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Jefferson Lab

Analysis of CLAS12 Single Pion ep → e'nπ⁺ Electroproduction

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clas

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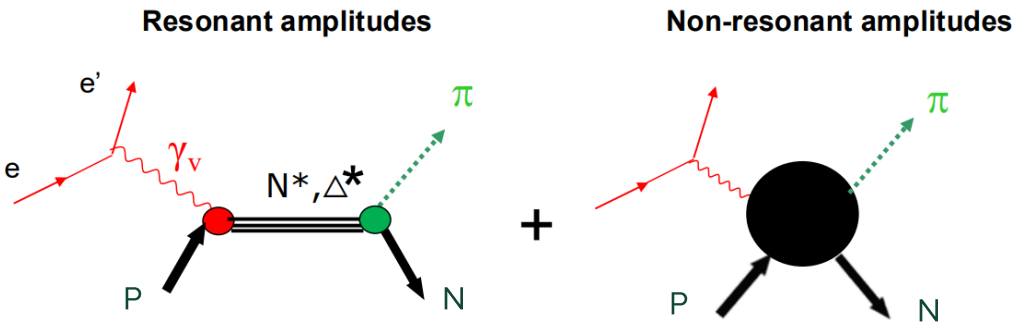
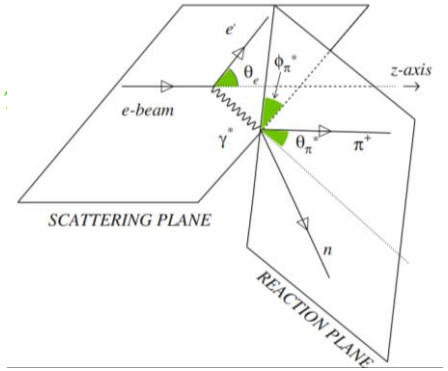
N* Structure in Experiments of CLAS12

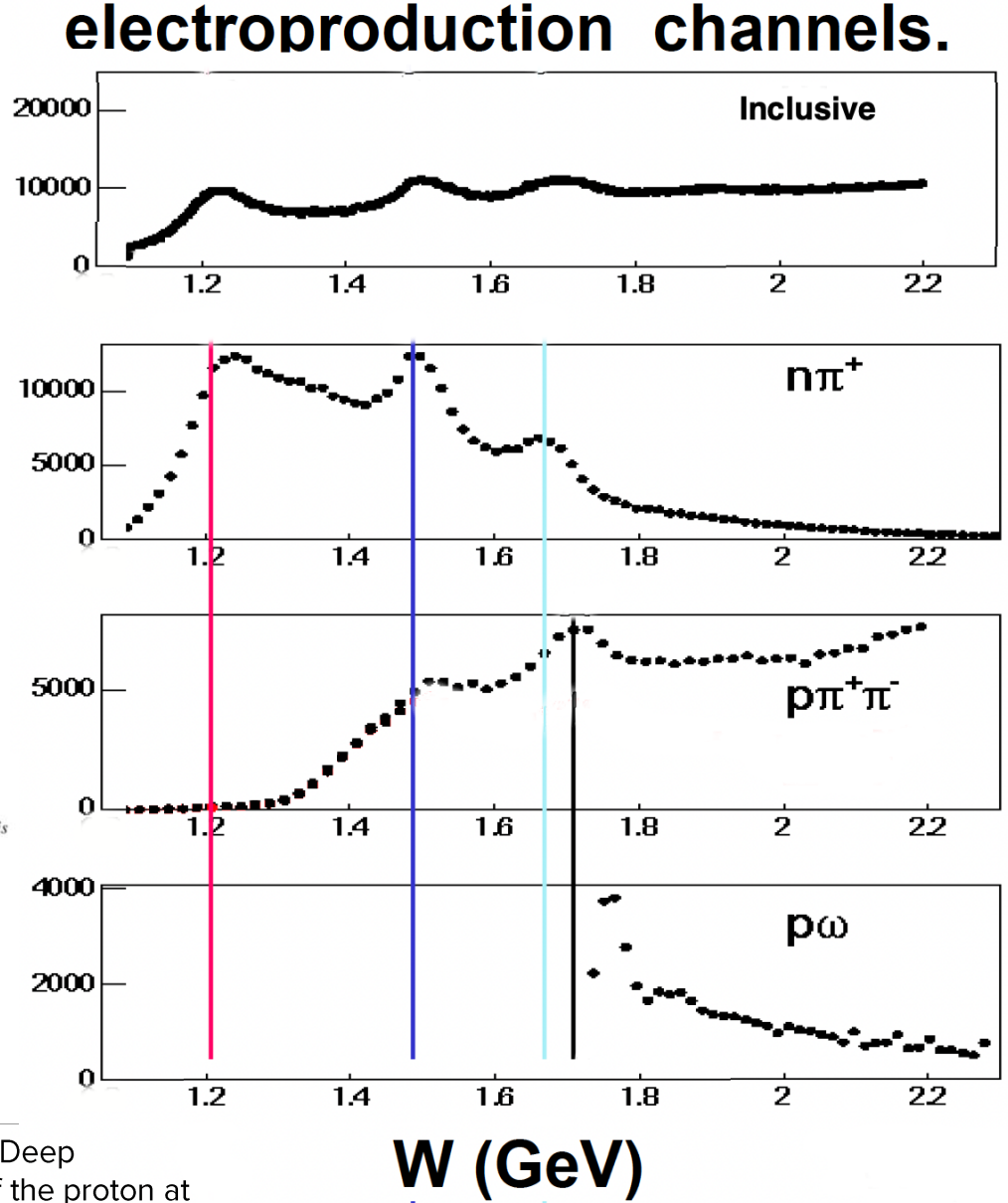
- N* structure as a window into strong QCD. Extract $\gamma_v pN^*$ electrocouplings from exclusive meson electroproduction observables with CLAS
- $n\pi^+ \rightarrow$ dominant channel in 1st and 2nd resonance regions with significant contributions in the 3rd.
- Goal: Extract differential cross sections & beam spin asymmetry for $ep \rightarrow e'n\pi^+$.



