Physics Topics: 1997/99 Workshops

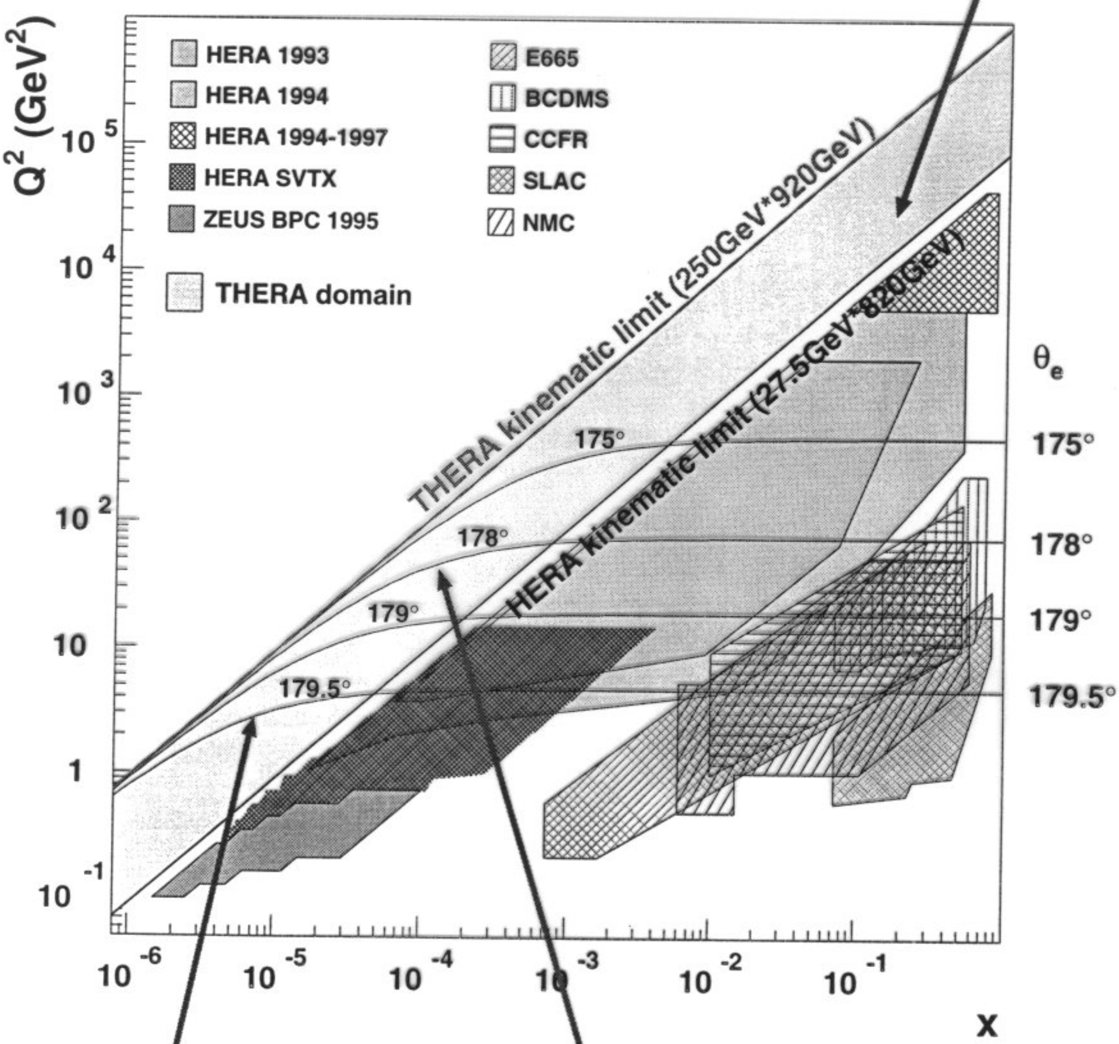
- Polarized Structure Functions g_1, g_5, g_2 $\surd\surd$
- Polarized Gluon Distribution ΔG:$\surd\surd$
  - NLO-pQCD fits of g_1
  - Di-Jet events in DIS
  - 2-Track events in DIS
  - Combined fits: g_1 + Di-Jets
  - Photoproduction
- Polarized semi-inclusive measurements $\surd$
- Polarized parton distribution in photon Δq^{γ} $\surd\surd$
- Diffraction/Vector Meson
- DHG Sum rule: $(\sigma_{\uparrow\downarrow} - \sigma_{\uparrow\uparrow})$ at $Q^2 = 0$$\surd\surd$
- $(W^{\pm}, Z^0)$ Production
- High Q^2 anomaly $\rightarrow$ polarized HERA$\surd\surd$
- Target fragmentation $\surd\surd$
- Λ Polarization $\surd$
- Deeply virtual polarized Compton scattering $\surd$
- $\vec{p}\vec{p}$ scattering with HERA-$\vec{N}$ $\surd\surd$

