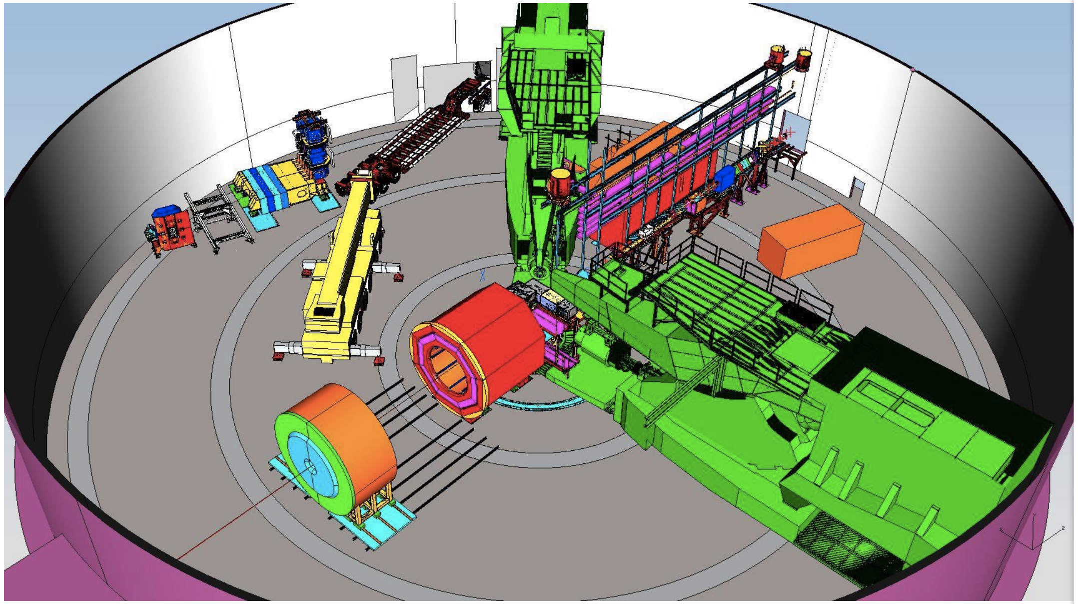
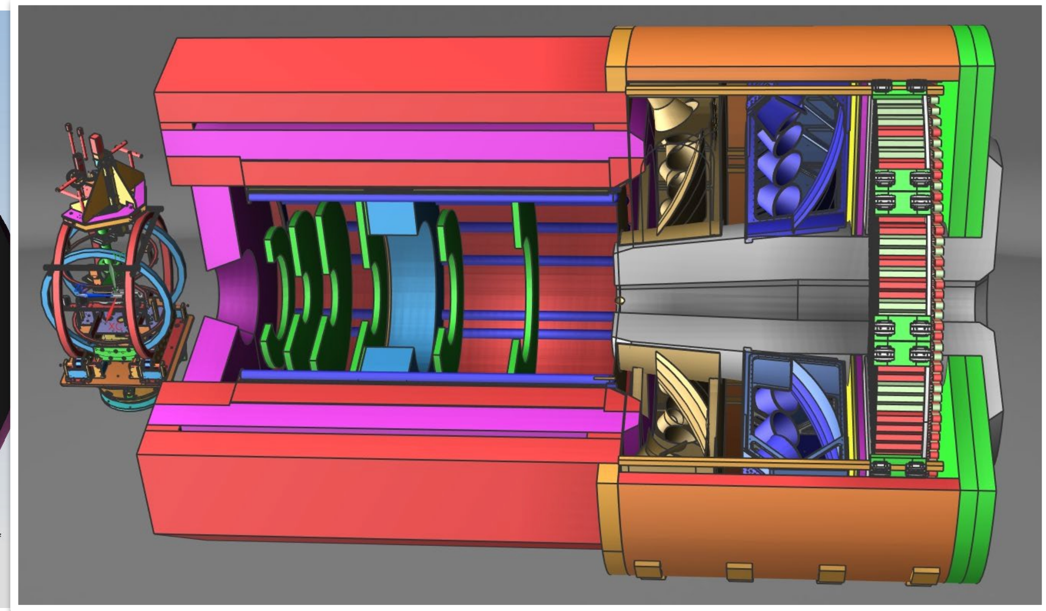
Overview of Solenoidal Large Intensity Device (SoLID) Physics Programs





Haiyan Gao (on behalf of the SoLID Collaboration)
Duke University
The 12th Workshop on “Hadron Physics and Opportunities Worldwide”

August 4-9, 2024
Dalian, China

Duke UNIVERSITY

SoLID Jefferson Lab

Outline

- Introduction
- Three pillars of the SoLID science
  - New Physics and QCD with **PVDIS**
  - Near Threshold Production of **J/Ψ:** mass and radius
  - Nucleon 3-D momentum tomography with **SIDIS**
- Newly approved and SoLID Run-Group experiments
- The SoLID Apparatus and Collaboration
- Summary

Recent SoLID Whitepaper: Arrington et al.,
J. Phys. G: Nuclear and Particle Physics ***50,*** *110501 (2023)*
Recent JLab 12-GeV Whitepaper: Arrington et al.,
Progress in Particle and Nuclear Physics ***127****, 103985 (2022)*

SoLID@JLab: QCD at the intensity frontier

SoLID will ***maximize*** the science return of the 12-GeV CEBAF upgrade by **combining...**

High Luminosity
$10^{37\text{-}39}$ /cm^2/s
[>100x CLAS12][>1000x EIC]

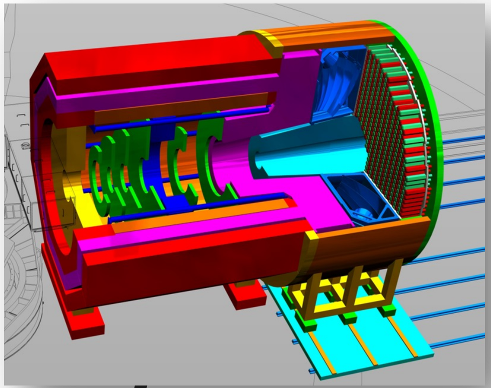
+

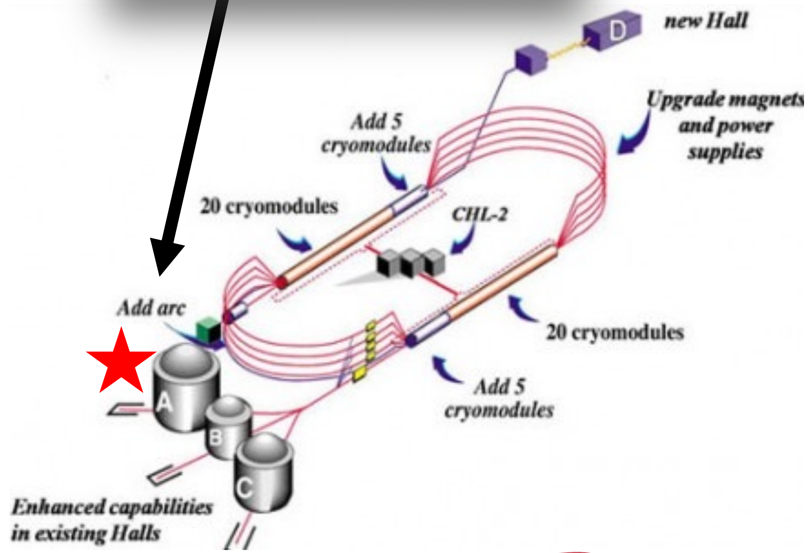
Large Acceptance
Full azimuthal ϕ coverage

Research at **SoLID** will have the ***unique*** capability to **explore** the QCD landscape while **complementing** the research of other key facilities

- Pushing the phase space in the search of new physics and of hadronic physics
- 3D momentum imaging of a relativistic strongly interacting confined system (**nucleon spin**)
- Superior sensitivity to the differential electro- and photo-production cross section of J/ψ near threshold (**proton mass**)

Synergistic with the pillars of EIC science (**proton spin** and **mass**) through high-luminosity valence quark tomography and precision J/ψ production near threshold





The *2023 NSAC Long Range Plan for Nuclear Science*

Recommendation 1: The highest priority of the nuclear science community is to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal.

- **Continuing effective operation of the national user facilities ATLAS, CEBAF, and FRIB, and completing the RHIC science program, pushing the frontiers of human knowledge.**

SoLID is an integral part of the JLab 12-GeV program

Recommendation 4: We recommend capitalizing on the unique ways in which nuclear physics can advance discovery science and applications for society by investing in additional projects and new strategic opportunities.

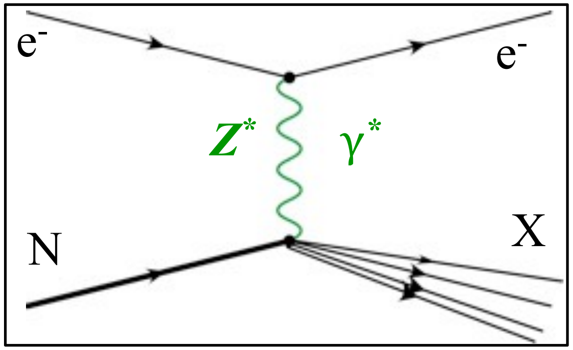
Projects that lay the foundation for the discovery science of tomorrow

- **Examples: FRIB400, SoLID, LHC upgrades, EDM, neutrino mass measurements**

SoLID was also highlighted in the 2015 NSAC LRP

PV Deep Inelastic Scattering

Off the simplest isoscalar nucleus and at high Bjorken *x*



$$A_{PV} = \frac{G_F Q^2}{2\sqrt{2}\pi\alpha}\left[g_A \frac{F_1^{\gamma Z}}{F_1^{\gamma}} + g_V \frac{f(y)}{2}\frac{F_3^{\gamma Z}}{F_1^{\gamma}}\right]$$

$Q^2 >> 1\ GeV^2$, $W^2 >> 4\ GeV^2$

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

$x \equiv x_{Bjorken}$

$y \equiv 1 - E'/E$

$$Y = \frac{1-(1-y)^2}{1+(1-y)^2 - y^2\frac{R}{R+1}}$$

$$R(x,Q^2) = \sigma^l/\sigma^r \approx 0.2$$

$$A_{iso} = \frac{\sigma^l - \sigma^r}{\sigma^l + \sigma^r} = -\left(\frac{3G_F Q^2}{\pi\alpha 2\sqrt{2}}\right)\frac{2C_{1u} - C_{1d}(1+R_s) + Y(2C_{2u} - C_{2d})R_v}{5+R_s}$$

At high x, A_{iso} becomes independent of pdfs, x & W, with well-defined SM prediction for Q^2 and y

$$R_s(x) = \frac{2S(x)}{U(x)+D(x)} \xrightarrow{\text{Large } x} 0$$

$$R_v(x) = \frac{u_v(x)+d_v(x)}{U(x)+D(x)} \xrightarrow{\text{Large } x} 1$$

Interplay with QCD

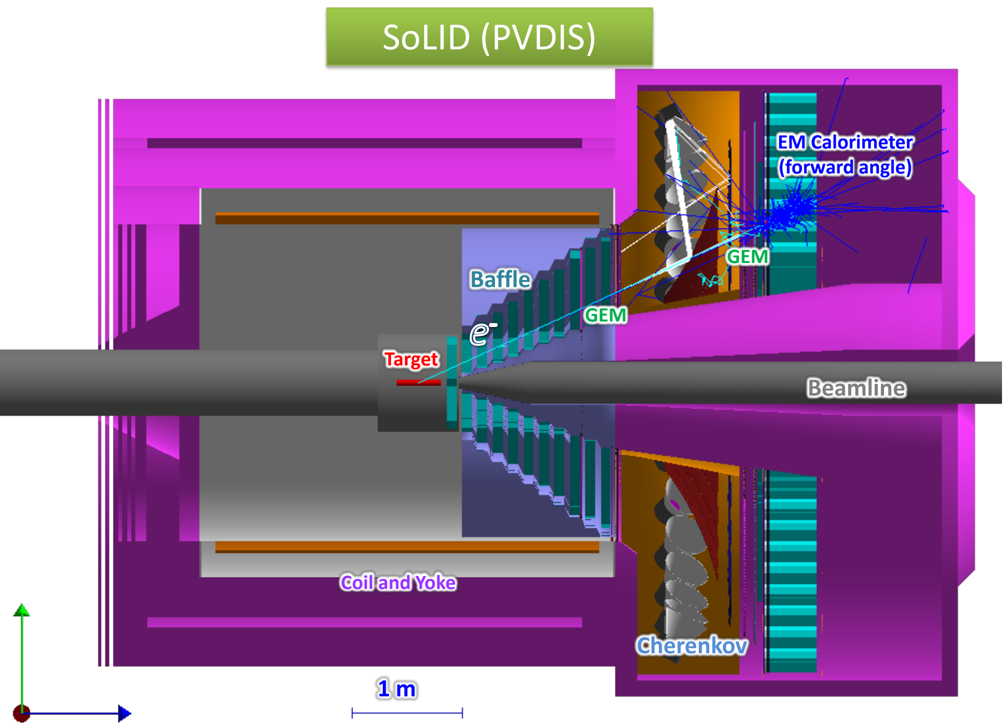
- Parton distributions (u, d, s, c)
- Charge Symmetry Violation (CSV)
- Higher Twist (HT) – quark-quark correlation

