CLAS Collaboration Meeting, JLAB

07/10 – 07/13/2018

Beam Spin Asymmetry of SIDIS pions with CLAS 12

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Introduction

- Physics motivation
- Partcile identification
- Preliminary results

- run 3432 (~ 1400 files)
  → 10.6 GeV
  → solenoid -100%, torus -100%
  → cooked with coatjava v. 5b.3.3

Physics Motivation

- The 3D nucleon structure can be described with GPDs and TMDs
- The **SIDIS** cross section can be expressed in terms of model independent structure functions:

$$\frac{d\sigma}{dx_B\, dQ^2\, dz\, d\phi_h\, dp_{h\perp}^2} = K(x,y,Q^2)\Big\{F_{UU,T} + \varepsilon F_{UU,L}$$

$$+\sqrt{2\,\varepsilon(1+\varepsilon)}\cos\phi_h F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h) F_{UU}^{\cos 2\phi_h} + \lambda_e\sqrt{2\,\varepsilon(1-\varepsilon)}\sin\phi_h F_{LU}^{\sin\phi_h}\Big\}$$

$$F_{LU}^{\sin\phi} = \frac{2M}{Q}\mathcal{C}\left(-\frac{\hat{\mathbf{h}}\cdot\mathbf{k_T}}{M_h}\left(xeH_1^{\perp} + \frac{M_h}{M}f_1\frac{\tilde{G}^{\perp}}{z}\right) + \frac{\hat{\mathbf{h}}\cdot\mathbf{p_T}}{M}\left(xg^{\perp}D_1 + \frac{M_h}{M}h_1^{\perp}\frac{\tilde{E}}{z}\right)\right)$$

twist-3 pdf (e)

Collins FF ($H_1^{\perp}$)

unpolarized dist. function (f_1)

twist-3 FF ($\tilde{G}^{\perp}$)

twist-3 t-odd dist. funcion ($g^{\perp}$)

Boer-Mulders ($h_1^{\perp}$)

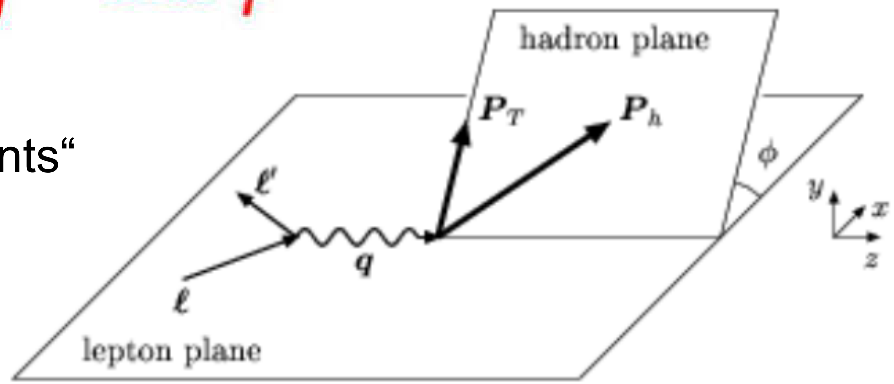
twist-3 FF ($\tilde{E}$)

Mulders, Tangerman (1995)

Physics Motivation

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

$$\approx A_{LU}^{\sin\varphi}\sin\varphi$$



- BSA is a good tool to extract the „moments“

Experimetally:

$$BSA_i = \frac{1}{P_e}\frac{N_i^+ - N_i^-}{N_i^+ + N_i^-}$$

- Helicity independent acceptance terms cancel out in the ratio!

Particle ID

- A clean particle ID is the key for all SIDIS analyses

→ There is no additional event selection criterium

→ Each particle should have a clear ID

→ It may be better to reject a particle than to assign it a wrong PID

a) Electron ID

→ Based on eventbuilder PID

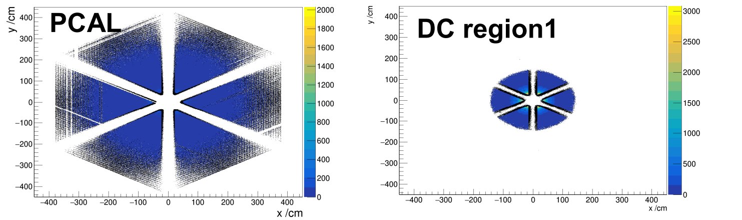
+ fiducial cuts for PCAL

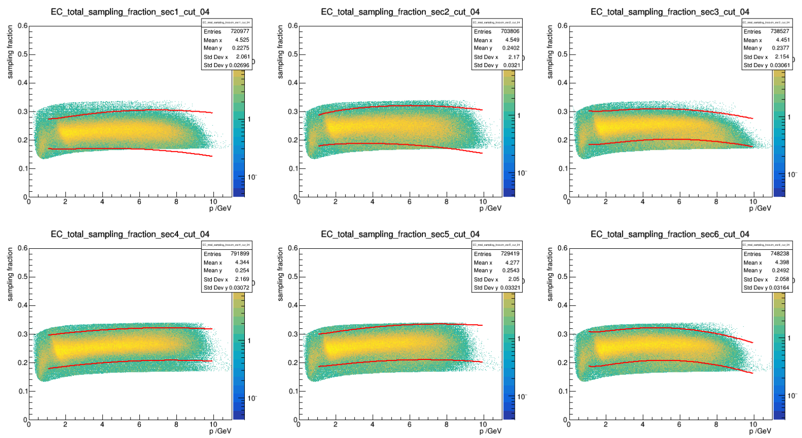
+ fiducial cuts for DC

+ Calorimeter sampling fraction cut limitted to real 3σ region

+ E > 1.5 GeV @ 10.6 GeV

+ relatively wide z vertex cut





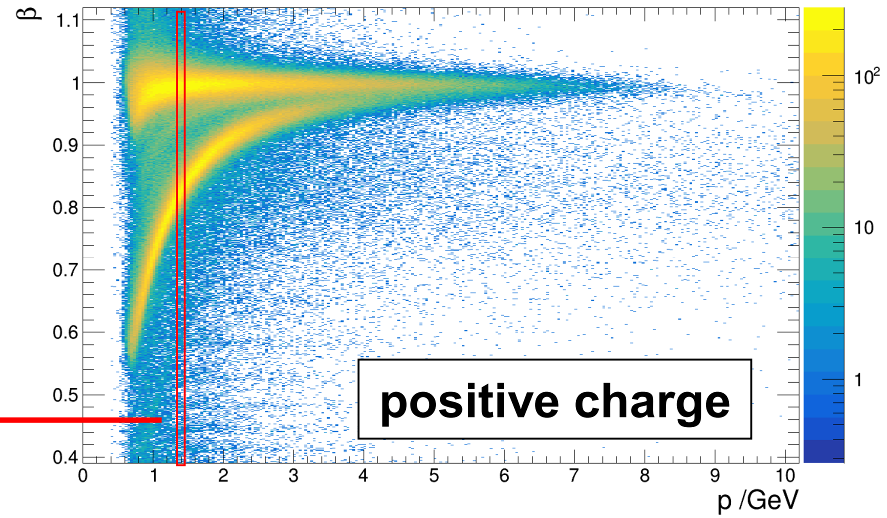
b) Photon ID

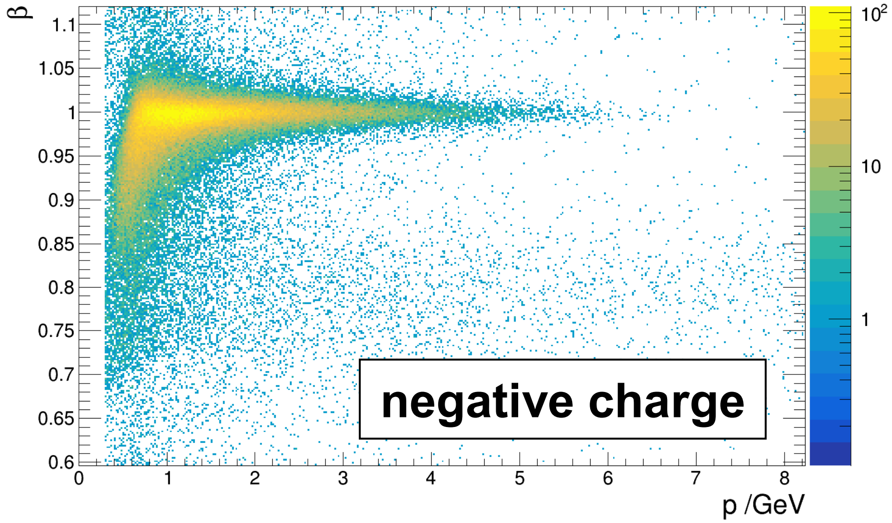
→ Based on standard PID + fiducial cuts for PCAL + β > 0.95