Green: Not good; $\surd$: Good; $\surd\surd$: Very Good

The THERA outreach

Extend HERA range by
~ 1 order of magnitude
to higher x and Q^2

+ "electroweak region"
+ new phenomena?
− small cross sections



Reach $x =$ a few $\times 10^{-6}$
at $Q^2 \gtrsim 1\,\text{GeV}^2$

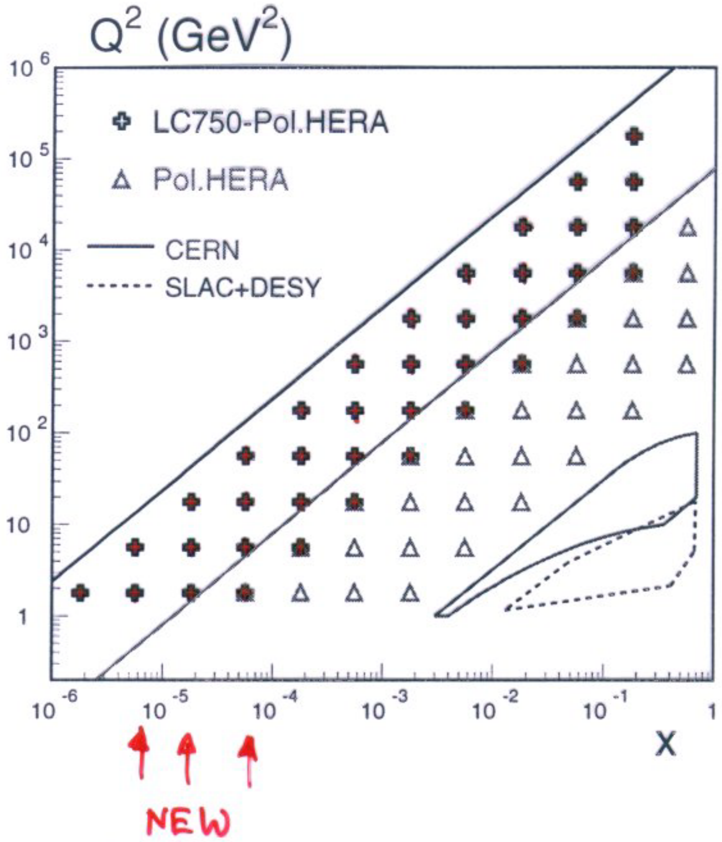
+ high parton densities
+ new QCD effects
+ large cross section
− difficult to measure

Cover one decade of Q^2
in perturbative regime
for $x \sim 10^{-4}$

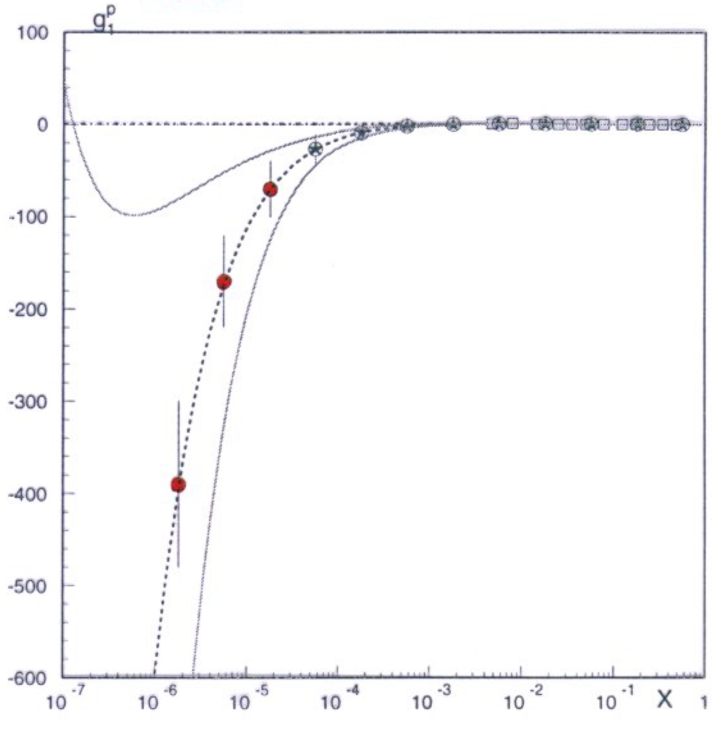
+ onset of pQCD
+ gluon density, α_s, ...
+ forward jets, ...

