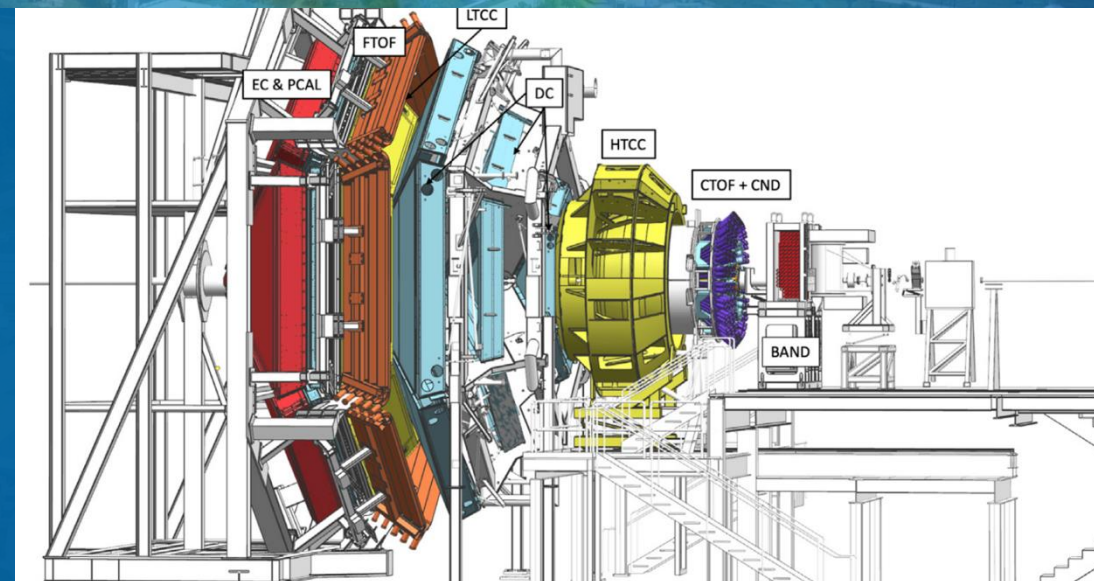


JULY 24TH 2026

FUTURE EXCLUSIVE MEASUREMENTS IN HALL B AT JEFFERSON LAB

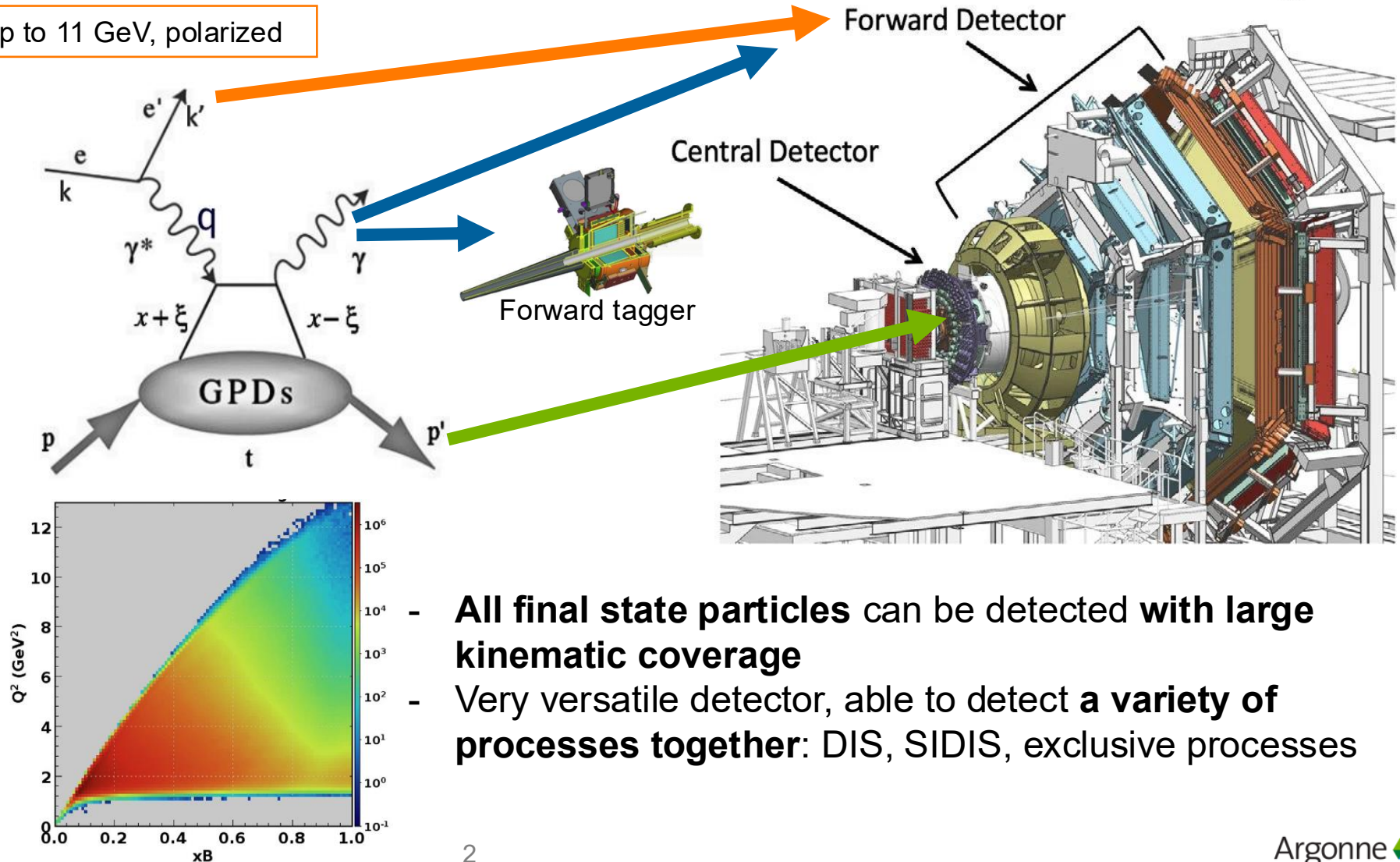
NOÉMIE PILLEUX
Postdoctoral appointee
Argonne National Laboratory



EXCLUSIVE REACTIONS WITH CLAS12



CEBAF electron accelerator, up to 11 GeV, polarized



A VERSATILE DETECTOR FOR GPD STUDIES

Data on **various targets**:

- Free protons
- Bound protons and neutrons in light nuclei
- Light nuclei
- Longitudinal polarization
- Transverse polarization
- Targets with different spins...

Access to **an abundance of exclusive reactions**:

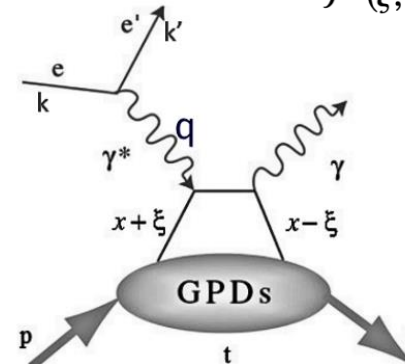
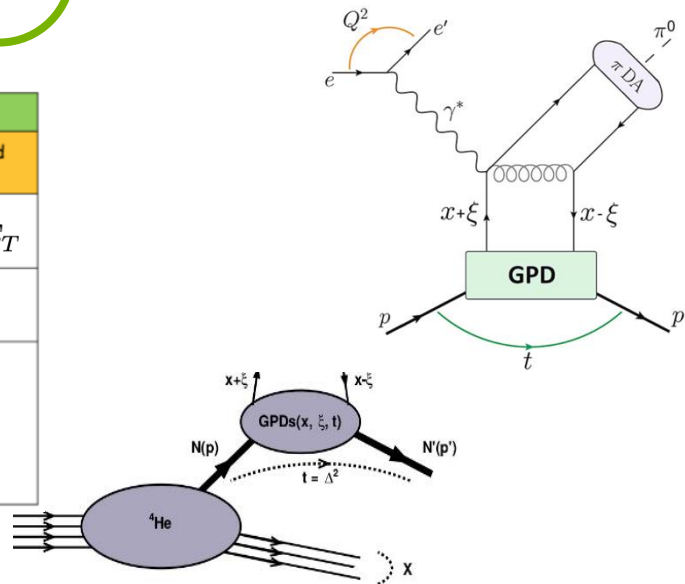
- DVCS
- TCS
- Scalar meson production
- Vector meson production

Over a wide kinematic range

Overall, a great playground for:

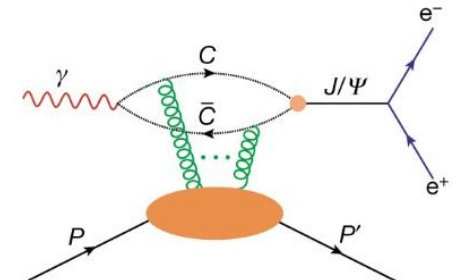
- Valence quarks and gluons
- Polarization, spin
- Flavor-dependence
- Twist
- Nuclear effects,...

