RECENT STUDIES OF HIGH LYING N* in DOUBLE CHARGED PION ELECTROPRODUCTION

presented by
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Analysis of the CLAS data on $\gamma_v p \to \pi^+\pi^- p$ channel in E-93-006 experiment (V.Burkert, M.Ripani Spokepersons)

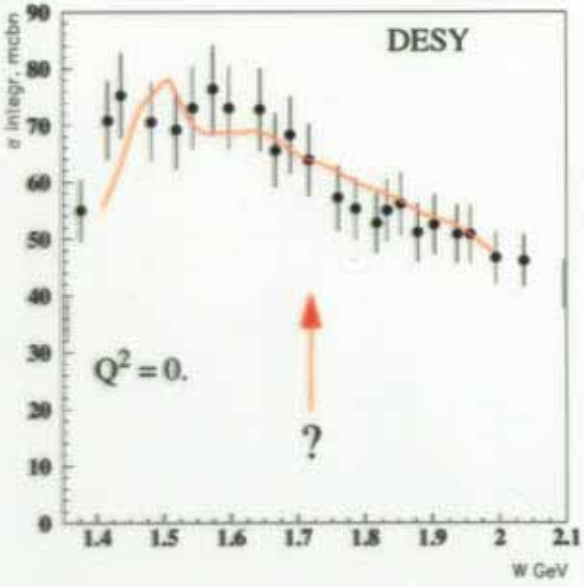
The goals of analysis

- To obtain first data on $A_{1/2}$, $A_{3/2}$ photocouplings at $Q^2>0$. for nucleon excitation with masses $1.6<M_{N^*}<2.0$GeV.
- To search for new ("missing") baryon states.
- To extract the parameters of single quark transition (SQTM) mechanism of N* excitations, allowing to predict Q^2-dependence of the photocouplings for all states in $(70,1^-)$ and $(56,2^+)$ supermultiplets.

N* Resonances in

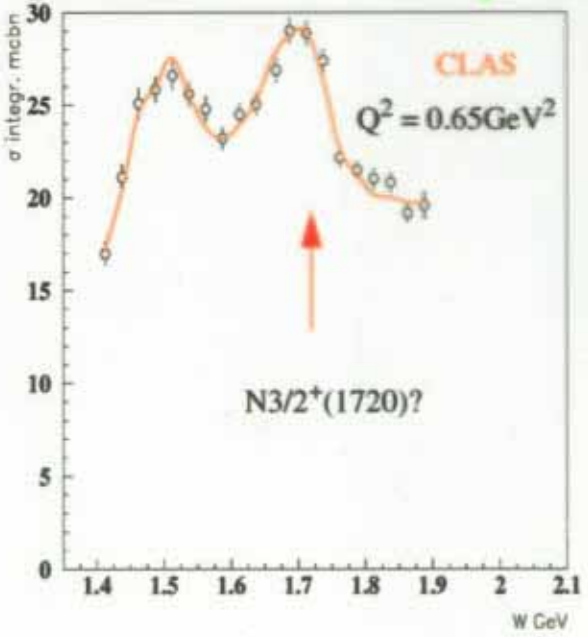
$\gamma^* p \longrightarrow p\pi^+\pi^-$

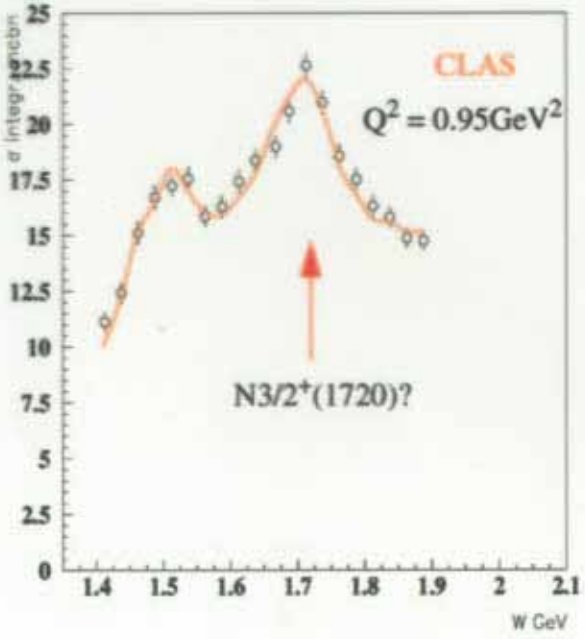
CLAS/E93-006

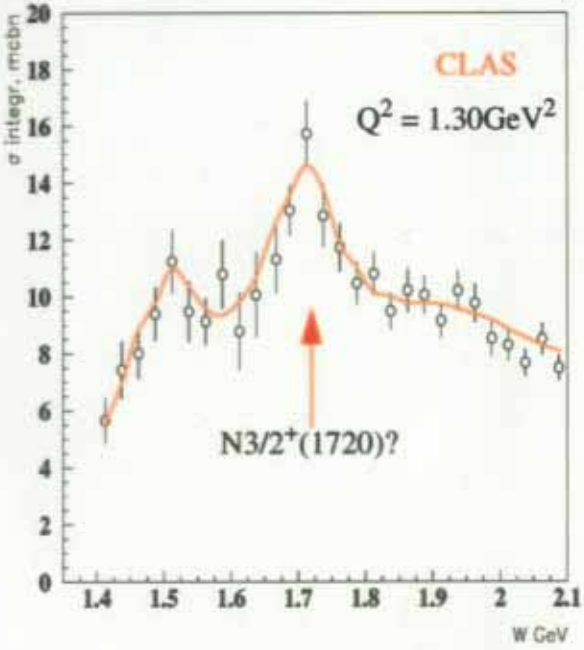


No resonance is seen in photo-production of $\pi^+\pi^-$

Resonance behavior emerges for virtual photons, S/N increasing with Q^2







Missing states

Quark models predict some states (not observed in the experiment so far) which are decoupled from πN channel but coupled to the $\pi\Delta$, ρN, ωN channels.

Res.	$\Gamma(\pi N)$ (MeV)	$\Gamma(\pi\Delta)$ (MeV)	$\Gamma(\rho N)$ (MeV)	$\Gamma(\omega N)$ (MeV)
$N_1(1880)+$	8	80	5	25
$N_3(1910)+$	1	300	10	70
$N_3(1950)+$	16	60	15	40
$N_1(1975)+$	4	20	6	10
$N_5(1980)+$	2	240	5	8

From
S. Capstick and W. Roberts,
Phys. Rev. D49, (1994) 4570
(Relativized $^3P_0$ model)

Therefore,
these states may be observed
in the channels of multihadron
production by photons
for instance
in two pion channel.

Good test
for different quark models.

