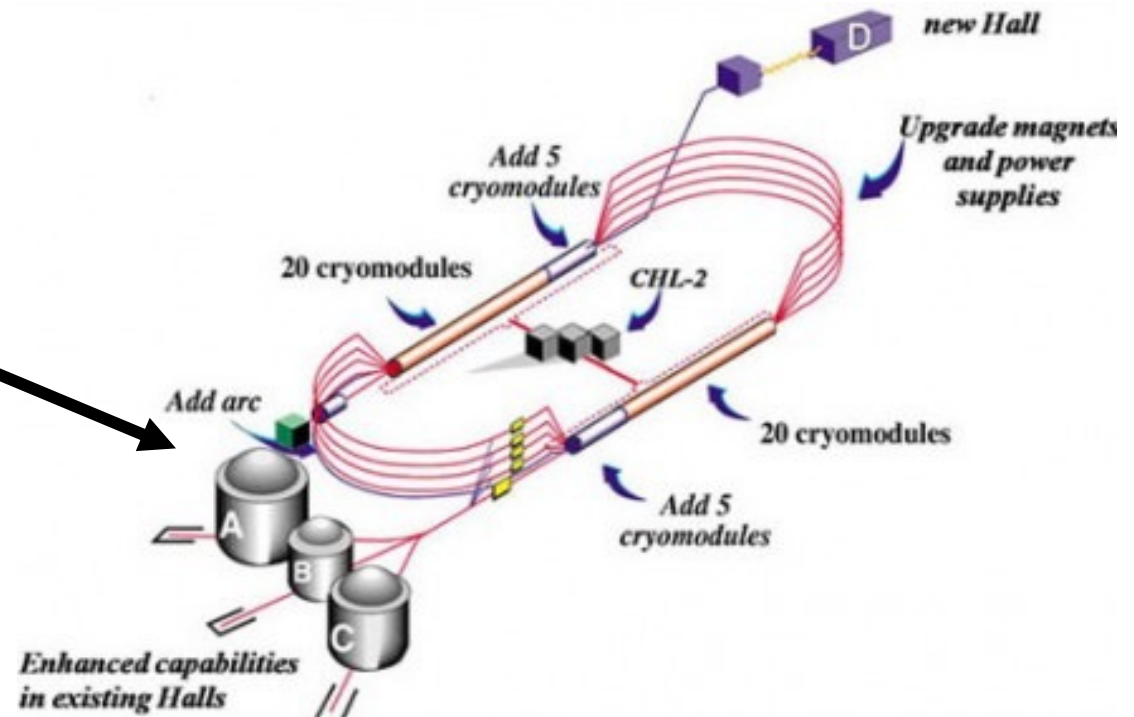
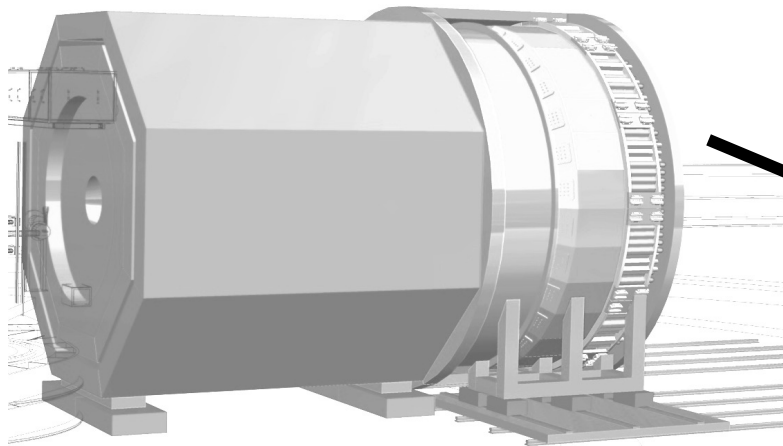


Overview of SoLID

Intensity Frontier for Cold QCQ

JLUO meeting on NSAC long range plan, September 8, 2022

Jian-ping Chen
Jefferson Lab



JLab 12 GeV Energy Upgrade

Acknowledgement: Thanks to [Haiyan Gao](#), [Zein-Eddine Meziani](#), [Paul Souder](#), [Xiaochao Zheng](#) and many other SoLID collaborators.

Outline

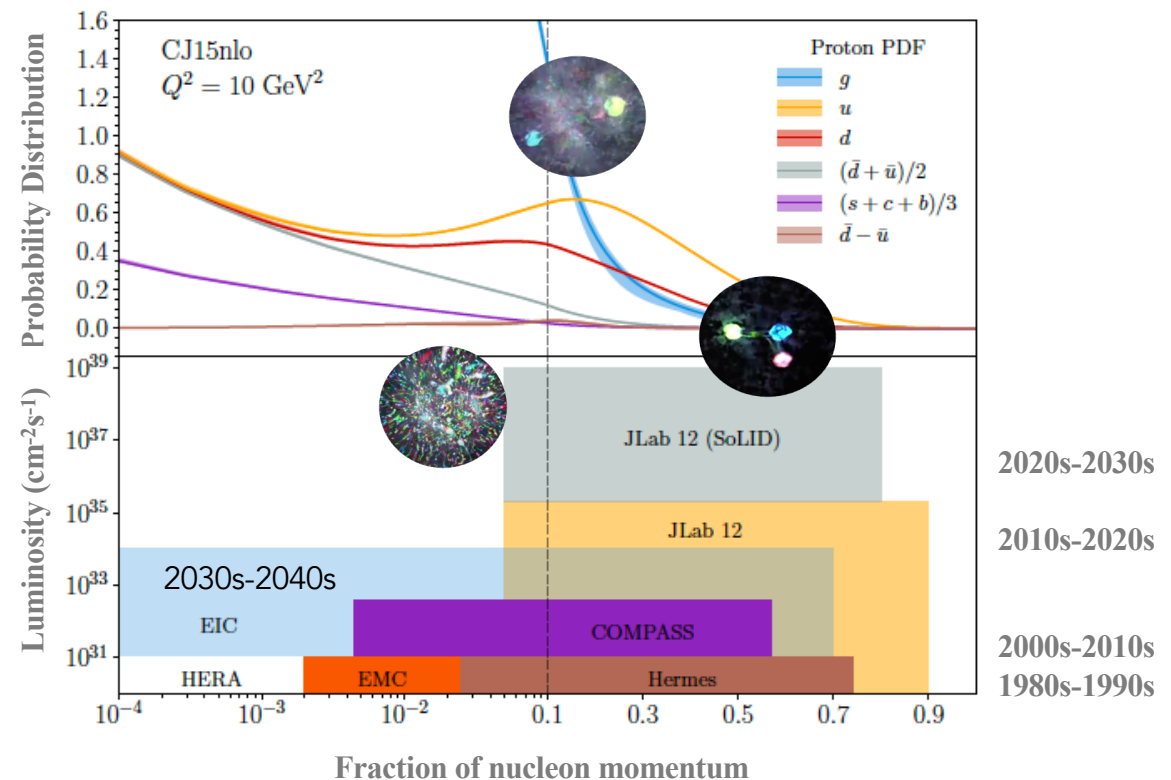
1. Overview of SoLID
2. SoLID Physics Program:
 - i) **SIDIS**: Transversity and TMDs
 - ii) **Threshold J/ψ** : Probe Strong Color Field and Proton Mass
 - iii) **PVDIS**: Precision Test of Standard Model
 - iv) Run-group Experiments: **GPDs**, TMDs and Spin
3. SoLID Device and Project
 - i) Detectors
 - ii) Cost and Schedule
 - iii) Collaboration

