Les Arcs, 24/03/03
XXVIIIth Rencontres de Moriond

Charm in electron-proton collisions

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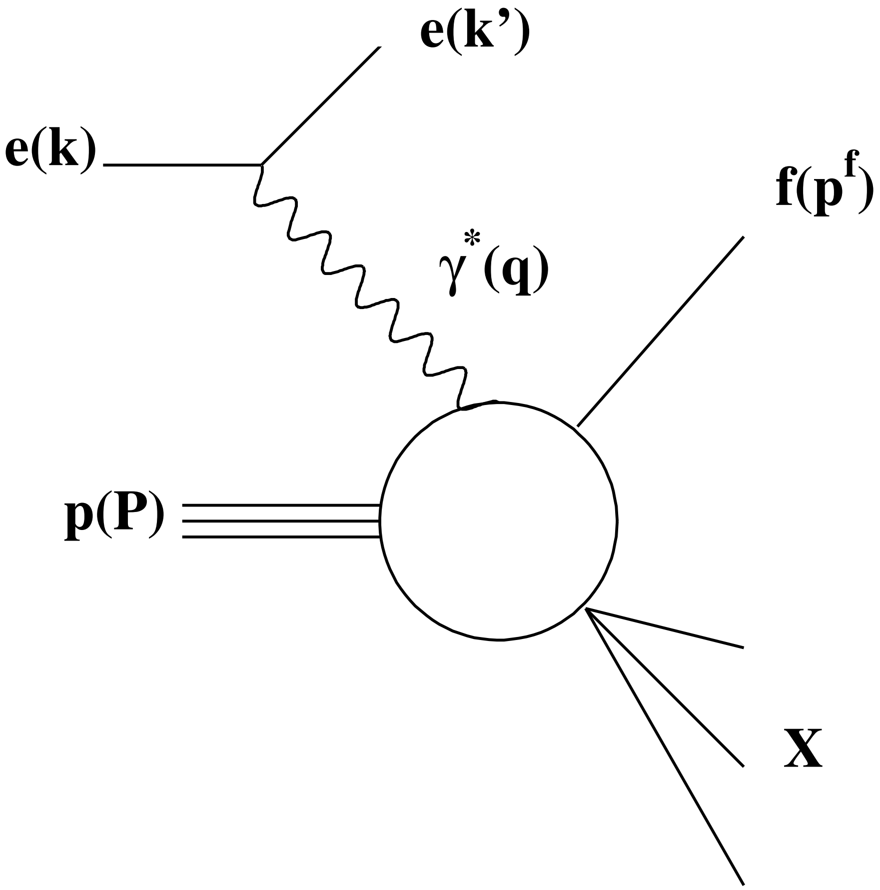
on behalf of the ZEUS and H1 Collaborations

