

Strangeness in GPDs and exclusive processes

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Physics opportunities in exclusive electroproduction of strange mesons/baryons at high Q^2

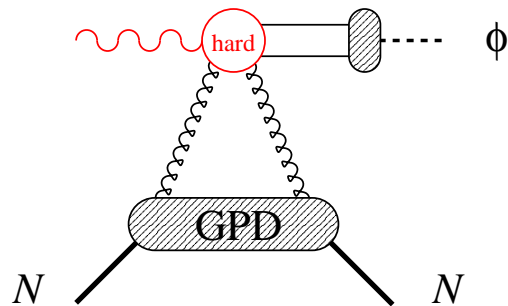
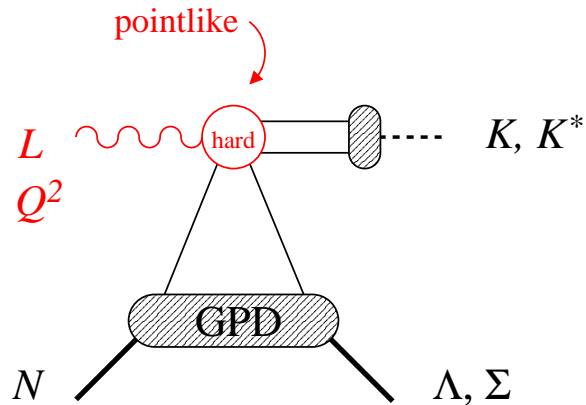
$\gamma^* N \rightarrow \phi + N$ Gluon GPD, “transverse imaging”

$\gamma^* p \rightarrow K^{*+} + \Lambda(\mathbf{S}_T)$ Quark helicity-flip GPD E from recoil polarization (cf. A_{UT})

$\gamma^* p \rightarrow \begin{matrix} K^+ + \Lambda \\ K^+ + \Sigma^0 \end{matrix}$ $\Delta s, \Delta \bar{s}$, hyperon resonances

[H. Avakian et al.: Λ polarization in the target fragmentation region, Letter of Intent to PAC 32 (2007)]

Exclusive meson production: Theory status



QCD factorization theorem
 [Collins, Frankfurt, Strikman 96; . . .]

- $Q^2 \sim \text{few GeV}^2$: Substantial higher-twist corrections
 - Finite size of $\bar{q}q$ ($\rightarrow t$ -slope)
 - Experience with pion FF

 - Theory predictions for absolute cross sections at JLab still uncertain
 - Leading + higher twist?
 - Modeling of GPDs?
 - NLO corrections?
- \rightarrow Use “ratio” observables

K^*/ρ^+ , K/π , etc.
 Spin asymmetries, t -slopes

Exclusive meson production: GPD spin/flavor

$\rho^+ n$	$2[u - d] - [\bar{u} - \bar{d}]$
$\rho^0 p$	$\frac{1}{\sqrt{2}}[2u + d] + \frac{1}{\sqrt{2}}[2\bar{u} + \bar{d}] + \text{gluon}$
ωp	$\frac{1}{\sqrt{2}}[2u - d] + \frac{1}{\sqrt{2}}[2\bar{u} - \bar{d}] + \text{gluon}$
$K^{*+} \Lambda$	$-\frac{2}{\sqrt{6}}[2u - d - s]$ $+\frac{1}{\sqrt{6}}[2\bar{u} - \bar{d} - \bar{s}]$
$K^{*+} \Sigma^0$	$-\frac{2}{\sqrt{2}}[d - s] + \frac{2}{\sqrt{2}}[\bar{d} - \bar{s}]$
$K^{*0} \Sigma^+$	$[d - s] + [\bar{d} - \bar{s}]$
$\pi^+ n$	$2[\Delta u - \Delta d] + [\Delta \bar{u} - \Delta \bar{d}]$
$\pi^0 p$	$\frac{1}{\sqrt{2}}[2\Delta u + \Delta d] - \frac{1}{\sqrt{2}}[2\Delta \bar{u} + \Delta \bar{d}]$
$K^+ \Lambda$	$-\frac{2}{\sqrt{6}}[2\Delta u - \Delta d - \Delta s]$ $-\frac{1}{\sqrt{6}}[2\Delta \bar{u} - \Delta \bar{d} - \Delta \bar{s}]$
$K^+ \Sigma^0$	$-\frac{2}{\sqrt{2}}[\Delta^d - \Delta^s] - \frac{1}{\sqrt{2}}[\Delta \bar{d} - \Delta \bar{s}]$
$K^0 \Sigma^+$	$[\Delta d - \Delta s] - [\Delta \bar{d} - \Delta \bar{s}]$

- Meson selects spin

$$\begin{array}{ll} 1^- & \rho, K^* \quad H \leftrightarrow q, \quad E \\ 0^- & \pi, K \quad \tilde{H} \leftrightarrow \Delta q, \quad \tilde{E} \end{array}$$

- SU(3) flavor symmetry relates $p \rightarrow \Lambda$ transition GPDs to “usual” GPDs in proton

