Transverse Momentum Distributions of Pions, Kaons and Protons in Pb–Pb Collisions at √s = 2.76 TeV and p–Pb Collisions at √s = 5.02 TeV in ALICE

Jonas Anielski for the ALICE Collaboration

Westfälische Wilhelms-Universität Münster

Phys. Rev. Lett. 109, 252301 (2012), arXiv:1303.0737

Particle Identification detectors

ITS:

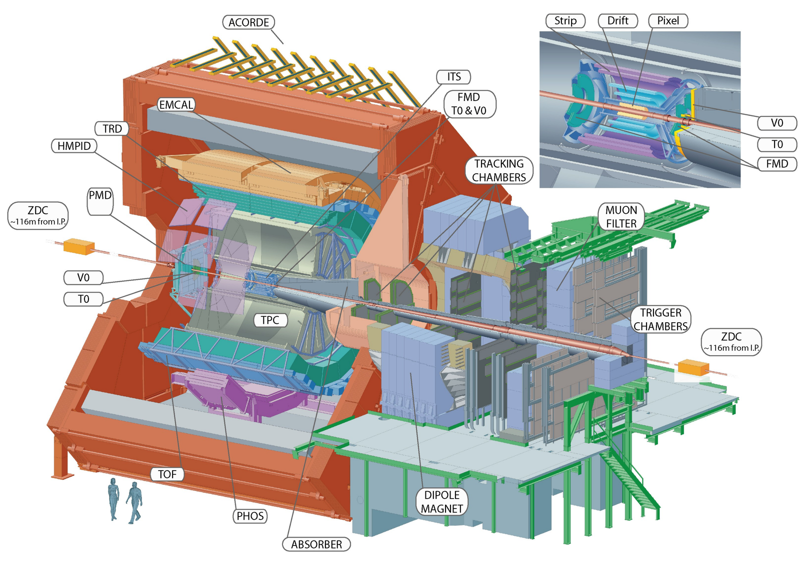
The Inner Tracking System consists of 6 silicon detector layers. Particles can be identified via the energy loss in 4 of the 6 silicon layers.

TPC:

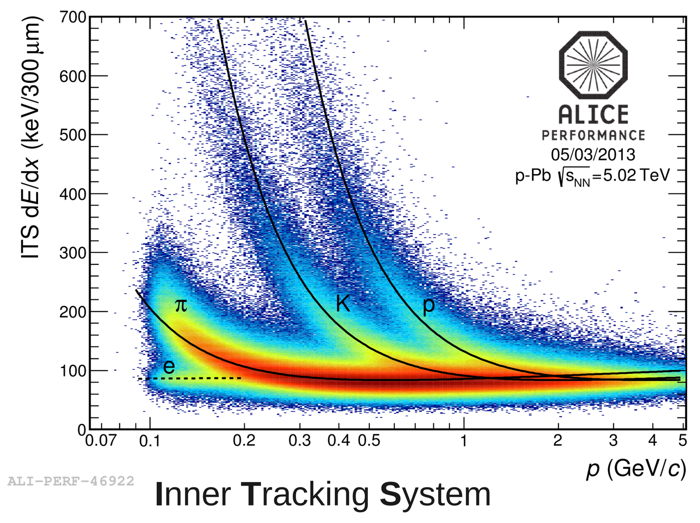
The Time Projection Chamber in ALICE is the largest ever built. Particles can be identified via the energy loss in the fill gas.

TOF:

