Quark Helicity Distributions from SIDIS

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EIC Collaboration Meeting Dec. 2008

Outline

- DIS and SIDIS
- Asymmetries and the Purity Method
- Previous Measurements
- Expectations for the EIC
- Future/Plans/Questions

Motivation

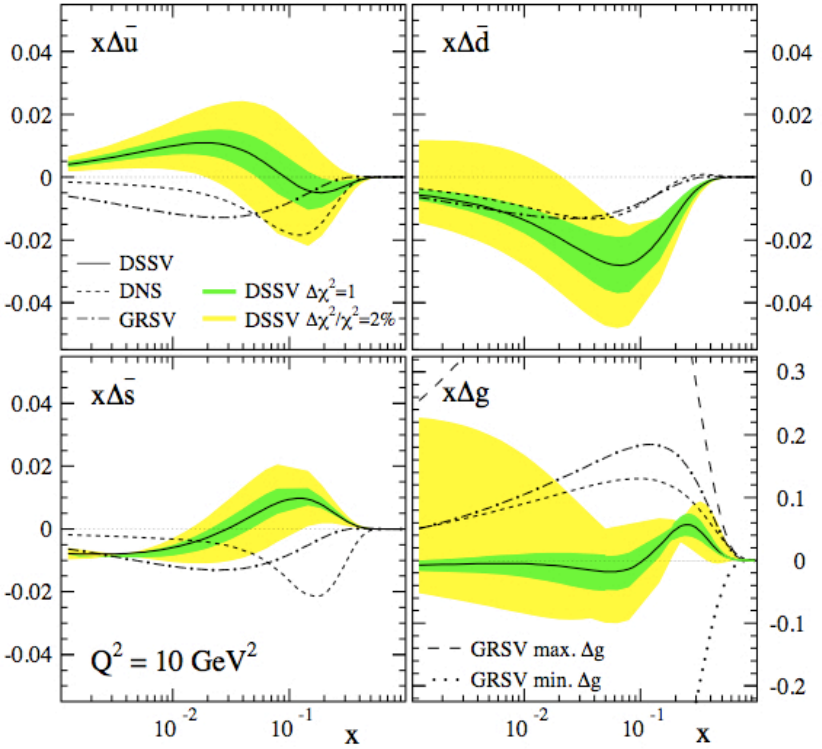
Inclusive DIS only gives charge weighted sum

$$\frac{d\Delta\sigma}{dxdQ^2} \propto \sum_q e_q^2 \Delta q \approx e_u^2 (\Delta u_v + \Delta u_s + \Delta\bar{u}) + e_d^2 (\Delta d_v + \Delta d_s + \Delta\bar{d}) + e_s^2 (\Delta s + \Delta\bar{s})$$

The valence piece is fairly well measured.

The polarized sea is still not well constrained.

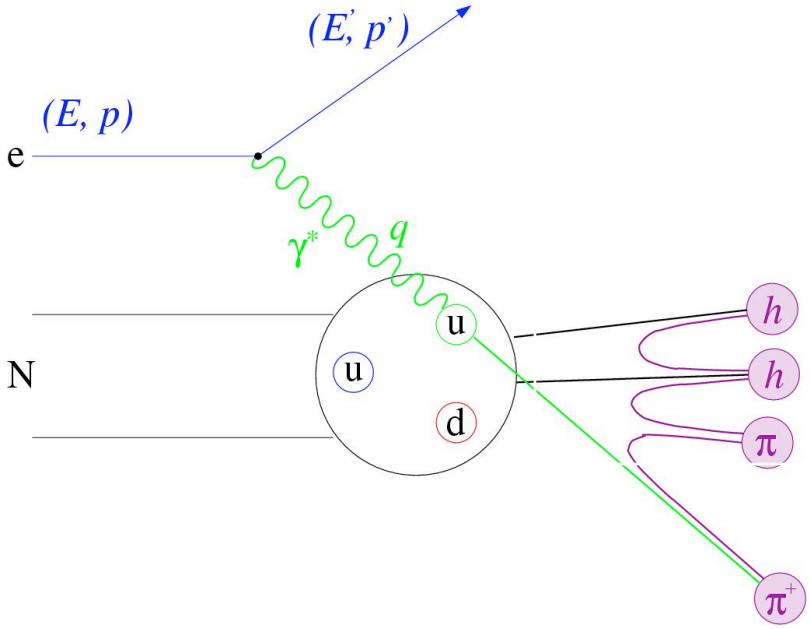
Two pieces will help constrain the sea components of the nucleon spin: Δs and $\Delta\bar{u} - \Delta\bar{d}$



DSSV

Semi-Inclusive DIS

In Semi-Inclusive Deep Inelastic Scattering (SIDIS), we measure a final state hadron in coincidence with the scattered electron



$$\frac{d\sigma^h}{dzdxdQ^2} \propto \sum_q e_q^2 q(x,Q^2) D_q^h(z,Q^2)$$

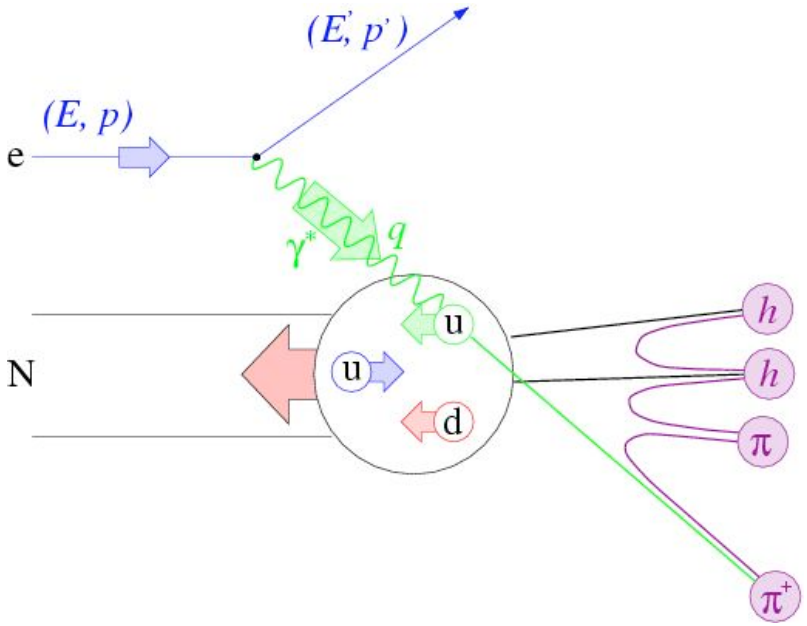
$$\frac{d\Delta\sigma^h}{dzdxdQ^2} \propto \sum_q e_q^2 \Delta q(x,Q^2) D_q^h(z,Q^2)$$

