Dijets in Diffractive Photoproduction

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On behalf of the

H1 Collaboration

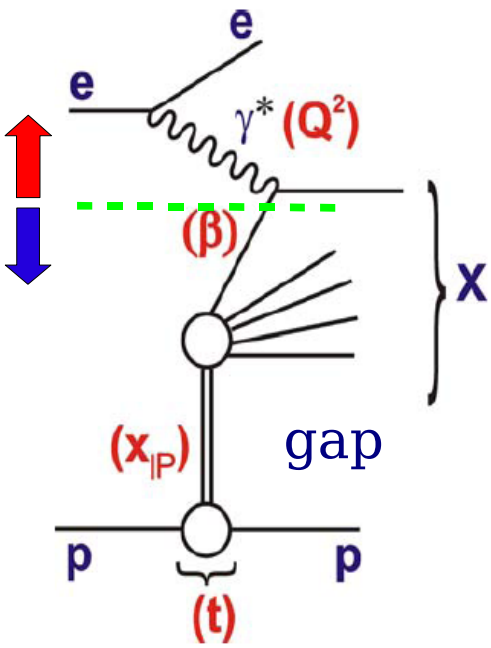
Introduction – QCD factorization

QCD hard factorization = assumption of:

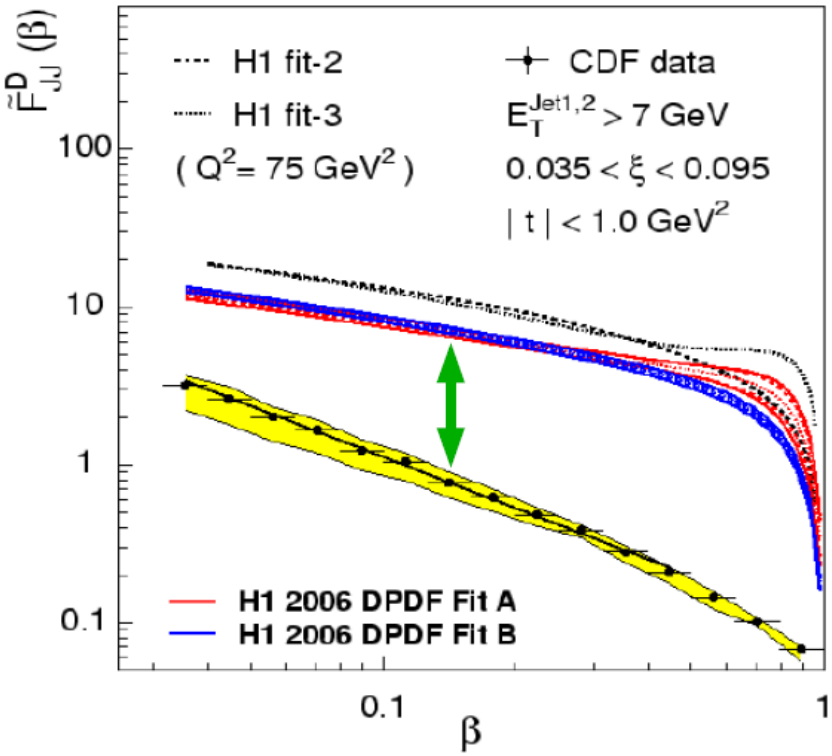
$$\sigma^{diff.}(ep \to e\,X\,p) \approx f_{i/p}(\beta, Q^2, x_{IP}, t) \times \sigma(\beta, Q^2)$$

diffractive parton distribution functions

QCD subprocess cross section



H1 fits vs. Tevatron



H1 DPDF fits fail to predict Tevatron data.

