Istituto Nazionale di Fisica Nucleare

HAS QCD
HADRONIC STRUCTURE AND QUANTUM CHROMODYNAMICS

UNIVERSITÀ DI PAVIA

Update on strong PV effects

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in collaboration with A. Bacchetta, L. Manna,

M. Radici and X. Zheng

SoLID Collaboration meeting — 12/08/2023

PDFs in DIS process

Quark Polarization

Nucleon Pol.	U	L	T
U			
L			
T			

PDFs in DIS process

Quark Polarization

Nucleon Pol.

	U	L	T
U	$f_1(x)$		
L		$g_1(x)$	
T			

PDFs in DIS process

Electric charge

Quark Polarization

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PDFs in DIS process

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PDFs in DIS process w/ P violation

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U	$f_1(x)$	$g_1^{\mathrm{PV}}(x)$	
L	$f_{1L}^{\mathrm{PV}}(x)$	$g_1(x)$	
T			

Axial charge

PDFs in DIS process w/ P violation

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U	$f_1(x)$	$g_1^{\mathrm{PV}}(x)$	
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Anapole moment

Axial charge

PDFs in DIS process w/ P violation

Electric charge

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T			

Anapole moment

Electric dipole moment

Axial charge

PDFs in DIS process w/ P violation

Quark Polarization

Nucleon Pol.

	U	L	T
U		$g_1^{\mathrm{PV}}(x)$ → Anapole moment	
L			
T			

Focus: structure function $xF_3(x, Q^2)$

$$xF_{3LU}(x, Q^2) = xF_3^{(\gamma)} - g_V^e \eta_{\gamma Z} xF_3^{(\gamma Z)} + ({g_V^e}^2 + {g_A^e}^2)\eta_Z xF_3^{(Z)}$$

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$$xF_3^{(\gamma Z)}(x, Q^2) = \sum_q 2e_q g_A^q x f_1^{(q-\bar{q})}$$

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Additional contributions due to the new PV parton distribution

$$x\Delta F_3^{(\gamma)}(x,Q^2) = -\sum_q e_q^2 x g_1^{\mathrm{PV}(q+\bar{q})}$$

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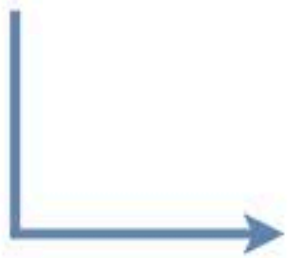

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MAIN INNOVATION OF PV-HYPOTESIS

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Phenomenology

Experimental observable

PVDIS Asymmetry

$$A_{\mathrm{PV}} \equiv \frac{d\sigma(\lambda = 1) - d\sigma(\lambda = -1)}{d\sigma(\lambda = 1) + d\sigma(\lambda = -1)}$$

PVDIS Collaboration, *Nature* 506 (2014)
D. Wang et al., Phys.Rev.C 91 (2015)

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$$= \frac{Y_+ F_{2LU} - y^2 F_{L,LU} - Y_- x F_{3LU}}{Y_+ F_{2UU} - y^2 F_{L,UU} - Y_- x F_{3UU}}$$

$Y_\pm = 1 \pm (1-y)^2$

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Contribution of g_1^{PV} in each of the structure functions due to γZ and Z channels

Experimental data: energy range

HERA dataset

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$$
\begin{aligned}
C_{1u} &= 2g_A^e g_V^u = 2\left(-\frac{1}{2}\right)\left(\frac{1}{2} - \frac{4}{3}\sin^2\theta_W\right) \\
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C_{1d} &= 2g_A^e g_V^d = 2\left(-\frac{1}{2}\right)\left(-\frac{1}{2} + \frac{2}{3}\sin^2\theta_W\right) \\
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\end{aligned}
$$

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$$C_{1u}^{\mathrm{SM}} = -0.1887 - 0.0011 \times \frac{2}{3}\ln(\langle Q^2\rangle/0.14\mathrm{GeV}^2)$$
$$C_{1d}^{\mathrm{SM}} = 0.3419 - 0.0011 \times \frac{-1}{3}\ln(\langle Q^2\rangle/0.14\mathrm{GeV}^2)$$
$$C_{2u}^{\mathrm{SM}} = -0.0351 - 0.0009\ln(\langle Q^2\rangle/0.078\ \mathrm{GeV}^2)$$
$$C_{2d}^{\mathrm{SM}} = 0.0248 + 0.0007\ln(\langle Q^2\rangle/0.021\ \mathrm{GeV}^2)$$

