Diffractive D* Production in DIS at H1

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on behalf of the H1 Collaboration

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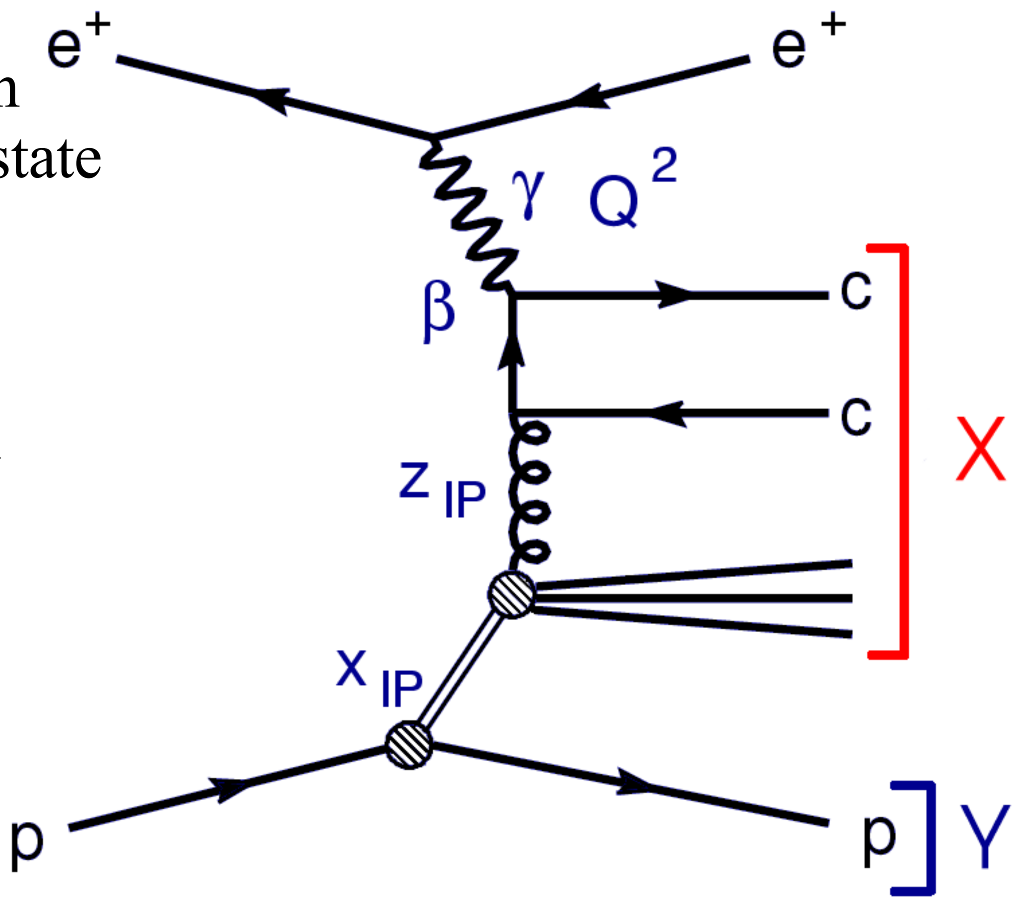
D* Production in Diffractive DIS

- Process: $ep \longrightarrow e\ D^{*\pm} X'\ Y$
- Two distinct hadronic systems
- X contains at least one D^* meson
- Y: elas scattered p or low mass state

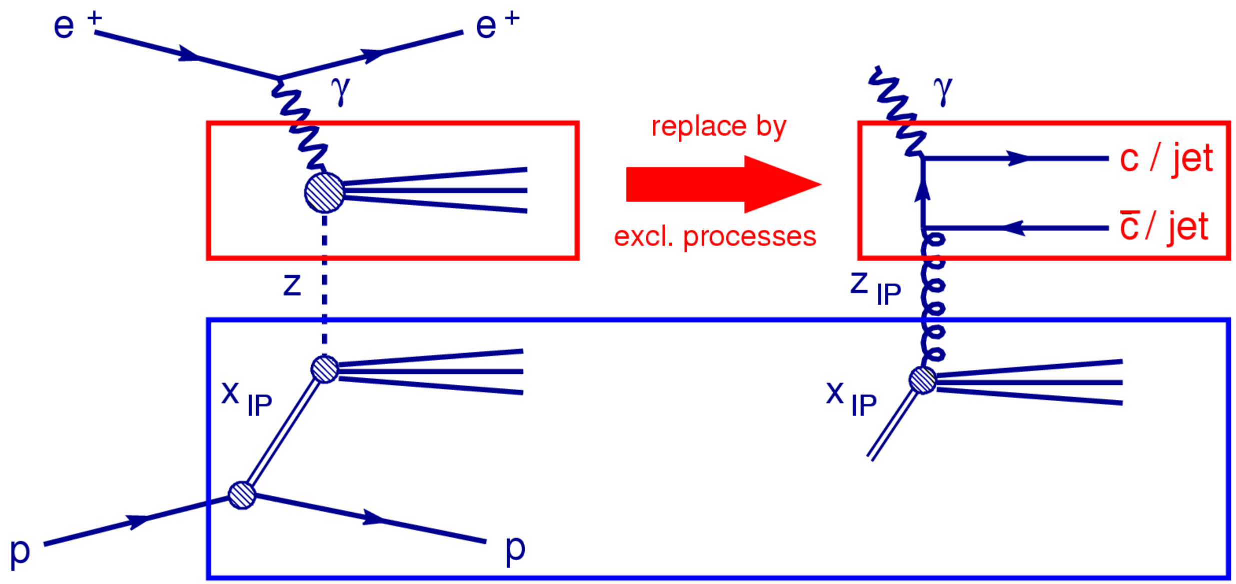
- x_{IP}: longitudinal momentum fraction of diffractive exchange relative to proton
- β: longitudinal momentum fraction of quark entering hard subprocess relative to diffractive exchange
- z_{IP}: longitudinal momentum fraction of gluon relative to diffractive exchange



