Hall B/JLAB physics program

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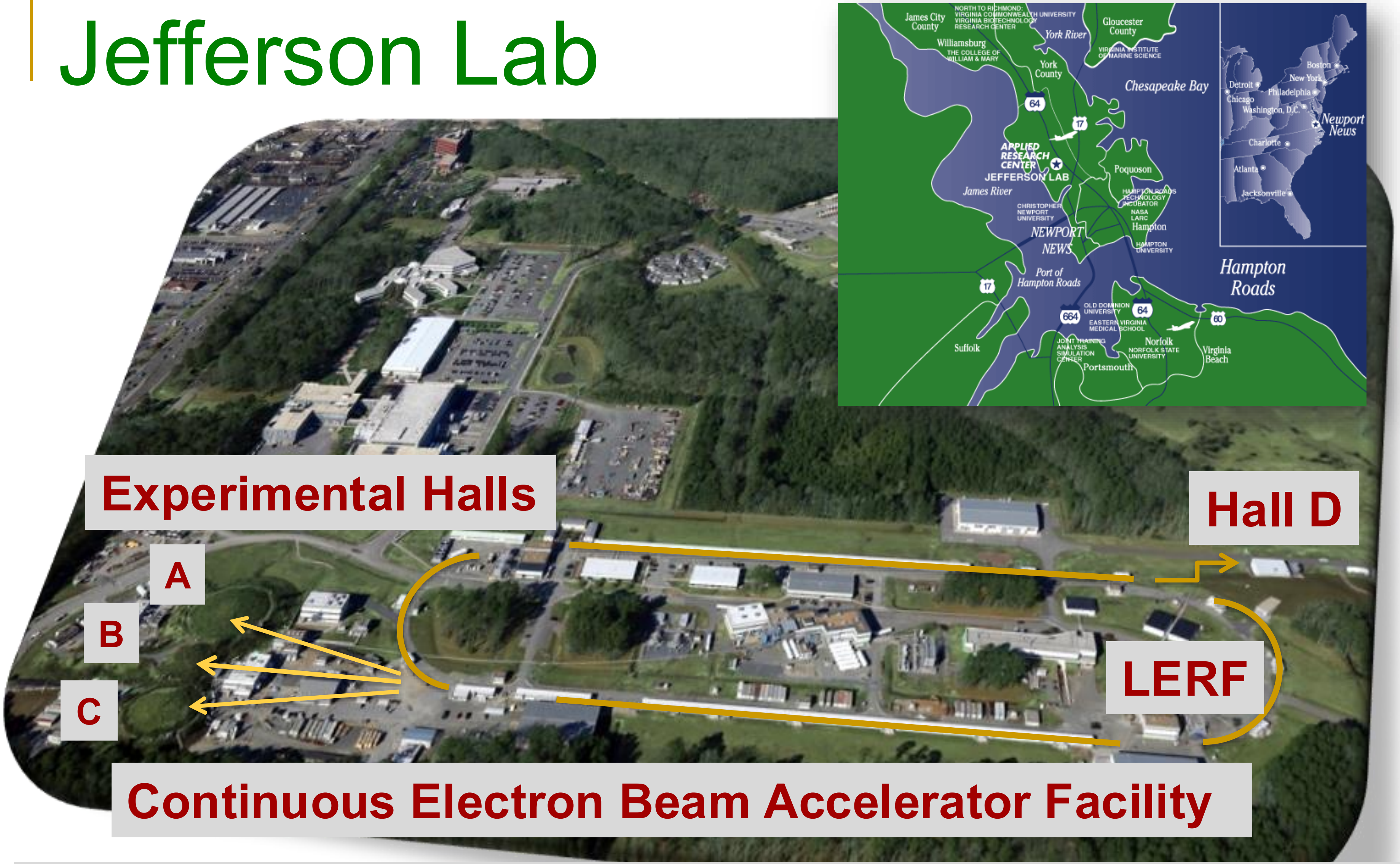
FUNDAMENTAL PROBLEMS IN SUBATOMIC PHYSICS 2026
THE NOVOTEL CAIRNS OASIS RESORT, QUEENSLAND, AUSTRALIA
SEPTEMBER 23 TO 27

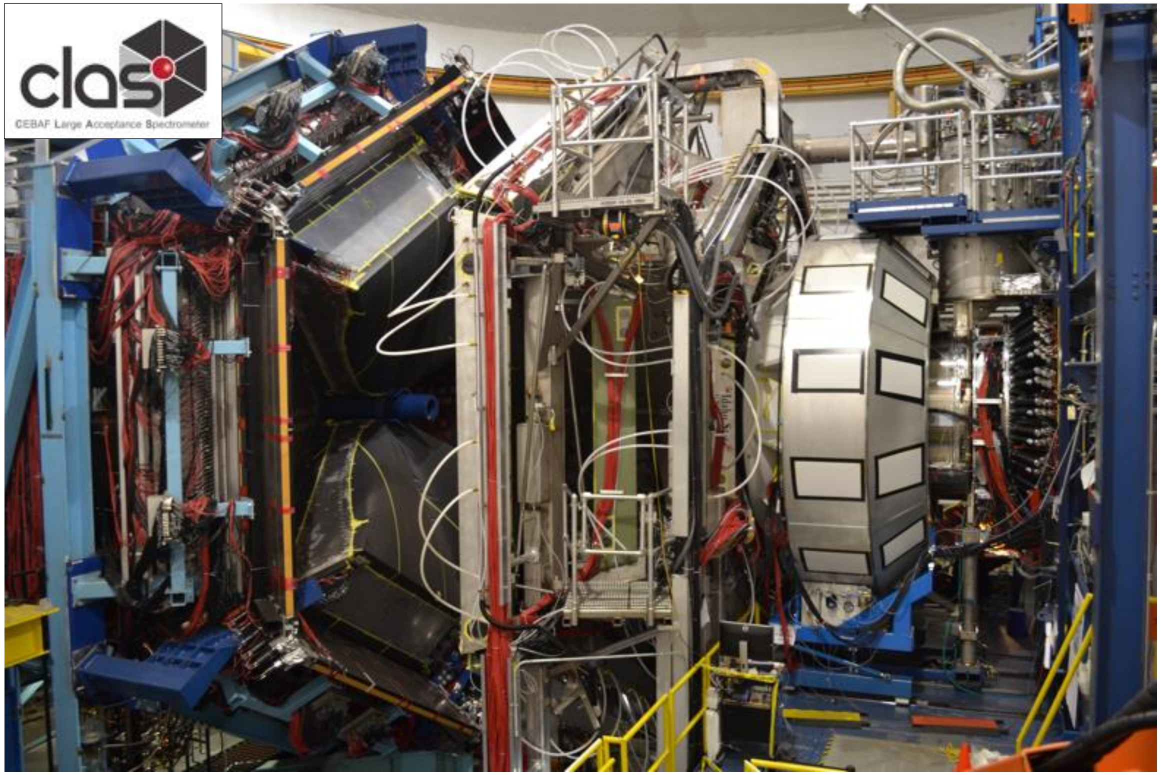
OFFICE OF SCIENCE

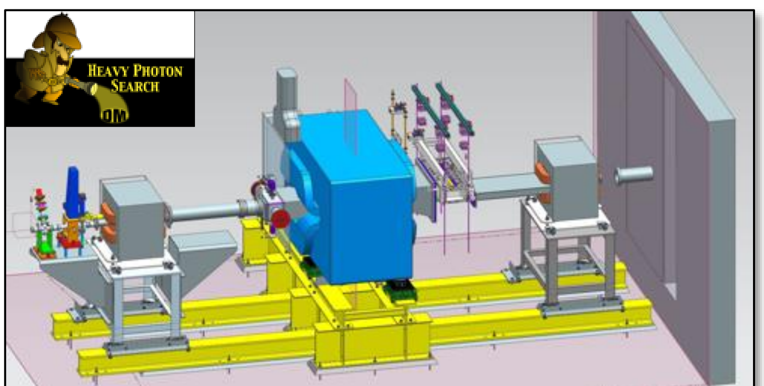
Jefferson Lab
Thomas Jefferson National Accelerator Facility

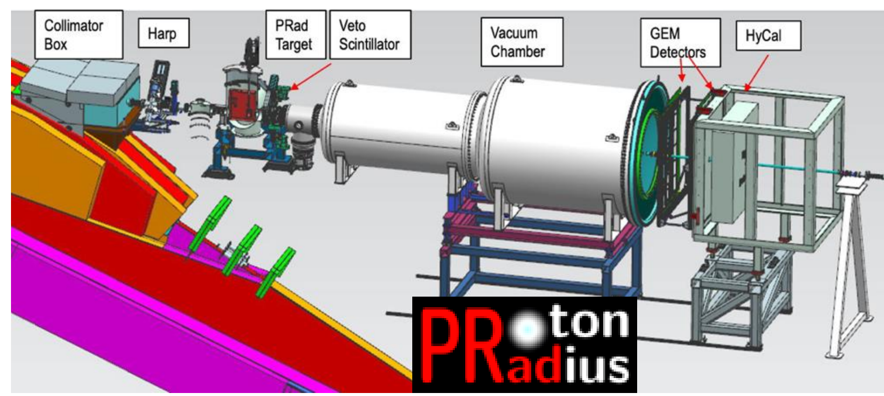
Jefferson Lab



Up to 12 GeV, polarized (P>80%) electron beams for experiments in Halls A, B, C, and D.


clas
CEBAF Large Acceptance Spectrometer

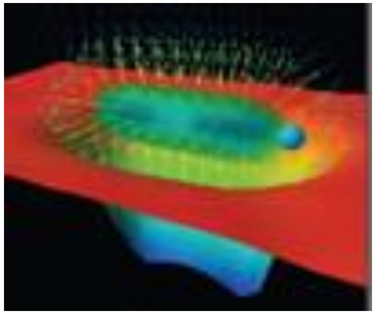

Heavy Photon Search


Collimator Box
Harp
PRad Target
Veto Scintillator
Vacuum Chamber
GEM Detectors
HyCal
PRoton Radius

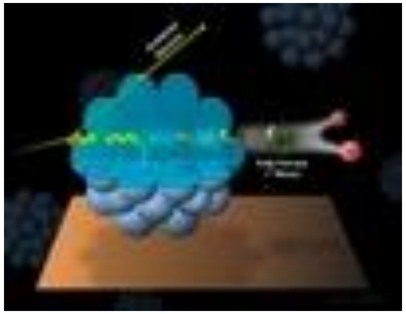
Physics program

- Nucleon and nuclear structure studies, spatial and momentum tomography, form-factors …

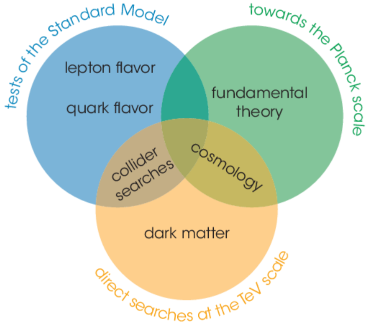
- Exploring the origin of confinement – meson and baryon spectroscopy, exotics …



- Cold nuclear matter, NN correlations, hadronization, color transparency…



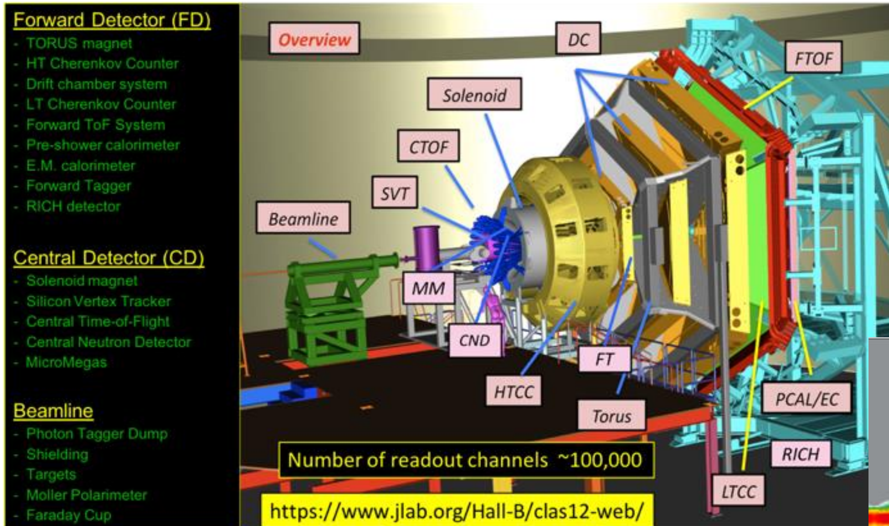
- Low-energy test of the Standard Model and fundamental symmetries.

