Forward and backward BSA from π⁺, π⁰ and π⁻
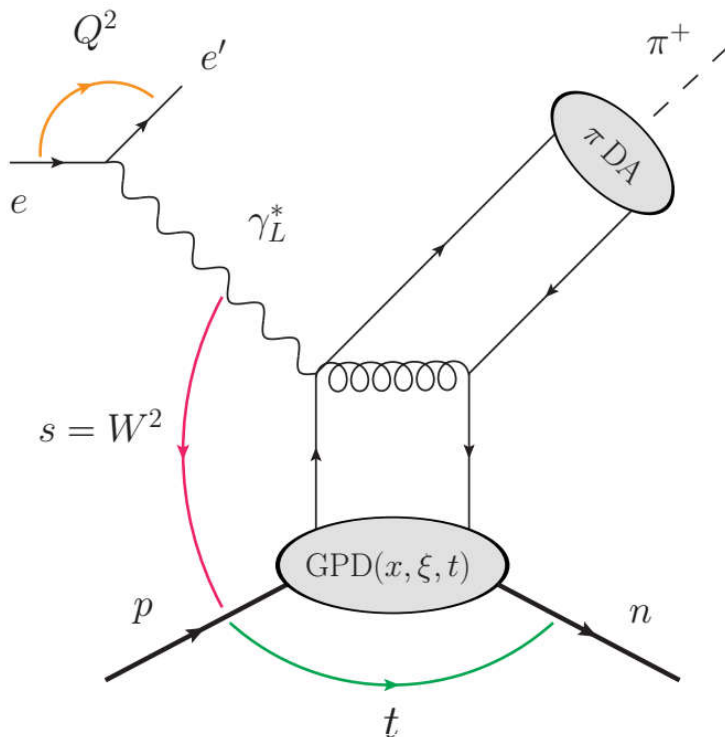
UCONN
UNIVERSITY OF CONNECTICUT

Stefan Diehl, David Riser,
Kyungseon Joo

University of Connecticut

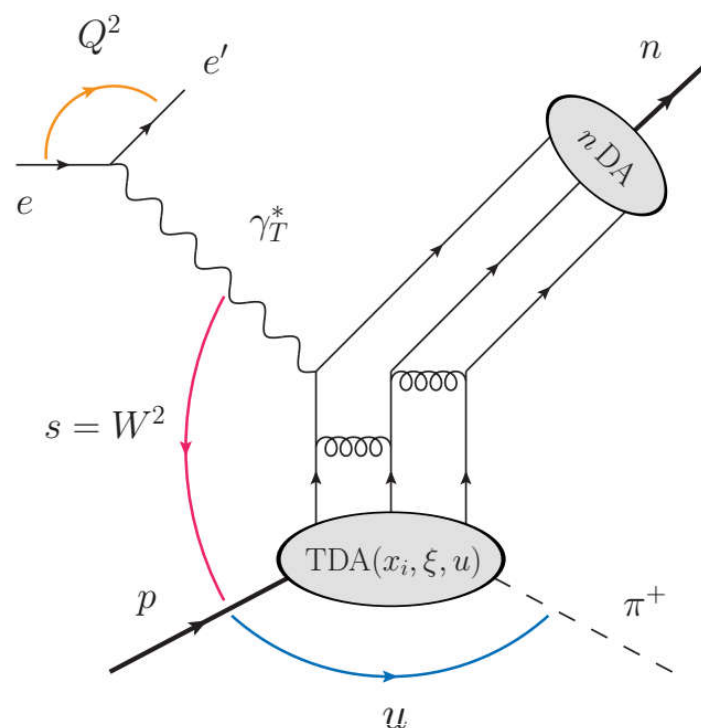# Physics motivation: reaction mechanism of e p → e n π⁺

➡️ center of mass frame with positive direction along incoming virtual photon

meson in nearly forward region

small t channel contribution
larger u channel contribution

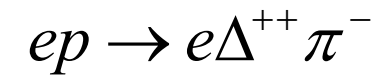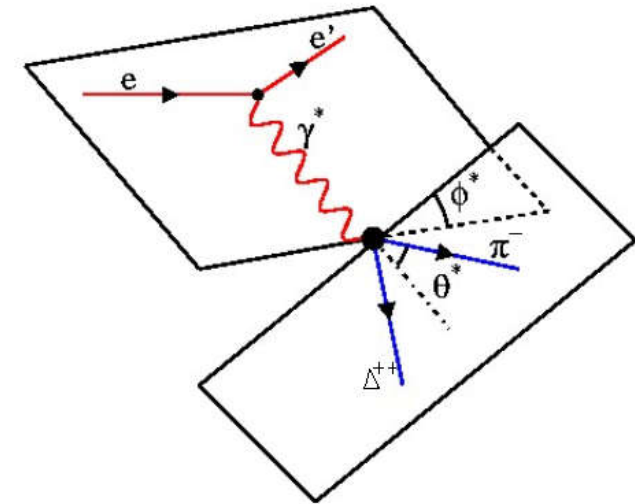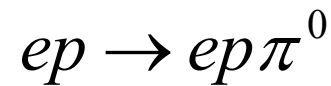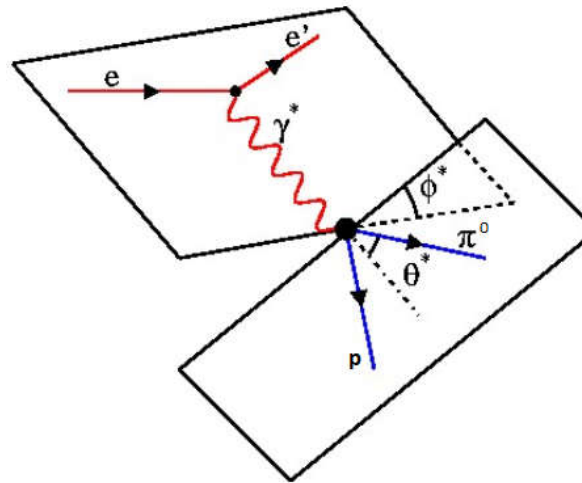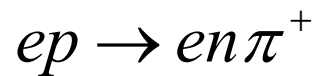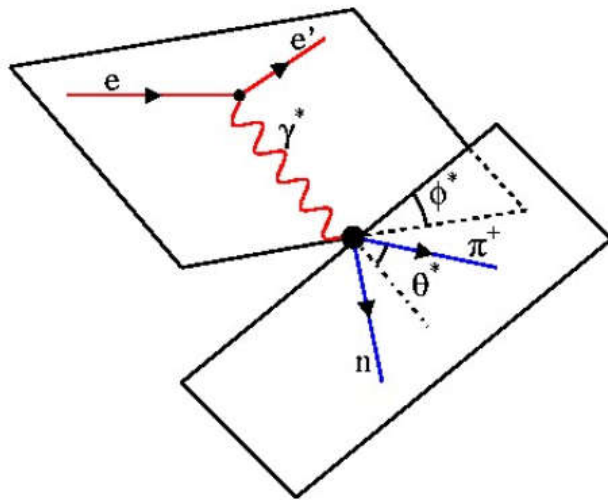hard perturb. QCD + GPDs + π DA

meson in neraly backward region

small u channel contribution
larger t channel contribution

hard. Perturb. QCD + p to π TDA + n DA

Hard exclusive single pion electroproduction

$$ep \rightarrow en\pi^{+}$$

$$ep \rightarrow ep\pi^{0}$$

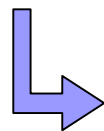$$ep \rightarrow e\Delta^{++}\pi^{-}$$

$$\frac{d^4\sigma}{dQ^2 dx_B d\phi dt} \sim \sigma_T + \varepsilon_L \sigma_L + \varepsilon \cdot \sigma_{TT} \cdot \cos(2\phi) + \sqrt{2 \cdot \varepsilon_L \cdot (1+\varepsilon)} \cdot \sigma_{LT} \cdot \cos(\phi) + h \cdot \sqrt{2 \cdot \varepsilon_L \cdot (1-\varepsilon)} \cdot \sigma_{LT'} \cdot \sin(\phi)$$
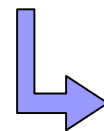
beam helicity

$$BSA = \frac{\sigma^{+} - \sigma^{-}}{\sigma^{+} + \sigma^{-}} \propto \frac{\sigma_{LT'}}{\sigma_T + \epsilon_L \sigma_L} \sin\varphi = A_{LU}^{\sin\varphi} \sin\varphi$$

