A_{LU} in semi-inclusive production of dihadrons with kaons at CLAS12

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Research supported by DOE
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Dihadron semi-inclusive DIS

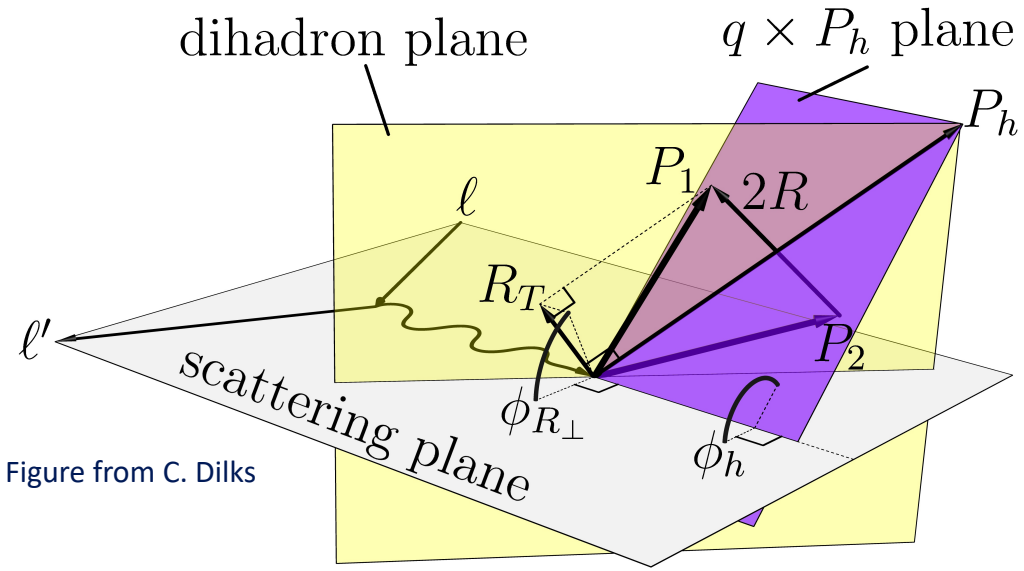


Figure from C. Dilks

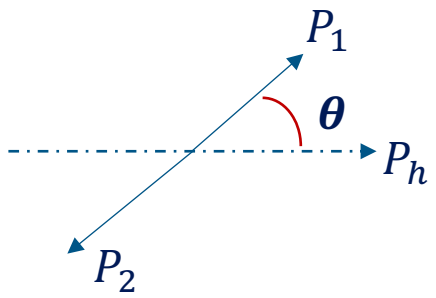
$$d\sigma_{LU} = \frac{\alpha^2}{4\pi x y Q^2}\left(1+\frac{\gamma^2}{2x}\right)\lambda_e \times \sum_{\ell=0}^{\ell_{\max}} \left\{ C(x,y) \sum_{m=1}^{\ell} \left[P_{\ell,m}\sin(m(\phi_h-\phi_{R_\perp}))\, 2\left(F_{LU,T}^{P_{\ell,m}\cos(m(\phi_h-\phi_{R_\perp}))} + \epsilon F_{LU,L}^{P_{\ell,m}\cos(m(\phi_h-\phi_{R_\perp}))}\right)\right] + W(x,y)\sum_{m=-\ell}^{\ell} P_{\ell,m}\sin((1-m)\phi_h + m\phi_{R_\perp}) F_{LU}^{P_{\ell,m}\sin((1-m)\phi_h+m\phi_{R_\perp})} \right\}.$$

Phys. Rev. D 90, 114027

$$P_h = P_1 + P_2$$

$$R = \frac{P_1 - P_2}{2}$$

Dihadron COM frame:



- Analyzing the production of two hadrons ($\boldsymbol{ep \to eh_1h_2X}$) with at least one **kaon**
  - $\boldsymbol{K^+\pi^-,\ \pi^+K^-, K^+K^-}$
- Relative $|l,m\rangle$ of hadrons → Infinite number of modulations in $(\phi_h, \phi_{R_\perp})$, expansion in θ $(P_{l,m})$
  - Each amplitude proportional to $\boldsymbol{PDF(x,k_\perp)\otimes DiFF^{[l,m\rangle}(z,M_h)}$

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Dihadron beam spin asymmetry

Measuring beam spin asymmetry (BSA) as

$$A_{LU} = \frac{1}{P}\frac{N_+ - N_-}{N_+ + N_-} \propto \frac{F_{LU}}{F_{UU}}$$

Taking $l_{max} = 2$ and measuring 7 azimuthal modulations of BSA integrated over θ (integrated over l):

Simple product!

$$A_{LU}^{sin(\varphi_{R\perp})} \propto \mathrm{e}(\mathrm{x}) H_1^{\sphericalangle}$$

Twist-3 PDF

Outgoing quark transverse polarization

$$A_{LU}^{sin(\varphi_H - \varphi_{R\perp})} \propto \mathrm{f}_1 \otimes G_1^{\perp}$$

