π^0 Single Spin Asymmetries Measurements with CLAS

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19 October 2009

LNF-INFN

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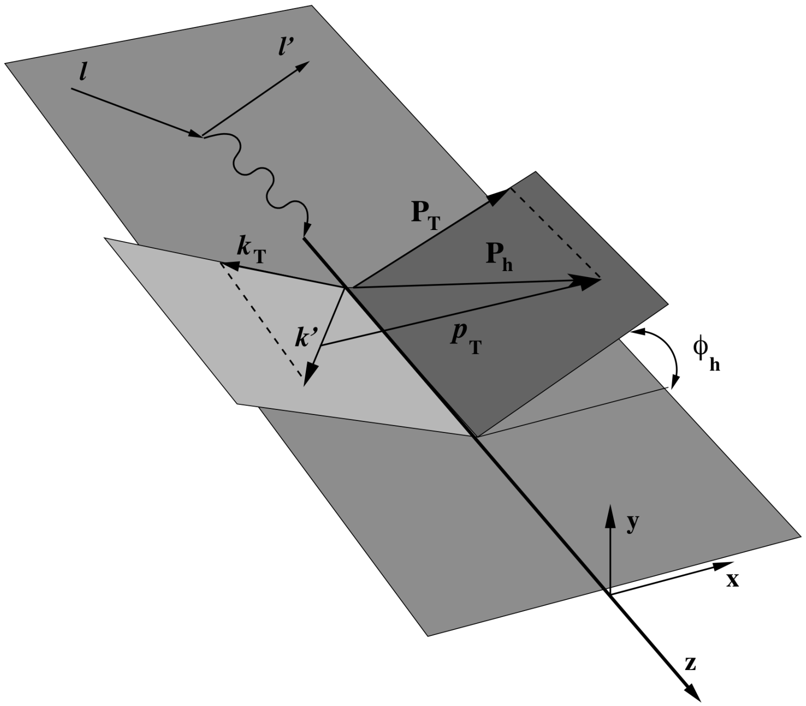
Semi-Inclusive DIS kinematics



$$\nu = E - E'$$

$$Q^2 = (l - l')^2$$

$$y = \nu / E$$

$$x = Q^2 / 2M\nu$$

$$z = E_h / \nu$$

$$\frac{d\sigma_N}{dx dy dz d\phi_h dP_T} \sim DF(x, k_T) \times \sigma(y) \times FF(z, P_T)$$

distribution functions :
probability to find a **u**-quark with a momentum fraction ***x***

fragmentation function
probability for a **u**-quark to produce a hadron with momentum fraction ***z***

BSA in SIDIS

$$\frac{d\sigma_{UU}}{dxdydz} \sim \left(1 - y + y^2/2\right) f_1(x) D_1(z)$$

$$\frac{d\sigma_{LU}}{dxdydzd\phi_h dP_{h\perp}^2} = \lambda_e \sqrt{y\left(1-y\right)} \sin\phi_h F_{LU}^{\sin\phi_h}$$

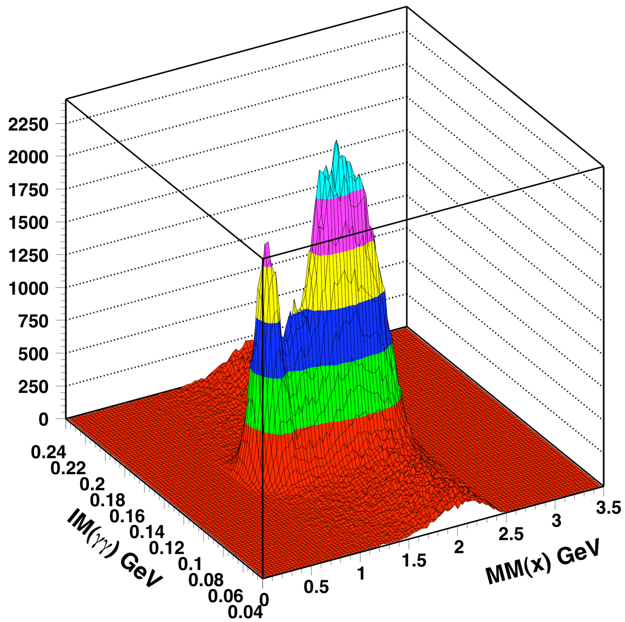
$D_1, H^{\perp}$ - Leading twist fragmentation functions

$e, g^{\perp}$ - Higher twist distribution functions

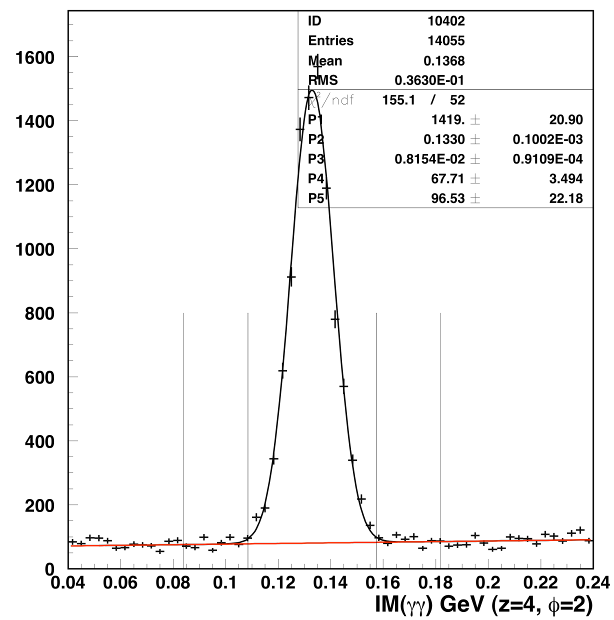
$$A_{LU}^{\sin(\phi_h)} = \frac{\sigma_{LU}}{\sigma_{UU}} \sim f\left(y\right)$$

$$f\left(y\right) = \frac{y\sqrt{1-y}}{1 - y + y^2/2}$$

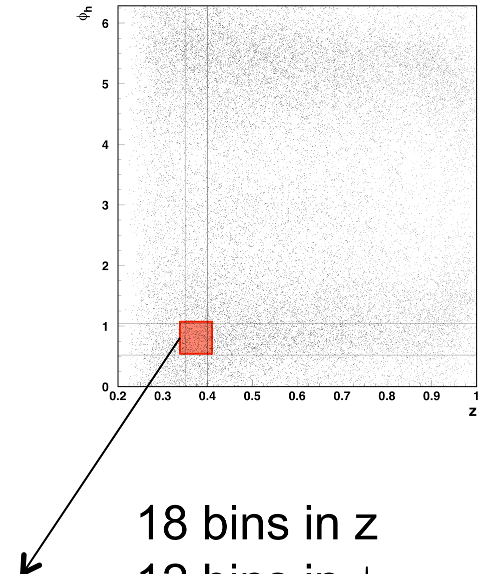
π^0 identification



Much higher background for semi-inclusive events than for exclusive.