The e16 and e1f runs of CLAS 6

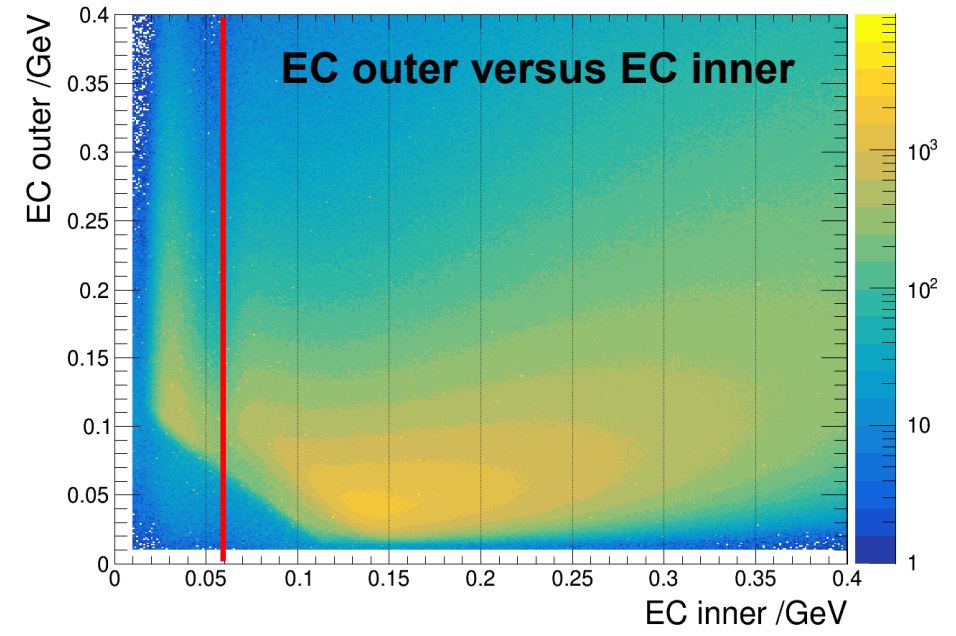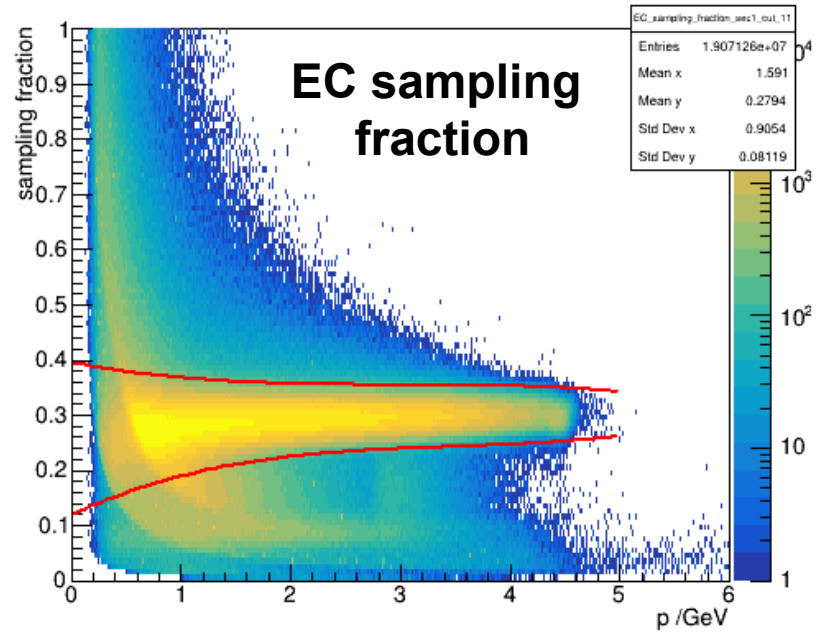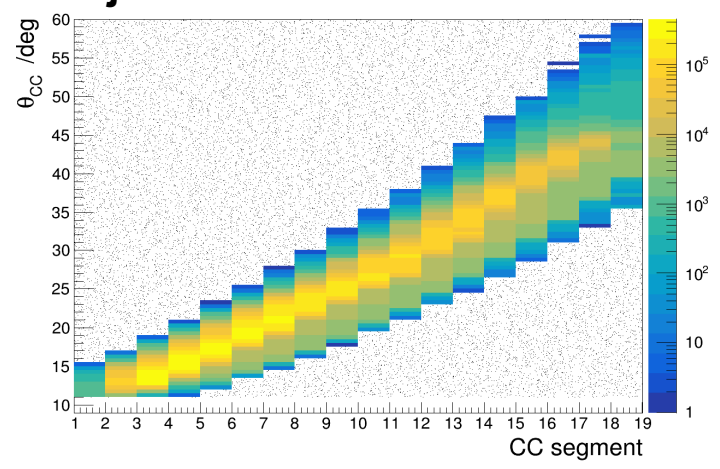| e1f	e16
electron beam	electron beam
5.498 GeV	**5.754 GeV**
~ 75 % polarisation	~ 70 % polarisation
unpolarized liquid hydrogen target	unpolarized liquid hydrogen target
60 % torus field	**100 % torus field**

Better detection of π^- Better detection of π^+

Electron identification

EC sampling fraction

EC outer versus EC inner
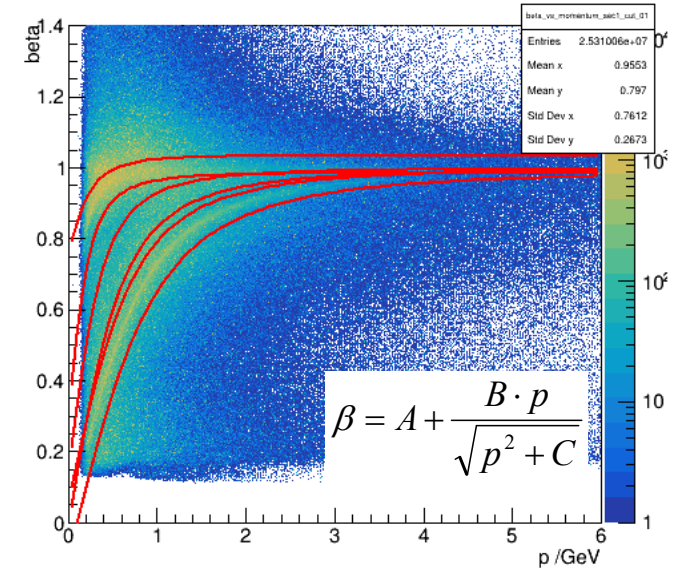
EC fiducial cut

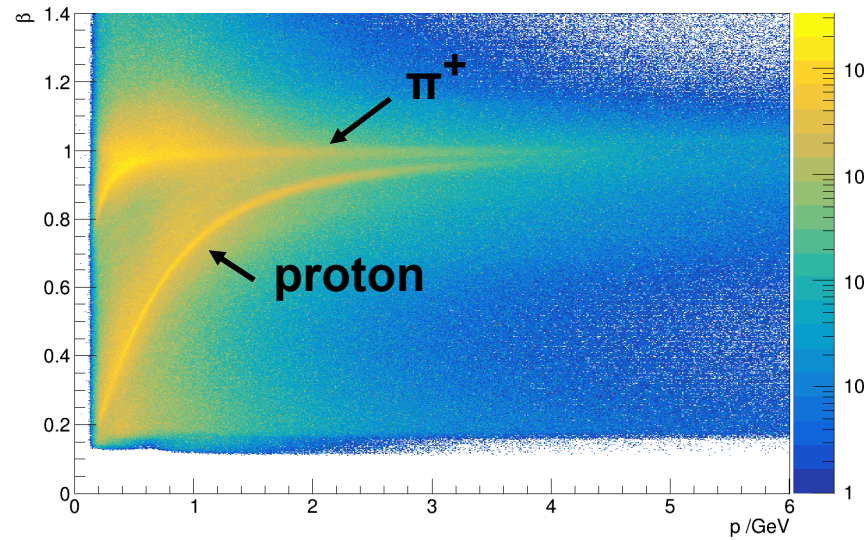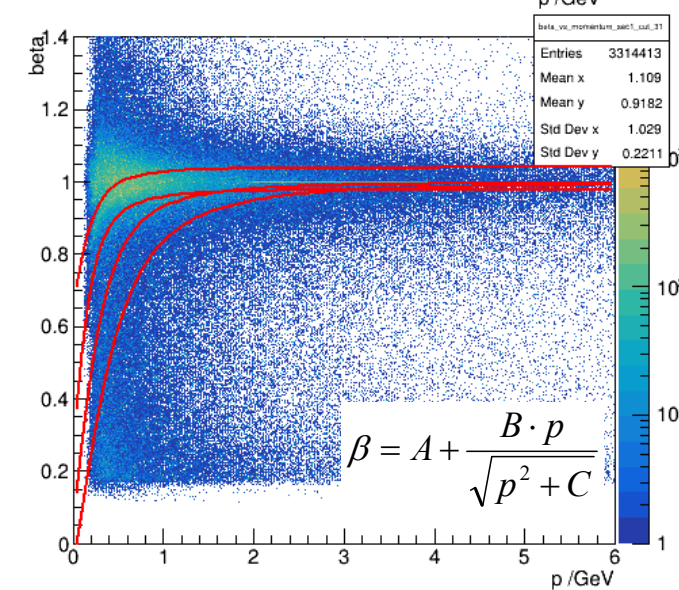CC fiducial and noise rejection cuts
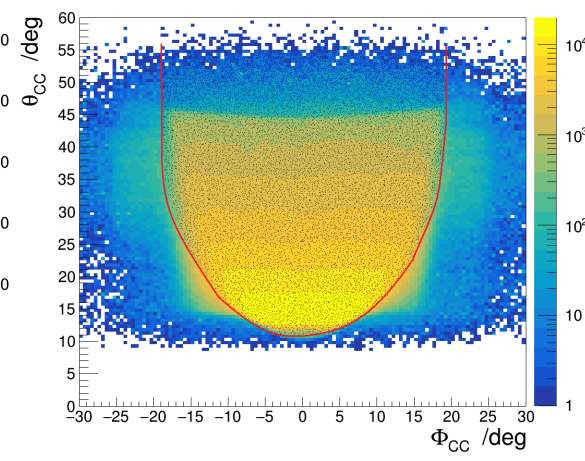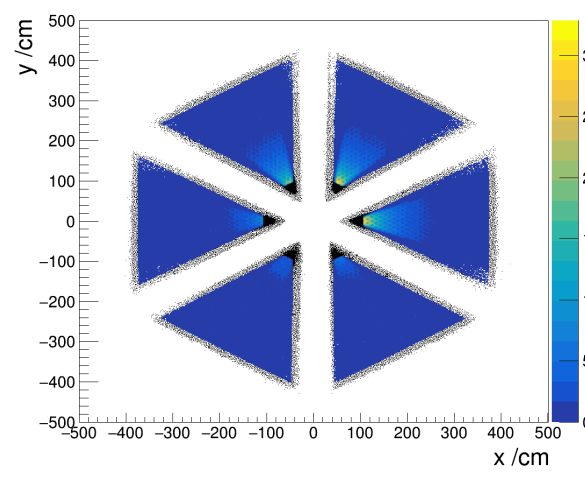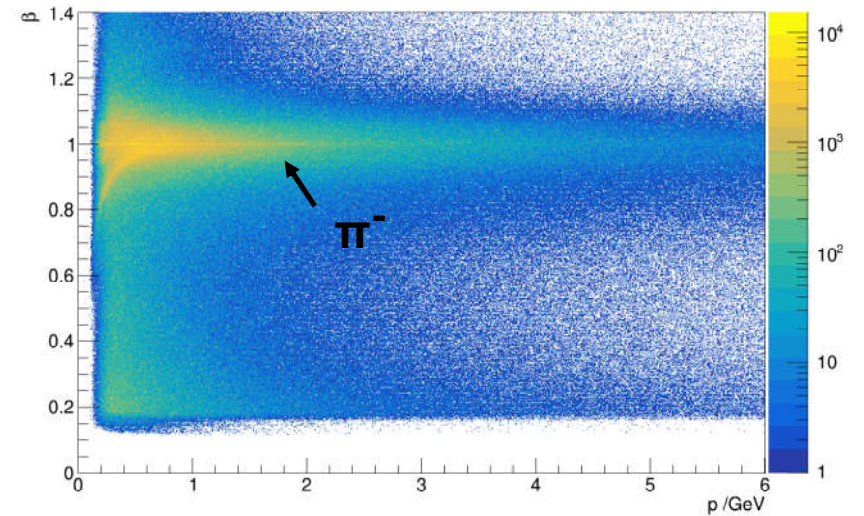
+ DC region 1 and 3 fiducial cuts   **+** z vertex cut

