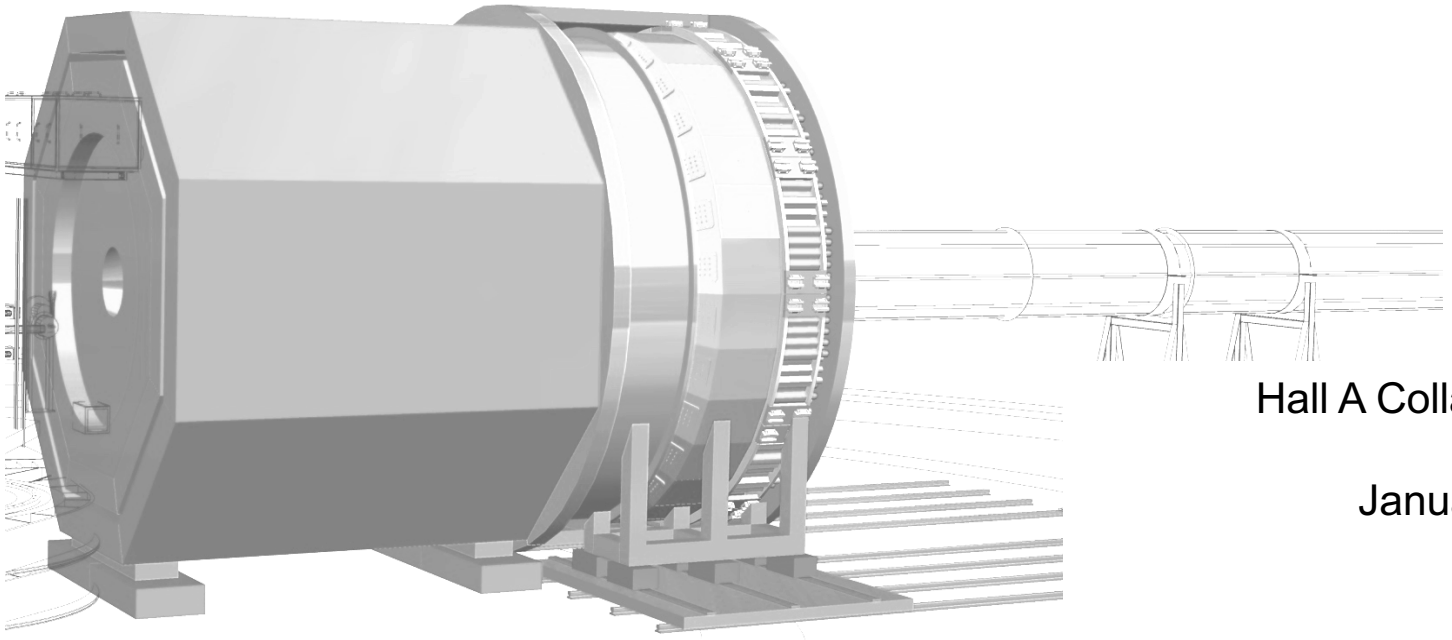
SoLID



Hall A Collaboration Meeting

January 31, 2020

SOLENOIDAL LARGE INTENSITY DEVICE

Paul Souder

Syracuse University

Outline

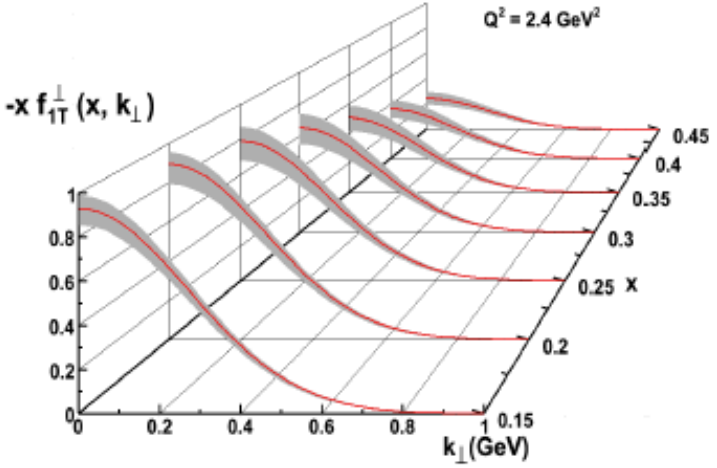
1. Physics reach of Solid
2. The Solid Spectrometer
3. Status of the experiment

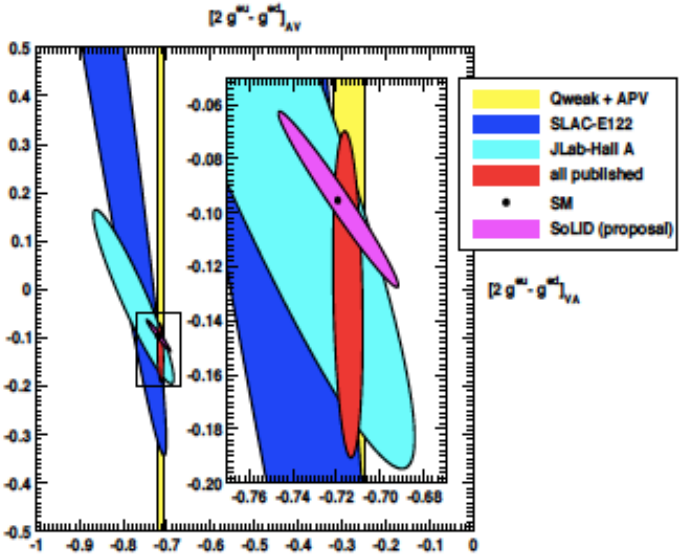
SoLID Physics Overview

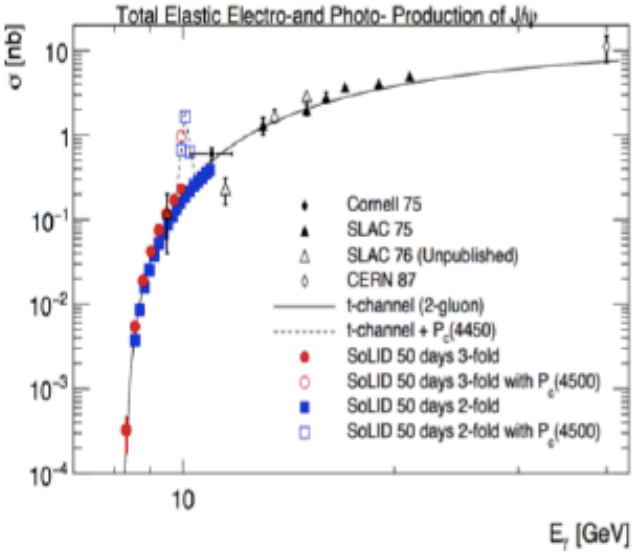
- **Full exploitation of JLab 12 GeV Upgrade to maximize scientific return**

A Large Acceptance Detector AND Can Handle High Luminosity (10^{37}-10^{39})

