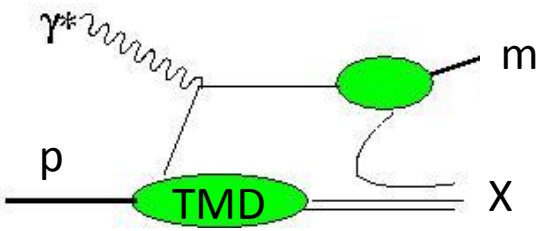
Hall C SIDIS Program – basic (e,e'π) cross sections

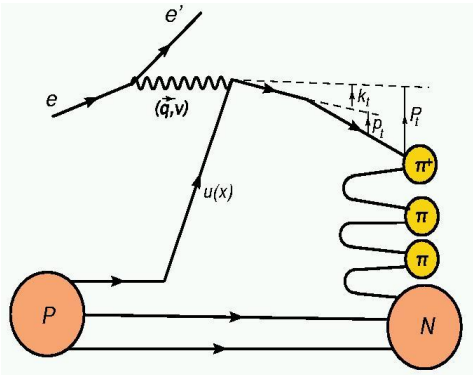
Linked to framework of *Transverse Momentum Dependent Parton Distributions*

- Validation of factorization theorem needed for most future SIDIS experiments and their interpretation
- Need to constrain TMD evolution w. precision data
- Questions on target-mass corrections and ln(1-z) resummations require precision large-z data



$TMD^q(x,k_T)$

Transverse momentum widths of quarks with **different flavor (and polarization)** can be different



$P_T = p_t + z\, k_t + O(k_t^2/Q^2)$

E12-13-007 goal: Measure the basic SIDIS cross sections of π^o production off the proton, including a map of the P_T dependence ($P_T \sim \Lambda < 0.5$ GeV), to validate(*) flavor decomposition and the k_T dependence of (unpolarized) up and down quarks

(*) Can only be done using spectrometer setup capable of %-type measurements (an essential ingredient of the global SIDIS program!)

Requires new ~25 msr Neutral-Particle Spectrometer

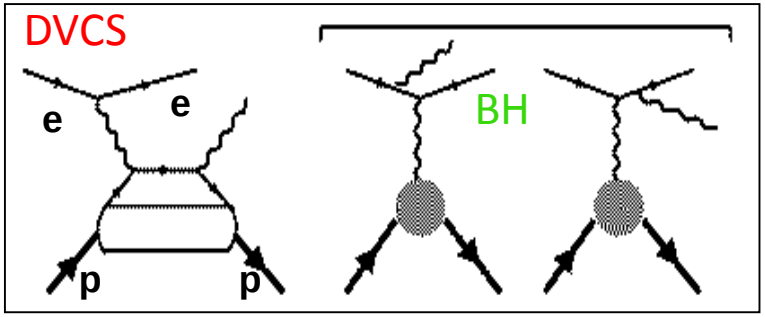
Advantages of $(e,e'\pi^o)$ beyond $(e,e'\pi^{+/-})$

- Many experimental and theoretical advantages to validate understanding of SIDIS with neutral pions
- Can verify: $\sigma^{\pi^o}(x,z) = ½\,(\sigma^{\pi^+}(x,z) + \sigma^{\pi^-}(x,z))$
- Confirms understanding of flavor decomposition/k_T dependence

PAC: "the **cross sections** are **such basic tests of the understanding of SIDIS** at 11 GeV kinematics that they will play a **critical role** in establishing the entire SIDIS program of studying the partonic structure of the nucleon."

Towards the 3D Structure of the Proton

Simplest process: **e + p → e' + p + γ (DVCS)**



E12-13-010 DVCS measurements follow up on DVCS measurements in Hall A:

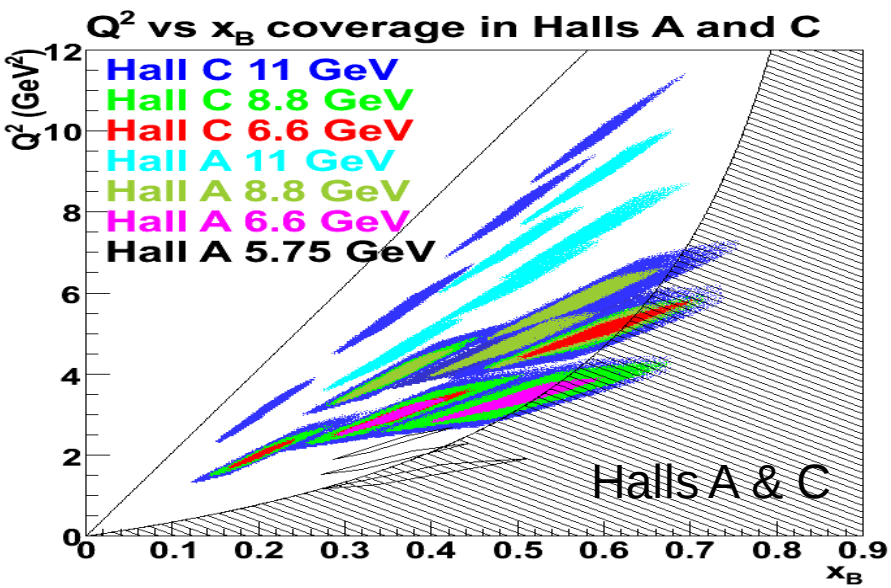
- Scaling of the Compton Form Factor
- Rosenbluth-like separation of DVCS:

$$\sigma = |BH|^2 + Re[DVCS^{\dagger}BH] + |DVCS|^2$$

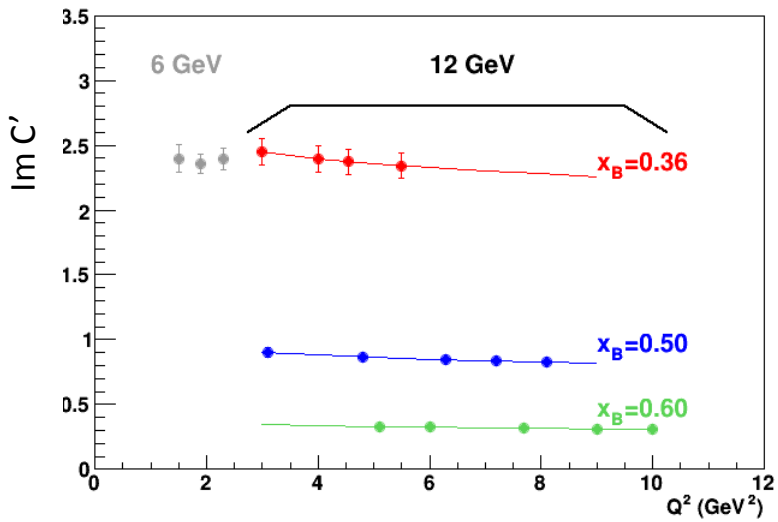
$$\sim E^2_{Beam} \qquad \sim E^3_{Beam}$$

- L/T Separation of π^o production

Hall A data for Compton form factor (over *limited* Q^2 range) agree with hard-scattering

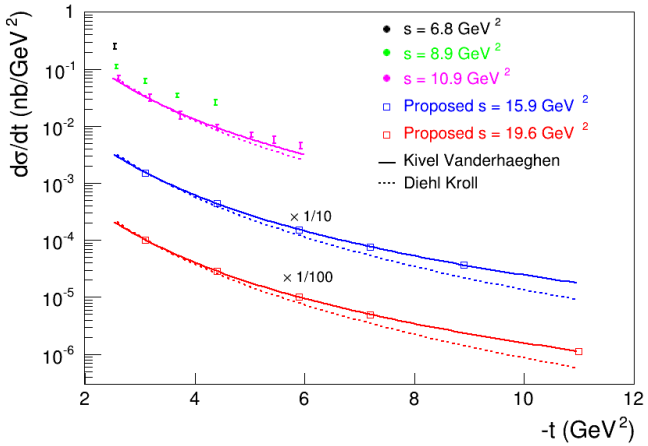


12 GeV projections: confirm formalism



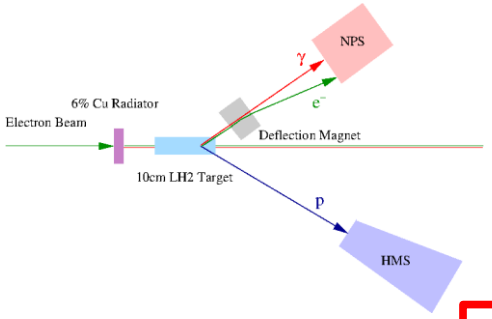
Extracting the real part of CFFs from DVCS requires measuring the cross section at multiple beam energies ($DVCS^2$–Interference separation)

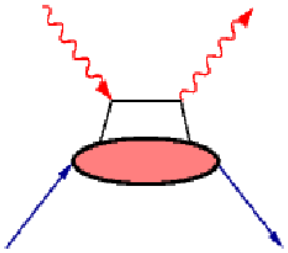
WACS - the process of choice to explore factorization in wide-angle processes



- WACS is a powerful but under-utilized probe of nucleon structure, for which there have been several theoretical approaches developed in recent years.
- Recent developments within the Soft Collinear Effective Theory (SCET) have demonstrated how important future WACS data for interpretation of a wide variety of hard exclusive reactions.

