SoLID Overview

Solenoidal Large Intensity Device

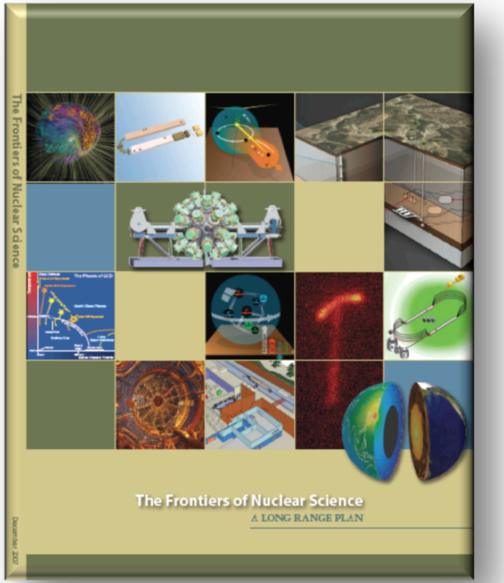
8th Workshop on Hadron Physics in China
and Opportunities Worldwide
August 8 – 11, 2016

Haiyan Gao
Duke University and Duke Kunshan University

Duke
UNIVERSITY

昆山杜克大学
DUKE KUNSHAN
UNIVERSITY

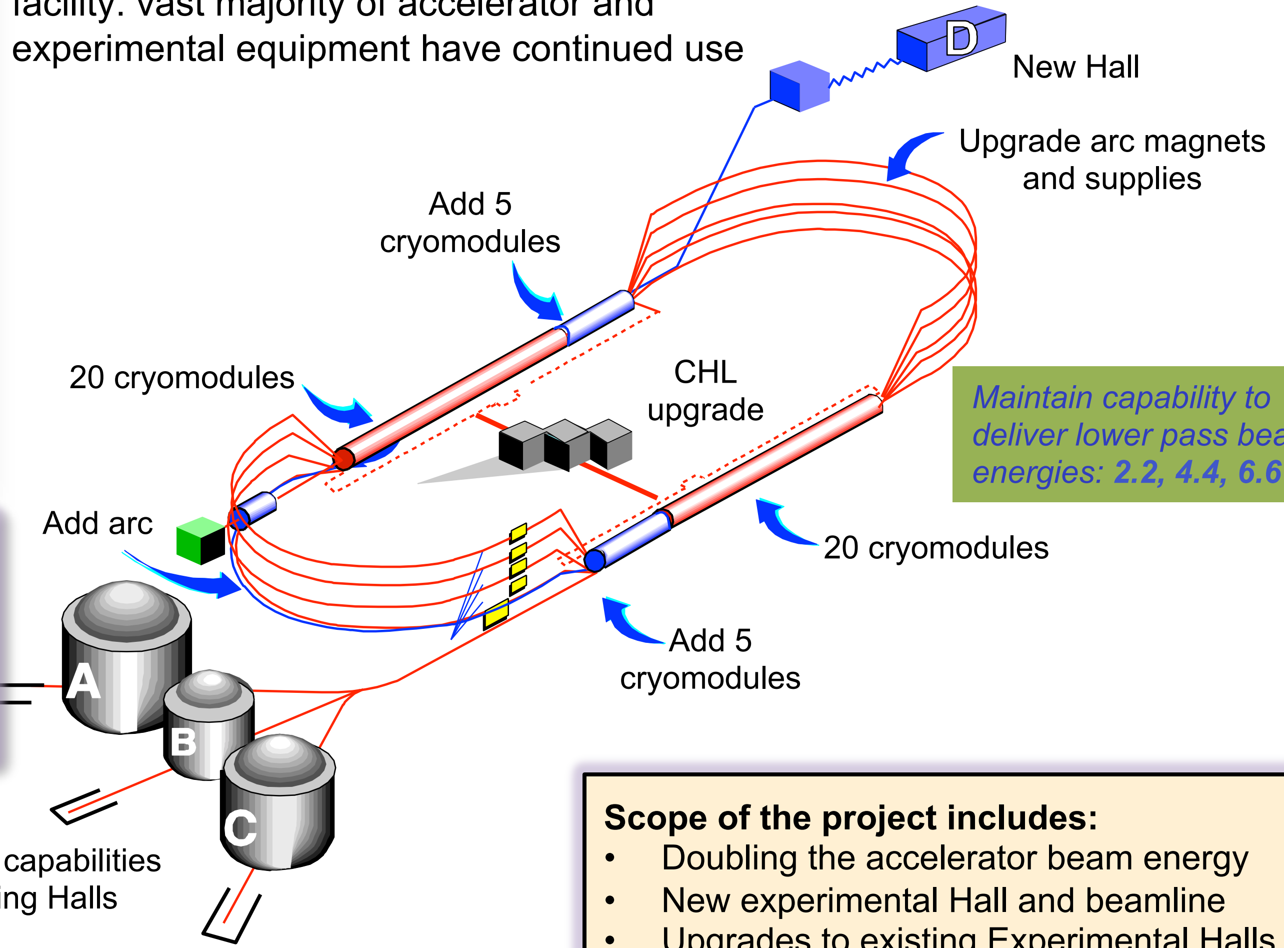
12 GeV Upgrade at JLab



The Frontiers of Nuclear Science

A LONG RANGE PLAN

Upgrade is designed to build on existing facility: vast majority of accelerator and experimental equipment have continued use



*Maintain capability to deliver lower pass beam energies: **2.2, 4.4, 6.6….***

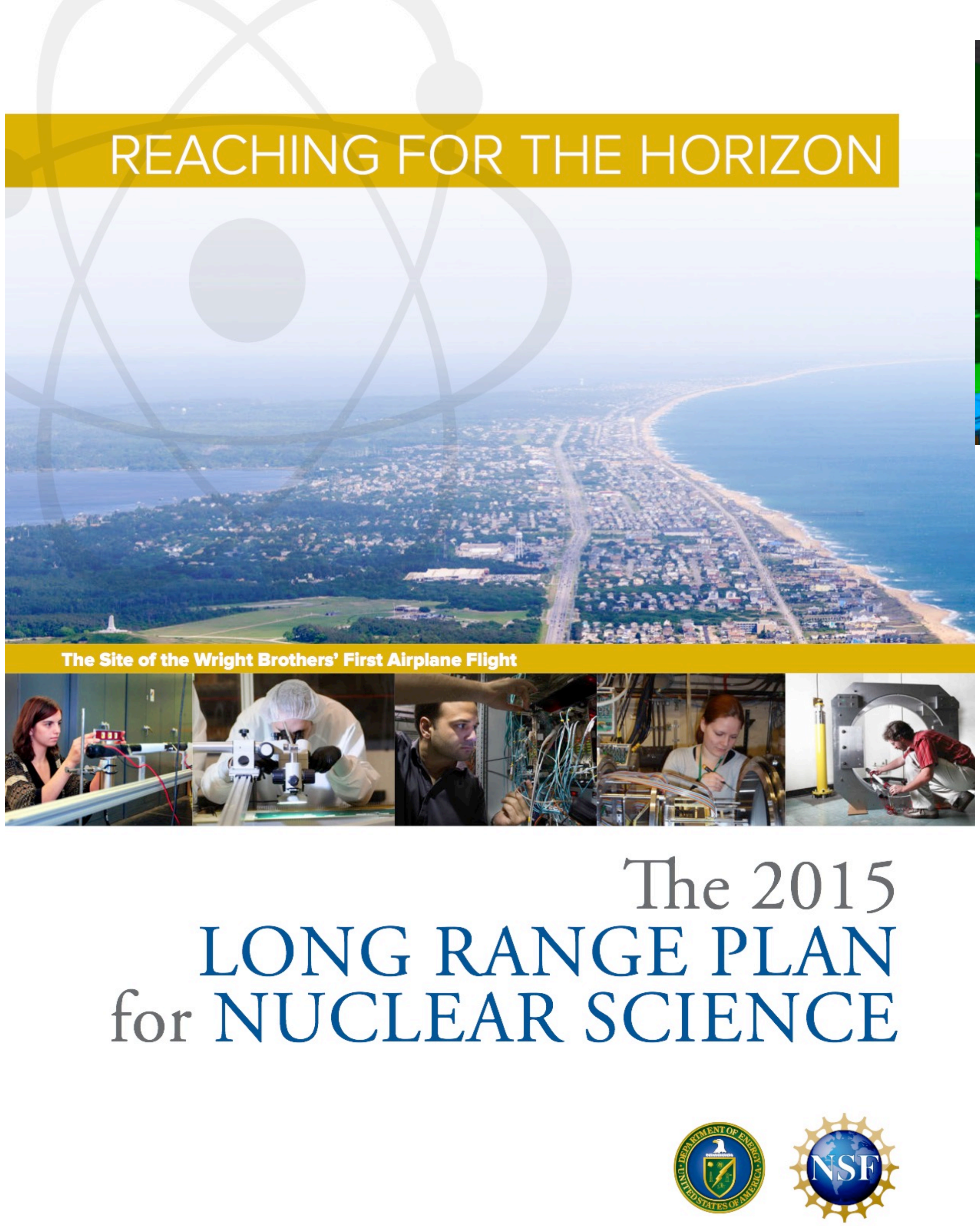
The completion of the 12 GeV Upgrade of CEBAF was ranked the highest priority in the 2007 NSAC Long Range Plan.

Scope of the project includes:

- Doubling the accelerator beam energy
- New experimental Hall and beamline
- Upgrades to existing Experimental Halls

Solenoidal Large Intensity Device (SoLID) proposed for Hall A

Allison Lung's presentation



REACHING FOR THE HORIZON

The Site of the Wright Brothers' First Airplane Flight

The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE

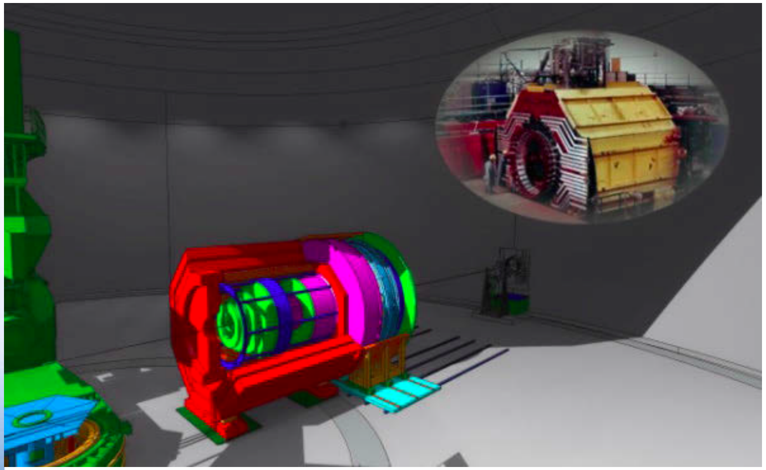


Figure 2.6: *The envisioned SoLID experiment in Hall A is centered around the CLEO-II magnet (insert) that will be relocated to JLab to enable a rich multipurpose science program. SoLID boasts large acceptance detection with operability at extremely high luminosities and offers unprecedented opportunities to provide precision 3D imaging of the motion of valence quarks in the nucleon and to probe the Standard Model.*

Overview of SoLID

Solenoidal **L**arge **I**ntensity **D**evice

- **SoLID is unique in that it provides equipment that combines**
  - **The capability to handle high luminosity ($10^{37\text{-}39}$)**
  - **A large acceptance detector with full ϕ coverage**

  → This allows a full exploitation of the JLab 12 GeV Upgrade
- SoLID takes advantage of the latest developments in detector and data acquisition technologies

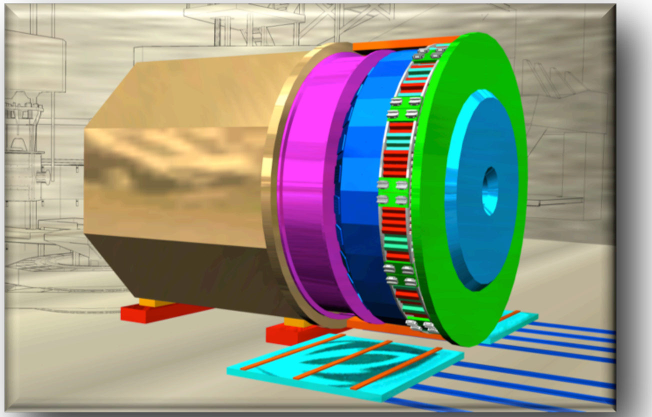
- **SoLID is unique as evidenced by the approval of already 5 highly rated experiments, covering a wide range of important science topics**
  - **500 PAC days (~ 5 years) of high-quality science program foreseen, both unique and multi-purpose**

- **There is wide interest in SoLID science as evidenced 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

Solenoidal Large Intensity Device (SoLID) Physics

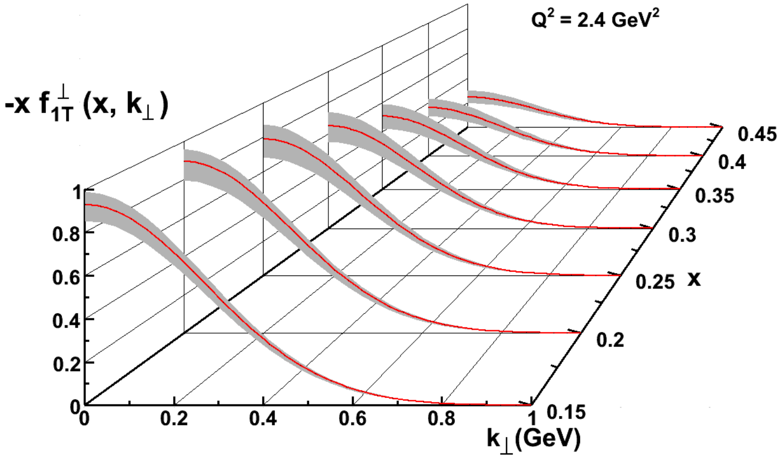
SoLID provides unique capability:

- ✓ high luminosity ($10^{37\text{-}39}$)
- ✓ large acceptance with full ϕ coverage

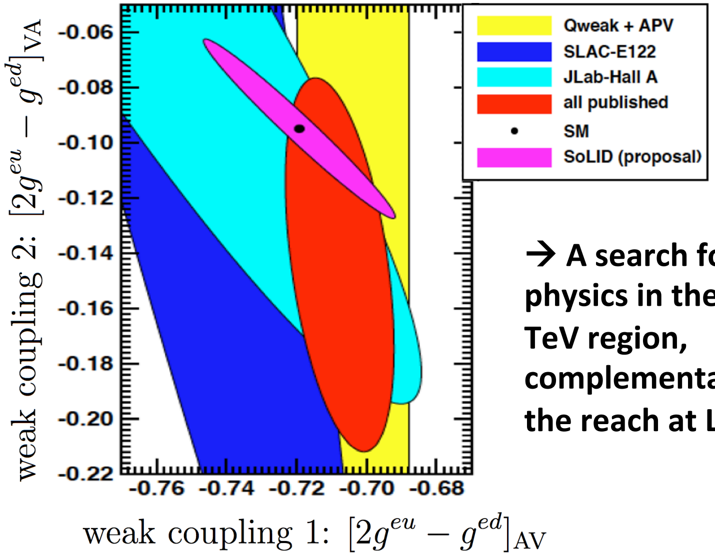


→ multi-purpose program to maximize the 12-GeV science potential

1) Precision in 3D momentum space imaging of the nucleon

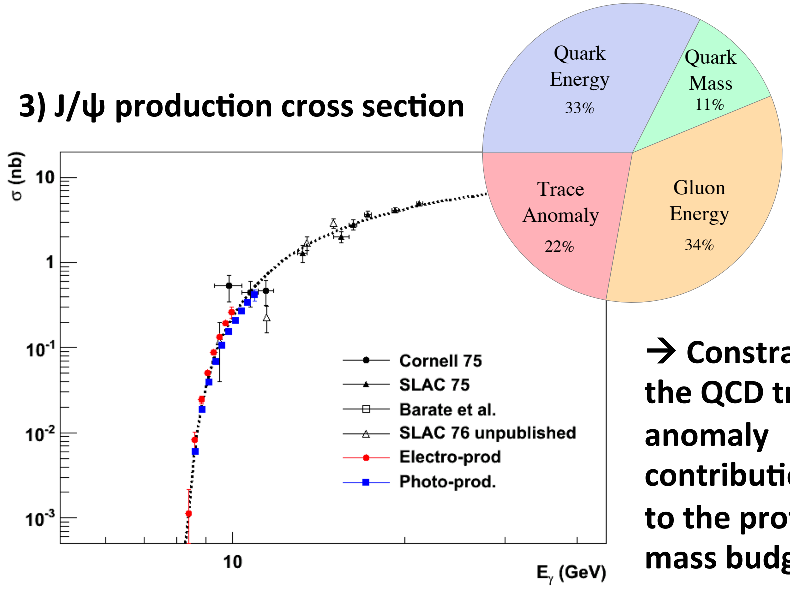


2) Precise determination of the electroweak couplings



→ A search for new physics in the 10-20 TeV region, complementary to the reach at LHC.

