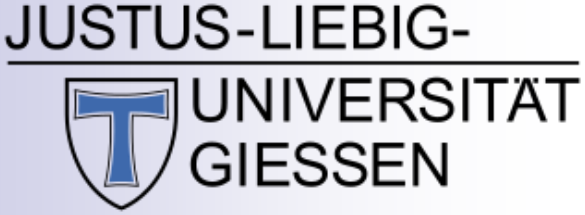
ECT*-APCTP joint workshop: Exploring resonance structure with transition GPDs

August 21 - 25 2023, Trento

Perspectives for the measurement of the N→N* DVCS process with CLAS12 at JLAB



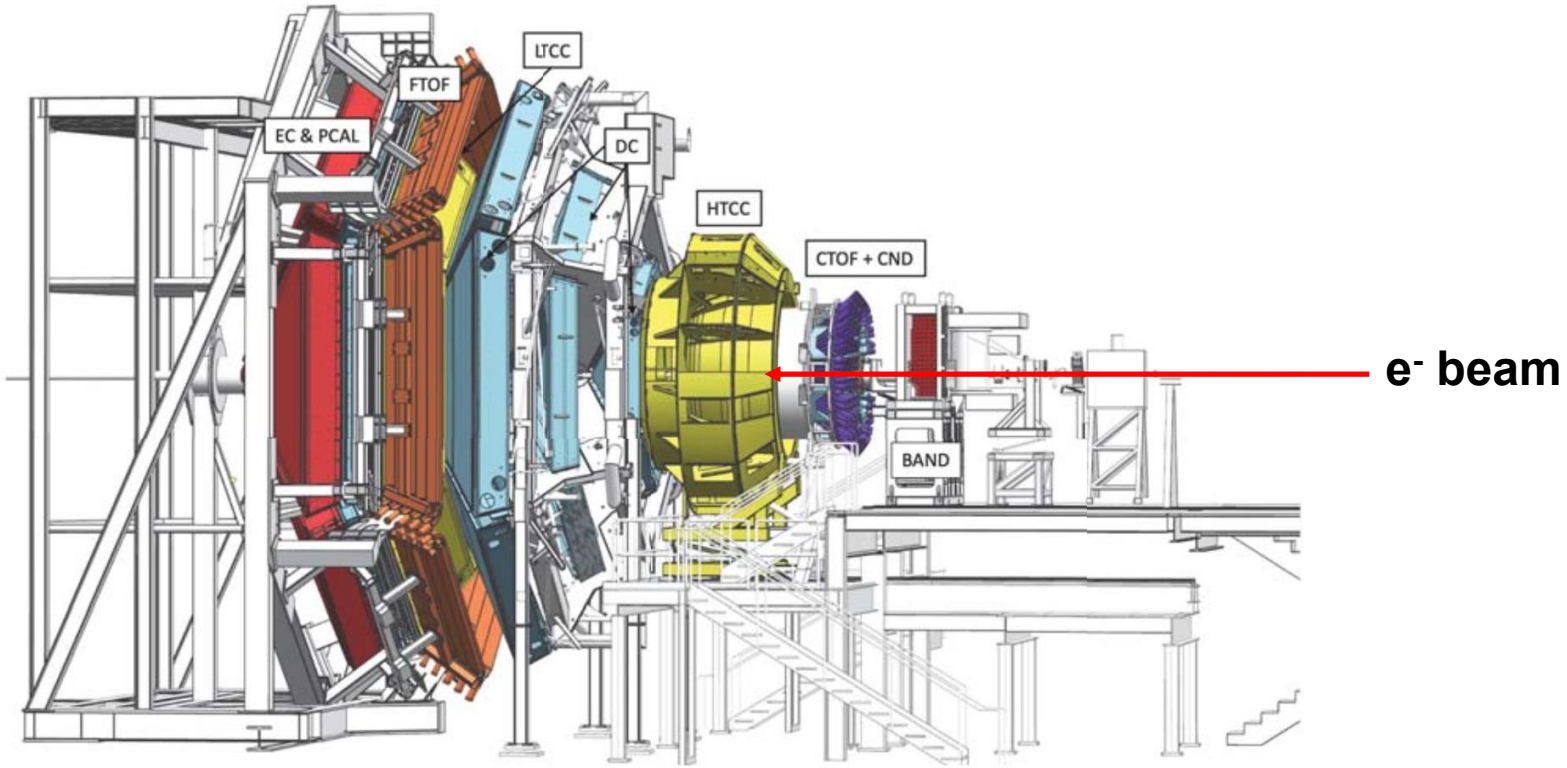
Stefan Diehl

Justus Liebig University Giessen

University of Connecticut

08/21/2022

CLAS12 experimental setup in hall B at JLAB

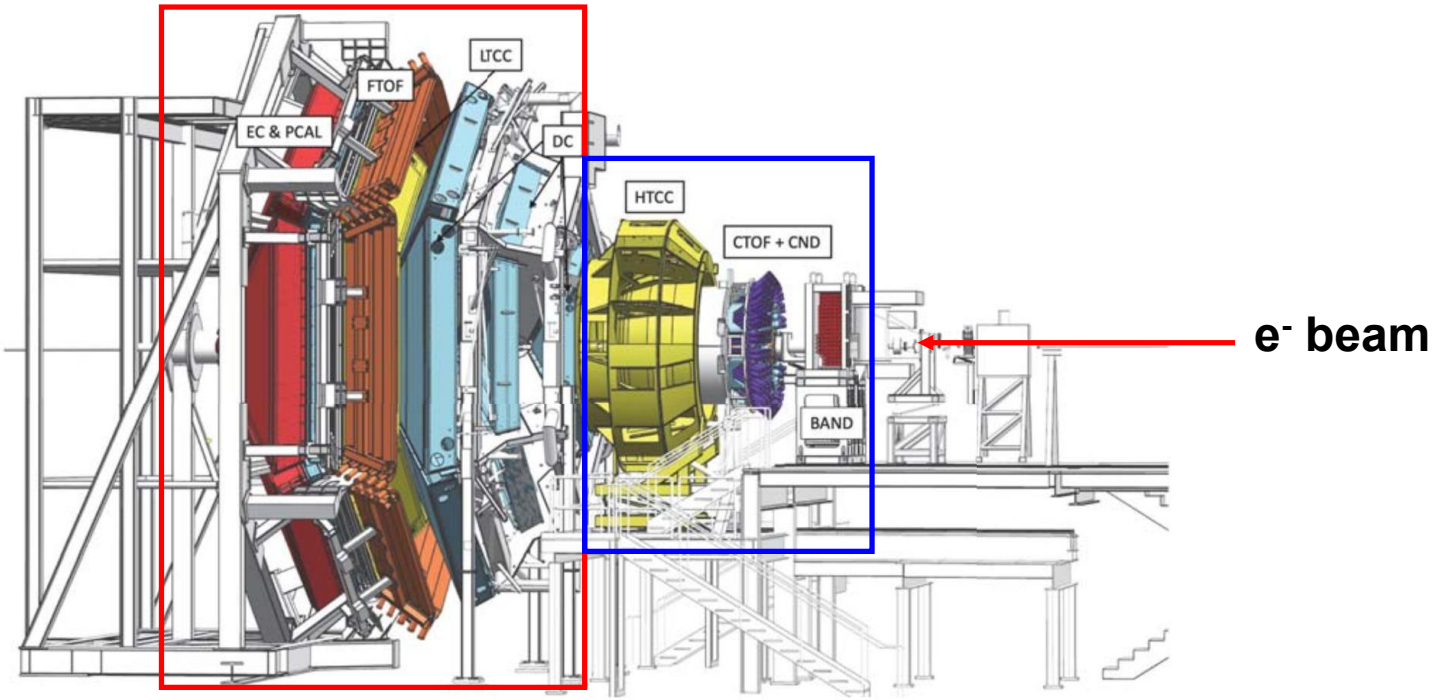


V. Burkert et al., Nucl. Instrum. Meth. A 959 (2020) 163419

➔ 10.2 - 10.6 GeV e^- beam ➔ ~87 % average polarization

➔ liquid H_2 target (RG-A) + Deuterium target (RG-B) + polarized targets

CLAS12 experimental setup in hall B at JLAB



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

Forward tagger (2.5° < θ < 4.5°): Calorimeter, hodoscope and tracker

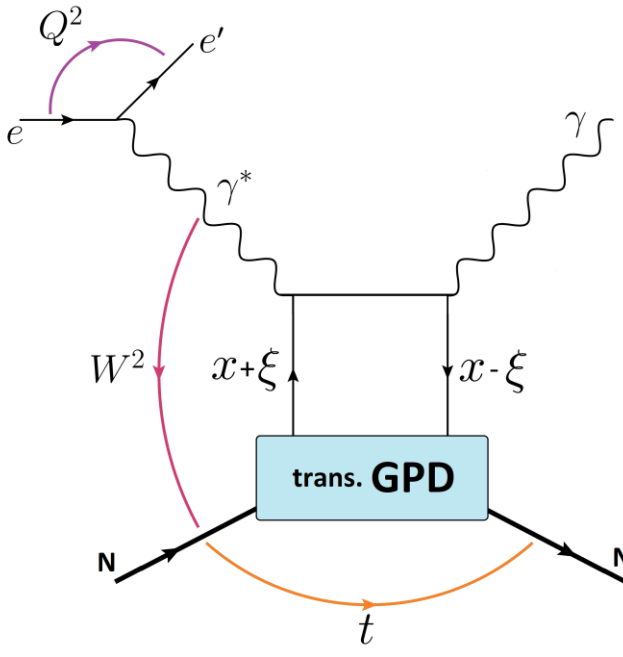
Forward detector: - 6 sector torus magnet with drift chamber system for tracking
5° < θ < 35° - FTOF and Cherenkov detectors for PID