If the fragmentation functions are known, the flavor separated pdfs (both pol. and unpol.) can be obtained.

Asymmetries and SIDIS

In practice, the asymmetries are measured and not polarized cross sections

$$A^h = \frac{N^{++} - N^{+-}}{N^{++} + N^{+-}} \propto \frac{\Delta\sigma}{\sigma} = \frac{\sum_q e_q^2 \Delta q(x,Q^2) D_q^h(x,Q^2)}{\sum_{q'} e_{q'}^2 q'(x,Q^2) D_{q'}^h(x,Q^2)}$$



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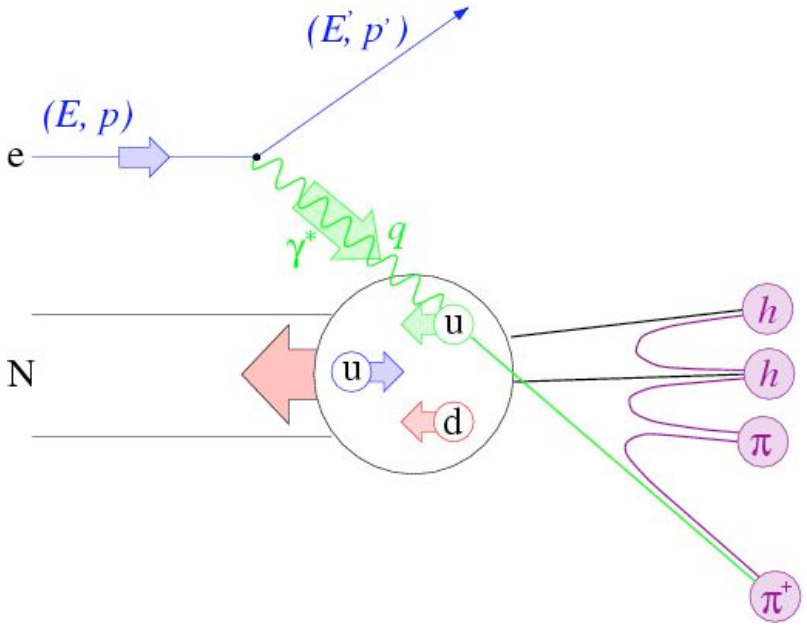

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$$A^h \propto \frac{\sum_q e_q^2 \Delta q(x,Q^2) D_q^h(x,Q^2)}{\sum_{q'} e_{q'}^2 q'(x,Q^2) D_{q'}^h(x,Q^2)} \equiv \sum_q P_q^h(z,x,Q^2) \frac{\Delta q(x,Q^2)}{q(x,Q^2)}$$

Purity

Polarization

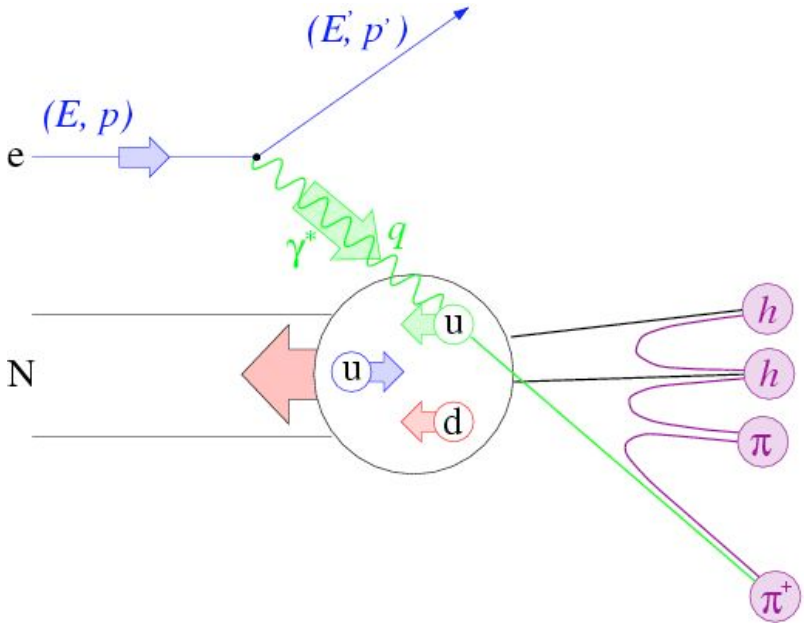
$$P_q^h(x,Q^2,z) = \frac{e_q^2 q(x,Q^2) D_q^h(z,Q^2)}{\sum_{q'} e_{q'}^2 q'(x,Q^2) D_{q'}^h(z,Q^2)} \rightarrow \frac{N_q^h}{\sum_{q'} N_{q'}^h}$$

Typically calculated in a Monte Carlo

Asymmetries and SIDIS II

Measuring the asymmetries of multiple species allows a better determination of the polarizations

$$\begin{pmatrix} A^{h_1} \\ A^{h_2} \\ \mathrm{M} \end{pmatrix} = \begin{pmatrix} P_{q_1}^{h_1} & P_{q_2}^{h_1} & \mathrm{L} \\ P_{q_2}^{h_2} & P_{q_2}^{h_2} & \mathrm{L} \\ \mathrm{M} & \mathrm{M} & \mathrm{O} \end{pmatrix} \begin{pmatrix} \Delta q_1 / q_1 \\ \Delta q_2 / q_2 \\ \mathrm{M} \end{pmatrix}$$