- inelastic J/ψ in PHP
- inelastic J/ψ in DIS
- $D^{\star}$ in PHP

HERA kinematics



27.5 GeV $e^{\pm} \Longrightarrow \Longleftarrow$ 820 / 920 GeV p

- $Q^2 \equiv -q^2$

  $Q^2 < 1$ GeV^2 $\Leftrightarrow$ PHP regime

  $Q^2 >$ a few GeV^2 $\Leftrightarrow$ DIS regime

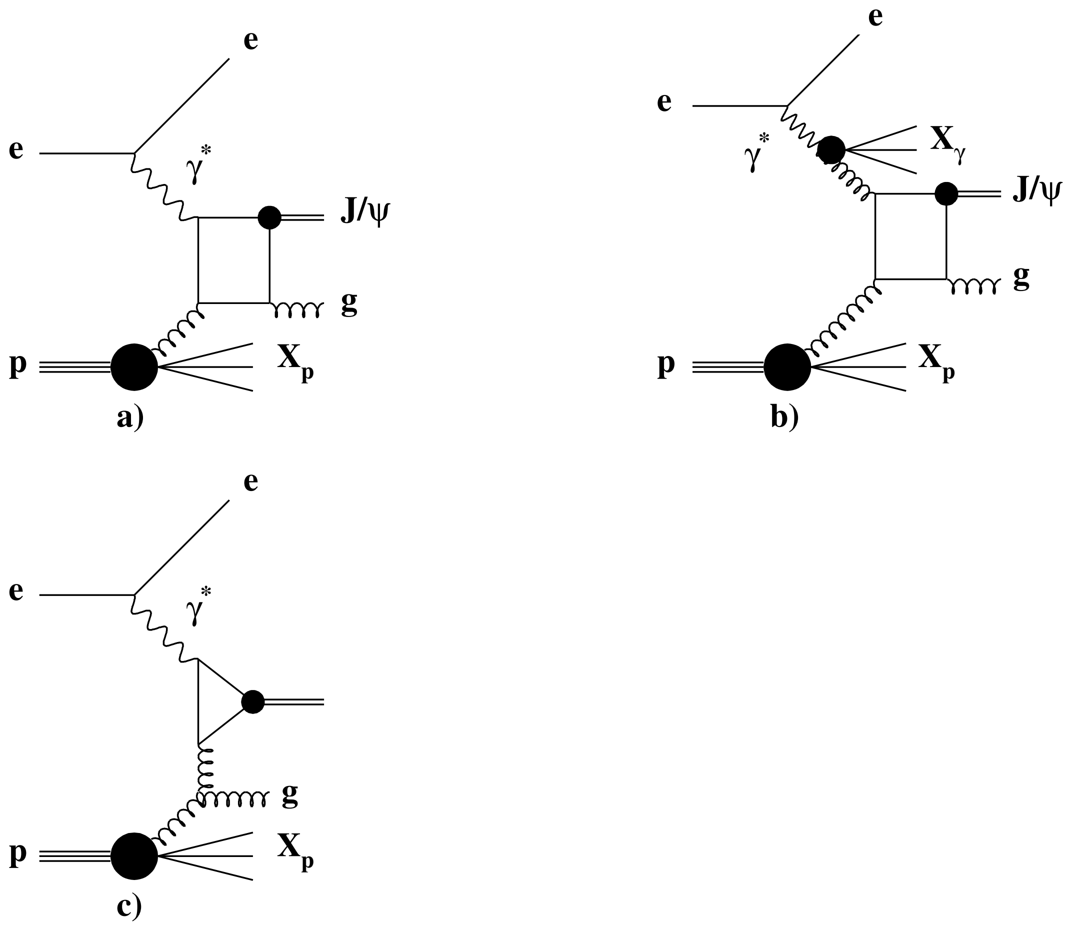
- $W^2 \equiv (P + q)^2$

- $z \equiv p^f \cdot P \ / \ q \cdot P$

  $(f = J/\psi, \ D^{\star}, \ ...)$

  $z = E_f \ / \ E_{\gamma^{\star}}$ in the p rest frame

