Inelastic J/Ψ production in DIS at H1

Michael Steder
on behalf of the H1 collaboration

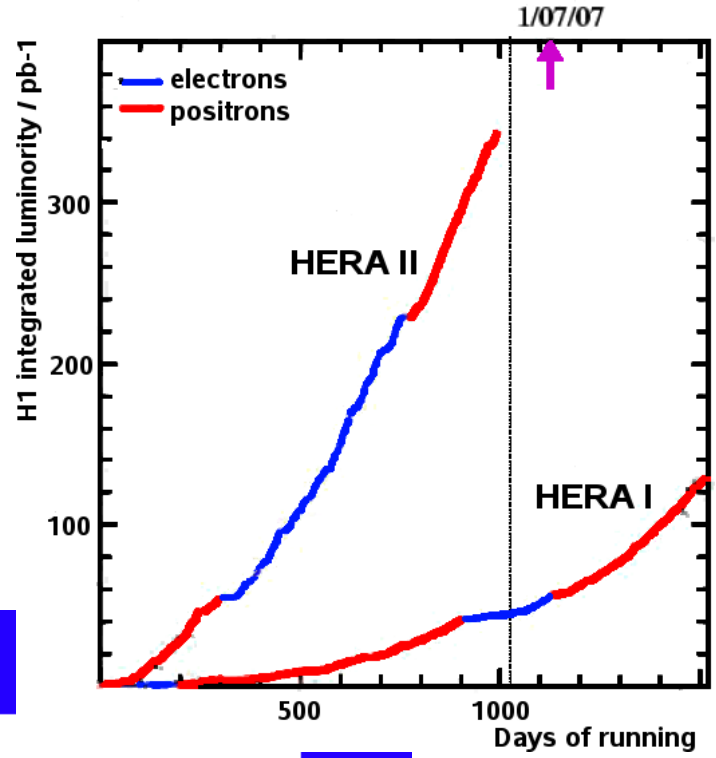
DIS 2007, München

1 introduction
2 event selection and kinematics
3 cross sections
4 summary and outlook

HERA and H1

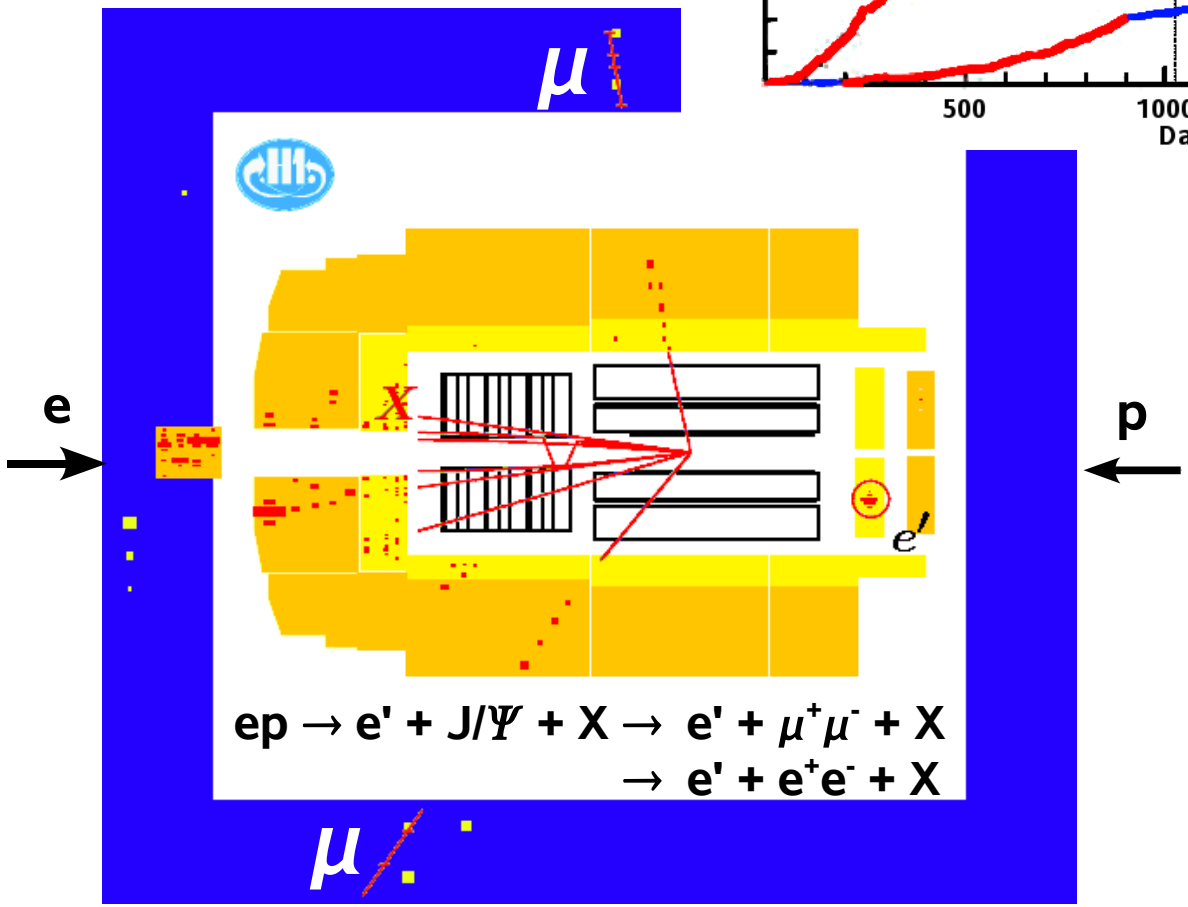
HERA

- electron proton collider
- center of mass energy 320 GeV
  - E_p = 920 GeV
  - E_e = 27.5 GeV
- total integrated luminosity
  - HERA I 120 pb^{-1}
  - HERA II 350 pb^{-1}



