Physics Topics

- **inclusive physics**
  - unpolarised structure funcions
  - polarised struture functions
- **electroweak physics**
  - tests of standard model
  - electroweak structur functions
- **semi-inclusive physics**
  - current quark fragmentation and flavour separation
  - target fragmentation and correlation between current and target fragmentation
- **polarised gluon distribution ΔG**
  - charm production
  - jets

Physics Topics

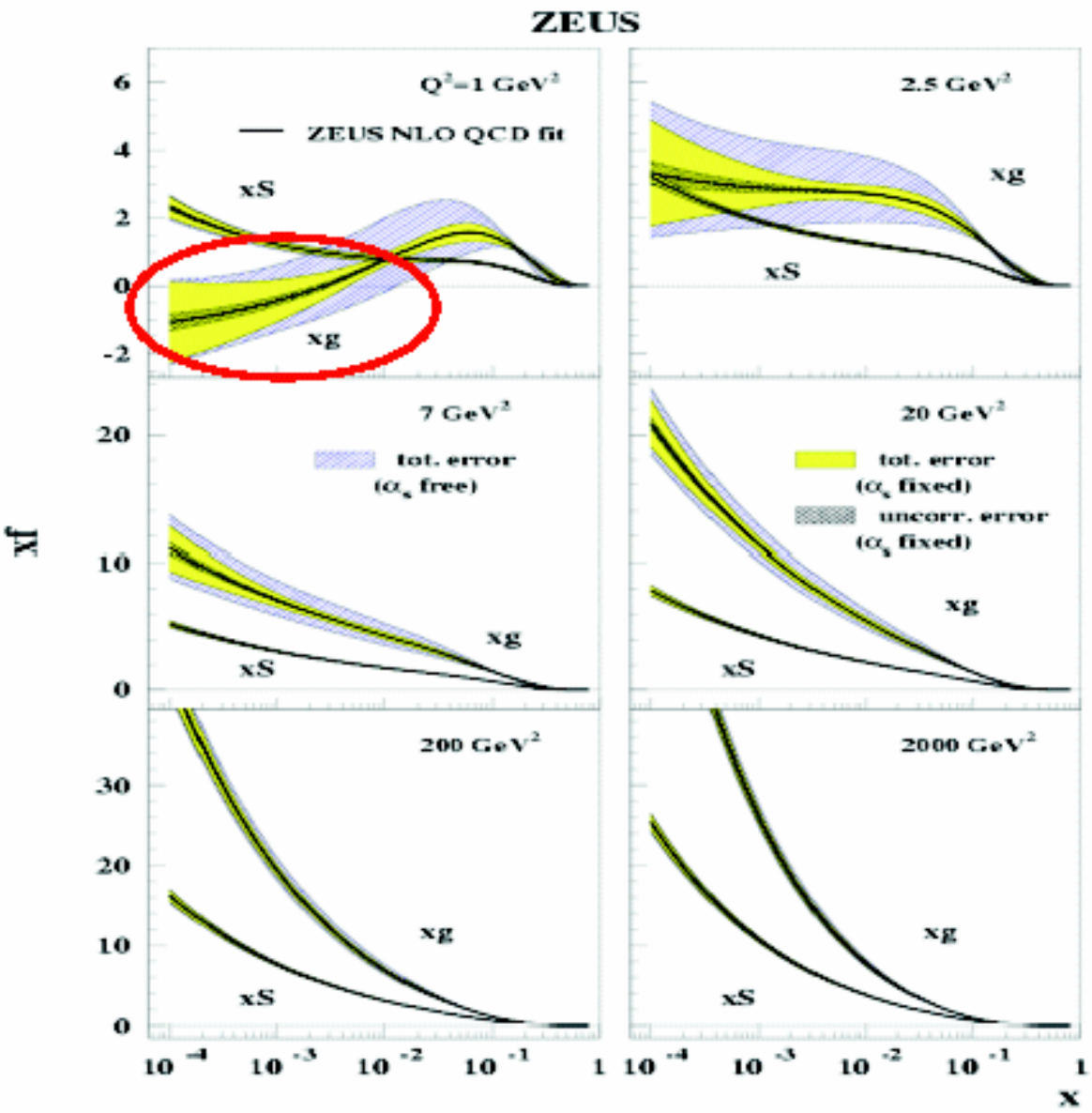
- **azimuthal asymmetries**
  - Transverse Momentum Dependent Parton Distributions
  - Sivers and Collins functions
  - Orbital momentum ?
- **exclusive processes and diffraction**
  - DVCS
  - Meson production
  - 3 dimensional image of the proton
  - orbital momentum ?
- **Photoproduction**

Negative gluon distribution!

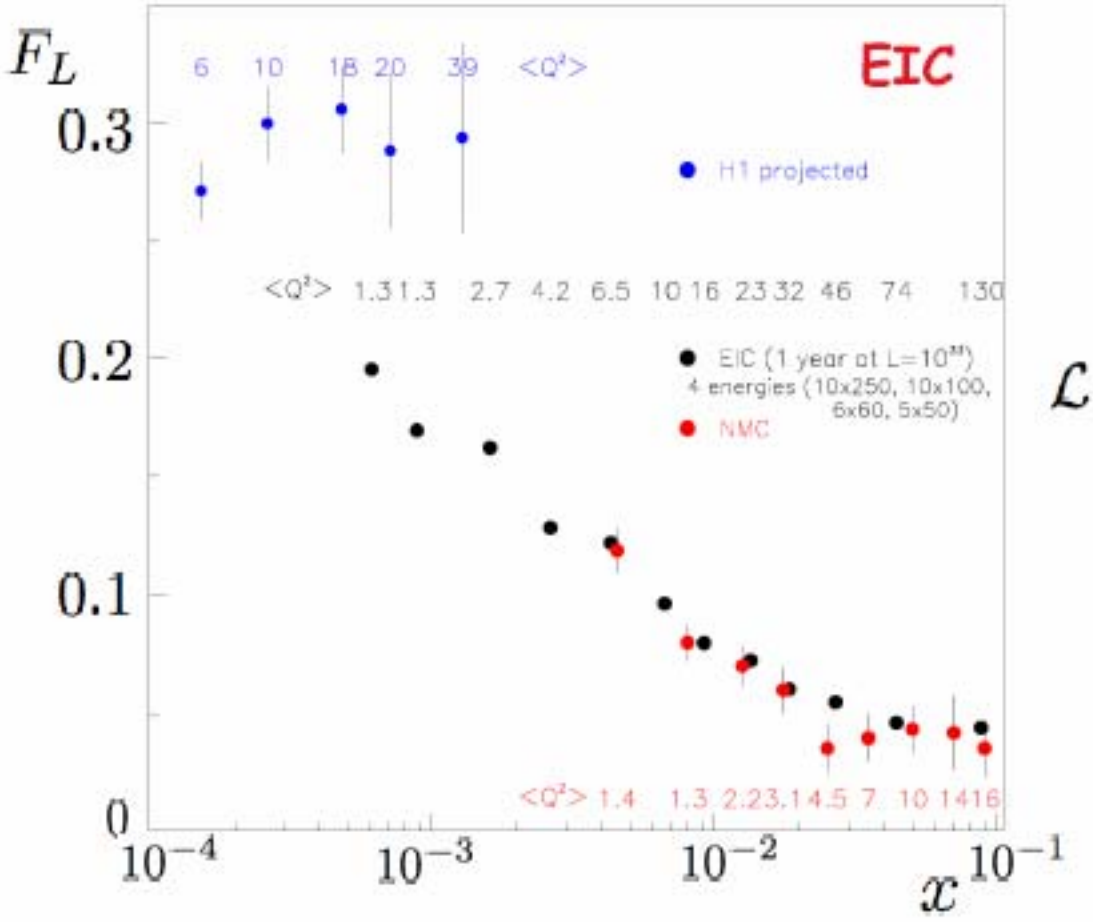
- NLO global fitting based on leading twist DGLAP evolution leads to negative gluon distribution
- MRST PDF's have the same features

Does it mean that we have no gluons at $x < 10^{-3}$ and $Q=1$ GeV?

