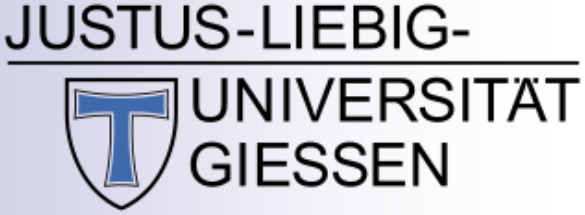
2022 Fall Meeting of the APS Division of Nuclear Physics

October 27-30, 2022, New Orleans, LA

Hard exclusive $\pi^- \Delta^{++}$ production off the proton with CLAS12 at JLAB



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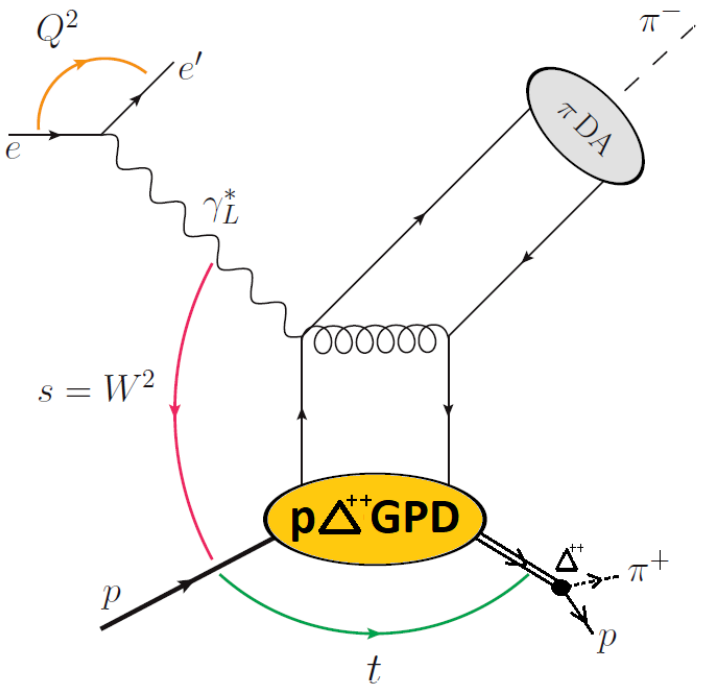
10/28/2022

Motivation

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



Factorisation expected for:

$-t / Q^2 << 1$ and $Q^2 > M_\Delta^2$

x_B fixed

➔ Provides access to p-Δ transition GPDs

➔ 3D structure of the Δ resonance and of the excitation process

Twist 2: **8 helicity non-flip trans. GPDs**

→ Connection to proton-proton GPDs via symmetry considerations

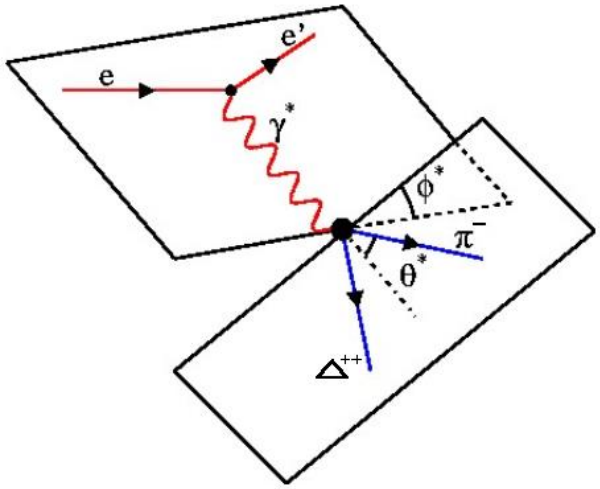
Twist 3: **8 helicity flip trans. GPDs** → Theory in progress (no publ. so far)

➔ $\pi^{\pm}$ is expected to be especially sensitive to the tensor charge of the resonance

