Tomographic Transversity Distributions and Deeply Exclusive Meson Production

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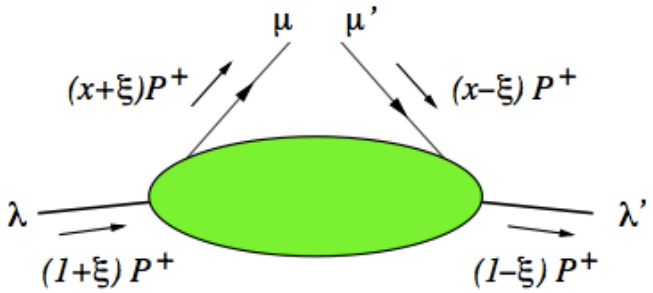
Generalized Parton Distributions



- GPDs are the functions of three kinematic variables: x, ξ and t
- There are 4 chiral even GPDs where partons do not flip helicity $H, \tilde{H}, E, \tilde{E}$
- 4 chiral odd GPDs flip the parton helicity

  $H_T, \tilde{H}_T, E_T, \tilde{E}_T$
- The chiral-odd GPDs (or transversity GPDs) are difficult to access since subprocesses with quark helicity-flip are suppressed

TransversityGPDs

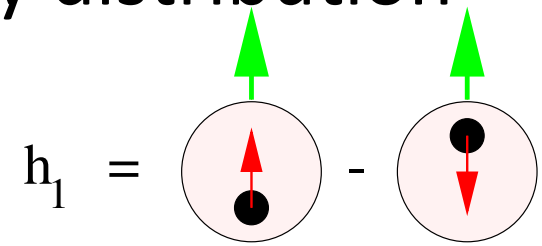
- Very little known about the transversity GPDs
- Anomalous tensor magnetic moment

$$\kappa_T = \int_{-1}^{+1} dx\ \bar{E}_T(x, \xi, t = 0)$$

- (Compare with anomalous magnetic moment)

$$\kappa = \int_{-1}^{+1} dx\ E(x, \xi, t = 0) = F_2(t = 0)$$

- Transversity distribution $H_T^q(x, 0, 0) = h_1^q(x)$



The transversity describes the distribution of transversely polarized quarks in a transversely polarized nucleon

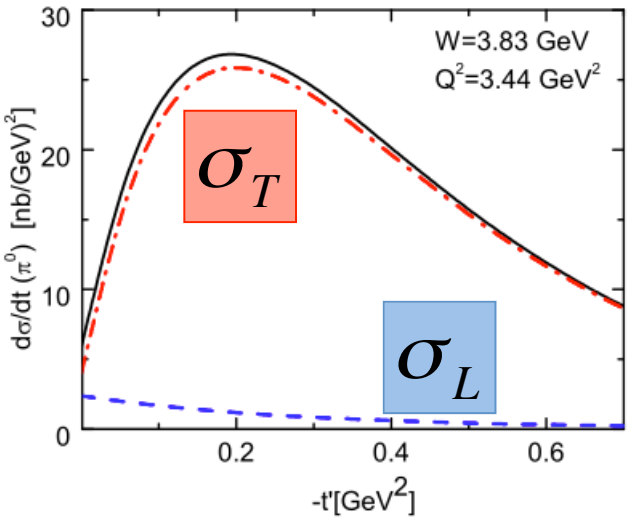
$ep \rightarrow ep\pi^0$

Structure functions and GPDs

$$\frac{d^4\sigma}{dQ^2 dx_B dt d\phi_\pi} = \Gamma(Q^2, x_B, E)\frac{1}{2\pi}(\sigma_T + \epsilon\sigma_L + \epsilon\cos 2\phi_\pi \sigma_{TT} + \sqrt{2\epsilon(1+\epsilon)}\cos\phi_\pi \sigma_{LT})$$

$$\sigma_T = \frac{4\pi\alpha_e}{2\kappa}\frac{\mu_\pi^2}{Q^4}[(1-\xi^2)|\langle H_T\rangle|^2 - \frac{t'}{8m^2}|\langle \bar{E}_T\rangle|^2]$$

$$\sigma_{TT} = \frac{4\pi\alpha_e}{2\kappa}\frac{\mu_\pi^2}{Q^4}\frac{t'}{8m^2}|\langle \bar{E}_T\rangle|^2$$