- Calorimeter for neutrals and e^- PID

Central detector: - Solenoid magnet with tracking system
35° < θ < 135° - CTOF for PID and CND for neutron detection

The N →N* DVCS process

$$\gamma^* p \rightarrow N^* \gamma \rightarrow N \; meson \; \gamma$$

factorisation for: -t/Q² small, x_B fixed, $Q^2 > M^2_{N^*}$



+ BH

- **Access to the helicity non-flip (twist-2) transition GPDs**
- **Detailed models for CLAS12 kinematics became available recently (see Marcs and Kirills talks)**

Expected distributions and studied reactions

$$\gamma^* p \rightarrow N^* \gamma \rightarrow N\ meson\ \gamma$$

→ backward in CM
→ central in LAB

low -t
→ very forward in CM
→ forward in LAB

➔ With the CLAS12 resolutions, **we need to detect all particles** to identify the process

$e\ p \rightarrow e'\ \Delta^+\ \gamma \rightarrow e'\ n\ \pi^+\ \gamma$

All particles can be detected with CLAS12

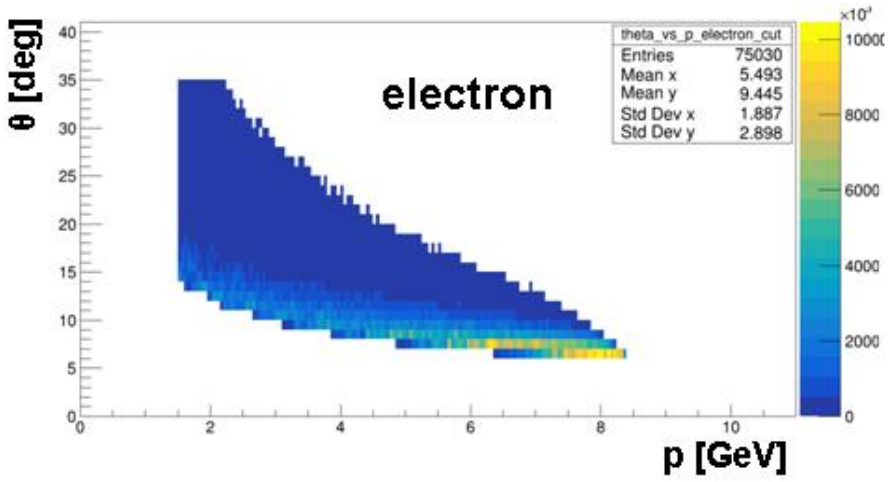
$e\ p \rightarrow e'\ \Delta^+\ \gamma \rightarrow e'\ p\ \pi^0\ \gamma$

