Studies of Diffractive Final States at H1

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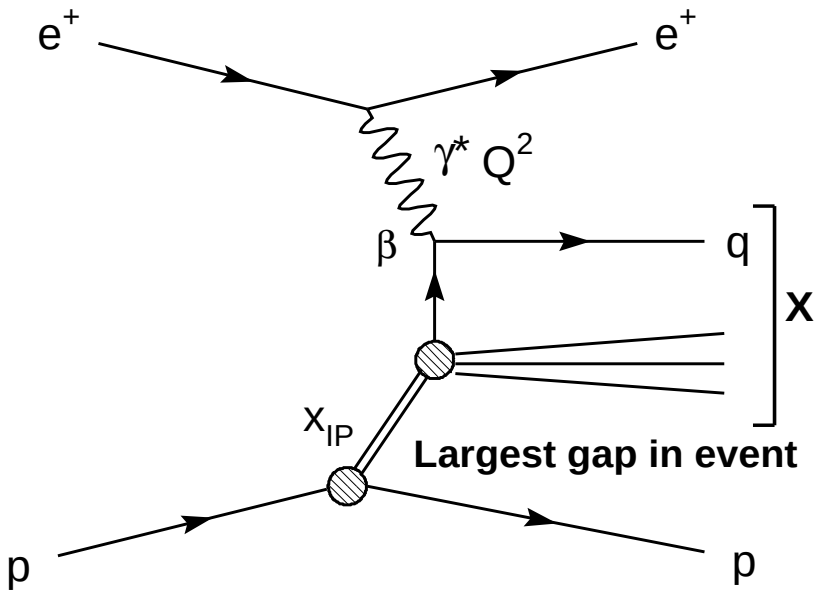
for the H1 Collaboration

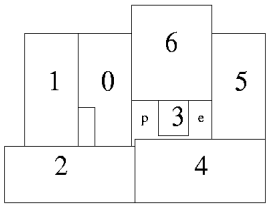
Low X meeting: Prague, Czech Republic, 15.-18.09.2004

Diffraction at H1



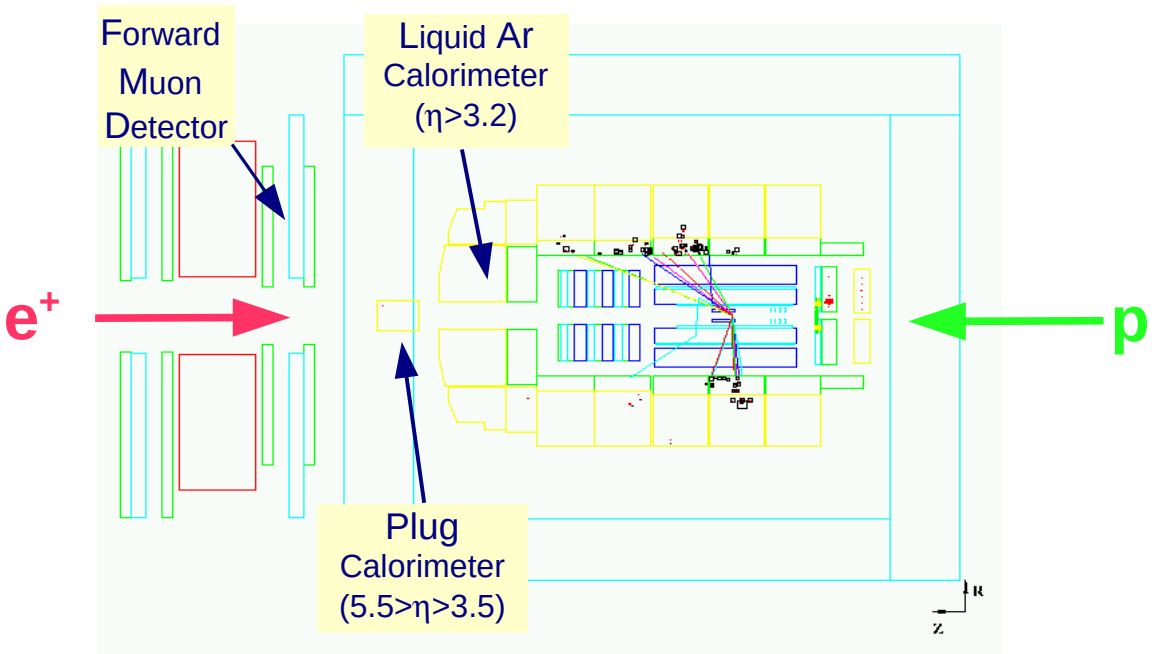
Experimental Signature

Select no activity above noise thresholds in forward direction of H1



z=26m

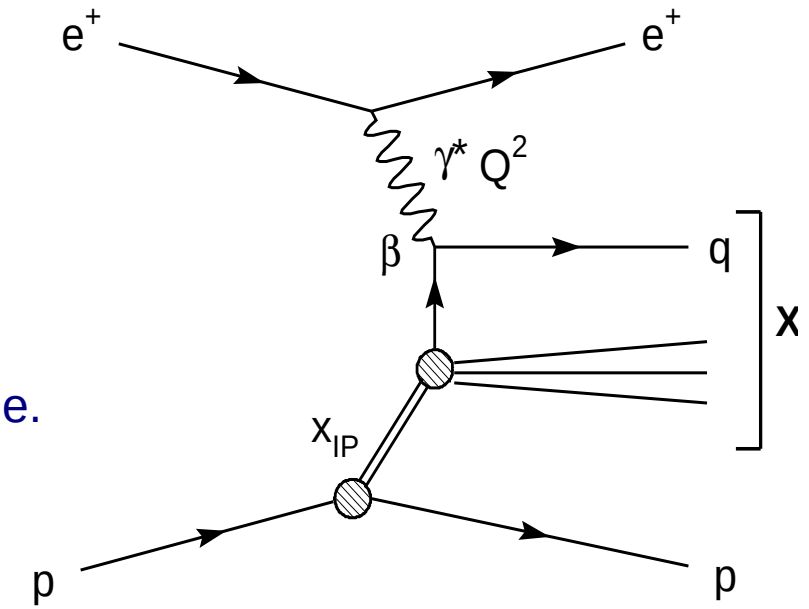
Proton Remnant Tagger



Kinematics of Diffraction

x_{IP} : long momentum fraction of the colorless exchange relative to the Proton.

β : x_{Bj} rel. to colorless exchange.



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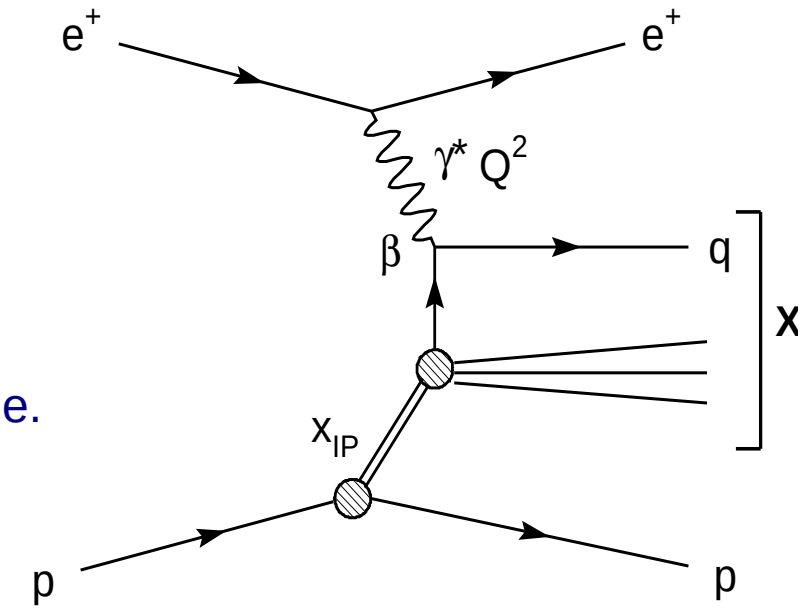
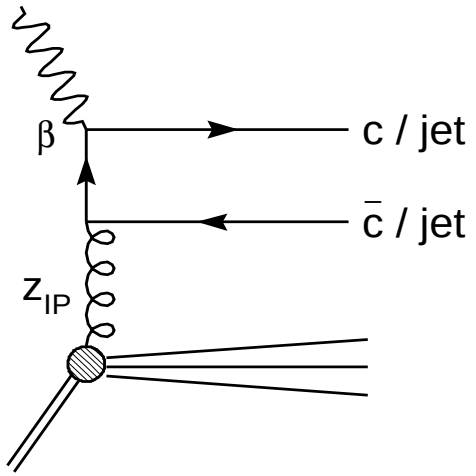
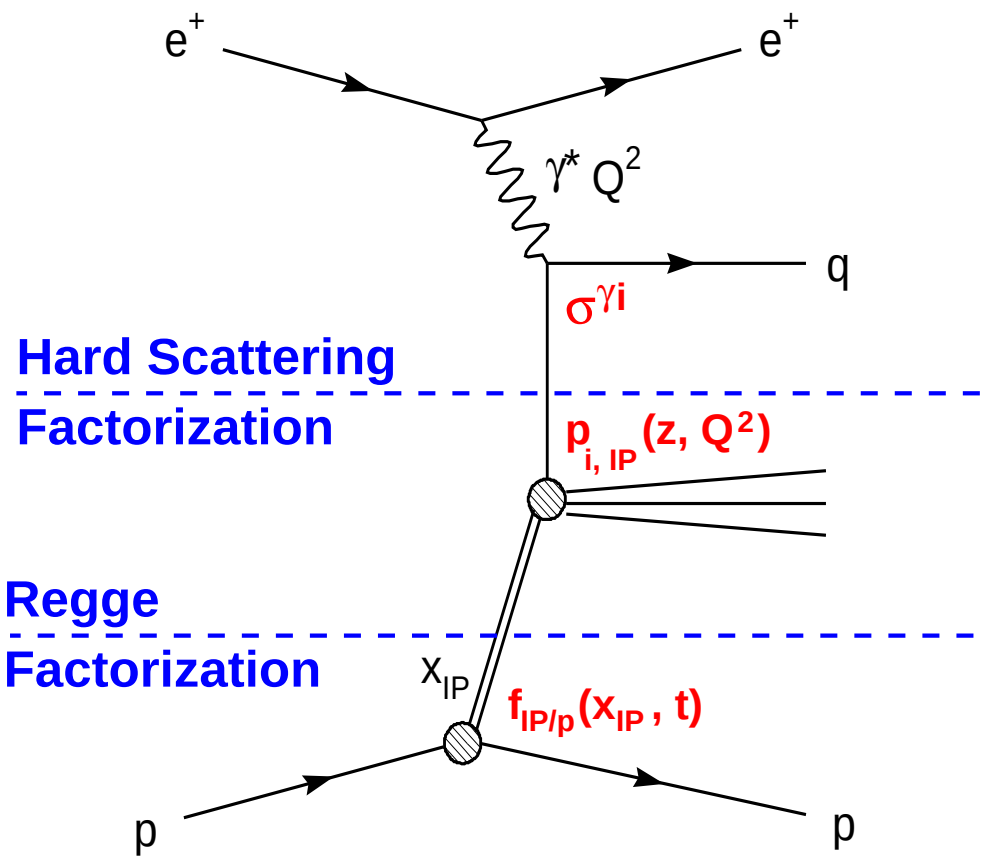


z_{IP} : longitudinal momentum fraction of gluon rel to colorless exchange.