No!



$$F_L \propto \frac{\alpha_s}{2\pi} x \int_x^1 \frac{d\xi}{\xi} \xi(1-\xi)\, g\left(\frac{x}{\xi}, Q^2\right) + \ldots$$

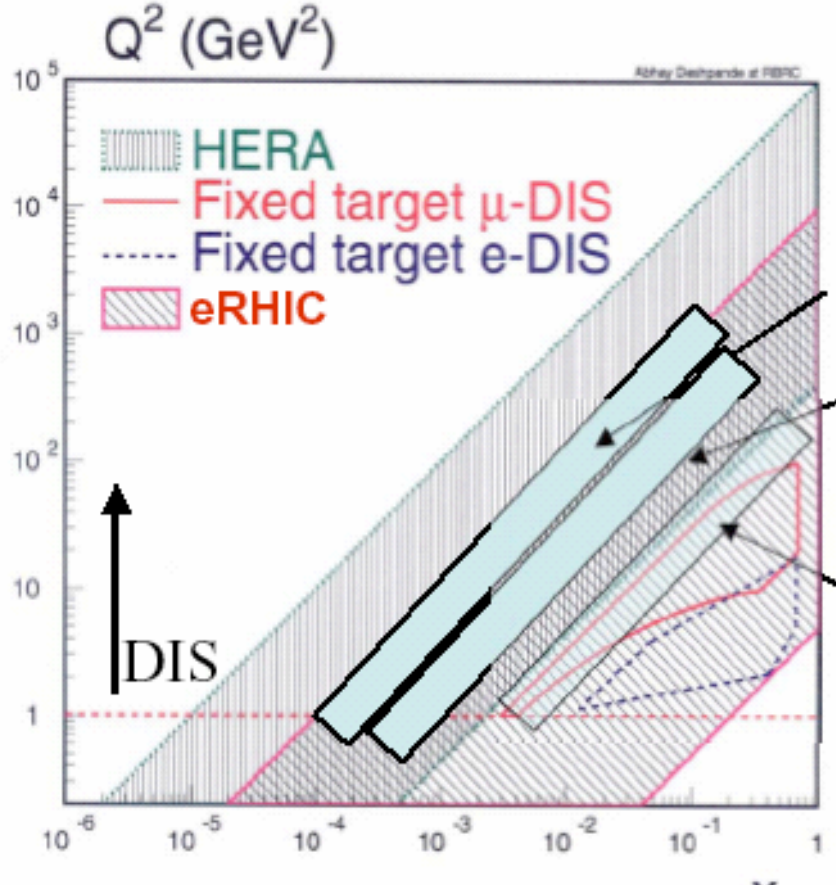


A. Bruell, R. Ent

$\mathcal{L} = 5\,\mathrm{fb}^{-1}$

One observable among many: $dF_2/dLog(Q^2)$, ep→jet+jet+X, charm, …

F_L: EIC & other Measurements



F_L measurement from EIC+HERA

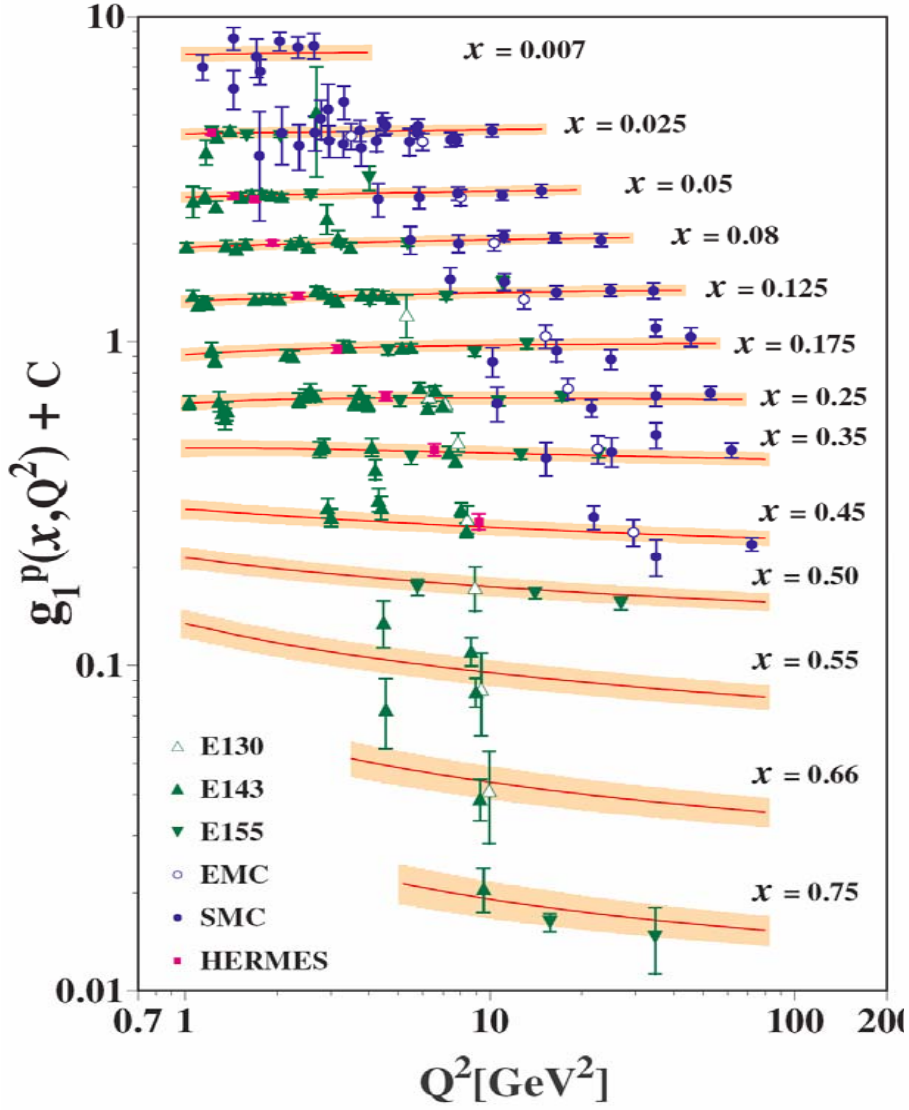
EIC standalone

F_L measurement from EIC+fixed target

EIC is in an optimal energy range to extract F_L via cross section comparisons to previous experiments.

