omega photoproduction at CLAS

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for the CLAS Collaboration

Motivation:

- *s*-channel contributions at low *W* ?
- QM predictions
- search for "missing resonances"

Experiment:

CLAS data on $\gamma p \rightarrow \omega p \rightarrow p \pi^+ \pi^- \pi^0$

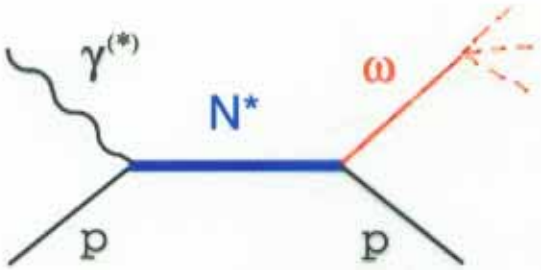
- process identification
- diff. X-section
- decay distribution

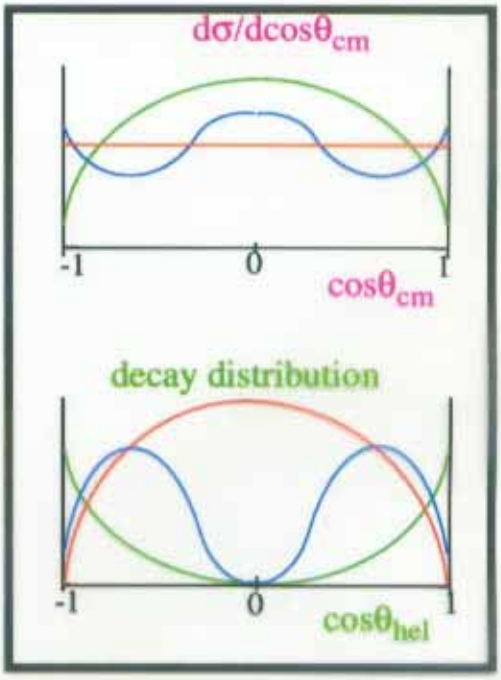
Model comparison

Summary and Outlook

Processes contributing to $\gamma p \rightarrow \omega p$

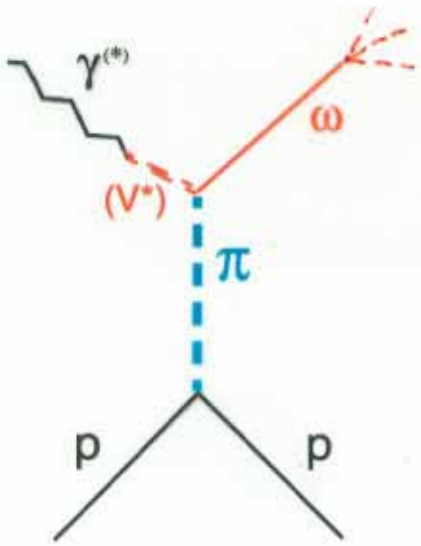
s-channel resonances

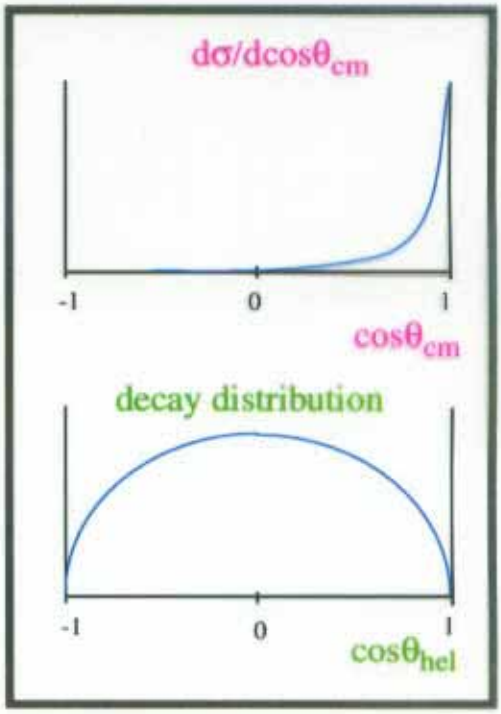




depend on P.W.

t-channel exchanges





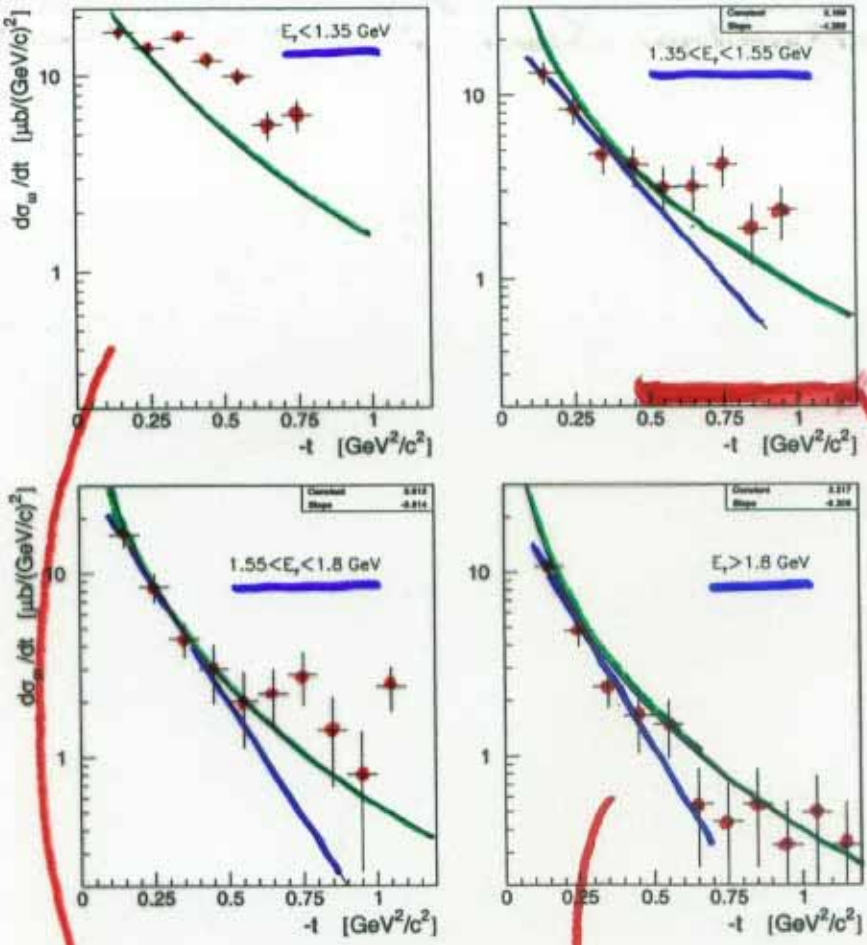
$\propto \frac{1}{t^2}$

$\propto \sin^2\vartheta_h$

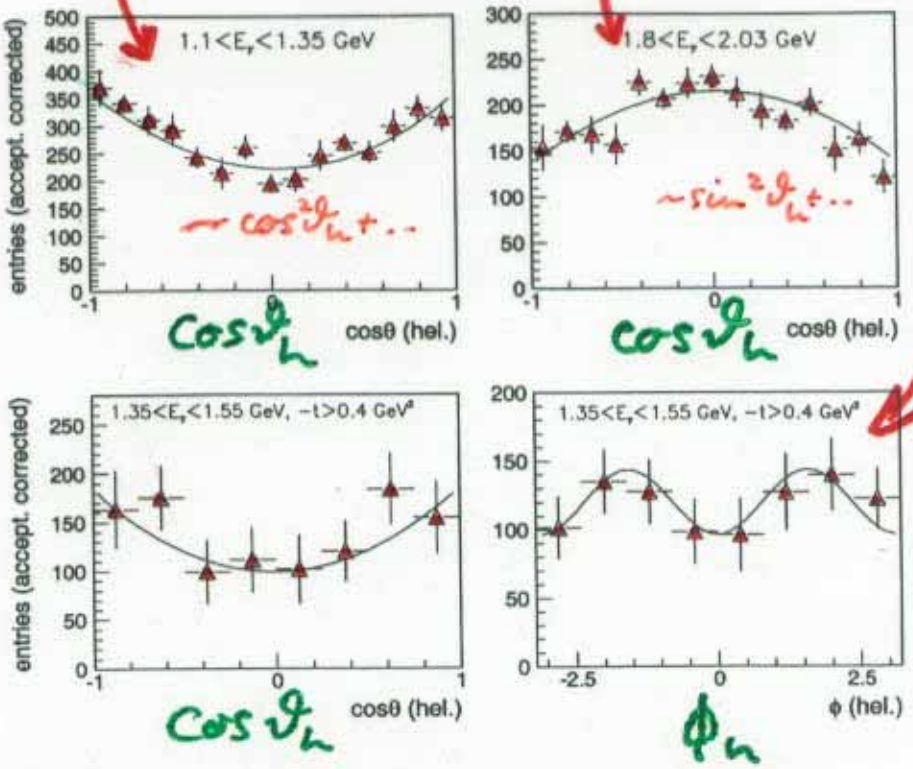
SAPHIR (prelim.) $\gamma p \to \omega p$

$\frac{d\sigma}{dt}$

- OPE (Friman-Soyeur)
- expon. fit

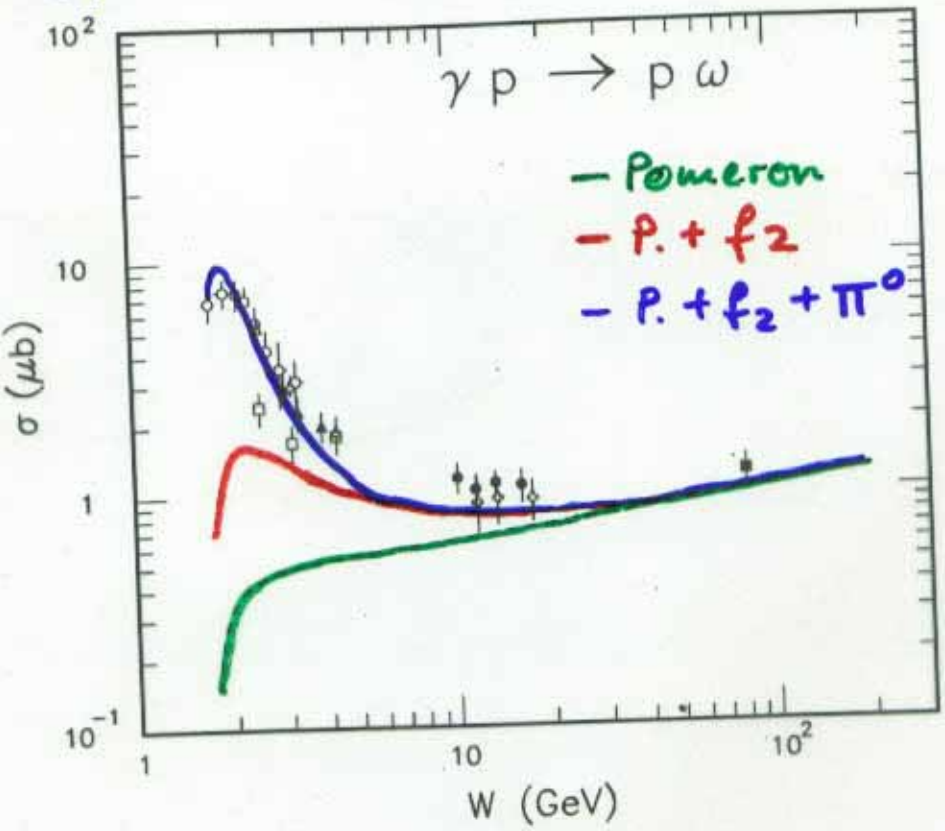


decay distr.:



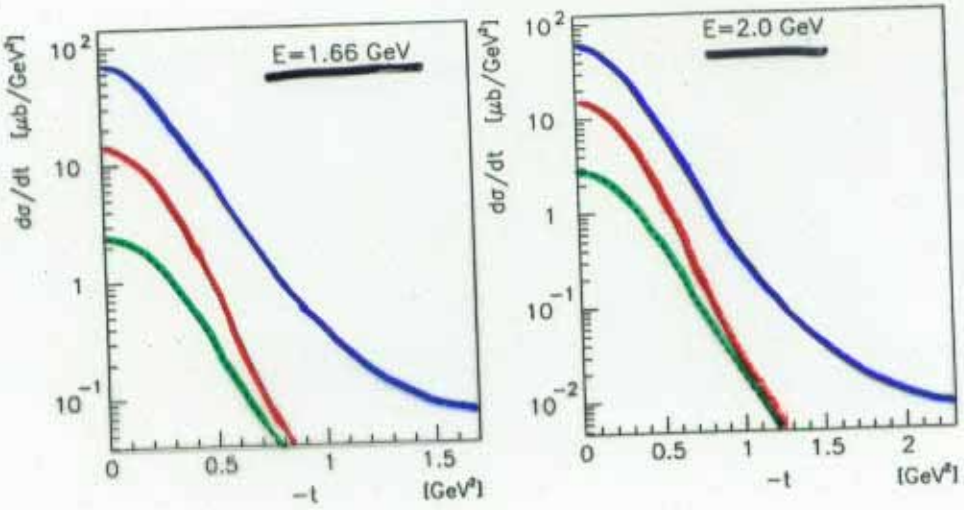
Regge calculation (t-exchange)

$\sigma(\gamma p \to \omega p)$



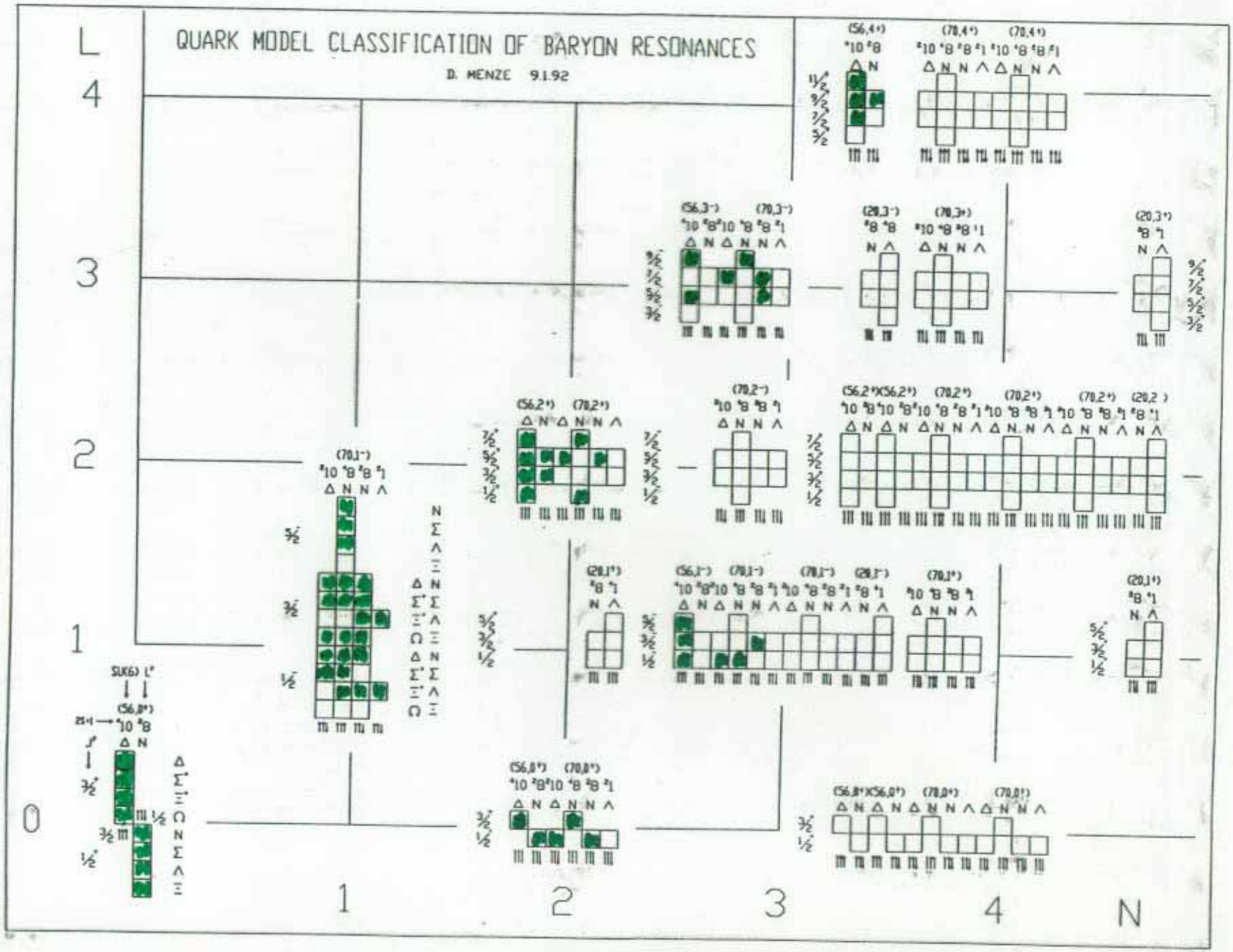
Pomeron } natural parity
f_2
π^0 unnatural parity

$d\sigma/dt$



Regge calculations by J.M. Laget of the ω cross section incoporating the processes: Pomeron trajectory (*dashed line*), Pomeron plus f_2 exchange (*dotted line*), Pomeron plus f_2 plus π exchange (*solid line*) in the t-channel. The experimental data points in the top figure are the world's data set (SLAC, DESY, CERN, FNAL, and HERA).

■ experimentally established (RPP)



Search for 'missing' baryon resonances

Table 1: SU(6) ⊗ O(3) supermultiplet assignments from the QCD-improved model of Cutkosky for the measured and *missing* baryon resonances. The boxed supermultiplets are fully consistent with the diquark model.

I = 1/2

N*	Status	SU(6) ⊗ O(3)	Parity	Δ*	Status	SU(6) ⊗ O(3)
P11(938)	****	(56,0+)	+	P33(1232)	****	(56,0+)
S11(1535)	****	(70,1−)	−			
S11(1650)	****	(70,1−)		S31(1620)	****	(70,1−)
D13(1520)	****	(70,1−)		D33(1700)	****	(70,1−)
D13(1700)	***	(70,1−)				
D15(1675)	****	(70,1−)				
P11(1520)	****	(56,0+)	+	P31(1875)	****	(56,2+)
P11(1710)	***	(70,0+)		P31(1835)		(70,0+)
P11(1880)		(70,2+)				
P11(1975)		(20,1+)				
P13(1720)	****	(56,2+)	+	P33(1600)	***	(56,0+)
P13(1870)	*	(70,0+)		P33(1920)	***	(56,2+)
P13(1910)		(70,2+)		P33(1985)		(70,2+)
P13(1950)		(70,2+)				
P13(2030)		(20,1+)				
F15(1680)	****	(56,2+)	+	F35(1905)	****	(56,2+)
F15(2000)	**	(70,2+)		F35(2000)	**	(70,2+)
F15(1995)		(70,2+)				
F17(1990)	**	(70,2+)	+	F37(1950)	****	(56,2+)

I = 3/2

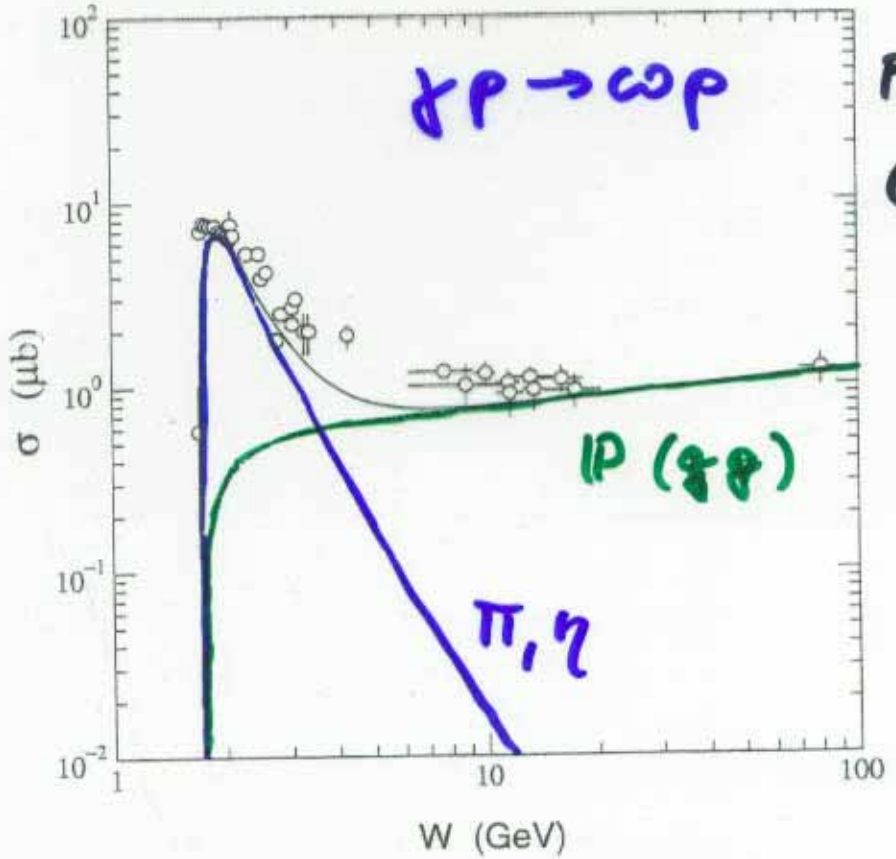
above ωp-threshold

ω as isospin-filter!

(I=0)

model Y. Oh, A. Titov, T.-S. H. Lee

- pomeron exch. (gg representation)
- OBE (π, η) [V]
- Nucleon Born term (s, u)
- N^* (parameters $^3P_0$: Capstick, Roberts)
  (N=2 +: 9 res. ; N=2, 3 −: 24 res.
  N≥4 : 8 res.)



