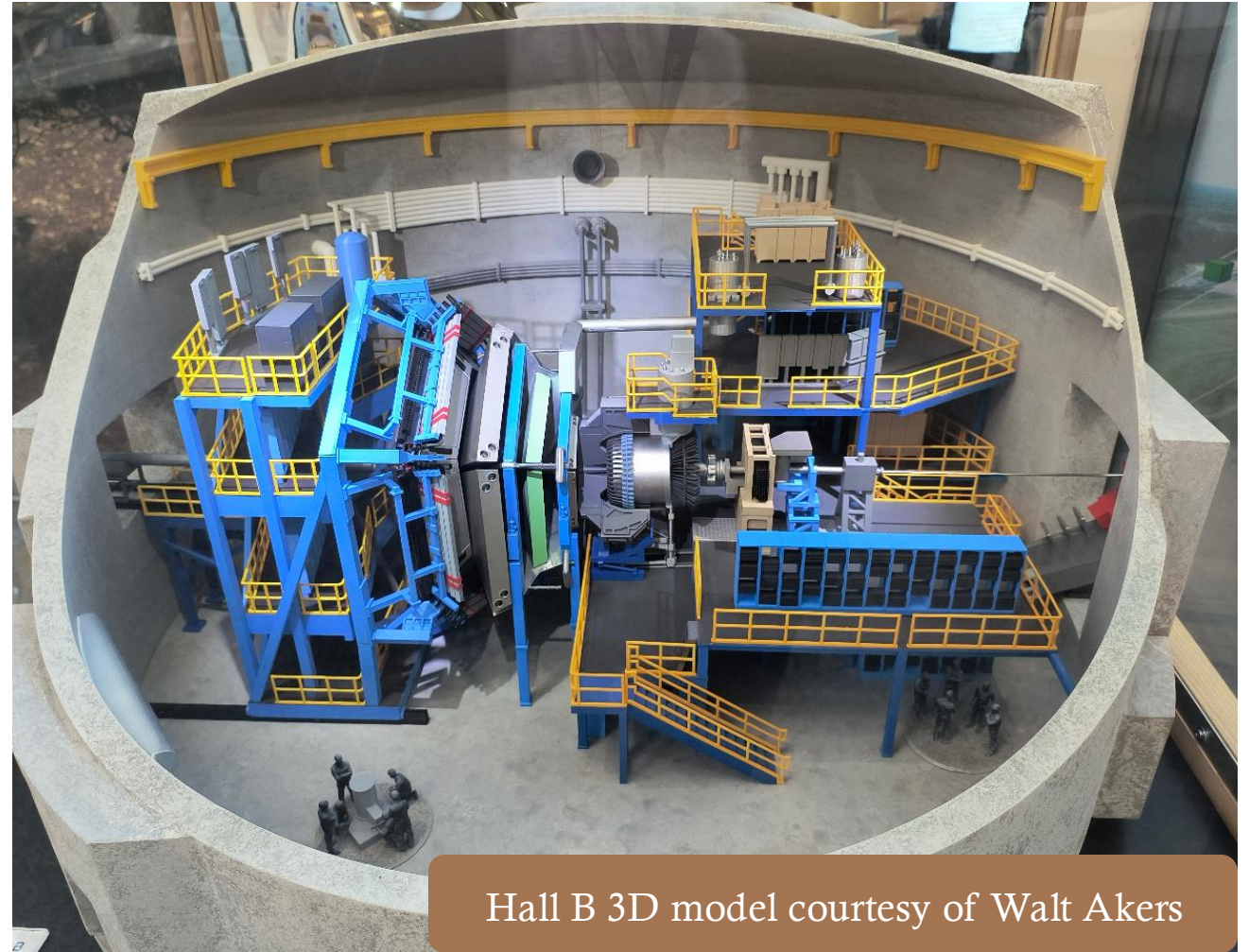


HIGHLIGHTS IN HALL B

Rafayel Paremuzyan (Jefferson Lab)
on behalf of Hall B

JLab Satellite Meeting at DNP, 2026
October 12, 2026



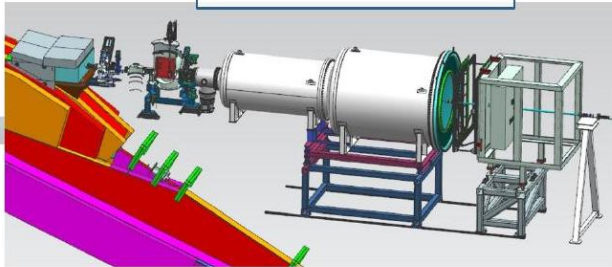
Hall B 3D model courtesy of Walt Akers

Experimental apparatus in Hall-B

Located right after the Tagger magnet
Installed only when the experiment is running

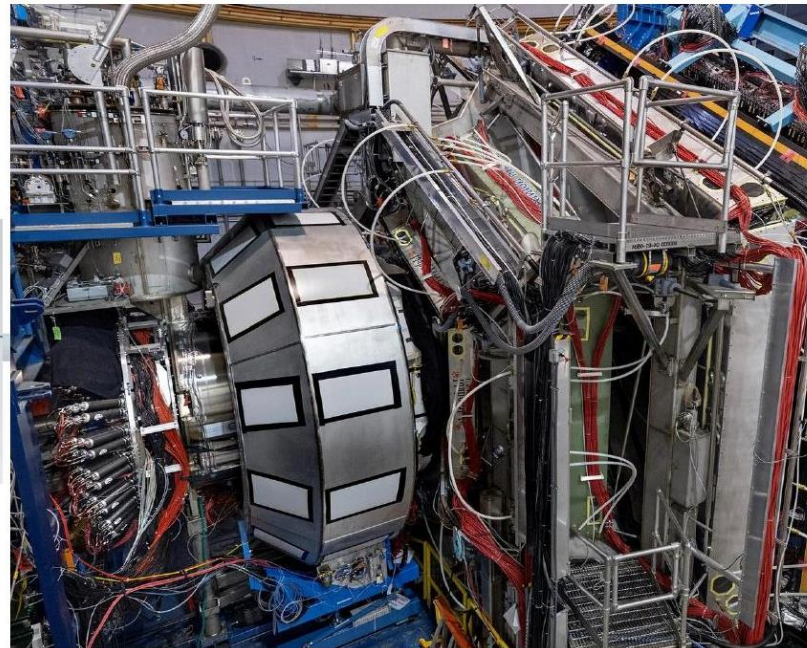
- X17 data taken; more planned
- PRad-II completed

PRad/X17



CLAS12: primary Hall-B detector.
Most detectors installed permanently

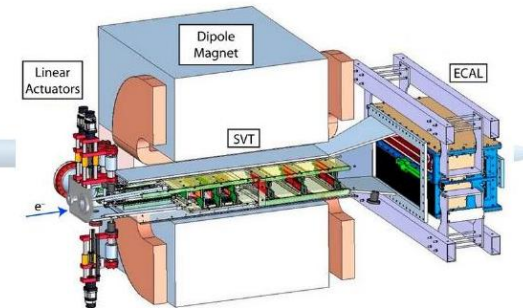
CLAS12



Located in the downstream
alcove.

HPS: Data taken 2015–2021;
more planned

HPS

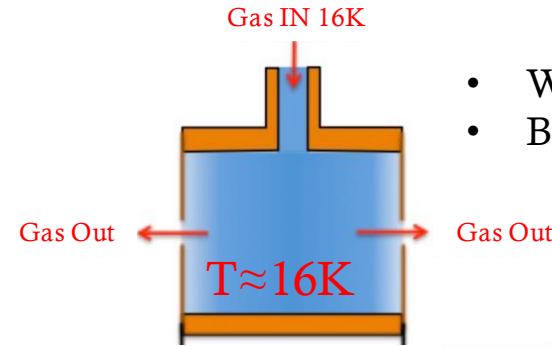


*first will overview dedicated experiments, then CLAS12, the main program

PRadII

PRad-I measured Proton charge radius (0.831fm) consistent with muonic hydrogen (and not with older e-p scatterings.)
PRad-II goal is to reduce uncertainty and verify possible systematic differences between e-p scattering and spectroscopy.

