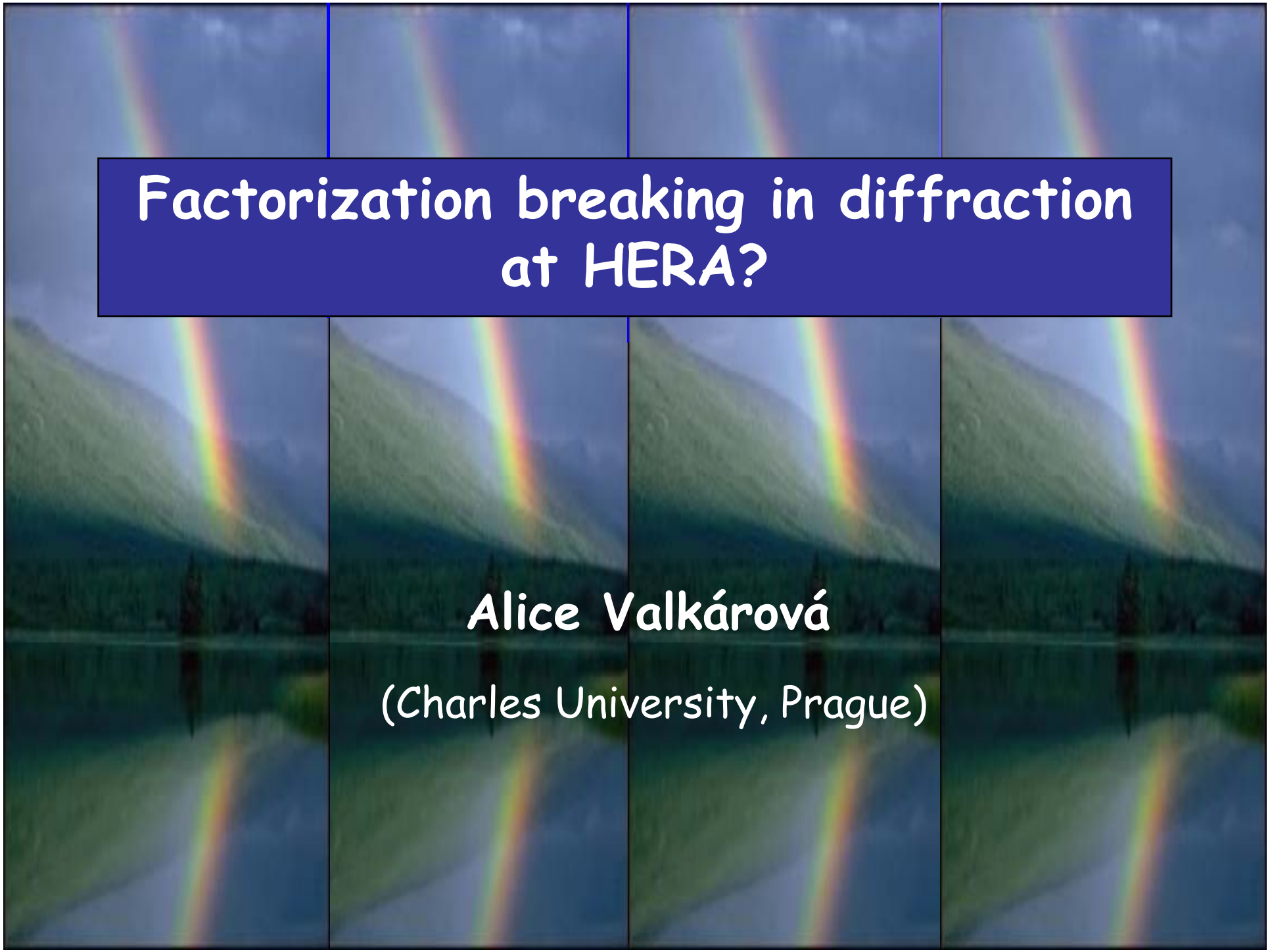


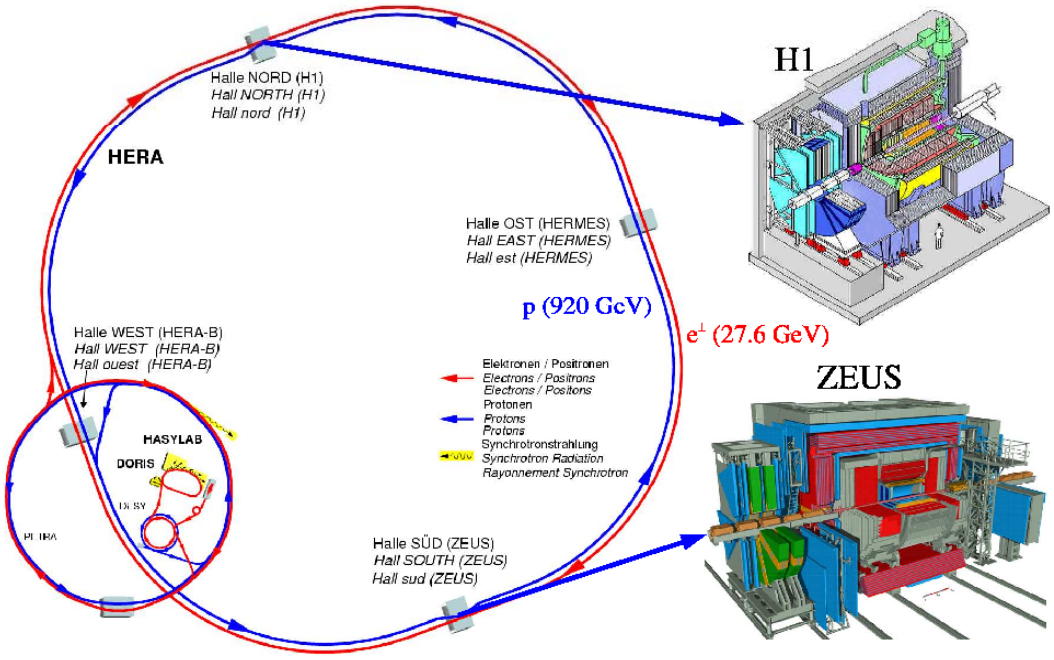
Factorization breaking in diffraction at HERA?