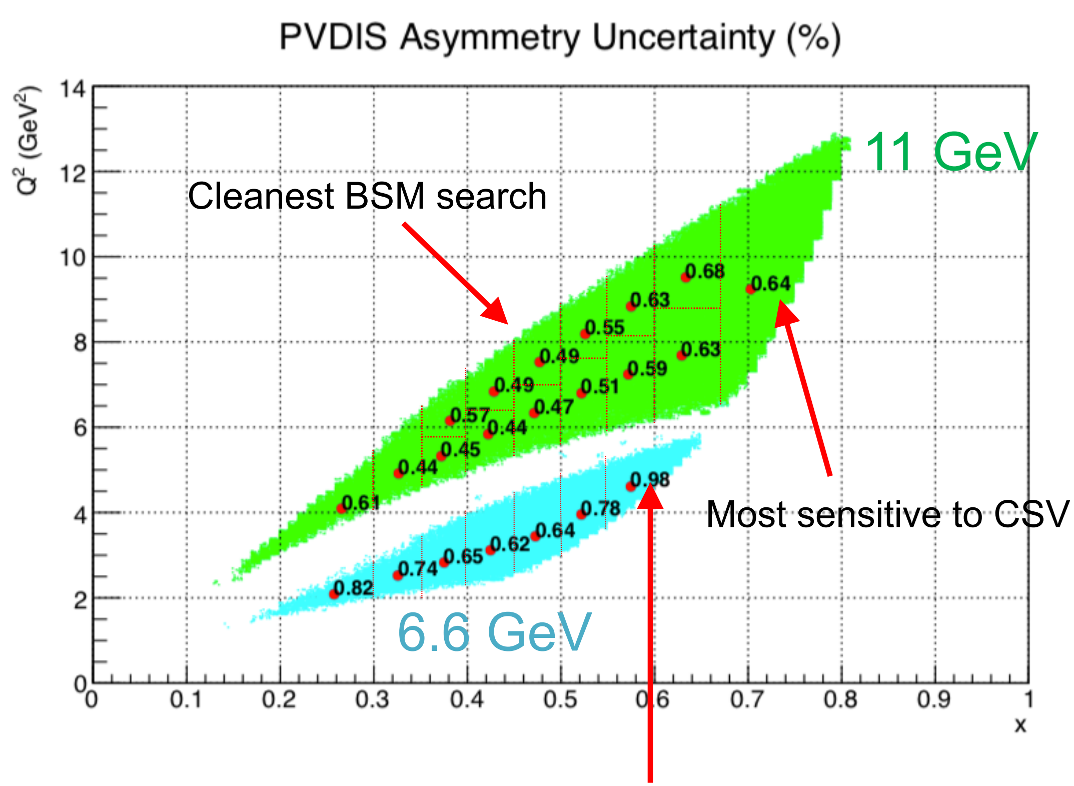
PVDIS @ SoLID: Experiment E12-10-007

12 GeV CEBAF: Extraordinary opportunity to do the ultimate PVDIS measurement

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

Targets: deuterium and hydrogen





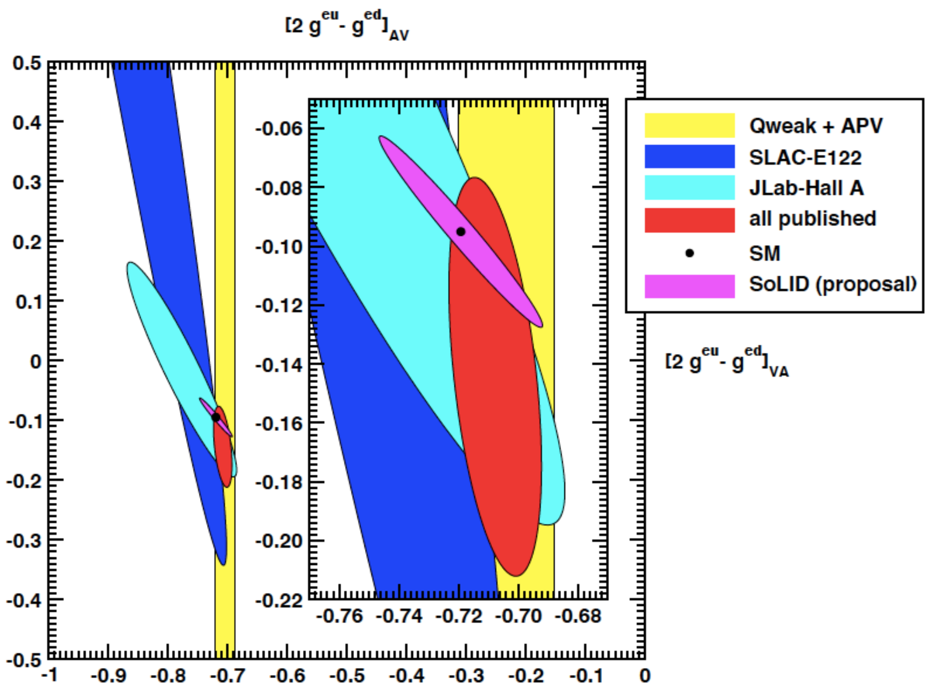
Spokespersons: Paul Souder (contact), Paul Reimer and Xiaochao Zheng

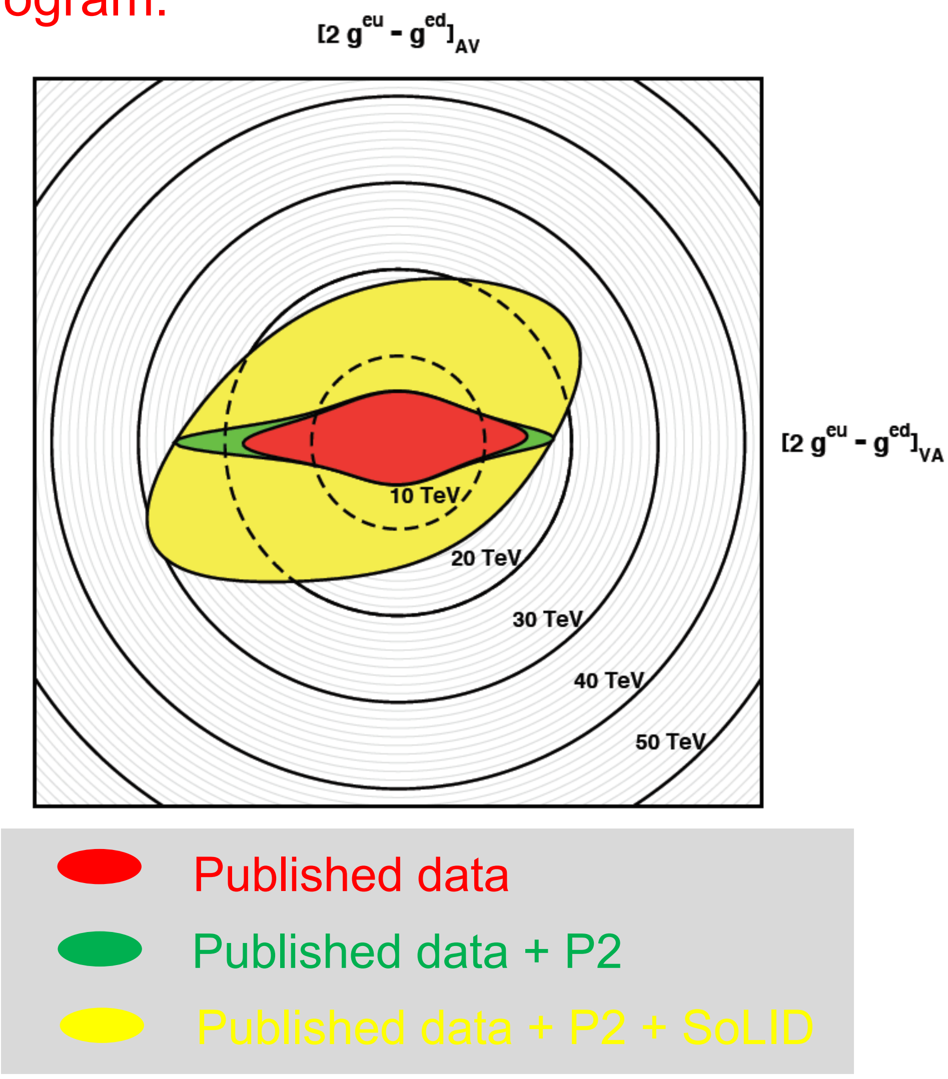
Projected Results

With this precision,
SoLID makes a unique contribution
to the Standard Model Effective Field Theory program.

Improvement in
energy reach for
electron-nucleon couplings

Improvement in
couplings





Proton Mass and Quantum Anomalous Energy

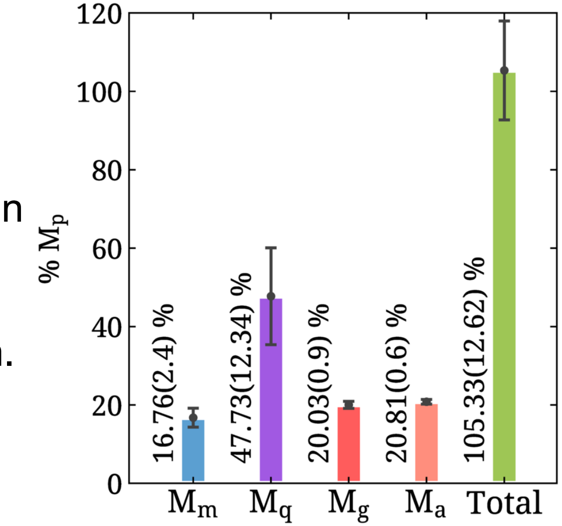
- **Nucleon mass is the total QCD energy in the rest frame (QED contribution small)**

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

$H_q =$	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	$\int d^3x \, \frac{1}{2}(\mathbf{E^2}+\mathbf{B^2})$
$H_a =$	Quantum Anomalous energy	$\int d^3x \, \frac{9\alpha_s}{16\pi}(\mathbf{E^2}-\mathbf{B^2})$

Sets the scale for the hadron mass!

First three contributions can be determined from PDFs and pi-N sigma term. And from lattice QCD→



X. Ji PRL 74 1071 (1995), X. Ji & Y. Liu, arXiv: 2101.04483

C. Alexandrou et al., (ETMC), PRL 116, 252001 (2016); PRL 119, 142002 (2017)
Y.-B. Yang *et al.*, (χQCD), PRL 121, 212001 (2018)

C. Lorce', EPJC 78 (2018) 2; C. Lorce', H. Moutarde and A. Trawińsk, EPJC79 (2019); Metz, Pasquini and Rodini, PRD102, 114042(2021); Lorce, Metz, Pasquini, Rodini, JHEP 11 (2021) 121; Rodini, Metz, Pasquini, JHEP 09 (2020) 067

- **Measuring quantum anomalous energy contribution in experiments is an important goal in the future** accessed through heavy quarkonium threshold (J/psi & Upsilon) production?
  D. Kharzeev, Proc. Int. Sch. Phys. Fermi 130, 105 (1996); Kharzeev, Satz, Syamtomov, and Zinovjev EPJC,9, 459, (1999); Gryniuk and Vanderhaeghen, PRD94, 074001 (2016); R. Wang, J. Evslin and X. Chen, Eur. Phys. J. C 80, 507 (2020); Y. Hatta, D-L Yang, PRD 98, 074003 (2018); Hatta et al., PRD 100, 014032 (2019); ……

Understanding reaction mechanisms:
GlueX, PRC**108**, 025201 (2023); Tang *et al.*, arXiv:2405.17675;….

J/ψ @ SoLID: Experiment E12-12-006

50 days of 3 μA beam on a 15 cm long LH_2 target at
10 more days include calibration/background run
SoLID configuration overall compatible with SIDIS

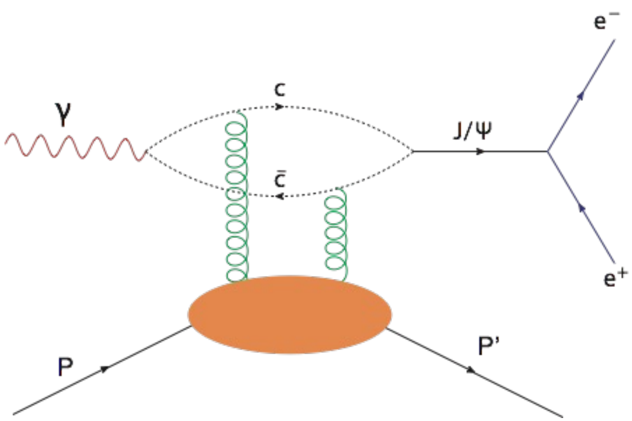
Electroproduction trigger: 3-fold coincidence of e, e^-e^+

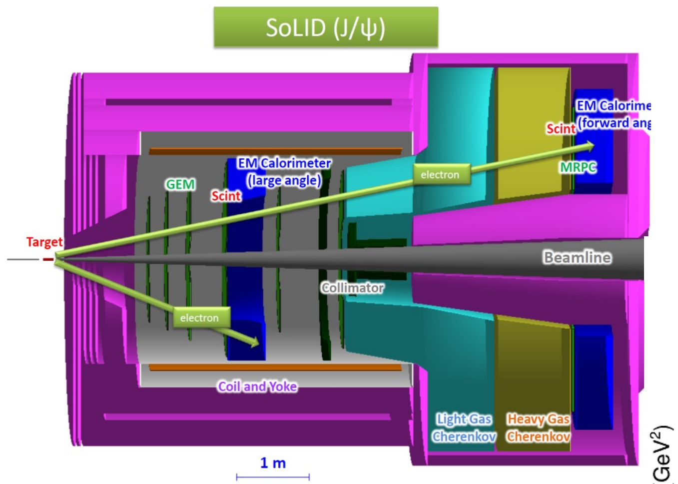
Photoproduction trigger: 3-fold coincidence of p, e^-e^+