Proton and π± identification

positive charge
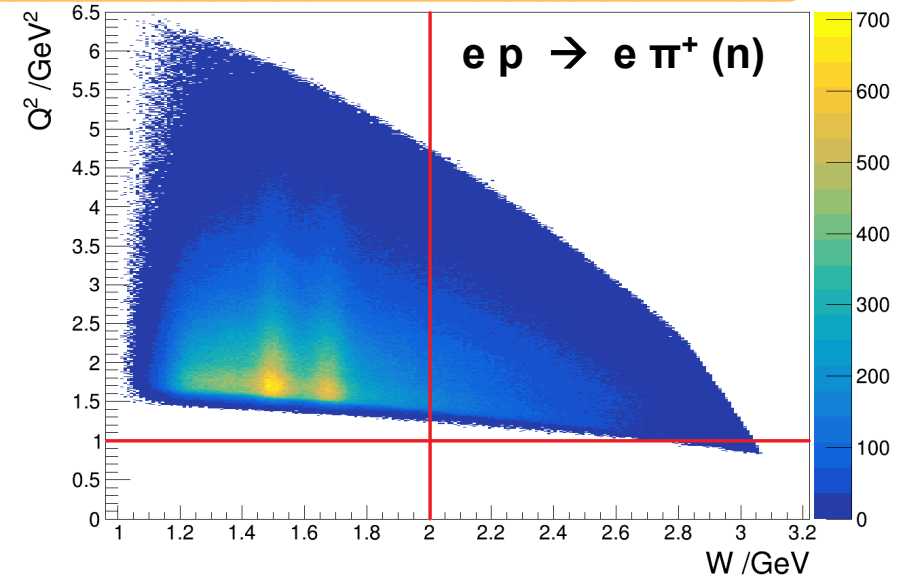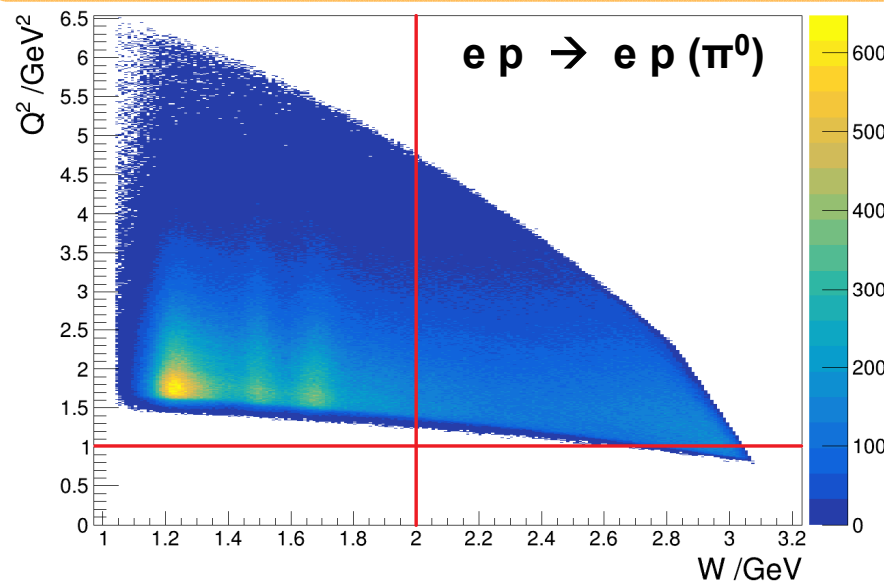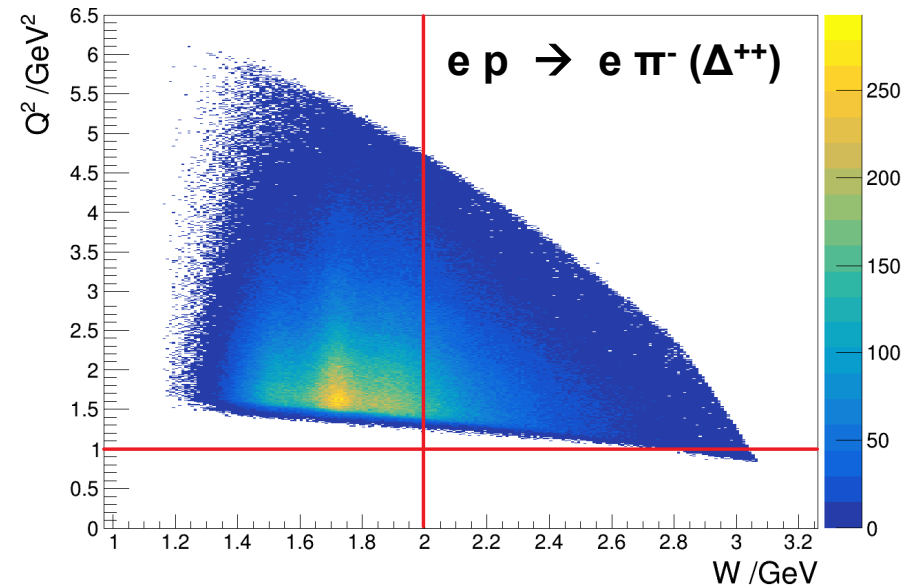
negative charge

$$\beta = A + \frac{B \cdot p}{\sqrt{p^2 + C}}$$

→ Fit adjusted to the 3σ region of a slice fit

Deep inelastic scattering (DIS) cuts

W > 2 GeV

Q² > 1 GeV²

Topology 1: e p → e π⁺ (n)
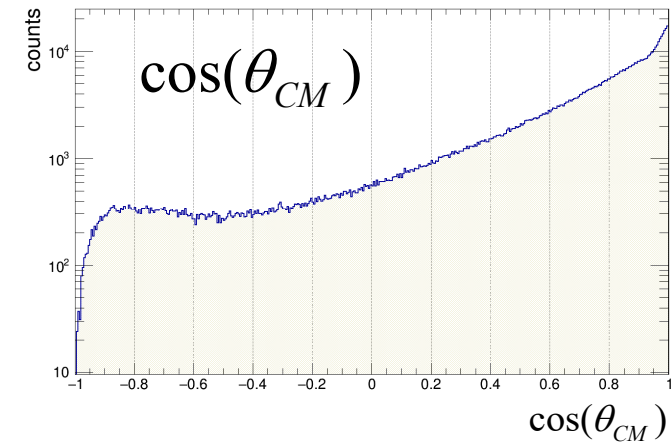### missing mass cut

