Inclusive and semi-inclusive experiments at CLAS

- Introduction
- Duality & Hall B
- Inclusive electron scattering
- Semi-inclusive meson production
- Conclusions

TAIUTI

Duality in Inclusive Scattering

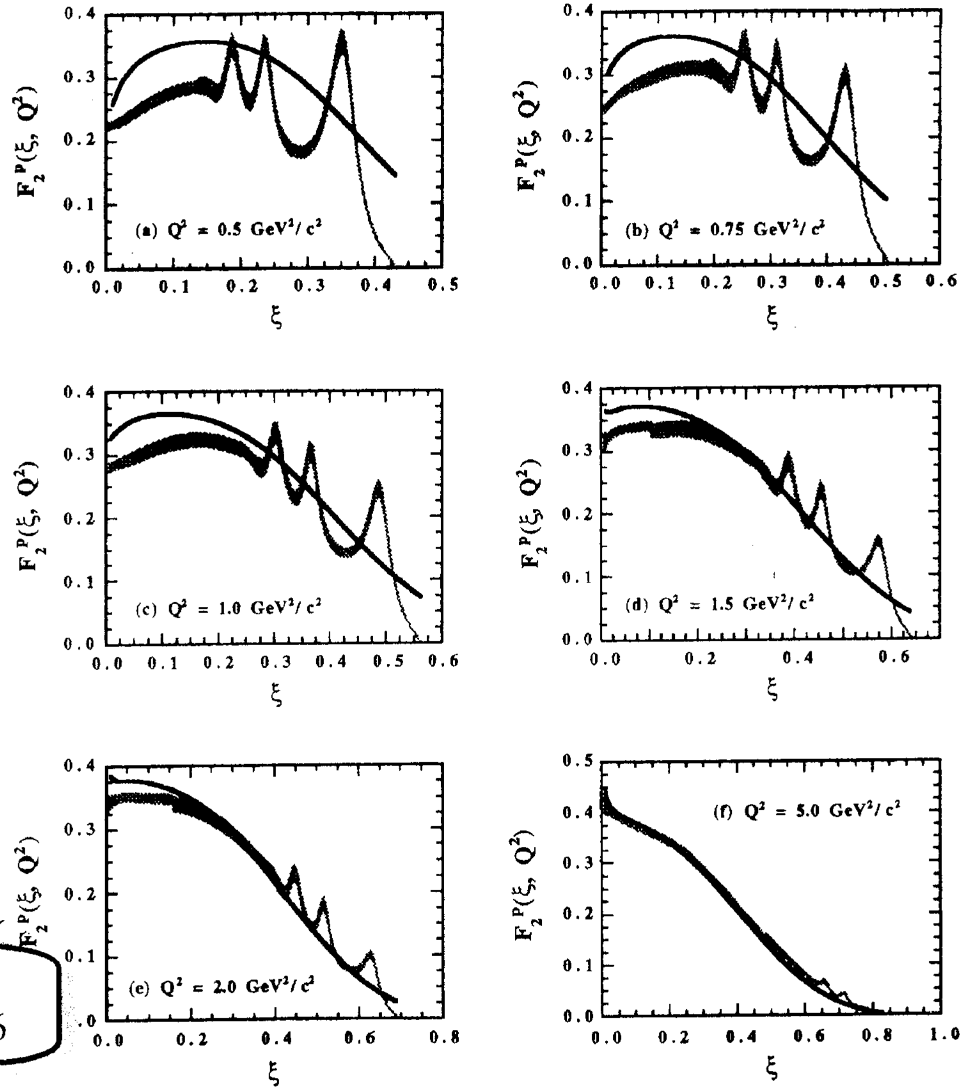
E.Bloom & F.Gilman
Phys.Rev.Lett. 25(1970)1140

• Parton-hadron local duality is a well known behaviour of structure function $\nu W_2(x,Q^2)$ in inclusive electron scattering.