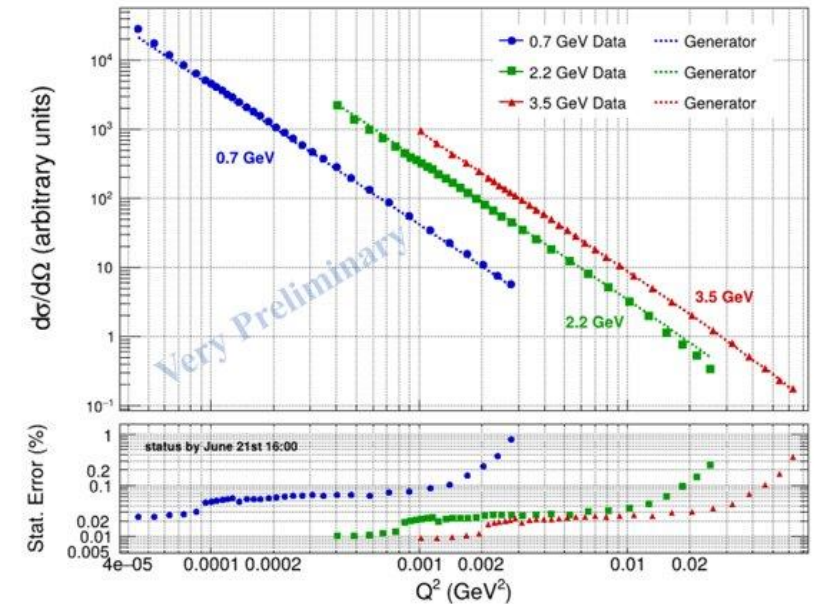
- Proton charge radius measurement through $ep \rightarrow ep$
- Measure the slope of the $G_E^p(Q^2)$ at $Q^2 \rightarrow 0$
- 2nd GEM layer is added
- Three different beam energies: 0.7, 2.2 and 3.5 GeV
- Q^2 as low as $4 \cdot 10^{-5} \text{ GeV}^2$.
- **Fully completed in June 2026**



- Windowless Gas H2 target
- Beam passes through a 2 mm diameter hole.

$$\langle r^2 \rangle = -6 \frac{dG_E^p(Q^2)}{dQ^2} \Big|_{Q^2=0}$$

e-p Cross Section



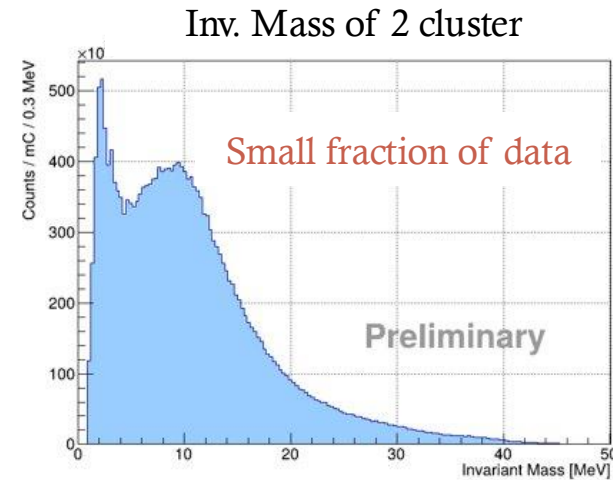
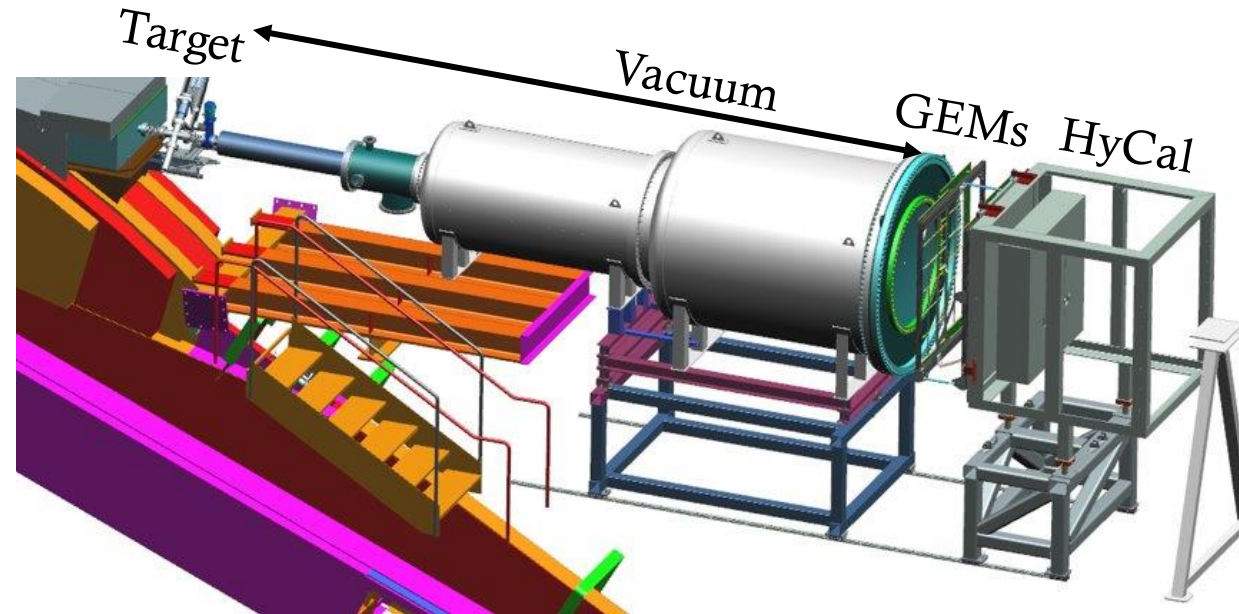
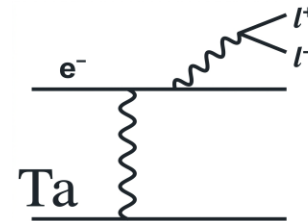
X17

Independently verify the ATOMKI anomalies in ^8Be , ^4He and ^{12}C nuclear transitions (e^+e^- angular correlation excess at $\approx 17\text{ MeV}$).

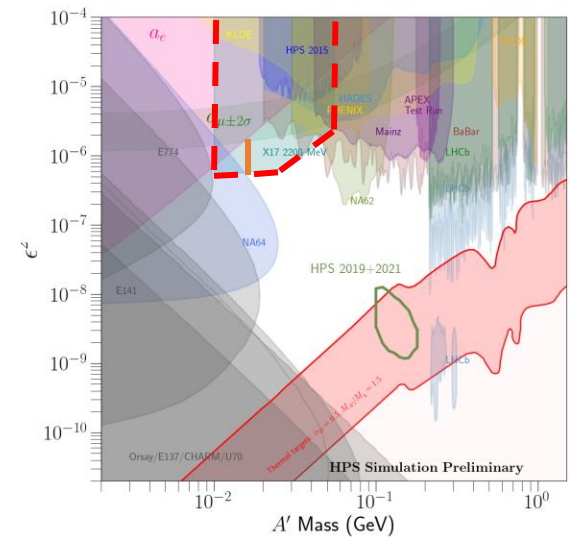
Search for dark photons through its decay to e^-e^+ in the 3 – 60 MeV region. (Can search through the $\gamma\gamma$ channel as well)

- All three leptons: $e^-e^+e^+$ detected
- Search for a bump over the huge EM background

- PRadII target is replaced with a cylindrical beam pipe; otherwise the setup is unchanged.
- X17 target: $1\text{ }\mu\text{m Ta}$.
- 41% of the total expected data collected
 - Next portion preliminary scheduled to run in March 2027

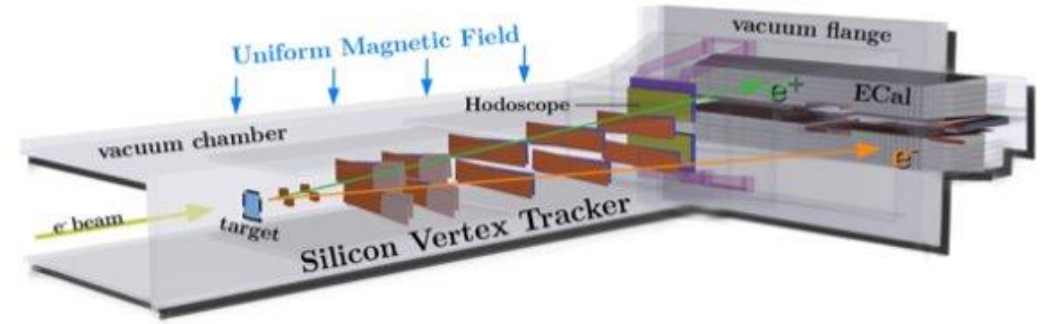


Projected reach 40 days at 50 nA on $1\text{ }\mu\text{m Ta}$.

