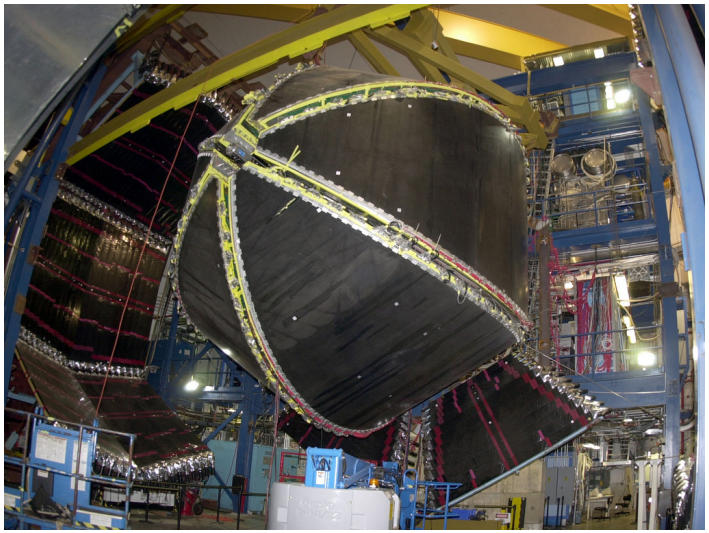


Vector meson production with CLAS

F.-X. Girod

JLab Hall-B

Dec. 17th13

Theory uncertainty in $\mathrm{Re}\Box^{V}_{\gamma Z}(E)$

Plots from M. Gorshteyn's talk

main caveat of the uncertainty estimate :
isospin decomposition of the high-energy background in total photo absorption cross section at low Q^2

assessed with the Vector Dominance Model.

$$\sigma_{\mathbf{tot}}(\gamma p) = \sum_{V=\rho,\omega,\phi} \sqrt{16\pi \frac{4\pi\alpha}{f_V^2} \frac{d\sigma^{\gamma p \to V p}}{dt}(t=0)}$$

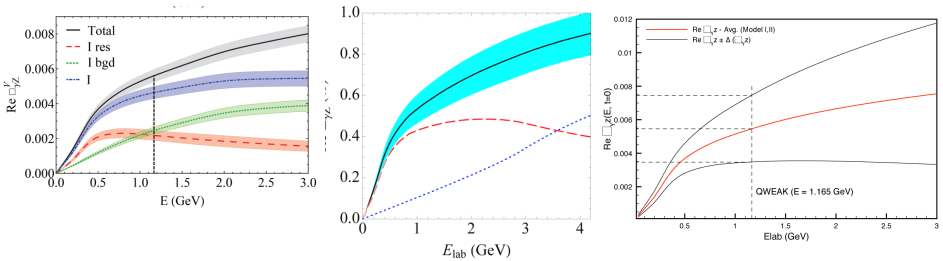
21% deficit of the VMD sum rule in HERA data ($E_\gamma \approx 80$ GeV)

Question :
Is this deficit still present at JLab energies ?
$\rightarrow$ CLAS vector meson production data

Hall *et al.*
PRD 88, 013011 (2013)

Carlson and Rislow
PRD 83, 113007 (2011)

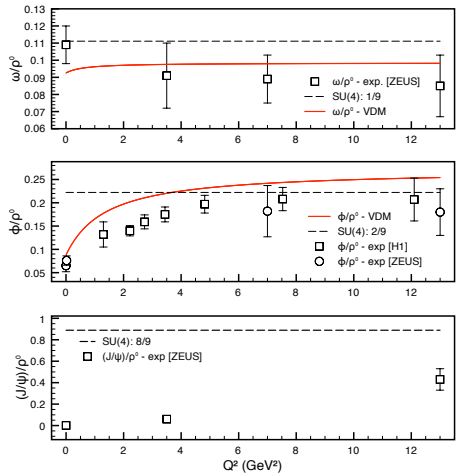
Gorchtein *et al.*
PRC 84, 015502 (2011)



$$\mathrm{Re}\Box^{V}_{\gamma Z}(E = 1.165\ \mathrm{GeV})$$

$(5.6 \pm 0.36) \times 10^{-3}$ $(5.7 \pm 0.9) \times 10^{-3}$ $(5.4 \pm 2.0) \times 10^{-3}$

Exp. data: W = 40-120 GeV



Existing data from CLAS

Both photo- and electro-production data
Electroproduction uses Hand convention for the virtual photon flux to connect $Q^2 \to 0$

$\sigma_{\gamma^* p \to pV}(Q^2, x_B, E) = \frac{1}{\Gamma(Q^2, x_B, E)} \frac{d^2\sigma_{ep \to epV}}{dQ^2 dx_B}$ with $\Gamma(Q^2, x_B, E) = \frac{\alpha}{8\pi} \frac{Q^2}{M^2 E^2} \frac{1-x_B}{x_B^3} \frac{1}{1-\epsilon}$

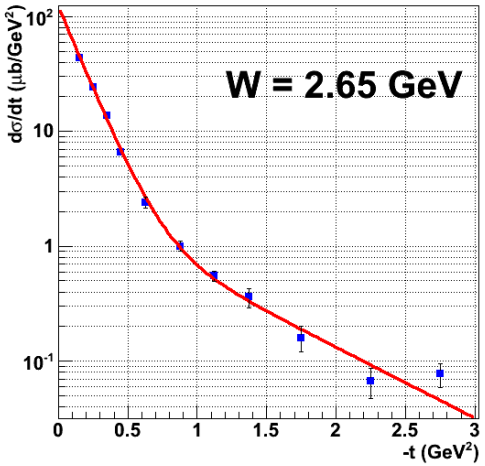
The following datasets are used in this presentation :

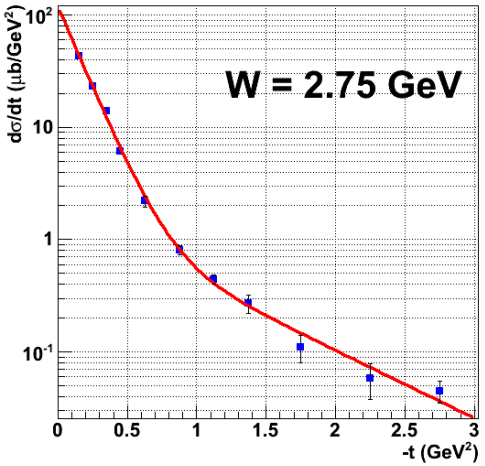
- *Photoproduction of ρ^0 meson on the proton at large momentum transfer*
  M. Battaglieri *et al.*, PRL 87, (2001) 172002
- *Exclusive ρ^0 electroproduction on the proton at CLAS*
  S.A. Morrow *et al.*, EPJ A 39, (2009) 5
- *Photoproduction of the ω meson on the proton at large momentum transfer*
  M. Battaglieri *et al.*, PRL 90, (2003) 022002
- *Deeply virtual and exclusive electroproduction of ω mesons*
  L. Morand *et al.*, EPJA 24, (2005) 445
- *Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\phi$*
  B. Dey *et al.*, under collaboration review

