ICHEP 2000, 28/7/2000

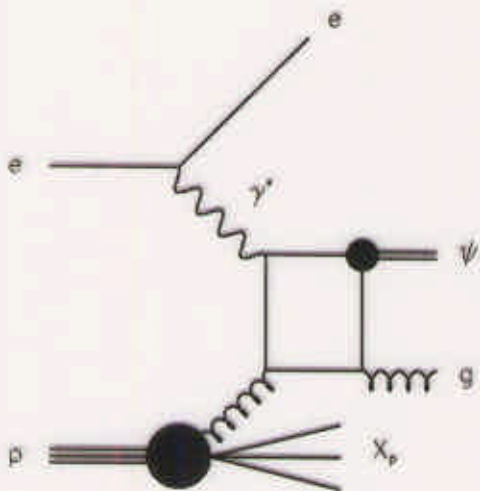# Production of Charmonia and Upsilon Mesons at HERA

A. Bertolin

Outline:

- production processes and kinematic region

- inelastic charmonium (ψ and $\psi(2S)$)
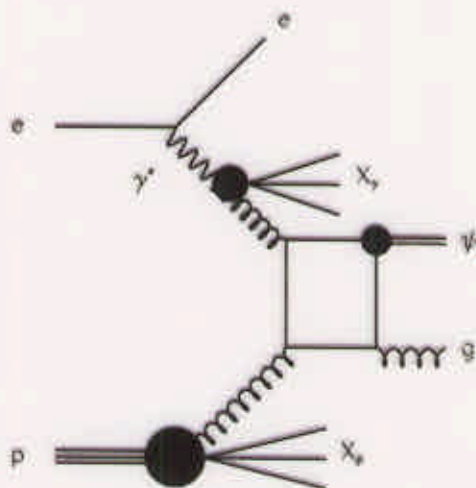
- Υ sector

Production processes

$$z = \frac{E_{J/\psi}}{E_{\gamma^*}} \ (p \text{ rest frame})$$
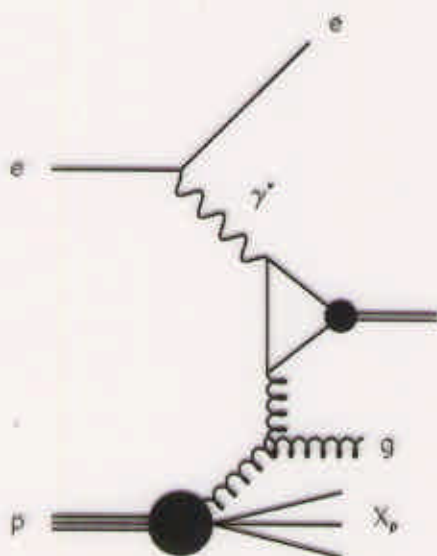