QCD Factorisation in Diffractive DIS

Factorise diffractive DIS into diffractive PDFs and hard scattering matrix elements

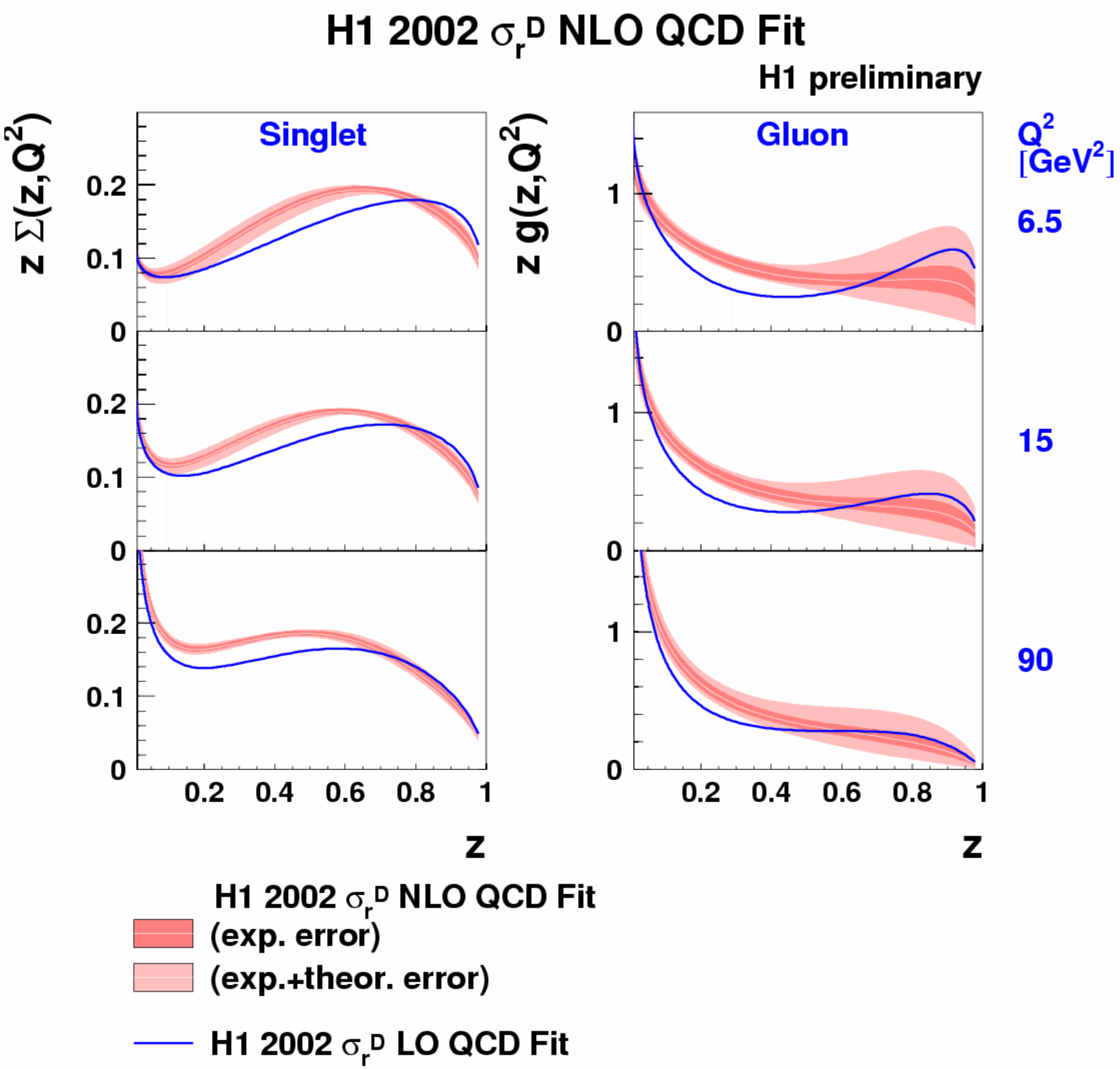
$$\sigma(\gamma^* \rightarrow XP) \sim p_{q/p}(x_{IP}, t, x, Q^2) \otimes \sigma_{\gamma^* q}(x, Q^2)$$



- universal diffractive parton densities
- hard scattering matrix element same as incl. heavy flavour prod.

