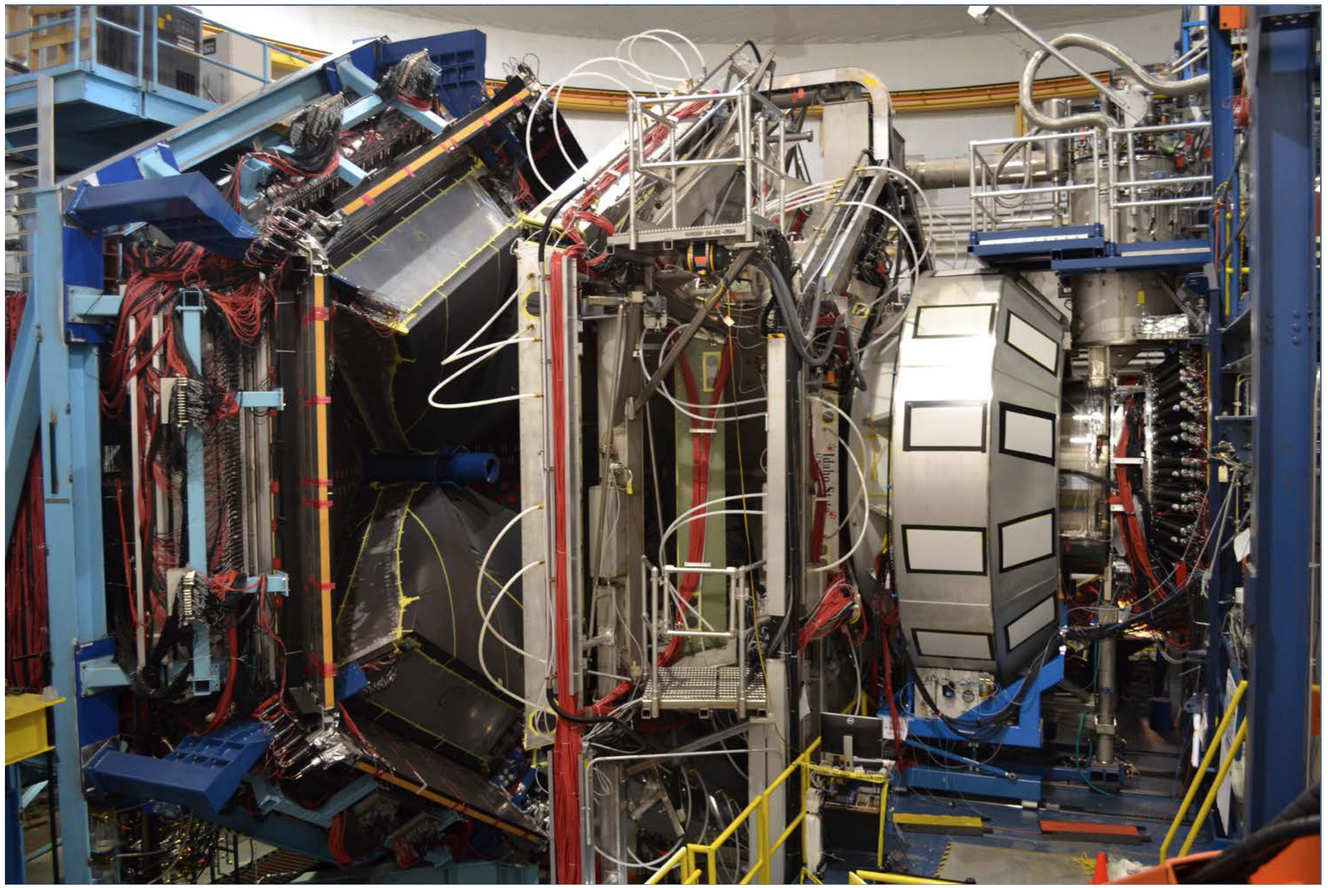
Hall B: overview and recent highlights

Tyler Kutz
MIT

JLUO Satellite Meeting

DNP/JPS joint meeting
Waikoloa Village, Hawaii
November 29, 2023

Hall B is home to JLab's large-acceptance, multi-purpose spectrometer



- CLAS12: CEBAF large-acceptance spectrometer
- Facilitates measurements of...
  - Rare processes
  - Exclusive reactions
  - Wide phase space
- Complementary to the small-acceptance, high-resolution spectrometers of Halls A, C

