SIDIS π/K production with CLAS12

Xiaodong Jiang, Los Alamos National Laboratory.

Hai-Jiang Lu, Univ. of Sci.&Tech. China.

- Opportunities of SIDIS with CLAS12.
- How do we know we hit a quark ?
- Cross sections of SIDIS π production at NLO.
- Instrumentation considerations.
- My list of SIDIS questions for CLAS12.

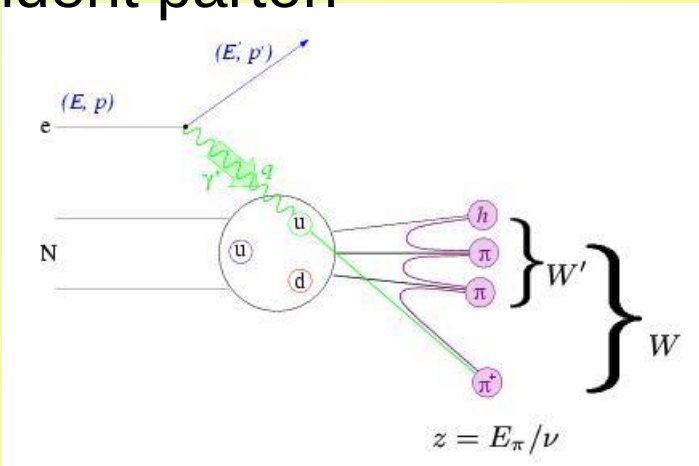
SIDIS with CLAS12

- A_{UT} trans. target SSA, Collins and Sivers asymmetries to access quark transversity and Sivers distribution function. $\pi^{+/0/-}$, $K^{+/-}$ etc.

- A_{LL} long. target double-spin asymmetries for quark spin-flavor decomposition, Δu, Δd, Δubar- Δdbar etc.

- Hadron azimuthal distribution in SIDIS, like cos(2φ), access transverse momentum dependent parton distributions.

and more…



Can we access quark information at CLAS12 ?

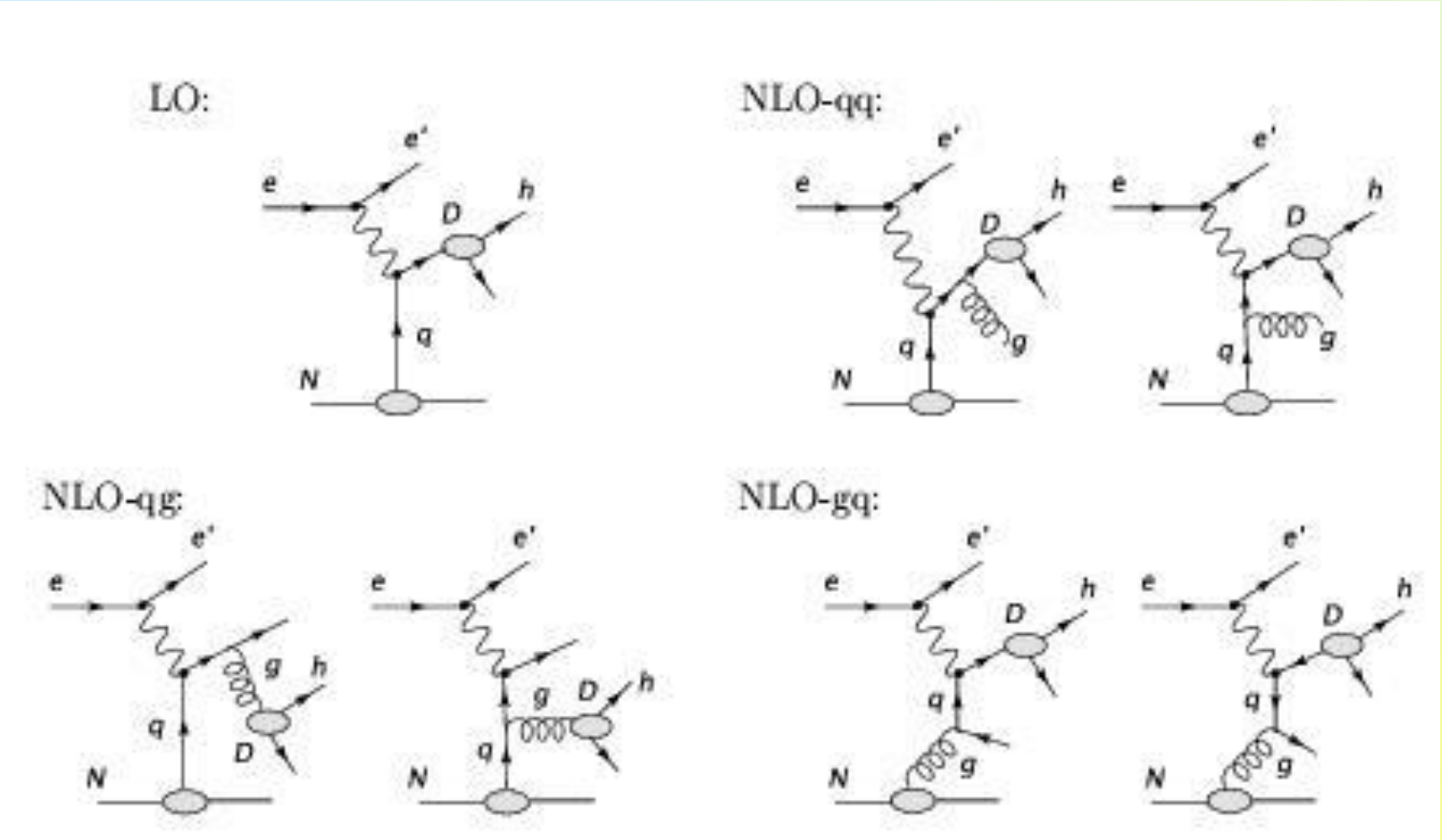
- Hard scattering. How do we know we hit a quark ?
- Fragmentation. Quark information carried out by hadron ?
- Universality of Frag. Func. Agree with e^+e^-, p+p data ?

Do we understand the fundamental cross sections in SIDIS, to NLO ?

Do we understand their relative relations, Q^2, z, p_t and φ-dependencies ?