Quark Polarization			
	Unpolarized (U)	Longitudinally Polarized (L)	Transversely Polarized (T)
Nucleon Polarization	U	H	$\bar{E} = 2\tilde{H}_T + E_T$
	L	$\tilde{H}$	$\tilde{E}_T$
	T	E	$H_T, \tilde{H}_T$

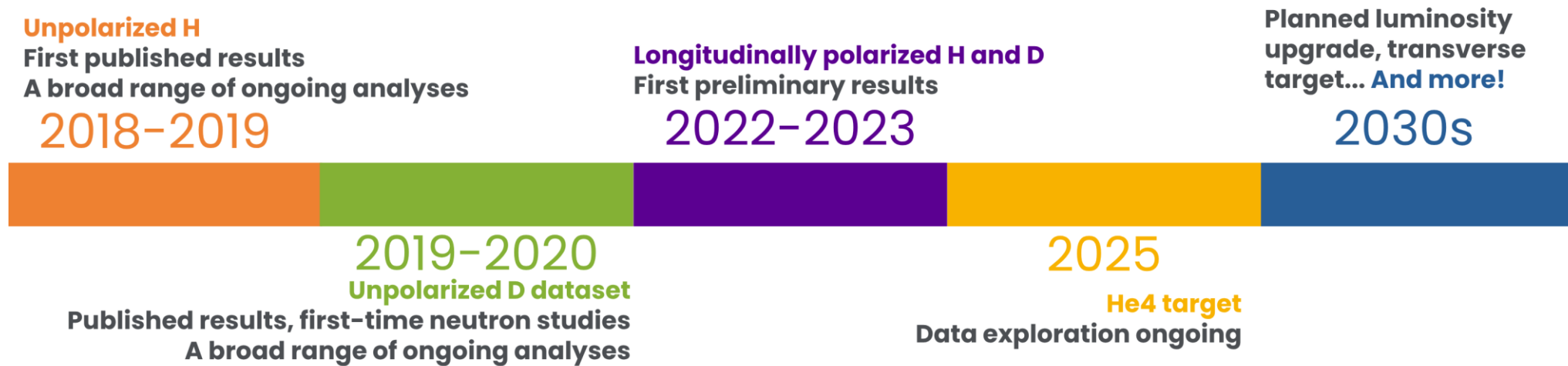


$$\mathcal{F}^u(\xi, t) = \frac{9}{15} (4\mathcal{F}_p(\xi, t) - \mathcal{F}_n(\xi, t))$$

$$\mathcal{F}^d(\xi, t) = \frac{9}{15} (4\mathcal{F}_n(\xi, t) - \mathcal{F}_p(\xi, t))$$



CLAS12 DATA TAKING TIMELINE



Today:

- Overview and preliminary results from ongoing analyses
- New configurations: longitudinally polarized target, light nuclei recoil detection
- Future upgrades: transverse polarization, high luminosity and dilepton detection

ONGOING ANALYSES



U.S. DEPARTMENT
of ENERGY

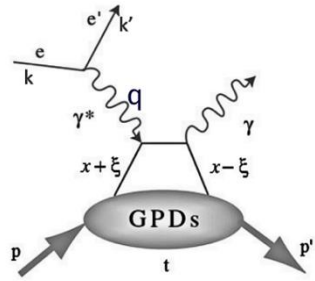
Argonne National Laboratory is a
U.S. Department of Energy laboratory
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FREE PROTON DVCS

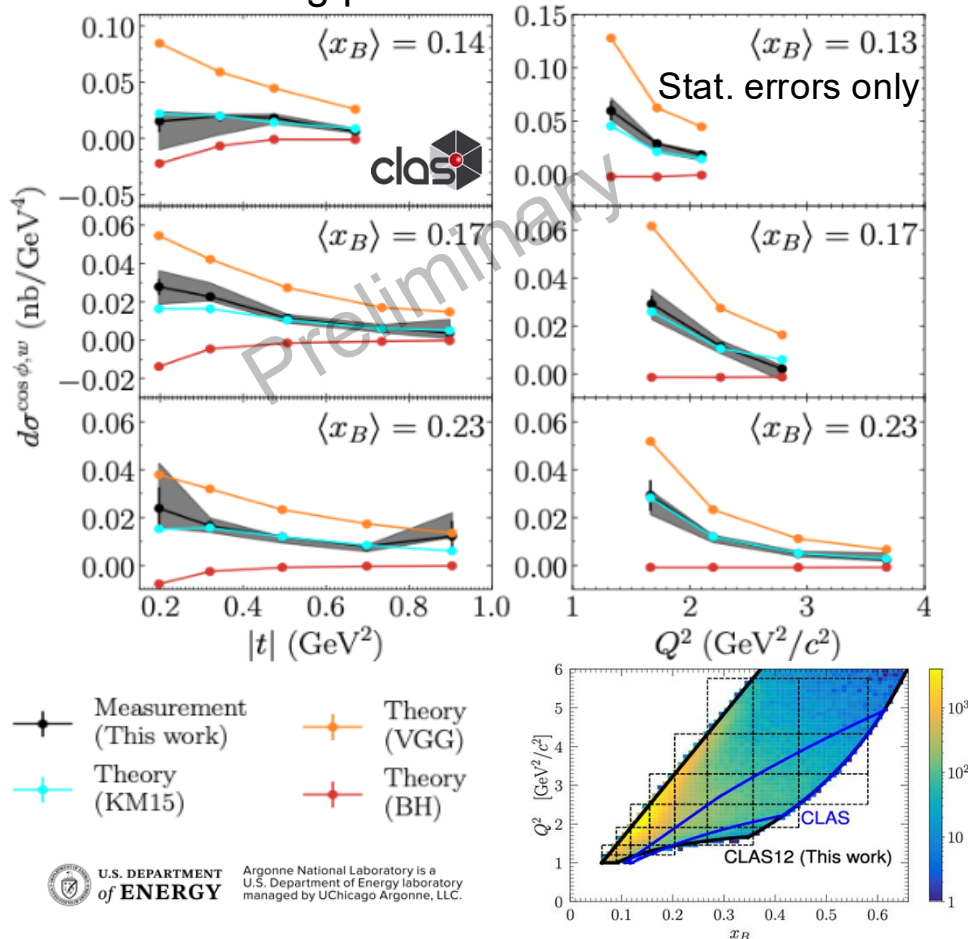
What was already done? Proton DVCS
Beam Spin Asymmetry (BSA)

G. Christiaens et al. Phys. Rev. Lett. 130, 211902 (2023)



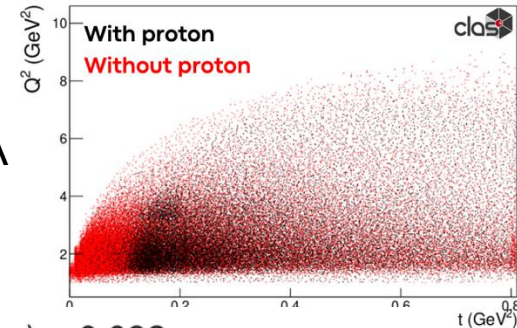
S. Lee

Cross section measurement under final collaboration review, paper to be submitted early August
Extending previous CLAS measurement

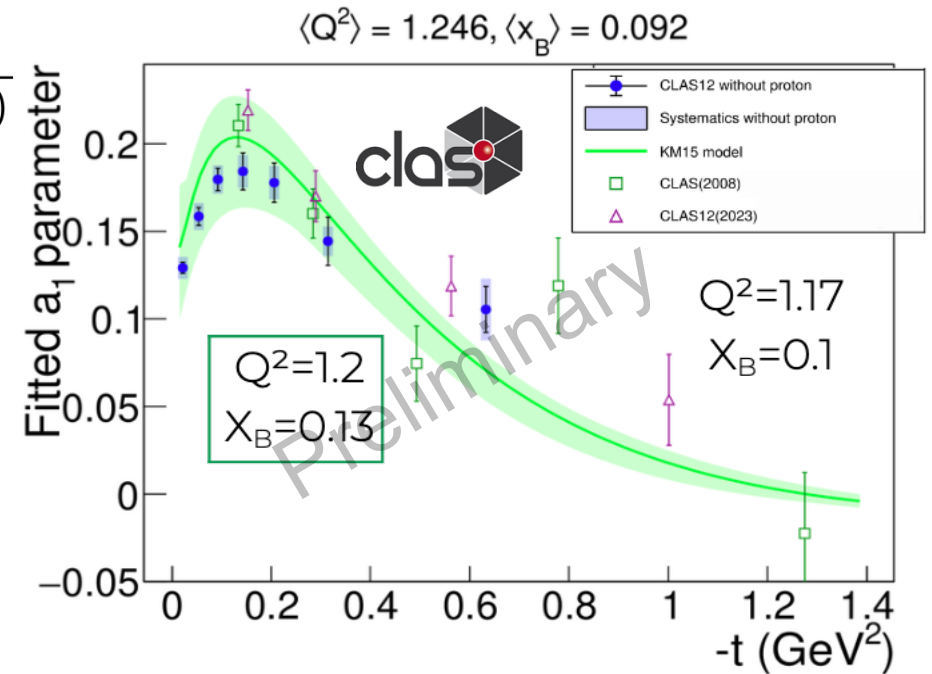


JS Alvarado

Machine-learning-assisted DVCS without proton detection
Update on previously published BSA
Extension of phase-space and important statistics



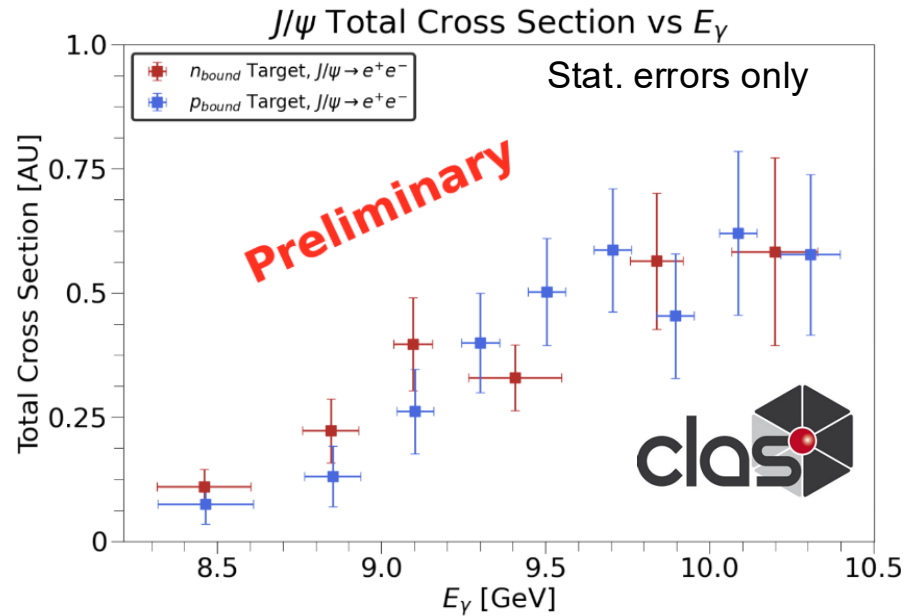
$$A(\phi) \equiv \frac{a_1 \sin(\phi)}{1 + a_2 \cos(\phi)}$$



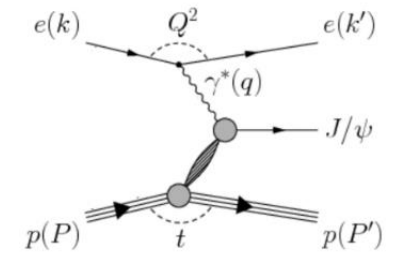
GLUON GPDs

R. Tyson

J/ψ electroproduction cross section on protons and neutrons in D
Test for the isospin invariance of production mechanisms

