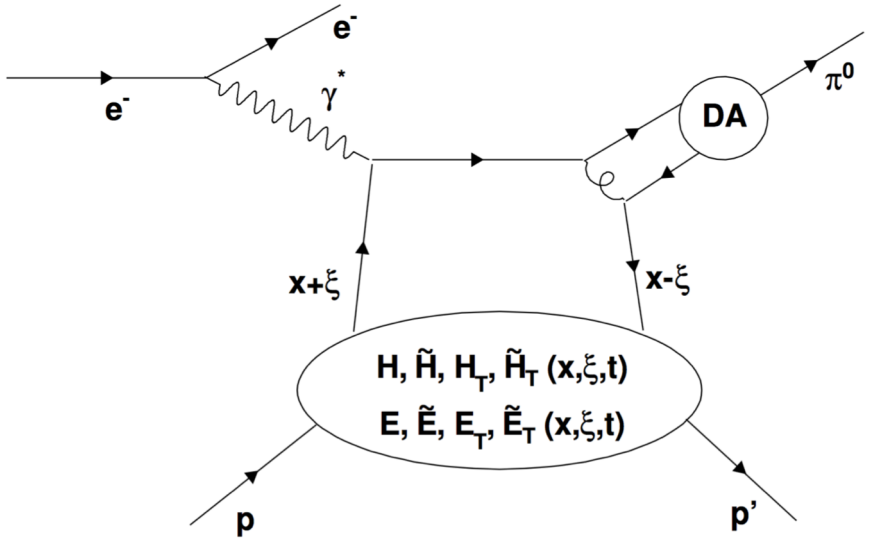
Recent π^0 e-production results

J. Roche (Ohio U.)

Award #1913170



- The soft structure of the hadron is described by
  - Chiral even GPDs, and
  - Chiral odd GPDs, aka transversity GPD_Ts.

- Factorization is only exact for longitudinal photons (Collins, Frankfurt, Strikman, 1997)
  Asymptotic QCD predicts $\sigma_L \sim Q^{-6}$ and $\sigma_T \sim Q^{-8}$

- The transverse photon induced amplitude can be effectively factorized and interpreted in term of transversity GPD_Ts (Liuti & Golstein (2009) and Goloskokov & Kroll (2011))

$$\sigma_{\mathbf{T}} = \frac{4\pi\alpha}{2\kappa}\frac{\mu_\pi^2}{\mathbf{Q^4}}\left((1-\xi^2)<\mathbf{H_T}>^2 - \frac{\mathbf{t'}}{\mathbf{8m^2}}<\bar{\mathbf{E}}_{\mathbf{T}}>^2\right)$$

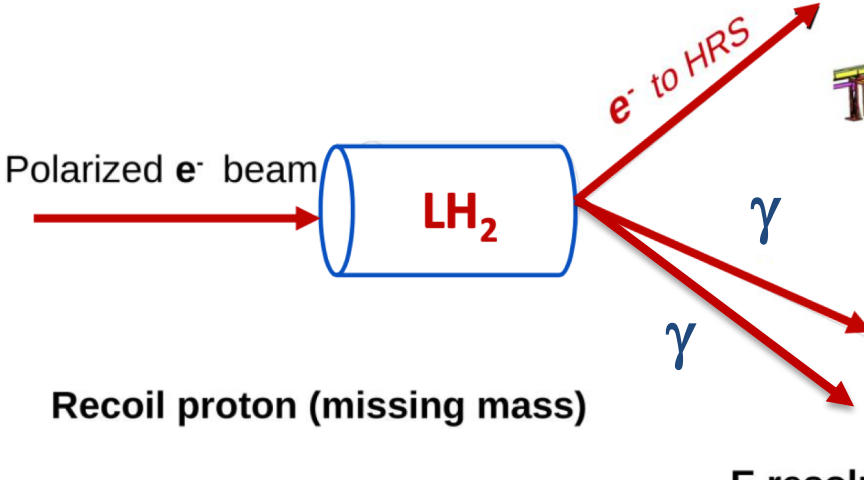
$$\sigma_{\mathbf{TT}} = \frac{4\pi\alpha}{2\kappa}\frac{\mu_\pi^2}{\mathbf{Q^4}}\frac{\mathbf{t'}}{\mathbf{8m^2}}<\bar{\mathbf{E}}_{\mathbf{T}}>^2$$

$$<\bar{\mathbf{E}}_{\mathbf{T}}> = \mathbf{2}\tilde{\mathbf{H}}_{\mathbf{T}} + \mathbf{E}_{\mathbf{T}}$$

