Probing the partonic degree of freedom in high multiplicity p+Pb $\sqrt{s}$ = 5.02 TeV collisions

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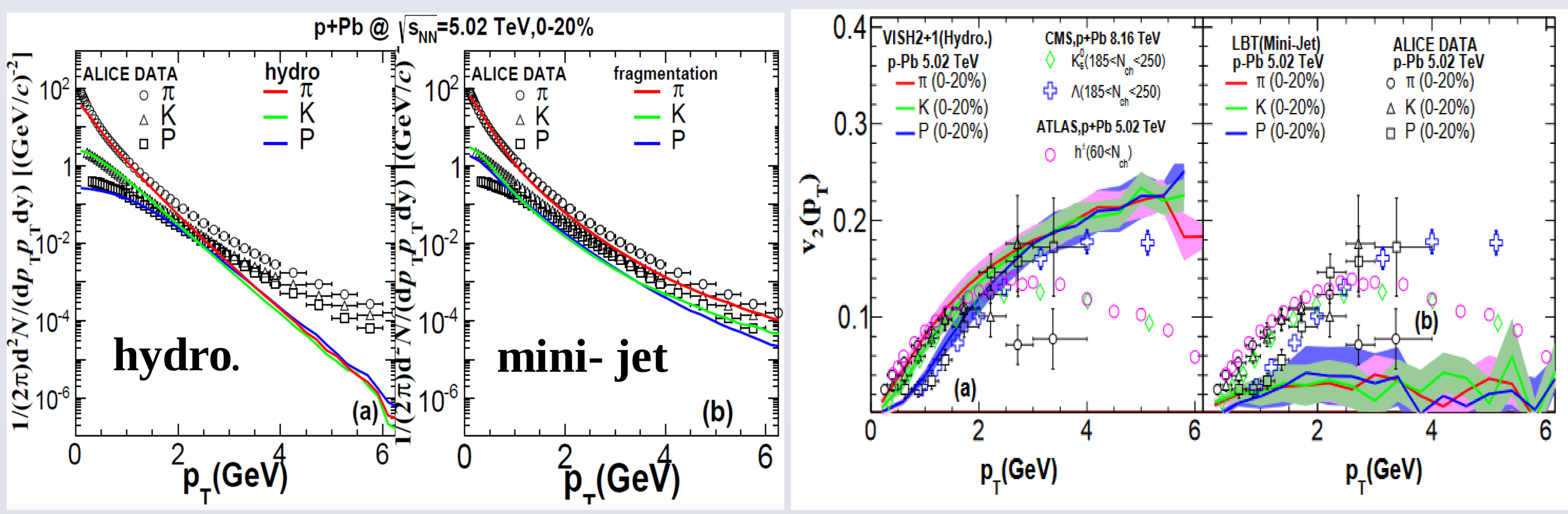
ABSTRACT

The number of constituent quark (NCQ) scaling of identified hadrons are important observables to probe the partonic degree of freedom in the created small system. In this work, we focus on the coalescence model calculations for the NCQ scaling of v_2 at intermediate p_T for the high multiplicity p+Pb collisions, which includes thermal-thermal, thermal-jet and jet-jet partons recombinations, using the thermal partons from hydrodynamics and jet partons after the energy loss of the Linear Boltzmann Transport (LBT) model. Such coalescence model calculations have also been smoothly connected with the low p_T hydrodynamic calculation and high p_T jet fragmentation. Within such combined framework, we present a nice description of the spectra and elliptic flow over the p_T range from 0 to 6 GeV, and obtain the approximately NCQ scaling at intermediate p_T as measured in experiment. We also switch off the coalescence process of partons and find that without such coalescence, one can not describe the differential elliptic flow and related NCQ scaling at intermediate p_T. Such comparison calculations also demonstrate the importance of the partonic degree of freedom and indicate the possible formation of QGP in the high multiplicity p+Pb collisions.

INTRODUCTION

Pure hydrodynamics or mini-jet can't describe the data.



-- Hydrodynamics: works at low p_T , but fails at intermediate and high p_T.

-- Mini-jet: can't generate enough flow at low and intermediate p_T

-- At intermediate p_T: one need to combine soft and hard parts.

MODEL AND SET-UP

-- <u>Thermal hadrons</u>: generated by hydro. with Cooper-Frye.

Meson: P_T< $2P_1$ GeV; baryon: P_T< $3P_1$GeV.

-- <u>Coalescence hadrons</u>: generated by coalescence process.