Outgoing quark helicity dependent

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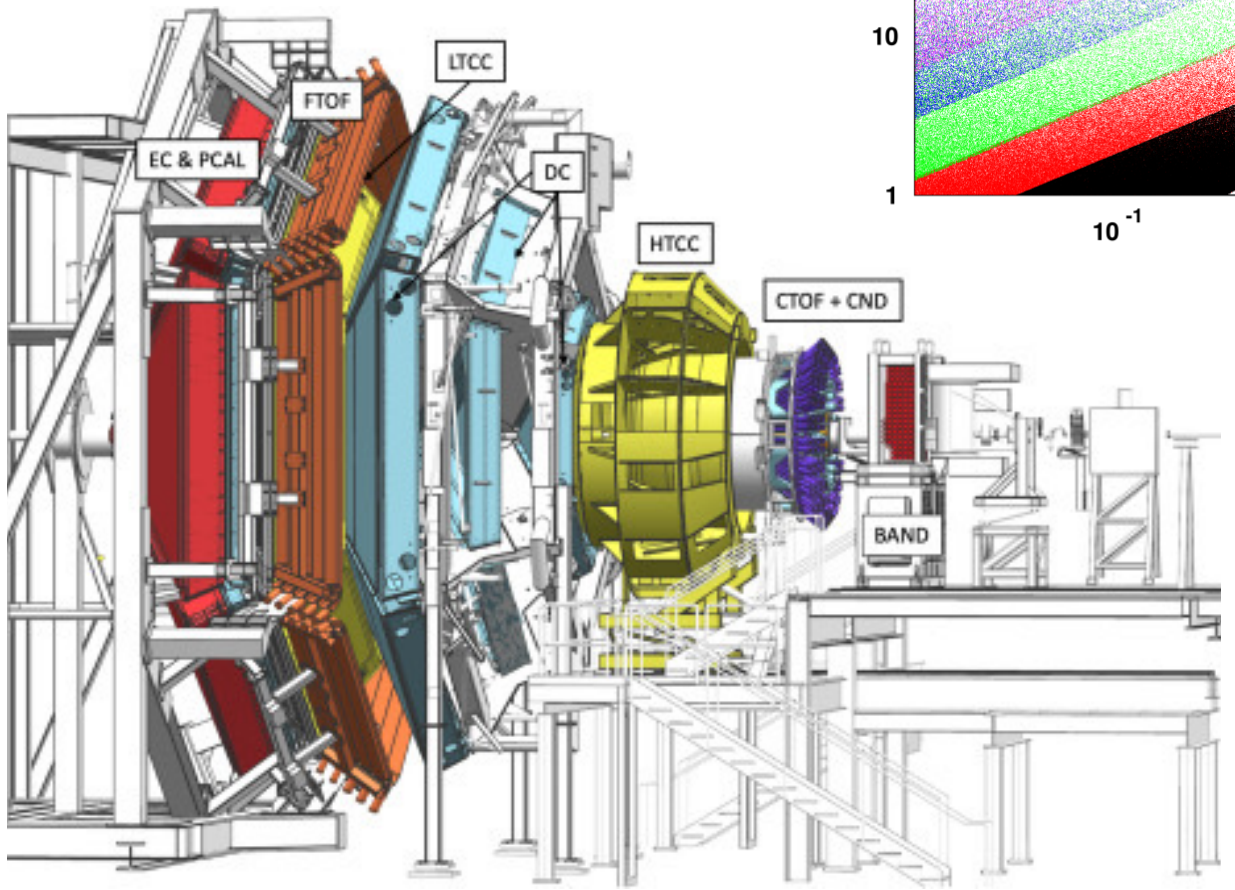
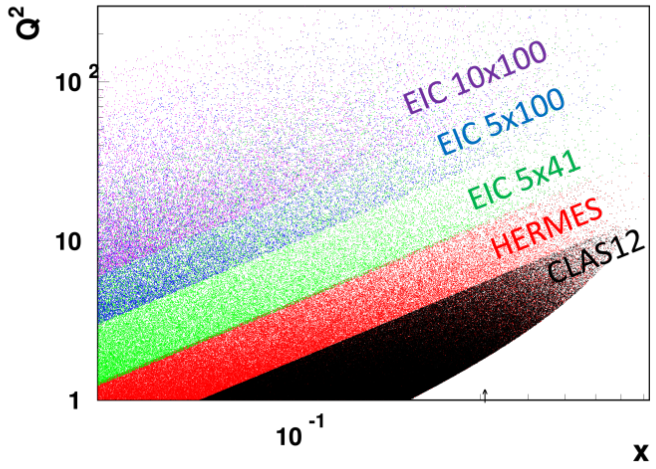
CEBAF Large Acceptance Spectrometer: CLAS12

- Spectrometer in Jefferson Lab Hall B
- Large forward-angle acceptance
- Operates up to luminosity of $10^{35} cm^{-2} s^{-1}$
- Data used in this analysis taken with **unpolarized LH_2 target in 2018-2019**
  - 10.6/10.2 GeV electron beam with average longitudinal polarization ~87%





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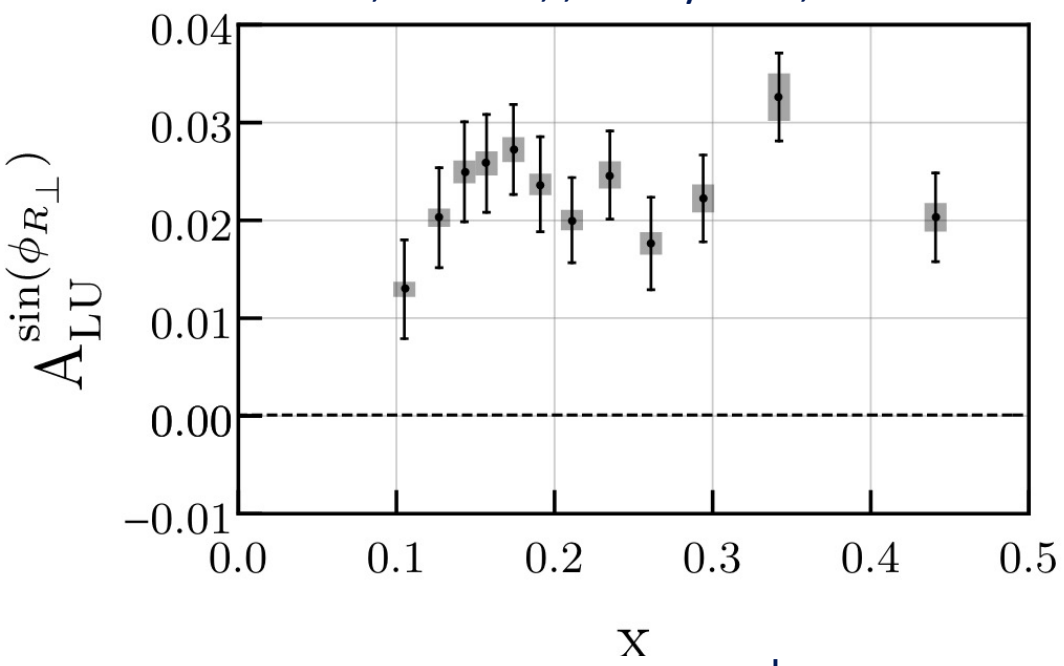
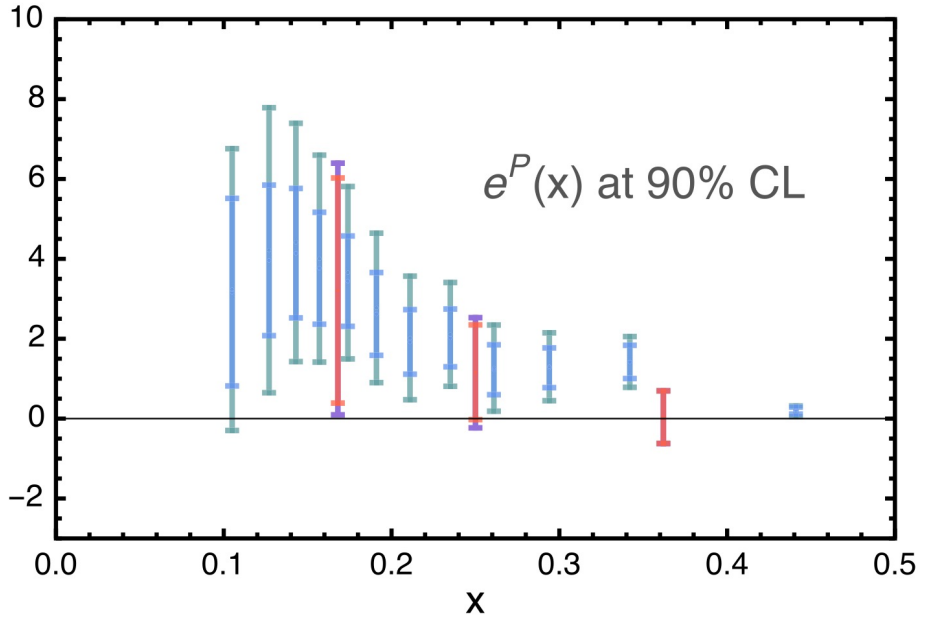
Dihadron measurements at CLAS12