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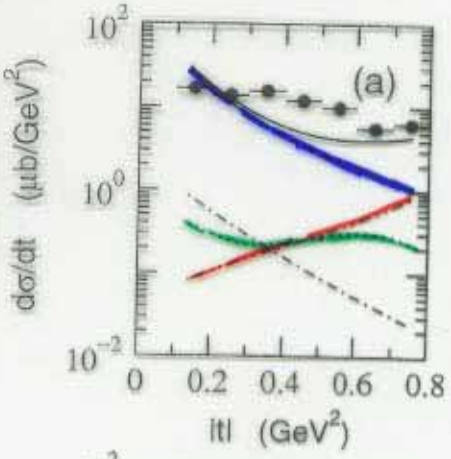
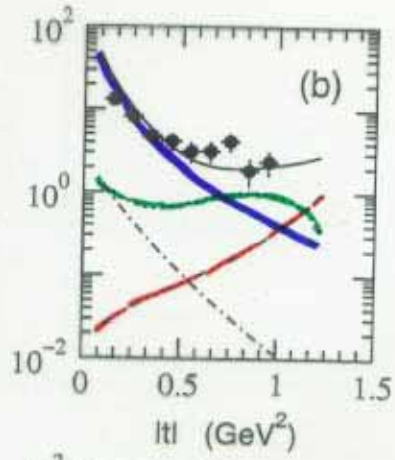
Y. Oh, A. Titov, T.-S.H. Lee

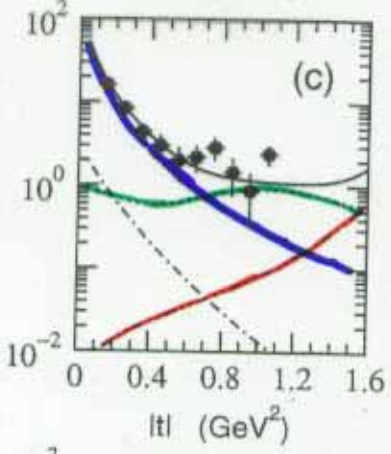
$E_\gamma = 1.23$ GeV

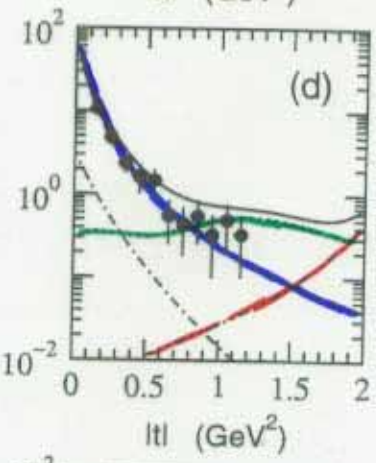




$E_\gamma = 1.45$ GeV

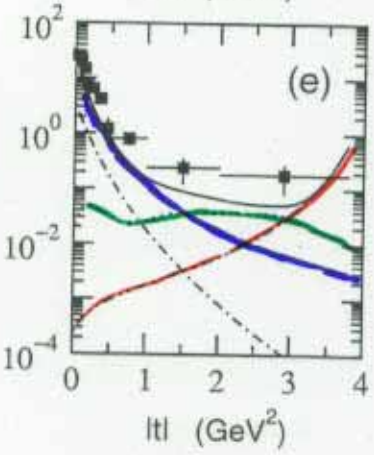
$E_\gamma = 1.68$ GeV

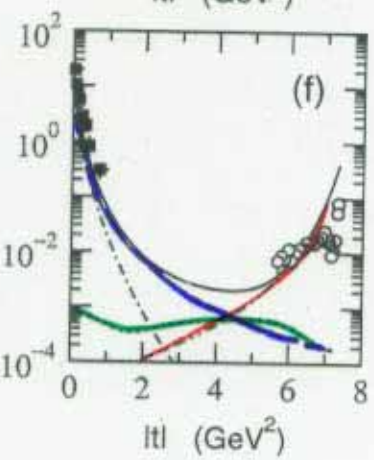




$E_\gamma = 1.92$ GeV

$E_\gamma = 2.8$ GeV



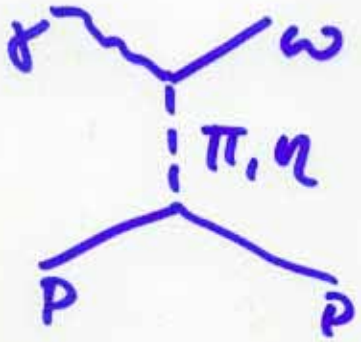


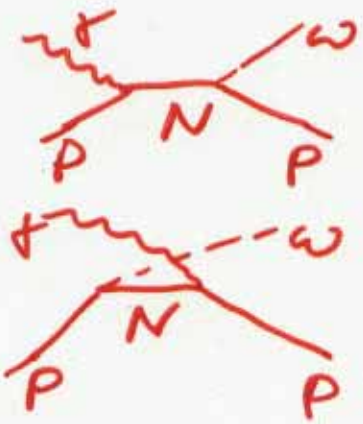
$E_\gamma = 4.7$ GeV

— π, η exch.

— N [illegible]

— N^* excit.





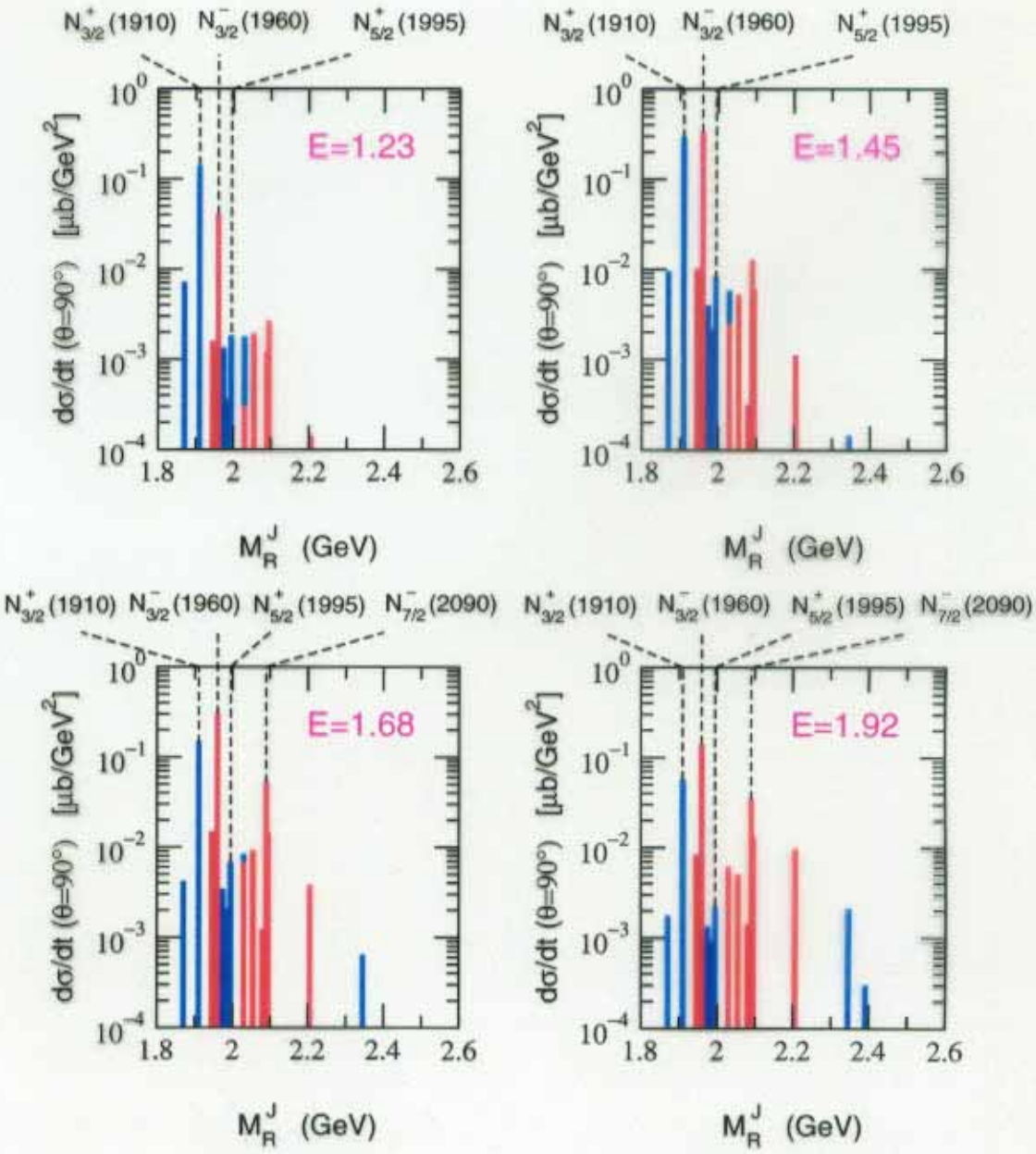
N^*	M_R^J	$A_{1/2}$	$A_{3/2}$	$G(1,1/2)$	$G(1,3/2)$		$\sqrt{\Gamma_{N\omega}^{\rm tot}}$	PDG [23]
$N\frac{1}{2}^+$	1880	0	—	−4.3	−1.6	—	4.6	
$N\frac{1}{2}^+$	1975	−12	—	−3.1	−0.8	—	3.1	
				$G(1,1/2)$	$G(1,3/2)$	$G(3,3/2)$		
$N\frac{3}{2}^+$	1870	−2	−15	0.0	+4.4	+0.6	4.5	$P_{13}(1900)^{**}$
$N\frac{3}{2}^+$	1910	−21	−27	−5.8	+5.7	−0.5	8.2	
$N\frac{3}{2}^+$	1950	−5	2	−5.4	−3.2	+0.7	6.3	
$N\frac{3}{2}^+$	2030	−9	15	−1.6	−2.9	+0.7	3.3	
				$G(3,1/2)$	$G(1,3/2)$	$G(3,3/2)$		
$N\frac{5}{2}^+$	1980	−11	−6	+2.1	−1.7	−1.1	2.9	
$N\frac{5}{2}^+$	1995	−18	1	−0.3	+3.1	−1.6	3.5	$F_{15}(2000)^{**}$
				$G(3,1/2)$	$G(3,3/2)$	$G(5,3/2)$		
$N\frac{7}{2}^+$	1980	−1	−2	−0.8	+1.4	0.0	1.6	$F_{17}(1990)^{**}$
$N\frac{7}{2}^+$	2390	−14	−11	−0.8	+2.1	+2.0	3.0	
$N\frac{7}{2}^+$	2410	+1	−1	−0.7	+1.3	0.0	1.5	
				$G(5,1/2)$	$G(3,3/2)$	$G(5,3/2)$		
$N\frac{9}{2}^+$	2345	−29	+13	−0.3	−2.9	−0.6	2.9	$H_{19}(2220)^{****}$

TABLE I. Parameters for positive parity nucleon resonances from Refs. [5,6]. The helicity amplitude A_λ is given in unit of 10^{-3} GeV$^{-1/2}$. $G(L,S)$ and $\sqrt{\Gamma_{N\omega}^{\rm tot}}$ are in unit of MeV$^{1/2}$. The resonance mass M_R^J is in unit of MeV.

