

# Longitudinal target polarization dependence of $\bar{\Lambda}$ polarization and polarized strangeness PDF

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## ● $\bar{\Lambda}$ polarization

- Unpolarized target

  - Strangeness distribution in nucleon

- Polarized target

  - Polarized strangeness in polarized nucleon

## ● Conclusions

# Simple model: LO, independent fragmentation for current fragmentation region

$$P_T = 0 \quad \longrightarrow \quad P^{\bar{\Lambda}} = P_{P_B,0}^{\bar{\Lambda}} = D(y)P_B \frac{\sum_q e_q^2 q(x) \Delta D_q^{\bar{\Lambda}}(z)}{\sum_q e_q^2 q(x) D_q^{\bar{\Lambda}}(z)}$$

*SU(6)* Model for spin transfer in fragmentation:

only  $\Delta D_{\bar{s}}^{\bar{\Lambda}}(z) \neq 0$ ,

$$\Delta D_{\bar{s}}^{\bar{\Lambda}}(z) = D_{\bar{s}}^{\bar{\Lambda}}(z)$$

$$S_x^{\bar{\Lambda}} = \frac{P^{\bar{\Lambda}}}{D(y)P_B} \approx \frac{\frac{1}{9} \bar{s}(x) D_{\bar{s}}^{\bar{\Lambda}}(z)}{\sum_q e_q^2 q(x) D_q^{\bar{\Lambda}}(z)} := F_{\bar{s}}^{\bar{\Lambda}}(x, z)$$

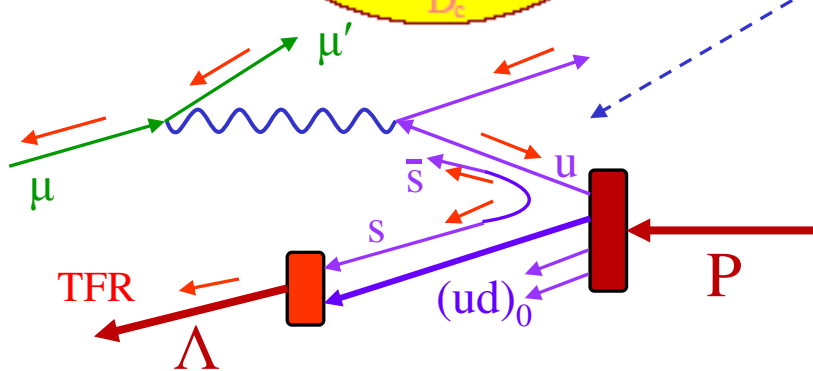
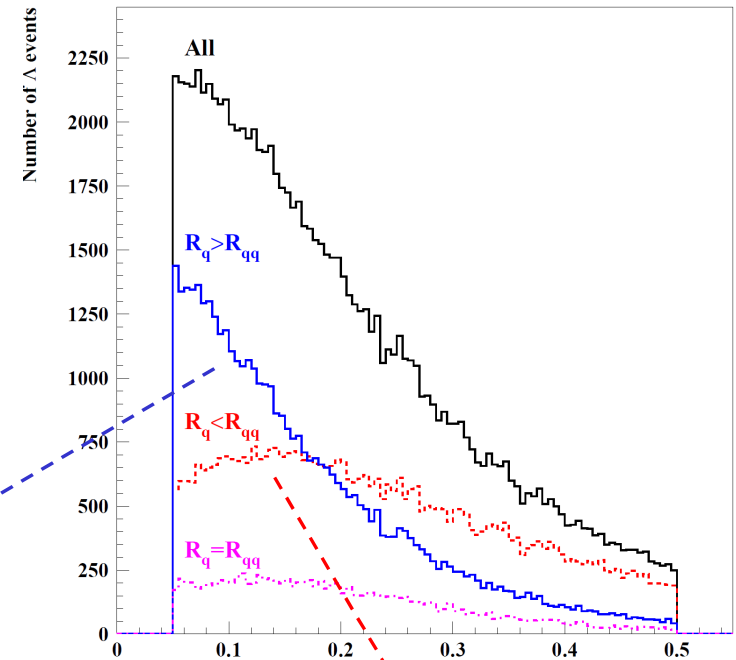
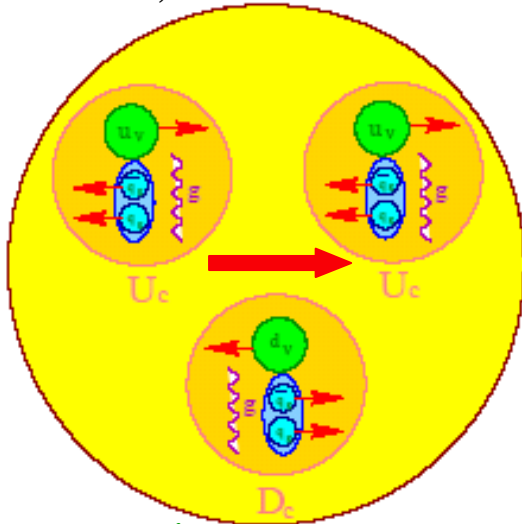
Fraction of events with  
hard scattering off s-bar  
(s-bar purity)

