Longitudinal Spin Transfer of Λ and $\overline{\Lambda}$ in Polarized Proton-Proton Collisions at $\sqrt{s}$=200GeV

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Outline

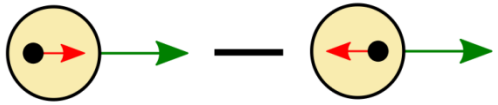
- Introduction and Motivation
- Data
- Existing D_{LL} Measurements
- D_{LL} Uncertainty Estimates
- Summary

Introduction and Motivation

- The quark spin contribution to the proton spin is small [1]
- Polarized fragmentation is not well understood [2]

Helicity Distribution

$$\Delta q(x, Q^2) = q^+(x, Q^2) - q^-(x, Q^2)$$



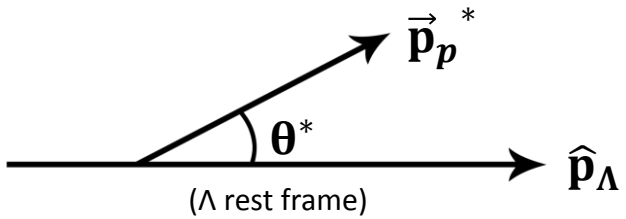
Longitudinal Spin Transfer

$$D_{LL} \equiv \frac{\sigma_{p^+p \to \Lambda^+ X} - \sigma_{p^+p \to \Lambda^- X}}{\sigma_{p^+p \to \Lambda^+ X} + \sigma_{p^+p \to \Lambda^- X}}$$

- The weak decay of the Λ is self-analyzing
- The weak decay channel, Λ → pπ, can be reconstructed at RHIC hence Λ polarization can be measured
- D_{LL} is expected to be sensitive to polarized fragmentation functions and polarized parton distribution functions

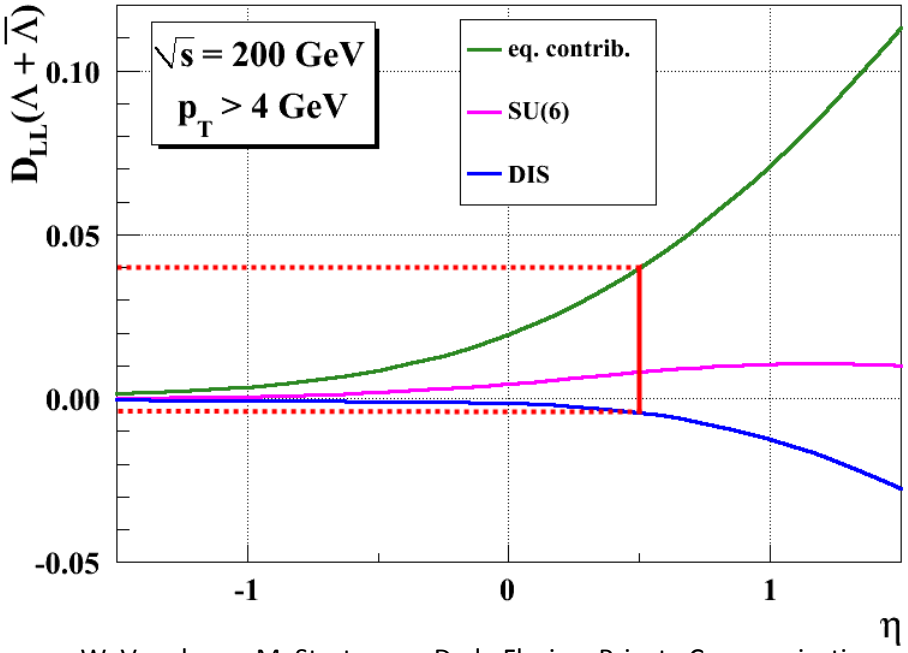
Analysis Method

$$D_{LL} = \frac{1}{P_B \cdot \alpha_W \cdot \langle \cos(\theta^*) \rangle} \cdot \frac{N^+ - R \cdot N^-}{N^+ + R \cdot N^-}$$



