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Production of pions, kaons and protons at high p_{T} in $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV Pb-Pb collisions

Antonio Ortiz Velasquez (for the ALICE Collaboration)[1]

Division of Particle Physics, Lund University, Sweden

Abstract

In this work we report on the production of charged pions, kaons, and (anti) protons in pp and Pb – Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV for $3 < p_{\mathrm{T}} < 20$ GeV/c. The evolution of the nuclear modification factor, R_{AA}, with collision centrality and transverse momentum is discussed.

Keywords: LHC, ALICE, identified particles, high p_{T}, heavy ions.

1. Introduction

Particle identification (PID) is an important tool to study the hot and dense matter created in relativistic heavy ion collisions. At intermediate p_{T} (2-8 GeV/c) hadrons can be produced not only by fragmentation but also by quark recombination. It allows us to learn how the medium affects the particle composition [1]. In Section 2 we describe the analysis to measure the production of π/K/p as a function of p_{T} (3-20 GeV/c). The discussion of the results and conclusions are presented in Sections 3 and 4, respectively.

2. Identification of charged hadrons at high p_{T}

The measurement of the yields of charged pions, kaons and (anti) protons in the range $3 < p_{\mathrm{T}} < 20$ GeV/c is statistically performed exploiting the features of the mean energy loss, $\langle \mathrm{d}E/\mathrm{d}x \rangle$, of particles traversing the TPC gas [2], in the relativistic rise regime ($\beta\gamma$: 3.6 – 1000) of the Bethe-Bloch (BB) curve.

The TPC response was calibrated using a clean sample of π (p) identified through the weak decay topology of $\mathrm{K}^0_{\mathrm{S}}$ (Λ). Primary pions and electrons were tagged using the Time of Flight (TOF) detector. After parametrization of the BB curve and of the dE/dx resolution as a function of the calibrated $\langle \mathrm{d}E/\mathrm{d}x \rangle$, the measured resolution of minimum ionizing particles were 5.6% and 7.5% for low (pp) and high (Pb – Pb 0-5%) multiplicity environment, respectively.

The yields were extracted by fitting the distribution of the quantity $\Delta_\pi = \mathrm{d}E/\mathrm{d}x - \langle \mathrm{d}E/\mathrm{d}x \rangle_\pi$ to a sum of four Gaussian functions (π/K/p/e) in each p_{T} interval. The means and sigmas were constrained using the aforementioned parametrization and the p_{T} spectra obtained via factorization, as described in [3].

[1] A list of members of the ALICE Collaboration and acknowledgements can be found at the end of this issue.

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The main source of systematic uncertainty comes from the estimation of the parameters of the fitted functions. A range of variation for those parameters was evaluated running the analysis without using the information from topological and TOF PID. The parameters were randomly varied in the estimated ranges, then the yields were extracted using the same algorithm as in data. At high $p_{\rm T}$ (> 10 GeV/c) the systematic uncertainties were 5%, 10% and ∼ 30 – 40% for π, K and p, respectively. Also, the systematic errors from the spectra of inclusive charged particles [4] were added.

3. Results

Figure 1 shows $(\mathrm{p}+\bar{\mathrm{p}})/(\pi^+ + \pi^-)$ as a function of $p_{\rm T}$ for Pb – Pb and pp collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. For completeness the lower $p_{\rm T}$ results are also displayed for Pb – Pb [5, 6]. At intermediate $p_{\rm T}$ the ratio is enhanced, a phenomenon first observed at RHIC [7]. The maximum is located at 3 GeV/c and reaches ∼ 0.8 (∼ 0.4) for the most central (peripheral) events. For higher $p_{\rm T}$ (> 8 GeV/c), the ratio is consistent with fragmentation in vacuum. Figure 2 shows a comparison with the ratio in pp collisions at $\sqrt{s}$ = 7 TeV. It is interesting that even the pp data exhibit a maximum in the same $p_{\rm T}$ region as observed in Pb – Pb collisions.