Transversity GPD model

S. Goloskokov and P. Kroll

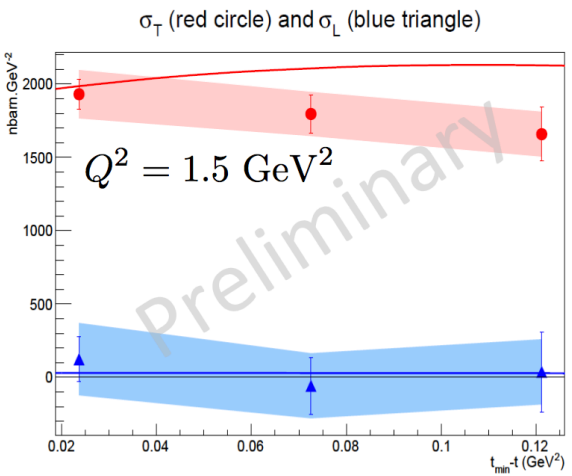
S. Liuti and G. Goldstein

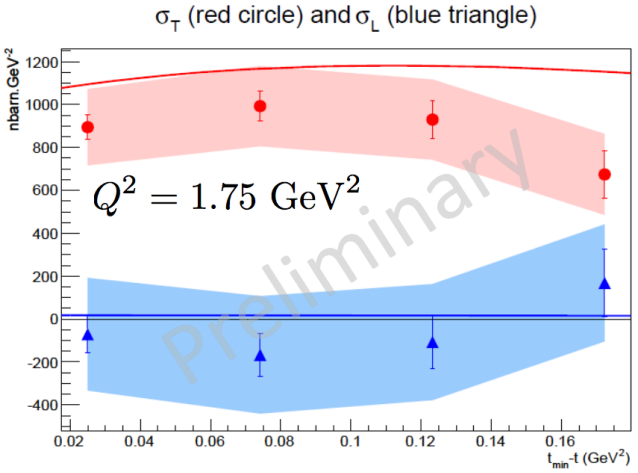
- $\sigma_L << \sigma_T$
- t-dependence at $t=t_{min}$ is determined by the interplay between H_T and $\bar{E}_T = 2\tilde{H}_T + E_T$

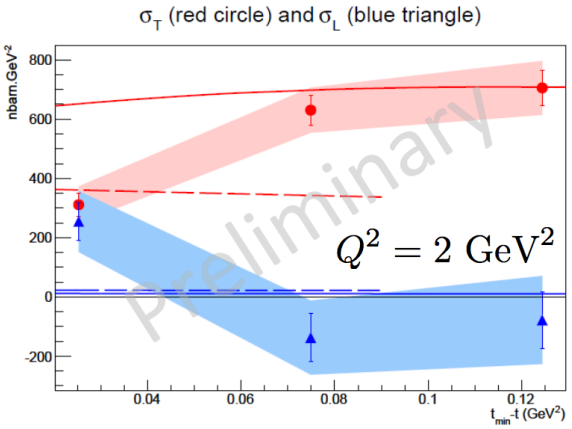
Rosenbluth separation σ_T and σ_L Hall-A Jefferson Lab

σ_T

σ_L







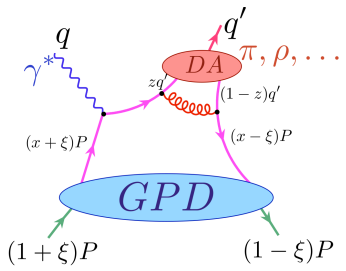
- Experimental **proof** that the transverse π^0 cross section is dominant!
- It opens the direct way to study the transversity GPDs in pseudoscalar exclusive production

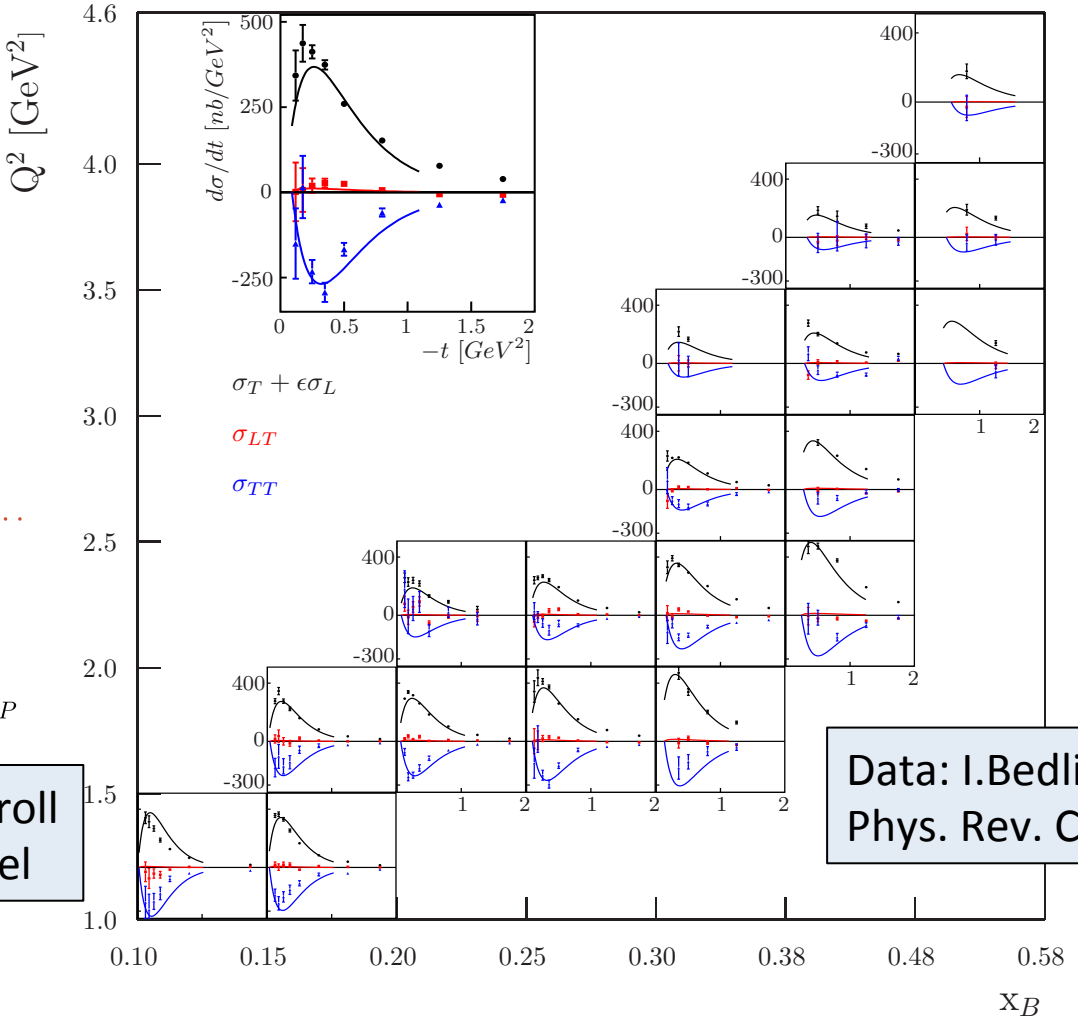
Hall-A, Phys.Rev.Lett. **117**,262001(2016)