# Intrinsic Strangeness Model (ISM) for $\Lambda$ polarization

J.Ellis, M.Karliner, D.Kharzeev, M.G.Sapozhnikov, 1995

J.Ellis, D.Kharzeev, A.K., 1996

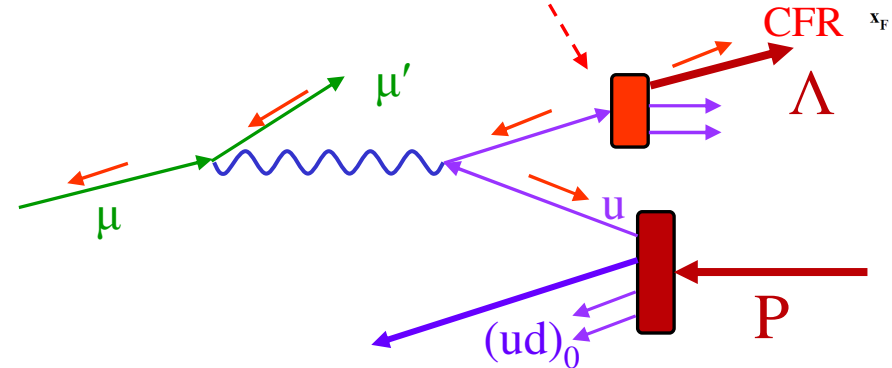
J. Ellis, A. K. & D. Naumov, 2002



$R_{qq} < R_q$ : spin transfer from intrinsic strangeness and polarized diquark

via heavier hyperons

Madrid, April 27, 2009



$R_q < R_{qq}$ : spin transfer only from final quark

# Spin transfer in SIDIS

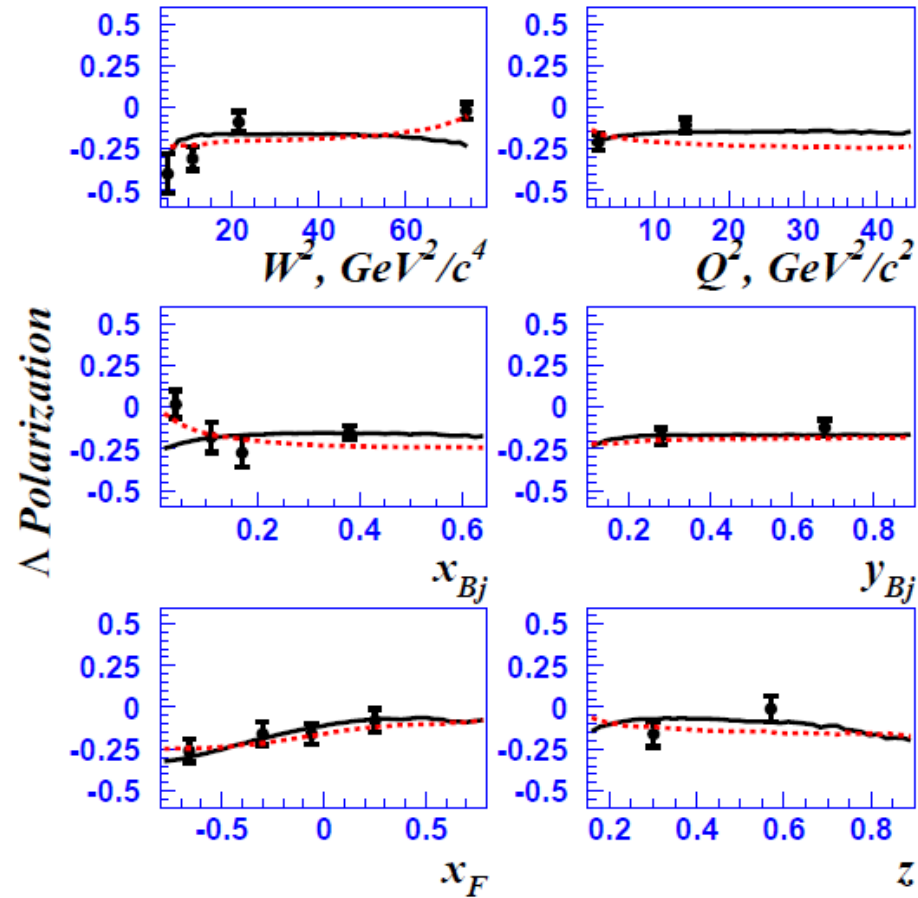
Spin transfer  
from qq side

$$\begin{aligned}
 P_{\Lambda}^{\nu d}(\text{prompt}; N) &= P_{\Lambda}^{\bar{\nu} u}(\text{prompt}; N) = P_{\Lambda}^{l u}(\text{prompt}; N) \\
 &= P_{\Lambda}^{l d}(\text{prompt}; N) = C_{sq} \cdot P_q, \\
 P_{\Lambda}^{\nu d}(\Sigma^0; n) &= P_{\Lambda}^{\bar{\nu} u}(\Sigma^0; p) = P_{\Lambda}^{l u}(\Sigma^0; p) = P_{\Lambda}^{l d}(\Sigma^0; n) \\
 &= \frac{1}{3} \cdot \frac{2 + C_{sq}}{3 + 2C_{sq}} \cdot P_q, \\
 P_{\Lambda}^{\nu d}(\Sigma^{*0}; n) &= P_{\Lambda}^{\nu d}(\Sigma^{*+}; p) = P_{\Lambda}^{\bar{\nu} u}(\Sigma^{*0}; p) \\
 &= P_{\Lambda}^{\bar{\nu} u}(\Sigma^{*+}; n) = P_{\Lambda}^{l u}(\Sigma^{*0}; p) = P_{\Lambda}^{l d}(\Sigma^{*0}; n) \\
 &= P_{\Lambda}^{l d}(\Sigma^{*+}; p) = P_{\Lambda}^{l u}(\Sigma^{*-}; n) = -\frac{5}{3} \cdot \frac{1 - C_{sq}}{3 - C_{sq}} \cdot P_q.
 \end{aligned}$$

Spin transfer  
from q side

$\Lambda^0$ 's parent	$C_u^{\Lambda^0}$		$C_d^{\Lambda^0}$		$C_s^{\Lambda^0}$	
	$SU(6)$	BJ	$SU(6)$	BJ	$SU(6)$	BJ
quark	0	-0.18	0	-0.18	1	0.63
$\Sigma^0$	-2/9	-0.12	-2/9	-0.12	1/9	0.15
$\Xi^0$	-0.15	0.07	0	0.05	0.6	-0.37
$\Xi^-$	0	0.05	-0.15	0.07	0.6	-0.37
$\Sigma^*$	5/9	-	5/9	-	5/9	-

