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Strange Particle Production and s-quark Asymmetry

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Using hadronic Z^0 decays recorded by the SLD experiment at SLAC, we have studied the production of strange particles as a function of momentum. A high-purity sample of $K^\pm$ was tagged using Cherenkov Ring Imaging Detector(CRID). The ϕ, Λ and K_s were reconstructed in the K^+K^-, $p\pi$ and $\pi^+\pi^-$ modes respectively, and CRID identification of $K^\pm$ and p was used to obtain pure samples of ϕ and Λ. We have used the high electron-beam polarisation delivered by the SLC to measure the left-right forward-backward production asymmetries of these particles, and discuss the relationship of these quantities to the underlying strange quark asymmetry in Z^0 decays.

1 Introduction

The tagging of strange events, $e^+e^- \rightarrow s\bar{s}$, would allow many interesting tests of the electroweak and strong interactions, for example of the s-quark production asymmetry parameter A_s, and of the inclusive properties of jets initiated by s-quarks. Many fragmentation models predict that the primary s and $\bar{s}$ in such events materialize as "leading" strange particles, that tend to have higher momentum than the bulk of the particles from the fragmentation process. The identification of a pure sample of high-momentum, strange particles might therefore provide a clean tag of $e^+e^- \rightarrow s\bar{s}$ events.

In this analysis we isolate high-purity samples of charged and neutral kaons, ϕ-mesons, and Λ^0-baryons in tagged light-quark events. In events containing two identified strange particles, we study the distribution of the difference in rapidity, separately, where possible, for pairs with total strangeness 0

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and ± 2.

2 Strange particle tags

The analysis presented here was based on a sample of 150,000 hadronic Z^0 decays recorded in the 1993-5 runs of the SLAC Linear Collider and recorded by the SLC Large Detector (SLD). The analysis used the charged tracks measured in the Central Drift Chamber (CDC) and Vertex Detector (VXD), along with identification information from the Cherenkov Ring Imaging Detector (CRID). Hadronic events well-contained within the barrel region of the detector were selected [1] and were further required to be consistent with containing light (u, d or s) primary quarks. For the latter purpose we considered events with a well-measured primary interaction point and required that all "quality"[1] tracks in the event extrapolate to within three standard deviations of this point in the plane transverse to the beam axis. A total of 56474 events passed these cuts, with a light-quark purity, estimated from a Monte Carlo simulation[1], of 85%.

Charged kaons are identified using a likelihood technique [2]. Pairs of identified, oppositely charged $K^{\pm}$ are tagged as $\phi \rightarrow K^+K^-$ decays if 1.015 < M_{KK} < 1.025 (GeV/c^2), and these $K^{\pm}$ are removed from the charged K sample. Pairs of oppositely charged tracks are considered as $\Lambda^0(\bar{\Lambda}^0)$ or K_s candidates if they forma good vertex that is well-separated from the IP and the total momentum vector is consistent with intersecting the IP [3]. If the higher momentum track is identified as a proton and 1.1106< $M_{p\pi}$ < 1.1206 (GeV/c^2) then the pair is tagged as a $\Lambda^0(\bar{\Lambda}^0)$. Otherwise if 0.4856< $M_{\pi\pi}$ < 0.5096 (GeV/c^2), the pair is tagged as a K_s. The purity of these strange samples are estimated to be above 80% for momentum above 10 GeV/c.

3 Correlations between strange particles and A_s

We then considered events containing at least two identified strange particles. We calculated the event thrust axis using all charged tracks in the event and calculated the rapidity of each strange particle $y \equiv 0.5\ln\{(E+p_{\|})/(E-p_{\|})\}$, where $p_{\|}$ is the component of the particle's momentum along the thrust axis.

Figure 1 shows the distribution of the absolute rapidity difference $\Delta y = |y_1 - y_2|$ for pairs of opposite-sign and like-sign charged kaons in the same event, in which both charged kaons have momentum above 10 GeV/c. There is a substantial excess of opposite-sign pairs at both low and high rapidity difference. At low Δy, this excess implies that strangeness conservation in the fragmentation process is quite local – when an $s\bar{s}$ pair is created from the

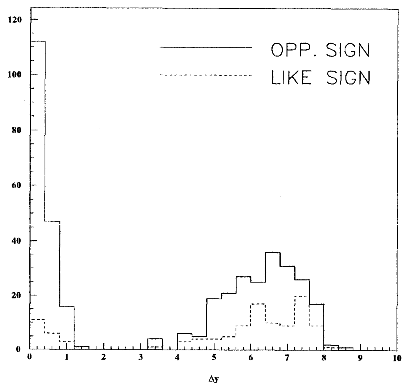

Figure 1: Rapidity difference for the pairs of opposite-sign *(solid)* and like-sign *(dashed)* charged kaons in which both of them have momentum above 10GeV/c

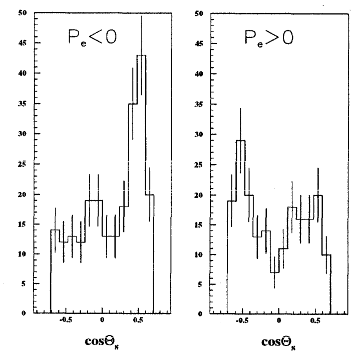

Figure 2: $\cos\theta_s$ using thrust axis direction signed by strangeness of particle in hemisphere. Electron polarisation P_e < 0(Left) and P_e > 0(Right)

vacuum, the s and $\bar{s}$ materialize in particles rather close to each other in phase space. The excess at high Δy indicates that the higher-rapidity charged kaons tend to be leading, since if leading charged kaons are produced by both the q and $\bar{q}$ in a Z^0 decay then these two kaons must have opposite charge, whereas kaons from the fragmentation chain have random charge. Consistent results (not shown) were obtained for $K^{\pm}\Lambda$ and $\Lambda\Lambda$ pairs, for which the sign of the strangeness can be known for both particles. The former indicate that an $s\bar{s}$ pair may be shared between a meson and a baryon close together in phase space.

In order to measure A_s one must both tag $s\bar{s}$ events with high purity and determine the s quark direction reliably. For this purpose, we considered events with at least one tagged strange particle in each hemisphere and used the one with highest momentum in each. At least one of these two particles was required to carry the sign of strangeness *(i.e.* to be a $K^{\pm}$ or $\Lambda(\bar{\Lambda})$) and if both did, they were required to have total strangeness 0. We determined the initial s quark direction $(\hat{u})$ using the event thrust axis $(\hat{t})$ signed by the strangeness *(s)* and momentum $(\vec{p})$ of the tagged strange particle: $\hat{u}=s(\vec{p}\cdot\hat{t})\hat{t}/\mid\vec{p}\cdot\hat{t}\mid$. Figure 2 shows the distribution of $\cos\theta_s \equiv \hat{u}_z$ for left- $(P_e < 0)$ and right- $(P_e > 0)$ handed electron beam. A significant production asymmetry is observed, with more s quarks produced at $cos\theta$ > 0(< 0) for P_e < 0(> 0) as expected if our sample contains more $s\bar{s}$ than $u\bar{u}$ and $d\bar{d}$ events. Once the $s\bar{s}$ event purity and correct sign fraction are understood then we can measure A_s from these two distributions.

We conclude that the identification of fast strange particles can be used as an $s\bar{s}$ event tag and that fast charged kaons and lambdas carry the sign of the strangeness of the initial (antiquark. Correlations between strange particles provide some important inputs needed for A_s measurements.

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