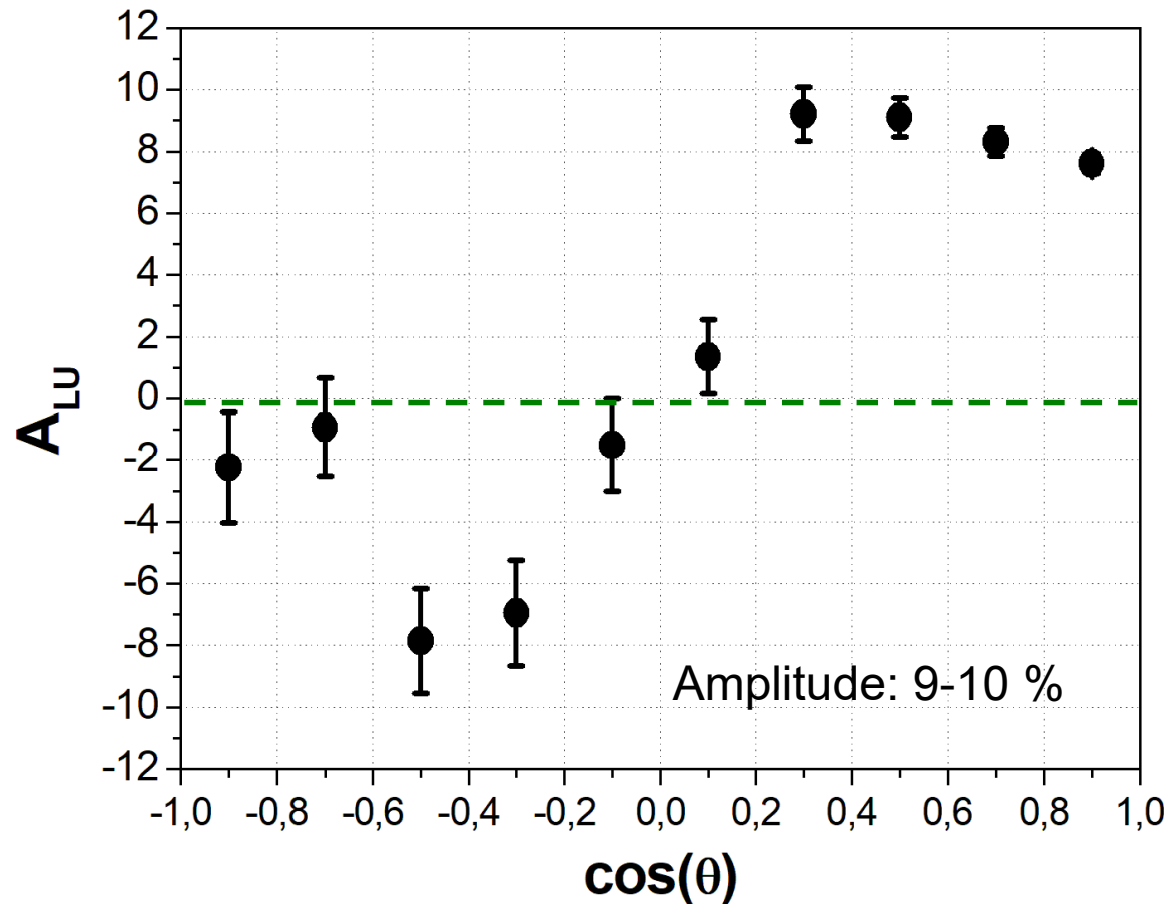# BSA for e p → e n π⁺

$$\frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} \propto A_{LU}^{\sin\varphi} \sin\varphi$$

A_{LU} for $e\,p \rightarrow e\,n\,\pi^{+}$

Amplitude: 9-10 %

$\cos(\theta_{CM})$
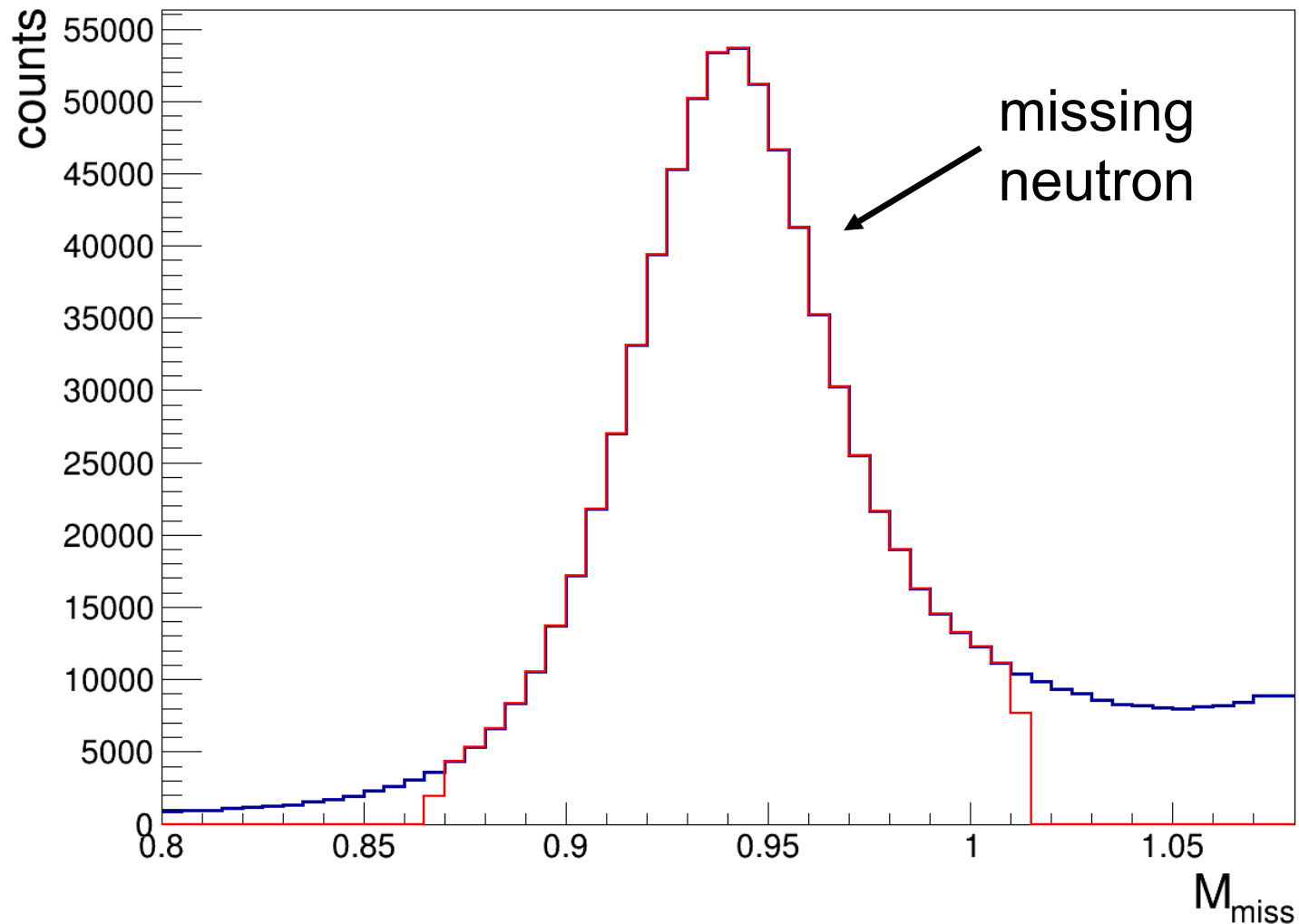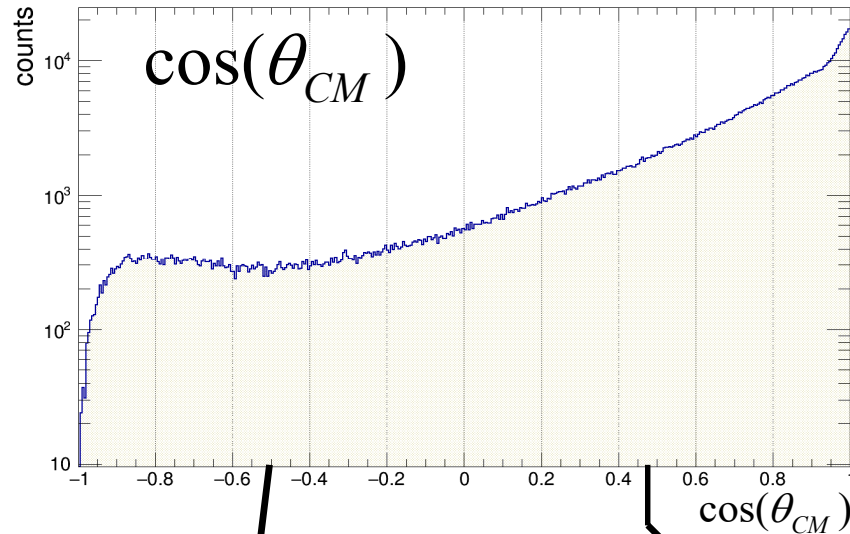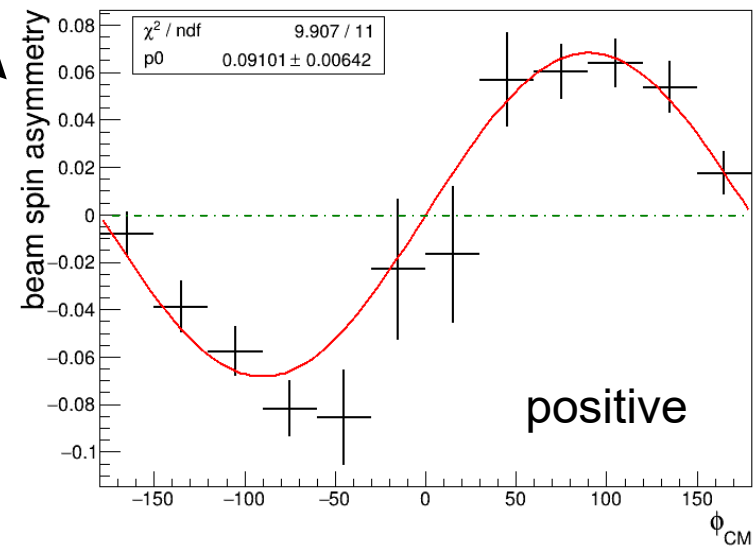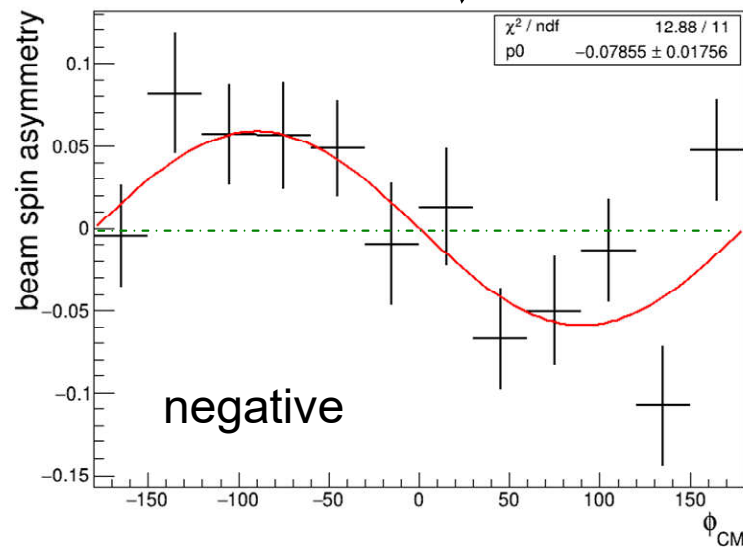
Reproduces the results David Riser showed at the last collaboration meeting