3) J/ψ production cross section

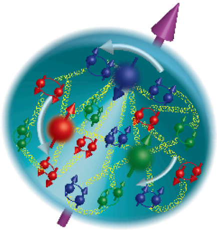


→ Constrain the QCD trace anomaly contribution to the proton mass budget

Semi-inclusive Deep-Inelastic Scattering and Nucleon Tomography in Momentum Space

Precision Probe of Nucleon 3-d Structure, Spin Structure, and QCD Dynamics

Nucleon Spin Decomposition



Proton spin puzzle

$$\Delta\Sigma = \Delta u + \Delta d + \Delta s \sim 0.3$$

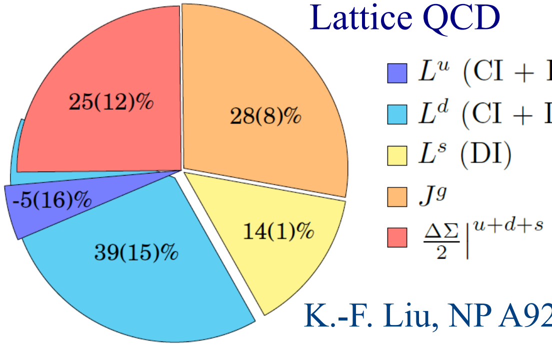
Quark spin only contributes a small fraction to nucleon spin.

J. Ashman et al., PLB 206, 364 (1988); NP B328, 1 (1989).

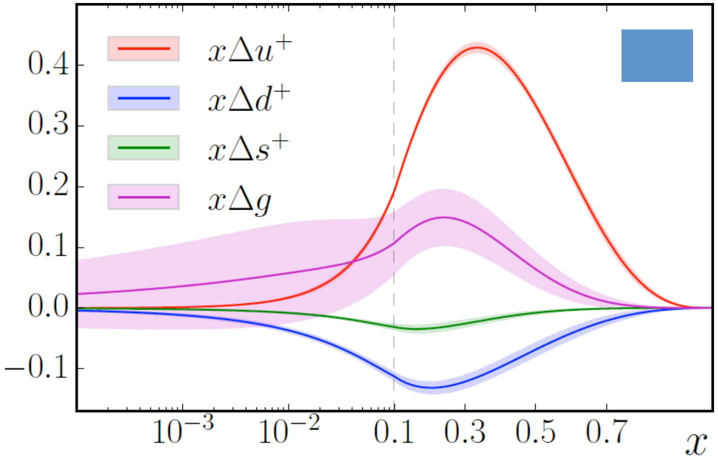
Spin decomposition

$$J = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

Lattice QCD



K.-F. Liu, NP A928, 99 (2014).



JAM Collaboration, to appear in PRD (2016).

Access to $L_{q/g}$

It is necessary to have transverse information.

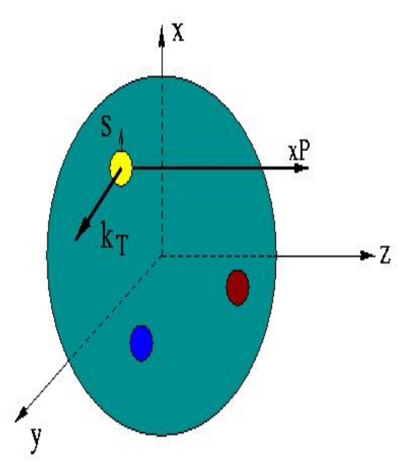
Coordinate space: GPDs
Momentum space: TMDs

3D imaging of the nucleon.

Unified View of Nucleon Structure

$W_p^u(x,k_T,\boldsymbol{r_T})$ Wigner distributions

5D Dist.

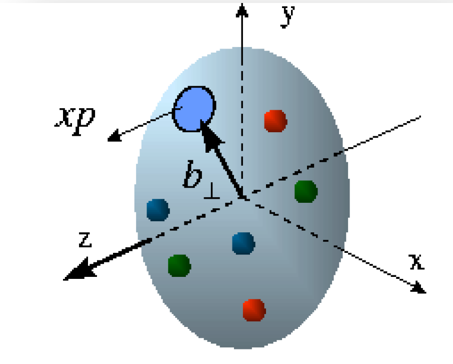


$d^2\boldsymbol{r_T}$

d^2k_T

TMD PDFs
$f_1^u(x,k_T)$, ..
$h_1^u(x,k_T)$

GPDs/IPDs

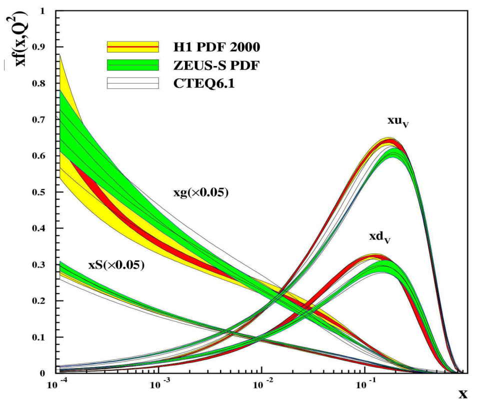


3D imaging

d^2k_T

d^2r_T

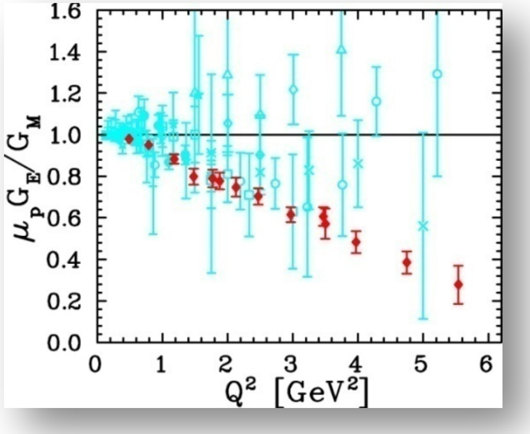
dx &
Fourier Transformation



PDFs
$f_1^u(x)$, ..
$h_1^u(x)$

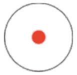
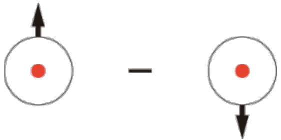
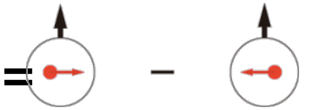
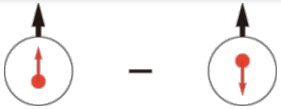
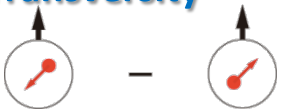
1D

Form Factors
$G_E(Q^2)$,
$G_M(Q^2)$

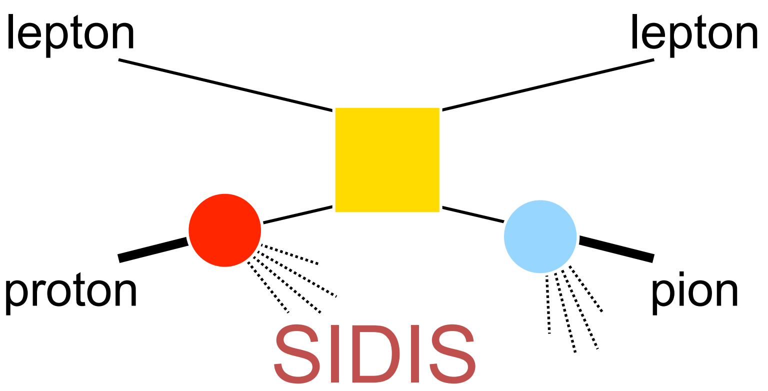


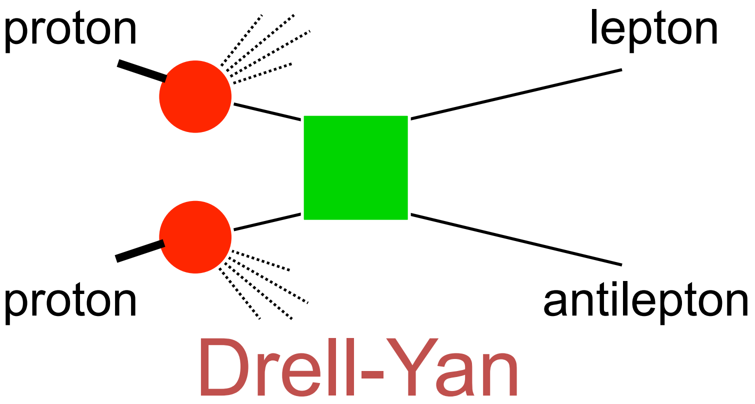
Leading Twist TMDs

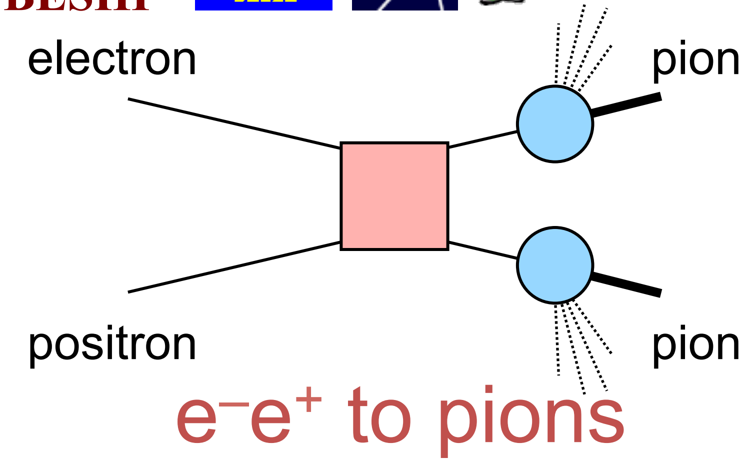
→ Nucleon Spin
→ Quark Spin

		Quark polarization		
		Un-Polarized	Longitudinally Polarized	Transversely Polarized
Nucleon Polarization	U	f_1 = 		$h_1^{\perp}$ =  **Boer-Mulder**
	L		g_1 =  **Helicity**	$h_{1L}^{\perp}$ = 
	T	$f_{1T}^{\perp}$ =  **Sivers**	$g_{1T}^{\perp}$ = 	h_{1T} =  **Transversity** $h_{1T}^{\perp}$ =  **Pretzelosity**

Access TMDs through Hard Processes







🟨 Partonic scattering amplitude

🔵 Fragmentation amplitude

🔴 Distribution amplitude

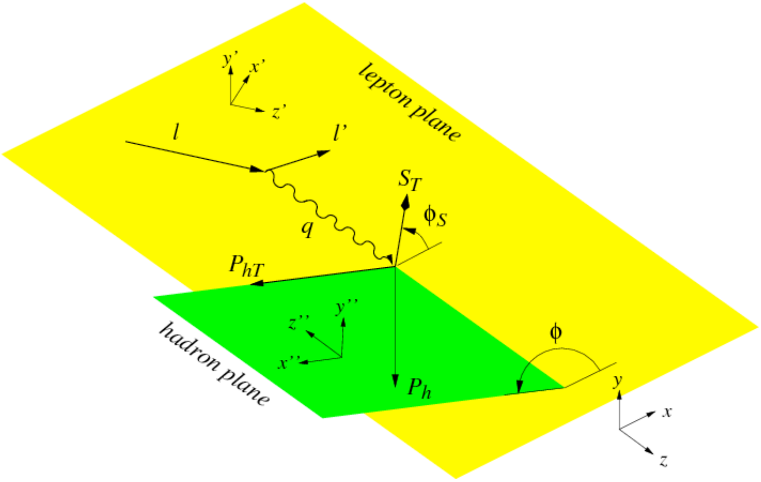
$$f_{1T}^{\perp q}(\text{SIDIS}) = -f_{1T}^{\perp q}(\text{DY})$$

$$h_1^{\perp}(\text{SIDIS}) = -h_1^{\perp}(\text{DY})$$

Drell-Yan Programs

SIDIS and Structure Functions

SIDIS differential cross section



[Diehl&Sapeta EPJC2005]

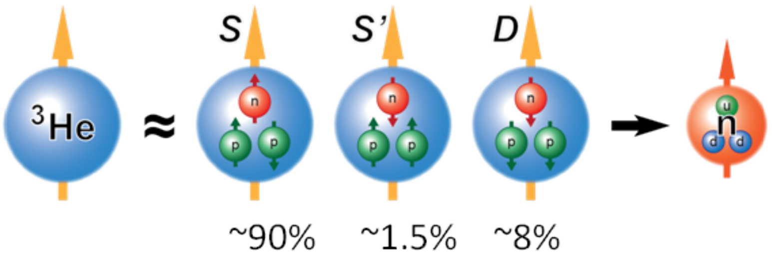
18 structure functions F(x, z, Q^2, P_T),
model independent. (one photon exchange approximation)

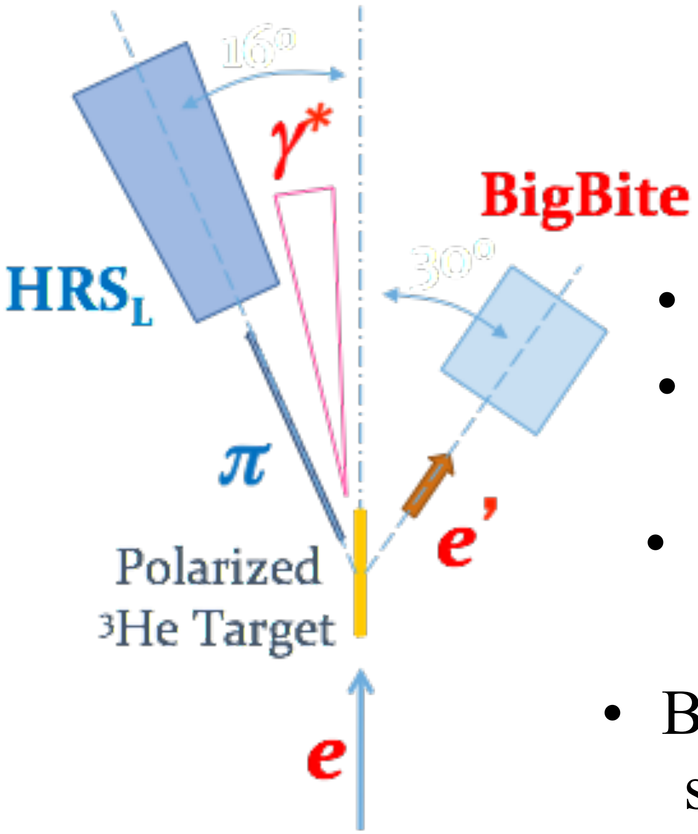
$$\frac{d\sigma}{dx\,dy\,dz\,dP_T^2\,d\phi_h\,d\phi_S}$$
$$= \frac{\alpha^2}{xyQ^2}\frac{y^2}{2(1-\epsilon)}\left(1+\frac{\gamma^2}{2x}\right)$$
$$\times\Big\{F_{UU,T}+\epsilon F_{UU,L}+\sqrt{2\epsilon(1+\epsilon)}F_{UU}^{\cos\phi_h}\cos\phi_h+\epsilon F_{UU}^{\cos 2\phi_h}\cos 2\phi_h+\lambda_e\sqrt{2\epsilon(1-\epsilon)}F_{LU}^{\sin\phi_h}\sin\phi_h$$
$$+S_L\left[\sqrt{2\epsilon(1+\epsilon)}F_{UL}^{\sin\phi_h}\sin\phi_h+\epsilon F_{UL}^{\sin 2\phi_h}\sin 2\phi_h\right]+\lambda_e S_L\left[\sqrt{1-\epsilon^2}F_{LL}+\sqrt{2\epsilon(1-\epsilon)}F_{LL}^{\cos\phi_h}\cos\phi_h\right]$$
$$+S_T\Big[\big(F_{UT,T}^{\sin(\phi_h-\phi_S)}+\epsilon F_{UT,L}^{\sin(\phi_h-\phi_S)}\big)\sin(\phi_h-\phi_S)+\epsilon F_{UT}^{\sin(\phi_h+\phi_S)}\sin(\phi_h+\phi_S)+\epsilon F_{UT}^{\sin(3\phi_h-\phi_S)}\sin(3\phi_h-\phi_S)$$
$$+\sqrt{2\epsilon(1+\epsilon)}F_{UT}^{\sin\phi_S}\sin\phi_S+\sqrt{2\epsilon(1+\epsilon)}F_{UT}^{\sin(2\phi_h-\phi_S)}\sin(2\phi_h-\phi_S)\Big]$$
$$+\lambda_e S_T\Big[\sqrt{1-\epsilon^2}F_{LT}^{\cos(\phi_h-\phi_S)}\cos(\phi_h-\phi_S)$$
$$+\sqrt{2\epsilon(1-\epsilon)}F_{LT}^{\cos\phi_S}\cos\phi_S+\sqrt{2\epsilon(1-\epsilon)}F_{LT}^{\cos(2\phi_h-\phi_S)}\cos(2\phi_h-\phi_S)\Big]\Big\}$$

SoLID:
4D bins in (x, z, Q^2, P_T)

In parton model, F(x, z, Q^2, P_T)s are expressed as the convolution of TMDs.

