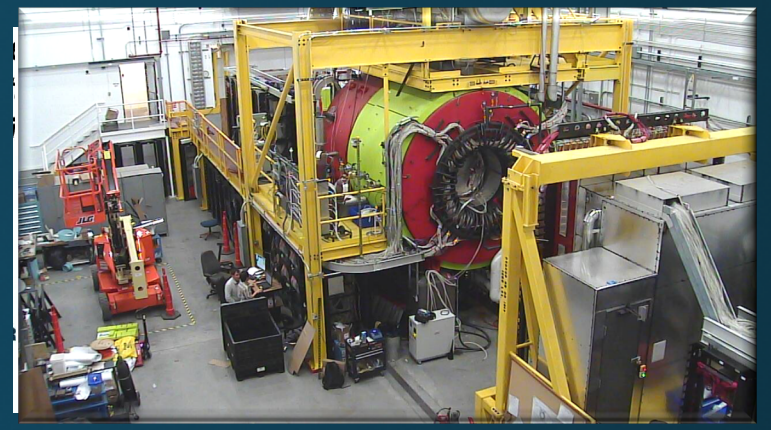
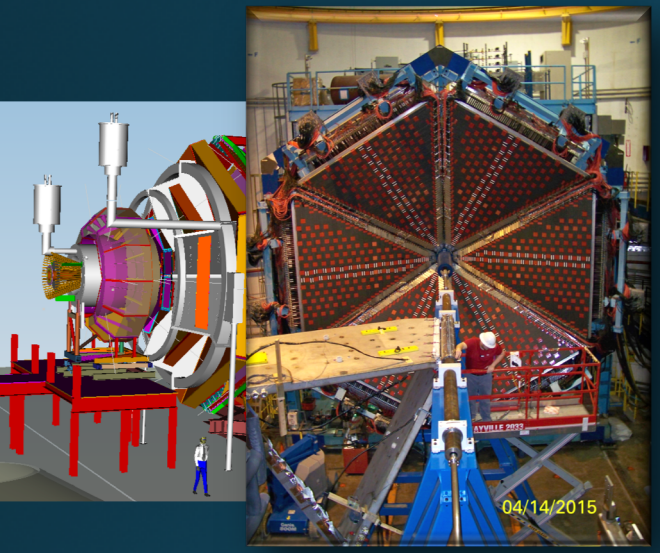
Solenoidal Large Acceptance Device (SoLID)

- JLab 12 GeV scientific capabilities
- SoLID; the tool for a full exploitation of the 12 GeV upgrade
- Physics Overview
  - Semi-Inclusive Deep Inelastic Scattering
  - Parity Violation in Deep Inelastic Scattering
  - Threshold Electro- and Photo-Production of J/Psi
- Summary

12 GeV Scientific Capabilities

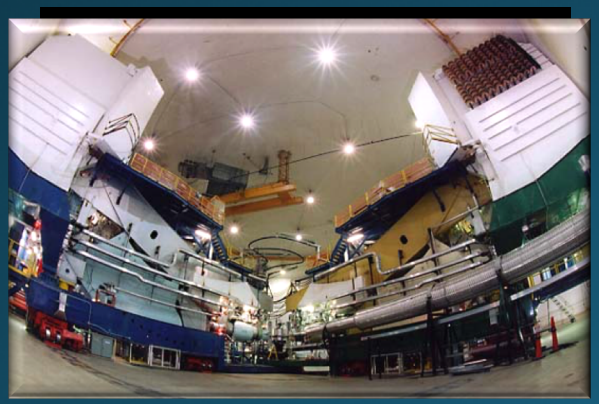


Hall D – exploring origin of confinement by studying exotic mesons



Hall B – understanding nucleon structure via generalized parton distributions and transverse momentum distributions

Hall C – precision determination of valence quark properties in nucleons and nuclei



Hall A – short range correlations, form factors, hyper-nuclear physics, future new experiments (e.g., SoLID and MOLLER)

