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A STUDY OF K_S, Λ AND $\overline{\Lambda}$ PRODUCTION IN HADRONIC Z^0 DECAYS[*] [†]

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ABSTRACT

We present a preliminary measurement of the inclusive production rates of K_S, Λ and $\overline{\Lambda}$ hadrons produced in e^+e^- annihilation at the Z^0 pole. The analysis is based upon approximately 50K Z^0 decays collected in the SLD experiment at SLAC in 1993. The observed rates of $\langle K_S \rangle = 1.02 \pm 0.02 \pm 0.09$ and $\langle \Lambda \rangle + \langle \overline{\Lambda} \rangle = 0.38 \pm 0.01 \pm 0.04$ are consistent with previous measurements. Our differential cross section peak-position results are shown to be consistent with QCD predictions based on the modified leading logarithm approximation and local parton-hadron duality.

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1. Introduction and Experimental Procedure

The SLAC Linear Collider produces polarized electron-positron annihilation events at the Z^0 resonance, which are recorded by the SLC Large Detector (SLD).[1] In the physics run between March and August 1993 a sample of approximately 50,000 hadronic Z^0 decays was collected by SLD.

A set of cuts was applied to select events that were well contained within the detector acceptance; this yielded a total of 29,724 events from the 1993 data sample. Oppositely charged tracks were systematically combined to form V^0 candidates. Candidate pairs were required to have a distance of closest approach less than 2.5 mm and 3σ in the transverse uncertainty of the common vertex point. Candidates were also required to point back to the interaction point within 1° in the plane transverse to the electron beam and 2° overall, and to have secondary vertices separated from the primary by at least $5\,\sigma$ in flight length. Potential gamma conversions were rejected by requiring the invariant mass of the charged track pair (assuming both tracks to be electrons) to be greater than 100 MeV/c^2. Lastly, the requirement that the momentum of the V^0 be greater than 300 MeV/c allowed kinematic separation of the Λ candidates from the $\overline{\Lambda}$ candidates according to the charge of the higher momentum decay track.

After applying this procedure to the hadronic event sample, a sample of 13,102 V^0 candidates was obtained. Figure 1 shows the invariant mass distributions for a) the $\pi\pi$ hypothesis and b) the $p(\overline{p})\pi$ hypothesis, where the higher momentum track was assigned the mass of the proton. As the mass resolution is a function of V^0 momentum, it was necessary to fit both distributions to the sum of two gaussians with a quadratic background in order to adequately describe the peak over the displayed momentum range of 0.3 to 20 GeV/c.

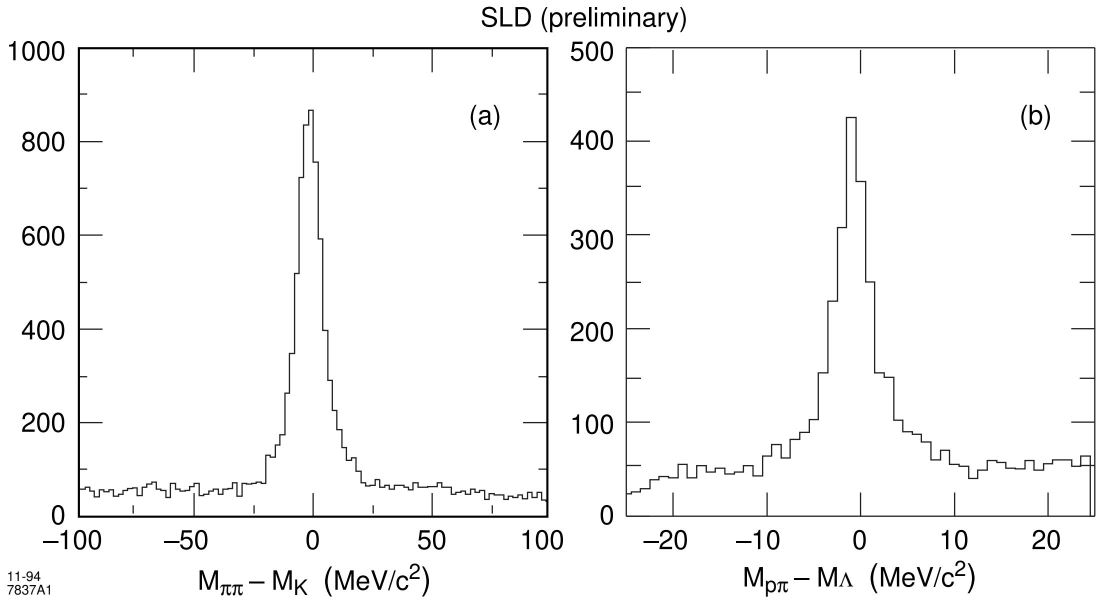

Fig. 1. Invariant mass distributions for (a) $M_{\pi\pi}$ to M_{K_S}, and (b) $M_{p\pi}$ to M_Λ for the V^0 momentum range of 0.3 to20.0 GeV/c.

