JLAB12 Collaboration Meeting
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ω production at 90º and test of counting rules

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Physic motivations

ds/dt(90^0) for γ p $\rightarrow$ p ω

Results

Hadronic exclusive reactions at large *t*

- **Huge phenomenology**
- **Both elastic and inelastic channels**

J.Gunion et al. Phys.Rev. D8 (1973) 287

- **Large -*t* in Constituent Interchange Model (CIM): parton exchange where only two constituents interact**

AGS-BNL: E755, E838: π, K, p beams s ~ 7 and 13 GeV² ds/dt(90⁰) -*t*: 4-5.5 GeV²

R.Baller et al. Phys.Rev.Lett. 60 (1988) 1188 C.White et al. Phys.Rev. D49 (1994) 58

No.	Interaction	Cross section E838	Cross section E755	n-2 $(\frac{d\sigma}{dt} \sim 1/s^{n-2})$
1	$\pi^+ p \to p\pi^+$	132 ± 10	4.6 ± 0.3	6.7 ± 0.2
2	$\pi^- p \to p\pi^-$	73 ± 5	1.7 ± 0.2	7.5 ± 0.3
3	$K^+ p \to pK^+$	219 ± 30	3.4 ± 1.4	$8.3^{+0.6}_{-1.0}$
4	$K^- p \to pK^-$	18 ± 6	0.9 ± 0.9	≥ 3.9
5	$\pi^+ p \to p\rho^+$	214 ± 30	3.4 ± 0.7	8.3 ± 0.5
6	$\pi^- p \to p\rho^-$	99 ± 13	1.3 ± 0.6	8.7 ± 1.0
13	$\pi^+ p \to \pi^+ \Delta^+$	45 ± 10	2.0 ± 0.6	6.2 ± 0.8
15	$\pi^- p \to \pi^+ \Delta^-$	24 ± 5	≤ 0.12	≥ 10.1
17	$pp \to pp$	3300 ± 40	48 ± 5	9.1 ± 0.2
18	$\bar{p}p \to p\bar{p}$	75 ± 8	≤ 2.1	≥ 7.5

Counting rules

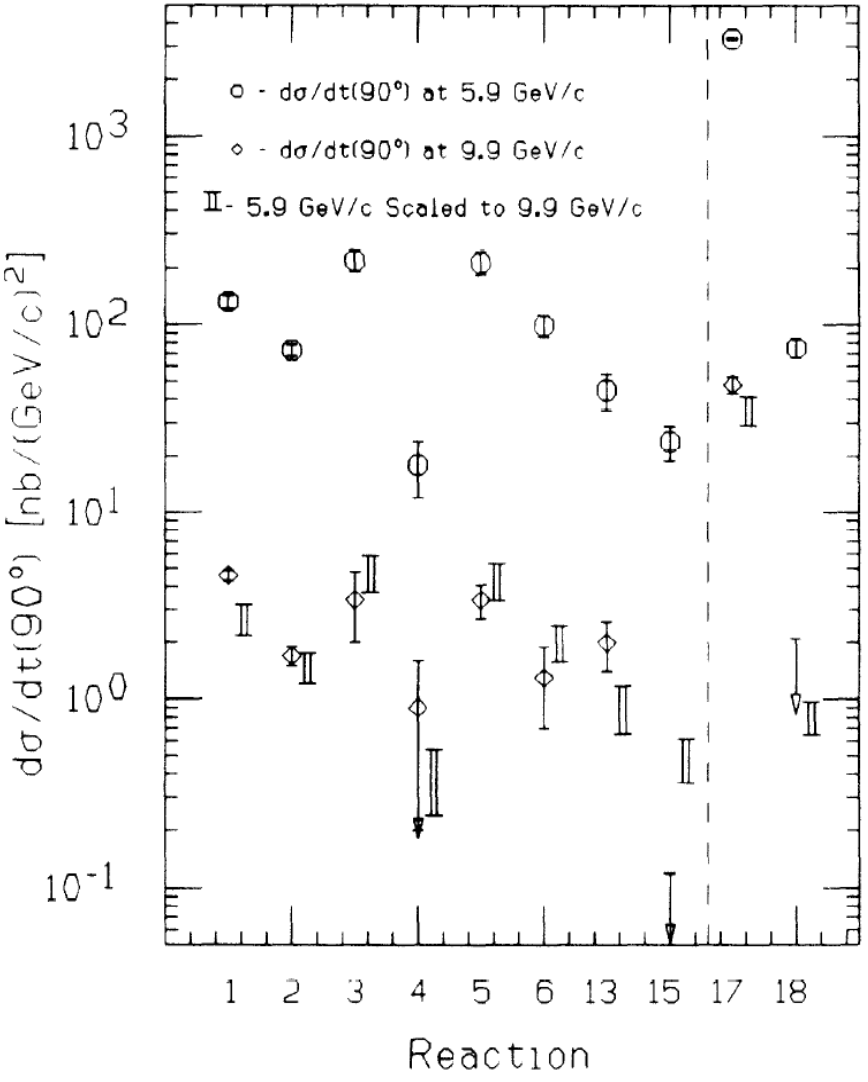
S.Brodsky G.Farrar Phys.Rev.Lett. 31 (1973) 1153