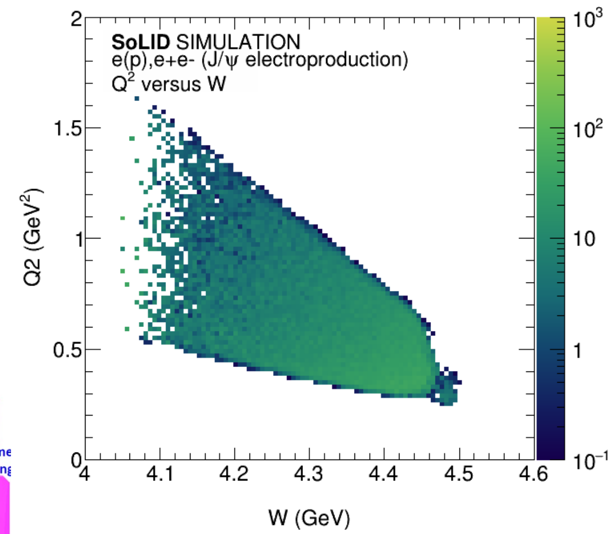
Additional trigger: 4-fold coincidence of ep, e^-e^+

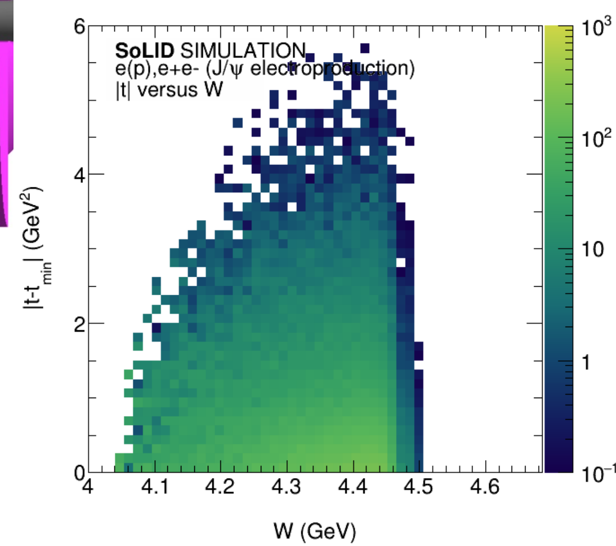
And (inclusive) 2-fold coincidence e^+e^-

$1 \times 10^{37}\mathrm{cm}^{-2}\mathrm{s}^{-1}$







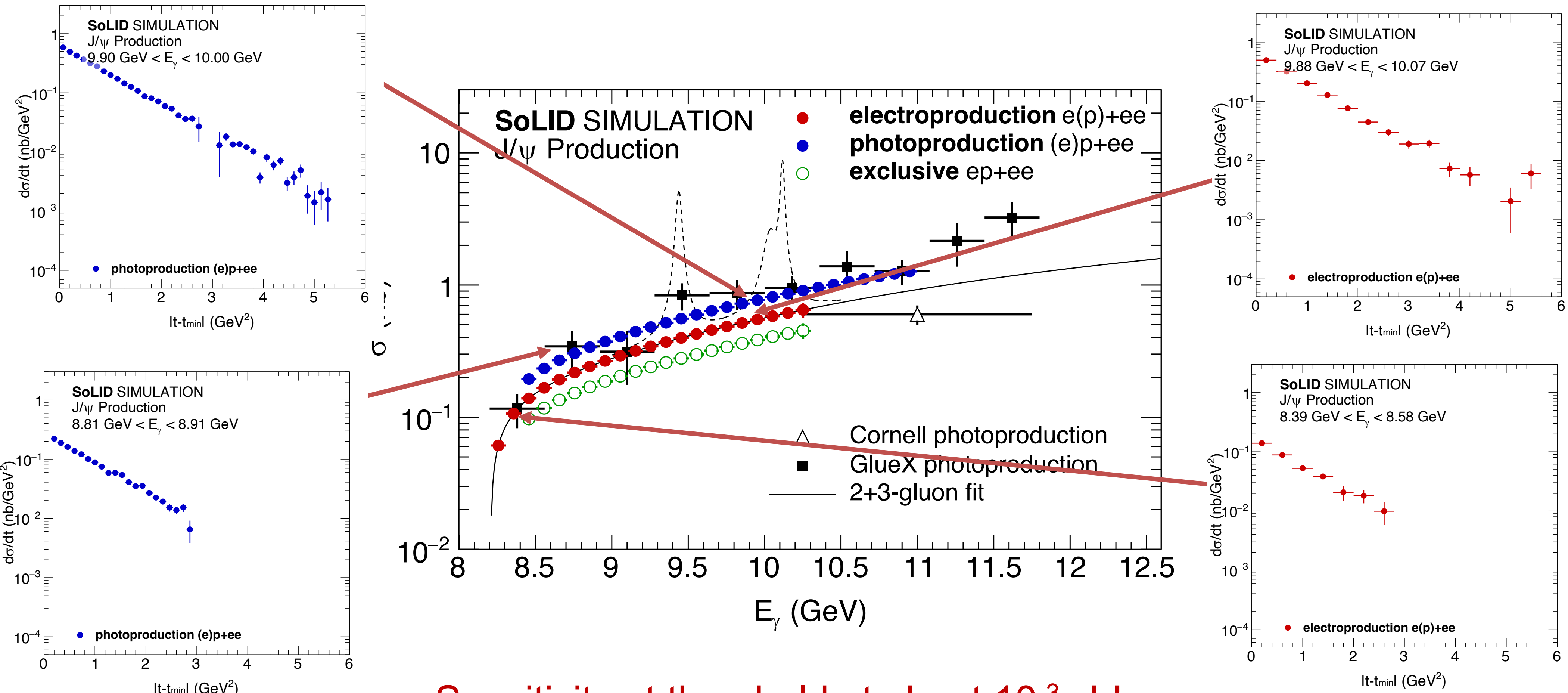


$$e^- + p \longrightarrow e^- + p + J/\psi\,(e^+ + e^-)$$

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

Spokespersons: K. Hafidi, X. Qian, N. Sparveris, Z.-E. Meziani (contact), Z. Zhao

J/Ψ Experiment E12-12-006 @ SoLID



Sensitivity at threshold at about 10^{-3} nb!

B. Duran *et al*., Nature **615**, 813 (2023)

Gravitational form factors of the proton and mass radius:

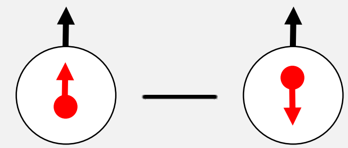
Hagler *et al* (2008); Y. Hatta, A. Rajan and K. Tanaka, JHEP 12, 008 (2018); Shanahan *et al* (2018);
K. Mamo & I. Zahed, Phys. Rev. D 101, 086003 (2020); Guo, Ji, Yuan (2023); Guo, Ji, Liu and Yang (2023);
D. Hackett *et al*, PRL 132, 251904 (2024); K.F. Liu; …….

TMDs – confined motion inside the nucleon

Transversely Polarized Nucleon TMDs

→ Nucleon Spin
→ Quark Spin

Transversity

$h_{1T} =$ 

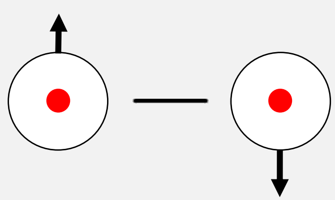
$$\mathbf{S}_T \cdot \mathbf{s}_q$$

Relevant Vectors

S_T: Nucleon Spin
s_q: Quark Spin
$k_\perp$: Quark Transverse Momentum
P: Virtual photon 3-momentum (defines z-direction)

- h_{1T} (h_1) = g_1 (no relativity)
- h_{1T} → tensor charge (lattice QCD calculations)
- Connected to nucleon beta decay and EDM

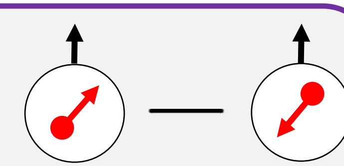
Sivers

$f_{1T}^{\perp} =$ 

$$\mathbf{S}_T \cdot \mathbf{k}_\perp \times \mathbf{P}$$

- Nucleon spin - quark orbital angular momentum (OAM) correlation – zero if no OAM (model dependence)

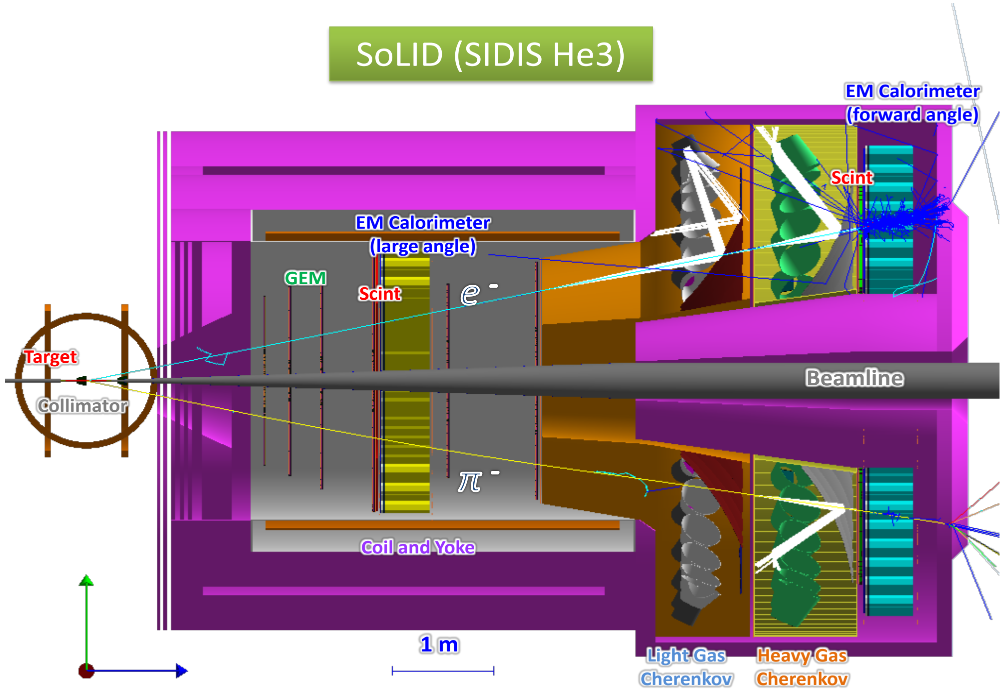
Pretzelosity

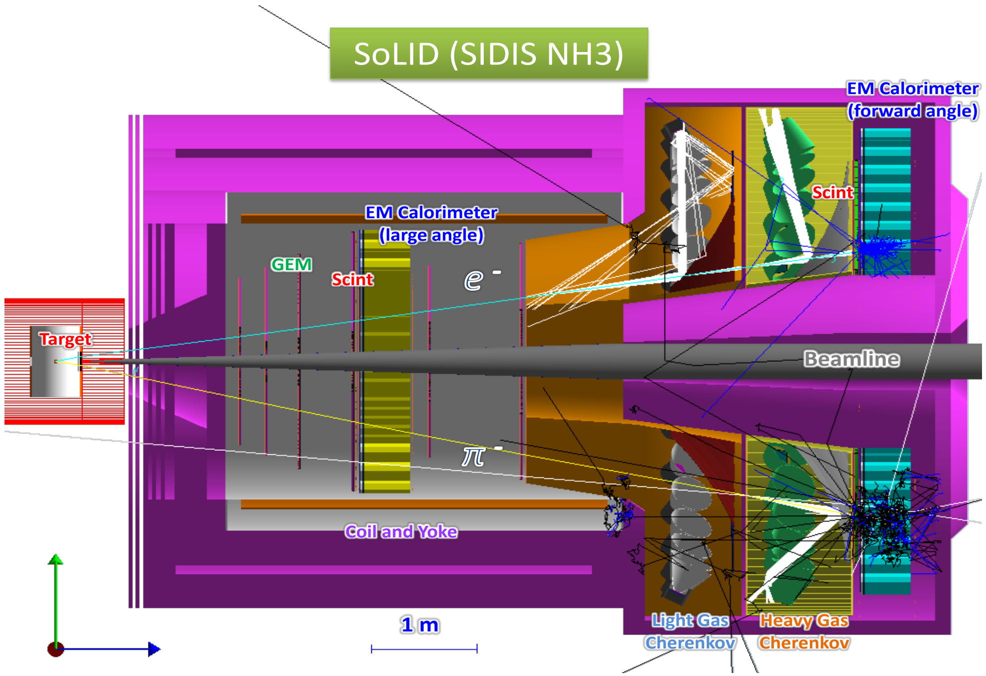
$h_{1T}^{\perp} =$ 

$$\mathbf{S}_T \cdot [\mathbf{k}_\perp \mathbf{k}_\perp] \cdot \mathbf{s}_{qT}$$

- Interference between components with OAM difference of 2 units (i.e., s-d, p-p) (model dependence)
- Signature for relativistic effect

SIDIS with polarized "neutron" and proton @ SoLID





E12-10-006: Single Spin Asymmetries on Transversely Polarized ^{3}He @ 90 days
Rating A Spokespersons: J.P. Chen, H. Gao (contact), J.C. Peng, X. Qian

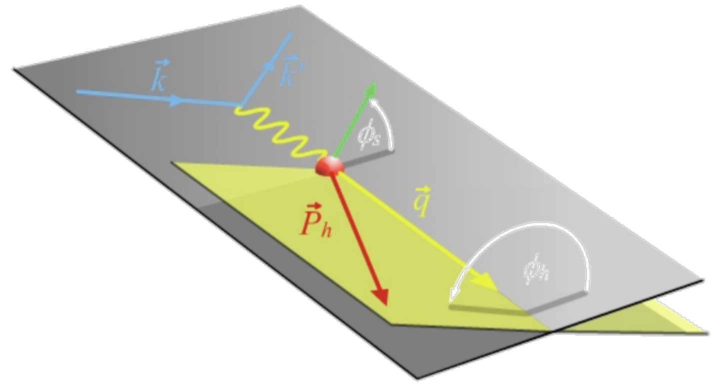
E12-11-007: Single and Double Spin Asymmetries on Longitudinally Polarized ^{3}He @ 35 days
Rating A Spokespersons: J.P. Chen (contact), J. Huang, W.B. Yan

E12-11-108: Single Spin Asymmetries on Transversely Polarized Proton @ 120 days
Rating A Spokespersons: J.P. Chen, H. Gao (contact), X.M. Li, Z.-E. Meziani

Run group experiments approved for TMDs, GPDs, and spin

Access the Leading Twist TMDs

SIDIS observables depend on 4-D variables (x, Q^2, z, P_T) and small asymmetries demand **large acceptance** + **high luminosity** allowing for measuring symmetries in 4-D binning with precision!