PRL 126, 152501, , T. Hayward, C. Dilks



PRD 106, 014027



- 2021: A_{LU} measured in $\pi^+\pi^-$ production with LH_2 target dataset (PRL 126, 152501)
- Measured $A_{LU}^{\sin(\phi_{R\perp})}$ combined with measured $H_1^{\sphericalangle}$ from BELLE data[(1)] used for **extraction of twist-3 $e(x)$** [(2)]
- A_{LU} with kaon final states: further access to flavor dependence, contributions to asymmetries/DiFFs from K^*, ϕ vector mesons

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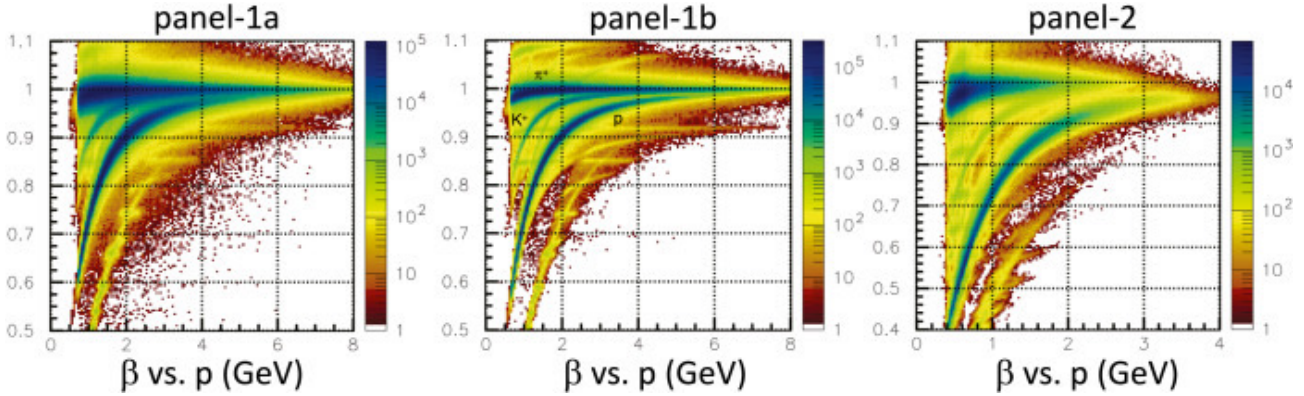
(1) PRL 107, 072004(2011)
(2) PRD 106, 014027

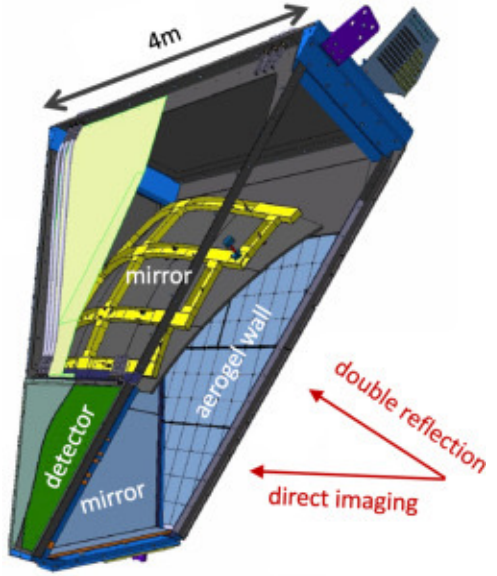
Kaon identification at CLAS12

- $p < 2.5 GeV/c$: forward time-of-flight (FTOF)
- $p > \sim 2 GeV/c$: Ring-imaging Cherenkov detector
  - Only in 1 of 6 sectors at time of data taking, used only for pion background estimate in this analysis
- Random forest model trained on simulated FTOF and calorimeter responses used to reduce pion background
  - Extend accepted momentum range to 3.5 GeV/c

FTOF performance (NIM A 960 (2020) 163629)



