

# *Physics with Polarized Positrons*

*e<sup>+</sup> @ JLab 12 GeV    e<sup>+</sup> @ eRHIC*

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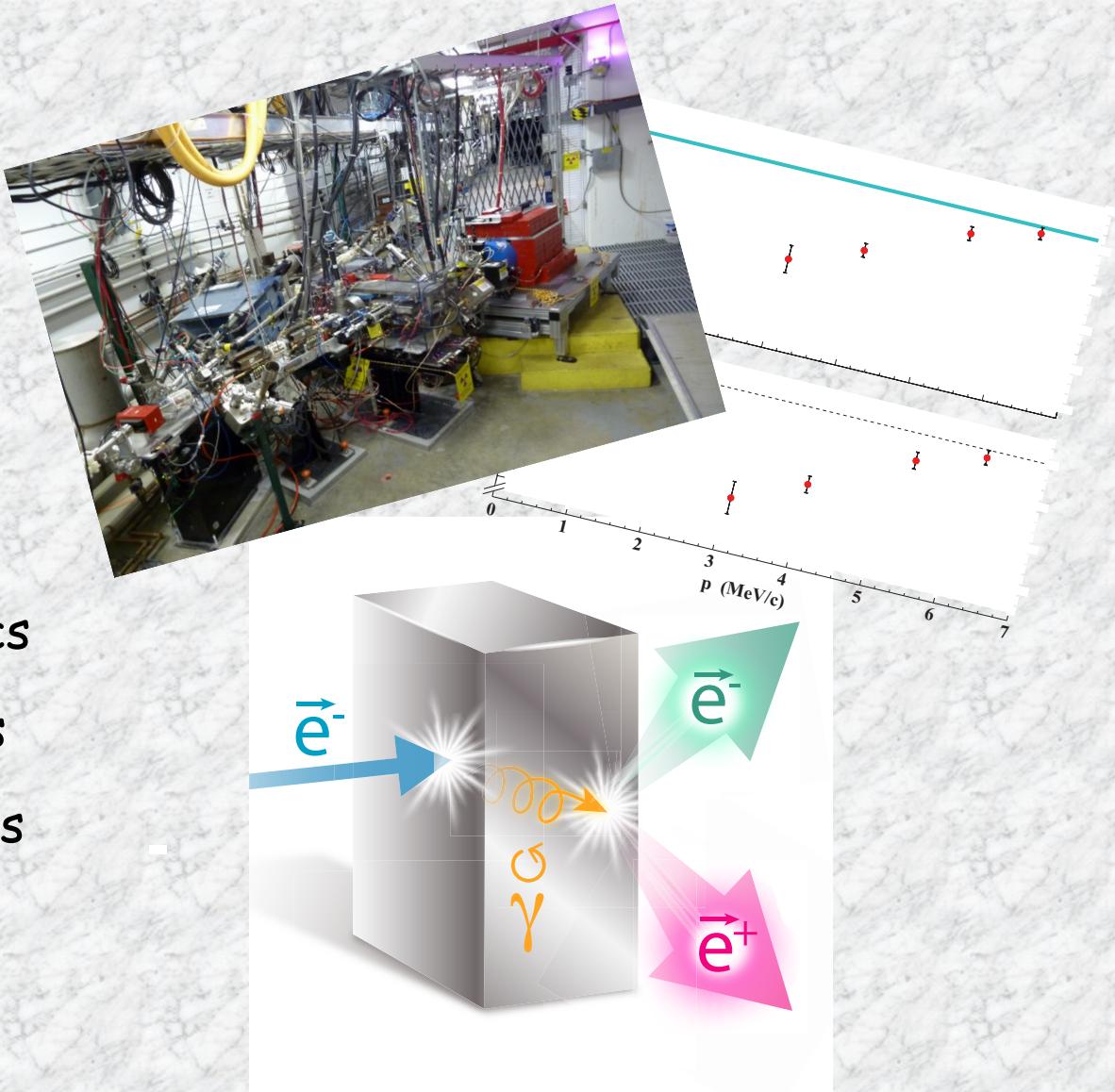
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...



- (i) Physics motivations
- (ii) Interference physics
- (iii) Structure functions
- (iv) Standard Model tests
- (v) Polarized positrons
- (vi) Summary



## JPos17

Proc. of the International Workshop on Physics with Positrons at Jefferson Lab, J. Grames and E. Voutier Edts. AIP Conf. Proc. 1970 (2018)



Volume 1970

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International Workshop on Physics with Positrons at Jefferson Lab



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<https://aip.scitation.org/toc/apc/1970/1?size=all&expanded=1970>

## LOI12-18-004

J. Grames, E. Voutier et al. Jefferson Lab LOI12-18-004 (2018), arXiv:1906.09419

Letter-of-Intent to PAC46  
LOI12-18-004

### Physics with Positron Beams at Jefferson Lab 12 GeV

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## Letter of Intent submitted to JLab PAC46 (July 2018)

### Highlighting 7 mini-LOI's

Supported by 127 members 39 institutions

	I (nA) $e^-$	Beam $e^+$	Time Polarization	Time (d)
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### Two-photon exchange

TPE @ CLAS12	60	60	No	53
TPE @ SupRos	-	1000	No	18
TPE @ SBS	40000	100	Yes	55

### Generalized Parton Distributions

p-DVCS @ CLAS12	75	15	Yes	83
n-DVCS @ CLAS12	60	60	Yes	80
p-DVCS @ Hall C	-	5000	No	56

