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Charged dihadron beam-spin asymmetries from CLAS12

Timothy B. Hayward
for the CLAS Collaboration

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Toward a full collinear description of the nucleon

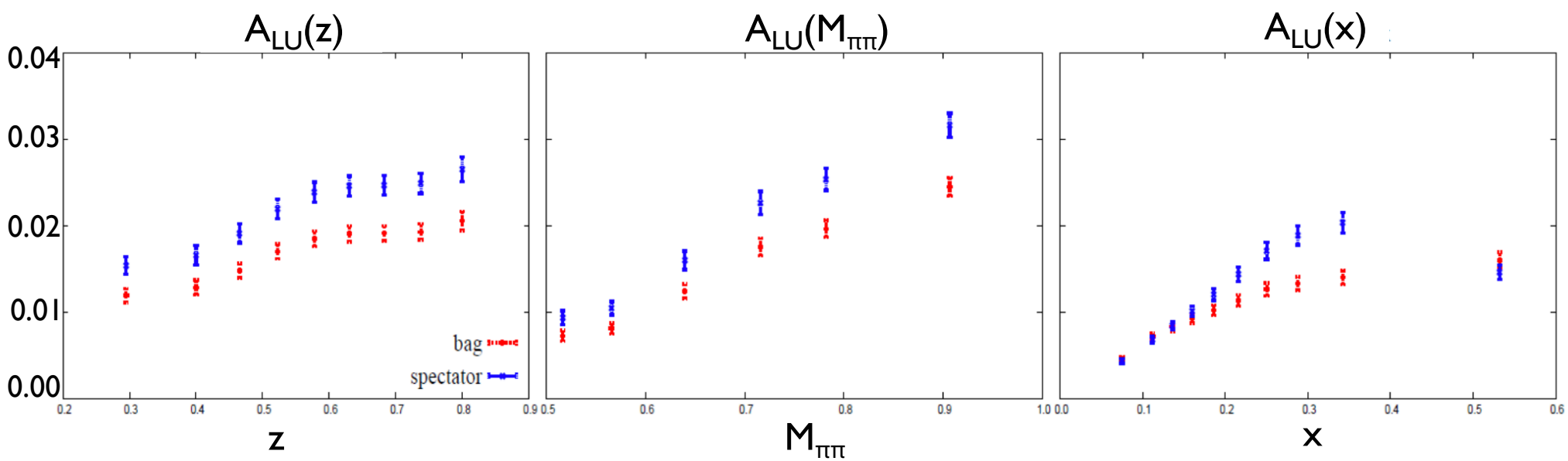
- At **twist-3**, the nucleon is described by 6 collinear PDFs.

twist-2	f(x)	g(x)	$h_1(x)$
twist-3	e(x)	$h_L(x)$	$g_T(x)$

- f(x), g(x) and $g_T(x)$ are measured through DIS.
- The transversity distribution, $h_1(x)$, is chiral-odd and so must be accessed through SIDIS where it couples to a chiral-odd fragmentation function.
- **e(x)** and $h_L(x)$ are poorly known.
- The golden channels to access these poorly known PDFs are through the SIDIS **dihadron** asymmetries $\mathbf{A_{LU}}$ and A_{UL}.

Colinear twist 3 PDF e(x)

- Insight into largely unexplored quark-gluon correlations.
- $\int x^2 e(x) dx$ → ⊥ force on ⊥ polarized quarks in an unpolarized nucleon, "Boer-Mulders force".
- x integral related to the marginally known scalar-charge of the nucleon and the pion-nucleon sigma term.
- BSA is sensitive to e(x) which has sizable model predictions:



Jaffe, Ji. Nucl. Phys. **B375**, 527-560 (1992).
Jakob, Mulders, Rodrigues. Nucl. Phys. **A626**, 937-965 (1997).