CLAS12 RICH



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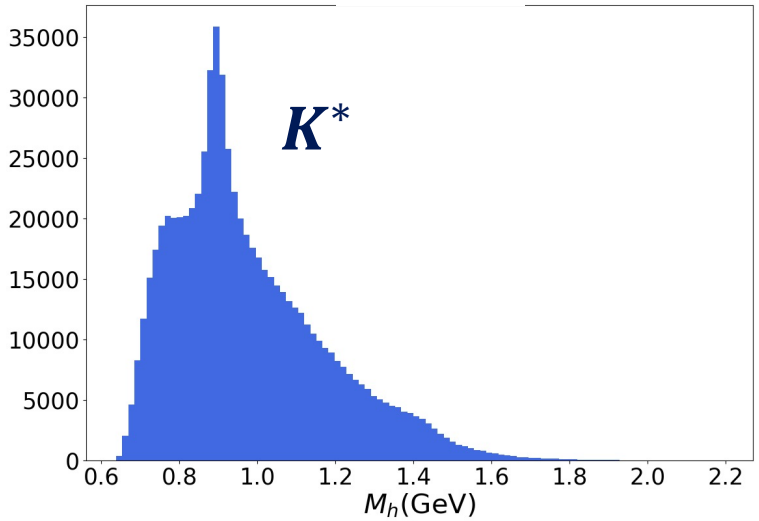
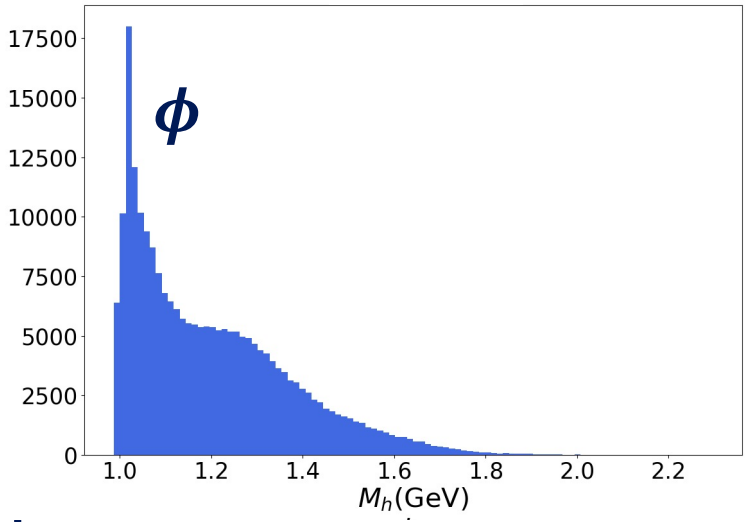
Dihadron SIDIS kinematics

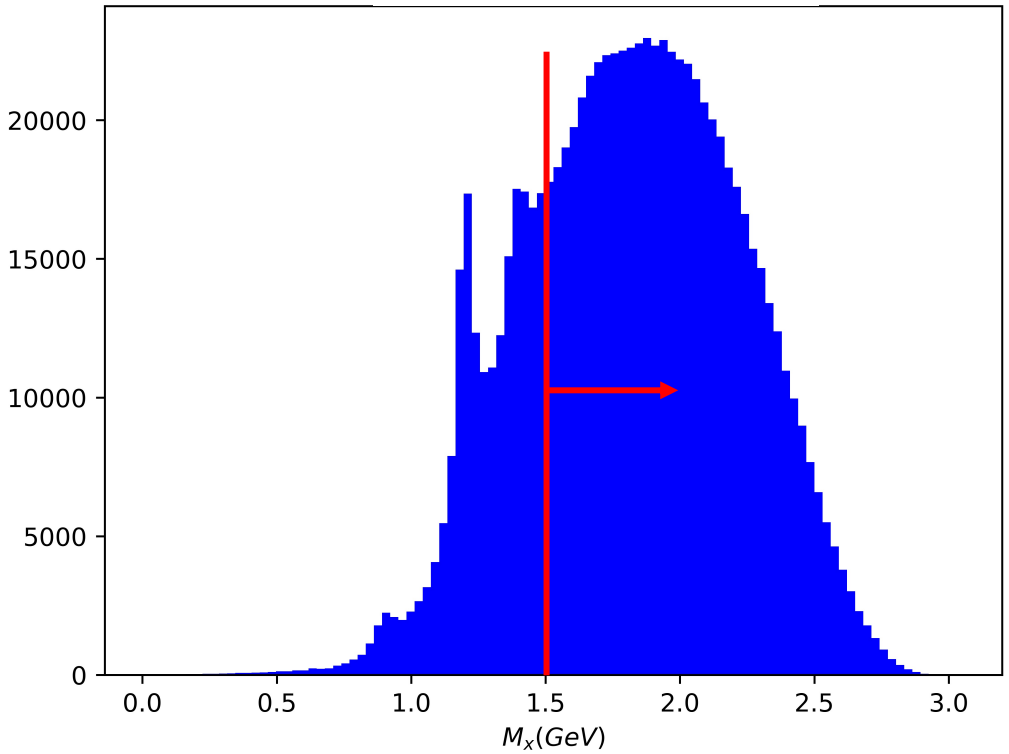
$K^+\pi^-$



K^+K^-



Missing mass, $K^+\pi^-$



- Require $Q^2 > 1\ GeV^2/c^2$, $W > 2\ GeV$, $y < 0.8$
- $M_x > 1.5 GeV/c$ for all final states
  - Handle to remove exclusive processes
- Large fraction of events from intermediary vector mesons