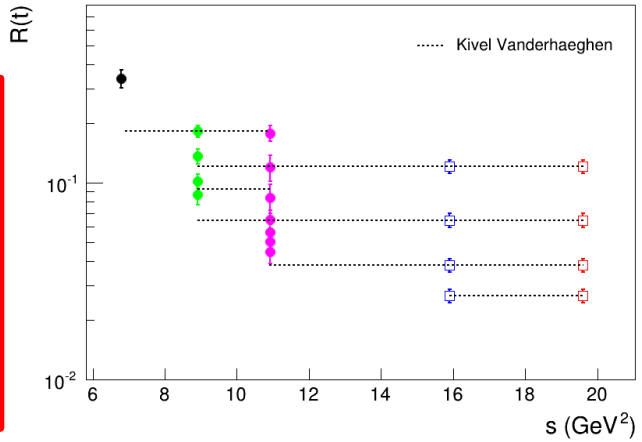
- Jlab Hall A data suggest factorization of the reaction mechanism into hard and soft-collinear parts (but limited in -t).
- E12-14-003 will use the Hall C HMS and the new **Neutral Particle Spectrometer** to measure the differential cross section with 18 days beam-time,.



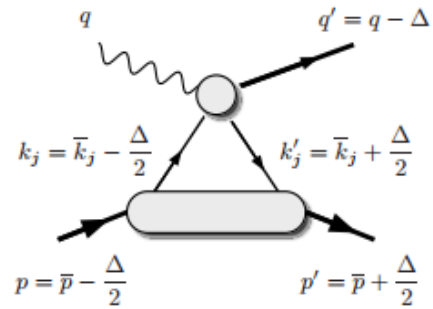


Two main goals of E12-14-003:

- Four fixed -t scans will allow for a rigorous test of factorization.
- The t-dependence of the Compton form factor will allow us to gain valuable insights into proton structure at high momentum transfer.

