Beam Spin Asymmetry Measurements from Exclusive Vector $\phi$ Meson Electroproduction with CLAS12

Motivation

The mechanism of confinement – the phenomenon resulting in no unbound quarks existing in nature – has been an ongoing research endeavor since the inception of QCD. Candidate mechanisms include:

- Formation of a gluon flux tube between quarks
- The QCD vacuum screens against the propagation of free quarks.

Understanding the mechanism of confinement is possible at JLAB 12-GeV kinematics with the tools of:

- Generalized Parton Distribution functions (GPDs)
- Deeply Virtual Meson Production (DVMP)

GPDs are part of the “3D nucleon imaging” program of JLAB to map the:

- 2D spatial × 1D longitudinal momentum distribution of quarks and gluons (this work)
- Sensitivity to GPDs $E$, $H$, and $F_{11}$.

Accessing gluons of the nucleon is best done using $\phi(1020)$ or $1/(W^2)$ production.

Experiments in this field ideal for $\phi$.

Finding a Needle in a Haystack

Vector $\phi$ meson is detected via $ep \rightarrow e\phi p \rightarrow e\phi pK^0$ in the Forward Detector.

Sort through the data to first select electrons to define an event…

...and the $pK^0$ in the forward detector. Select through the data to first select electrons to define an event…

Exhausting data to first select electrons to define an event…

Exclusive Vector $\phi$ Meson Beam Spin Asymmetry Measurements

Method 1 – Asymmetry with Sideband

- Subtracting the difference in beam spin asymmetry between signal and background

Method 2 – Individual Fits Per Bin of $\phi_{LAB}$ for Each Helicity

- Two independent methods:
  1. Extract beam BSA by removing background asymmetry using "sideband subtraction".
  2. Calculate signal events for each $\phi_{LAB}$ bin using fit to $K^0^+K^0^-$ mass for each helicity state.

Both methods yield comparable asymmetry measurements.

Kinematic Coverage

CLAS12 produced data over a wide range of electron and hadron momentum and angles for superb coverage in $Q^2$, $x_F \rightarrow 0$.

Multidimensional binning provides insight into how our measurements change at different energy scales.

References and Support

1. I. Sh云南

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CLAS12 Detector

Continuous Electron Beam Accelerator Facility Large Angle Spectrometer at 12 GeV (CLAS12):

- 10.8 GeV polarized electron beam on a liquid H$_2$ target.
- Symmetric magnetic field for 8 independent sectors.
- Large displaced charged and neutral particles.
- Momentum Reconstruction $<1%$.
- Timing Resolution -60 to 160 ps

Electroproduction and Beam Spin Asymmetry Measurements from Exclusive Vector $\phi$ Meson Electroproduction with CLAS12