Transverse Momentum Distributions of identified particles produced in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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Introduction

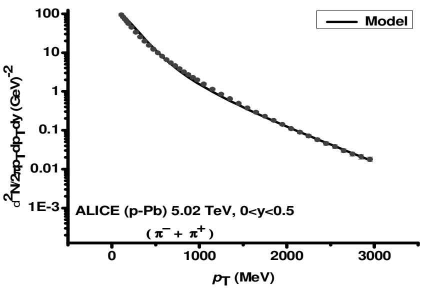
The Statistical and hydrodynamic models predicted the existence of a hot and dense matter produced in the initial stage, which rapidly expands and cools down, ultimately undergoing a transition to a hadron gas phase [1]. A collective hydrodynamic flow developed from the initially generated pressure gradients results in a characteristic dependence of the shape of the transverse momentum (p_T) distribution on the particle mass, which can be described with a kinetic freeze-out temperature T and a collective expansion velocity β_T [2]. The interpretation of heavy-ion results depends crucially on the comparison with results from smaller collision systems such as proton-proton (pp) or proton-nucleus (pA). Comparing particle production in pp, pA, and AA reactions has frequently been used to separate initial state effects from the final state effects. In this analysis, we have reproduced the mid-rapidity (0<y<0.5) p_T-distributions of some particles produced in p-Pb collisions at LHC by employing our earlier proposed Unified Statistical Thermal Freeze-out Model (USTFM) [3-7] which incorporates the effects of both longitudinal as well as transverse hydrodynamic flow in the produced system. The various freeze-out conditions so obtained are studied and compared to those obtained from heavy ion collisions at RHIC and LHC.

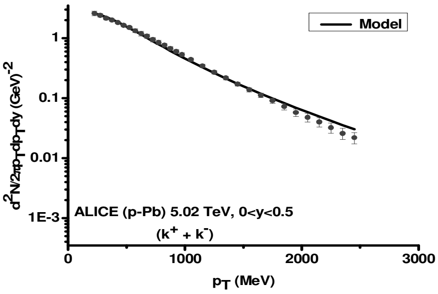
Results and Discussion

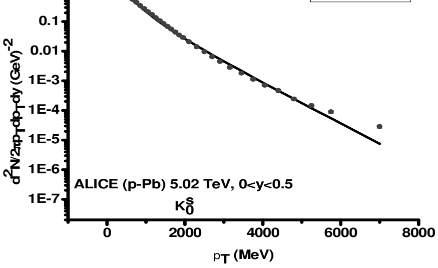
In our analysis of the p_T-spectra of various hadrons produced in p-Pb collisions at LHC, we have assumed the baryon chemical potential to be ~ 0, [3] under the assumption of a baryon symmetric matter expected to be formed under the condition of a high degree of nuclear transparency in the nucleus-nucleus collisions at LHC energy, i.e Bjorken's approach. We employ the minimum χ^2 /dof method to fit the experimental data [8]. The p_T- distributions are found to be *insensitive* to the value of σ (the width of the matter distribution) thus it is set equal to 5 in our model [3]. In Figure 1, we have shown the p_T-spectra of pions, kaons, protons and lambda particles produced in most central (0-5)% p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. A good agreement seen between the experimental data and the model predictions suggest the statistical nature of the particle production and hence the validity of our approach. The various freeze-out conditions so obtained are given in Table 1 below. It is seen from the table that collective flow velocity decreases and the thermal freeze-out temperature increases on going from lighter mass particles to heavier particles. The reason for this can be attributed to an early freeze-out for the massive particles (hyperons) when the thermal temperature is high and the collective flow is in the early stage of development and consequently β_T^0 is small. The early freeze-out of these particles is due to their smaller cross-section with the hadronic matter. A comparison of the freeze-out parameters with those obtained in Pb-Pb collisions at LHC [3] shows that the freeze-out temperature of the hadrons produced in Pb-Pb collisions are lower than those obtained in p-Pb collisions. This fact can be attributed to the formation of relatively smaller sized system in p-Pb collisions, due to which the particles remain relatively for less time period in the medium and are thus ejected at higher temperatures than that in Pb-Pb collision system. Also, the similar freeze-out conditions of kaons indicate their near simultaneous freeze-out from the system. The value of transverse flow velocity parameter n is found to decrease from lower mass particles to higher mass particles. This trend was also observed in Pb-Pb collisions at LHC [3]. A similar comparison of the freeze-out parameters with those obtained at RHIC [4, 5] indicates that the collective flow increases considerably where as the freeze-out temperature decreases significantly on going from RHIC to LHC energies. This fact is understood to be due to the large energies available for particle production at LHC which results in a larger system size than that produced at RHIC and hence to the larger collective flow and smaller freeze-out temperatures.

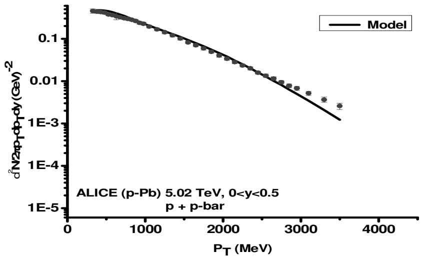
Table 1: Thermal Freeze-out Conditions.

Particle	β_T^0	T (MeV)	n
Pion	0.93	95.0	2.74
Proton	0.90	105.0	1.33
K_0^s	0.89	131.0	2.33
Kaon	0.89	133.0	1.50
Lambda	0.78	160.0	1.12









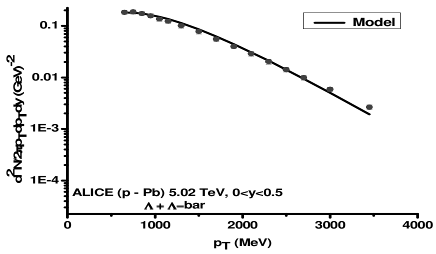


Fig. 1 p_T – distributons of various hadrons.

Conclusion

The mid-rapidity p_T spectra are successfully reproduced by our model. The thermal freeze-out conditions show the phenomena of a sequential freeze-out of the various particles as seen in heavy ion collisions at LHC. A larger collective flow and a smaller freeze-out temperature is found in p-Pb collisions at LHC as compared to the heavy ion collisions at RHIC. Kaons are found to freeze-out simultaneously from the system.

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