π^0 Structure Functions

$(\sigma_T + \varepsilon\sigma_L)$ σ_{TT} σ_{LT}

$$\gamma^* p \rightarrow p\pi^0$$





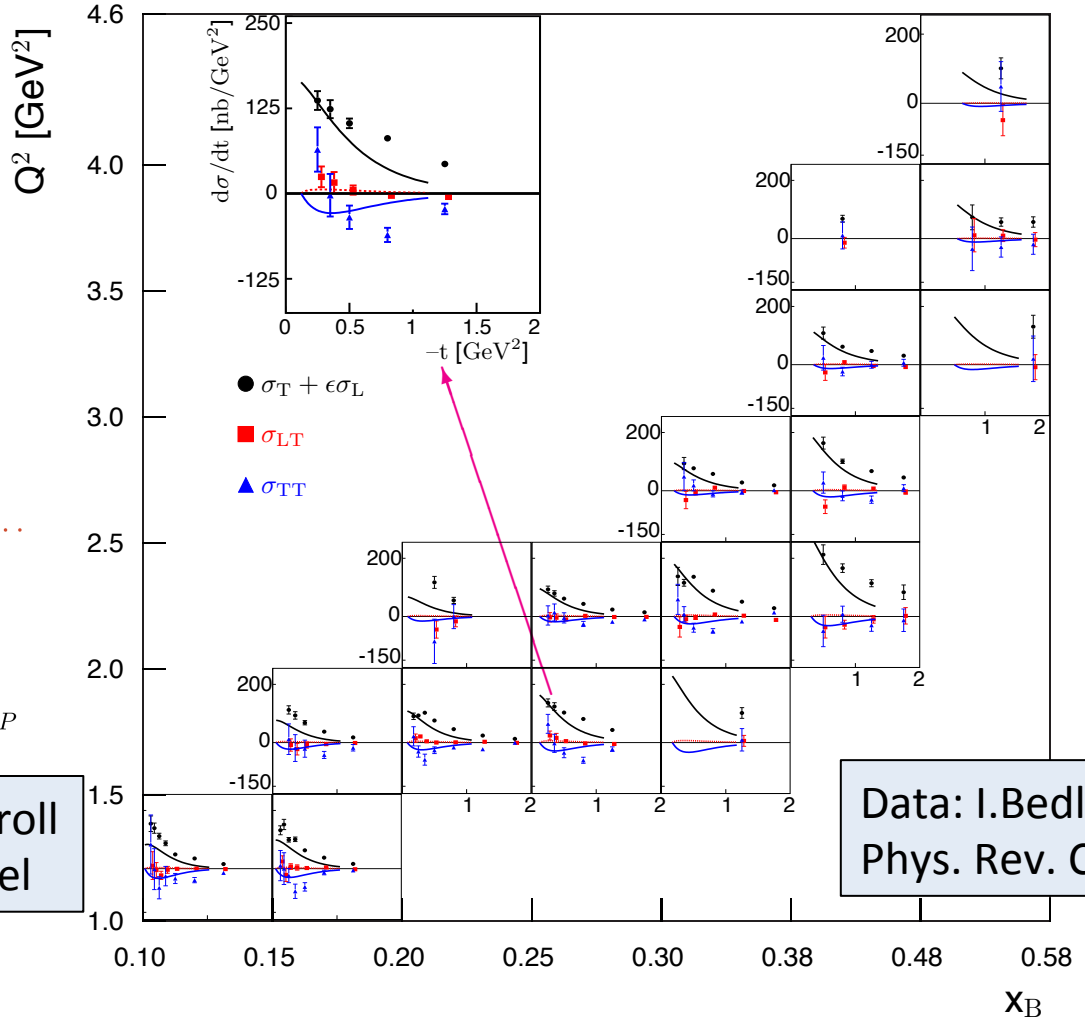
Curves: Goloskokov, Kroll
Transversity GPD model

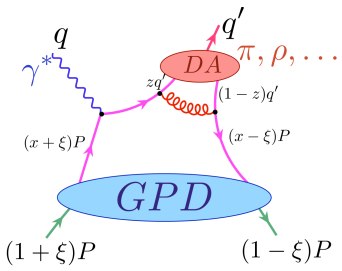
Data: I.Bedlinskiy et al. (CLAS)
Phys. Rev. C 95, 039901 (2014)

