New Experimental Results on GPDs
and
Perspectives at JLab with a Positron Beam

GPDs @ Ce$^+$BAF

Eric Voutier

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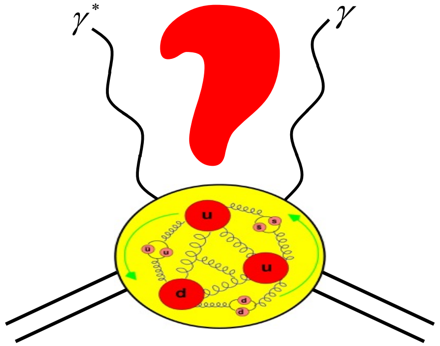
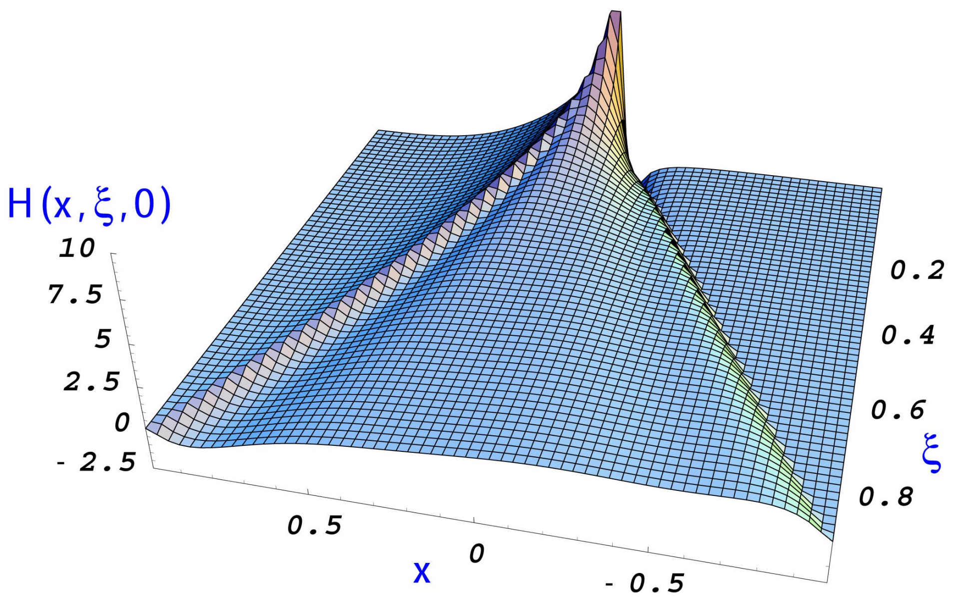


(i) Generalized parton distributions
(ii) Deeply virtual Compton scattering
(iii) Future measurements
(iv) Perspectives
(v) Ce$^+$BAF

Parton Promenade

D. Müller, D. Robaschik, B. Geyer, F.M. Dittes, J. Horejsi, FP 42 (1994) 101 X. Ji, PRD 55 (1997) 7114
A. Radyushkin, PRD 56 (1997) 5524

- Generalized Parton Distributions (GPDs) encode the correlations between partons and contain information about the internal dynamics of hadrons which express in properties like the angular momentum or the distribution of the forces experienced by quarks and gluons inside hadrons.

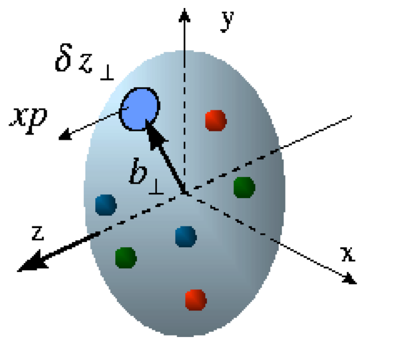


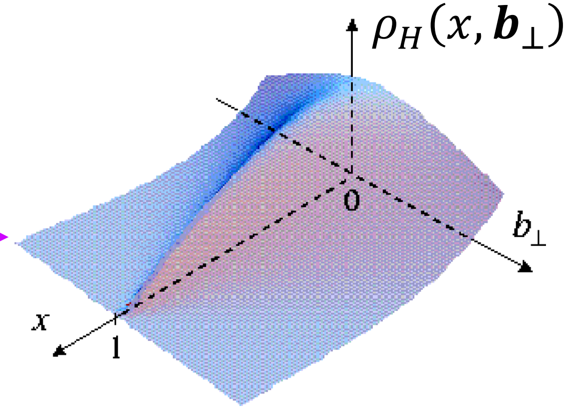
Q^2 Hard scale

x Average parton momentum

ξ Skewness

t Momentum transfer





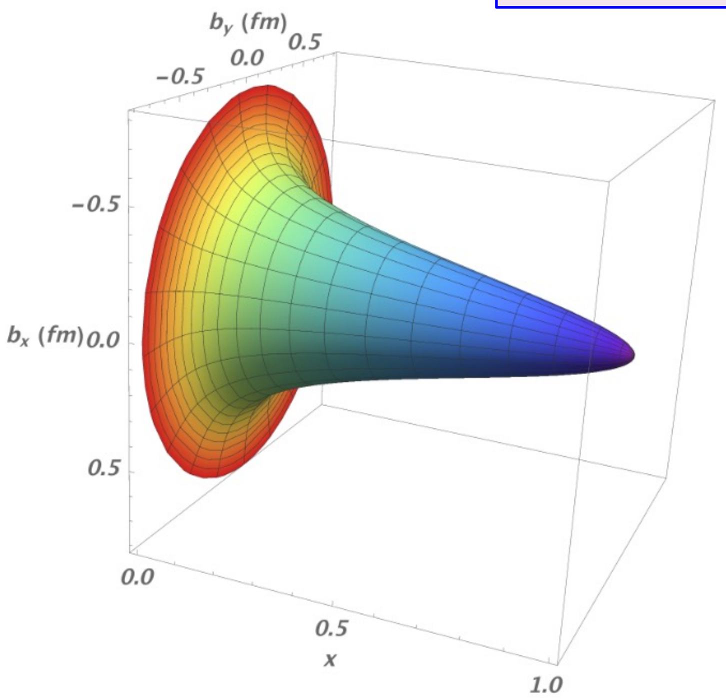
GPDs can be interpreted as a 1/Q resolution distribution in the transverse plane of partons with longitudinal momentum x.

M. Burkardt, PRD 62 (2000) 071503 M.Diehl, EPJC 25 (2002) 223

Nucleon Femtography

M. Burkardt PRD 62 (2000) 071503 M. Diehl EPJC 25 (2002) 223 J.P. Ralston, B. Pire PRD 66 (2002) 111501
A.V. Belitsky, D. Müller, NPA 711 (2002) 118c

$$\rho_H^q(x,\boldsymbol{b}_\perp) = \int \frac{d^2\boldsymbol{\Delta}_\perp}{(2\pi)^2} e^{i\boldsymbol{b}_\perp\cdot\boldsymbol{\Delta}_\perp} [H^q(x,0,-\Delta_\perp^2) + H^q(-x,0,-\Delta_\perp^2)]$$



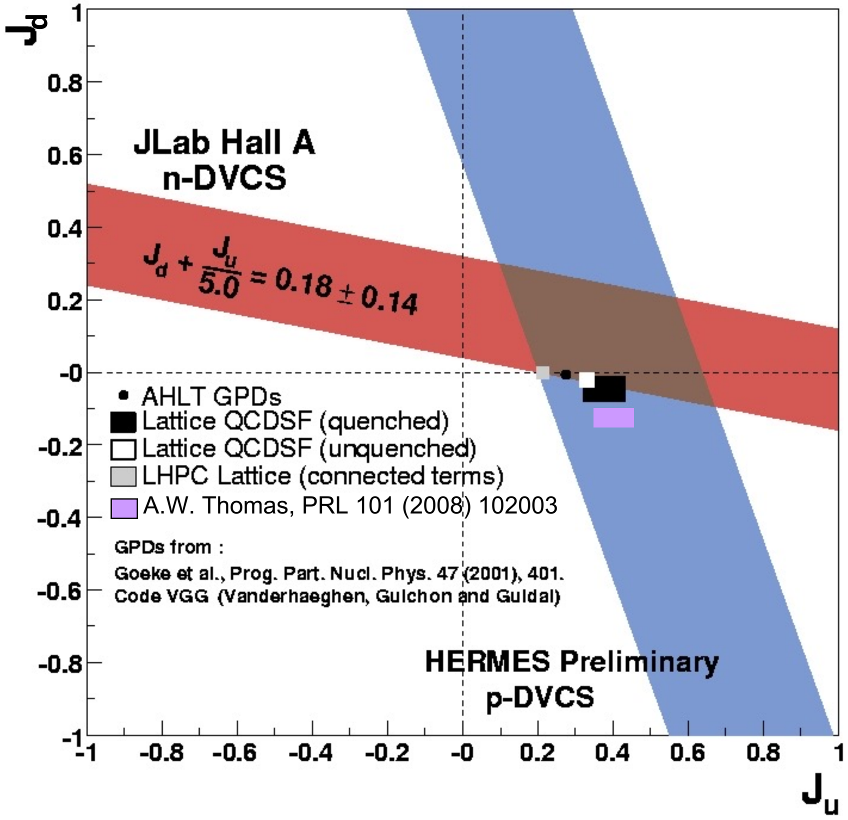
- The **transverse densities** of partons in nucleons and nuclei are related to the transverse momentum transfer ($-\Delta_\perp^2$) dependence of GPDs at **zero-skewness**.
- The **experimental knowledge** of the **ξ-dependence** of GPDs at **fixed** longitudinal momentum fraction x and transverse momentum transfer t is required to constrain the **zero-skewness extrapolation**.

R. Dupré, M. Guidal, M. Vanderhaeghen, PRD 95 (2017) 011501

Nucleon Spin

X. Ji, PRL 78 (1997) 610

$$\lim_{t\to 0}\int_{-1}^{1} x\,[H^q(x,\xi,t)+E^q(x,\xi,t)]\,dx = J^q$$



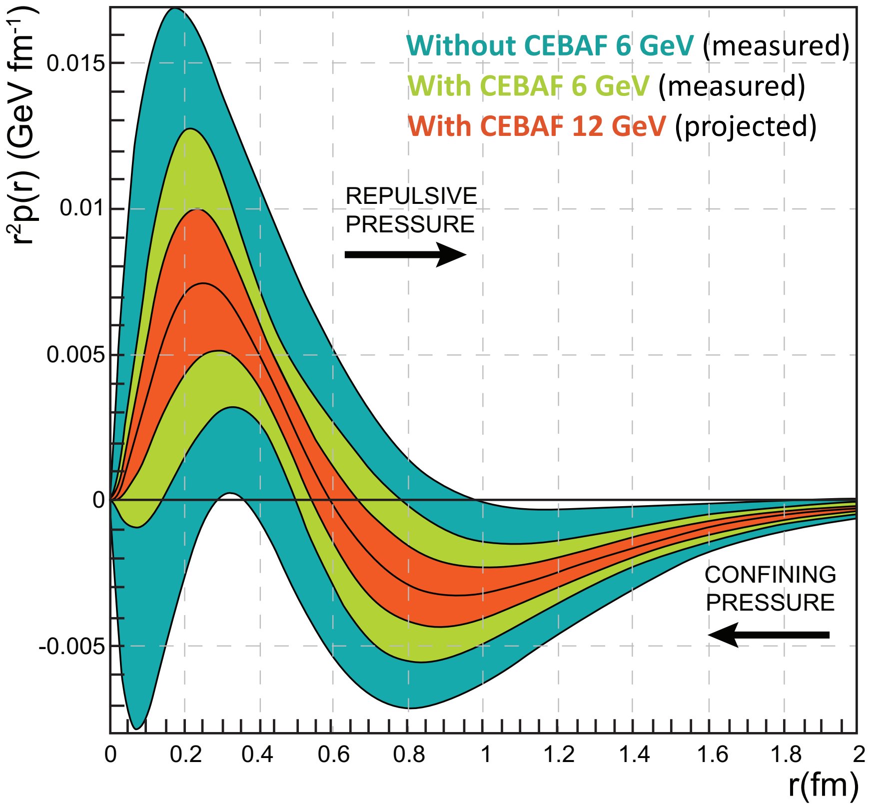
- The **total angular momentum of partons** inside the nucleon can be inferred from the Ji sum rule which involves the **forward limit** of the **second Mellin moment** of partons helicity conserving GPDs.
- The E^q GPD is a new piece of information which does not have a Deep Inelastic Scattering equivalent.
- The **experimental knowledge** of the x- and t**-dependence** of GPDs at **fixed** skewness ξ is required to access the **orbital angular momentum** carried by partons inside the nucleon.

M. Mazouz et. al. PRL 99 (2007) 242501 A. Airapetian et al. JHEP 06 (2008) 066

Nucleon Forces

X. Ji, PRL 78 (1997) 610 M.V. Polyakov, PLB 555 (2003) 57 M.V. Polyakov, P. Schweitzer, IJMP A 33 (2018) 1830025

$$\int_{-1}^{1} x \sum_q H^q(x,\xi,t)\ dx = M_2(t) + \frac{4}{5}\xi^2 d_1(t)$$



- The **skewness dependence** of the **second Mellin moment** of the GPD H accesses to the **Gravitational Form Factors** (GFFs) of the energy momentum tensor of the nucleon.

$$\mathfrak{Re}[\mathcal{H}(\xi,t)] \stackrel{\text{LO}}{=} D(t) + \mathcal{P}\left\{\int_{-1}^{1}\left[\frac{1}{\xi - x} - \frac{1}{\xi + x}\right]\mathfrak{Im}[\mathcal{H}(x,t)]\ dx\right\}$$

- Dispersion relations provide another access to the D-term GFF via the **real** and **imaginary** parts of the **Compton Form Factors** (CFFS).
- The **experimental knowledge** of the ***x*-, *ξ*-** and ***t*-dependence** is required to access the **GFFs** of the nucleon.