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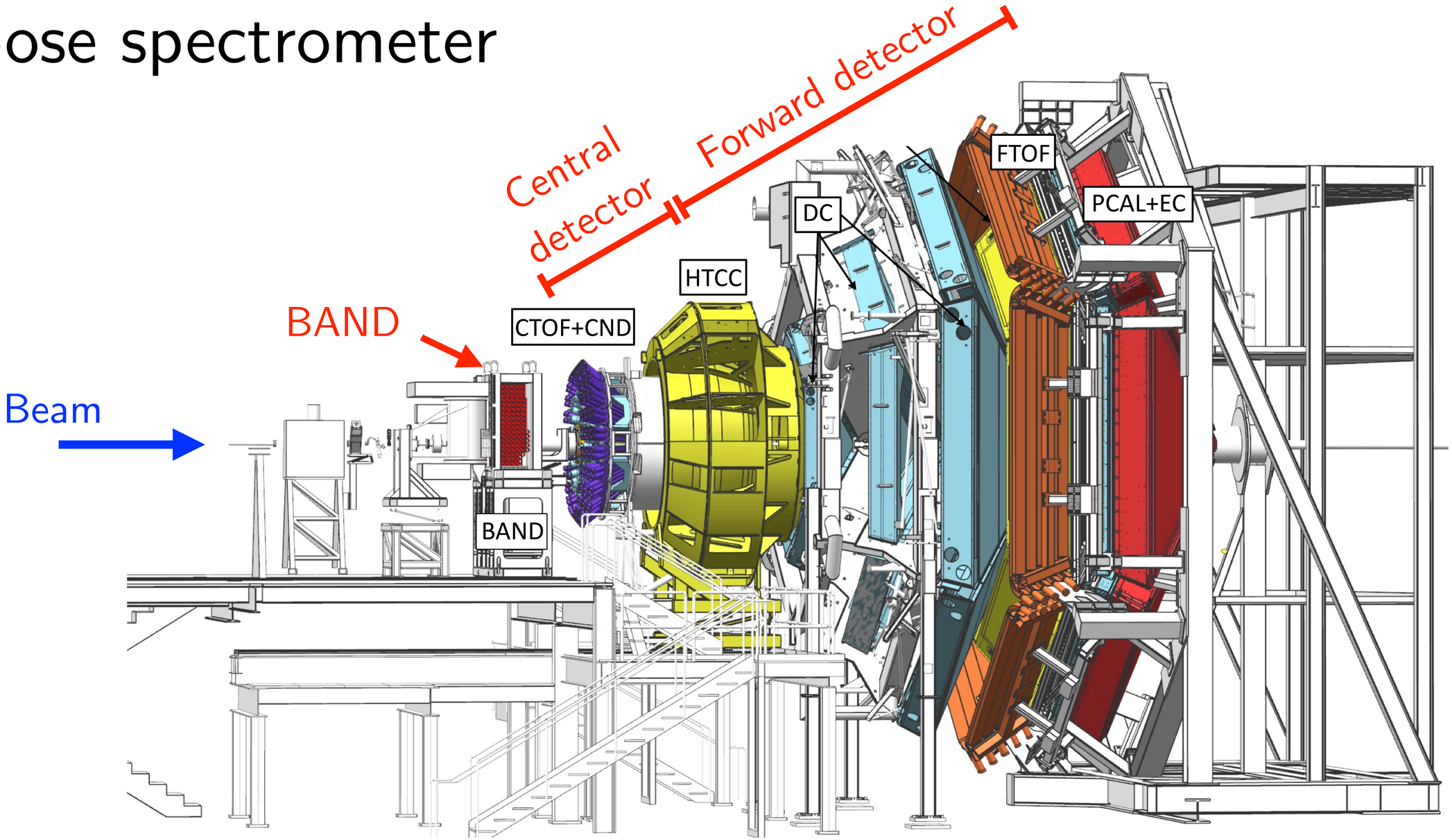


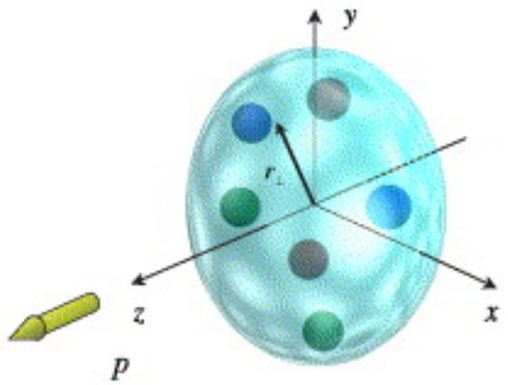
V.D. Burkert et al., NIM A 959, 163419 (2020)

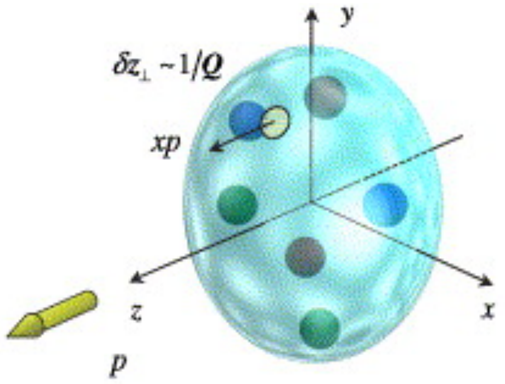
10 published/submitted CLAS results in 2023...

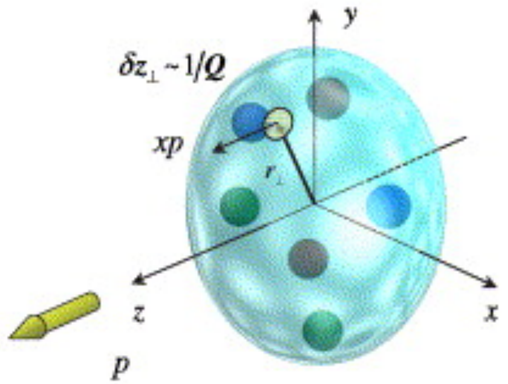
- A. Kim *et al.*, "Beam Spin Asymmetry Measurements of Deeply Virtual π^0 Production with CLAS12" submitted to PRL (2023)
- I.A. Skorodumina *et al.*, "Double-Pion Electroproduction off Protons in Deuterium: Quasi-Free Cross Sections and Final State Interactions", accepted for publication in PRC (2023)
- C. Kim *et al.*, "Measurements of the Helicity Asymmetry E for the $\gamma p \to p\pi^0$ Reaction in the Resonance Region" EPJA 59 217 (2023)
- S. Diehl *et al.*, "First Measurement of Hard Exclusive π^- Δ^{++} Electroproduction Beam Spin Asymmetries off the Proton", PRL 131 021901 (2023)
- I. Korover *et al.*, "Observation of Large Missing-Momentum $(e, e'p)$ Cross-Section Scaling and the Onset of Correlated-Pair Dominance in Nuclei", PRC 107 L061301 (2023)
- G. Christiaens *et al.*, "First CLAS12 Measurement of DVCS Beam-Spin Asymmetries in the Extended Valence Region", PRL 130 211902 (2023)
- T. Chetry *et al.*, "First Measurement of Λ Electroproduction off Nuclei in the Current and Target Fragmentation Regions", PRL 130 14 (2023)
- S. Diehl *et al.*, "A Multidimensional Study of the Structure Function Ratio $\sigma_{LT'}/\sigma_0$ from Hard Exclusive π^+ Electroproduction off Protons in the GPD Regime", PLB 839 137761 (2023)
- H. Avakian *et al.*, "Observation of Correlations Between Spin and Transverse Momenta in Back-to-Back Dihadron Production at CLAS12", PRL 130 022501 (2023)
- Y. Tian *et al.*, "Exclusive π^- Electroproduction off the Neutron in Deuterium in the Resonance Region". PRC 107, 015201 (2023)