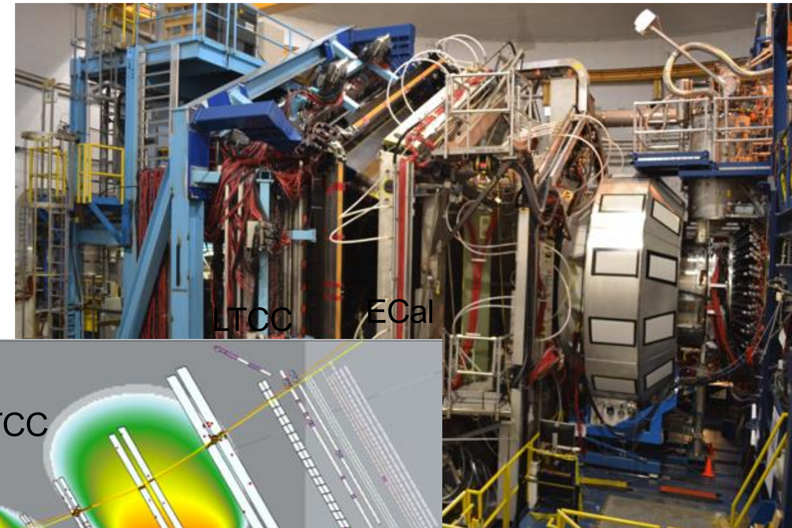


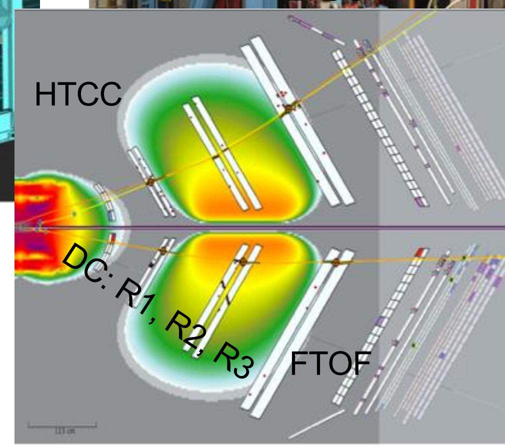
A total of 60 approved experiments, combined into 18 run groups.

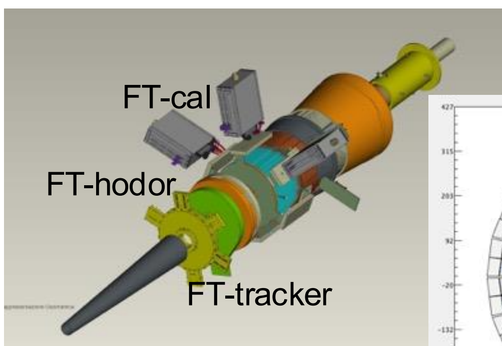
CLAS12 in Hall-B at JLAB

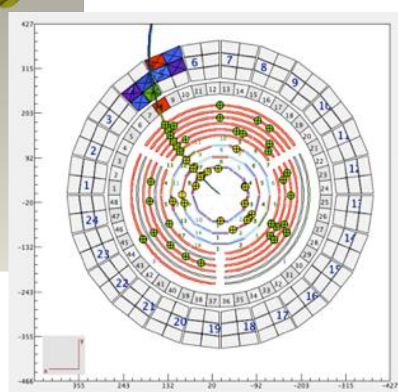
Designed luminosity $10^{35}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$



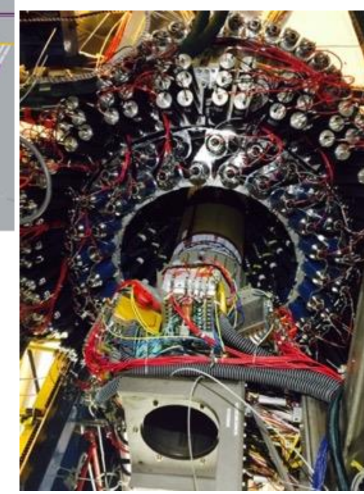








Physics targets:
- LH_2, LD_2, LHe, LAr, D, ^4He
- ^{12}C to ^{208}Pb
- Polarized NH_3, ND_3

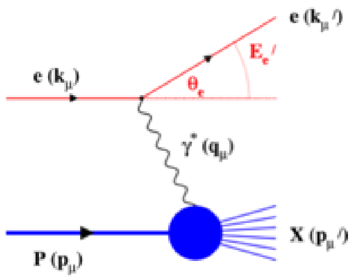


3-D Structure of the Nucleon: TMDs and GPDs

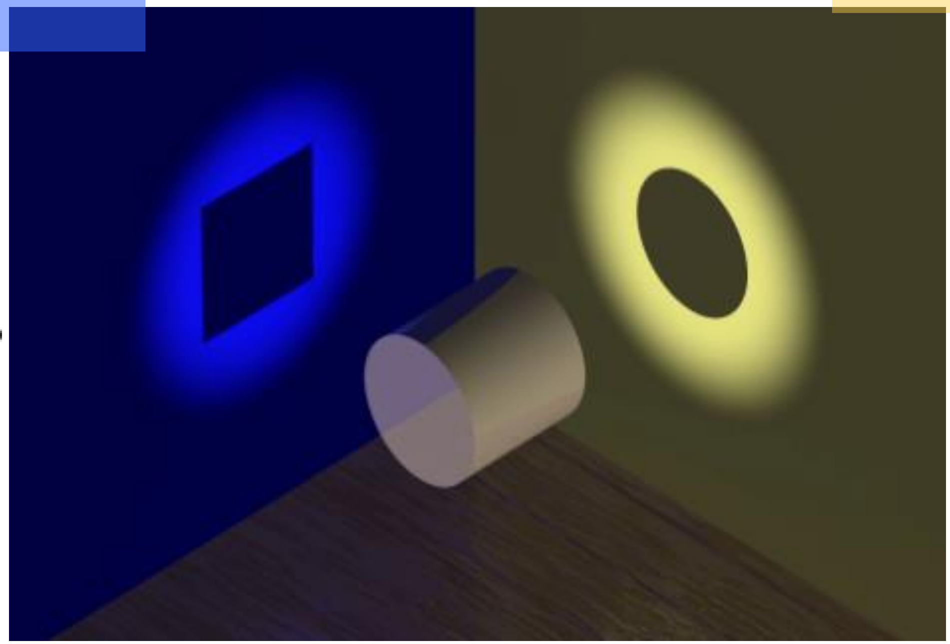
DIS Parton Distribution Functions

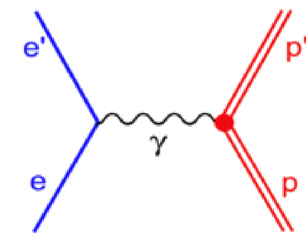
Two orthogonal views.

Elastic Form Factors



No information on the spatial location of the constituents



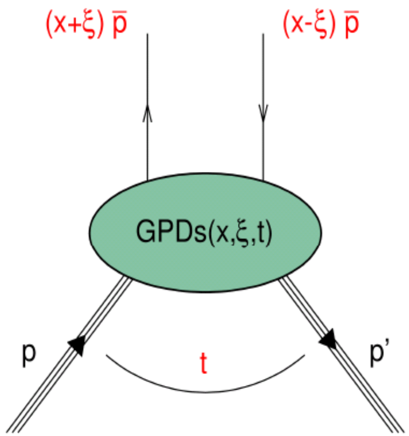


No information about the underlying dynamics of the system

Transverse Momentum Distributions & Generalized Parton Distributions

3-D imaging of the nucleon, the correlation of quark/antiquark transverse spatial and longitudinal momentum distributions, and the quark angular momentum distribution

3-D imaging in coordinate space – GPDs



- Four leading-twist chiral-even GPDs: $H,\ E,\ \widetilde{H},\tilde{E}$
- Four chiral-odd transversity GPDs: $H_T,\ E_T,\ \widetilde{H}_T,\tilde{E}_T$

Nucleon spin

$$\mathbf{J_Q = \sum_q \frac{1}{2}\int_{-1}^{1} dx\, x(H^q(x,\xi,0) + E^q(x,\xi,0))}$$

Nucleon tomography

$$\mathbf{H^q(x,b_\perp) = \int \frac{d^2\Delta_\perp}{(2\pi)^2} e^{-ib_\perp\Delta_\perp} H^q(x,0,-\Delta_\perp^2)}$$

Link to the energy-momentum tensor

$$\mathbf{\int_{-1}^{1} dx\, xH^q(x,\xi,t) = A^q(t) + \xi^2 D^q(t)}$$

$$\mathbf{\int_{-1}^{1} dx\, xE^q(x,\xi,t) = B^q(t) - \xi^2 D^q(t)}$$

- In the forward limit ($t \to 0$): *GPDs* $\to$ *PDFs*
- First moments of: *GPDs* $\to$ *FFs*

Deeply virtual exclusive reactions: *DVCS, TCS, DVMP, DDVCS*.

A major thrust of the CLAS12 GeV physics program:

- Compton scattering: observables depend on CFFs, which are convolutions of hard-scattering coefficients with GPDs.
- Deeply Virtual Meson Production (DVMP): amplitudes involve GPD × DA convolutions, providing complementary sensitivity to GPDs through different meson channels.

Polarization	Proton	Neutron
UU	$\mathcal{H}$	$\mathcal{H}$
LU	$\mathrm{Im}\,\mathcal{H}$	$\mathrm{Im}\,\mathcal{E}$
UL	$\widetilde{\mathcal{H}}$	$\widetilde{\mathcal{H}}$
LL	$\widetilde{\mathcal{H}}$	$\widetilde{\mathcal{H}}$
UT	$\mathcal{E}$	$\mathcal{E}$
LT	$\mathcal{E},\widetilde{\mathcal{H}}$	$\mathcal{E},\widetilde{\mathcal{H}}$

Compton scattering

Golden channel for studying GPDs: JLB flagship program

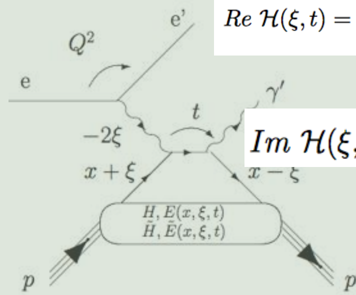
Started with CLAS DVCS in 2001, PRL 87, 182002 (2001).

First experimental measurement with CLAS12, PRL 127, 262501 (2021)

Observables: beam/target asymmetries and the cross sections of in TCS and DVCS access only two out of the three variables that GPDs depend on.

DVCS

Hard scale is defined by space-like photon

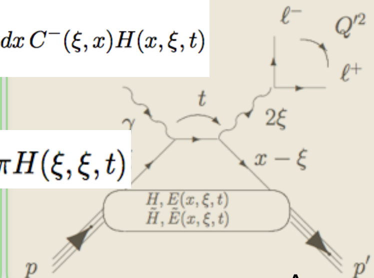


$$Re\ \mathcal{H}(\xi,t) = PV \int_{-1}^{1} dx\, C^{-}(\xi,x) H(x,\xi,t)$$

$$Im\ \mathcal{H}(\xi,t) = i\pi H(\xi,\xi,t)$$

TCS

Hard scale is defined by time-like photons



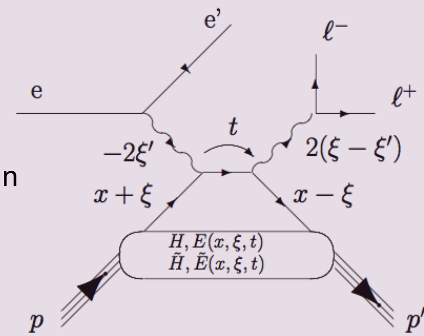
Access to the Re-part of the Compton amplitude

DDVCS provides access to all three dimensions of GPDs, and Jefferson Lab, at the luminosity frontier, is the only place in the world where it can be measured!

μCLAS12 in Hall B is a high-luminosity facility that can carry out this measurement.