• QDC description of local-duality based on structure function moments

$$M_n(Q^2) = \int_0^1 d\xi\, \xi^{n-2} F_2(\xi,Q^2)$$

ξ = Nachtmann variable

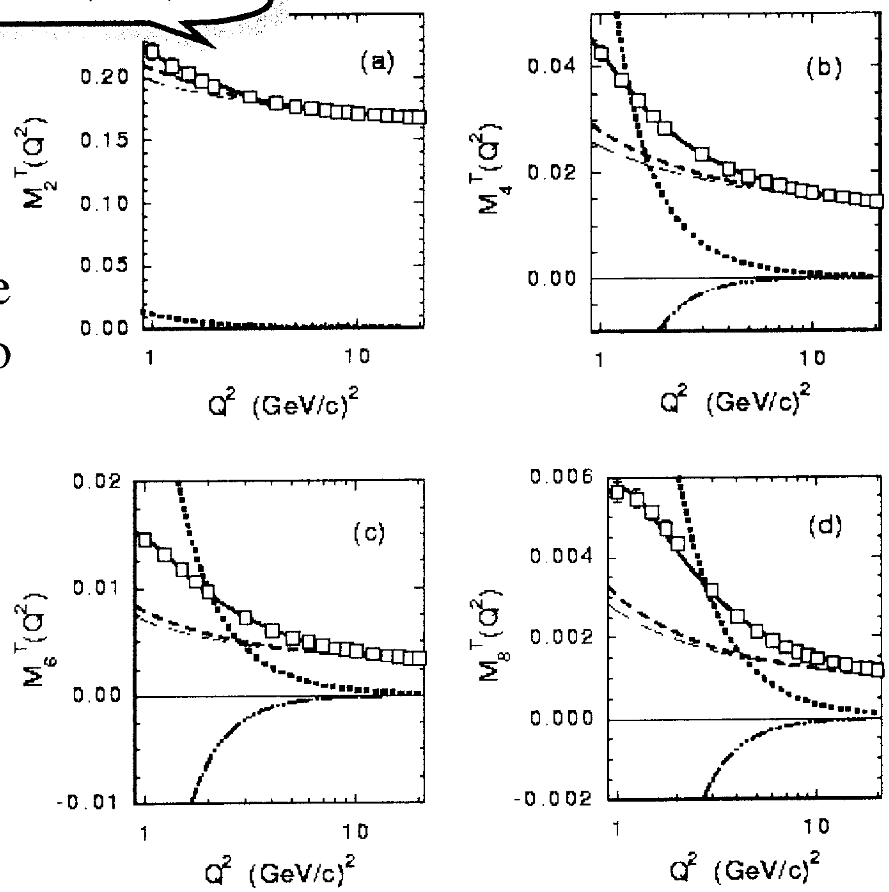


G.Ricco et al.
Phys.Rev. C57(1998)356

Moments & Higher Twist

G.Ricco et al.
Nucl.Phys. B555(1999)306

transverse response



- OPE describes F_2 moments evolution through pQCD twists

$$M_n(Q^2) = A_n(Q^2) + Higher\ Twists$$

- Presently data above $Q^2 = 1$ GeV^2/c^2 are scattered and assumptions are required to analyse Q^2 evolution of F_2 moments.

- *New data are being produced at TJNAF !!*

- To perform an OPE analysis the knowledge of F_2 in a wide x, Q^2 region is required.

