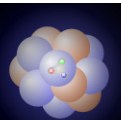


Exclusive DIS processes and GiBUU

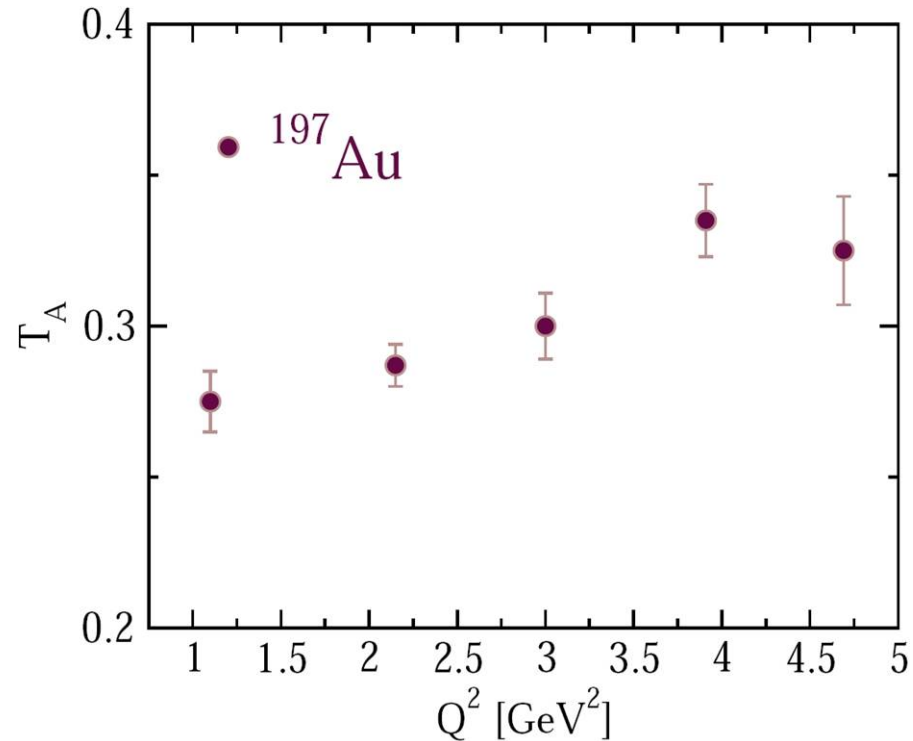
K. Gallmeister, M. Kaskulov, U. Mosel

- Exclusive pion production
 - Regge-pole model
 - DIS (Lund model)
 - Hadronic channel basis
 - Results on Transparency
- Exclusive ρ^0 production (CLAS)



Motivation: CT in $A(e,e'\pi^+)A'$

- JLAB: B. Clasie et al., PRL 99 (2007) 242502



■ CT ?

■ Longitudinal or Transverse ???

Motivation: pion form factor F_π

■ $N(e, e'\pi)N'$

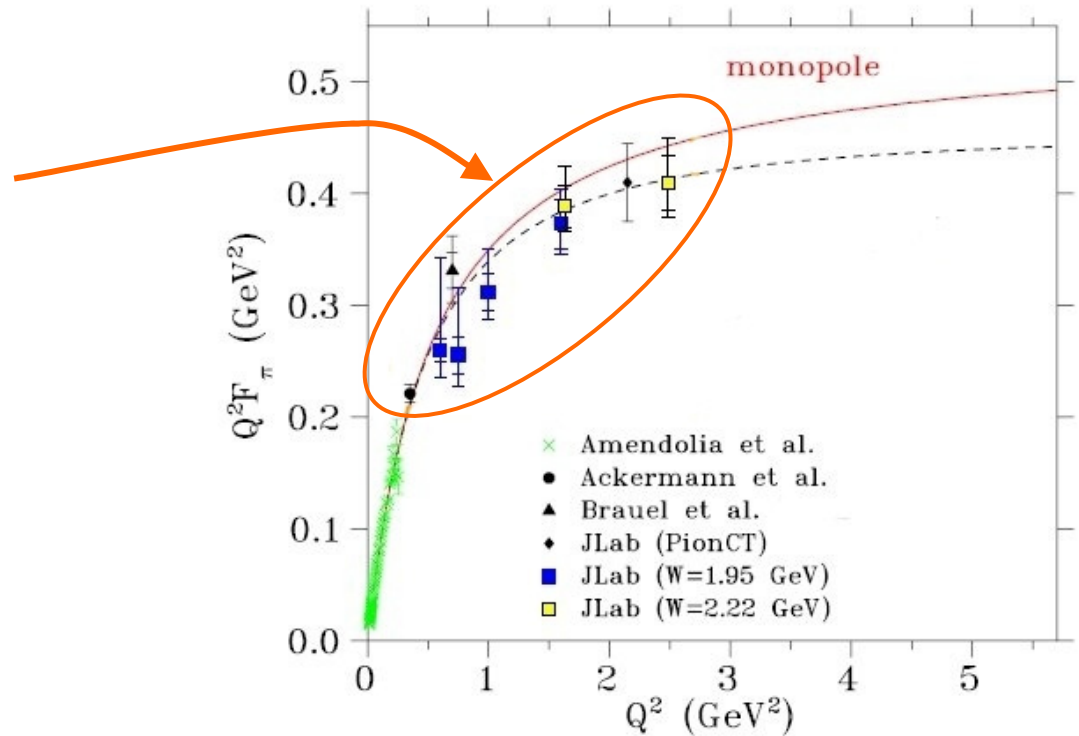
$$\frac{d\sigma_e}{dQ^2 d\nu dt} = \frac{\pi \Phi}{E_e(E_e - \nu)} \left[\frac{d\sigma_T}{dt} + \varepsilon \frac{d\sigma_L}{dt} \right]$$

■ π quasi-elastic knockout
(pole at low $-t$!)

$$\sigma_L \propto \left[\frac{F_\pi(Q^2)}{t - m_\pi^2 + i0^+} \right]^2$$

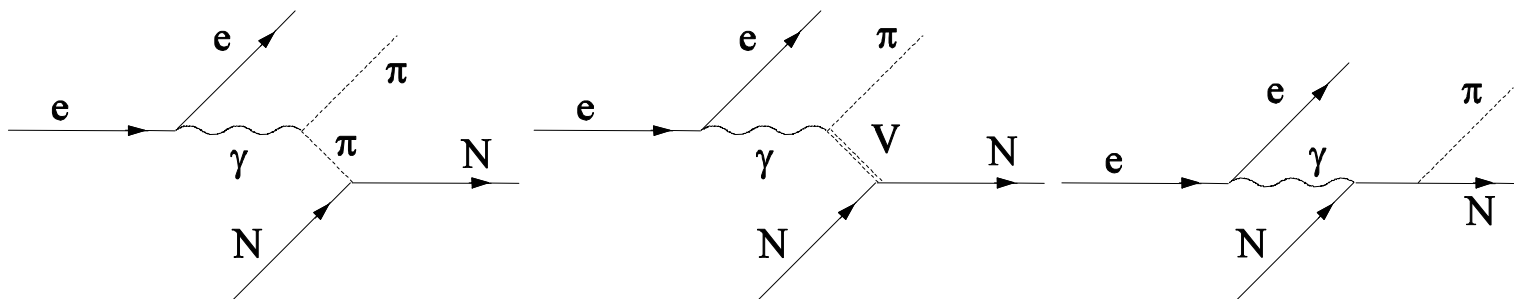
■ model dependence !!!