# NOMAD data

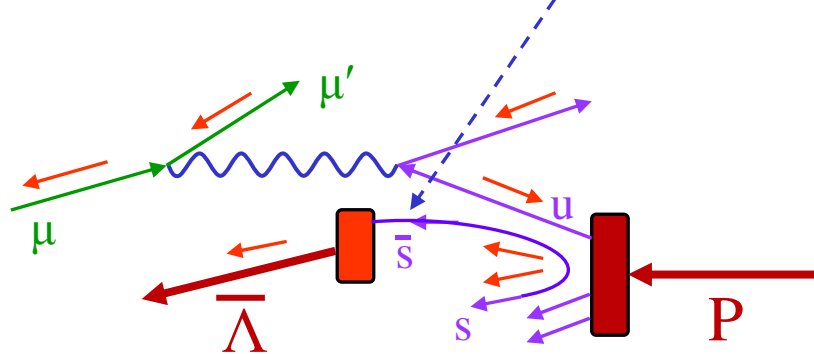
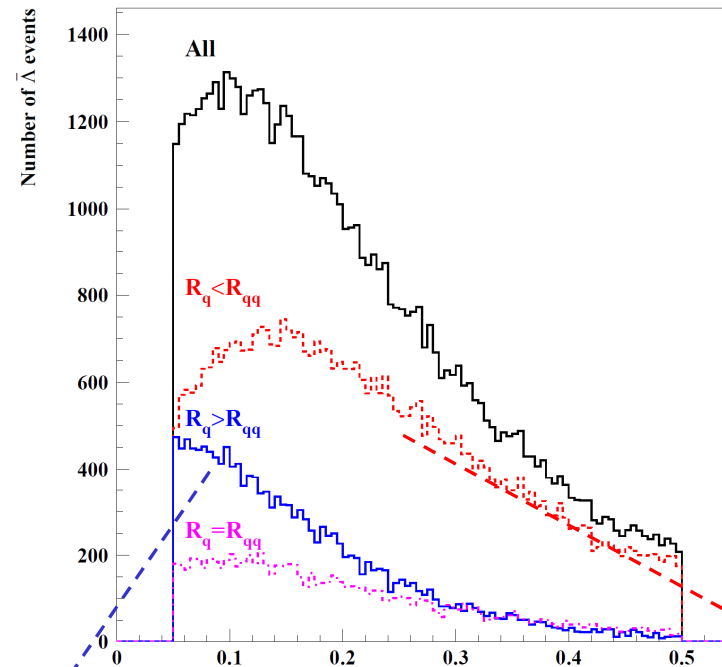


Model A:  $C_{sq\text{ val}} = -0.35 \pm 0.05$ ,  $C_{sq\text{ sea}} = -0.95 \pm 0.05$ ,

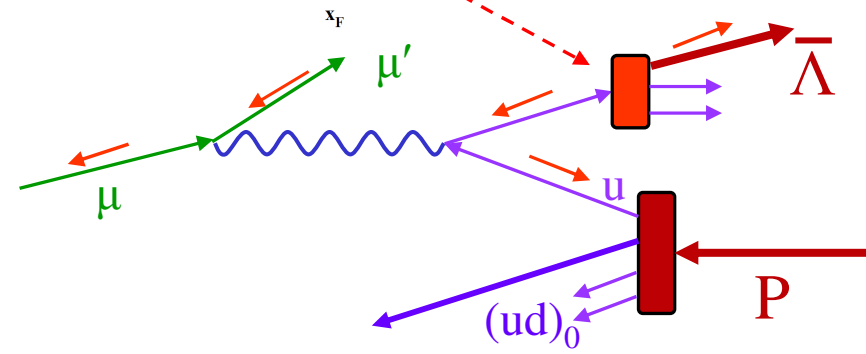
Model B:  $C_{sq\text{ val}} = -0.25 \pm 0.05$ ,  $C_{sq\text{ sea}} = 0.15 \pm 0.05$ .