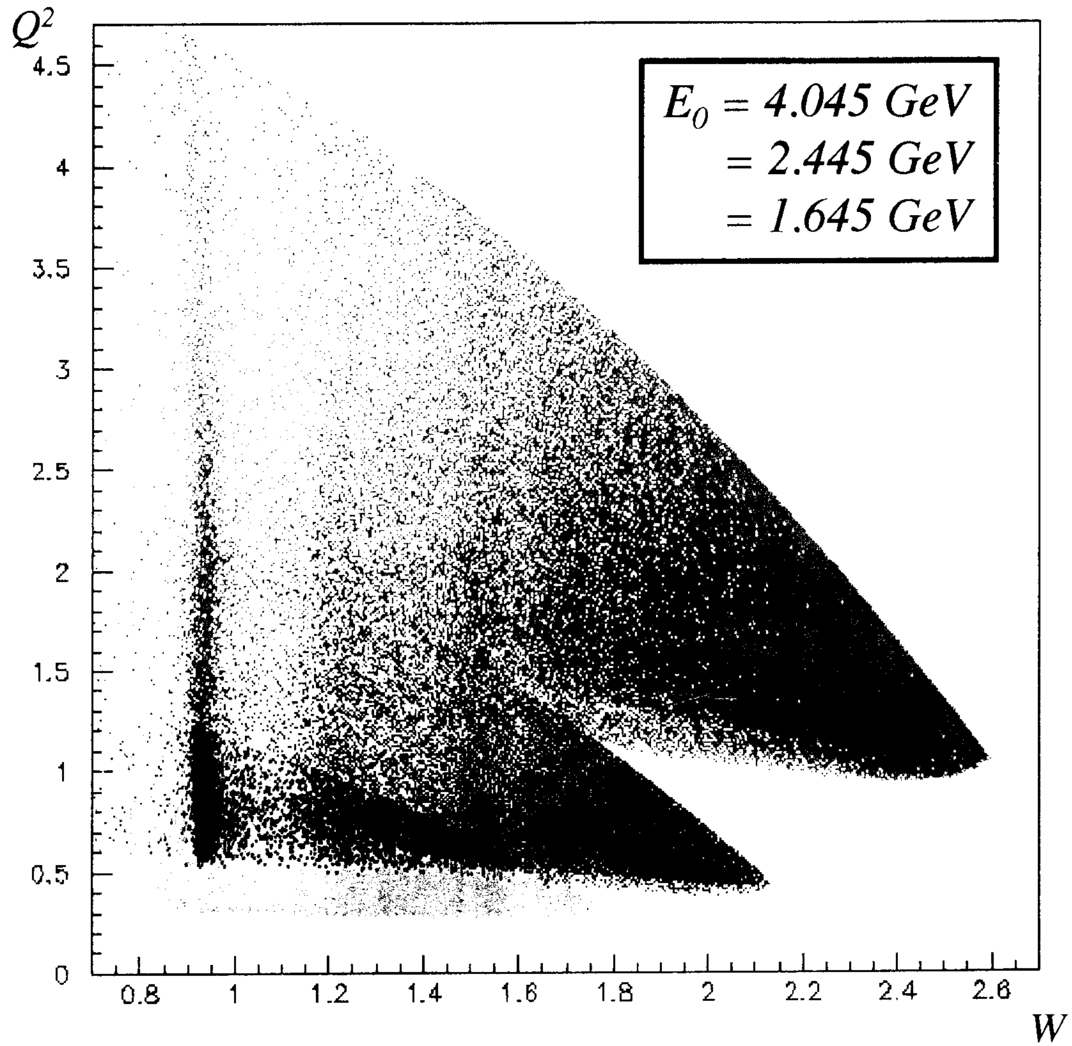
Inclusive Scattering at CLAS

- CLAS accesses to a large Q^2,W region with a few energy settings.

- CLAS can provide *continuous* x,Q^2 coverage.

- CLAS could also provide Q^2 and W coverage wide enough to perform L/T separation.

- Highly precise knowledge of $R = \sigma_L/\sigma_T$ *NOT* required.