DDVCS

Both space-like and time-like photons can set the hard scale

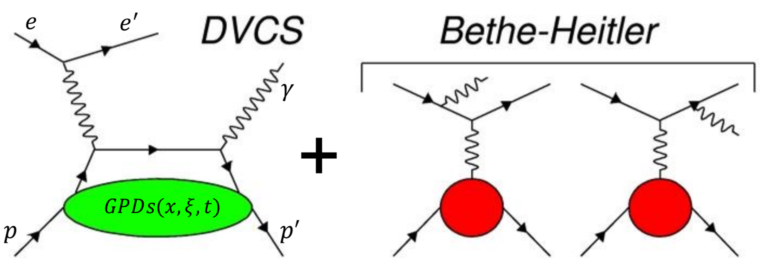


$$\int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x-(2\xi'-\xi)+i\epsilon} + \ldots$$

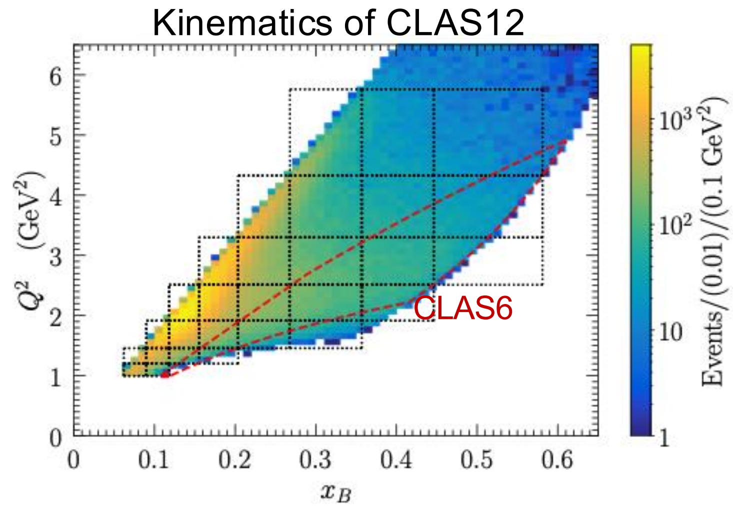
$$H(2\xi'-\xi,\xi,t) + H(-(2\xi'-\xi),\xi,t)$$

σ-DDVCS is three orders of magnitude smaller than σ-DVCS

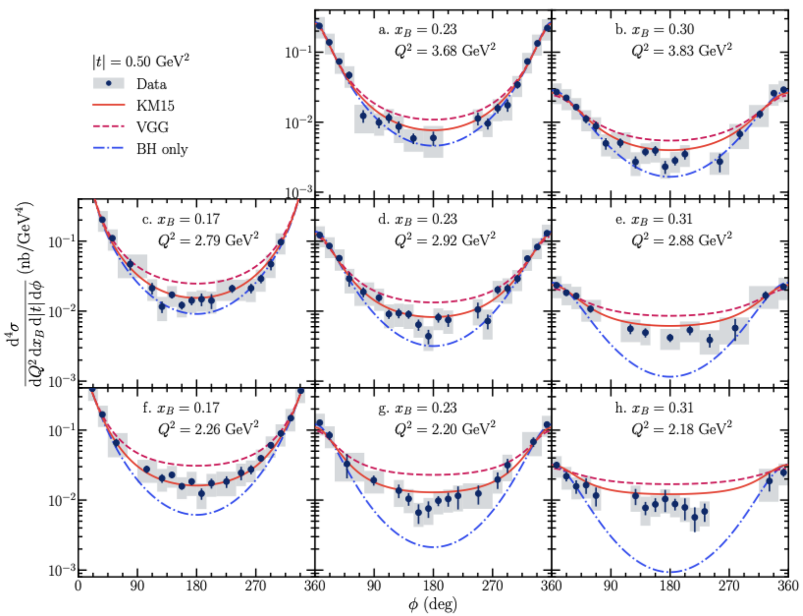
Proton DVCS



$$\frac{d^4\sigma_{ep\to e'p'\gamma}}{dx_B\, dQ^2\, d|t|\, d\phi} = 2\pi\Gamma\left(|\mathcal{T}_{\mathrm{DVCS}}|^2 + |\mathcal{T}_{\mathrm{BH}}|^2 + \mathcal{I}\right)$$



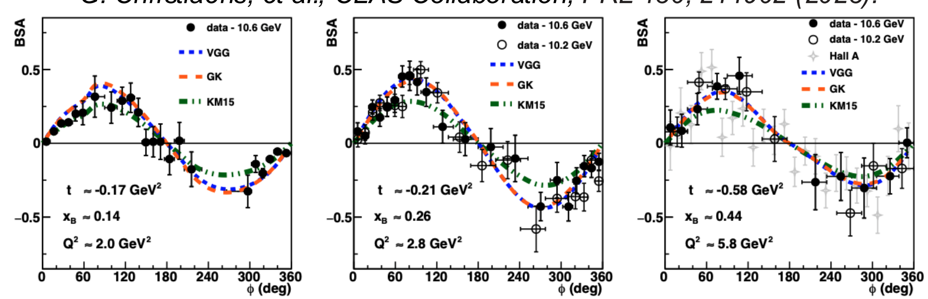
S. Lee, et al., CLAS Collaboration, arXiv:2608.20585 submitted to *PRC.*



$$A_{\mathrm{LU}}(\phi) \sim \frac{s^{\mathcal{I}}_{1,\mathrm{unp}} \sin\phi}{c^{\mathrm{BH}}_{0,\mathrm{unp}} + (c^{\mathrm{BH}}_{1,\mathrm{unp}} + c^{\mathcal{I}}_{1,\mathrm{unp}} + \cdots)\cos\phi \cdots}$$

$$s^{\mathcal{I}}_{1,\mathrm{unp}} \propto \Im\mathrm{m}\left[F_1\mathcal{H} + \xi(F_1+F_2)\tilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}\right]$$

G. Christiaens, et al., CLAS Collaboration, PRL 130, 211902 (2023).



Neutron DVCS

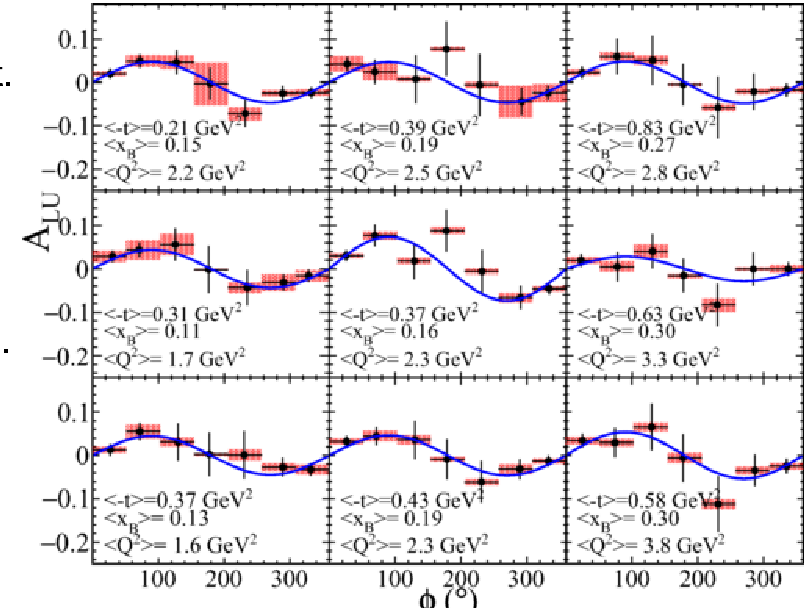
A. Hobart et al., CALS collaboration, Phys. Rev. Lett. 133, 211903 (2024).

The first measurement of BSA for *n*DVCS in a fully exclusive reaction using deuterium as a neutron target.

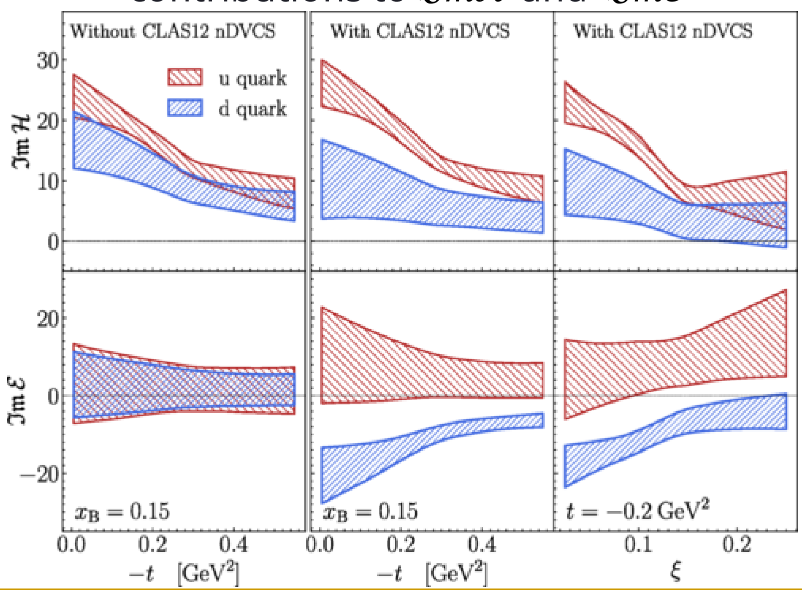
$$\sigma(ed \rightarrow e'n\gamma(p)) = \sigma_{BH} + \sigma_{DVCS} + \sigma_{INT}$$

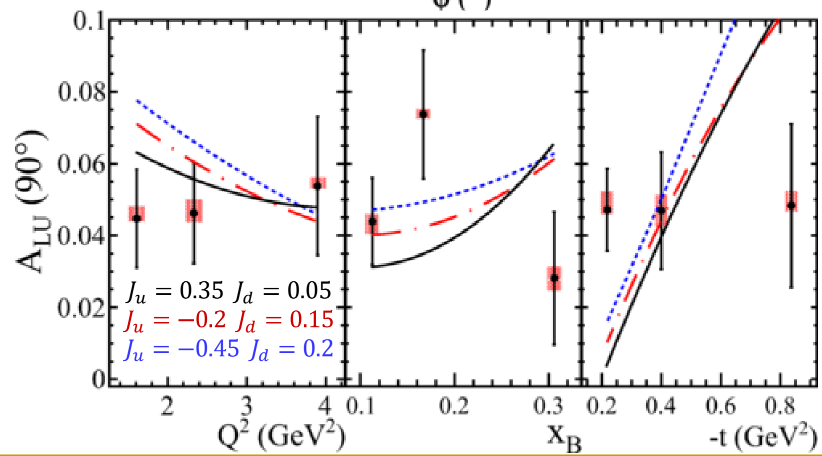
$$A_{LU} \propto \sin\phi\ \Im m(F_1\mathcal{H} + \xi(F_1+F_2)\tilde{\mathcal{H}} - \frac{t}{4M^2}\mathcal{E})$$

BSA is sensitive to the CFF E and provides access to the GPD E, one of the ingredients in Ji's spin sum rule.



Extraction of the ***u*** and ***d*** quark contributions to $\Im m\mathcal{H}$ and $\Im m\mathcal{E}$





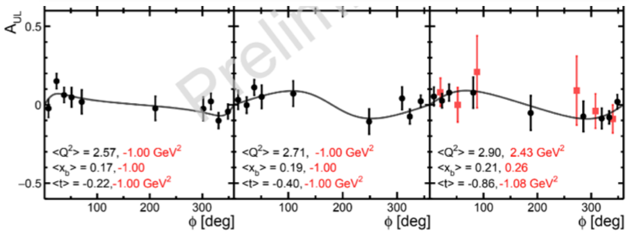
DVCS with polarized targets

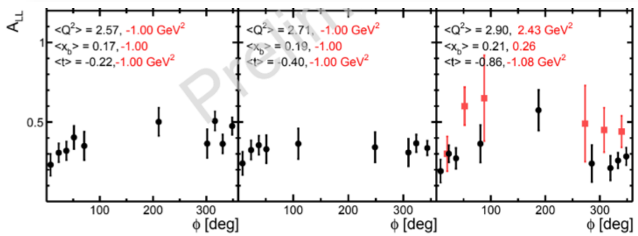
Longitudinally polarized NH_3 and ND_3

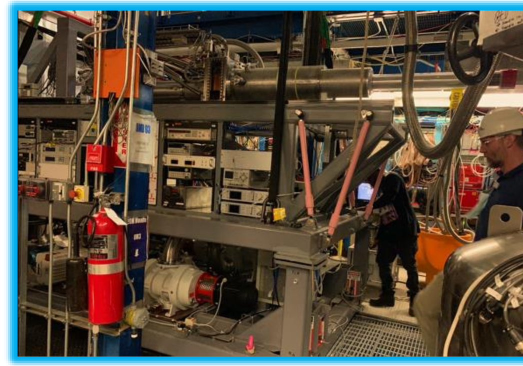
Observables $\boldsymbol{A_{UL}}$ for the imaginary part of the CFF $\mathcal{H}$ and $\widetilde{\mathcal{H}}$, and $\boldsymbol{A_{LL}}$ to access to the real part.

$$A_{\mathrm{UL}}(\phi) \sim \frac{s^{\mathcal{I}}_{1,\mathrm{LP}} \sin\phi}{c^{\mathrm{BH}}_{0,\mathrm{unp}} + (c^{\mathrm{BH}}_{1,\mathrm{unp}} + c^{\mathcal{I}}_{1,\mathrm{unp}} + \cdots)\cos\phi}$$

$$A_{\mathrm{LL}}(\phi) \sim \frac{c^{\mathrm{BH}}_{0,\mathrm{LP}} + c^{\mathcal{I}}_{0,\mathrm{LP}} + (c^{\mathrm{BH}}_{1,\mathrm{LP}} + c^{\mathcal{I}}_{1,\mathrm{LP}})\cos\phi}{c^{\mathrm{BH}}_{0,\mathrm{unp}} + (c^{\mathrm{BH}}_{1,\mathrm{unp}} + c^{\mathcal{I}}_{1,\mathrm{unp}} + \cdots)\cos\phi}$$







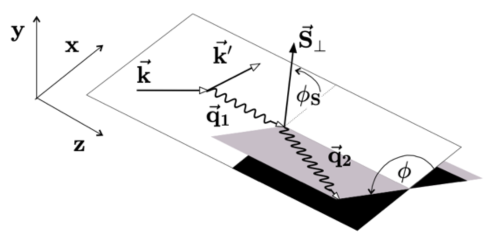
Transversely polarized NH_3

- A single-target spin (UT) and double-spin (LT) asymmetry give access to the imaginary and real parts of CFFs.
- The main target is the CFF $\mathcal{E}$. Together with nDVCS, this experiment will provide data for flavor separation of GPD E.