Hard Exclusive π^- Electroproduction and BSA

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

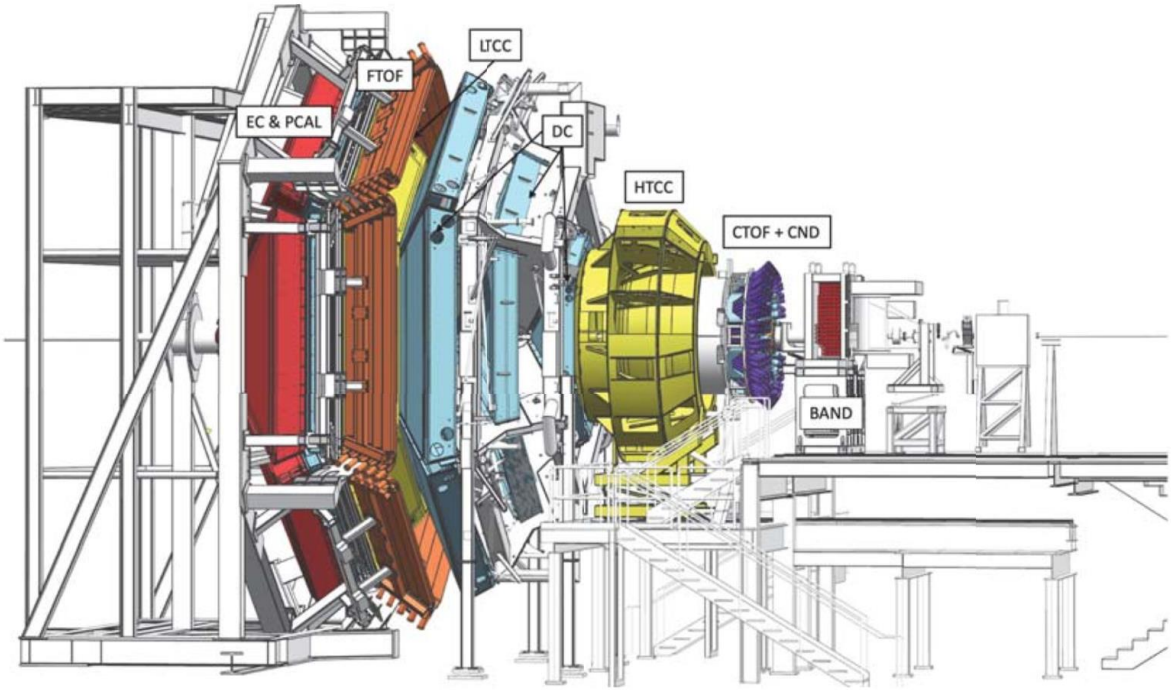
$$2\pi\frac{d^2\sigma}{dtd\phi} = \frac{d\sigma_T}{dt} + \epsilon\frac{d\sigma_L}{dt} + \epsilon\cdot cos(2\phi)\frac{d\sigma_{TT}}{dt} + \sqrt{2\epsilon(1+\epsilon)}\cdot cos(\phi)\frac{d\sigma_{LT}}{dt} + h\cdot\sqrt{2\epsilon(1-\epsilon)}\cdot sin(\phi)\frac{d\sigma_{LT'}}{dt}$$



Beam Spin Asymmetry:

$$BSA(t,\phi,x_B,Q^2) = \frac{d\sigma^+ - d\sigma^-}{d\sigma^+ + d\sigma^-} = \frac{\sqrt{2\epsilon(1-\epsilon)}\frac{\sigma_{LT'}}{\sigma_0}\sin\phi}{1+\sqrt{2\epsilon(1+\epsilon)}\frac{\sigma_{LT}}{\sigma_0}\cos\phi+\epsilon\frac{\sigma_{TT}}{\sigma_0}\cos 2\phi}$$

CLAS12 Experimental Setup in Hall B at JLAB



V. Burkert et al., Nucl. Instrum. Meth.A 959 (2020) 163419

➔ Data recorded with CLAS12 during fall 2018 and spring 2019

➔ 10.6 / 10.2 GeV e^- beam ➔ ~87 % average polarization ➔ liquid H_2 target

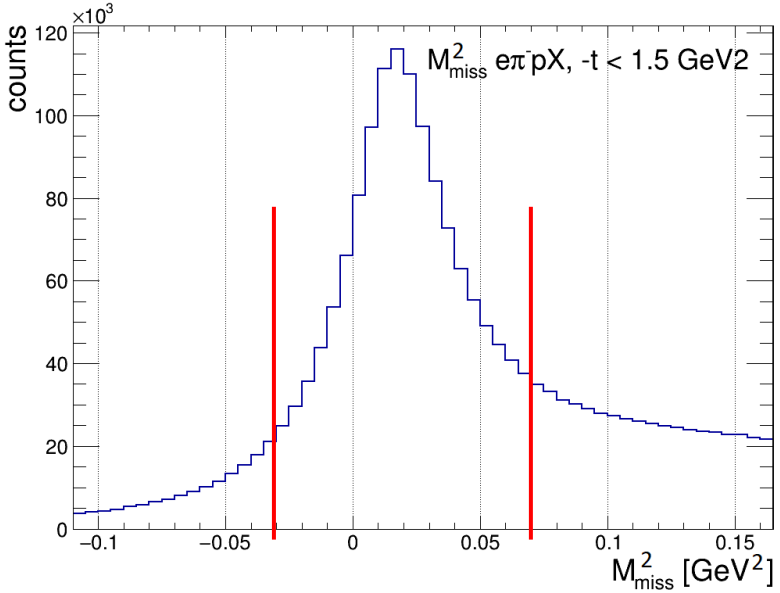
➔ Analysed data ~ 35 % of the approved RG-A beam time