SoLID

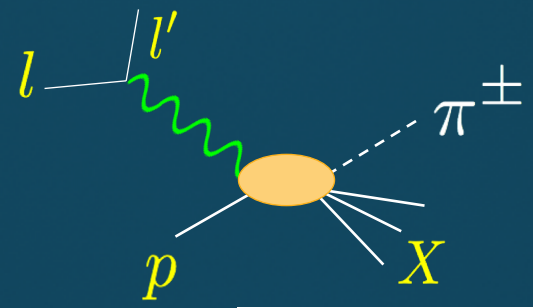
A key tool for a full exploitation of the 12 GeV upgrade

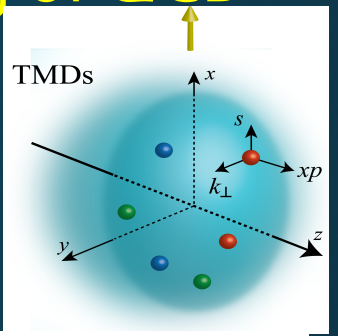
- SoLID is unique in that it provides equipment that combines - The capability to handle high luminosity (10^{37-39} cm^{-1} s^{-1}) - A large acceptance detector with full ϕ coverage
- SoLID takes advantage of the latest developments in detector and data acquisition technologies
- SoLID is unique as evidenced by the approval of already 5 highly rated experiments, covering a wide range of important science topics:
  - Nucleon structure: transverse momentum imaging of valence quarks
  - Fundamental symmetries: new physics in the 10-20 TeV region
  - QCD: constraining the conformal (trace) anomaly
  - …including spatial imaging
- There is wide interest in SoLID science as manifested by:
  - More than 250 collaborators over 50 institutions and 13 countries - Already quite significant international contributions and potential
- further commitments, **particularly from China** - strong theoretical support

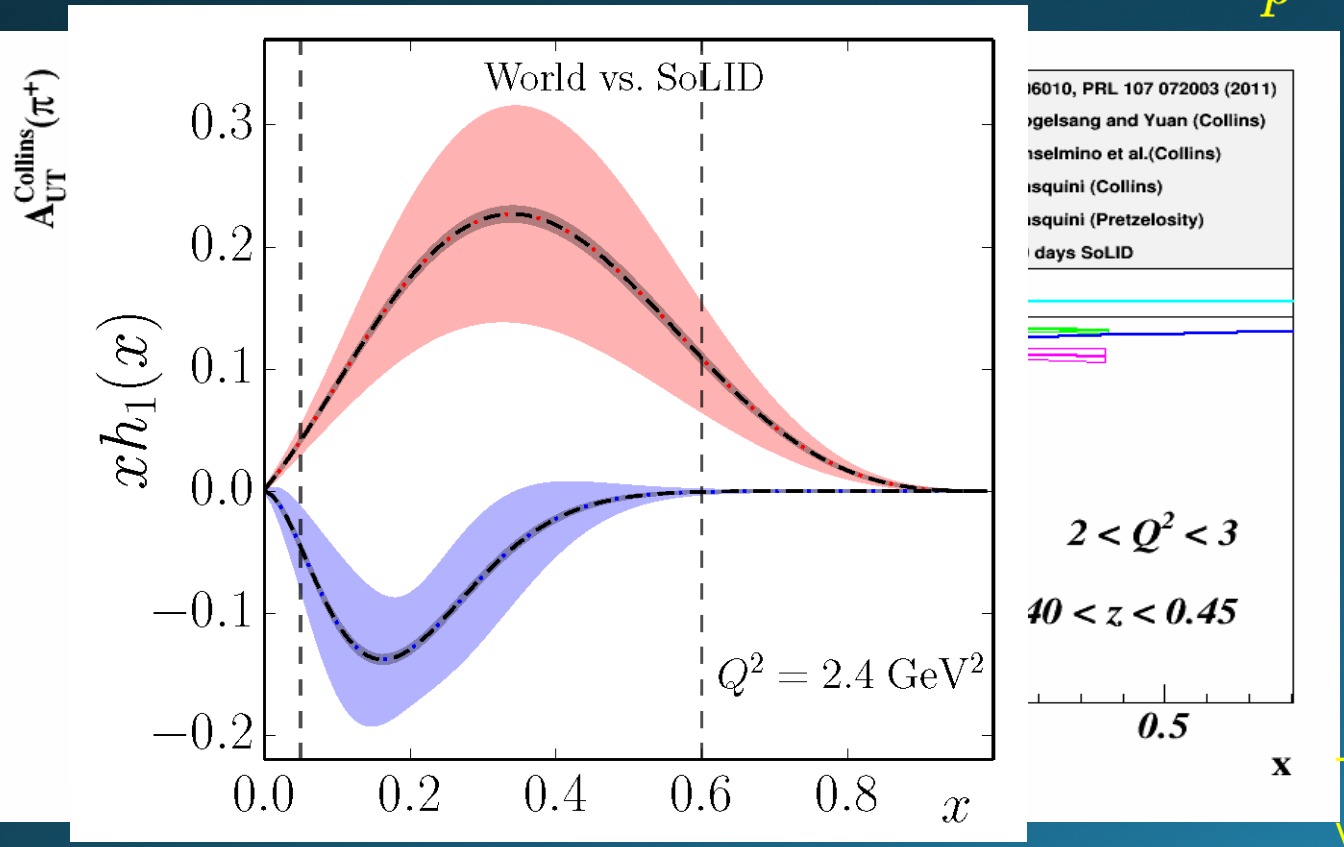
SIDIS @ SoLID:

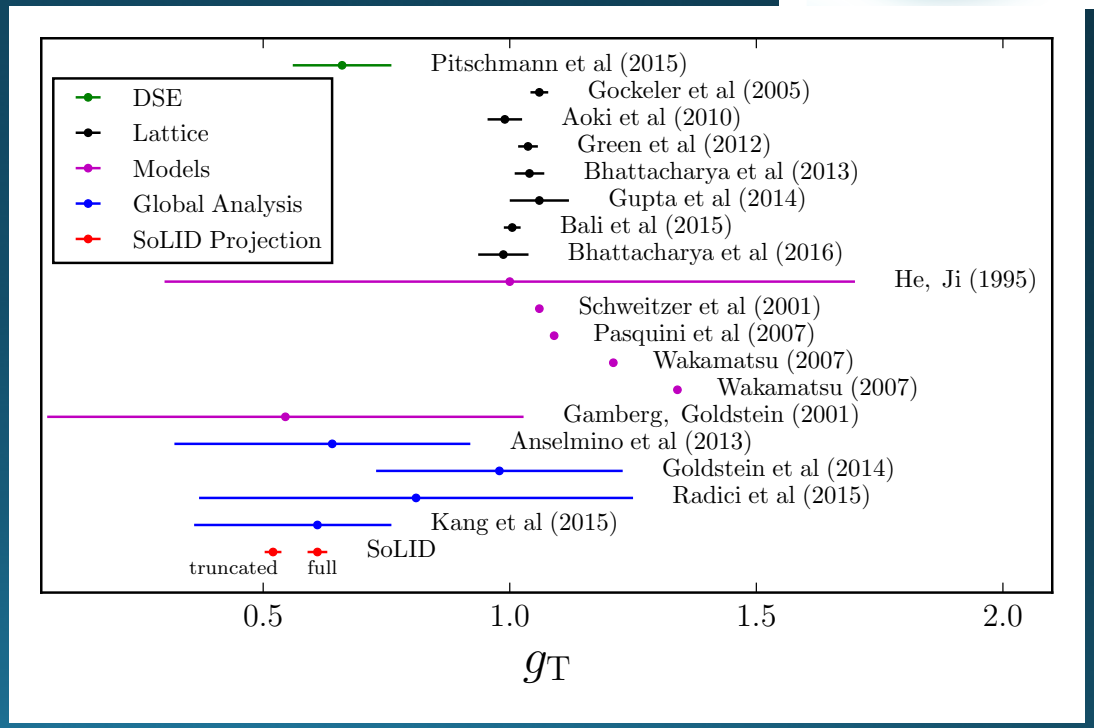
An unprecedented tool to unravel the rich structure and dynamics of nucleon structure in the valence region and the inner working of QCD