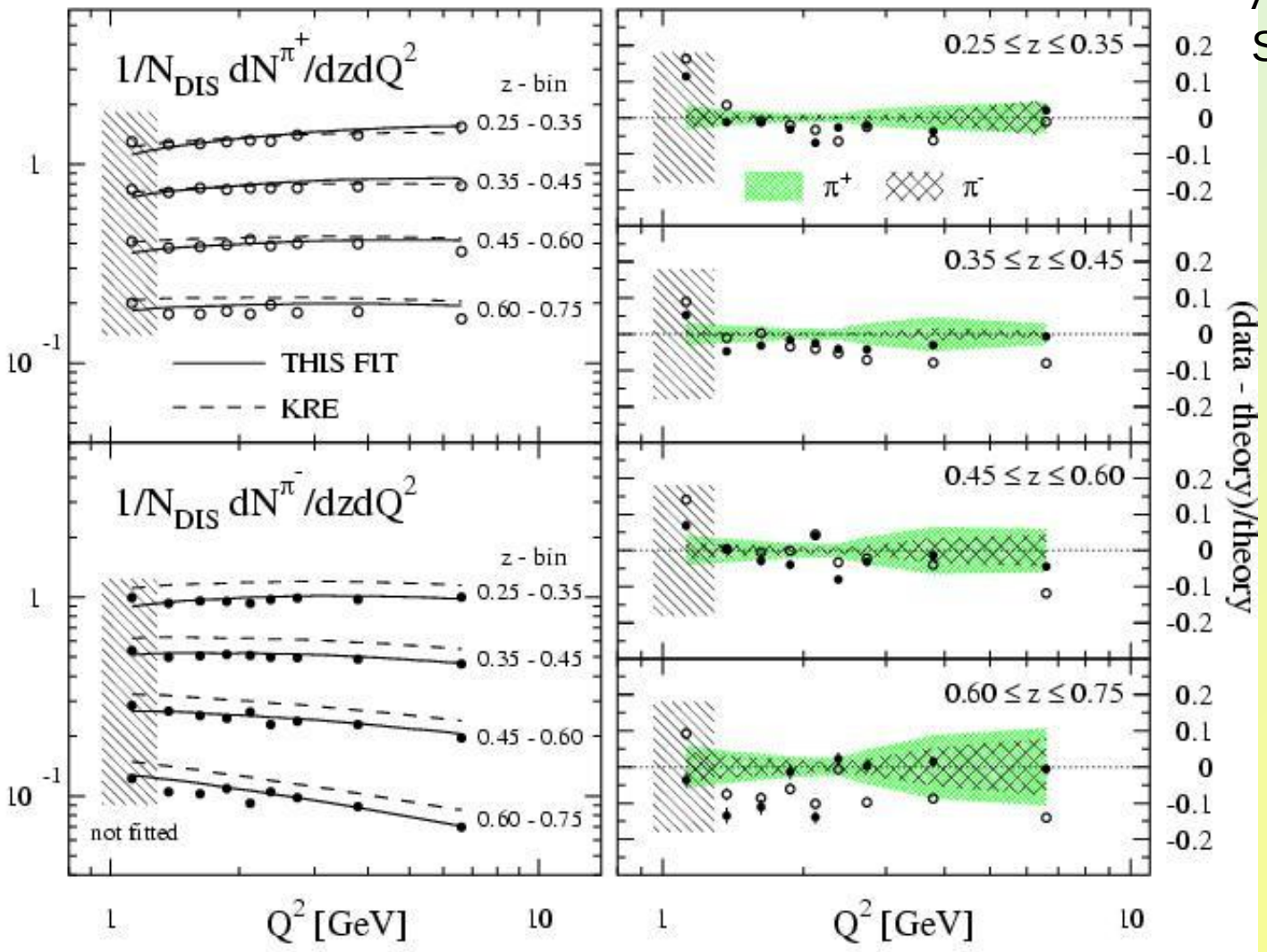
Establish the baseline of interpretation.

SIDIS cross sections at NLO



$$q(x,Q^2)\cdot D(z,Q^2)\Rightarrow \int\frac{dx'}{x'}\int\frac{dz'}{z'}q\left(\frac{x}{x'}\right)C(x',z')D\left(\frac{z}{z'}\right)$$

NLO global fits for Fragmentation Functions



A global fit to e+e-, SIDIS and p+p data.

Predict cross section at NLO for Jlab12.

Fit compare with HERMES SIDIS data, R. Sassot et al. 2007.

Experiment with CLAS12: SIDIS $\pi^{+/0/-}$ production

$$ep(d) \rightarrow e'\pi X$$

Measure counts: $N_{\pi^+}, N_{\pi^-}, N_{\pi^+} / N_{\pi^-},$

$$\left(N_{\pi^+} + N_{\pi^-}\right)^p / \left(N_{\pi^+} + N_{\pi^-}\right)^d$$

$$\left(N_{\pi^+} - N_{\pi^-}\right)^p / \left(N_{\pi^+} - N_{\pi^-}\right)^d$$

Dependence on Q2, xbj, z, Pt

High Luminosity $10^{35} cm^{-2} s^{-1}$

Without integrating others for a dependence measurement !!!