direct photon

color singlet model

medium z

resolved photon

color singlet model

low z

direct photon

color octet model
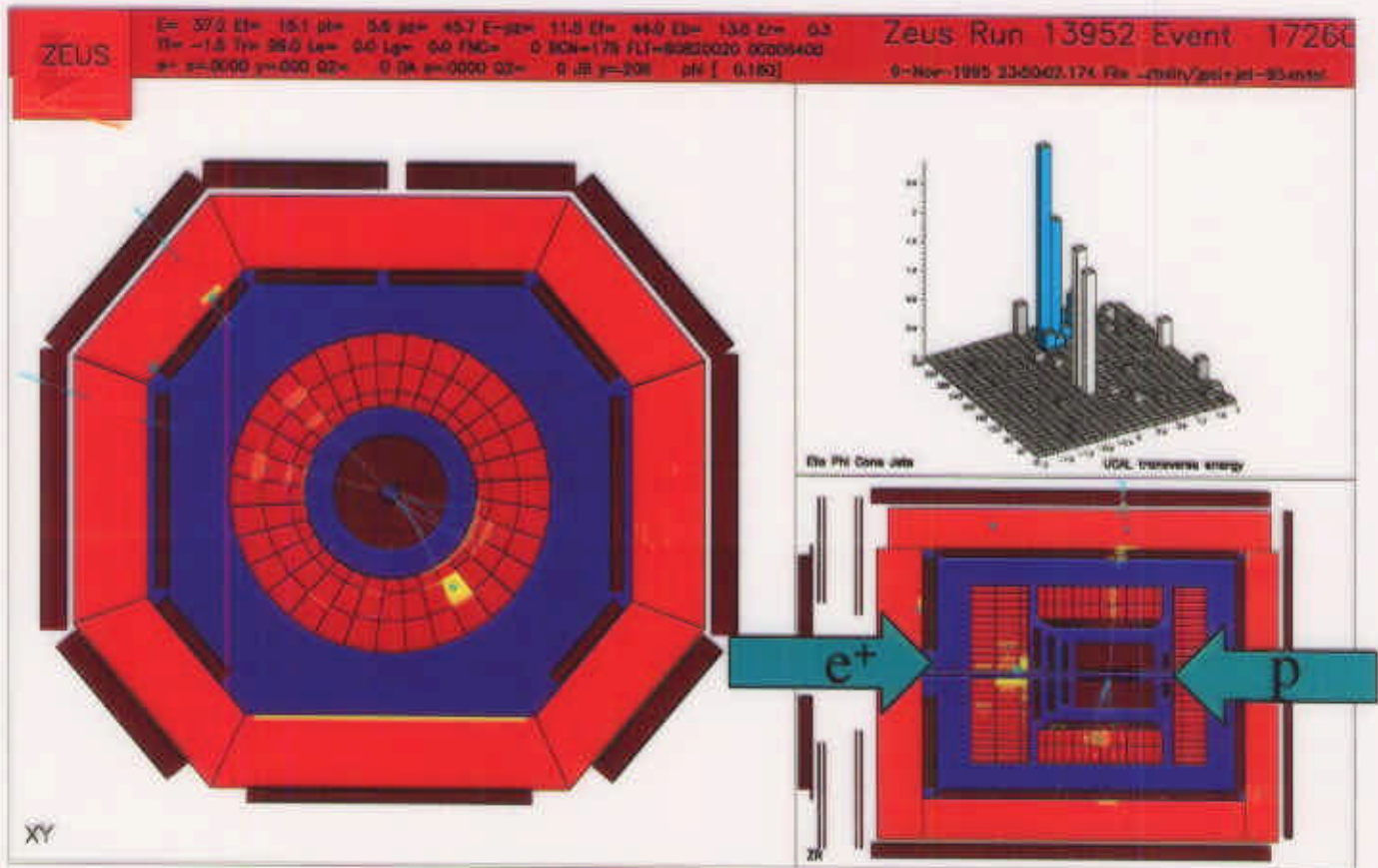
Kinematic region

27.5 GeV e$^+$ 820/ 920 GeV p

- $Q^2 < 1$ GeV^2 (photoproduction regime)
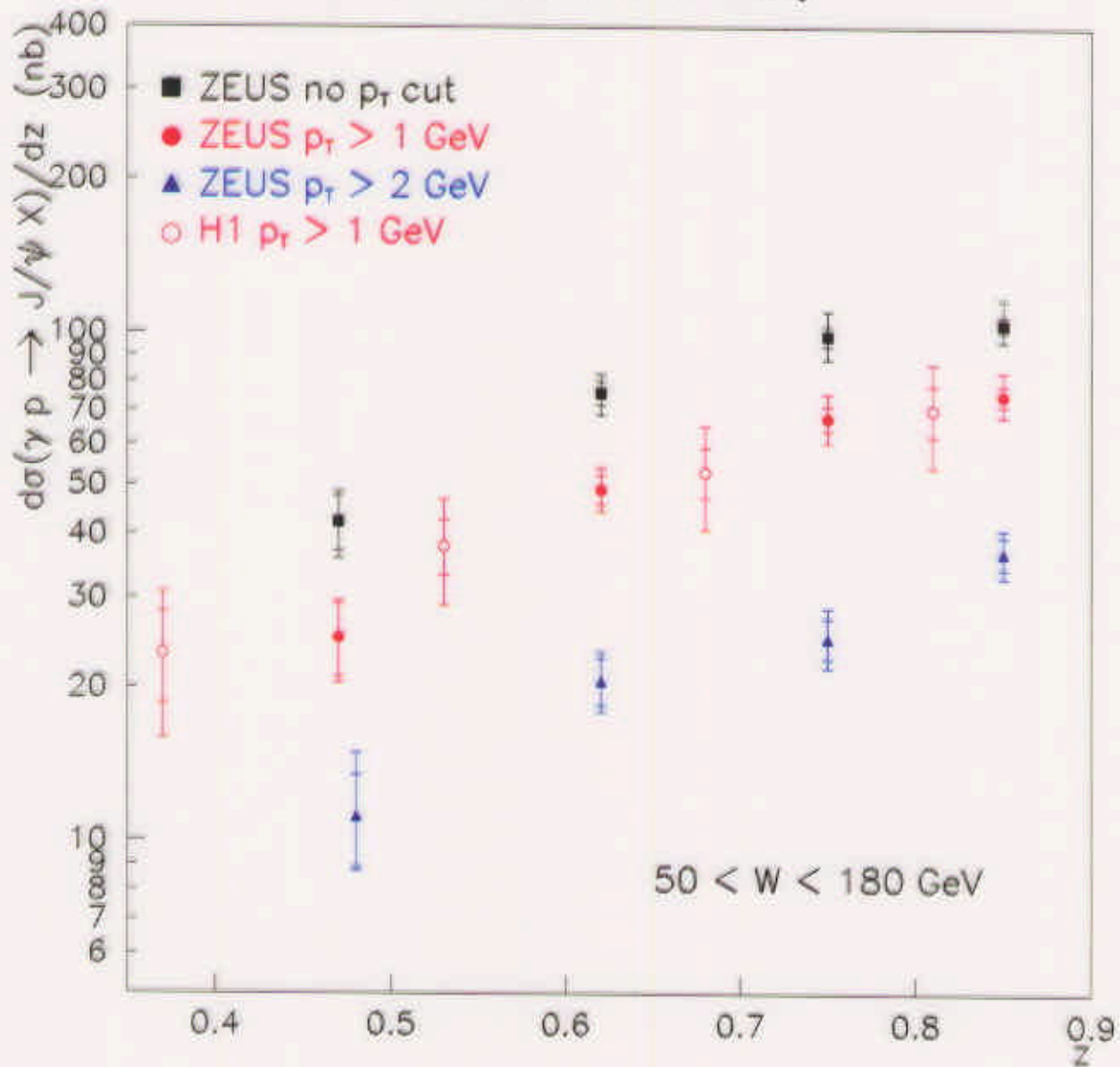
- wide $W_{\gamma p}$ coverage (30 – 270 GeV)

