Svetlana Vinokurova

Diffractive production of charm and jets

September 18-23

Diffraction 2004
Gala Gonone
Sardinia
ITALY

September 18-23

Diffraction 2004

Gala Gonone

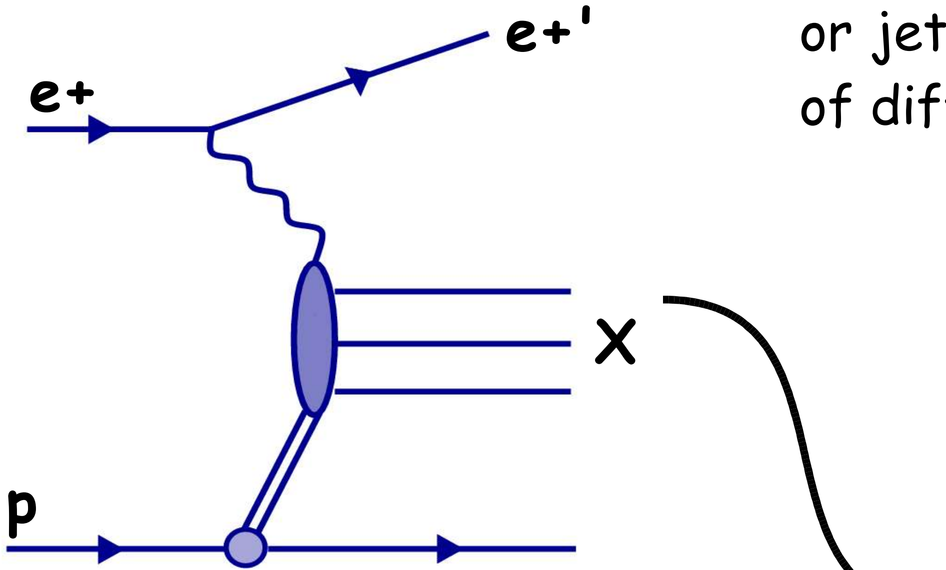
Sardinia

ITALY

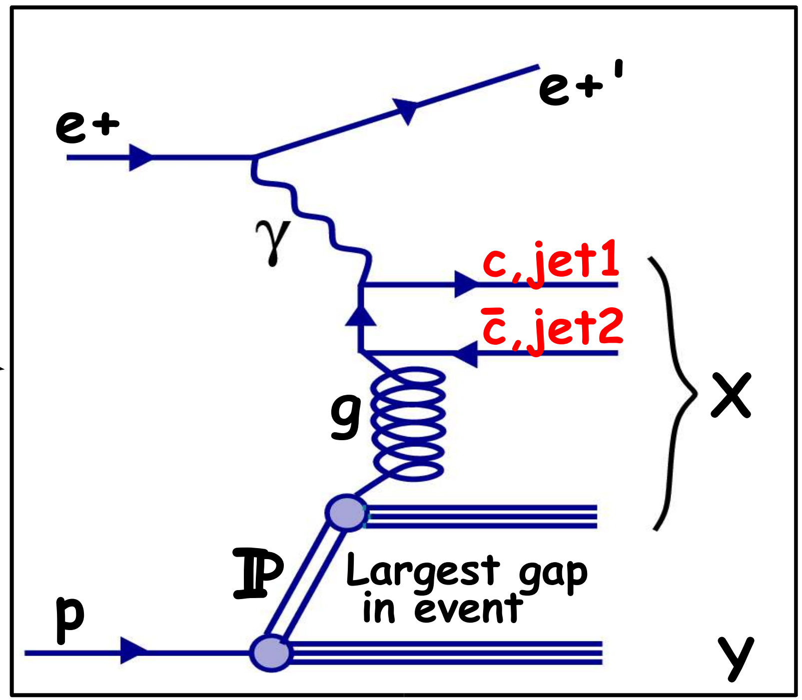
Diffractive production of charm and jets

- Testing QCD factorization in diffraction
- Diffractive D* in DIS
- Diffractive Dijets in DIS
- Dijets in diffractive photoproduction

from Inclusive Diffraction to final states



Looking into hadronic final states charm or jets production give access to details of diffractive parton densities



Factorization Theorem:

- Factorization theorem establishes universality of diffractive parton densities for class of processes to which the Theorem applies.
- This means that one may extract parton densities from subset of data and then, using same densities, reliable predict other diffractive distributions.

$$\sigma^D = \sum_{\text{partons } i} f_i^D \otimes \hat{\sigma}^{\gamma i}$$

hard diffractive cross section can be written as convolution of diffractive parton densities of proton : f_i^D
with hard parton-parton cross section : $\hat{\sigma}^{\gamma i}$

Test it...

- Hard scale :
  - Q^2
  - p jet
  - heavy quarks

– Based on QCD hard scattering factorization it should be possible to predict hard diffractive final states using diffractive PDFs

- DIS
  - D*
  - Dijets
- Photoproduction
  - Dijets

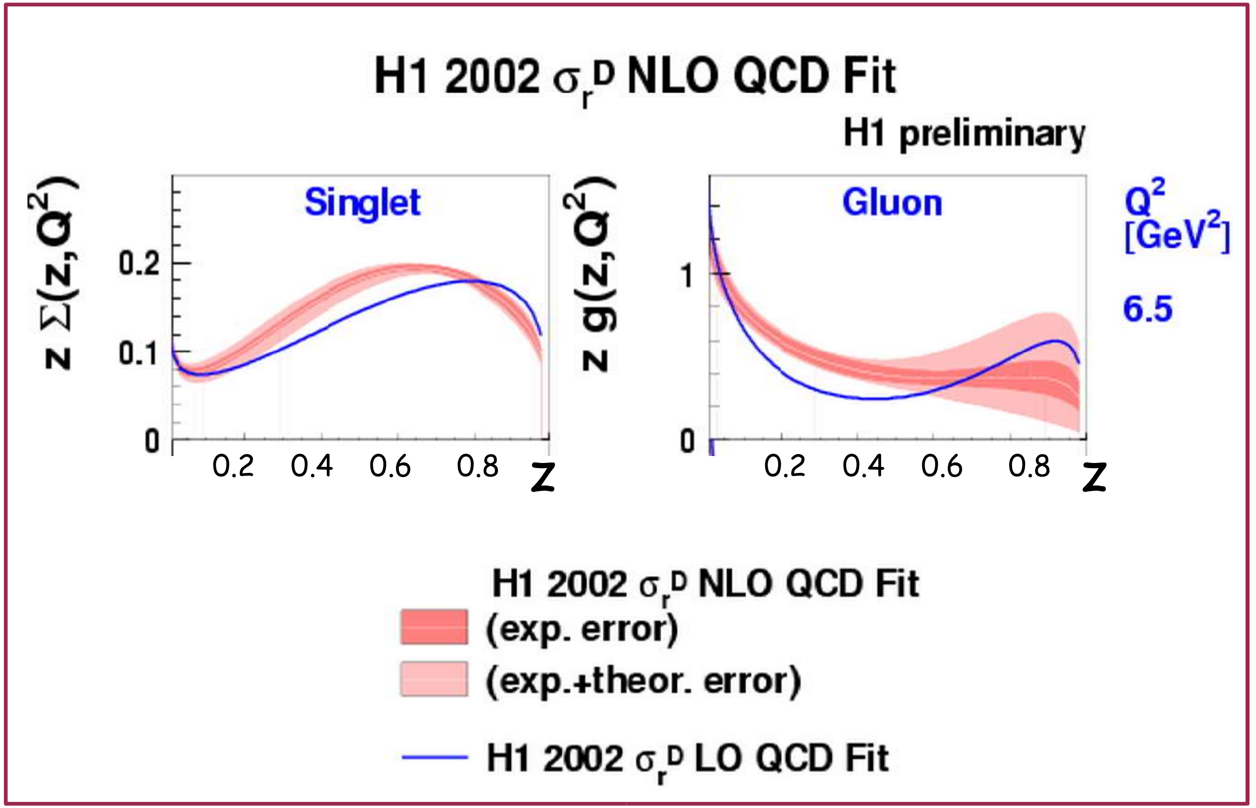
– Experimental tests of Factorization Theorem

Collinear factorization approach

- ✗ Using diffractive parton densities from QCD fit to $F_2^{D(3)}$

- ✗ Charm production via the BGF: sensitive to diffractive gluon density

- ✗ Gluon dominant (75 ± 15 %)



NLO, MC comparison with D* in DIS

NLO Calculation

- HVQDIS with NLO diff.PDFs and charm quark fragmentation
- $\mu_r^2 = \mu_f^2 = Q^2 + 4m_c^2$

scale uncertainty : μ_r varied by factors 2, 0.5 >> inner band in fig.

- $m_{charm} = 1.5$ GeV

varied: 1.35 ... 1.65 >> outer band in fig

- Peterson fragmentation :

$\varepsilon = 0.078$ varied: 0.035 ... 0.1

>> outer band in fig.

