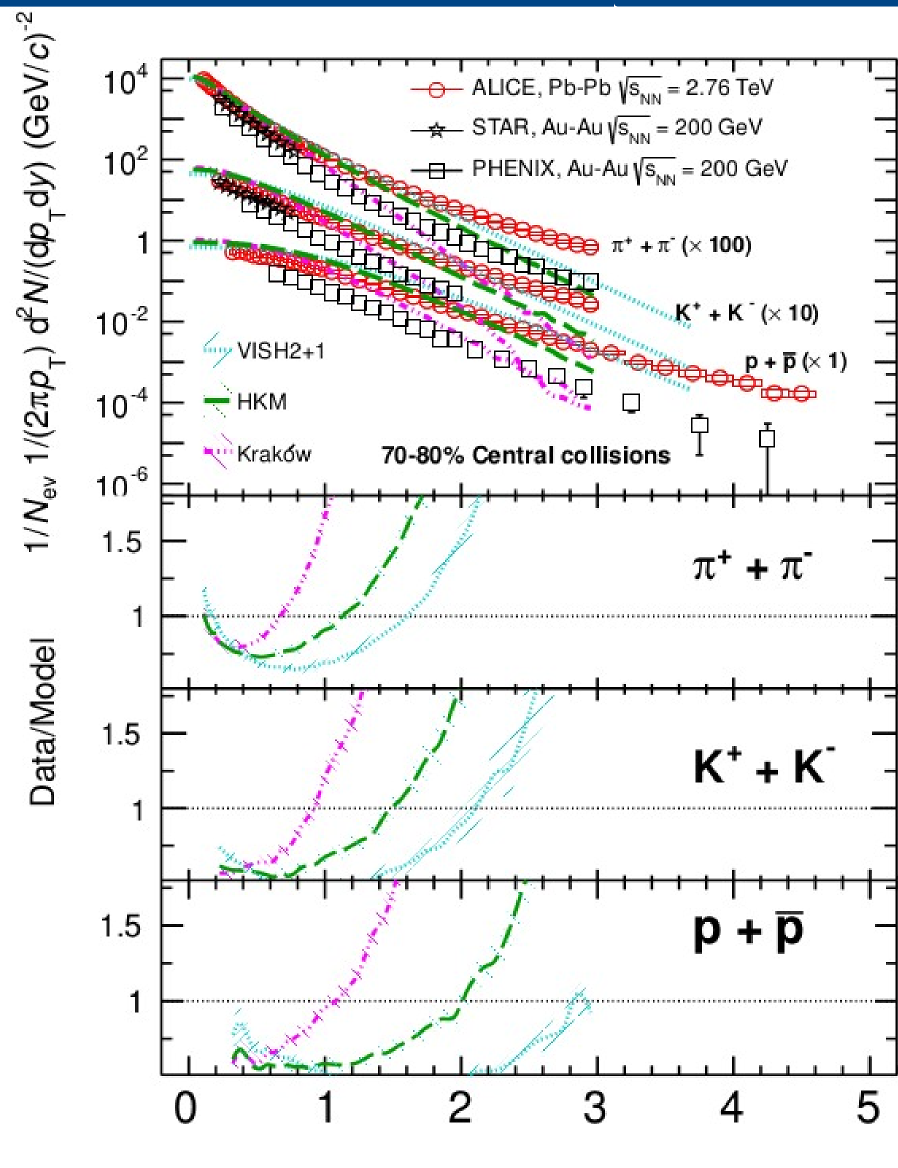
Pb-Pb collisions,
$\sqrt{s_{NN}}$=2.76 TeV
70-80%



$\langle N_{par} \rangle$=15.3

ALICE Collaboration, arXiv:1301.4361

- Hydrodynamics describes quite well the transverse momentum, p_T, spectra of different particle species. This is true in the p_T (< 2 GeV/c) region where collective effects are expected.
- The limit of the hydrodynamical picture is observed in the most peripheral collisions.



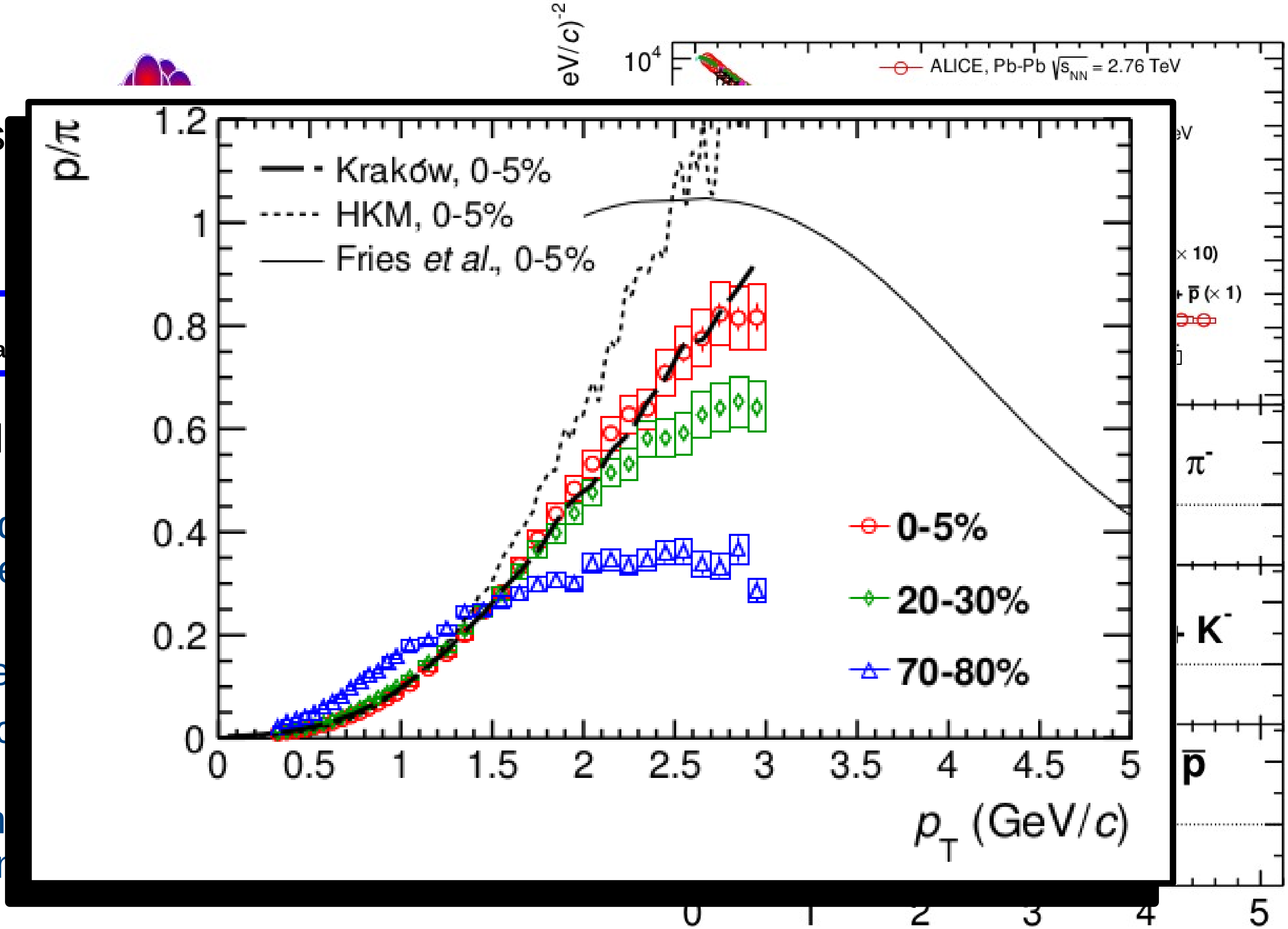
ALICE Collaboration, arXiv:1303.0737

Baryon to meson ratio

Pb-Pb collisions
$\sqrt{s_{NN}}$=2.76 TeV
70-80%

The features of the hydrodynamical flow can be studied from the particle ratios as a function of p_T: heavier hadron yield divided by the lighter hadron yield.

➢ The limit of the h
observed in the r



ALICE Collaboration, arXiv:1303.0737

Baryon to meson ratio

At higher momentum, $p_T > 2$ GeV/c, we observe the so-called baryon anomaly which has not been fully understood .

Pb-Pb collisions
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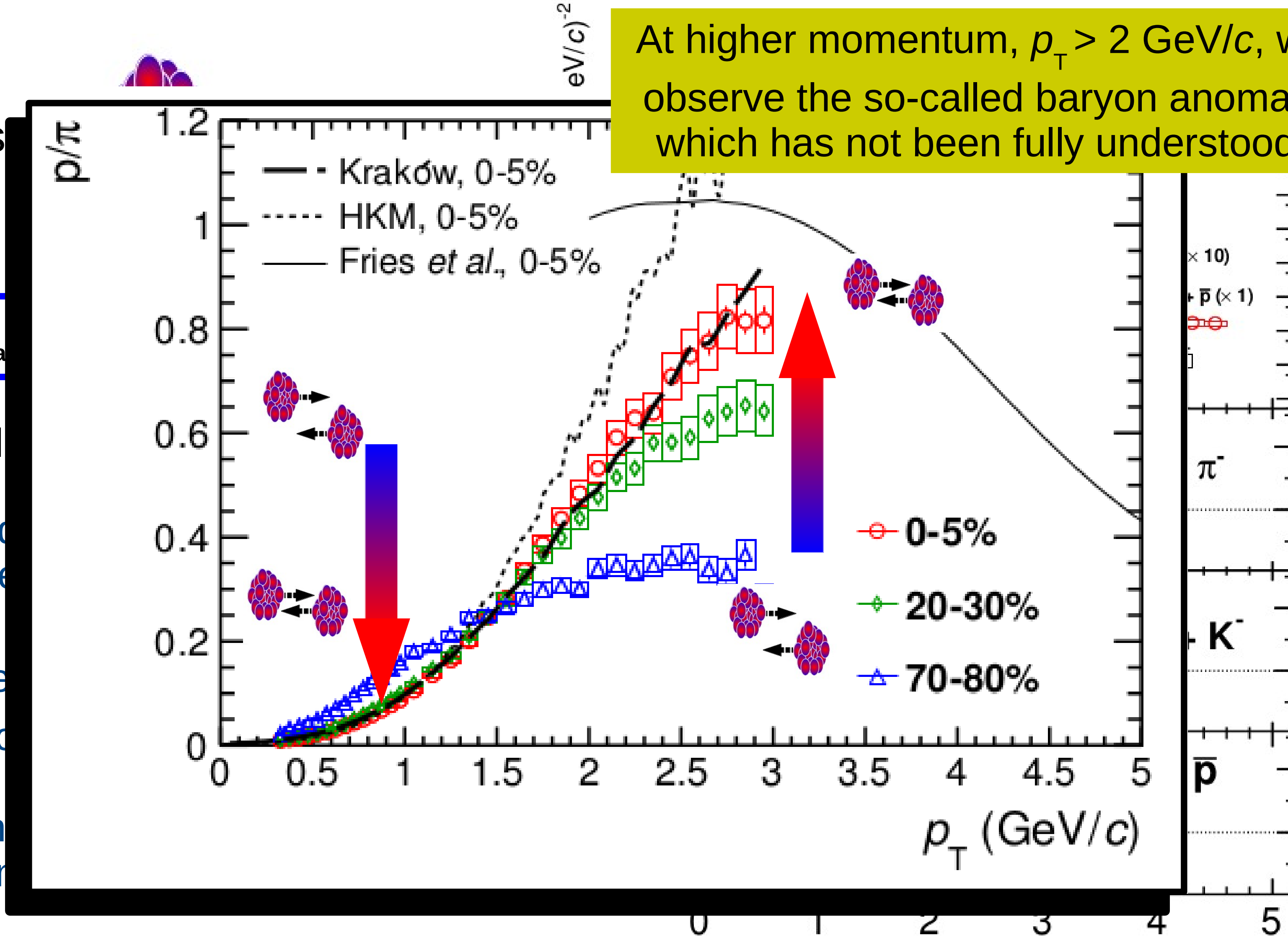