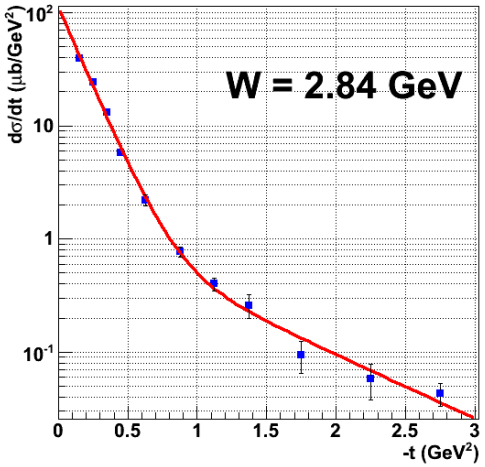
CLAS database at the web address : http://clasweb.jlab.org/physicsdb/

Photoproduction of ρ^0 meson on the proton at large momentum transfer

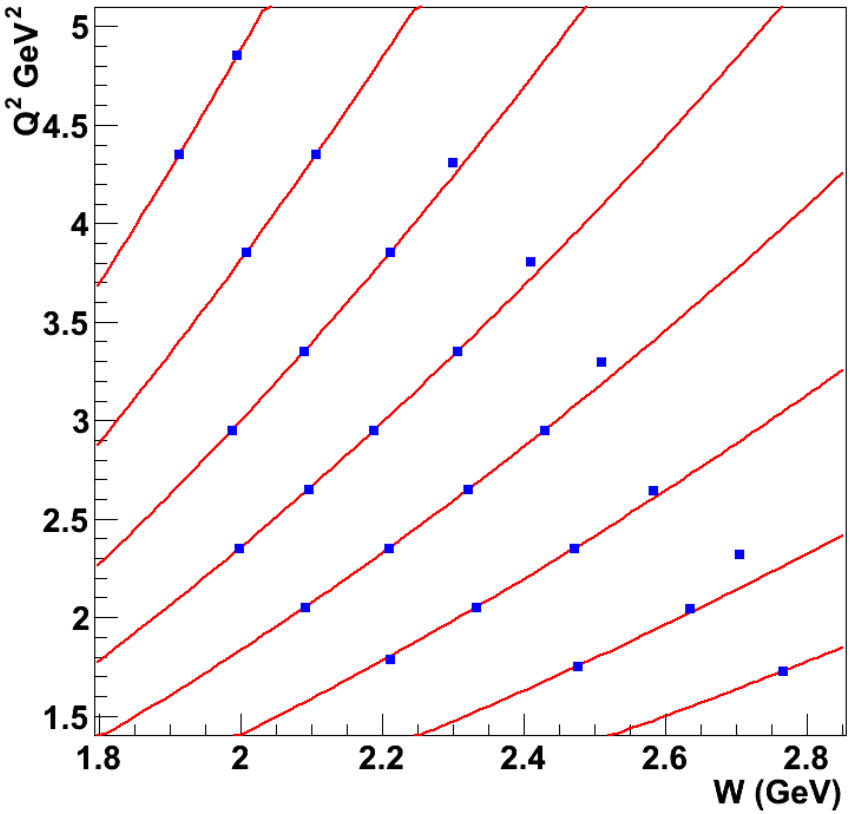
$E_{\text{electron}} = 4.1$ GeV
$E_\gamma = 3.19$ to 3.91 GeV
$\approx 4 \times 10^6 \gamma/\text{s}$
All topologies analyzed
$p\pi^+$, $p\pi^-$, $\pi^+\pi^-$, and $p\pi^+\pi^-$

