# Elastic Photoproduction of $J/\psi$ Mesons at low $|t|$

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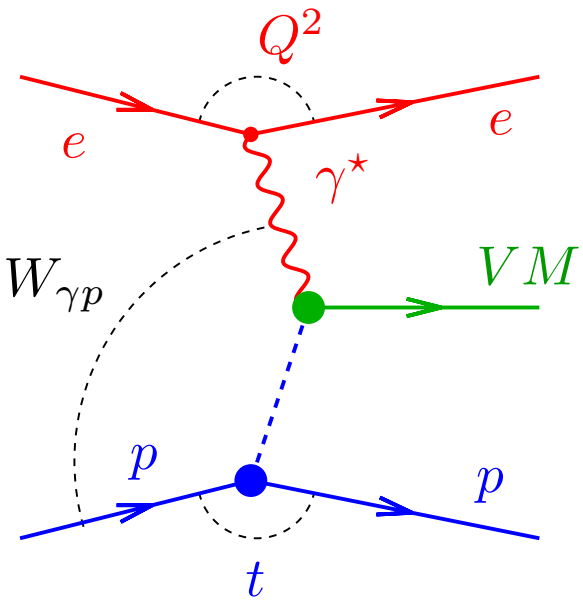
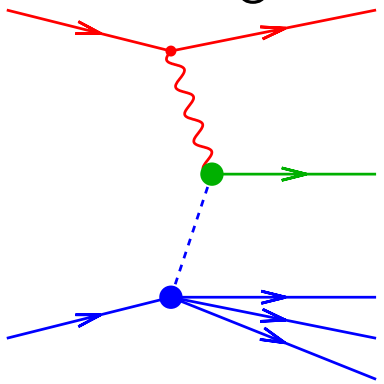
# Elastic Vector Meson Production at HERA

$$ep \longrightarrow e\,\mathrm{VM}\,p$$

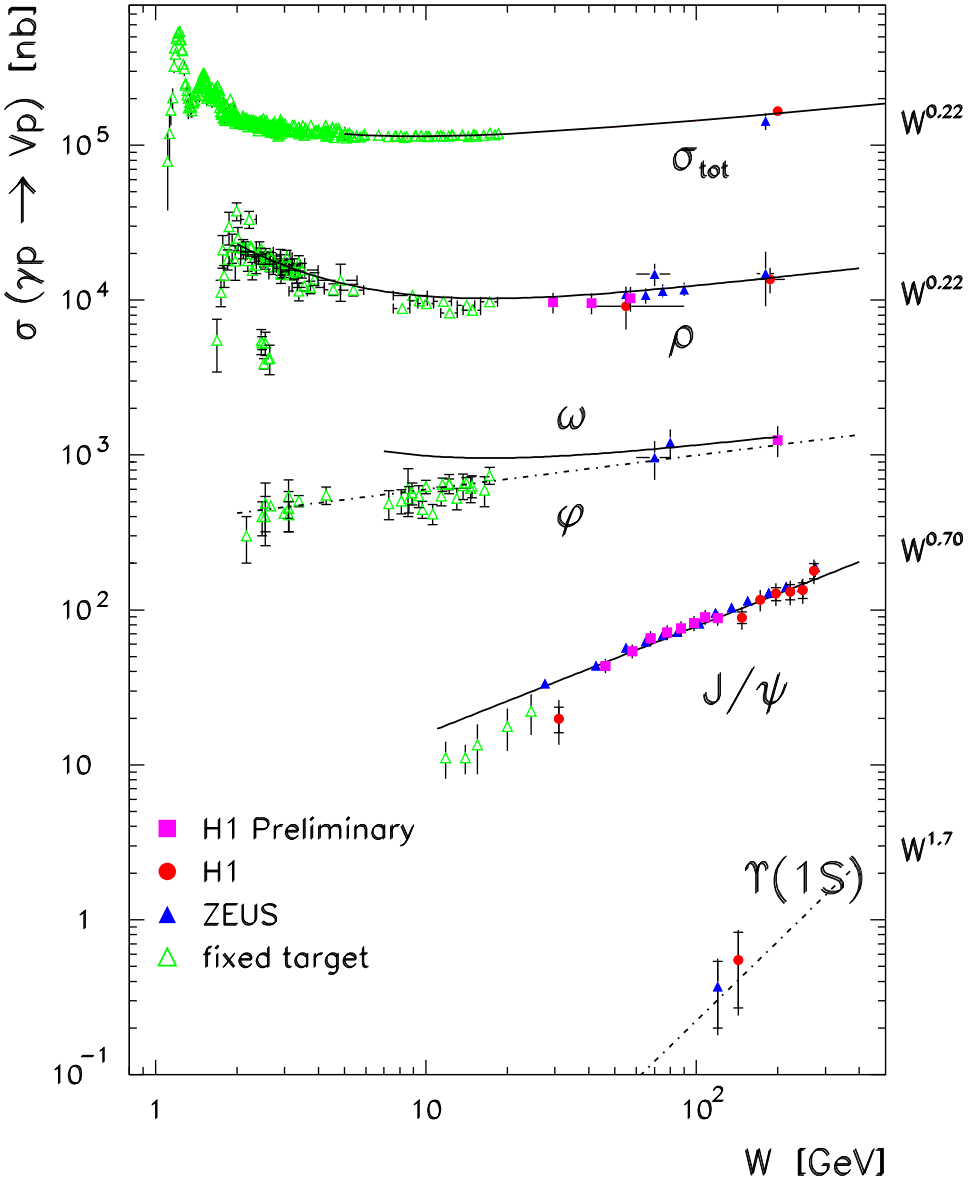



main background:



| | | |
|---|---|---|
| $Q^2$ | $\gamma^*$ virtuality | $0 < Q^2 < 100$ GeV$^2$ |
| $W_{\gamma p}$ | energy of $\gamma^*$p system | $20 < W_{\gamma p} < 290\,\mathrm{GeV}$ |
| $t$ | (4 mom. transfer)$^2$ at p vertex | $0 < \lvert t\rvert < 30\,\mathrm{GeV}^2$ |
| VM | vector meson | $\rho^0,\ \omega,\ \phi,\ J/\psi,\ \Upsilon$ |

# Elastic Photoproduction of Vector Mesons




$Q^2 \approx 0$, $|t| \approx 0$

$\sigma \sim W^{\delta}$ **yields:**

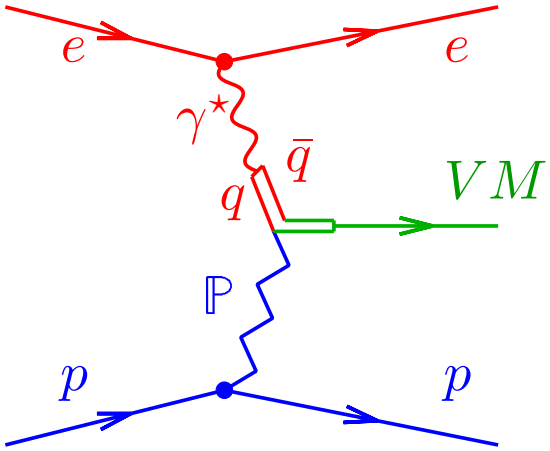
light VM: $\delta \approx 0.22$ (weak W dep.)

heavy VM: $\delta \gtrsim 0.7$ (strong W dep.)

$\Rightarrow$ **steeper rise for heavy VM**

# Diffractive Vector Meson Production

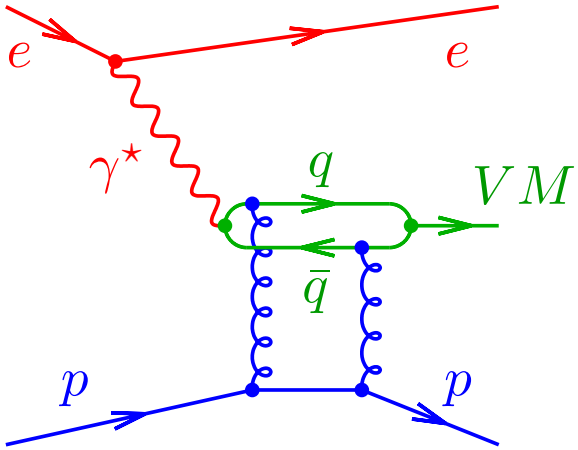
## Soft Pomeron Model:




- exchange of a colourless object
  $\alpha_{\mathbb{P}}(t) = \alpha_0 + \alpha' \cdot t$
- $\sigma \propto W^{4(\alpha_{\mathbb{P}}(t)-1)} \approx W^{0.22}$
- $\frac{d\sigma}{dt} \propto e^{bt}$
  $b(W) = b_0 + 4\alpha' \cdot \ln(\frac{W}{W_0})$