# $\bar{\Lambda}$ polarization

J.Ellis, A.K., D.Naumov  
and M.Sapozhnikov  
**EPJ.C52:283-294,2007**

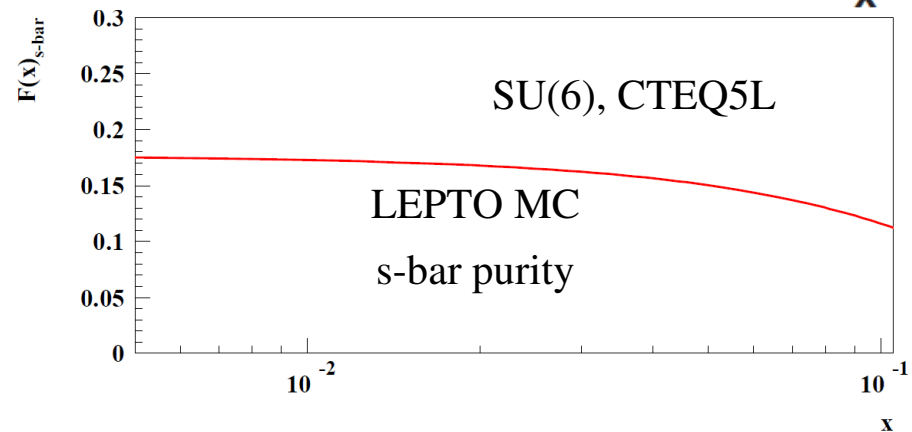
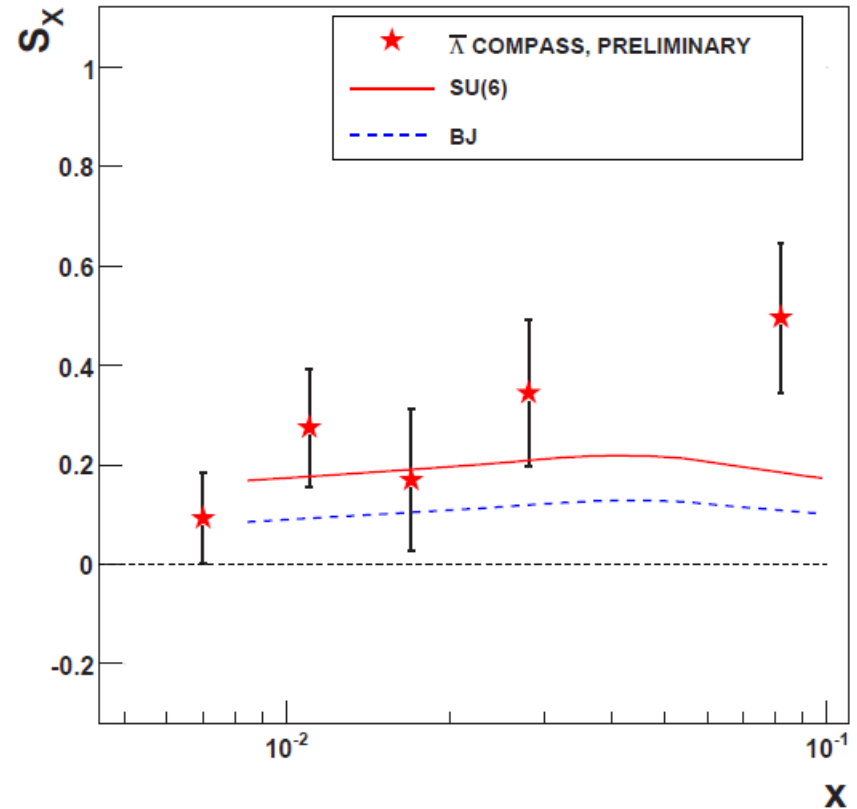
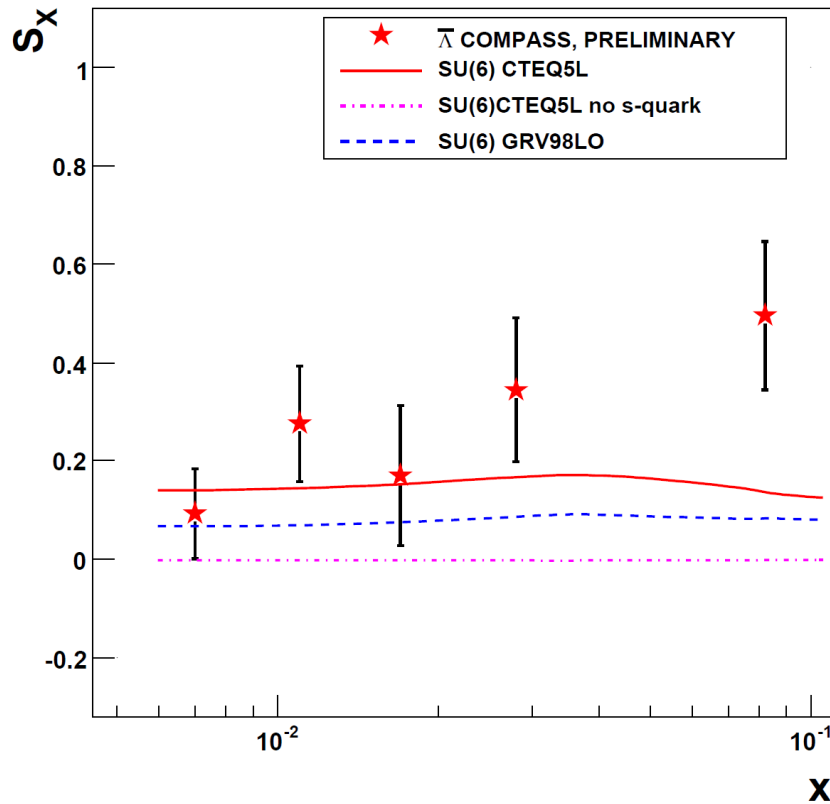


$R_{qq} < R_q$ : spin transfer only  
from intrinsic strangeness



$R_q < R_{qq}$ : spin transfer only  
from final quark

# Unpolarized target



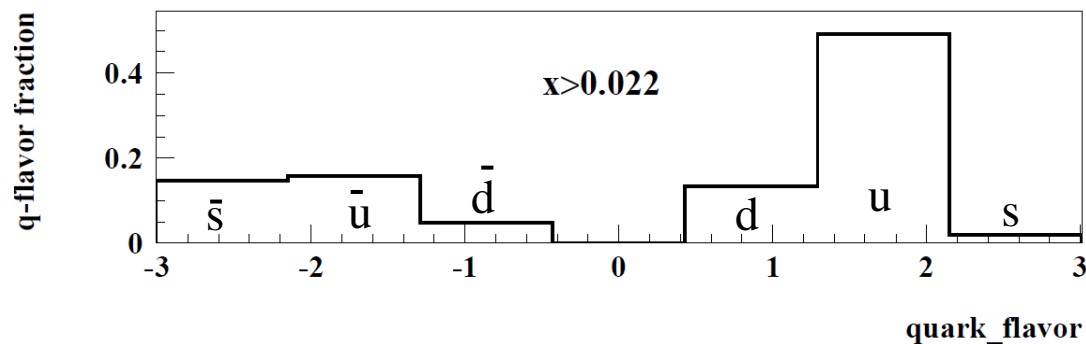
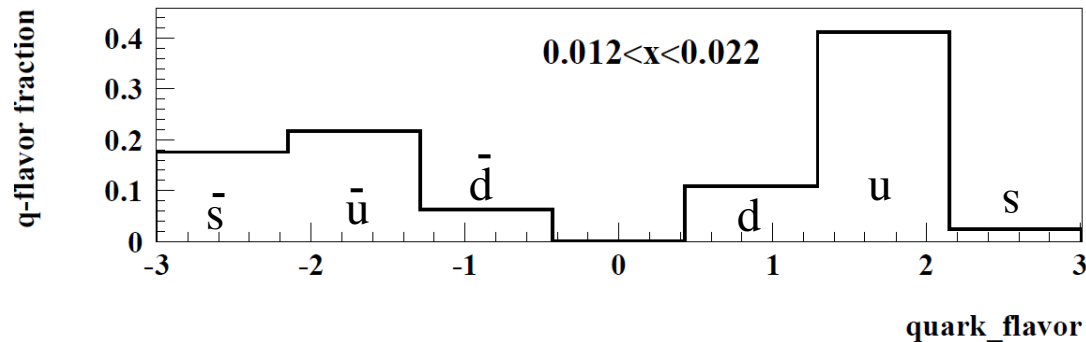
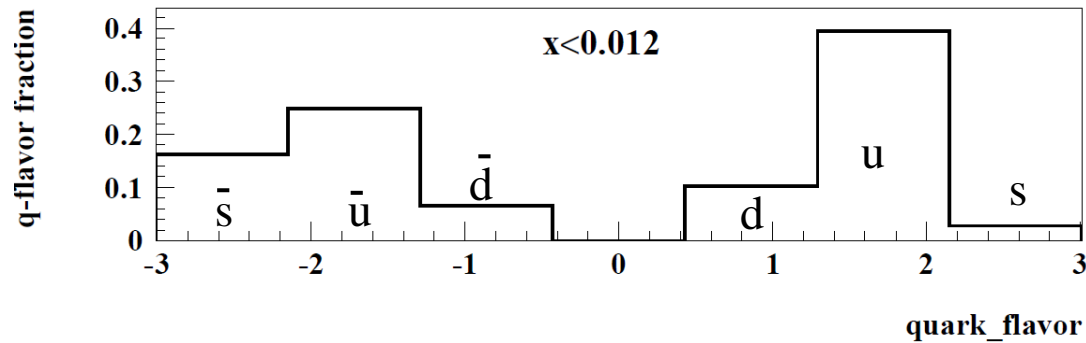
NOMAD tuning used  
 Best description with **SU(6)**  
 model for spin transfer.