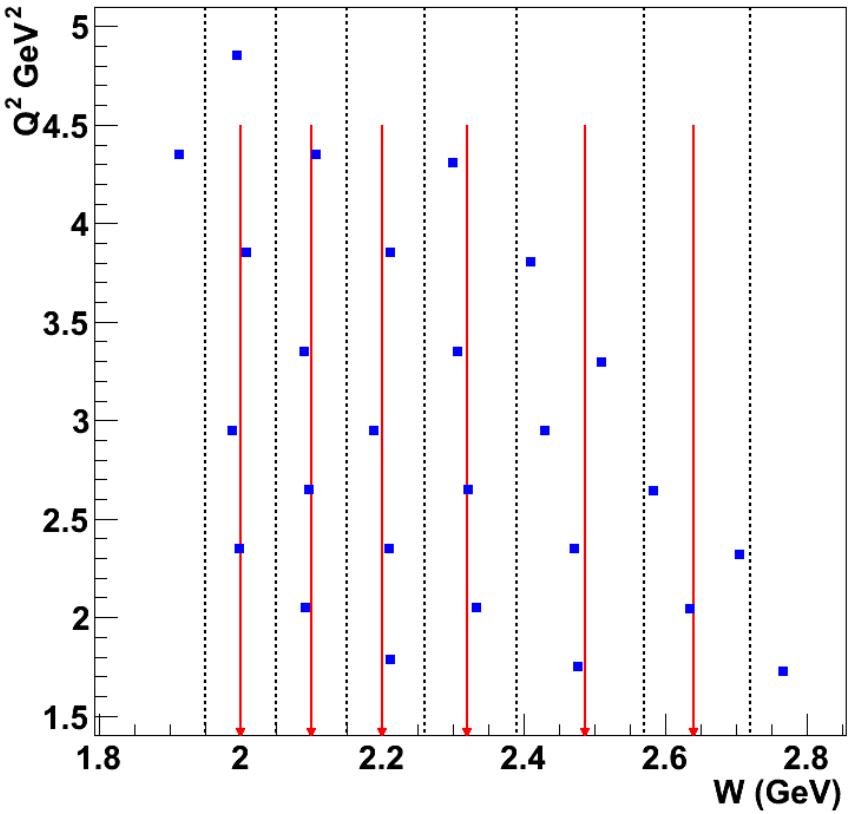




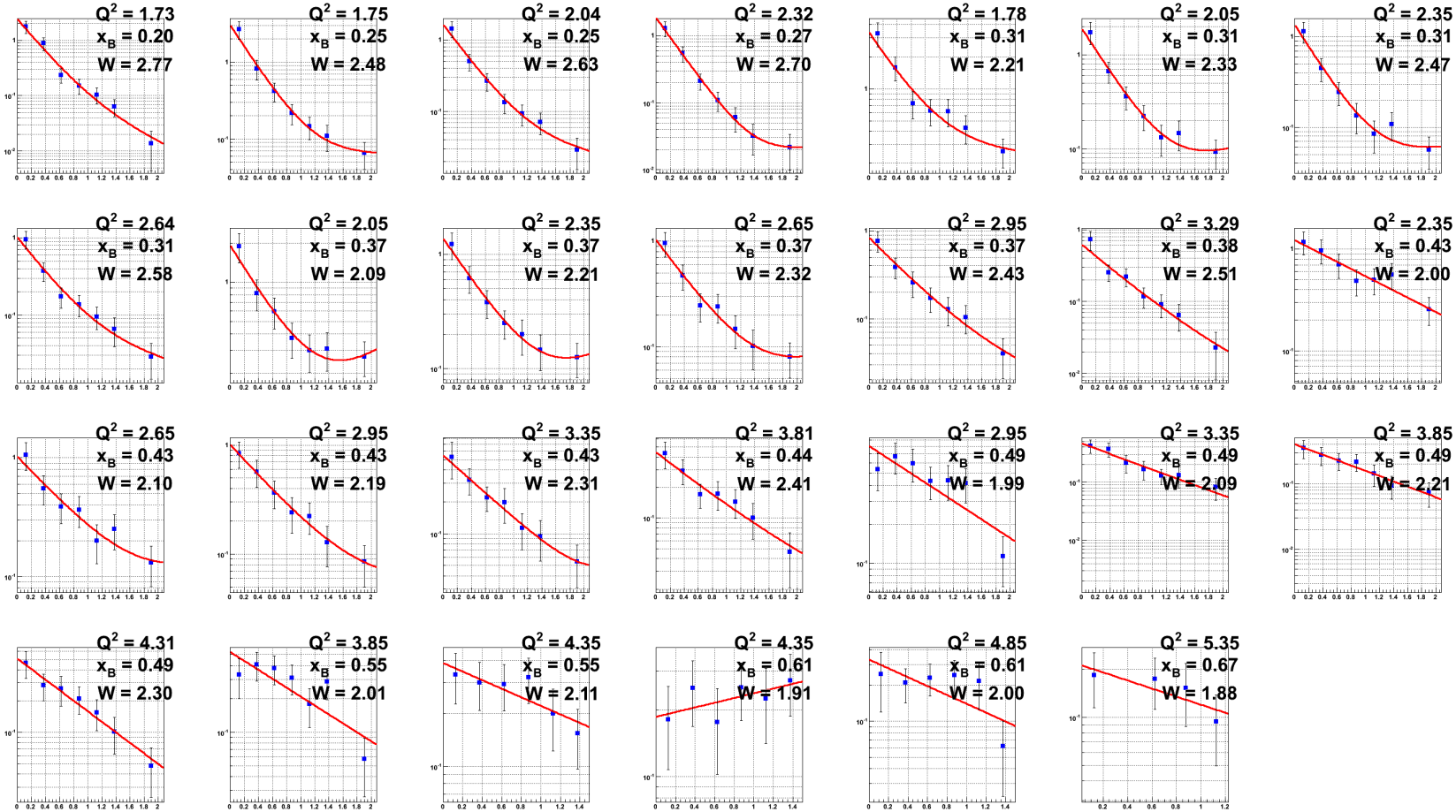


Data binning in (x_B, Q^2), approximate binning in (W, Q^2)

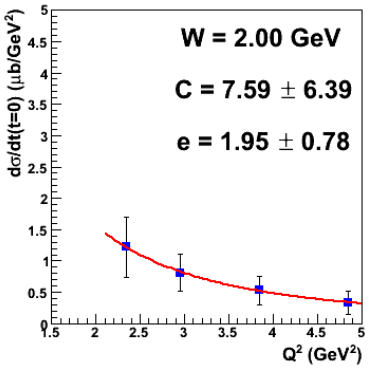


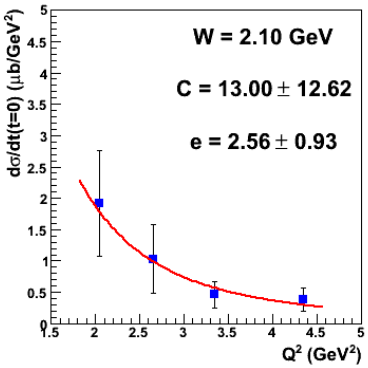


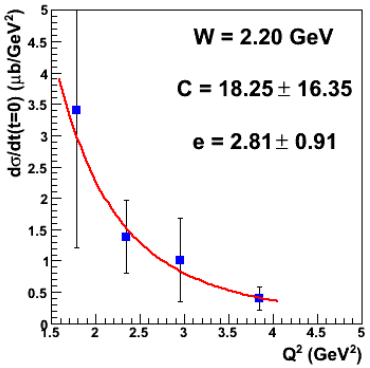
Fit to $d\sigma/dt$ (μb/GeV^2) versus $-t$ with two exponential components

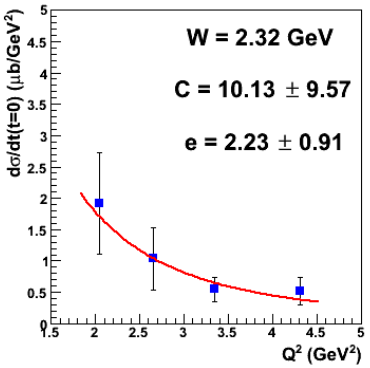


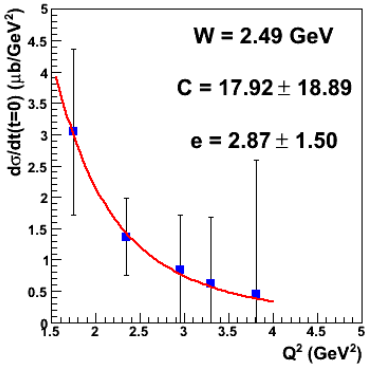
Q^2 dependence of $d\sigma/dt(t=0)$ and fixed W