Results of the fit: $g_1^{PV}(x, Q^2)$ extraction

$$g_1^{\mathrm{PV}}(x) = \alpha \; g_1(x)$$

$$\alpha = (-1.01 \pm 0.66) \cdot 10^{-4}$$

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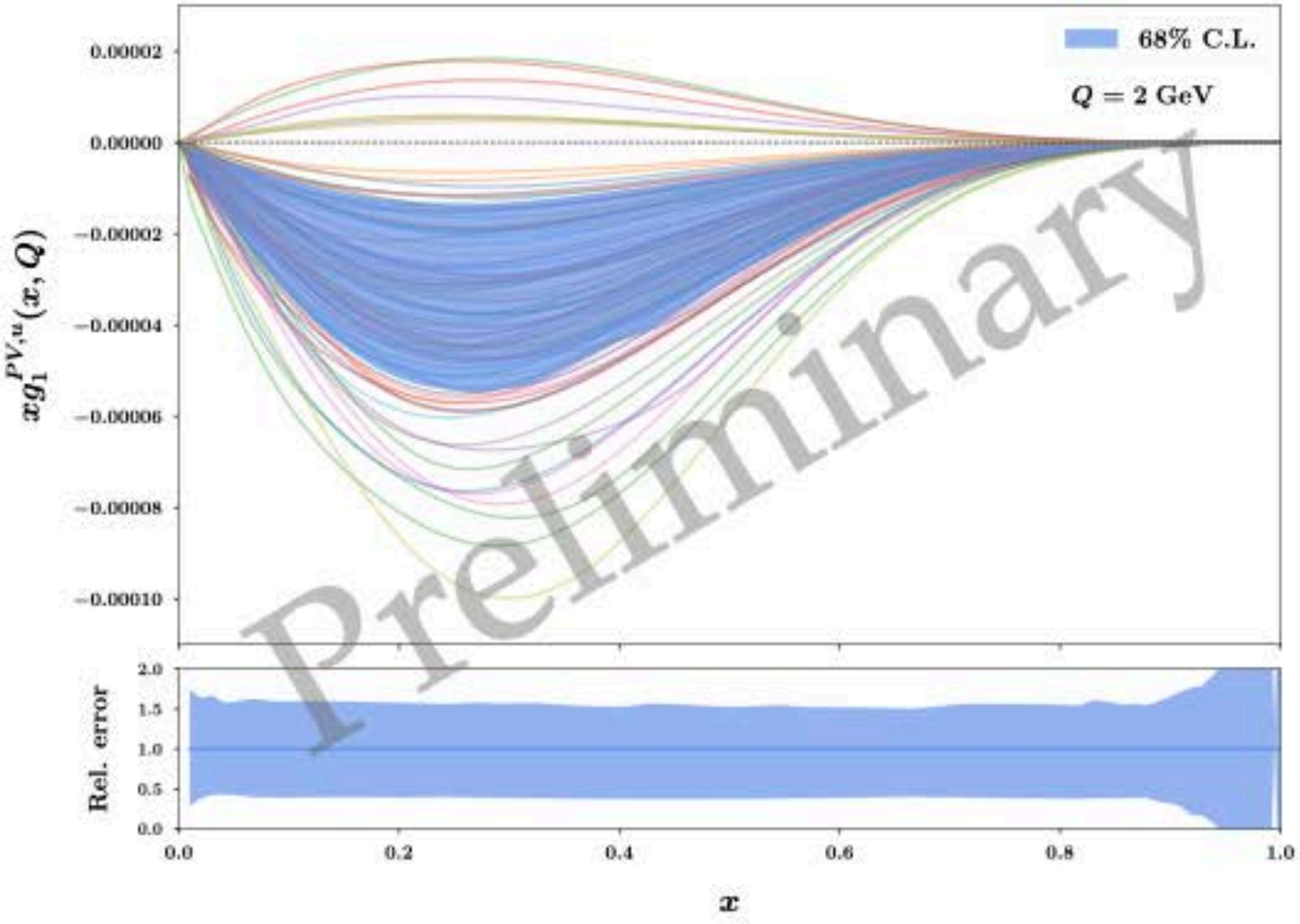

Preliminary

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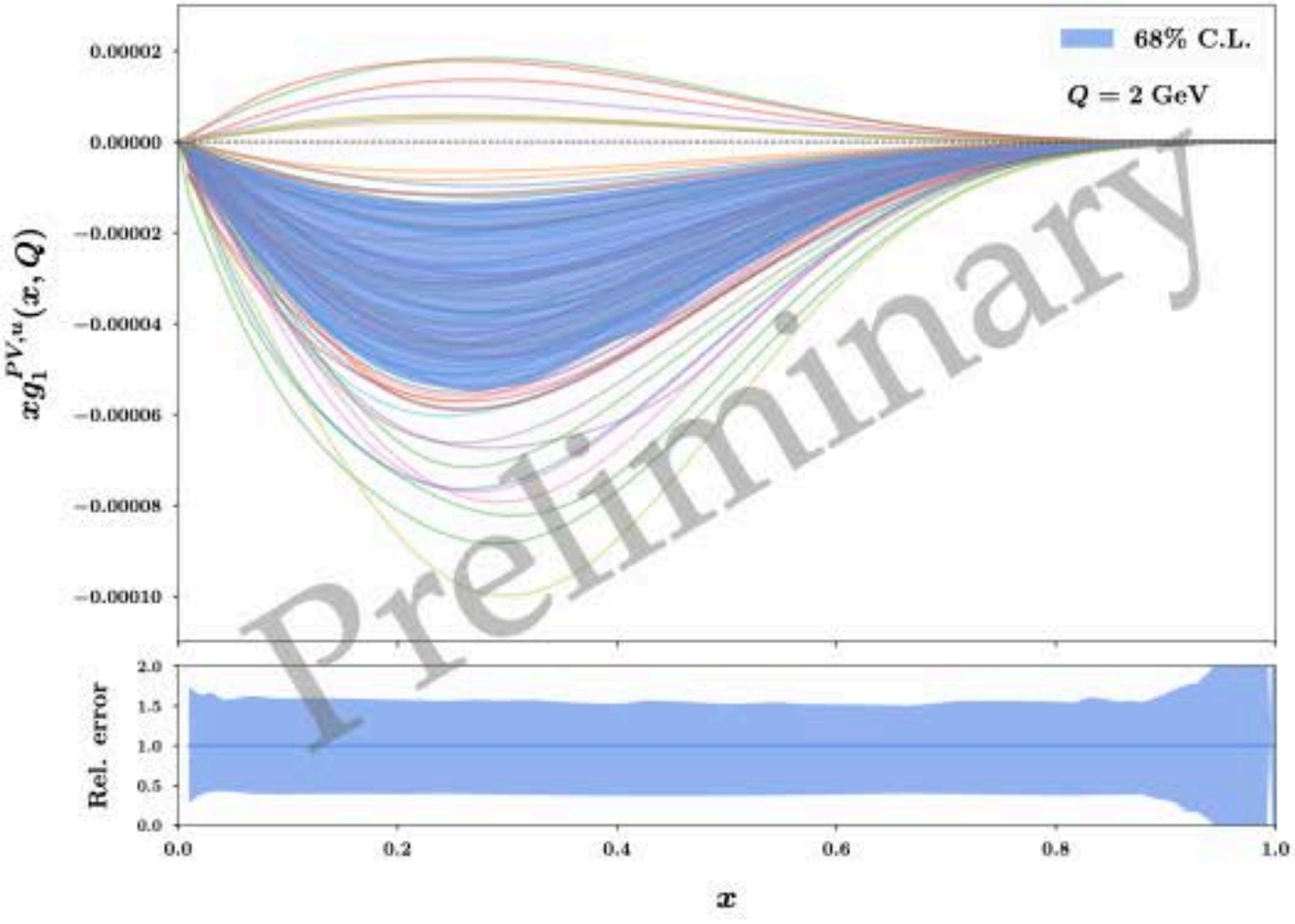