Linear Collider on Polarized HERA

A. Deshpande



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



LARGE EXTENTION OF Q^2 RANGE

... BUT LUMINOSITY !

IMPORTANT :

* VALID EVENTS ARE AT HIGH y (DEPOLARIZATION FACTOR) $\left(y = \frac{Q^2}{x \cdot s}\right)$

* PRECISION

$$A_m \approx 10^{-4}$$

$$\delta A_m = \frac{1}{\sqrt{N_{tot}}}$$

$$A_m = \frac{N^{\uparrow\uparrow} - N^{\uparrow\downarrow}}{N^{\uparrow\uparrow} + N^{\uparrow\downarrow}} = P_p P_e D \cdot A_1$$

LOW x EXTRAPOLATION

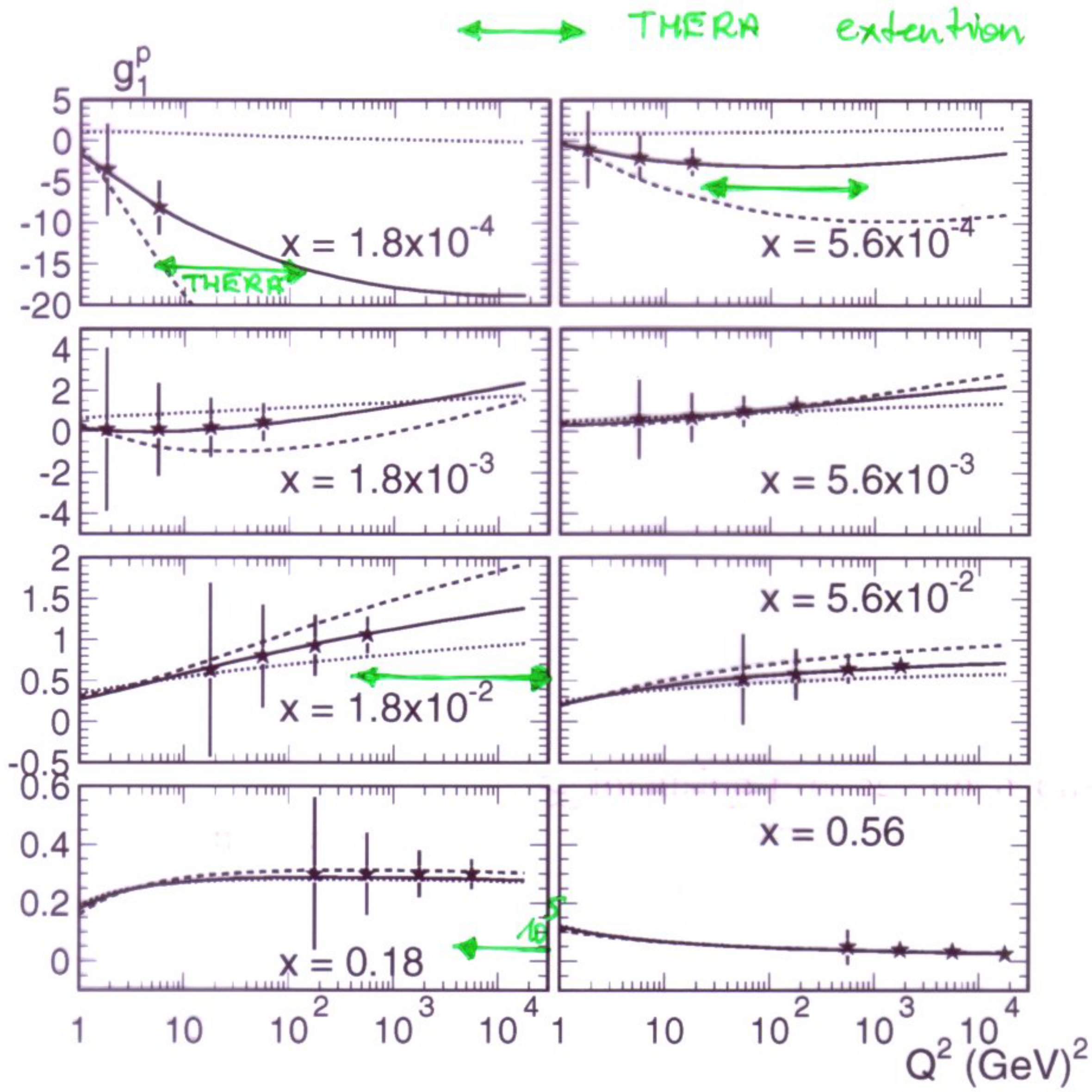
- PREDICTIONS q^{NS} EASIER

q^{SI} IMPORTANT CORRECTIONS

$\Rightarrow$ g_2 REQUIRES TRANSVERSE PROTON POLARIZATION

MORE DATA COMMING FROM SLAC

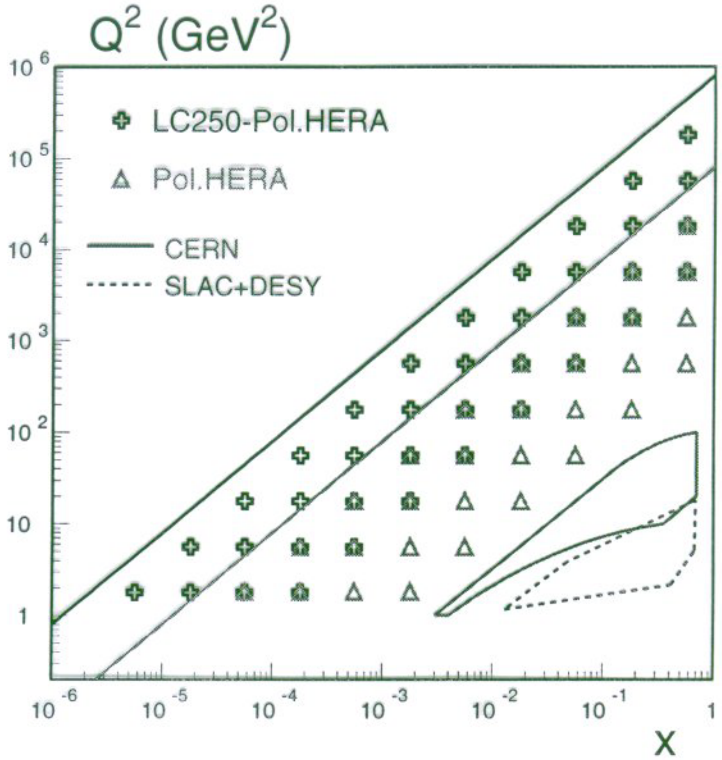
g_1^p at HERA vs. Q^2

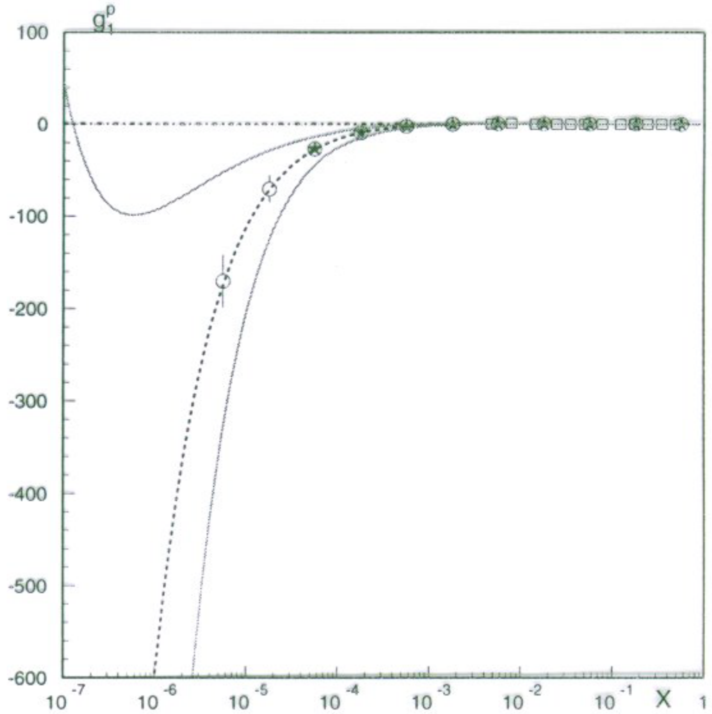


Standard Fit
Minimal Gluon Fit, $\Delta G(Q^2 = 1\ \mathrm{GeV}^2) = 0$
Maximal Gluon Fit, $\Delta G(Q^2 = 1\ \mathrm{GeV}^2) = a_8$