E06-010 Experiment @ Hall A

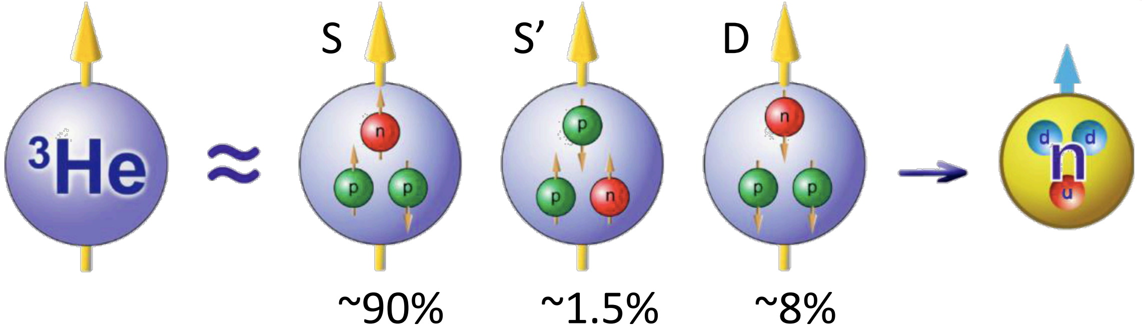




- First neutron data in SIDIS
- Electron beam energy: 5.9 GeV
  Average current: 12μA
- 40cm transversely polarized ^{3}He target
  Average polarization: 55.4 ± 2.8%
- BigBite at 30° as **electron** arm
  scattered electron momentum 0.6~2.5 GeV/c
- HRS at 16° as **hadron** arm
  hadron momentum ~ 2.35 GeV/c

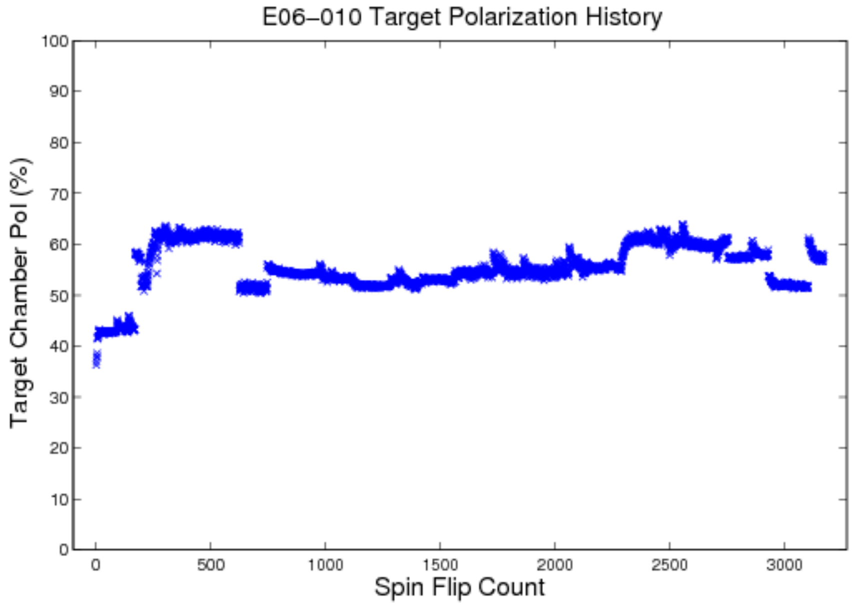
HERMES and COMPASS
SIDIS experiments

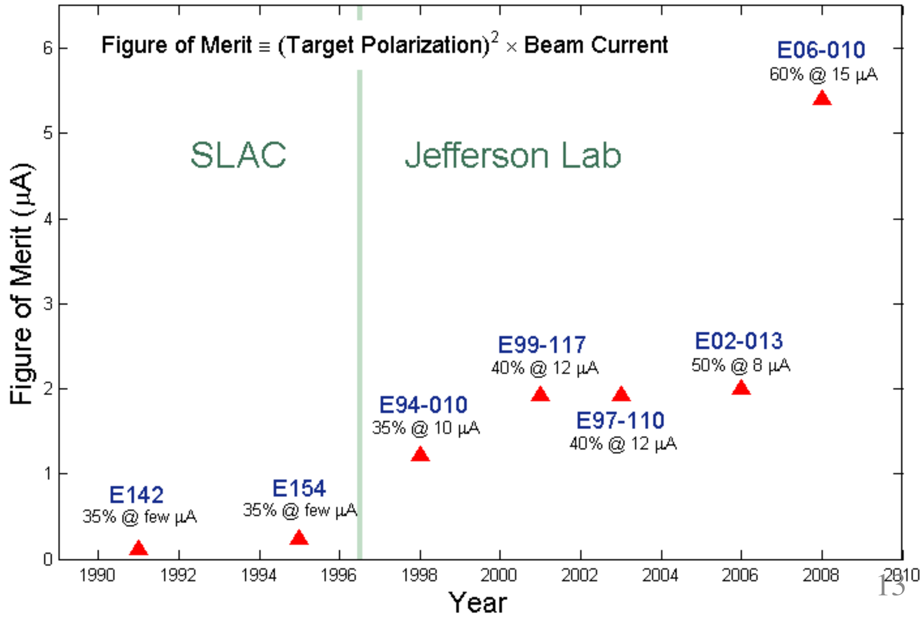
Polarized ^{3}He Target



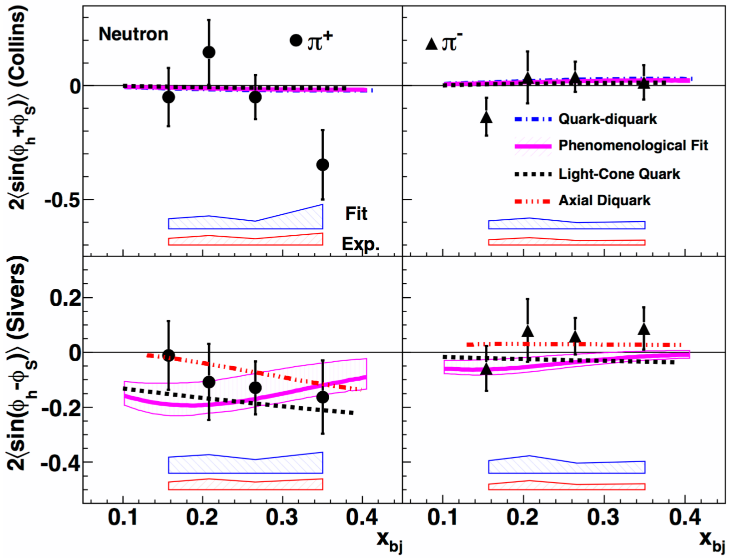
Effective Polarized Neutron Target!

- Polarized ^{3}He ran reliably throughout the experiment, and the following three experiments.
- Reached **55%-60%** polarization with 15 μA beam and 20 minute spin flip! **A NEW RECORD!**

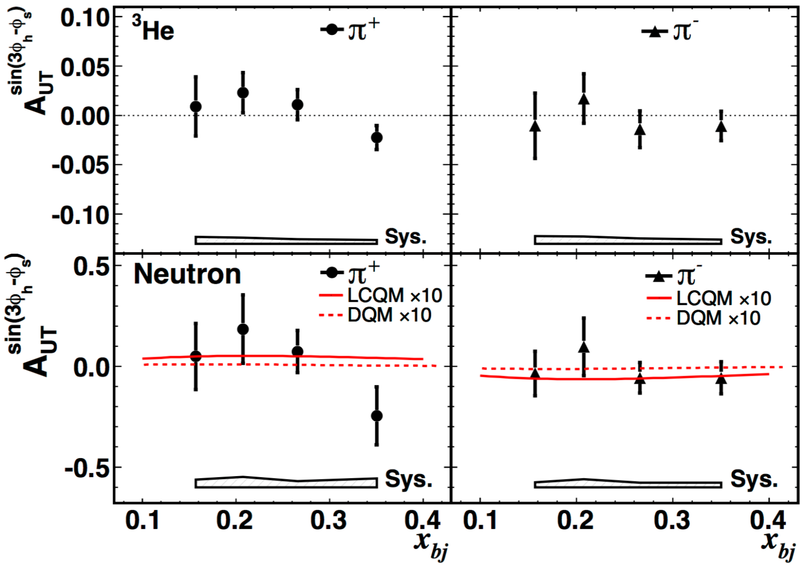




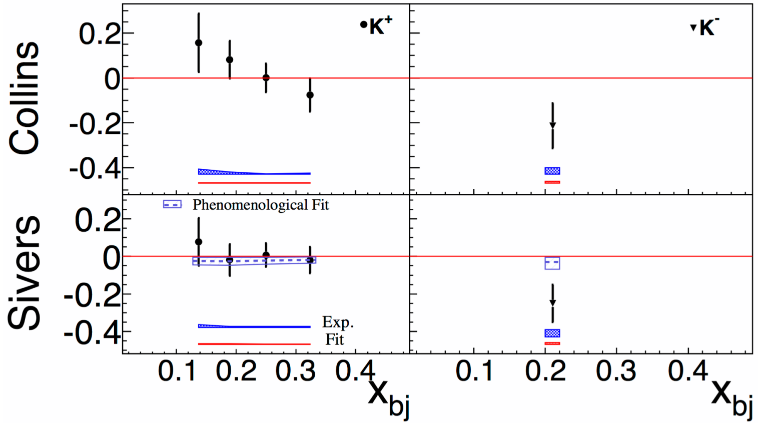
SIDIS SSA/DSA Results



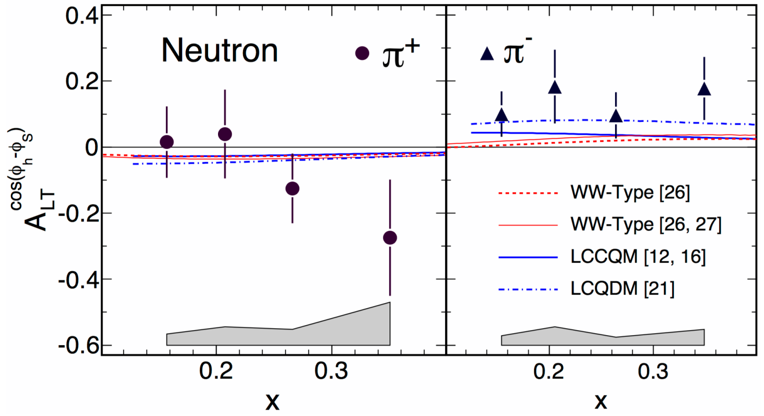
X. Qian *et al.*, PRL 107, 072003 (2011)



Y. Zhang *et al.*, PR C90, 055209 (2014)



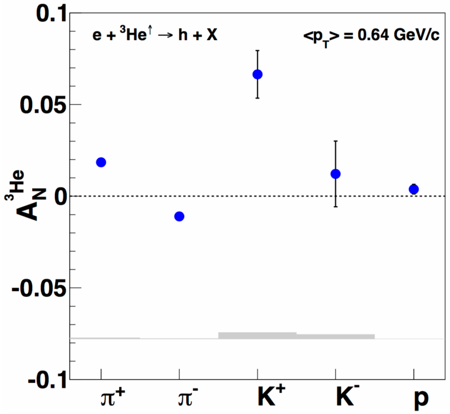
Y.X. Zhao *et al.*, PR C90, 055201 (2014)

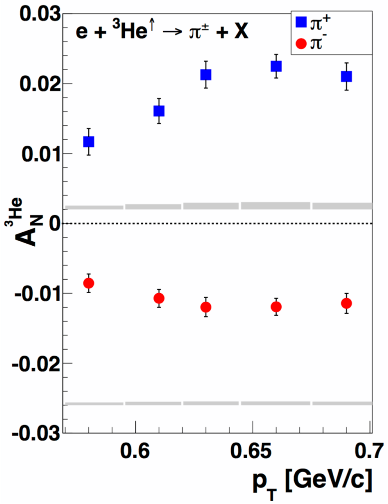


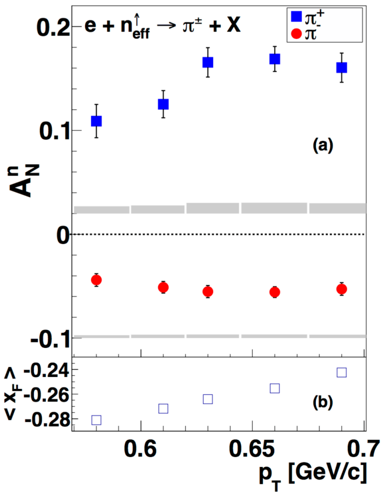
J. Huang *et al.*, PRL 108, 052001 (2012)

Inclusive Hadron Production SSA/DSA Results

Target single spin asymmetry

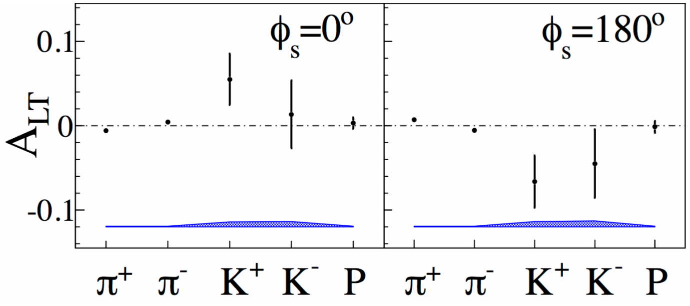


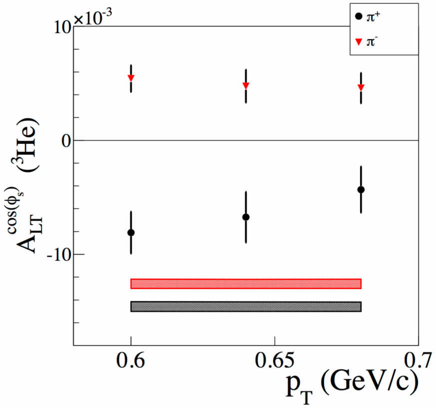


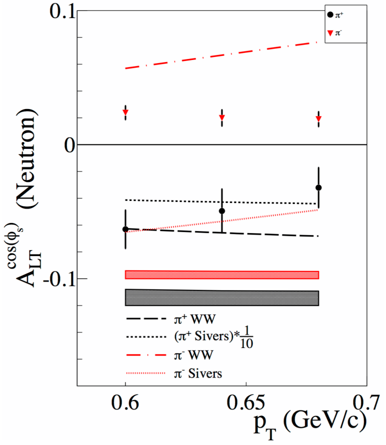


K. Allada *et al.*, PR C89, 042201 (2014)

Beam-target double spin asymmetry



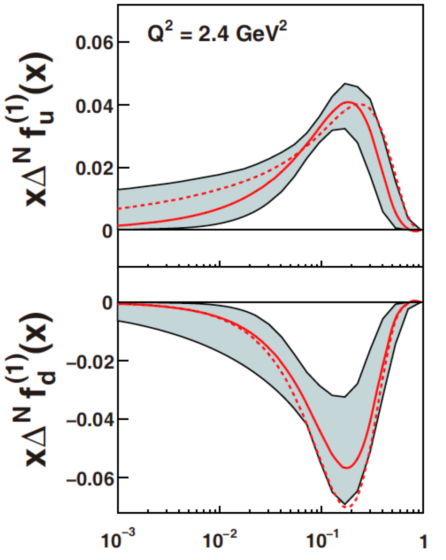




Y.X. Zhao *et al.*, PR C92, 015207 (2015)

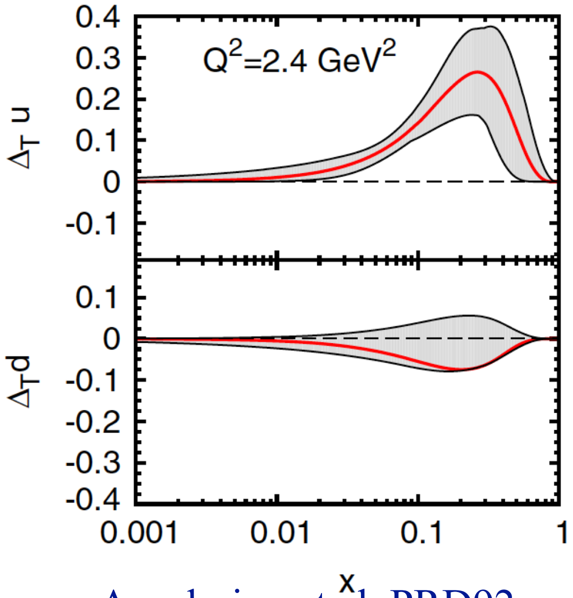
Present Status On TMD Extractions

Sivers



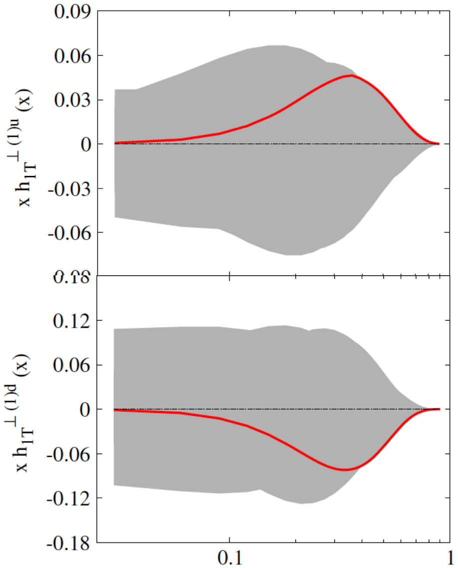
Anselmino et al, EPJA39, 89 (2009)