$$\sigma_L = \sigma^{(\text{exp})} - \sigma_T^{(\text{model})}$$

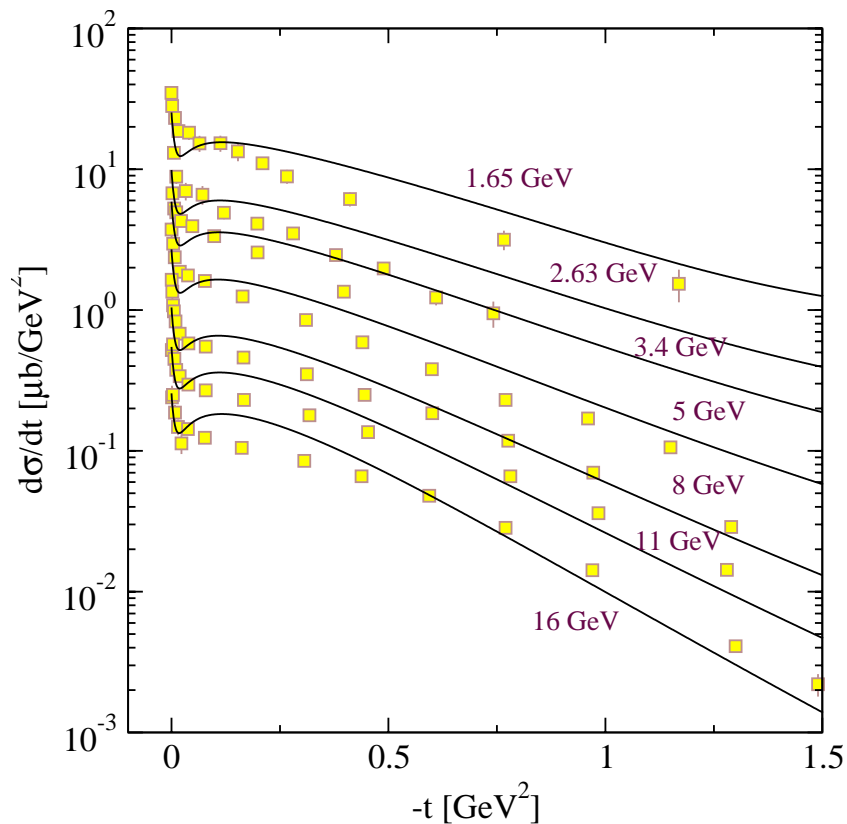
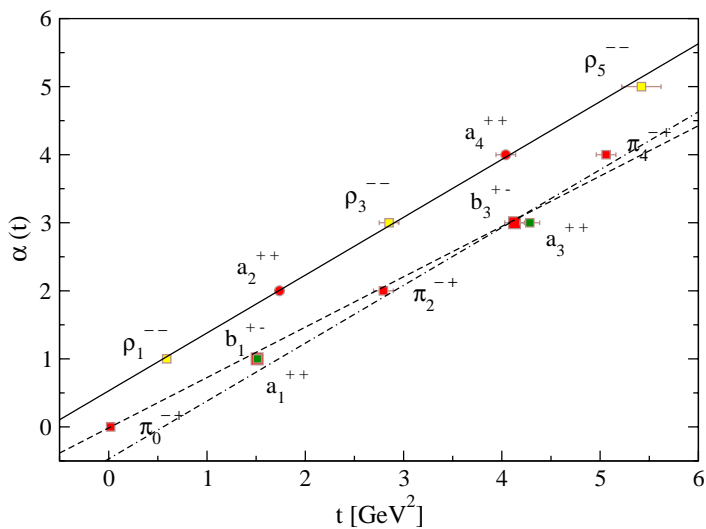


π^+ photo-/electroproduction: Regge-pole model

Regge-pole model (Vanderhaeghen et al.)

