Lambda $^0$

Polarization

by Vincenzo Lia
LAMBDA POLARIZATIONS
FROM POLARIZED ZS

SLD COLLAB. MEETING
KIRKWOOD 9/14/98

VINCENZO LIA
MASS. INST. OF TECH

OUTLINE

- MOTIVATIONS
- TECHNIQUE
- CURRENT STATUS
- SUMMARY
• TEST FRAGMENTATION THROUGH SPIN PROPAGATION

• SEARCH FOR CLUES TO CONFINEMENT ON $\gamma^*$ PEAK SM. PREDICTS

$$P_{ij} = \frac{2V_{ij}Q_{ij}}{V_{ij}^2 + Q_{ij}^2}$$

\[ \gamma \rightarrow 0.90 \text{ for } q\bar{q} \]

\[ \gamma \rightarrow 0.60 \text{ for } u, c \]

\[ \Lambda \text{ CAN BE USEFUL BECAUSE} \]

• LIKELY TO HAVE SIMPLE SPIN STRUCTURE

$$\text{(u, d, s)} \ \left[ (u, d) = \pi s = 0 \right] \oplus \ s = 1 \ s' = \frac{1}{2} \]$$

• THERE ARE LOTS OF THEM AROUND

• THEY DECAY WEAKLY

384
As can reveal polarization of fragmenting quarks, e.g.,

\[
\frac{dN}{d(\cos \theta^*)} \sim 1 + \alpha P_L \cos \theta^* \quad (\alpha = 0.642)
\]

Here \( P_L \) = longitudinal polarization.
SOME THINGS ONE CAN DO:

* ESTABLISH CONNECTION λ IS PRIMORDIAL
  BY SELECTING HIGH MOMENTUM λ (≈ 300)
  \[ \Rightarrow p_T^s \propto p_T^\lambda \Rightarrow \] TEST FRAGMENT
  WITHIN SM AND CONSTITUENT QUARK MODEL
  Gustafsson and Hakkinen (1993)

* MEASURE TRANSVERSE POLARIZATION OF λ
  IF ≠ 0 THEN OUTCOME IS SENSITIVE
  TO HADRONIZATION (NO \( p_T^q \) IS
  EXPECTED FROM PRIMARY QUARKS)

* LU (1995) : POSSIBLE CONNECTION
  WITH TRANSVERSE POLARIZATION
  IN λ HADROPRODUCTION.
**LEP RESULTS**

* Longitudinal Polarization

\[ P_L^\uparrow \text{ Predicted } \chi = -0.30 \text{ (for } \tau > 0.3) \]

\[ P_L^\uparrow \text{ Measured } \]

\[ -0.32 \pm 0.04 \quad \text{ALEPH} \]

\[ -0.329 \pm 0.055 \pm 0.052 \quad \text{OPAL} \]

* Transverse Polarization

\[ \hat{Q} = \hat{p}_{H_{2z}} \times \hat{P}_L^\uparrow \]

\[ \frac{dN}{d(\cos \varphi^*)} \sim 1 + \alpha \hat{P}_L^\uparrow \cos \varphi^* \]

\[ (\varphi_p = \hat{q} \cdot \hat{P}_L^\uparrow) \]

\[ P_T^\uparrow = \]

\[ \begin{cases} 
0.019 \pm 0.004 & , \quad P_T > 0.6 \text{ GeV} \quad \text{ALEPH} \\
0.041 \pm 0.01 \pm 0.004 & , \quad P_T > 0.6 \text{ GeV} \quad \text{OPAL}
\end{cases} \]
WHAT SLD CAN DO

* LONGITUDINAL POLARIZATION

With 1/8 of LEP data SLD cannot compete directly on precision measurement but can still give important contrib.

C8.

- CR1D: Reduce systematics, analyze very pure a sample

- FLAVOR TAGGING:
  1. Reject a from 'Wrong' flavor
  2. (With more statistics) can measure polarization of τc, τb

- POLARIZED e-
  3. Electroweak checks
  4. Cosθ dependence
POLARIZATION MEASUREMENTS CORRESPOND TO POLARIZED FRAGMENTATION FUNCTIONS

\[ \Delta D_q^\wedge(q^2) = D_{q(+)i}^\wedge(q^2) - D_{q(+)i}^\wedge(q^2) \]

\[ D_{q(+)i}^\wedge(q^2) = \text{PROBABILITY OF } + \text{ QUARK TO FRAGMENT INTO } + \wedge \]

* SLD HAS EXCELLENT CAPABILITIES FOR STUDYING \( \Delta D_q^\wedge \)

* NLO CALCULATIONS EXIST FOR POLARIZED \( \wedge \) PRODUCTION AT 2\(^\circ\) PEAK

Burkardt & Jaffe (1993)

Ravindran (1996)

Stratmann & Vogelsang (1996)

de Florian, Stratmann & Vogelsang (1997)
* Transverse Polarization

SLD can measure $P_t^\uparrow$ for low momentum $\wedge$. Use $q, \bar{q}$ tag to test for the first time semiclassical Lund string model. Andersson Gustavson and Ingelman (1979) knowledge of $q, \bar{q}$ direction is crucial.

\[ \begin{array}{c}
q \\
\end{array} \]

\[ \begin{array}{c}
\langle u d \rangle \\
\end{array} \]

Assume 1. Local conservation of transverse momentum and 2. Color field has no transverse degrees of freedom $\Rightarrow \frac{1}{s}$ needs to compensate for angular momentum $\Rightarrow \wedge$ is polarized.
SLD can separate $s, \bar{s}$ jets because of $\bar{e}$ polarization.