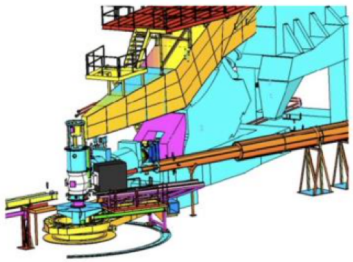
DVCS3@Hall A

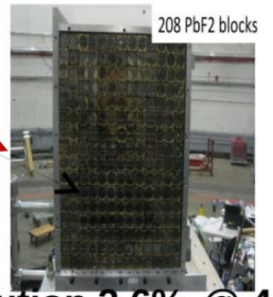
DVCS $ep \rightarrow ep\gamma$

π^0 production $ep \rightarrow ep\pi^0 \rightarrow ep\gamma\gamma$



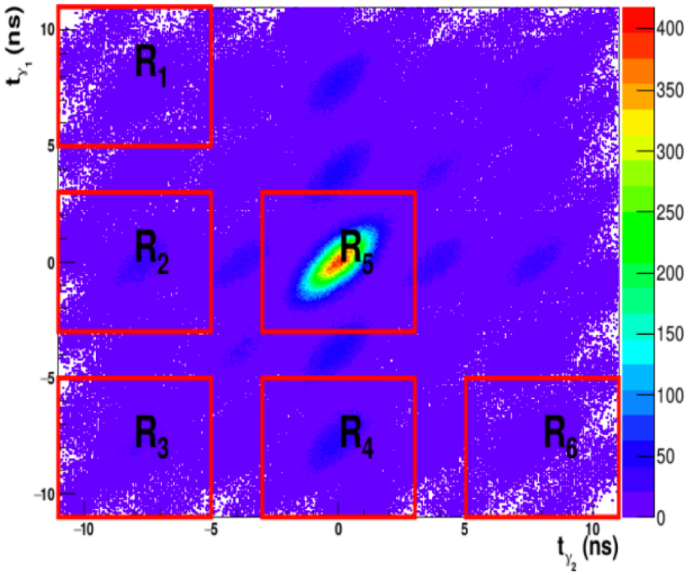
δP/P Resolution 10^{-4} @ 4.3 GeV



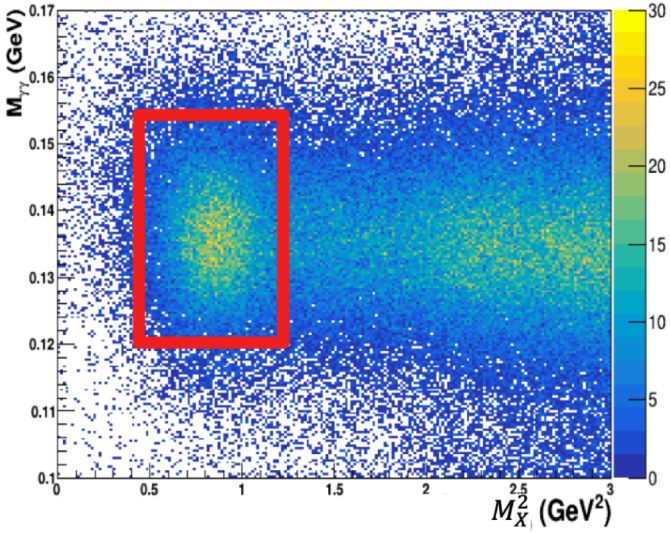


E resolution 3.6% @ 4.2 GeV

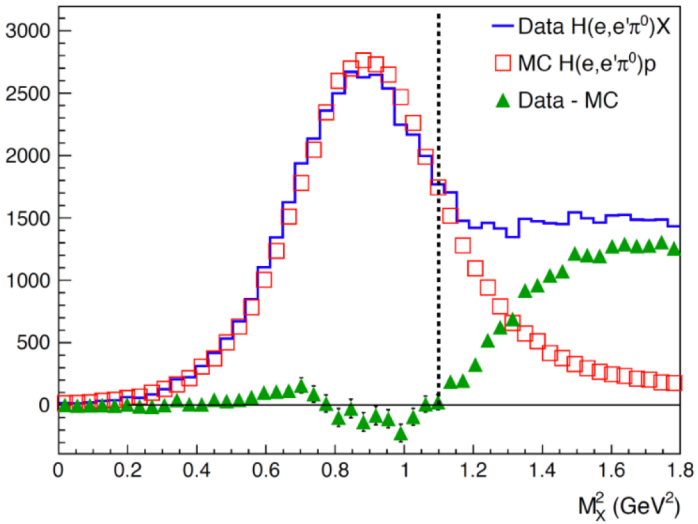
γγe coincidence time



γγ invariant mass



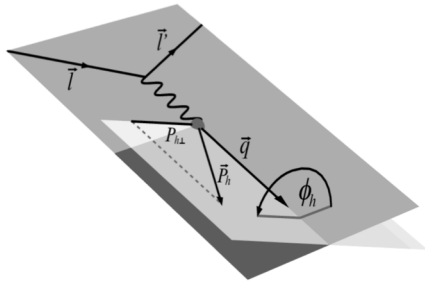
Missing mass squared