Definition and cuts

$$Q^2, \nu, x_{bj} = \frac{Q^2}{2\nu M}$$

$$ep(d) \rightarrow e' \pi X$$

W´ hadronic system without detected pi

W hadronic system

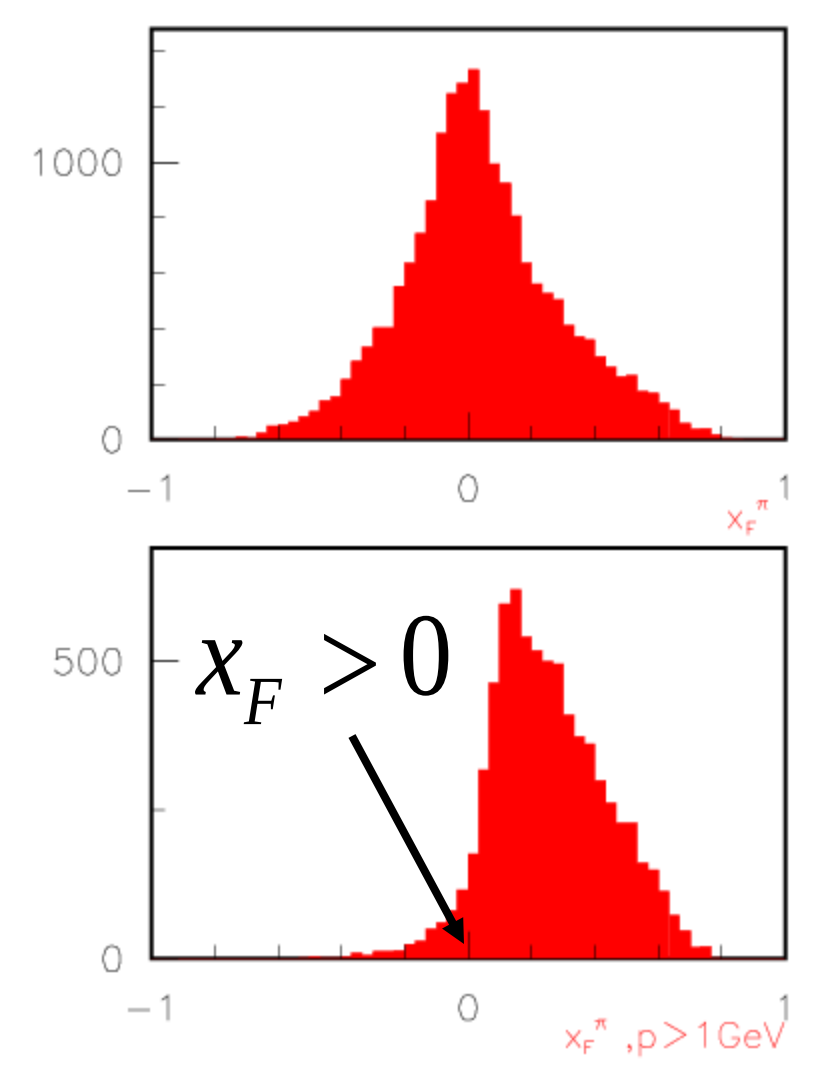
$$z_\pi = \frac{E_\pi}{\nu}$$

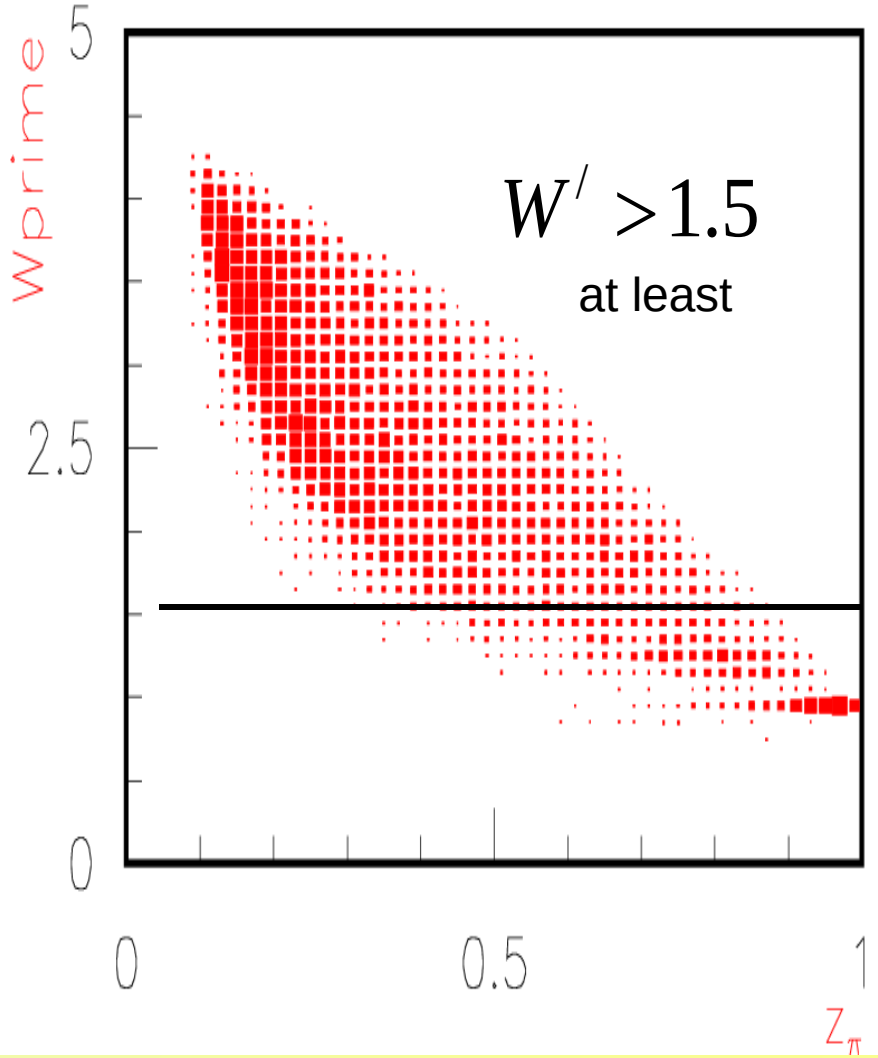
$$x_F = \frac{2p^*_{//}}{W}$$

* Virtual-photon nucleon CM

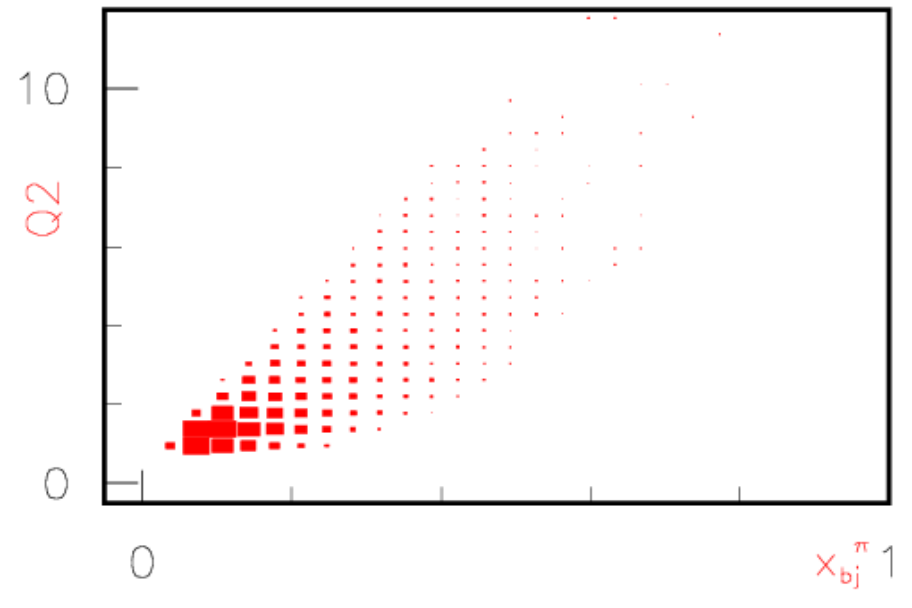
$$Q^2 > 1, W > 2$$

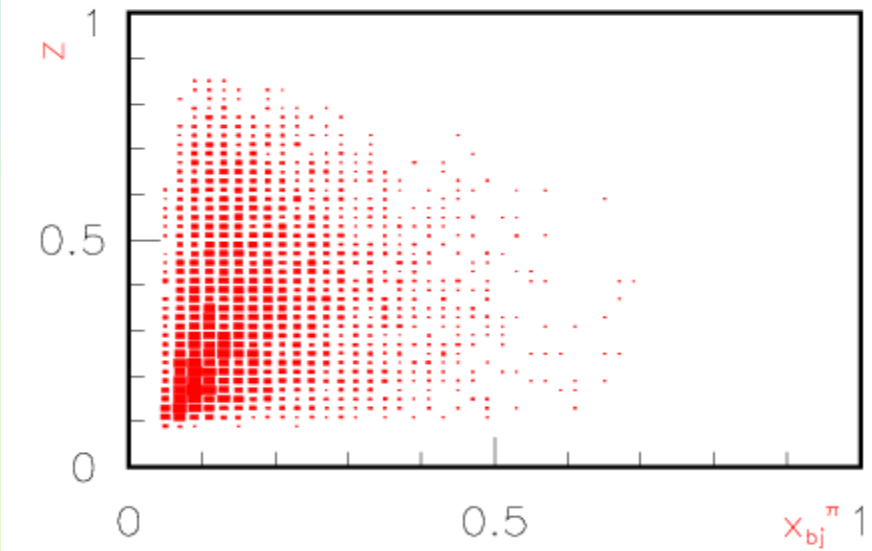
Cuts for pion on x_F, W'