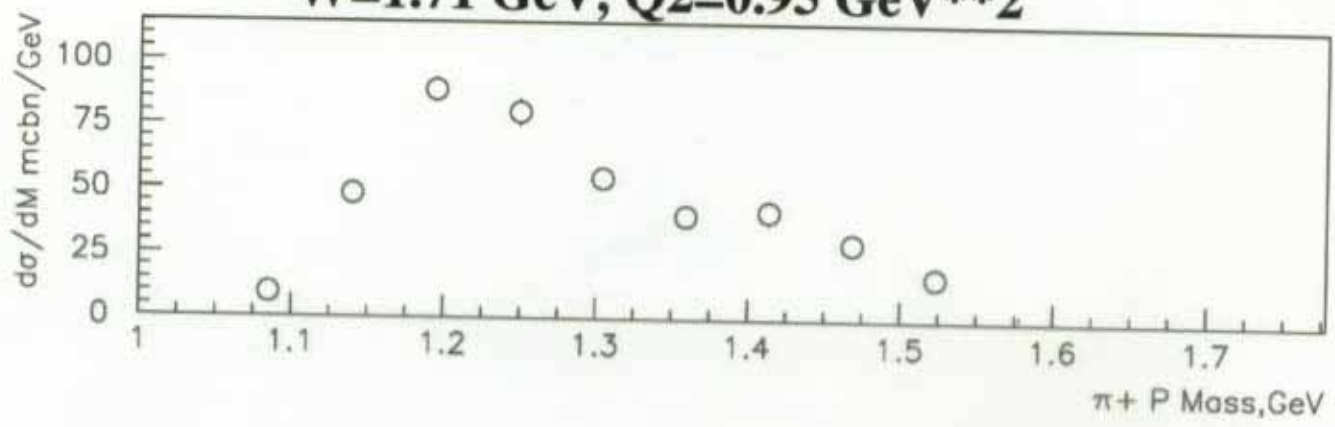
GENOVA-MOSCOW PHENOMENOLOGIAL MODEL FOR DOUBLE CHARGED PION PRODUCTION BY REAL AND VIRTUAL PHOTONS

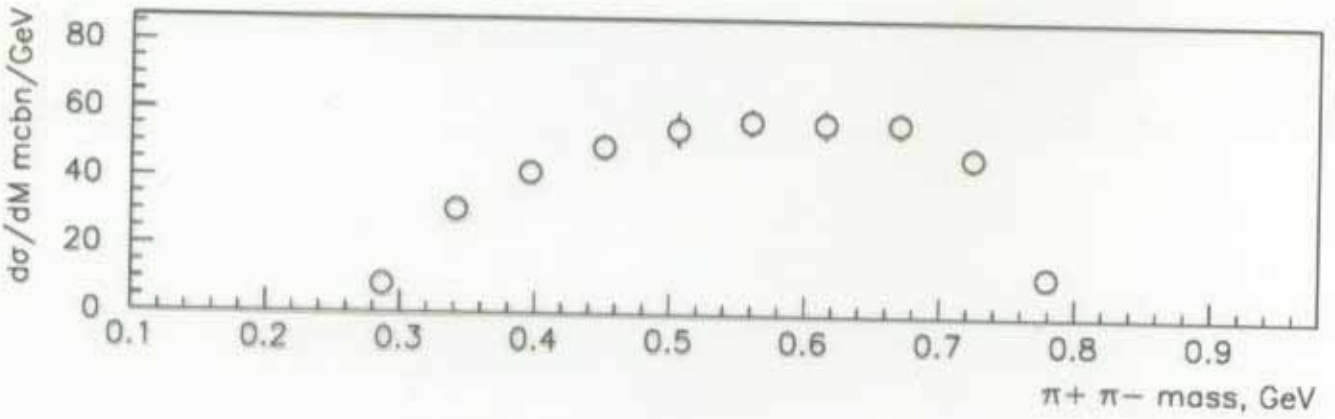
Published in:

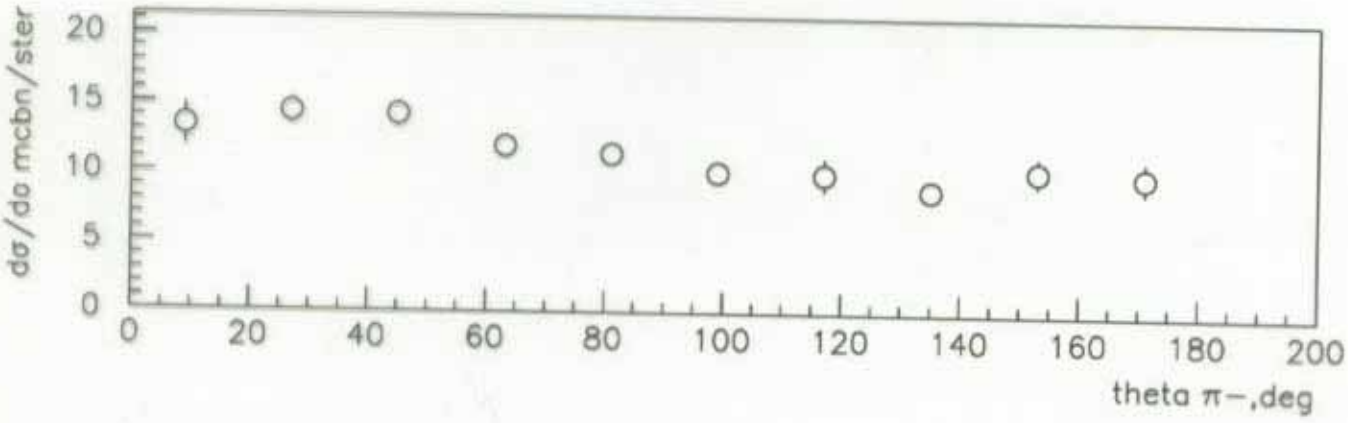
- V.Mokeev,e.a. Phys of Atom Nucl. 64, 1292 (2001)
- M.Ripani,e.a. Phys of Atom Nucl. 63 1943 (2000)
- V.D.Burkert e.a. Phys of Atom Nucl accepted for publ. in 2002
- M.Ripani e.a. Nucl. Phys. A672 220 (2000)
- V.Mokeev e.a. Proceedings of NSTAR 2001 Conference 7-10 March, Mainz, Germany, Editors: D. Drechsel, L. Tiator., 181
- V.Mokeev e.a. Proceedings of NSTAR 2000 Conference 16-19 Feb Newport News, USA, Editors: V. D. Burkert, L.Elouadrhiri, J. J. Kelly, R. C. Minehart. World Scientific 2000, 234

The model relates N* photocouplings to the measured differential cross-sections, polarization asymmetries, allowing extraction of N* electromagnetic and some strong couplings from data fit.

