High $p_T$ Spectra of Identified Particles Produced in Pb+Pb Collisions at 158 GeV/nucleon Beam Energy

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ABSTRACT

Transverse momentum spectra of $\pi^\pm$, $p$, $\bar{p}$, $K^\pm$, $K_s^0$ and $\Lambda$ at midrapidity were measured at high $p_T$ in Pb+Pb collisions at 158 GeV/nucleon beam energy by the NA49 experiment. Particle yield ratios ($p/\pi$, $K/\pi$ and $\Lambda/K_s^0$) show an enhancement of the baryon/meson ratio for $p_T > 2$ GeV/c. The nuclear modification factor $R_{CP}$ is extracted and compared to RHIC measurements and pQCD calculations.

1. INTRODUCTION

One of the most interesting features discovered at RHIC is the suppression of high $p_T$ particle production in central nucleus-nucleus reactions relative to peripheral ones or p+p collisions. This is generally interpreted as a sign of parton energy loss in hot and dense nuclear matter. Additionally, an enhancement of baryon/meson ratios above unity at high $p_T$ was observed and can be explained in the context of quark coalescence models. The aim of this analysis is to investigate the energy dependence of these effects by studying nucleus-nucleus reactions at top SPS energy ($\sqrt{s_{NN}} = 17.3$ GeV/nucleon) (see: [1, 8]).

2. DATA ANALYSIS

Centrality selection is based on a calorimetric measurement of the energy observed in the projectile spectator region of phase space (see [3]). Charged particle spectra ($\pi^\pm$, $p$, $\bar{p}$ and $K^\pm$) in the center of mass rapidity interval $[-0.3, 0.7]$ are analyzed in the centrality ranges (0-5)%, (12.5-23.5)%, (33.5-80)% of the total inelastic cross section. The tracking efficiency for single tracks is above 95% and an efficient fake track rejection is applied. The particle identification is done by unfolding the energy loss spectra measured in different phase-space bins. The typical $dE/dx$ resolution varies between 3 and 6%. The $\pi^\pm$ and $p$, $\bar{p}$ yields were not corrected for feed down from the decay of $K_s^0$ and hyperons; furthermore the $K^\pm$ yields were not corrected for decay loss.

Neutral strange particles were analyzed in the centrality range (0-23.5)%. They are identified via the topology of their weak decay into the channels $K_s^0 \rightarrow \pi^+\pi^-$ (BR = 68.95%) and $\Lambda \rightarrow p\pi^-$ (63.9%). For the V0-candidates, selected by geometrical criteria, the invariant mass of the daughter particles is calculated as a function of $p_T$ and the yields of $K_s^0$ and $\Lambda$ are extracted on a statistical basis. The shown results are for the rapidity interval $[-0.5, 0.5]$ and corrected for acceptance and reconstruction inefficiency. The $\Lambda$ yields are not corrected for feed down from the decay of heavier hyperons.

3. PHYSICS RESULTS

The proton/pion and the kaon/pion ratios are shown in Fig. 1. These ratios exhibit a monotonic increase with $p_T$ and centrality at high $p_T$. The kaon/pion ratios show a
saturation tendency at high $p_T$, particularly the $K^-/\pi^-$ ratio.

![Graphs showing proton/pion and kaon/pion ratios vs. $p_T$ and centrality.](image)

**Figure 1.** Proton/pion (upper panels) and kaon/pion (lower panels) ratios vs. $p_T$ and centrality.

In the left panel of Fig. 2, our measurement of proton/pion ratio is compared to RHIC data. The shape of these curves is approximately energy independent. The right panel of Fig. 2 shows NA49 baryon/meson ratios, compared to a Blast-Wave (BW, see [7]) parametrization of $m_T$ spectra and radius parameters from Bose-Einstein correlations of pions, fitted simultaneously at low $p_T$. The BW model curve does not describe the data at high $p_T$.

The nuclear modification factor $R_{CP}$ is defined by $R_{CP} := N(\text{Peripheral}) \cdot \frac{\text{Yield(Central)}}{\text{Yield(Peripheral)}}$. Here $N$ can be either the number of binary collisions or the number of wounded nucleons obtained from model calculations in the given centrality range. The upper panels of Fig. 3 show the energy dependence of $R_{CP}$ vs. $p_T$ of pions with binary collision and with wounded nucleon scaling. At high $p_T$ there is a strong energy dependence with both scalings, however at low $p_T$ wounded nucleon scaling makes $R_{CP}$ energy independent. A similar phenomenon was pointed out for unidentified particles in [6]. The lower panels of Fig. 3 show the comparison of our data to pQCD calculations (see [10]). $R_{CP}$ is consistent with the pQCD calculation at $p_T > 2$ GeV/c. However, the pQCD prediction for the antibaryon/meson ratio is very far from the data below 4 GeV/c.
4. CONCLUDING REMARKS

First NA49 results on particle yields around midrapidity in the range $2 \text{ GeV/c} \leq p_T < 4.5 \text{ GeV/c}$ were presented from a study of $158 \text{ GeV/nucleon}$ beam energy $\text{Pb+Pb}$ collisions.

A monotonic increase of baryon/meson ratios and kaon/pion ratios with $p_T$ and centrality was observed at high $p_T$. The $p_T$ shape of the baryon/meson ratio is approximately energy independent. The measured baryon/meson ratios were compared to a Blast-Wave model: the model predictions exceed the data for $p_T > 1.5 \text{ GeV/c}$.

The nuclear modification factors $R_{CP}$ were also determined from the particle yields for various particle species, as a function of $p_T$. The measured $R_{CP}$ ratio does not show Cronin enhancement for the mesons at larger $p_T$ when using binary collision scaling. The behavior is qualitatively similar to the $p_T$ shape observed at RHIC. A strong energy dependence of the $R_{CP}$ ratios was observed at high $p_T$ with both binary collision and wounded nucleon scaling. However, at low $p_T$, the wounded nucleon scaling factorizes out the energy dependence. Results for $R_{CP}$ with binary collision scaling are consistent with pQCD model calculations at $p_T > 2.5 \text{ GeV/c}$. However, the pQCD calculation strongly overpredicts the observed antibaryon/meson ratio for $p_T < 4 \text{ GeV/c}$.

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Figure 3. Energy dependence of $R_{CP}$ vs. $p_T$ (upper panels): binary collision scaling (left panel) and wounded nucleon scaling (right panel). Comparison of data to pQCD calculations (lower panels): the nuclear modification factor $R_{CP}$ (left panel) and the baryon/meson ratio (right panel).

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