Diffractive Open Charm at H1

Paul Thompson - Birmingham University
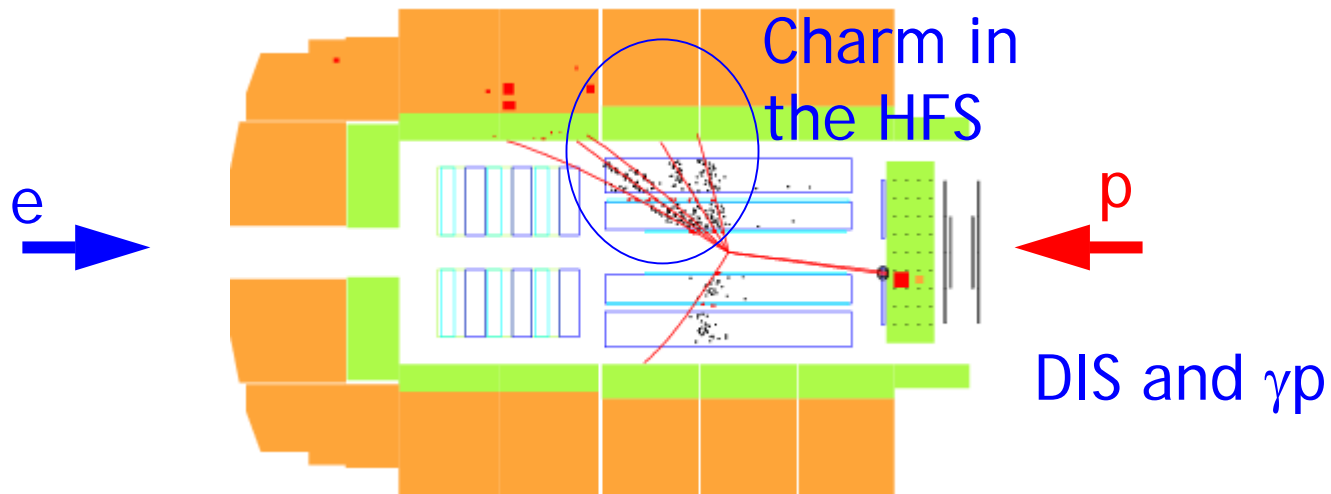
- Experimental Techniques

- Theoretical Motivation

- Results

- Conclusions/Implications

Measurement Overview

• **Exclusive** reconstruction of charmed D* mesons in tracking system for both γp and DIS.

• **Inclusive** measurement of charm using precise measurement in vertex detector of displaced tracks due to charmed hadron lifetime.

• Inclusive method only for DIS due to trigger.

QCD Factorization

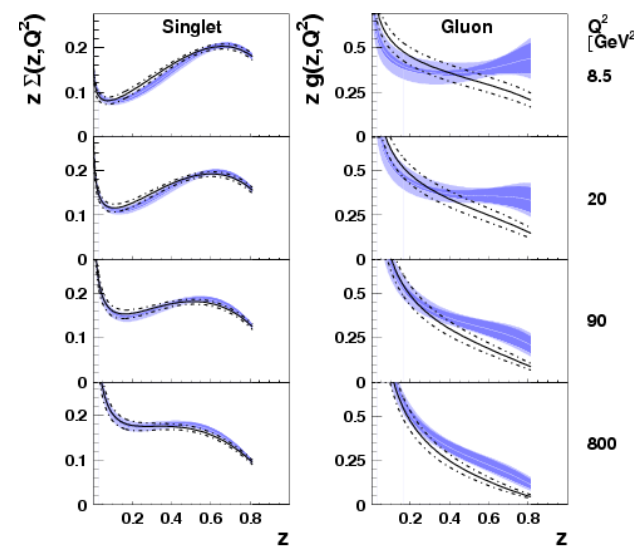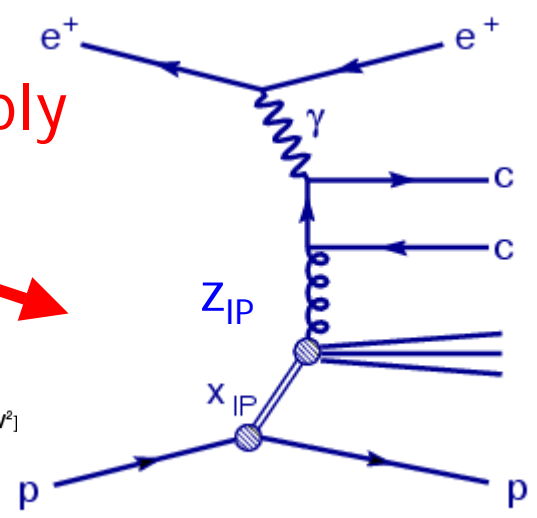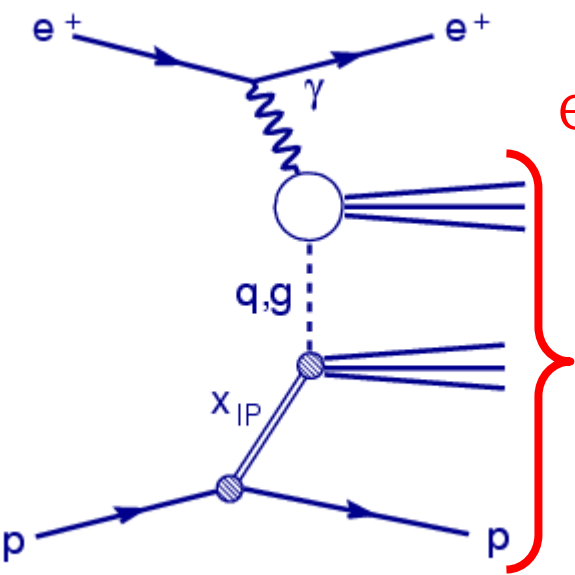$$\sigma_{meas} = (\textbf{universal DPDFs}) \otimes (\textbf{Hard ME})$$