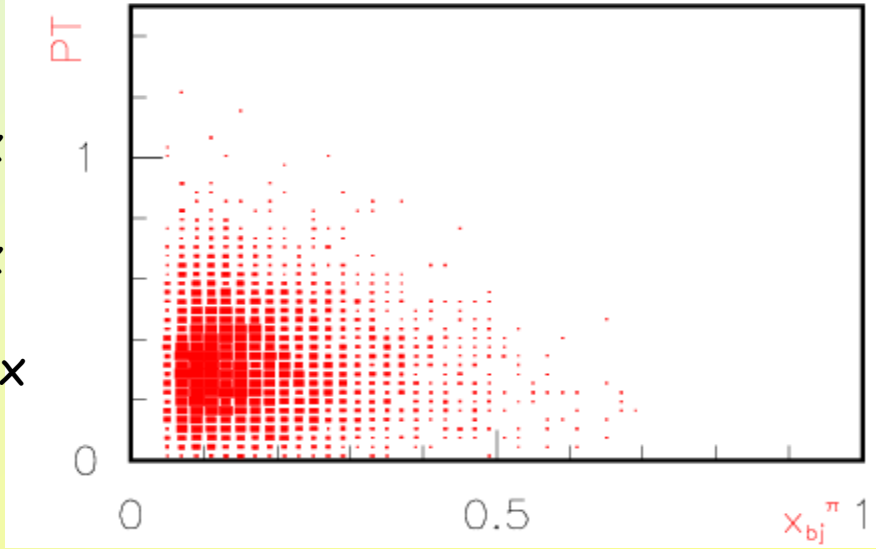




Q2 vs. x, z vs. x, Pt vs. x





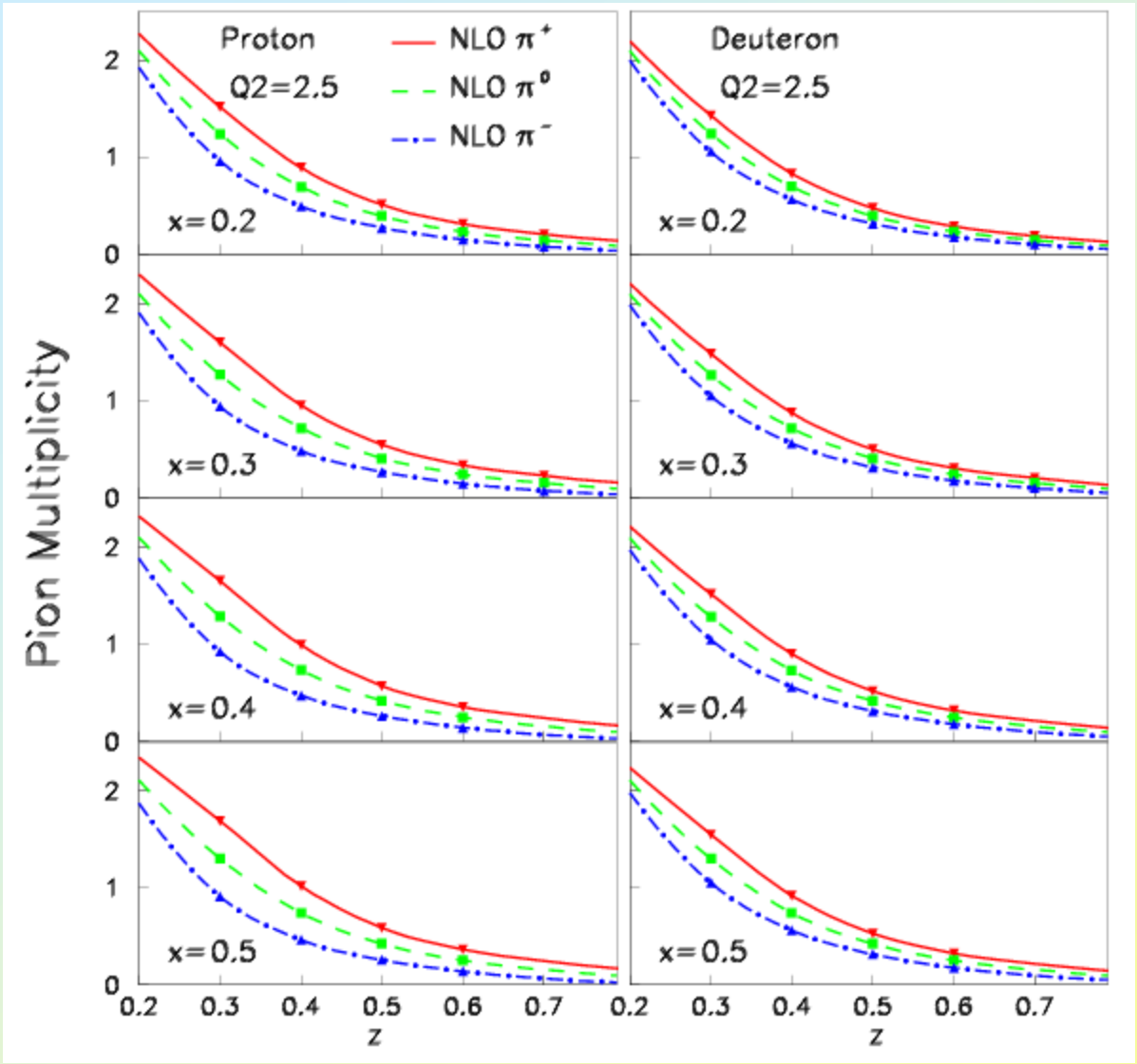


Check Q2 dependence for a given z and x

Check z dependence for a given Q2 and x

Check Pt dependence for a given Q2 and x

Expected results: z-dependence



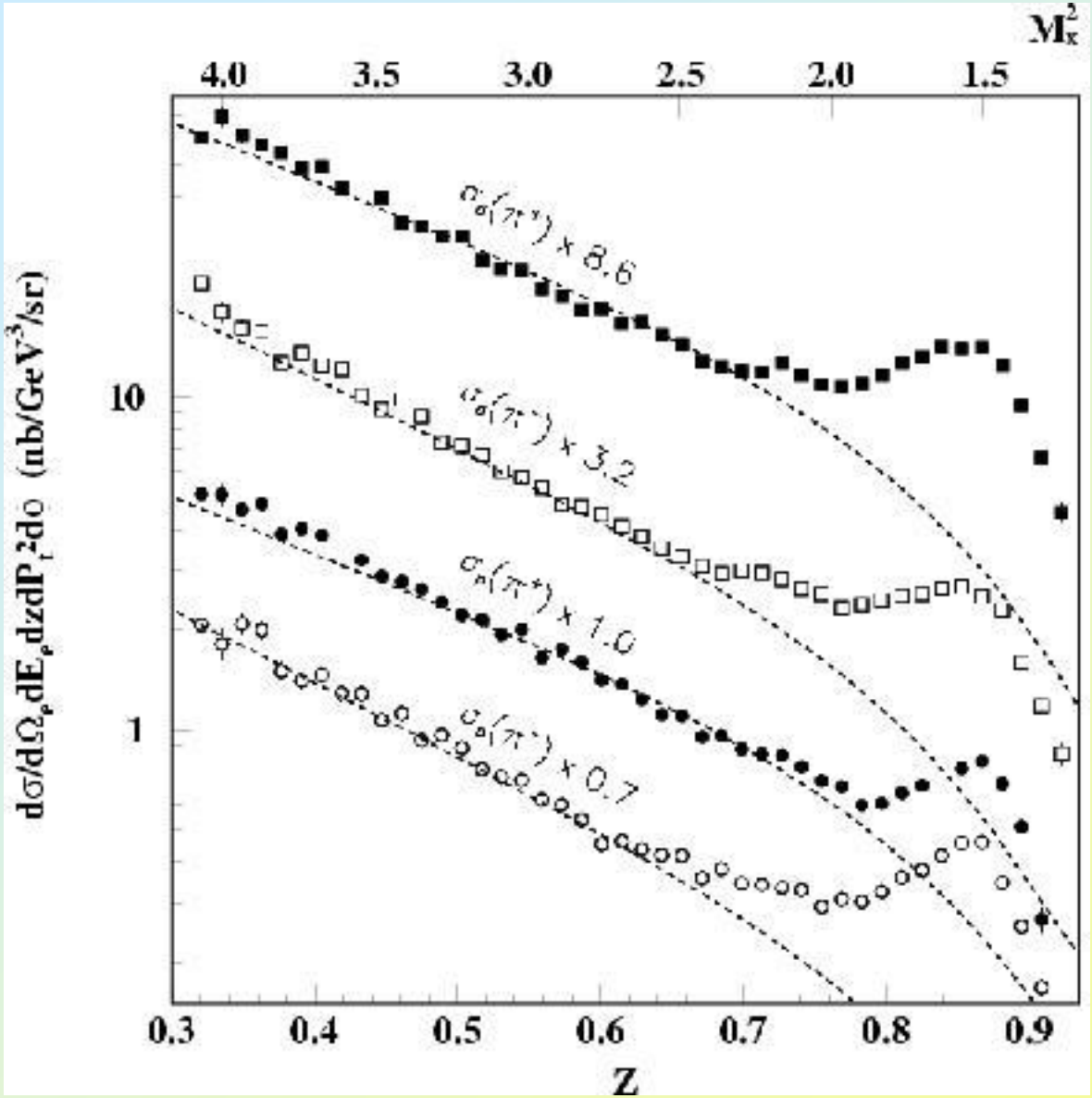