<u>Input</u>:

a. Thermal partons generated by hydro. with $P_1 < P_T$ < 4 GeV.

b. Hard partons originally generated by PYTHIA8, then suffered with energy loss by LBT with α=0.15. Get the hard parton with $P_T > P_2$.

<u>Coalescence:</u>

$$\frac{dN_M}{d^3P_M} = g_M \int d^3x_1 d^3p_1 d^3x_2 d^3p_2 f_q(x_1,p_1) f_{\bar{q}}(x_2,p_2) W_M(y,k) \delta^3(P_M - p_1 - p_2)$$

$$\frac{dN_B}{d^3P_B} = g_B \int d^3x_1 d^3p_1 d^3x_2 d^3p_2 d^3x_3 d^3p_3 f_{q_1}(x_1,p_1) f_{q_2}(x_2,p_2) f_3(x_3,p_3) W_B(y,k) \delta^3(P_M - p_1 - p_2 - p_3)$$

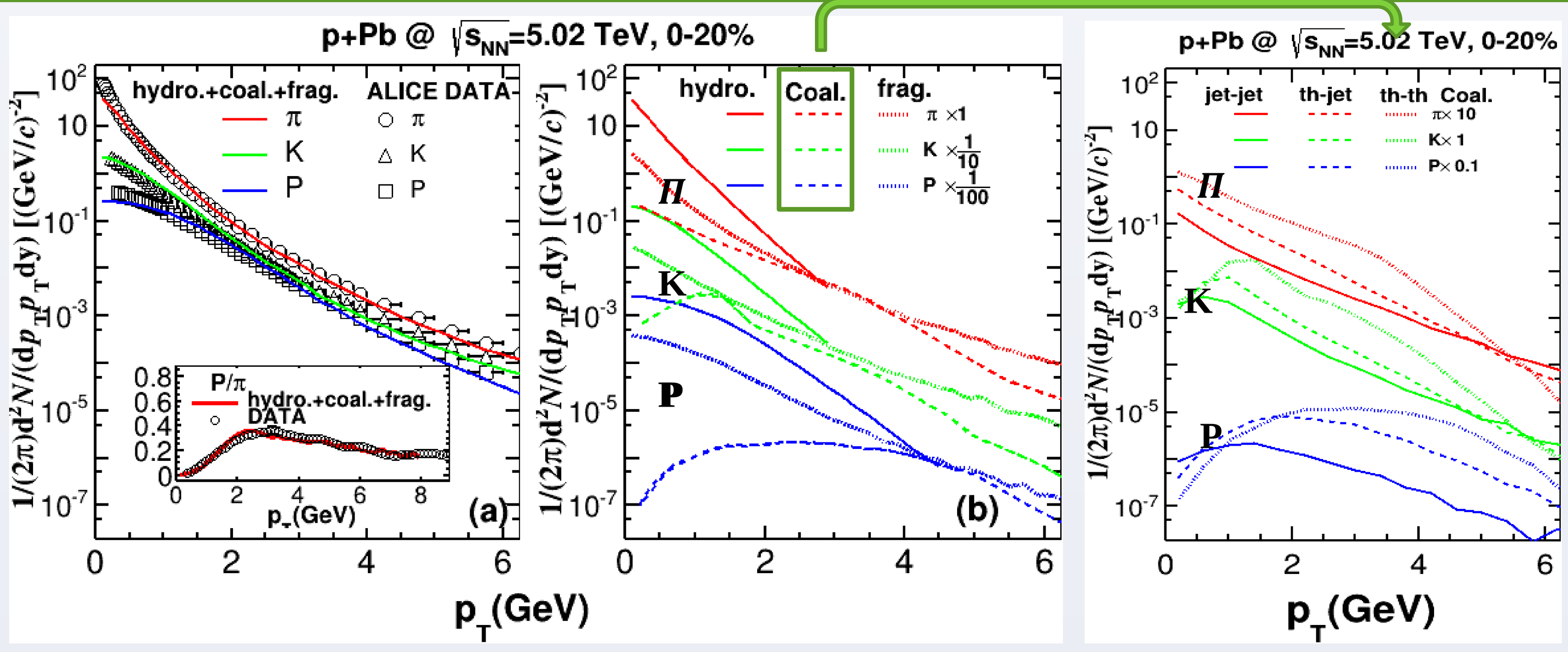
with meson's and baryon's excited states up to 10, including thermal-thermal, thermal-hard and hard-hard coalescence.