Links and previous years available on Hall B webpage

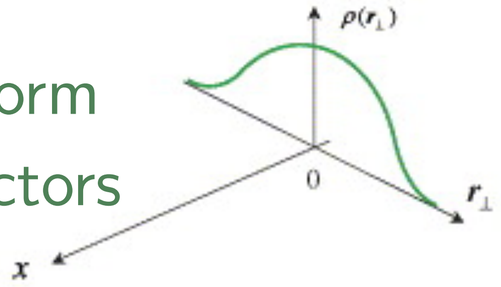
3D nuclear imaging is cornerstone of CLAS12 program

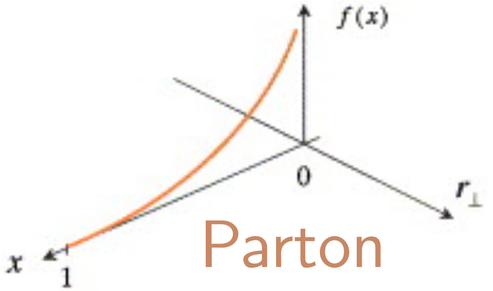




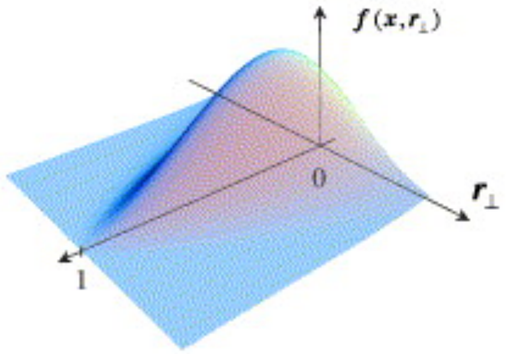


Form factors





Parton distribution functions

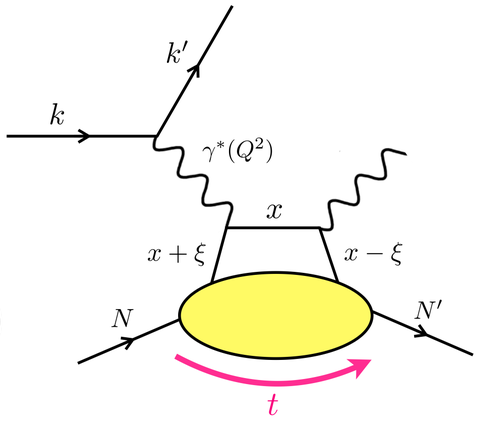


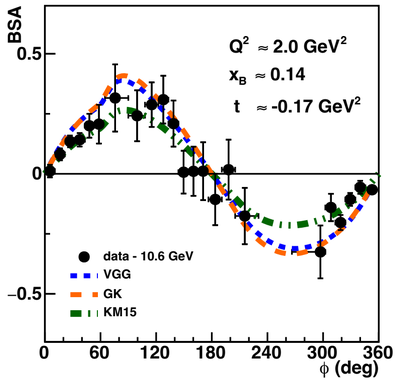
Generalized parton distributions

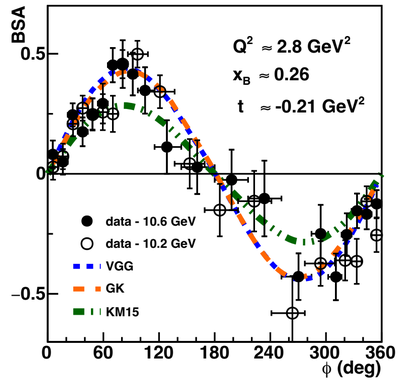
- Compton scattering golden channel to access GPDs
- Historically, deeply virtual Compton scattering (DVCS) preferred tool
- Commonly accessed through beam spin asymmetries (BSA)

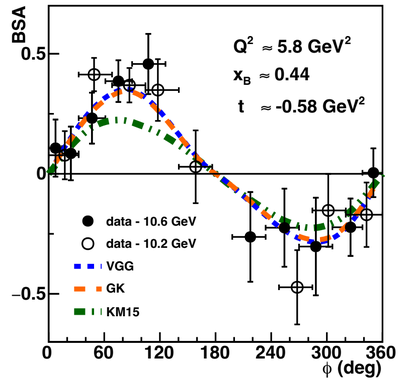
Recent DVCS measurements from CLAS12

- Christiaens *et al.* (CLAS) PRL 130 211902 (2023)
- First CLAS12 measurement in valence region (up to $x_B \approx 0.44$)