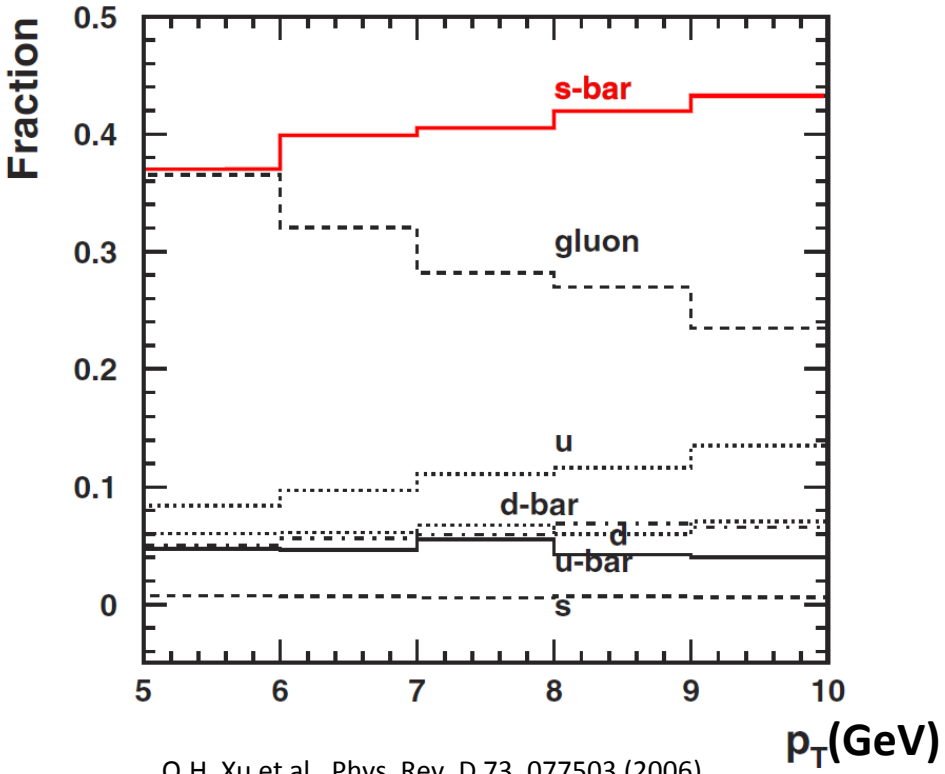
[1] EMC, J. Ashman et al, Nucl. Phys. B 328 (1989) 1
[2] e.g. Z.T. Liang and C. Boros, Phys.Rev.D57:4491-4494,1998