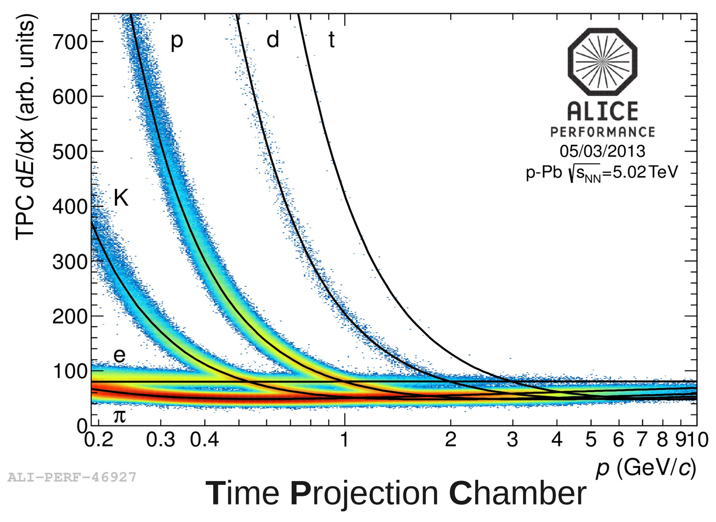
With the measured time of flight and the momentum, different mass hypotheses on the particle identity can be made.



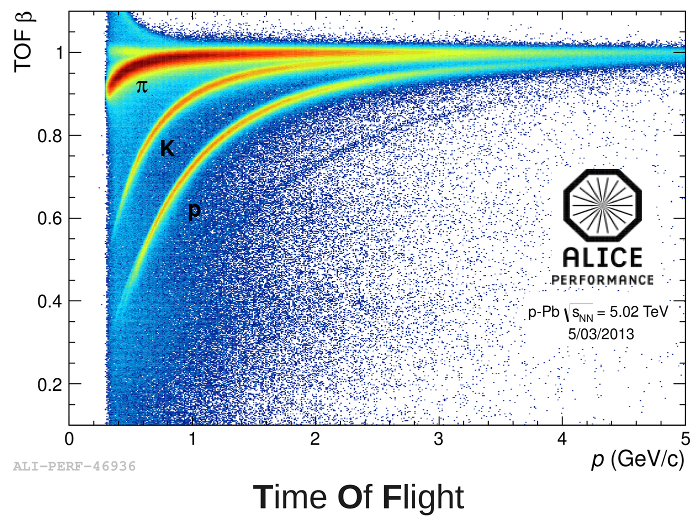
Excellent performance of the PID detectors during the p-Pb 2013 run – First results soon!



Inner Tracking System



Time Projection Chamber



Time Of Flight

PID Approaches

ITS standalone:
For this method the standalone tracking of the ITS is used to be able to account for low momentum particles decaying between ITS and the TPC. The ID is assigned according to the distance to the expected energy loss curves.

TPC/TOF:
For this method the global tracking of ITS, TPC and TRD is used. In this region a track-by-track ID is possible by requiring the track to be within 3σ of the expected values. For lower p_T only the TPC is used.

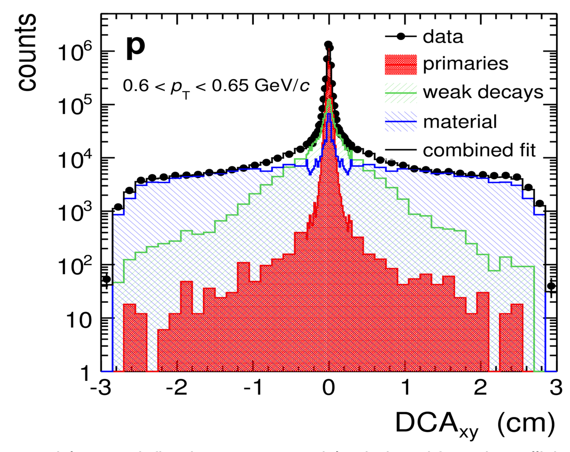
TOF fits:
This method uses global tracks as well. Here the ID is assigned with a statistical method by performing a fit of the time of flight with the expected shapes to the distributions for each mass hypothesis.

