94-005

Determination of the $N\Delta$ Axial Vector Transition Form Factor $G_A^{N\Delta}$ from the $ep \rightarrow e'\Delta^{++}\pi^-$ Reaction

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CLAS Collaboration

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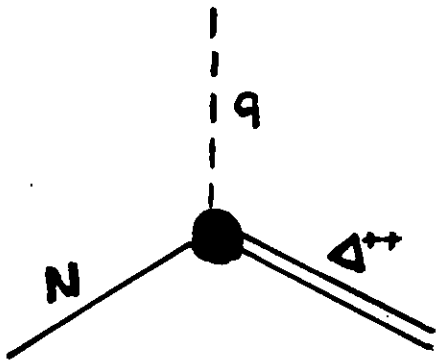
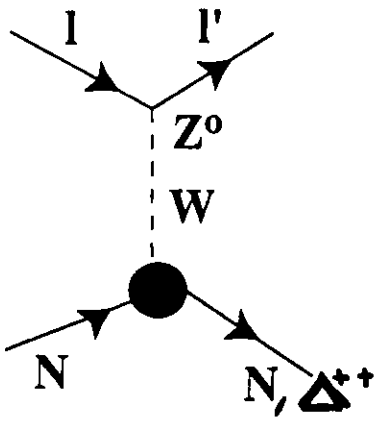
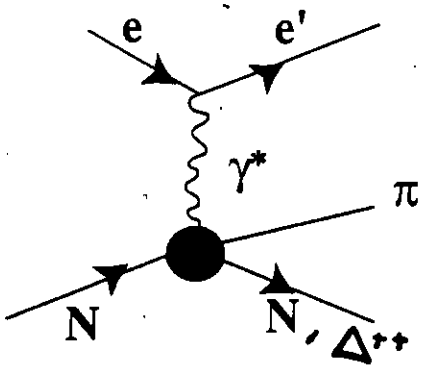
- Goal of hadronic physics at intermediate energies
  - Describe the structure of the nucleon in terms of its **fundamental constituents.**

- Extended experimental program at CEBAF to study the electromagnetic structure of the hadronic current
  - Elastic form factors of the Nucleon $eN \rightarrow eN$
  - Resonance transition form factors $eN \rightarrow eN^*, e\Delta^*$

- Axial structure of hadronic current of similar importance
  - Independent information about nucleon structure
  - Test QCD motivated models, QCD lattice calculations



$$< \Delta^{++}(\vec{p}')|\underline{A_\mu^\Delta}|p(\vec{p}) >= \bar{\Delta}^{++\nu}(\vec{p}')[\underline{d_1}(q^2)g_{\mu\nu} + \frac{\underline{d_2}(q^2)}{M^2}P^\alpha(q_\alpha g_{\mu\nu} - q_\nu g_{\alpha\mu}) - \frac{\underline{d_3}(q^2)}{M^2}p_\nu q_\mu + i\frac{\underline{d_4}(q^2)}{M^2}\epsilon_{\mu\nu\alpha\beta}P^\alpha q^\beta\gamma_5]u(\vec{p})$$

Weak interaction	e.m. interaction
$\nu, \bar{\nu}$ scattering	pion electroproduction at the threshold
	
Leptonic current $\gamma\mu\,(1+\gamma^5)$	Leptonic current $\gamma\mu$
Direct access to the axial part A_μ	Access to A_μ only if pion production Chiral symmetry and PCAC
⇓	⇓
But: low statistics requires model dependent fit, e.g. $G_A^{N\Delta}(Q^2) = \frac{G_A^{N\Delta}(O)}{(1 + M_A^{*2}/Q^2)^2}$	$G_A(Q^2)$ $G_p(Q^2)$, $G_A^{N\Delta}(Q^2)$