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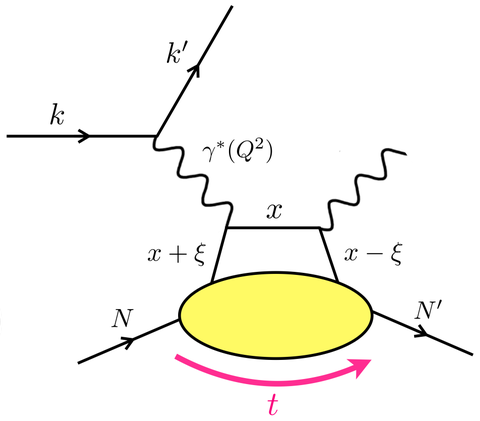
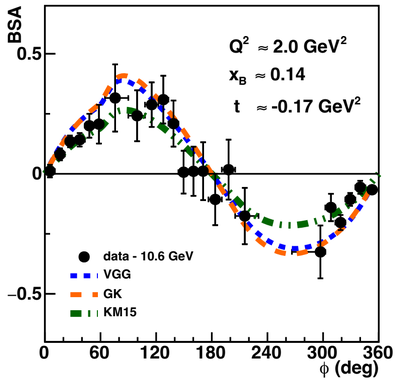
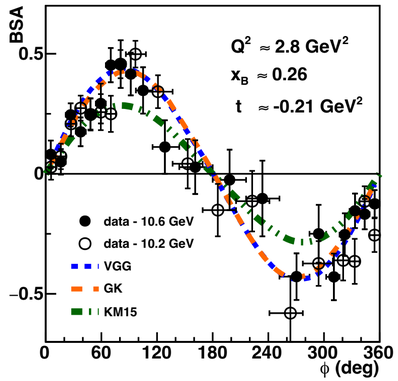
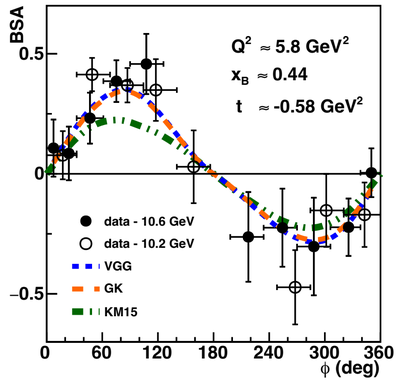
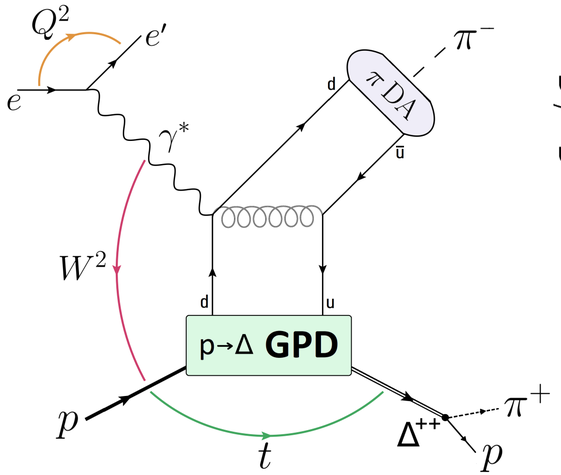


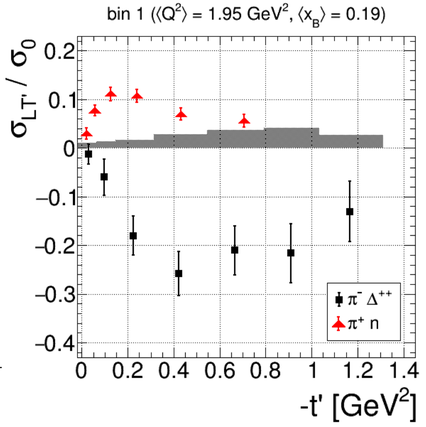


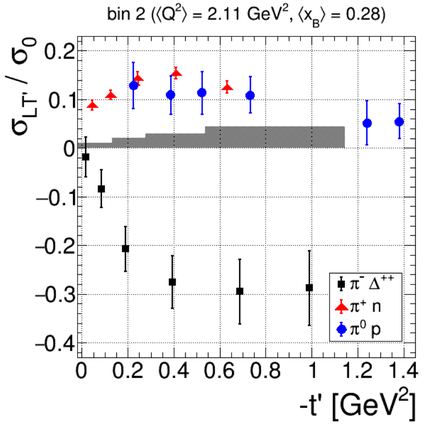


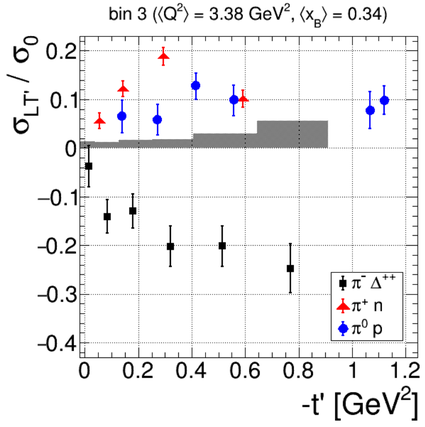


- Diehl *et al.* (CLAS)
  PRL 131 021901 (2023)
- Novel access to d content, $p \to \Delta^{++}$ transition GPDs



