



2019 Fall Meeting of the APS Division of Nuclear Physics

October 14 - 17, 2019, Crystal City, VA

**TDA measurements based
on hard exclusive pion
electroproduction
with CLAS at JLAB**

JUSTUS-LIEBIG-



UNIVERSITÄT
GIESSEN



Session GH
Oct. 15 2019
2:11 PM

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for the CLAS collaboration

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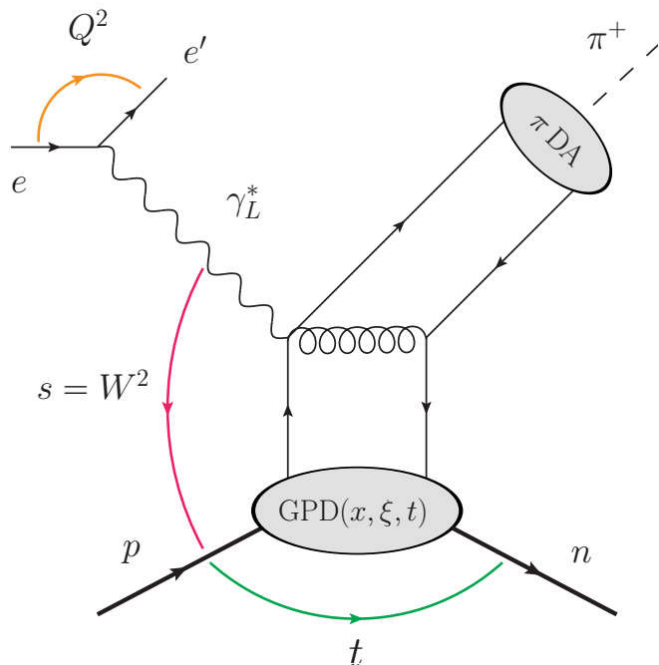
Hard exclusive π^+ electroproduction $ep \rightarrow en\pi^+$

colinear factorization theorem

GPD based description

large Q^2 and s
small t channel contribution

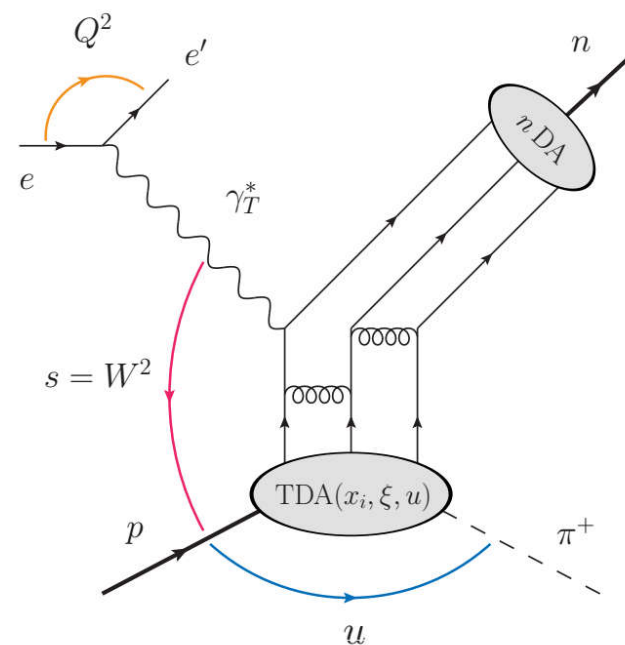
→ π^+ in forward region



TDA based description

large Q^2 and s
small u channel contribution

→ π^+ in backward region



Physics motivation

GPDs: describe hadronic structural information in terms of quark and gluon degrees of freedom

- tool to study the nature and origin of the nucleon spin
- impact parameter space: spatial femto-photographs of the hadron structure in the transverse plane