p_T ranges in GeV/*c*

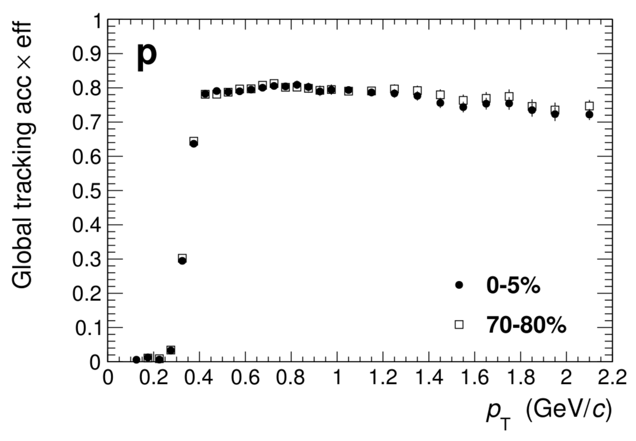
Analysis	π	K	p
ITSsa	0.10 – 0.60	0.20 – 0.50	0.30 – 0.60
TPC/TOF	0.20 – 1.20	0.25 – 1.20	0.45 – 1.80
TOF fits	0.50 – 3.00	0.45 – 3.00	0.50 – 4.60

Corrections

Contamination from secondary particles* :
The good impact parameter resolution allows the different contributions of primaries and secondaries to be distinguished. The measured DCA_{xy} distribution is fitted with the expected shapes of the different contributions.

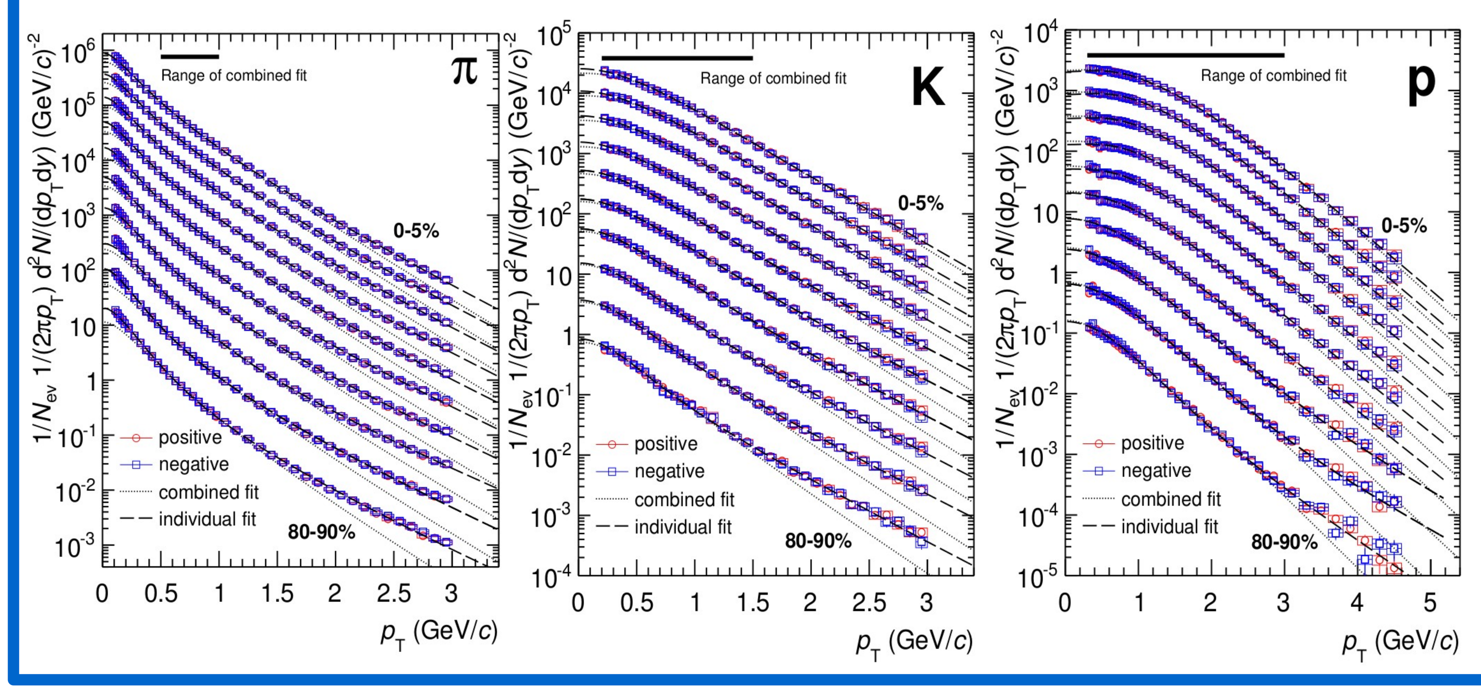


Tracking efficiency and acceptance:
The tracking efficiency and acceptance correction is obtained by using a HIJING generator tuned to reproduce the average multiplicity. Different transport models (Geant 3, Geant 4, Fluka) have been used to correct for a few percent with respect to Geant 3 and to study systematic effects.