η Structure Functions

$(\sigma_T + \varepsilon\sigma_L)$ σ_{TT} σ_{LT}

$\gamma^* p \rightarrow p\eta$

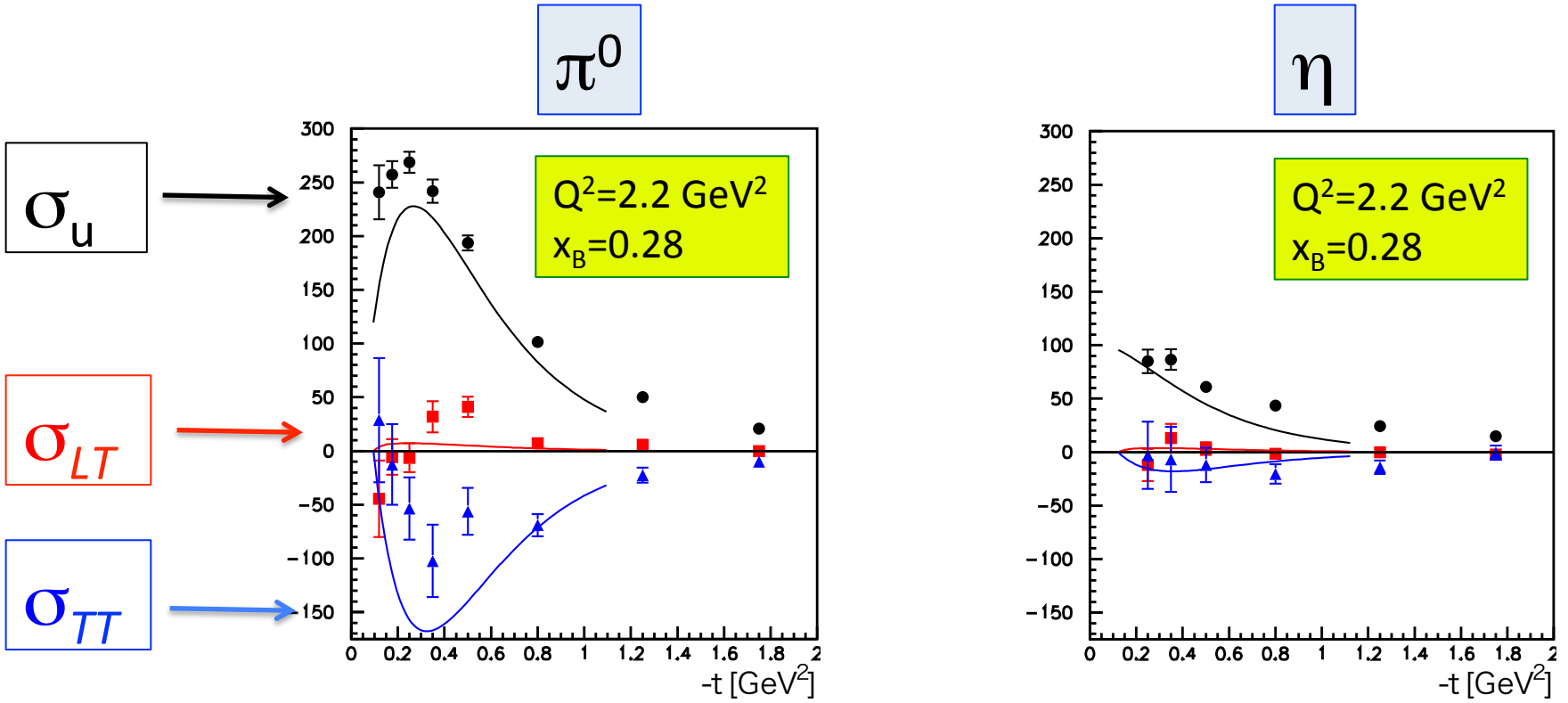




Curves: Goloskokov, Kroll
Transversity GPD model

Data: I.Bedlinskiy et al. (CLAS)
Phys. Rev. C **95**, 035202 (2017)

Comparison π^0/η

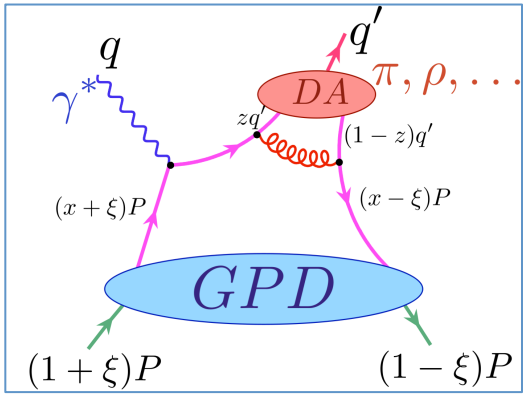


- $\sigma_U=\sigma_T+\varepsilon\sigma_L$ drops by a factor of 2.5 for η
- σ_{TT} drops by a factor of 10
- The GK GPD model (curves) follows the experimental data
- The statement about the transversity GPD dominance in the pseudoscalar electroproduction becomes more solid with the inclusion of η data