Inclusive Diffraction   **Exclusive Final State**

extract   apply
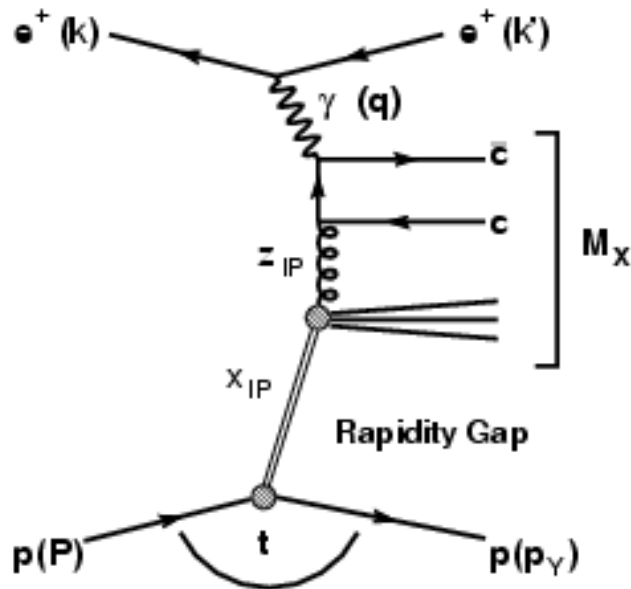
DPDFs

H1 2006 Fit

z_{IP}

x_{IP}

'massive' NLO BGF (α_s^2) from DPDF gluon distribution with IP momentum fraction z

H1 2006 DPDF Fit A
(exp. error)
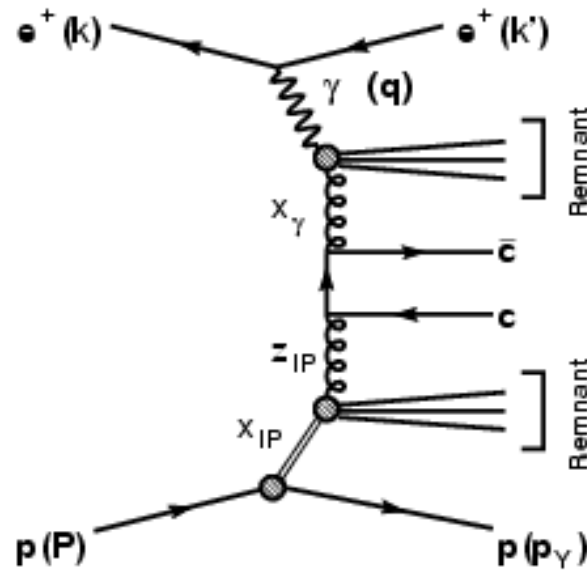(exp.+theor. error)

H1 2006 DPDF Fit B
(exp.+theor. error)

Factorization in γp

Direct γ

Photon-hadron

Resolved γ

hadron-hadron

~10% of charm events

~40% of dijet events

➡ Diffractive charm expected to be dominated by direct γ component

2 Gluon Models

Describe diffraction via simplest colourless exchange (2g)

BJKLW

- k_t factorization (CCFM *proton* PDFs)

- For ccg process parameter p_t^g ensures calculation is perturbative

- valid for where secondary Reggeon exchanges are suppressed $x_{IP} < 0.01$

MRW Model

- 'Hybrid' 2g/DPDF approach

- low β - resolved IP - BGF (α_s^2) from DPDF gluon distribution

- High β – direct IP contribution
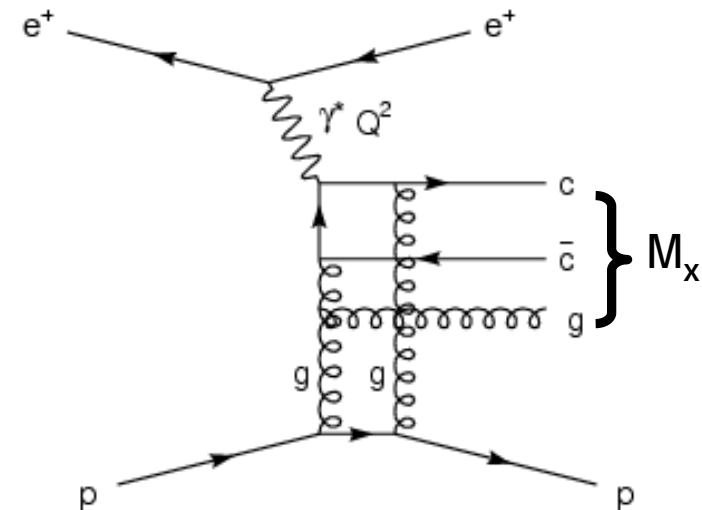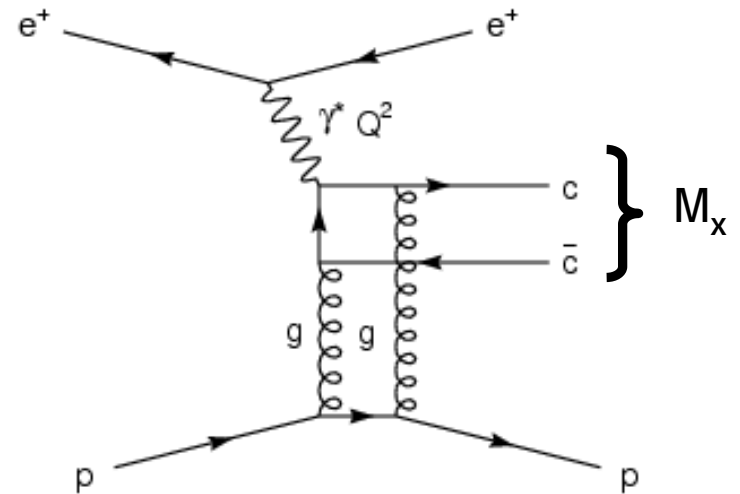
D* Event Selection

