SIDIS Studies with CLAS12

- Semi-Inclusive DIS: Experiment
- Final states (π0, π+, π+π− ,…)
- What we can learn from longitudinal target measurements
- Dissecting SIDIS
- Evolution studies as validation test
- Comparing ALU with AUL
- Summary

Observables with longitudinally pol. target

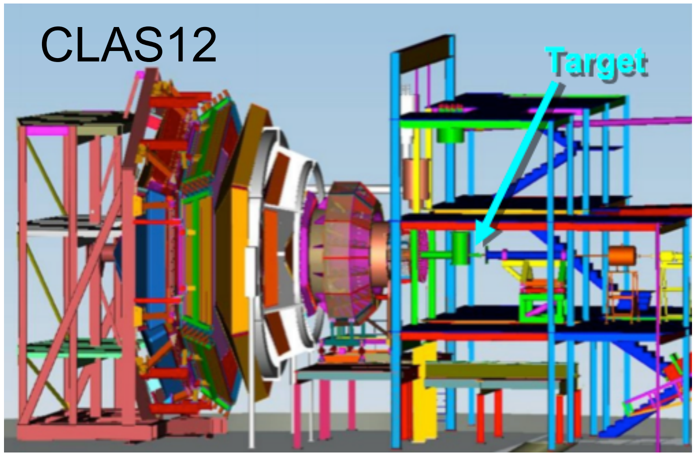
$$\sigma^{\lambda\Lambda} = \sigma_{UU} + \lambda\sigma_{LU}\sin\phi + \Lambda\sigma_{LU}\sin\phi + \lambda\Lambda(\sigma_{LL} + \sigma_{LL}^{\cos}\cos\phi)$$

λ and $\Lambda \rightarrow$ helicities of e- and proton (normalizing lumi of positive and negative targets

$N^{++}+N^{-+}$ = sum of events (with +/- helicities of e-) for positive target polarization
$N^{+-}+N^{--}$ = sum of events (with +/- helicities of e-) for negative target polarization
$N^{++}+N^{+-}$ = sum of events (with +/- helicities of p) for positive e- helicity
$N^{-+}+N^{--}$ = sum of events (with +/- helicities of p) for negative e- helicity
Observables
beam SSA $(N^{++} + N^{+-} - N^{-+}-N^{--})/(N^{++} + N^{+-} + N^{-+}+N^{--})= (a_{lu}\sin\phi)/(1+b_{uu}\cos\phi)$
use the $(1+b_{uu}\cos\phi)$ containing cos from acceptance and Cahn for others
target SSA
$(N^{++} + N^{-+} - N^{+-}-N^{--})/(N^{++} + N^{+-} + N^{-+}+N^{--})= (a_{ul}\sin\phi+b_{ul}\sin2\phi)/(1+b_{uu}\cos\phi)$
Target double spin asymmetries
1) $(N^{++} - N^{-+})/(N^{++} + N^{-+}) =(a_{ul}\sin\phi+b_{ul}\sin2\phi+a_{LL}+b_{LL}\cos\phi)/(1+b_{uu}\cos\phi)$
2) $(N^{--} - N^{+-})/(N^{--} + N^{+-}) =(-a_{ul}\sin\phi-b_{ul}\sin2\phi+a_{LL}+b_{LL}\cos\phi)/(1+b_{uu}\cos\phi)$
use the same helicity
1) $(N^{++} - N^{+-})/(N^{++} + N^{+-}) =(a_{lu}\sin\phi+a_{LL}+b_{LL}\cos\phi)/(1+b_{uu}\cos\phi)$
2) $(N^{--} - N^{-+})/(N^{--} + N^{-+}) =(-a_{lu}\sin\phi+a_{LL}+b_{LL}\cos\phi)/(1+b_{uu}\cos\phi)$

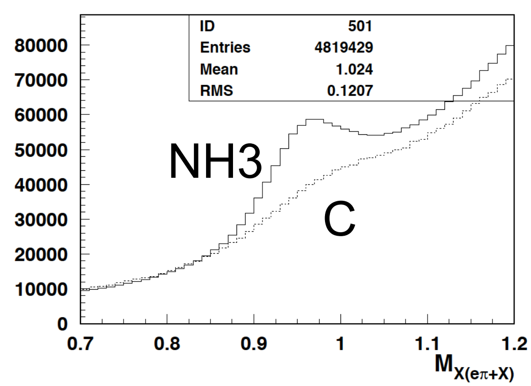
Longitudinally polarized target offers several observables critical for test

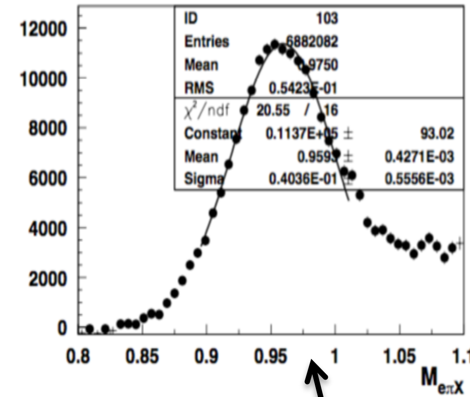
CLAS12 RGC experiment with longitudinally polarized target



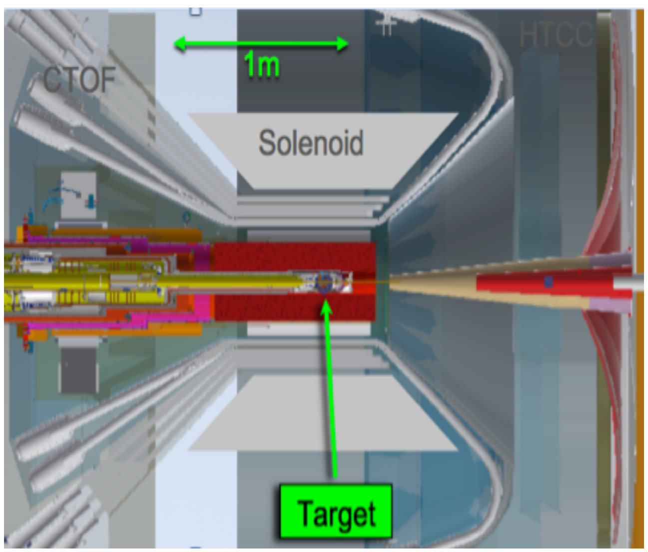
E12-06-109, E12-06-119, E12-07-107, E12-09-009

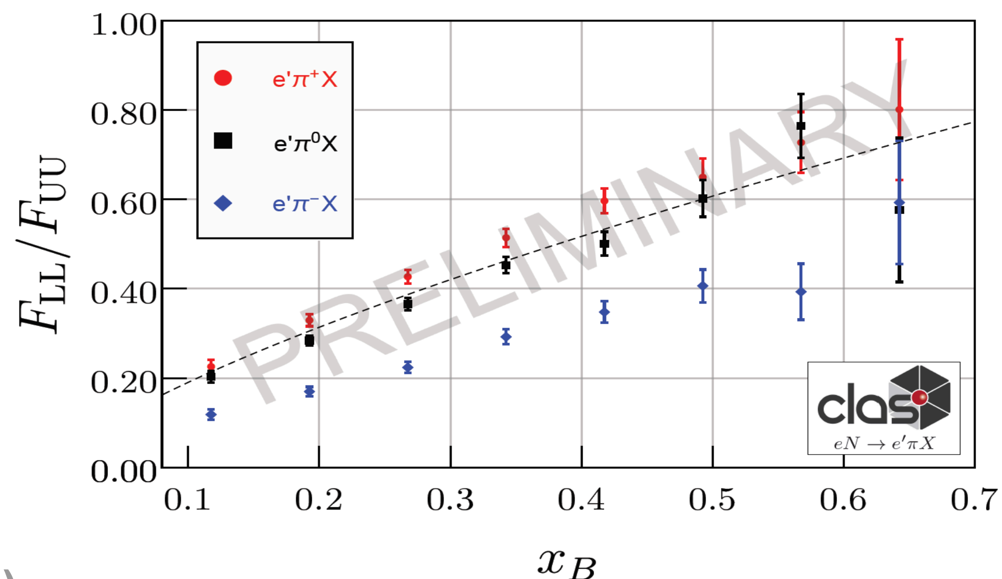
Electroproduction on longitudinally polarized NH3 and ND3





Subtracting carbon data from NH3 (nice neutron peak)





Dynamic Nuclear Polarization (DNP)

Single pion DSAs

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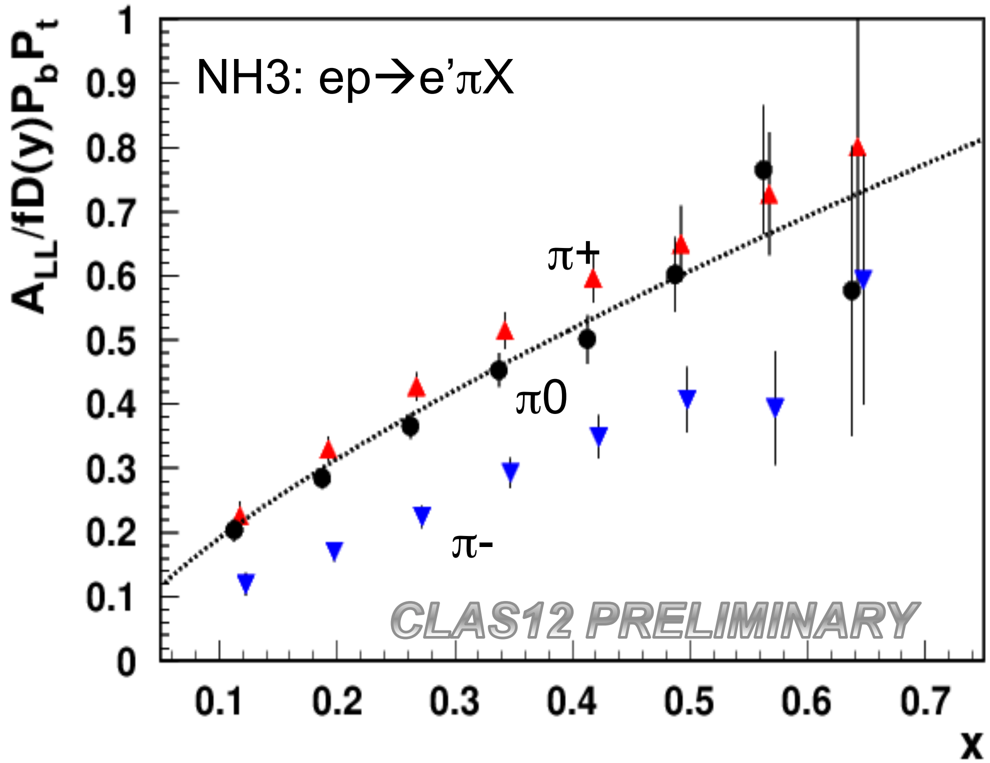
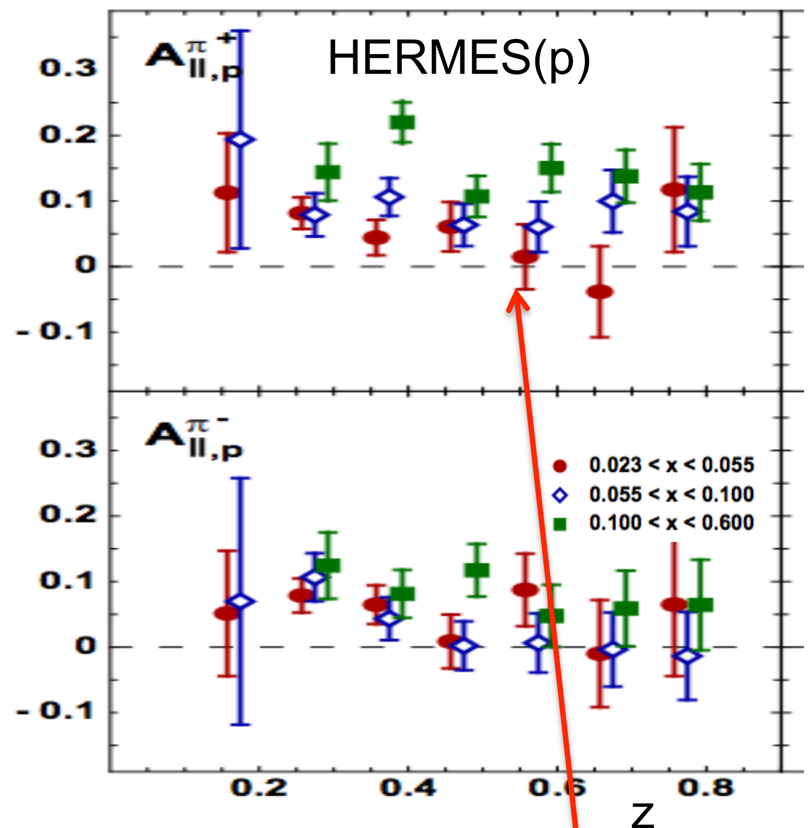


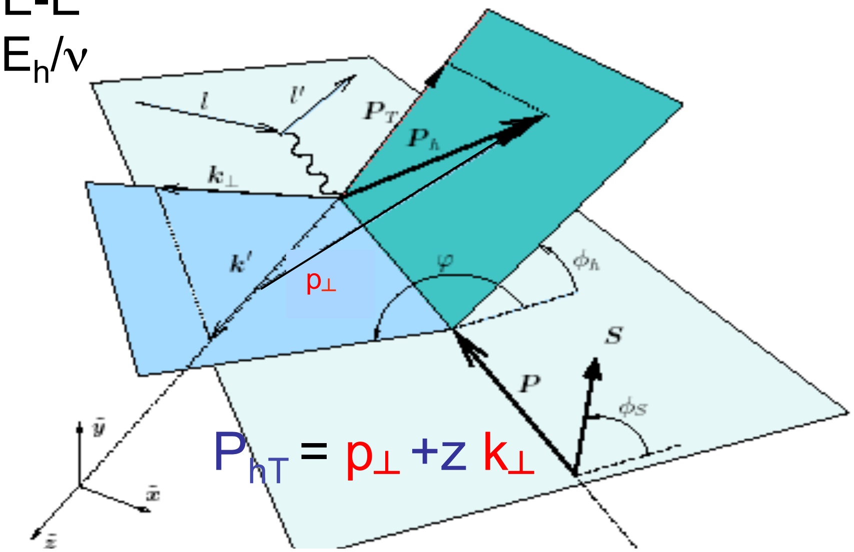


- Double spin asymmetries for ep→eπ+X seem to decrease at large z and effect more significant at low x
- The ep→eπ+X drops faster at low x than ep→eπ0X (consistent with DIS fit)
- Note: →exclusive rho contributions more significant at large z and low x

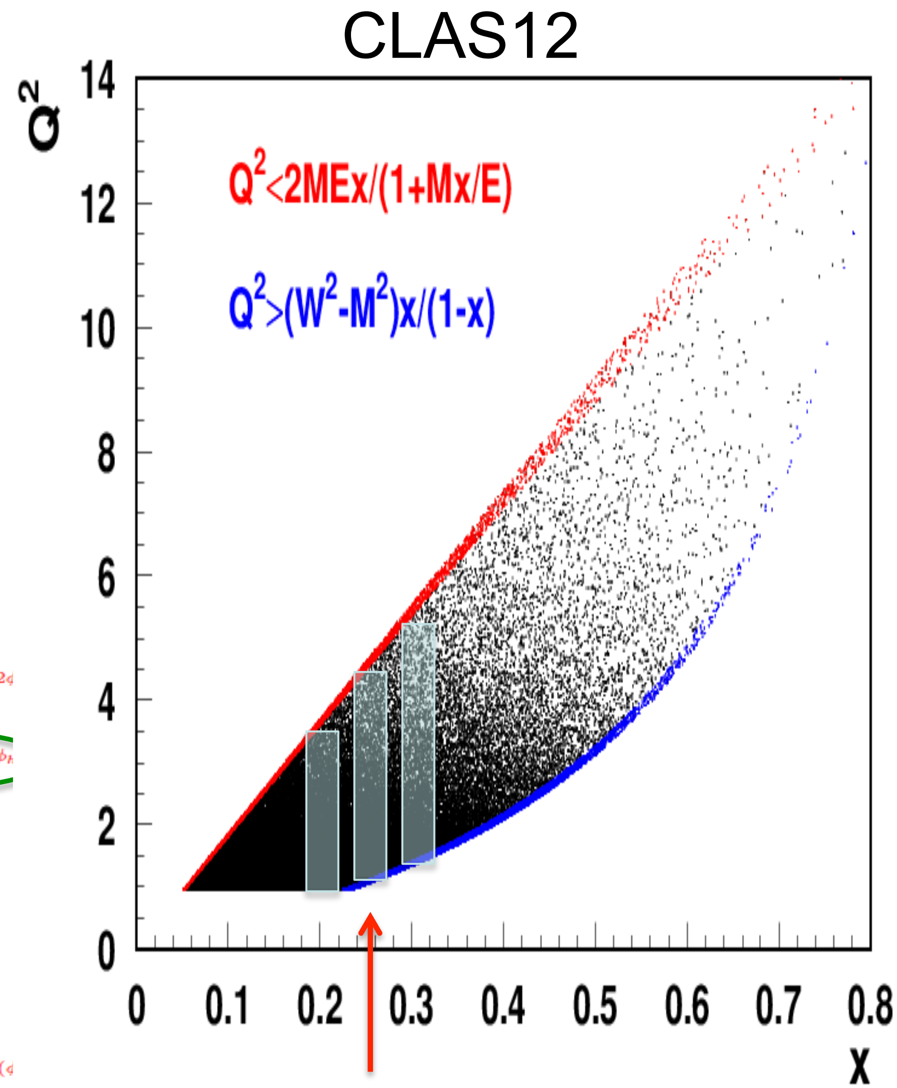
DIS kinematical coverage and observables