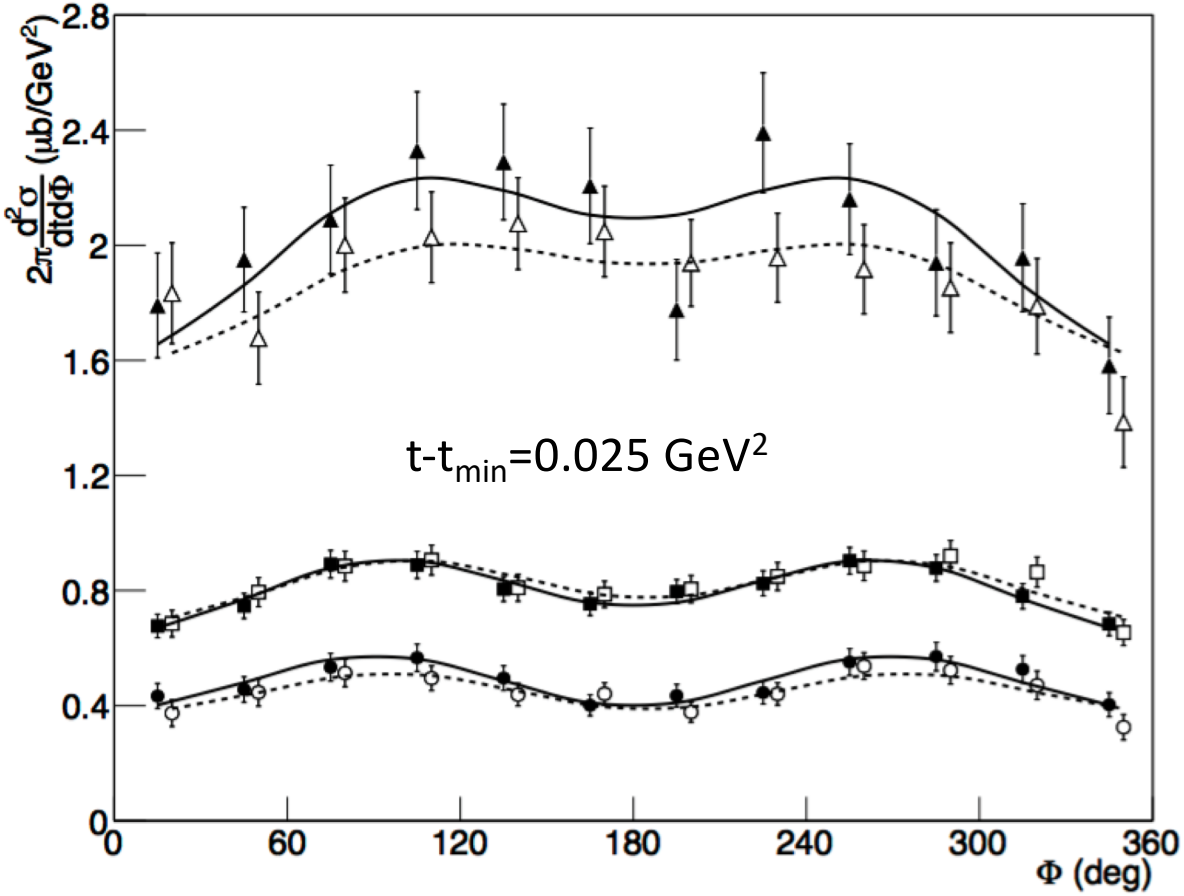


Missing mass squared

$$\frac{d^4\sigma}{dt d\phi dQ^2 dx_B} = \frac{1}{2\pi}\Gamma_{\gamma^*}(Q^2, x_B, E_e)\left[\frac{d\sigma_T}{dt} + \epsilon\frac{d\sigma_L}{dt} + \sqrt{2\epsilon(1+\epsilon)}\frac{d\sigma_{TL}}{dt}\cos(\phi) + \epsilon\frac{d\sigma_{TT}}{dt}\cos(2\phi)\right]$$

Setting	E (GeV)	Q^2 (GeV^2)	x_B	ϵ
2010-Kin1	(3.355 ; 5.55)	1.5	0.36	(0.52 ; 0.84)
2010-Kin2	(4.455 ; 5.55)	1.75	0.36	(0.65 ; 0.79)
2010-Kin3	(4.455 ; 5.55)	2	0.36	(0.53 ; 0.72)