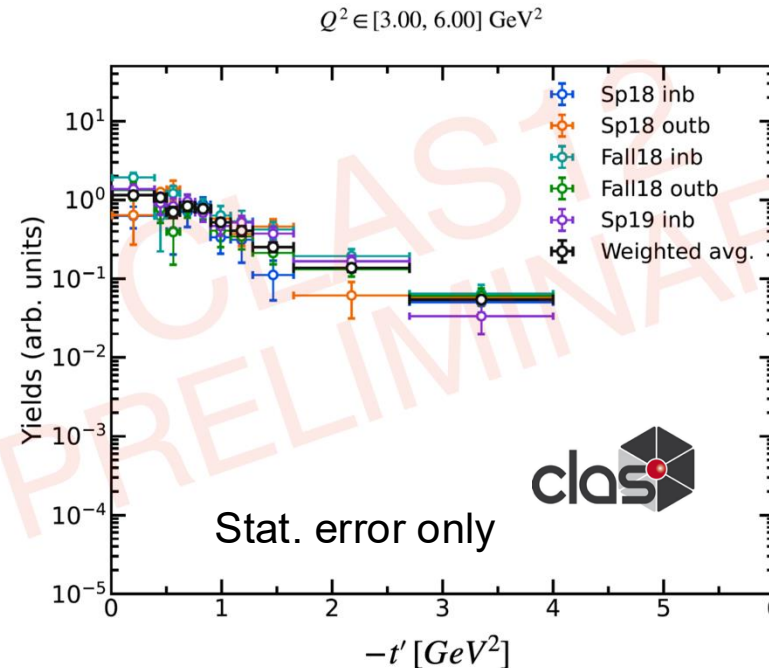


What was already done? J/ψ electroproduction cross section on the proton
P. Chatagnon *et al.*, Phys. Rev. C. 113, 065203 (2026).



B. Singh

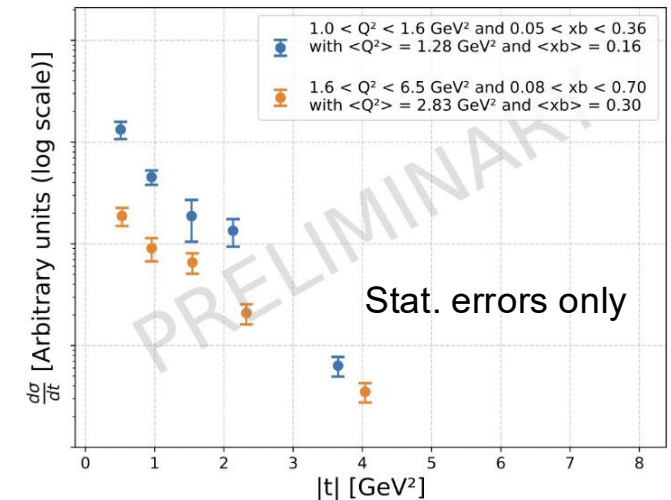
ϕ DVMP cross section
Gluonic radius, strangeness
Able to achieve good statistical power using a missing kaon analysis
Energy scan 6.5, 7.5, 10.6 GeV



M. Ronayette

ϕ DVMP cross section on protons and neutrons in D.

See Mathieu's talk on Monday



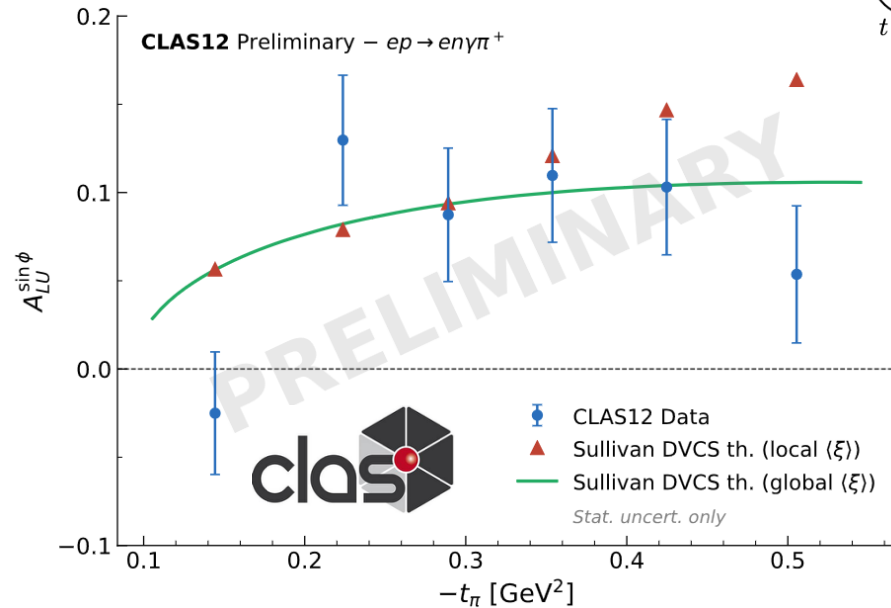
Coherent ϕ production on D
also ongoing (R. Tyson)

BEYOND SPIN 1/2

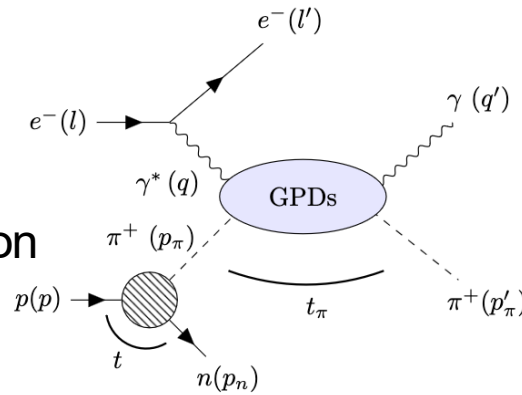
E. Ferrand

Sullivan process BSA
Spin 0, simple spin structure
Virtual meson cloud from the proton

Stat. errors only

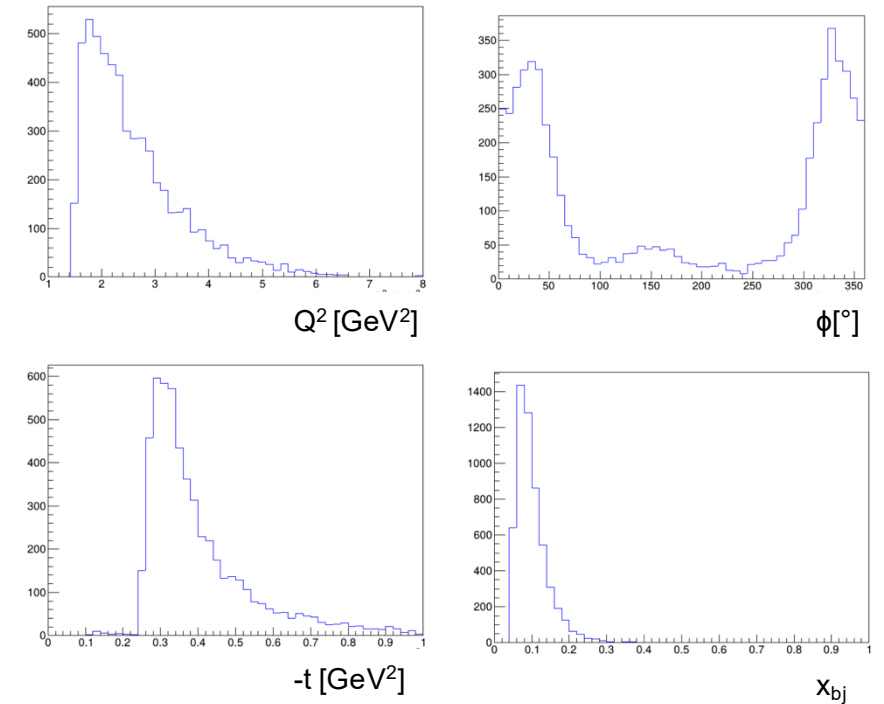


Baryon resonance transitions treated from predictions



M. Bousseau

Recently started: coherent DVCS on D
D detection with CLAS12 being explored



MORE STUDIES WITH CLAS12

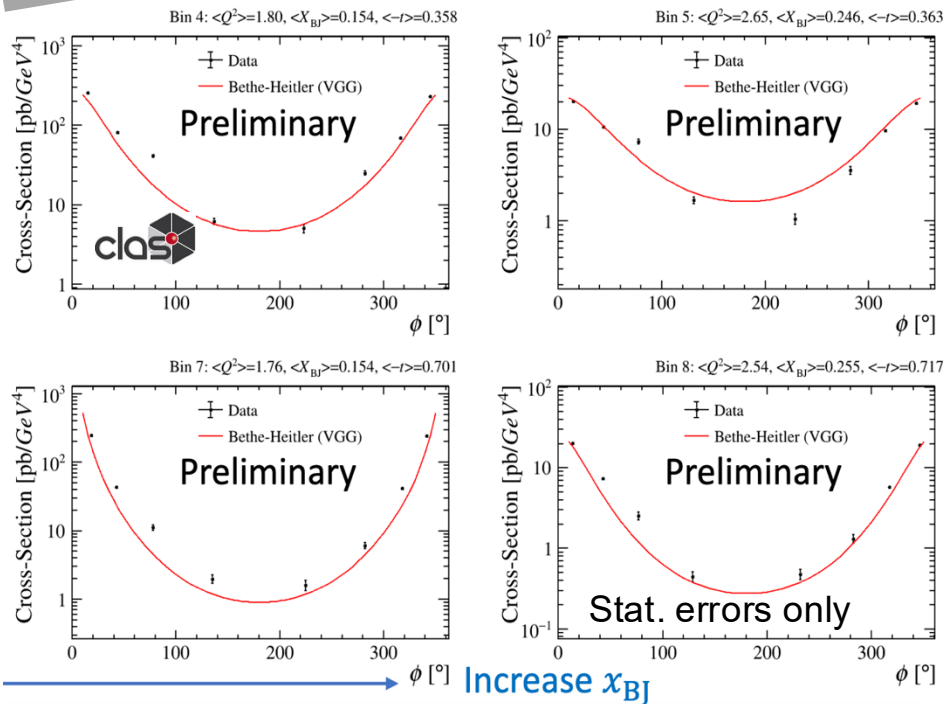
Transversity GPDs

Flavor separation

What was already done? Neutron DVCS BSA in D
A. Hobart *et al.*, Phys. Rev. Lett. 133, 211903 (2024).

