

GiBUU treatment of DIS

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on the nucleon

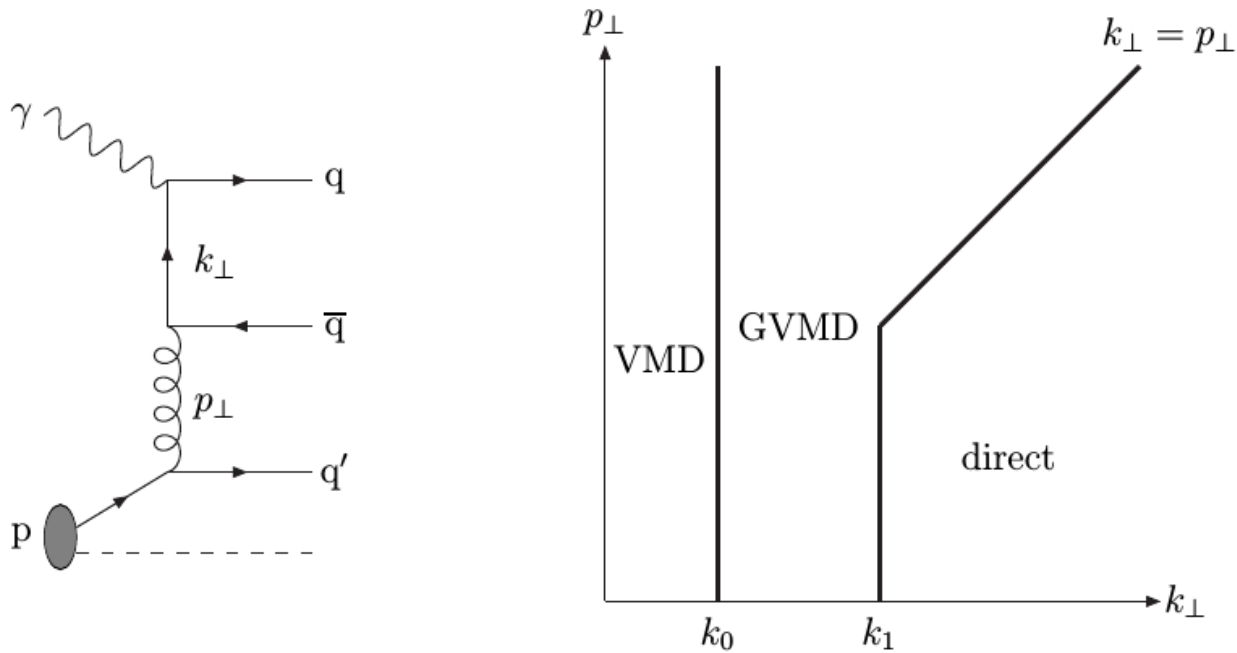
in the nucleus

final state

on the nucleon: em DIS

- Pythia 6 machinery: „*gamma/lepton*“
 - C. Friberg, T. Sjöstrand,
``Total cross-sections and event properties from real to virtual photons,``
JHEP **0009**, 010 (2000)
 - C. Friberg, T. Sjöstrand,
``Effects of longitudinal photons,``
Phys. Lett. B **492**, 123 (2000)
- initial & final state radiation (ISR, FSR)
- intrinsic kT
- resolved and direct photons

Pythia 6 gamma/lepton



■ resolved photons: VMD, GVMD

■ direct:

$$\gamma^* q \rightarrow q$$

(LO) DIS

$$\gamma^* q \rightarrow gq$$

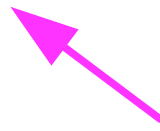
QCD Compton

$$\gamma^* g \rightarrow q\bar{q}$$

boson-gluon fusion

Pythia 6 gamma/lepton

$$\sigma_{\text{tot}}^{\gamma^* p} = \sigma_{\text{DIS}} \exp\left(-\frac{\sigma_{\text{dir}}}{\sigma_{\text{DIS}}}\right) + \sigma_{\text{dir}} + \left(\frac{W^2}{Q^2 + W^2}\right)^n (\sigma_{\text{VMD}} + \sigma_{\text{GVMD}})$$



empirical

Sudakov suppression:

$$\sigma_{\text{DIS}} = \left(\frac{Q^2}{Q^2 + m_\rho^2}\right)^2 \frac{4\pi^2 \alpha_{\text{em}}}{Q^2} F_2(x, Q^2)$$