$\nu = E - E'$

$z = E_h / \nu$

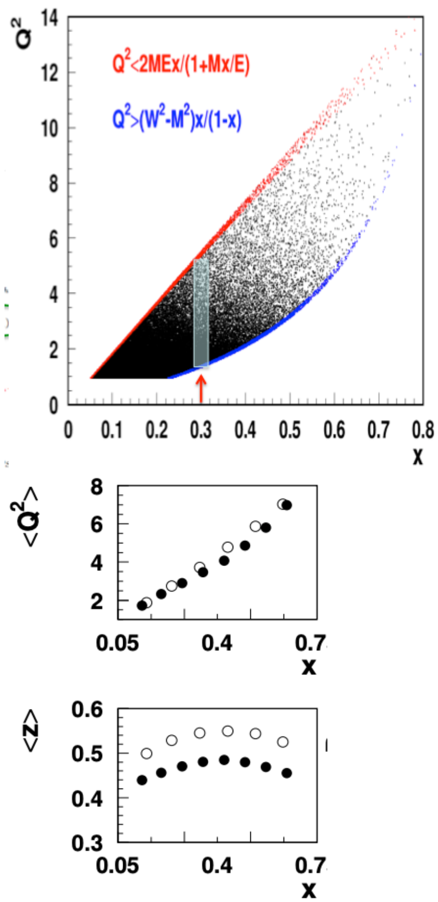


$$
\begin{aligned}
\frac{d\sigma}{dx\, dy\, d\phi_S\, dz\, d\phi_h\, dP_{h\perp}^2}
&= \frac{\alpha^2}{x\, y\, Q^2} \frac{y^2}{2(1-\varepsilon)} \Big\{ F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\varepsilon(1+\varepsilon)}\, \cos\phi_h\, F_{UU}^{\cos\phi_h} + \varepsilon \cos(2\phi_h)\, F_{UU}^{\cos 2\phi_h} \\
&+ \lambda_e \sqrt{2\varepsilon(1-\varepsilon)}\, \sin\phi_h\, F_{LU}^{\sin\phi_h} + S_L \Big[\sqrt{2\varepsilon(1+\varepsilon)}\, \sin\phi_h\, F_{UL}^{\sin\phi_h} + \varepsilon \sin(2\phi_h)\, F_{UL}^{\sin 2\phi_h} \Big] \\
&+ S_L \lambda_e \Big[\sqrt{1-\varepsilon^2}\, F_{LL} + \sqrt{2\varepsilon(1-\varepsilon)}\, \cos\phi_h\, F_{LL}^{\cos\phi_h} \Big] \\
&+ S_T \Big[\sin(\phi_h - \phi_S) \Big(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon F_{UT,L}^{\sin(\phi_h-\phi_S)} \Big) + \varepsilon \sin(\phi_h + \phi_S)\, F_{UT}^{\sin(\phi_h+\phi_S)} \\
&\quad + \varepsilon \sin(3\phi_h - \phi_S)\, F_{UT}^{\sin(3\phi_h-\phi_S)} + \sqrt{2\varepsilon(1+\varepsilon)}\, \sin\phi_S\, F_{UT}^{\sin\phi_S} \\
&\quad + \sqrt{2\varepsilon(1+\varepsilon)}\, \sin(2\phi_h - \phi_S)\, F_{UT}^{\sin(2\phi_h-\phi_S)} \Big] + S_T \lambda_e \Big[\sqrt{1-\varepsilon^2}\, \cos(\phi_h - \phi_S)\, F_{LT}^{\cos(\phi_h-\phi_S)} \\
&\quad + \sqrt{2\varepsilon(1-\varepsilon)}\, \cos\phi_S\, F_{LT}^{\cos\phi_S} + \sqrt{2\varepsilon(1-\varepsilon)}\, \cos(2\phi_h - \phi_S)\, F_{LT}^{\cos(2\phi_h-\phi_S)} \Big] \Big\}
\end{aligned}
$$

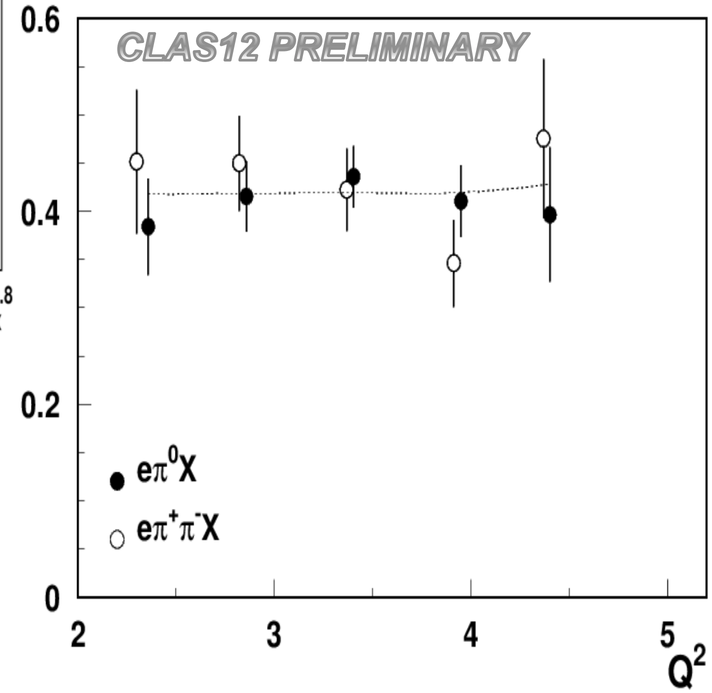


x-slices to study Q^2-dependence

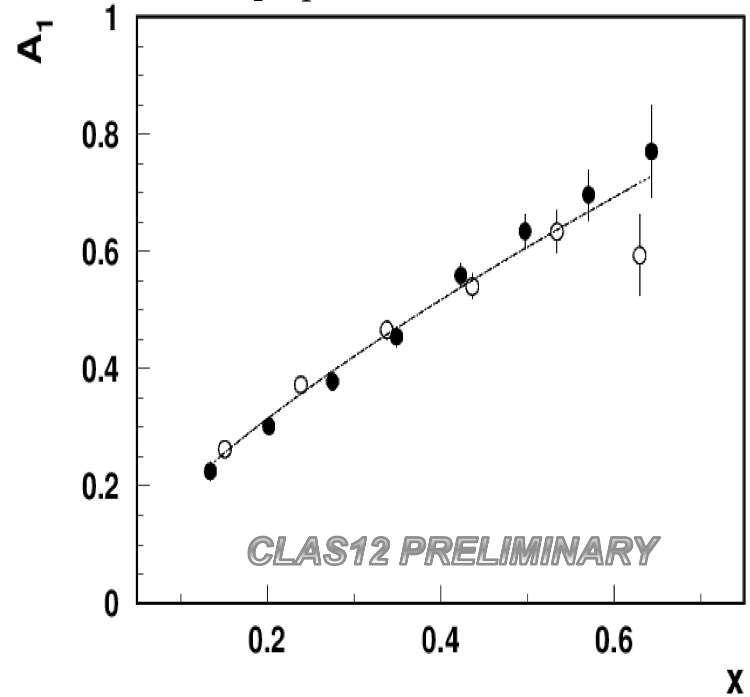
A_1 x-dependence for ep→e'π^0X vs ep→e'π+π−X



0.3<z<0.8, y<0.75



$$A_1(\pi) \propto \frac{\sum_q e_q^2 g_1^q(x) D_1^{q\to\pi}(z)}{\sum_q e_q^2 f_1^q(x) D_1^{q\to\pi}(z)}$$



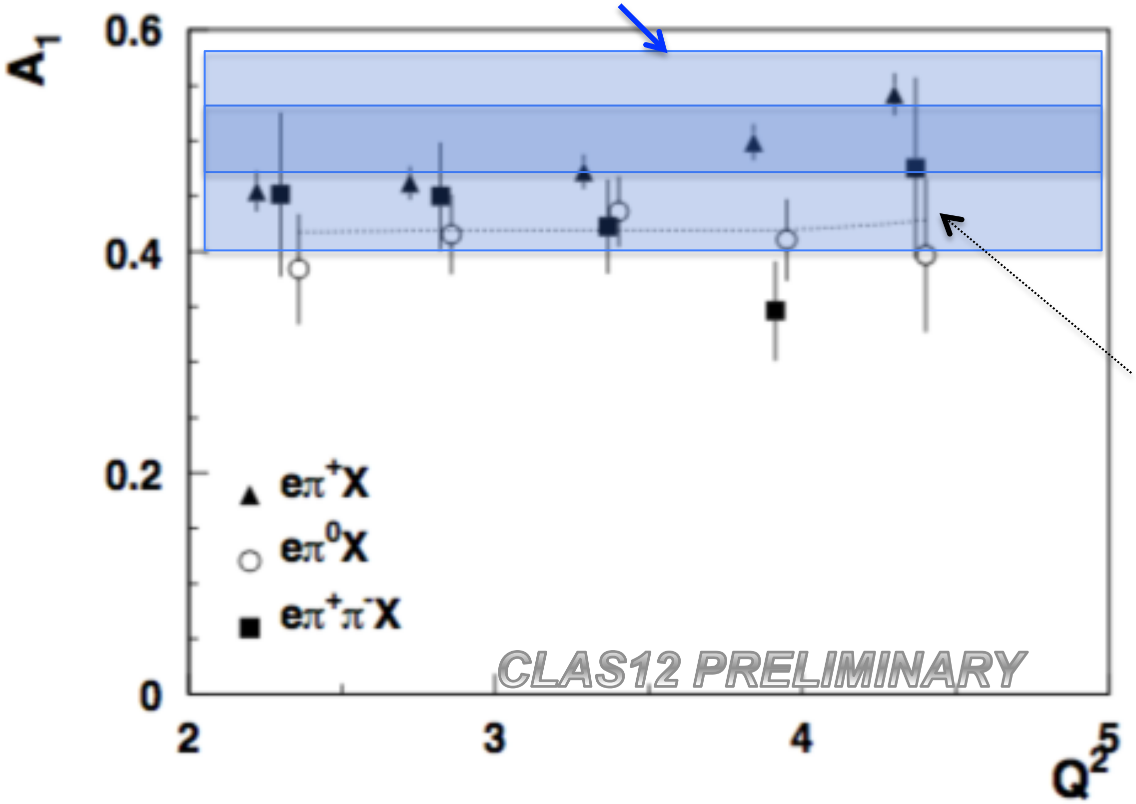
the line $x^{0.72}$(DIS)

- DSA extracted for ep→e'π^0X (filled) and ep→e'π+π−X for 0.3<z<0.8(empty circles) consistent
- No contributions from exclusive ep→e'ρ^0X
- Consistent with simple fit to world data (no major Q^2-dependence)

DSAs: comparing different processes

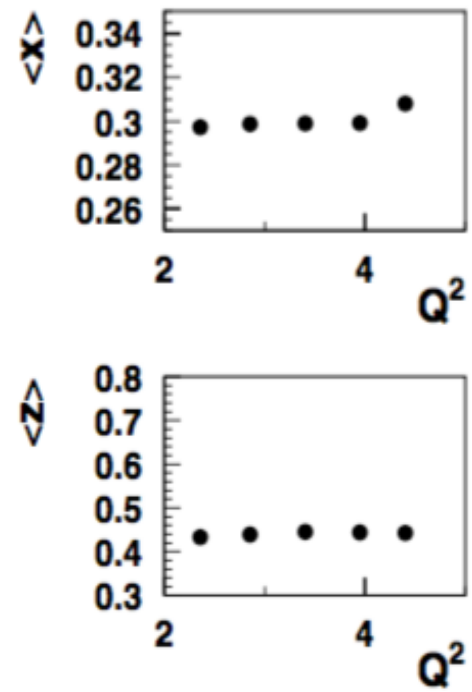
0.28<x<0.32, 0.3<z<0.8, y<0.75

A. Bongallino(ep→e'π+X)



the DIS line $x^{0.72}$

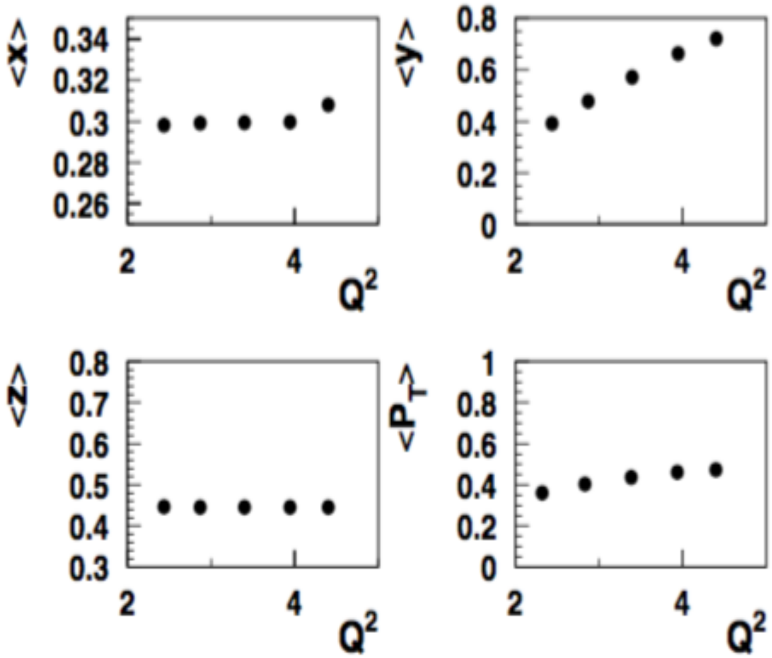
ep→e'π+X



- DSA for ep→e'π+X vs ep→e'π0X and ep→e'π−π+X consistent
- No major Q^2-dependence apart from for ep→e'π+X

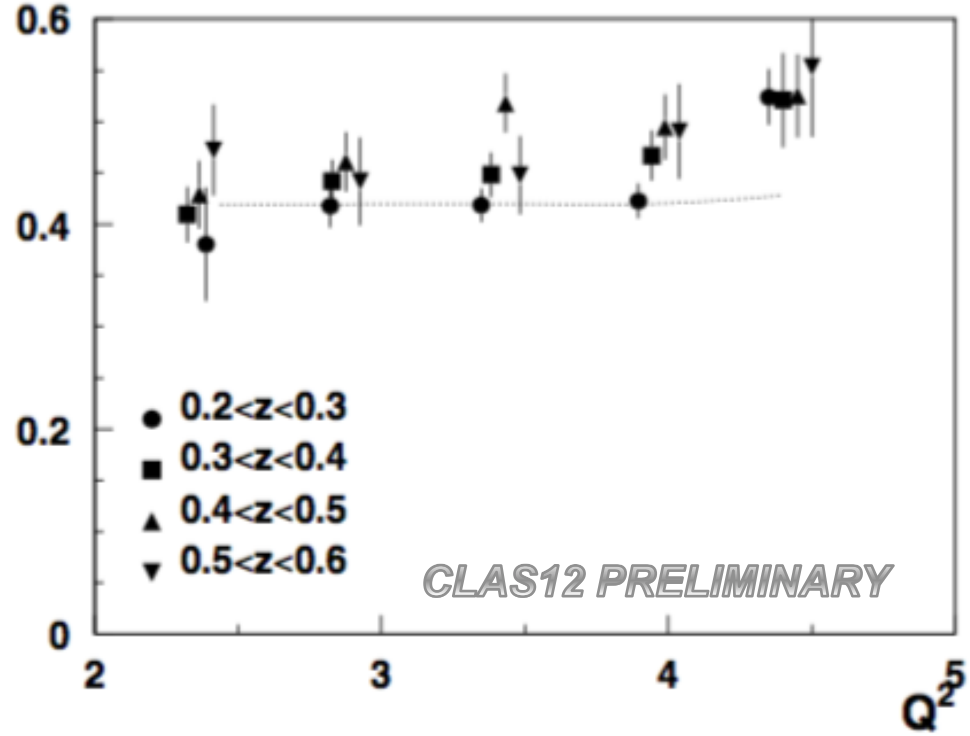
DSAs: Q^2-dependence in z-bins

0.28<x<0.32, y<0.75



ep→eπ+X

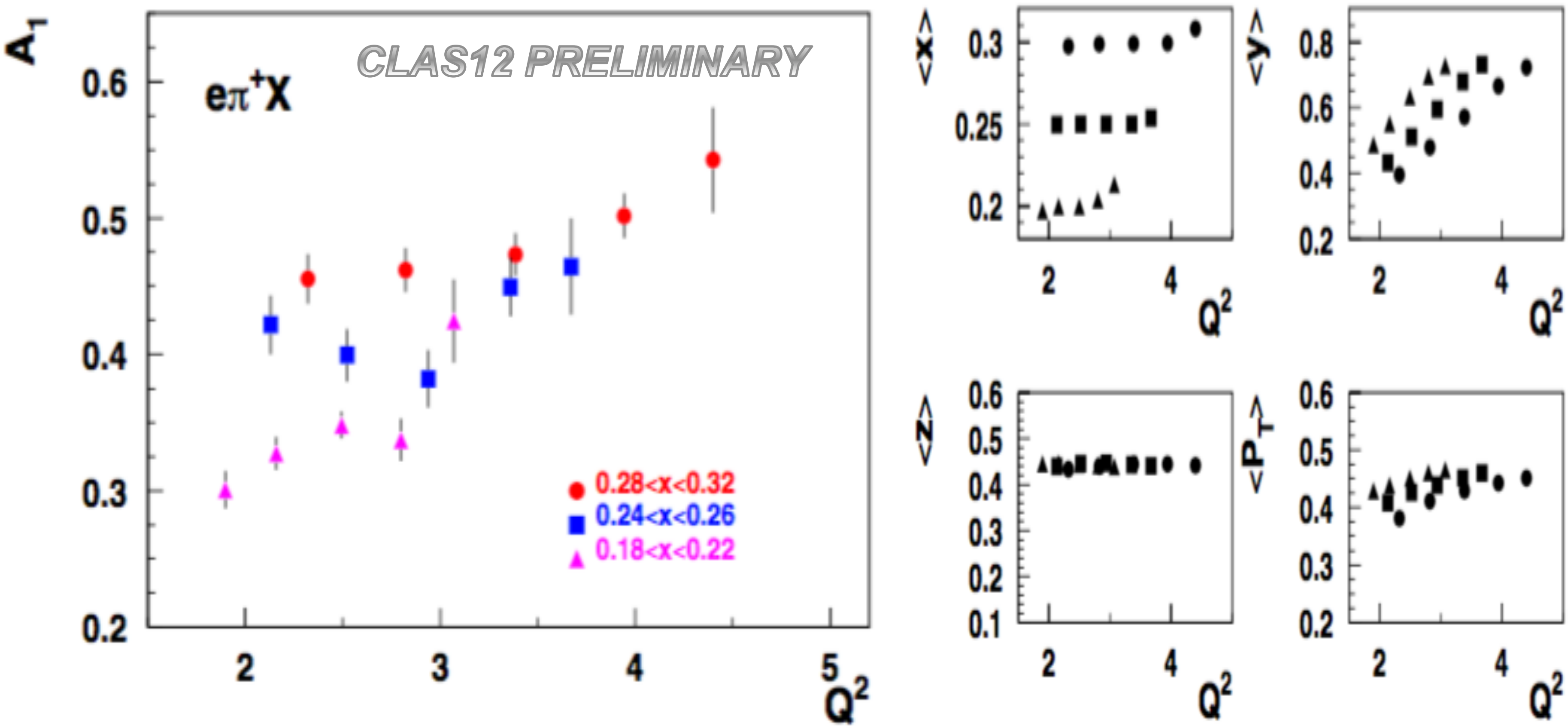
the line $x^{0.72}$



- DSA for ep→e'π+X for z-bins
- Tendency to increase with Q^2 stays for bins in z