Curve: Prediction in NLO from R. Sassot .

Q2=2.5,
x=0.2,0.3,0.4,0.5

SU(2) symmetry in the fragmentation process ?

$\pi^0=(\pi^+ + \pi^-)/2$

Hall C data at 5.5 GeV: cross sections

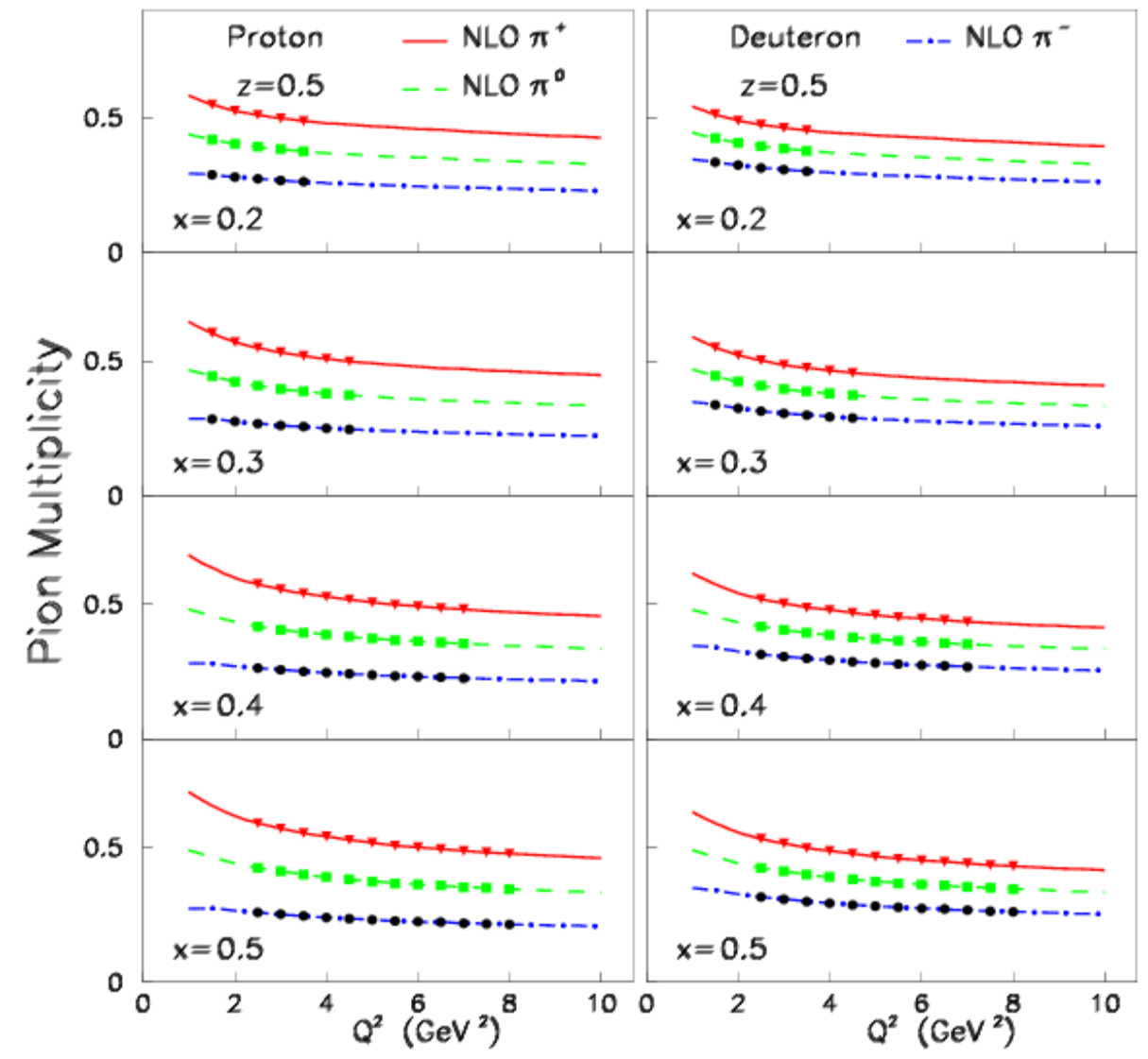


X=0.32, Q^2=2.3 GeV^2.

smooth in 0.4<z<0.65

agree with LO.