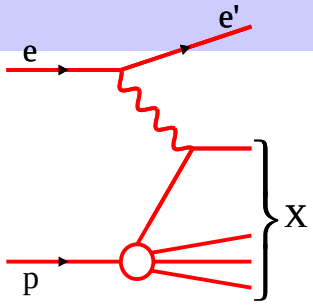
Alice Valkárová

(Charles University, Prague)

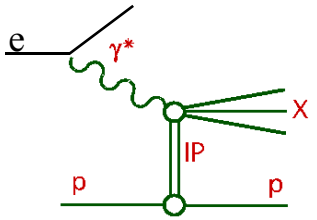
HERA collider experiments

- 27.5 GeV electrons/positrons on 920 GeV protons $\rightarrow \sqrt{s}$=318 GeV
- two experiments: H1 and ZEUS
- HERA I: 16 pb^{-1} e-p, 120 pb^{-1} e+p
- HERA II: ~ 550 pb^{-1}, ~ 40% polarisation of e+,e-





DIS: Probe structure of proton $\rightarrow F_2$



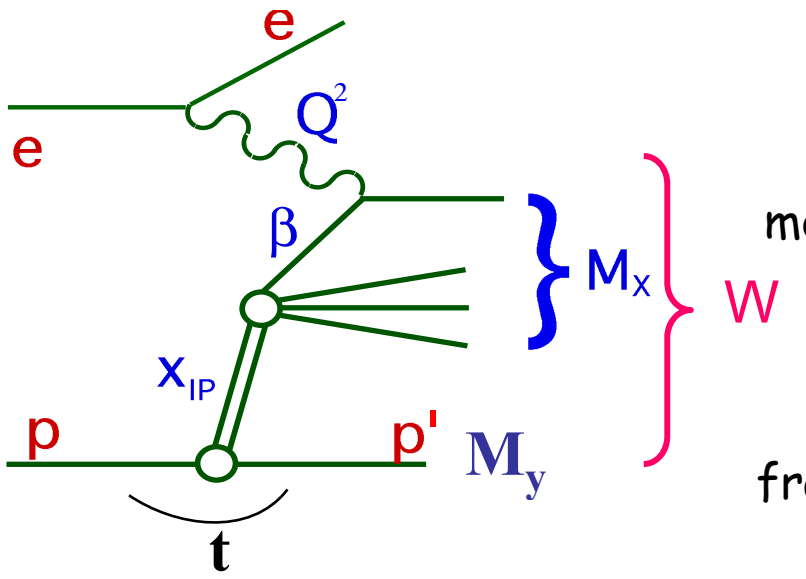
Diffractive DIS: Probe structure of color singlet exchange $\rightarrow F_2^D$

Diffraction and diffraction kinematics

HERA: ~10% of low-x DIS events are diffractive

Why to study diffraction?

- **fundamental aim**: to understand high energy limit of QCD (gluodynamics)
- **novelty**: for the first time probe partonic structure of diffractive exchange
- **practical motivations**: to study factorization properties of diffraction – try to transport to **hh** scattering (e.g.predict diffractive Higgs production at LHC)



$$x_{IP} = \frac{q\cdot(p-p')}{q\cdot p} \approx \frac{Q^2+M_X^{\,2}}{Q^2+W^2}$$ →

momentum fraction of color singlet exchange

$$\beta = \frac{x}{x_{IP}} \approx \frac{Q^2}{Q^2+M_X^{\,2}}$$ →

fraction of exchange momentum, coupling to γ*

$t=(p-p')^2$ → 4-momentum transfer squared

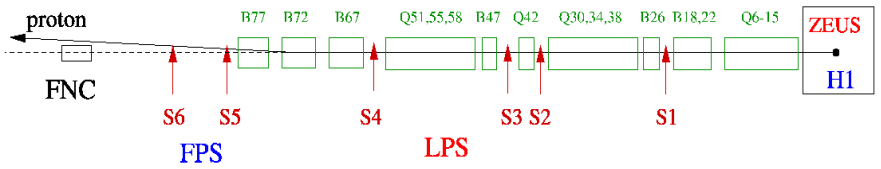
Diffractive Event Selection

1) Proton Spectrometers:

- ZEUS: LPS (1993-2000)
- H1: FPS (1995-), VFPS (2004-)