We set P_1 =1.6 GeV, P_2=2.6 GeV.

-- <u>Fragmentation process</u>: the remnant hard quarks feed to fragmentation in Pythia8.

-- All hadrons feed to the UrQMD model.

RESULTS



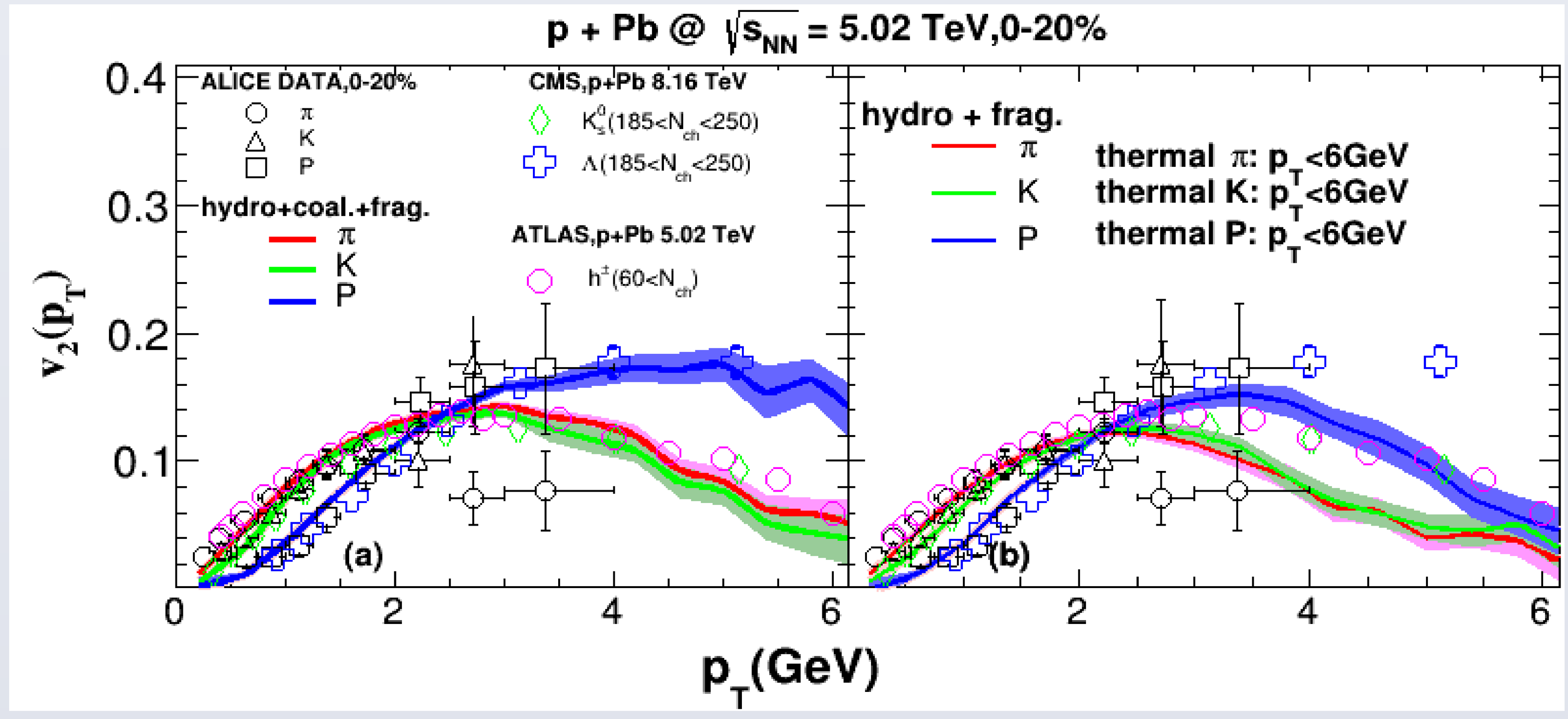
Nice description of spectra and the P/π from 0 to 6 GeV