Impact of SoLID on our knowledge of the Transversity distributions









Tensor Charge, an intrinsic property as important axial vector charge, charge and magnetic moment of the nucleon

results

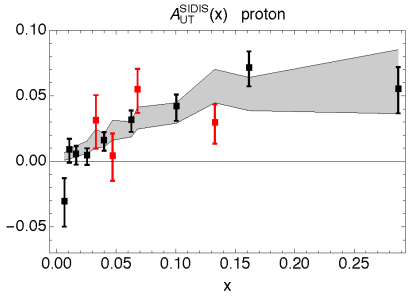
global fit published in

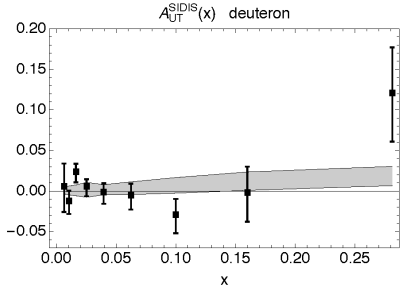
*Radici and Bacchetta, P.R.L. **120** (18) 192001*

SIDIS

COMPASS — *Adolph et al., P.L. **B713** (12)*

hermes — *Airapetian et al., JHEP **0806** (08) 017*



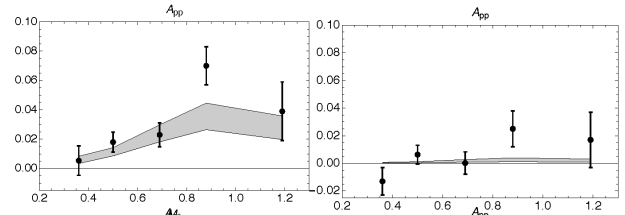


pp collisions

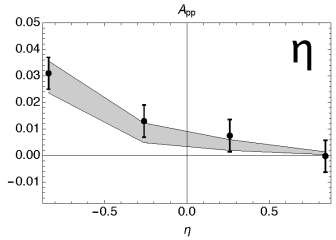
STAR

*Adamczyk et al., P.R.L. **115** (2015) 242501*

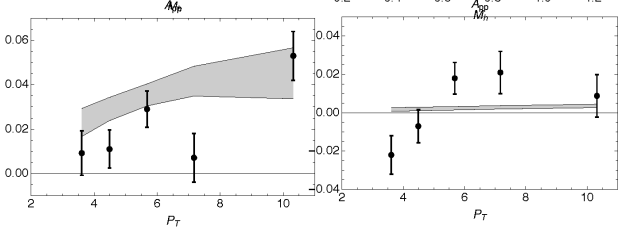
M_h, $\eta<0$



M_h, $\eta>0$



p_T, $\eta<0$

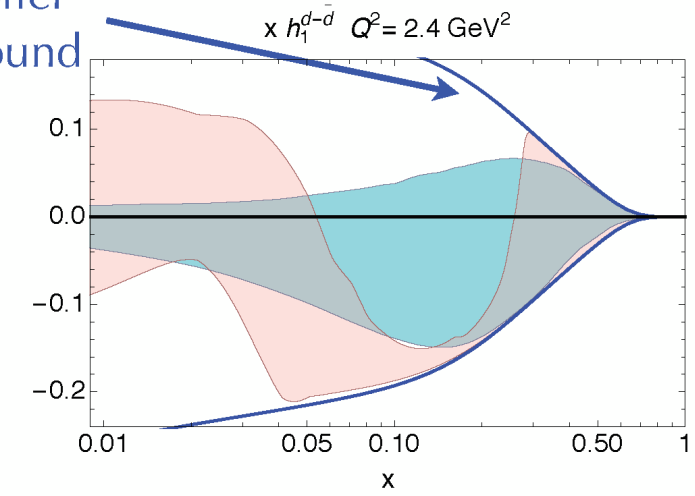