$\sigma_{\text{dir}} = \dots$ matrix elements

$$\sigma_{\text{LO DIS}} = \sigma_{\text{DIS}} - \sigma_{\text{dir}} < 0 \quad \text{for } Q^2 \rightarrow 0$$

■ additional GiBUU cuts:

- $W > 1.6$ GeV for DIS
- $W > 2.0$ GeV for VMD/GVMD

electron scattering

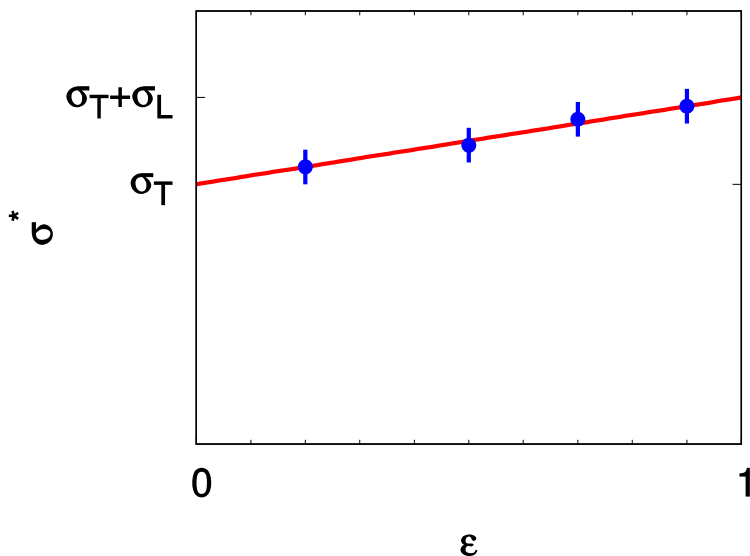
cross section

$$\frac{d\sigma}{d\Omega'dE'} = \Gamma (\sigma_T + \varepsilon\sigma_L)$$

$$\Gamma = \frac{\alpha}{2\pi^2} \frac{E'}{E} \frac{W^2 - m_N^2}{2m_N Q^2} \frac{1}{1 - \varepsilon}$$

