PHYSICS WITH POLARISED PROTONS AT HERA

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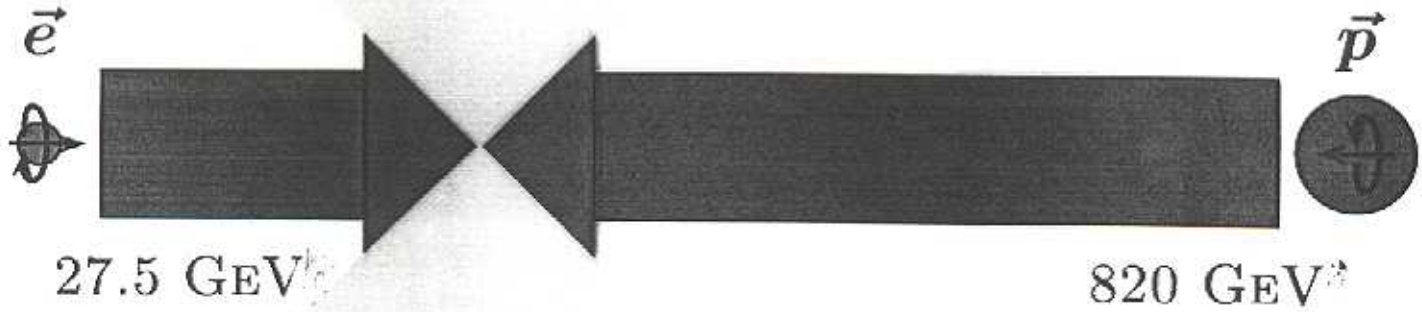
CERN/DESY

BNL, RHIC-SPIN, APRIL 27-29, 1998



$\sqrt{s} = \mathbf{300}$ GeV

SUMMARY

★ BEHAVIOUR OF $g_1(x, Q^2)$ AT SMALL x AND LARGE $Q^2 \rightarrow$ TIGHT CONTRAINTS ON QCD FITS

★ $\Delta G(x, Q^2)$ FROM SEVERAL METHODS:
– TRACKS AND JETS: SHAPE OF $\Delta G(x, Q^2)$ IN THE RANGE $0.002 < x_g < 0.2$
– NLO FITS TO g_1: $\delta \int \Delta G dx \rightarrow 20\%$
– NLO FITS g_1+JETS: $\delta \int \Delta G dx \rightarrow 10\%$
– PHOTOPROD. OF JETS AND HIGH P_T TRACKS

★ POLARISED PARTON DISTRIBUTIONS IN THE PHOTON Δq_γ FROM PHOTOPRODUCTION STUDIES

★ DIRECT DETERMINATION OF $\Delta q_V = \Delta q - \Delta \bar{q}$ FROM CHARGED CURRENT EVENTS

★ $\vec{N}N$ AND $\vec{N}\vec{N}$ SCATTERING AT $\sqrt{s} = 40$ GEV: SHAPE OF $\Delta G(x, Q^2)$ FOR $0.1 < x_g < 0.4$

...AND MUCH MORE

MANY OF THESE ARE UNIQUE TO HERA

STATUS

- MACHINE + PHYSICS REVIEW WORKSHOP PLANNED FOR $\approx$ MAY '99
- $\vec{e}\vec{p} \geq 2004$?

POLARIZED HERA

HUNTING ΔG...

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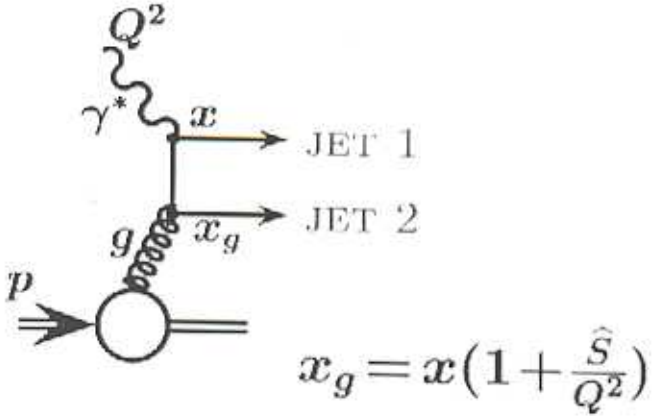
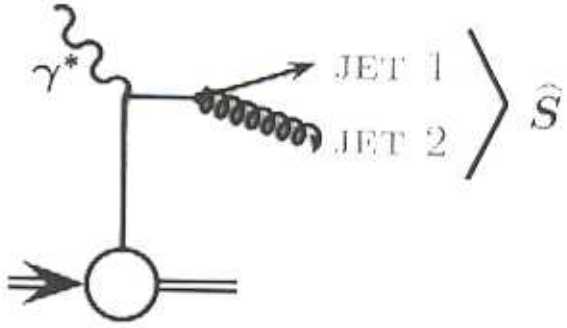
HTTP://WWW.DESY.DE/~GEHRT/HERASPIN

