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PRODUCTION OF $\pi^{\pm}, K^{\pm}$, p, K_s^0, Λ^0, K^{*0} and ϕ IN HADRONIC Z^0 DECAYS

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Production rates and momentum distributions have been measured for $\pi^{\pm}, K^{\pm}$, p, K_s^0, Λ^0, K^{*0} and ϕ in 150,000 hadronic Z^0 decays recorded by the SLD detector at the SLC collider at SLAC. The analysis uses the SLD Cerenkov Ring Imaging Detector (CRID) for clean and efficient identification of charged tracks and significant background reduction. In addition, K^{*0} production has been studied in quark and anti-quark jet samples, which were identified by their electroweak forward-backward asymmetries using the SLC high electron-beam polarization. A difference between the two samples is observed in the K^{*0} rate at high-momentum, consistent with leading particle and strangeness suppression hypotheses.

1 Introduction

An important aspect of the study of hadronization is the measurement of production rates of identified particle species. We study inclusive production of charged $\pi^{\pm}, K^{\pm}$, p, as well as neutral K_s^0, K^{*0}, ϕ and Λ^0 in a sample of 150,000 hadronic Z^0 decays recorded by the SLD experiment at the SLAC Linear Collider (SLC).

This analysis used charged tracks measured in the Central Drift Chamber (CDC) [1] and identified by the Cerenkov Ring Imaging Detector (CRID) [2]. The CRID information provides clean identification of charged hadrons over a wide momentum range as well as very good suppression of combinatoric and resonant backgrounds.

The highly polarized e^- beam of the SLC allows discrimination between quark and anti-quark jets and a further study of K^{*0} production was performed on these two samples.

2 Production rates

From the global event sample a sub-sample of approximately 90,000 hadronic events was selected by requiring a minimum of 7 charged tracks per event, 18

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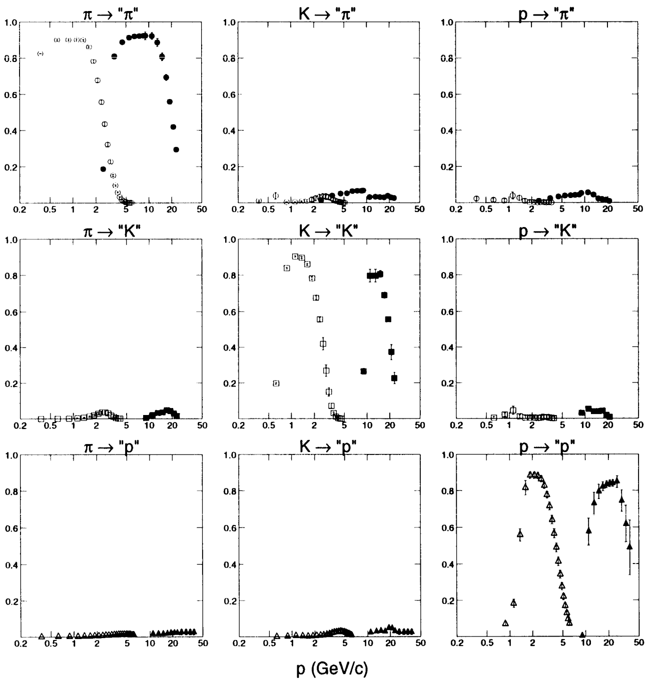

Figure 1: CRID performance matrix. The diagonal elements are the ID efficiencies with respect to particle momentum and the off-diagonal elements, the mis-ID rates

GeV of visible energy in the calorimeter and that the thrust[3] axis be contained in the barrel region of the detector, $|cos(\theta_{thrust})| < 0.7$.

For our benchmark analysis[4], the charged hadrons, a set of stringent quality cuts was applied to select tracks with very reliable CRID information. The charged hadron identification matrix for these tracks is shown in figure 1. The diagonal elements are the identification efficiencies versus track momentum, which are typically above 80%. The misidentification rates (off-diagonal elements) are at most 8%, typically much lower. Production rates of $\pi^{\pm}, K^{\pm}$ and p were measured[4] by using this matrix in unfolding the rates of identified pions, kaons and protons from each momentum bin.