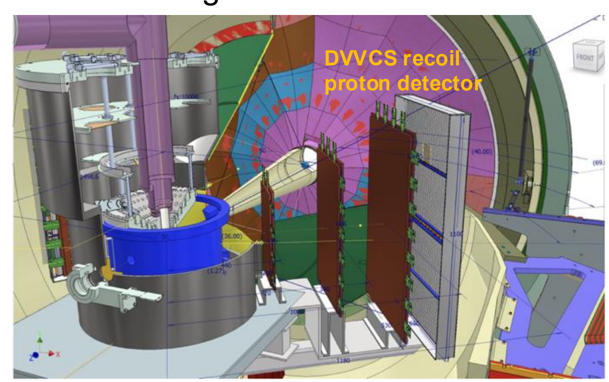
$$A_{UT}^{\sin(\phi_S-\phi)} \propto \cos\phi\, \Im m(C^{I}_{TP})$$

$$A_{LT}^{\sin(\phi_S-\phi)} \propto \sin\phi\, \Re m(C^{I}_{TP})$$

$$C^{I}_{TP} \propto \frac{1-x_B}{2-x_B}\frac{t}{m^2}F_2\mathcal{H} + (2-x_B)\frac{t}{4m^2}F_1\mathcal{E}$$



Target inside HTCC

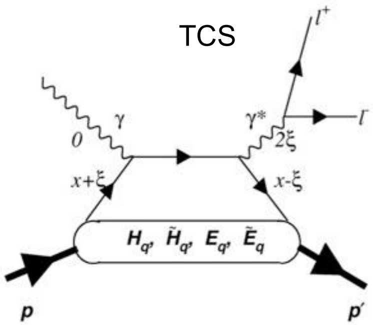


Run is scheduled for 2031

First experimental measurement of TCS

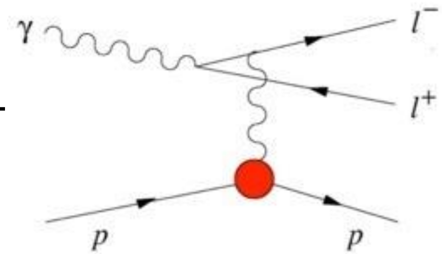
$$ep \rightarrow e^+e^-p'(X \equiv e')$$

TCS



+

Bethe-Heitler (BH)



$$\frac{d\sigma_{INT}}{dQ'^2\,dt\,d(\cos\theta)\,d\varphi} = -\frac{\alpha_{em}^3}{4\pi s^2}\frac{1}{-t}\frac{M}{Q'}\frac{1}{\tau\sqrt{1-\tau}}\frac{L_0}{L}\left[\cos\varphi\frac{1+\cos^2\theta}{\sin\theta}\mathrm{Re}\tilde{M}^{--} - \cos 2\varphi\sqrt{2}\cos\theta\,\mathrm{Re}\tilde{M}^{0-} + \cos 3\varphi\,\sin\theta\,\mathrm{Re}\tilde{M}^{+-} + O\left(\frac{1}{Q'}\right)\right]$$

Photon polarization

$$-\lambda\frac{\alpha_{em}^3}{4\pi s^2}\frac{1}{-t}\frac{M}{Q'}\frac{1}{\tau\sqrt{1-\tau}}\frac{L_0}{L}\left[\sin\varphi\frac{1+\cos^2\theta}{\sin\theta}\mathrm{Im}\tilde{M}^{--} - \sin 2\varphi\sqrt{2}\cos\theta\,\mathrm{Im}\tilde{M}^{0-} + \sin 3\varphi\,\sin\theta\,\mathrm{Im}\tilde{M}^{+-} + O\left(\frac{1}{Q'}\right)\right].$$

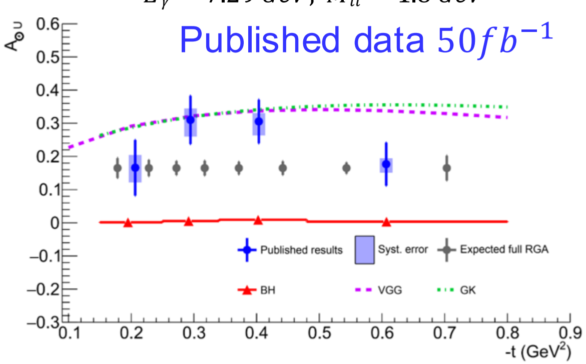
$A_{\odot U} \sim \sin\varphi ImM^{--}$, universality of GPDs

$$\tilde{M}^{--} = \frac{2\sqrt{t_0-t}}{M}\frac{1-\xi}{1+\xi}\left[F_1(t)\mathcal{H} - \xi\big(F_1(t)+F_2(t)\big)\tilde{\mathcal{H}} - \frac{t}{4M^2}F_2(t)\mathcal{E}\right]$$

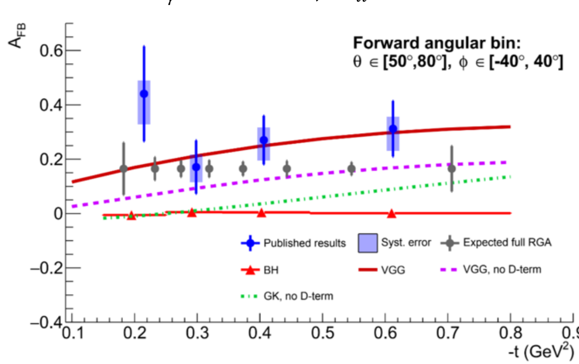
$A_{FB} \sim \cos\varphi ReM^{--}$, access to the EM FF $D^Q(t)$ (D-term).

P. Chatagnon, et al. (CLAS Collaboration), PRL 127, 262501 (2021).

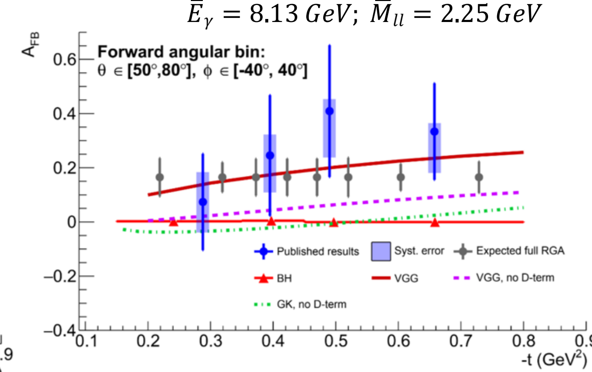
$\bar{E}_\gamma = 7.29\ GeV;\ \bar{M}_{ll} = 1.8\ GeV$



$\bar{E}_\gamma = 7.23\ GeV;\ \bar{M}_{ll} = 1.81\ GeV$



$\bar{E}_\gamma = 8.13\ GeV;\ \bar{M}_{ll} = 2.25\ GeV$



The available data is about $155 fb^{-1}$. The expected full data set will be $760 fb^{-1}$ (grey predictions on the plots).

Future plans μCLAS12 @ $10^{37} cm^{-2} s^{-1}$

$$ep \rightarrow e'\gamma^* p' \rightarrow e'\mu^+\mu^- p'$$

The setup is based on the existing CLAS12 forward detector.

- *A* *lead shield* *to reduce pion background in the FD.*
- *A PbWO4* calorimeter *for scattered electron identification.*
- *A* *GEM Forward Vertex* tracker *will be used for vertexing.*
- *A recoil proton detector –* *μRWELL recoil tracker* *surrounds the target, and a* *Central Scintillator Hodoscope*.

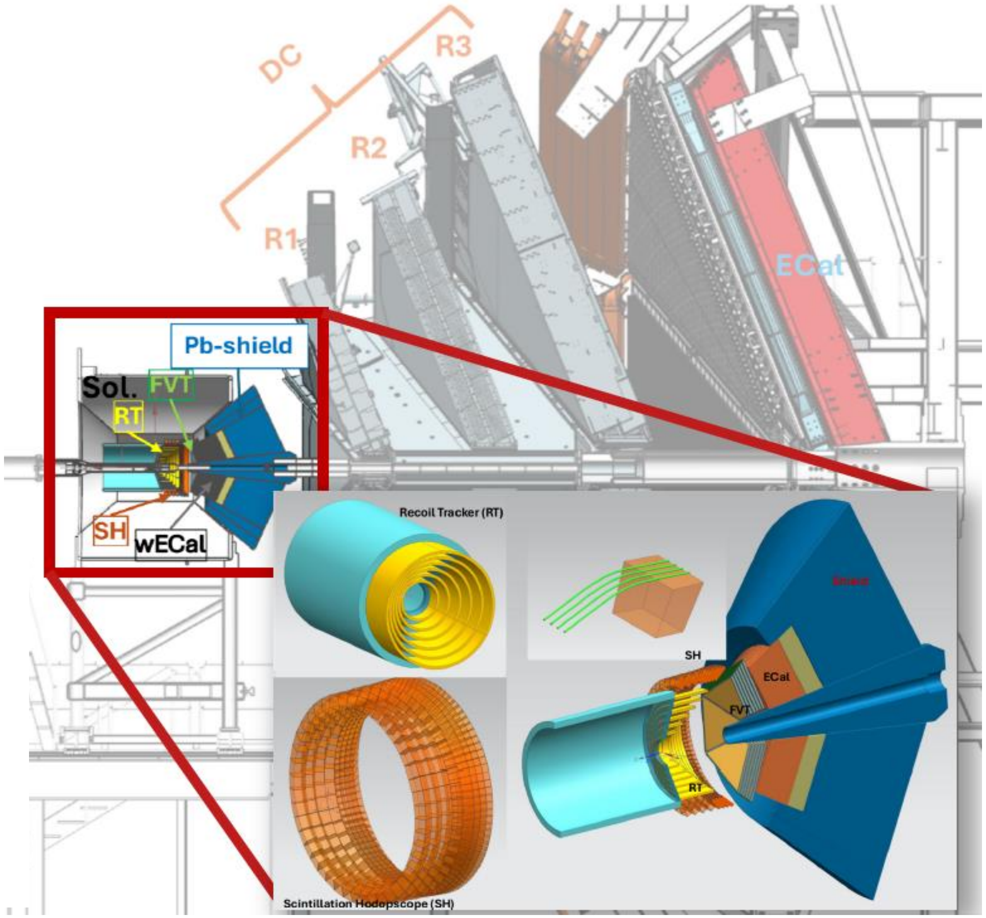
Single MIP (μ) Trigger rate: 21kHz.

