# HERMES measurements

# of $\Lambda$ polarization

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on behalf of the  hermes  collaboration

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# Main topics of interest:

- Spin structure of $\Lambda$ hyperon

- Spin-transfer from <u>longitudinally</u> polarized quark q to $\Lambda$, spin-dependent fragmentation function $G_{1,q}^{\Lambda}(z)$ (this talk, hep-ex/0607004)

- Transverse $\Lambda$ polarization in electroproduction (final HERMES result coming soon)

- Spin-transfer from <u>transversely</u> polarized quark to $\Lambda$, measurement of transversity distribution $\delta q^p(x)$ in proton ?? (not very realistic)
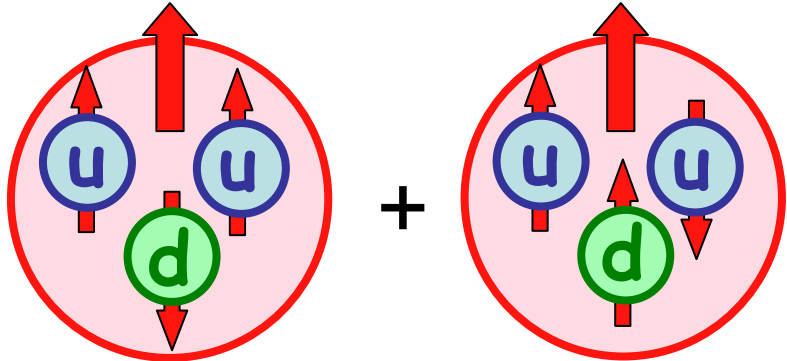
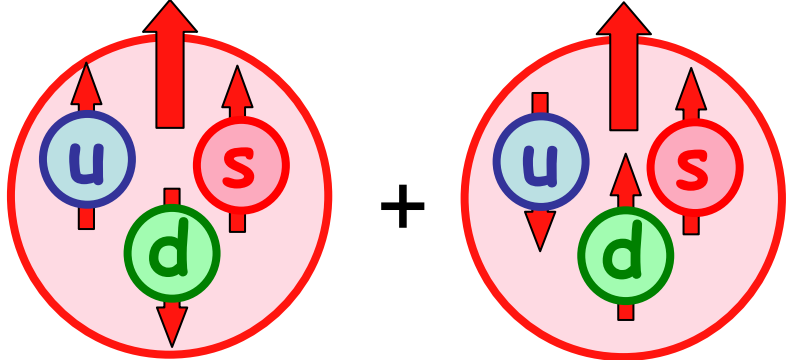# Spin structure of $\Lambda$ hyperon

**Constituent-Quark-Model:**

**Proton:**      $\Delta u + \Delta d = 1$, $\Delta s = 0$



**$\Lambda$:**      $\Delta u + \Delta d = 0$, $\Delta s = 1$



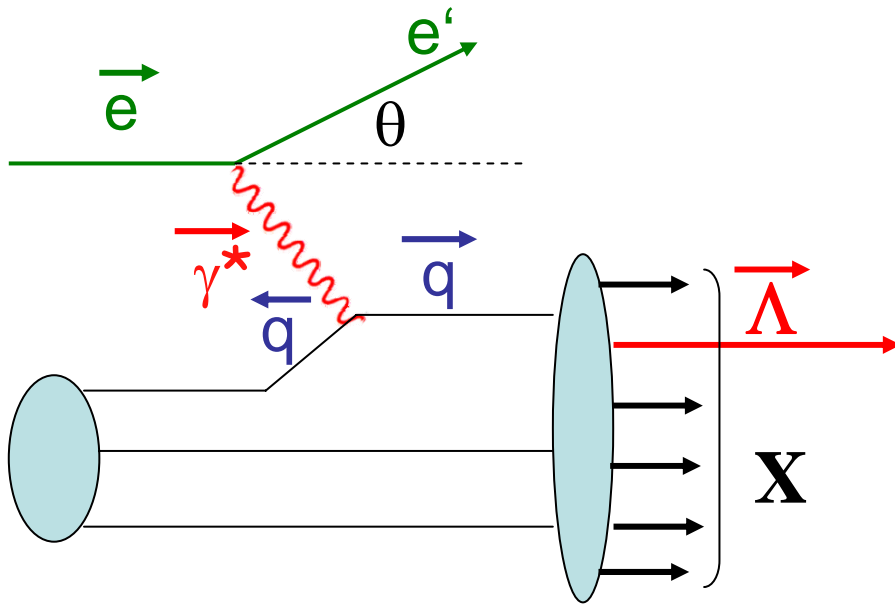**Semi-inclusive DIS + SU(3) flavour rotation** (a la Burkardt, Jaffe):