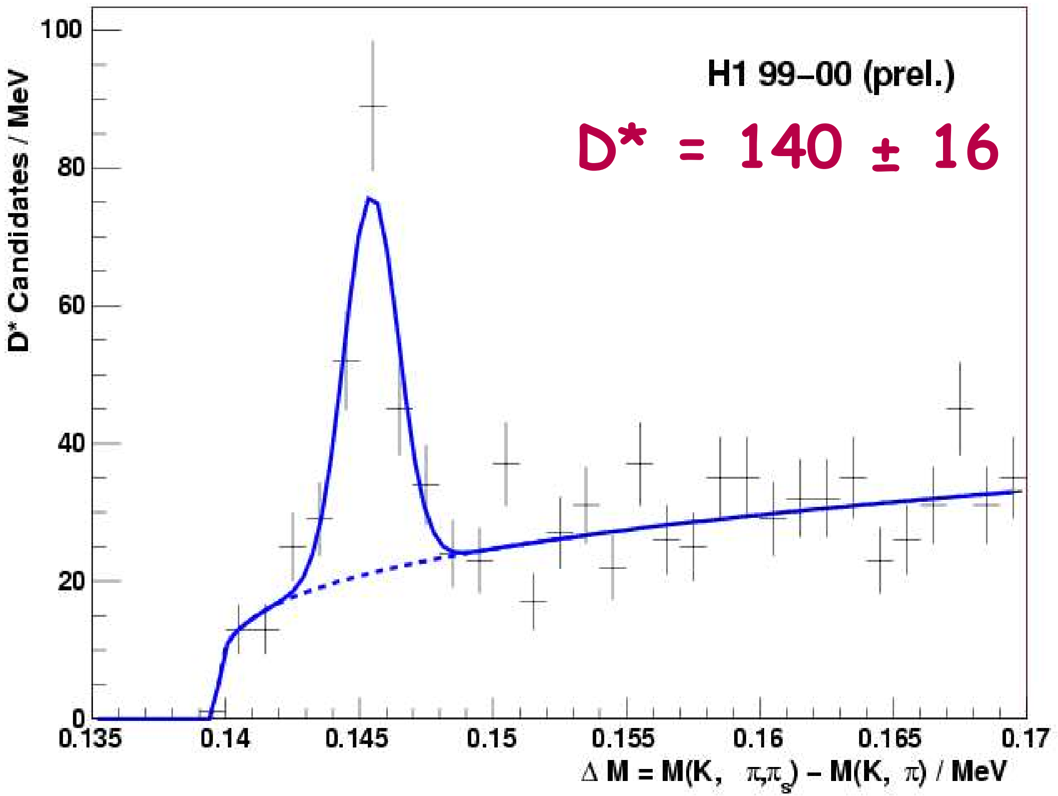
Monte Carlo

Rapgap : LO generator, based on matrix elements and diffractive parton densities supplemented with parton showers

$$\mu_r^2 = \mu_f^2 = Q^2 + p_t^2 + 4m_c^2$$

Diffractive DIS D*

- $D^* \to D^0\pi_s \to K\pi\pi_s$
- Lumi = 42.3 pb^{-1}
- Rapidity Gap Selection



Diffractive DIS D*

- kinematical region

$y \in [\ 0.05\ ;\ 0.7\ ]$
$Q^2 \in [\ 2\ ;\ 100\ ]$ GeV

xpom < 0.04

pt (D*) > 2 GeV
$|\eta(D^*)| < 1.5$

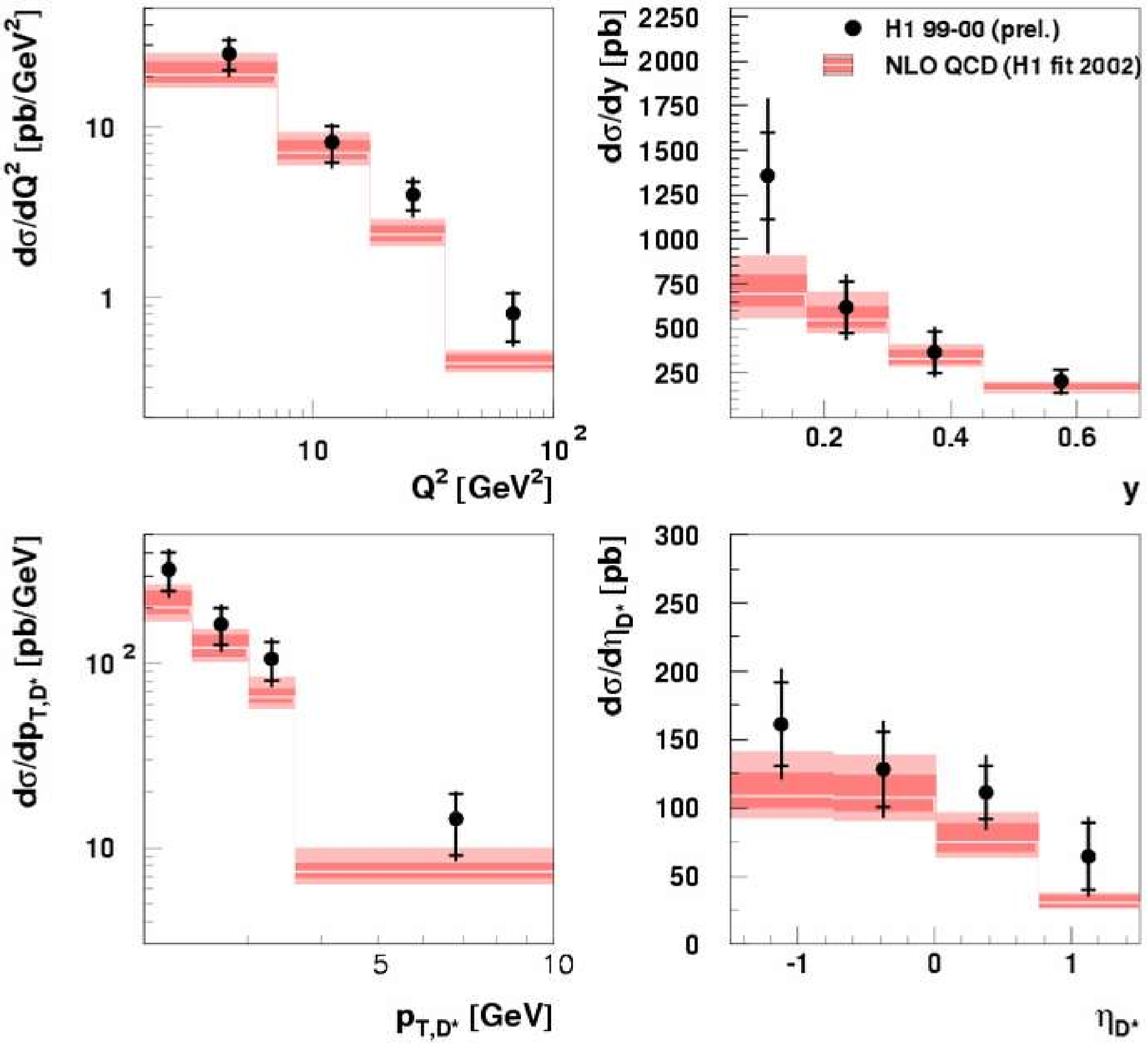
My < 1.6 GeV
$|t| < 1.$ GeV^2

σvis = 333 ± 42(stat) ± 62(sys) pb

(dominant sys.) : Track Reconstruction,
Signal Extraction from Fit,
Model Dependencies ...

