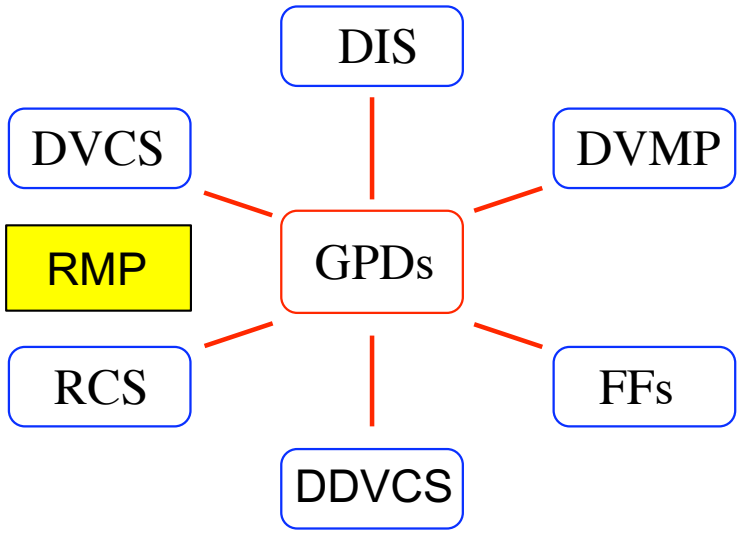
Jefferson Lab
Thomas Jefferson National Accelerator Facility

Double Spin Asymmetry in Wide-Angle Charged Pion Photoproduction

Why is this experiment important?

B. Wojtsekhowski

The nucleon structure in terms of GPDs



Reduction formulas at $\xi = t = 0$
for DIS and $\xi = 0$ for FFs

$$H^q(x, \xi = 0, t = 0) = q(x)$$

$$\tilde{H}^q(x, \xi = 0, t = 0) = \Delta q(x)$$

$$\int_{-1}^{+1} dx\, H^q(x, 0, Q^2) = F_1^q(Q^2)$$

$$\int_{-1}^{+1} dx\, E^q(x, 0, Q^2) = F_2^q(Q^2)$$

Twist-3 contributions to wide-angle photoproduction of pion

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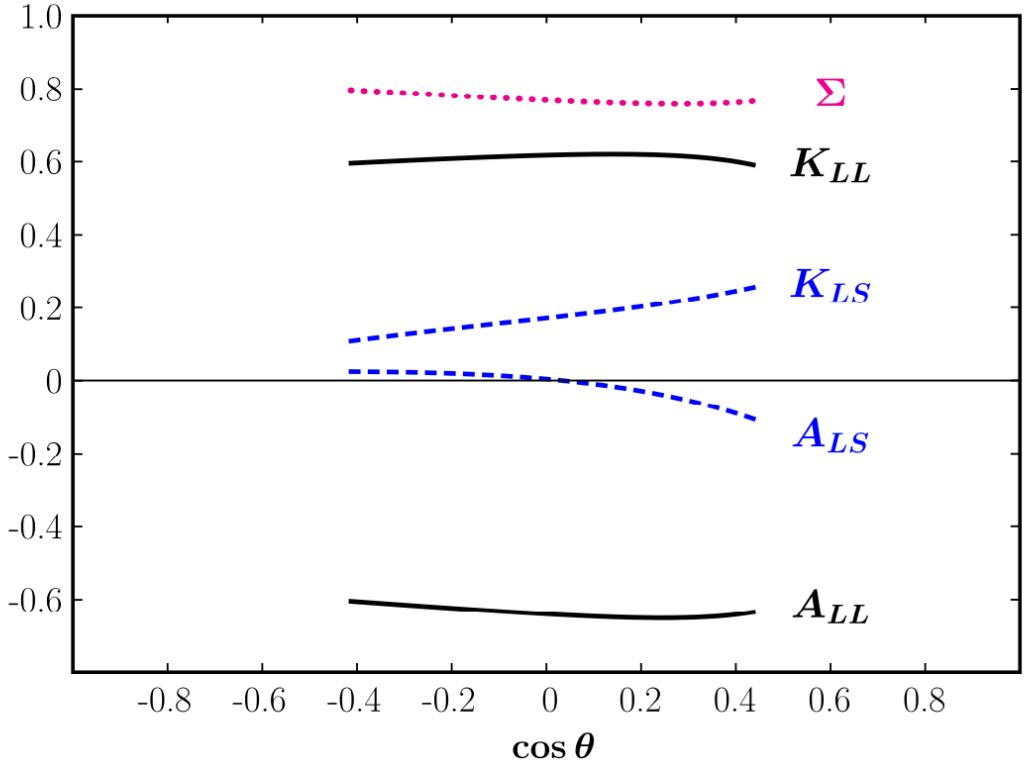
We investigate wide-angle π^0 photoproduction within the handbag approach to twist-3 accuracy. In contrast to earlier work both the 2-particle as well as the 3-particle twist-3 contributions are taken into account. It is shown that both are needed for consistent results that respect gauge invariance and crossing properties. The numerical studies reveal the dominance of the twist-3 contribution. With it fair agreement with the recent CLAS measurement of the π^0 cross section is obtained. We briefly comment also on wide-angle photoproduction of other pseudoscalar mesons.