effects are expec

- The limit of the h
observed in the r

ALICE Collaboration, arXiv:1303.0737

Similarities between p-Pb and Pb-Pb collisions

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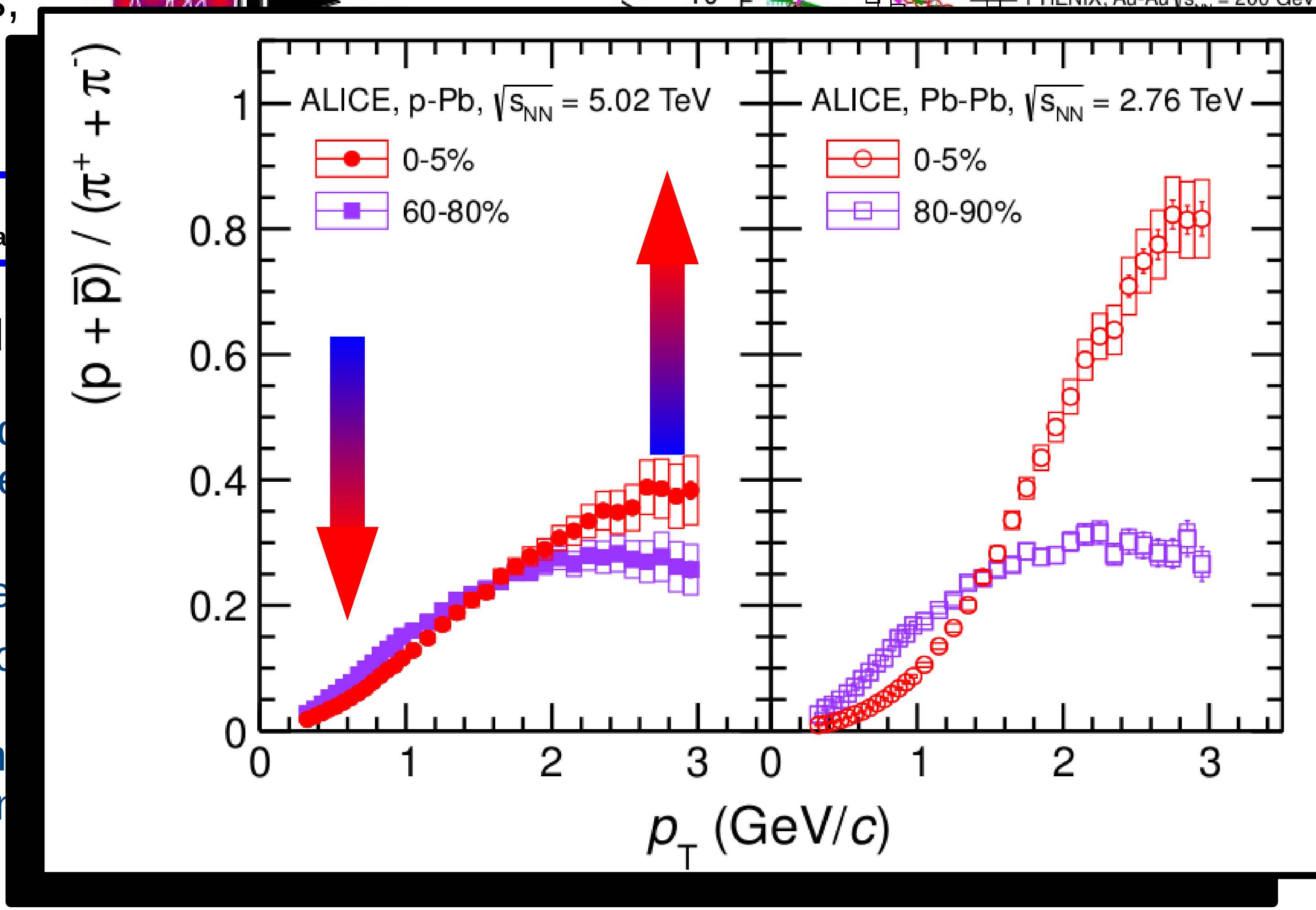
But recently, we have learned that the hydro features and the baryon anomaly appear in smaller systems like p-Pb collisions.

Pb-Pb collisions, $\sqrt{s_{NN}}$=2.76 TeV
70-80%

The features of the hydrodynamical flow can be studied from the particle ratios as a function of p_T: heavier hadron yield divided by the lighter hadron yield.



ALICE Collaboration, arXiv:1307.6796

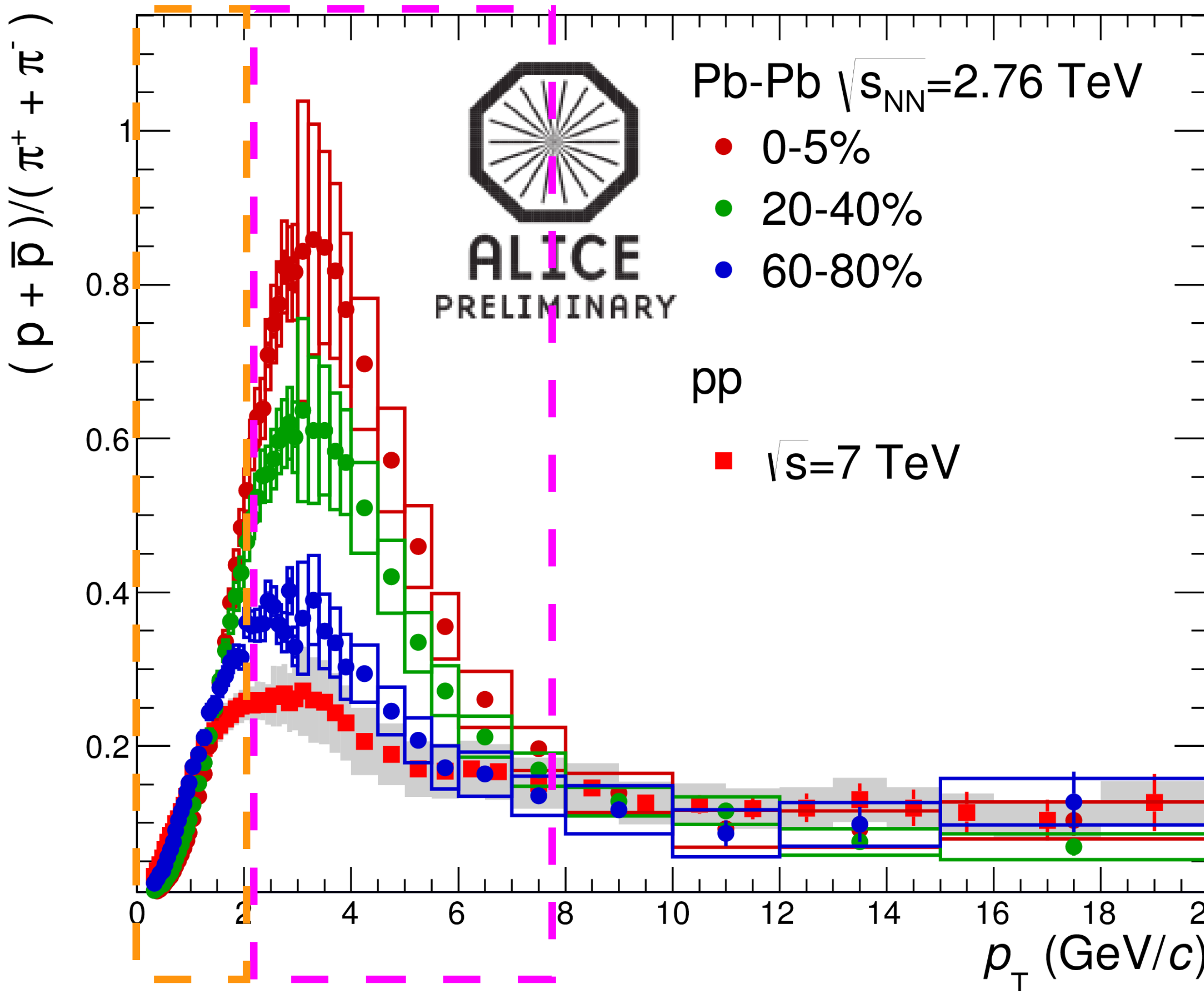
- The limit of the h… observed in the r…

p/π vs p_T in pp collisions

But we observed that in pp collisions the baryon to meson ratio shows:

- A small enhancement in the same p_T region where the baryon anomaly is seen in Pb-Pb collisions.
- At lower p_T the ratios follow a "multiplicity ordering":

$p/\pi_{pp} > p/\pi_{60\text{-}80\%} > \ldots > p/\pi_{0\text{-}5\%}$



ALICE Collaboration,
Nucl. Phys. A 904-905 (2013) 763c-766c

p/π vs p_T in pp collisions

But we observed that in pp collisions the baryon to meson ratio shows:

- A small enh
  same p_T reg
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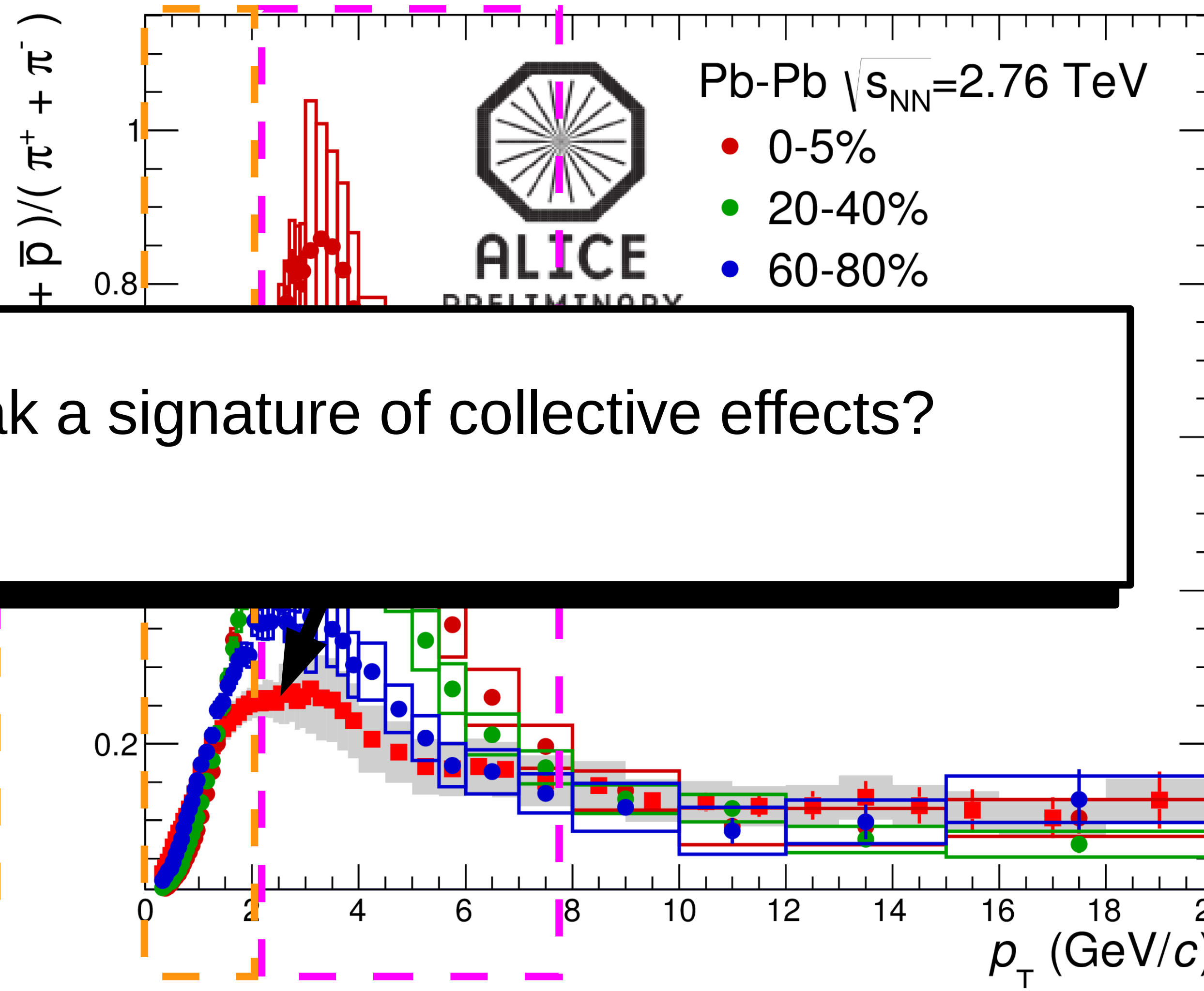
  collisions.

Is this peak a signature of collective effects?

- At lower p_T the ratios follow a “multiplicity ordering”:

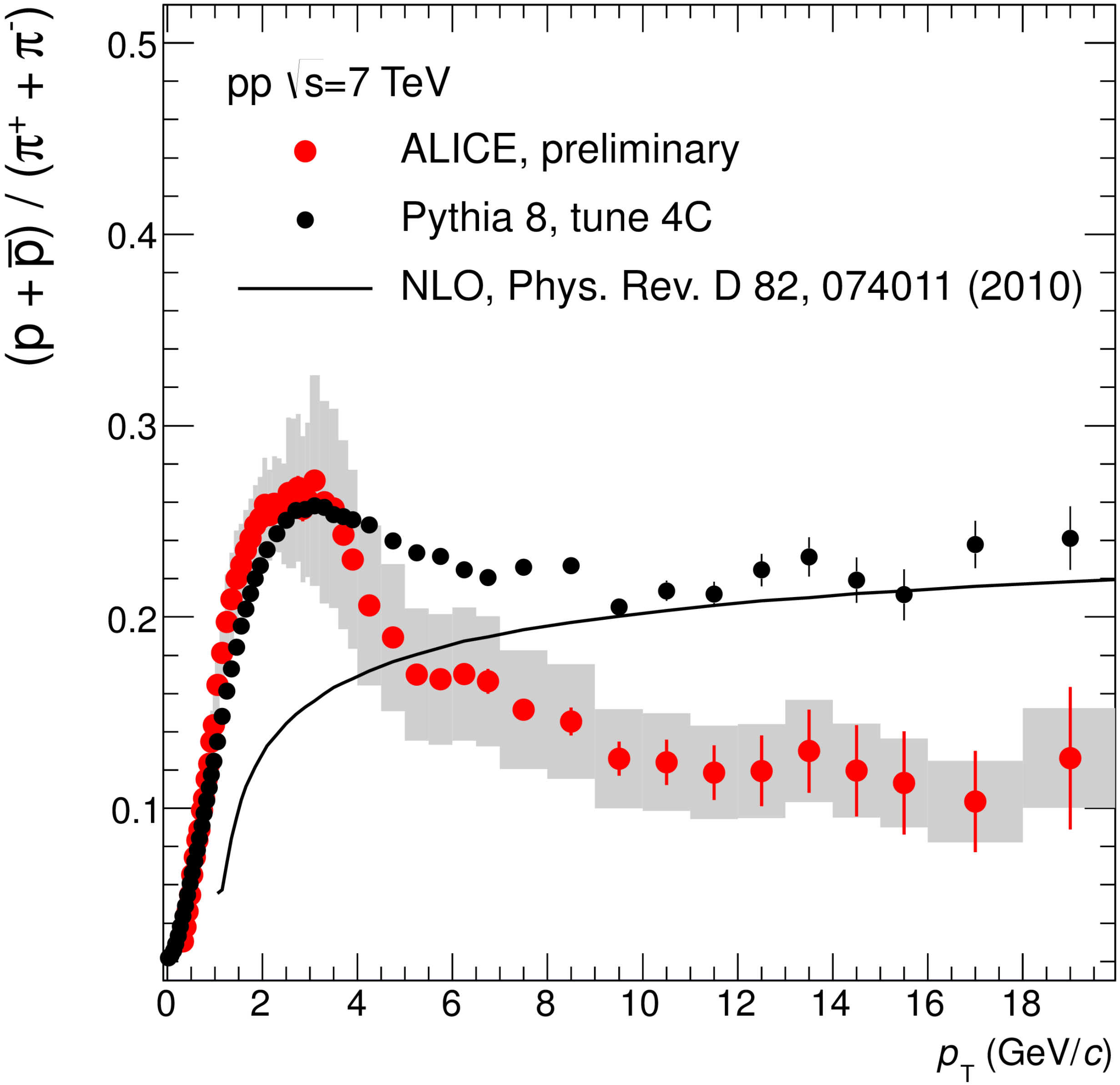
  $p/\pi_{pp} > p/\pi_{60\text{-}80\%} > \ldots > p/\pi_{0\text{-}5\%}$



ALICE Collaboration,
Nucl. Phys. A 904-905 (2013) 763c-766c

The framework

- We chose Pythia 8 tune 4C because it qualitatively reproduces the shape of the ratio at low p_T (other observables like $<p_T>$ vs multiplicity are well described by this tune).