$$W_{\gamma p} = \sqrt{4 E_e E_p} \, \sqrt{y}$$

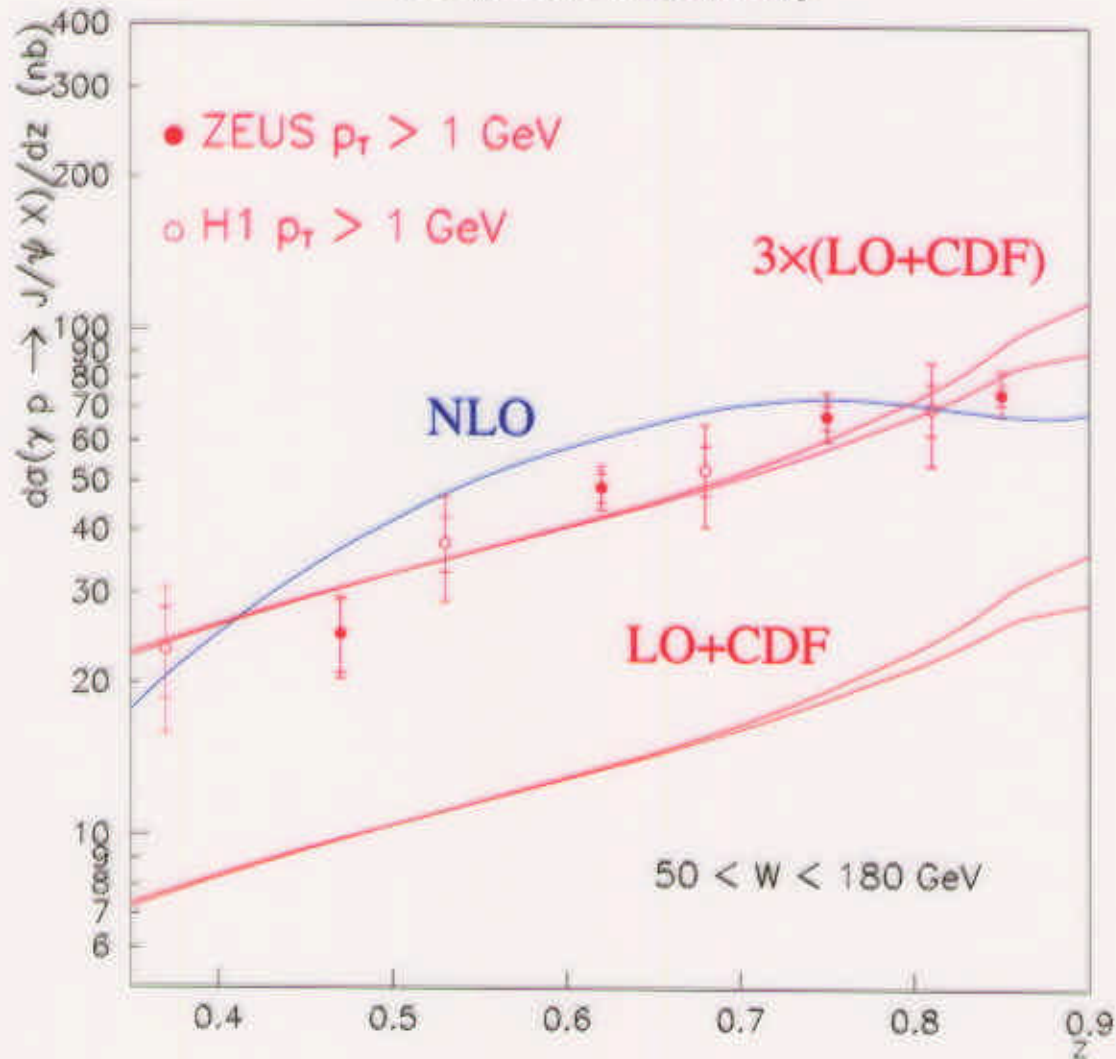$$y = \frac{E_{\gamma^*}}{E_e} \ (p \text{ rest frame})$$