L. Xu

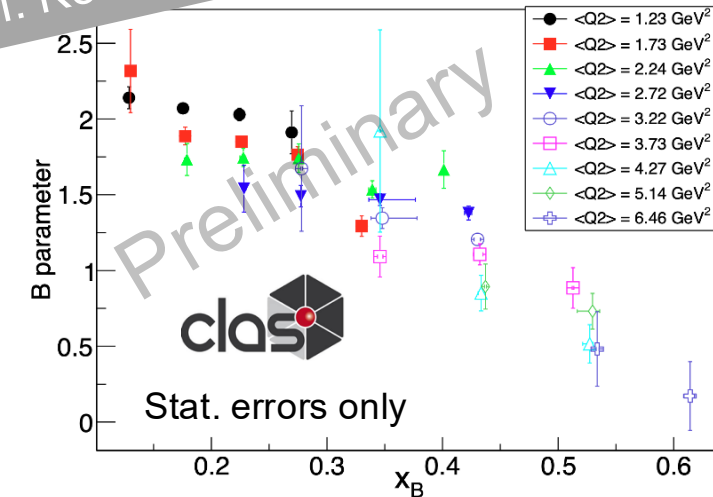
nDVCS cross section in D



What was already done? π^+ DVMP BSA
Diehl *et al.*, PLB 839, 137761(2023)

I. Korover

π^0 DVMP cross section



$$\frac{d\sigma_U}{dt} = A e^{-B|t|}$$

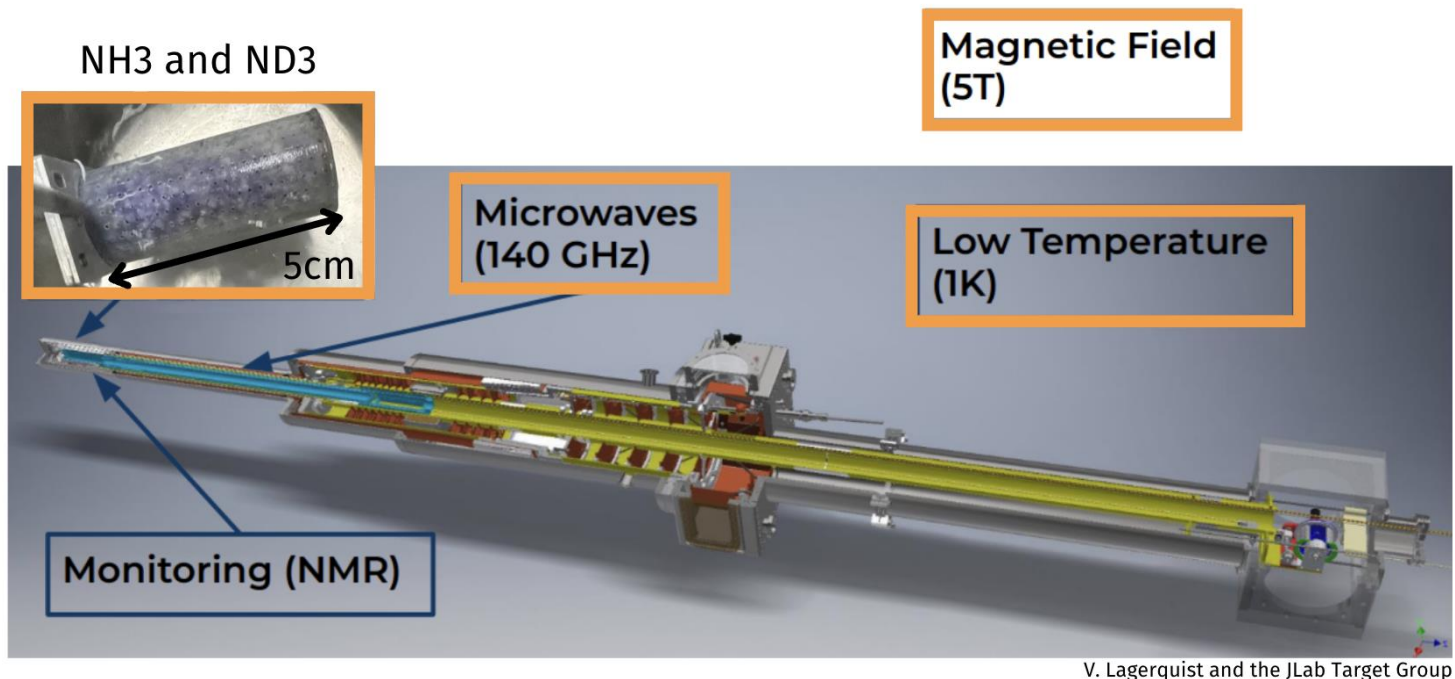
Non-exhaustive review of ongoing analyses! Also ongoing:

- Energy scans (6.4, 6.5, 7.5, 8.4, 10.5 GeV)
- $N \rightarrow N^*$ for transition GPDs
- η, ρ, ω production
- Nuclear targets
- And more as students and postdocs tackle new channels!

UPCOMING RESULTS WITH THE LONGITUDINALLY POLARIZED TARGET

POLARIZED DATASET

- 2022-2023 were dedicated to a longitudinally polarized target run.
- NH_3 and ND_3 targets: everything can be compared between protons and neutrons!
- A full program for exclusive measurements: pDVCS, nDVCS, π^0 DVMP, $\text{en}\pi^+$, J/ψ , and more.



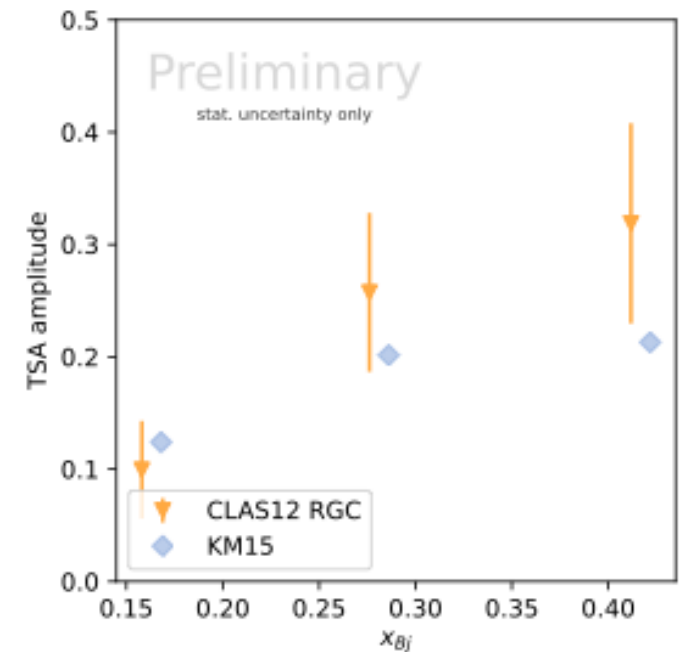
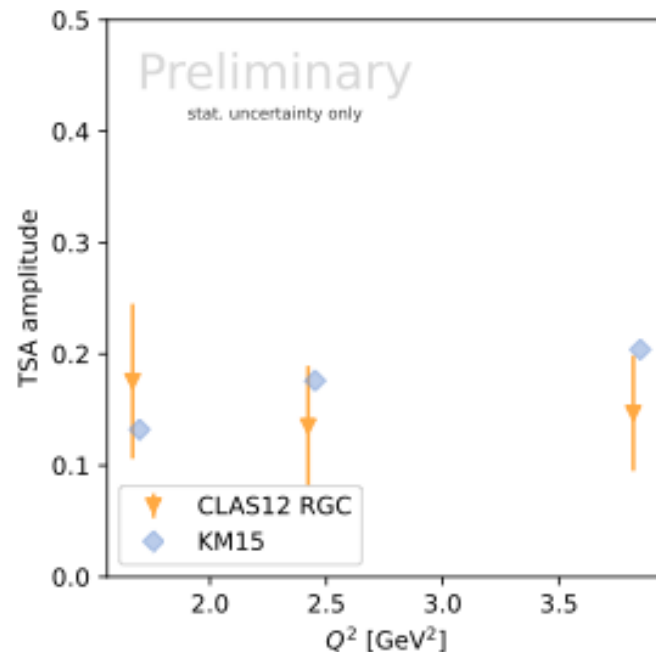
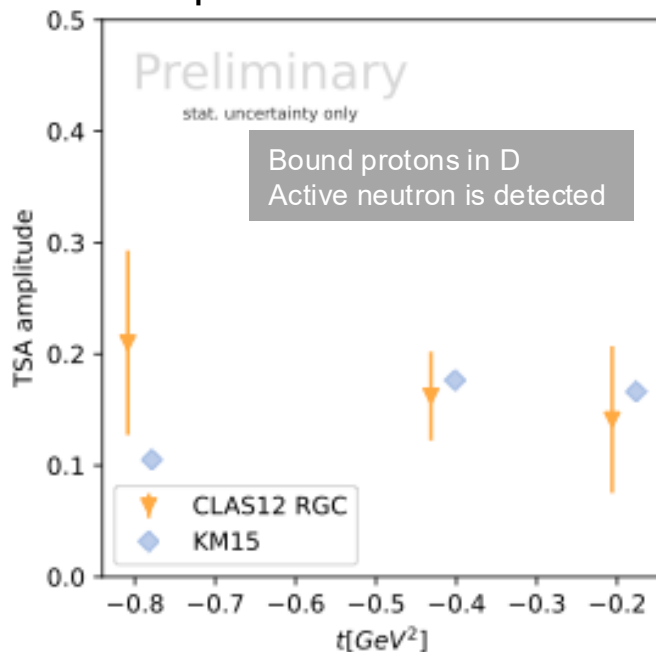
- Currently scheduled to run again in 2028 for +50% of the currently accumulated data
- **Will run together with an experiment on longitudinally polarized ^7Li !**

LONGITUDINALLY POLARIZED pDVCS IN D

N. Pilleux

- Beam-, target- and double-spin asymmetries on protons and neutrons:
 - Sensitive to a variety of GPDs.
 - Flavor dependence.
- No free neutron target? Comparison between free protons and protons in D.
- First-time measurements on both protons and neutrons in polarized D!