Diffractive PDFs & Factorisation



- Diffraction is studied in terms of diffractive PDFs.
- To extract these PDFs 2 Factorisation steps are applied.

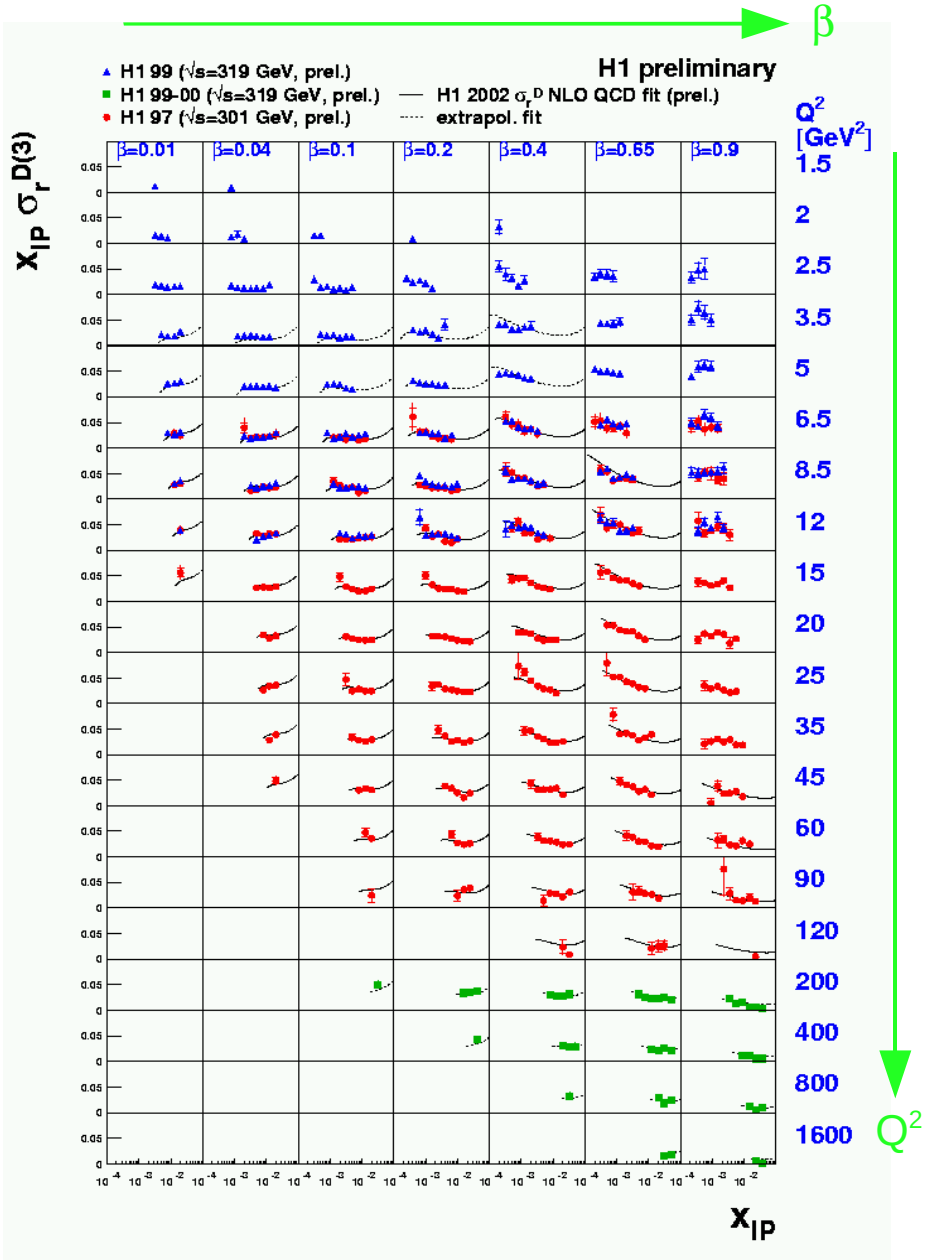
$$\sigma^D = \sum f_{IP/p}(x_{IP}, t) \cdot p_{i,IP}(z, Q^2) \circ \sigma^{\gamma,i} + \ldots$$

$\sigma^{\gamma,i}$: partonic cross section

$p_{i,IP}(z,Q^2)$: diffractive parton density

$f_{IP/p}(x_{IP},t)$: pomeron flux factor

Results from inclusive Diffraction

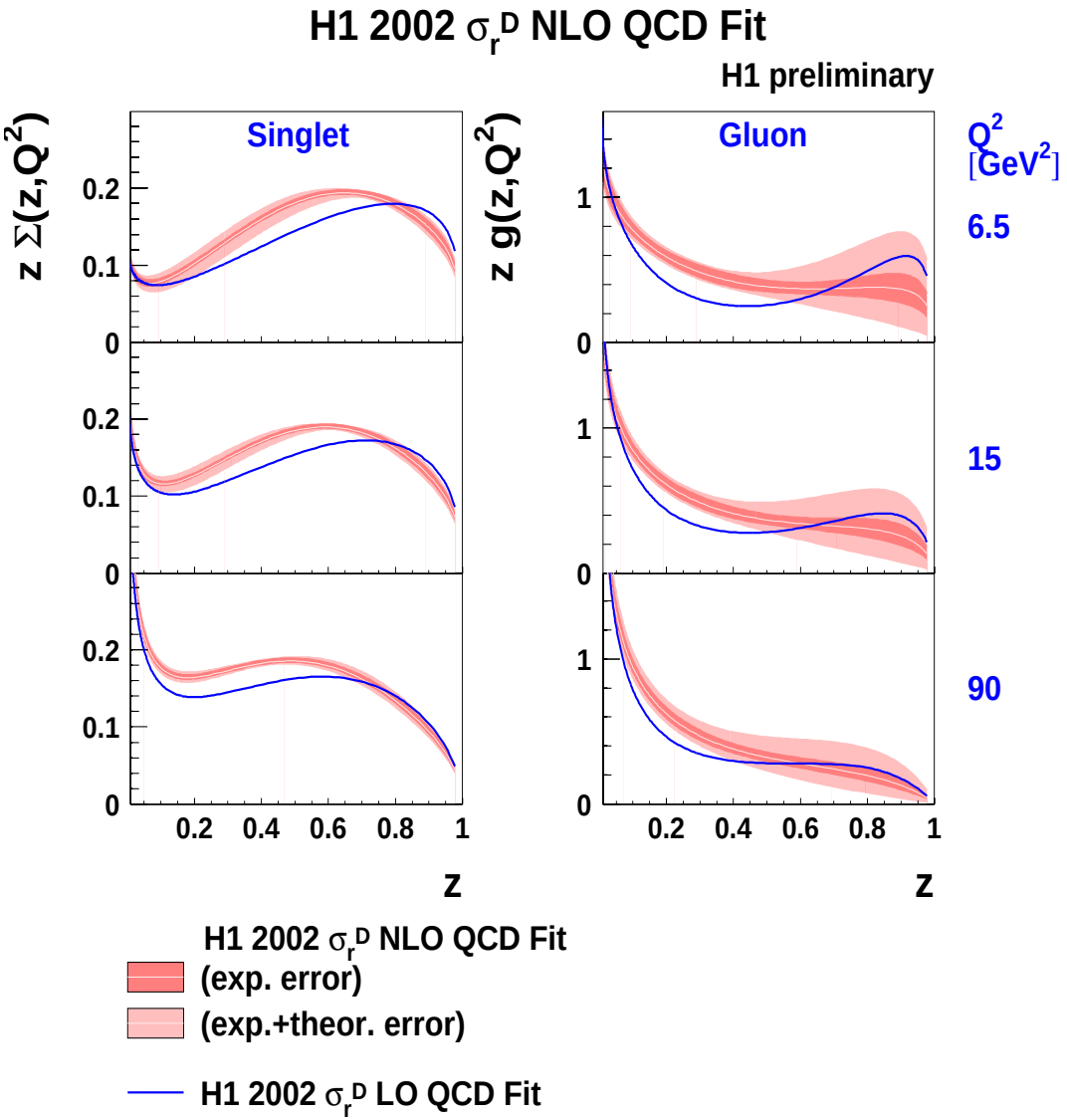


Reduced Cross Section from incl. Diffractive Data (ICHEP04 / 06-175)

- Get diffractive PDFs from a NLO (LO) DGLAP QCD Fit to inclusive data from 6.5 GeV^2 to 120 GeV^2 (e.g.ICHEP02 / 980).
- Extrapolation of the Fit
  - to lower Q^2
  - to higher Q^2

  gives a reasonably good description of inclusive data (from ~3.5 GeV^2 -1600 GeV^2)!

Diffractive PDFs from incl. Measurements

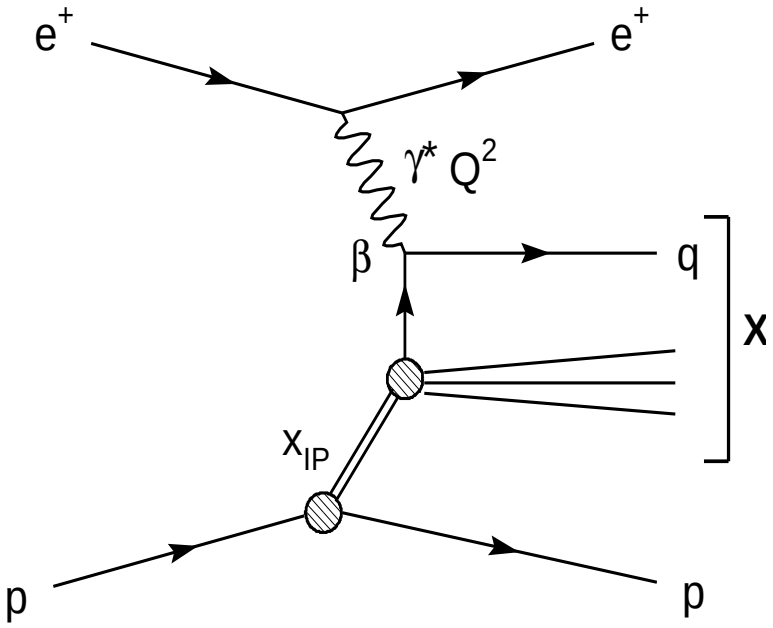


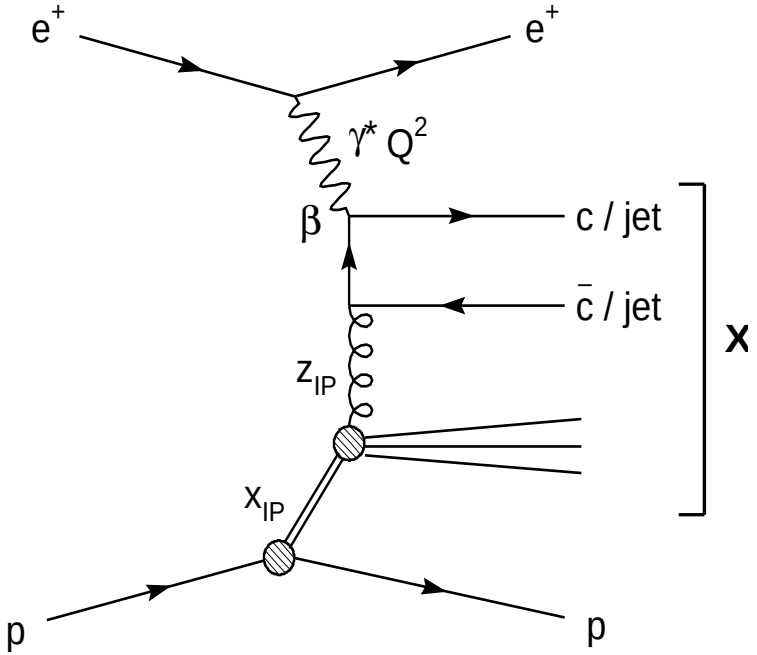
- Gluon Contribution dominates (carrying ~75% of the IP momentum).
- For gluon PDFs uncertainties increase towards higher z (EPS03 / 5-089).