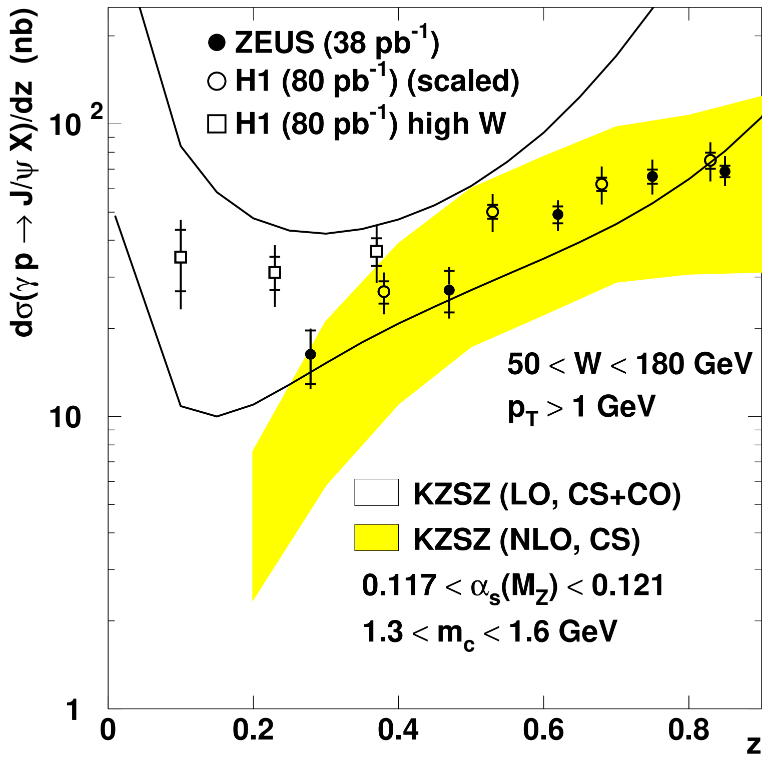
Inelastic J/ψ: main processes

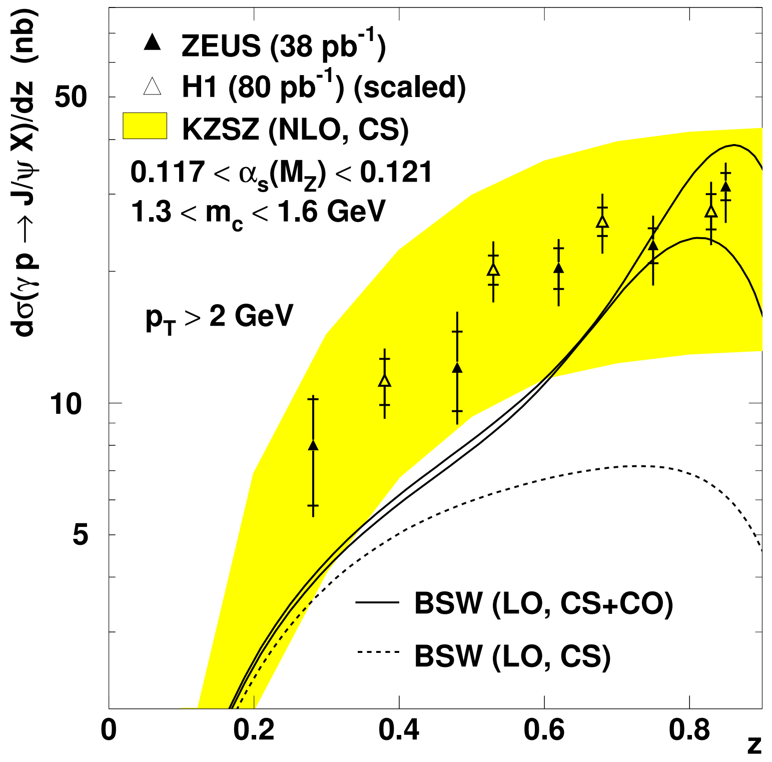


30 years after J/ψ discovery still investigating production mechanisms

- a: CSM direct–γ process: only one LO diagram, no free parameters ! $0.2 \lesssim z < 0.9$
- b: CSM resolved–γ process: only one LO diagram, no free parameters ! z $\lesssim 0.2$
- c: CO direct/resolved–γ processes: many LO diagrams, many free parameters, the color octet matrix elements, extracted from J/ψ data