DDVCS and J/ψ electroproduction:

$$e'\mu^+\mu^-$$

Time-like Compton scattering

$$p'\mu^+\mu^-$$



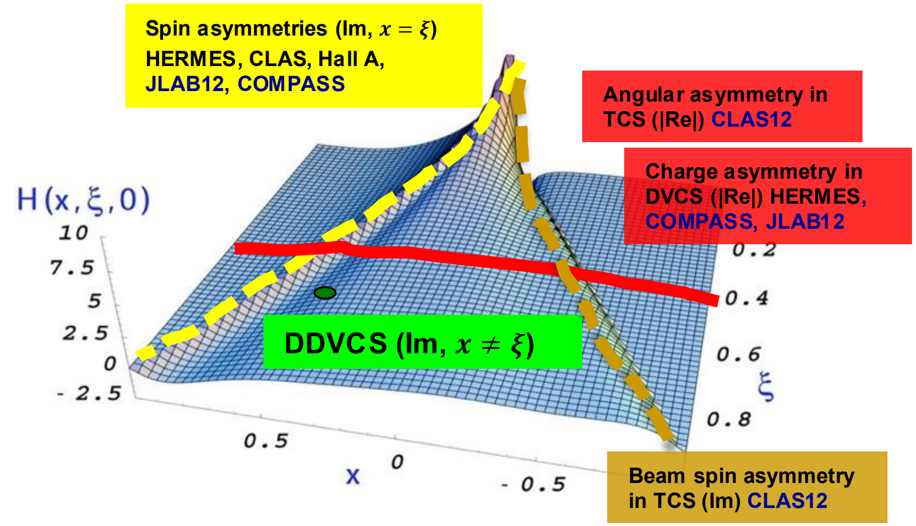
DDVCS: $ep \to\to e'\mu^+\mu^-(p')$

Challenges:

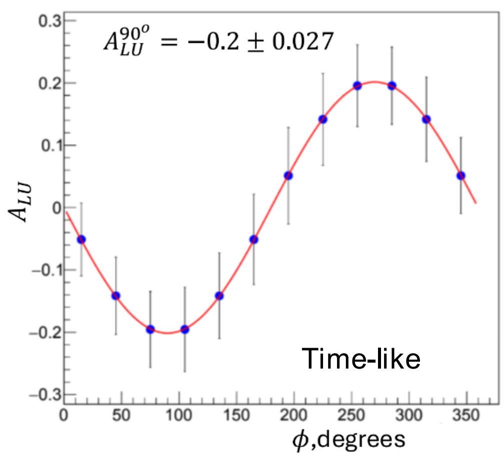
a) Small cross-section requires high luminosity;
b) Muon detection is needed to overcome ambiguities and anti-symmetrization issues with the decay and scattered leptons.

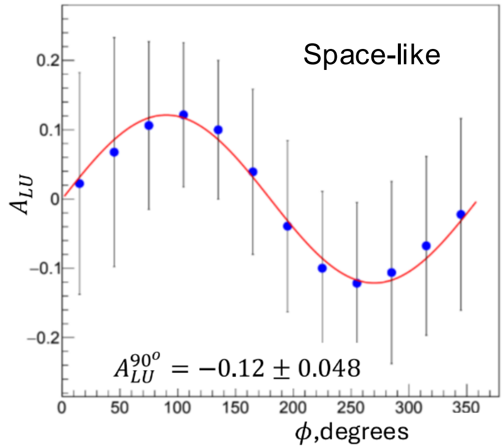
Key measurements include:

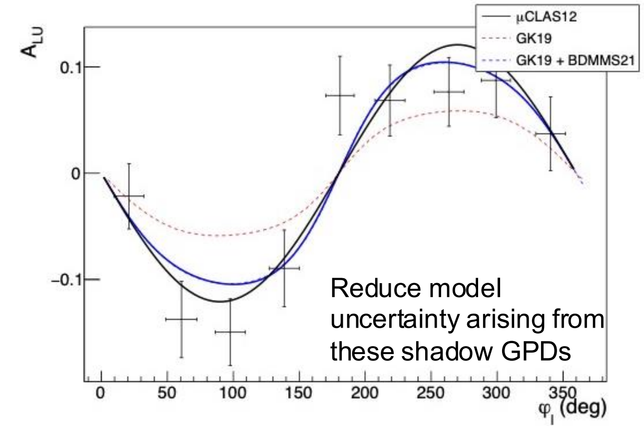
- A_{LU} in the transition from a ***time-like*** to a ***space-like*** region to validate the GPD formalism;
- *t*-dependence of A_{LU} to constrain models;
- Contribute to resolving the ***shadow GPDs***.



$$\Delta\sigma_{LU} \propto \mathrm{Im}[F_1\mathcal{H}(\xi',\xi,t) + \xi'(F_1+F_2)\tilde{\mathcal{H}}(\xi',\xi,t) - \frac{t}{4M^2}F_2\mathcal{E}(\xi',\xi,t)]\sin\phi$$

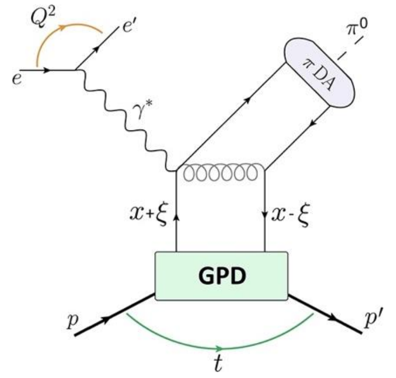






DVMP and transversity GPDs

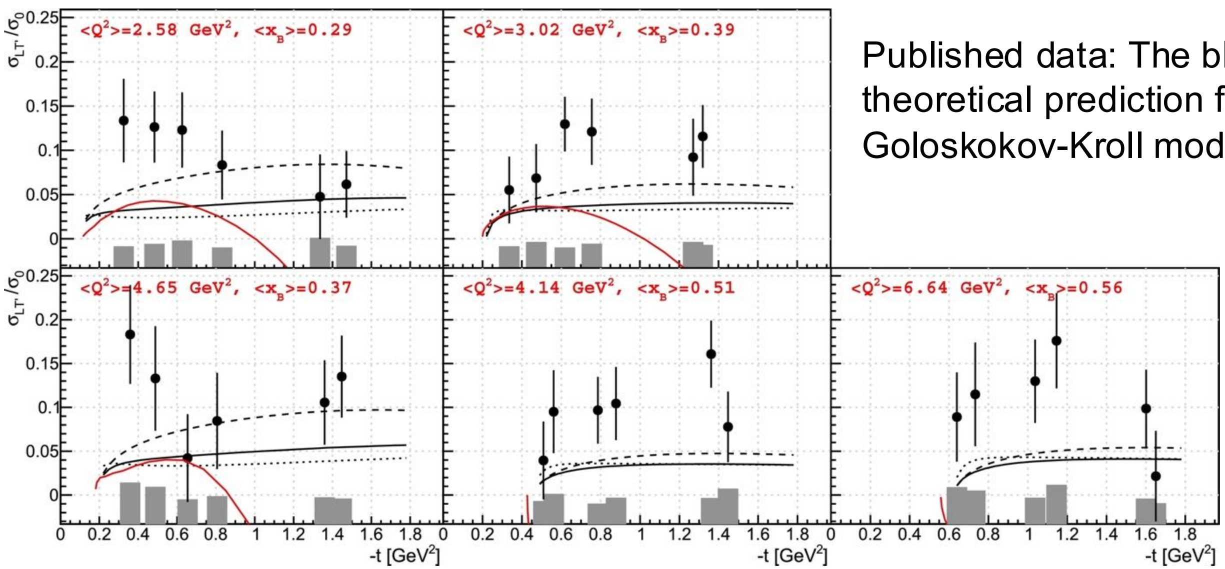
A. Kim et al., CLAS collaboration, Phys. Lett. B 849 (2024) 138459.



- Deeply virtual exclusive production of π^0 has an increased sensitivity to chiral-odd GPD, $\bar{E}_T = 2\widetilde{H}_T + E_T$.
- The $\sin\phi$ moment of BSA projects out $\sigma_{LT'}/\sigma_0$:

$$BSA = \frac{\sqrt{2\epsilon(1-\epsilon)}\frac{\sigma_{LT'}}{\sigma_0}\sin\phi}{1+\sqrt{2\epsilon(1+\epsilon)}\frac{\sigma_{LT}}{\sigma_0}\cos\phi+\epsilon\frac{\sigma_{TT}}{\sigma_0}\cos 2\phi}$$

$$\frac{\sigma_{LT'}}{\sigma_0} \sim \frac{Im[\langle\bar{E}_T\rangle^*\langle\widetilde{H}\rangle + \langle H_T\rangle^*\langle\widetilde{E}\rangle]}{(1-\xi^2)\left|\langle H_T\rangle\right|^2 - \frac{t'}{8m^2}\left|\langle\bar{E}_T\rangle\right|^2 + \epsilon\sigma_L}.$$

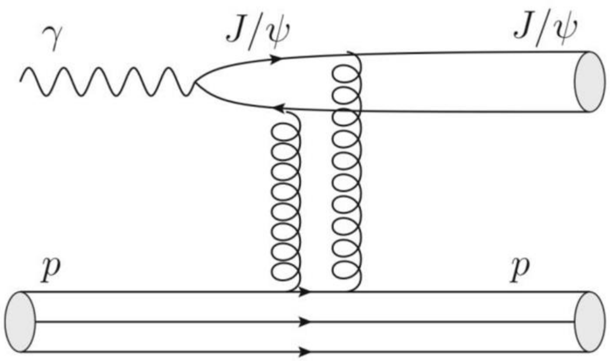


Published data: The black curves show the theoretical prediction from the GPD-based Goloskokov-Kroll model. The other curves are:

- The black dashed lines show the effect of the GPD $\tilde{E}_T$ multiplied by a factor of 0.5,
- the black dotted lines show the effect of the GPD H_T multiplied by a factor 0.5.
- The red curve shows the theoretical predictions from the Regge-based JML model.

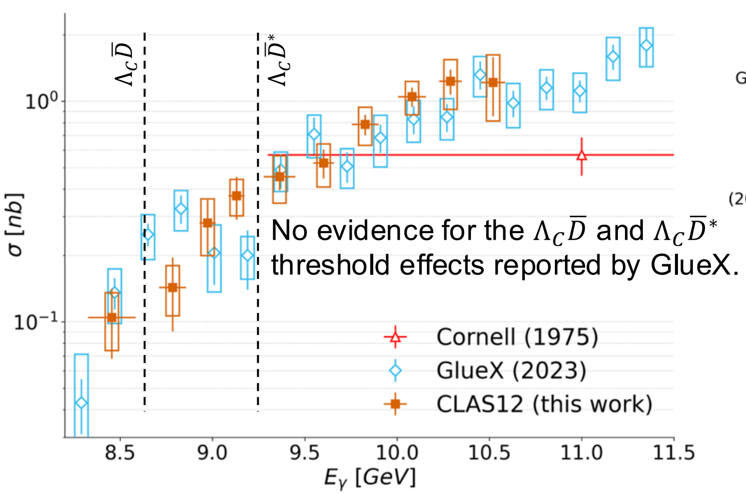
Near threshold J/ψ production gluonic structure of the nucleon

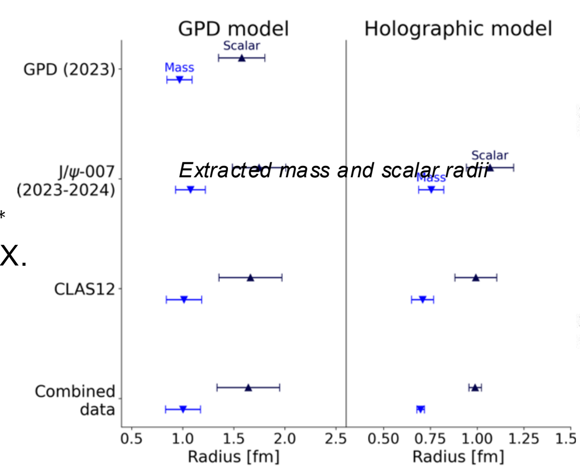
- At the energy-production threshold, the t-dependence of the cross-section provides access to gluon Gravitational Form Factors (GFFs) and the nucleon mass radius.
- Study the gluon Gravitational Form Factors $A_g(t)$ and $C_g(t)$ (GPD and holographic-QCD approaches).