**Proton:** $\Delta u^p = 0.60 \pm 0.06$, $\Delta d^p = -0.23 \pm 0.06$, $\Delta s^p = 0.03 \pm 0.03$

**$\Lambda$:** $\Delta u^\Lambda = \Delta d^\Lambda = -0.09 \pm 0.06$, $\Delta s^\Lambda = 0.47 \pm 0.07$

# Longitudinal spin-transfer $D_{LL'}^{\Lambda}(z)$



$$Q^2 = -(k-k')^2 = 2EE'(1-\cos\theta)$$

$$\nu = E - E', \quad z = E_\Lambda / \nu$$

$$x = Q^2/(2M\nu)$$

$\Lambda$-Pol.: $\quad P_{L'}^{\Lambda} = P_b \, D(y) \, D_{LL'}^{\Lambda}$

$$D_{LL'}^{\Lambda}(x,z,Q^2) = \frac{\sum_q e_q^2 \, q(x,Q^2) \, G_{1,q}^{\Lambda}(z,Q^2)}{\sum_q e_q^2 \, q(x,Q^2) \, D_{1,q}^{\Lambda}(z,Q^2)}$$
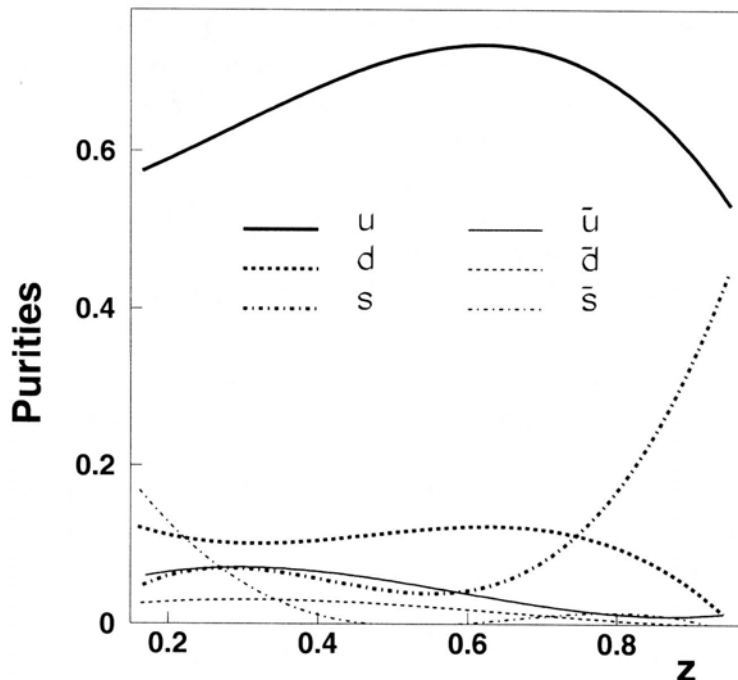
L: primary quantization axis ($\gamma^*$ direction), L': secondary quantization axis

$G_{1,q}^{\Lambda}(z,Q^2)$: spin-dependent ($q \rightarrow \Lambda$) fragmentation function

# Longitudinal spin-transfer $D_{LL'}^{\Lambda}(z)$

$$D_{LL'}^{\Lambda}(z)_{Q2=\langle Q2 \rangle} \cong \sum_q \underbrace{\frac{G_{1,q}^{\Lambda}(z)}{D_{1,q}^{\Lambda}(z)}}_{\text{partial spin-transfer}} \underbrace{\int \frac{e_q^2\, q(x)\, D_{1,q}^{\Lambda}(z)}{\sum_{q'} e_{q'}^2\, q'(x)\, D_{1,q'}^{\Lambda}(z)}\, dx}_{\text{purities}}$$