DSA ep→e'π+X: more bins in x

0.28<x<0.32, 0.3<z<0.8, y<0.75



- Inclusive (in progress) and π+ samples may have significant contributions from longitudinal photons (VMs)
- Behavior of the double spin asymmetry for π+ is consistent with increase with Q^2

Theory-Experiment Dialogue

$$\frac{d\sigma^{lN\to l'hX}}{dx_B dQ^2 dz dP_{h\perp}^2 d\phi_h} = \frac{\pi\alpha^2 y}{x_B y Q^2(1-\epsilon)}[F_{UU,T} + \qquad \ldots\ldots]$$

$$lN \to l'\pi^+ X$$
$$lN \to l'\rho^0 X$$
....

$$lN \to l'\pi^+ X$$

Fragmentation Function
→ probability to produce π+

$$F^h_{XY}(x,z,P_T,Q^2) \propto \sum H^q \times f^q(x,k_T,..) \otimes D^{q\to h}(z,p_T,..) + Y(Q^2,P_T) + \mathcal{O}(M/Q)$$

$$\gamma^*_T p \to \pi^+ X(\pi^+ n, \pi^+\Delta, \pi^+\pi^- p, \pi^+\pi^0\pi^- \ldots)$$
....

$$\gamma^*_L p \to \pi^+ X(\pi^+ n, \pi^+\Delta, p\rho^0, \pi^+\pi^0\pi^- \ldots)$$

$$lN \to l'\pi^+ X$$

theory

$$\gamma^*_L p \to p\rho^0_L$$

→ most significant
→ increases at higher energies

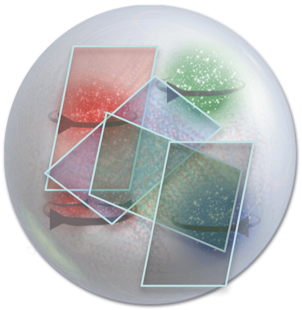
γ^*_L and γ^*_T → different dynamics

Theory-Experiment Dialogue: How to proceed

1. Keeping the formalism the same, including the input data where it works well, and try to get a better description using more sophisticated TMD models for TMD PDFs, and TMD FFs.

2. Try to extend the theory adding contributions assumed irrelevant in existing phenomenology, including also accounting of NLO terms. Note that all kinds of perturbative calculations for azimuthal moments (sin,cos, F_UU,L,...) in perturbative approaches were order of magnitude less than non-perturbative quantities (ex. Cahn)

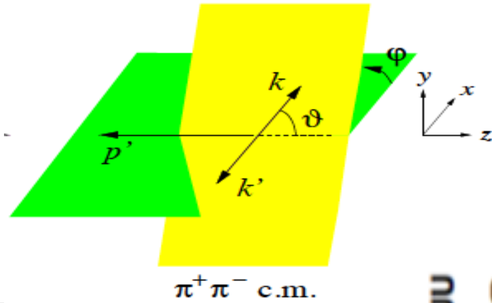
3. Try to extend the theory coverage by eliminating from the input data set the contributions that are not accounted for in the phenomenology, most importantly the longitudinal photon contributions



Measurements of Q^2-dependence of observables is key for validation!!!

What we know about the longitudinal rho

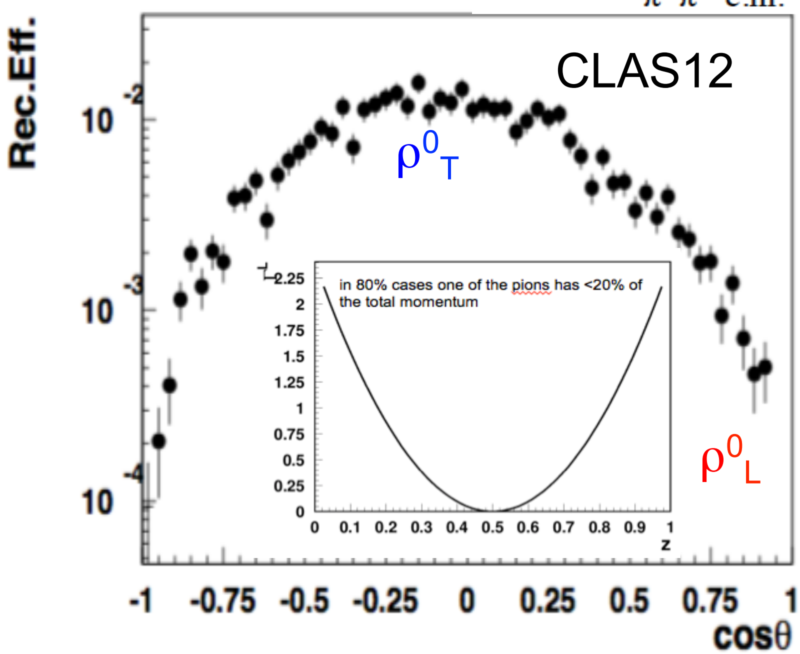
$$\gamma_L^* p \to p \rho_L^0$$

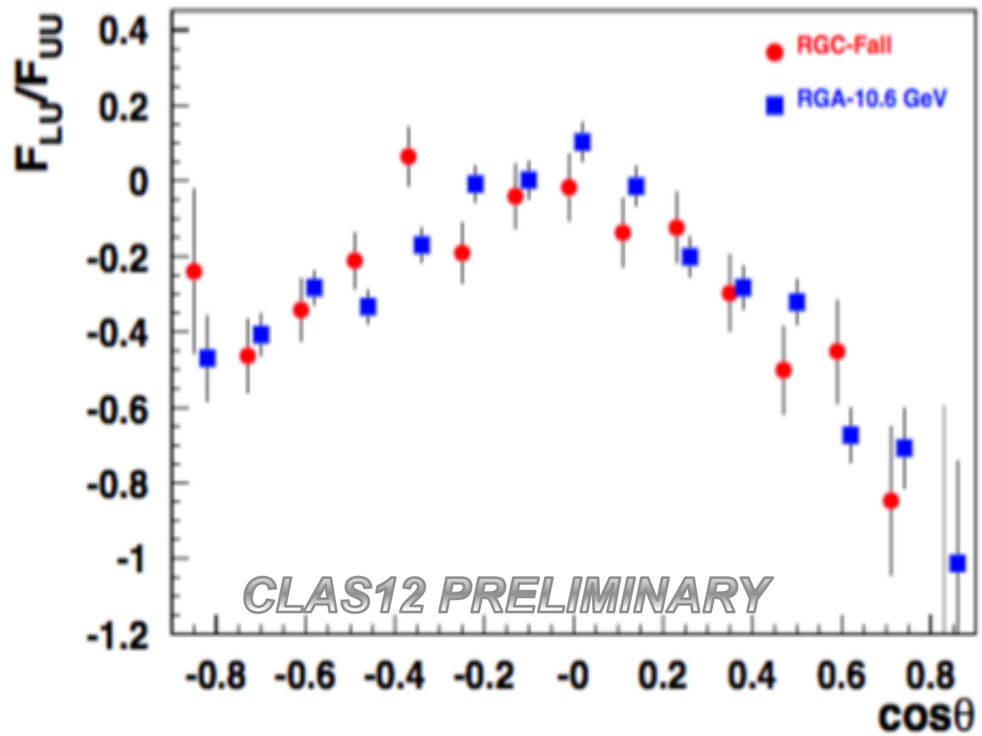


longitudinal ρ→ source of info on γ^*_L

$$\cos\theta \sim (2z-1)$$

Has huge SSAs (negative for beam SSA)



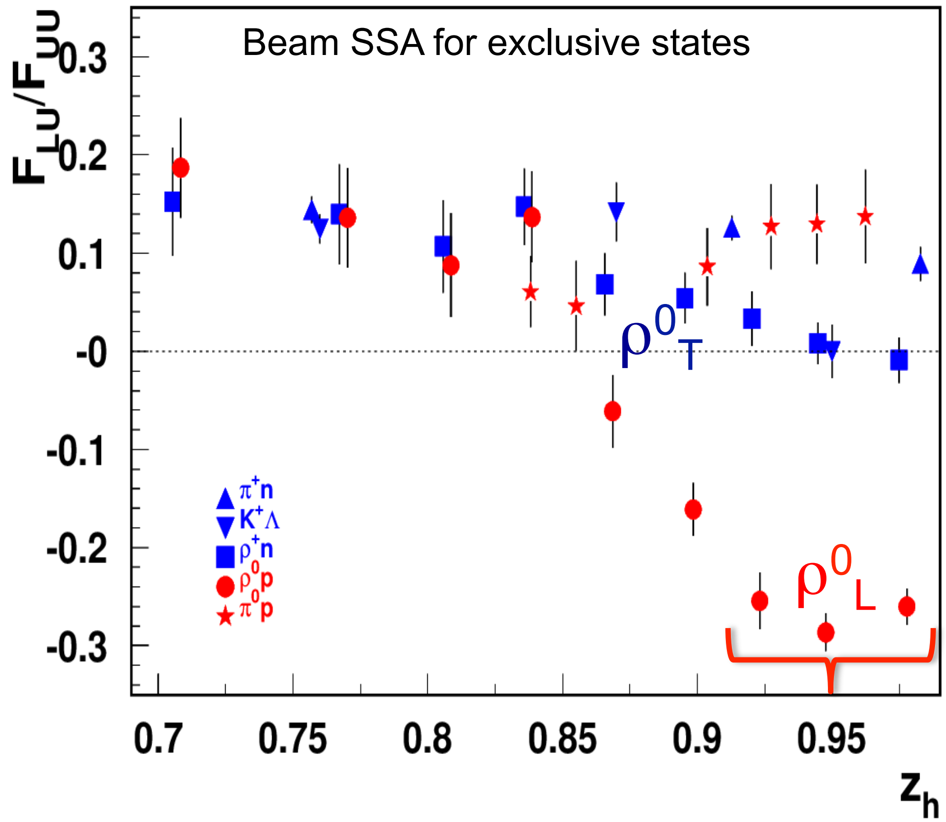


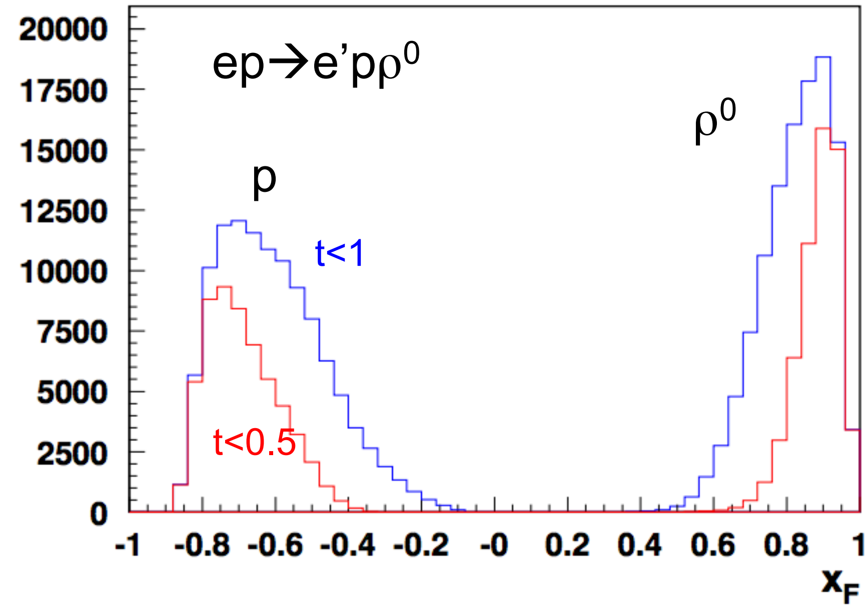
Very challenging to measure
→ asymmetric decays hard to detect and identify

Interference of $\gamma_T^* \to \rho_L$ and $\gamma_L^* \to \rho_L$

$\mathrm{Im}\, u^{0\,0}_{0+} = r^8_{00}/\sqrt{2}$ ← measured 0 at HERMES/COMPASS

“diffractive” VMs: rapidity gap





ρ^0_L and ρ^0_T →2 different particles!!!

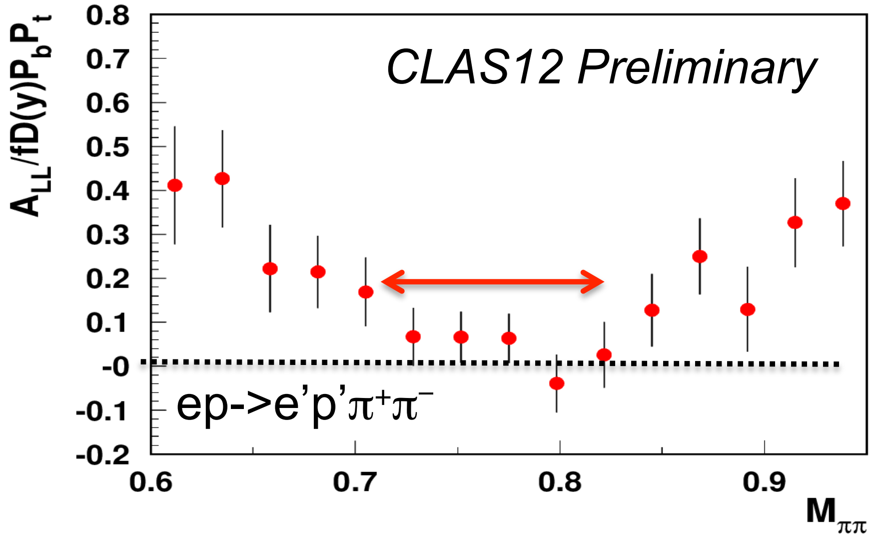
Significant rapidity gap between protons (backward) and rho (forward)

What is the fraction of VMs in DDIS?

What is the relative fraction of VMs as a function of W and Q^2?