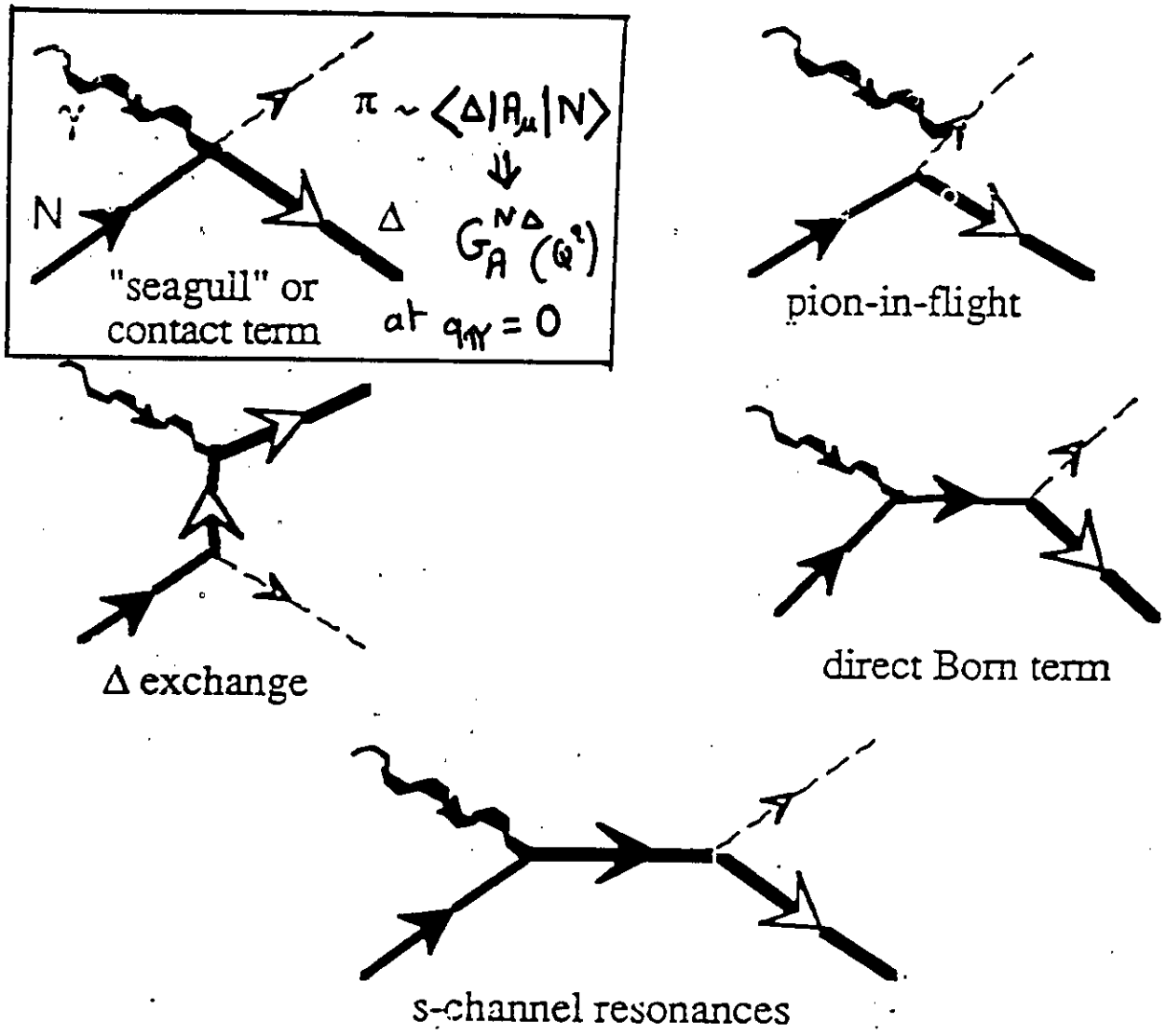
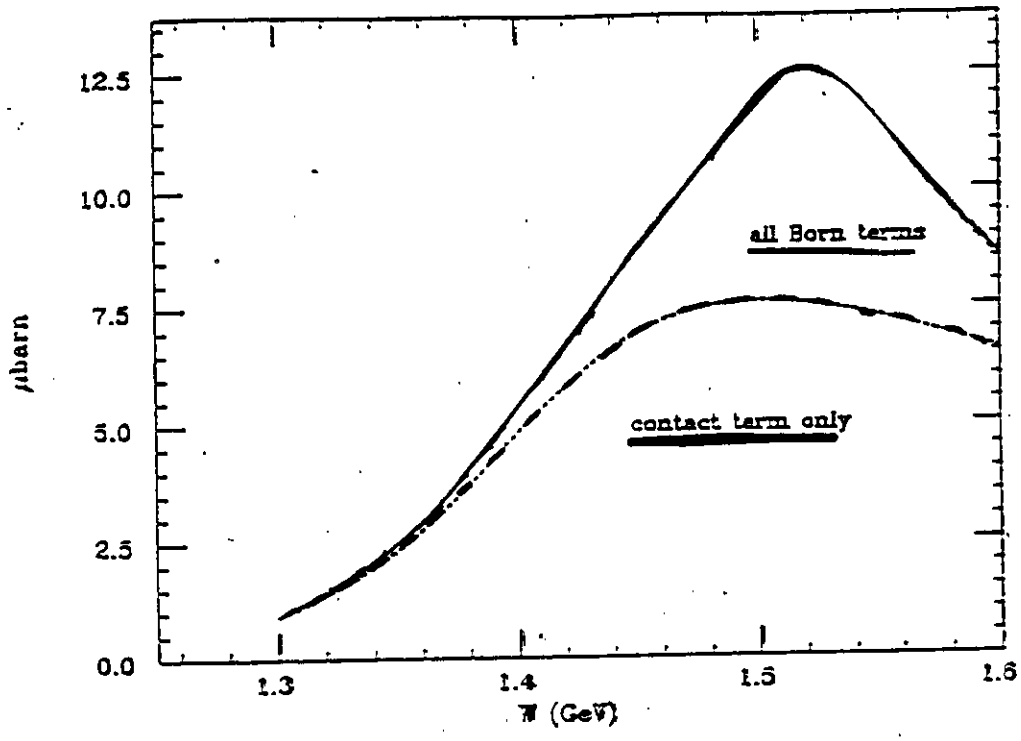