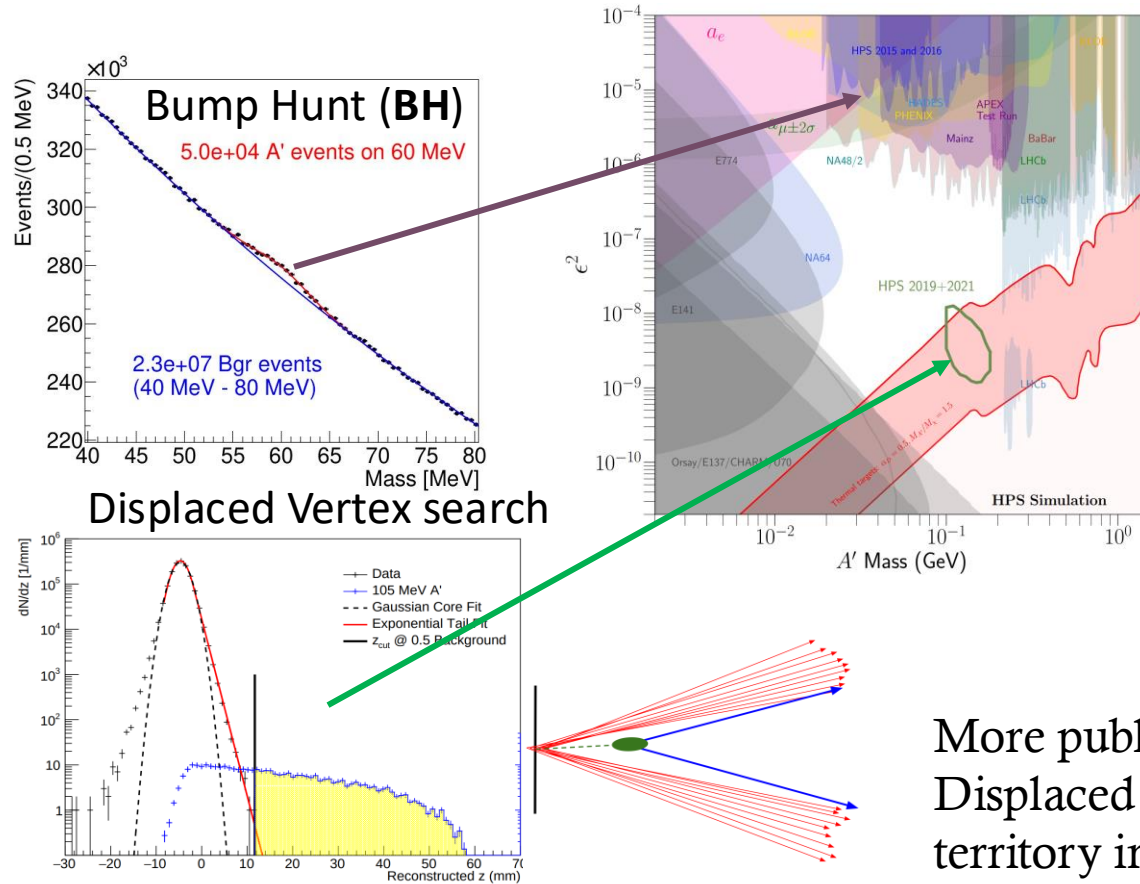
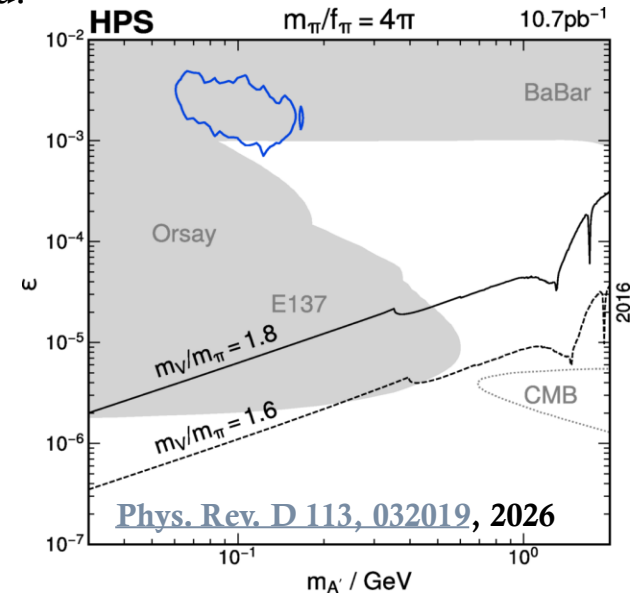
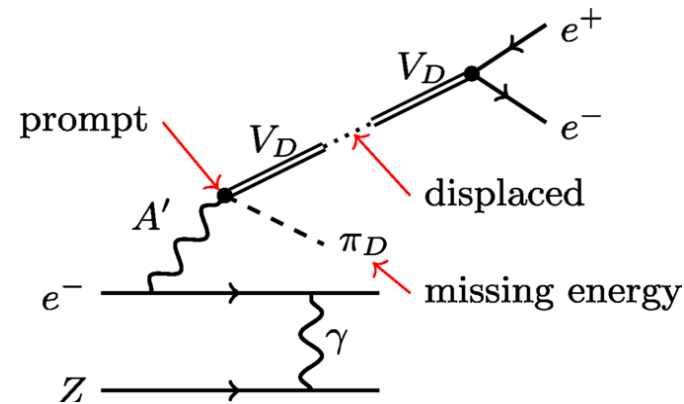


Heavy Photon Search

Main goal: Search for a dark photon through its decay to e^+e^- .
Search through Bump Hunt and displaced vertex search.



In SIMP models, $A' \rightarrow \pi_D V_D$; the dark vector meson V_D can be long-lived and decays to e^+e^- at a displaced vertex.
New uncovered territory is achieved.



More publications to come including First Displaced Vertex search covering a new territory in minimal DP model.

CLAS12 detector

A wide spectrum of physics topics with Deep Exclusive and Semi-inclusive measurements with a Large Acceptance detector.

- Quark-gluon structure of the nucleon: through Deep Exclusive or SIDIS reactions
 - GPDs, TMDs, GFFs
- Cold nuclear matter, Short Range Correlations, hadronization using nuclear targets
- Meson and Baryon Spectroscopy
 - Exploring the origin of confinement.
- Standard Luminosity: $10^{35} \text{cm}^{-2} \text{s}^{-1}$.
- Typical beam energy: $\approx 10.6 \text{ GeV}$. Sometimes lower.
- LH_2 , LD_2 , ^4He , C, Al, Sn and other nuclear targets.
- Polarized targets (longitudinal and **transverse***)

***Transversely** polarized not yet used.

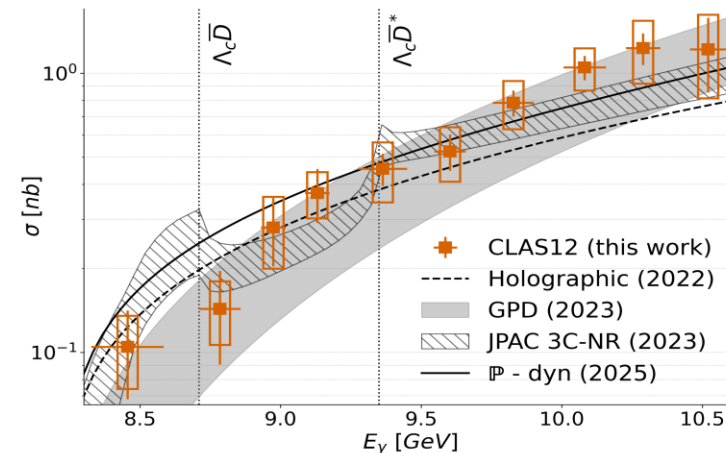


Recent publication highlights from CLAS12

Near-threshold J/ψ production is dominated by gluon exchange, so it gives access to the gluonic gravitational form factors $A_g(t)$, $C_g(t)$ and the mass radius.

First CLAS12 J/ψ cross-section released early 2026: P. Chatagnon et al. [Phys. Rev. C 113, 065203](#)

- Total and differential cross-sections
- Extraction of the mass radius of the proton with different models.
- Extraction of $A_g(t)$ and $C_g(t)$ GFFs
- Consistent with Hall C (J/ψ -007) and GlueX (Hall D) data