Structure functions and GPDs

$$\frac{d\sigma_T}{dt} = \frac{4\pi\alpha}{2k'}\frac{\mu_P^2}{Q^8}\left[(1-\xi^2)\,|\langle H_T\rangle|^2 - \frac{t'}{8m^2}|\langle \bar{E}_T\rangle|^2\right]$$

$$\frac{d\sigma_{TT}}{dt} = \frac{4\pi\alpha}{k'}\frac{\mu_P^2}{Q^8}\frac{t'}{16m^2}|\langle \bar{E}_T\rangle|^2$$



Goloskokov, Kroll
Transversity GPD model

$$|\langle \bar{E}_T\rangle^{\pi,\eta}|^2 = \frac{k'}{4\pi\alpha}\frac{Q^8}{\mu_P^2}\frac{16m^2}{t'}\frac{d\sigma_{TT}^{\pi,\eta}}{dt}$$

$$|\langle H_T\rangle^{\pi,\eta}|^2 = \frac{2k'}{4\pi\alpha}\frac{Q^8}{\mu_P^2}\frac{1}{1-\xi^2}\left[\frac{d\sigma_T^{\pi,\eta}}{dt} + \frac{d\sigma_{TT}^{\pi,\eta}}{dt}\right]$$

$$\langle H_T\rangle = \Sigma_\lambda \int_{-1}^{1} dx M(x,\xi,Q^2,\lambda) H_T(x,\xi,t)$$

$$\langle \bar{E}_T\rangle = \Sigma_\lambda \int_{-1}^{1} dx M(x,\xi,Q^2,\lambda) \bar{E}_T(x,\xi,t)$$

The brackets <F> denote the convolution of the elementary process with the GPD F (generalized form factors)

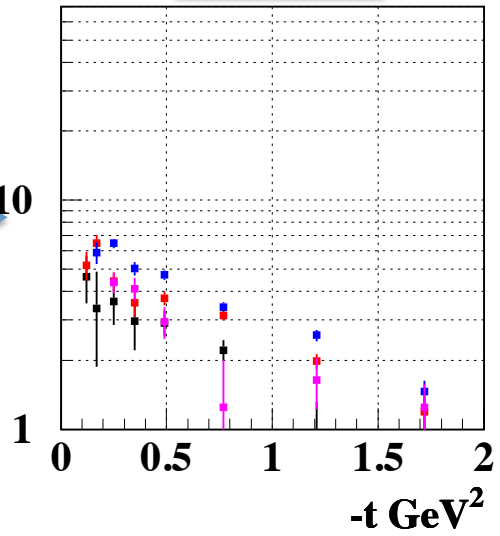
- Taking into account that the transversity GPDs dominance, that is supported by Jlab data, $\sigma_L << \sigma_T$ we have direct access to the generalized form factors for π and η production.

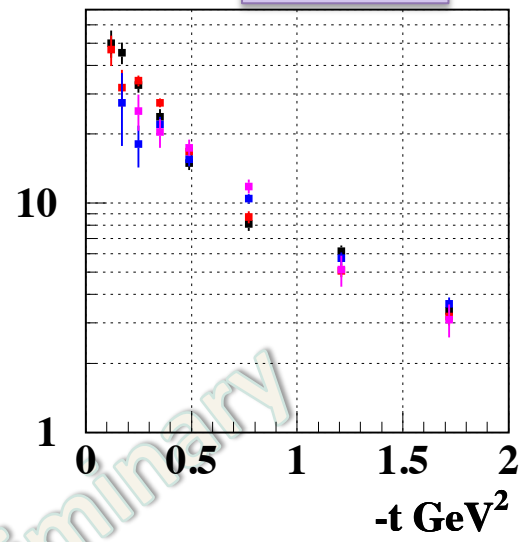
$$\bar{E}_T = 2\tilde{H}_T + E_T$$

Generalized Form Factors

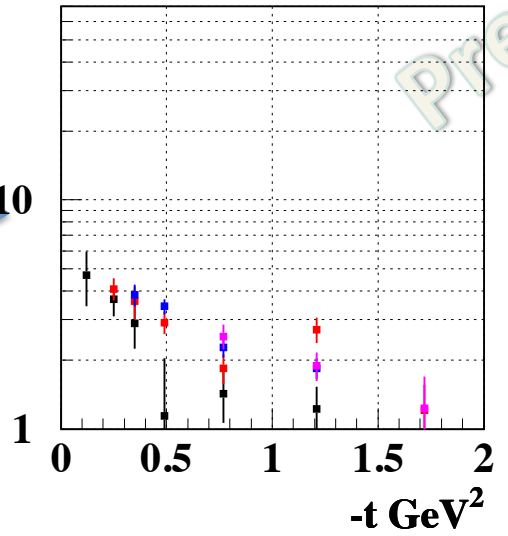
$|\langle H_T \rangle|$ $|\langle \bar{E}_T \rangle|$