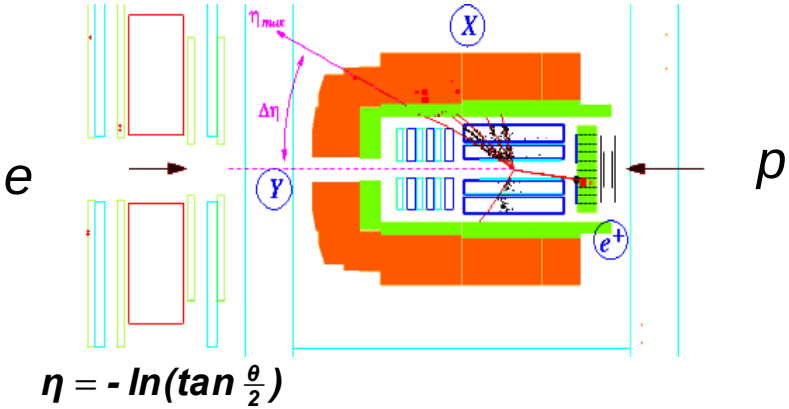
→ t measurement

- access to high x_{IP} range
- free of p-dissociation background at low x_{IP}
- small acceptance → low statistics ☠



2) Large Rapidity Gap, H1, ZEUS:

- Require no activity beyond η_{max}
- t not measured, some p-diss background ☠

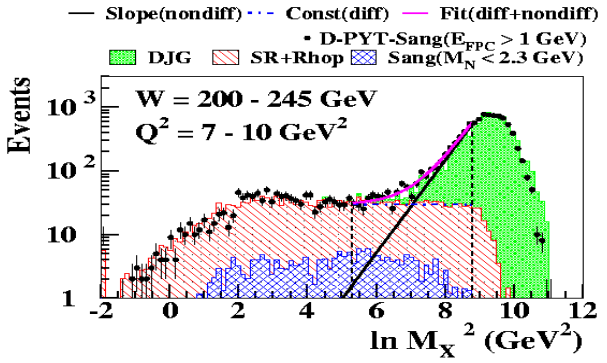


3) M_x method, ZEUS:

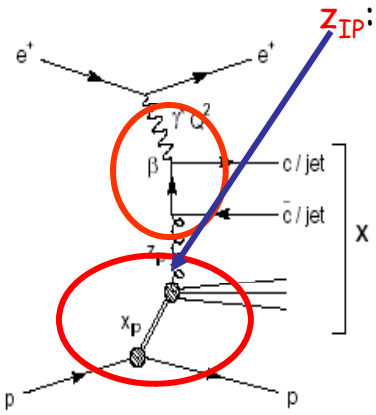
- Diffractive vs non-diffractive: exponential fall off vs constant distribution in ln M_x^2
- Some p-diss contribution ☠

$$\frac{dN}{d\ln M_x^2} \propto D + Ce^{B\ln M_x^2}$$

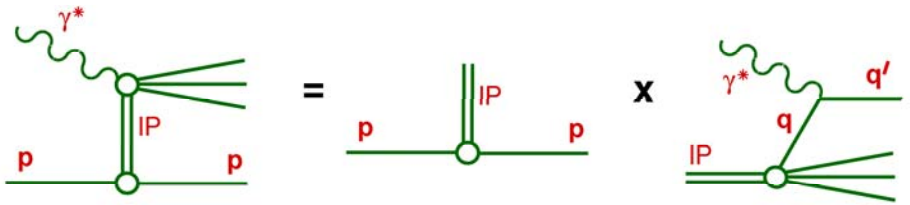
diff. non-diff



Factorization properties in diffraction



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



QCD factorization & Regge factorization

rigorously proven for DDIS by Collins at al

conjecture, e.g. Resolved Pomeron Model by Ingelman, Schlein

$$\sigma^D(\gamma^* p \to Xp) \propto \sum_{parton\_i} f_i^{\,D}(x, Q^2, x_{IP}, t) \cdot \sigma^{\gamma^* i}(x, Q^2)$$

Regge motivated pomeron flux

$$f_{IP/p}(x_{IP}, t) = \frac{e^{Bt}}{x_{IP}^{2\alpha(t)-1}}$$

$$f_i^{\,D}(x, Q^2, x_{IP}, t) = f_{IP/p}(x_{IP}, t) \cdot f_i^{\,IP}(\beta = x / x_{IP}, Q^2)$$

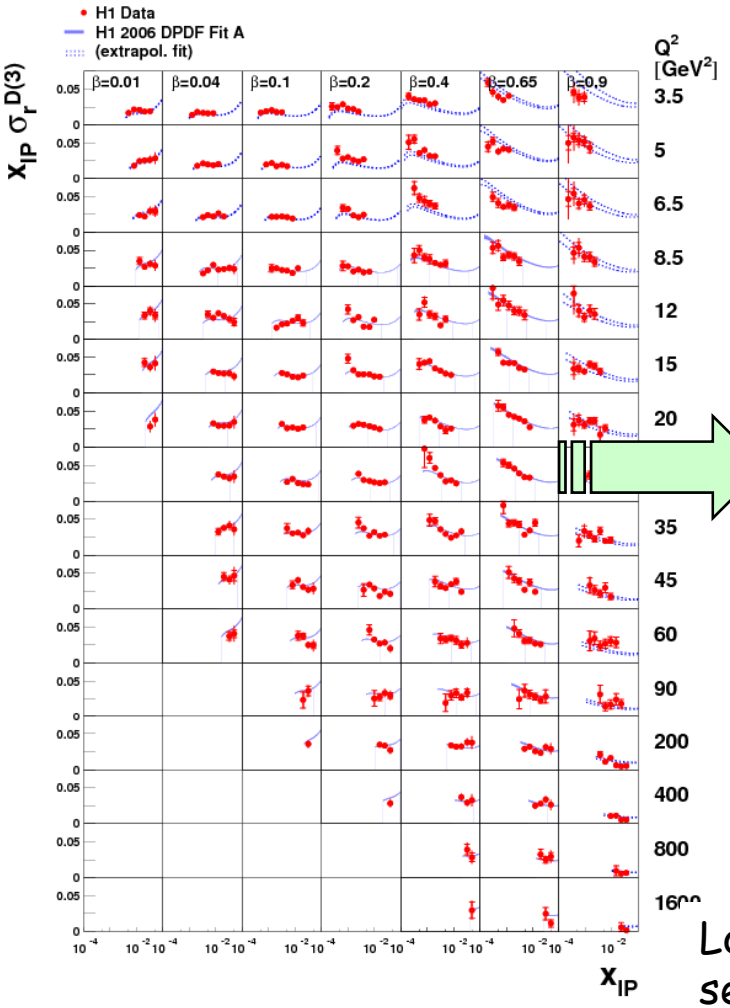
Extracted from inclusive diffraction!

