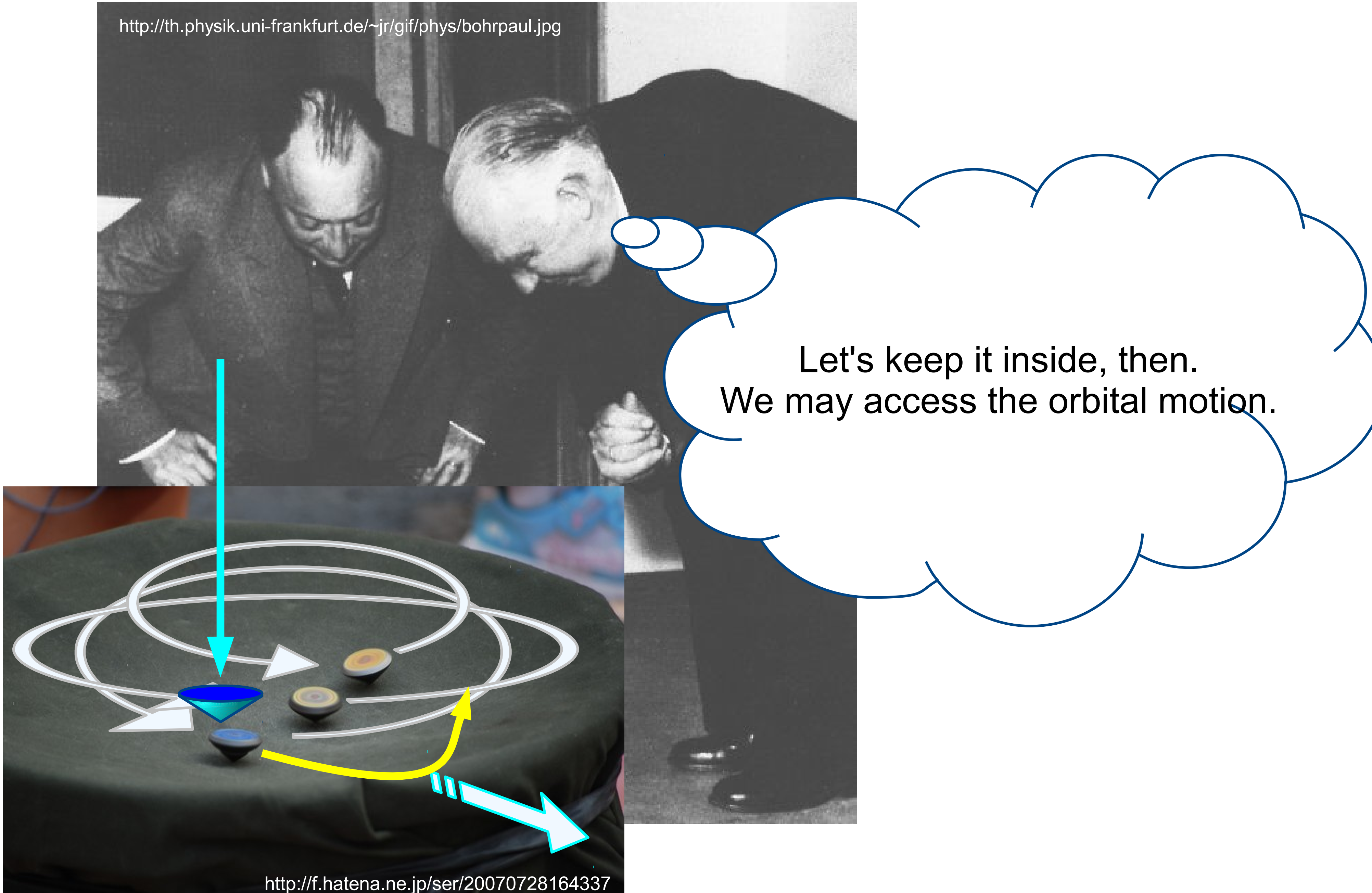
4. Generalized Parton Distribution functions



YAMAGATA UNIVERSITY

4. Generalized Parton Distribution functions

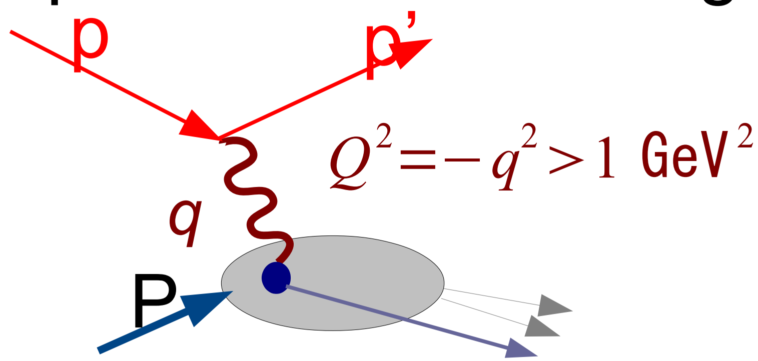
- Hard Exclusive Production and GPD
    - Marriage of PDF (DIS) and Form Factor (Elastic Scattering)
  - Deeply Virtual Compton Scattering
- Experimental highlights
- COMPASS II

Deep Inelastic Scattering

- Scattered off "a free parton"
- Elastic scattering

だるま落とし
Daruma
Otoshi

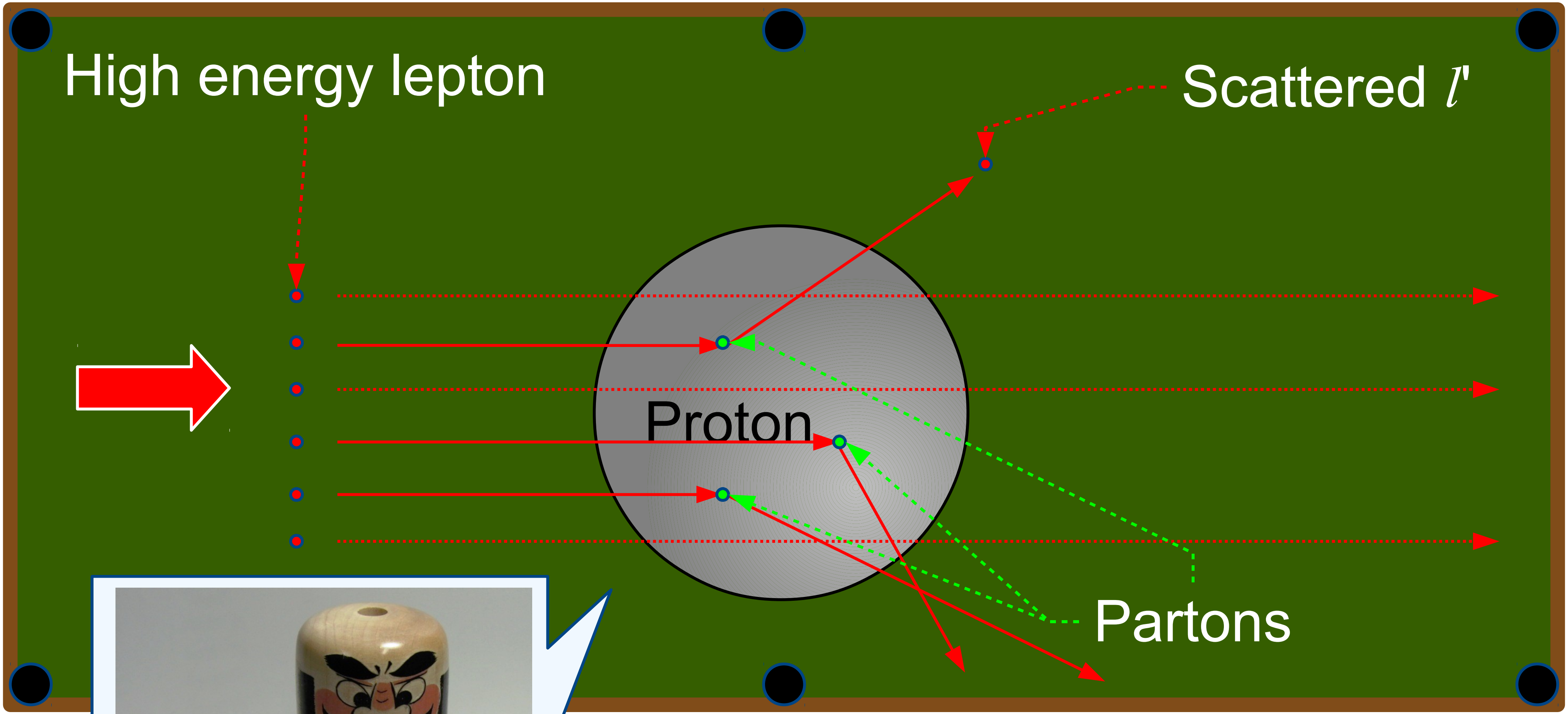
Deep Inelastic Scattering



Parton distribution: **q(x), Δq(x)**

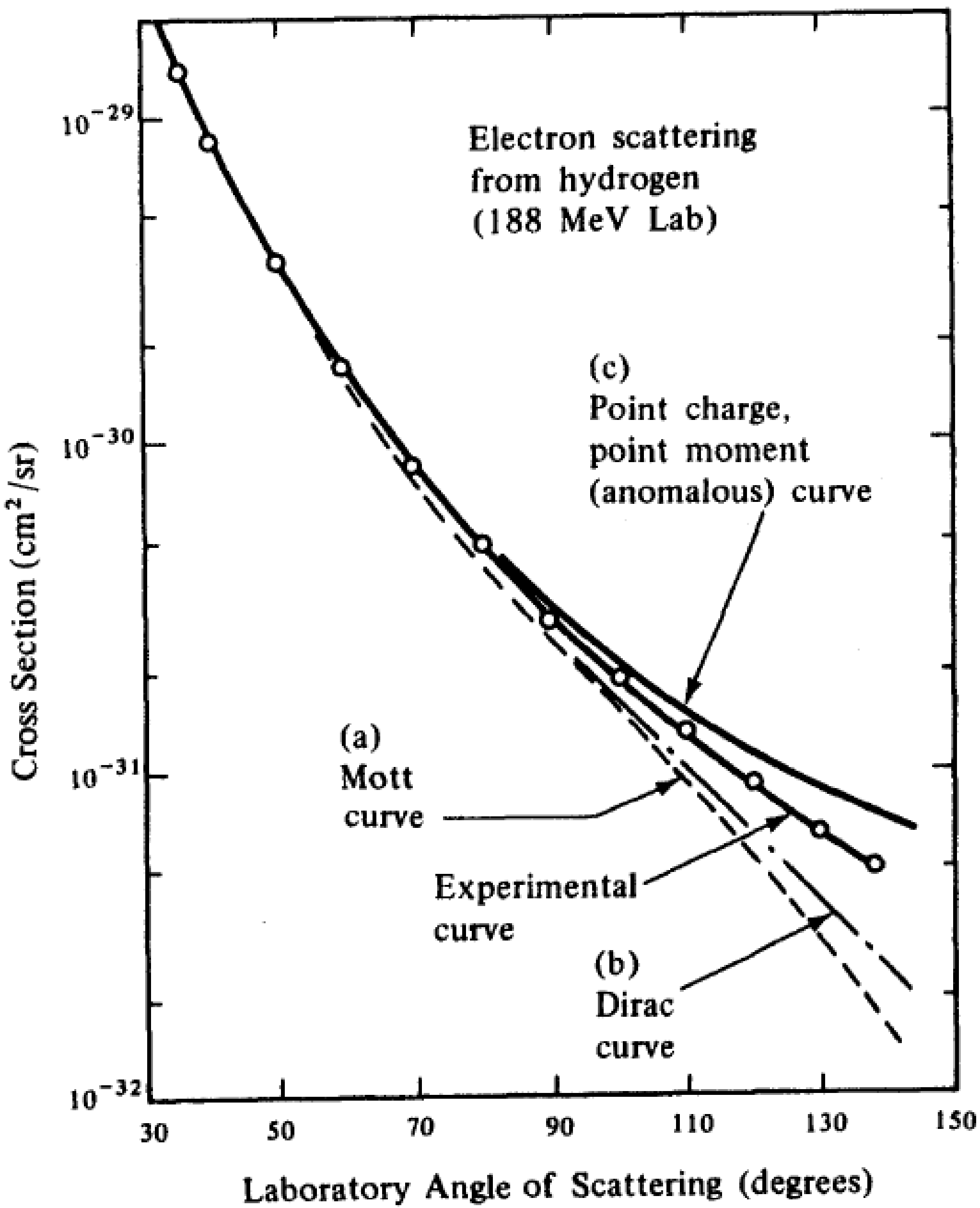
l-*N* "Inelastic scattering"
→ braking a target

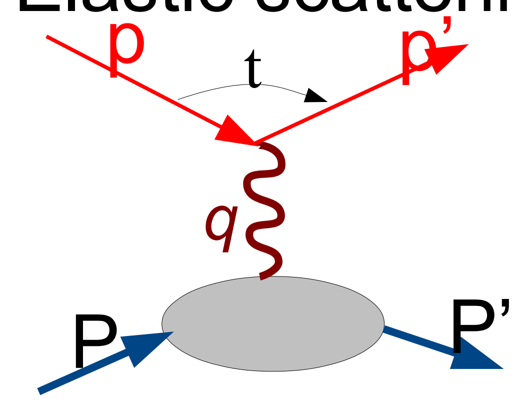
Deep Inelastic Scattering



How many parton with x in the proton?

Elastic scattering and Form Factor





Form Factor: F(t), G(t)

$$\frac{d\sigma(\theta)}{d\Omega} = \frac{dY}{I \cdot \rho \cdot d\Omega}$$

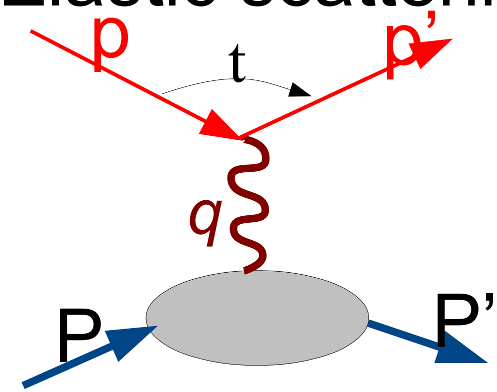
$$= |F(q)|^2 \frac{d\sigma_0}{d\Omega}$$

$$F(q) = \int dV \rho(r) e^{-i\vec{q}\cdot\vec{r}}$$

Hard Exclusive Production and GPD

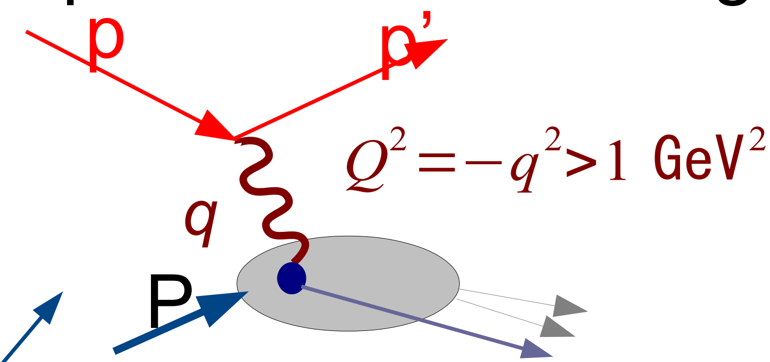
YAMAGATA UNIVERSITY

Elastic scattering



Form Factor: F(t), G(t)

Deep Inelastic Scattering

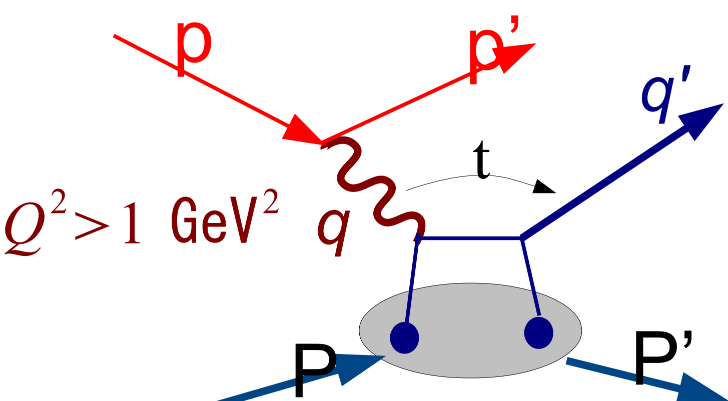


Parton distribution: **q(x), Δq(x)**

$\int_{-1}^{1} dx$

Forward limit

Hard Exclusive Production:



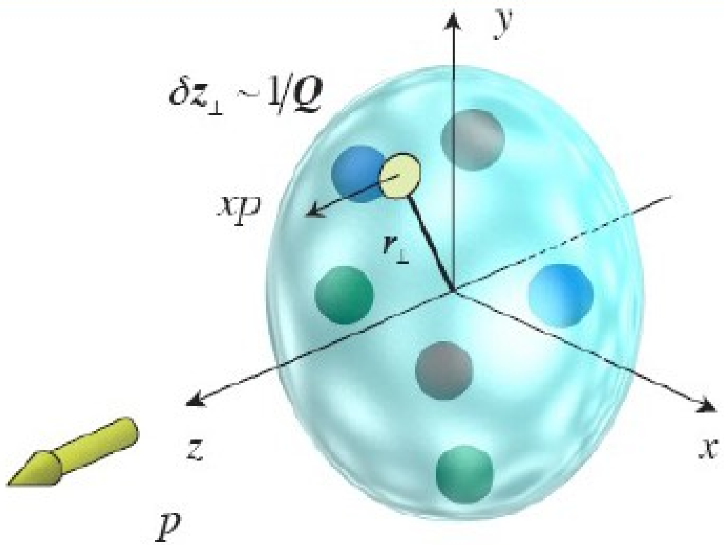
$$e + N \rightarrow e' + N' + \{\gamma,\ \rho,\ \pi, \ldots\}$$

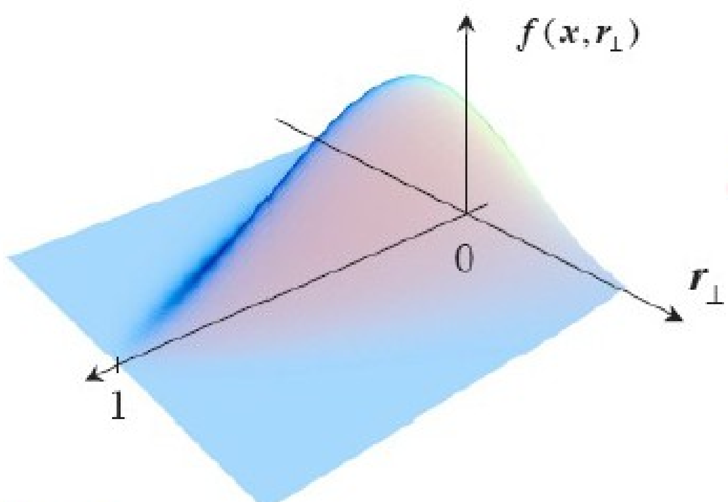
Generalized Parton Distribution:

$$\boldsymbol{H},\ \boldsymbol{E},\ \boldsymbol{\tilde{H}},\ \boldsymbol{\tilde{E}}$$

$$J_q = \frac{1}{2}\int_{-1}^{1} dx\, x\,[H^q(x,\xi,t\rightarrow 0) + E^q(x,\xi,t\rightarrow 0)]$$

Generalized Parton Distributions (GPDs)





- Multidimensional description of nucleon structure (longitudinal momentum vs transverse position)
- Include parton distribution functions and form factors as forward limits and moments, respectively
- Can provide access to the total (and hence orbital) angular momentum of quarks in the nucleon via Ji relation:

$$J_q = \lim_{t \to 0} \int_{-1}^{1} dx \; x[H_q(x, \xi, t) + E_q(x, \xi, t)]$$

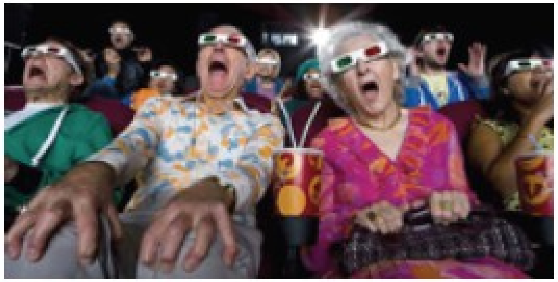
- Four GPDs in case of proton target:

$$H, \widetilde{H}, E, \widetilde{E}$$

Multi-Dim. structure of the proton

M. Stratmann, DIS2013

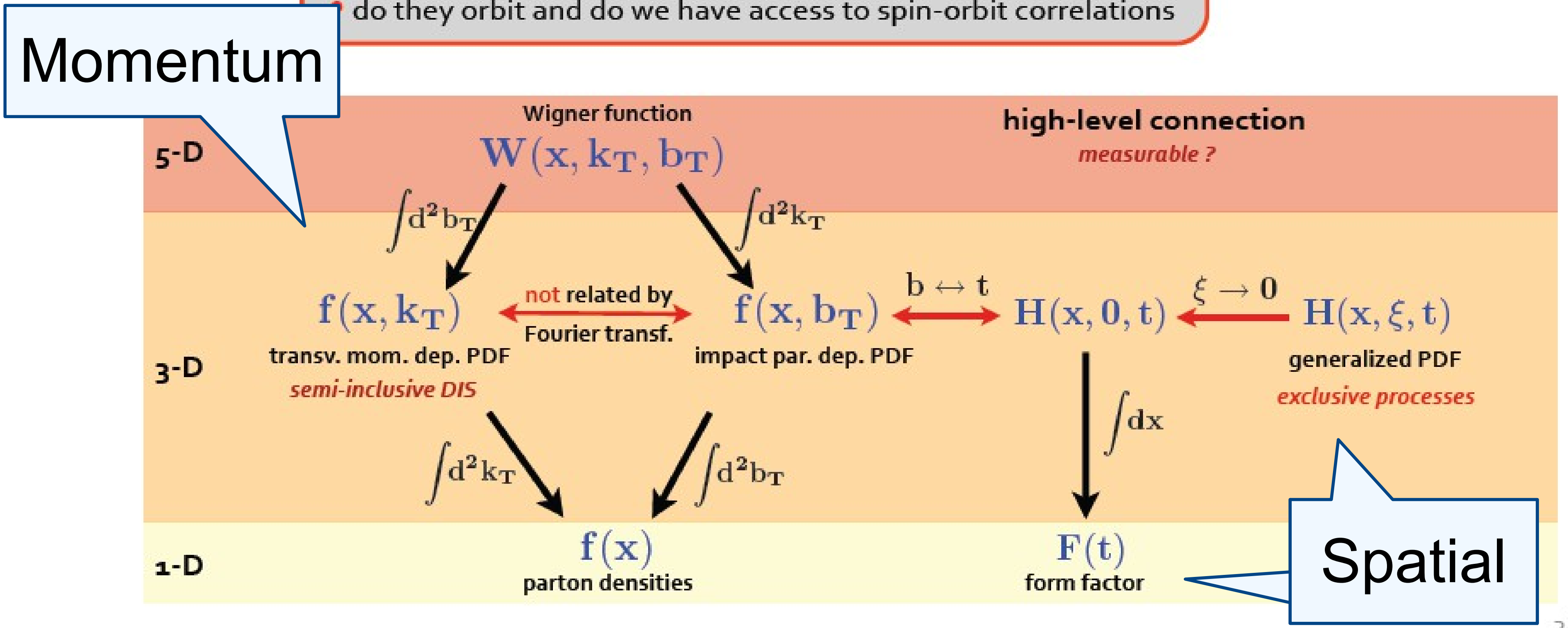
big picture: the 3-D experience



standard PDFs do not resolve transverse positions in the nucleon

compelling questions

- how are quarks and gluons spatially distributed
- how do they move in the transverse plane
- do they orbit and do we have access to spin-orbit correlations

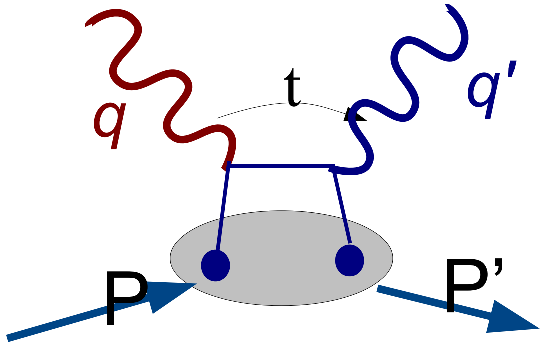


Hard Exclusive Production and GPD

Deeply Virtual Compton Scattering:

$$e+N \rightarrow e'+N'+\gamma$$

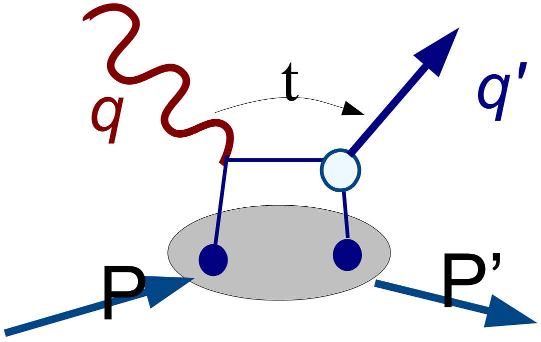
Involved GPDs: H, E, $\tilde{H}$, $\tilde{E}$
clean reaction



Hard exclusive meson production:

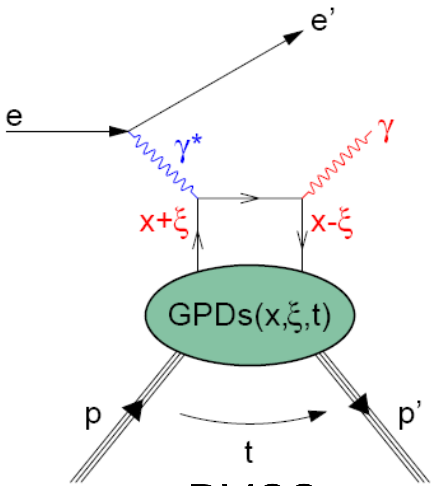
$$e+N \rightarrow e'+N'+\{\rho,\ \pi,\ldots\}$$

vector meson: H, E
pseudo-scalar meson: $\tilde{H}$, $\tilde{E}$
Meson amplitude involved



DVCS vs Bethe-Heitler

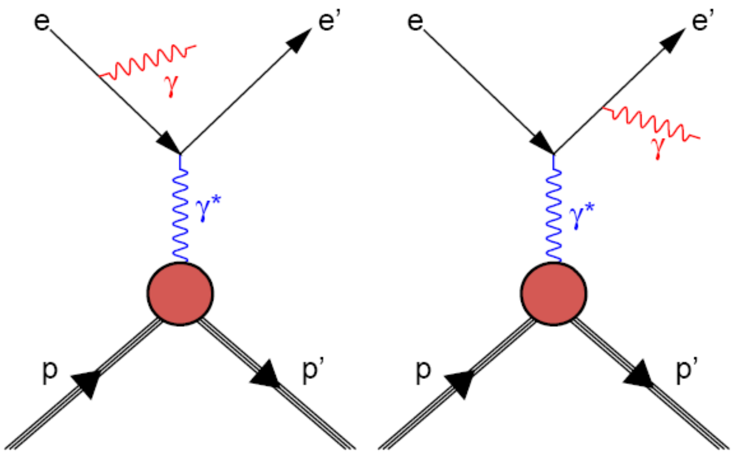
$e + N \to e' + N + \gamma$



DVCS

$\sigma_{DVCS} \ll \sigma_{BH}$

@HERMES



Bethe-Heitler (BH)

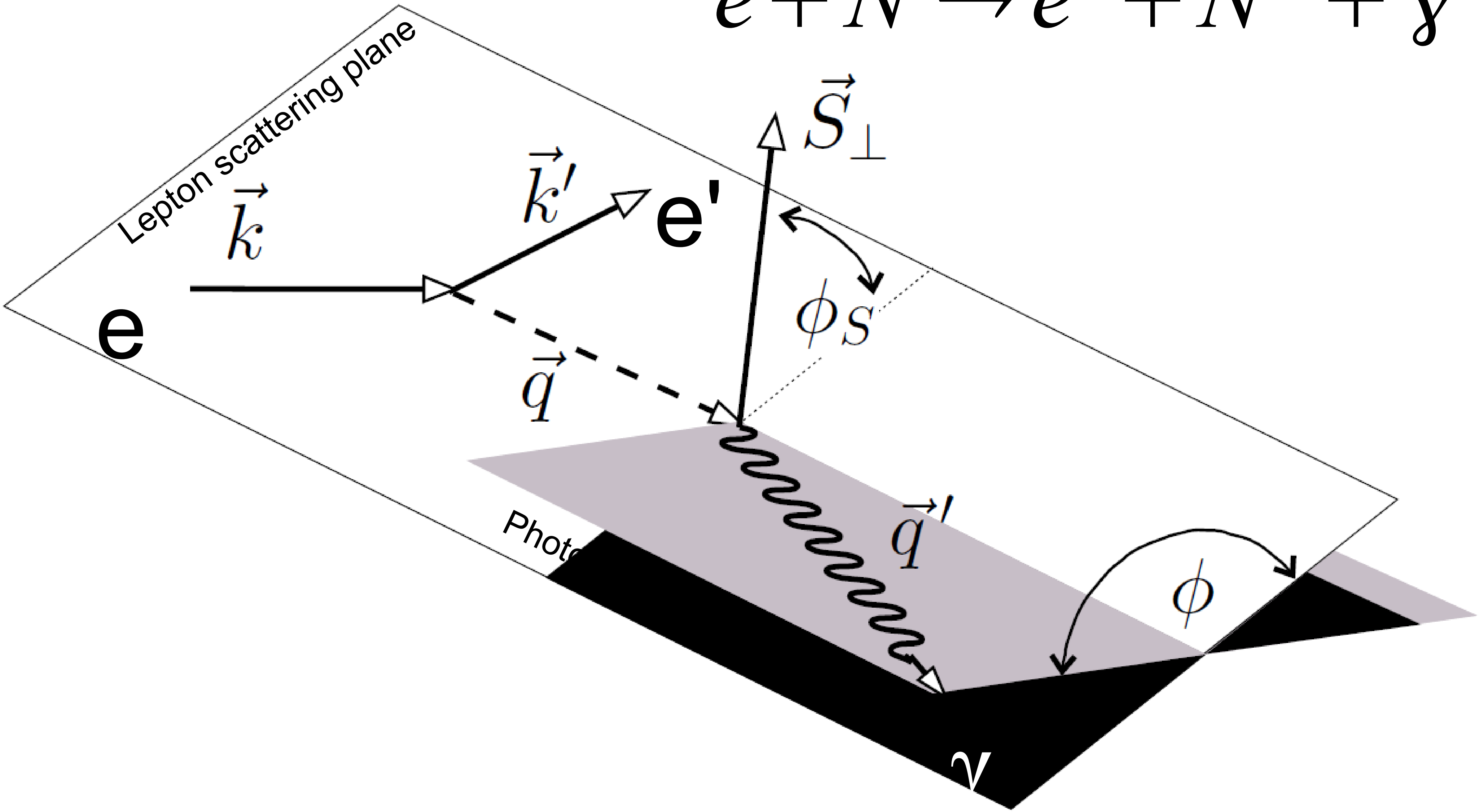
$$\frac{d^4\sigma}{dQ^2\, dx_B\, dt\, d\phi} = \frac{x_B e^6}{32(2\pi)^4 Q^4 \sqrt{1+\epsilon^2}} |\mathcal{T}_{ep\to ep\gamma}|^2,$$

$$|\mathcal{T}_{ep\to ep\gamma}|^2 = |\mathcal{T}_{BH}|^2 + |\mathcal{T}_{DVCS}|^2 + \mathcal{I},$$

$$\mathcal{I} = \mathcal{T}_{BH}\mathcal{T}^*_{DVCS} + \mathcal{T}_{DVCS}\mathcal{T}^*_{BH}.$$