- SIDIS - reaching ultimate precision for tomography of the nucleon (E12-10-006, E12-11-007, E12-11-108)
- PVDIS in high-x region - providing sensitivity to new physics at 10-20 TeV (E12-10-007)
- Threshold J/ψ - probing strong color fields in the nucleon and the origin of its mass (trace anomaly) (E12-12-006)





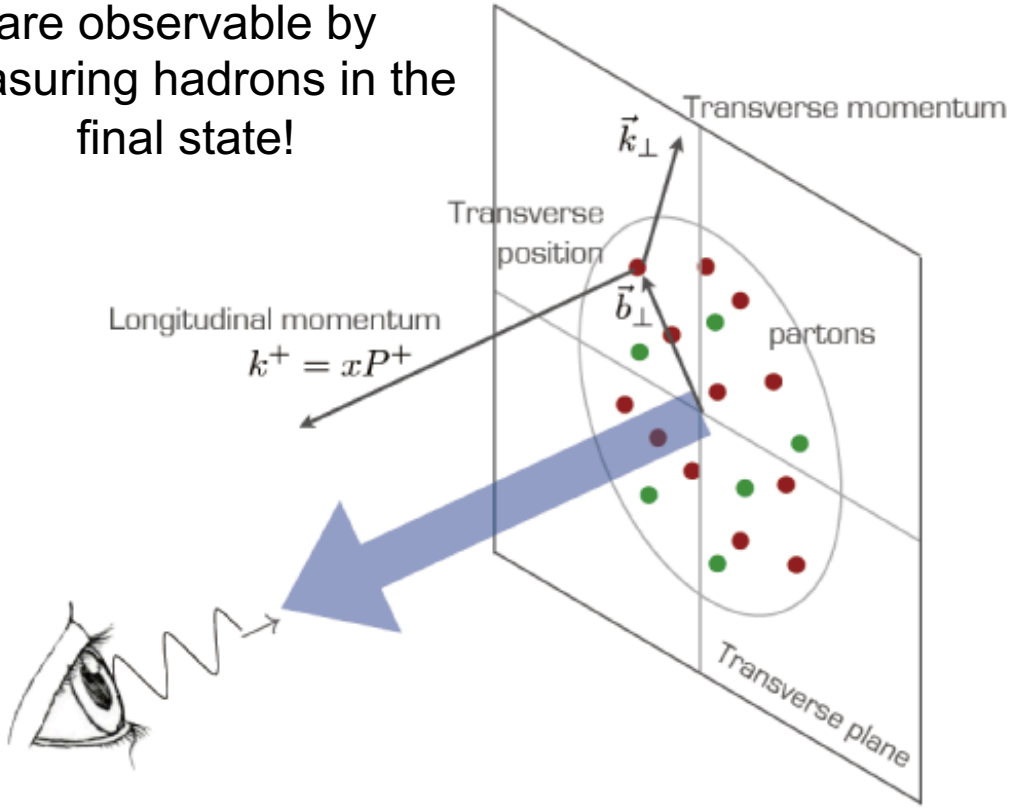


- **2015 LRP recommendation IV**

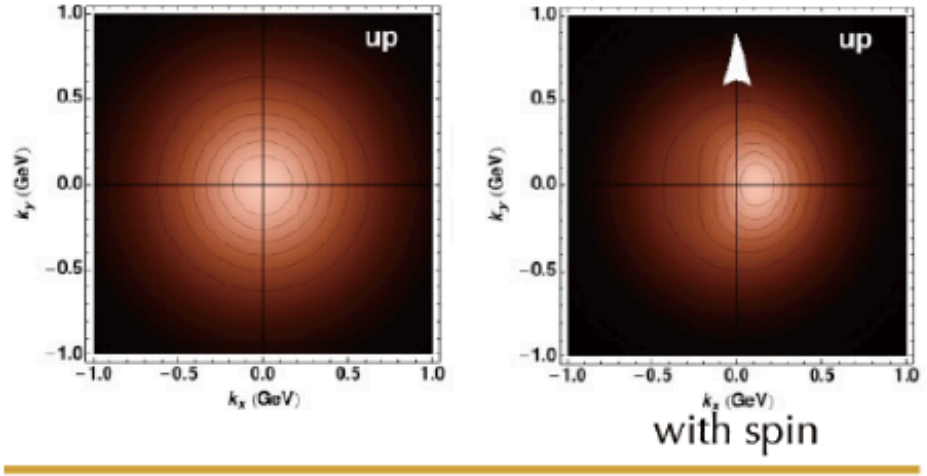
- We recommend increasing investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories – **SoLID – mid-scale project**

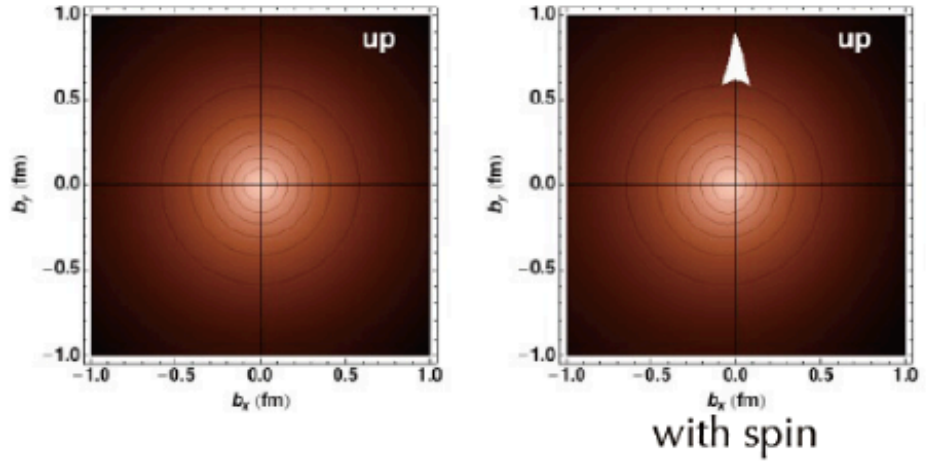
3D Nuclear Structure

Transverse momentum and spin of struck quark are observable by measuring hadrons in the final state!



Effects are big!