N^*	M_R^J	$A_{1/2}$	$A_{3/2}$	$G(0,1/2)$	$G(2,3/2)$		$\sqrt{\Gamma_{N\omega}^{\rm tot}}$	PDG [23]
$N\frac{1}{2}^-$	1945	+12	—	−0.9	−5.6		5.7	$S_{11}(2090)^*$
$N\frac{1}{2}^-$	2030	+20	—	−0.1	−2.8		2.8	
				$G(2,1/2)$	$G(0,3/2)$	$G(2,3/2)$		
$N\frac{3}{2}^-$	1960	+36	−43	−4.3	−0.2	−4.6	6.3	$D_{13}(2080)^{**}$
$N\frac{3}{2}^-$	2055	+16	0	+2.0	−1.3	−2.7	3.6	
$N\frac{3}{2}^-$	2095	−9	−14	−3.2	+1.9	+3.8	5.3	
				$G(2,1/2)$	$G(2,3/2)$	$G(4,3/2)$		
$N\frac{5}{2}^-$	2080	−3	−14	−2.2	−0.3	+2.0	2.9	
$N\frac{5}{2}^-$	2095	−2	−6	−3.1	+3.3	+0.8	4.6	$D_{15}(2200)^{**}$
				$G(4,1/2)$	$G(2,3/2)$	$G(4,3/2)$		
$N\frac{7}{2}^-$	2090	−34	+28	−1.5	−3.7	−1.7	4.4	$G_{17}(2190)^{****}$
$N\frac{7}{2}^-$	2205	−16	+4	−0.2	−5.1	+0.3	5.1	
				$G(4,1/2)$	$G(4,3/2)$	$G(6,3/2)$		
$N\frac{9}{2}^-$	2215	0	+1	−1.0	+1.7	0.0	2.0	$G_{19}(2250)^{****}$

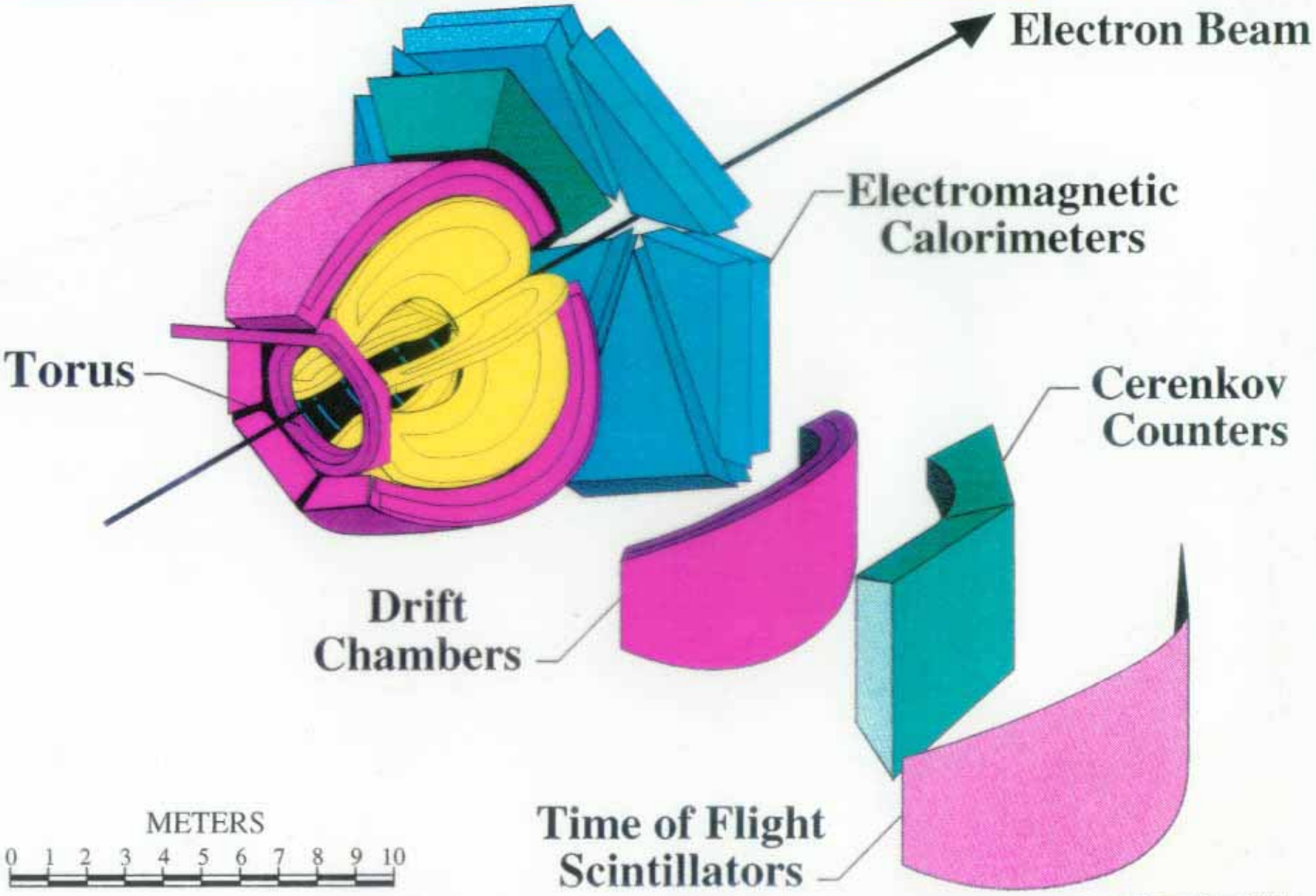
TABLE II. Parameters for negative parity nucleon resonances from Refs. [5,6]. The units are the same as in Table I.