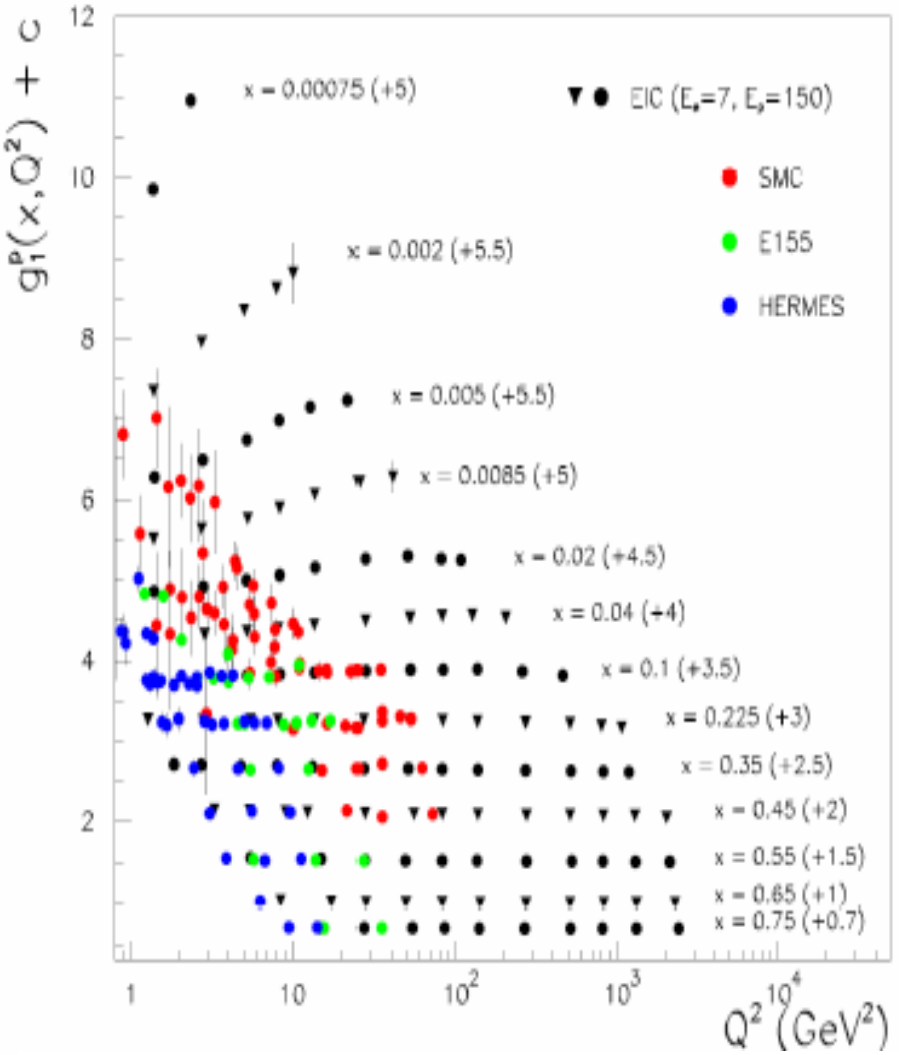
~~ΔG from charm production~~

World Data on g_1^p



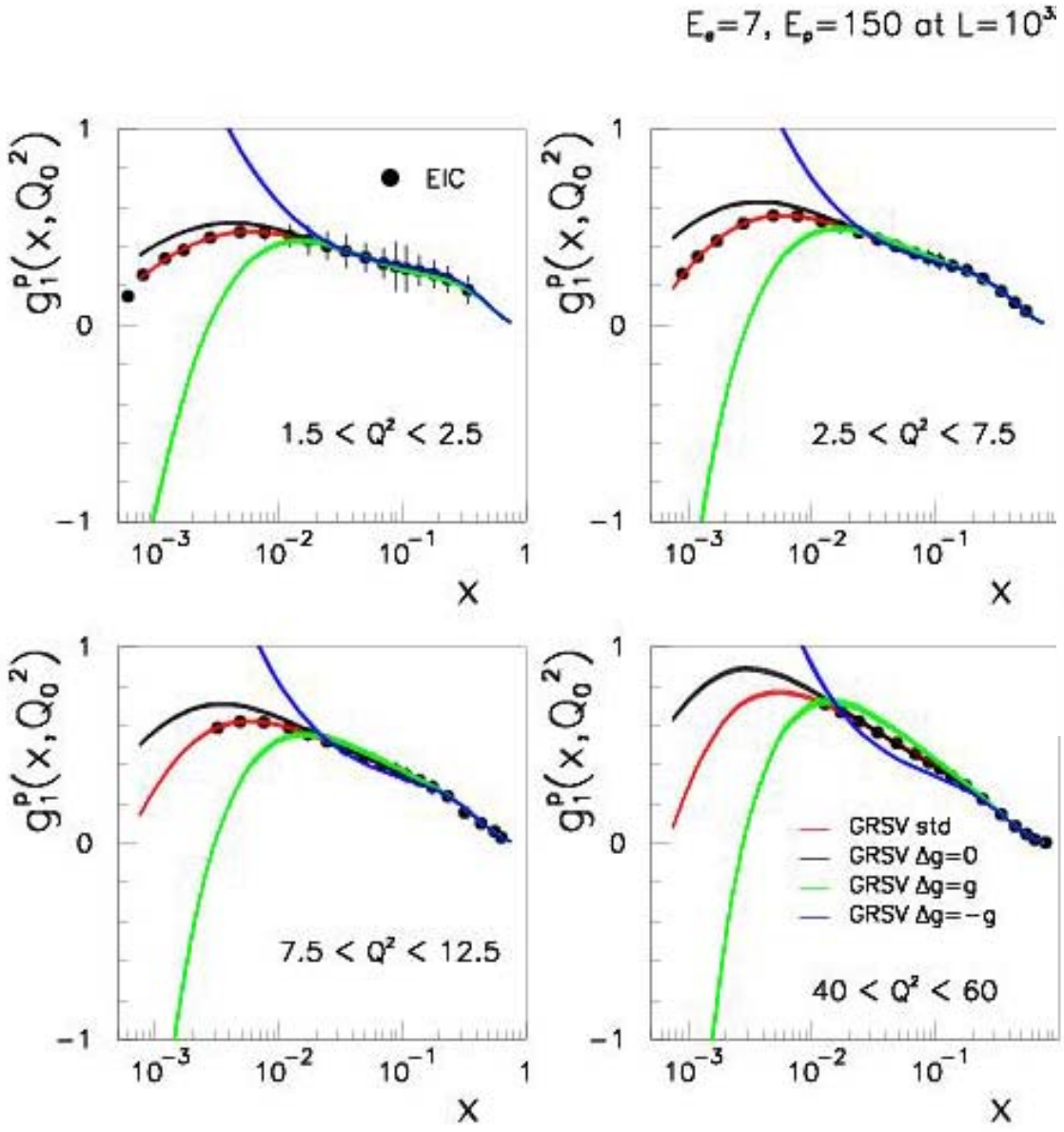
< 2 orders of magnitude, precision !!!