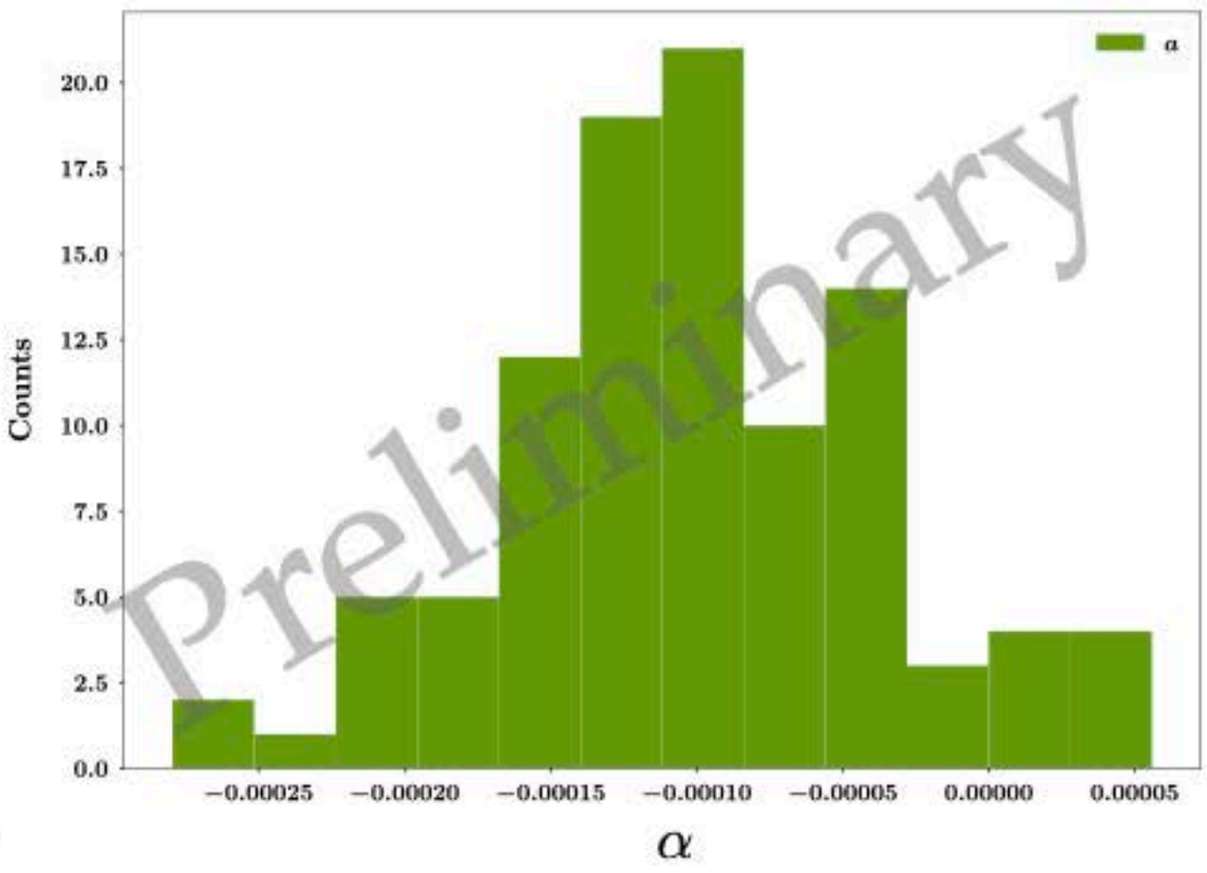

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