Exclusive Final States in Diffraction

Get PDFs from inclusive Diffraction

Predict Cross Sections from exclusive Final States in Diffraction



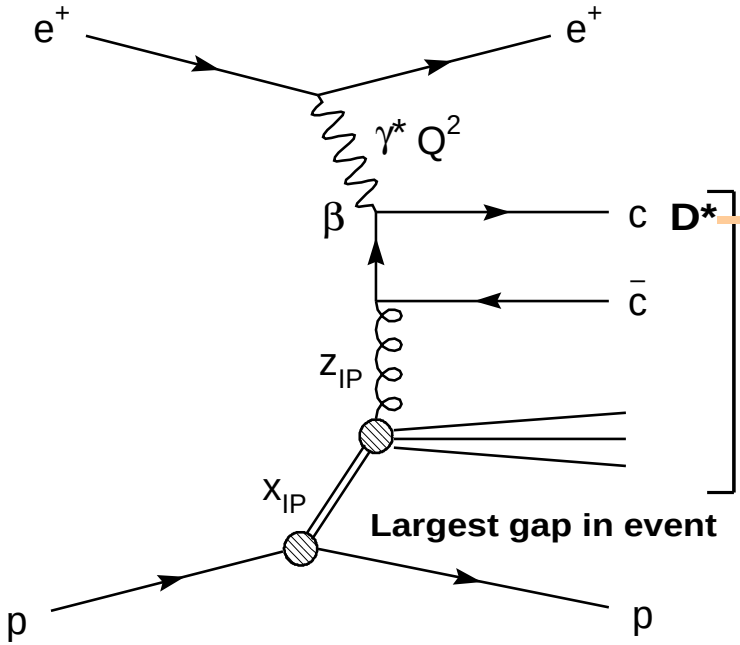


Gluon density only indirectely from scaling violations

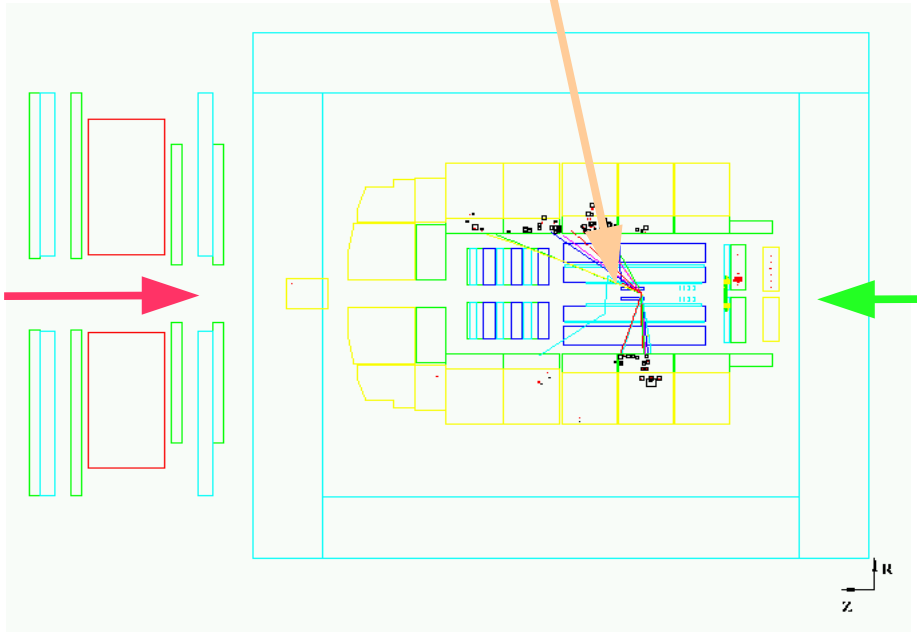
Direct access to gluon density

- Test of universality of PDFs (= QCD Factorisation)
- Test of DGLAP evolution

Diffractive D* Production in DIS



Reconstruct D*-Meson via decay
D* -> K π π_s

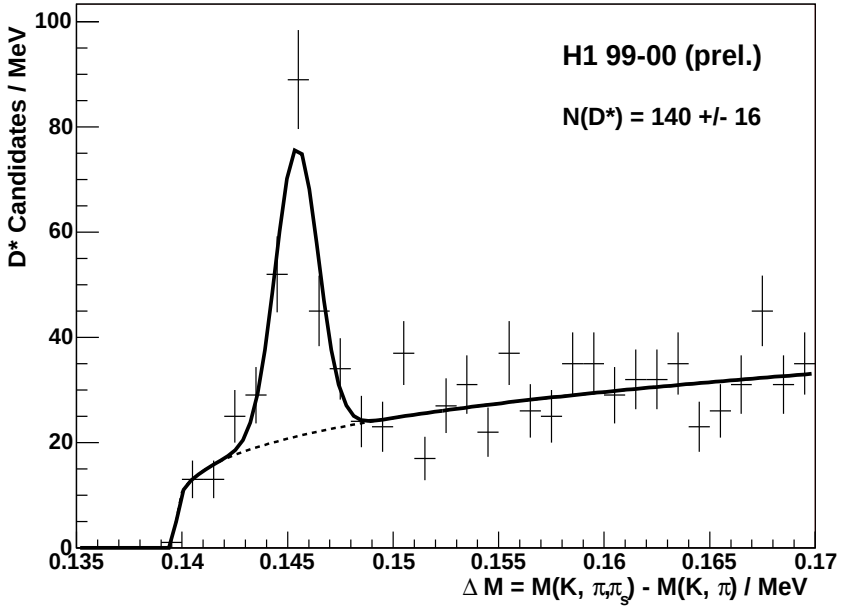


Event Selection for Diffractive D*'s in DIS

Kinematic Range:

- $0.05<y_e<0.7$
- $2\ GeV^2 < Q^2 < 100\ GeV^2$

- $p_T(D^*) < 2\ GeV$
- $|\eta(D^*)| < 1.5$



Diffractive Selection:

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

Visible Cross Section:

$\sigma_{vis} = 333 +/- 42(stat) +/- 62(sys)\ pb$

Dominant Systematics:

- Track Efficiency
- Model Uncertainties
- Proton Dissociation

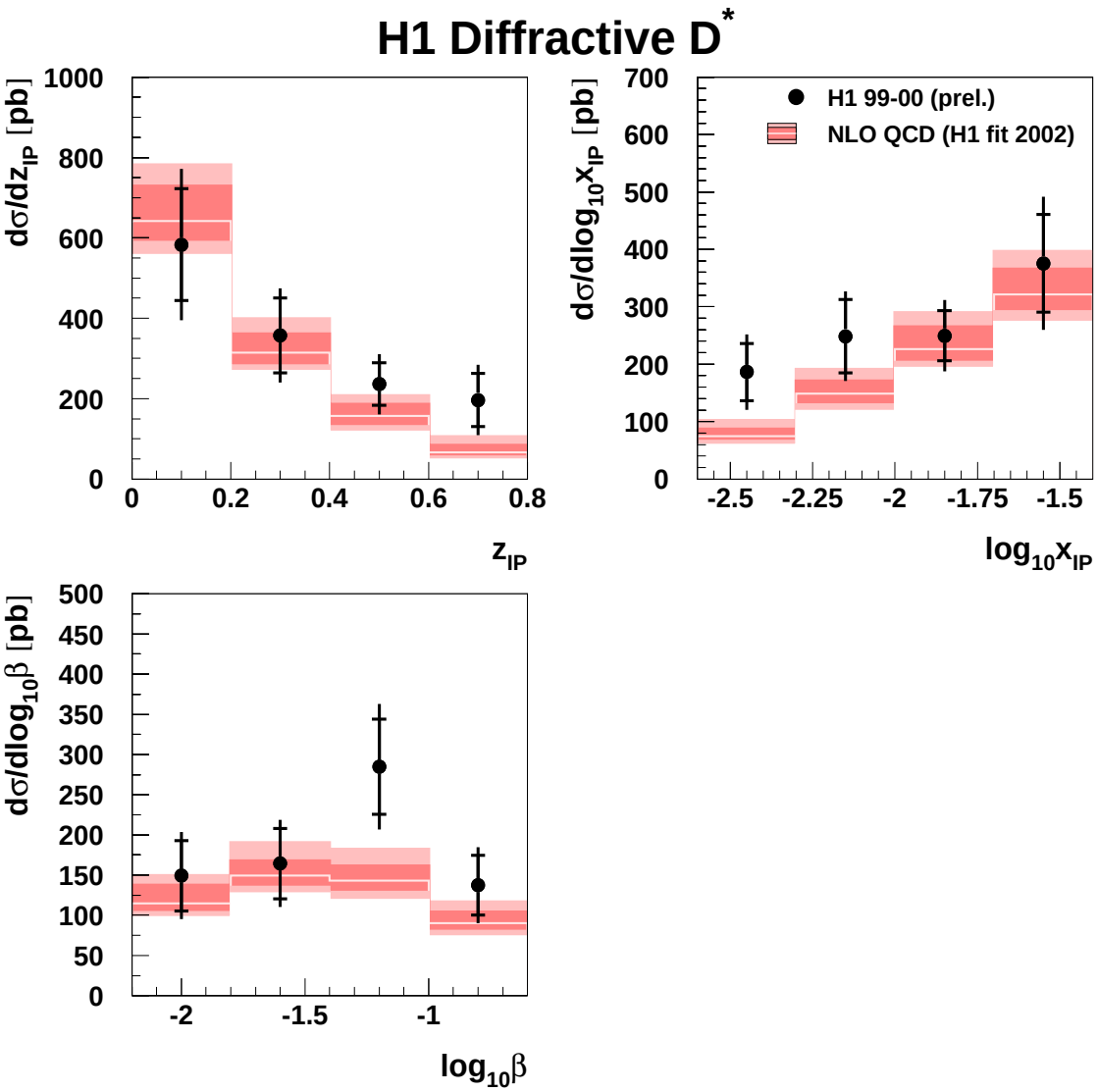
$\sigma_{vis} = 241 + 66/- 39\ pb$ (from NLO)

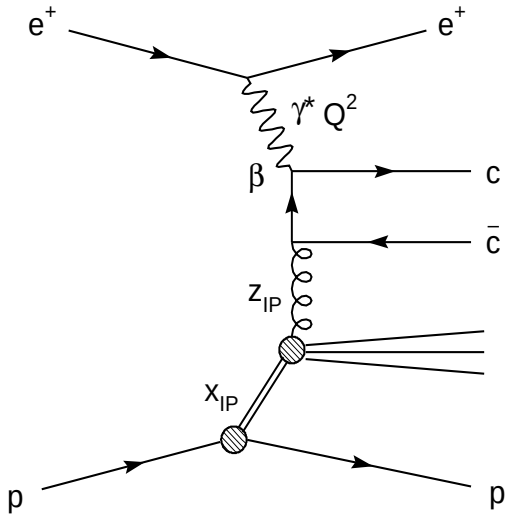
NLO Calculations for diffractive D*'s in DIS

HVQDIS Harris & Smith (hep-ph/9503484) with diffractive extension by Alvero et al (hep-ph/9806340) interfaced to diff PDFs of H1.