Generalized parton distribution (GPD)
Transverse momentum dependent parton distribution (TMD)

SoLID SIDIS Projection: Major Improvement in Precision

Compare SoLID with World Data

Fit Collins and Sivers asymmetries in SIDIS and e^+e^- annihilation

World data from HERMES, COMPASS and JLab-6 GeV

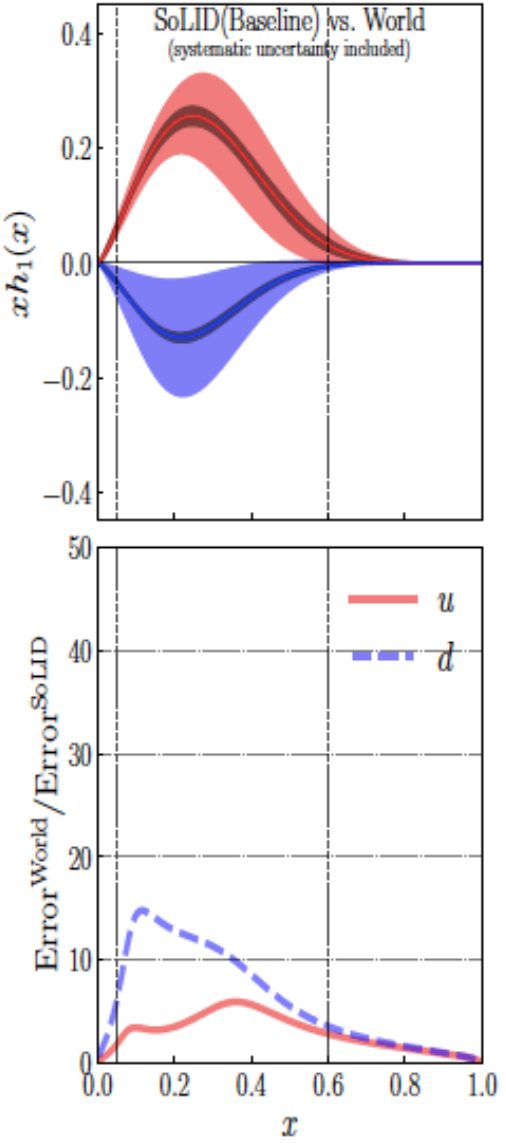
e^+e^- data from BELLE and BABAR

Monte Carlo method with nested sampling algorithm is applied

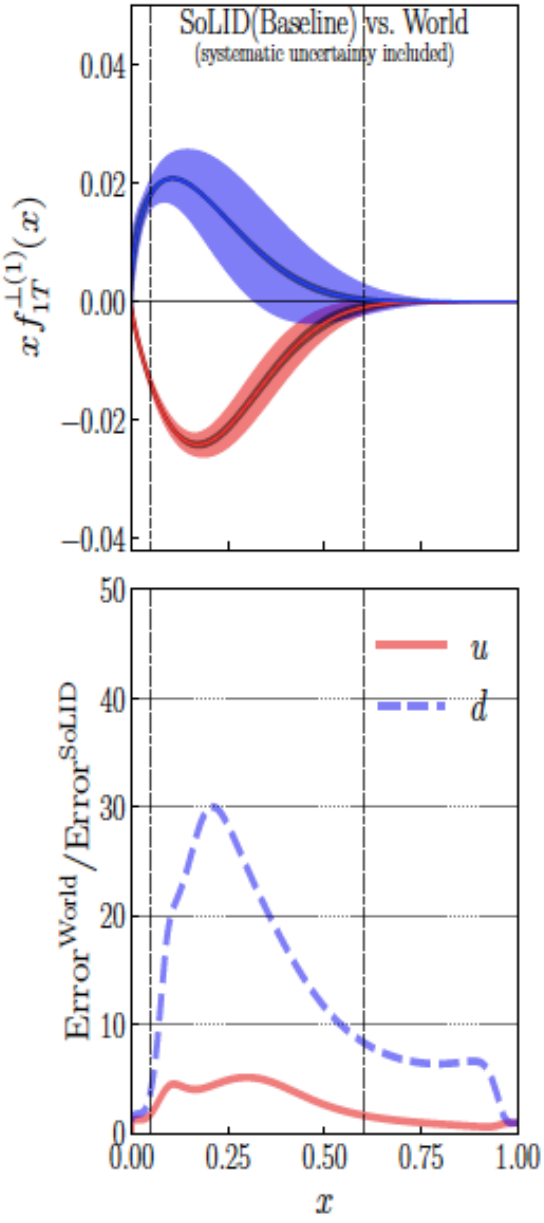
Including both systematic and statistical uncertainties

Ref: Z. Ye *et al*, Phys. Lett. B 767, 91 (2017)

Transversity



Sivers



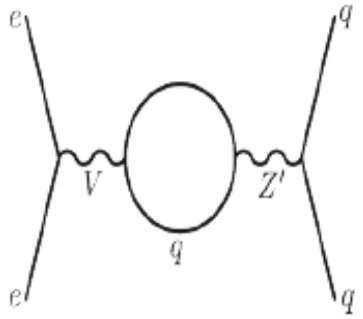
SoLID baseline used

PVDIS: BSM Search

Possible scenarios:

- All data fall on Standard Model $\sin^2\theta_W(Q^2)$ curve.
- Dark Z' modifies $\sin^2\theta_W(Q^2)$ curve for all experiments.
- Other BSM Physics can make additional contributions to the **geq** in any pattern.

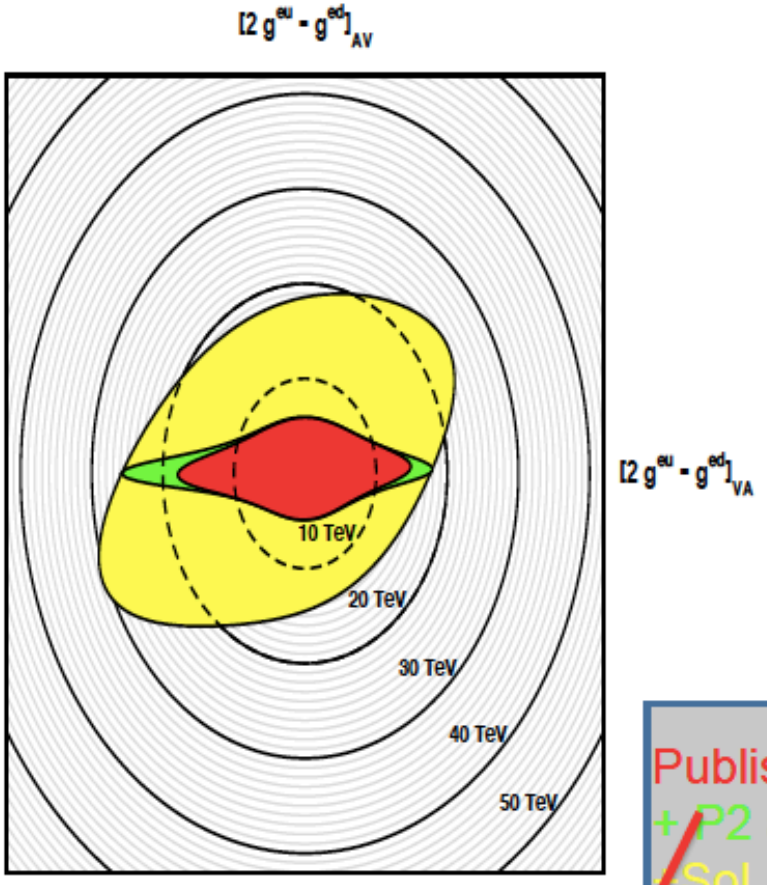
Example: lepto-phobic Z' contributes only to g^{eq}_{VA}



PVDIS also probes hadronic physics:

- Charge symmetry at the quark level.
- Isovector EMC effect.
- Isolate quark-quark correlations.