c) Hadron Particle ID

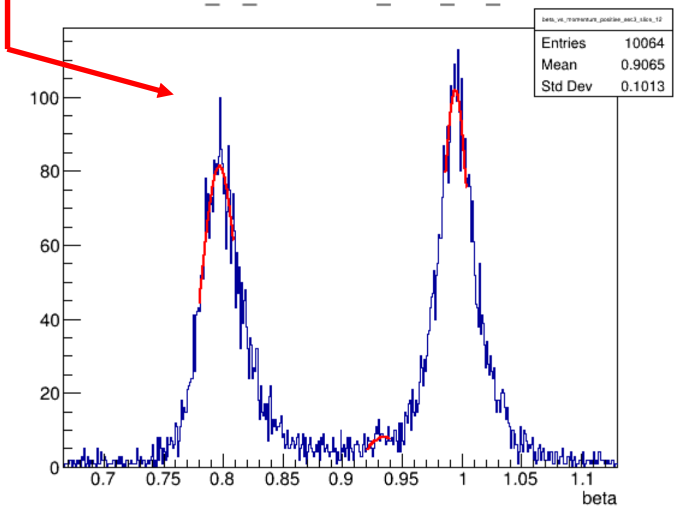
i) Fiducial cuts on the 3 Driftchamber regions

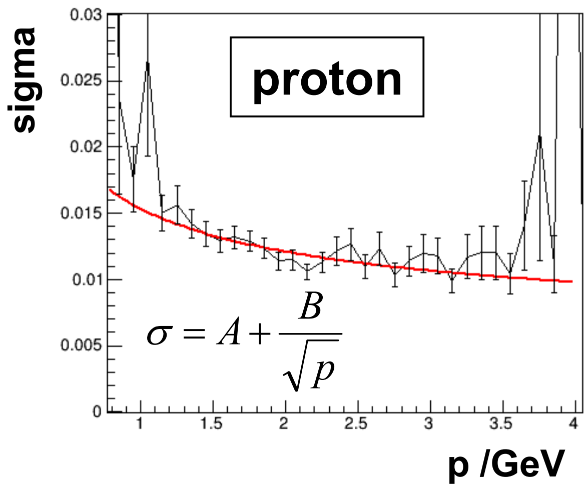
ii) Particle selection based on β vs p correlation

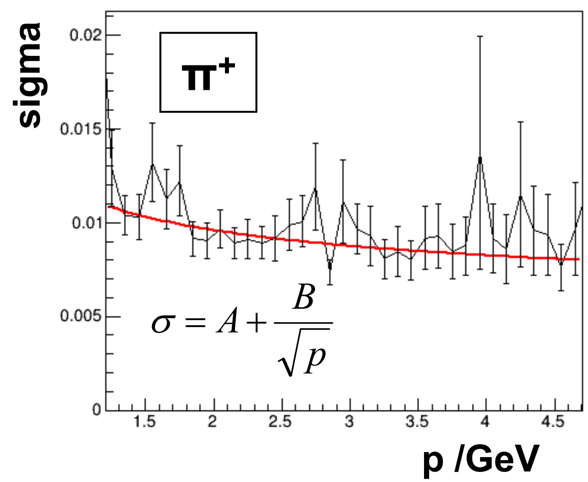




100 MeV p slices for each sector



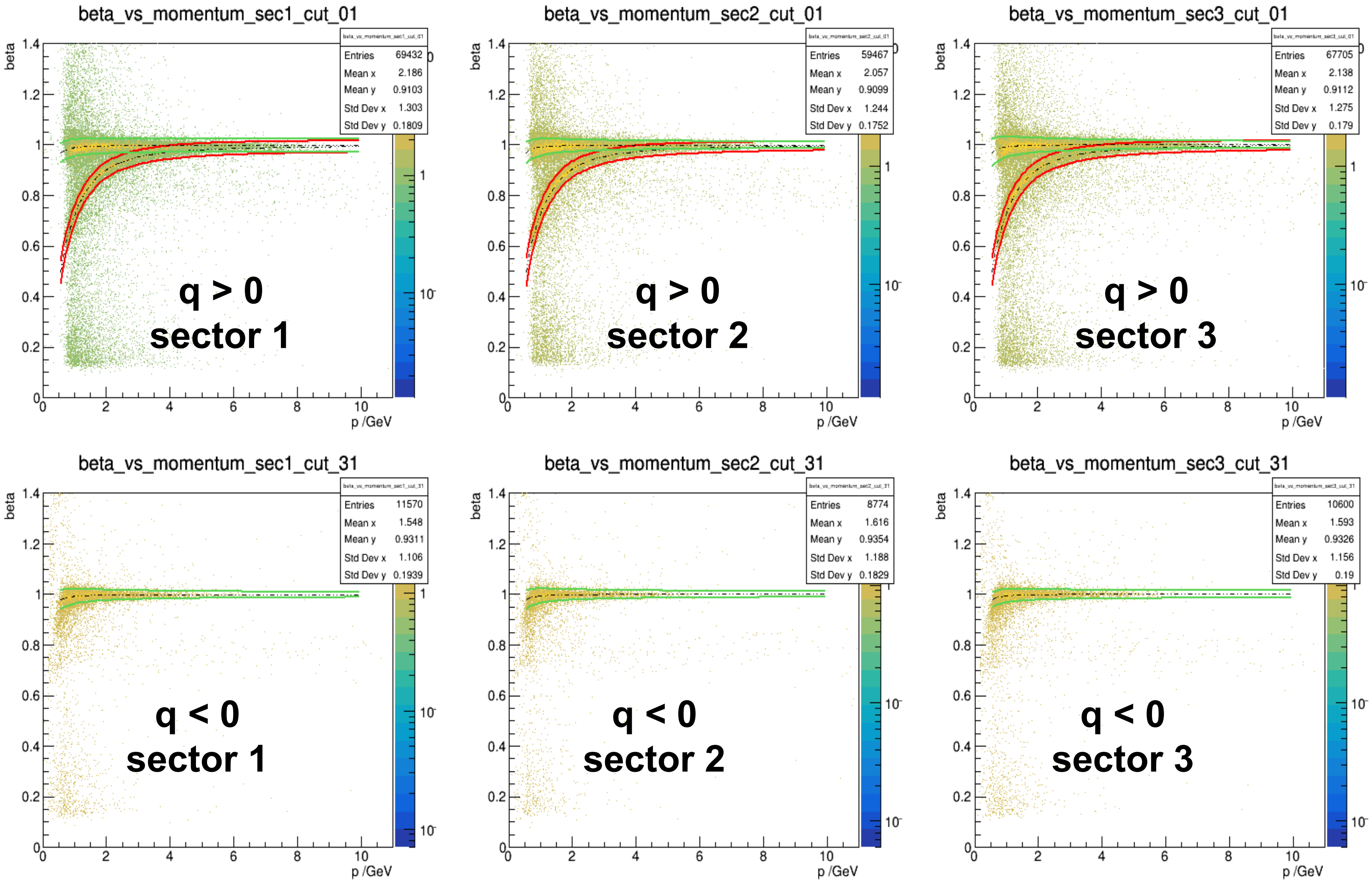




Mean and 3 sigma region

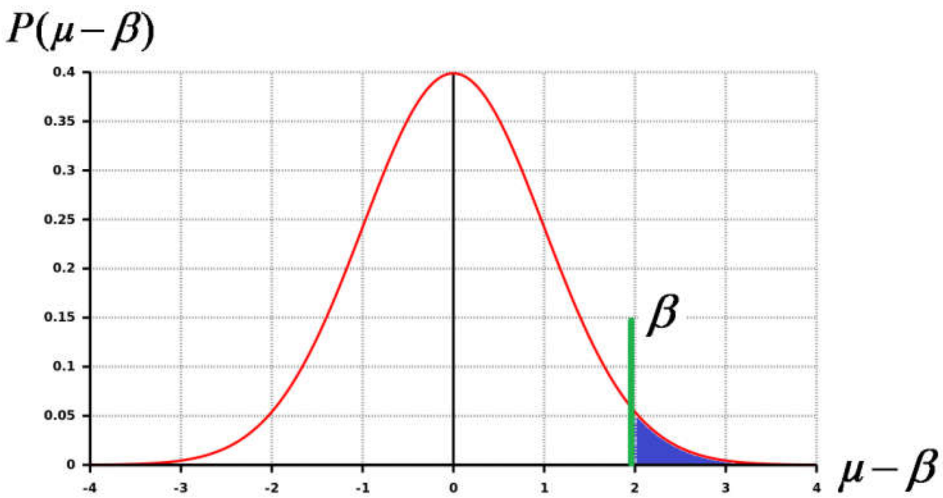
q > 0

q < 0



Maximum Likelihood Particle ID

- Simple β vs p cut: particles are double assigned in the overlap region
  ➔ Assignment of each particle based on statistical probabilities



$$P(\beta)=\frac{1}{\sqrt{2\pi\sigma}}\cdot\exp\left(-\frac{1}{2}\left(\frac{\beta-\mu}{\sigma}\right)^2\right)$$