p_T, $\eta>0$

Slides from TMDs at JLab Present and Future, Pavia 19-20 December 2018

comparison with previous fit

Soffer bound



*Radici & Bacchetta, P.R.L. **120** (18) 192001*

down

global fit

p-p: up~down , gluon @LO
but
SIDIS: up~(8x)down , gluon @NLO

old fit

*Radici et al., JHEP **1505** (15)*

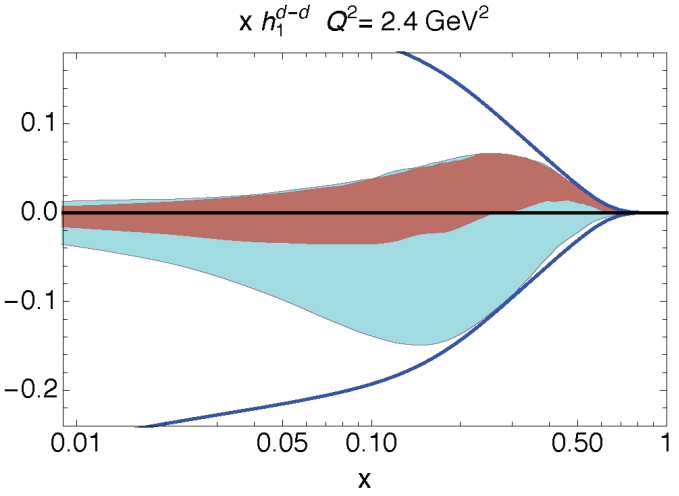
need data from target more sensitive to down : deuteron, ^{3}He …

down

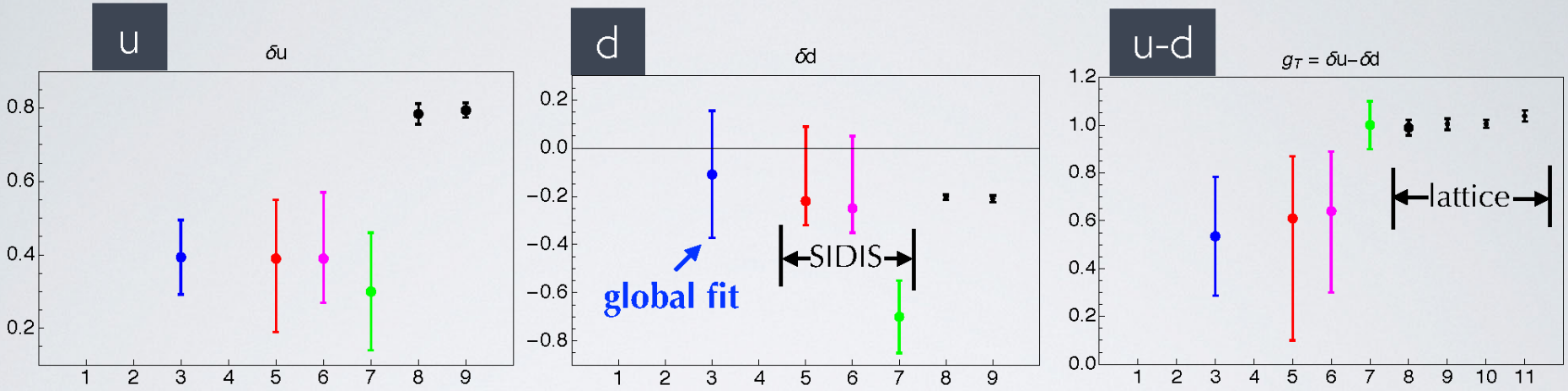
sensitive to uncertainty on gluon D_1

$$D_1^g(Q_0) = 0$$

$$D_1^g(Q_0) = \begin{cases} 0 \\ D_1^u/4 \\ D_1^u \end{cases}$$



tensor charge



no simultaneous compatibility between lattice and phenomenology

Q^2=4 GeV^2 *

JAM includes "lattice data"