Inelastic J/ψ in PHP: inelasticity distribution

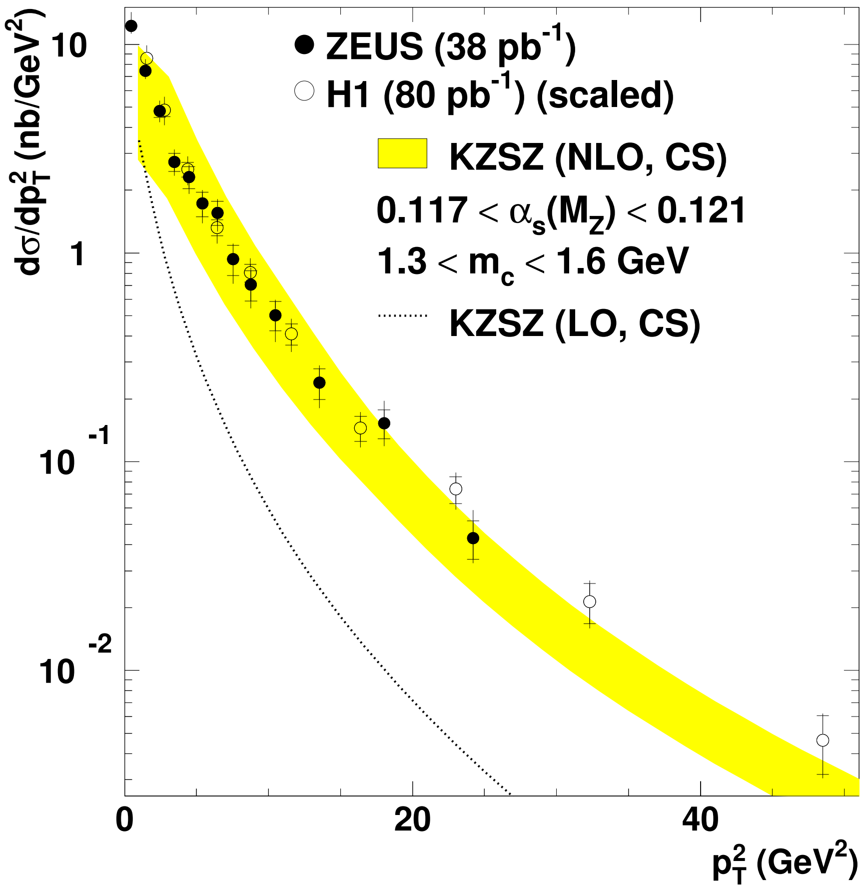


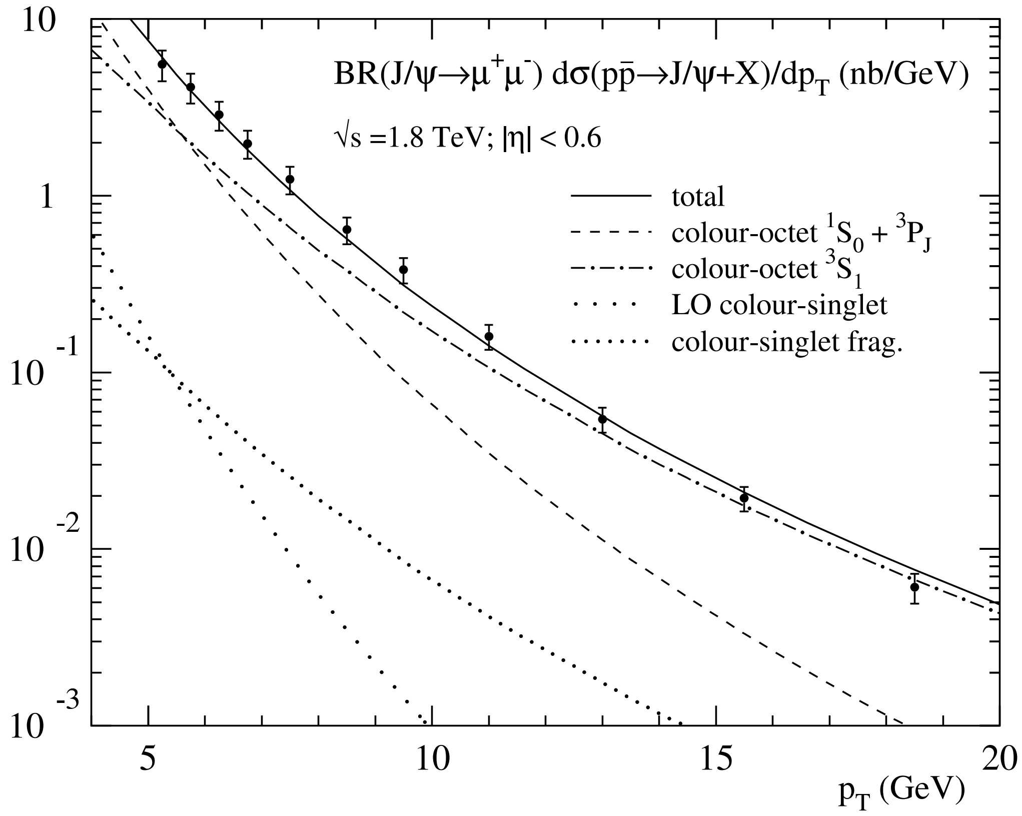


theoretical uncertainties does not allow strong conclusions on CO

enhanced theoretical treatment in the high z region

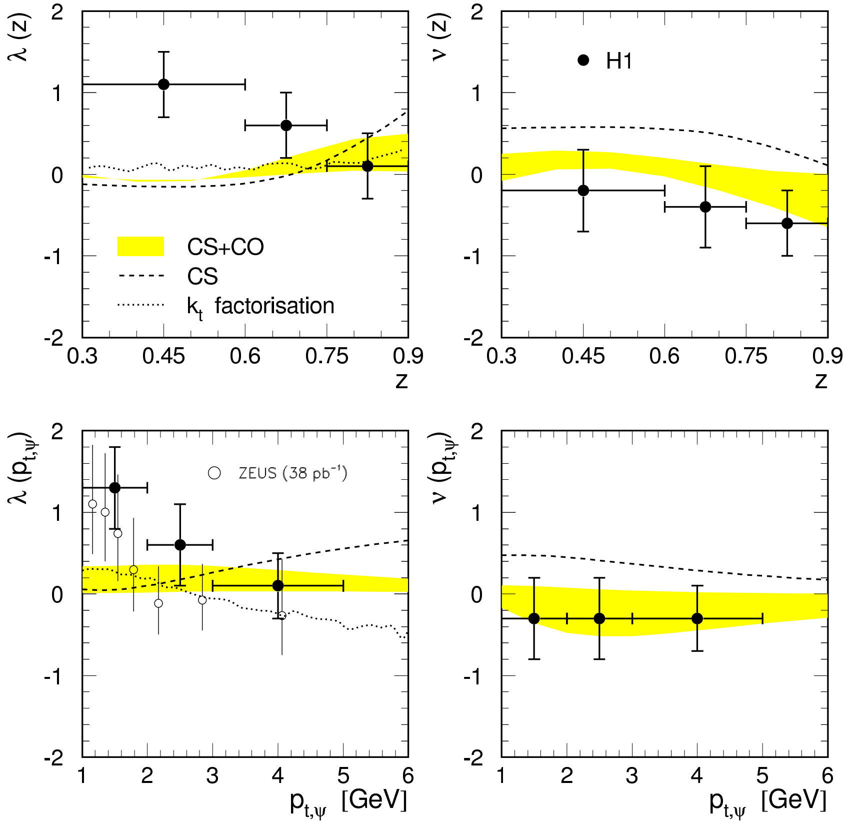
Inelastic J/ψ in PHP: p_T^2 distribution





at HERA direct–γ NLO fills the gap between data and theory ...

