Measurement of D^* Production in Diffractive DIS at HERA

Karel Černý

(Charles University in Prague)

on behalf of

the H1 Collaboration

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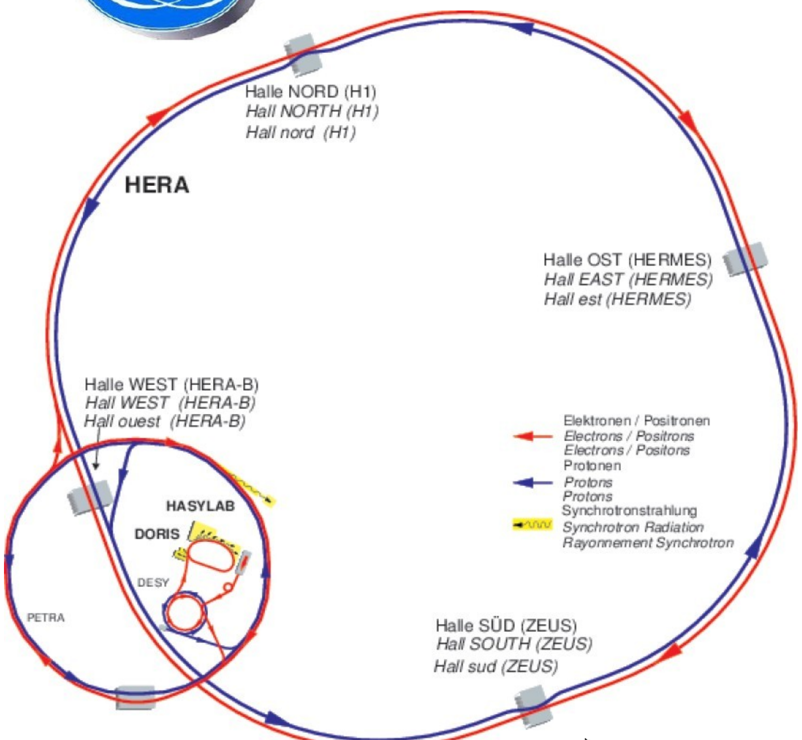
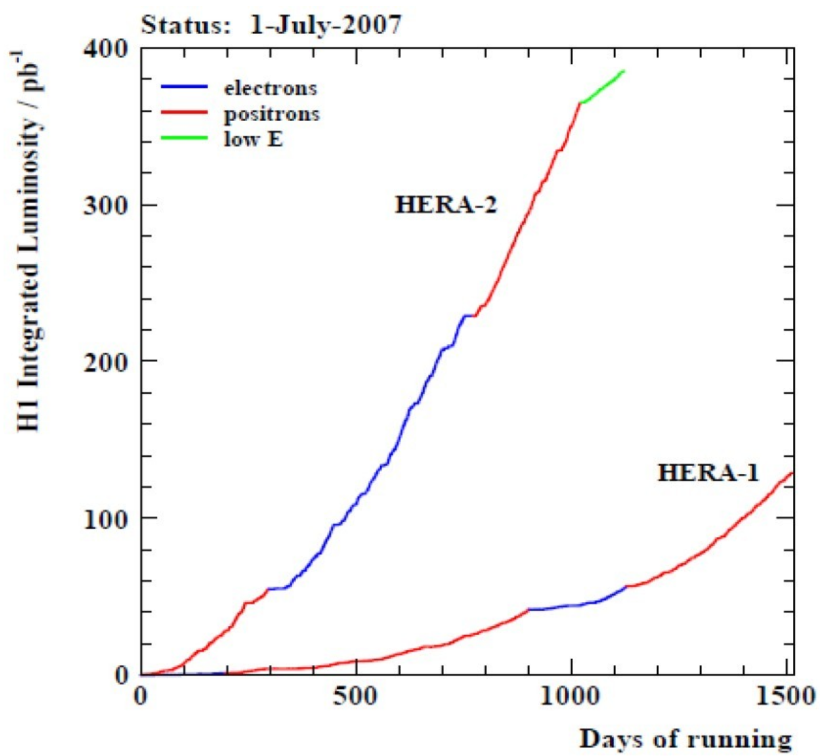
HERA

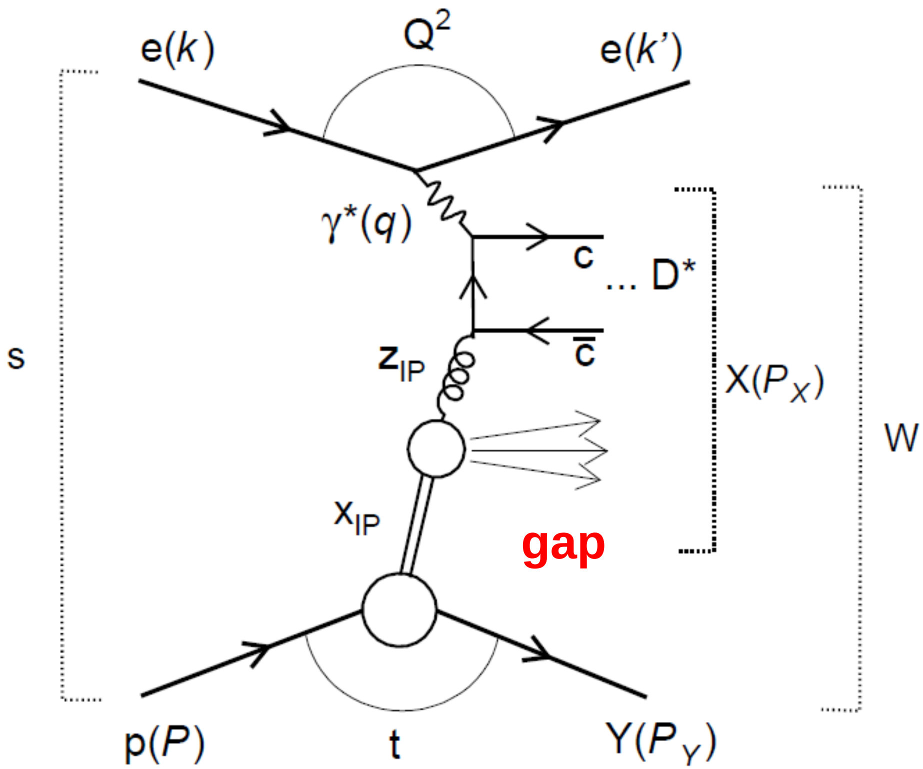
ep collider
(DESY, Hamburg, 1993-2007)