$\Rightarrow$ directly sensitive to gluon content of diffractive exchange

Diffractive Parton Densities



- Gluon contribution dominates (~75% of momentum of diffractive exchange)
- Singlet distribution well constrained
- Increased uncertainties for gluon distribution at higher *z*
- Boson-gluon fusion processes provide test of gluon diffractive PDFs (e.g. diffractive dijet and charm)

Event Selection

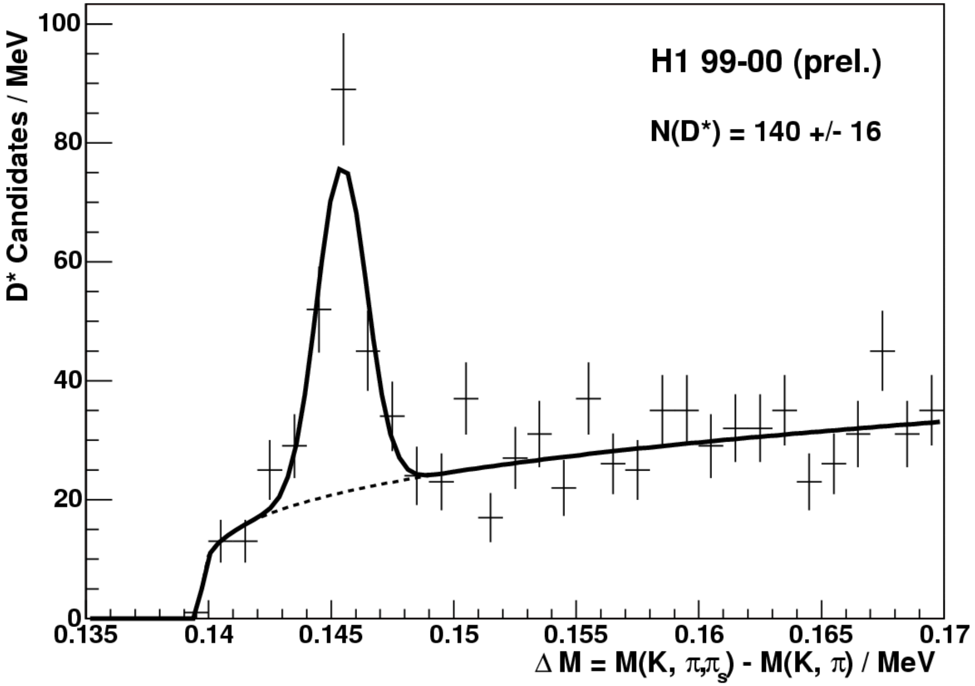
1999-2000 $\mathscr{L}$=42.6 pb^{-1}

Kinematic Phase Space:

- $2 < Q^2 < 100$ GeV^2
- $0.05 < y < 0.7$
- $p_T(D^*) > 2$ GeV
- $|\eta(D^*)| < 1.5$

Diffractive Selection:

- $M_Y < 1.6$ GeV
- $|t| < 1$ GeV^2
- $x_{IP} = \frac{Q^2 + M_X^2}{Q^2 + W^2} < 0.04$



Diffractive $D^{*\pm}$ yield: N(D^*) = 140 ± 16

Dominant systematic errors:

- Track efficiency: ±8%
- Model uncertainties (including p dissociation): ±12%

Total Diffractive $D^{*\pm}$ Cross Section

- H1 99-00 Prelim:

$$2 < Q^2 < 100 \text{ GeV}^2,\ 0.05 < y < 0.7,\ x_{IP} < 0.04,\ M_Y < 1.6 \text{ GeV},$$
$$t < 1 \text{ GeV}^2,\ p_{T,D^*} > 2 \text{ GeV},\ |\eta_{D^*}| < 1.5$$

$$\sigma_{\text{vis}}(ep \rightarrow e\, D^{*\pm}\, X' Y) = 333 \pm 38(stat.) \pm 57(sys.)\,\text{pb}$$

- H1 96-97:

$$\sigma_{\text{vis}}(ep \rightarrow e\, D^{*\pm}\, X' Y) = 246 \pm 54(stat.) \pm 56(sys.)\,\text{pb}$$

- ZEUS (rescaled to H1 kinematic phase space):

$$\sigma_{\text{vis}}(ep \rightarrow e\, D^{*\pm}\, X' Y) = 305 \pm 25(stat.)^{+20}_{-34}(sys.)\,\text{pb}$$