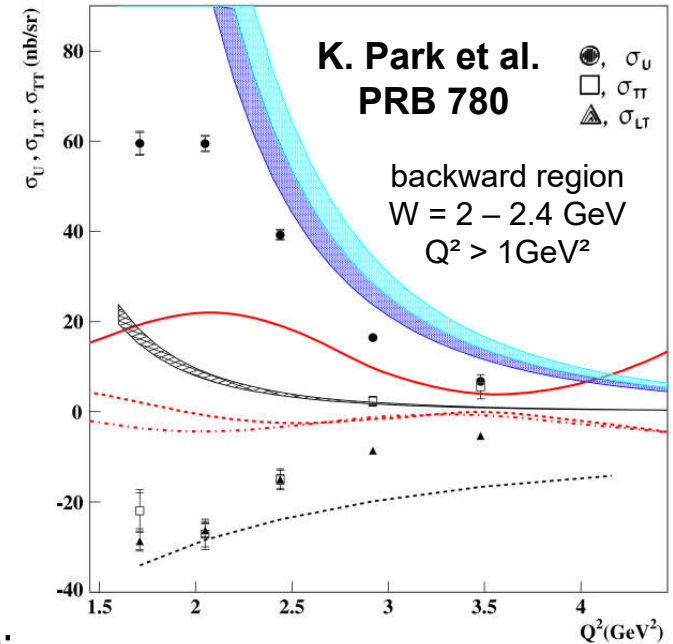
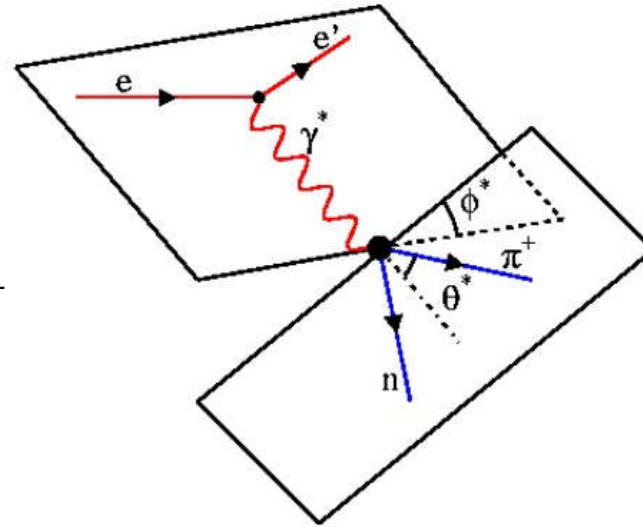
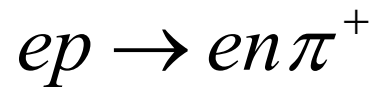
Baryon to meson TDAs: encoded physical picture close to GPDs

- probe partonic correlations between states of different baryonic charge
 - access to non-minimal Fock components of baryon light-cone wave functions
- impact parameter space: Femto-photography of hadrons from a new perspective
- spatial imaging of the structure of the pion cloud inside the nucleon

Aim:

Investigate the GPD and TDA kinematic regime and study the transition

Hard exclusive π^+ electroproduction

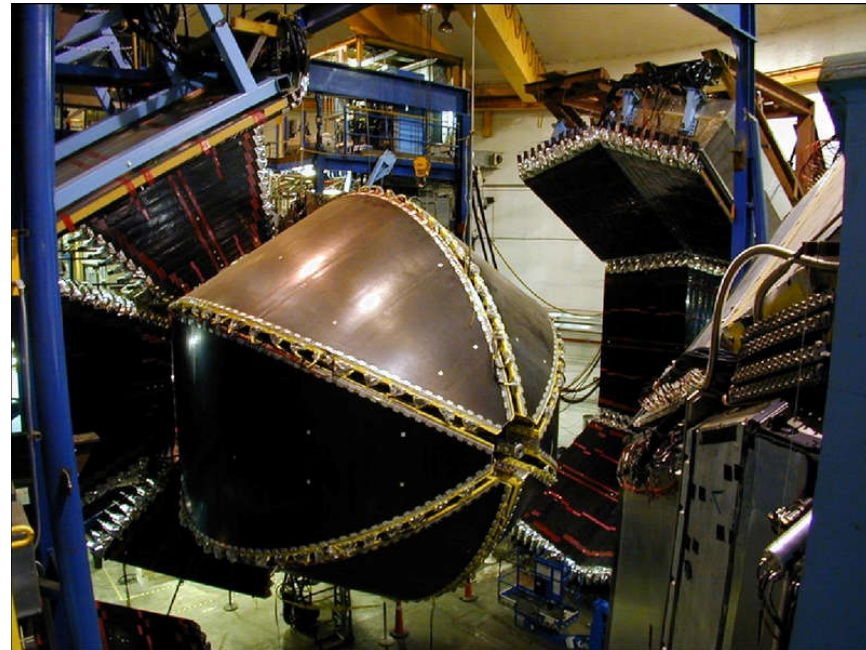
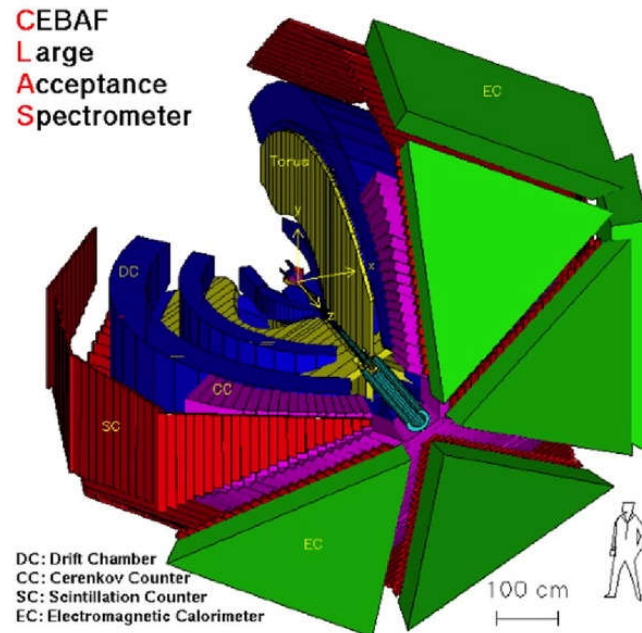