Evolution p/π with N_{mpi}

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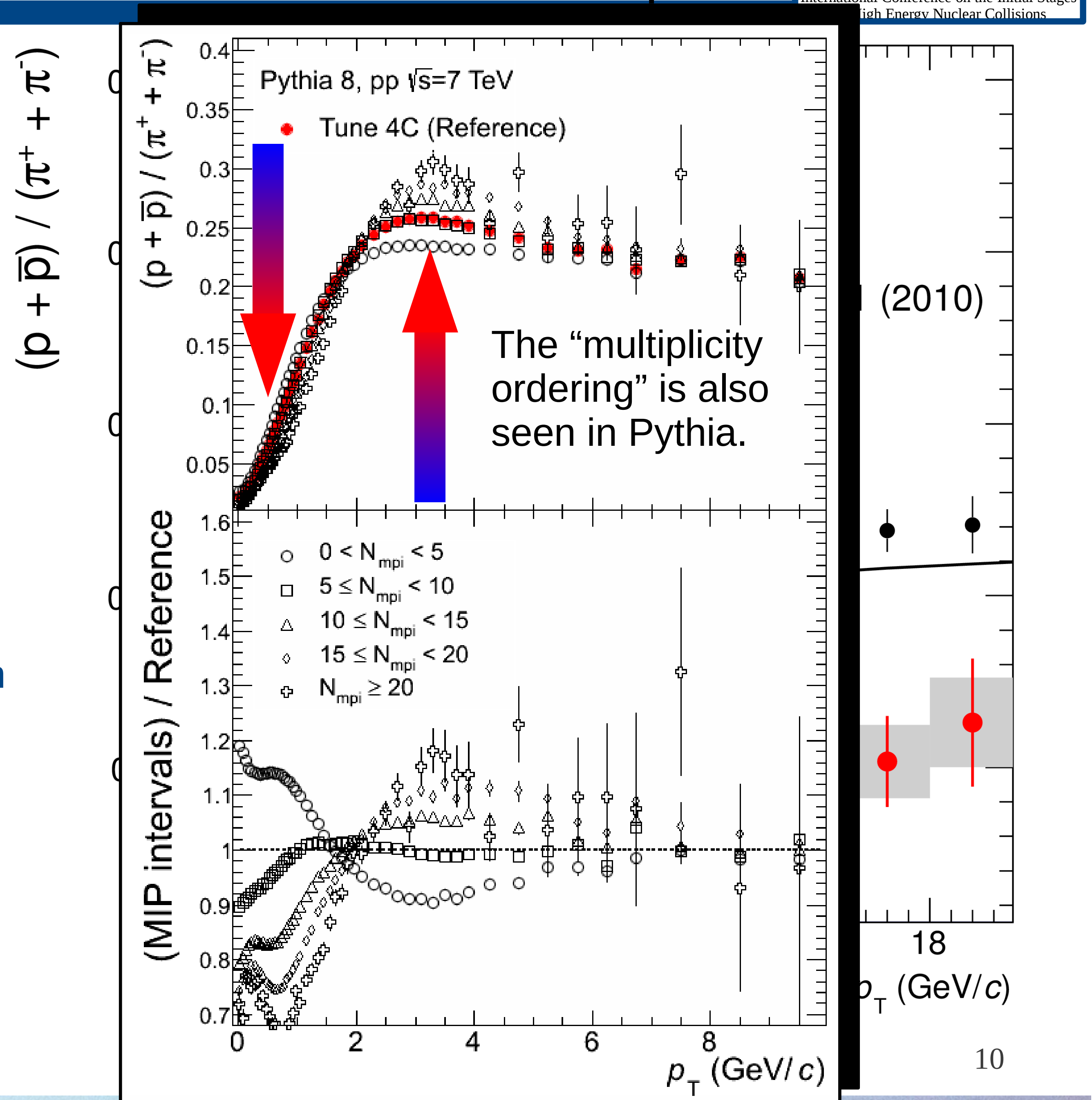
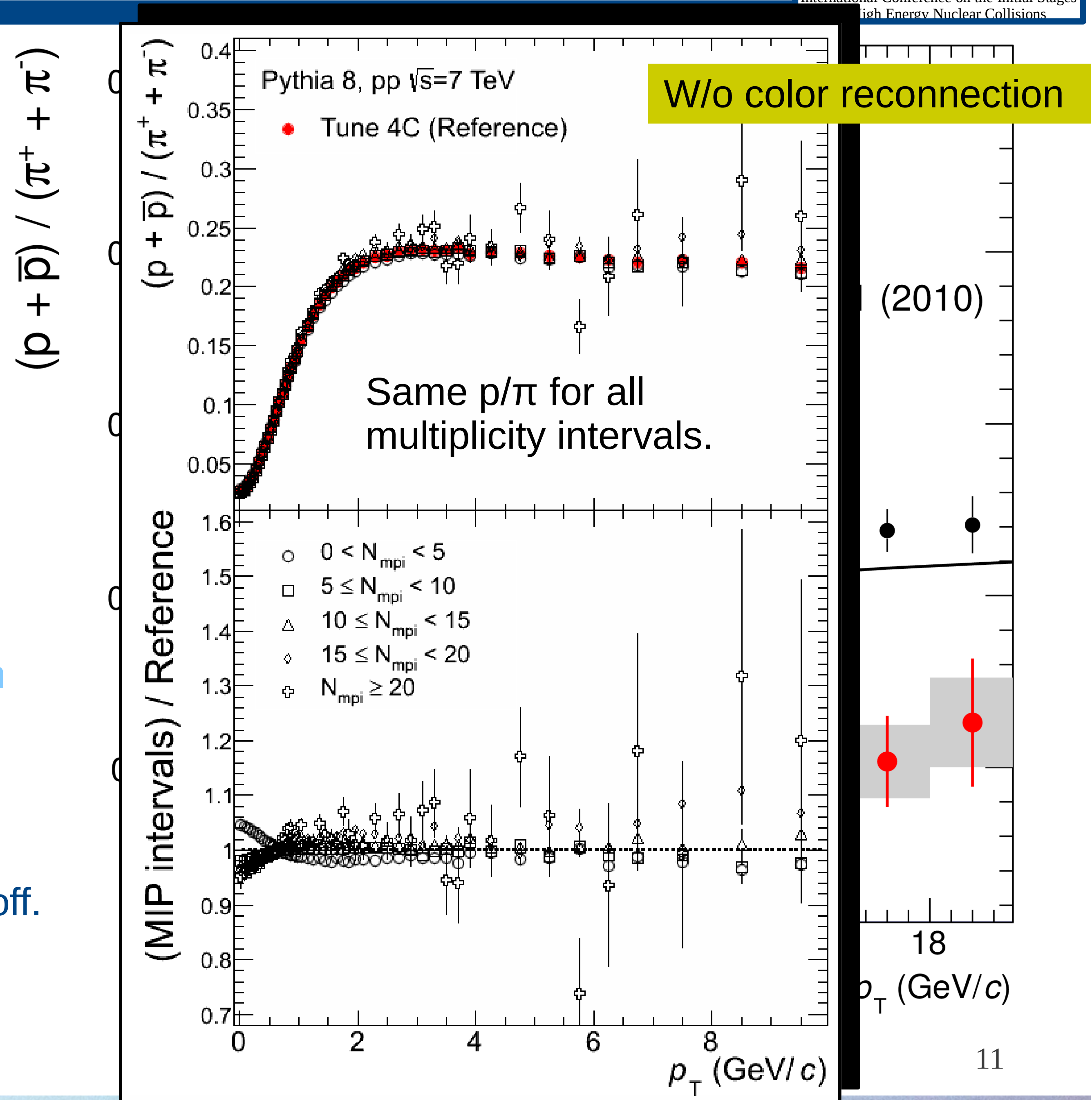
- We chose Pythia 8 tune 4C because it qualitatively reproduces the shape of the ratio at low p_T (other observables like $<p_T>$ vs multiplicity are well described by this tune).

- The evolution of the ratio with multiplicity (N_{mpi}: number of multi-paton interactions) is reminiscent to that observed in Pb-Pb collisions.



Effect of color reconnection

- We chose Pythia 8 tune 4C because it qualitatively reproduces the shape of the ratio at low p_T (other observables like $\langle p_T \rangle$ vs multiplicity are well described by this tune).
- The evolution of the ratio with multiplicity (N_{mpi}: number of multi-paton interactions) is reminiscent to that observed in Pb-Pb collisions.
- The "multiplicity ordering" is destroyed when color reconnection, CR, is switched off. THERE IS NOT p/π peak at 3 GeV/*c*.



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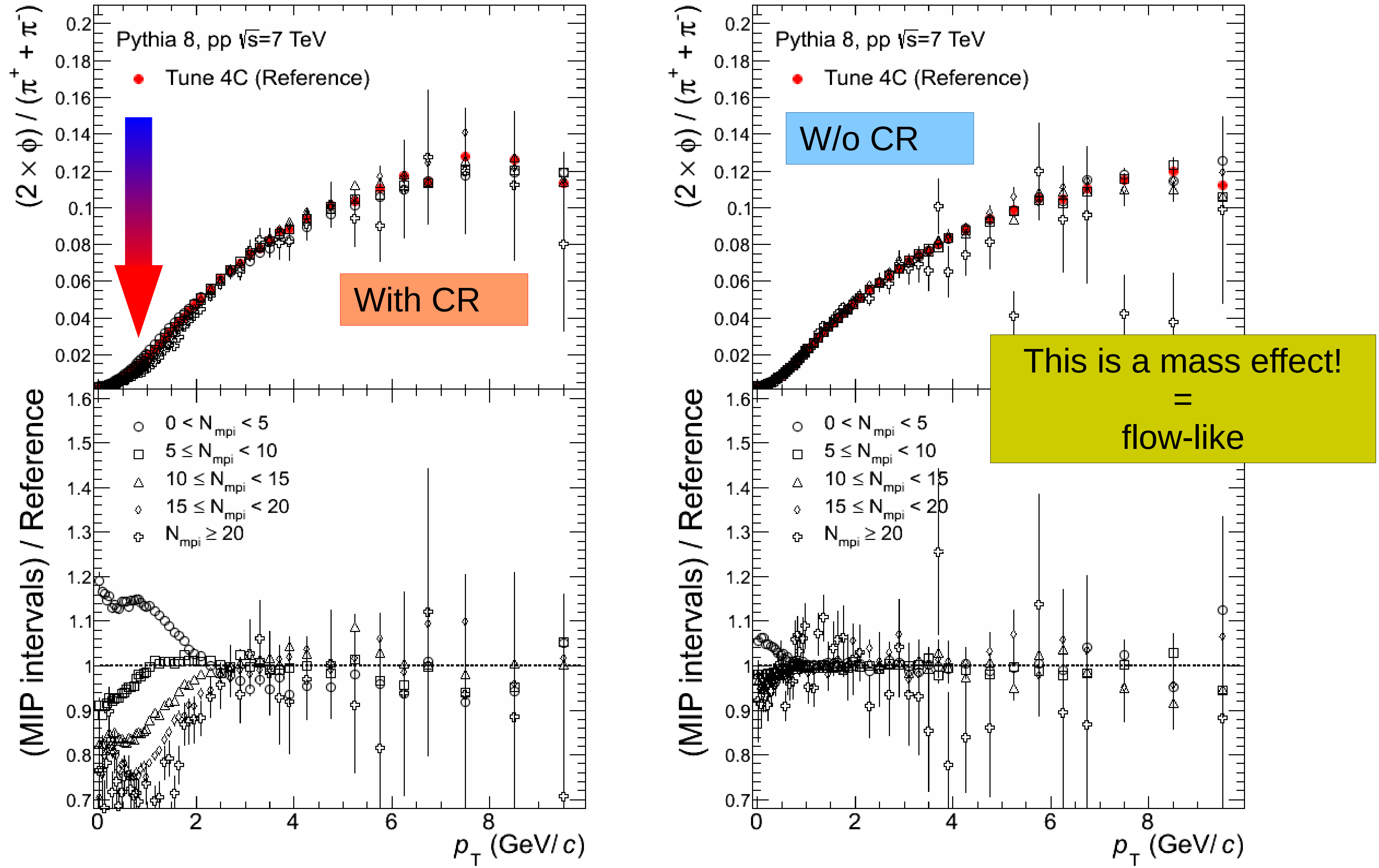
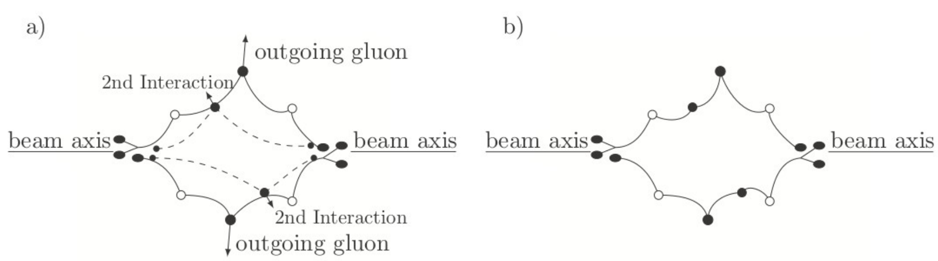
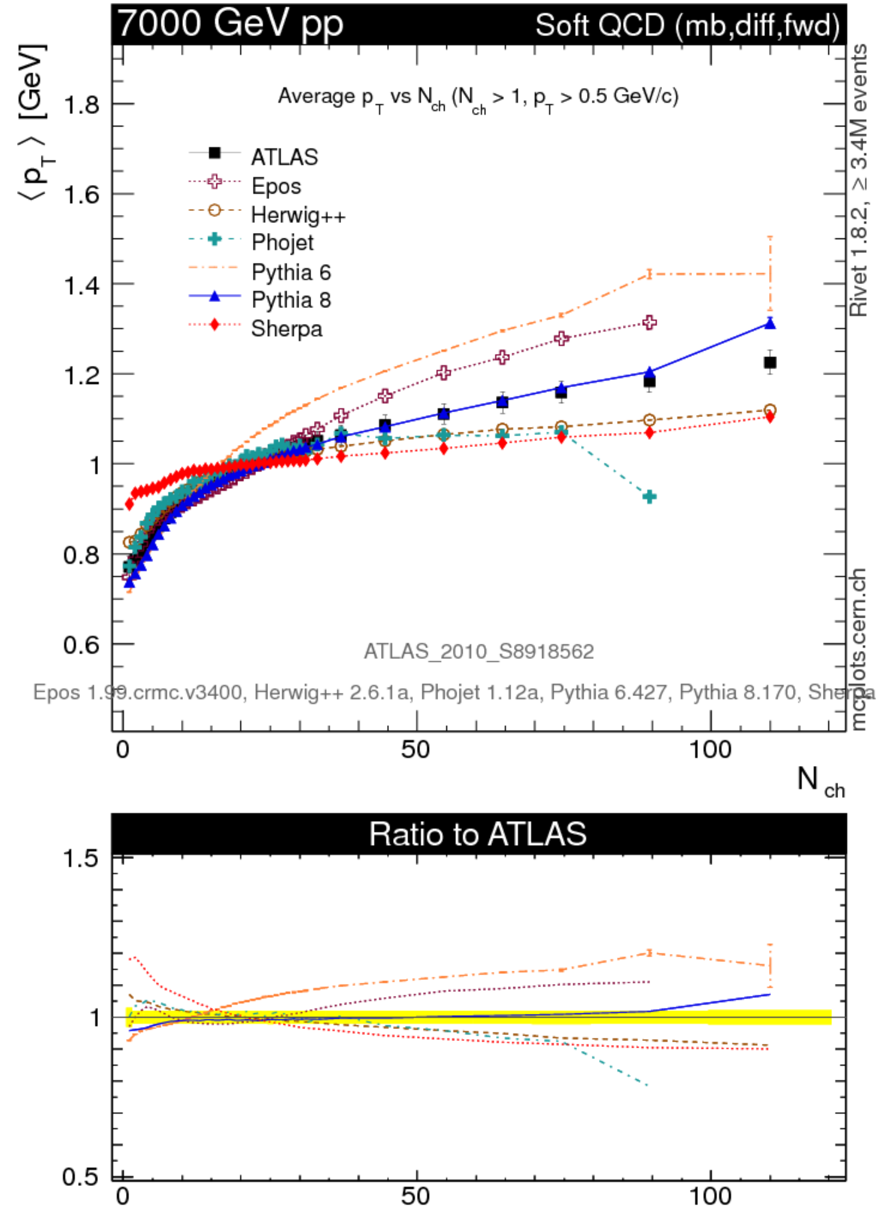
Effect on φ/π