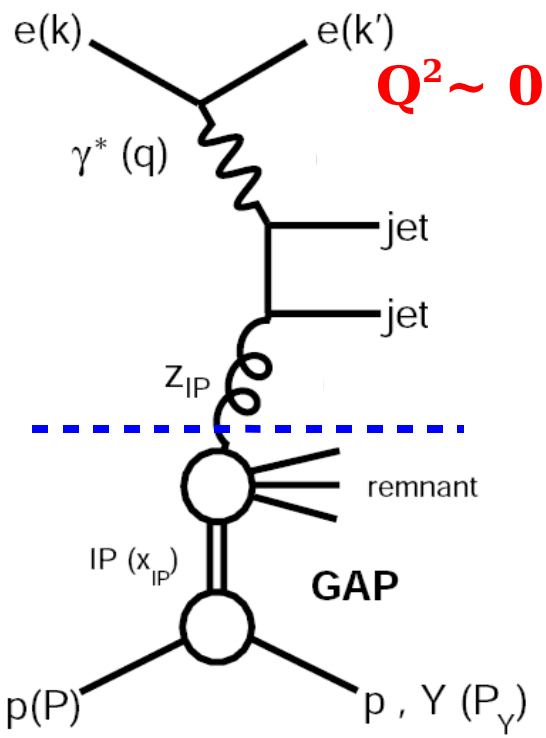
QCD factorization not expected to hold in diffractive h-h scattering (Kaidalov et al., 2003).

Introduction
Test of factorization in photoproduction

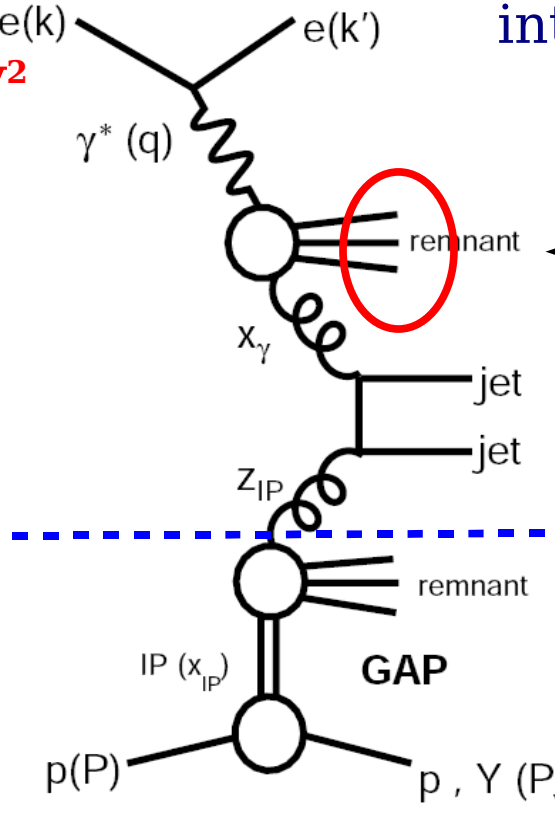
direct γ ($x_\gamma = 1$)

resolved γ ($x_\gamma < 1$)