- Good agreement between measured total cross sections

Comparison to NLO Calculation(x_{IP}<0.04)

H1 99-00 Prelim: $\sigma(ep \rightarrow e D^{*\pm} X' Y) = 333 \pm 38(stat.) \pm 57(sys.)$ pb

- NLO with NLO diffractive parton densities (HVQDIS):

Harris, Smith *Nucl. Phys* **B452** (1994) 74 L. Alvero, J.C. Collins, J.J. Whitmore, hep-ph/9806340

- NLO diff. parton densities from H1 2002 Prelim. NLO QCD fit

– QCD Parameters: m_c = 1.5 GeV, Λ_{QCD} = 0.2 GeV, N_f = 4
– Renormalisation and fragmentation scales: $\mu_f^2 = \mu_r^2 = Q^2 + 2m_c^2$
– Peterson fragmentation function: $\epsilon = 0.078$

– Uncertainties:
  - Vary μ_r^2 and μ_f^2 by ¼ and 4 (keeping $\mu_f^2 = \mu_r^2$)
  - Vary m_c = 1.35-1.65 GeV and $\epsilon = 0.035 - 0.1$

H1 2002 Prelim NLO: $\sigma_{vis}(ep \rightarrow e D^{*\pm} X' Y) = 241^{+66}_{-39}$ pb

– Prediction lower than data, but consistent within uncertainties
– Data and NLO agreement supports hard scattering factorisation

Comparison to LO Calculation (x_{IP}<0.04)

H1 99-00 Prelim: $\sigma(ep \rightarrow e\, D^{*\pm}\, X'\, Y) = 333 \pm 38(stat.) \pm 57(sys.)$ pb

- O(α_s) MEs + LO diff. parton densities (RAPGAP):

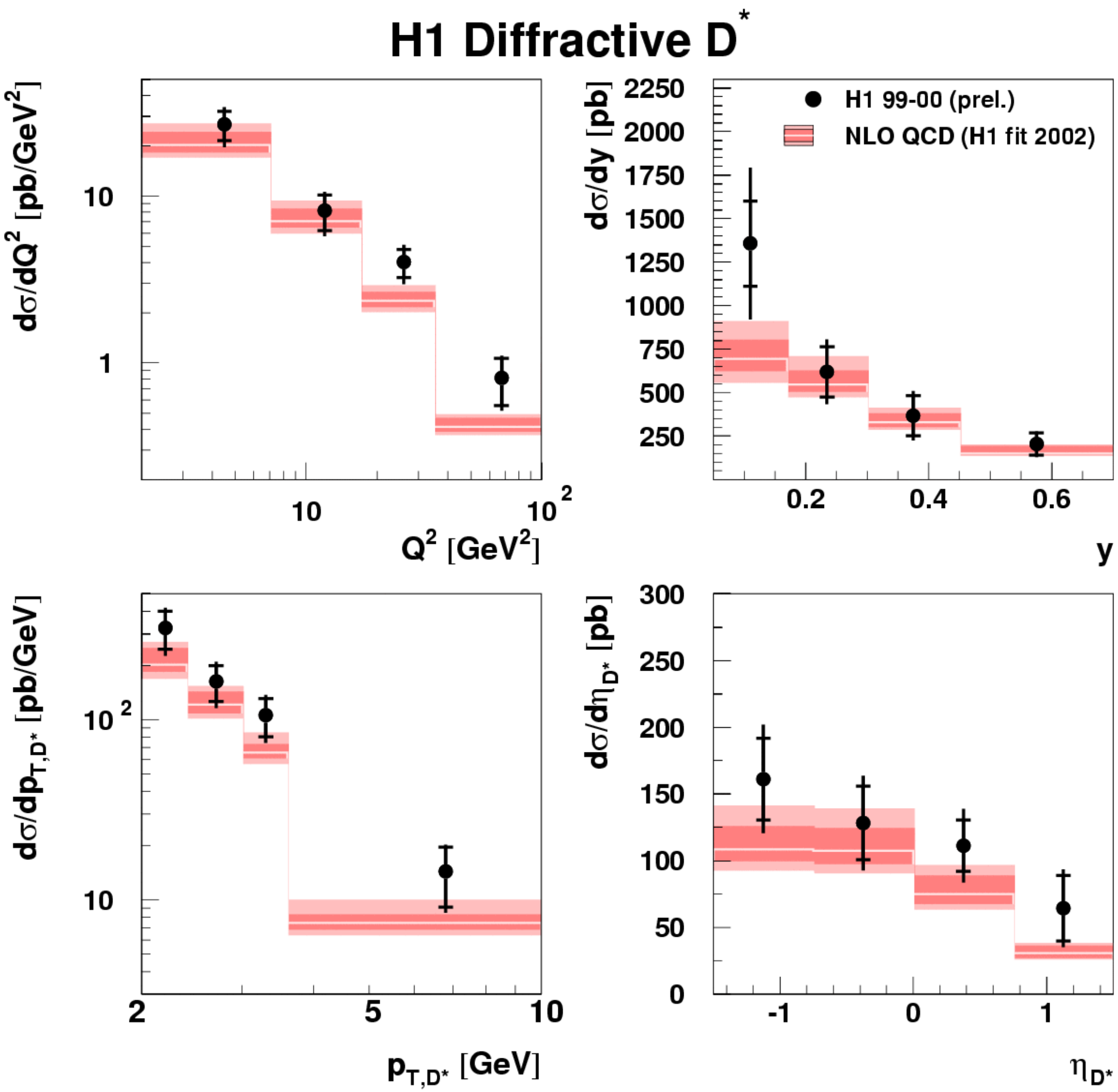
- QCD Parameters: m_c = 1.5 GeV, Λ_{QCD} = 0.2 GeV, N_f = 4
- D^* fragmentation by Lund string model
- Renormalisation and fragmentation scales: $\mu_f^2 = \mu_r^2 = Q^2 + p_T^2 + 2\, m_c^2$