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- similar shape for $p_T > 1$ GeV and no p_T cut
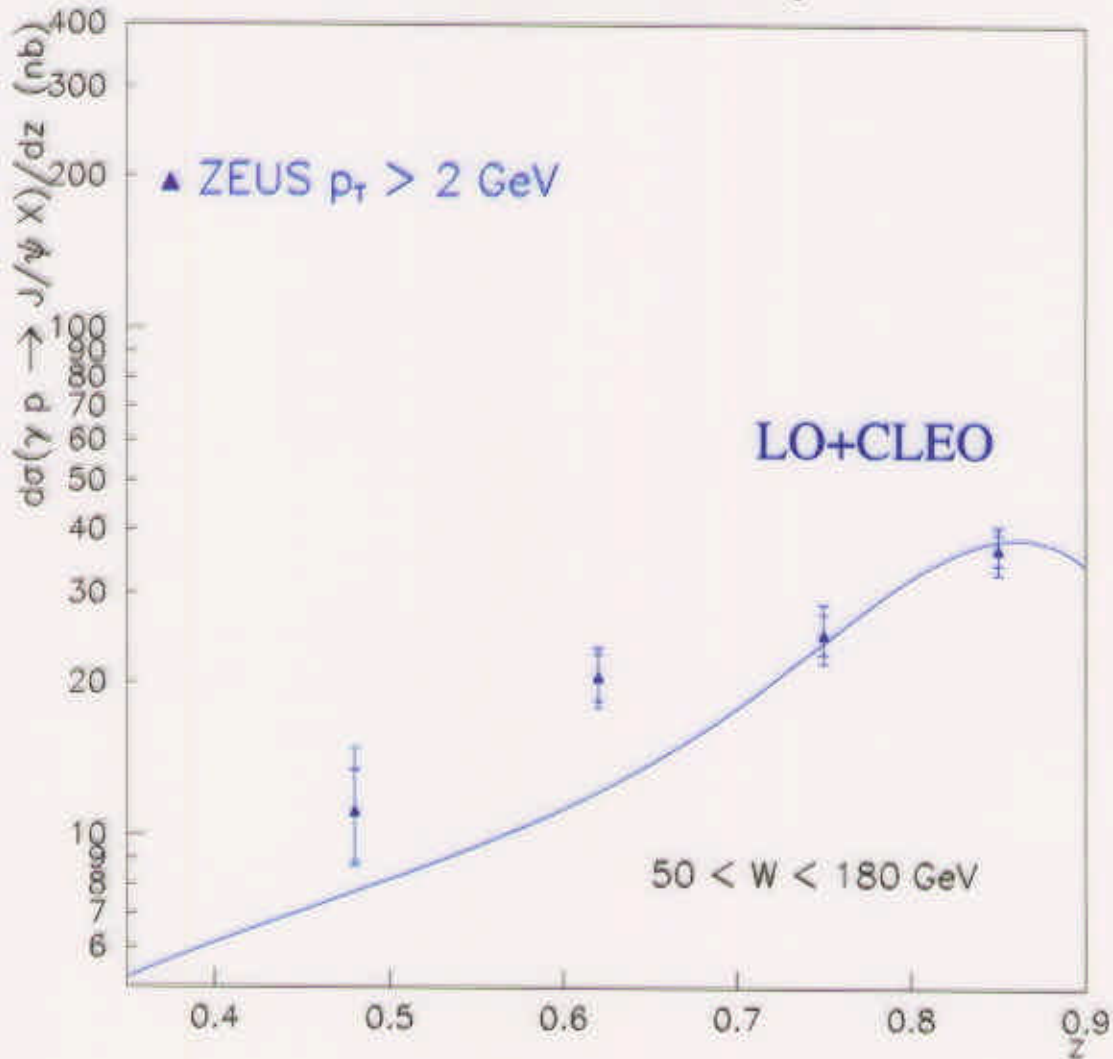
Inelastic Ψ

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- color singlet + octet with CDF octet matrix elements: undershoots data but shape is fine