Event Selection and Kinematic Cuts

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

$$X = \pi^{+}$$

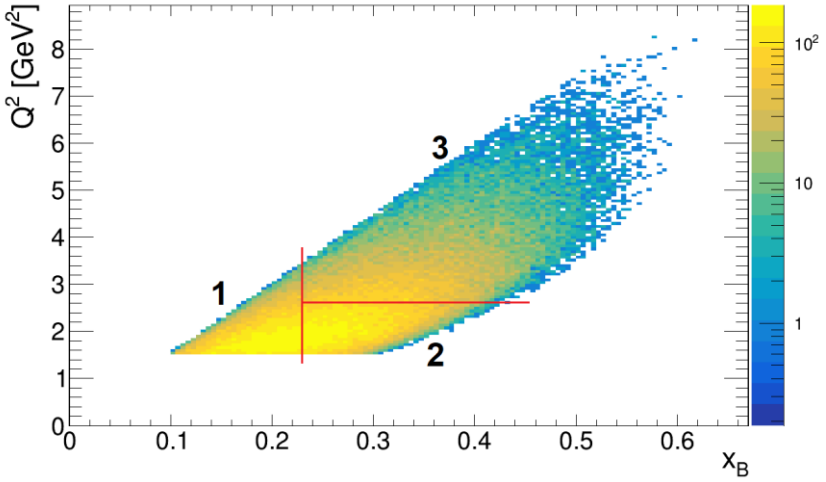
➔ 2 σ cut around the missing π^+



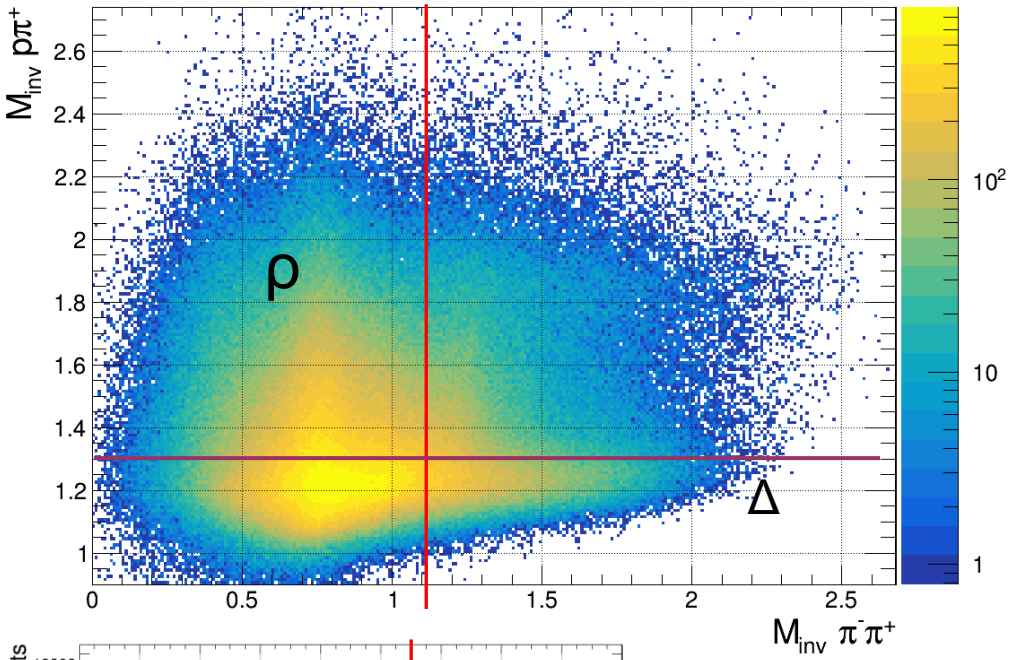
Kinematic cuts:

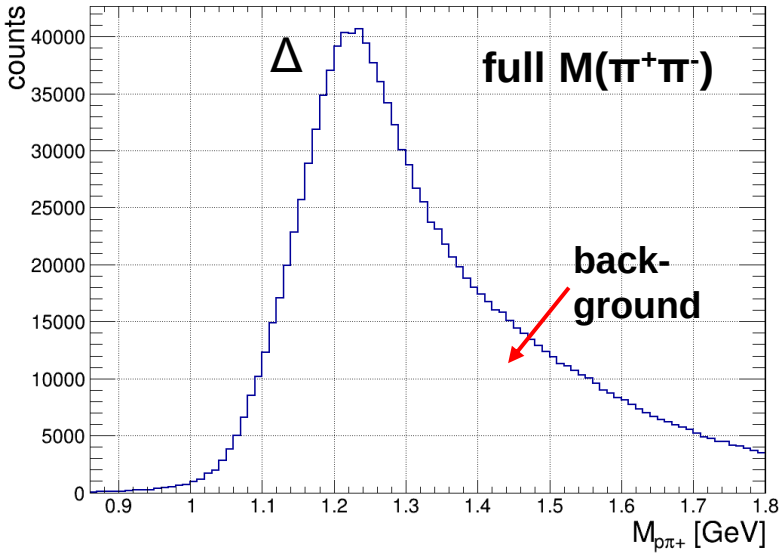
$Q^2 > 1.5$ GeV² W > 2 GeV y < 0.75

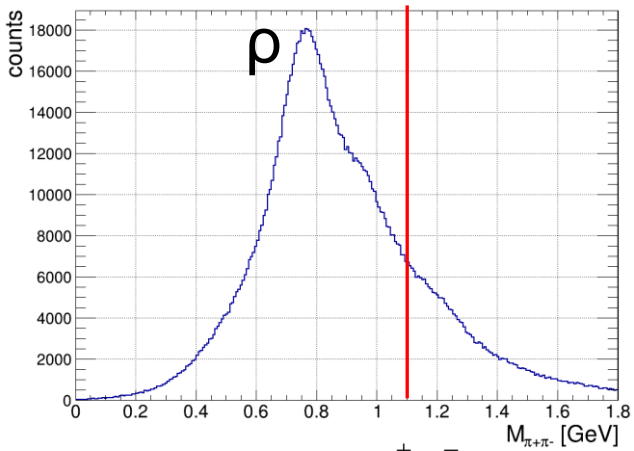
-t < 1.5 GeV² (only the forward region)