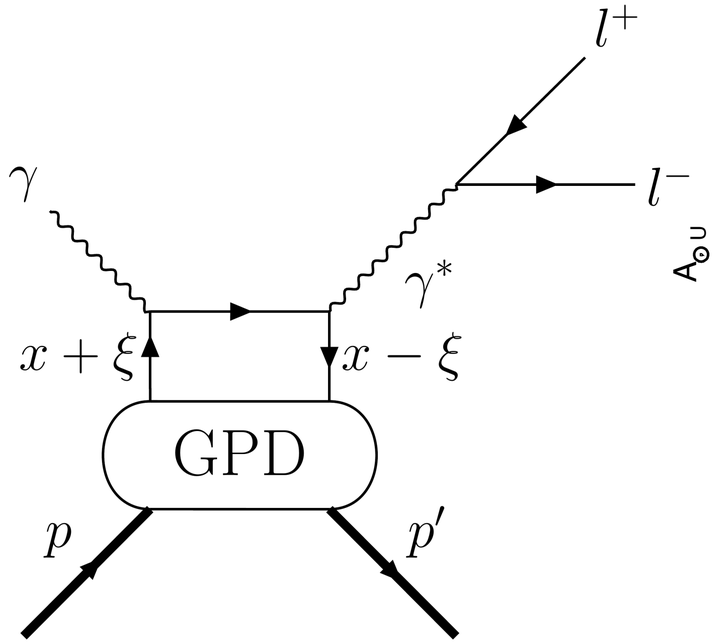


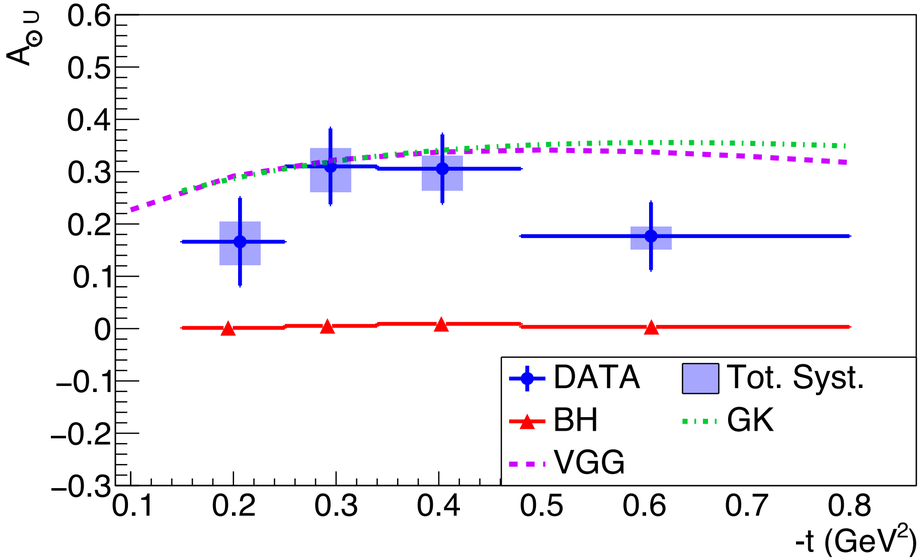


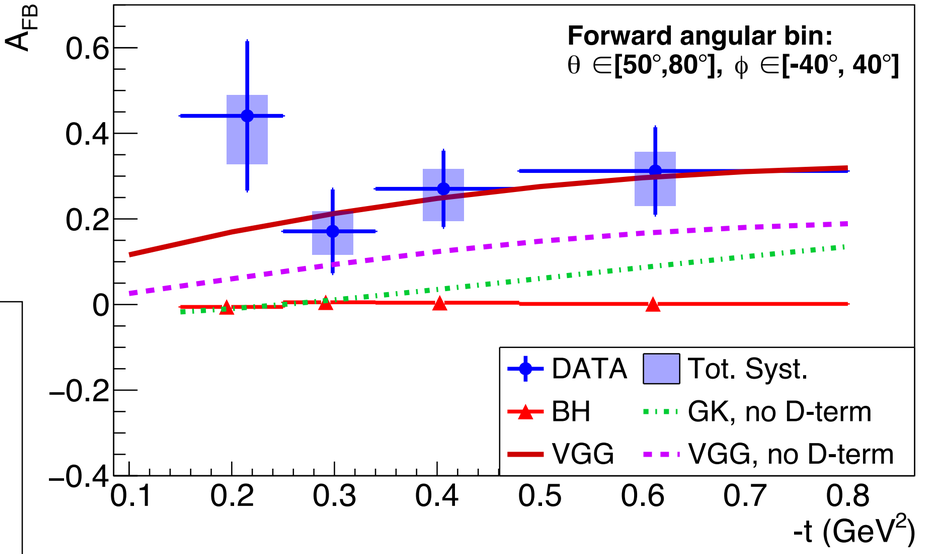


First observation of timelike Compton scattering

(Chatagnon *et al.* PRL 127 262501 (2021)



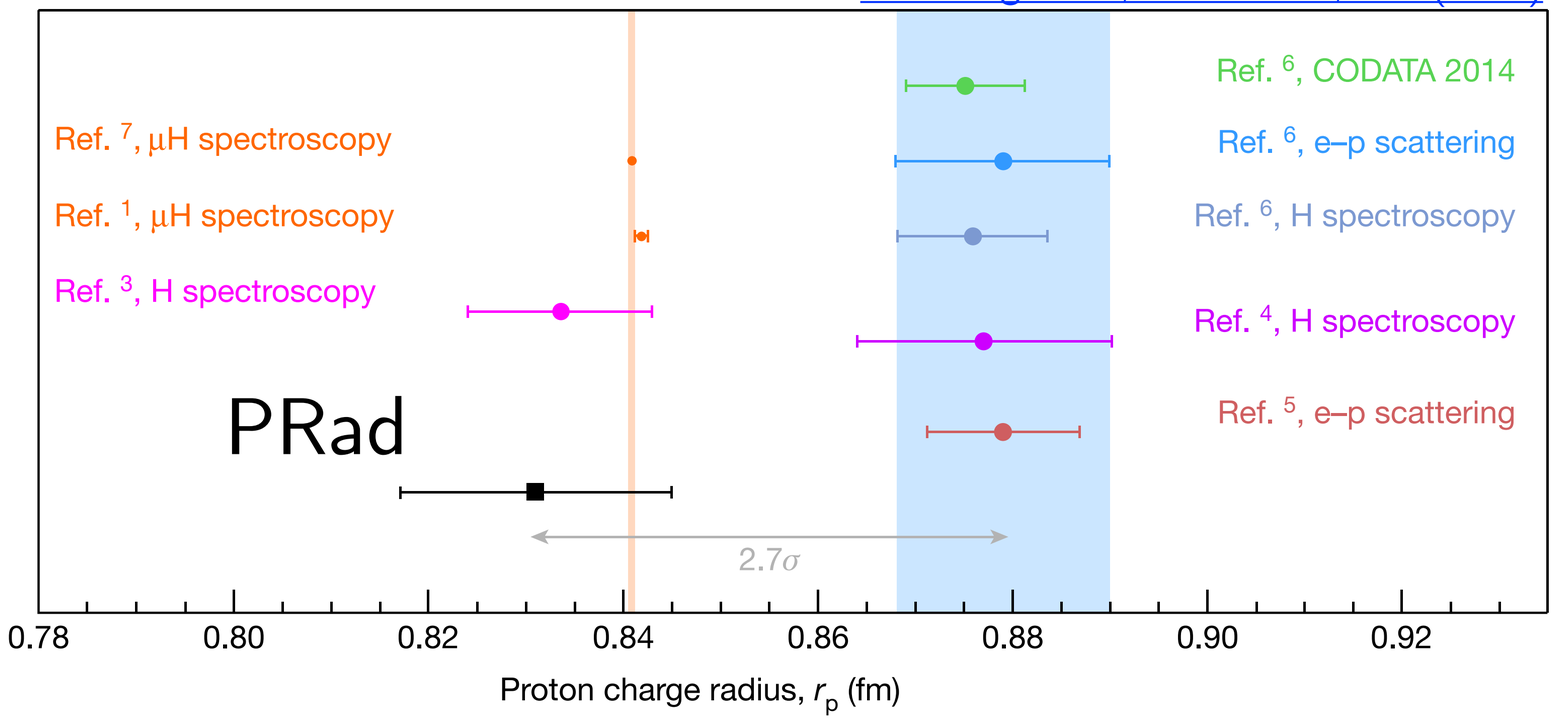




- Time-reversal symmetric to DVCS
- Non-zero photon polarization ($A_{\odot U}$) and forward-backward (A_{FB}) asymmetries suggest contributions from quark-level mechanisms