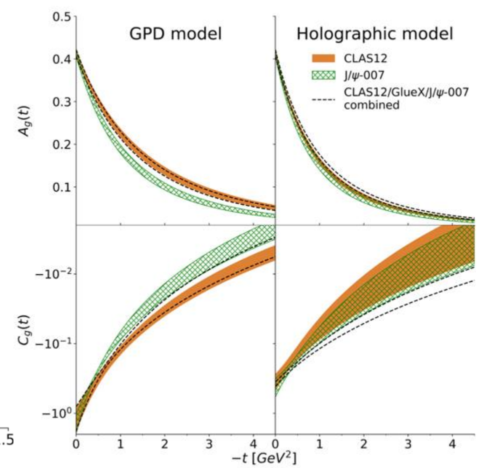


$$\frac{d\sigma_{\gamma p\to J/\Psi p}}{dt} = \frac{1}{64\pi s}\frac{1}{|p_{\rm cm}|^2}|\mathcal{M}_{\gamma p\to J/\Psi p}(t)|^2 \qquad \mathcal{M}_{\gamma p\to J/\Psi p}(t) \propto \langle p'|T^g_{\mu\mu}|p\rangle$$

$$\langle p',s'|\hat{T}^a_{\mu\nu}(x)|p,s\rangle = \bar{u}'\left[A^a(t)\frac{\gamma_{\{\mu}P_{\nu\}}}{2} + B^a(t)\frac{iP_{\{\mu}\sigma_{\nu\}\rho}\Delta^\rho}{4m} + D^a(t)\frac{\Delta_\mu\Delta_\nu - g_{\mu\nu}\Delta^2}{4m} + m\bar{c}^a(t)g_{\mu\nu}\right]ue^{i(p'-p)x}$$



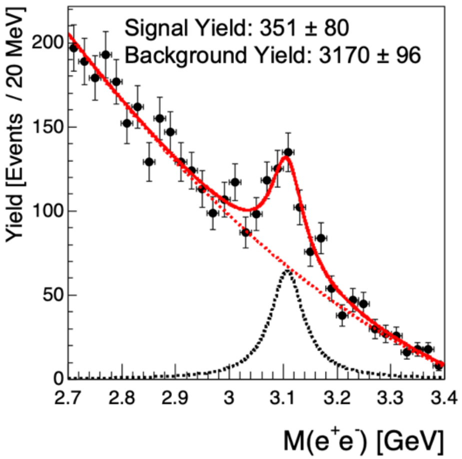


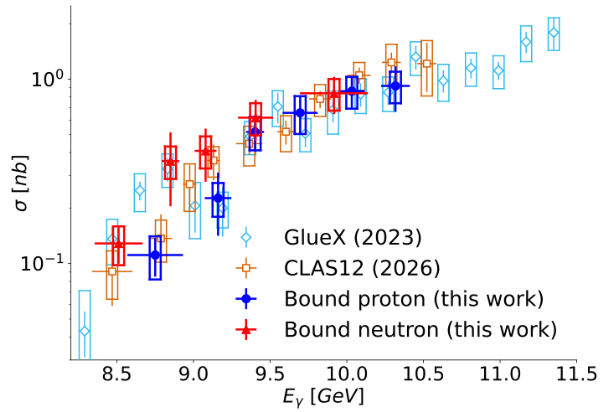


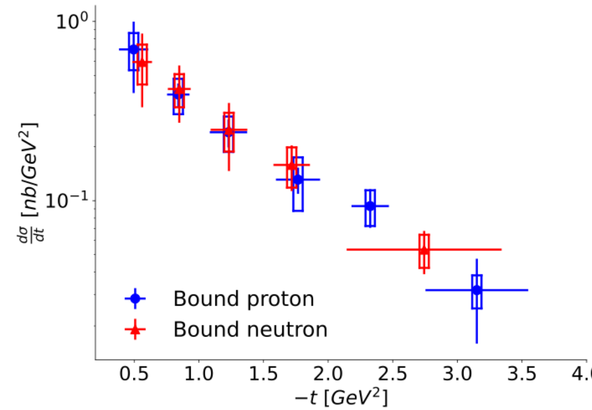
P. Chatagnon *et al.*, [the CLAS Collaboration], Phys. Rev. C. 113, 065203 (2026).

J/ψ photoproduction on the deuteron

First exclusive near-threshold photoproduction of $\gamma n \to n' J/\psi$, a comparison of gluonic properties in the neutron and proton, as well as in free and bound nucleons, including the gluonic mass and scalar radii.

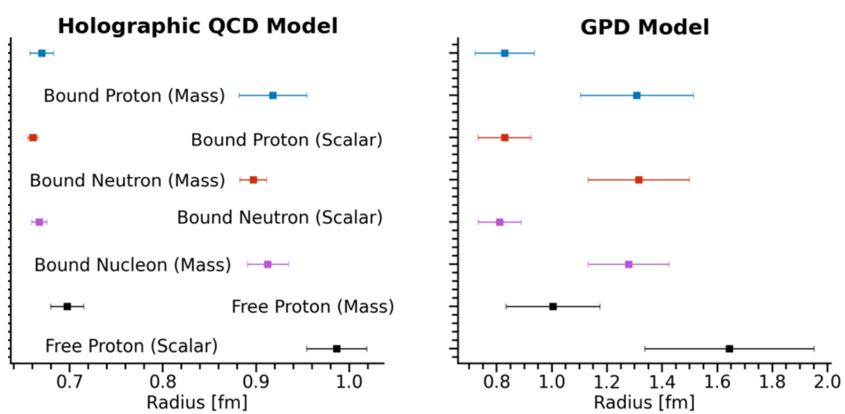


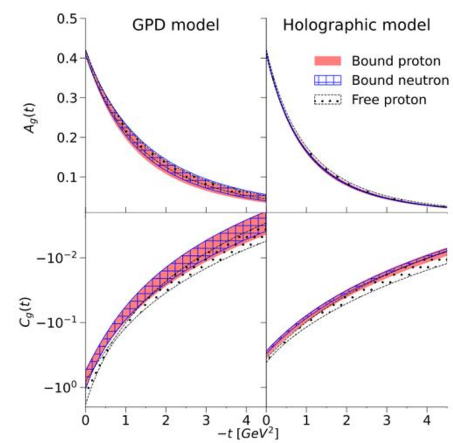




$$A_g(t) = \frac{A_g(0)}{\left(1 - \frac{t}{m_A^2}\right)^3},$$

$$C_g(t) = \frac{C_g(0)}{\left(1 - \frac{t}{m_C^2}\right)^3},$$





R. Tyson *et al.*, [the CLAS Collaboration], arXiv:2609.03579 submitted to PRL.

3-D imaging in momentum space – TMDs

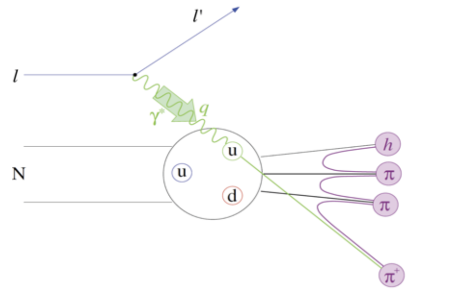
Leading-twist TMD PDFs

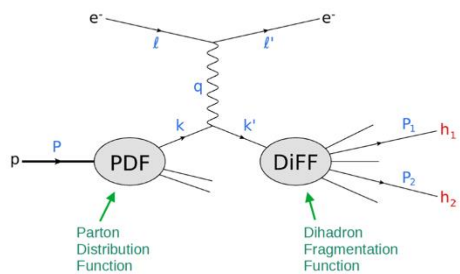
N\q	U	L	T
U	f_1	—	$h_1^{\perp}$
L	—	g_{1L}	$h_{1L}^{\perp}$
T	$f_{1T}^{\perp}$	g_{1T}	$h_1,\ h_{1T}^{\perp}$

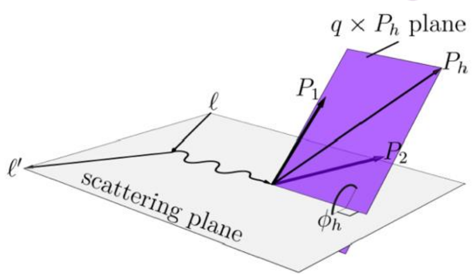
$$\sigma = F_{UU} + P_t F_{UL}^{\sin\phi} \sin 2\phi + P_b F_{LU}^{\sin\phi} \sin\phi \ldots$$

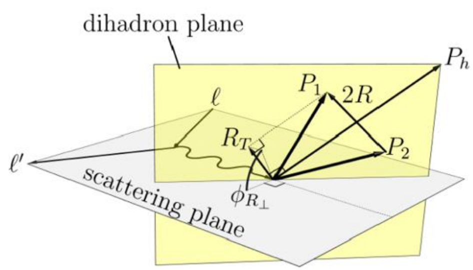
- **Diagonal terms:** unpolarized, helicity, and transversity PDFs; **off-diagonal terms**: Sivers, Boer–Mulders, and worm-gear distributions.
- **Single- and dihadron SIDIS:** different PDF–fragmentation-function combinations provide complementary access to nucleon spin and 3D structure.

With high luminosity, high efficiency for multiparticle final states, polarized electron beams, and longitudinally, transversely, and unpolarized targets, CLAS12 enables a broad program of spin-dependent measurements to access $PDF(x) \otimes TMDFF(x, p_T)$ in single and $PDF(x) \otimes DiFF(x, M_{hh}, R_T)$ dihadron SIDIS.





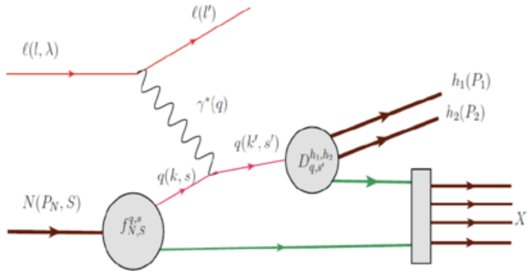




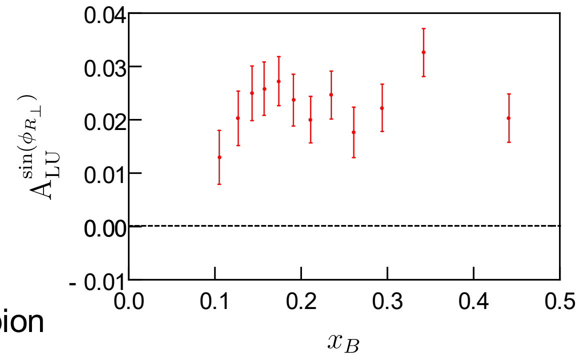
Polarization: BT	Single hadron: PDF × FF	Dihadron: PDF × DiFF	Main physics
UU	$f_1 \otimes D_1$	$f_1 \otimes D_1$	Unpolarized
LU	$e \otimes H_1^{\perp}$, $g^{\perp} \otimes D_1$	$e \otimes H_1^{\sphericalangle}$	Beam-spin; twist-3
UL	$h_{1L}^{\perp} \otimes H_1^{\perp}$	$h_L \otimes H_1^{\sphericalangle}$	L-target spin
LL	$g_1 \otimes D_1$	$g_1 \otimes D_1$	Helicity
UT	$f_{1T}^{\perp} \otimes D_1$: $h_1 \otimes H_1^{\perp}$: $h_{1T}^{\perp} \otimes H_1^{\perp}$	— $h_1 \otimes H_1^{\sphericalangle}$ —	Sivers : Transversity : Pretzelosity
LT	$g_{1T} \otimes D_1$	— / subleading contributions	Worm-gear

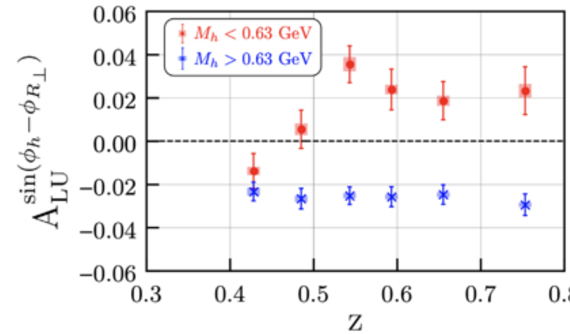
Di-hadron production in SIDS

BSA in the Process $ep \to e\pi^+\pi^- X$ *with CLAS12*



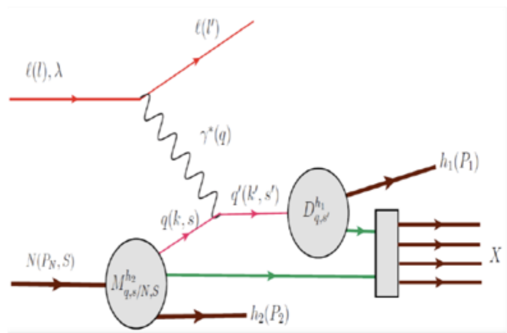
$$d\sigma_{\mathrm{LU}} \propto W\lambda_e \sin(\phi_{R_\perp})\left[xe(x)H_1^{\sphericalangle}(z,M_h)+\frac{1}{z}f_1(x)\tilde{G}^{\sphericalangle}(z,M_h)\right]$$