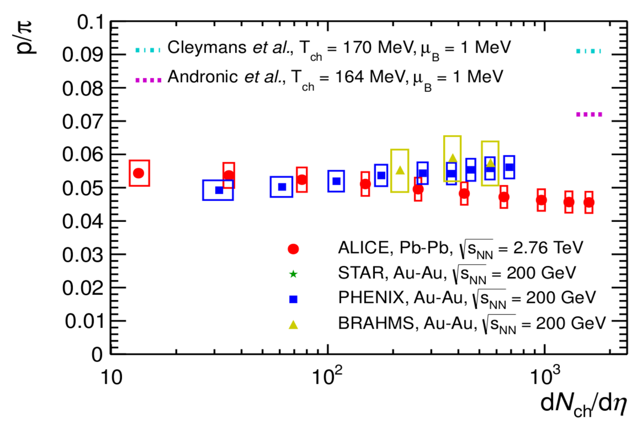
* Primary particles are defined as prompt particles induced from the collision, including decay products, except those from weak decays.

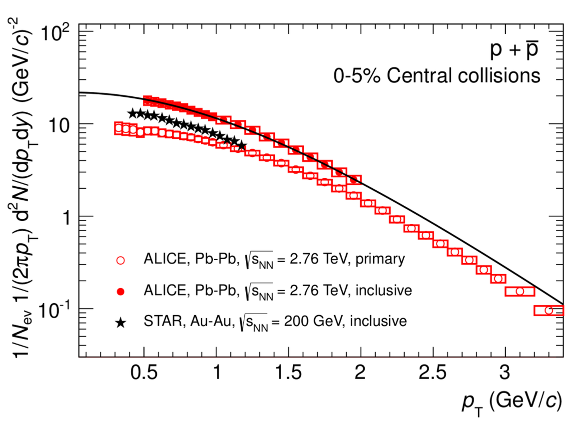
π, K, p Spectra in Pb-Pb as a function of centrality



The resulting spectra for the different centrality bins. Each spectrum is fitted with an individual Blast-wave fit to obtain the integrated yields and the mean p_T. In addition a combined Blast-wave fit is performed for each centrality bin. The range of the combined fit is indicated in the spectra.

Particle ratios and thermal model

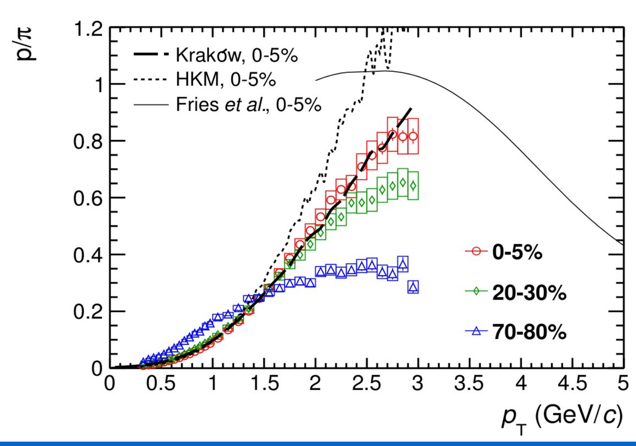




The ratio of the integrated yield of Protons over Pions at the LHC is not in agreement with the thermal model. At RHIC a potential disagreement is seen as well, but it was not considered significant due to experimental uncertainties in the subtraction of secondary particles, differences between thermal model implementations and model uncertainties.

To allow for a more direct comparison with previous experiments, the inclusive proton spectrum was also measured. By using the TPC information only, the spectrum includes protons from decays. The secondaries from material were subtracted by using the DCA fit-correction mentioned above.