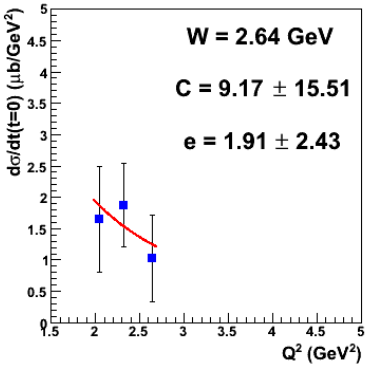












as an example,

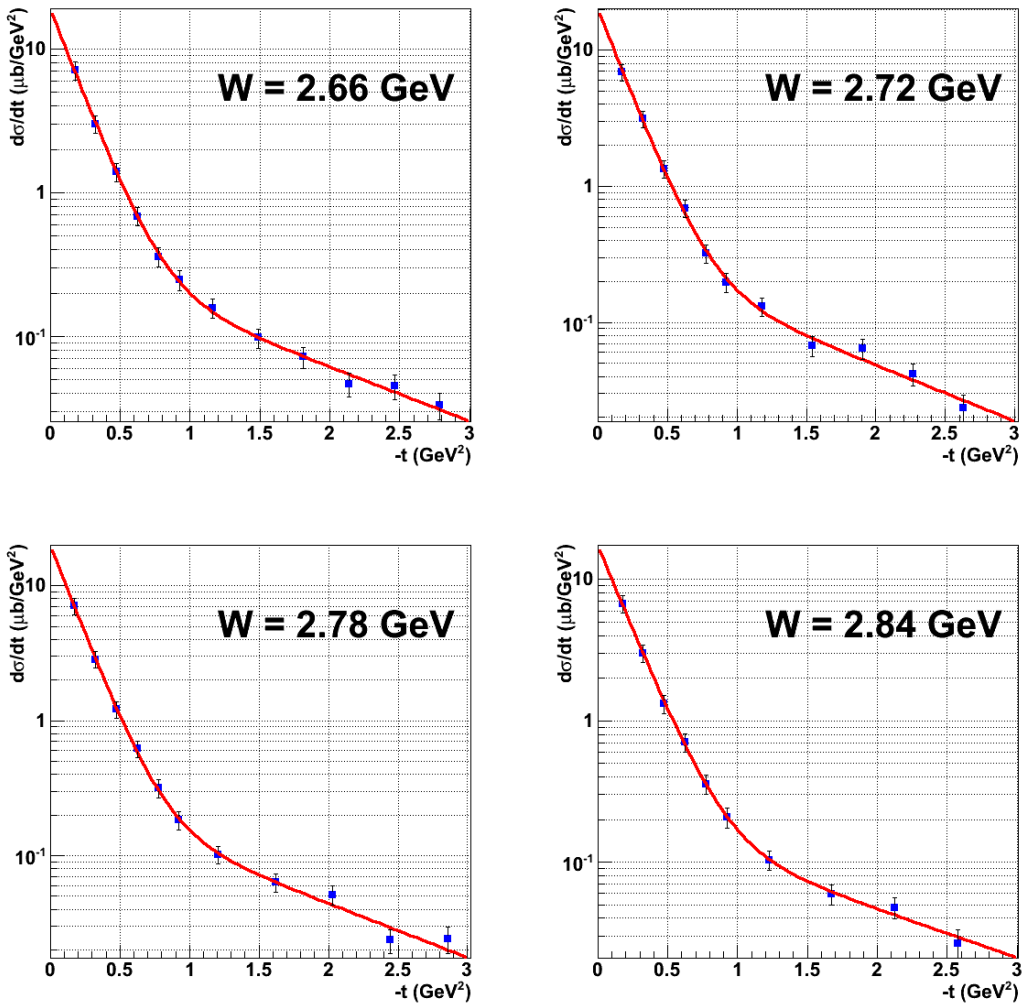
cross-sections fitted with :

$$\frac{C}{1+Q^{2e}}$$

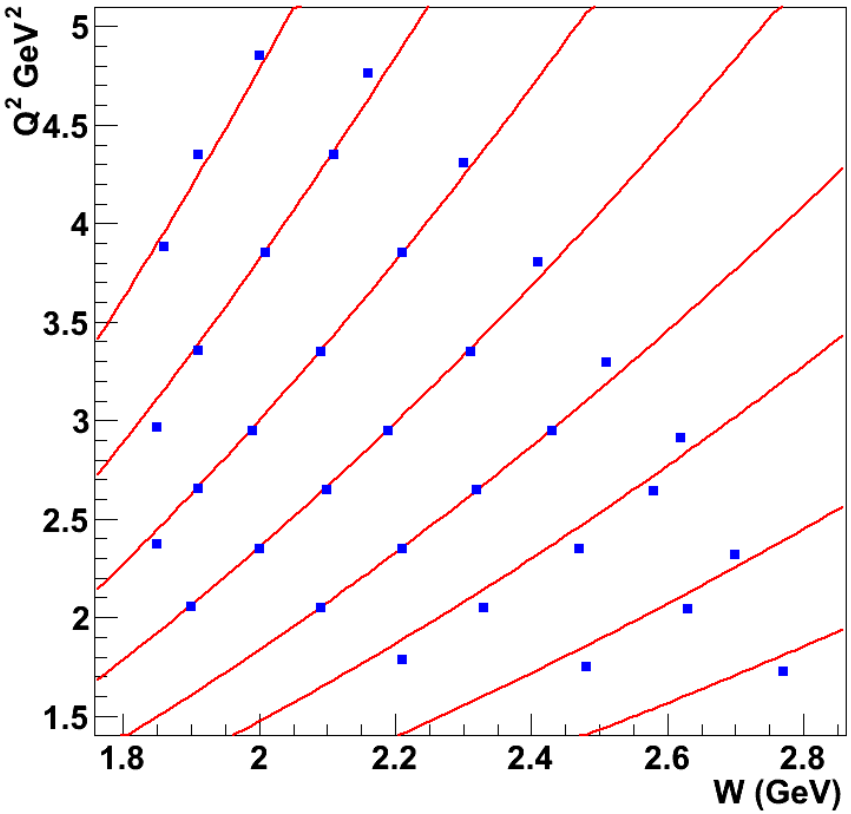
$\rightarrow$ need theoretical guidance for functional shape extrapolation to $Q^2 = 0$