$\sigma^{\gamma^* i}$ universal hard scattering cross section (same as in inclusive DIS)

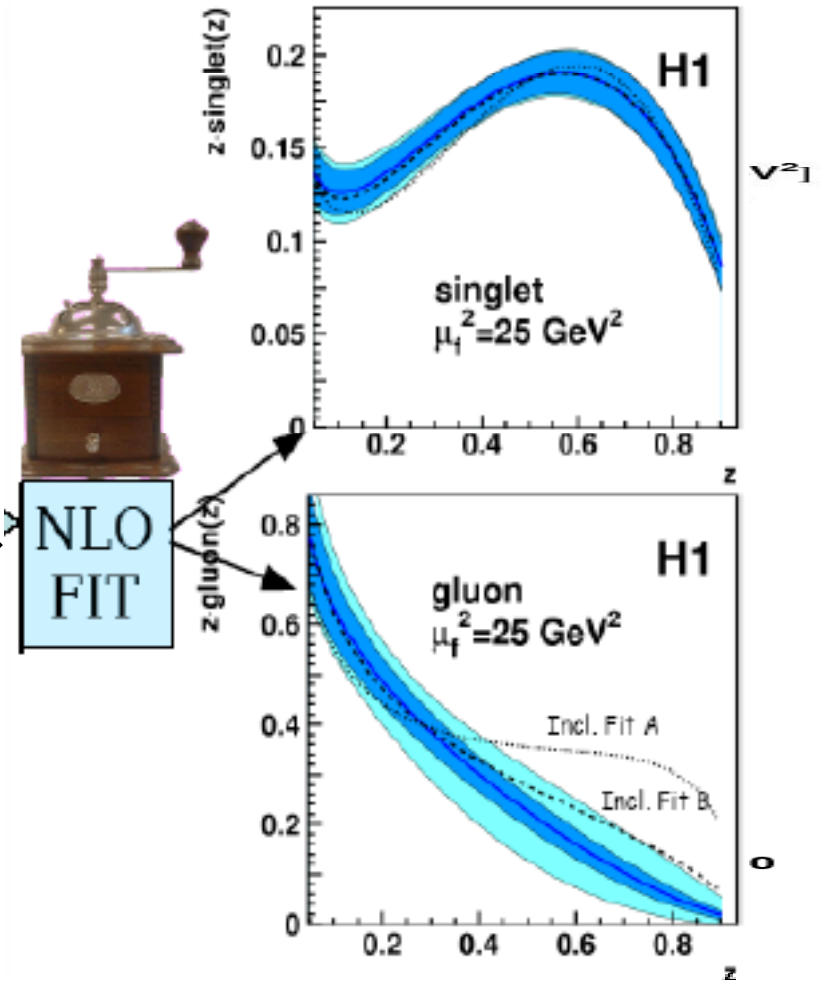
$f_i^{\,D}$ diffractive parton distribution functions → obey DGLAP, universal for diffractive *ep* DIS (inclusive, di-jets, charm)

Extraction of Diffractive Parton Densities

Diffractive cross sections



Diffractive PDFs



Low sensitivity of fits to inclusive cross section to gluon PDF especially at large z_{IP} → use jets to combined fits!

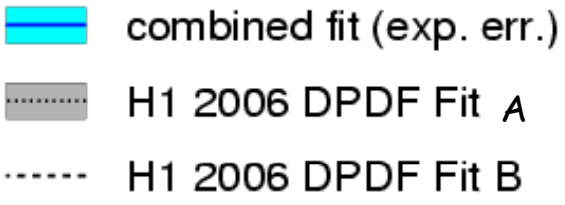
QCD factorization in diff. DIS

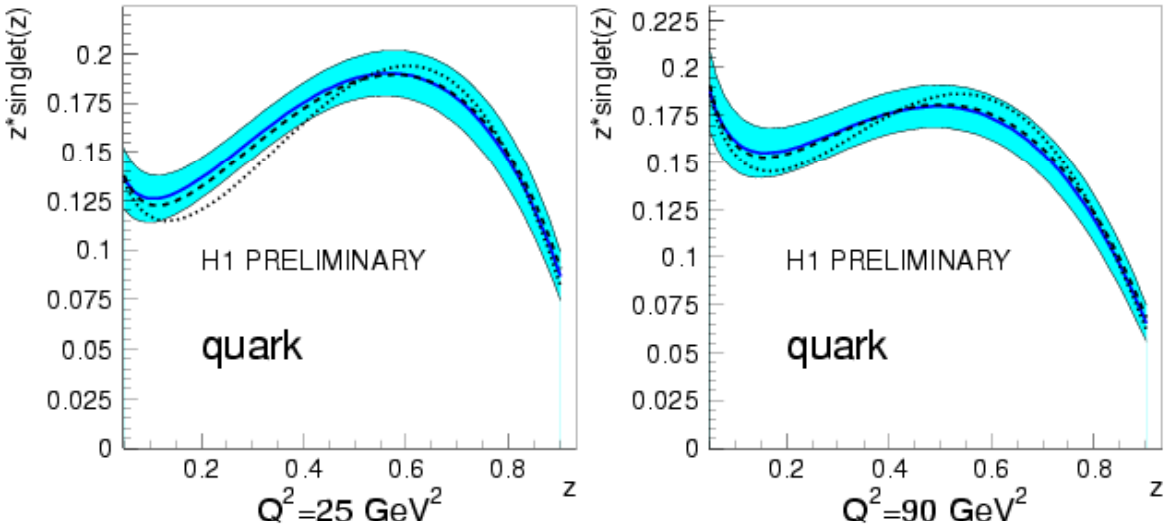
Factorization in DIS difraction dijets proven by both H1 and ZEUS