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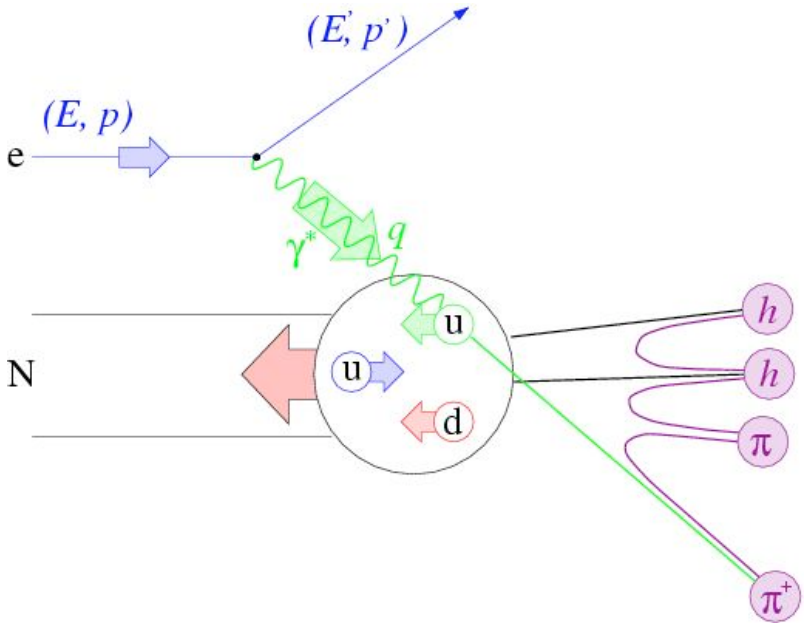
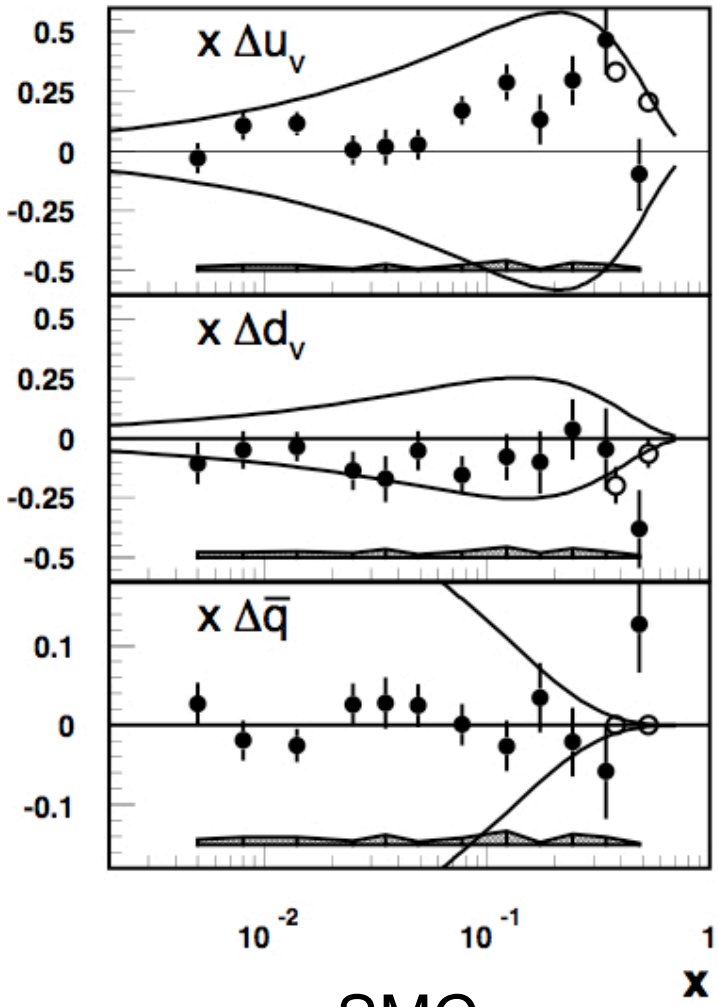
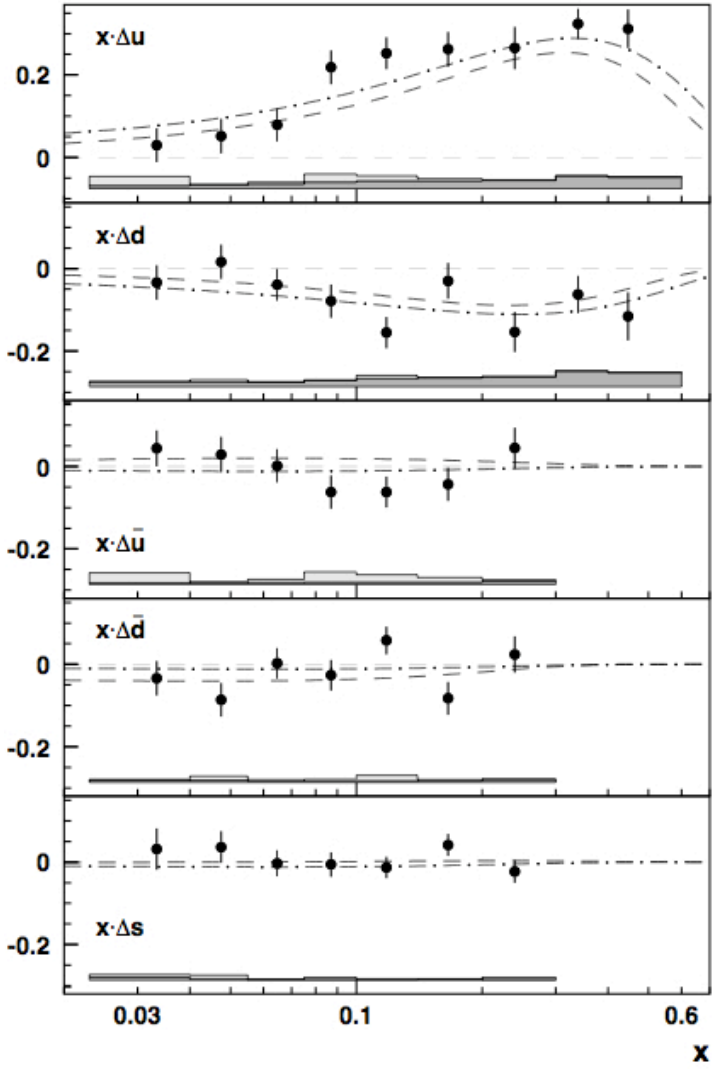