Linear Collider on Polarized HERA

A. Deshpande





OVERLAP WITH HERA $x \approx 10^{-6}$

NEW DEVELOPEMENT (THIS SUMMER)

eRHIC in BNL becomes more realistic
(after 2007)

e linear accelerator 10-15 GeV

+ p and/or A from RHIC 250-325 GeV
POLARIZED

place for additional detector exists

$\sqrt{s} \sim \frac{1}{2}$ HERA

also option for lower energy
(≈ 30 GeV) if joined effort
with MIT EPIC project

* HIGH LUMINOSITY

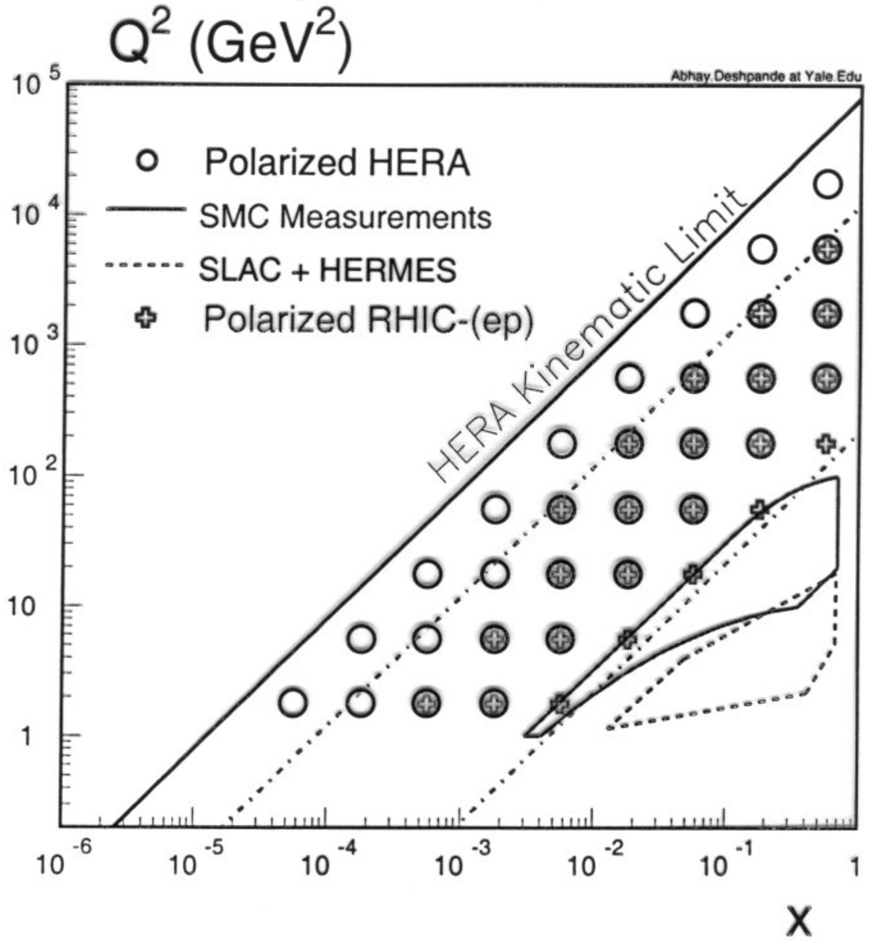
* POLARIZATION AVALIABLE

* IDEA TO LOOK AT VERY LOW x WITH NUCLEI
($x \approx 10^{-8} \div 10^{-9}$ POSSIBLE

BUT WOULD NEED CROSS CHECK
WITH <u>ep</u>

An Electron Ring in RHIC Tunnel

- Possible 10-12 GeV electron ring in RHIC tunnel (??)
- Will enable $e \cdot A$ and $\vec{e} \cdot \vec{p}$ scattering
- $\vec{e} \cdot \vec{p}$ Collisions with $\sqrt{s} \sim 100$ GeV $\Longrightarrow$ A Mini-Hera
  Recall for HERA $\sqrt{s} \sim 300$ GeV



- Physics program similar to Polarized HERA: but somewhat limited Is this enough?
  Luminosity issues might be crucial
- e-p beam energy imbalance similar to HERA $\longrightarrow$ New detector?
- Dedicated studies needed

$\Rightarrow$ g_5

INCLUSIVE CC CROSS SECTION ASYMMETRY

$$ep \rightarrow \nu_e X$$

$$A_{cc} = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} = \frac{a \cdot g_5^{W^\pm} + b\, g_1^{W^\pm}}{a \cdot F_1^{W^\pm} + b\, F_3^{W^\pm}}$$

$$g_5^{W^-} = -(\Delta u - \Delta \bar{d} + \Delta c - \Delta \bar{s} \ldots)$$

$$g_5^{W^+} = -(\Delta d - \Delta \bar{u} + \Delta s - \Delta \bar{c} \ldots)$$

LARGE ASYMMETRIES

REQURED STATISTICS SIMILAR AS FOR UNPOLARIZED PROGRAM

QUANTITY SENSITIVE TO ΔG

1 JET ASYMMETRY VS RAPIDITY

($\sim 100\ pb^{-1}$)

DETERMINATION OF $\Delta q_v = \Delta q - \Delta \bar{q}$

$\simeq$ DIRECTLY

BUT HERE LOW x NOT SO INTERESTING, Q^2 DEP.