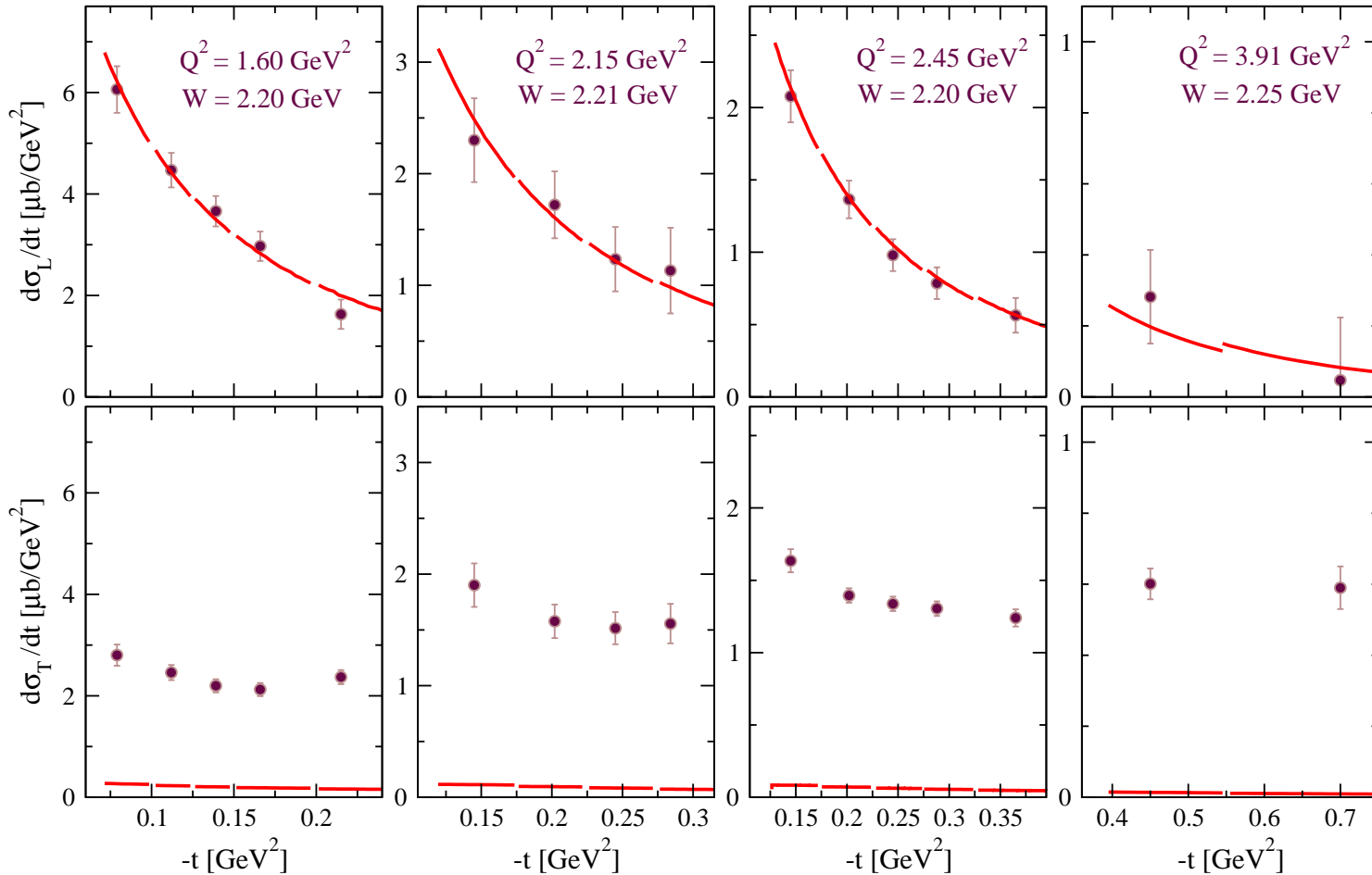


$\pi/b_1(1235)$, $\rho(770)/a_2(1300)$, $a_1(1260)$ trajectories



Regge-pole model at high Q^2

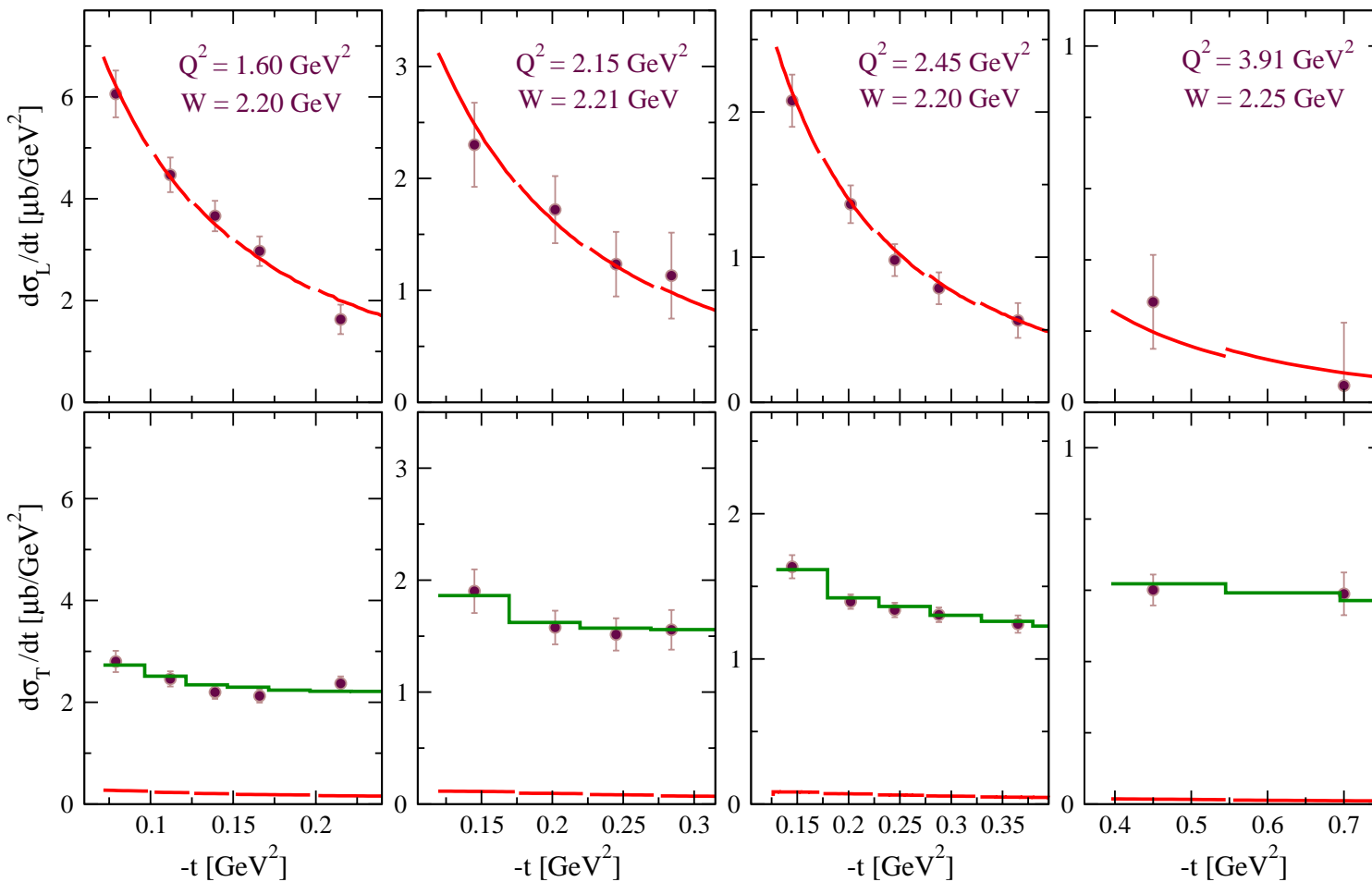
JLAB F_{π^2} ,
JLAB π CT



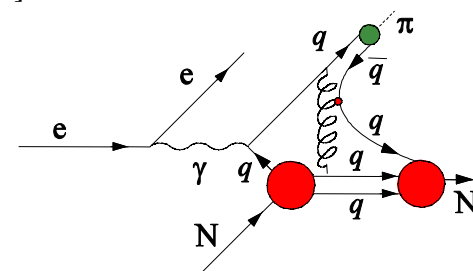
- V,A-exchange marginal
- σ_T underestimated ($\times 10 \dots \times 40$)

Regge-pole model at high Q^2

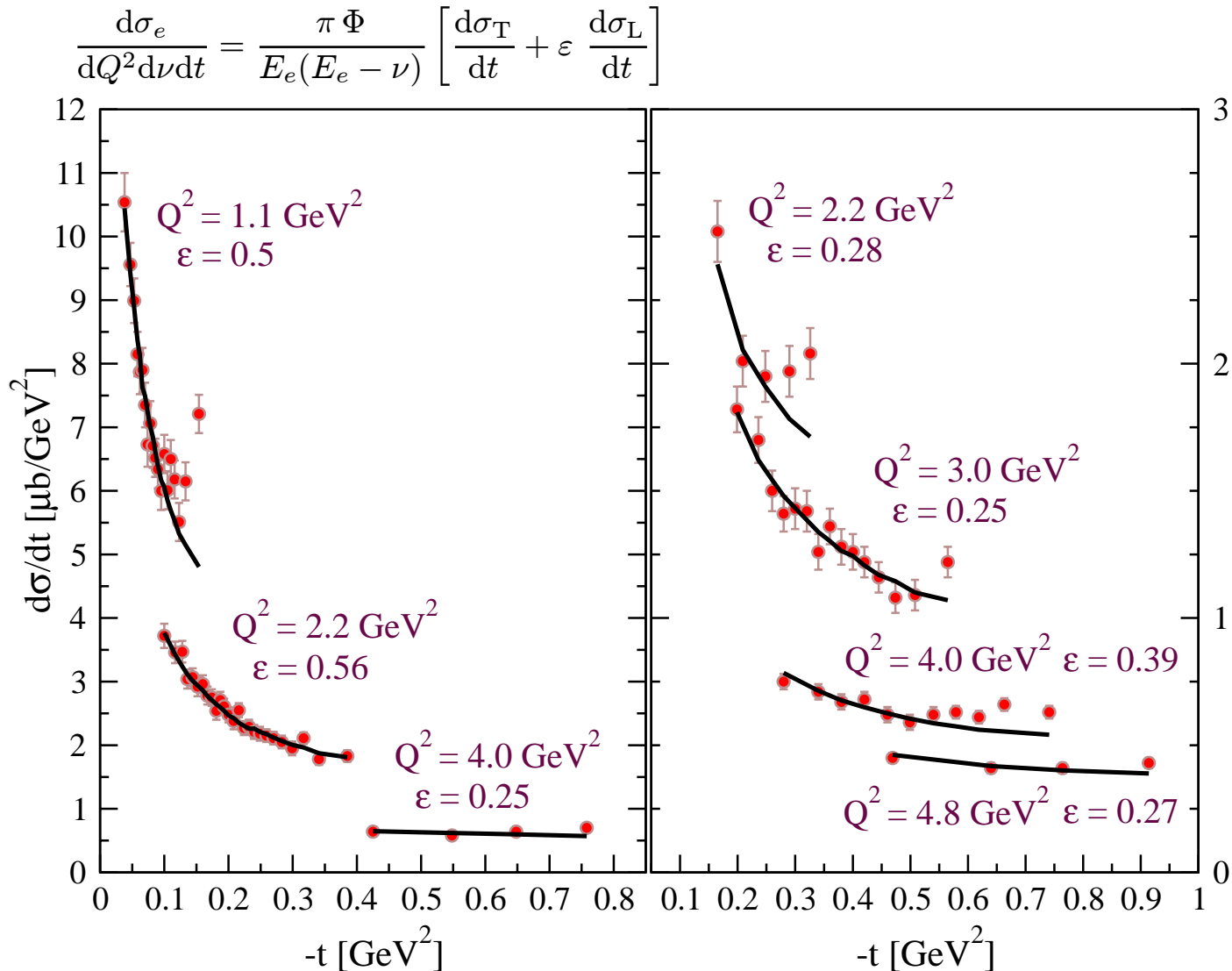
JLAB $F\pi 2$,
JLAB π CT



■ σ_T : exclusive limit ($z \rightarrow 1$) of SIDIS (Lund model)