W=1.71 GeV, Q2=0.95 GeV**2

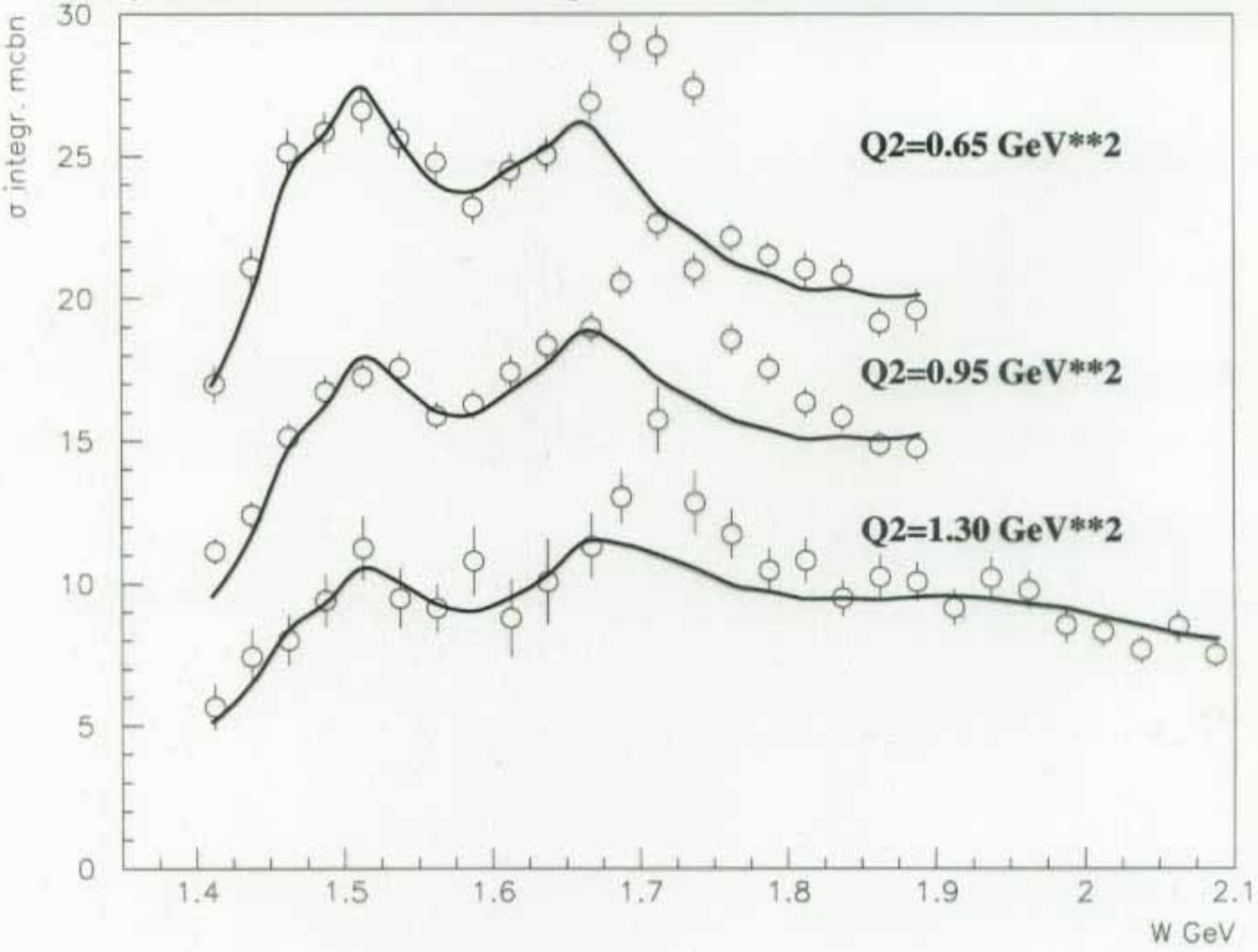






Conv N* with photocoupl.fitted to 2pi data

P11(1440) longitud. strength fitted to the data at W below 1.5 GeV
Photocoupl. were allowed to deviate from SQTM expectation 20% r.m.s
Poorly known D13(1700) hadr coupl. were varied inside uncertainties of hadr. exper.



THE NOMINAL CALCULATIONS (Prediction, not fit)

- The $A_{1/2}$, $A_{3/2}$ photocouplings for 12 established states below 2.0 GeV masses with observed π-Δ and ρ-p decays are taken from interpolation of world data based on Single Quark Transition Model (SQTM)

SQTM assumptions

N* excitation proceeds via single quark transition between SU(6) configuration in the ground and excitation nucleon states

General expression for single quark transition electromagnetic current:

$$J_+ = AL_+ + BS_+ + CS_z L_+ + DS_- L_+ L_+$$

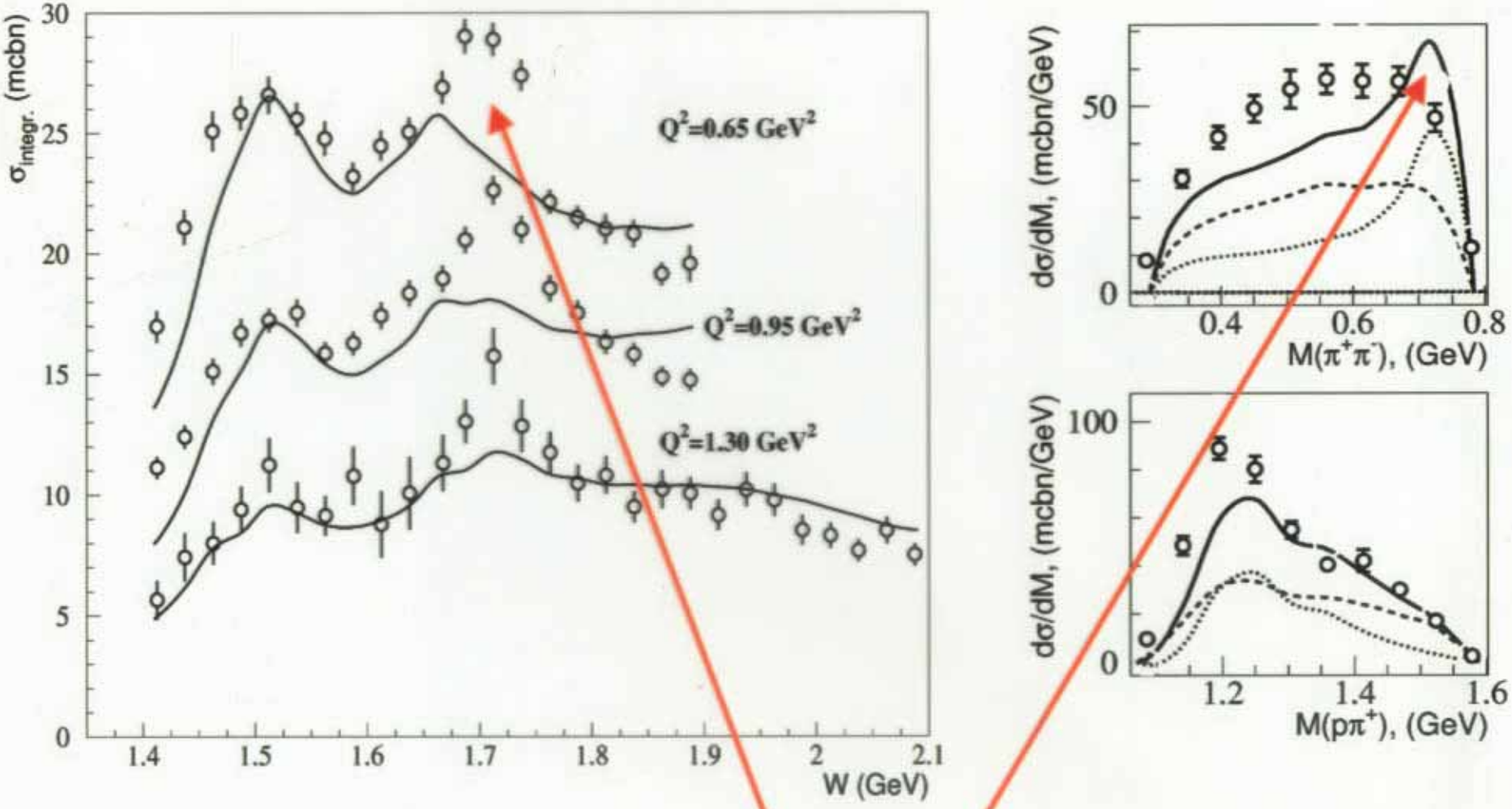
SQTM allows to express: 9 $A_{1/2}$, $A_{3/2}$ photocouplings of (70, 1^-) states through 3 SQTM multipoles e11(Q^2), m11(Q^2), m12(Q^2)