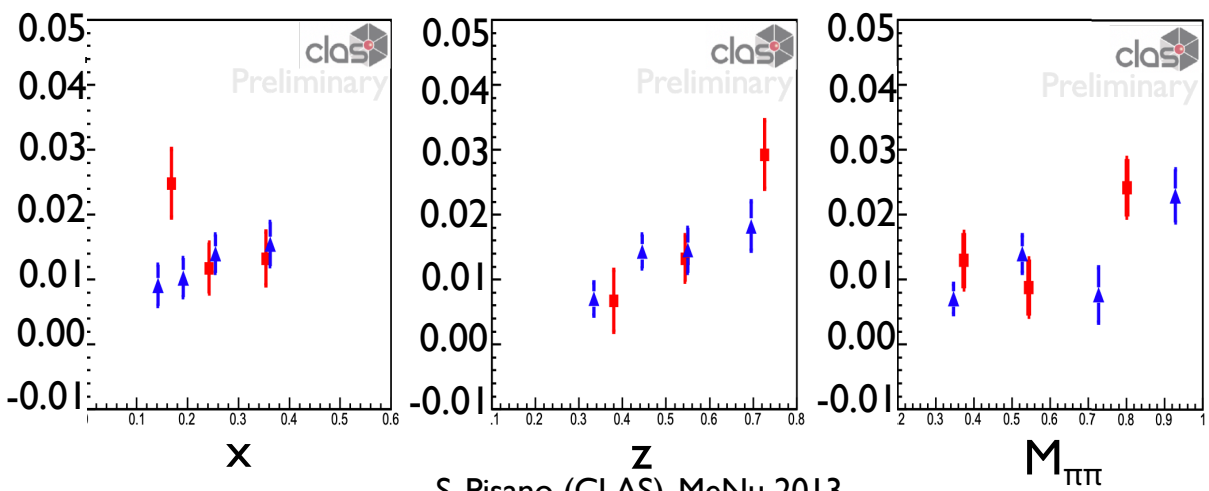
$BSA\ ep \rightarrow e'\pi^+\pi^- + X$: Clean access to e(x)

- See e.g. Aurore Courtoy, arXiv:1405.7659

$$F_{LU}^{\sin\phi_R} = -x\frac{|\vec{R}|\sin\theta}{Q}\left[\frac{M}{M_{\pi\pi}}xe^q(x)H_1^{\sphericalangle q}(z, cos\theta, M_{\pi\pi}) + \frac{1}{z}f_1^q(x)\tilde{G}(z, \cos\theta, M_{\pi\pi})\right]$$

- The PDF e(x) appears coupled to the Interference Fragmentation Function.
- Evidence for non-zero BSA

$A_{LU}^{sin\phi_R} = \frac{F_{LU}^{\sin\phi_R}}{F_{UU}}$ from CLAS6:



S. Pisano (CLAS), MeNu 2013

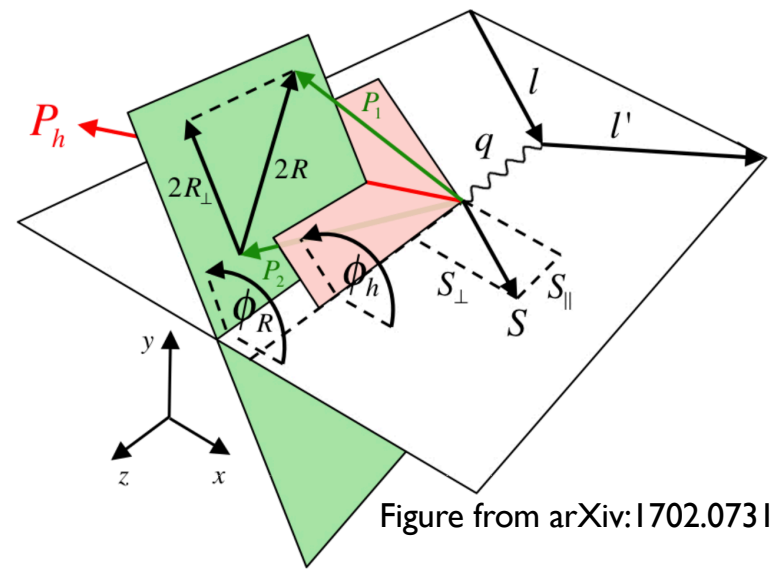
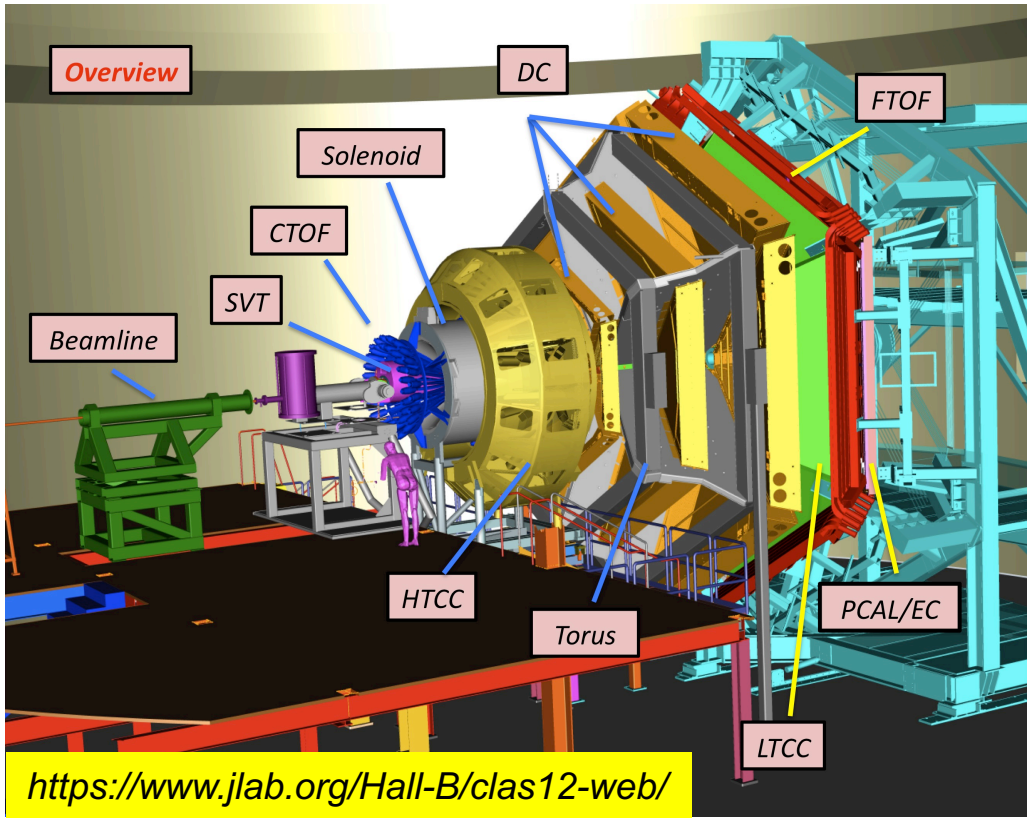
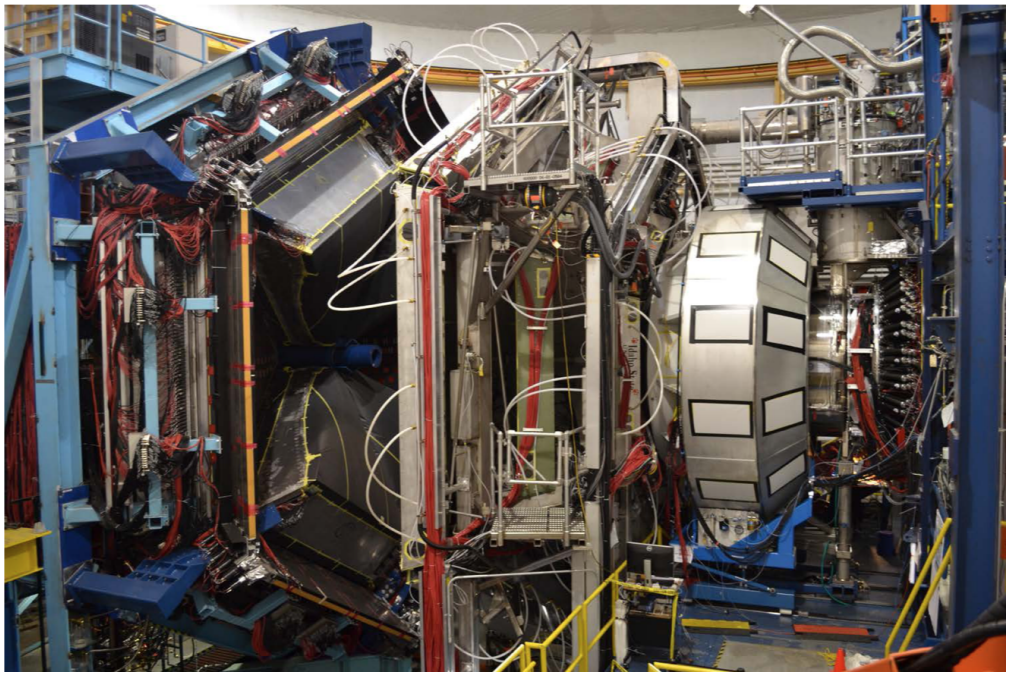