- QCD Parameters: $m_c = 1.5$ GeV; $\Lambda_{QCD} = 0.20$ GeV; $N_f = 4$; $\mu_r = \mu_f = Q^2 + 4m_c^2$.
- Peterson Fragmentation with ε=0.078.
- Uncertainties:
  - Variation of of μ_r and μ_f by ½ and 2 (deep red inner band).
  - Variation of m_c=1.35...1.65 GeV and ε=0.035...0.1 (pale red outer band).

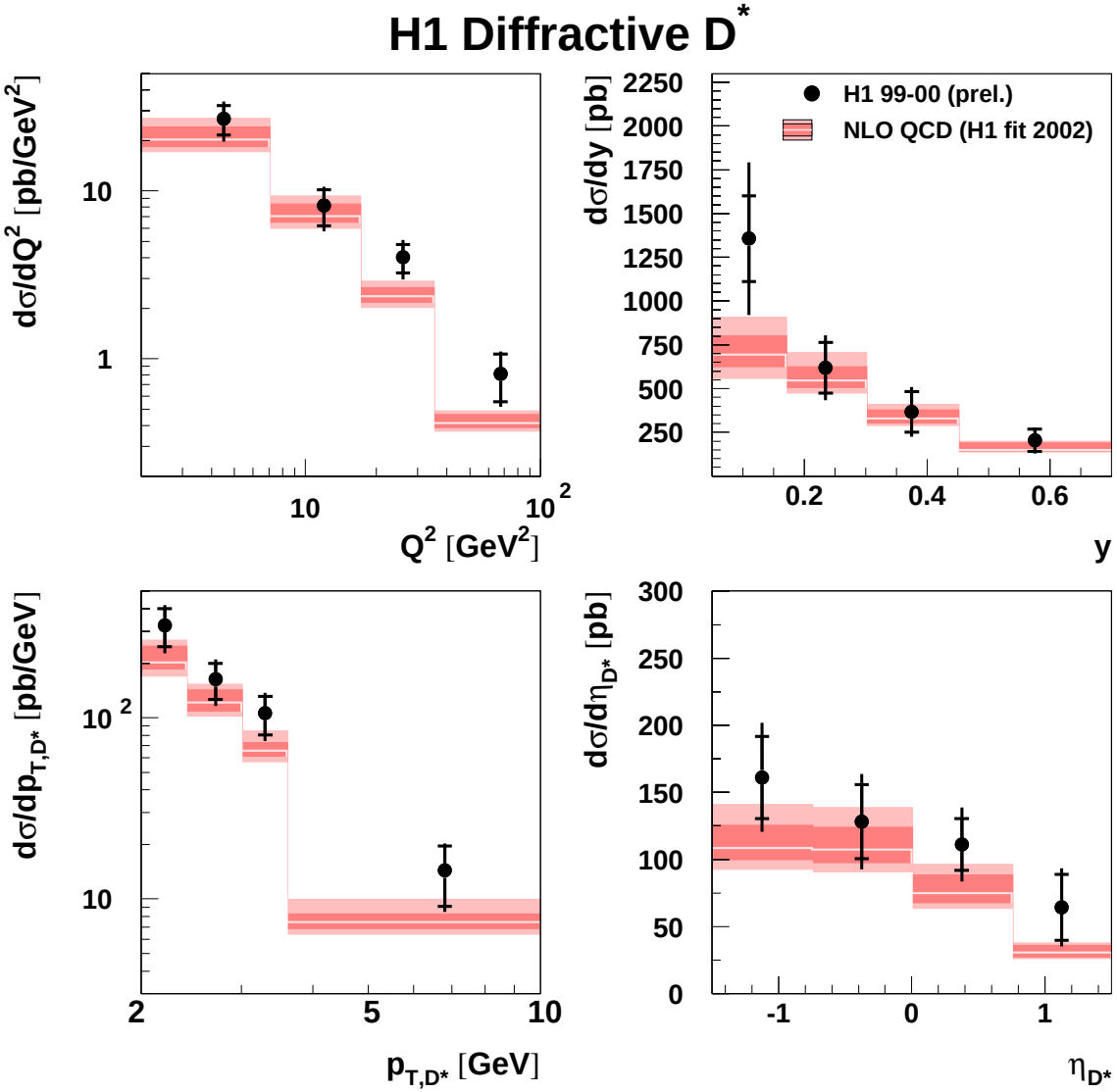
Cross Sections for diffractive D*'s in DIS





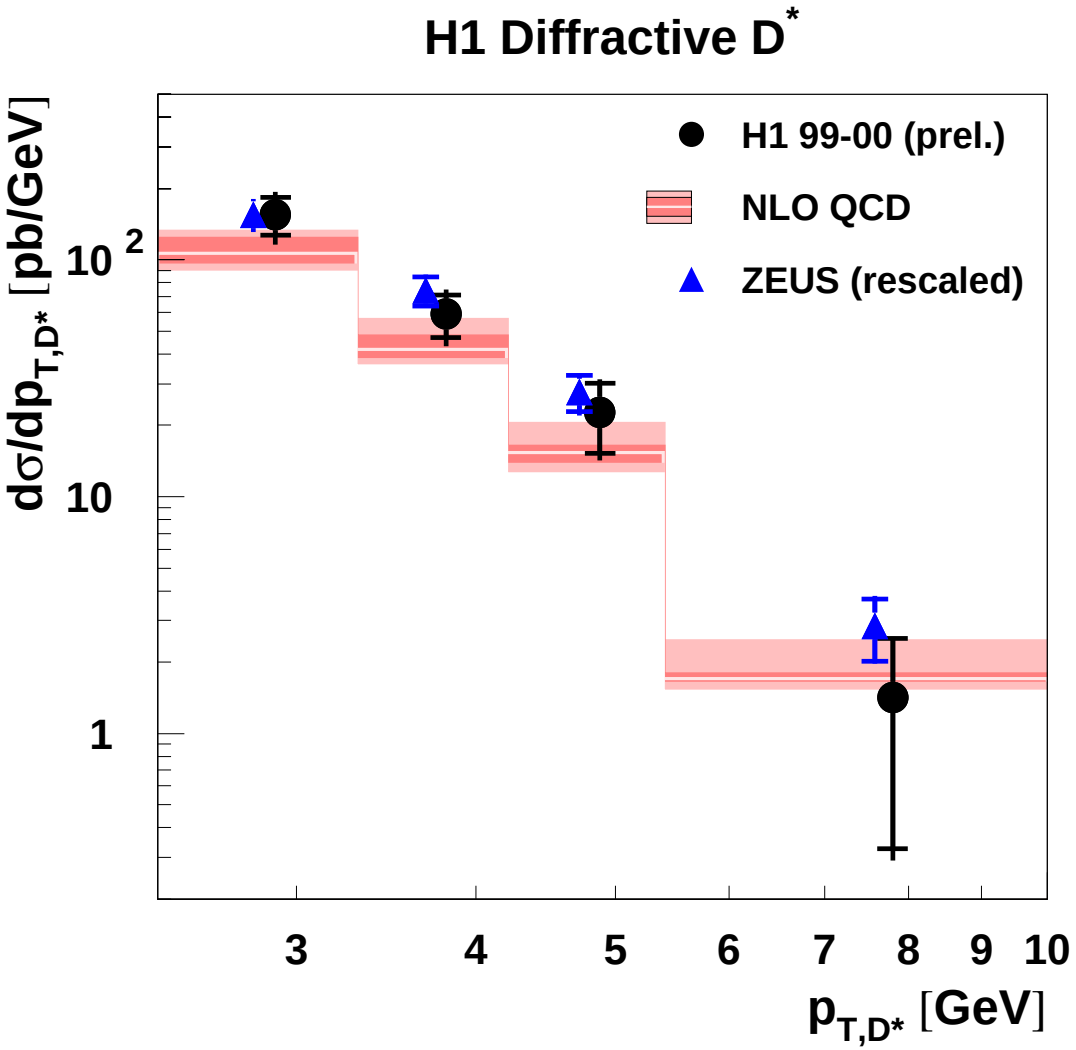
Good agreement within experimental & theoretical uncertainties.

Cross Sections for diffractive D*'s in DIS



Good agreement within experimental & theoretical uncertainties for all differential distributions.

A comparison with the ZEUS measurement



- ZEUS points rescaled to kinematic range of H1 measurement ($p_T > 1.5$ GeV --> $p_T > 2$ GeV).
- Good agreement of both measurements within stat errors!