11 $A_{1/2}$, $A_{3/2}$ photocouplings of (56, 2^+) states through 4 SQTM multipoles e22(Q^2), m21(Q^2), m22(Q^2), m23(Q^2)

The SQTM multipoles represent linear combination of A, B, C, D coefficients

- The strong couplings are taken from π N $\rightarrow \pi$ π N reaction analysis

Nominal calculation



Missing strength at W≈1.7 GeV

prominent (ρp) sub-channel impact. $P_{13}(1720)$: B(ρp)~77%

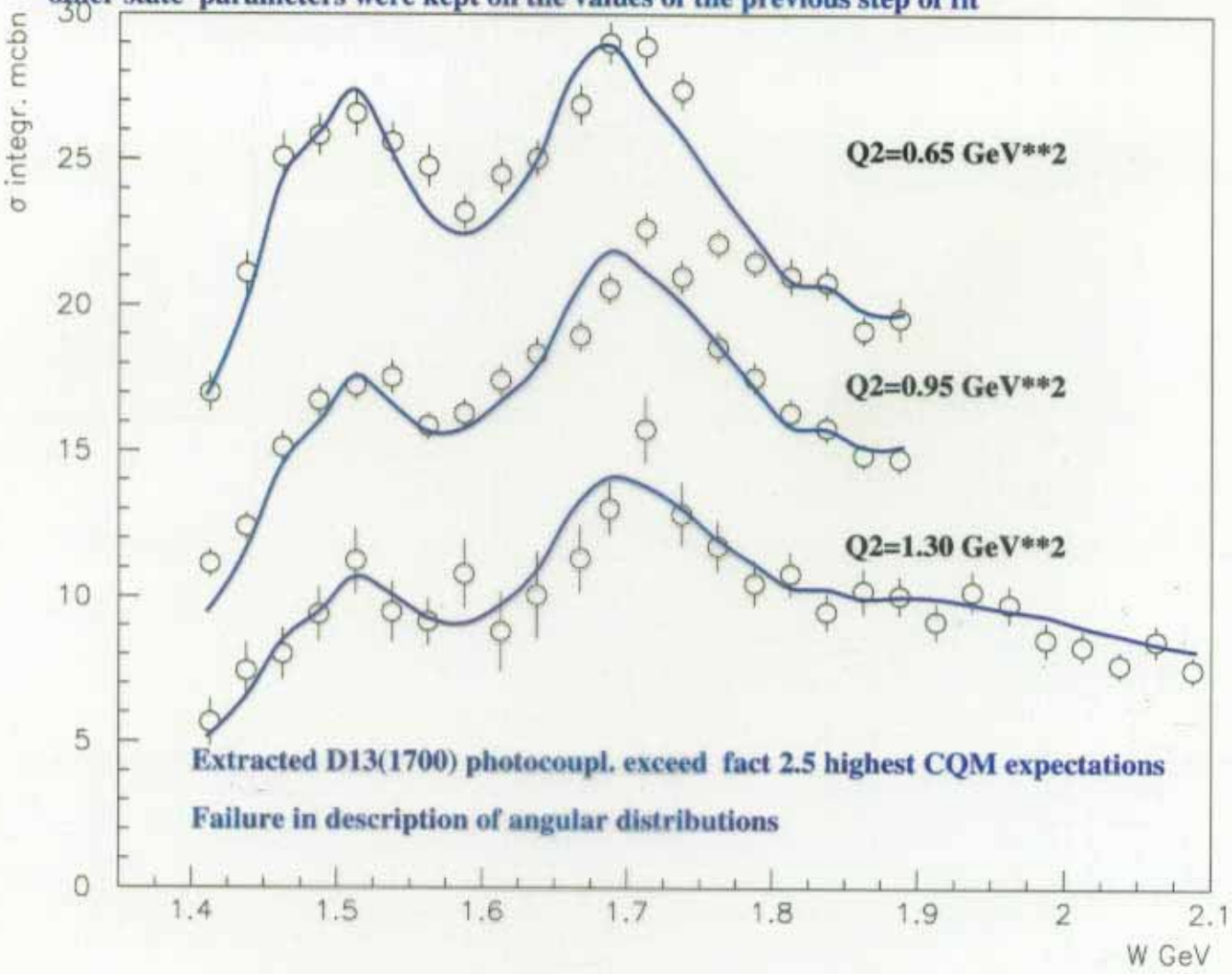
Fit I Conventional (PDG) states only

The most likely candidates to fill structure at 1.7 GeV are: D13(1700) P11(1710) P13(1720) (D33(1700) is too wide (300 MeV width) and does not match observed structure width (100MeV))

Three fits were performed, allowing deviation from expect at values in a wide range for the parameters of the states contributed in the structure at 1.7 GeV.