Phys.Rev. D11 (1975) 1303

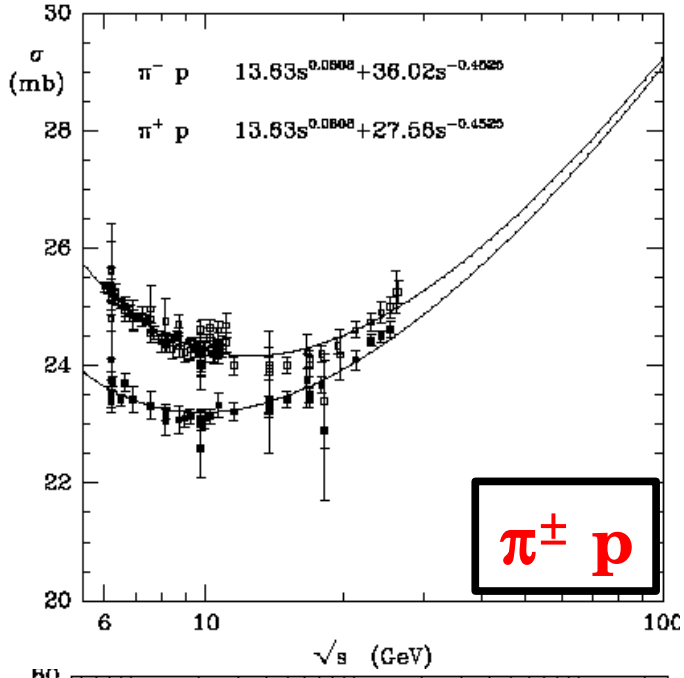
***-t* → ∞**

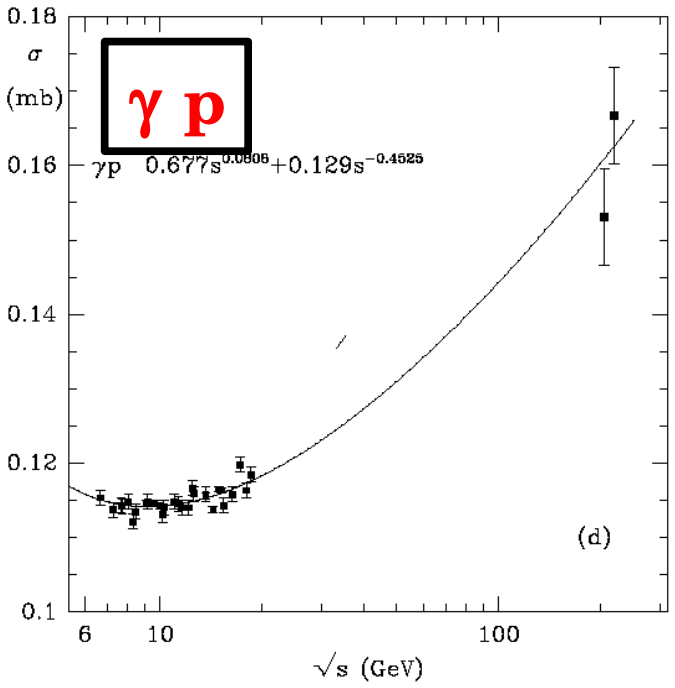
***t/s* fixed**

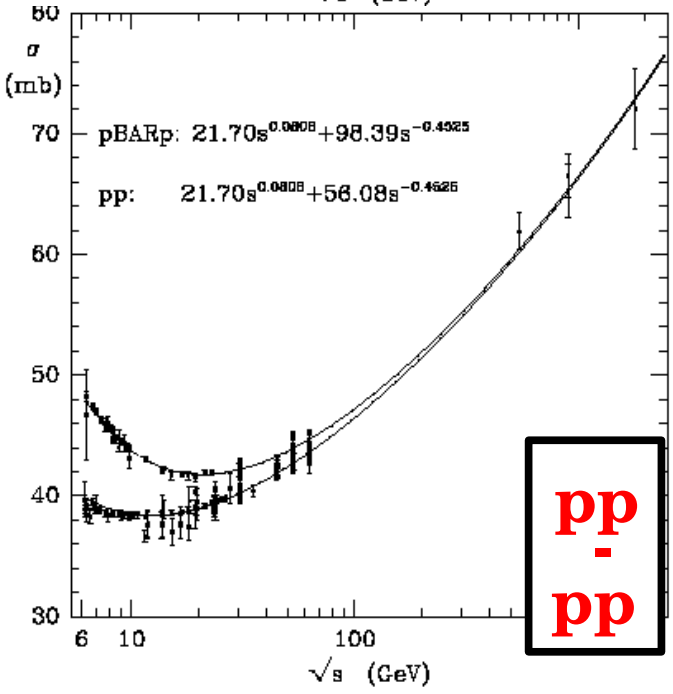
$ds/dt(a\ b \to a\ b) \sim 1/s^{(n-2)}\ f_{ab}(t/s)$



Total and differential cross-sections





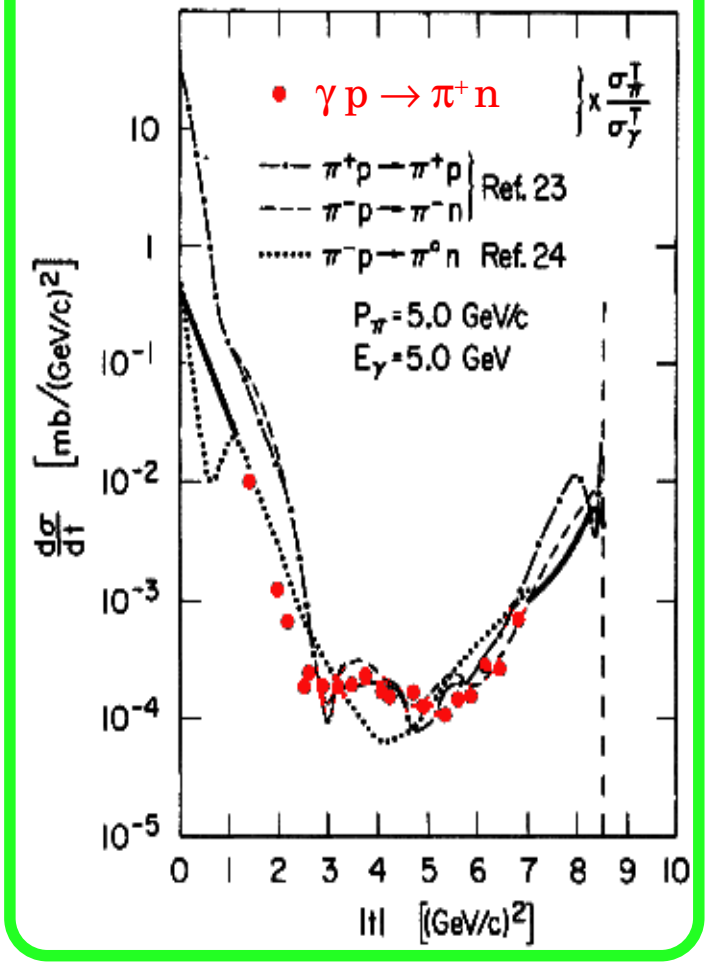


- **Universal behavior**

$$\sigma_{tot} = A\, s^{-0.4525} + B\, s^{0.0808}$$

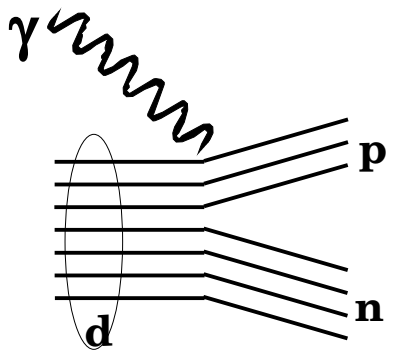
Simple interpretation in Regge Theory (Pomeron + reggeon exchange)

Differential cross-sections at large momentum transfer



Vector dominance hypothesis

Hadronic scattering ⇔ photoproduction



Should scale as s^{-11}

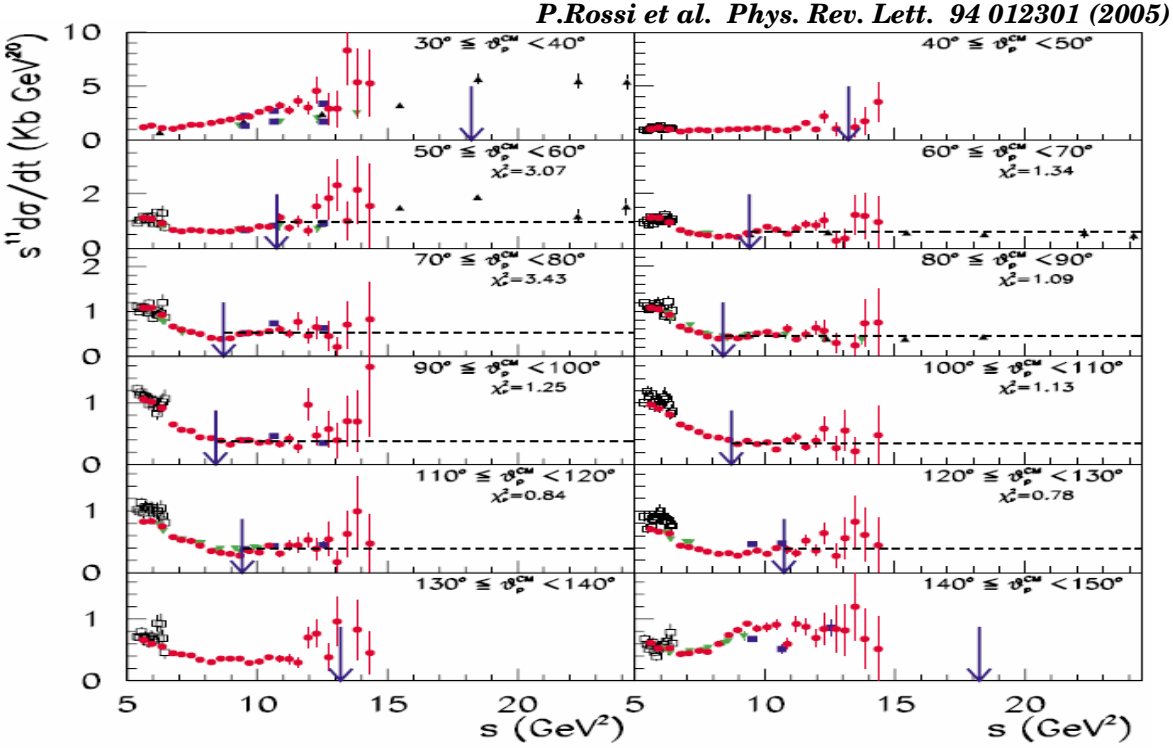
$$P_T = \sqrt{\frac{1}{2} E_\gamma M_d \sin^2(\vartheta_p^{\text{c.m.}})}$$