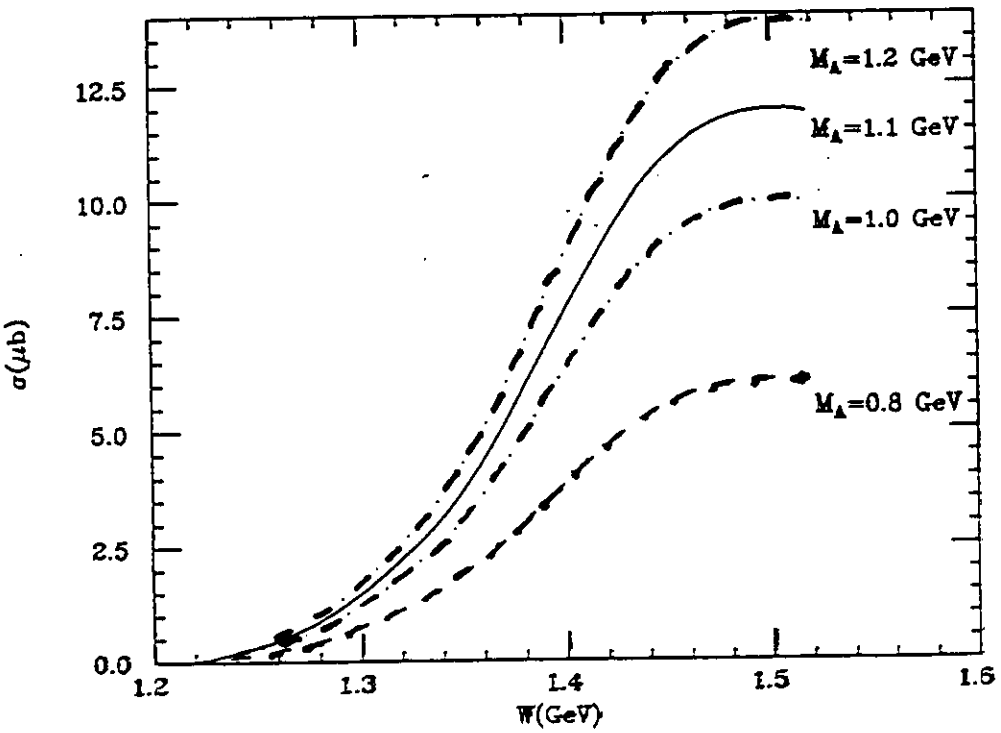
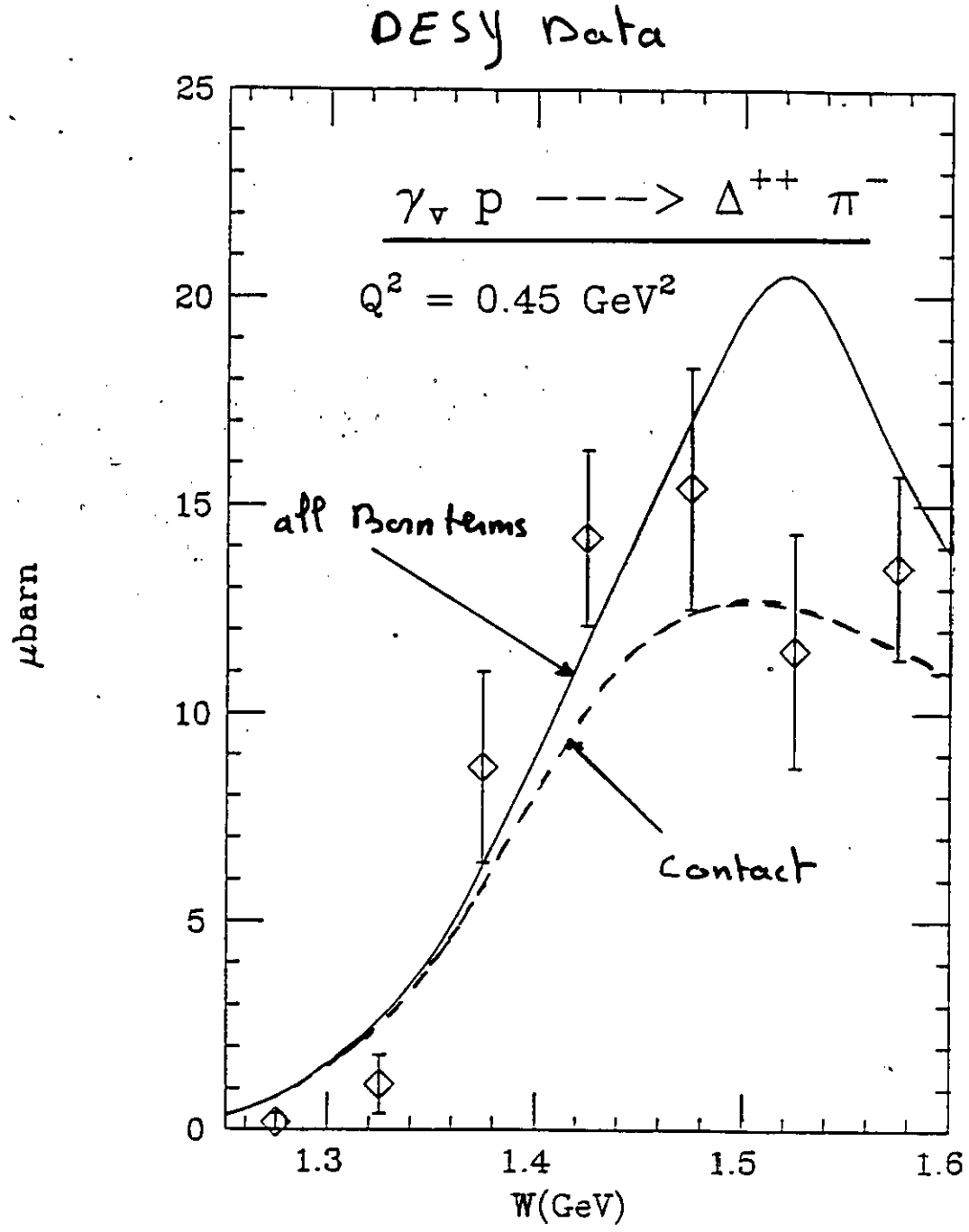


