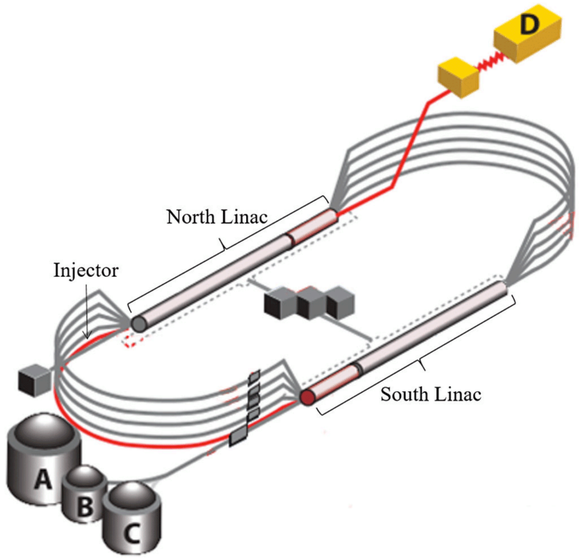
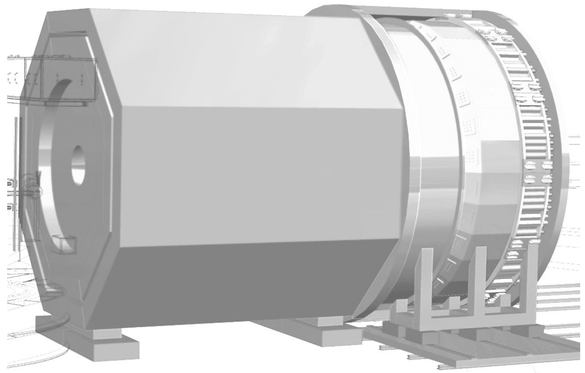


The Jefferson Lab 12 GeV Program



SoLID
SOLENOIDAL LARGE INTENSITY DEVICE

Program Successes and Future Run Plan

Jim Napolitano, Temple University

Nuclear Physics QCD Long Range Plan Town Meeting

MIT 23-25 September 2022

ELSEVIER

Progress in Particle and Nuclear Physics

Available online 8 July 2022, 103985

In Press, Corrected Proof

Review

Physics with CEBAF at 12 GeV and future opportunities

J. Arrington [a], M. Battaglieri [b, o], A. Boehnlein [b], S.A. Bogacz [b], W.K. Brooks [j], E. Chudakov [b], I. Cloët [c], R. Ent [b], H. Gao [d], J. Grames [b], L. Harwood [b], X. Ji [e, f], C. Keppel [b], G. Krafft [b], R.D. McKeown [b, h], J. Napolitano [g], J.W. Qiu [b, h], P. Rossi [b, n] ... X. Zheng [k]

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Physics Topics I Will Mention

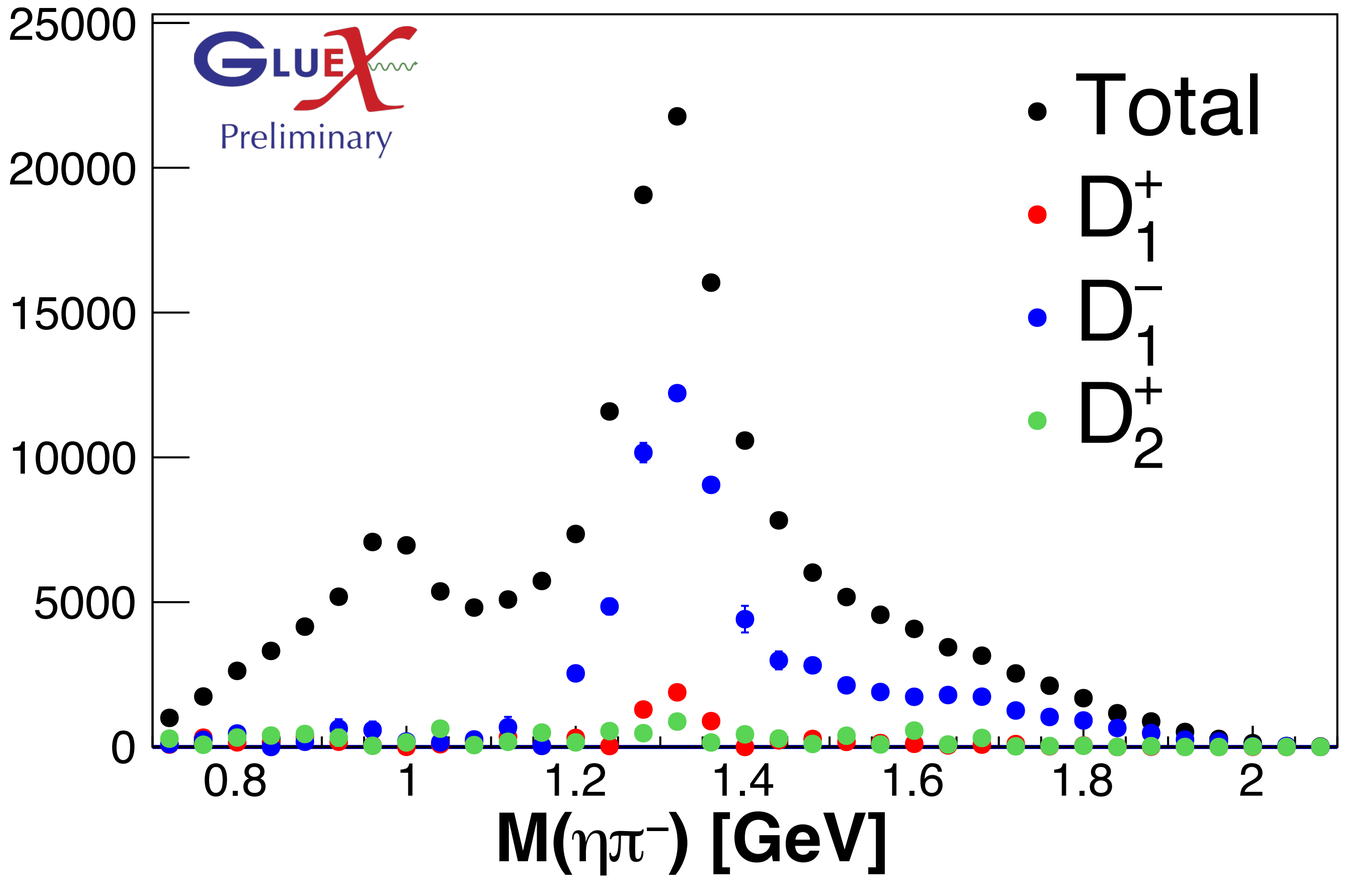
- Hadron Spectroscopy
- QCD and Nuclear Structure
- (Quasi-)Static Properties of Nucleons
- Fundamental Symmetries (Technical Progress)
- Towards the Wigner Function of the Nucleon

The 12 GeV CEBAF program has produced a wealth of new results, with many more experiments to run in the foreseeable future

My apologies to all of the people whose hard work and successes are not included in this brief talk!