$\gamma d \rightarrow np$
CLAS data shows
s^{-11} behavior
for P_T ³ 1.1 GeV

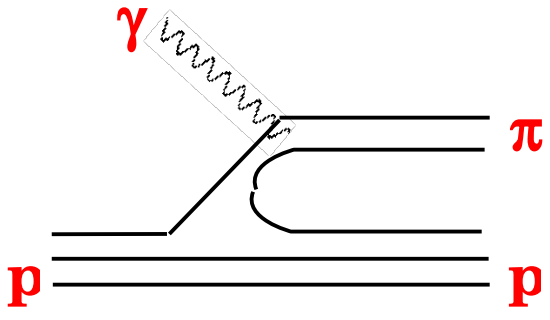
Deuteron photodisintegration

$d\sigma/dt$ *s*-dependence

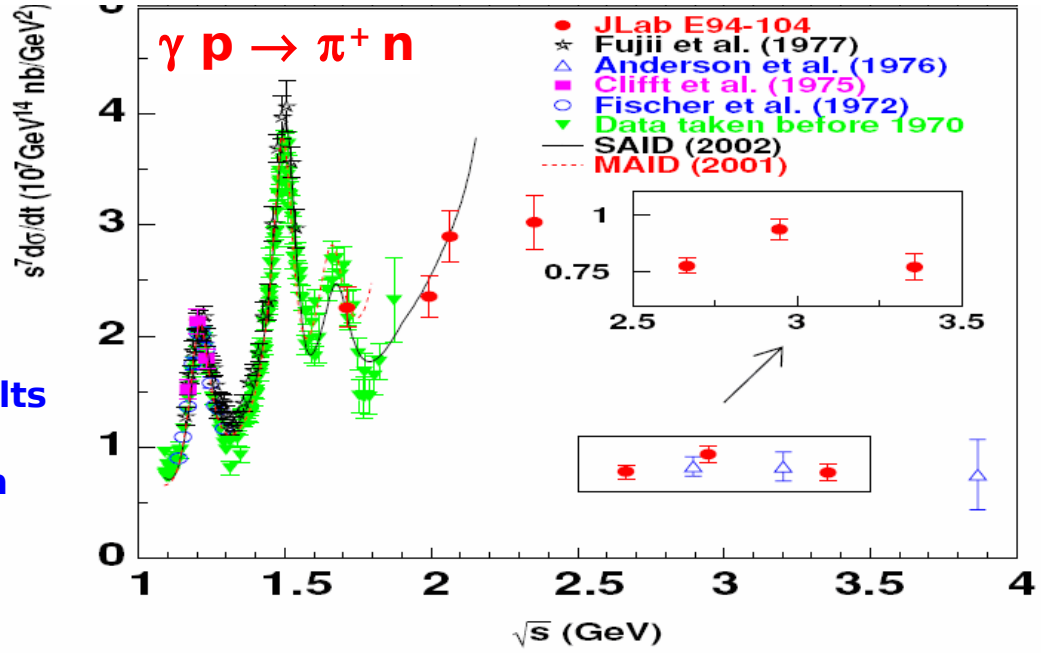
P.Rossi et al. Phys. Rev. Lett. 94 012301 (2005)



Single pion photoproduction



Should scale as s^{-7}



- Jlab – Hall A results
- Indication of a possible oscillation
- New analysis on g10 data (CAA)