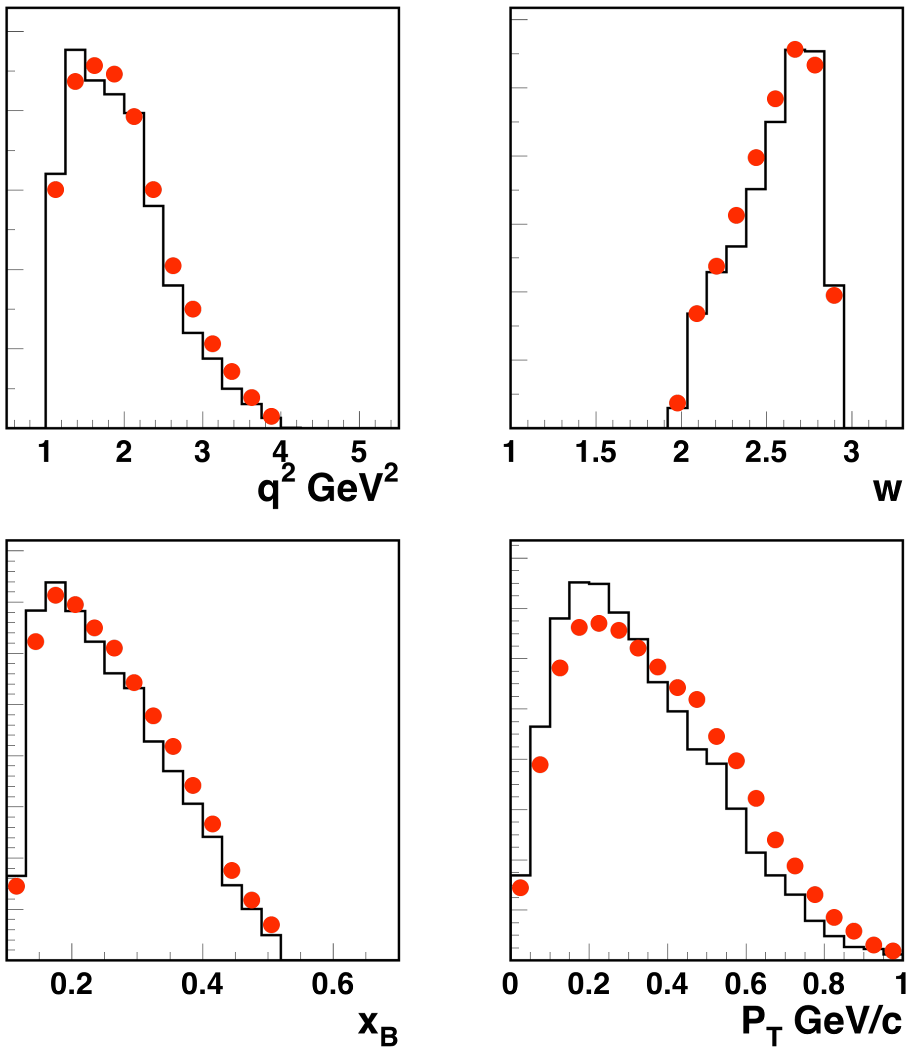
For each bin IM(γγ) have been fitted with Gaussian plus linear polinom.

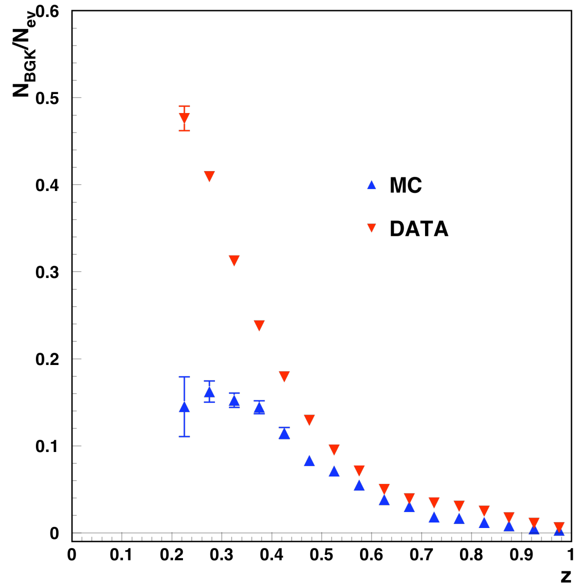


18 bins in z

12 bins in ϕ_h

CLAS data vs LUND MC

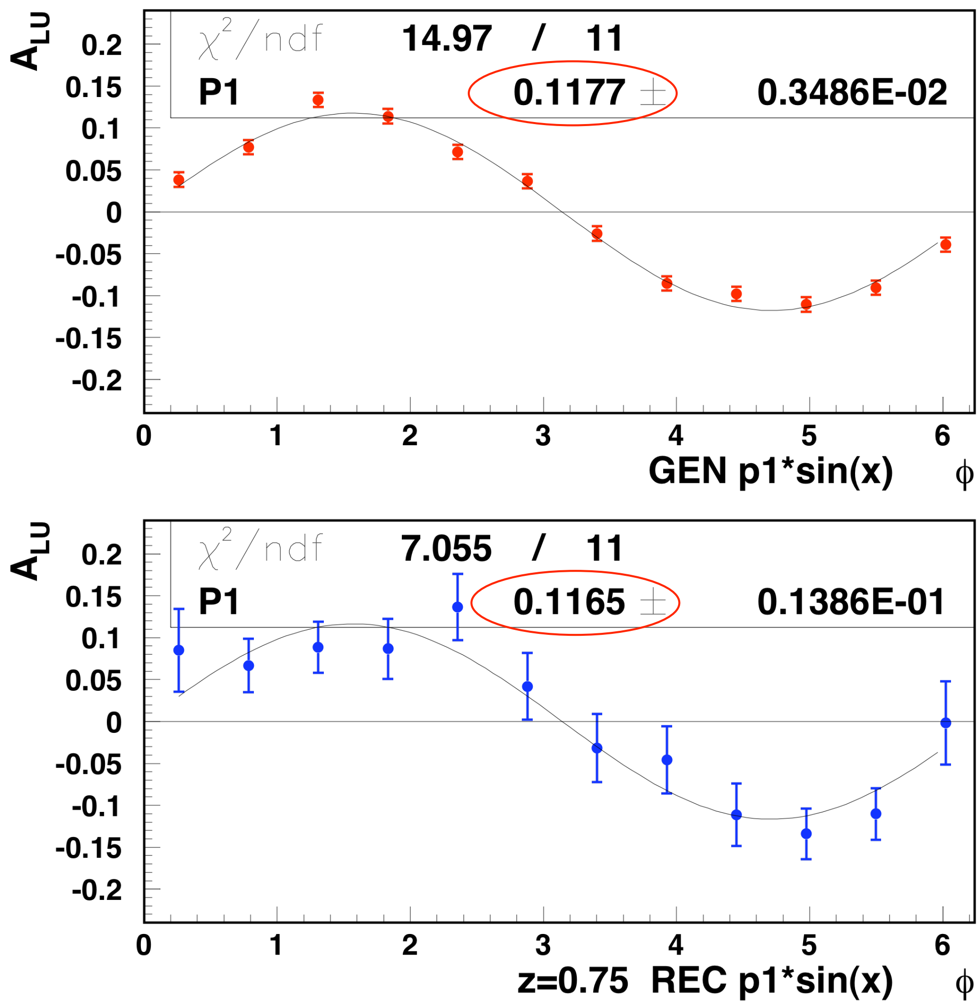




More background in data than in MC especially at low z.