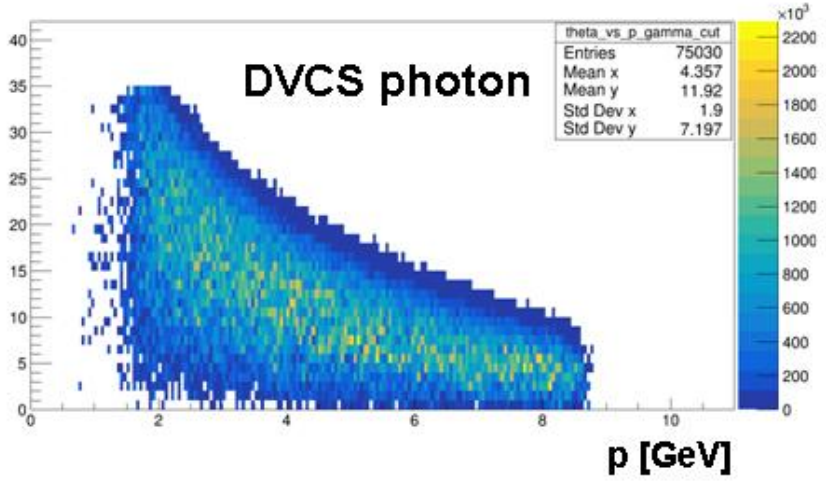
Hard to measure, since γs from π^0 are mostly > 35° → No EMC in CD

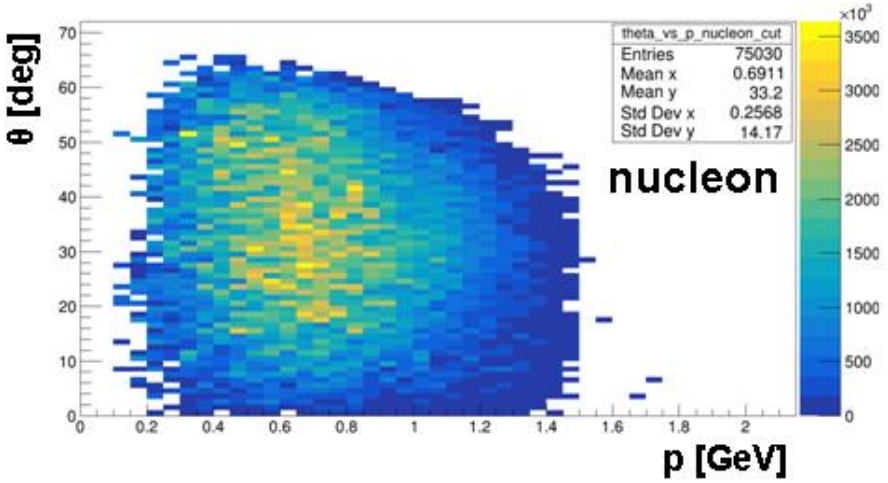
MC simulation of p→Δ⁺ DVCS

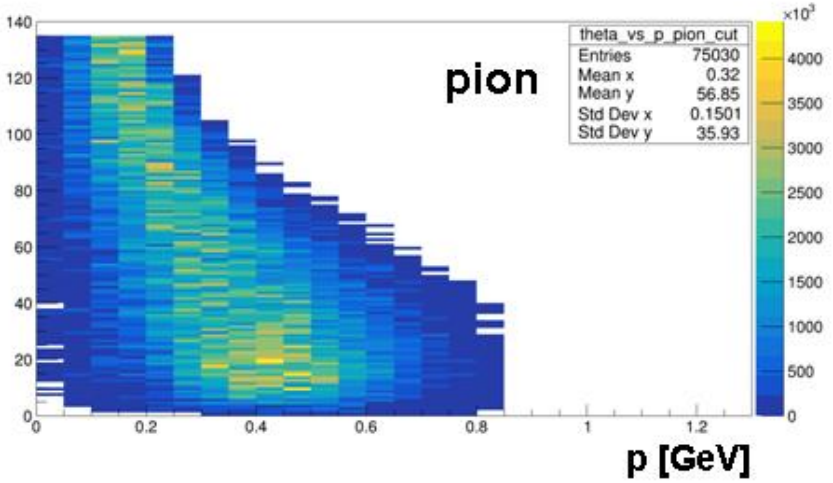
➔ **Realistic simulation with Δ mass distribution and DVCS cross section**

generated data:





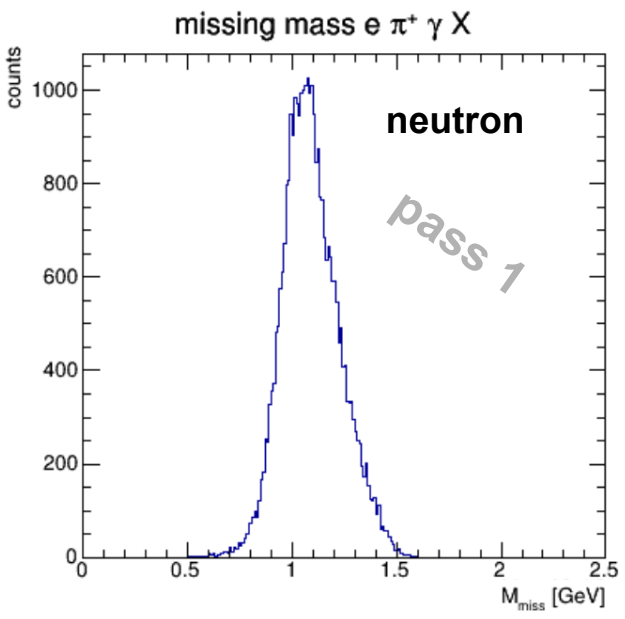


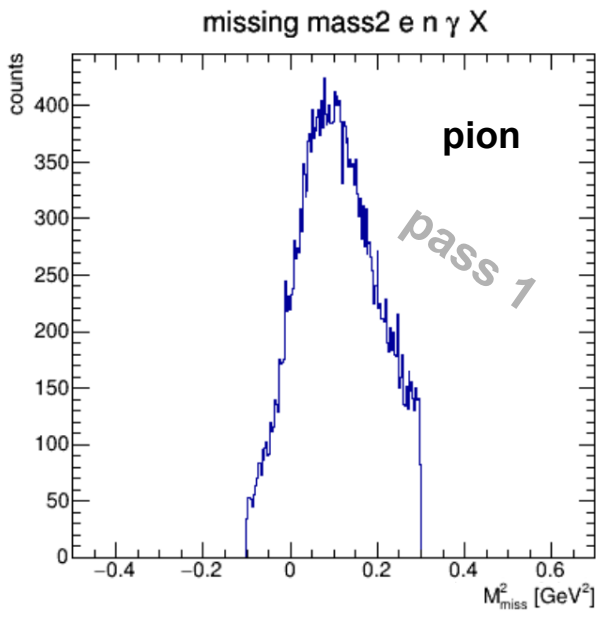


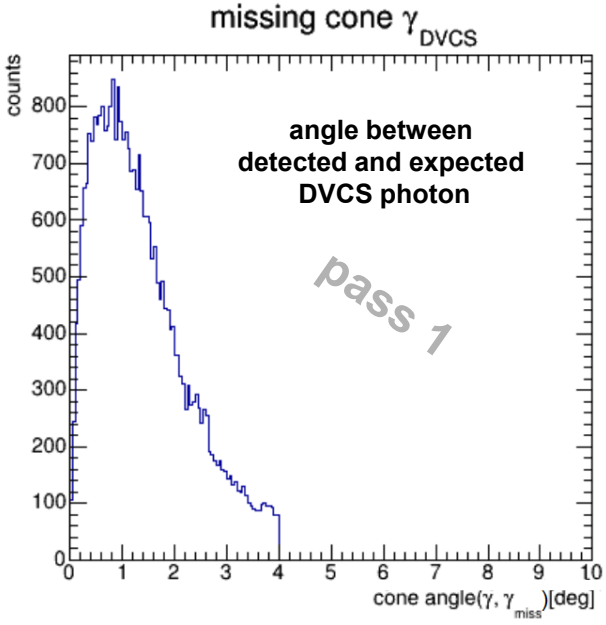
Exp data: Identification of exclusive N→N* DVCS events

- **A series of exclusivity cuts has been applied for event selection**

Some examples for exclusive events:





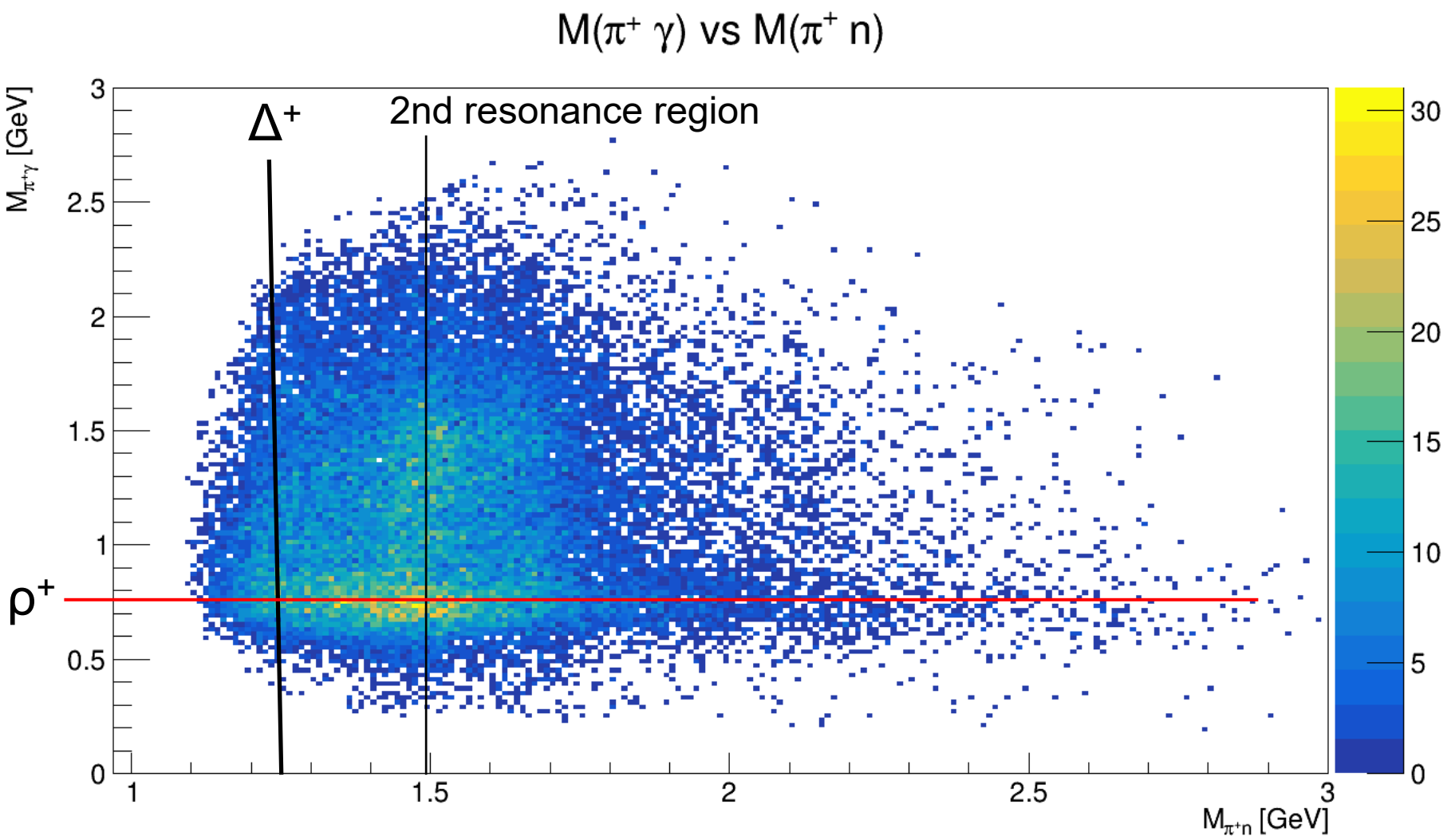


➔ **pass 1 data: CD no aligned …**

Kinematic cuts:

$W > 2$ GeV $Q^2 > 1$ GeV² $y < 0.8$ $-t < 2$ GeV² $E_{\gamma\text{-DVCS}} > 2$ GeV