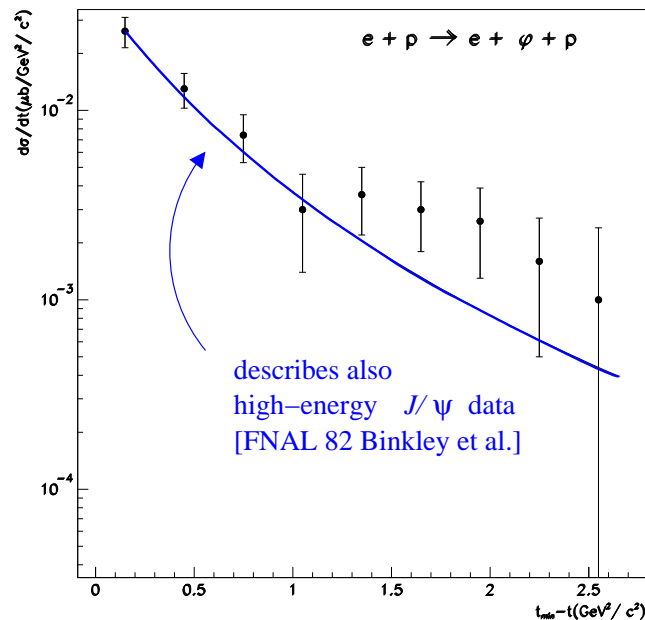
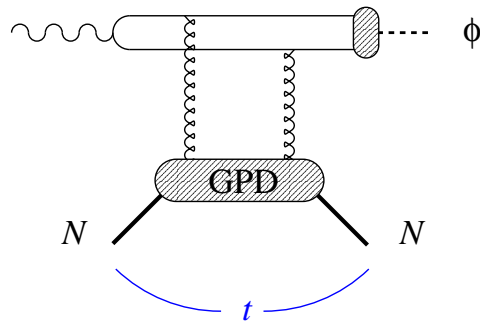
$$\langle \Lambda | \bar{s}u | p \rangle = -\frac{1}{\sqrt{6}} \langle p | 2\bar{u}u - \bar{d}d - \bar{s}s | p \rangle$$

→ Extract information on proton GPDs

- SU(3) for meson wavefunctions?

[from Diehl, Kugler, Schäfer, CW 05]

ϕ production: Gluon GPD

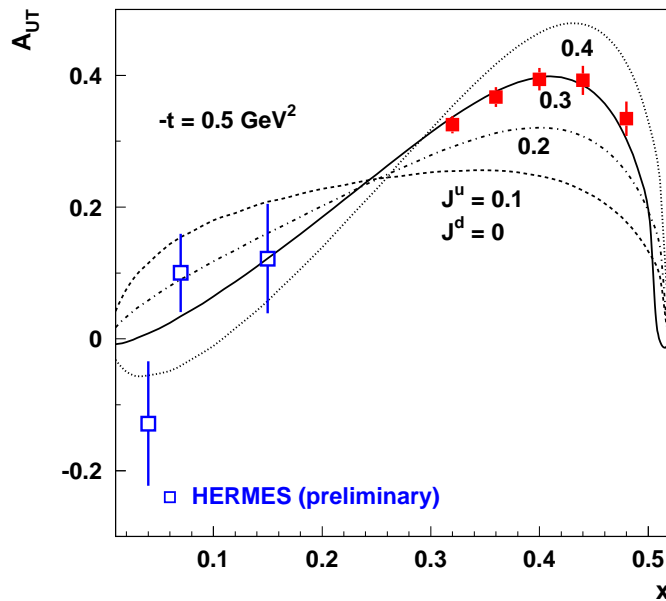
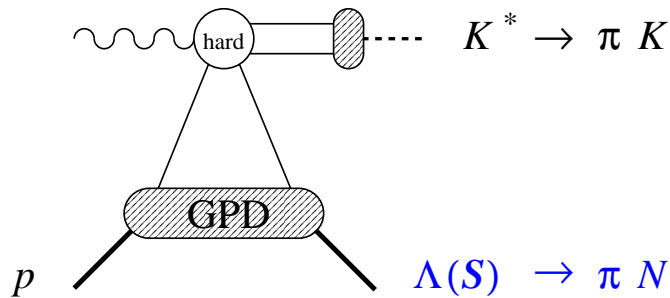


[CLAS 01 Lukashin et al.;
Theory: Frankfurt, Strikman 02]

- Clean probe of gluon ($g \gg \bar{s}, s$) even at JLab energies
- Interesting observable: t -distribution, change with Q^2 and x
 - Size of $\bar{s}s$ (higher twist)
 - Transverse gluon imaging
- L/T separation from $\phi \rightarrow K^+ K^-$ decay + SCHC
- Benefits from RICH?
HERA: No kaon ID; peak in $M^2(+ -)$

“Clean” GPD interpretation!