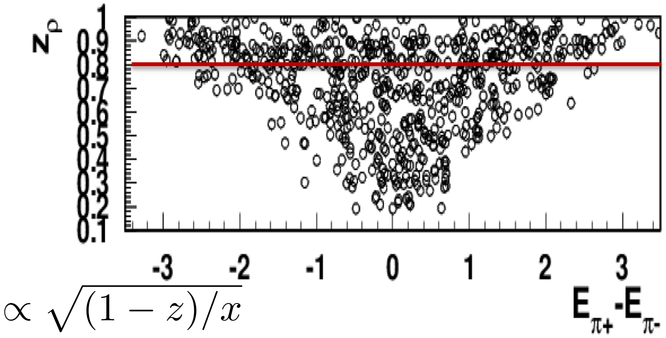
Identify kinematics of “diffractive” ρ^0 by comparison with ρ^+

Studies of ρ^0 impact with longitudinally polarized NH_3 target

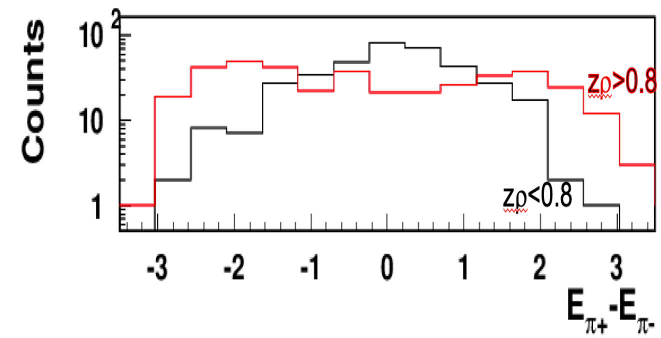


Need clear separation of hydrogen from NH_3
and "diffractive" exclusive ρ0s from exclusive $\pi+\pi-$

Polarization of rho



$$\gamma^*_T \to \rho_L \propto \sqrt{(1-z)/x}$$



- DSA is P-even, SSA is P-odd
- longitudinal photon cross section is P-odd

→ contribution appears only in the SSA, a P-odd observable, and does not appear in DSA(→significant dilution in DSA)

At large z (small t) the shapes of distributions (getting asymmetric) clearly indicate dominance of longitudinal rho

What we know about longitudinal rho: ZEUS

ZEUS diffraction $1/Q^6$ at low M_X

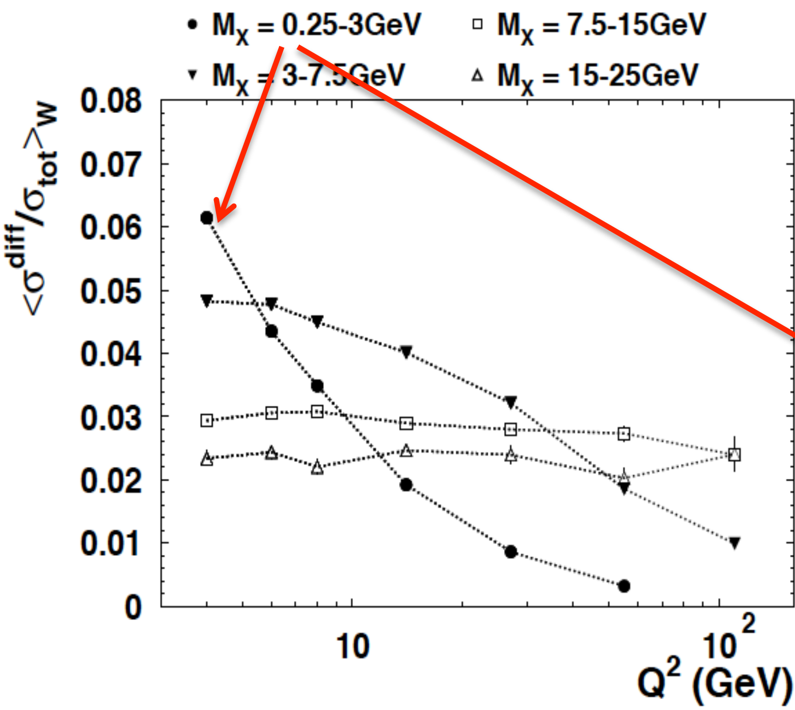
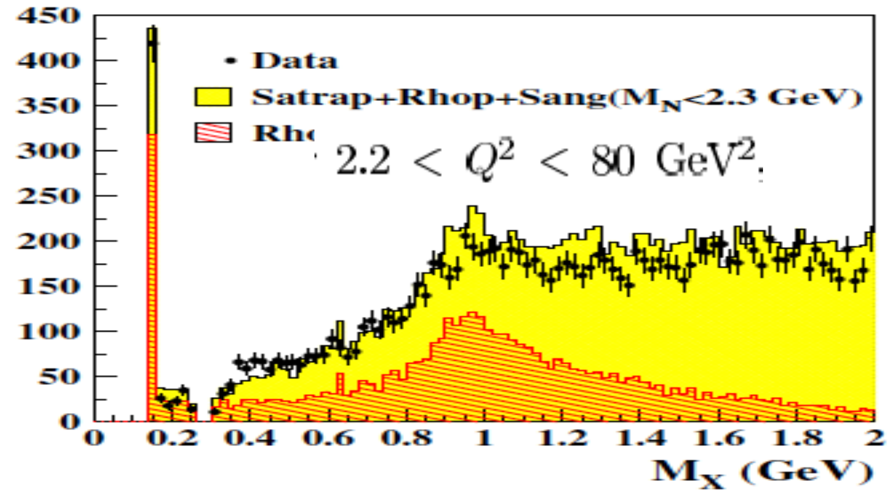
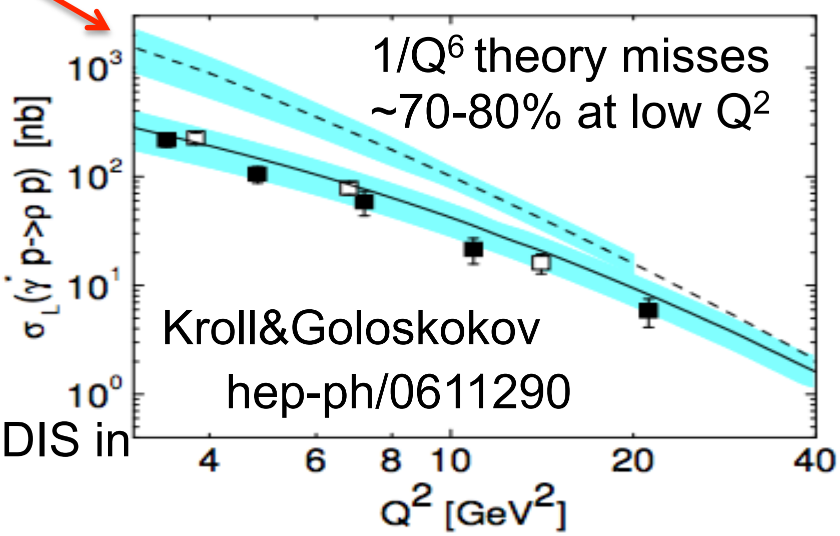


Figure 11.7: The ratio of the diffractive cross section σ^{diff} and the total $\gamma^* p$ cross section σ^{tot} is shown as a function of Q^2 for different bins of M_X. To guide the eye the dotted lines connect points corresponding to the same M_X values.



~20-30% of DDIS comes from rho
What about the Q^2~4GeV^2?

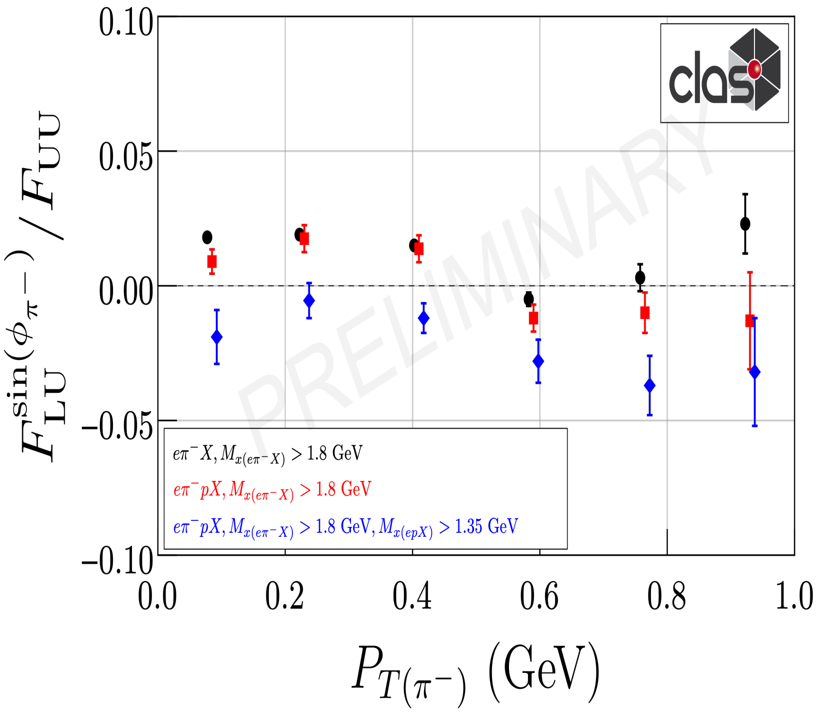


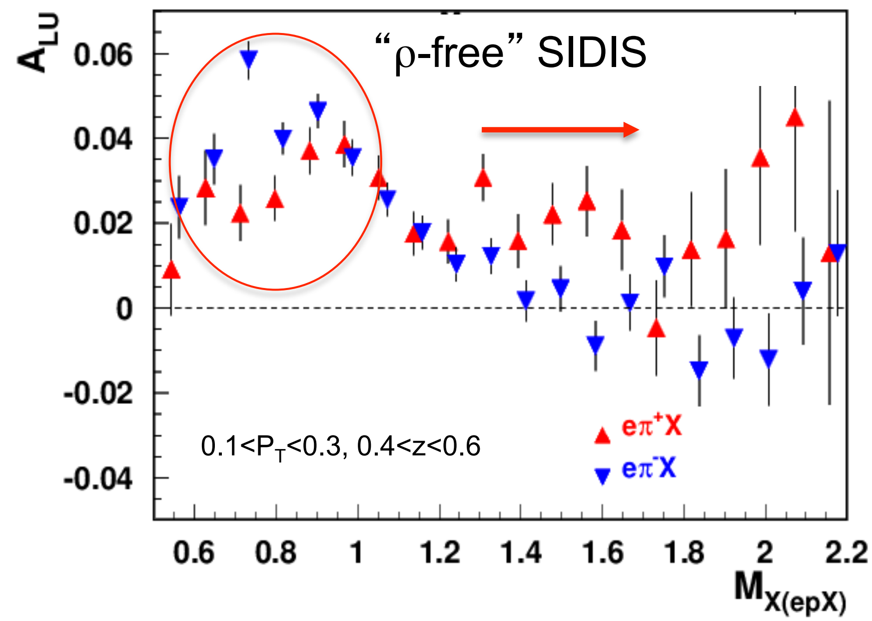
$1/Q^6$ theory misses ~70-80% at low Q^2

Kroll&Goloskokov hep-ph/0611290

What are the other ~70-80% contributions to DDIS in the low MX bin, at low Q^2, in particular?

Exclusive ρ contributions to π: P_T-dependence





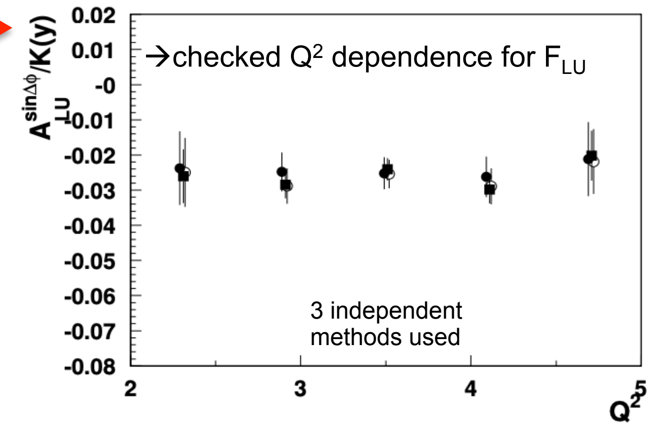
- Can change the pion SSAs, in particular at small PT
- The same sign and size of π+ and π- SSA indicates the rho0 may not be properly subtracted(require detailed MC studies, which require proper SDMEs)
- While VM contributions are ~20% in multiplicities in SSA they can be >100%
- Detection of the target proton introduces much smaller bias on the inclusive charged pion SSA, than the exclusive rho contributions

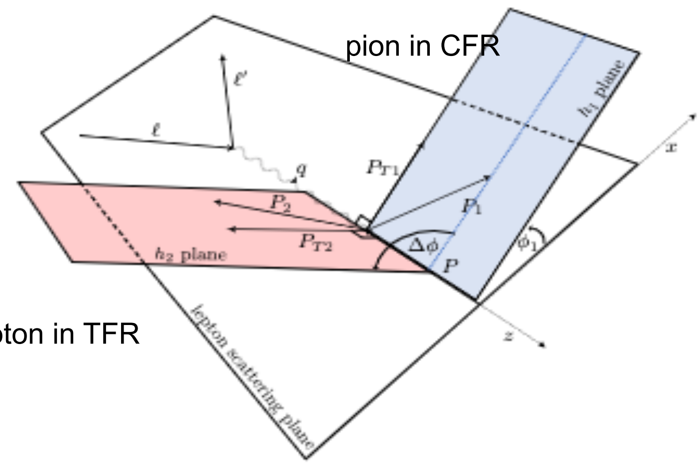
Azimuthal modulations in B2B production

N/q	U	L	T
U	$\hat{u}_1$	$\hat{l}_1^{\perp h}$	$\hat{t}_1^h, \hat{t}_1^\perp$
L	$\hat{u}_{1L}^{\perp h}$	$\hat{l}_{1L}$	$\hat{t}_{1L}^h, \hat{t}_{1L}^\perp$
T	$\hat{u}_{1T}^h, \hat{u}_{1T}^\perp$	$\hat{l}_{1T}^h, \hat{l}_{1T}^\perp$	$\hat{t}_{1T}, \hat{t}_{1T}^{hh}, \hat{t}_{1T}^{\perp\perp}, \hat{t}_{1T}^{\perp h}$

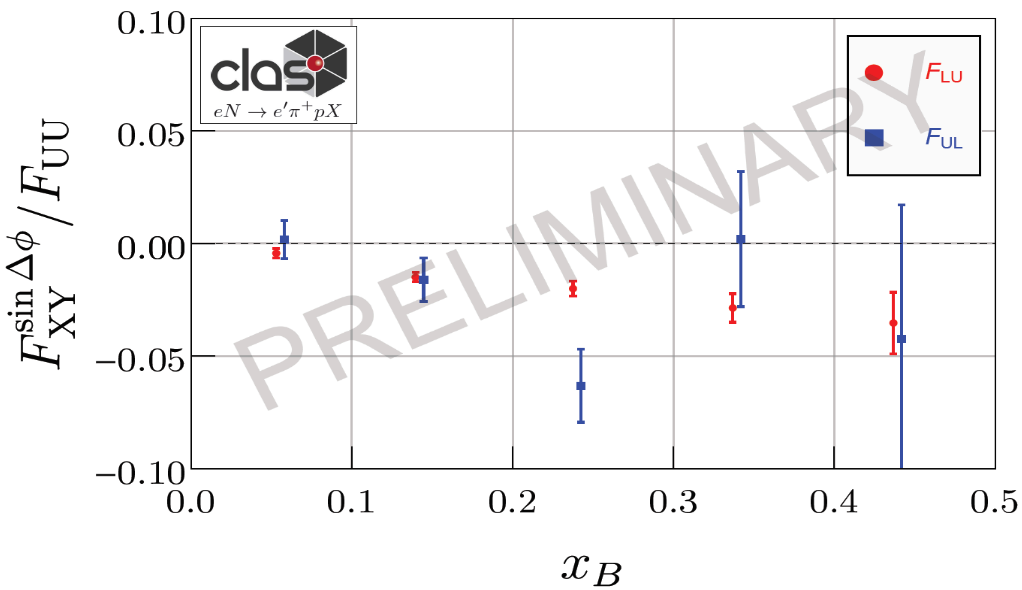
$$\sigma_{LU} = -\frac{P_{T1}P_{T2}}{m_N m_2} F_{k1}^{\hat{l}_1^{\perp h}\cdot D_1} \sin(\Delta\phi),$$

$$\sigma_{UL} = -\frac{P_{T1}P_{T2}}{m_N m_2} F_{k1}^{\hat{u}_{1L}^{\perp h}\cdot D_1} \sin(\Delta\phi)$$





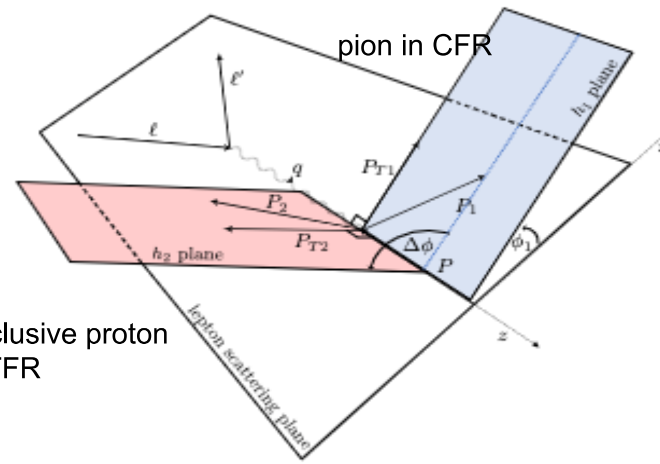
→ F_{UL} and F_{LU} comparable (consistent with epX))
→ No suppression at higher energies for F_{UL}



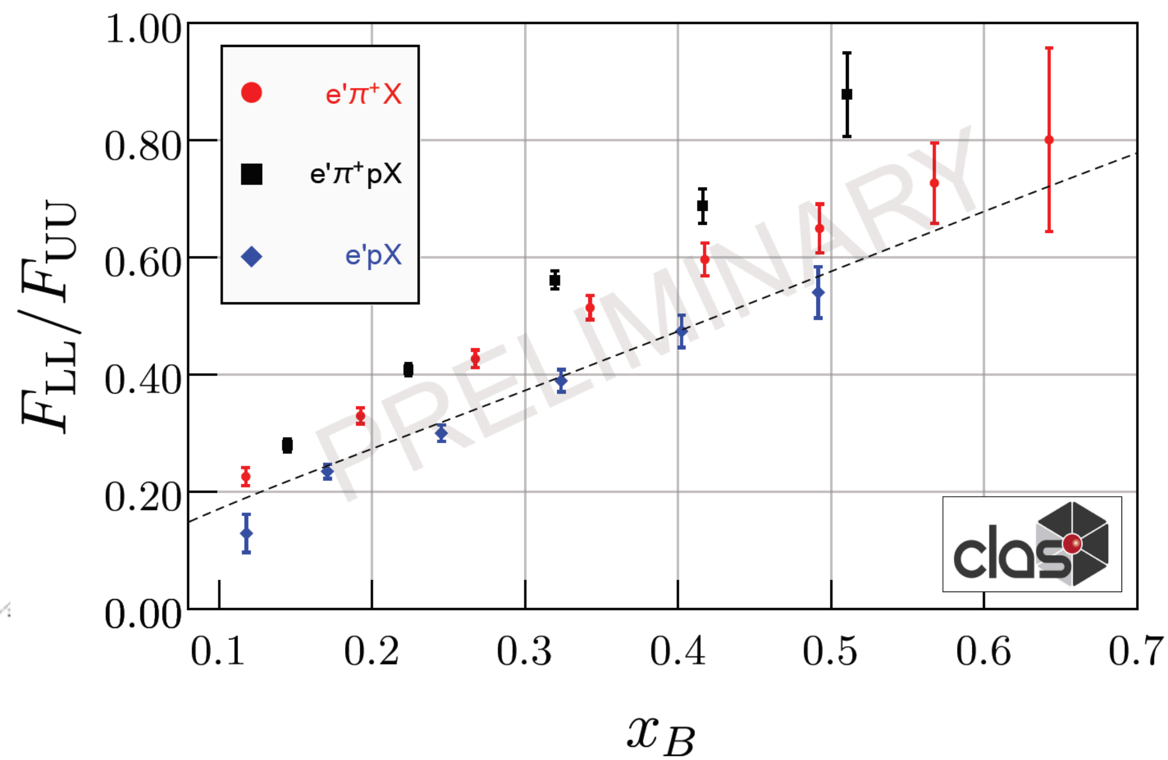
Full CLAS12 longitudinally polarized target set (x4) will provide a significant measurement of the target single spin asymmetry $A_{UL}^{\sin\Delta\phi}$, which has no suppression at higher energies and can be measured at colliders!