This method gives the polarizations as well as their uncertainties and correlations

Previous Measurements



SMC



HERMES

Simulations

The cross sections, correlations, yields, and purities were simulated using LEPTO

An integrated luminosity of 100 days at $10^{33}cm^{-2}s^{-1}$

3 proposed energies were simulated (E_{e^-} on E_p) 5 on 50, 7 on 150, and 10 on 250

Cuts consistent with DIS and basic detector requirements

Perfect PID

Event level and scattered lepton cuts

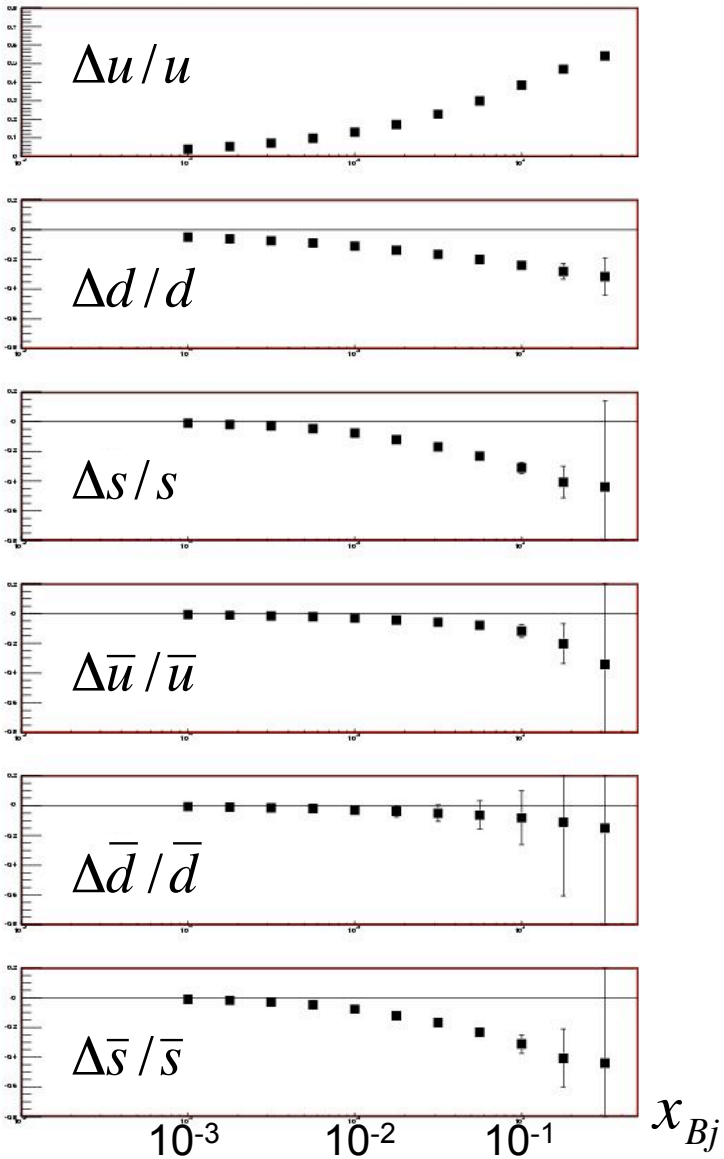
$E'_{lepton} > 1GeV$
$Q^2 > 1\ GeV^2$
$0.05 < y < 0.85$
$5^o < theta < 175^o$
$W^2 > 10\ GeV^2$