H1

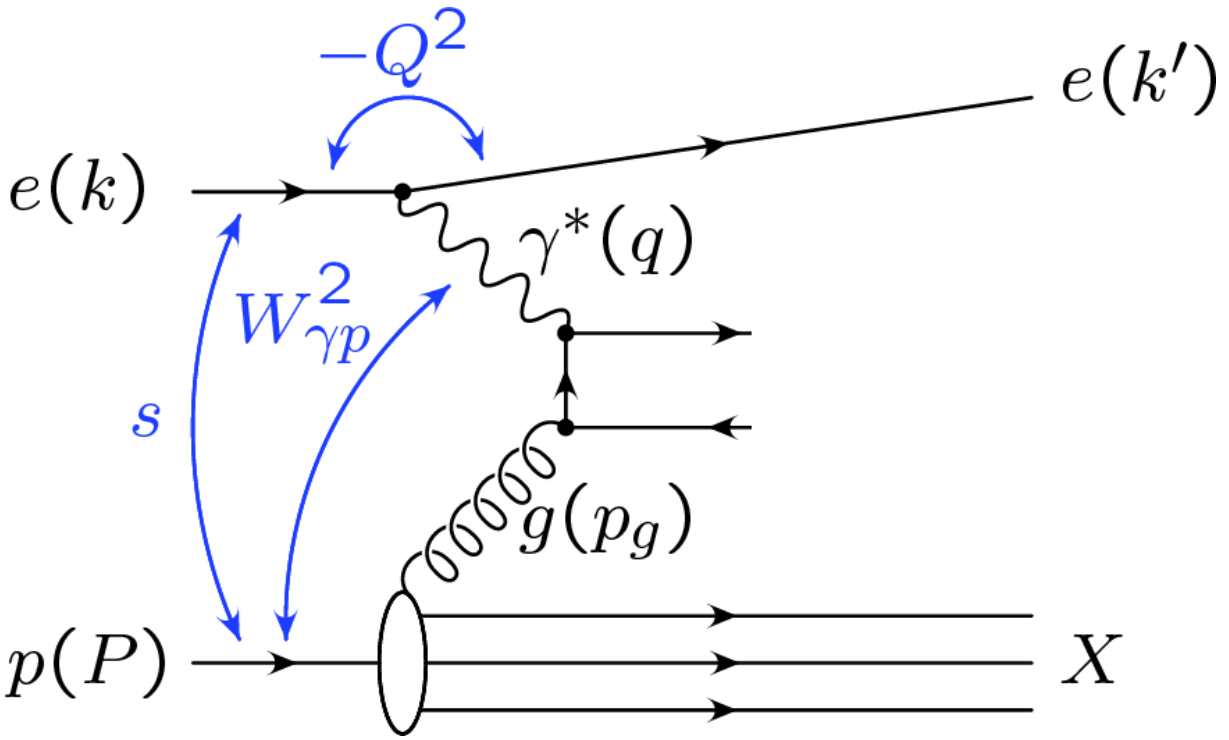
- 4π multi purpose detector
- inelastic J/Ψ event in DIS
  - scattered lepton
  - two decay leptons
  - additional particles
- lepton identification in
  - calorimeter (e/μ)
  - muon detector (μ)
- H1 sensitive down to
  $P_T(J/\Psi) = 0$ GeV



boson gluon fusion (BGF)

main charm production process

- γ^* + g → c + $\bar{c}$



kinematic variables

$$Q^2 = -q^2$$

$$s = (P+k)^2$$

$$W^2_{\gamma p} = (P+q)^2$$

$$z = \frac{p_\psi \cdot P}{q \cdot P}$$

in p rest frame

$$= \frac{E^*_\psi}{E^*_\gamma}$$

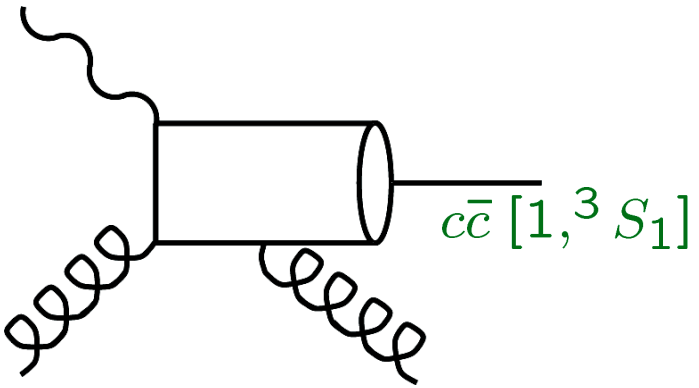
inelastic J/Ψ production

color singlet model (CS)

LO: Berger et al, Baier et al, 1981

NLO (direct): Krämer et al, 1995

- radiation of hard gluon
- coupling to quark pair determined by $|R_\Psi(0)|$
  - radial wave function at origin
  - calculated from $\Gamma(J/\Psi \to l^+l^-)$

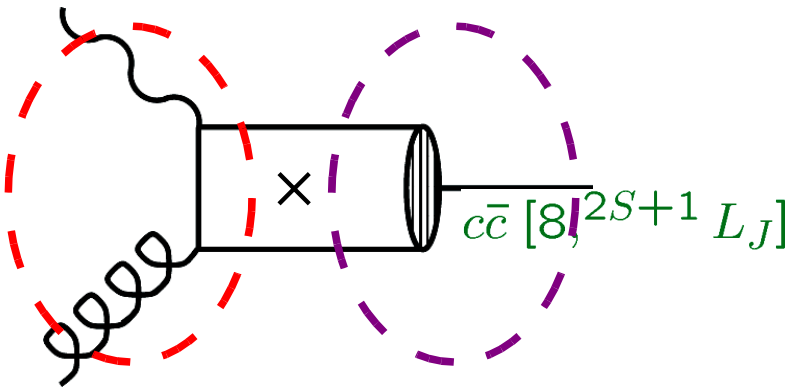


factorization ansatz in NRQCD (color octet model, CO)