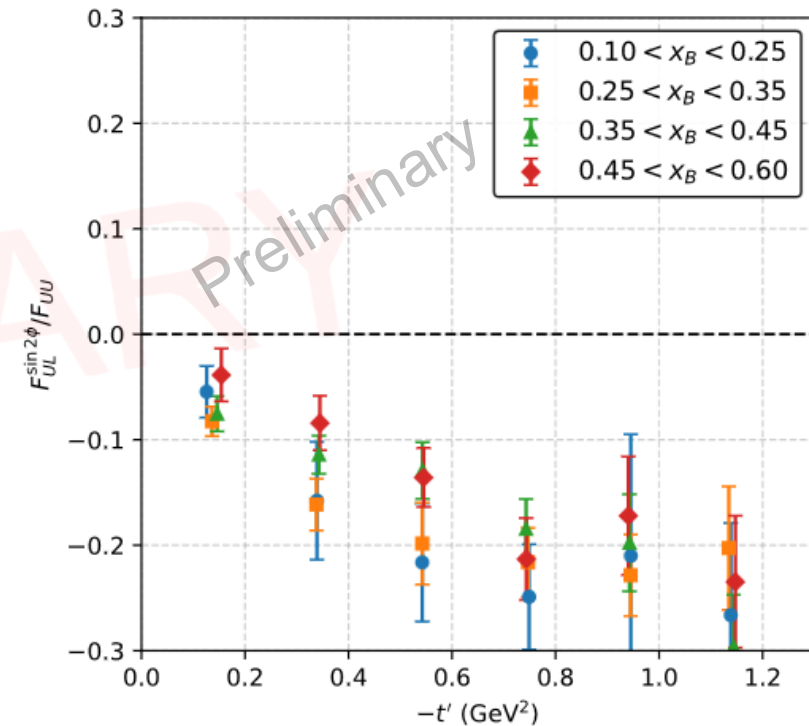
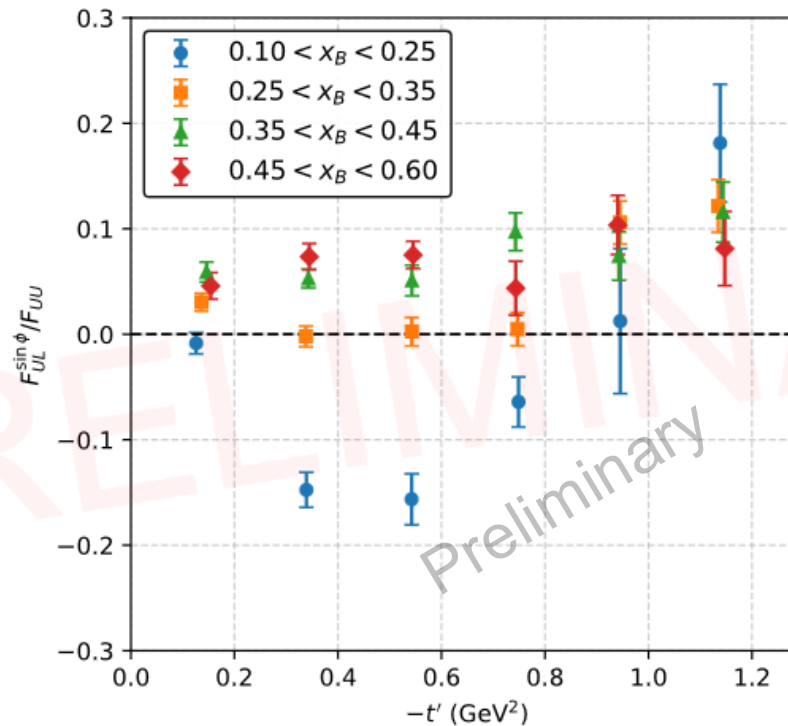
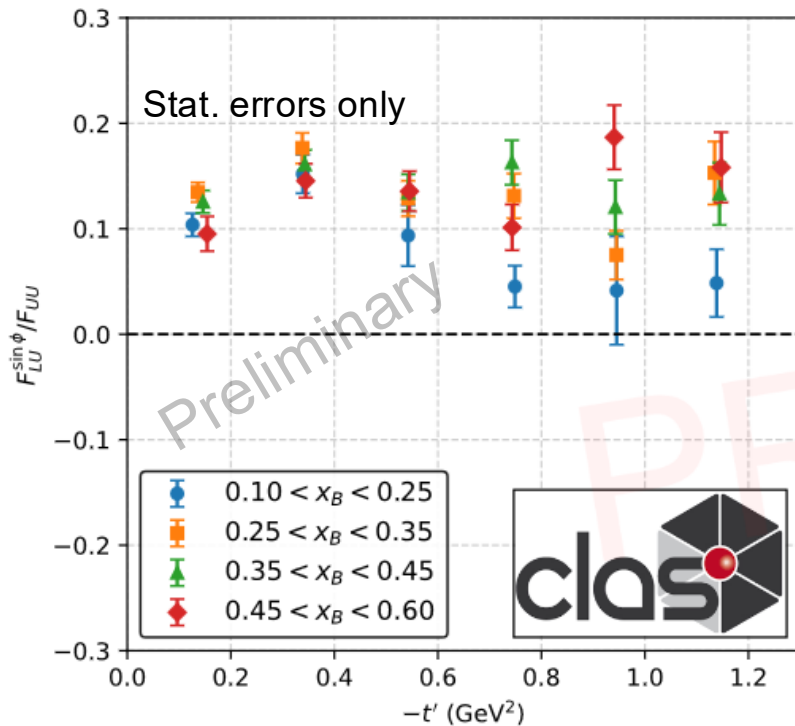
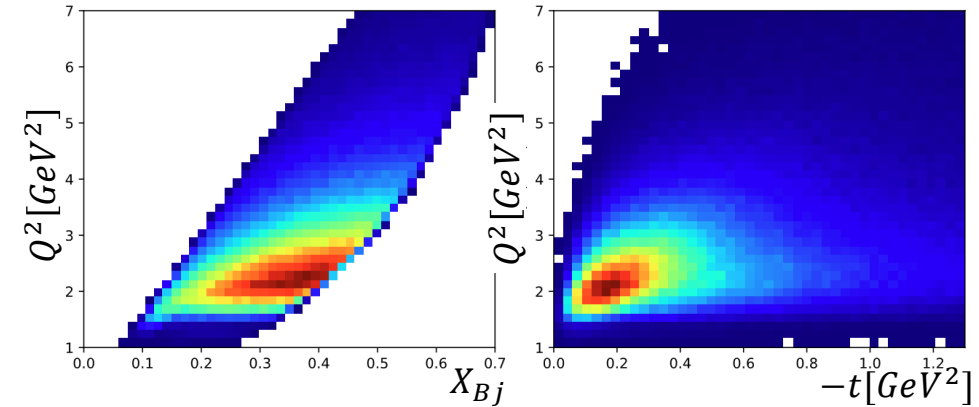
$$\begin{aligned}
 \Delta\sigma_{LU} &\propto \sin(\phi) \Im \left[F_1 \mathcal{H} + \xi(F_1 + F_2) \tilde{\mathcal{H}} - \xi \frac{t}{4M^2} F_2 \mathcal{E} \right] \\
 \Delta\sigma_{UL} &\propto \sin(\phi) \Im \left[F_1 \tilde{\mathcal{H}} + \xi(F_1 + F_2) (\mathcal{H} + \frac{x_{bj}}{2} \mathcal{E}) - \xi (\frac{x_{bj}}{2} F_1 + \frac{t}{4M^2} F_2) \tilde{\mathcal{E}} \right] \\
 \Delta\sigma_{LL} &\propto (A + B \cos(\phi)) \Re \left[F_1 \tilde{\mathcal{H}} + \xi(F_1 + F_2) (\mathcal{H} + \frac{x_{bj}}{2} \mathcal{E}) - \xi (\frac{x_{bj}}{2} F_1 + \frac{t}{4M^2} F_2) \tilde{\mathcal{E}} \right]
 \end{aligned}$$



LONGITUDINALLY POLARIZED $ep \rightarrow en\pi^+$

T. Hayward

- Single and double-spin asymmetries probing transverse GPDs
- $\sin(2\phi)$ modulation in F_{UL} is sensitive to $\tilde{E}_T$ and $\tilde{H}_T$, first-time measurement!
- Free proton in H