⇒ works for light VM
at $\boldsymbol{Q^2 \approx 0,\ t \approx 0}$

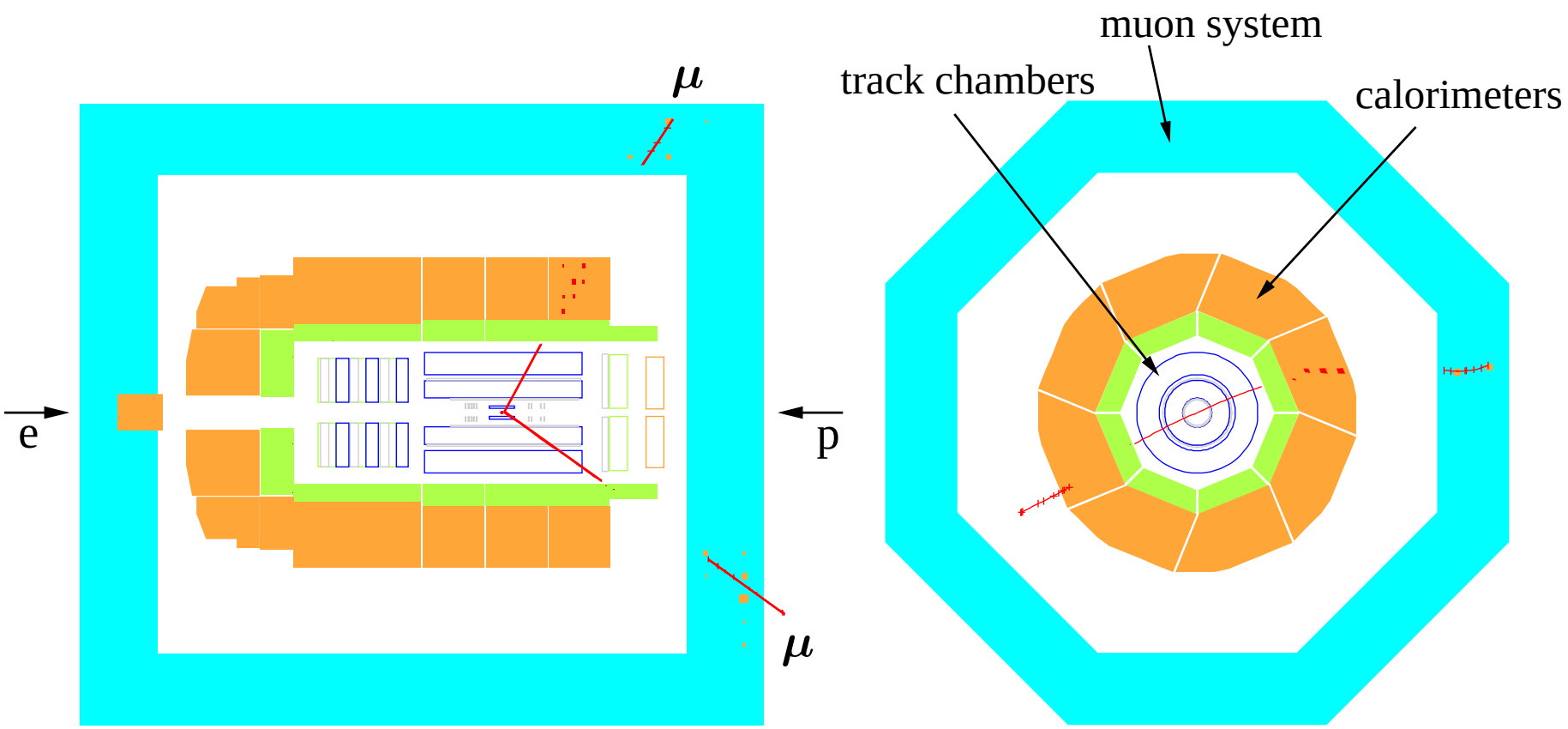
## Perturbative QCD:




- exchange of $\geq 2$ gluons
- $\sigma \propto [g(x, Q^2)]^2$
  steeper rise as a function of $W$
- no or small shrinkage expected