E_p = 920 GeV $E_{e\pm}$ = 27.5 GeV
0.5 fb^{-1}… per experiment





Open charm in diffractive DIS at HERA



Kinematics

$$ep \to X(D^*)Y$$

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

$$Q^2 = -q^2 = (k-k')^2$$

$$y = \frac{q.P}{k.P}$$

$$x = \frac{Q^2}{2q.P}$$

$$M_X^2 = (P_X)^2$$

$$M_Y^2 = (P_Y)^2$$

$$t = (P-P_Y)^2$$

$$x_{I\!P} = \frac{q.(P-P_Y)}{q.P}$$

$$z_{I\!P} = \frac{\hat{s}+Q^2}{M_X^2+Q^2}$$

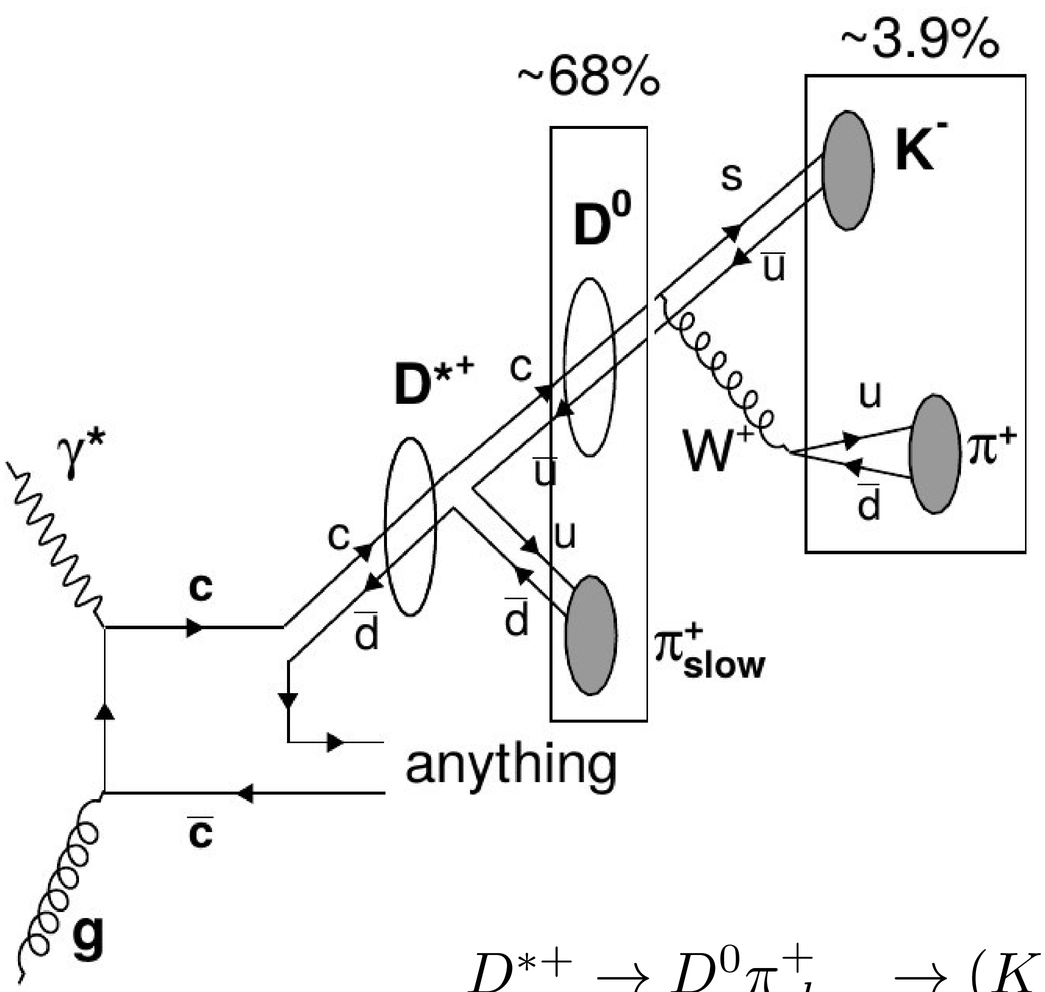
photon gluon fusion

$$\gamma^* g \to c\bar{c}$$

collinear factorisation in DDIS

- DPDF
- massive c($\bar{c}$) quark in FFNS

D* production



charm fragmentation

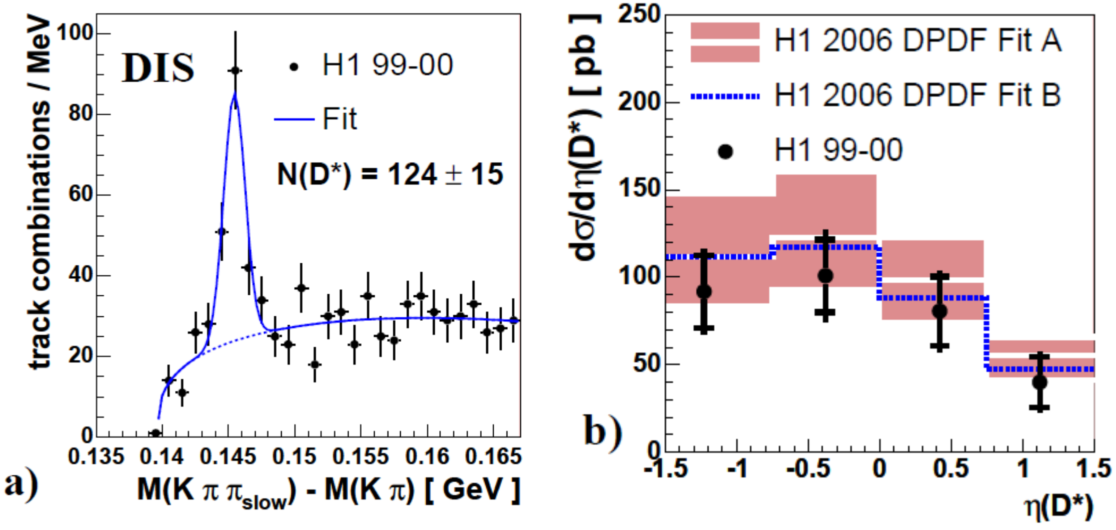
into D*(2010) $m_{D*}^{\mathrm{PDG}} = 2010.26 \pm 0.05\ \mathrm{GeV}$