H1 2002 Prelim ME+PS: $\sigma_{\text{vis}}(ep \rightarrow e\, D^{*\pm}\, X'\, Y) = 224$ pb

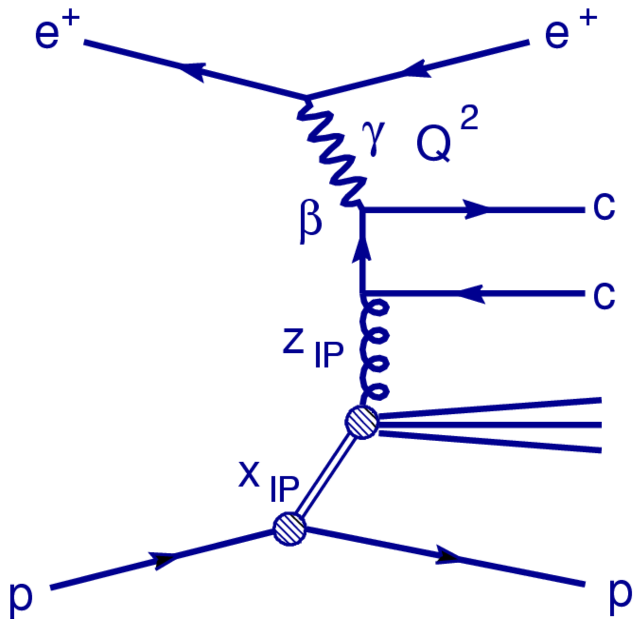
- Predictions lower than data

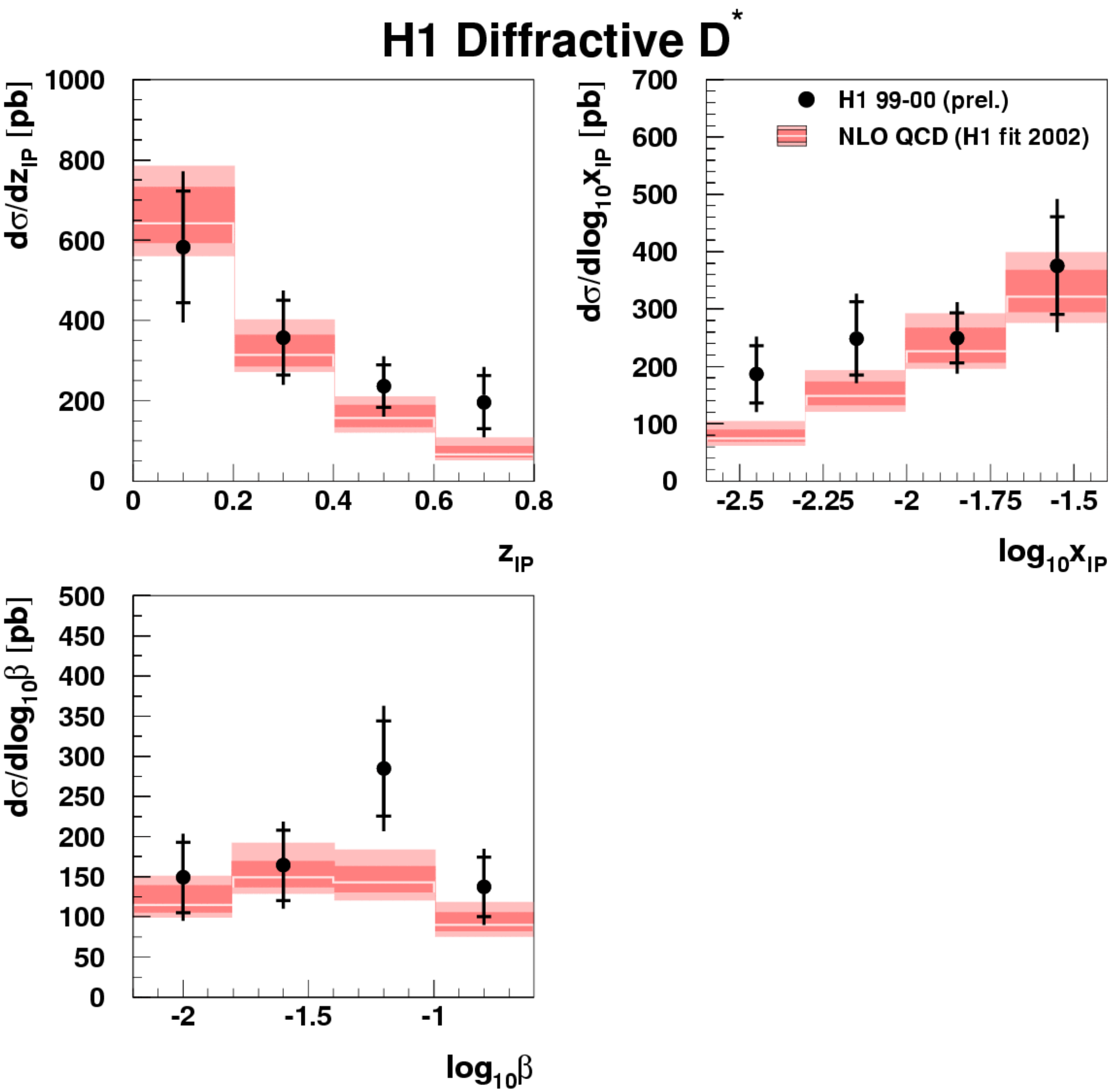
Differential Cross Sections (x_{IP}<0.04)