V. Burkert, L. Elouadrhiri, F.-X. Girod, Nat. 557 (2018) 396; arXiv:nucl-ex:2104.02031; arXiv:hep-ph:2310.11568 K. Kumerički, Nature 570 (2019) E1

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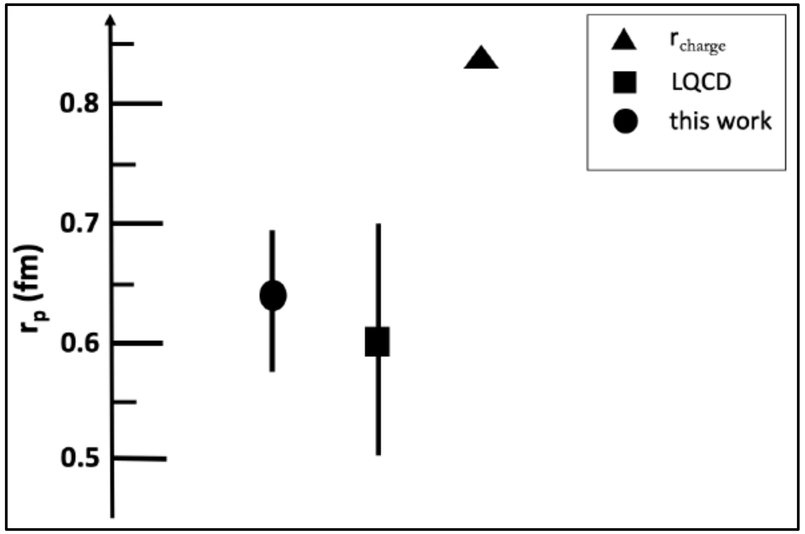

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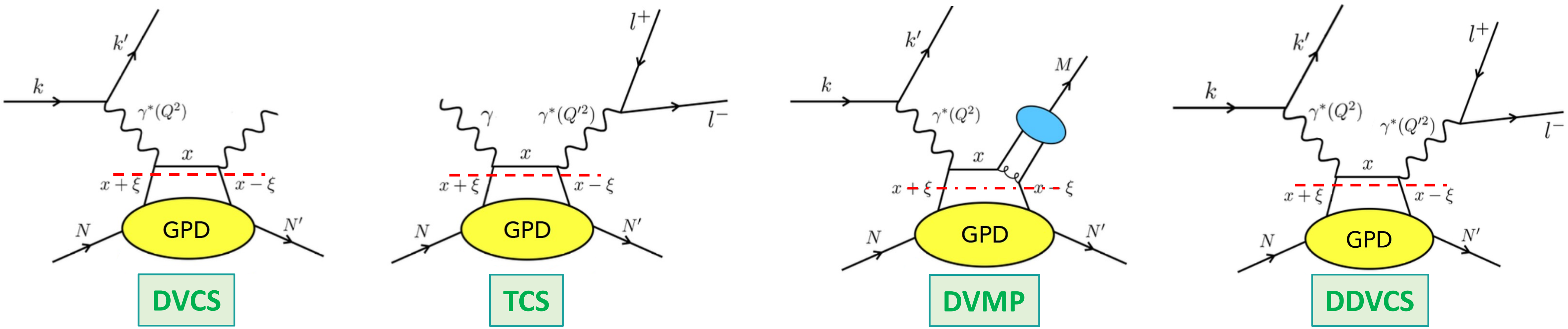
E. Voutier
IJCLab Irène Joliot-Curie

Experimental Access

- Several GPDs parameterize the non-perturbative structure of the nucleon, but they are universal and can be accessed in different processes, as long as the factorization of the reaction amplitude is preserved.



Factorization is fully proven for DVCS/TCS/DDVCS ($-t \ll Q^2, Q^2 \gg M^2$)
and partially proven for DVMP at leading order for longitudinally polarized photons.

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Experimental Access

- Several GPDs parameterize the non-perturbative structure of the nucleon, but they are universal and can be accessed in different processes, as long as the factorization of the reaction amplitude is preserved.

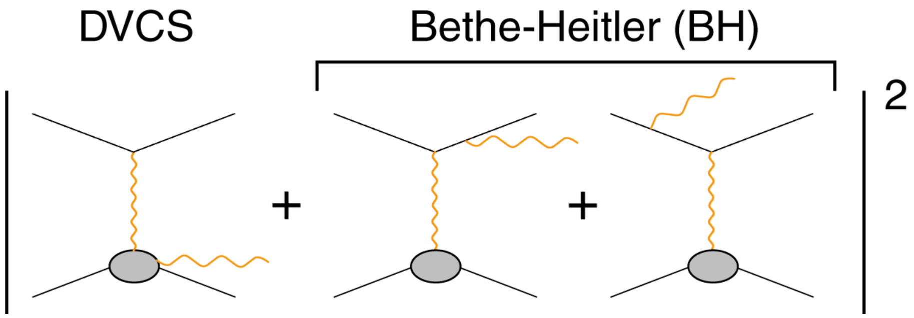
GPD		Quark polarization U	Quark polarization L	Quark polarization T
Nucleon Polarization	U	H		E_T
Nucleon Polarization	L		$\widetilde{H}$	$\widetilde{E}_T$
Nucleon Polarization	T	E	$\widetilde{E}$	H_T $\widetilde{H}_T$

- GPDs in blue reduce to usual PDFs in the forward limit.
- GPDs in red vanish if there is no quark orbital angular momentum.
- Transversity GPDs are chiral odd and other GPDs are chiral even.

Deeply Virtual Compton Scattering

M. Diehl at the CLAS12 European Workshop, Genova, February 25-28, 2009

$\sigma(eN \longrightarrow eN\gamma) =$



CFF = Compton Form Factors

$\propto$ to the **real part** of a **CFF linear combination**

$\propto$ to the **imaginary part** of a **CFF linear combination**

$$d^5\sigma^e_{P0} = d^5\sigma_{BH} + d^5\sigma_{DVCS} + P\, d^5\tilde{\sigma}_{DVCS} - e\,[d^5\sigma_{INT} + P\, d^5\tilde{\sigma}_{INT}]$$

$\propto$ to the **real part** of a **CFF bilinear combination**

$\propto$ to the **imaginary part** of a **CFF bilinear combination**

$$d^5\sigma^e_{PS} = d^5\sigma^e_{P0} + S\,[P\, d^5\Delta\sigma_{BH} + (Pd^5\Delta\sigma_{DVCS} + d^5\Delta\tilde{\sigma}_{DVCS}) - e(Pd^5\Delta\sigma_{INT} + d^5\Delta\tilde{\sigma}_{INT})\,]$$

Polarized electrons and positrons allow to separate the unknown amplitudes of the cross section for electro-production of photons.

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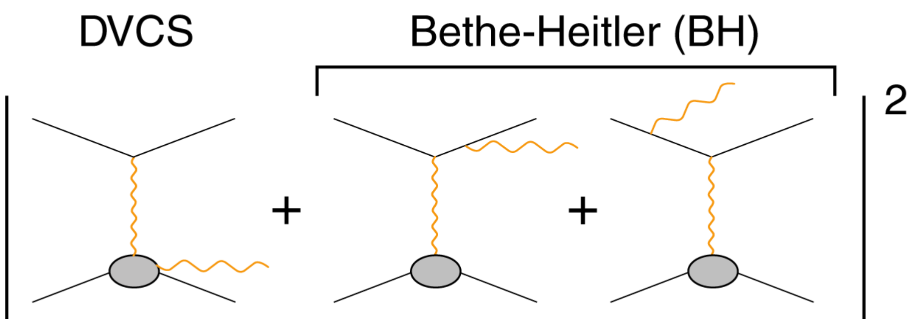

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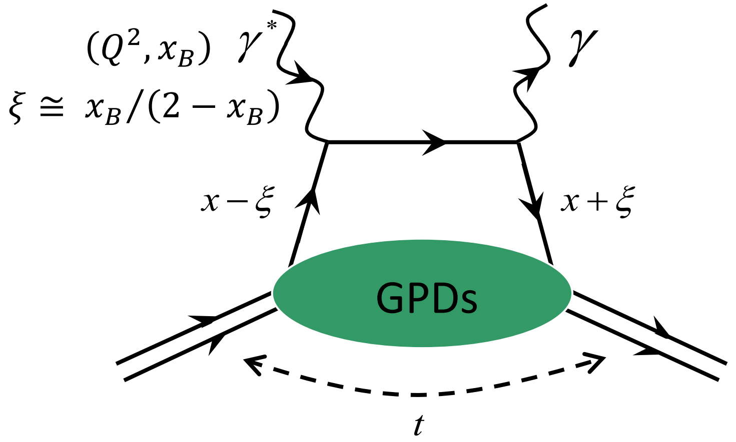
Compton Form Factors



○ GPDs enter the epγ cross section via the Compton Form Factors (CFFs) representing an integral over the intermediate quark longitudinal momentum.

$$d^5\sigma \propto \int_{-1}^{+1} dx \frac{\mathbf{GPD}(x,\xi,t)}{x \pm \xi \mp i\epsilon} = \mathcal{P}\int_{-1}^{+1} dx \frac{\mathbf{GPD}(x,\xi,t)}{x \pm \xi} \pm i\pi\,\mathbf{GPD}(x=\pm\xi,\xi,t)$$

$\sigma_{INT,DVCS}$ $\tilde{\sigma}_{INT,DVCS}$

➢ At twist-2 and leading α_{QCD}-order, the epγ reaction accesses the four chiral even and parton helicity conserving GPDs $\{H, \tilde{H}, E, \tilde{E}\}$ of the proton via the CFFs $\{\mathcal{H}, \tilde{\mathcal{H}}, \mathcal{E}, \tilde{\mathcal{E}}\}$.

$$\mathcal{C}^{DVCS} = 4(1-x_B)\left[\mathcal{H}\mathcal{H}^* + \tilde{\mathcal{H}}\tilde{\mathcal{H}}^*\right] - x_B^2\left[\mathcal{H}\mathcal{E}^* + \mathcal{E}\mathcal{H}^* + \tilde{\mathcal{H}}\tilde{\mathcal{E}}^* + \tilde{\mathcal{E}}\tilde{\mathcal{H}}^*\right] - \left(x_B^2 + (2-x_B)^2\frac{t}{4M^2}\right)\mathcal{E}\mathcal{E}^* - x_B^2\frac{t}{4M^2}\tilde{\mathcal{E}}\tilde{\mathcal{E}}^*$$

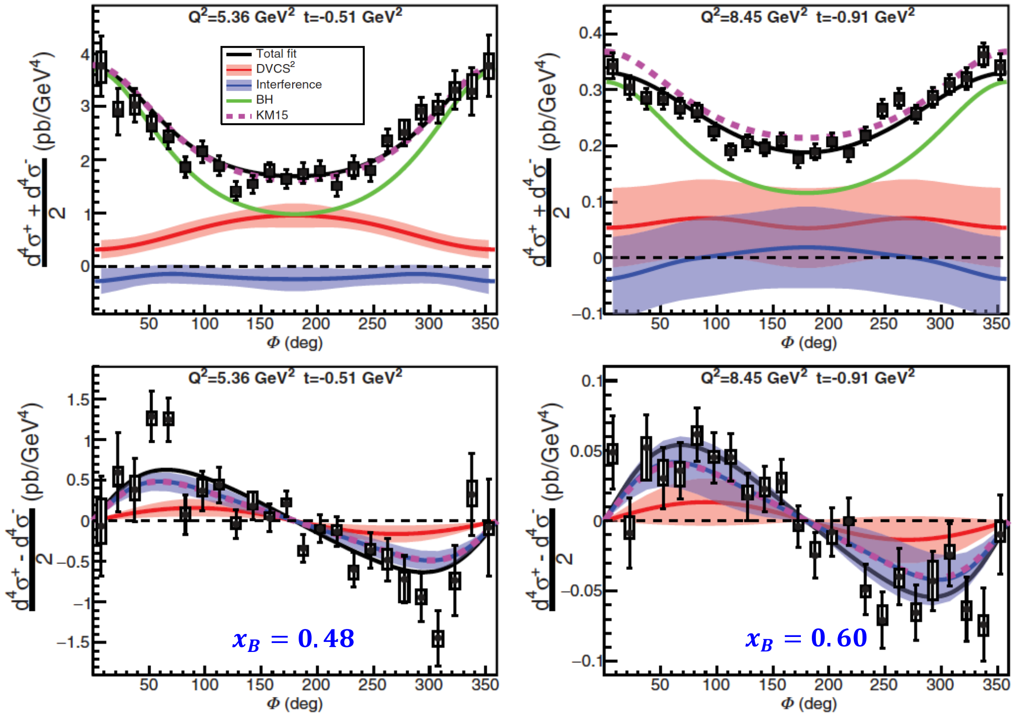
$$\mathcal{C}^{INT} = F_1\mathcal{H} - \xi[F_1 + F_2]\tilde{\mathcal{H}} - \frac{t}{4M^2}\mathcal{E}$$

Importance of the **separation** of the **DVCS** and **INT** reaction amplitudes for the **determination** of **CFFs**.

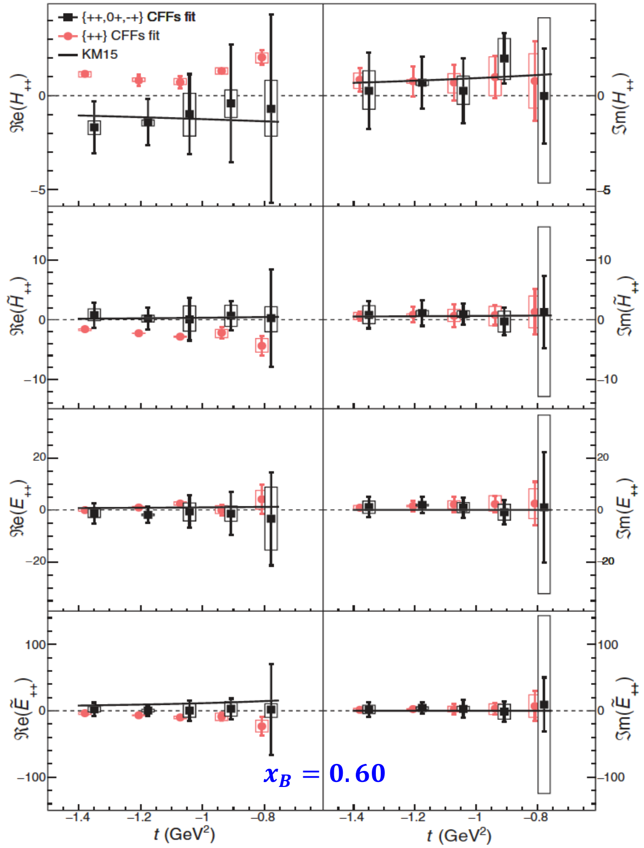
DVCS Cross Section

(Hall A Collaboration) F. Georges et al. PRL 128 (2022) 252002

- **First 12 GeV era results** exploring DVCS at high Q^2(2.7-8.4 GeV^2) and x_B(0.36-0.60).
- Analysis of the cross sections in the NLO+HT scenario using 3 different beam energies.
- Determination of the **4 helicity-conserving CFFs**.



CFFs extraction within the **BMMP formalism** considering kinematic power corrections $\sim(t/Q^2, M^2/Q^2)$.