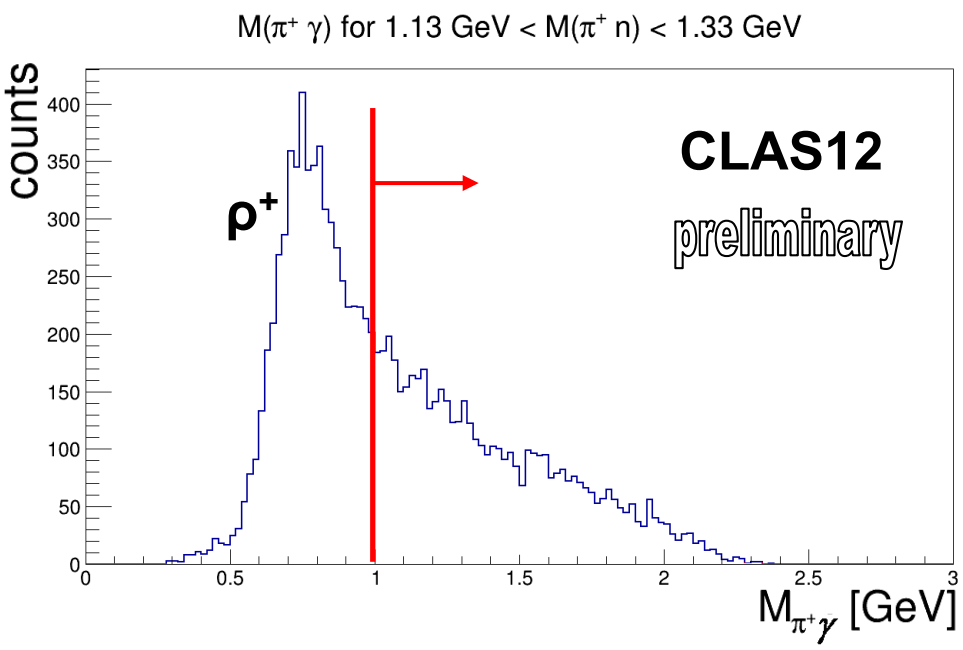
Non-resonant background in the exclusive sample



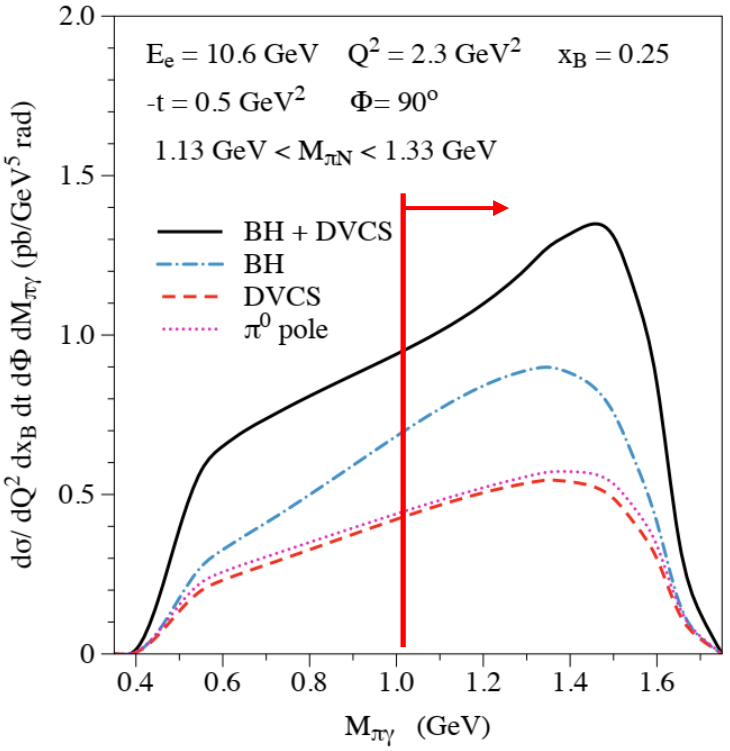
Suppression of the ρ^+ background

$$e\ p \rightarrow e'\ \Delta^+\ \gamma \rightarrow e'\ n\ \pi^+\ \gamma$$

- Dominant background from $\rho^+ \rightarrow \pi^+\ \gamma$



$p \rightarrow \Delta^+$ DVCS and BH

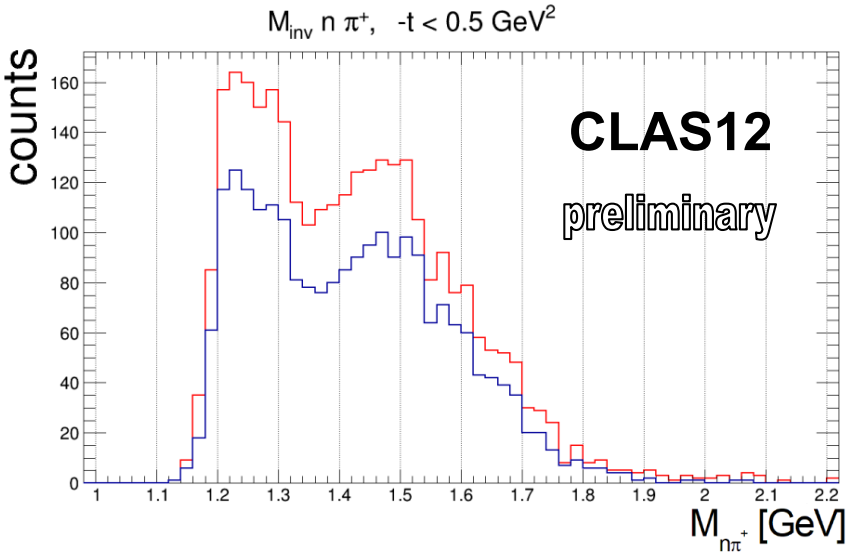


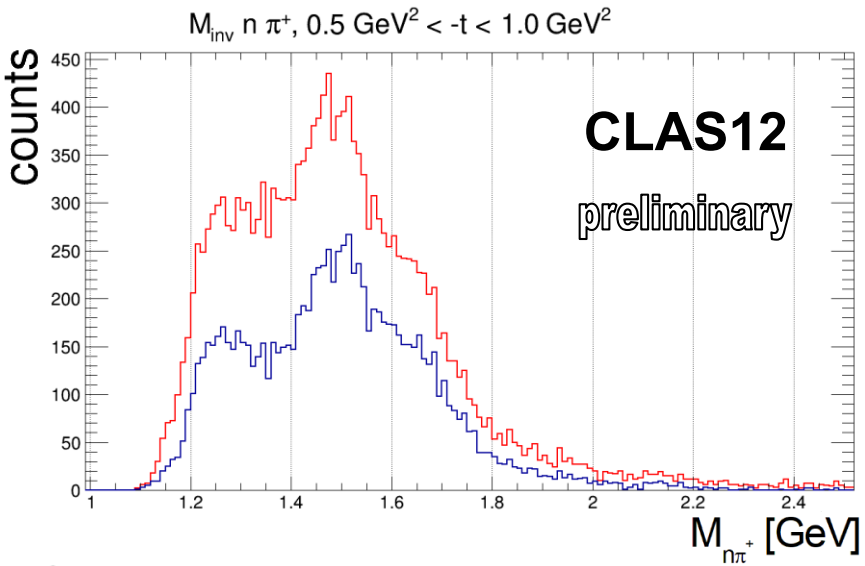
Semenov-Tian-Shansky, Vanderhaeghen, arXiv:2303.00119 (2023)