- Compare data to NLO calculation in collinear approach
- Inner error bar: renormalisation scale uncertainty
- Outer error bar:inner ⊕ charm mass and Peterson fragmentation uncertainties
- NLO calculations below data, but reproduce data within uncertainties



Differential Cross Sections (x_{IP}<0.04)

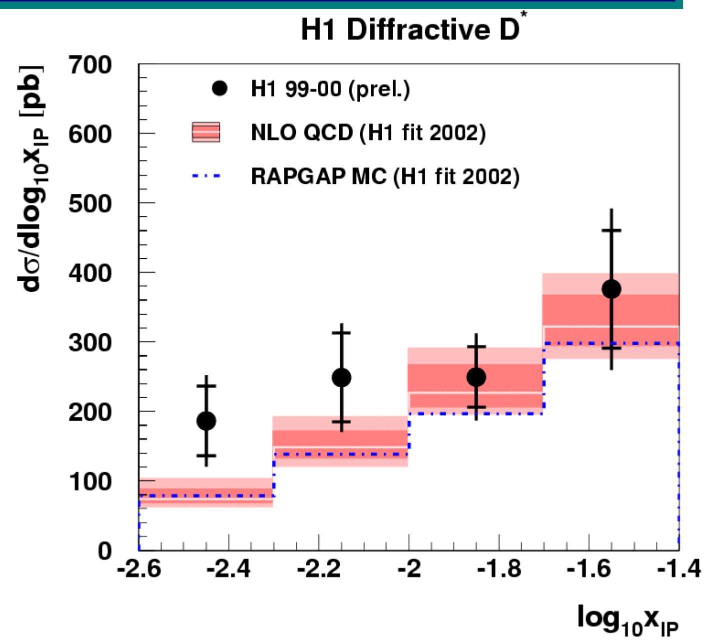




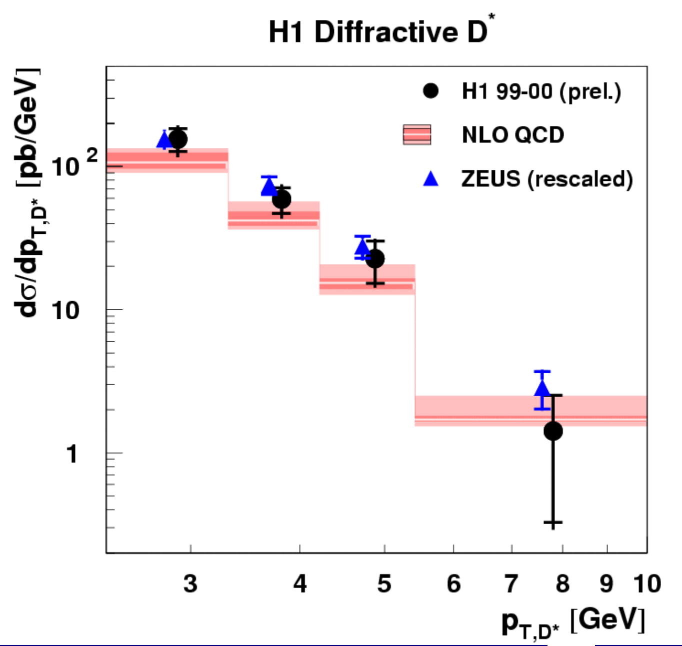
- Differential cross sections in diffractive variables also reproduced by NLO calculation within uncertainties

x_{IP} and $p_T(D^*)$ Cross Sections

- Compare x_{IP} cross section to
  - NLO calculation
  - LO calculation (RAPGAP)
- RAPGAP prediction in agreement with full NLO calculations