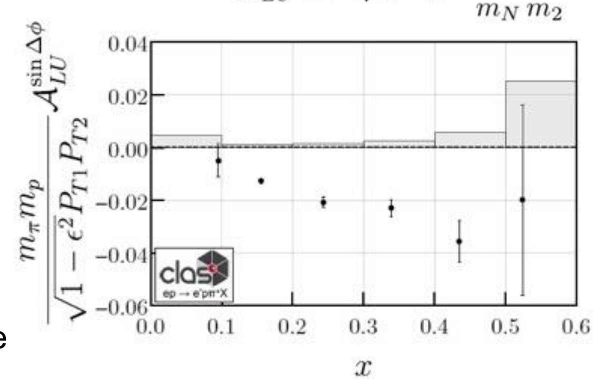


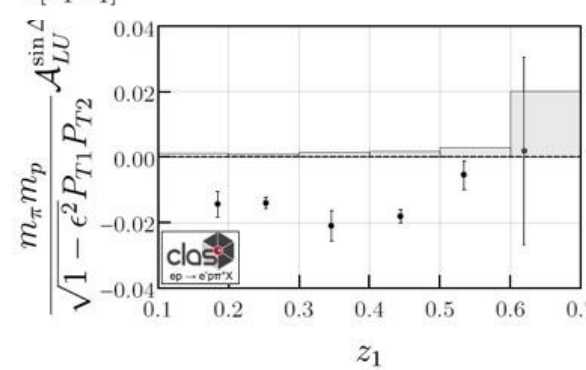
- Extraction of twist-3 collinear PDF $A_{LU}^{\sin(\phi_{R\perp})} \sim \boldsymbol{e(x)}$
- Sensitive to the helicity-dependent two-pion fragmentation function $A_{LU}^{\sin(\phi_h-\phi_{R\perp})} \sim \boldsymbol{G_1^{\perp}}$

BSA in back-to-back di-hadron production in the reaction $ep \to ep\pi^+ X$



$$A_{LU} = -\sqrt{1-\epsilon^2}\,\frac{|\vec{P}_{T1}||\vec{P}_{T2}|}{m_N\, m_2}\,\frac{\mathcal{C}[w_5\,\hat{l}_1^{\perp h} D_1]}{\mathcal{C}[\hat{u}_1 D_1]}\,\sin\Delta\phi.$$



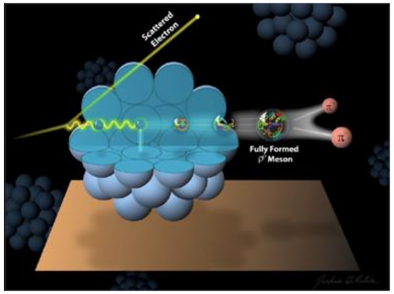


One of hadrons in CFR another in TFR, provides access to *leading twist* fracture functions, $\hat{l}_1^{\perp h}$ and $\hat{u}_1$.

H. Avakian et al., [CLAS Collaboration] PRL 130, *022501 (2023)*

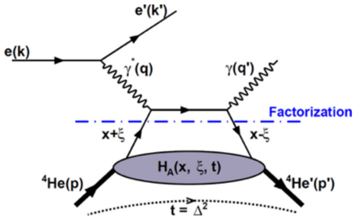
QCD and nuclei

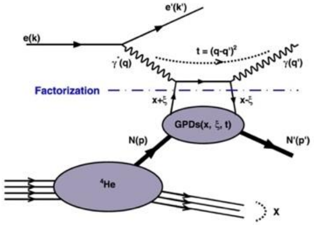
- Nucleon modification, tagged EMC.
- Short-range NN correlations.
- Quark/hadron propagation and CT.
- Nuclear DVCS



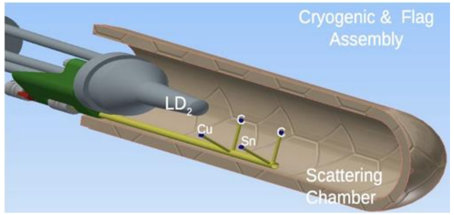
$e^4He \rightarrow e'^4He'\gamma$

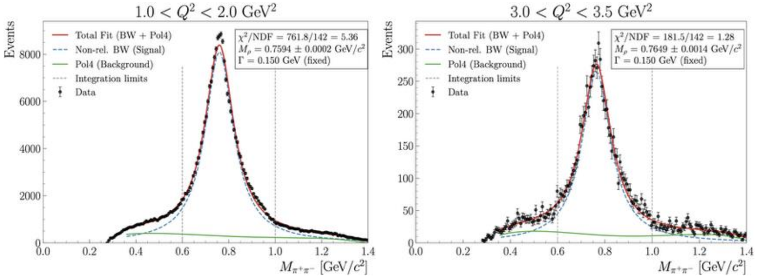
$e^4He \rightarrow e'p'\gamma X$



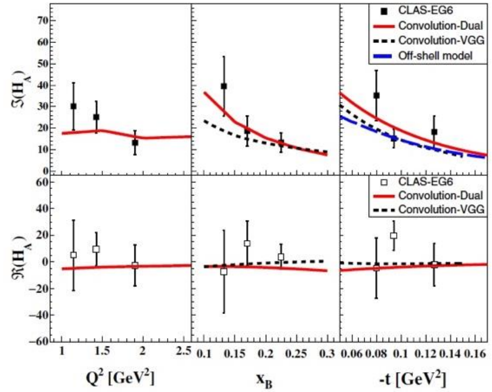


RG-D (CT)



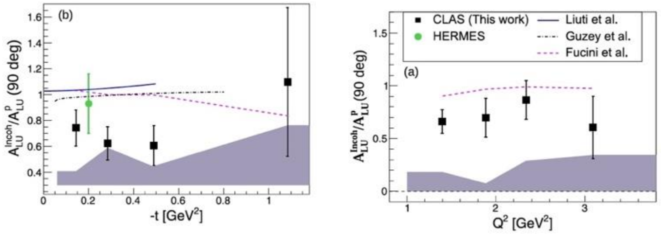


6 GeV CLAS results



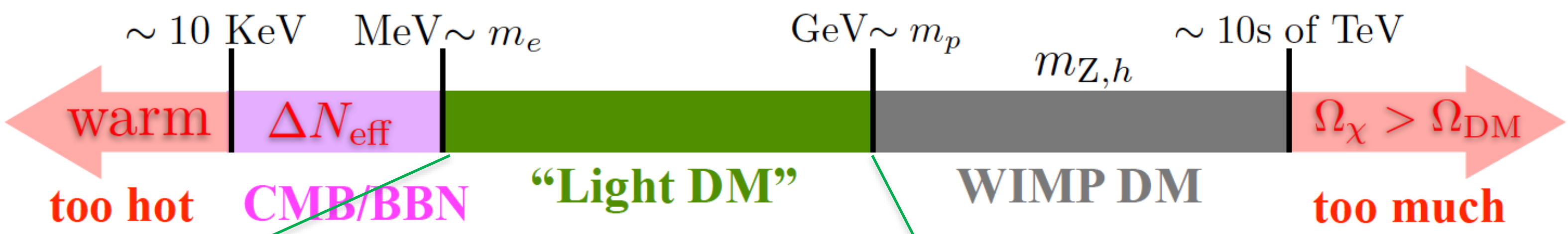
RG-L (ALERT – nuclear DVCS)

RG-E (quark propagation)

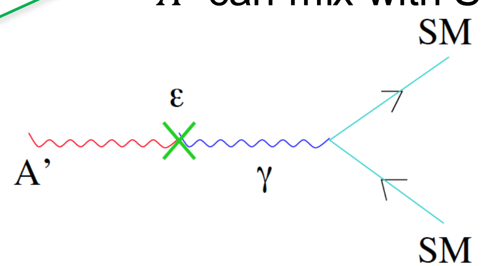


Heavy Photon Search experiment

MeV-GeV thermal relic DM with comparably light mediators (A').



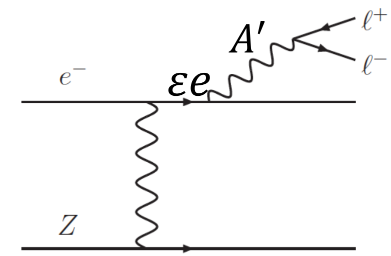
A' can mix with SM photon

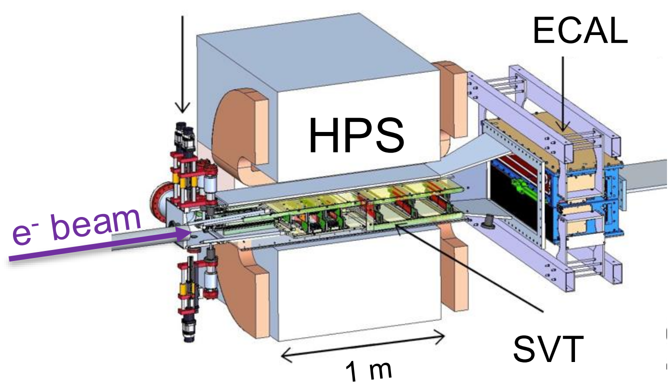


$\varepsilon \sim 10^{-5} - 10^{-2}$

If GUT, ε can be as small as 10^{-7}

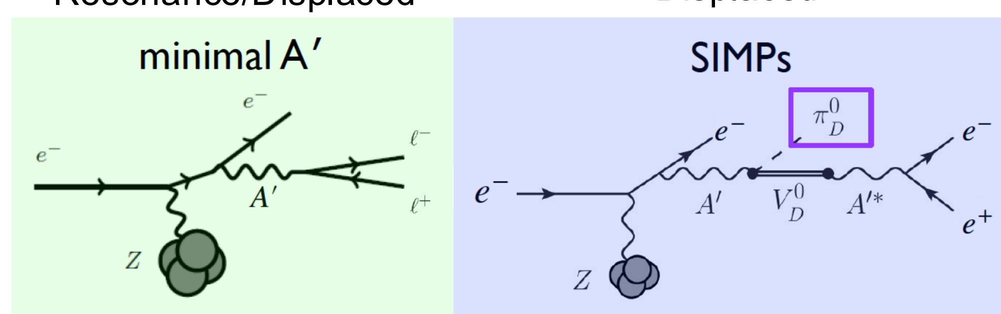
"Dark bremsstrahlung"





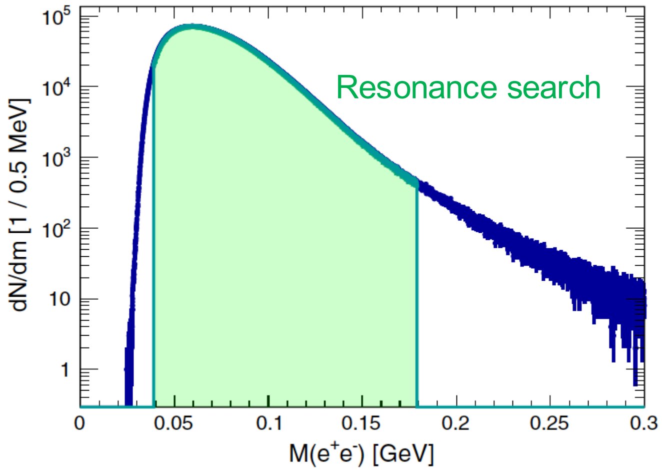
Resonance/Displaced

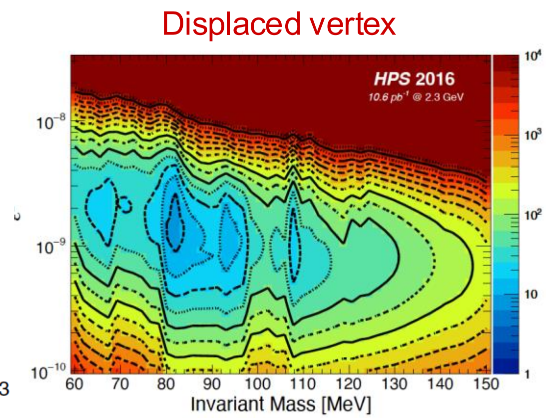
Displaced

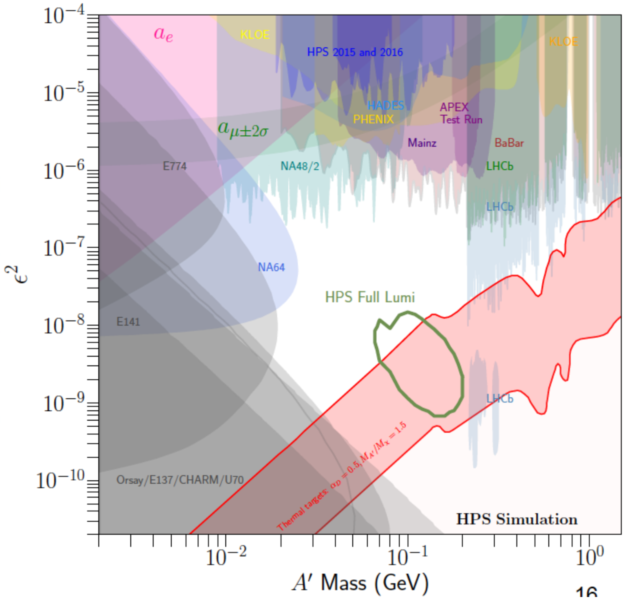


HPS's recent results

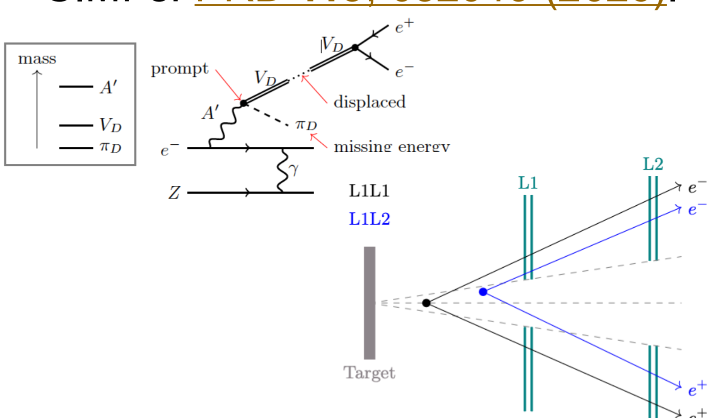
Canonical A': PRD 108, 012015 (2023)