x_γ – four-momentum fraction of the photon in the hard interaction



$Q^2 \sim 0$ GeV^2



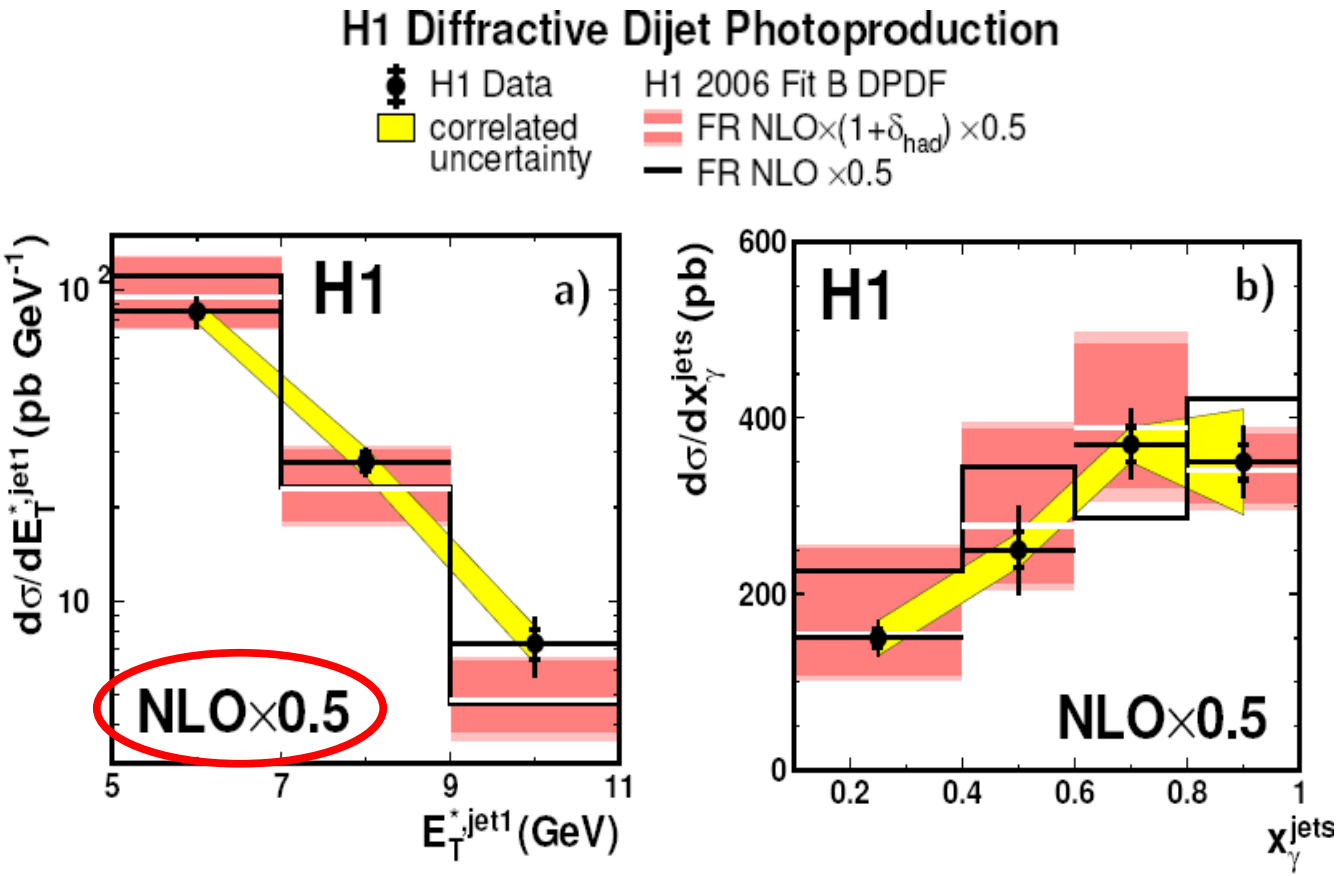
Rescattering of γ remnant in resolved makes the gap less likely to survive.

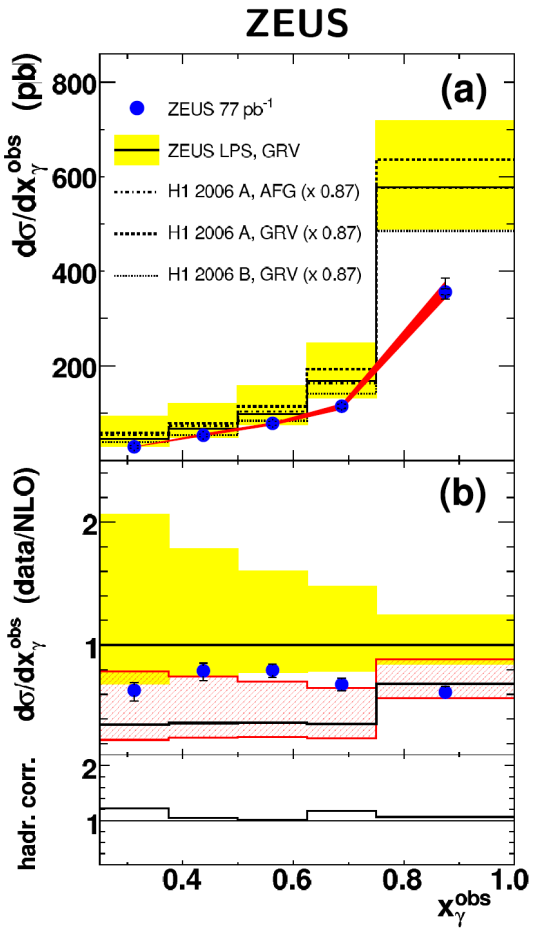
Resolved photon interactions are similar to h-h scattering