Azimuthal angles in DVCS

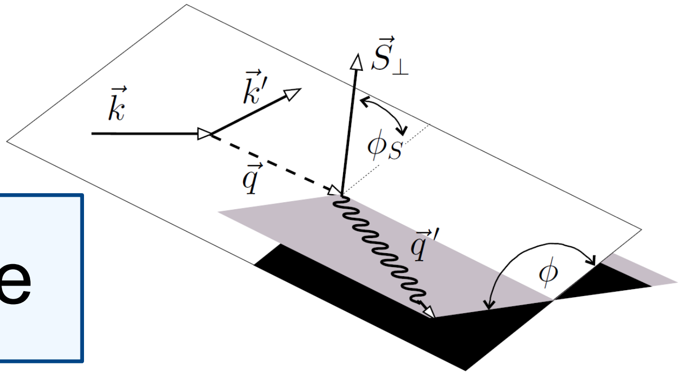
$$e + N \rightarrow e' + N' + \gamma$$



DVCS cross section

Unpol. target

$$d\sigma \propto |\mathcal{T}_{\rm BH}|^2 + |\mathcal{T}_{\rm DVCS}|^2 + \mathcal{I},$$



Azimuthal angle dependence

$$|\mathcal{T}_{\rm BH}|^2 = \frac{K_{\rm BH}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left(c_0^{\rm BH} + \sum_{n=1}^{2} c_n^{\rm BH}\cos(n\phi)\right),$$

$$|\mathcal{T}_{\rm DVCS}|^2 = K_{\rm DVCS}\left(c_0^{\rm DVCS} + \sum_{n=1}^{2} c_n^{\rm DVCS}\cos(n\phi) + \lambda s_1^{\rm DVCS}\sin\phi\right),$$

$$\mathcal{I} = \frac{-e_\ell K_{\mathcal{I}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left(c_0^{\mathcal{I}} + \sum_{n=1}^{3} c_n^{\mathcal{I}}\cos(n\phi) + \lambda\sum_{n=1}^{2} s_n^{\mathcal{I}}\sin(n\phi)\right).$$

Beam Charge

Beam helicity

DVCS asymmetries

A_{C}

A_{LU}

$$\mathcal{I} = \frac{-e_\ell K_{\mathcal{I}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)} \left(c_0^{\mathcal{I}} + \sum_{n=1}^{3} c_n^{\mathcal{I}} \cos(n\phi) + \lambda \sum_{n=1}^{2} s_n^{\mathcal{I}} \sin(n\phi) \right)$$

$$s_1^{\mathcal{I}} \approx 8 \frac{\sqrt{-t}}{Q} y(2-y)\, \Im\mathrm{m}(\mathcal{C}_{\mathrm{unp}}^{\mathcal{I}}).$$

$$\mathcal{C}_{\mathrm{unp}}^{\mathcal{I}} = F_1 \mathcal{H} + \frac{x_{\mathrm{B}}}{2-x_{\mathrm{B}}}(F_1+F_2)\widetilde{\mathcal{H}} - \frac{t}{4M_p^2} F_2 \mathcal{E},$$

$$\mathcal{C}^{\mathcal{I}}_{\rm unp} = F_1\mathcal{H} + \frac{x_{\rm B}}{2-x_{\rm B}}(F_1+F_2)\widetilde{\mathcal{H}} - \frac{t}{4M_p^2}F_2\mathcal{E};$$

Compton form factors

NPB629 (2002) 323-392

$$\left\{\mathcal{H},\mathcal{E},\mathcal{H}^3_+,\mathcal{E}^3_+,\widetilde{\mathcal{H}}^3_-,\widetilde{\mathcal{E}}^3_-\right\}(\xi) = \int_{-1}^{1} dx\, C^{(-)}(\xi,x)\left\{H,E,H^3_+,E^3_+,\widetilde{H}^3_-,\widetilde{E}^3_-\right\}(x,\eta)_{|\eta=-\xi},$$

$$\left\{\widetilde{\mathcal{H}},\widetilde{\mathcal{E}},\widetilde{\mathcal{H}}^3_+,\widetilde{\mathcal{E}}^3_+,\mathcal{H}^3_-,\mathcal{E}^3_-\right\}(\xi) = \int_{-1}^{1} dx\, C^{(+)}(\xi,x)\left\{\widetilde{H},\widetilde{E},\widetilde{H}^3_+,\widetilde{E}^3_+,H^3_-,E^3_-\right\}(x,\eta)_{|\eta=-\xi},$$

Sum of quark flavors

@HERMES

$$\mathcal{C}^{\mathcal{I}}_{\rm unp} = F_1\mathcal{H} + \frac{x_{\rm B}}{2-x_{\rm B}}(F_1+F_2)\widetilde{\mathcal{H}} - \frac{t}{4M_p^2}F_2\mathcal{E};$$

Negligible

Beam spin asymmetry

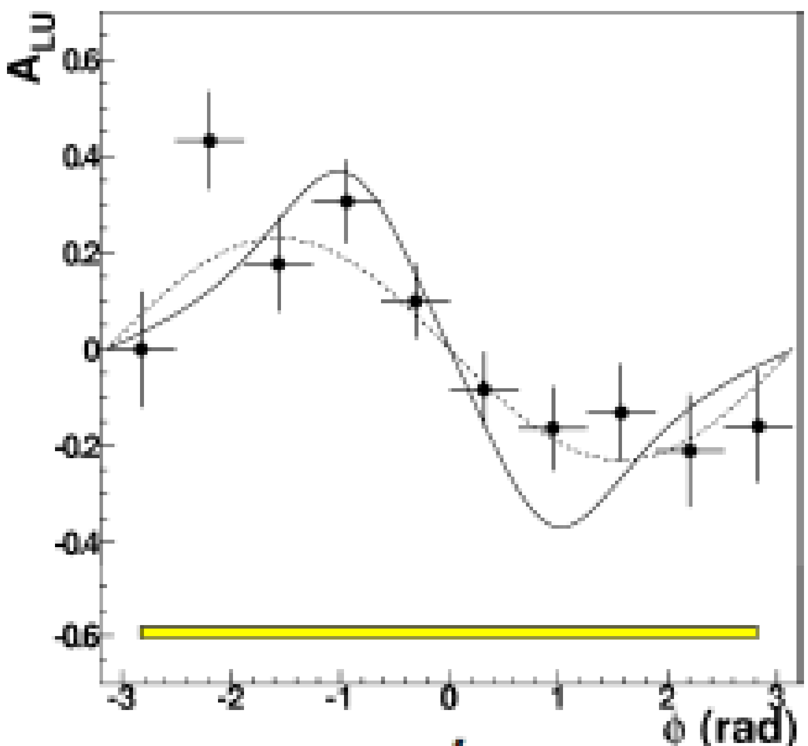
$\mathcal{A}_{\mathrm{LU}}$ ⇨ $\propto \Im m \mathcal{H}$

⇨ GPD H

Beam spin asymmetry in 2001

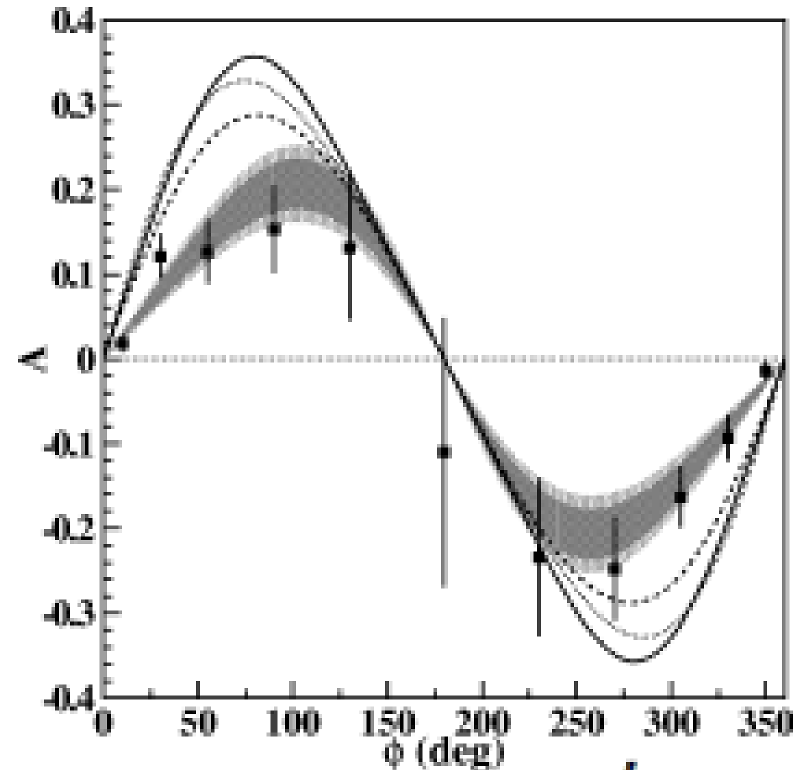
A_{LU}

HERMES (DESY)



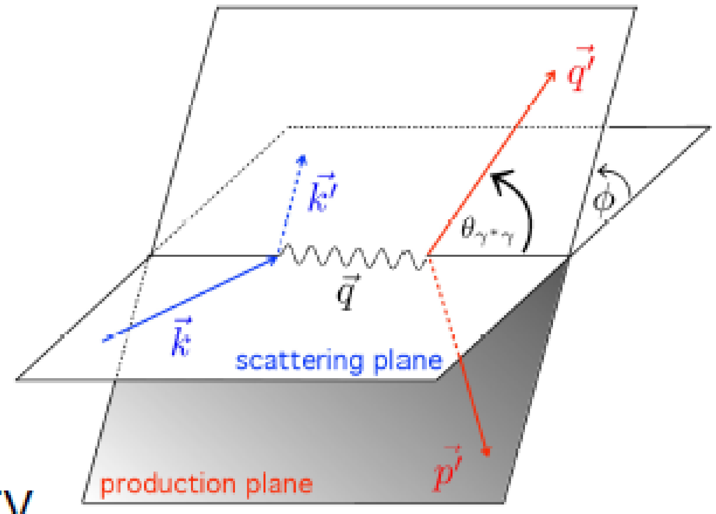
ϕ

CLAS (JLab)



ϕ

Beam spin, charge asymmetry



- Cross section $\sigma_{LU}(\phi, P_B, C_B) =$

$$\sigma_{UU}[1 + P_B A_{LU}^{DVCS} + C_B P_B A_{LU}^{I} + C_B A_C$$

- Beam-charge asymmetry

$$A_C(\phi) = \frac{\sigma^+(\phi) - \sigma^-(\phi)}{\sigma^+(\phi) + \sigma^-(\phi)} \propto \Re e\mathcal{H}$$

- Charge-difference beam-helicity asymmetry

$$A_{LU}^{I}(\phi) = \frac{(\sigma^{+\rightarrow}(\phi) - \sigma^{+\leftarrow}(\phi)) - (\sigma^{-\rightarrow}(\phi) - \sigma^{-\leftarrow}(\phi))}{(\sigma^{+\rightarrow}(\phi) - \sigma^{+\leftarrow}(\phi)) + (\sigma^{-\rightarrow}(\phi) - \sigma^{-\leftarrow}(\phi))} \propto \Im m\mathcal{H}$$

- Charge-averaged beam-helicity asymmetry

$$A_{LU}^{DVCS}(\phi) = \frac{(\sigma^{+\rightarrow}(\phi) + \sigma^{-\rightarrow}(\phi)) - (\sigma^{+\leftarrow}(\phi) + \sigma^{-\leftarrow}(\phi))}{(\sigma^{+\rightarrow}(\phi) + \sigma^{-\rightarrow}(\phi)) + (\sigma^{+\leftarrow}(\phi) + \sigma^{-\leftarrow}(\phi))} \propto \Im m[\mathcal{H}\mathcal{H}^* + \widetilde{\mathcal{H}}\widetilde{\mathcal{H}}^*]$$

- Separation of contribution from DVCS and interference term
- Impossible in case of single-charge asymmetry

$$A_{LU}(\phi) = \frac{\sigma^{\rightarrow} - \sigma^{\leftarrow}}{\sigma^{\rightarrow} + \sigma^{\leftarrow}}$$

DVCS with a transversely polarized target

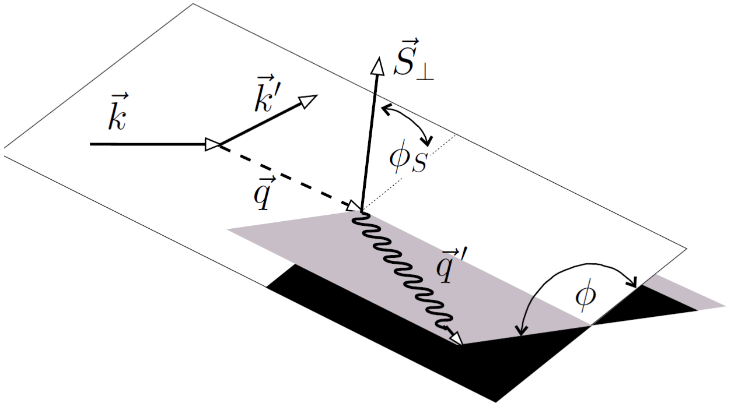
$$|\mathrm{T_{BH}}|^2 = \frac{K_{\mathrm{BH}}}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\left(c^{\mathrm{BH}}_{0,\mathrm{UU}} + \left\{c^{\mathrm{BH}}_{1,\mathrm{UU}}\cos\phi + \left\{c^{\mathrm{BH}}_{2,\mathrm{UU}}\cos(2\phi)\right\}\right\}\right),$$

UU: Unpol. Beam & Target

$$|\mathrm{T_{DVCS}}|^2 = K_{\mathrm{DVCS}}\Big(c^{\mathrm{DVCS}}_{0,\mathrm{UU}} + c^{\mathrm{DVCS}}_{2,\mathrm{UU}}\cos(2\phi) + \{c^{\mathrm{DVCS}}_{1,\mathrm{UU}}\cos\phi$$
$$+S_\perp\Big[c^{\mathrm{DVCS}}_{0,\mathrm{UT}}\sin(\phi-\phi_S) + c^{\mathrm{DVCS}}_{2,\mathrm{UT}}\sin(\phi-\phi_S)\cos(2\phi)$$
$$+s^{\mathrm{DVCS}}_{2,\mathrm{UT}}\cos(\phi-\phi_S)\sin(2\phi)$$
$$+\{c^{\mathrm{DVCS}}_{1,\mathrm{UT}}\sin(\phi-\phi_S)\cos\phi + s^{\mathrm{DVCS}}_{1,\mathrm{UT}}\cos(\phi-\phi_S)\sin\phi\}\Big]\Big)$$

UT: Unpol. Beam T-pol. Target

$$\mathrm{I} = \frac{-K_{\mathrm{I}}e_l}{\mathcal{P}_1(\phi)\mathcal{P}_2(\phi)}\Big(c^{\mathrm{I}}_{1,\mathrm{UU}}\cos\phi + c^{\mathrm{I}}_{3,\mathrm{UU}}\cos(3\phi)$$
$$+\{c^{\mathrm{I}}_{0,\mathrm{UU}} + c^{\mathrm{I}}_{2,\mathrm{UU}}\cos(2\phi)\}$$
$$+S_\perp\Big[c^{\mathrm{I}}_{1,\mathrm{UT}}\sin(\phi-\phi_S)\cos\phi + s^{\mathrm{I}}_{1,\mathrm{UT}}\cos(\phi-\phi_S)\sin\phi$$
$$+c^{\mathrm{I}}_{3,\mathrm{UT}}\sin(\phi-\phi_S)\cos(3\phi) + s^{\mathrm{I}}_{3,\mathrm{UT}}\cos(\phi-\phi_S)\sin(3\phi)$$
$$+\{c^{\mathrm{I}}_{0,\mathrm{UT}}\sin(\phi-\phi_S) + c^{\mathrm{I}}_{2,\mathrm{UT}}\sin(\phi-\phi_S)\cos(2\phi)$$
$$+s^{\mathrm{I}}_{2,\mathrm{UT}}\cos(\phi-\phi_S)\sin(2\phi)\}\Big]\Big).$$