The neutral hadrons were reconstructed in the $K_S^0 \rightarrow \pi^+\pi^-, \Lambda^0 \rightarrow \ p\pi^-$ $\phi \rightarrow \ K^+K^-$ and $K^{*0} \rightarrow K^+\pi^-$ modes. For the K_S^0 and Λ^0 the combinatorial background was suppressed by requiring a vertex which is well separated

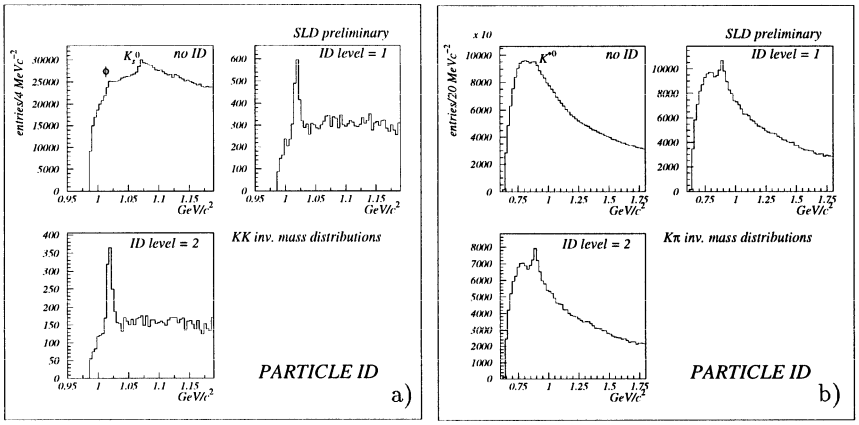

Figure 2: Unlike sign invariant mass distributions for increasing levels of particle ID : a) KK invariant mass, b) $K\pi$ invariant mass

from the interaction point (IP) and a total momentum vector consistent with originating at the IP. Cross-contamination of K_s^0 and Λ^0 was suppressed using kinematic cuts [5]. For the ϕ and K^{*0}, combinatorics and resonant backgrounds were suppressed by identification of the kaon candidates. Other notable reflections such as Λ^0, K_s^0 and γ, were suppressed using flight distance information. Figure 2 shows how increasing levels of particle identification reveal the ϕ and K^{*0} signals in the data.

Signals were extracted by performing fits in a set of momentum bins to the appropriate invariant mass distributions. Two examples are shown in figure 3. For K_s^0, Λ^0 and ϕ the signal was parametrized by a gaussian and the background by a simple monotonic function. In the case of the K^{*0}, the distribution was assumed to be described by a relativistic Breit-Wigner signal and a background including residual contributions from resonances such as ρ^0 and ω^0. Production rates versus momentum for all of the studied particles are shown in figure 4. It is observed that replacing a d with a u quark in a particle yields similar production rates, $K^\pm$ and K_s^0, while replacing either the u, or the d with an s quark will lead to a suppression in the production rate, $\pi^\pm$ and $K^\pm$, K^{*0} and ϕ, p and Λ^0.

3 Leading Particle Effect

Production of hadrons in the fragmentation process is expected to be identical in quark and antiquark jets. Hence any difference found in the production

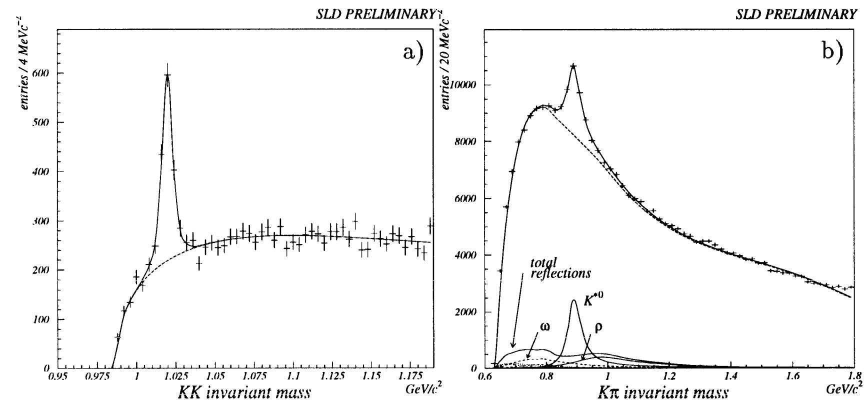

Figure 3: Example fits for : a) ϕ, b) K^{*0}The notable contributions to the background are shown.