- byproduct: sensitive to the direct color singlet process
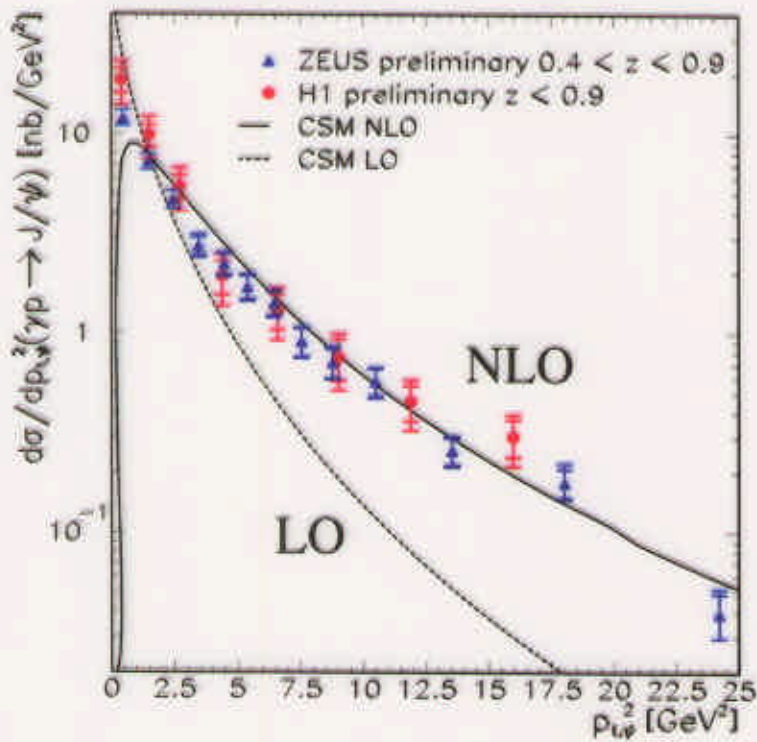
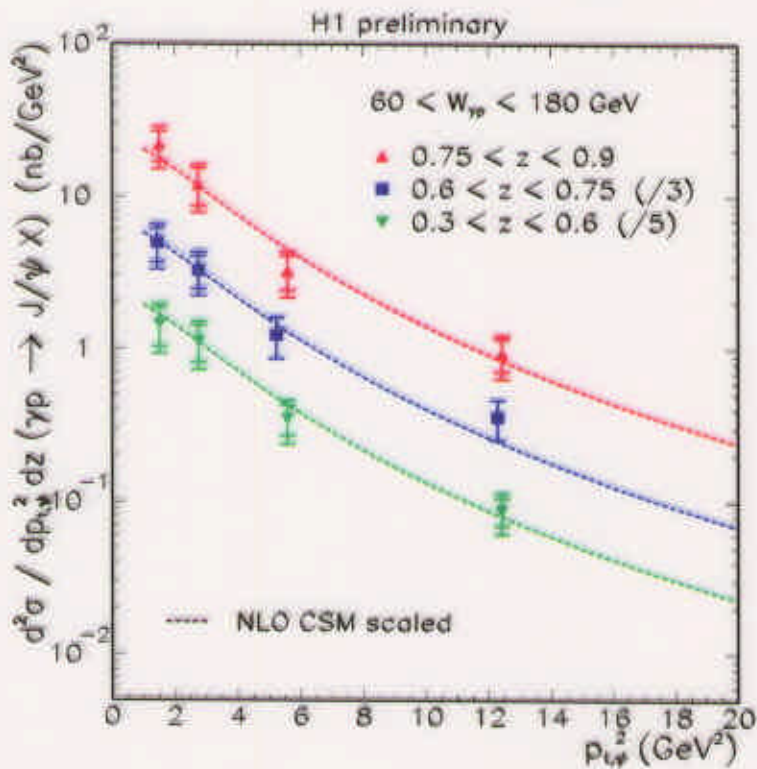- NLO direct color singlet: fine !

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* color singlet + octet with CLEO octet matrix elements: looks interesting (no K− factor !)