Extract the leading twist terms of TMD through SIDIS-π differential cross section measurement

Nucleon Polarization	Quark Polarization: U	L	T
U	f_1 Unpolarized		$h_1^{\perp}$ Boer-Mulders
L		g_{1L} Helicity	$h_{1L}^{\perp}$ Worm-gear (longi-transversity)
T	$f_{1T}^{\perp}$ Sivers	g_{1T} Worm-gear (trans-helicity)	h_1 Transversity $h_{1T}^{\perp}$ Pretzelosity

Worm-gear TMDs:

E12-11-007 Longitudinally Polarized ^{3}He

$$A_{UL}^{\sin 2\phi_h} \propto h_{1L}^{\perp} \otimes H_1^{\perp}$$

$$A_{LT}^{\cos(\phi_h-\phi_S)} \propto g_{1T} \otimes D_1$$

(combined with E12-10-006 data)

Sivers, Transversity, and Pretz. TMDS:

E12-10-006 Transversely Polarized ^{3}He

E12-11-108 Transversely polarized NH_3

$$A_{UT} = \frac{1}{P}\frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

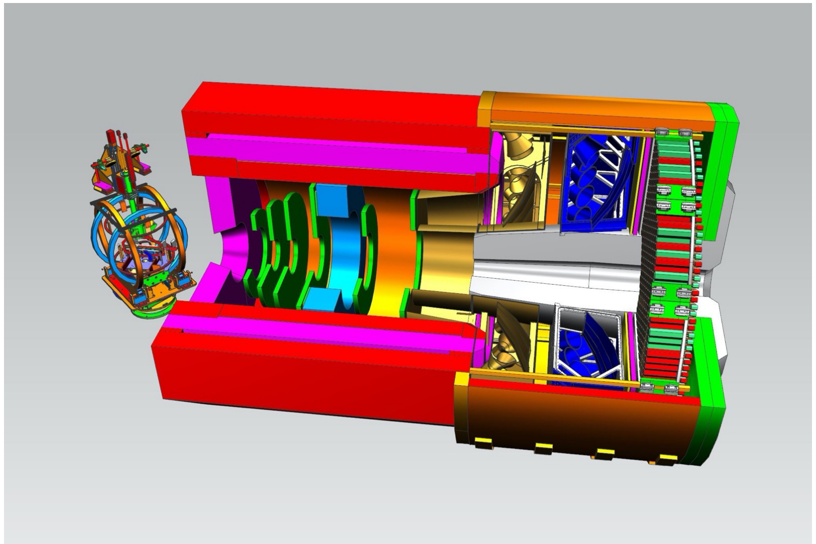
$$= A_{UT}^{Collins} \sin(\phi_h + \phi_S) \quad \propto h_{1T} \otimes H_1^{\perp}$$

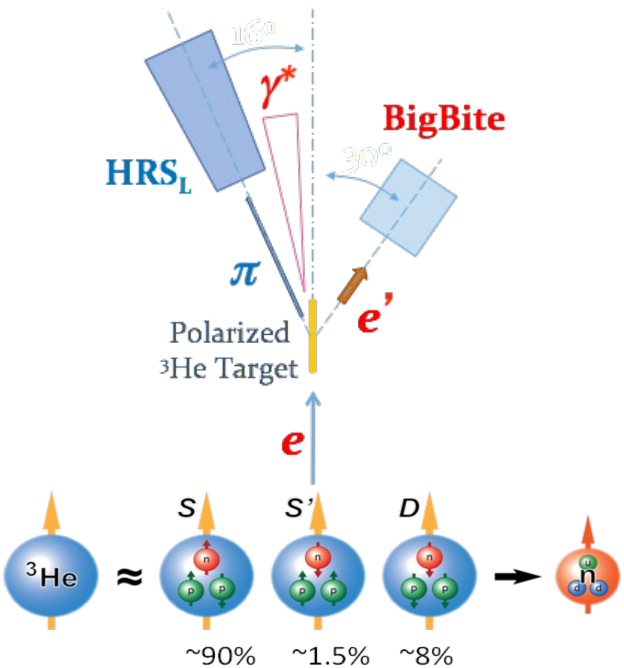
$$+ A_{UT}^{Sivers} \sin(\phi_h - \phi_S) \quad \propto f_1^{\perp} \otimes D_1$$

$$+ A_{UT}^{Pretz.} \sin(3\phi_h - \phi_S) \quad \propto h_{1T}^{\perp} \otimes H_1^{\perp}$$

Large acceptance and precision measurement of asymmetries in 4D phase space is essential for extraction

QCD intensity frontier with SoLID: large-acceptance & high luminosity





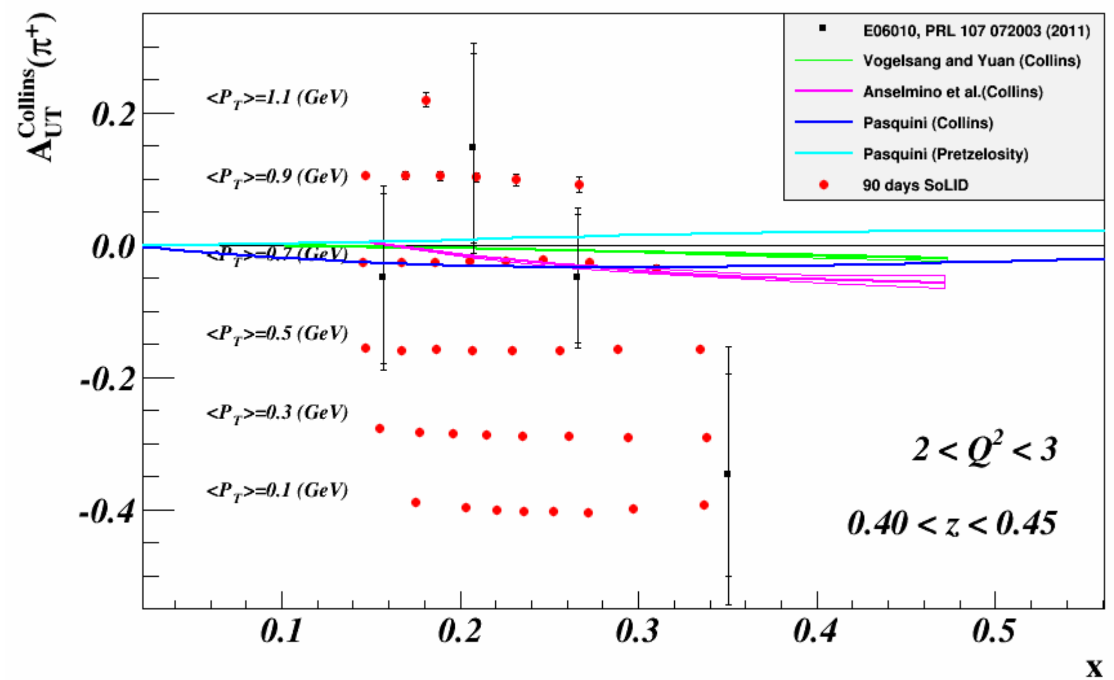
X. Qian et al., PRL107, 072003(2011)

Precision 4-D binning!

SoLID-SIDIS program: Large acceptance, Full azimuthal coverage + High luminosity

- 4-D mapping of asymmetries with precision

  $\Delta z = 0.05$, $\Delta P_T = 0.2$ GeV, $\Delta Q^2 = 1$ GeV^2, x bin sizes vary with median bin size 0.02 (statistical uncertainty for each bin: $\delta A \leq 0.02$)
- Constrain models and forms of TMDs, Tensor charge, …
- Lattice QCD, QCD dynamics, models



- **More than 1400 bins in x, Q^2, P_T and z for 11/8.8 GeV beam.**

SIDIS acceptance and efficiency ^{3}He (left) NH_3 (right)

Polarized lumi ~1e^{36}/cm^2/s
Unpolarized lumi ~1e^{37}/cm^2/s

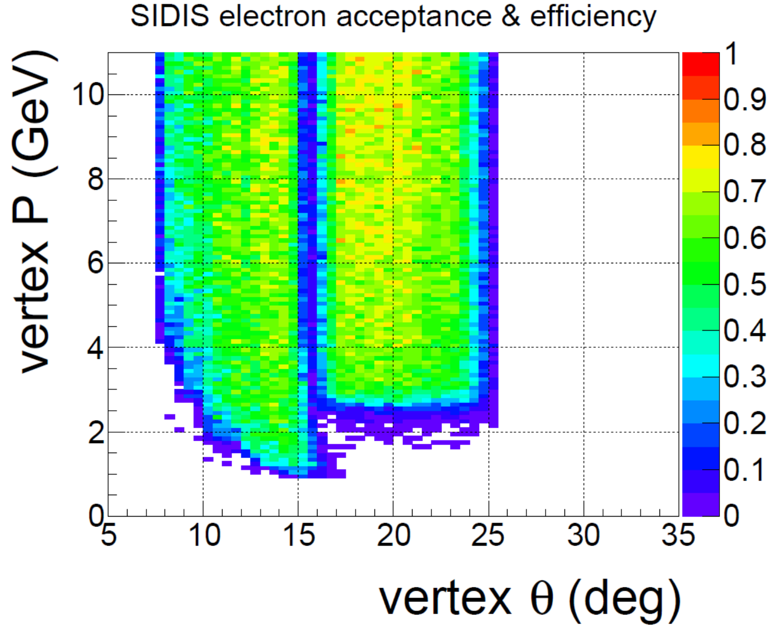
Polarized lumi ~1e^{35}/cm^2/s
Unpolarized lumi ~6e^{35}/cm^2/s

Coverage

- Polar angle: e$^-$ 8-24 deg, π$^-$/π$^+$ 8-15deg
- Azimuthal angle: full

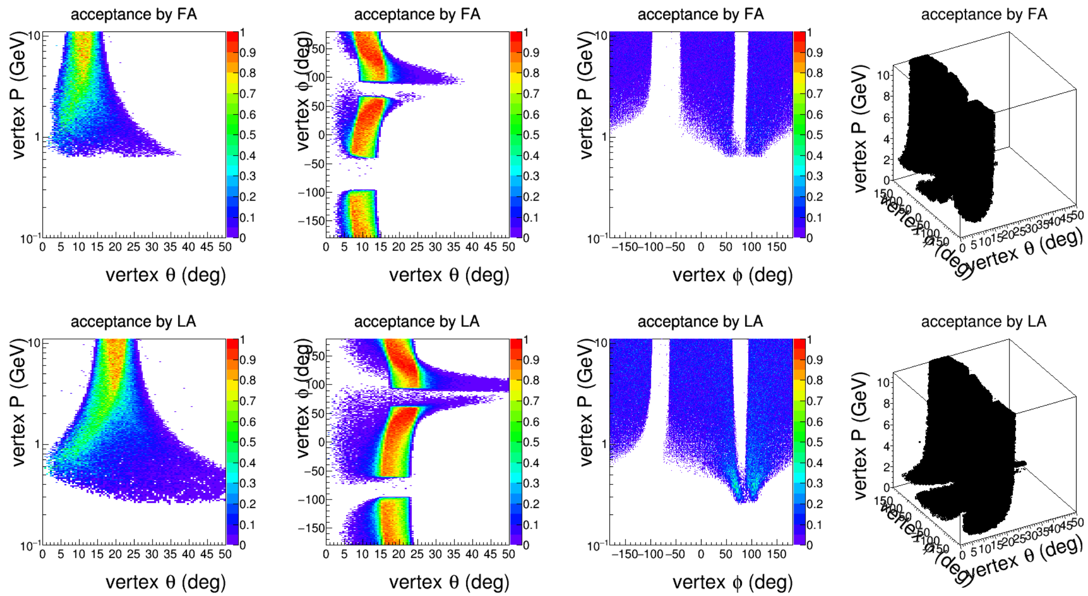
Detection

- e- at forward angle with EC and Cerenkov to reject pions
- e- above 3GeV detected at large angle with EC to reject pions
- pions detected at forward angle with TOF and Cerenkov to suppress kaons



Detection is similar to ^{3}He setup

5T transverse target field
High radiation sheet of flame areas need to be cut away or shielded



e- acceptance shown, π$^-$ acceptance is similar
π$^+$ acceptance is reversed, along phi=0 plane

SoLID SIDIS Projection

Compare SoLID with World Data

- Fit Collins and Sivers asymmetries in SIDIS and e^+e^- annihilation
- World data from HERMES, COMPASS
- e^+e^- data from BELLE, BABAR, and BESIII
- Monte Carlo method is applied
- Including both systematic and statistical uncertainties