$\bar{\Lambda}$  polarization = s(x) filter

Madrid, April 27, 2009

Aram Kotzinian

# Quark type fraction in anti-Lambda production



LEPTO MC  
with CTEQ5L  
and COMPASS cuts

In contrast to K  
production asymmetry,  
here **mainly s-bar**  
contributes to

$$P^{\bar{\Lambda}} \text{ and } \Delta P^{\bar{\Lambda}}$$

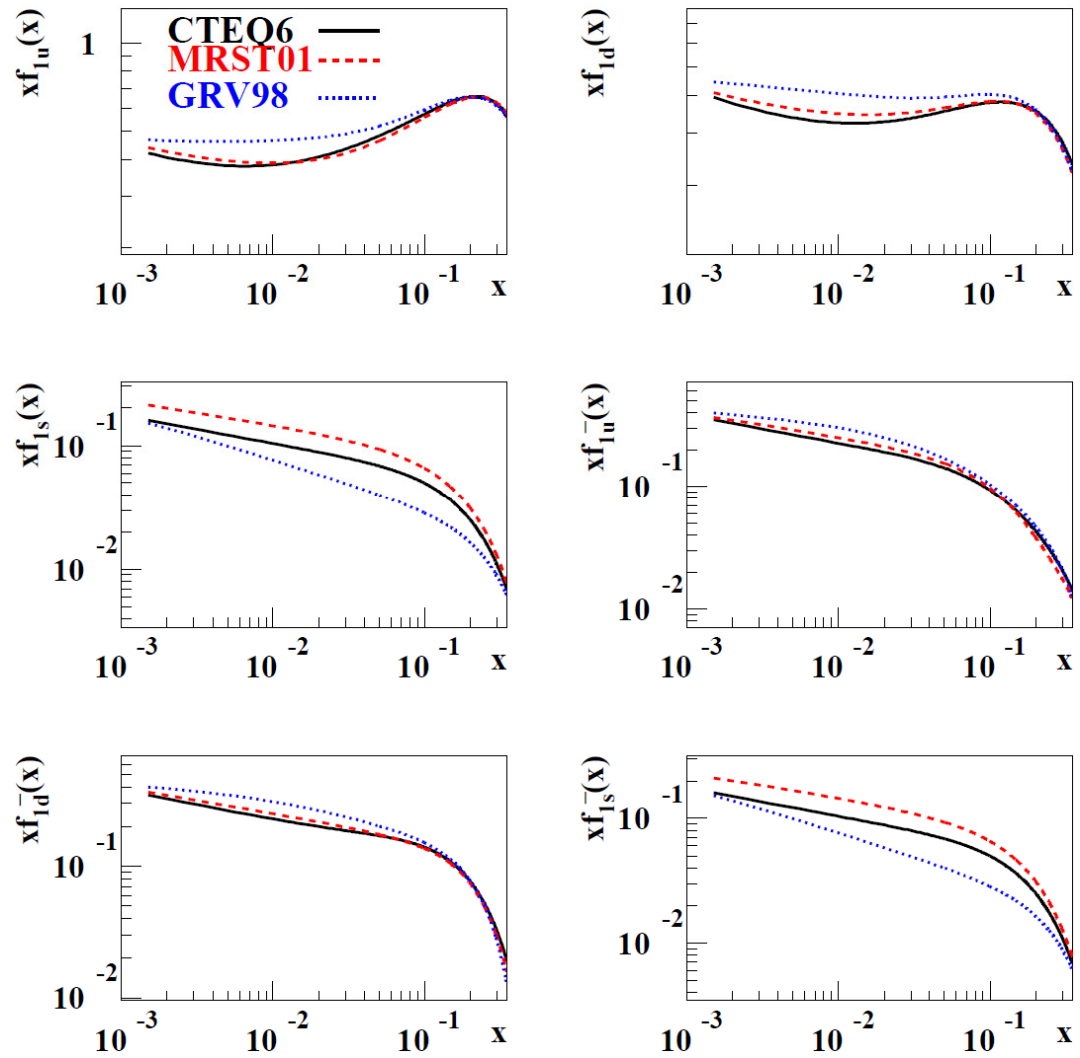
$$F_{\bar{s}}^{\bar{\Lambda}}(x) \approx 0.15 \div 0.2$$

for  $x \leq 0.1$



# PDFs

LO



$$Q^2 = 2.5 \text{ (GeV/c)}^2$$

# Hyperon production x-section and polarization for polarized beam and target

From general considerations for double and triple longitudinal polarization observables:

$$\sigma_{P_B, \pm P_T}^{\bar{\Lambda}} = \sigma^{\bar{\Lambda}} \left( 1 \mp P_B P_T \frac{\Delta\sigma^{\bar{\Lambda}}}{\sigma^{\bar{\Lambda}}} \right)$$