Bodwin, Braaten, Lepage, 1995

- color octet states contribute
- soft gluon radiation
- σ ~ sum of all color and spin states
- factorizes into
  - hard scattering process
  - transition to real J/Ψ (non perturbative LDME)

$$\sigma_{J/\psi X} = \sum \hat{\sigma}(p\bar{p} \to c\bar{c}[n]X) \times \mathrm{LDME}[n]$$



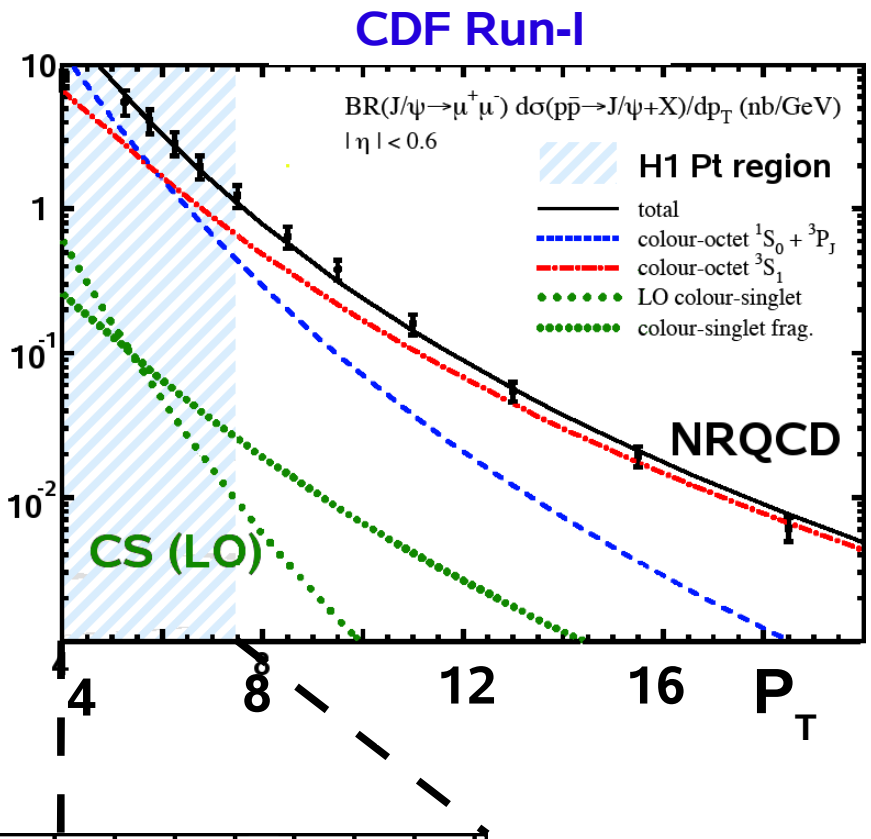
inelastic J/Ψ production

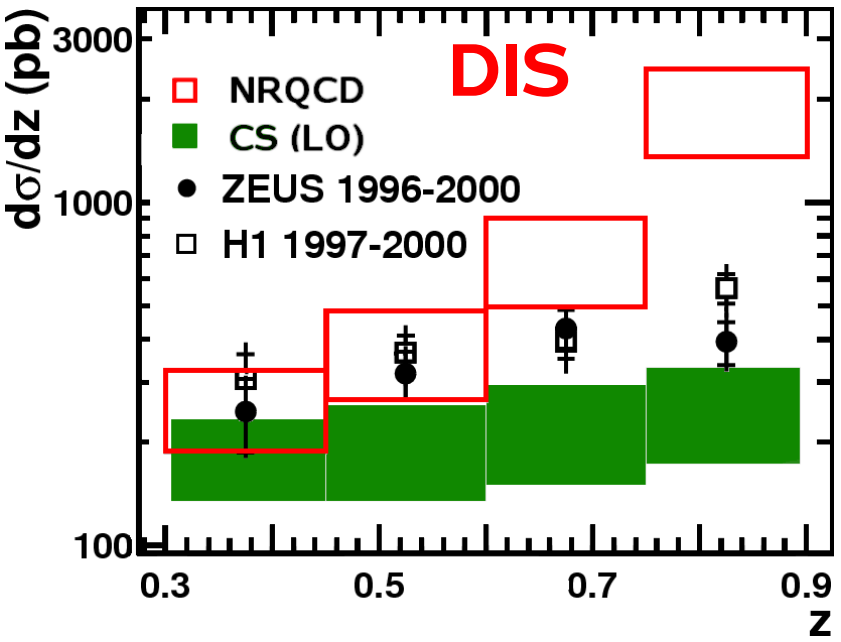
long distance matrix elements (LDME)

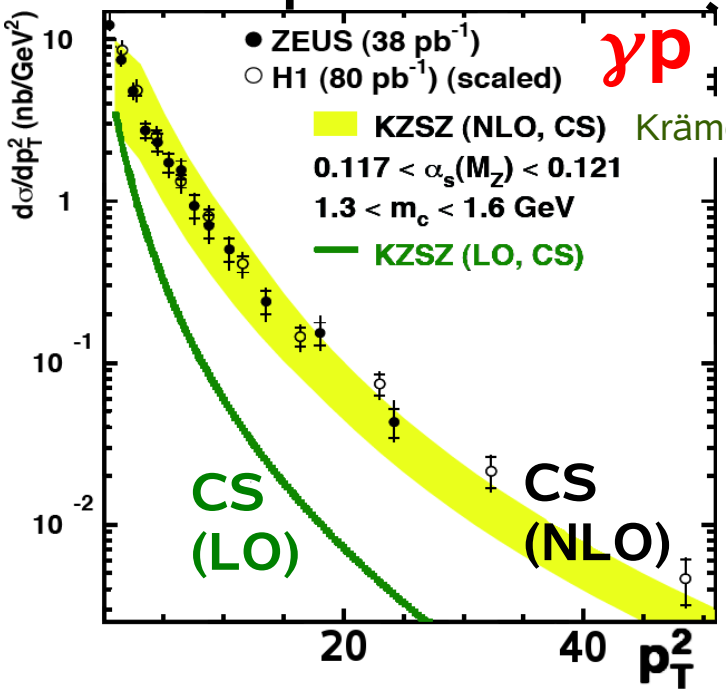
- extracted from NRQCD fit to Tevatron data
- expected to be universal

predictions for HERA

- NRQCD prediction fails to describe HERA data
- CS (LO) general agreement with HERA data
- photoproduction:
  - CS (NLO) describes HERA data good
- **no NLO calculations in DIS**