Consider: Particles have momentum dependend population fractions

$$n_{\pi^+}(p)=\frac{N_{\pi^+}(p)}{N_{\pi^+}(p)+N_P(p)+N_{K^+}(p)}$$

$$\Rightarrow \boxed{p_{\pi^+}=n_{\pi^+}(p)\cdot P(\beta,p)}$$

→ Calculate p(β) for each particle species

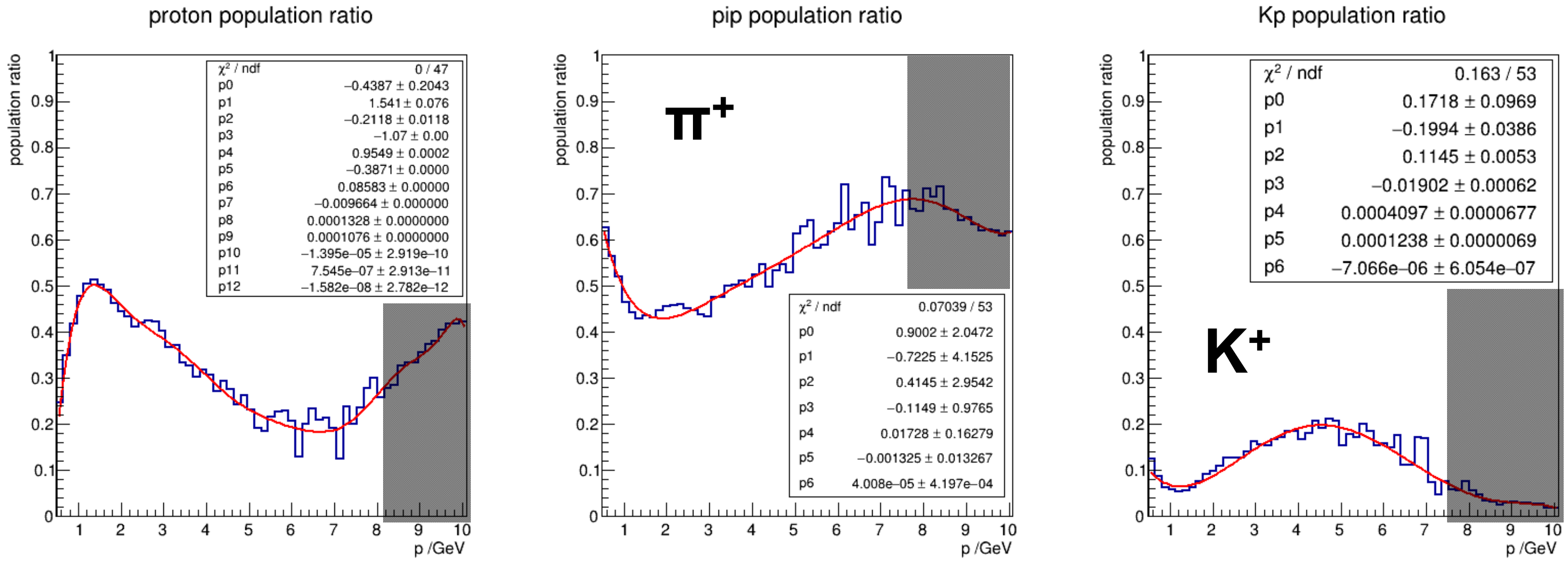
→ Assign particle to species with the highest probability

→ Calculate the confidence level for the particle species

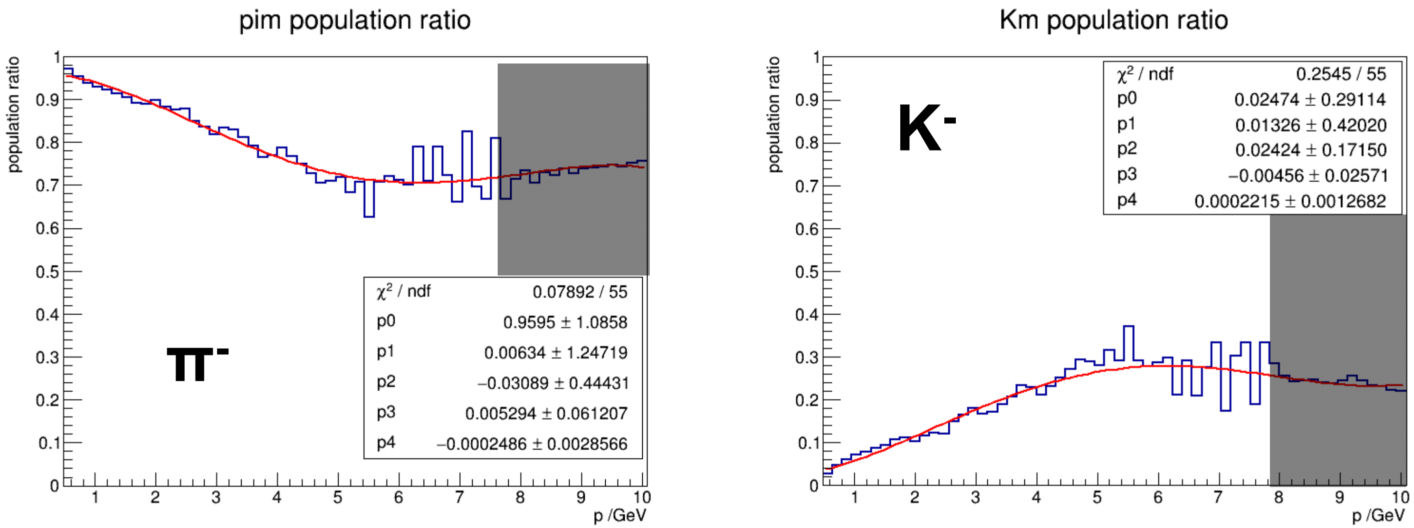
→ Check if particle is within the 3 sigma region (conf. lev. > 0.27%)

Population ratio for detected particles (outbending)