1. Overview of SoLID

SoLID@JLab: at the QCD Intensity Frontier

- Nucleon spin, proton mass, beyond standard model experiments require **precision measurements of small cross sections and asymmetries**, combined with multiple particle detection
 - critical need for **high luminosity** and **large acceptance**

- SoLID – extremely high intensity
 - 3D imaging of the nucleon
 - Beyond Standard Model searches
 - Exploration of gluonic-force



SoLID@JLab: at the QCD Intensity Frontier

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

High Luminosity

$10^{37-39} / \text{cm}^2/\text{s}$

[>100x CLAS12][>1000x EIC]

+

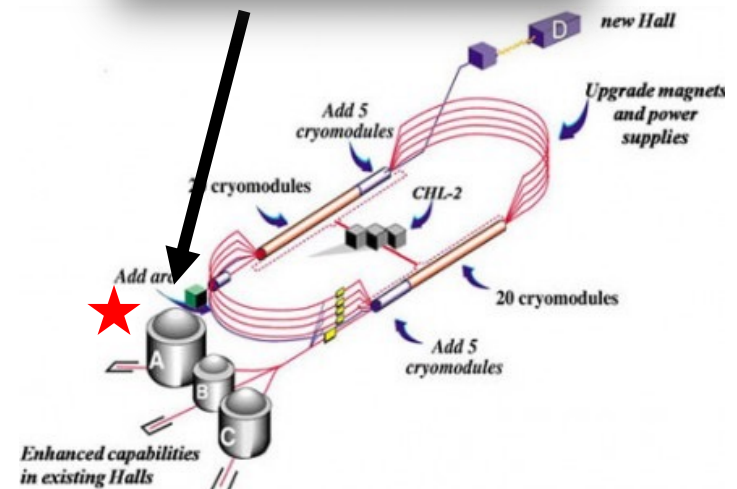
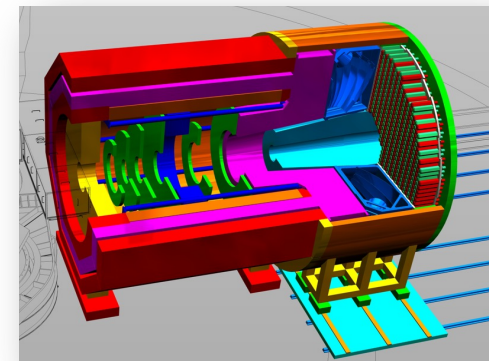
Large Acceptance

Full azimuthal ϕ coverage

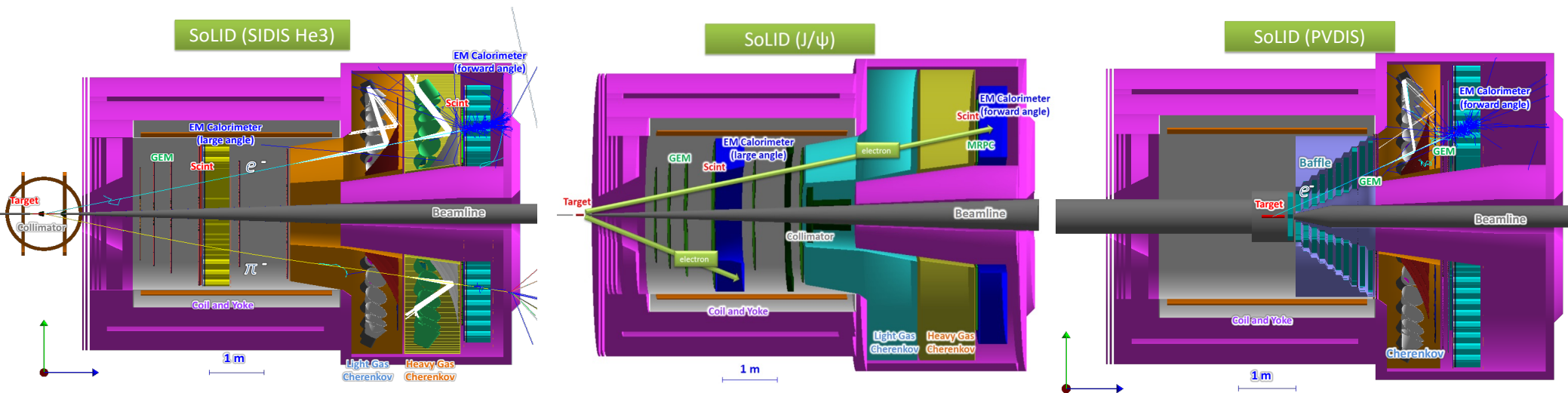
Research at **SoLID** will have the *unique* capability to **explore** the QCD landscape while **complementing** the research of other key facilities

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

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



Approved SoLID Experiments



A) SIDIS: (3) Transversely Polarized ^3He (n): Transversity, Sivers, Pretzlosity TMDs
 Rating A Longitudinally Polarized ^3He (n): Worm-gear TMDs
 Transversely Polarized Proton: Transversity/Sivers, Pretzlosicty TMDs