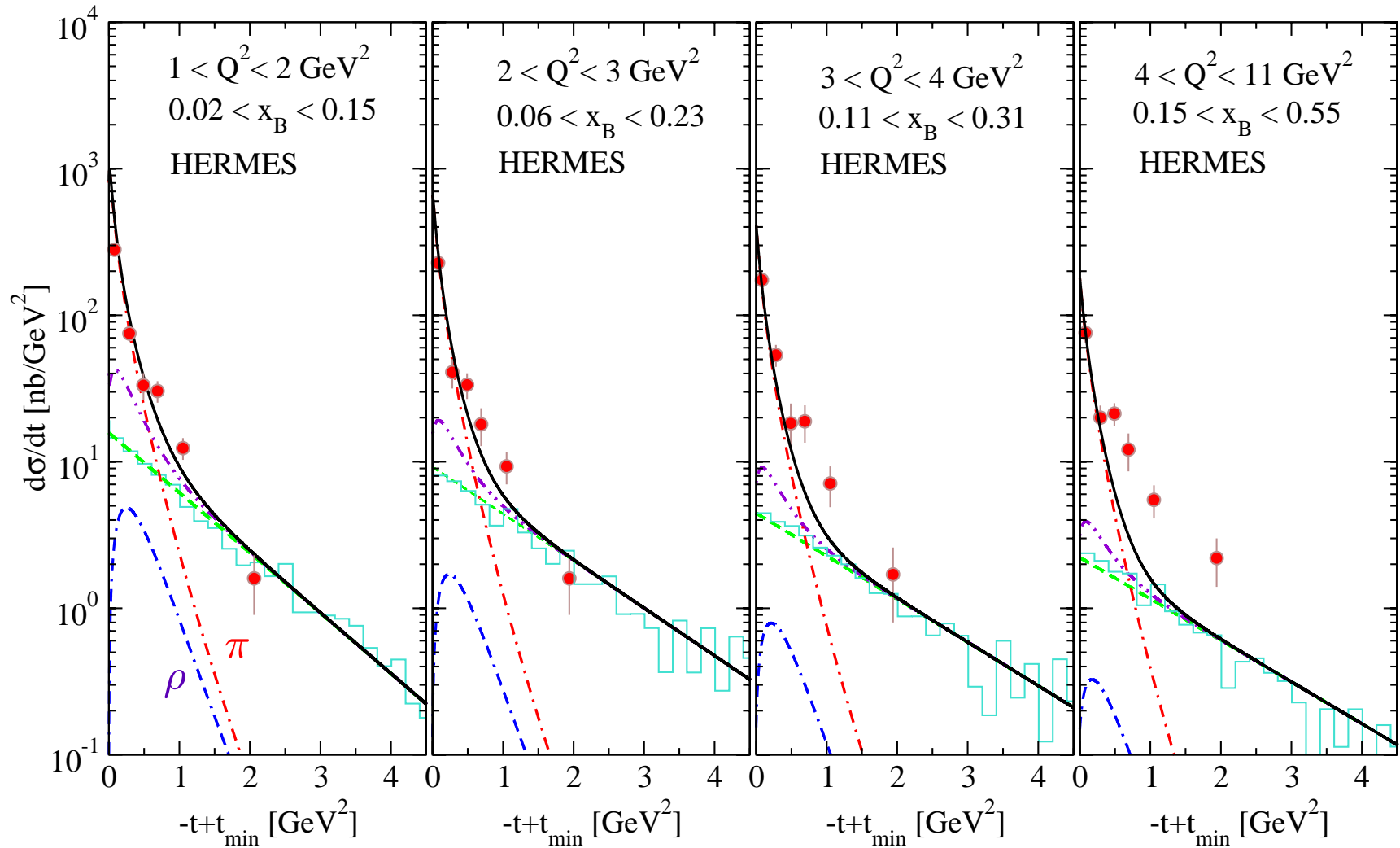


Q² dependence at fixed W ≈ 2.2 GeV



data: X. Qian, PRC (to be published)

Results for HERMES



- Exclusive-Inclusive connection works very well
- Longitudinal/Transverse responses: Dynamics different
 - Longitudinal cross section → hadronic
 - Transverse cross section → partonic

However:

- No amplitudes, only cross sections
- No access to interference or polarization observables

$$\frac{d\sigma}{dQ^2 d\nu dt d\phi} = \frac{\Phi}{2\pi} \left[\frac{d\sigma_T}{dt} + \varepsilon \frac{d\sigma_L}{dt} + \sqrt{2\varepsilon(1+\varepsilon)} \frac{d\sigma_{LT}}{dt} \cos(\phi) + \varepsilon \frac{d\sigma_{TT}}{dt} \cos(2\phi) + h \sqrt{2\varepsilon(1-\varepsilon)} \frac{d\sigma_{LT'}}{dt} \sin(\phi) \right],$$

Therefore...

Hadronic Channel Basis

- Relate partonic and hadronic sectors

- Incoherent sum over quarks in DIS

$$F_2^p(x_B, Q^2) = x_B \sum_q e_q^2 f_q(x_B, Q^2)$$

- Dual Bloom-Gilman connection → Coherent sum over resonances

$$F_2^p(x_B, Q^2) = \sum_R (M_R^2 - M_p^2 + Q^2) W(Q^2, M_R) \delta(s - M_R^2)$$

- How to sum up the infinite tower of resonances?

Method proposed in

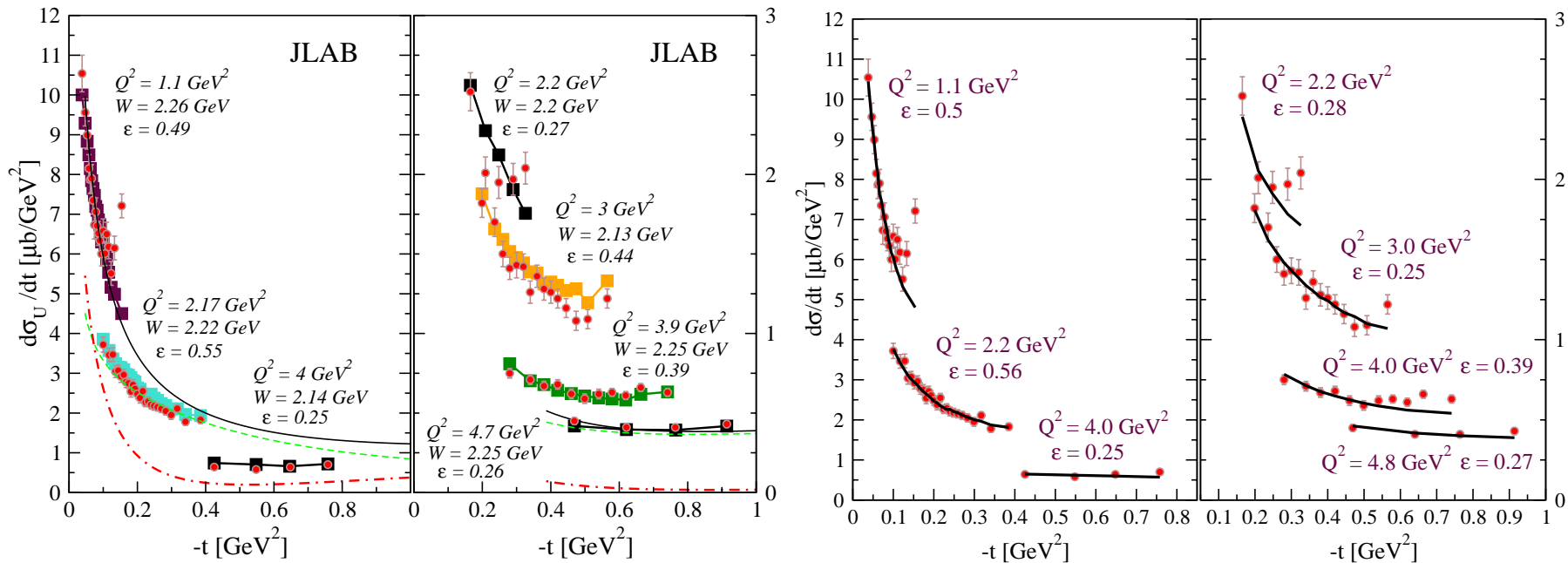
M.Kaskulov, U.Mosel, PRC (in print), arXiv:1001.1952

Exclusive-inclusive connection between hadronic form factors and deep-inelastic structure functions