x_{IP} – four-momentum fraction of proton carried by diff. exchange IP

z_{IP} – four-momentum fraction of IP carried by parton

Introduction - Recent results





H1 96-97: $E_T^{jet1} > 5$ GeV suppression by **0.5**

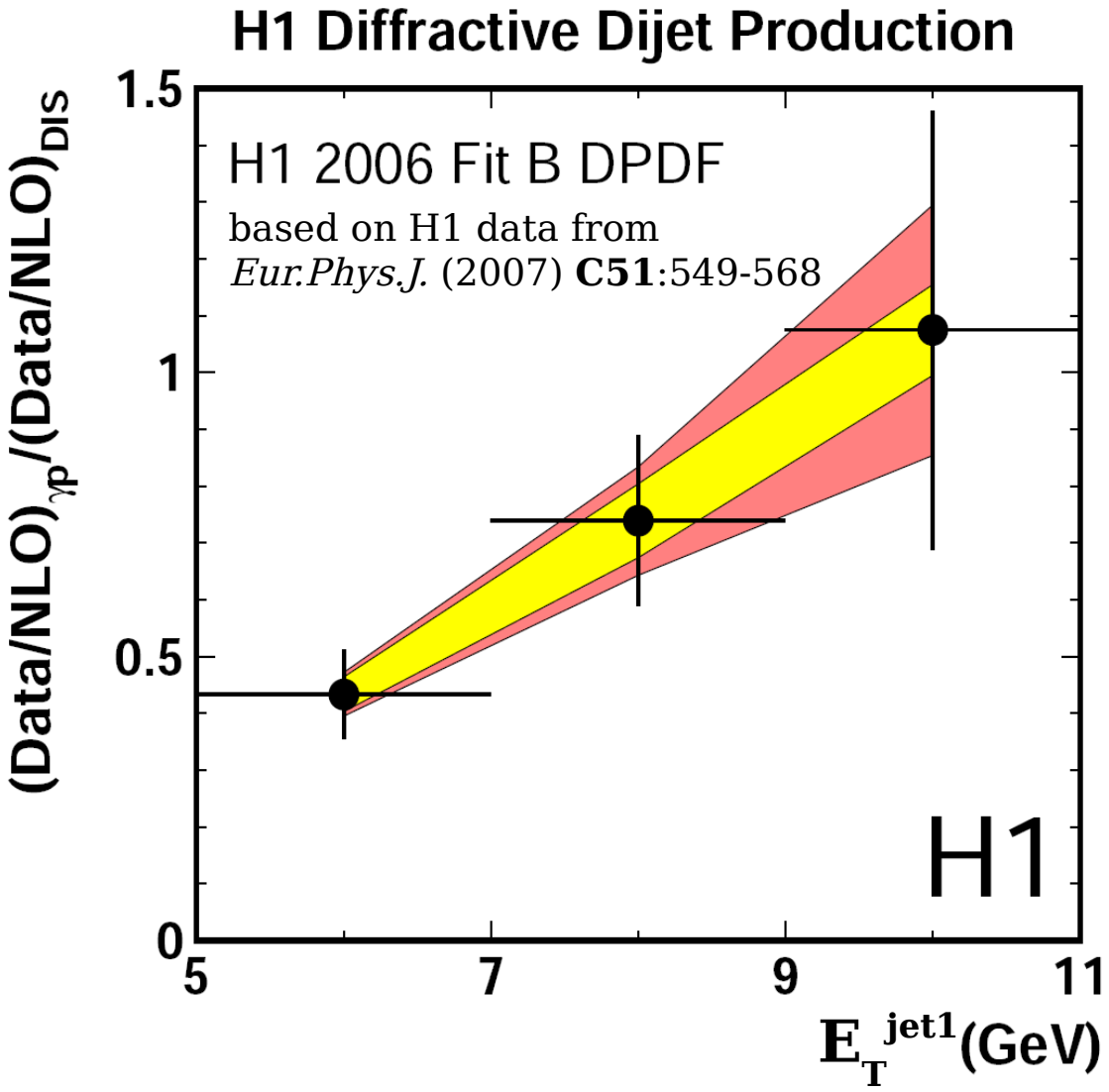
ZEUS 99-00: $E_T^{jet1} > 7.5$ GeV **weak** (0.6 -0.9) suppression

Possible explanation: **different E_T ranges** (ZEUS@DIS07)

Neither experiment sees difference between direct and resolved regions, in contrast to theoretical expectations.