Figure from arXiv:1702.07317

$$\overrightarrow{P_h} = \overrightarrow{P_\pi^+} + \overrightarrow{P_\pi^-}, \qquad \vec{R} = \overrightarrow{P_\pi^+} - \overrightarrow{P_\pi^-}$$

CLAS12 Experimental Setup



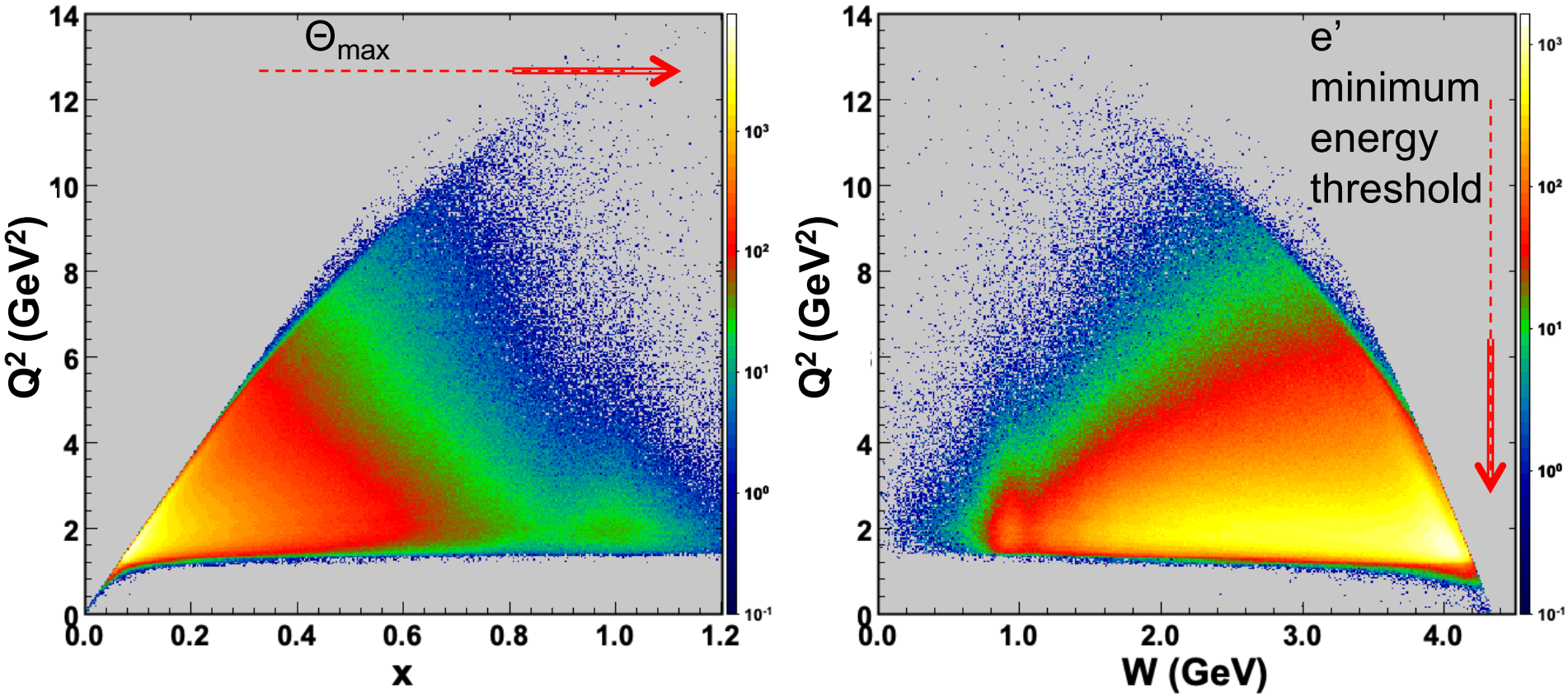


- Data taken during Fall 2018.
- 10.6 GeV, longitudinally polarized beam, H_2 target.
- Analyzed data ~3% of approved beam time.

CLAS12 kinematic reach

- The low Q^2 range of Jefferson Lab is ideal for extraction of twist-3 PDFs.