$$A_{LU} \propto \sin(\theta) \cdot \mathrm{Im}(F_{+0}^{++} + F_{+0}^{--})$$

Topology 2: e p → e p (π⁰)
missing mass cut

radiative photons have been rejected

$\alpha(\text{beam},X) > 5°$ and $\alpha(e`,X) > 3°$

missing π^0

M^2_{miss}

BSA for e p → e p π⁰

$$\frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} \propto A_{LU}^{\sin\varphi} \sin\varphi$$

$\cos(\theta_{CM})$

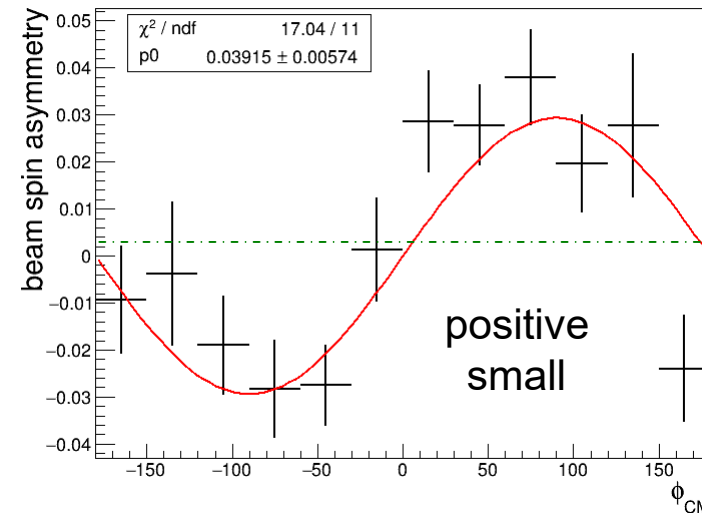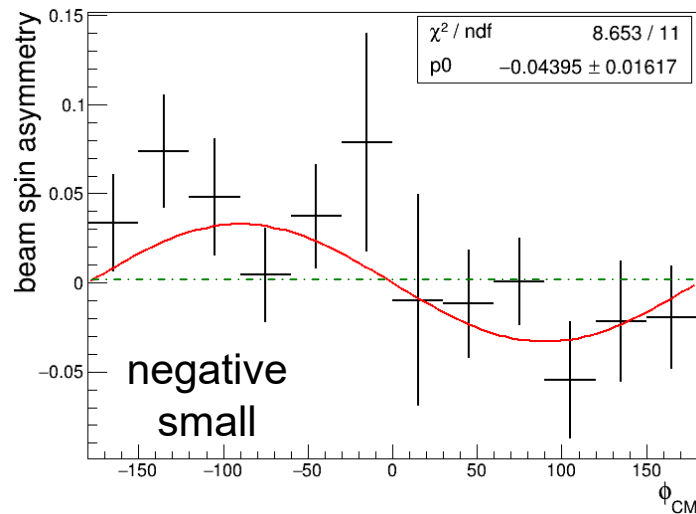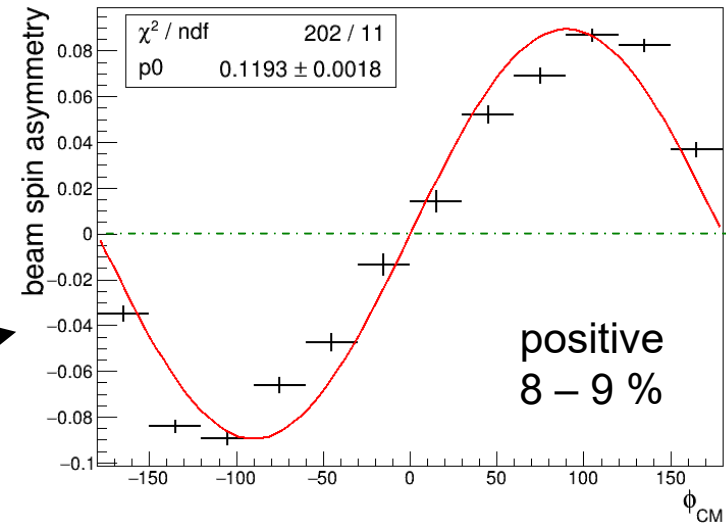positive
8 – 9 %