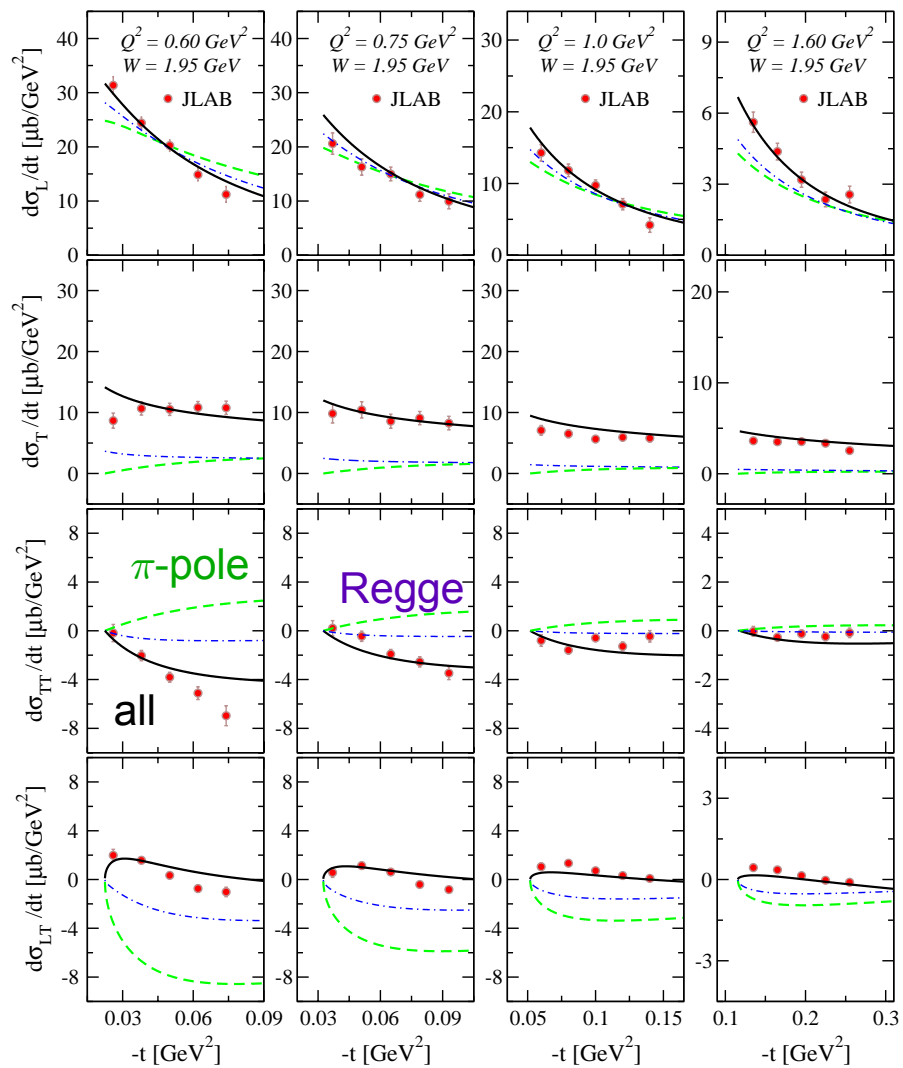
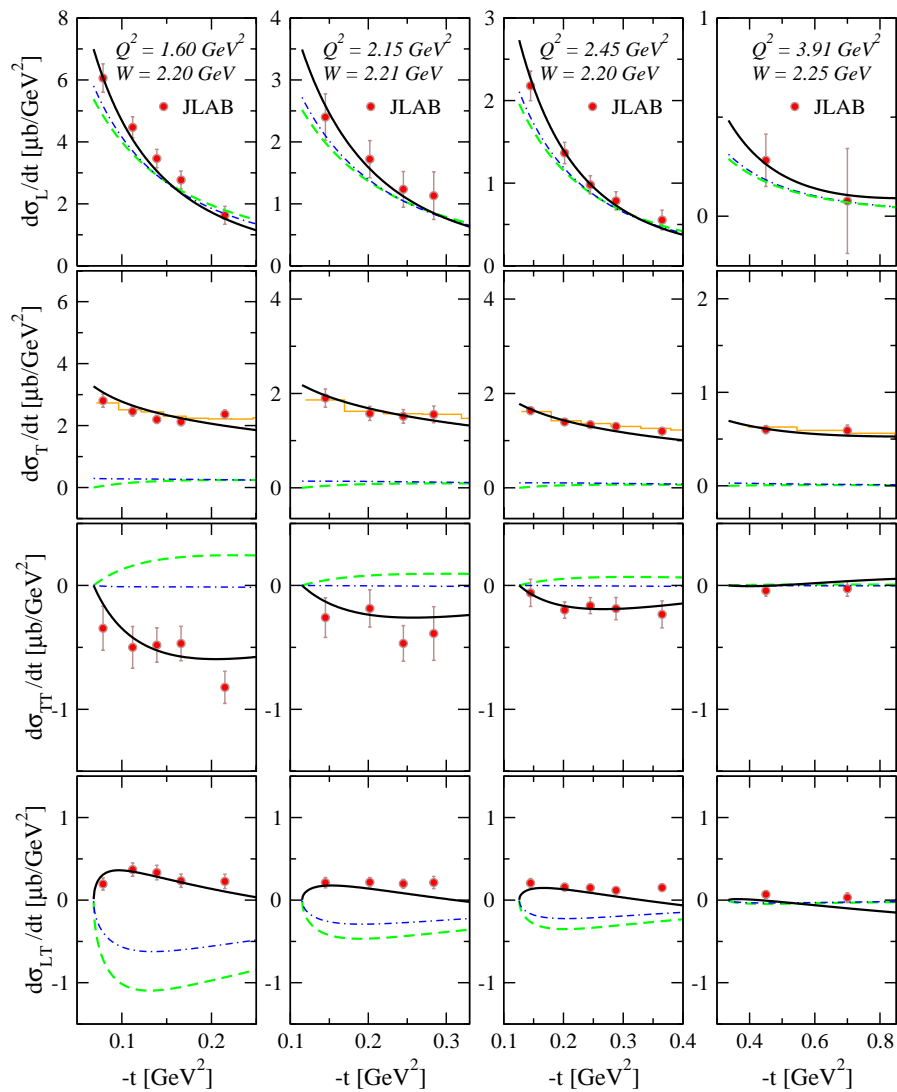
Resonances vs. partonic: JLAB data

Hypothesis: Partons are dual to nucleon resonances

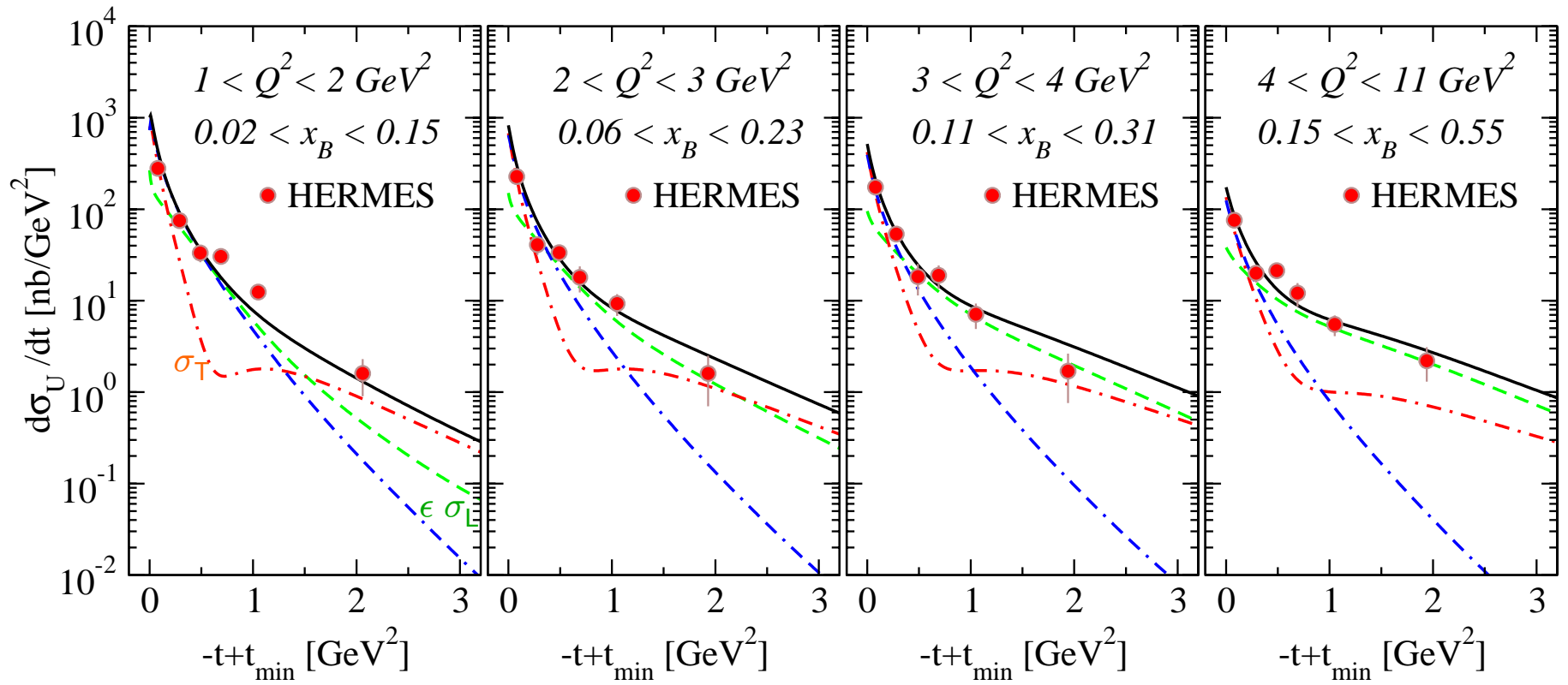
$$\sum |N^*\rangle\langle N^*| = 1 \quad \longleftrightarrow \quad \sum |q\rangle\langle q| = 1$$