DVCS with a transversely polarized target

YAMAGATA UNIVERSITY

$$c_{0,\mathrm{UT}}^{\mathrm{DVCS}} \propto -\frac{\sqrt{-t}}{M}\mathrm{Im}\left\{\mathcal{H}\mathcal{E}^* - \mathcal{E}\mathcal{H}^* + \xi\widetilde{\mathcal{E}}\,\widetilde{\mathcal{H}}^* - \widetilde{\mathcal{H}}\,\xi\widetilde{\mathcal{E}}^*\right\},$$

$$c_{1,\mathrm{UU}}^{\mathrm{I}} \propto \frac{\sqrt{-t}}{Q}\mathrm{Re}\left\{F_1\mathcal{H} + \xi(F_1+F_2)\widetilde{\mathcal{H}} - \frac{t}{4M^2}F_2\mathcal{E}\right\},$$

$$c_{0,\mathrm{UU}}^{\mathrm{I}} \propto -\frac{\sqrt{-t}}{Q}c_{1,\mathrm{UU}}^{\mathrm{I}},$$

Target spin asymmetry: UT

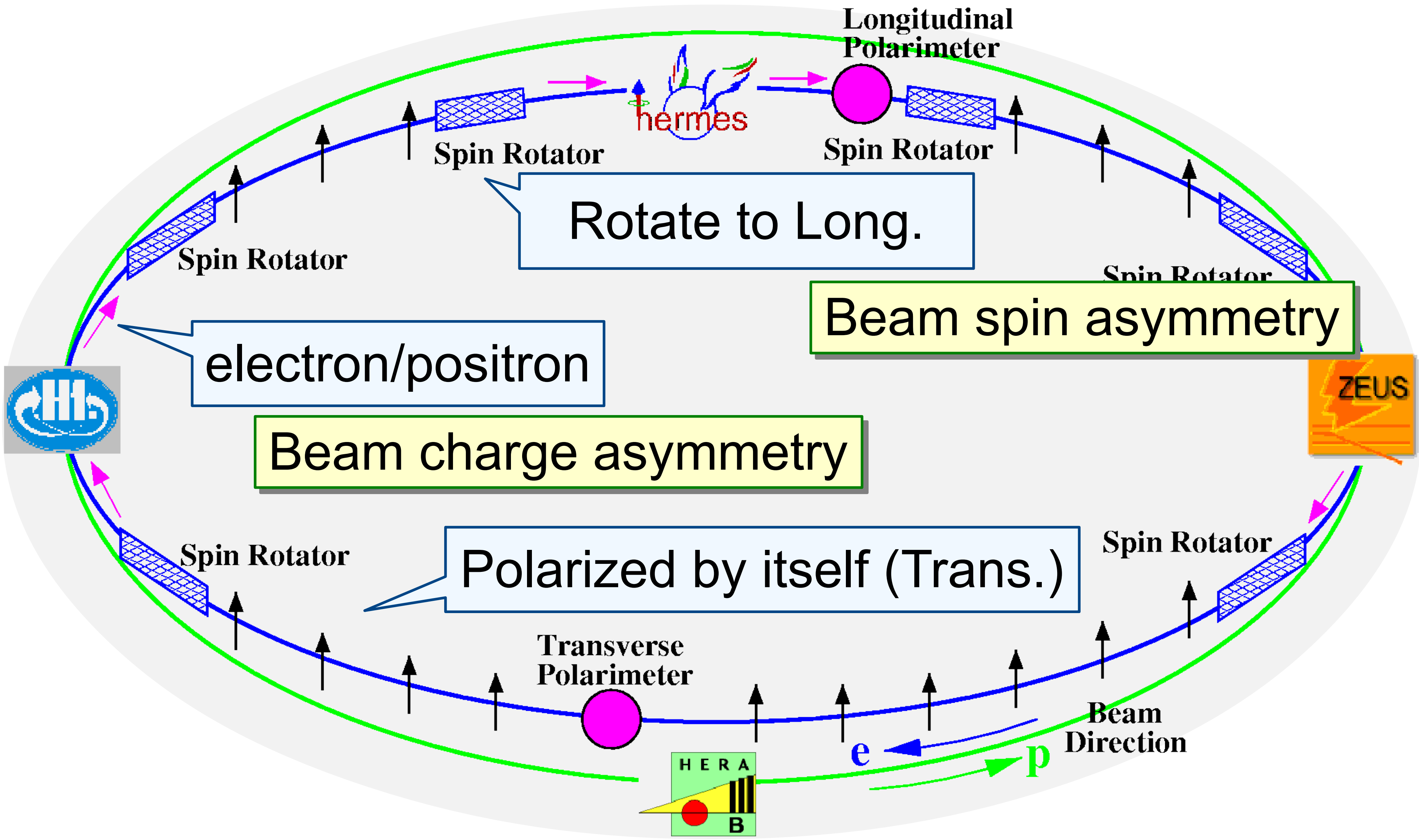
$$c_{1,\mathrm{UT}}^{\mathrm{I}} \propto -\frac{M}{Q}\mathrm{Im}\left\{\frac{t}{4M^2}\left[(2-x_B)F_1\mathcal{E} - 4\frac{1-x_B}{2-x_B}F_2\mathcal{H}\right] + x_B\xi\left[F_1(\mathcal{H}+\mathcal{E}) - (F_1+F_2)\left(\widetilde{\mathcal{H}} + \frac{t}{4M^2}\widetilde{\mathcal{E}}\right)\right]\right\}$$

$$c_{0,\mathrm{UT}}^{\mathrm{I}} \propto -\frac{\sqrt{-t}}{Q}c_{1,\mathrm{UT}}^{\mathrm{I}},$$

$$s_{1,\mathrm{UT}}^{\mathrm{I}} \propto -\frac{M}{Q}\mathrm{Im}\left\{\frac{t}{4M^2}\left[4\frac{1-x_B}{2-x_B}F_2\widetilde{\mathcal{H}} - (F_1+\xi F_2)x_B\widetilde{\mathcal{E}}\right] + x_B\left[(F_1+F_2)\left(\xi\mathcal{H} + \frac{t}{4M^2}\mathcal{E}\right) - \xi F_1\left(\widetilde{\mathcal{H}} + \frac{x_B}{2}\widetilde{\mathcal{E}}\right)\right]\right\}$$

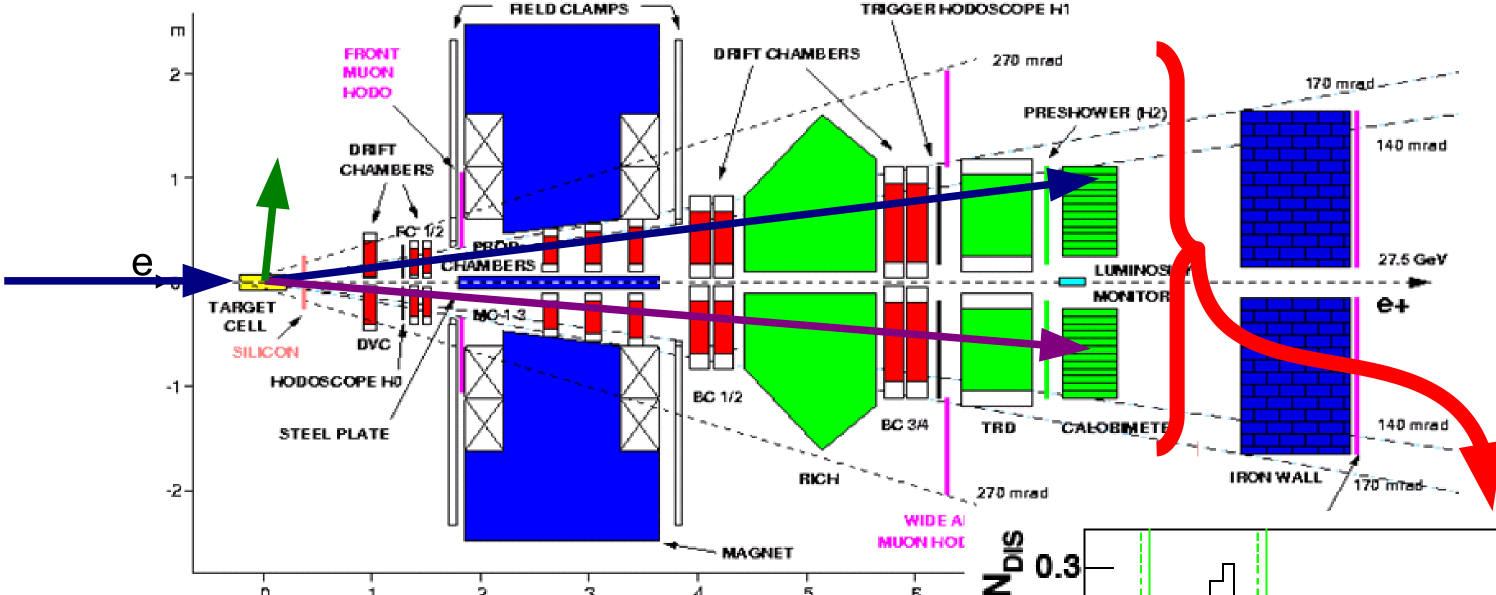
UT $\longrightarrow$ GPD E

HERMES polarized electron/positron beam



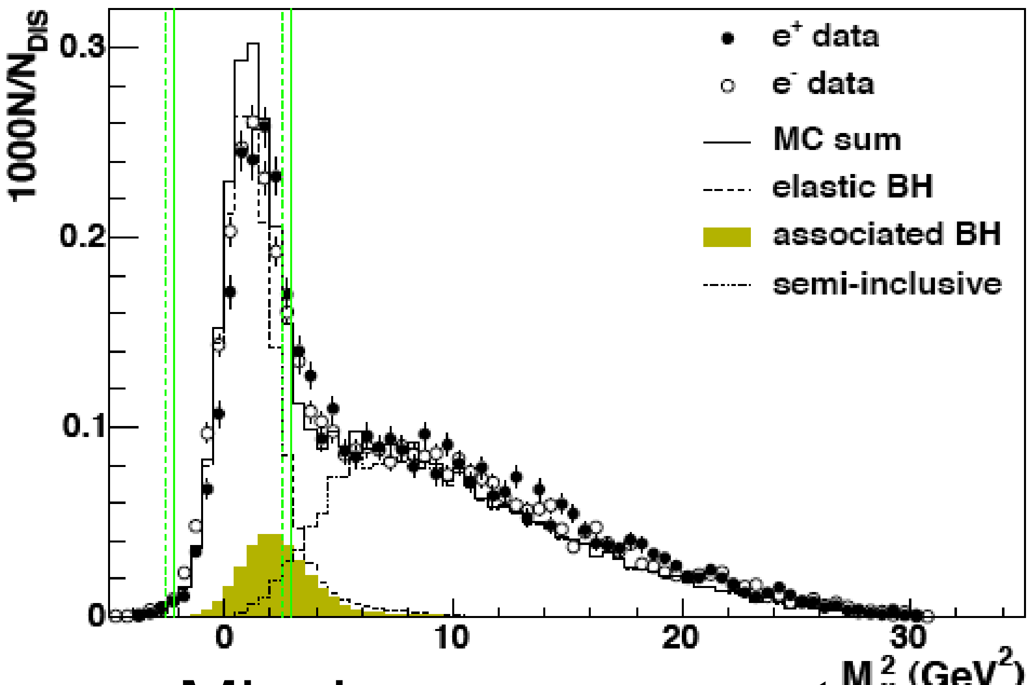
Measurement of exclusive production at hermes

$$e + N \rightarrow e' + N + \gamma$$



1996 ~ 2005:

- No detector for the recoil proton
- Cut on missing-mass spectrum



Missing-mass spectrum

DVCS @ HERMES

YAMAGATA UNIVERSITY

Year	Beam Charge	Helicity	Targets Pol.	Unpol.	Detector
1996	+	+	H(l)	H, D, ^{3}He	
1997	+	+, -	H(l)	H, D, N	
1998	-	+, -	D(l)	H, D, Kr	
1999	+	+, -	D(l)	D, N, Kr	
2000	+	+, -	D(l)	H, D, ^{4}He, Ne, Kr	
2002	+	-	**H(t)**	H, D, Kr	
2003	+	+	**H(t)**	H, Kr	
2004	+	+, -	**H(t)**	H, D, Kr, Xe	
2005	-	+, -	**H(t)**	H, D, Xe	
2006	-, +	+, -		H, D	Recoil
2007	+	+, -		H, D	Recoil

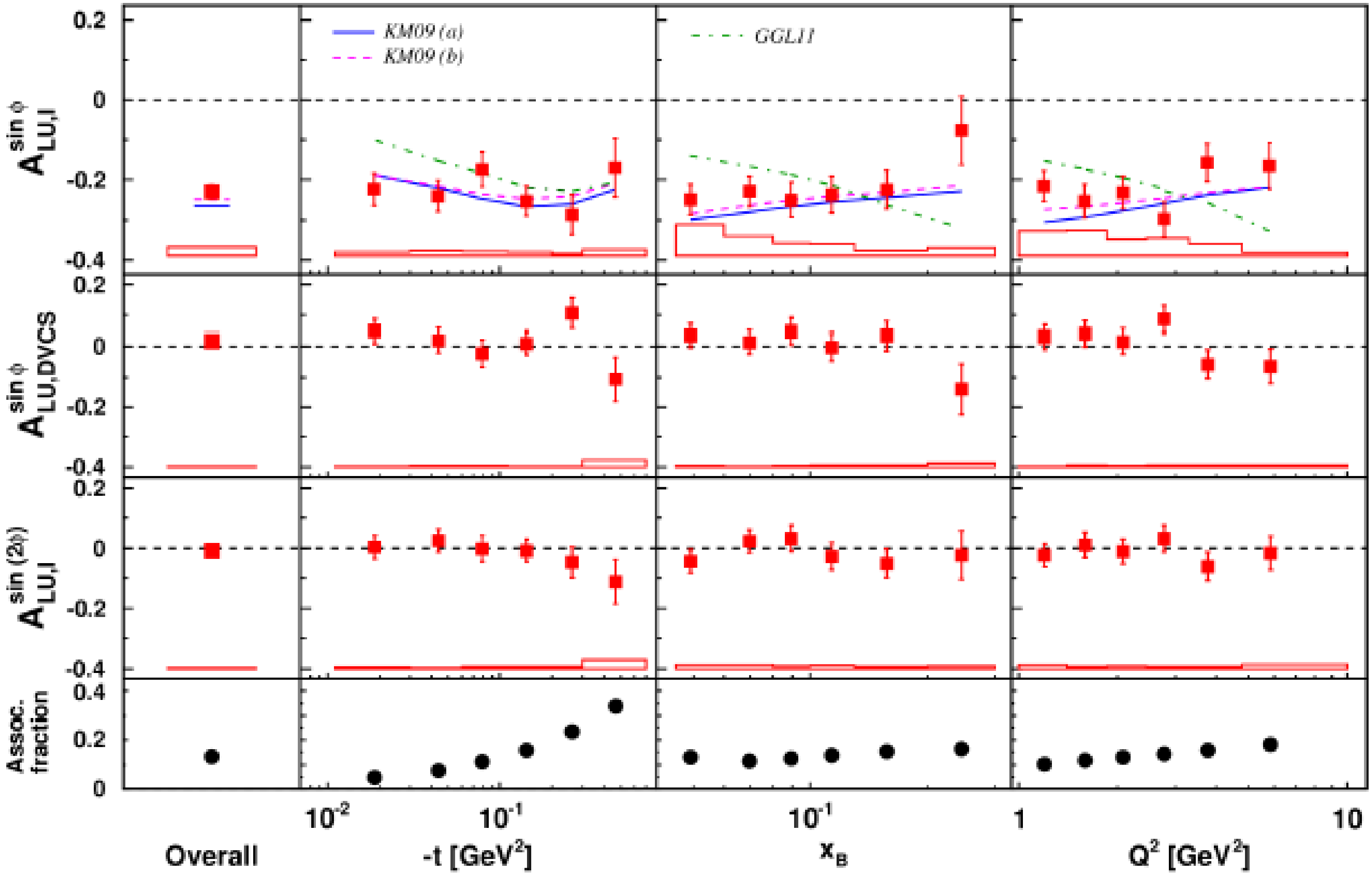
DVCS @ HERMES

YAMAGATA UNIVERSITY

- Beam spin, charge asymmetry	H	PRL87 (2001) 182001
	H	JHEP 11 (2009) 083
	H	JHEP 07 (2012) 032
	D	NPB829 (2010) 1-27
- Beam spin **with Recoil detector**	H	JHEP 10 (2012) 042
- Beam charge asymmetry	H	PRD75 (2007) 011103
- Longitudinal target spin asymmetry	H	JHEP 06 (2010) 019
	D	NPB842 (2011) 265-298
- Transverse target spin asymmetry	H	JHEP 06 (2008) 066
- DVCS on nucleus targets		PRC81 (2010) 035202