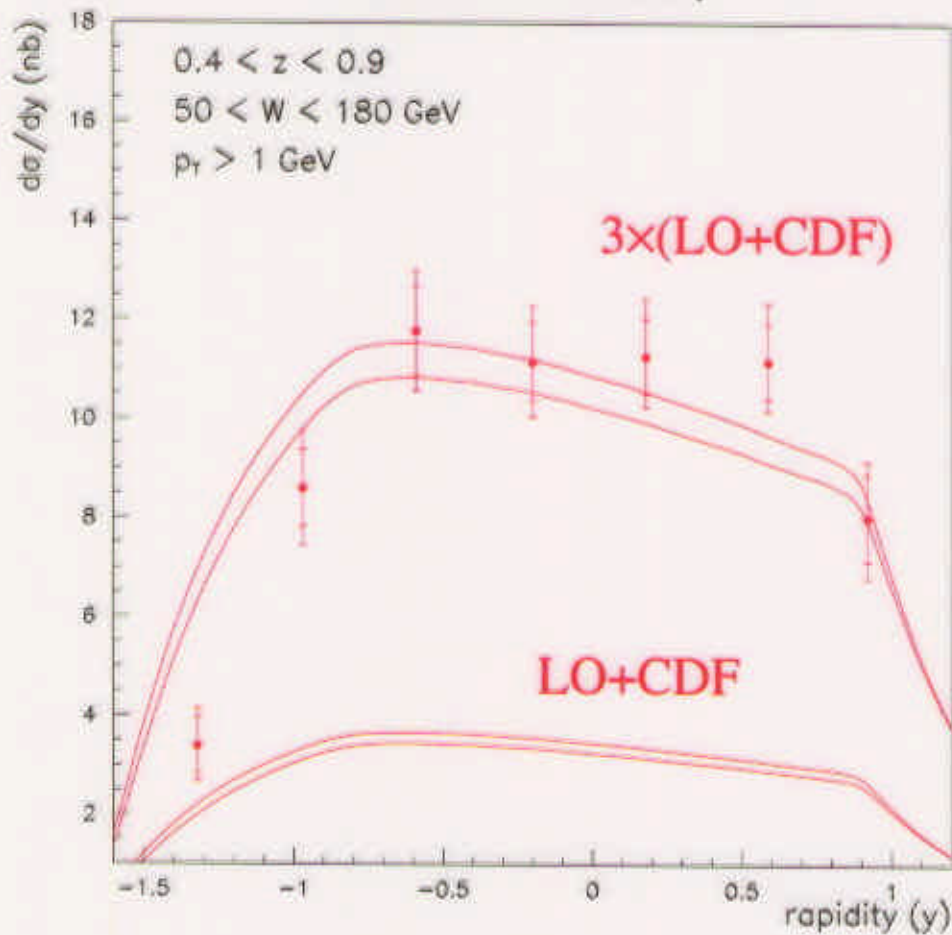CLEO octet matrix elements or $p_T > 2$ GeV ?

Inelastic ψ

• NLO direct color singlet nicely reproduce shape and normalization

$$\frac{d^2\sigma}{dz\,dp_T^2} = f(z)\,g(p_T^2)$$

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Inside plot:
$0.4 < z < 0.9$
$50 < W < 180$ GeV
$p_T > 1$ GeV

3×(LO+CDF)

LO+CDF

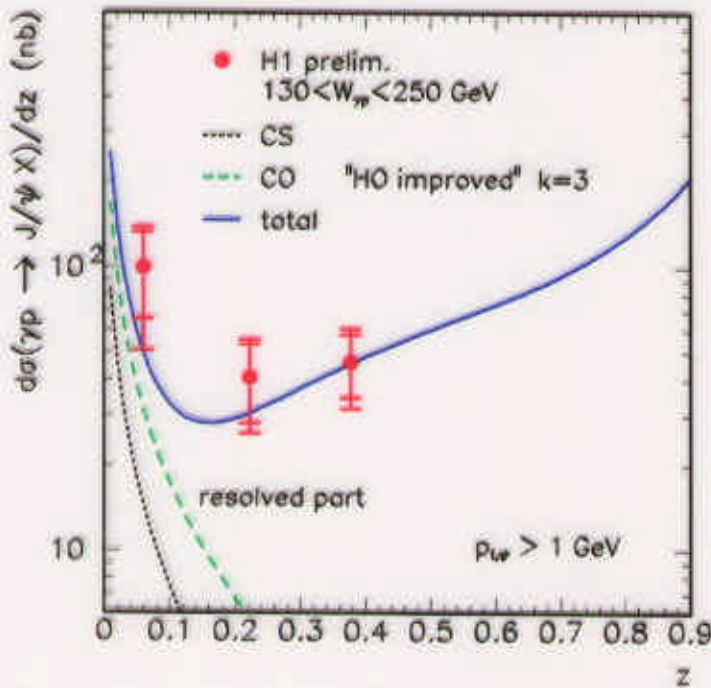y-axis: $d\sigma/dy$ (nb)
x-axis: rapidity (y)