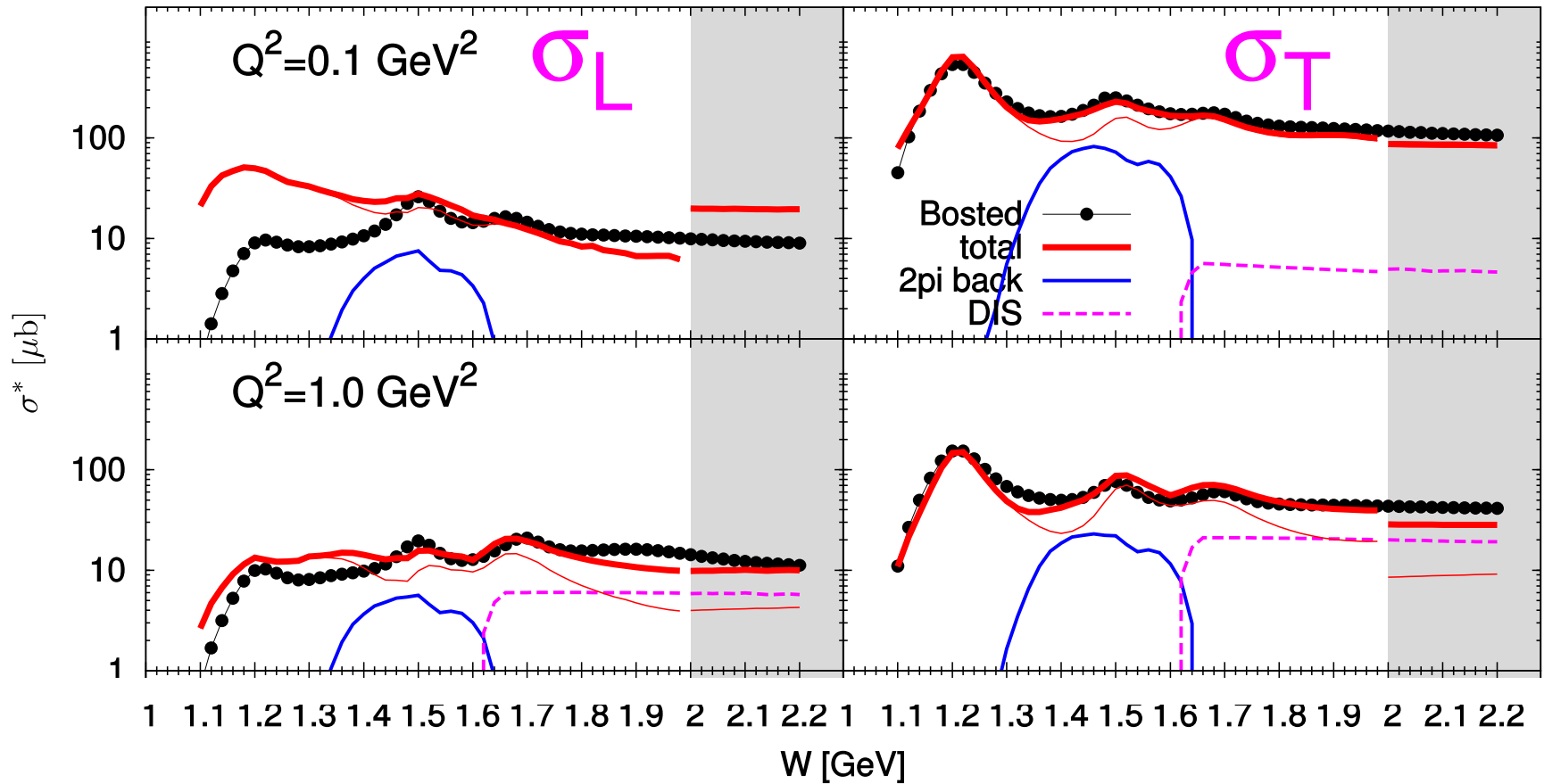
$$\varepsilon = \left[1 + 2 \left(1 + \frac{\nu^2}{Q^2} \right) \tan^2 \frac{\theta}{2} \right]^{-1}$$