Figure 3: *Processes contributing to $\Delta\pi$ production off the nucleon*

$Q^2=0.6\ GeV^2$


12.5
10.0
7.5
5.0
2.5
0.0
μbarn
all Born terms
contact term only
1.3
1.4
1.5
1.6
W (GeV)


12.5
10.0
7.5
5.0
2.5
0.0
σ(μb)
M_A=1.2 GeV
M_A=1.1 GeV
M_A=1.0 GeV
M_A=0.8 GeV
1.2
1.3
1.4
1.5
1.6
W(GeV)


DESY Data
γ_v p ---> Δ^{++} π^-
Q^2 = 0.45 GeV^2
all Born terms
Contact
μbarn
W(GeV)
0
5
10
15
20
25
1.3
1.4
1.5
1.6

Projected Results for CLAS Experiment

- Cross section and Event generator
  - Gauge invariant formalism of Stichel and Scholz
  - Form factor parametrization with $G_A^\Delta = (1 + Q^2/M_\rho^2)^{-1}$.

- Experimental Method
  - Detect e', p, π^+ in CLAS
  - Identify $ep \rightarrow e'\Delta^{++}\pi^-$ using missing mass method

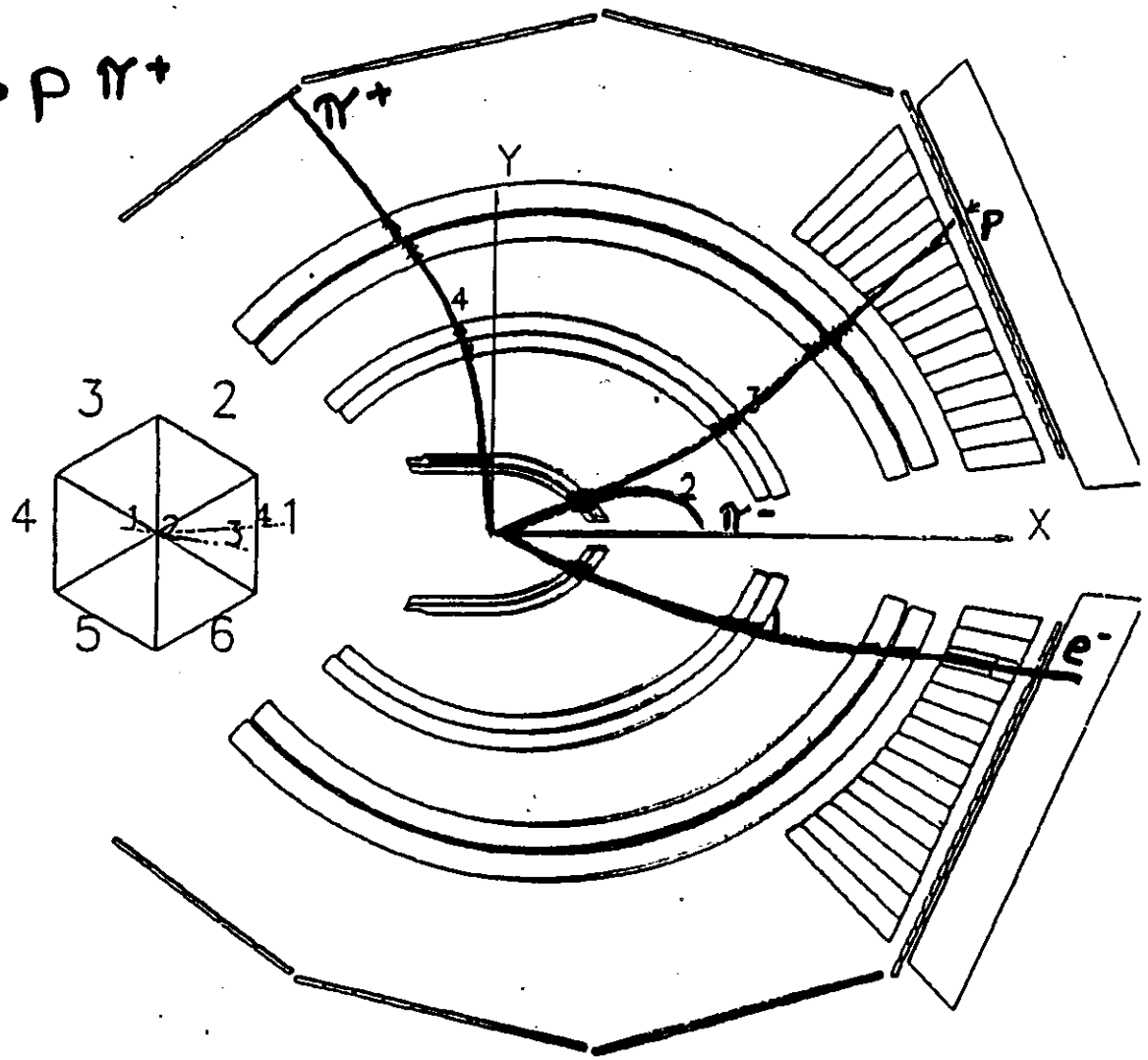
- Analysis Method
  - Identify Δ^{++} in invariant mass distribution of $p\pi^+$
  - Separate $\Delta^{++}\pi^-$ from $\Delta^0\pi^+$ and $(p\pi^+\pi^-)_{ps}$ in fit to Dalitz density distributions (tested in trial analysis)
  - Test π^- angular distribution for different cuts on $W_{\Delta\pi}^{max}$ and $p_{\pi^-}^{max}$
  - Identify 'contact' term in angular distribution (s-wave)