$$y \approx -\tfrac{1}{2} \ln \tan \theta/2$$

• color singlet + octet with CDF octet matrix elements: undershoots data, some shape discrepancy at negative y (incoming positron direction)
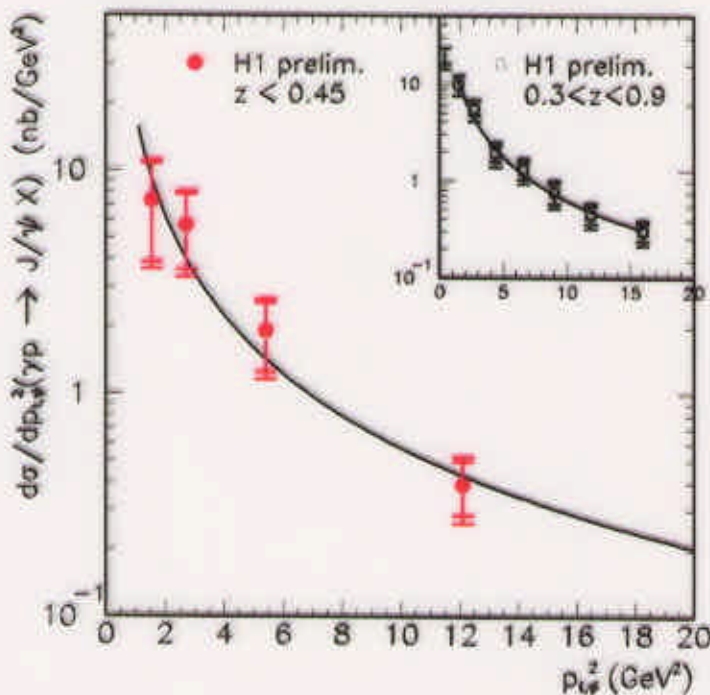
• others predictions ?

Inelastic ψ

• **low z region: never explored before HERA**

• color singlet + octet
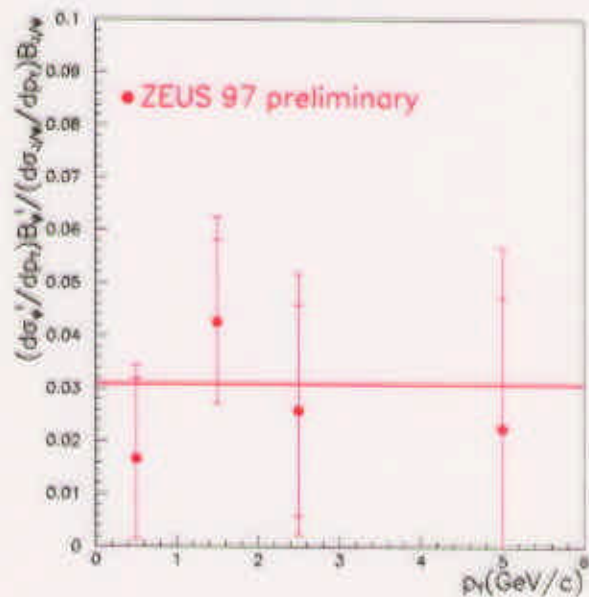with CDF octet matrix
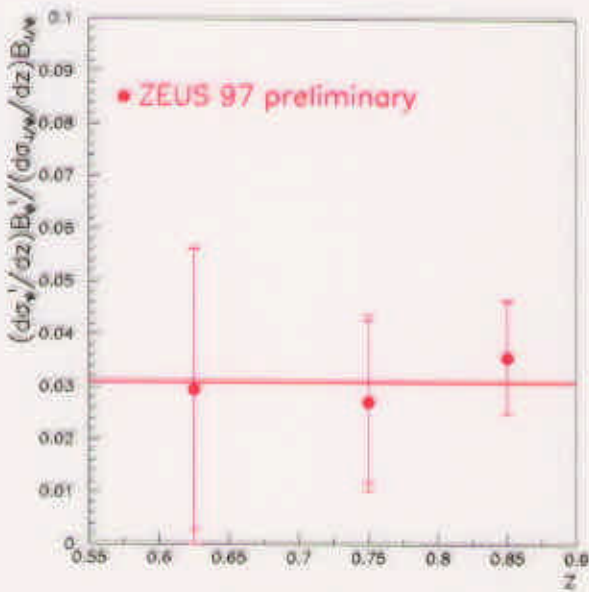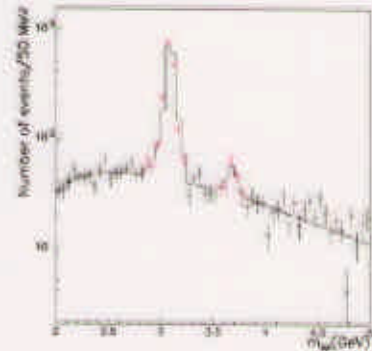elements: undershoots
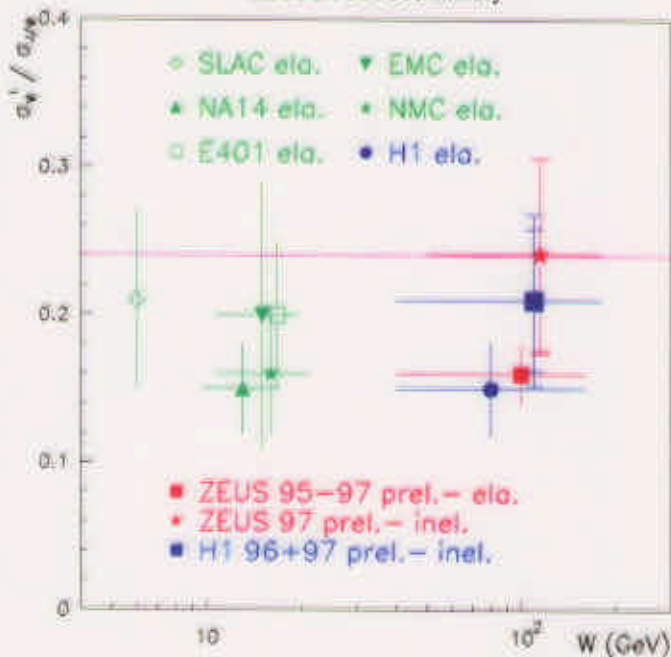data but shape is fine