$<p_T>$ vs multiplicity

CR was originally introduced in order to reproduce the rise of the mean p_T with multiplicity observed in hadronic interactions.





Final partons originated from independent semi-hard scatterings are connected via color strings, this reduces the average multiplicity and increases the average p_T of the events.

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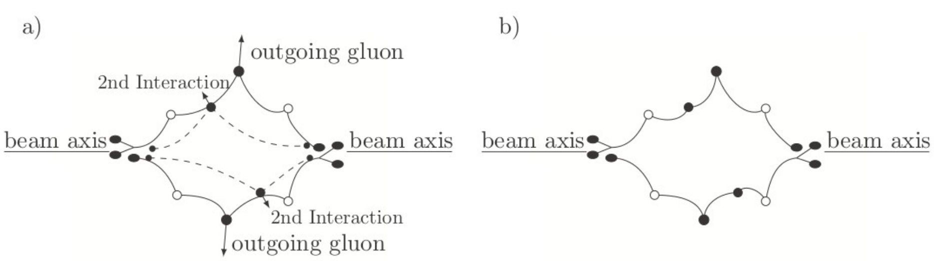

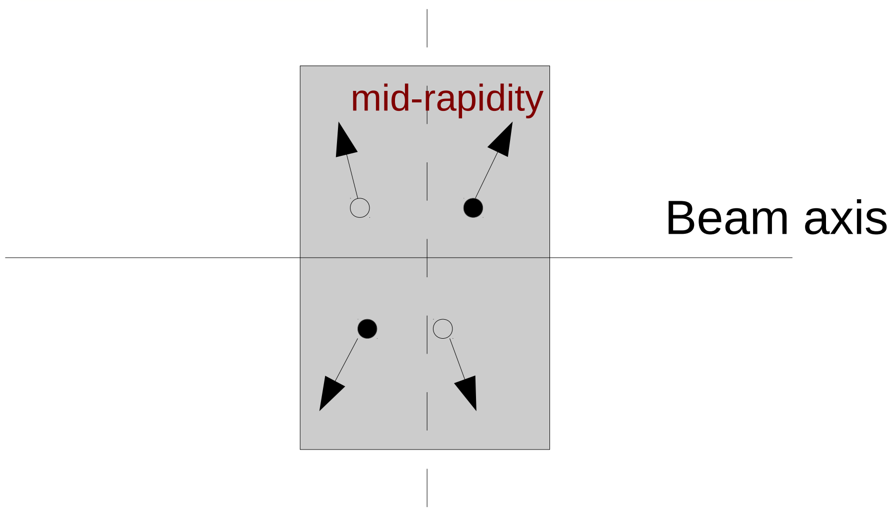

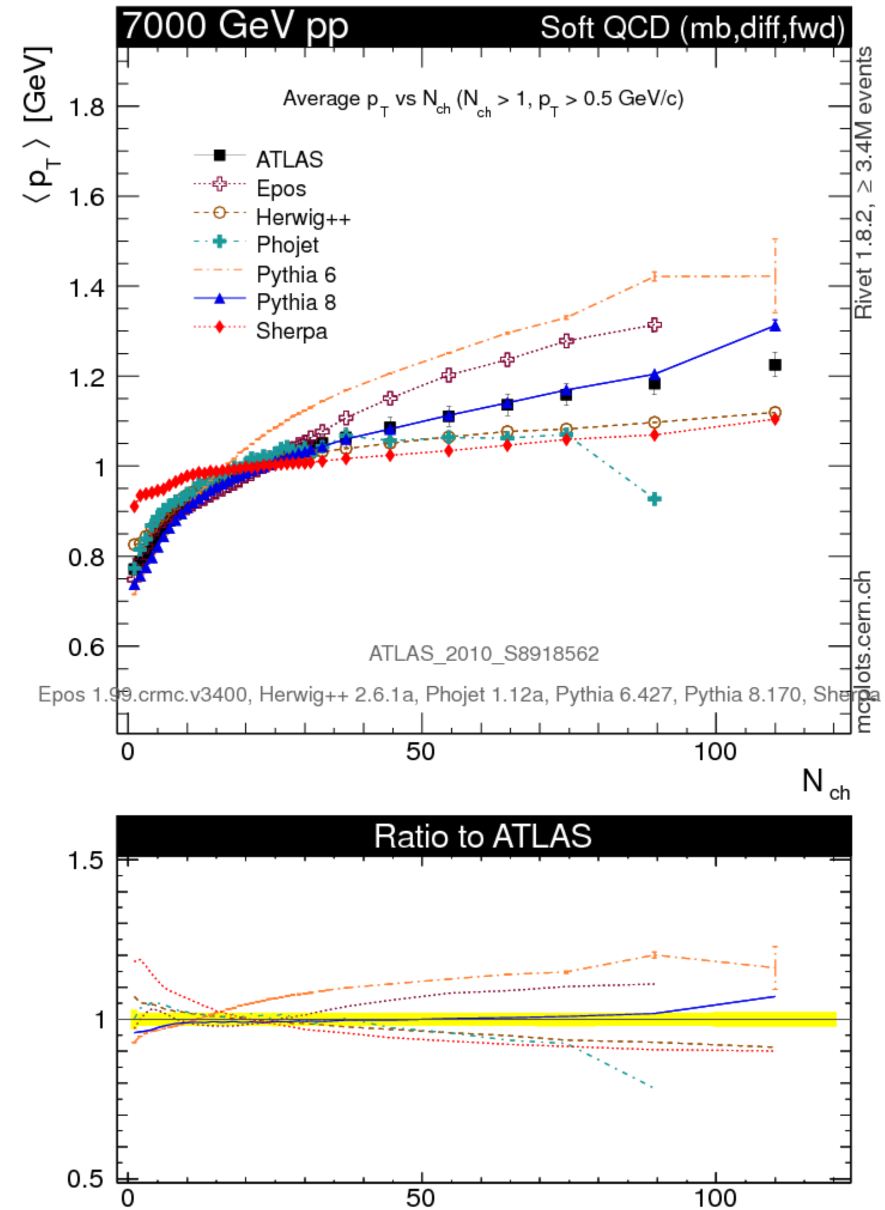

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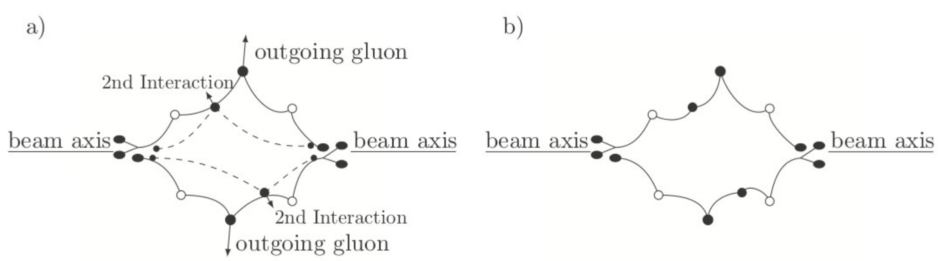