Model Predictions



W. Vogelsang, M. Stratmann, D. de Florian, Private Communication

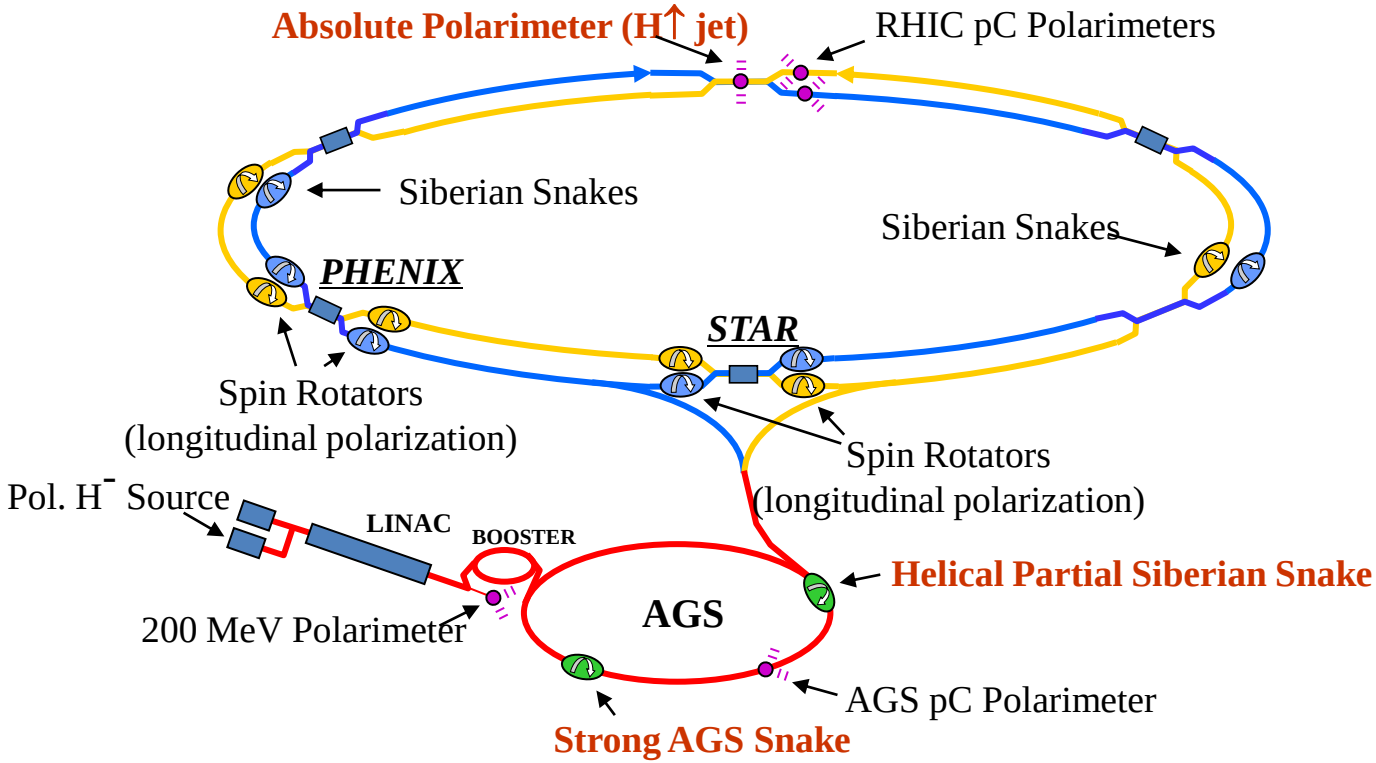
D. de Florian, et al., Phys. Rev. Lett. 81, 530 (1998)



Q.H. Xu et al., Phys. Rev. D 73, 077503 (2006)

- $D_{LL}(\Lambda+\bar{\Lambda})$ curves are calculated using different polarized quark fragmentation models
- $\bar{s}$ fragmentation is expected to dominate $\bar{\Lambda}$ production at high p_T

Relativistic Heavy Ion Collider (RHIC)



Year	$\sqrt{s}$ (GeV)	$L_{recorded}$ (pb^{-1}) (long.)	Polarization (%)(blue/yellow)
2005	200	3.1	51/48
2006	200	8.5	53/53
2009	200	22	58/57

Solenoidal Tracker At RHIC (STAR)

Time Projection Chamber (TPC)

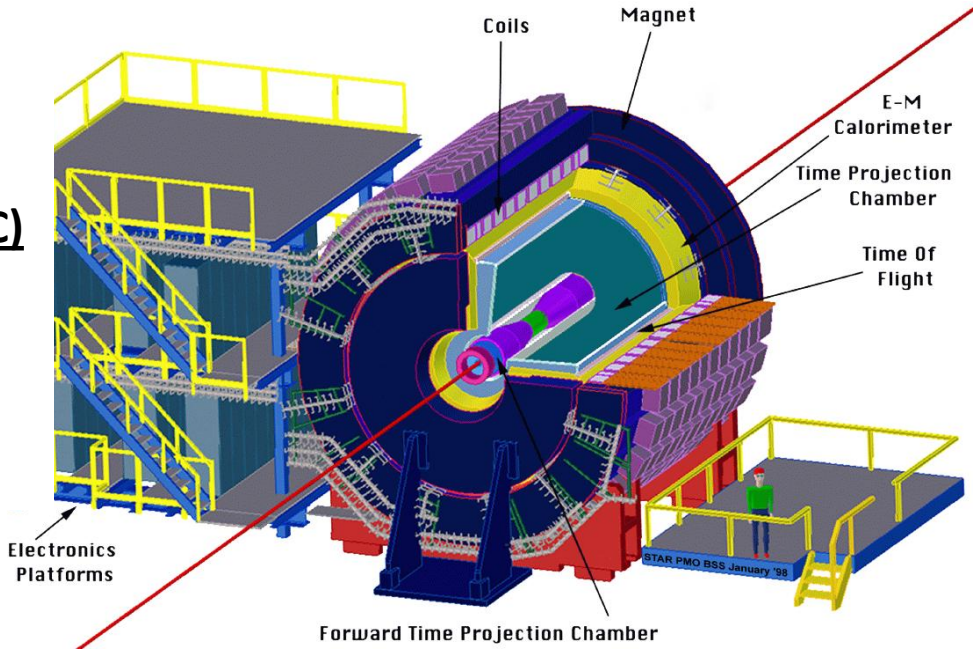
- $|\eta| < 1.4$
- Particle Identification via $\left(\frac{dE}{dx}\right)$
- Charged Particle Track Reconstruction