★ ΔG FROM NLO FITS TO g_1 "INDIRECT"

★ ΔG FROM 2-JET EVENTS (LO) "DIRECT"





"BOSON GLUON FUSION (BGF)" SIGNAL

"QCD-COMPTON" BACKGROUND

★ ΔG FROM 2-HIGH-p_T TRACKS WITH OPPOSITE AZIMUTH, SAME DIAGRAMS AS ABOVE EXCHANGE "JET" $\leftrightarrow$ "TRACK"

★ ΔG FROM A COMBINED FIT (g_1 + JETS)

★ ΔG FROM JETS/TRACKS IN PHOTOPRODUCTION DATA

★ ΔG FROM VECTOR MESON AND CHARM PRODUCTION ⊖ AT HERA

ΔG FROM g_1^p

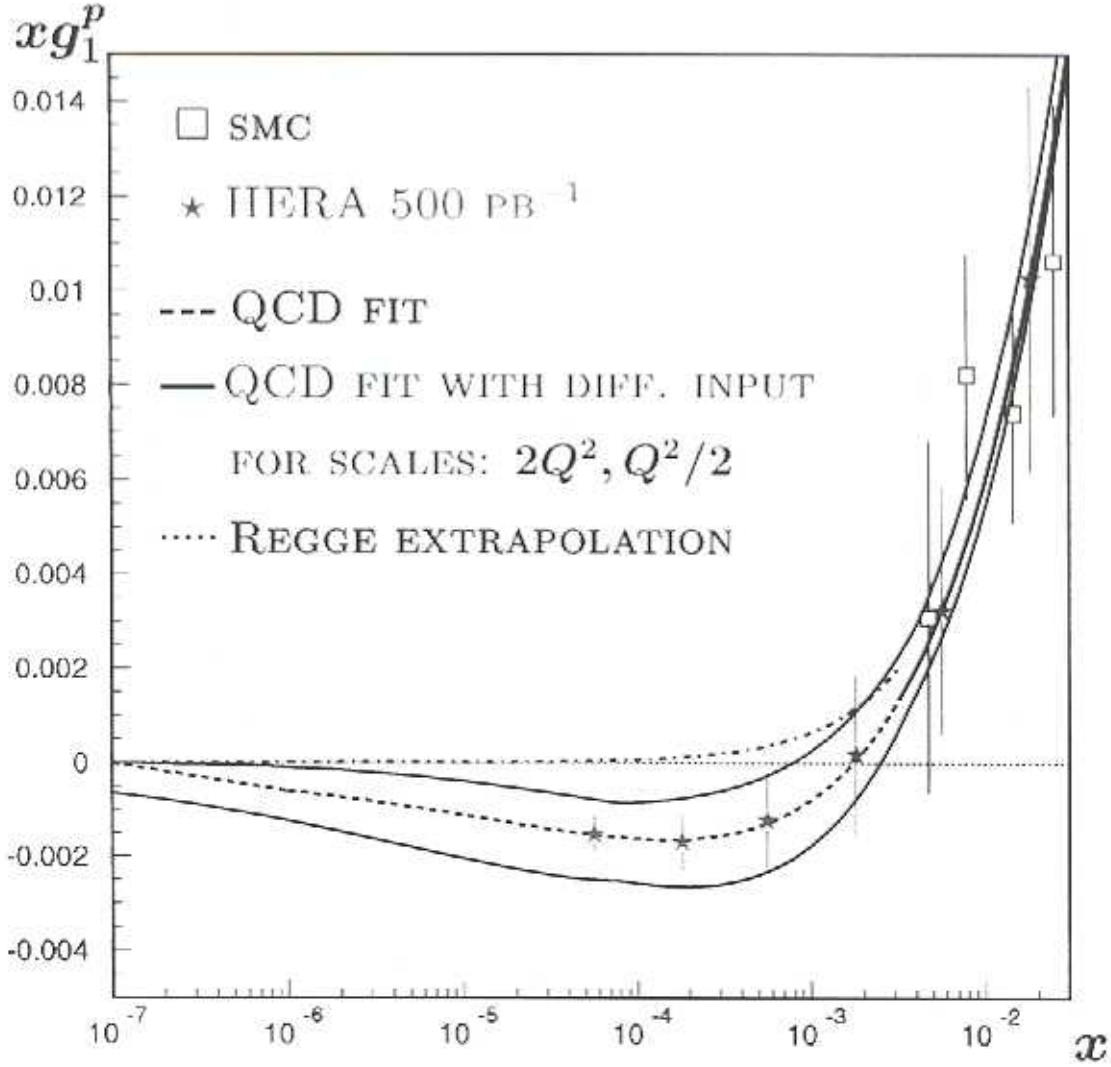
ΔG TODAY FROM SCALING VIOLATIONS, E.G.:

$$\delta(\Delta G) = \pm 0.3\,(\text{EXP}) \pm 1.0\,(\text{THEORY})$$

(SMC, PLB 412 (1997),414)

$+$ HERA 'DATA': $\delta(\Delta G) = \pm 0.2\,(\text{EXP})$

LARGEST CONTRIBUTIONS TO THEORETICAL ERROR:
RENORMALIZATION & FACTORIZATION SCALES (Q^2)



HERA DATA DIFFERENTIATES BETWEEN SCALES
$\rightarrow \delta(\Delta G)_{\text{SCALES}}$ DECREASES BY $\approx$ FACTOR 3

ΔG FROM 2-JETPRODUCTION

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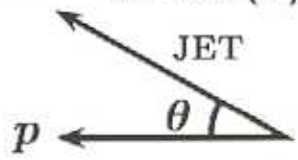
SELECTION:

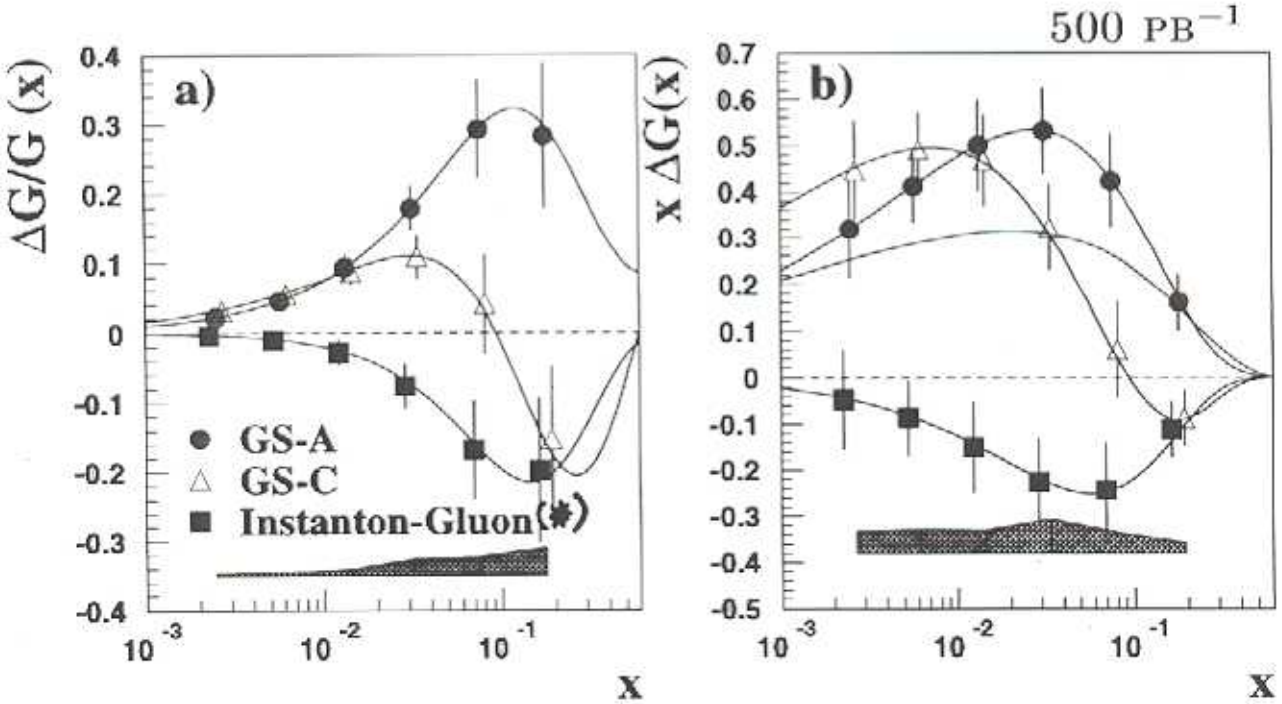
- $5 < Q^2 < 100$ GEV^2
- $0.3 < y < 0.85$
- $p_T^{\mathrm{JET}} > 5$ GEV
- $|\eta_{\mathrm{LAB}}^{\mathrm{JET}}| < 2.8$