Beam spin asymmetry

Published: *A. Airapetian et al, JHEP 07 (2012) 032*

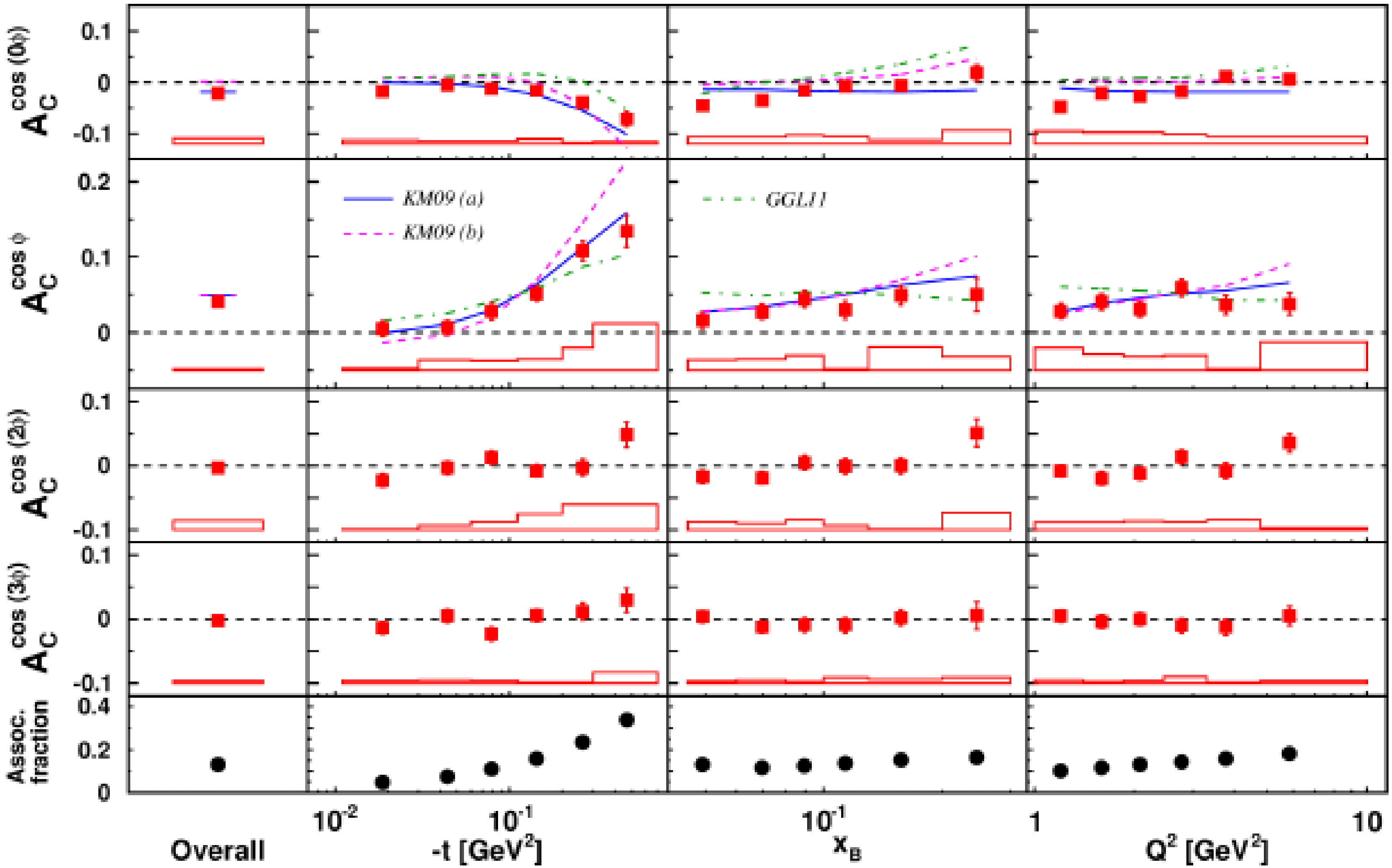


$\propto \Im m \mathcal{H}$

Beam charge asymmetry

YAMAGATA UNIVERSITY

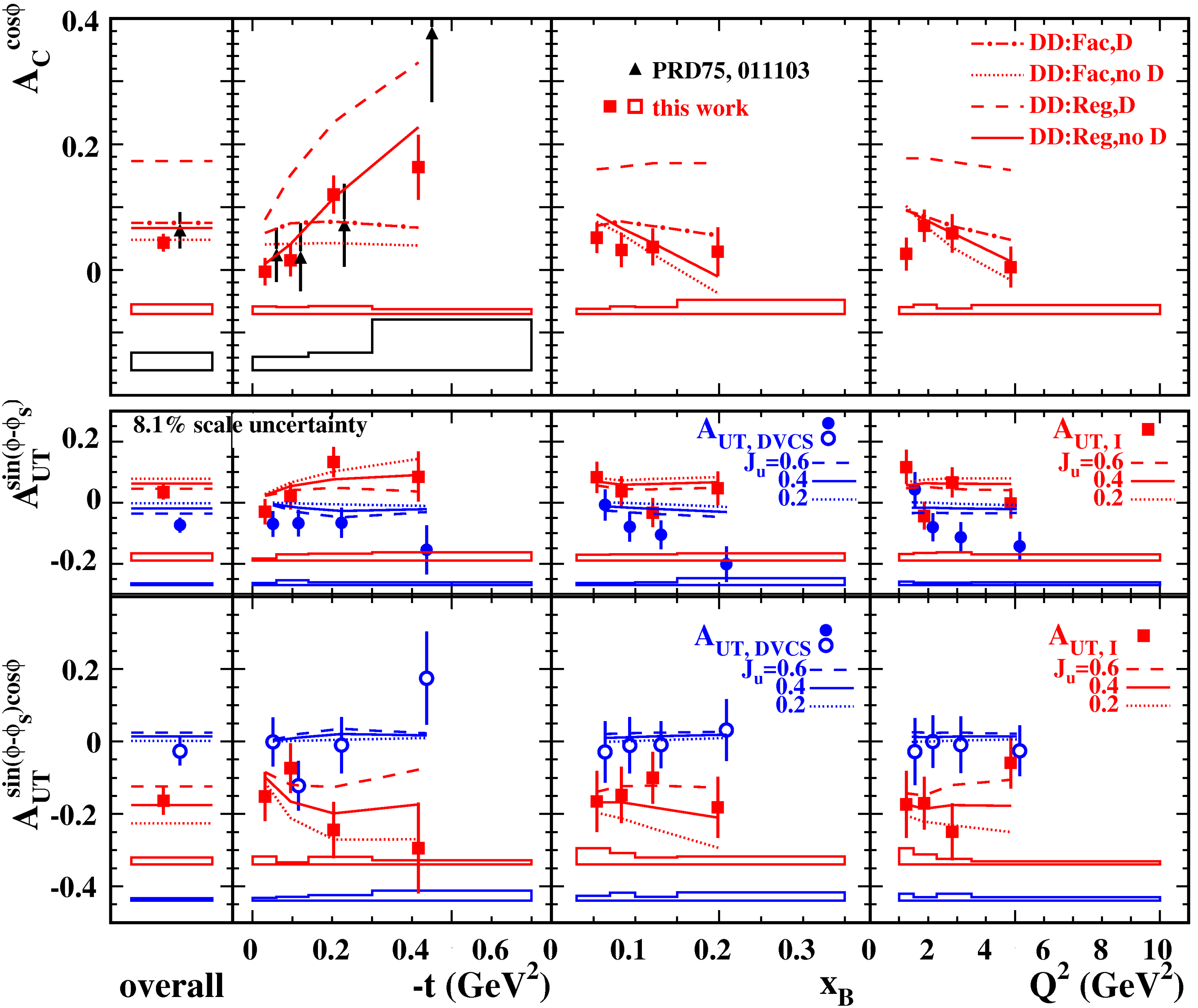
Published: *A. Airapetian et al, JHEP 07 (2012) 032*



$\propto \Re e\mathcal{H}$

DVCS with T-pol. H target

HERMES Collaboration, JHEP06 (2008) 066



$$A_C^{\cos\phi} \propto \Re[F\mathcal{H}]$$

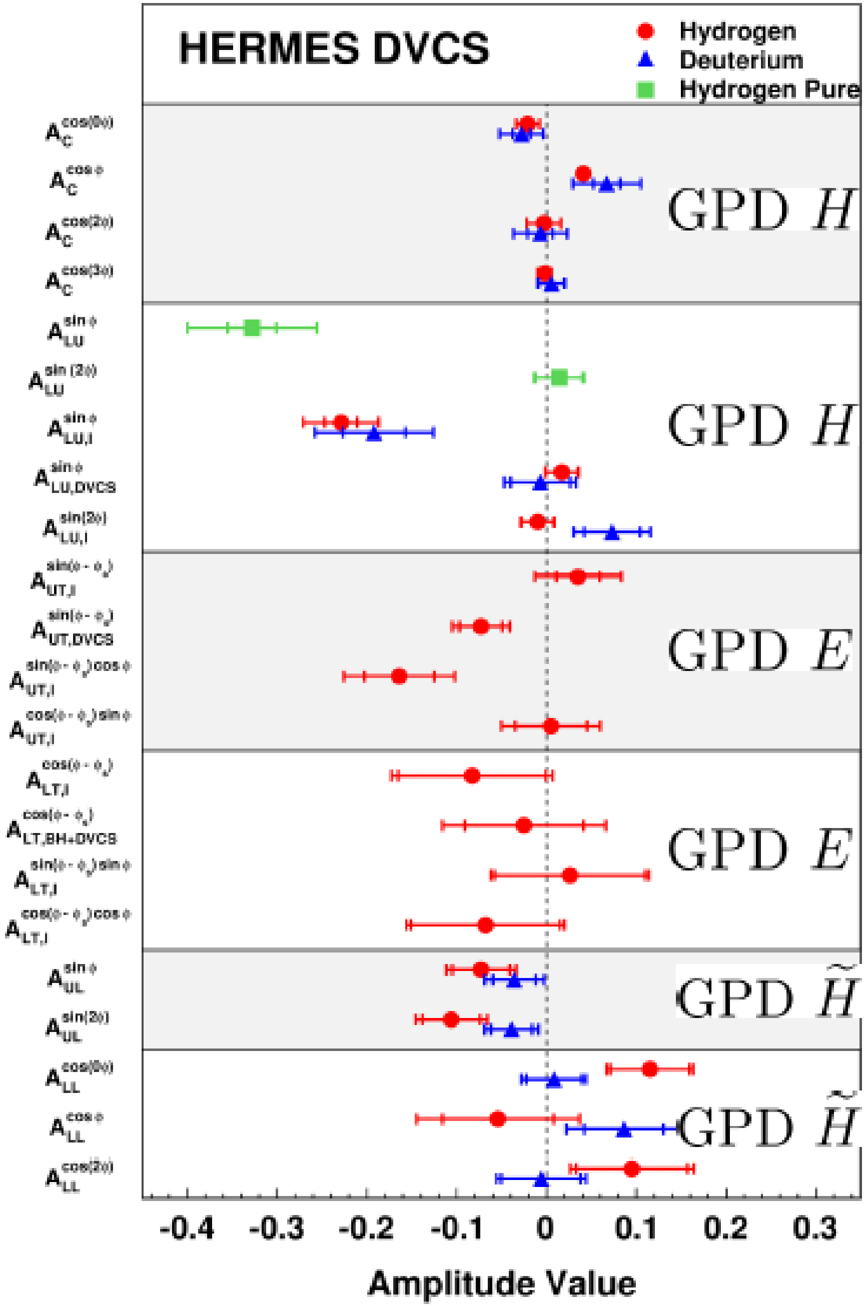
$$A_{UT,DVCS}^{\sin(\phi-\phi_s)} \propto \Im[\mathcal{H}\mathcal{E}^* - \mathcal{E}\mathcal{H}^* + \xi\tilde{\mathcal{E}}\tilde{\mathcal{H}}^* - \tilde{\mathcal{H}}\xi\tilde{\mathcal{E}}^*]$$

$$A_{UT,I}^{\sin(\phi-\phi_s)} \propto -A_{UT,I}^{\sin(\phi-\phi_s)\cos\phi} \propto \Im[F_1\mathcal{E} - F_2\mathcal{H}]$$

DVCS amplitudes measured at HERMES

YAMAGATA UNIVERSITY

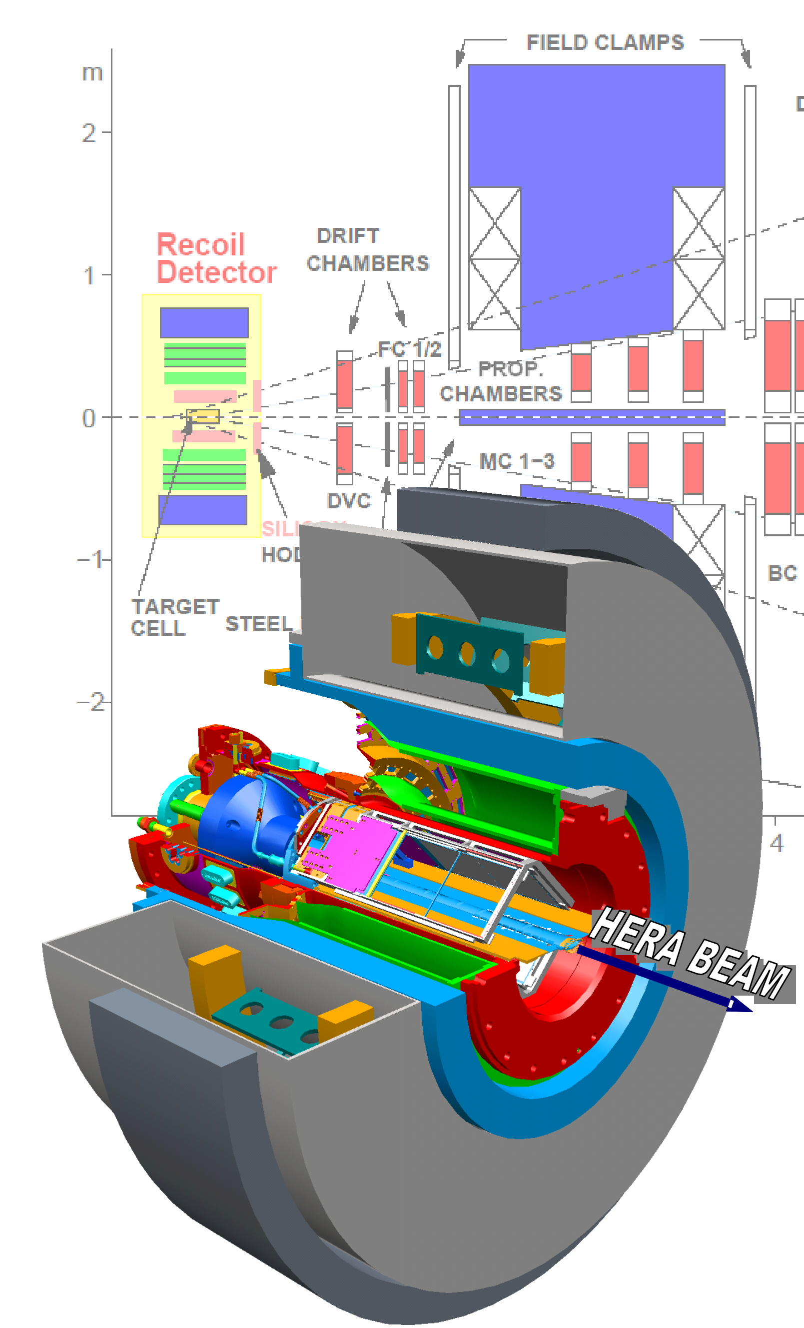
S. Yaschenko, DIS2013



- Beam-charge and beam-spin asymmetry
  - *PRL 87 (2001) 182001*
  - *PRD 75 (2007) 011103*
  - *JHEP 11 (2009) 083*
  - *JHEP 07 (2012) 032*, *JHEP 10 (2012) 042*
  - *Nucl. Phys. B 829 (2010) 1*
- Transverse target-spin asymmetry
  - *JHEP 06 (2008) 066*
- Transverse double-spin asymmetry
  - *Phys. Lett. B 704 (2011) 15*
- Longitudinal target spin asymmetry
  - *JHEP 06 (2010) 019*
- Longitudinal target & double spin asymmetry
  - *Nucl. Phys. B 842 (2011) 265*

