Exclusive phi meson electro-production for CLAS12: Comparing Data to Simulation.

Fall 2019 CLAS12 Collaboration Meeting

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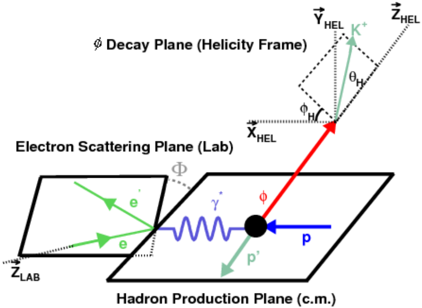
Outline

- Physics motivation
- Overview of the experiment
- Data Analysis
- Conclusion

Exclusive ϕ Production ($ep \rightarrow ep\phi(1020) \rightarrow epK^+K^-$)

Here the angle, Φ, is the angle between the lepton and hadron plane which is defined by the electron and proton, respectively.



$$Q^2 = (e - e')^2 \qquad W^2 = m_p - Q^2 + 2m_p\upsilon$$

$$\upsilon = E_e - E_{e'} \qquad x_B = \frac{Q^2}{2m_p\upsilon} \qquad t = (P - P')^2$$

[1] J. P. Santoro et al. Electroproduction of phi(1020) mesons at $1.4 < Q^2 < 3.8\ GeV^2$ measured with the CLAS spectrometer

Differential Cross Section ($ep \rightarrow ep\phi$)

Cross section for $ep \rightarrow e'p'\phi$ for an unpolarized proton with polarized electron beam can be written in the form

$$\frac{d^4\sigma}{dQ^2 dx_B dt d\phi} = \Gamma(Q^2, x_B, E) \frac{1}{2\pi}\left\{ \boxed{\frac{d\sigma_T}{dt} + \epsilon\frac{d\sigma_L}{dt}} + \epsilon \boxed{\frac{d\sigma_{TT}}{dt}} cos(2\phi) + \sqrt{\epsilon(\epsilon+1)} \boxed{\frac{d\sigma_{LT}}{dt}} cos(\phi) + \lambda\sqrt{2\epsilon(1-\epsilon)} \boxed{\frac{d\sigma_{LT'}}{dt}} sin(\phi) \right\} \quad (1)$$

Measuring the beam spin asymmetry will help test and validate various aspects of this analysis.

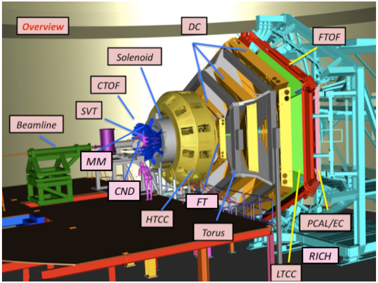
The beam spin asymmetry is defined as

$$BSA = \frac{d\sigma^{+} - d\sigma^{-}}{d\sigma^{+} + d\sigma^{-}} = \frac{\alpha sin(\phi)}{1 + \beta cos(\phi) + \gamma cos(2\phi)} \tag{2}$$

Effort is focused on determining $\alpha = \frac{\sqrt{2\epsilon(1-\epsilon)}\sigma_{LT'}}{\sigma_T + \epsilon\sigma_L}$

- Interference structure functions can test s-channel helicity conservation (SCHC)

CLAS12 is uniquely designed to provide coverage over a wide kinematic range for charged and neutral particles.



Exp. Detail	Value
Beam	10.6 GeV @ 50 nA
Avg. Beam Polarization	85%
Target	Unpolarized LH2
Field Config Field	inbending
Data	3% of approved beam time

Using GEant Monte Carlo we can replicate CLAS12 experimental conditions to better understand the detector.

Exp. Detail	Value
Beam	10.6 GeV
Target	Unpolarized LH2
Field Config Field	inbending
Reconstruction software	6.3.1
GEMC version	4.3.0
GCARD	rga-fall2018.gcard
YAML	rga-fall2018.yaml

Focus on the data analysis for $ep \to e'p'\phi$ through $e'p'K^+K^-$

- Electron ID
- Hadron ID
- Comparison of Data to Simulation
  - Individual Particle Kinematics
  - Event Specific Kinematics

Electron ID requires multiple cuts to select a clean sample of events.

- Sampling fraction cut
- Minimum energy deposited in calorimeter
- Number of photoelectrons produced in Cherenkov counters
- EventBuilder PID 11

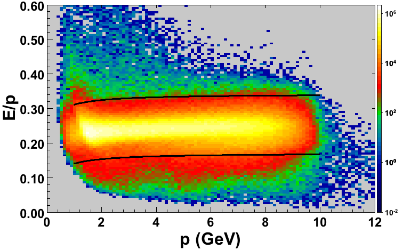


Figure: Sampling Fraction vs p for run 5038. Black lines represent EventBuilder cut boundaries.