It is seen, that the disagreement with the thermal model is most prominent for the primary protons, while strange baryons feeding into the proton yield are likely better described.



The particle ratio p/π shows a pronounced increase as a function of centrality at intermediate p_T and a corresponding depletion at low p_T.

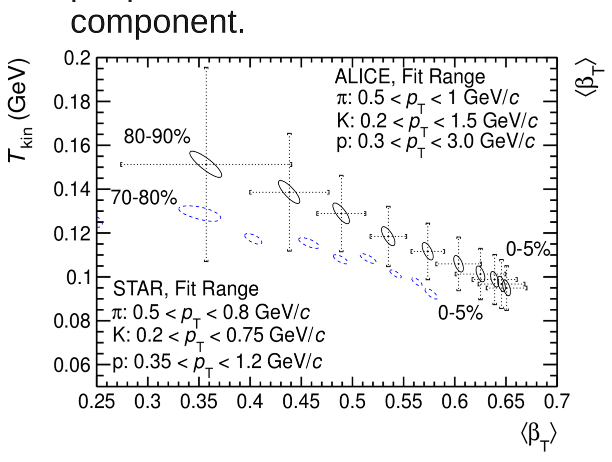
This is reminiscent of the increase in the baryon-to-meson ratio observed at RHIC, which is suggestive of recombination models, where the increase in the ratio could be a consequence of hadronization via recombination of quarks from the plasma.

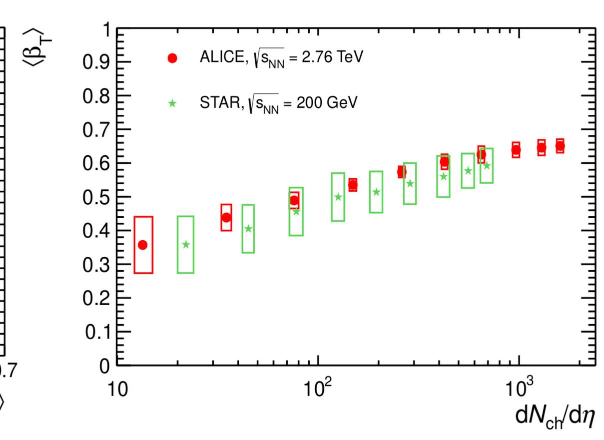
The rise of the ratio is also an intrinsic feature of hydrodynamical models, describing the mass ordering induced by radial flow.