Beyond CLAS12...proton radius experiment (PRad)

W. Xiong et al., Nature 575, 147 (2019)

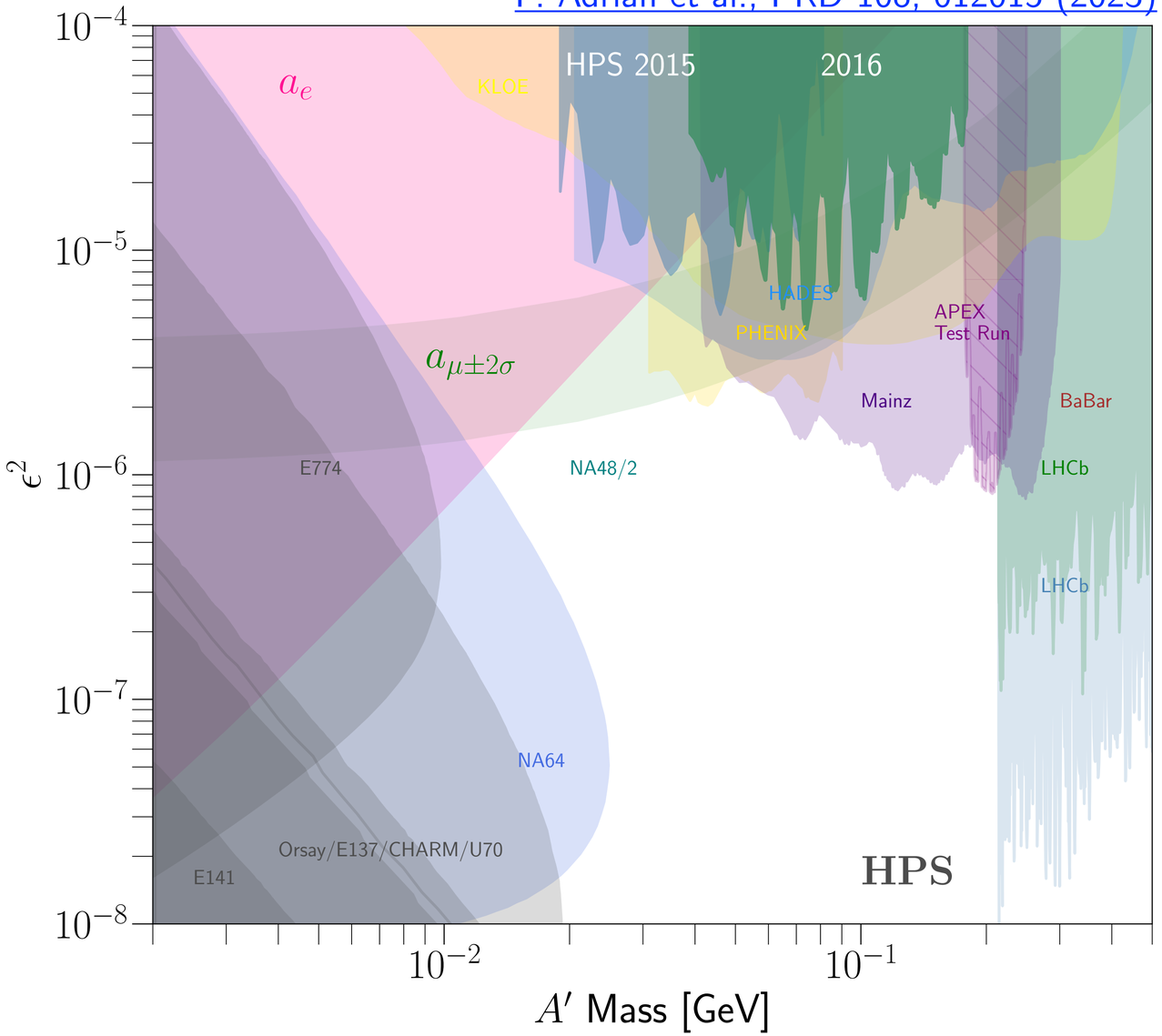


- Calorimetric measurement of elastic ep scattering down to Q^2 = 2.1 x 10^{-4} GeV^2 .
- First experiment observed "small" radius (consistent with μ spectroscopy)
- Upgraded PRad-II would reduce PRad experimental uncertainties by nearly factor of 4x, provide first lepton scattering data in range of 10^{-5} GeV^2

Heavy photon search (HPS)