Transversity



Anselmino et al, PRD92, 114023 (2015)

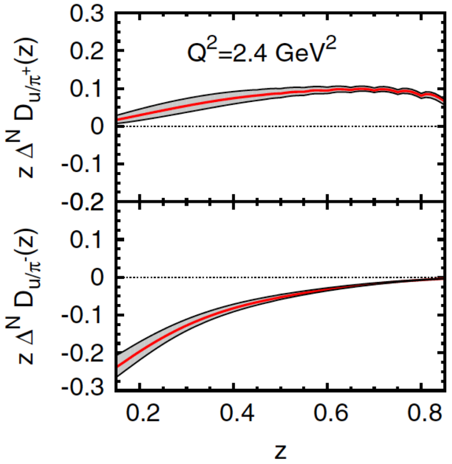
Pretzelosity

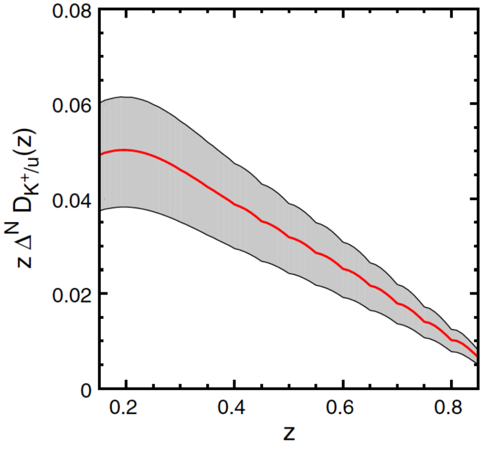


Lefky et al, PRD91, 034010 (2015)

Collins fragmentation

Anselmino et al, PRD92,
114023 (2015)
PRD93,
034025 (2016)





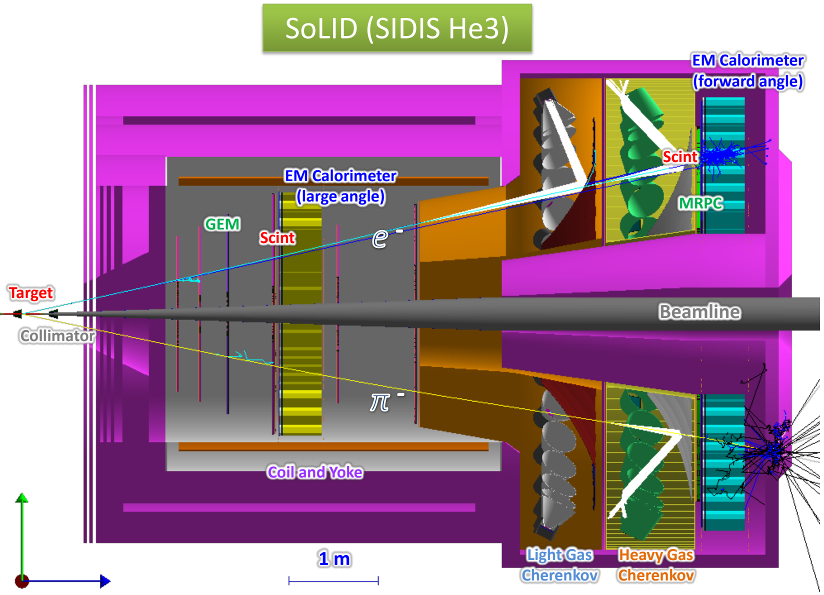
Preliminary Cross Section Results

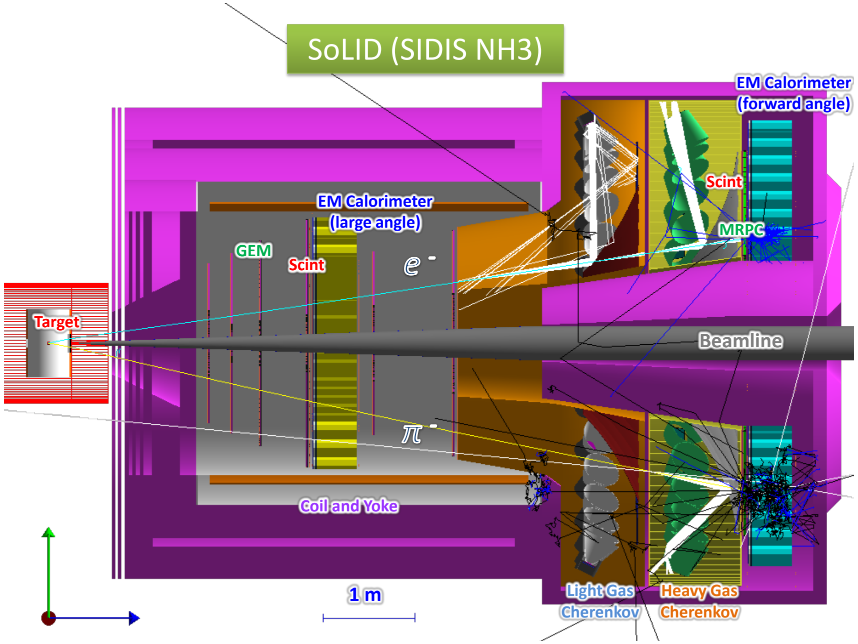
First measurement of unpolarized SIDIS differential cross section on ^{3}He target

Data compared with parametrization V. Barone *et al.*, PR D91, 074019 (2015)

X. Yan *et al.*, in preparation

SoLID-Spin: SIDIS on ^{3}He/Proton @ 11 GeV





E12-10-006: Single Spin Asymmetry on Transverse ^{3}He @ 90 days, **rating A**

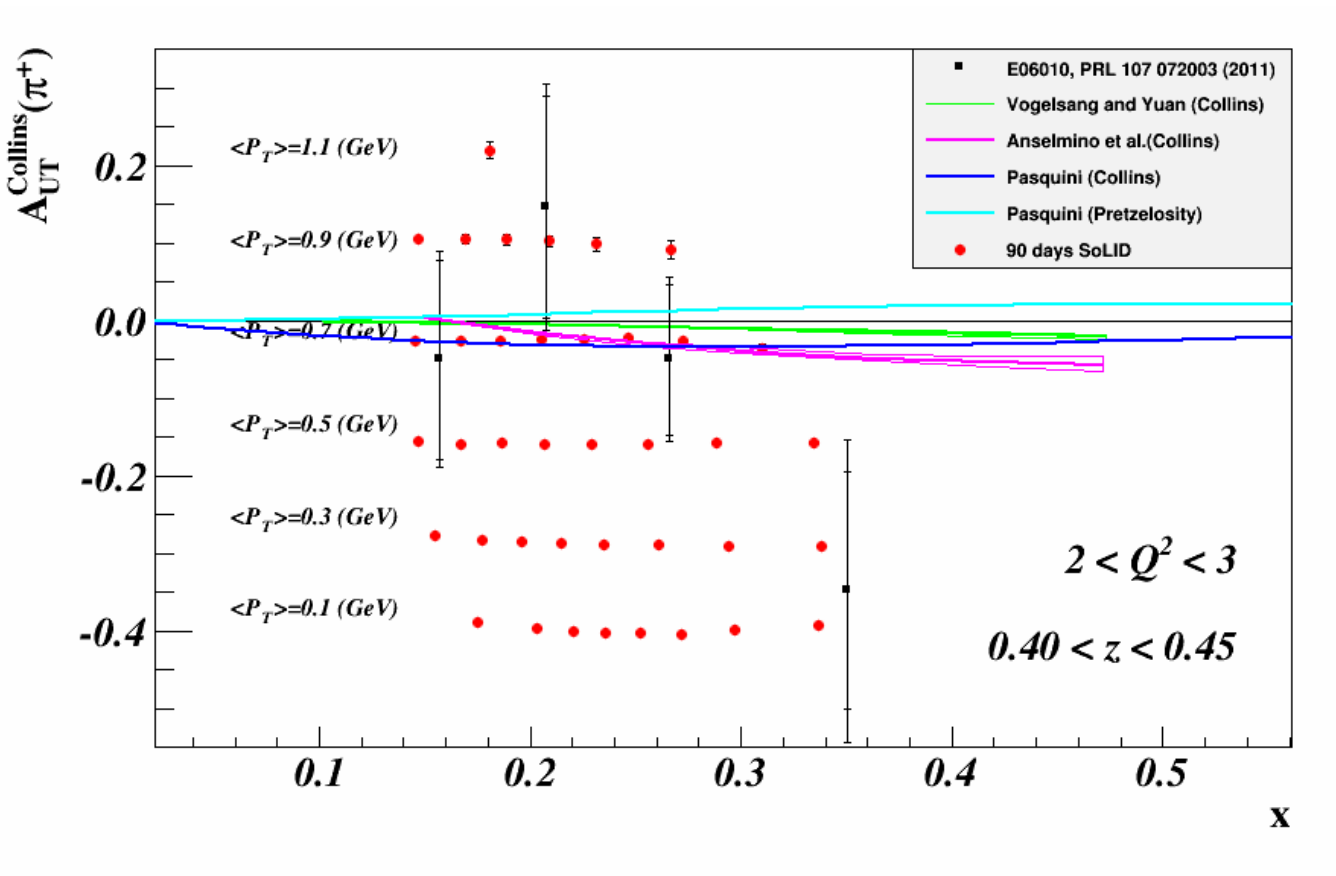
E12-11-007: Single and Double Spin Asymmetry on ^{3}He @ 35 days, **rating A**

E12-11-108: Single and Double Spin Asymmetries on Transverse Proton @120 days, **rating A**

Three run group experiments approved: TMDs, GPDs, and much more

Key of SoLID-Spin program:
Large Acceptance
+ High Luminosity
→ **4-D** mapping of asymmetries
→ Tensor charge, TMDs …
→Lattice QCD, QCD Dynamics, Models.

Projected Data (E12-10-006)



- Total 1400 bins in x, Q^2, P_T and z for 11/8.8 GeV beam.
- z ranges from 0.3 ~ 0.7, only one z and Q^2 bin of 11/8.8 GeV is shown here. π^+ projections are shown, similar to the π^- .

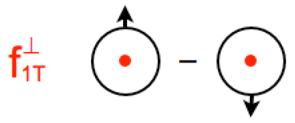
E12-10-006 Spokespersons: Chen, Gao (contact), Jiang, Qian and Peng

X. Qian et al in PRL 107, 072003

Unpolarized Quark in p↑

$$f_{q/p\uparrow}(x,\mathbf{k}_\perp) = f_1^q(x,k_\perp) - f_{1T}^{\perp q}(x,k_\perp)\frac{\hat{\mathbf{P}}\times\mathbf{k}_\perp\cdot\mathbf{S}}{M}$$

Sivers distribution



naively time-reversal odd.

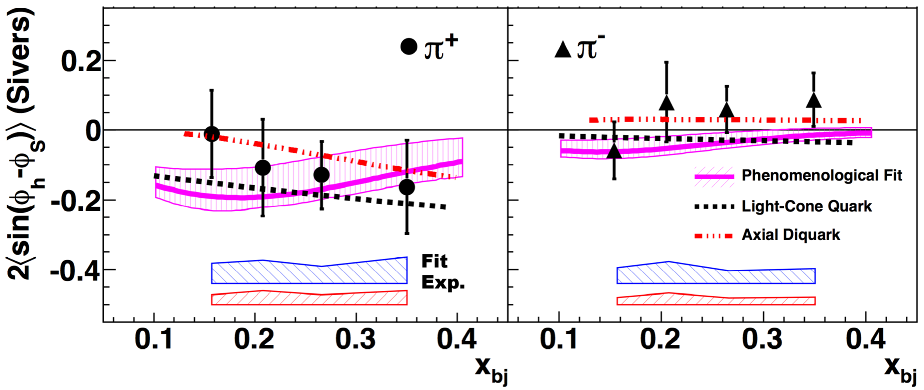
$$f_{1T}^{\perp q}(x,k_\perp)\Big|_{\text{SIDIS}} = -f_{1T}^{\perp q}(x,k_\perp)\Big|_{\text{DY}}$$

Measurement in SIDIS

Single spin asymmetry

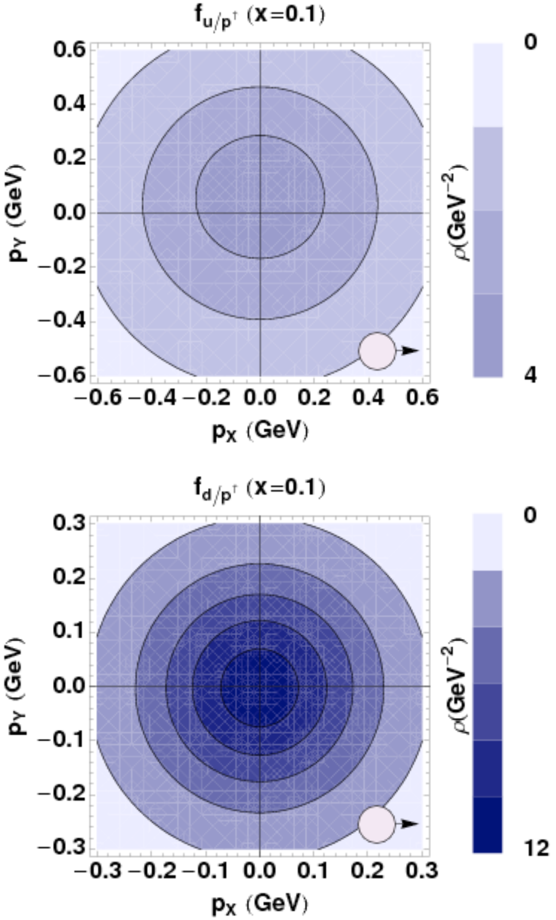
(Sivers asymmetry)

$$A_{UT}^{\sin(\phi_h-\phi_S)} \sim f_{1T}^{\perp}(x,k_\perp) \bigotimes D_1(z,p_\perp)$$



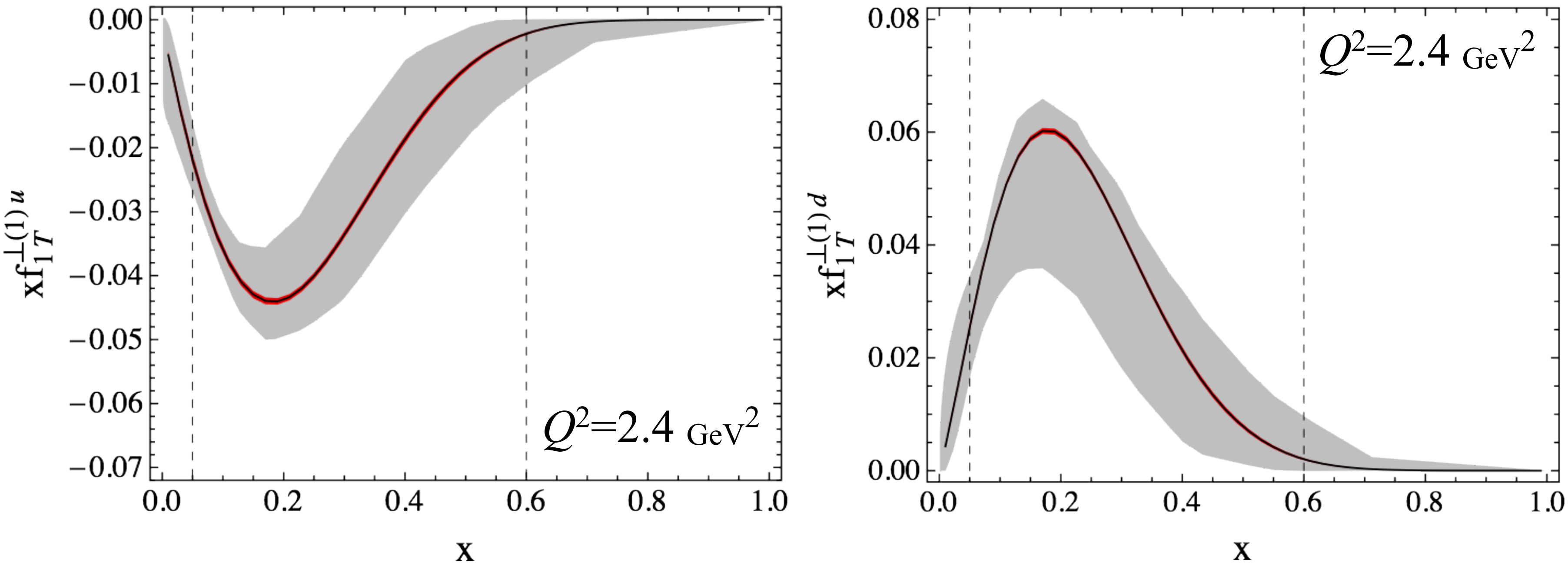
6 GeV JLab E06-010, X. Qian et al., PRL 107, 072003 (2011).