GLUON POLARIZATION

* QCD FITS TO g_1
* 2 JET EVENTS
* 2 HIGH p_T TRACKS
* $c\bar{c}$, $b\bar{b}$ PRODUCTION

(UNREALISTIC WITH COLIDER OPTIONS)

↳ lower x_g , SMALL SPIN ASYM.

↓

IF NO SURPRISES

BETTER IN γp OPTION

BUT ALSO AT THE LIMIT

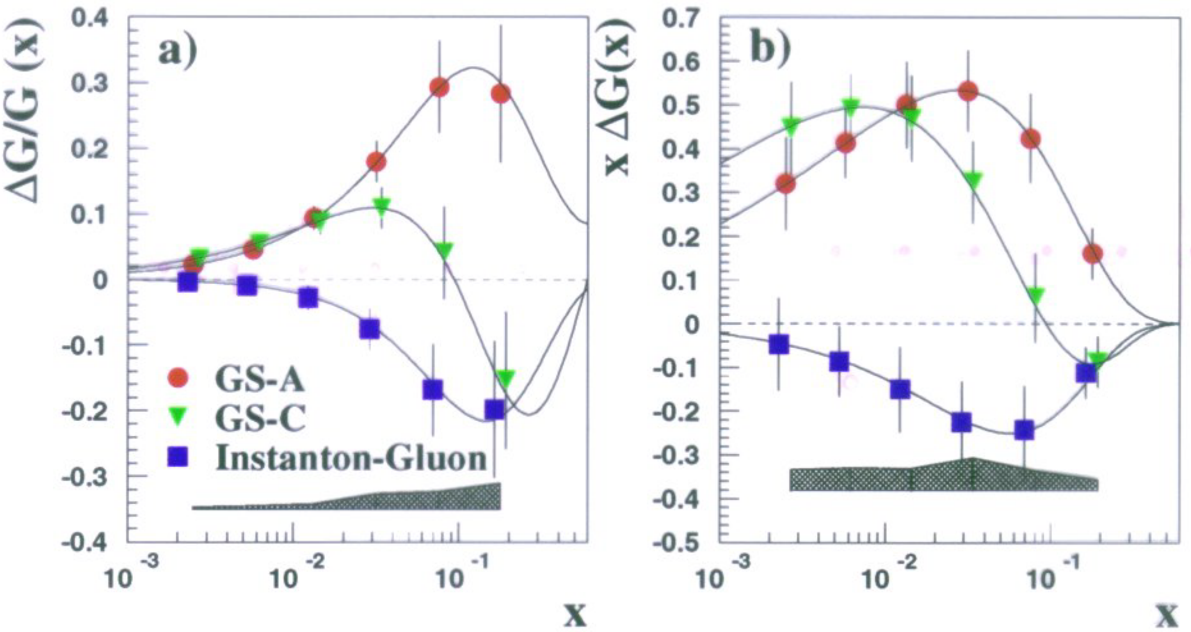
FIXED TARGET ?

ΔG from Di-Jet Production

A. De Roeck, M. Maul, G.Rädel

- **MC Simulation:** signal + background; hadronization, higher order effects via parton showers
- **Event Selection:**
  $\Longrightarrow 5 \leq Q^2 \leq 100\ \mathrm{GeV}^2$
  $\Longrightarrow 0.3 \leq y \leq 0.85$
  $\Longrightarrow p_T^{\mathrm{Jet}} \geq 5\ \mathrm{GeV}$
  $\Longrightarrow |\eta_{\mathrm{Lab}}^{\mathrm{Jet}}| \leq 2.8;\qquad \eta_{\mathrm{Lab}}^{\mathrm{Jet}} = -\ln\left[\tan(\theta^{\mathrm{Jet-p}}/2)\right]$
- **Detector effects** included

Gluon extracted at Leading Order at $Q^2 = 20\ \mathrm{GeV}^2$ assuming integrated luminosity $\mathcal{L} = 500\ \mathrm{pb}^{-1}$