D.S. Carman, K. Joo , V.I. Mokeev, Strong QCD Insights from Excited Nucleon Structure Studies with CLAS and CLAS12



K. Park, M. Guidal, R. Gothe, et al. Deep exclusive π+ electroproduction off the proton at CLAS

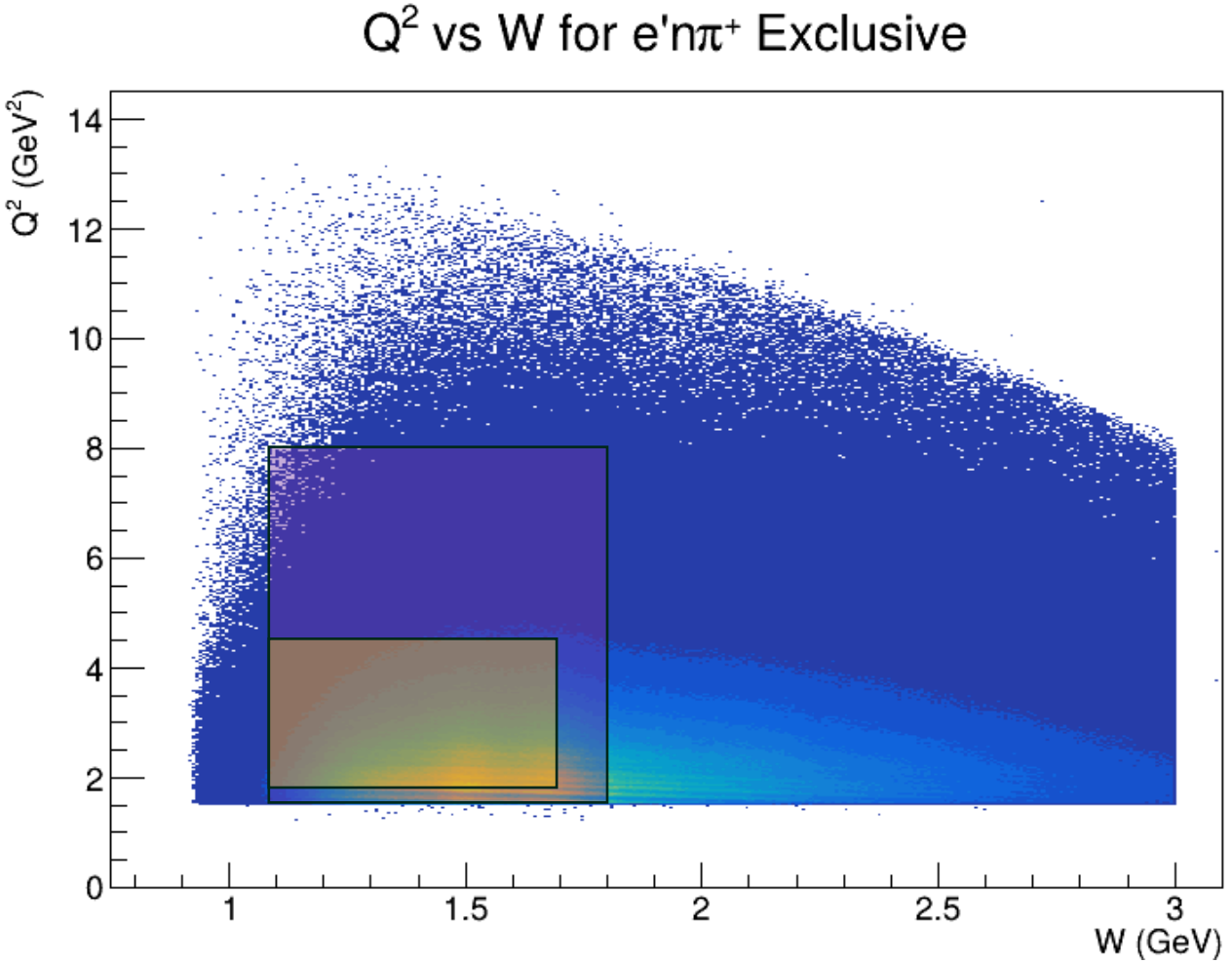


V.I. Mokeev, Baryon Transition Form Factors from Experiment

Previous Analysis & Aims of Current Work

Hadron Final State	W Coverage (GeV)	Q^2 Coverage (GeV^2)	Measured Observables
$\pi^+ n$	1.1–1.38	0.16–0.36	$\frac{d\sigma}{d\Omega}$
	1.1–1.55	0.3–0.6	$\frac{d\sigma}{d\Omega}$
	1.1–1.70	1.7–4.5	$\frac{d\sigma}{d\Omega}$, A_b
	1.1–1.66	0.4–0.65	A_{bt}
	1.6–2.00	1.8–4.5	$\frac{d\sigma}{d\Omega}$

- Goal: To extend the π^+n analysis of the cross section and asymmetry in Q^2 up to ~8 GeV^2 moving closer toward the transition region between nonperturbative QCD and perturbative QCD.
- Restricted by statistics & available event generators.