Model Calculation



Bacchetta, Conti, Radici
PR D 78, 074010 (2008).

SoLID Impact on Sivers

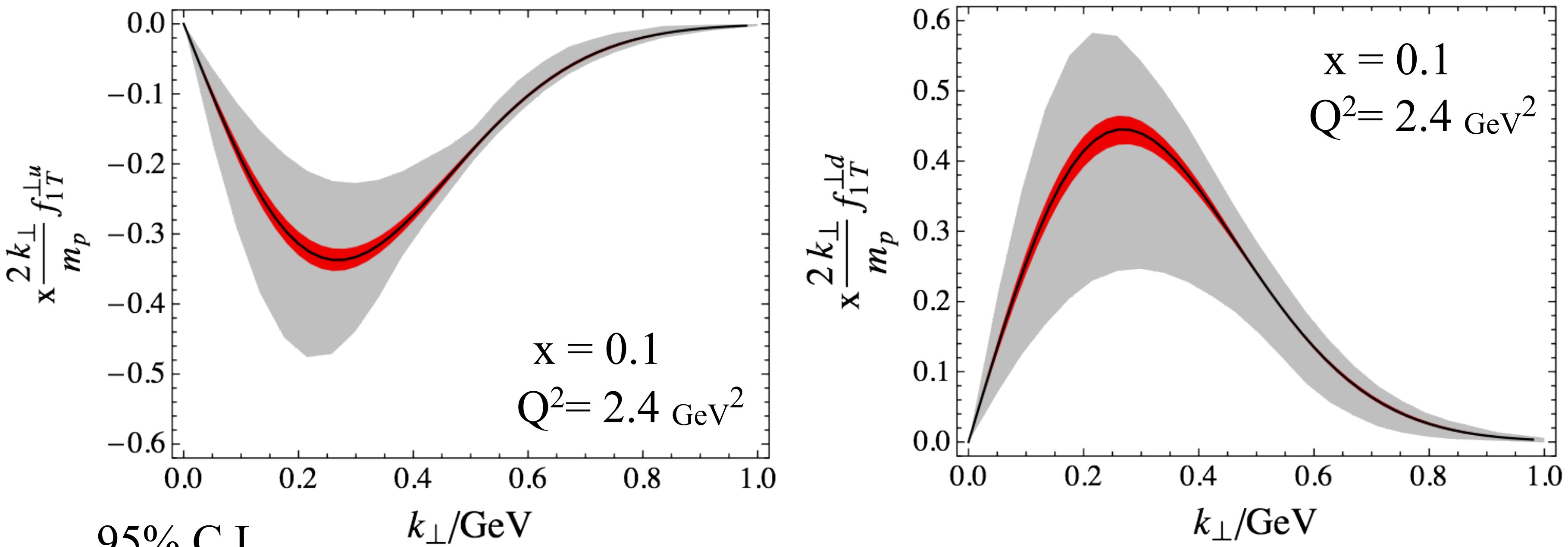


95% C.L.

Gray: parametrization by M. Anselmino *et al*., EPJ A 39, 89 (2009).

Red: SoLID projection with transversely polarized neutron/proton data.

Quark Transverse Momentum in p↑



95% C.L.

▨ parametrization by M. Anselmino et al., EPJ A 39, 89 (2009).

🟥 SoLID projection with transversely polarized neutron and proton data.

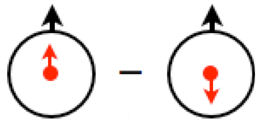
$$\langle \mathbf{k}_\perp \rangle = -M \int \mathrm{d}x\, f_{1T}^{\perp(1)}(x)\,(\mathbf{S}\times\hat{\mathbf{P}})$$

	$\langle k_\perp \rangle^u$	$\langle k_\perp \rangle^d$
▨	96^{+60}_{-28} MeV	-113^{+45}_{-51} MeV
🟥	$96^{+2.8}_{-2.4}$ MeV	$-113^{+1.3}_{-1.7}$ MeV

Transverse Spin Structure

Transversity

h_1



(Collinear & TMD)

A transverse counter part to the longitudinal spin structure: helicity g_{1L}

They are NOT the same due to relativity.

Chiral-odd

Unique for the quarks.
No mixing with gluons.
Simpler evolution effect.

NOT accessible via inclusive DIS process.
Must couple to another chiral-odd function.
(*e.g.* Collins function $H_1^\perp$)

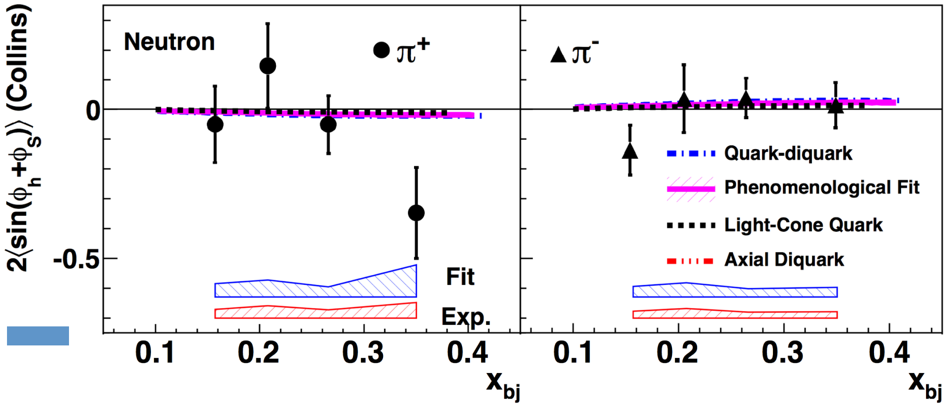
Measured via
SIDIS (E12-10-006, E12-11-008), Drell-Yan
Di-hadron (approved as run group with E12-10-006)

Measurement in SIDIS

Single spin asymmetry
(Collins asymmetry)

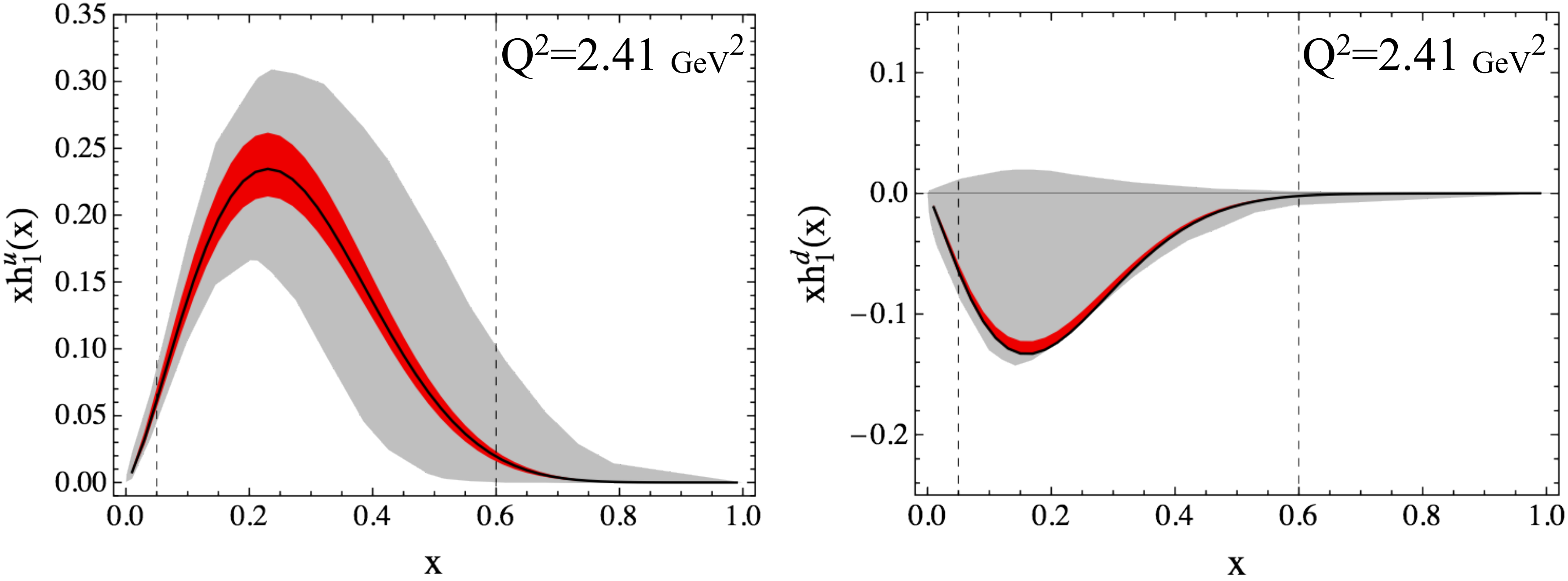
$$A_{UT}^{\sin(\phi_h+\phi_S)} \sim h_1(x,k_\perp) \otimes H_1^\perp(z,p_\perp)$$

$H_1^\perp(z,p_\perp)$ Collins fragmentation function



6 GeV JLab E06-010, X. Qian et al., PRL 107, 072003 (2011).

SoLID Impact on Transversity

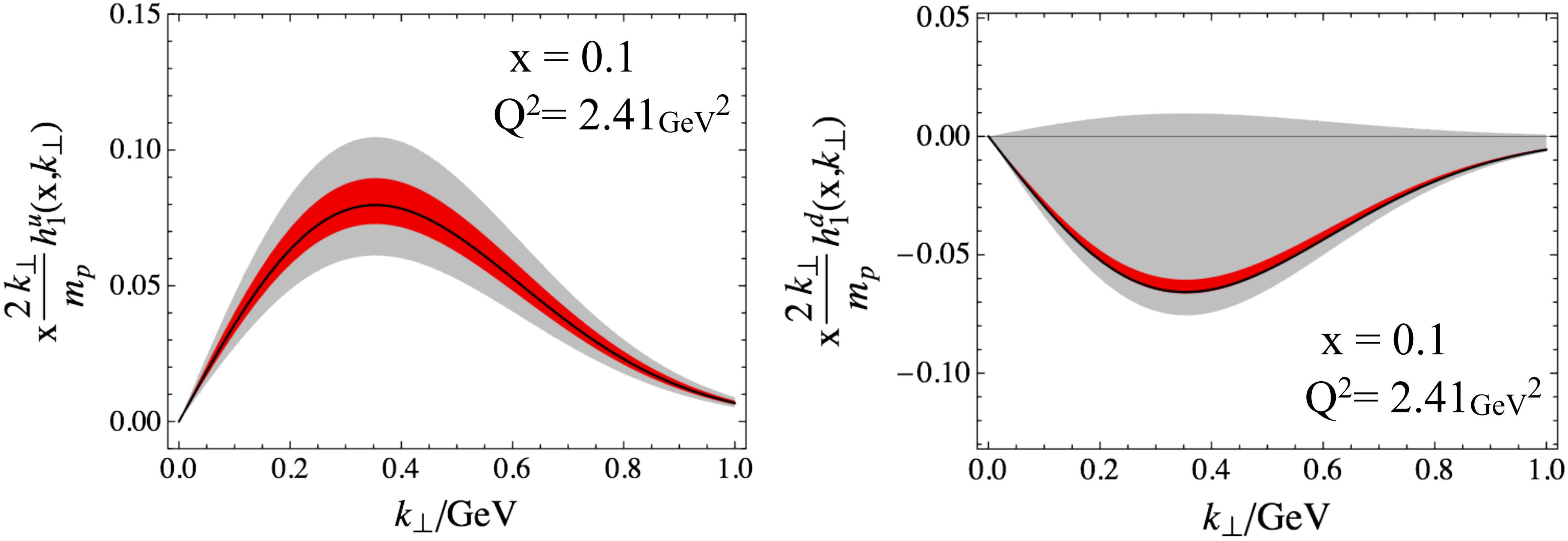


95% C.L.

▨ parametrization by M. Anselmino et al., PR D 87, 094019 (2013).

🟥 SoLID projection with transversely polarized neutron and proton data.

SoLID Impact on Transversity TMD



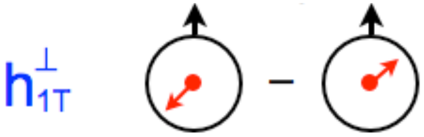
95% C.L.

▨ parametrization by M. Anselmino et al., PR D 87, 094019 (2013).

🟥 SoLID projection with transversely polarized neutron and proton data.

Pretzelosity

Pretzelosity distribution



Chiral-odd. NO gluon analogy.
Interference of light-front wave functions differing by ΔL = 2.
Measuring the difference between helicity and transversity, and hence relativistic effects. (spherically symmetric models)

Relation to OAM (canonical)

$$L_z^q = -\int \mathrm{d}x\mathrm{d}^2\mathbf{k}_\perp \frac{\mathbf{k}_\perp^2}{2M^2} h_{1T}^{\perp q}(x,k_\perp) = -\int \mathrm{d}x h_{1T}^{\perp(1)q}(x)$$

(model dependent)

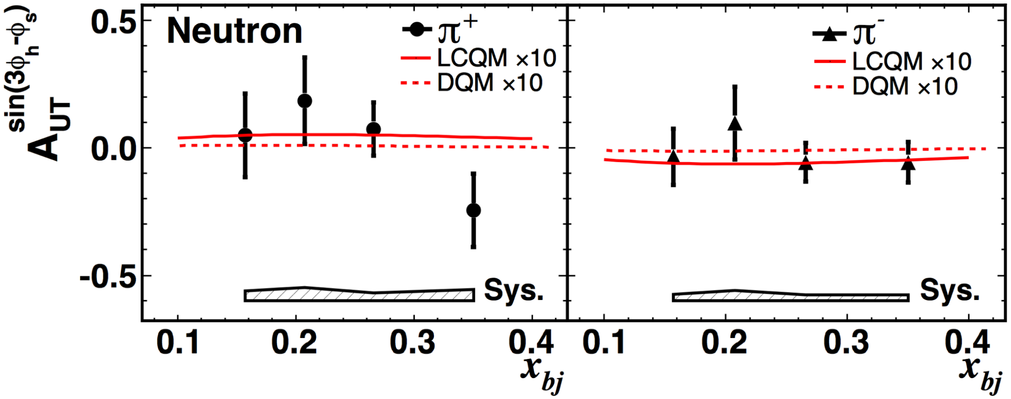
Measurement in SIDIS

Single spin asymmetry

$$A_{UT}^{\sin(3\phi_h-\phi_S)} \sim h_{1T}^{\perp}(x,k_\perp) \bigotimes H_1^{\perp}(z,p_\perp)$$

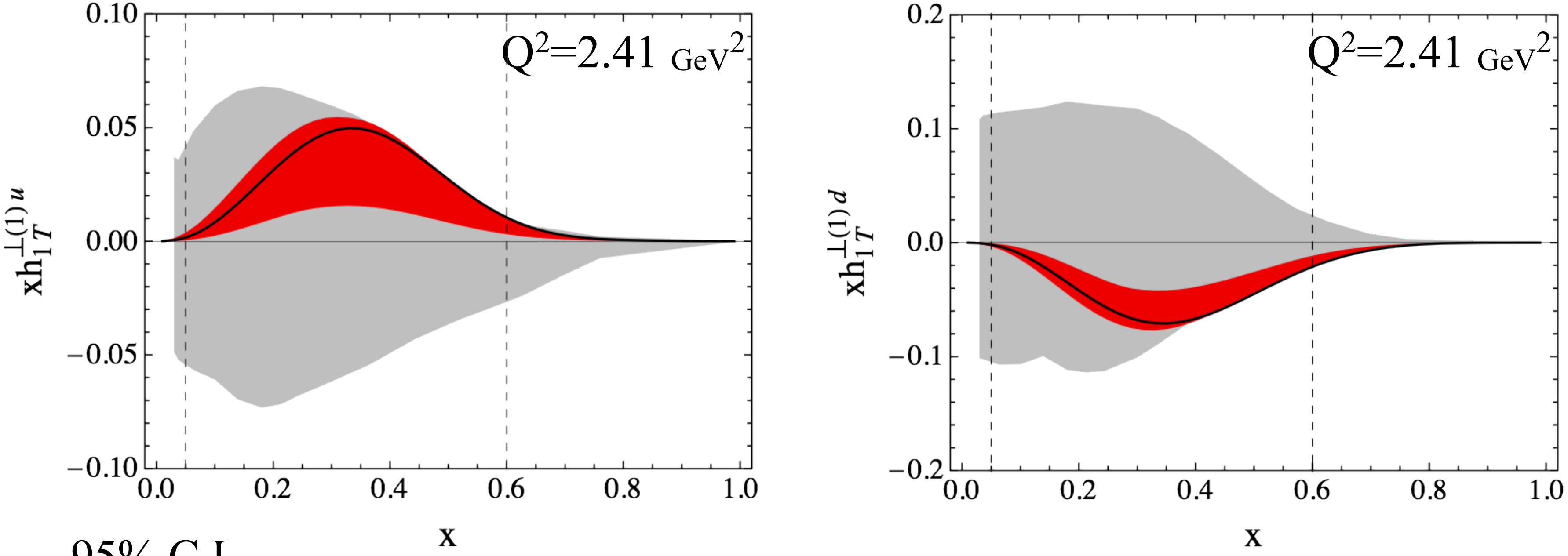
A global fit to 175 data from COMPASS, HERMES, and JLab found comparable with null signal hypothesis at 72% C.L..