Barrel Electromagnetic Calorimeter (BEMC)

- $|\eta| < 1.0$
- Jet Patch Trigger
- Jet Reconstruction

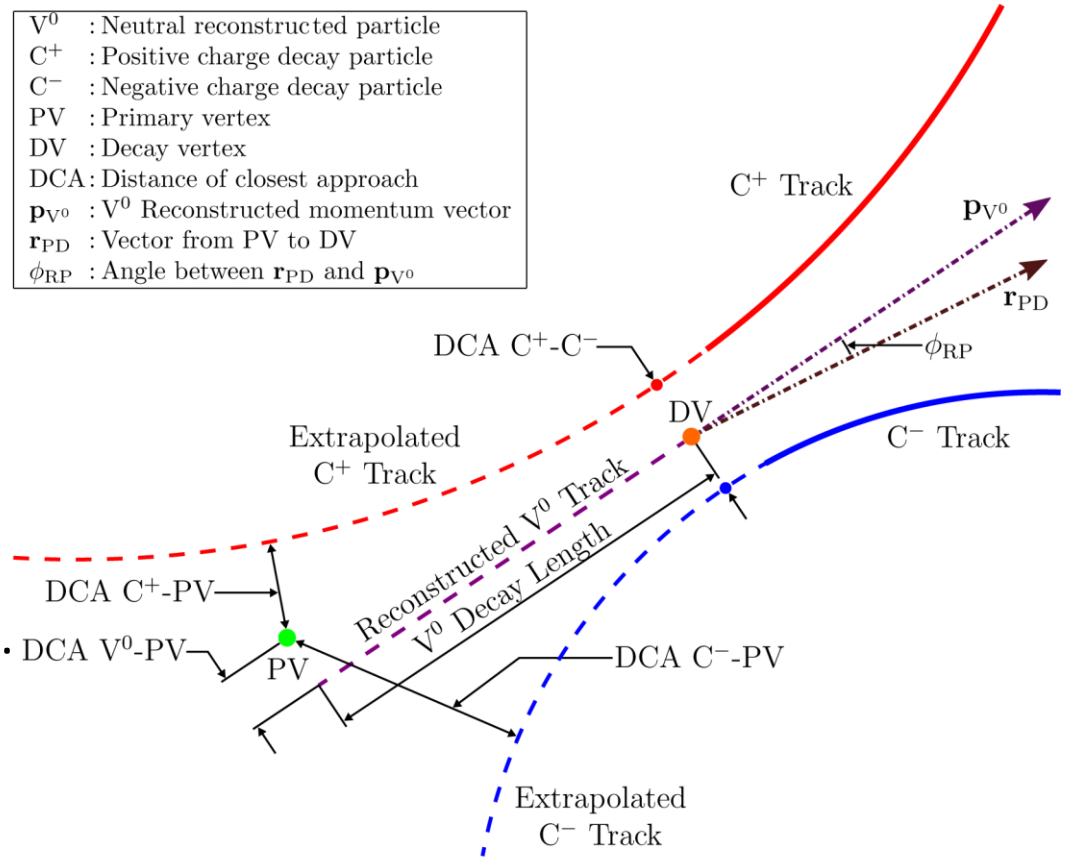
Beam-Beam Counters (BBC)