positive charge



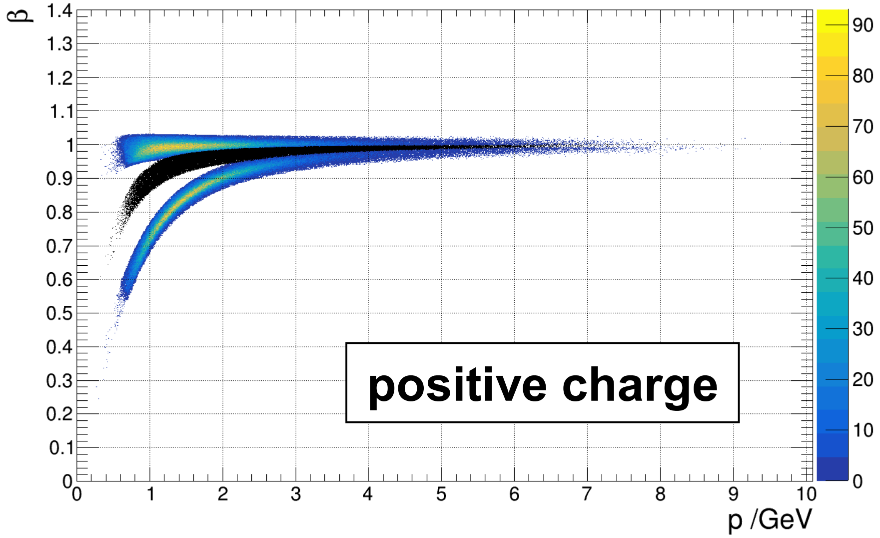
negative charge

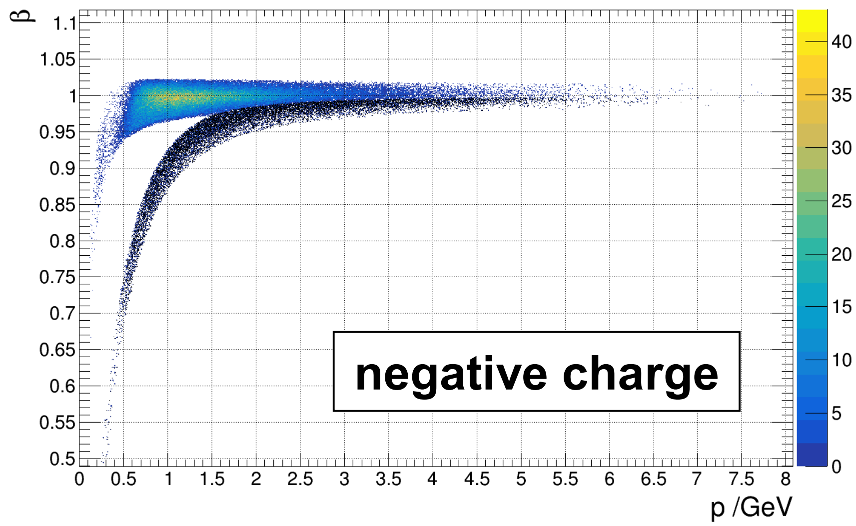


based on SIDIS simulations

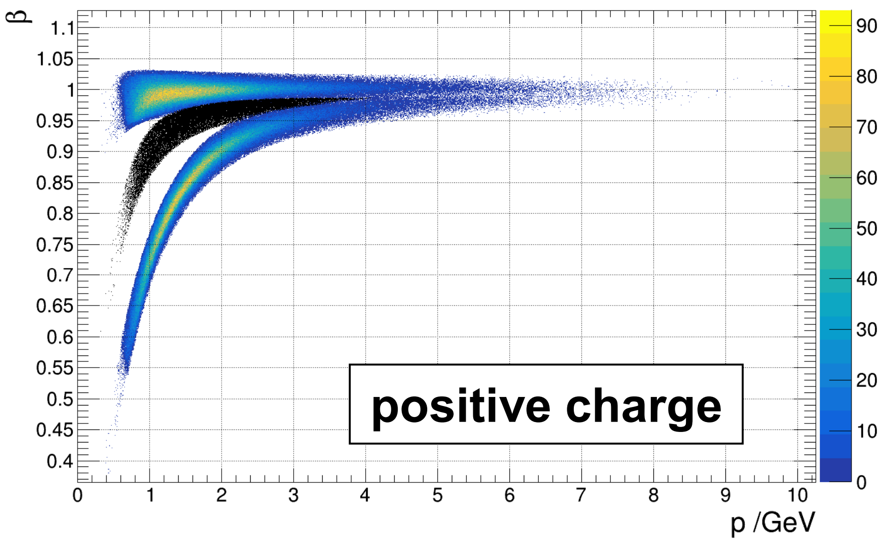
Maximum Likelihood Particle ID

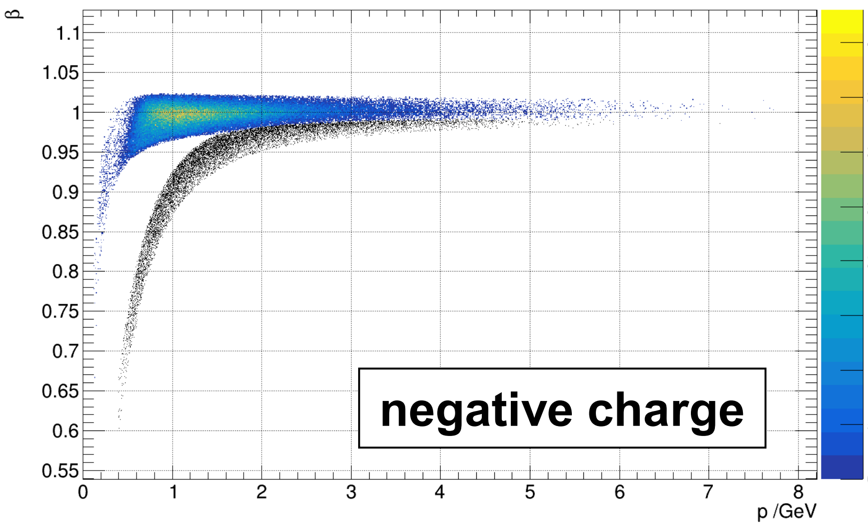
no population weighting





population weighting

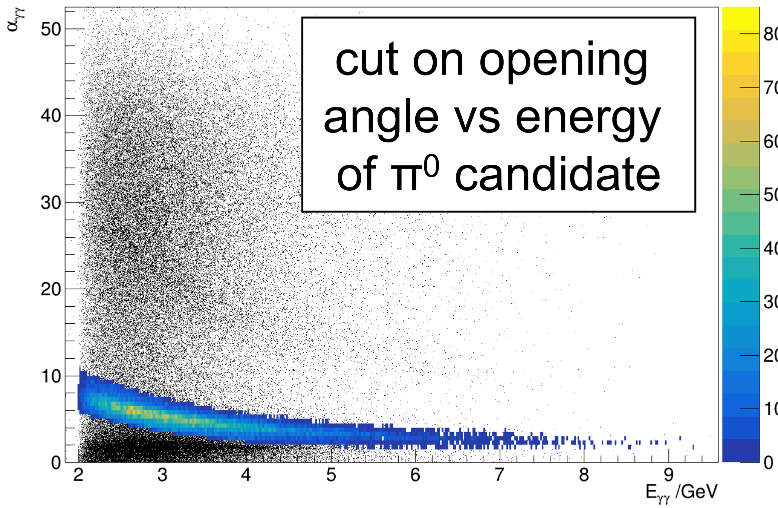


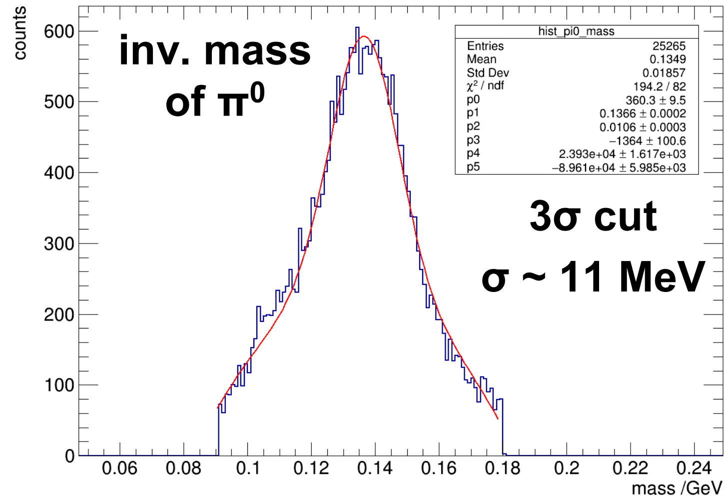


π^0 Selection and kinematic coverage

π^0 selection:

$E_\gamma > 1$ GeV





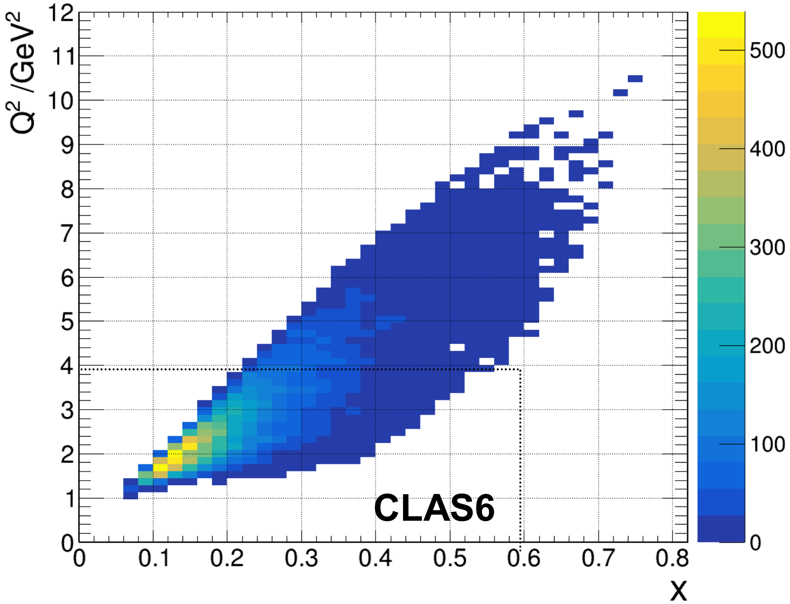
DIS cut: $Q^2 > 1$ GeV² $W > 2$ GeV

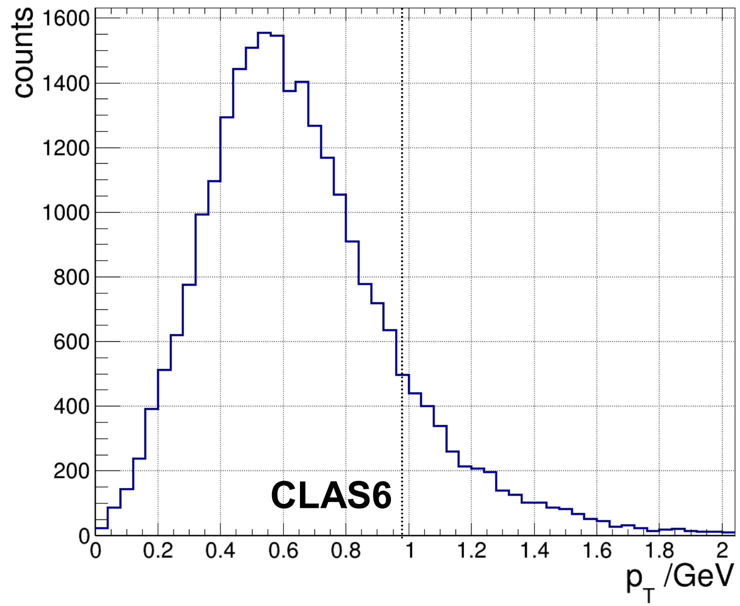
kinematic coverage significantly extended compared to CLAS6

CLAS6:

$Q^2 < 4$ GeV²

$p_T < 1$ GeV



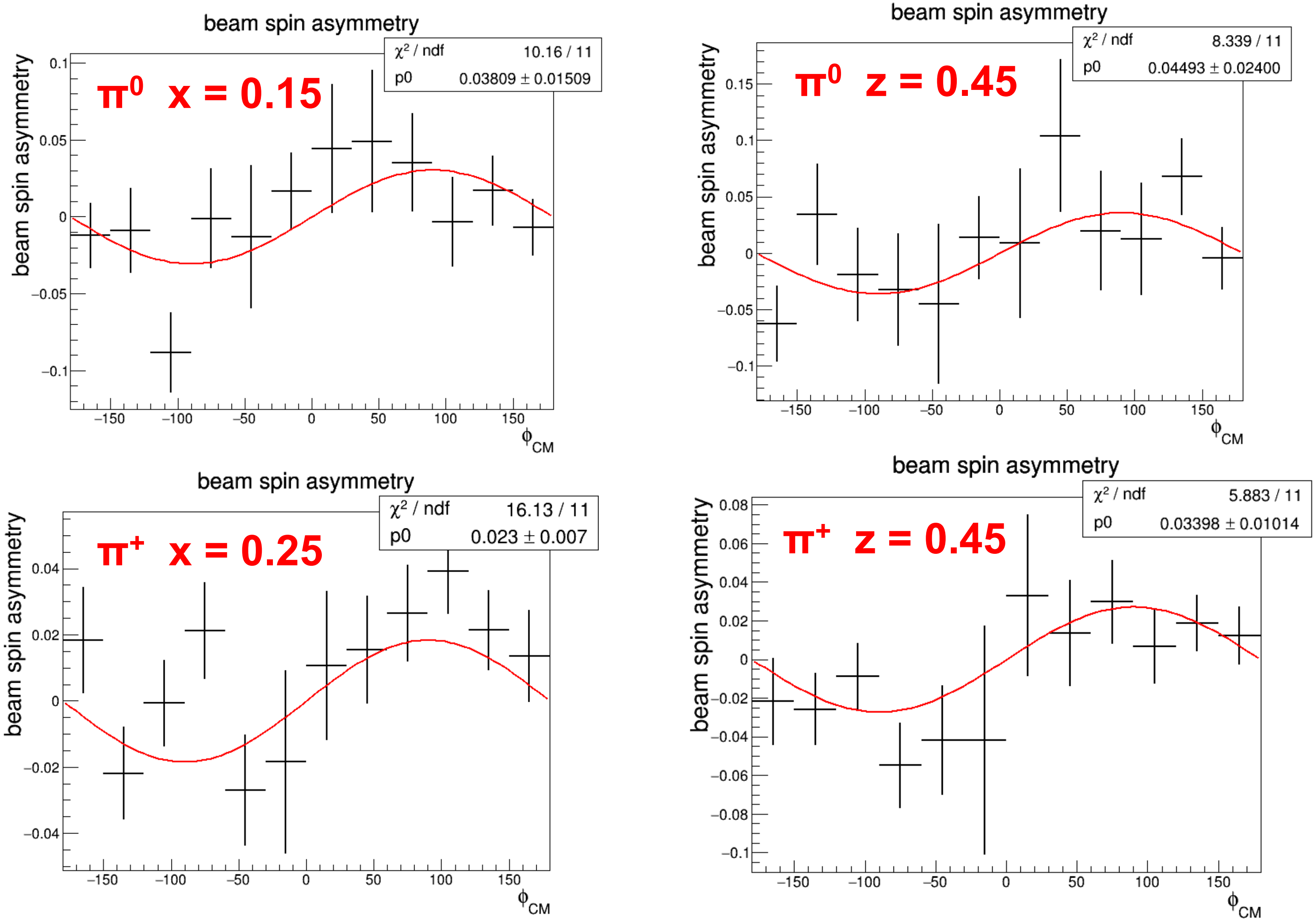


BSA for a single detected pion

binned in z, x, pt and Q²

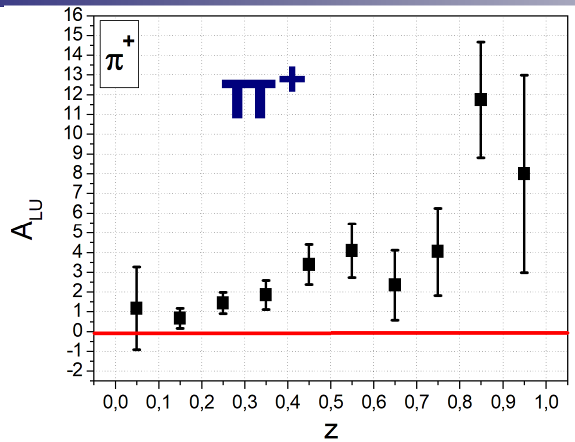
π^0

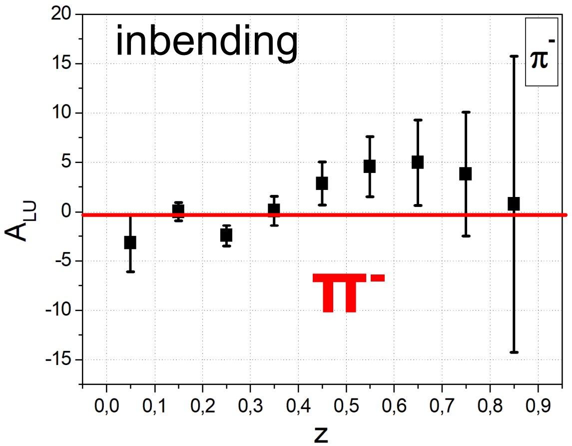
π^+

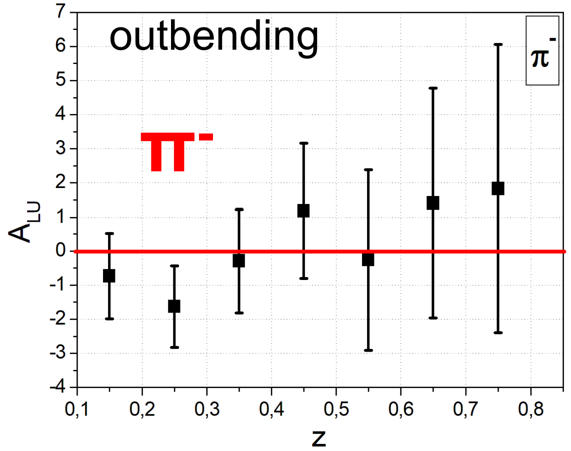


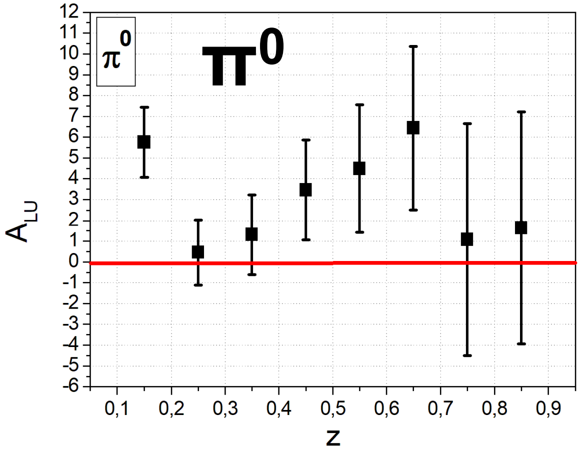
CLAS 12

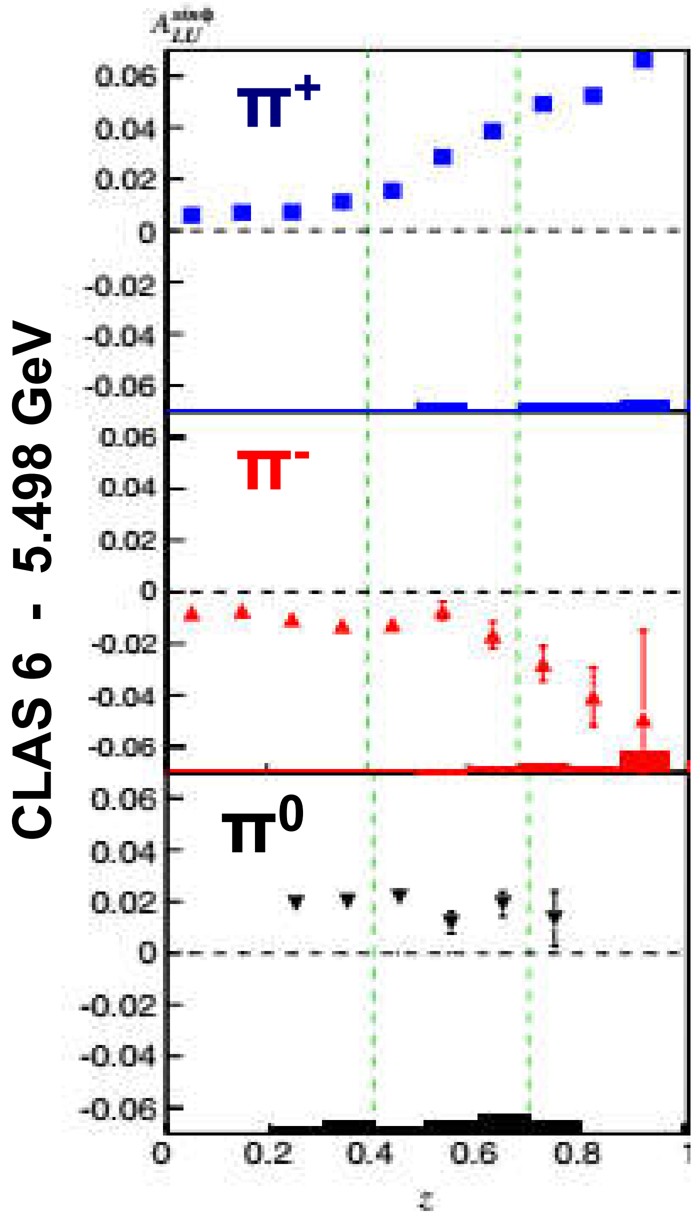
10.6 GeV









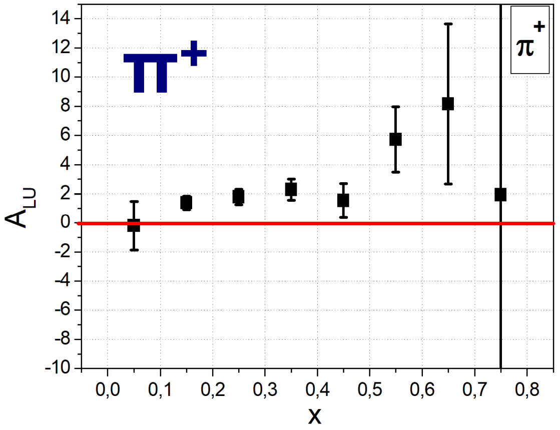


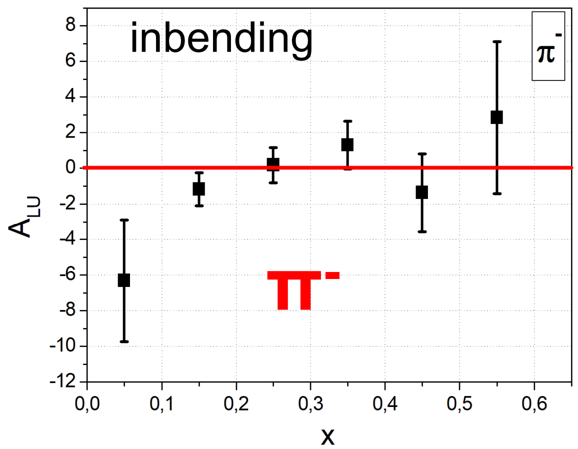
W. Gohn et al., CLAS collaboration, PHYSICAL REVIEW D 89, 072011 (2014)