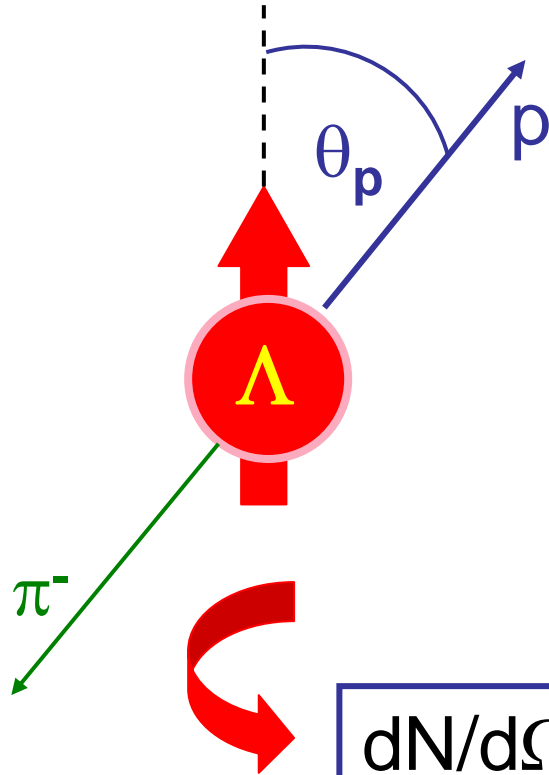JETSET MC for proton target ($x_F>0$) and HERMES kinematics:

🟢 $\Lambda$ production from current fragmentation dominated by up-quarks

🟢 Substantial s-quark contribution only at high z

# Measurement of Λ polarization:

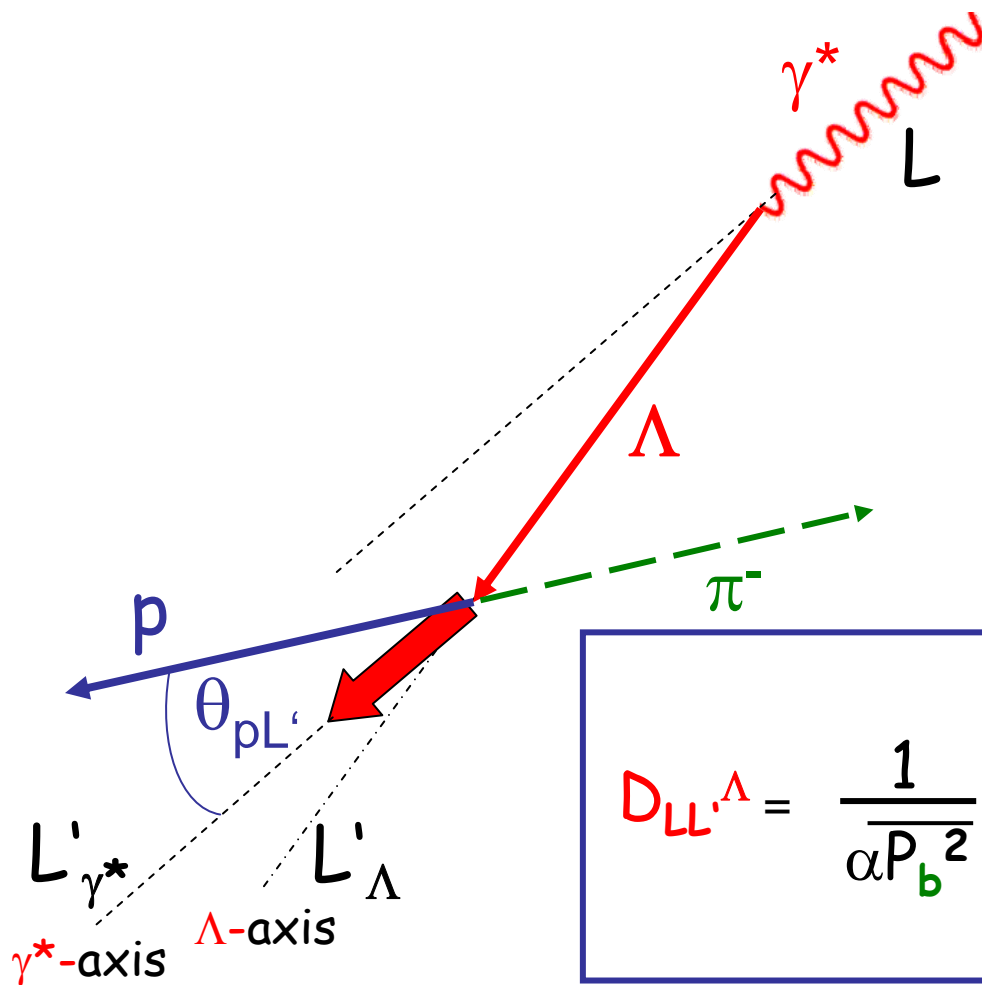Parity violating weak decay $\boxed{\Lambda \rightarrow p\ \pi^-}$ :