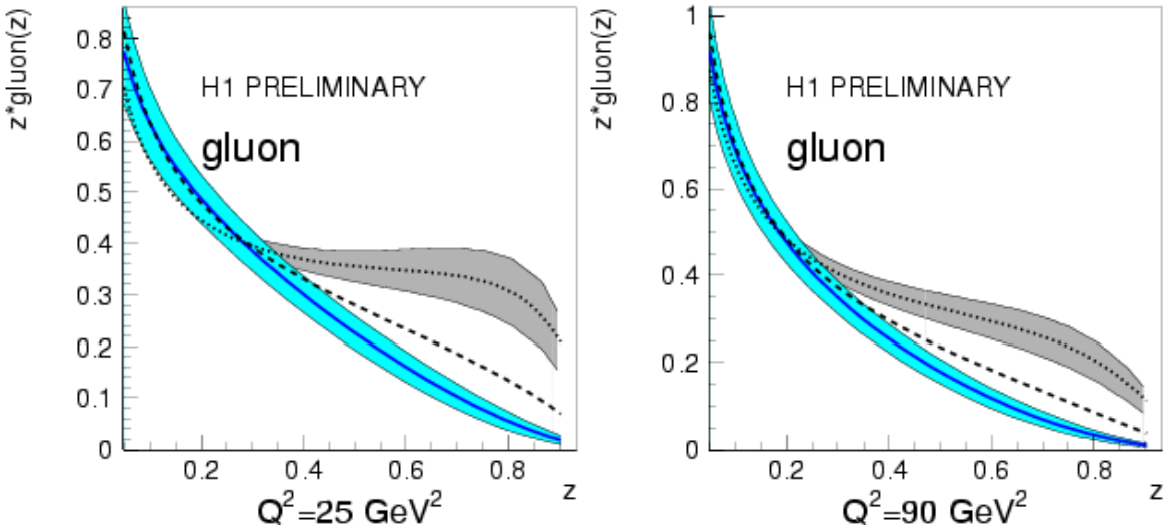
Factorization in diffractive DIS D*production proven by both H1 and ZEUS

H1 dijet DIS measurement:

- new NLO QCD fit



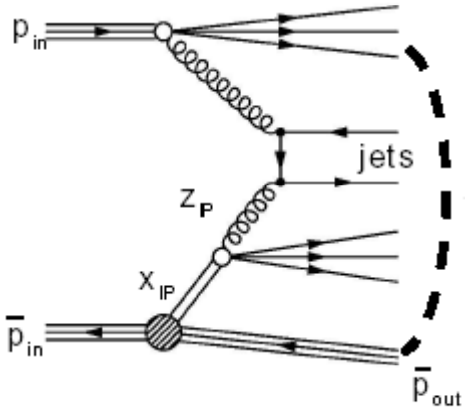


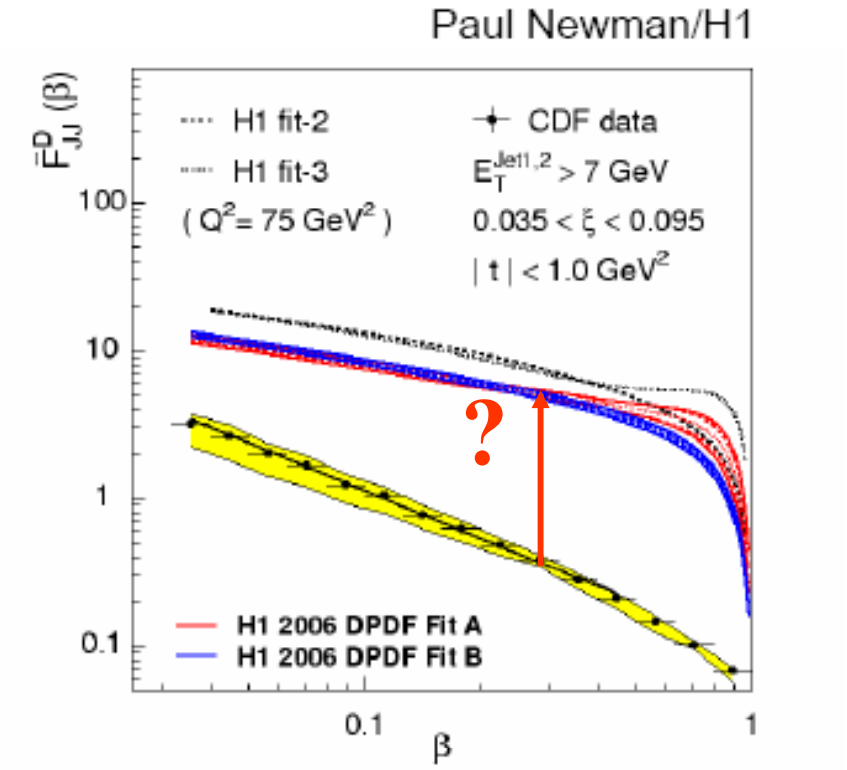


Exporting PDFs from HERA to the Tevatron.....