Meson Spectroscopy from GlueX

$\vec{\gamma}\, p \to a_2^-(1320)\, \Delta^{++} \quad a_2^-(1320) \to \eta\pi^-$

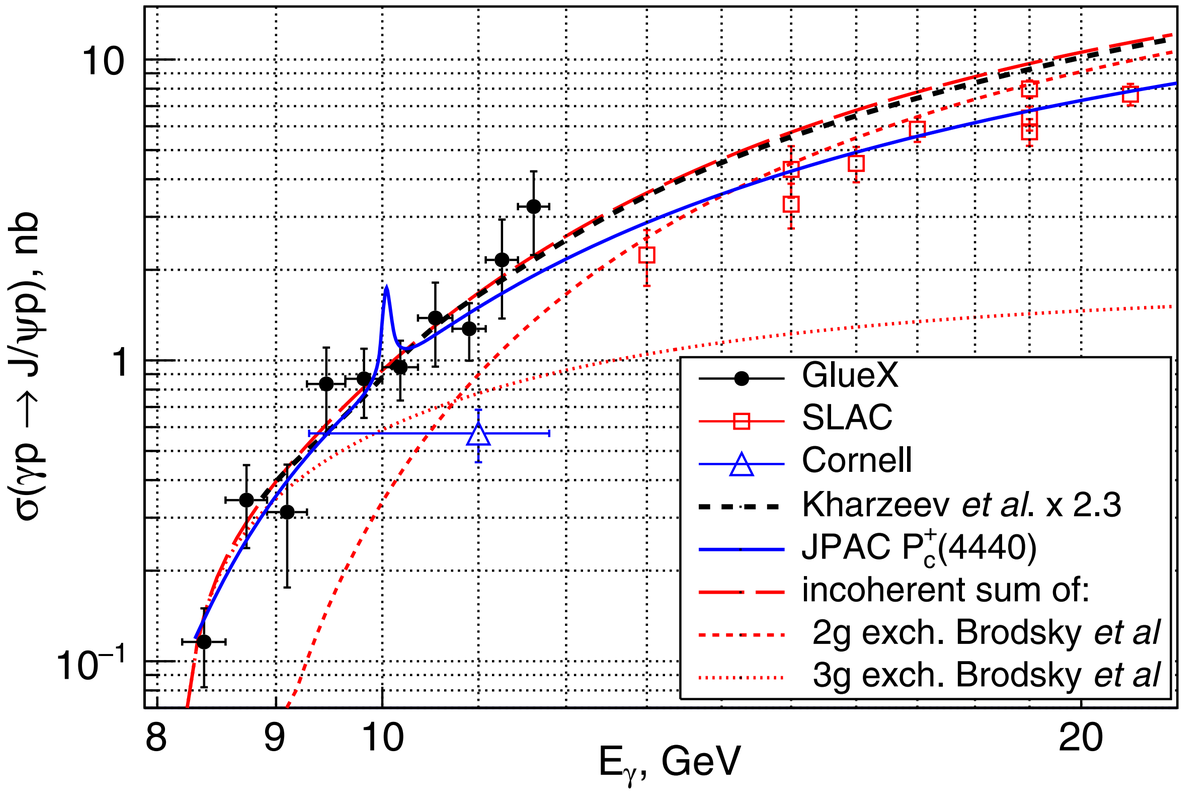


Exotic mesons analyses

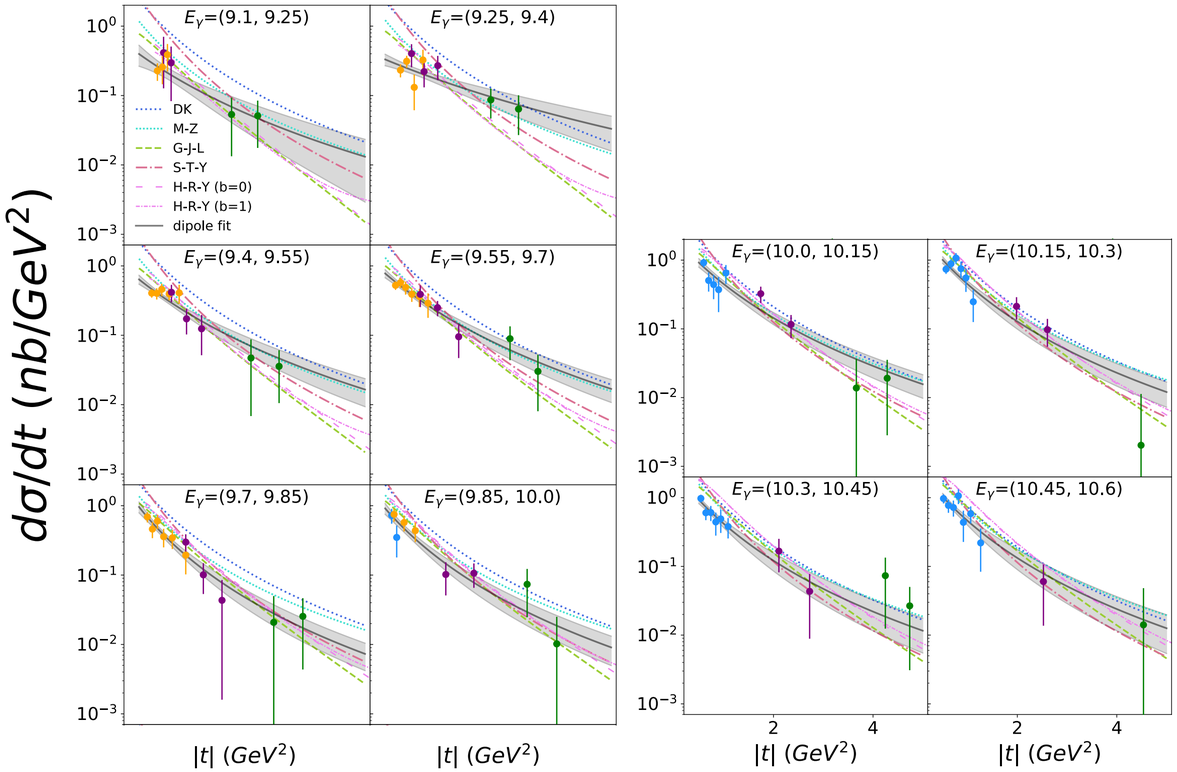
- Focus now is on $\pi_1(1600)$
- Continuing study of $(\eta\pi)_{\ell=1}$
- Dominant $b_1\pi$ decay predicted by PRD 103(2021)054502 is leading to new analyses
- Other channels available with kaon decay signatures

J/ψ Photoproduction Near Threshold

PRL 123(2019)072001



arXiv:2207.05212

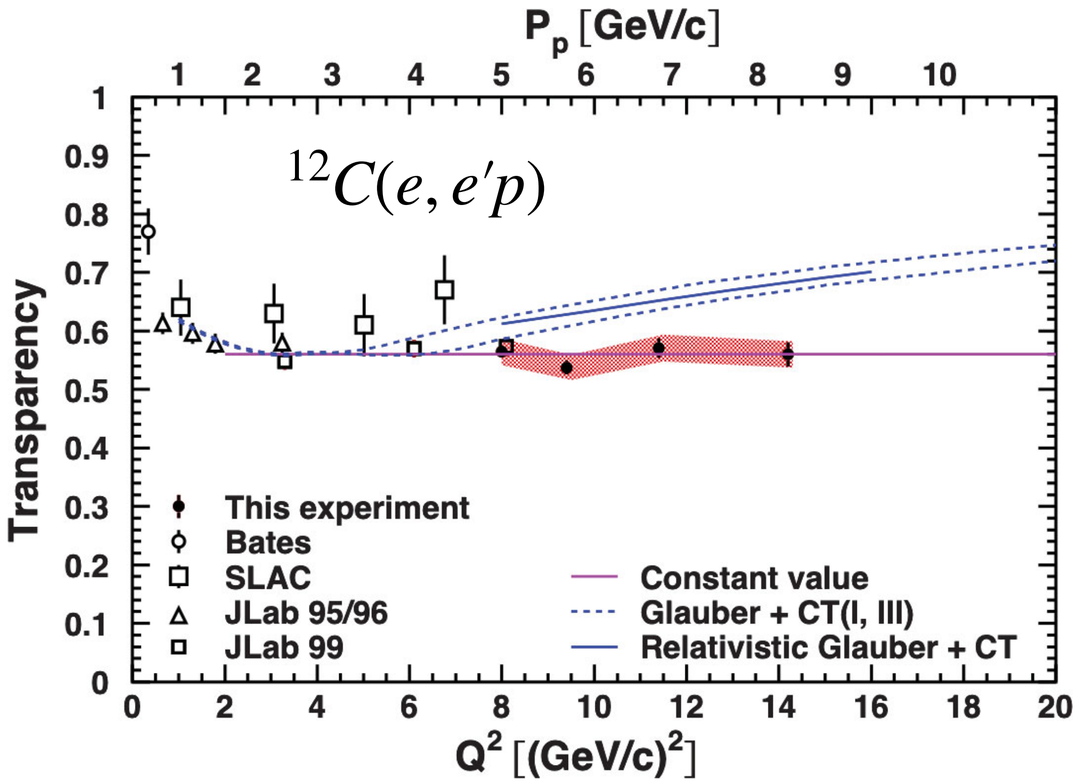


Implications for the proton mass radius. Precision results will come from SoLID.