PVDIS in high-x SoLID has high-energy reach complimentary with the LHC.

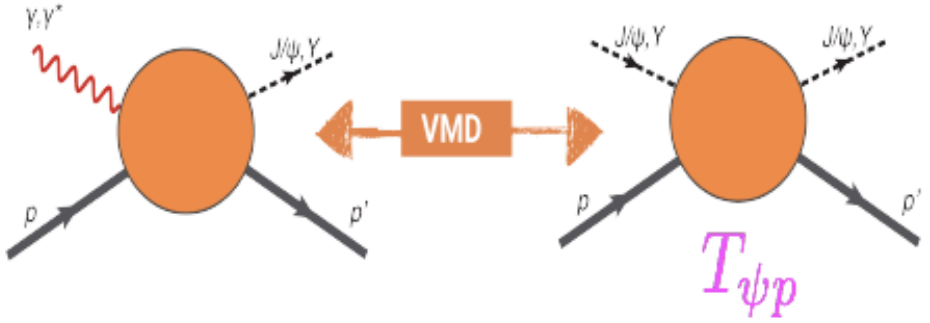


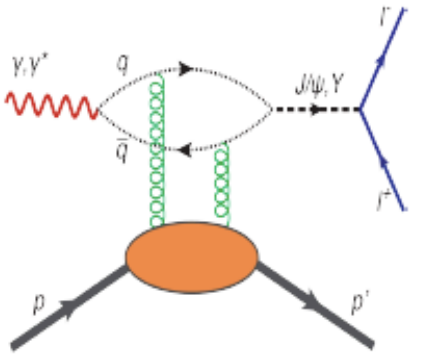
Published data
+ P2 at Mainz
+ SoLID

Nature **557**, no. 7704, 207 (2018)

Nature **506**, no. 7486, 67 (2014)

J/ψ Production: Relationship to Proton Mass





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

Heavy quark – dominated by two gluons

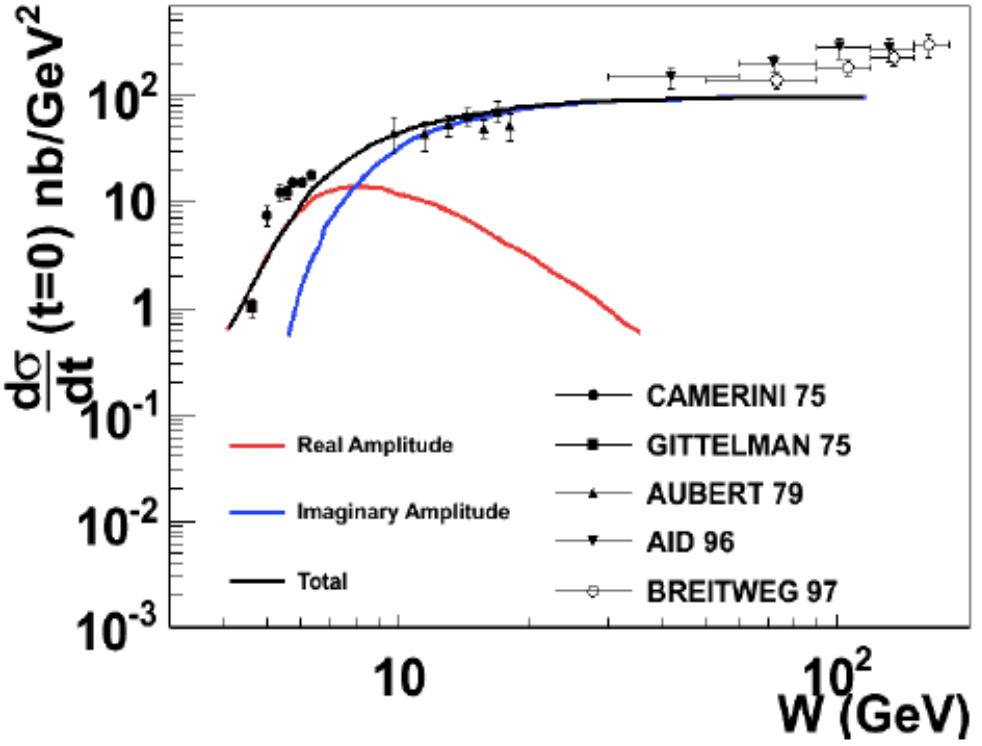
$$\langle P|T^{\alpha}_{\alpha}|P\rangle = 2P^{\alpha}P_{\alpha} = 2M_p^2$$

$$\frac{d\sigma_{\gamma N\to\psi N}}{dt}(s,t=0) = \frac{3\Gamma(\psi\to e^+e^-)}{\alpha m_\psi}\left(\frac{k_{\psi N}}{k_{\gamma N}}\right)^2 \frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0)$$

$$\frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0) = \frac{1}{64\pi}\frac{1}{m_\psi^2(\lambda^2-m_N^2)}|\mathcal{M}_{\psi N}(s,t=0)|^2$$