- $3.4 < |\eta| < 5.0$
- Relative Luminosity
- Local Polarimeter



V^0 Reconstruction

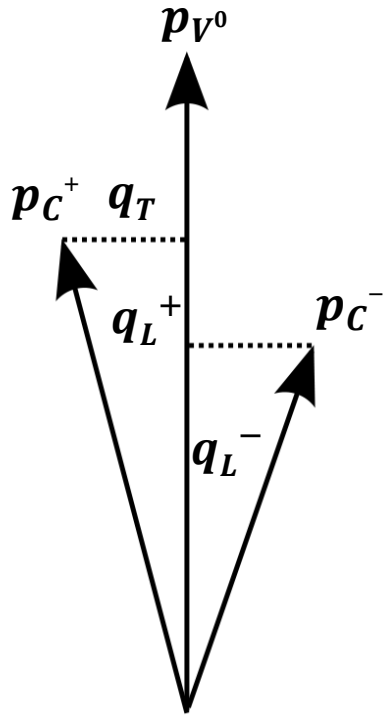
- Relaxed selection cuts:
  - DCA C^+-C^- < 1.5 cm.
  - DCA V^0-PV < 1.5 cm.
  - DCA π-PV > 0.15 cm.
  - DCA p-PV > 0.25 cm.
  - Λ Decay Length > 3.0 cm.
  - K_s^0 Decay Length > 2.0 cm.
  - **ϕ_{RP} < 0.25 rad.**



- Selection cuts are tuned per p_T range, further reducing the combinatorial background
- The min Λ decay length cut trends upward from 5cm to 13cm as p_T increases

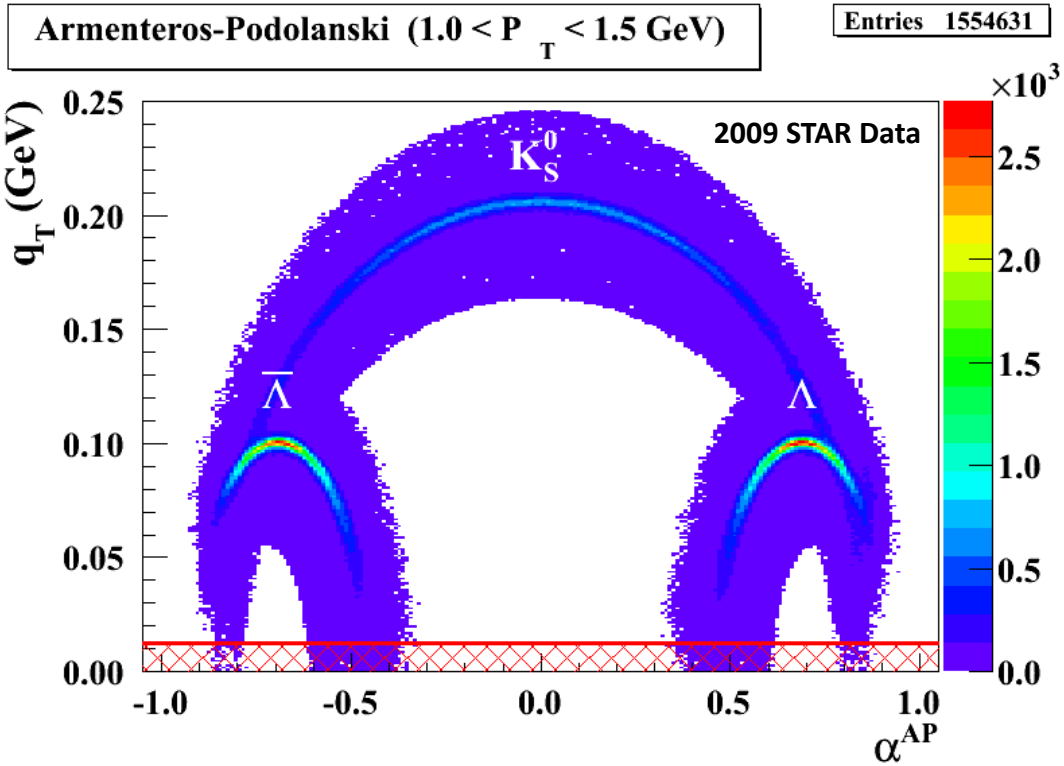
Λ Identification & Background

- Armenteros-Podolanski relation allows identification of unstable neutral particle species



$$\alpha^{AP} = \frac{q_L{}^+ - q_L{}^-}{q_L{}^+ + q_L{}^-}$$

(JP1 Trigger, tuned)