beam spin asymmetry

negative
small

positive
small

A_{LU} for $e\,p \to e\,p\,\pi^0$

$\cos(\theta_{CM})$
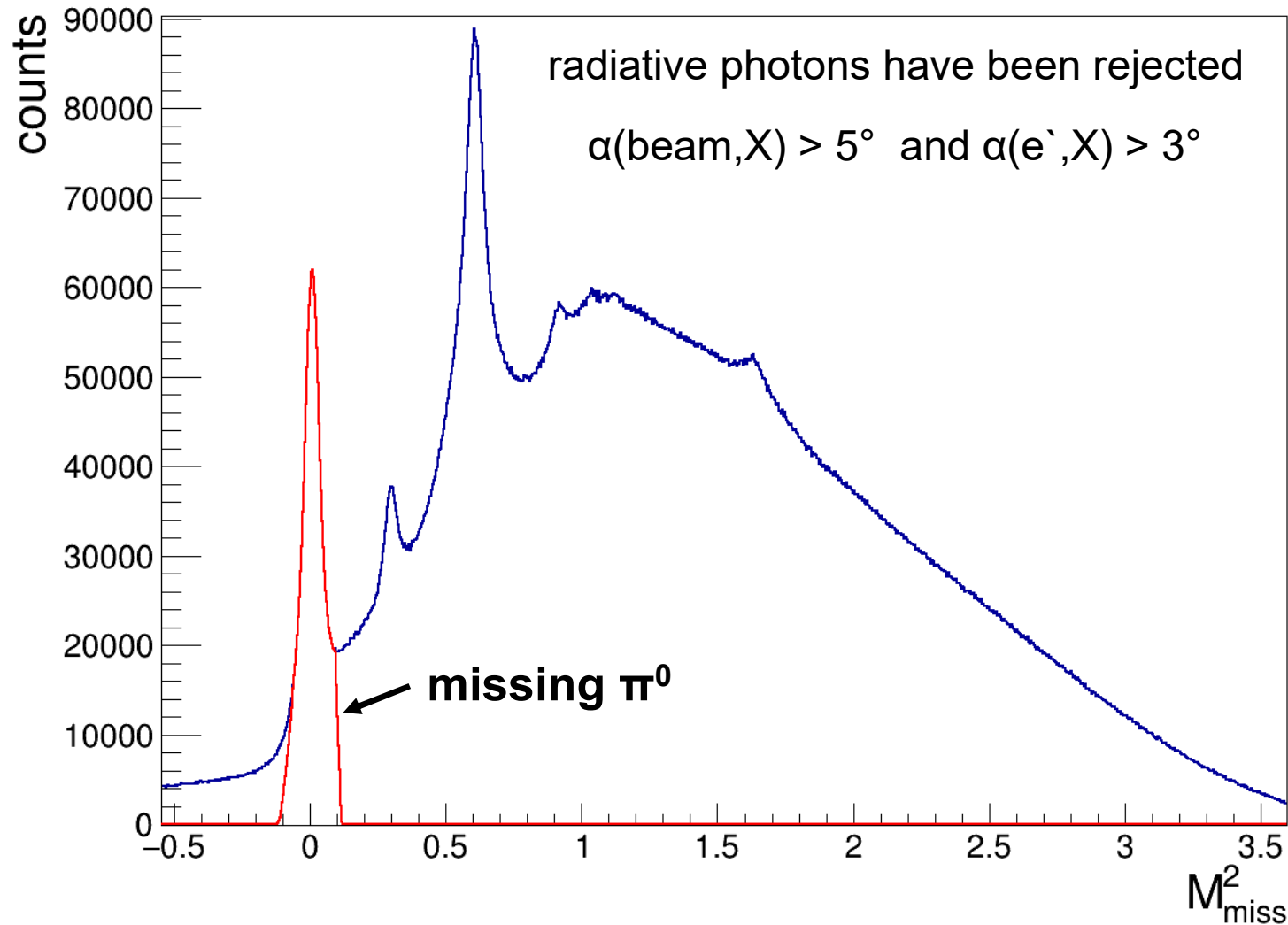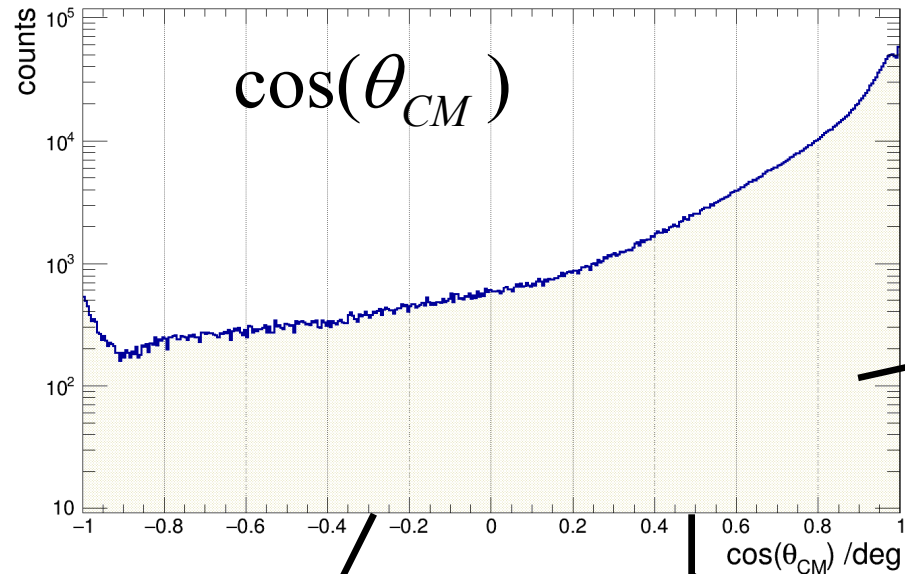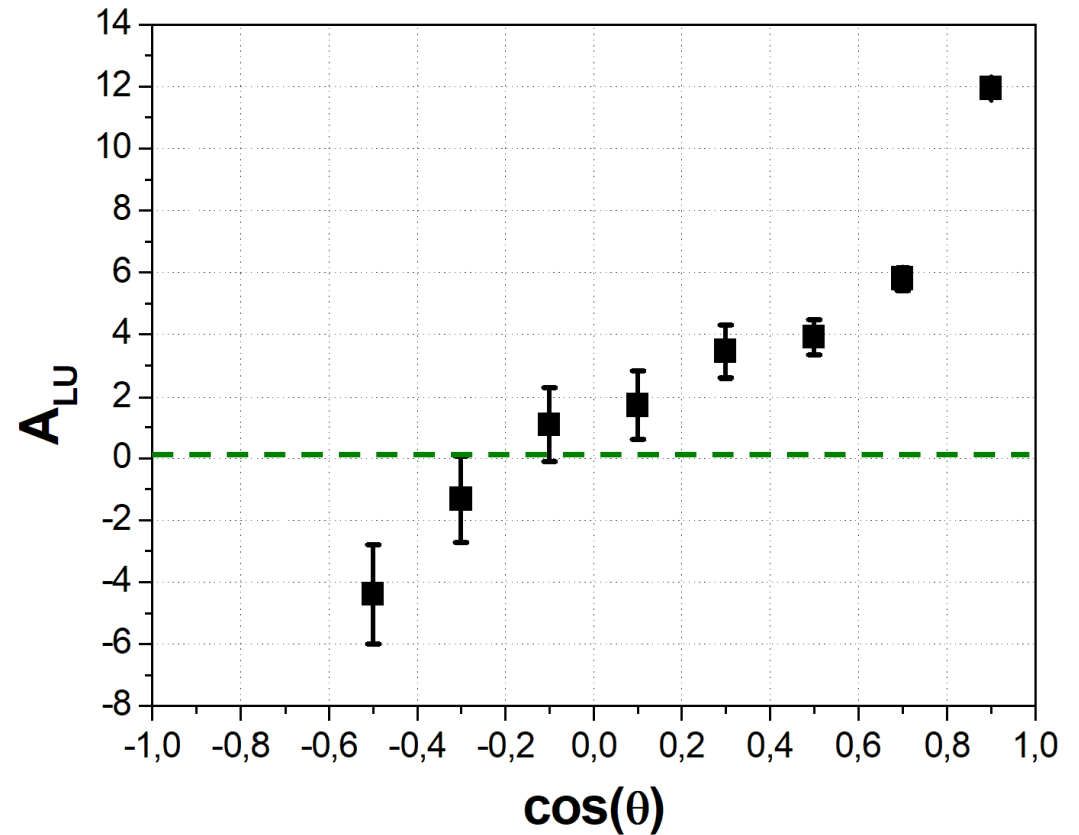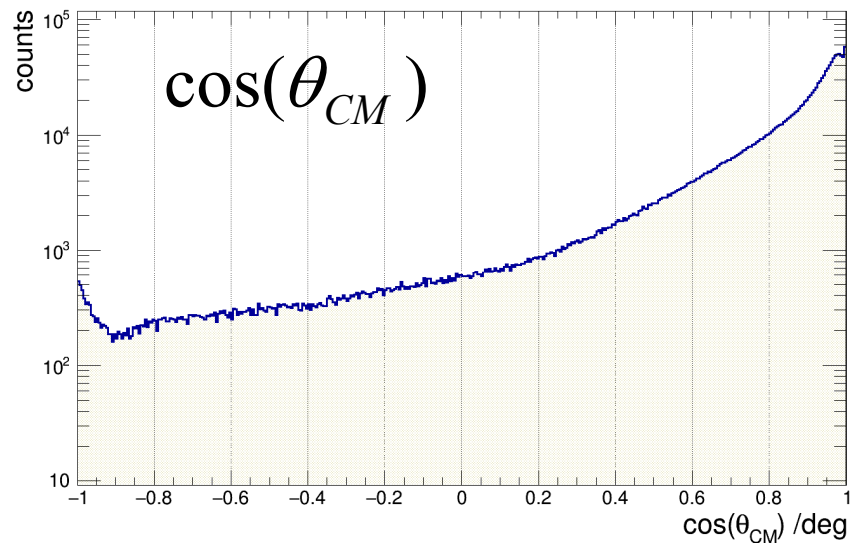
A_{LU} increases in forward directions