Inelastic J/ψ in PHP: polarization studies



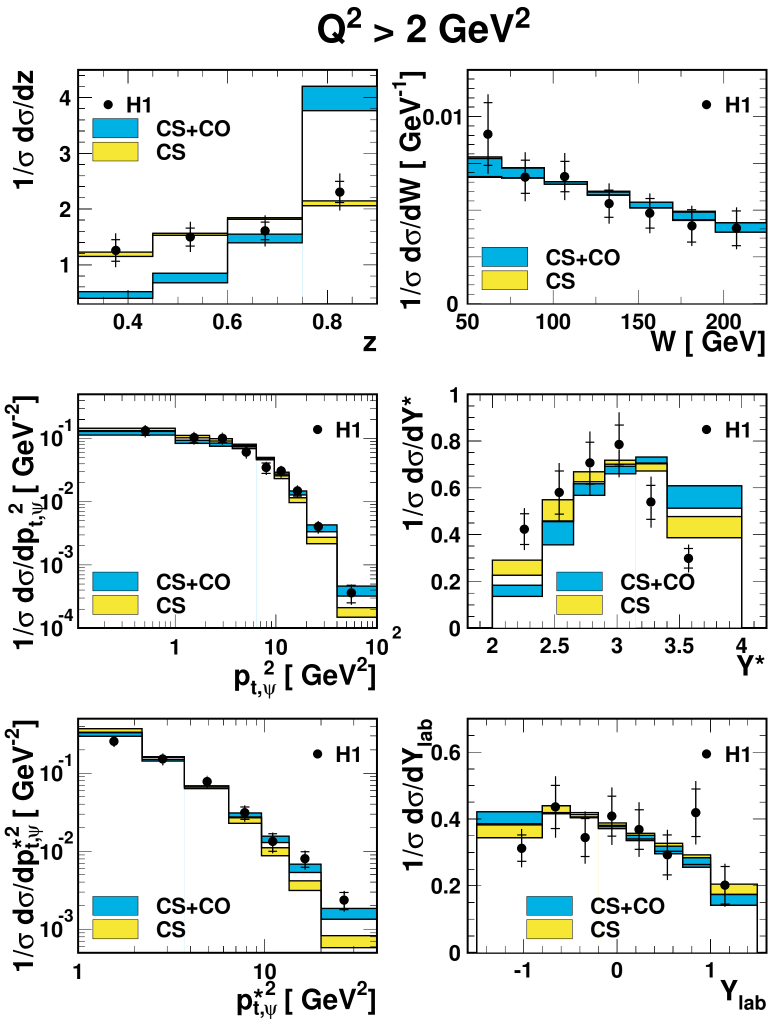
$\lambda \Leftrightarrow$ polar distribution of the μ^+ w.r.t. the J/ψ in the p rest frame

$\nu \Leftrightarrow$ azimuthal distribution of the μ^+ w.r.t. the J/ψ in the p rest frame

advantage: smaller theoretical uncertainties with respect to cross section predictions

both HERA and the TEVATRON can play this game

Inelastic J/ψ in DIS



advantage with respect to PHP: CO terms are expected to be enhanced with respect to the CS contribution

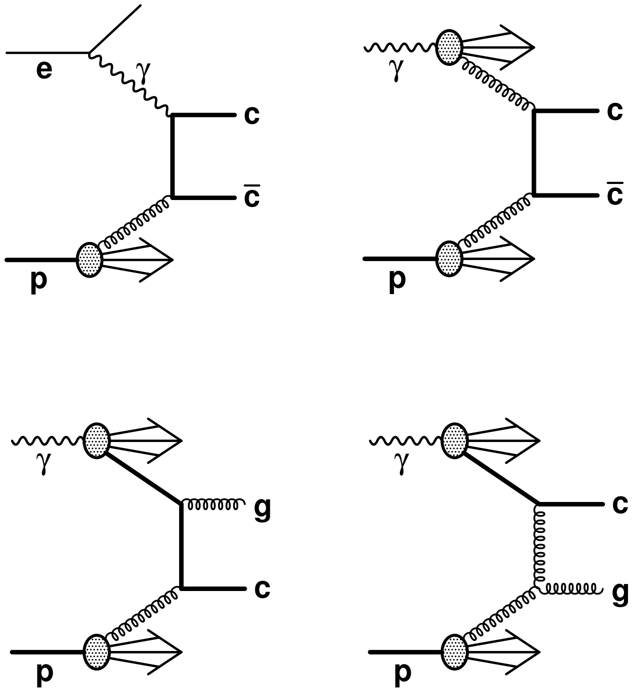
the z distribution has a CS–like shape

but the CS LO contribution undershoots the data by a factor ~ 2.5

Summary on inelastic J/ψ

- precise data over most of the phase space
- more NLO predictions would help
- polarization studies will improve with HERA II data
- HERA can contribute, together with the TEVATRON, to clarify charmonium production mechanisms