- Statistics and Systematic Error on $(G_A^\Delta)^2$
  - Statistics: 0.5% - 5% (high Q^2) $\mathcal{L} = (3\text{-}10)\,10^{33}\,cm^{-2}\,sec^{-1}$
  - Acceptance: 3% - 5%, Analysis: 2% - 5%

  $\rightarrow$ Total estimated error in G_A^Δ: 2.2% to 7%.

$e p \rightarrow e' \Delta^{++} \pi^-$

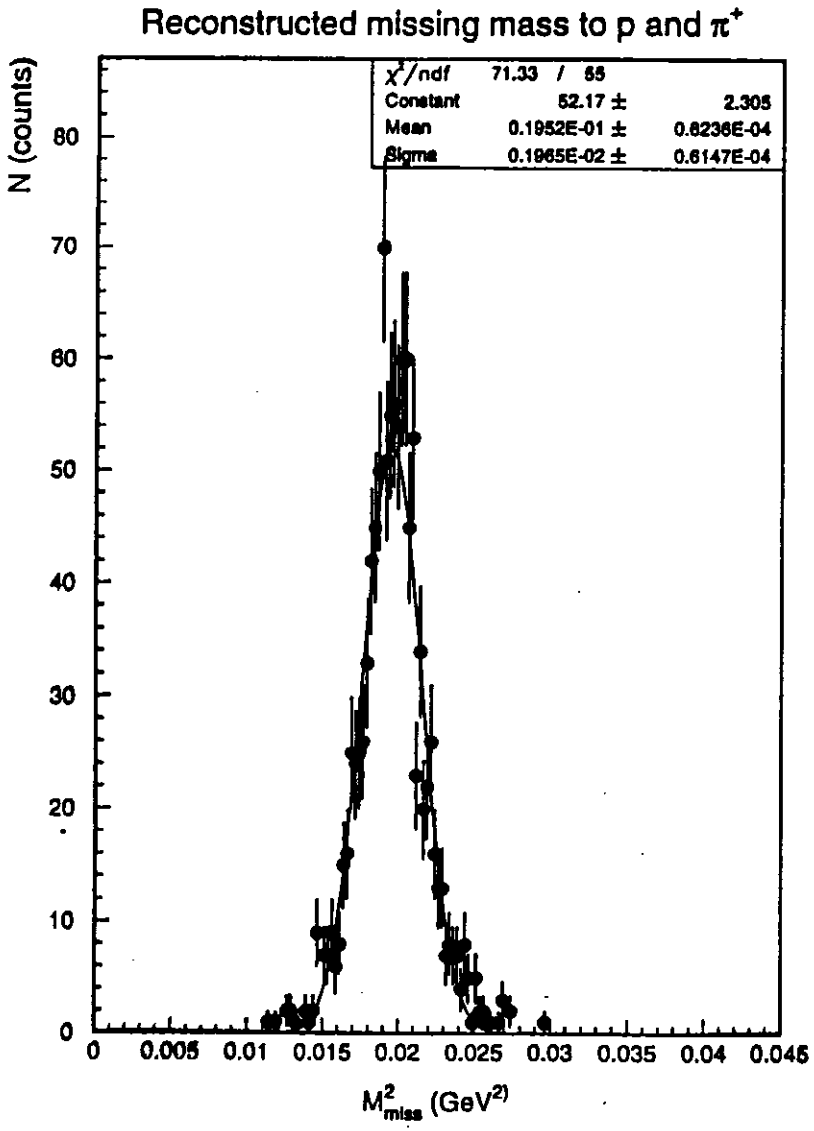
$\Delta^{++} \rightarrow p \pi^+$

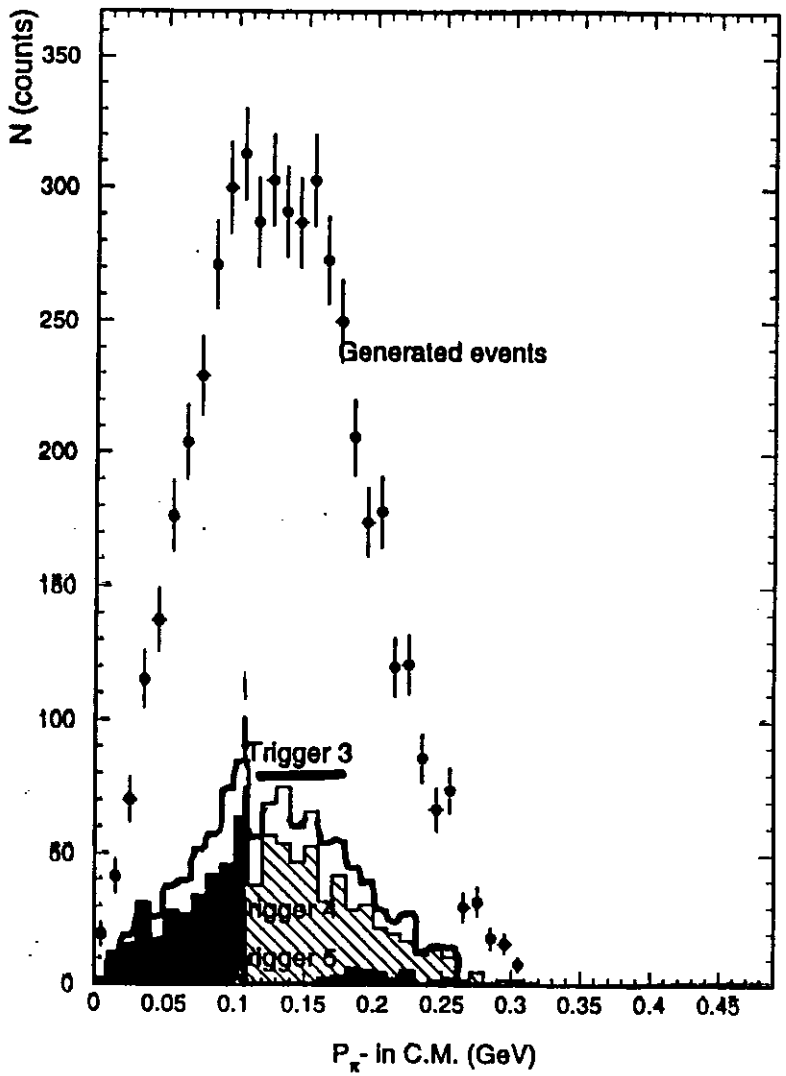


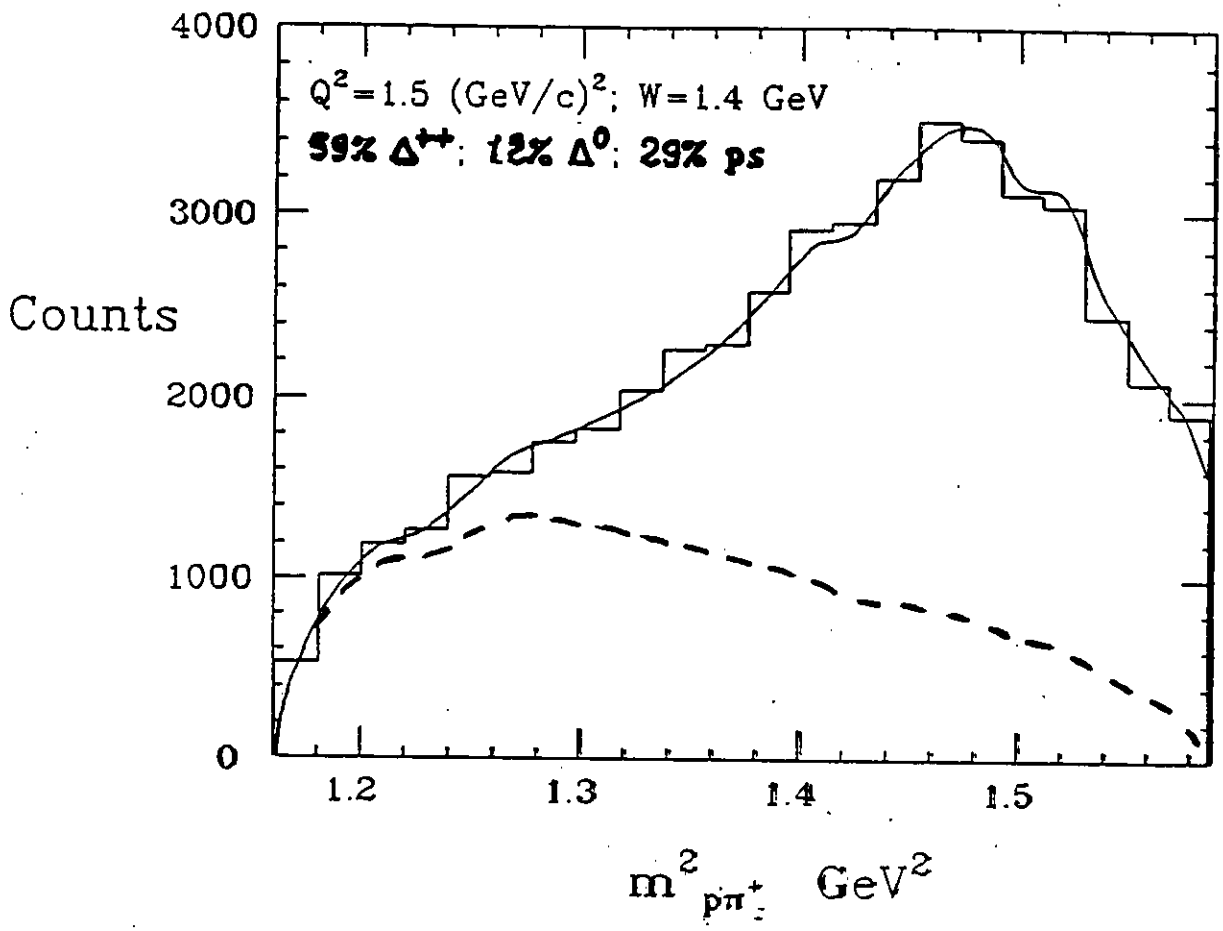
CLAS

SDA Event Reconstruction

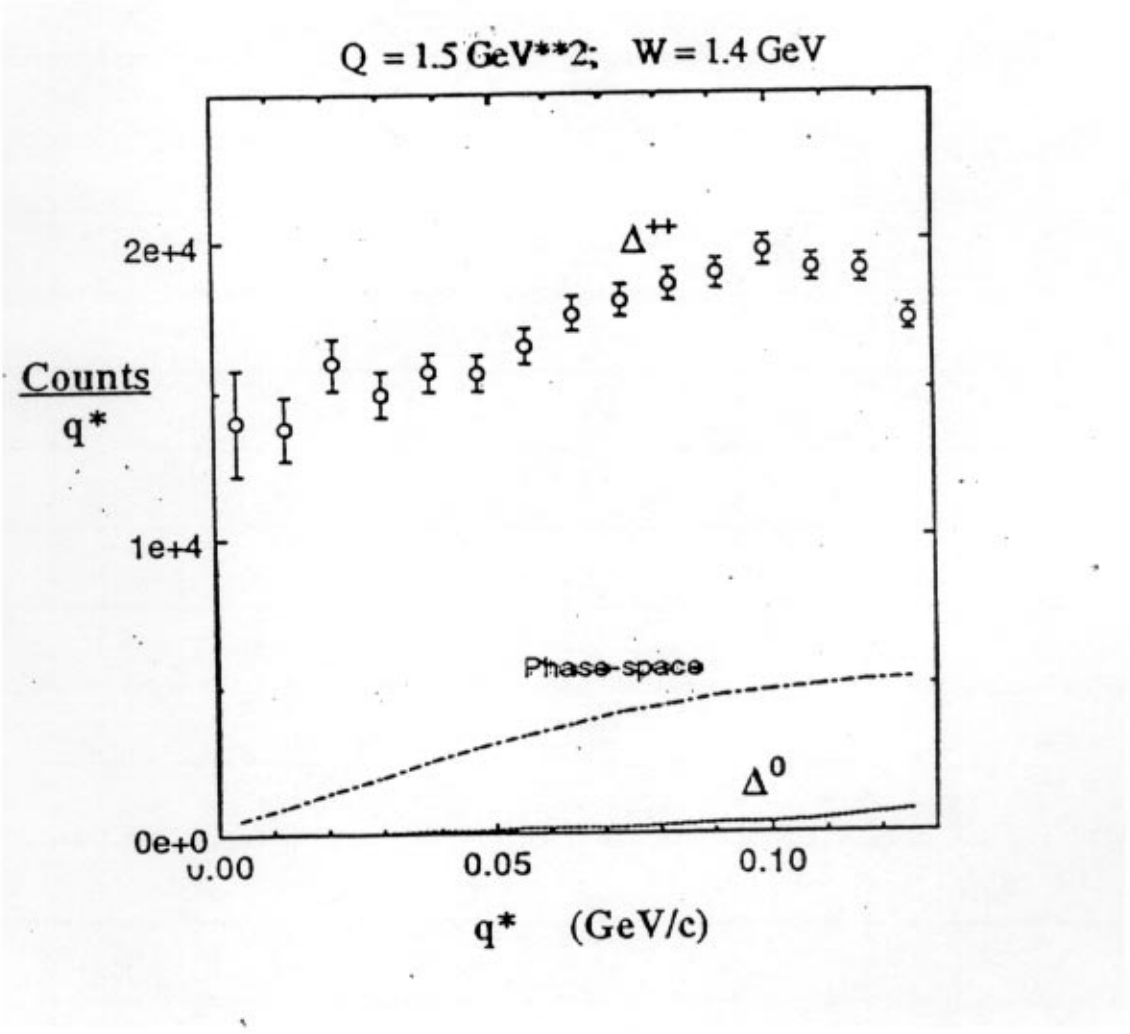
$E = 4$ GeV , $1.5 < Q^2 < 3$ (GeV/c) , $W < 1.5$ GeV