p(e,e')X

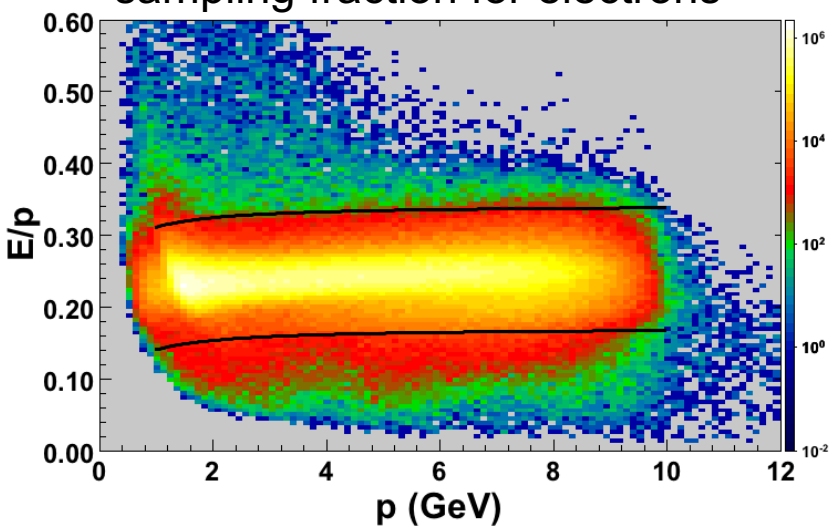


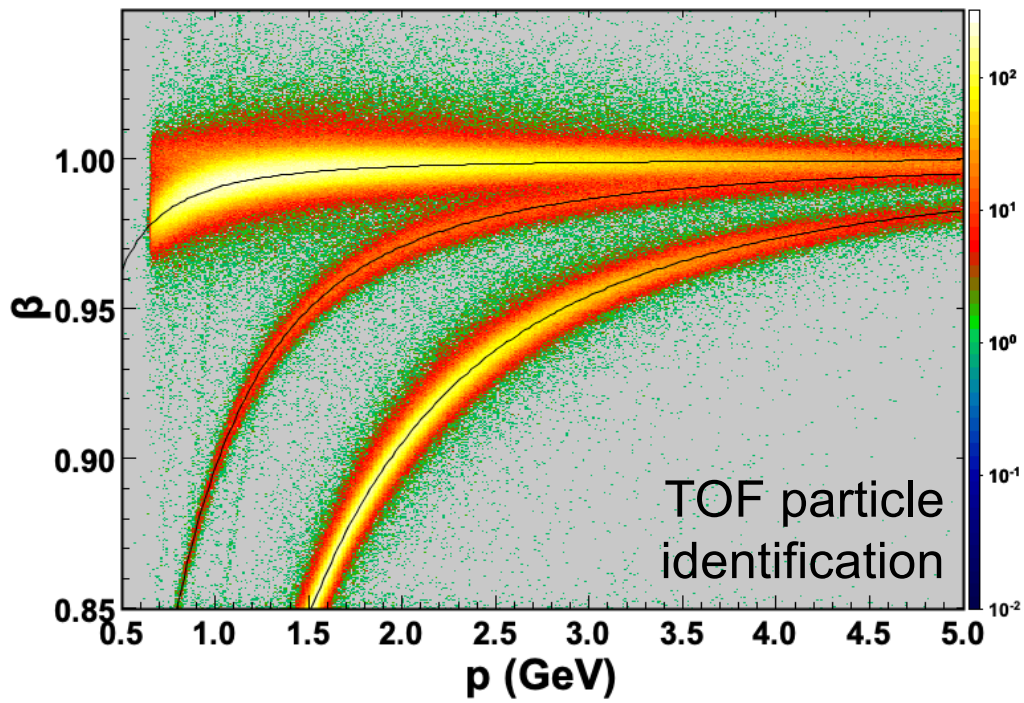
Plots based on 200 min. of data taking

Particle ID

- Electron
  - Electromagnetic calorimeter.
  - Cherenkov detector.
  - Vertex and fiducial cuts.
- Hadron
  - β vs p comparison between vertex timing and event start time.
  - Vertex and fiducial cuts.