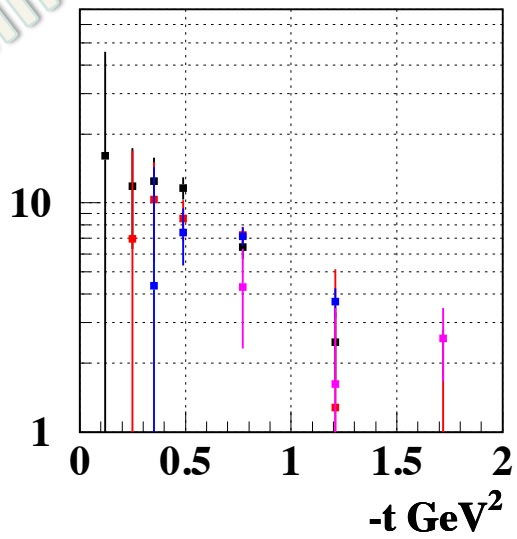
π^0





η

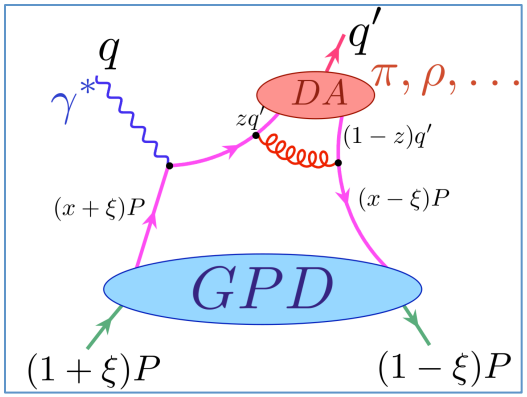


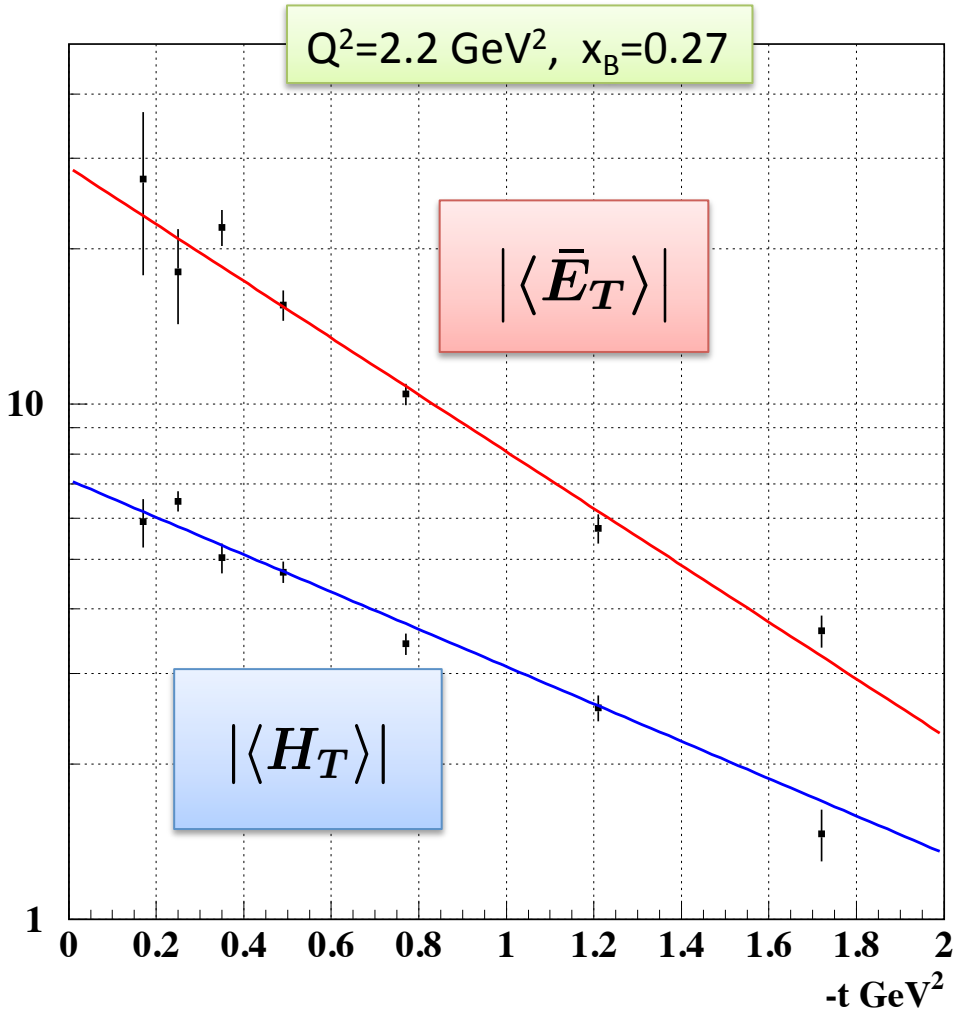


Q^2 GeV²	x_B
1.2	0.15
1.8	0.22
2.2	0.27
2.7	0.34

- $\bar{E}_T > H_T$ for π^0 and η
- t-dependence is steeper for $\bar{E}_T$ than for H_T
- Estimation of the systematic uncertainties connected with the used approximation is in progress

π^0 Generalized Form Factors





- $\bar{E}_T$ > H_T
- t-dependence is steeper for $\bar{E}_T$ than for H_T

- $|\langle E_T, H_T \rangle| \sim \exp(bt)$
- $b(E_T)$=1.27 GeV^{-2}
- $b(H_T)$=0.98 GeV^{-2}