⇒ works in presence of hard scales
$\boldsymbol{(M_q,\ Q^2,\ t)}$

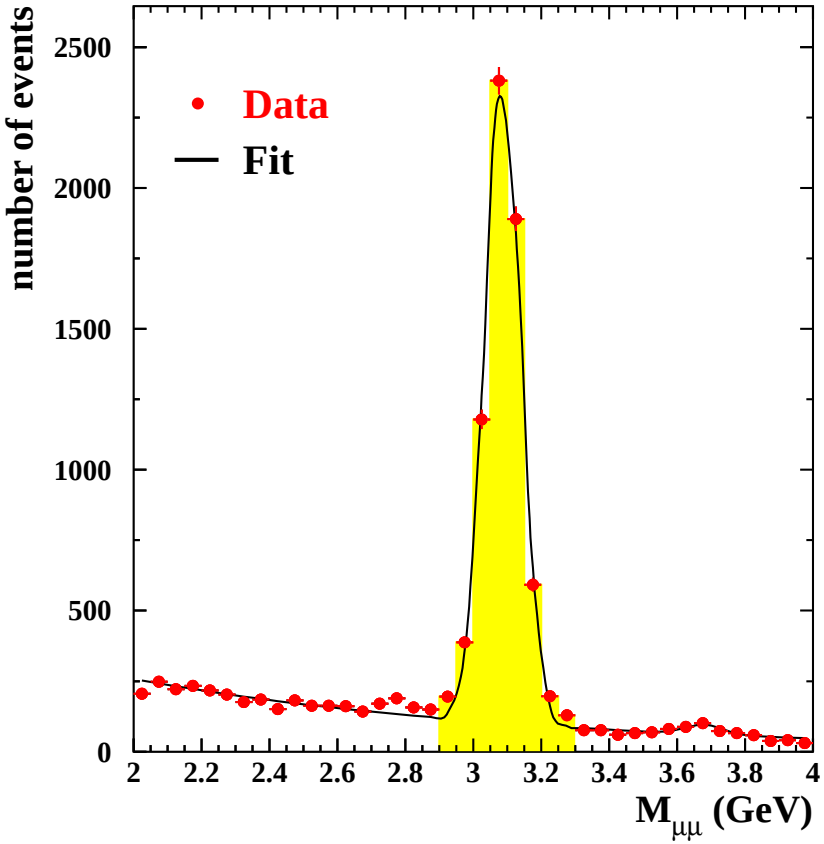
# $J/\psi$ Mesons in the H1 Detector




used decay channel: $J/\psi \to \mu^+\mu^-$ branching ratio: $(5.88 \pm 0.10)\%$

data set: 1999 - 2000 luminosity: $54.8\ pb^{-1}$

# Differential Cross Section as a Function of $|t|$

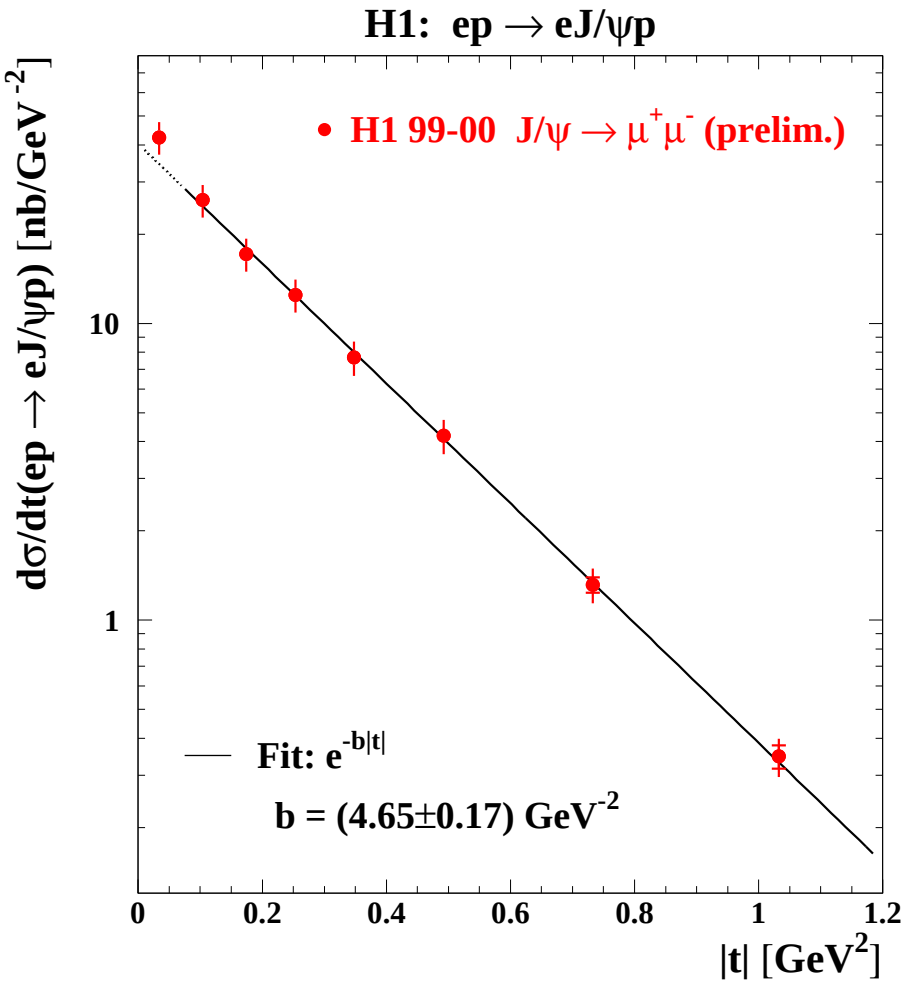