Di-Jets analysis will measure the polarized gluon distribution accurately

It will map the region: $0.002 \leq x_g \leq 0.2$

Next to Leading Order Corrections Small: $\sim 10\%$

E. Mirkes & S. Willfahrt

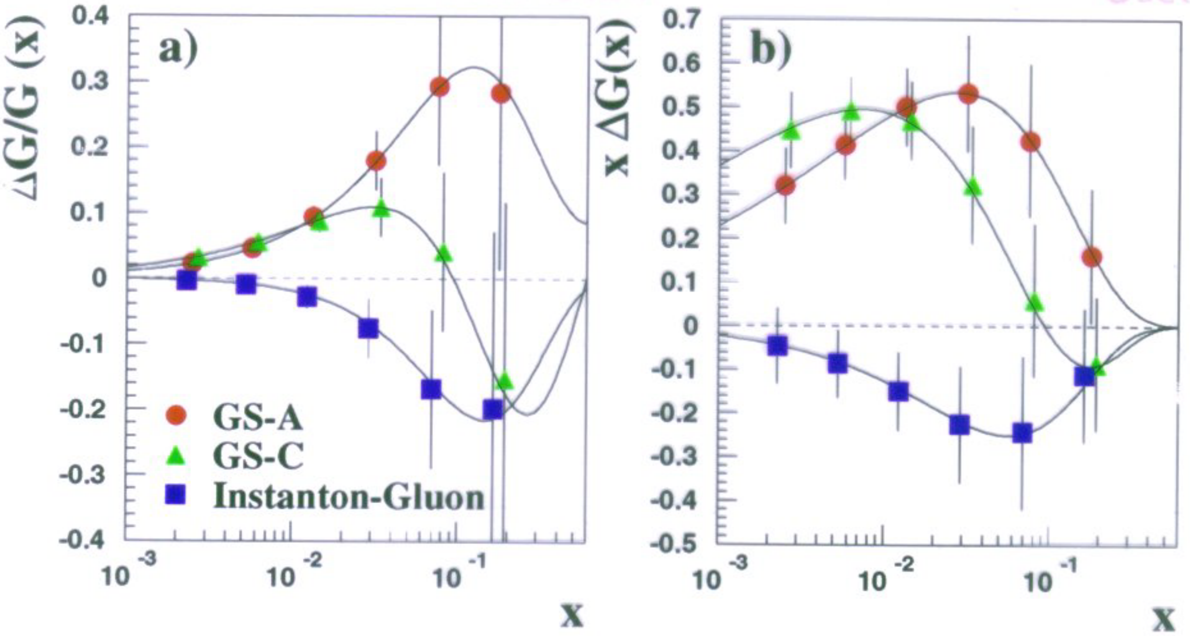
ΔG From High-p_T Hadrons at HERA

A. De Roeck, G. Rädel

Event Selection:

- $5 \le Q^2 \le 100\ \mathrm{GeV}^2$
- $0.3 \le y \le 0.85$
- $p_T^{had} > 1.5\ \mathrm{GeV}$
- $-1.5 < \eta_{Lab}^{had} < 2.5$
- $|\eta_{had1} - \eta_{had2}| < 2$
- $|\phi_{had1} - \phi_{had2}| < 60^o$

Gluon extracted at Leading Order at $Q^2 = 20\ \mathrm{GeV}^2$
assuming integrated luminosity $\mathcal{L} = 500\ \mathrm{pb}^{-1}$



- Results similar to Di-Jet analysis
  - Worse at high x: Can be improved??
  - Reaches lower x
- 2-Jet/2-Hadron event sample overlap $\sim 40\%$

MORE EXOTIC TOPICS :

SPIN DEPENDENCE WILL BRING EXTRA INFORMATION FOR

- CONTACT INTERACTIONS

  (AT HERA $\underbrace{\text{SENSITIVITY}}_{\text{SCALE}}$ ~ 7 TeV)

- TARGET FRAGMENTATION

- CORRELATIONS ?