VK, arXiv:1601.04367

GPD Flavor Decomposition

$$H_T^\pi = \frac{1}{3\sqrt{2}}[2H_T^u + H_T^d]$$
$$H_T^\eta = \frac{1}{\sqrt{6}}[2H_T^u - H_T^d]$$

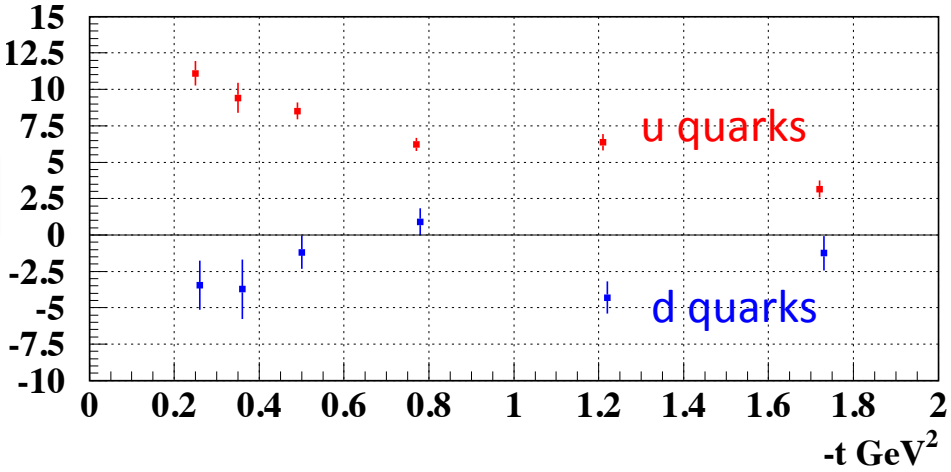
$$H_T^u = \frac{3}{2\sqrt{2}}[H_T^\pi + \sqrt{3}H_T^\eta]$$
$$H_T^d = \frac{3}{\sqrt{2}}[H_T^\pi - \sqrt{3}H_T^\eta]$$

Similar expressions for $\bar{E}_T$

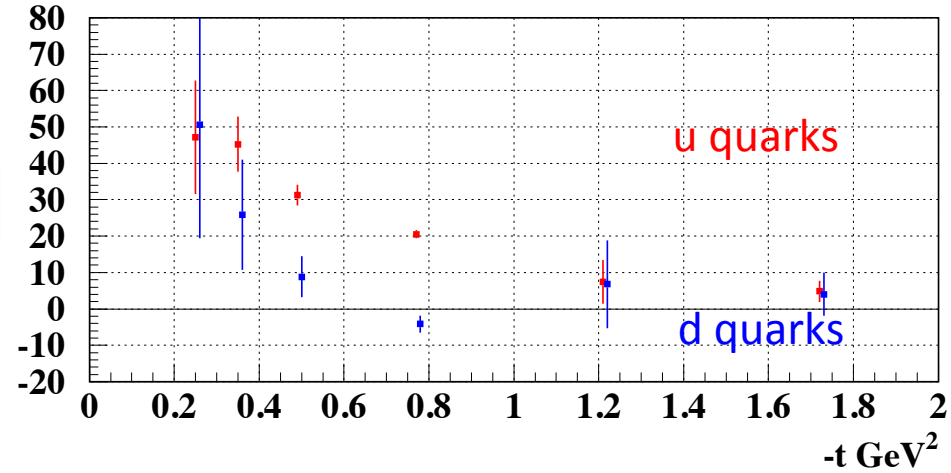
- GPDs appear in different flavor combinations for π^0 and η
- The combined π^0 and η data permit the flavor (u and d) decomposition for GPDs H_T and $\bar{E}_T$
- The u/d decomposition was done under simple assumption that the relative phase between u and d is 0.