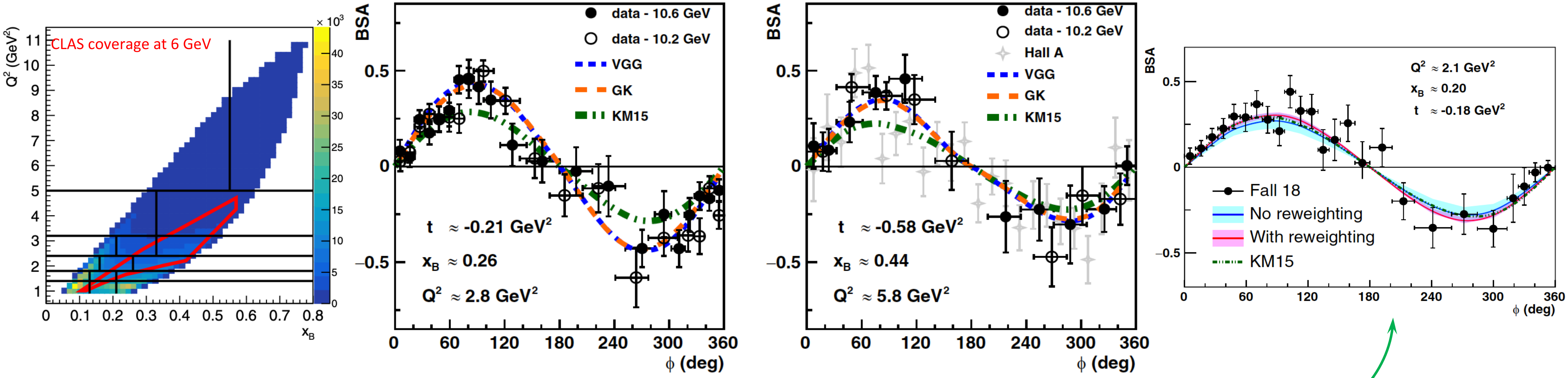


V.M. Braun, A.N. Manashov, D. Müller, B.M. Pirnay, PRD 89 (2014) 074022

DVCS Beam Spin Asymmetry

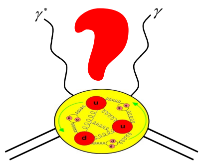
(CLAS Collaboration) G. Christiaens et al. PRL 130 (2023) 211902

- A new set of BSAs extending over 64 bins in (Q^2, x_B, t) and exploring an **unmeasured** large **phase space**.
- **More statistics to come** as these results corresponds to 25% of the allocated beam-time.



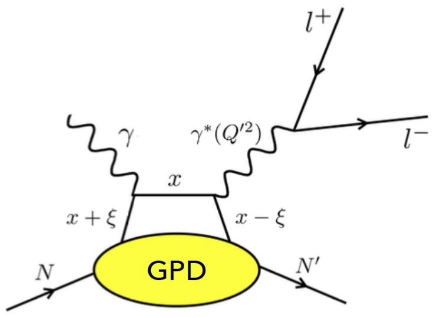
Despite a reduced data set, experimental data are already statistically competitive with the 6 GeV program.

K. Kumerički, D. Müller, EPJ Web Conf. 112 (2016) 01012 B. Berthou et al. EPJ C 78 (2018) 478 H. Moutarde, P. Sznadjer, J. Wagner, EPJ C 79 (2019) 614



Timelike Compton Scattering

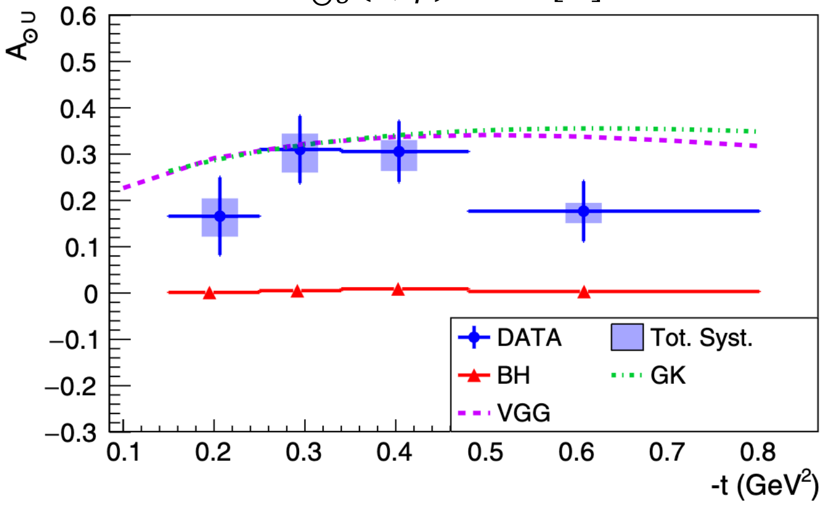
(CLAS Collaboration) P. Chatagnon et al. PRL 127 (2021) 262501

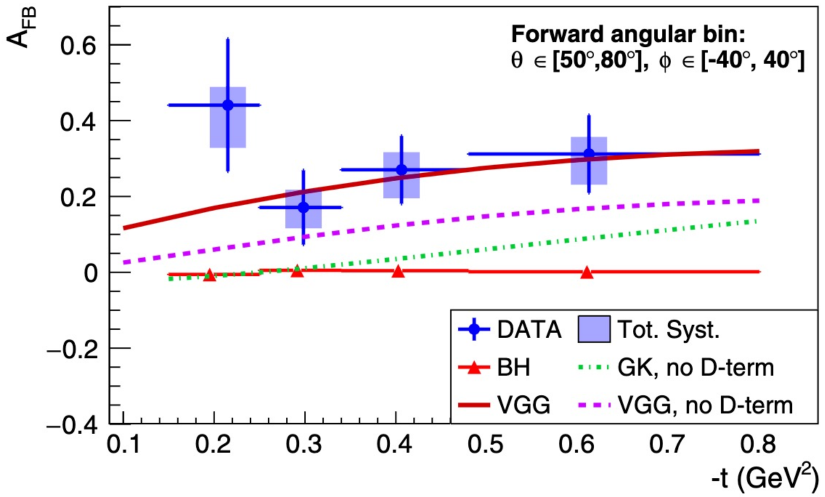


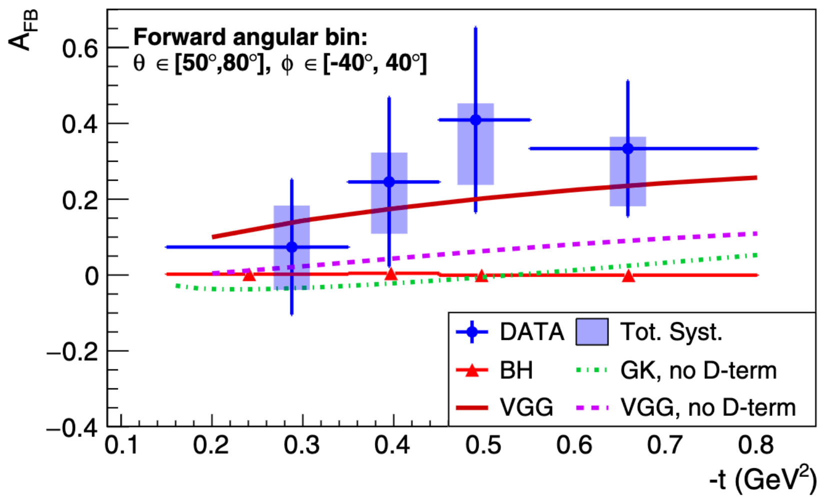
- **First ever measurement** of this channel **conjugate to DVCS** and testing **GPDs universality**.
- The **asymmetry** with respect to the orientation of **circular polarization** of the photon accesses the **imaginary part** of the CFFs, **similarly to the BSA**.
- The **forward-backward asymmetry** accesses the **real part** of the CFFs, sensitive to the **D-term.**

$$A_{\odot U}(\theta,\phi) \propto \mathfrak{Im}[\mathcal{F}]$$

$$A_{FB}(\theta,\phi) = \frac{d^4(\theta,\phi) - d^4(\pi-\theta,\phi+\pi)}{d^4(\theta,\phi) + d^4(\pi-\theta,\phi+\pi)} \propto \mathfrak{Re}[\mathcal{F}]$$







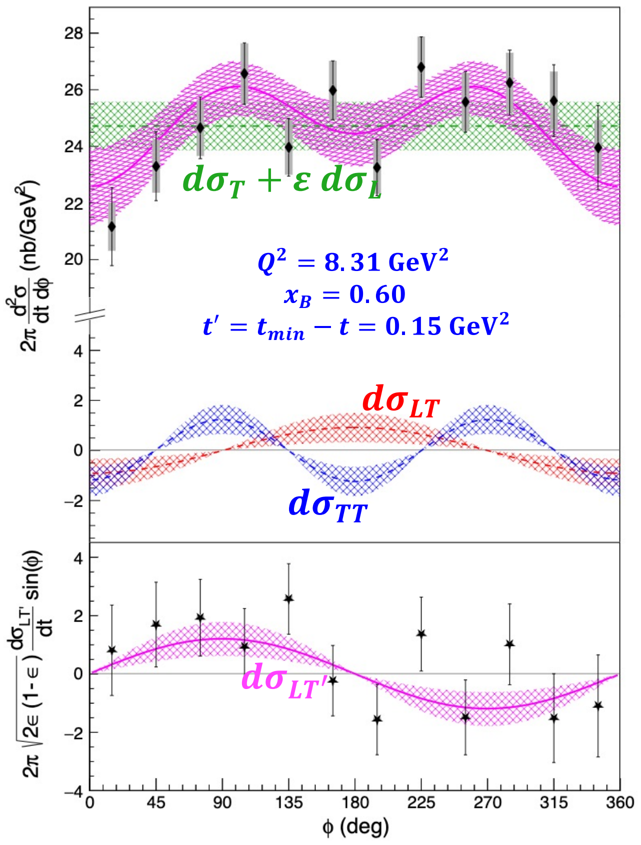
$$\mathcal{F} = F_1\mathcal{H} - \xi(F_1+F_2)\widetilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}$$

☛ *Difficulty : cross sections are very small and require higher luminosities.*

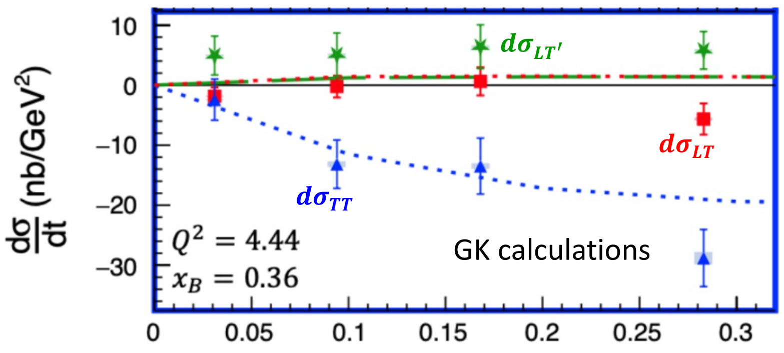
Transversity GPDs

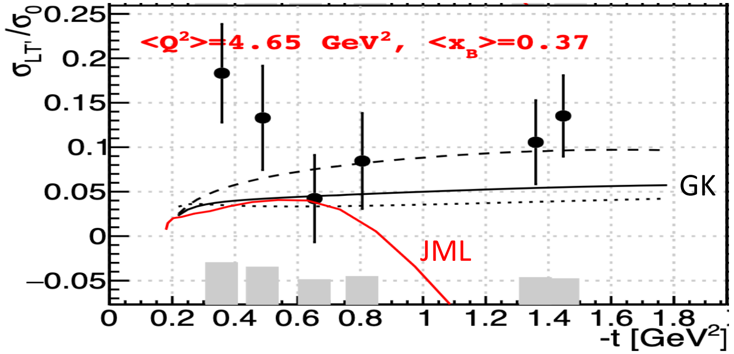
(Hall A Collaboration) M. Dlamini et al. PRL 127 (2021) 152301 (CLAS Collaboration) A. Kim et al. arXiv:2307.07874

$$\frac{d\sigma}{dt} = \frac{d\sigma_T}{dt} + \varepsilon\,\frac{d\sigma_L}{dt} + \sqrt{2\varepsilon(1+\epsilon)}\,\frac{d\sigma_{LT}}{dt}\cos(\phi) + \varepsilon\,\frac{d\sigma_{TT}}{dt}\cos(2\phi) + h\sqrt{2\varepsilon(1-\epsilon)}\,\frac{d\sigma_{LT'}}{dt}\sin(\phi)$$



- ○ π^0-electroproduction accesses the partonic content of the nucleon through the coupling of twist-3 distribution amplitudes with transversity GPDs.





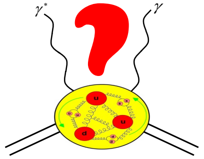
$$d\sigma_T \propto (1-\xi^2)|\mathcal{H}_T|^2 - \frac{t'}{8m^2}\left|2\widetilde{\mathcal{H}}_T + \mathcal{E}_T\right|^2$$

$$d\sigma_{TT} \propto \left|2\widetilde{\mathcal{H}}_T + \mathcal{E}_T\right|^2$$

$$d\sigma_{LT'} \propto \Im m\left[\left(2\widetilde{\mathcal{H}}_T^* + \mathcal{E}_T^*\right)\widetilde{\mathcal{H}} + \mathcal{H}_T^*\widetilde{\mathcal{E}}\right]$$

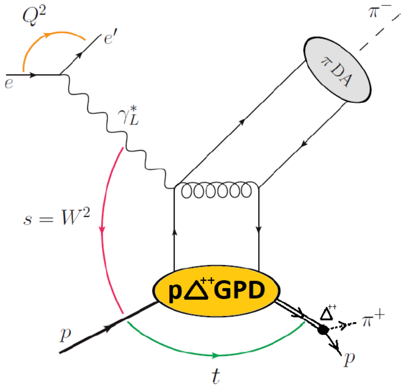
- π^0-electroproduction is confirmed to be almost purely transverse.
- Experimental data are fairly described by a GPD based model (GK).

