EXCLUSIVE MESON PRODUCTION IN HALL C AT JLAB 12 GeV

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Two ways to look at meson electroproduction

- Described by t-channel exchange meson pole term in limit of small $t$
- Spatial distribution described by *form factor*

- At sufficiently high $Q^2$, process can be described in terms of the “handbag diagram”
- Non-perturbative (soft) physics is represented by the GPDs
• Form factors and GPDs are essential to understand the structure of hadrons

• But measurements of form factors and GPDs have certain prerequisites:
  – For form factors, must make sure that $\sigma_L$ is dominated by the meson pole term at low $-t$
  – For GPDs, must demonstrate that factorization applies

• A comparison of pion and kaon production data may shed further light on the reaction mechanism
  – quasi-model independent
  – more robust than calculations based on QCD factorization and present GPD models
Factorization Tests

- ... are tests of the reaction mechanism

- One of the most stringent tests of factorization is the $Q^2$ dependence of the electroproduction cross section
  - $\sigma_L$ scales to leading order as $Q^{-6}$
  - $\sigma_T$ scales as $Q^{-8}$
  - As $Q^2$ becomes large: $\sigma_L \gg \sigma_T$

- Factorization theorems for meson electroproduction have been proven rigorously only for longitudinal photons [Collins, Frankfurt, Strikman, 1997]

$$2\pi \frac{d\sigma}{dtd\phi} = \frac{d\sigma_T}{dt} + \varepsilon \left( \frac{d\sigma_L}{dt} \right) + \sqrt{2\varepsilon (1 + \varepsilon)} \frac{d\sigma_{LT}}{dt} \cos \phi + \varepsilon \frac{d\sigma_{TT}}{dt} \cos 2\phi$$
To access physics contained in GPDs, one is limited to the kinematic regime where hard-soft factorization applies.

A test is the $Q^2$ dependence of the cross section:
- $\sigma_L \sim Q^{-6}$ to leading order
- $\sigma_T \sim Q^{-8}$

Difficult to draw a conclusion from current $\pi^+, K^+ \sigma_L/\sigma_T$ ratios
- Limited $W$ and $Q^2$ coverage
- Uncertainties from scaling in $x, t$

High quality $\sigma_L$ and $\sigma_T$ data for both kaon and pion would provide important information for understanding the meson reaction mechanism.
Approved experiment E12-09-011 will provide first L/T separated kaon data above the resonance region (W>2.5 GeV)

- Onset of kaon factorization
- Understanding of hard exclusive reactions
  - QCD model building
  - Coupling constants

E12-09-011: Precision data for W > 2.5 GeV
Recent data suggest strong contributions from transversally polarized photons


Relative contribution of $\sigma_L$ and $\sigma_T$ in $\pi^0$ production is a good probe of transversity effects

- Could confirm the large contribution of transversely polarized photons to this process
- May subsequently allow for detailed investigation of transversity GPDs
JLAB / SHMS Detector System: How to Measure Kaons

Kaon Aerogel Cerenkov Detector inside the SHMS, in Hall C.

Cherenkov radiation:
• Threshold in particle’s velocity for the radiation of light.
• Refractive index of material determine this threshold.

SHMS particle identification system (for the full momentum range):
• Kaon Aerogel Detector: $K/\rho$
• Noble gas Cerenkov: $e/\pi$
• Heavy gas Cerenkov: $\pi/K$
• Lead glass: $e/\pi$

**Kaon Aerogel Detector Design Overview**

- **Diffusion box, covered with reflective material**
- **Replaceable aerogel tray, with a ~10cm layer of aerogel**

**MF-Millipore Membrane Filters**

**Refractive index options:**
- \( n = 1.030 \)
- \( n = 1.020 \)
- \( n = 1.015 \)

**External dimensions of the detector box:**
\( 1.10 \times 1.00 \times 0.45 \ \text{m}^3 \)
Components Characterization

PMTs sensitivity

Step motors to position a blue LED in front of the PMT

Aerogel Refractive index uniformity

Aerogel Transmittance of light

\[ \Phi 5'' \]
The detector system will consist of PbWO$_4$ blocks of the PRIMEX setup in a new temperature controlled frame. A sweeping magnet. Essentially deadtime-less digitizing electronics. HV bases with built-in amplifiers.

Measurement of the photons from DVCS/π$^0$ decay.

Detector features:

- 31 x 36 matrix of PbWO$_4$ crystals
- 2.05 x 2.05 x 18 cm$^3$ each crystal
Summary

• Meson production plays an important role in our understanding of hadron structure

• JLab 12 GeV will allow rigorous tests of factorization in meson production, for instance, kaon factorization
  – Extended kinematic reach and studies of additional systems
  – Essential prerequisite for studies of valence quark spin/flavor/spatial distributions

• The kaon aerogel Cherenkov detector adds capability to detect kaons to SHMS to carry out our kaon experiments at 12 GeV

• A new neutral particle detection facility will augment Hall C scientific capabilities to include measurements with neutral final states, e.g., DVCS, WACS, $\pi^0$ production

Work supported in part by NSF grants PHY-1019521 and PHY-1039446
Thanks for JSA and GSA/CUA support to attend this conference.