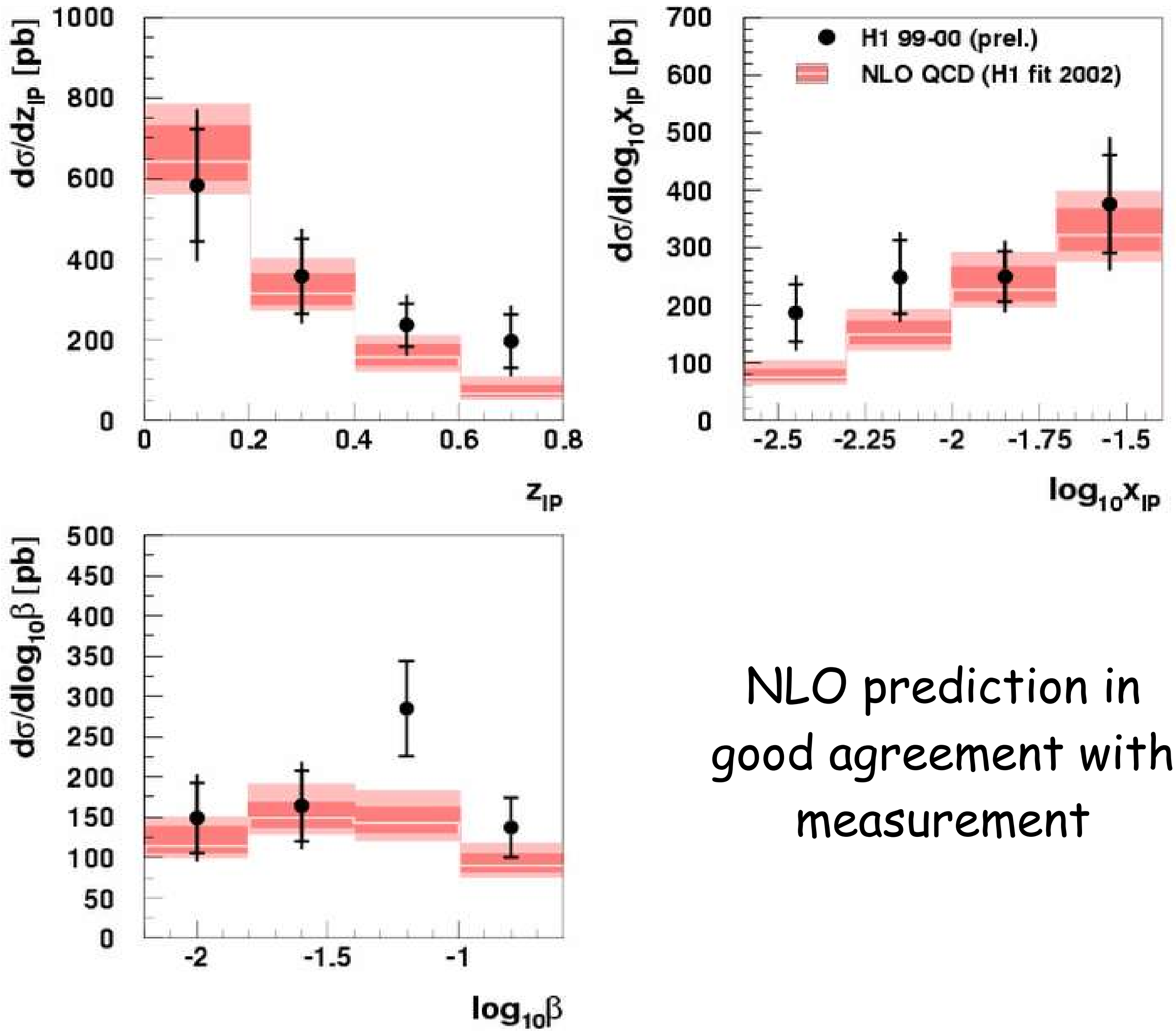
NLO Predictions $\sigma = 241^{+66}_{-39}$ pb