B2B production: exclusive baryon in TFR

N/q	U	L	T
U	$\hat{u}_1$	$\hat{l}_1^{\perp h}$	$\hat{t}_1^h, \hat{t}_1^\perp$
L	$\hat{u}_{1L}^{\perp h}$	$\hat{l}_{1L}$	$\hat{t}_{1L}^h, \hat{t}_{1L}^\perp$
T	$\hat{u}_{1T}^h, \hat{u}_{1T}^\perp$	$\hat{l}_{1T}^h, \hat{l}_{1T}^\perp$	$\hat{t}_{1T}, \hat{t}_{1T}^{hh}, \hat{t}_{1T}^{\perp\perp}, \hat{t}_{1T}^{\perp h}$



Exclusive proton in TFR



Detection of proton allows implementation of the "rho free" SIDIS. The same DSA ep→eπ+X with detection of proton, allowing to cut out the exclusive rho is higher.

theory

•Semi-exclusive processes, involving GPDs/ GTMDs on proton side (TFR) and FFs on pion side (CFR) Yuan and Guo

summary

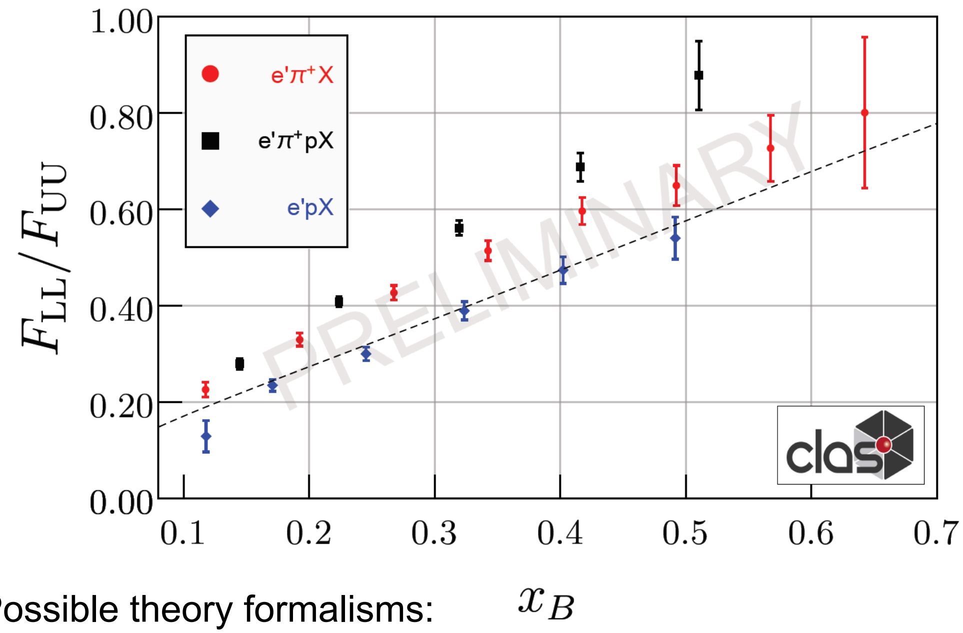
Huge amount of semi-inclusive and exclusive hadron production data accumulated by CLAS12 allowing detailed studies of variety of contributions, critical for providing adequate data for QCD phenomenology for 3D studies (TMDs and GPDs/GTMDs?)

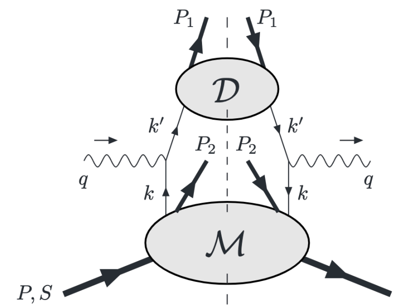
- First data from longitudinally polarized target, confirms importance of sorting out longitudinal photon contributions in general, and longitudinal rho0s, in particular
- Studies of evolution properties of all relevant observables has been shown to be a critical validation test
- *The SIDIS data on neutral pions, free of VM contributions, is ready for phenomenological studies!!!*

Looking forward for Theory-Experiment Dialog on most efficient way for using JLab data in 3D phenomenology

Support slides

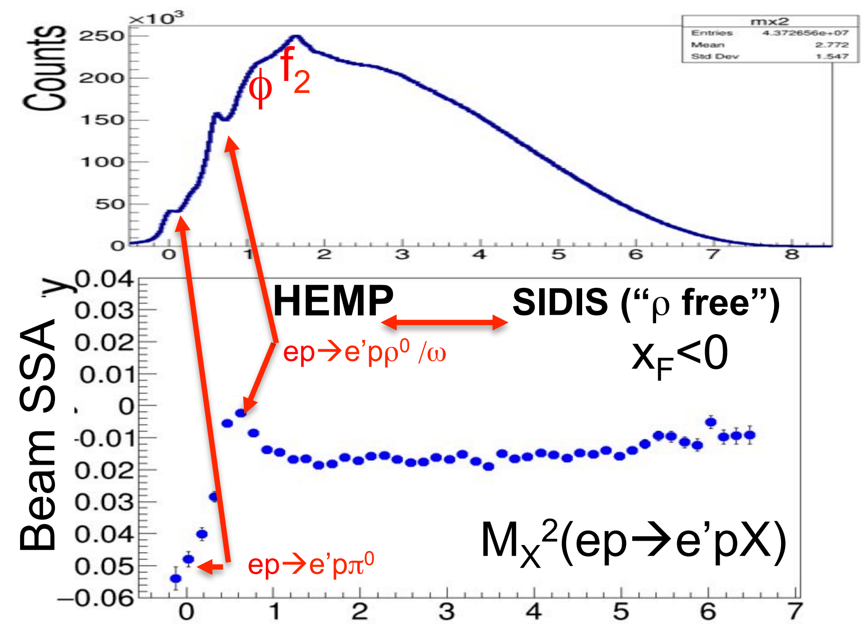
Longitudinally polarized quarks in B2B SIDIS





N/q	U	L	T
U	$\hat{u}_1$	$\hat{l}_1^{\perp h}$	$\hat{t}_1^h, \hat{t}_1^{\perp}$
L	$\hat{u}_{1L}^{\perp h}$	$\hat{l}_{1L}$	$\hat{t}_{1L}^h, \hat{t}_{1L}^{\perp}$
T	$\hat{u}_{1T}^h, \hat{u}_{1T}^{\perp}$	$\hat{l}_{1T}^h, \hat{l}_{1T}^{\perp}$	$\hat{t}_{1T}, \hat{t}_{1T}^{hh}, \hat{t}_{1T}^{\perp\perp}, \hat{t}_{1T}^{\perp h}$

Detection of proton allows elimination of exclusive rho!

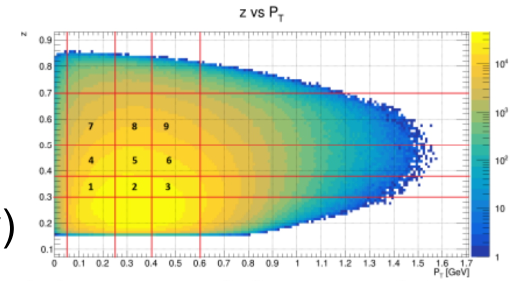


Possible theory formalisms:

- **Formalism based on fracture functions (Anselmino, Barone, Kotzinian (back-to-back, b2b, hadron production, DSIDIS)**
- **Semi-exclusive processes, involving GPDs/GTMDs on proton side (TFR) and FFs on pion side (CFR) Yuan and Guo**

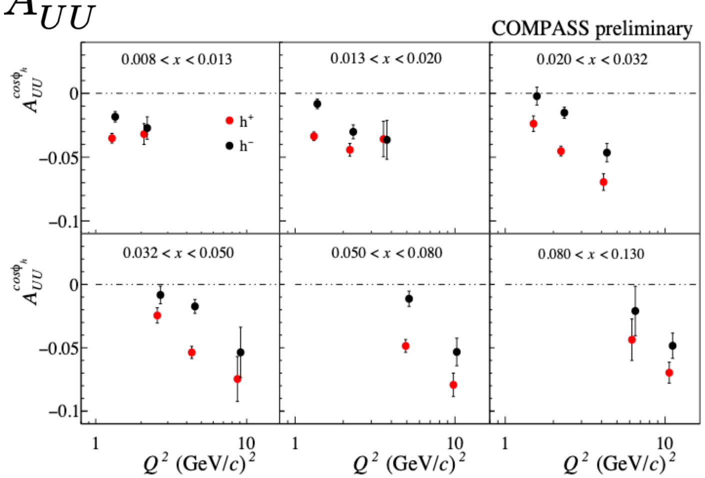
- Differences in A_{LL}, due to different weights on PDFs can provide additional info on impact of possible ingredients
- Measurements of A_{LL} for ρ^0 indicate very small values, and can be one of the reasons for higher A_{LL} with protons with a M_X cuts above 1.5 GeV (excluding exclusive ρ^0)

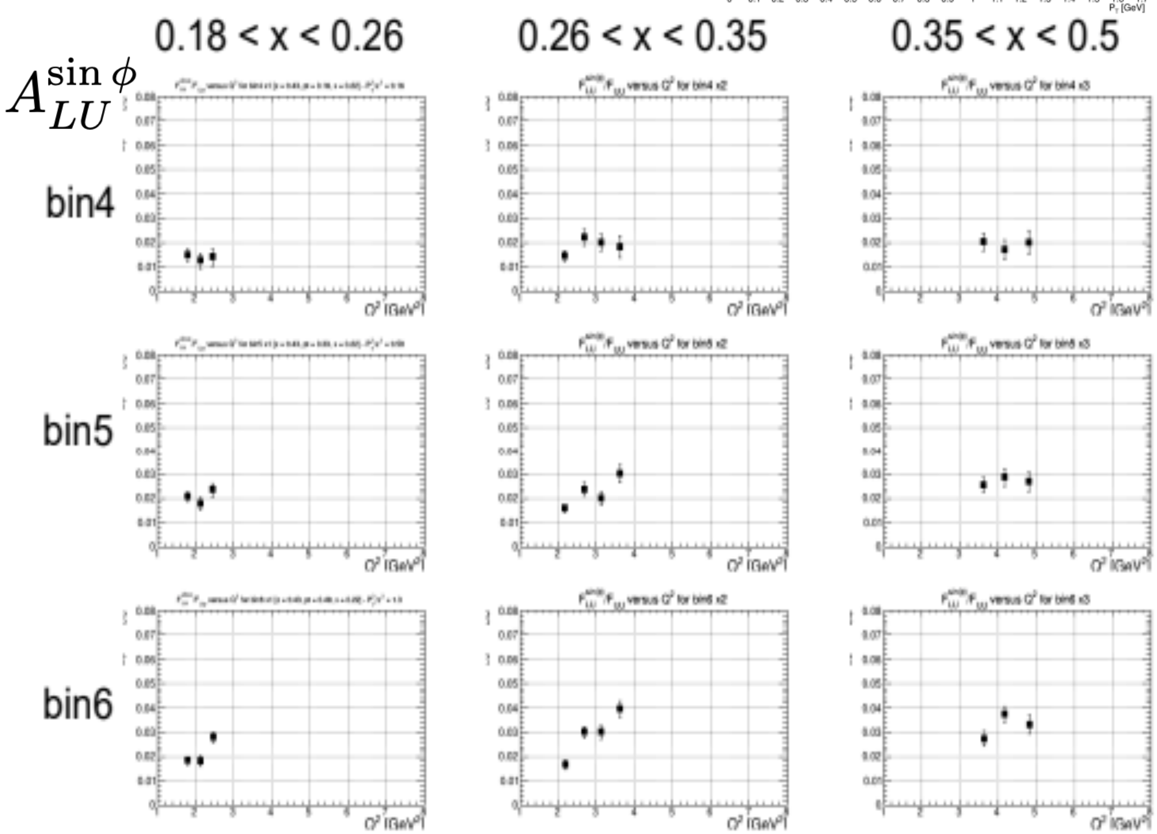
Attempts to understand Q^2-dependence of HT



CLAS12(preliminary)

J. Matousek COMPASS





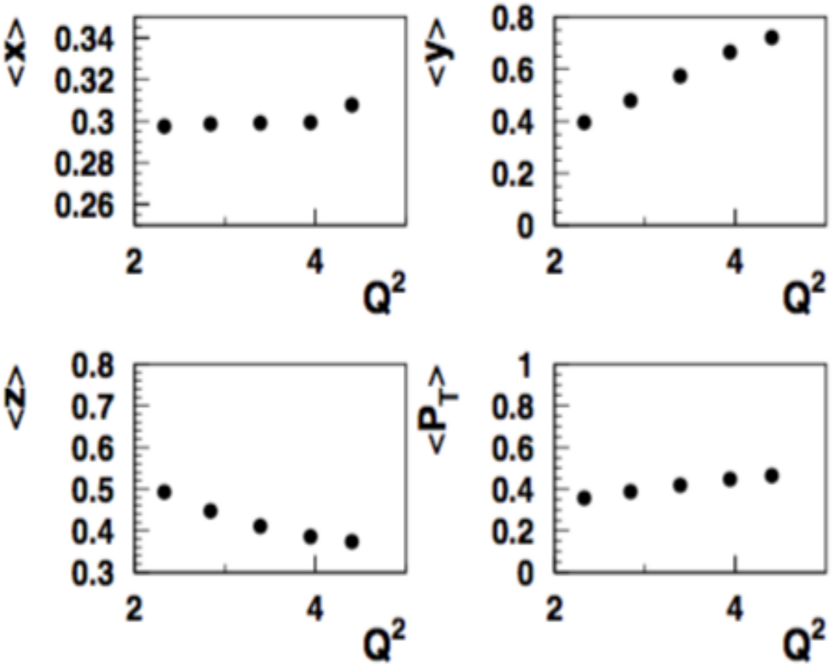
- We always measure ratio to

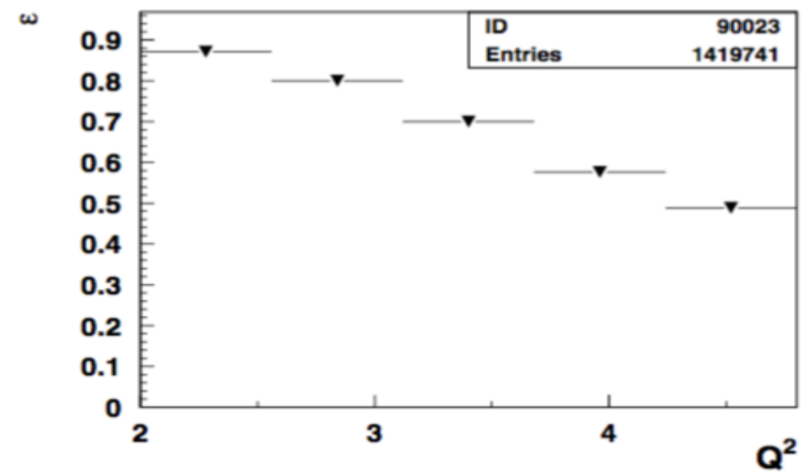
$$F_{UU,T} + \varepsilon F_{UU,L}$$

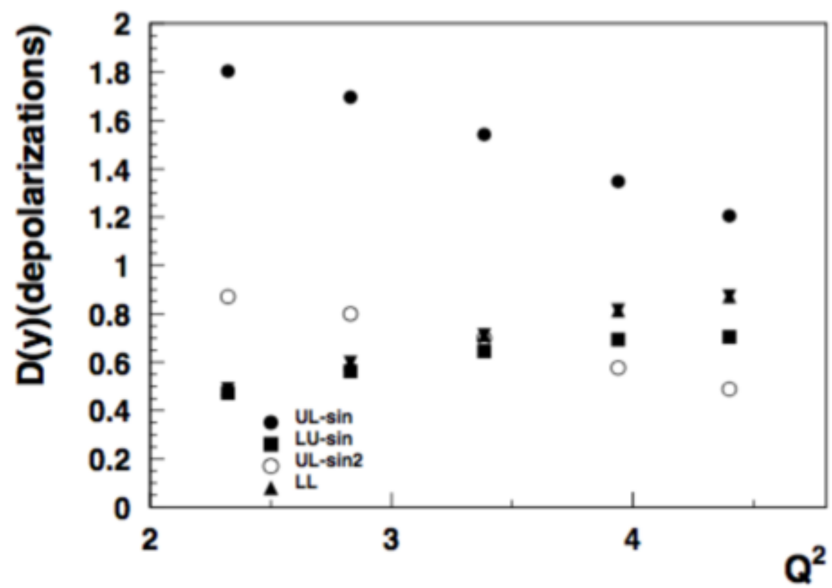
- The moments defined as a ratio to ϕ-independent x-section(to $F_{UU,T}$), are not decreasing with Q!!!
- The HT observables, don't look much like HT observables, something missing in understanding
- **Understanding of these behavior can be a key to understanding of other inconsistencies**
- Checking the Q^2 and P_T-dependences of the $F_{UU,L}$ may provide crucial input for validation