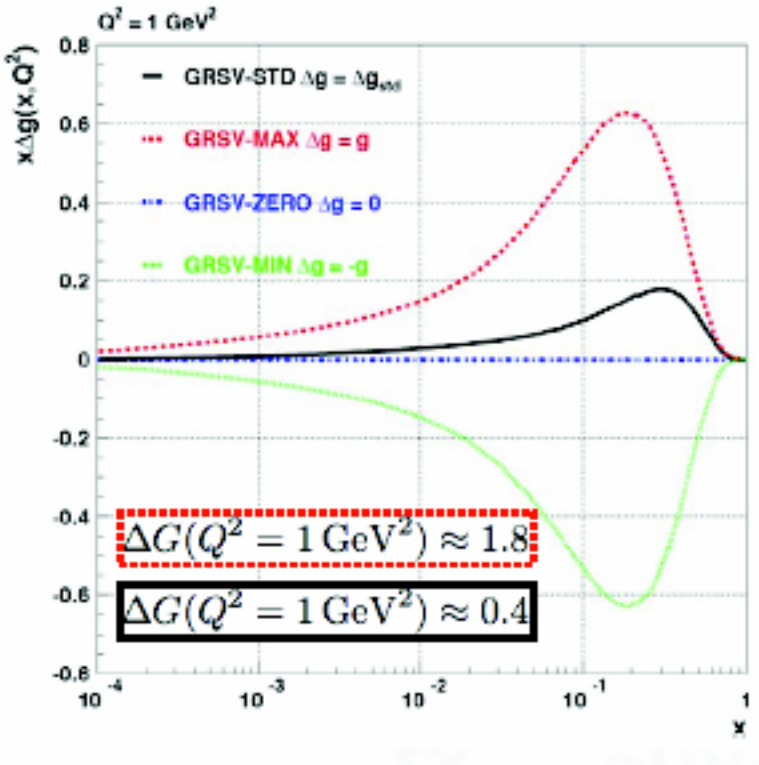
EIC Data on g_1^p



Sufficient coverage in x and Q^2 to detrmine ΔG

ΔG from scaling violations of g_1





- **Bjorken's sum rule**

$$\int_0^1 \mathrm{d}x\, g_1^{ep-en}(x,Q^2) = \frac{1}{6}\frac{g_A}{g_V}\left\{1 - \frac{\alpha_s(Q^2)}{\pi} - \frac{43}{12}\frac{\alpha_s^2(Q^2)}{\pi^2} - 20.215\frac{\alpha_s^3(Q^2)}{\pi^3}\right\}$$

high-order perturbation theory

$$+ \frac{M^2}{Q^2}\int_0^1 x^2\,\mathrm{d}x\left\{\frac{2}{9}g_1^{ep-en}(x,Q^2) + \frac{1}{6}g_2^{ep-en}(x,Q^2)\right\}$$

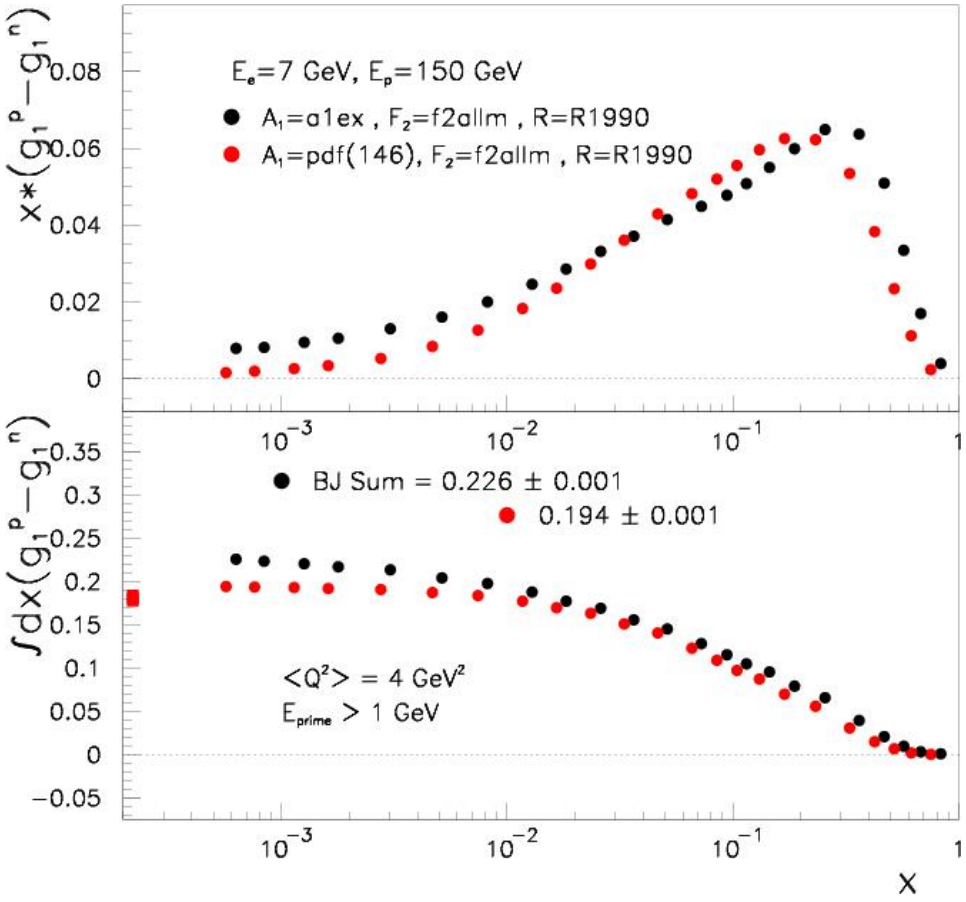
target-mass corrections

$$- \frac{1}{Q^2}\frac{4}{27}\mathcal{F}^{u-d}(Q^2)$$

Twist-4 matrix elements $\sim \langle\, \bar{q}\tilde{F}q \,\rangle$

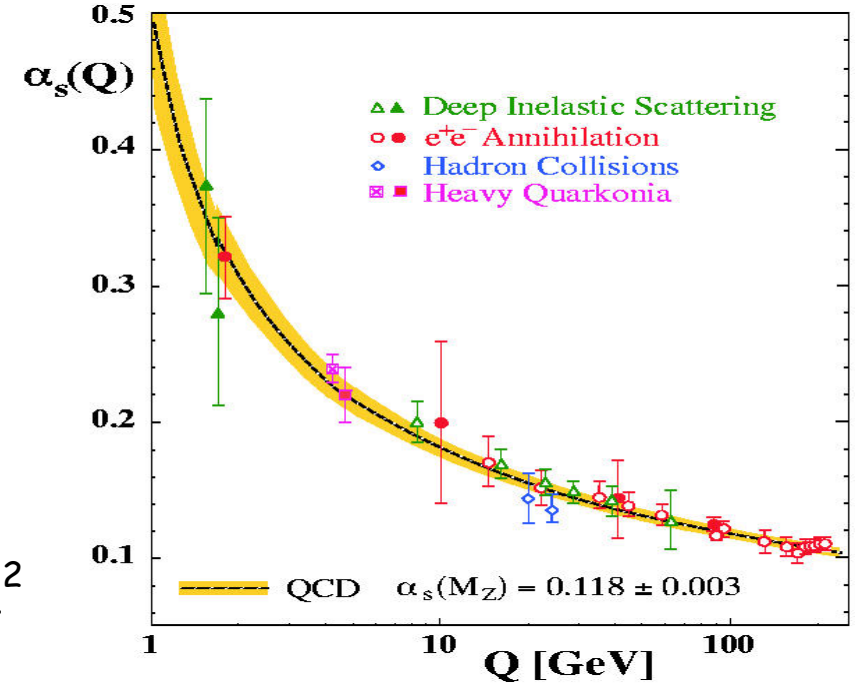
- **Precision QCD. Currently tested at ~10%.**
  Can it be tested at ~1 or 2% ?