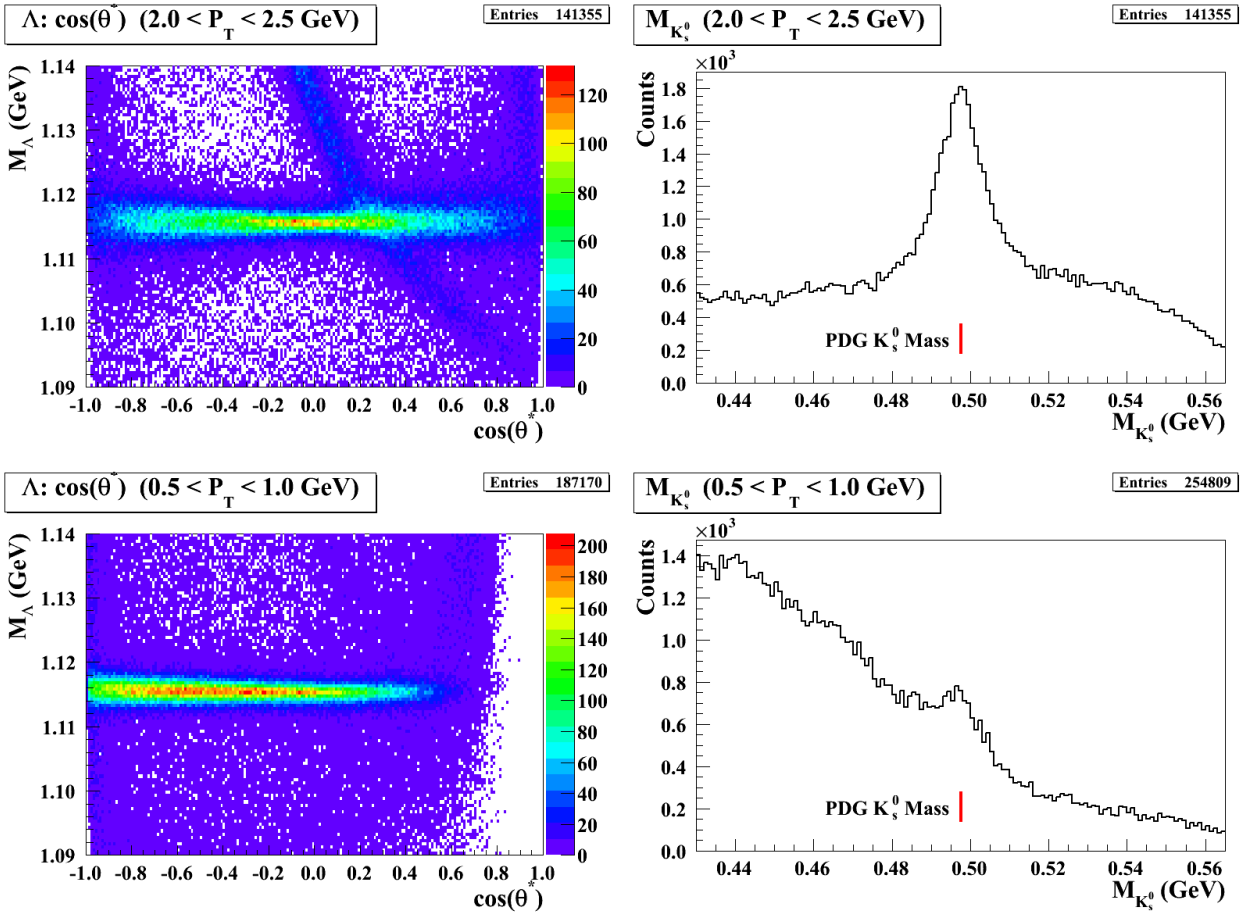


- A limit q_T > 12.5 MeV is placed to reduce electron contamination

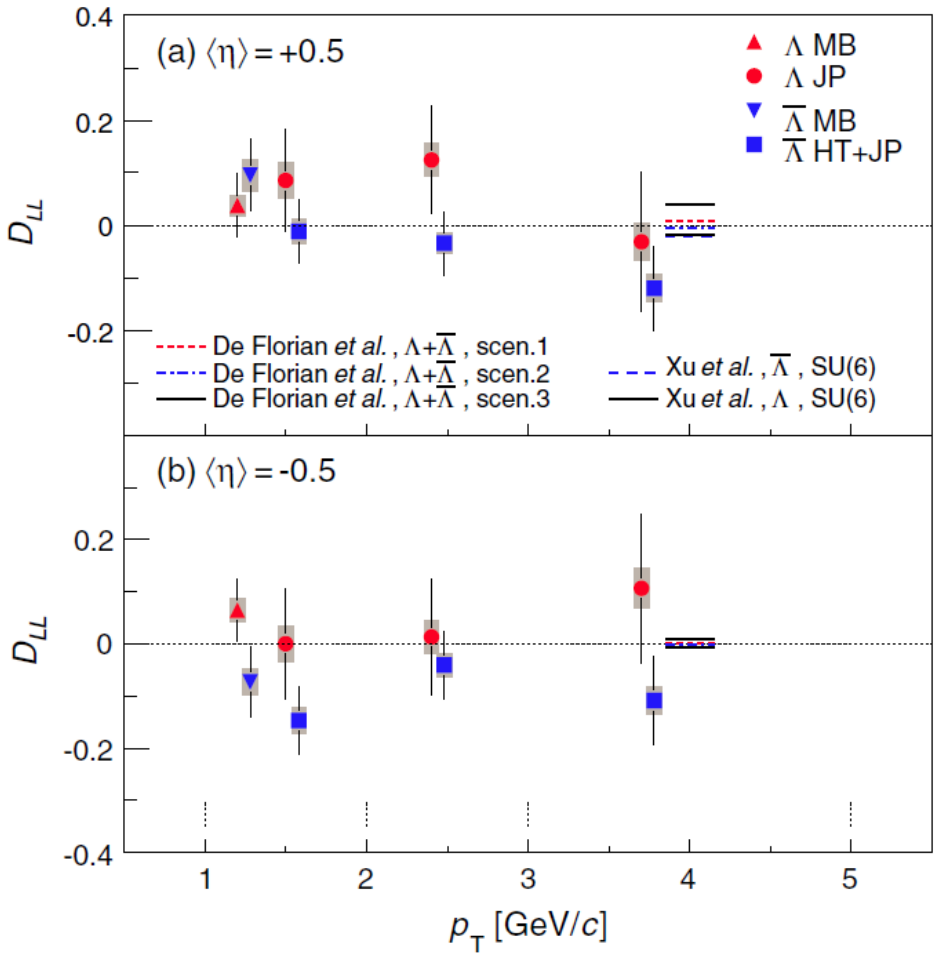
K_S^0 Background

- A small sample of pions is misidentified as protons to form a Λ candidate
- K_S^0 are spin-zero particles which will dilute the Λ polarization
- Λ candidates which also satisfy K_S^0 conditions are rejected if they have ionization energy loss values closer to the expected K_S^0 range

(L2JetHigh Trigger, tuned)