Resonance spectra

$e\ p \rightarrow e'\ \Delta^+\ \gamma \rightarrow e'\ n\ \pi^+\ \gamma$

raw M($\pi^+\gamma$) > 1.0 GeV





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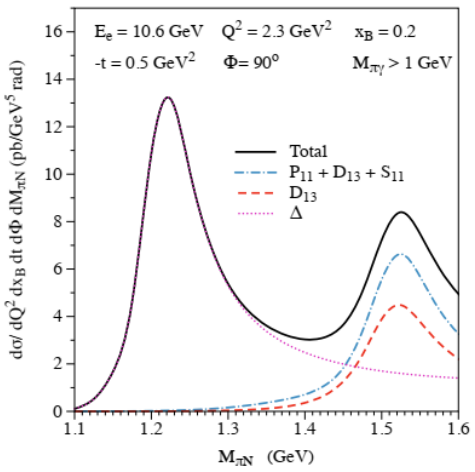
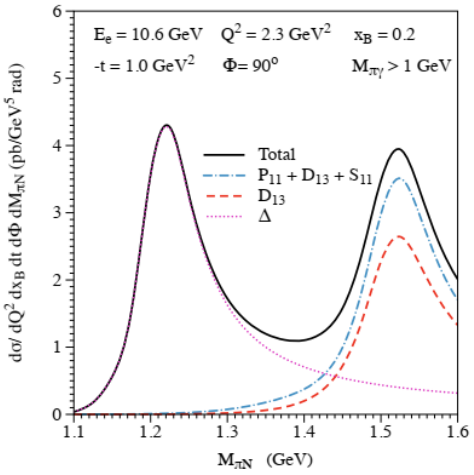
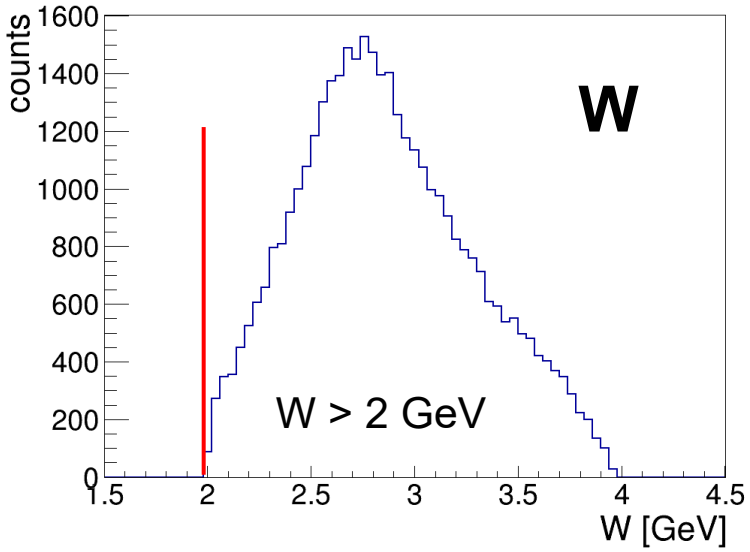
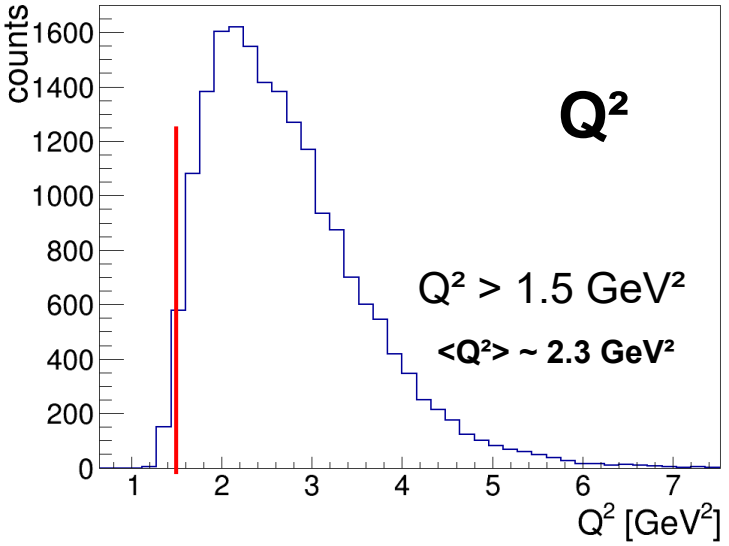
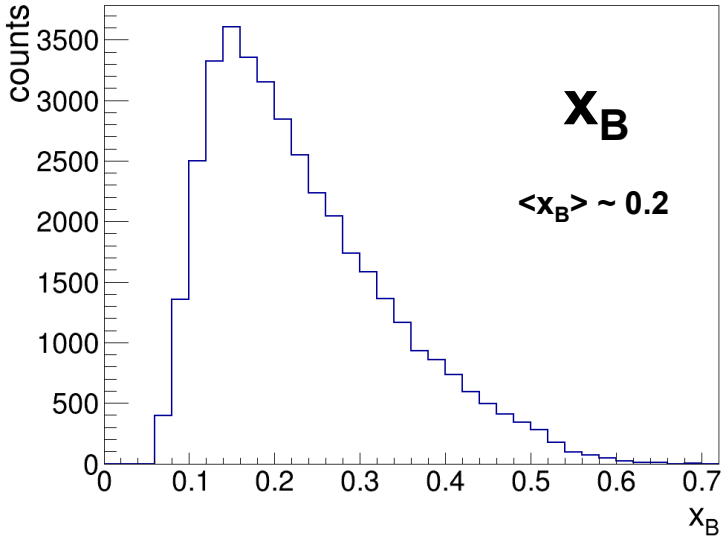