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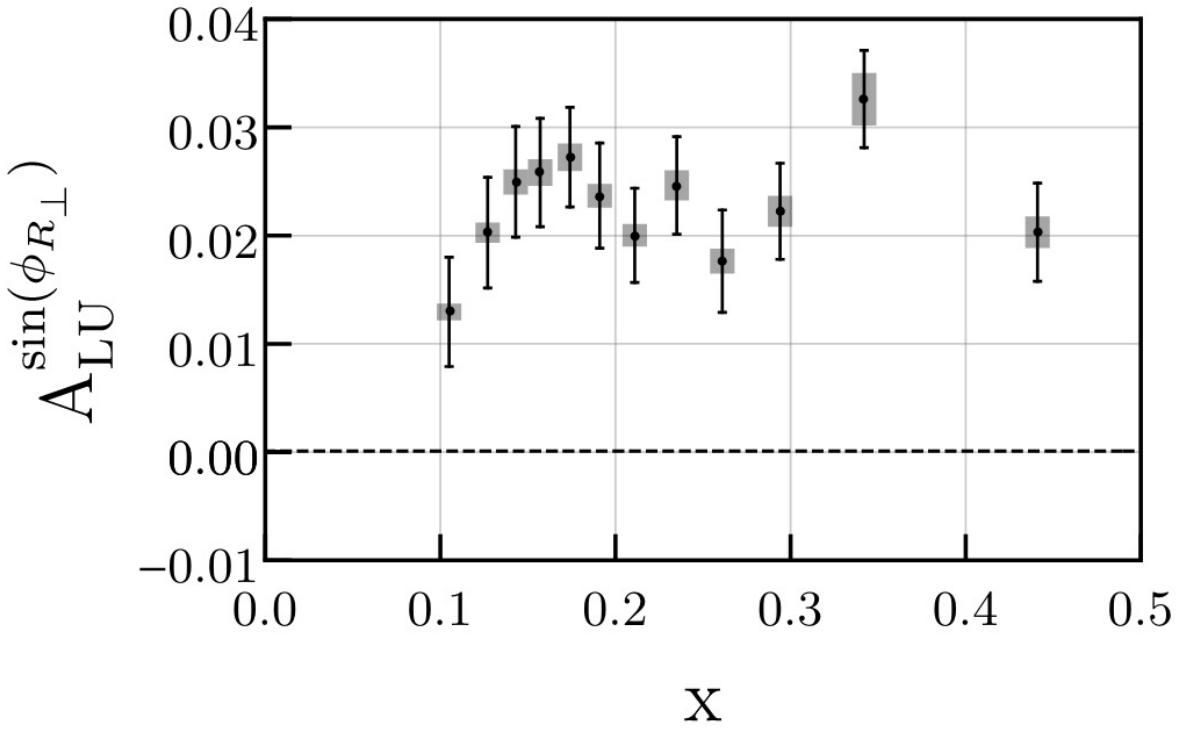
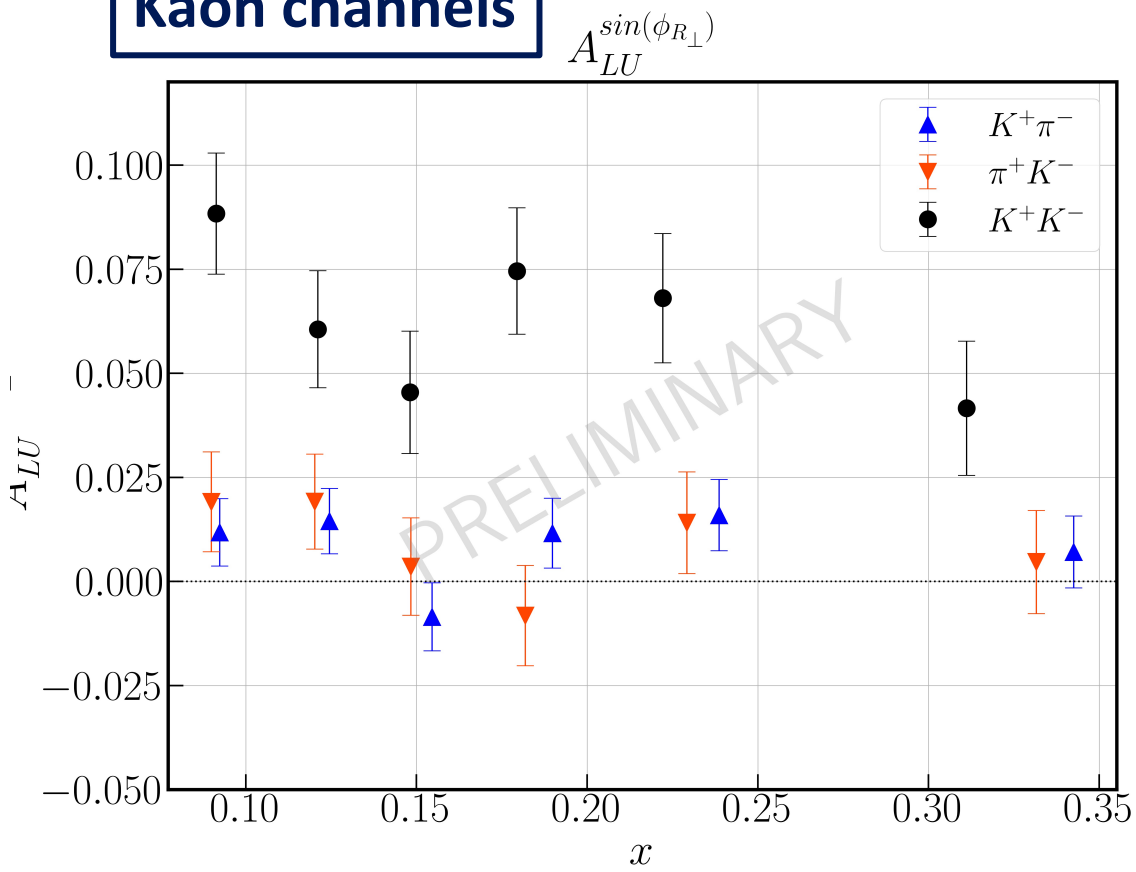
$$A_{LU}^{\sin(\phi_{R\perp})} \propto e(x)H_1^{\sphericalangle}$$