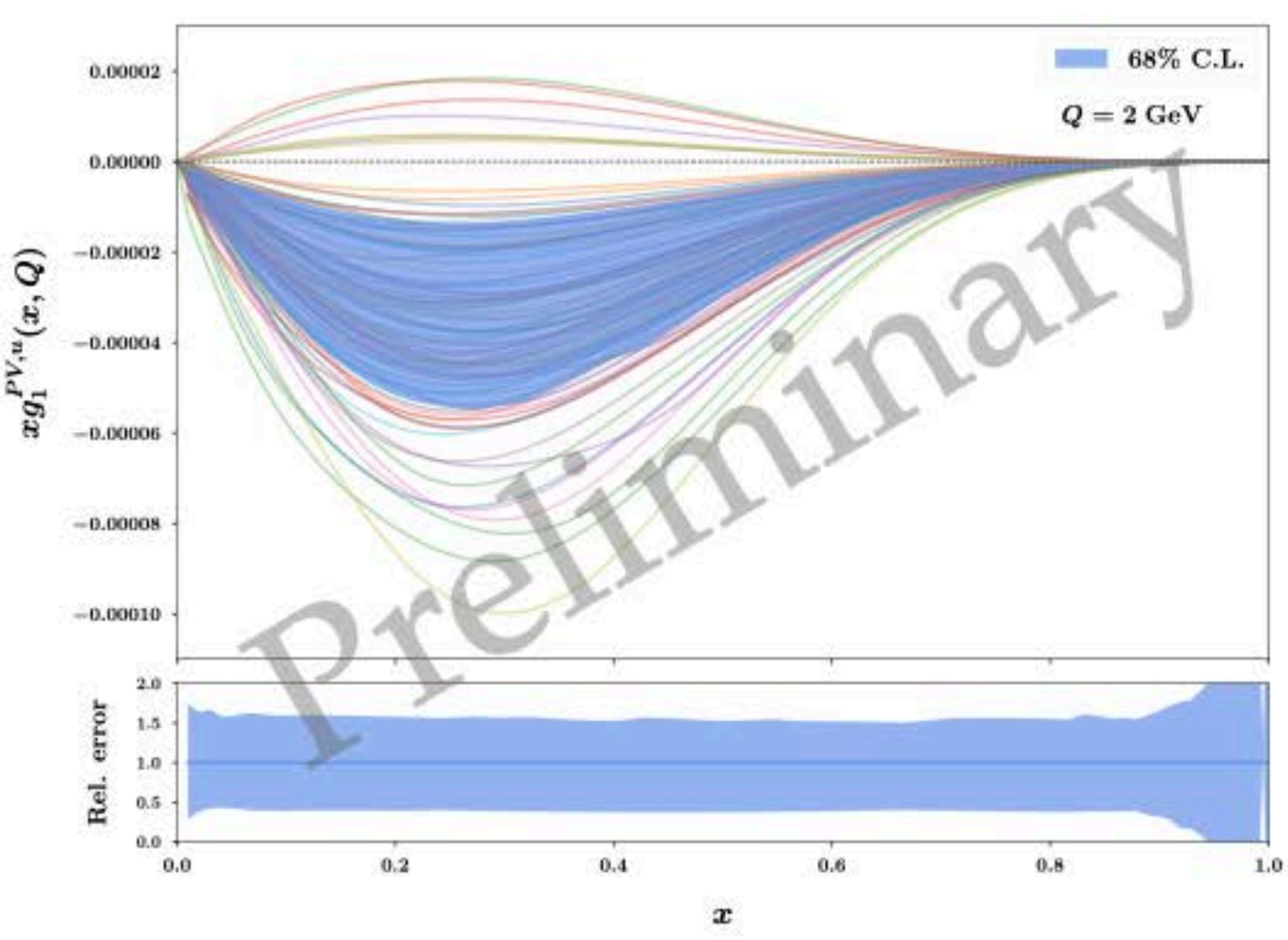