B) Threshold J/ψ : Rating A Gluon Field, Proton Mass

C). PVDIS: Rating A Test Standard Model

Run group experiments (6) approved for **GPDs**, TMDs, and spin

PAC50 (2022): Approved 2 New SoLID Experiments: Beam Normal SSA (A-)
 PVEMP (C2)

2. SoLID Physics Program

- i. **SIDIS**: Transversity and TMDs
- ii. **Threshold J/ψ** : Gluon Field and Proton Mass
- iii. **PVDIS**: Test of Standard Model
- iv. Run-groups: ***GPDs***, TMDs, Spin

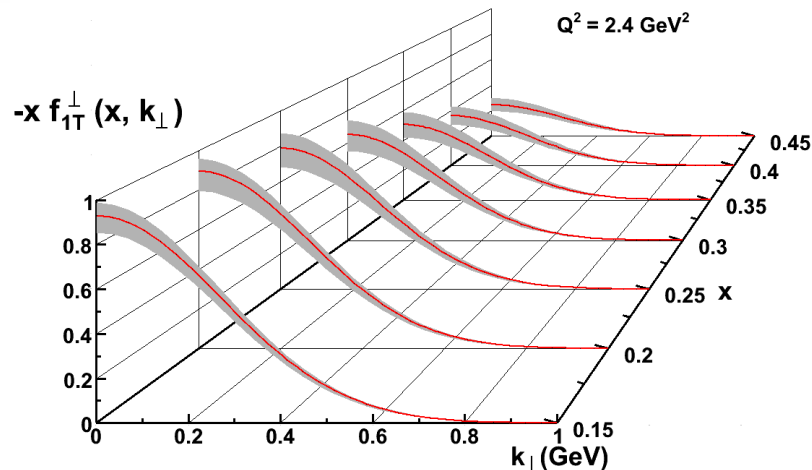
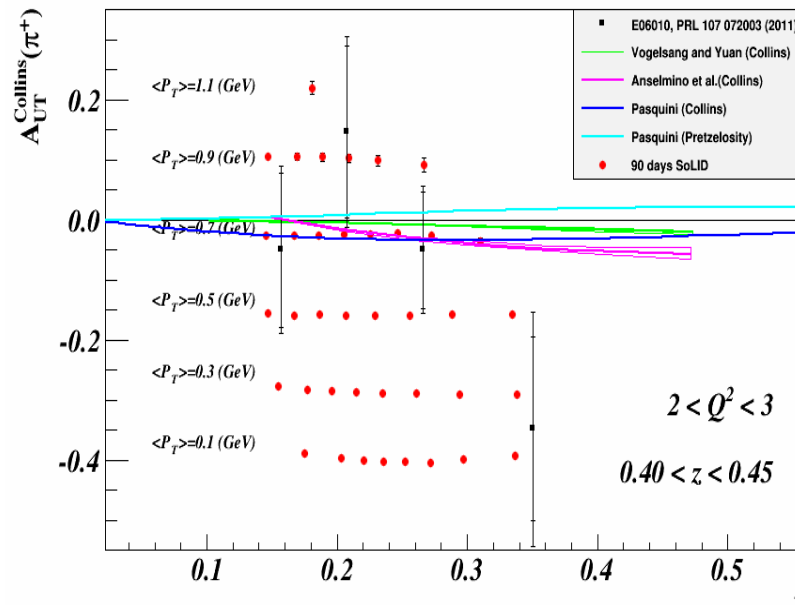
SoLID-SIDIS: Precision Mapping in Multi-Dimension

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

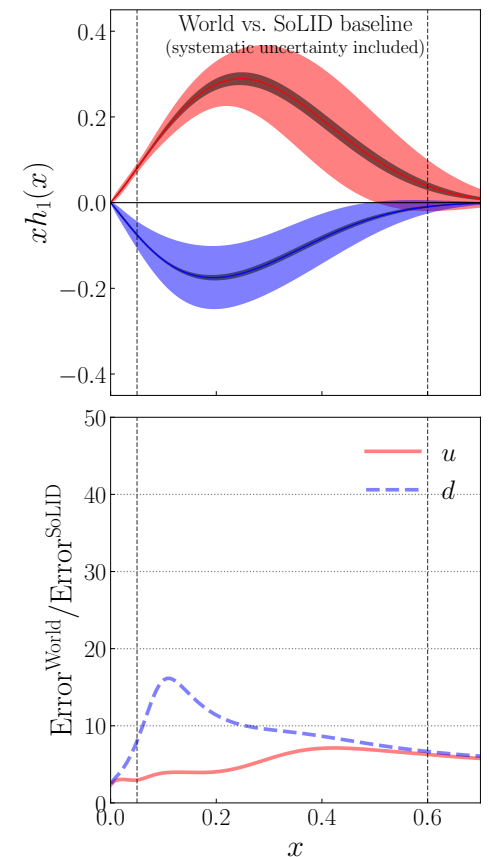
- 4-D mapping of asymmetries with precision
- Constrain models and forms of TMDs, Tensor charge, ...
- Lattice QCD, QCD dynamics