*Radici & Bacchetta, P.R.L. **120** (18) 192001* 3) global fit '17

*Kang et al., P.R. D**93** (16) 014009* 5) "TMD fit" * Q^2=10

*Anselmino et al., P.R. D**87** (13) 094019* 6) Torino fit * Q^2=1

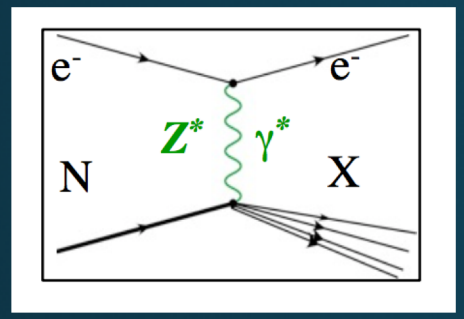
*Lin et al., P.R.L. **120** (18) 152502* 7) JAM fit '17 * Q_0^2=2

8) PNDME '18 *Gupta et al., P.R. D**98** (18) 034503*

9) ETMC '17 *Alexandrou et al., P.R. D**95** (17) 114514; E P.R. D**96** (17) 099906*

10) RQCD '14 *Bali et al., P.R. D**91** (15)*

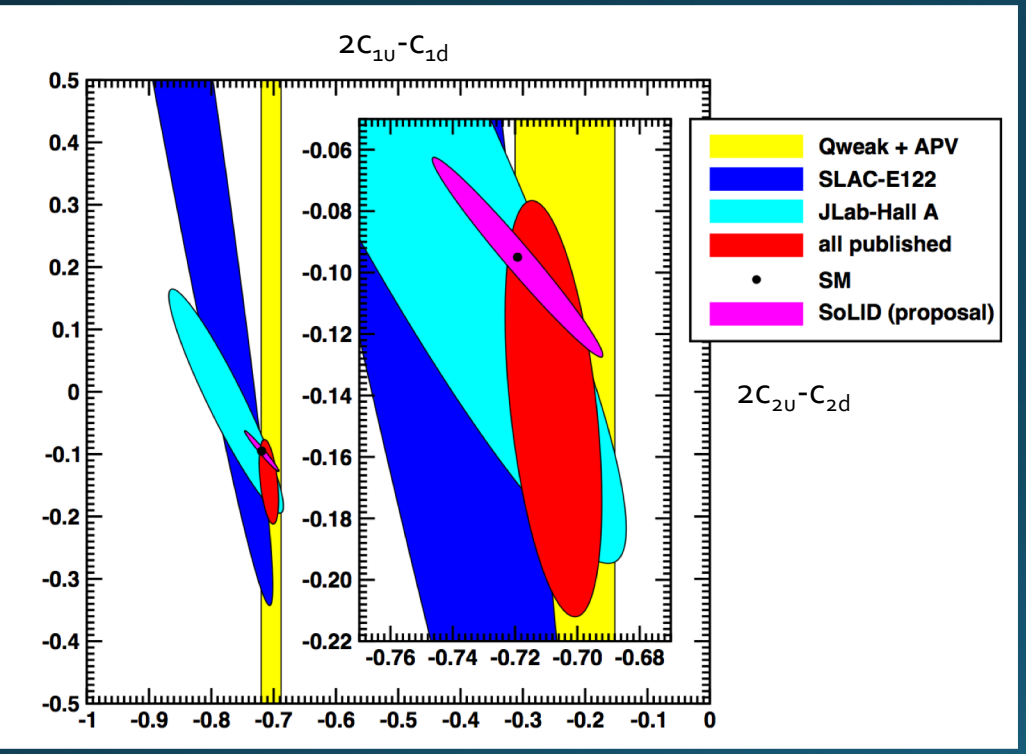
11) LHPC '12 *Green et al., P.R. D**86** (12)*