SSAs for dihadrons: kinematics

0.28<x<0.32, 0.3<z<0.8, y<0.75





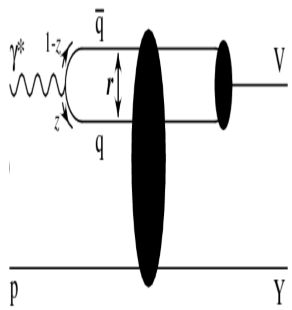


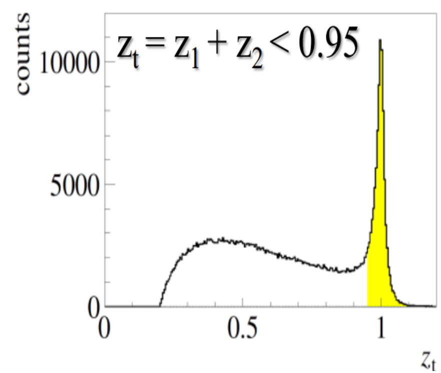
Hadronic variables, z also have some variations in x-bins and P_T

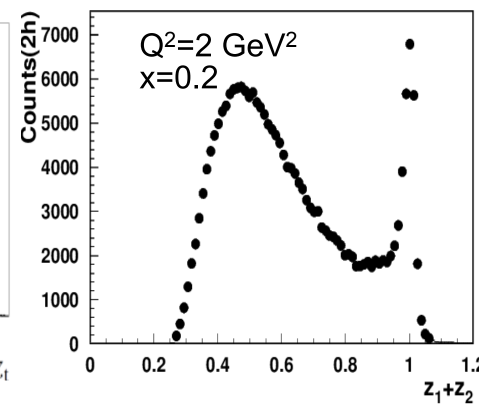
Addressing PAC/theory comments

What exactly are identified so far sources of "factorization breakdown" in SIDIS and where is the evidence that "few GeV" matters?

2) Diffractive VMs (ρ^0)







CLAS12 measurements indicate the 2hadron exclusive sample is dominated by "diffractive rho0"produced at very small ***t***

JLab provides possibility of detailed studies of those rhos, crucial for interpretation in terms of TMDs of SIDIS data in general, and for EIC in particular.

Estimated ~20% contributions from rho to charged pion SIDIS, consistent with ~10% of diffractive DIS in inclusive DIS

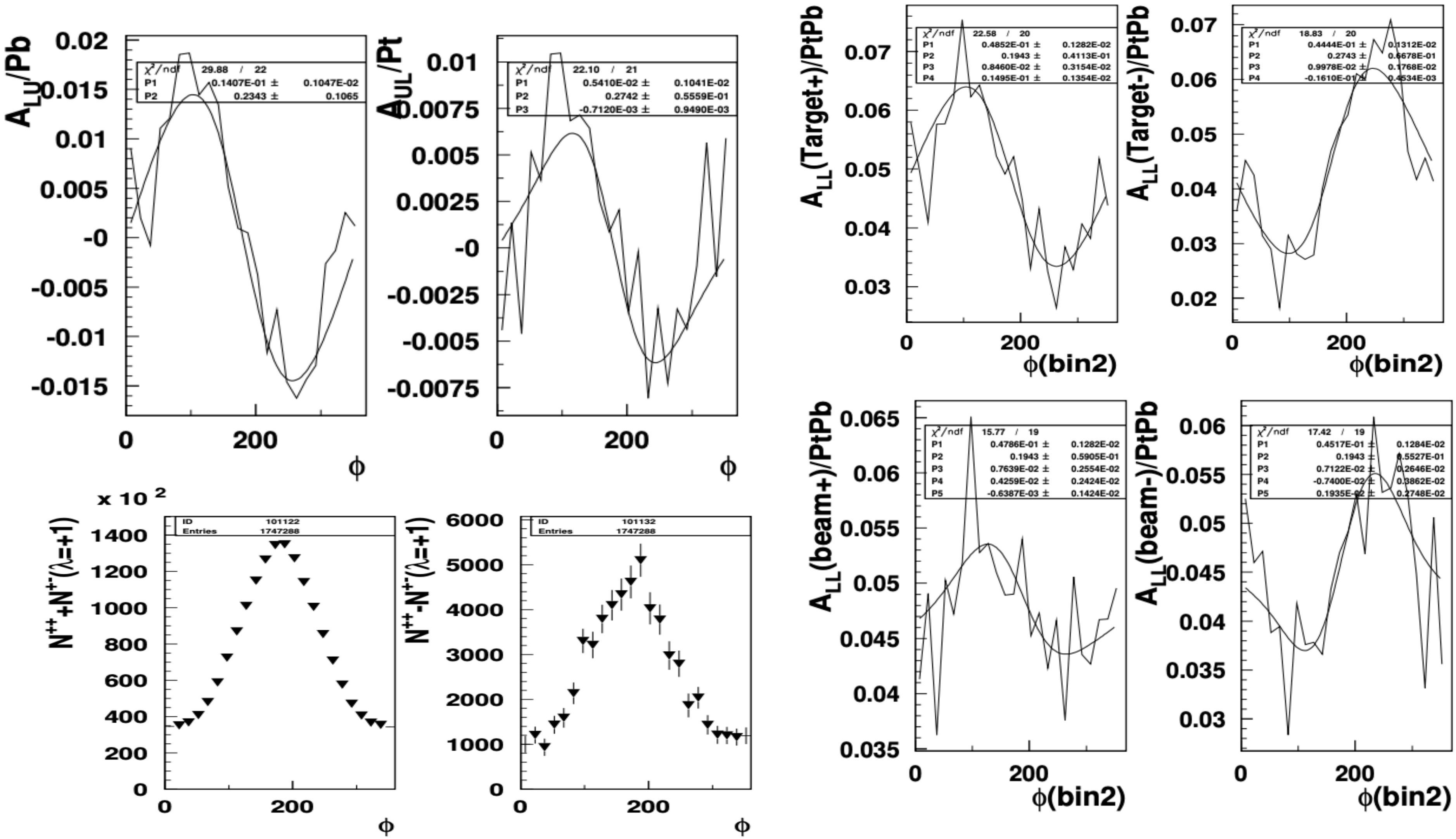
indication: most longitudinally polarized ρ^0

note: higher the Q^2 lower is ε

Studies of exclusive processes require high resolution and multidimensional measurements !!!

SSAs for $ep \rightarrow e'\pi^+\pi^- X$

0.09<x<0.69 bin-2, <x>=0.24, 0.3<z<0.8, y<0.75

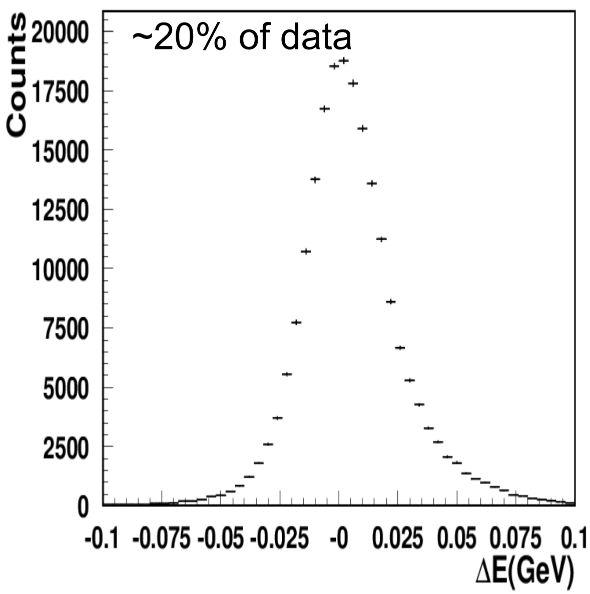


CLAS12 Experiments involved: Exclusive rhos

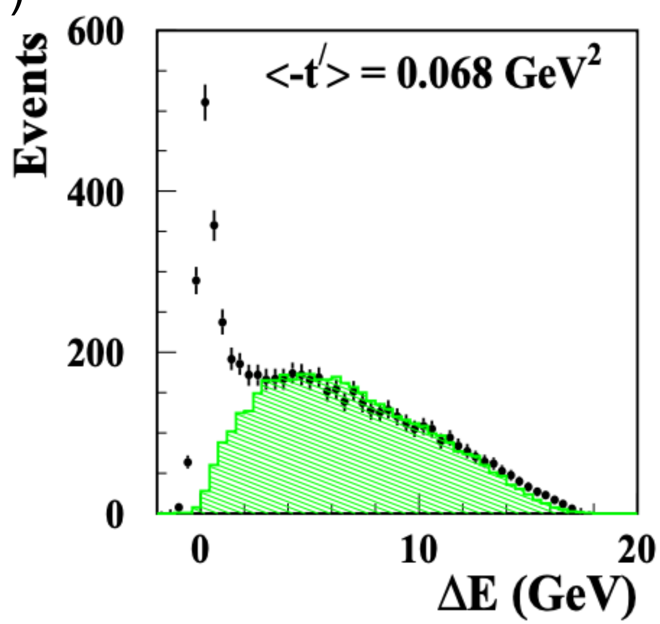
Exclusivity condition defined by the missing Energy:

$$M_X^2 = (p + q - p_{\pi^+} - p_{\pi^-})^2 \qquad E_{\text{miss}} = \frac{M_X^2 - M^2}{2M}$$

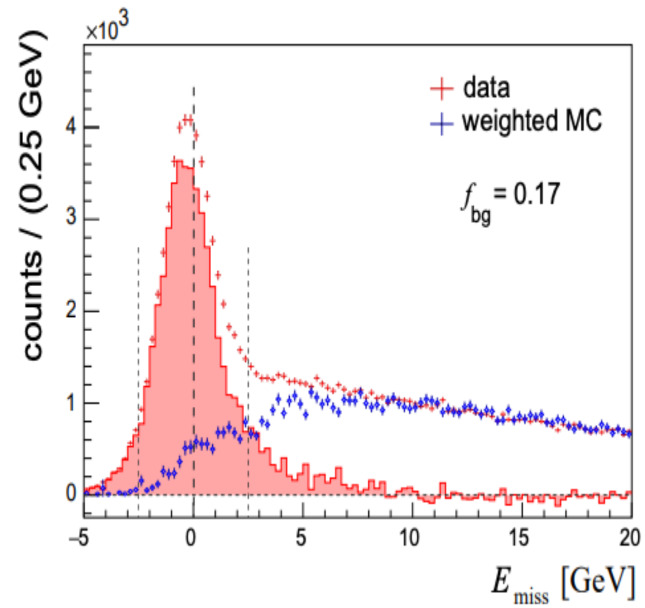
CLAS12 (width <0.1GeV)



HERMES(width ~0.6GeV)

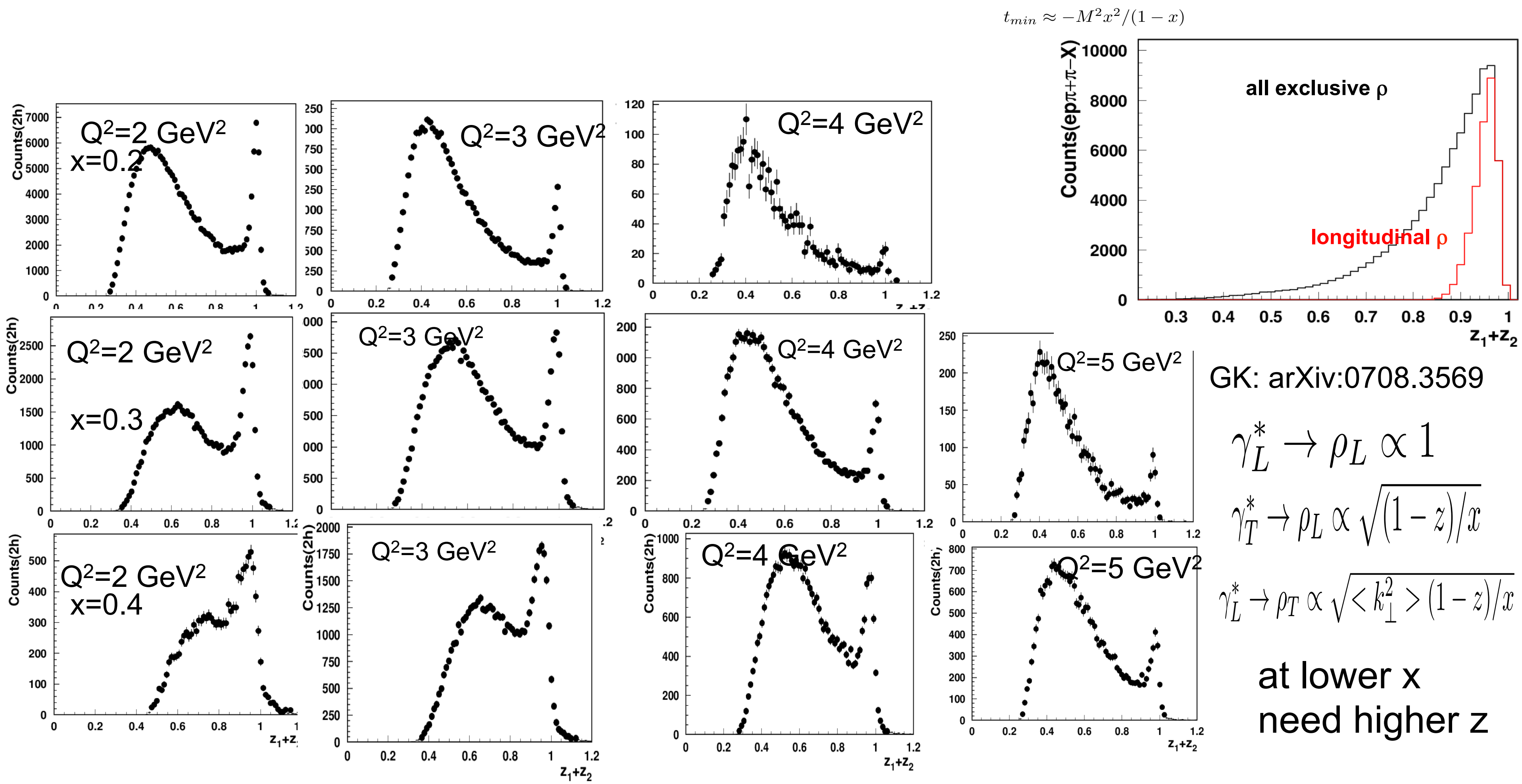


COMPASS(width ~2GeV)



- Guarantying the “exclusivity” requires good resolutions (get worse at higher energies)
- Subtraction procedure relays on normalization, based on exclusive limit of LUND-MC
- All distributions have tails, indicating the RC may not be negligible
- Extraction of SDMEs, will require validation in the multi-D space (significant samples)

Exclusive dihadrons from CLAS12



The exclusive rho contributions in SIDIS (multiplicity) drop with Q^2 ($\sim 1/Q^2$)
At large $z=z_1+z_2$ the transverse photon contributions to ρ_L suppressed