Hadronic cuts

$E_{had} > 1\ GeV$
$5^o < theta < 175^o$
$0.2 < z < 0.8$
$x_F > 0.15$

6 species were used in this study: $\pi^+, \pi^-, K^+, K^-, p, \bar{p}$

5 on 50 Expectations



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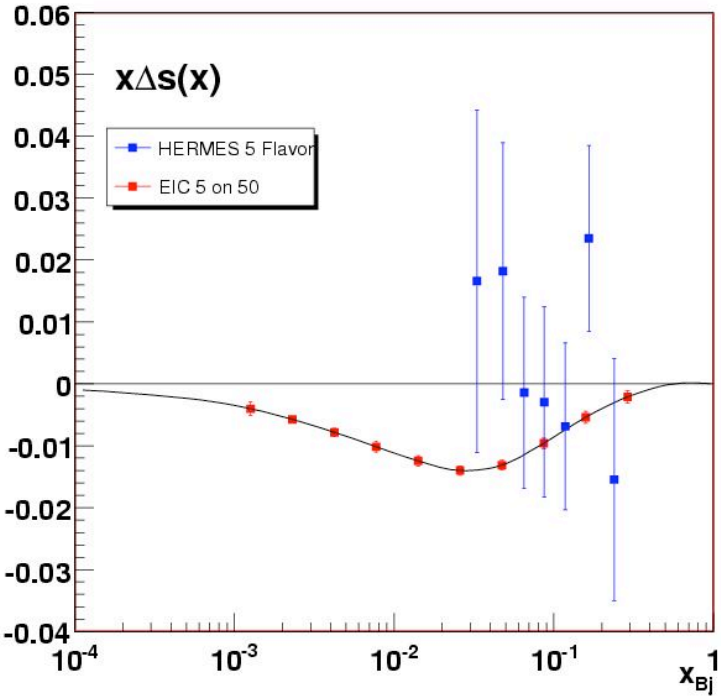
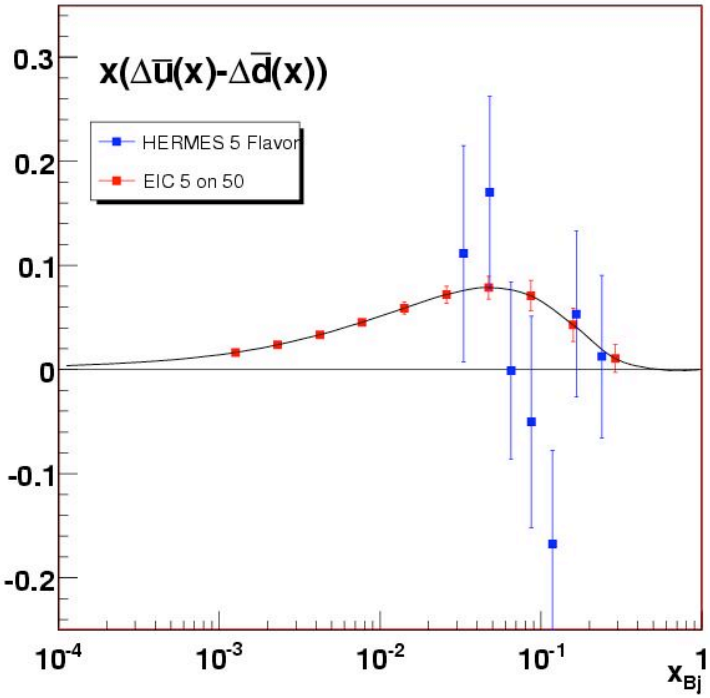
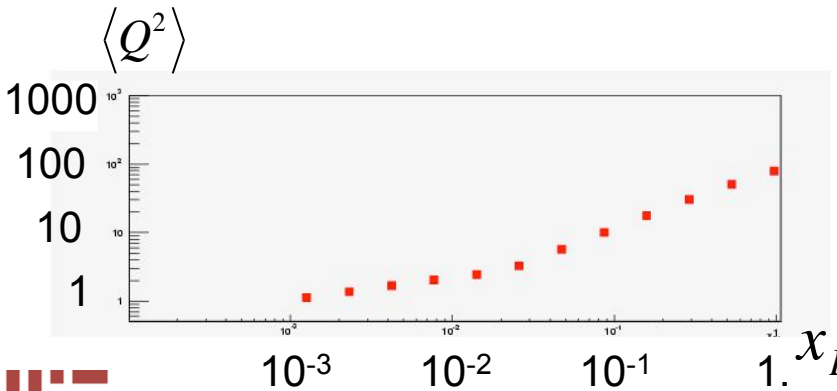
The matrix inversion yields all the flavors, their errors, and their correlations