**proton** prefers to be emitted along Λ **spin** direction
(in Λ rest frame)

$$dN/d\Omega_p \propto 1 + \alpha\ \vec{P}^\Lambda \cdot \hat{k}_p$$

$$= 1 + \alpha\ P^\Lambda \cos\theta_p$$

$$\alpha = 0.642 \pm 0.013$$

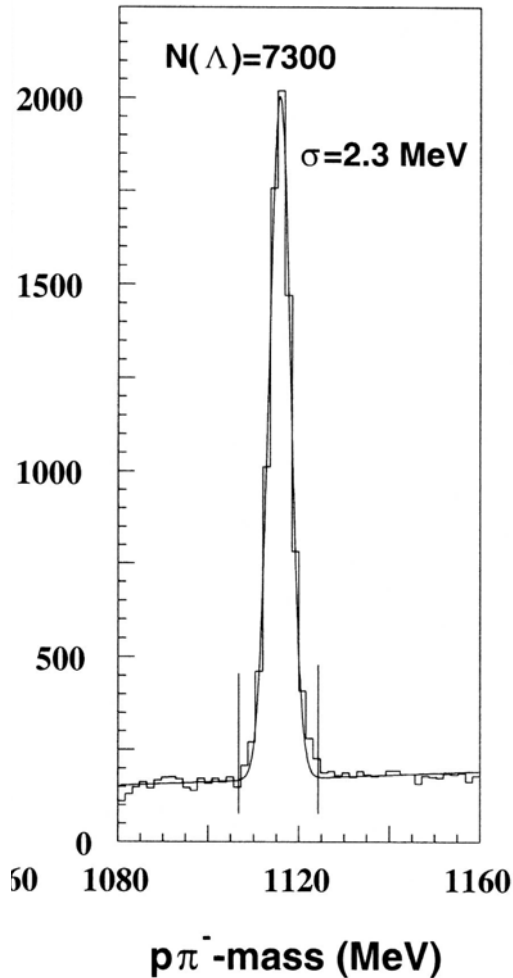$$dN/d\Omega_p \propto 1 + \alpha\ P_b D(y)\ D_{LL'}^\Lambda \cos\theta_{pL'}$$

# Determination of $D_{LL'}^{\Lambda}$

$\gamma^*$

L

$\Lambda$

$\pi^-$

p

$\theta_{pL'}$

$L'_{\gamma^*}$   $L'_{\Lambda}$

$\gamma^*$-axis   $\Lambda$-axis

$$D_{LL'}^{\Lambda} = \frac{1}{\alpha \overline{P_b^2}} \cdot \frac{\sum_{i=1}^{N_\Lambda} P_{b,i} \, D(y_i) \cos \theta_{pL'}^i}{\sum_{i=1}^{N_\Lambda} D^2(y_i) \cos^2 \theta_{pL'}^i}$$

# The Data



N($\Lambda$)=7300

$\sigma$=2.3 MeV

$p\pi^-$-mass (MeV)

🟢 Requirements:

- 🟥 $Q^2 > 0.8$ GeV$^2$, W > 2 GeV, y < 0.85

  (In total 30.3 x 10$^6$ inclusive DIS events)

- 🟥 1998-2000 data: leading proton identified by RICH

- 🟥 1995-1997 data: Leading hadron is not a pion (from threshold Cherenkov counter)