JLAB data



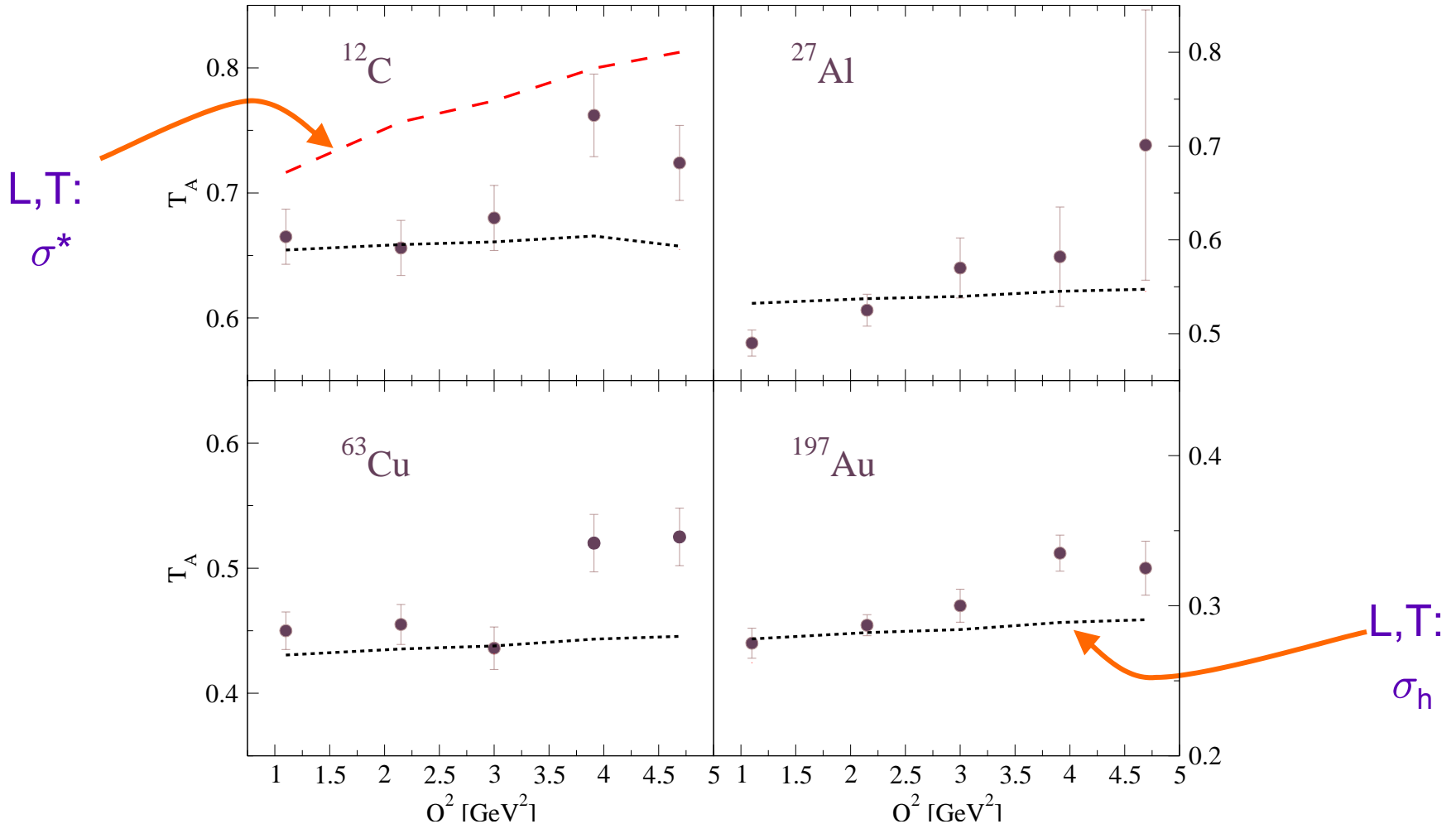
HERMES data



JLAB@5GeV: exclusive $A(e^-, e^-\pi^+)$

$$\frac{\sigma^*}{\sigma_h} = X_0 + (1 - X_0) \left(\frac{t - t_P}{t_F - t_P} \right)$$

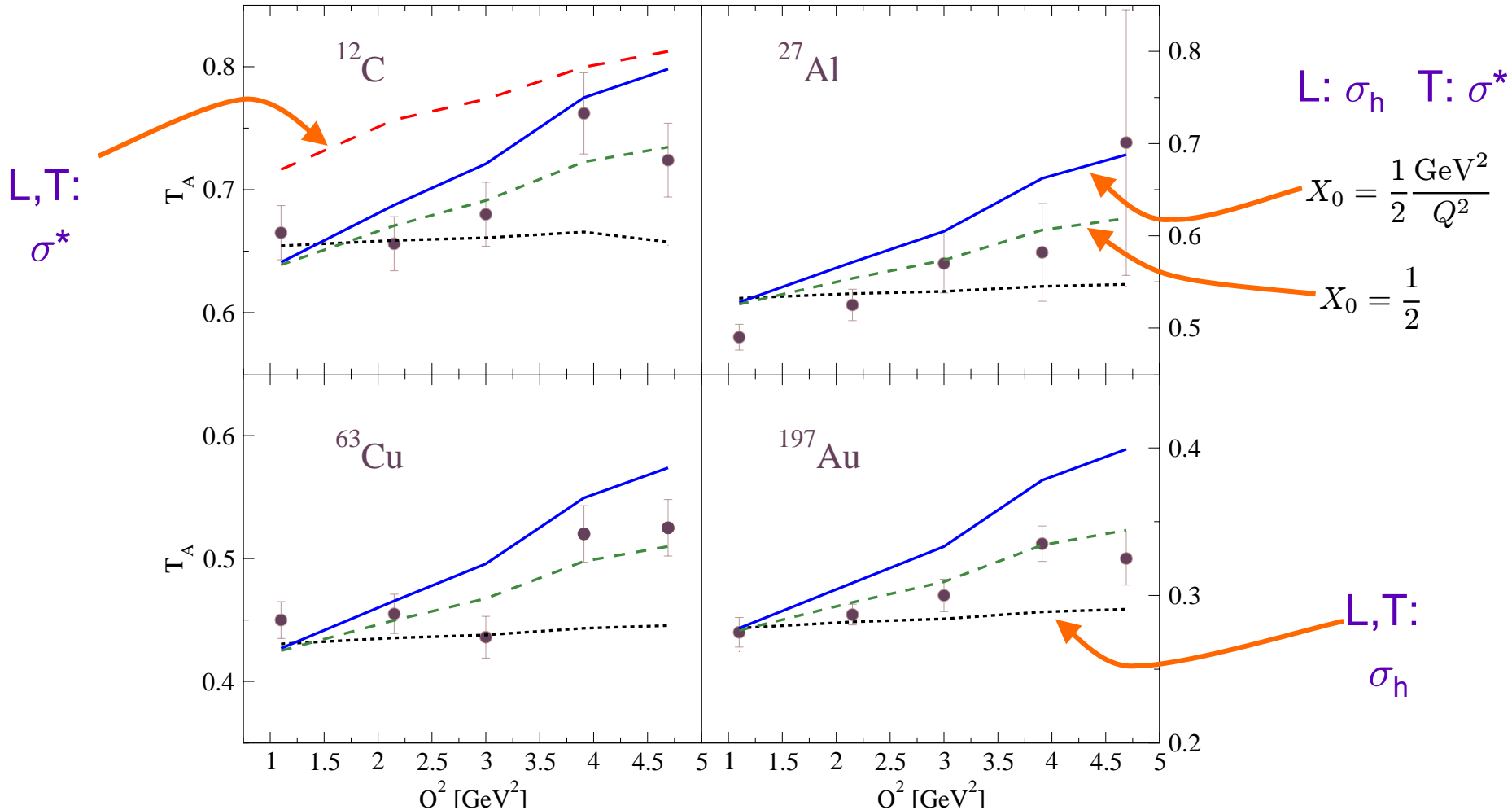
$$\tau_F = 0.17 \text{ fm} \longrightarrow \begin{matrix} t_P = 0 \\ t_F = \gamma\tau_F = 3 \cdots 5 \text{ fm} \end{matrix}$$