At Tevatron HERA PDF's do not work....

Dijet cross section factor **5-10 lower** than the QCD calculation using HERA PDFs

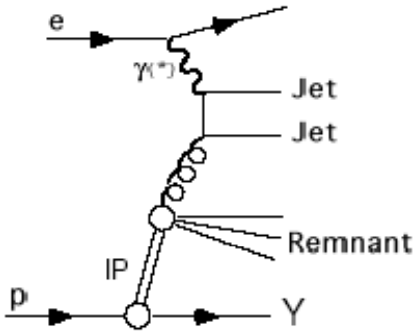




Direct and resolved photoproduction at HERA

x_γ - fraction of photon's momentum in hard subprocess

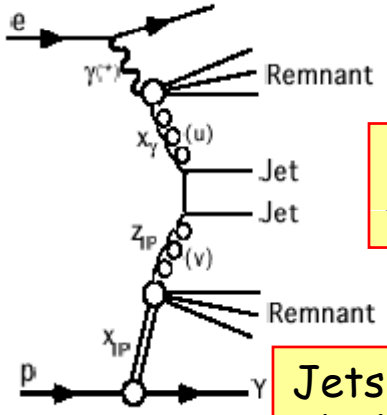
$$x_\gamma = x_\gamma^{OBS} = \frac{\sum (E - p_z)_{jets}}{(E - p_z)_{hadrons}}$$



DIS (Q^2>5GeV^2) and direct photoproduction ($Q^2 \simeq 0$):

- photon directly involved in hard scattering
- $x_\gamma = 1$

unsuppressed! ?



Resolved photoproduction ($Q^2 \simeq 0$):

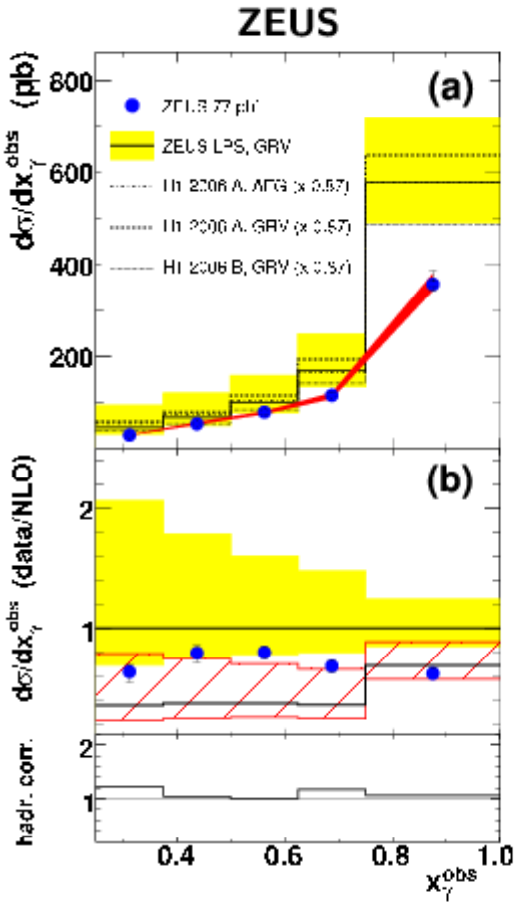
- photon fluctuates into hadronic system, which
- ronic scattering
- $x_\gamma < 1$

Secondary interactions between spectators??

suppressed! ?

Jets in photoproduction thought to be ideal testing ground for rescattering

Diffraction in Photoproduction-dijets



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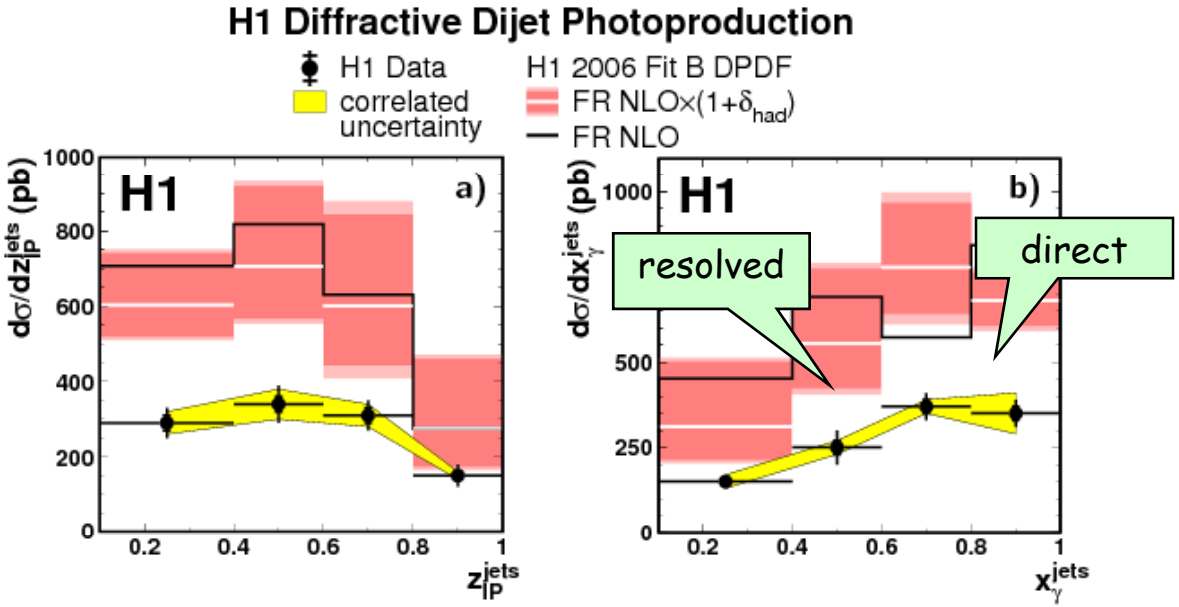

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Different H1 and ZEUS observations!!