model Y.Oh:
Resonant contribution to ω photoproduction at $\theta = 90°$

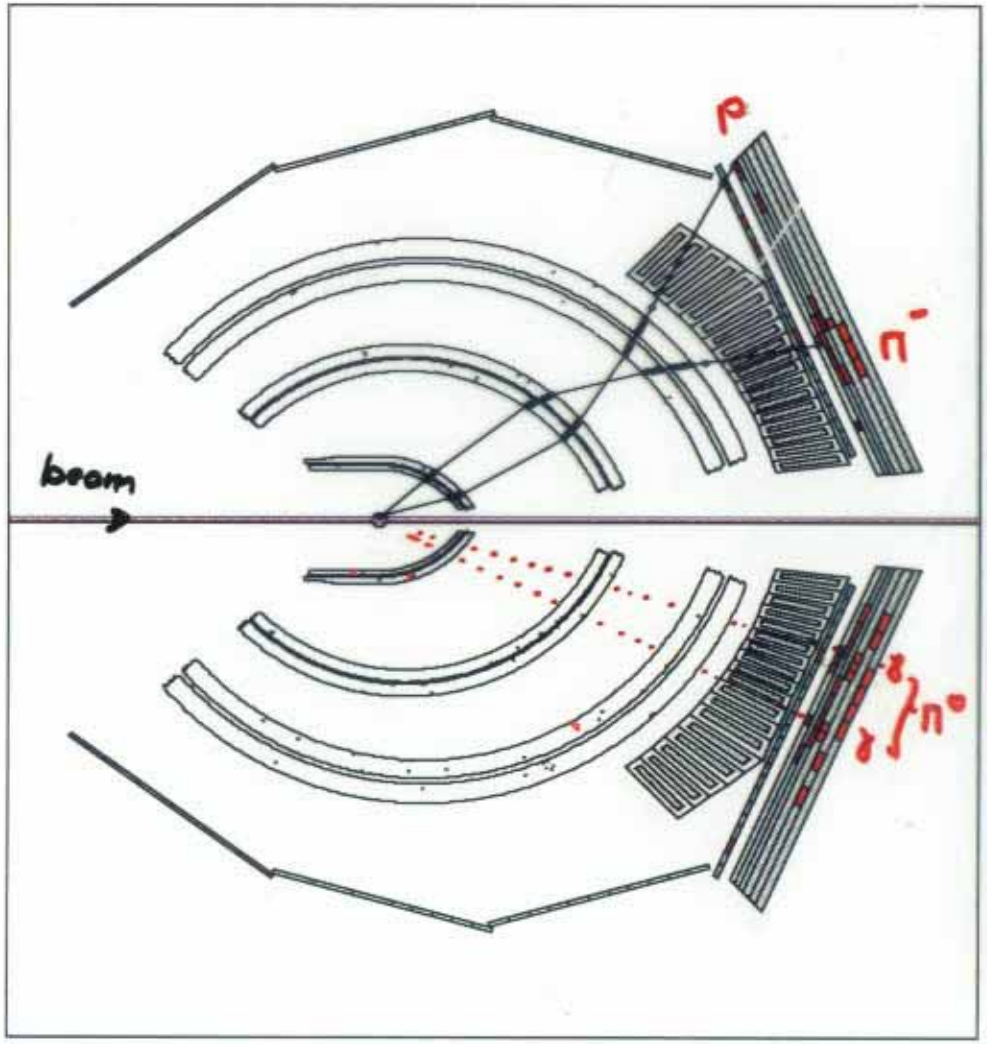


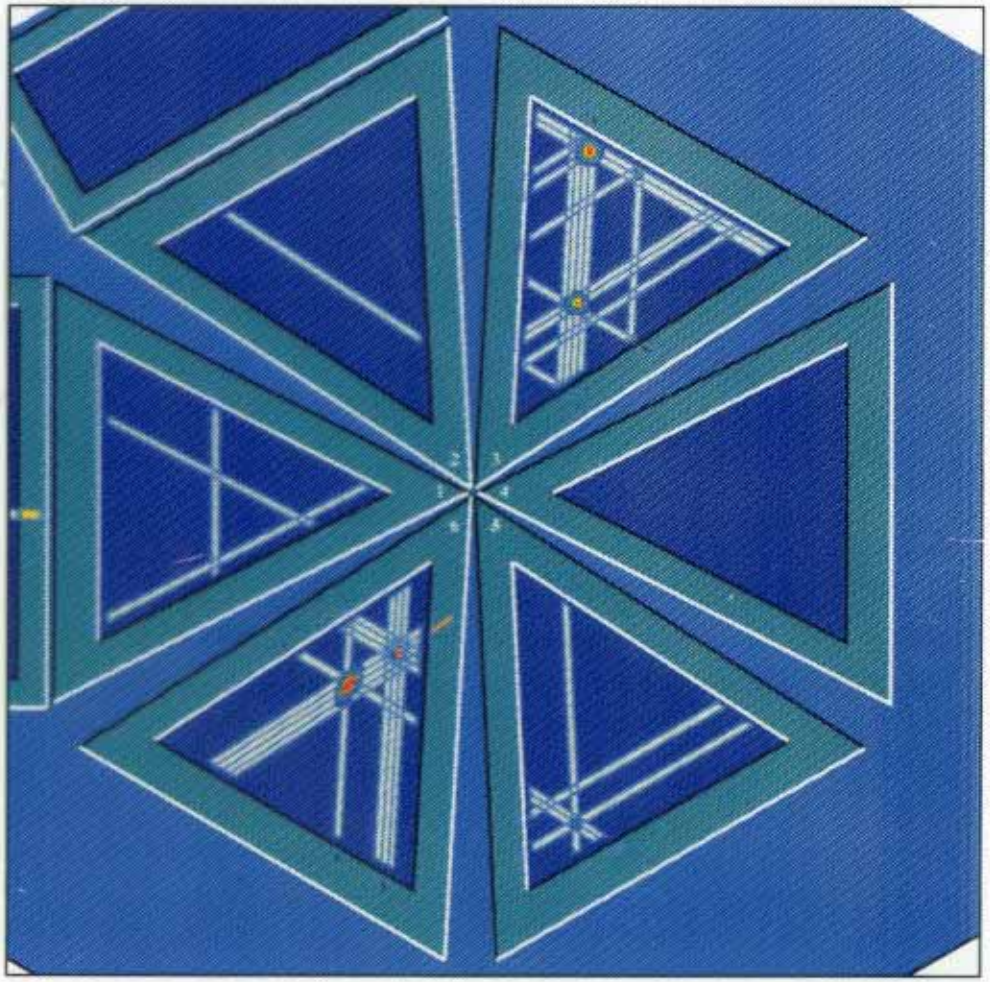
LARGE ACCEPTANCE SPECTROMETER

CEBAF

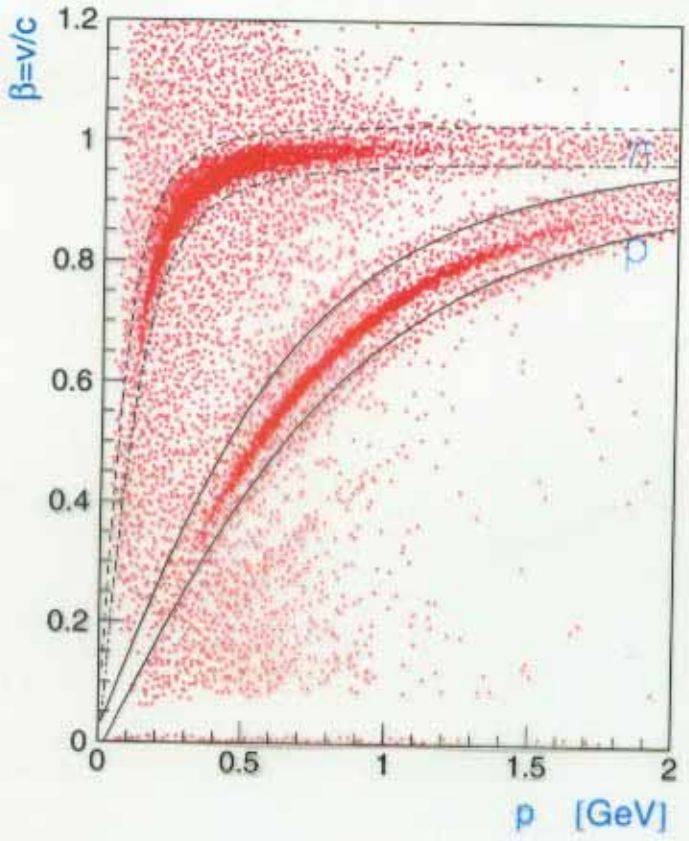


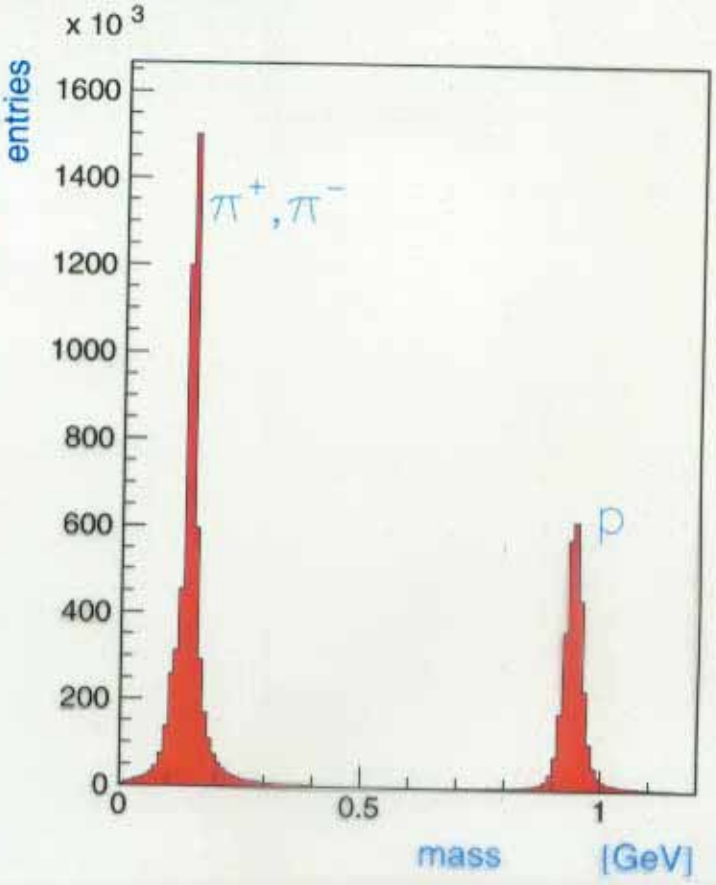
$\gamma p \to p \underbrace{\pi^0 \pi^- \pi^+}_{\pm m_\omega}$ event in CLAS June '97

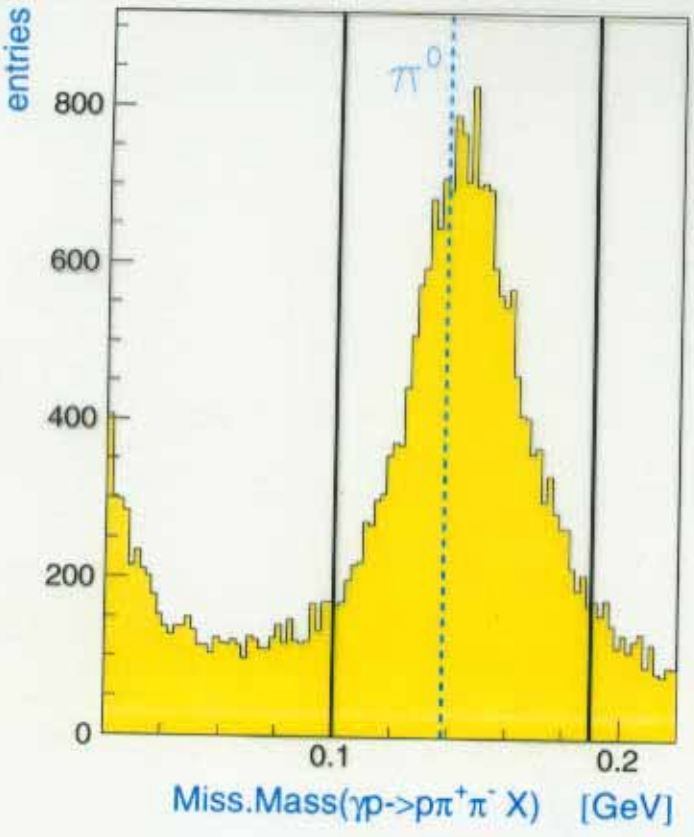


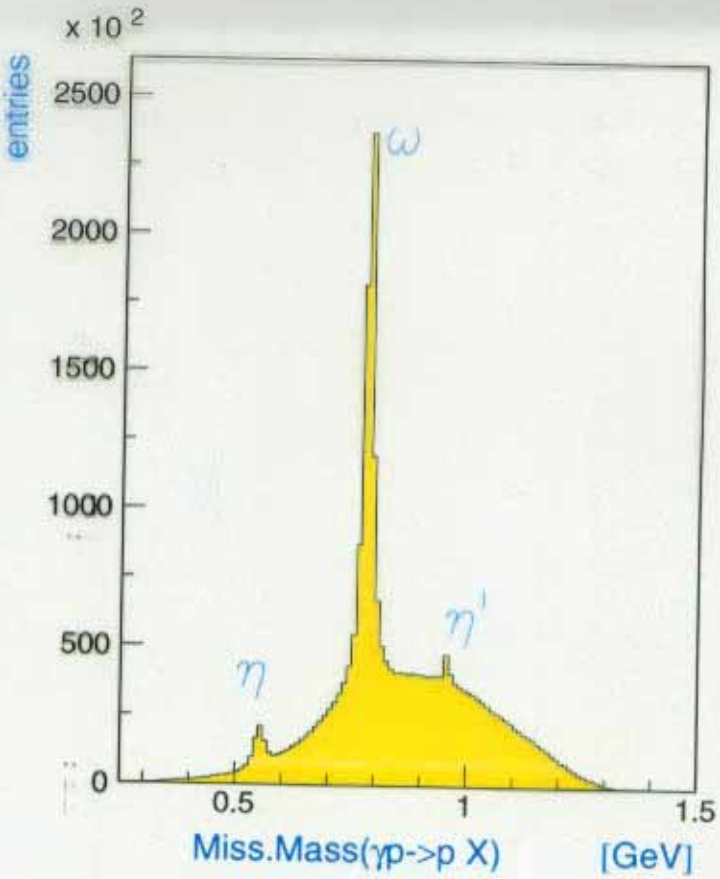


CLAS g1c data: process ident.