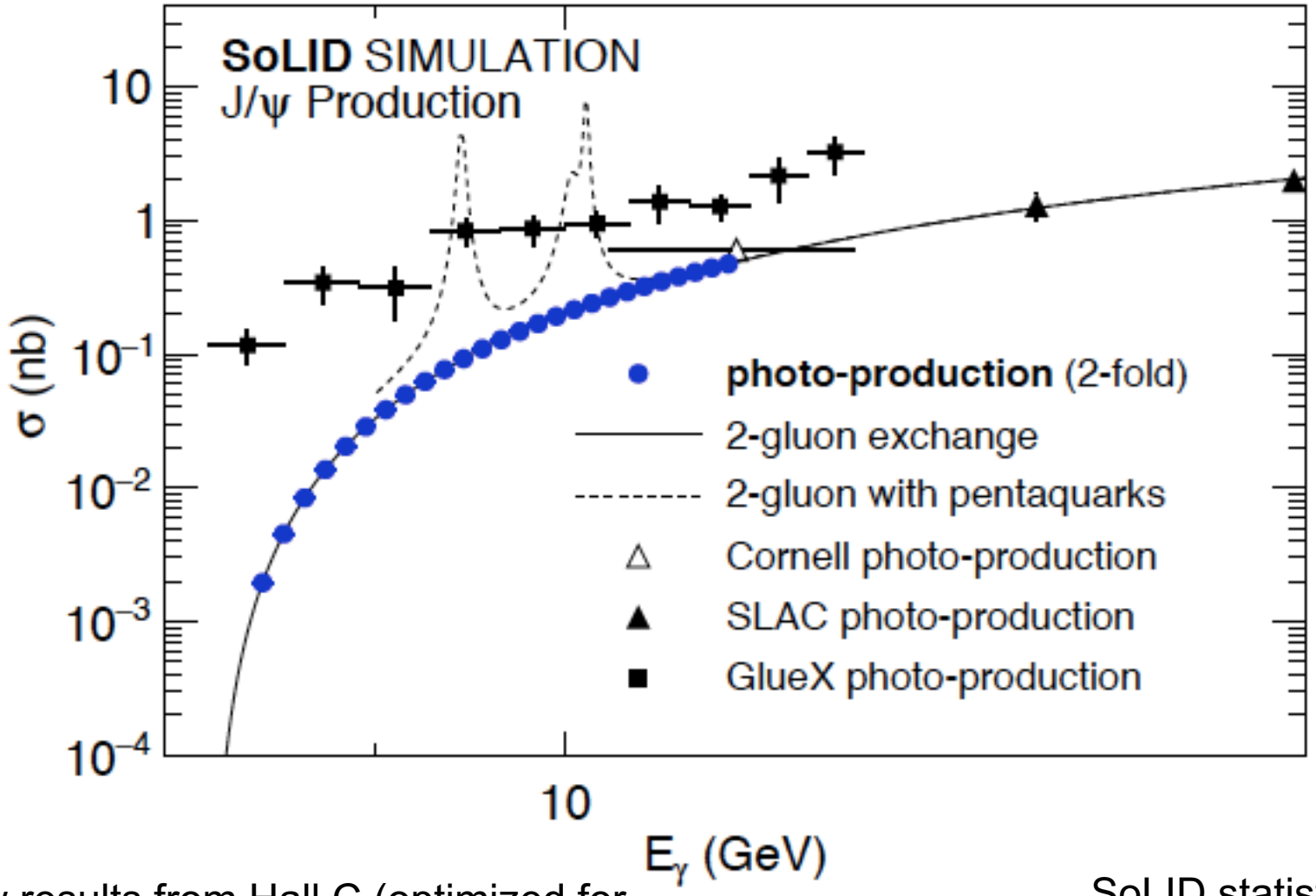
VMD relates photoproduction cross section to quarknium-nucleon scattering amplitude

- **Imaginary part** is related to the total cross section through optical theorem
- **Real part contains the conformal (trace) anomaly;** Dominate the near threshold region and constrained through dispersion relation



A measurement near threshold could allow access to the trace anomaly

LHCb Pentaquark?



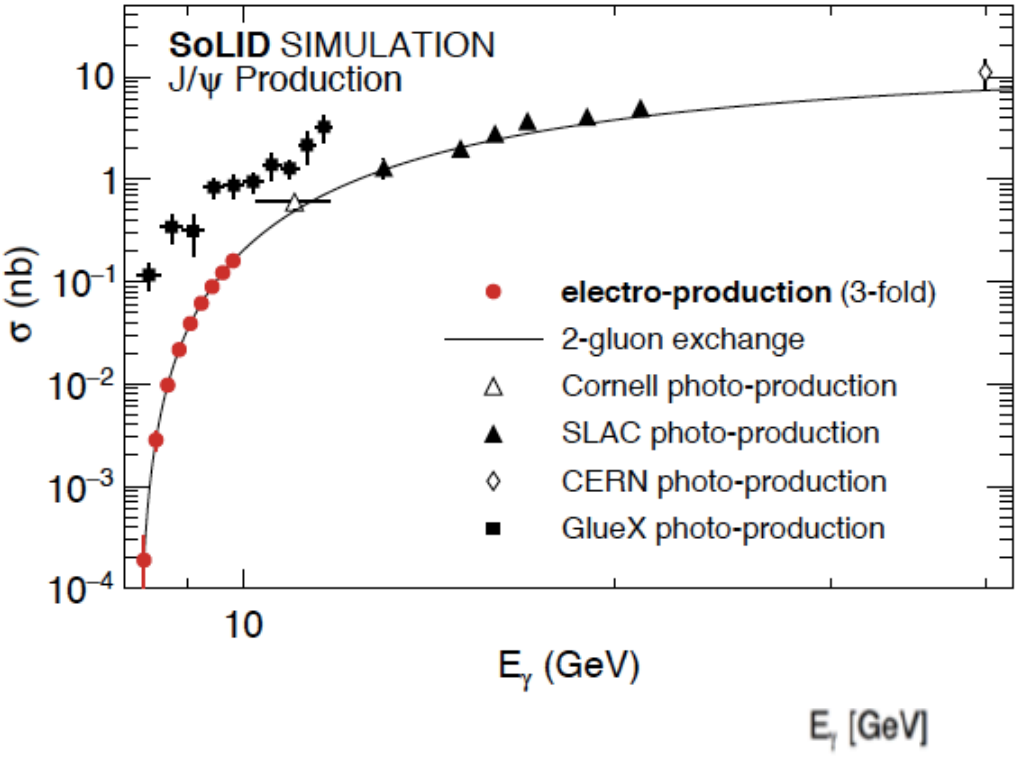
New results from Hall C (optimized for pentaquark search) expected this spring

SoLID statistics allow us to explore Q2 and t dependence

J/ψ with SoLID vd Upsilon Production at the EIC

SoLID with J/ψ

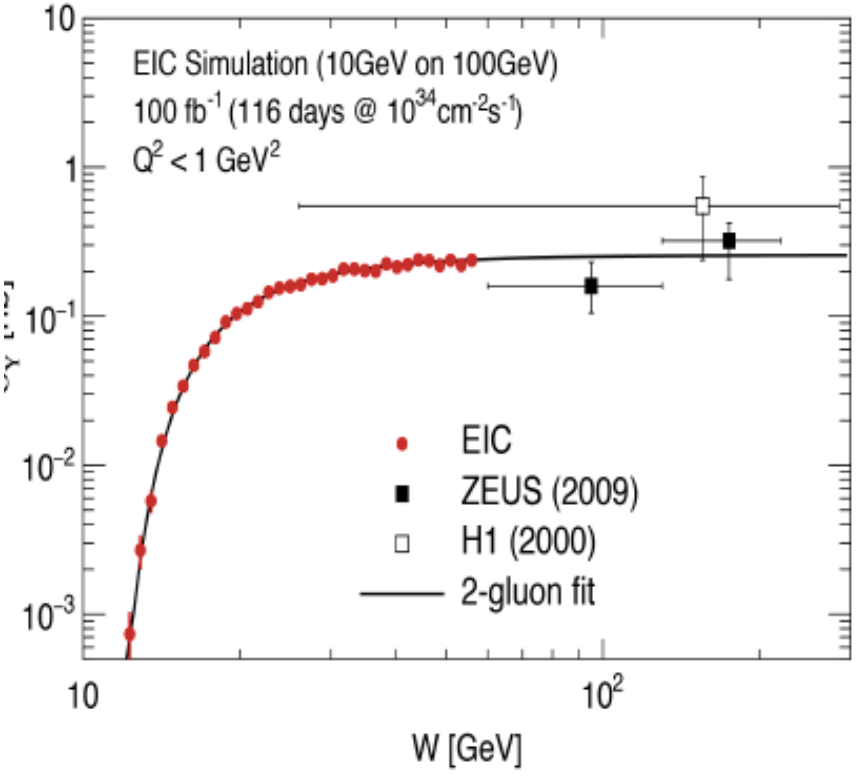
Total elastic electro and photo-production of J/psi