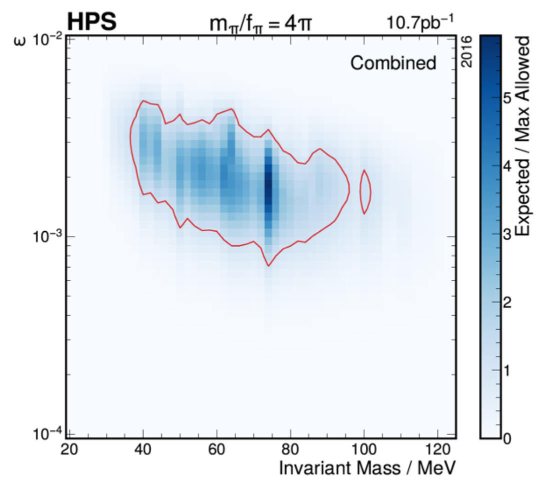


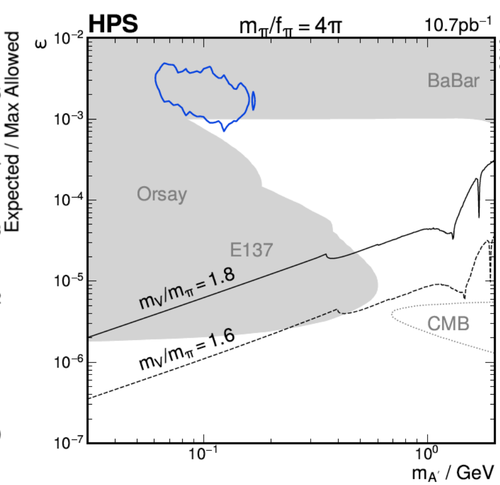




SIMPs: PRD **113**, 032019 (2026).



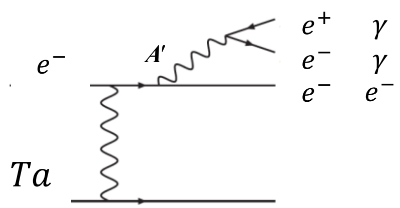


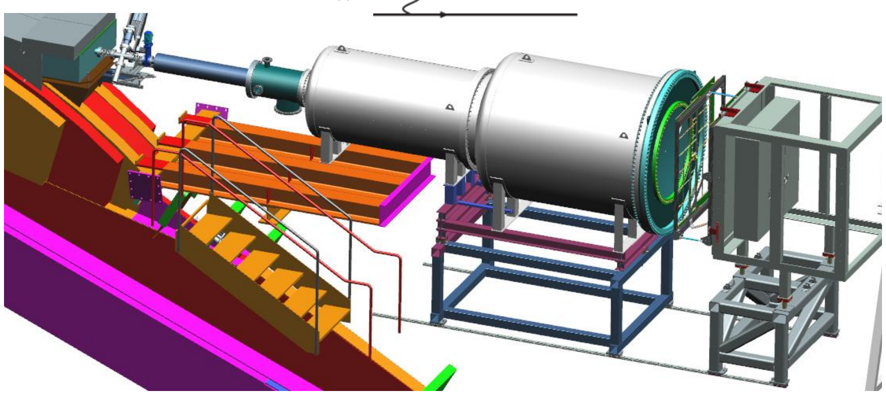


X17 experiment

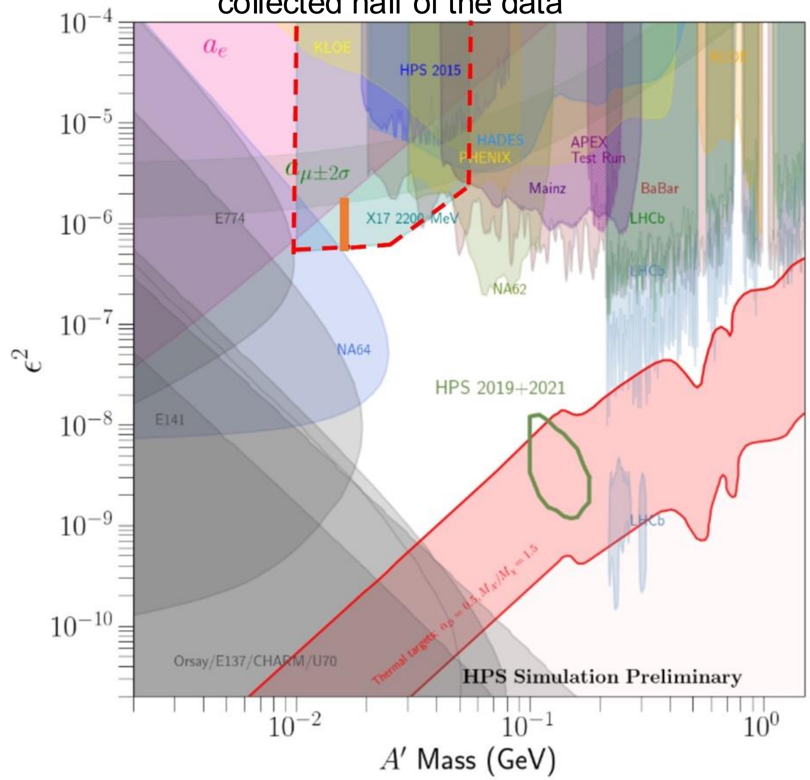
PRoton Radius

- The experiment searches for a hypothetical 17 MeV neutral boson observed in nuclear transitions by the Atomki group.
- A non-magnetic spectrometer based on a $PbWO_4$ calorimeter and a GEM tracking system.
- Searching for a resonance in the mass distributions of 2-charged or 2-neutral pairs in three-cluster events from ~2 GeV electron scattering off a 4 μm Ta target.

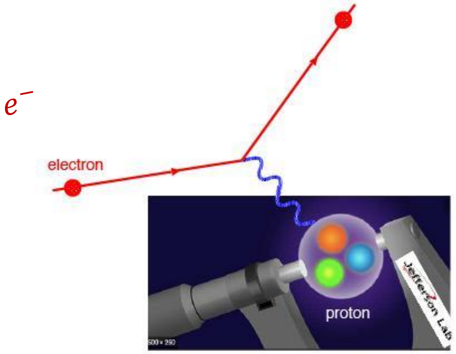




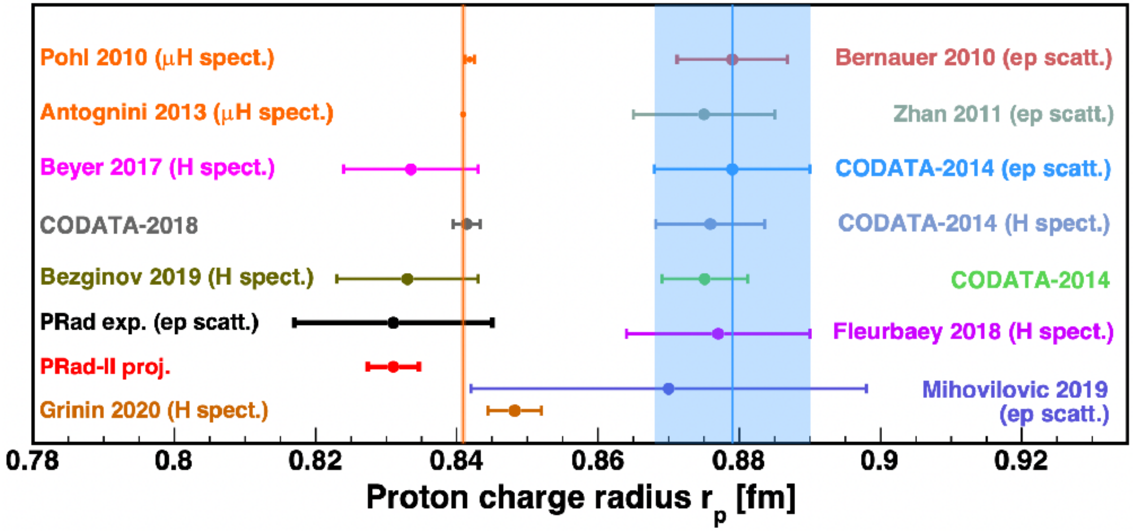
Reach with full statistics, recently collected half of the data



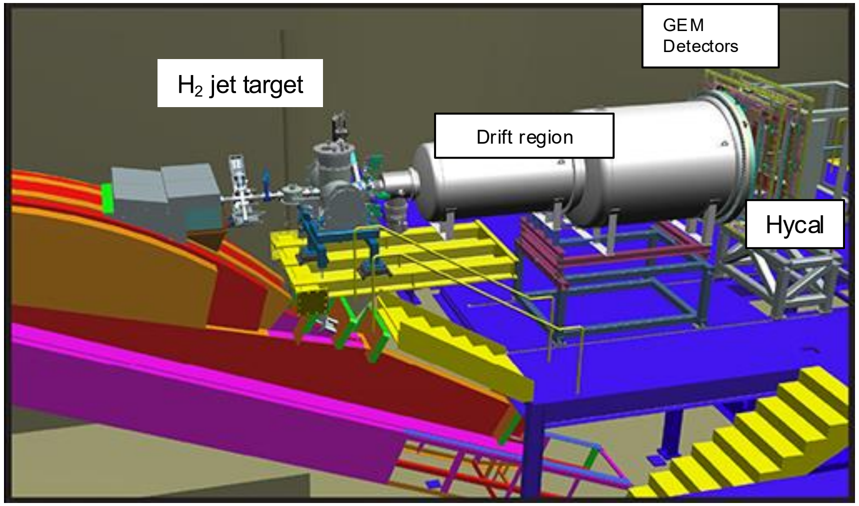
Proton charge Radius experiment - II



The only ep-scattering experiment that measured smaller r_p, ***Nature 575 (2019)***, close to *H*-spectroscopy results.



- Completed new measurements with an improved windowless, high-density, cryo-cooled hydrogen gas flow target, an improved GEM tracking system, and a calorimeter readout.
- All planned data at beam energies of 0.7, 2.1, and 3.5 GeV were collected.
- The original goals and performance expectations were achieved:
  - Lowest Q^2 ~ **10^{-5} GeV^2**,
  - beam background **~ 2%**,
  - stat. uncertainties **< 0.1%.**



Summary

- Hall B's 12 GeV physics program, carried out by three collaborations: CLAS, HPS, and PRad, covers a wide range of topics, including hadron spectroscopy, nuclear and nucleon structure studies, and the search for BSM physics.
- The CLAS collaboration will continue producing a large data set on nucleon and nuclear structure studies using up to 11 GeV polarized electron beams and liquid hydrogen, deuterium, helium, and polarized targets.
- HPS and X17 are expected to produce new search results and cover uncharted phase space in ϵ and m of A' over the next couple of years, and will extend searches for long-lived particles.
- PRad will produce a new r_p measurement with significantly improved uncertainties to put the proton charge radius *puzzle* to rest.
- In the future, CLAS12 plans to become a high-luminosity facility, first reaching $2\times10^{35} cm^{-2}s^{-1}$ and then extending it to $10^{37} cm^{-2}s^{-1}$ for specific measurements, e.g., DDVCS. Other configurations in between are possible if there is a physics case.