  + $z_2 - z_1 > 10$ cm
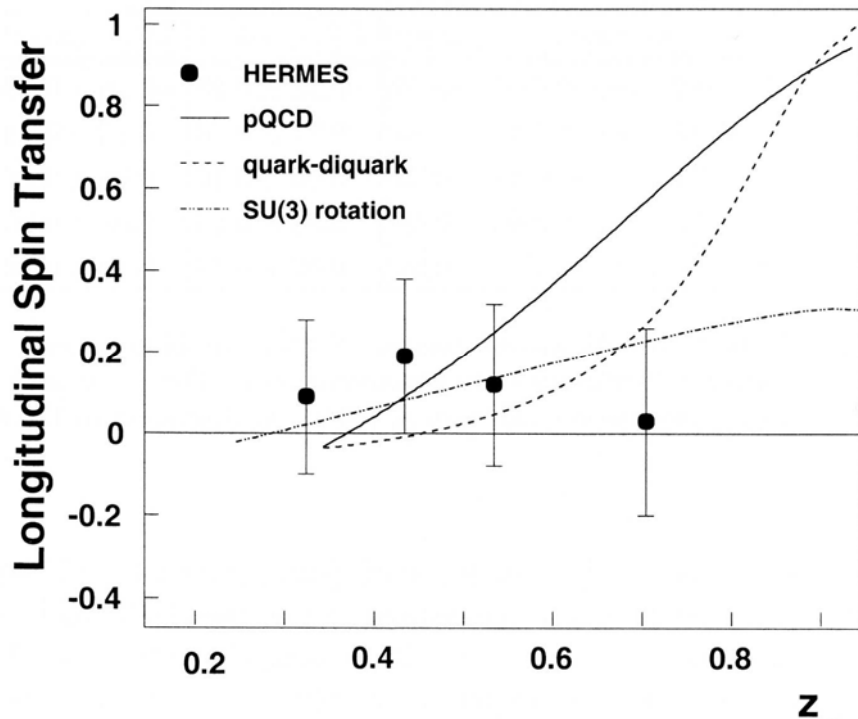
  $\Lambda$ decay vertex          interaction vertex

- 🟥 $x_F > 0$

🟢 Average kinematics:

- 🟥 <Q2> = 2.4 GeV$^2$, <x>=0.088, <z> = 0.45, <x$_F$> = 0.30

# Results for $D_{LL'}^\Lambda - 1$
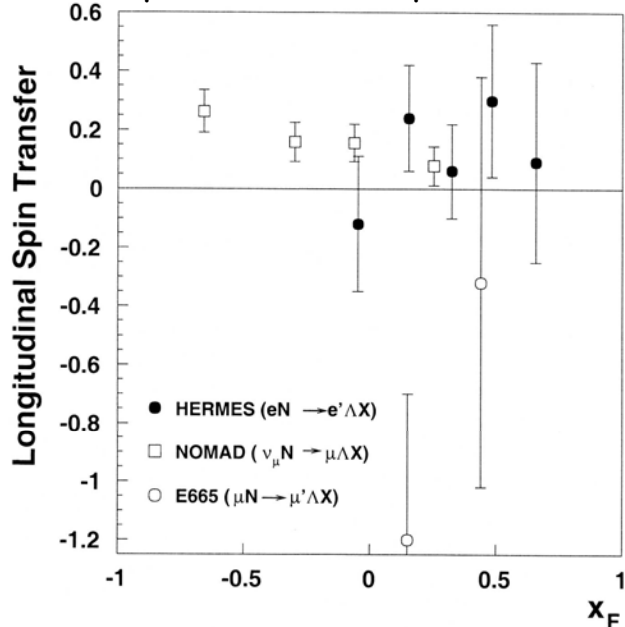
A. Airapetian et al., hep-ex/0607004



- Helicity balance: $\overline{P_b} \equiv \frac{1}{L}\int P_b\, dL = 0$ minimizes acceptance effects

- Background contribution to $D_{LL'}^\Lambda$: from events outside the $\pm 3.3\sigma$ mass window above and below peak

- False contributions to $D_{LL'}^\Lambda$: from $K^0_s$ events

- No significant dependence of result on choice of L' axis

$$D_{LL'}^\Lambda(\Lambda\text{-axis}) = 0.11 \pm 0.10\,(\text{stat}) \pm 0.03\,(\text{syst})$$

- Slightly positive, but compatible with zero within 1 $\sigma$

# Results for $D_{LL'}^{\Lambda}$ - 2

A. Airapetian et al., hep-ex/0607004



NOMAD: P. Astier et al., Nucl. Phys. B 588 (2000) 3
E665: M.R. Adams et al., Eur. Phys. J. C 17 (2000) 263

- Good agreement with NOMAD data for $x_F < 0$

- Interpretation difficult, since from MC studies (see N. Makins, contr. to CIPANP 2003):
  - Significant contribution from heavier hyperon decays (40%-60%)
  - Very few $\Lambda$'s (about 10%) contain struck quark
  - Many $\Lambda$'s contain target remnant, even when $x_F > 0$
  - Data: $N(\bar{\Lambda})/N(\Lambda) \cong 0.25$ for $x_F > 0$ !!

- Hope to access transversity $\delta q$ by transverse spin transfer from transversely polarized target not very realistic