E_γ [GeV]

EIC with Upsilon

Total elastic electro and photo-production of Upsilon



Trace of EMT proportional to Quarkonium-proton scattering amplitude
to be measured at JLab with J/psi at SoLID or Upsilon at EIC

Both SoLID and EIC are needed to confirm the trace anomaly extraction and could lead to a solution of the nucleon mass puzzle

Synergy Between SoLID and the EIC

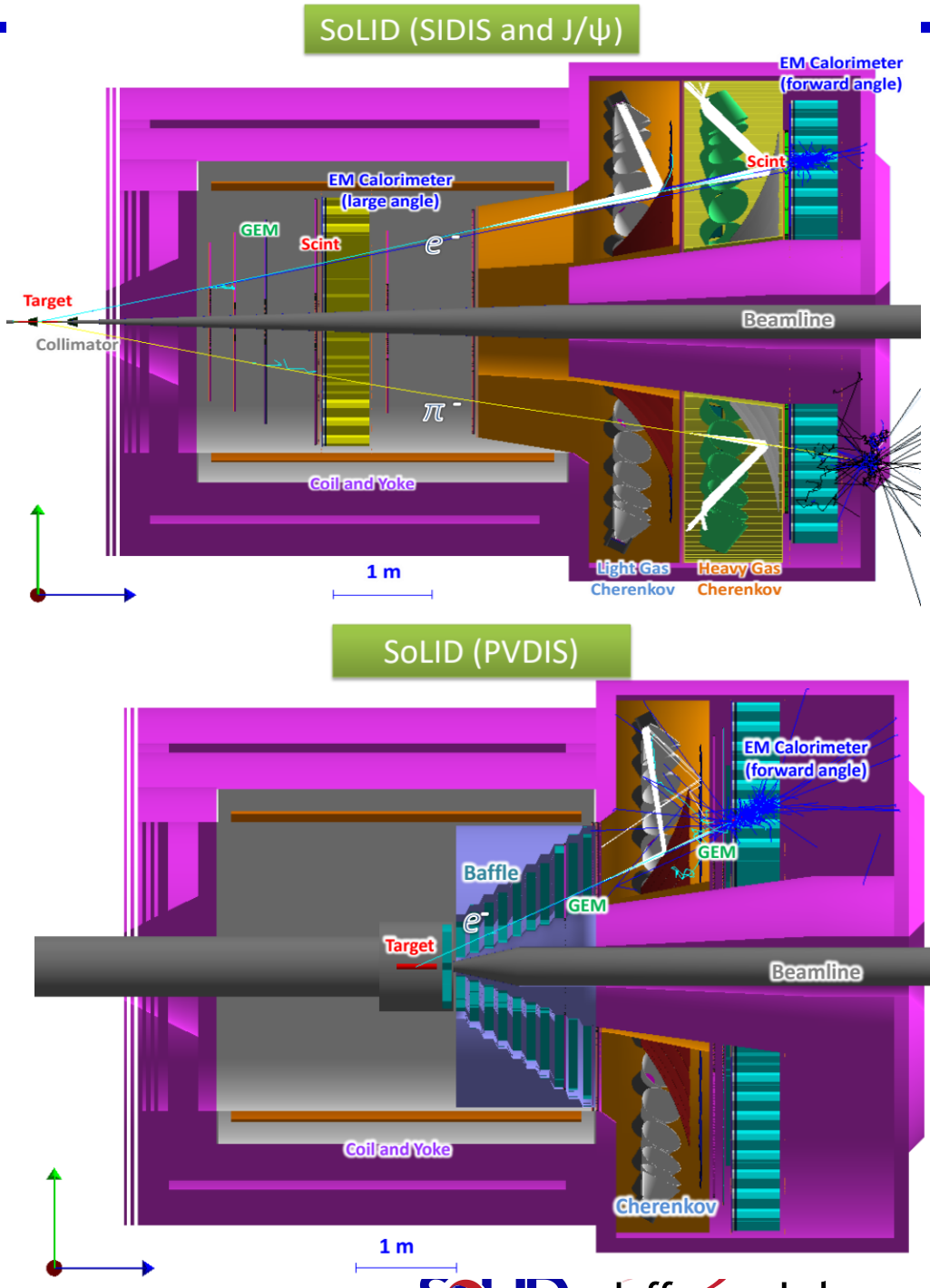
A. Physics
    1. Proton Mass
    2. Proton Spin
    3. 3D Imaging (Complementary range in x)
B. Experimental Techniques
    1. Streaming Readout
    2. Machine Learning for tracking
    3. Large Scale DAQ

SoLID will be a bridge that helps train the workforce for the EIC.

SoLID Apparatus

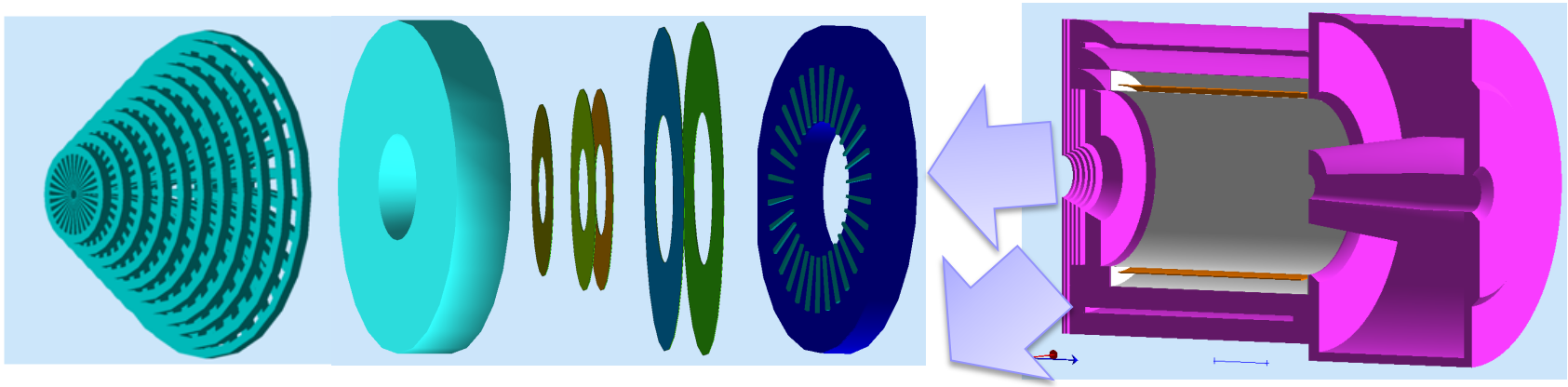
Requirements are Challenging

- High Luminosity (10^{37}-10^{39})
- High data rate
- High background
- Low systematics
- High Radiation
- Large scale (Like RHIC)
- New Technologies
  - GEM's
  - Shashlyk Ecal
  - Pipeline DAQ