After selecting the electron, one must identify the hadrons for this analysis.

- Charged particle ID
  - Momentum information from drift chambers
  - Timing information from time-of-flight
  - EventBuilder PID 2212, 321, -321

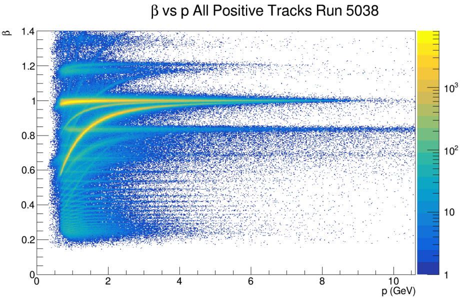


Figure: β vs p for positive hadrons for run 5038. β is determined from EventBuilder hadrons only in the FD.

Example of candidate hadrons using EventBuilder PID from Data.

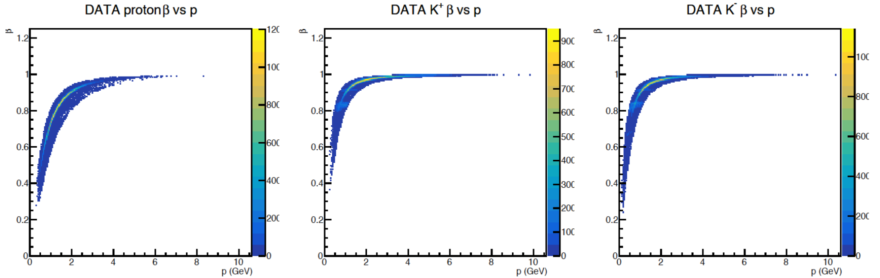


Figure: β vs p for EventBuilder hadrons only in the FD prior to applying event selection criteria.

Once the particles in the final state are detected, we define which events to compare between simulation and data.

- **Identify all final state particles** $e'p'K^+K^-$
- All hadrons are identified in the Forward Detector of CLAS12
- Apply exclusivity cuts for $ep \to ep\phi$
  - Missing energy cut at $\pm 3\sigma$
  - Missing Mass Squared on eK^+K^-X
  - Missing Mass Squared on epK^+X
  - Missing Mass Squared on epK^-X
- Select events within 3σ of ϕ mass (1.019 GeV)

Exclusivity variables used to select final state events for data and simulation.

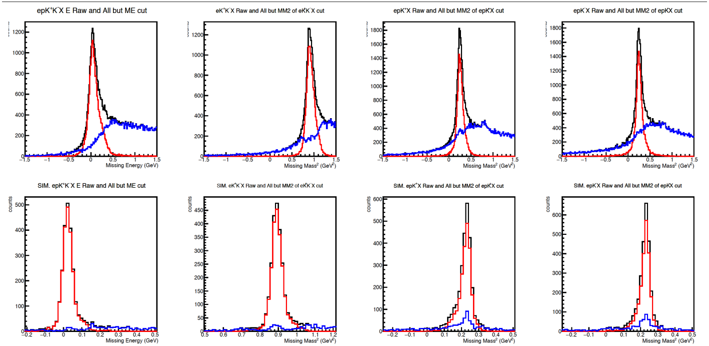


Figure: Exclusivity variables for inbending data set (TOP), simulation (BOTTOM) (black all events, red pass all cuts but property shown, blue, fail at least one cut)

Comparison of reconstructed Electron - data and simulation.

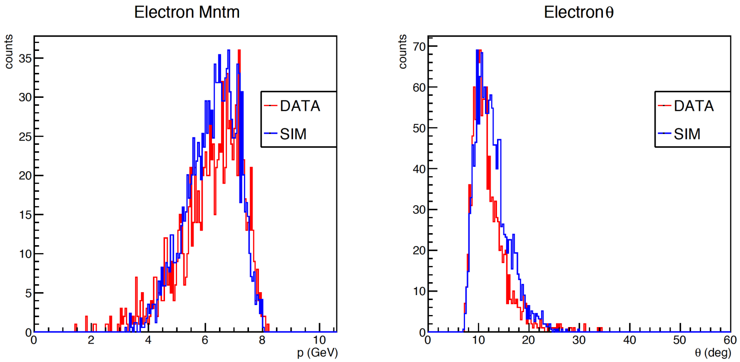


Figure: Electron kinematics (simulation scaled to max height of data)

Comparison of reconstructed Proton - data and simulation.