Cross section (longitudinally pol. beam and unpol. target):

$$d\sigma = d\sigma_0(1 + A_{UU}^{\cos(2\phi)} \cos(2\phi) + A_{UU}^{\cos(\phi)} \cos(\phi) + hA_{LU}^{\sin(\phi)} \sin(\phi))$$

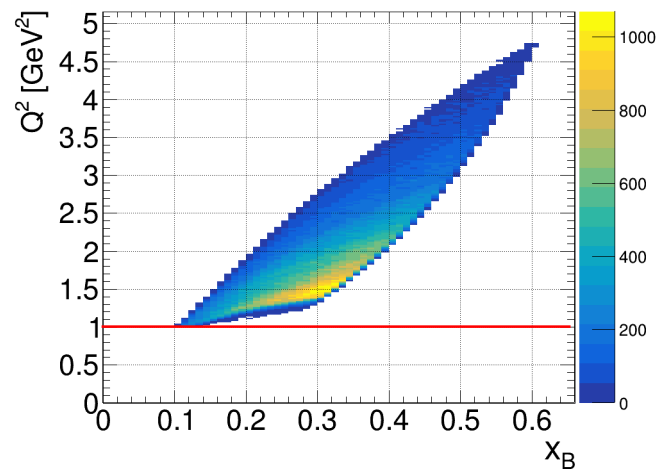
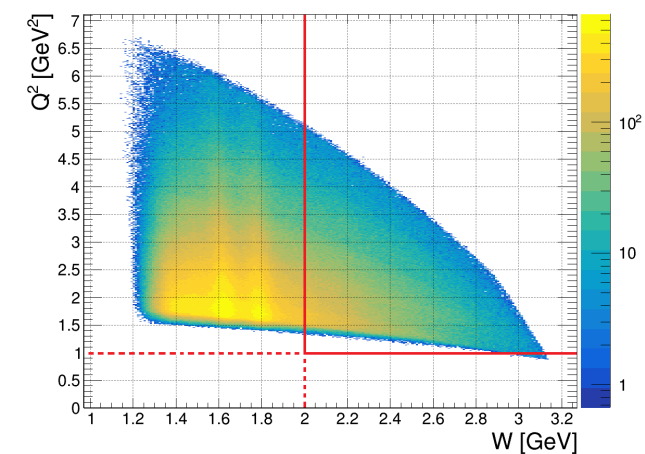
$$BSA = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{A_{LU}^{\sin \phi} \sin \phi}{1 + A_{UU}^{\cos \phi} \cos \phi + A_{UU}^{\cos(2\phi)} \cos(2\phi)}$$