$40 < W_{\gamma p} < 150\,\mathrm{GeV}$

$0 < |t| < 1.2\,\mathrm{GeV}^2$

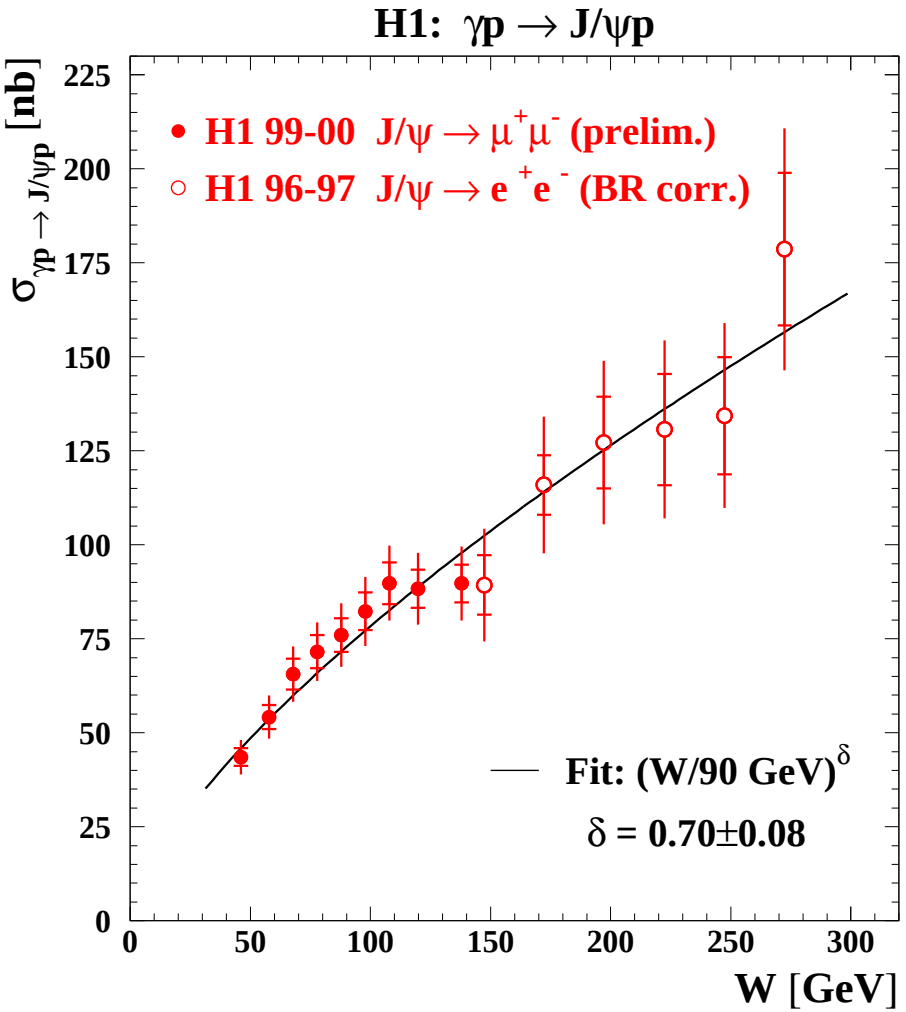
$Q^2 < 1\ \mathrm{GeV}^2$

fit: Gaussian + power law

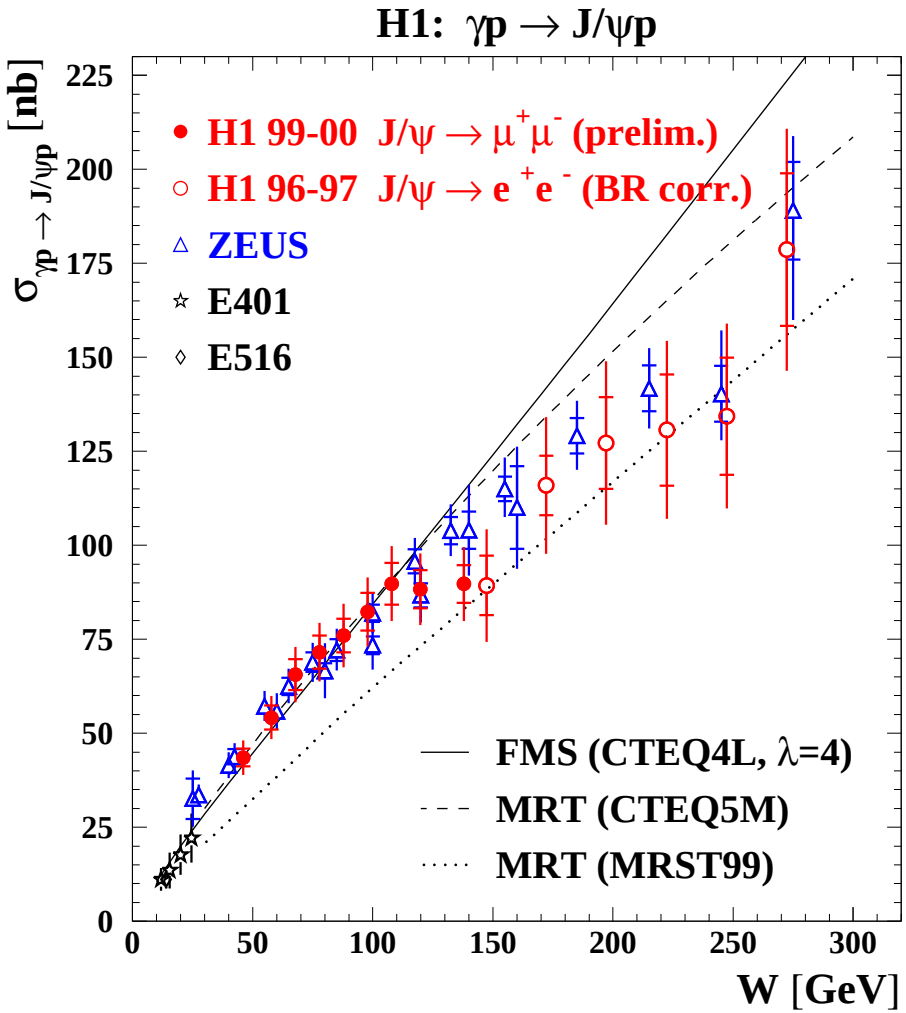



$\Rightarrow$ exponential fit gives good description

# Cross Section as a Function of $W_{\gamma p}$



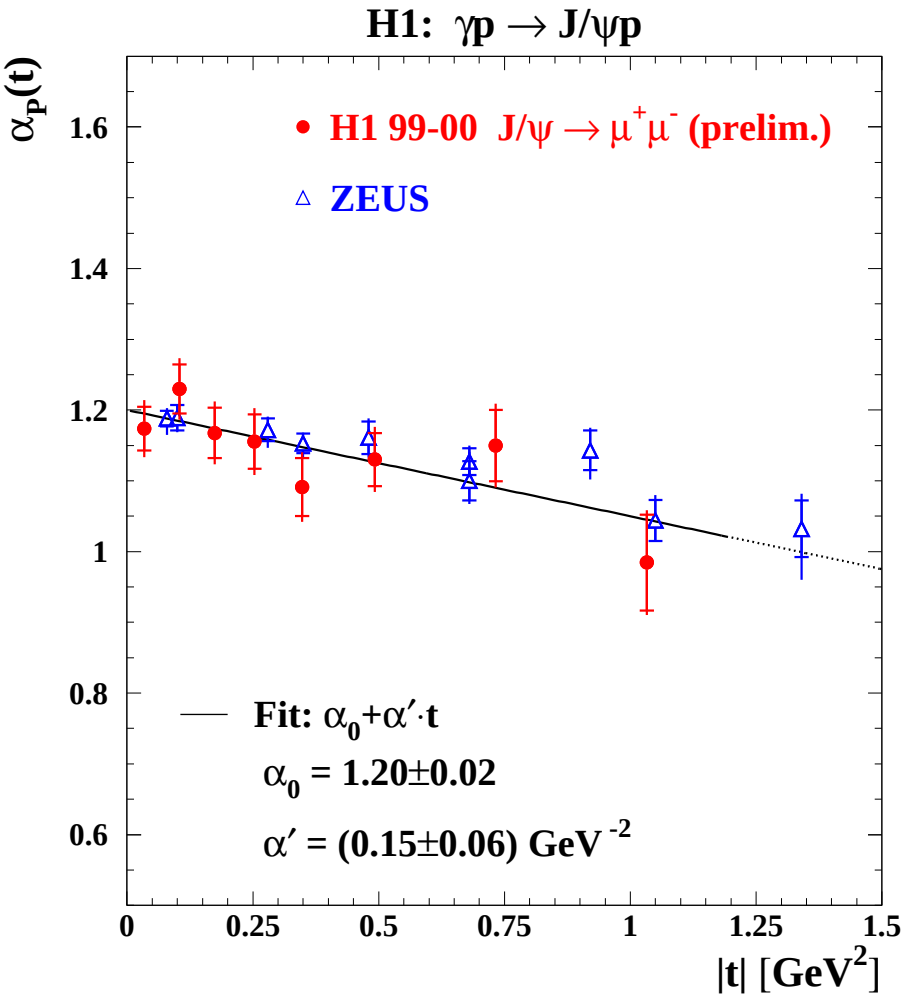