DVCS2 @ Hall A

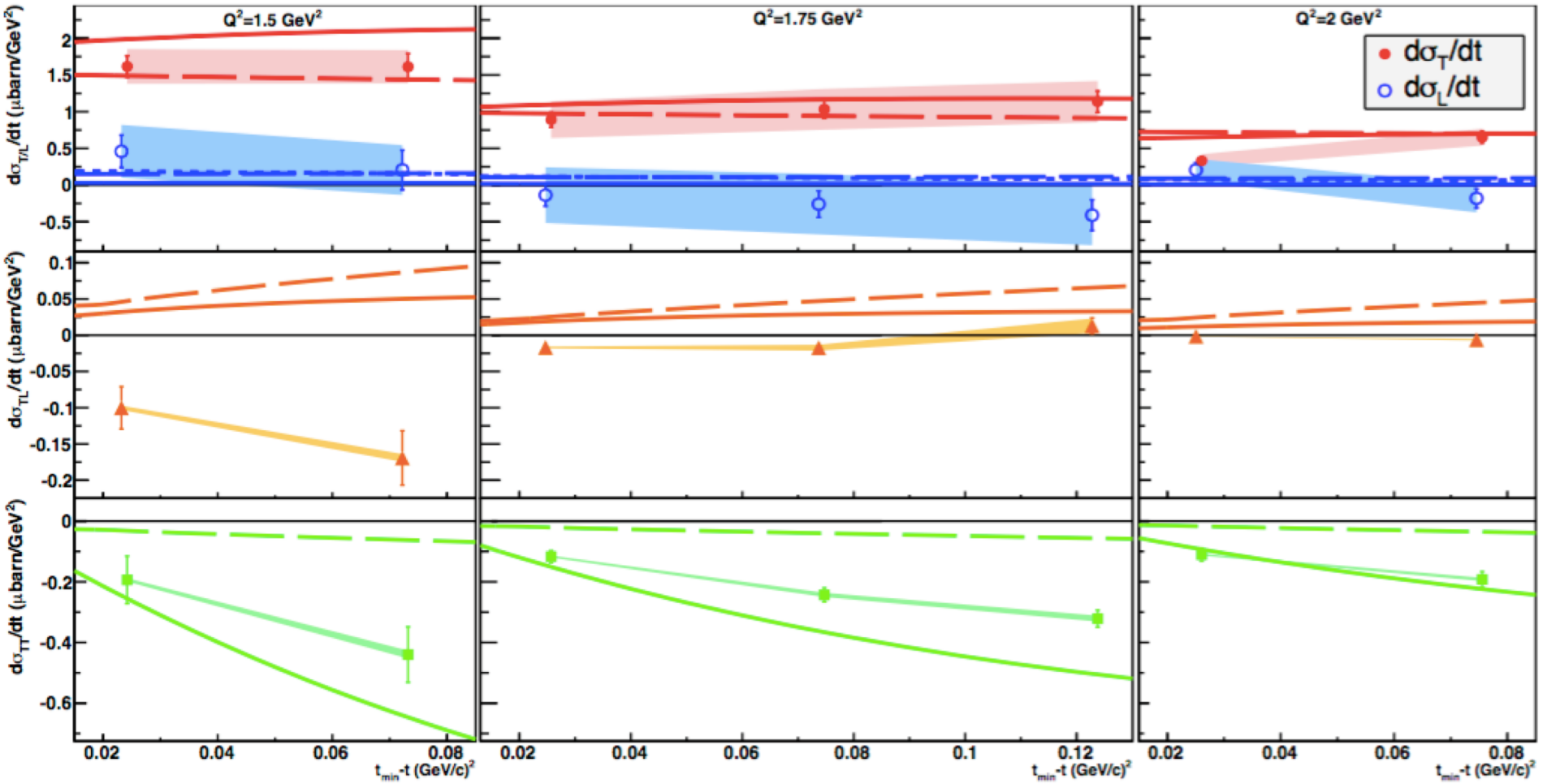
π^0 production

M. Defurne et al.

PRL 117, 26 (2016)

DVCS2@Hall A results: separated contributions using data taken with two beam energies

M. Defurne et al. PRL 117, 26 (2016)



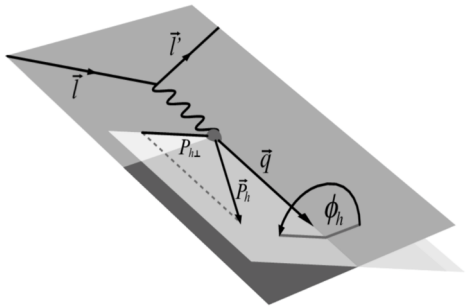
G. R. Goldstein, J. O. Hernandez, and S. Liuti, Phys.Rev. D84, 034007 (2011

S. Goloskokov and P. Kroll, Eur.Phys.J. A47, 112 (2011)

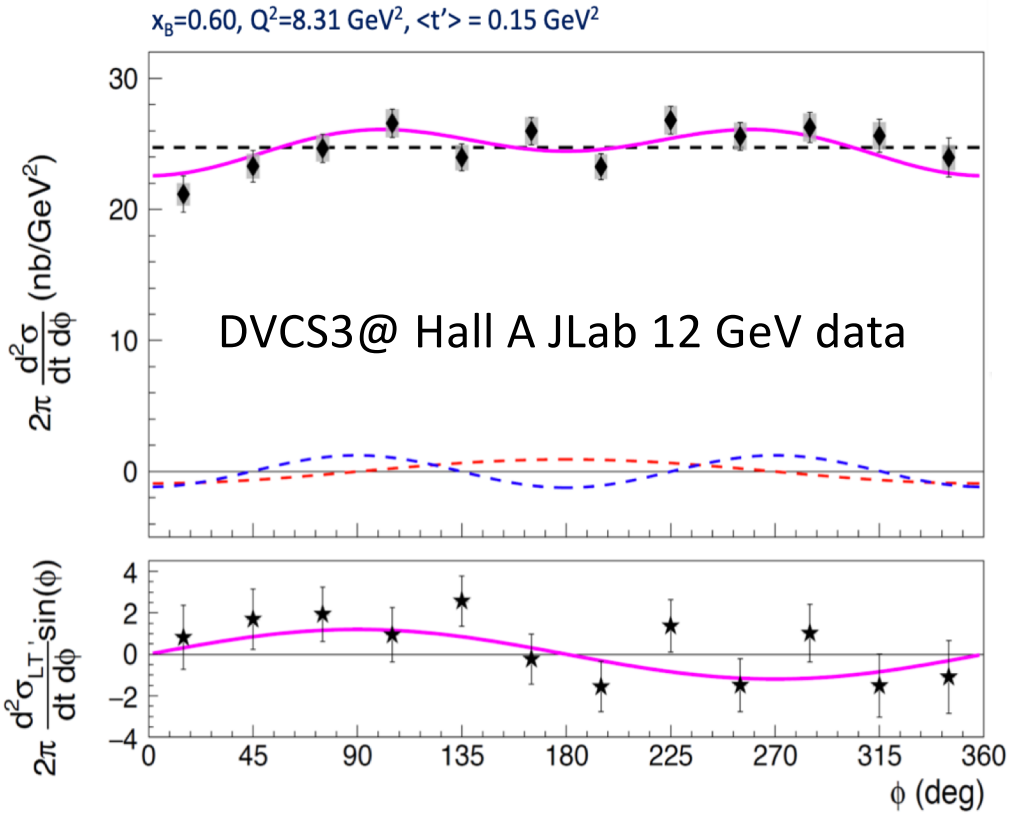
Small $d\sigma_L$, large $d\sigma_T$: transversity models agree with this