Bjorken Sum Rule



Needs:
O(1%) Ion Polarimetry!!!

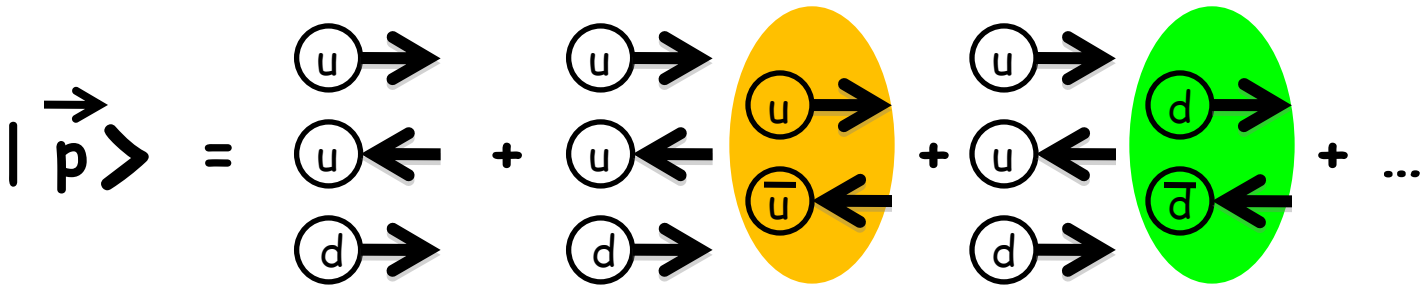
excellent
determination of $\alpha_s(Q^2)$



- Sub-1% statistical precision at ELIC (averaged over all Q^2)
- 3-4% precision at various values of Q^2

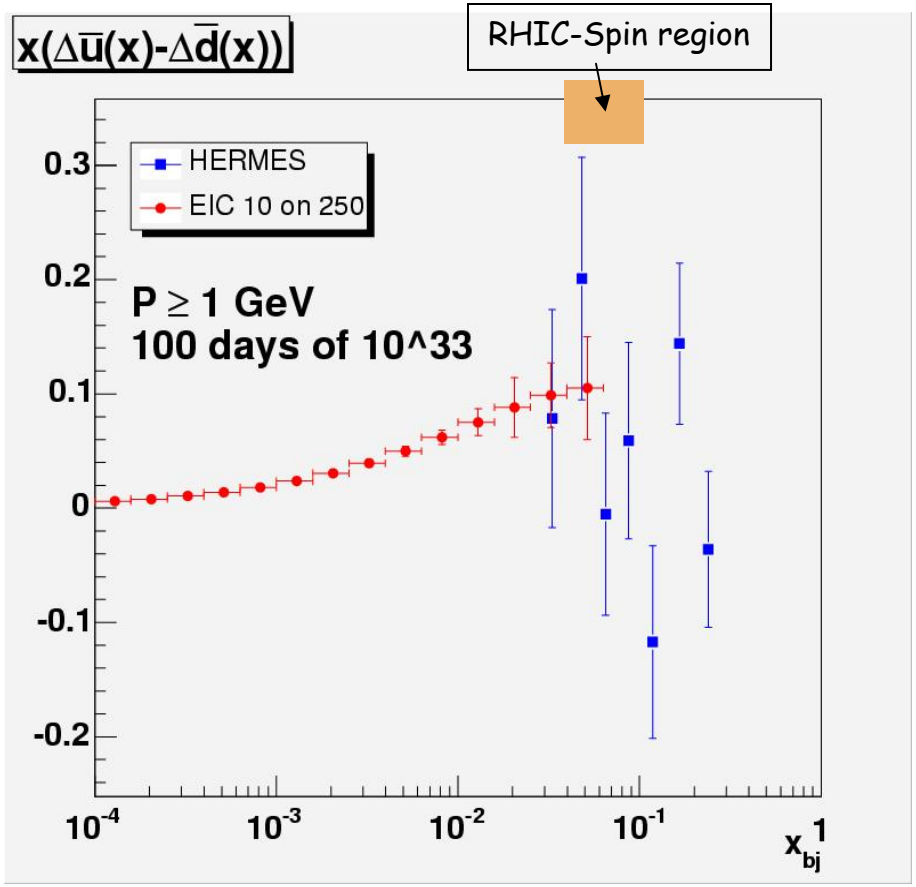
Precisely image the sea quarks

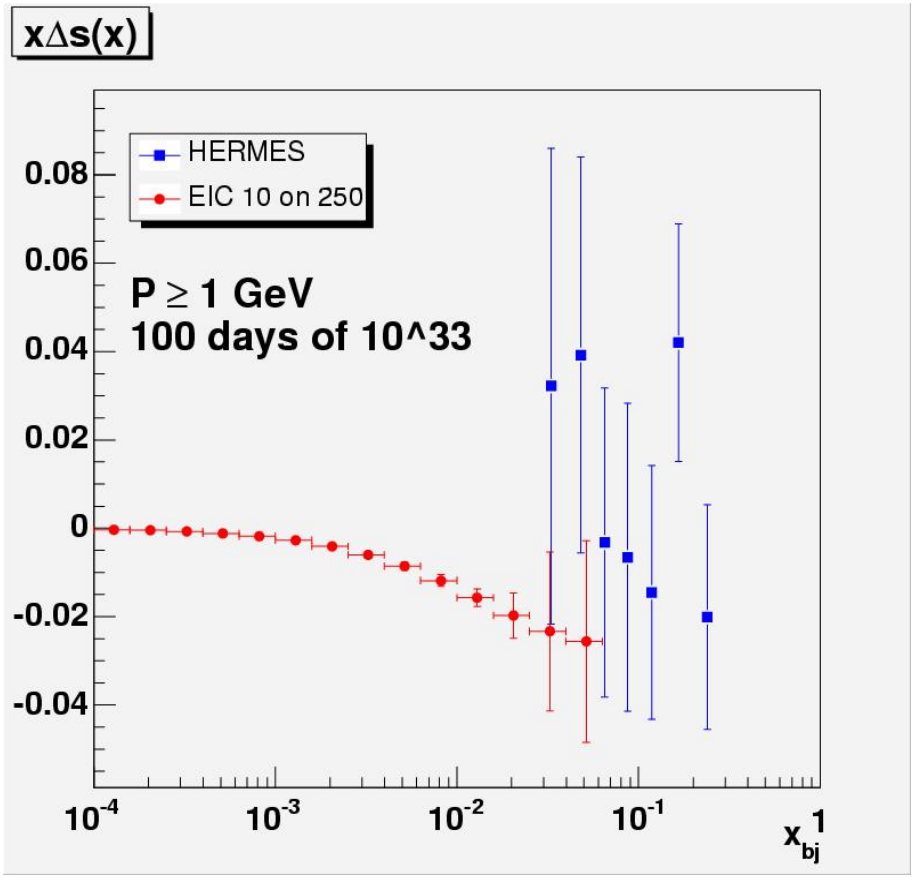
Spin-Flavor Decomposition of the Light Quark Sea