Bound nucleons: Challenges for Theory

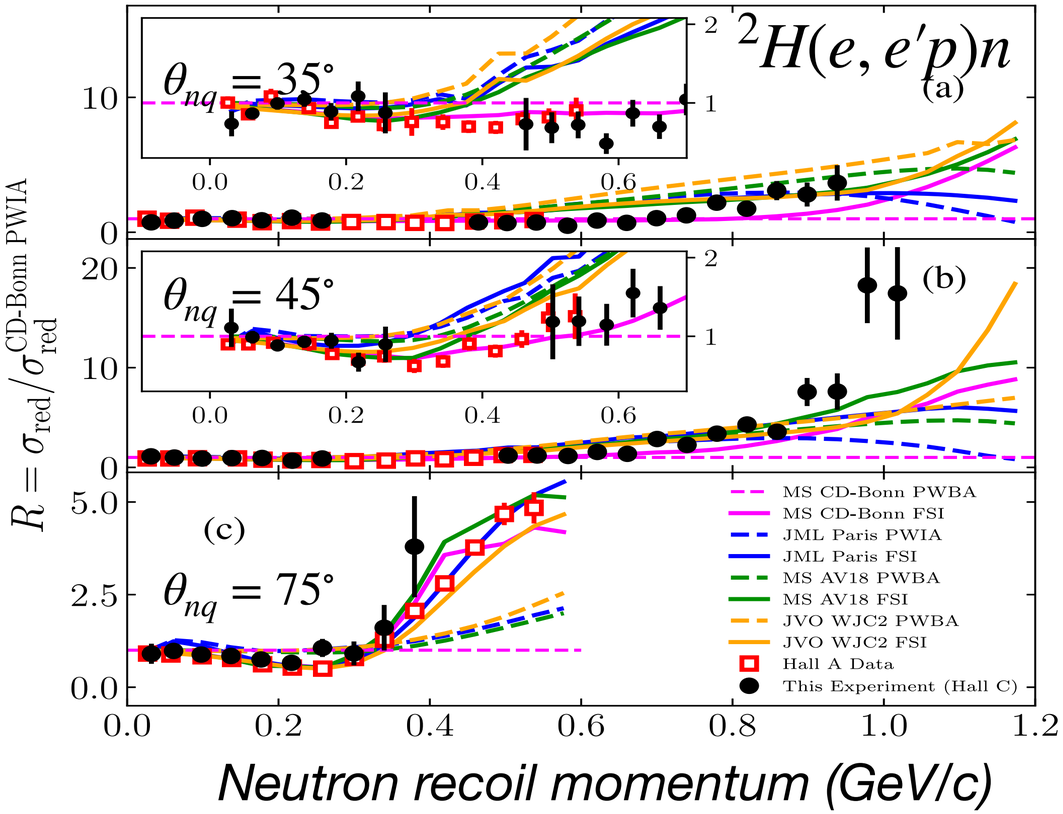
PRL 126 (2021) 082301

Ruling out Color Transparency



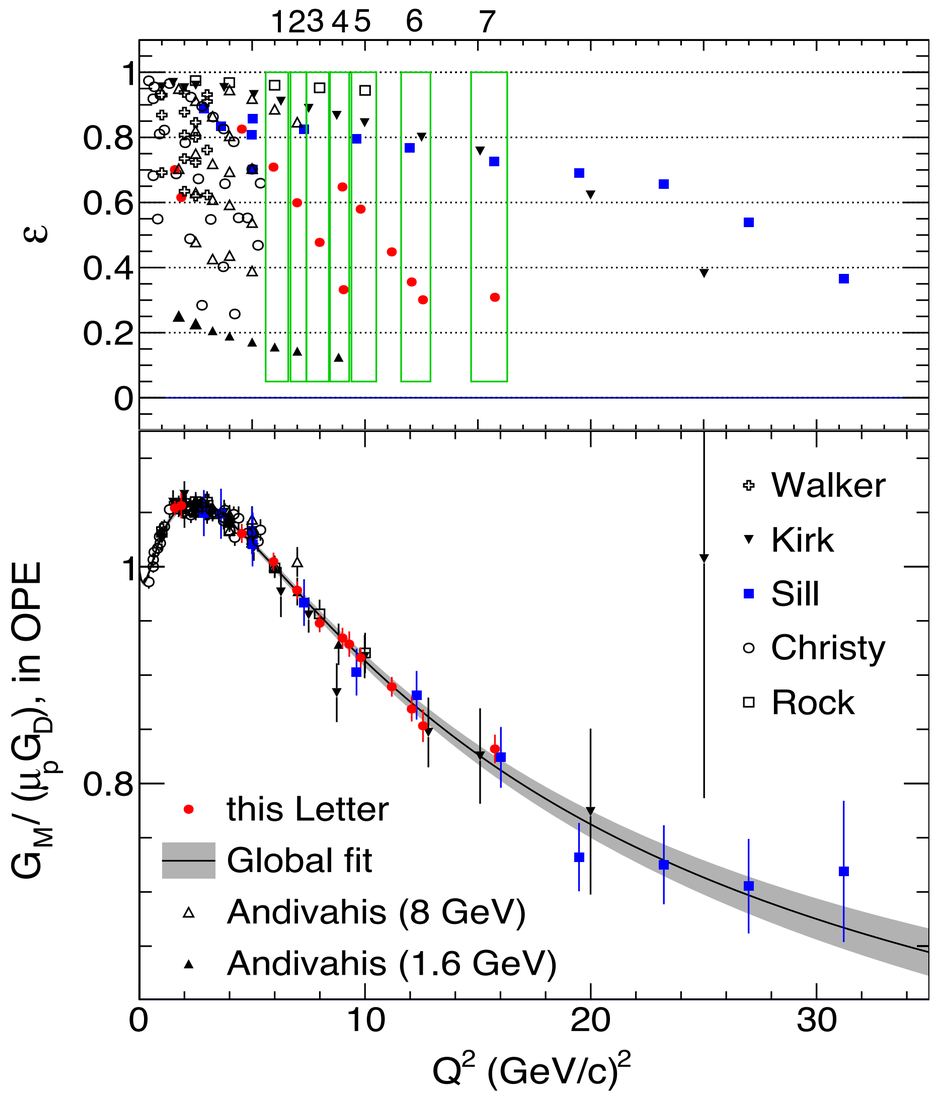
PRL 125 (2020) 262501

High momenta in the deuteron

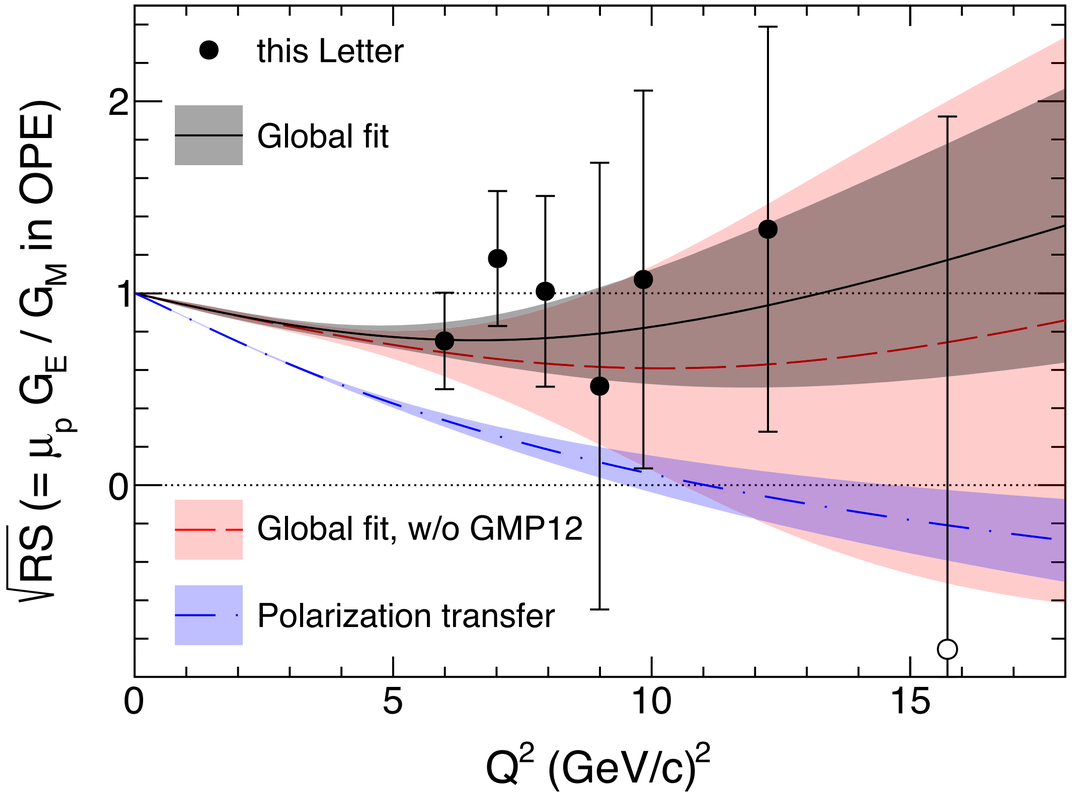


Proton Elastic Form Factors

PRL 128 (2022) 102002

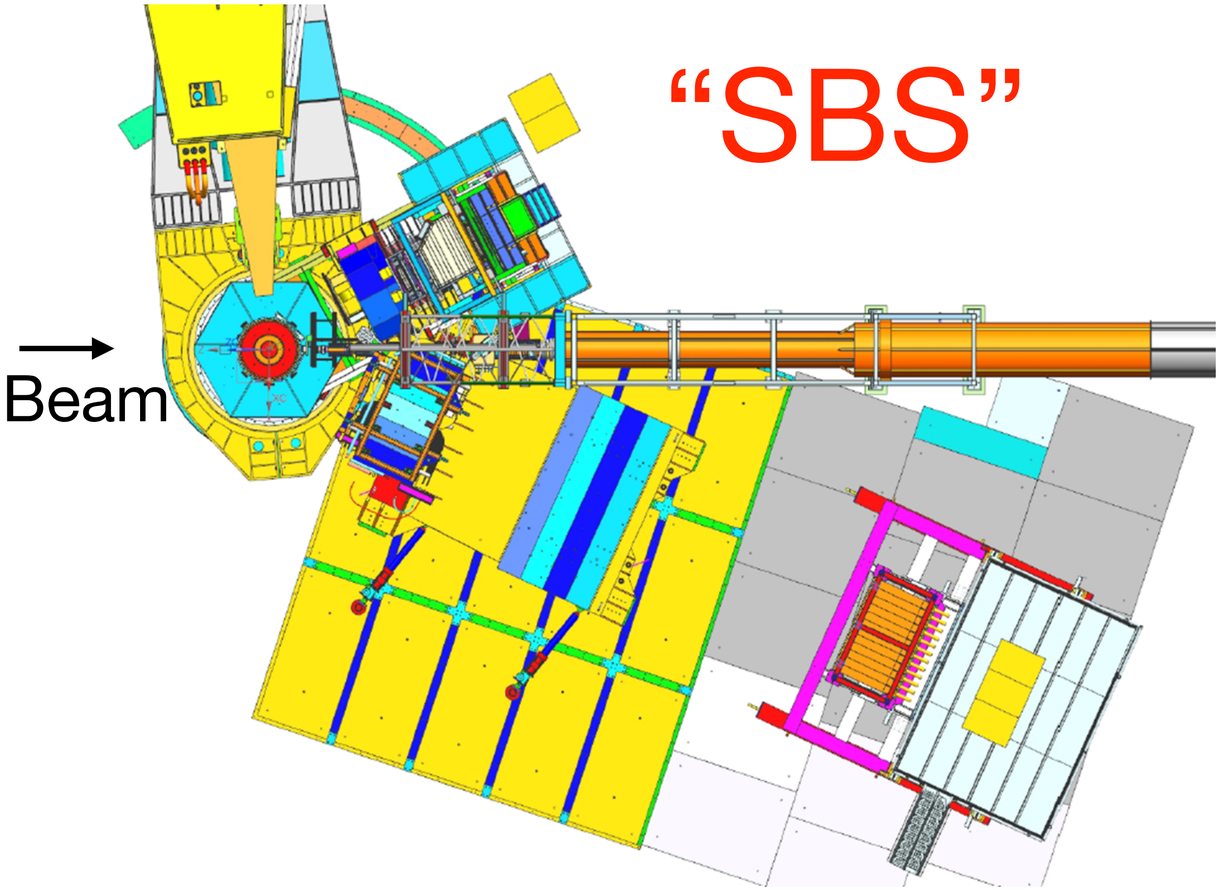


- Precision Rosenbluth separation
- Hard two-photon exchange needed for agreement with recoil polarization results
- Polarization experiment scheduled