$d\sigma_{TL}$ sizeable => $d\sigma_L$ is small but not null

Structure functions from data taken with single beam energy



$$\frac{d^4\sigma}{dQ^2 dx_B dt d\phi} = \frac{1}{2\pi}\frac{d^2\,\Gamma_\gamma}{dQ^2 dx_B}(Q^2, x_B, E)$$
$$\left[\frac{d\sigma_T}{dt} + \epsilon\frac{d\sigma_L}{dt} + \sqrt{2\epsilon(1+\epsilon)}\frac{d\sigma_{LT}}{dt}\cos(\phi) + \epsilon\frac{d\sigma_{TT}}{dt}\cos(2\phi)\right.$$
$$\left. + h\sqrt{2\epsilon(1-\epsilon)}\frac{d\sigma_{LT'}}{dt}\sin(\phi)\right]$$



DVCS1@Hall A

E. Fuchey *et al*, Phys.Rev. C 83, 025201 (2011)

Q^2=1.9 - 2.5 GeV^2, x_B=0.36, -t : 0.1-0.3 GeV^2

CLAS π^0 and η (flavor separation!)

Bedlinskiy et al., Phys.Rev. C 95, 039901 (2014)

Q^2=1-4.6 GeV^2, x_B=0.1-0.6, -t : 0-2 GeV^2

DVCS3@Hall A (JLab 12)