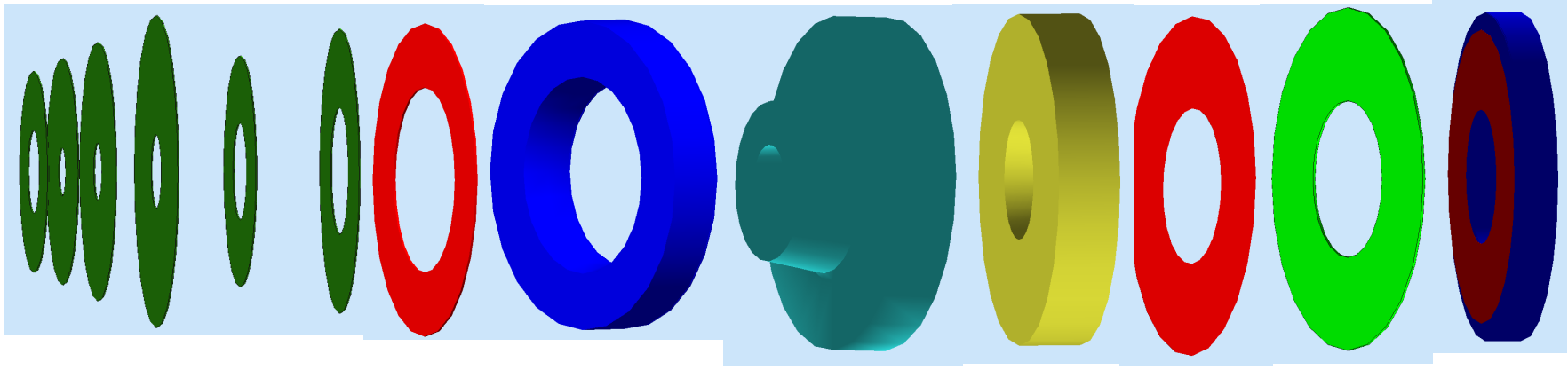


SoLID Detector Subsystems

PVDIS: Baffle LGC 5xGEMs EC



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



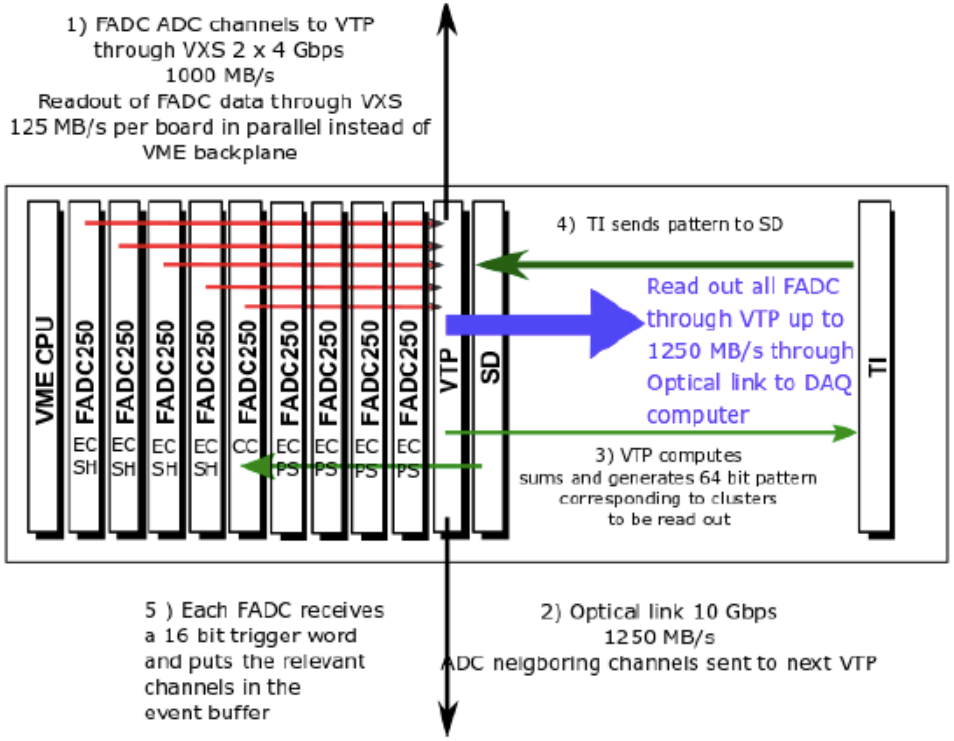
Uses full capability of Jlab electronics

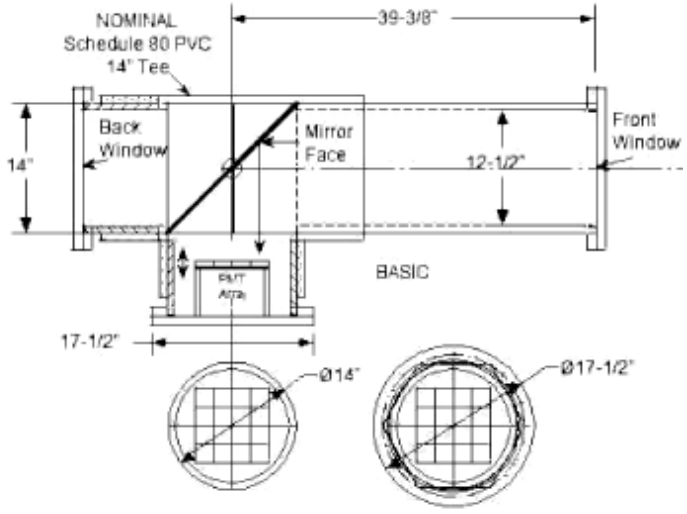
SoLID Progress Timeline

- Since 2010: Five SoLID experiments approved by PAC with high rating
  3 SIDIS with polarized ^{3}He/p target, 1 PVDIS, 1 threshold J/ψ
  Five run-group experiments approved
- 2013: CLEO-II magnet requested, agreed, arrived at JLab 2016,
  steel arrived August 2019.
- **2014: pCDR submitted to Jlab with cost estimation and proposed schedule**
  estimation based on Hall D and CLAS12 experience
- 2015: Director's Review, positive with many recommendations
- 2017: Updated pCDR submitted to JLab with responses to the recommendations
- 7/2018: DOE NP visit and discussion: → **update cost estimation**
- 1/2019: **Updated cost estimation (updated pCDR) submitted to the lab**
- **8/2019: New cost estimation with WBS structure and proposed schedule**
- 9/2019: Director's Review 9/9-9/11 with WBS structure and proposed schedule
- 11/2019 Pre-R&D Plan Funded
- 12/2019 pCDR submitted to the DOE