DOI: 10.1103/PhysRevD.97.074023

Twist-3 contributions to wide-angle photoproduction of pion



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Theore ... *Croatia*

We investigat ... twist-3 accuracy. In contrast to ear ... tions are taken into account. It is sho ... riance and crossing properties. The n ... th it fair agreement with the recent ... comment also on wide-angle photo ...

DOI: 10.1103/Phys

FIG. 4. Predictions for spin observables of π^0 photoproduction at $s = 11.06$ GeV^2. The parametric uncertainty is $\simeq$15% near 90 deg.

In Fig. 4 we show predictions on the spin-dependent observables for π^0 photoproduction. One sees that A_{LL} and K_{LL} are large in absolute value and almost mirror symmetrical. The observables A_{LS} and K_{LS} are small in

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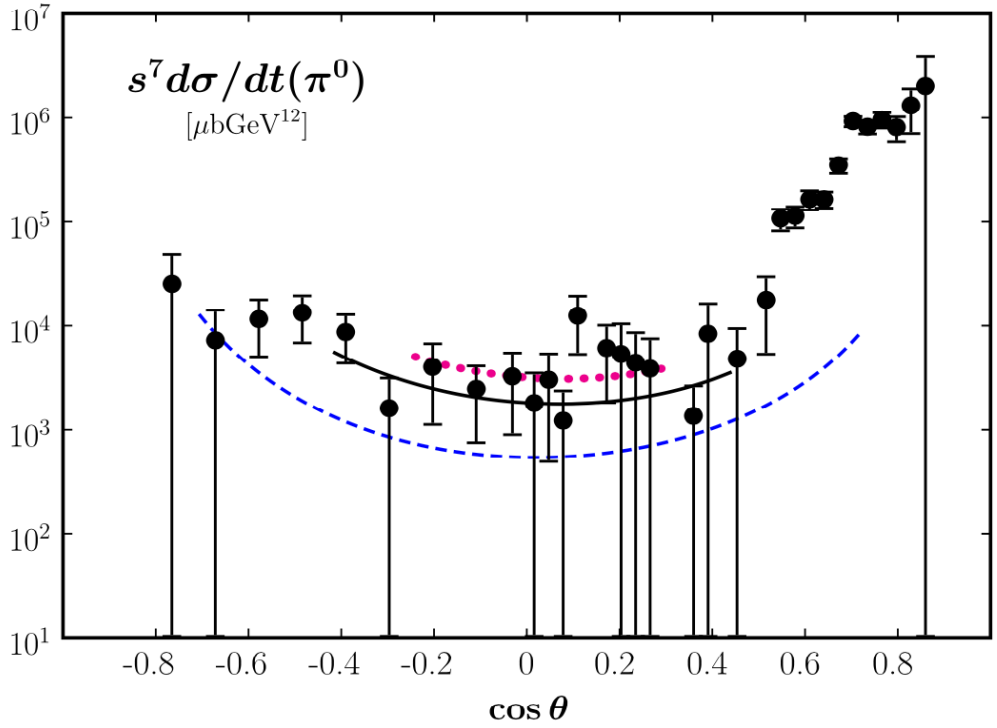
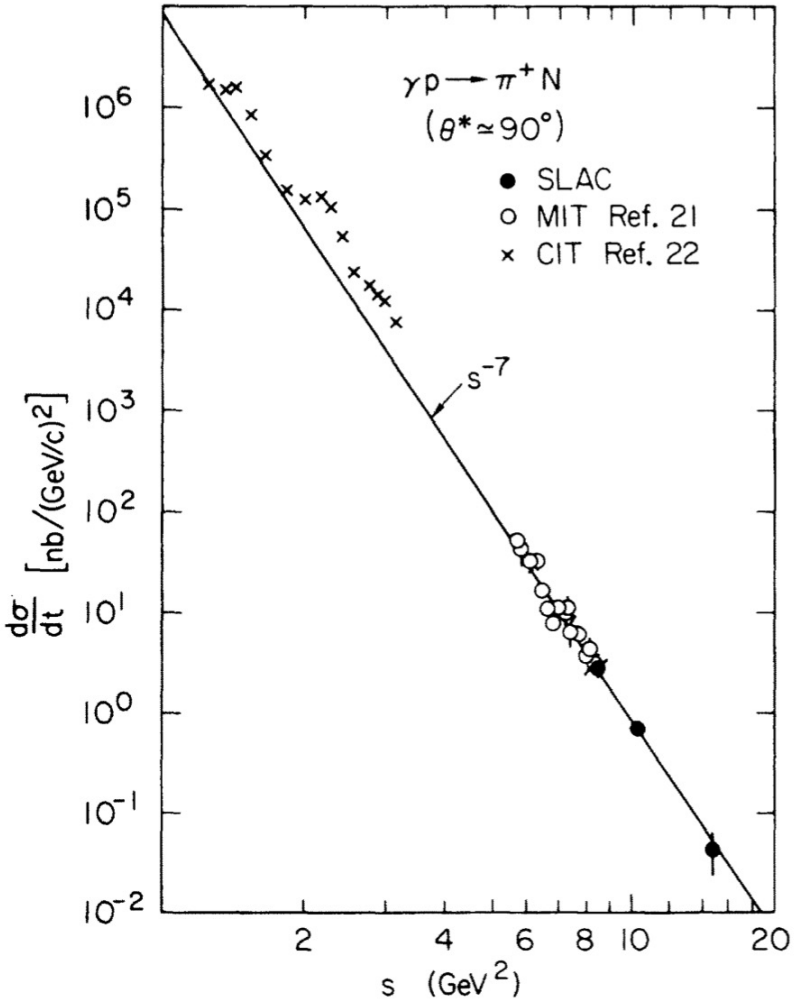


FIG. 3. Results for the cross section of π^0 photoproduction versus the cosine of the c.m.s. scattering angle, θ. The solid (dashed, dotted) curves represent our results at $s = 11.06(20, 9)$ GeV^2. The data at $s = 11.06$ GeV^2 are taken from CLAS [34]. The cross sections are multiplied by s^7, and the theoretical results are only shown for $-t$ and $-u$ larger than 2.5 GeV^2.

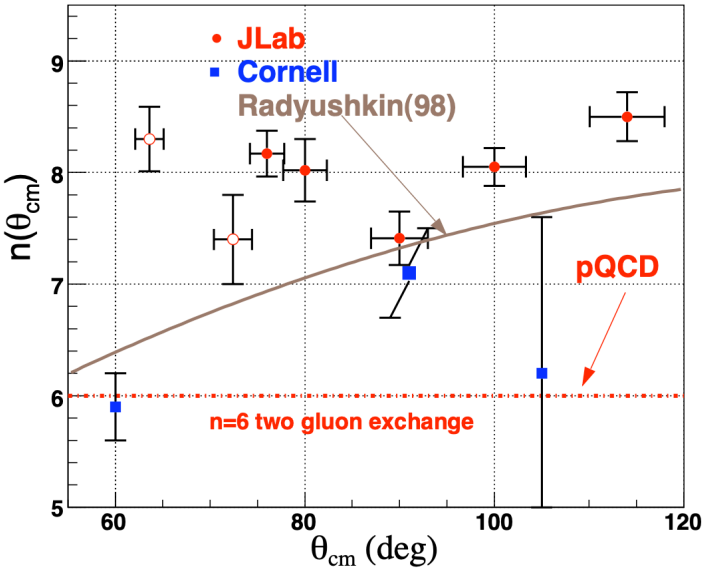
Scaling: Pion production and real Compton scattering