MC-simulation based on LUND provides satisfactory description of the data

Asymmetry extraction and fitting in MC

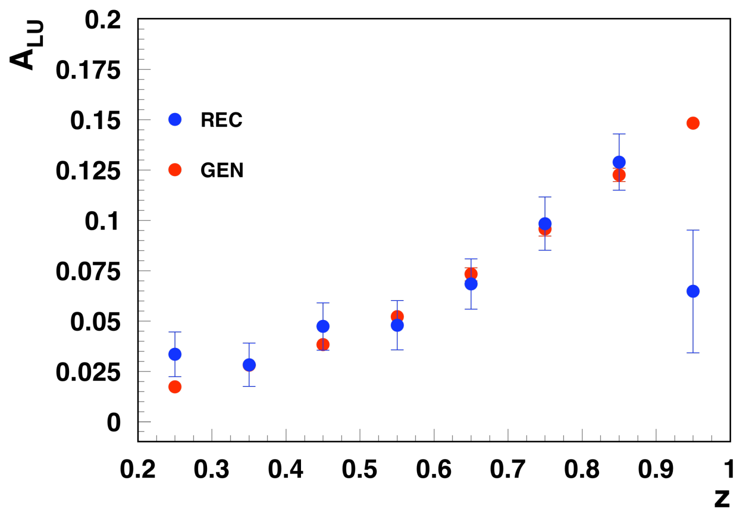


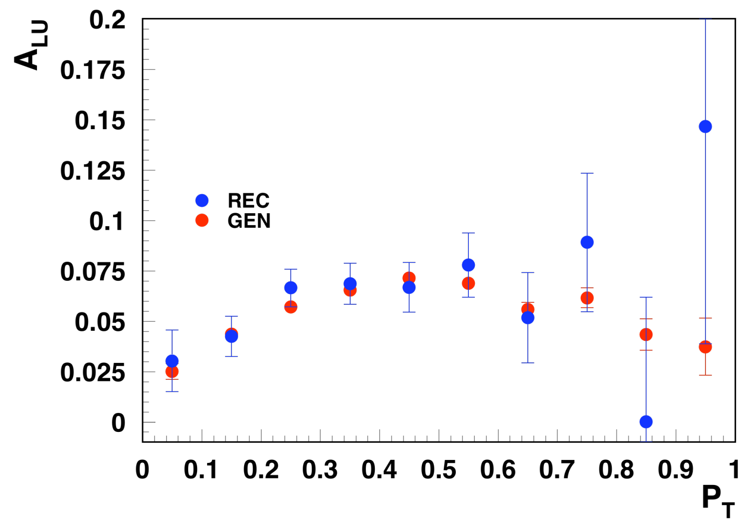
$$A_{LU} = \frac{1}{P}\frac{N^{+} - N^{-}}{N^{+} + N^{-}}$$

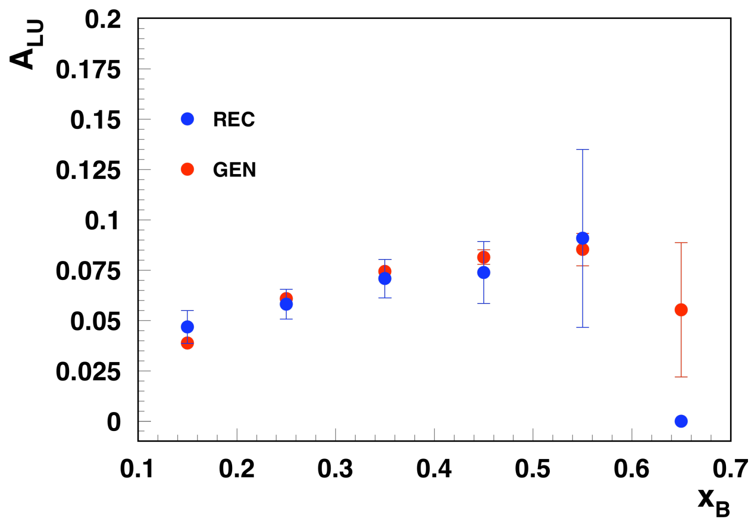
Asymmetry extraction procedure checked on MC and there is no acceptance effects on asymmetry.