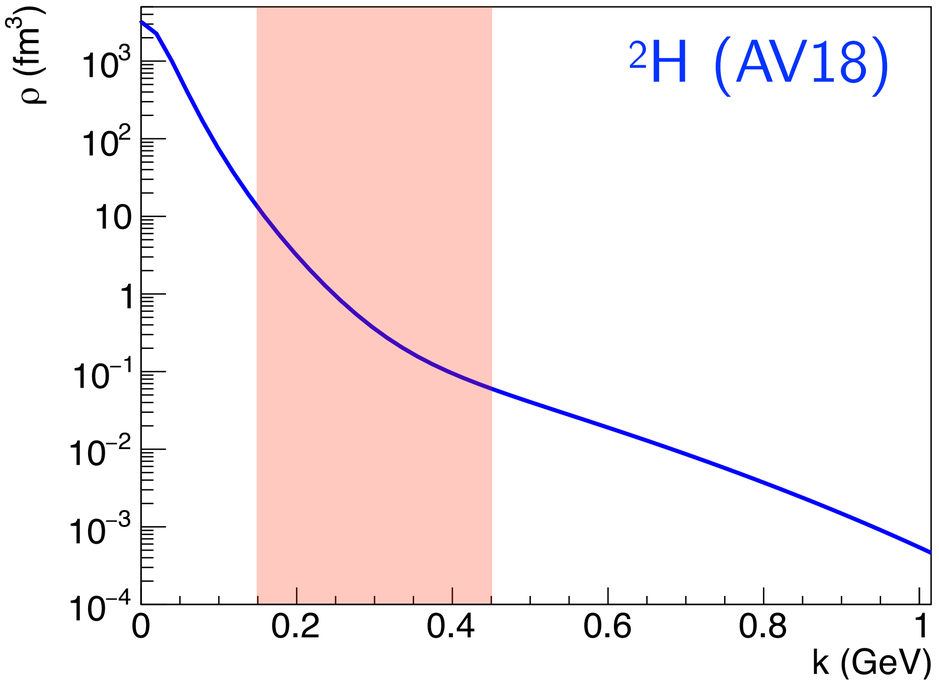
- Search for electroproduced dark photon
- Resonance search with 2016 data set conforms previous experiments
- Displaced vertex search probes region of $60 < M_{A'} < 150$ MeV, $10^{-8} < \epsilon^2 < 10^{-10}$.
- Statistics insufficient to reach sensitivity needed to observe A' production
- 2019 and 2021 data runs will increase luminosity by order of magnitude

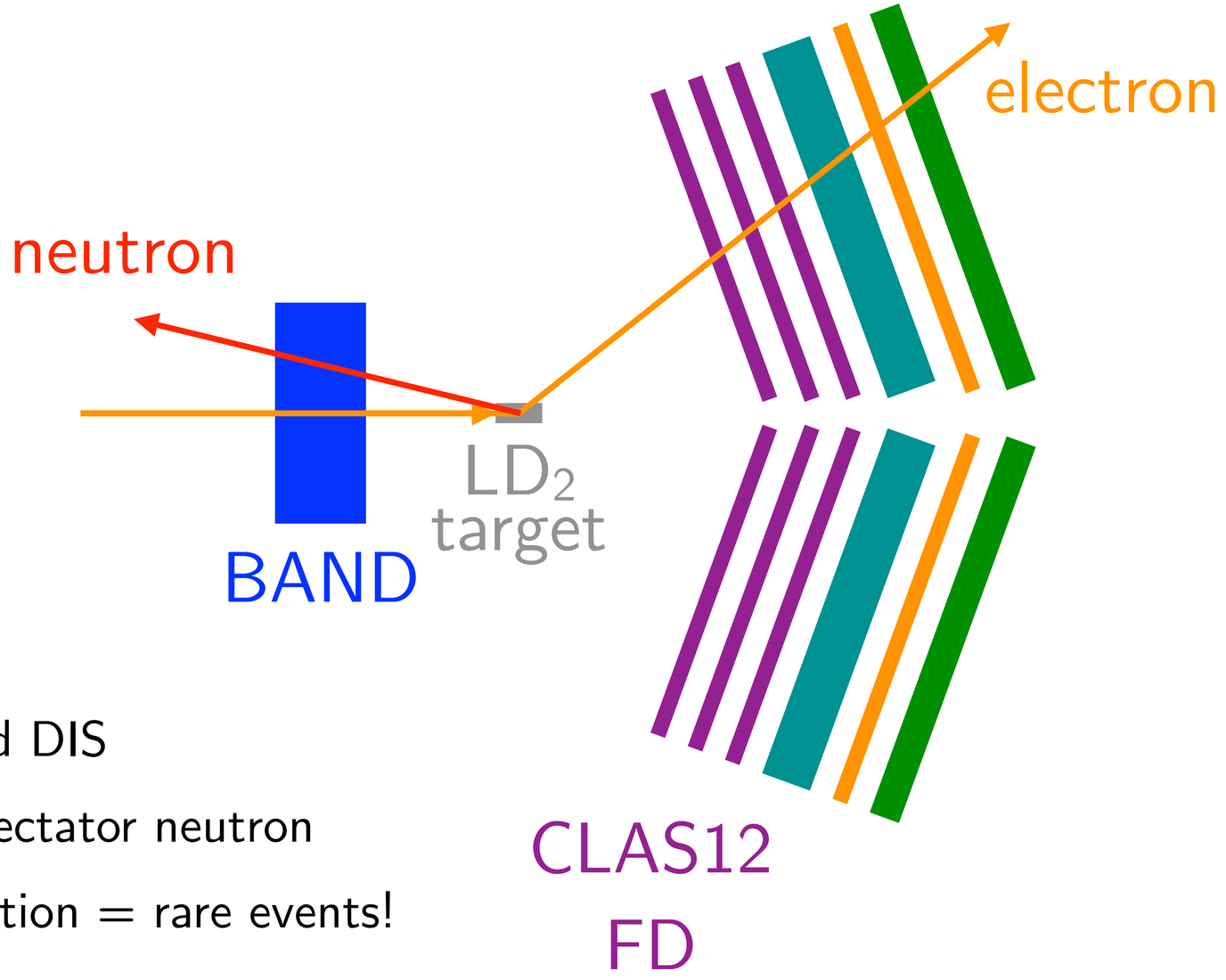
P. Adrian et al., PRD 108, 012015 (2023)



Structure of high-momentum protons bound in deuterium

(ongoing analysis by Kutz, *et al.*)