Introduction
γp / DIS - motivation for E_T dependence

Double ratio of $(\text{data/NLO})^{\gamma p}$ / $(\text{data/NLO})^{DIS}$
based on 96-97 data from: *Eur.Phys.J.* (2007) **C51**:549-568



Further suggestion of possible dependence of the gap survival on the E_T range.

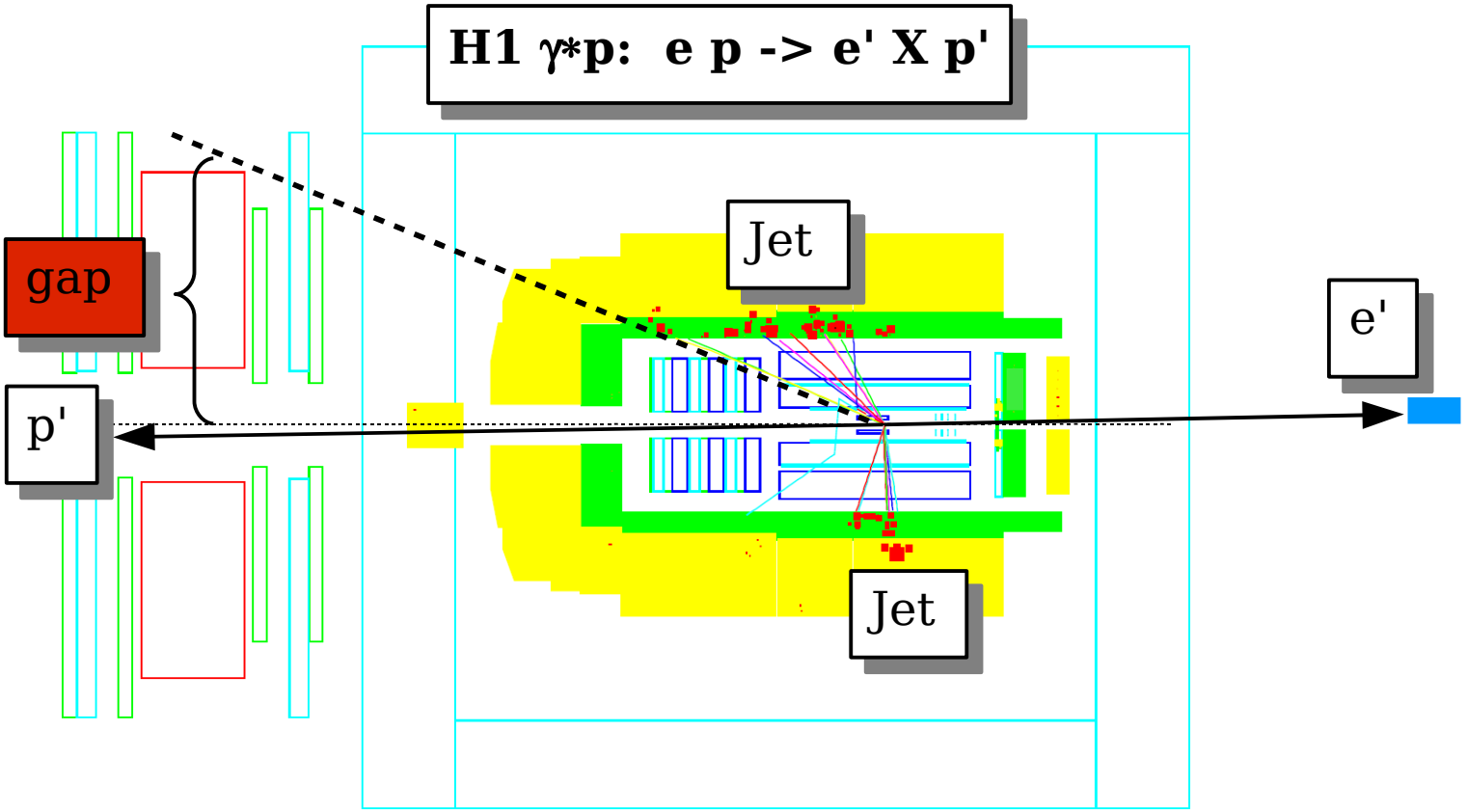
Large uncertainties dominated by statistics.