**4-D binning
for the first
time!**

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

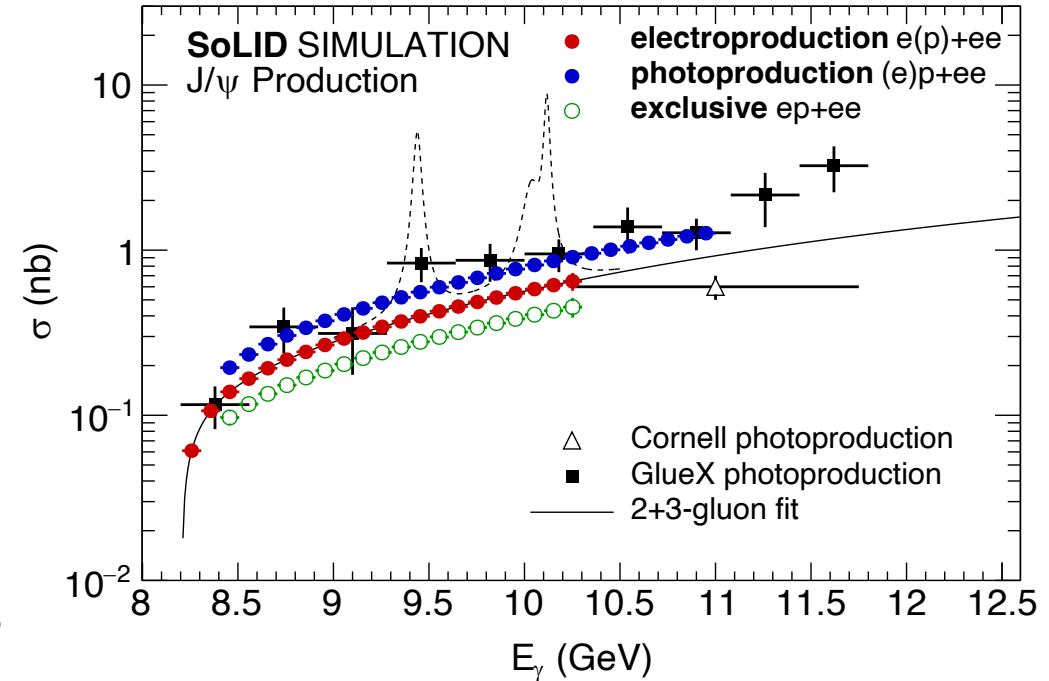
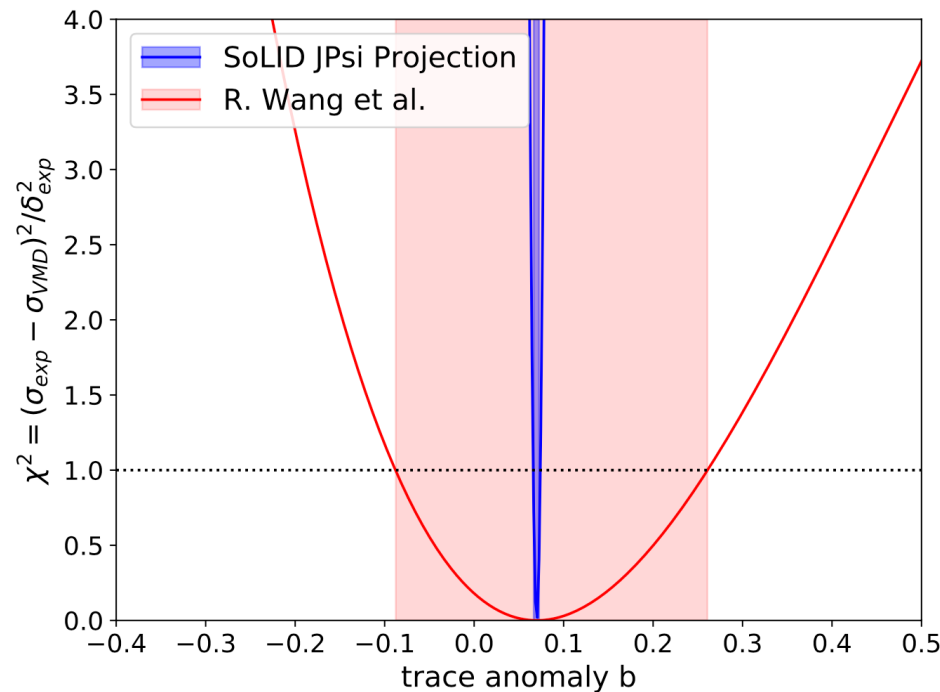


Transversity

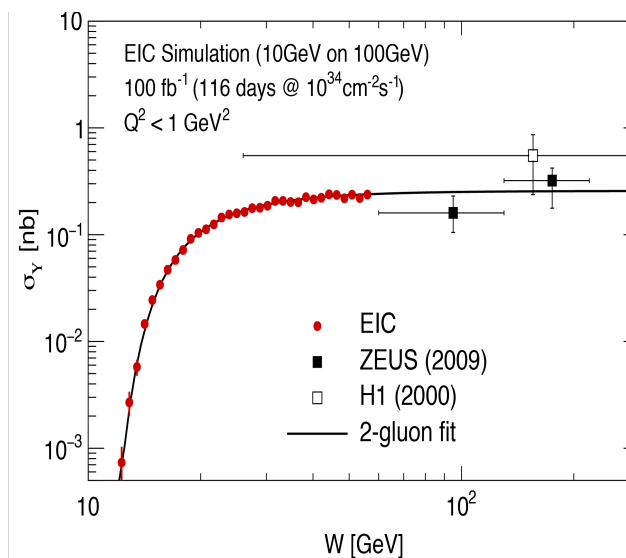
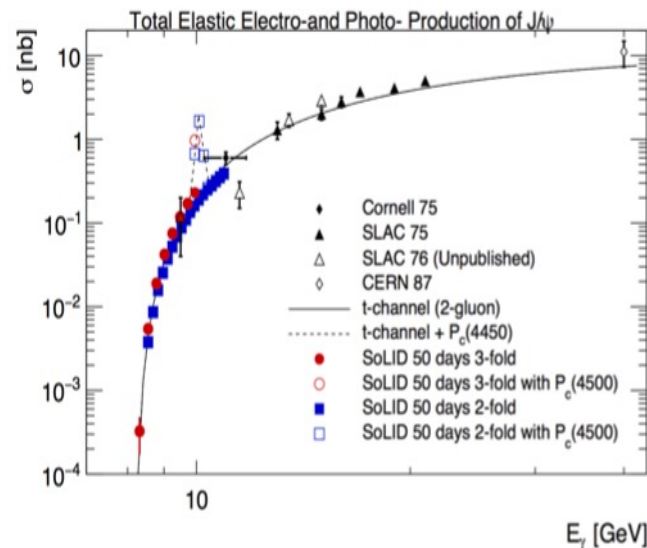


- **Sivers:** Confined quark motion
- Quantum correlations between nucleon spin and quark motion
- QCD dynamics