• sensitive to the
resolved singlet +
octet component

• again the p_T^2
shape does not
depend on z

Inelastic charmonium

- **first observation at HERA**

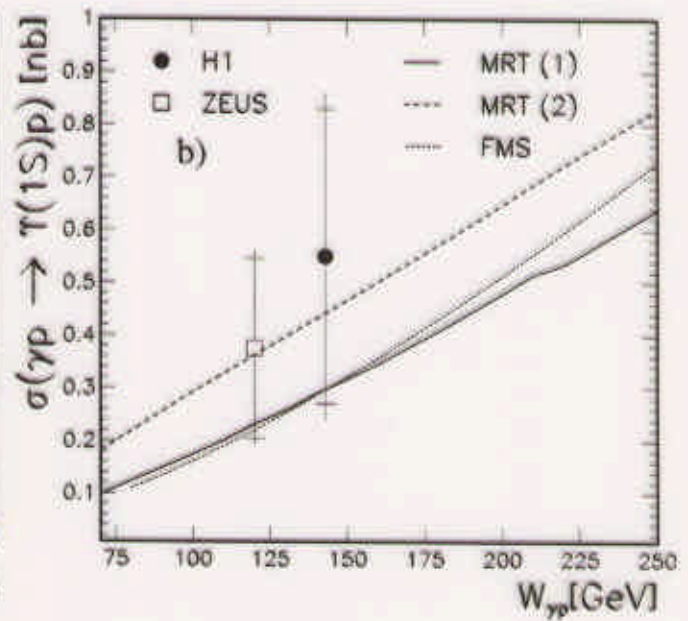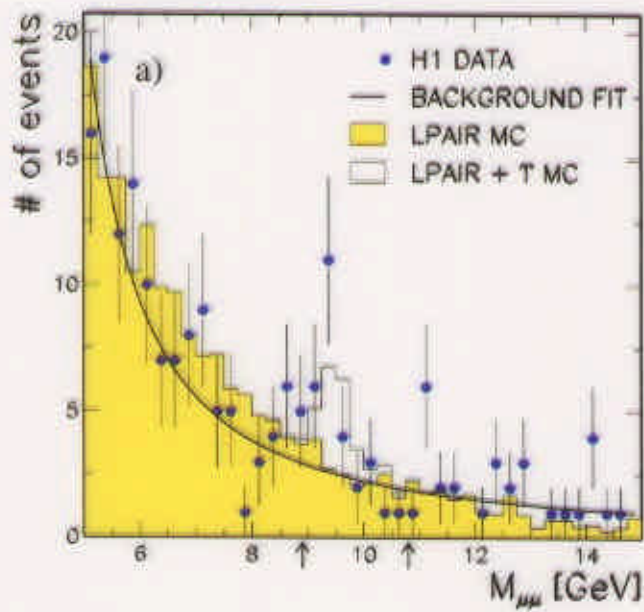- $\psi(2S) \to \psi\,(\to \mu^+\mu^-)\,X$ contamination

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- **same production mechanism** $\to$ flat cross section ratios

- **magnitude** in agreement with the 24 % naive expectation

- cascade decay gives a **10 %** contribution to the ψ cross sections

Elastic Upsilon

- $Y \rightarrow \mu^+ \mu^-$ $(Y = Y(1S) + Y(2S) + Y(3S))$

- elastic channel

magnitude of the cross-section can be understood by QCD

Conclusions

- accurate inelastic ψ photoproduction measurements for z > 0.4

  - agree with the color singlet direct photon process

  - no need for color octet

- first look at low z ψ : we may need color octet resolved photon

- first look at $\psi(2S)$ / ψ: same production mechanism

- first look at the elastic Y sector: magnitude of the cross section can be understood by QCD

- much more will come:

  - on a short term scale adding 98 → 00 data

  - on a longer time scale due to the HERA lumi upgrade (> 2001 150 pb^{-1} / year)

so stay tuned!