DPDF uncertainty cancels in the double ratio.

The plot not presented, so far – based on published data.

Data and Event Selection (1/2)

- Analysis based on 99-00 e+ HERA data.
- Integrated luminosity ~ 54 pb^{-1} (three times higher than prev. H1 analysis).
- Outgoing electron is tagged in an electron tagger.
- Diffractive events selected by Large Rapidity Gap (LRG).



Data and Event Selection (2/2)

Measurements are carried out in two kinematic ranges.

	low E_T	**high E_T**
	$E_T^{jet1} > 5$ GeV	$E_T^{jet1} > 7.5$ GeV
	$E_T^{jet2} > 4$ GeV	$E_T^{jet2} > 6.5$ GeV
	$-1 < \eta^{(\text{jet 1 and 2})} < 2$	$-1.5 < \eta^{(\text{jet 1 and 2})} < 1.5$
	$x_{IP} < 0.03$	$x_{IP} < 0.025$
limited by the e-tagger acceptance	$0.3 < y_e < 0.65$	$0.3 < y_e < 0.65$ … $0.2 < y_{JB} < 0.85$ **ZEUS**
limited by the e-tagger acceptance	$Q^2 < 0.01$ GeV^2	$Q^2 < 0.01$ GeV^2 … $Q^2 < 1$ GeV^2
proton dissociation is allowed	$\lvert t\rvert < 1$ GeV^2	$\lvert t\rvert < 1$ GeV^2
proton dissociation is allowed	$M_Y < 1.6$ GeV	$M_Y < 1.6$ GeV

different from ZEUS

Theoretical Predictions

The measured cross sections are compared with NLO QCD calculations: GRV γ PDFs, $N_f=5$, $\Lambda_4=0.228$ MeV, $\mu_r=\mu_f=E_T^{jet1}$

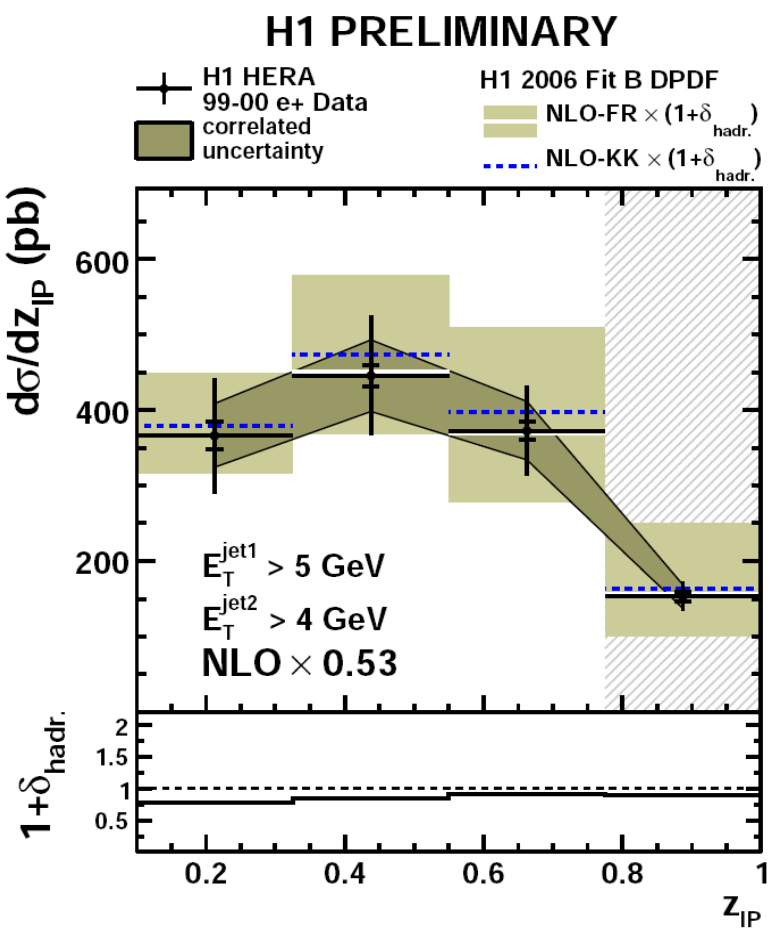
- Frixione-Ridolfi program: H1 2006 DPDF Fit A & B ... Eur.Phys.J.C48:715-748,2006
  H1 2007 DPDF Fit Jets ... JHEP 0710:042,2007