Differential Cross Section

$$\frac{d^4\sigma}{dW\, dQ^2\, d\cos\theta_\pi\, d\phi_\pi} = \frac{1}{A\, E_C\, R} \cdot \frac{\left(\frac{\Delta N_{\text{Full}}}{\Delta Q_{\text{Full}}} - \frac{\Delta N_{\text{Empty}}}{\Delta Q_{\text{Empty}}}\right)}{L \Delta W\, \Delta Q^2\, \Delta \cos\theta_\pi\, \Delta\phi_\pi}$$

- ΔN_{Full} and ΔN_{Empty}: The number of good single pion events in a given bin for a full target and empty target run.
- ΔQ_{Full} and ΔQ_{Empty}: The total charge collected by the Faraday cup for each bin.
- A: The acceptance correction which accounts for the loss of good events through detector efficiency, geometrical acceptance, and particle identification cuts.
- E_c: Correction due to efficiency difference of simulation and experiment.
- R: Radiative correction as the electron may radiate a photon during its interaction with the proton.
- L: Integrated luminosity which represents the number of potential interactions.

$$A_b = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-} \rightarrow$$

- Will look at polarization dependence of the integrated cross section which factors into higher order corrections for the electrocouplings.

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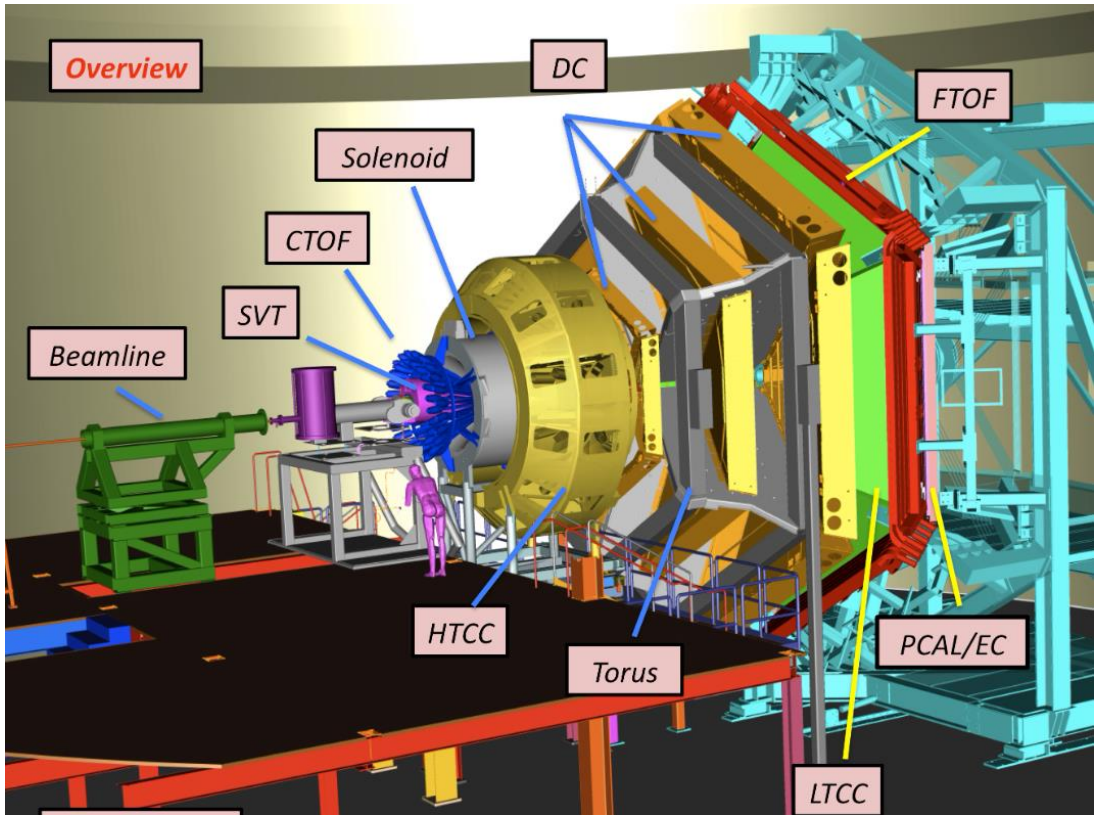
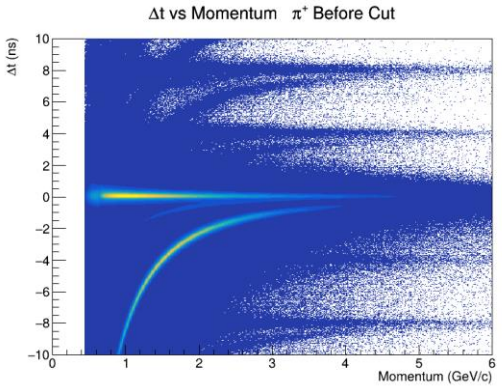
CLAS12 Detector System