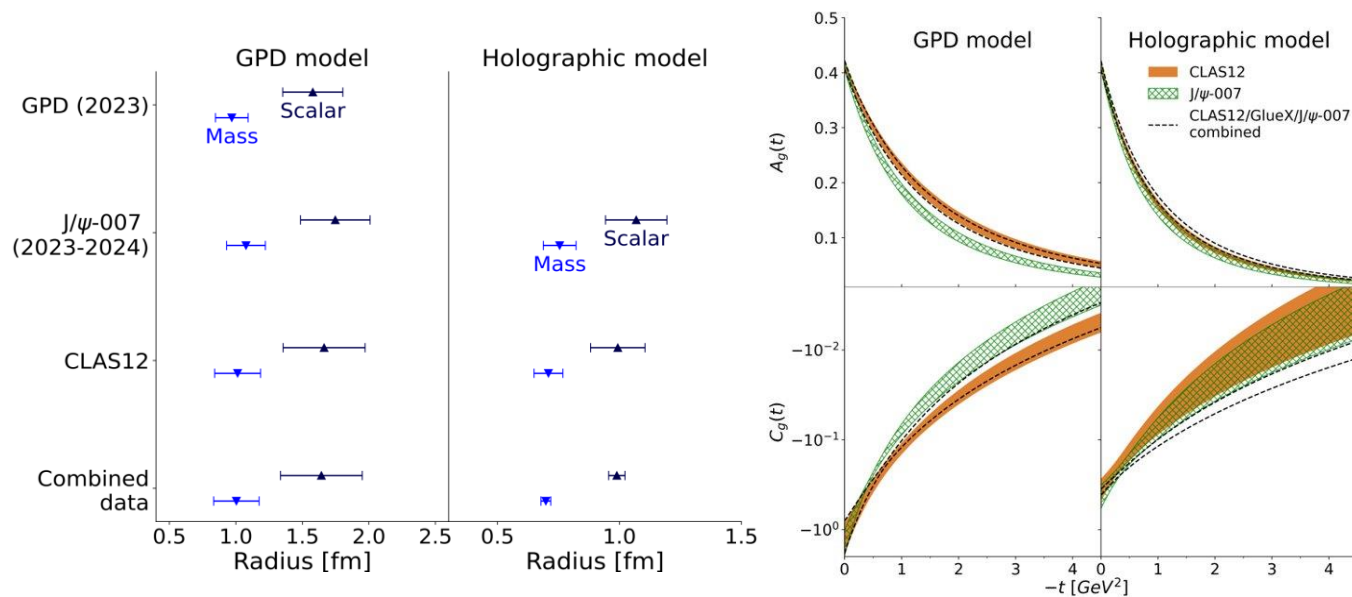
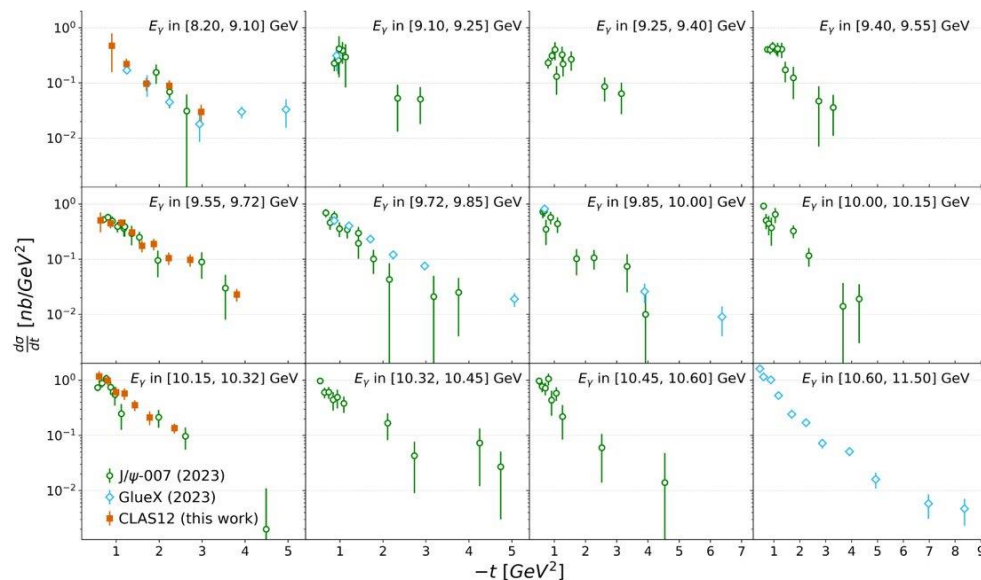


[Phys. Rev. D 106, 086004](#)

[Phys. Rev. D 108, 034003](#)

[Phys. Rev. D 108, 054018](#)

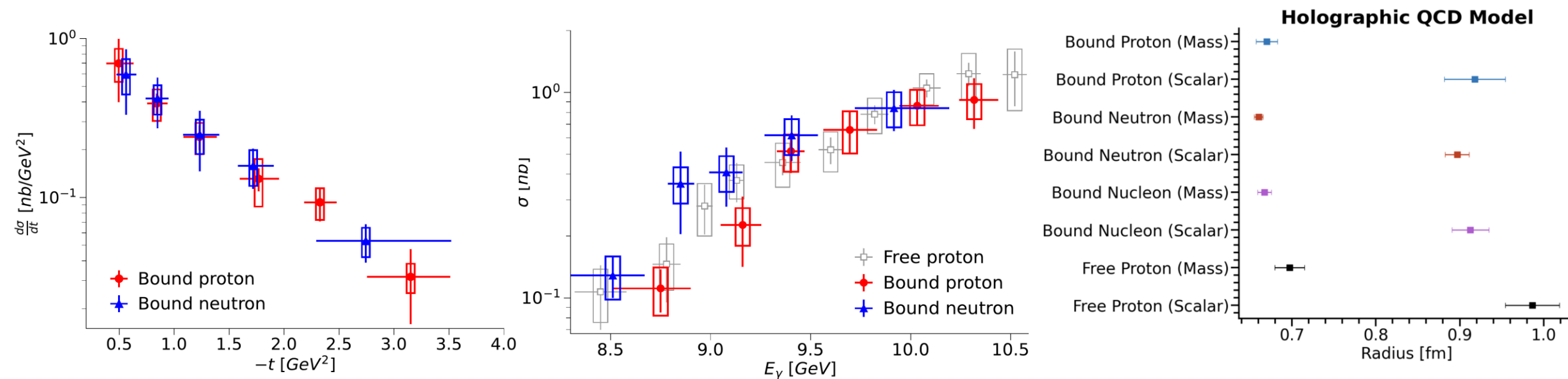
[arXiv:2510.08845](#) (Pomeron exchange)



Recent publication highlights from CLAS12

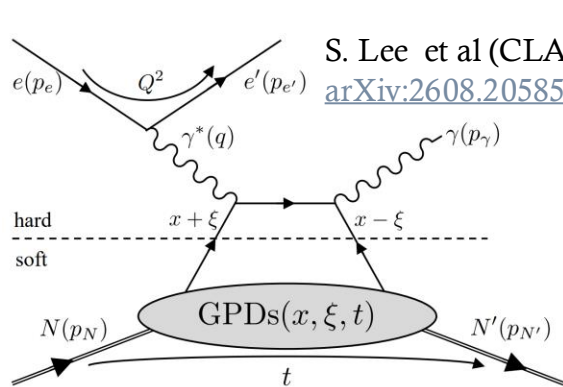
First Measurement of Near-Threshold J/ψ Photoproduction on the Neutron. Sep. 2026 (submitted to PRL). [ArXiv:2609.03579v2](https://arxiv.org/abs/2609.03579v2)

- Total and differential cross-sections
- Extraction of the mass radius of the bound proton and bound neutron (using Holographic QCD, GPD and VMD models)
- Extraction of $A_g(t)$ and $C_g(t)$ GFFs
- Smaller mass and scalar radii for bound nucleons than for the free proton
 - Consistent with GlueX (Hall D) sub-threshold J/ψ photoproduction on nuclei results ([Phys. Rev. Lett. 134,201903](https://arxiv.org/abs/1304.7160)) : hints at in-medium modification of the nucleon's gluonic structure.



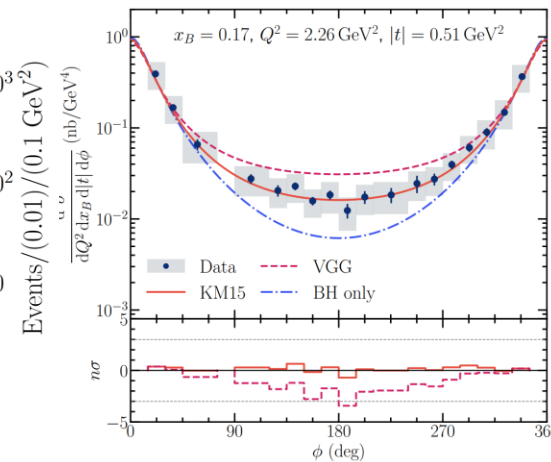
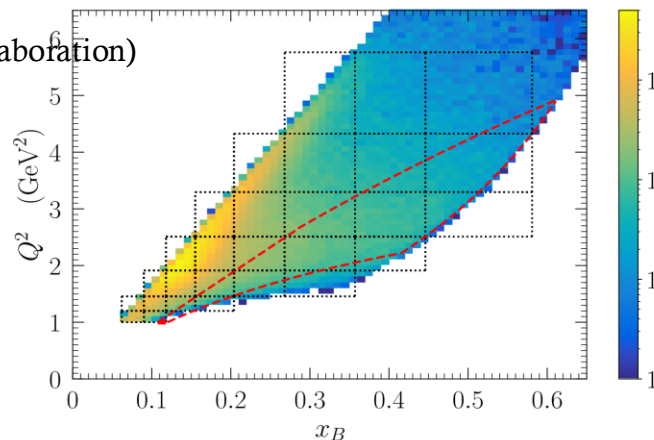
Recent publication highlights from CLAS12

First DVCS cross-section with CLAS12



S. Lee et al (CLAS collaboration)

[arXiv:2608.20585v1](https://arxiv.org/abs/2608.20585v1)



More than 1300 kinematic points:

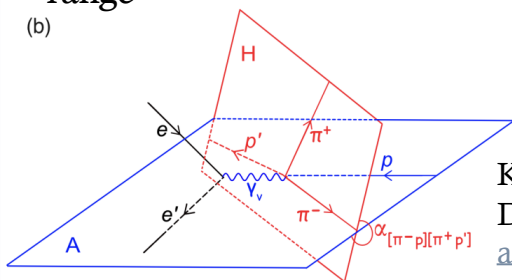
Important input to global CFF extraction efforts.



