# A DETERMINATION OF $\alpha_s$ FROM POLARIZED DEEP INELASTIC SCATTERING DATA

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Results obtained in collaboration with Richard Ball, Stefano Forte and Guido Altarelli.

IS IT POSSIBLE TO USE ALSO $g_A$ AND/OR $\alpha_s$ AS FREE PARAMETERS?

# YES

THANKS TO RECENTLY-IMPROVED MEASUREMENTS WITH P AND D TARGETS, AND TO RECENT N DATA.

→ DIRECT TEST OF THE BJORKEN SUM RULE

→ A MEASUREMENT OF $\alpha_s$

A CAREFUL ESTIMATE OF UNCERTAINTIES IS NECESSARY.

DETERMINATION OF $\alpha_s$

$\alpha_s$ AS A FIT PARAMETER

$\Rightarrow$ **NOT** FROM THE BJORKEN SUM

ONLY: SCALING VIOLATIONS

PLAY AN IMPORTANT ROLE.

IN FACT, FITS A - D ALL GIVE

VALUES OF $\alpha_s(m_Z)$ AROUND

$$\alpha_s(m_Z) \cong 0.120$$

$\rightarrow$ $\alpha_s$ IS FIXED IN THE MEASURED

REGION, SMALL-$x$ EXTRAPOLATION

NOT SO IMPORTANT.

FURTHERMORE, THE DISCREPANCY $g_A^{\text{FITTED}} - g_A^{\text{MEAS.}}$

WOULD REQUIRE A MUCH LARGER $\alpha_s$.

$\alpha$ MUCH BETTER CONSTRAINED BY THE

OVERALL PATTERN OF SCALING VIOLATION

THAN BY THE BJORKEN INTEGRAL

ALONE.

WITH $\alpha_s = 0.118$ FIXED:

| | | |
|---|---|---|
| $g_A =$ | 1.168 | FIT A |
| | 1.234 | FIT B |
| | [illegible] | FIT C |
| | 1.141 | FIT D |

WITH $g_A = 1.2573$ FIXED:

| | | |
|---|---|---|
| $\alpha_s(M_Z) =$ | 0.119 | FIT A |
| | 0.122 | FIT B |
| | [illegible] | FIT C |
| | 0.120 | FIT D |

MUCH SMALLER SPREAD IN THE BJORKEN SUM IF $\alpha_s$ IS A FIT PARAMETER $\longrightarrow$ $\alpha_s$ FIXED BY $Q^2$ EVOLUTION

$$\left( \Gamma_{Bj} = \frac{g_A}{6} \left( 1 - \frac{\alpha_s}{\pi} \right) \right)$$

# UNCERTAINTIES:

- EXPERIMENTAL ERRORS
- FIT PROCEDURE
  - ↳ DIFFERENT PARAMETRIZATIONS
- HIGHER ORDERS

$$\frac{Q^2}{2} < \mu_R^2, \mu_F^2 < 4Q^2$$

- HIGHER TWISTS:

1) add $\frac{a}{Q^2}$ to Bj sum

2) cut data below $Q^2 = 2\ \mathrm{GeV}^2$

# ERRORS ON PHYSICAL QUANTITIES

| | $g_A$ | $\Delta\Sigma$ | $\Delta g$ | $a_0$ | $\alpha_s$ |
|---|---|---|---|---|---|
| experimental | $\pm 0.05$ | $\pm 0.04$ | $\pm 0.4$ | $\pm 0.05$ | $^{+0.004}_{-0.005}$ |
| fitting | $\pm 0.05$ | $\pm 0.05$ | $\pm 0.5$ | $\pm 0.07$ | $\pm 0.001$ |
| $\alpha_s$ & $a_8$ | $\pm 0.03$ | $\pm 0.01$ | $\pm 0.2$ | $\pm 0.02$ | $\pm 0.000$ |
| thresholds | $\pm 0.02$ | $\pm 0.05$ | $\pm 0.1$ | $\pm 0.01$ | $\pm 0.003$ |
| higher orders | $\pm 0.03$ | $\pm 0.04$ | $\pm 0.6$ | $^{+0.15}_{-0.07}$ | $^{+0.007}_{-0.004}$ |
| higher twists | $\pm 0.03$ | - | - | - | $\pm 0.004$ |
| theoretical | $\pm 0.07$ | $\pm 0.08$ | $\pm 0.8$ | $^{+0.17}_{-0.010}$ | $^{+0.009}_{-0.006}$ |