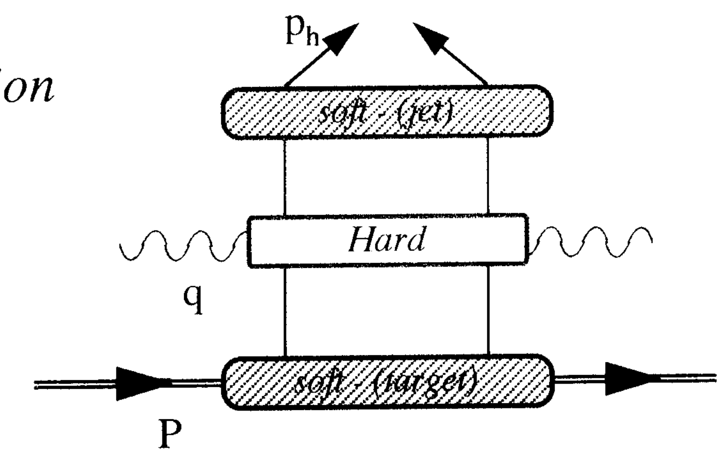


Semi-inclusive electron scattering

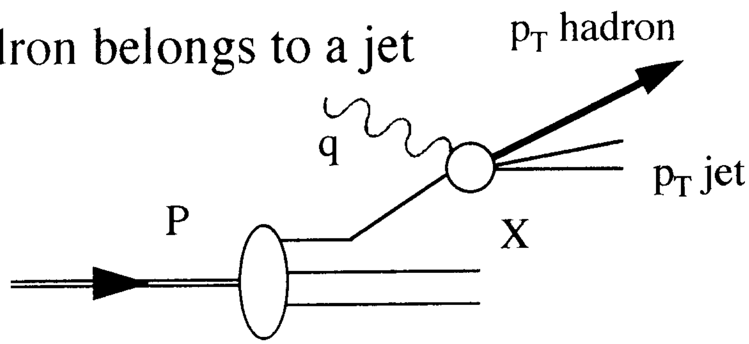
• Detection of a particle in coincidence with the electron permits to access to more structure functions depending on the outgoing particle ϕ angle:

$$\frac{d\sigma}{d^3 p_h d\Omega dE'} = \left(\frac{d\sigma}{d\Omega}\right)_M \frac{Q^2}{q^2}\frac{1}{\varepsilon}\frac{1}{2E_h}\left[\begin{array}{l} W_T + \varepsilon W_L + \\ \varepsilon W_{TT}\cos(2\phi_h) + \sqrt{\varepsilon(\varepsilon+1)/2}\,W_{LT}\cos(\phi_h) \end{array}\right]$$

• pQCD leading order models allows *factorization* of different contributions to cross section



• Hadron belongs to a jet



Leading Order Models

J.Levelt & P.Mulders
Phys.Rev. D49(1994)96

Introducing parton distribution and fragmentation functions (and integrating over the jet momentum)

$$x_B = \frac{Q^2}{2M\nu}$$

$$y = \frac{P \bullet q}{P \bullet k} = \frac{\nu}{E}$$

$$z = \frac{P \bullet p_h}{P \bullet q} \stackrel{TRF}{=} \frac{E_h}{\nu}$$

$$\mathcal{H}_1\left(x_{B,}, z, Q^2, p_{h\perp}^2\right) = \frac{1}{2}\sum_{i=q,\bar{q}} e_i^2 \int d^2 p_\perp f_{i/H}\left(x_{B,} p_\perp\right) D_{h/i}\left(z, p_{h\perp} - z p_\perp\right)$$

$$\mathcal{H}_2\left(x_B, z, Q^2, p_{h\perp}^2\right) = x_{B,} \sum_{i=q,\bar{q}} e_i^2 \int d^2 p_\perp f_{i/H}\left(x_{B,} p_\perp\right) D_{h/i}\left(z, p_{h\perp} - z p_\perp\right)$$

$$\mathcal{H}_3 = \frac{2x_{B,}}{z} \sum_{i=q,\bar{q}} e_i^2 \int d^2 p_\perp \frac{p_\perp \bullet p_{h\perp}}{p_{h\perp}^2} \left\{ \begin{array}{l} -f_{i/H}\left(x_{B,} p_\perp\right) D_{i/h}^{\perp}\left(z, p_{h\perp} - z p_\perp\right) + \\ z\left(f_{i/H}\left(x_{B,} p_\perp\right) - x_{B,} f_{i/H}^{\perp}\left(x_{B,} p_\perp\right)\right) D_{h/i}\left(z, p_{h\perp} - z p_\perp\right) + \\ f_{i/H}\left(x_{B,} p_\perp\right)\left[\frac{1}{z} D_{i/h}^{\perp}\left(z, p_{h\perp} - z p_\perp\right) - D_{h/i}\left(z, p_{h\perp} - z p_\perp\right)\right] \end{array} \right\}$$

$$\mathcal{H}_4\left(x_{B,}, z, Q^2, p_{h\perp}^2\right) = \mathcal{O}\left(Q^{-2}\right)$$