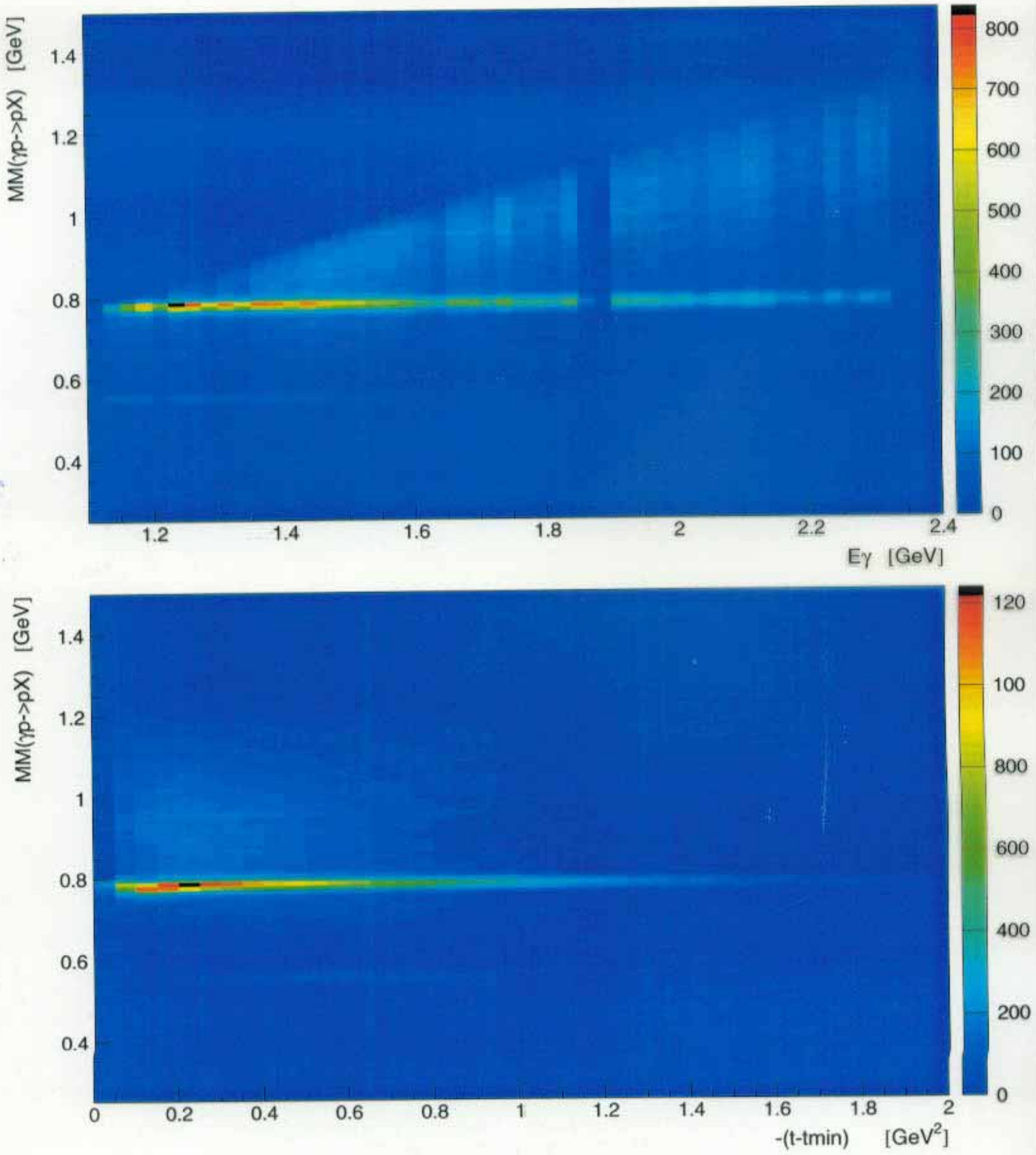








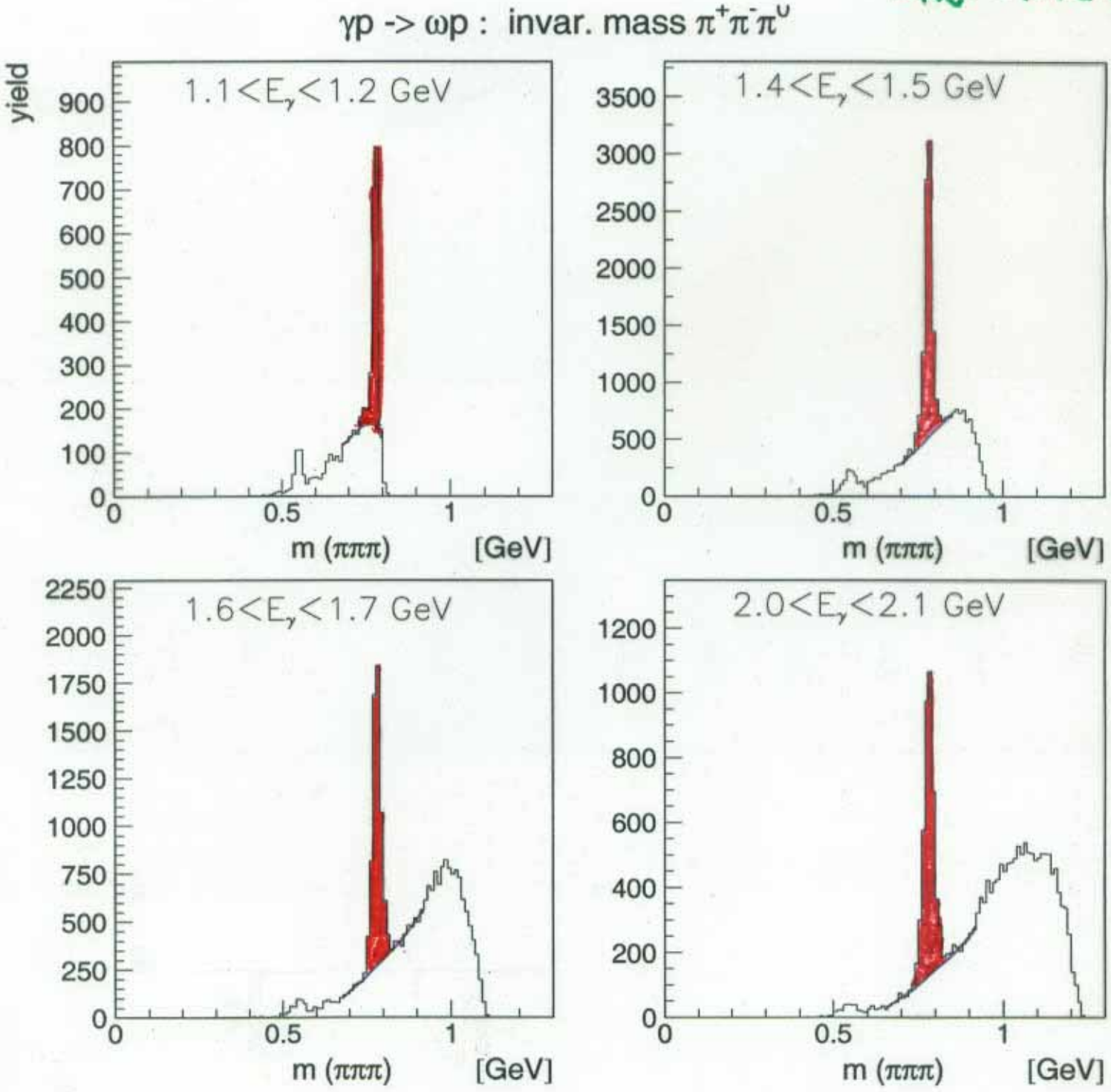
γp -> ωp


MM(γp->pX) [GeV]
1.4
1.2
1
0.8
0.6
0.4
1.2
1.4
1.6
1.8
2
2.2
2.4
Eγ [GeV]
800
700
600
500
400
300
200
100
0
MM(γp->pX) [GeV]
1.4
1.2
1
0.8
0.6
0.4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
-(t-tmin) [GeV²]
120
100
800
600
400
200
0