2. Production Rates

To obtain inclusive production rates of K_S, Λ and $\overline{\Lambda}$, the invariant mass distribution for each hypothesis were binned by V^0 momentum and fitted to a single gaussian with a quadratic background. The signal in each bin of momentum was then corrected for detector reconstruction efficiency (Fig. 2), which was evaluated using simulated hadronic data generated with JETSET[2] and passed through a detailed detector simulation. To determine $\langle\Lambda\rangle$ and $\langle\overline{\Lambda}\rangle$, separate efficiency corrections were used. The resulting spectrum was then fitted to a decaying exponential function and integrated from $p = 1$ to $M_Z/2$ GeV/c. JETSET was used to determine the size of the unobserved low momentum contribution relative to the observed region, and then the differential cross sections and production rates were calculated. The mean production multiplicities found for all decay modes were $\langle K_S\rangle = 1.02 \pm 0.02 \pm 0.09$

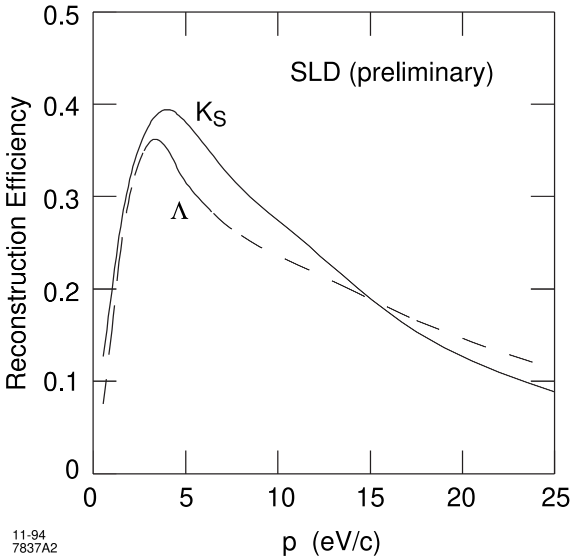

Fig. 2. Detector reconstruction efficiency.

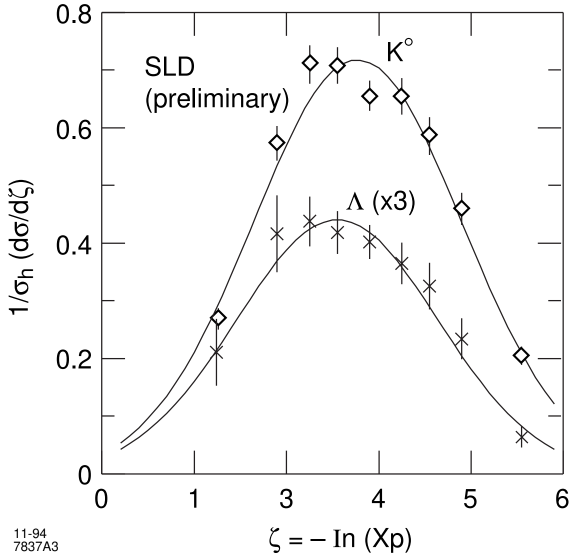

Fig. 3. Differential cross sections. Sample gaussian fits are shown as solid lines.

and $\langle\Lambda\rangle+\langle\overline{\Lambda}\rangle = 0.38\pm0.01\pm0.04$, which are in good agreement with previous measurements.[3] The leading source of systematic error was the uncertainty in reconstruction efficiency. The ratio $N_\Lambda/N_{\overline{\Lambda}}$ was found to be 0.94 ± 0.07 (stat. only).

3. MLLA Comparisons

Modified leading log approximation (MLLA) QCD calculations[4] have predicted a depletion in particle yield at low momentum due to destructive interference of coherently emitted soft gluons. This behavior is expected to be observed in the final state hadrons when the hadronization process is viewed in the context of local parton-hadron duality (LPHD), and has been detected in both neutral and charged particle production.[5]

The analysis described above was repeated in bins of the variable $\zeta = -\ln x_p$, where $x_p = p/E_{beam}$. Figure 3 shows the single particle inclusive cross sections for $\Lambda(+\overline{\Lambda})$ and $K^0(+\overline{K^0})$. MLLA calculations predict that the shape of this distribution will approximate a gaussian, and that the peak position (ζ^*) will increase with cm energy $\sqrt{s}$ and decrease as the mass of the produced particle increases. Results of $\zeta^*_{K^0} = 2.65 \pm 0.24$ and $\zeta^*_{\Lambda} = 2.43 \pm 0.24$ were found, where the errors shown are a sum in quadrature of the statistical uncertainty of the individuals fits and the rms uncertainty of the peak position due to the variations on the gaussian fit ranges. This shows general agreement with MLLA predictions. When comparing the results with measurements at lower energies,[5] the predicted $\sqrt{s}$ behavior is also observed.

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