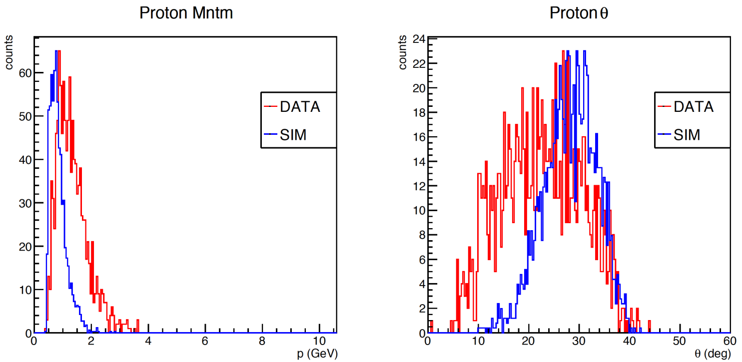


Figure: Proton kinematics (simulation scaled to max height of data)

Comparison of reconstructed K^+ - data and simulation.

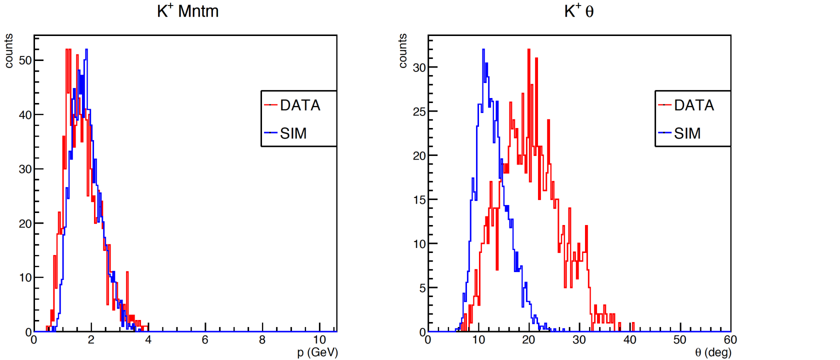


Figure: K^+ kinematics (simulation scaled to max height of data)

Comparison of reconstructed K^- - data and simulation.

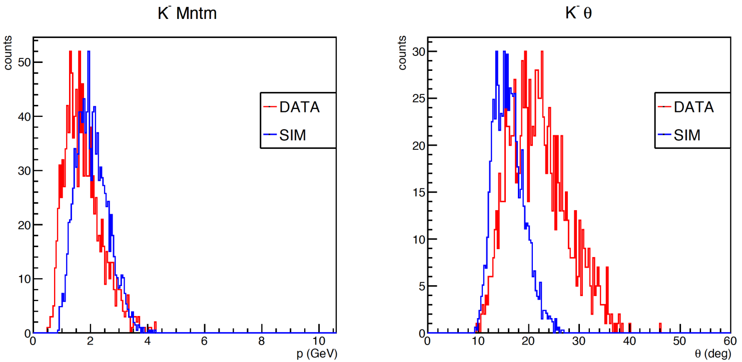


Figure: K^- kinematics (simulation scaled to max height of data)

Comparison of reconstructed Q^2 and $-t$ - data and simulation.

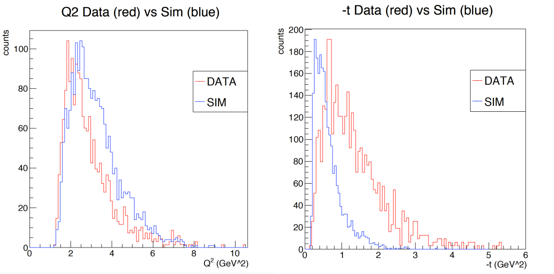


Figure: Q^2 and $-t$ kinematics (simulation scaled to max height of data)

Comparison of reconstructed Kinematic range - data and simulation.

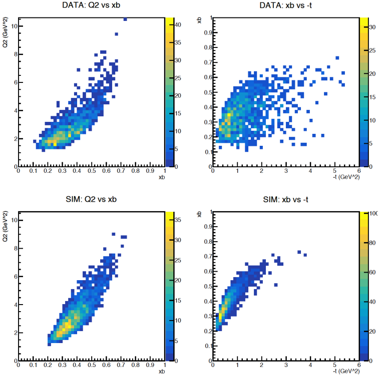


Figure: Comparison of kinematic coverage between data (TOP) and simulation (BOTTOM).

Concluding Remarks

- Undergoing cross check analysis to better understand the differences between GEMC and Data.
- Systematically compare inbending against outbending data sets for quality comparison.
- Compare similar metrics defined above against complementary channel $ep\pi^+\pi^-$.
- Investigate applying kinematic corrections to particles.