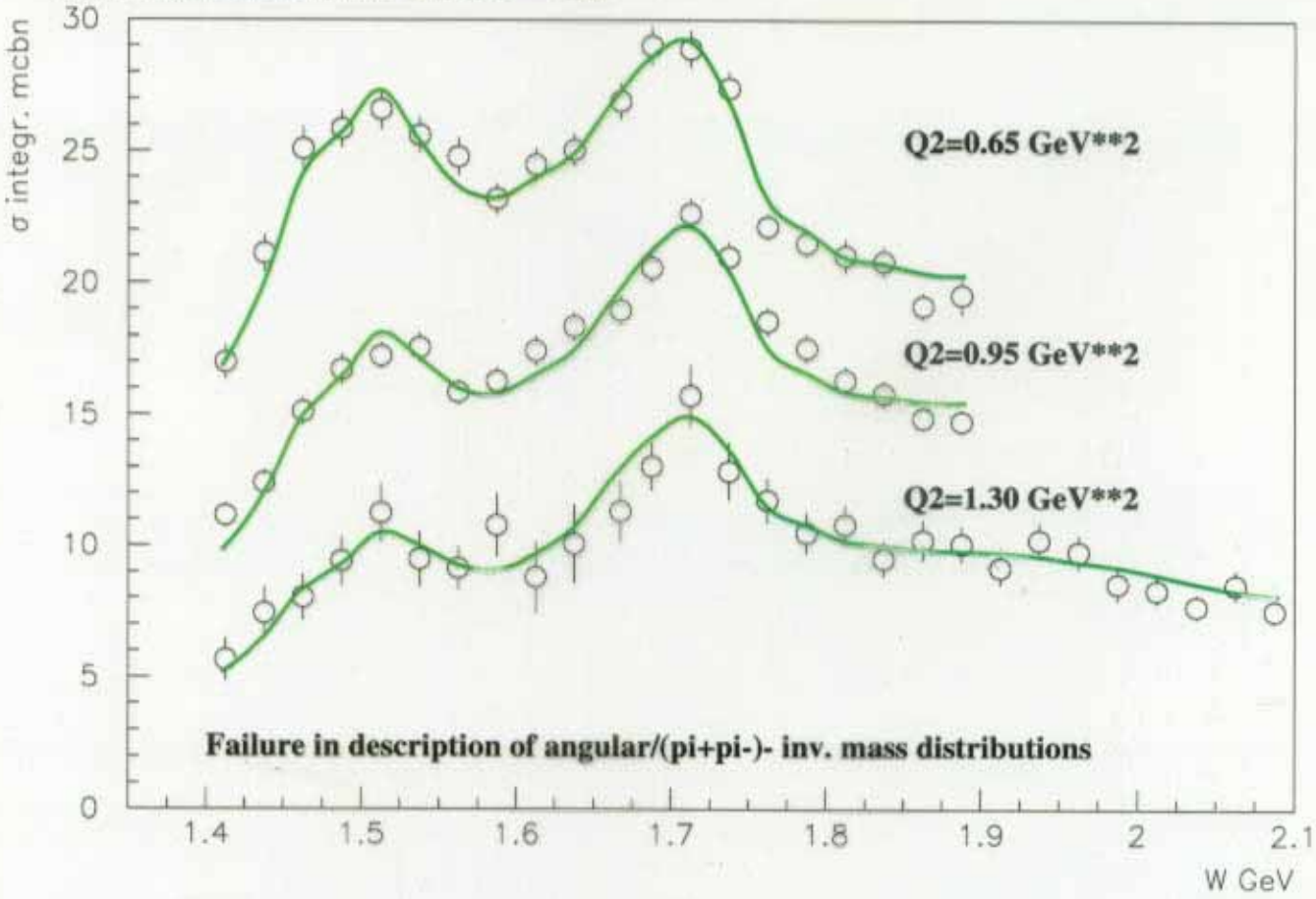
Fit A

D13(1700) photocoupl. were varied within factor 3 around CQM
D13(1700) hadr coupl were varied in a wide range resulting in 50-500 MeV total width variation
D13(1700) mass was varied between 1.65-1.75 GeV
other state parameters were kept on the values of the previous step of fit