NEW DATA ON LIGHT NUCLEI



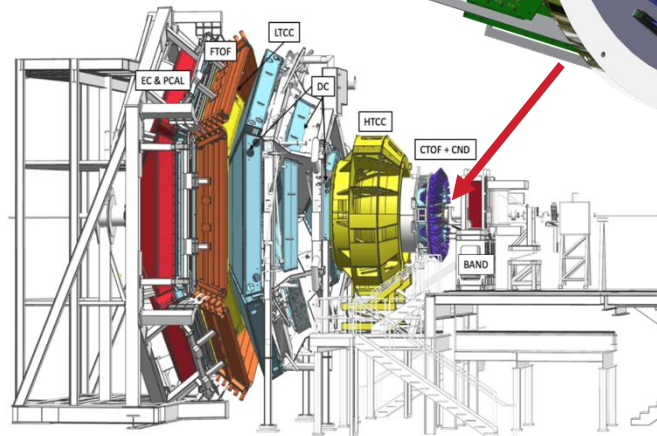
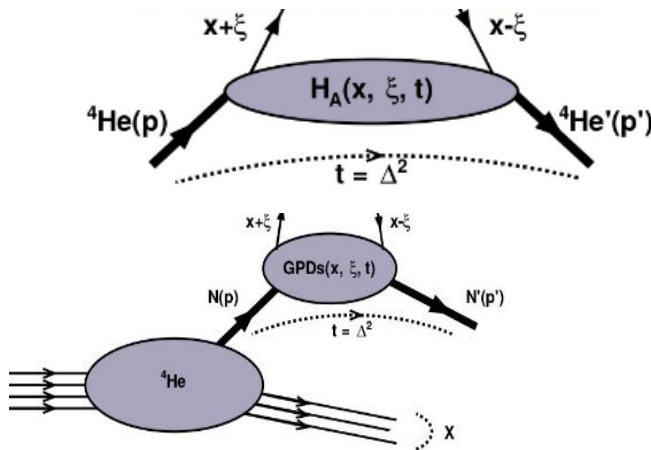
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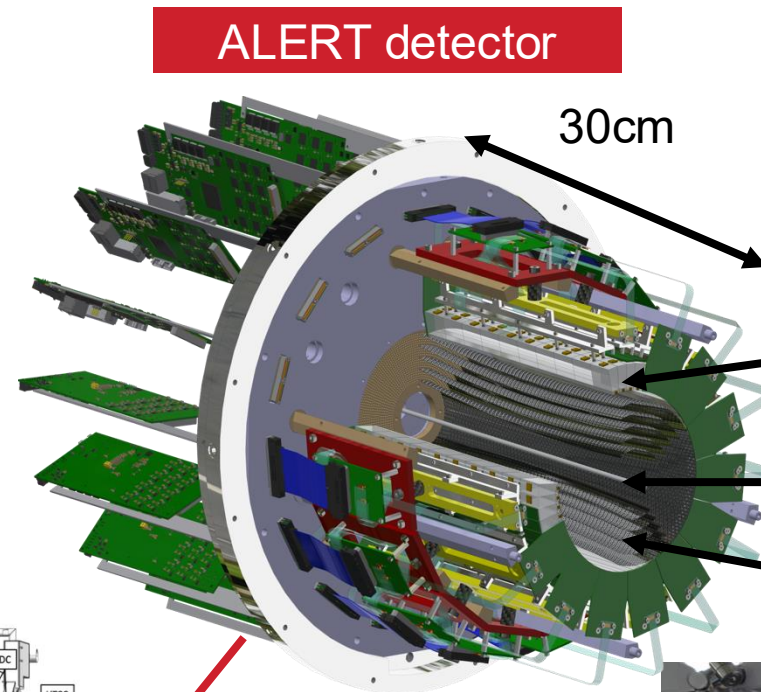
Argonne 
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RECOIL DETECTION

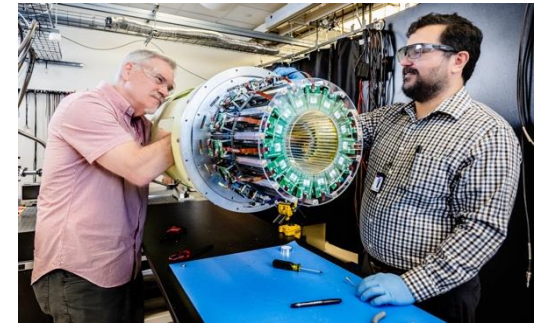
- 2025 run with **A** **L**ow **E**nergy **R**ecoil **T**racker
- DVCS, DVMP in He4 and D.
- Both coherent and incoherent!
- Nuclear effects, beyond DIS EMC ratios
- He4: light, spin0, important binding effects
→ great for nuclear medium studies!
- Recoil detection/tagging of light ions at low momenta (p, D, He3, tritium, He4)



See Whitney's talk on Tuesday



ALERT collaboration
arXiv:1708.00835
arXiv:1708.00888



Scintillator array with SiPM readout

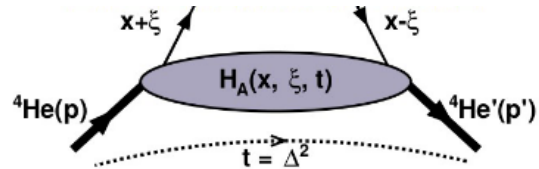
Target straw

Hyperbolic drift chamber

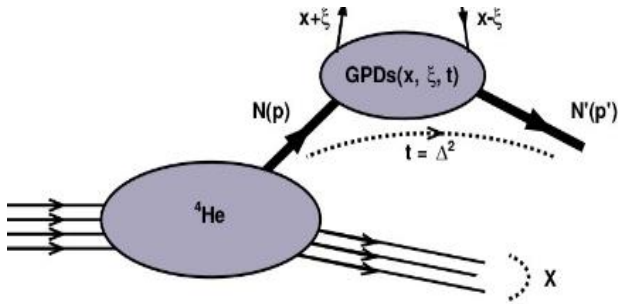


THE ALERT EXCLUSIVE PHYSICS PROGRAM

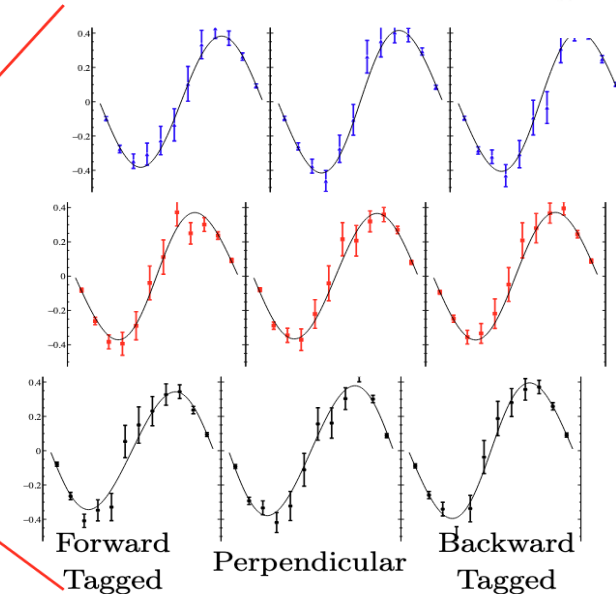
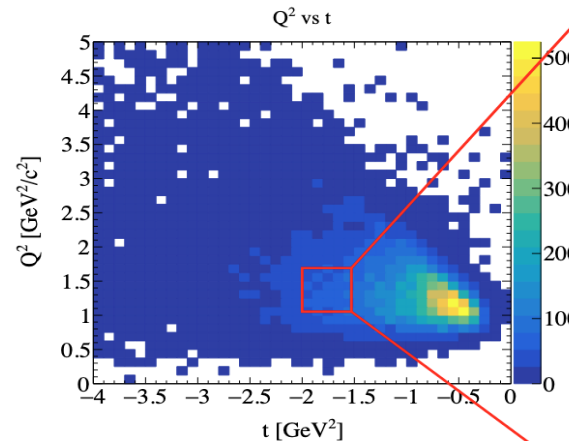
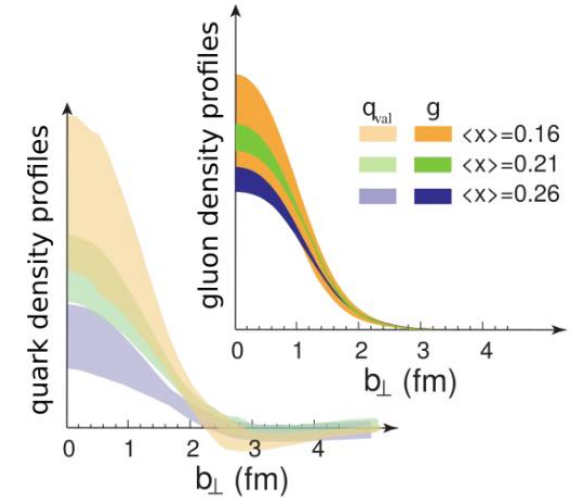
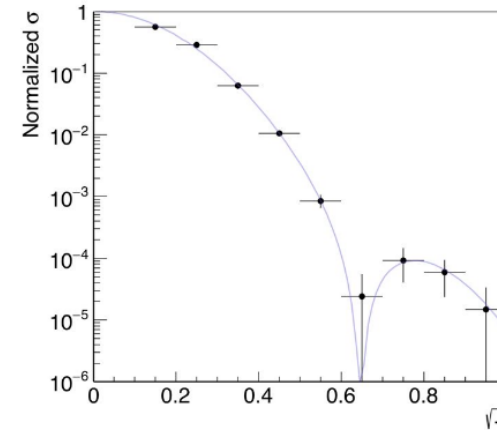
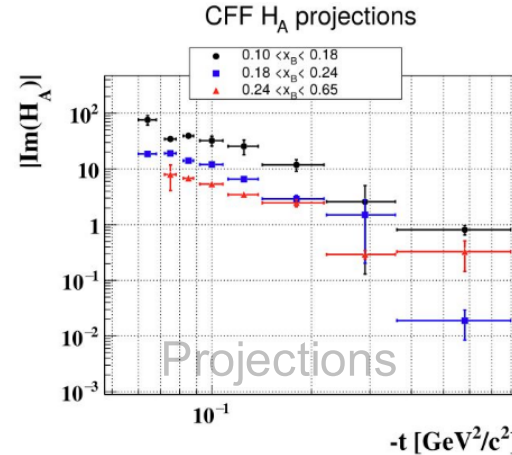
- Nuclear GPDs with coherent exclusive processes