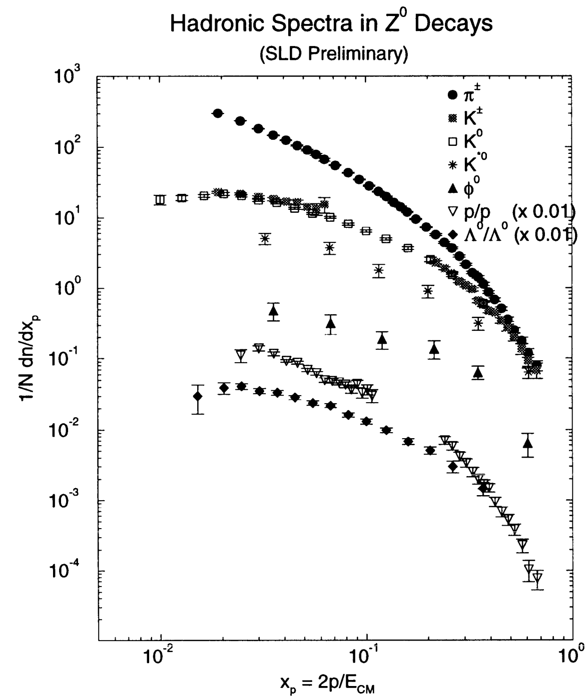

Figure 4: Particle production rates versus momentum

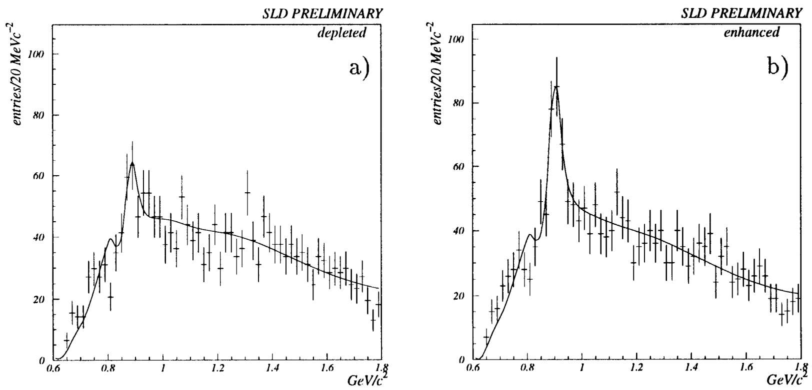

Figure 5: $K\pi$ invariant mass distributions for p > 22GeV/c^2: a) depleted sample, b) enhanced sample

rates in quark and antiquark jets would be attributable to hadrons coming from the initiating parton of the jet.

At SLD it is possible to study separately quark and antiquark jets due to the large electron beam polarization delivered by the SLC. We approximated the primary parton direction by the event thrust axis. Using the large electroweak quark production asymmetry [6] and the electron beam polarization we have signed the thrust axis to point into the quark hemisphere. For instance left-handed incident electrons produce preferentially quarks at small angles with respect to the electron beam direction.

From a valence-quark point of view the K^{*0} consists of $d\bar{s}$. Under the "leading particle" assumption, a high momentum K^{*0} moving along the quark direction carries a primary quark, the d, and an anti-quark from the QCD vacuum, the $\bar{s}$. Similarly, a $\overline{K^{*0}}$ would contain the primary quark, in this case the s, and a $\bar{d}$ from the QCD vacuum. Due to the difference in mass of the s and d quarks the production of high momentum K^{*0} in quark jets is suppressed with respect to that of $\overline{K^{*0}}$.

For this analysis we define two samples of K^{*0}: a "depleted" sample, consisting of K^{*0} moving along the quark direction and $\overline{K^{*0}}$ along the antiquark direction and an "enhanced" sample, consisting of K^{*0} moving along the antiquark direction and $\overline{K^{*0}}$ along the quark direction.

A clear excess of production in the "enhanced" sample is visible in fig. 5. Figure 6 shows the normalized difference between the "enhanced" and "depleted" production rates versus momentum. At low momentum the nor-

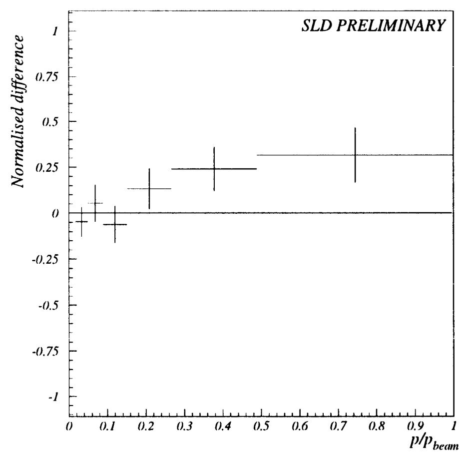

Figure 6: Normalized difference between K^{*0}production rates in quark and anti-quark jets versus K^{*0} momentum

realized difference between the two samples is consistent with zero, whereas at high momentum it reaches 25-30%. This excess supports the leading particle and strangeness suppression hypotheses.

We have shown the performance of a new generation of particle ID system and a study of particle production rates at SLD. In particular, the K^{*0}produc-tion has been studied in quark and antiquark jets, yielding a new method for direct strangeness suppression measurement.

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