Exclusive $p\pi^+\pi^-$ electroproduction in the resonance region at high Q^2

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The studies of N* electrocouplings: motivation & objectives

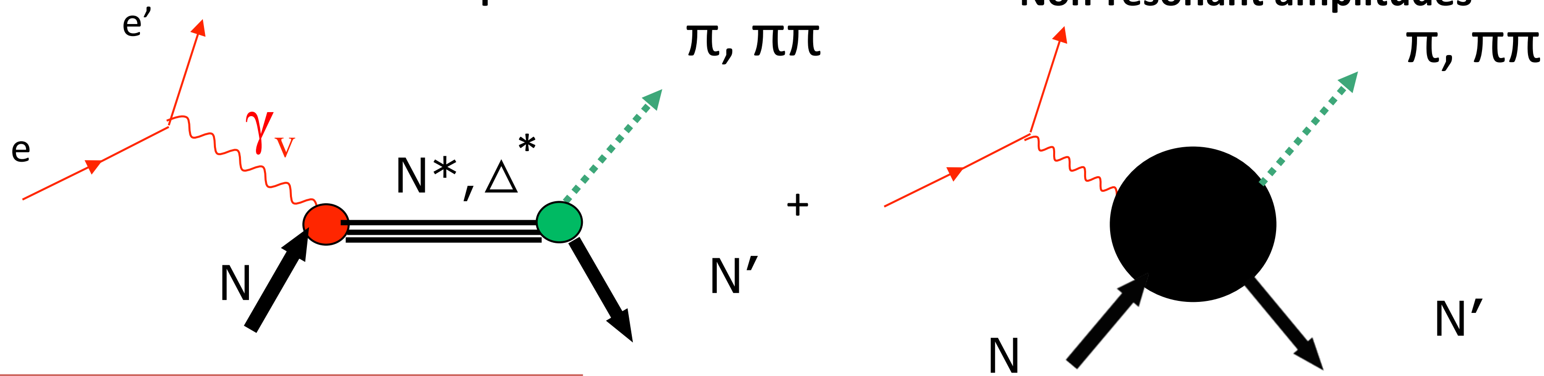
- **My analysis seeks to determine**

γNN* transition helicity amplitudes (electrocouplings) at photon virtualities $2.0 < Q^2 < 5.0$ GeV^2 for most of the excited proton states at W < 2 GeV from double pion electroproduction channel.

- Consistent results on electrocouplings of N* states determined in independent analysis of major Nπ and Nππ exclusive channels will demonstrate reliable extraction of this fundamental quantities
- Explore signals from 3/2+ (1720) candidate state and search for possible new states at 1.8<M<2.0 GeV
- For the first time determine electrocouplings of high lying N*(>1.6 GeV) which decay mostly to Nππ.
- Physics analysis of expected resonance electrocouplings will allow us explore behavior of the structure of exited states of different quantum numbers at the distances which correspond to the transition from combined contributions from inner quark core and external meson-baryon cloud to dominance of quark degrees of freedom

Extraction of $g_v NN^*$ electrocouplings from the data on exclusive meson electroproduction off protons

Resonant amplitudes **Non-resonant amplitudes**



- $A_{1/2}(Q^2)$, $A_{3/2}(Q^2)$, $S_{1/2}(Q^2)$
  or
- $G_1(Q^2)$, $G_2(Q^2)$, $G_3(Q^2)$
  or
- $G_M(Q^2)$, $G_E(Q^2)$, $G_C(Q^2)$

N*'s photo-/electrocouplings $g_v NN^*$ are defined at $W=M_{N^*}$ through the N* electromagnetic decay width :

$$\Gamma_\gamma = \frac{q_{\gamma r}^2}{\pi}\frac{2M_N}{(2J_r+1)M_{N^*}}\left[\left|A_{1/2}\right|^2+\left|A_{3/2}\right|^2\right]$$

See details in: I.G.Aznauryan and V.D.Burkert, Progr. Part. Nucl. Phys. 67, 1 (2012).

- Consistent results on $g_v NN^*$ electrocouplings from different meson electroproduction channels and different analysis approaches demonstrate reliable extraction of N* parameters.
- For electrocouplings extracted from one pion channels, please see talk by Ki Jun Park and I.G.Aznauryan et al., CLAS Coll., Phys Rev. C80, 055203 (2009).