Rosenbluth separation



$$R = \frac{\sigma_L}{\sigma_T} \quad \text{experimentally known}$$

Rosenbluth separation



“data“: M.Christy, P.Bosted, PRC 81(2010),055213

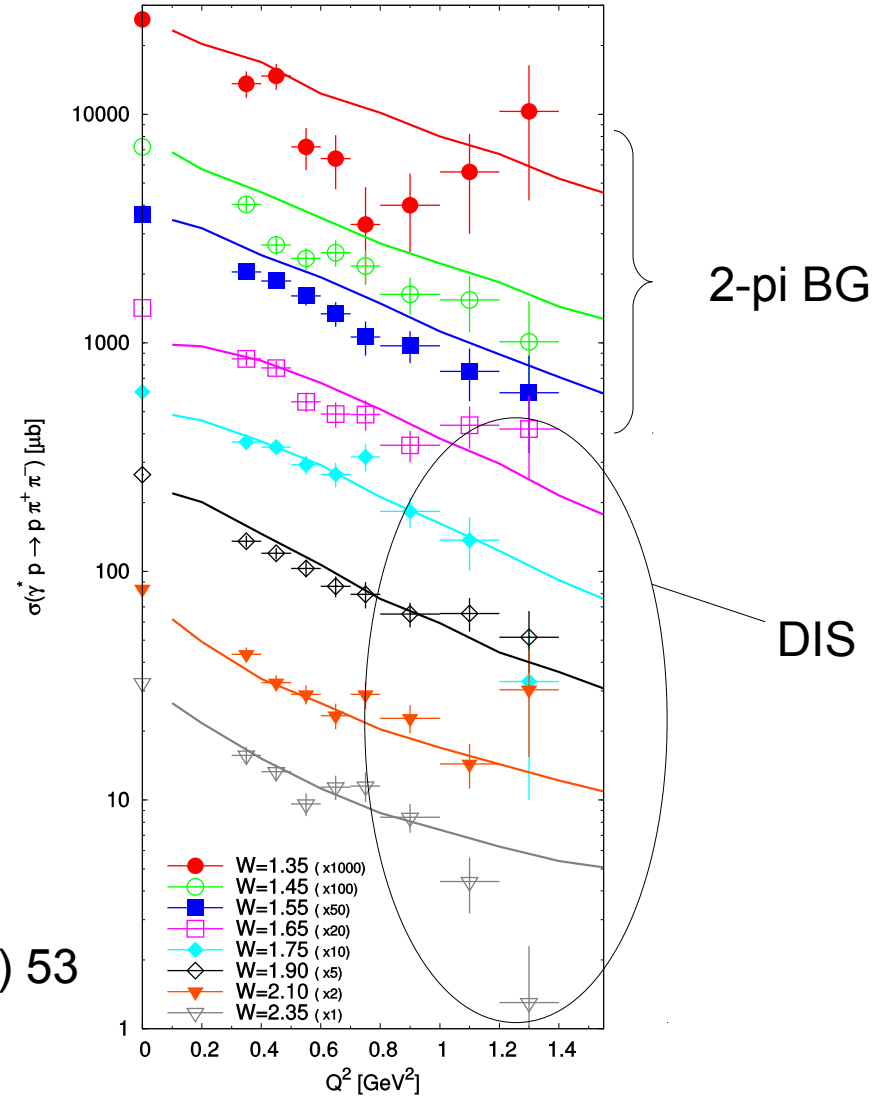
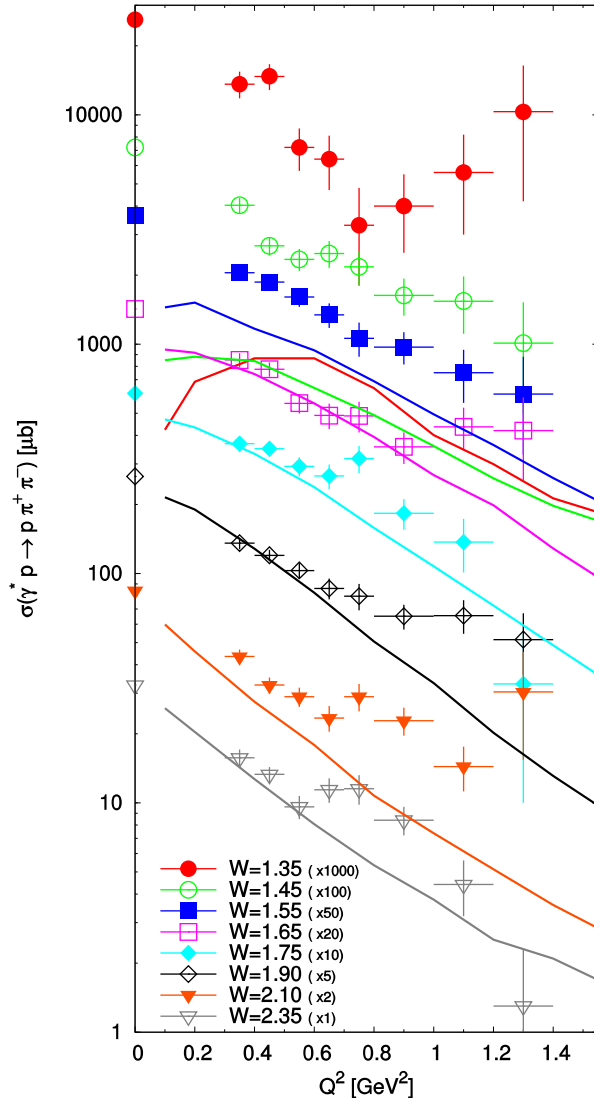
2-pion background needed with different Q^2 behavior