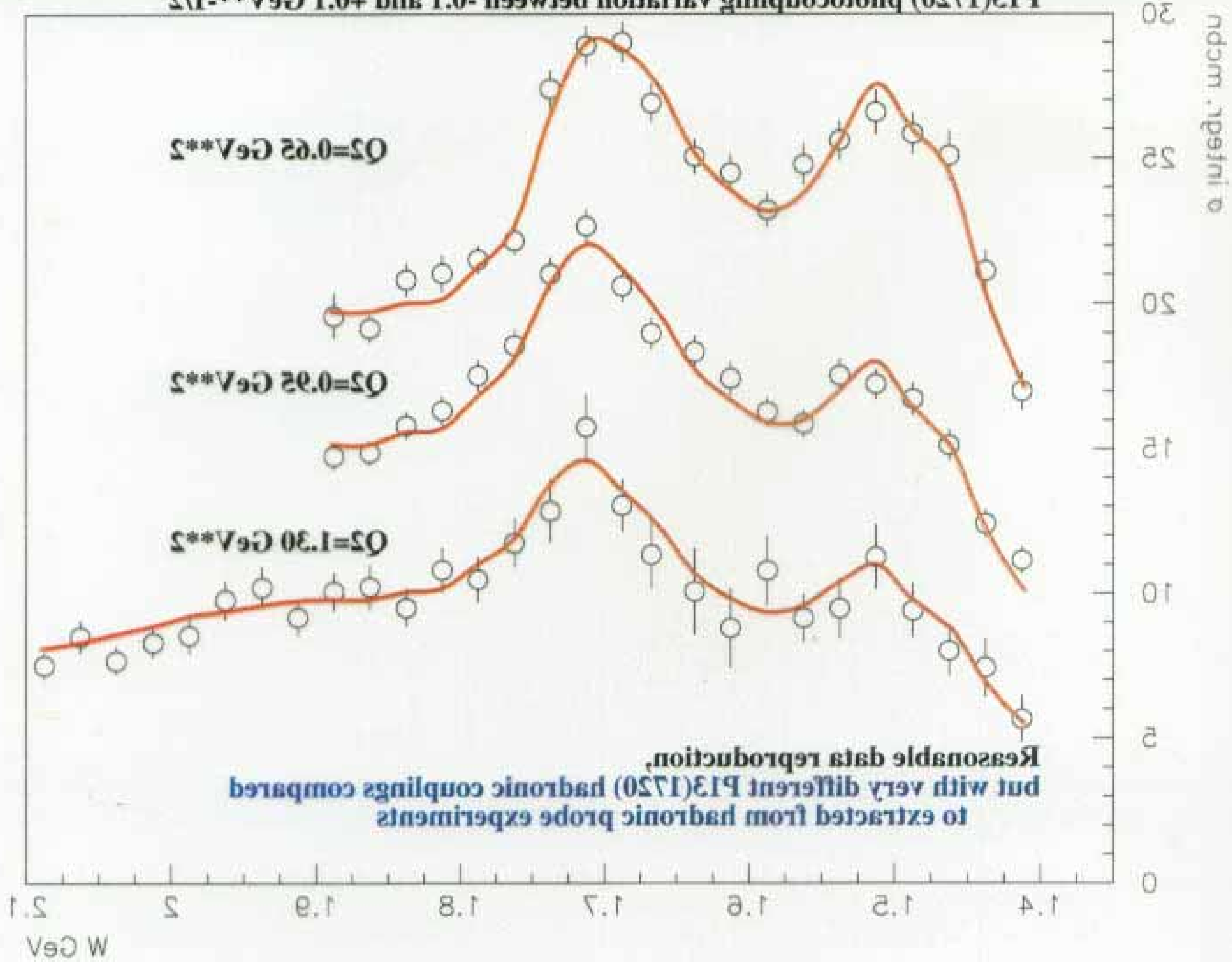
Fit B

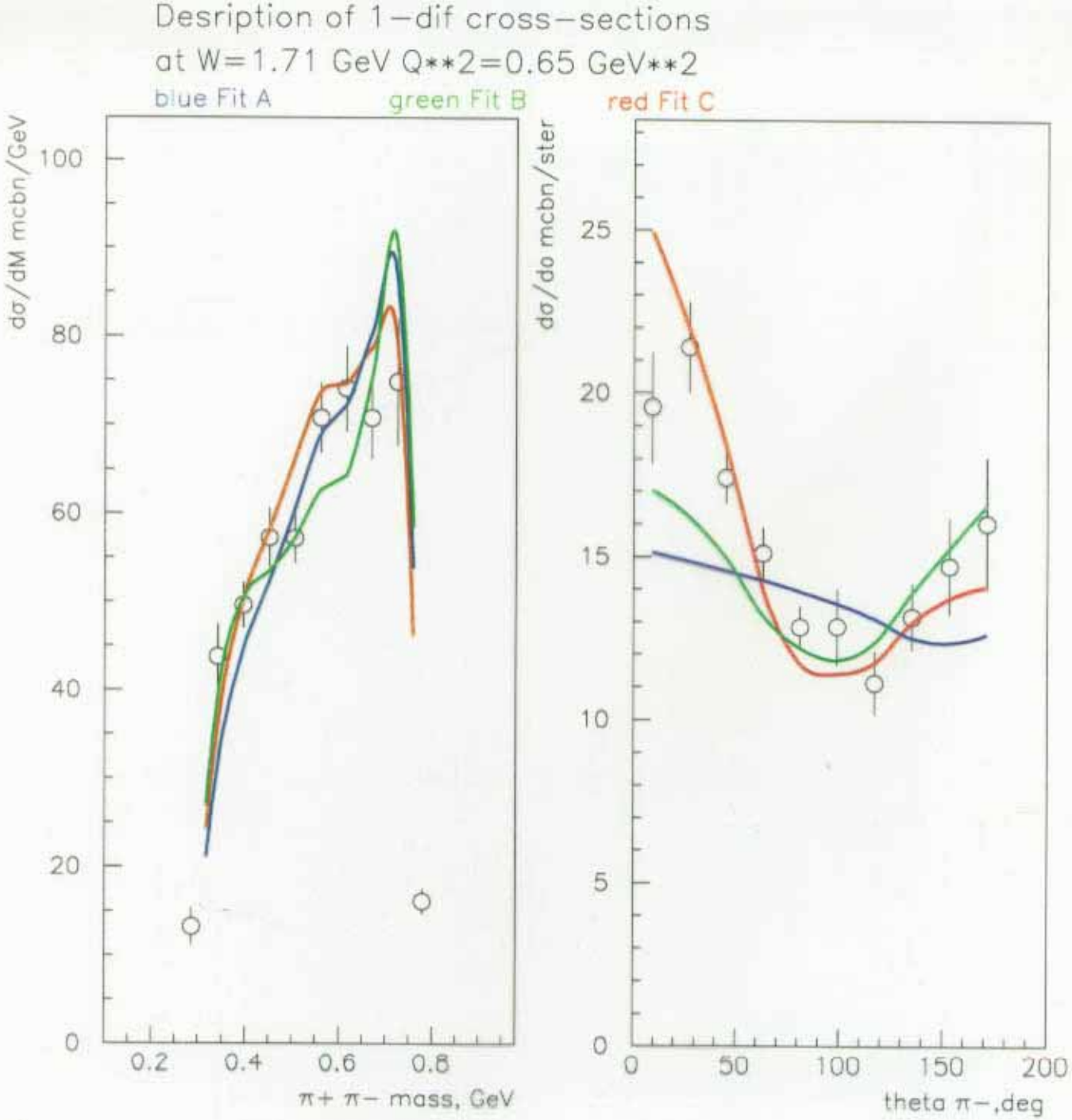
Variation of P11(1710) D13(1700) hadr. coupl. in a range of Fit A, masses between 1.69-1.74 GeV
Variation of D13(1700), P13(1720) photocouplings 100% with respect to values of prev. step of fit
P11(1710) between 0.and -0.1 GeV-1/2**



Fit C

**Simultaneous variation of D13(1700) and P13(1720) hadr. coupl.
in a range of Fit A and their's masses between 1.69-1.74 GeV?
OUTSIDE of uncertainties for P13(1720) hadr. couplings from experiments with hadronic probes
P13(1720) photocoupling variation betwween -0.1 and +0.1 GeV**-1/2**




Desription of 1−dif cross−sections
at W=1.71 GeV Q**2=0.65 GeV**2
blue Fit A
green Fit B
red Fit C
dσ/dM mcbn/GeV
100
80
60
40
20
0
0.2
0.4
0.6
0.8
π+ π− mass, GeV
dσ/do mcbn/ster
25
20
15
10
5
0
0
50
100
150
200
theta π−,deg

FIT I RESULTS

Fits I A and B failed to describe π^- angular and $\pi^+\pi^-$ invariant mass distributions for (W,Q^2) bins inside 1.7 GeV structure

Fit I C reproduced data reasonably, however with very different π-Δ and ρ- p BF, compared to recent analyses of $\pi p \rightarrow \pi \pi p$ data (D.M.Manley and E.M.Salesky Phys Rev D45 4002 (1992); T.P.Vrana et al Phys. Rept. 328 181 (2000))

Properties of P13(1720) from analysis of $\pi N \rightarrow \pi \pi N$ and double charged pion electroproduction

	M (MeV)	Γ (MeV)	$\Gamma_{\pi\Delta}/\Gamma$ %	$\Gamma_{\rho N}/\Gamma$ %
D.M.Manley e.a. (1992)	1716±12	121 ±39	0.	87±5
T.P.Vrana e.a. (2000)	1717 ±31	383 ±79	0.	91±1
PDG	1650-1750	100-200	0	70-85
Our fit with conv. states	1725 ±20	114 ±19	63 ±12	19 ±9

FIT II Implementation of new state

Test of quantum numbers:

J^P: $1/2^-$, $1/2^+$, $3/2^-$, $3/2^+$, $5/2^-$, $7/2^-$.

Masses, hadronic couplings, and photocouplings of missing state candidate and D13(1700) conventional state were varied simultaneously in a wide range resulting in a 50-500 MeV total width variation, 100% variation of D13(1700) photocouplings, between -0.1 +0.1 $GeV^{-1/2}$ for new state photocouplings.

The parameters of all other N* were fixed in the values, obtained at the previous step (of fit).

FIT II RESULT

The best fit is achieved for ($3/2^+$) missing state. The fit quality is the same as for the fit with P13(1720) conventional state after sizeable modification of it's hadronic couplings.