Charm

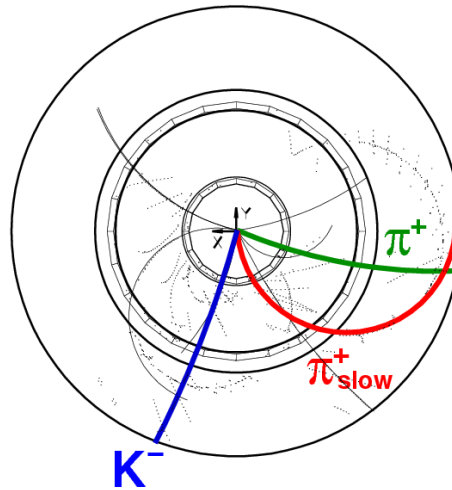- D* -> K π π_s
- $p_t(D^*) > 2.0$ GeV
- $|\eta(D^*)| < 1.5$

Diffraction

- $|t| < 1$ GeV^2
- $M_Y < 1.6$ GeV
- $x_{IP} < 0.04$

L ~ 48 pb^{-1}

DIS

- $2 < Q^2 < 100$ GeV^2
- $0.05 < y < 0.70$

γp

- $Q^2 < 0.01$ GeV^2
- $0.3 < y < 0.65$

π^+

π^+_{slow}

K$^-$

- H1 99-00
- Fit

N(D*) = 124 $\pm$ 15

M(K π π_{slow}) - M(K π) [GeV]