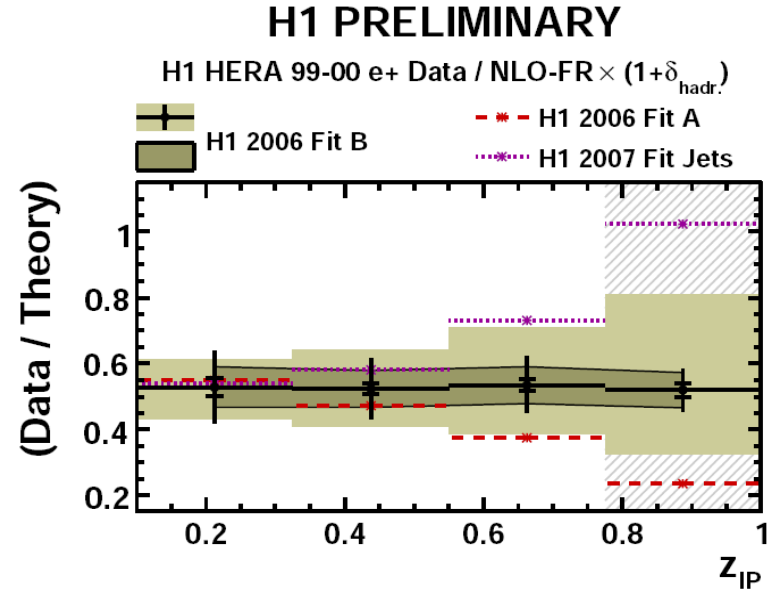
- Klasen & Kramer program calculations (provided by Michael Klasen): H1 2006 DPDF Fit B

More than one DPDF fits used in order to estimate the effect of DPDF uncertainties.

Hadronization corrections are calculated by means of a LO Rapgap MC generator. The results are compared at the level of stable hadrons.

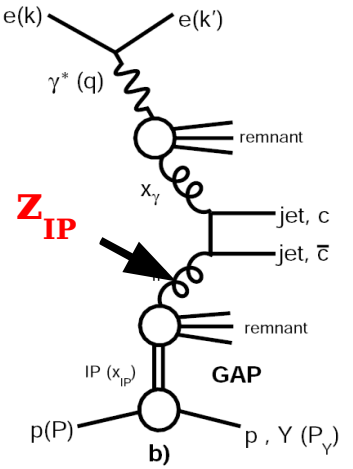
Results





Differential cross sections in z_{IP}

$$z_{IP} \sim \frac{\Sigma_{jets}(E + p_z)}{2 \cdot E^{beam}_{proton} \cdot x_{IP}}$$