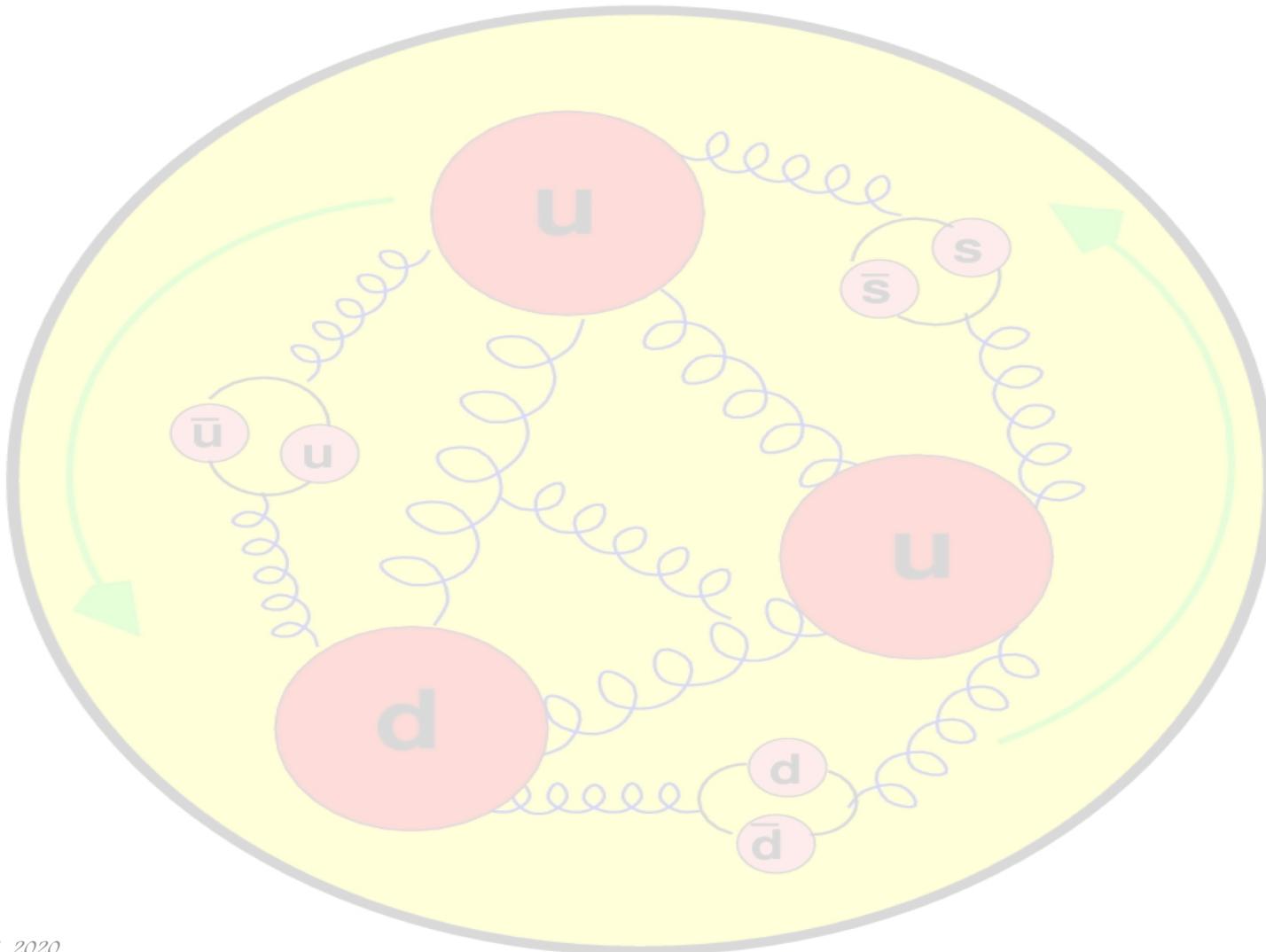
### Test of the Standard Model

$A'$ search	-	10-100	No	180
Total Data Taking Time				525

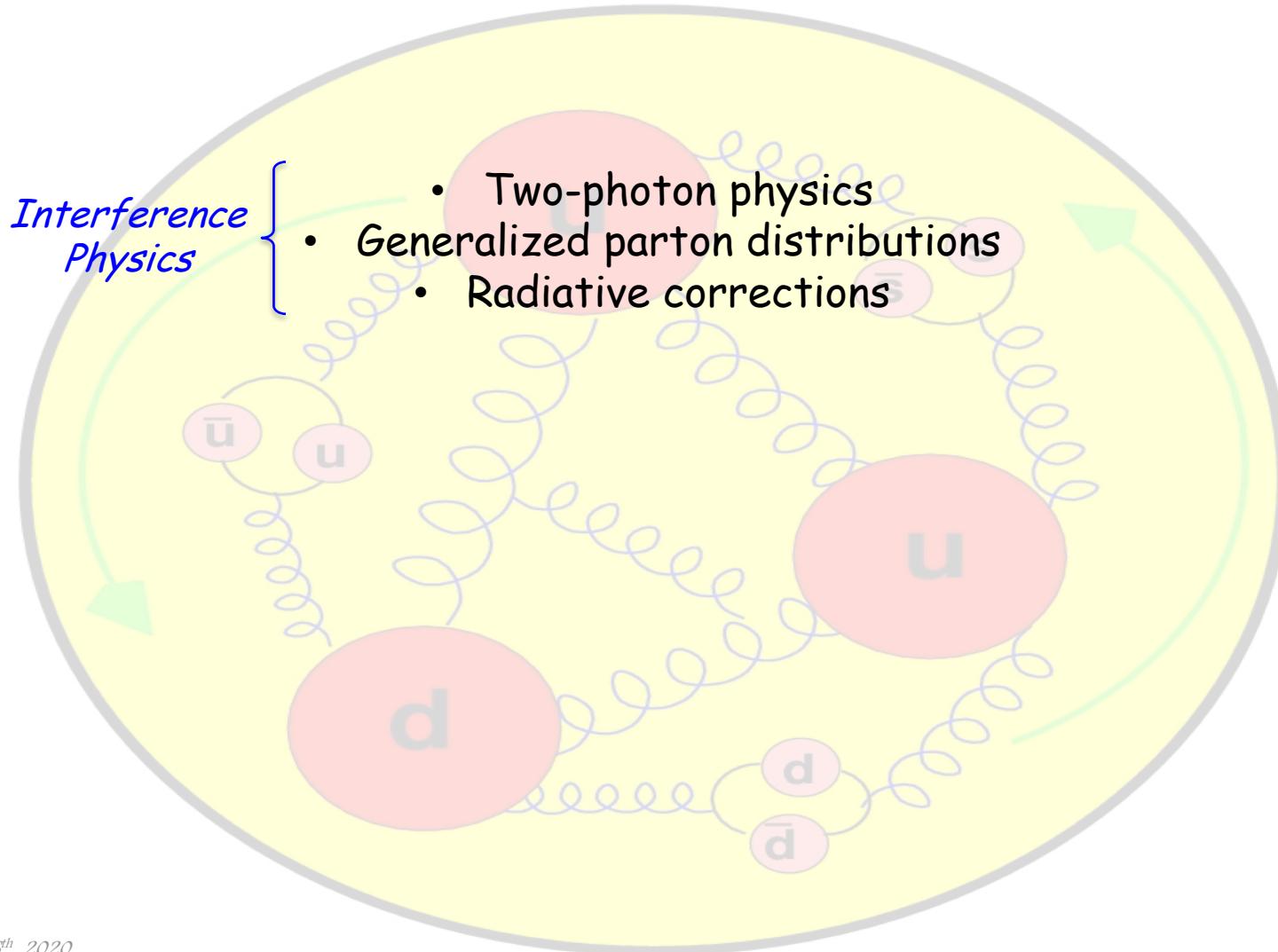
**"These measurements all have significant physics interest.  
The proposers should carefully evaluate feasibility and  
present the best case possible in a future proposal."**

PR12-20-009 PR12-20-012  $e^+@\text{JLab White Paper}$

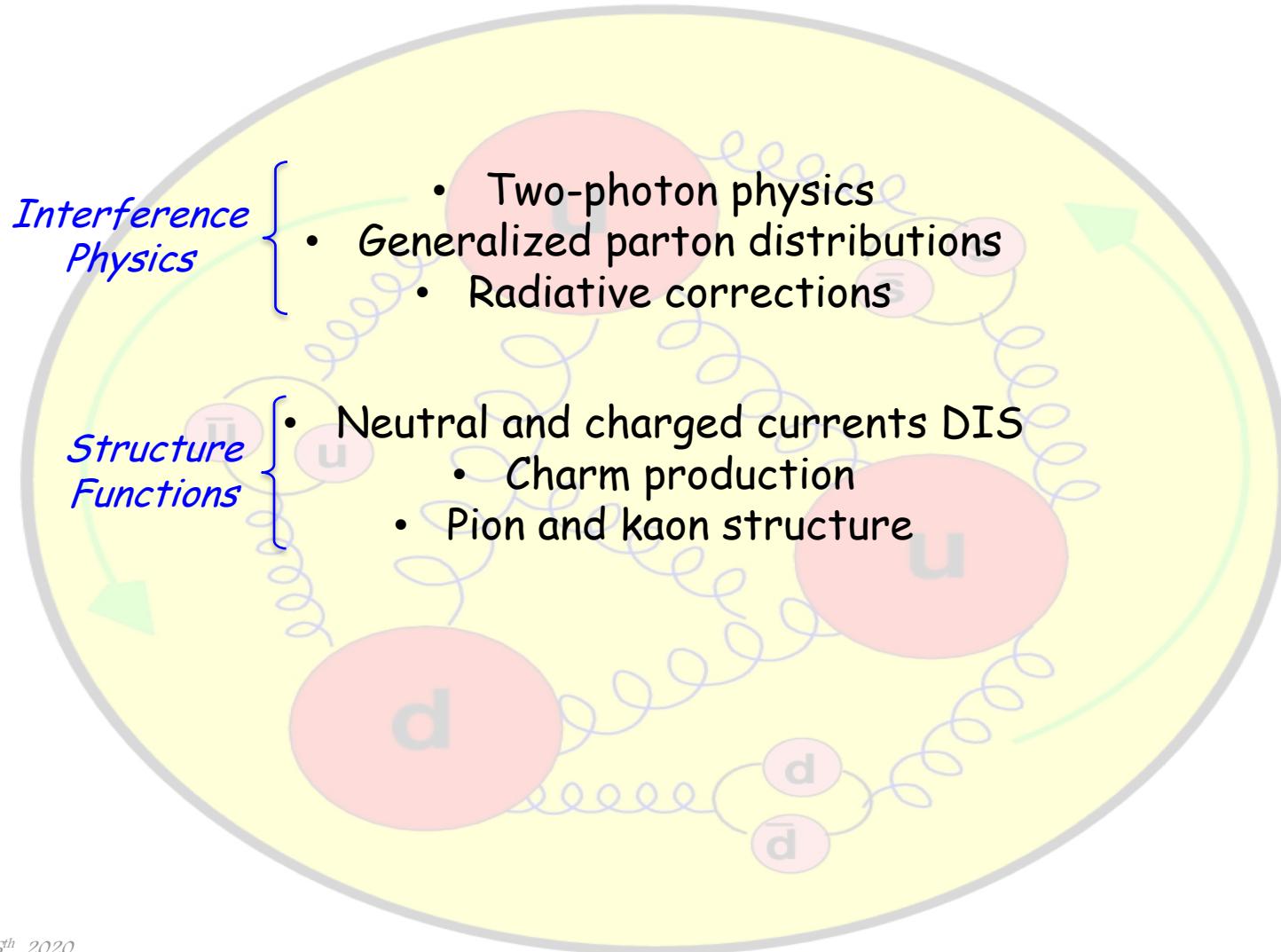
## Positron Physics



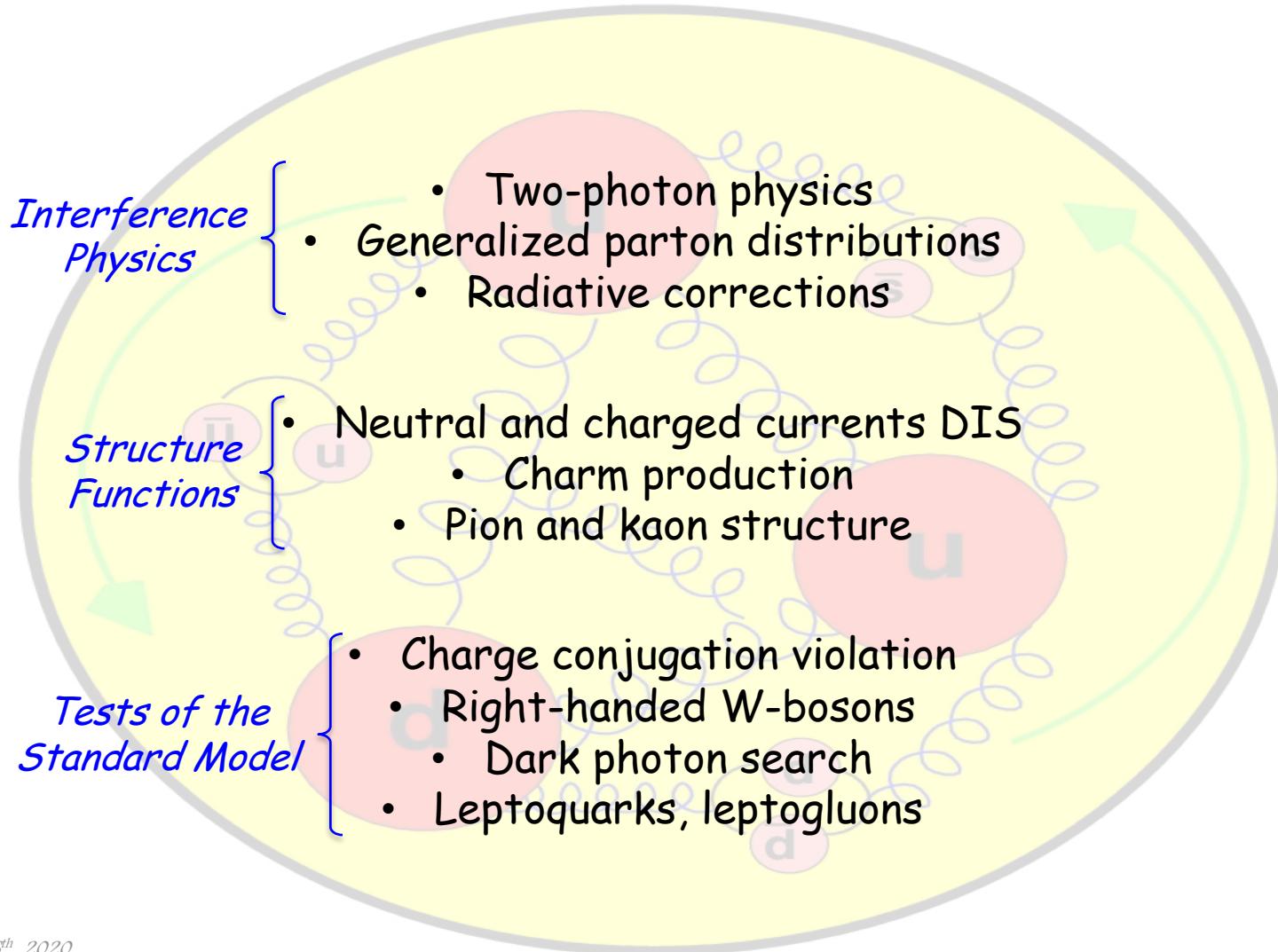
## Positron Physics



## Positron Physics



## Positron Physics



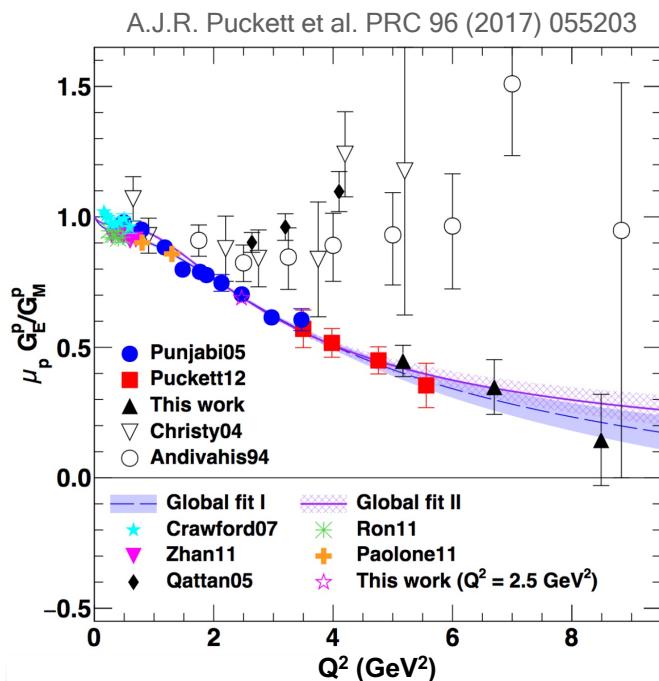
## *Interference Physics*

- Two-photon physics
- Generalized parton distributions
  - Radiative corrections

## Electromagnetic Form Factors

P.A.M. Guichon, M. Vanderhaeghen, PRL 91 (2003) 142303    P.G. Blunden, W. Melnitchouk, J.A. Tjon, PRL 91 (2003) 142304

- Measurements of **polarization transfer** observables in **electron elastic scattering off protons** question the **validity of the  $1\gamma$  exchange approximation** of the electromagnetic interaction.