Event Selection and Background Rejection





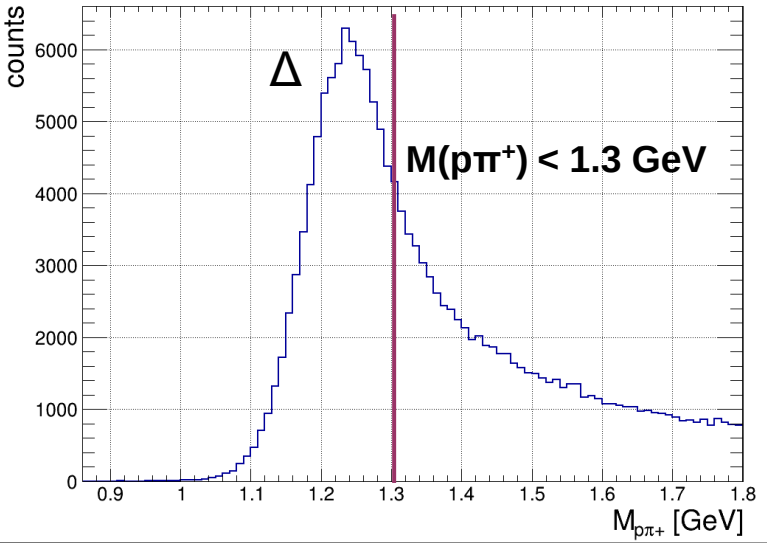


$ep \rightarrow ep\rho \rightarrow ep\pi^+\pi^-$

M(π⁺π⁻) > 1.1 GeV

ρ contamination

< 0.8 %



Monte Carlo Simulations

2 MC samples have been used:

a) Semi-inclusive DIS MC

→ Does not contain the $\pi^- \Delta^{++}$ production in „forward“ kinematics

→ Contains nonres. background as well as ρ production and other potential BG channels

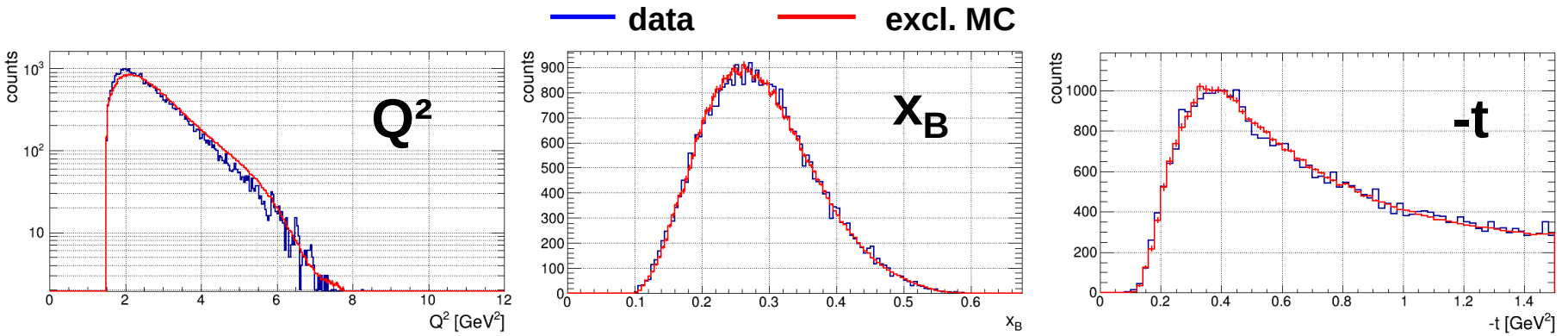
➔ Used to estimate background shape and contaminations

b) Exclusive $\pi^- \Delta^{++}$ MC

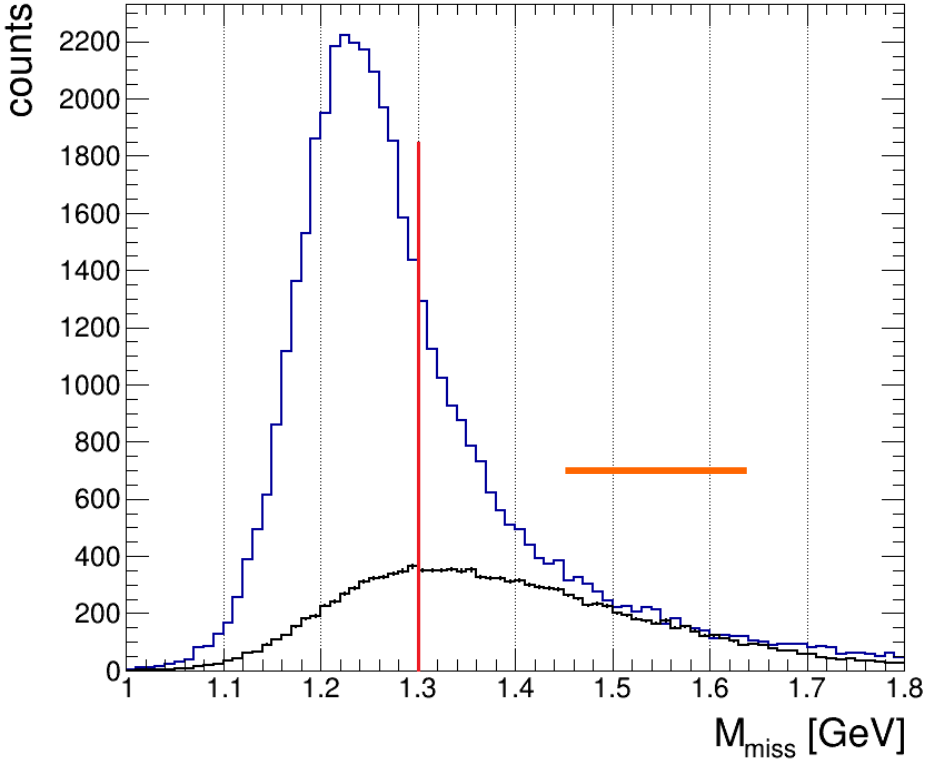
→ Phase space simulation with a weigth added to match experimental data