S.V. Goloskokov, P. Kroll, EPJ A 47 (2011) 112 J.-M. Laget PLB 695 (2011) 199



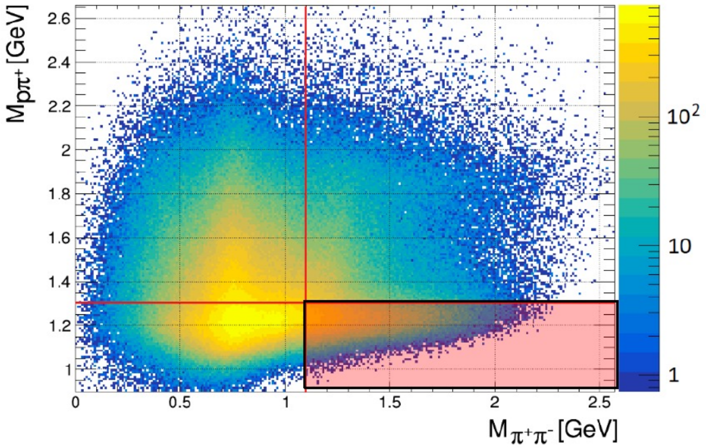
Transition GPDs

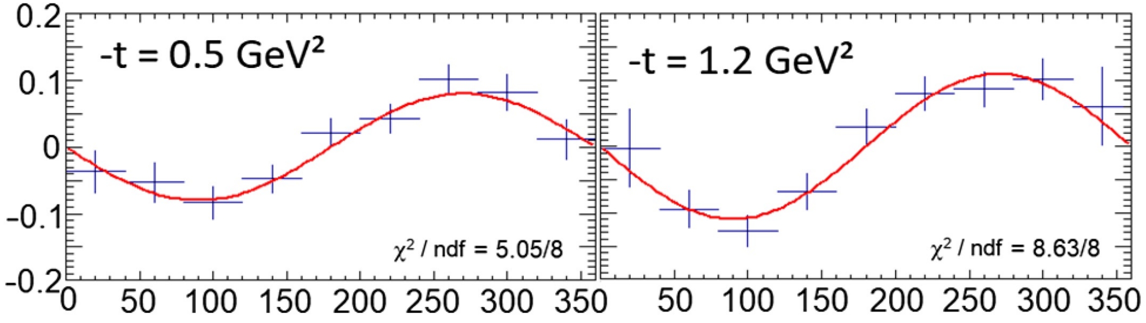
(CLAS Collaboration) S. Diehl et al. PRL 131 (2023) 021901



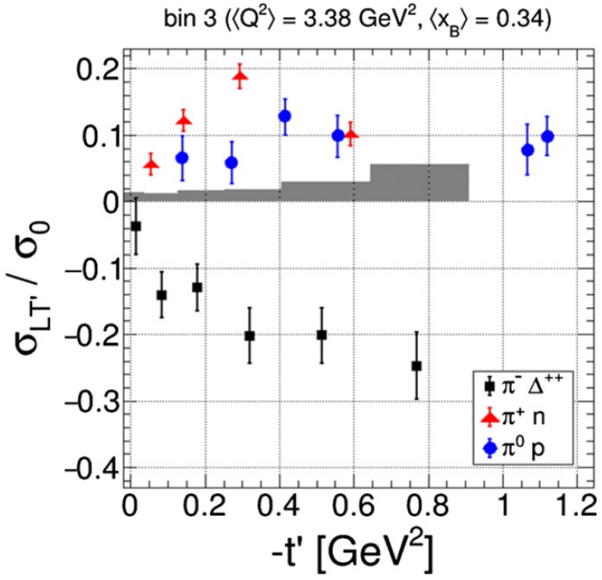
- Investigation of a novel DVCS **channel experimentally unexplored**.
- The partonic content of the **p➛Δ transition** is parametrerized by **8 helicity conserving** transition GPDs and **8 helicity-flip** transition GPDs.
- Access to **transition GPDs** via the **BSA**.
- On-going theoretical work.

$$A_{LU}(\phi) \propto \sqrt{2\varepsilon(1-\varepsilon)}\,\frac{\sigma_{LT'}}{\sigma_0}\sin(\phi)$$



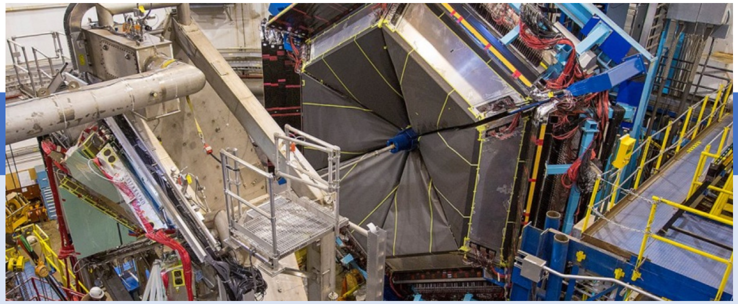


$Q^2 = 2.48$ GeV^2 $x_B = 0.36$

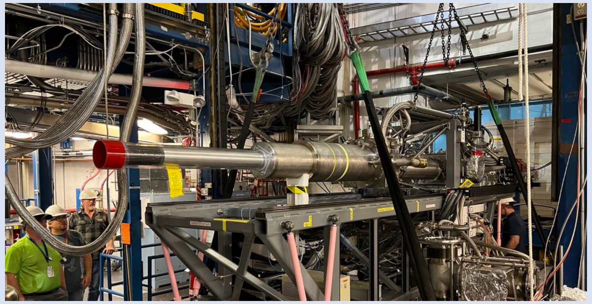


P. Kroll, K. Passek-Kumerički, PRD 107 (2023) 054009 K.M. Semenov-Tian-Shansky, M. Vanderhaeghen PRD 108 (2023) 034021

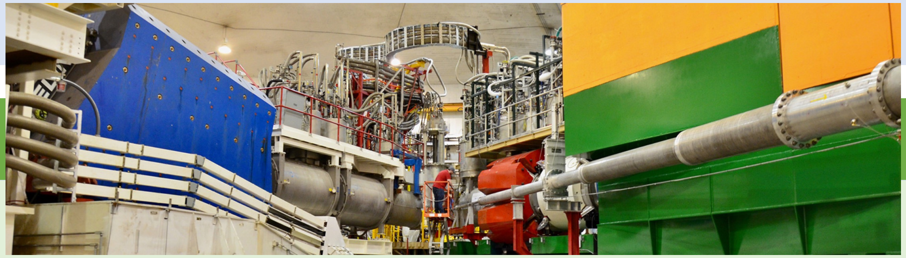
More Experiments



Analyses in progress



- Beam spin asymmetries off the neutron
- Beam spin asymmetries off the bound proton in deuterium
- Longitudinal target asymmetries off proton and neutron
- DVCS cross sections off the proton from Hall B
- New DVCS and π^0,ρ^0-electroproduction data from COMPASS



Short & Mid term Data Taking

- DVCS cross sections off the proton and the neutron with the Neutral Particle Spectrometer (NPS) in Hall C
- Coherent and incoherent DVCS beam spin asymmetries off helium with ALERT in Hall B

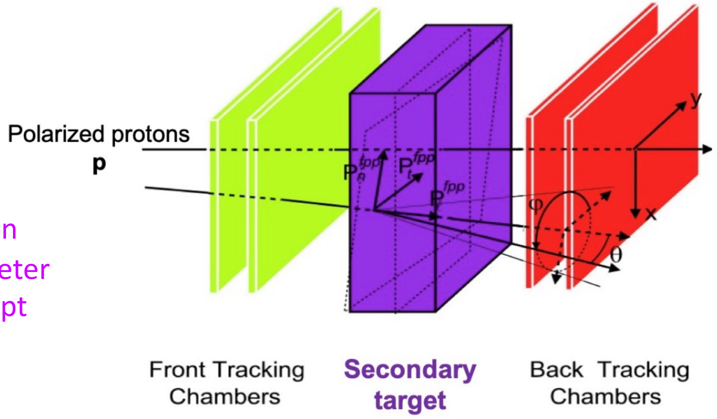
Talks of A. Hobart, S. Niccolai, C. Riedl

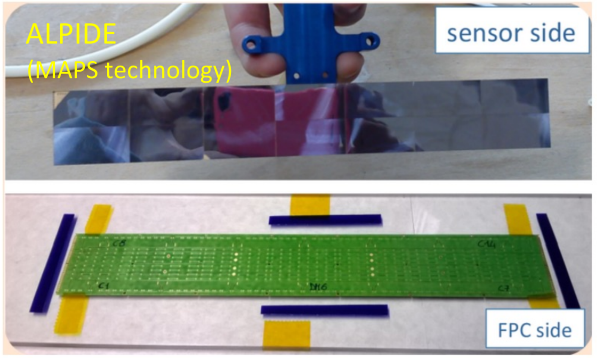
LoI12-23-003/LoI12-23-014
M. Defurne et al.

O. Bessidskaia Bylund, M. Defurne, P.A.M. Guichon PRD 107 (2023) 014020

- The polarization of the final state particles in the DVCS process provides a novel access to GPDs:
  - the recoil **proton polarization** component P_y normal to the scattering plane is sensitive to E
  - the recoil **proton polarization** component P_x transverse to the proton momentum is sensitive to $\widetilde{H}$
  - the **linear polarization of the photon** P_l is sensitive to the **gluon transversity GPDs**.

Proton Polarimeter Concept





Pair Polarimeter Concept

Polarimeters ask for **high luminosities** which can only be accessed at JLab.

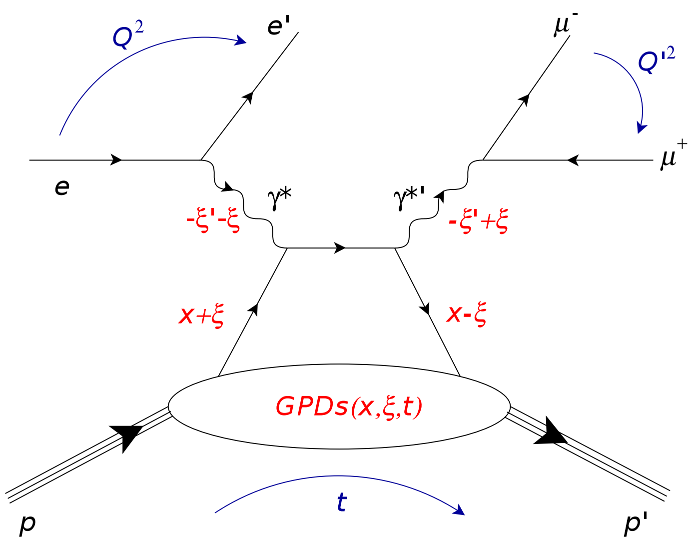
Double Deeply Virtual Compton Scattering

M. Guidal, M. Vanderhaeghen, PRL 90 (2003) 012001 A.V. Belitsky, D. Müller PRL 90 (2003) 022001; PRD 68 (2003) 116005

- Because of the virtuality of the final photon, **DDVCS** allows a direct access to GPDs at $x \neq \pm\xi$, which is of importance for their modeling and for the investigation of nuclear dynamics.

$$\mathcal{F}(\xi', \xi, t) = \mathcal{P}\int_{-1}^{1} dx\, F_+(x,\xi,t)\left[\frac{1}{x-\xi'} \pm \frac{1}{x+\xi'}\right] - i\pi F_+(\xi',\xi,t)$$

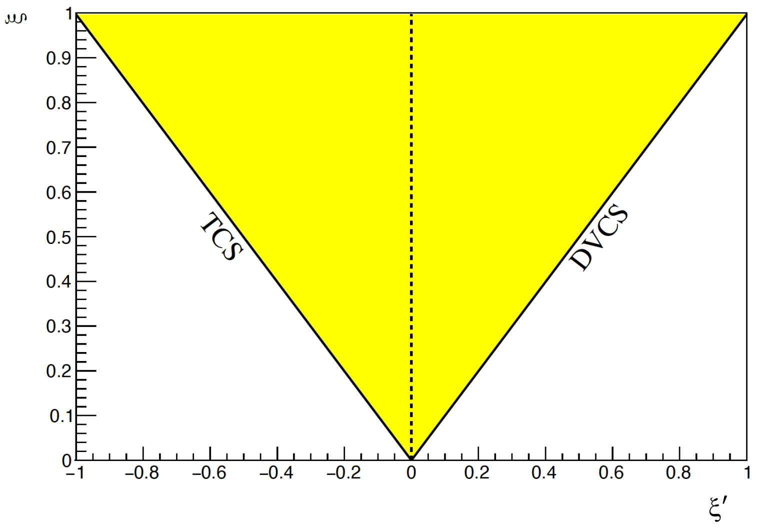
$$F_+(x,\xi,t) = \sum_q \left(\frac{e_q}{e}\right)^2 \left[F^q(x,\xi,t) \mp F^q(-x,\xi,t)\right]$$



I.V. Anikin et. al. APPB 49 (2018) 741

$$\xi' = \frac{Q^2 - Q'^2 + t/2}{2Q^2/x_B - Q^2 - Q'^2 + t}$$

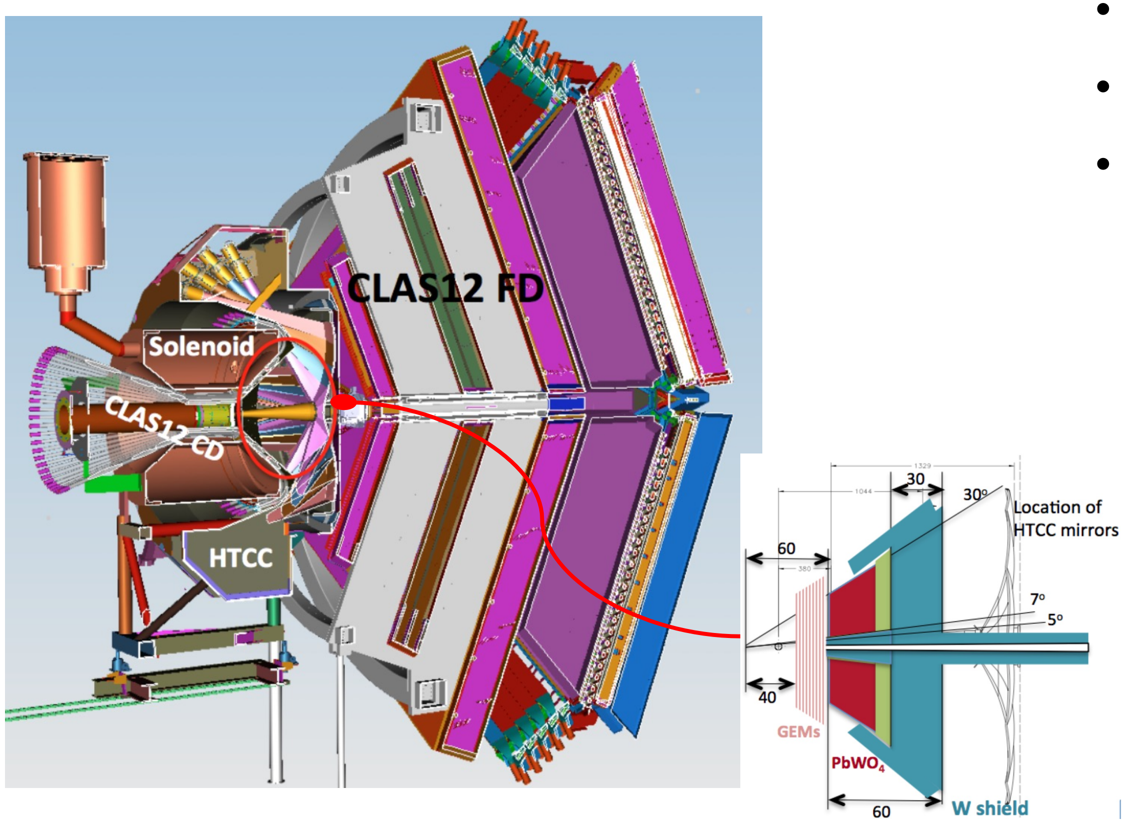
$$\xi = \frac{Q^2 + Q'^2}{2Q^2/x_B - Q^2 - Q'^2 + t}$$



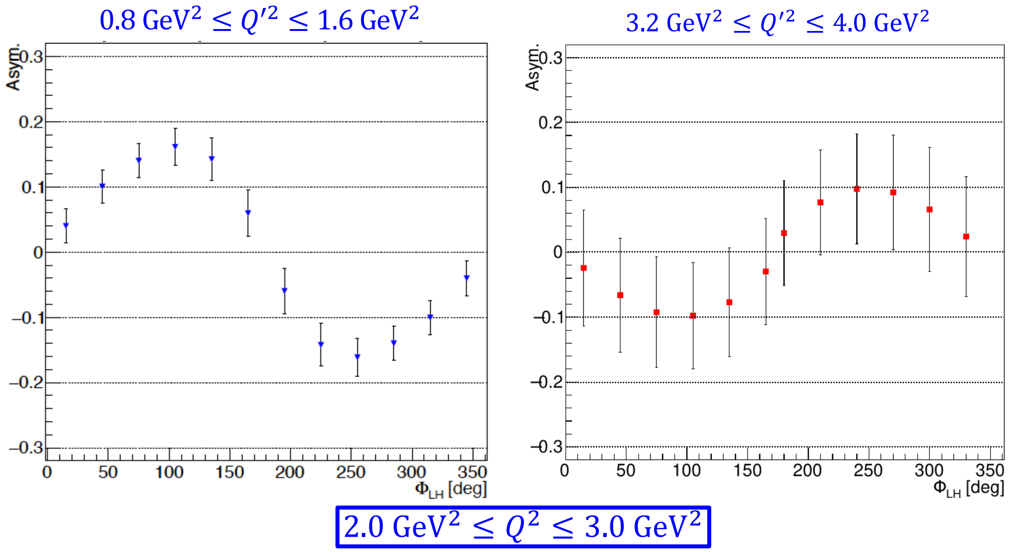
- Following the sign change of ξ' around $Q'^2=Q^2$, the CFF $\mathcal{H}$ and $\mathcal{E}$ **change sign**, providing a testing ground of **GPDs universality**.