- H1 99-00
- Fit

N(D*) = 70 $\pm$ 13

M(K π π_{slow}) - M(K π) [GeV]
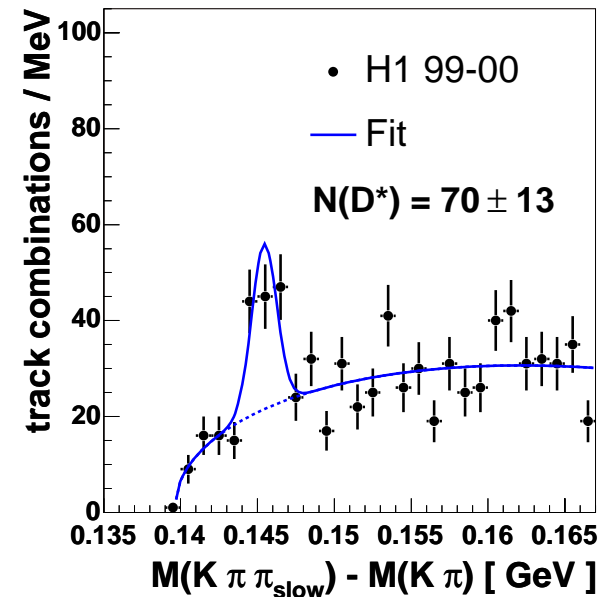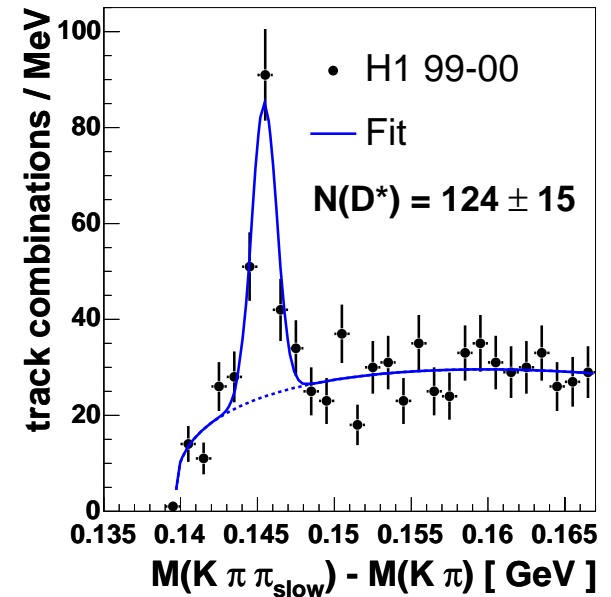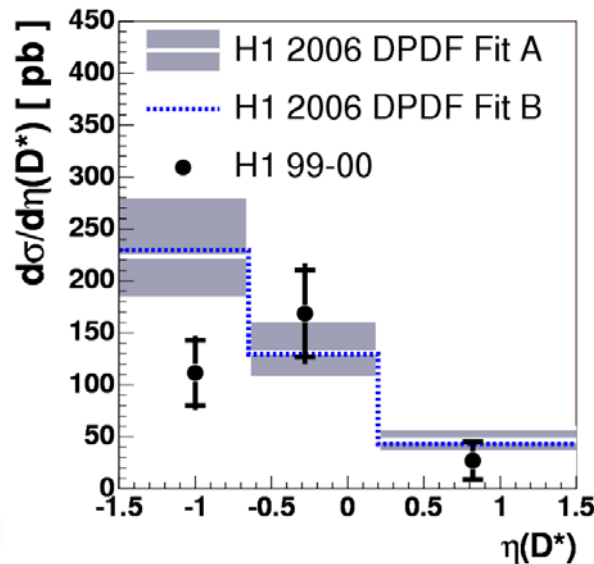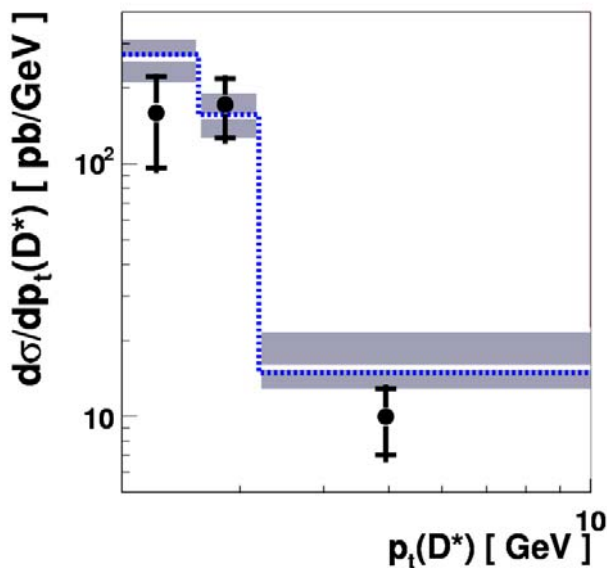
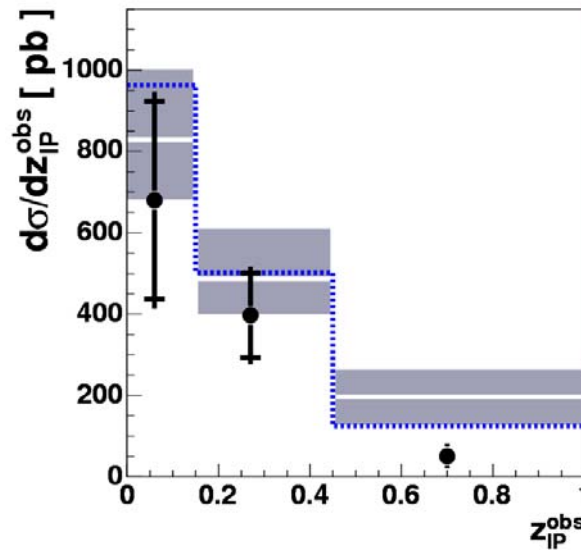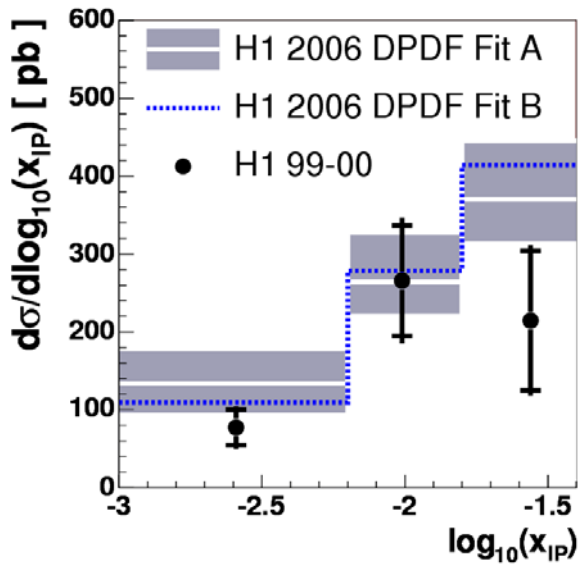# D* Cross Sections in DIS
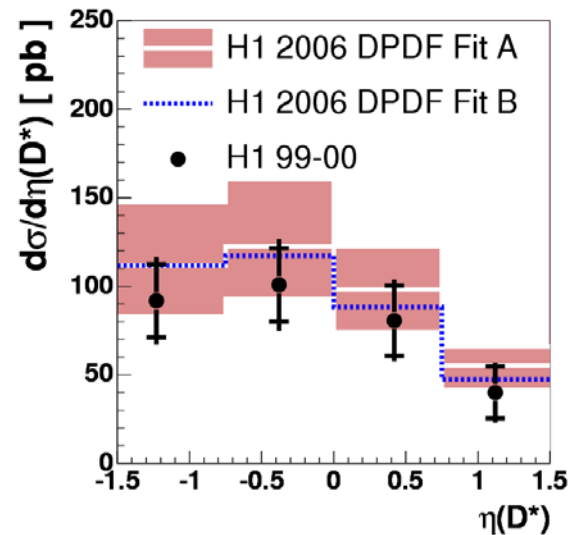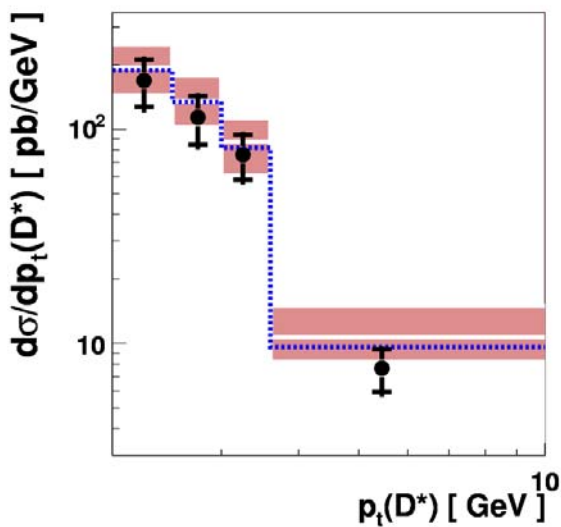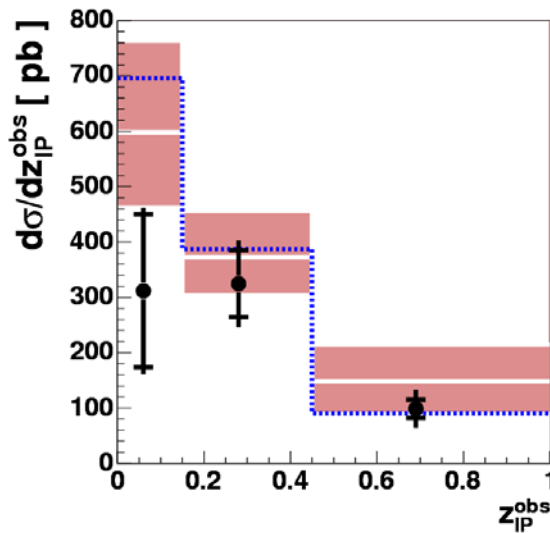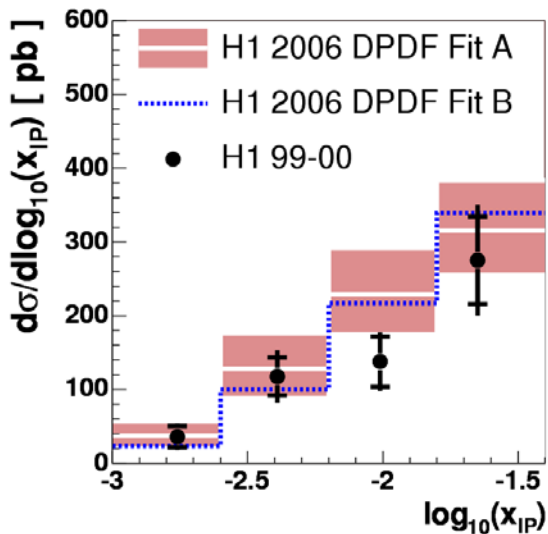
Comparison