$\pi^+\pi^-$



Kaon channels



Displayed uncertainties on BSA with kaons purely statistical

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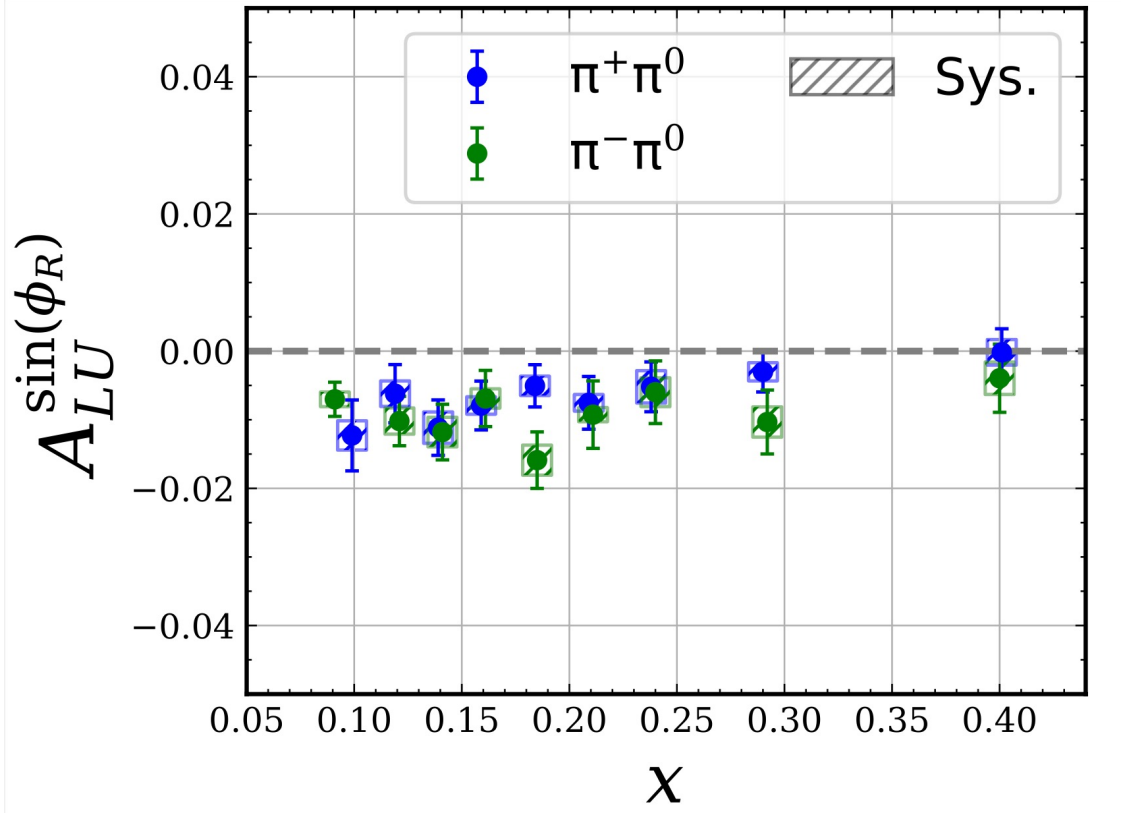
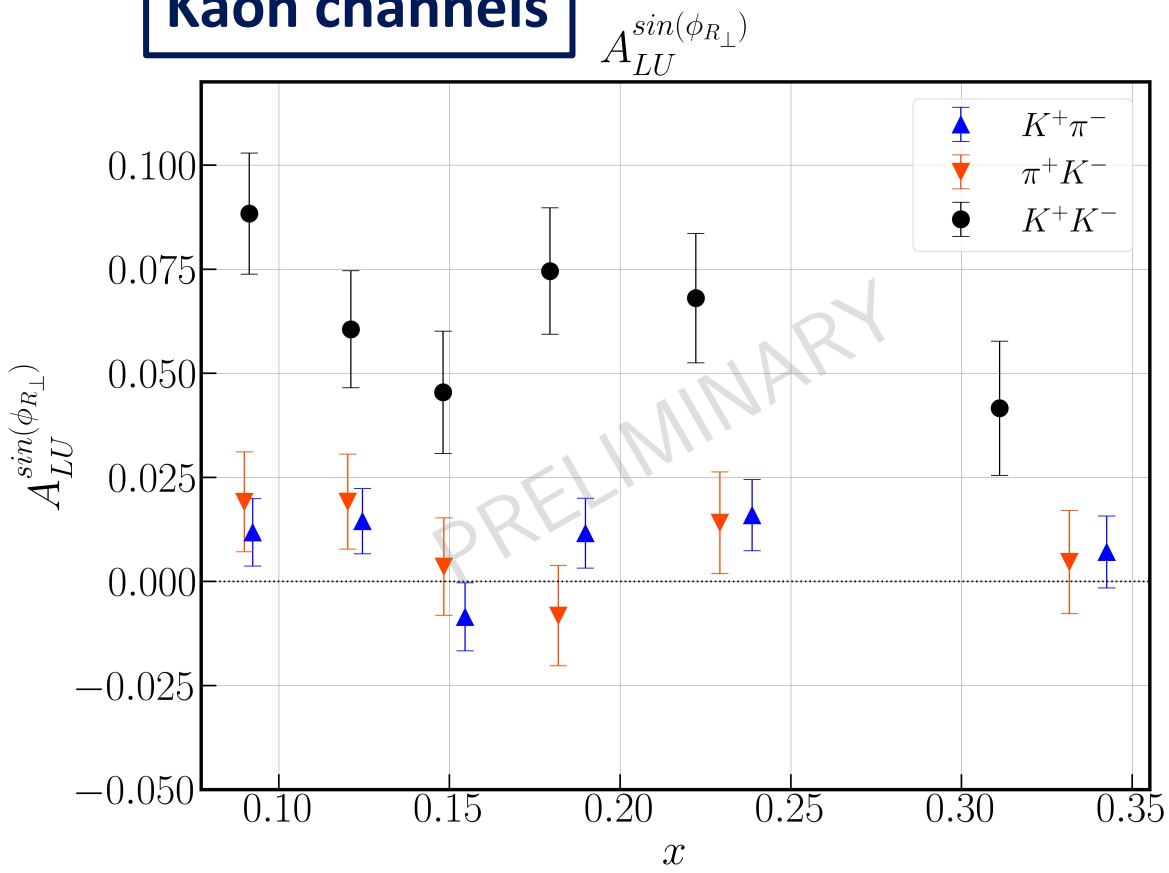
$$A_{LU}^{\sin(\phi_{R\perp})} \propto e(x)H_1^{\sphericalangle}$$

$\pi^{+/-}\pi^0$



Kaon channels



$\pi^{+/-}\pi^0$ analysis by G. Matousek (Duke)