Krämer et al, 1995

data sample and selection

H1 data – HERA II 2004-2006

$\mathcal{L} \approx 258\ \text{pb}^{-1}$

kinematic range

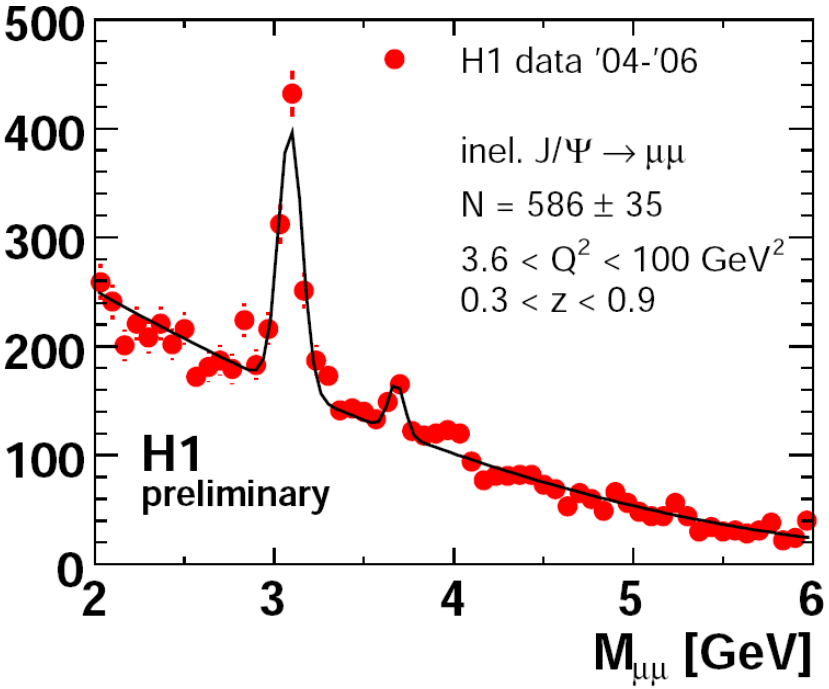
$3.6 < Q^2 < 100\ \text{GeV}^2$

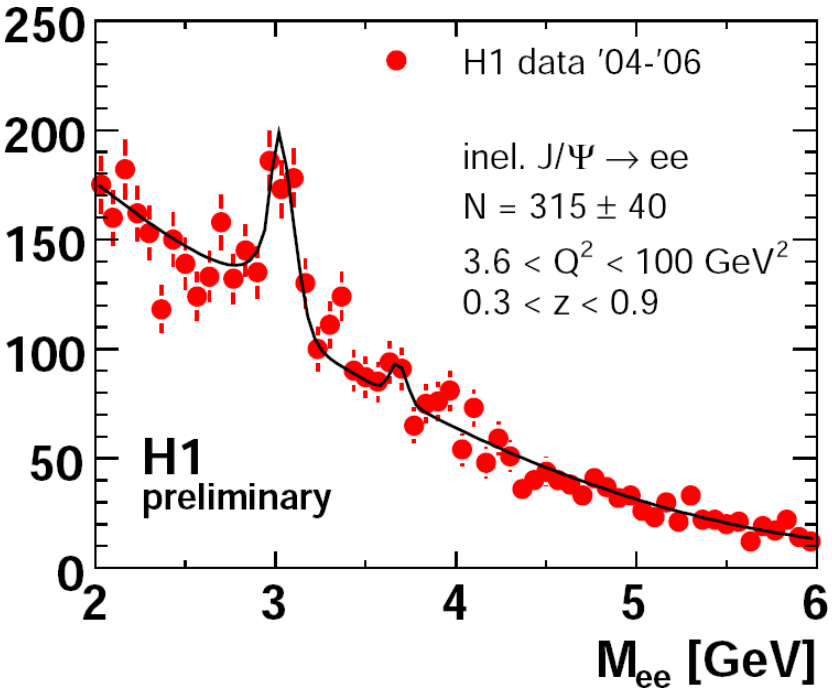
$50 < W_{\gamma p} < 225\ \text{GeV}$

$0.3 < z_{J/\Psi} < 0.9$ (z > 0.9: diffraction predominant)

$P_{T,\Psi}^{*} > 1.0\ \text{GeV}$ (P_T in γp rest frame)

$$\sigma = \frac{N_{sig}}{\mathcal{L} \cdot \varepsilon \cdot \mathcal{BR}} = \frac{N_{sig}}{\mathcal{L} \cdot \mathcal{BR}} \cdot \frac{1}{\varepsilon_{Trig} \cdot \varepsilon_{Rec} \cdot \mathcal{A}_{geom}}$$





backgrounds from indirect J/Ψ production

diffractive Ψ(2S)