Flavor Decomposition of the Transversity GPDs

$\langle H_T \rangle$



$\langle \bar{E}_T \rangle$



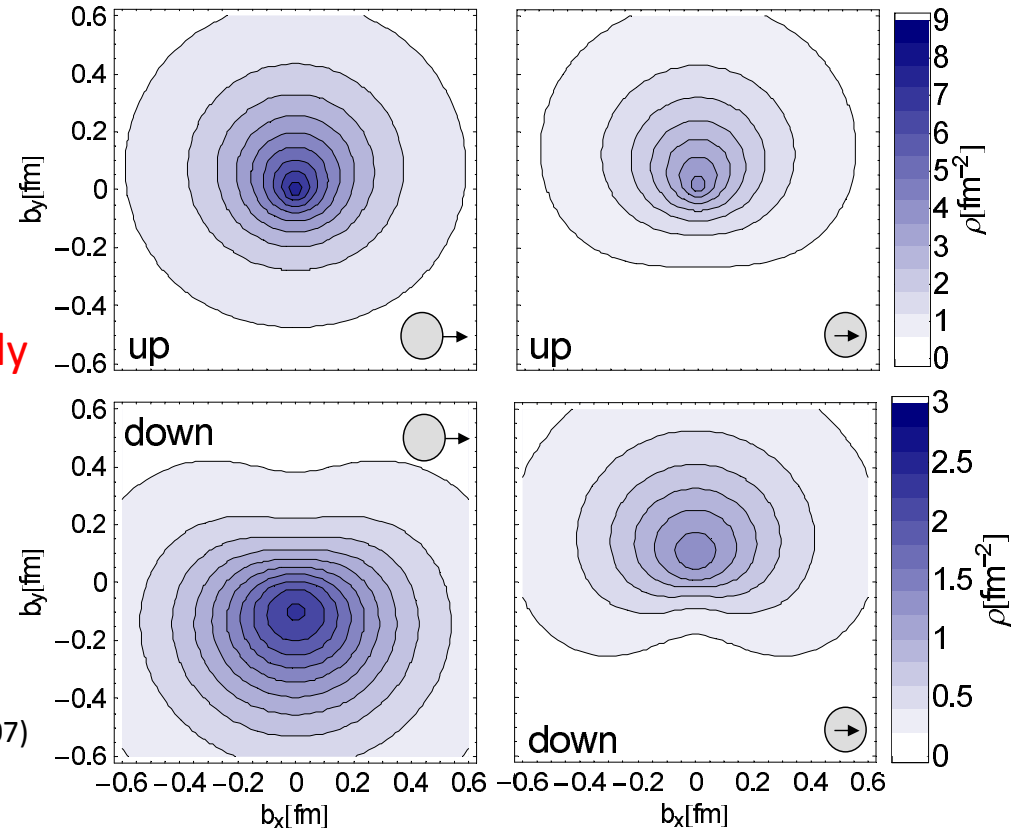
Q^2=1.8 GeV², x_B=0.22

- $\langle H_T \rangle^u$ and $\langle H_T \rangle^d$ have different signs for u and d-quarks in accordance with the transversity function h_1 (Anselmino et al.)
- $\langle \bar{E}_T \rangle^d$ and $\langle \bar{E}_T \rangle^u$ seem to have the same signs
- Decisions shown with positive values of u-quark's GPDs only

Preliminary

Transverse Densities for u and d Quarks in the Nucleon

Strong distortions for unpolarized quarks in transversely polarized nucleon



Strong distortions for transversely polarized quarks in an unpolarized nucleon

Lattice Calculations
Phys.Rev.Lett. 98,222001(2007)

Described by E

Described by $\bar{E}_T=2H_T+\tilde{E}_T$

Gockeler et al, hep/lat/0612032

Future developments

- CLAS12 first experiments will take data with proton and neutron targets
- Cross sections:

$$ep \rightarrow ep(\pi^0, \eta)$$

$$en \rightarrow en(\pi^0, \eta)$$

- Asymmetries:

$$\mathcal{A}_{LU} - beam\ spin$$

$$\mathcal{A}_{UL} - target\ spin$$

$$\mathcal{A}_{LL} - beam\ target$$

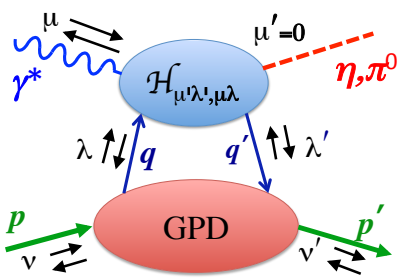
Summary

- Jlab π^0 and η data supports the dominance of the transversity GPDs H_T and $\bar{E}_T$ in the processes of the pseudoscalar meson electroproduction

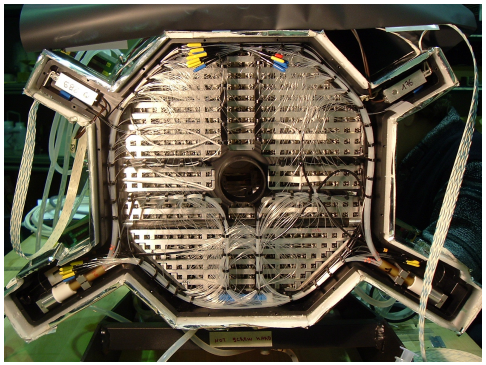
- The generalized form factors $\langle H_T \rangle$ and $\langle \bar{E}_T \rangle$ are directly connected to the structure functions σ_T and σ_{TT} within handbag approach

- The combined π^0 and η data will provide the way for the flavor decomposition of transversity GPD

The End


μ
μ′=0
γ*
$\mathcal{H}_{\mu'\lambda',\mu\lambda}$
η,π0
λ
q
q′
λ′
p
GPD
p′
ν
ν′

+



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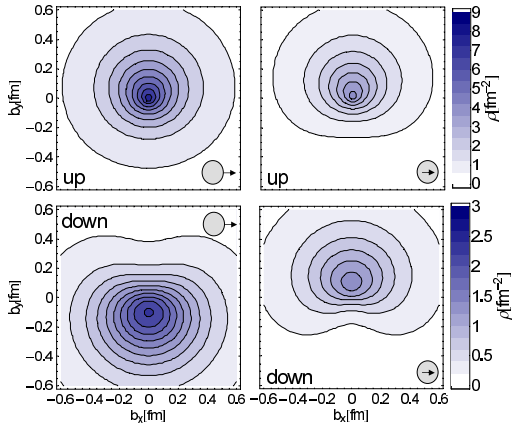
up
up
down
down
b_y[fm]
b_x[fm]
ρ[fm^{-2}]