D meson production: main processes

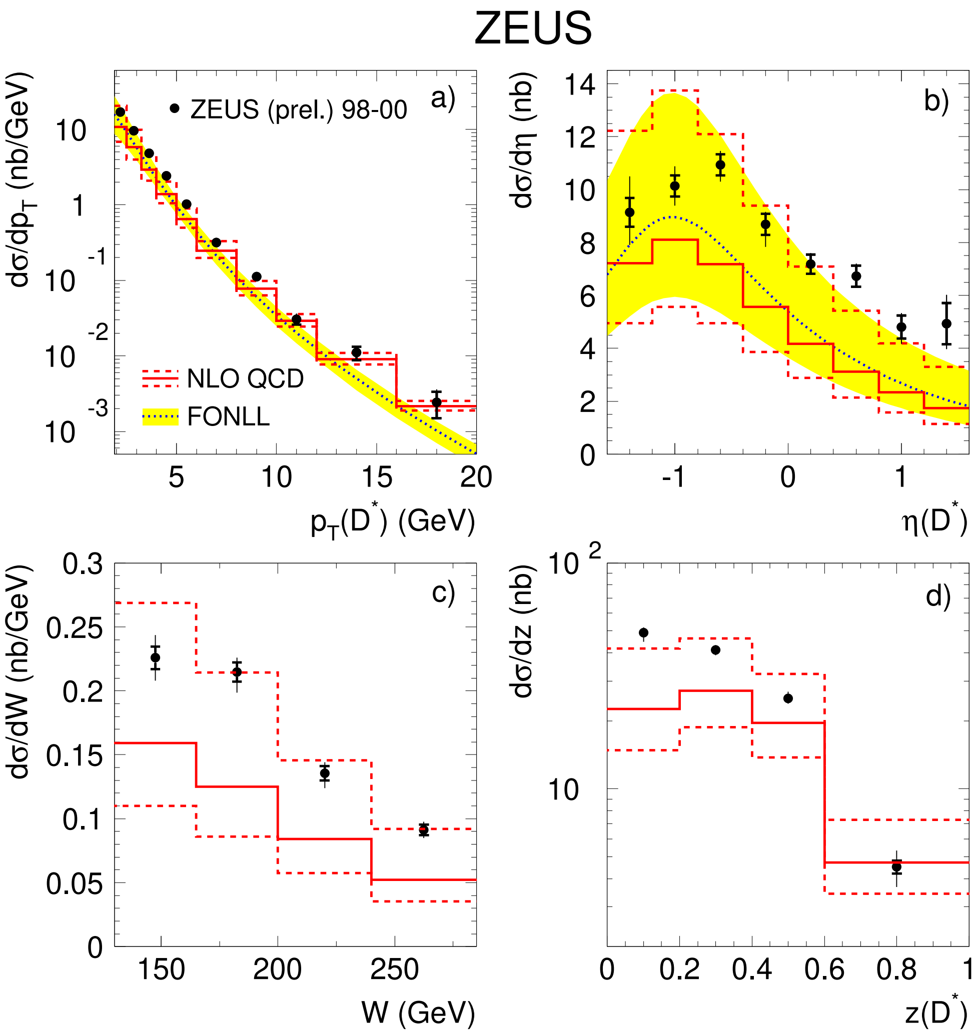


aim: probe the p and γ parton content

- direct–γ processes
- resolved–γ processes
- γ flavor excitation processes where c, like the others light quarks and the g, is considered an active flavor in the γ
- the c polar spectra in the parton–parton rest frame depends on the spin, S, of the exchanged propagator (Rutherford experiment)

$$d\sigma/d|\cos\theta^{\star}| \approx (1 - |\cos\theta^{\star}|)^{-2S}$$

Inclusive $D^{\star}$ in PHP



$D^{\star\pm} \to D^0(\to K^{\mp}\pi^{\pm})\pi^{\pm}$

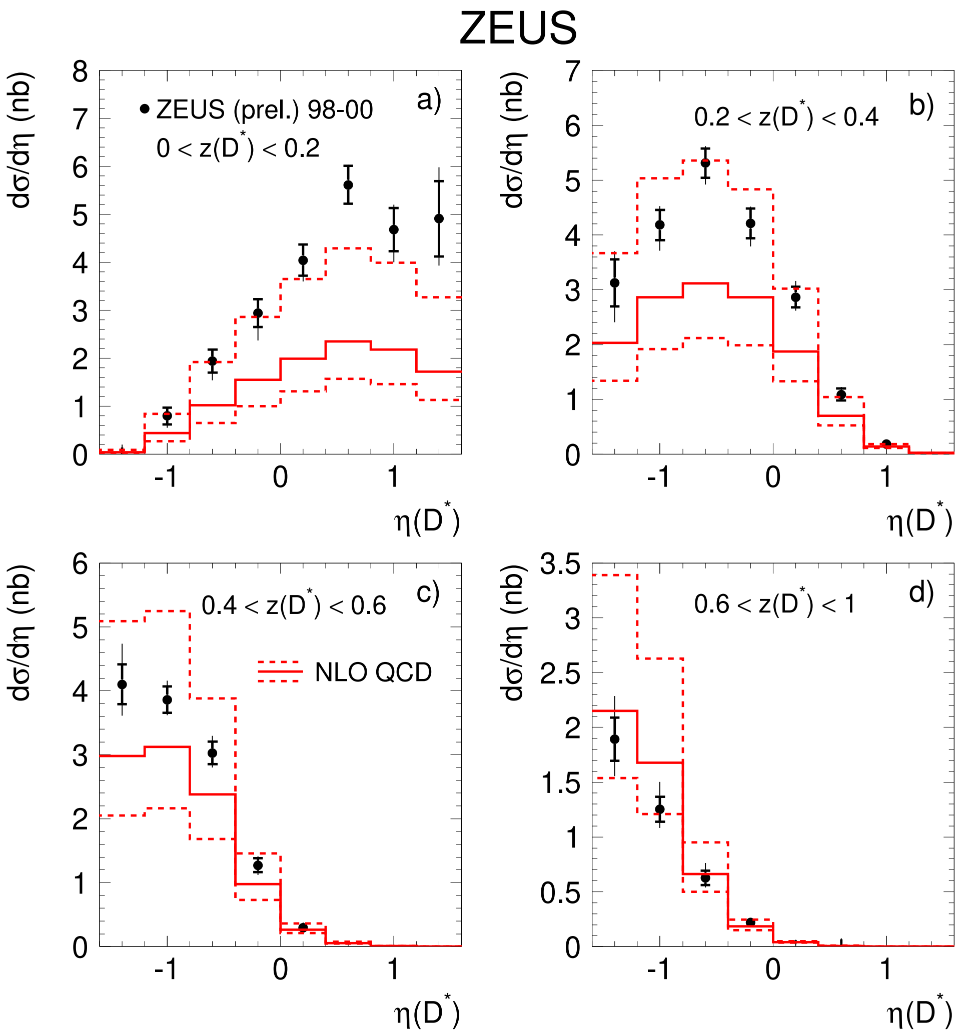
NLO: c quarks are perturbatively produced only