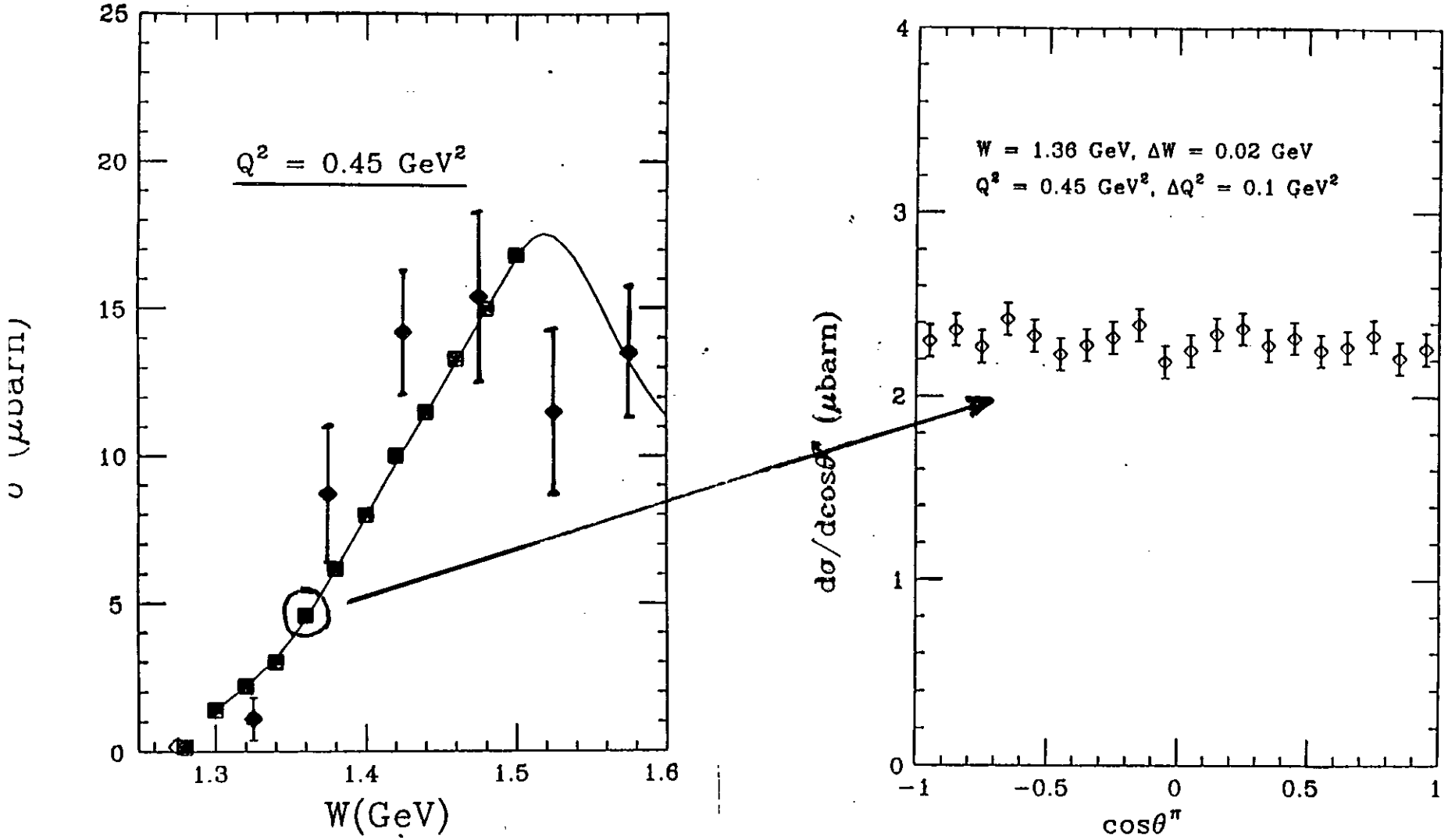




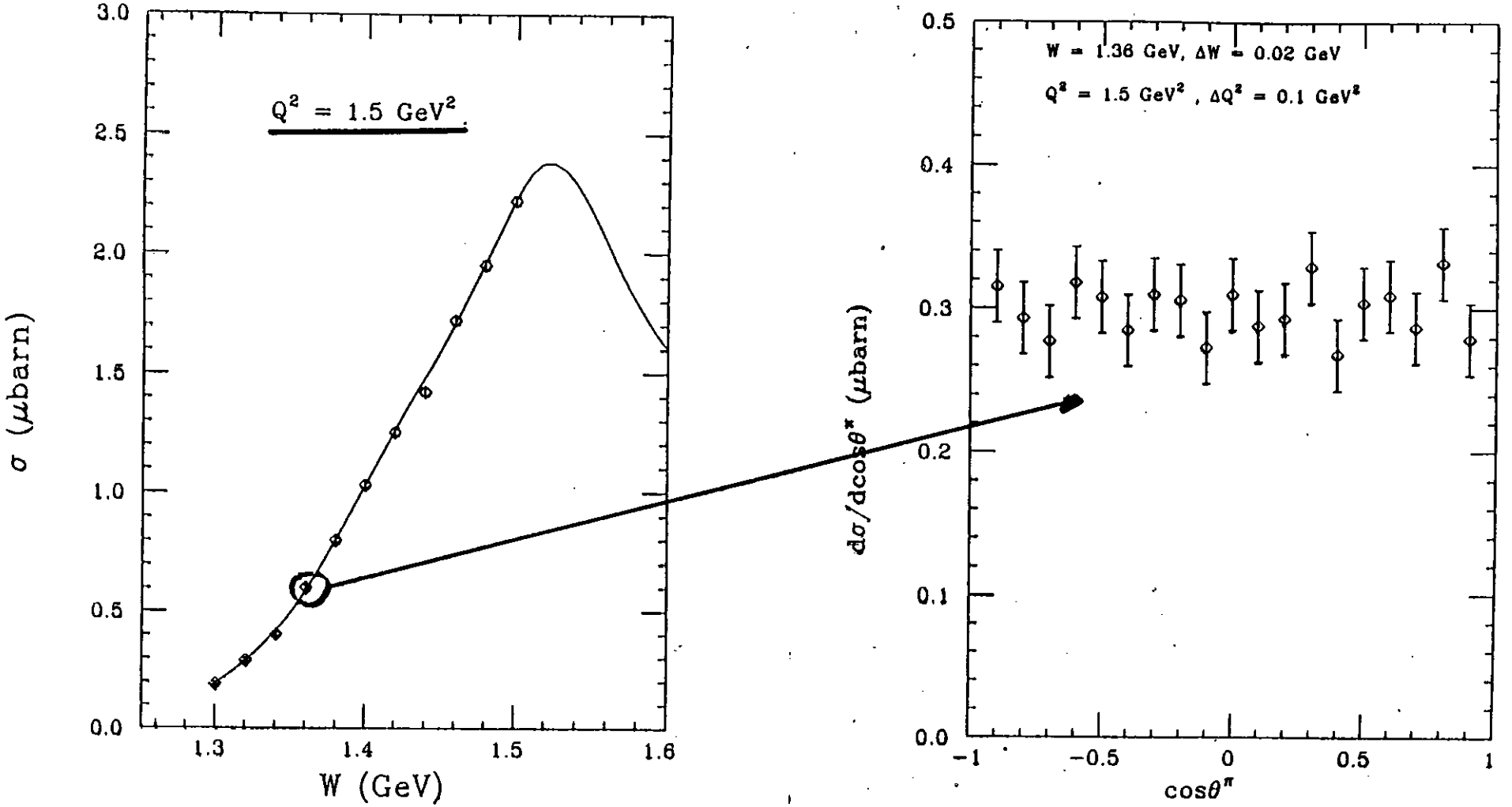
Parameter	Input value	Fitted value
$a_{\Delta++}$	30000	30218 ± 625
a_{Δ^0}	6000	5720 ± 558
a_{ps}	15000	15525 ± 1018


Q = 1.5 GeV**2; W = 1.4 GeV
2e+4
1e+4
0e+0
Counts
q*
Δ++
Phase-space
Δ0
0.00
0.05
0.10
q* (GeV/c)