Neutron Elastic Form Factors

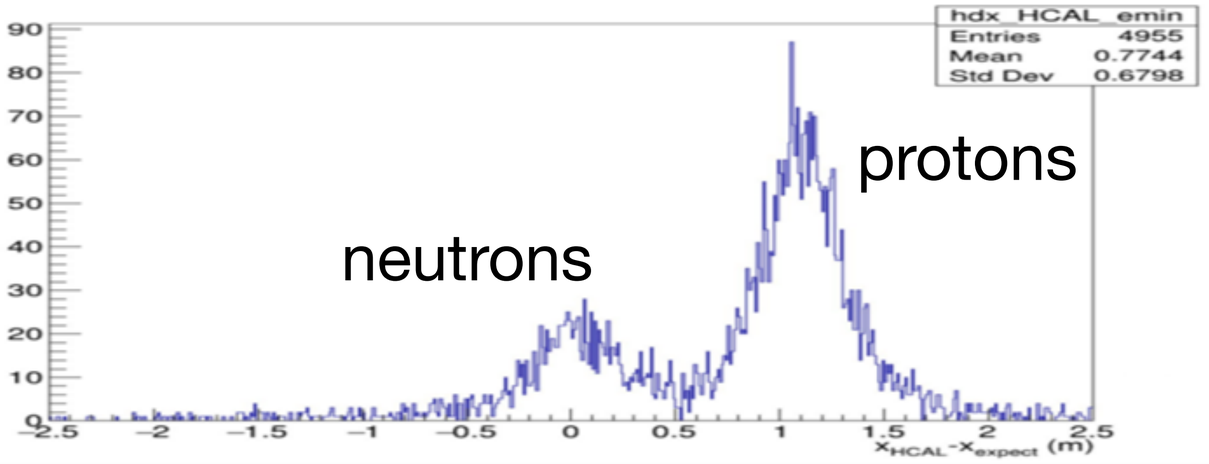
Now and Future



"SBS"

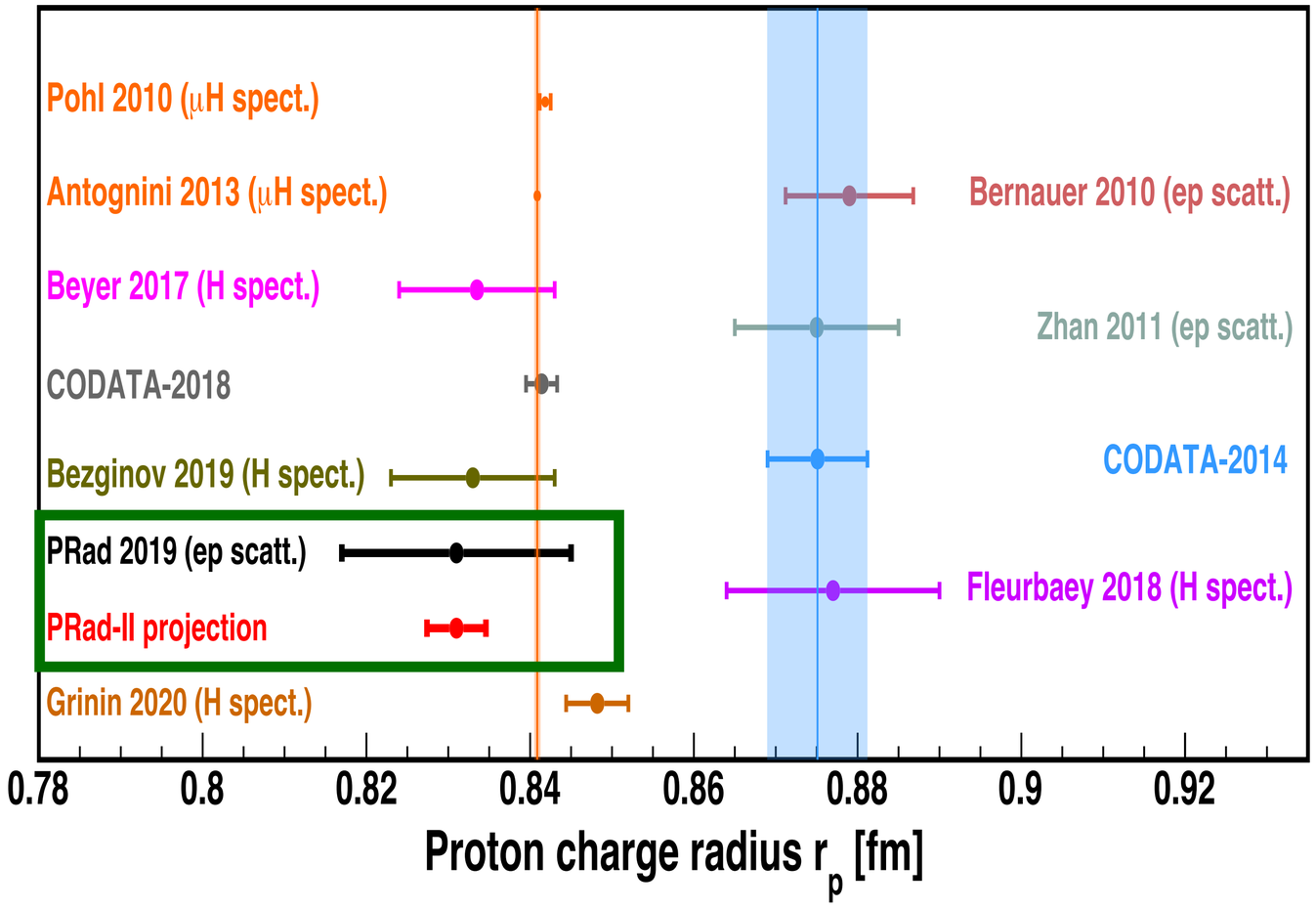
- GMn data is being analyzed
- GEn experiment (polarized 3He target) is on the floor now.

GMn data



Precision Proton Static Properties

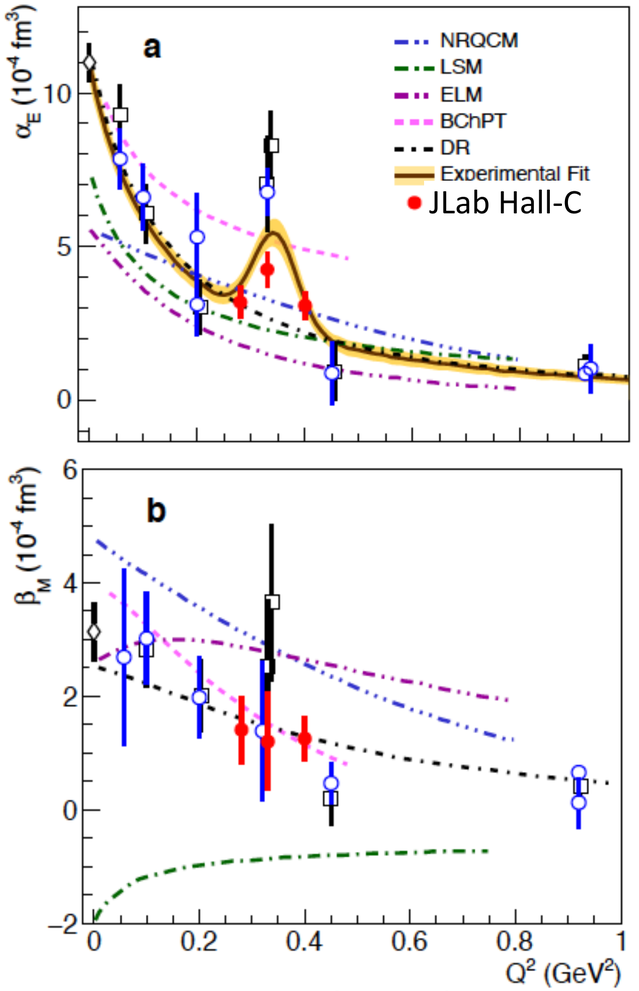
PRad: Charge radius Nature 575(2019)147



Electric Polarizability

Nature (in press)

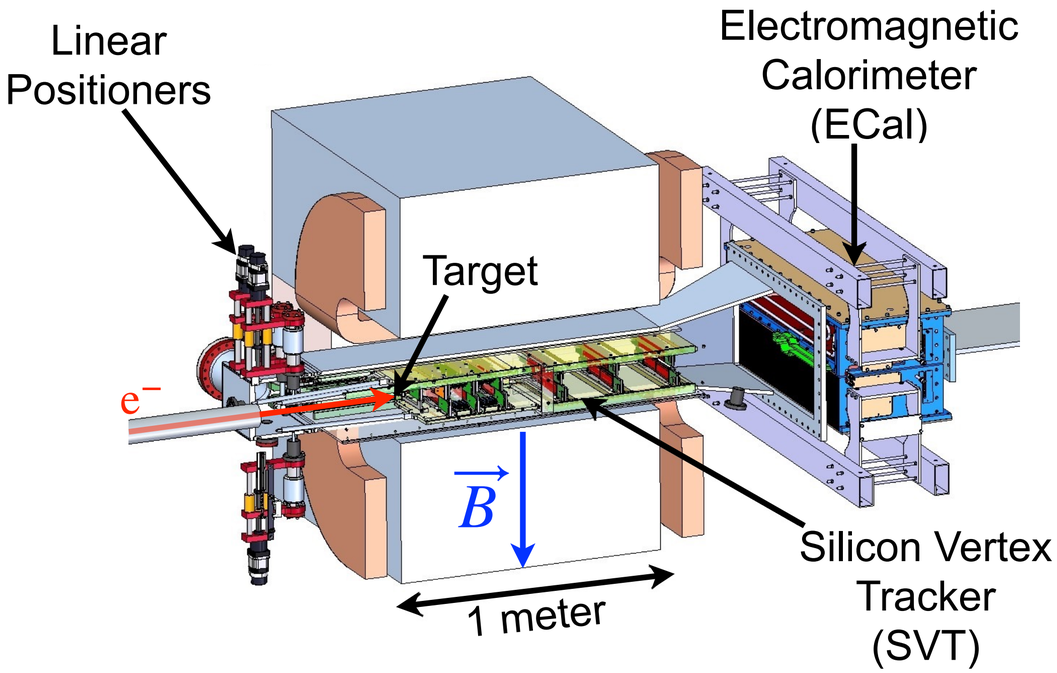
Magnetic Polarizability



See also
X. Zheng, et al Nature Phys 17(2021)736
V. Sulkosky, et al Nature Phys 17(2021)687