- Compare p_T cross section to ZEUS data rescaled to H1 kinematic range using RAPGAP
- Good agreement between H1 and published ZEUS data
- Data reproduced by NLO calculation within uncertainties

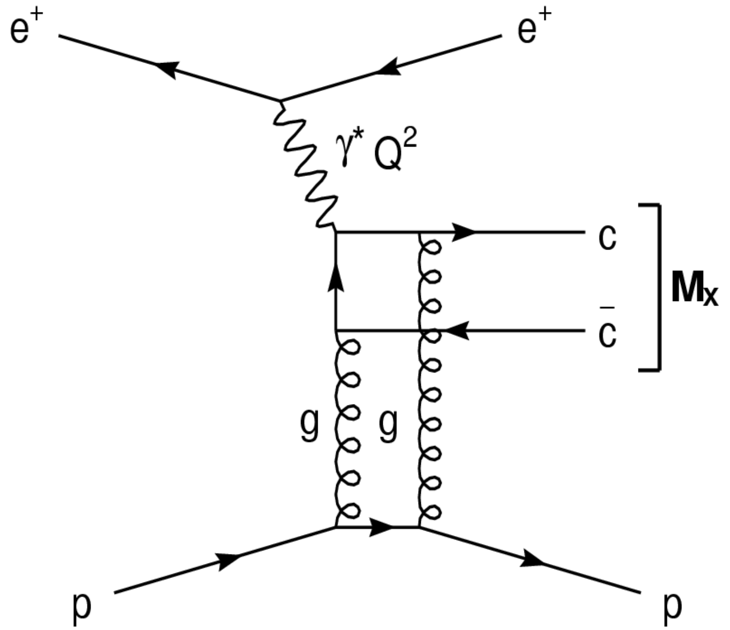


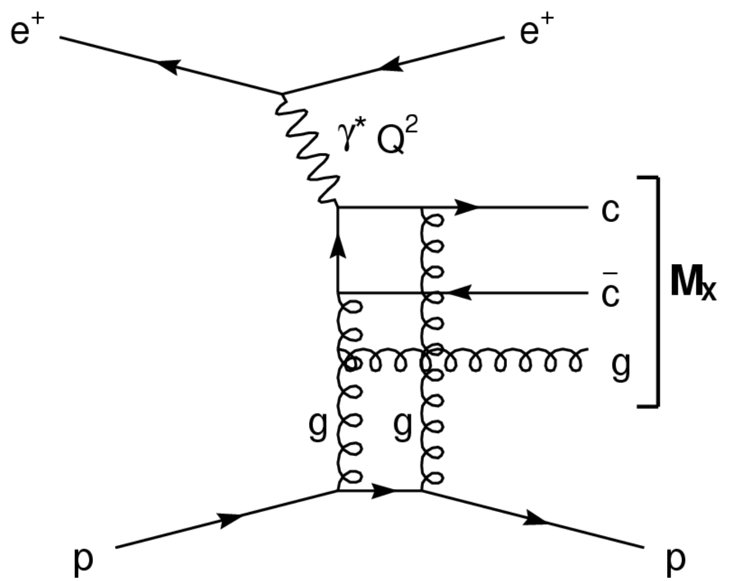
BJKLW Two Gluon Model

H. Bartels et al *Eur. Phys. J.* **C24** (2002) 555

- Describe diffractive exchange as colour singlet exchange of at least two gluons
- Couple directly to $c\bar{c}$ pair or to $c\bar{c}g$
- Unintegrated gluon distributions from inclusive structure function F_2
- Only valid for small x_{IP} (quark exchange neglected)
- $p_T > 1.5$ GeV cut for gluon in $c\bar{c}g$

  $\Rightarrow$ use perturbation theory





Comparisons to Calculations (x_{IP}<0.01)

H1 99-00 Prelim: $\sigma(ep \rightarrow e D^{*\pm} X'Y) = 131 \pm 24(stat.) \pm 24(sys.)$ pb

- NLO with NLO diff. parton densities (HVQDIS):

H1 2002 Prelim NLO: $\sigma_{vis}(ep \rightarrow e D^{*\pm} X'Y) = 76^{+17}_{-10}$ pb

- $O(\alpha_s)$ MEs + LO diff. parton densities (RAPGAP):