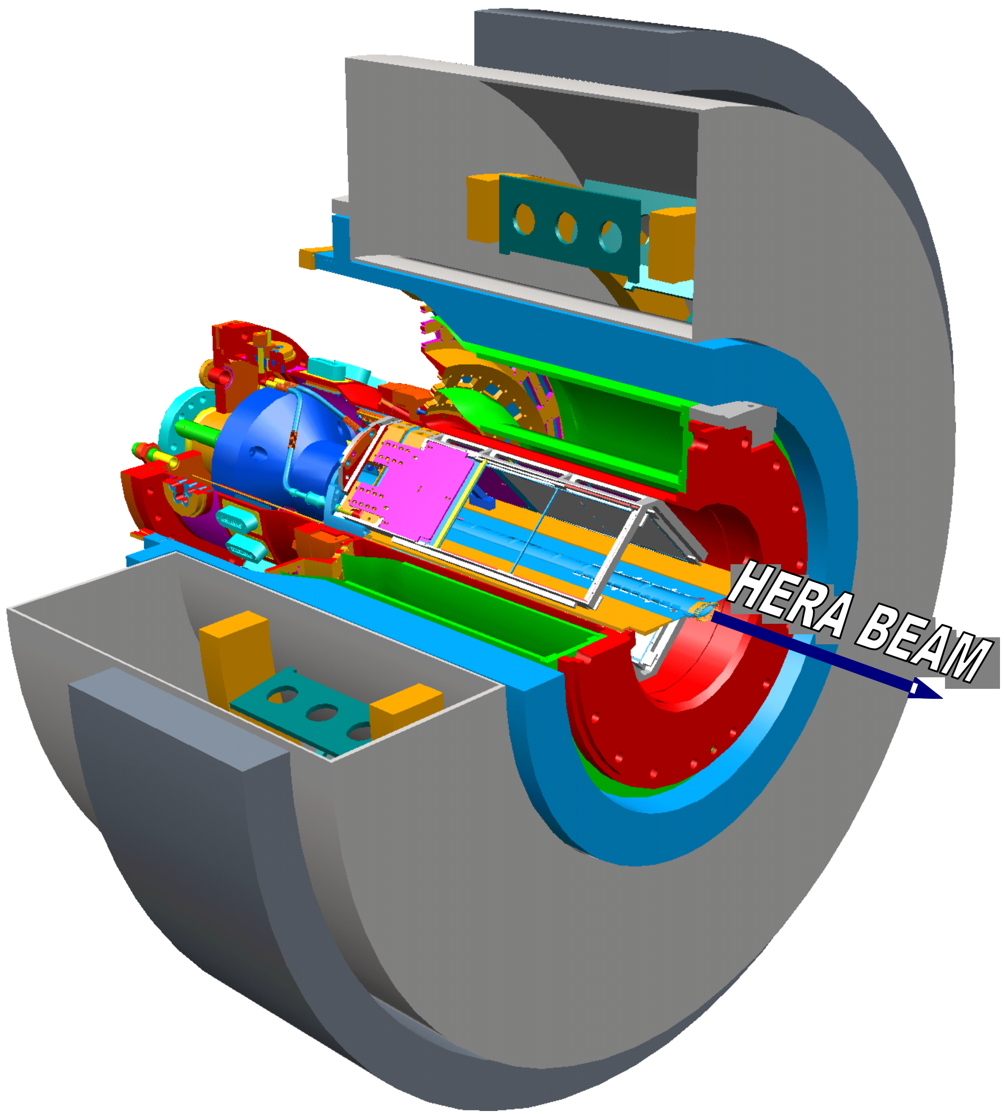
With Recoil

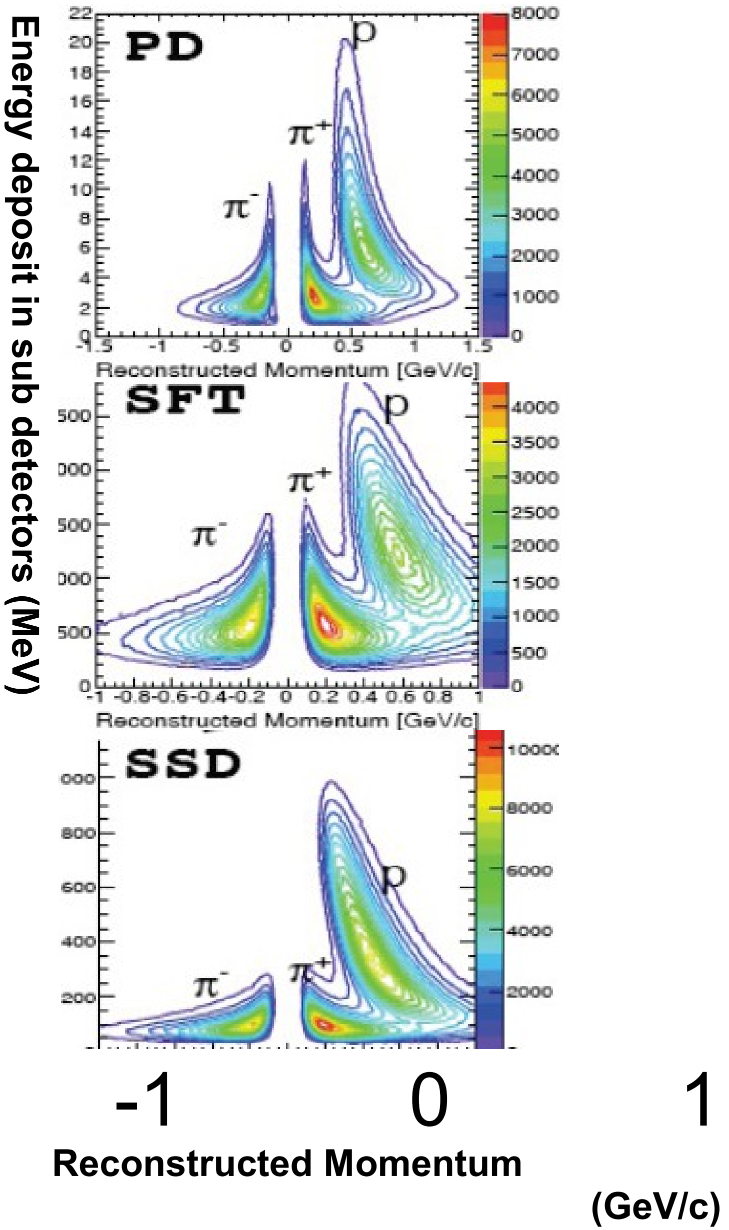
HERMES Recoil Detector:



- Sub-detectors in 1 T Solenoid
  - Photon Detector (**PD**)
    - 3 Tungsten/Scintillator layers, π^0, π/p
  - Scintillation Fiber Tracker (**SFT**)
    - 2 x (2 Parallel and 2 Stereo layers), momentum reconstruction and π/p
  - Silicon Strip Detector (**SSD**)
    - 2 layers of 16 double sided sensor, momentum reconstruction and π/p
- Unpol. H&D targets: (2006, 2007)

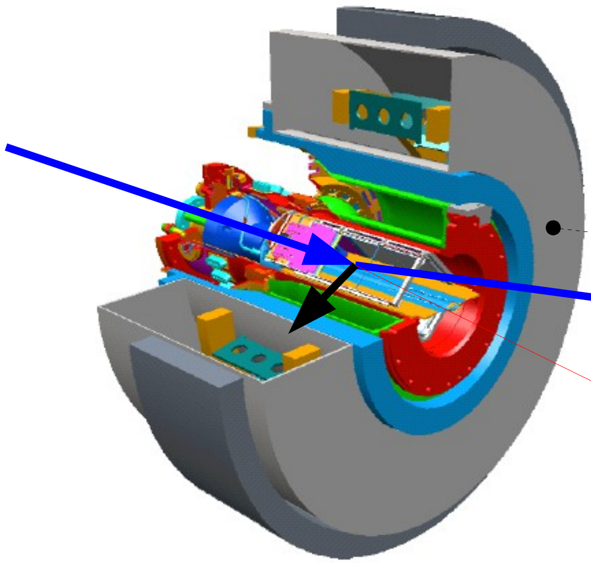
HERMES Recoil Detector

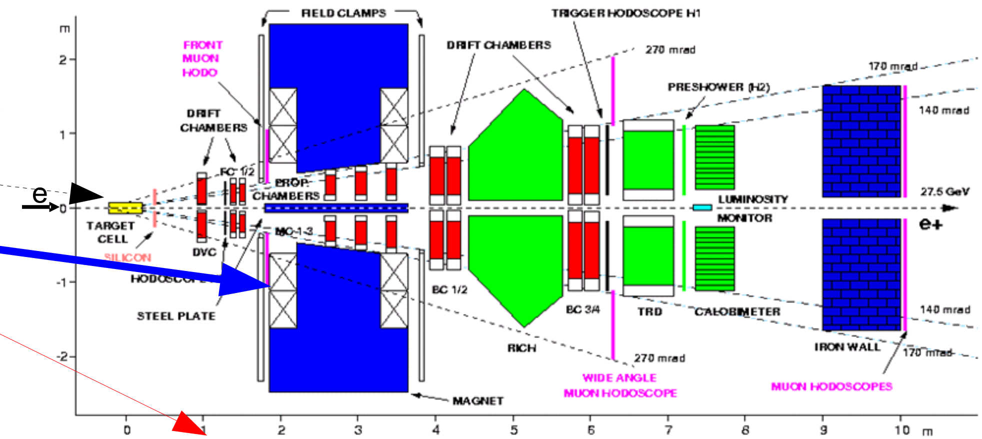


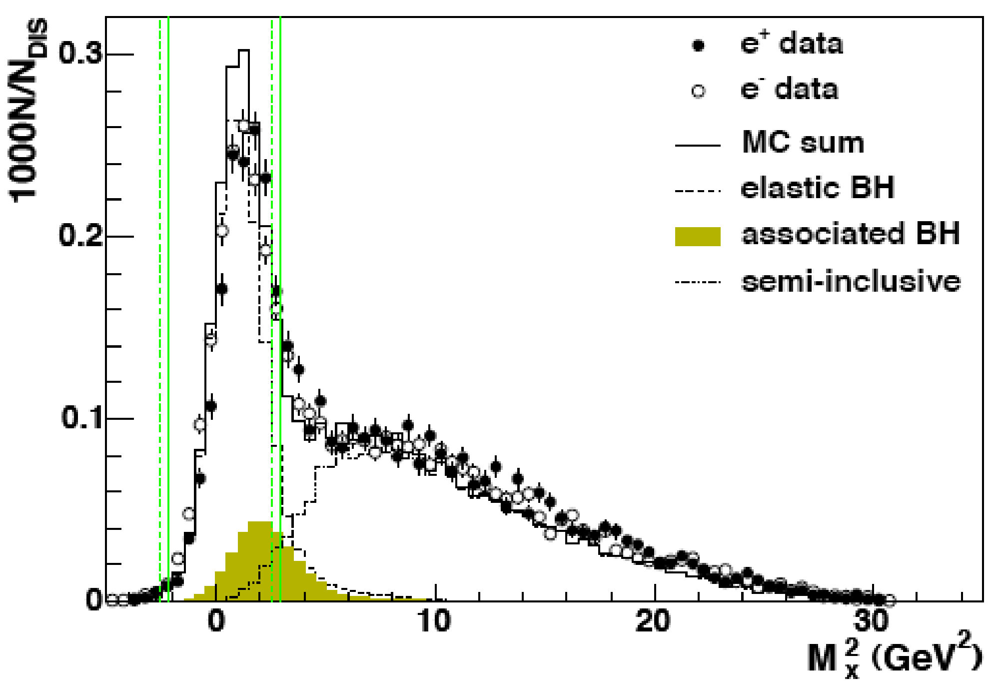


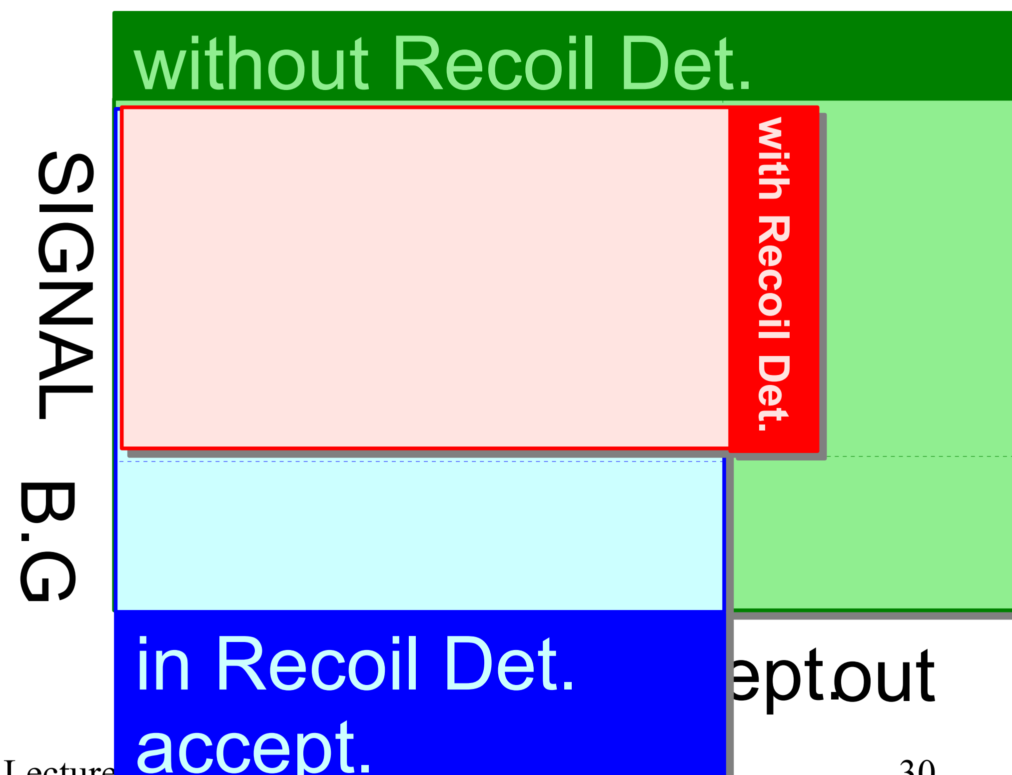
Exclusive production with Recoil Detector