Technical achievements for precision physics

Heavy Photon Search

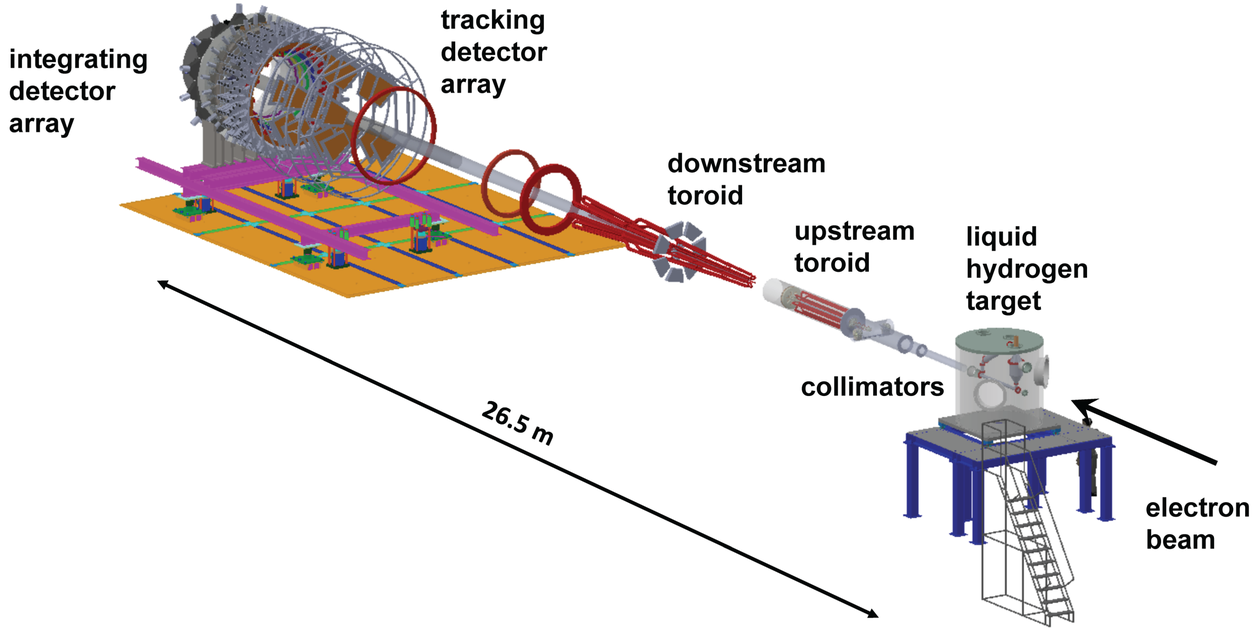


Engineering Run: PRD 98 (2018) 091101

More data taken. See arXiv:2203.08324

Upgrades in progress

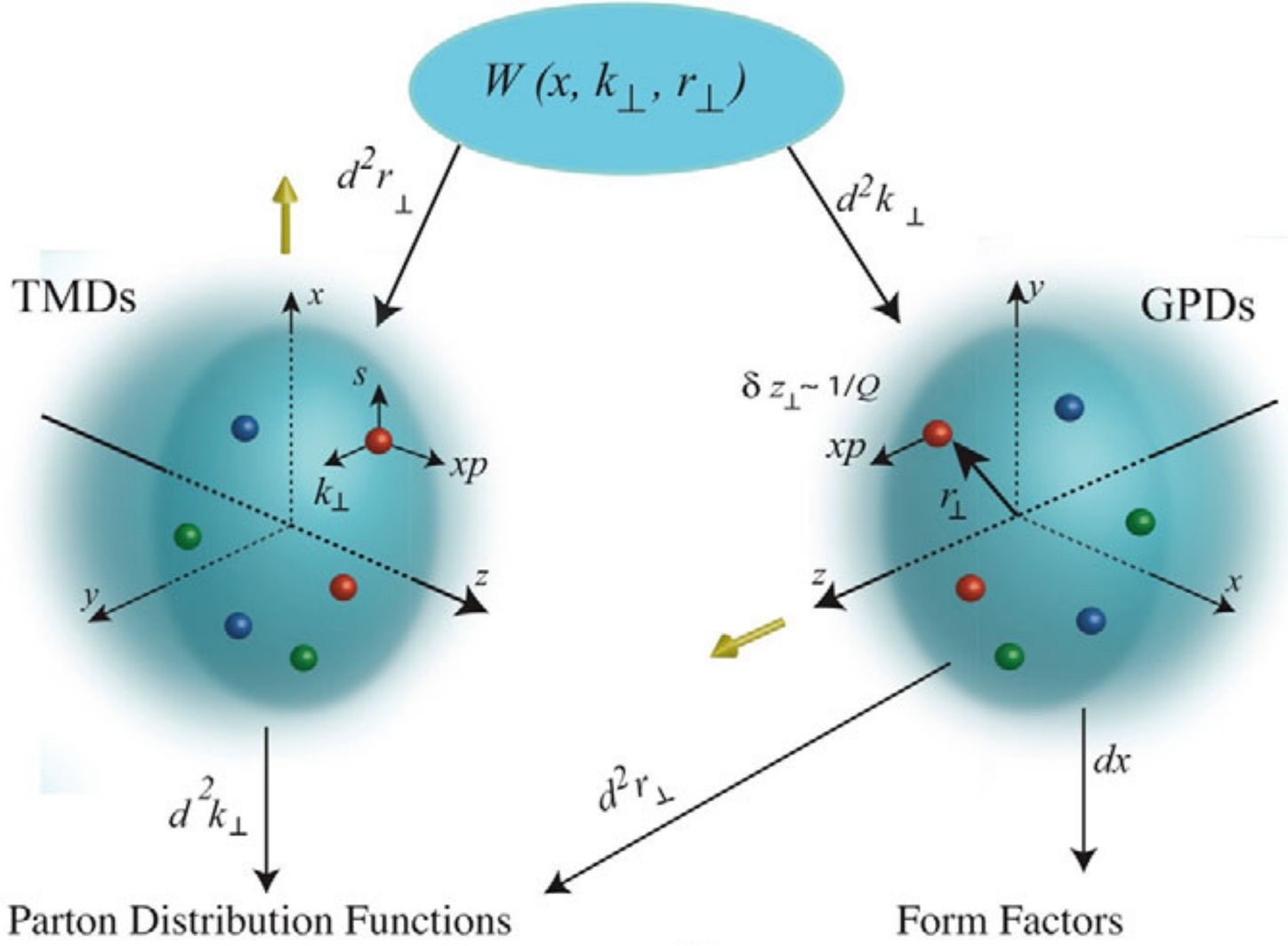
MOLLER



DOE Project Schedule defined

Expect installation in 2025

Nuclear Femtography



The ultimate (and lofty!) goal is to determine $W(x, k_\perp, r_\perp)$ and compare to theory.

Program of experimentation:

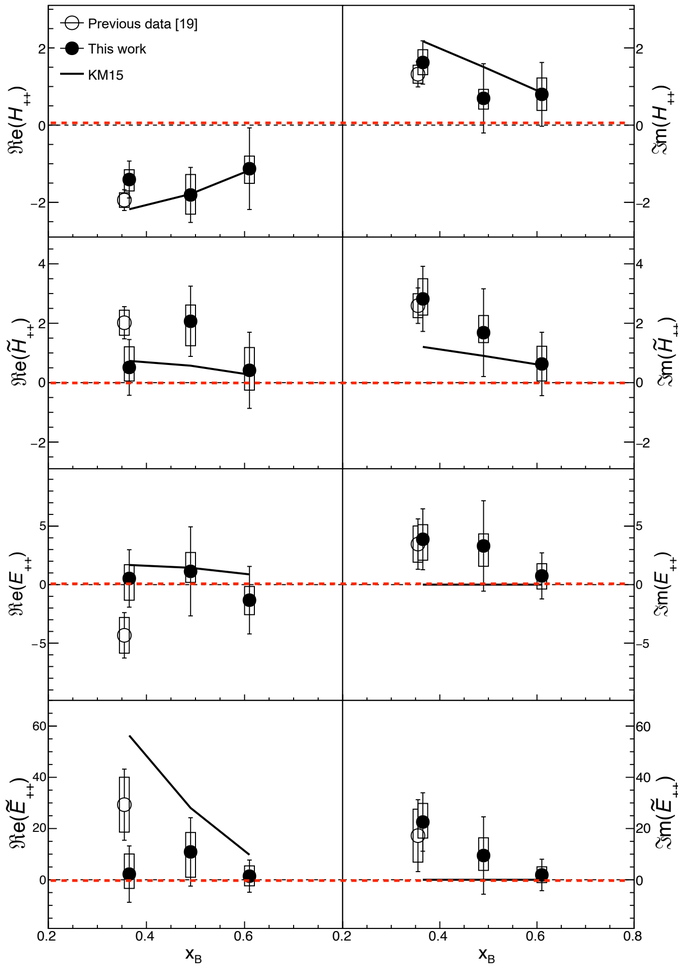
- Ongoing measurements of PDFs and Form Factors
- A start on determining the Generalized Parton Distributions
- Planning for measurements of the Transverse Momentum Distribs