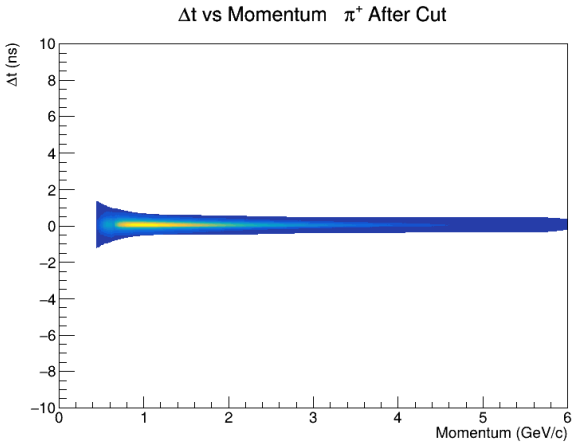


https://www.jlab.org/physics/hall-b/clas12

- 10^{35} cm^{-2} sec^{-1} luminosity, $1.5 < Q^2 < 10$ GeV^2 coverage.
- Current data presented from fall2018 10.6 GeV beam energy.
- Forward Detector covers 5^0-35^0, Central detector covers 35^0-125^0

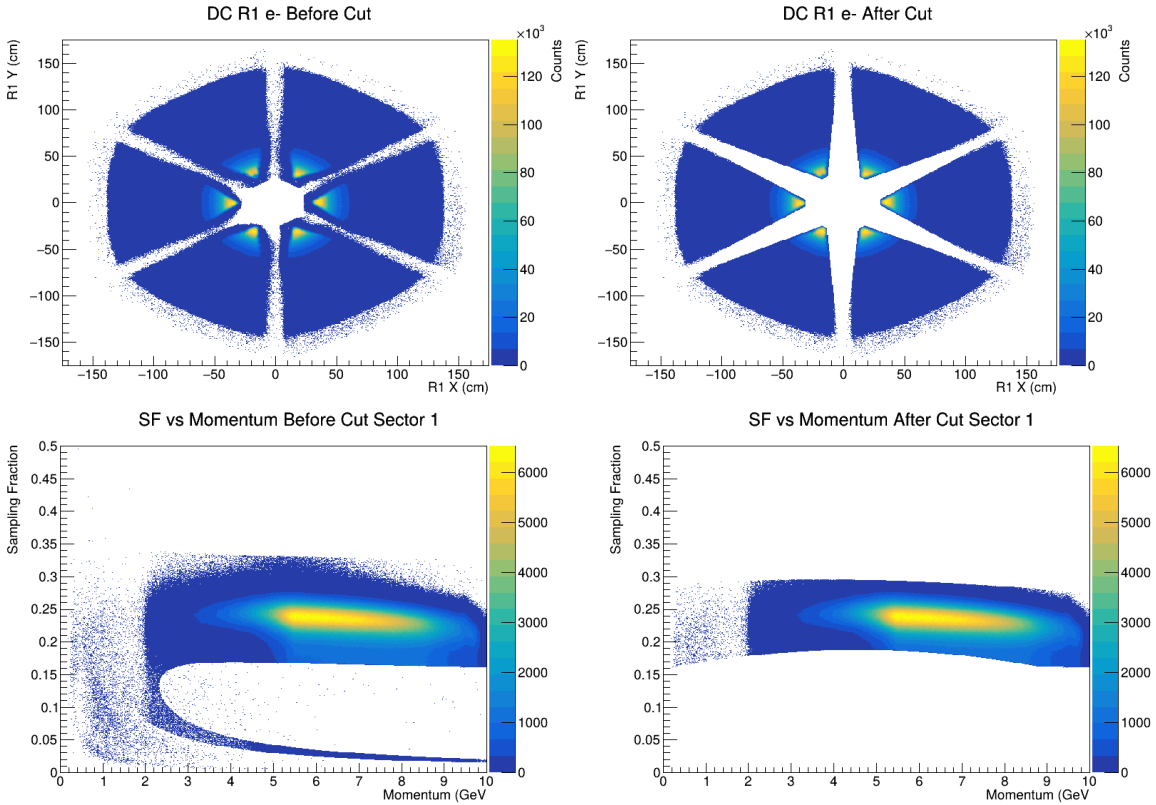
Event Selection





Hadron

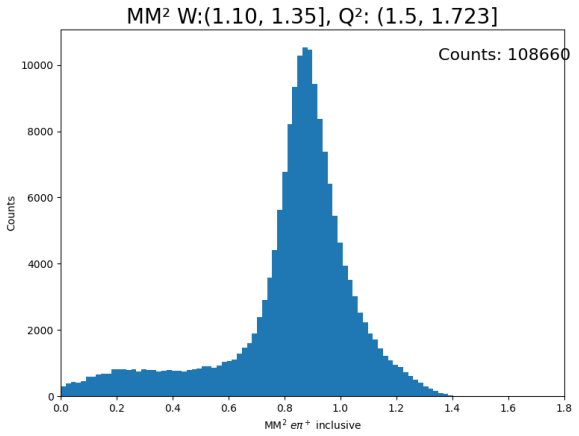
- Vertex z coordinate
- DC & PCAL Fiducial
- Momentum > 0.45 GeV
- Δt & pid χ^2 cut – both cut on Δt but the first cuts near zero, the second minimizes Δt for each particle.