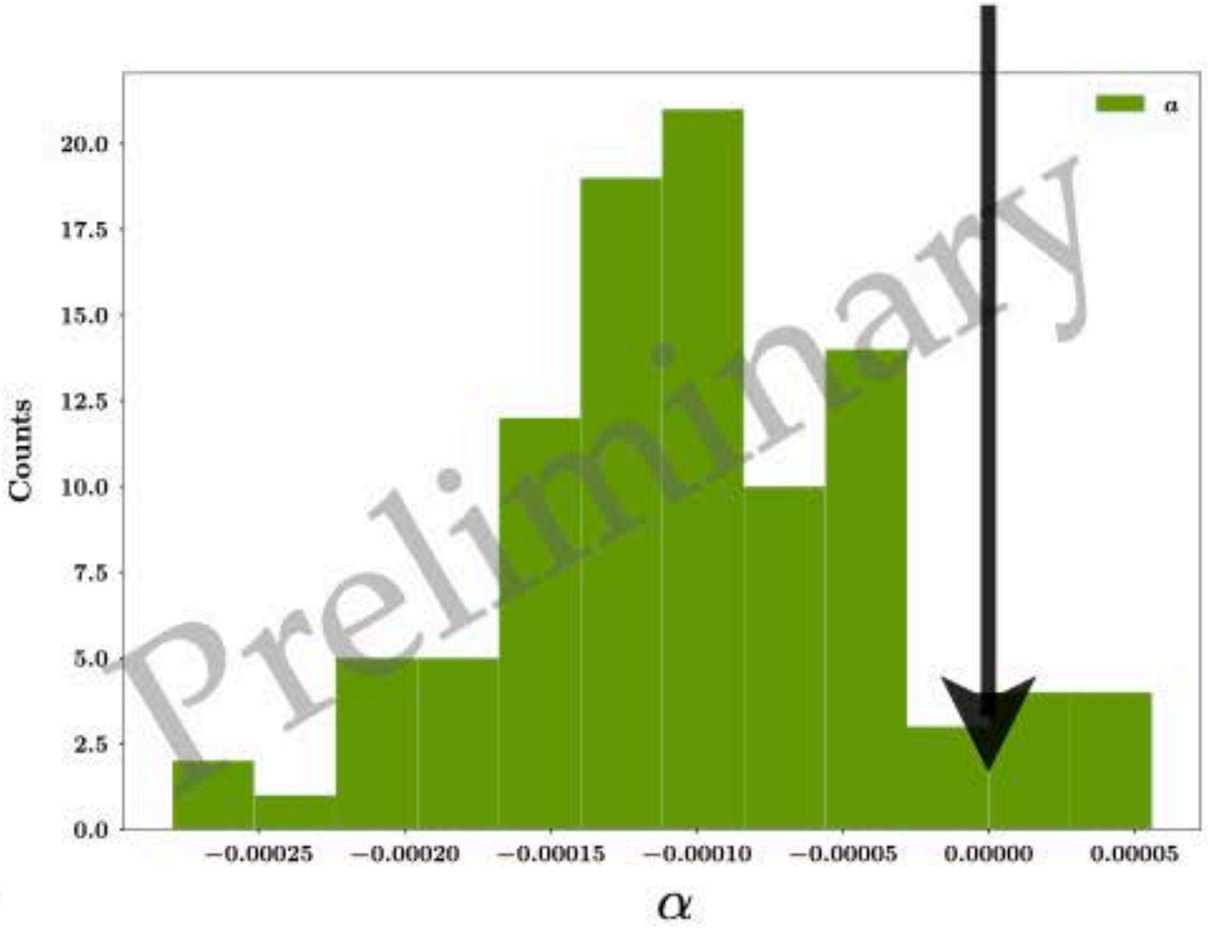
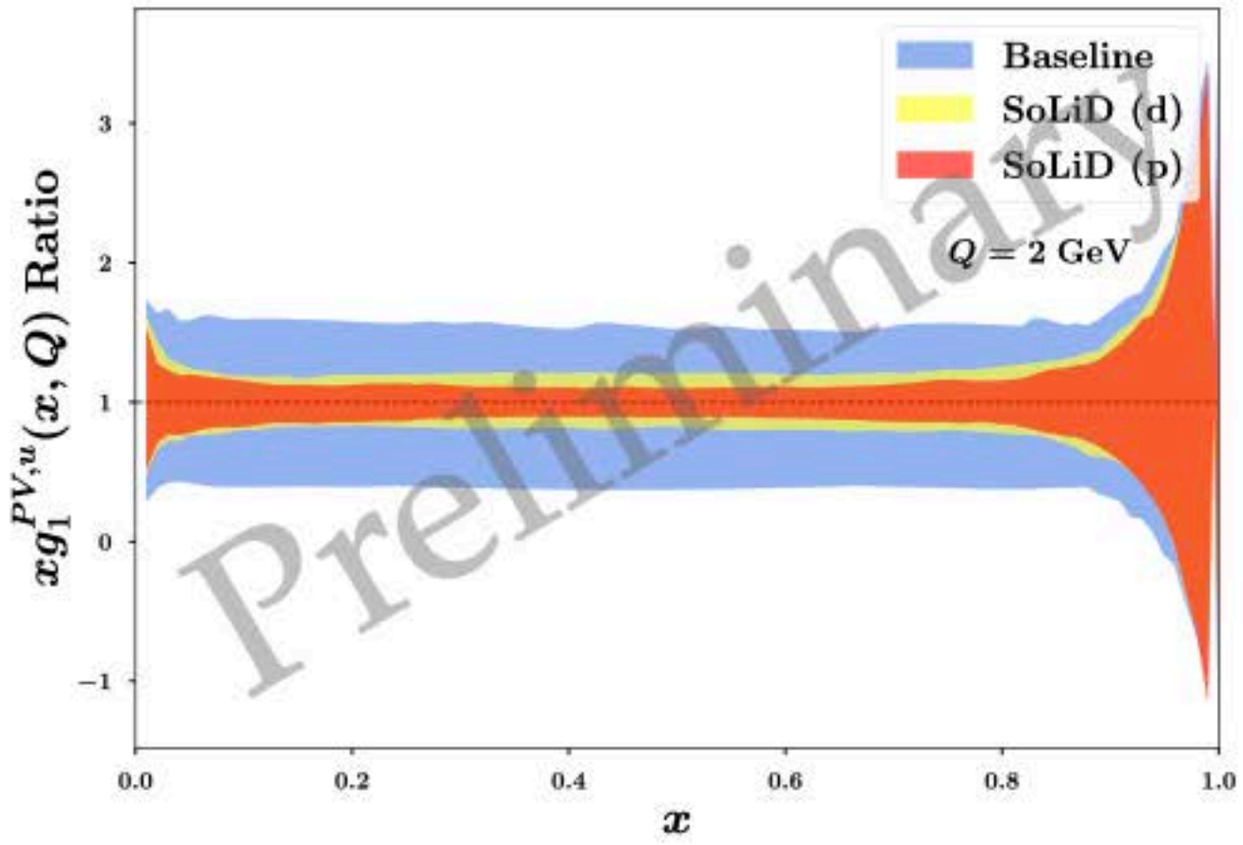