Phenomenology/Theory

- Lots of model-building
- Fundamental theory calculations are currently underway

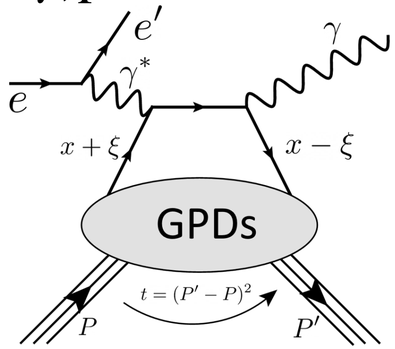
DVCS and TCS

Compton FF's

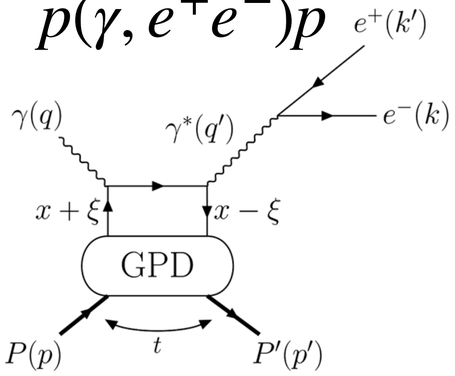


PRL 128 (2022) 252002

$p(e, e'\gamma)p$

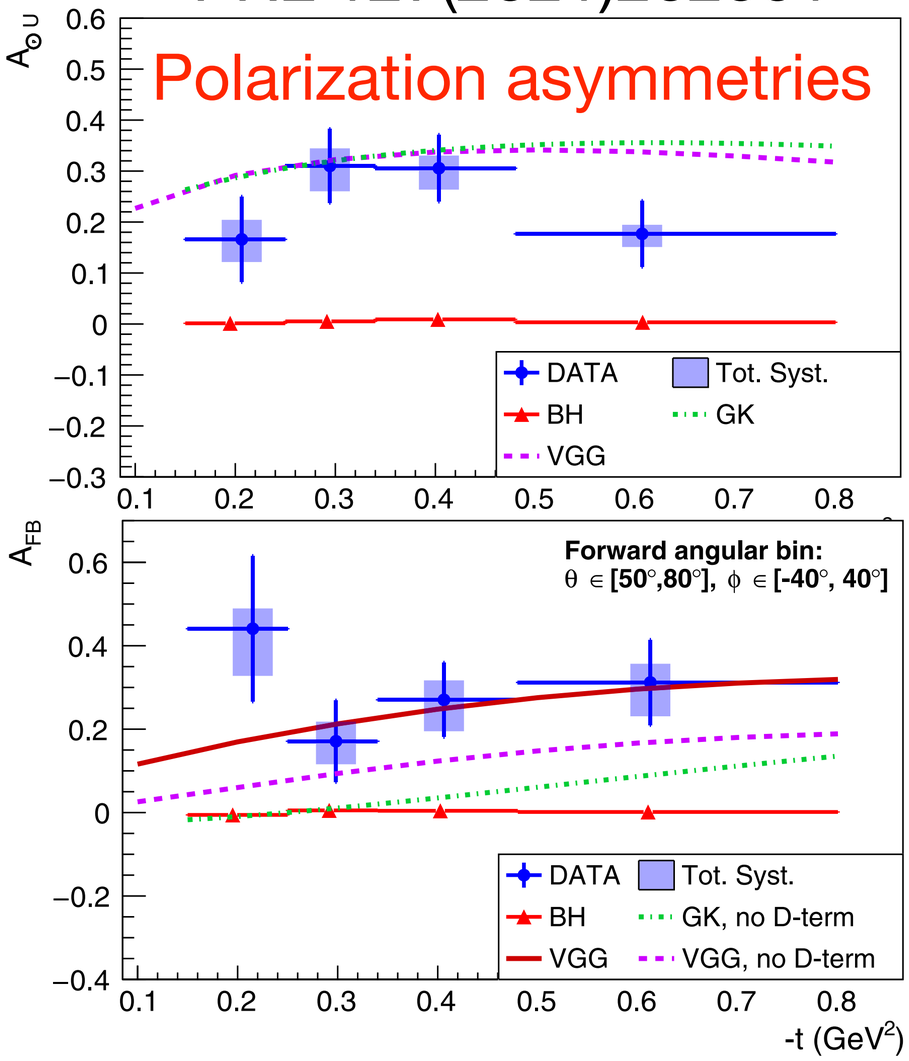


$p(\gamma, e^+e^-)p$



PRL 127(2021)262501

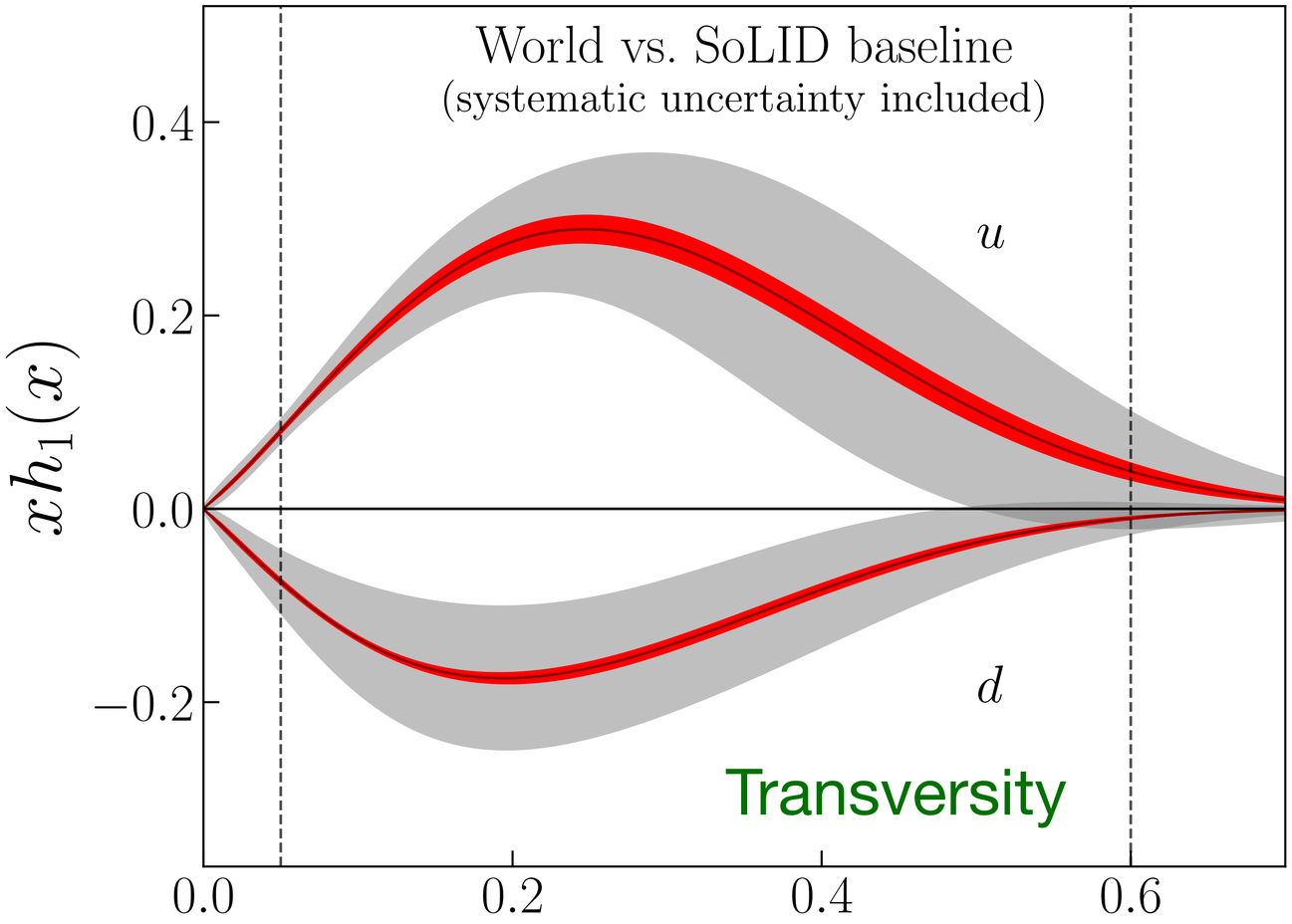
Polarization asymmetries

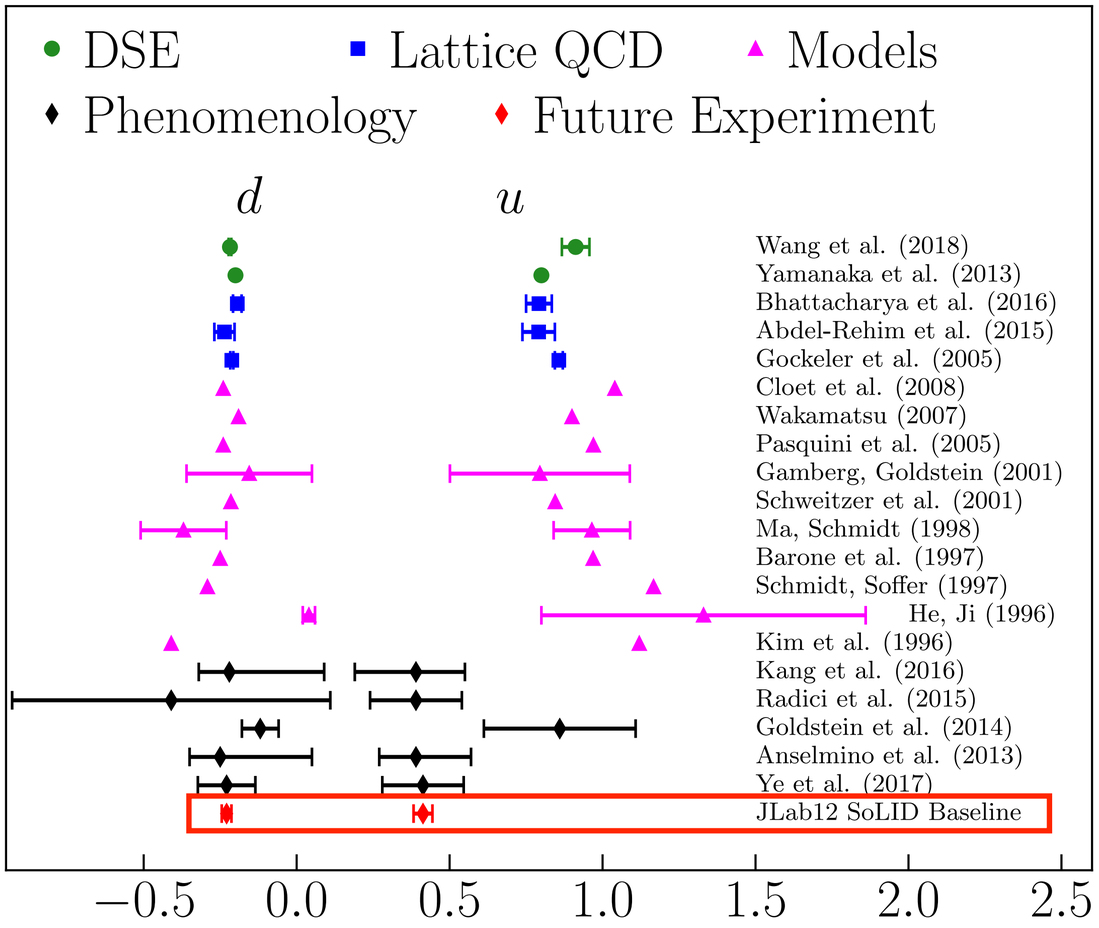