Many models predict

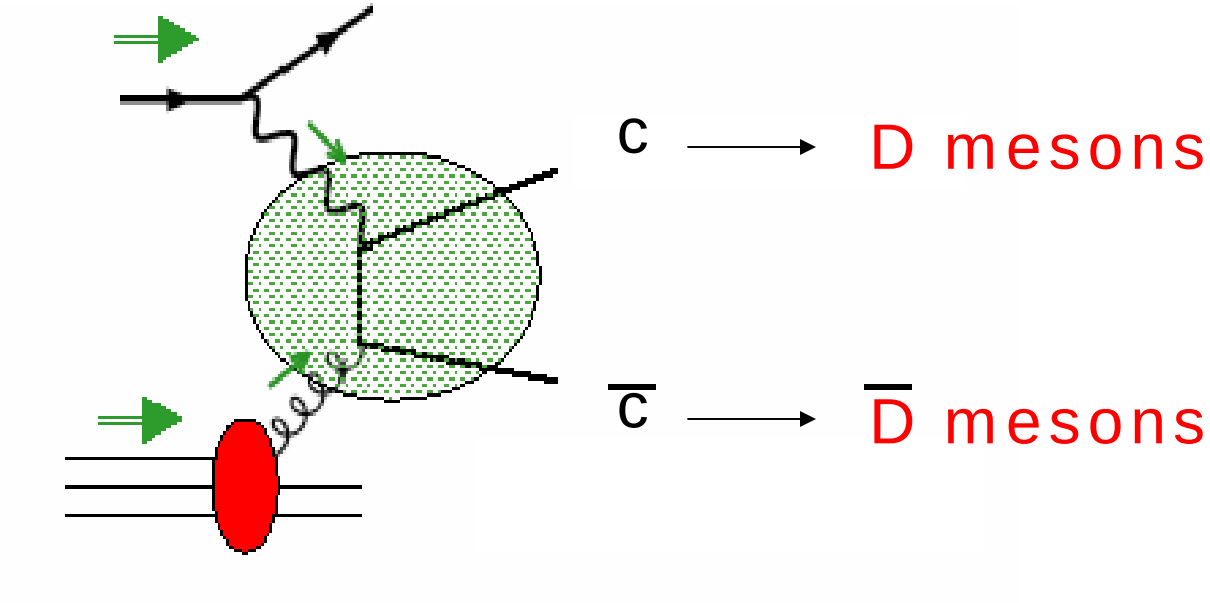
$\Delta\bar{u} > 0, \Delta\bar{d} < 0$





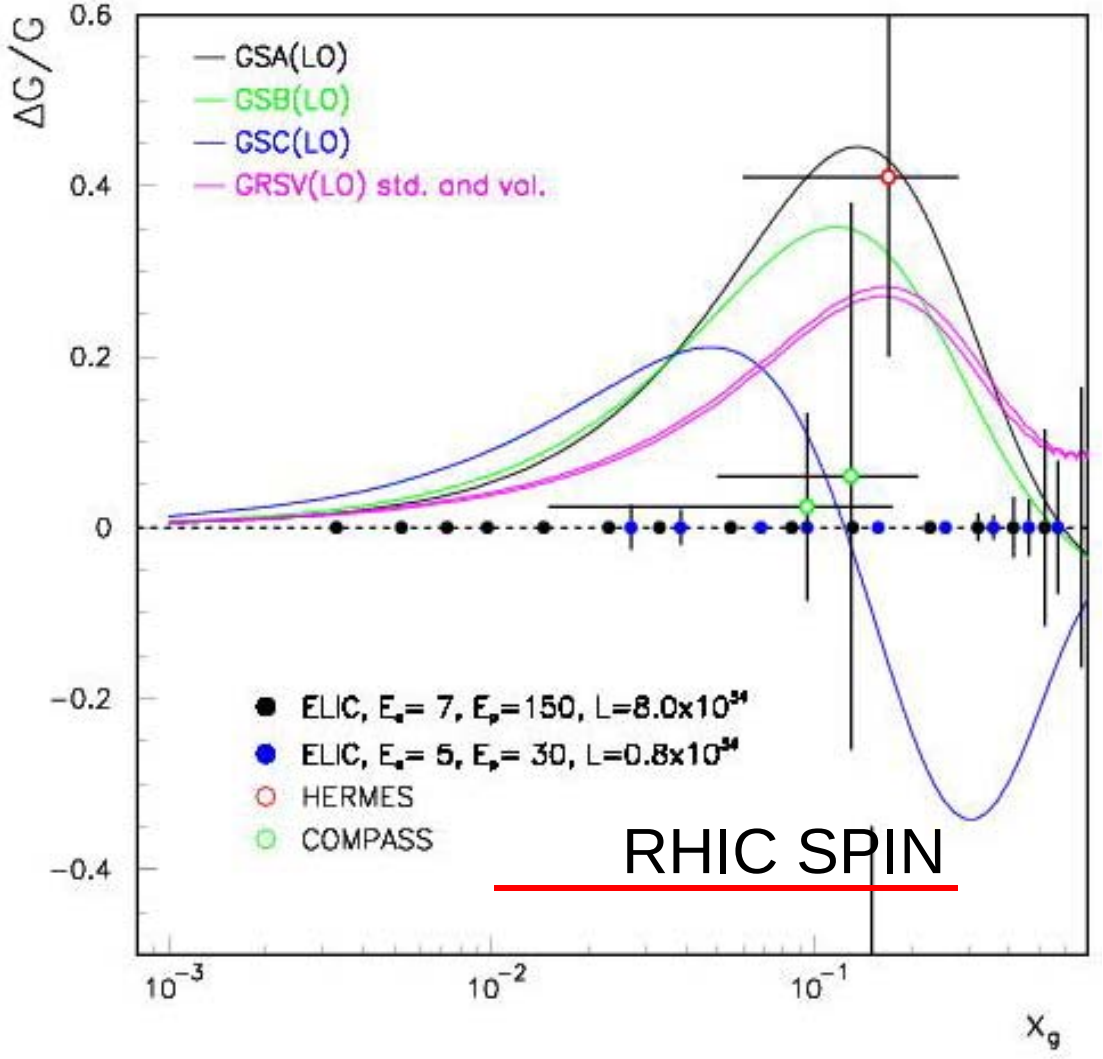
Polarized gluon distribution via charm production

very clean process !



LO QCD: asymmetry in D production directly proportional to $\Delta G/G$

Polarized gluon distribution via charm production



Precise determination of $\Delta G/G$ for **$0.003 < x_g < 0.4$**

at common Q^2 of 10 GeV^2

however...