- NLO calculation (HVQDIS – massive scheme)

- H1 2006 DPDF Fit A,B

- $\mu^2 = 4m_c^2 + Q^2$, $\varepsilon = 0.035$

- error band - scale, mass, frag. variations ~ 25%

Result

- Overall good description

- QCD Factorization valid for charm production in DIS

D* Cross Sections in γp

Comparison

- NLO calculation (FMNR – massive scheme)

- H1 2006 DPDF Fit A,B

- $\mu^2 = 4m_c^2 + p_t^2$

Result

- Overall good description

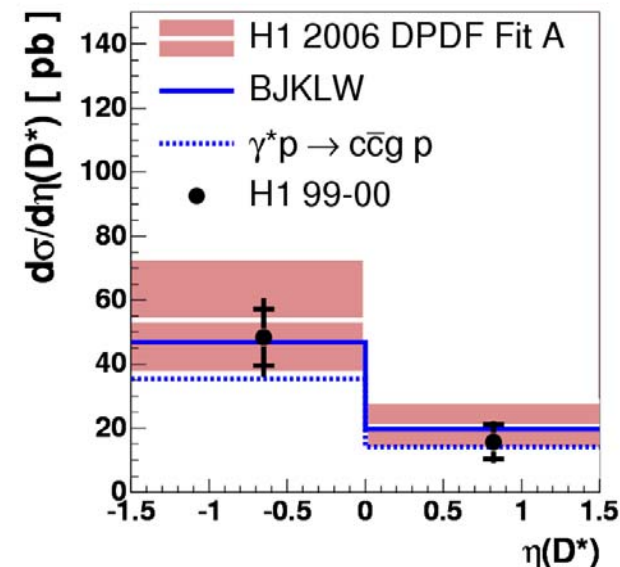- QCD Factorization valid for charm production in γp

Results on γp Factorization
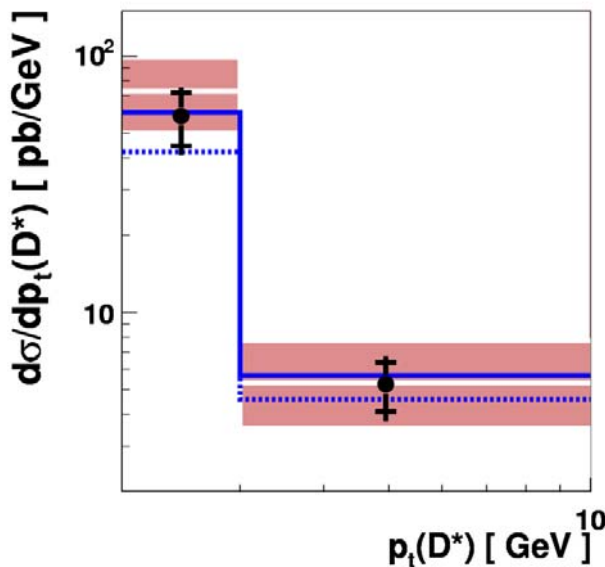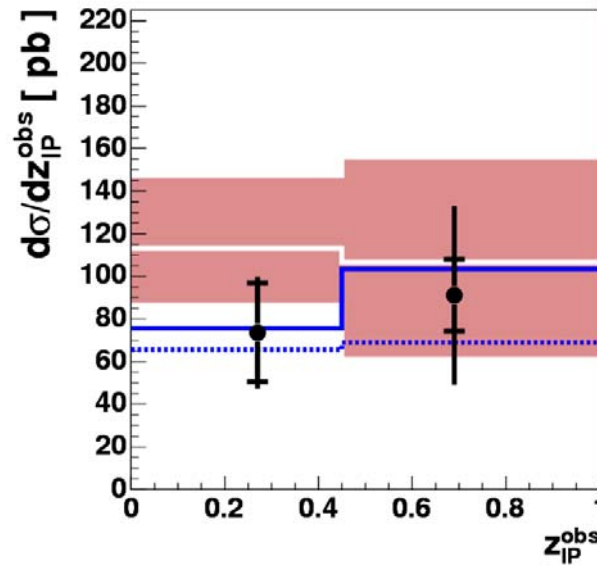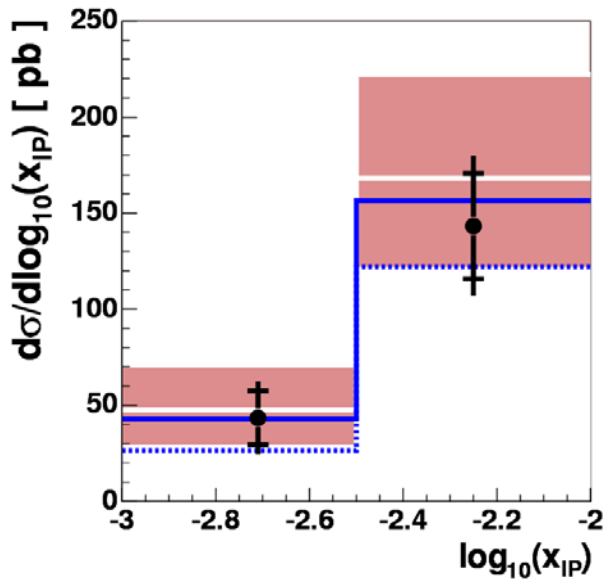
Consider double ratio (less sensitive to theory input):

