

Study of the production of charged pions, kaons, and protons in p-Pb collisions at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$

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In this research project, we have examined the generation of pions, kaons and protons resulting from proton-lead (pPb) collision at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$, utilizing experimental data obtained from the ALICE detector at the Large Hadron Collider (LHC). The primary motivation behind the study of primary charged particles is to study Quark-Gluon plasma(QGP) in pPb collision. Researchers have found the QGP in the lead lead collision where the temperature and densities both are too high, but in the case of pPb collision we have the high temperature not the densities that's why QGP is not formed. The pPb collisions provide the necessary baseline for ultra-relativistic heavy-ion collisions. We used the PYTHIA 8.309 Monte Carlo Event Generator for pPb collisions to achieve our goal. Yield of pions, kaons and protons is produced as a function of p_T in pPb collision at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$ in the mid-rapidity range of $|y| < 1$. The Monte Carlo Event Generator yield is compared with data obtained from ALICE. The model-generated distributions are displayed alongside the experimental data collected by the ALICE collaboration and sourced from the HepData database for comparative analysis.

The study primarily focused on

- Produced pion, kaon, and proton yields vs p_T in p-Pb collisions.
- Provided baseline data for studying QGP formation in Pb-Pb collisions.
- Studied the influence of strange quarks on the strong force.
- Analyzed nuclear medium effects on particle production.

Production of Pions, Kaons, and Protons in p-Pb Collisions

The Pythia 8.309 distribution for primary charged particles are presented along ALICE data at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$ with the ALICE at the LHC as a function of p_T with a mid-rapidity range of $|y| < 1$.

- **Production of π^+ , K^+ and p**

Transverse momentum is produced for (π^+ , K^+) mesons and protons as a function of p_T in p-Pb collisions.

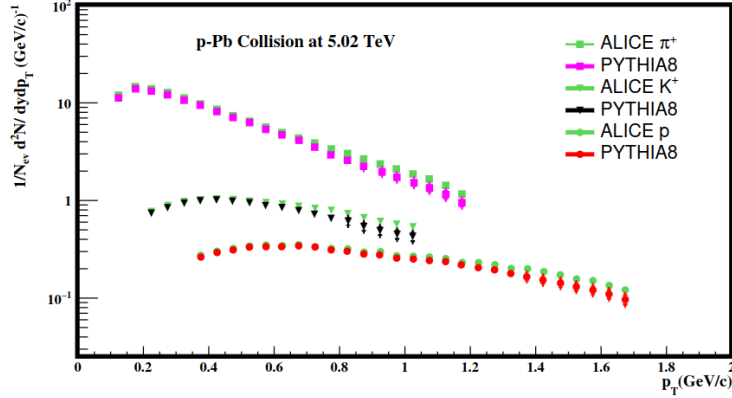


Figure 1: Production of π^+ , K^+ and p

Reason: Pythia8 is plotted along ALICE data distributions. In low p_T , model data give us good estimate with ALICE data but deviation in high p_T is due to multiparton interactions (MPI) and due to perturbative QCD in Pythia model.

- **Production of π^- , K^- and p^-**

Transverse momentum is produced for (π^- , K^-) mesons and for antiprotons.

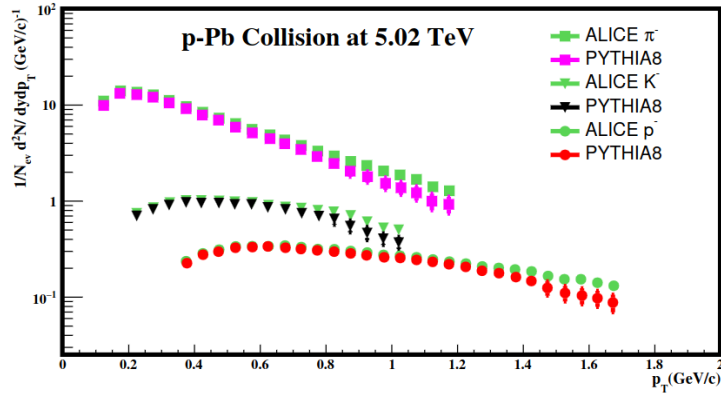


Figure 2: Production of π^- , K^- , and p^-

Reason: Pythia8 is plotted along ALICE data distributions. In low p_T , model data give us good estimate with ALICE data but deviation in high p_T is due to multiparton interactions (MPI) and due to perturbative QCD in Pythia model.

- **Production of π^+ , K^+ , $\pi^+ + K^+$ and proton**

Transverse momentum produced for π^+ , K^+ , $\pi^+ + K^+$ and proton in p-Pb collisions.

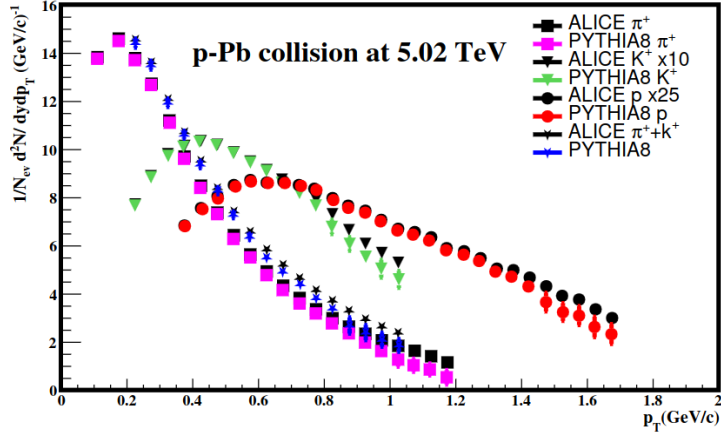


Figure 3: Production of π^+ , K^+ , $\pi^+ + K^+$ and proton

Reason: Model gives us a good estimate with ALICE data, no deviations in low p_T but it shows deviation in high p_T .