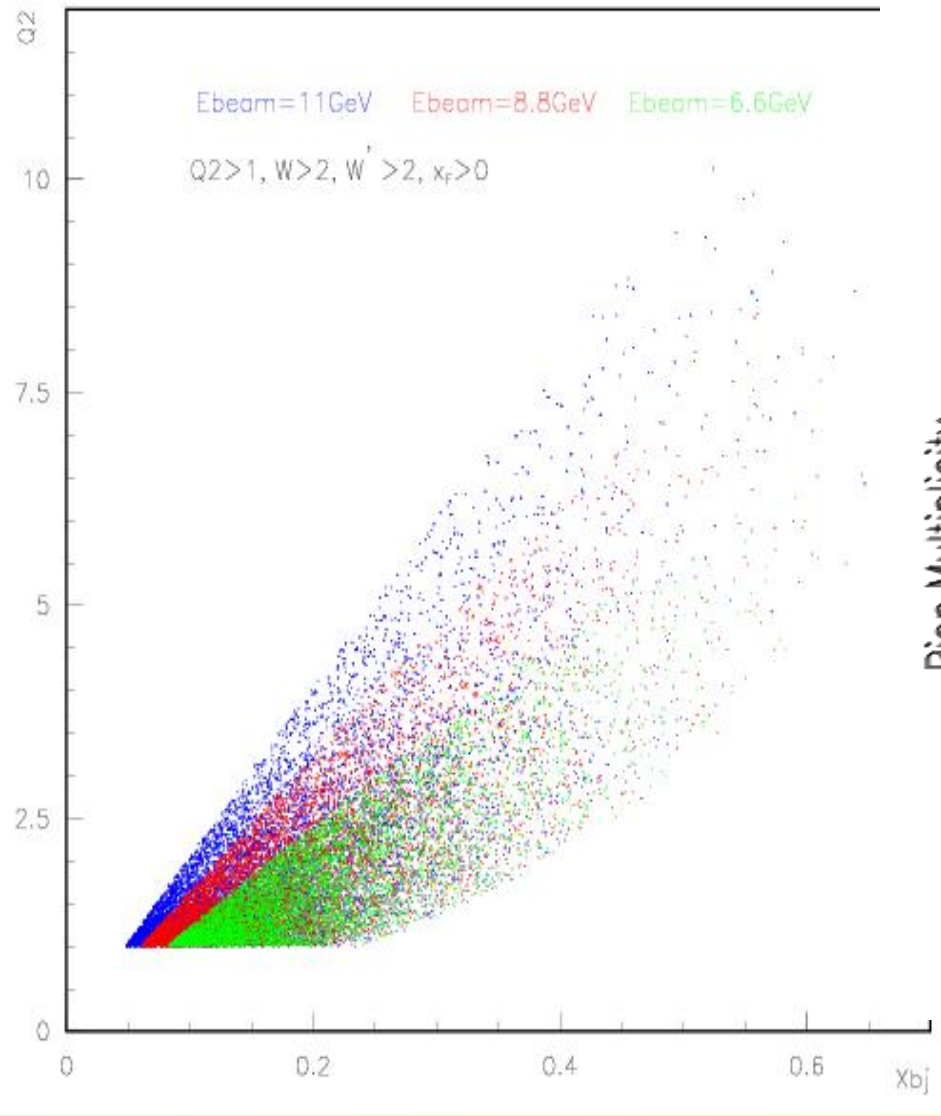
Expected results: Q2 dependence

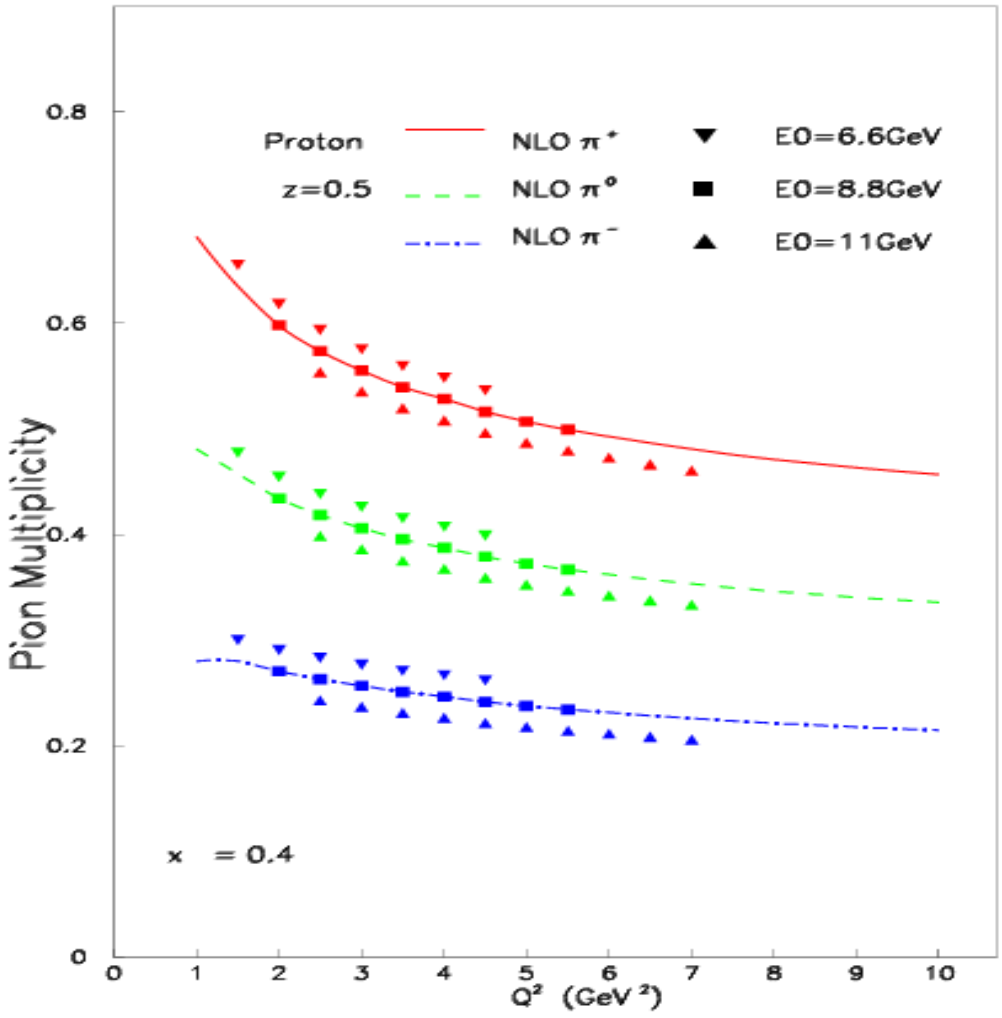


Curve: Prediction in NLO from R. Sassot.