Diffractive DIS D*

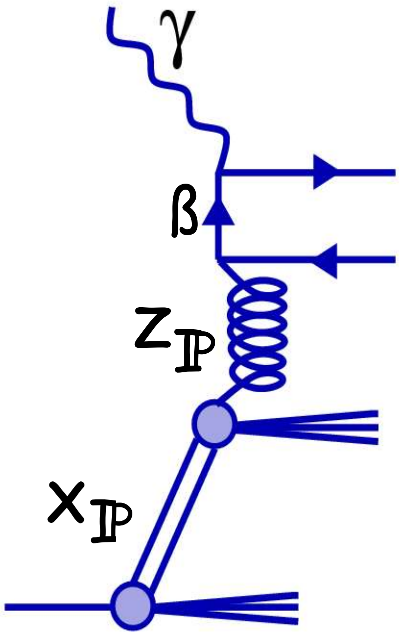


Reasonable description of all distributions by NLO calculation

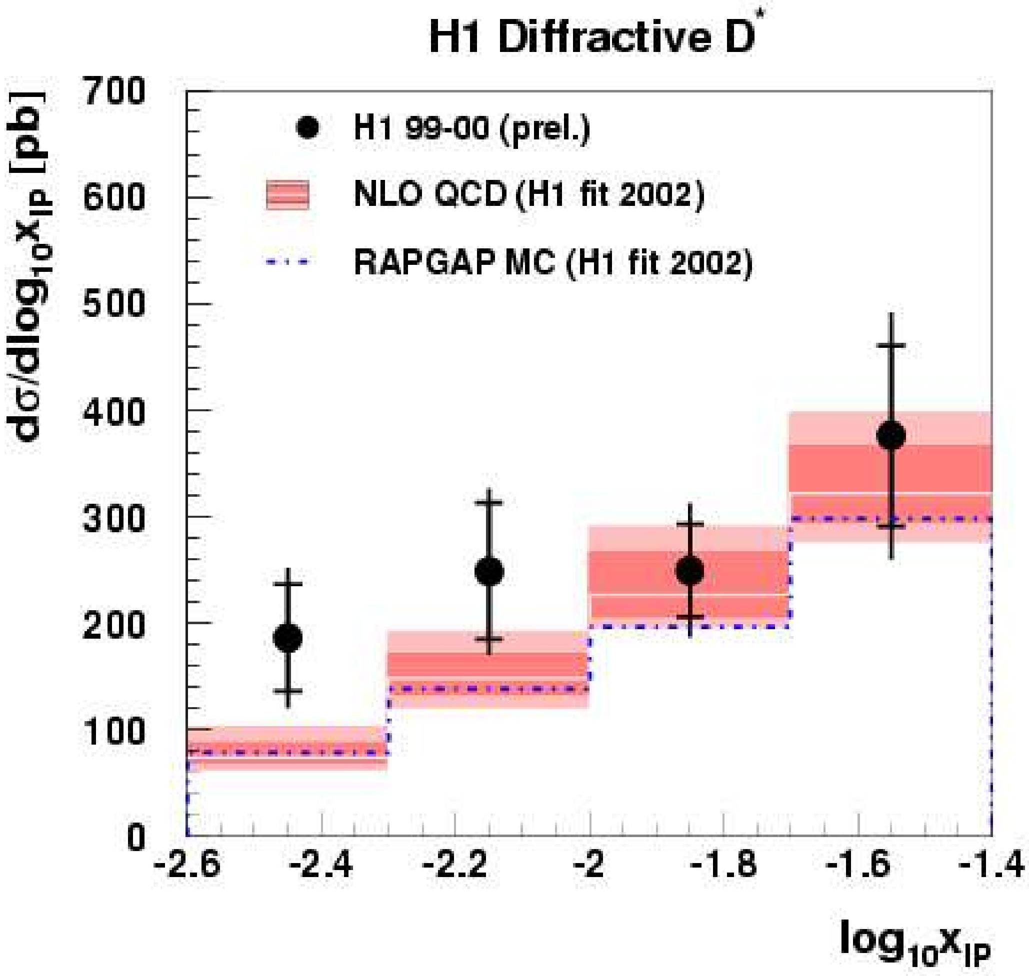
Diffractive DIS D*



NLO prediction in good agreement with measurement



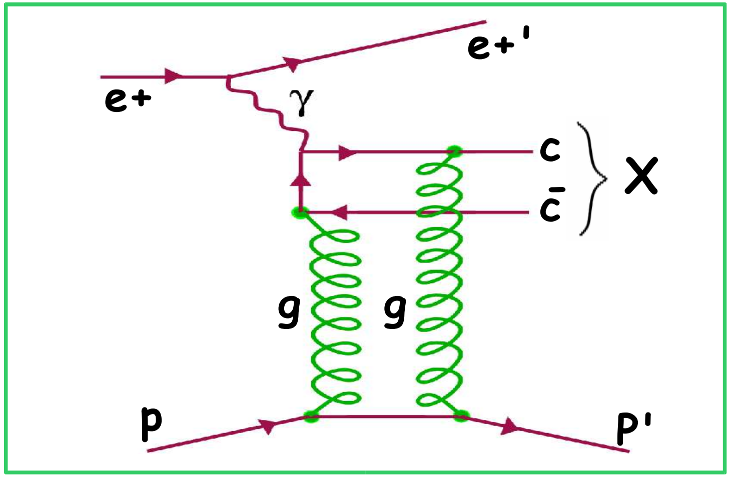
Diffractive DIS D*

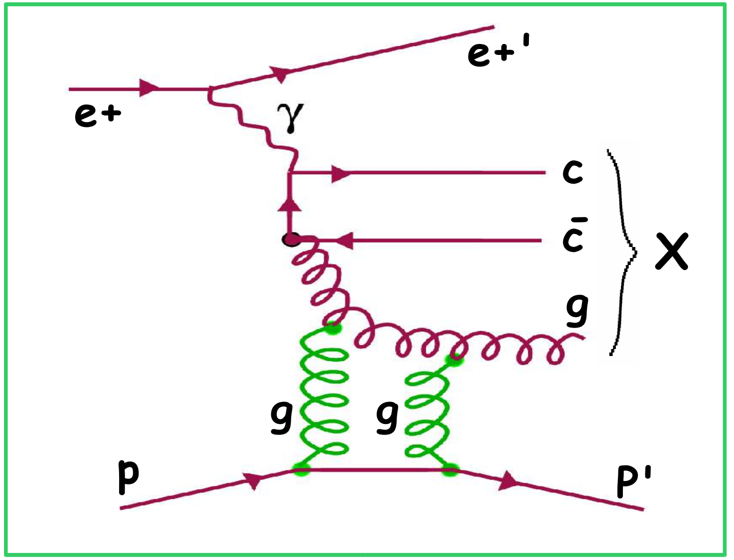


- *Good agreement data and theory*
- *MC with Parton Showers is similar to NLO*

Perturbative 2-gluon approach

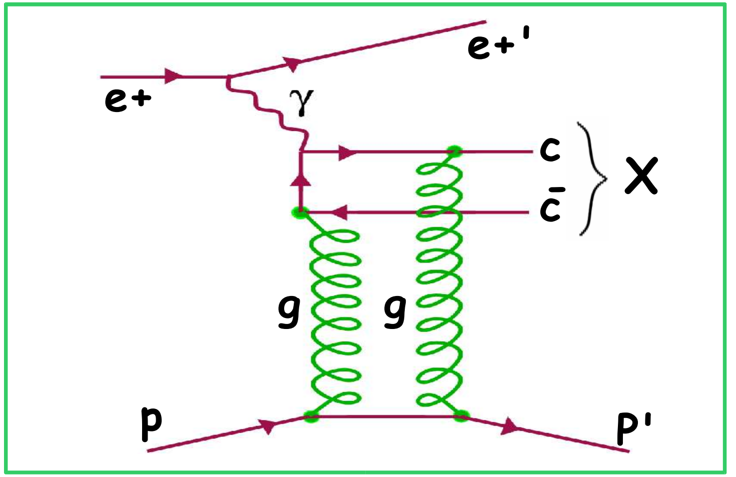
- Xpom < 0.01 (to suppress q-exchange)
- using un-integrated gluon densities of proton
- diffraction as exchange of colorless 2-gluon state
- significant Pt of gluon in ccg system – no room for soft diffractive remnant

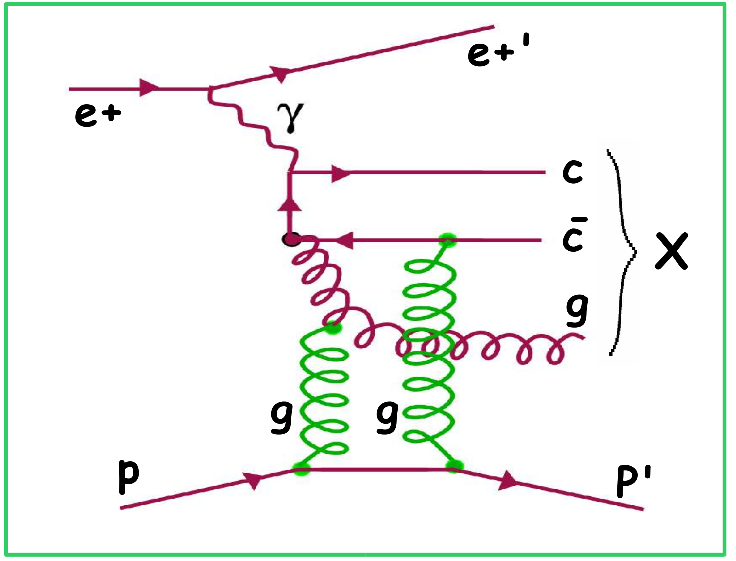




Perturbative 2-gluon approach

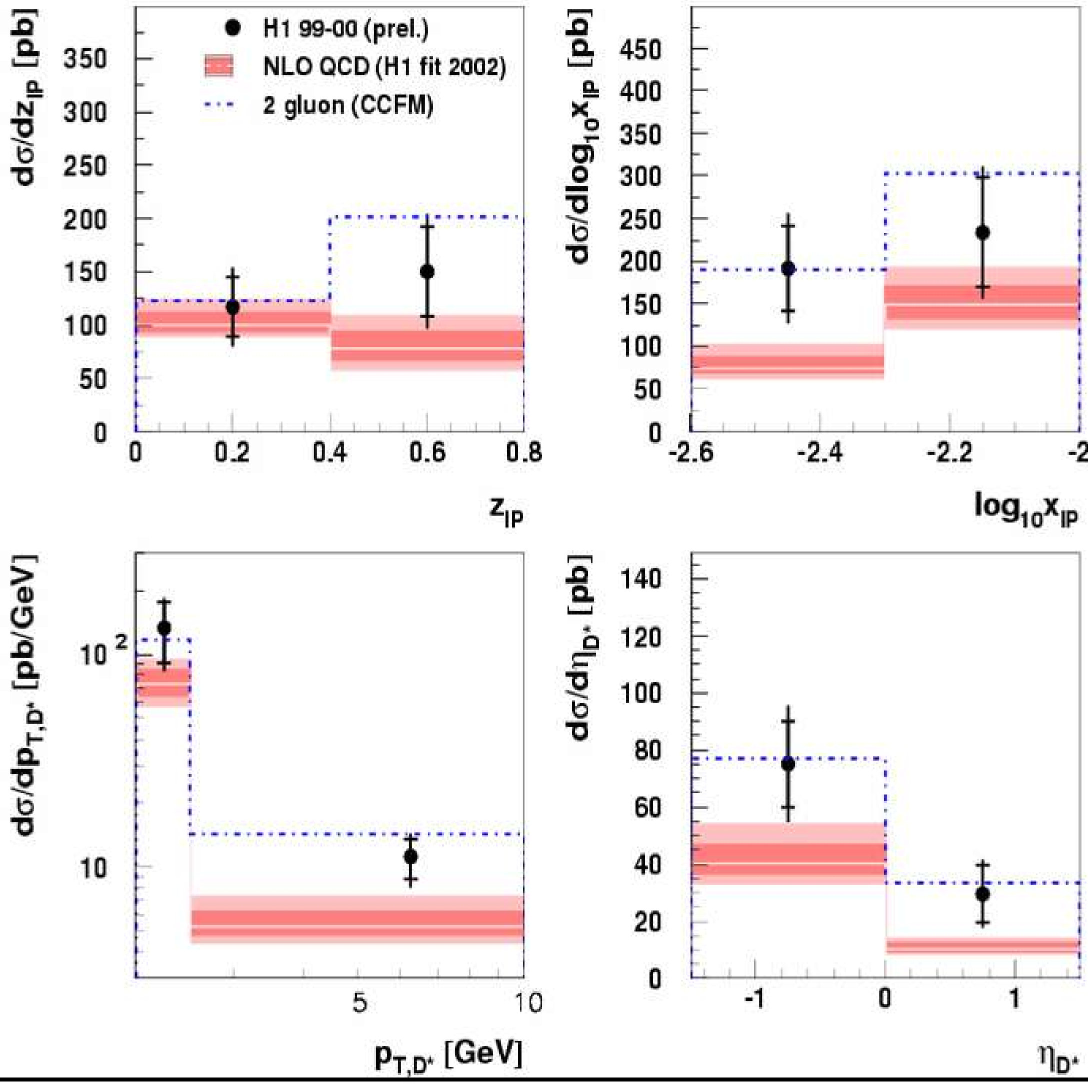
- Xpom < 0.01 (to suppress q-exchange)
- using un-integrated gluon densities of proton
- diffraction as exchange of colorless 2-gluon state
- significant Pt of gluon in ccg system – no room for soft diffractive remnant



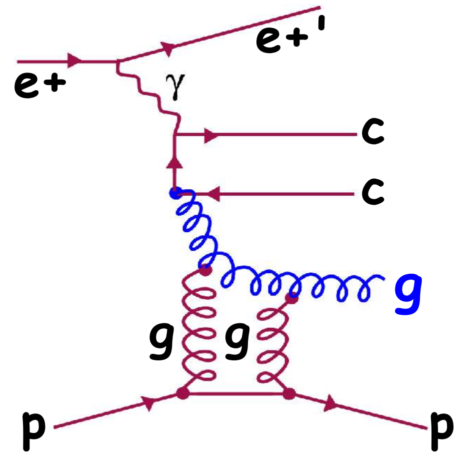


Some contributions, which are not covered by factorization theorem J.Collins ??