- **Production of π^- , K^- , $\pi^- + K^-$ and antiproton**

Transverse momentum is produced for π^- , K^- , $\pi^- + K^-$, and antiprotons.

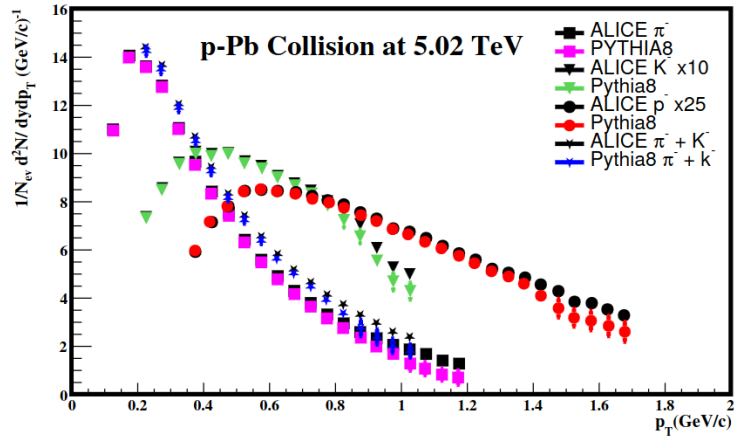


Figure 4: Production of π^+ , K^+ , and protons

Reason: It seems that model gives us a good estimate with ALICE data, no

deviations in low p_T but it shows deviation in high p_T because of multiparton interactions and perturbative QCD effects in PYTHIA8 model.

- Yield ratio

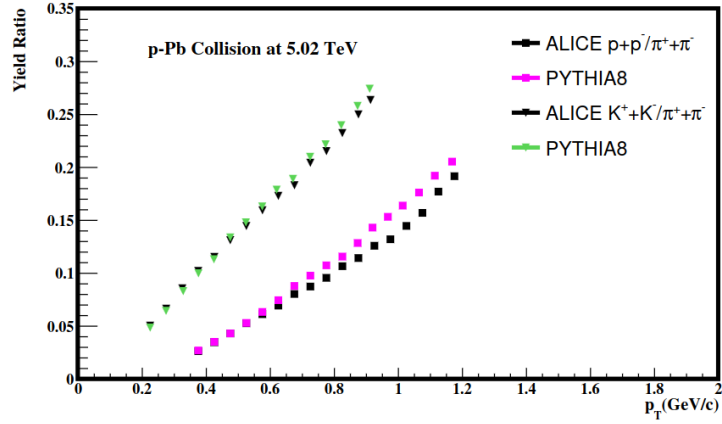


Figure 5: Yield ratio

Reason: Pythia 8 distributions are plotted along ALICE data distributions. Model Pythia8 and experimental ALICE Data show that the production of baryon (proton) and kaon increases at high p_T values.

- Yield Ratio

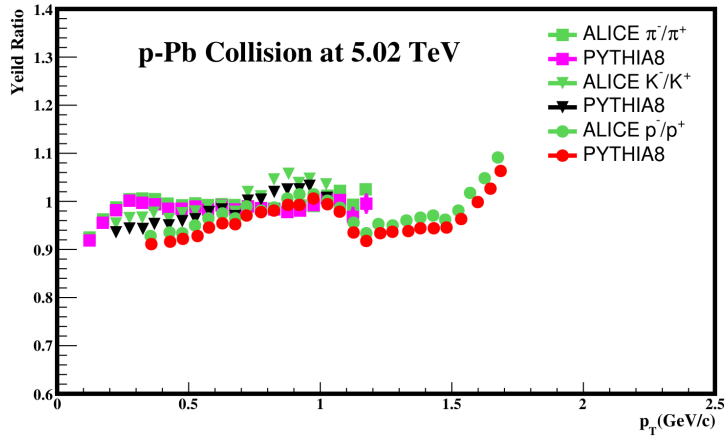


Figure 6: Yield ratio

Reason: There is small deviation in high and low p_T , as this yield ratio show that production of particle and antiparticle in p-Pb collisions can be roughly

balanced at 5.02 TeV. The small deviation in high p_T is due to multiparton interactions in Pythia model.

We used the PYTHIA model to simulate the production of π^+ , π^- , K^+ , K^- , p , and \bar{p} in p-Pb collisions. In addition, we analyzed the particle yield ratios $(p + \bar{p})/(\pi^+ + \pi^-)$ and $(K^+ + K^-)/(\pi^+ + \pi^-)$. Based on our investigation, **we conclude that:**

- The PYTHIA prediction underestimates the ALICE data mostly at low p_T . At high p_T , the PYTHIA yields are higher and overestimate the experimental data.
- Overall, PYTHIA provides a good description of the $\pi^+ + \pi^-$, $K^+ + K^-$, and $p + \bar{p}$ yields, with small deviations observed at both low and high p_T values.
- The PYTHIA yields for $(p + \bar{p})/(\pi^+ + \pi^-)$ showed good agreement with the experimental data at low p_T in the range of $0 < p_T < 1$ GeV/ c , but later it deviated significantly and underestimated the ALICE data at high $p_T > 1$ GeV/ c .
- The deviations of the PYTHIA prediction from the ALICE data could be connected to multi-parton interactions at both low and high p_T values.