Conclusion

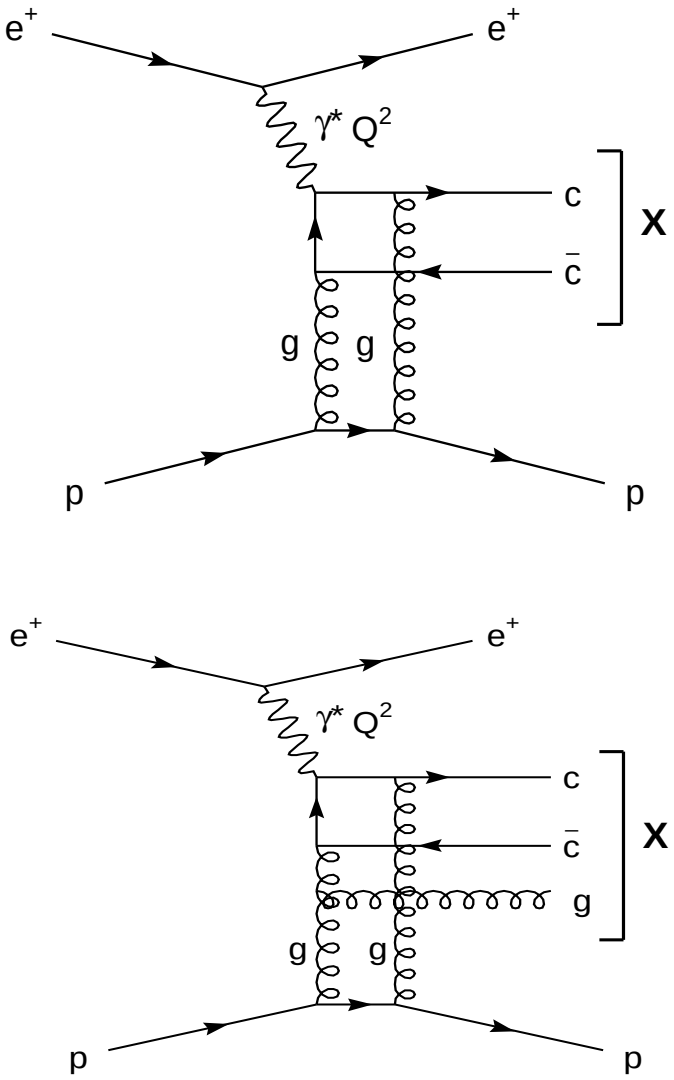
NLO calculations with PDFs from inclusive Diffraction.

provide

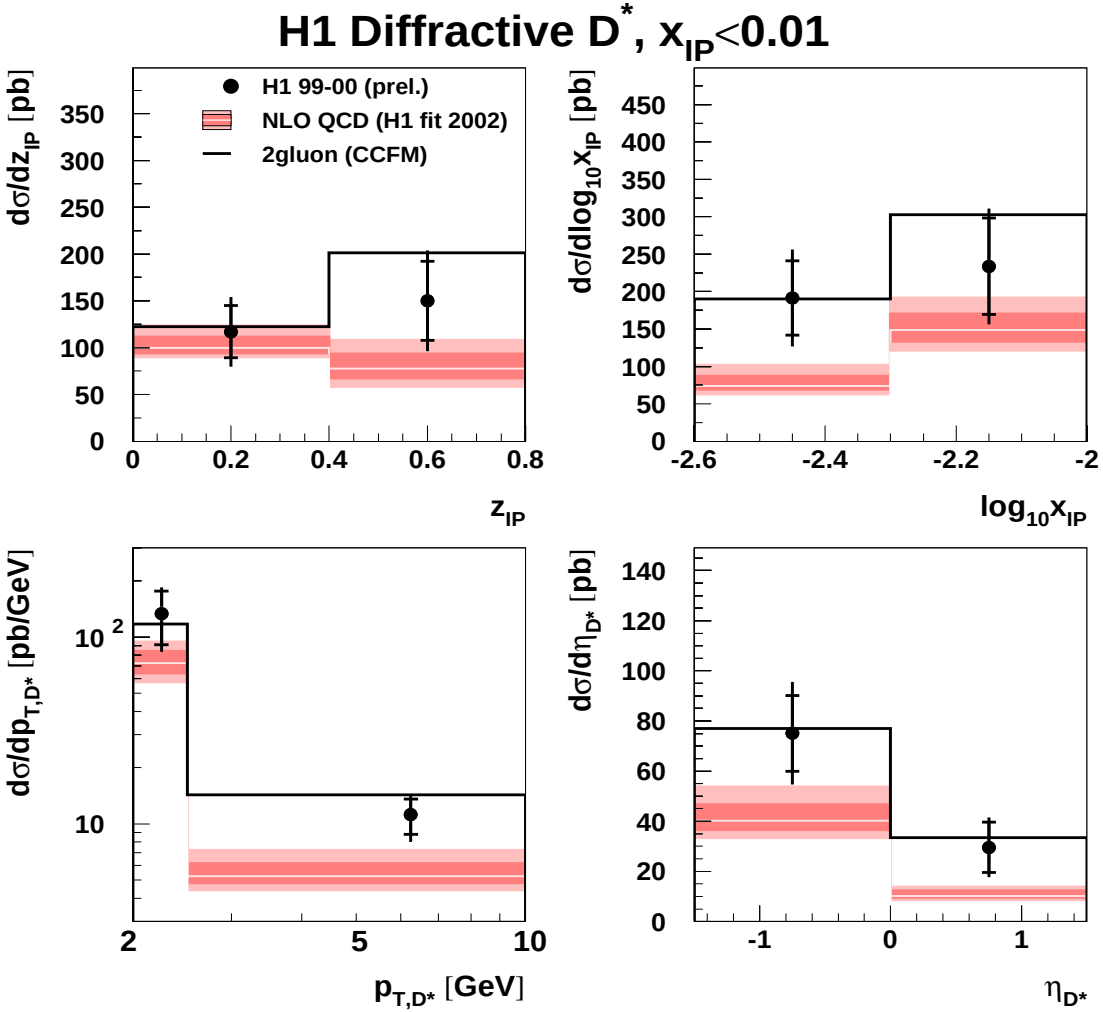
Good description of diffrative D* Production in DIS ($2\ \mathrm{GeV}^2 < Q^2 < 100\ \mathrm{GeV}^2$).

Parenthesis: 2 Gluon Model of BJKLW

- Describes Pomeron as color singlet exchange of 2 gluons (cc- & ccg-component taken into account).
- Use unintegrated gluon densities from Fit to incl Structure Function F_2 (hep-ph/0309009).
- Only valid for small x_{IP} (neglects quark exchanges).
- p_T cut needed for ccg (pertubation theory applicable / tunes normalisation & shape / p_T>1.5 GeV).

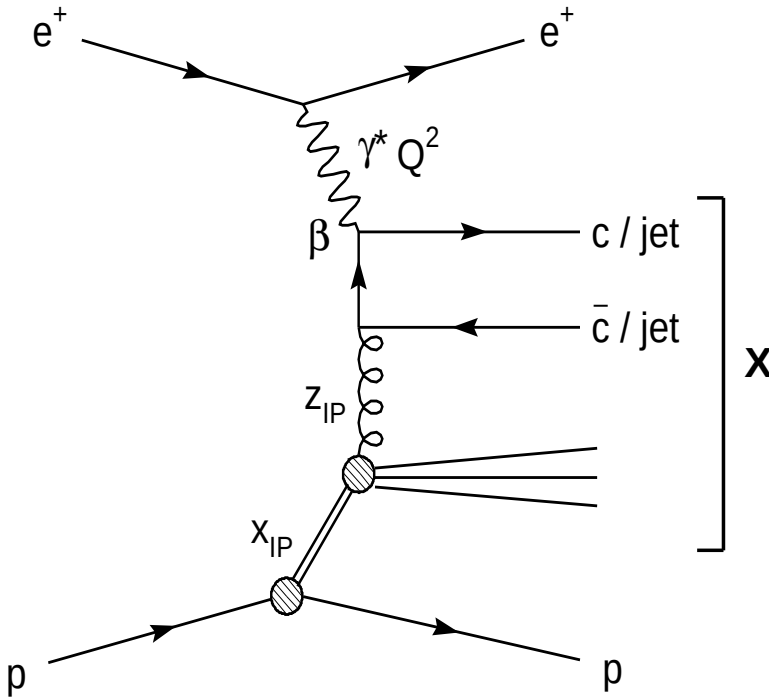


Differential Cross Sections for $x_{IP} < 0.01$



In its range of validity ($x_{IP}<0.01$) & with p_T cut at 1.5 GeV the two gluon approach is able to describe the data.

Diffractive Dijet Production in DIS



Kinematic Range:

- 165 GeV < $W_{\gamma p}$ < 242 GeV
- 4 GeV^2 < Q^2 < 80 GeV^2 (DIS)

Dijet Selection:

- inclusive k_T Algorithm in γp cms
- Distance Paramerter 1

- E_T^{*Jet1} > 5 GeV
- E_T^{*Jet2} > 4 GeV
- Jet axes of 2 leading jets well within Calo acceptance ($-1<\eta_{Jet,\,lab}<2$)

Diffractive Selection:

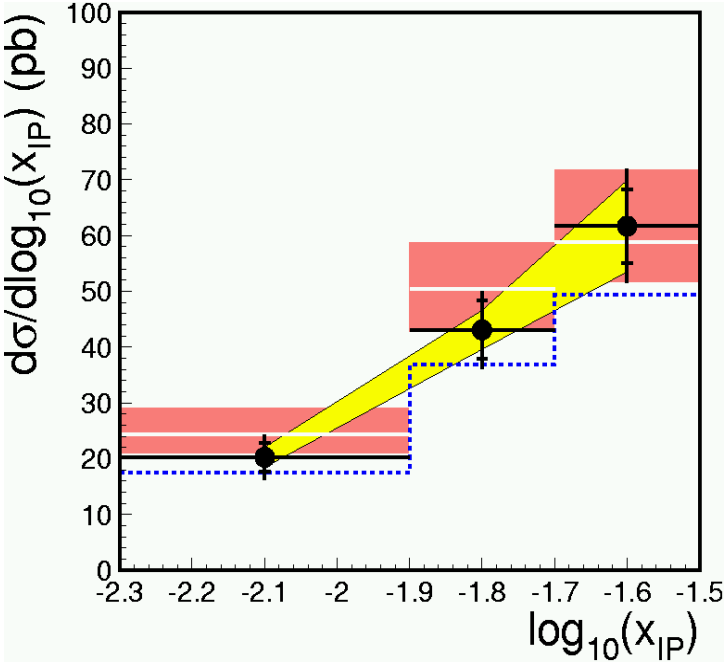
- x_{Pom} < 0.03
- M_Y < 1.6 GeV, $|t|$ < 1 GeV^2

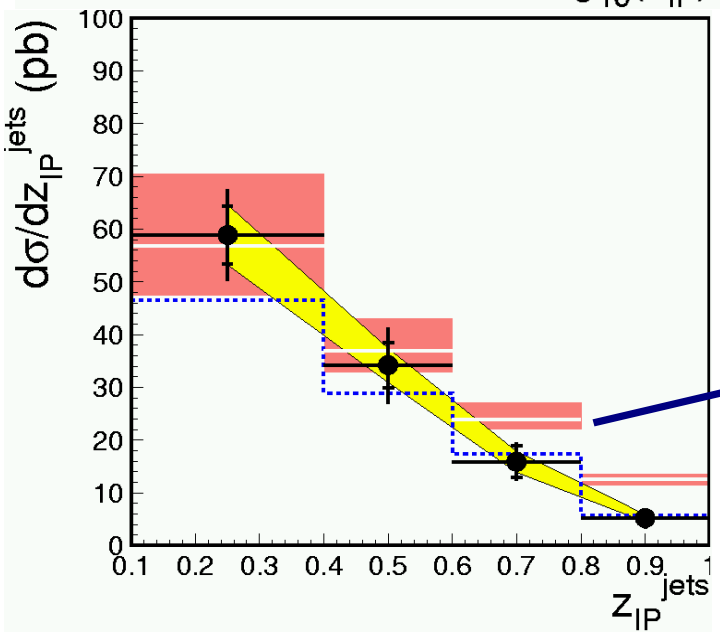
NLO Calculations for diffractive Dijets in DIS

Diffractive Extension of DISENT Catani & Seymour
(Nucl Phys **B485** (1997) 29 / **B510** (1997) 503) interfaced to diff PDFs of H1.