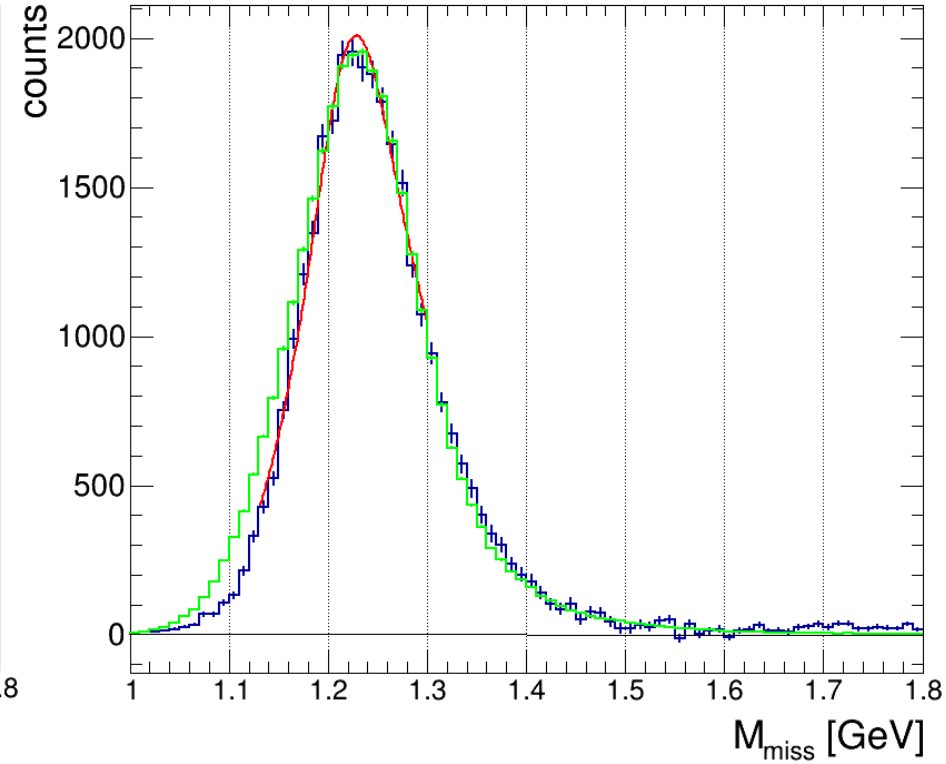
→ Δ peak with PDG mass and FWHM

➔ Both MCs are processed through the full simulation and reconstruction chain



Event Selection and Background Estimate





experimental data

SIDIS MC (same cuts)