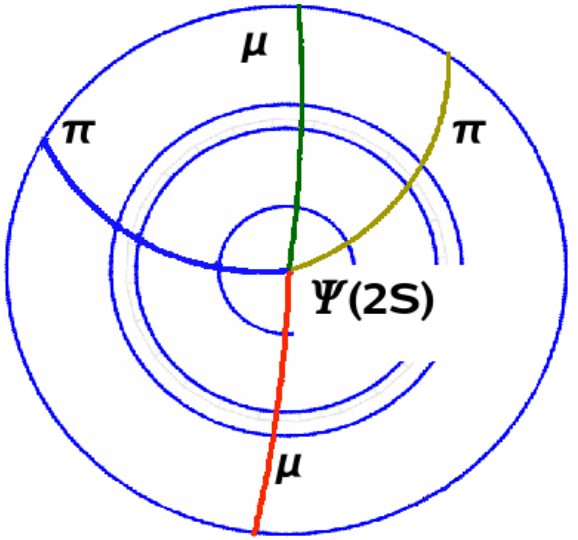
- high z region
- Ψ(2S) $\rightarrow$ J/Ψ $\pi^+\pi^-$ (BR ~30%)

$\rightarrow$ $N_{Tracks} \geq 5$ (in addition to scat. lepton)

- suppresses Ψ(2S) contribution
- previous (HERA I) analyses in DIS: $N_{Tracks} \geq 3$
- cross sections are corrected for this cut

- contribution to cross sections:

- overall: ~ 1.5%
- highest z bin: ~ 5%



B meson decays

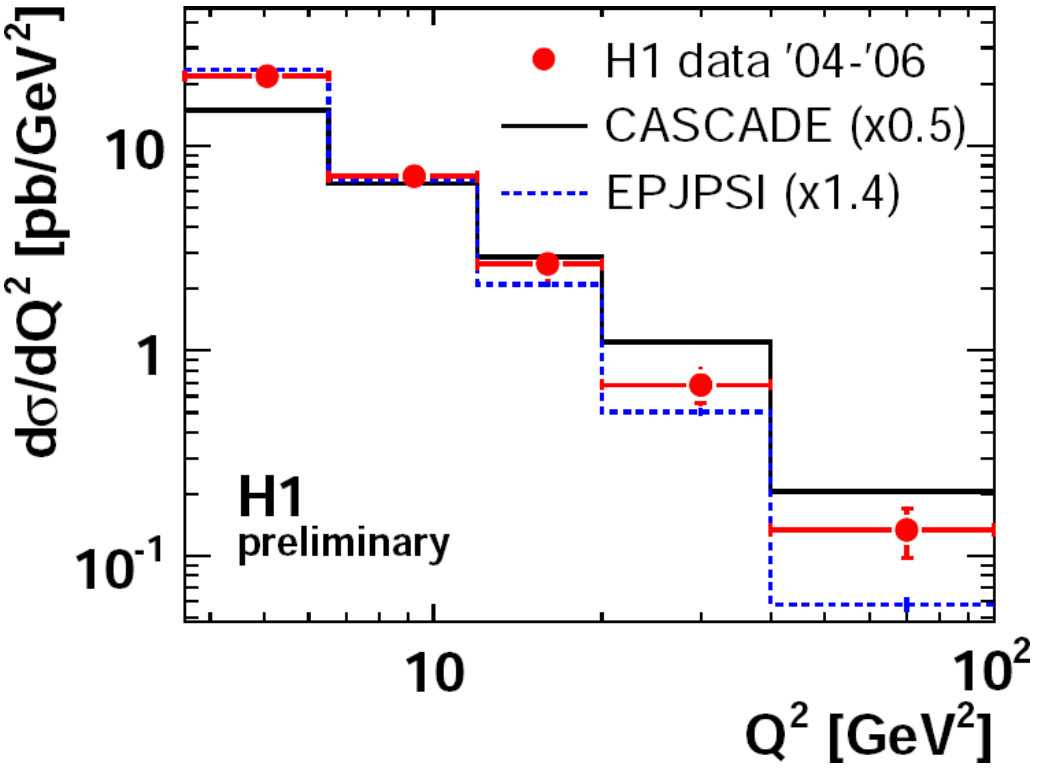
- low z region
- high track multiplicity
- large P_T(J/Ψ)

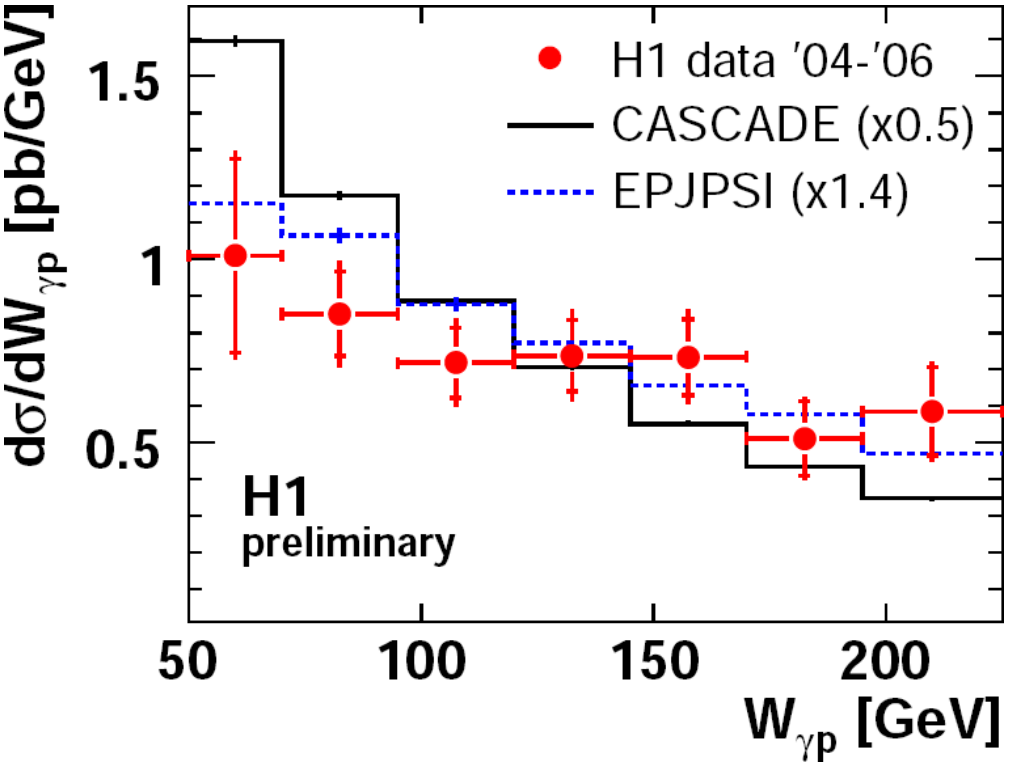
- contribution to cross sections:

- overall: ~ 3.5%
- lowest z bin: ~ 20%

$\rightarrow$ contributions are not subtracted from cross sections

cross sections





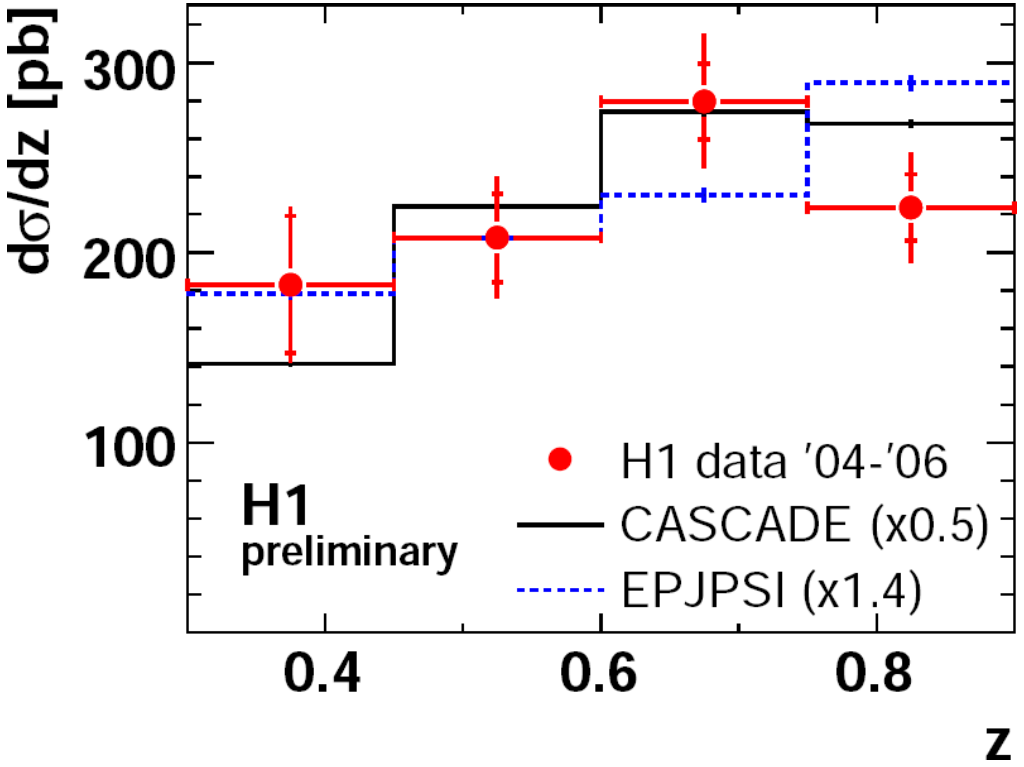
CS LO (EPJPSI MC):

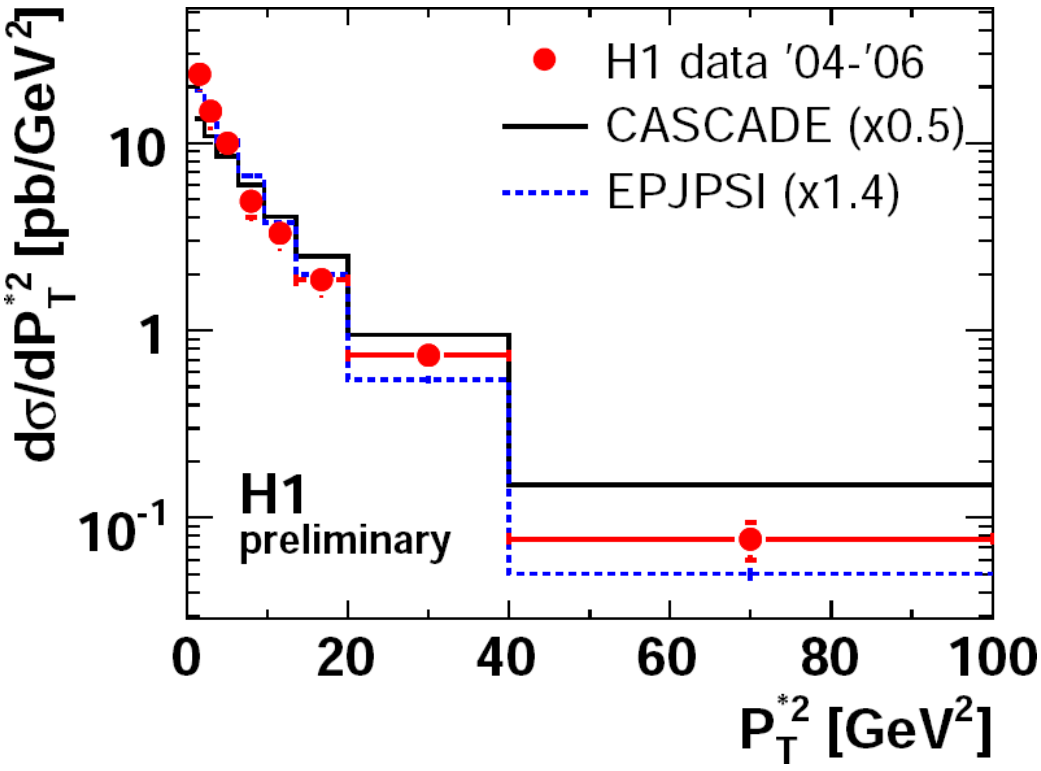
- DGLAP evolution
- normalization too low
- Q^2 shape too steep