Experimental Setup



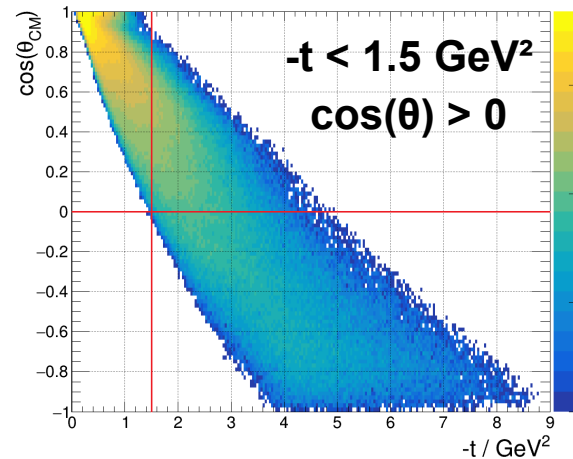
- CLAS (e1f run period)
- 5.5 GeV longitudinally polarized electron beam
- unpolarized hydrogen target
- **Electron ID** based on electromagnetic calorimeter and Cherenkov counters
- **π^+ ID** based on a maximum likelihood particle selection from TOF based β vs p correlation

Kinematic coverage and exclusivity cuts

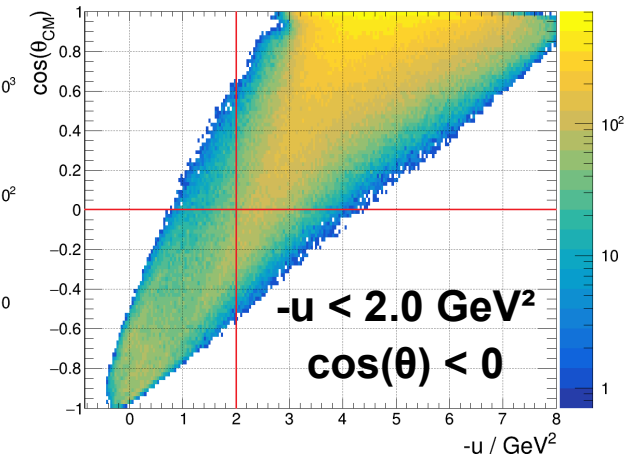


DIS cuts:
 $W > 2 \text{ GeV}$
 $Q^2 > 1 \text{ GeV}^2$

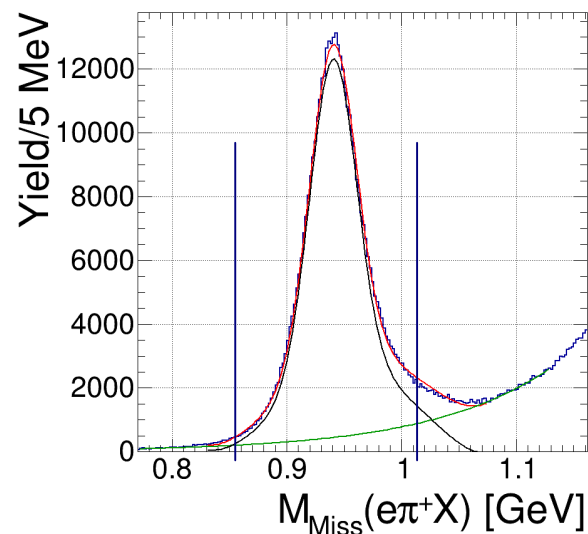
forward region „small t “



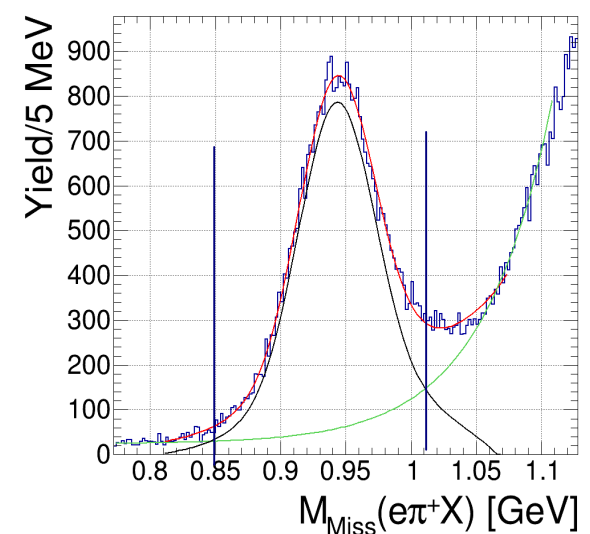
backward region „small u “



missing mass



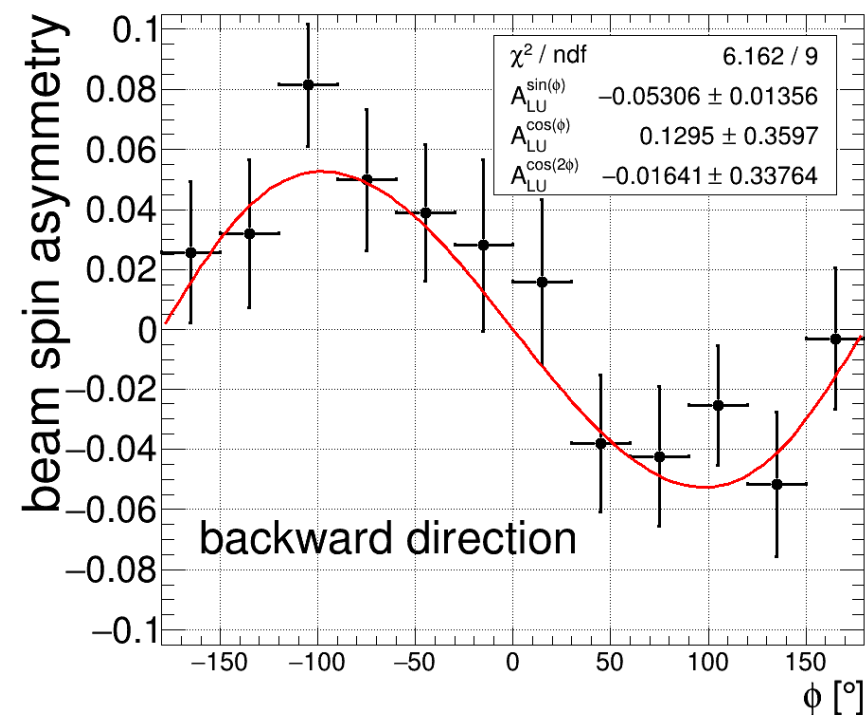
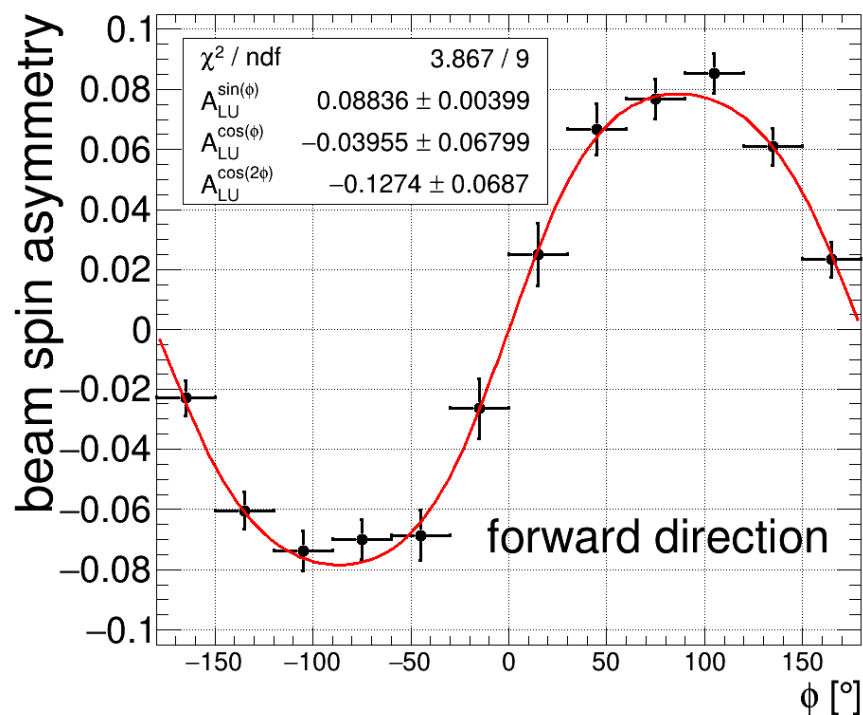
missing mass