MC reconstructed moments is consistent with generated

Asymmetry in MC

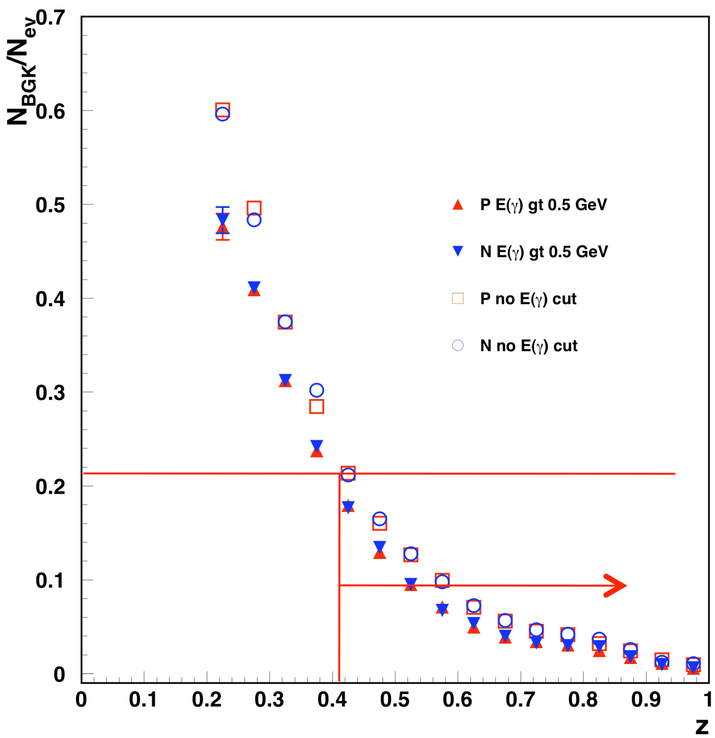


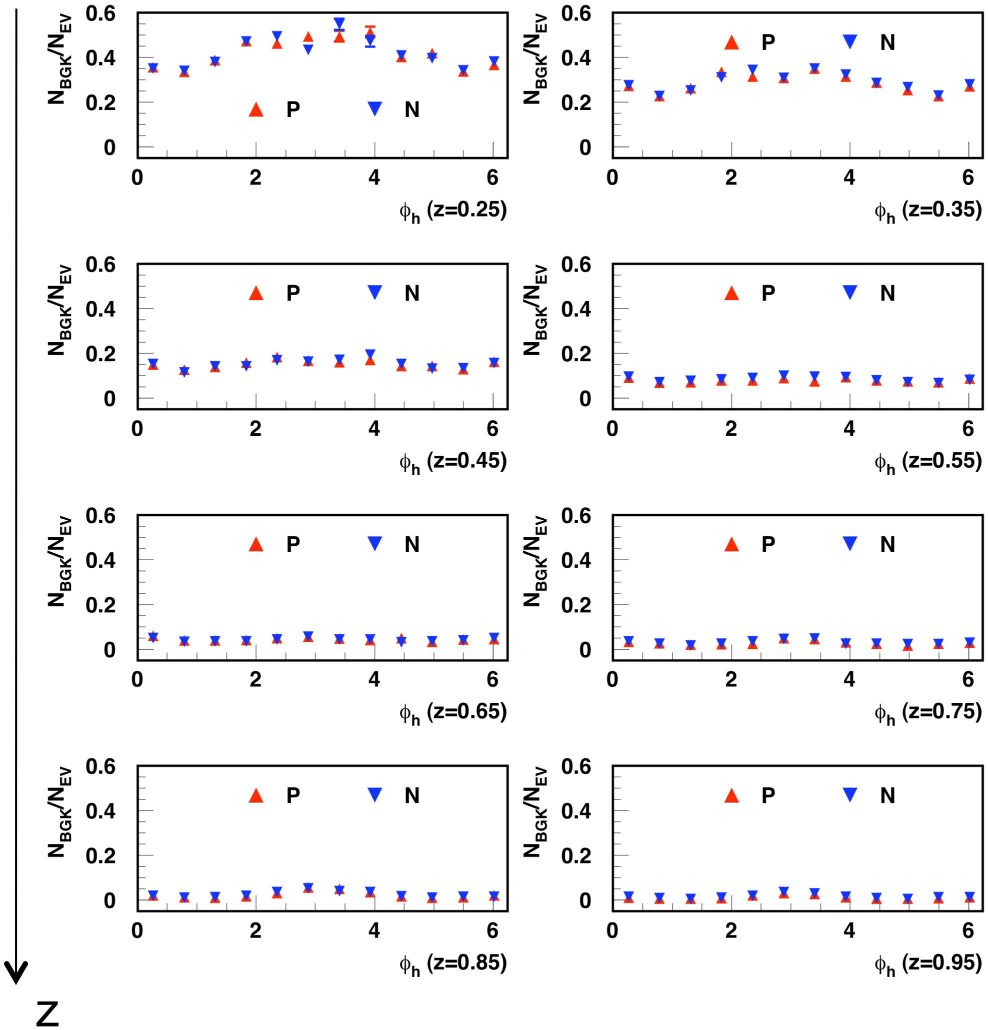




Asymmetry extraction procedure checked on MC and there is no acceptance effects on asymmetry.

Background behavior





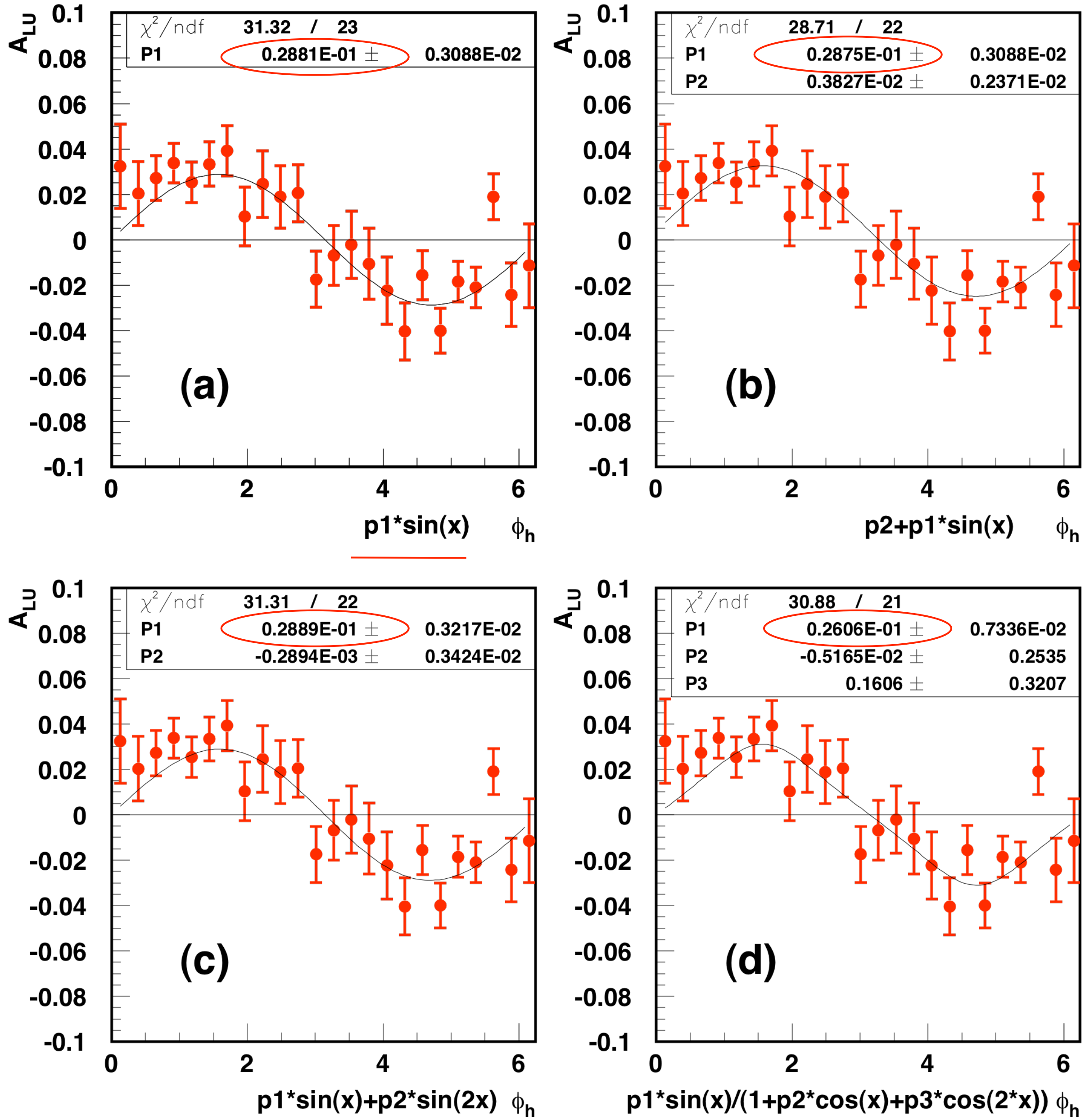
E(γ)>0.5 GeV cut decrease background fraction significantly