- QCD Parameters: $\Lambda_{QCD} = 0.20$ GeV; $N_f = 4$;
  $\mu_r = E_T^{*Jet1}$; $\mu_f = 6.2$ GeV (~$<E_T^{*Jet1}>$)
- Corrected for hadronisation with the Monte Carlo Generator RAPGAP (LO Monte Carlo Generator with parton showers).
- Uncertainties:
  - Variation of of μ_r by ½ and 2 (red band ~20%).
  - NOT included: Variation of μ_f (by ½ and 2: ~10%) and uncertainty of hadronisation effects.

Cross Sections for diffractive Dijets in DIS





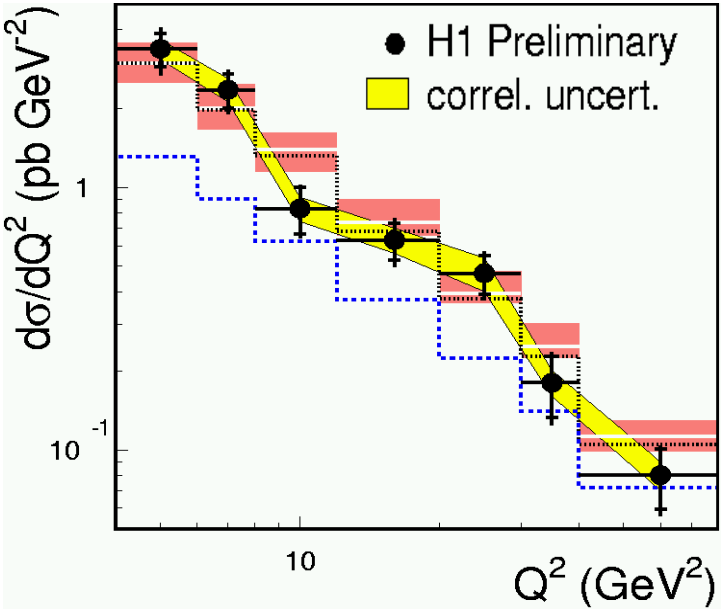
H1 Preliminary
correl. uncert.

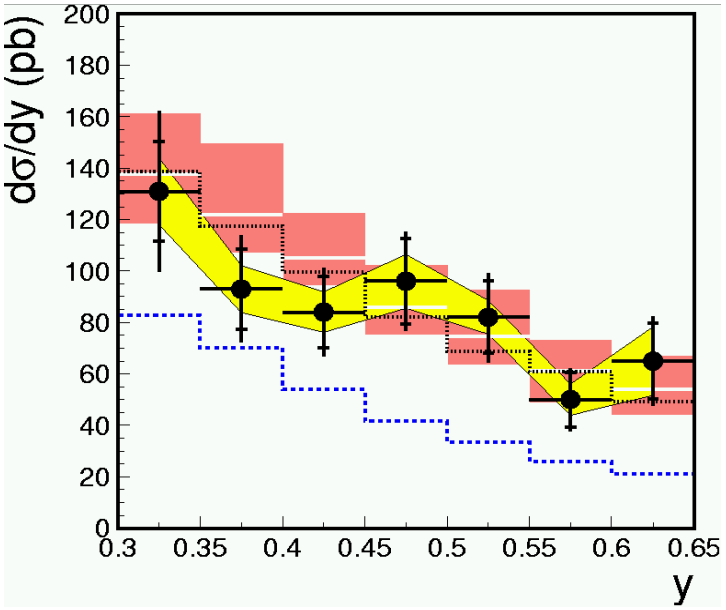
H1 2002 fit (prel.)
DISENT NLO*(1+δ_{had})
RAPGAP

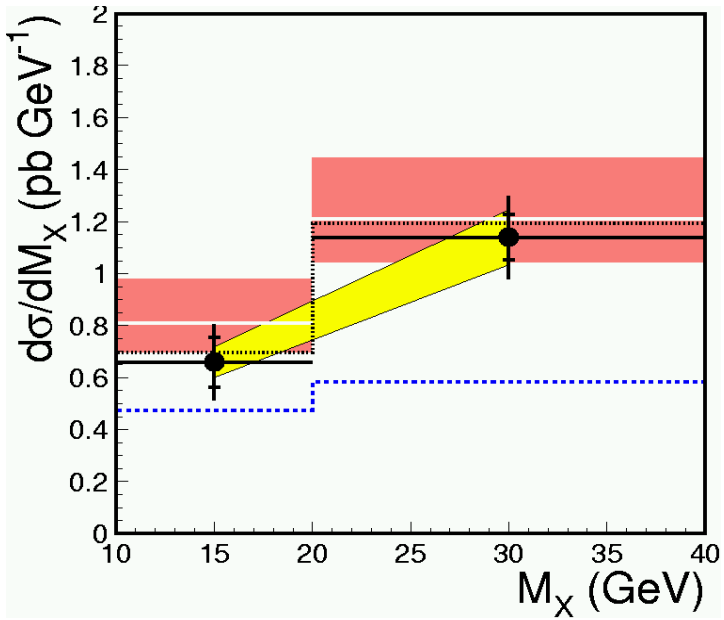
Good description within experimental and theoretical uncertainties.

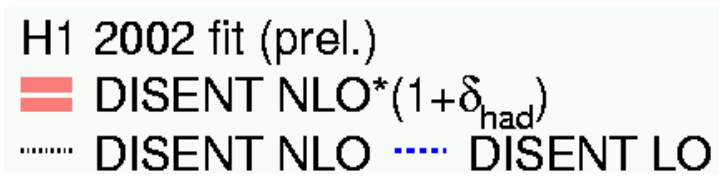
Uncertainties of PDFs not included in theoretical error band.

Cross Sections for diffractive Dijets in DIS









Good agreement within experimental & theoretical uncertainties for all differential distributions.

Conclusion

NLO calculations with PDFs from inclusive Diffraction.

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Good description of diffrative D* Production in DIS ($2\ \text{GeV}^2 < Q^2 < 100\ \text{GeV}^2$).

Good description of diffrative Dijet Production in DIS ($4\ \text{GeV}^2 < Q^2 < 80\ \text{GeV}^2$).

Test of QCD Factorisation

NLO calculations with PDFs from inclusive Diffraction.

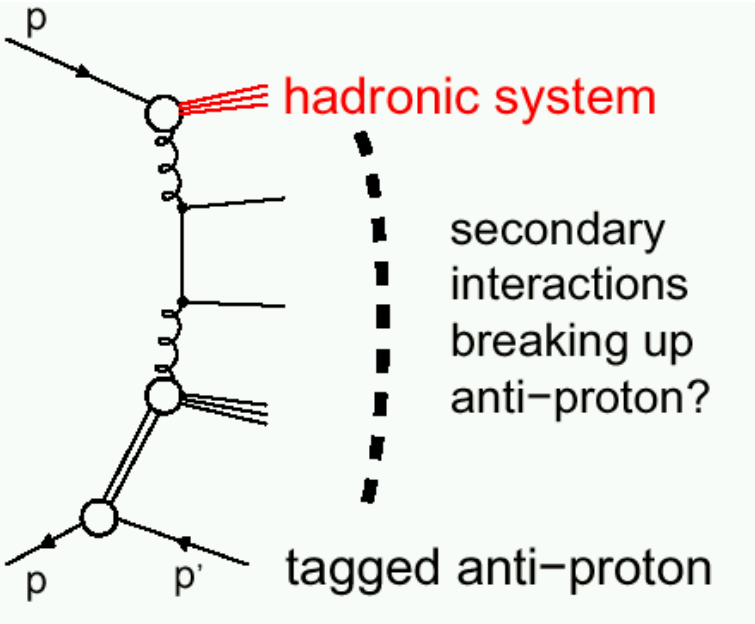
provide

Good description of diffrative D* Production in DIS ($2\ \text{GeV}^2 < Q^2 < 100\ \text{GeV}^2$).

Good description of diffrative Dijet Production in DIS ($4\ \text{GeV}^2 < Q^2 < 80\ \text{GeV}^2$).

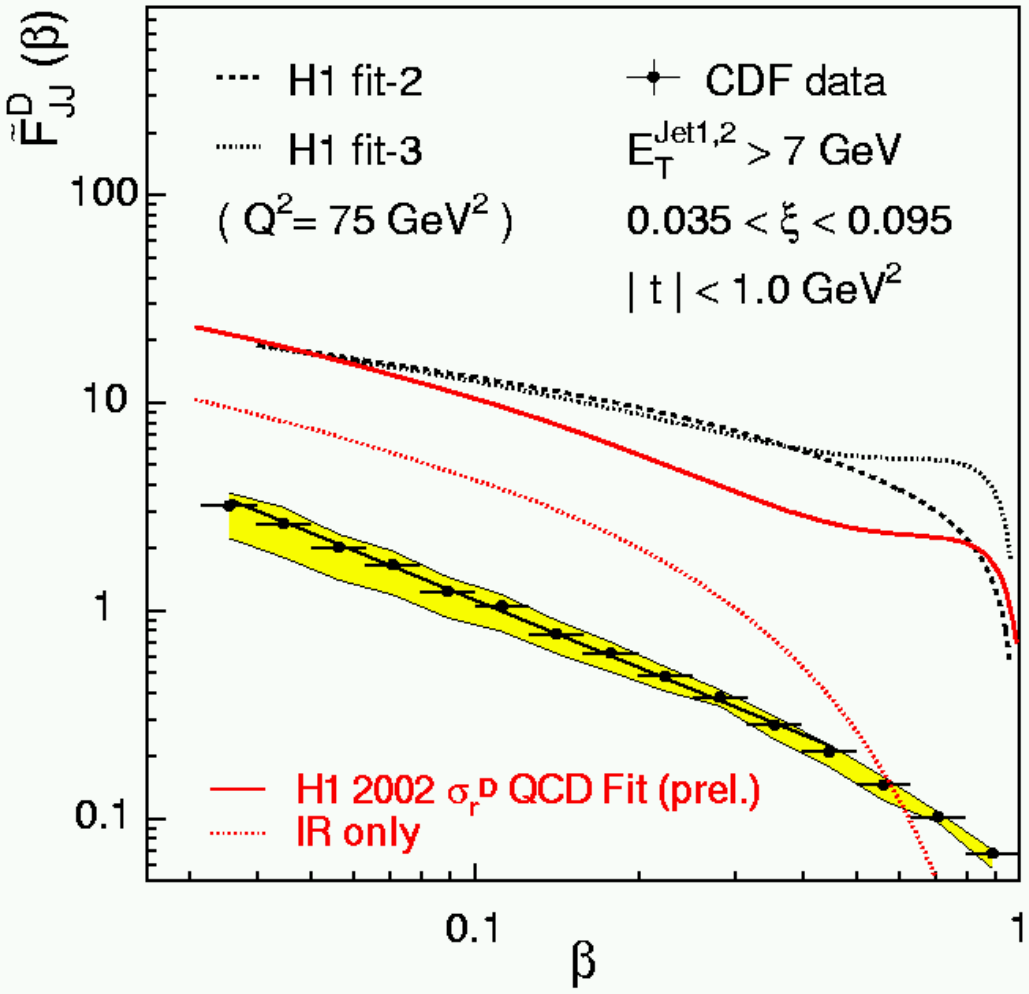
(Within experimental and theoretical uncertainties)
Hard Scattering Factorisation is successfully tested in DIS!