Within the  **$2\gamma$  exchange hypothesis**, the electromagnetic structure of the nucleon may be parametrized by 3 generalized form factors, corresponding to **8 unknown quantities**.

$$\begin{aligned}\tilde{G}_M &= G_M(Q^2) + e_1 \delta \tilde{G}_M(Q^2, \varepsilon) \\ \tilde{G}_E &= G_E(Q^2) + e_1 \delta \tilde{G}_E(Q^2, \varepsilon) \\ \tilde{F}_3 &= e_1 \delta \tilde{F}_3(Q^2, \varepsilon)\end{aligned}$$

## Experimental Observables

M.P. Rekalo, E. Tomasi Gustafsson, NPA 742 (2004) 322    C. Carlson, M. Vanderhaeghen, ARNPS 57 (2007) 171

- Unpolarized  $e^\pm$  elastic scattering and polarization transfert observables off the nucleon involve up to 5 unknown quantities.

Cross Section

$$\sigma_R = G_M^2 + \frac{\varepsilon}{\tau} G_E^2 \pm 2G_M \Re[f_0(\delta\tilde{G}_M, \delta\tilde{F}_3)] \pm 2\frac{\varepsilon}{\tau} G_E \Re[f_1(\delta\tilde{G}_E, \delta\tilde{F}_3)]$$

Polarization Transfert

$$\sigma_R P_t = -\sqrt{\frac{2\varepsilon(1-\varepsilon)}{\tau}} (G_E G_M \pm G_E \Re[\delta\tilde{G}_M] \pm G_M \Re[f_1(\delta\tilde{G}_E, \delta\tilde{F}_3)])$$

$$\sigma_R P_l = \sqrt{1-\varepsilon^2} (G_M^2 \pm 2G_M \Re[f_2(\delta\tilde{G}_M, \delta\tilde{F}_3)])$$

5 unknown contributions for 6 independent observables

## Experimental Observables

M.P. Rekalo, E. Tomasi Gustafsson, NPA 742 (2004) 322    C. Carlson, M. Vanderhaeghen, ARNPS 57 (2007) 171

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$$\sigma_R P_t = -\sqrt{\frac{2\varepsilon(1-\varepsilon)}{\tau}} (G_E G_M \pm G_E \Re[\delta\tilde{G}_M] \pm G_M \Re[f_1(\delta\tilde{G}_E, \delta\tilde{F}_3)])$$

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5 unknown contributions for 6 independent observables

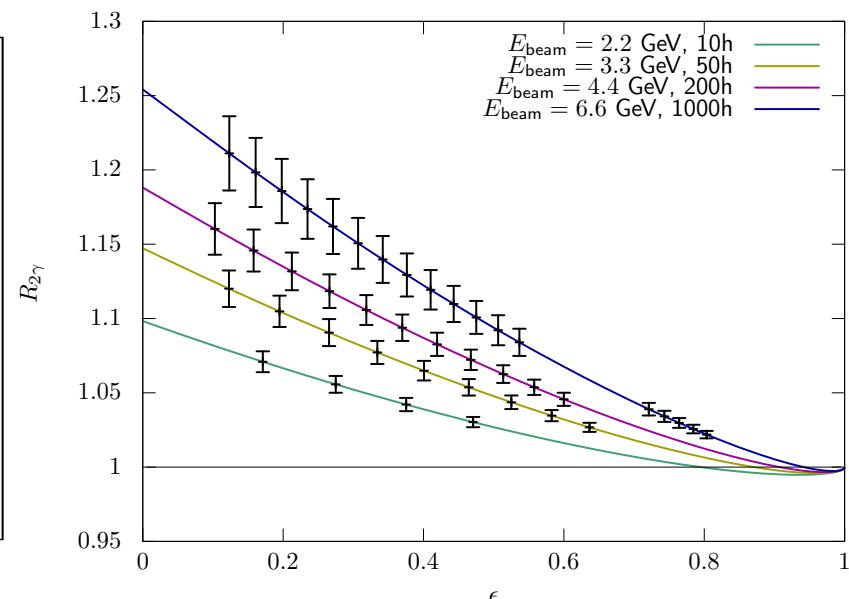
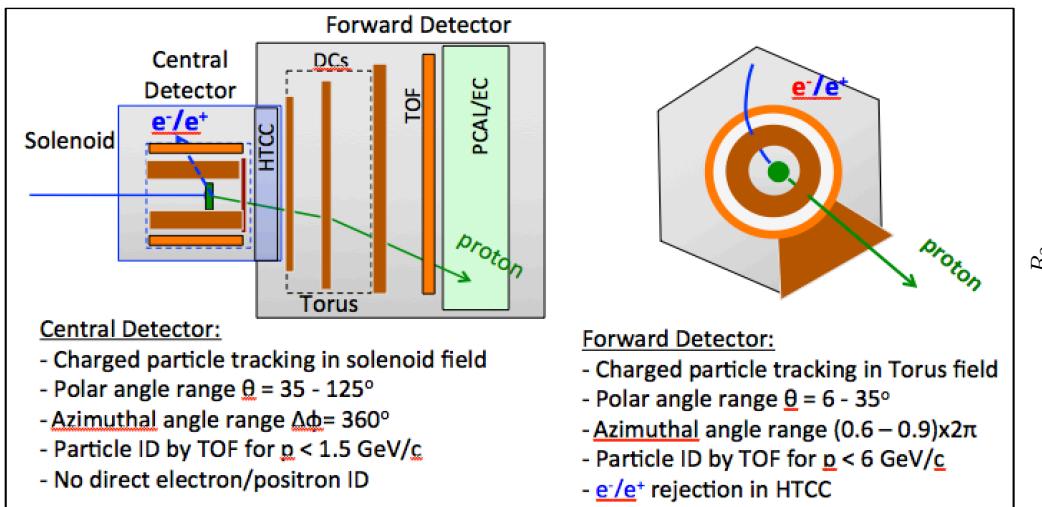
Combining polarized electrons and positrons allows a model independent separation of the electromagnetic form factors of the nucleon.

**LOI12-18-004**

J. Arrington, J. Bernauer, V. Burkert, A. Schmidt et al.

- A **modified CLAS12** hosting an electromagnetic calorimeter in place of the Central Neutron Detector would allow to **map out the  $2\gamma$ -effects** in the  $(Q^2, \epsilon)$  space, providing a **conclusive answer about** the relevance of  $2\gamma$ -effects.

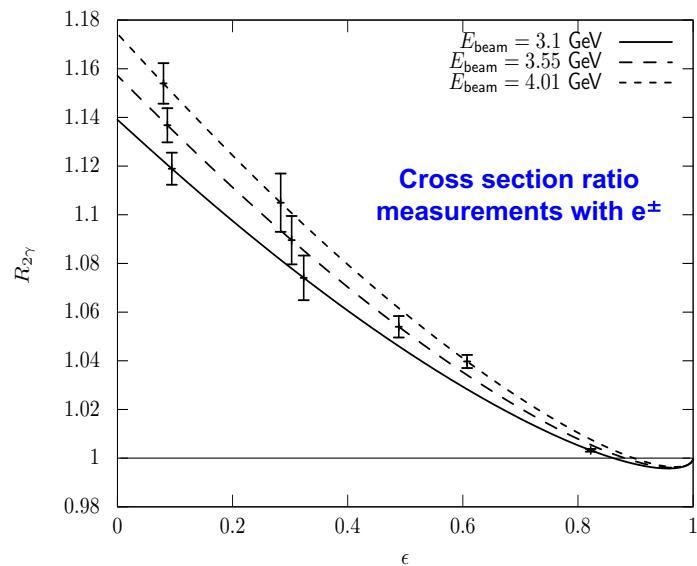
$$R_{2\gamma} = \frac{\sigma_{e^+}}{\sigma_{e^-}} \approx 1 + \delta_{2\gamma}$$



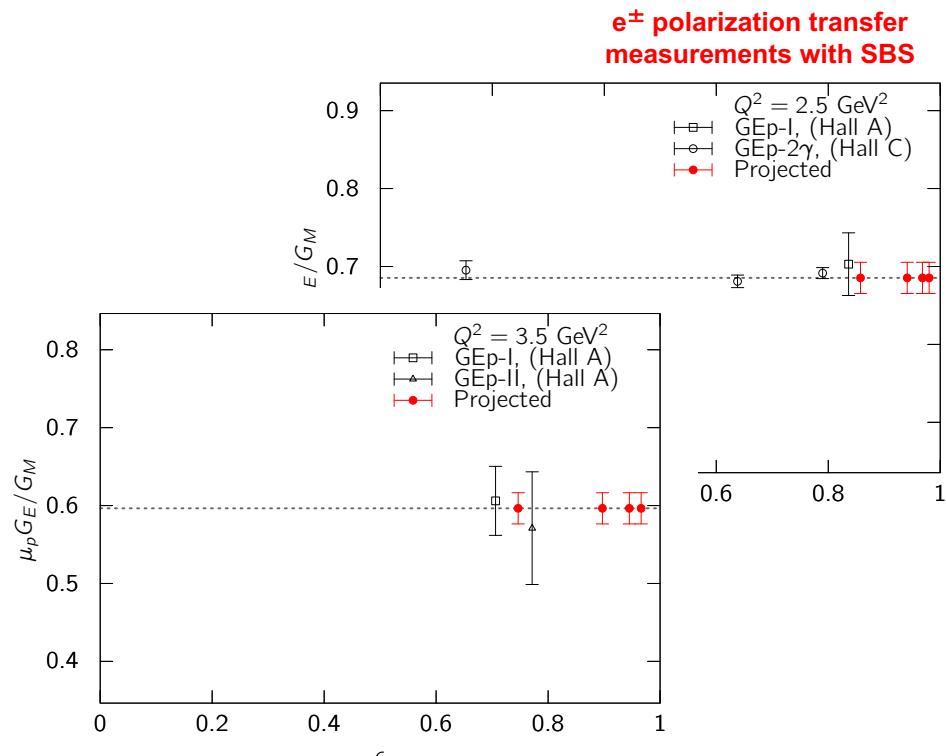
**LOI12-18-004**

J. Arrington, J. Bernauer, A. Puckett, A. Schmidt et al.

➤ High impact measurements are also feasible in Hall A & C to sign the existence of  $2\gamma$ -effects, better control systematics with the Super-Rosenbluth technique, and to provide unique polarization transfer data.