LoI12-16-004
S. Stepanyan et al.

- A modified **CLAS12** spectrometer featuring a **new tracker**, a **new calorimeter** and a **tungsten shield** in the HTCC volume region would allow to increase CLAS12 luminosity up to **10^{37}cm^{-2}•s^{-1}**.



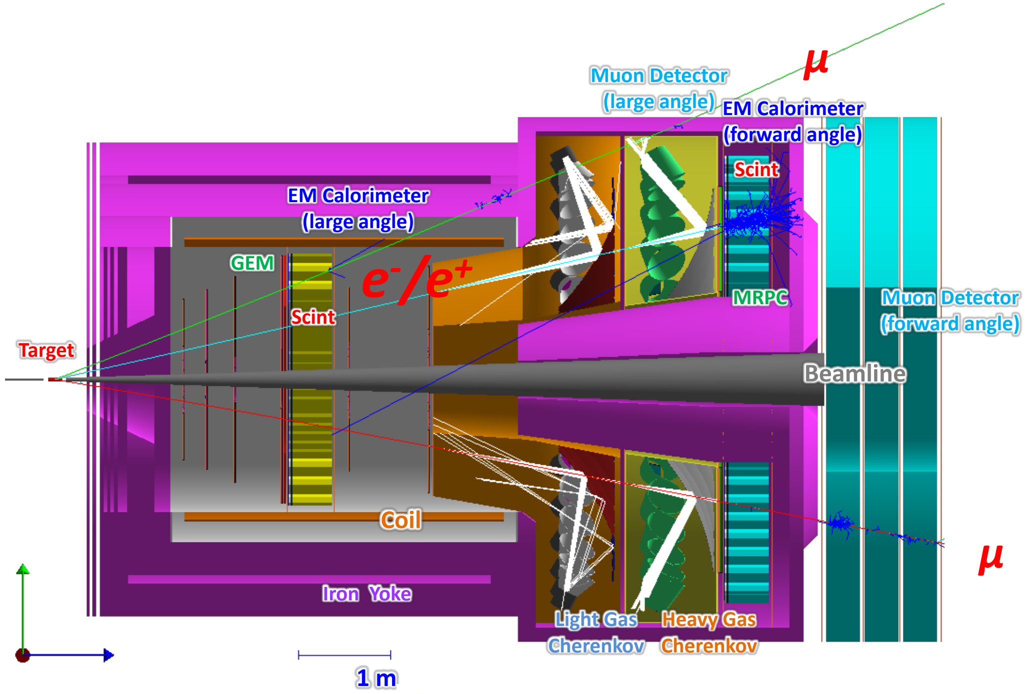
- The new detection system serves electron identification
- The **CLAS12 forward detector** acts as a **muon detector**
- This reconfigured CLAS12 spectrometer would measure **DDVCS** and **J/Ψ** electroproduction over a 100 days run.

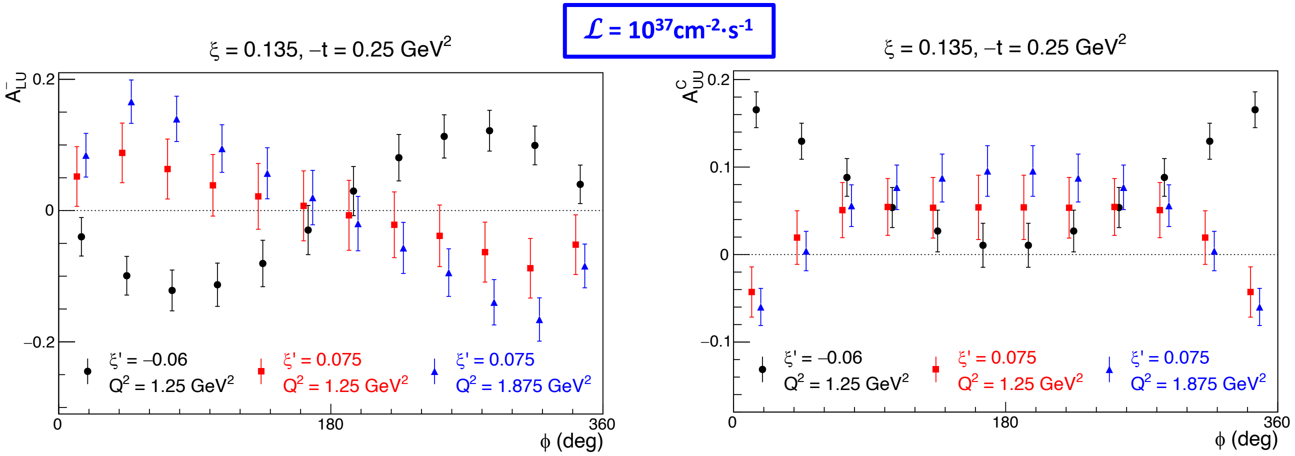


LoI12-23-012
M. Boer, A. Camsonne, E. Voutier, Z. Zhao et al.

S. Zhao et al. EPJ A 57 (2021) 240

- The **SoLID** apparatus completed with a **muon detector** at forward and large angles, enables **DDVCS** measurements with both **polarized electron and positron** beams at 11 GeV.



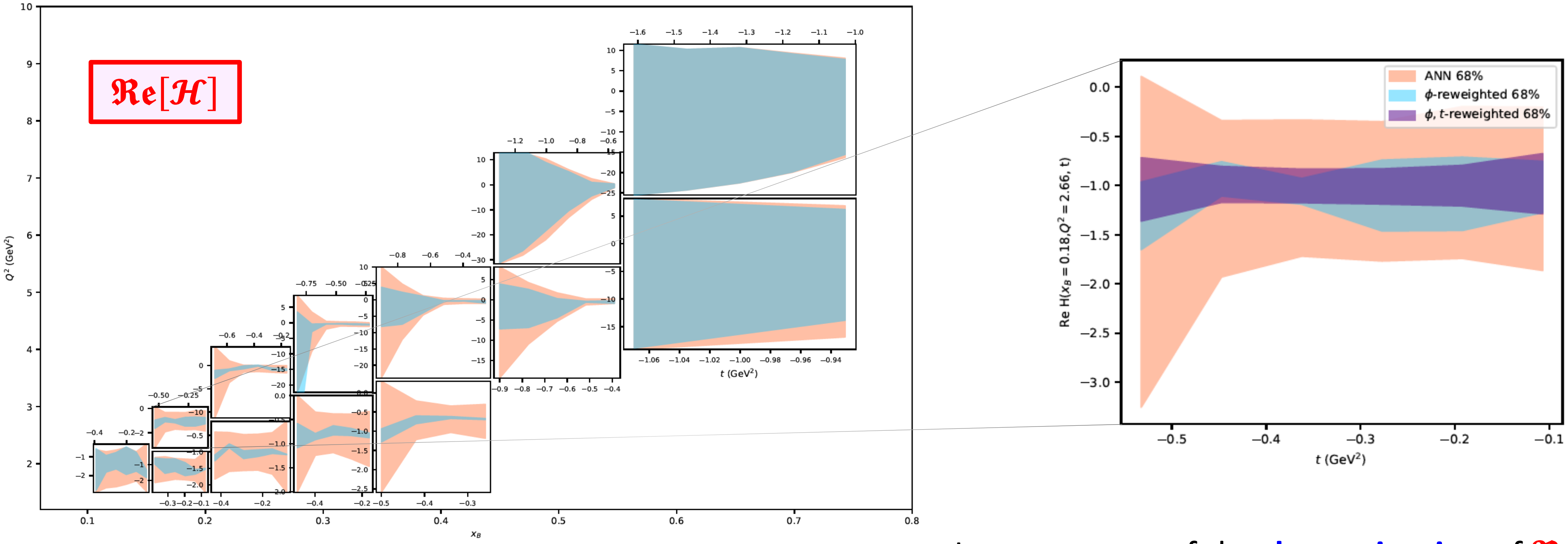


- The initial LoI discussed **electron BSA** measurements over a **50 days** run parasitic to the J/Ψ approved experiment.
- Completing this program with a **50 days positron beam** run would provide **unpolarized BCA** data.

Impact of Positron Measurements

H. Dutrieux, V. Bertone, H. Moutarde, P. Sznajder, EPJ A 57 (2021) 300

- The **existing DVCS world data set** (H1, ZEUS, HERMES, JLab 6 GeV, COMPASS) is analyzed within a **global fit** based on an Artificial Neural Network procedure within PARTONS to extract CFFs.
- The impact of **projected CLAS12 BCA** data on the proton is evaluated from a **Bayesian reweighting analysis** of CFFs.



☛ Improvement of the **determination** of $\Re e[\mathcal{H}]$.

PR12+23-002

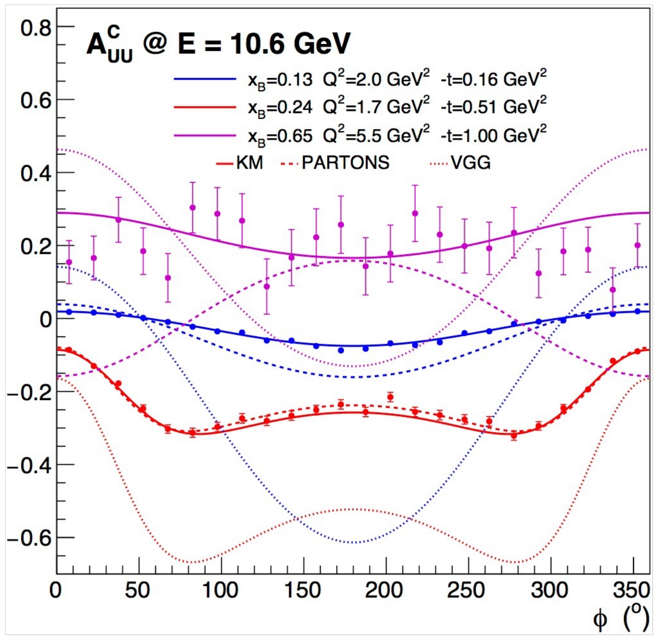
E. Voutier, V. Burkert, S. Niccolai, R. Paremuzyan et al.

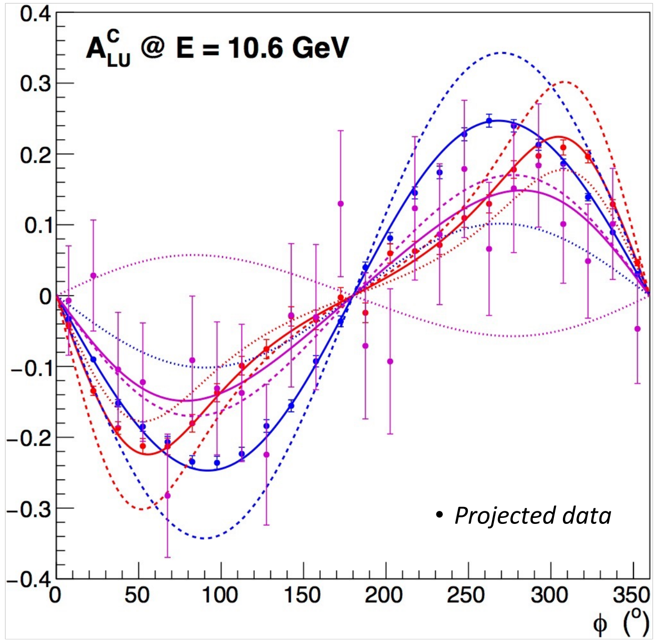
V. Burkert et al. EPJ A 57 (2021) 186

- Measurements of beam charge asymmetries with CLAS12 will provide a full set of new GPD observables:

  - the **unpolarized beam charge asymmetry** A_{UU}^C, sensitive to the **CFF real part**;
  - the **polarized beam charge asymmetry** A_{LU}^C, sensitive to the **CFF imaginary part**;
  - the **charge averaged beam spin asymmetry** A_{LU}^0, signature of **higher twist effects**.