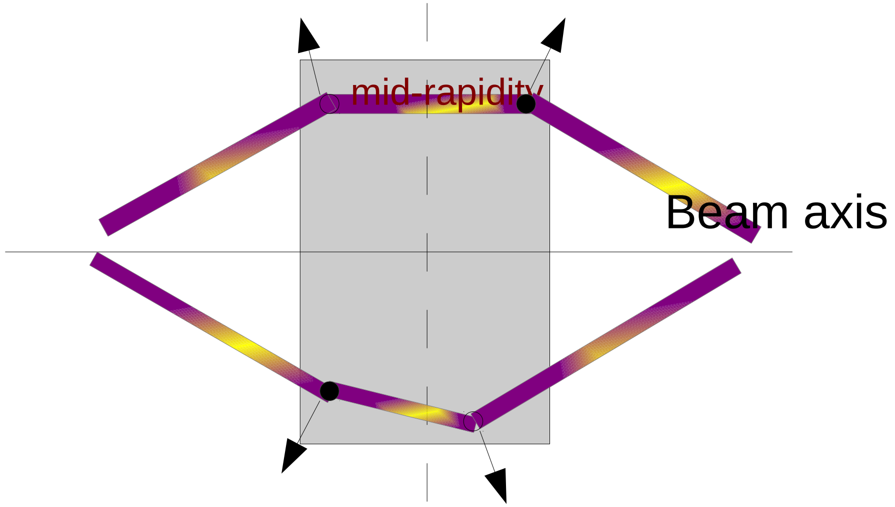

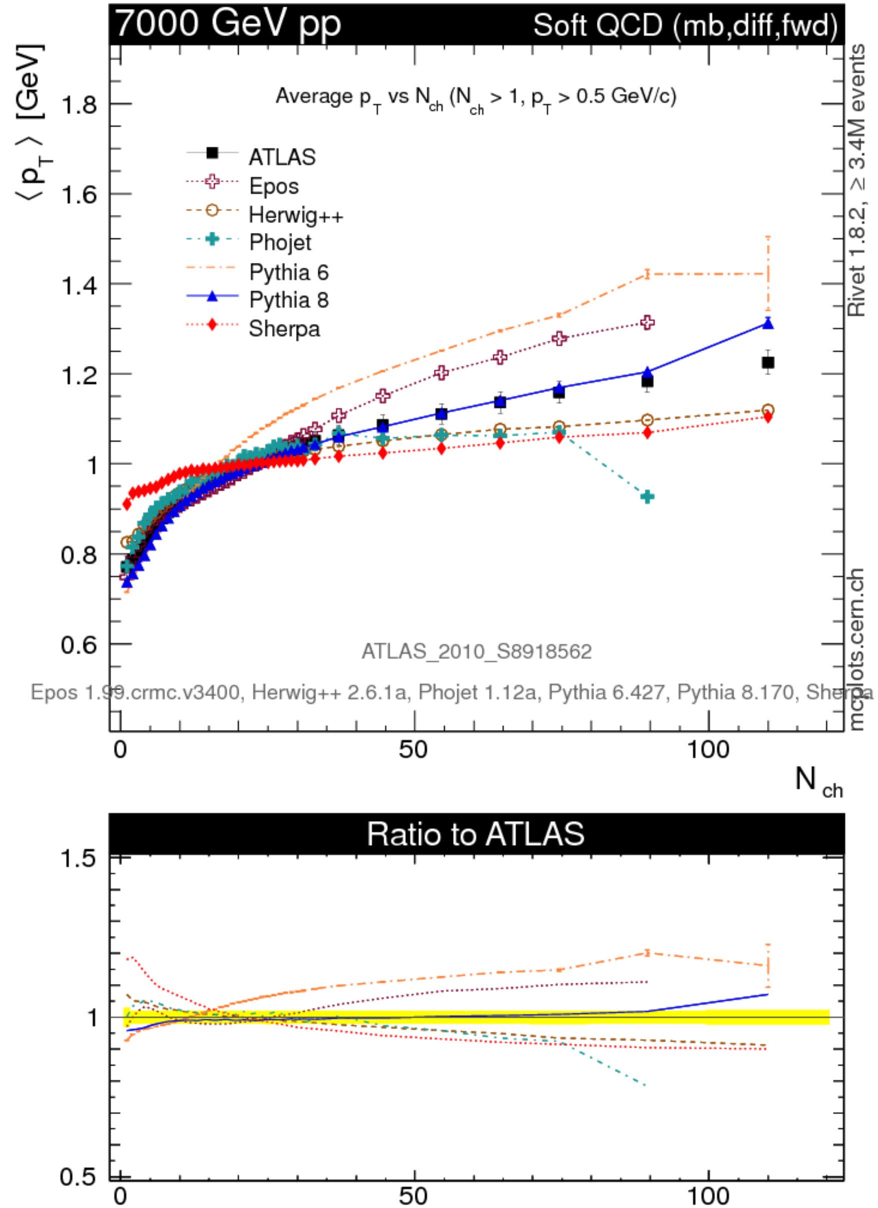

$\langle p_T \rangle$ vs multiplicity

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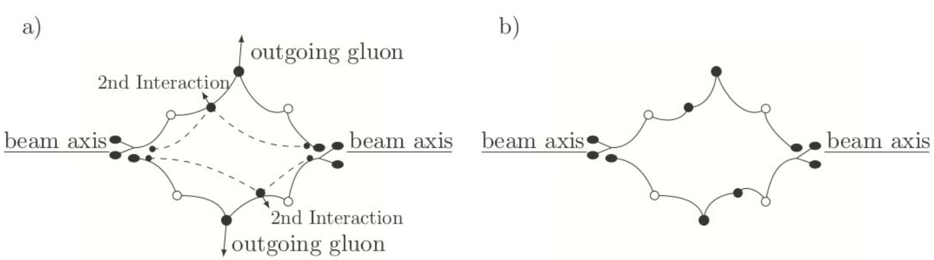
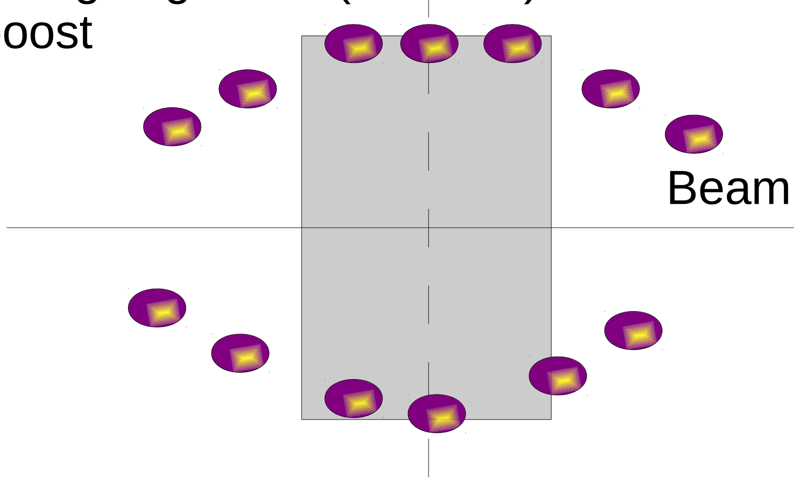
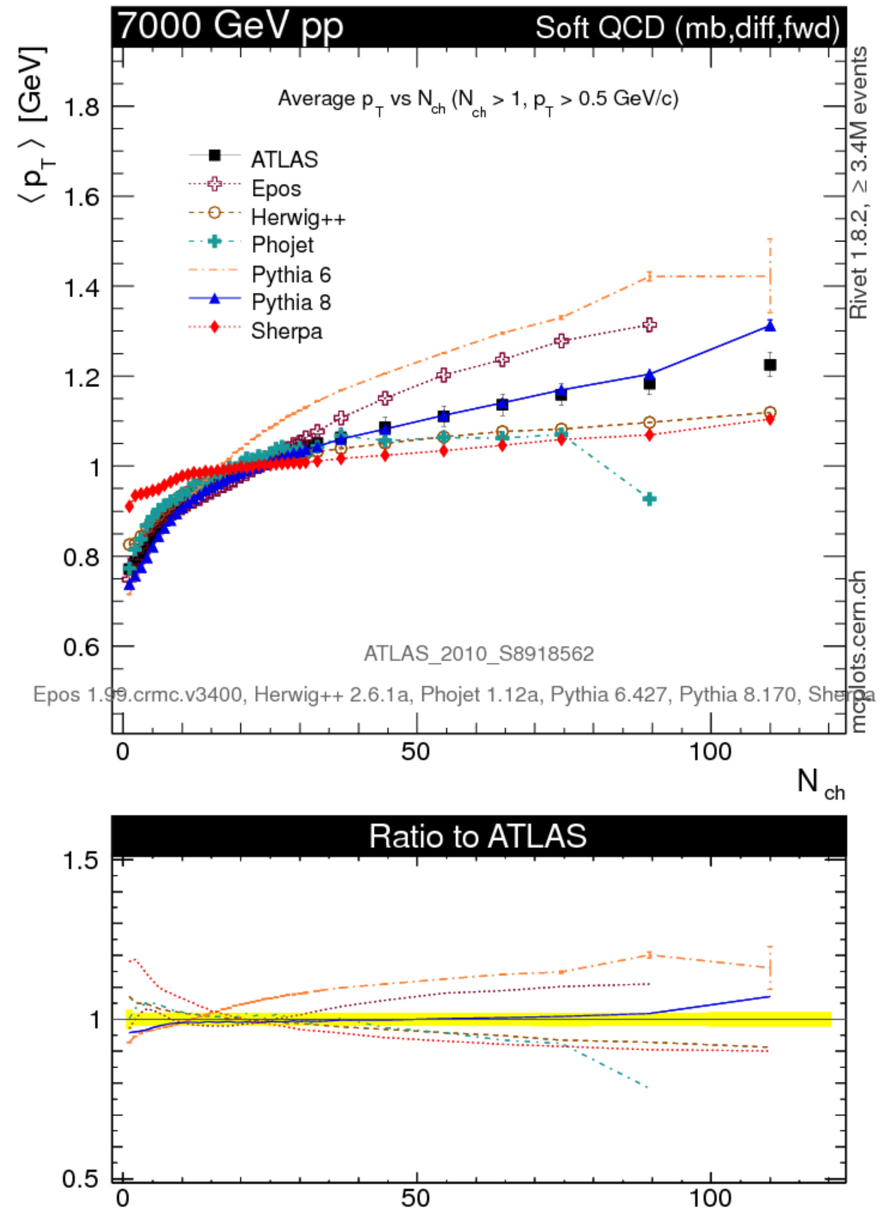