2-pion production

$$\gamma^* p \rightarrow p \pi^+ \pi^-$$

■ no DIS, no 2-pion BG

■ with DIS & 2-pion BG



on the nucleon: em+CC+NC DIS

- Pythia process no. 10: $f_i f_j \rightarrow f_k f_l$
set incoming lepton/neutrino, target nucleon, type of exchange boson
- initial & final state radiation (ISR, FSR)
- intrinsic kT

- GiBUU formfactors and cuts:

- $\left(\frac{Q^2}{Q^2 + m_{\text{DIS}}^2} \right)^n \quad \begin{cases} n = 2 & \text{EM} \\ n = 1 & \text{CC, NC} \end{cases}$

- $W \gtrsim 1.5 \text{ GeV}$



in the nucleus

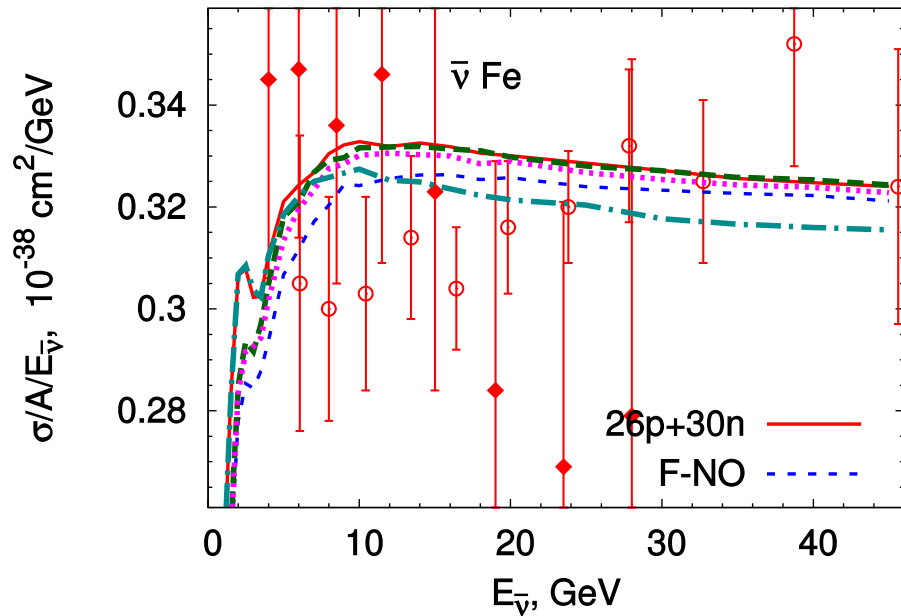
- initial nucleons: **Fermi motion**
- final nucleons: **Pauli blocking**
- initial & final nucleons (+others?): (binding) **potential**
- potential may be momentum dependent

- **DIS: no consistent description possible** (in contrast to QE, 1π , ...)

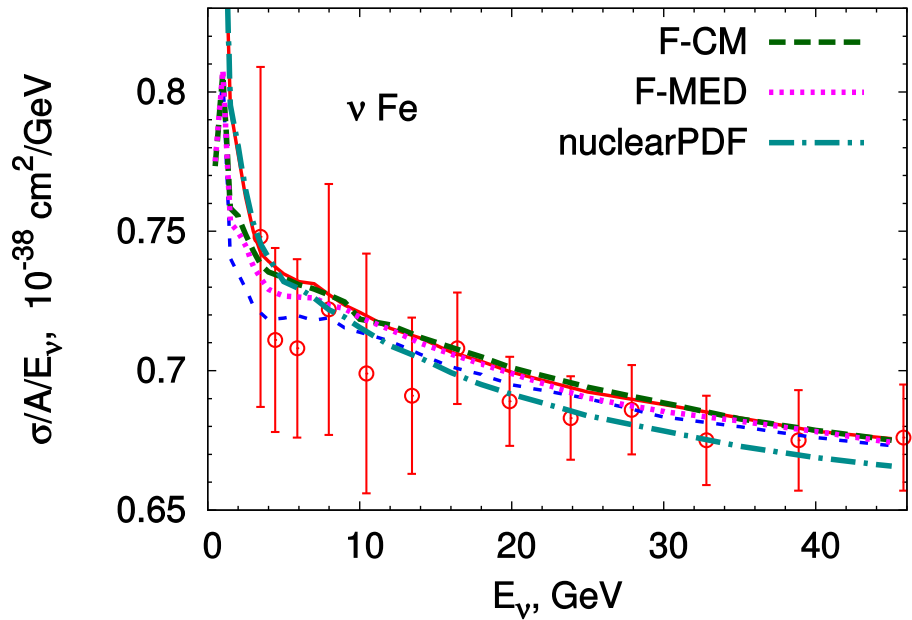
- **recipe:**
 - 1) calculate energy for collision on a free nucleon
(not unique)
 - 2) do collision
 - 3) correct final state