Polarized gluon distribution via charm production

Precise determination of $\Delta G/G$ for

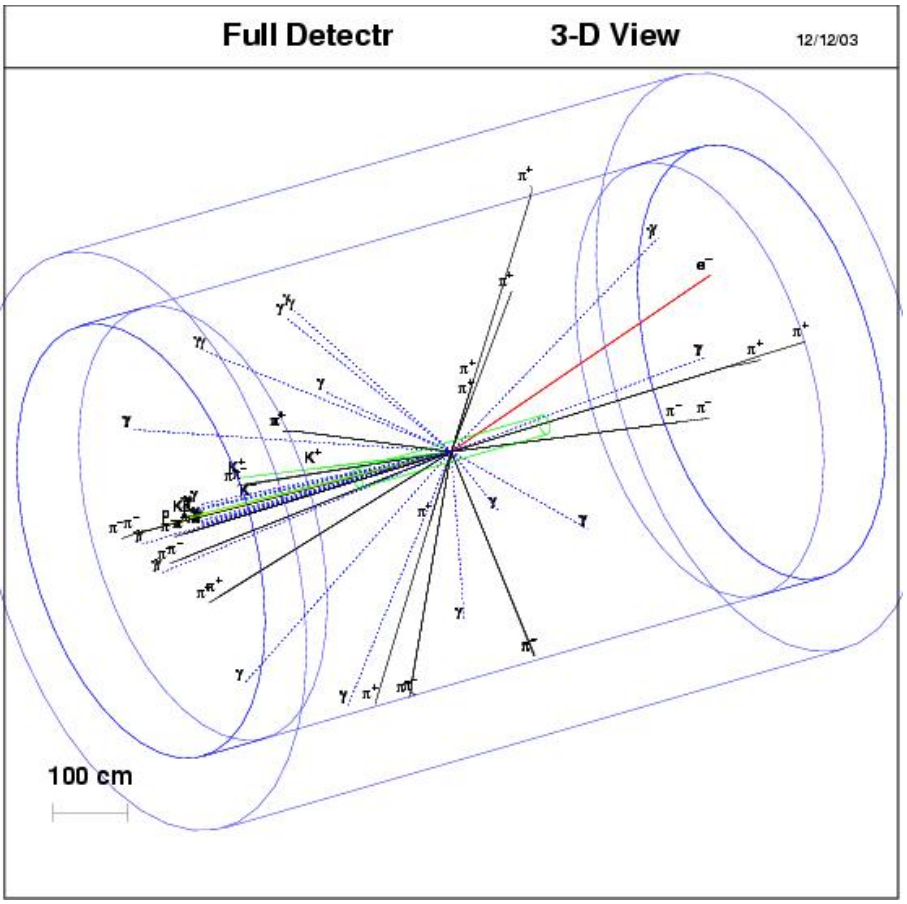
$0.003 < x_g < 0.4$

at common Q^2 of 10 GeV^2

If:

- We can measure the scattered electron even at angles close to 0^0 (determination of photon kinematics)
- We can separate the primary and secondary vertex down to about 100 μm
- We understand the fragmentation of charm quarks (🗐)
- We can control the contributions of resolved photons
- We can calculate higher order QCD corrections (🗐)

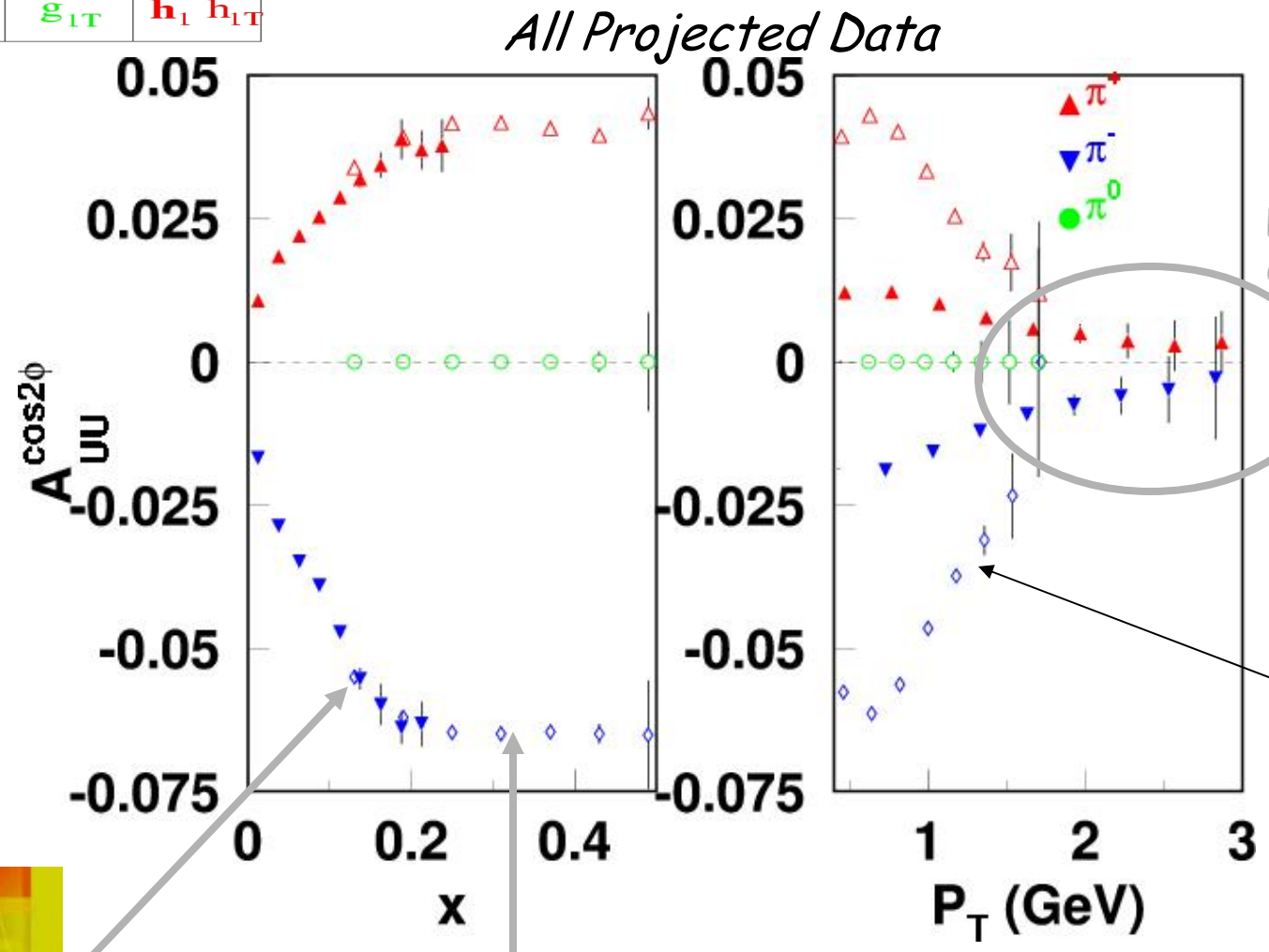
charm production: detector consequences



- Need to measure the scattered electron at angles close to 0^0 ➔ how ?
- Need to separate the primary and secondary vertex down to about 100 μm ➔ how to determine the primary vertex ?
- For charm decay products need to instrument only ± 15-20^0 around proton direction
- Simple set of silicon disks might be sufficient for vertex detection
- Momenta of decay products between 1.5 and 10(15) GeV

Correlation between Transverse Spin and Momentum of Quarks in Unpolarized Target

N \ q	U	L	T
U	f_1		$h_1^\perp$
L		g_1	$h_{1L}^\perp$
T	$f_{1T}^\perp$	g_{1T}	h_1 $h_{1T}^\perp$



ELIC

Hard exclusive processes at collider energies

$W^{\gamma^* p} > 10$ GeV

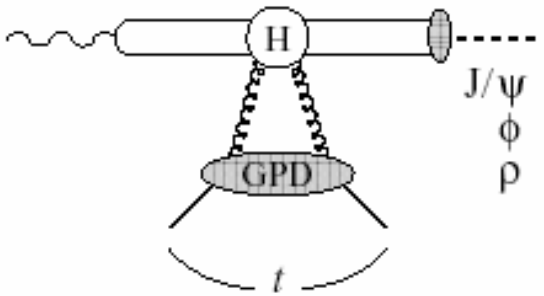
- "Diffractive" channels: J/ψ, ϕ, ρ^0, γ (DVCS)
  - Cross sections grow with energy
  - Probe gluon and singlet quark GPDs
  - Need to be studied together!