DIS Semi-inclusive electron scattering

Most general cross section expressions

J.Levelt & P.Mulders
Phys.Rev. D49(1994)96

$$\frac{d\sigma}{dx_B\,dz\,dy\,dp_{h\perp}^2\,d\varphi_h} \overset{DIS}{=} \frac{4\pi\alpha^2 ME}{Q^4}\left[\begin{array}{l} x_B y^2 \mathcal{H}_1 + (1-y)\mathcal{H}_2 + \\ +\frac{|p_{h\perp}|}{Q}(2-y)\sqrt{1-y}\cos(\varphi_h)\mathcal{H}_3 + \\ +\frac{p_{h\perp}^2}{Q^2}(1-y)\cos(2\varphi_h)\mathcal{H}_4 \end{array}\right] \begin{array}{l} \leftarrow \textit{Leading twist} \\ \leftarrow \textit{twist-3} \\ \leftarrow \textit{twist-4} \end{array}$$

Integrating over the transverse component of the hadron momentum

$$\frac{d\sigma}{dx_B\,dz\,dy} \overset{DIS}{=} \frac{8\pi\alpha^2 ME}{Q^4}\left[x_B y^2 \mathcal{H}_1 + (1-y)\mathcal{H}_2\right]$$

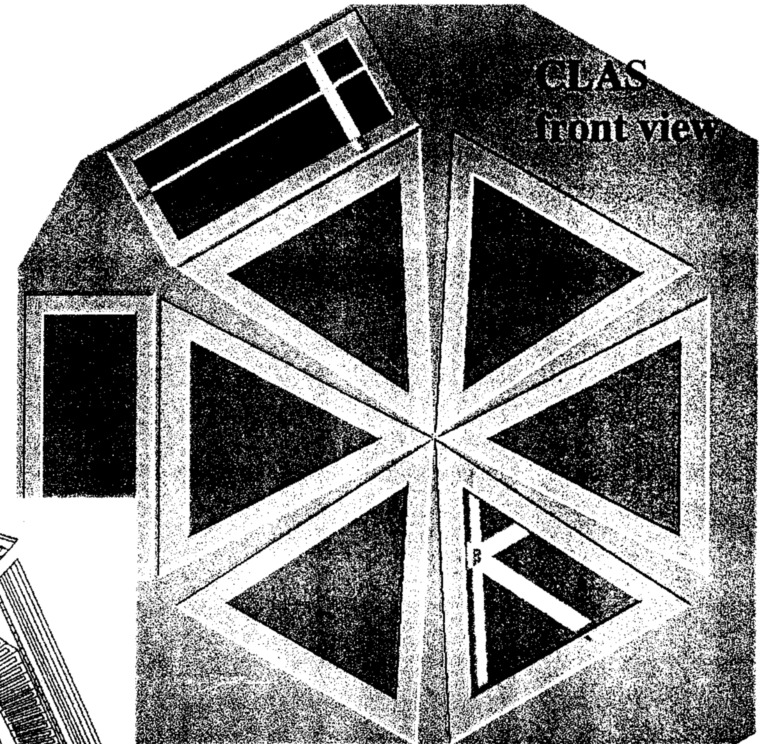
Experimental program

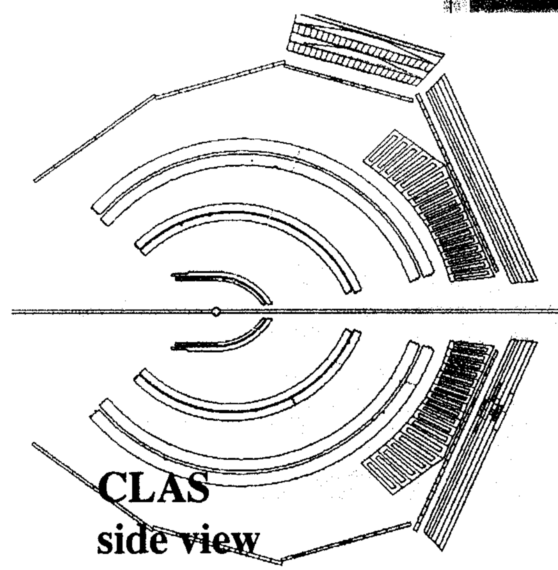
• Study Q^2 evolution of structure functions dominated by leading twist to test factorization. *Large angular acceptance for pion detection is required*

• Extend to out-of-plane reaction to extract higher twists.

• Extend to $x \rightarrow 1$ to test parton distributions.