Phys. Rev. D **14**, 679 (1976)

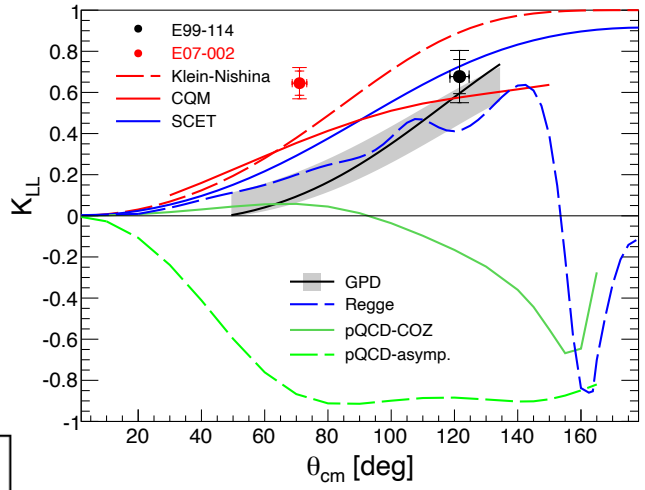


$$\frac{d\sigma}{dt}(s,t) \sim \frac{1}{s^{n-2}} F\left(\frac{t}{s}\right)$$

E99-114, PRL 98, 152001 (2007)

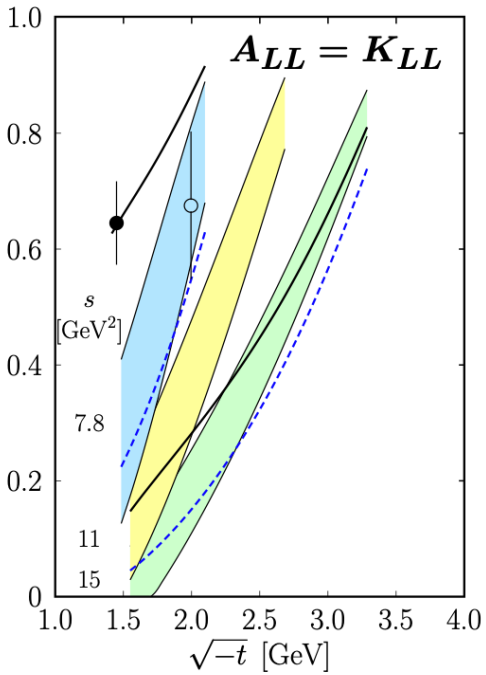


KLL in Real Compton scattering and GPDs



K_{LL} is an average value of the longitudinal proton spin in the γp cm system for 100% circular polarization of incident photon.

$$K_{LL} = \frac{1}{2}\left\{\frac{\sigma(+,\uparrow)-\sigma(+,\downarrow)}{\sigma(+,\uparrow)+\sigma(+,\downarrow)} - \frac{\sigma(-,\uparrow)-\sigma(-,\downarrow)}{\sigma(-,\uparrow)+\sigma(-,\downarrow)}\right\}$$