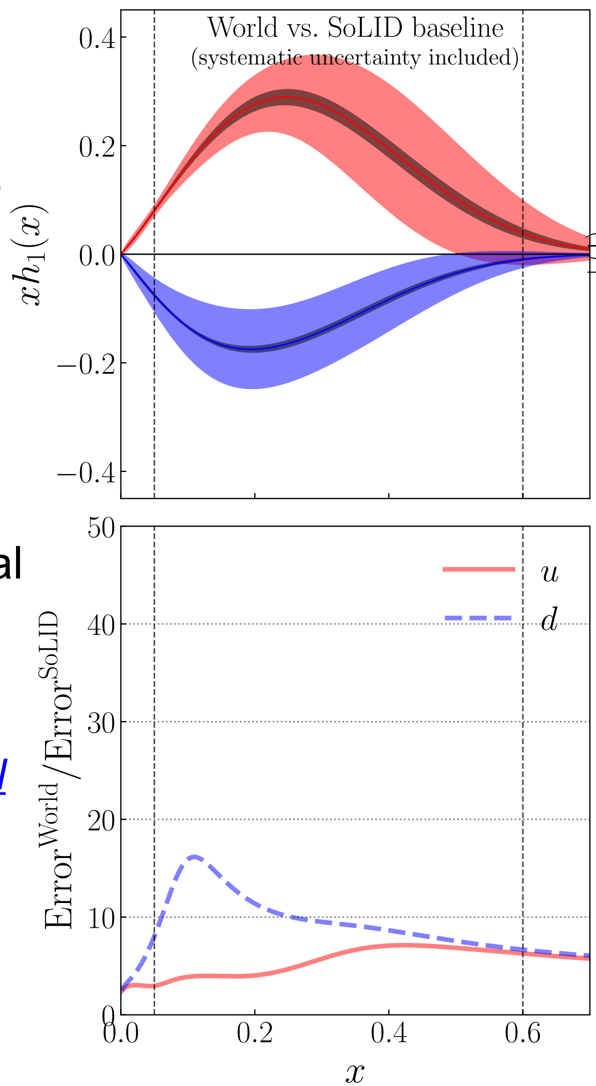
World data according to SoLID preCDR (2019) [*https://solid.jlab.org/experiments.html*](https://solid.jlab.org/experiments.html)

SoLID baseline used

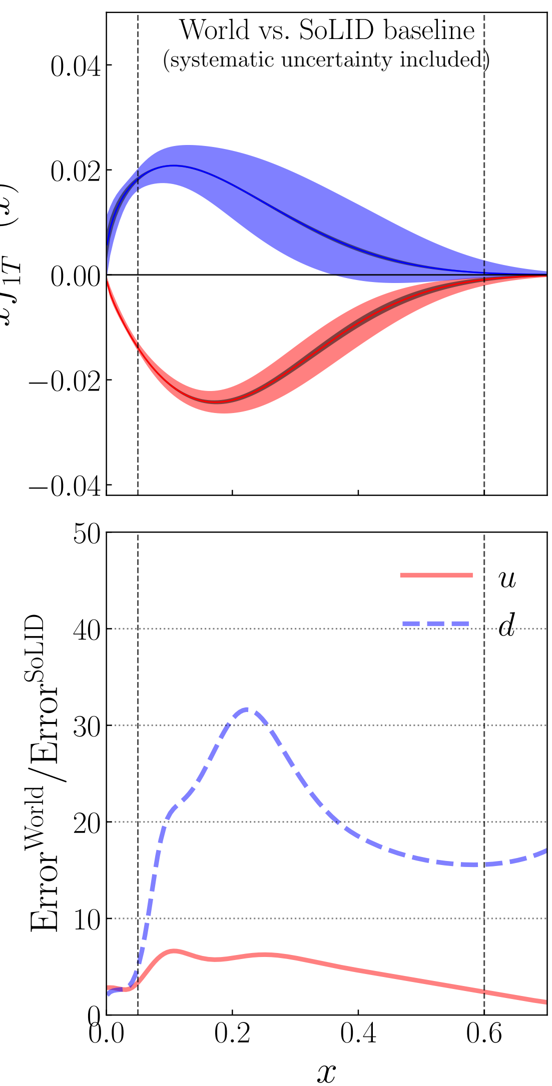
D'Alesio et al., Phys. Lett. B 803 (2020)135347
Anselmino et al., JHEP 04 (2017) 046

Z. Ye et al., PLB 76, 91 (2017)
T. Liu (2018): https://pos.sissa.it/317/036

Transversity

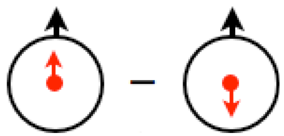


Sivers



Transversity and Tensor Charge

Transversity distribution

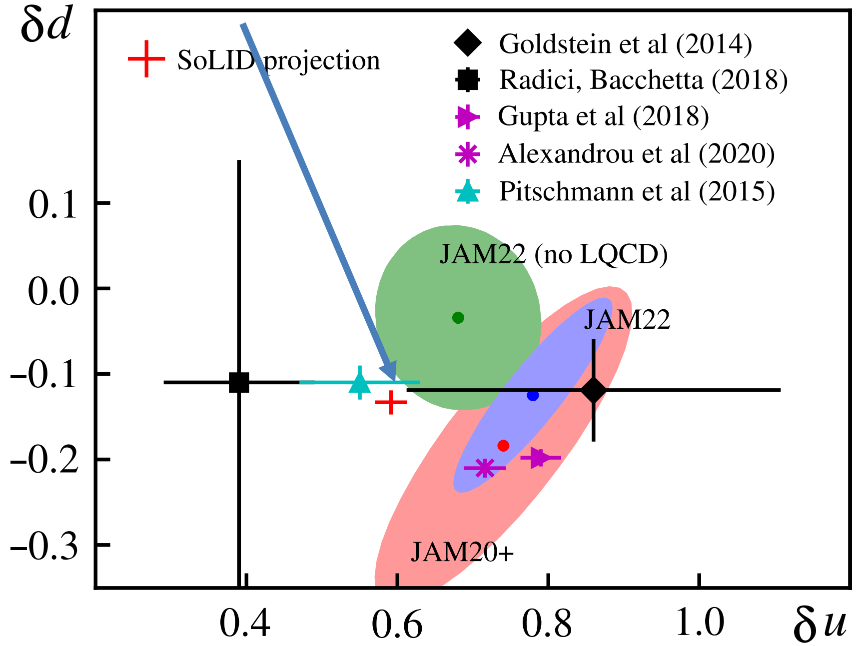
h_1  (Collinear & TMD)

- Chiral-odd, unique for the quarks
- No mixing with gluons, simpler evolution effect
- Tensor charge:

$$\langle \mathrm{P,S}|\overline{\psi}_q i\sigma^{\mu\nu}\psi_q|\mathrm{P,S}\rangle = g_T^q \overline{u}(\mathrm{P,S}) i\sigma^{\mu\nu} u(\mathrm{P,S})$$

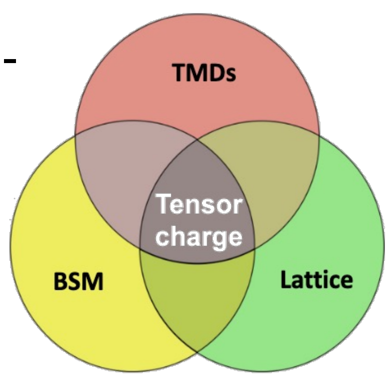
$$g_T^q = \int_0^1 \left[h_1^q(x) - h_1^{\overline{q}}(x)\right] dx$$

  - A fundamental QCD quantity dominated by valence quarks
  - Precisely calculated on the lattice
  - Difference from nucleon axial charge is due to relativity
  - SoLID measurements allows for high-precision test of LQCD predictions
  - Global analysis including LQCD (PRL 120 (2018) 15, 152502



SoLID projection: statistical and systematic uncertainties included (shifted for visibility)

J. Cammarota et al, PRD 102, 054002 (2020) (JAM20+)
L. Gamberg et al., PRD 106, 034014 (2022) (JAM22)



Nucleon Electric Dipole Moment and Tensor Charge

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

$$d_p = g_T^u\, d_u + g_T^d\, d_d + g_T^s\, d_s$$

Constraint on Quark EDMs

Constraint on quark EDMs with combined proton and neutron EDMs

	d_u upper limit	d_d upper limit
Current g_T + current EDMs	$1.27\times10^{-24}e$ cm	$1.17\times10^{-24}e$ cm
SoLID g_T + current EDMs	$6.72\times10^{-25}e$ cm	$1.07\times10^{-24}e$ cm
SoLID g_T + future EDMs	$1.20\times10^{-27}e$ cm	$7.18\times10^{-28}e$ cm

Include 10% isospin symmetry breaking uncertainty

Sensitivity to new physics

$$d_q \sim em_q/(4\pi\Lambda^2)$$

Three orders of magnitude improvement on quark EDM limit → Probe to 30 ~ 40 times higher scale

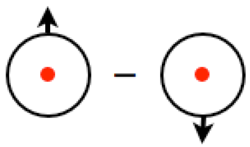
Current quark EDM limit: $10^{-24}e$ cm → ~ 1 TeV

Future quark EDM limit: $10^{-27}e$ cm → 30 ~ 40 TeV

H. Gao, T. Liu, Z. Zhao, PRD 97, 074018 (2018)

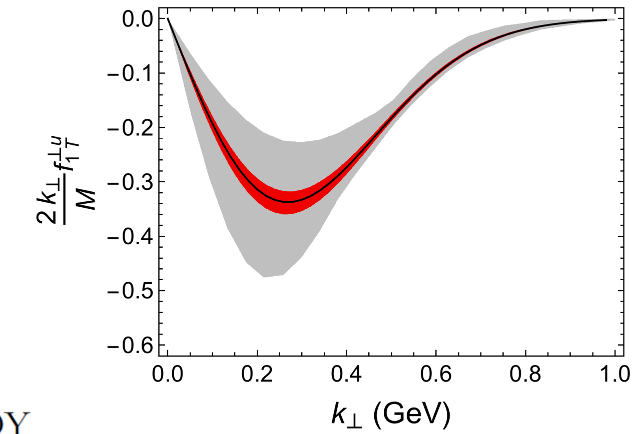
Confined motion inside the nucleon

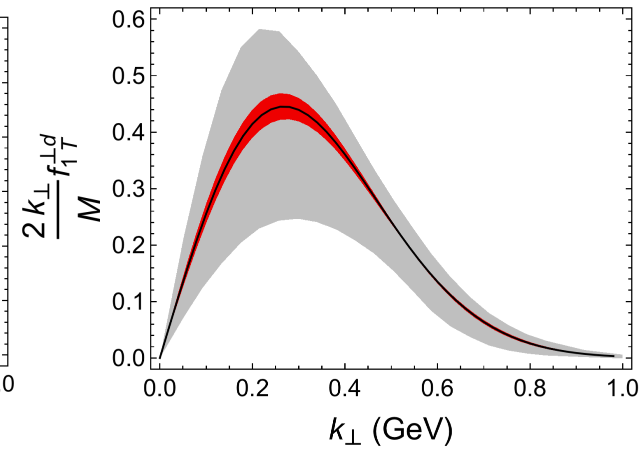
Sivers distribution

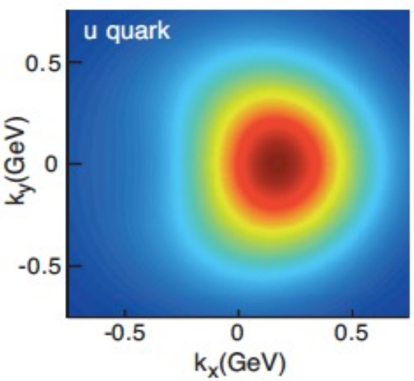
$f_{1T}^{\perp}$ 

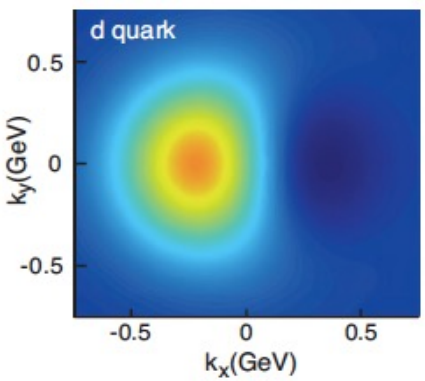
naively time-reversal odd

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









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

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

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

SoLID projection with transversely polarized n/p

	$\langle k_\perp\rangle^u$	$\langle k_\perp\rangle^d$
Parametrization (grey)	96^{+60}_{-28} MeV	-113^{+45}_{-51} MeV
SoLID projection (red)	$96^{+2.8}_{-2.4}$ MeV	$-113^{+1.3}_{-1.7}$ MeV

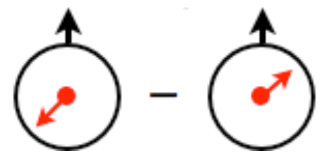
Nucleon spin - quark orbital angular momentum (OAM) correlation
– zero if no OAM (collinear, massless quarks)

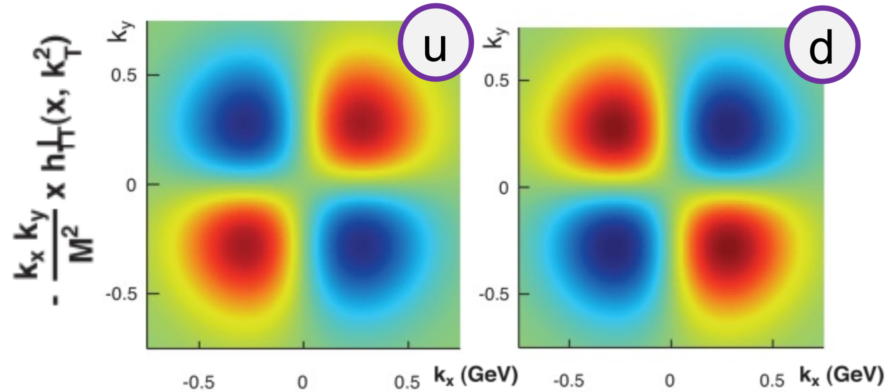
Exact finding is model dependent but SoLID impact is model-independent!