N^* electrocouplings at high $Q^2 \approx 2-8 \text{ GeV}^2$ probe the dressed-quark mass function / emergence of hadron mass

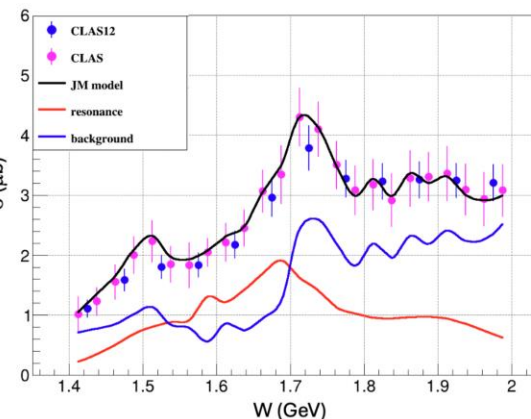
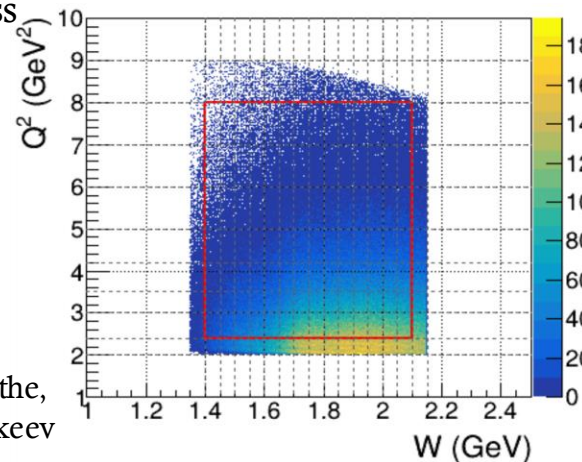
Total and nine single-differential cross sections of $\gamma_v p \rightarrow \pi^+ \pi^- p'$ over a wide kinematic range

(b)



K. Neupane, R.W. Gothe, D.S. Carman, V.I. Mokeev

[arXiv:2609.19395v2](https://arxiv.org/abs/2609.19395v2)



First exclusive $\pi^+ \pi^- p$ cross section for $Q^2 = 2.4 - 8.0 \text{ GeV}^2$ ($W = 1.4 - 2.1 \text{ GeV}$). Doubles Q^2 reach of the prior CLAS data.

Nine single-differential and the fully integrated cross sections per (W, Q^2) bin feed the JM model to extract $\gamma_v p N^*$ electrocouplings.

Excellent agreement with CLAS (6 GeV) data.

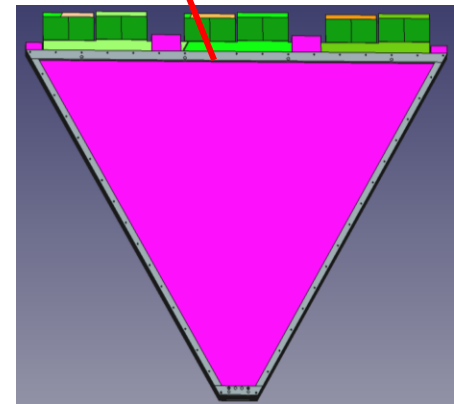
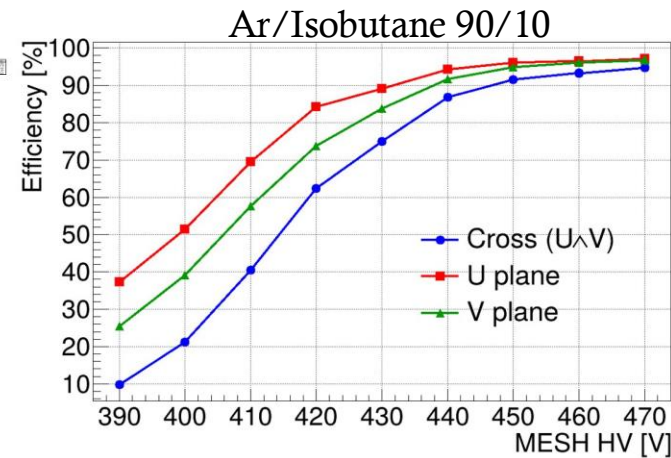
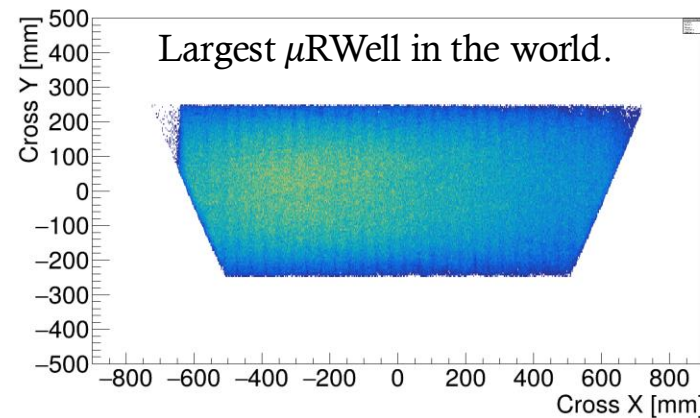
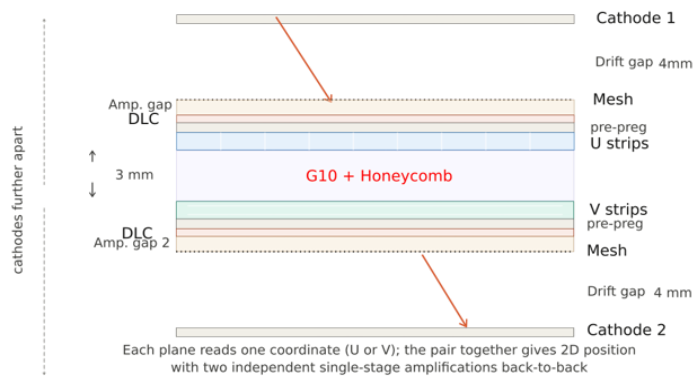
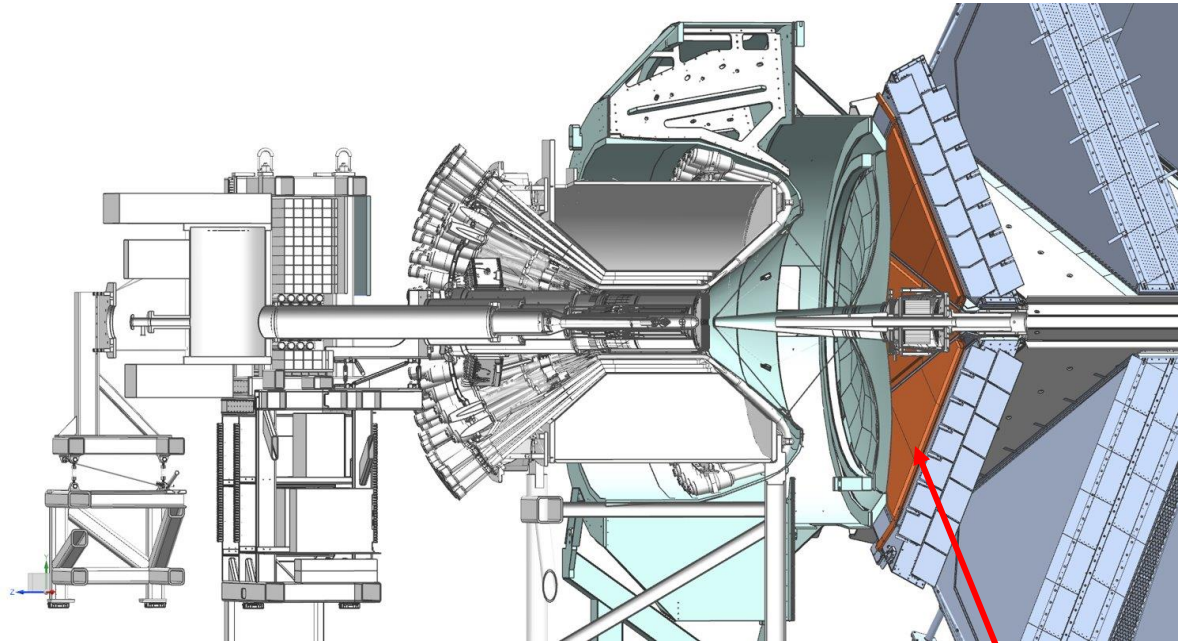
μ RWell detector developments