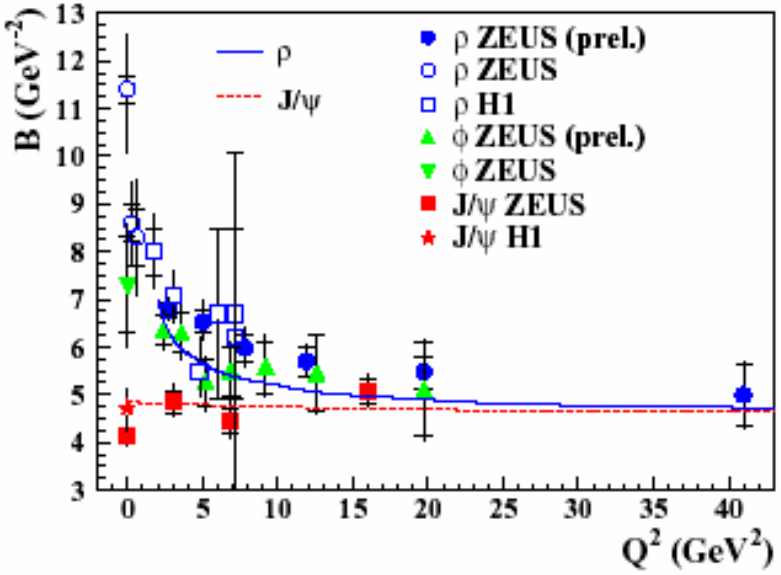
"Transverse gluon imaging of nucleon"

- "Non-diffractive" channels: π, η, K, $\rho^+, \ldots$
  - Cross sections small, do not grow with energy
  - Probe spin/flavor/charge non-singlet GPDs
  - Comparisons between different channels

"Spin/flavor structure of nucleon"

Diffractive channels: HERA results





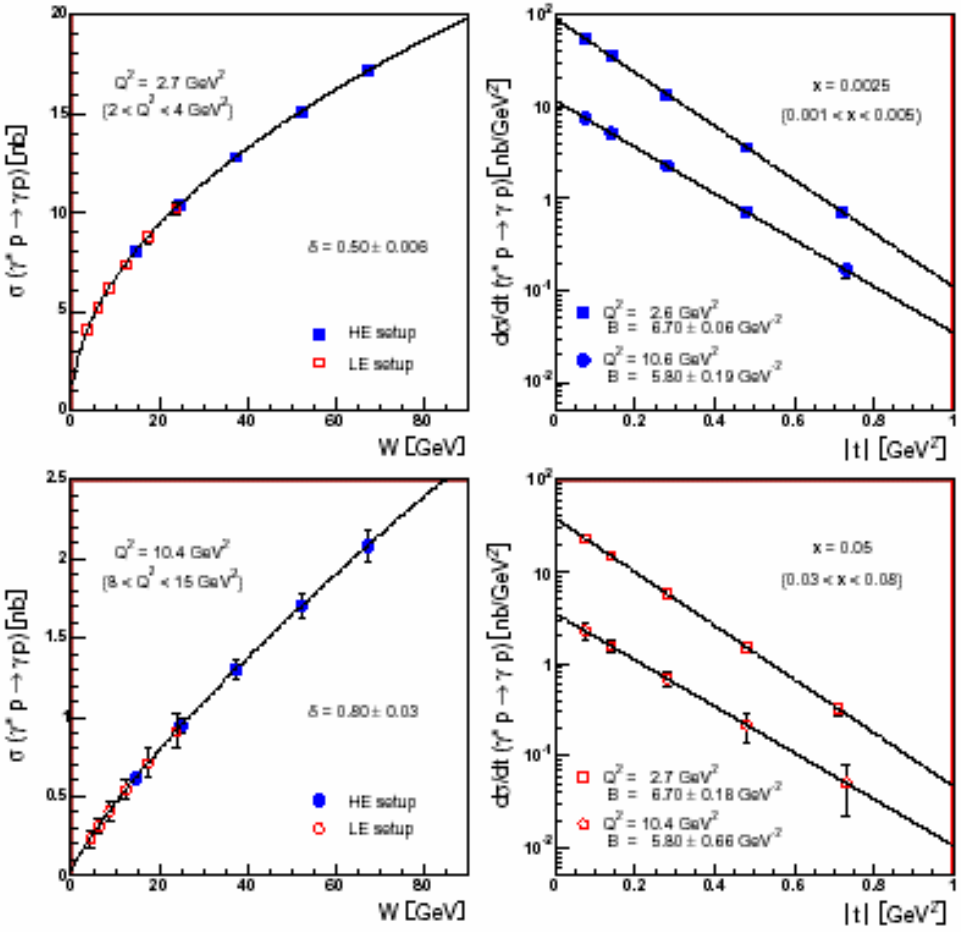
[Levy; Frankfurt, Strikman, CW 05]

- LO QCD factorization $\leftrightarrow$ Dipole picture
  Gluon GPD $\leftrightarrow$ Color dipole moment

- Measurements of diffractive channels $(J/\psi,\ \phi,\ \rho,\ \gamma)$ have confirmed applicability of QCD factorization:
  - Energy dependence changes with Q^2
  - t–slopes universal at high Q^2
  - Flavor relations $\phi : \rho$

- Transverse gluonic size of nucleon
  . . . essential input for small–x physics!

Diffractive channels: EIC projections



[DVCS with eRHIC HE/LE, $530/180\,\mathrm{pb}^{-1}$
A. Sandacz, GPD White Paper (2007)]

- Aim: Transverse gluon/singlet quark imaging of nucleon over wide range $10^{-3} < x < 10^{-1}$
- Requirements:
  - $Q^2 \sim$ 10–20 GeV^2: Factorization
  - Wide Q^2–range: Leading/higher twist, QCD evolution
  - Wide W–range: x–dependence, overlap with fixed–target
  - Luminosity: Differential measurements in W, Q^2, t

Feasible with high–luminosity EIC; need to work out details

Summary and Next Steps

- **goals:**
  - realistic estimates for key processes
  - consequencs for detector design for all key processes
- **status:**
  - realistic estimates for very few processes
  - hardly any idea about detector constrains
  - simulation of some more processes just started
  - several interested people identified
- **next steps:**
  - continue in identification of people interested/capable to do some real work
  - start working group meetings (around collaboration meetings)