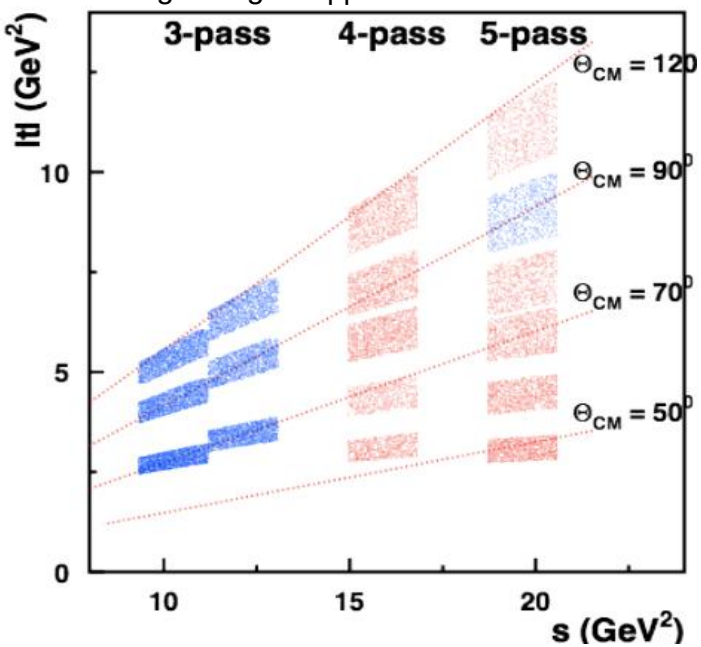


Wide-Angle exclusive photo-production of π^0 mesons

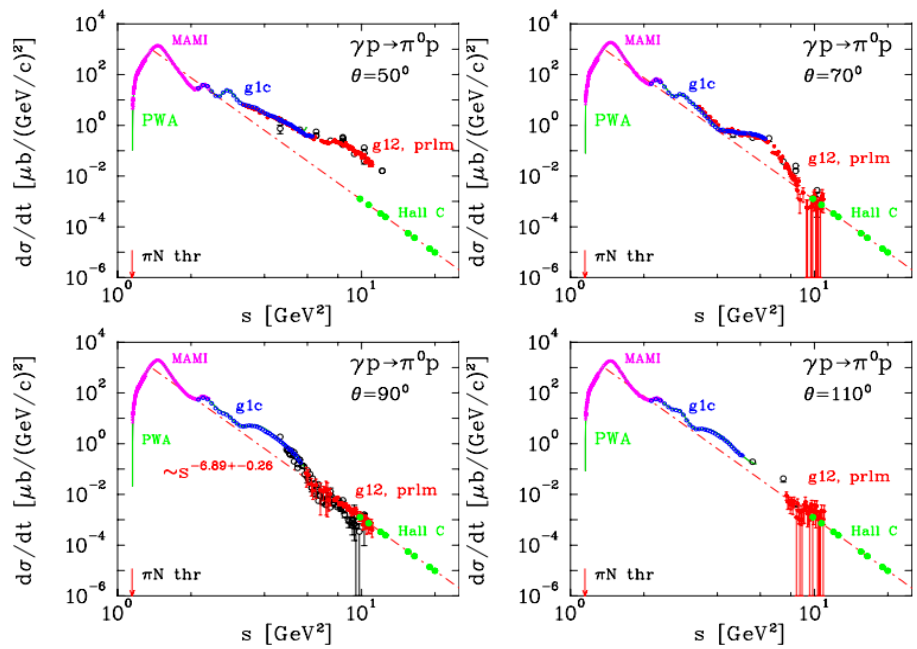


The next simplest reaction after Compton scattering, but model predictions disagree with data by orders of magnitude!

Using the NPS E12-14-005 will cover a large range in |t| and s



E12-14-005 projections



E12-14-005: basic cross section to confirm scaling and provide wide angular coverage for testing models based on the dominance of handbag mechanism.

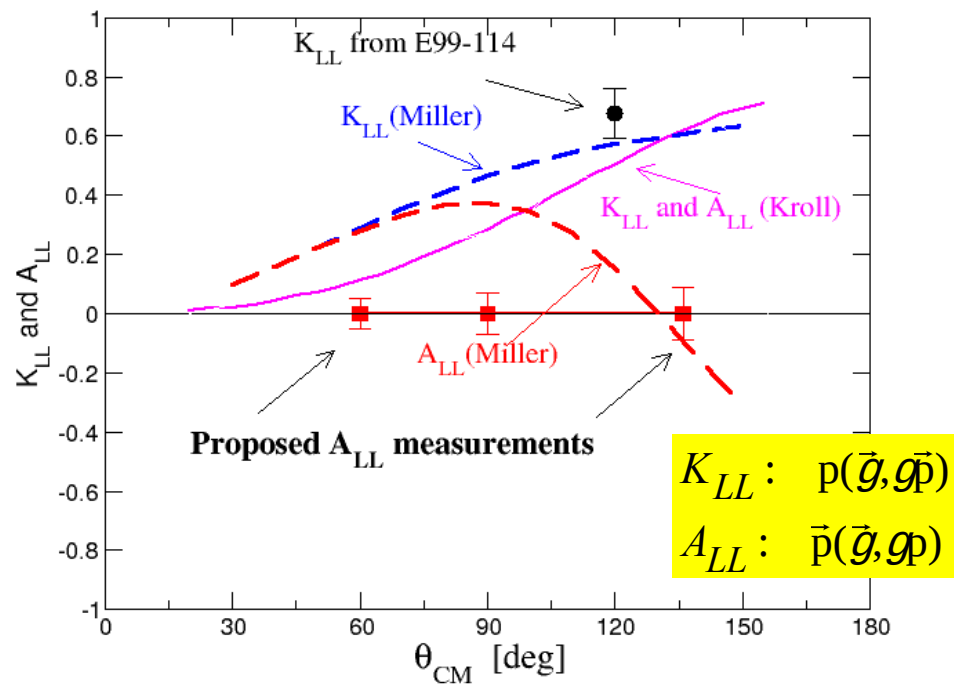
Also help with extracting Regge trajectories

Polarization observables in Wide-Angle Compton Scattering

- Polarized WACS allows for studies of the size of *power-suppressed corrections* in the reaction mechanism due to, e.g., quark mass effects in a constituent quark model framework or to dressed-quark mass effects