CLAS12 plans to double its luminosity (to $2 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$)

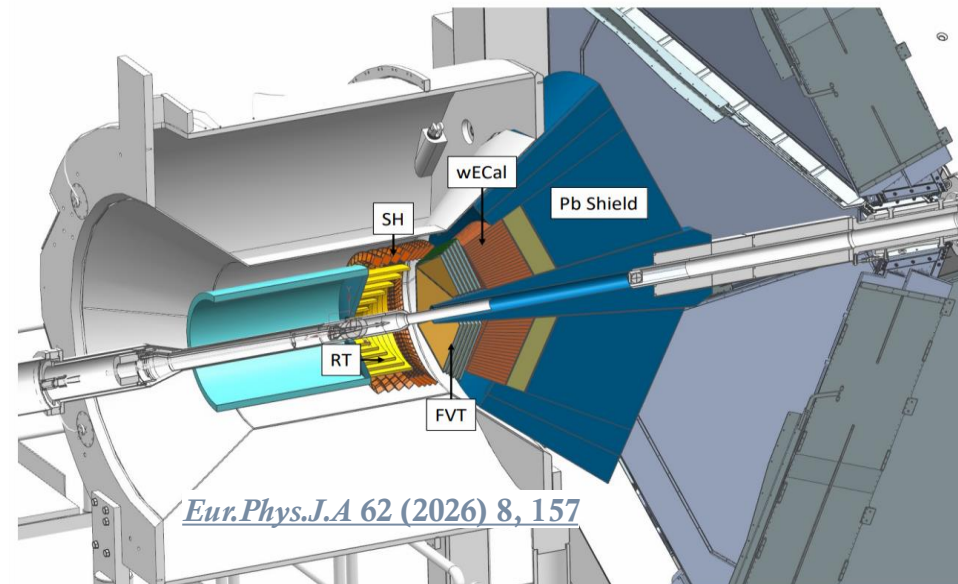
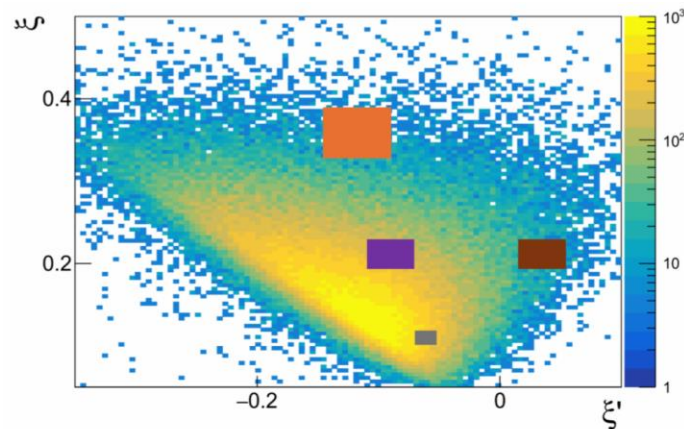
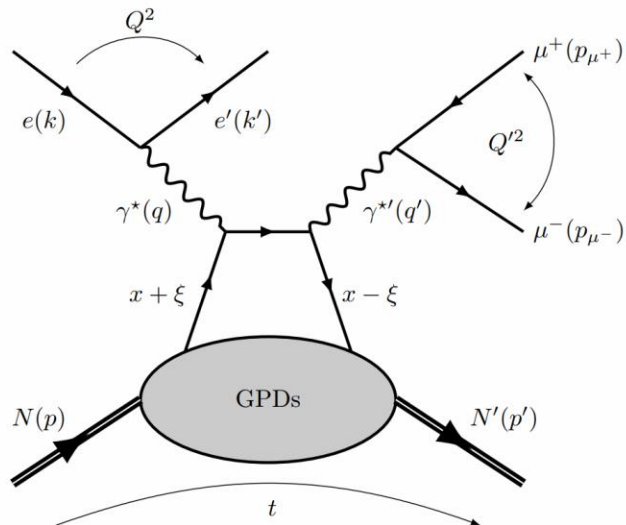
A double layer of μ RWell tracking detector is to be installed upstream of R1 Drift Chambers to recover tracks otherwise lost because of large hit combinatorics in Region 1 Drift Chambers.

Tests with 1st prototype led to 2nd prototype.

The second prototype decouples the U and V readouts: each coordinate has its own amplification stage within a single detector, giving better signal efficiency than the first prototype.



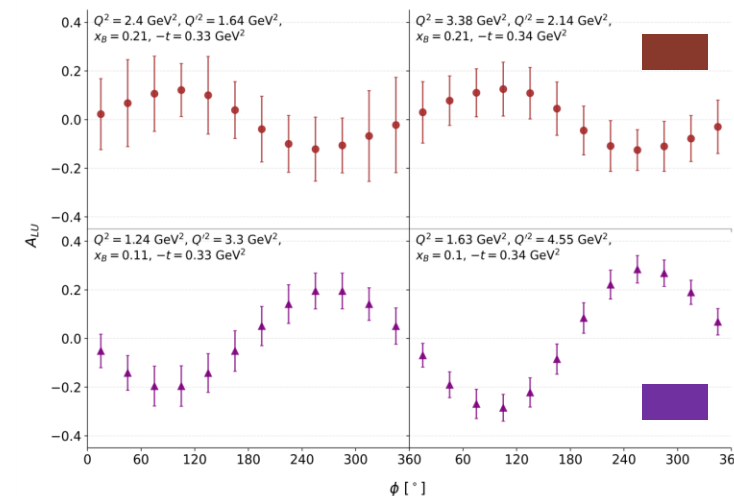
Major future detector upgrades: μ CLAS12 detector



- At leading order, DVCS and TCS only probe GPDs at $x = \pm \xi$.
- DDVCS allows direct access to GPDs in the $-\xi < x < \xi$ region
 - Never measured : the cross section is suppressed by α_{em} relative to DVCS
- Why muons? $\mu^-\mu^+$ instead of e^-e^+ avoids antisymmetrization with the scattered electron, and shielding lets the detector reach $10^{37}\text{cm}^{-2}\text{s}^{-1}$
- μ CLAS12 can operate at a Luminosity of $10^{37}\text{cm}^{-2}\text{s}^{-1}$ allowing DDVCS measurements.
- The same setup will allow high precision TCS and J/ψ measurements
 - Allowing high-precision measurement of CFFs and gluon GFFs
- Approved for 200 days of running at $10^{37}\text{cm}^{-2}\text{s}^{-1}$.
- Ongoing efforts to explore feasibility of using μ CLAS12 with LD_2 target

E12-25-001

Ssee P. Chatagnon's talk for more details, Wed 11:00 am – Session Q02



Transversely polarized target

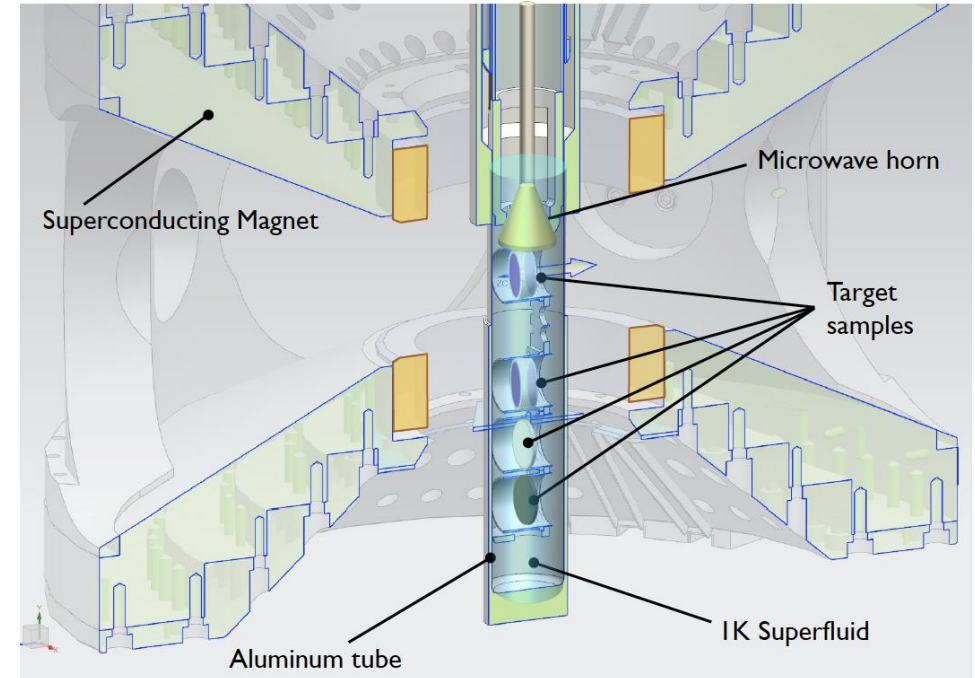
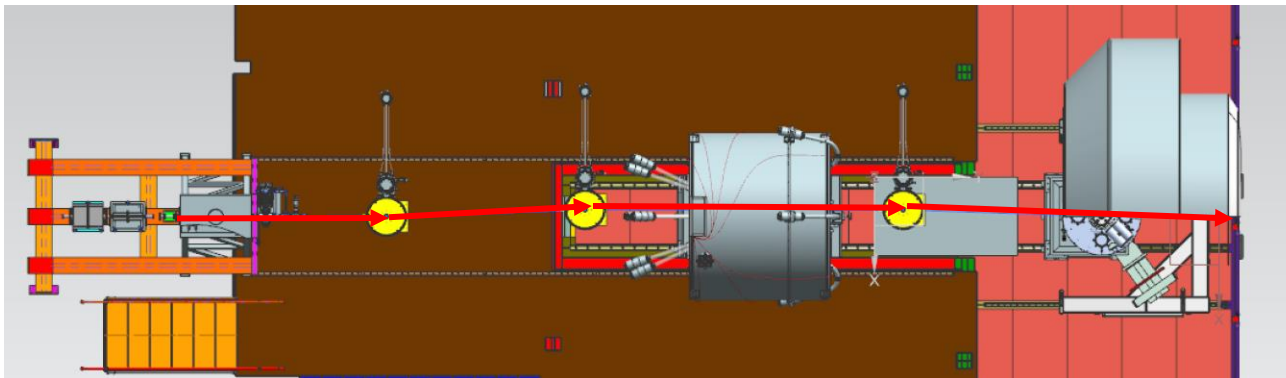
Physics case — Run Group H (RGH)