z=0.5,
x=0.2,0.3,0.4,0.5

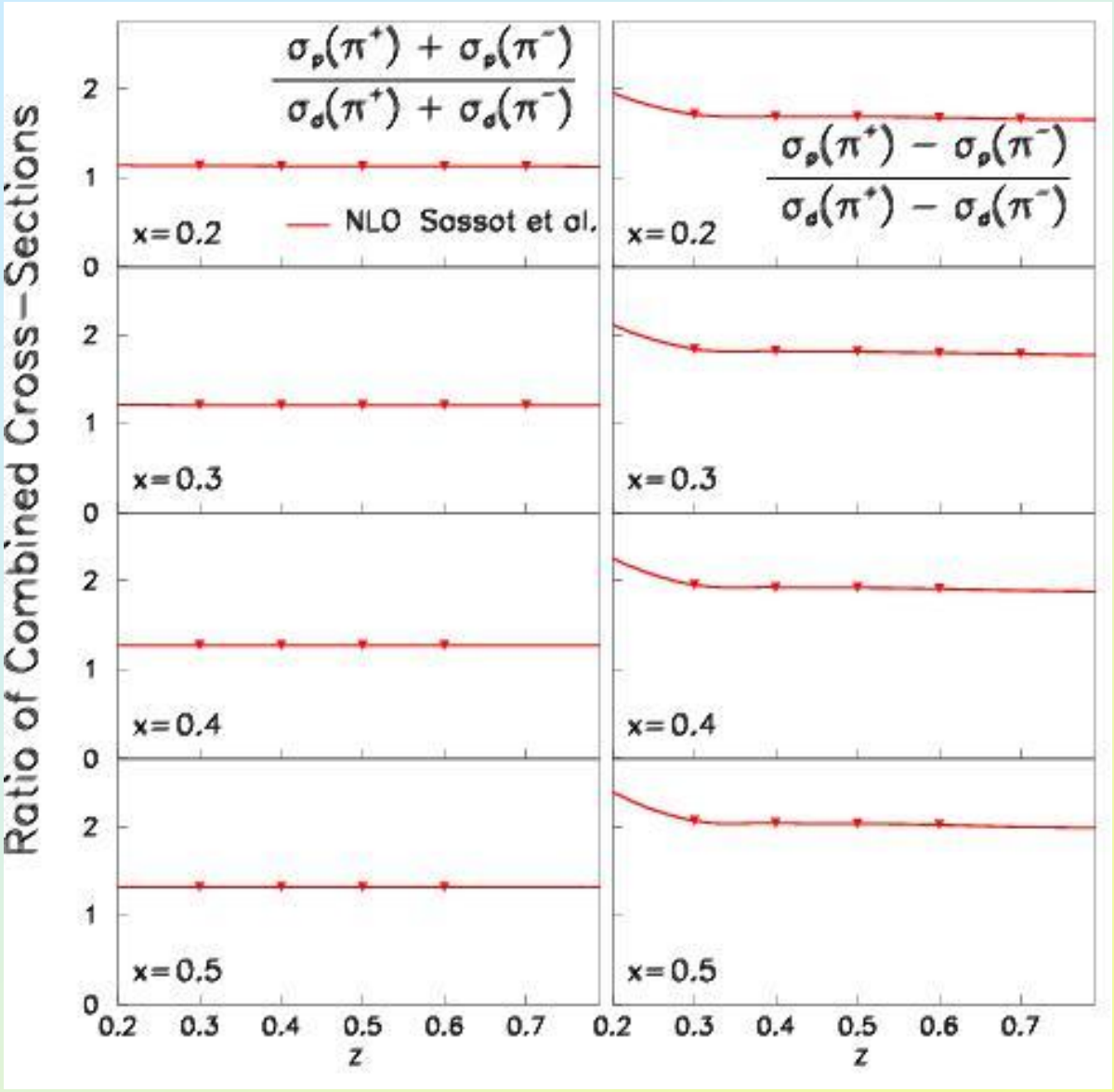
At beam energy 11,8.8 and 6.6 GeV





Q^2-dependence , same Q^2 point covered by different beam energy.

The combined-ratios of multiplicities



At LO no z-dependency.

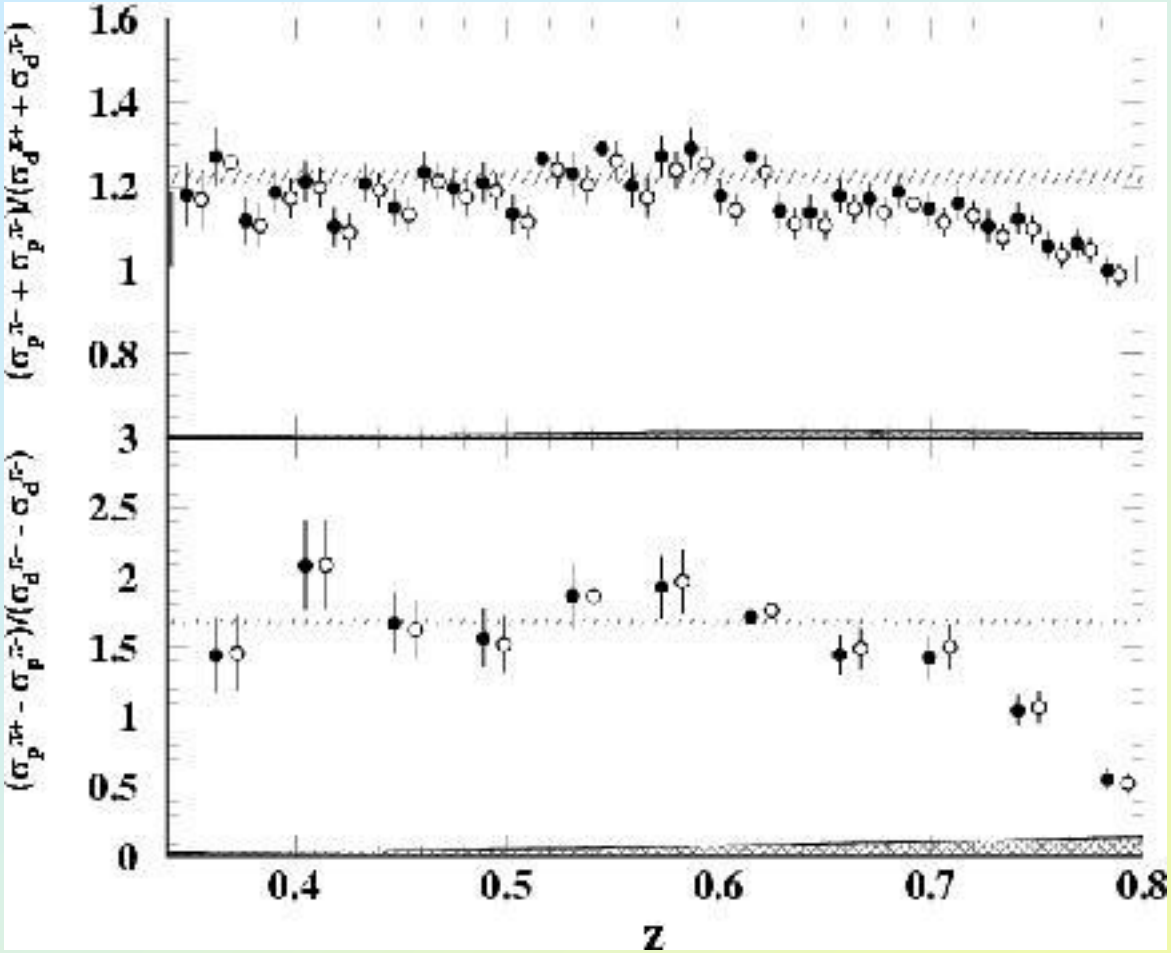
Even at NLO, z-dependency mostly disappeared.