$$e + N \rightarrow e' + N + \gamma$$



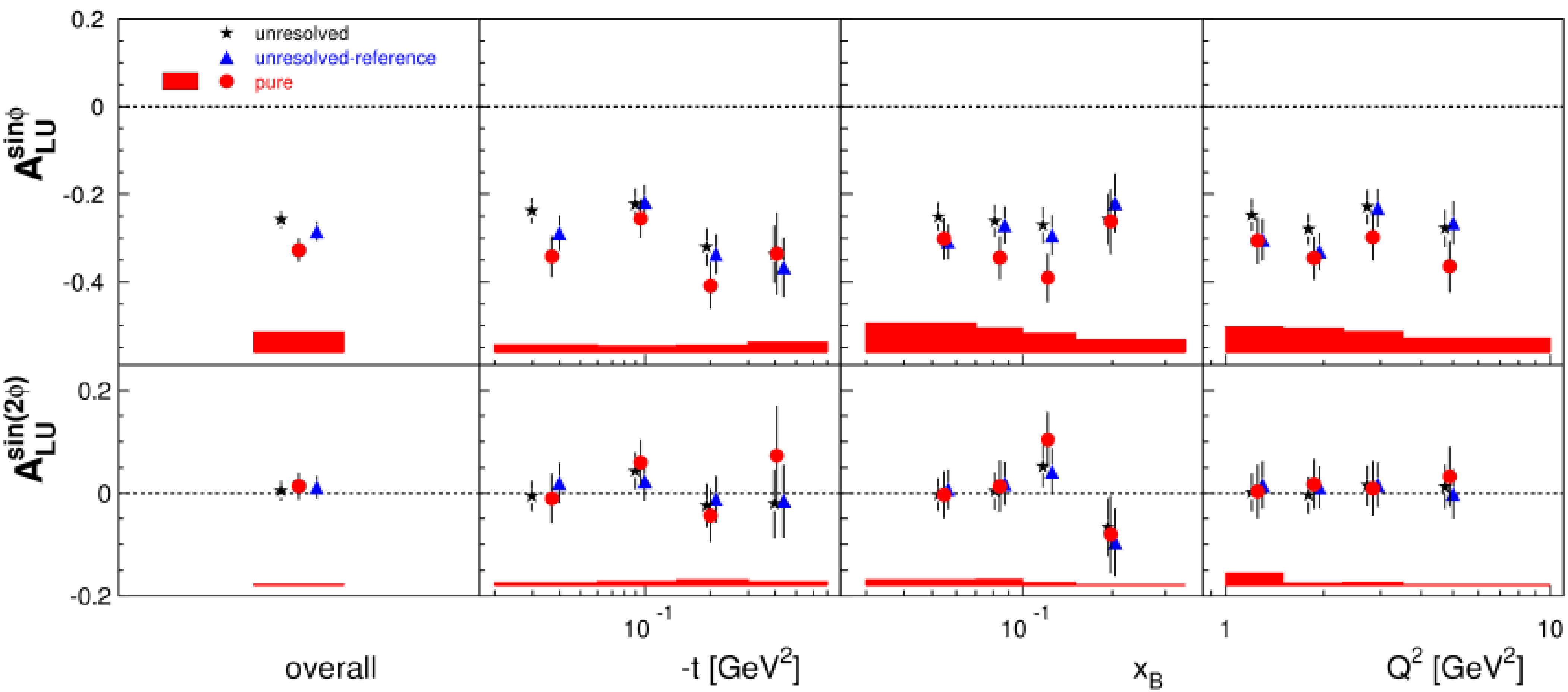






DVCS amplitudes with Recoil Detector at

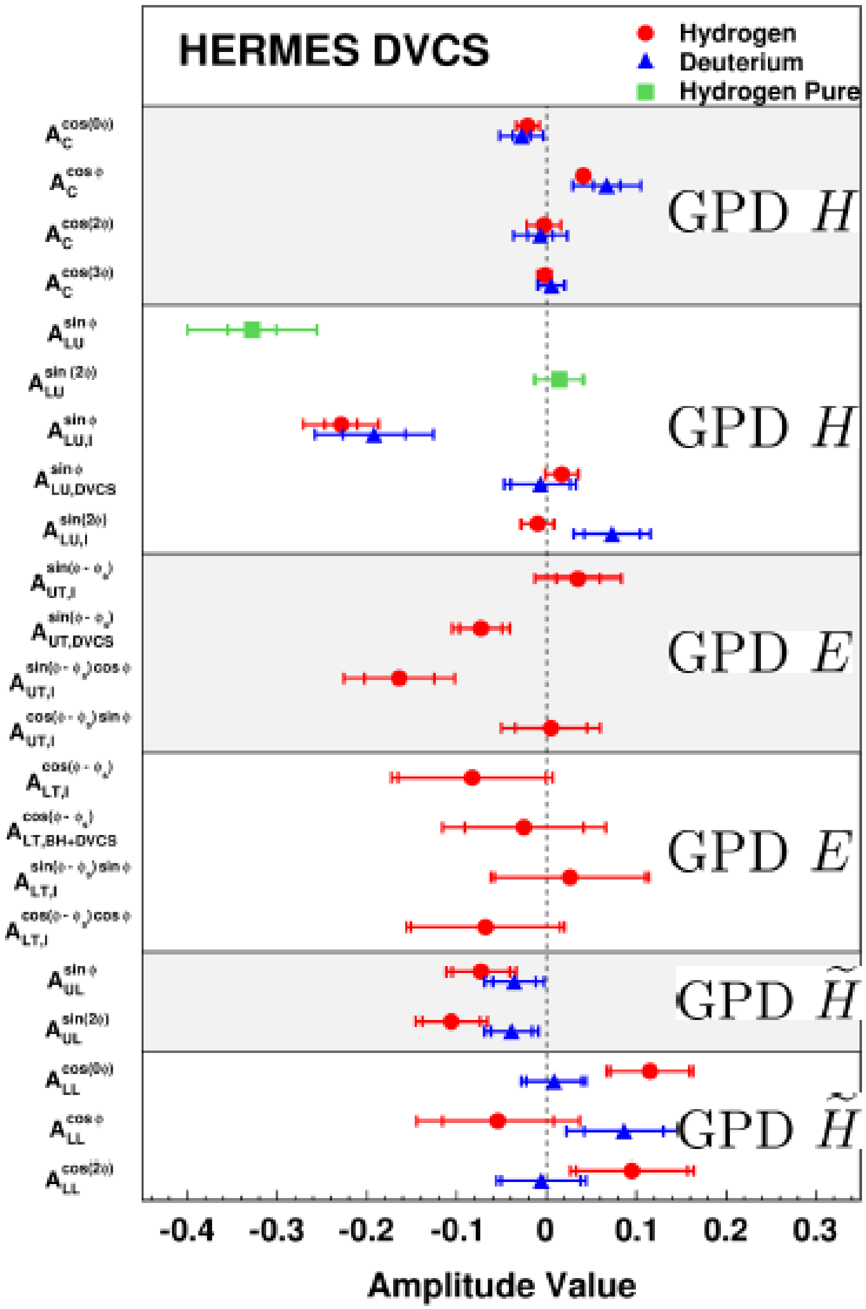
YAMAGATA UNIVERSITY



DVCS amplitudes measured at HERMES

YAMAGATA UNIVERSITY

S. Yaschenko, DIS2013



- Beam-charge and beam-spin asymmetry
  - *PRL 87 (2001) 182001*
  - *PRD 75 (2007) 011103*
  - *JHEP 11 (2009) 083*
  - *JHEP 07 (2012) 032*, *JHEP 10 (2012) 042*
  - *Nucl. Phys. B 829 (2010) 1*
- Transverse target-spin asymmetry
  - *JHEP 06 (2008) 066*
- Transverse double-spin asymmetry
  - *Phys. Lett. B 704 (2011) 15*
- Longitudinal target spin asymmetry
  - *JHEP 06 (2010) 019*
- Longitudinal target & double spin asymmetry
  - *Nucl. Phys. B 842 (2011) 265*

With Recoil

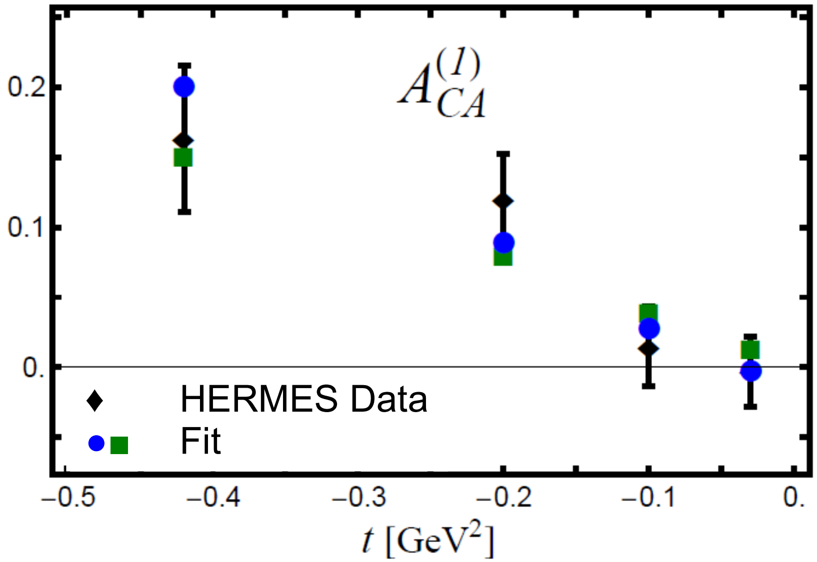
DESY

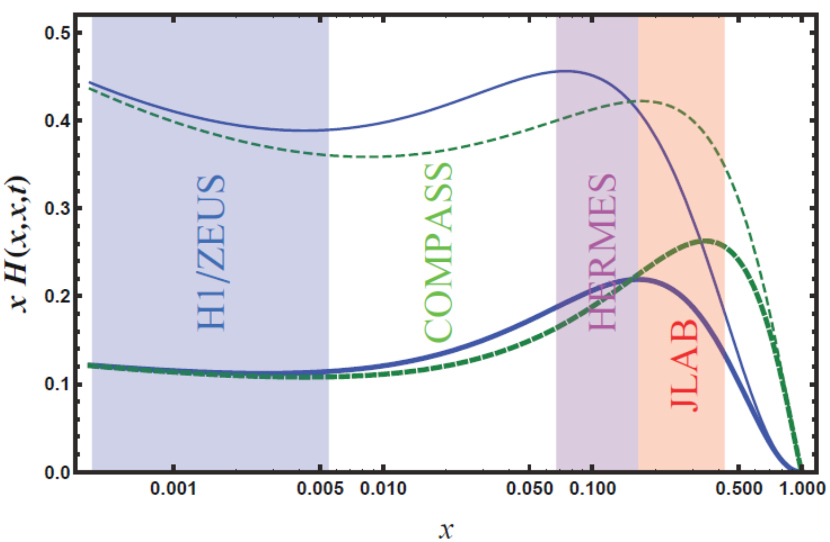
HERMES Results on DVCS and Associated Processes | 24.04.13 | Page 18

Fit to the HERMES data

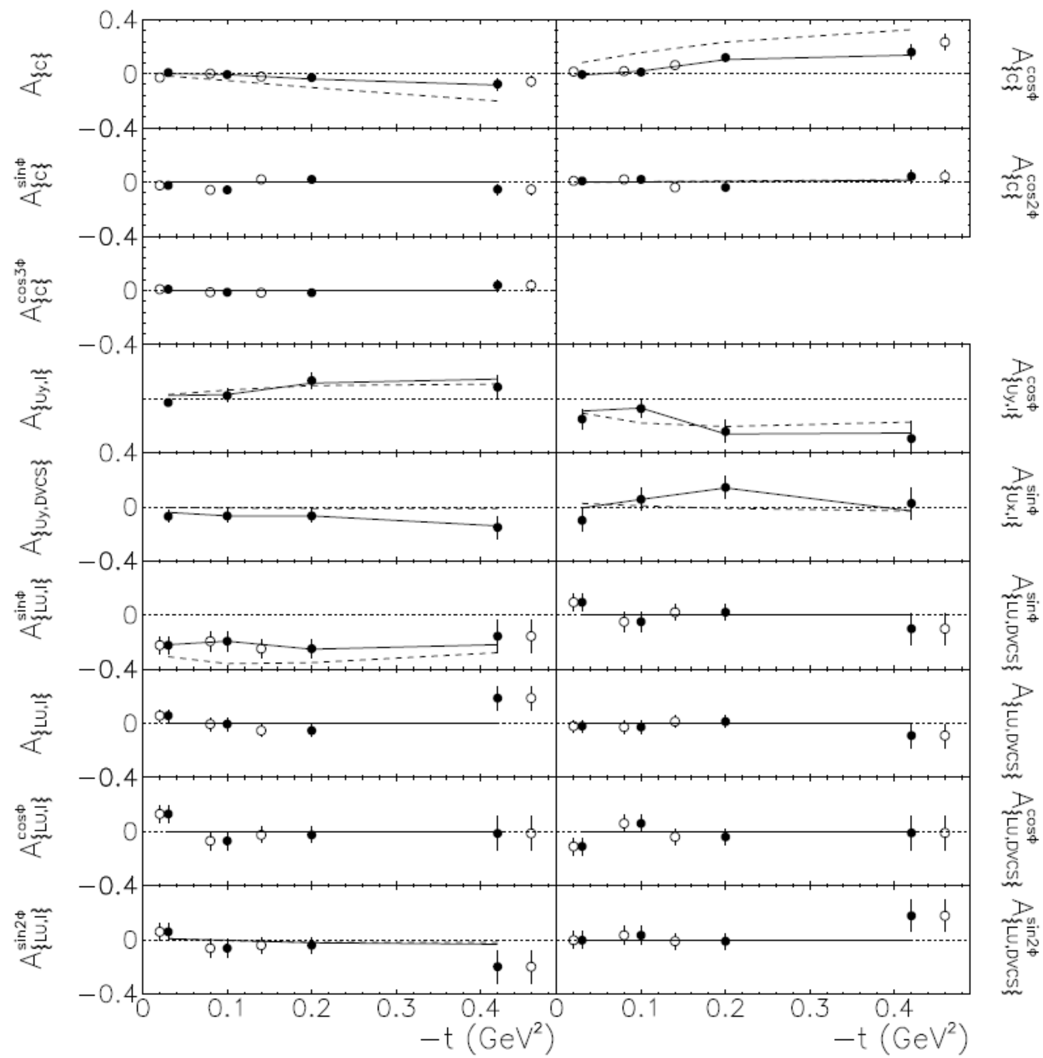
YAMAGATA UNIVERSITY

K. Kumericki and D. Muller, arXiv:0904.0458





M. Guidal and H. Moutarde, arXiv:0905.1220



YAMAGATA UNIVERSITY

New programs (COMPASS II)