M. Dlamini *et al*, arXiv:2011.11125, 2020

Q^2=3-8 GeV^2, x_B=0.36-0.6, -t : 0.1-0.6 GeV^2

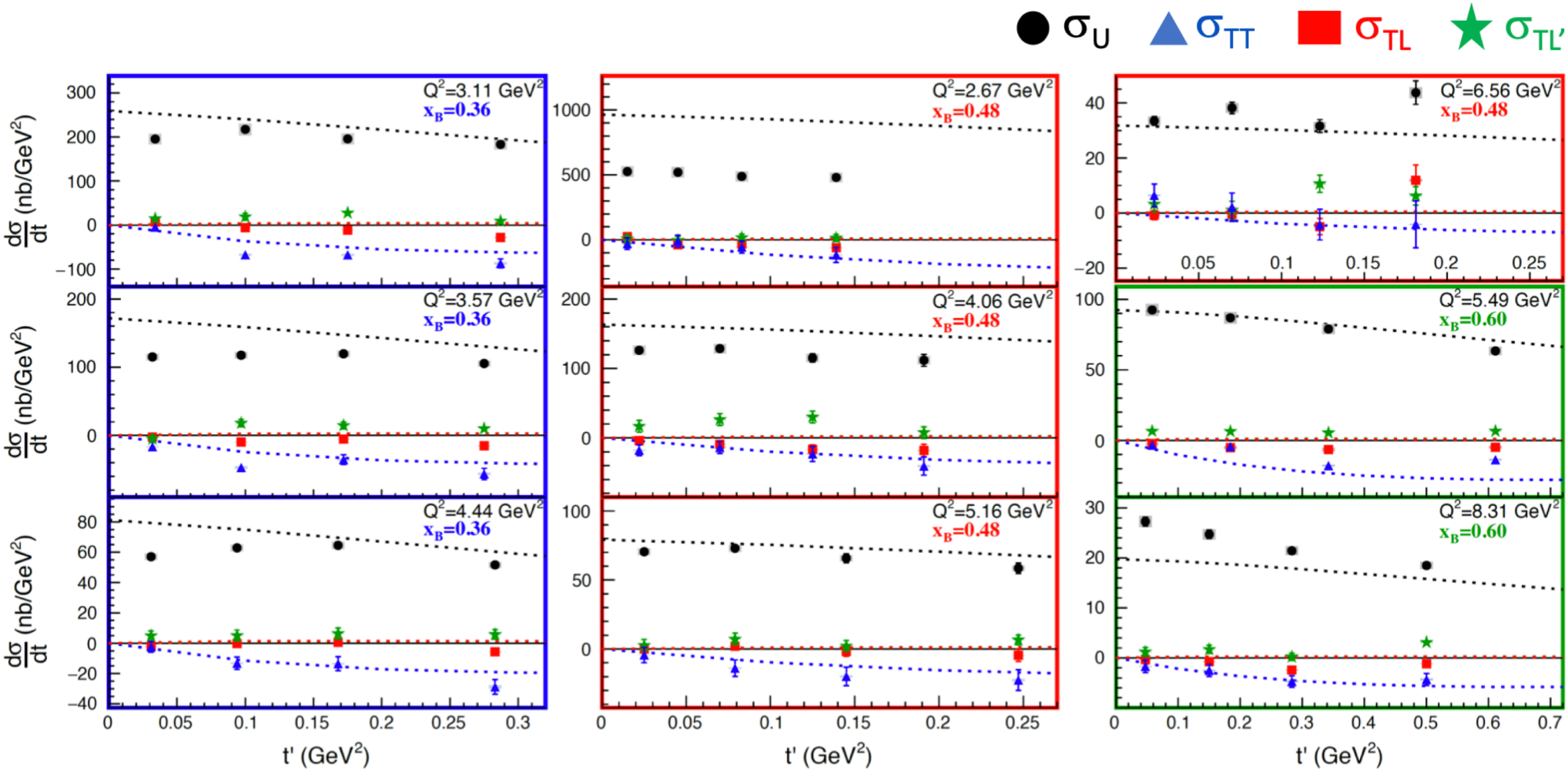
COMPASS

M.G. Alexeev at *al*., arXiv:1903.12030, 2019

Q^2=2 GeV^2, x_B=0.093, -t : 0.08-0.64 GeV^2