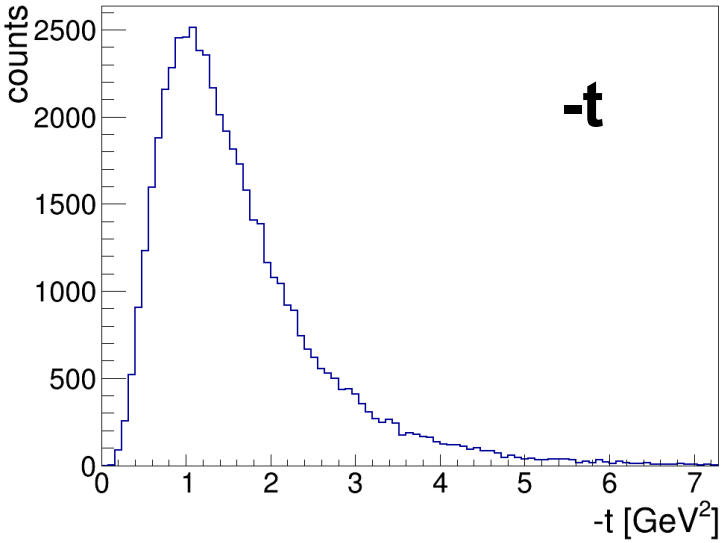


Accessible kinematics



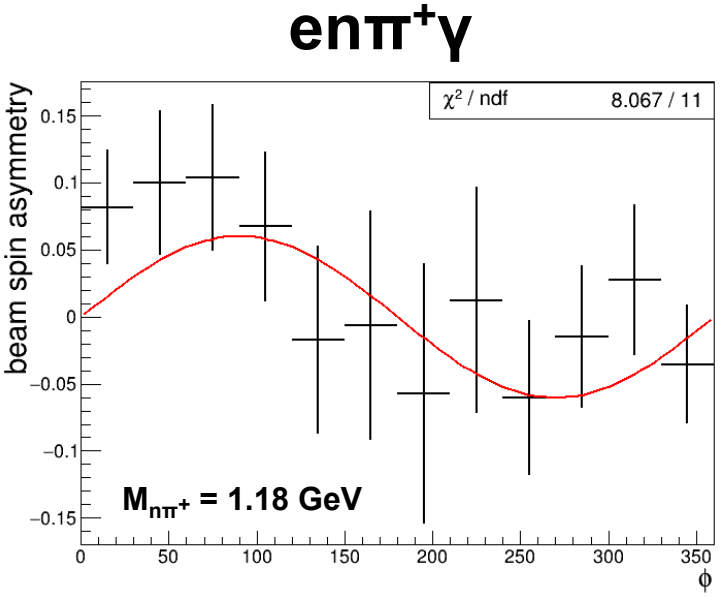


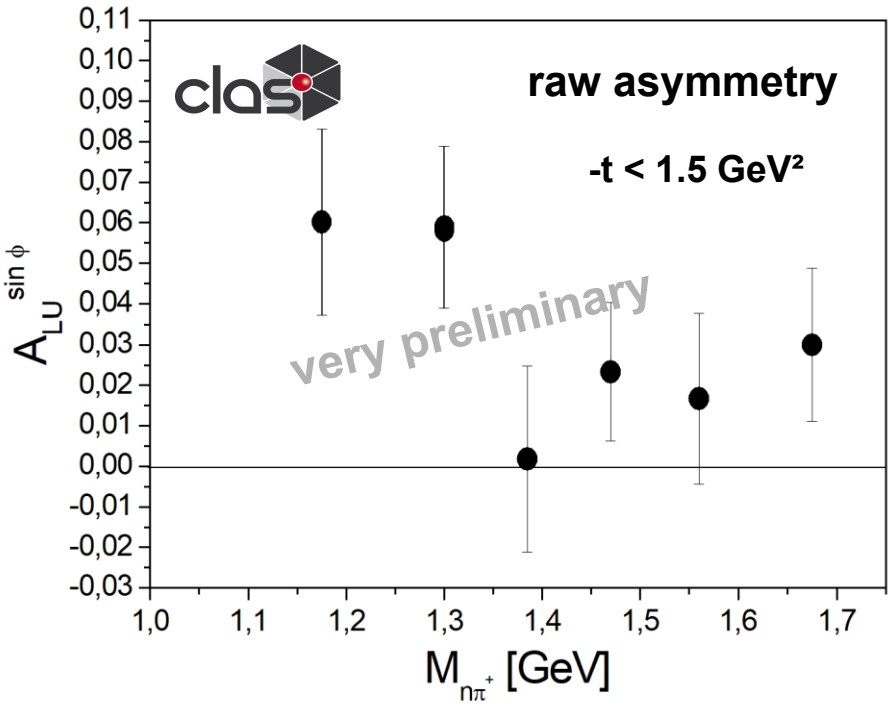




A first look on raw BSA based on pass 1

$$A = \frac{1}{P}\frac{N^+ - N^-}{N^+ + N^-} \approx A_{LU}^{\sin\phi}\sin\phi$$



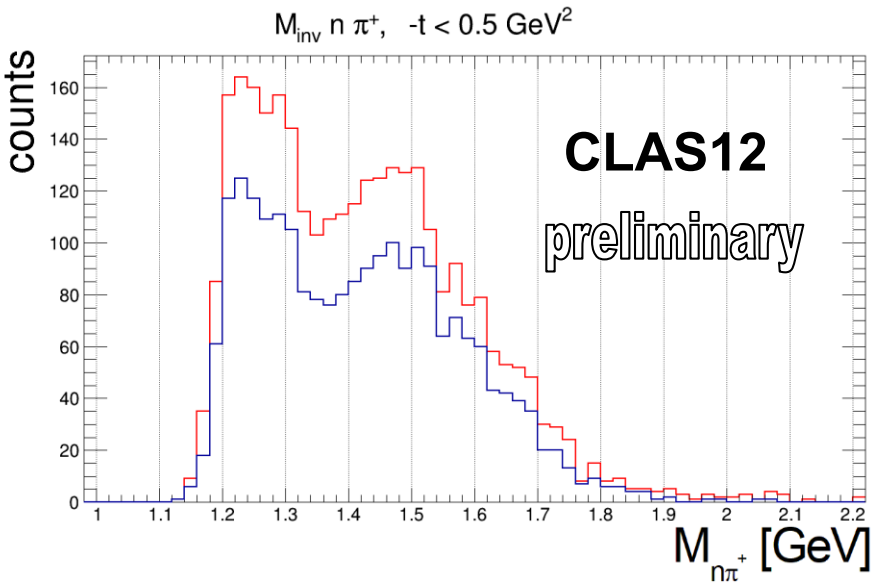


- Raw asymmetry (no backgrounds considered …)
- Background subtracted asymmtries will be released for pass 2 (this fall)
- So far results from pilot studies look very promissing and are in agreement with theory