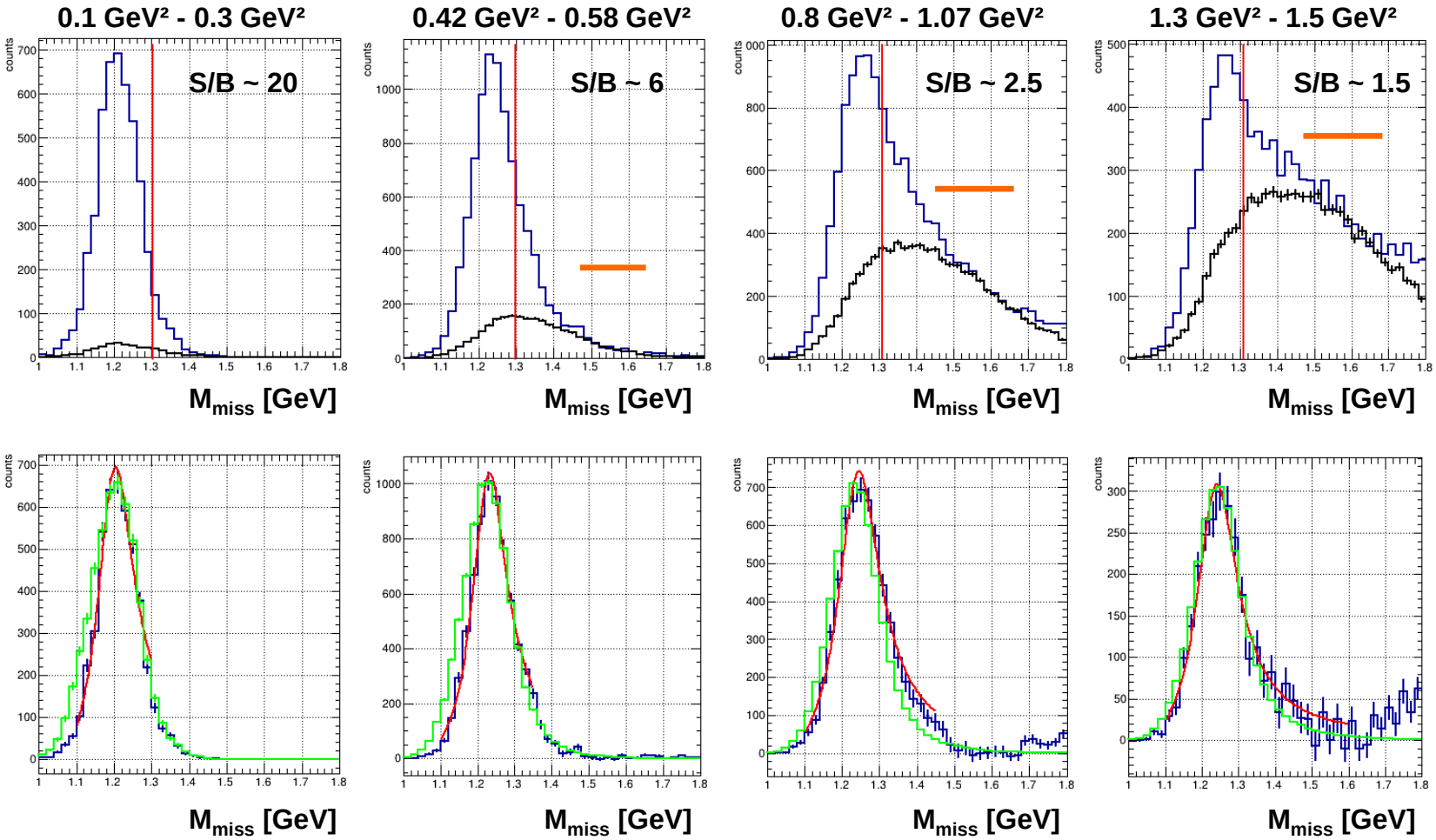
data after SIDIS MC subtraction

fit of a Sill function (BW with thr. effects)

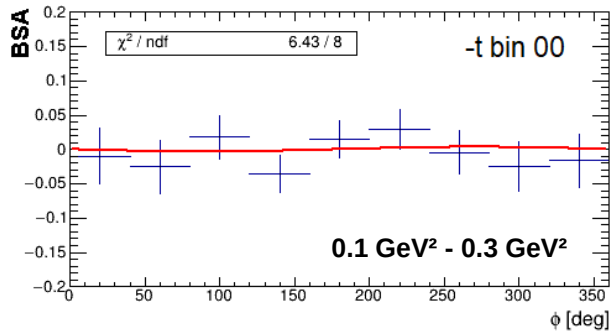
exclusive MC (for comparison)

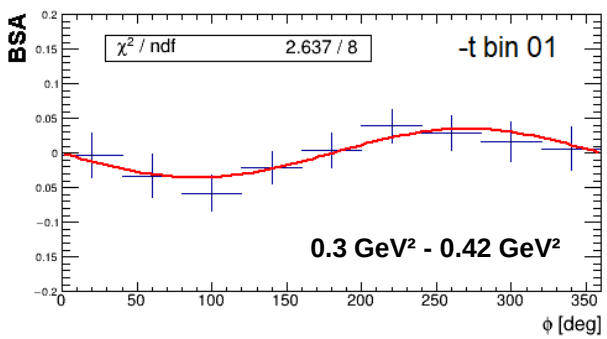
Background: 98 – 99 % non-resonant events

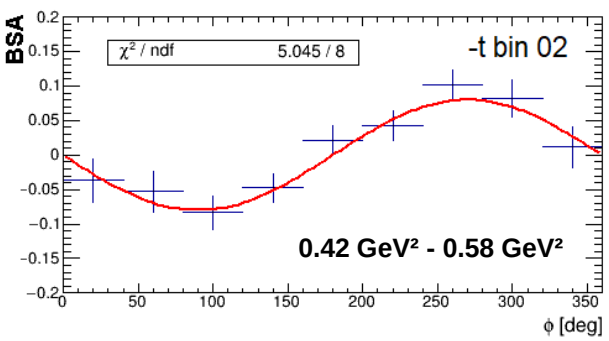
Event Selection and Background Estimate

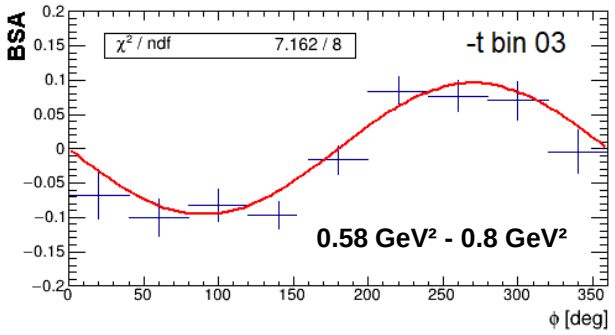


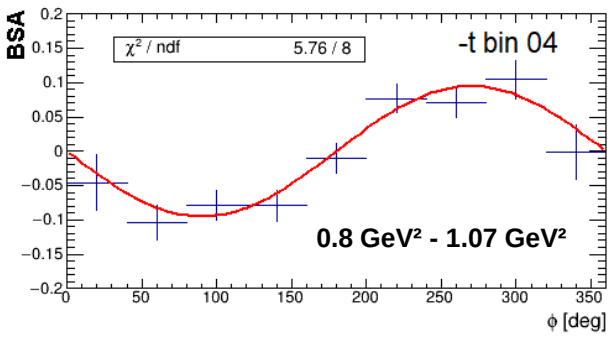
Resulting Beam Spin Asymmtries (Q^2-x_B integrated)