5 on 50 Expectations



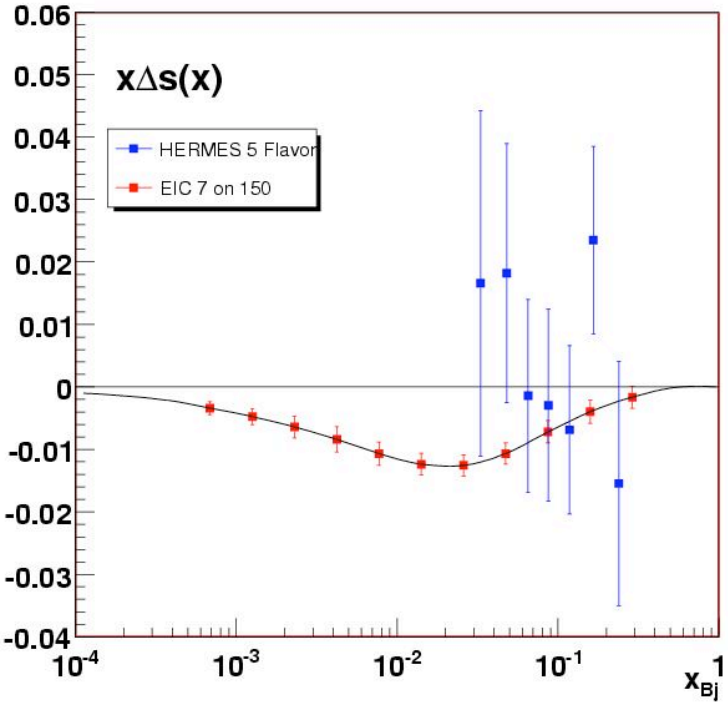


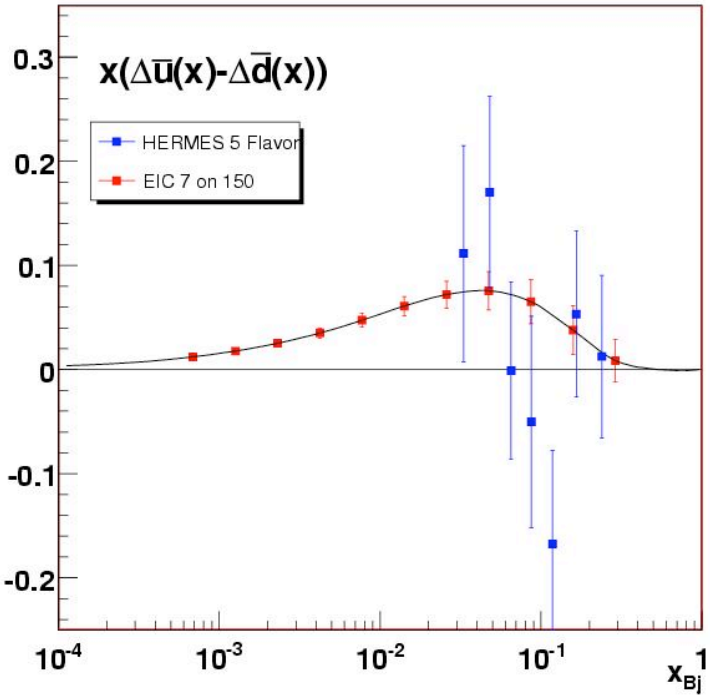


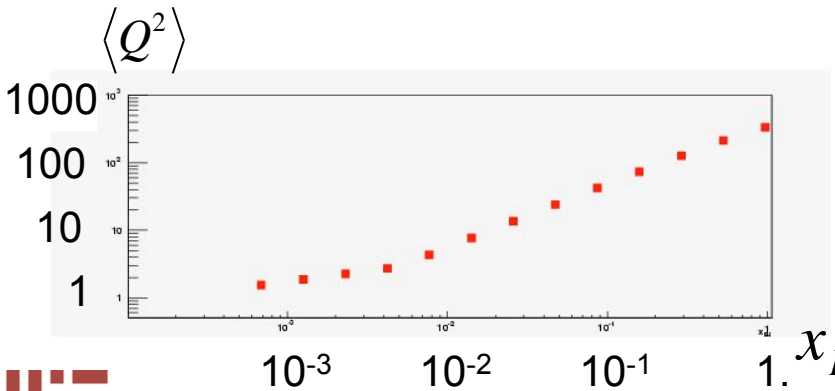
Curves are GRSV

Phys. Rev. D63:094005,2001

7 on 150 Expectations







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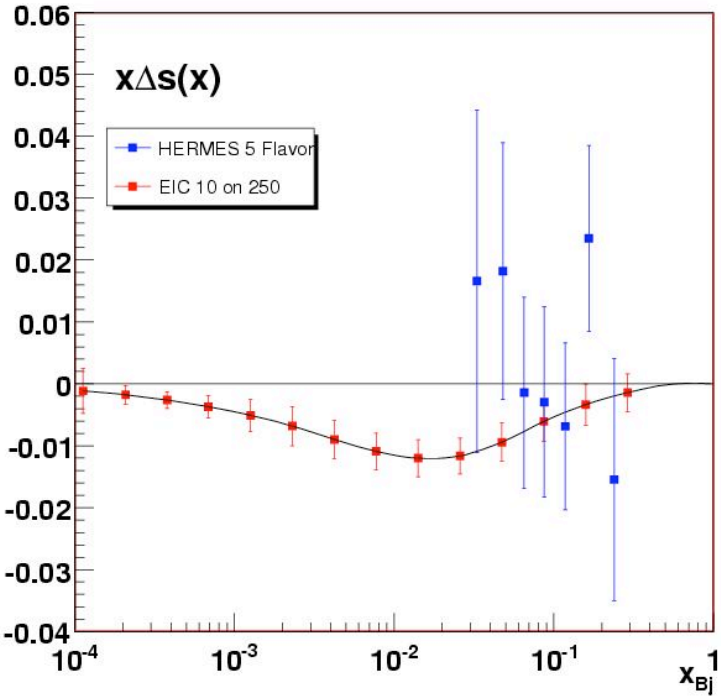
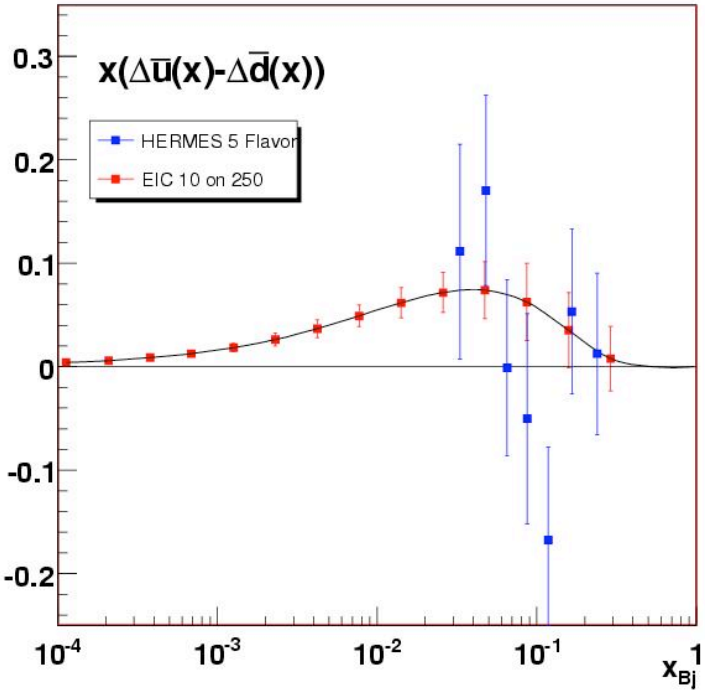
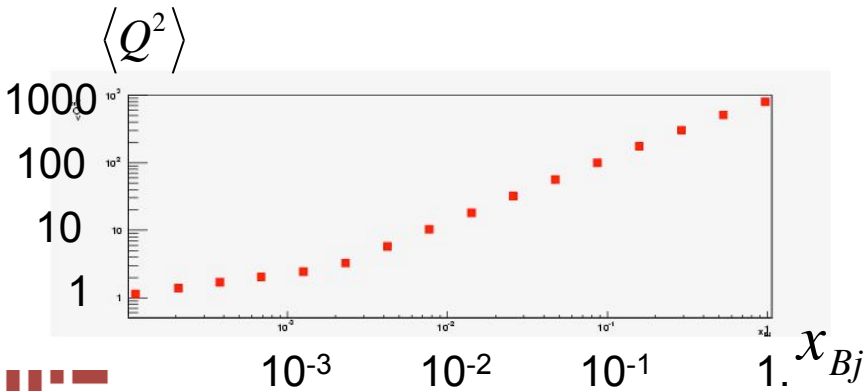
10 on 250 Expectations