Triple-spin effect  $\rightarrow$

$$P_{P_B, \pm P_T}^{\bar{\Lambda}} = \frac{P_B S_B \pm P_T S_T}{1 \mp P_B P_T \frac{\Delta\sigma^{\bar{\Lambda}}}{\sigma^{\bar{\Lambda}}}}$$

Target polarization sign is written explicitly

Beam polarization contains sign

# Polarization Asymmetry $A_{P^{\bar{\Lambda}}}(x)$

$$P^{\bar{\Lambda}} := \frac{1}{2} \left( P_{P_B, -P_T}^{\bar{\Lambda}} + P_{P_B, P_T}^{\bar{\Lambda}} \right)$$

$$\Delta P^{\bar{\Lambda}} := P_{P_B, -P_T}^{\bar{\Lambda}} - P_{P_B, P_T}^{\bar{\Lambda}}$$

Polarization asymmetry

$$A_{P^{\bar{\Lambda}}}(x) := \frac{\Delta P^{\bar{\Lambda}}(x)}{P^{\bar{\Lambda}}(x)}$$

# Factorized LO QCD parton model

$$P_{P_B, P_T}^{\bar{\Lambda}} = \frac{\sum_q e_q^2 \left[ D(y) P_B - f P_T \frac{\Delta q(x)}{q(x)} \right] q(x) \Delta D_q^{\bar{\Lambda}}(z)}{\sum_q e_q^2 \left[ 1 - D(y) P_B f P_T \frac{\Delta q(x)}{q(x)} \right] q(x) D_q^{\bar{\Lambda}}(z)}$$

$$P_T^{eff} = f P_T \approx \begin{cases} 0.2 \text{ for Deuteron} \\ 0.14 \text{ for Proton} \end{cases}$$

$$\langle D(y) \rangle \approx 0.5 - 0.85, \quad \left| \frac{\Delta q(x)}{q(x)} \right| \leq 0.5$$

$$\left| D(y) P_B f P_T \frac{\Delta q(x)}{q(x)} \right| \leq 0.85 \cdot 0.8 \cdot 0.2 \cdot 0.5 = 0.068$$

We can neglect  
pol.dep. part in denom.

ISM expression is more complicated, but results are almost unchanged

# $A_{P^{\bar{\Lambda}}}(x)$ in LO QCD parton SU(6) model

$$P^{\bar{\Lambda}} \approx \langle D(y) \rangle P_B \frac{\frac{1}{9} \bar{s}(x) D_{\bar{s}}^{\bar{\Lambda}}(z)}{\sum_q e_q^2 q(x) D_q^{\bar{\Lambda}}(z)}, \quad \Delta P^{\bar{\Lambda}} \approx 2fP_T \frac{\Delta \bar{s}(x)}{\bar{s}(x)} \frac{\frac{1}{9} \bar{s}(x) D_{\bar{s}}^{\bar{\Lambda}}(z)}{\sum_q e_q^2 q(x) D_q^{\bar{\Lambda}}(z)}$$

$$\frac{\Delta \bar{s}(x)}{\bar{s}(x)} \approx \frac{\langle D(y) \rangle P_B}{2fP_T} \frac{\Delta P^{\bar{\Lambda}}(x)}{P^{\bar{\Lambda}}(x)} = \frac{\langle D(y) \rangle P_B}{2fP_T} A_{P^{\bar{\Lambda}}}(x)$$

$$\left| \frac{\langle D(y) \rangle P_B}{2fP_T} \right| \approx 1, \text{ for COMPASS Deuteron target}$$

$$A_{P^{\bar{\Lambda}}}(x) = \frac{\Delta P^{\bar{\Lambda}}(x)}{P^{\bar{\Lambda}}(x)} (\text{COMPASS}) \approx \frac{\Delta \bar{s}(x)}{\bar{s}(x)}$$

# ISM calculations using LEPTO

Nomad settings and  $c_{\bar{s}q} = c_{sq}$

Symbolic notations: Lund Model is realization of Fracture Functions.

Spin transfer via heavy hyperons is taken into account.

$$P_{P_B, P_T}^{\bar{\Lambda}}(x, x_F, \dots) = \frac{N_q(x, x_F, \dots) + N_{qq}(x, x_F, \dots)}{N(x, x_F, \dots)}$$