CS LO using kt-factorization (CASCADE MC):

- CCFM evolution
- unintegrated gluon density
  - off-shell gluon allowed
- normalization too high
- Q^2 shape too hard
- $W_{\gamma p}$ fall-off somewhat steeper

cross sections





- shape of inelasticity z in good agreement with CS LO MC cross sections

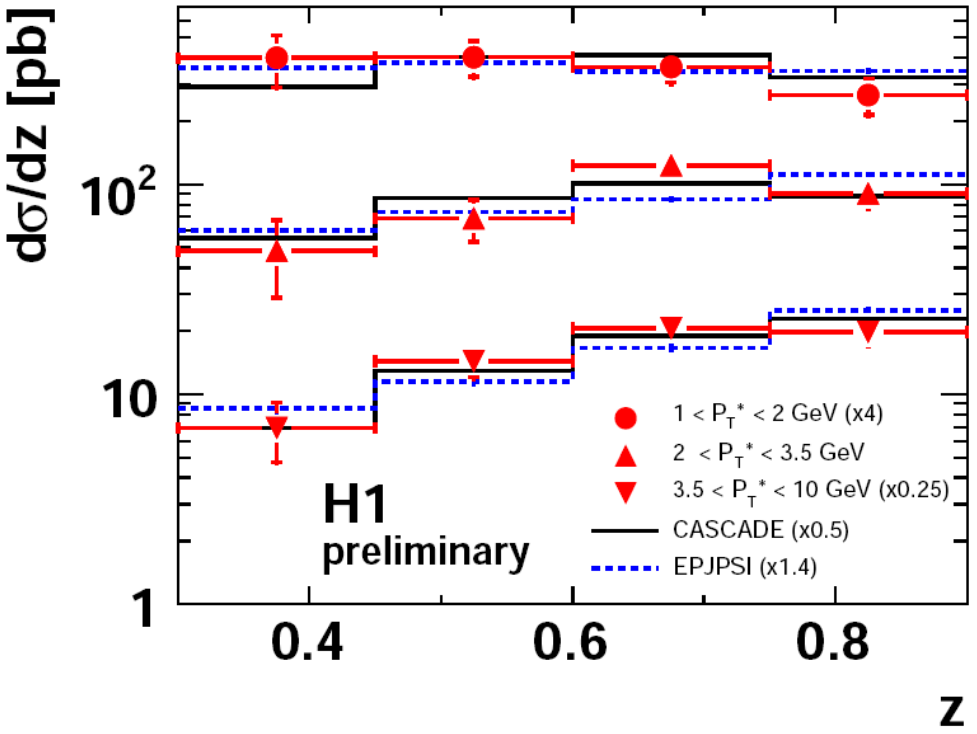
- P_T spectrum of CS LO with kt-factorization (CASCADE MC) somewhat too hard

cross sections

as function of inelasticity z in bins of P_T^*

- good agreement with CS LO MC
  - overall,
  - in bins of P_T^* and
  - especially at large values of z
- normalization somewhat wrong