Displayed uncertainties on BSA with kaons purely statistical

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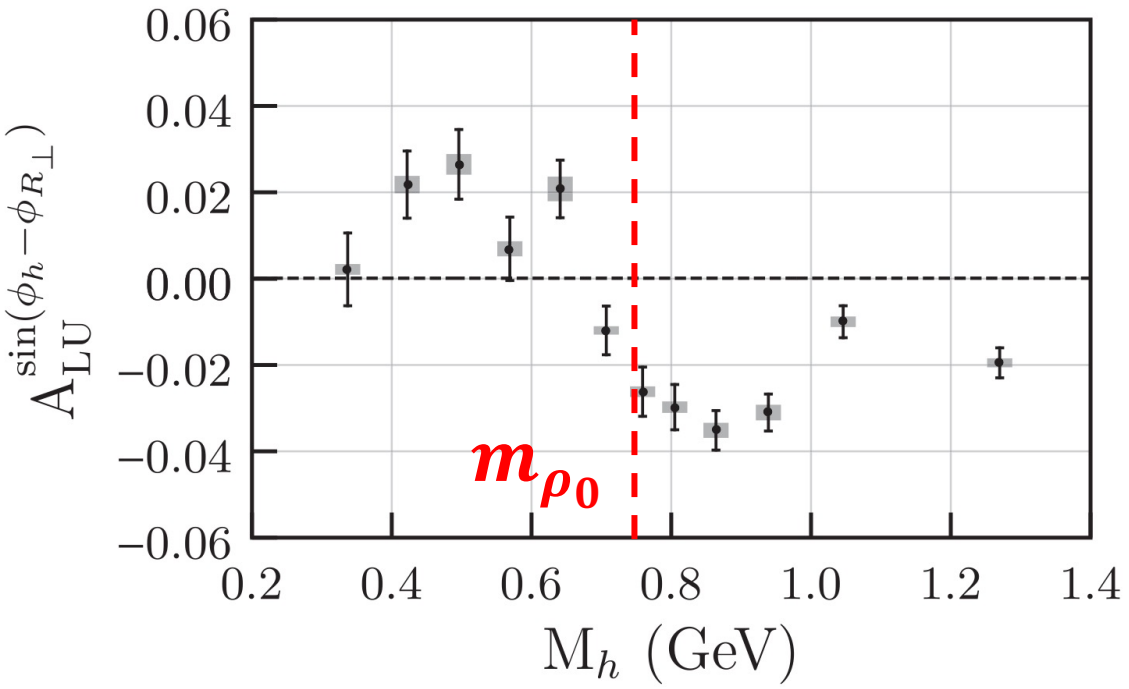
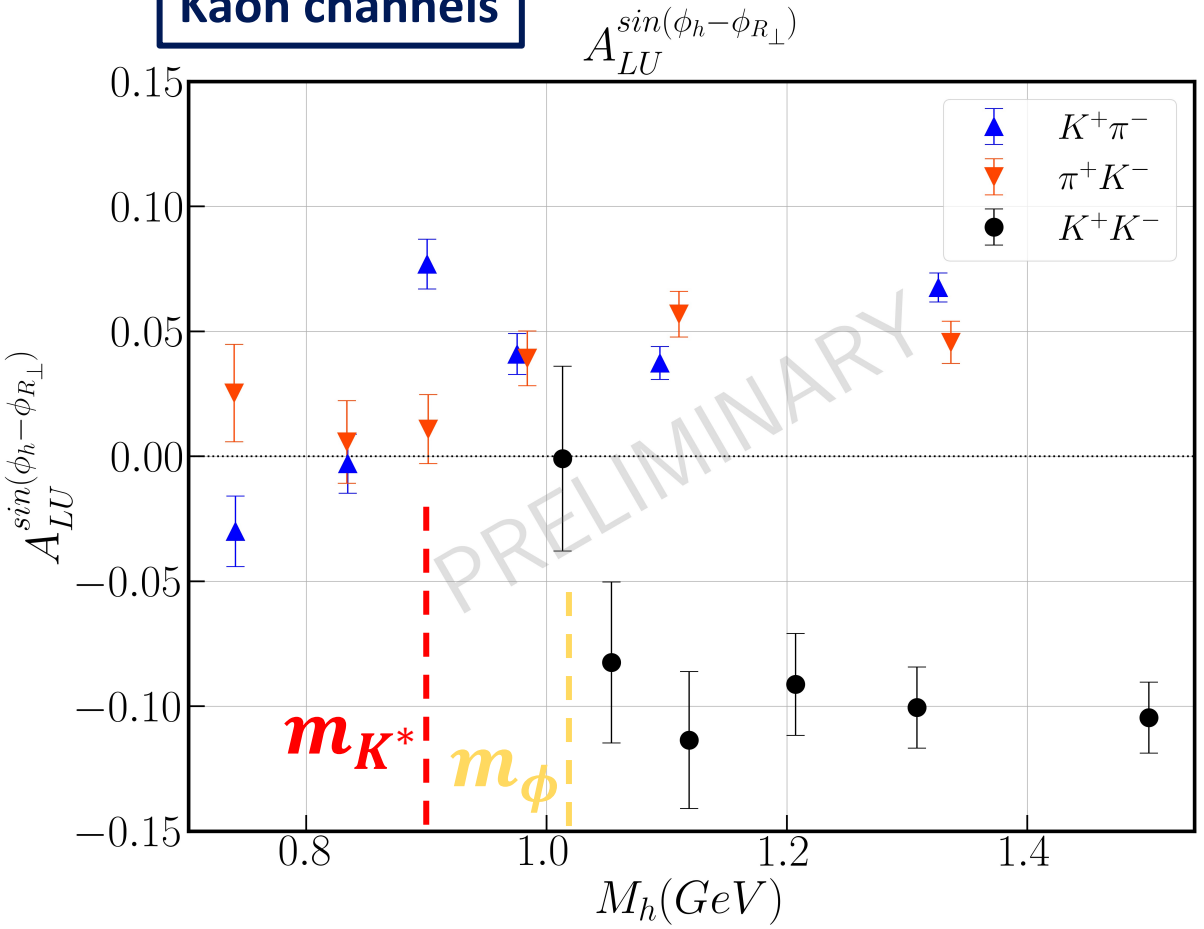
$$A_{LU}^{\sin(\phi_h-\phi_{R\perp})} \propto f(x)\otimes G_1^{\perp}$$