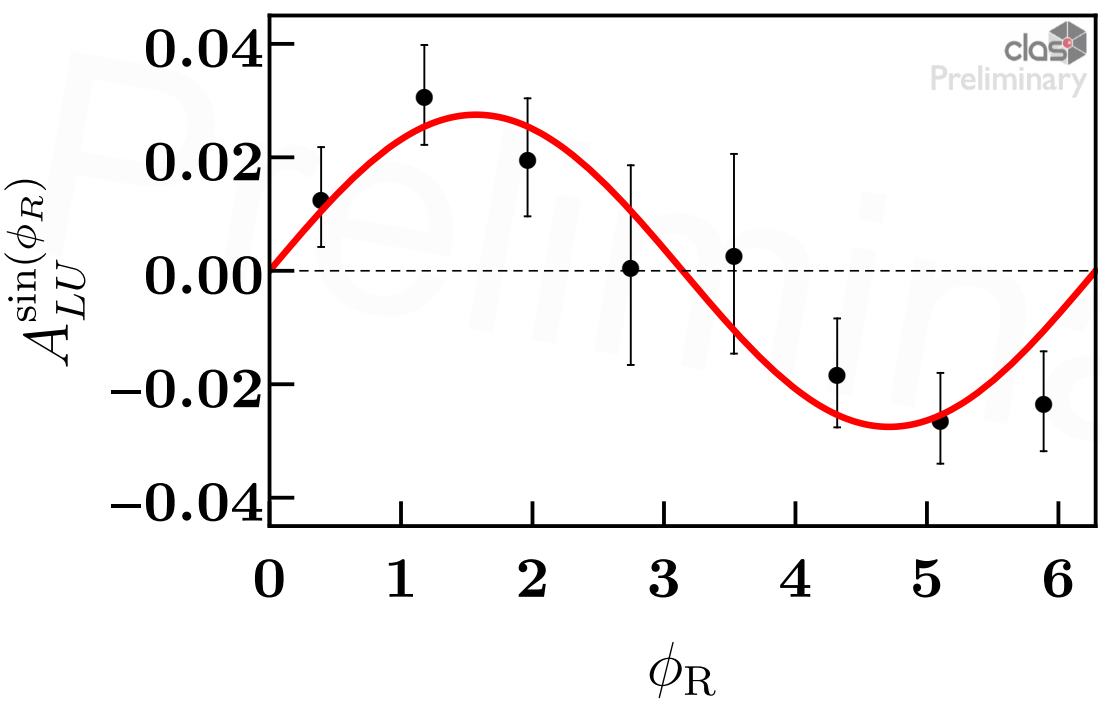
Forward Calorimeter
sampling fraction for electrons





Extracting A_{LU}

- Select $ep \rightarrow e'\pi^+\pi^- + X$.
- Calculate ϕ_R angle of pion pair.
- Fit to asymmetry $\frac{N^+ - N^-}{N^+ + N^-}(\phi_R) \rightarrow A_{LU}^{sin\phi_R}$.
- Correct with kinematic factor and P_{beam}~86%.
- Example for 0.22 < x < 0.25:

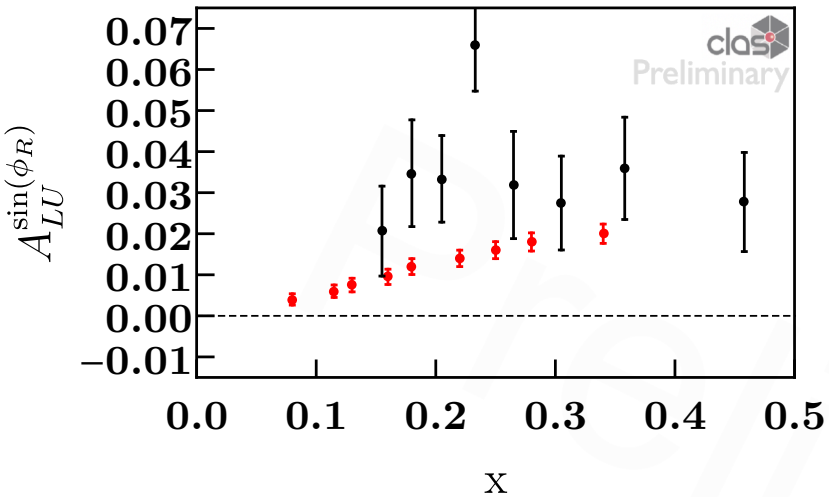


Channel selection

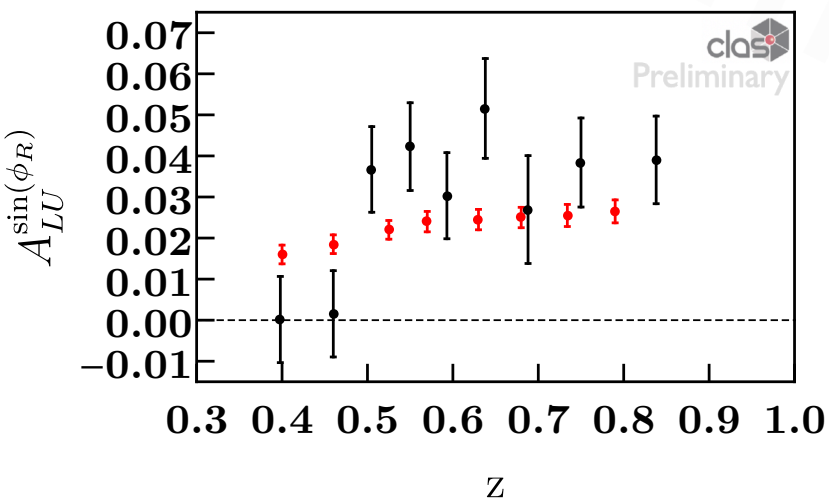
- Q^2>1.0 GeV^2
- W>2.0 GeV
- z_i>0.1
- z<0.95
- M_{miss}>1.05 GeV
- x_F>0
- y<0.8
- $p_{\pi i}$ > 1.25 GeV
- p_e > 2.00 GeV

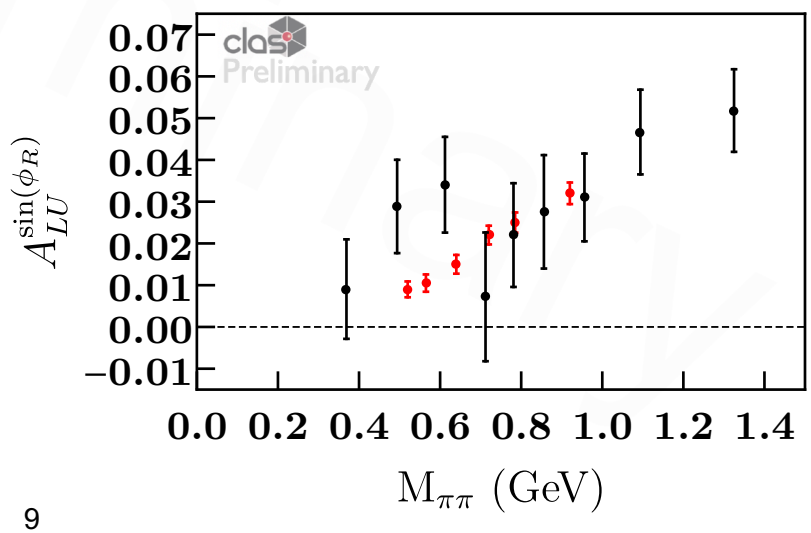
Preliminary results on ϕ_R modulations

- A_{LU} approximately 3% asymmetries.
- Trend of increasing asymmetries in x, z and $M_{\pi\pi}$ expected.