Things are starting to move quickly

Pre-R&D Plan Part A-Electronics Part B-Cerenkov



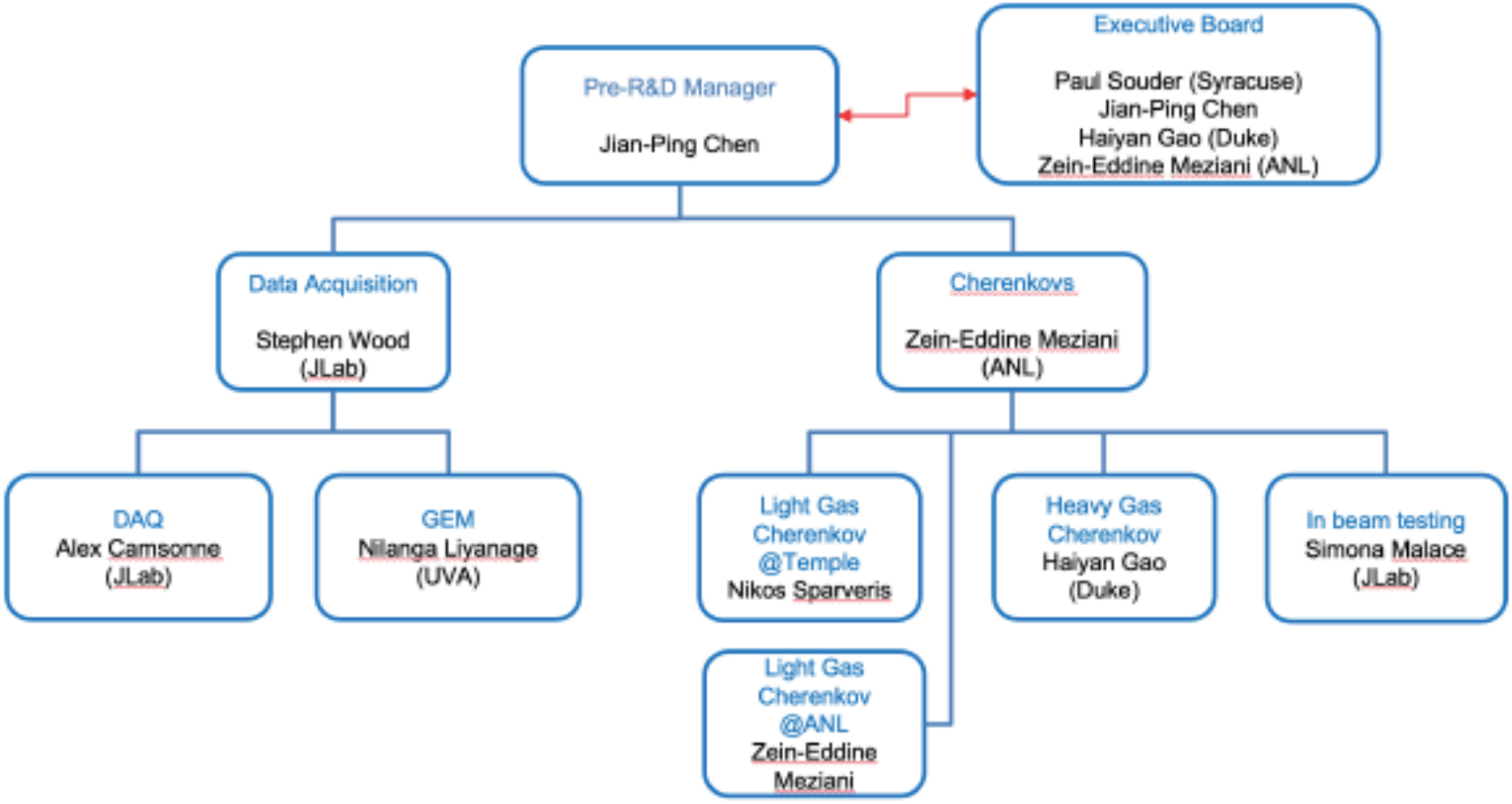


Uses full capability of Jlab FADC electronics

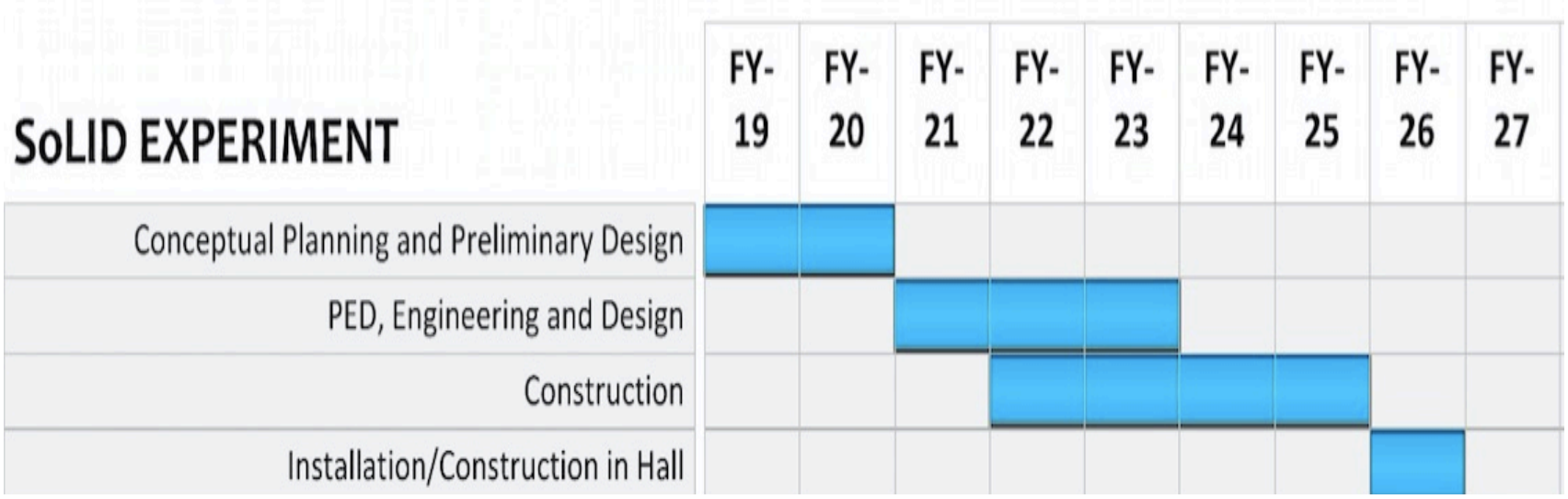
Equipment to be tested: MAPMT, wavelength shifter, summing and MAROC electronics

SoLID: You are Welcome to Get Involved

Example: Pre-R&D Plan. Contact anyone on the chart to start.



Proposed Schedule Presented to the DOE (2018)



Summary

1. Exciting, varied physics program
2. State-of-the-art apparatus
3. Gateway to the EIC
4. Now is a good time to get involved