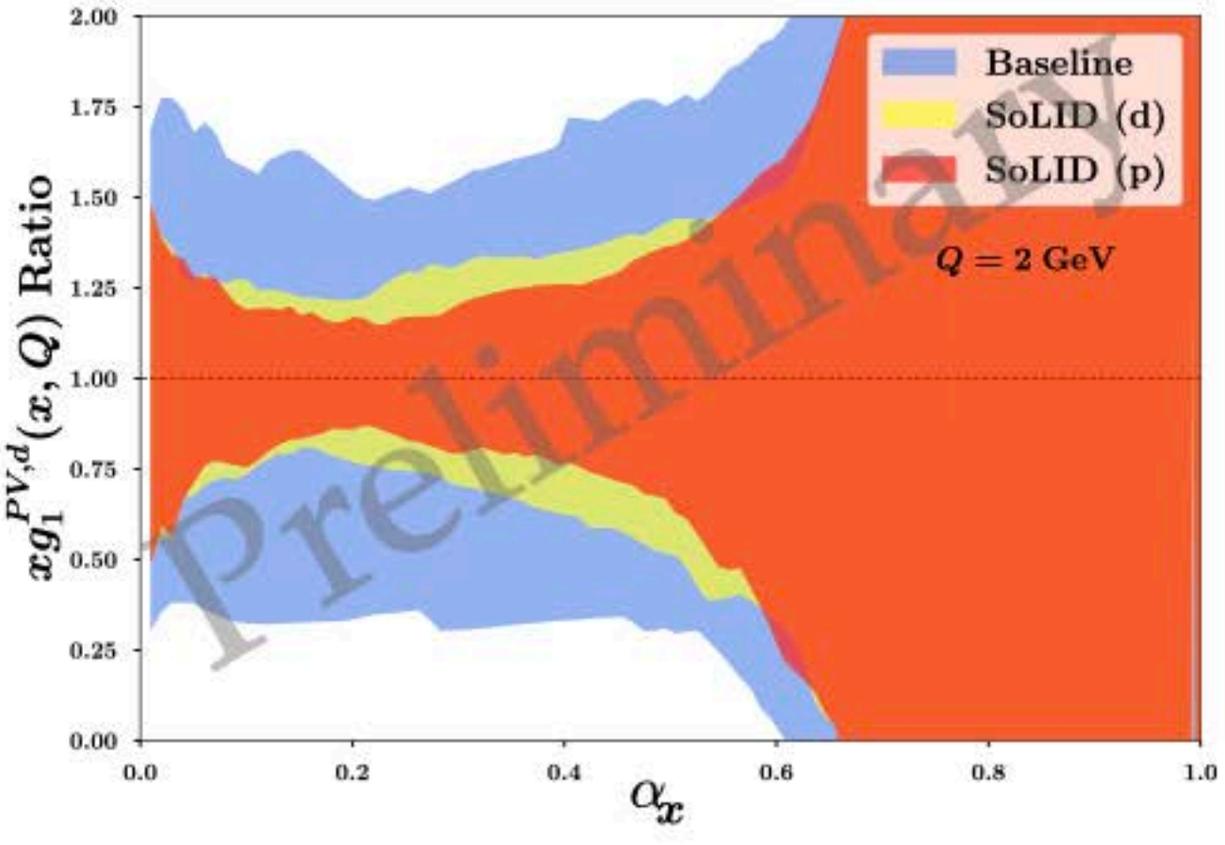


Preliminary

Impact of SoLID on $g_1^{PV}(x, Q^2)$

Baseline $\alpha = (-1.01 \pm 0.66) \cdot 10^{-4}$





Preliminary