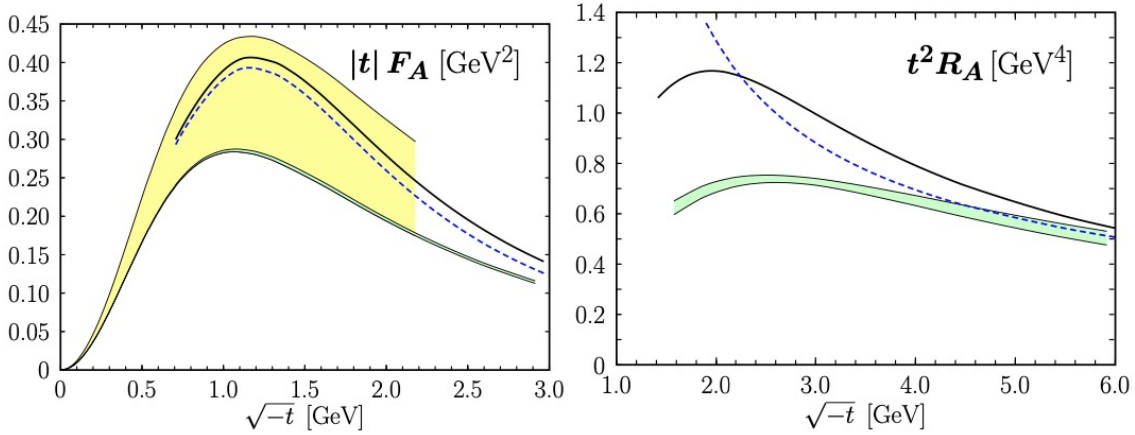
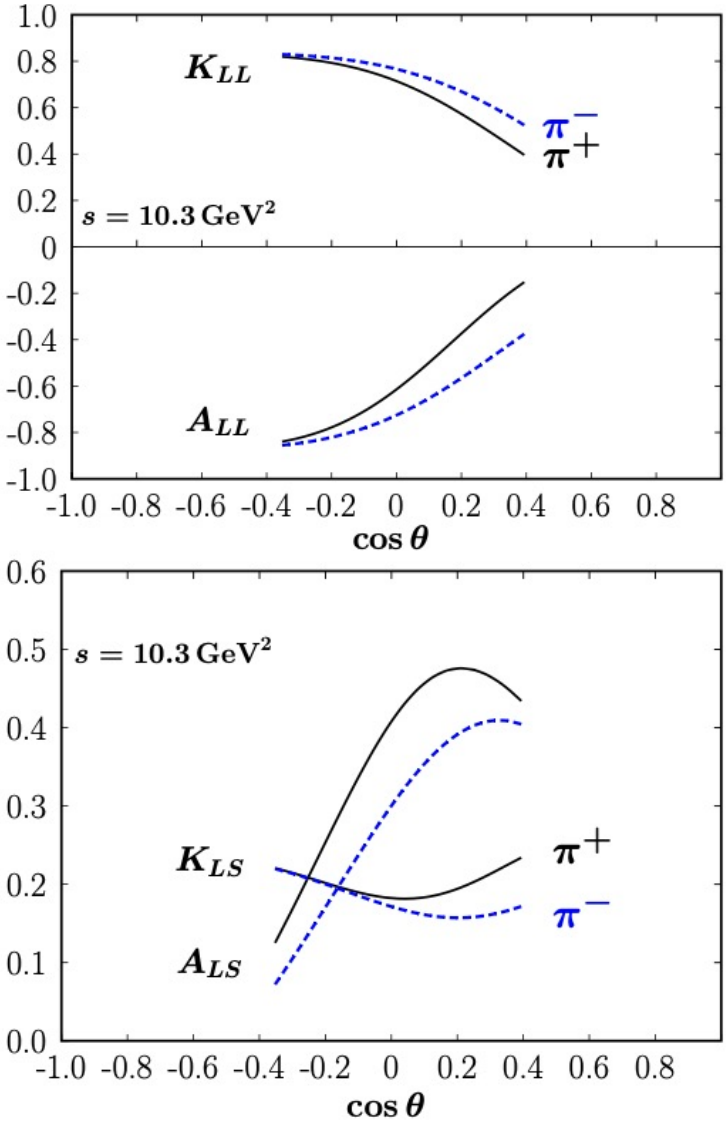


Figure 2: Left: The axial form factor, scaled by $-t$, versus $\sqrt{-t}$. The data [22] are shown as the broad shaded band. The narrow shaded band represents the results of [15]. The solid (dashed) line is the example #1 (#2).

Pion photo-production with GPD

Peter Kroll, report at SBS meeting, 2/2021



photoproduction of charged pions

$A_{LL}^{twist-2} = K_{LL}^{twist-2}$ as for WACS

$$A_{LL}^{twist-3} = -K_{LL}^{twist-3} \simeq -\frac{4}{F}\, S_T \left[S_T - \frac{t}{2m^2} S_S \right]$$

$$A_{LS}^{twist-3} = -K_{LS}^{twist-3} \simeq -\frac{2}{F}\, \frac{\sqrt{-t}}{m}\, \bar{S}_T S_T$$

characteristic signature

for dominance of twist-3

like $\sigma_T \gg \sigma_L$ in DVMP

Pion photo-production from nucleon

PHYSICAL REVIEW D **97,** 074023 (2018)