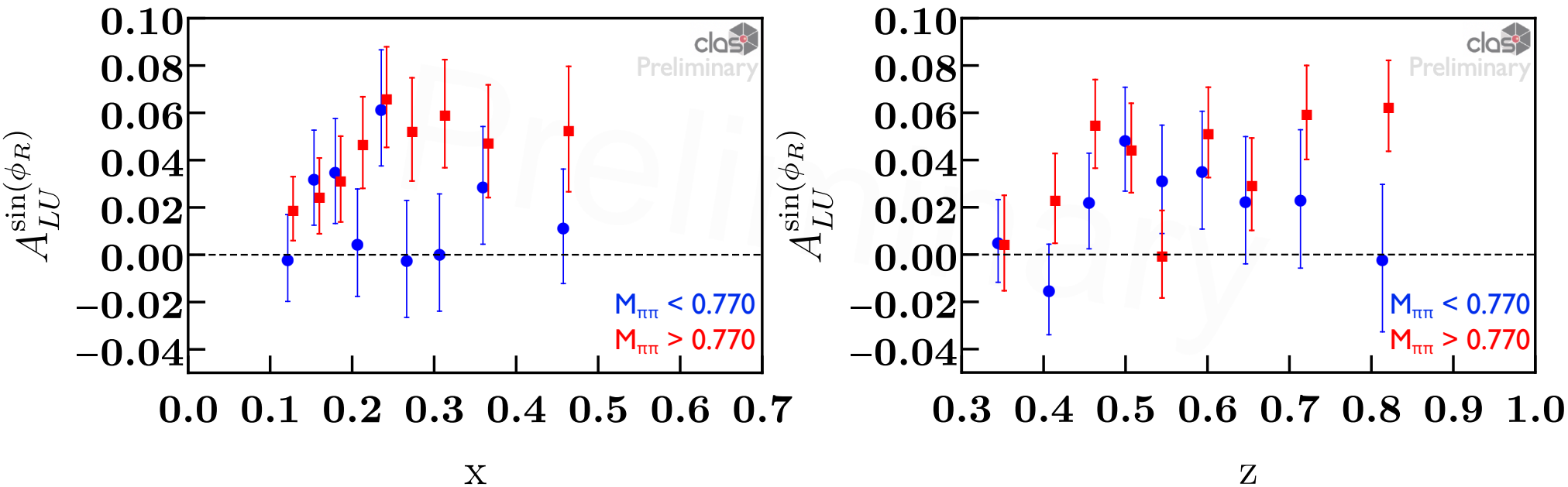


- CLAS12 (Data)
- Spectator (Model)





Multidimensional binning



- Asymmetries enhanced when binned in $M_{\pi\pi}$.
- Much finer multidimensional binning coming with more statistics.

Summary

- Preliminary results of ϕ_R modulations in dipion events from the CLAS12 Fall 2018 dataset shown.
- Indications of signal consistent with previous measurement and model predictions.
- Full statistics will enable a rich multidimensional analysis.

- Possible future efforts
  - Expansion to other pion combinations ($\pi^+ \pi^0$, $\pi^- \pi^0$, etc.)
  - Same sign pairs to test the ρ-resonance model.
  - Kaon asymmetries with improved RICH detector calibrations.
  - Flavor separation when data combined with CLAS12 deuterium target experiments.

Backup Slides

Kinematic Distributions of dipion Events

- A_{LU} sensitive to PDF e(x) and FF $H_1^{\sphericalangle q}(z, cos\theta, M_{\pi\pi})$