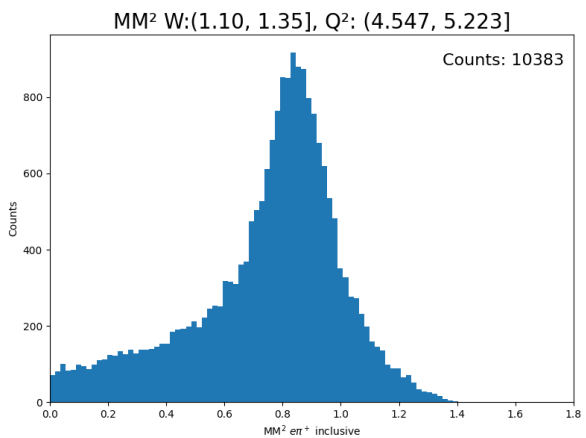


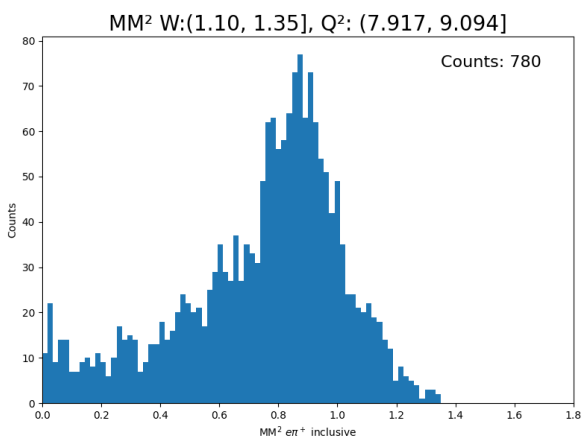
Electron

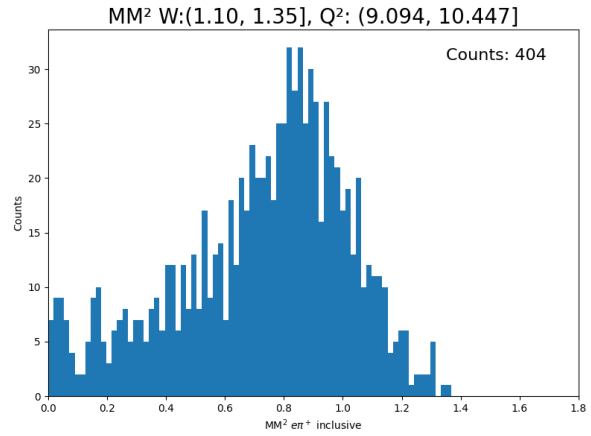
- Vertex z coordinate
- DC & PCAL Fiducial
- Momentum > 0.45 GeV
- Sampling fraction
- Number of photoelectrons in the HTCC