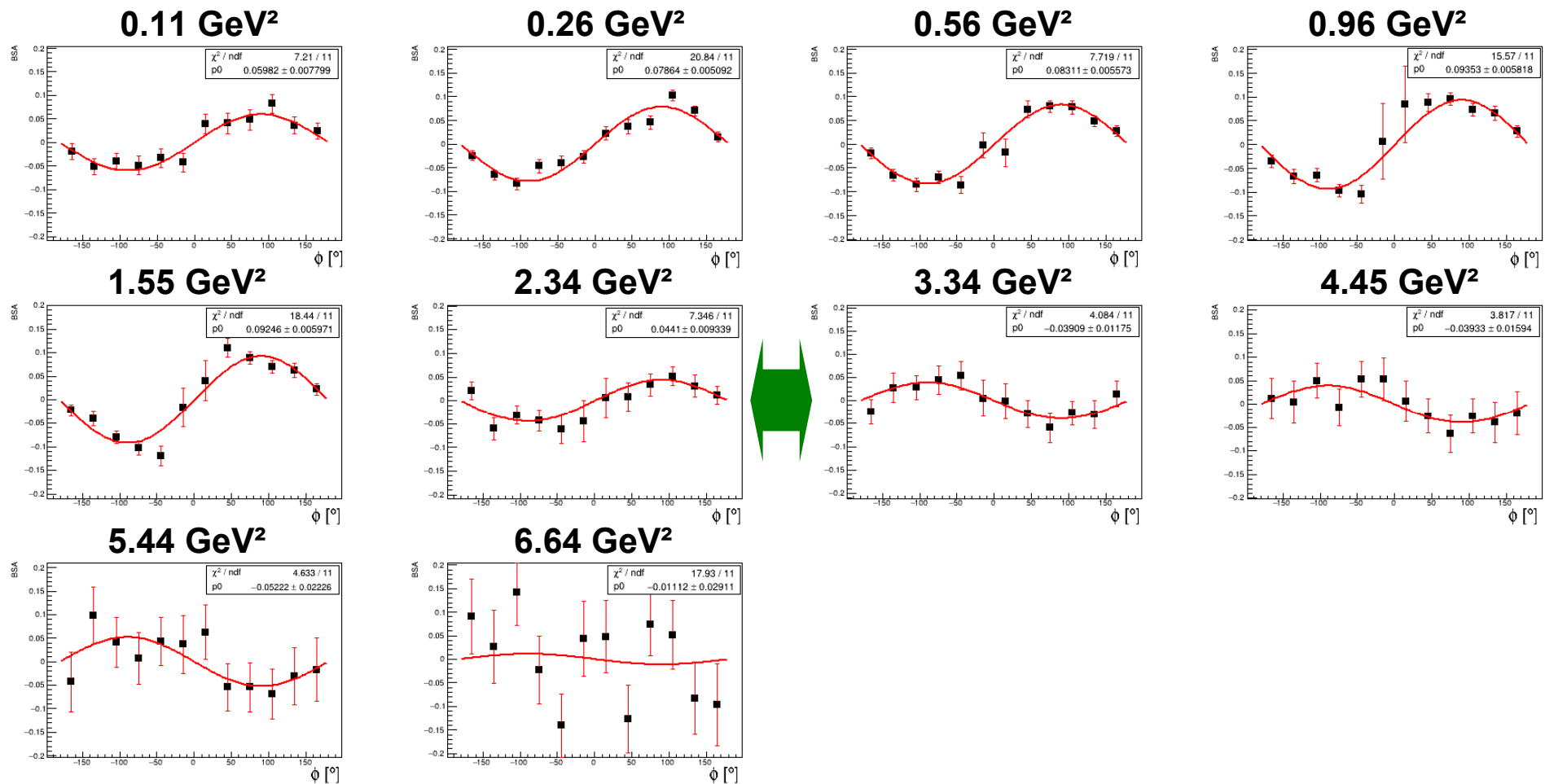
Beam spin asymmetry

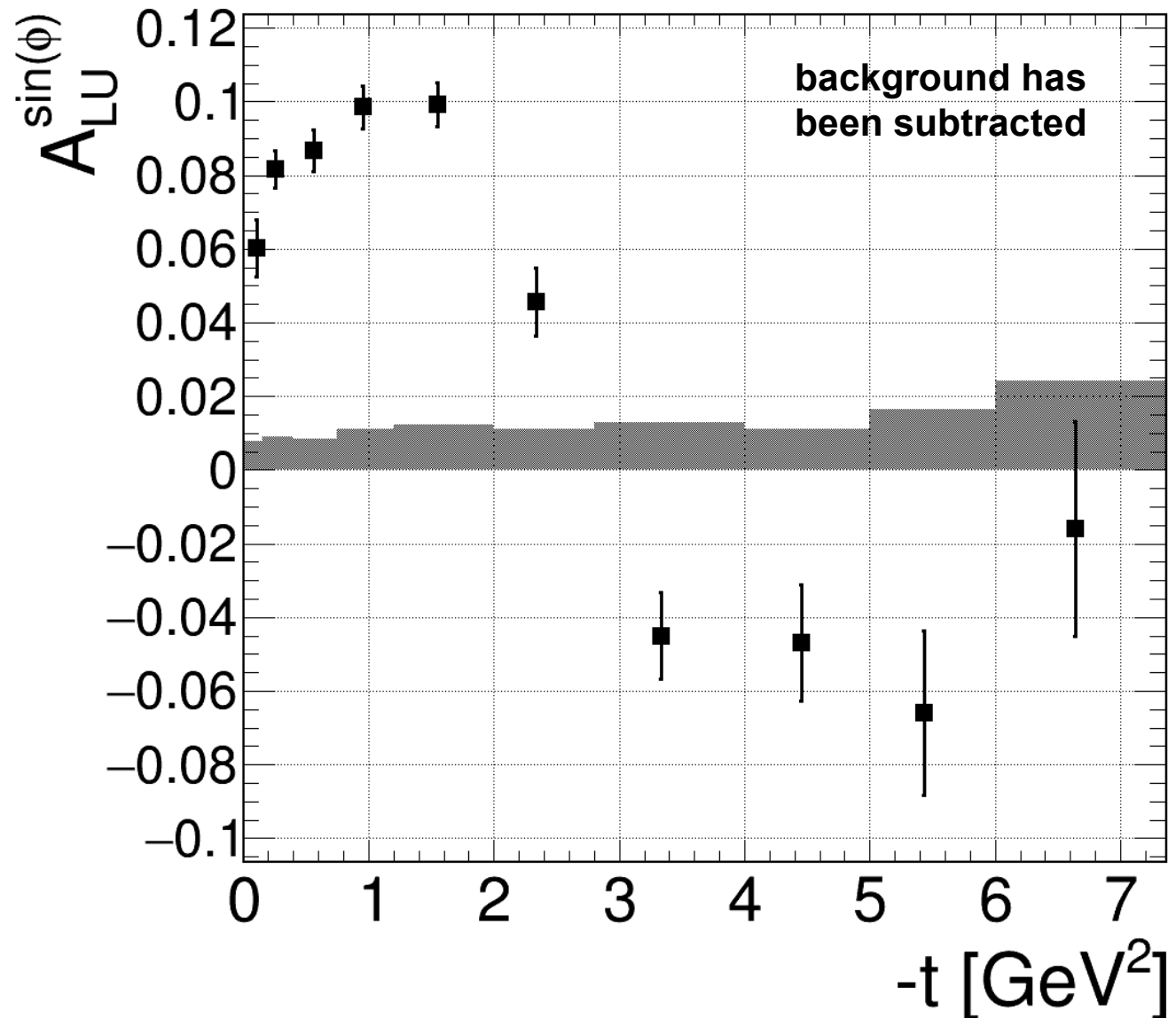
$$BSA_i = \frac{1}{P_e} \cdot \frac{N_i^+ - N_i^-}{N_i^+ + N_i^-} \quad P_e = 75 \% : \text{average } e^- \text{ beam polarisation}$$

Integrated over all kinematic variables in forward / backward region:



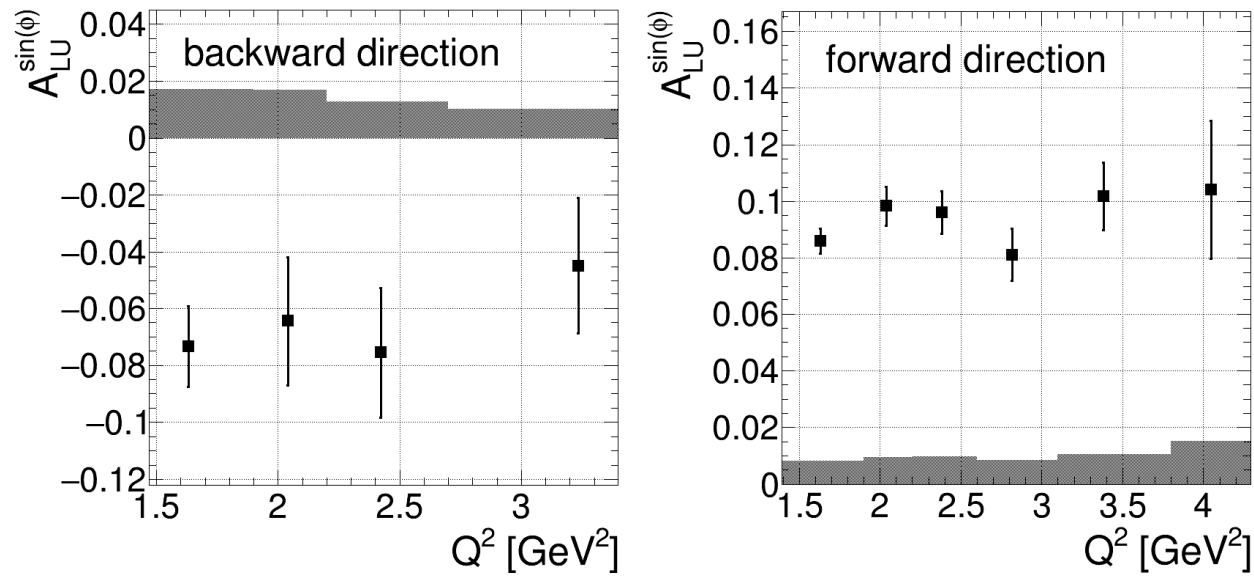
BSA for different -t bins



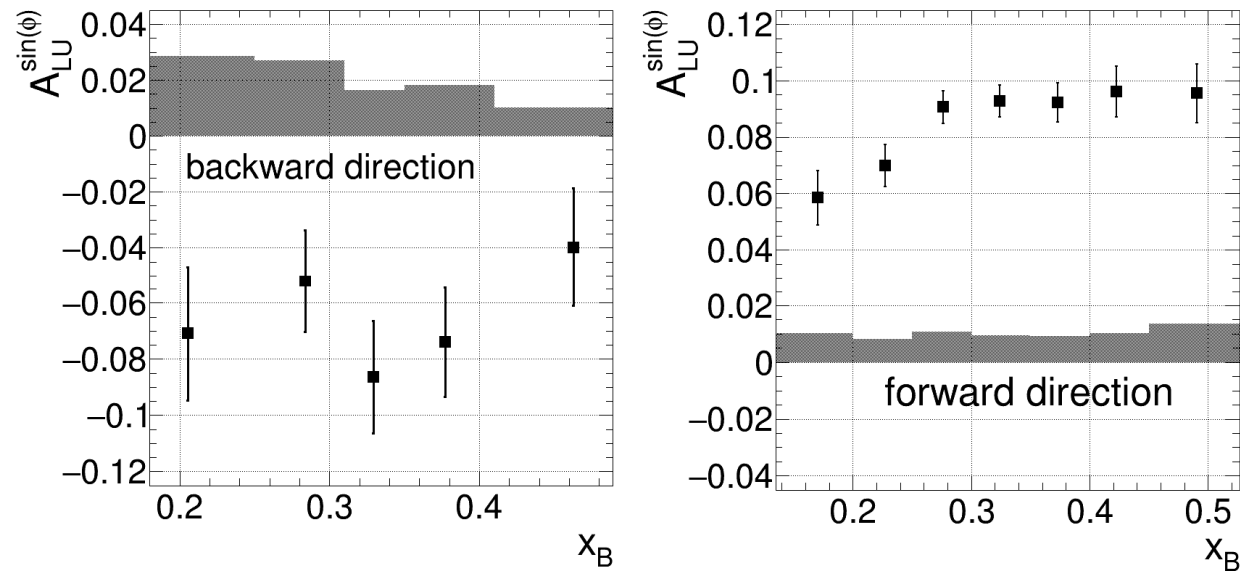
-t dependence of $A_{LU}^{\sin(\phi)}$ 

Q^2 and x_B dependence of $A_{LU}^{\sin(\phi)}$

Q^2



x_B



Summary and Outlook

- $A_{LU}^{\sin(\phi)}$ moment from the hard exclusive π^+ channel has been extracted for the first time over a large range of kinematics.
- The results show a clear sign change from forward to backward angles, which may indicate a transition from the GPD to the TDA regime.
- Measurements with higher statistics will be performed with CLAS12.
- The crossed reaction $\bar{N}N \rightarrow \gamma^* \pi$ will be accessible with PANDA at FAIR.