FONNL: incorporate mass effects up to NLO and resumms p_T logarithms up to the NLL level

NLO describes data in the forward region and at low z only using extreme parameters ($m_c = 1.3$ GeV)

for $0.6 < z(D^{\star}) < 1$ NLO describes the data well

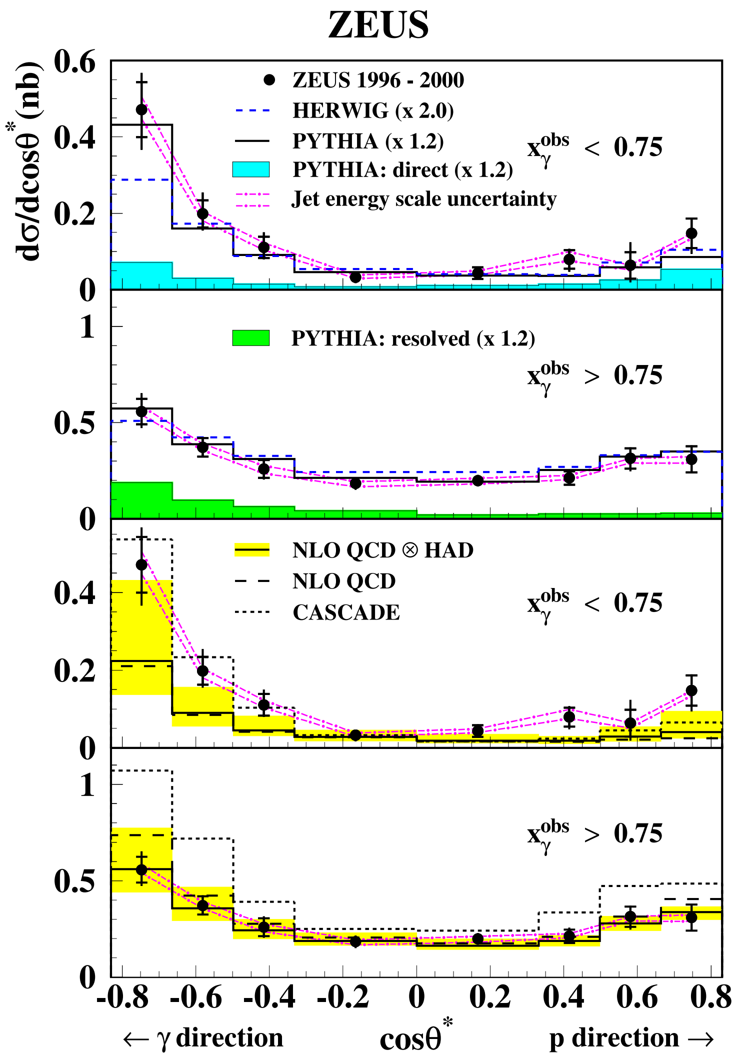
Inclusive $D^\star$ in PHP



the agreement between data and NLO degrades progressively with decreasing $z(D^\star)$

high $z(D^\star)$ region $\Leftrightarrow$ direct–γ processes are well described by NLO

Charmed dijet angular distributions



$$x_\gamma^{obs} = \frac{\Sigma_{jets} E_t^{jet} e^{-\eta^{jet}}}{2yE_e}$$

resolved–γ / direct–γ $\Leftrightarrow$ $x_\gamma^{obs} \lessgtr 0.75$

$\vartheta^\star$ $\equiv$ angle between the jet–jet axis and the p–γ axis in the parton–parton rest frame