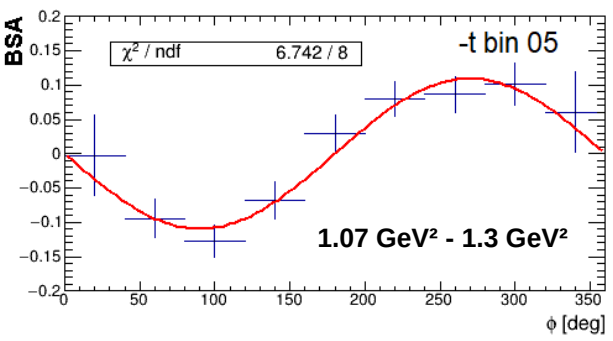


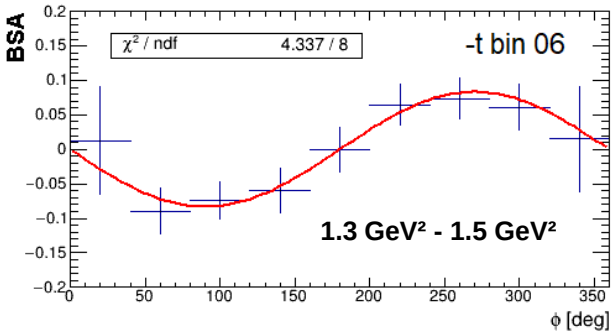






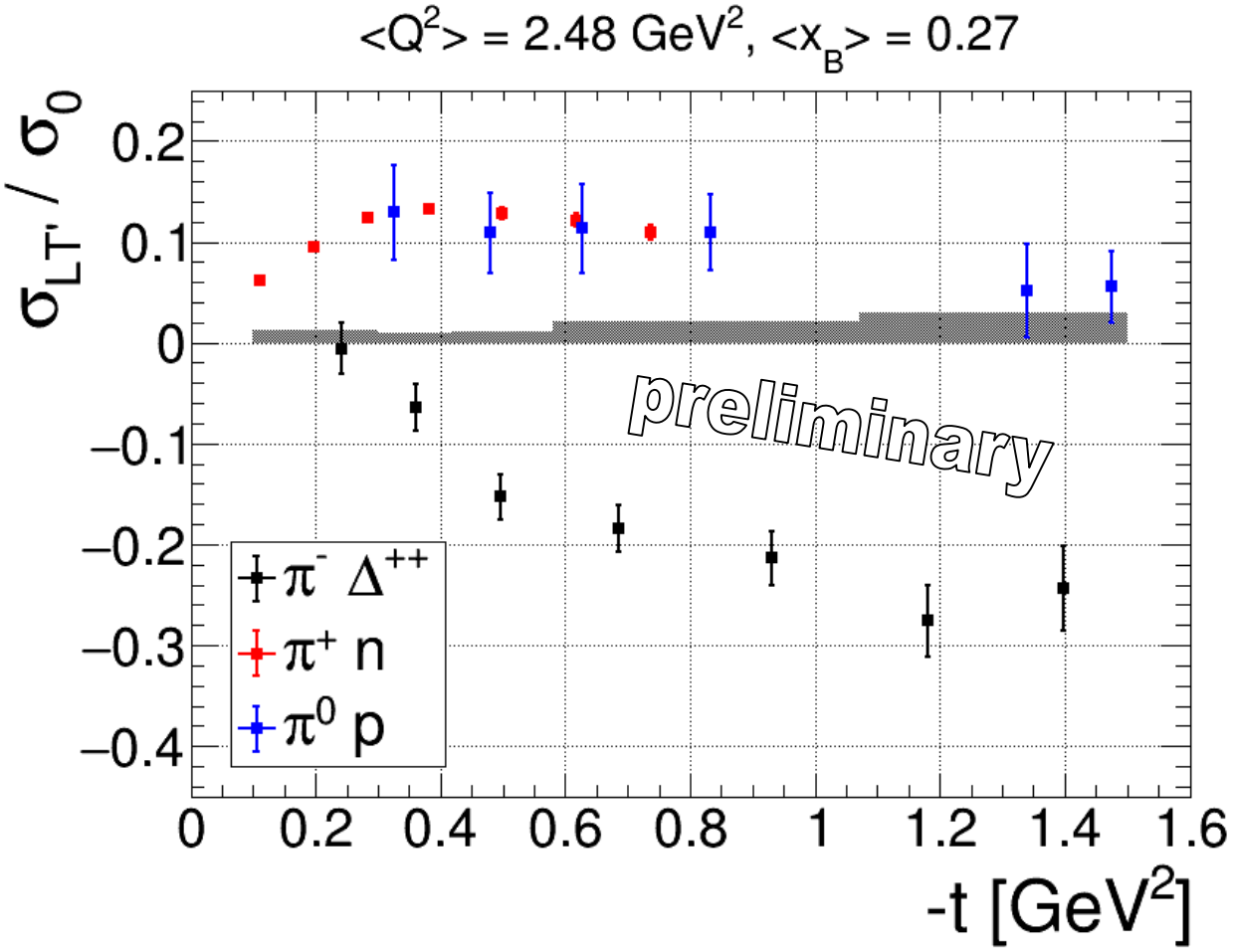






preliminary

Q^2 - x_B Integrated Result



- The contribution of the non-resonant back-ground has been subtracted

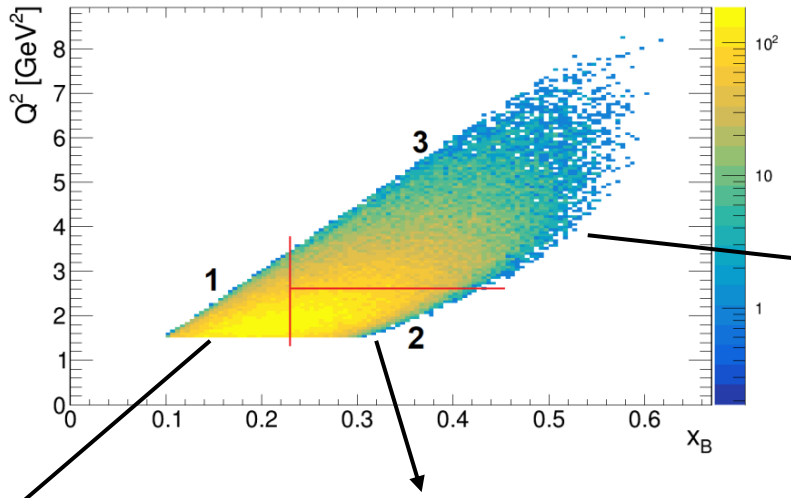
$$|\pi^+\rangle = |u\bar{d}\rangle$$

$$|\pi^-\rangle = |d\bar{u}\rangle$$

$$|\pi^0\rangle = \frac{1}{\sqrt{2}}\left[|u\bar{u}\rangle - |d\bar{d}\rangle\right]$$

Different sources of systematic uncertainty have been studied:
beam polarisation, background subtraction, fiducial volume, extraction method, acceptance, bin migration, radiative effects