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Future/Plans/Open Questions

- Add detector effects/imperfect PID
- Optimize detector vs. cost for this measurement (-> What can be done with staged implementation?)
- Study accuracy needs of fragmentation functions and pdfs
- Radiative corrections
- Do the study at NLO (-> Plug into a code like DSSV to see effect on uncertainties)

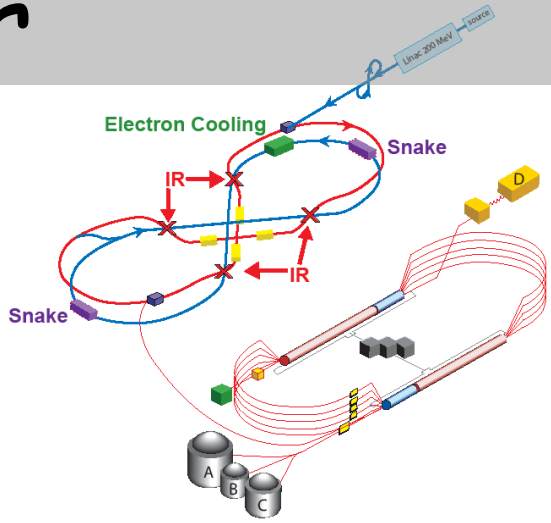
Backup Slides

Where do the particles go?

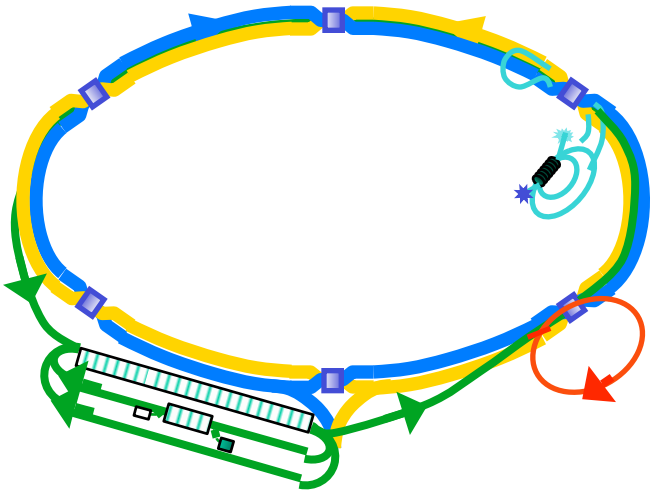
Electron-Ion Collider

A proposed high luminosity ep and eA collider.

electrons and positrons
polarized p,d,He3, maybe Li
unpolarized ion species up to Pb