$$R = \frac{(\sigma_{vis}/NLO)_{\gamma p}}{(\sigma_{vis}/NLO)_{DIS}}$$

DIS restricted to same y range as γp

$$R = 1.15 \pm 0.40 \text{ (stat.)} \pm 0.09 \text{ (syst)}$$

No evidence for a suppression of γp but low statistics mean large errors.

D* in DIS ($x_{IP} < 0.01$)

BJKLW 2g model

- CASCADE MC (CCFM, k_t)
- J2003 set 2
- $p_t^g > 2$ GeV
- cc and ccg contribute

Result

- Overall good description by 2g model
- ccg contribution dominates
- DPDF also describes data

Inclusive diff. charm cross section σ^{cc}_D

■ Measure charm contribution to inclusive diffractive cross section

$$\frac{d^3\sigma}{d\beta\, dQ^2 d x_{IP}} = \frac{4\pi\alpha^2}{\beta Q^4}(1-y+\frac{y^2}{2})\sigma_r^{D(3)}(\beta,\ Q^2, x_{IP})$$

Measure also fraction $f_D^{cc} = \sigma^{cc}_D/\sigma_D$

■ Use info from vertex detector (CST) to determine displacement for all tracks (method used in inclusive F_2^{cc} and F_2^{bb} measurements).

Signed impact parameter δ

$\alpha < 90^{\circ} \longrightarrow \delta = +|\delta|$ $\alpha > 90^{\circ} \longrightarrow \delta = -|\delta|$

■ Reduces extrapolation to full phase space (D* factor ~3) for Q^2 region where quark jet in CST acceptance.
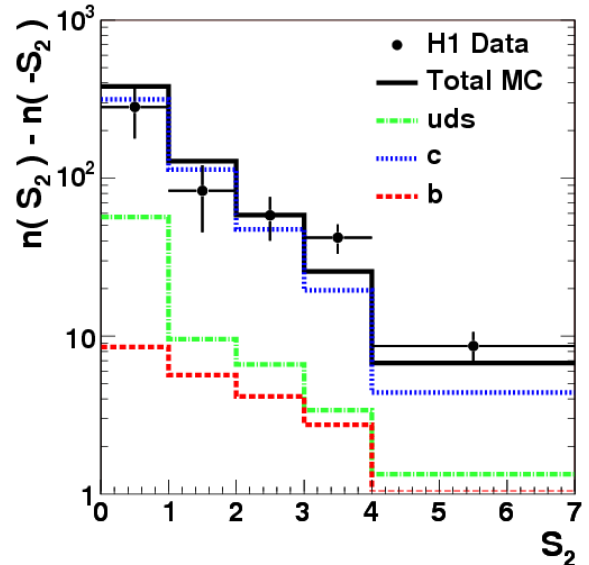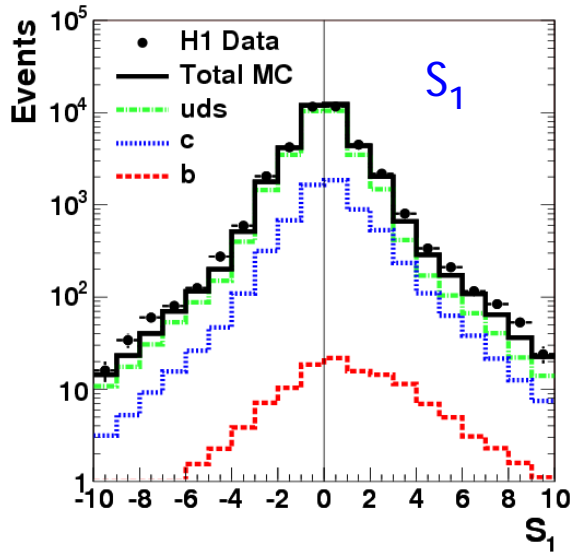
Charm has large $+\delta$ S = $\delta / \sigma(\delta)$