D* kinematics reconstructed fully from tracks in golden decay channel

$$D^{*+} \rightarrow D^0\pi^+_{slow} \rightarrow (K^-\pi^+)\pi^+_{slow}(+C.C.)$$

Previous result from H1

$L_{int} = 47\ pb^{-1}$ of HERA-1 data DESY-06-164 , Eur.Phys.J.C50 (2007) 1



Cross Section [pb]		
Data	H1 2006 DPDF	
	Fit A	Fit B
$234 \pm 29\,(\text{stat.}) \pm 34\,(\text{syst.})$	$287\pm^{81}_{70}$	$272\pm^{78}_{71}$

$$
\begin{array}{rclcl}
2 & < & Q^2 & < & 100\ \text{GeV}^2, \\
0.05 & < & y & < & 0.7, \\
 & & p_t(D^*) & > & 2.0\ \text{GeV}, \\
 & & |\,\eta(D^*)\,| & < & 1.5, \\
 & & x_{I\!P} & < & 0.04, \\
 & & M_y & < & 1.6, \\
 & & |\,t\,| & < & 1.\ \text{GeV}^2
\end{array}
$$

New measurement

New measurement of D* DDIS production by H1: arXiv:1703.09476

H1 HERA-2 data

2005e-, 2006e-, 2006/2007e+ @ $\sqrt{s}$ = 319 GeV with L_{int} = 287 pb^{-1}

Measurement of diffractive cross sections

large rapidity gap method of diffractive selection

total and differential cross sections

compared with NLO QCD predictions

Measurement of fraction of diffractive contribution

using a non-diffractive measurement by H1 as a reference
Eur.Phys.J. C71 (2011) 1769, Erratum: Eur.Phys.J. C72 (2012) 2252

Analysis procedure

scattered electron in a backward elmg. calorimeter (Spacal)

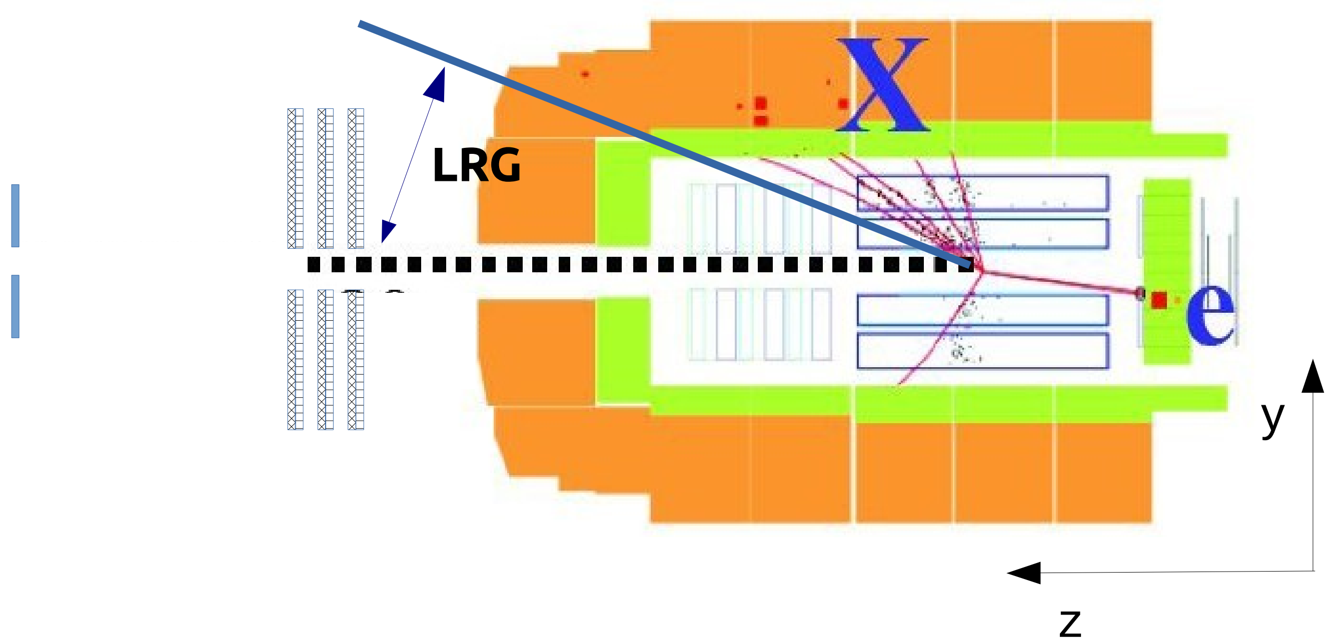
$$5 < Q^2 < 100 \text{ GeV}^2 \qquad 0.02 < y < 0.65$$

large rapidity gap (LRG) … allows proton dissociation (PD)

$$x_{I\!P} < 0.03 \quad M_Y < 1.6 \text{ GeV} \quad |t| < 1 \text{ GeV}^2$$

D* in the final state

$$p_{t,D^*} > 1.5 \text{ GeV} \qquad |\eta_{D^*}| < 1.5$$



D* signal extraction

all combinations of candidate tracks used

$$p_{t,K} > 0.3 \text{ GeV} \quad p_{t,\pi} > 0.3 \text{ GeV} \quad p_{t,\pi_{slow}} > 0.12 \text{ GeV}$$

signal in mass difference: right charge combinations

$$\Delta m = m(K^{\mp}\pi^{\pm}\pi^{\pm}_{slow}) - m(K^{\mp}\pi^{\pm}), \;\; \Delta m^{\text{PDG}} \approx 0.145 \text{ GeV}$$