Most Sensitive Asymmetries

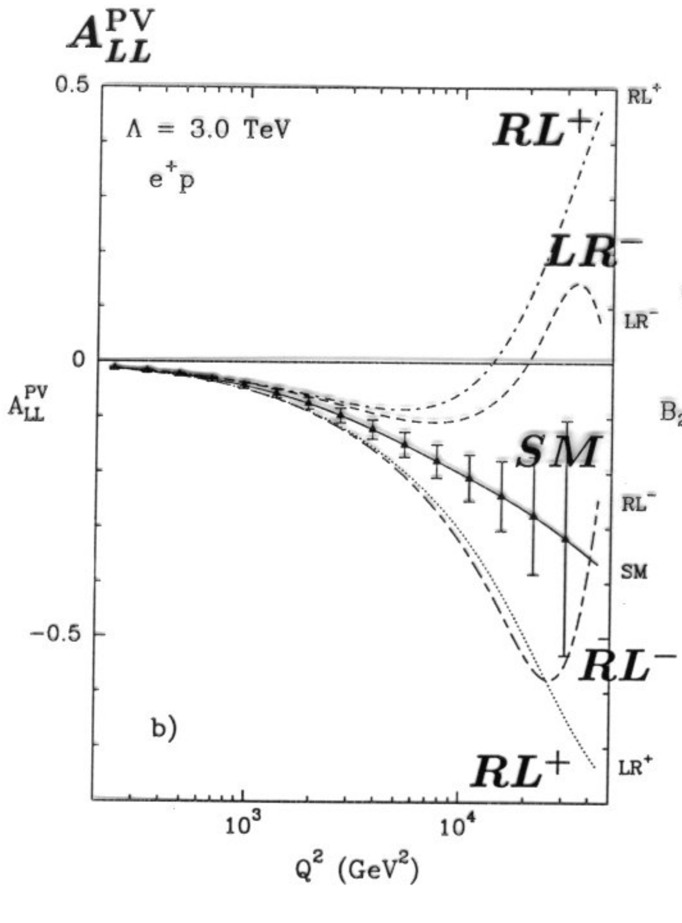
Partity Violating

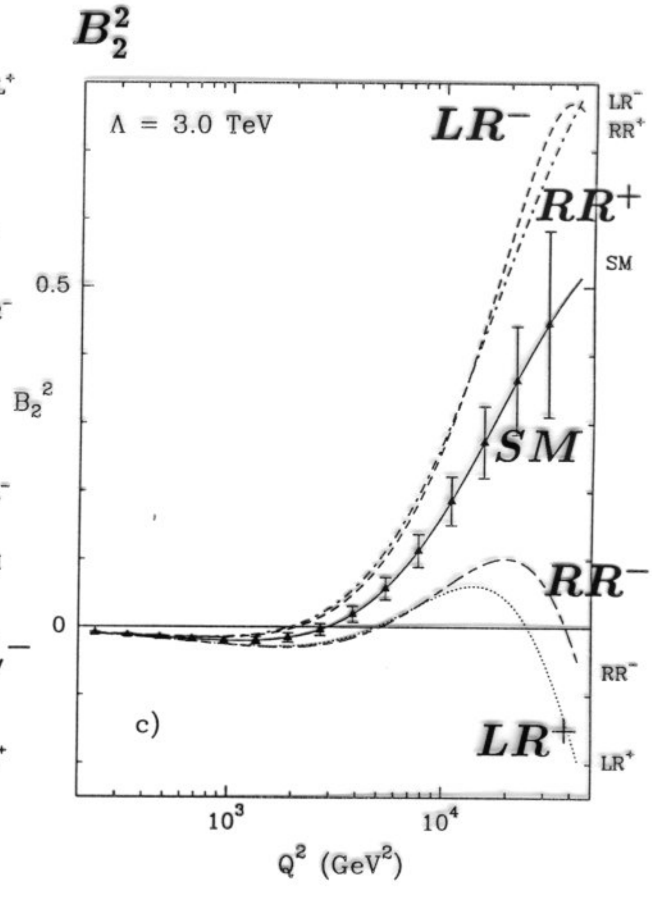
$$A_{LL}^{PV} = \frac{\sigma^{--}{}_{+} - \sigma^{++}{}_{+}}{\sigma^{--}{}_{+} + \sigma^{++}{}_{+}}$$

"Mixed"

$$B_2^2 = \frac{\sigma_{-}^{++} - \sigma_{+}^{++}}{\sigma_{-}^{++} + \sigma_{+}^{++}}$$

Helicity structure sensitivity up to scales ~ 7 TeV





Helicity structure of the new interaction could be probed/resolved

SUMMARY :

- THERA CAN BRING EXTENTION IN $x - Q^2$ COVERAGE FOR BASIC MEASUREM. OF SPIN DEP. STR. FUNCTIONS
  - ↳ IMPORTANT FOR QCD TESTS
- ΔG MEASUREMENTS POSSIBLE, BUT EXTENTION TO THE REGION WHER VERY SMALL EFFECTS EXPECTED (IF NO SURPRISES)
- IF CONTACT INTERACTIONS SEEN – IMPORTANT CONSTRAINTS CAN BE OBTAINED
- NEW STRUCTURE FUNCTION g_5 IN CC