$$A_{UU}^C = \frac{d^5\sigma_{INT}}{d^5\sigma_{BH} + d^5\sigma_{DVCS}}$$





$$A_{LU}^C = \frac{d^5\tilde{\sigma}_{INT}}{d^5\sigma_{BH} + d^5\sigma_{DVCS}}$$

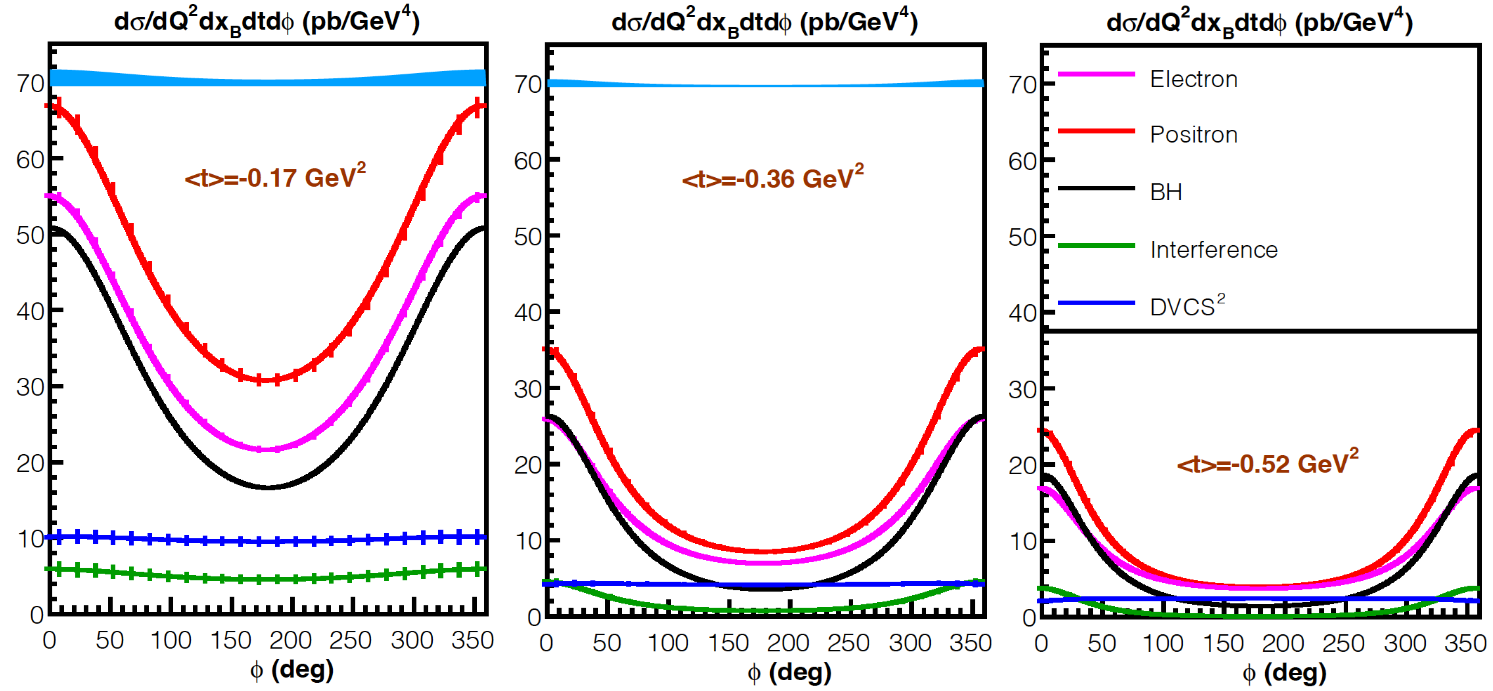
E. Voutier
IJCLab Irène Joliot-Curie

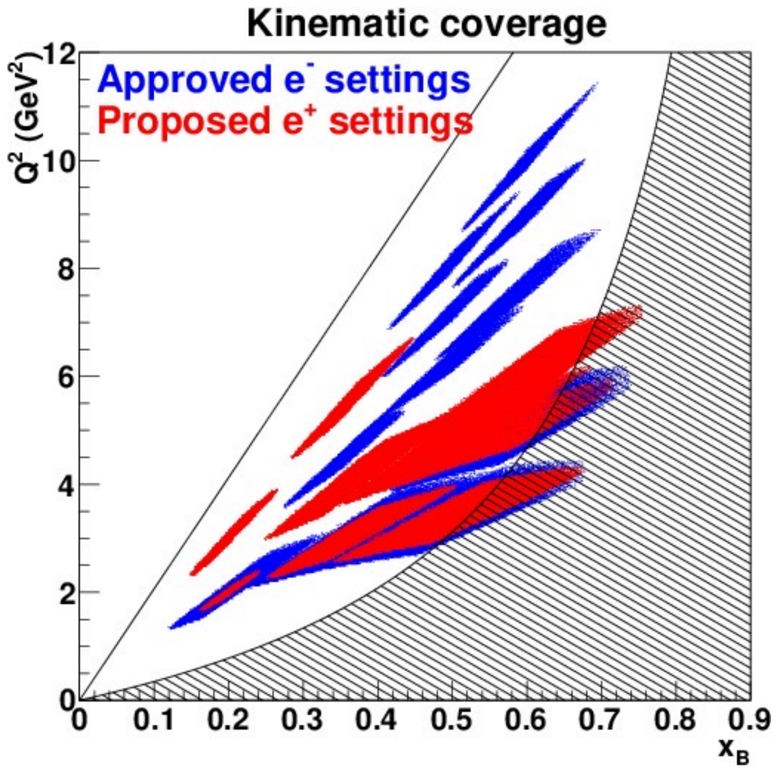
PR12+23-006
C. Muñoz Camacho, M. Mazouz et al.

A. Afanasev et al. EPJ A 57 (2021) 300

- Combining the HMS and the NPS spectrometers, precise cross section measurements with unpolarized positron beam are proposed at selected kinematics where electron beam data will soon be accumulated.

$x_B = 0.36 \quad Q^2 = 4.0\ GeV^2$

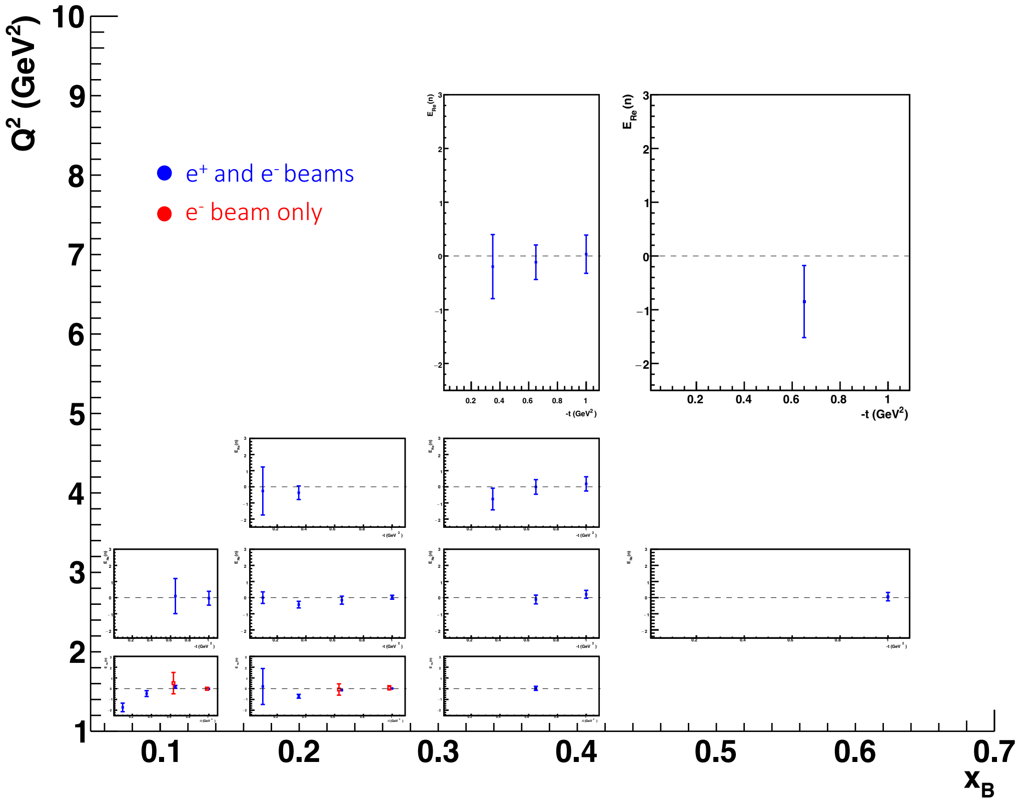




LoI12-18-004
Jefferson Lab Positron Working Group

S. Niccolai, P. Chatagnon, M. Hoballah, D. Marchand, C. Muñoz Camacho, E. Voutier, EPJ A 57 (2021) 226

- Contrary to H, the GPD **E flips the spin of the nucleon** and is consequently not constrained by Deep Inelastic Scattering data.



X. Ji, PRL 78 (1997) 610

$$\int_{-1}^{1} x\,[H(x,\xi,t\to 0) + E(x,\xi,t\to 0)]\,dx = J$$

$$A_{UU}^{C} \propto \frac{1}{F_2}\,\Re e\left[\xi \widetilde{H}_n - \frac{t}{4M^2} E_n\right]$$

The **BCA** on the neutron accesses the **real part** of the CFF **E**, and is sensitive to $\widetilde{\mathrm{H}}$ at some kinematics.

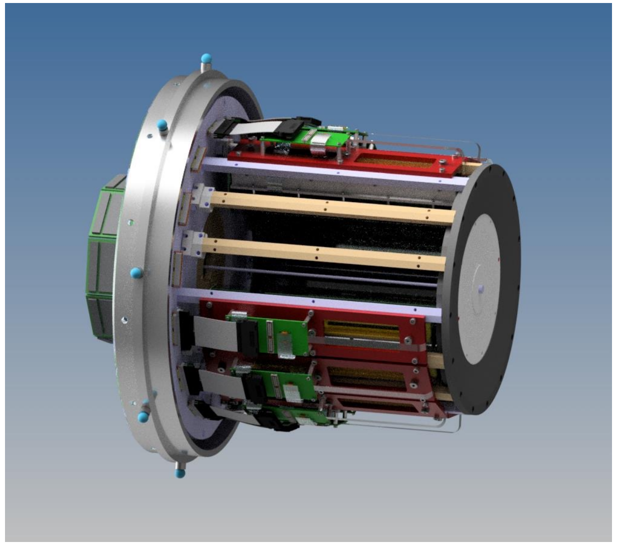
Coherent He-DVCS

M. Rinaldi, S. Scopetta, PRC 85 (2012) 062201; PRC 87 (2013) 035208 S. Fucini et al. EPJ A 57 (2021) 273

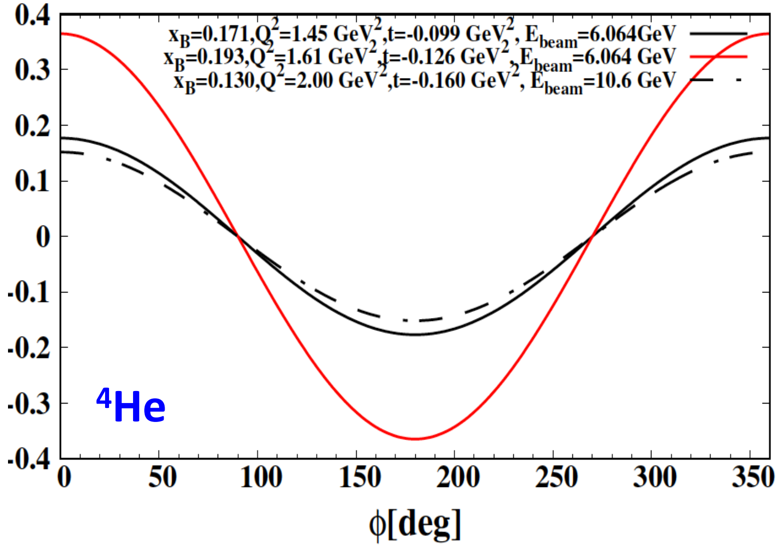
- The association of the **ALERT** recoil detector and the **CLAS12** spectrometer together with high-energy **electron** and **positron** beams offer a new tool for the **investigation** of the **nuclear force**.

$$\Re e[\mathcal{H}_A(\xi,t)] = \mathcal{P}\int_0^1 \left[\frac{1}{\xi+x}+\frac{1}{x-\xi}\right] H_A(x,\xi,t)\,dx = \frac{1}{\pi}\mathcal{P}\int_0^1 \left[\frac{1}{\xi+x}+\frac{1}{x-\xi}\right] \Im m[H_A(x,x,t)]\,dx - \delta(t)$$

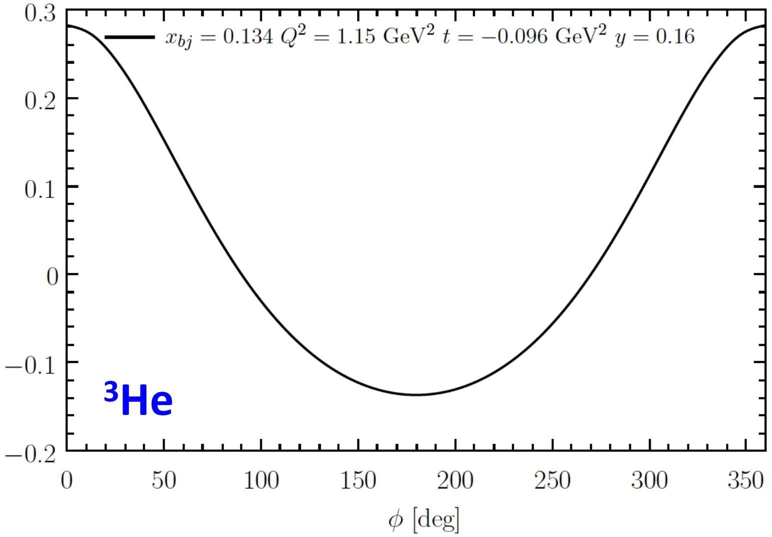
Courtesy of Raphaël Dupré (IJCLab)



Unpolarized Beam Charge Asymmetry

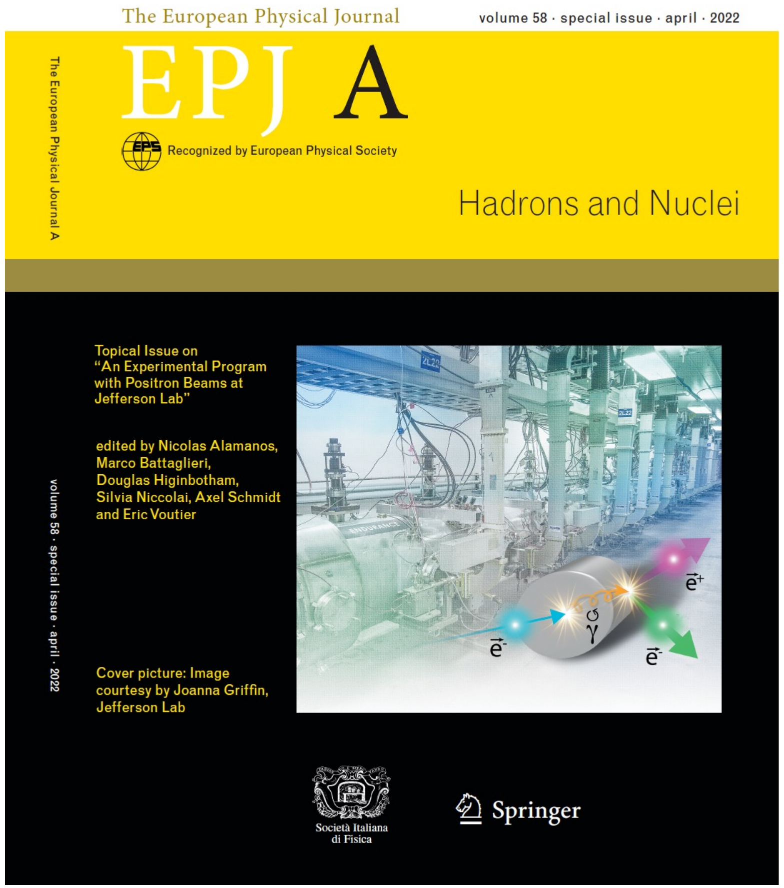


Nuclear imaging



Sensitivity to neutron GPDs

Positron Working Group



- The **JLab Positron Working Group** (PWG) developed the perspectives of an experimental program with **positron beams at CEBAF** in a topical EPJ A issue.

- This document constitutes the final **JLab Positron White Paper**, gathering 19 single contributions and a summary article, all peer-reviewed.

JLab PWG = ~**250** Physicists
from **75** Institutions and **16** countries

(Jefferson Lab Positron Working Group) A. Accardi *et al.* EPJ A 57 (2021) 261

Subscribe** to the JLab Positron Working Group mailing list **pwg@jlab.org

Jefferson Lab PAC51

- The **Positron Experimental Program** at **JLab** has formally **started** with the C1 approval of 5 positron proposals at the PAC meeting of **Juy 2023**, constituting **3 calendar years** of single hall running.