QCD fundamentals for TMD extraction

https://wiki.jlab.org/sidiswiki/index.php/Main_Page

TMD factorization theorem separates a transversely differential cross section into a perturbatively calculable part and several well-defined universal factors

$$d\sigma_{\rm SIDIS} = \sum_f \mathcal{H}_{f,\rm SIDIS}(\alpha_s(\mu), \mu/Q) \otimes F_{f/H_1}(x, k_{1T}; \mu, \zeta_1) \otimes D_{H_2/f}(z, k_{2T}; \mu, \zeta_2) + Y_{\rm SIDIS}$$

corrections for the region of large kT~Q

TMDs may in general contain a mixture of both perturbative and non-perturbative contributions

$$b_*(b_T) \equiv \frac{b_T}{\sqrt{1 + b_T^2/b_{\rm max}^2}}.$$

Aybat,Collins,Qiu,Rogers 2012
Collins&Rogers 2015

non perturbative

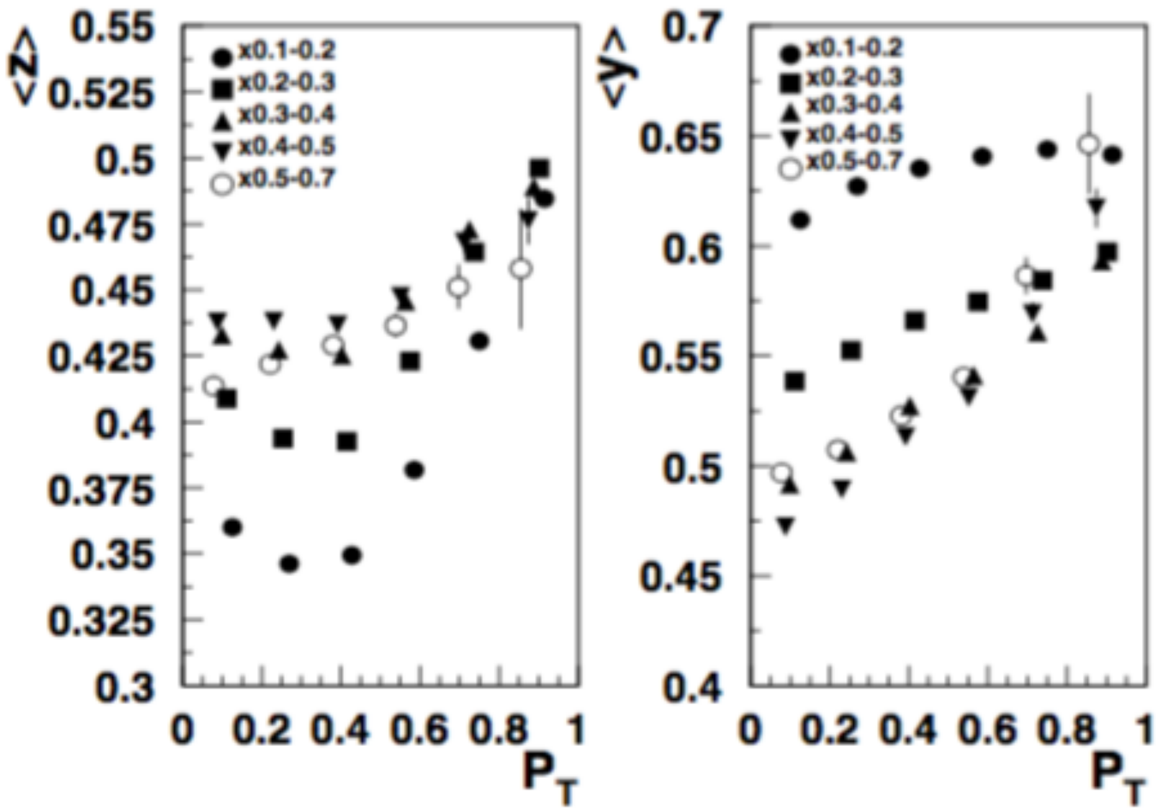
$$\tilde{F}_{H_1}(x, b_T; Q, Q^2) = \tilde{F}_{H_1}(x, b_*; \mu_b, \mu_b^2) \exp\left\{ -g_1(x, b_T; b_{\rm max}) - g_K(b_T; b_{\rm max}) \ln\left(\frac{Q}{Q_0}\right) + \ln\left(\frac{Q}{\mu_b}\right) \tilde{K}(b_*; \mu_b) + \int_{\mu_b}^{Q} \frac{d\mu'}{\mu'} \left[\gamma_{\rm PDF}(\alpha_s(\mu'); 1) - \ln\left(\frac{Q}{\mu'}\right) \gamma_K(\alpha_s(\mu')) \right] \right\}$$

perturbatively calculable

$$P_T \sim \Lambda_{QCD} \ll Q, \quad \Lambda_{QCD} \ll P_T \ll Q, \quad P_T \sim Q, \text{ and } P_T > Q.$$

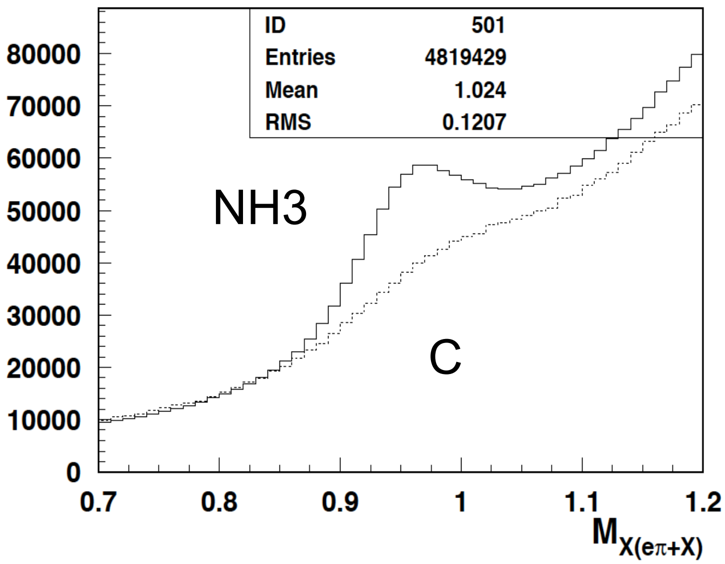
semi-inclusive pi0 production

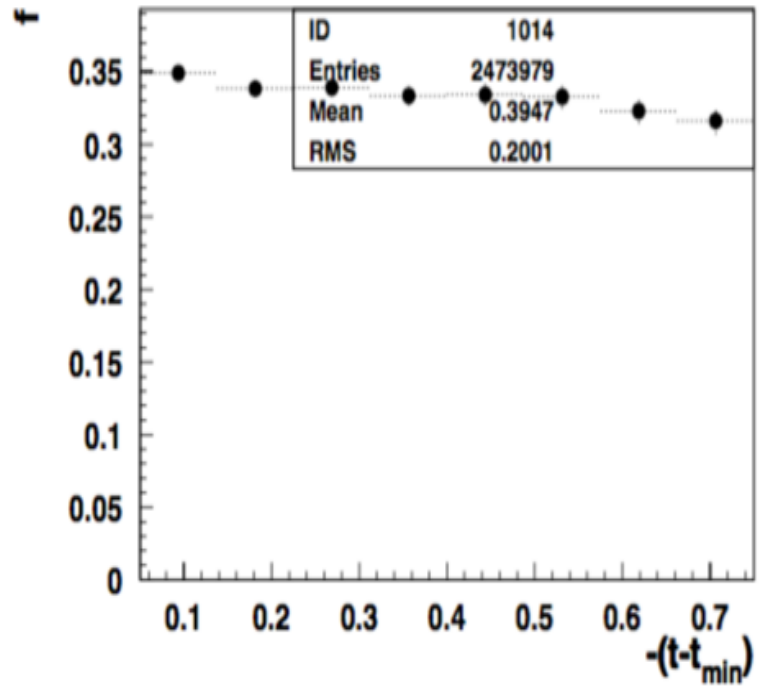
Study PT-dependence in bins in x

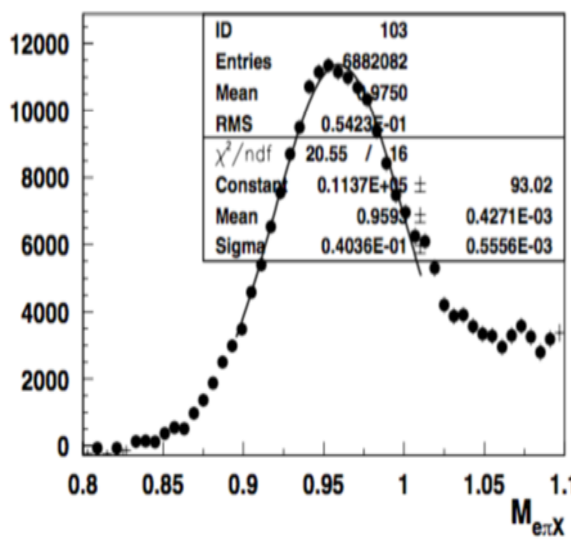


Average kinematics is changing within bins

CLAS12 exclusive pions from RGC

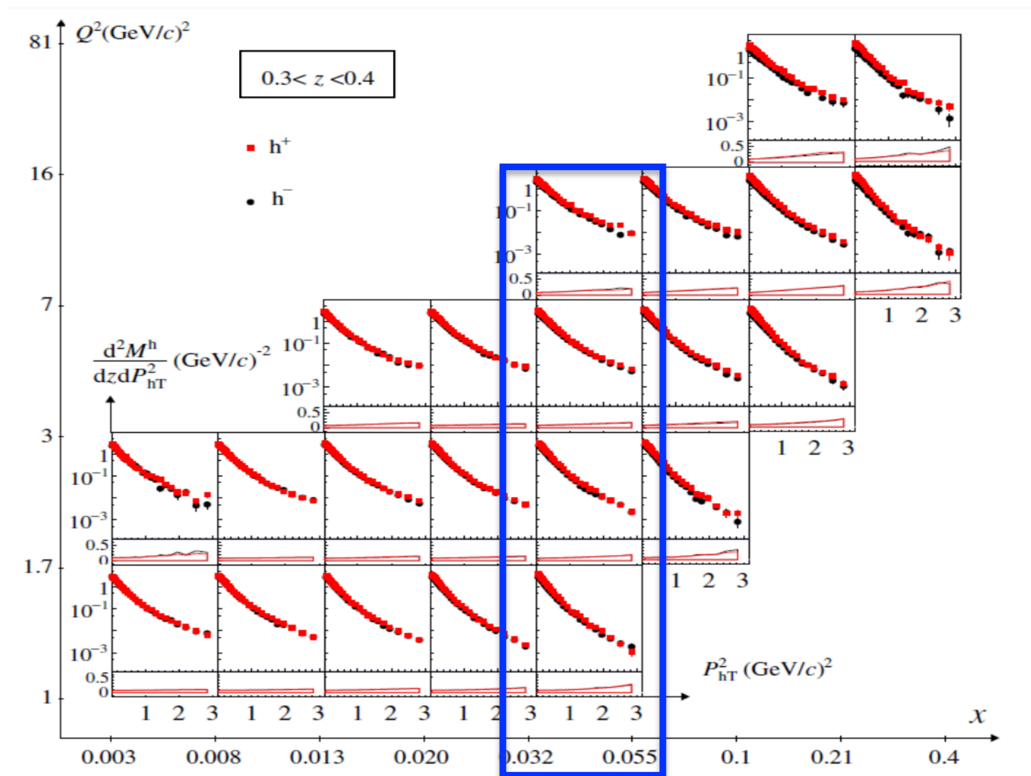






Normalizing carbon and NH3 for MX below 0.8 and subtracting to get the dilution factor as a function of the variable of interest

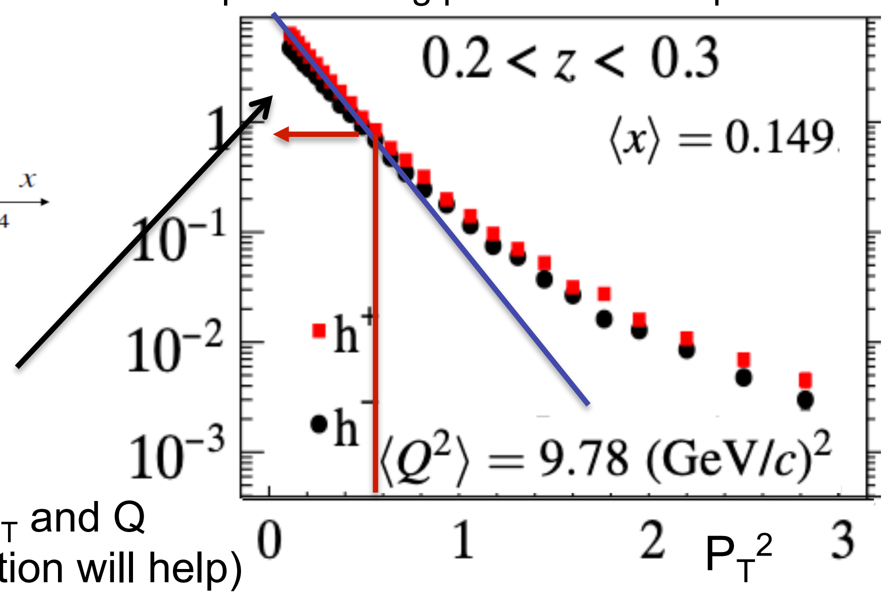
q_T-crisis or misinterpretation



Request to theory:
provide comparison with COMPASS with and without evolution to see the impact

3) Cuts not only most of the JLab data, but practically all accessible in polarized SIDIS large P_T samples , including ones from HERMES COMPASS, and even EIC.

https://arxiv.org/pdf/1709.07374.pdf

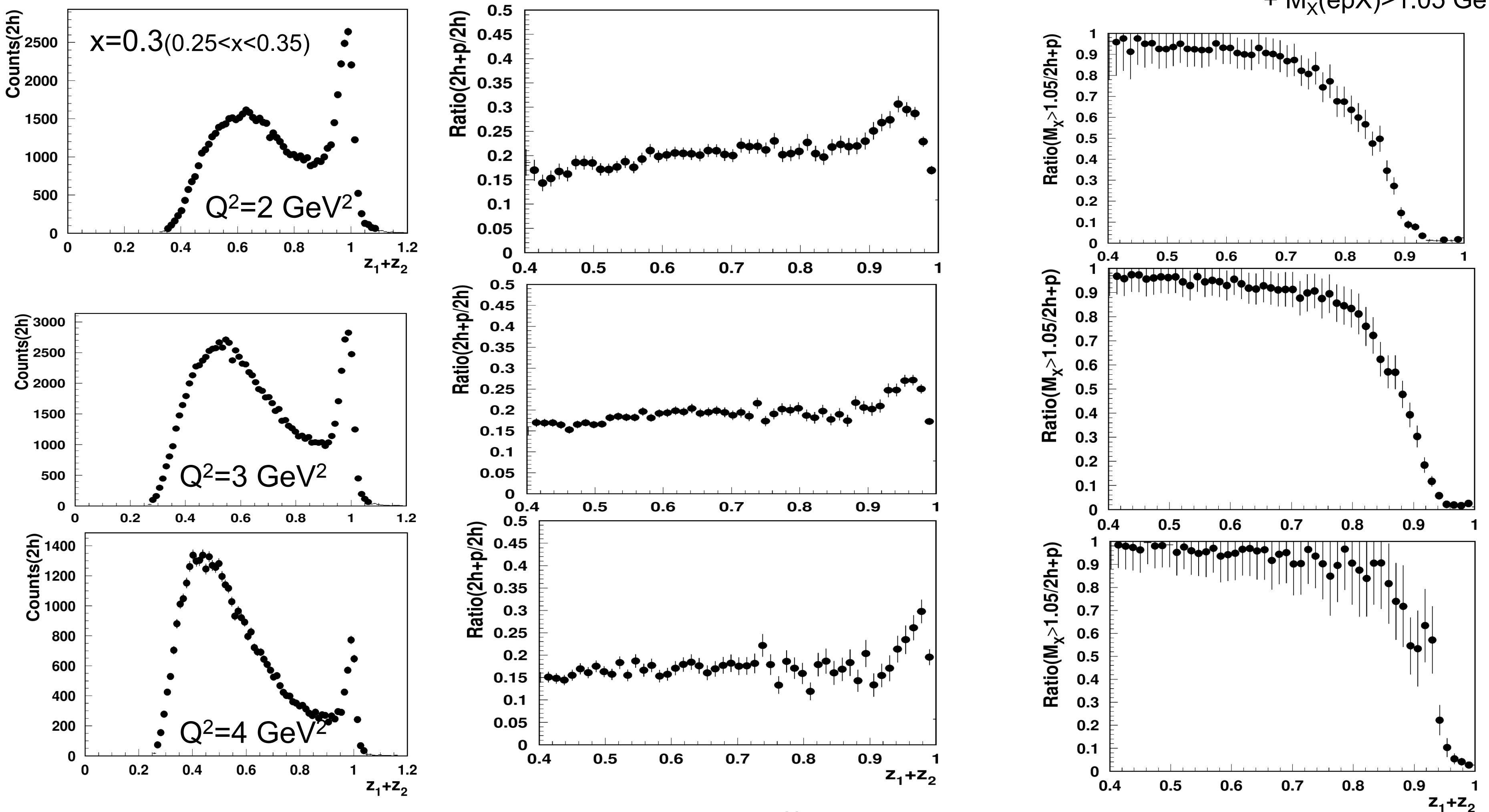


at higher Q^2 the slope in P_T changes, why?
possible reason → less diffractive rho at higher Q^2 filling the low P_T in pion SIDIS (what about π^0?)