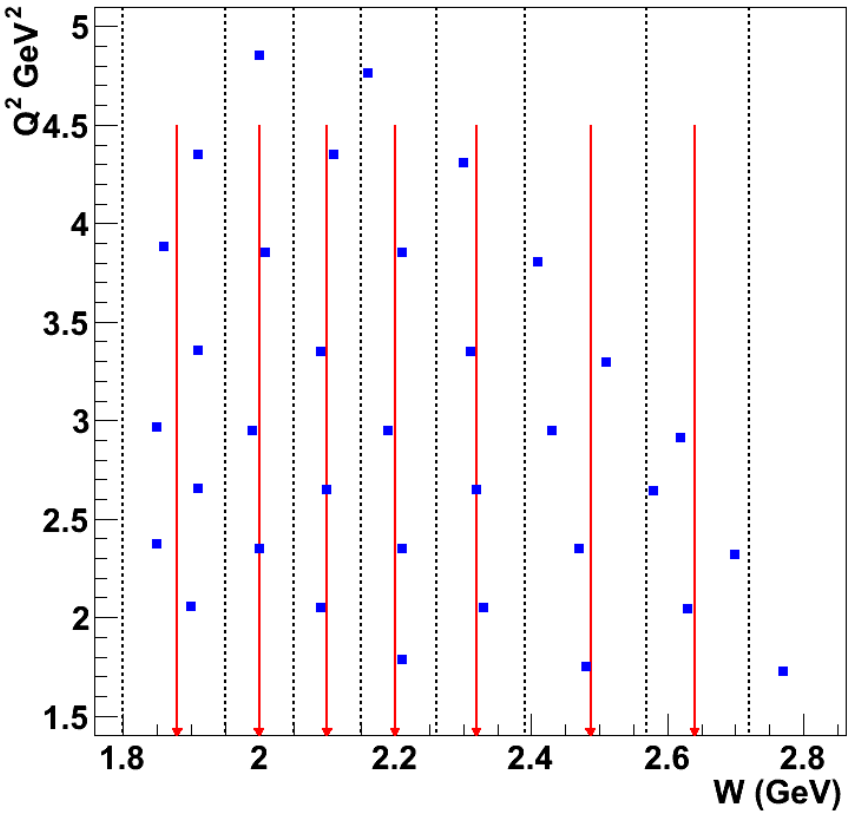
Photoproduction of the ω meson on the proton at large momentum transfer

Same dataset as ρ^0 photoproduction
$\omega \to \pi^+\pi^-\pi^0$ mode
detection of proton and π^+
identification from missing masses
$\gamma p \to p\pi^+ X$ and $\gamma p \to pX$

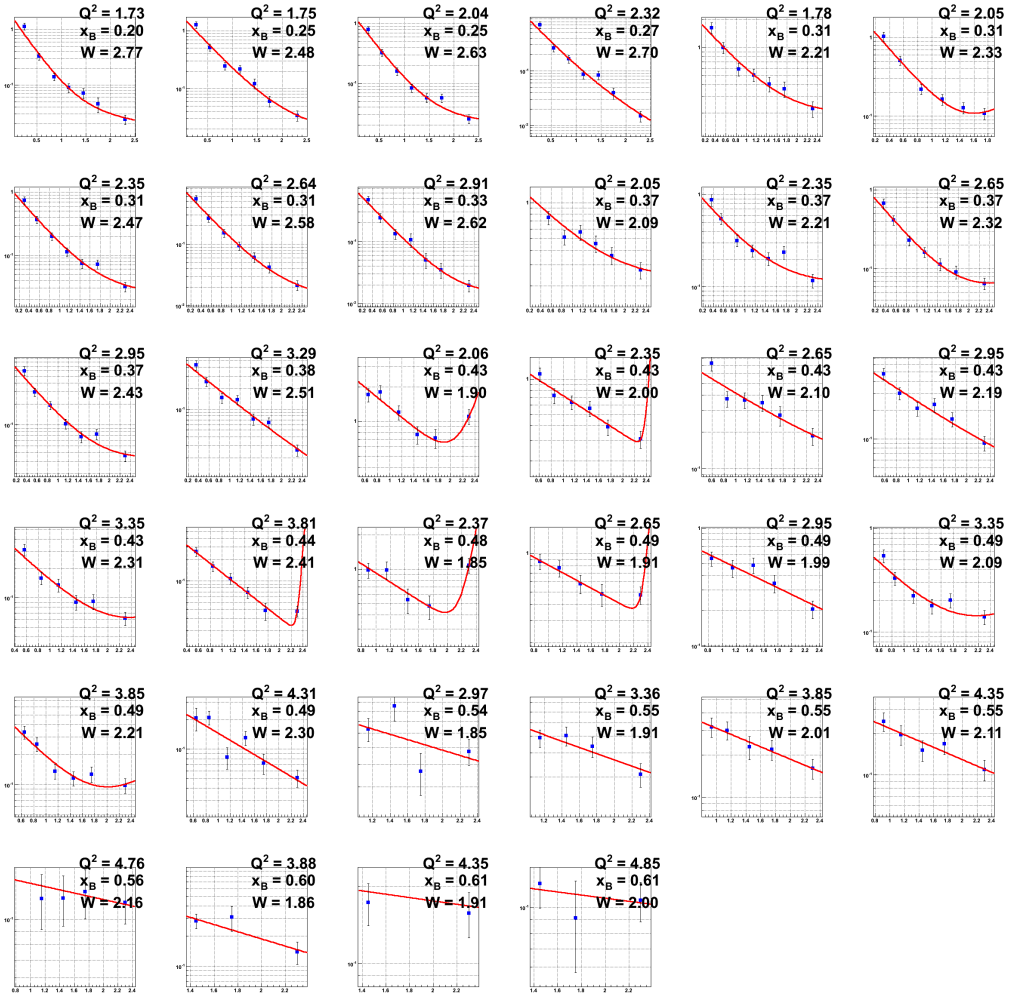


Data binning in (x_B, Q^2), approximate binning in (W, Q^2)