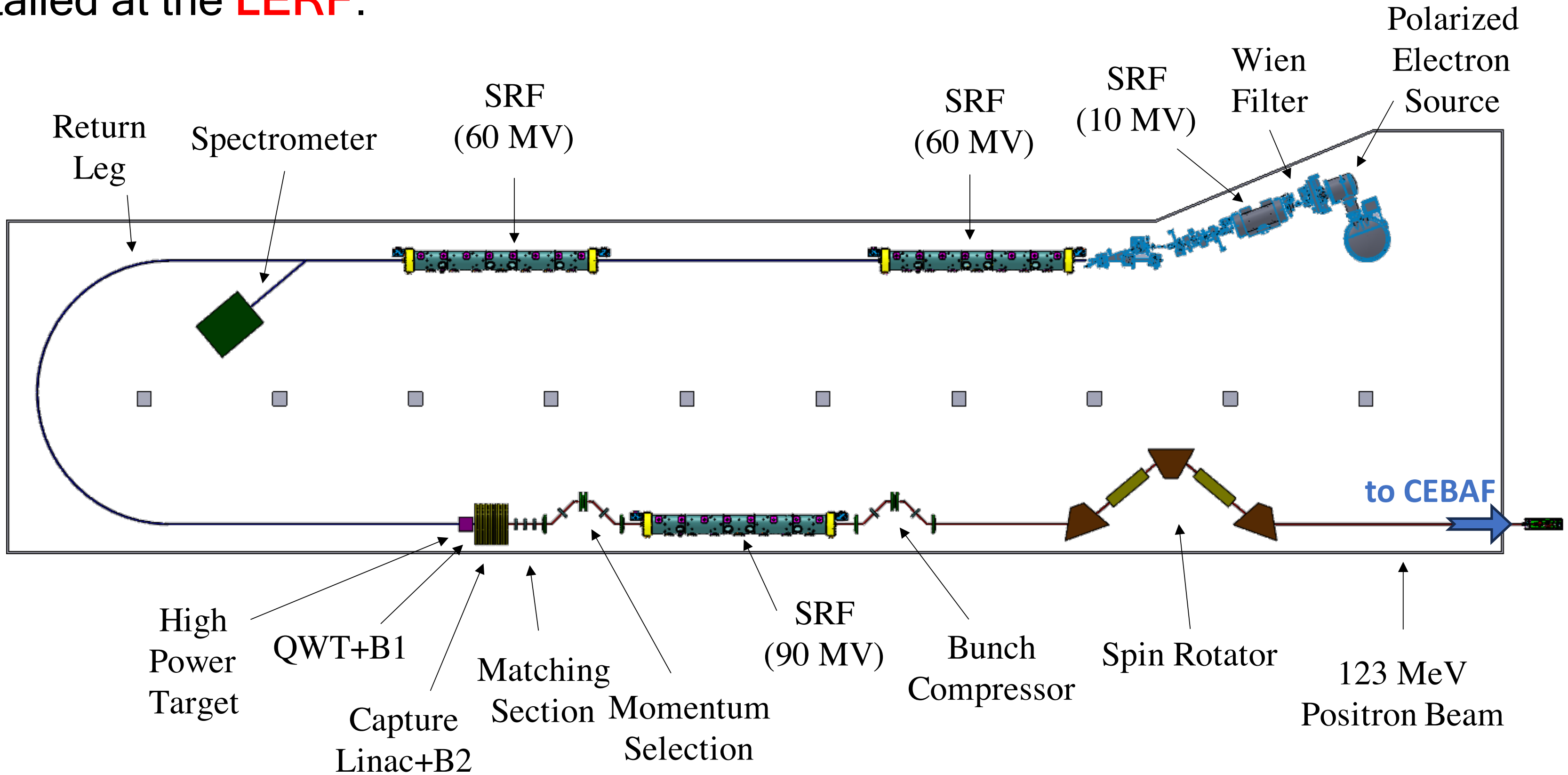
NUMBER	TITLE	PHYSICS THEME	CONTACT PERSON	HALL	DAYS AWARDED	SCIENTIFIC RATING	PAC DECISION
PR12+23-002	Beam Charge Asymmetries for Deeply Virtual Compton Scattering on the Proton at CLAS12	GPDs	Eric Voutier	B	100	**A-**	**C1**
PR12+23-003	Measurement of Deep Inelastic Scattering from Nuclei with Electron and Positron Beams to Constrain the Impact of Coulomb Corrections in DIS	TPE	Dave Gaskell	C	9.3	**A-**	**C1**
PR12+23-006	Deeply Virtual Compton Scattering using a positron beam in Hall C	GPDs	Carlos Muñoz Camacho	C	137	**A-**	**C1**
PR12+23-008	A Direct Measurement of Hard Two-Photon Exchange with Electrons and Positrons at CLAS12	TPE	Axel Schmidt	B	55	**A**	**C1**
PR12+23-012	A measurement of two-photon exchange in unpolarized elastic positron–proton and electron–proton scattering	TPE	Michael Nycz	C	56	**A-**	**C1**

C1 = Conditionally Approved with Technical Review by the Lab

e+@LERF

(Ce+BAF Working Group) J. Grames *et al.* JACoW IPAC2023 (2023) MOPL152; arXiv2309.15581

- Taking advantage of the **existing infrastructure** (electric and cryogenic power supplies, shielding…), a new **positron injector** based on the **PEPPo** (Polarized Electrons for Polarized Positrons) concept will be installed at the **LERF**.



Nominal

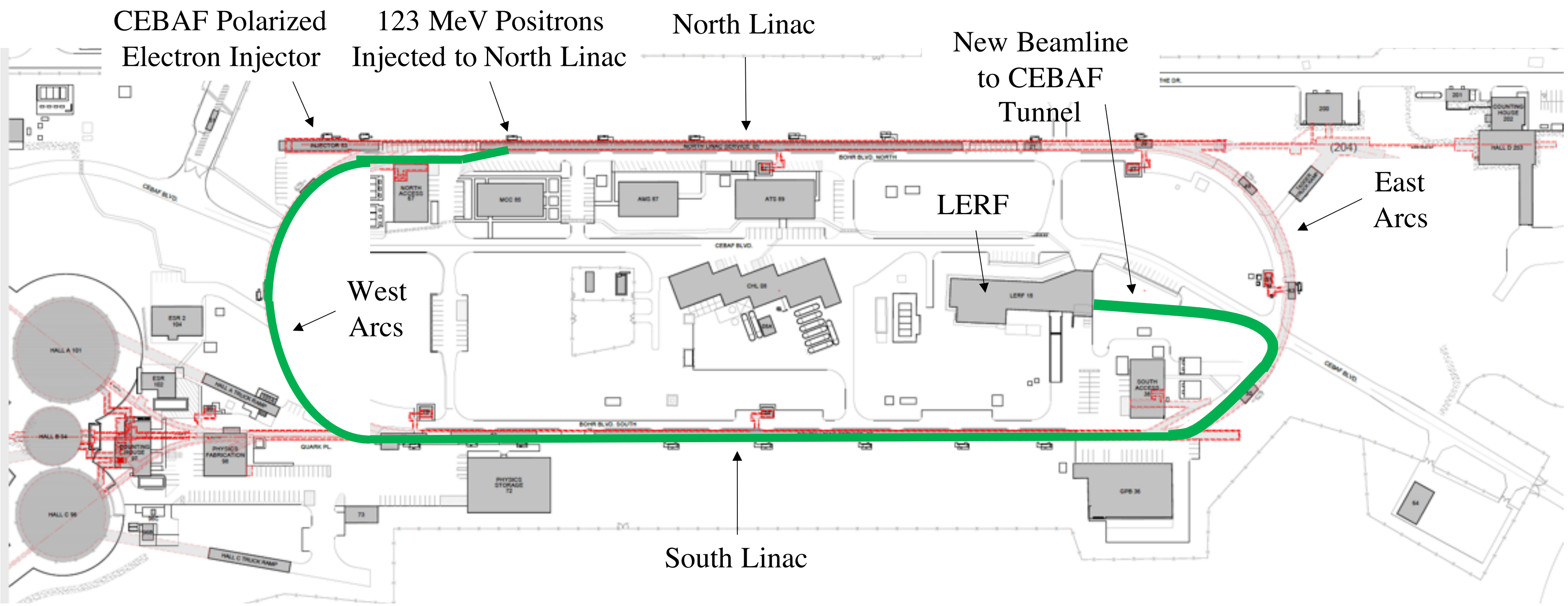
$I_{e+} > 50$ nA @ $P_{e+} = 60\%$

$I_{e+} > 1$ µA @ $P_{e+} = 0\%$

(PEPPo Collaboration) D. Abbott *et al.* PRL 116 (2016) 214801 S. Habet, Y. Roblin et al. JACoW IPAC (2022) 457 S. Habet, Doctorate, Université Paris-Saclay, 12/2023

e^+@CEBAF (Ce+BAF Working Group) J. Grames *et al.* JACoW IPAC2023 (2023) MOPL152; arXiv2309.15581

- A new beam transport line attached to the ceiling of the existing tunnel will guide the **123 MeV e^+ beam** till the **injection point** at the entrance of the **North LinAc**.



D. Turner and Y. Roblin (JLab)

E. Voutier
IJCLab Irène Joliot-Curie

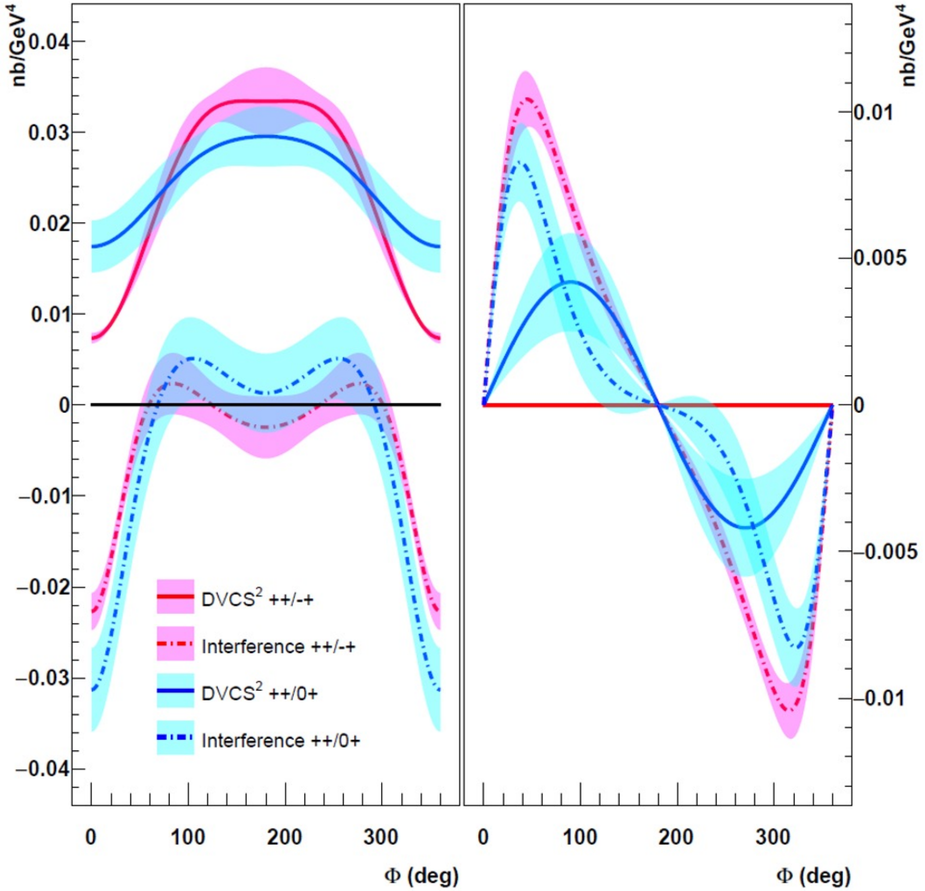
Conclusion

- Thirty years after their theoretical formulation, the experimental landscape of GPDs in the valence region is rich and improving rapidly.
- New promising channels and observables have been identified and will become available in a short future.
- Polarized and unpolarized positron beams at Jefferson Lab would uniquely enlarge the physics reach of GPDs at CEBAF.
- A strong accelerator R&D effort is progressing towards the final design and implementation of positron beams at CEBAF.

Merci de Votre Attention

Rosenbluth-like DVCS separation

(Hall A Collaboration) M. Defurne et al. Nat. Com. 8 (2017) 1408



- The **DVCS** and **INT** contributions to the unpolarized **epγ** cross section are **separated** following on the one hand a scenario including **Next-to-Leading Order** (**NLO**) contributions, and on the other hand **Higher-Twists** effects (**HT**).

The **DVCS** and **INT** amplitudes **signifcantly differ** in each scenario.

Future measurements

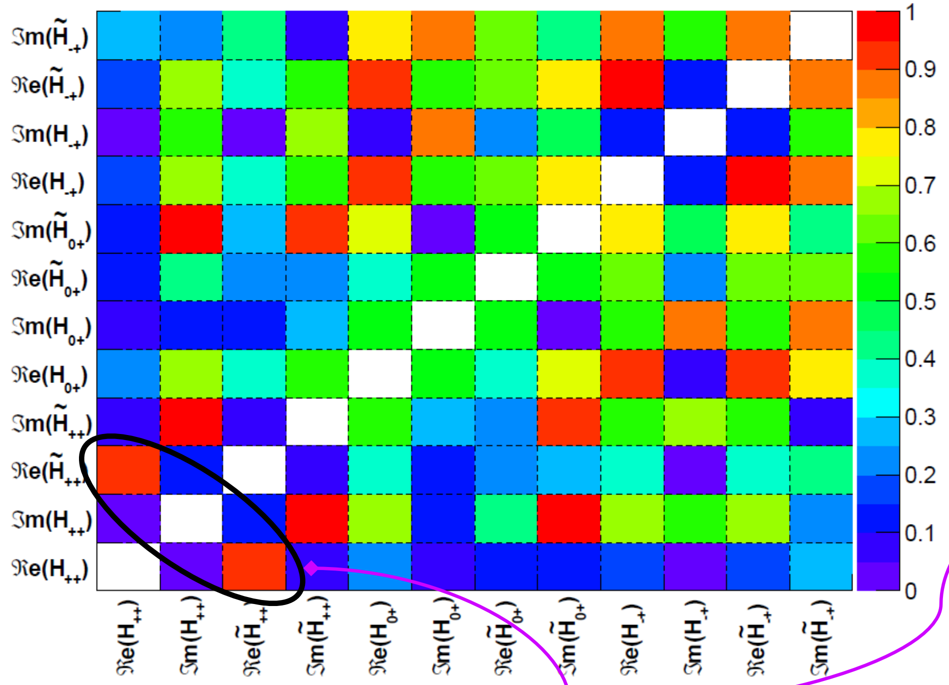
PR12+23-006

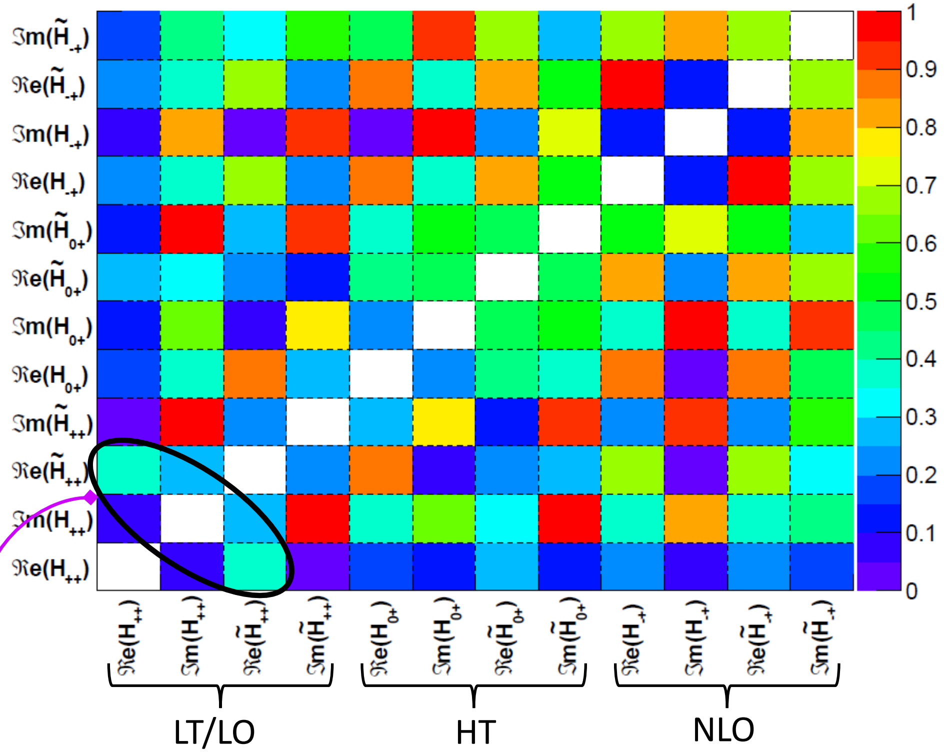
C. Muñoz Camacho, M. Mazouz et al.