$Q^2 > 16$ GeV^2, $0.07 < y < 0.7$, $M_X > 6$ GeV₁₁

# Significance

Negative subtraction
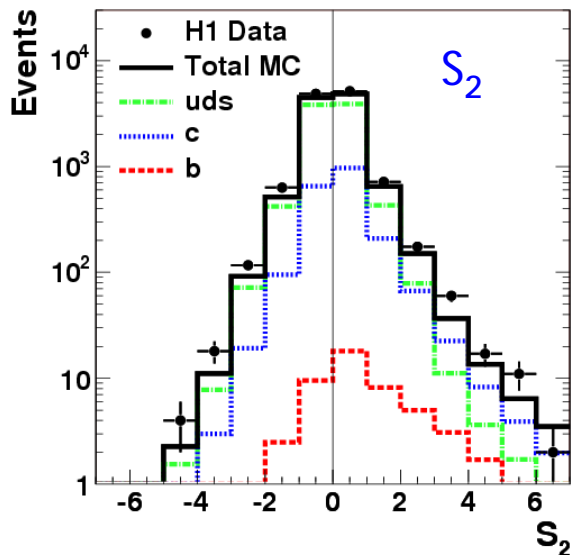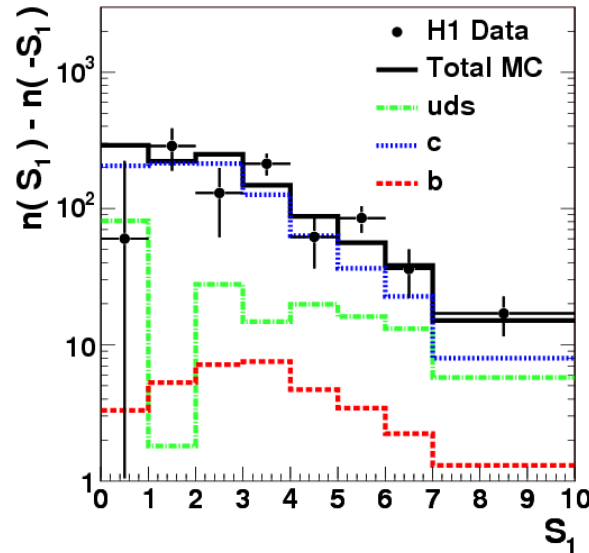
- Tracks with highest S_1 and second highest S_2

- Subtract neg from pos values (less sensitive to resolution description)

- Fit using MC templates for uds/c/b.

- b is suppressed, fix to MC prediction. Variation by –100 +400% leads to large asymmetric systematic error

- Divide into 3 M_X bins

Cross Section and Charm Fraction

low x_{IP} Cross section   high x_{IP}
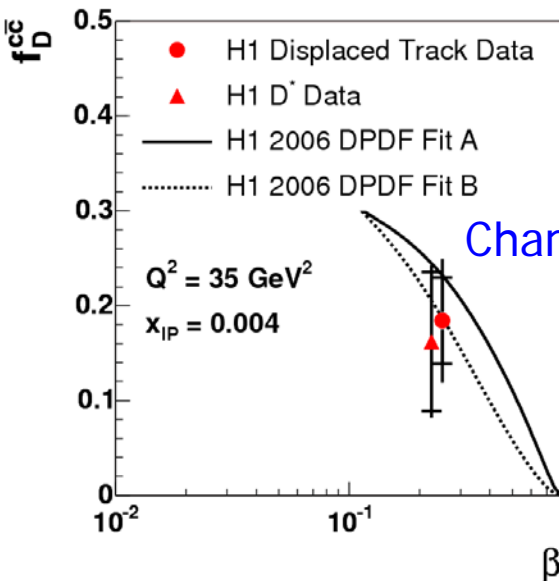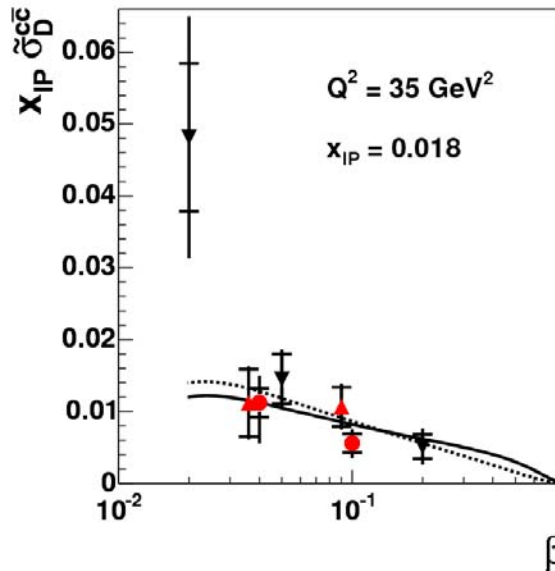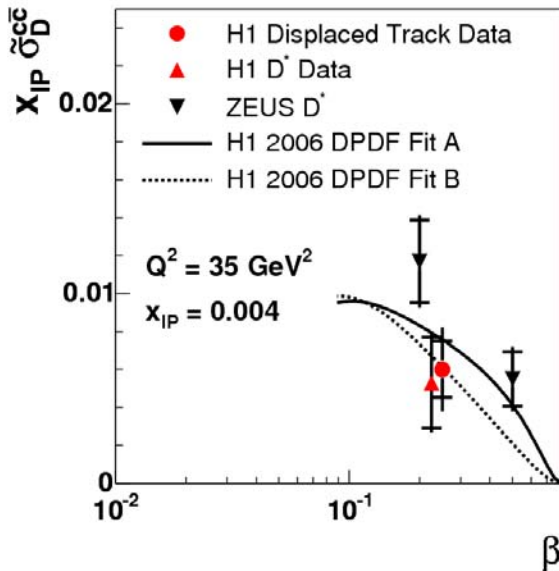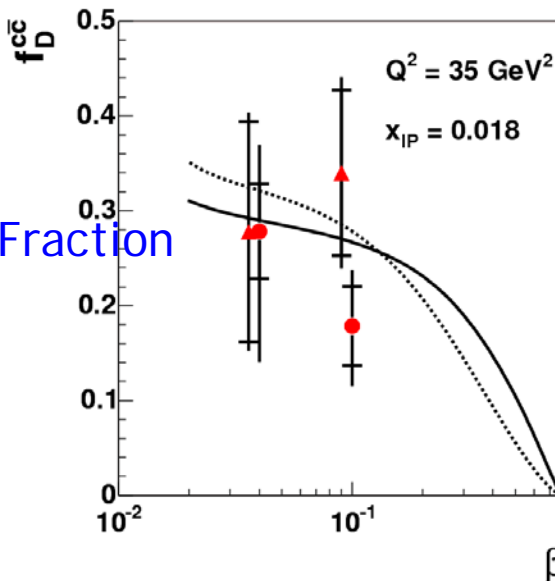
Charm Fraction