2-gluon with Diffractive DIS D*



- Xpom < 0.01
  (dominant gluon contribution)
- cut on Pt(g) = 1.5 GeV



- adjusted to fit also diffractive jet data

Dijets in diffractive DIS

Data

- Lumi = 18 pb^{-1}
- Rapidity Gap Selection

$Q^2 \in [4;80]$ GeV^2

165 < W < 242 GeV

inclusive k_T cluster algorithm

$E_T^{*,jet1(2)} > 5(4)$ GeV

Xpom < 0.03

My < 1.6 GeV

|t| < 1. GeV^2

NLO prediction DISENT program for standart DIS, interfaced to diffractive PDFs

$\mu_R = E_T^{*,jet1}$, μ_f = 6.2 GeV

scale uncertainty 20% : μ_r varied by factors 2 & 0.5 >> error band

calculations : jets of partons

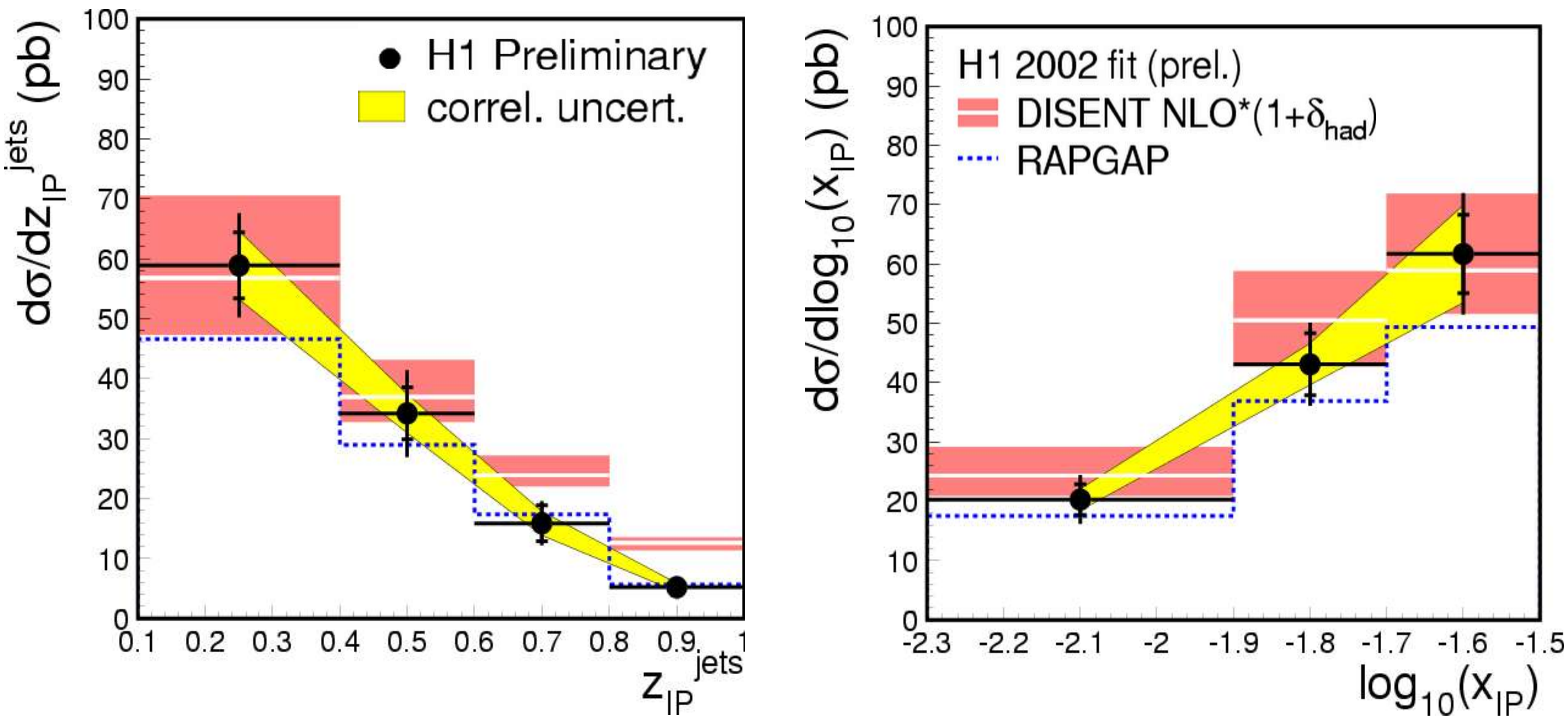
measurements : jets of hadrons

NLO cross sections corrected for hadronisation effect

Monte Carlo LO Matrix Elements with Parton Showers

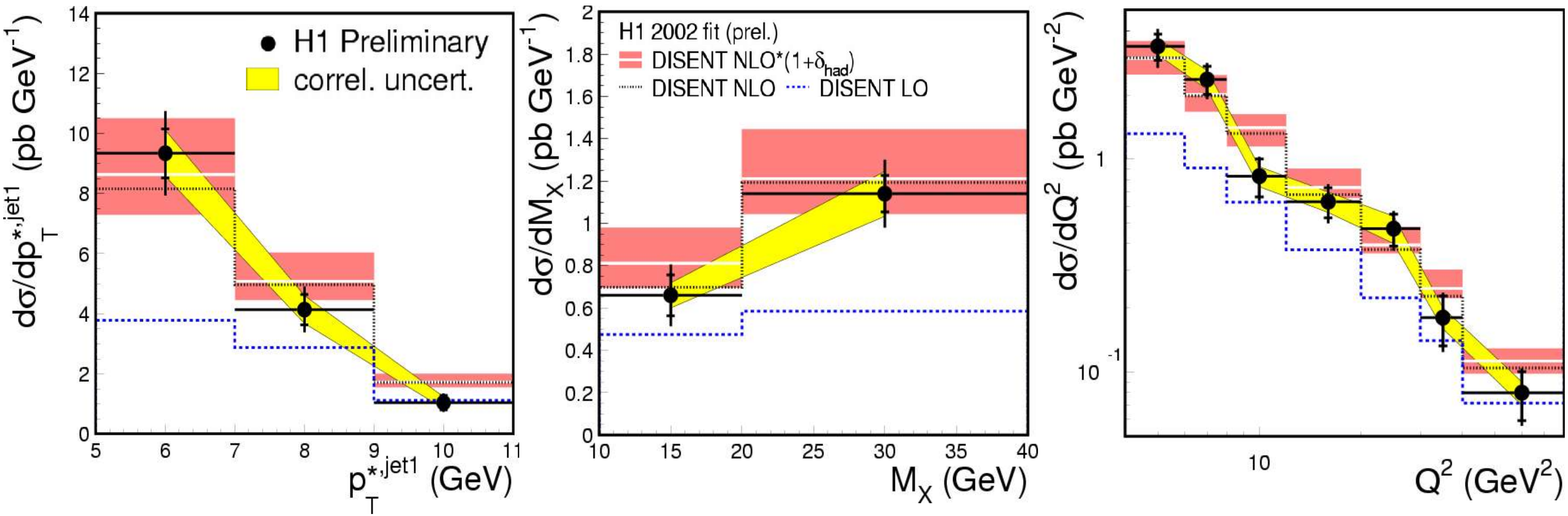
PDFs scale : $\mu^2 = \hat{p}_T^2 + 4\, m_{qq}^2$

Diffractive Dijets in DIS



Distributions well described by NLO

Diffractive DIS Dijets



- NLO calculation gives reasonable description of data

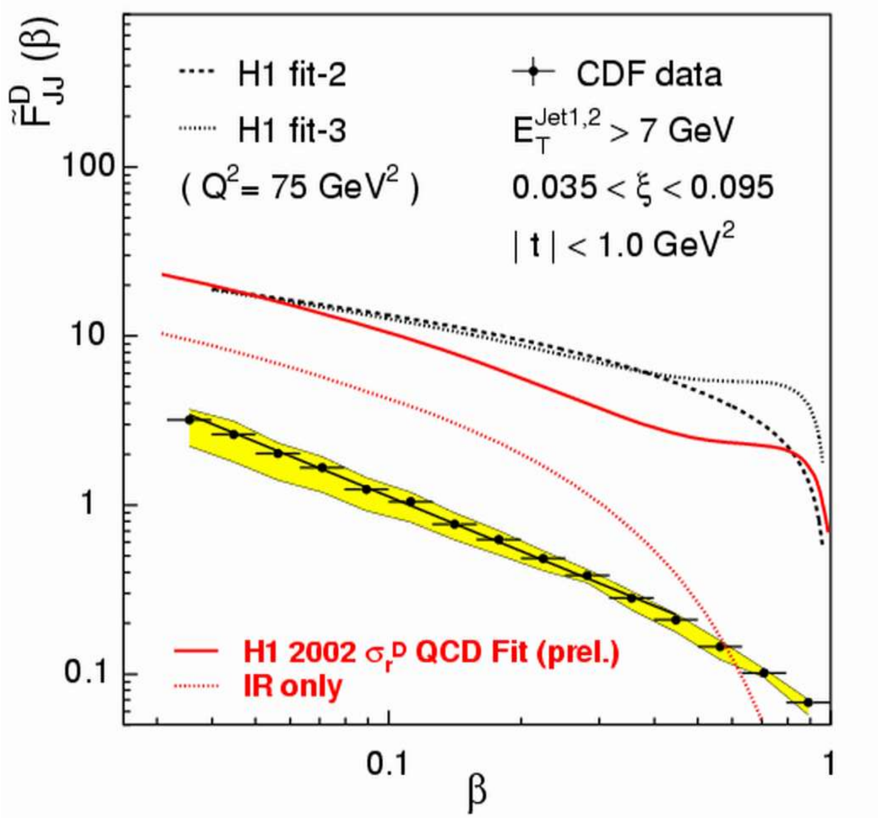
- LO results too low, shape not described

Summary Diffractive DIS:

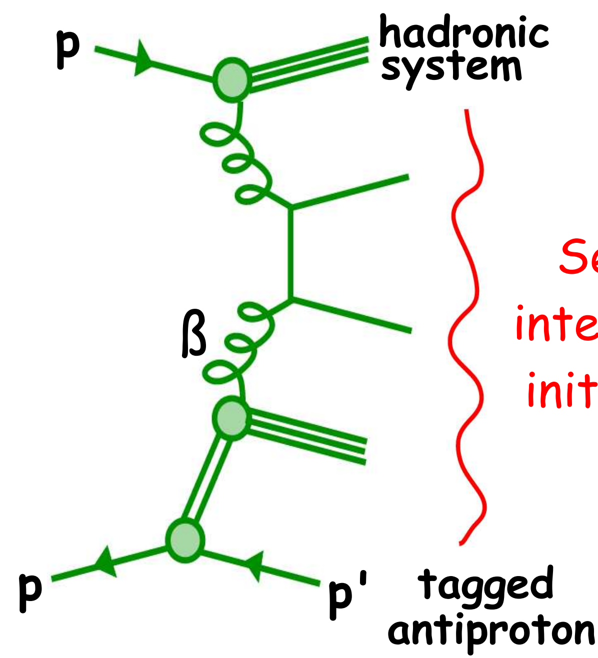
- ✔ QCD Factorisation is applicable in diffractive DIS, tested in D* and Dijets production

Dijets with tagged $\bar{p}$ at the Tevatron

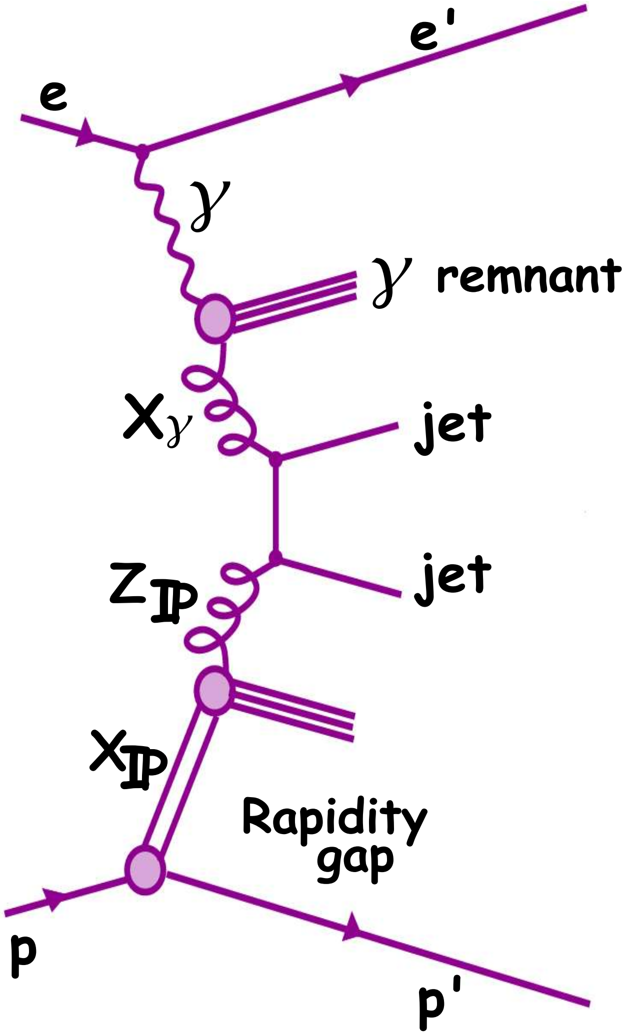
Diffractive structure function of Antiproton



- Breakdown of factorization (by factor ~10) at Tevatron, if H1 PDF's used



Dijets in Diffractive Photoproduction



Quasi-real photon ($Q^2 \approx 0$) can develop hadronic structure

x_γ - momentum fraction of photon entering hard process

$x_\gamma = 1$ direct photon coupling, similar to DIS

$x_\gamma < 1$ resolved interaction, similar to hadron-hadron scattering

Does QCD Factorization also work in diffractive photoproduction ?

Data, NLO and MC in diffractive Photoproduction

Data

- Lumi = 18 pb^{-1}
- Rapidity Gap Selection

$Q^2 < 0.01$ GeV^2

165 < W < 242 GeV

inclusive k_T cluster algorithm

$E_T^{*,jet1(2)} > 5(4)$ GeV

Xpom < 0.03

My < 1.6 GeV

|t| < 1. GeV^2

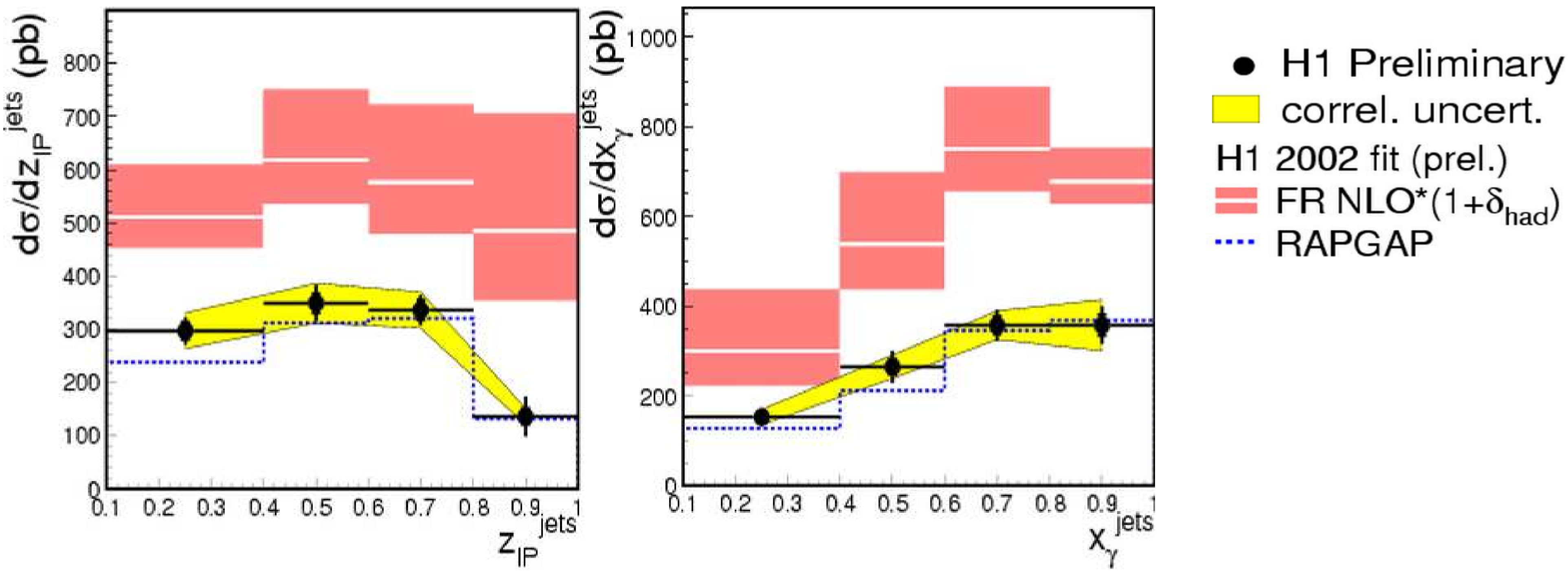
NLO prediction obtained with Frixione et al. program interfaced to NLO 'H1 2002 fit' diffractive PDFs and NLO GRV photon PDFs

$$\mu_R = \mu_f = E^{*,jet1}$$

Monte Carlo LO Matrix Elements with Parton Showers

$$\mu_R = \mu_f = p_T^2$$

Dijets in diffractive Photoproduction



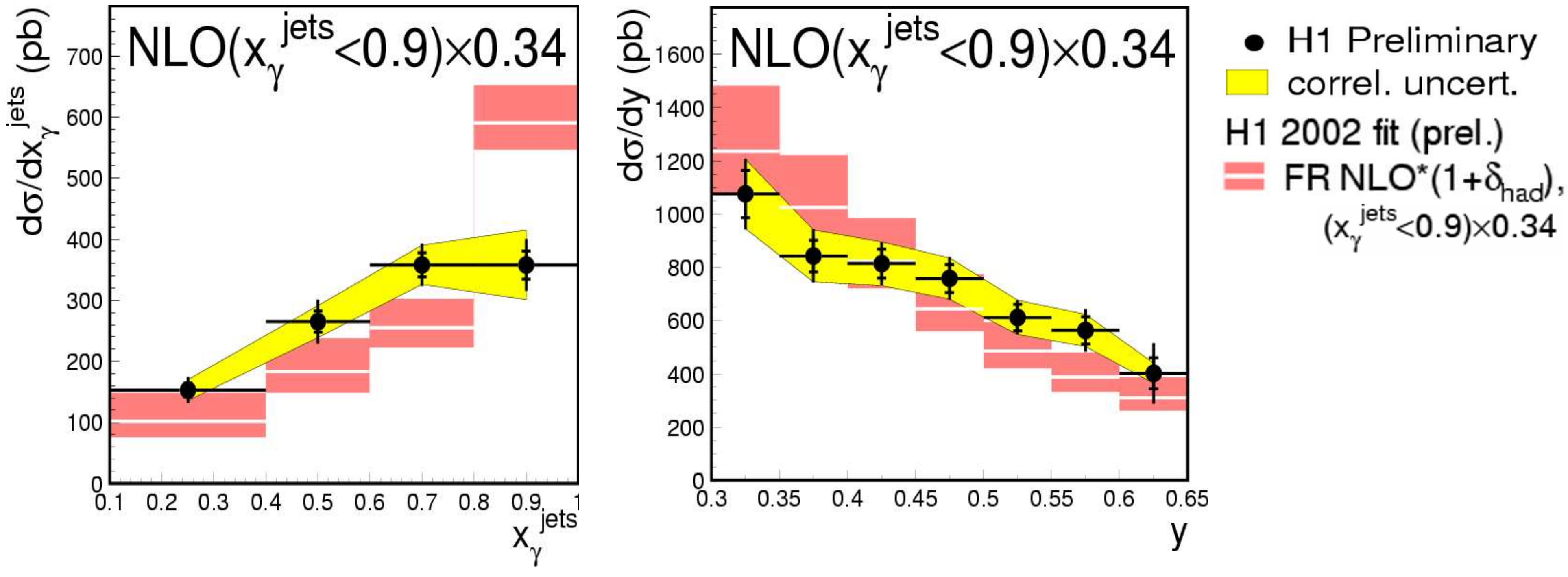
- NLO prediction using PDFs is above data by factor ~ 2
  (compared to factor ~ 10 at the Tevatron)