Transverse Momentum Distributions

Towards the Wigner Function

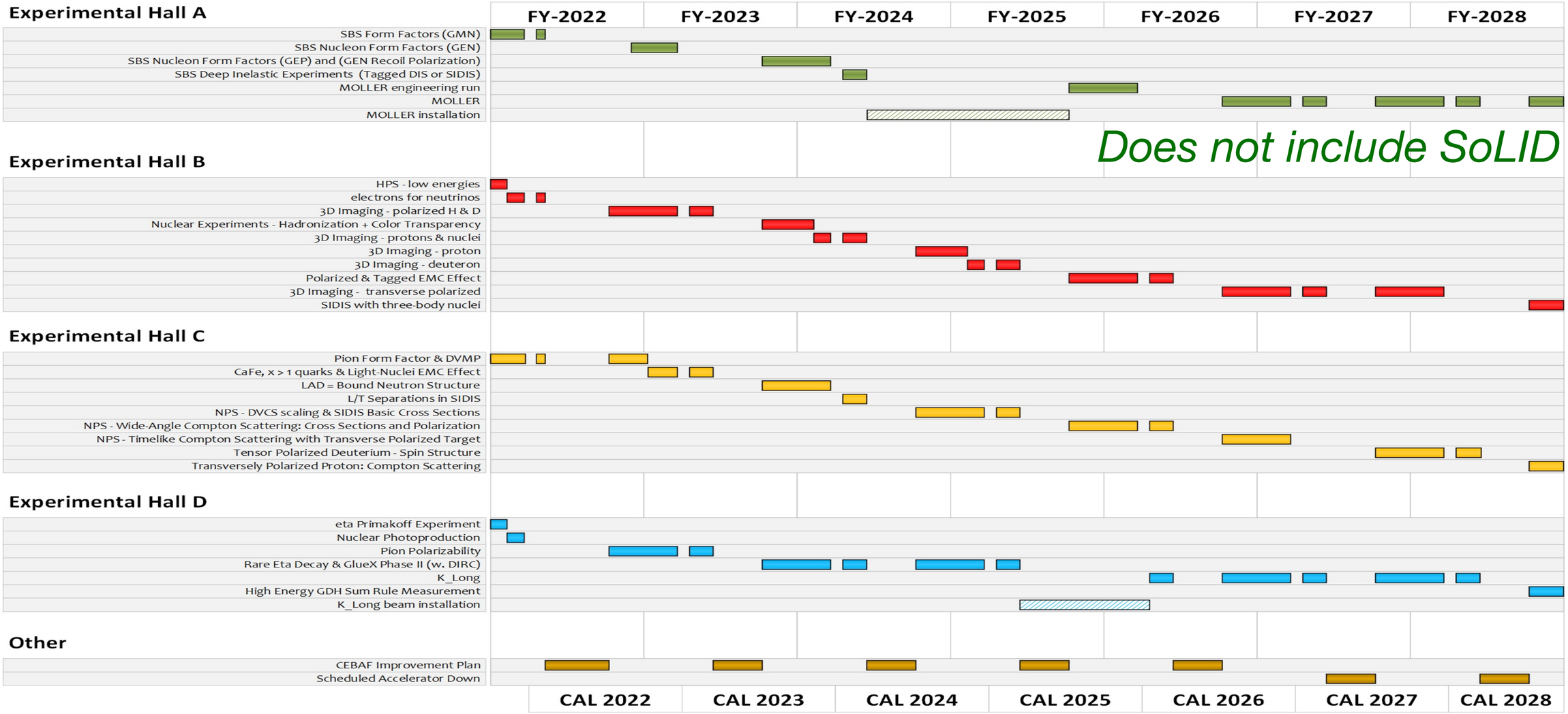
Semi Inclusive Deep Inelastic Scattering (SIDIS) at 12 GeV with SoLID





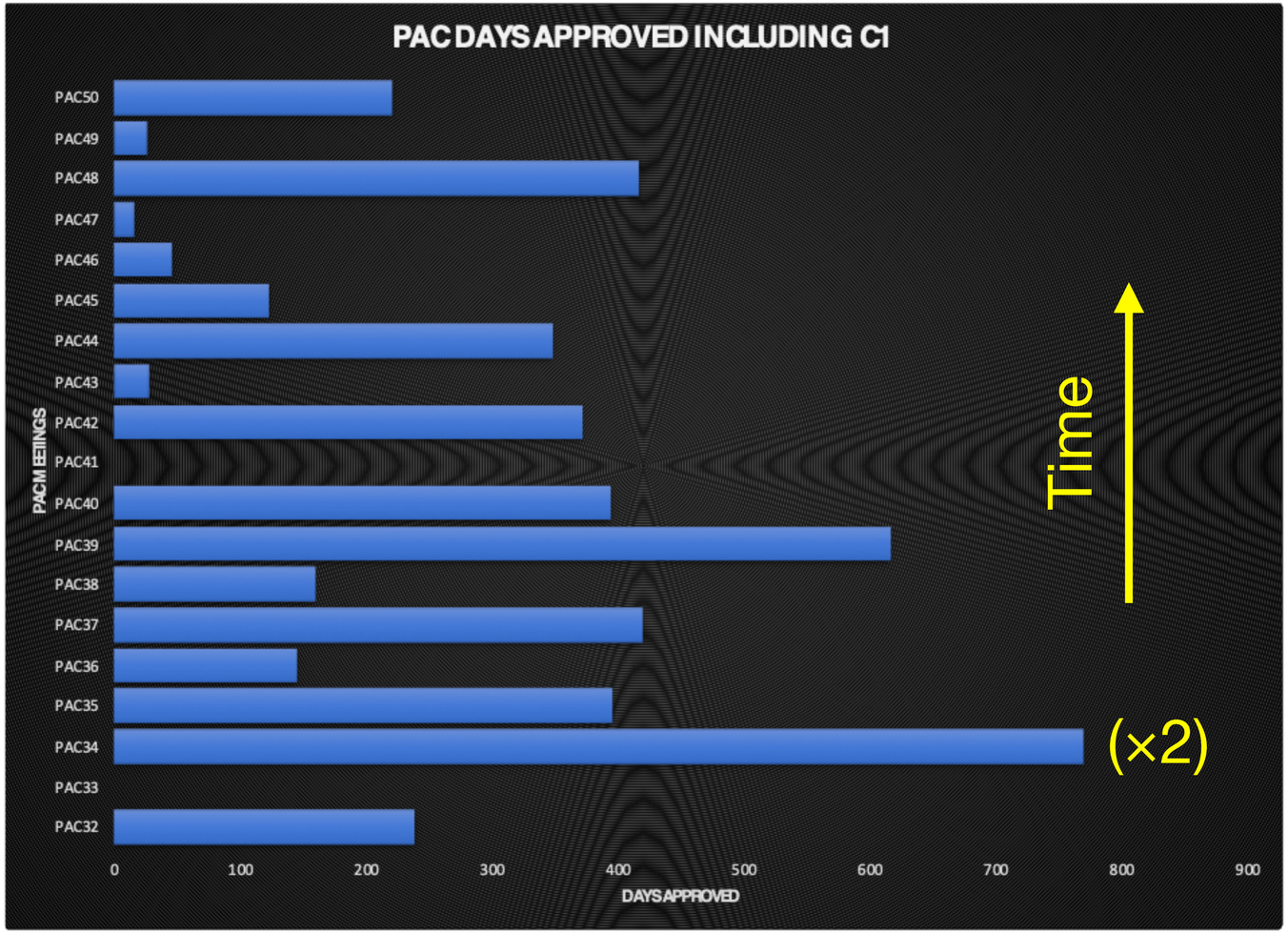
x ⟶ *Integrate* ⟶ g_T Tensor charge

Current CEBAF Experiment Schedule



57 approved experiments now, ≈8 years at ≈30 weeks per year, more PAC's to come

JLab 12 GeV PAC Proposal Approval History



Many more days proposed than approved by the PAC!