$\Rightarrow W^{\delta}$ fit gives good description



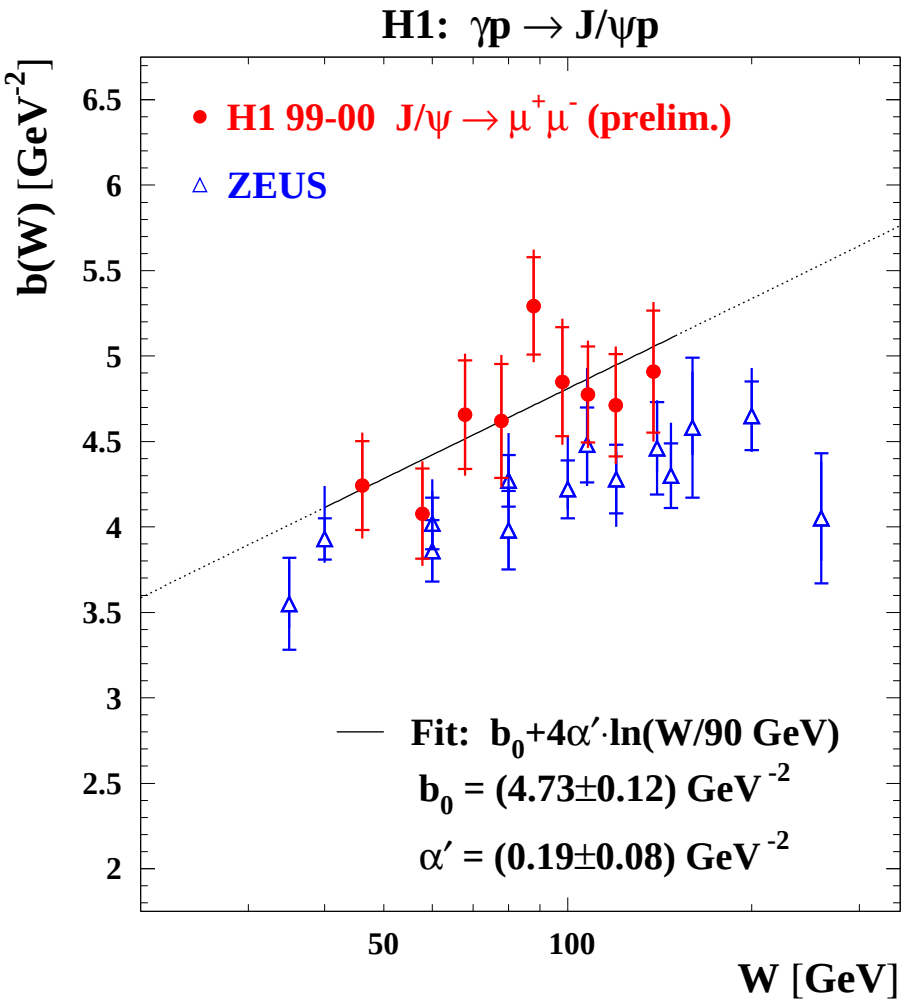

$\Rightarrow$ QCD calculations qualitively describe the rise

# Double Differential Cross Sections

$\sigma \propto W^{4(\alpha_{I\!P}(t)-1)}$ fit in bins of $t$

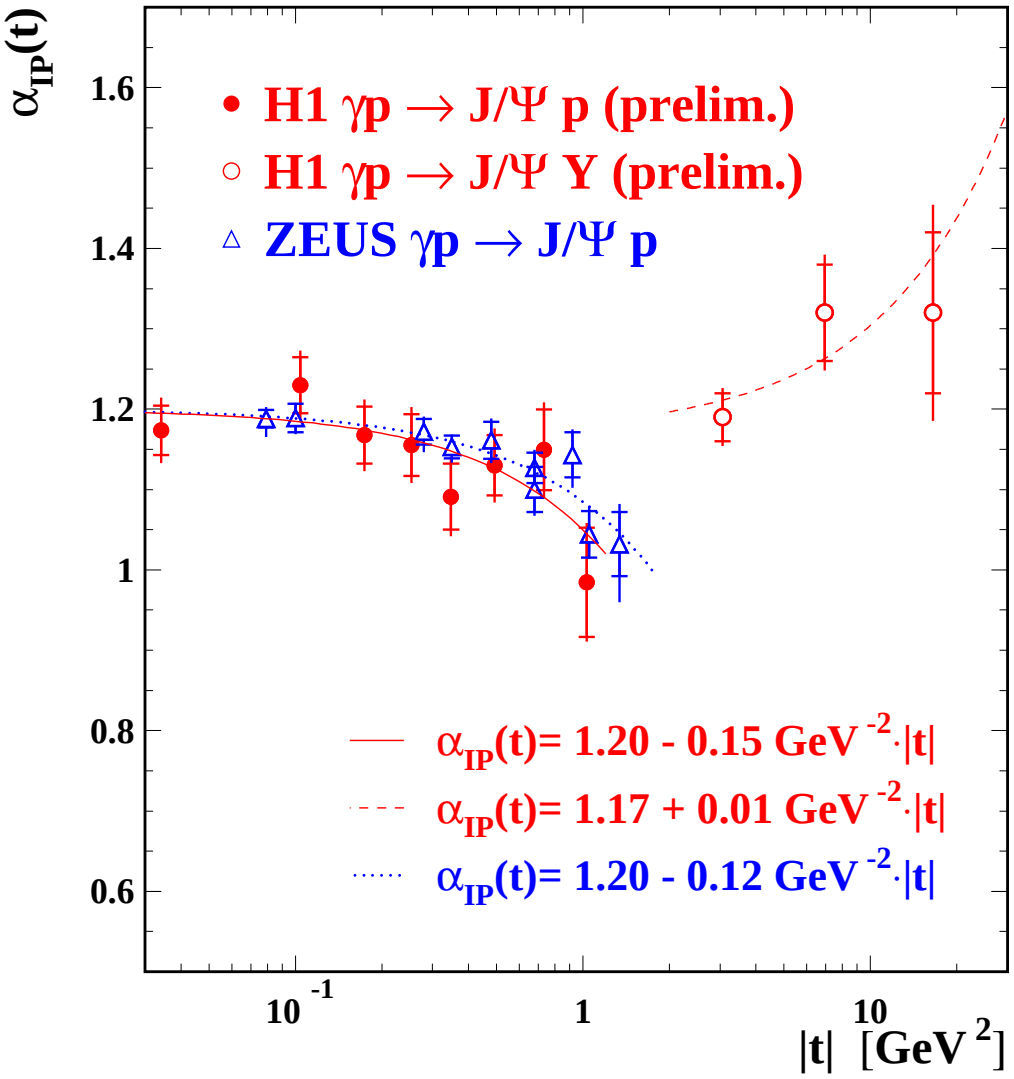



$\frac{d\sigma}{dt} \propto e^{-b(W)|t|}$ fit in bins of $W$