SoLID-J/ ψ (and EIC): Gluon Field and Proton Mass



Charm @ SoLID and Beauty @ EIC



S. Joosten, Z.E. Meziani,
PoS 308 (2017)
doi.org/10.22323/1.308.0017

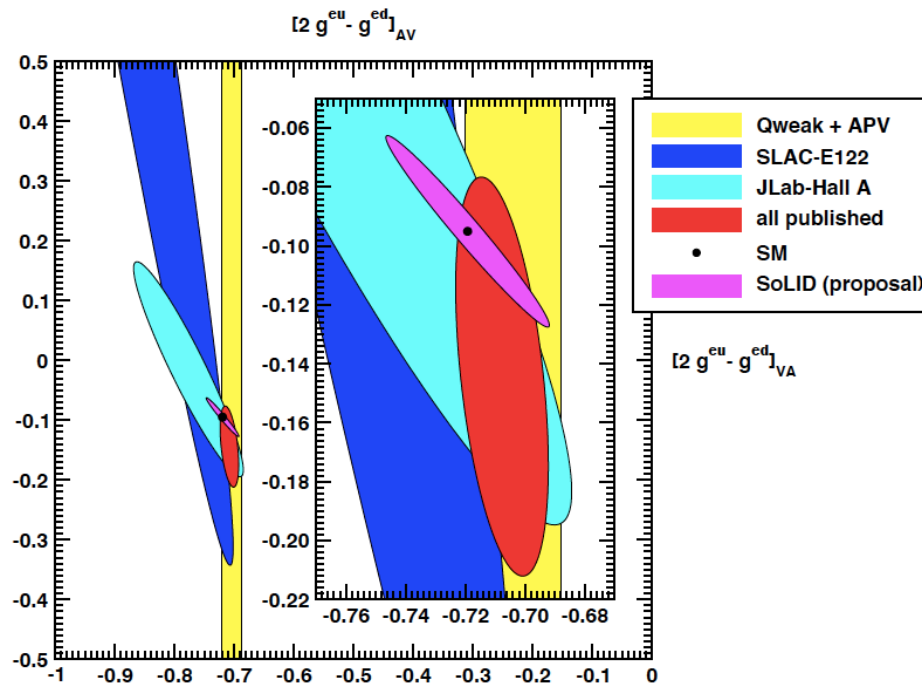
Gryniuk, Joosten, Meziani, and
Vanderhaeghen, PRD 102,
014016 (2020) (for update)

GlueX on J/ψ Ali et al., PRL 123,
072001(2019)

SoLID-PVDIS: Precision Test of Standard Model

SoLID makes a unique contribution to the SMEFT program.

Improvement in couplings



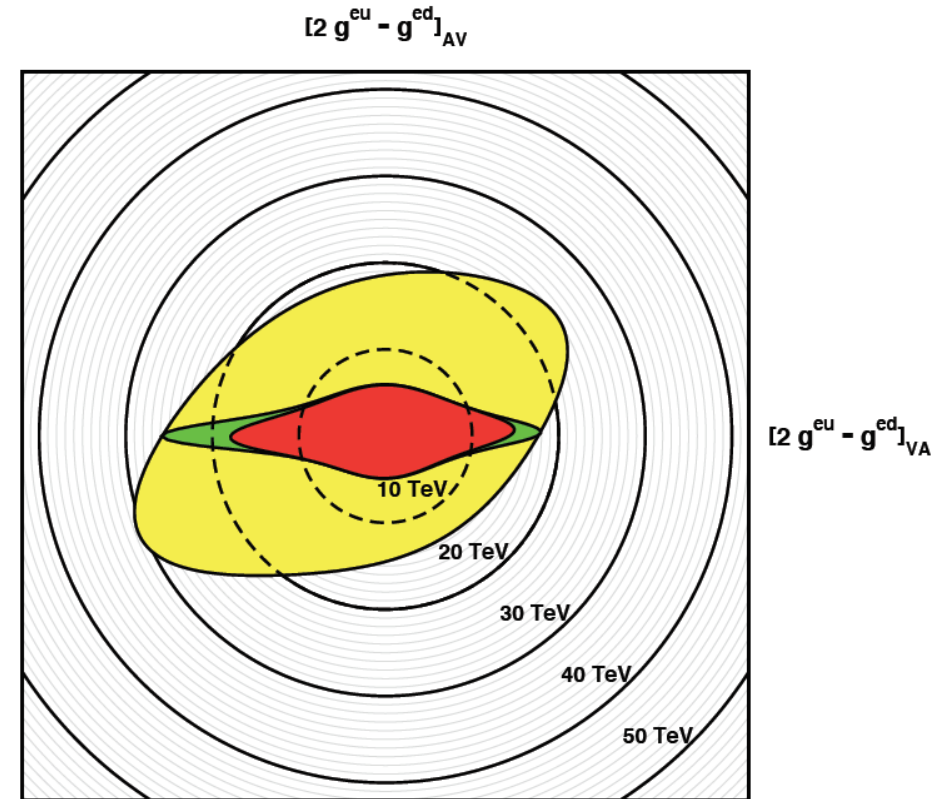
Unique sensitivity to

- lepto-phobic Z' , dark boson Z_d

Also provides precision study of

- charge symmetry violation
- high-twist effects
- d/u at high- x

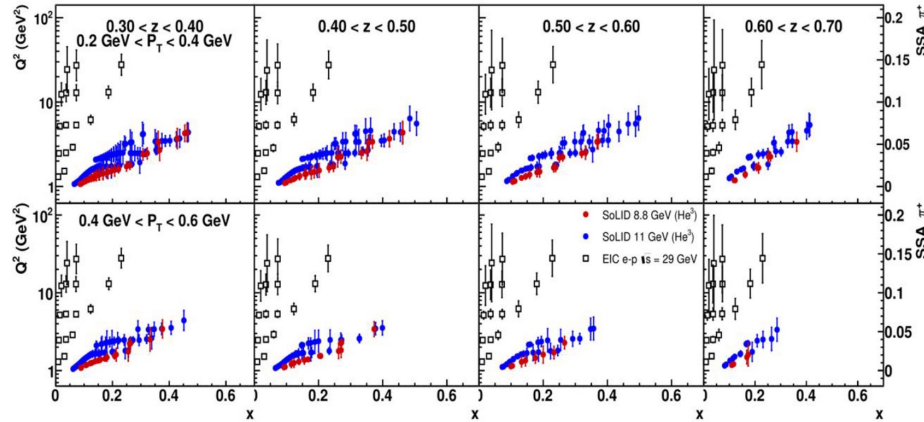
Improvement in energy reach for electron-nucleon couplings