- Rapgap describes data

Suppression of only resolved component...

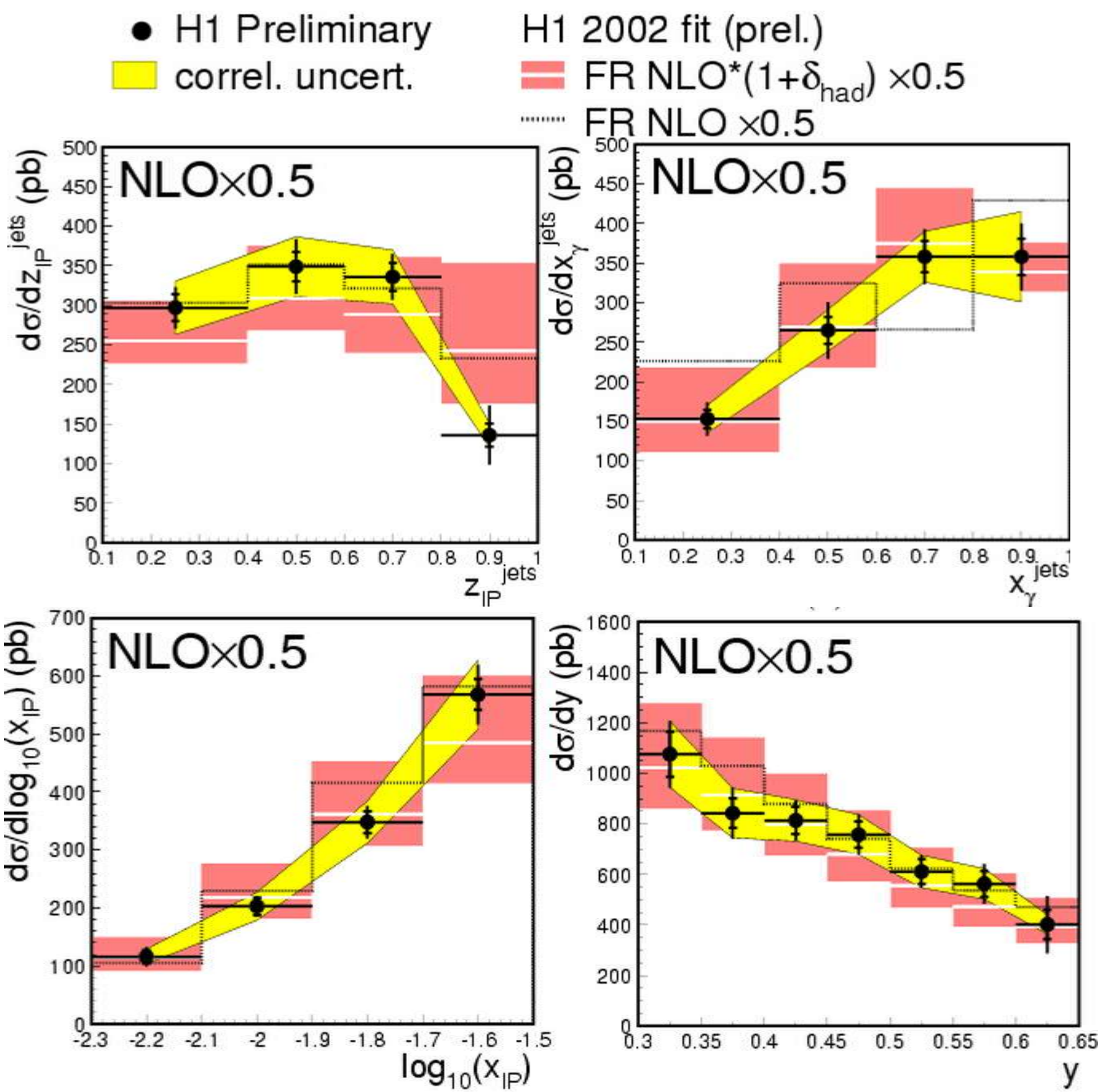
Theoretical prediction of suppression factor (R = 0.34) of resolved contribution :

A.B.Kaidalov, V.A.Khoze, A.D.Martin and M.G.Ryskin "Unitarity effects in hard diffraction at HERA", Phys. Lett. B567 (2003) 61



✗ This approximation also doesn't describe data

Diffractive Dijets in photoproduction

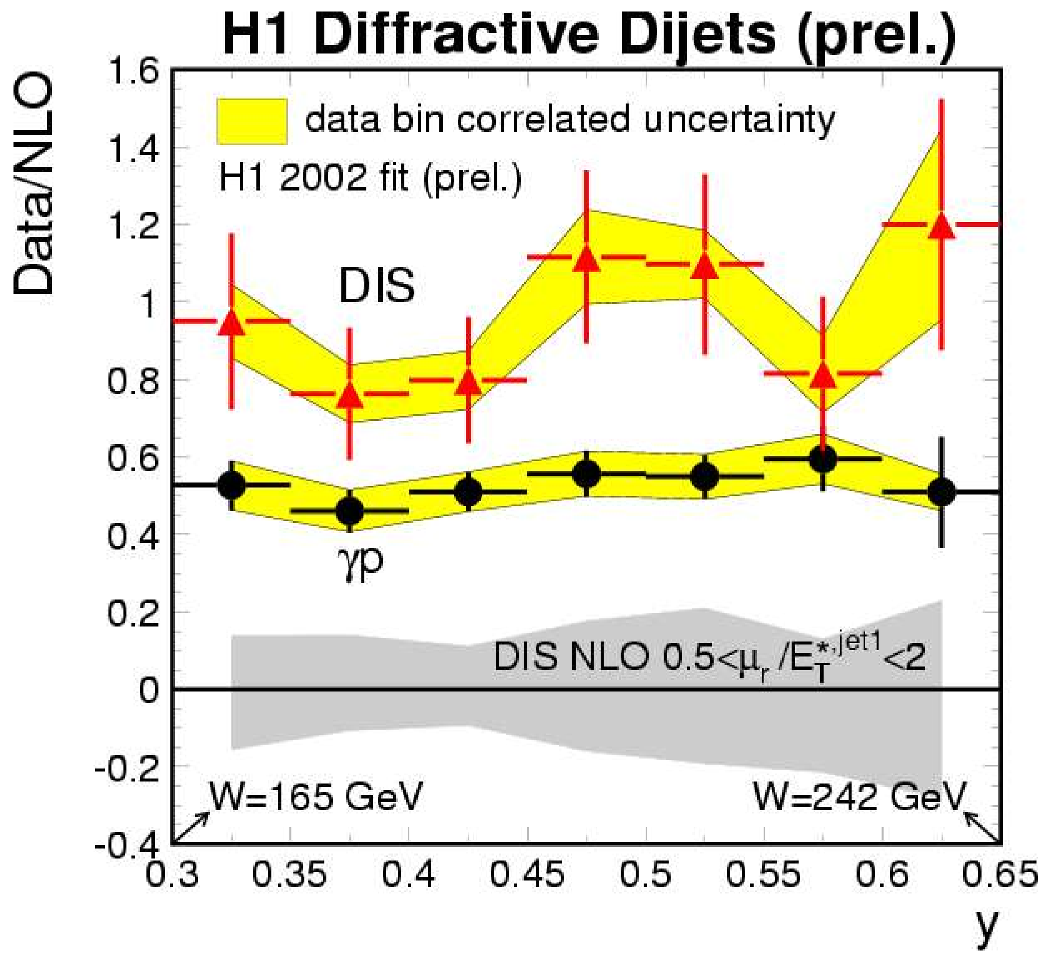


Overall normalisation of NLO :

$$\begin{pmatrix} \text{hadron-like} \\ \text{point-like} \end{pmatrix} \times 0.5$$

with this suppression factor good agreement between data and NLO prediction

Ratio of Data to NLO Prediction



- $\text{Ratio}(y) = \dfrac{\sigma_{\text{measured}}}{\sigma_{\text{predicted by NLO}}}$