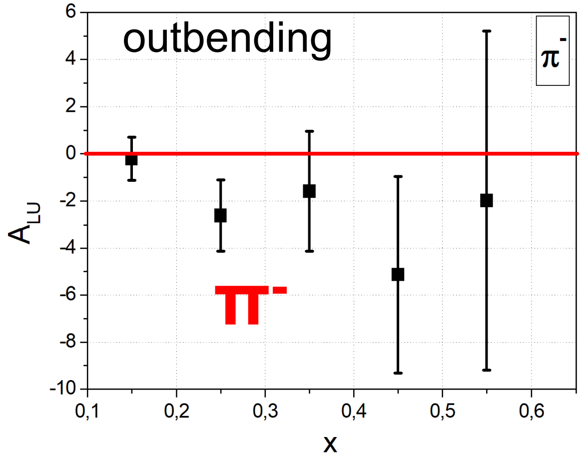
CLAS 12

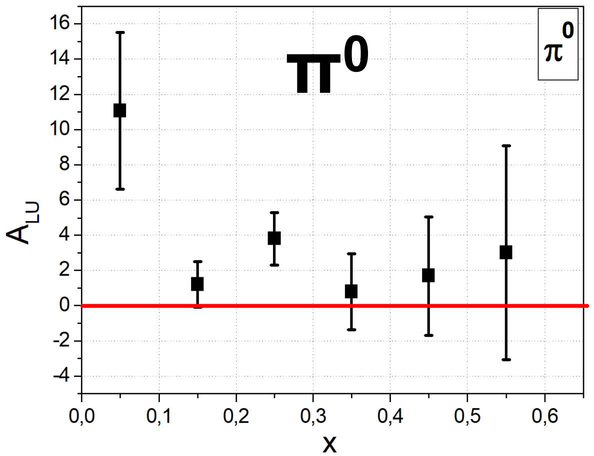
10.6 GeV

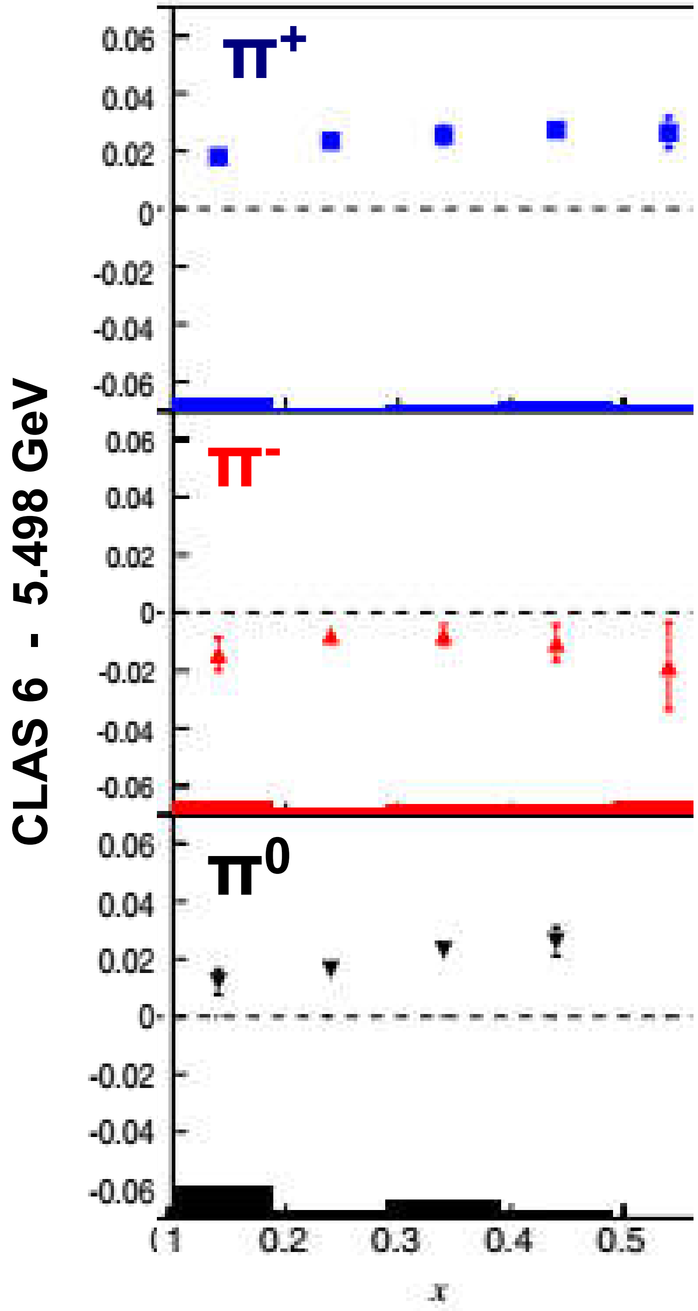
no z cut !







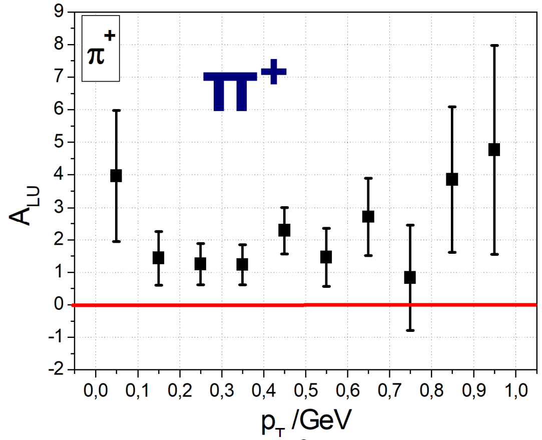


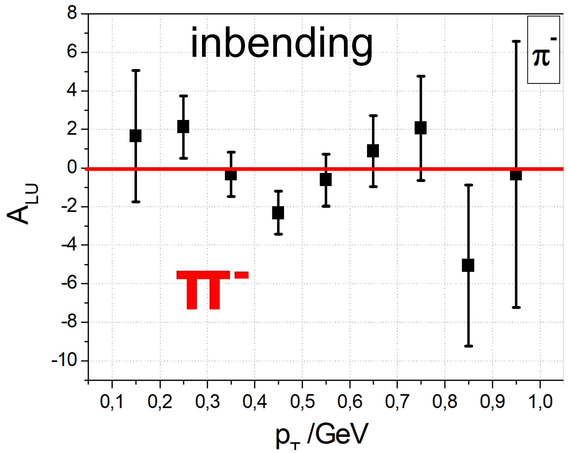


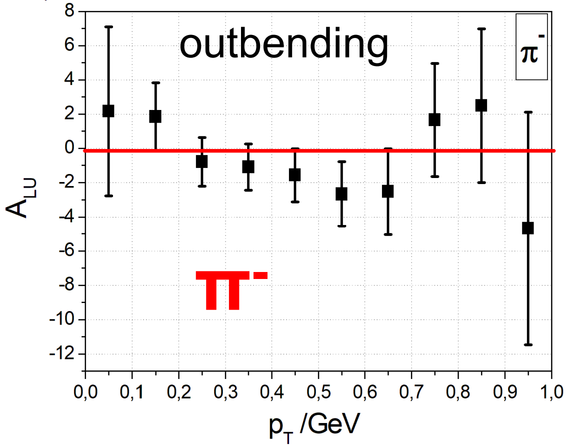
CLAS 12

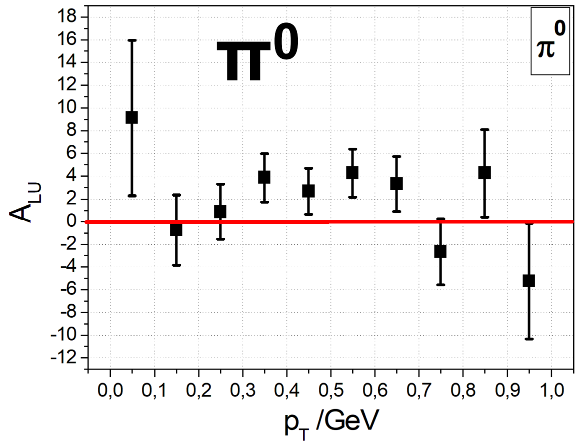
10.6 GeV

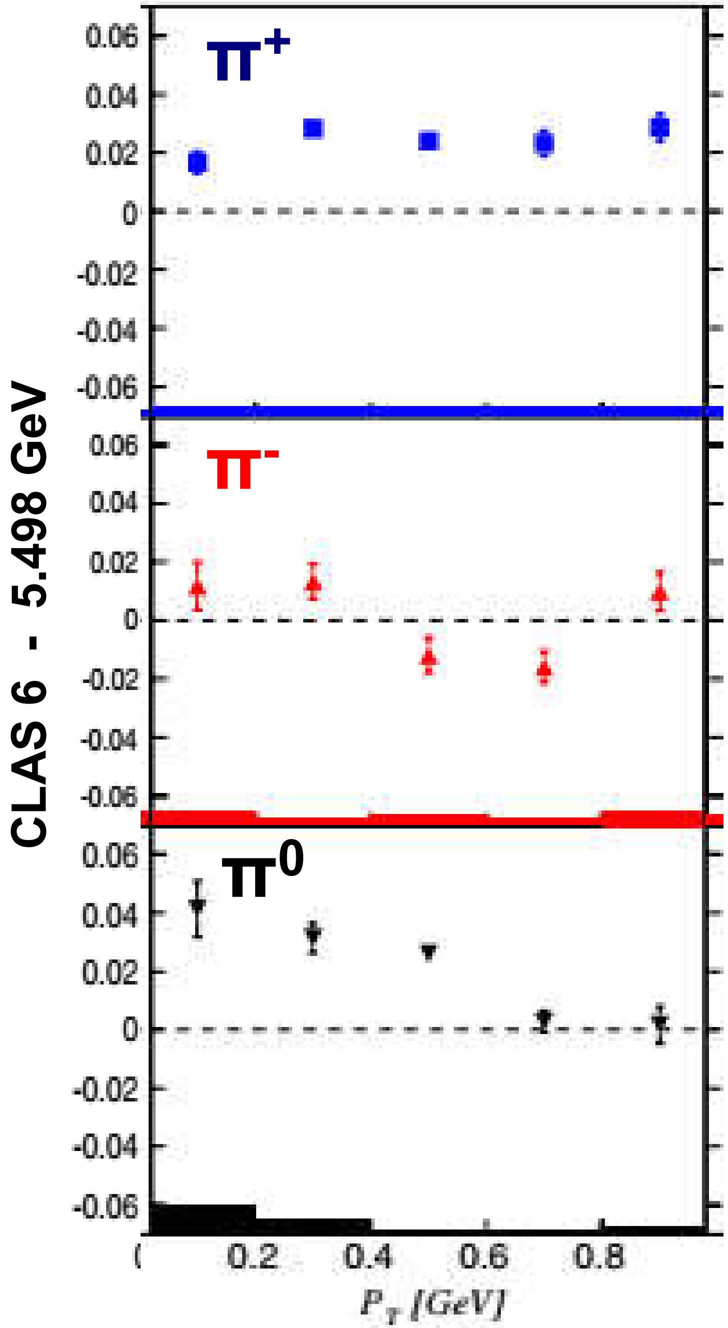
no z cut !