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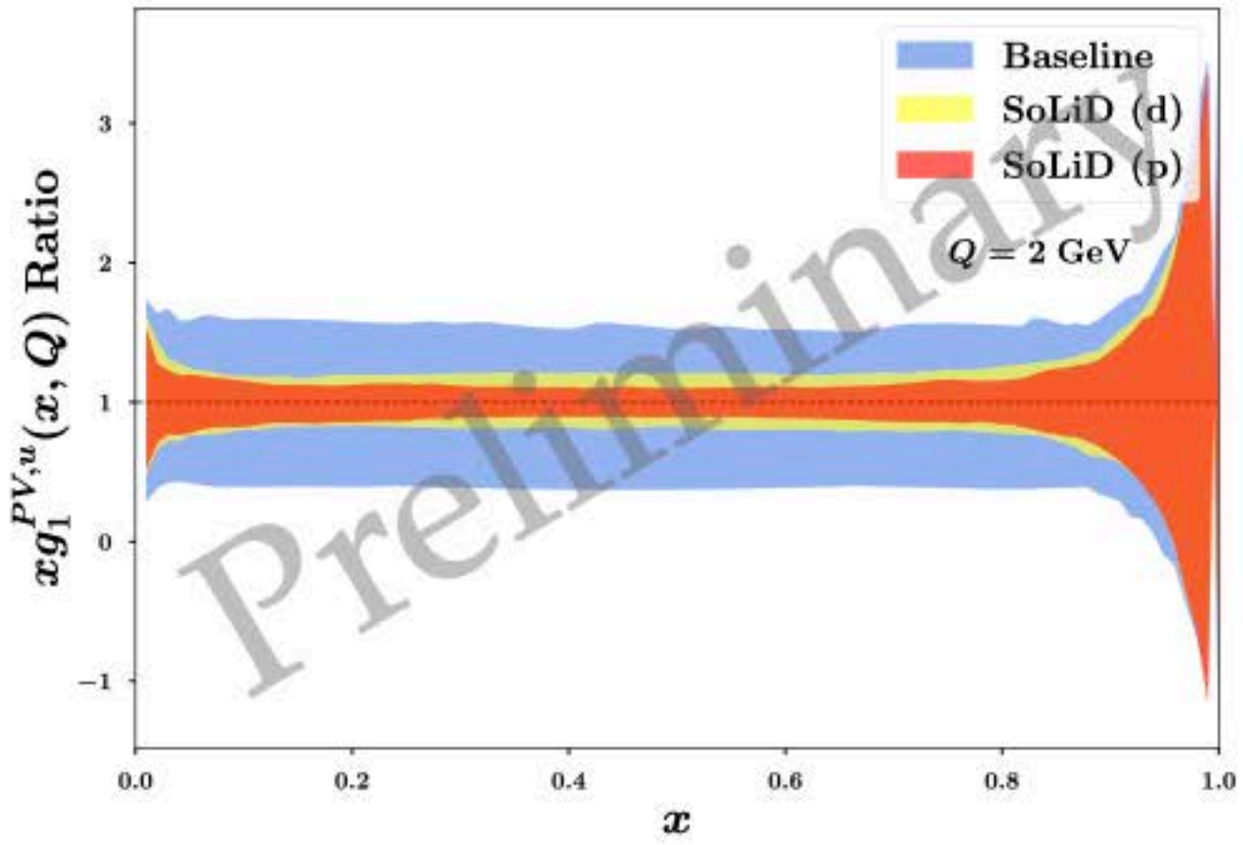
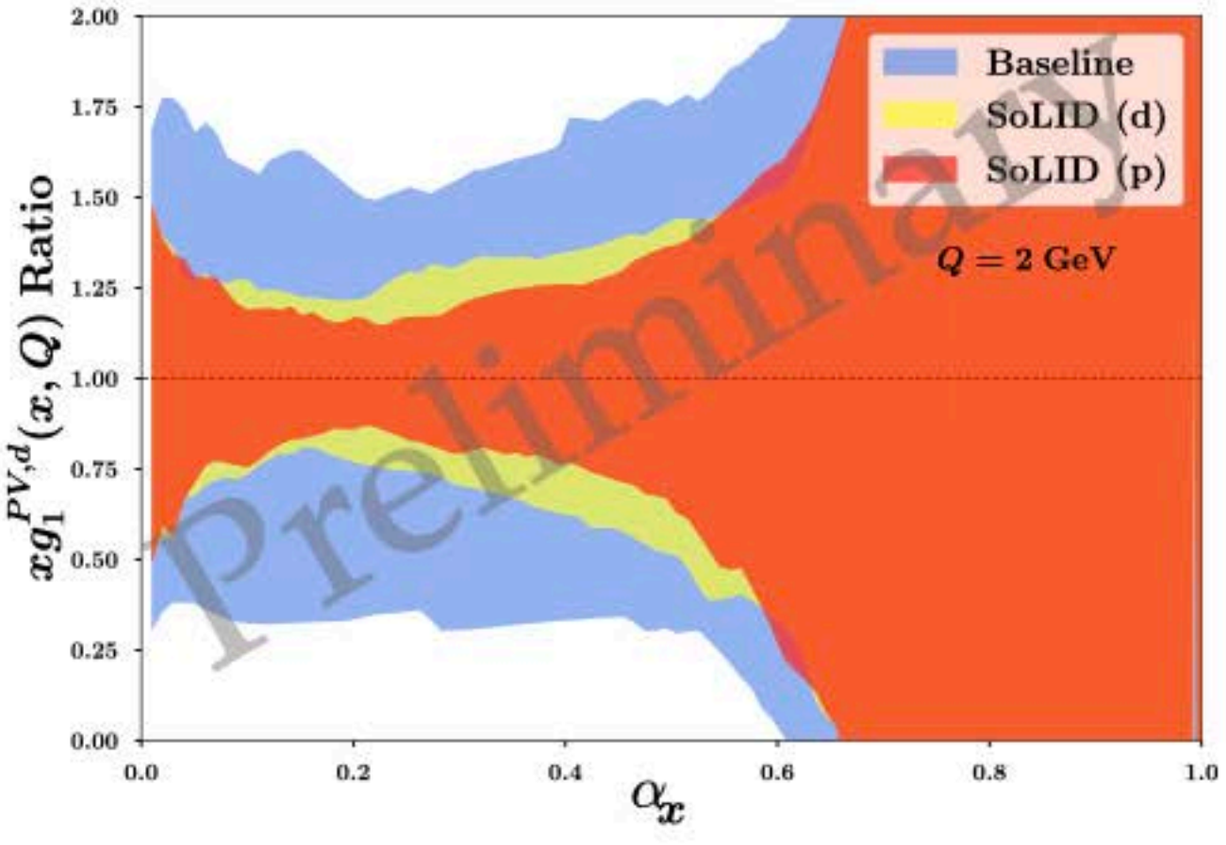
SoLID (d)	$\alpha = (-1.01 \pm 0.21) \cdot 10^{-4}$