C. Lefky, A. Prokudin, PR D 91, 034010 (2015).



6 GeV JLab E06-010, Y. Zhang et al., PR C 90, 055209 (2014).

SoLID Impact on Pretzelosity



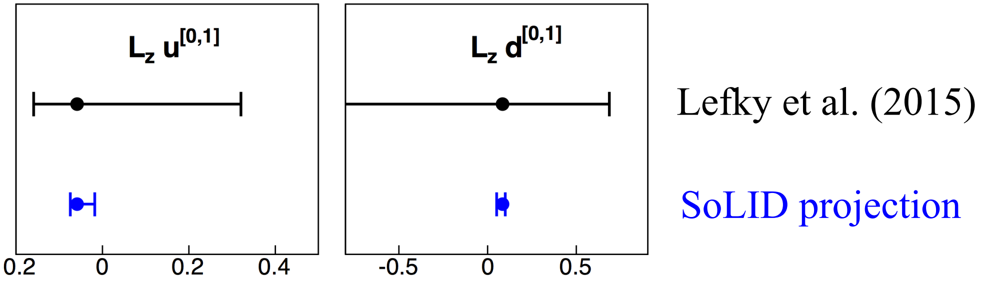
95% C.L.

▨ parametrization by C. Lefky et al., PR D 91, 034010 (2015).

🟥 SoLID projection with transversely polarized neutron and proton data.

OAM:

$$L_z^q = -\int \mathrm{d}x\mathrm{d}^2\mathbf{k}_\perp \frac{\mathbf{k}_\perp^2}{2M^2} h_{1T}^{\perp q}(x, k_\perp) = -\int \mathrm{d}x h_{1T}^{\perp(1)q}(x)$$



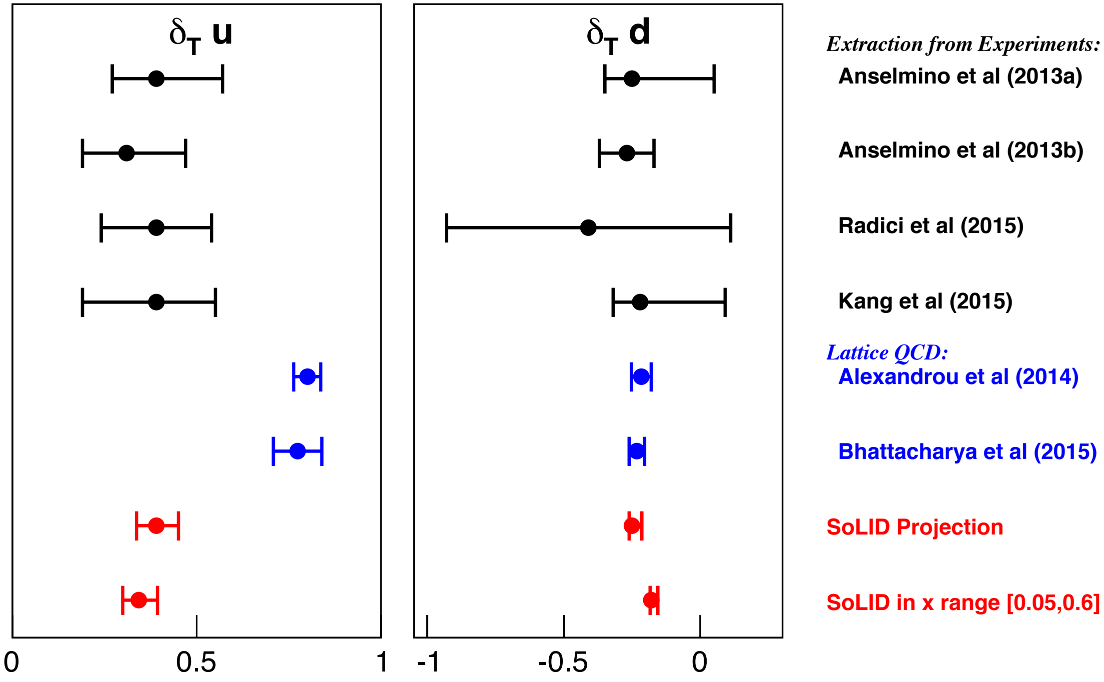
Tensor Charge

Definition

$$\langle P,S|\bar{\psi}_q i\sigma^{\mu\nu}\psi_q|P,S\rangle = \delta_T q\,\bar{u}(P,S)i\sigma^{\mu\nu}u(P,S) \quad \delta_T q = \int_0^1 \left[h_1^q(x) - h_1^{\bar{q}}(x)\right]\mathrm{d}x$$

A fundamental QCD quantity. Matrix element of local operators.
Moment of transversity distribution. Valence quark dominant.
Calculable in lattice QCD.

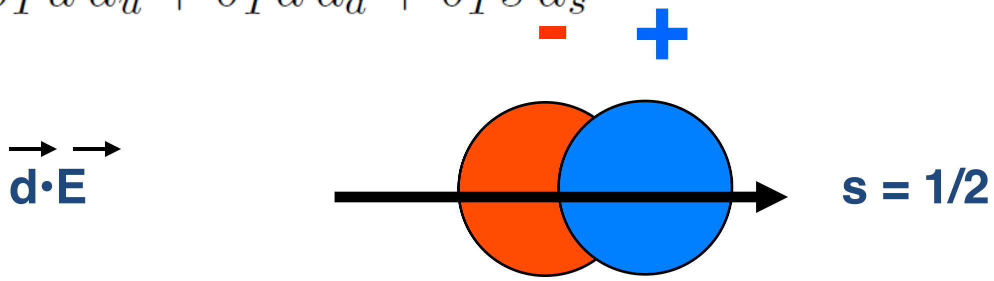
SoLID impact

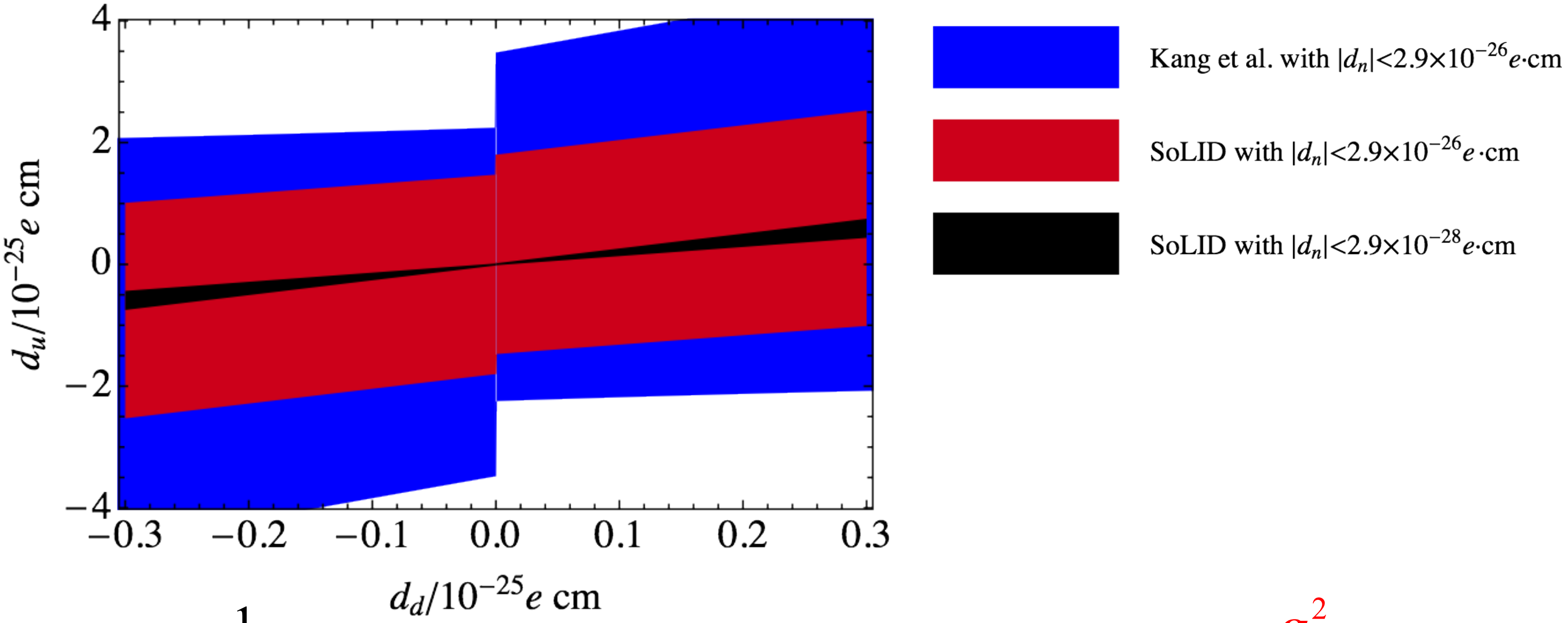


Tensor Charge and Neutron Electric Dipole Moment (EDM)

Current limit (10^{-26} θ) e.cm , next generation of experiments aim at (10^{-28} θ) e.cm

$$d_n = \delta_T u\, d_u + \delta_T d\, d_d + \delta_T s\, d_s$$





$$L_{QCD} = -\frac{1}{4}G^{\alpha}_{\mu\nu}G^{\alpha\mu\nu} - \sum_n \bar{\psi}_n[i\gamma^\mu\partial_\mu + g\gamma^\mu G^\alpha_\mu T^\alpha + m_n]\psi_n + \theta\frac{g^2}{32\pi^2}G^{\alpha\mu\nu}\tilde{G}^\alpha_{\mu\nu}$$

Parity Violating Deep-Inelastic Scattering

Precision Test of Standard Model
Unique Information on Nucleon Structure

Jian-Ping Chen's talk

Electroweak Interactions at scales much lower than the W/Z mass

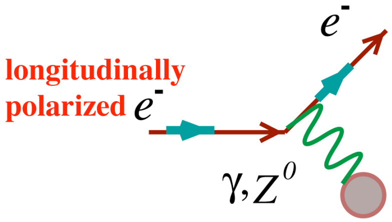
TeV-Scale Probe: Indirect Clues

NP: Fundamental Symmetries; HEP: The Intensity/Precision Frontier

Examples: Heavy Z's, light (dark) Z's, technicolor, compositeness, extra dimensions, new ideas???, …

How can the Standard Model, with all of its holes, predict precision measurements so well??

Parity-violating Electron Scattering



$$-A_{LR} = A_{PV} = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} \sim \frac{A_{weak}}{A_\gamma} \sim \frac{G_F Q^2}{4\pi\alpha}(g_A^e g_V^T + \beta g_V^e g_A^T)$$

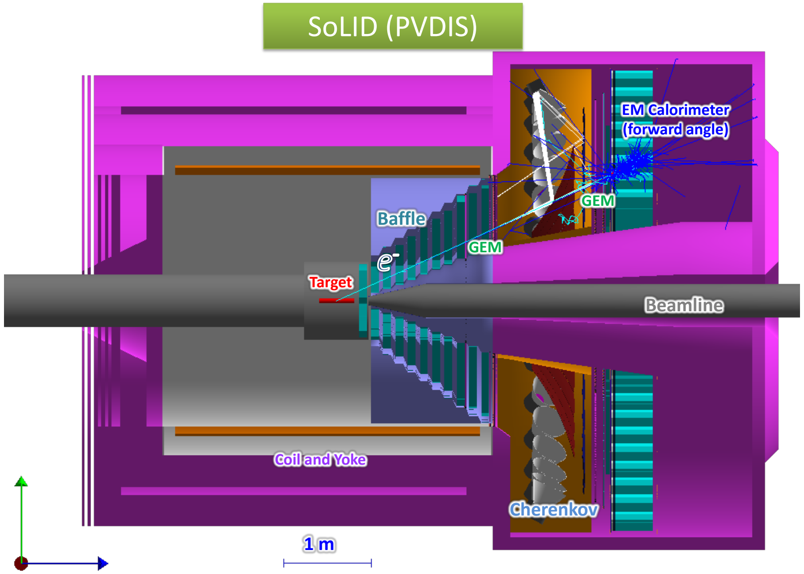
g_V and g_A are function of $\sin^2\theta_W$

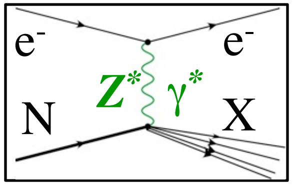
$A_{PV} \sim 10^{-5} \cdot Q^2$ to $10^{-4} \cdot Q^2$

Specific choices of kinematics and target nuclei probes different physics:

- *In mid 70s, goal was to show $\sin^2\theta_W$ was the same as in neutrino scattering*
- *Since early 90's: target couplings probe novel aspects of hadron structure (strange quark form factors, neutron RMS radius of nuclei)*
- *Future: precision measurements with carefully chosen kinematics can probe physics at the multi-TeV scale, and novel aspects of nucleon structure*

SOLID with the 12 GeV Upgrade



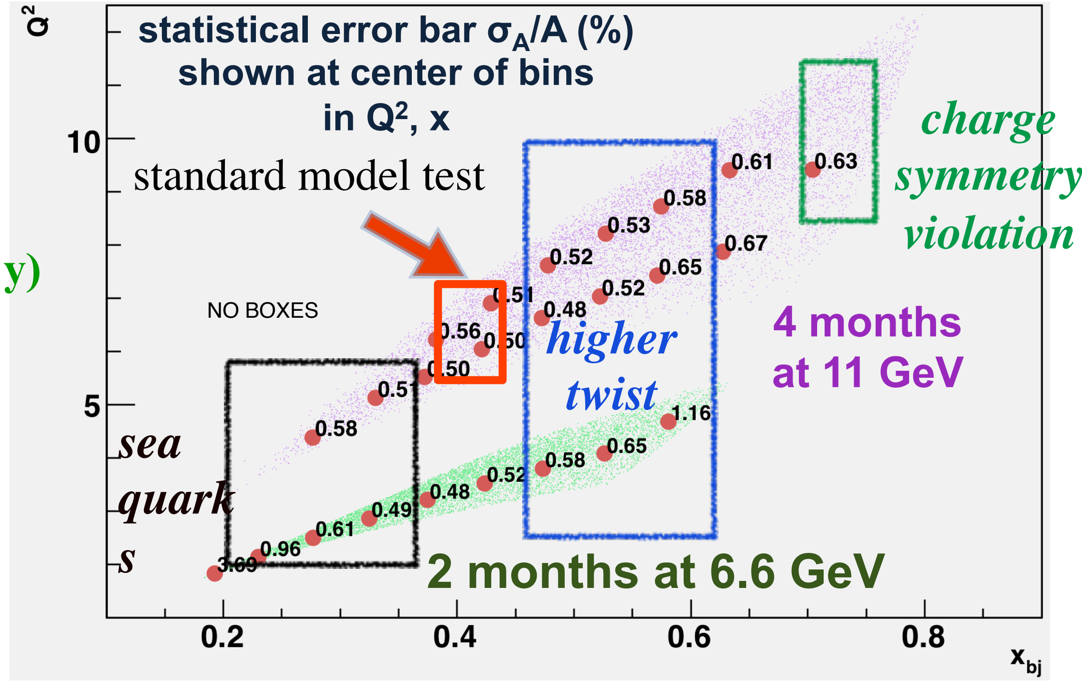


$$A_{PV} = \frac{G_F Q^2}{\sqrt{2}\pi\alpha}\left[a(x) + f(y)\boxed{b(x)}\right]$$

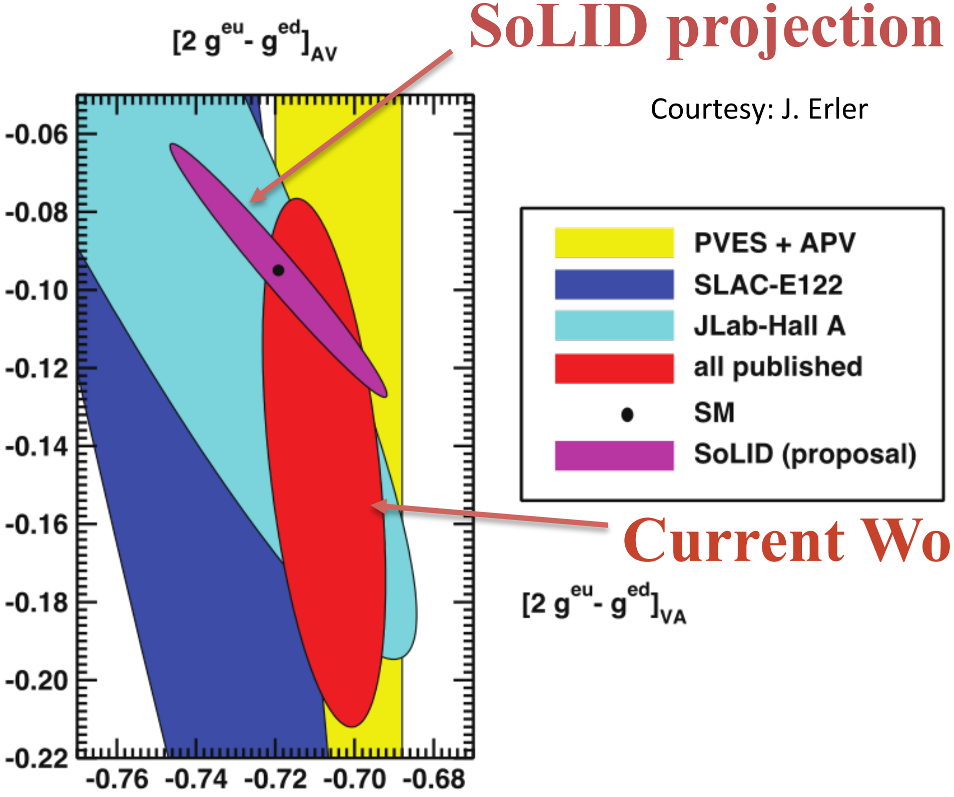
<u>Strategy:</u> sub-1% precision over broad kinematic range: **sensitive Standard Model test** *and* **detailed study of hadronic structure contributions**

