Hard exclusive pion electroproduction at backward angles with CLAS

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We report on the first measurement of cross sections for exclusive deeply virtual pion electroproduction off the proton, $ep \to e'n\pi^+$, above the resonance region at backward pion center-of-mass angles. The φ^*_π-dependent cross sections were measured, from which we extracted three combinations of structure functions of the proton. Our results are compatible with calculations based on nucleon-to-pion transition distribution amplitudes (TDAs).

We have measured for the first time the cross section of $ep \to e'n\pi^+$ at large photon virtuality, above the resonance region, for pions at backward angles, using the CLAS detector at Jefferson Lab [1]. The motivation to address such a kinematic regime was provided by the potentially applicable collinear factorized description in terms of nucleon-to-pion TDAs that encode valuable nucleon structural information. The final goal was an experimental validation of the factorized description and the extraction of nucleon-to-pion TDAs from the observed quantities. Our analysis represents a first encouraging step towards this goal.

The QCD collinear factorization theorems state that for special kinematic conditions a broad class of hard exclusive reactions can be described in terms of universal nucleon structure functions. The universal structure functions accessible in "nearly-backward" kinematics are nucleon-to-meson TDAs. On the right panel of Fig. 1 we illustrate the corresponding factorization mechanism involving TDAs for $ep \to e'n\pi^+$. Since momentum conservation imposes the constraint $\sum_i x_i{=}2\xi$, TDAs depend effectively on only 4 variables.

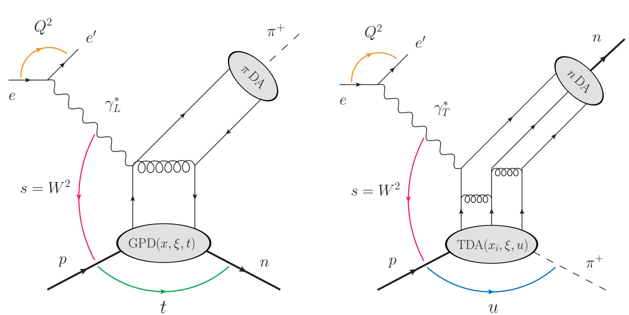

FIG. 1: **Left:** QCD factorization mechanism for the exclusive electroproduction of a meson (π^+) on the nucleon (proton) in the "nearly-forward" kinematic regime at large Q^2 and small $|t|$ (GPDs; bottom blob of the diagram) and of the meson (the pion DA upper blob of the diagram). **Right:** factorization mechanism for the same reaction in the complementary "nearly-backward", where $Q^2 \gg$, $W^2 \gg$, fixed x_{BJ}, and small $|u|$, the non-perturbative nucleon-to-pion transitions (TDAs) (bottom blob of the diagram) and the nucleon DA (upper blob of the diagram).

In Fig. 2, we compare our data for σ_U $(= \sigma_T + \epsilon\sigma_L)$ to the theoretical predictions of σ_T from the nucleon pole exchange πN TDA model suggested in the TDA model.

The curves show the results of three theoretical calculations using different input phenomenological solutions

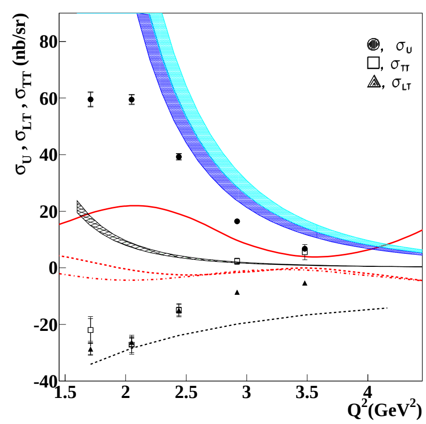

FIG. 2: (Color online) The structure functions σ_U (●), σ_{TT} (□) and σ_{LT} (▲) as a function of Q^2. The inner error bars are statistical and the outer error bars are total $(=\sqrt{\delta^2_{stat} + \delta^2_{sys}})$ uncertainties. The bands refer to model calculations of σ_u in the TDA description.

for the nucleon DAs with their uncertainties represented by the bands. Black band: BLW NNLO, dark blue band: COZ, and light blue band: KS. The black dashed curve, inspired by the higher twist nature of σ_{LT} and σ_{TT} in the TDA picture, shows $(-\Delta^2_T/Q^2)\sigma_U$ parameterized from the experimental data. The red curves are the predictions of Regge model for bold solid: σ_U, dashed: σ_{LT}, dot-dashed: σ_{TT}. We see a very reasonable agreement between the TDA model-dependent calculation and our data. However, this is not incontrovertible evidence for the validity of the factorized description, and the Regge-based description yields a similar result for the last Q^2 point but a very different Q^2 dependence.

[1] K. Park *et al.* [CLAS Collaboration], Phys. Letts. B **780**, 340 (2018).