in the nucleus

Effect of 'free kinematics':



data: MINOS, IHEP-JINR



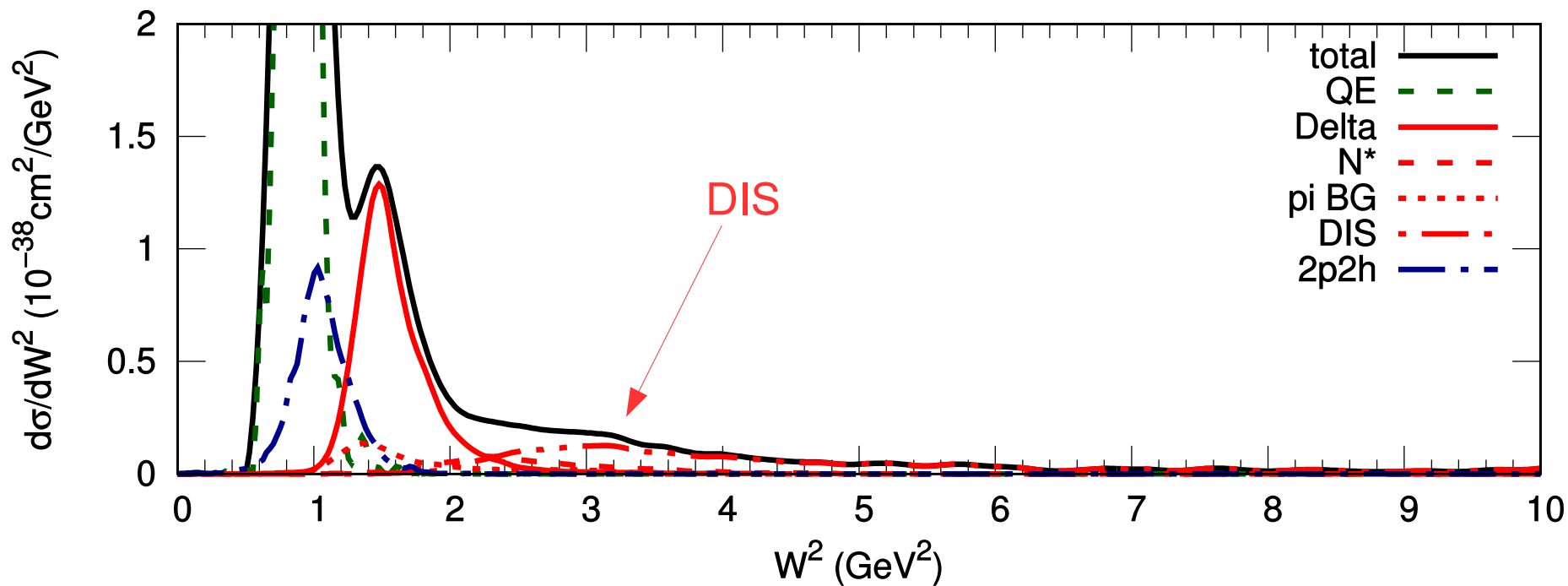
O.Lalikulich, KG, U.Mosel, PRC 86(2012),014607