Multidimensional Results



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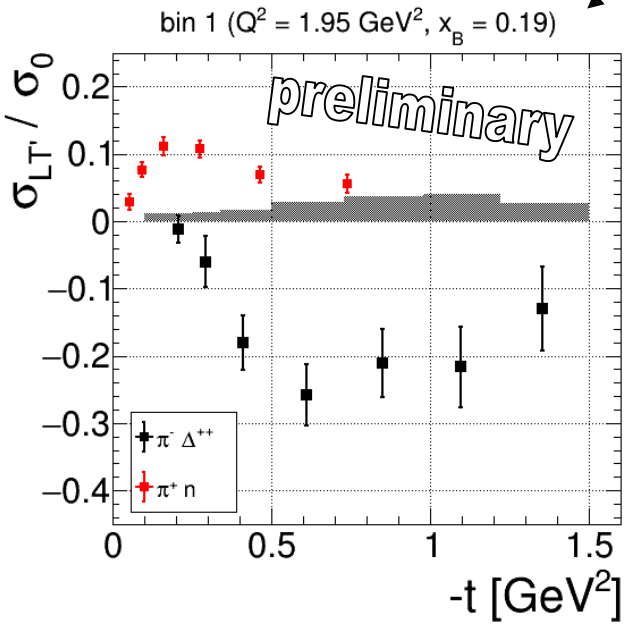

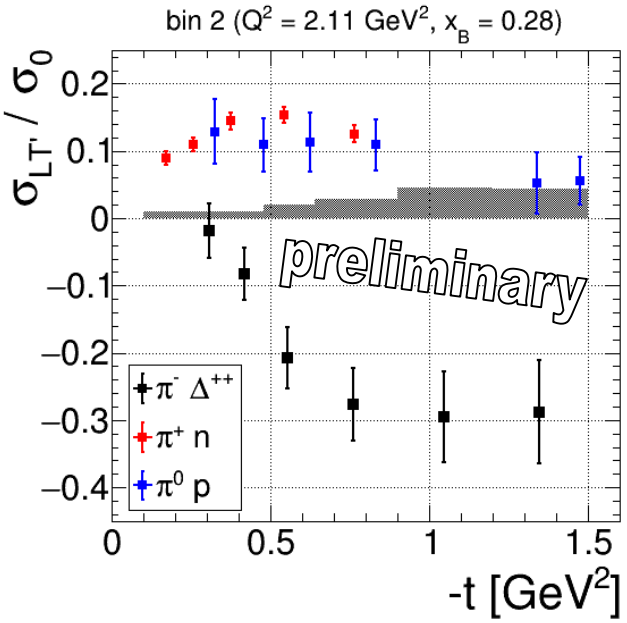

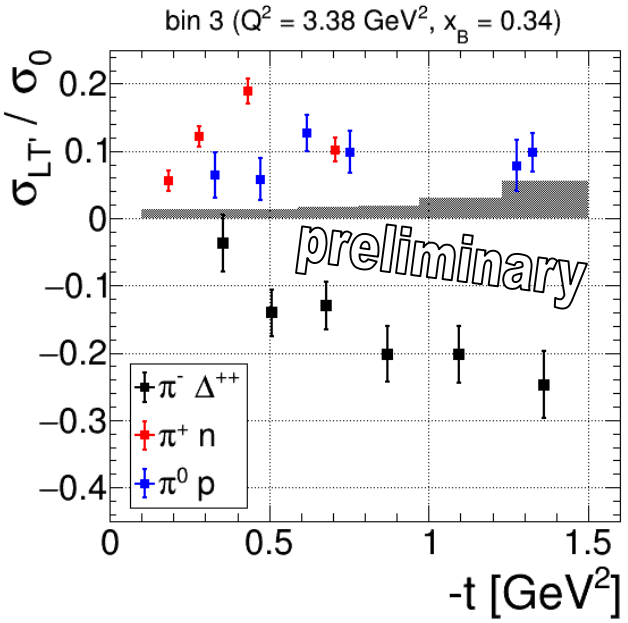

Conclusion and Outlook

- Hard exclusive $\pi^- \Delta^{++}$ production can be well measured with CLAS12
- The obtained BSA is clearly negative and ~ 2 times larger than for the hard exclusive π^+ production
- The extracted BSA is a potential first „clean“ observable sensitive to p-Δ transition GPDs
- Theory predictions based on twist-3 transition GPDs are in progress