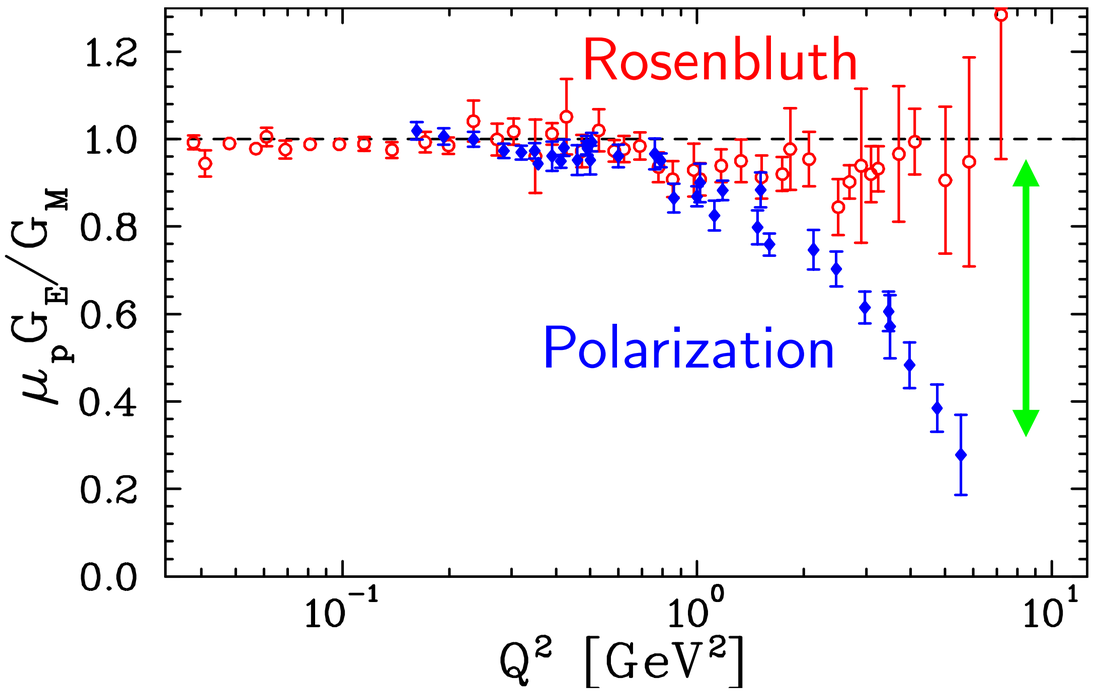




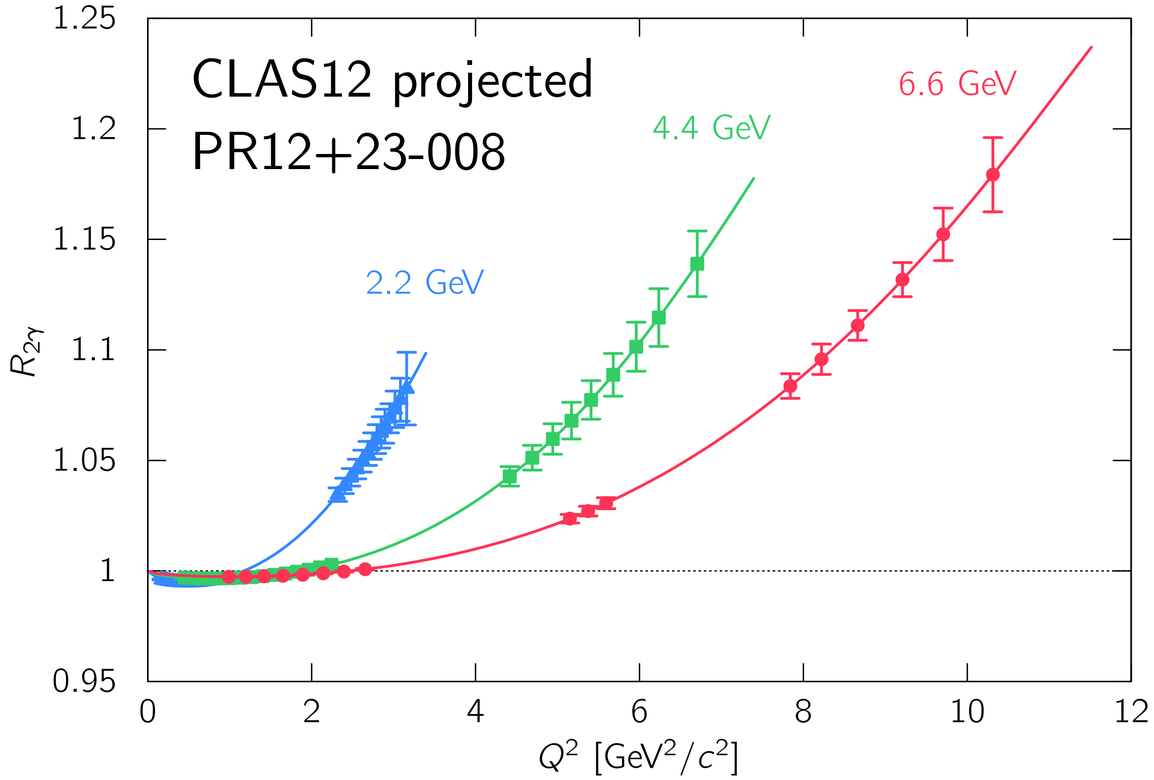
- Study structure of bound protons with tagged DIS
- DIS off of proton, detect high-momentum spectator neutron
- Tail of nuclear wavefunction + neutron detection = rare events!

Measurement of TPE with e^+/e^- elastic scattering

(proposal by Kutz, *et al.*)



TPE?



- Proton form factor discrepancy due to two-photon exchange?
- Existing measurements of $R_{2\gamma} = e^+p/e^-p$ inconclusive
- CLAS12 ideal for definitive measurement across wide kinematic range
- Proposal conditionally approved with A rating (PAC 51)

Summary

- Hall B's multi-purpose CLAS12 facilitates wide range of measurements on nuclear and nucleon structure
- Other major efforts in Hall B:
  - Precision proton radius (PRad)
  - Dark matter search (HPS)
- For more details on tagged DIS and TPE measurements with CLAS12, please see my talks:
  - E11.00001 Wednesday 7pm (this evening)
  - F03.00007 Thursday 10:30am (tomorrow morning)