Kaon channels

$\pi^+\pi^-$





Displayed uncertainties on BSA with kaons purely statistical

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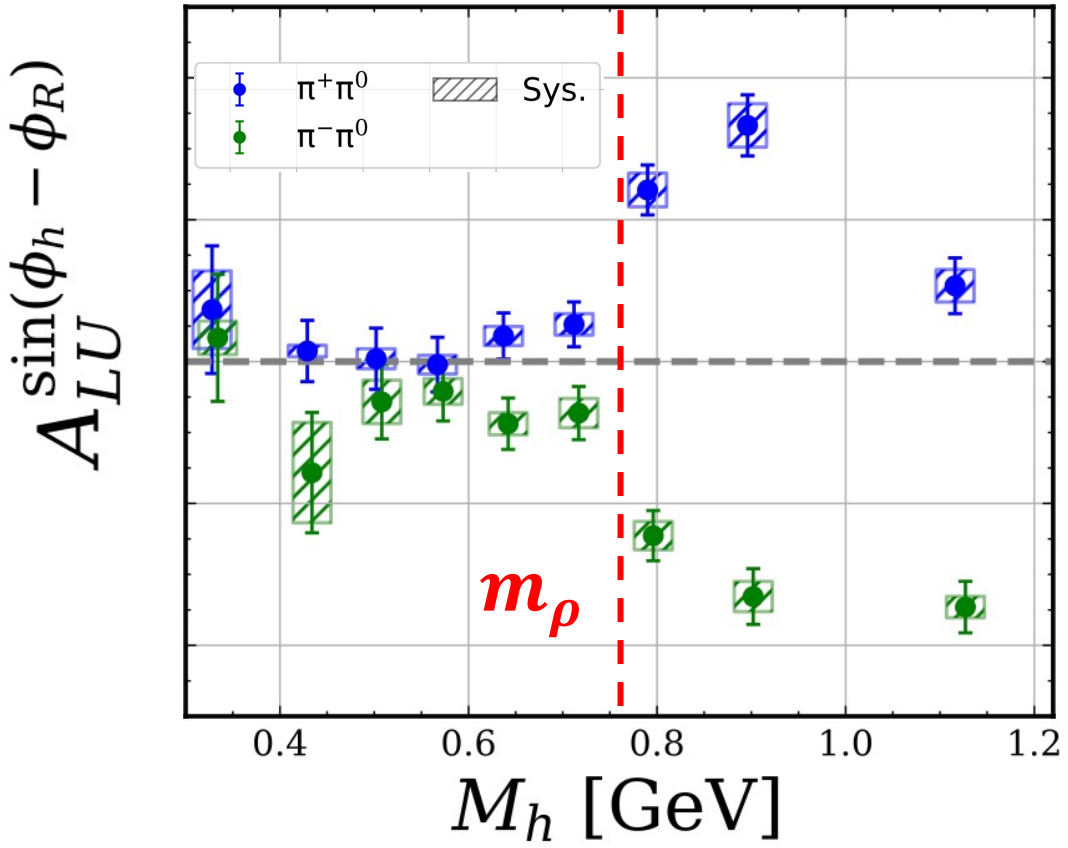
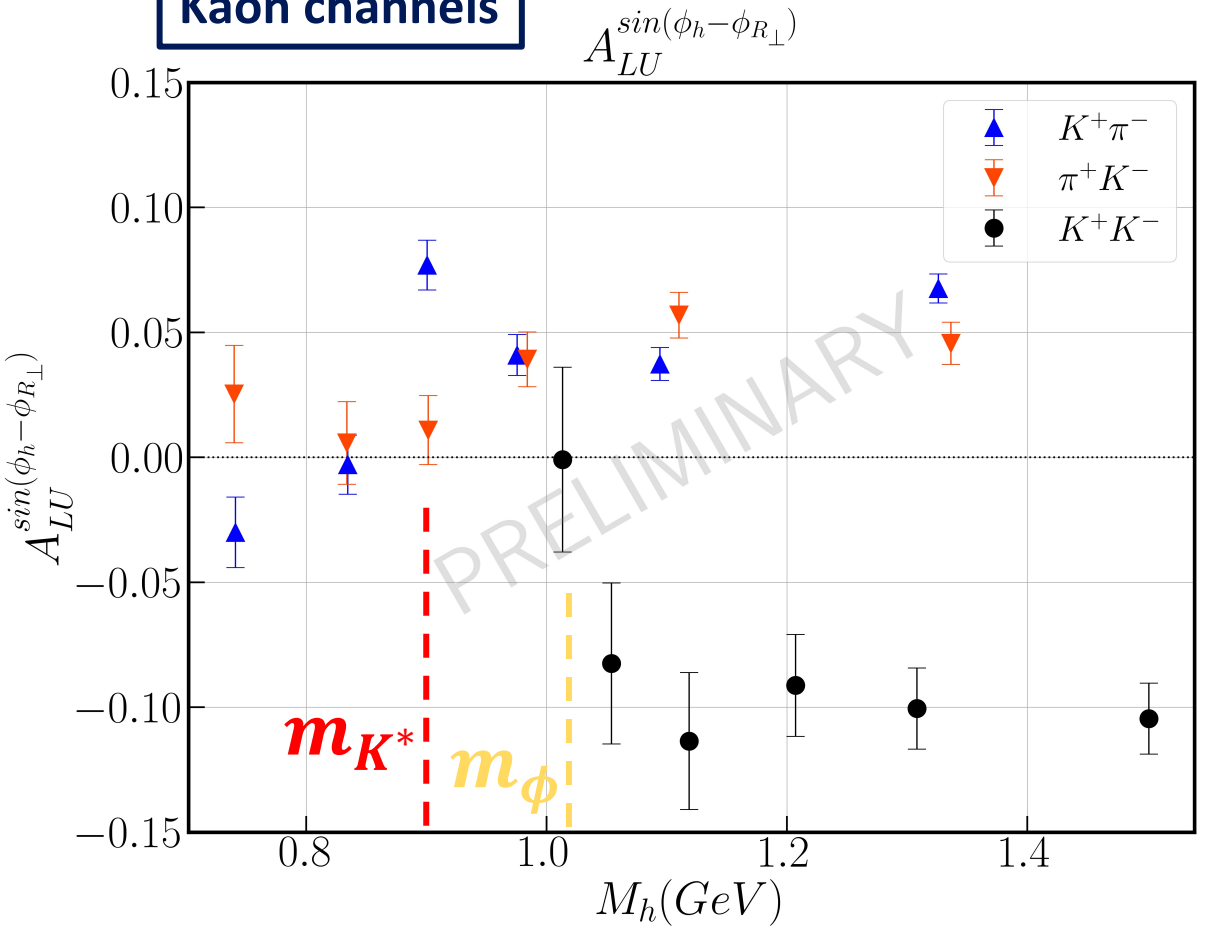
$$A_{LU}^{\sin(\phi_h-\phi_{R_\perp})} \propto f(x)\otimes G_1^\perp$$

$\pi^{+/-}\pi^0$



Kaon channels



Displayed uncertainties on BSA with kaons purely statistical

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Summary

- Preliminary results shown on measurement of BSA in semi-inclusive $K^+\pi^-,\ \pi^+K^-, K^+K^-$ with CLAS12
- Variety of dihadron final states now measured at CLAS12 ($\pi^+\pi^-, \pi^{+/-}\pi^0$) providing novel access to flavor dependence in hadronization and probing effects of vector mesons

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