ELIC@JLab



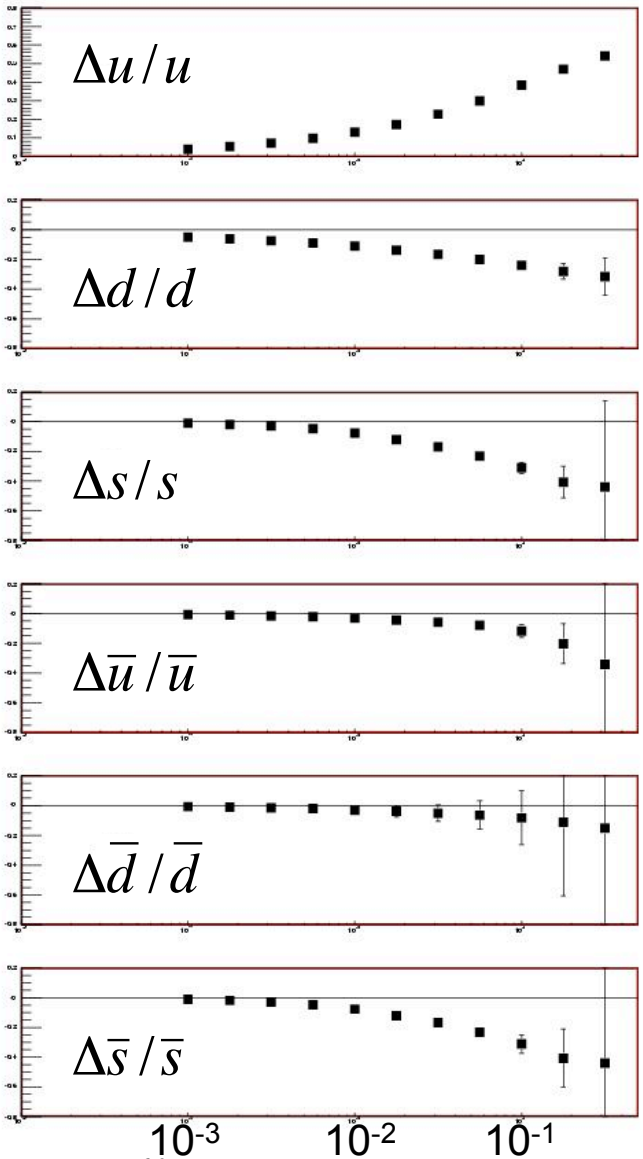
eRHIC@BNL

$\langle L \rangle_{min} = 10^{33}\ cm^{-2}s^{-1}$

P ~ 70-80%

CM energy between 20 and 100 GeV

5 on 50 Expectations



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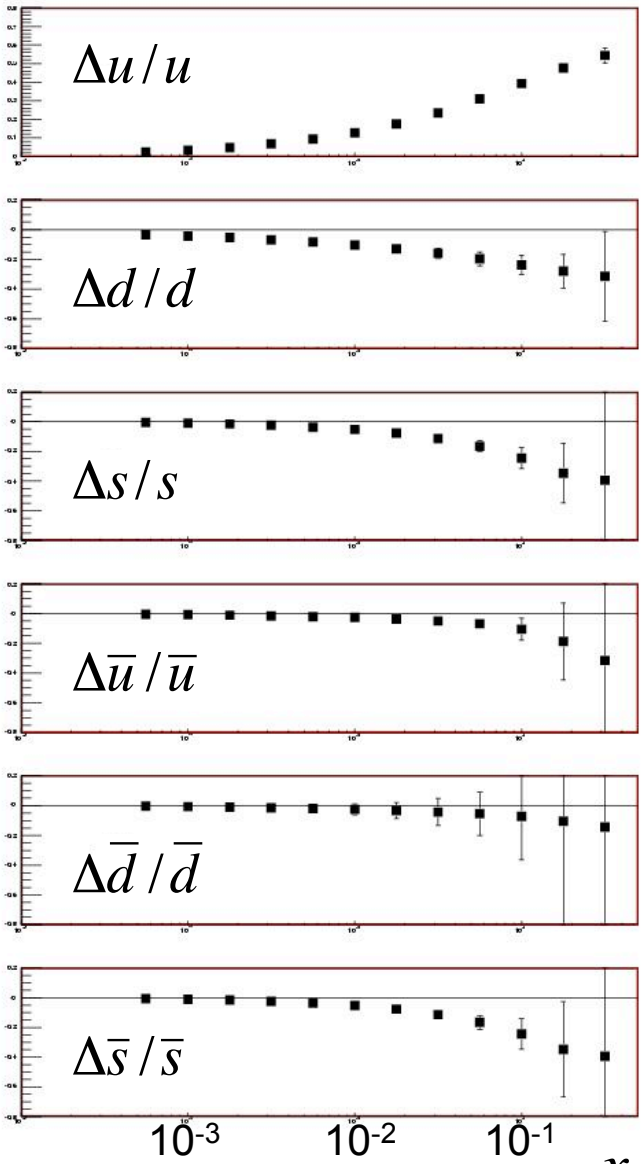

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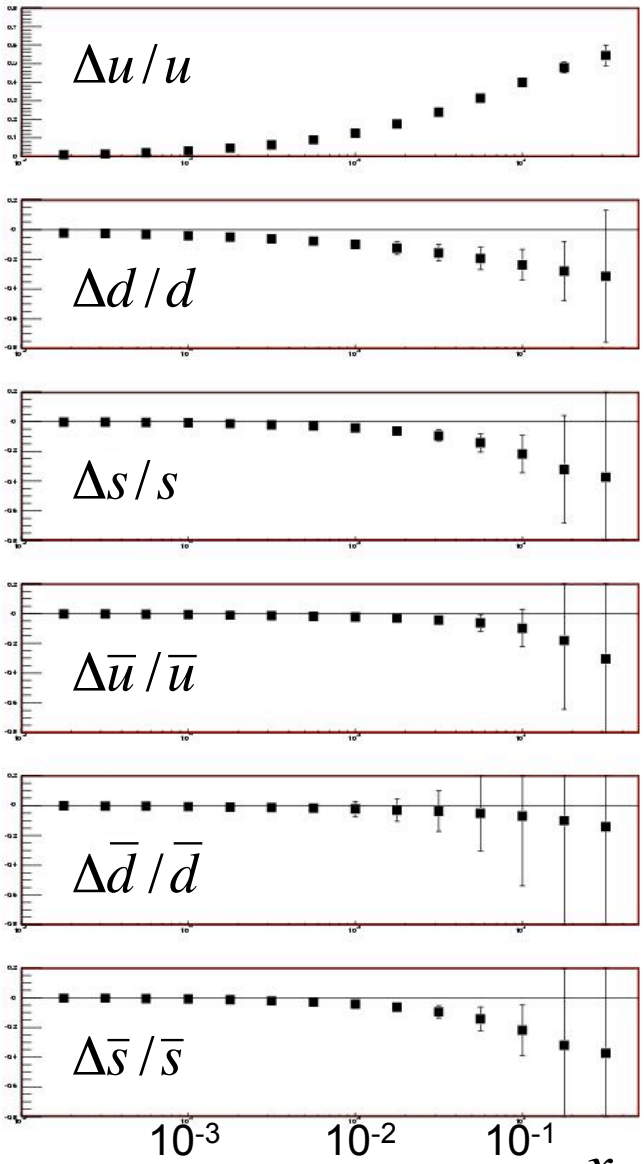
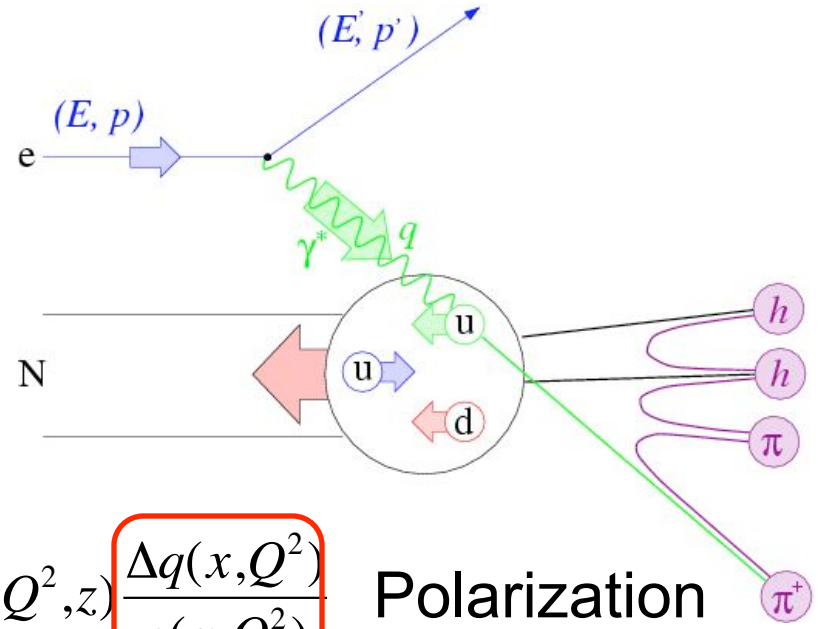


Asymmetries and SIDIS

By measuring counting asymmetries in hadron production between different helicity configurations, the polarized pdfs can be accessed



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Polarization

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