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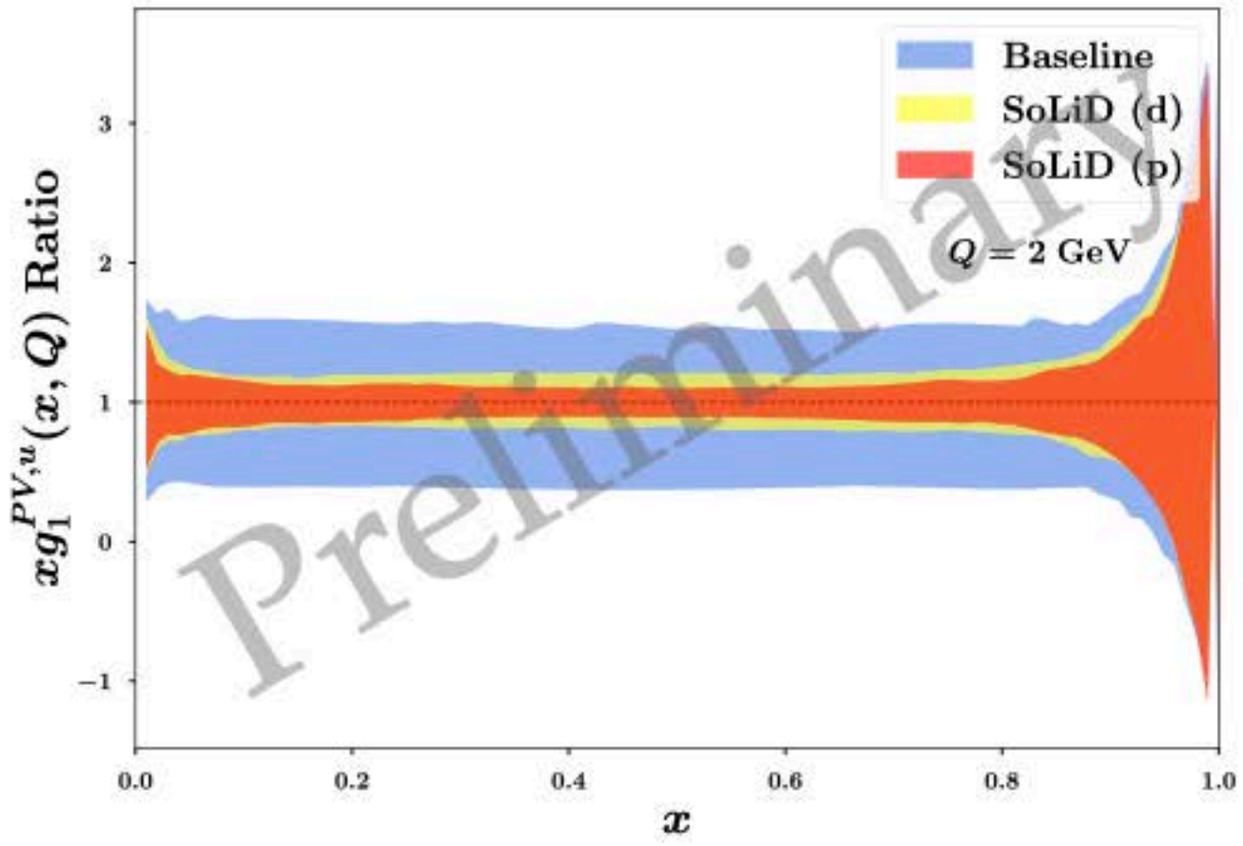
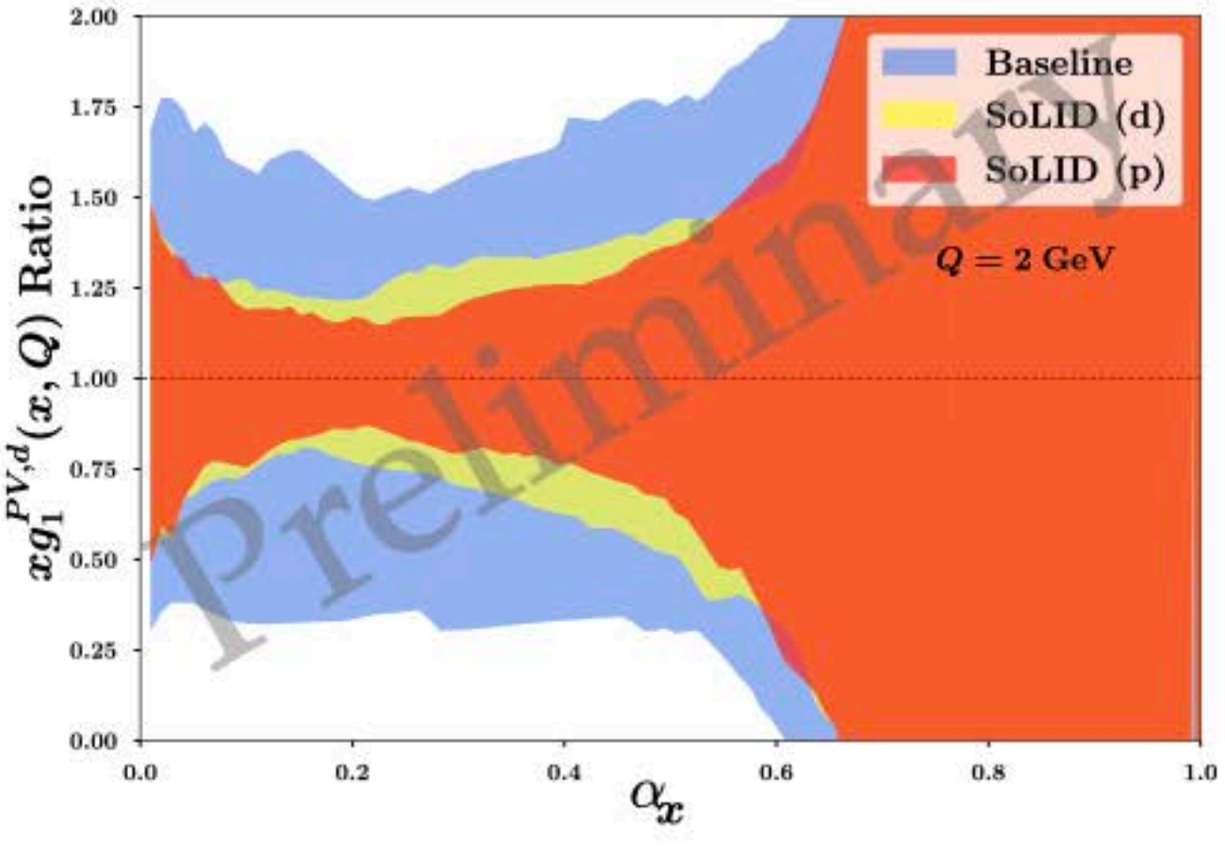
SoLID (p)	$\alpha = (-1.01 \pm 0.15) \cdot 10^{-4}$





Preliminary

Conclusions and Outlook

- The strong P- violation can give origin to a new structure function in DIS cross section for one-photon exchange

- A global fit of present experimental data is compatible with a non-zero contribution from a new strong PV parton density at more than 1 sigma

- The impact of SoLID data on the g1PV is sizeable and would allow us to make more precise investigations on its actual size