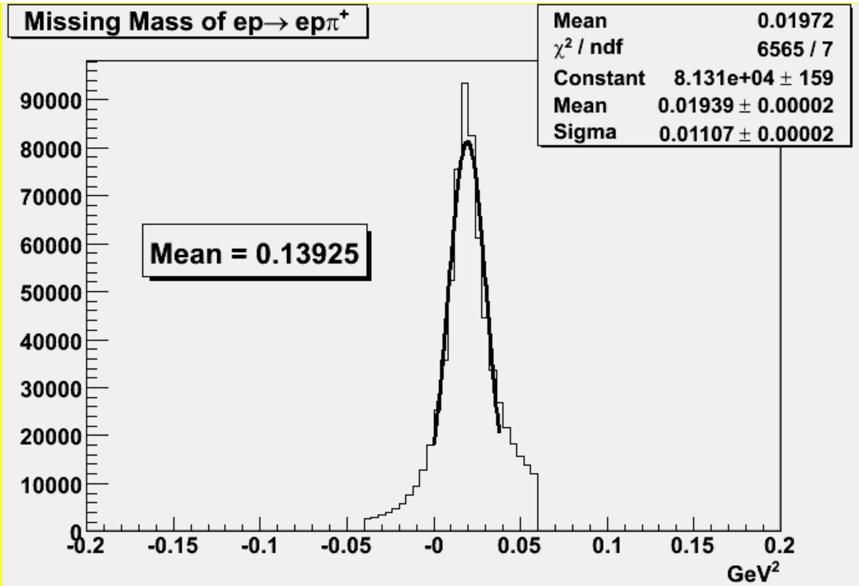
Summary on events selection

- Electron ID
  - Calorimeter cuts
  - Cherenkov cut
  - Fiducial cuts
  - Zvertex cut
  - Momentum corrections
  - Zvertex corrections

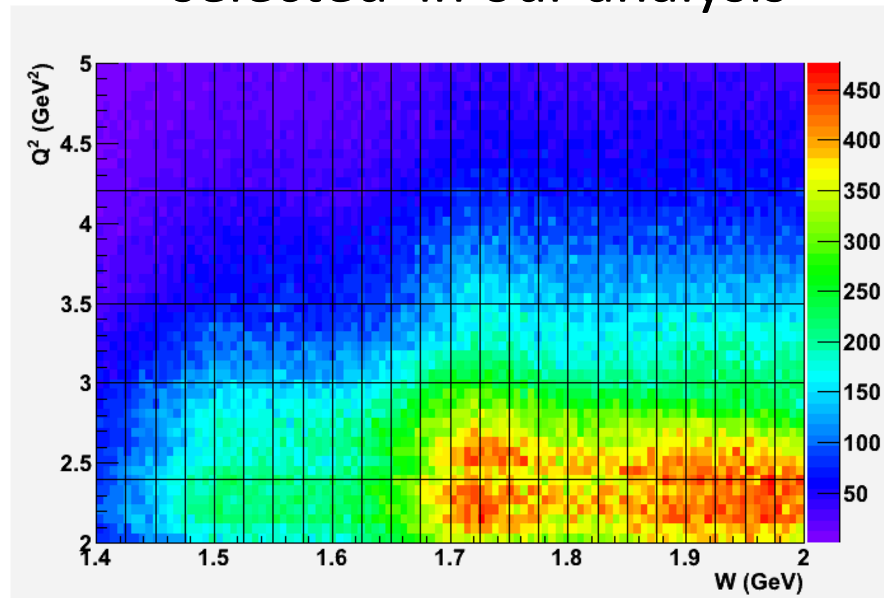
Charged hadrons ID

- Beta vs Momentum cut
- Fiducial cuts
- Zvertex cut
- Theta vs p cuts
- Bad scintillators cut
- Momentum corrections for positive pion
- Energy loss corrections for proton

Exclusivity cut

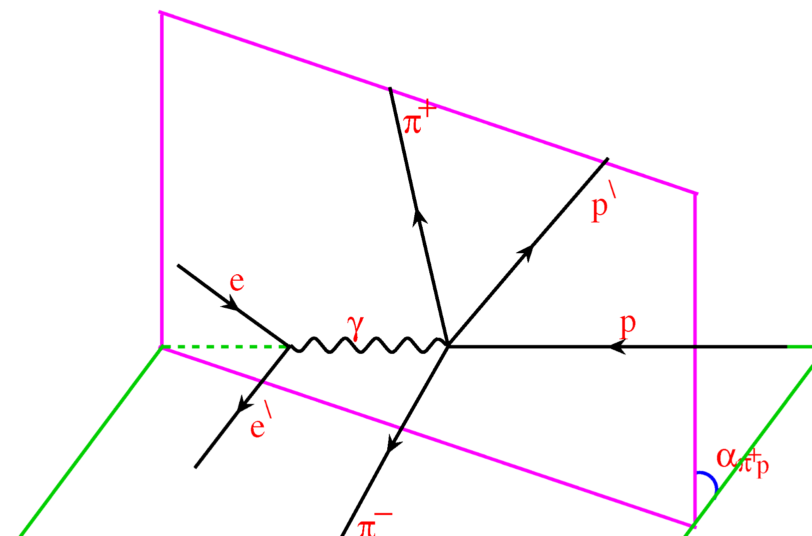


W & Q^2 distribution for $\pi^+\pi^- p$ events selected in our analysis



3-body final state kinematics variables

3-body final state kinematics variables:
$M_{\pi\pi}$, $M_{p\pi}$ are invariant masses of the $\pi^+\pi^-$ and $p\pi^+$ systems respectively;
$d\Omega = d(\cos\theta)d\varphi$ is solid angle for emitted π^-;
$\alpha_{p\pi^+}$ is the angle between two planes on the plot.