- **H1** – suppression by factor 0.5, independent of x_γ (for H1 2006 fit B)
- **ZEUS** – weak (if any) suppression (~0.9, for H1 2006 fit B), independent of x_γ,

for LPS ZEUS fit suppression ~0.7

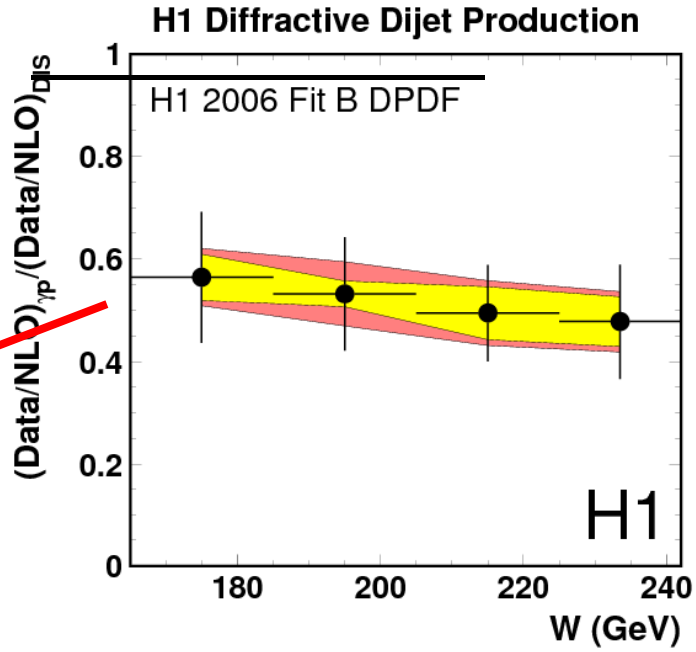
H1 went further……

Compare DIS and γ*p dijets
- Identical kinematic range
- Same data set
- Same DPDFs

$$\frac{\text{Data/NLO}\quad(\gamma^*p)}{\text{Data/NLO}\quad(\text{DIS})}$$

- reduced systematic uncertainties
- independent of used DPDF!
- constant within errors in whole region of W

0.5 ± 0.1



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Contradiction in H1 and ZEUS??

Photoproduction of dijets

H1

$E_t(1) > 5$ GeV
$E_t(2) > 4$ GeV
$-1 < \eta_{jets} < 2$
$Q^2 < 0.01$ GeV^2
$x_{IP} < 0.03$
$165 < W < 242$

ZEUS

$E_t(1) > 7.5$ GeV
$E_t(2) > 6.5$ GeV
$-1.5 < \eta j_{ets} < 1.5$
$Q^2 < 1$ GeV^2
$x_{IP} < 0.025$
$143 < W < 295$

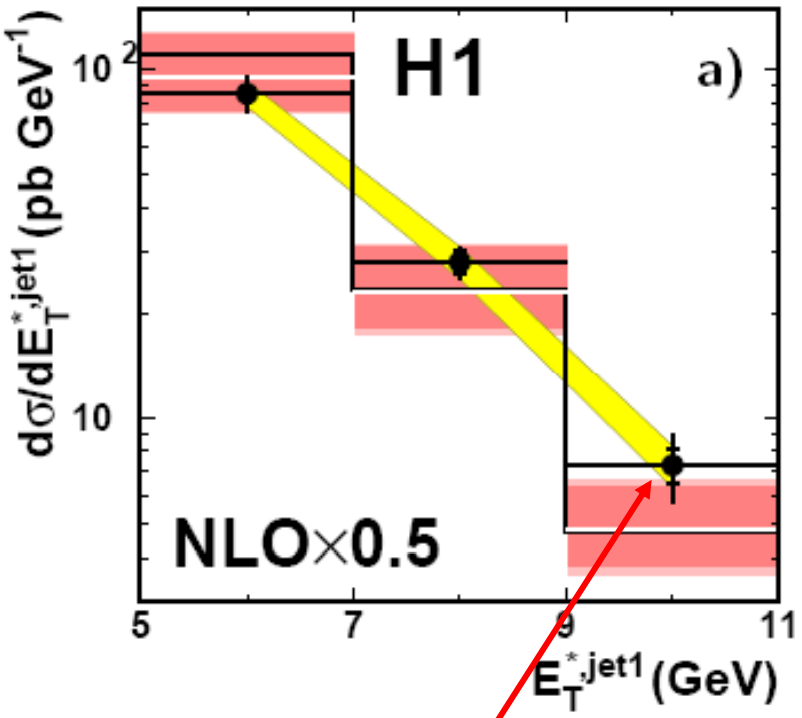
- different kinematic regions, ZEUS studied harder jets than H1
- (→ H1 larger resolved component than ZEUS), different η range and slightly different range of x_{IP}, H1 tagged photoproduction