$\gamma p \to p\omega \hookrightarrow \pi^+\pi^-\pi^0$

identified: p, π^+, π^-

$E_{thr} = 1.72$ GeV



CLAS acceptance for $\gamma p \to \omega p$

$\hookrightarrow \pi^+\pi^-\pi^0$

detected: p, π^+, π^-

detected: $p, \pi^+, \gamma\gamma\ (\pi^0)$

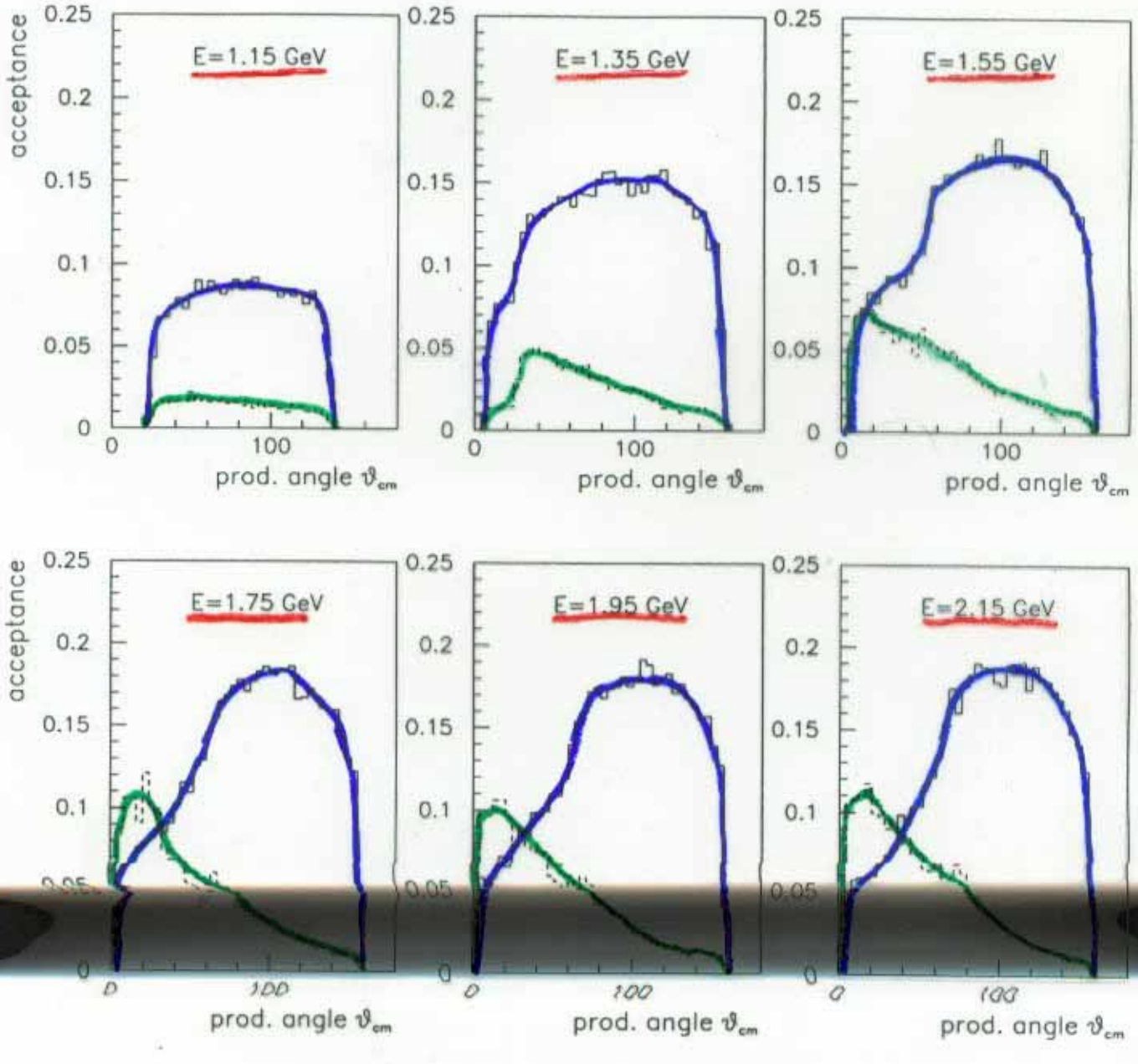
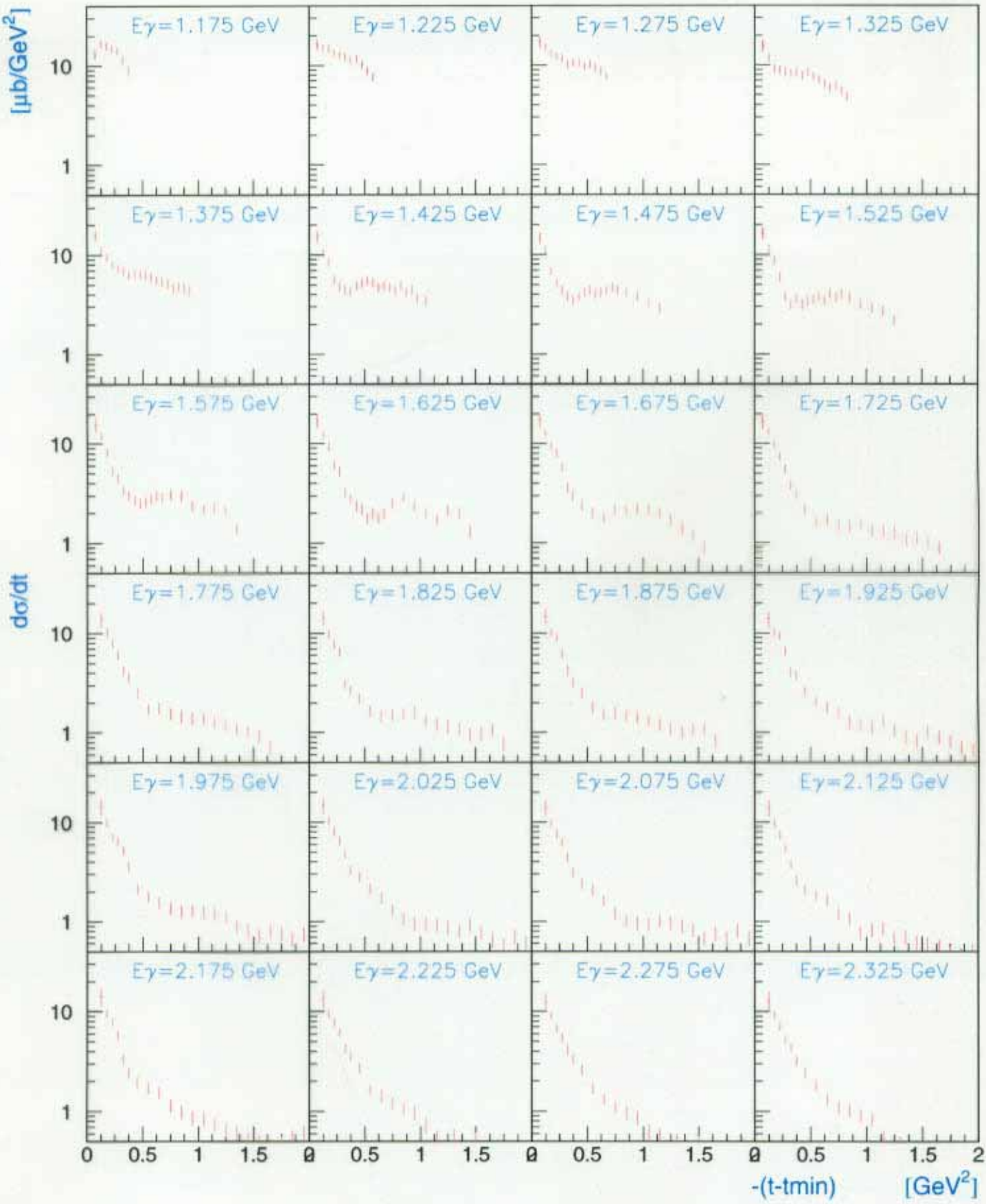
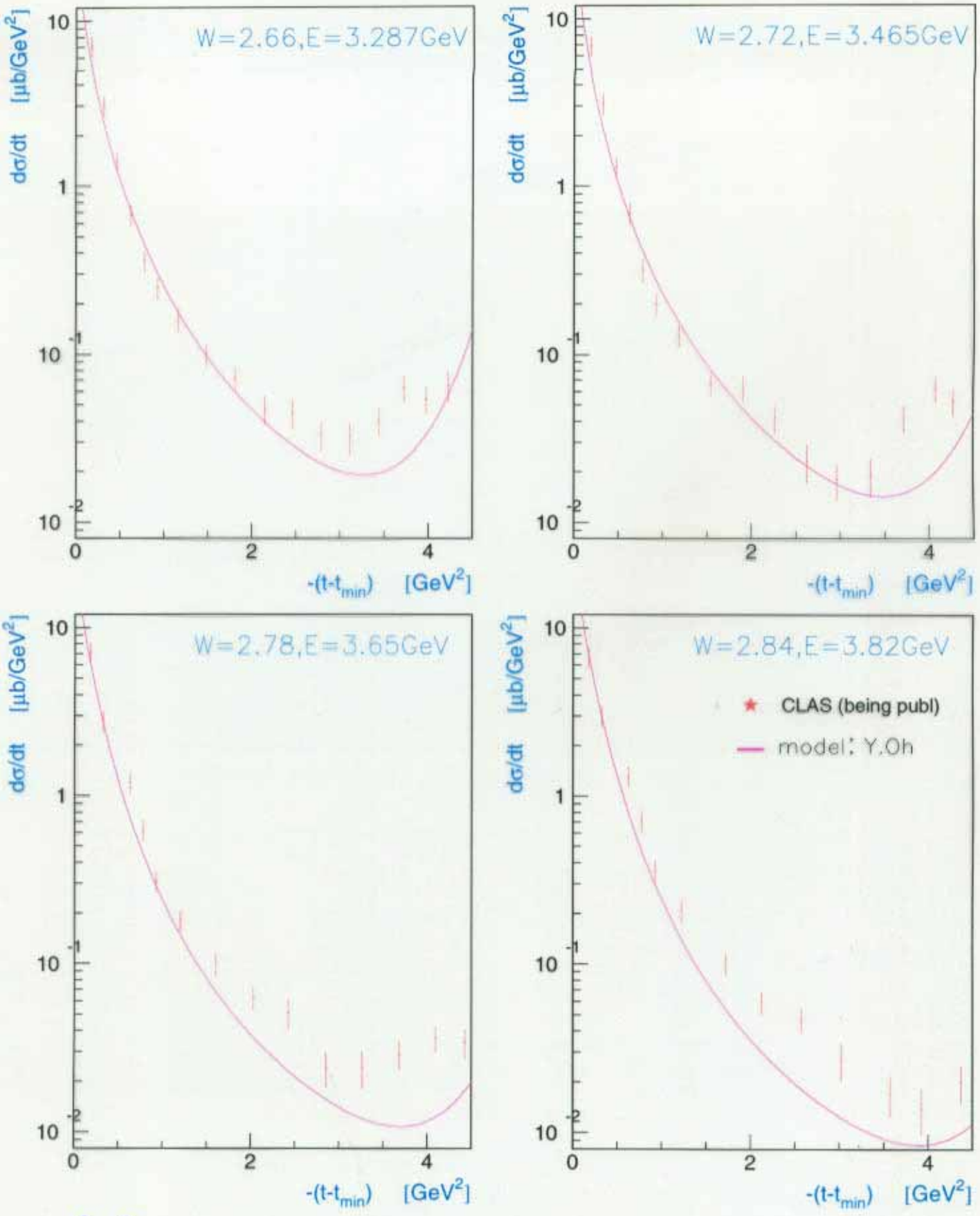


Figure 17: Acceptance for $\gamma p \to \omega p$ as a function of the production angle θ_{cm}

I need 2 of 3 pions in order to define
• the decay plane !


CLAS g1c data: γp -> ωp
preliminary
dσ/dt [μb/GeV²]
Eγ=1.175 GeV
Eγ=1.225 GeV
Eγ=1.275 GeV
Eγ=1.325 GeV
Eγ=1.375 GeV
Eγ=1.425 GeV
Eγ=1.475 GeV
Eγ=1.525 GeV
Eγ=1.575 GeV
Eγ=1.625 GeV
Eγ=1.675 GeV
Eγ=1.725 GeV
Eγ=1.775 GeV
Eγ=1.825 GeV
Eγ=1.875 GeV
Eγ=1.925 GeV
Eγ=1.975 GeV
Eγ=2.025 GeV
Eγ=2.075 GeV
Eγ=2.125 GeV
Eγ=2.175 GeV
Eγ=2.225 GeV
Eγ=2.275 GeV
Eγ=2.325 GeV
10
1
0
0.5
1
1.5
2
-(t-tmin) [GeV²]