- Bound nucleon GPDs with incoherent DVCS



- PAC proposal for running again: J/ψ and more statistics-hungry channels



Projections

arXiv:1708.00835

arXiv:1708.00888

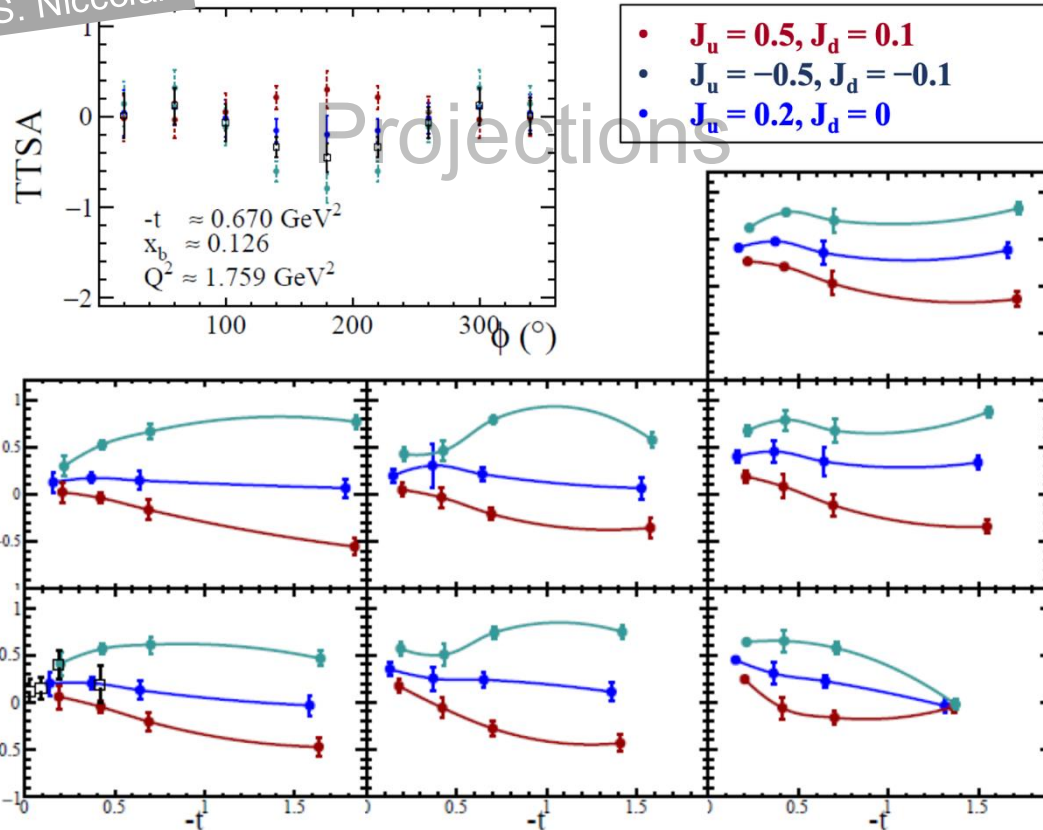
2030'S PROGRAM WITH TRANSVERSE POLARIZATION

A FUTURE TRANSVERSELY POLARIZED TARGET EXPERIMENT

The RGH collaboration

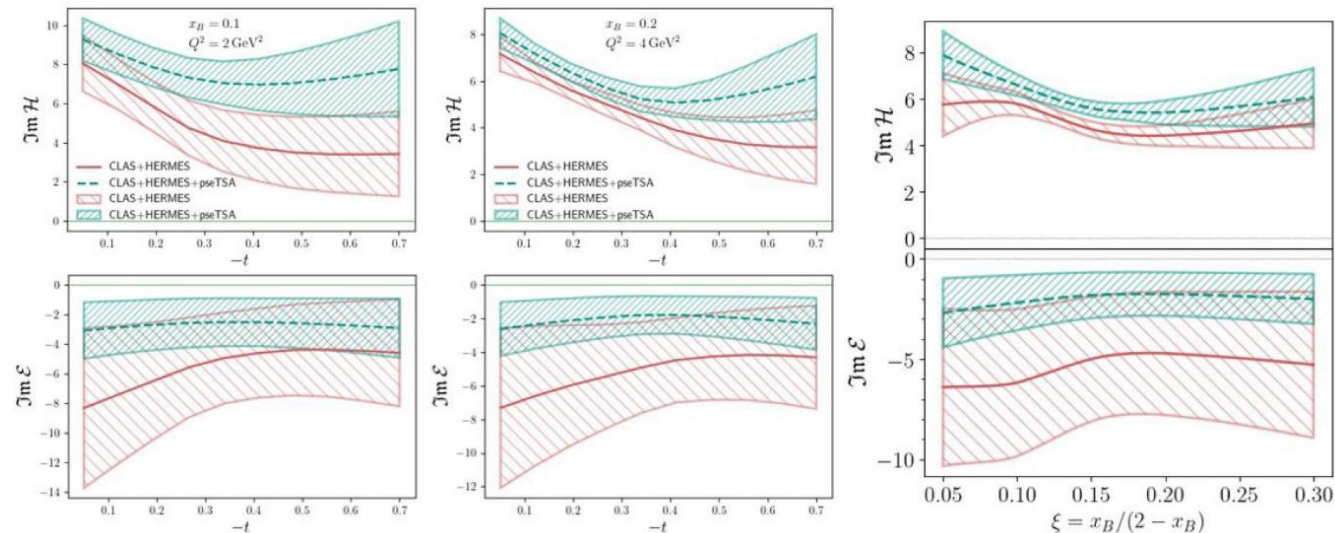
- Future transverse polarized target to complete the set of proton GPDs
- Proposed for the early 2030s
- Includes a SIDIS and DVCS program
- DVCS Transverse target spin asymmetry (TTSA) sensitive to E GPD for the proton
- Projection to reduce the uncertainty on $\Im E$ by a factor ~ 3

S. Niccolai



M. Higuera Angulo

Impact study



TRANSVERSELY POLARIZED TARGET APPARATUS

The RGH collaboration

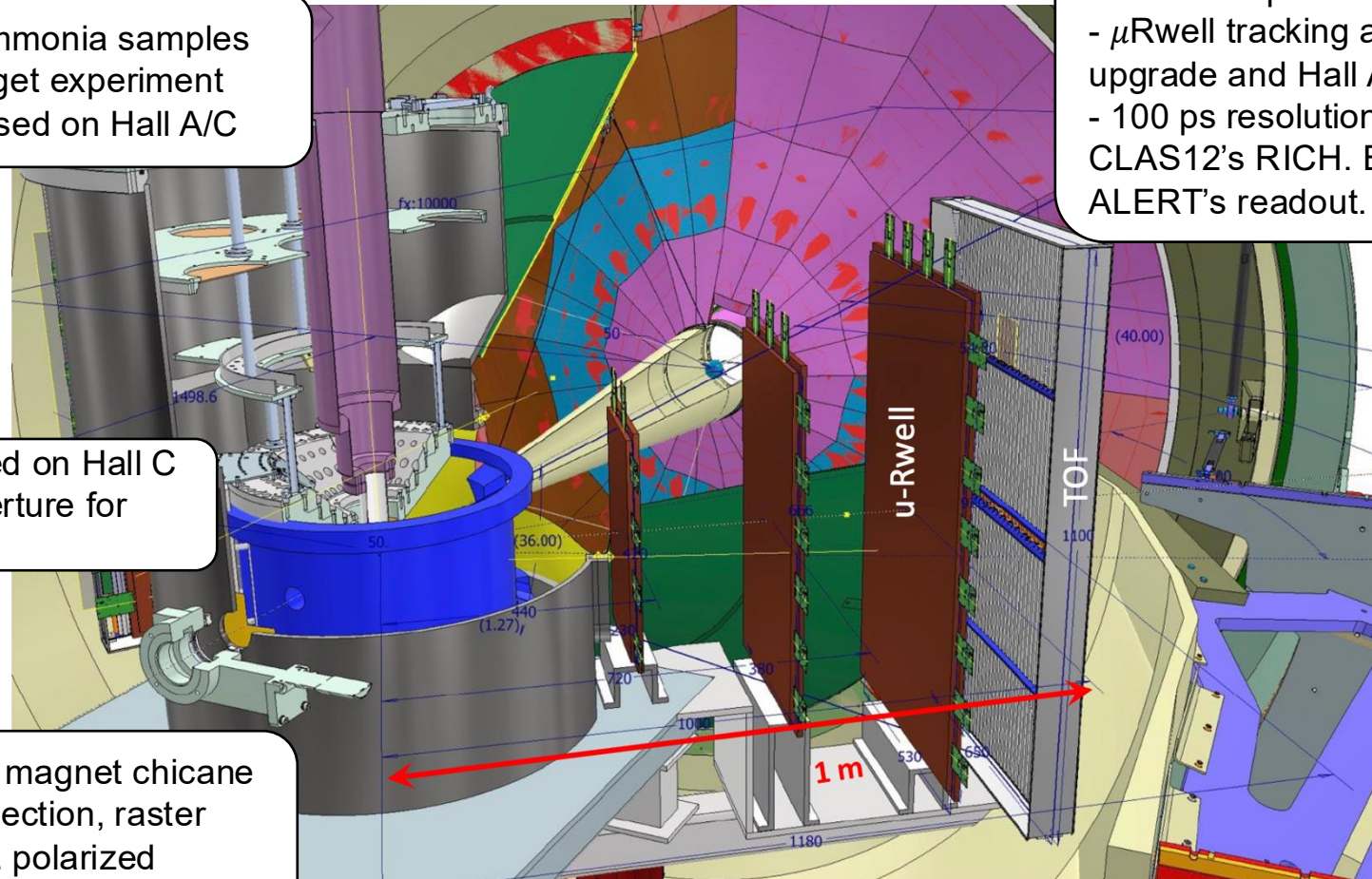
Dynamic polarization ammonia samples as in long. polarized target experiment
Target ladder design based on Hall A/C

5T split-coil magnet based on Hall C design, adapted with aperture for scattered proton

Augmented beam line, magnet chicane for beam electrons deflection, raster magnets from the long. polarized experiment

Addition of proton detector:

- μ Rwell tracking akin to CLAS12 luminosity upgrade and Hall A SBS
- 100 ps resolution on TOF, readout similar to CLAS12's RICH. Better solution based on ALERT's readout.