Single Diffractive Dijets at the Tevatron



- Rate overestimated by a factor of ~7.
- Breakdown of Factorisation!
- Secondary interactions due to the hadronic system of the underlying event.

LO comparison to diffractive PDFs from HERA



Diffractive Dijets in Photoproduction

Same Event Selection as for diffractive Dijets in DIS BUT $Q^2 < 0.01\ GeV^2$

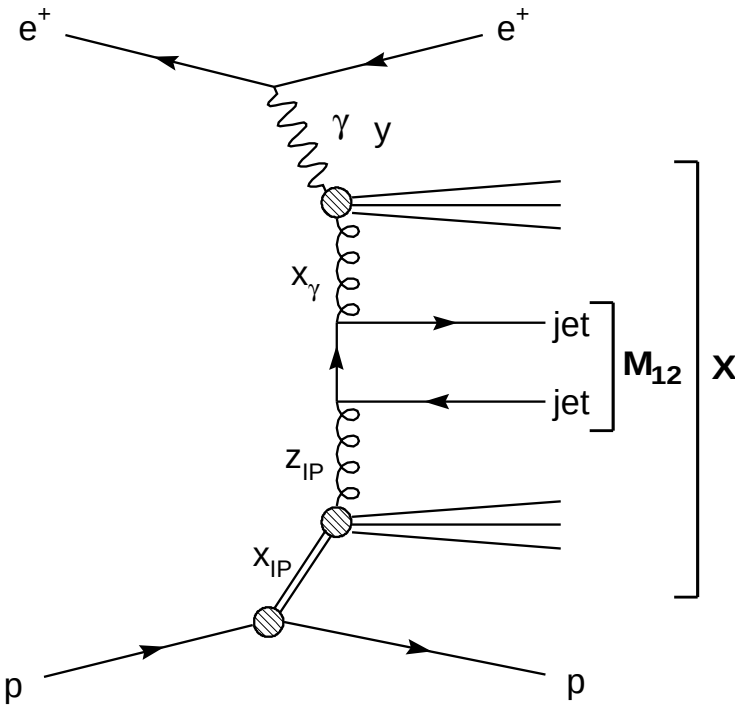
Quasi real photon can dissociate into hadronic system.

$0 < x_\gamma < 1$

p fraction of the γ entering the hard scattering process

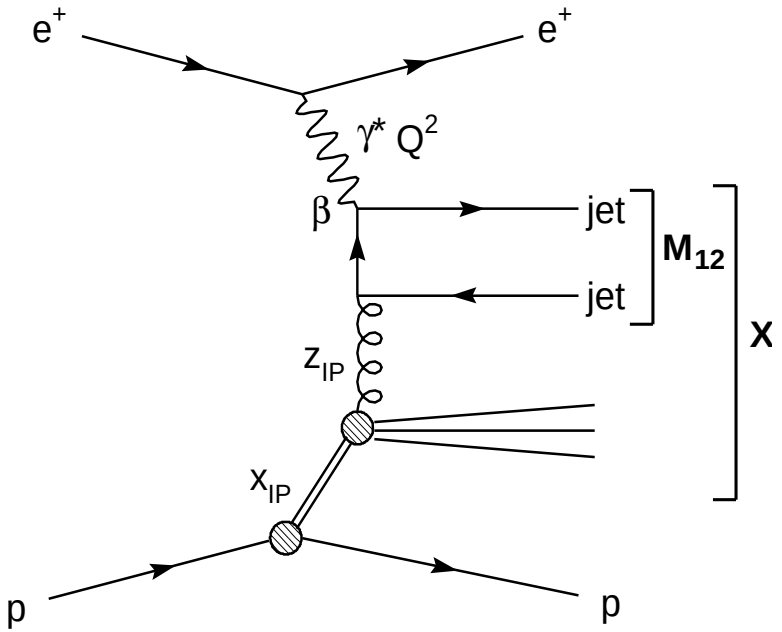
Resolved

Hadron like



Direct

DIS like

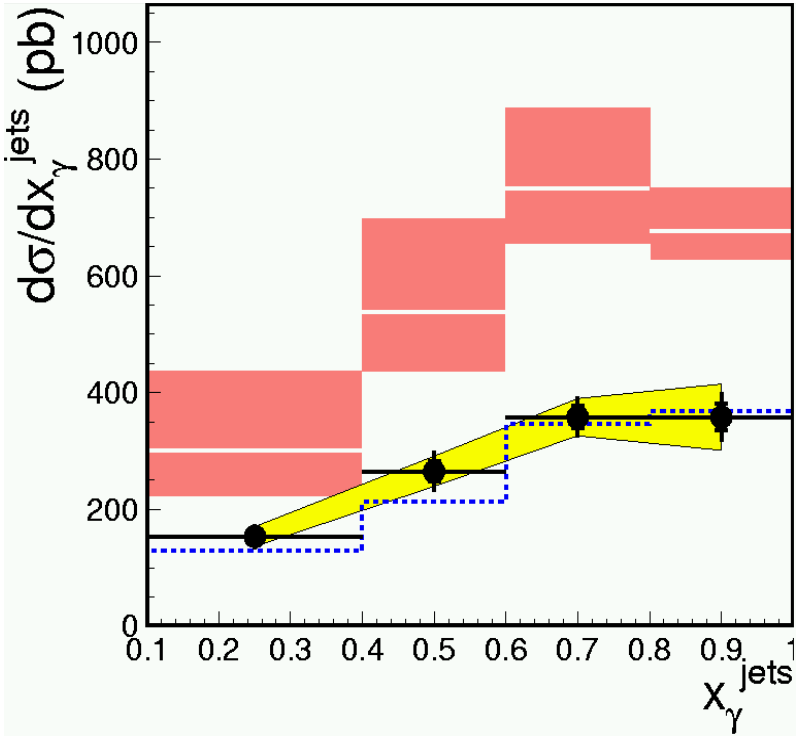


NLO Calculations for diffractive Dijets in γp

(Nucl Phys B467 (1996) 399 / B507 (1997) 295) with interfaced to diff PDFs of H1.
Diffractive extension of program by Frixione et al

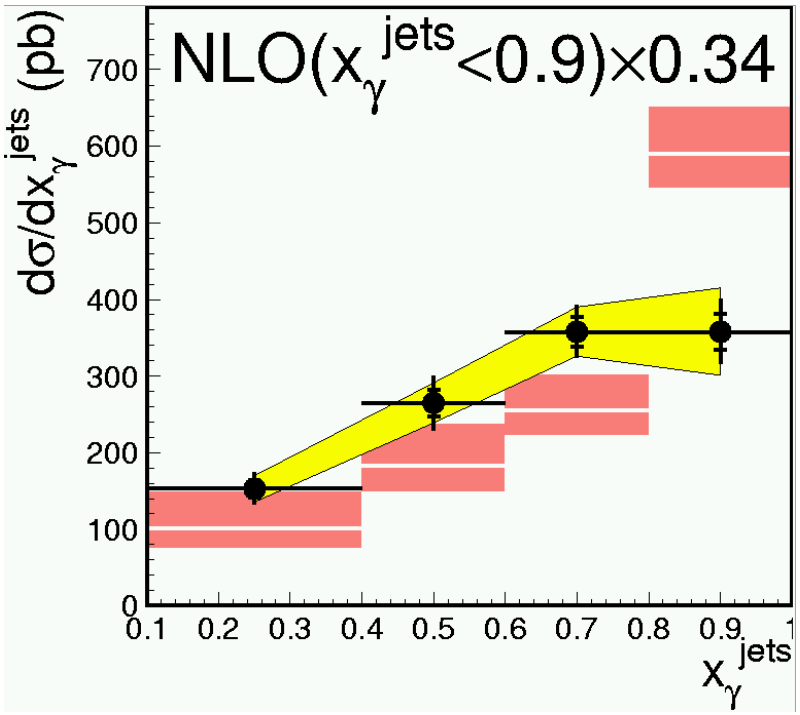
- QCD Parameters: $\Lambda_{QCD} = 0.20$ GeV; $N_f = 4$;
  $\mu_r = \mu_f = E_T^{*Jet1}$; $\mu_f = 6.2$ GeV ($<E_T^{*Jet1}>$)
- Corrected for hadronisation with the Monte Carlo Generator RAPGAP.
- Uncertainties:
  - Simultaneous Variation of of μ_r and μ_f by ½ and 2 (red band).
  - NOT included: uncertainty of hadronisation effects (~10%).

Cross Sections for diffractive Dijets in γp



- NLO prediction overestimates cross sections by a factor of ~2 (compare to ~7 at the Tevatron).
- Direct and resolved component are equally suppressed.
- Suppression also seen in all other distributions.
- LO Monte Carlo Generator RAPGAP with Parton Showers gives good description.

Suppression only of Resolved NOT enough



H1 Preliminary

correl. uncert.

H1 2002 fit (prel.)

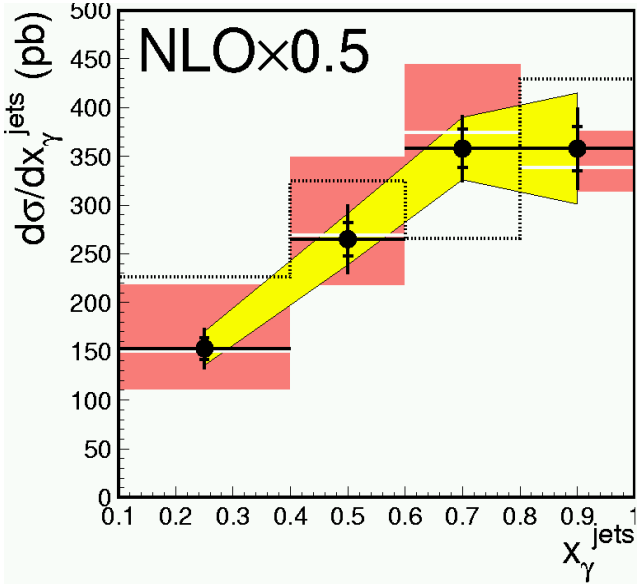
FR NLO*(1+δ_{had}), (x_γ^{jets}<0.9)×0.34

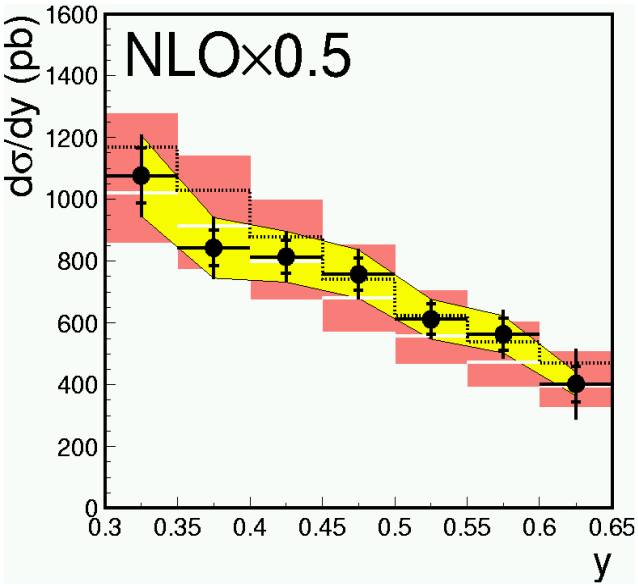
As suggested by Kaidalov et al (Phys Lett B567 (2003) 61): only resolved contribution should be suppressed by **~1/3**.