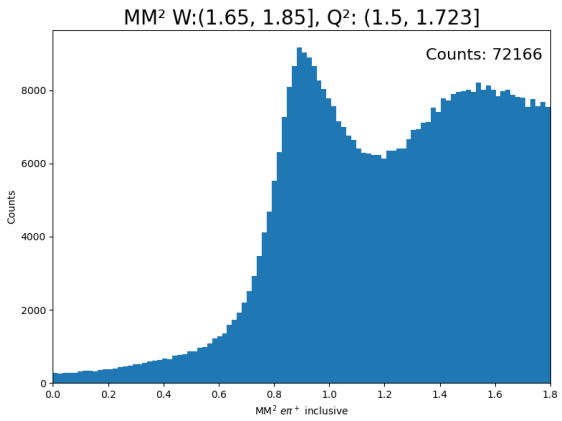
Event Selection

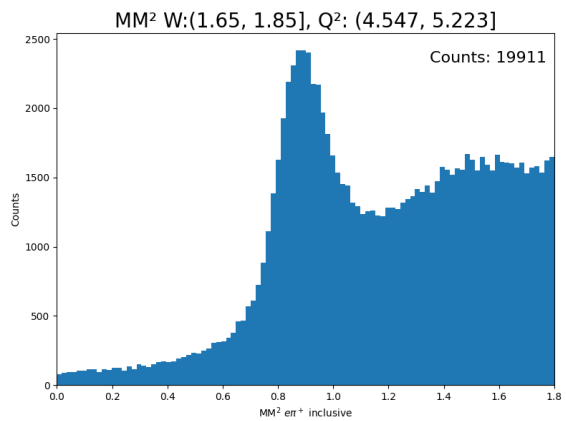


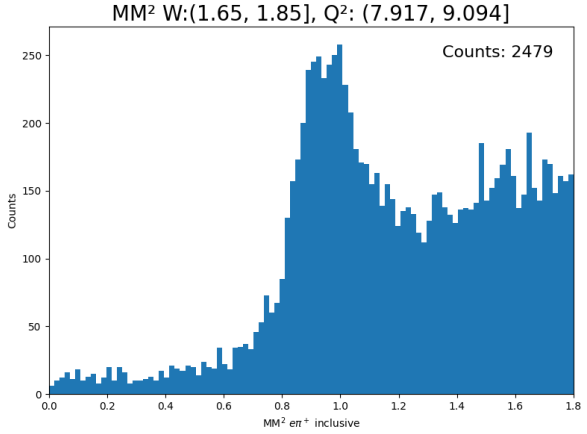


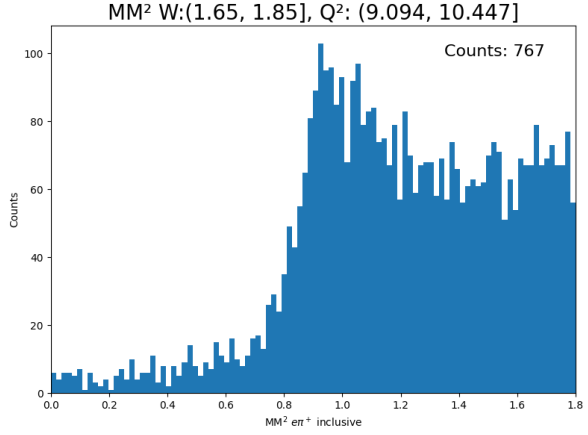












- Fit peak to select neutron and count e’nπ$^+$ exclusive events.
- Work on background subtraction, determine appropriate binning especially for high Q^2.

Simulation

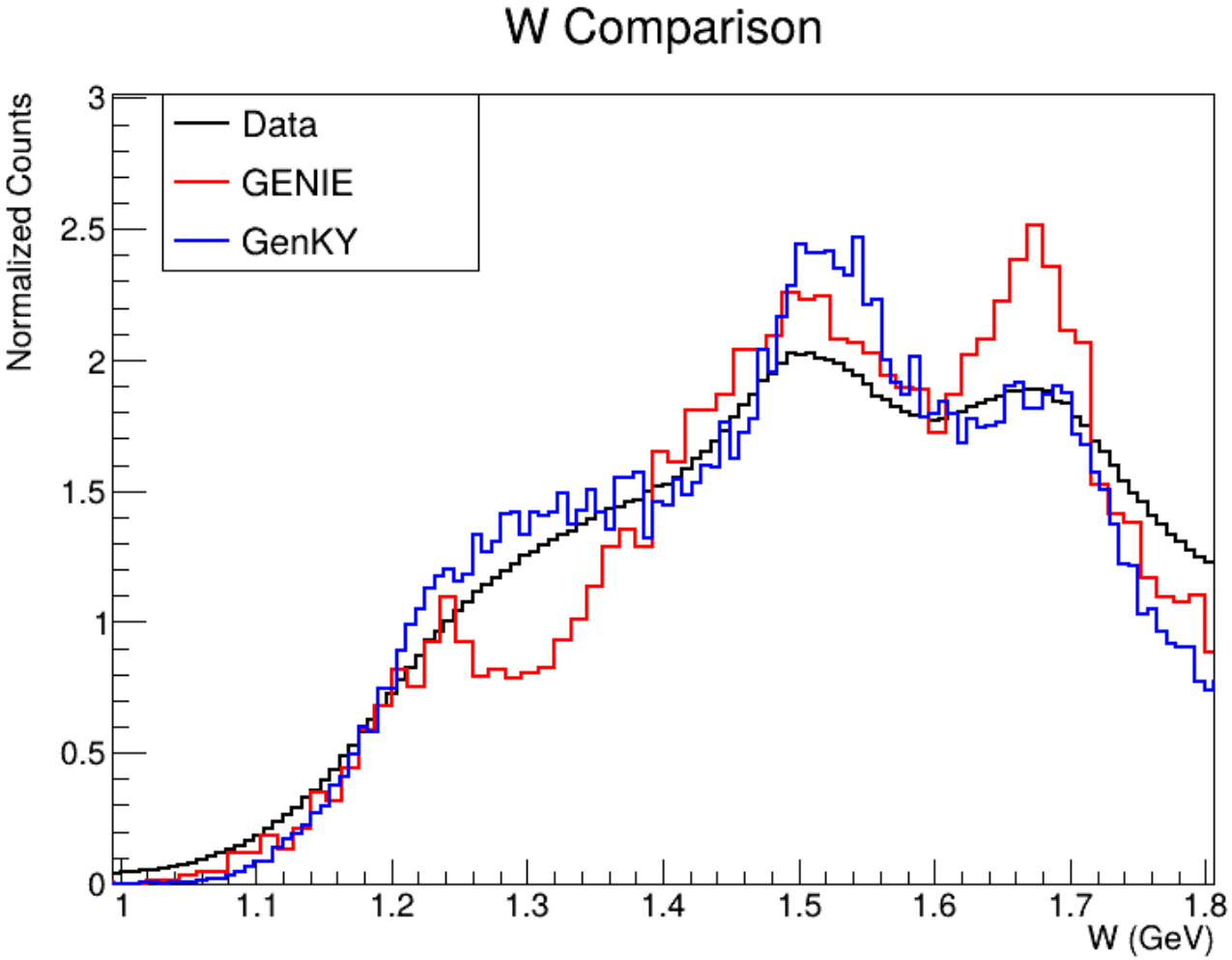
- GENIE → Uses Berger Sehgal model for resonance production, Bodek and Yang for nonresonant production. Implementation of MAID to come in the future.