Confined motion inside the nucleon

Pretzelocity distribution

$h_{1T}^{\perp}$



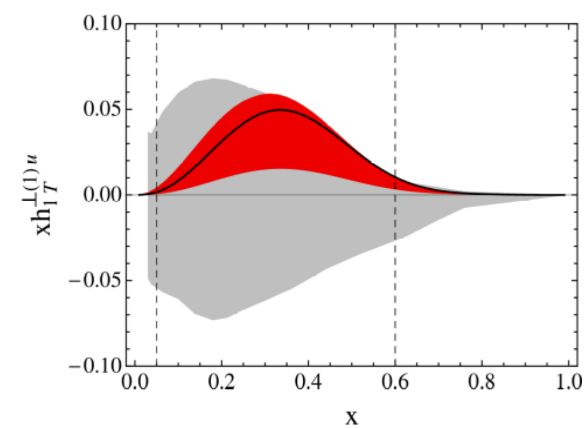


Images from PRD 91 034010 (2015)

- Chiral-odd, no gluon analogy
- Quadrupole modulation of parton density in the distribution of transversely polarized quarks in a transversely polarized nucleon
- Measuring the difference between helicity and transversity (relativistic effects)

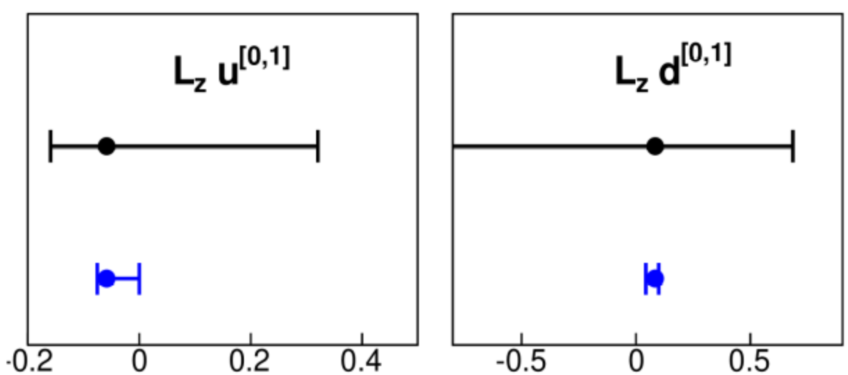
Parametrization by C. Lefky et al., PRD 91, 034010 (2015)

SoLID projection with transversely polarized n and p data



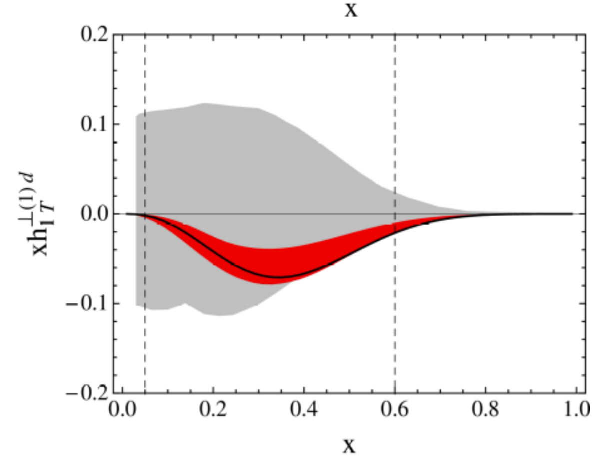
Relation to OAM (canonical)

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



Lefky and Prokudin PRD 91, 034010 (2015)

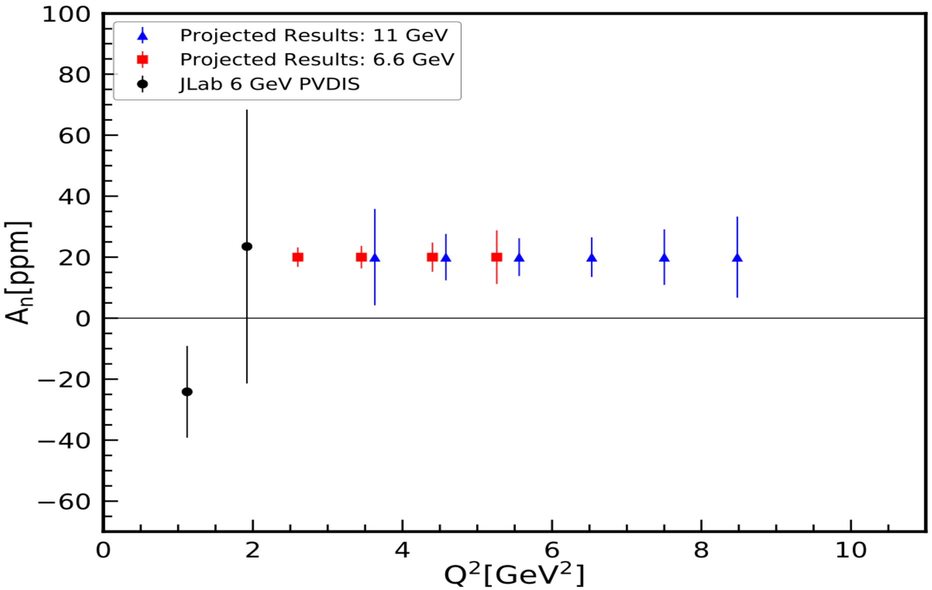
SoLID projection

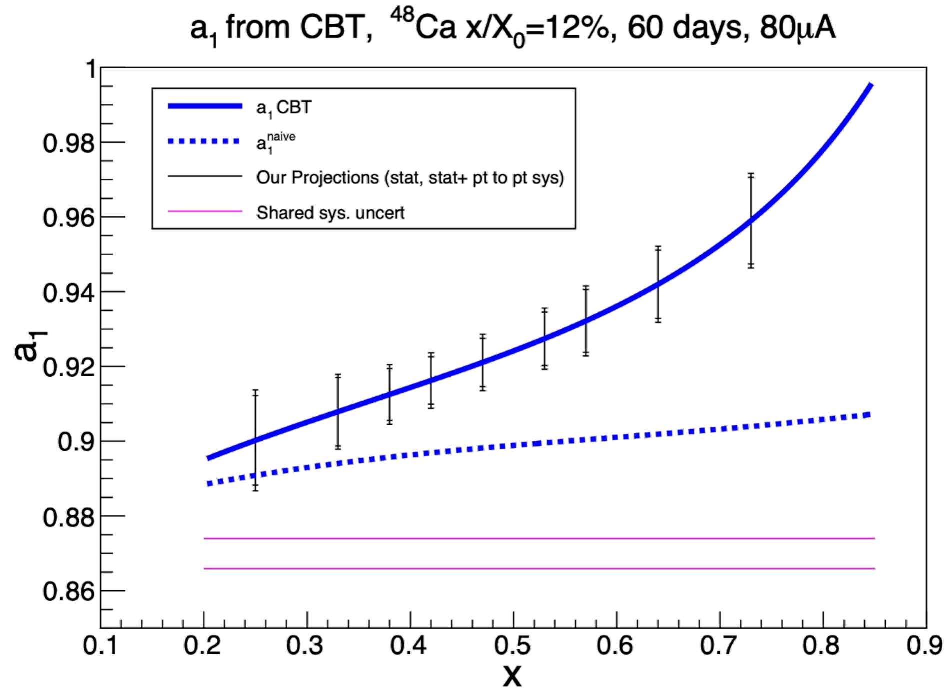


BNSSA and PVEMC Experiments

- Beam Normal Single Spin Asymmetry
  - Approved proposal
  - Investigate the effect of two-photon exchange in DIS
  - Q2 dependence of the asymmetry
- Flavor Dependent EMC effect
  - Conditionally approved proposal
  - Measure PVDIS on ^{48}Ca
  - A_{pv} directly sensitive to flavor dependence of EMC

$$a_1 \simeq \frac{9}{5} - 4\sin^2\theta_W - \frac{12}{25}\frac{u_A^+ - d_A^+}{u_A^+ + d_A^+}$$





SoLID SIDIS run group experiments

- SIDIS Dihadron with Transversely Polarized ^{3}He

J.-P. Chen, A. Courtoy, H. Gao, A. W. Thomas, Z. Xiao, J. Zhang, Approved as run group (E12-10-006A)

- SIDIS in Kaon Production with Transversely Polarized ^{3}He

T. Liu, S. Park, Z. Ye, Y. Wang, Z.W. Zhao, Approved as run group (E12-10-006D)

- Ay with Transversely Polarized ^{3}He

T. Averett, A. Camsonne, N. Liyanage, Approved as run group (E12-10-006A)

- g_2^n and d_2^n with Transversely and Longitudinally Polarized ^{3}He

C. Peng, Y. Tian, Approved as run group (E12-10-006E)

- Deep exclusive π^- Production with Transversely Polarized ^{3}He

Z. Ahmed, G. Huber, Z. Ye, Approved as run group (E12-10-006B)

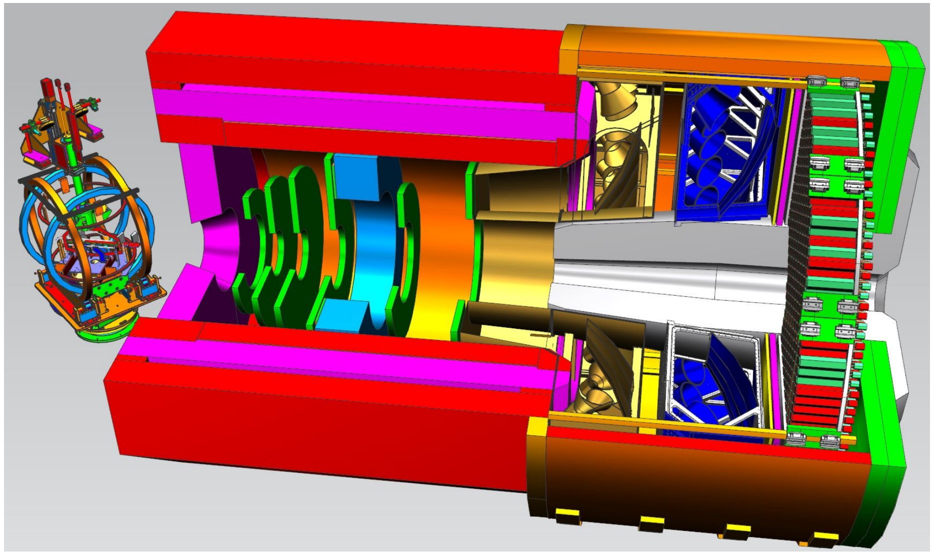
- Timelike Compton TCS circular polarized beam and unpolarized LH2 target M. Boer, P. Nadel-Turonski, J. Zhang, Z. Zhao, Approved as run group (E12-12-006A)

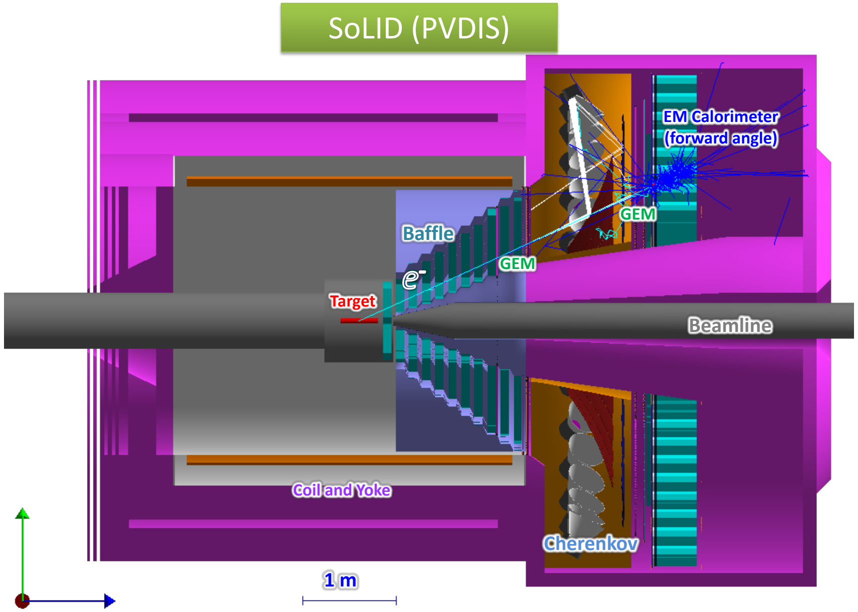
SoLID Apparatus

Requirements are Challenging

- High Luminosity (10^{37}-10^{39})
- High data rate
- High background
- Low systematics
- High Radiation
- Large scale
- Modern Technologies
  - GEM's
  - Shashlik ECal
  - Pipeline DAQ
  - Rapidly Advancing Computational Capabilities
- High Performance Cherenkov
- Baffles