no signal in wrong charge combinations

$$\Delta m = m(K^{\pm}\pi^{\pm}\pi^{\mp}_{slow}) - m(K^{\pm}\pi^{\pm})$$

background suppression by D^0 mass cut

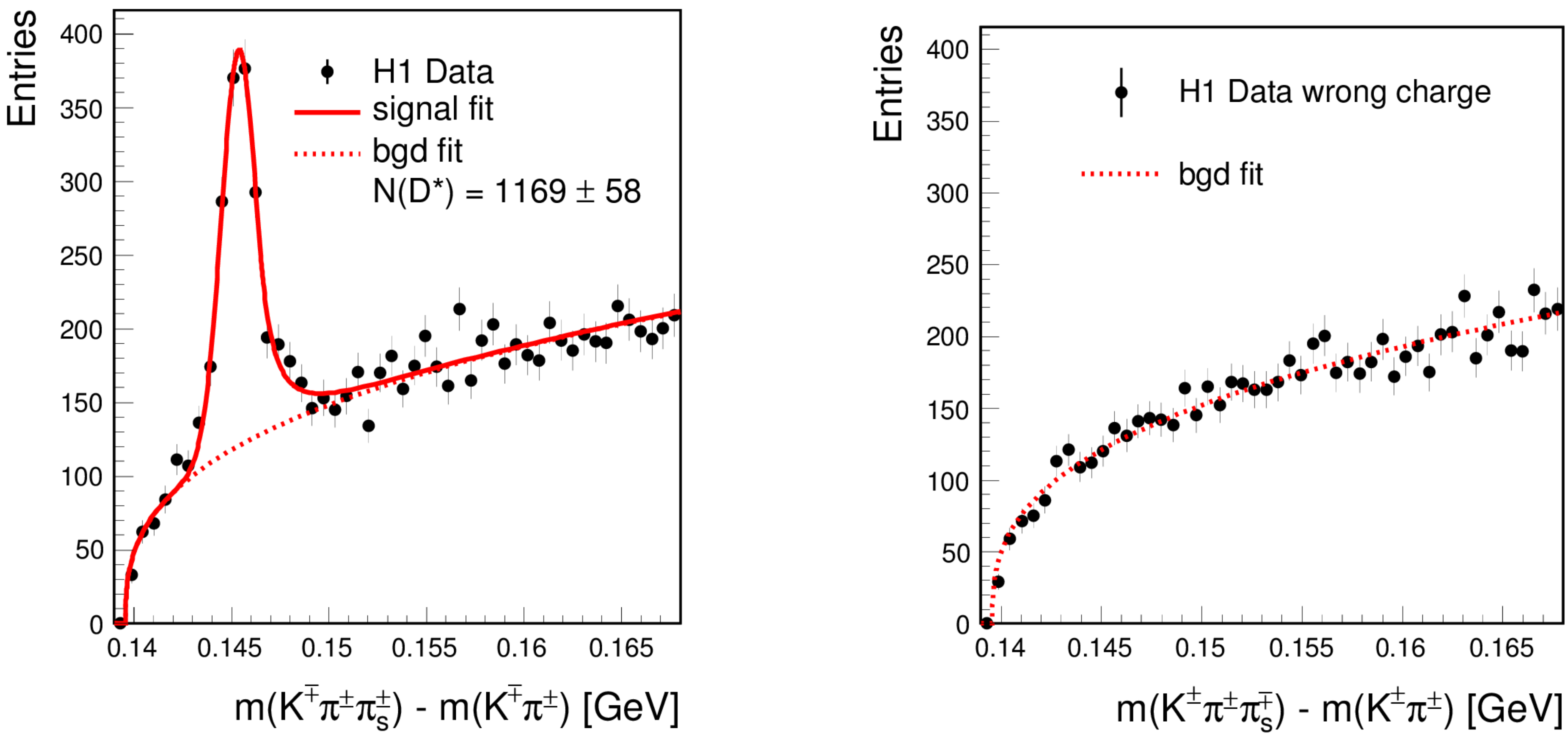
$$\left| m(K \mp \pi^{\pm}) - m({D^0}_{\text{PDG}}) \right| < 80 \text{ MeV} \qquad m_{D^0}^{\text{PDG}} = 1864.83 \pm 0.05 \text{ GeV}$$

N(D*) obtained from fits to Δm distributions done simultaneously for right and wrong charge combinations

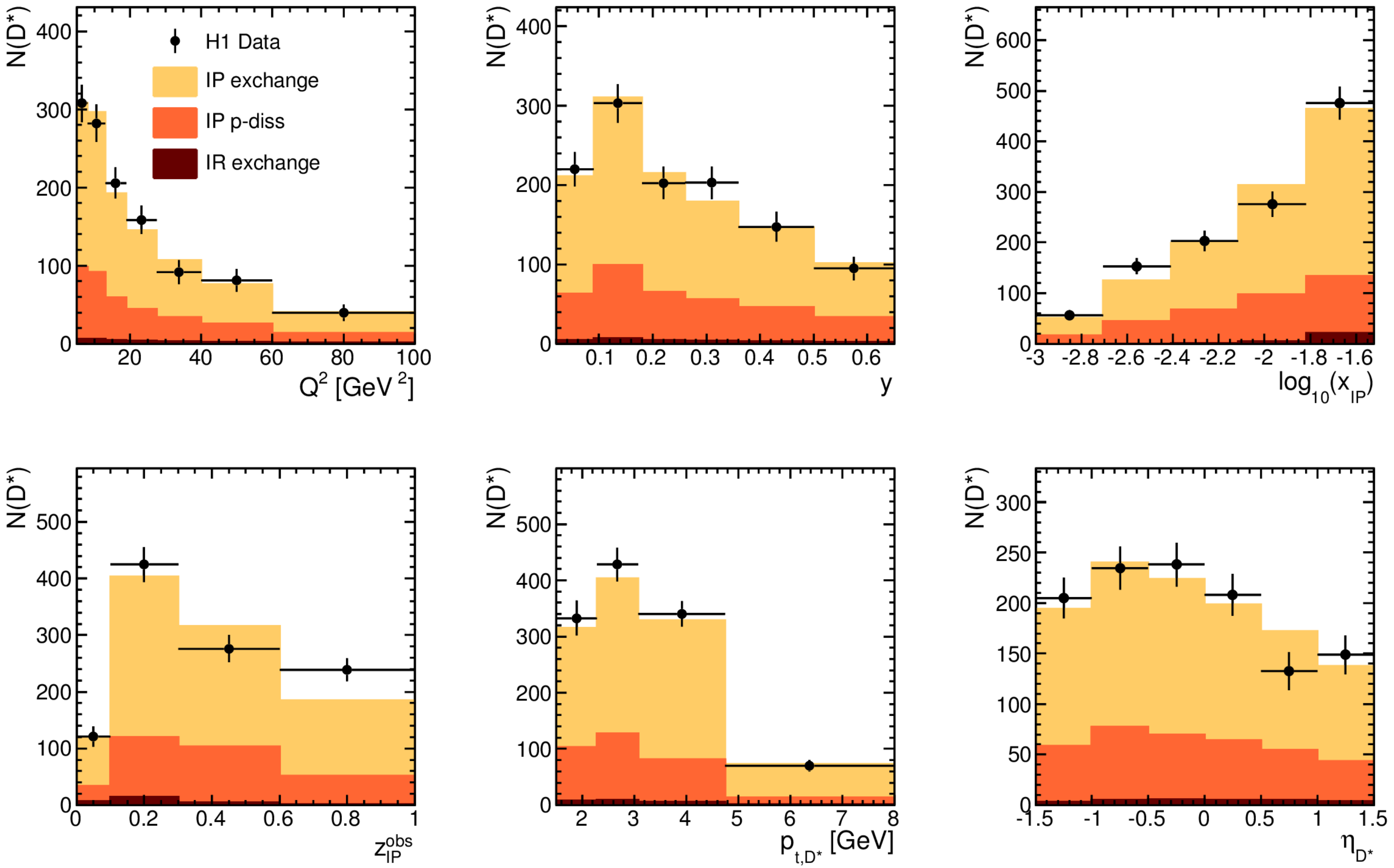
signal: Crystal Ball … gaussian with pow. law tail

background: Granet fcn: $f(\Delta m - m_{\pi^{\pm}}) = (\Delta m - m_{\pi^{\pm}})^{p_1} \cdot \exp(-p_2(\Delta m - m_{\pi^{\pm}}))$