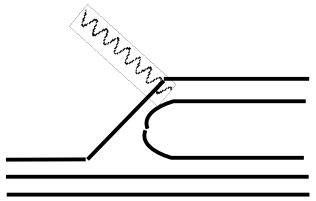
ω production at 9

Rho and Omega

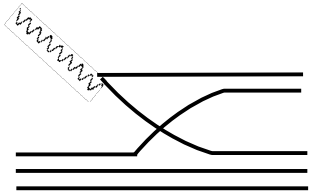
$d\sigma/dt(90^0)$ s-dependence

Quark exchange

Power law behavior according dimensional counting

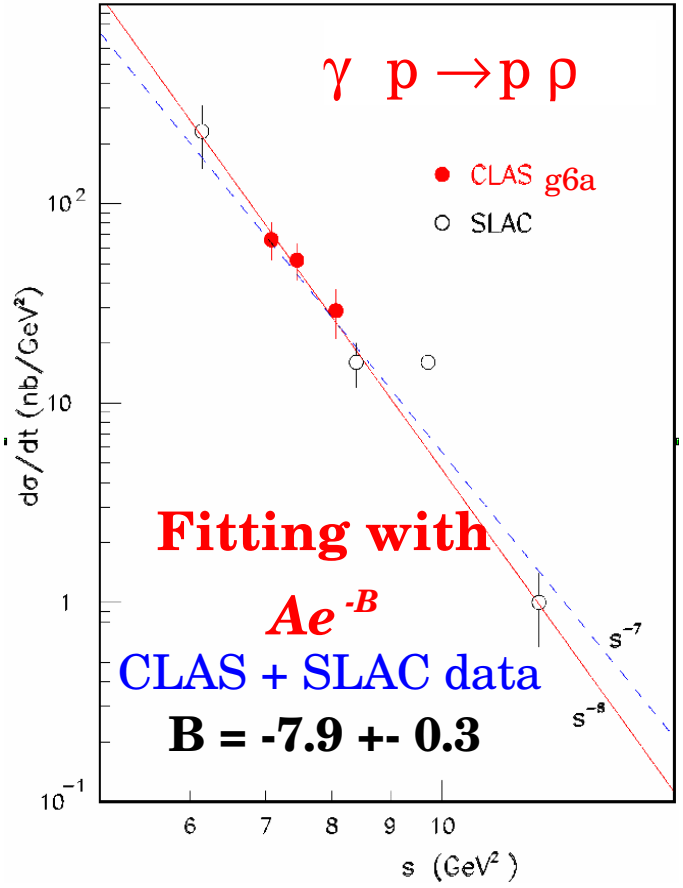


Should scale as s^{-7}



Should scale as s^{-8}

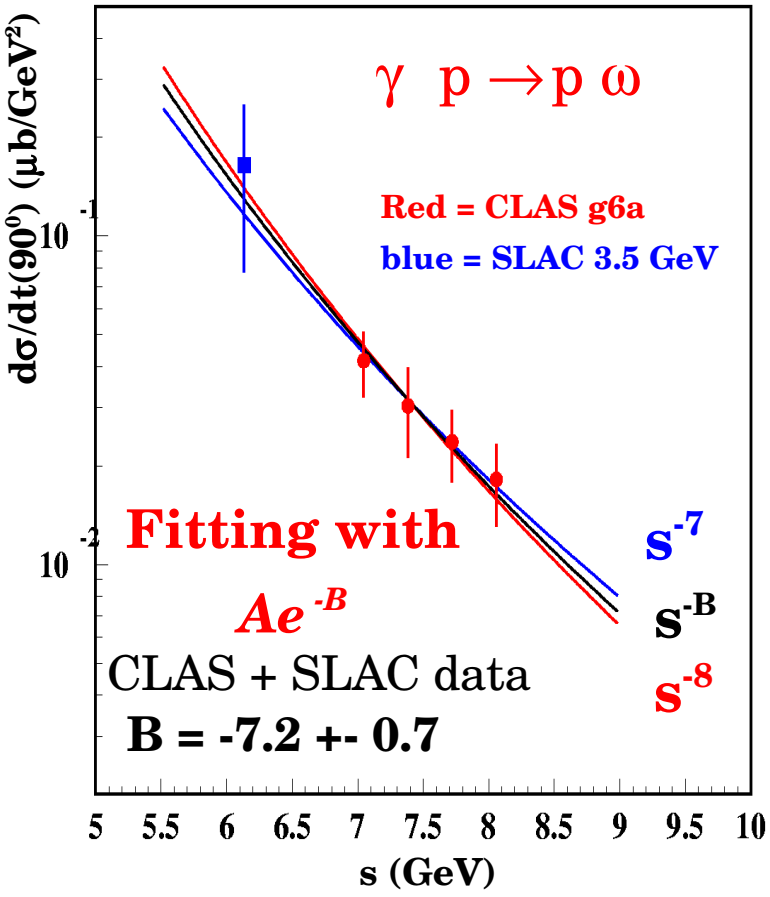
M.Battaglieri et al. Phys. Rev. Lett. 87 172002 (2001)



ρ photoprod:
CLAS data confirms the s^{-8} behavior

ω photoprod:
CLAS data show for the first time s^{-7} behavior

M.Battaglieri *et al. Phys. Rev. Lett. 90 022002 (2003)*

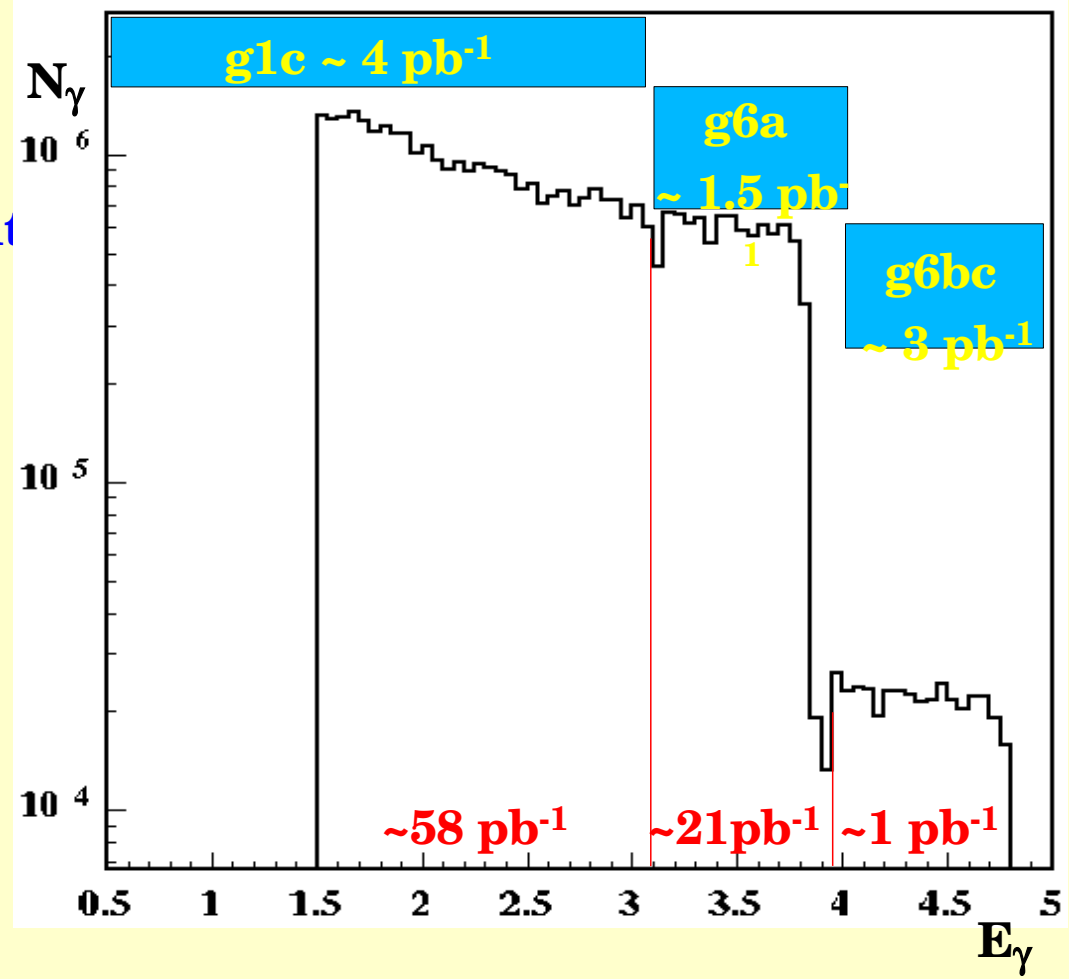


$d\sigma/dt(90^0)$ s-dependence Exclusive photoproduction g11

- E_0=4 GeV (5.8 GeV), 65 nA electron beam
- $X/X_0 = 8 \cdot 10^{-5}$ radiator
- Hall B photon tagger (0.2 – 0.95) x E_0
- 40 cm LH_2 target and new Start Count
- Inbending torus field (0.5 B_{max})
- Trigger: (Tagger) x (ST) x (TOF)

  → <u>2charged particles</u>
- ~7 10^9 triggers

  (400M with E_0= 5 GeV)
- 20 Tb of raw data
- <u>L (1.8 < E_γ < 3.8 GeV) ~ 80 pb^{-1}</u>



$\gamma p \rightarrow p\omega$ Cross sections Extraction

- **Analysis of the entire g11 data set**
- **Event selected in three different topologies**
  - $\rightarrow p \pi^+ (\pi^- \pi^0)$ **Topology 1**
  - $\rightarrow p \pi^+ \pi^- (\pi^0)$ **Topology 2**
  - $\rightarrow p \pi^- (\pi^+ \pi^0)$ **Topology 3**
- **Standard g11 package for kinematic corrections (eloss+tagger energy correction + momentum correction)**
- **Minimal set of fiducial cuts**
- **Efficiency correction evaluated through full MC simulation**
- **Physics event generator optimized based on extracted cross section**

(ω decay angular distribution based on analysis of g6 data)