approved by CERN Research Board in 2010

- Polarized Drell-Yan measurement — 2014

  TMD PDFs — *π^- beam with polarized proton target*

- GPD measurement — *μ^+ μ^- beam with liquid hydrogen target*

  Transverse imaging — 2015 - 2016

- Pion and Kaon polarizability

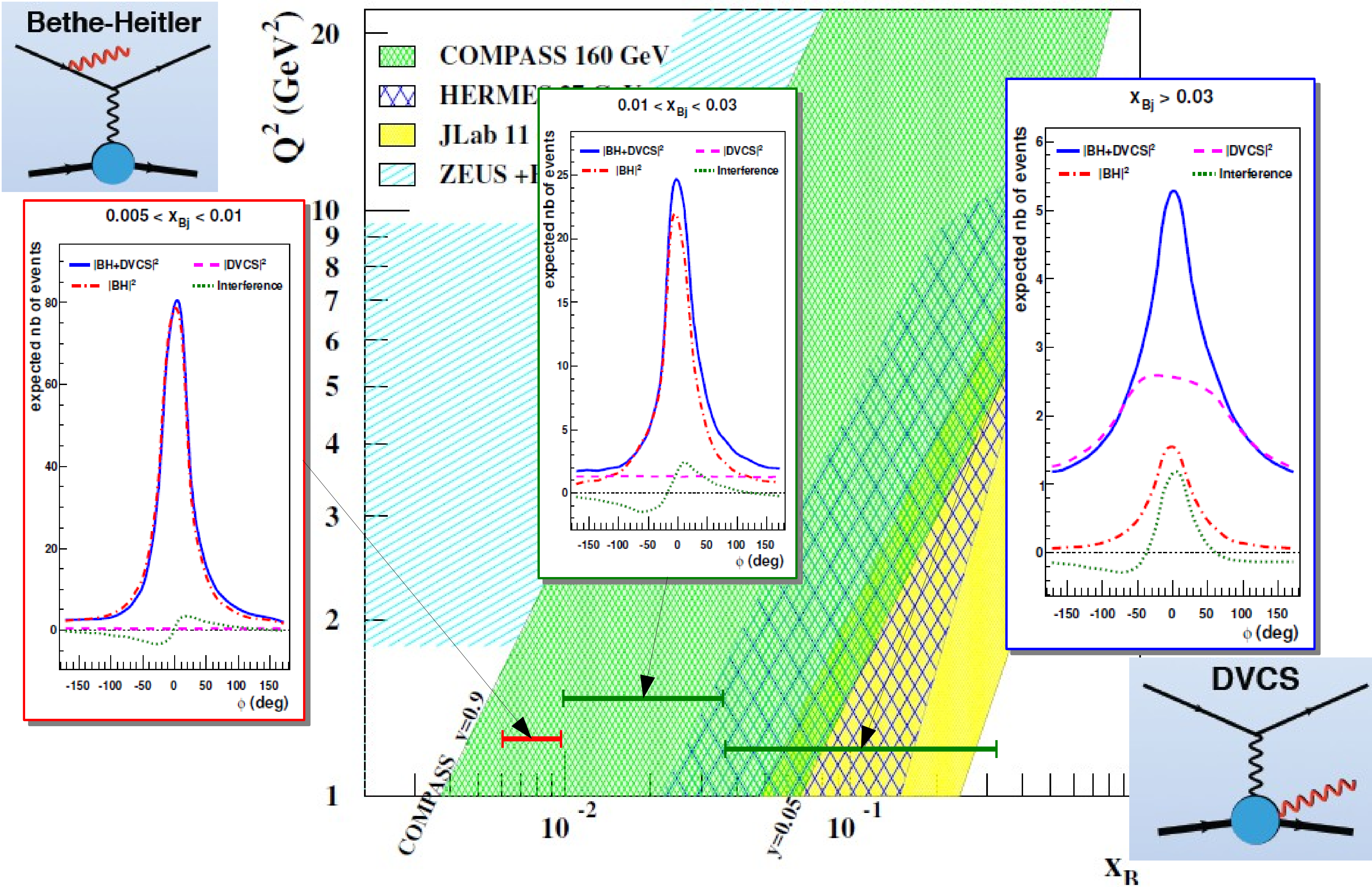
  Chiral perturbation theory — *π^-, K^- (μ^-) beam with nucleus target*

With a upgraded COMPASS spectrometer

COMPASS polarized beam

Proton beam from SPS
→ secondary hadrons
→ weak decay to muon
→ select muon charge & momentum by magnet
→ polarized muons

COMPASS II : GPD



COMPASS II: GPD

YAMAGATA UNIVERSITY

(1) The beam charge & spin sum of cross sections

$$\mathcal{S}_{CS,U} \equiv \mathrm{d}\sigma^{\overset{+}{\leftarrow}} + \mathrm{d}\sigma^{\overset{-}{\rightarrow}} = 2(\mathrm{d}\sigma^{BH} + \mathrm{d}\sigma^{DVCS}_{unpol} + e_\mu P_\mu \mathrm{Im}\, I),$$

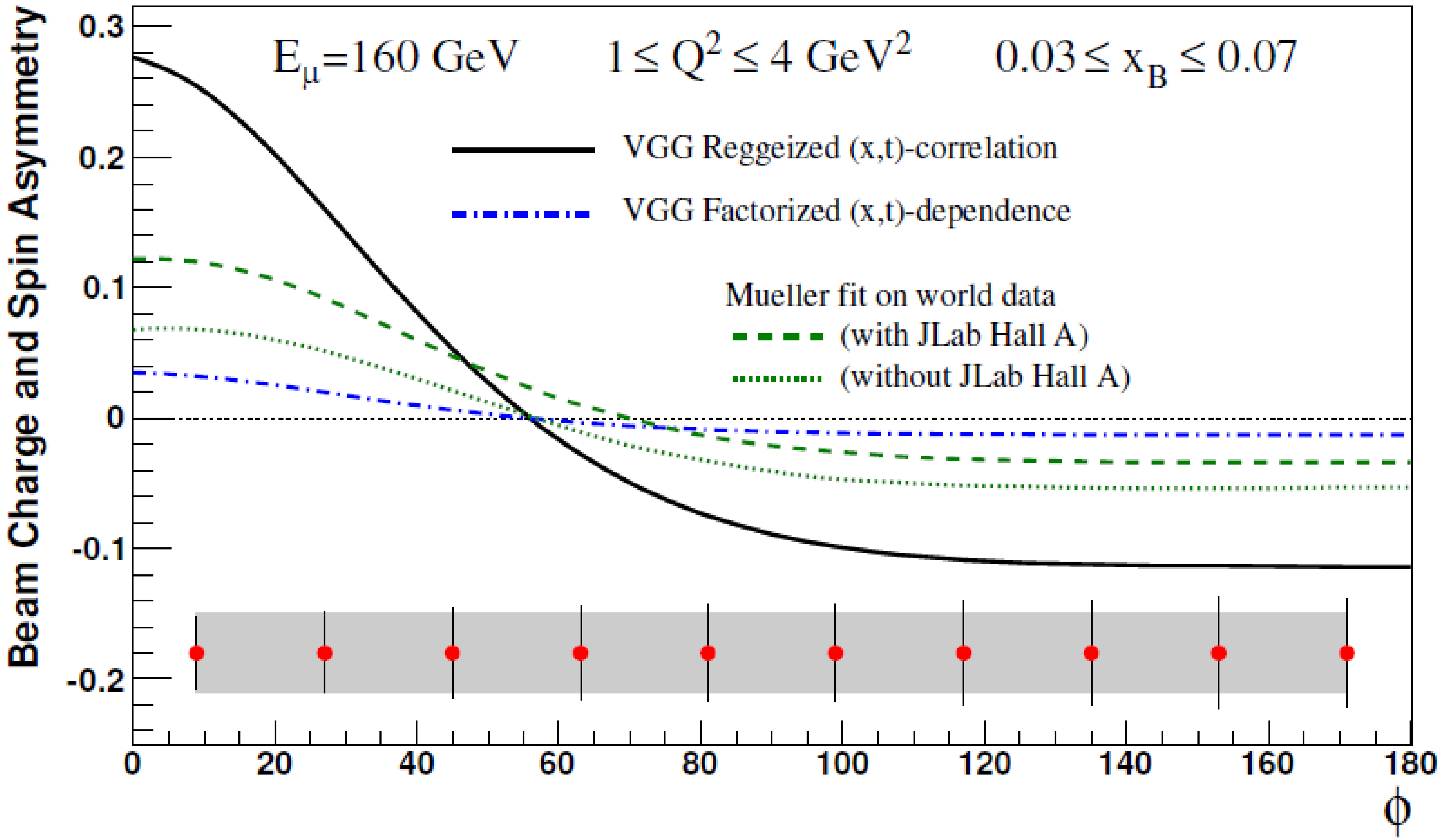
(2) The beam charge & spin difference of cross sections

$$\mathcal{D}_{CS,U} \equiv \mathrm{d}\sigma^{\overset{+}{\leftarrow}} - \mathrm{d}\sigma^{\overset{-}{\rightarrow}} = 2(P_\mu \mathrm{d}\sigma^{DVCS}_{pol} + e_\mu \mathrm{Re}\, I),$$

(3) The beam charge & spin asymmetry of cross sections

$$\mathcal{A}_{CS,U} \equiv \frac{\mathrm{d}\sigma^{\overset{+}{\leftarrow}} - \mathrm{d}\sigma^{\overset{-}{\rightarrow}}}{\mathrm{d}\sigma^{\overset{+}{\leftarrow}} + \mathrm{d}\sigma^{\overset{-}{\rightarrow}}} = \frac{\mathcal{D}_{CS,U}}{\mathcal{S}_{CS,U}},$$

COMPASS II: GPD, expected asymmetry

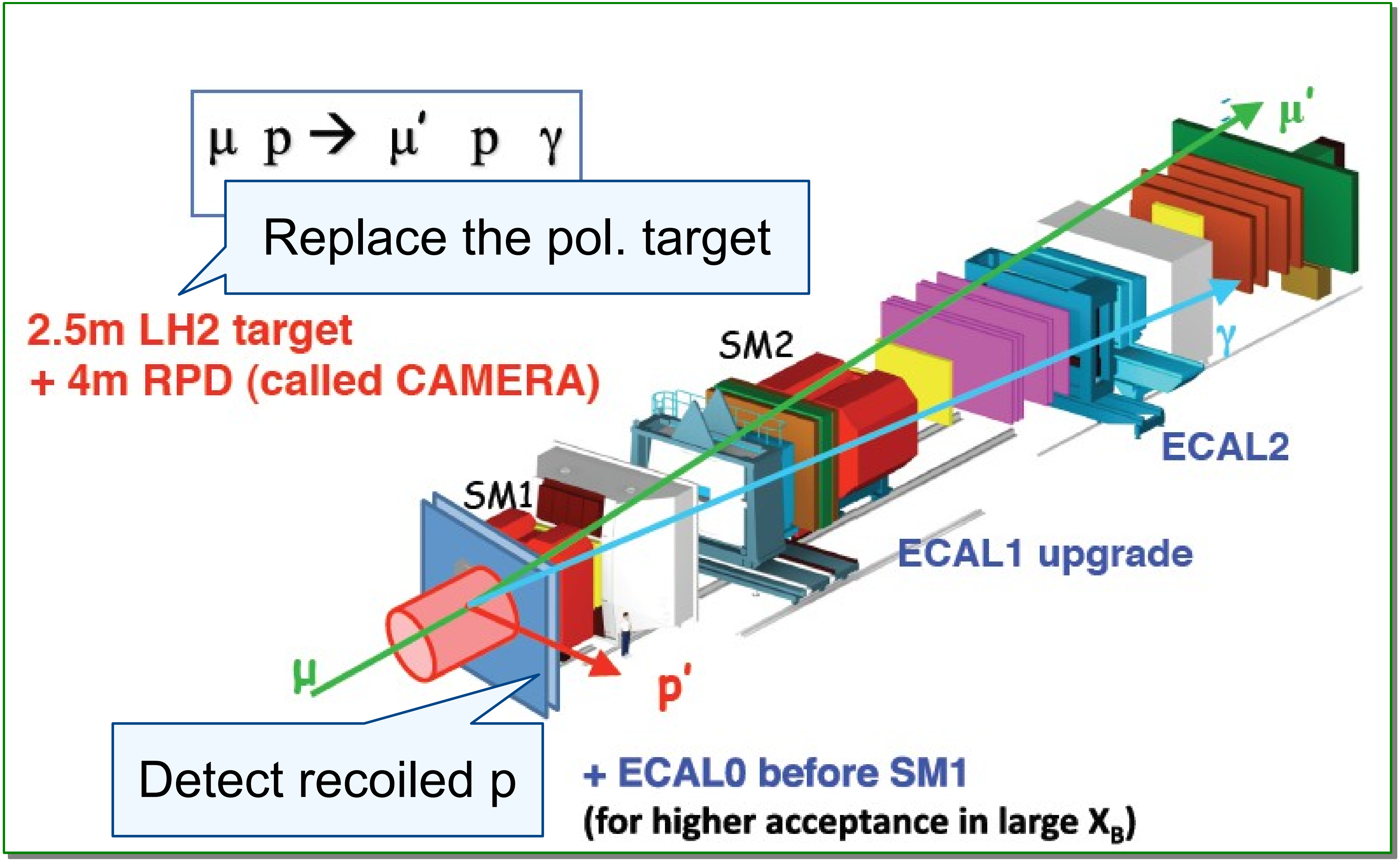


$$c_1^I \propto \mathrm{Re}\left(F_1 \mathcal{H} + \xi (F_1 + F_2) \widetilde{\mathcal{H}} - \frac{t}{4M^2} F_2 \mathcal{E} \right)$$

SP
A. Ferrero

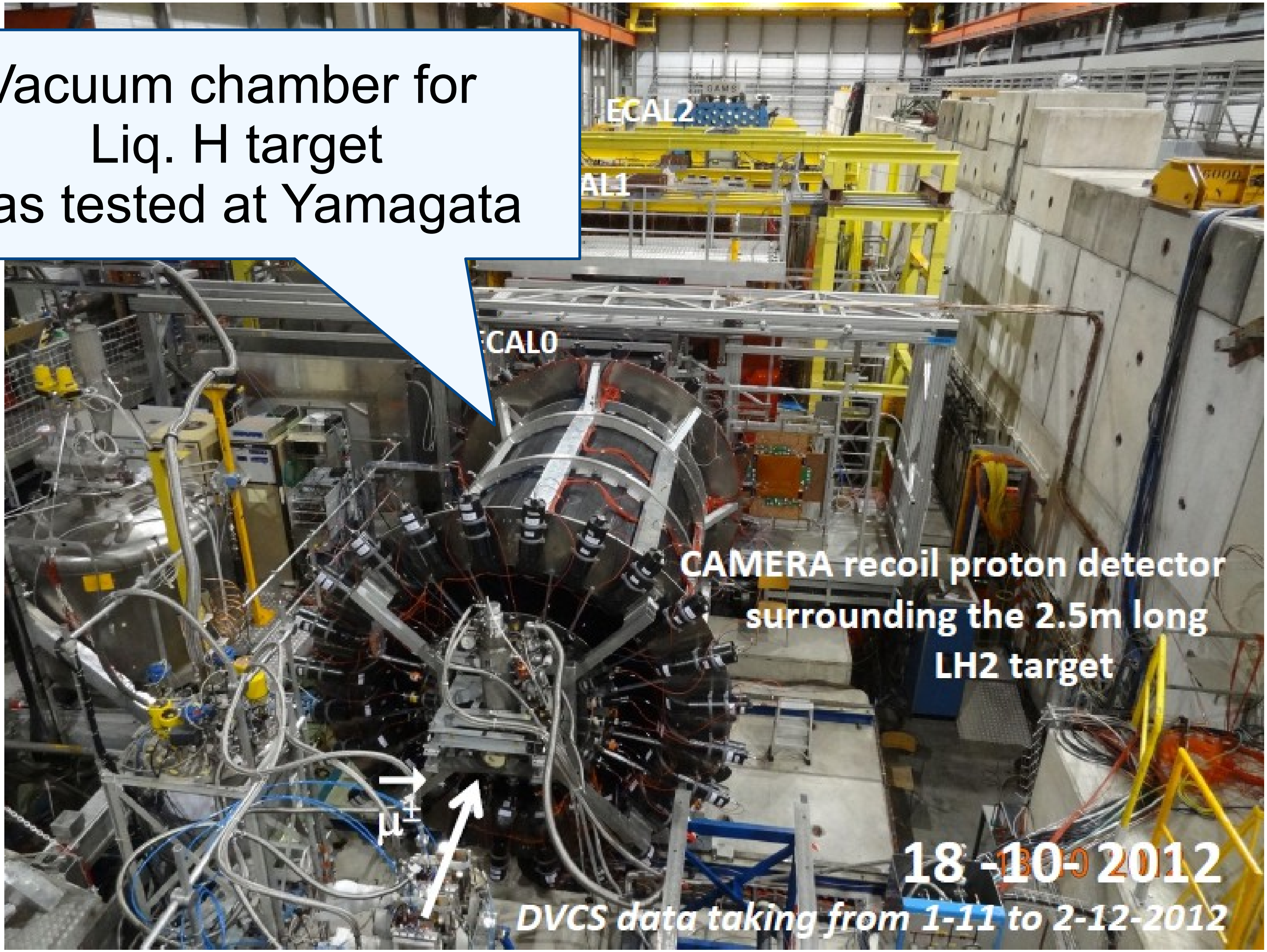
COMPASS II: GPD setup

YAMAGATA UNIVERSITY



COMPASS II: GPD 2012 “short” RUN

Vacuum chamber for
Liq. H target
was tested at Yamagata



CAMERA study