π^0 e-production from DVCS 3 Hall A (JLab 12)

M. Dlamini *et al*, arXiv:2011.11125, 2020



….. P. Kroll's model, private communication

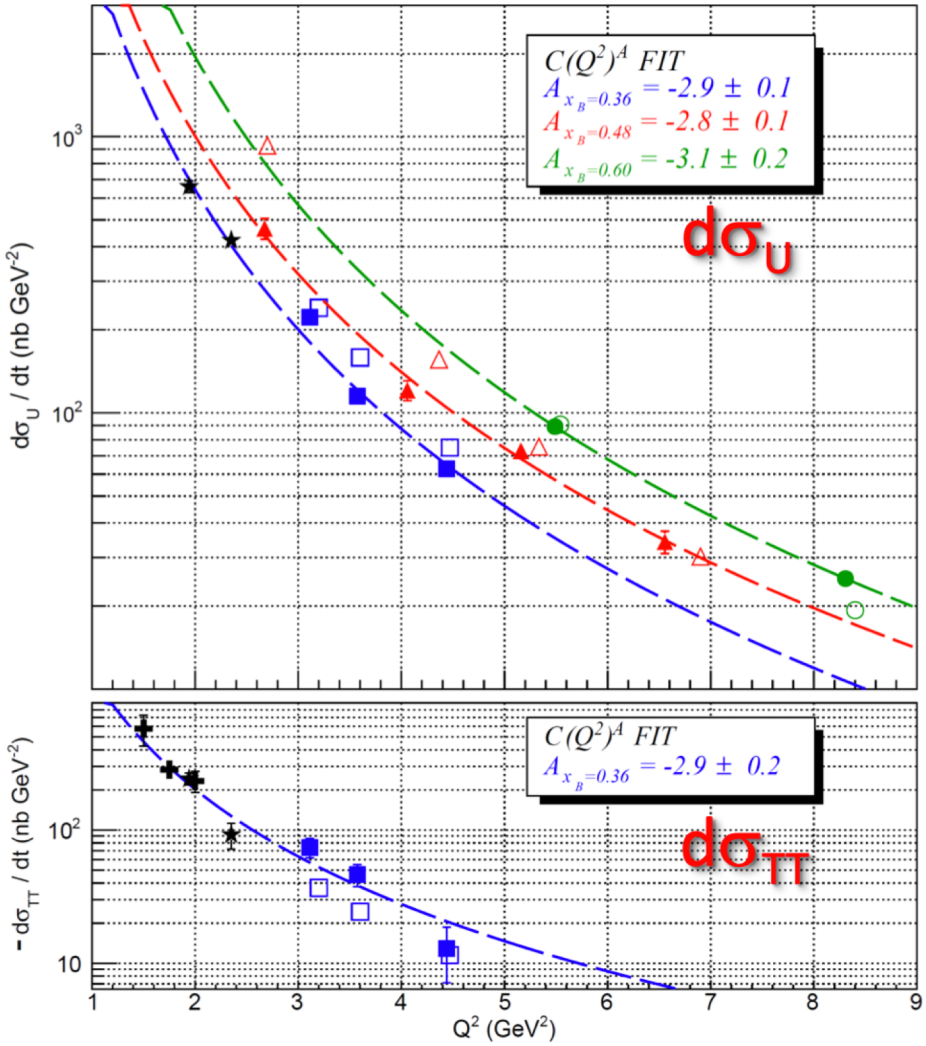
Transversity hypothesis qualitatively validated