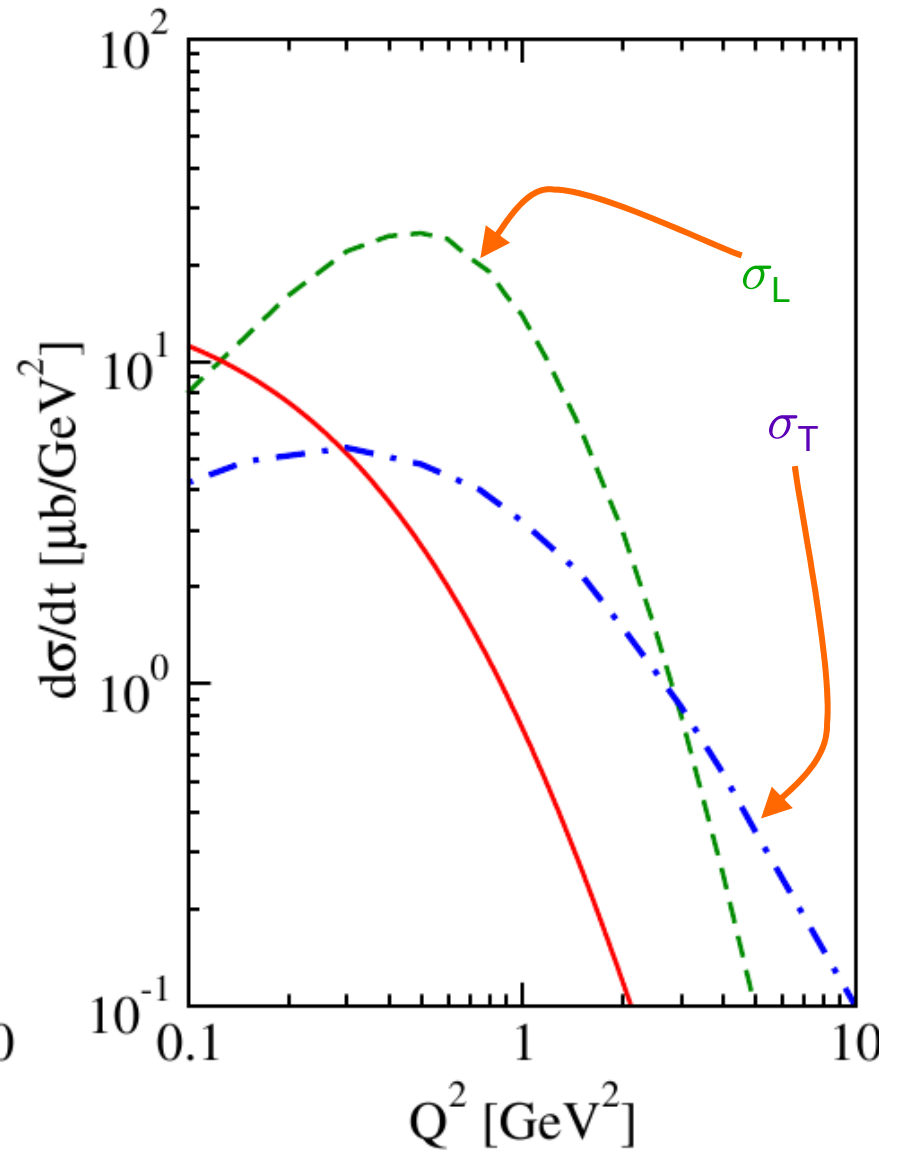
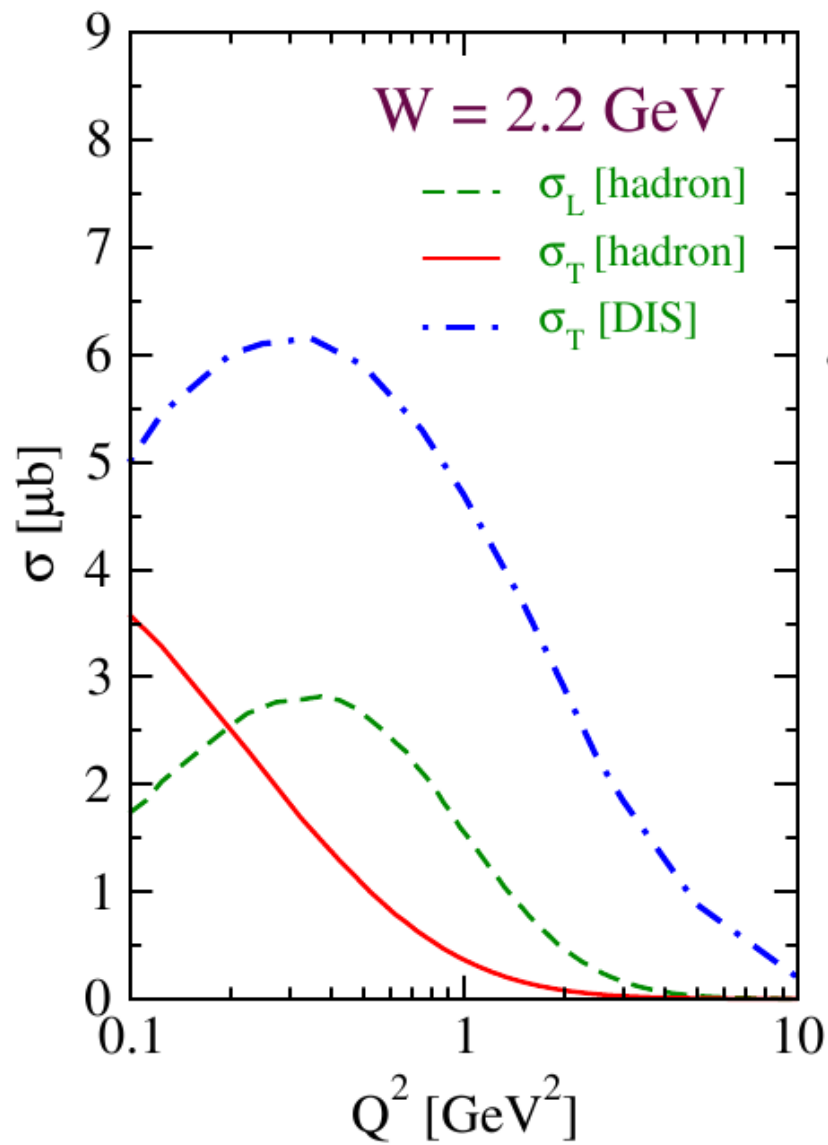
JLAB@5GeV: exclusive $A(e^-, e^-\pi^+)$

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$$\tau_F = 0.17 \text{ fm} \longrightarrow \begin{matrix} t_P = 0 \\ t_F = \gamma\tau_F = 3 \cdots 5 \text{ fm} \end{matrix}$$



Forward π^+ production



Summary exclusive π

■ Longitudinal/Transverse responses: Dynamics different

- Longitudinal cross section → hadronic
- Transverse cross section → partonic (DIS)

■ DIS:

- Lund String fragmentation (cross section level)
- s-channel baryonic resonances (amplitude level)

■ describe data with CT in σ_T

Exclusive rho0 production (CLAS)

■ Toy model init: $\gamma^*N \rightarrow \rho^0N$

$$\frac{d\sigma}{dWdQ^2}, \quad \frac{d\sigma}{dt} \simeq \exp bt$$

according Morrow et al.,
EPJ A39, 5 (2009)

■ experimental cuts:

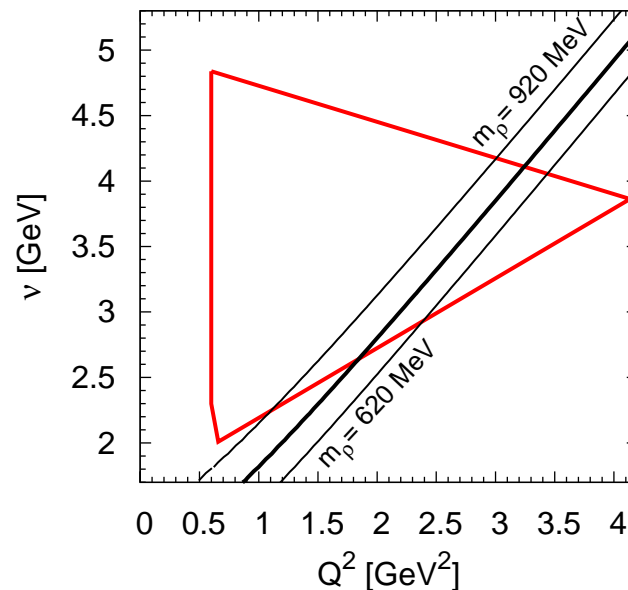
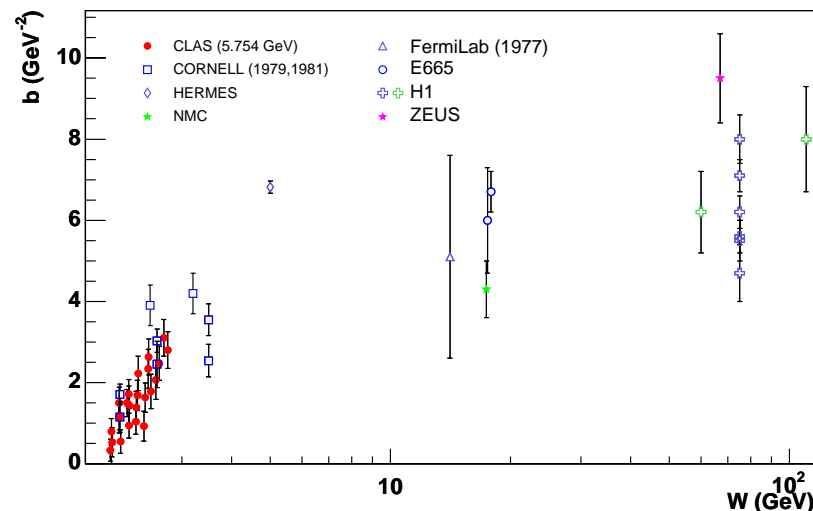
$$W > 2 \text{ GeV}$$