The SQTM parameters extracted from data fit of $\gamma_v p \to \pi^+\pi^- p$ exclusive channels

New features:

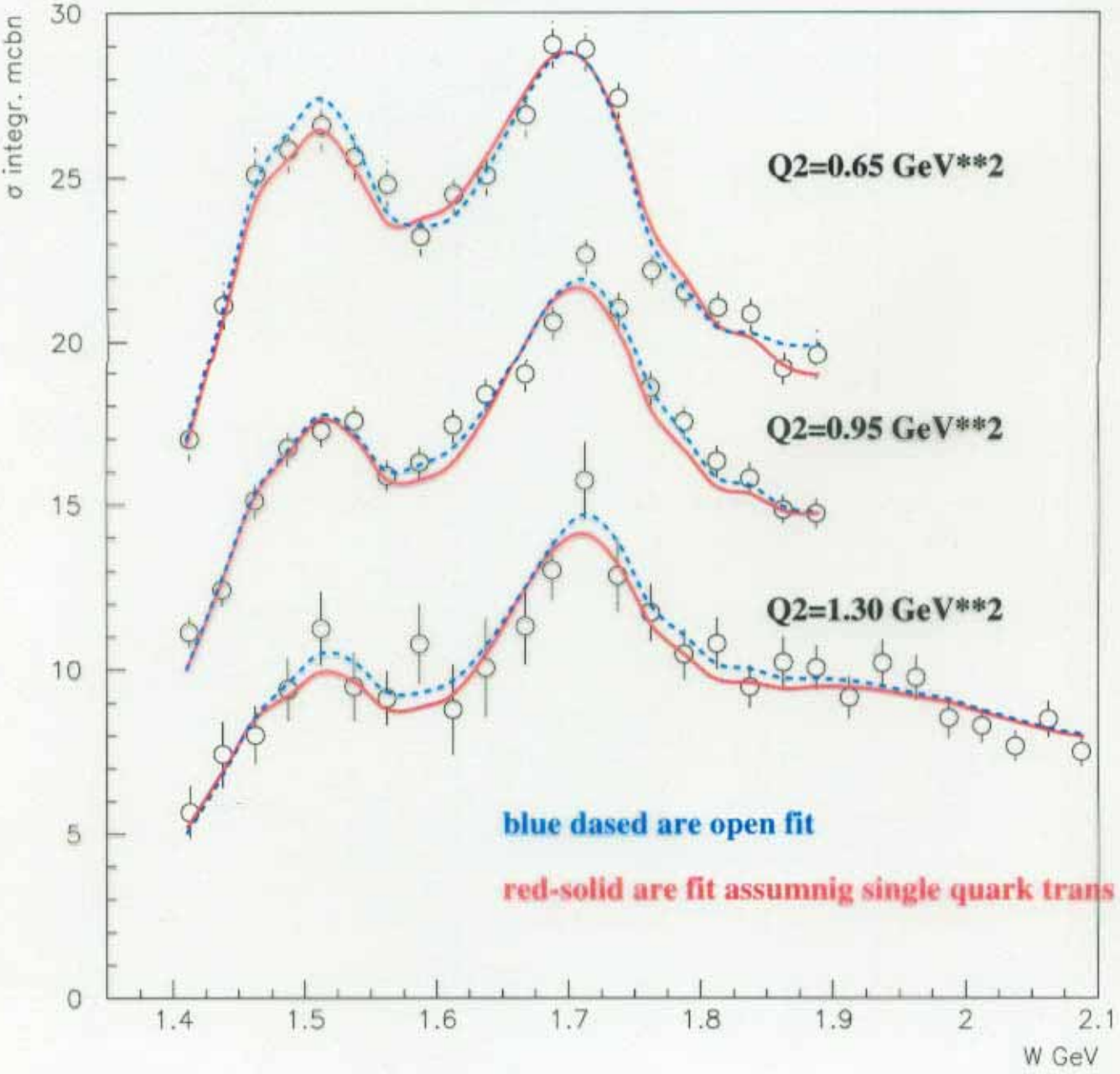
- The values of SQTM parameters e22, m21, m22, m23 for $(56,2^+)$ supermultiplet were determined without ad hoc assumptions, previously used due to lack of data.
- Conjunction of SQTM approach and 2-π electroproduction model allow to fit SQTM multipole directly to measured cross-sections, accounting all N* and their interference, while previously they were extracted from data on the photocouplings of few states D13(1520), S11(1535) and F15(1680).

The SQTM multipoles matrix elements were varied within 100%(σ) around expectations, obtained in the analysis of the single pion data.

Mixing angles between S and D states of $(70,1^-)$ supermultiplets and between new state and P13(1710) of $(56,2^+)$ supermultiplet were varied between 0 and 360°. Q^2-independence of these mixing angles was imposed.

Additional restrictions were imposed on $A_{1/2}$ $A_{3/2}$ of D13(1520), S11(1535), F15(1685), requiring their values, estimated from SQTM multipoles, should be inside the uncertainties obtained in single π and η electroproduction analysis.

The open/SQTH constrained fits of the CLAS $\gamma_v p \to \pi^+ \pi^- p$ data



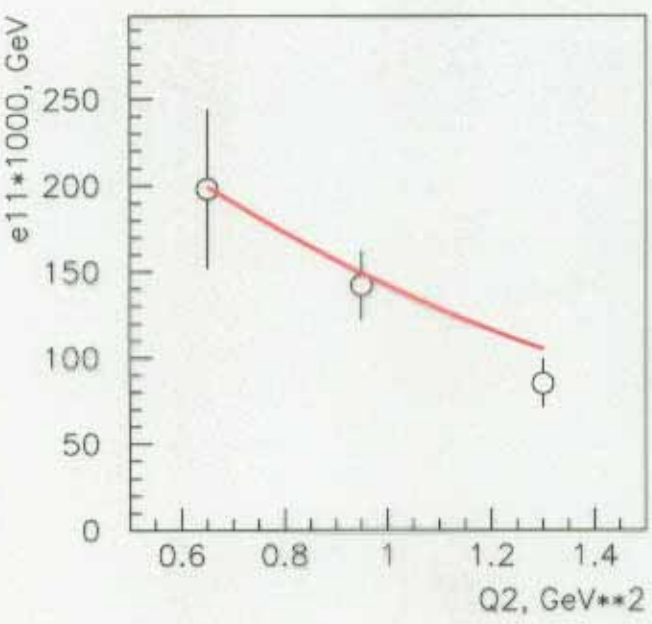
SQTM CONSTRAINED AND OPEN FIT RESULTS

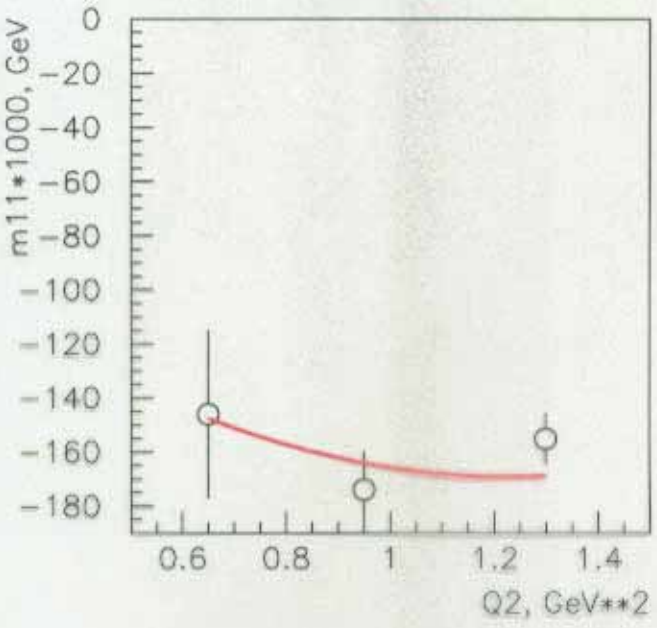
The quality of two pion data description is very close for open fit and SQTM constrained fit.