  C. Andreopoulos, J. Berger, J. Hewes, M. Roda, Genie Physics & User Manual

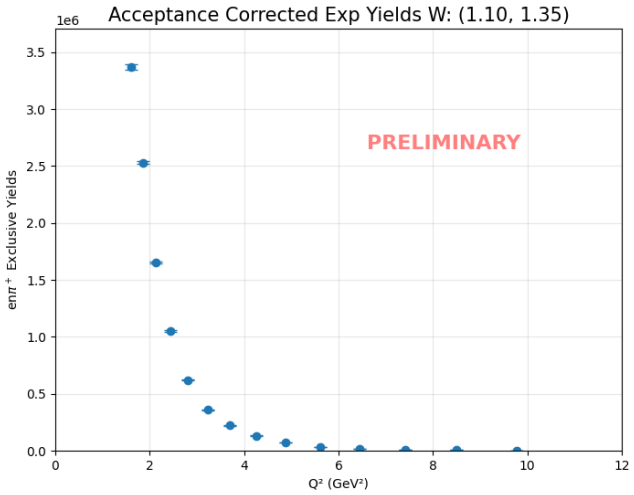
- genKYandOnePion → Fit to data up to 1.8 GeV in W and 5 GeV^2 in Q^2 and extrapolated beyond.

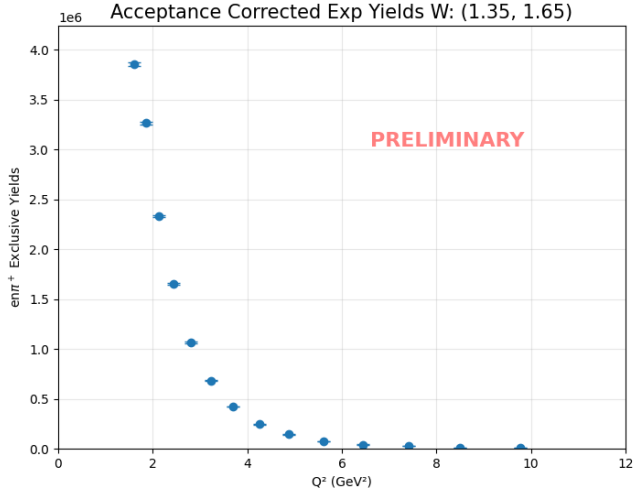
  V. Klimenko, D.S. Carman, V.I. Mokeev, The genKYandOnePion Event Generator

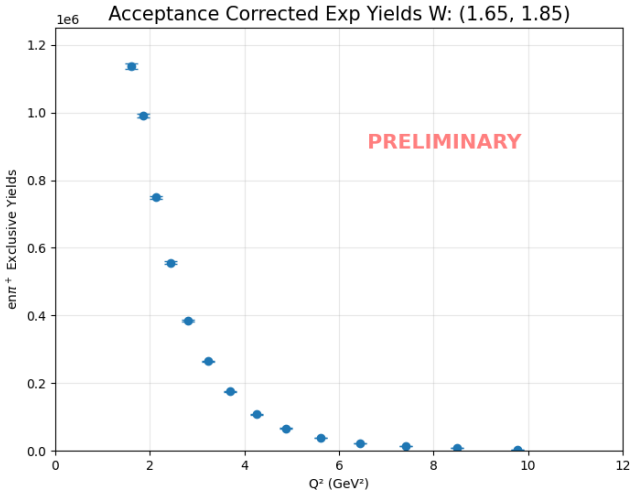
- Aao_gen in the future, based on MAID 2000 https://github.com/JeffersonLab/aao_gen