Twist-3 contributions to wide-angle photoproduction of pions

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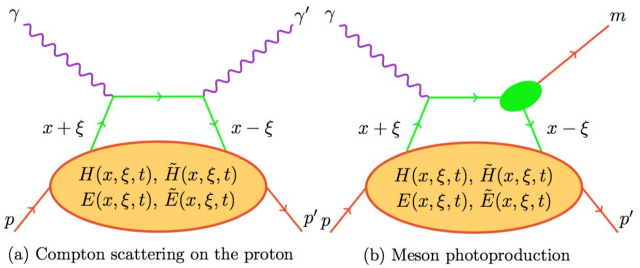


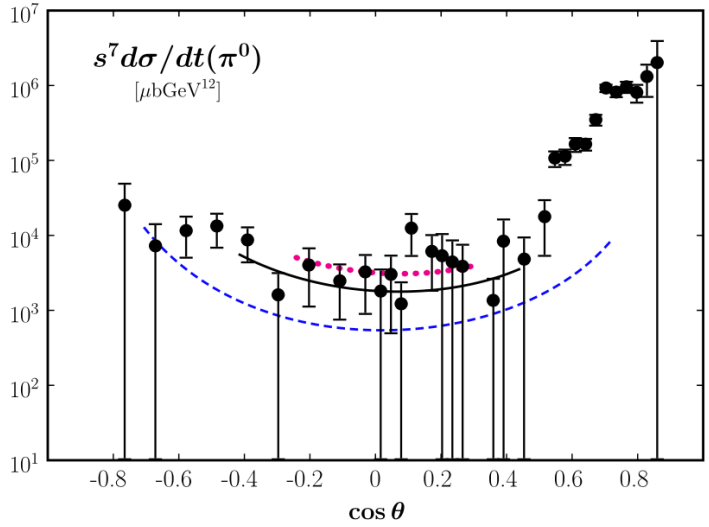
(a) Compton scattering on the proton (b) Meson photoproduction

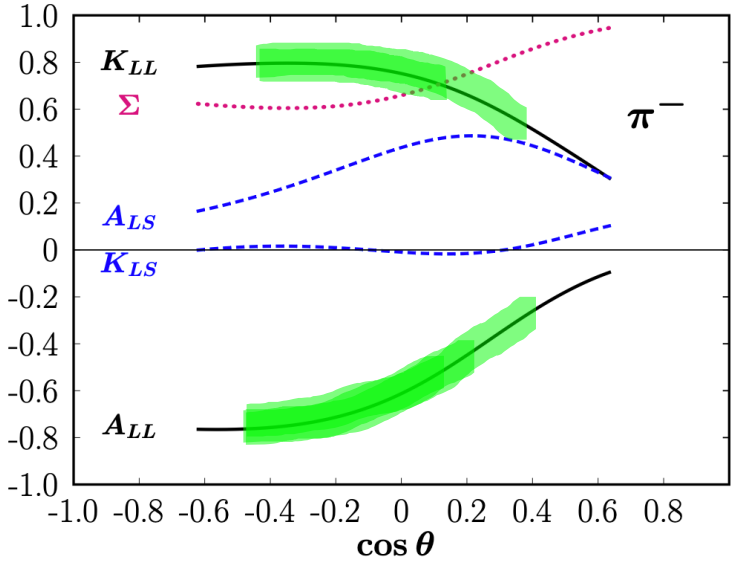
Figure 1.6: Compton scattering and meson photoproduction in the handbag model.

$$A_{\mathrm{LL}}^{\mathrm{twist-3}} = -K_{\mathrm{LL}}^{\mathrm{twist-3}}, \tag{51}$$

while for the twist-2 contribution

$$A_{\mathrm{LL}}^{\mathrm{twist-2}} = K_{\mathrm{LL}}^{\mathrm{twist-2}} \tag{52}$$





PR12-21-005

Scientific Rating: A−

Recommendation: Approved

Title: Double Spin Asymmetry in Wide-Angle Charged Pion Photoproduction

Spokespersons: B. Wojtsekhowski (contact), R. Montgomery, G. Cates, A. S. Tadepalli

Motivation: This experiment plans to measure the polarization transfer observable A_{LL} for π^- photoproduction in the wide-angle regime. The nature of the interaction mechanism for this relatively simple process is not yet well understood. Theoretical studies based on Generalized Parton Distributions (GPDs) suggest the dominance of twist-3 contributions and predict a sizeable and negative A_{LL}. The experiment plans to study also the θ and s dependence of this asymmetry, which is important for understanding the reaction mechanism.