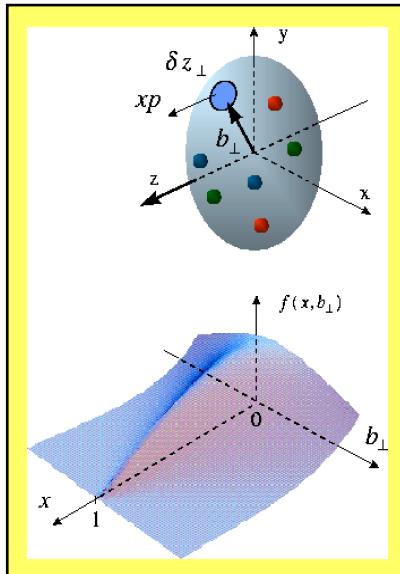
Cross section ratio  
measurements with  $e^\pm$



## Parton Imaging

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

- GPDs parameterize the **partonic structure** of hadrons and offer the unprecedented possibility to access the **spatial distribution** of partons.



GPDs encode the **correlations between partons** and contain information about the dynamics of the system like the **angular momentum** or the **distribution of the strong forces** experienced by quarks and gluons inside hadrons.

X. Ji, PRL 78 (1997) 610

M. Polyakov, PL B555 (2003) 57

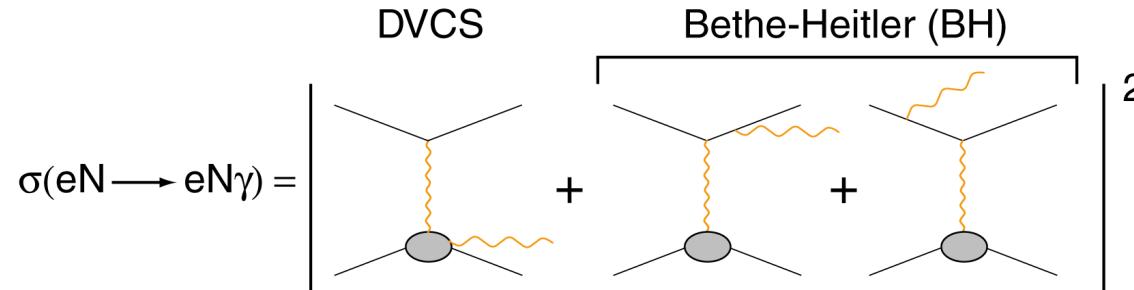
M. Burkardt, PRD 62 (2000) 071503   M. Diehl, EPJC 25 (2002) 223

GPDs can be interpreted as a **distribution** in the **transverse plane** of partons carrying some **fraction** of the **longitudinal momentum** of the nucleon.

A new light  
on hadron  
structure

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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



$$\sigma_{P0}^e = \sigma_{BH} + \sigma_{DVCS} + P_1 \tilde{\sigma}_{DVCS} + e_l (\sigma_{INT} + P_1 \tilde{\sigma}_{INT})$$

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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

$$\sigma(eN \rightarrow eN\gamma) = \left| \text{DVCS} + \text{Bethe-Heitler (BH)} \right|^2$$

$$\sigma_{P0}^e = \sigma_{BH} + \sigma_{DVCS} + P_1 \tilde{\sigma}_{DVCS} + e_l (\sigma_{INT} + P_1 \tilde{\sigma}_{INT})$$

Electron  
observables

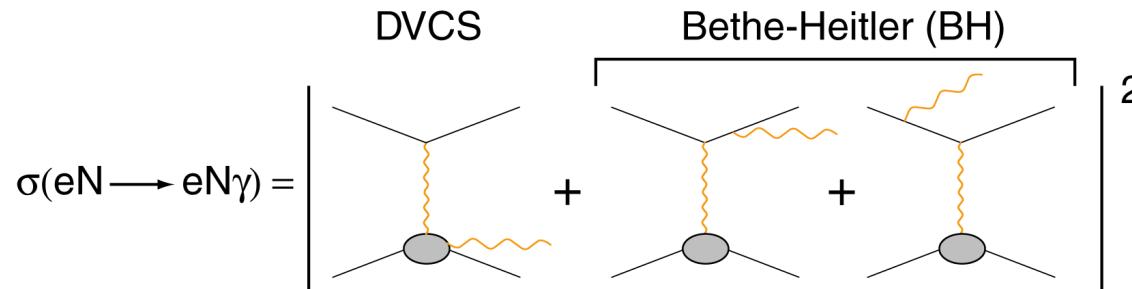


$$\sigma_{00}^- = \sigma_{BH} + \sigma_{DVCS} - \sigma_{INT}$$

$$\sigma_{+0}^- - \sigma_{-0}^- = 2 \tilde{\sigma}_{DVCS} - 2 \tilde{\sigma}_{INT}$$

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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



$$\sigma_{P0}^e = \sigma_{BH} + \sigma_{DVCS} + P_1 \tilde{\sigma}_{DVCS} + e_l (\sigma_{INT} + P_1 \tilde{\sigma}_{INT})$$

Electron  
observables

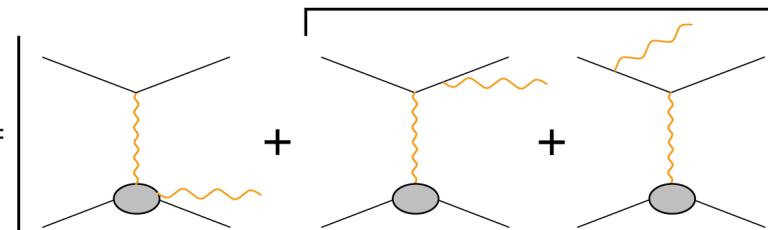
$$\begin{aligned} \sigma_{00}^- &= \sigma_{BH} + \sigma_{DVCS} - \sigma_{INT} \\ \sigma_{+0}^- - \sigma_{-0}^- &= 2 \tilde{\sigma}_{DVCS} - 2 \tilde{\sigma}_{INT} \end{aligned}$$

Electron & positron  
observables

$$\begin{aligned} \sigma_{00}^+ - \sigma_{00}^- &= 2 \sigma_{INT} \\ [\sigma_{+0}^+ - \sigma_{-0}^+] - [\sigma_{+0}^- - \sigma_{-0}^-] &= [\sigma_{+0}^+ - \sigma_{+0}^-] - [\sigma_{-0}^+ - \sigma_{-0}^-] = 4 \tilde{\sigma}_{INT} \end{aligned}$$

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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

$$\sigma(eN \rightarrow eN\gamma) = \left| \text{DVCS} + \text{Bethe-Heitler (BH)} \right|^2$$


$$\sigma_{PS}^e = \sigma_{P0}^e + S [ P_1 \Delta\sigma_{BH} + (\Delta\tilde{\sigma}_{DVCS} + P_1 \Delta\sigma_{DVCS}) + e_1 (\Delta\tilde{\sigma}_{INT} + P_1 \Delta\sigma_{INT}) ]$$

Electron  
observables

$$\begin{aligned}\sigma_{00}^- &= \sigma_{BH} + \sigma_{DVCS} - \sigma_{INT} \\ \sigma_{+0}^- - \sigma_{-0}^- &= 2\tilde{\sigma}_{DVCS} - 2\tilde{\sigma}_{INT}\end{aligned}$$

Electron & positron  
observables

$$\begin{aligned}\sigma_{00}^+ - \sigma_{00}^- &= 2\sigma_{INT} \\ [\sigma_{+0}^+ - \sigma_{-0}^+] - [\sigma_{+0}^- - \sigma_{-0}^-] &= [\sigma_{+0}^+ - \sigma_{+0}^-] - [\sigma_{-0}^+ - \sigma_{-0}^-] = 4\tilde{\sigma}_{INT}\end{aligned}$$

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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

$$\sigma(eN \rightarrow eN\gamma) = \left| \text{DVCS} + \text{Bethe-Heitler (BH)} \right|^2$$

$$\sigma_{PS}^e = \sigma_{P0}^e + S [ P_1 \Delta\sigma_{BH} + (\Delta\tilde{\sigma}_{DVCS} + P_1 \Delta\sigma_{DVCS}) + e_1 (\Delta\tilde{\sigma}_{INT} + P_1 \Delta\sigma_{INT}) ]$$

### Additional observables

Electron  
observables

$$\sigma_{0+}^\pm - \sigma_{0-}^\pm = 2\Delta\tilde{\sigma}_{DVCS} \pm 2\Delta\tilde{\sigma}_{INT}$$



$$\sigma_{00}^- = \sigma_{BH} + \sigma_{DVCS} - \sigma_{INT}$$

$$\sigma_{+0}^- - \sigma_{-0}^- = 2\tilde{\sigma}_{DVCS} - 2\tilde{\sigma}_{INT}$$

Electron & positron  
observables

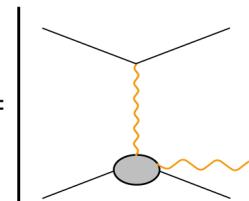
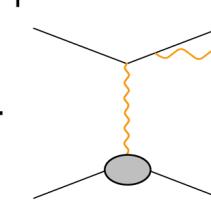
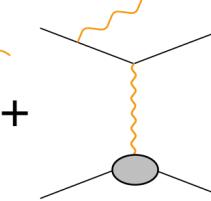
$$[\sigma_{++}^\pm - \sigma_{+-}^\pm] - [\sigma_{-+}^\pm - \sigma_{--}^\pm] = 4\Delta\sigma_{BH} + 4\Delta\sigma_{DVCS} \pm 4\Delta\sigma_{INT}$$

$$\sigma_{00}^+ - \sigma_{00}^- = 2\sigma_{INT}$$

$$[\sigma_{+0}^+ - \sigma_{-0}^+] - [\sigma_{+0}^- - \sigma_{-0}^-] = [\sigma_{+0}^+ - \sigma_{+0}^-] - [\sigma_{-0}^+ - \sigma_{-0}^-] = 4\tilde{\sigma}_{INT}$$

## $\mathcal{N}(e, e'\gamma N)$ Differential Cross Section

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

$$\sigma(eN \rightarrow eN\gamma) = \left| \begin{array}{c} \text{DVCS} \\ + \\ \text{Bethe-Heitler (BH)} \\ + \\ \text{[Diagram 1]} \end{array} \right|^2$$




$$\sigma_{PS}^e = \sigma_{P0}^e + S [ P_1 \Delta\sigma_{BH} + (\Delta\tilde{\sigma}_{DVCS} + P_1 \Delta\sigma_{DVCS}) + e_1 (\Delta\tilde{\sigma}_{INT} + P_1 \Delta\sigma_{INT}) ]$$

### Additional observables

Electron  
observables

$$\sigma_{0+}^\pm - \sigma_{0-}^\pm = 2\Delta\tilde{\sigma}_{DVCS} \pm 2\Delta\tilde{\sigma}_{INT}$$

$$[\sigma_{++}^\pm - \sigma_{+-}^\pm] - [\sigma_{-+}^\pm - \sigma_{--}^\pm] = 4\Delta\sigma_{BH} + 4\Delta\sigma_{DVCS} \pm 4\Delta\sigma_{INT}$$

$$\sigma_{00}^- = \sigma_{BH} + \sigma_{DVCS} - \sigma_{INT}$$

$$\sigma_{-0}^- - \sigma_{-0}^+ = 2\tilde{\sigma}_{DVCS} - 2\tilde{\sigma}_{INT}$$

Electron & positron  
observables

$$\sigma_{00}^+ - \sigma_{00}^- = 2\sigma_{INT}$$

$$[\sigma_{+0}^+ - \sigma_{-0}^+] - [\sigma_{+0}^- - \sigma_{-0}^-] = [\sigma_{+0}^+ - \sigma_{+0}^-] - [\sigma_{-0}^+ - \sigma_{-0}^-] = 4\tilde{\sigma}_{INT}$$

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

## Nucleon Internal Pressure

V. Burkert, L. Elouadrhiri, F.-X. Girod, Nature 557 (2018) 396    M.V. Polyakov, P. Schweitzer, Int. J. Mod. Phys. A33 (2018) 1830025  
 K. Kumerički, Nature 570 (2019) E1

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

The 2<sup>nd</sup> order **Mellin moment** of GPDs allow to access the pressure distribution inside hadrons through the **skewness dependency** of GPDs... (**DDVCS**).