- $\text{Ratio}(y)_{\text{DIS}} \approx 1.$
- $\text{Ratio}(y)_{\gamma p} \approx 0.5$

Indicates breaking of QCD factorisation in diffractive dijet production

Conclusion

- Measurements of Jets and D* production are presented
- Different perturbative QCD approaches to diffraction are tested

Diffractive DIS

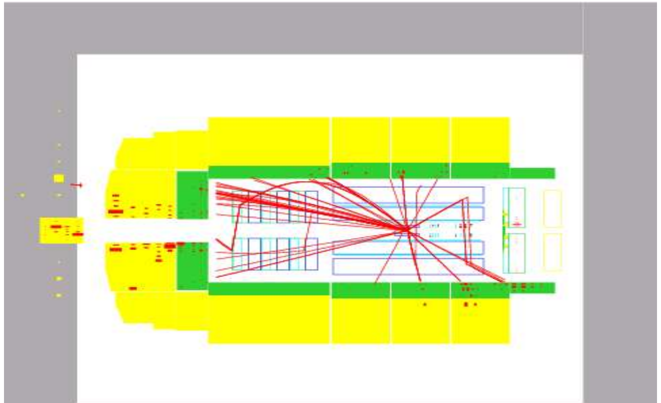
I. Collinear factorization approach is applicable in description Dijet and D* events in DIS.

QCD Factorization
in agreement with DIS data

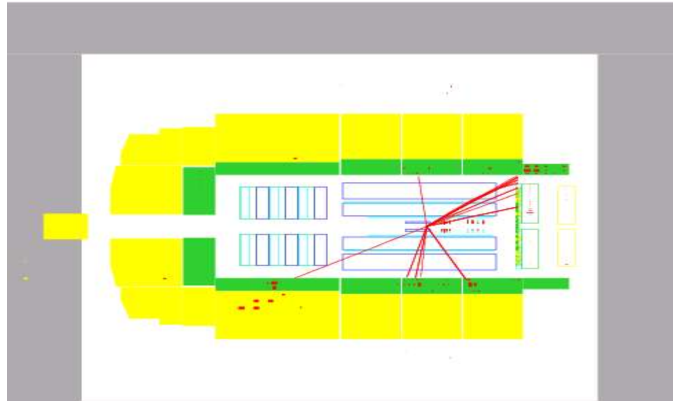
II. Perturbative 2g calculation in agreement with diffractive DIS D* cross sections for Xpom < 0.01

Diffractive Photoproduction

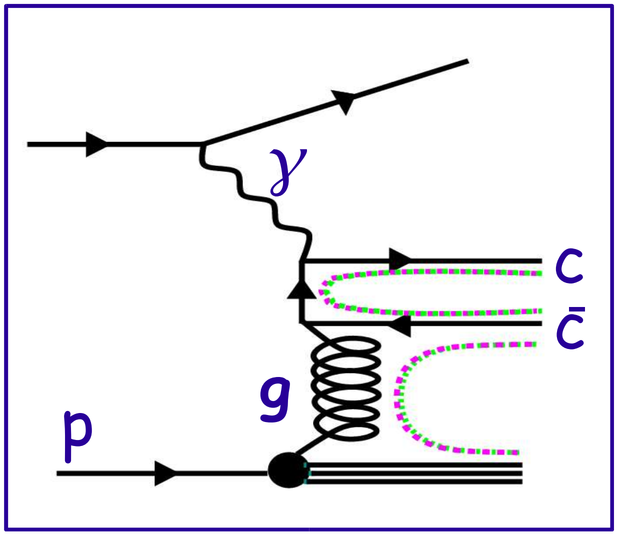
I. Dijet measurements show that NLO prediction is above data by factor ~ 2

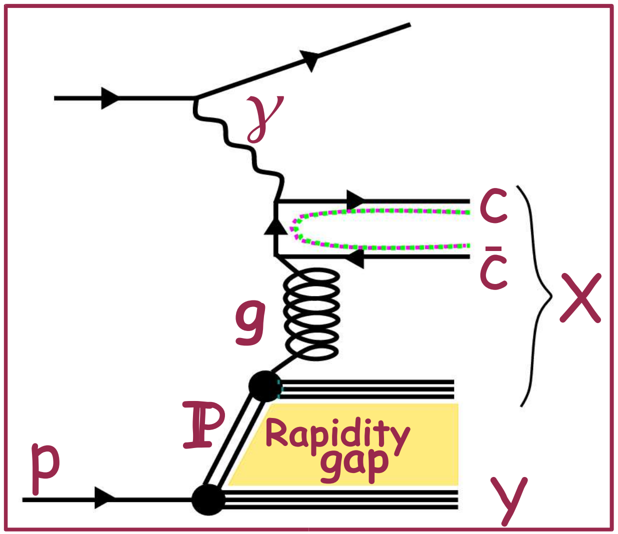


non-diffractive event



diffractive event





Kinematic reminder

Q^2: photon virtuality

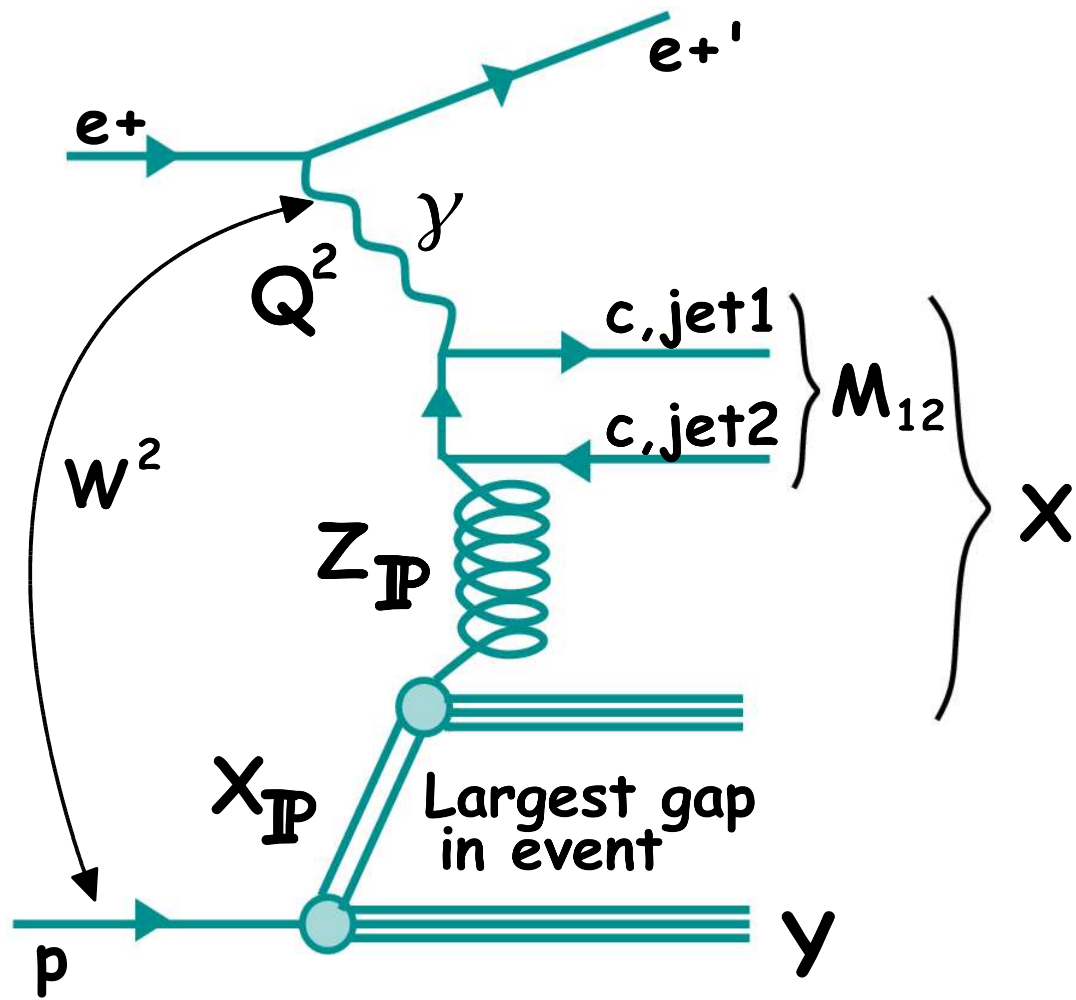
$W^2 = (p+q)$: γ^*p CMS energy

M_{12}: mass of cc pair or two jets

M_X : mass of diffractively produced system

$$x_{\mathbb{P}} = \frac{M_X^2 + Q^2}{W^2 + Q^2}$$ momentum fraction of diffractive exchange with respect to incoming proton

$$z_{\mathbb{P}} = \frac{M_{12}^2 + Q^2}{M_X^2 + Q^2}$$ diffractive exchange



 Svetlana Vinokurova