A. Afanasev et al. EPJ A 57 (2021) 300

- The combination of electron and positron measurements strongly reduce correlations between CFFs, from 94% without to 39% at the considered kinematics.

Electrons only





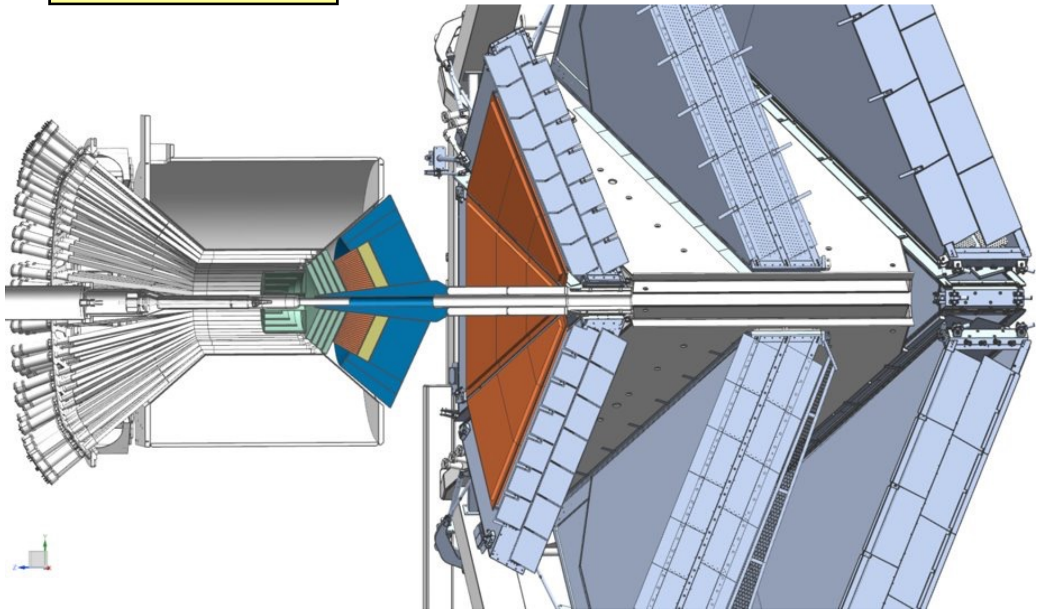
Electrons & Positrons

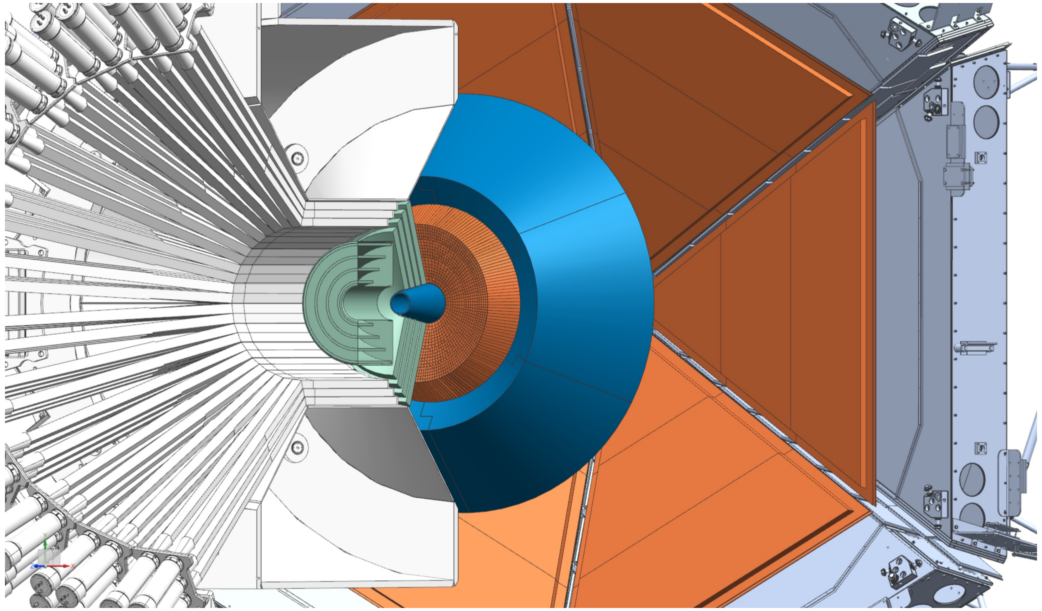
Better determination of LT/LO $\mathcal{H}$ and $\widetilde{\mathcal{H}}$.

Perspectives

E. Voutier

CLAS12$^{\mu}$



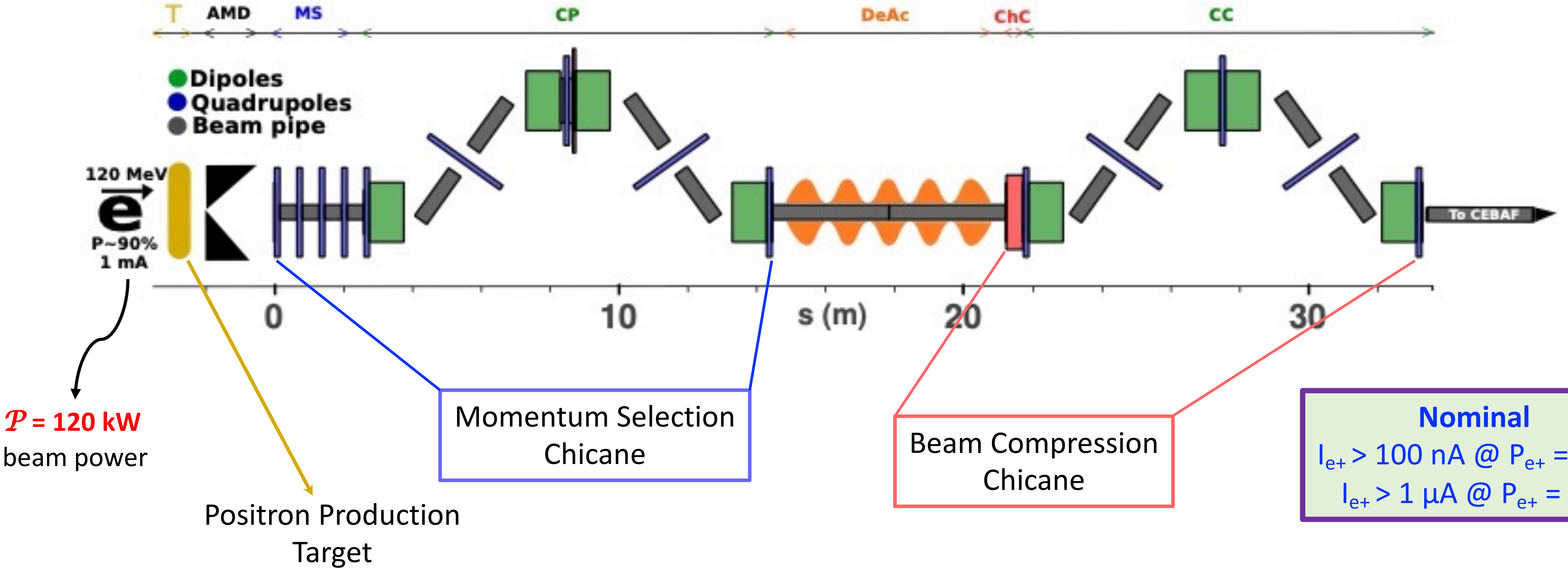


- Add a **new fast-tracking detector** in between HTCC and DC regions
- Remove HTCC and install a **Møller cone** in tungsten
- Add a **new PbWO4 calorimeter** to cover the **7°-30°** region together with a **thick tungsten shield** protecting the full FD region
- Install a **new Micro Pattern Gas Detector** in front of the calorimeter

Positron Injector

S. Habet, Y. Roblin et al. JACoW IPAC (2022) 457   S. Habet, Doctorate, Université Paris-Saclay, 12/2023

- The design of the JLab positron source evolved towards the today's latest concept :



Nominal
$I_{e+} > 100$ nA @ $P_{e+} = 60\%$
$I_{e+} > 1$ μA @ $P_{e+} = 0\%$

***High duty cycle**, **intensity**, and **polarization** distinguish JLab positron beam from any past or existing others.*

$Ce^{+}BAF$ Working Group

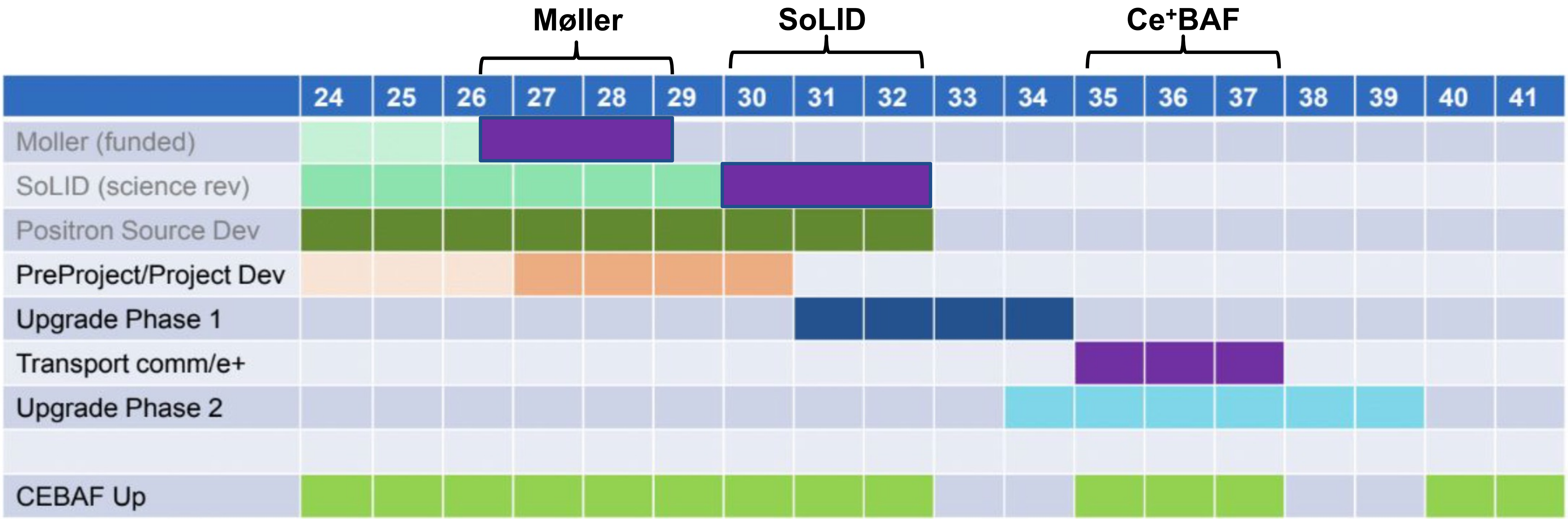
J. Benesch, A. Bogacz, L. Cardman, J. Conway, S. Covrig, J. Grames, J. Gubeli, C. Gulliford, S. Habet, C. Hernandez-Garcia, D. Higinbotham, A. Hofler, R. Kazimi, V. Kostroun, F. Lin, V. Lizarraga-Rubio, M. Poelker, Y. Roblin, A. Seryi, K. Smolenski, M. Spata, R. Suleiman, A. Sy, D. Turner, A. Ushakov, C. Valerio, E. Voutier, S. Zhang, Y. Zhang

($Ce^{+}BAF$ Working Group) J. Grames *et al.* JACoW IPAC2023 (2023) MOPL152

S. Habet *et al.* JACoW IPAC2022 (2022) 457   R. Kazimi *et al.* JACoW IPAC2023 (2023) WEPA035   A. Sy *et al.* JACoW IPAC2023 (2023) MOPM081
A. Ushakov *et al.* JACoW IPAC2023 (2023) WEPM120

Rough Timeline

D. Dean at the International Workshop on CLAS12 Physics and Future Perspectives at JLab, Paris, March 21-24, 2023



- Phase 1 includes building a positron source and the tunnel & beamline connecting to CEBAF
- Phase 2 includes new permanent magnets to allow 22 GeV within current CEBAF footprint

Long Range Plan

- The 2023 NP LRP recommends priorities to US funding agencies for the next 7-8 year cycle.

RECOMMENDATION 1

The highest priority of the nuclear science community is to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal.

RECOMMENDATION 2

As the highest priority for new experiment construction, we recommend that the United States lead an international consortium that will undertake a neutrinoless double beta decay campaign, featuring the expeditious construction of ton-scale experiments, using different isotopes and complementary techniques.

RECOMMENDATION 3

We recommend the expeditious completion of the EIC as the highest priority for facility construction.

RECOMMENDATION 4

We recommend capitalizing on the unique ways in which nuclear physics can advance discovery science and applications for society by investing in additional projects and new strategic opportu-nities.

Recommendations 1&4 strengthen current CEBAF operations and future upgrades.