D* in diffractive DIS



Fit to the total data statistics



Differential N(D*) distributions from fits to data and simulations

elastic proton IP exchange dominant … p → eX(D*)p

contribution of PD

small IR exchange

non-diffractive contribution negligible due to LRG cuts

Cross section measurement

measured N(D*) corrected for

- detector effects
- branching ratio $D^* \rightarrow K \pi \pi$
- other D^0 decay channels
- QED effects

$$\left(\frac{d\sigma}{dx}\right)_i = \frac{N_i^{\rm data} - N_i^{\rm sim,bgr}}{\mathcal{L}_{\rm int}\ \Delta_i^x\ B_r\ \varepsilon_{\rm trigg}\ A_i} C_{{\rm corr},i}^{\rm QED}$$

$$A_i = \frac{N_i^{\rm sim} - N_i^{\rm sim,bgr}}{n_i^{\rm sim}}$$

comparison with theory in NLO QCD

- HVQDIS code (heavy flavour σ in DIS)
  B. W. Harris and J. Smith, *Nucl. Phys.* **B452** (1995) 109
  Phys. Rev. **D57** (1998) 2806
- modified for diffraction, H1 2006 Fit B
- independent fragmentation of charm added *H1 Eur. Phys. J.* **C59** (2009) 589

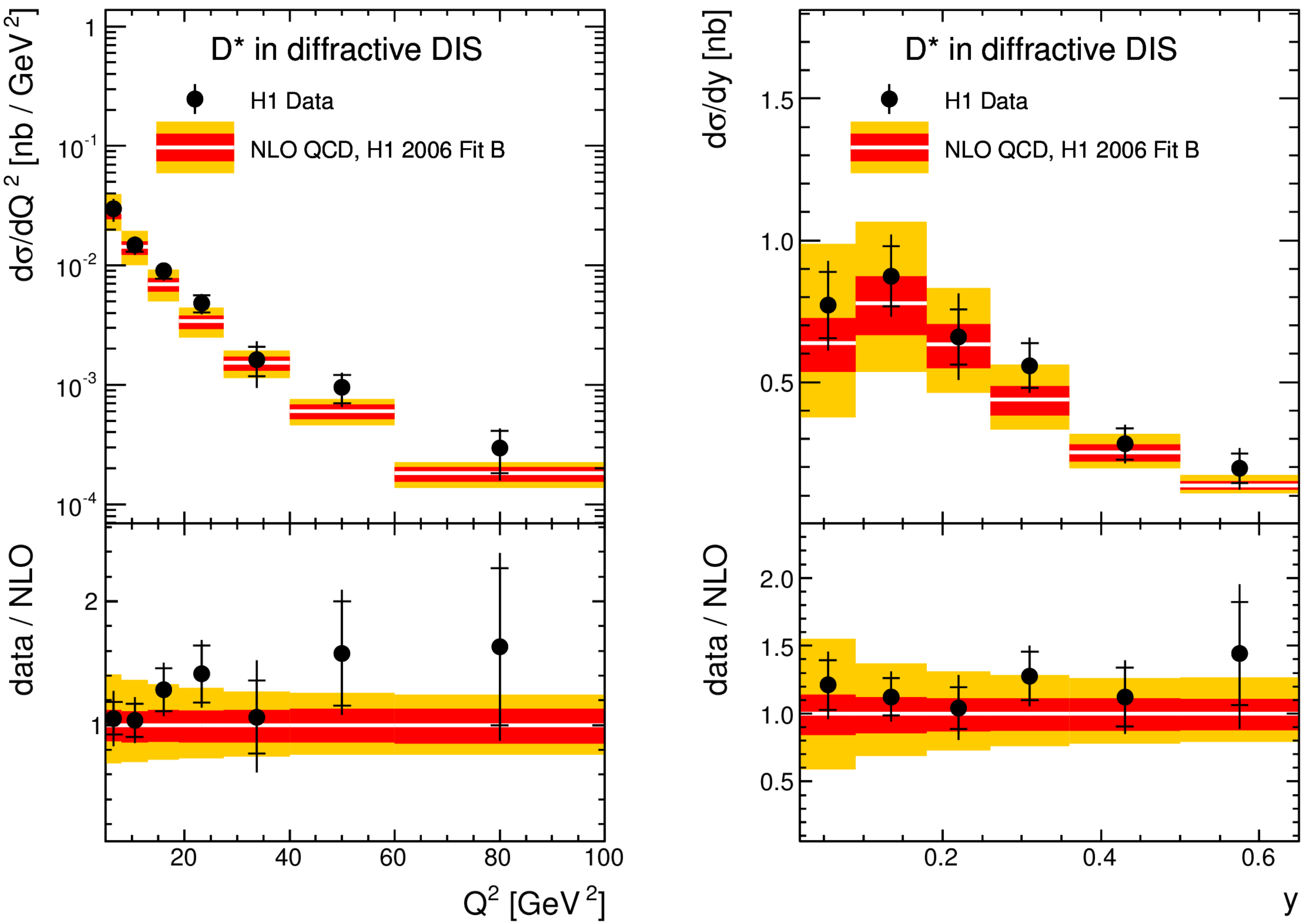
DIS phase space
$5 < Q^2 < 100$ GeV^2 $0.02 < y < 0.65$
D^* kinematics
$p_{t,D^*} > 1.5$ GeV $-1.5 < \eta_{D*} < 1.5$
Diffractive phase space
$x_{I\!P} < 0.03$ $M_Y < 1.6$ GeV $\lvert t\rvert < 1$ GeV^2

$$\sigma_{ep\rightarrow eYX(D^*)} = 314 \pm 23\ ({\rm stat.})\ \pm 35\ ({\rm syst.})\ \ {\rm pb}$$