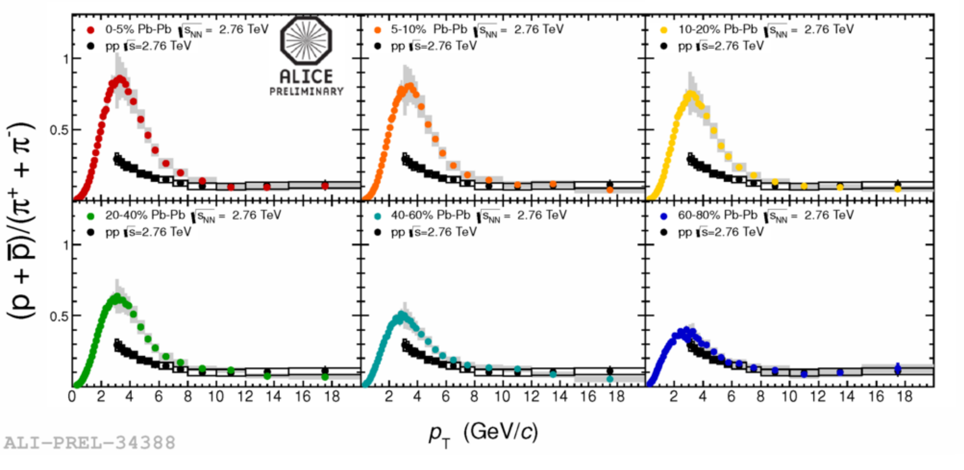

Figure 1: Centrality dependence of the $(\mathrm{p}+\bar{\mathrm{p}})/(\pi^+ + \pi^-)$ ratio a a function of $p_{\rm T}$ compared to pp at 2.76 TeV. Statistical and systematic uncertainties are displayed as error bars and boxes, respectively. The low $p_{\rm T}$ results come from the combined PID of ITS, TPC and TOF [6].

ALICE previously reported the nuclear modification factor ($R_{\rm AA}$) for π and p + K [3]. Now Figure 3 shows the $R_{\rm AA}$ as a function of $p_{\rm T}$ for pions, kaons and protons, the results are presented for 0-5% and 60-80%. For the most central events and at intermediate $p_{\rm T}$ (2-8 GeV/c), $R_{\rm AA}{}^{\pi} < R_{\rm AA}{}^{\rm p}$ and $R_{\rm AA}{}^{\pi} \sim R_{\rm AA}{}^{\rm K}$, no significant species dependence is seen at high $p_{\rm T}$.

4. Conclusions

At intermediate $p_{\rm T}$, we observe an enhancement of the $(\mathrm{p}+\bar{\mathrm{p}})/(\pi^+ + \pi^-)$ ratio. Within systematics, π/K/p are equally suppressed at high $p_{\rm T}$ which suggests that the fragmentation is not modified by the medium.

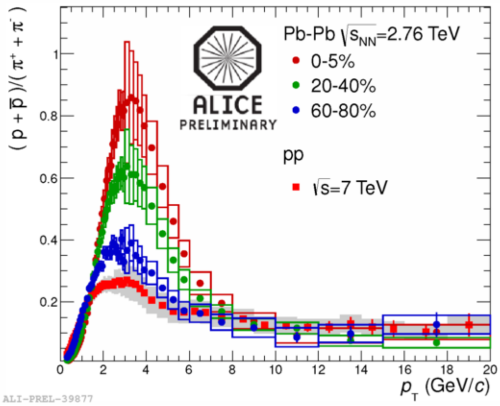

Figure 2: Comparison of the $(\mathrm{p}+\bar{\mathrm{p}})/(\pi^{+}+\pi^{-})$ ratio as a function of p_{T} between Pb−Pb and pp collisions at $\sqrt{s}_{\mathrm{NN}} = 2.76$ TeV and 7 TeV, respectively. Statistical and systematic uncertainties are displayed as error bars and boxes, respectively. The low p_{T} results come from the combined PID of ITS, TPC and TOF [6]. In addition the pp result includes the information of the Cherenkov detector, HMPID.

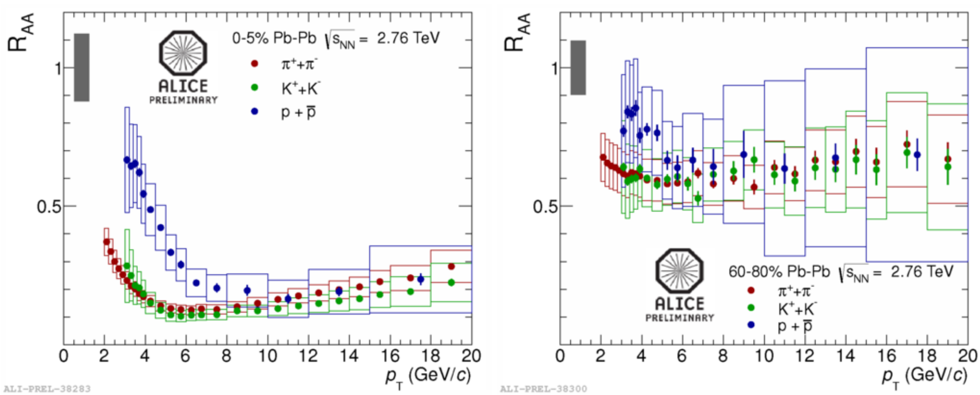

Figure 3: R_{AA} as a function of p_{T} for π/K/p in 0-5% (left) and 60-80% (right) Pb − Pb collisions. Statistical and systematic uncertainties are displayed as error bars and boxes, respectively.

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