Topology 3: e p → e π⁻ (Δ⁺⁺)

missing mass cut

BSA for e p → e Δ⁺⁺ π⁻

A_{LU} for $e\,p \rightarrow e\,\Delta^{++}\,\pi^-$

amplitude: 4-5 %
offset: - 4-5 %
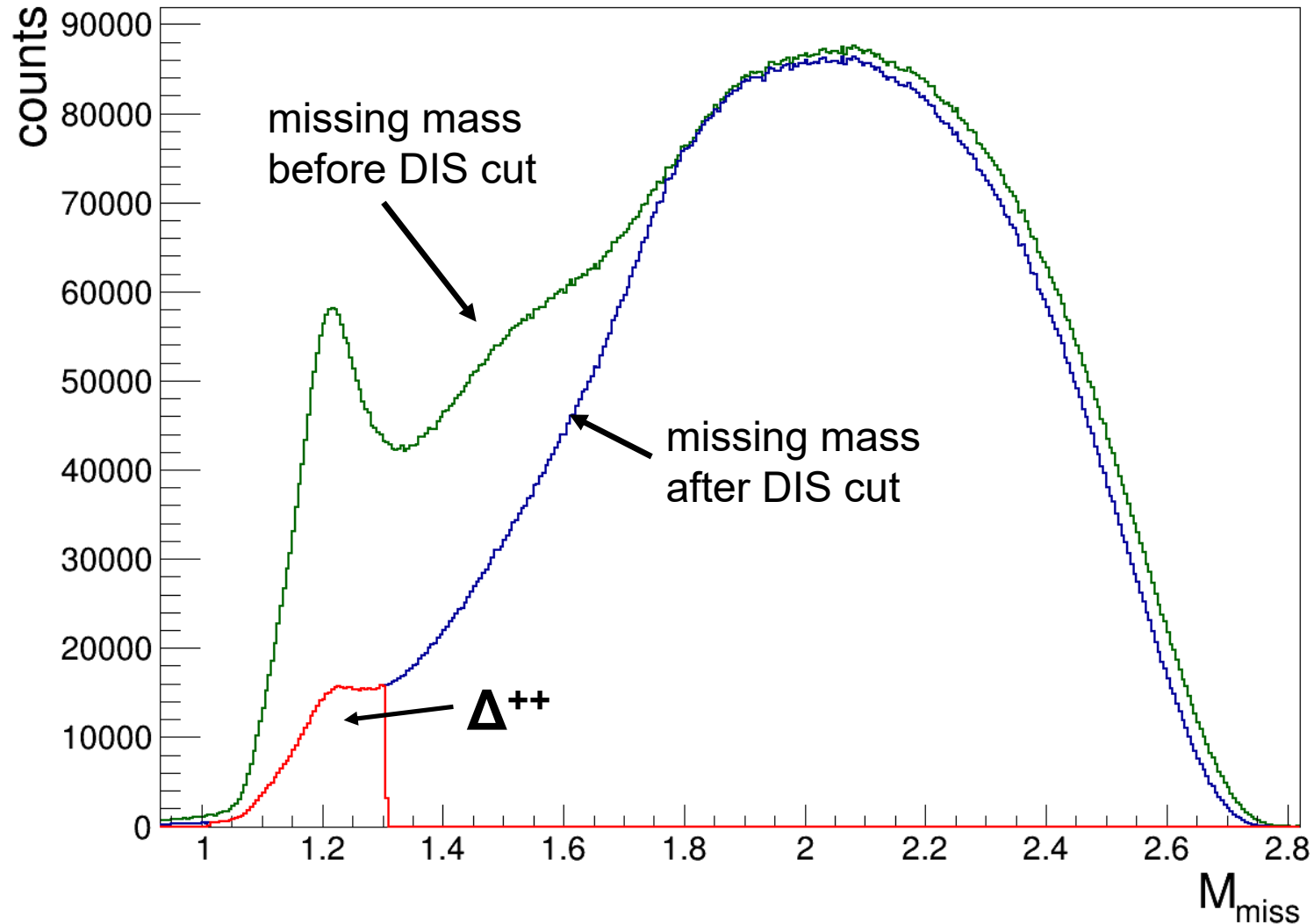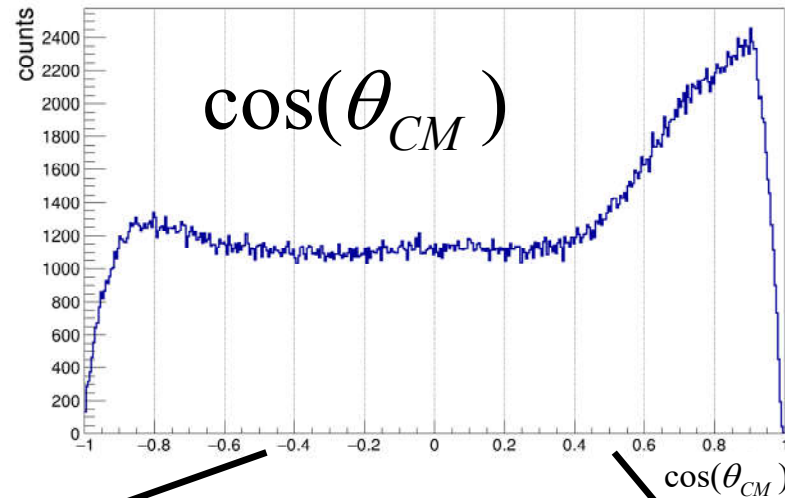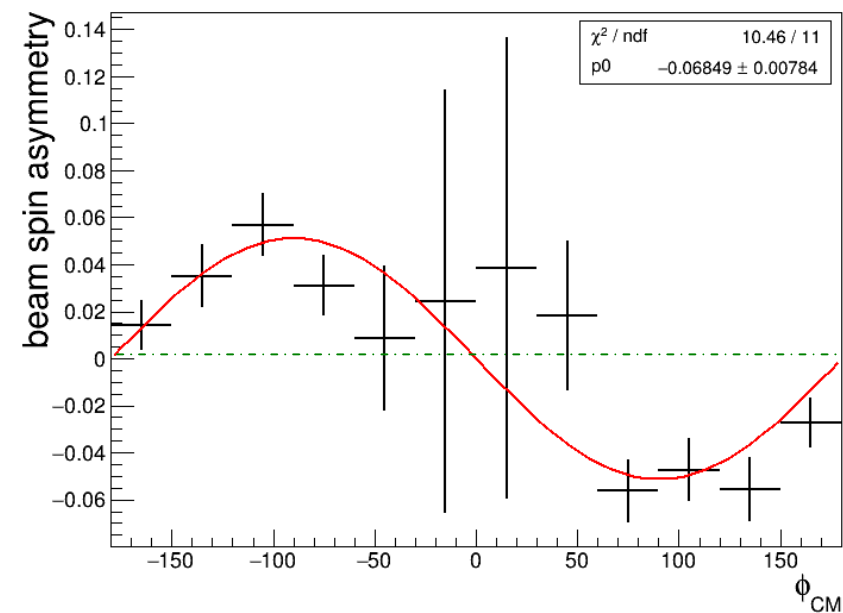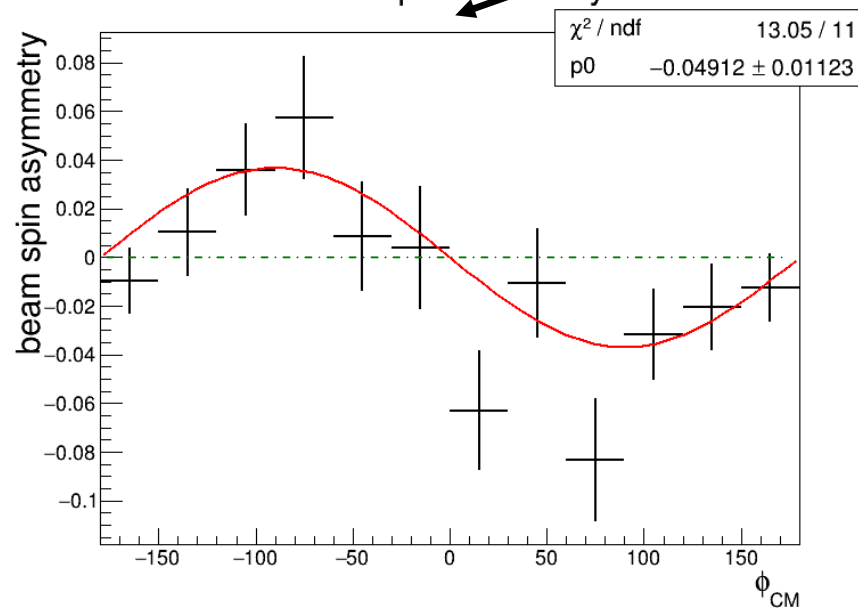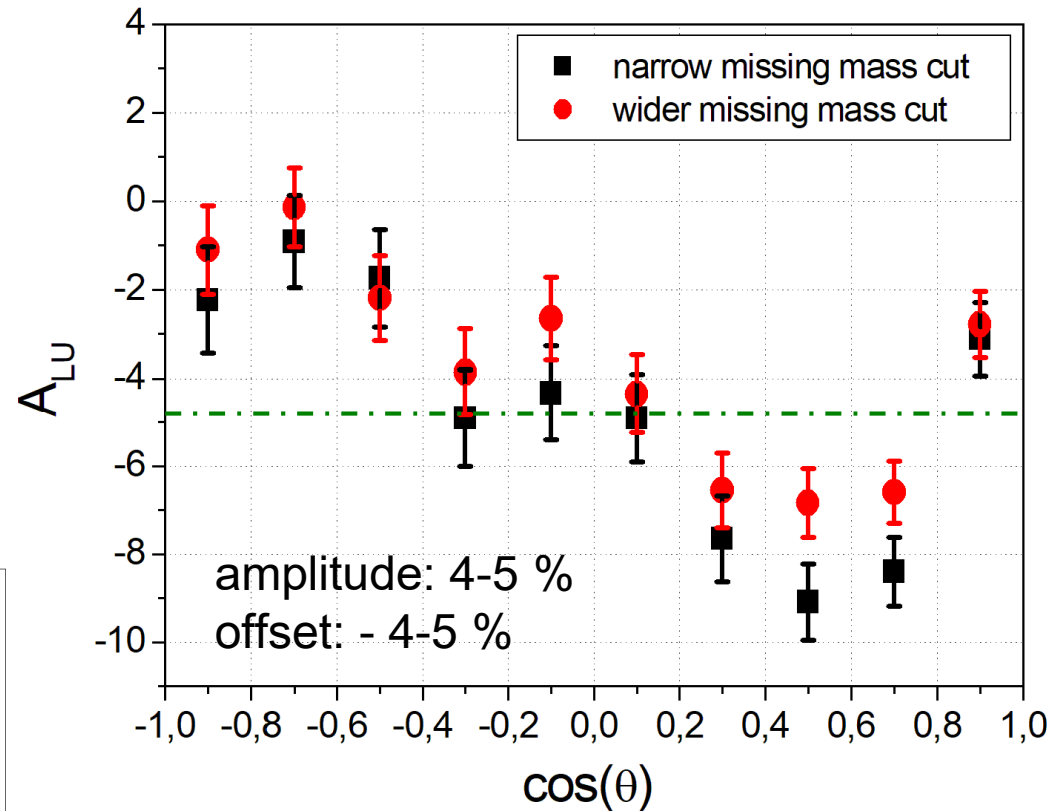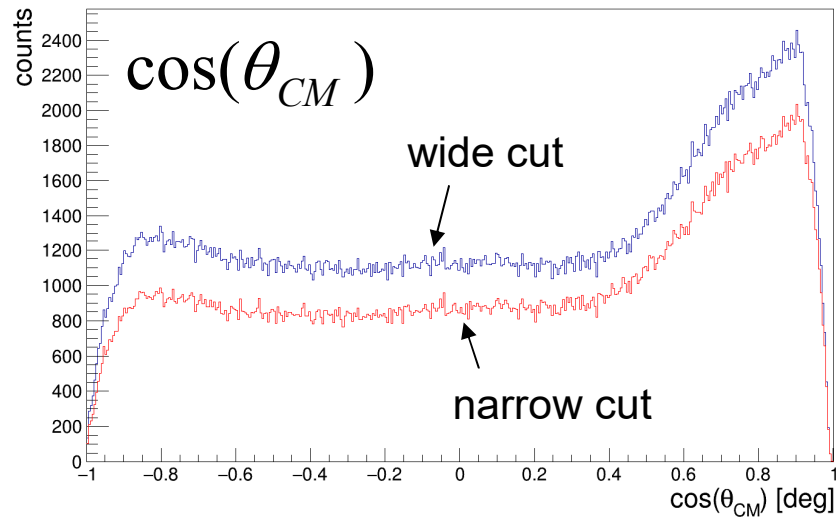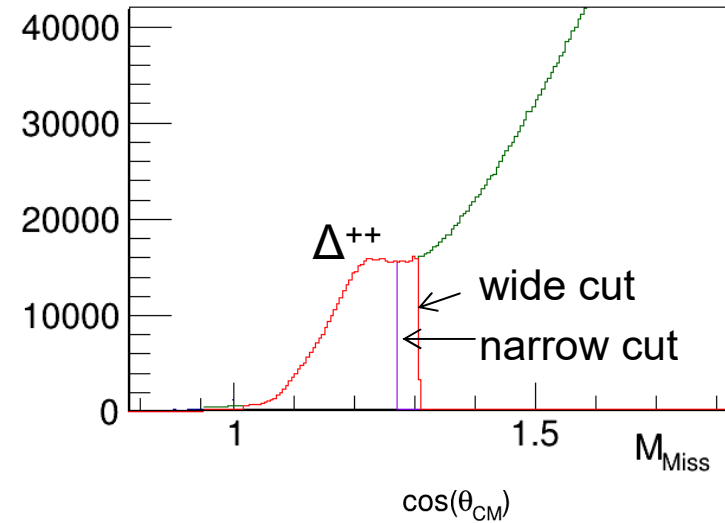
→ Negative offset