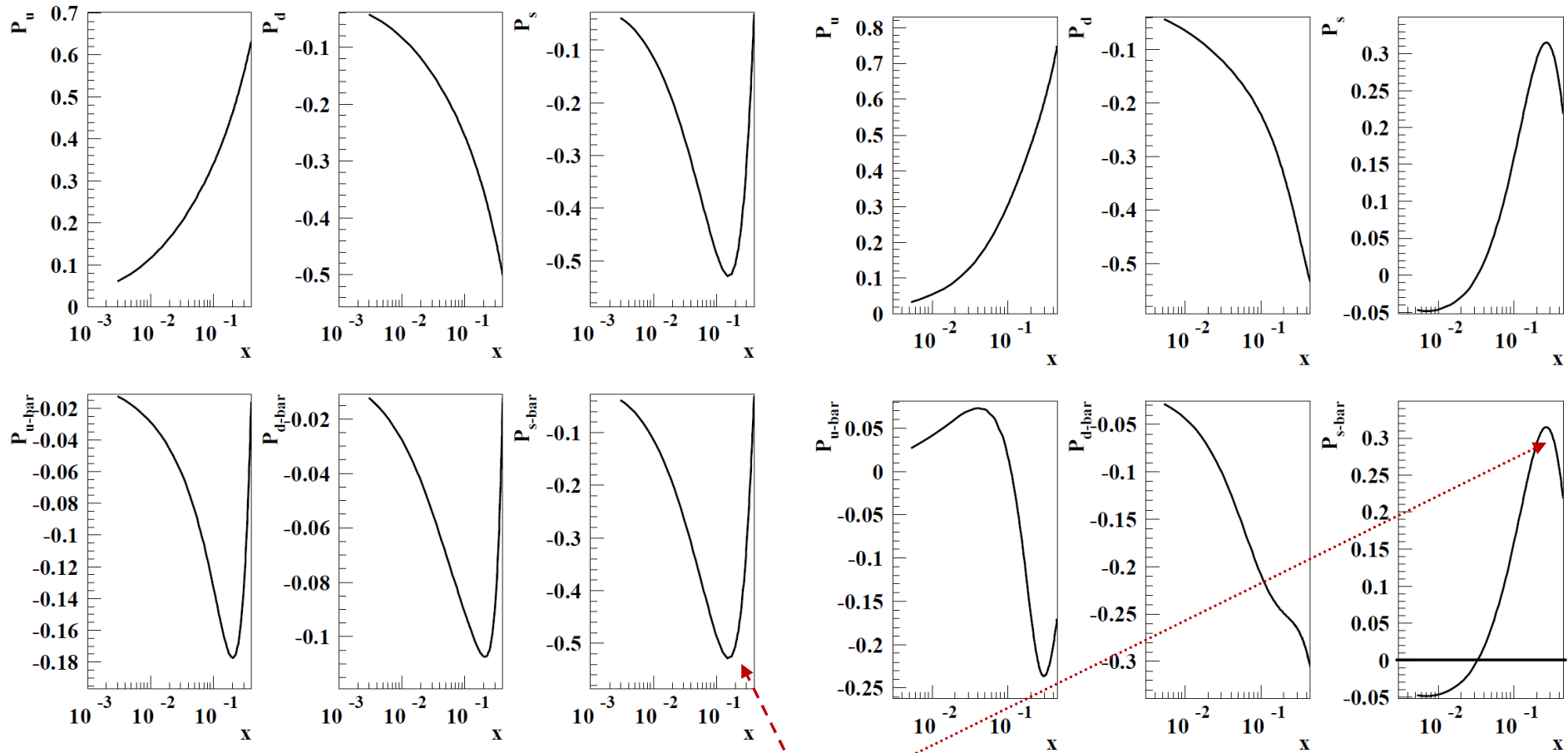
$$N_q(x, x_F, \dots) = \sum_{q(R_q \leq R_{qq})} e_q^2 \left[ D(y)P_B - fP_T \frac{\Delta q(x)}{q(x)} \right] q(x) D_q^{\bar{\Lambda}}(z) S_q^{\bar{\Lambda}}$$

$$N_{qq}(x, x_F, \dots) = - \sum_{q(R_q > R_{qq})} e_q^2 \left[ D(y)P_B - fP_T \frac{\Delta q(x)}{q(x)} \right] q(x) D_q^{\bar{\Lambda}}(z) c_{\bar{s}q}$$

$$N(x, x_F, \dots) = \sum_q e_q^2 \left[ 1 - D(y)P_B fP_T \frac{\Delta q(x)}{q(x)} \right] q(x) D_q^{\bar{\Lambda}}(z)$$

Separately calculate numerator and denominator by  
reweighting each generated event

# Two inputs for $P_q = \Delta q/q$



**GRSV+GRV**

**2000**

$P_{\bar{s}}$

**DSSV+MRST02**

**2008**

# COMPASS cuts

$$Q^2 > 1 \text{ (GeV/c)}^2; 0.2 < y < 0.9$$

Primary vertex:  $-100 < z < 100$  or  $-30 < z < 30$  (cm)

Decay vertex:  $35 < z_{\text{dec}} < 140$  (cm)