Measurement and Feasibility: The measurement will take place at Hall A, using the apparatus of the polarized ^{3}He experiment E12-09-016, scheduled to run in 2022, with minor modifications. The proposal requests 10 PAC days. The result will be a measurement of the polarization observable A_{LL} and a check of the expected opposite sign of A_{LL} in comparison to the observable K_{LL}. The latter will be measured by E12-20-008, scheduled to run in 2021.

Issues: It would be interesting to have comparisons of the future data with more than one theoretical calculation, including the associated errors.

Summary: The PAC believes that the combination of data from this experiment and E12-20-008 will make it possible to check the theoretical prediction of opposite signs between the A_{LL} and K_{LL} observables, and contribute to the understanding of the basic mechanism of wide-angle pion photoproduction. The PAC recommends approval of the requested 10 PAC days.

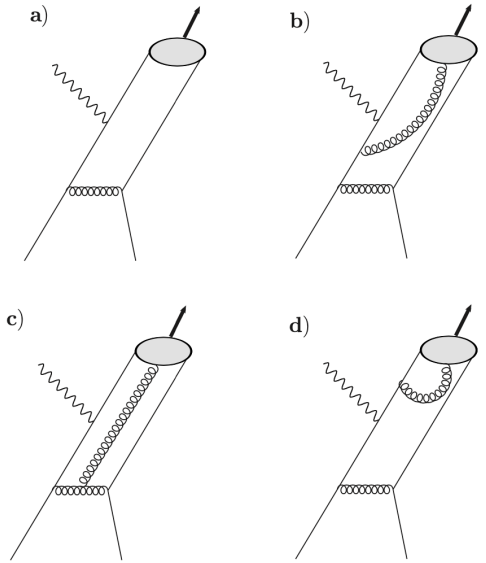


Figure 2: Typical leading-order Feynman graphs for $\gamma q \to \pi^0 q$. a) for a 2-particle Fock component of a pseudoscalar meson. b) and c) contribution from the $q\bar{q}g$ Fock component without and with triple gluon coupling. d) a soft contribution which is to be considered as part of the 3-particle DA.

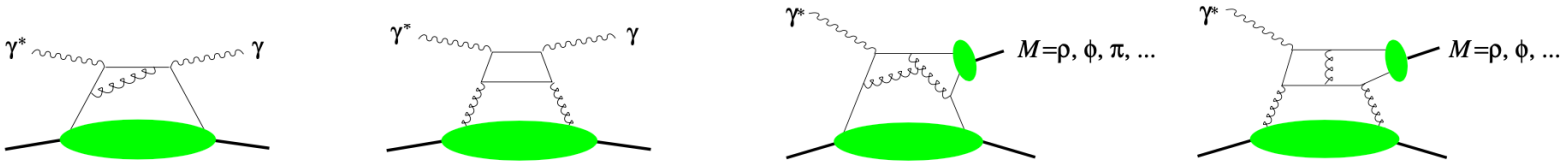
On Friday, wrote: ›rg>

Dear Bogdan,
indeed similar twist-3 effects contribute also to meson electroproduction. In a series of papers that I wrote in
collaboration with Sergey Goloskokov (see arXiv) we studied electroproduction of vector and pseudoscalar
mesons. For the letter twist-3, feeding the amplitudes for transversally polarized photons, are even
dominant. In pi^0 production the twist-2 long. cross section is much smaller than the twist-3 transverse one.

For SIDIS twist-3 may even contribute but I don't know really.

Best, Peter

Nucleon tomography: GPDs



- principle:

  exclusive processes $\longrightarrow$ scattering amplitudes

  $\longrightarrow$ hard scattering$(x, \xi, Q/\mu) \underset{x}{\otimes}$ GPDs$(x, \xi, t; \mu)$ using factorisation

  $\longrightarrow$ GPDs$(x, \xi, t; \mu)$

  $\longrightarrow$ impact parameter distributions after Fourier trf. from $\boldsymbol{\Delta}_T \to \boldsymbol{b}_T$

from M.Diehl's talk at EINN2023