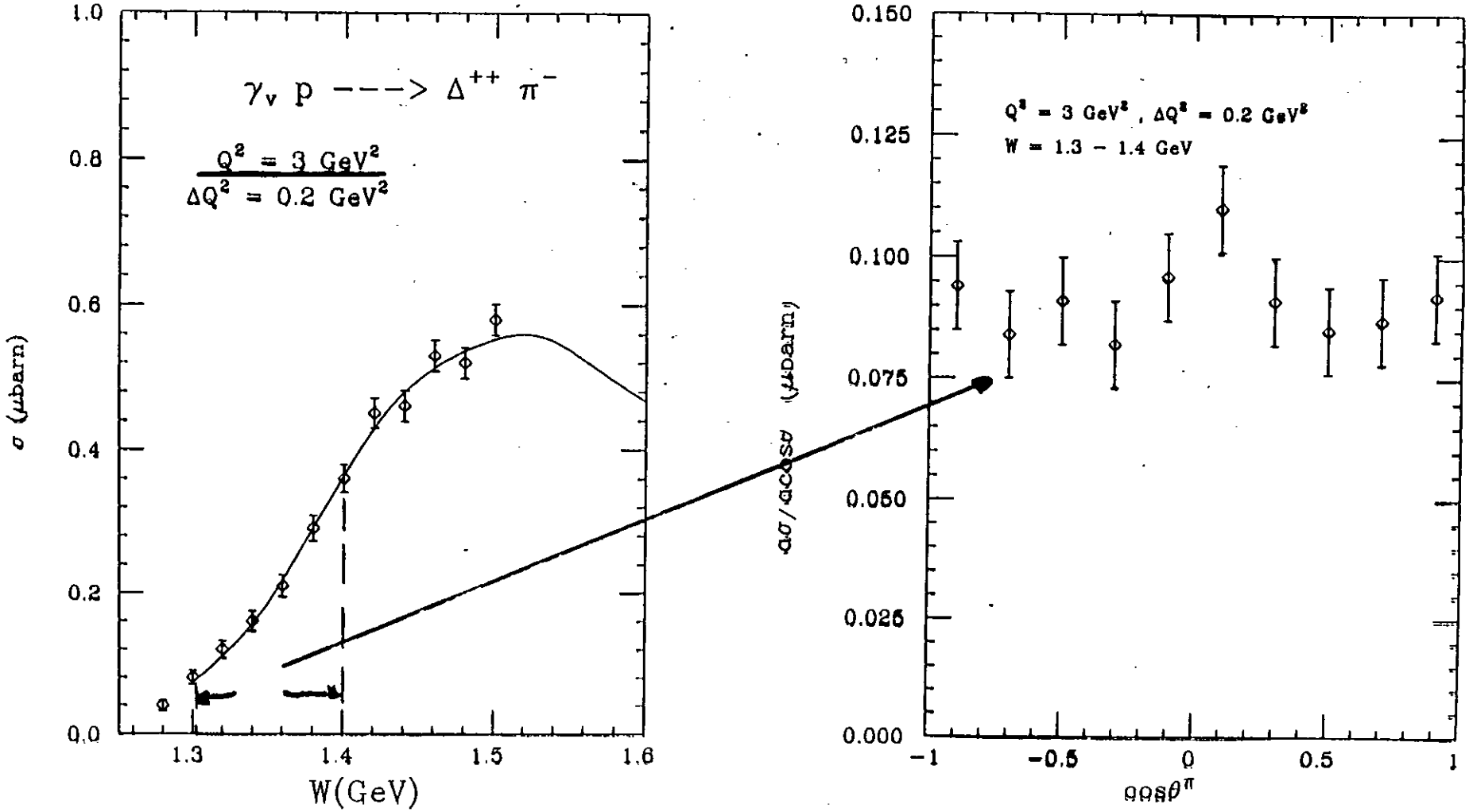
Projected Errors for CLAS Experiment



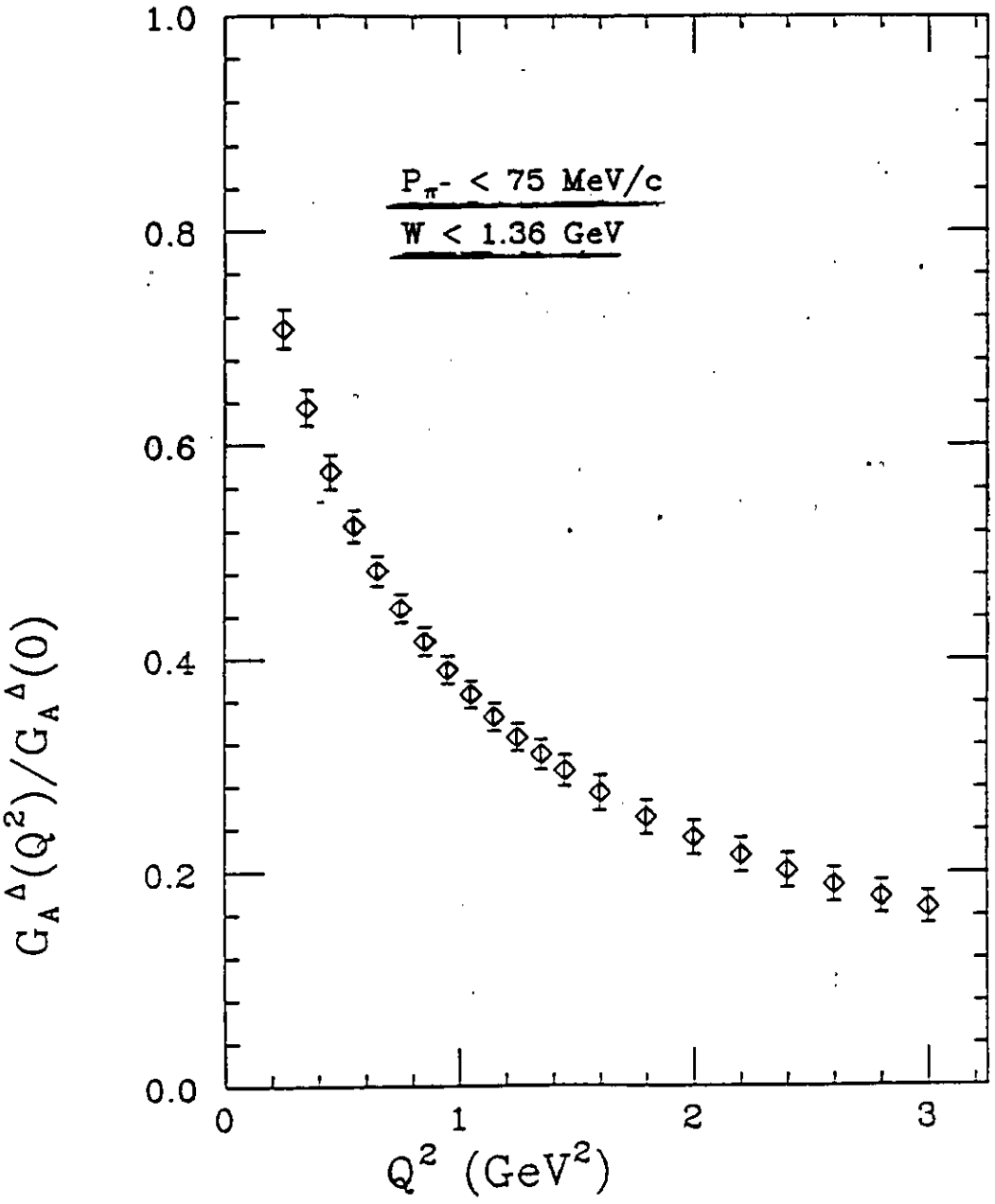
Projected Errors for CLAS Experiment



Projected Errors for CLAS Experiment



Projected Errors for CLAS Experiment



CONCLUSIONS

- Cross section measurements of $ep \rightarrow e'\Delta^{++}\pi^-$ near threshold allow determination of the axial vector transition form factor $G_A^{N\Delta}$
  - data on $ep \rightarrow e'\Delta^{++}\pi^-$ of unprecedented quality
  - high statistics $\rightarrow$ measurement close to threshold where axial vector contribution dominates the cross section
  - large range in Q^2
- Opens a window for new physics to be explored at CEBAF
- Tests of Chiral Perturbation Theory at low Q^2

Beam time request

Target	Energy	time	comment
H_2 gas	E = 1.6 GeV	150 hrs	parallel to N^* program
H_2 gas	E = 2.4 GeV	250 hrs	parallel to N^* program
H_2 gas	E = 4.0 GeV	800 hrs	parallel to N^* program
empty	1.6, 2.4, 4.0 GeV	72 hrs	new beam time