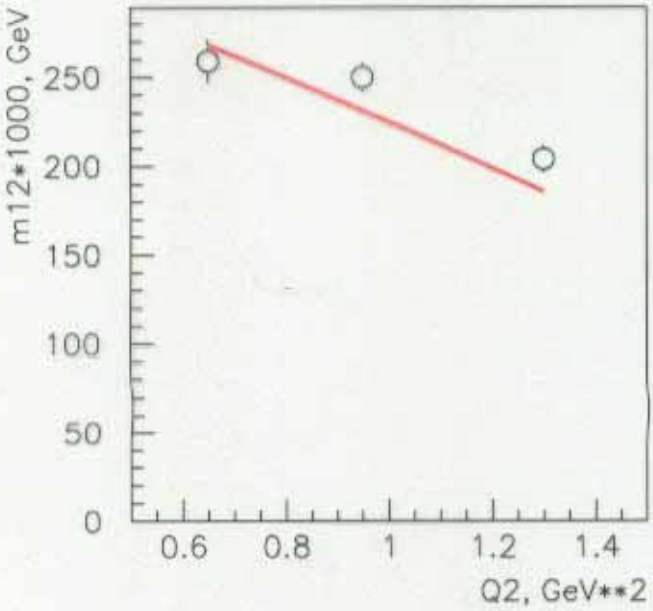
χ^2 values			
Q^2, GeV^2	0.65	0.95	1.3
open fit	4.24	3.73	2.04
model fit	4.20	3.69	2.04

SINGLE QUARK TRANSITION BETWEEN COHERENT 3-QUARK SU(6) CONFIGURATION IN THE GROUND AND EXCITED NUCLEON STATES PLAYS AN IMPORTANT ROLE IN NUCLEON RESONANCE EXCITATIONS AT THE HADRONIC DISTANCE SCALE

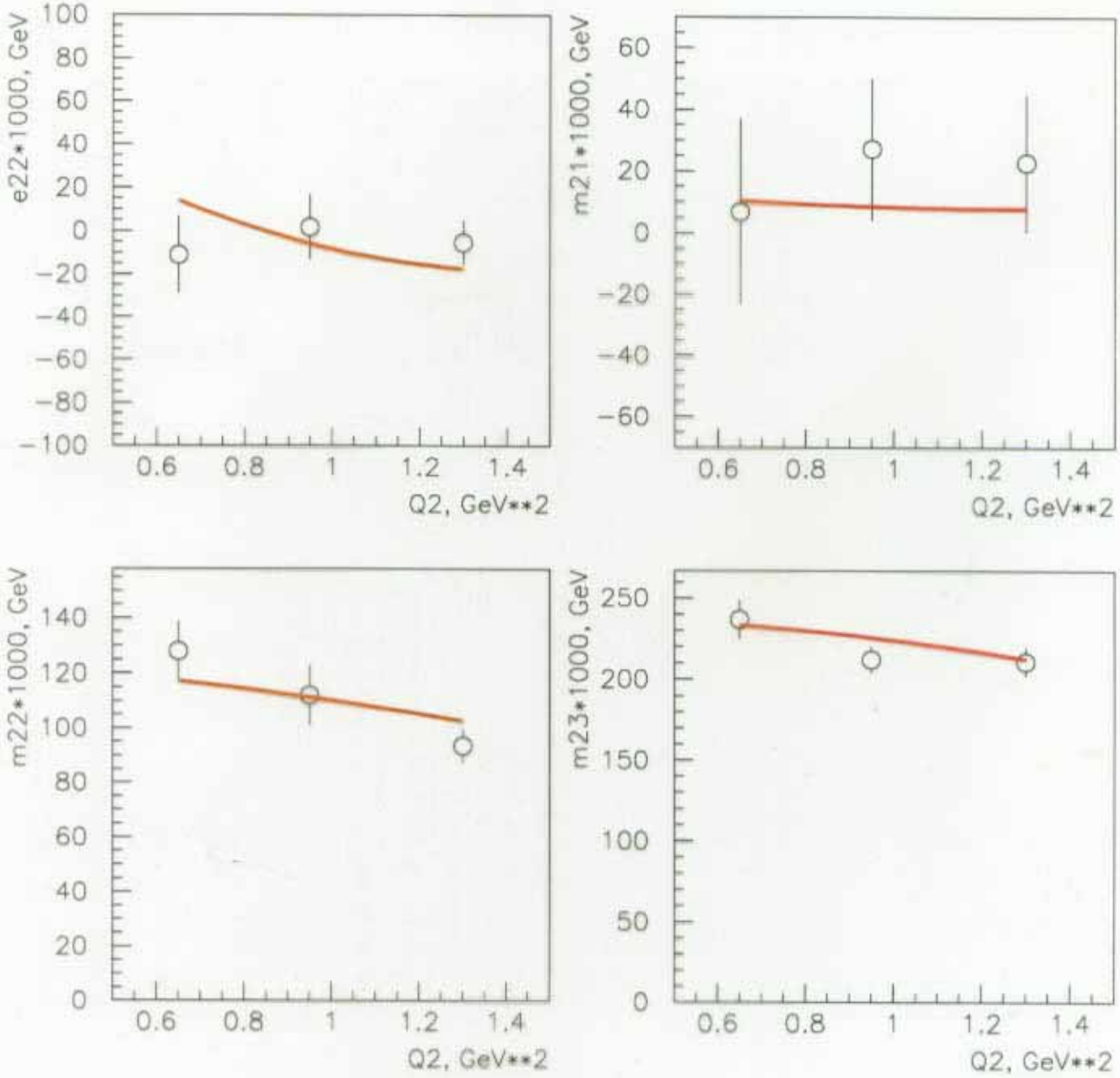
(70,1−) supermultiplet







(56,2+) supermultiplet



Conclusions

- Physics analysis of the first CLAS data on double charged pion production at $W<2.1$GeV and $Q^2<1.5$ GeV^2 have been performed in the framework of isobaric model, aimed to extract information on N* photocouplings from data fit. CLAS. data were reproduced reasonably in overall kinematic domain apart from structure at 1.7 GeV with N* photocouplings changed not more than 30% with respect to world data interpolation in the framework of SQTM approach and recent data on hadronic couplings

- Two possible ways to describe structure near 1.7 GeV were found:

a) considering the contributions of conventional states alone a reasonable fit was obtained with hadronic couplings of P13(1720) which are very different from the one established in recent analyses of experiments with hadronic probes;

b) implementing a missing state with quantum numbers $3/2^+$, and hadronic couplings obtained in the fit, while keeping couplings of all other states inside uncertainties of recent analyses of hadronic probes.

- The SQTM parameters were fitted to measured 2π cross-sections without any ad hoc assumptions on theirs values, allowing reliable predictions for Q^2-dependece of photocouplings for $(70,1^-)$ and $(56,2^+)$ nucleon excitations.