DETECTOR EFFECTS INCLUDED

$\eta = -\ln\tan(\theta/2)$



EXTRACTED GLUON (LO) AT $Q^2 = 20$ GEV^2



→ MEASURE THE POLARISED GLUON DISTRIBUTION

FOR $0.002 < x_g < 0.2$

NLO CORRECTIONS STUDIED: $\sim 10\%$ SMALL !

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ΔG FROM 2 HIGH-p_T HADRONS AT HERA

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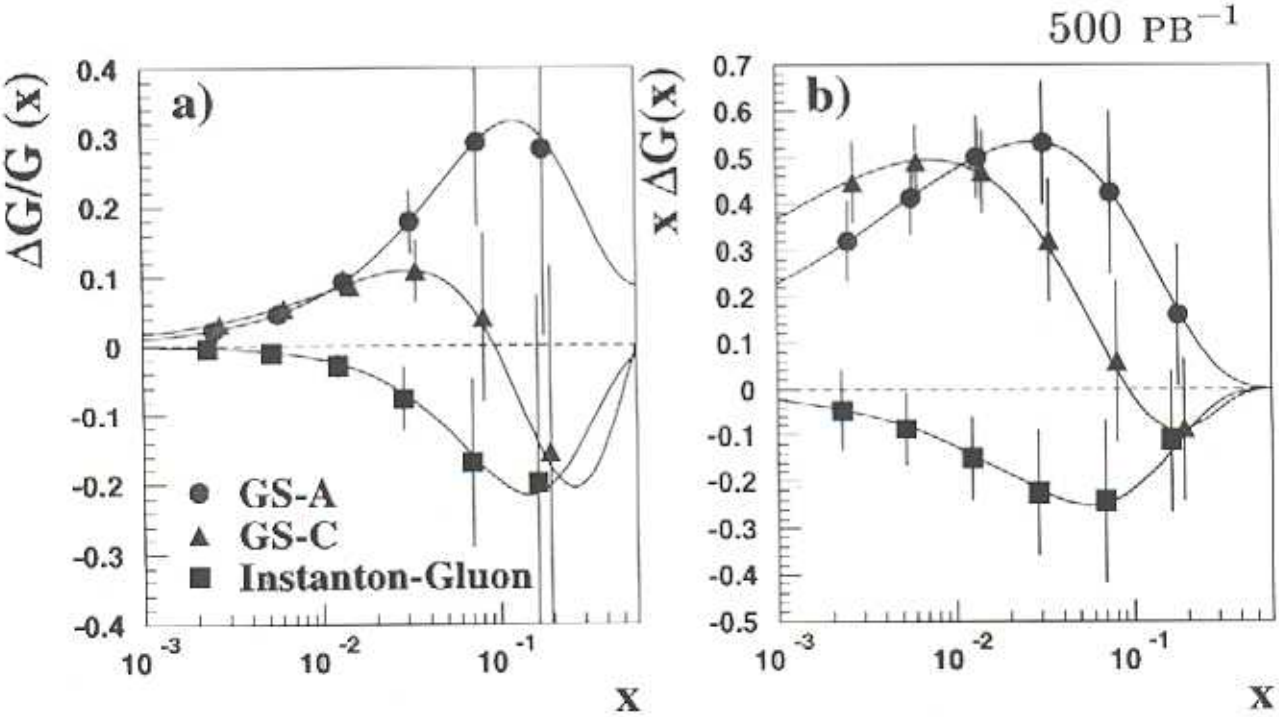
SELECTION:

- $5 < Q^2 < 100$ GeV^2
- $0.3 < y < 0.85$
- $p_T^{\mathrm{HAD}} > 1.5$ GeV
- $-1.5 < \eta_{\mathrm{LAB}}^{\mathrm{HAD}} < 2.5$
- $|\Phi_{\mathrm{HAD}\ 1} - \Phi_{\mathrm{HAD}\ 2}| < 60°$

EXTRACTED GLUON (LO) AT $Q^2 = 20$ GeV^2



→ SIMILAR RESULT AS FOR 2-JET ANALYSIS, BUT:

– WORSE AT HIGHEST x (CAN BE IMPROVED)
– POTENTIAL TO REACH LOWER x

OVERLAP 2-JET/2-HADRON SAMPLE $\sim 40\%$

COMBINED FITS

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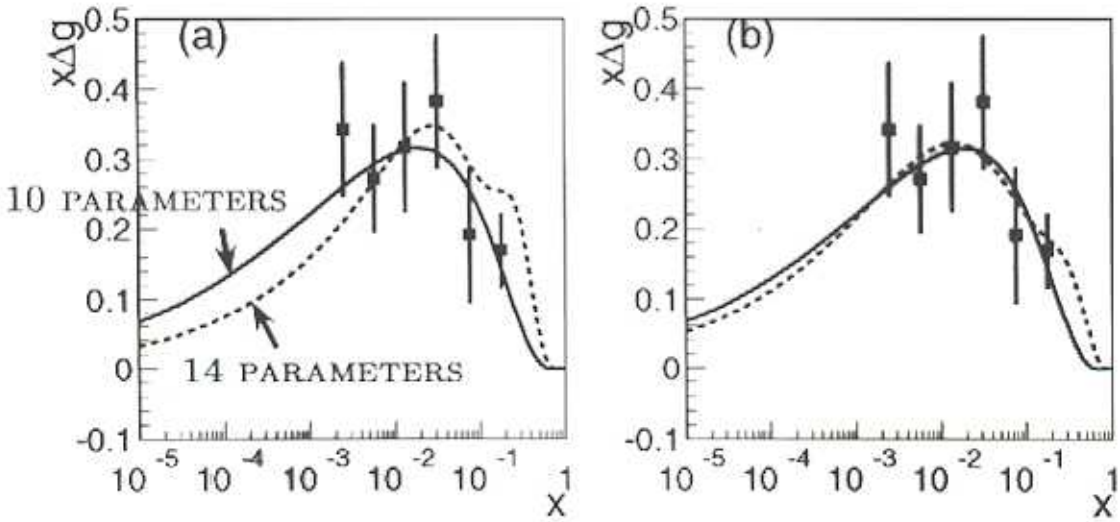
USE DATA ON $g_1(x, Q^2)$ AND ΔG FROM 2-JET EVENTS IN A COMBINED FIT

CHECK IMPACT ON: ★ $\delta(\int \Delta G dx)$

★ SHAPE OF $\Delta G(x)$

FIT RESULT: JET INFORMATION

NOT USED USED



DATA USED	$\delta(\int \Delta G)_{\text{EXP}}$
PRESENT FIXED TARGET g_1 →	30%
+ HERA $g_1(x, Q^2)$ →	20%
+ HERA 2-JETS →	10%

→ SIGNIFICANT IMPROVEMENT ON $\delta(\int \Delta G)_{\text{EXP}}$

SHAPE BETTER CONSTRAINED