Requirements

- **High Luminosity with E > 10 GeV**
- **Large scattering angles (for high x & y)**
- **Better than 1% errors for small bins**
- **x-range 0.25-0.75**
- **$W^2 > 4$ GeV^2**
- **Q^2 range a factor of 2 for each x**
  - **(Except at very high x)**
- **Moderate running times**



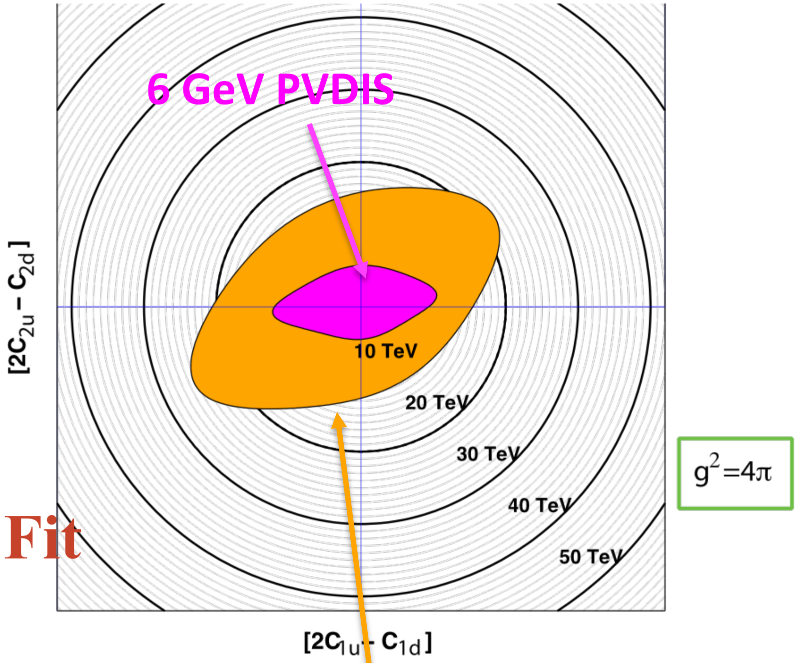
SOLID New Physics Sensitivity



SoLID projection

Courtesy: J. Erler

Current World Fit



6 GeV PVDIS

Final Qweak result + projected SOLID

Qweak and SOLID will expand sensitivity that will match high luminosity LHC reach with complementary chiral and flavor combinations

Jlab 6-GeV PVDIS results
Wang *et al.*, Nature 506,
No. 7486, 67 (2014)

Threshold J/ψ Production

Gluon Dynamics, Proton Mass, Conformal Anomaly

J/ψ Opportunity at JLab 12GeV

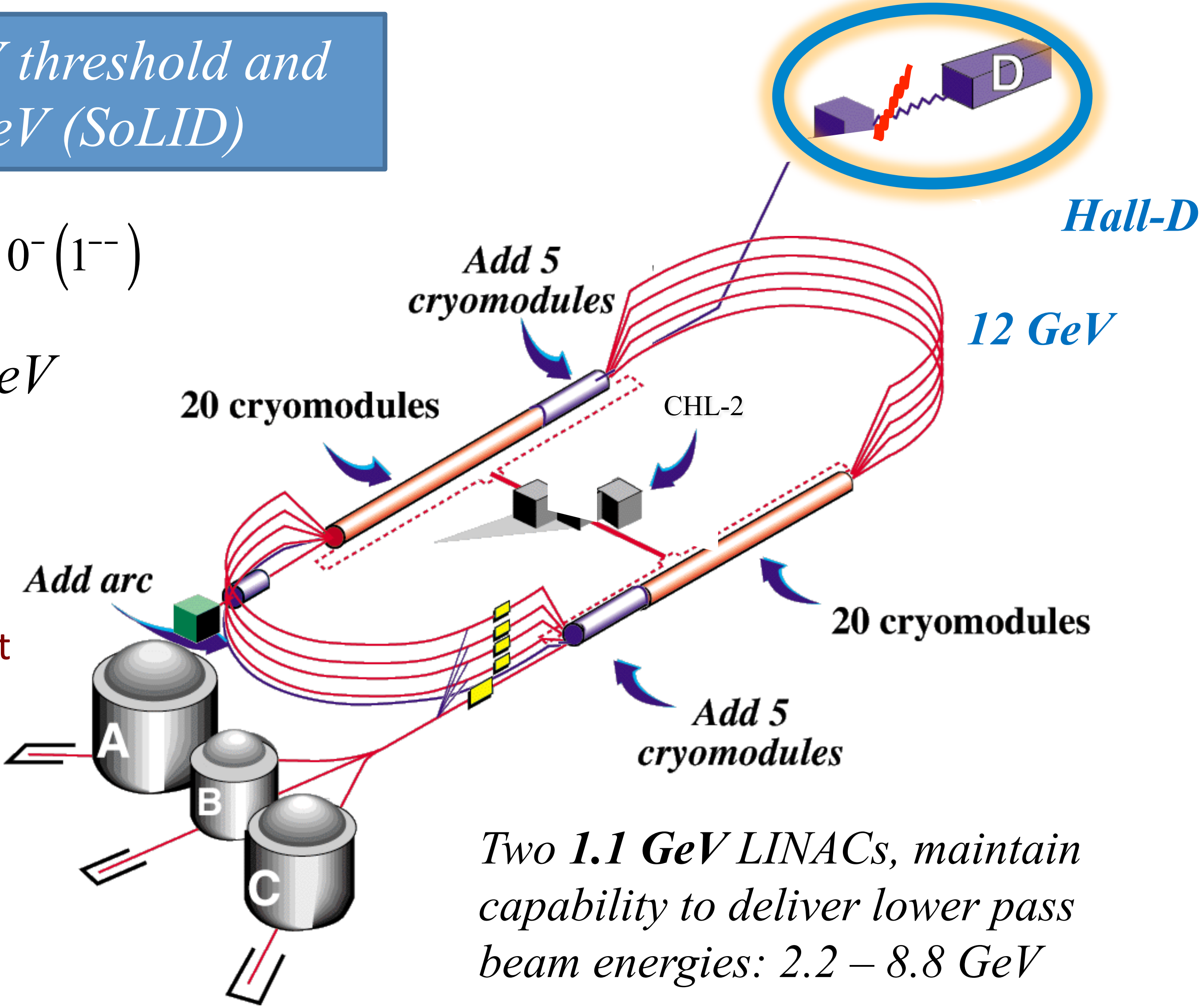
Cross 8.2 GeV threshold and reach 11GeV (SoLID)

$$J/\psi(1S): I^G\left(J^{PC}\right) = 0^-\left(1^{--}\right)$$

$$M_{J/\psi} \approx 3.097 GeV$$

Quark exchange interactions strongly suppressed, gluonic interactions dominant

J/ψ as probe of the strong color field in the nucleon



*Two **1.1 GeV** LINACs, maintain capability to deliver lower pass beam energies: 2.2 – 8.8 GeV*

Photo- and Electro-production of J/ψ at JLab is an opportunity

Mass vs. Spin

☐ Mass – intrinsic to a particle:

= Energy of the particle when it is at the rest

✧ QCD energy-momentum tensor in terms of quarks and gluons

$$T^{\mu\nu} = \frac{1}{2}\,\overline{\psi} i\overleftrightarrow{D}^{(\mu}\gamma^{\nu)}\psi + \frac{1}{4}\,g^{\mu\nu}F^2 - F^{\mu\alpha}F^{\nu}{}_{\alpha}$$

✧ Proton mass:

$$m = \frac{\langle p|\int d^3x\, T^{00}\,|p\rangle}{\langle p|p\rangle} \sim \mathrm{GeV}$$

X. Ji, PRL (1995)

☐ Spin – intrinsic to a particle:

= Angular momentum of the particle when it is at the rest

✧ QCD angular momentum density in terms of energy-momentum tensor

$$M^{\alpha\mu\nu} = T^{\alpha\nu}x^{\mu} - T^{\alpha\mu}x^{\nu} \qquad J^i = \frac{1}{2}\epsilon^{ijk}\int d^3x M^{0jk}$$

✧ Proton spin:

$$S(\mu) = \sum \langle P,S|\hat{J}^z_f(\mu)|P,S\rangle = \frac{1}{2}$$

Proton Mass Budget

$$< N | \frac{\beta(g)}{2g} G^{\alpha\beta\gamma} G^{\gamma}_{\alpha\beta} + \sum_{u,d,s,} m_q \bar{q} q | N >= M_N$$

$$H_{QCD} = H_q + H_m + Hg + H_a$$

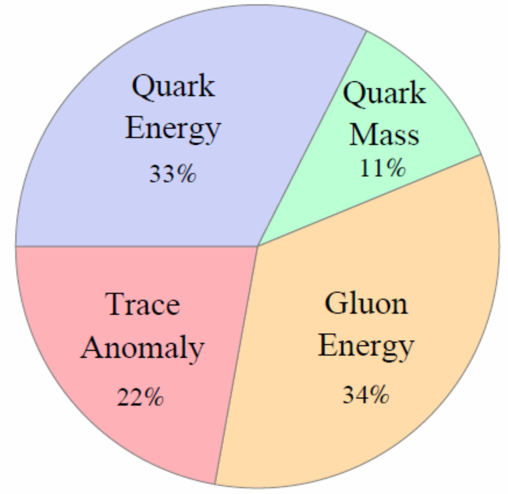
$H_q =$ Quark energy $\int d^3x\, \psi^\dagger\, (-i\mathbf{D}\cdot\alpha)\, \psi$

$H_m =$ Quark mass $\int d^3x\, \bar{\psi} m \psi$

$H_g =$ Gluon energy $\int d^3x\, \frac{1}{2}\, (\mathbf{E}^2 + \mathbf{B}^2)$

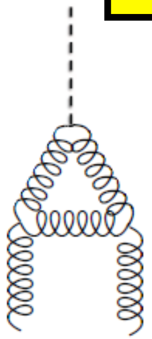
$H_a =$ Trace anomaly $\int d^3x\, \frac{9\alpha_s}{16\pi}\, (\mathbf{E}^2 - \mathbf{B}^2)$

X. Ji PRL 74 1071 (1995)



H.Gao *et al.* The Universe (2015)

$$G^{\alpha\beta\gamma} G^{\gamma}_{\alpha\beta}$$



Trace (conformal) anomaly sets the scale for proton mass

At the chiral limit, the entire mass is from gluons

Access Trace Anomaly Experimentally

$$M_q = \frac{3}{4}(a-b)\,M$$
$$M_m = bM$$
$$M_g = \frac{3}{4}(1-a)M$$
$$M_a = \frac{1}{4}(1-b)M$$

quark momentum fraction

$$a(\mu^2) = \sum_q \int_0^1 dx[f^q(x) + f^{\bar{q}}(x)]$$

scalar charge

$$b(\mu^2) = \langle P|m_u\bar{u}u + m_d\bar{d}d + m_s\bar{s}s|P\rangle/M$$

$$\frac{d\sigma_{J/\psi N\to J/\psi N}}{dt} = \frac{1}{64\pi}\frac{1}{m_{J/\psi}^2(\lambda^2 - m_N^2)}F_{J/\psi N}^2$$

J/ψ-N scattering

$$F_{J/\psi N} = r_0^3 d_2 \frac{2\pi^2}{27}(2M^2 - bM)$$

J/ψ production on N

$$\frac{d\sigma_{\gamma N\to J/\psi N}}{dt} = \frac{3\Gamma(J/\psi\to e^+e^-)}{\alpha m_{J/\psi}}\left(\frac{k_{J/\psi N}}{k_{\gamma N}}\right)^2 \frac{d\sigma_{J/\psi N\to J/\psi N}}{dt}$$

D. Kharzeev et al Eur.Phys.J. C9 459 (1999), D. Kharzeev, Proc. Int. Sch. Phys. Fermi 130, 105 (1996)

J/ψ @ SoLID

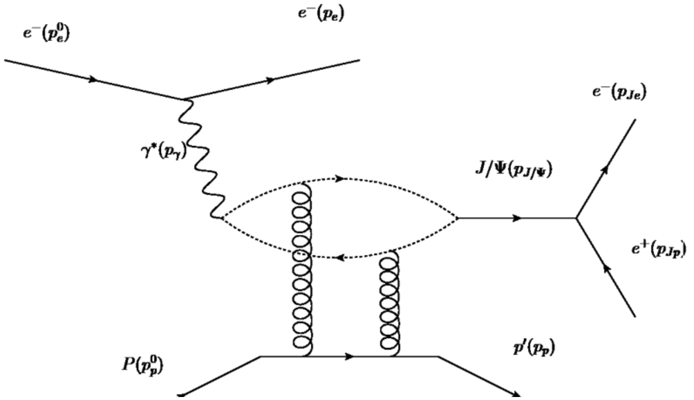
Cross 8.2 GeV threshold at JLab 12GeV era

$$\gamma^* + N \rightarrow N + J/\psi$$

Threshold J/Ψ production, probing strong color field in the nucleon, QCD trace anomaly (important to proton mass budget)

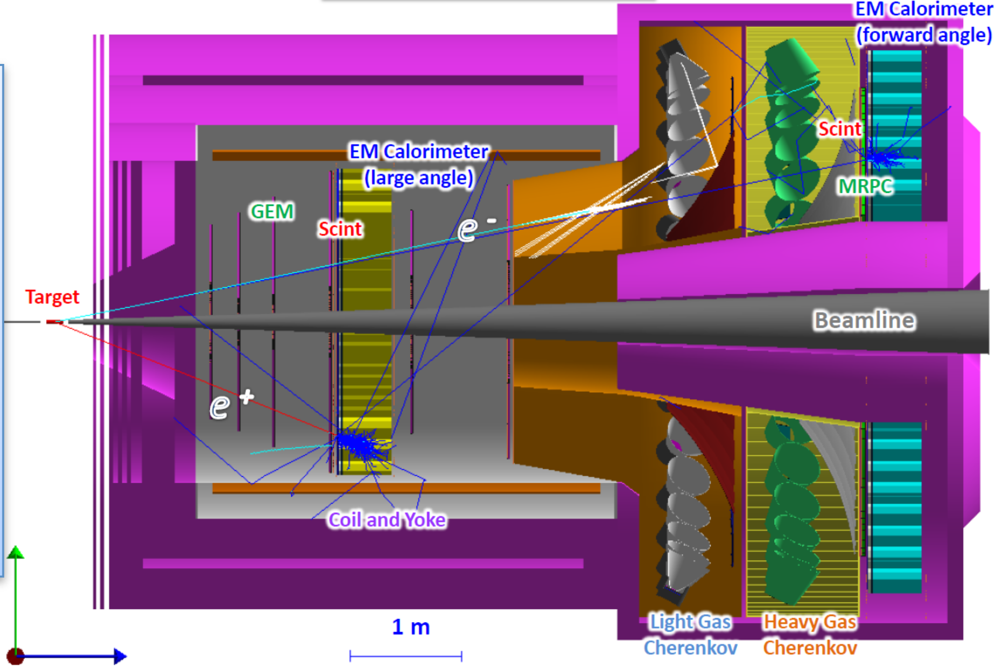
$$e\ p \rightarrow e'\ p'\ J/\psi(e^-\ e^+)$$