μ CLAS12



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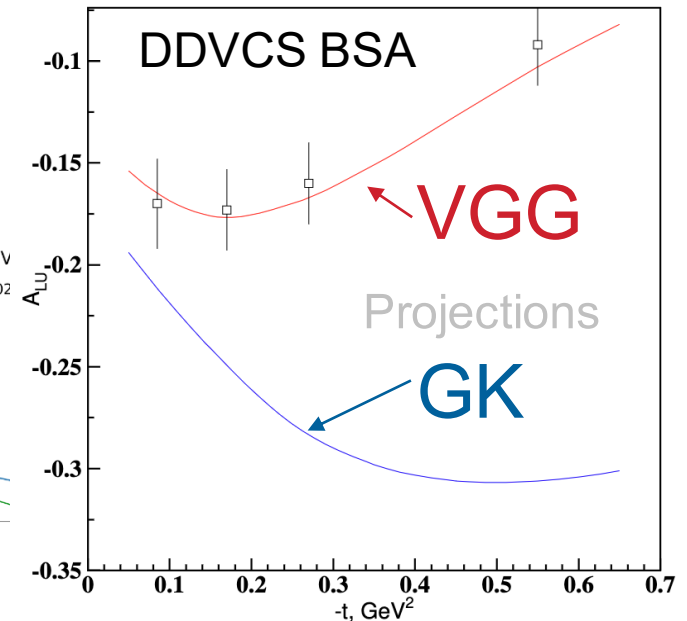
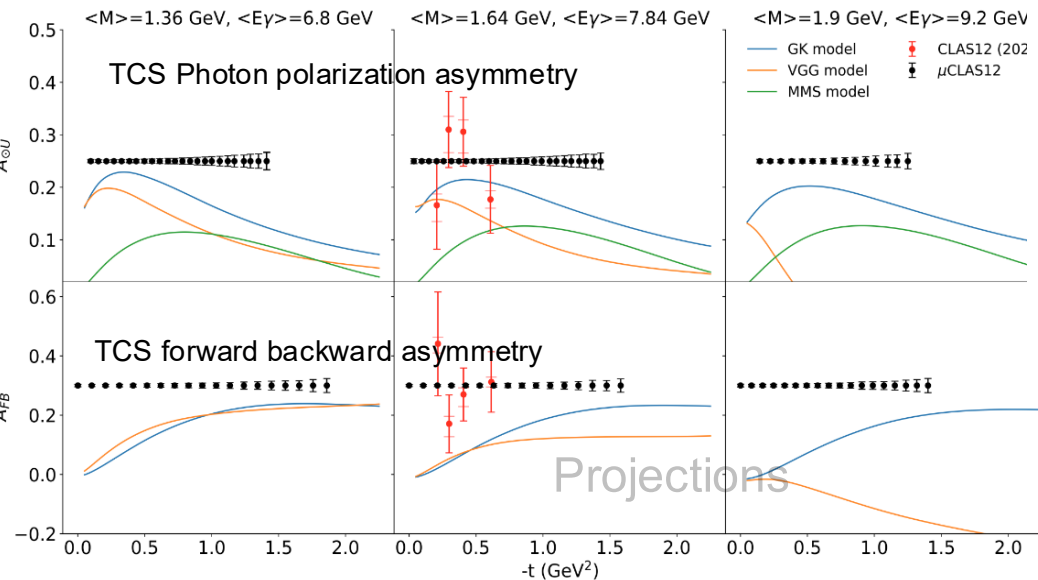
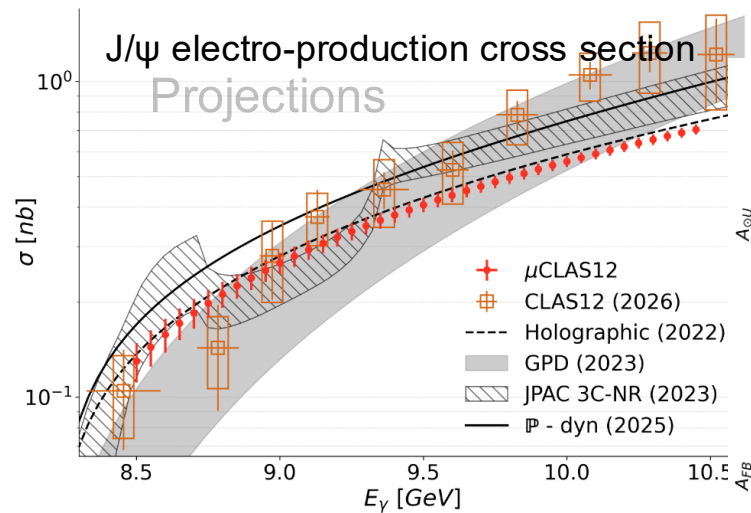


BEYOND DVCS AND DVMP - μ CLAS12

See Rafayel's talk
on Tuesday

- CLAS12 as full acceptance detector, close to the target
→ limiting achievable luminosities
- High luminosity and lepton detection upgrade
- Geared towards Double DVCS, GPDs beyond CFFs
- Di-muon electro- and photoproduction experiments: TCS, J/ψ

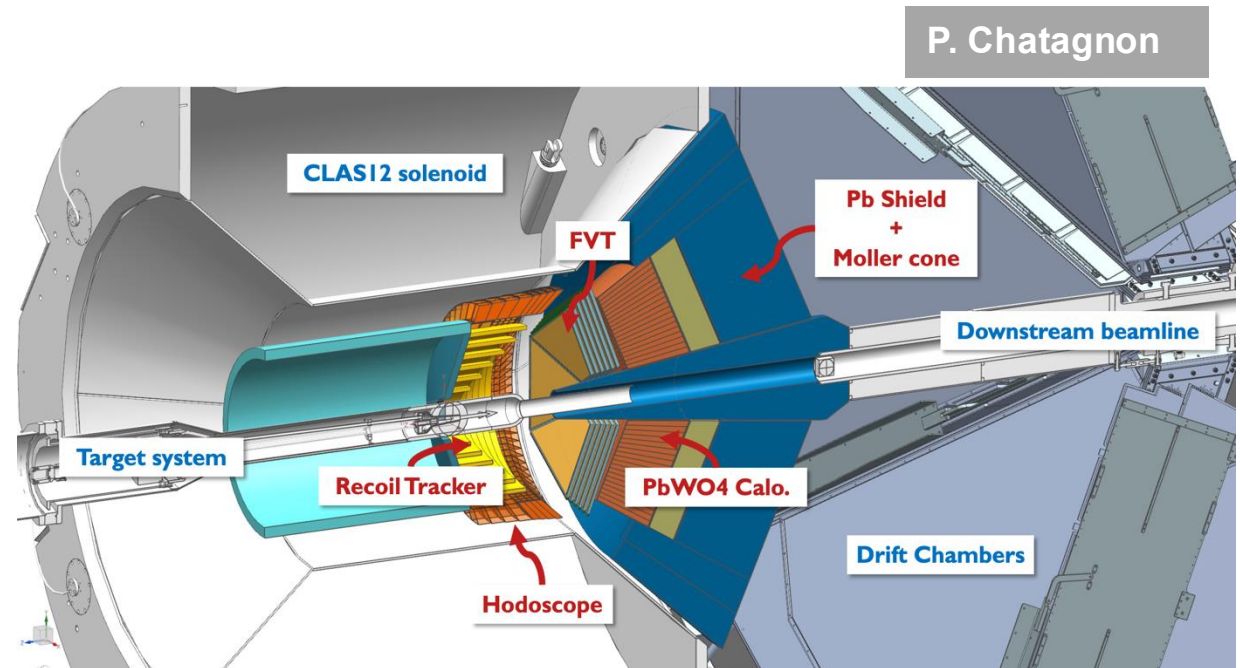
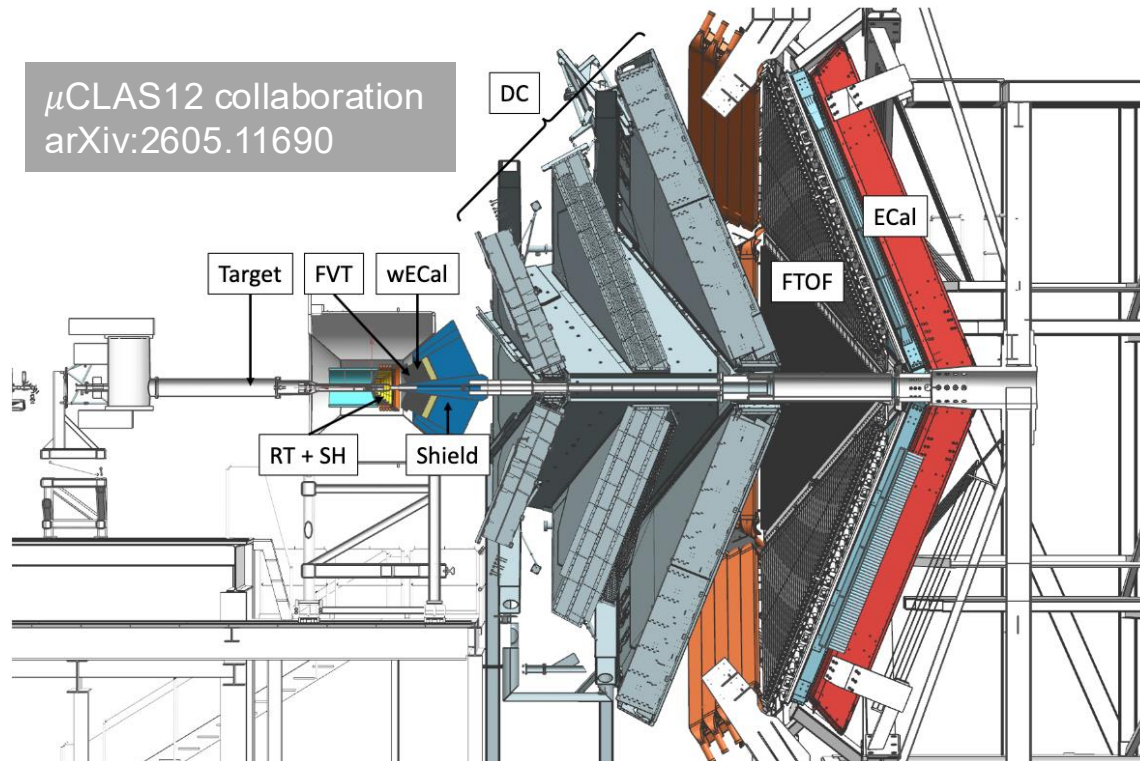
μ CLAS12 collaboration
arXiv:2605.11690



μ CLAS12 APPARATUS

- Replacing the central part of CLAS12
- Accommodating high luminosities $> 10^{37} \text{ cm}^{-2} \text{ s}^{-1}$
- And muon detection

- Shield isolating the forward detector
- PWO electromagnetic calorimeter
- High-rate Forward Vertex Tracker
- Recoil proton: scintillation hodoscope and Micro-Pattern Gaseous Detector
- ℓ H2 target



SUMMARY

- CLAS12's large acceptance and variety of subsystems
→ measurements of a broad range of electron scattering channels, in particular exclusive channels.
- CLAS12 accommodates innovative configurations and targets
→ observables involving different combinations of GPDs to explore:
 - Extraction of individual CFFs/GPDs,
 - Flavor dependence,
 - Simple and complex spin structures,
 - Nuclear effects...
- A lot of efforts from bright students and postdocs to make the most of the collected data.
- High impact measurements to come with new configurations: longitudinally polarized H and D, He4.
- Leading a long-term program for transversely polarized targets and first DDVCS access.