different prescriptions: some percent effect

inclusive cross section

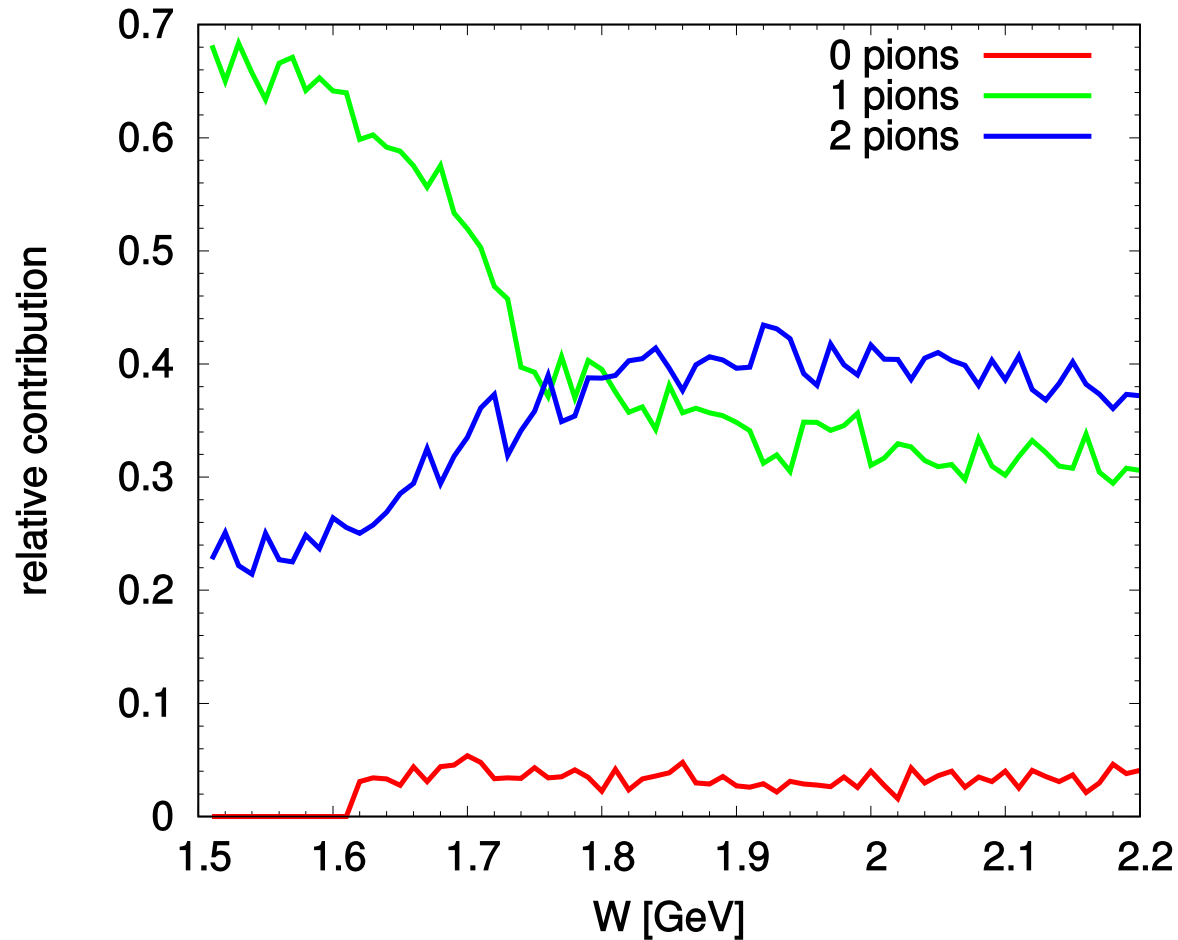
■ atmospheric flux on H₂O

Wrec, resprodFF=0



0, 1, ... DIS

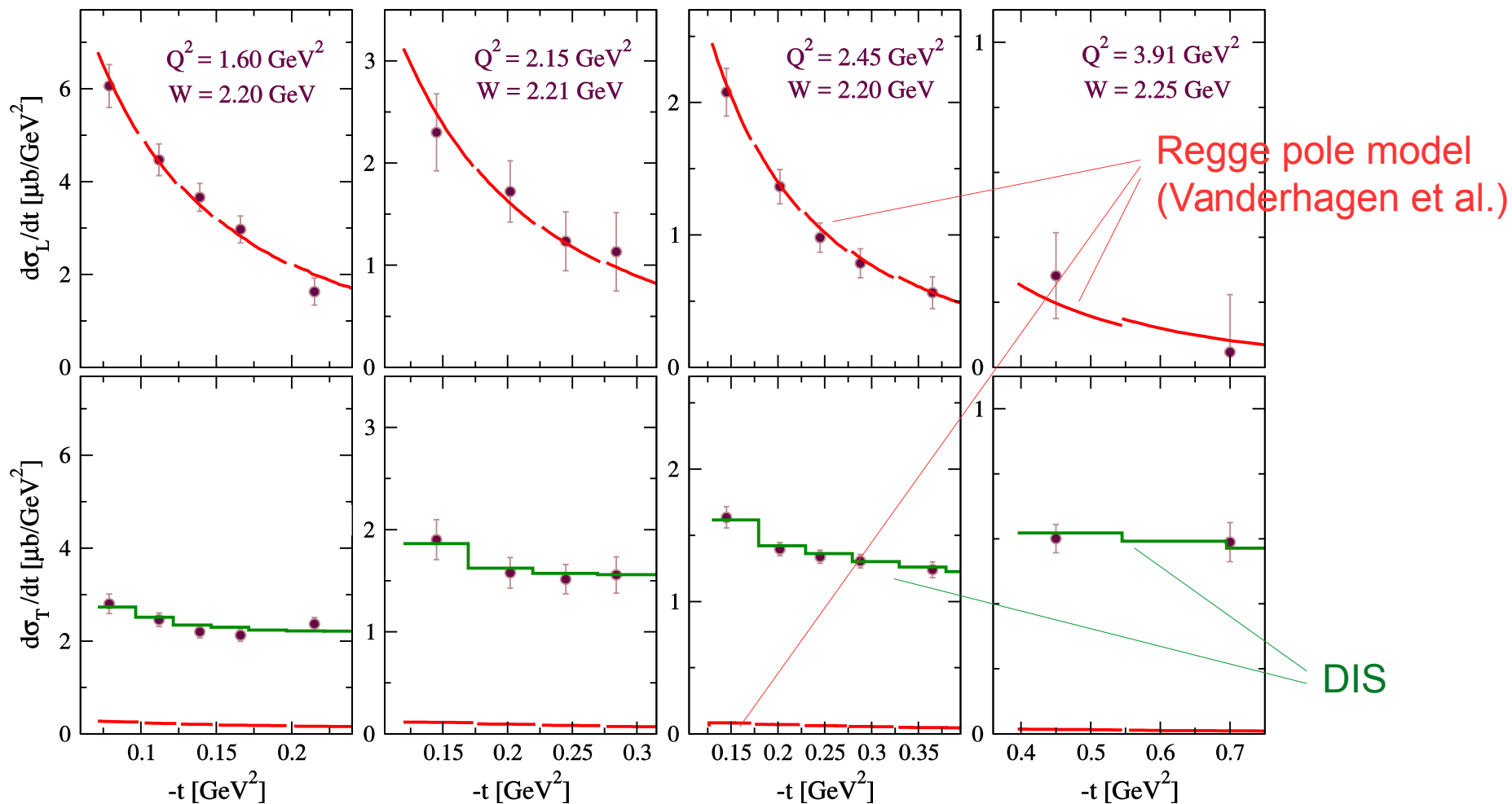
■ final state from Pythia



DIS at these energies is not „multiple“ pions

exclusive pion production

JLAB $p(e, e' \pi^+) n$



Conclusion

- GiBUU, pure em-DIS: Pythia 6 „*gamma/lepton*“
- GiBUU, em+NC+CC: Pythia 6 process 10
+ form factor
- $W=1.4-1.6$ GeV: 2-pion Background, non-DIS
- $W>1.6$ GeV: DIS

- ‘energy correction’ to respect potential

- Pythia fragmentation contributes to 1-pi, 2-pi, ...