- Jlab data on recoil obervable K_{LL} indicate partonic mechanism

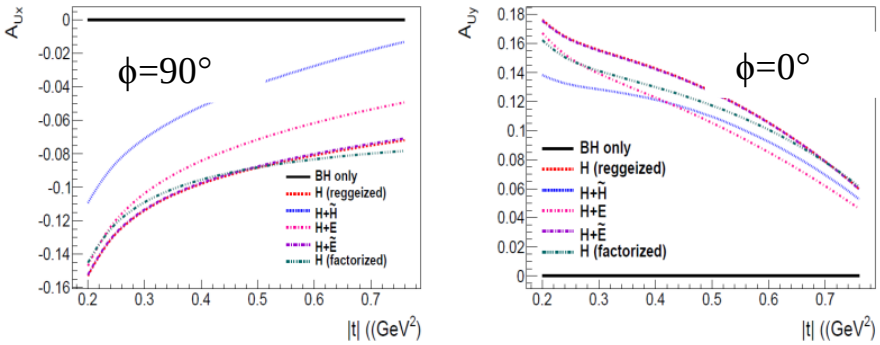
- Theoretical models do not describe the data well
  - GK: Elementary quarks, x ~ 1 kinematic approx.
  - Miller: Constituent qqq wave function; Good fit to Elastic G_E, G_M



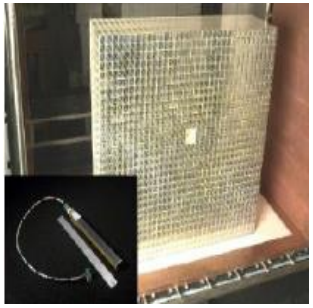
E12-14-006: measurements of target polarization observable A_{LL}. Any difference between A_{LL} and the recoil observable K_{LL} is indicative of the scale at which one approaches the leading order partonic mechanism

Timelike Compton Scattering with Transverse targets

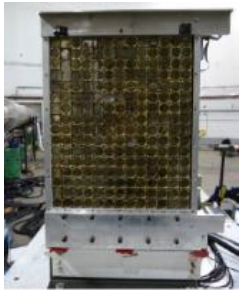
- Features of TCS measurements with transversely polarized target
  - Theoretical calculations show that transverse asymmetries are very sensitive to GPDs
    [M. Boer, M. Guidal, arXiv:1412.2036]
  - Asymmetries for the BH the main background for TCS is zero!
  - Predictions for asymmetries with different assumption of GPDs vary up to 20%



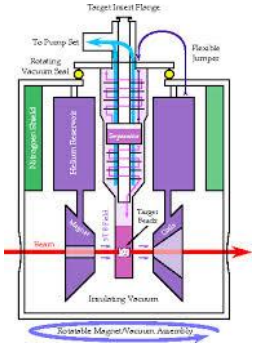
- TCS event detection with NPS
  - Lepton pair will be detected by pair of NPS
  - Recoil detection by combination of tracking and TOF



$PbWO_4$

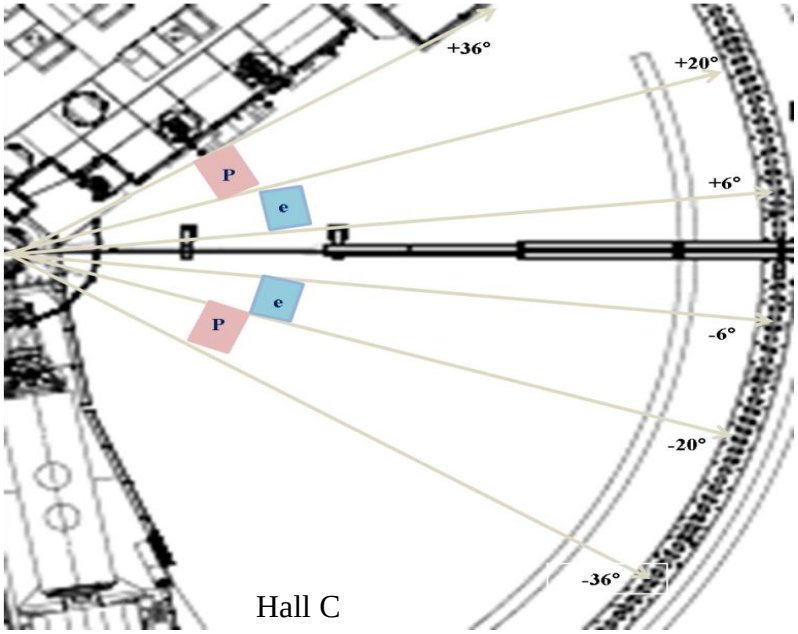


PbF_2



NH_3 Target

Possible versions for the NPS



Hall C