• This program matches very well CLAS performancies





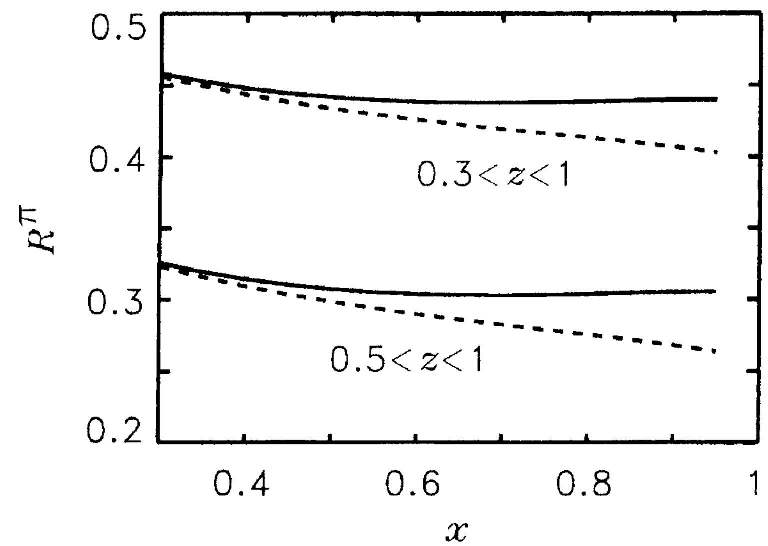
π semi-inclusive electro-production

charged pion semi-inclusive electroproduction could provide detailed information on the flavour contents of the proton

$$\frac{d\sigma}{dx_B dz dy}^{DIS} = \frac{8\pi\alpha^2 ME}{Q^4}\left[(1-y)+\frac{y^2}{2}\right]\sum_{i=q,\bar{q}} e_i^2 x_B f_{i/H}(x_{B,}) D_{h/i}(z)$$

W.Melnitchouck et al.
Phys.Lett. B435(19948)420

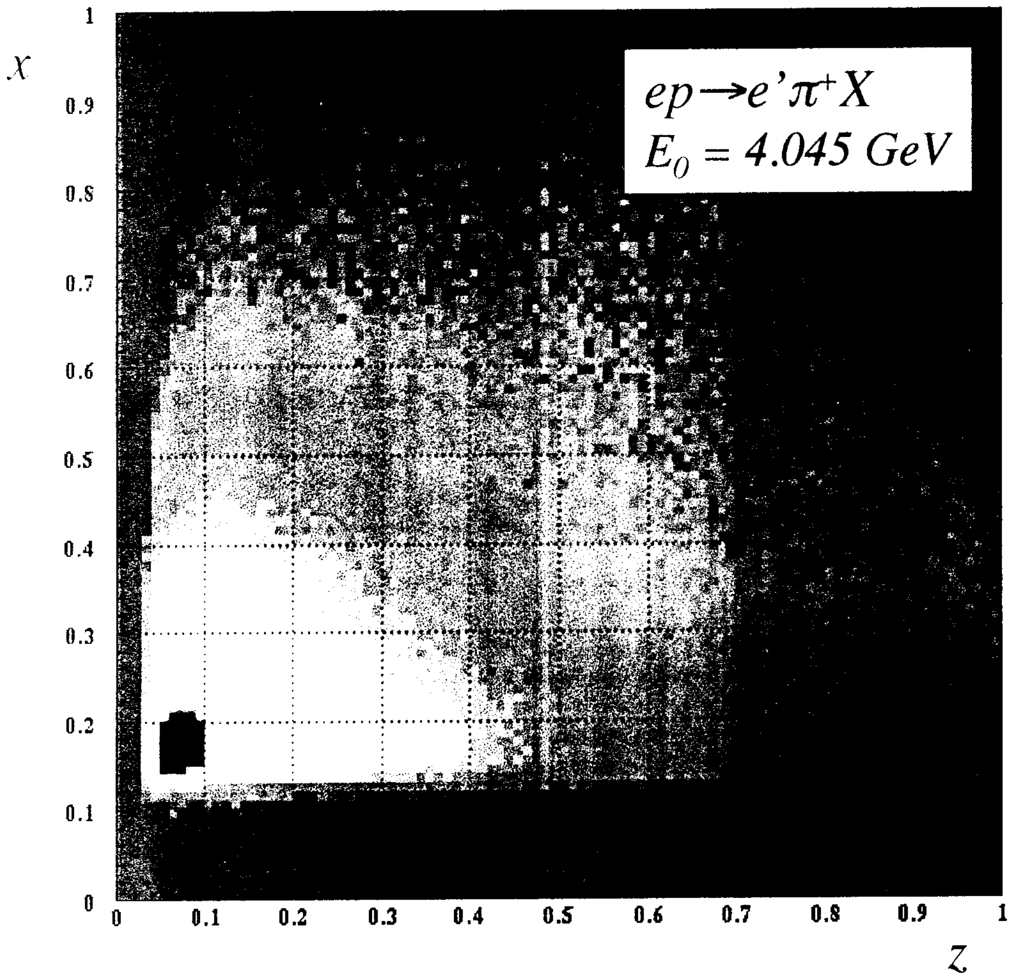
$D_{\pi^+/u}(z) = D_{\pi/d}(z) = D^+(z)$ is leading