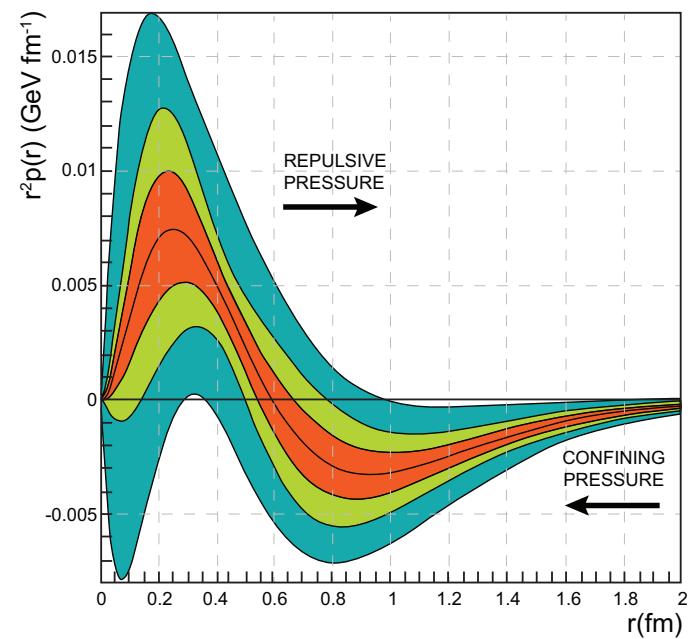
CFF

$$\mathcal{H}(\xi, t) = \int_{-1}^1 \left[ \frac{1}{\xi - x - i\epsilon} - \frac{1}{\xi + x - i\epsilon} \right] H(x, \xi, t) dx$$

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

$$D(t) = \frac{1}{2} \int_{-1}^1 \frac{D(z, t)}{1-z} dz$$

$$D(z, t) = (1 - z^2) \left[ d_1(t) C_1^{3/2}(z) + \dots \right]$$



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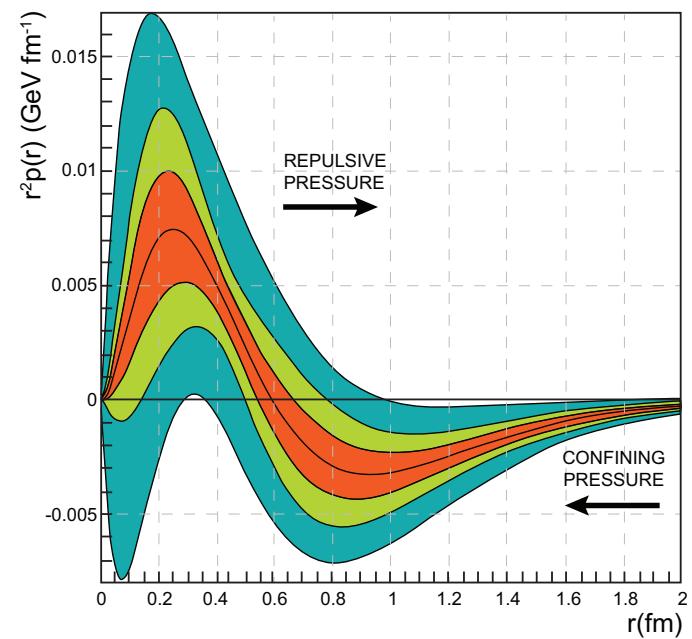
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**Real part of Compton form factors  
( $\sigma_{\text{INT}}$ )**



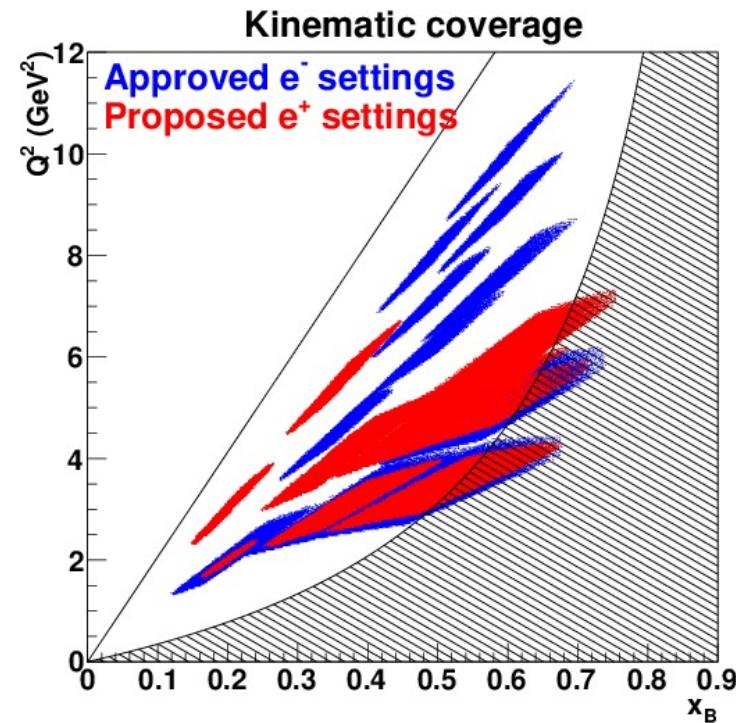
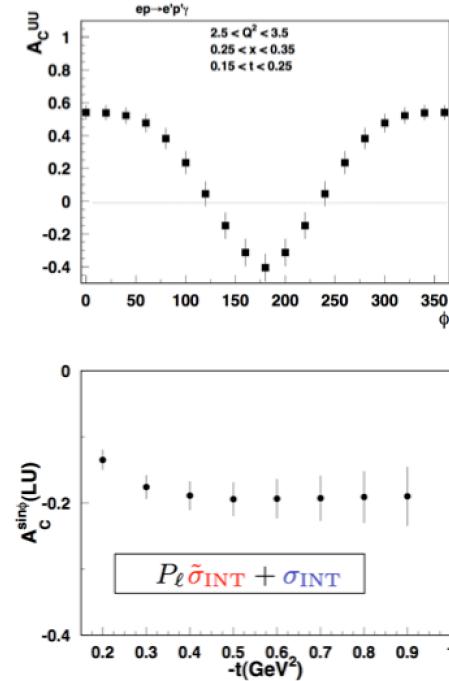
Also accessible in **TCS** testing GPDs **universality**.

**LOI12-18-004**

V. Burkert, L. Elouadrhiri, F.-X. Girod, C. Muñoz Camacho et al.

- It is proposed to measure **polarized** and **unpolarized** beam **charge asymmetries** off **protons** and **neutrons** (CLAS12), and **unpolarized p-DVCS cross section** with positrons (HMS+NPS).

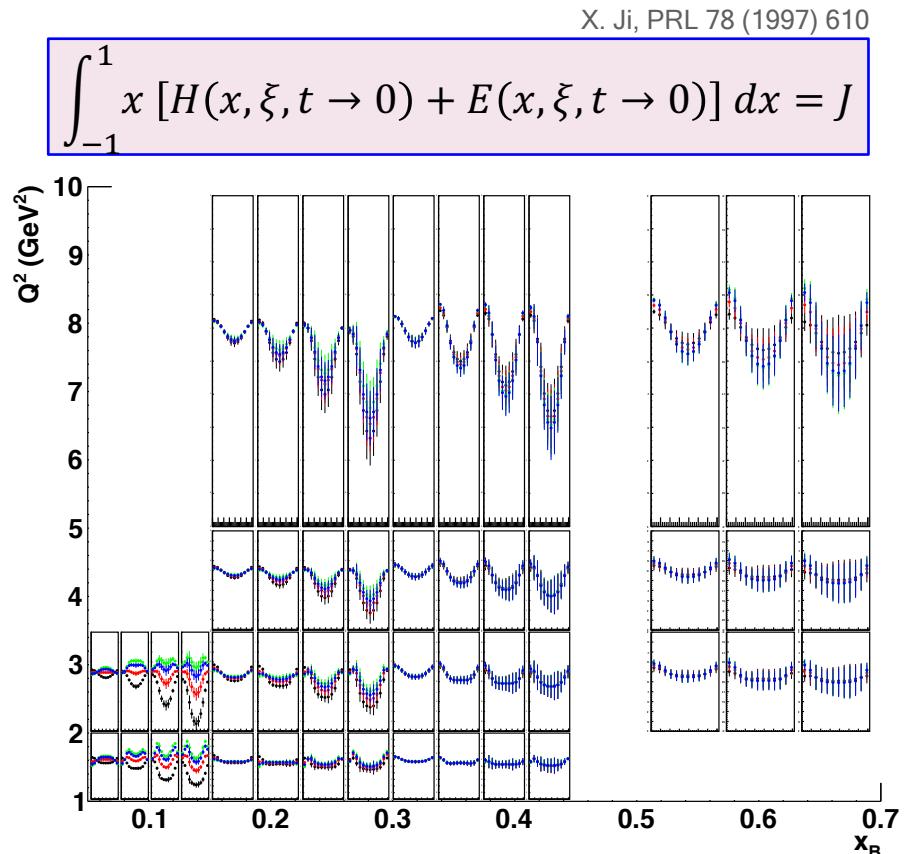
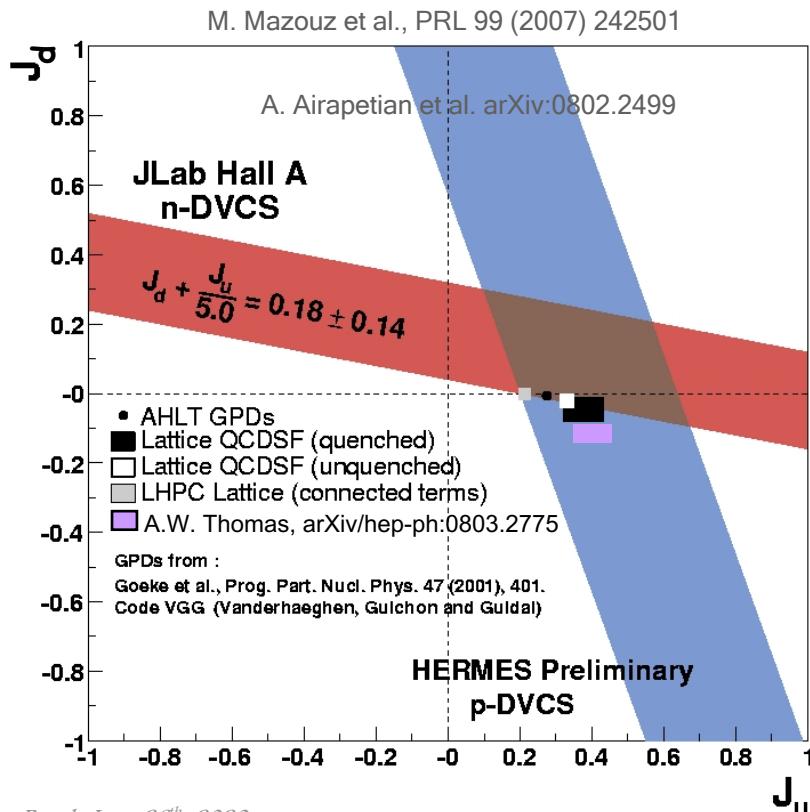
H. Avakian, V. Burkert, V. Guzey (JPos09) AIP CP 1160 (2009) 43