CLAS g6a data: $\gamma p \to \omega p$

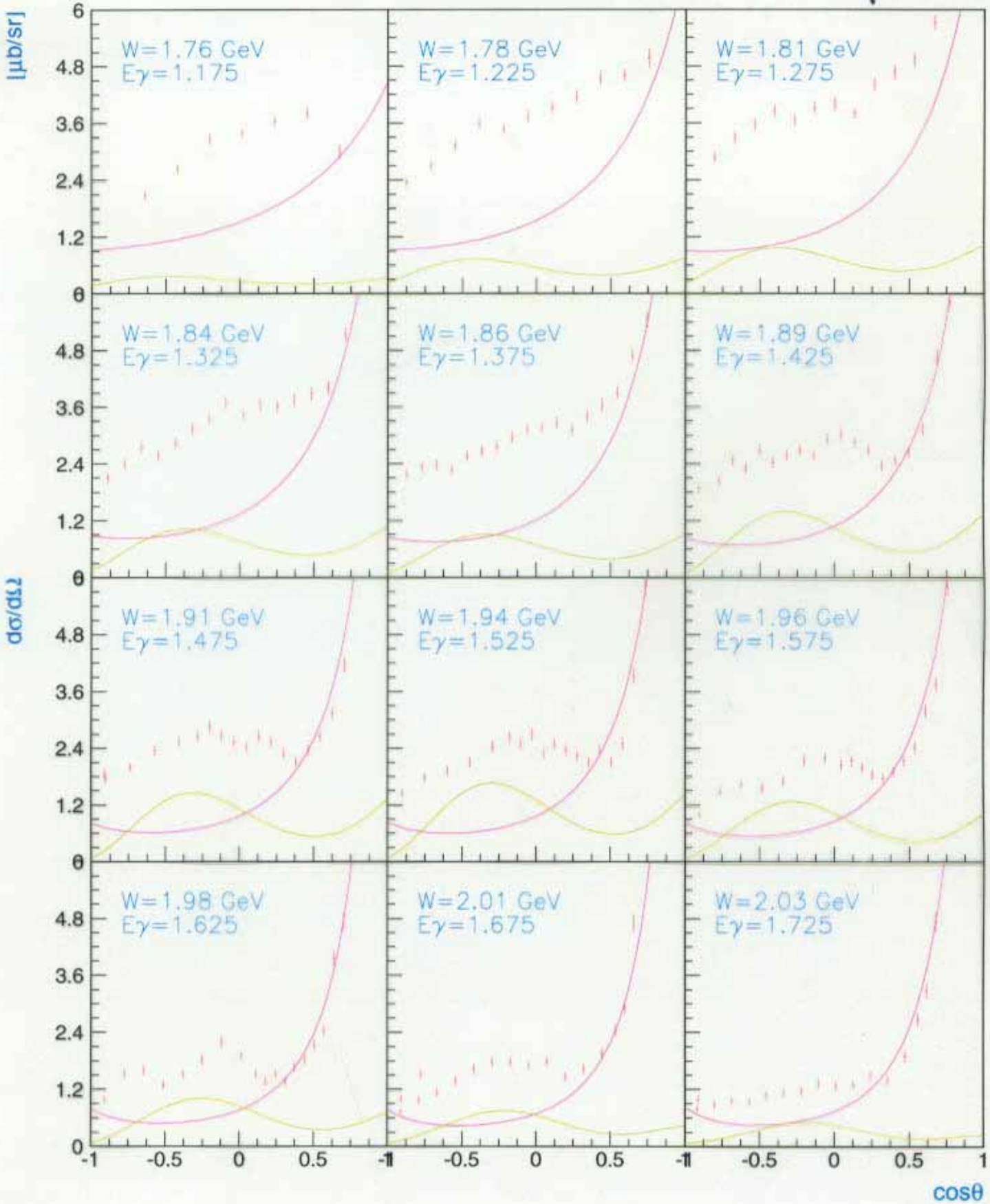


model parameters : pomeron $\beta_u = \beta_d = 2.3 \leftarrow 2.05$

OBE $\lambda_{\pi NN} = 0.8$ GeV $\leftarrow 0.7$

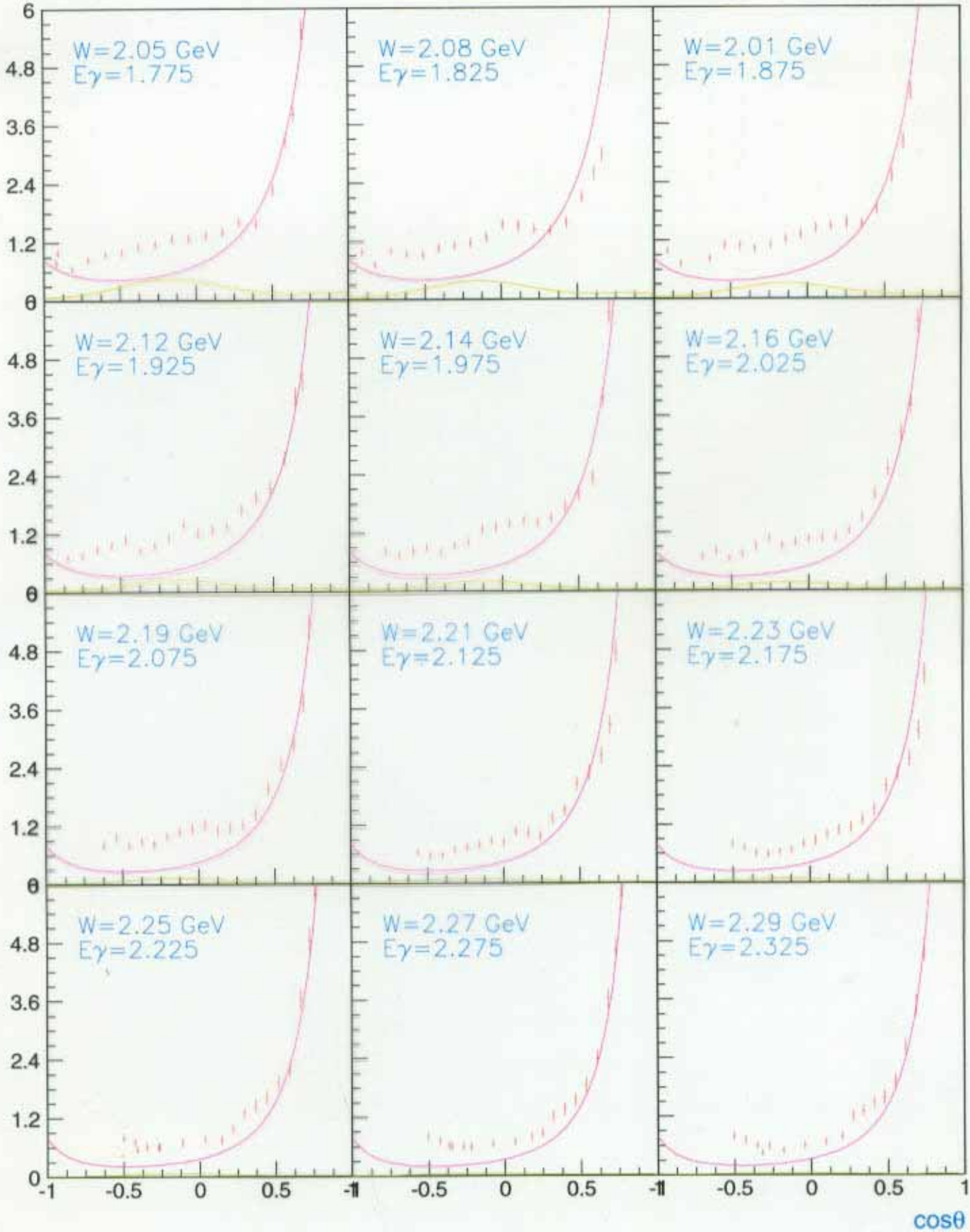
CLAS g1c data + Y.Oh model

prelim.

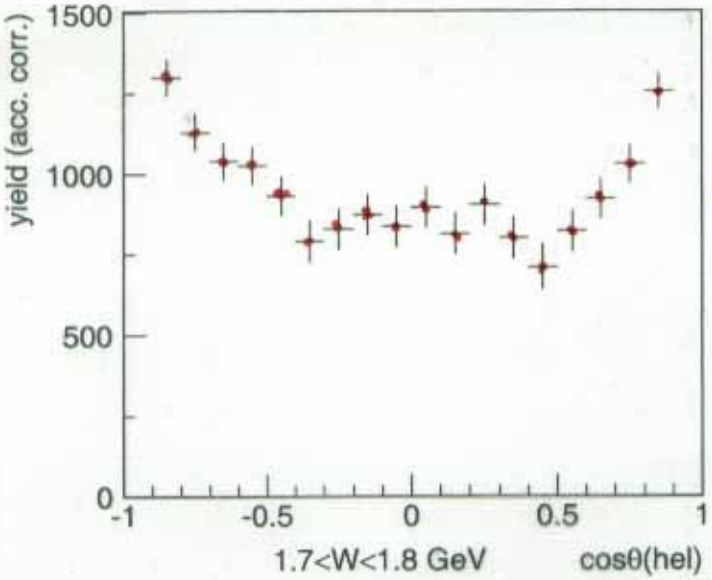


CLAS g1c data + Y.Oh model

prelim.



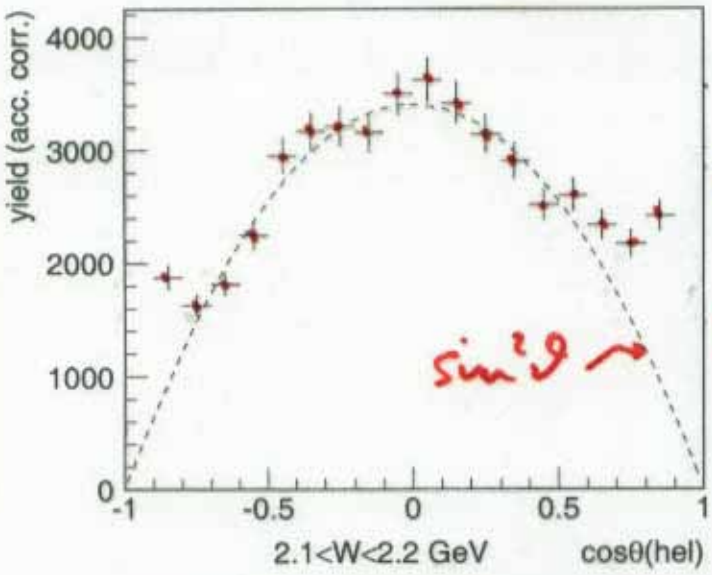
$\gamma p \to \omega p$: decay distr. ($\cos\theta_{hel}$)



near threshold:

$W(\cos\vartheta, \varphi) \propto \cos^2\vartheta + \ldots$

$\rightsquigarrow \rho^0_{00} \neq 0$

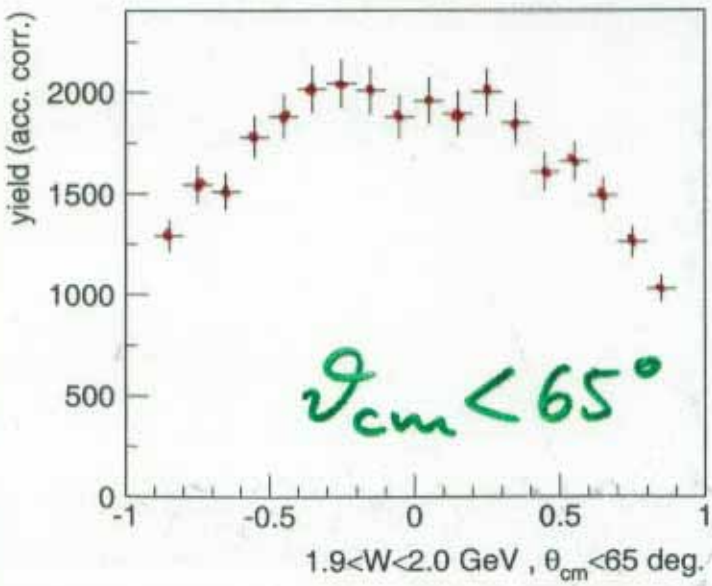


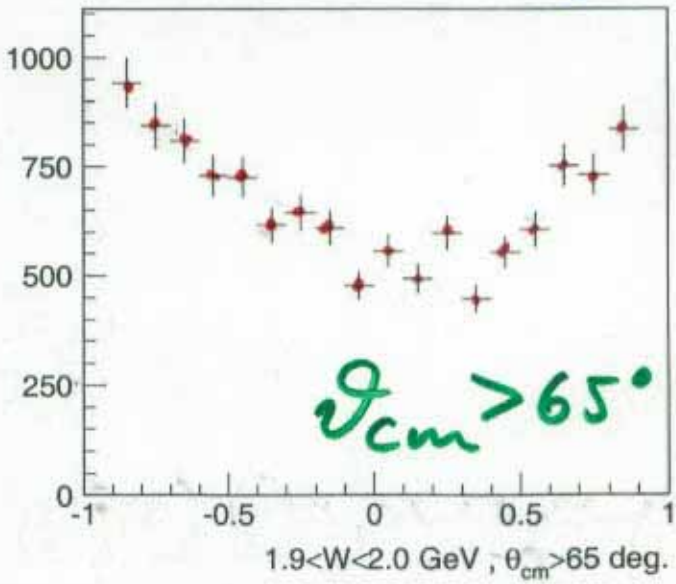
above resonance region:

$W(\cos\vartheta, \varphi) \propto \sin^2\vartheta + \ldots$

t-exchanges: $W(\cos\vartheta, \varphi) \propto \sin^2\vartheta$

in resonance region:





Summary and Outlook

- measured X-section shows

  strong indication for s-channel contributions

  below $E\gamma$ ~2 GeV

- flat X-section near threshold (S11 ?)

- QM predictions not consistent with data ?

- models for VM photoproduction insufficient ?

need for polarization data :

- linearly polarized photon beam

  (CLAS g8: Summer'01, Fall'03)

- polarized beam + polarized target (2004+)