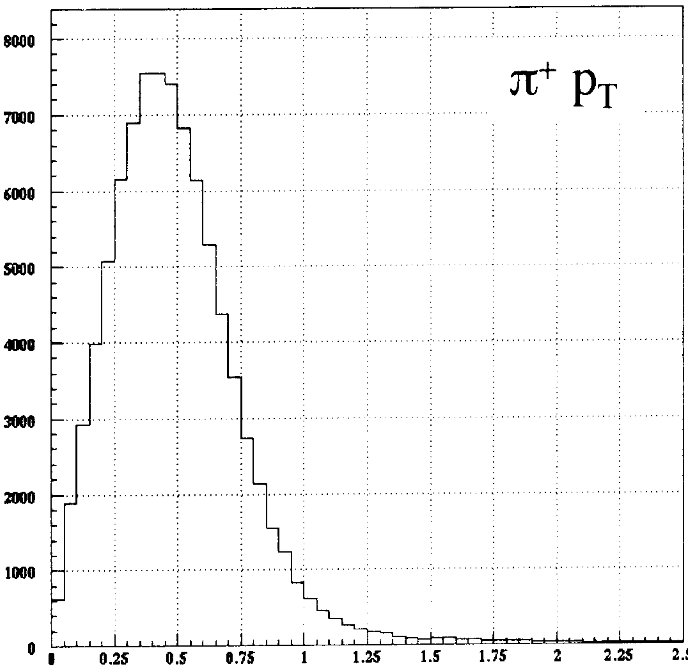


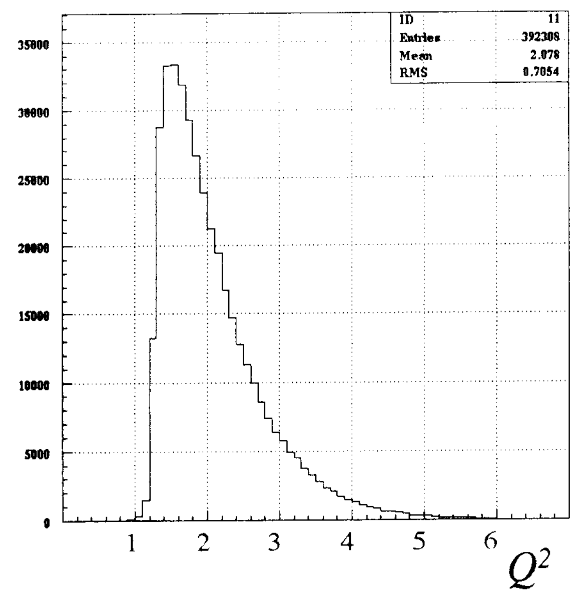
$$R^\pi(x,z) = \frac{N_p^{\pi^-}}{N_p^{\pi^+}} = \frac{4D^-(z)/D^+(z) + d(x)/u(x)}{4 + d(x)/u(x) D^-(z)/D^+(z)}$$

can probe QCD models at x→1

CLAS Response







Conclusions

- TJNAF at *12 GeV* could be the right place to study Higher Twists in Inclusive and Semi-inclusive Scattering at Q^2 higher than $1\ GeV^2/c^2$
- Out-of-plane Semi-inclusive π production is dominated by Higher Twists
- CLAS could play, together to other Halls, a major role