BUT

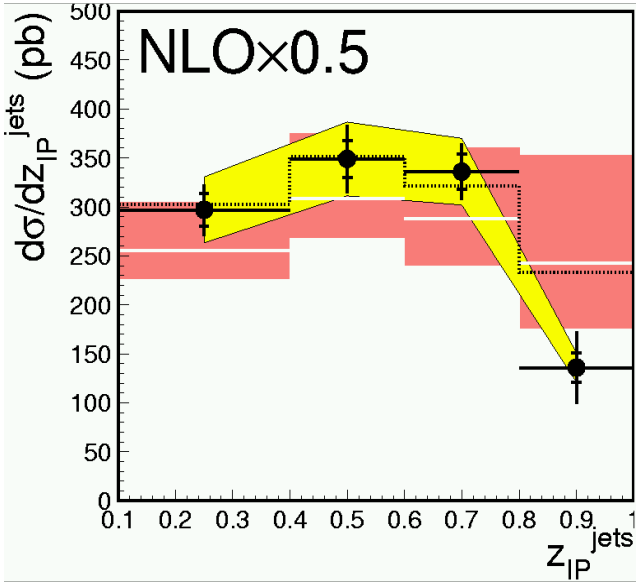
A suppression of only the resolved contribution **can not** describe the data.

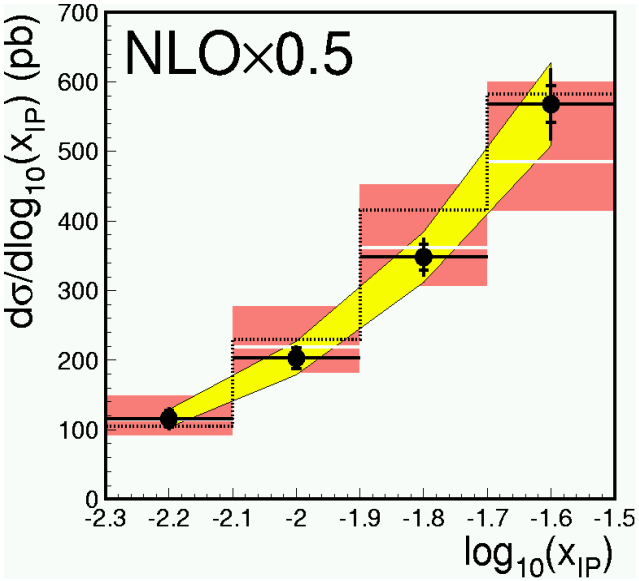
Cross Sections with NLO x 0.5





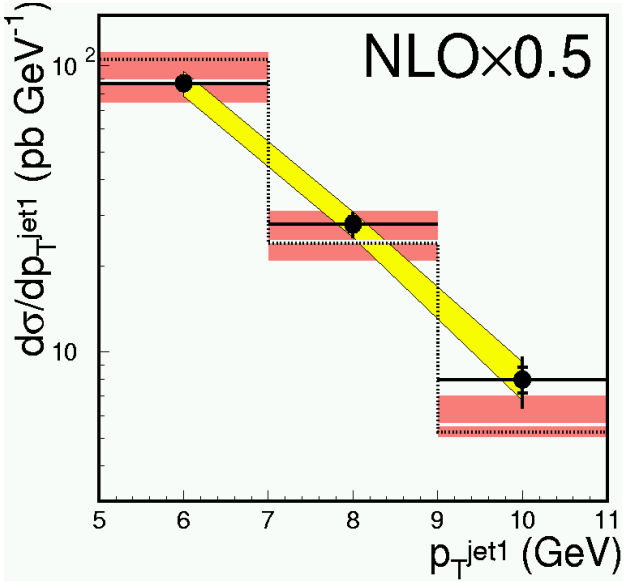
H1 Preliminary
correl. uncert.
H1 2002 fit (prel.)
FR NLO*(1+δ_{had}) ×0.5
FR NLO ×0.5

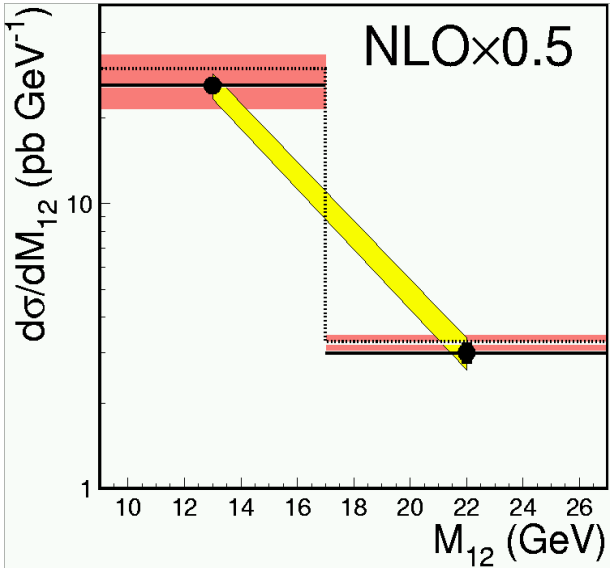


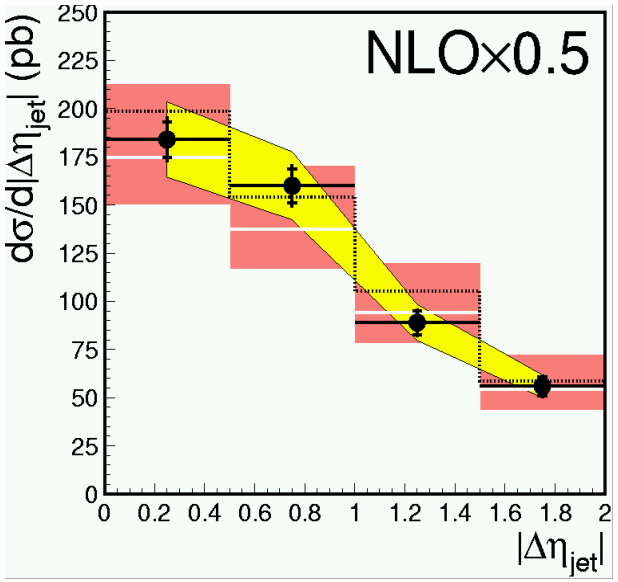


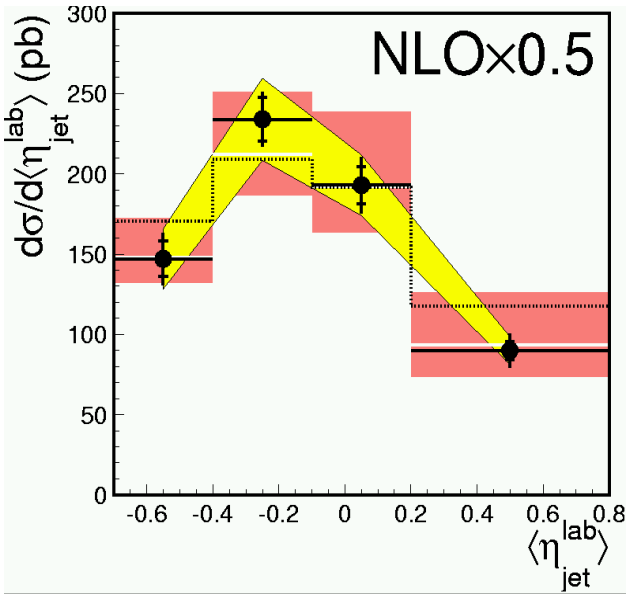
Good description of all distributions within exp & theo uncertainties.

Cross Sections with NLO x 0.5









H1 Preliminary

correl. uncert.

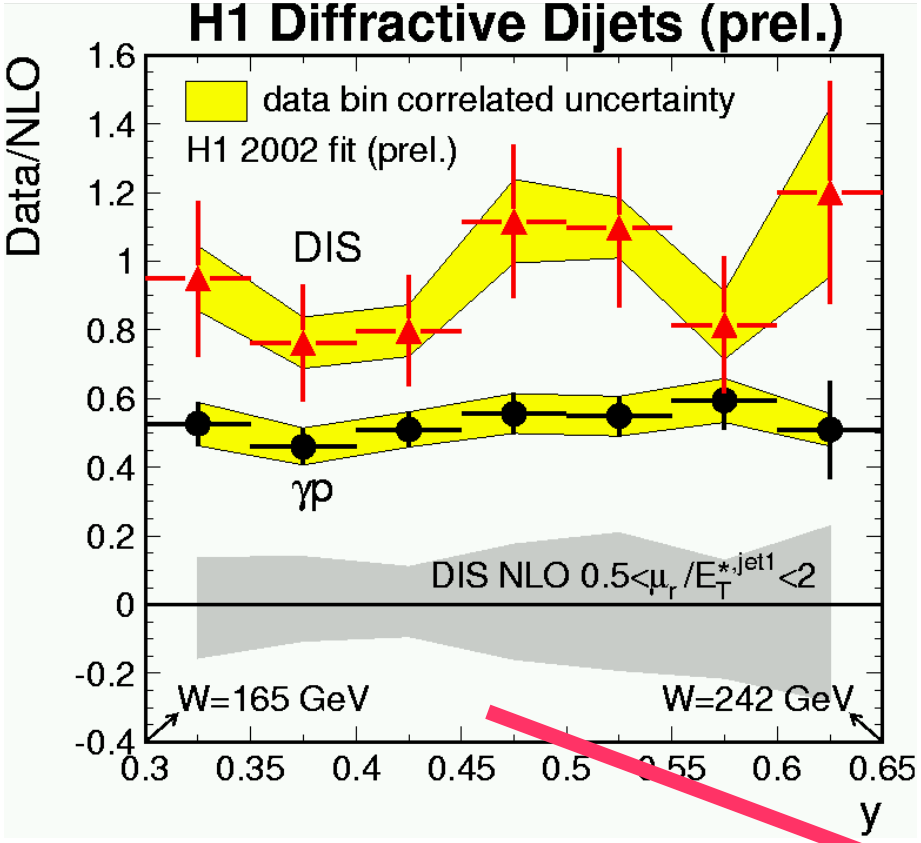
H1 2002 fit (prel.)

FR NLO*(1+δ_{had}) ×0.5

FR NLO ×0.5

Good description of all distributions within exp & theo uncertainties.

Ratio: Data over NLO Prediction



- **No suppression** observed in DIS.
- Overall suppression **factor of 0.5 needed** in γp (for both direct & resolved).

No significant Dependence of γp cms Energy within the covered W range.

Final Conclusion

New results presented on exclusive Final states in Diffraction.

DIS

- Factorisation successfully tested in NLO for: diffractive D*'s & diffractive Dijets.

γp

- NLO overestimates measured Cross Section for Dijet Production by a factor of ~2.
- Direct and Resolved are equally suppressed.