# FIRST MOMENTS OF $g_1$

| | $\langle Q^2 \rangle$ | Meas. Range | Full Range |
|---|---|---|---|
| SMC : p | 10 | $0.133 \pm 0.016$ | $0.116 \pm 0.022$ |
| SMC : d | 10 | $0.045 \pm 0.008$ | $0.021 \pm 0.016$ |
| SMC : I=1 | 10 | $0.176 \pm 0.036$ | $0.191 \pm 0.037$ |
| E143 : p | 3 | $0.108 \pm 0.009$ | $0.107 \pm 0.017$ |
| E143 : d | 3 | $0.040 \pm 0.005$ | $0.021 \pm 0.014$ |
| E142 : n | 2 | $-0.032 \pm 0.009$ | $-0.068 \pm 0.015$ |
| E154 : n | 5 | $-0.034 \pm 0.011$ | $-0.070 \pm 0.015$ |
| SLAC : I=1 | 3 | $0.139 \pm 0.013$ | $0.177 \pm 0.018$ |

ABFR

TAKING INTO ACCOUNT ALL UNCERTAINTIES WE OBTAIN

$$\alpha_s(m_Z) = 0.120^{+0.004}_{-0.005}{}^{(EXP)}{}^{+0.009}_{-0.006}{}^{(TH)}$$

$$= 0.120^{+0.010}_{-0.008}$$

CAN BE IMPROVED WITH MORE DATA, EVEN IF THE THEORETICAL ERROR DOMINATES: IN FACT, IT IS GENERATED BY SMALL-$Q^2$ DATA. THE ERROR IS TWICE AS LARGE WITHOUT NEUTRON DATA.

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FROM BJORKEN ONLY: (PURE EXP. ERR.)

$$\alpha_s(m_Z) = \begin{cases} 0.111^{+0.035}_{-0.111} \leftarrow & \text{SMC ONLY} \\ 0.118^{+0.010}_{-0.026} & \text{SLAC ONLY} \\ 0.118^{+0.010}_{-0.024} & \text{ALL DATA} \end{cases}$$

FITTING BOTH $g_A$ AND $\alpha_s$ IS ALSO POSSIBLE.

FIT "A" GIVES

$$g_A = 1.16 \pm 0.07 \quad (\text{EXP})$$

$$\alpha_s = 0.117 \pm ?$$

$$\eta_g = 0.92 \pm 0.47$$

$$\eta_q = 0.39 + 0.04 \equiv \Delta\Sigma(1)$$

POSSIBLE BECAUSE $\alpha_s$ IS FIXED BY SCALING VIOLATIONS

CONCLUSION

AN ACCURATE MEASUREMENT OF $\alpha_s$ FROM SCALING VIOLATION IN POLARIZED DIS.

CAN BE IMPROVED BY MORE $g_1$ DATA + DIRECT DETERMINATION OF $\Delta g$.

CONCLUSIONS

- INCLUDING ALL AVAILABLE EXPERIMENTAL INFORMATION + PERTURBATIVE QCD, WE FIND THE BJORKEN SUM RULE SATISFIED TO WITHIN ONE STANDARD DEVIATION AT THE 8% LEVEL
- AN ACCURATE MEASURE OF $\alpha_s$ FROM SCALING VIOLATION.

  COULD BE IMPROVED BY MORE $g_2$ DATA, OR BY AN INDEPENDENT DETERMINATION OF THE POLARIZED GLUON DISTRIBUTION.