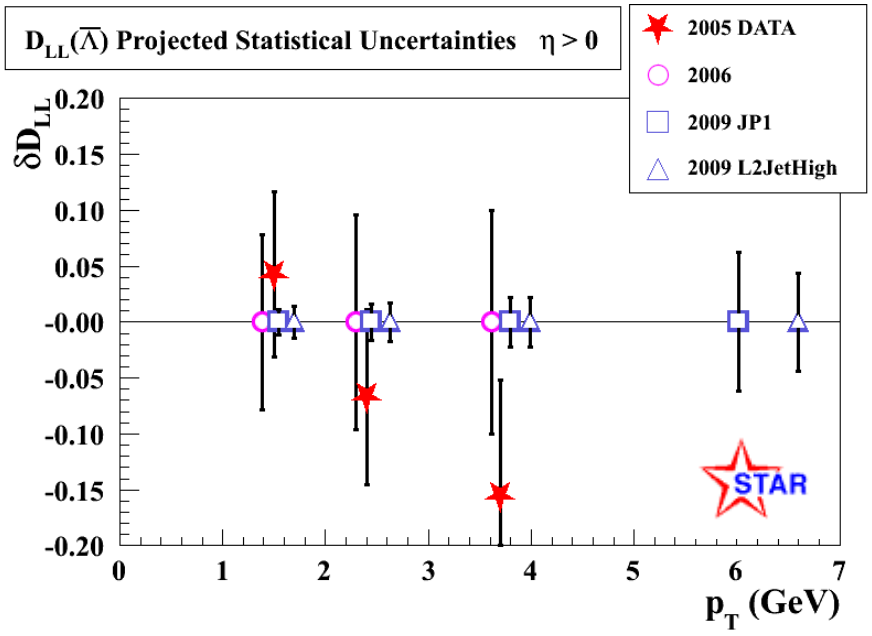
Existing STAR D_{LL} Measurement

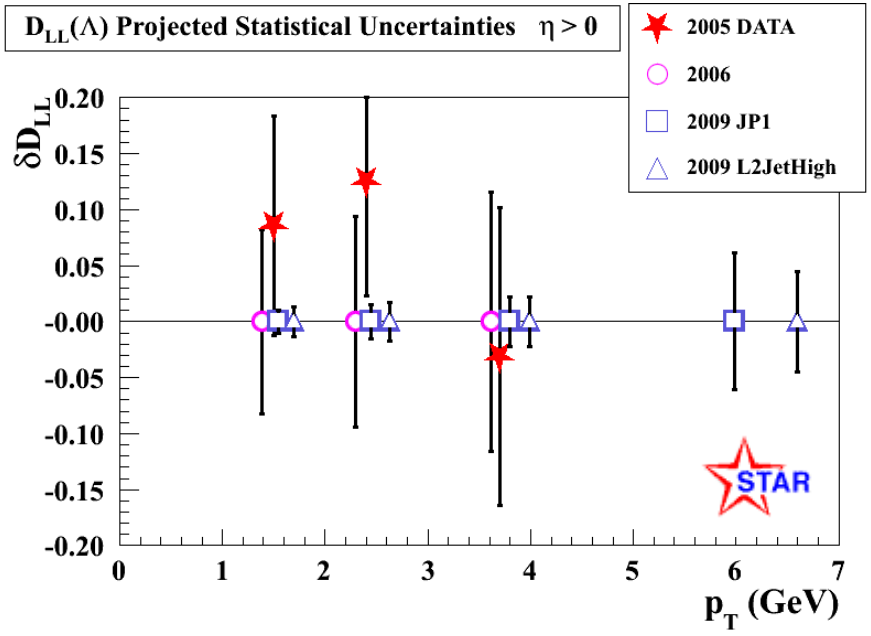


- Data taken in 2005
- $1 < p_T < 5$ GeV
- Half of BEMC was operational
- Limited by statistics
- At $\langle p_T \rangle = 3.7$GeV and $\langle \eta \rangle = 0.5$
  - $D_{LL}(\Lambda) = -0.03 \pm 0.13 \pm 0.04$
  - $D_{LL}(\overline{\Lambda}) = -0.12 \pm 0.08 \pm 0.04$
- For highest p_T, statistical uncertainties are comparable to the spread between the model predictions

B.I. Abelev et al.[STAR Collaboration] Phys.Rev.D80:111102,2009

2009 D_{LL} Uncertainty Estimates





- 2006 shows similar precision as 2005
- 40x more Λ's in run 2009 than in 2005
- 2009 improves on 2005 statistical uncertainties
- Additional sample of away side Λ's with similar precision

Summary

- The statistical uncertainty from 2005 D_{LL} measurement is comparable to the model prediction spread at large p_T
- 4x smaller statistical uncertainties for 2009
- D_{LL} will extend in p_T up to ~6-7 GeV for 2009
- Systematic uncertainties are being studied
- K_s^0 sample will be used for a null measurement
- Similar-sized sample of away side Λ's will complement the near side D_{LL} analysis