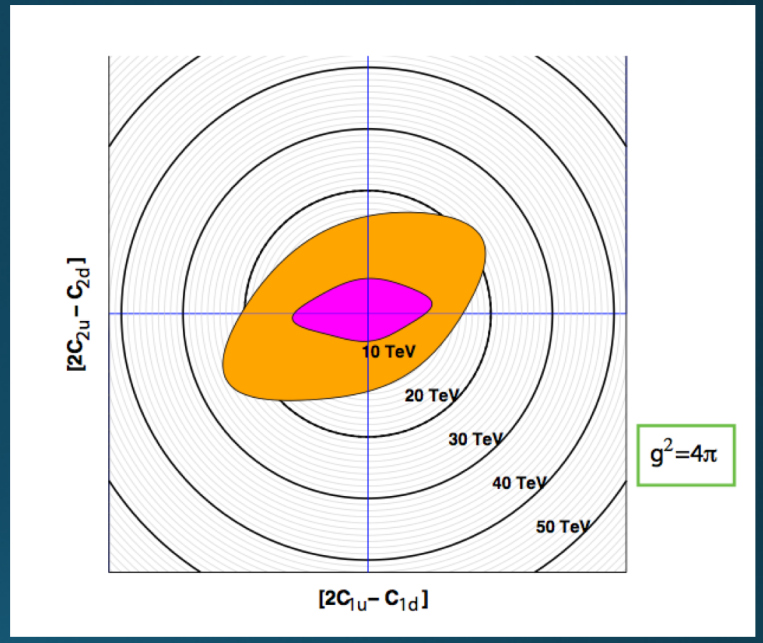
PVDIS@SoLID: Ultimate PVDIS measurement

Searching for Physics Beyond the Standard Model

An asymmetry is measured: $A_{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$



- Sensitive to fundamental couplings $2C_{2u}-C_{2d}$
- Charge symmetry violation in the parton distribution functions
- Clean measurement of d/u ratio in the valence region



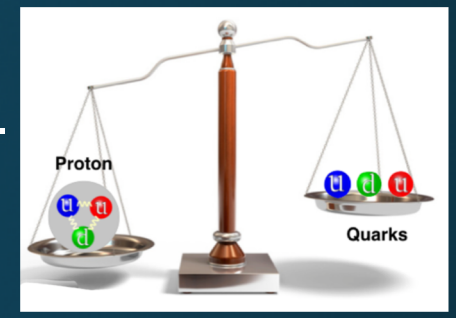
Results from the PVDIS experiment, Wang et al., Nature 506 No. 7486, 67 (2014) together with projected results from PVDIS@SoLID

Projected mass limits for composite models. Purple region is excluded by published data Orange region is the projected reach with SoLID and final Qweak result