$$-t = 0.1 \dots 0.4 \text{ GeV}^2$$

$$z > 0.9$$

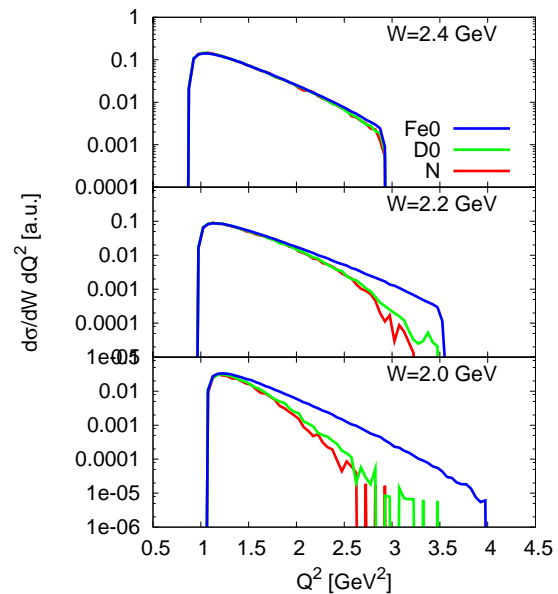
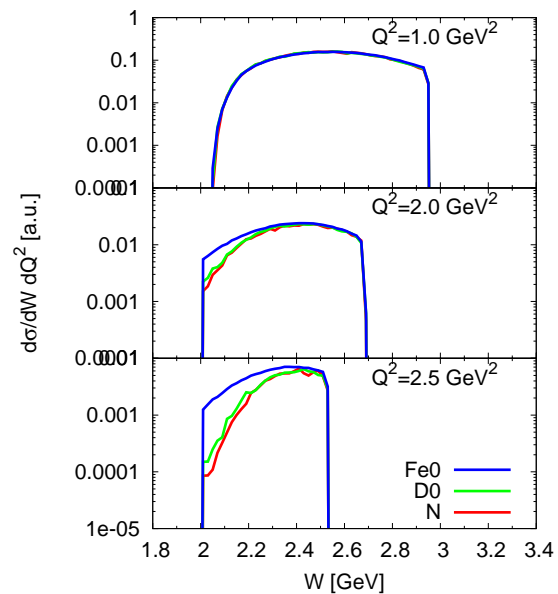
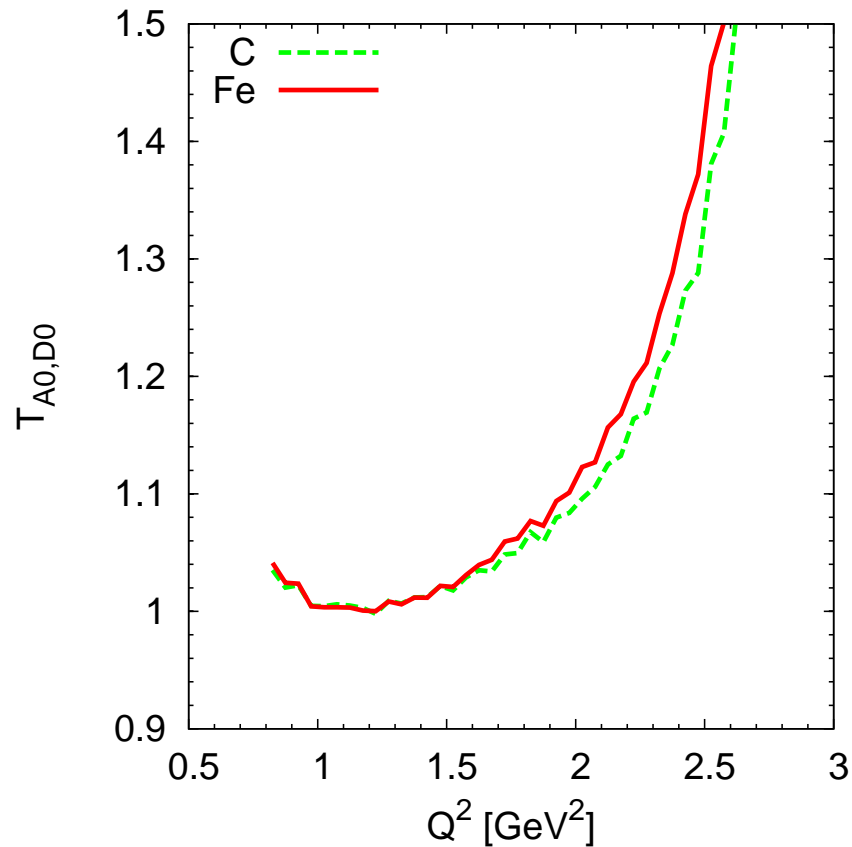
physical constraints:

$$t = t_{\min} \dots t_{\max}$$



Exclusive rho0 production (CLAS)

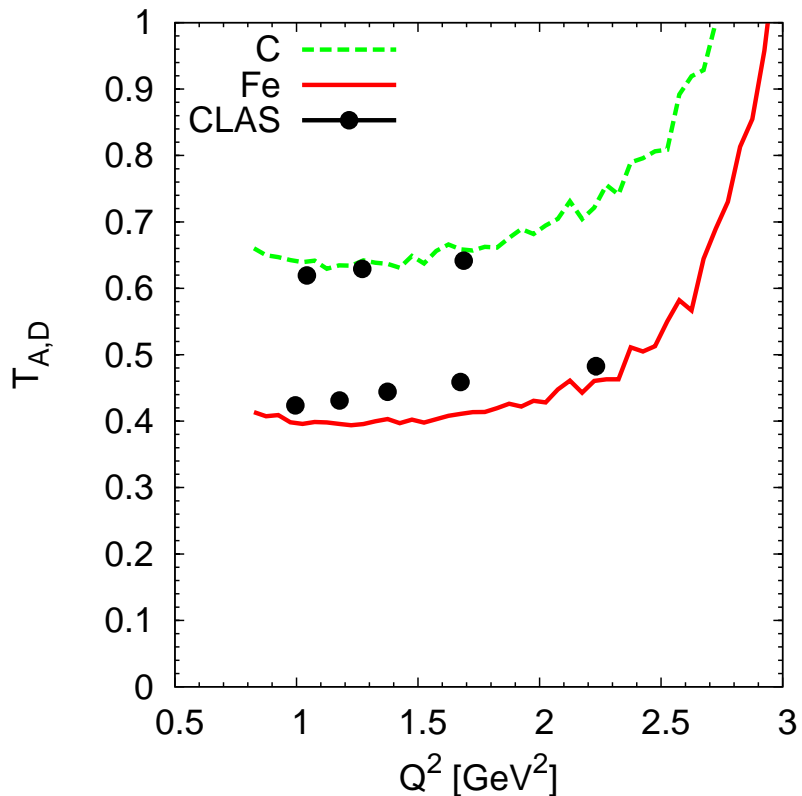
Effect of Fermi Motion



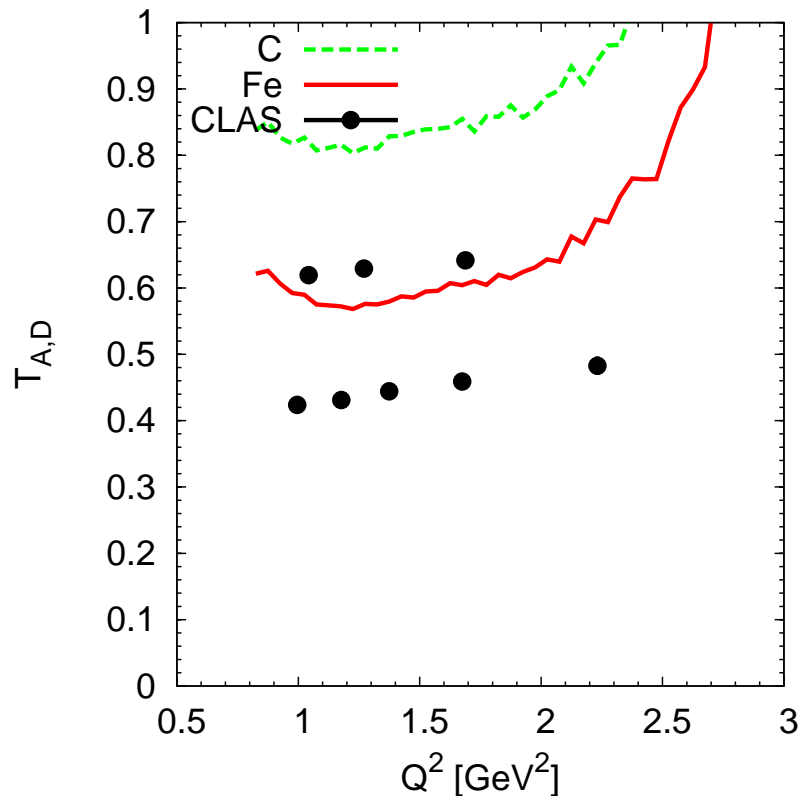
Exclusive rho0 production (CLAS)

Final State Interactions

no CT



with CT



FSI also for D

Fermi motion effect

data: L. El Fassi, PhD

Summary exclusive rho0

- Strong effect of Fermi Motion with Q^2
- FSI for D important
- large contribution of pion FSI
- Describe data with (nearly) no CT
- Sensitive to details,
complicated interplay of cuts