Fit to $d\sigma/dt$ with two exponential components



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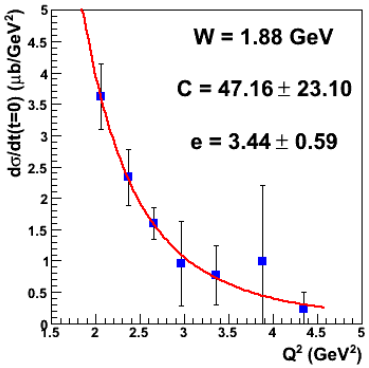
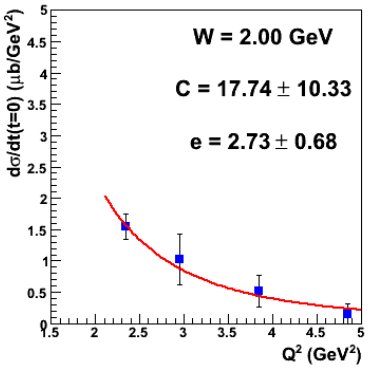
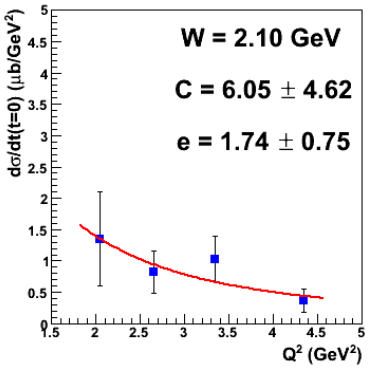
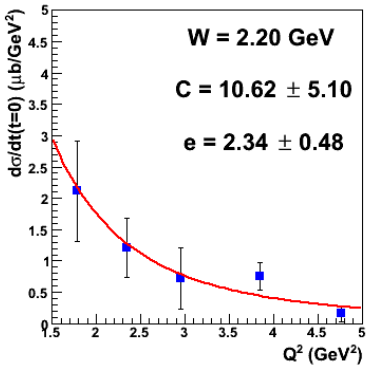
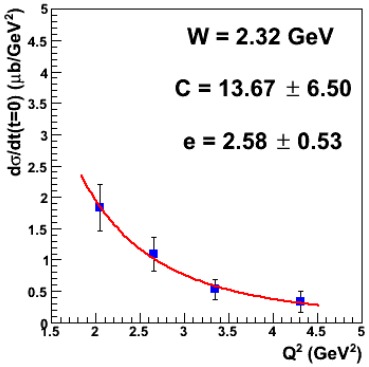
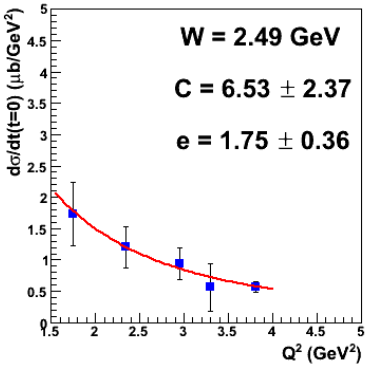


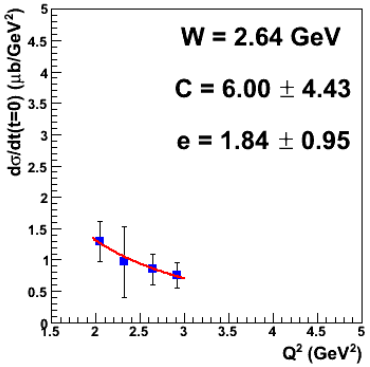












as an example,

cross-sections fitted with :

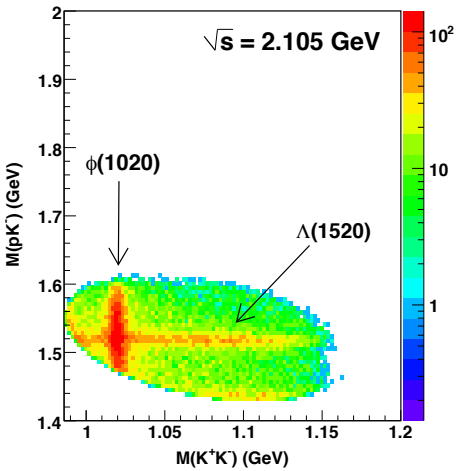
$$\frac{C}{1+Q^{2e}}$$

$\rightarrow$ need theoretical guidance for functional shape extrapolation to $Q^2 = 0$

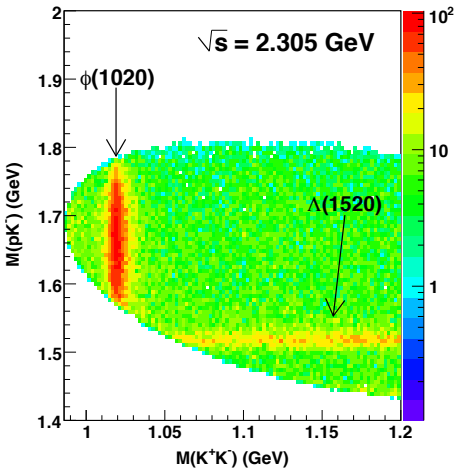
Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\phi$

- High statistics measurement of the differential cross-sections $\gamma p \to \phi p$, $\phi \to K^+(K^-)$
- missing K^- identified by kinematical fit
- $1.97 < W < 2.84$ GeV, complete $\theta^{\phi}_{\text{c.m.}}$ coverage
- Illustration of overlap with background from the $\Lambda(1520)$
- Biplab Dey User Group annual JSA Thesis Prize award