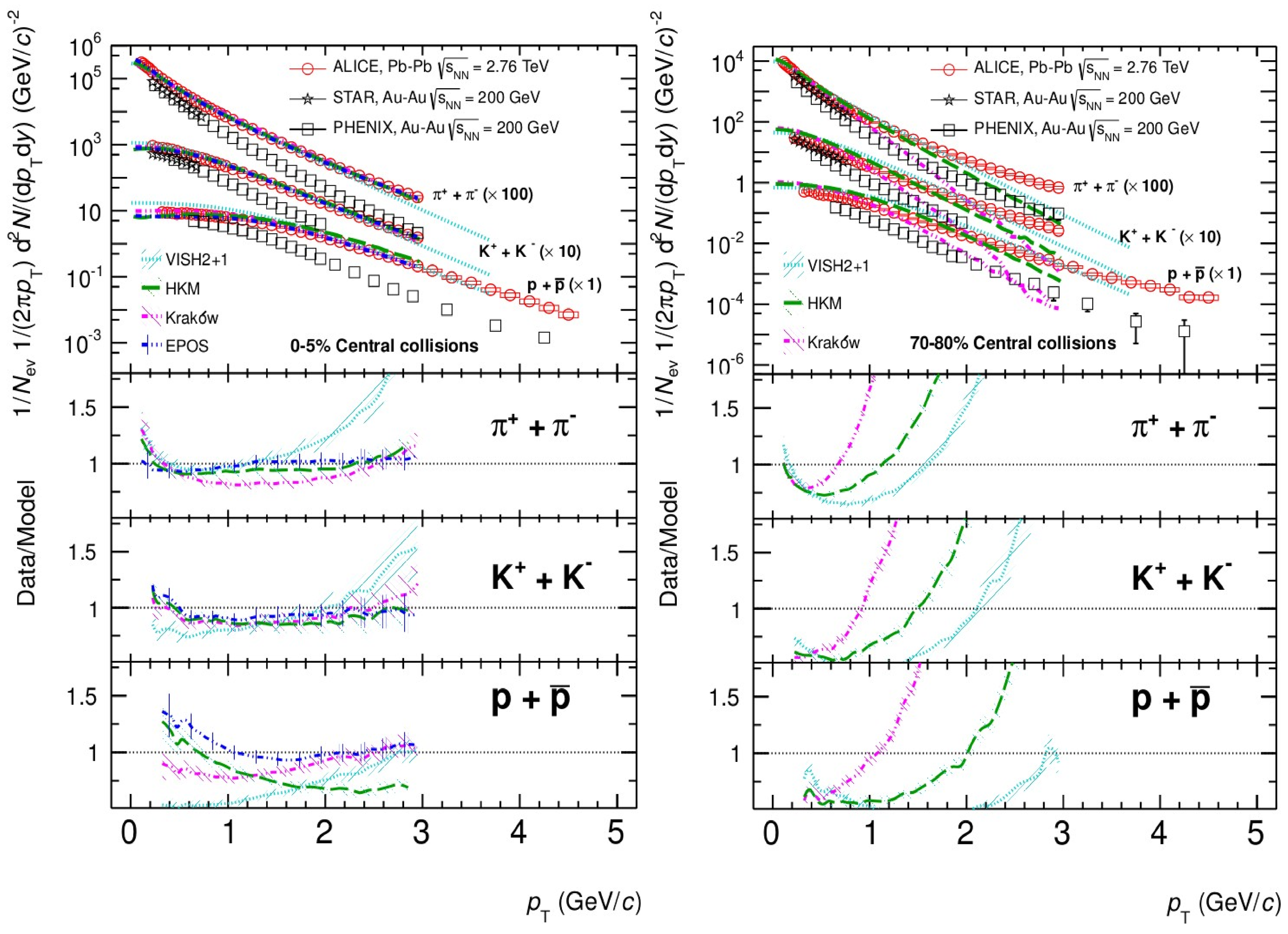
Comparison to RHIC and hydrodynamical models

Comparison to RHIC:
A dramatic change in spectral shapes is observed, which is particularly obvious for protons, which are much flatter. From the comparison of the results from the combined Blast-wave fits (bottom), the extracted radial flow velocity is about 10% greater at LHC than at RHIC.

Comparison with hydrodynamical models:
In the most central bin the models describe the K and π spectra fairly well. A deviation for higher p_T ,especially for more peripheral collisions, might show the limit of hydrodynamical models. The data could indicate the onset of a non-thermal (hard) component, which in more peripheral collisions is not dominated by the flow-boosted thermal component.







Conclusion and Outlook

In Pb-Pb collisions a clear evolution of the spectral shape is seen, with an almost exponential behavior at high p_T, and a flattening at low p_T. These observations are compatible with the development of strong collective flow with centrality. Compared to the results from Au-Au at √s = 200 GeV the radial flow is 10% stronger in central collisions at LHC.

It is observed that the primary proton yield in Pb-Pb collisions at the LHC is not compatible with the thermal model.

In the recently published paper "Long range angular correlations in the near and away side in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV"* by the ALICE collaboration results were shown, that are compatible with an indication of radial flow in p-Pb collisions.

To gain further insight into this effect a careful analysis of the evolution of the spectral shapes of identified particles with the multiplicity in p-Pb (and pp) collisions could prove to be very useful.

With the recent p-Pb run earlier this year, ALICE collected an integrated luminosity of 30 nb^{-1}. The extraction of the Pion, Kaon and Proton spectra from this data is on-going. New results soon!

For both, Pb-Pb and p-Pb, an analysis, that uses a statistical PID method for p_T, that are within the relativistic rise of energy loss in the TPC is on-going. This will extend the reach in transverse momentum up to about 20 GeV/c.

*Physics Letters B719 (2013), 29-41