$\Rightarrow$ data compatible with moderate shrinkage

# $\alpha_{\mathbb{P}}$ as a Function of $|t|$




$\gamma p \to J/\psi p$:

$$\alpha'_{\mathrm{H1}} = 0.154 \pm 0.054 \pm 0.023$$

$$\alpha'_{\mathrm{ZEUS}} = 0.115 \pm 0.018^{+0.008}_{-0.015}$$

$$\alpha'_{\mathrm{soft}} = 0.25$$

$\Rightarrow$ moderate shrinkage seen

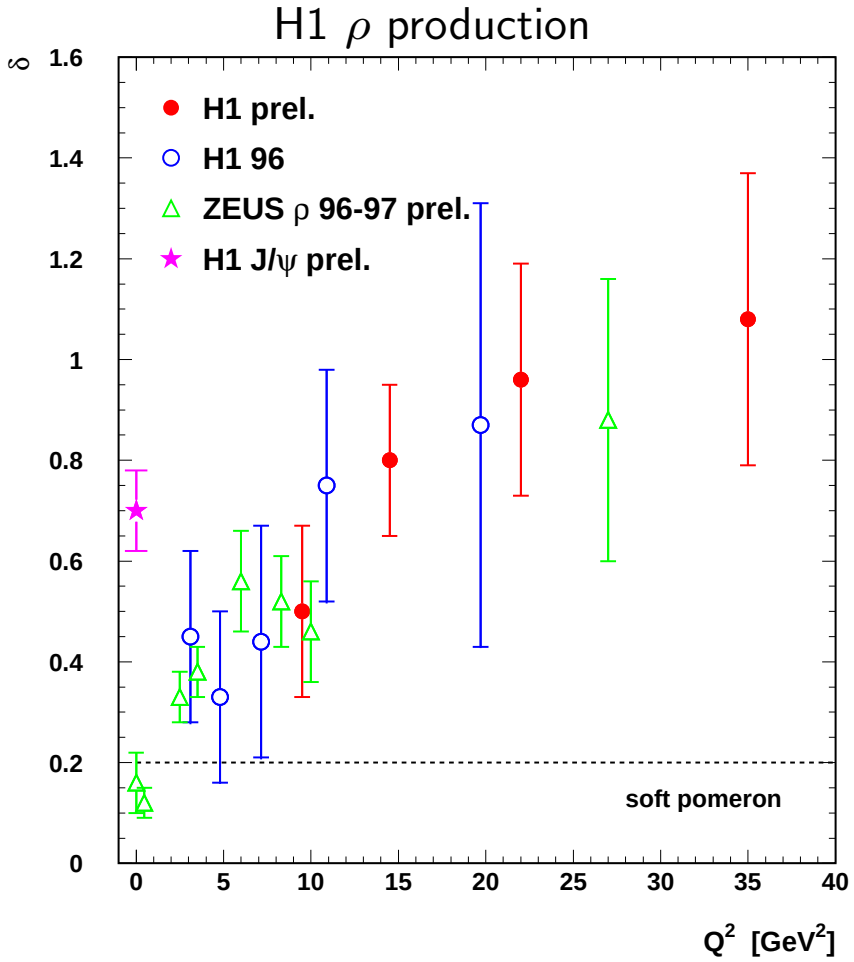
$\gamma p \to J/\psi Y$:

$$\alpha'_{\mathrm{H1}} = -0.013 \pm 0.007 \pm 0.007$$

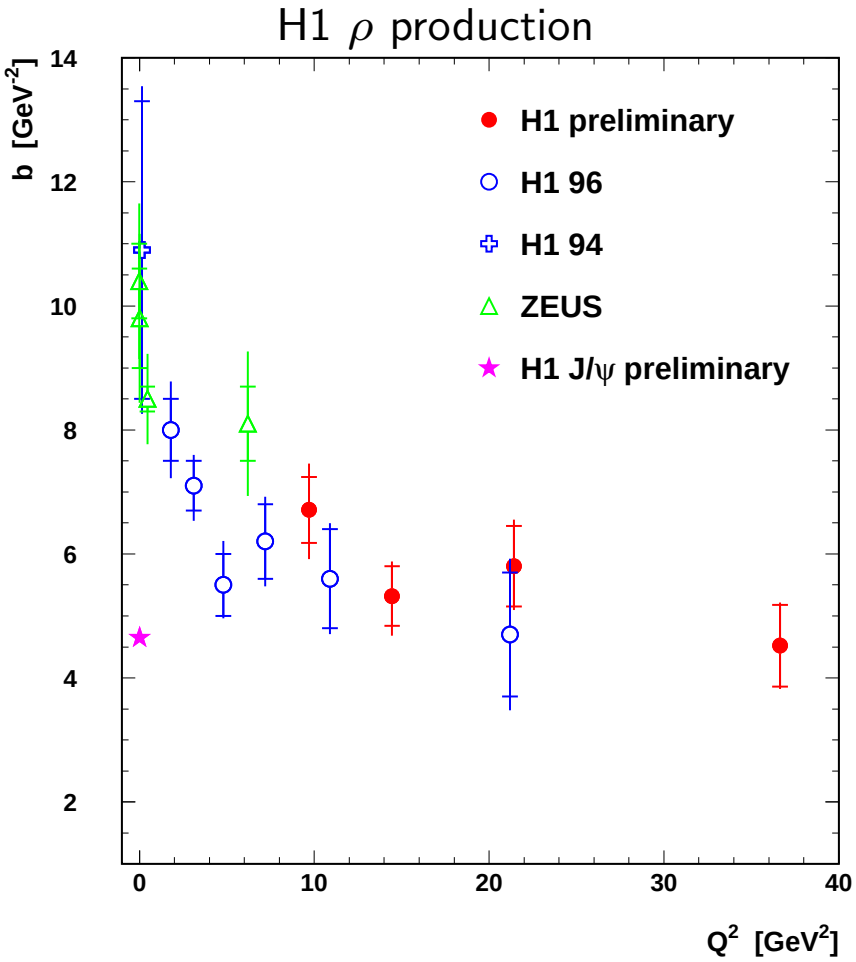
$\Rightarrow$ shrinkage consistent with zero

# Comparison of $J/\psi$ with $\rho$ at high $Q^2$

$\sigma \propto W^{\delta}$ fit in bins of $t$




$\frac{d\sigma}{dt} \propto e^{-b|t|}$ fit in bins of $W$




$\Rightarrow$ similar values as for the $J/\psi$ photoproduction

$\Rightarrow$ high $Q^2$ possible hard scale

# Conclusions

- new results on elastic photoproduction of $J/\psi$ mesons
  $\Rightarrow$ increased statistics

- measured in $W$ and $|t|$
  $\Rightarrow$ single and double differentially

- steep rise $\sigma_{J/\psi}(W)$ as a function of $W$
  $\Rightarrow$ $\delta \approx 0.7$ (light VM: $\delta \approx 0.2$)

- $|t|$-dependence of cross section $\sigma_{J/\psi}(t)$
  $\Rightarrow$ fit $\frac{d\sigma}{dt} \propto e^{bt}$ yields $b \approx 4.7$ GeV$^{-2}$

- data compatible with moderate shrinkage
  $\Rightarrow$ $\alpha' \approx 0.15$ GeV$^{-2}$ (Soft Pomeron Model: $\alpha' \approx 0.25$ GeV$^{-2}$)

- similar $W$- and $t$-dependence for $\rho$ at high $Q^2$ as for $J/\psi$ at $Q^2 \approx 0$
  $\Rightarrow$ transition from soft to hard diffraction