- DVCS target-spin asymmetry → GPD E (quark orbital angular momentum, Ji sum rule)
- SIDIS → Sivers and transversity (tensor charge)
- PAC53 (2025): 4 experiments approved, rated A, with NH₃ target (100+25 days)

Status

- Magnet geometry & performance defined; cryostat design complete; procurement package in preparation
- Beamline chicane magnets + new μ RWell/TOF recoil detector: R&D expected complete 2027

Chicane system w/ commercial 7.5 T magnets



How the target is polarized

- NH₃ (ammonia) samples cooled to ~1 K in superfluid He
 - Polarized via microwave-driven Dynamic Nuclear Polarization (DNP)
 - Housed in a 5 T superconducting magnet (transverse field)
- Design based on the Hall-A G2p/GEp target and Hall-C E12-15-005 magnet*

Possible run plan

Start with a low-energy (~ 1 GeV/pass) machine, about 21 PAC days. Continue X17 for ~ 10 PAC days.

FY 2027

Run Group	Setup / Status	Target	Beam Energy	Start Date	End Date	Scheduled Calendar Days	Remaining PAC Days Before Run	Scheduled PAC Days	Actual PAC Days from ABUs	Remaining PAC Days After Run
RG-K		liq. H2	8.8			120	52	60		0
	reconfigure	change				7		4		
RG-E		liq. D2 & nucl. doublet	11			66	33	33		0
							sum:	97		

FY 2028

Run Group	Setup / Status	Target	Beam Energy	Start Date	End Date	Scheduled Calendar Days	Remaining PAC Days Before Run	Scheduled PAC Days	Actual PAC Days from ABUs	Remaining PAC Days After Run
RG-C		long. pol. NH3/ND3	11			80	40	40		0
RG-G		long. pol. 7LiD	11			110	55	55		0
							sum:	95		

High-luminosity physics in Hall B: workshop highlights

Strong Hall B participation in the workshop on the **Physics Program with High Luminosity Facilities**

Standard CLAS12 with μ RWell ($2 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$)

- N^* electrocouplings up to $Q^2 \approx 12\text{--}13 \text{ GeV}^2$ (V. Moiseev)

μ CLAS12 ($10^{37} \text{ cm}^{-2} \text{ s}^{-1}$): one of the well-motivated projects

- DDVCS; high-statistics J/ψ ($\sim 3 \times 10^4$ events) and TCS (7.7×10^6 events)

Staged approach to μ CLAS12 (under study)

- Stage II (up to $10^{36} \text{ cm}^{-2} \text{ s}^{-1}$): new physics, e.g., J/ψ photoproduction on the bound neutron in deuterium, $\sim 26\times$ the RG-B sample

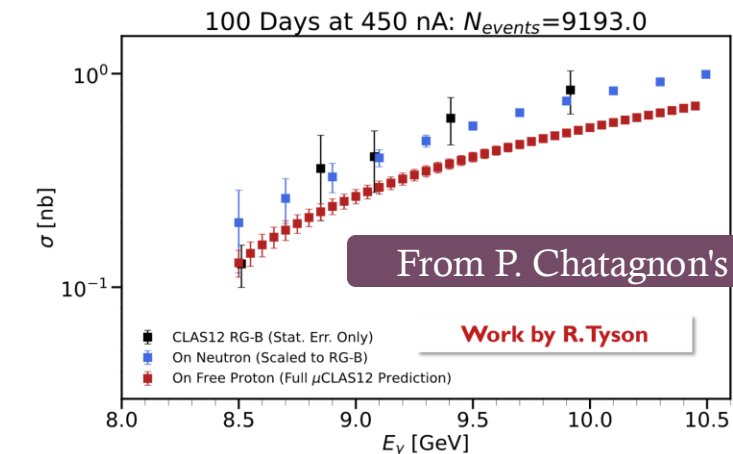
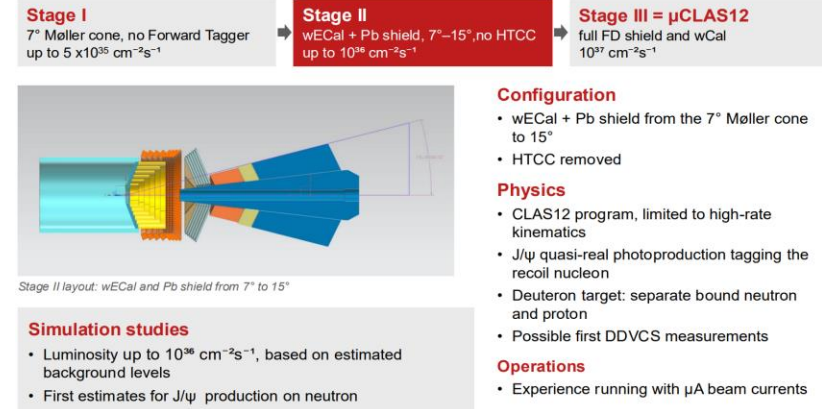
New interest in using μ CLAS12/CLAS12 for BSM physics

- CLFV: search for $eN \rightarrow \mu X$ (e.g., via leptoquarks); high luminosity is key (Y. Furlanova)
- LNV: lepton double charge exchange $A(e^-, \mu^+/e^+)X$, complementary to $0\nu\beta\beta$ decay; (F. Cappuzzello)

Outcome: a white paper by the end of January 2027

Upgrade path: Stage II

R. De Vita's slide



Workshop Indico page: <https://indico.jlab.org/event/1089/>

Publications and Theses since Sep. 2025

PhD theses completed: 3 CLAS and 2 HPS

1. Samy Polcher Rafael (Saclay, France) "Nucleon Structure Studies: DVCS on Polarized Protons with CLAS12 Experiment", September 2025. [CLAS]
2. Juan Sebastian Alvarado (Orsay, France) "Exploring the Nucleon Structure via Deep Electroproduction Processes", September 2025. [CLAS]
3. Rory O'Dwyer (Stanford University) "Displaced Vertex Search: SIMPS", June 2026. [HPS]
4. Mariana Tenorio Pita (Old Dominion University) "Tagged J/ψ Photoproduction Near Threshold", June 2026. [CLAS]
5. Sarah Geiser (Stanford University) "Searching for Long-Lived Dark Photons with the HPS Experiment" July 2026 [HPS]