$\gamma p \rightarrow p\omega$ Event Selection

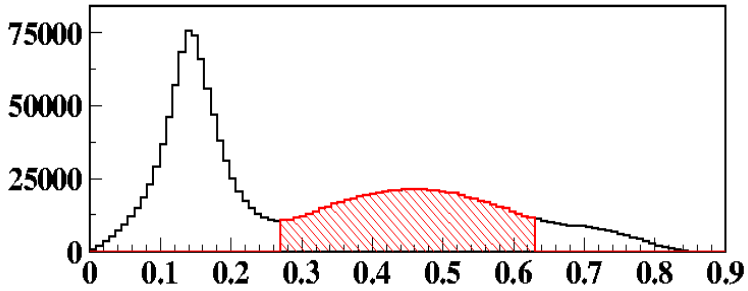
- Particle Identification based on SEB scheme
- Exclusive reaction selected via the missing mass technique
- ω yield extracted in each E,Th bin with a BW($\Gamma_\omega \sim 8.5$ MeV) convoluted with a gaussian (CLAS resolution ~ 7-30 MeV) + polynomial

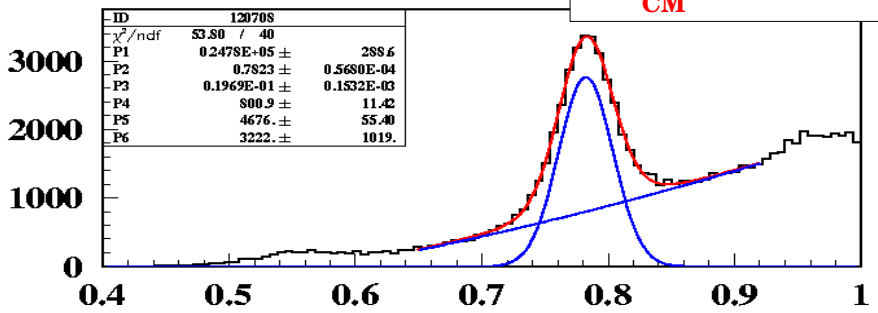
E_γ = 2.8-3.0 GeV

θ_{CM} = 86° - 94°

Topology 1:

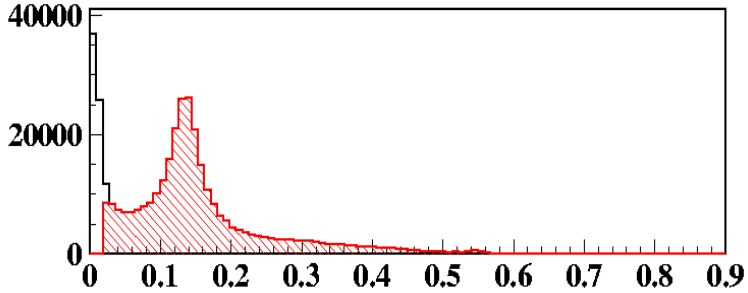
$p\,\pi^+\,(\pi^-\pi^0)$

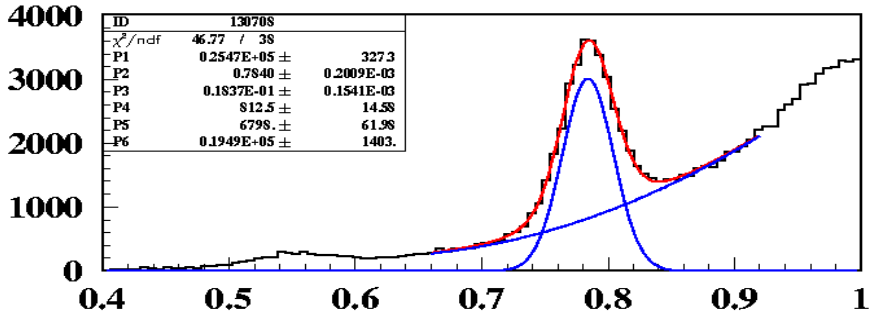




Topology 2:

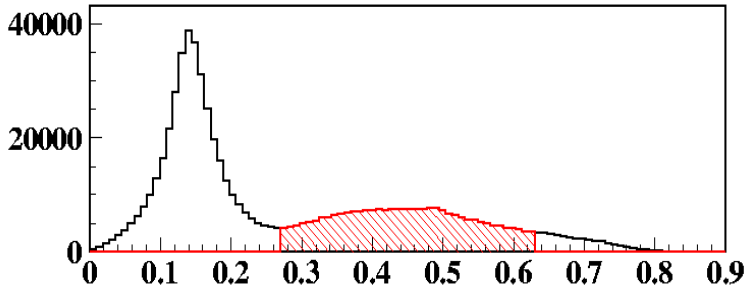
$p\,\pi^+\,\pi^-\,(\pi^0)$

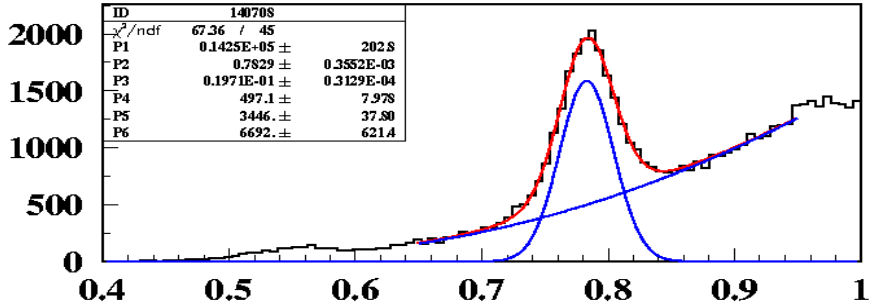




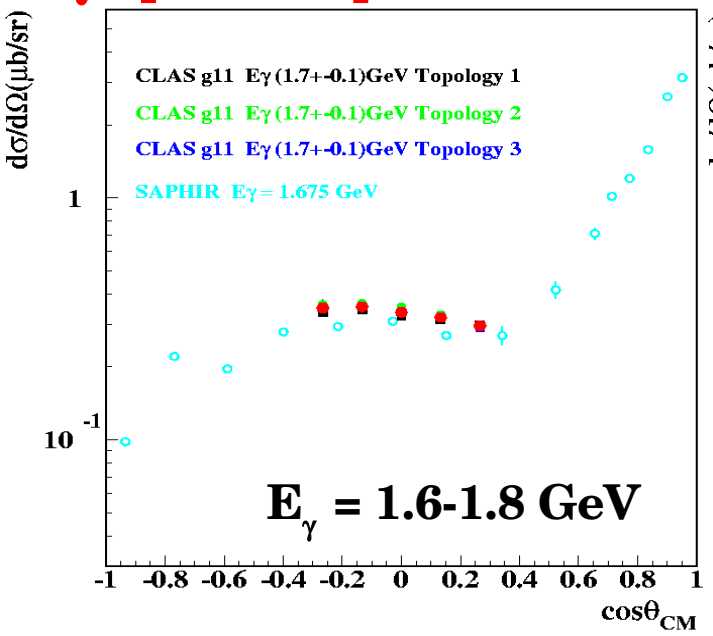
Topology 3:

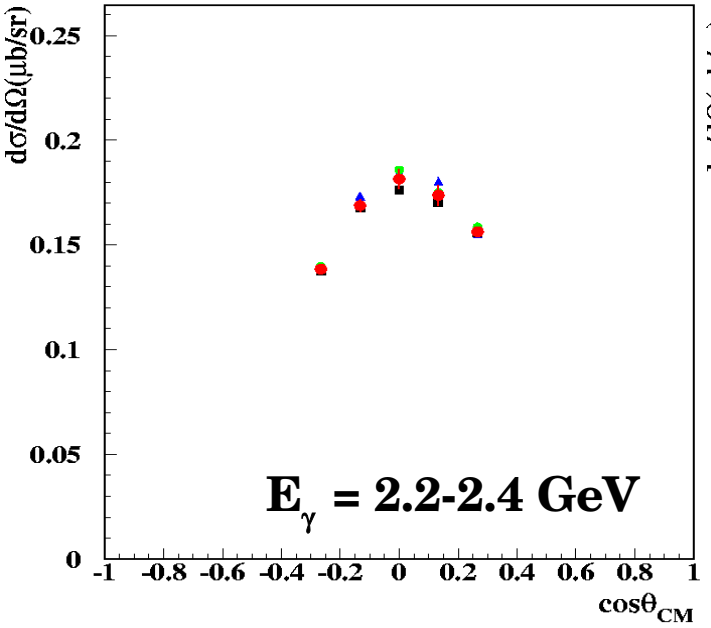
$p\,\pi^-\,(\pi^+\pi^0)$

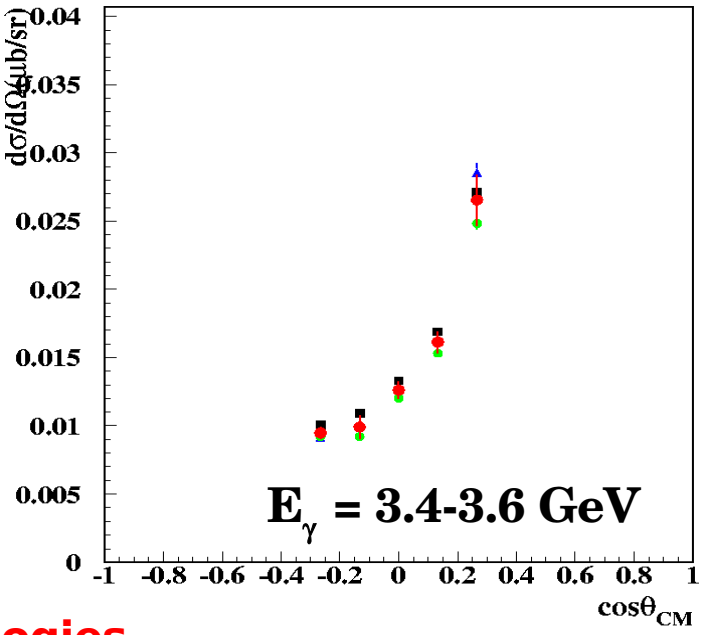




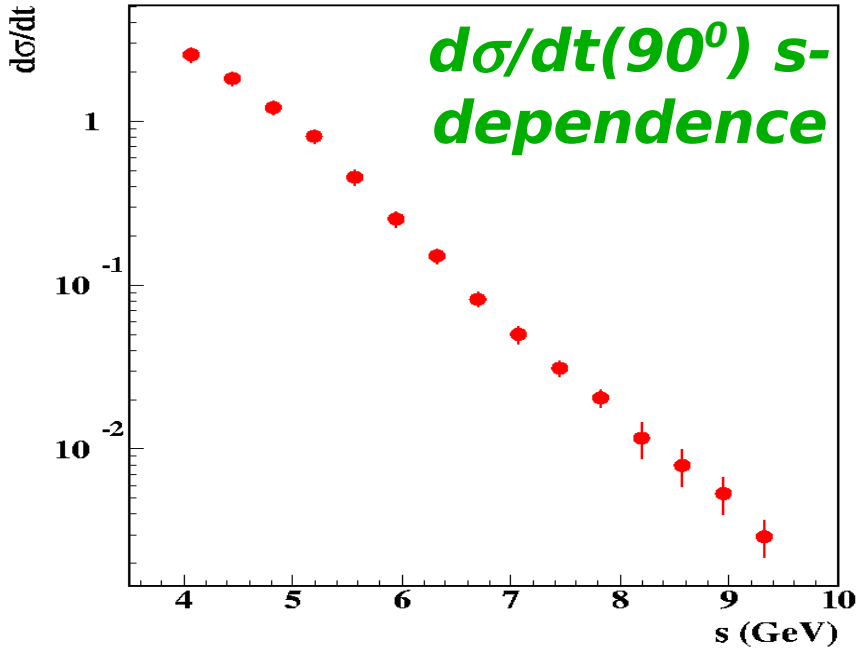
$\gamma p \rightarrow p\omega$ Differential Cross Section