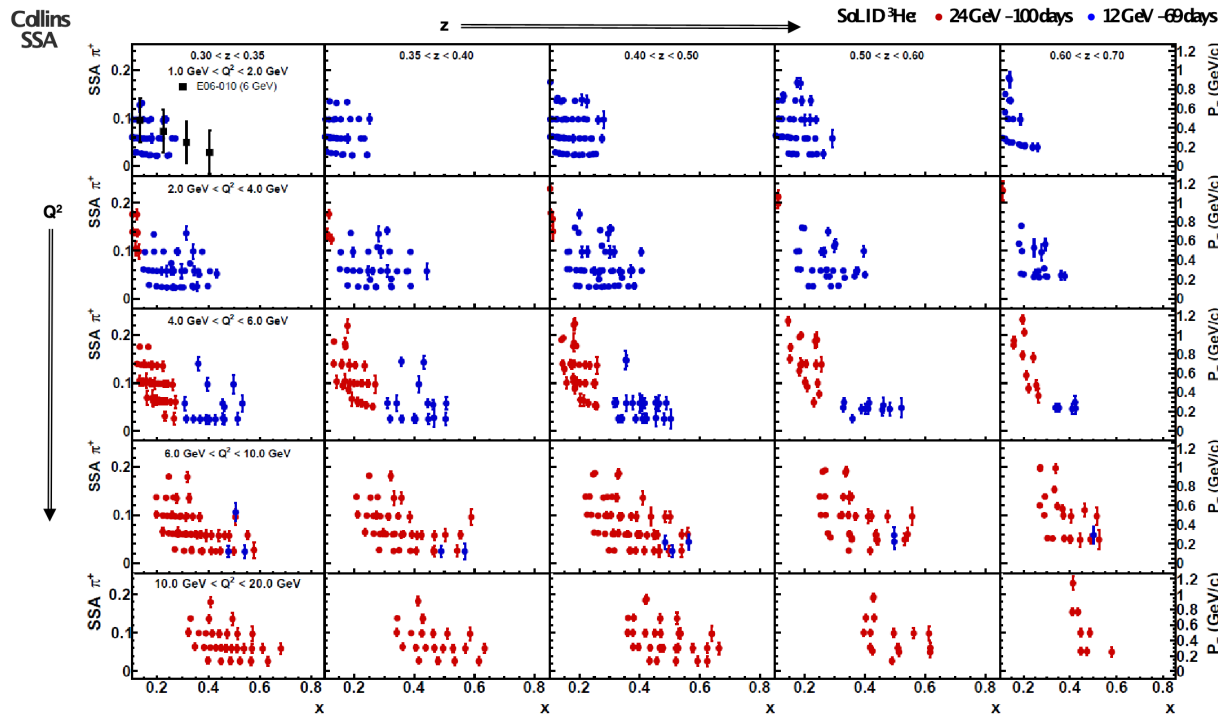
- Published data
- Published data + P2
- Published data + P2 + SoLID

Potential of SoLID in EIC Era (JLab20+, Positron, ...)

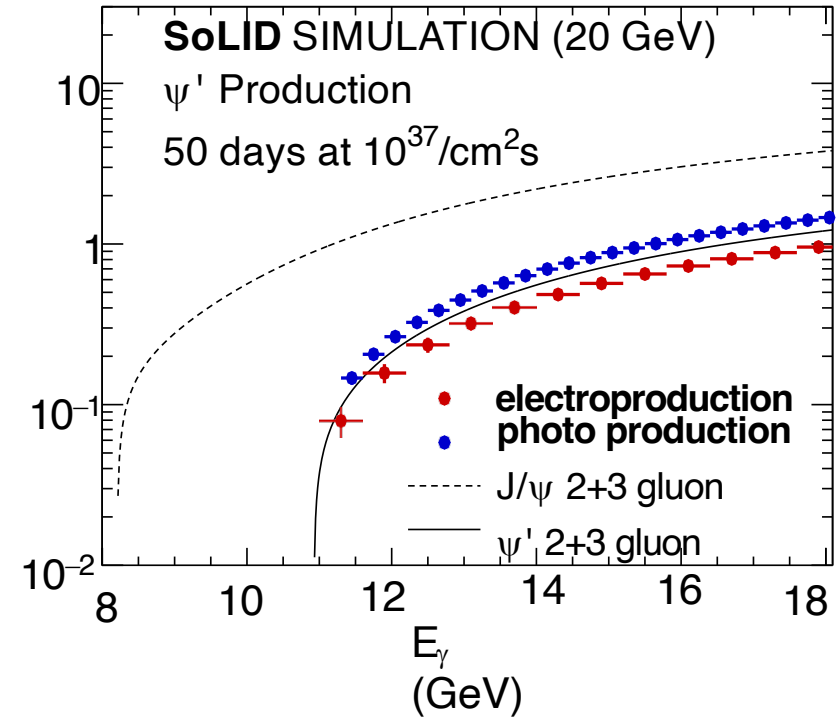
1) SIDIS: Single Spin Asymmetry: EIC and JLab12



SIDIS: Collins Asymmetry: 20 GeV and 12 GeV



2) ψ' : Complementary probe of the gluonic field (color dipole size)