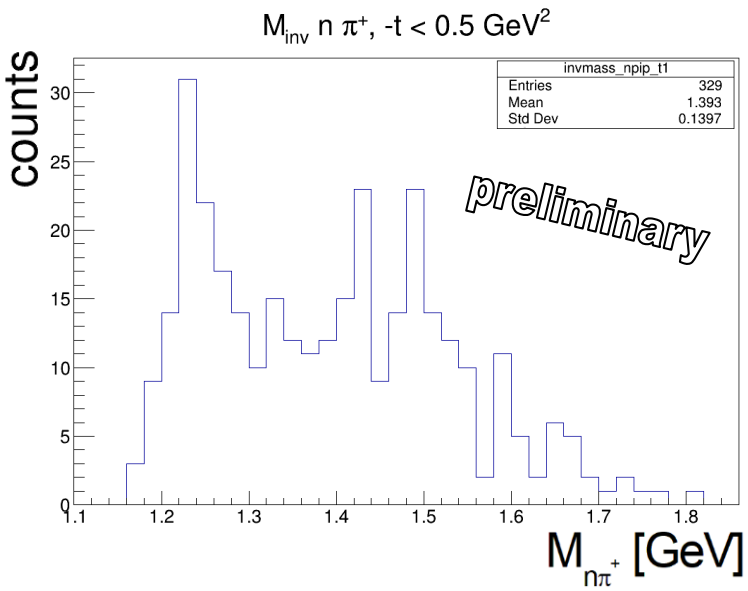
Resonance spectra: pass 1 vs pass 2

$$e\ p \rightarrow e'\ \Delta^+\ \gamma \rightarrow e'\ n\ \pi^+\ \gamma$$

pass 1



pass 2 (small fraction)

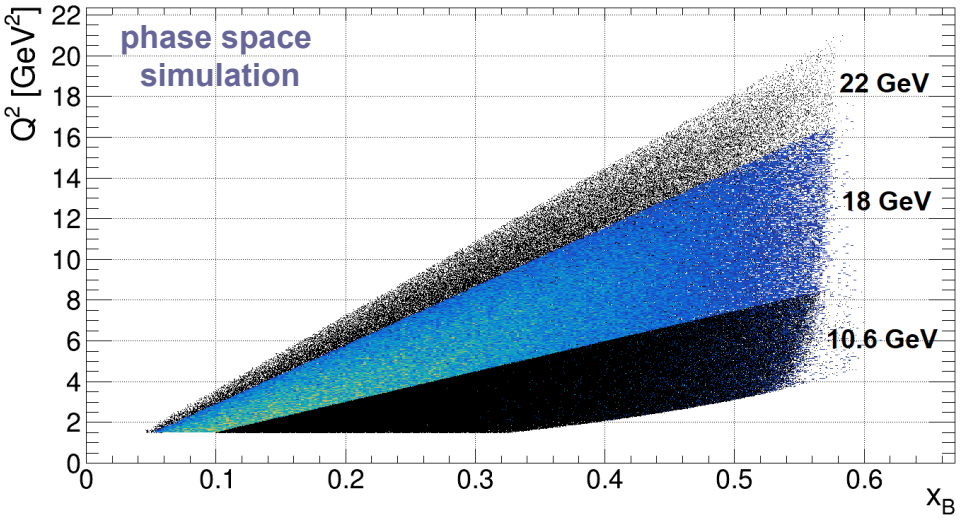


➔ **Improved resolution**

➔ **Increased efficiency (statistics)**

➔ **Cooking of the full dataset is ongoing**

Perspectives for a 22 GeV JLAB upgrade



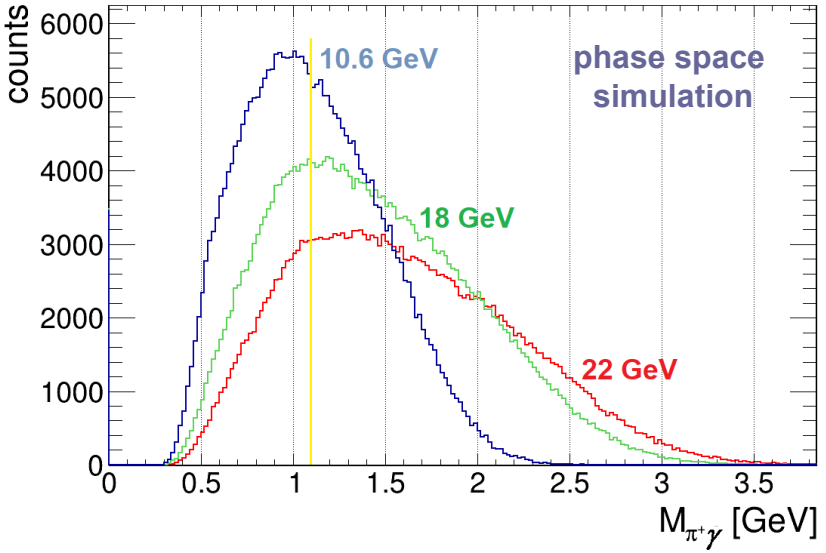
$$ep \rightarrow e\,\Delta^+\,\gamma \rightarrow e\,n\,\pi^+\,\gamma$$

Extended Q² range

➔ **Advantage for factorisation**

Better signal / background separation

➔ **Higher efficiency**



Conclusion and Outlook

- N→N* DVCS can be well measured with CLAS12
- BSAs from the N→N* DVCS process will be published based on RG-A pass 2
- The fesability of cross section measurements is under inevestigation
  (precise models and MC needed)
- Background from e p → e‘ Δ^+ π^0 → e‘ (n π^+) (γ γ) is under investigation
  (suppression / subtraction)
- A JLAB energy and luminosity upgrade will help to significantly
  improve these measurements and the extraction of transition GPDs
- Potential studies with COMPASS / AMBER are under investigation