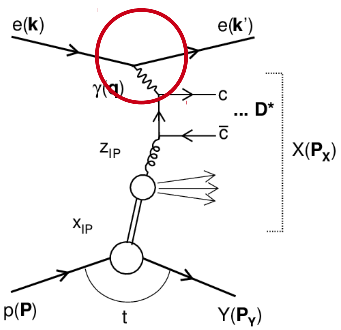
dominant PD norm. (22 pb)

$$\sigma^{\rm theory}_{ep\rightarrow eYX(D^*)} = 265\ ^{+54}_{-40}\ ({\rm scale})\ ^{+68}_{-54}\ (m_c)\ ^{+7.0}_{-8.2}\ ({\rm frag.})\ ^{+31}_{-35}\ ({\rm DPDF})\ \ {\rm pb}$$

μx 0.5(2) m_c =1.5 (1.3 ,1.7)

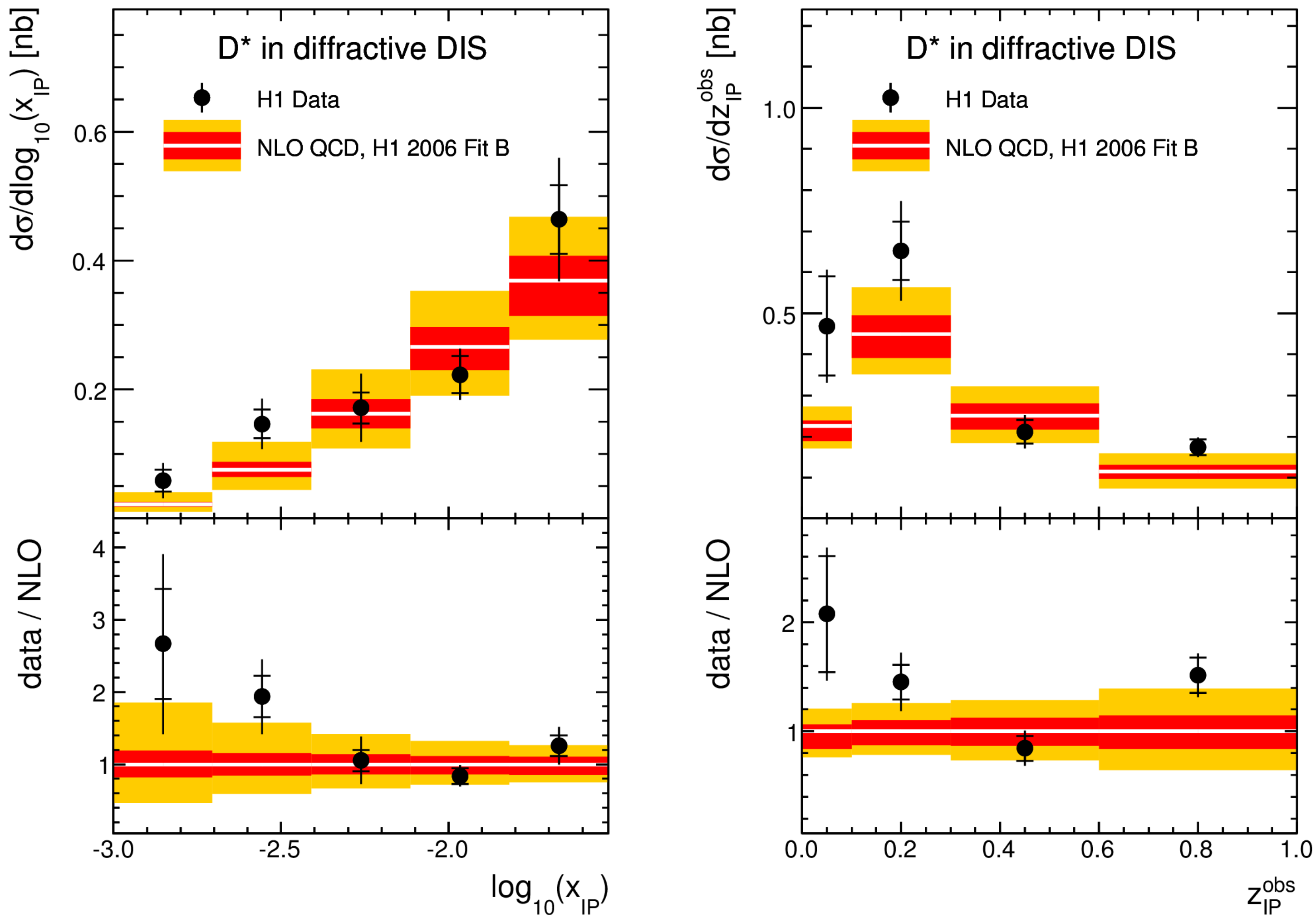


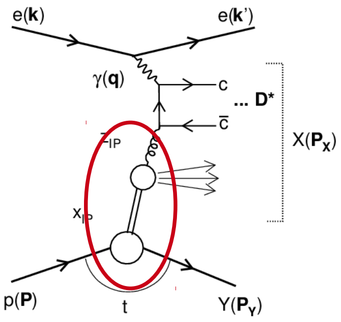
D* in diffractive DIS
H1 Data
NLO QCD, H1 2006 Fit B
dσ/dQ 2 [nb / GeV 2]
data / NLO
Q2 [GeV 2]
dσ/dy [nb]
y