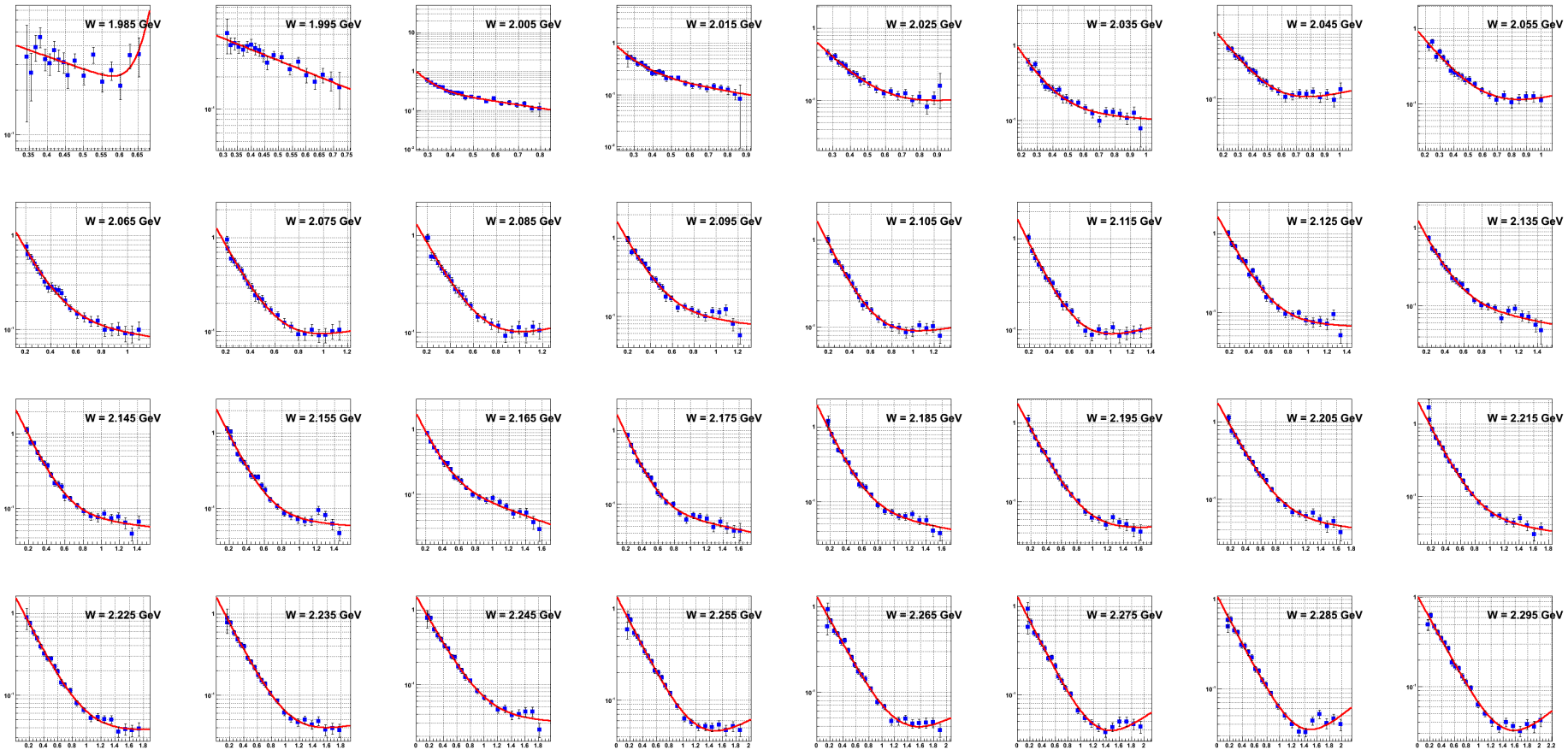
The following slides show fits to $\mathrm{d}\sigma/\mathrm{d}t$ with two exponential components



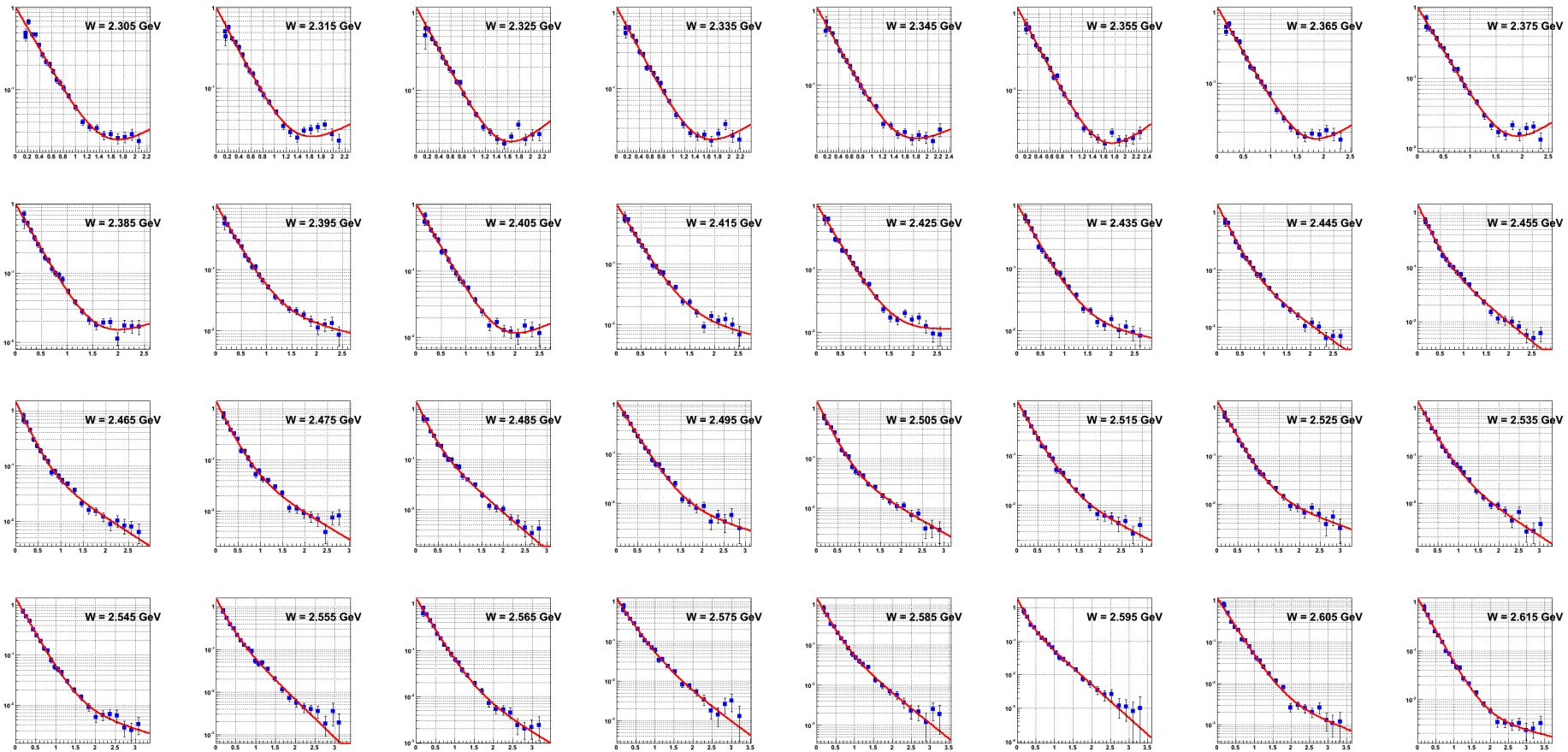
(a)



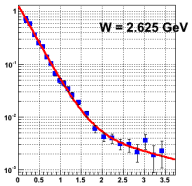
Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\phi$

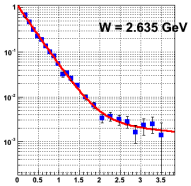


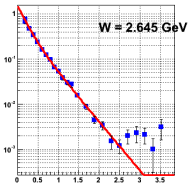
Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\phi$

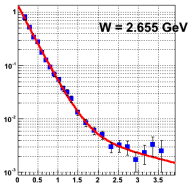


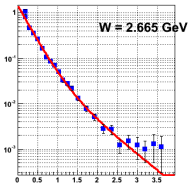
Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\phi$