$K^{*+} \Lambda$ production: Recoil polarization

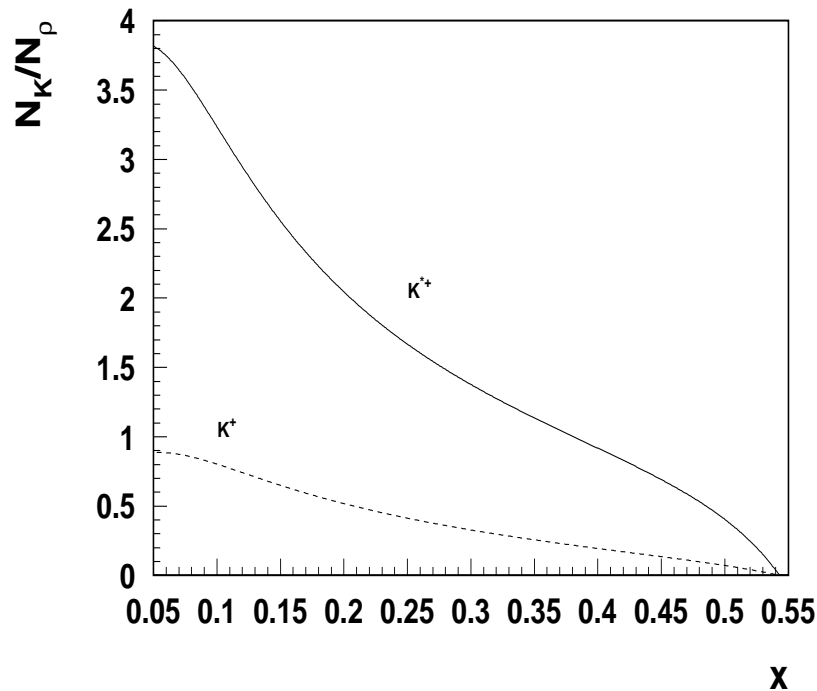


[CLAS 12 GeV projected ρ^0 ;
Model: Vanderhaeghen et al.]

- Λ recoil polarization asymmetry transverse to reaction axis sensitive to quark helicity-flip GPD
- $$E(p \rightarrow \Lambda) = 2E_u - E_d - E_s \quad \text{w. SU(3)}$$
- cf. target polarization A_{UT}
- Combine with target polarization (incl. longitudinal)?
 - L/T separation from $K^* \rightarrow K\pi$ decay + SCHC

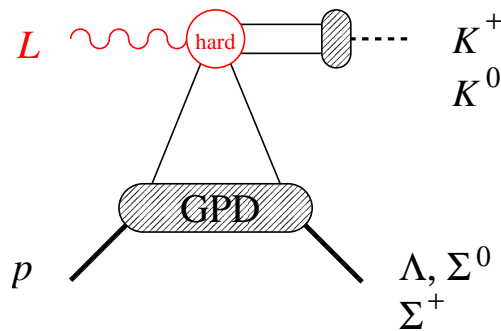
Complements/extends measurements with transversely polarized target

$K^{*+} \Lambda$ production: K^{*+}/ρ^+ ratio



- Quark exchange only, no gluons
- Prediction for K^{*+}/ρ^+ ratio [Kugler et al. 07]
- Expected to be more robust than absolute cross sections
e.g. Renormalon model of higher twist in meson production [Belitsky 04].

$K\Lambda, K\Sigma$ production: Strangeness polarization

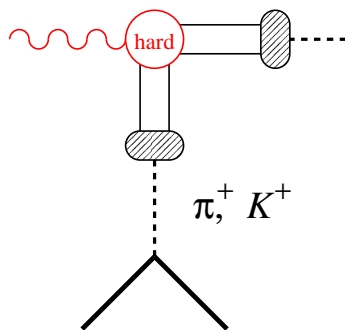


- π, η, η', K probe “polarized” GPDs
 $\tilde{H} \leftrightarrow \Delta q, \tilde{E}$

π^+, K^+ : Pole term in \tilde{E} prominent
 (cf. π/K form factor measurements)

π^0, η, K^0 : Pole term zero/small,
 access to $\Delta d/\Delta u, \Delta s/\Delta u$
 through cross section ratios

[Eides, Frankfurt, Strikman 99]



- SU(3) in meson wave functions?
- L/T by Rosenbluth separation
- Also interesting: High- t meson production
 . . . Reaction mechanism?

Connections and extensions

- Exclusive Λ production is limiting case of **target fragmentation** in DIS
 - Fracture functions [Trentadue, Veneziano 94; DeFlorian, Sassot et al., . . .]
 - Correlations between current/target jets
 - . . . Unexplored field!
- Hard exclusive processes with **resonance excitation**
e.g. $\gamma_L^* p \rightarrow K^+ \Lambda^*(1405)$
 - Transition induced by well-defined QCD operator
 - New information about resonance structure

Summary

- “Diverse” physics in hard exclusive production of strange mesons/baryons
- Need to discuss need for/benefits from RICH channel by channel
- Theory: Work on absolute cross sections in GPD approach
 ϕ channel seems to offer best chances — simplest