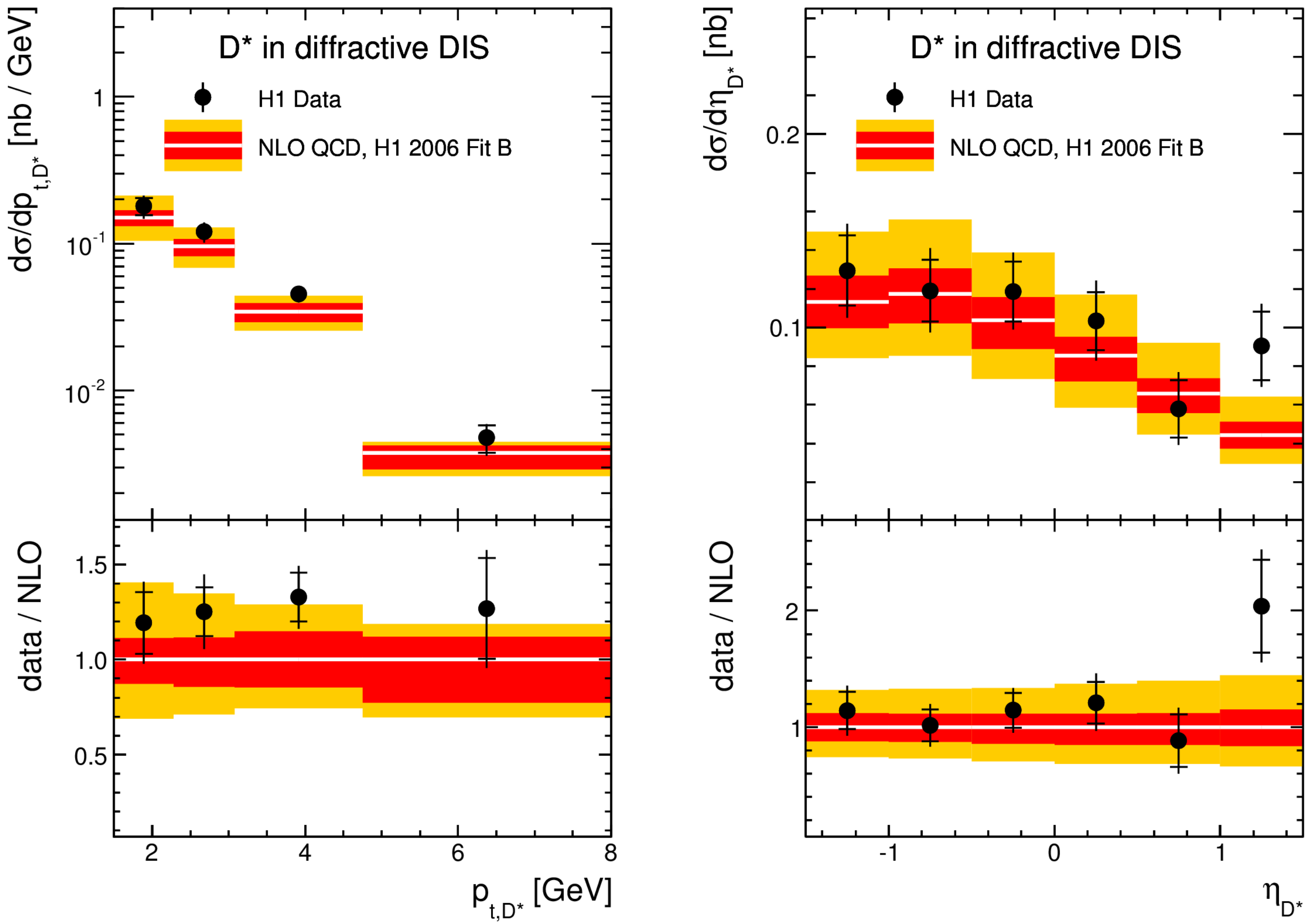
e(k)
e(k')
γ(q)
c
... D*
c̄
X(PX)
zIP
xIP
p(P)
t
Y(PY)

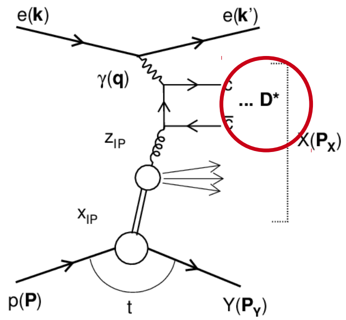
DPDF ⊕ frag





DPDF $\oplus$ frag





DPDF $\oplus$ frag

Diffractive fraction

using non-diffractive D* DIS cross sections published by H1

Eur.Phys.J. C71 (2011) 1769, Erratum: Eur.Phys.J. C72 (2012) 2252

extrapolations by HVQDIS to a common PS (~ 1% - 3.5%)

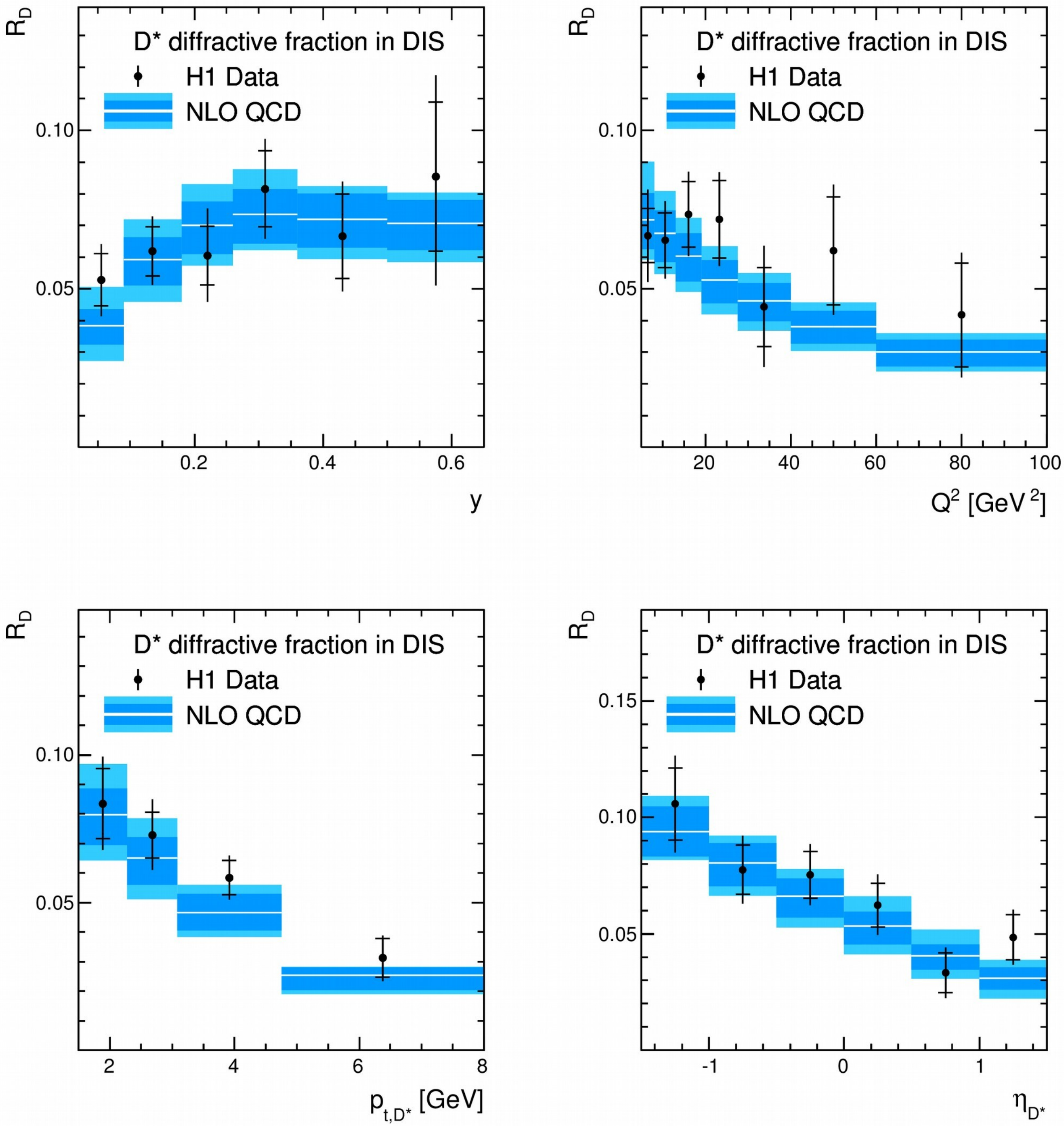
partial cancellation of systematic uncertainties