Background fraction is independent on helicity
Background fraction decreases with increase of z

Asymmetry extraction and fitting

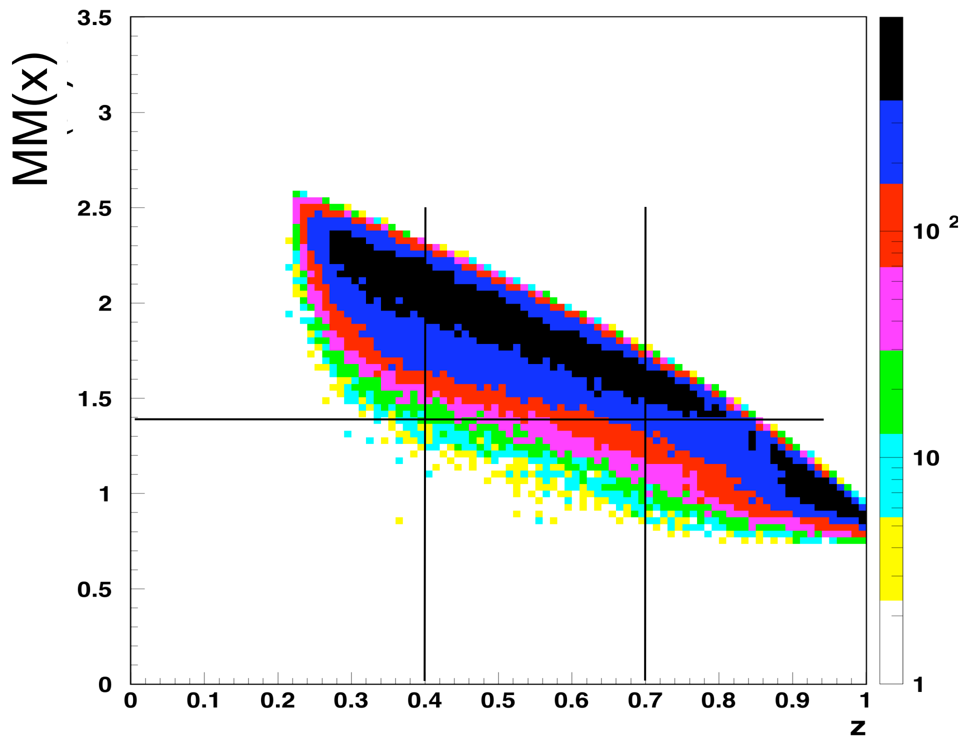
$$A_{LU} = \frac{1}{P}\frac{N^+ - N^-}{N^+ + N^-}$$

0.4<*z*<0.7
MM(*x*)>1.2GeV
E(γ)>0.5 GeV



Fit with 24 bins in ϕ_h provide consistent values for four different functions.