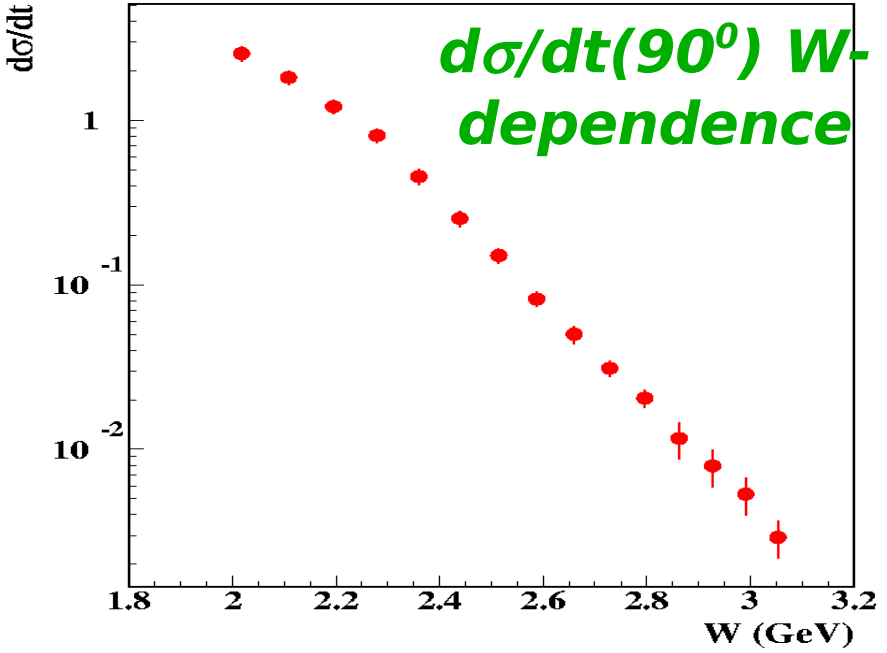




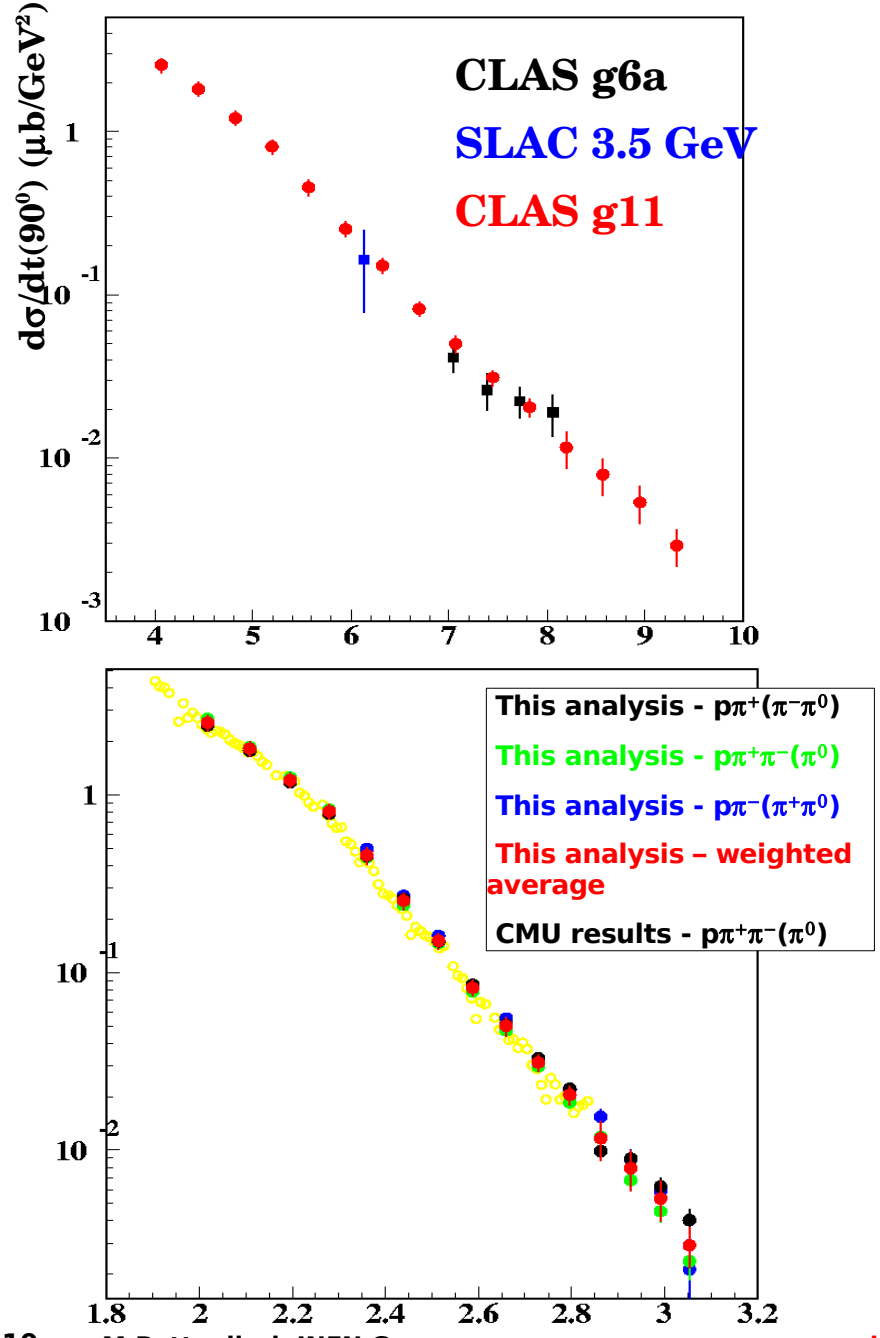


- **Final cross section as weighted average of the 3 topologies**
- **Error² = (Stat.)² + (Max topo diff)² + (10% syst)²**