String segments (hadrons) have a common boost





$<p_T>$ vs multiplicity

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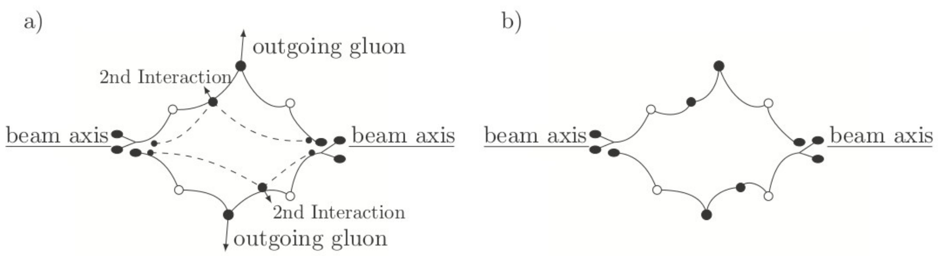
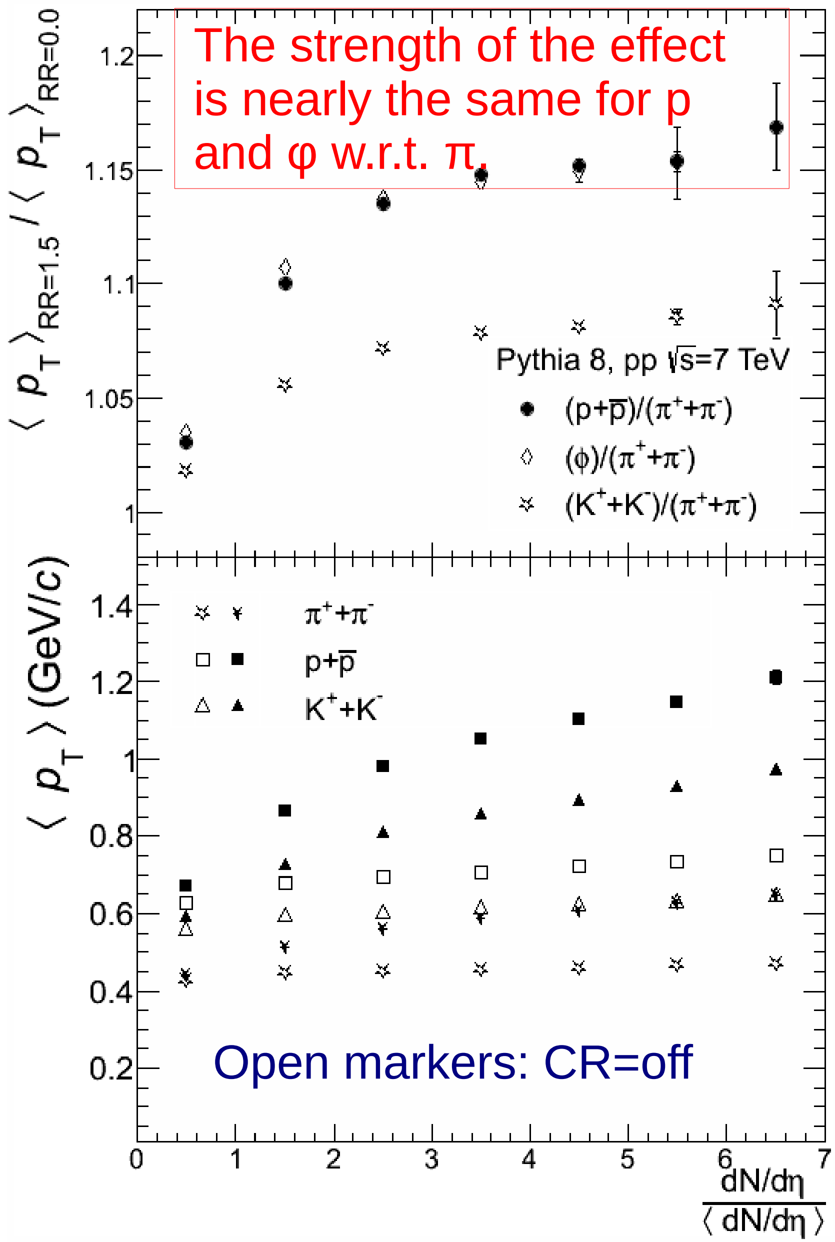


This produces a steeper rise of $<p_T>$ for heavier particles!



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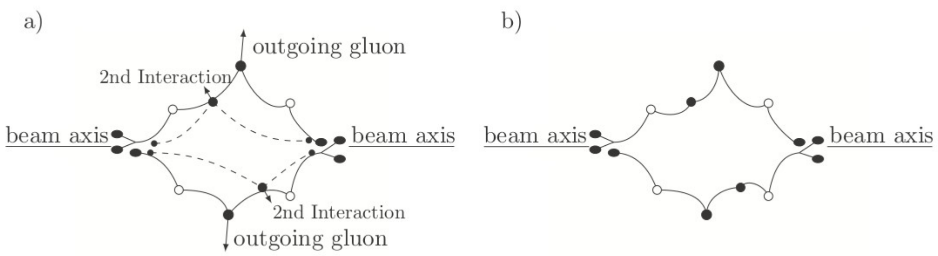
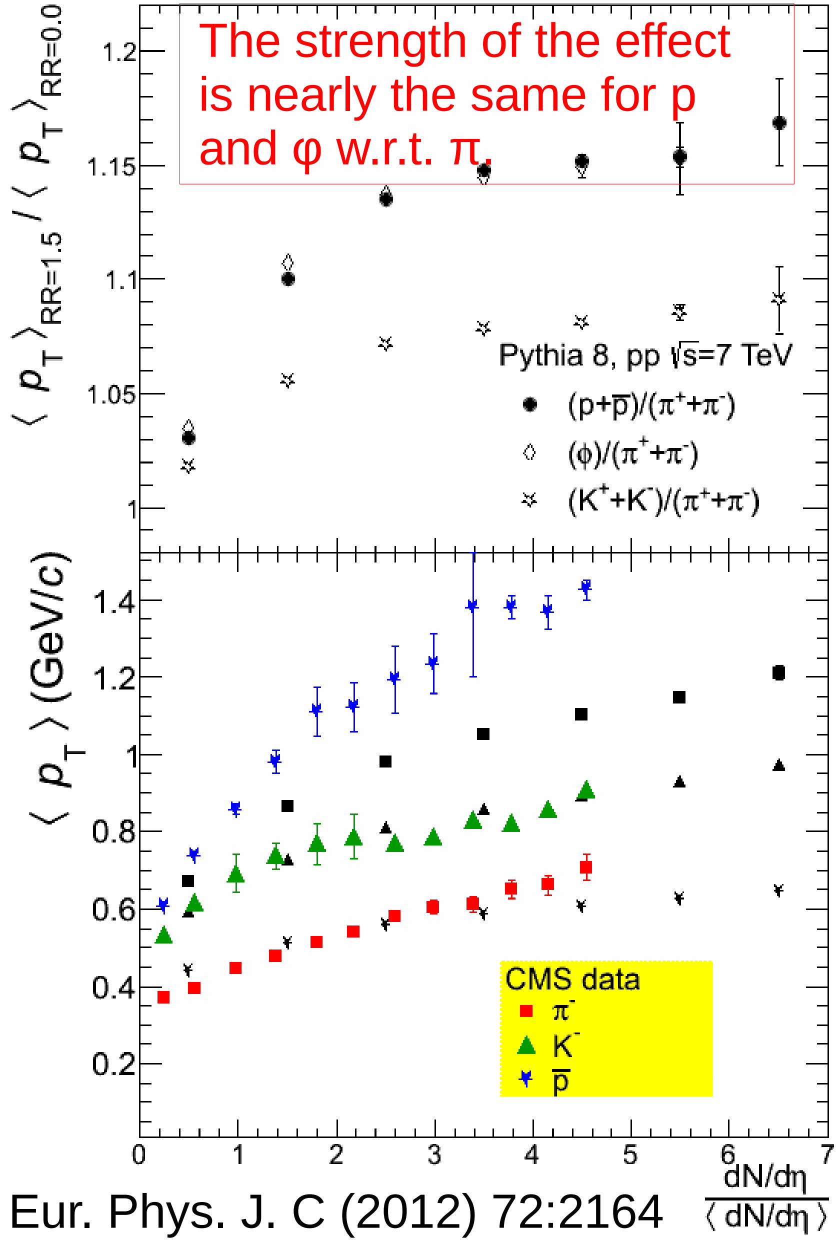


This produces a steeper rise of $\langle p_T \rangle$ for heavier particles!

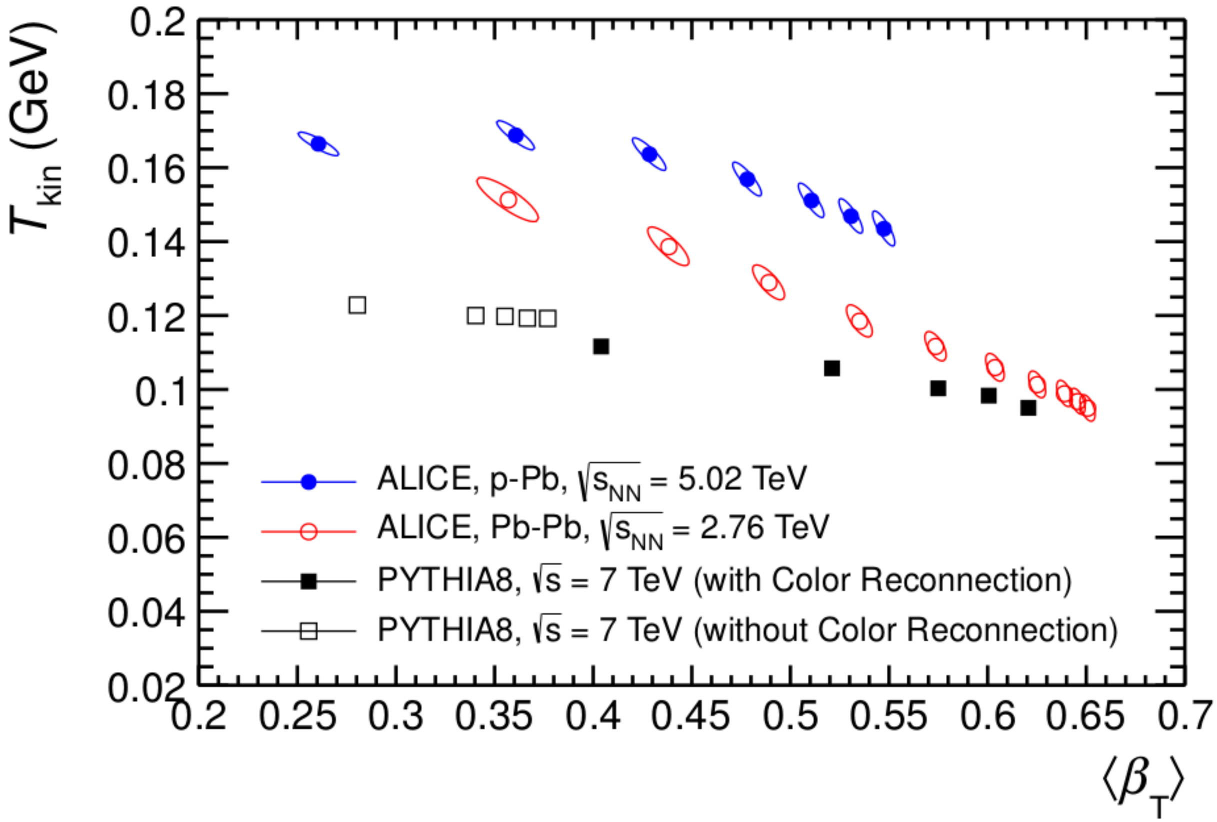
To describe CMS data Pythia requires the flow-like mechanism.