**LOI12-18-004**

S. Niccolai, E. Voutier et al.

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

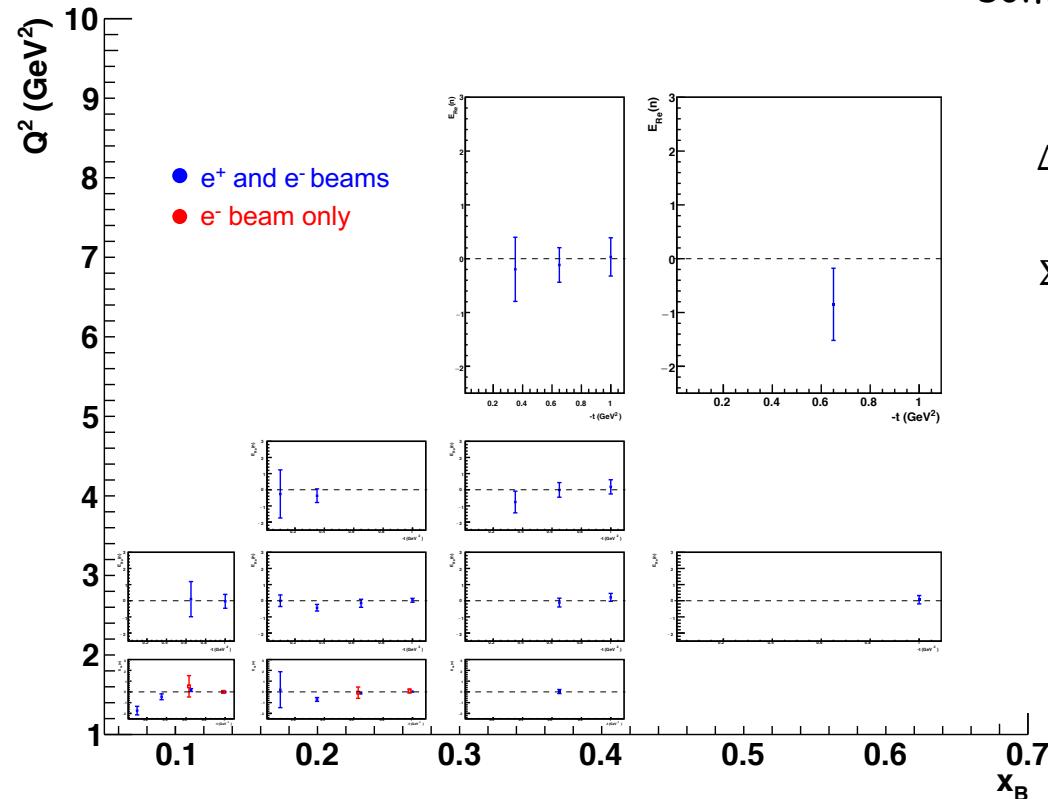


**LOI12-18-004**

S. Niccolai, E. Voutier et al.

$$A_C \propto \frac{1}{F_2} \operatorname{Re} \left[ \xi \tilde{H}_n - \frac{t}{4M^2} E_n \right]$$

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



$$\Delta_{LU}^C = \frac{(d^4\sigma_{+0}^+ - d^4\sigma_{-0}^+) - (d^4\sigma_{+0}^- - d^4\sigma_{-0}^-)}{d^4\sigma_{+0}^+ + d^4\sigma_{-0}^+ + d^4\sigma_{+0}^- + d^4\sigma_{-0}^-} \quad \propto \tilde{\sigma}_{\text{INT}}$$

$$\Sigma_{LU}^C = \frac{(d^4\sigma_{+0}^+ - d^4\sigma_{-0}^+) + (d^4\sigma_{+0}^- - d^4\sigma_{-0}^-)}{d^4\sigma_{+0}^+ + d^4\sigma_{-0}^+ + d^4\sigma_{+0}^- + d^4\sigma_{-0}^-} \quad \propto \tilde{\sigma}_{\text{DVCS}}$$

$$A_{LU} = \frac{\Sigma_{LU}^C}{1 - A_C} - \frac{\Delta_{LU}^C}{1 - A_C}$$

Polarized positron beams provide a different access to the **imaginary part**, and probe the importance of **higher twists**.

The diagram illustrates a nucleon (proton or neutron) as a composite system. It features four pink circles representing quarks: two 'u' quarks (one large, one small), one 'd' quark (large), and one 's' quark (small). These are connected by blue wavy lines representing gluons. A green curved arrow on the left indicates the flow of gluons from the quarks. In the center, the text 'Structure Functions' is written in blue.

## Structure Functions

- Neutral and charged currents DIS
  - Charm production
  - Pion and kaon structure

## Deep Inelastic Scattering

E. Aschenauer, T. Burton, T. Martin, H. Spiesberger, M. Stratman, PRD 88 (2013) 114025

- Charge current DIS access quark flavors combination different from those measured with the electromagnetic interaction.

$$\frac{d^2 \Delta\sigma_{PL}^e}{dx dy} = -\frac{8\pi\alpha^2}{yQ^2} (1 + e_l P_l)^2 \eta_W \left[ Y_+ g_5^{W^{e_l}} + e_l Y_- g_1^{W^{e_l}} \right]$$

Polarized electron  
off protons

Leading order

$$g_1^{W^-} = \Delta u + \Delta \bar{d} + \Delta \bar{s} + \Delta c \quad g_5^{W^-} = -\Delta u + \Delta \bar{d} + \Delta \bar{s} - \Delta c$$

Direct access to  $\Delta\Sigma$

$$g_1^{W^+} = \Delta \bar{u} + \Delta d + \Delta s + \Delta \bar{c} \quad g_5^{W^+} = \Delta \bar{u} - \Delta d - \Delta s + \Delta \bar{c}$$

$$g_1^{W^-} + g_1^{W^+} = \Delta\Sigma$$

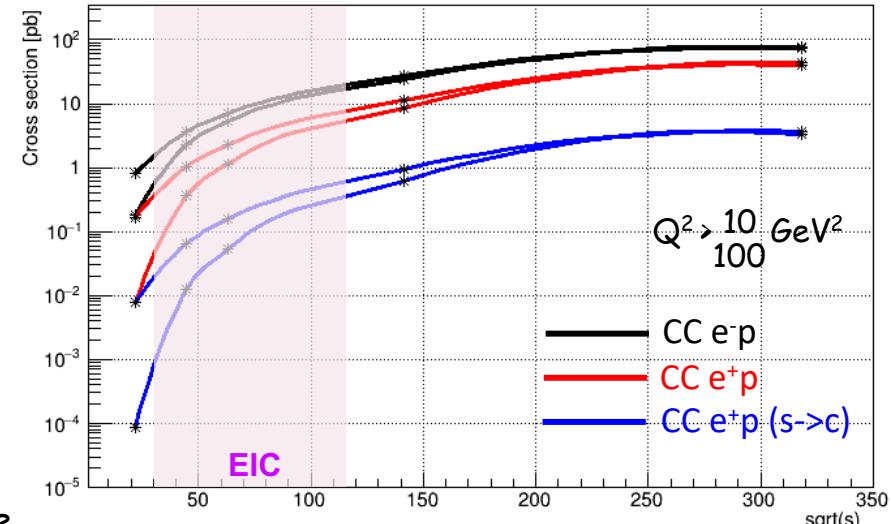
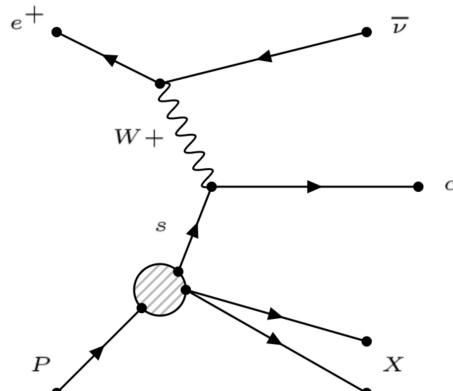
Polarized positron  
off protons

Access to strange polarized PDF free of hadronization ambiguities

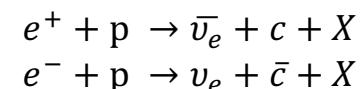
$$g_5^{W^-}(p) - g_5^{W^+}(p) + g_5^{W^-}(n) - g_5^{W^+}(n) = 2[\Delta c + \Delta \bar{c}] - 2[\Delta s + \Delta \bar{s}]$$

## Strangeness Tagging

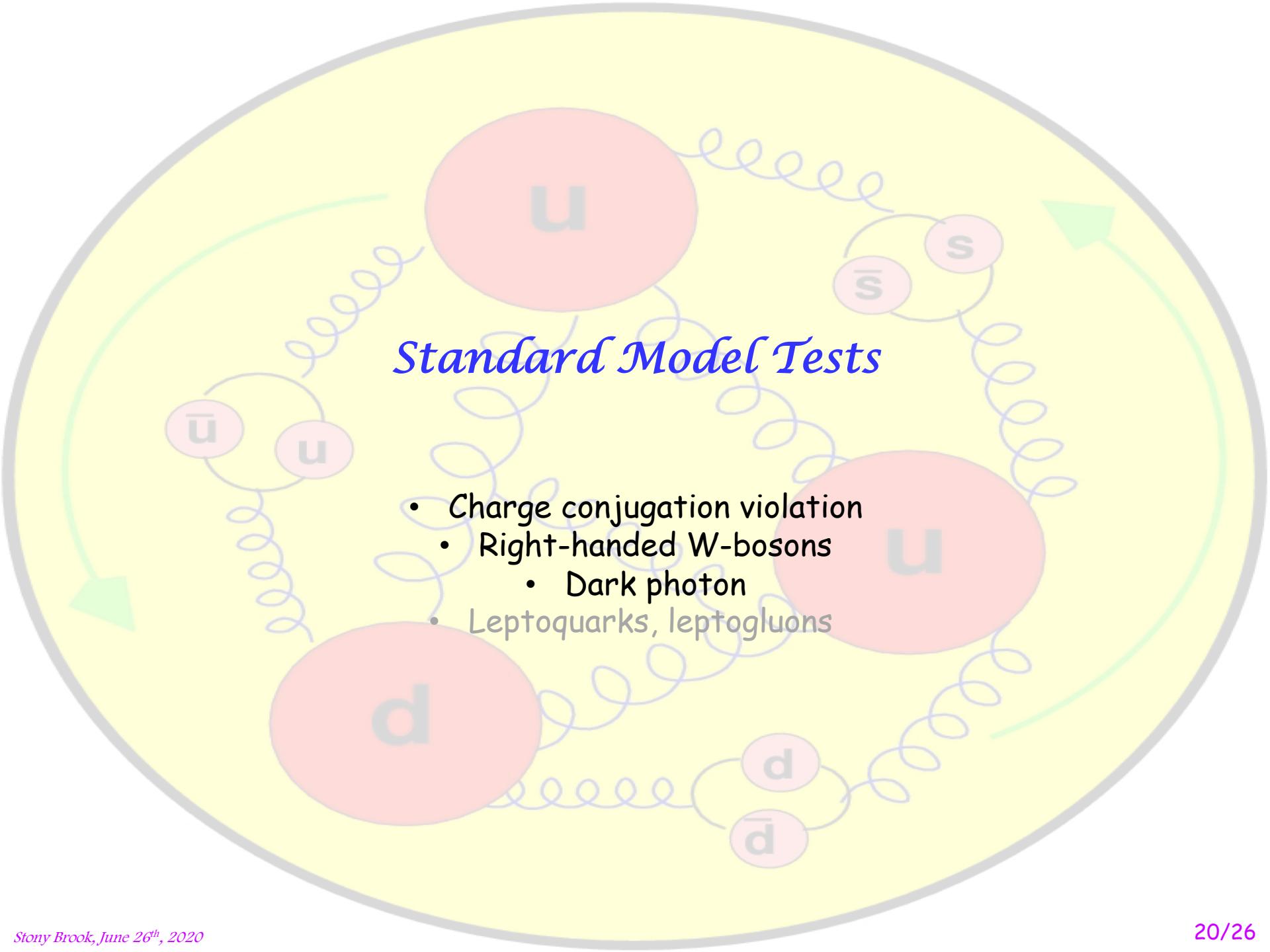
- The modest center-of-mass energy at the EIC can be compensated by the high luminosity and polarization degree of the lepton beam, to help for precise measurements of the small charge current cross section.