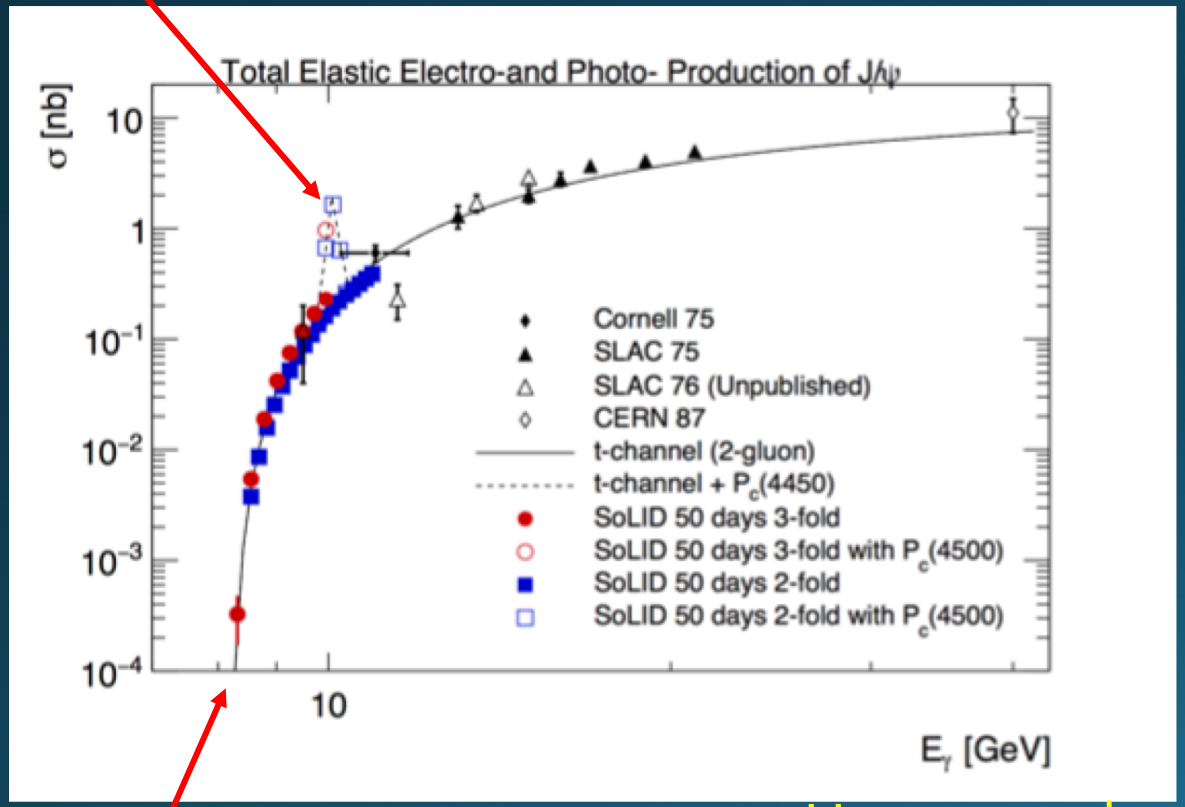
Sensitive to new physics, example: Leptophobic Z'

J/Psi@ SoLID; The threshold region, the mass of the proton and the LHCb charmed pentaquark

- Measure the contribution of the gluons to the mass of the proton directly.
- Poduce and determine the quantum numbers of the LHCb pentaquark if it exist.



LHCb Pentaquark production



Threshold

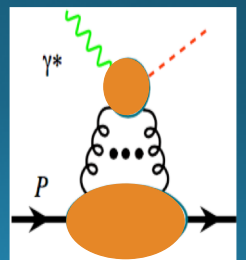
How does QCD generate the mass of the proton?

✧ Trace of the QCD energy-momentum tensor:

$$T^{\alpha}_{\alpha} = \underbrace{\frac{\beta(g)}{2g} F^{\mu\nu,a} F^{a}_{\mu\nu}}_{\text{QCD trace anomaly}} + \sum_{q=u,d,s} m_q (1+\gamma_m) \bar{\psi}_q \psi_q$$

$$\beta(g) = -(11 - 2n_f/3) g^3/(4\pi)^2 + \ldots$$

J/Ψ, ϒ, …



➡ Heavy quarkonium production near the threshold, from JLab12 to EIC

Summary

- SoLID science program is rich and impactful and leads naturally to the EIC science program.
- SoLID complements well the 12 GeV existing science tools but takes advantage of the full potential the 12 GeV upgrade offers.
- The key factors are luminosity and acceptance.