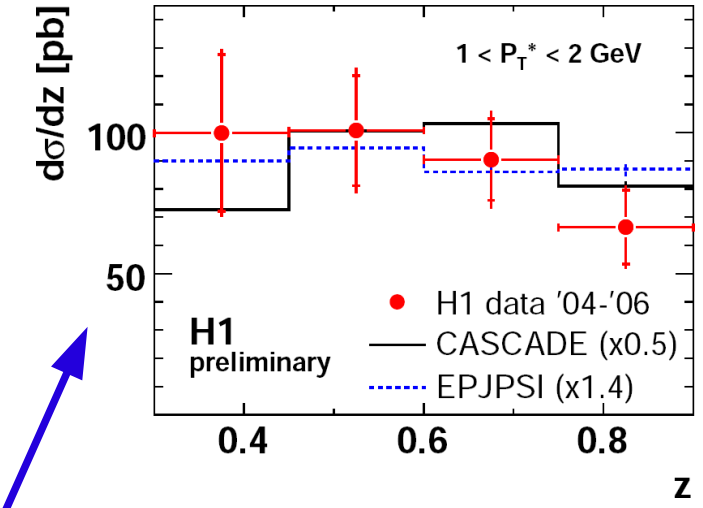
→ no indication for other contributions

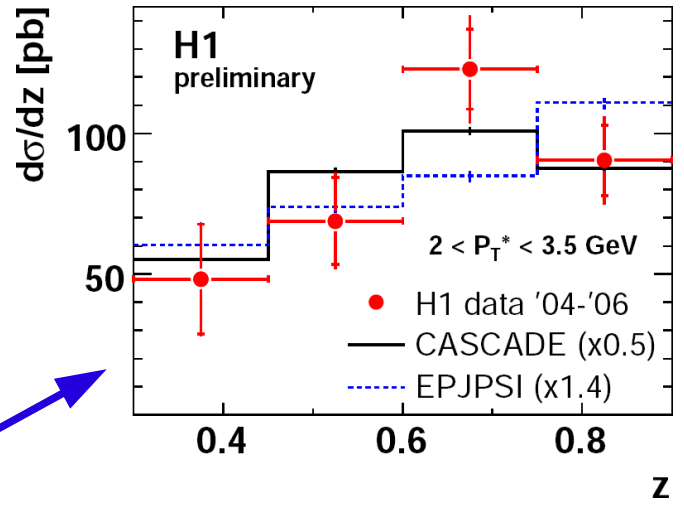


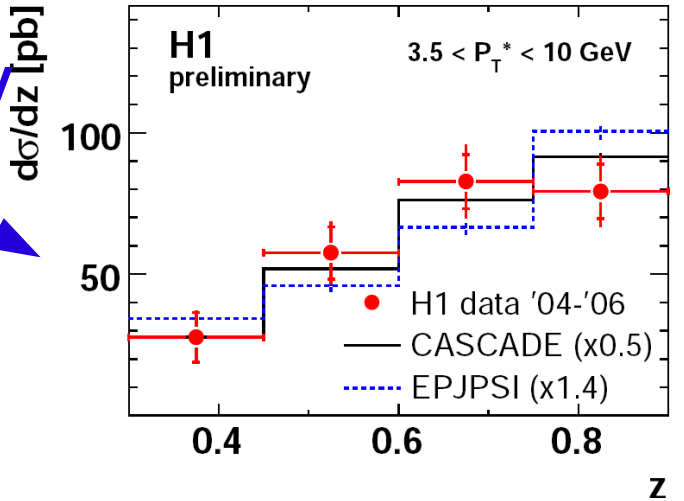
$1 < P_T^* < 2$ GeV

$2 < P_T^* < 3.5$ GeV

$3.5 < P_T^* < 10$ GeV





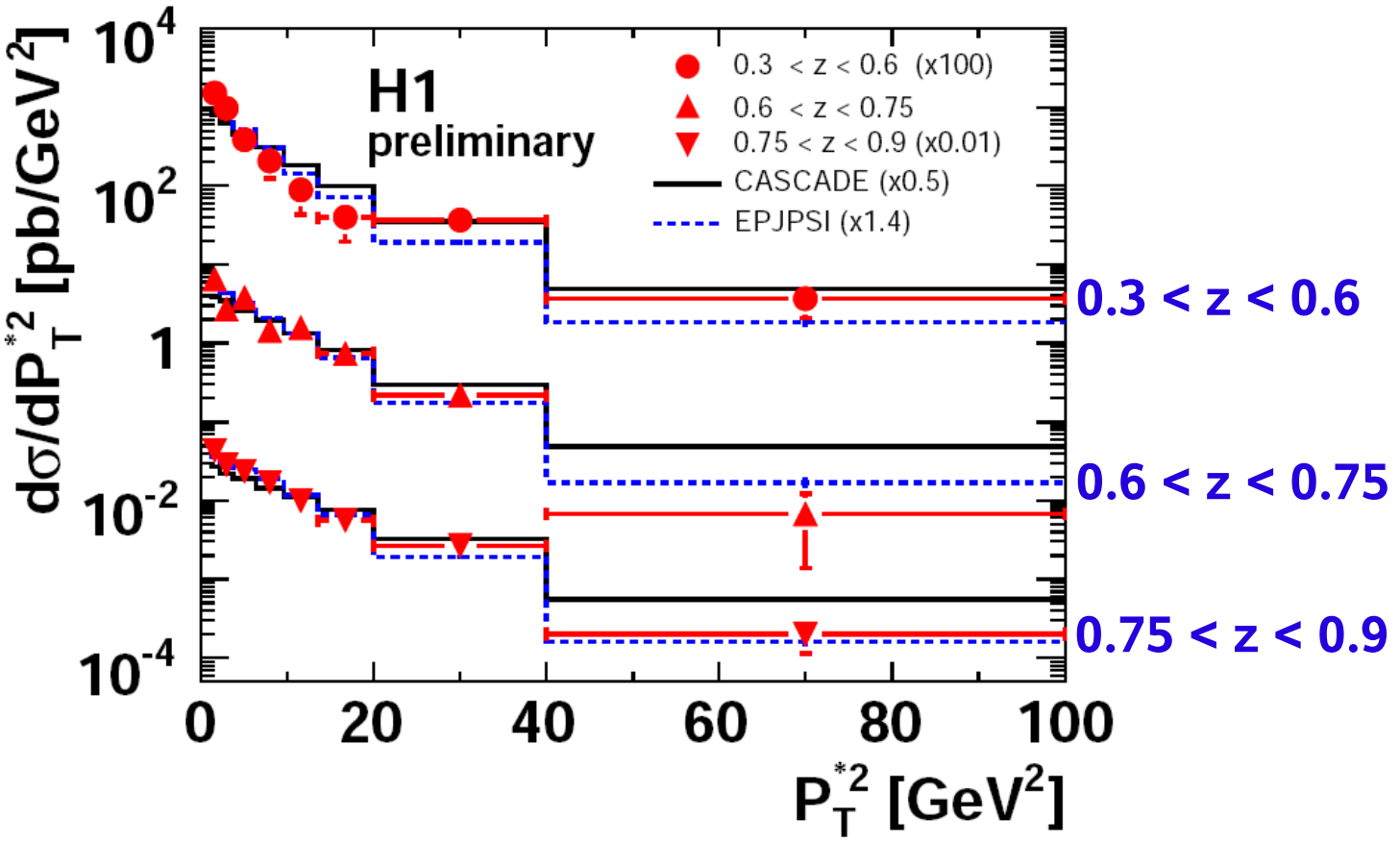


cross sections

as function of P_T^{*2} in bins of z

- P_T^* spectrum becomes harder with increasing z
- in agreement with CS LO MC cross sections

→ no indication for other contributions



summary

new H1 measurement of inelastic J/Ψ in HERA II data

- improved signal purity / reduced background from diffr. Ψ(2S)
- higher luminosity
  - so far 75% of HERA II luminosity analyzed
  - smaller statistical and systematic errors

results agree with CS (LO) MC predictions

- no indication for other contributions
- additional contributions have to be
  - similar to CS (LO) in shape or
  - small

no recent theory calculations available

outlook

perform analysis with combined HERA I+II data

- factor 2 more statistics

extend analysis to photoproduction regime

measure polarization of J/Ψ meson