ratios become completely determined by quark distributions.

A clear evidence to prove that quark information is well-preserved in the fragmentation process.

At 5.5 GeV, we already know from Hall C data …

Hall C data at 5.5 GeV: combined-ratio of multiplicities

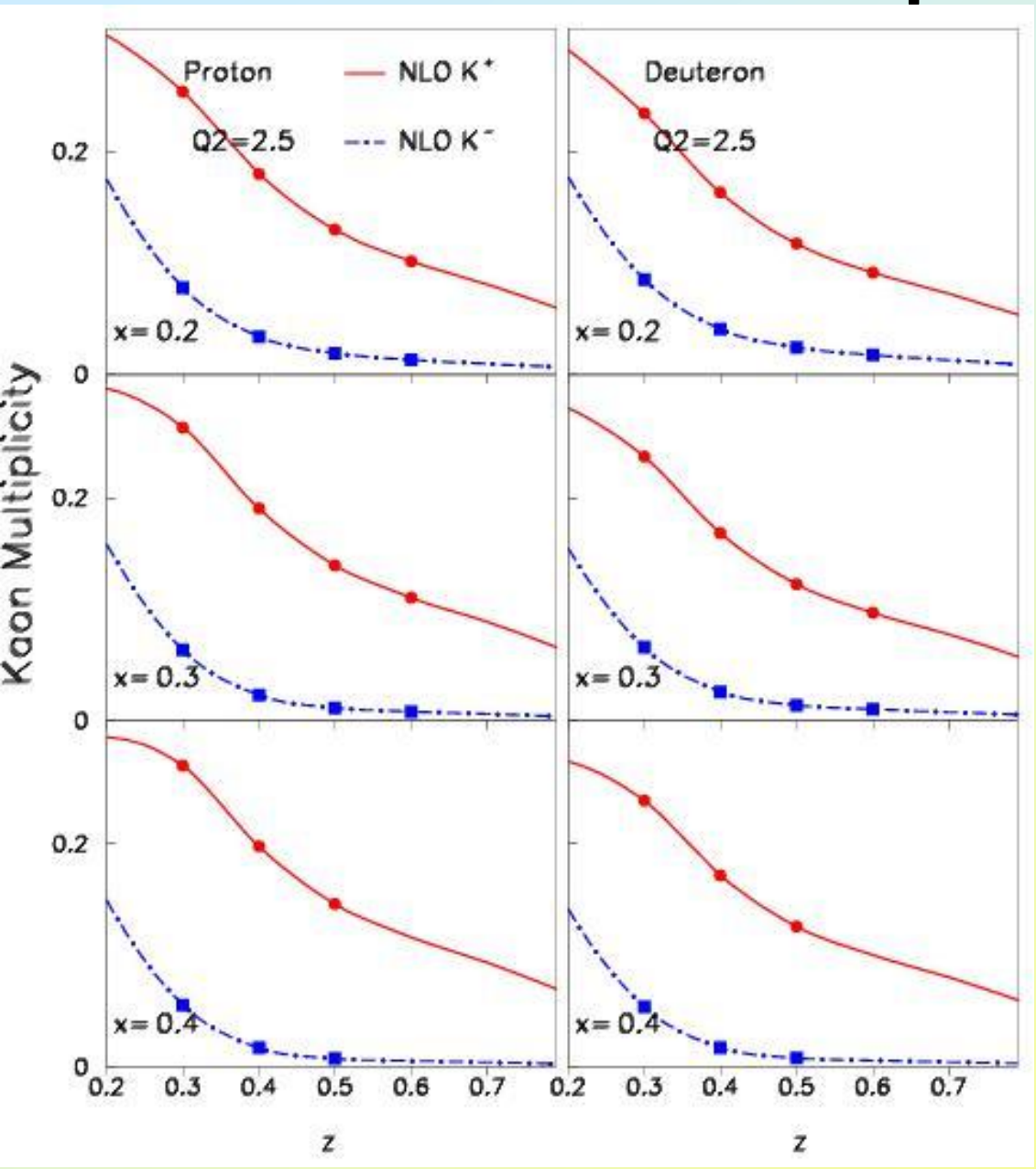


X=0.32, Q^2=2.3 GeV^2.

Flat in 0.4<z<0.7

Agree with LO parton ratios.

Kaon multiplicities



Cut on P_K<3.0 GeV/c, no RICH.

A RICH detector helps in:

1. Eliminate π contamination.
2. Expand coverage to high-z, to study the transition to exclusive KY channels.

Kaon from the hit-quark ?

A list of questions in SIDIS

- π Frag. Func. agree with e^+e^-, p+p data ?
- Fragmentation to other mesons: η, K_s^0, ρ, ω and ϕ. Ratio π^0/η.
- Connection between Frag. Func. to hadron structure.
- ϕ(s-sbar) in SIDIS carry information of s-quarks ? What about spin asymmetries, Sivers asymmetries ?
- Transition from SIDIS to the exclusive limit, a theory picture ?
- Λ production and Λ polarization. Spin-transfer, induced polarization, transverse spin asymmetry to access quark transversity.

summary

- SIDIS@CLAS12 offers many new physics opportunities.
- Firmly establish the baseline of interpretation is the critical step.

- π-production as the first step.
- Kaon production with a RICH detector opens a new field.
- Two-sector RICH is the bare minimum.

LOI at http://www.jlab.org/~jiang/pac32/

Please consider to join the proposal.

LO Cross Sections from each flavor