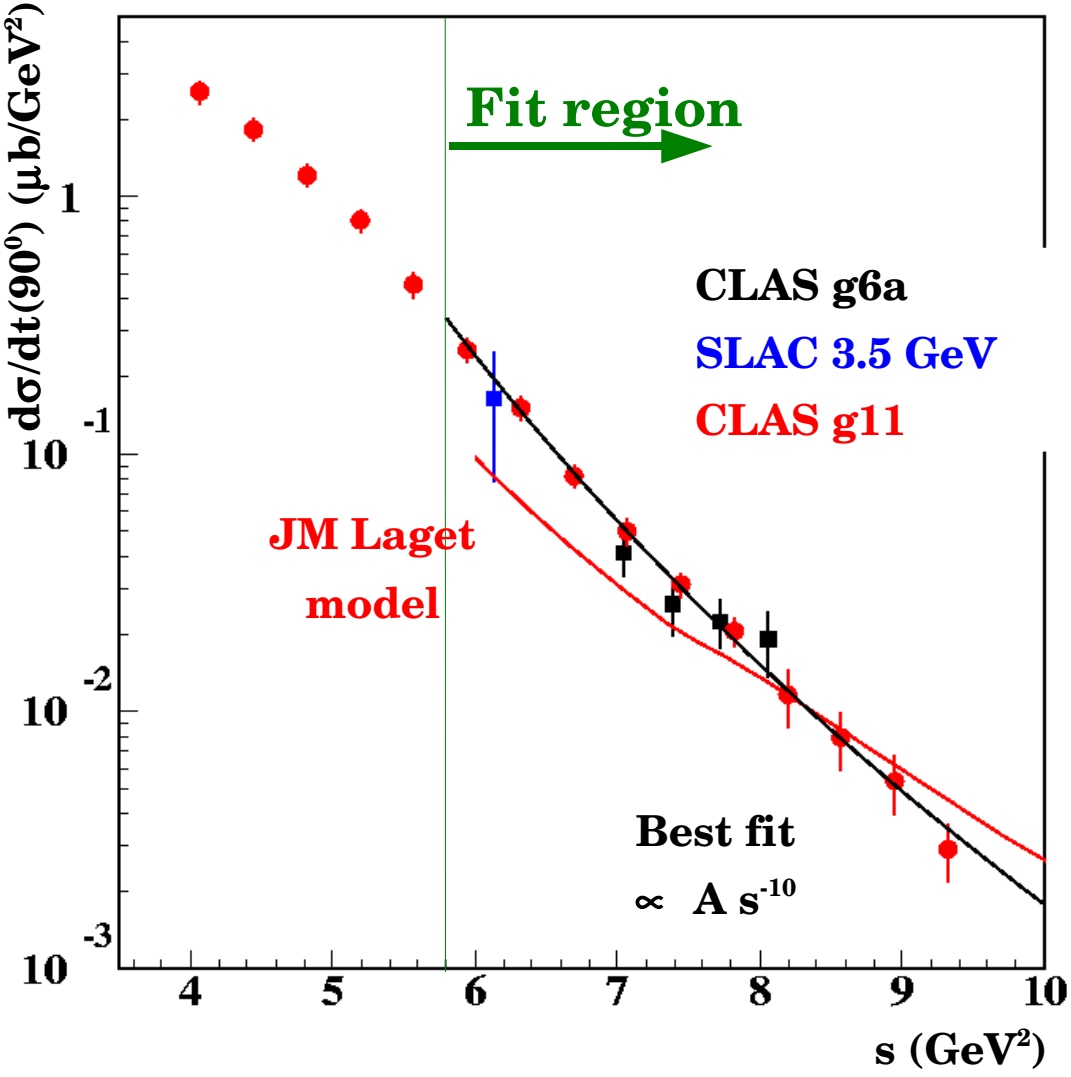




Comparison with existing data and other analyses



Best fit



Fitting with As^{-B} **B = -9.6 ± 0.3** $\chi^2 = 1.3$

$d\sigma/dt(90^0)$

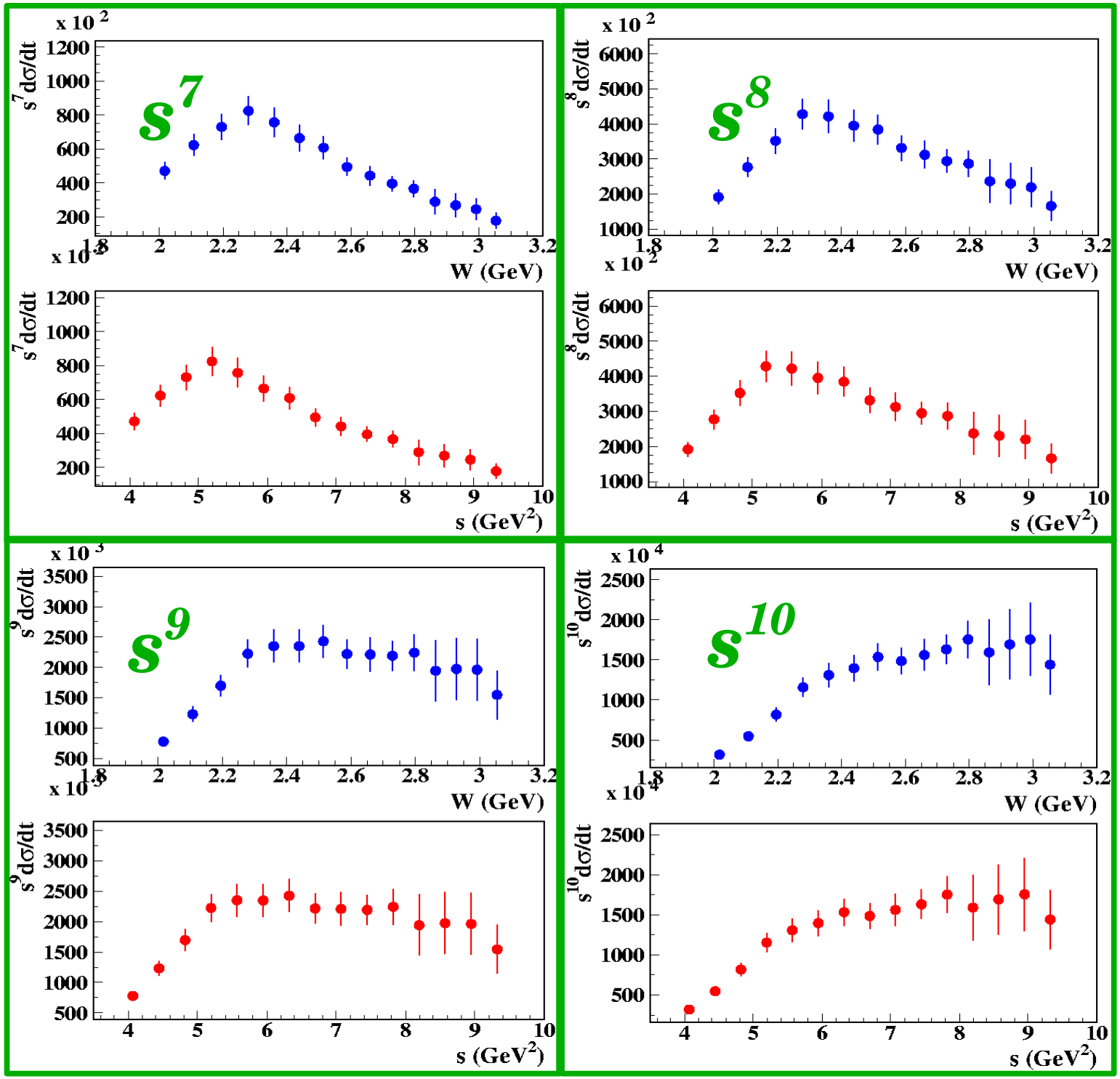
$\times\ s^{power}$

W-dependence

s-dependence

Higher power than naïve expectation

Is the theory able to reproduce this behavior?



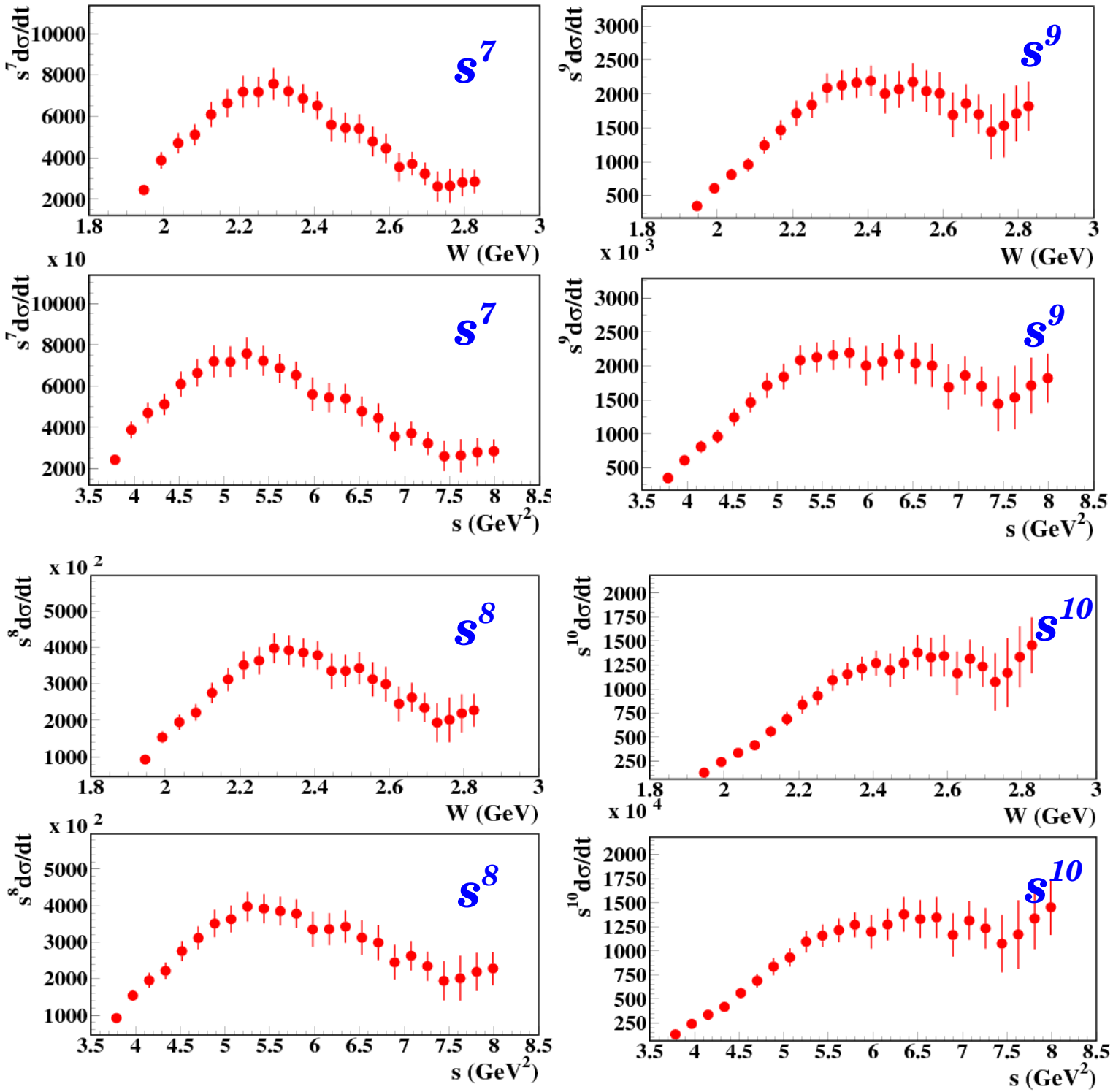
$\gamma p \rightarrow p\omega$

E_γ^{Max}=3.8 GeV

$d\sigma/dt(90^0) \times s^{power}$

Higher power or a hint of oscillation?

Is the theory able to reproduce this behavior?



Summary

- The ω differential cross section at 90° has been extracted from the g11 data set
- Consistent results obtained from different event topologies
- Good agreement with prev SLAC and CLAS (g6a,G11-CMU) data
- The s dependence of ds/dt(90°) is smooth and does not indicate significant oscillations
- Fit of ds/dt(90°) with s^{-C} gives C=9.6±0.3 larger than the naive prediction of s^{-7} for s^{-8} based on counting rules
- Analysis note written as integration of CMU Analysis Note (draft submitted to PRC)
- Ready to send the note to the HSWG for review