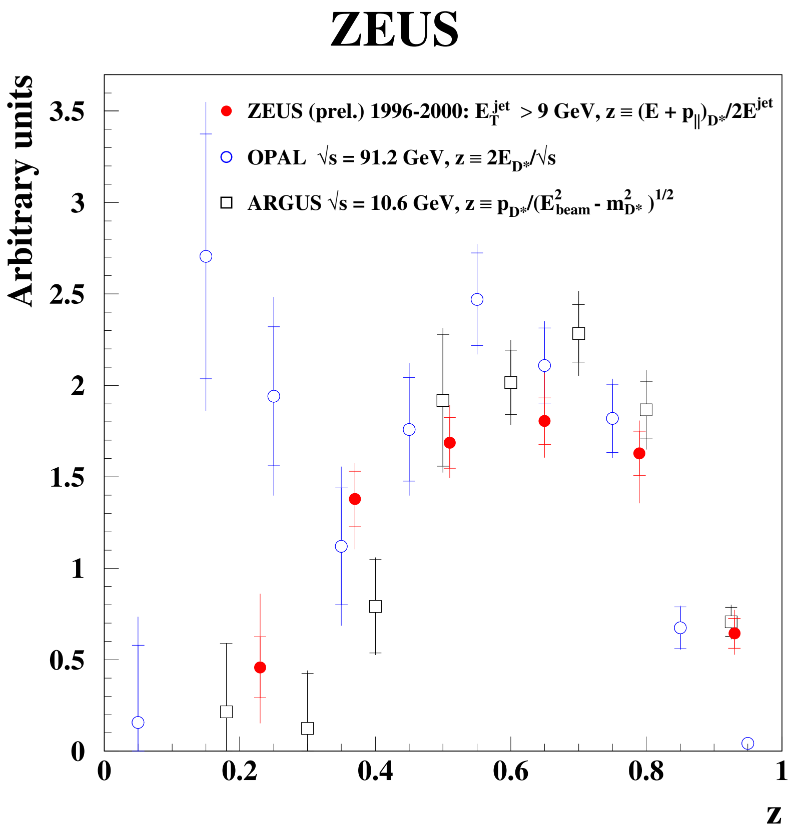
$$d\sigma/d|\cos\theta^\star| \approx (1 - |\cos\theta^\star|)^{-2S}$$

peak in the γ direction for resolved–γ events due to spin 1 propagator

$\rightarrow$ gluon exchange

$\rightarrow$ c in the γ

Charm fragmentation



$$f(z) \propto \frac{1}{[z(1-1/z-\epsilon/(1-z))^2]}$$

$$\epsilon = 0.064 \pm 0.006^{+0.011}_{-0.008}$$

- vector / (pseudoscalar + vector) ratio

  $P_V \equiv D^{\star +}/(D^+ + D^{\star +} \cdot BR(D^{\star +} \to D^0 \pi^+))$

  $0.693 \pm 0.045 \pm 0.010$ (H1 prelim.)

  $0.546 \pm 0.045 \pm 0.028$ (ZEUS PHP prelim.)

- strangeness suppression factor

  $\gamma_s \equiv 2D_s^+/(D^+ + D^0)$

  $0.36 \pm 0.10 \pm 0.08$ (H1 prelim.)

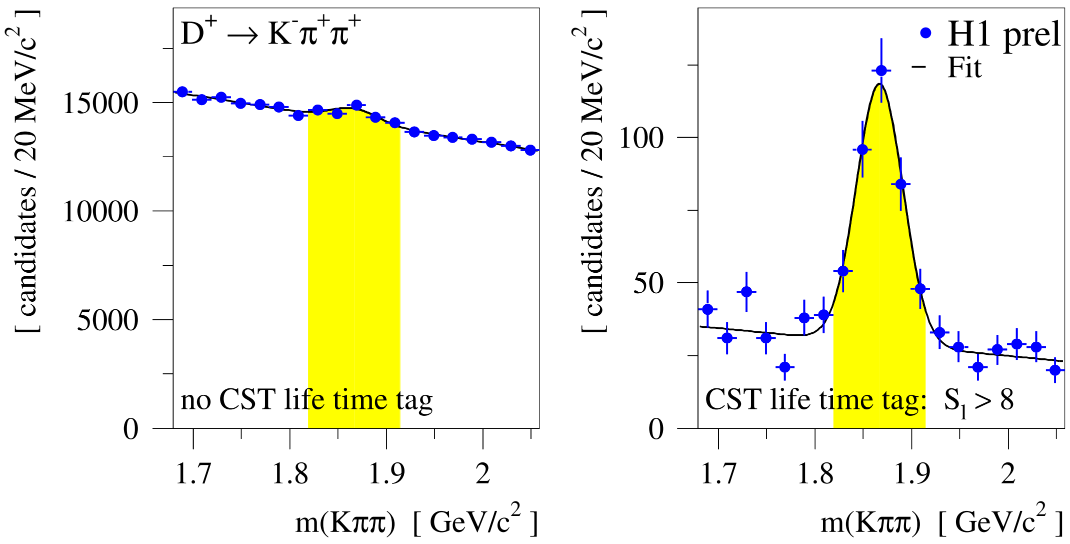
  $0.27 \pm 0.05 \pm 0.07$ (br.) (ZEUS PHP)

agreement with LEP data

Summary on D mesons

- QCD describes the DIS region (cf F_2^c studies)
- QCD also works where direct–γ processes are dominant
- the resolved–γ part can be presently understood only by adding c quarks to the γ structure

much more will come from the analysis of HERA II data due to improved detectors and higher luminosity



HERA I data, 48 pb^{-1}