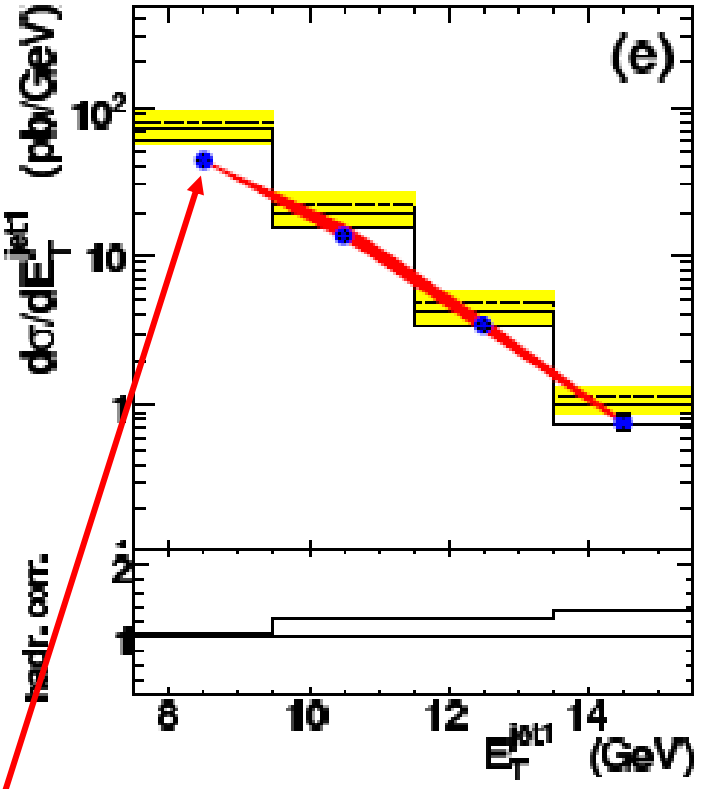
- different NLO programs used for comparison -> (Frixione/Ridolfi-H1) (Kramer/Klasen-ZEUS)

Direct H1 vs ZEUS data comparison not possible….

The crosschecks of NLO programs and used parameters were done, it seems that they are OK within ~10%

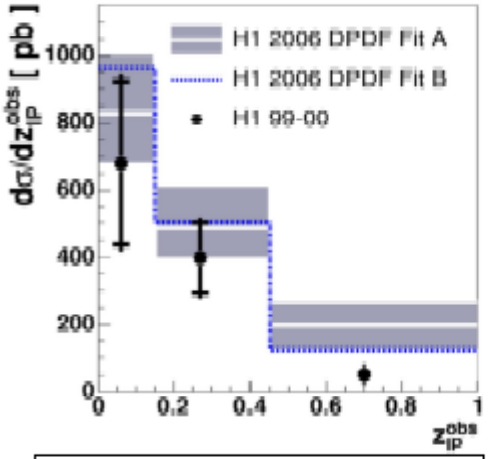
ZEUS explanation





Some hint that E_t data spectrum is softer for ZEUS first bin and harder for H1 last bin than NLO….?? Are data/NLO comparisons E_t dependent?

D⋆ in photoproduction



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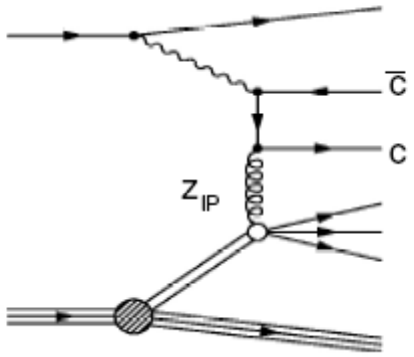
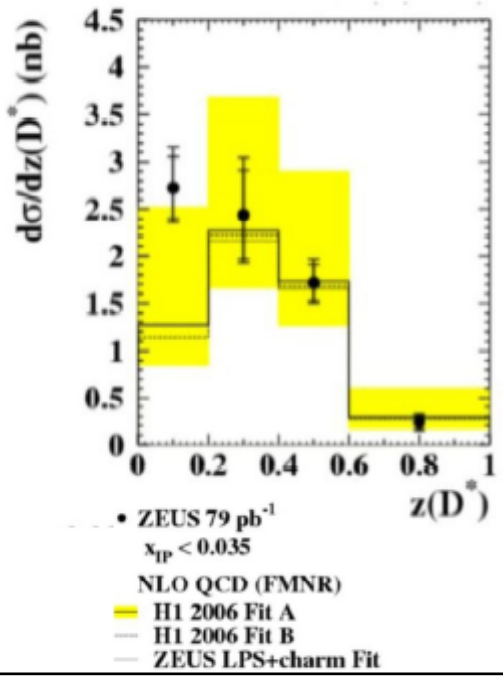


Hard scale: c mass



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- large NLO uncertainties
- reasonable agreement
- dominated by direct contribution

Factorization holds within errors

Summary

HERA:

Factorization tested with diffractive DIS and photoproduction dijets and charm production:

- holds for production of dijets and $D^{\star}$ in DIS (as expected) and $D^{\star}$ in photoproduction (direct component dominates) Large theoretical uncertainties in the NLO calculations. Dijets data used to constrain the dPDFs.

- situation in photoproduction of dijets still not clear -> different conclusions obtained by H1 and ZEUS. Due to different theoretical predictions or different kinematic regions? E_t region of jets crucial? Several 10-20% effects (proton dissociation, E_t range, different NLO programs…) responsible for observed differences?