Challenging for theory to explain the correlation of P_T and Q
need experimental subtraction of rhos (proton detection will help)

“ρ-free SIDIS” free: target proton bias

$ep \to e'\pi\pi X$ | $ep \to e'p\pi\pi X$ + $x_{Fproton}<0$ | $ep \to e'p\pi\pi X$ + $x_{Fproton}<0$ + $M_X(epX)>1.05$ GeV



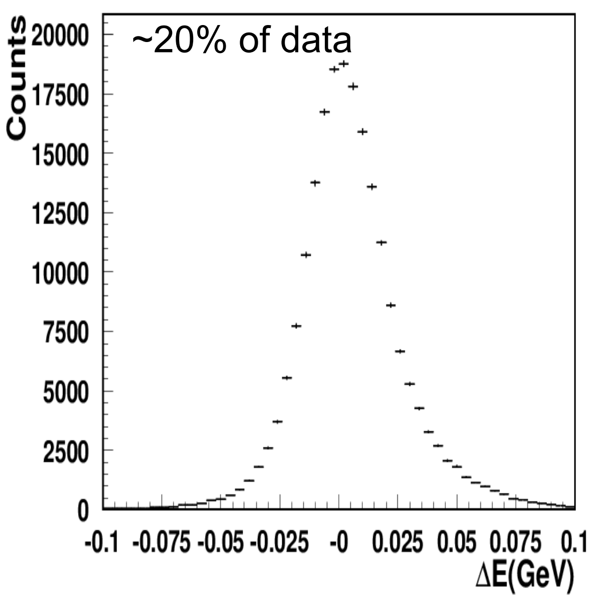
While the detected proton introduces slight difference in the kinematic distributions, the cut on the proton missing mass makes significant impact (clear at large z).

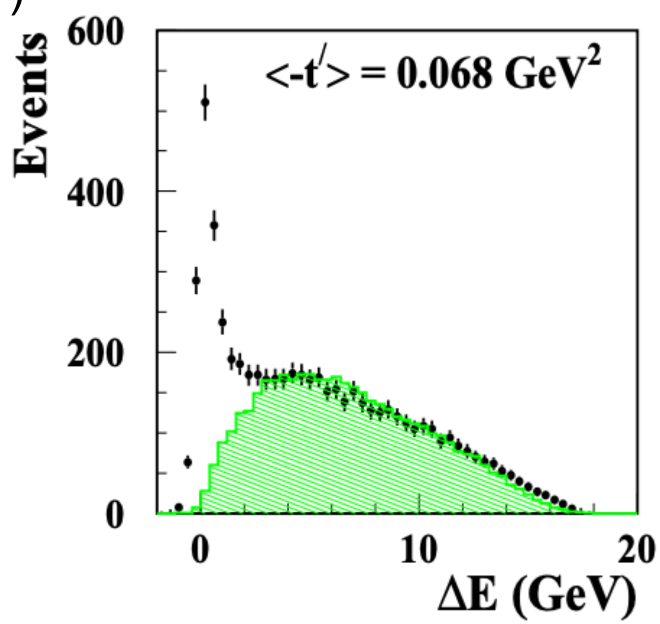
CLAS12 Experiments involved: RGA superiority

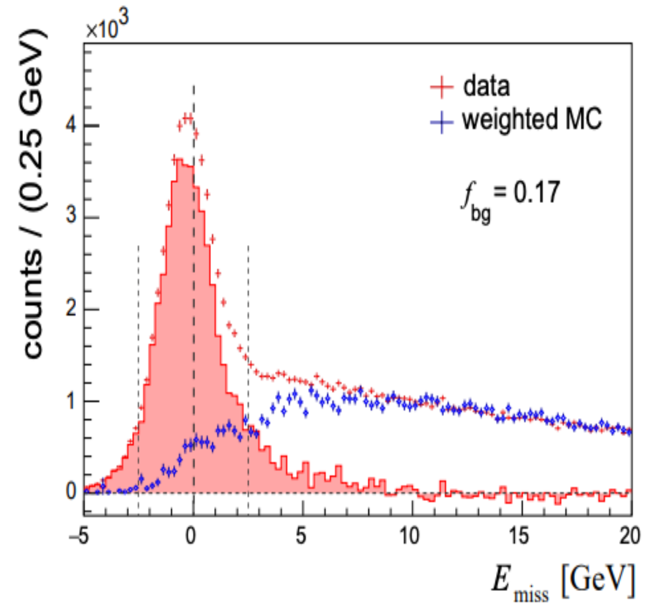
Exclusivity condition defined by the missing Energy:

$$M_X^2 = (p + q - p_{\pi^+} - p_{\pi^-})^2 \qquad E_{\mathrm{miss}} = \frac{M_X^2 - M^2}{2M}$$

CLAS12 (width <0.1GeV) HERMES(width ~0.6GeV) COMPASS(width ~2GeV)

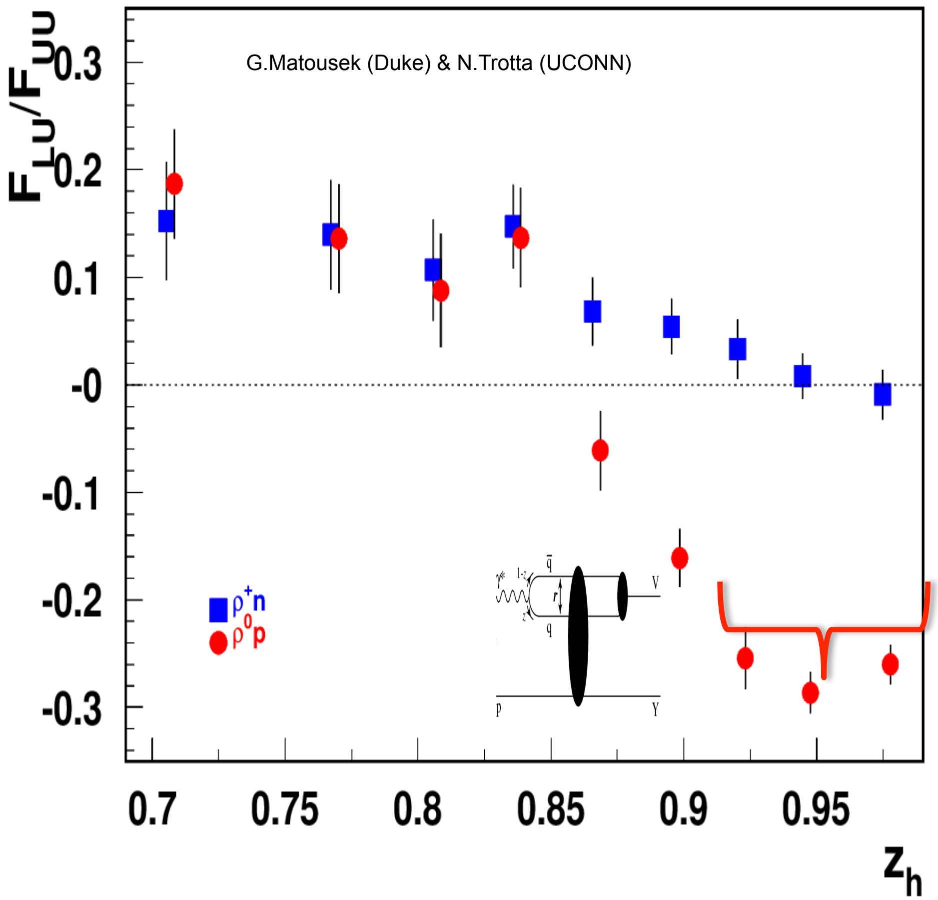


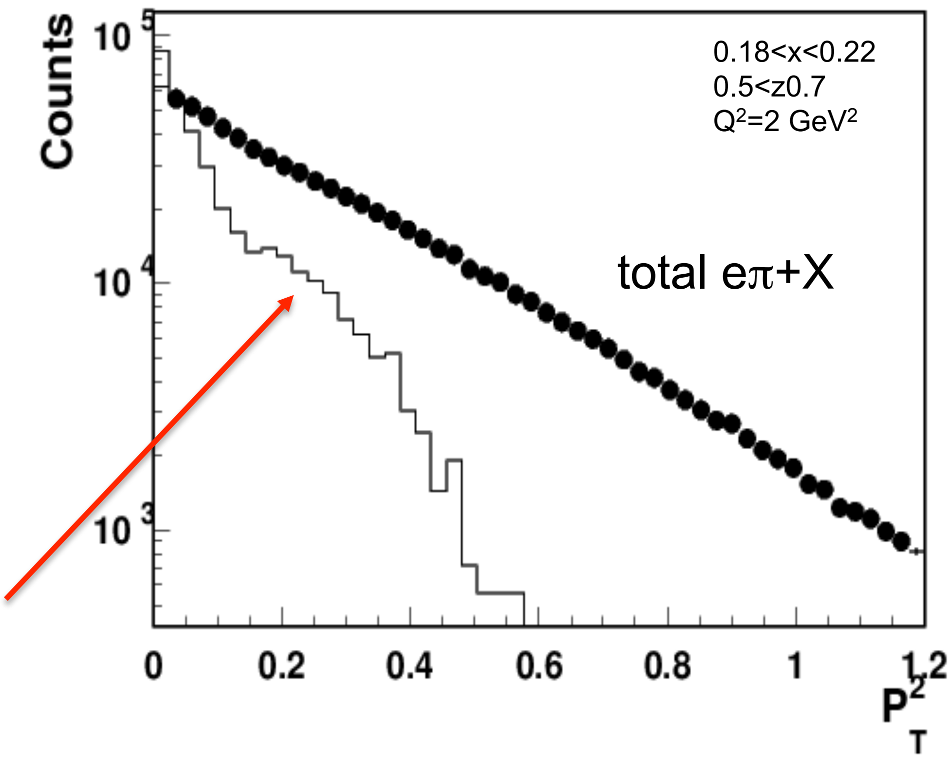




- Guarantying the “exclusivity” requires good resolutions (get worse at higher energies)
- Subtraction procedure relays on normalization, based on exclusive limit of LUND-MC
- All distributions have have tails, indicating the RC may not be negligible
- Extraction of SDMEs, will require validation in the multi-D space (significant samples)

“diffractive rho0s” in SIDIS multiplicities





$t_{min} \approx -M^2x^2/(1-x)$

Estimated ~20% contributions from rho, mainly show up at low P_T in SIDIS

The “diffractive” rho will bias extractions of TMDs, unless properly subtracted in multidimensional space of SIDIS measurements.

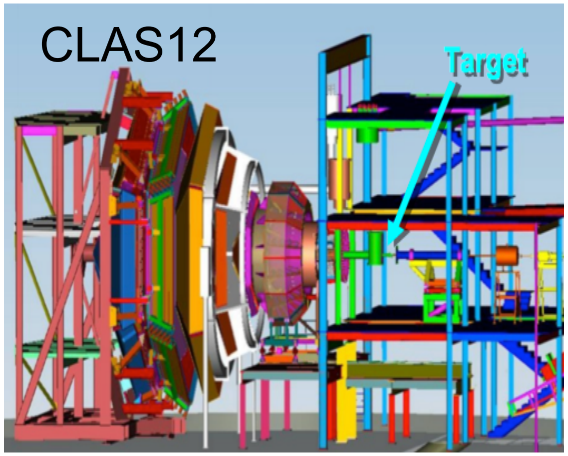
RGC: Kinematical cuts for results and x-checks

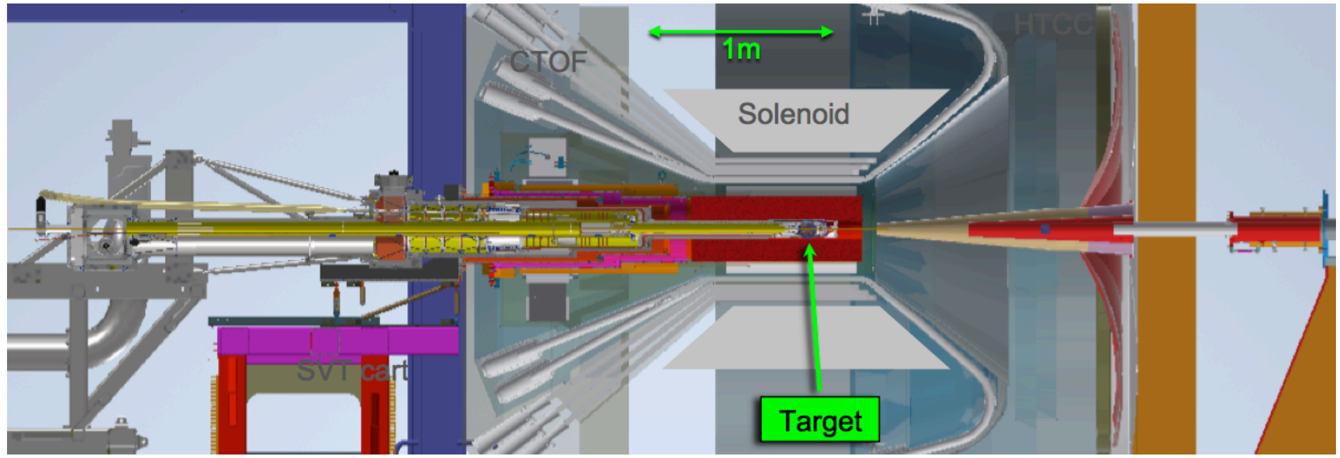
- Start with Fall22 Tpol+=0.7,Tpol-=-0.7
- Kineamtics of e' withing fiducial acceptance
- W>2, Q^2>1,y<0.75 (study dependence, mainly for y)
- |Vz+Vz0|<5, Vz0= 2.2 for RGC-Fall 2.5 for RGA-spring19

- Kinematics of single pions ep→e'πX
- M_X>1.3 pi-/0, M_X>1.8 for pi+ (study dependence)
- xF>0, 0.8>z>0.3 for integrated (study z-dependence from 0.1<z<1)
- |Vz-Vz\pi+|<7, |Vz-Vz\pi-|<5 (study the Vz-dependence)

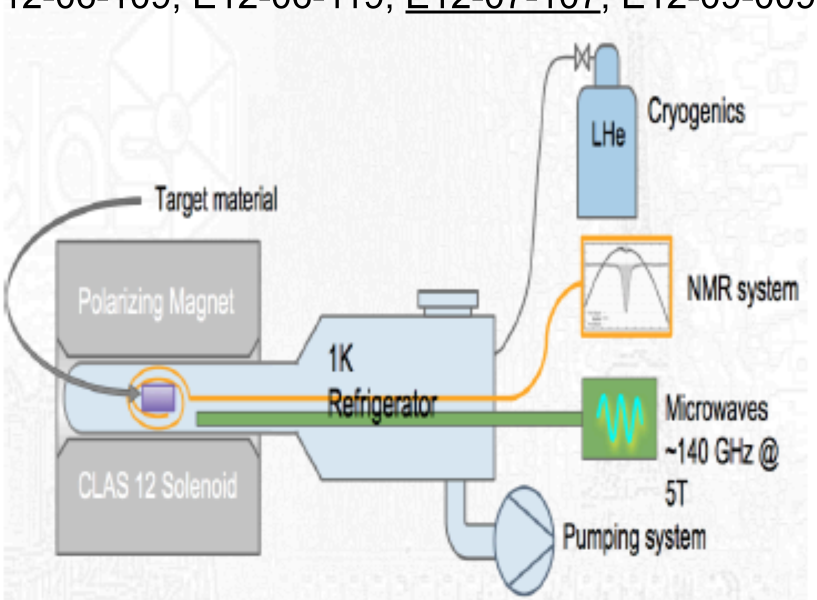
- Kinematics for dihadrons ep→e'$\pi\pi$X
- M_X(ep→e'πX)>1.3 pi-/0, M_X>1.8 for pi+ (study dependence, cut resonances)
- z<0.85 (beam SSA negative)
- MX(e'$\pi\pi$X)>1.3 (cut exclusive rho, should mainly overlap with z)

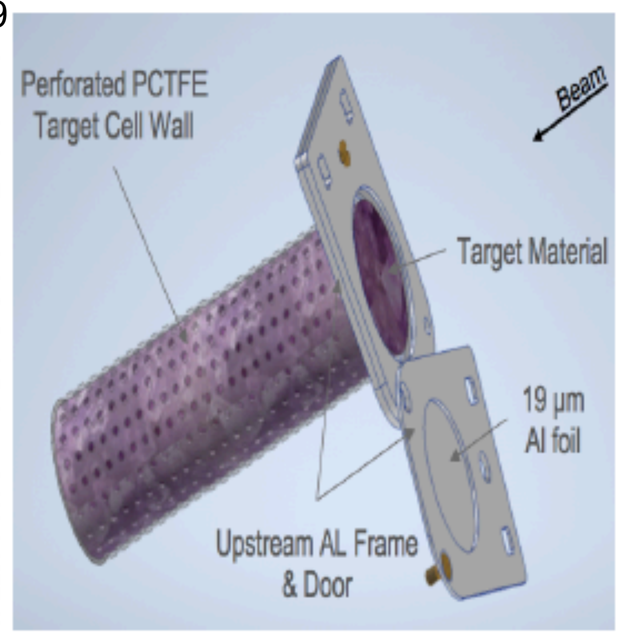
CLAS12 RGC experiment with longitudinally polarized target

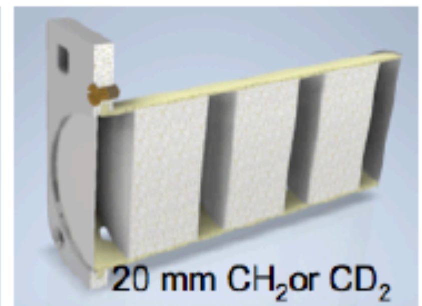


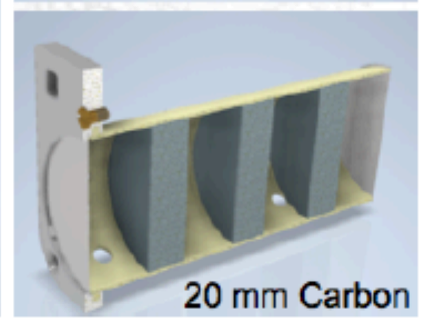


E12-06-109, E12-06-119, E12-07-107, E12-09-009









A Dynamic Nuclear Polarized