Polarized ^{3}He (``neutron") @ SoLID



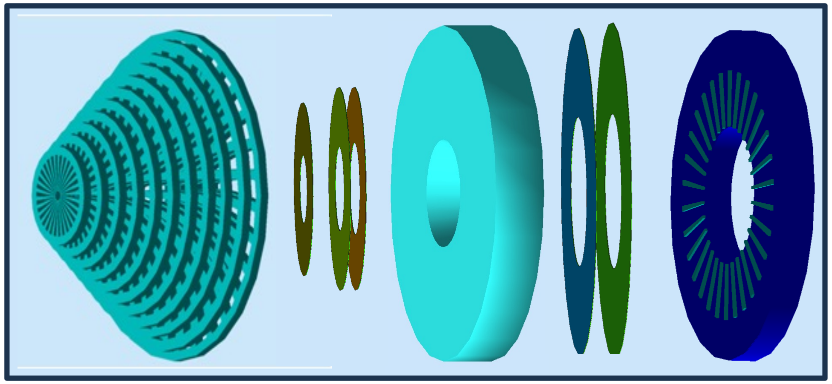


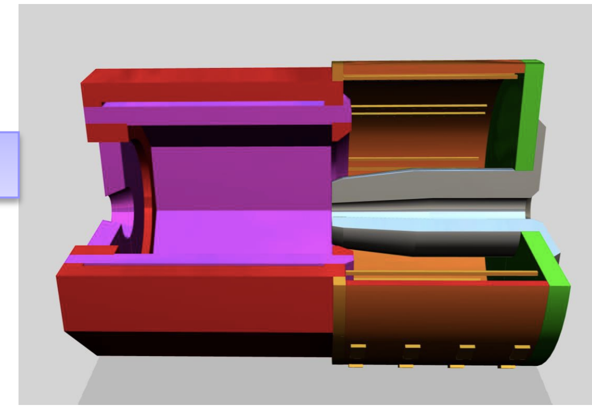
SoLID Detector Subsystems

Uses full capability of
JLab electronics

PVDIS

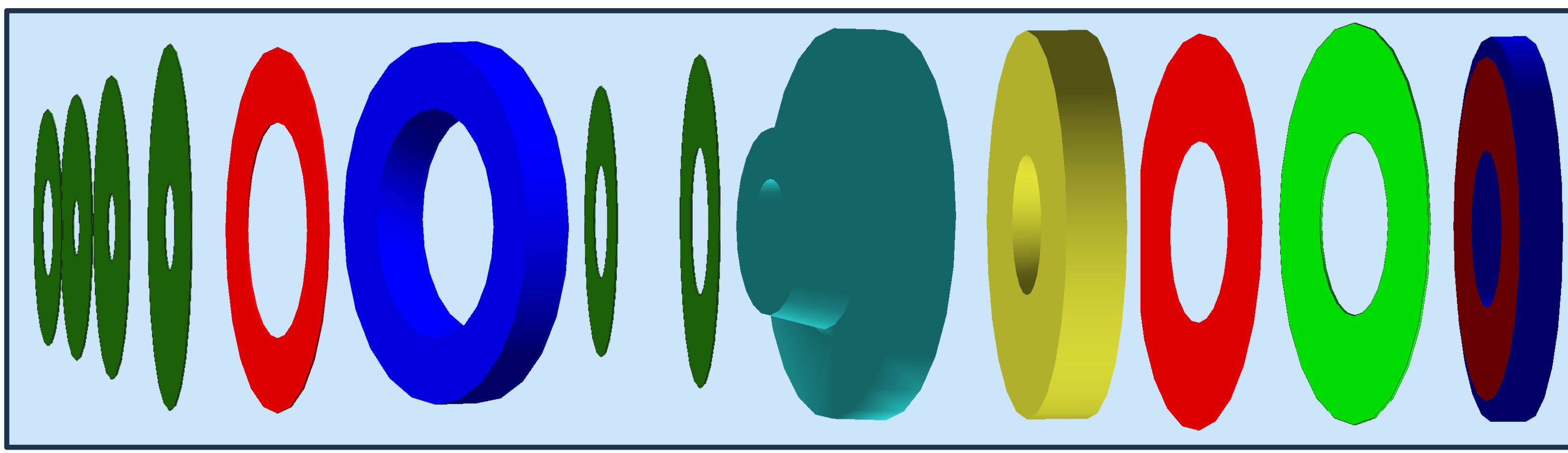
Baffle 3xGEMS LGC 2xGEMs EC





SIDIS-J/ψ

4xGEMs LASPD LAEC 2xGEMs LGC HGC FASPD (MRPC) FAEC



Pre-R&D items: LGC, HGC, GEM's, EC,
DAQ/Electronics, Magnet

Magnet: Requirement and Design

Requirements:

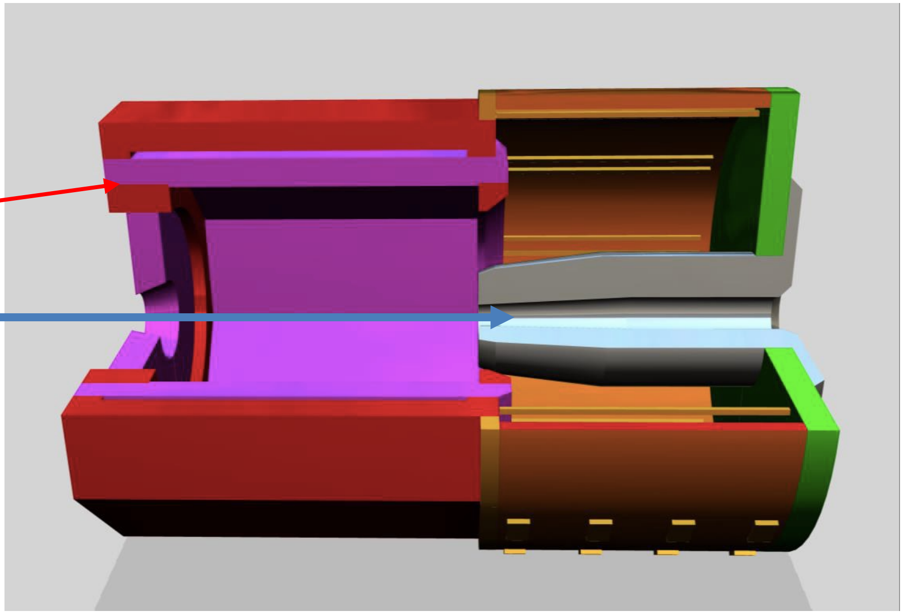
→Acceptance: P: 1.0 – 7.0 GeV/c;
Φ: 2π; θ: 8^o-24^o (SIDIS), 22^o-35^o (PVDIS)

→ Resolution: $\delta P/P \sim 2\%$
(requires 0.1 mm tracking resolution)

→ Fringe field at the ^{3}He target < 5 Gauss

CLEO II magnet at JLab

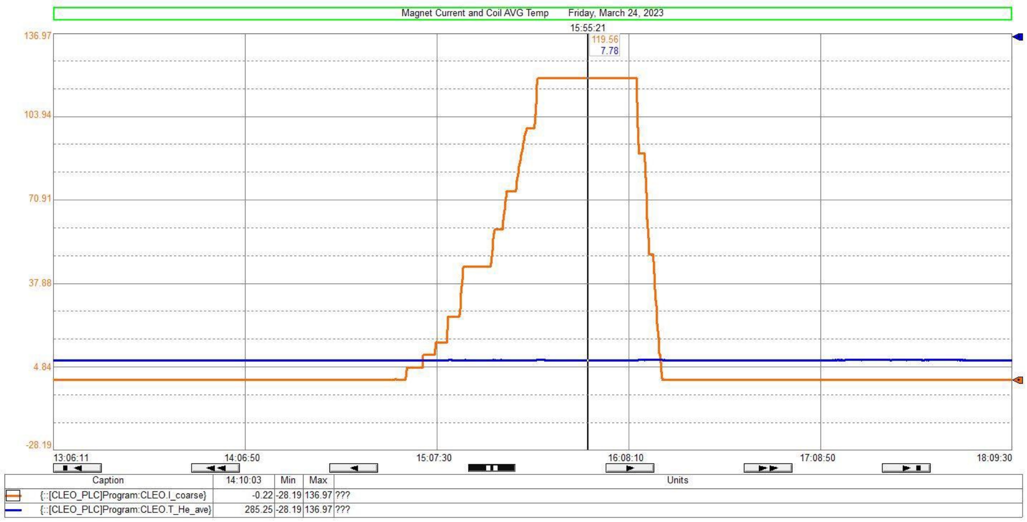
- Use CLEO II magnet with the following modifications
  - Two of three layers of return yoke needed
  - Add thickness to front endcap
  - Add extended endcap

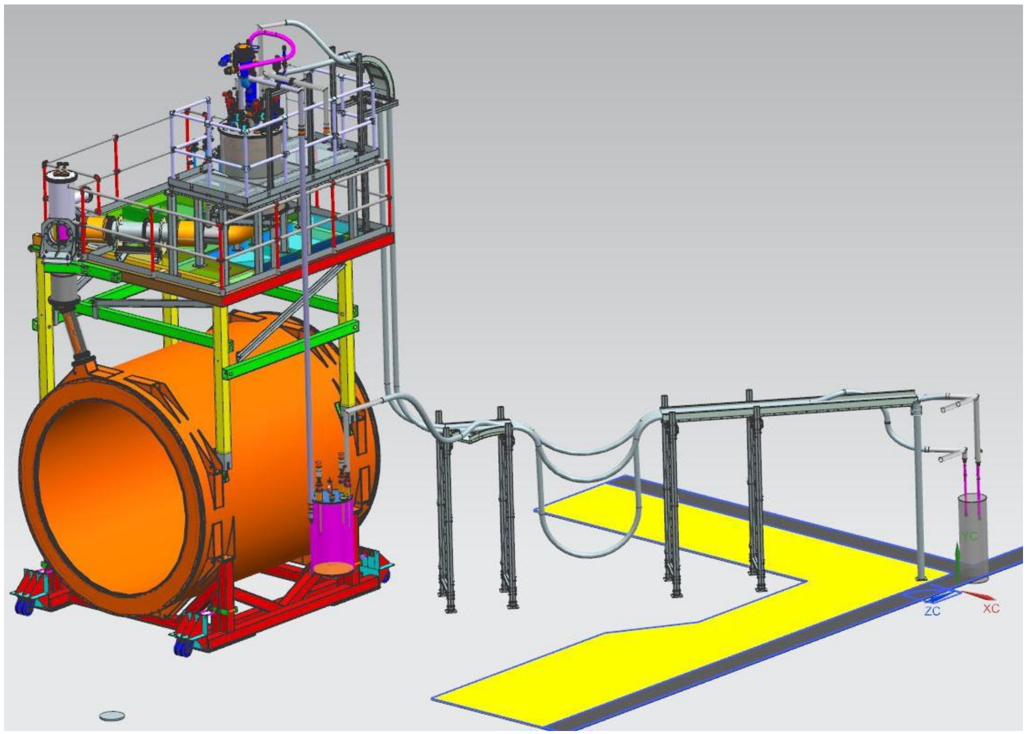


Yoke for SoLID

Magnet Cold Test

- Magnet assembly completed
- Cryogenic system assembled and commissioned
- Instrumentation and control system commissioned
- Energized the coil with 120 A while temperature was stable
- Under data analysis and report writing