Missing mass vs z

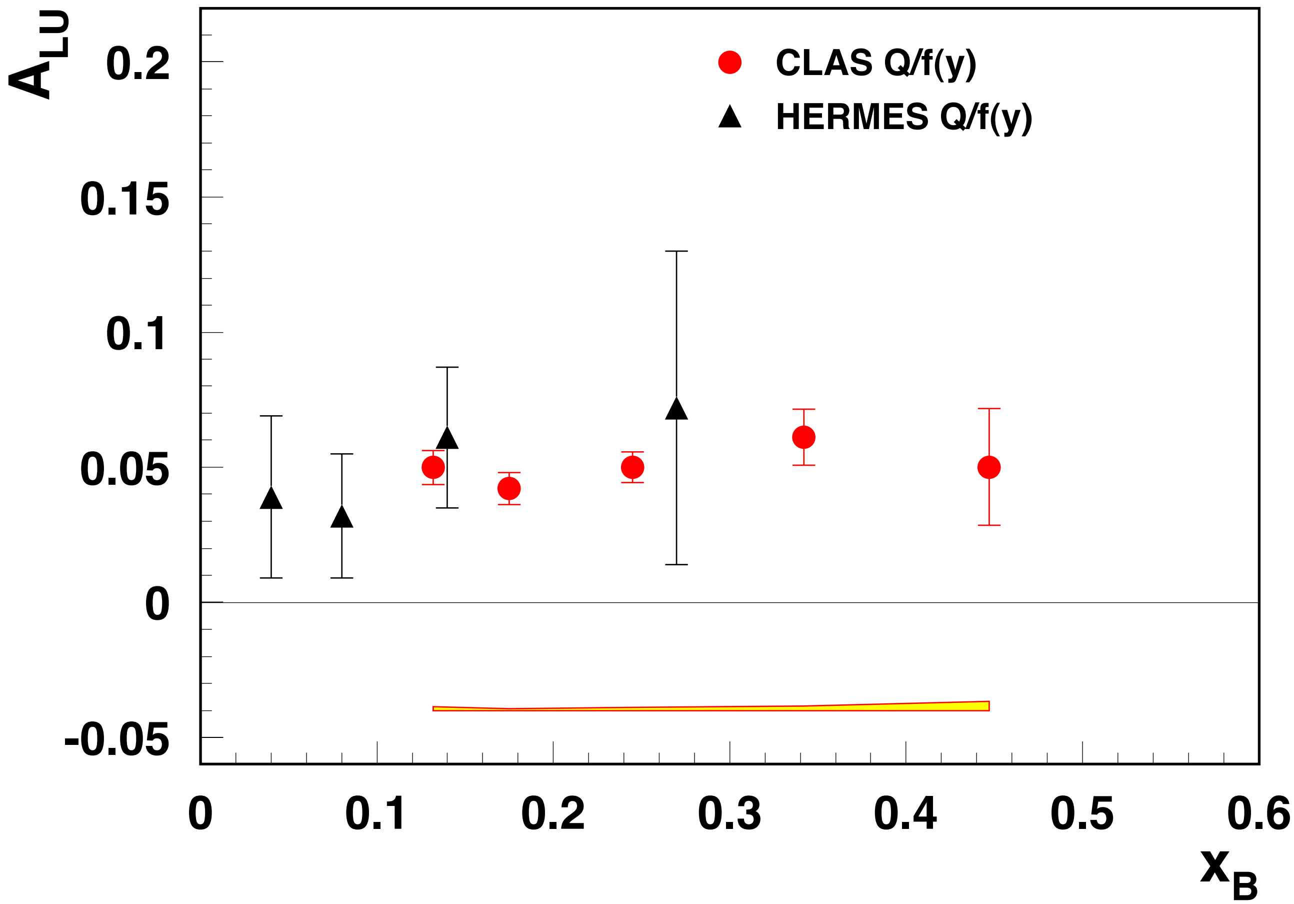


Significant contribution from exclusive processes

For further analyses safe cuts 0.4<z<0.7 and MM(x)>1.4 GeV have been applied

Comparison with HERMES

RED: CLAS preliminary , BLACK : HERMES



$$A_{LU} \sim \frac{1}{Q} f(y) \frac{g^{\perp u}}{f_1^u}$$

assuming u quark dominance and Sivers type contributions

$0.4 < z < 0.7$
MM(x)>1.4 GeV
W > 2. GeV

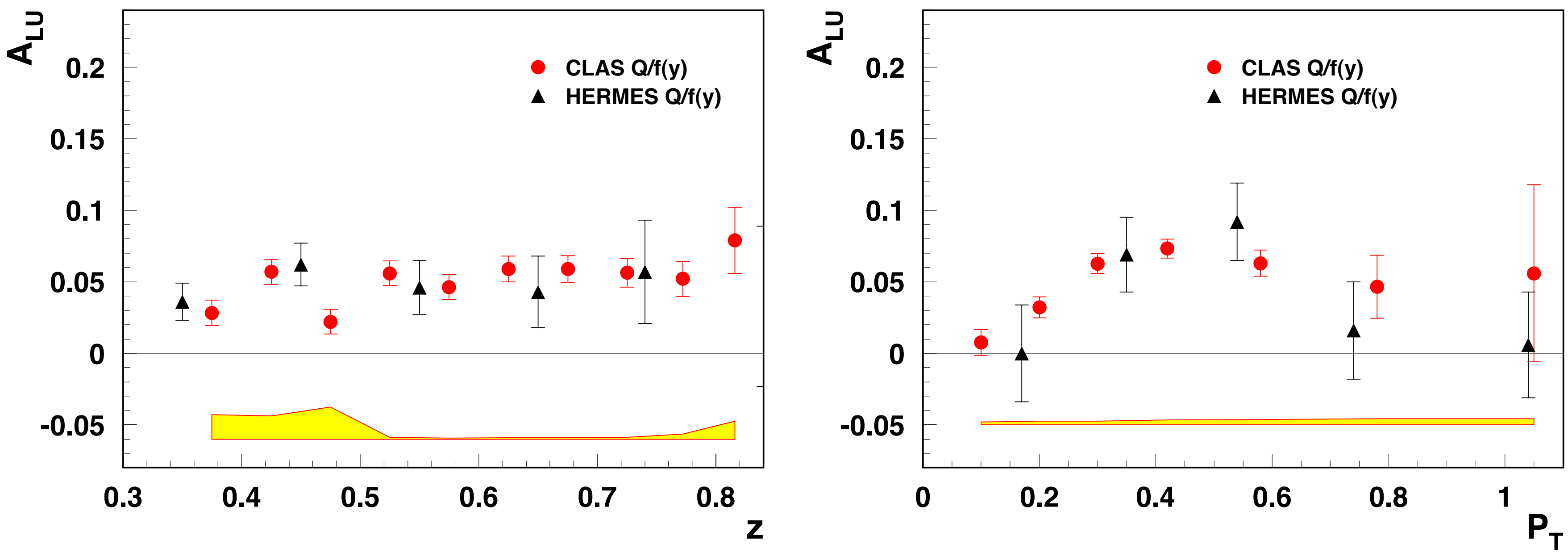
CLAS extends the x_B range and improves significantly uncertainties.

<Q>/*f(y)* correction factor is applied!

$$f(y) = \frac{y\sqrt{1-y}}{1-y+y^2/2}$$

Comparison with HERMES

RED: CLAS preliminary , BLACK : HERMES



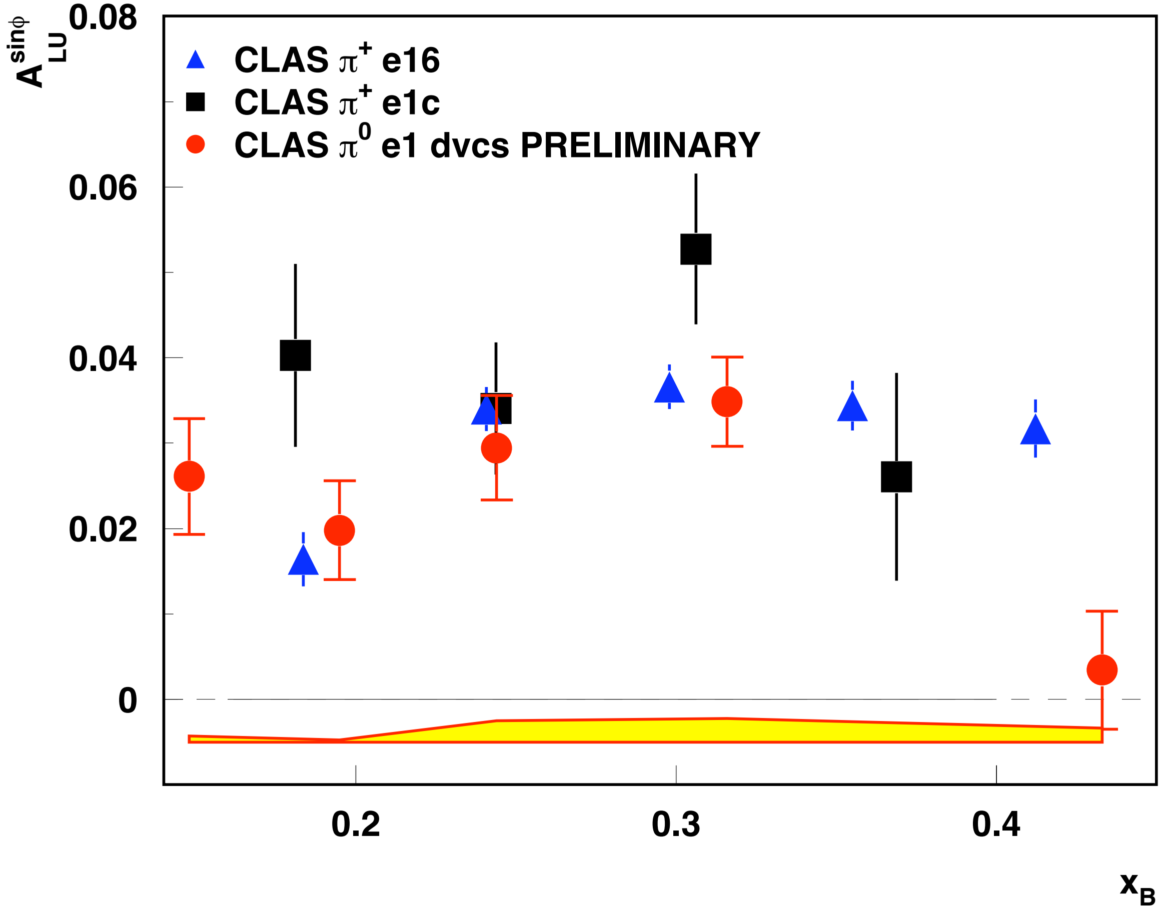
MM(x)>1.4 GeV

$0.4 < z < 0.7$

Agreement is good within the error bars. Systematic uncertainties calculated from background subtraction and fitting procedures.