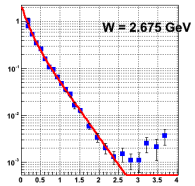


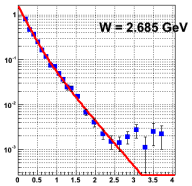


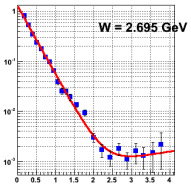


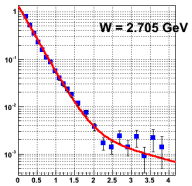


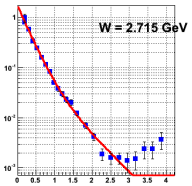


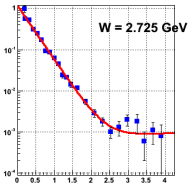


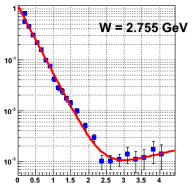


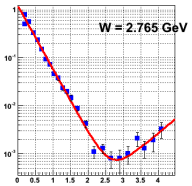


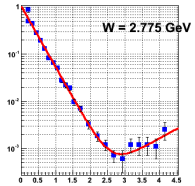


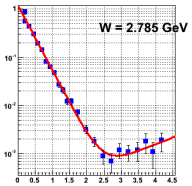


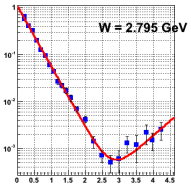


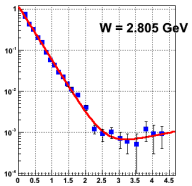


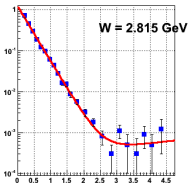


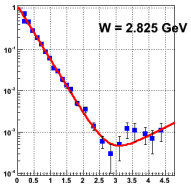


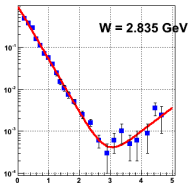




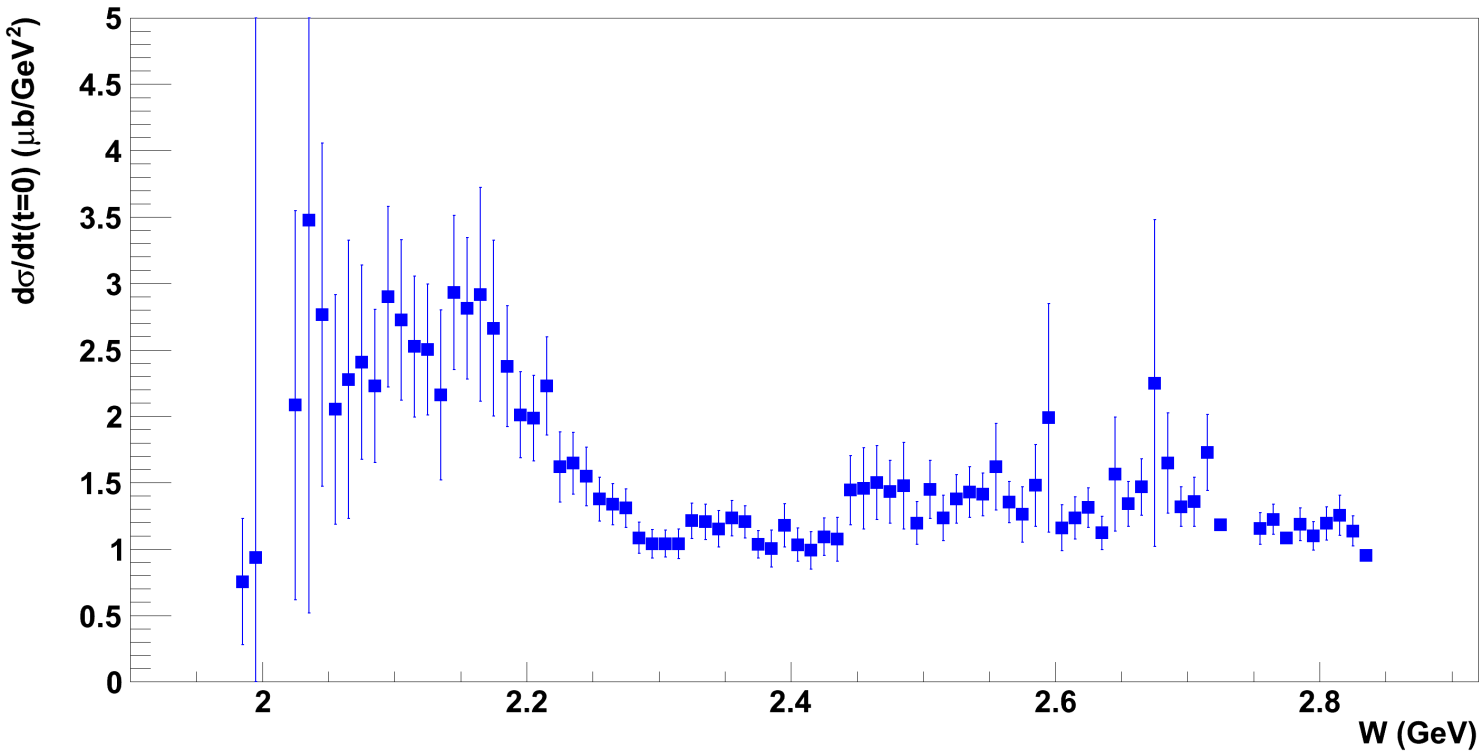








Result for the fitted values of $d\sigma/dt(t=0)$ (μb/GeV^2) as a function of W



The dependence shows some resonant-like structures

Summary

- Vector Meson Production can help reduce the $\mathrm{Re}\Box^{V}_{\gamma Z}(E)$ theoretical uncertainty
- Electro- and Photo- production data from CLAS available in public database
- Precise results from photoproduction of ρ and ω in limited phase space
- Larger coverage for electroproduction of ρ and ω,
  extrapolation to $Q^2 = 0$ requires guidance
- Very extensive coverage for ϕ photoproduction will soon be available
- Differential cross sections and spin density matrix elements for the reaction $\gamma p \to p\omega$
  M. Williams *et al.* PRC 80, (2009) 065208
  has much larger W coverage and will be included next
- Dedicated re-analysis for ρ^0 and for low Q^2 and W ?
- Test of the VMD sum rule with CLAS data