(σ_U is dominated by σ_T)

x_B-label	0.36			0.48				0.60	
$\langle x_B \rangle$	0.36	0.36	0.36	0.48	0.45	0.46	0.46	0.59	0.60
E (GeV)	7.38	8.52	10.59	4.49	8.85	8.85	10.99	8.52	10.59
Q^2 (GeV^2)	3.11	3.57	4.44	2.67	4.06	5.16	6.56	5.49	8.31
W^2 (GeV^2)	6.51	7.29	8.79	3.81	5.62	6.67	8.32	4.58	6.46
$-t_{min}$ (GeV^2)	0.16	0.17	0.17	0.33	0.35	0.35	0.36	0.67	0.71
ϵ	0.61	0.62	0.63	0.51	0.71	0.55	0.52	0.66	0.50

π^0 e-production from DVCS 3 Hall A (JLab 12)

M. Dlamini *et al*, arXiv:2011.11125, 2020



- Open Markers: P. Kroll, private communications
- Solid Markers: Experimental measurements

<t'> = 0.1 GeV^2

- This work, x_B = 0.36
- This work, x_B = 0.48
- This work, x_B = 0.60
- E. Fuchey *et al*, Phys. Rev. C 83, 025201 (2011)
- M. Defurne *et al*, Phys. Rev. Lett. 117, 262001 (2016)

- $C(Q^2)^A$ fit to experimental results in different x_B
- Q^2 dependence closer to Q^{-6}, rather than Q^{-8} as expected for σ_T at high Q^2
- At this Q^2 and x_B coverage, the asymptotic limit is still far away

TABLE II. Combined (Q^2, t') fits $d\sigma_U = C(Q^2)^A \exp(-Bt')$ at each x_B setting. Only the data of this publication are included. The fits and error bars are based on the statistical and systematic uncertainties of the data, added in quadrature.

x_B	C	A	B	χ^2	№
	μb/GeV^2		GeV^{-2}	Total	d.o.f.
0.36	8.6 ± 1.4	3.3 ± 0.1	0.34 ± 0.17	18.	9
0.48	8.3 ± 0.9	2.9 ± 0.1	0.69 ± 0.3	27.	13
0.60	$20. \pm 4.$	3.1 ± 0.1	0.75 ± 0.1	1.6	5

Slide prepared by Po-Ju Lin (IJCLab-Orsay and CEA Saclay)

Outlook on π^0 e-production (in the valence region)

LT separated cross–section measurements show the dominance of transverse photon induced process.

- Unique opportunities for accessing the transversity GPDs from the transverse contribution.
- Data show longitudinal component small but not null.
- Using neutron and proton data allows for flavor separation (data not shown because of time constraints)
- More LT separated data coming with NPS@Hall C (Q^2= 2-10 GeV^2 and x_B=0.2-0.6).

Unseparated cross–section measurements

- DVCS3@Hall A large Q^2 span (2-8 GeV^2) shows the asymptotic limit is still far away : σ_U seem to be dominated by σ_T but varies as Q^{-6} instead of Q^{-8}
- CLAS 12 Experiment E12-06-118 : π^0 and η production at 11 GeV

Target and double spin asymmetries measurements (CLAS)

also support importance of the transverse contribution
(A. Kim, et al. (CLAS Collaboration), Phys. Lett. B 768 (2017) 168.)