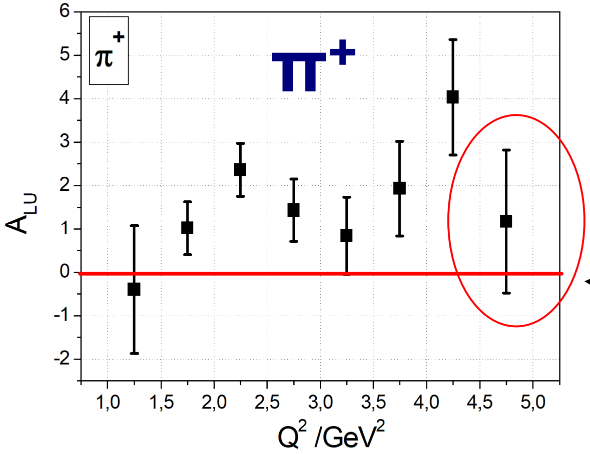




CLAS 12

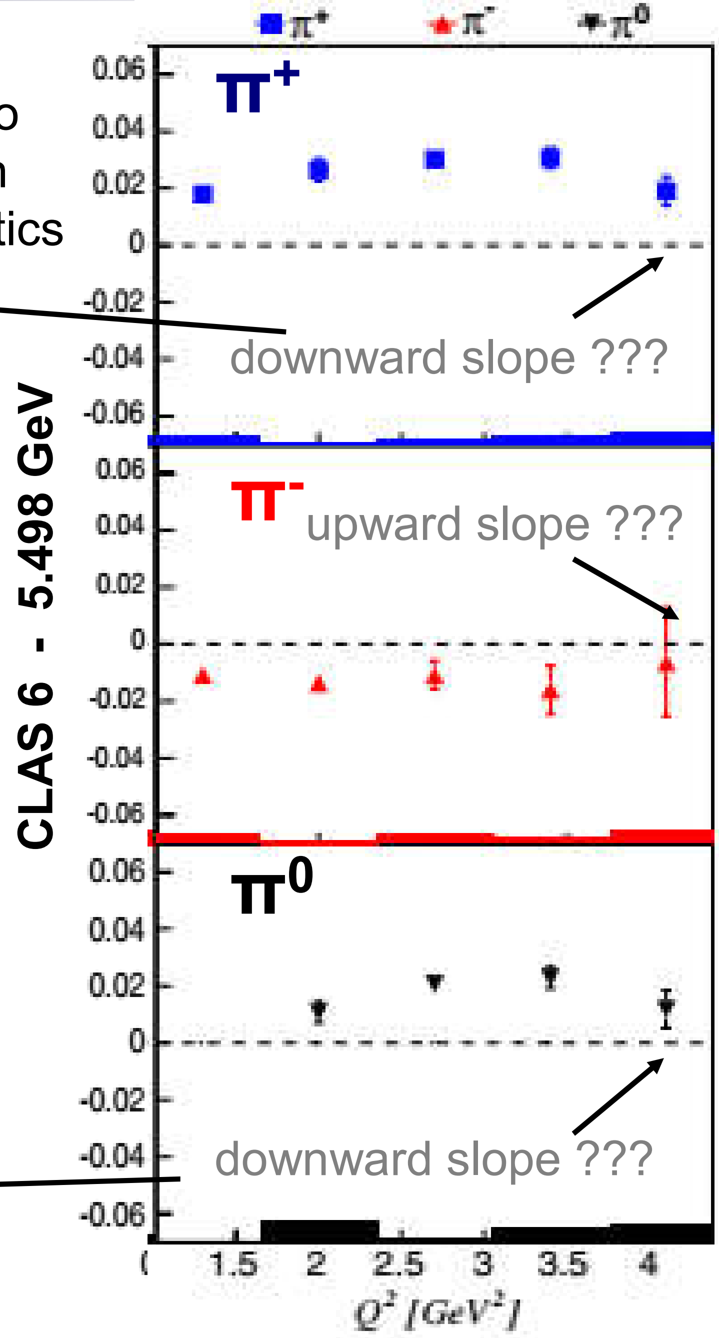
10.6 GeV

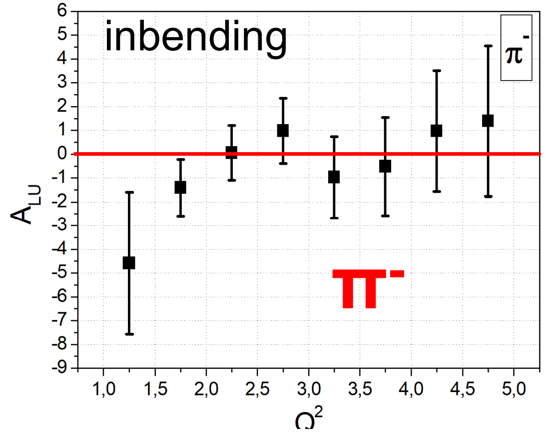
no z cut !

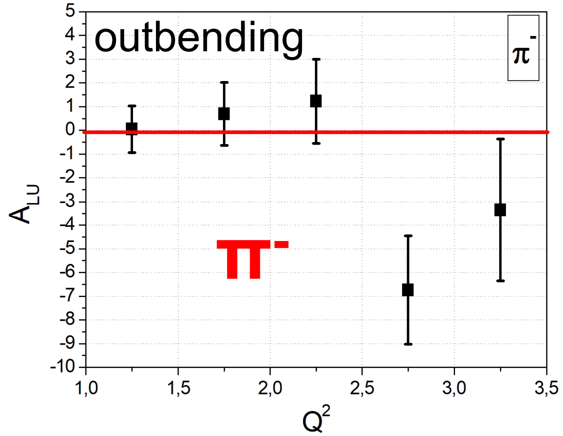


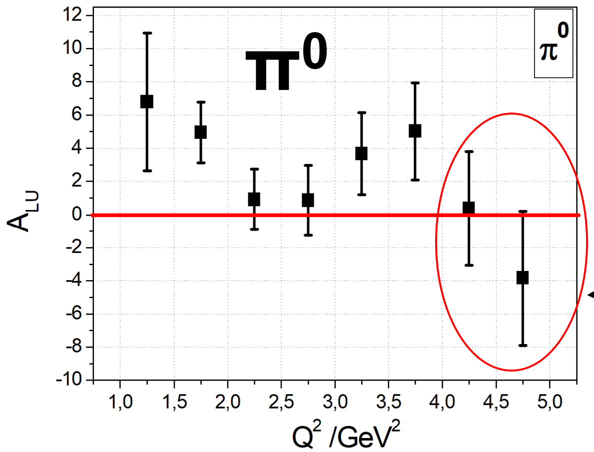
CLAS 12:

- extension to 8 GeV² with more statistics









Summary and Outlook

- SIDIS BSA at 10.6 GeV shows a similar behaviour as at 5.5 GeV (CLAS 6)
- Cuts on $z > 0.3$ and $z < 0.7$ have to be added for the Q^2, p_T and x binning
  → $z > 0.3$ removes the "target fragmentation region"
  → $z < 0.7$ removes contamination by pions from exclusive channels
- Expected kinematic coverage:

	CLAS 6	**CLAS 12**
x_B	0.1 - 0.6	0.1 - 0.7
p_T	0 - 1 GeV	0 - 3 GeV
Q^2	1 - 4 GeV²	1 (1.5) - 8 GeV²

- ~ 1440 files of run 3432 have been used (0.3 % of spring run)
  → 5%/ 10%/ 25%/ 100% of spring run will reduce errors by a factor 4/6/9/18
- LTCC can provide better Pion/Kaon separation from 3.5 GeV to 9 GeV
  → Only 4 sectors available (only 1 filled with C_4F_{10})
- Theoretical modells will be provided by Peter Schweitzer (UCONN)