→ Significant background

→ Turning point at ~ 90°

Comparison of A_{LU} for the three pions
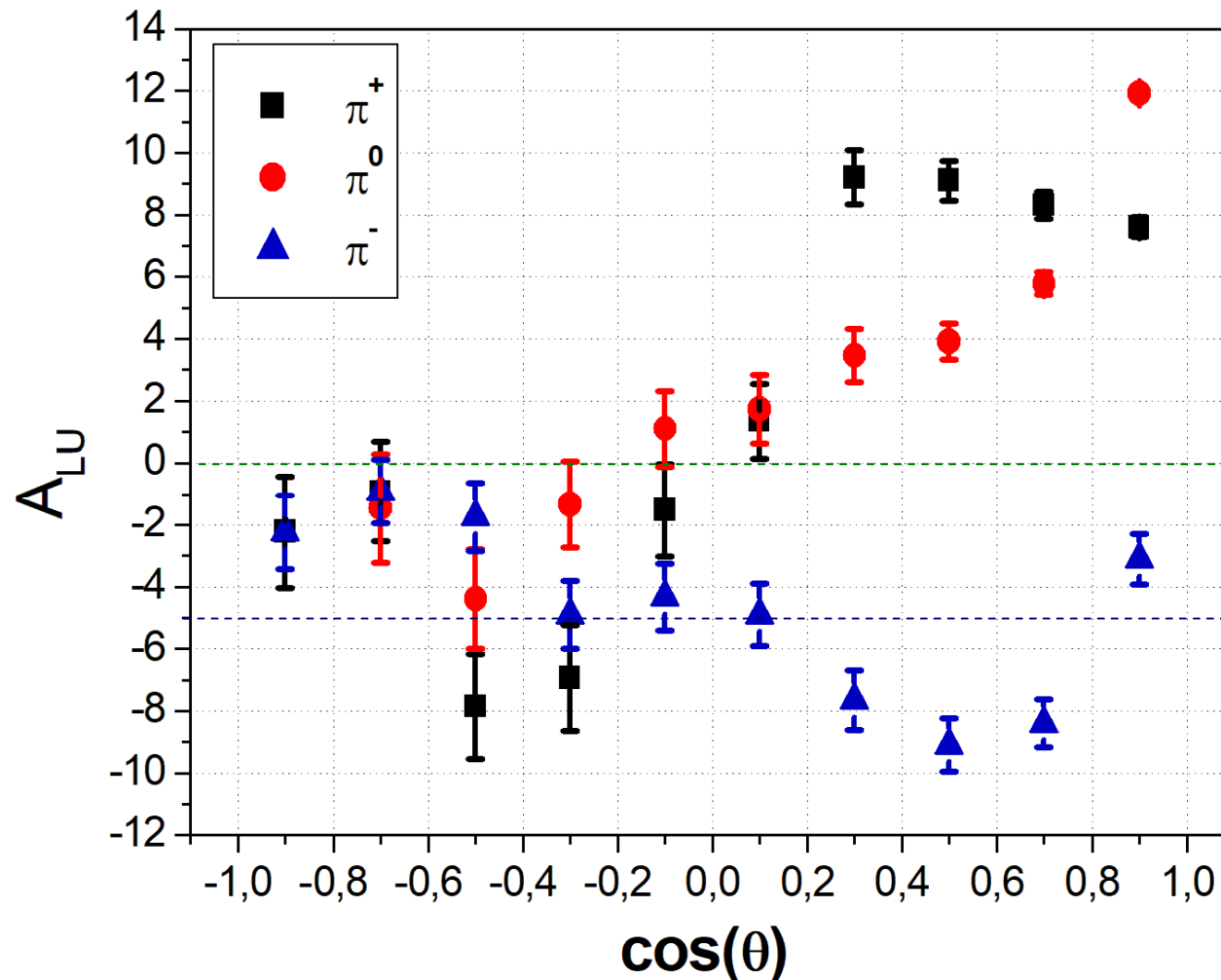
A_{LU} of π^+ is positive in forward directions and negative in backward directions

→ sign changes at 90°

A_{LU} of π^- shows an opposite bahviour if the offset is considered

→ turning point at 90°

A_{LU} of π^0 is small in the central region, but increases in very forward directions

→ sign changes ~ 90°

Summary and Outlook

➡ The forward – backward asymmetry has been determined for the first time for all three pions

➡ A sign change of A_{LU} from positive to negative has been observed for π^+ and π^0 if we go from the forward to the backward region

➡ Considering the offset, π^- shows an opposite bahaviour

➡ Additional topologies will be studied:

  e p → e p X   (missing η, ρ)
  e p → e π^0 X   (missing proton)
  e p → e p π^0,   e p → e p η   (exclusive)

➡ Kinematic fitting will be applied to achive a better background separation (see next talk by Frank Cao)

➡ BSA will be extracted with the established procedures for 2.2, 6.4 and 10.6 GeV data of CLAS 12