Can measure $\Delta D_s^{\chi^-(H_{\mu})}$ consistently.

Now ...  

\[ \int_0^{k_1} d\Delta D_s^{\chi^-(H_{\mu})}(z, q^2) dk_1, \quad k_1 \text{ fixed} \]

Evolution independent?

Stan Brodsky seems to think so ...  

It is an exciting perspective!
V selection

* Follow Ken Baird

* For each charged track
  - $p_t > 150$ MeV
  - $> 40$ hits in CDC
  - $|\cos \theta| < 0.8$

* $V_0$ candidate formed only if POCA or the 2 charged tracks < 15 mm

* V selection

<table>
<thead>
<tr>
<th>KEN</th>
<th>VINCENZO</th>
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<tbody>
<tr>
<td>$x^2_b &lt; 5.4$</td>
<td>$x^2_b &lt; 9$</td>
</tr>
<tr>
<td>$\cos \theta_b &gt; 0.999$</td>
<td>$\cos \theta_b &gt; 0.999$</td>
</tr>
<tr>
<td>$l/n_c &gt; 5$</td>
<td>$l/n_c &gt; 10$</td>
</tr>
<tr>
<td>$\nu TP &gt; 0.1$ cm</td>
<td>$\nu TP &gt; 1$ cm</td>
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<tr>
<td>$VTVET0 = 0$</td>
<td>$VTVET0 = 0$</td>
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180,000 HAD EVENTS FROM MONTECARLO
SUMMER 94
WINTER 95

IN_VARIABLE MASS OF CANDIDATE VES
180,000 EVENTS FROM MONTECARLO
SUMMER 94
WINTER 95

Pt - invariant mass

with \( V \) selection cuts +

\( 1.105 < m_{\Lambda} < 1.113 \)
V. SELECTION CUTS IN
NARROW SIGNAL WINDOW

Entries 7578
Mean -0.1095

TRUE Λ

BACKGROUND

Entries 3720
Mean -0.7943E-01

(δ → e⁺e⁻)

k° → u⁺u⁻

FAKES
180,000 had events from Monte Carlo
Summer 84
Winter 85

120 c
L
100
80
60
40
20
Meon -0.1037
100
80
60
40
20
0 1
true Λ

Entries 7528
Mean -0.1037
Kinematics
Drop

Entries 3089
Mean 0.1051

Fake

κ → τ+τ-

396
180,000 HAD EVENTS FROM MONTECARLO
SUMMER 94
WINTER 95

SIDEBAND ESTIMATE OF BACKGROUND

REGION 1

Entries 1706
Mean 0.1072

BACKGR. IN TRUE A WINDOW

Entries 3089
Mean 0.1051

REGION 2

Entries 1394
Mean 0.9374E-01

397
SUMMER '84
WINTER '85
180,000 HAD. EVENTS FROM MONTECARLO

GRID TEST OF PROTON ID. (V.S. PION ID.
FOR HIGHER MOMENTUM PARTICLE

TRUE A

HIGHER MOMENTUM PARTICLE IS ASSIGNED PROTON HYPOTHESIS

BECAUSE OF GRID INTER-
-SECTION EFFICIENCY ≈ 40%
SUMMER 94
WINTER 95
180,000 HAD EVENTS FROM MONTECARLO

IF $L_p - L_\pi > 0$

<table>
<thead>
<tr>
<th>Entries</th>
<th>5145</th>
</tr>
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<tbody>
<tr>
<td>Mean</td>
<td>1.110</td>
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</table>

$\text{LMass} \equiv M_{p\alpha}$
SUMMER 94
WINTER 95
180,000 HAD EVENTS FROM MONTECARLO

\[ \text{if } L_p - L_\pi > 0 \]

**TRUE \wedge**

- **Entries**: 3065
- **Mean**: -0.1070

**BACKGROUND**

- **Entries**: 238
- **Mean**: -0.4346E-02

\[ \text{KADNS} \]
CONCLUSIONS

- \( \Lambda \) POLARIZATION STUDIES AT SLD ARE FUN AND INTERESTING

- WITH 0.55 M \( \Lambda \)S WE CAN
  - IMPROVE \( p_L^\Lambda \) UNDERSTANDING AT HIGH \( \xi \)
  - MAKE 1ST CONSISTENT DETERMINATION OF \( p_T^\Lambda \) AT LOW \( \xi \) AND TEST LUND MODEL
  - MEASURE \( \Delta \Delta q(-) \) ALONG VARIOUS DIRECTIONS
  - START ATTACKING DETERMINATION OF NLO LONGITUD. POLARIZED FRAG. FUNC.

- WITH 1-2 M \( \Lambda \)S WE WILL BE ABLE TO
  - COMPLETE \( \Lambda \) \( s \) STUDIES
  - STUDY \( \Lambda_c, \Lambda_b \) AND ASSOCIATED POLARIZED FRAGMENTATION FUNCTIONS