$\langle Q \rangle / f(y)$ correction factor is applied! $$f(y) = \frac{y\sqrt{1-y}}{1 - y + y^2/2}$$

π^0 and π^+

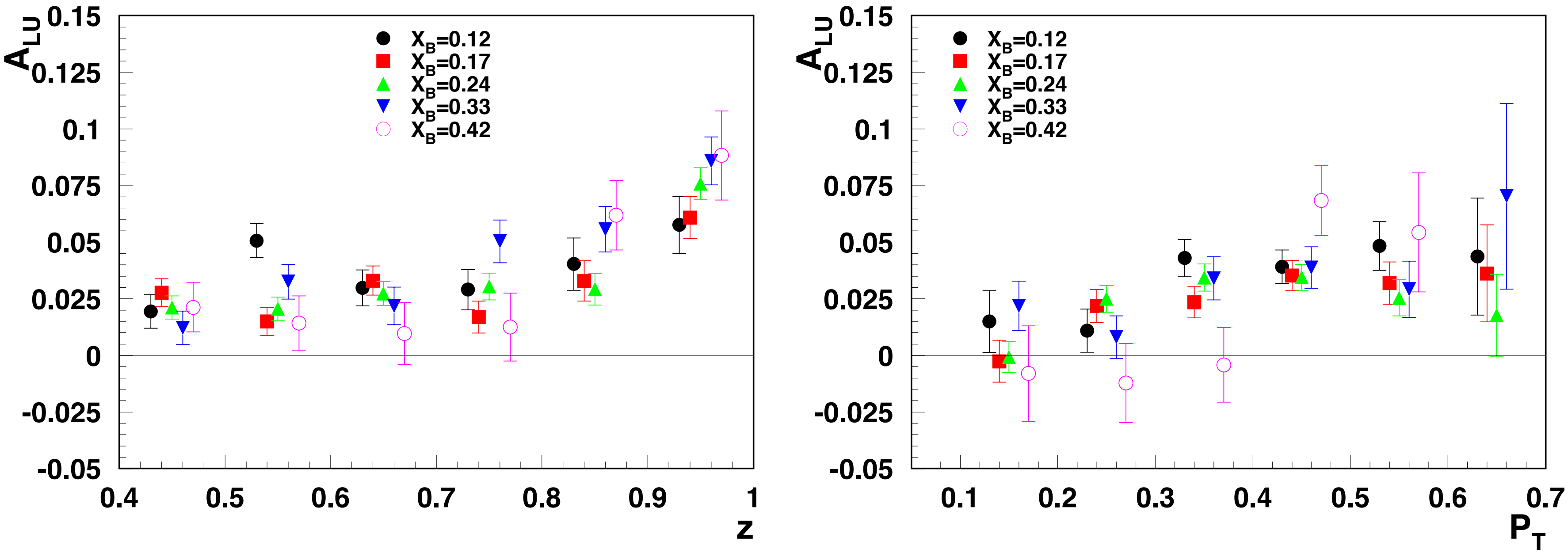


$F_{LU}^{\sin\phi_h} \propto xg^{\perp}D_1$ Sivers type contribution

$F_{LU}^{\sin\phi_h} \propto xeH_1^{\perp}$ Collins type Contribution Suppressed for π^0

π^0 and π^+ asymmetries are comparable, indicating that Sivers mechanism is providing dominating contribution (Collins function suppressed for π^0).

A_{LU} vs z and P_T for different x_B bins



$$F_{LU}^{\sin\phi_h} \propto x g^{\perp}(x) D_1(z)$$

Sivers type contribution ?

Conclusions

- SIDIS MC consistent with data.
- Asymmetry extraction procedure checked (dependence on binning and fitting procedures).
- **Significantly improved SSA measurement for semi- inclusive π^0.**
- **Asymmetry versus z, P_T and x_B extracted.**
- **Comparison of π^0 and π^+ SSA indicates that Sivers mechanism is dominant.**
- **More analyses underway with 2009 data!**

Support slides

A. Afanaseva, E. Carlson, arXiv:hep-ph/0603269v2 (2006)

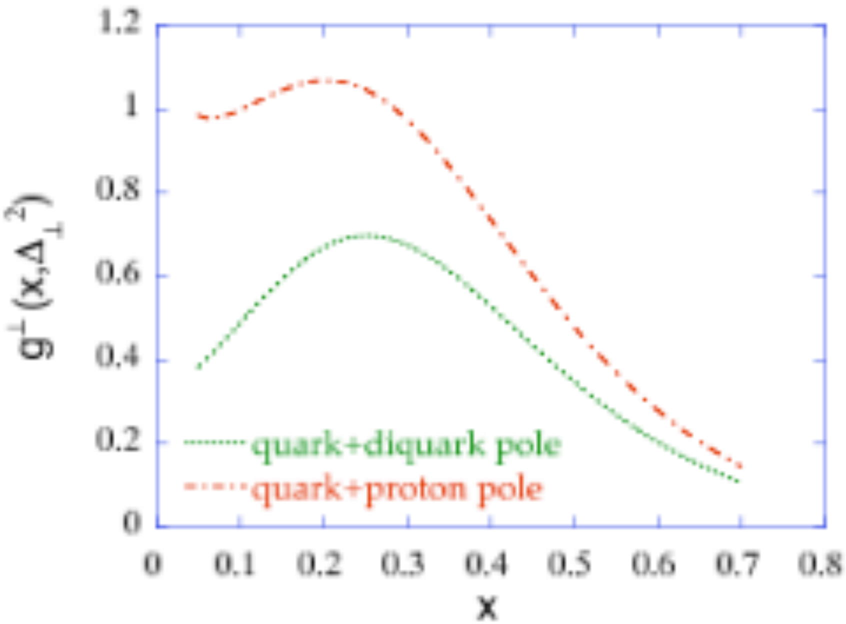


FIG. 6: The distribution function $g^{\perp}(x, \vec{\Delta}_{\perp}^{2})$ for $|\vec{\Delta}_{\perp}| = 0.4$ GeV. The two special cases are described in detail in the text. A short summary is that the nucleon in the quark+diqurk pole case is overall electrically neutral, and in the quark+proton pole case has unit charge. In both cases all flavors of quark in the final state are summed.