theoretical prediction by HVQDIS in NLO QCD

the same fragmentation for diff. and n-diff. prediction

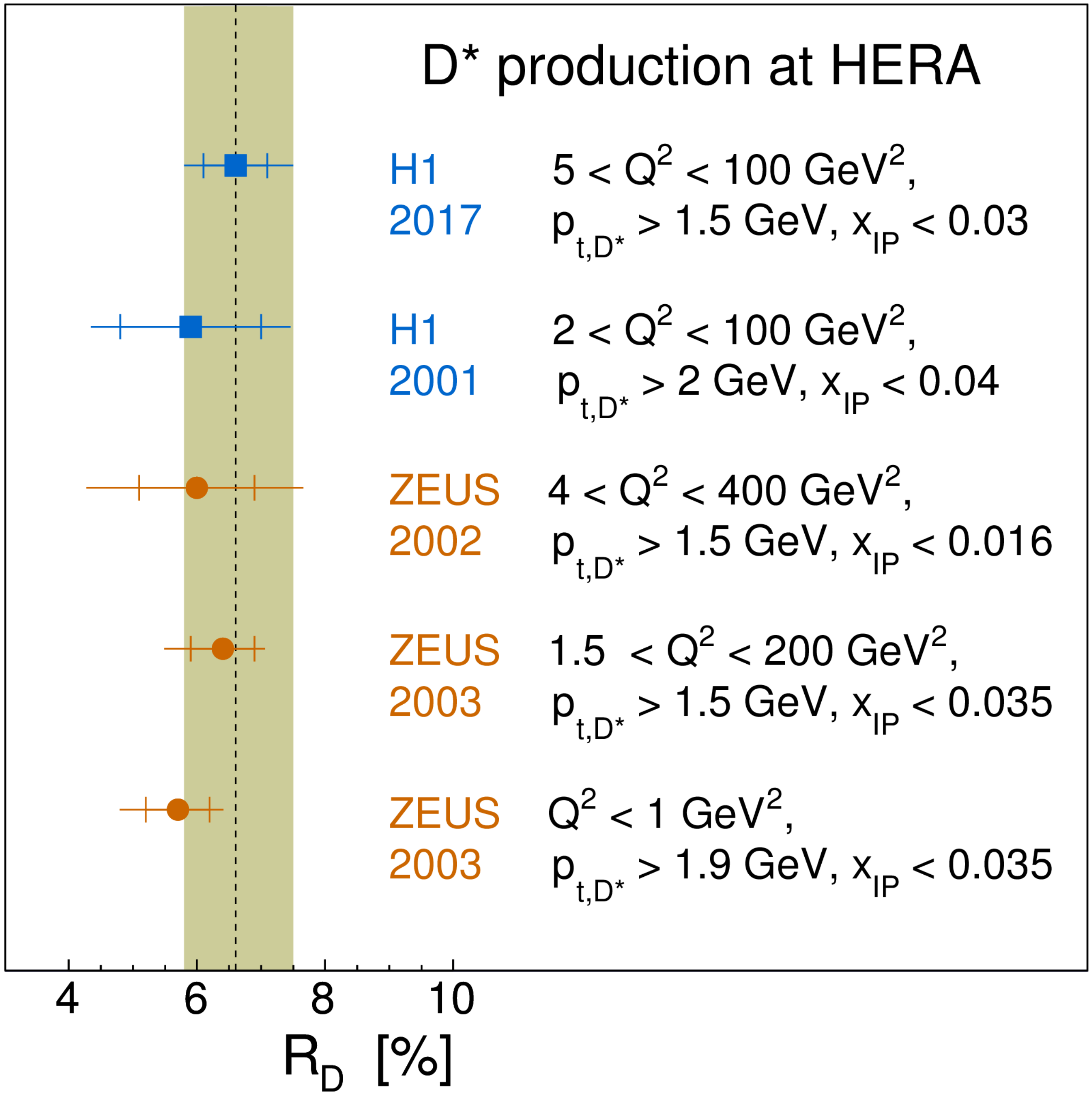
using CT10F3 PDF *Phys.Rev.* **D82** (2010) 074024.

Differential and integrated diffractive fractions R_D measured



D* diffractive fraction in DIS
H1 Data
NLO QCD
R_D
0.10
0.05
0.2
0.4
0.6
y
Q^2 [GeV ^{2}]
20
40
60
80
100
$p_{t,D*}$ [GeV]
2
4
6
8
η_{D*}
0.15
-1
0
1

Diffractive fraction



present result

H1 Phys. Lett. B520 (2001) 191

ZEUS Phys. Lett. B545 (2002) 244

ZEUS Nucl. Phys. B672 (2003) 3

ZEUS Eur.Phys.J. C 51 (2007) 301

Conclusions

Diffractive D* production cross sections in DIS measured by H1

with higher statistics … N(D*) ~ 1200 (120 @ HERA-1)

within uncertainties both shapes and normalisation
well reproduced by NLO QCD predictions using H1 2006 DPDF Fit B

support for collinear factorisation in DDIS

Diffractive fraction

differential shapes are in agreement with theoretical
prediction showing kin. dependence due to limitations
of the diffractive phase space

integrated fraction is in agreement with previous HERA
measurements, on average there is a weak sensitivity on
details of the phase space definition