3) Electron weak coupling C_3 with e^+ and e^-

7. SoLID Device and Project

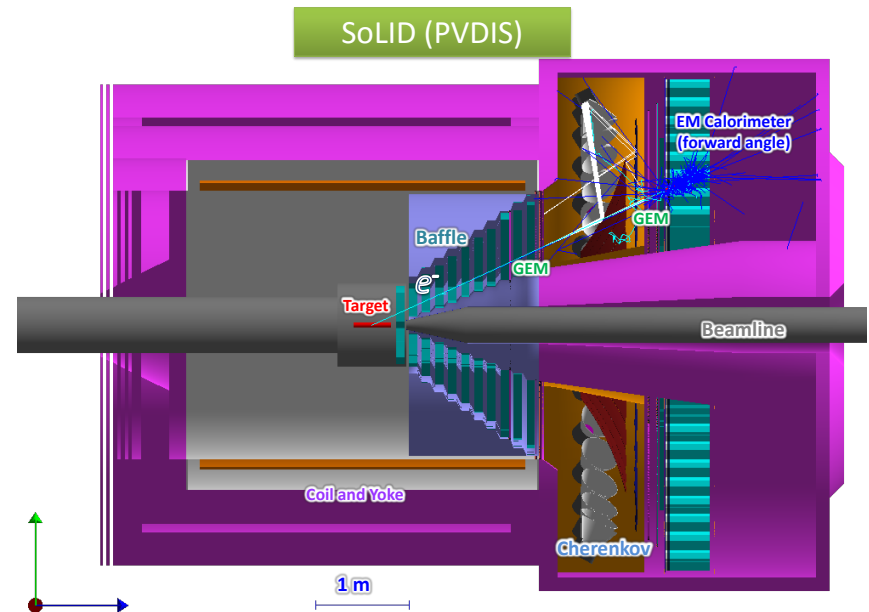
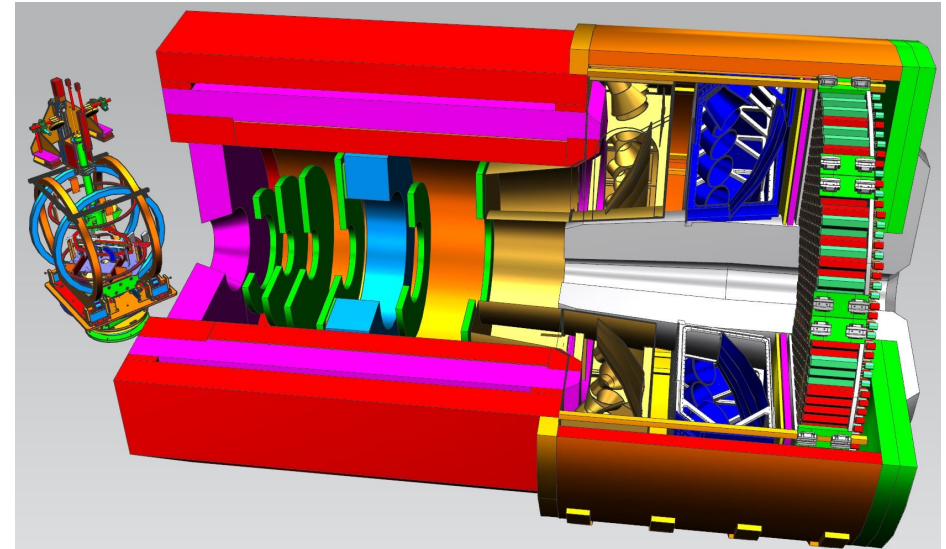
Detectors, Cost and Schedule, Collaboration

SoLID Apparatus

Requirements are Challenging

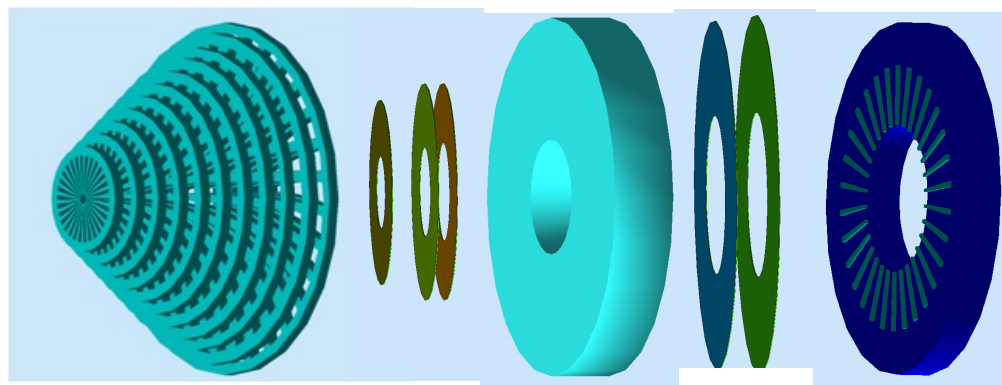
- High Luminosity (10^{37} - 10^{39})
- High data rate
- High background
- Low systematics
- High Radiation
- Large scale
- **Modern Technologies**
 - GEM's
 - Shashlik ECal
 - Pipeline DAQ
 - Rapidly Advancing Computational Capabilities
- High Performance Cherenkovs
- Baffles

Polarized ^3He ("neutron") @ SoLID

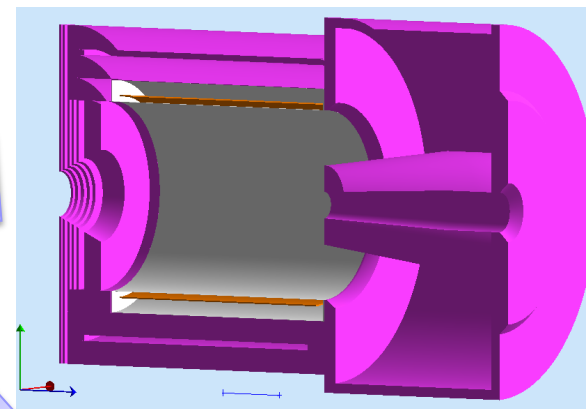


SoLID Detector Subsystems

PVDIS: Baffle 3xGEMS LGC 2xGEMs EC

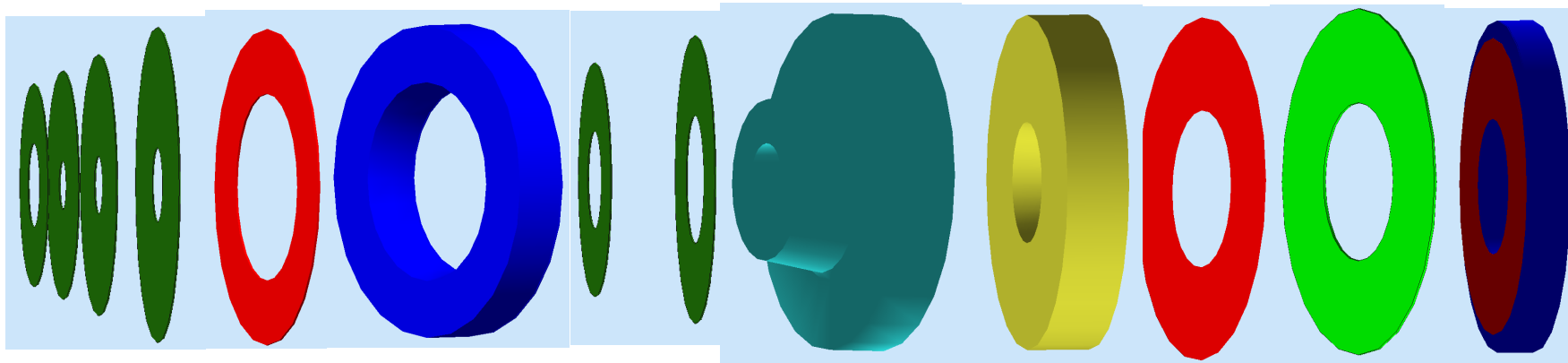


Uses full capability of JLab electronics



SIDIS&J/y:

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



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

WBS	Subsystem	Cost –M\$ (with overhead)
1.01	PM	1.5
1.02	EM	10.1
1.03	LGC	5.6
1.04	HGC	6.0
1.05	GEM	5.8
1.06	DAQ	6.2
1.07	Software	0.7
1.08	Magnet	7.8
1.09	Infrastructure	9.6
1.10	OPC	

Each L2 WBS includes design and construction

Cost before contingency and escalation: 53.3 M\$

With contingency 72.2 M\$

With escalation **82.4 M\$ (Total Equipment Cost)**

(Additional escalation for 2022 estimation)

SoLID Project Schedule Estimations

Assumptions:

DOE Science Review (2021)

1.5 Years pre-R&D (in progress)

Project starts in FY2022, 2 Years Project Engineering and Design (PED) (FY22-FY23), Construction long-lead items start in FY23

Main construction starts in FY24, 3+ Years **construction, complete by end of 2026.**

1 Year Installation 2027

Testing/commissioning: start with magnet/testing, then ECal/GEM with DAQ for testing, Then HGC/LGC

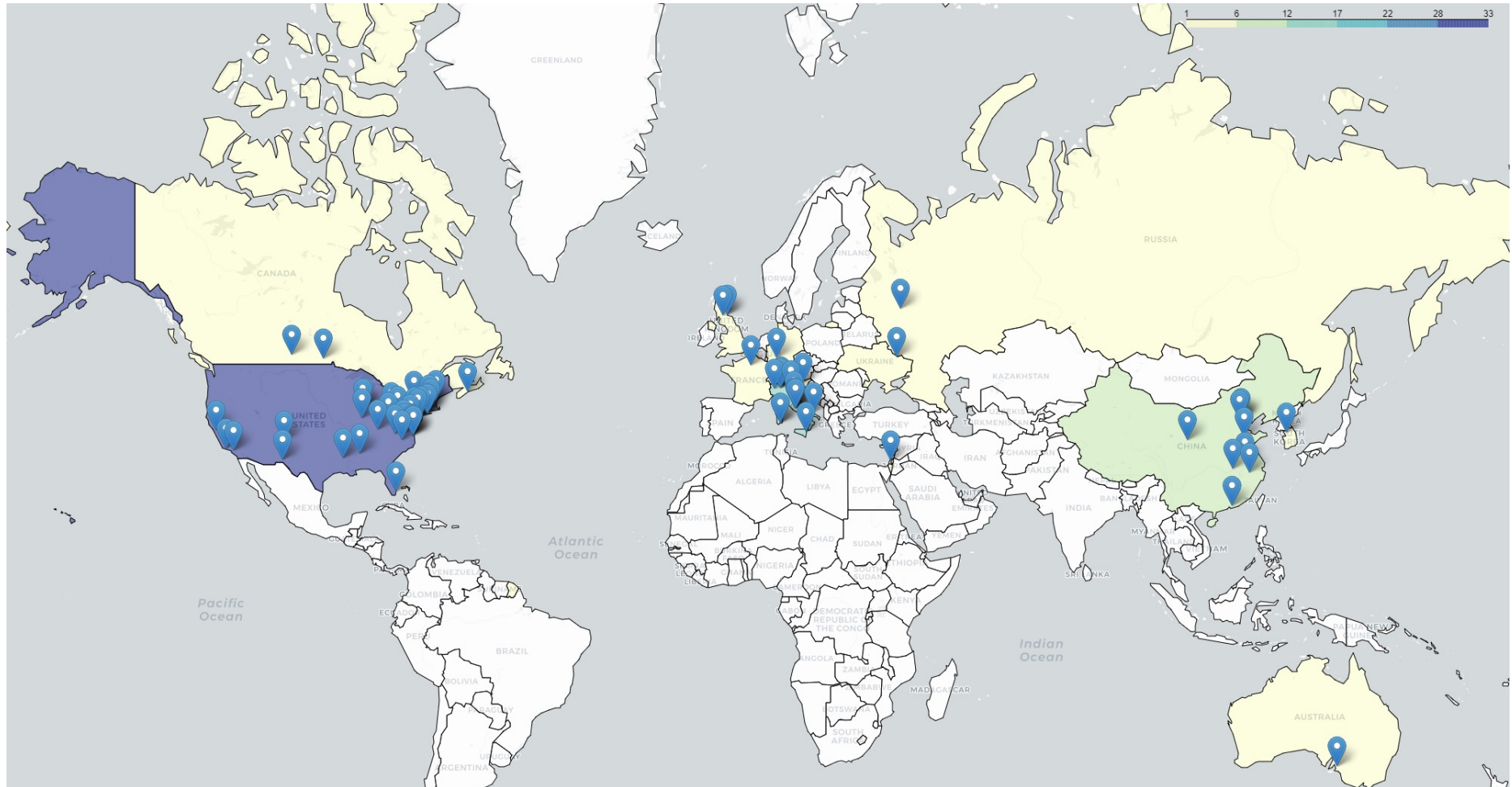
Schedule contingency ~ 1 year

Start Physics in 2029

With CD0 delayed, above schedule is expected to be late by ~1 year

Strong Collaboration

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



full list available at <https://solid.jlab.org/collaboration/full.html>

Summary

- SoLID: A **large acceptance** device which can handle **very high luminosity** to allow full exploitation of JLab 12 GeV potential
→ pushing the limit of the intensity frontier for Cold QCD
- SoLID has a rich and vibrant science program complementary and synergistic to the proposed EIC science program

Three pillars on SIDIS, PVDIS and J/Psi production + more

- After a decade of hard work, we have a mature pre-conceptual design with expected performance to meet the challenging requirements for the approved experiments
- Completed the DOE science review (2021)
- 270+ collaborators, 70+ institutions from 13 countries

<https://solid.jlab.org/>