Sometimes several experiments included within “Run Groups”

Does not include SoLID, or the large number of “C2” approvals

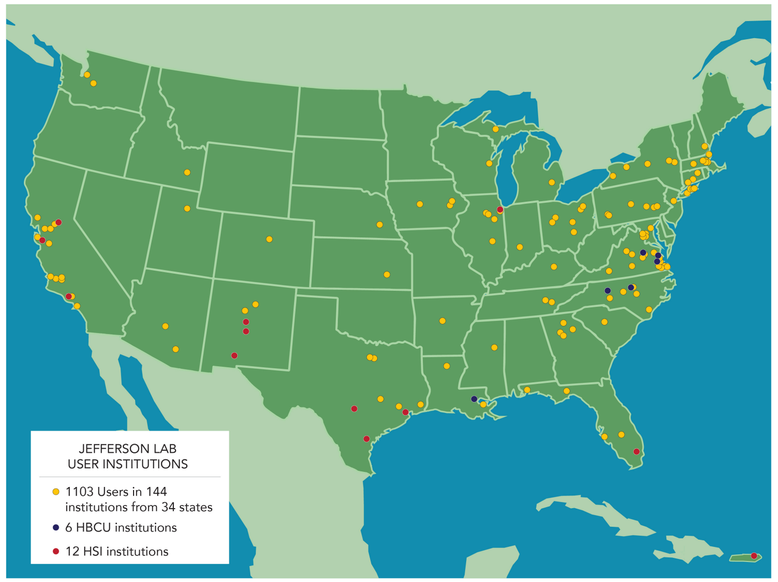
The CEBAF user community remains active and enthusiastic about proposing new experiments!

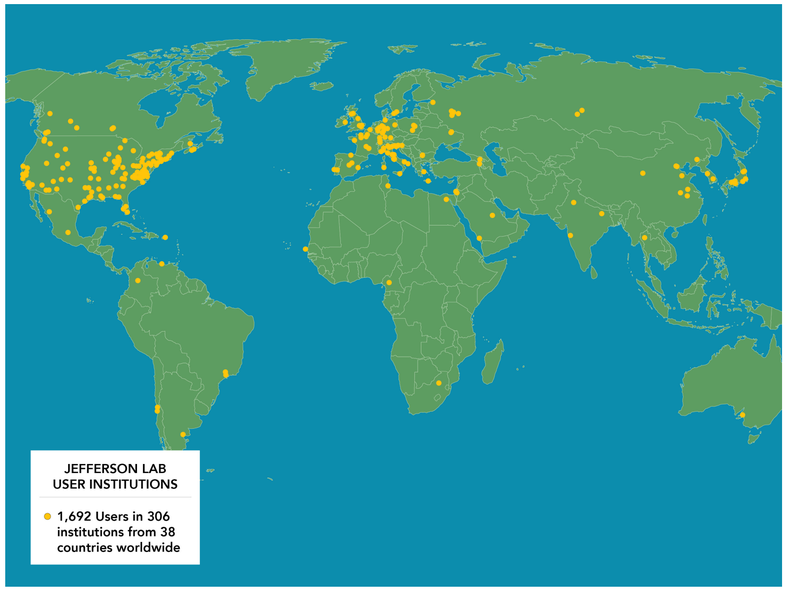
The CEBAF User Community

A large *and* growing nuclear physics community of **more than 1700 users** from 39 countries and more than 275 institutions and 34 US states.

Outstanding scientific progress resulting in more than 2200 papers published in refereed journals.

CEBAF is a unique and powerful facility for fixed-target, high luminosity experimentation, that will remain in high demand into the EIC era.



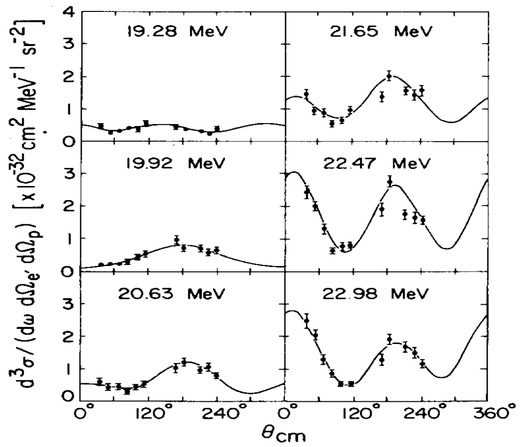


Progress in Electromagnetic Nuclear Physics

1984

$^{12}C(e,e'p)$

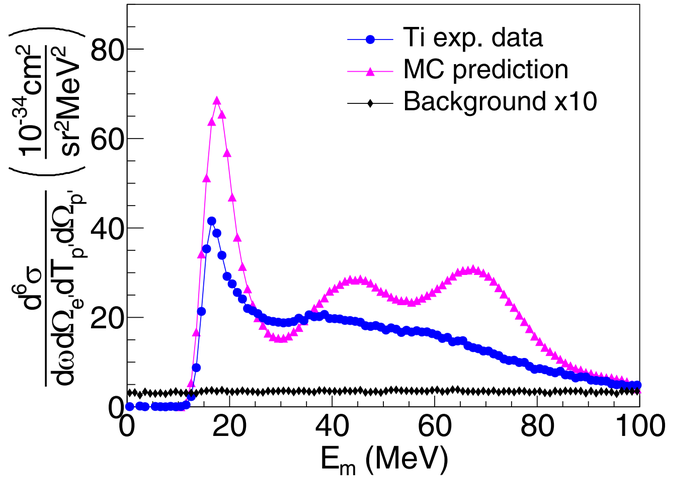
Phys Lett
146B, 179



2021

$^{48}Ti(e,e'p)$

Phys Rev C
103, 034604

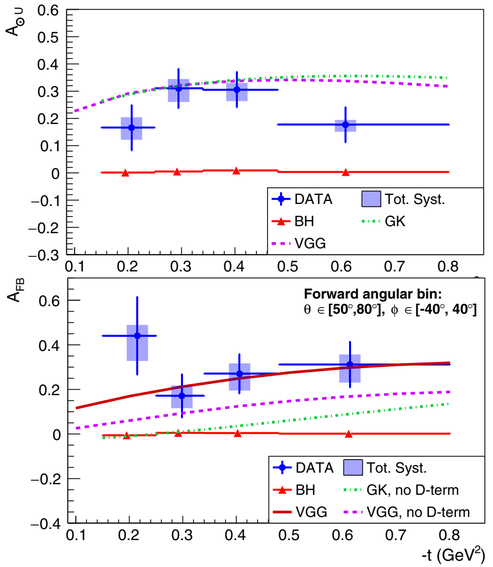


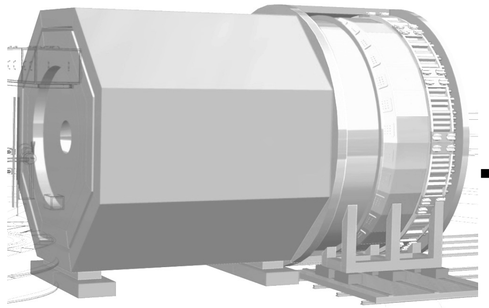
2021

$\gamma p \rightarrow \gamma^* p$

$\rightarrow e^+e^-p$

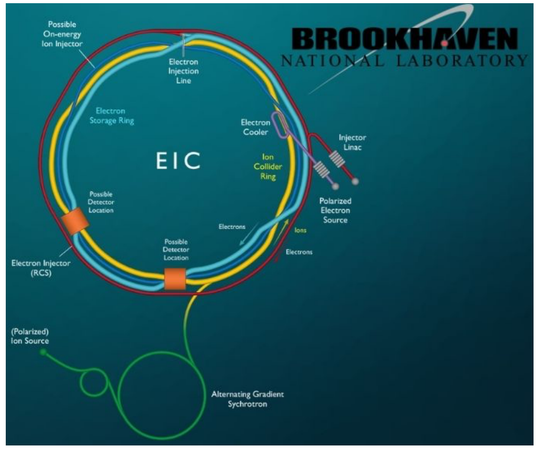
Phys Rev Lett
127, 262501





SOLID
SOLENOIDAL LARGE INTENSITY DEVICE

+



Recommendation

The Nuclear Physics Community embraces with highest priority the scientific capitalization of investments made at CEBAF. This will allow CEBAF to realize a broad program of nuclear physics experiments, including unprecedented luminosities with SoLID. Therefore, we strongly support optimal running of the 12 GeV program, including the construction and deployment of SoLID.

Furthermore, full utilization of CEBAF during EIC construction will build and strengthen the scientific workforce in preparation for successful operation of the EIC, and provides the opportunity for a future complementary program at Jefferson Lab during EIC operations.

“Run the program!”