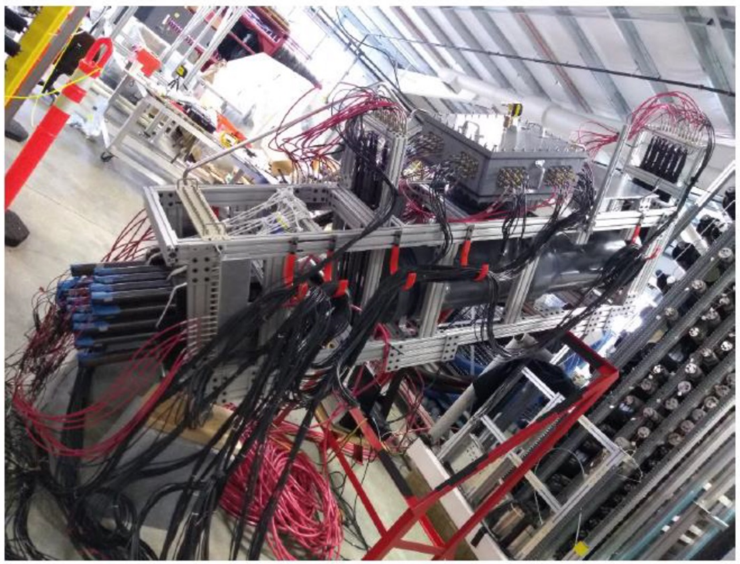


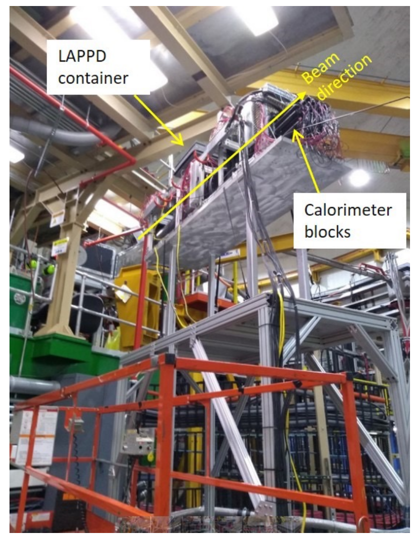


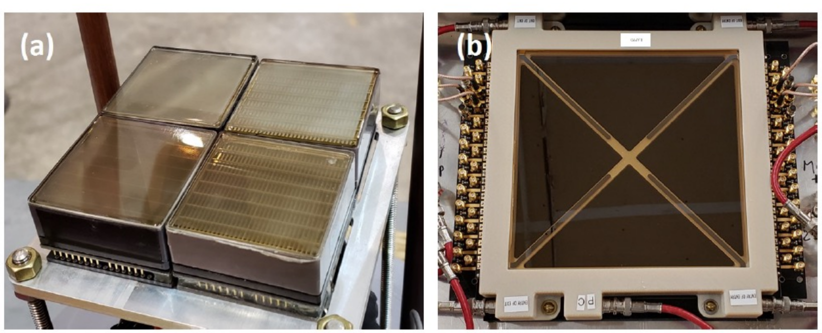
Whit Seay et al. at Jlab

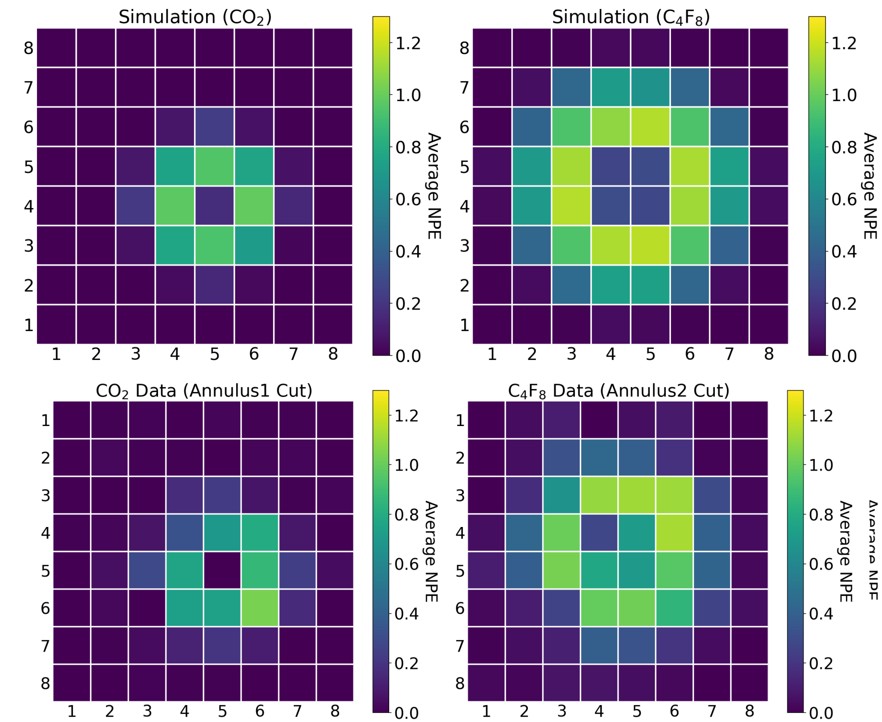
Beam Tests for Cherenkov Prototype

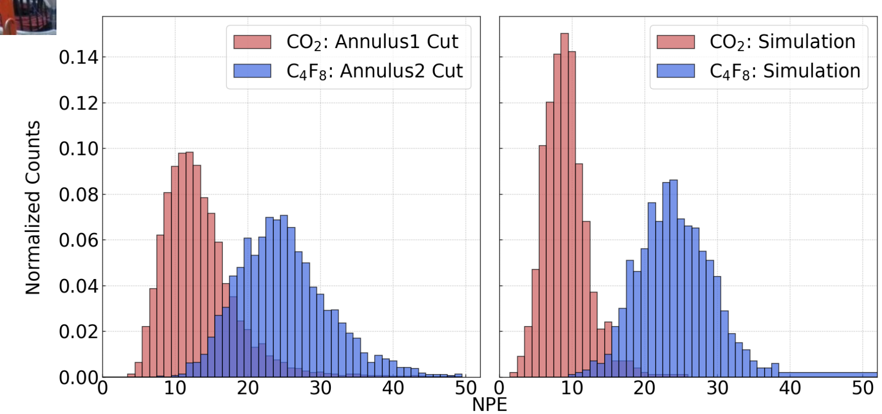
2 beam tests for MaPMT/LAPPD in high-rate background
SoLID expected rates achieved (> 5 MHz/PMT)
1st test *C. Peng et al., JINST 17 (2022), P08022*
2nd test *J. Xie et al., accepted by JINST*





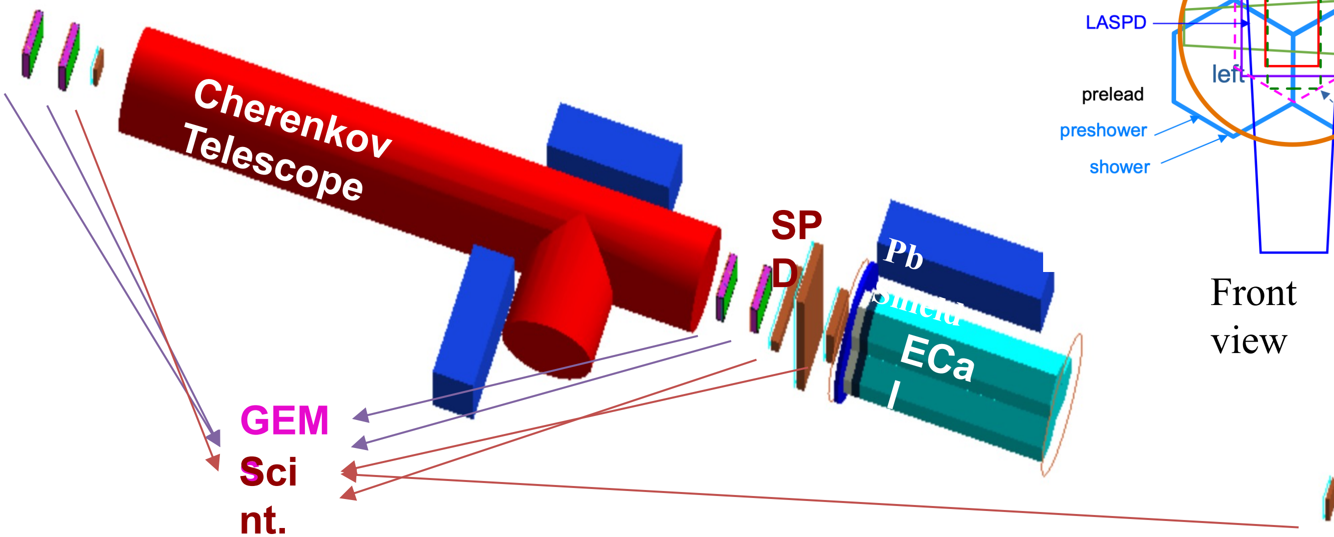


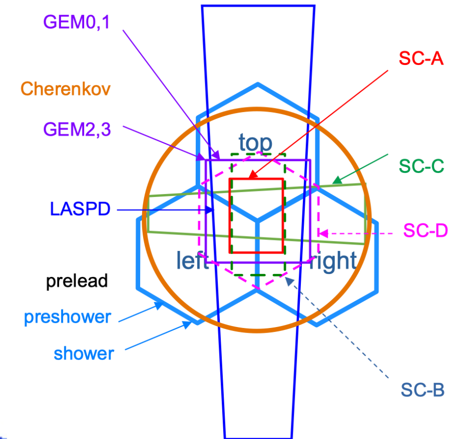




Beam Tests for Ecal and Preliminary Results

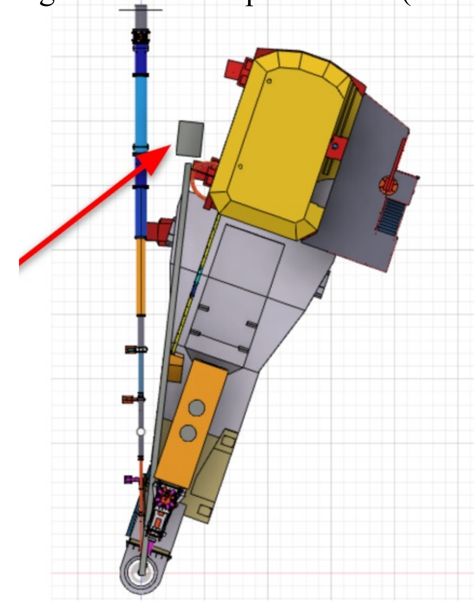
Similar setup to SoLID detector (no magnet)
~10^2 krad
3-stage test in Hall C at JLab



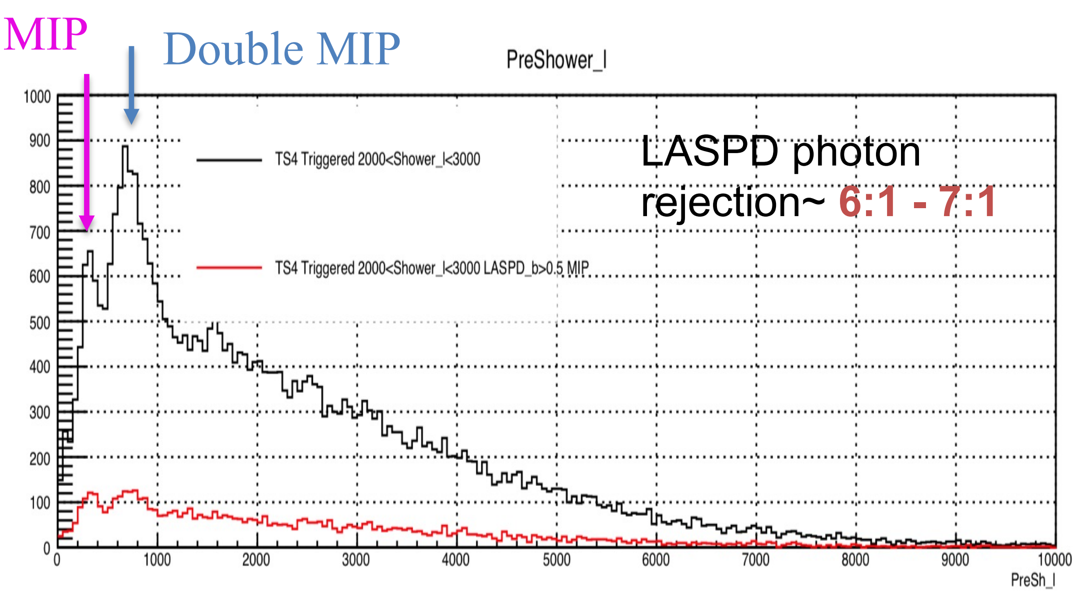


Front view

High Momentum Spectrometer (HMS)



- June 2022: install at (L) 82°
- Jan 2023: moved to (R) 7°
- Feb 2023: moved to (R) 18°



<u>Photon rejection:</u>

N_{raw}/N_{cut} (LASPD>0.5 MIP)

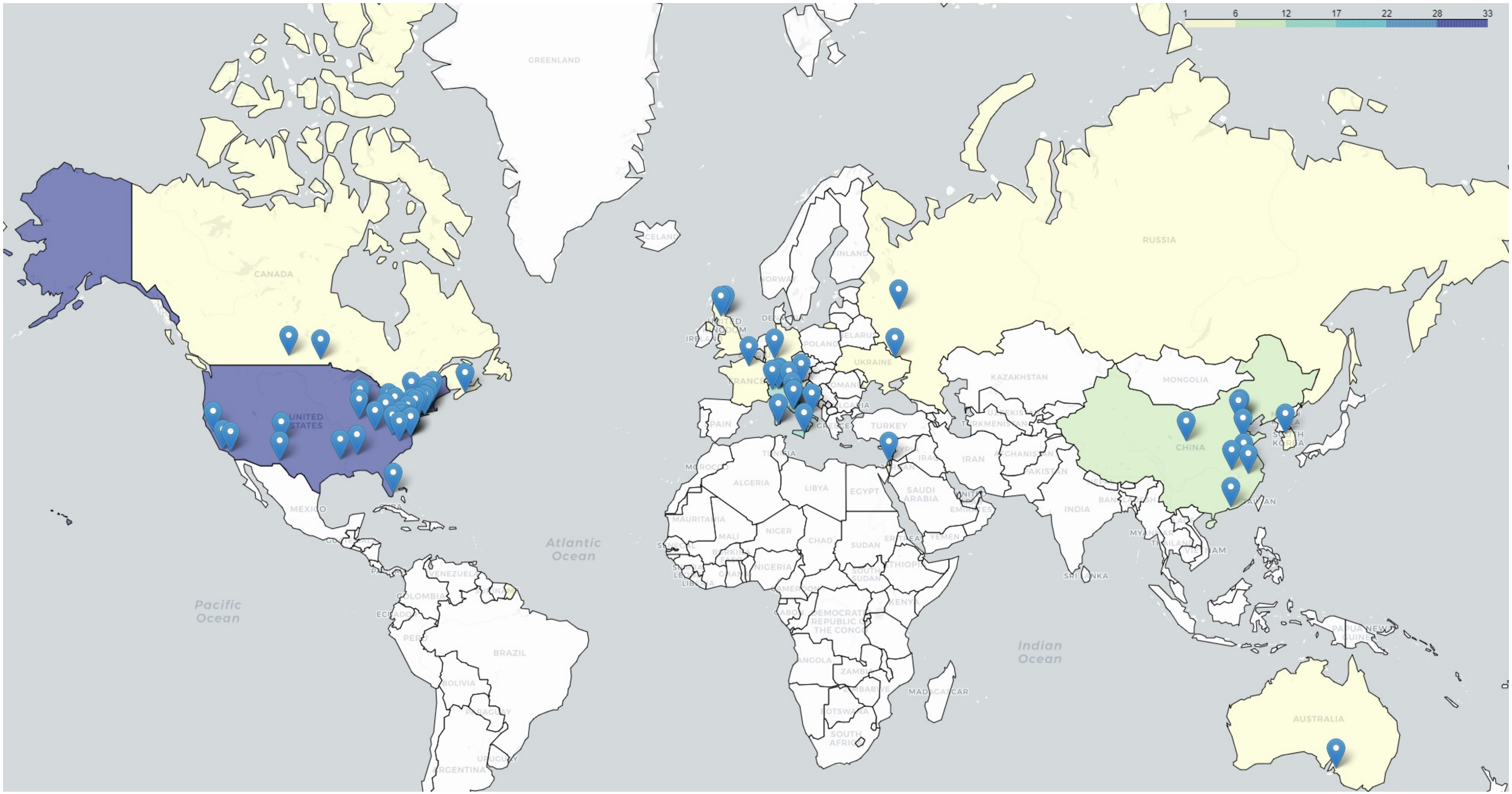
Important to PVDIS for reducing DAQ rate

Wanted ~**10:1 rejection**

- Cut on shower to select photon dominant events to study the photon rejection.

Strong Collaboration

- 270+ collaborators, 70+ institutions from 13 countries
- Large international participations and anticipate contributions
- Strong theory support



https://solid.jlab.org/

Summary

- SoLID: A **large acceptance** device which can handle **very high luminosity** to allow full exploitation of JLab12 potential
  → pushing the limit of the luminosity frontier
- SoLID has rich and vibrant science programs complementary and synergistic to the proposed EIC science program
  Three pillars on SIDIS, PVDIS and J/ψ production;
  Nuclear PDF from PVDIS PR12-22-002 (C2 approval);
  Beam normal SSA from DIS PR12-22-004 approved (A-);
  A diverse set of approved run-group experiments and new ideas (e.g., GPD program Zhiwen Zhao's talk)
- After a decade of hard work, we have a mature pre-conceptual design with expected performance meeting requirements for the three major science programs
- Completed the DOE science review (March 8-10, 2021)
- SoLID is a core part of JLab 12-GeV program, highlighted in 2023 NSAC LRP Recommendations
- Working with JLab on a path forward to bring the project cost down

Acknowledgement: J.P. Chen, Z.-E. Meziani, P. Souder, Xiaochao Zheng, Peng Chao, Zhiwen Zhao, and many others in the SoLID collaboration, supported in part by the U.S. Department of Energy under contract number DE-FG02-03ER41231