Publications : 7 based on CLAS12, 7 based on CLAS and 1 based on HPS data

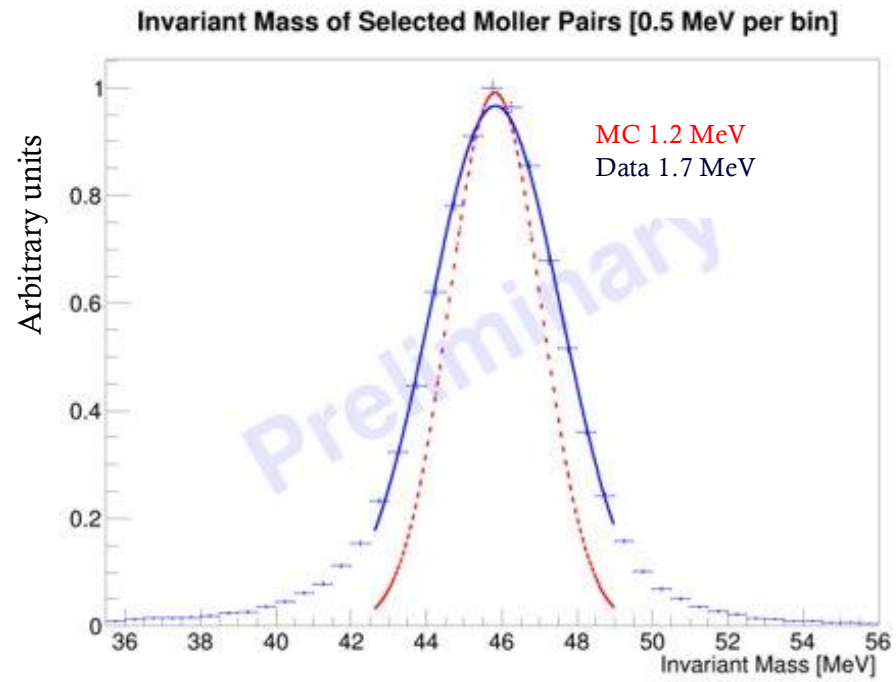
1. K. Neupane (CLAS collaboration) "Measurements of $\gamma p \rightarrow \pi^+ \pi^- p'$ Cross Sections with the CLAS12 Detector for Q^2 from 2.4-8.0 GeV² and W from 1.4-2.1 GeV", Submitted to Phys. Rev. C. ([arXiv](#))
2. R. Tyson, (CLAS collaboration) "First Measurement of Near-Threshold J/ψ Photoproduction on the Neutron", Submitted to PRL, ([arXiv](#))
3. S. Lee, (CLAS collaboration) "Multi-Differential DVCS Cross Section Measurement on the Proton in the Valence Region with CLAS12", Submitted to Phys. Rev. C, ([arXiv](#))
4. H. Jiang et al. "Polarization observables T and F in the $\gamma p \rightarrow \pi^0 p$ reaction at CLAS", *Phys.Rev.C* 114 (2026) 1, 015203
5. T. Hu, et al. (CLAS collaboration), "First measurement of polarized spin-density matrix elements and differential cross sections $d\sigma/dt$ in ω photoproduction off the proton for $2.7 < E_\gamma < 5.2$ GeV using CLAS at Jefferson Lab", *Phys.Lett.B* 880 (2026) 140845. ([arXiv](#))
6. A. Trivedi et al. (CLAS collaboration), "Measurements of $\gamma p \rightarrow \pi^+ \pi^- p'$ Cross Sections with the CLAS Detector for Q^2 from 2.0 - 5.0 GeV² and W from 1.4 - 2.125 GeV". Submitted to Phys. Rev. C ([arXiv](#)).
7. A.G. Acar et al. (CLAS Collaboration), "Measurements of Beam Spin Asymmetry of $\pi^\pm \pi^0$ DiHadrons at CLAS12", arXiv:2602.14271, submitted to Phys. Rev. Lett.. ([arXiv](#))
8. P. Chatagnon et al. (CLAS Collaboration), "Measurement of the Near-Threshold J/ψ Photoproduction Cross Section with the CLAS12 Experiment", Phys. Rev. C 113, 065203 (2026). ([paper](#))
9. M. McEneaney et al. (CLAS Collaboration), "Longitudinal Spin Transfer to Λ Hyperons in Semi-Inclusive Deep Inelastic Scattering with the CLAS12 Spectrometer", Phys. Rev. C 113, 092019 (2026). ([paper](#))
10. S.A. Dytman et al. (CLAS Collaboration), "Proton Transparency and Neutrino Physics: New Methods and Modeling", Phys. Rev. D, 113, 092007 (2026). ([paper](#))
11. S. Paul et al. (CLAS Collaboration), "First Study of the Nuclear Response to Fast Hadrons via Angular Correlations between Pions and Slow Protons in Electron-Nucleus Scattering", Phys. Lett. B 874, 140250 (2026). ([paper](#))
12. P.H. Adrian et al. (HPS Collaboration), "First displaced vertex search for electroproduced dark-sector strongly interacting massive particles by the HPS experiment", Phys. Rev. D 113, 032019 (2026). ([paper](#))
13. S. Adhikari et al. (CLAS Collaboration), "Measurement of Beam-Recoil Observables C_x and C_z for $K^+ \Lambda$ Photoproduction", Phys. Rev. C 112, 065211 (2025). ([paper](#)), ([summary](#))
14. P. Roy et al. (CLAS Collaboration), "Measurement of Single- and Double-Polarization Observables in the Photoproduction of $\pi^+ \pi^-$ Pairs off the Proton Using CLAS at Jefferson Laboratory", Phys. Rev. C 112, 035201 (2025). ([paper](#))
15. D.S. Carman et al. (CLAS Collaboration), "Recoil Polarization in $K^+ Y$ Electroproduction in the Nucleon Resonance Region with CLAS12", Phys. Rev. C 112, 035206 (2025). ([paper](#)), ([summary](#))

Summary

- Hall-B continues to make progress on all fronts: publications, PhD theses, detector upgrades, experiment installation and operations.
- PRad-II experiment fully completed in June 2026.
- X17 collected 41% of its planned data.
- Luminosity upgrade of CLAS12 is progressing well. The second prototype μ RWell detector is currently being tested in Hall-B
 - Next detector is expected to be full size prototype/production detector
- The μ CLAS12 upgrade will allow operation at $10^{37} \text{ cm}^{-2}\text{s}^{-1}$ and hence enabling the first DDVCS measurement.
- New exciting physics ideas in Hall-B were discussed in the high luminosity meeting.
 - Stay tuned for white paper by the end of January

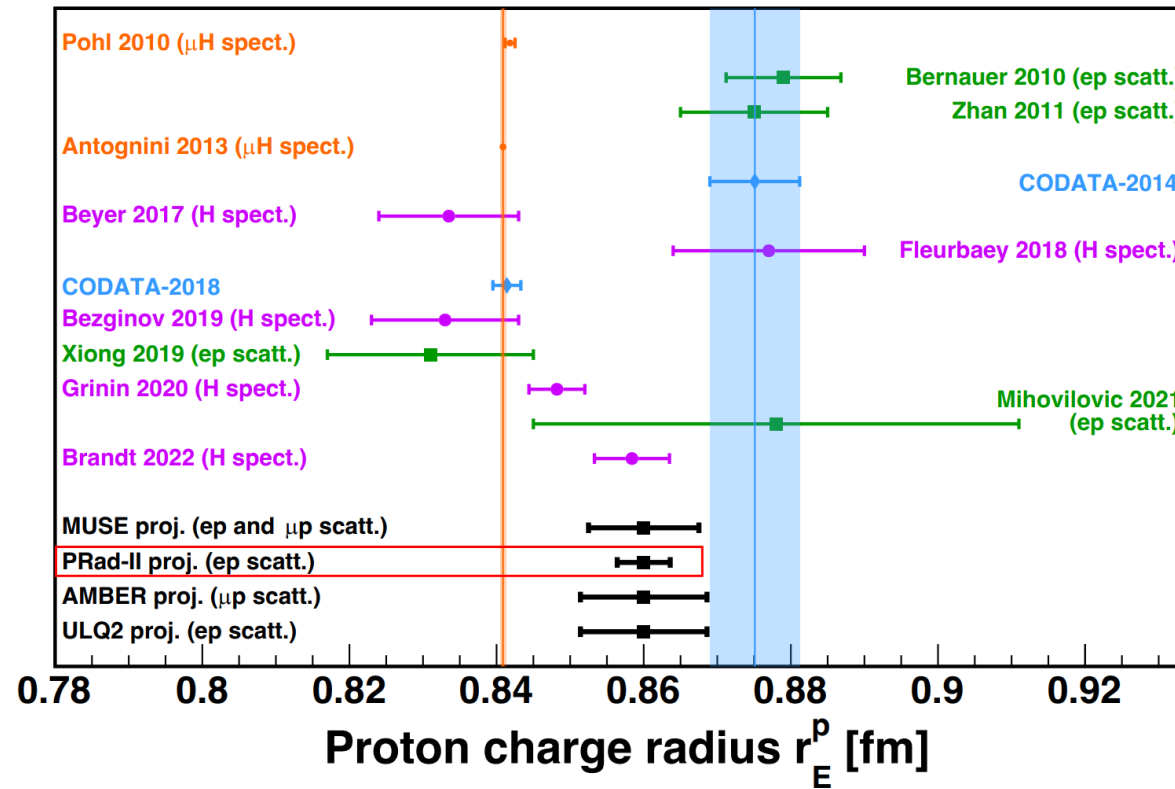
BACKUP SLIDES

X17 backup



Slide from W. Xiong [presentation](#)

Projected Results



Weizhi Xiong

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