N/q	U	L	T
U	$\mathbf{f_1}$		$h_1^\perp$
L		$\mathbf{g_{1L}}$	$h_{1L}^\perp$
T	$f_{1T}^\perp$	g_{1T}	h_1 , $h_{1T}^\perp$

Table 1: Leading twist transverse momentum dependent distribution functions. The U,L,T correspond to unpolarized, longitudinally polarized and transversely polarized nucleons (rows) and quarks (columns)

N/q	U	L	T
U	$f^\perp$	$g^\perp$	h ,e
L	$f_L^\perp$	$g_L^\perp$	h_L ,e_L
T	f_T , $f_T^\perp$	g_T , $g_T^\perp$	h_T ,e_T ,$h_T^\perp$, $e_T^\perp$

Table 2: Twist-3 transverse momentum dependent distribution functions. The U,L,T correspond to unpolarized, longitudinally polarized and transversely polarized nucleons (rows) and quarks (columns)

$$F_{LU}^{\sin\phi_h} = \frac{2M}{Q}\,\mathcal{C}\left[-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M_h}\left(xe\,H_1^\perp + \frac{M_h}{M}\,f_1\frac{\tilde{G}^\perp}{z}\right) + \frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M}\left(xg^\perp D_1 + \frac{M_h}{M}\,h_1^\perp\frac{\tilde{E}}{z}\right)\right]$$

$$\frac{\tilde{G}^\perp}{z} = \frac{G^\perp}{z} - \frac{m}{M_h}\,H_1^\perp,$$

$$\frac{\tilde{E}}{z} = \frac{E}{z} - \frac{m}{M_h}\,D_1,$$

RC

QEDRadiativeCorrectionsin Processes of Exclusive Pion Electroproduction
A. Afanaseva, I. Akushevichb,
V. Burkerta, K. Jooa
arXiv:hep-ph/020813v1 (2002)

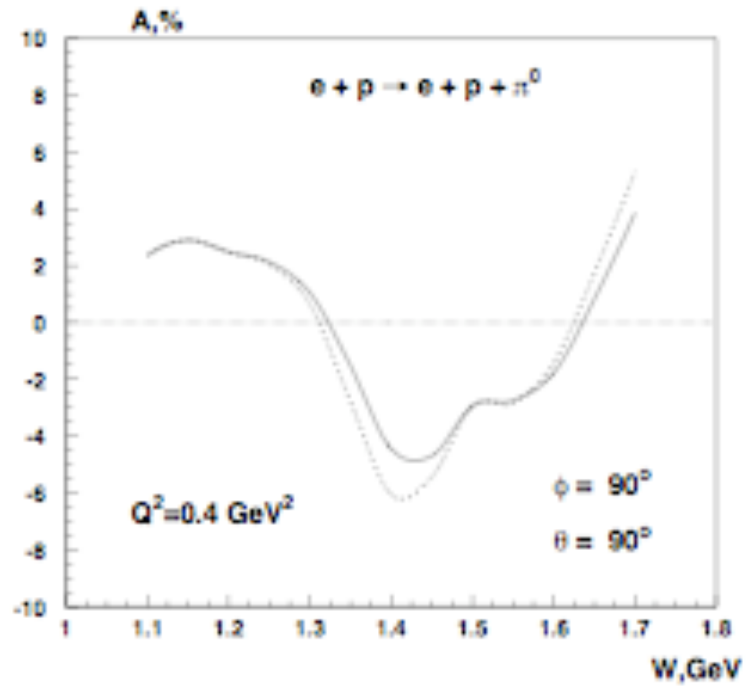
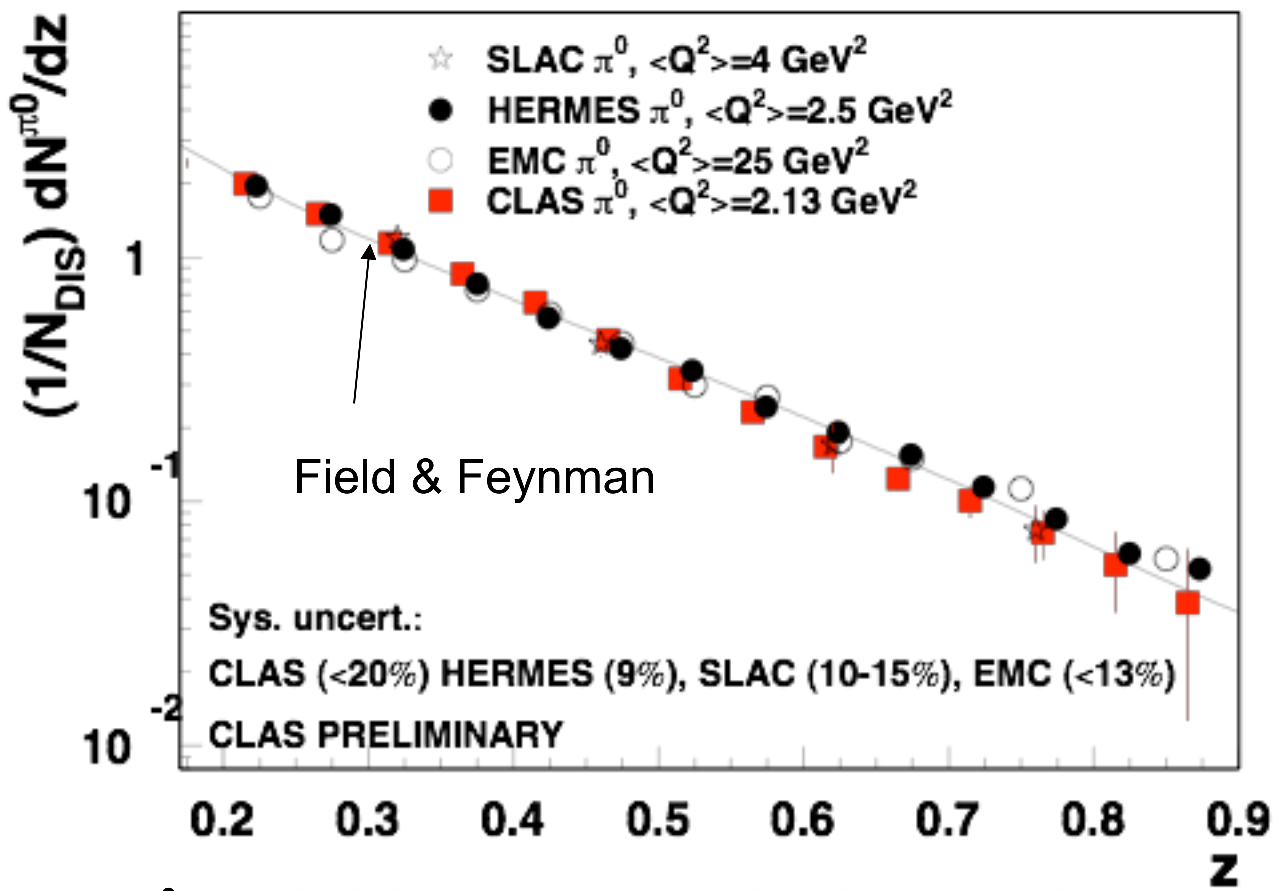


FIG. 7: W-dependence of the beam polarization asymmetry in neutral pion production. The solid (dashed) curve denote the asymmetry with (without) RC. MAID2000 was used to compute the structure functions.

Multiplicity z dependence from e1dvcs

$$\frac{1}{N^{DIS}}\frac{dN^{\pi^0}}{dz} = \frac{\sum_q e_q^2 f_1^q D_1^q}{\sum_q e_q^2 f_1^q} \approx D^{u\to\pi^0}$$



π^0 multiplicity consistent with the partonic picture.