Comparison

- NLO calculation (massive scheme)
- H1 2006 DPDF Fit A,B
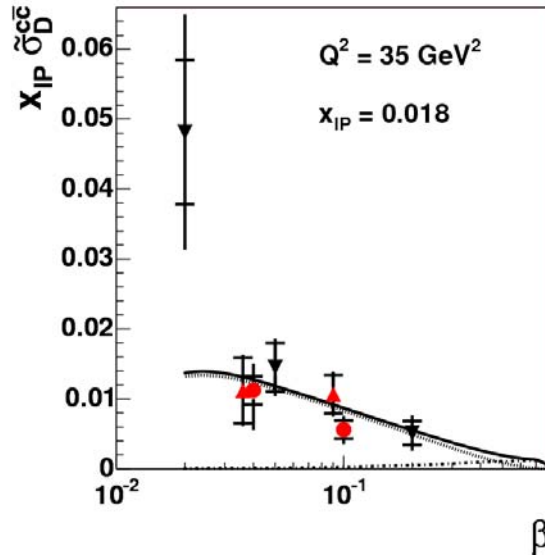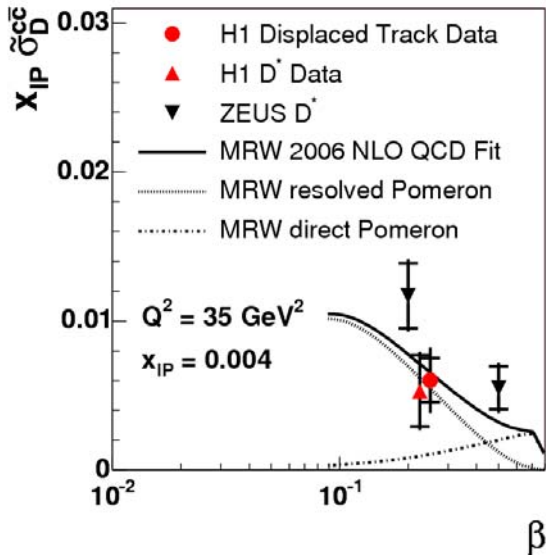- $\mu^2 = 4m_c^2$

Result

- Good agreement between D* and displaced track data and H1 and ZEUS
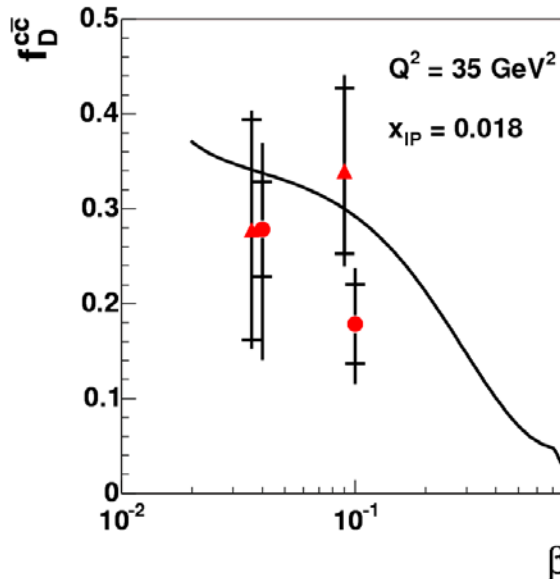- Good description by H1 DPDFs
- High Charm fraction

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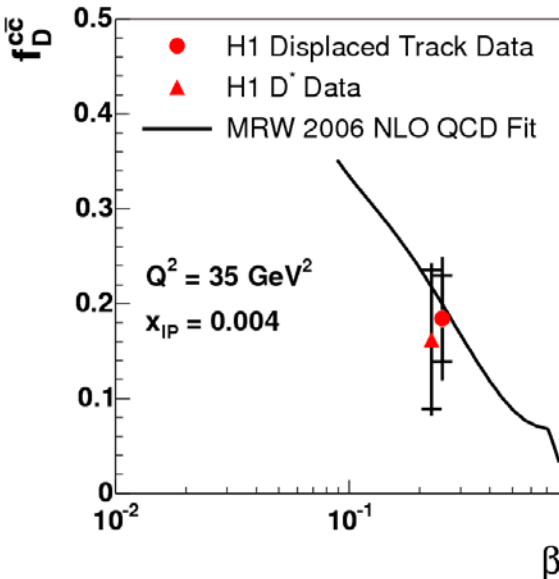# MRW model

low x_{IP} Cross section   high x_{IP}

Charm Fraction

Comparison

- MRW2006 NLO QCD Fit: massive scheme

Result

- Overall good description by the model

- Resolved pomeron contribution dominates

- direct component contributes at high β

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Conclusions

- Final results on HERA-I diffractive open charm from H1.

- D* in γp well described by NLO QCD and DPDFs. No evidence for suppression within statistics.

- D* in DIS well described by NLO QCD and DPDFS, supporting factorization and diffractive gluon PDF.

- Measurement of inclusive diffractive charm contribution using displaced tracks with vertex detector information. Results consistent with cross sections from extrapolated D* and with NLO QCD.

- DIS data also well described by pert. 2g model valid at low x_{IP} and 2g/NLO QCD MRW model.