CMS Collaboration, Eur. Phys. J. C (2012) 72:2164

Blast-wave analysis

Blast-wave analysis is a good tool to characterize the evolution of the spectral shapes with multiplicity, and compare the results from different systems. Of course the results depend quite a lot on the p_T range used for fitting the data.

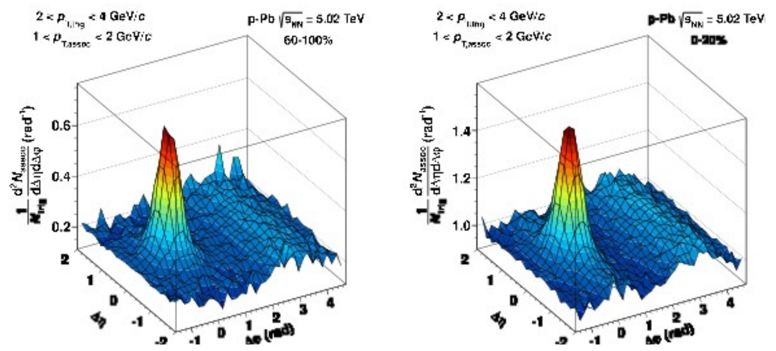


T_{kin} vs $<\beta_T>$ in pp evolves with multiplicity as seen in heavy ion collisions. This evolution is only well described by Pythia when the flow-like mechanism, color reconnection, is tuned on.

ALICE Collaboration, arXiv:1307.6796

Summary

- Several similarities among the different colliding systems have been seen at RHIC and at LHC: evolution of the spectral shapes with multiplicity, the ridge structure, the “baryon anomaly”.

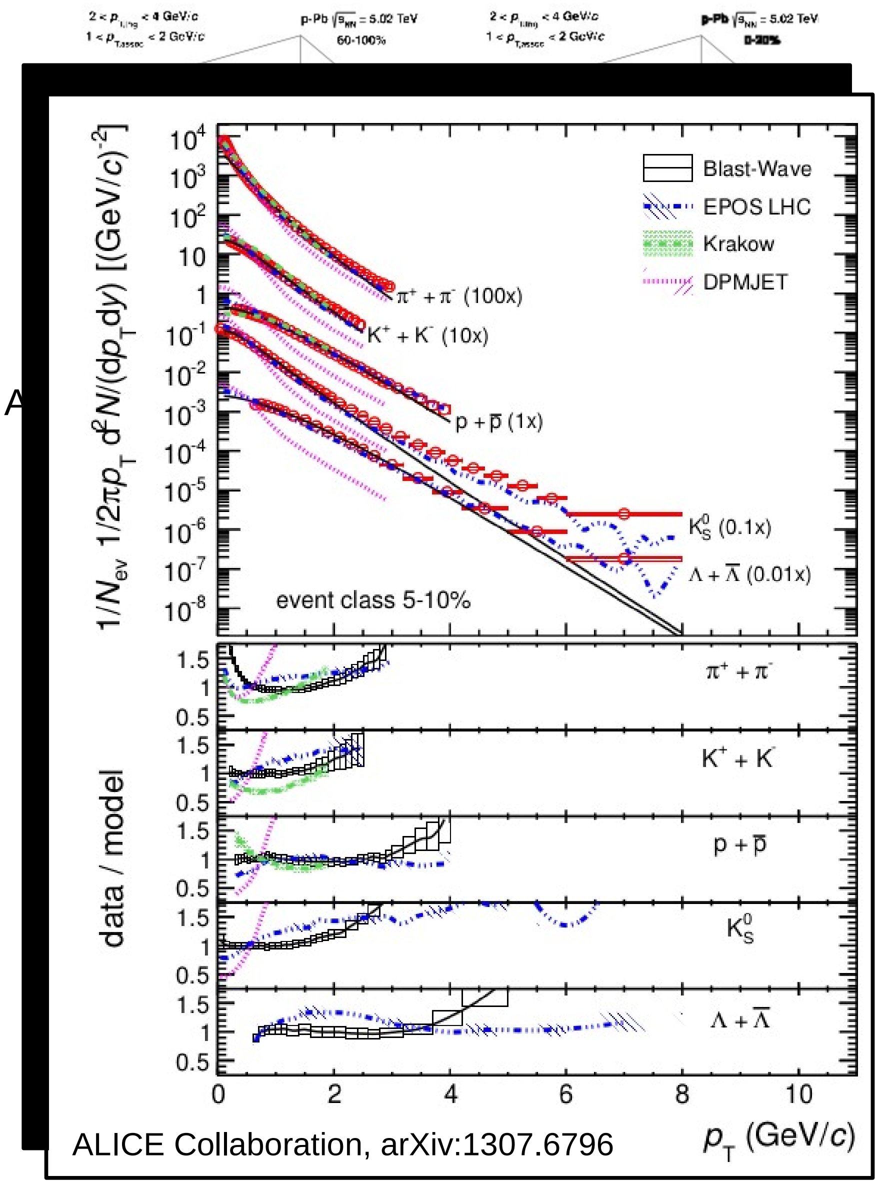


ALICE Collaboration, Phys. Lett. B719 (2013) 29-41

Summary

- Several similarities among the different colliding systems have been seen at RHIC and at LHC: evolution of the spectral shapes with multiplicity, the ridge structure, the “baryon anomaly”.

- Most of the explanations of the observed phenomena in small systems suggest the presence of collective phenomena. For example the low p_T ID spectra in p-Pb collisions are better described by models which include hydro.



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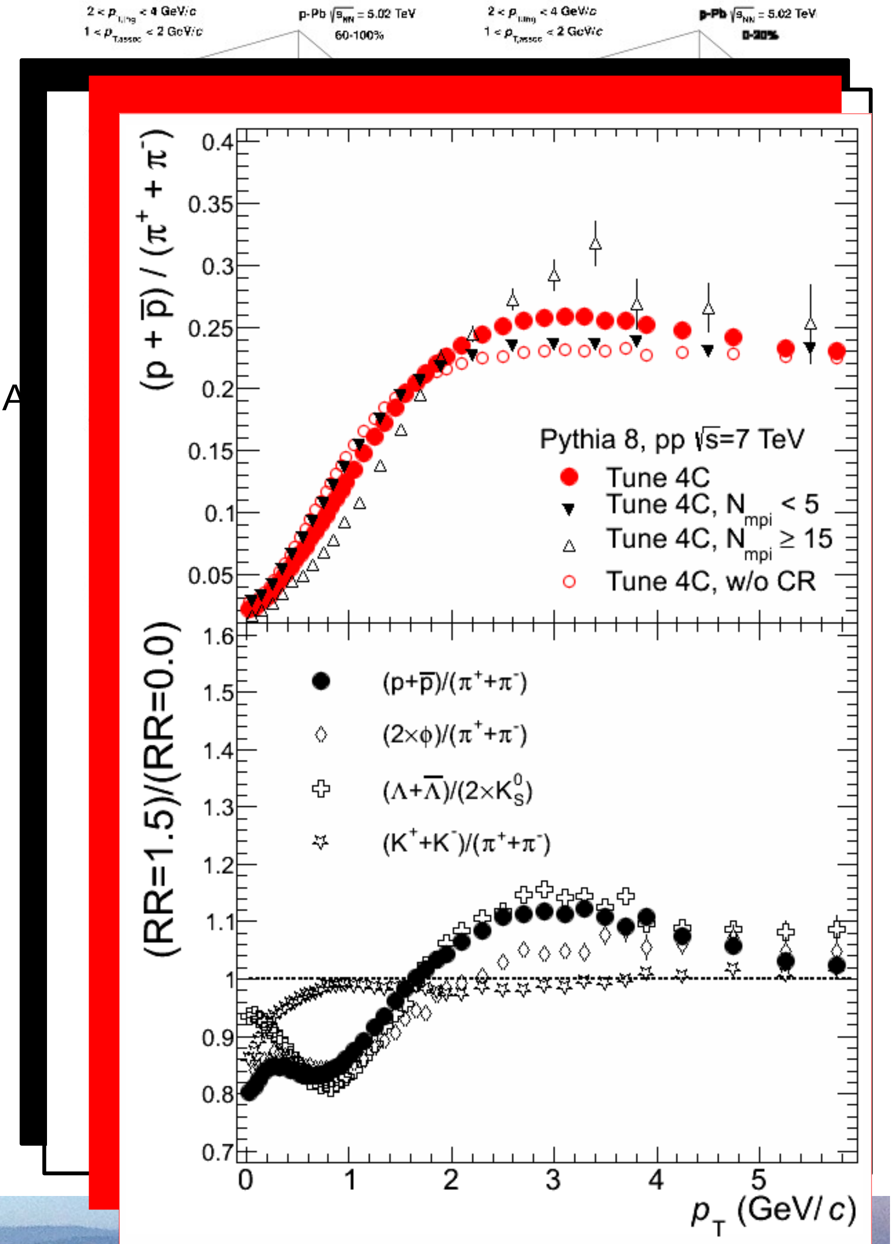
- Most of the explanations of the observed phenomena in small systems suggest the presence of collective phenomena. For example the low p_T ID spectra in p-Pb collisions are better described by models which include hydro.

- However, in this work we propose that other kind of collectivity (no hydro) can be built up in systems with a large number of final partons interacting via color strings.
  Phys. Rev. Lett. 111, 042001 (2013).



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Further investigations are needed in order to understand the possible effects of mechanisms like CR in larger systems.

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Phys. Rev. Lett. 111, 042001 (20...