- Charm production via charged current exchange preferentially couples to the strange content of the nucleon.



An integrated luminosity of  $10 \text{ fb}^{-1}/\text{year}$  would provide  $\sim 1500 \text{ events/year}$ .



The diagram features a central yellow circle containing a red quark loop (u, u-bar) and a blue quark loop (d, d-bar). Surrounding this are several gluon loops (represented by blue wavy lines) and a green fermion loop (s, s-bar). A large green arrow on the left points clockwise, and another on the right points counter-clockwise, indicating the direction of particle flow or a cycle. The background is light yellow.

## Standard Model Tests

- Charge conjugation violation
  - Right-handed W-bosons
    - Dark photon
  - Leptoquarks, leptogluons

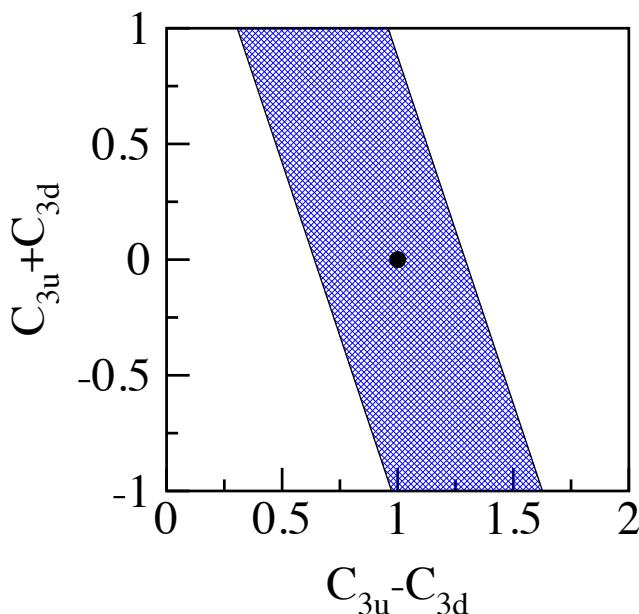
## Weak Neutral Current Couplings

S.M. Berman, J.R. Primack , Phys. Rev. D 9 (1974) 2171   X. Zheng, JPos09, Newport News (2009)

- The comparison of **polarized electron** an **polarized positon** scatterings provides access to the **charge conjugation-violation** coupling  $C_{3q}$  from the interference between the weak neutral and electromagnetic currents.

$$\mathcal{L} = \frac{G_F}{\sqrt{2}} \sum_q \left[ C_{1q} \bar{\ell} \gamma^\mu \gamma_5 \ell \bar{q} \gamma_\mu q + C_{2q} \bar{\ell} \gamma^\mu \ell \bar{q} \gamma_\mu \gamma_5 q + C_{3q} \bar{\ell} \gamma^\mu \gamma_5 \ell \bar{q} \gamma_\mu \gamma_5 q \right]$$

$\circlearrowleft g_A^e g_A^q$



The combination of  $C_{3q}$  couplings is **poorly known**; have only been measured at CERN using **muon** and **anti-muon** beams on a carbon target.

$$0.81 (2C_{2u} - C_{2d}) + 2C_{3u} - C_{3d} = 1.53 \pm 0.45$$

D. Wang et al. Phys. Rev. C 91 (2015) 045506

$$2C_{3u} - C_{3d} = 1.65 \pm 0.45$$

$C_{3q}$  are known only within 30%

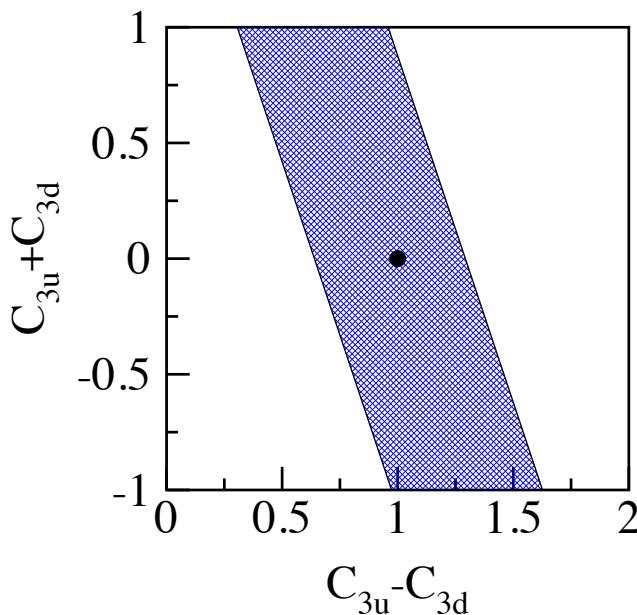
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$$\mathcal{L} = \frac{G_F}{\sqrt{2}} \sum_q \left[ C_{1q} \bar{\ell} \gamma^\mu \gamma_5 \ell \bar{q} \gamma_\mu q + C_{2q} \bar{\ell} \gamma^\mu \ell \bar{q} \gamma_\mu \gamma_5 q + C_{3q} \bar{\ell} \gamma^\mu \gamma_5 \ell \bar{q} \gamma_\mu \gamma_5 q \right]$$

$\nearrow g_A^e g_A^q$



$$A^{e_L^- - e_R^+} = \frac{d\sigma(e_L^- N) - d\sigma(e_R^+ N)}{d\sigma(e_L^- N) + d\sigma(e_R^+ N)}$$

$$A_p^{e_L^- - e_R^+} = \left( \frac{3G_F Q^2}{2\pi\alpha\sqrt{2}} \right) \frac{y(2-y)}{2} \frac{2C_{2u}u_V - C_{2d}d_V + 2C_{3u}u_V - C_{3d}d_V}{4u+d}$$

$$A_d^{e_L^- - e_R^+} = \left( \frac{3G_F Q^2}{2\pi\alpha\sqrt{2}} \right) \frac{y(2-y)}{2} \frac{2C_{2u} - C_{2d} + 2C_{3u} - C_{3d}}{5} \frac{u_V + d_V}{u + \bar{u} + d + \bar{d}}$$

$$A_d^{e_L^- - e_R^+} \approx 108 \frac{y(2-y)}{2} (2C_{3u} - C_{3d}) Q^2 \text{ ppm}$$

There exists a unique opportunity for a polarized electron and positron beam to improve the  $C_{3q}$  knowledge.

## Polarized Charged Current Cross Section

Y. Furletova, S. Mantry, (JPos17) AIP CP 1970 (2018) 030005

- The **polarization dependence** of the charge current cross section can be measured to potentially reveal *deviations from the Standard Model prediction*.

$$\frac{d^2\sigma_{SM}^{e^+p}}{dx dQ^2} = (1 + P_e) \frac{G_F^2}{2\pi} \left( \frac{M_W^2}{M_W^2 + Q^2} \right)^2 [\bar{u} + \bar{c} + (1 - y^2)(d + s)]$$

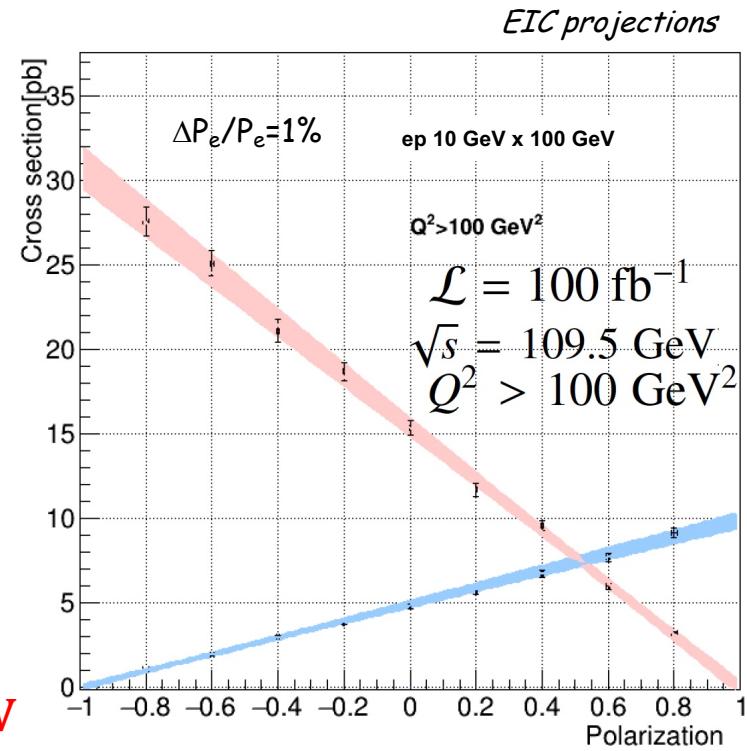
$$\frac{d^2\sigma_{SM}^{e^-p}}{dx dQ^2} = (1 - P_e) \frac{G_F^2}{2\pi} \left( \frac{M_W^2}{M_W^2 + Q^2} \right)^2 [u + c + (1 - y^2)(\bar{d} + \bar{s})]$$

$\sigma^{e^\pm p} (P_e = \mp 1) \neq 0 \rightarrow$  Limit on the mass of right-handed W-boson

95% confidence level upper bound

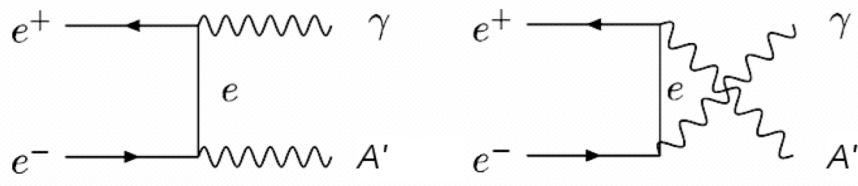
$\sigma^{e^\pm p} (P_e = \mp 1) < 0.0776 \text{ pb} \rightarrow M_R \geq 270 \text{ GeV}$