Vertexes colinearity cut:  $\theta_{\text{col}} = 0.01$

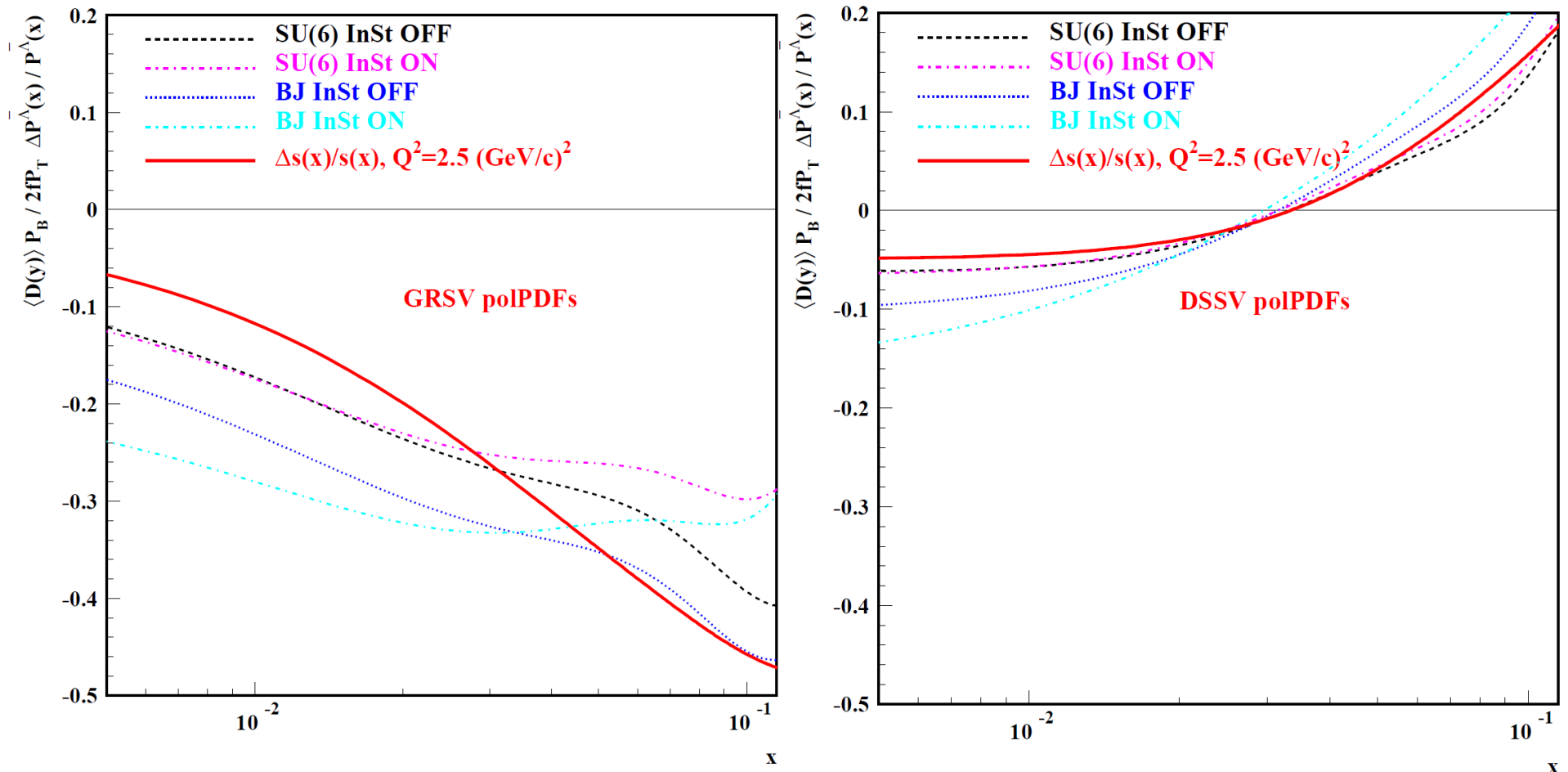
Decay particles momentum:  $p > 1 \text{ GeV/c}$

Feynman variable:  $0.05 < x_F < 0.5$

$\Lambda$  rest frame decay angle cut:  $\cos(\theta^*) < 0.6$

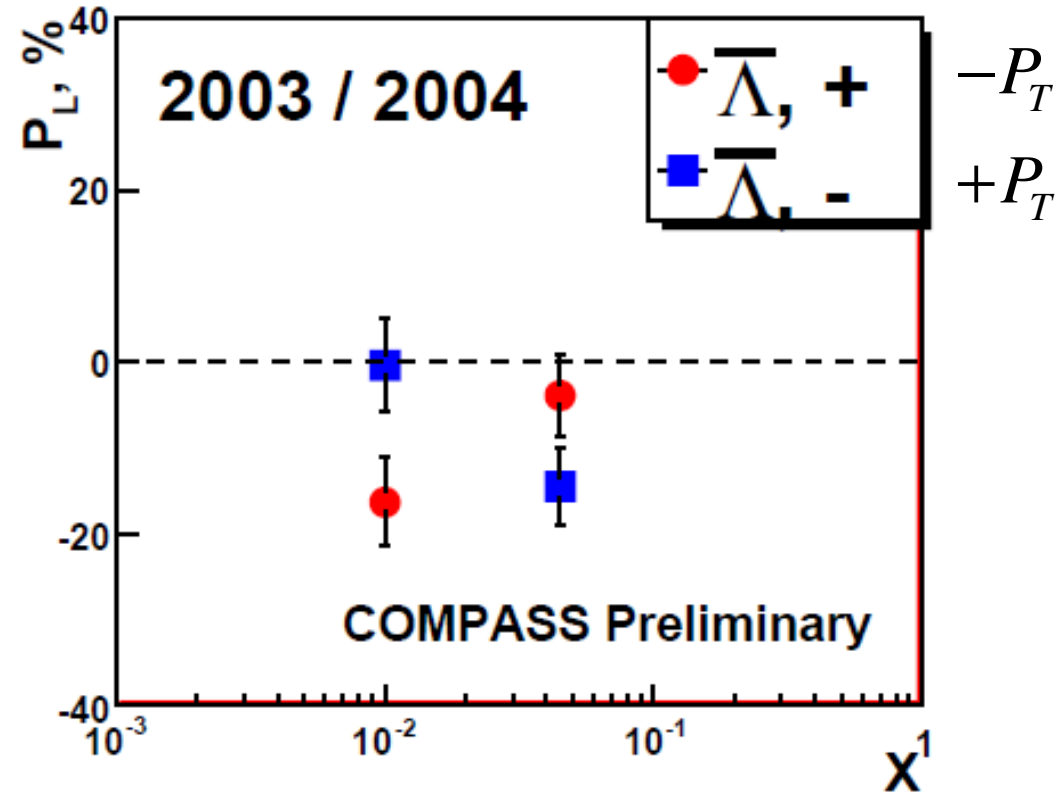


# Dependence on pol. PDFs



To verify sign change of  $\Delta \bar{s}$   
 measure in two bins of  $x$ :  $x < 0.03$  and  $0.03 < x$

# COMPASS preliminary



Sing change of  $\Delta P$  corresponds to DSSV PDFs

# Conclusions

- (Anti)Lambda polarization measurements in SIDIS of polarized leptons off unpolarized and polarized targets can shed light unpolarized and polarized s-bar distributions in nucleon
  - ✱ (Anti)Lambda polarization on unpolarized target strongly depends on strangeness PDF
  - ✱ Polarization asymmetry strongly depends on strangeness polarization shape
- (Anti)Lambda polarization in SIDIS is well suited filter for nucleon strangeness study