$$\gamma\ p \rightarrow p'\ J/\psi(e^-\ e^+)$$

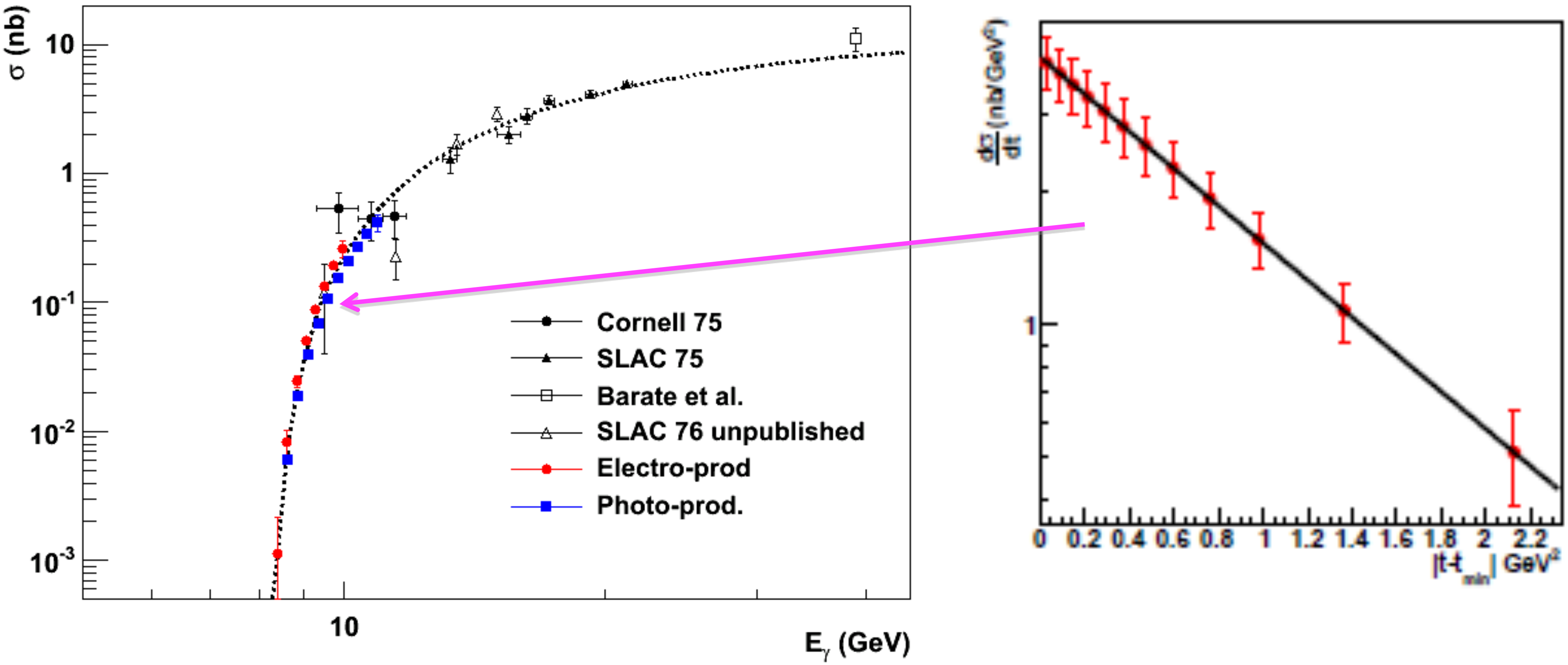


- <u>high luminosity & large acceptance</u> capability of SoLID enables a unique "precision" measurement near threshold
- Search for possible enhancement
- Study multiple gluons exchange
- Shed light on the low energy J/ψ-nucleon interaction (color Van der Waals force)
- Shed light on the trace anomaly, an important piece in the proton mass budget

SoLID (J/ψ)



Projection of Differential and Total Cross Section



Luminosity $1.2*10^{37}/cm^2/s$, 11GeV 3uA e- on 15cm LH2 50 Days

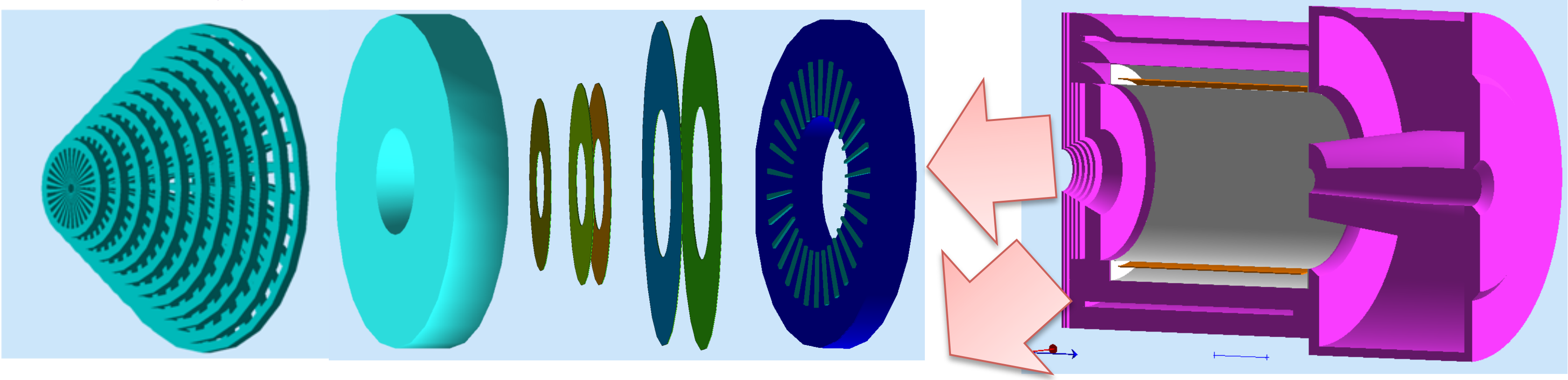
No competition in statistics

Study the threshold behavior of cross section with high precision **could shed light on the conformal anomaly**

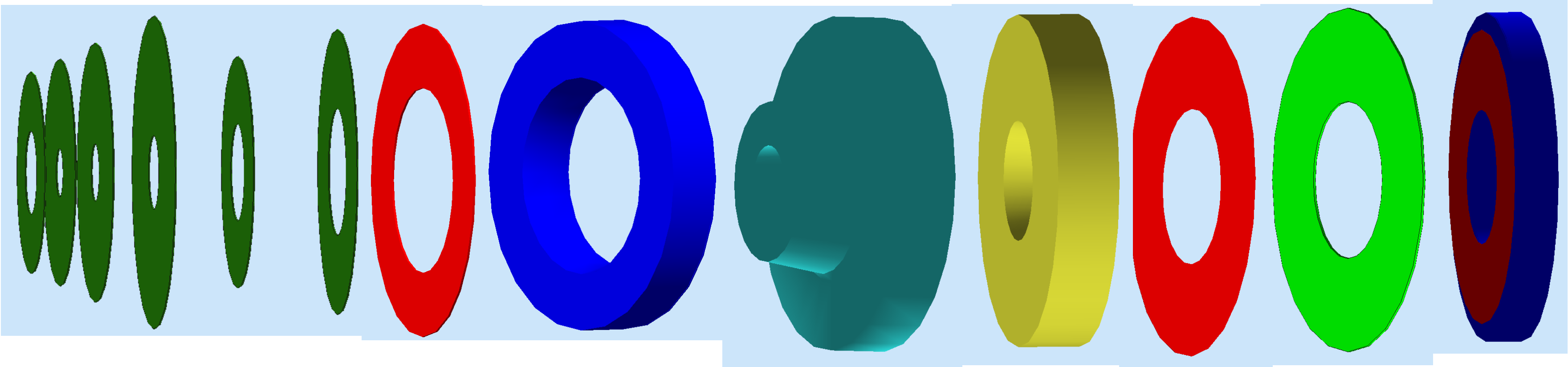
Proposed SoLID Detectors

SoLID Detector Overview

PVDIS: Baffle LGC 5xGEMs EC



SIDIS&J/Psi:
6xGEMs LASPD LAEC LGC HGC FASPD MRPC FAEC

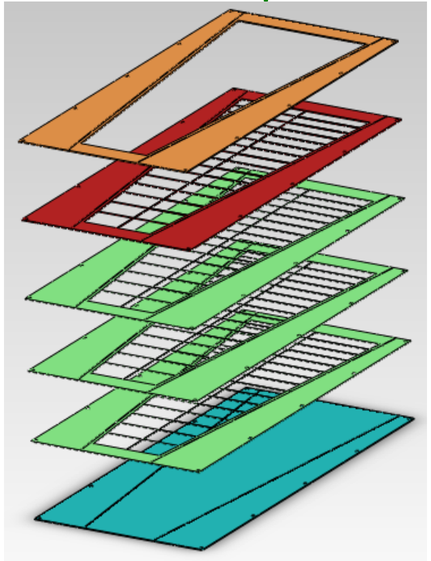


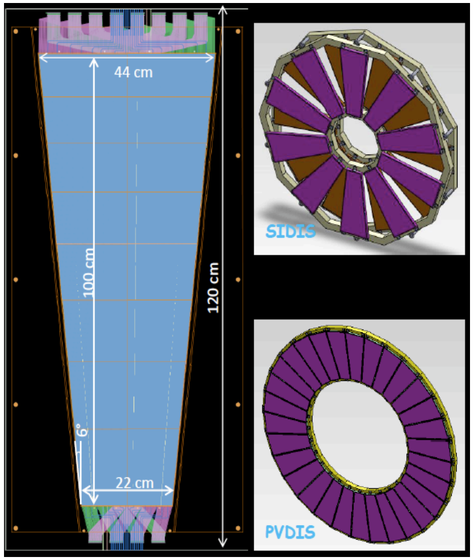
When the 12 GeV upgrade was proposed, much of this instrumentation was not fully developed.

GEM Progress

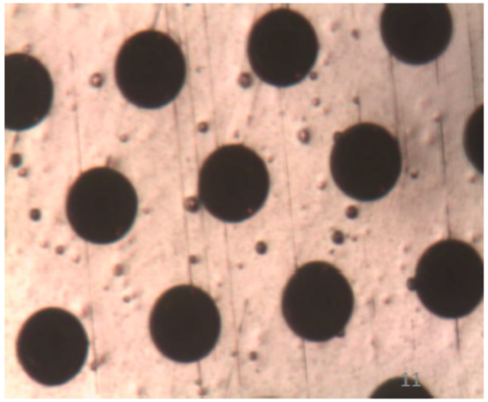
Chinese Collaboration

- First full size prototype assembled at UVA, tested in beam (Fermi Lab)
- 30x30 cm prototype constructed, readout tested (CIAE/USTC/Tsinghua/Lanzhou)
- GEM foil production facility under development at CIAE (China)





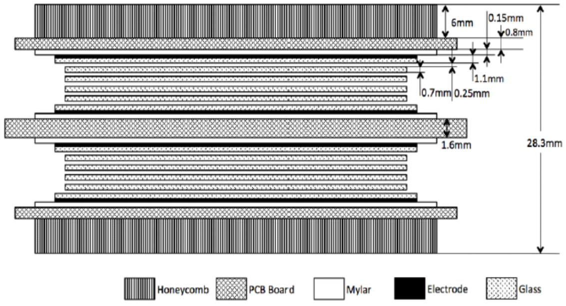
GEM foils made at CIAE

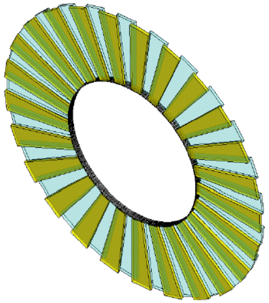


> 95 % efficiency

Timing resolution ~ 85 ps

MRPC – High Resolution TOF

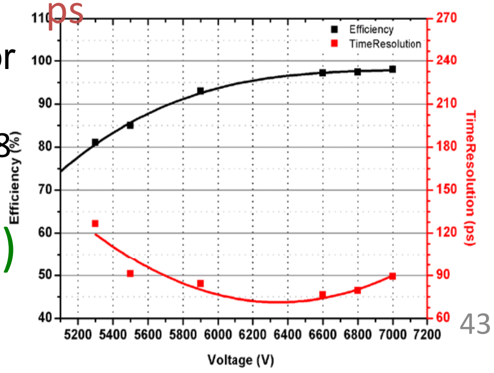




A MRPC prototype for SOLID-TOF in JLab

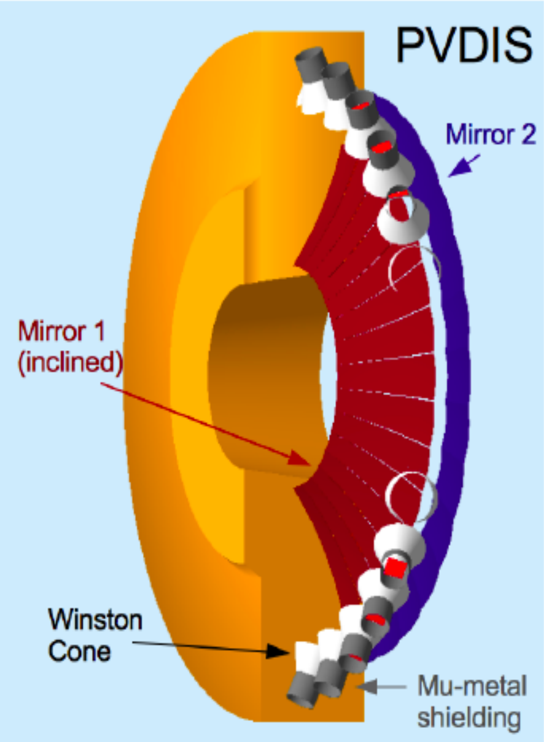
Y. Wang, et al. JINST 8 (2013) P03003

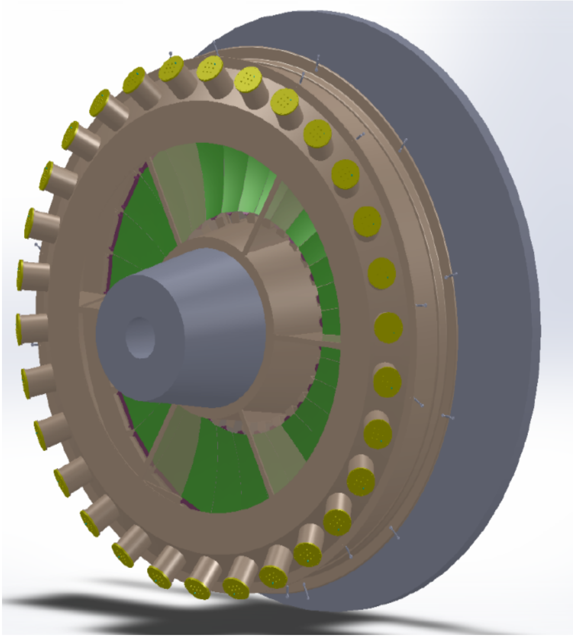
(Tsinghua, USTC)



SoLID Detector Development

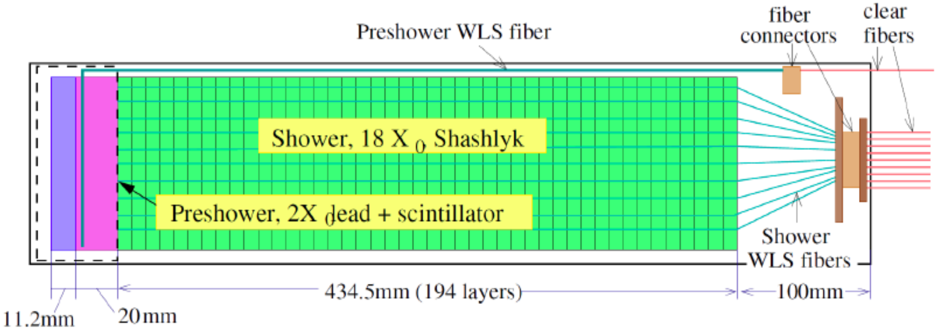
Simulations now with realistic backgrounds



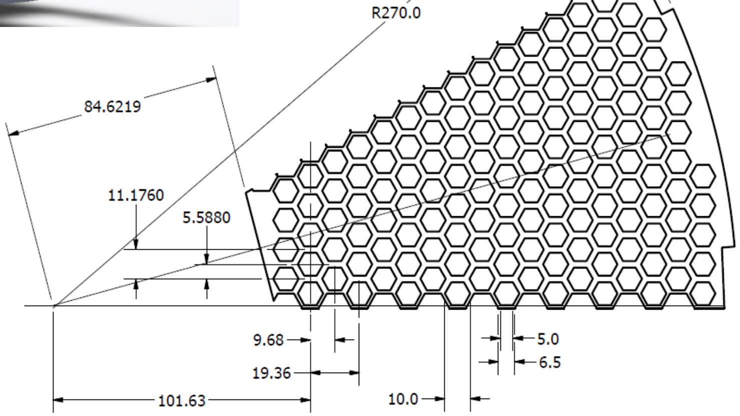


Heavy Gas Cerenkov (Duke, Regina)

Light Gas Cerenkov (Temple)



ECal (UVA, W&M, Shandong, Tsinghua)



ECal Mounting Design (ANL)

Summary

Full exploitation of JLab 12 GeV Upgrade
→ SOLID: A Large Acceptance Detector that can handle High Luminosity (10^{37}-10^{39})
Rich, important physics program to address some of the most fundamental questions in Nuclear Physics.

SoLID will provide the community with a large acceptance detector capable of operating at very high luminosities making high-precision JLab 12-GeV measurements in QCD (TMD, GPD, J/ψ, d/u), and electroweak physics. It also provides access to a broad set of other reactions.

SoLID could be an initial detector for the future EIC.

Supported in part by U.S. Department of Energy under contract number DE-FG02-03ER41231

Thanks to J.P. Chen, R. Ent, T. Keppel, T.-B. Liu, P. Souder, Z.-E. Meziani, and Z. Zhao

Detailed information: see the SoLID whitepaper: arXiv:1409.7741;
and http://hallaweb.jlab.org/12GeV/SoLID/