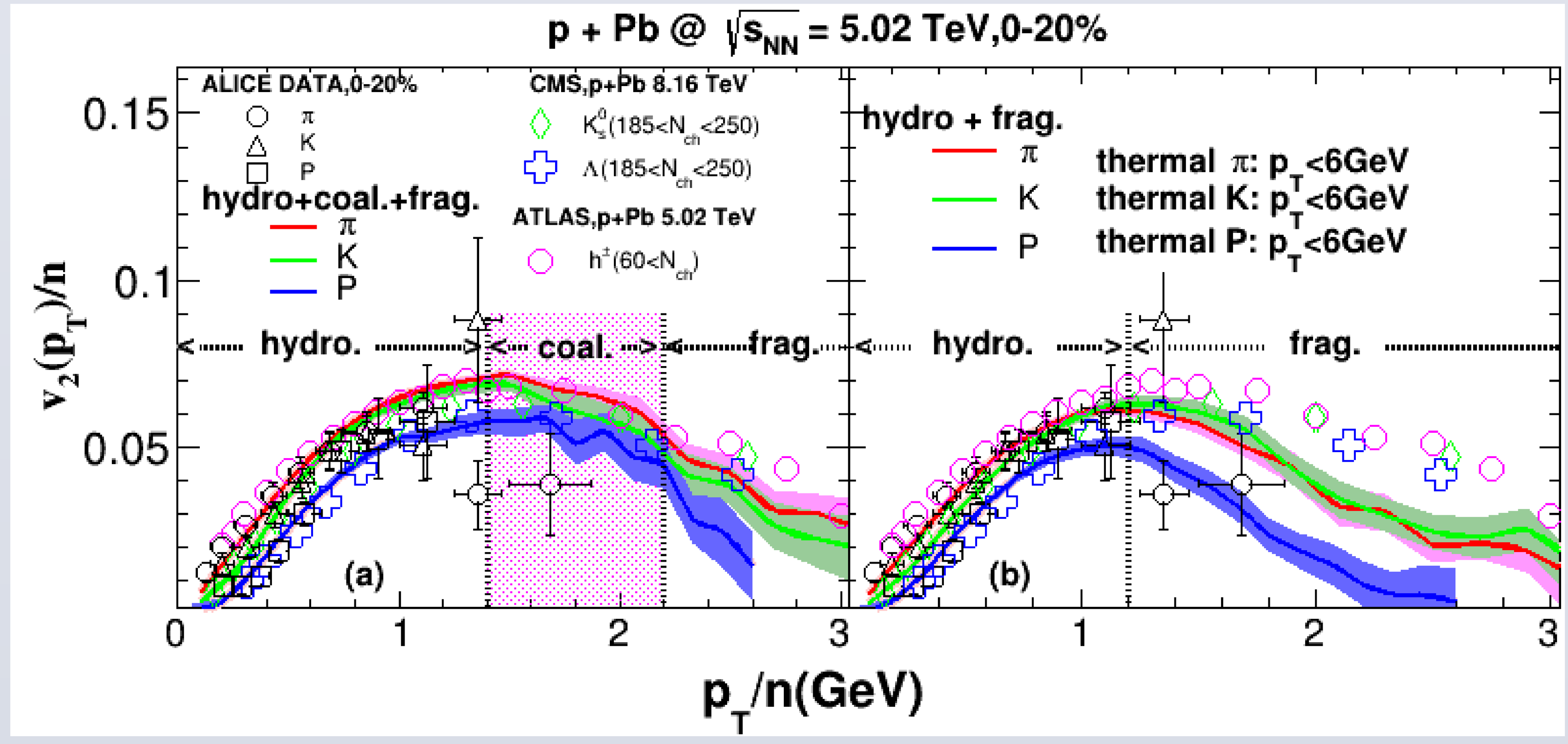
-- Low p_T: hydrodynamics dominates;

-- Intermediate p_T: coalescence and fragmentation;

-- High p_T : Fragmentation dominates.

<u>Coalescence hadrons</u>: Thermal-thermal coalescence dominates.





Nice description of data. Coalescence is a must to describe data.

-- Hydro.+Coal.+Frag. nicely describe $v_2(p_T)$ of π, K and P from 0 to 6 GeV.

-- Hydro.+Coal.+Frag. can get the approximately NCQ scaling of pion, kaon and proton at intermediate p_T as the data shows.

-- Without coalescence process, hydro. + fragmentation underestimates the measured $v_2(p_T)$ greatly, and violates NCQ scaling at intermediate p_T.

CONCLUSIONS

-- Coalescence is necessary in high multiplicity p+Pb collisions. One needs combine Hydro, Coal. and Frag. together to describe the spectra and $v_2(p_T)$ as well as get the approximately NCQ scaling.

-- This implies the existence of the partonic degree of freedom in the high multiplicity p+Pb collisions.

REFERENCES

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