Cross-section extraction

$$\frac{d^7\sigma}{dWdQ^2d\tau} = \frac{1}{L}\cdot\frac{\Delta N}{eff\cdot\Delta W\Delta Q^2\Delta\tau}$$

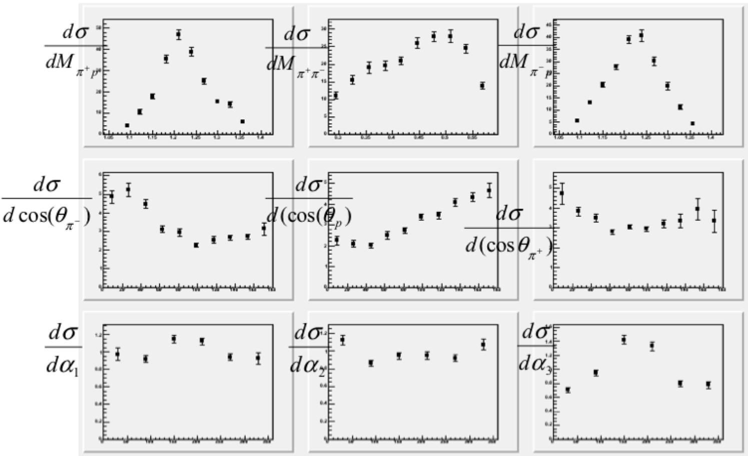
7-fold differential cross-section

$$d\tau = dM_{\pi^+\pi^-}dM_{\pi^+p}d\cos(\theta_{\pi^-})d\varphi_{\pi^-}d\alpha_{\pi^+p}$$

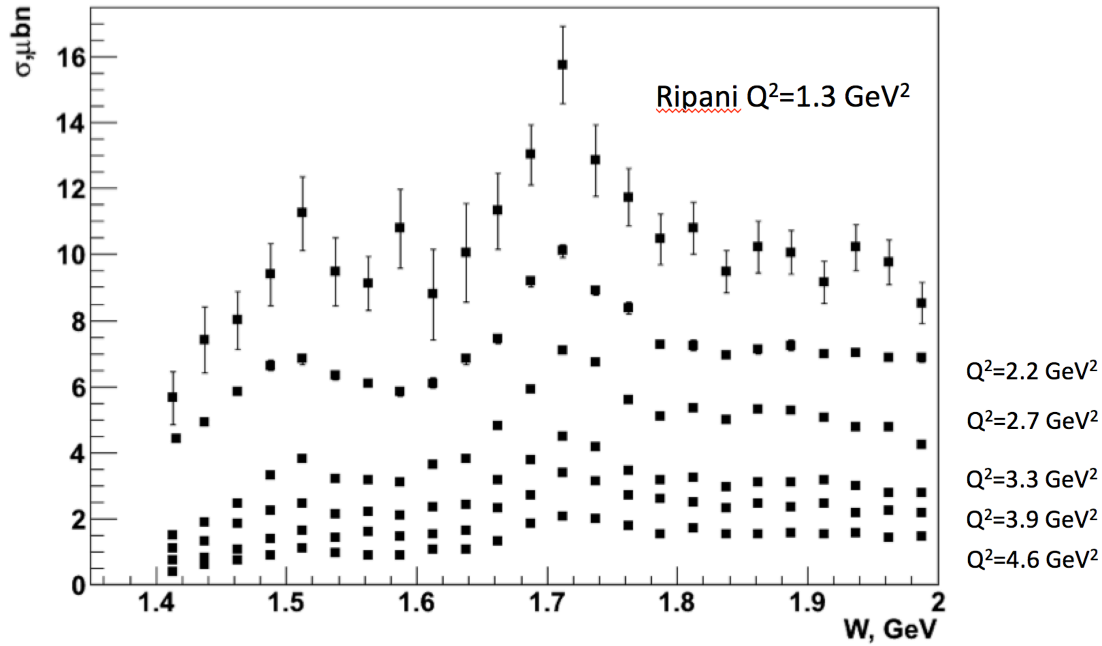
L – luminosity, ΔN – number of events inside multidimensional cell, eff-efficiency determined from monte-carlo simulation. Then we obtain virtual photon cross-section

$$\frac{d^5\sigma}{d\tau} = \frac{1}{\Gamma_v}\frac{d^7\sigma}{dWdQ^2d\tau}$$

2.0<Q²<2.4 GeV² 1.5<W<1.525 GeV



Q² Evolution of fully integrated cross section



Cross-sections obtained by integrating in 5 variables

D13(1520)
S11(1535)

D33(1700),P13(1720)
3/2⁺(1720),F15(1685)

Conclusions and outlook

- For the first time nine 1-fold differential double pion cross-section have become available at

  $2.0 < Q^2 < 5.0$ GeV^2 $1.4 < W < 2$ GeV
- Binning corrections and $\pi^+\pi^-$ invariant mass corrections are being made over entire W&Q^2 area
- Analysis note preparation
- Fit within the framework of the JM model