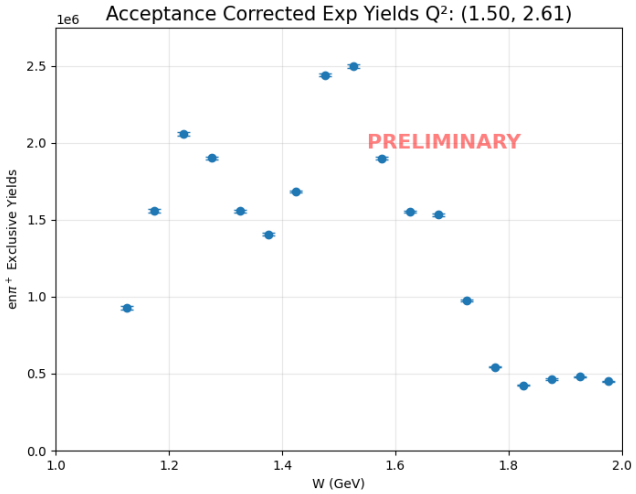


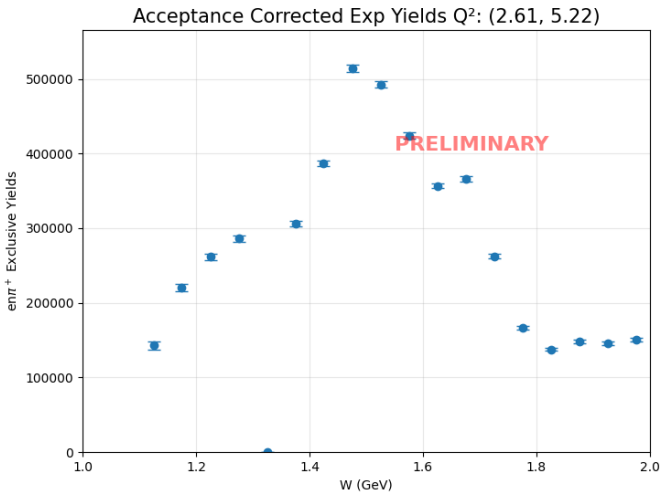
Yields

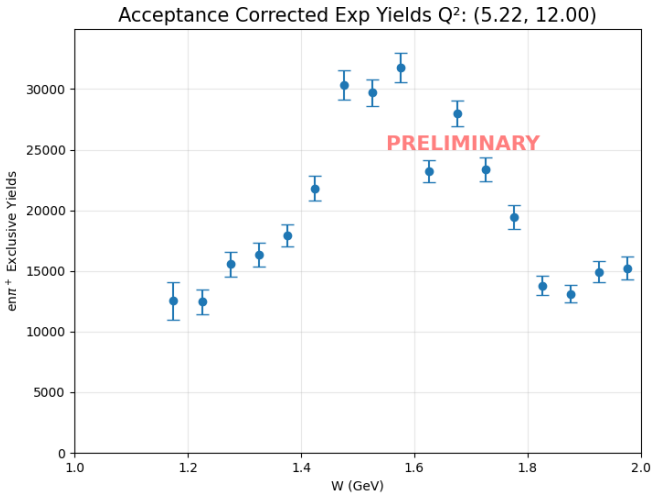

Acceptance Corrected Exp Yields W: (1.10, 1.35)
1e6
enπ⁺ Exclusive Yields
Q² (GeV²)
PRELIMINARY


Acceptance Corrected Exp Yields W: (1.35, 1.65)
1e6
enπ⁺ Exclusive Yields
Q² (GeV²)
PRELIMINARY


Acceptance Corrected Exp Yields W: (1.65, 1.85)
1e6
enπ⁺ Exclusive Yields
Q² (GeV²)
PRELIMINARY

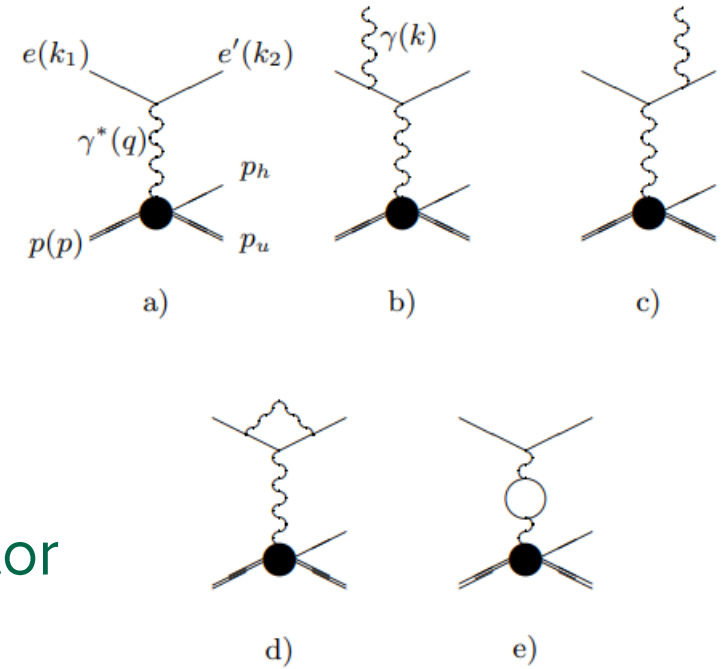

Acceptance Corrected Exp Yields Q²: (1.50, 2.61)
1e6
enπ⁺ Exclusive Yields
W (GeV)
PRELIMINARY


Acceptance Corrected Exp Yields Q²: (2.61, 5.22)
enπ⁺ Exclusive Yields
W (GeV)
PRELIMINARY


Acceptance Corrected Exp Yields Q²: (5.22, 12.00)
enπ⁺ Exclusive Yields
W (GeV)
PRELIMINARY

Next

- Radiative Corrections & EXCLURAD – Takes into account Hadron radiation which is crucial for exclusive meson production.
  A. Afanasev, I. Akushevich, V. Burkert, K. Joo, QED Radiative Corrections in Processes of Exclusive Pion Electroproduction



- Energy & Momentum Corrections – Energy lost in detector interactions
- Bin Centering – The distribution across each differential cross section bin is not necessarily linear, so the center of the bin may not be the average.
- Bin Migration – Due to measurement uncertainties, events can end up in neighboring bins. Is take care of if event generator is reasonably close to the shape of the measured cross section.