H1 2002 Prelim ME+PS: $\sigma_{vis}(ep \rightarrow e D^{*\pm} X'Y) = 76$ pb

  - Predictions lower than data

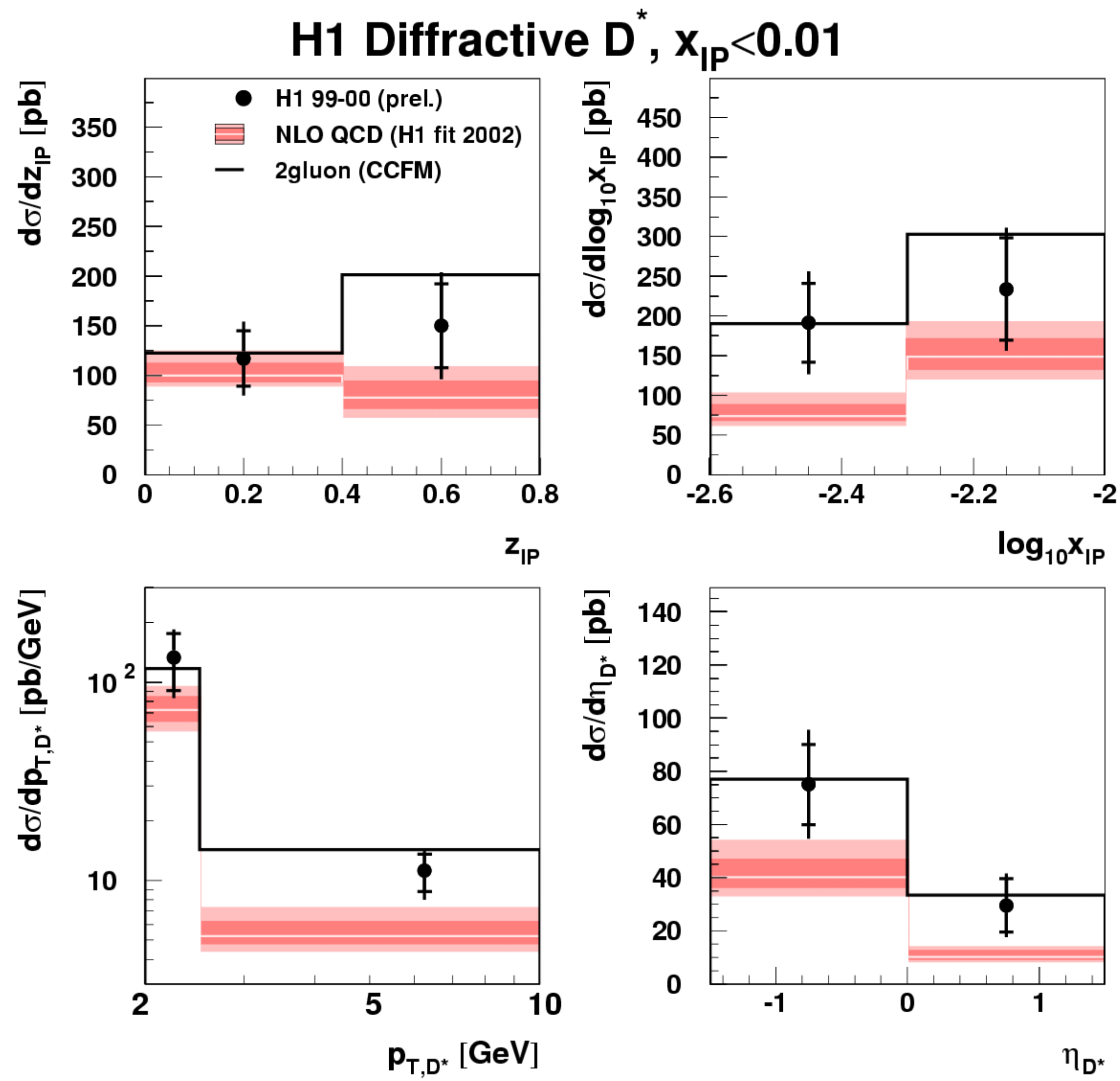
- pert. 2-gluon, unintegrated gluon density (CCFM):

CCFM set 1 BJKLW (p_T > 1.5 GeV):
$\sigma_{vis}(ep \rightarrow e D^{*\pm} X'Y) = 139$ pb

- Visible cross section well reproduced by 2-gluon model

Differential Cross Sections (x_{IP}<0.01)

- Compare $x_{IP} < 0.01$ cross sections to
  - NLO calculation
  - perturbative 2-gluon
- Only extra free parameter $p_T > 1.5\,\text{GeV}$ for gluon in $c\,\bar{c}\,g$ (also used for inclusive jets)
- Data described by both NLO and two gluon models



Conclusions

- New measurement of diffractive open charm in DIS at HERA
- Total visible cross section:

  $$\sigma_{\text{vis}}(ep \rightarrow e\,D^{*\pm}\,X'Y) = 333 \pm 38(stat.) \pm 57(sys.)\,\text{pb}$$

  - agreement with previous H1 and ZEUS measurements
- LO and NLO models:
  - lie below data, but describe data within uncertainties
  - describes shape of data well
- Agreement supports validity of QCD factorisation in DIS
- Two gluon model describes inclusive and differential cross sections in range of validity ($x_{IP} < 0.01$, $p_T < 1.5$ GeV)