(HERA limit in  $e^+p$  is 208 GeV)

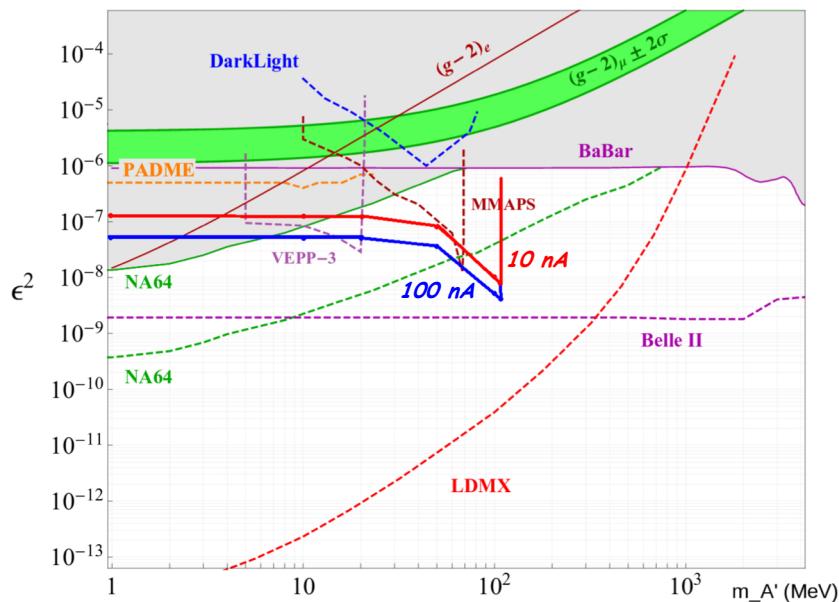


**LOI12-18-004**

M. Battaglieri, A. Celentano, L. Marsicano et al.



- The  **$e^+e^-$ -annihilation** offers an alternative way to **probe** the existence of a **dark photon** by measuring the **photon spectra** in the **A'** invisible decay channel.

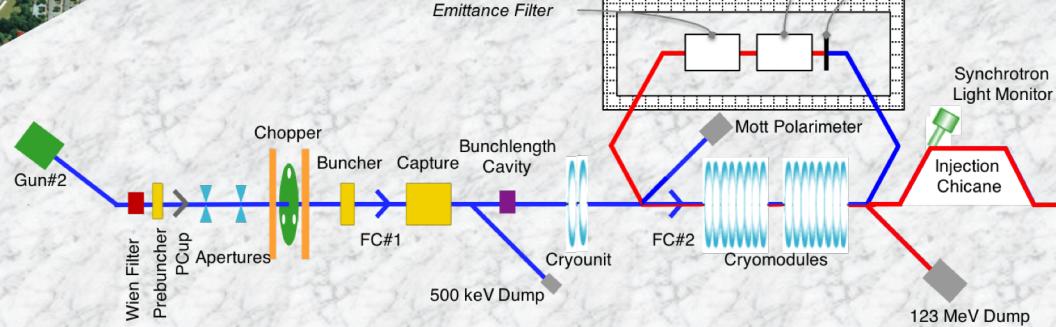
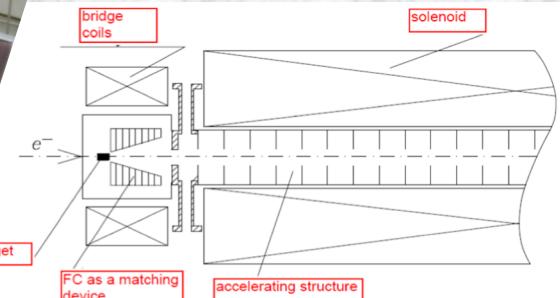
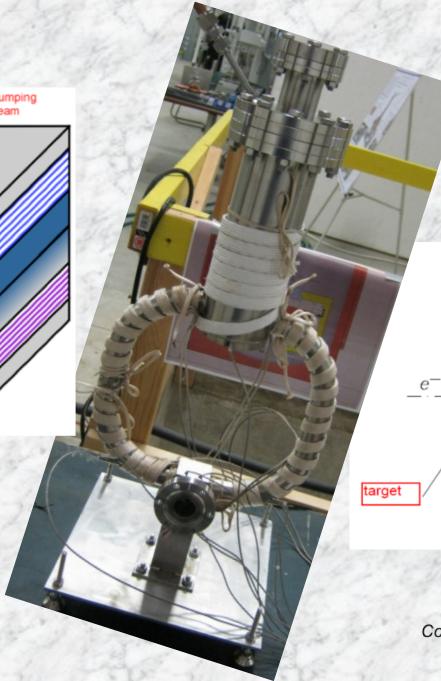
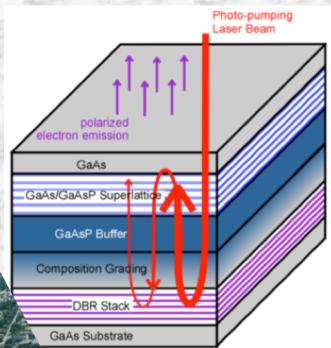
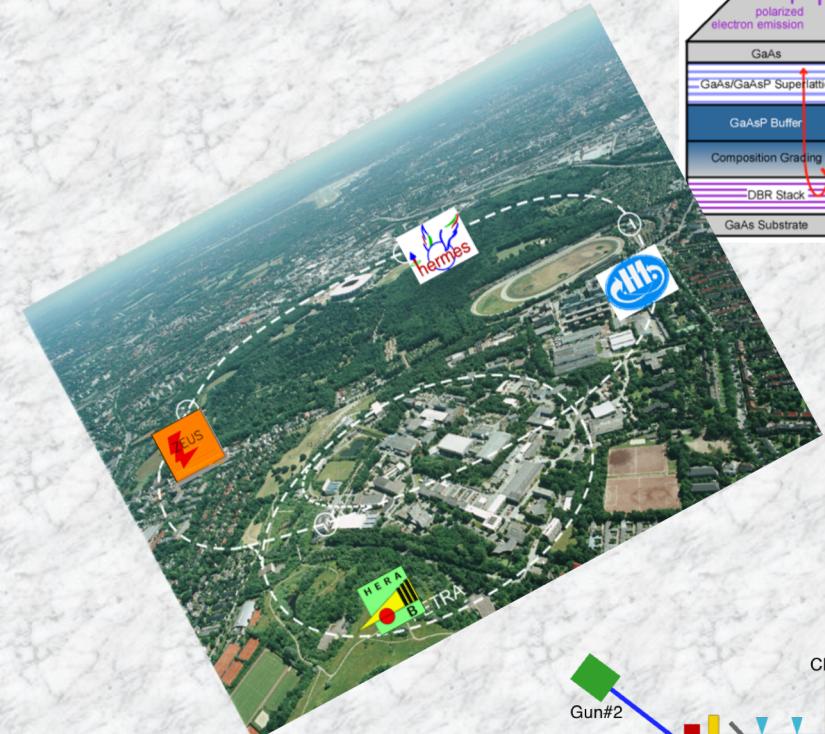


P. Valente, J. Alexander, (JPos17) AIP CP 1970 (2018) 020007  
L. Marsicano, (JPos17) AIP CP 1970 (2018) 020008

**180 days** data taking with a high energy positron beam would extend the **A'** mass reach up to **100 MeV** and would improve by a **factor 10** the coupling strength sensitivity.

# Polarized Positrons

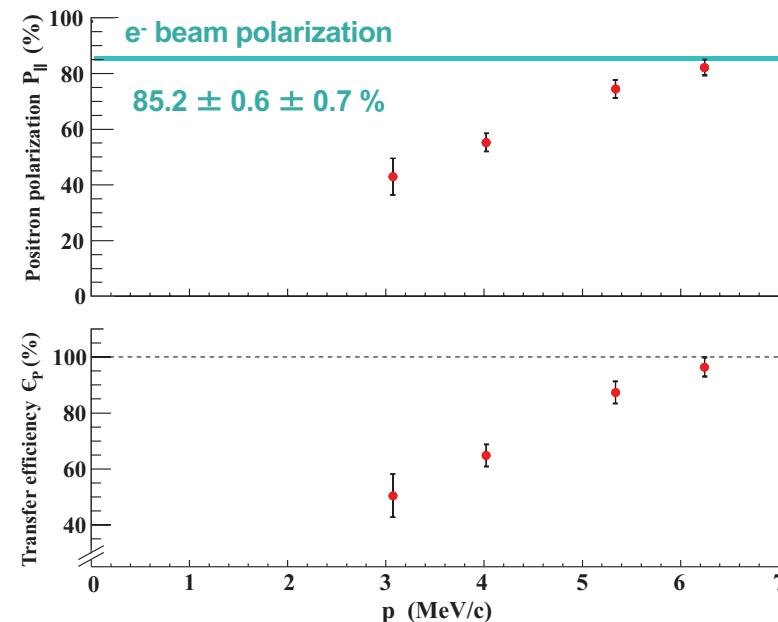
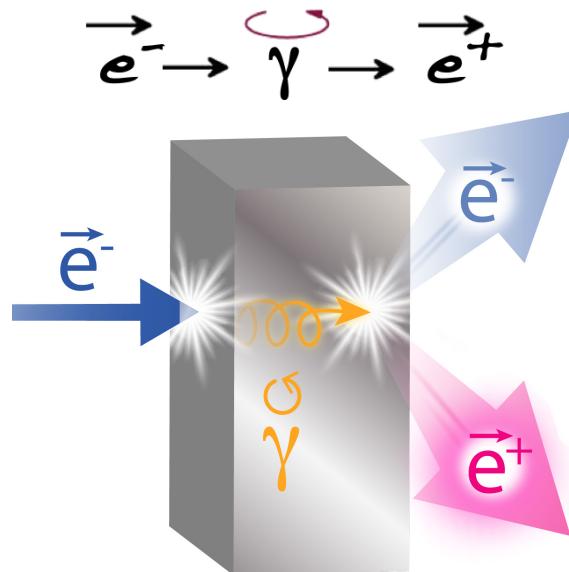
See J. Grames' talk



## Polarized Electrons for Polarized Positrons

(PEPPo Collaboration) D. Abbott et al. , PRL 116 (2016) 214801

- PEPPo demonstrated **efficient polarization transfer** from 8.2 MeV/c electrons to **positrons**, expanding polarized positron capabilities **from GeV to MeV accelerators**.



The PEPPo technique can achieve up to **100% transfer** of the electron.

## $e^+@eRHIC$

**Unpolarized** and **polarized positron beams** provide a unique opportunity to **enhance** the **physics reach** at JLab and eRHIC.

*Interferences, neutral and charged currents, test of the Standard Model...*

**Unpolarized positron beams are determinant for the GPD program.**

☞ **Positron** beams would be a **small addition** to eRHIC.

☞ **Unpolarized** beams are **straightforward**, **polarized** beams are challenging but **achievable**.

*The  $e^+@JLab$  White paper will be soon available.... Stay tuned !!*