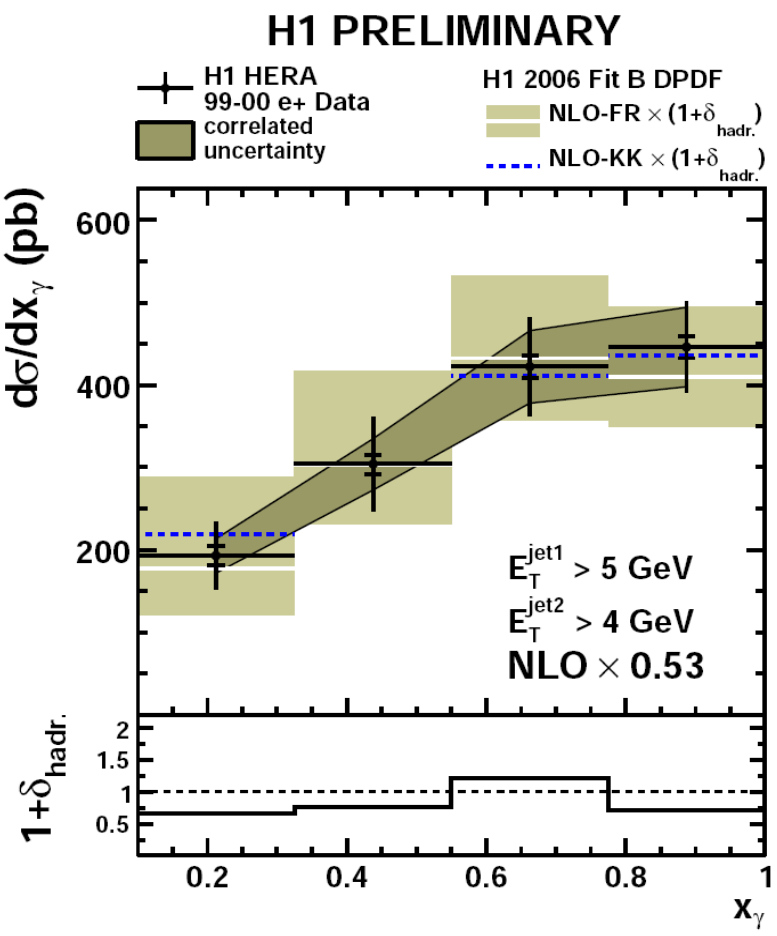


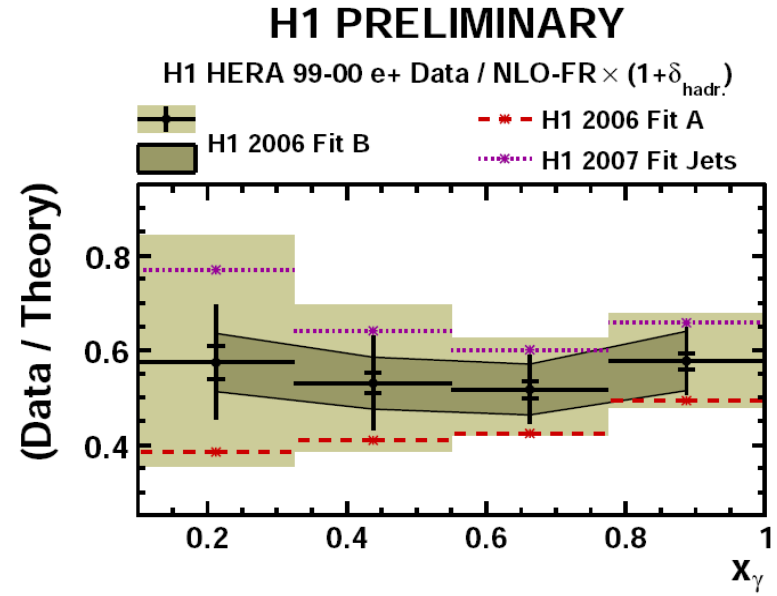
Global suppression
(or survival probability)
~ 0.5 confirming previous H1 result.

Best shape description by Fit B.

DPDF uncertainties are small at low z_{IP} but large at high z_{IP}.

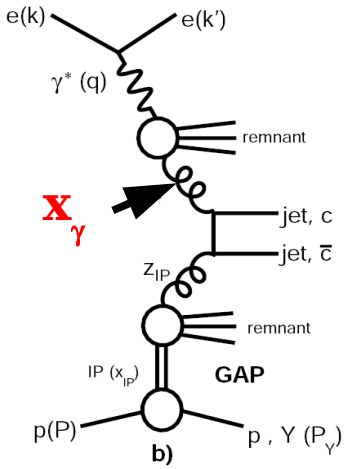
Last z_{IP} bin is beyond the range of DPDF fits so the predictions must be taken cautiously.





Differential cross sections in x_γ

$$x_\gamma \sim \frac{\Sigma_{jets}(E-p_z)}{\Sigma_{HFS}(E-p_z)}$$



There is no evidence for any difference in survival probabilities for resolved and direct photons.

Integrated survival probabilities:

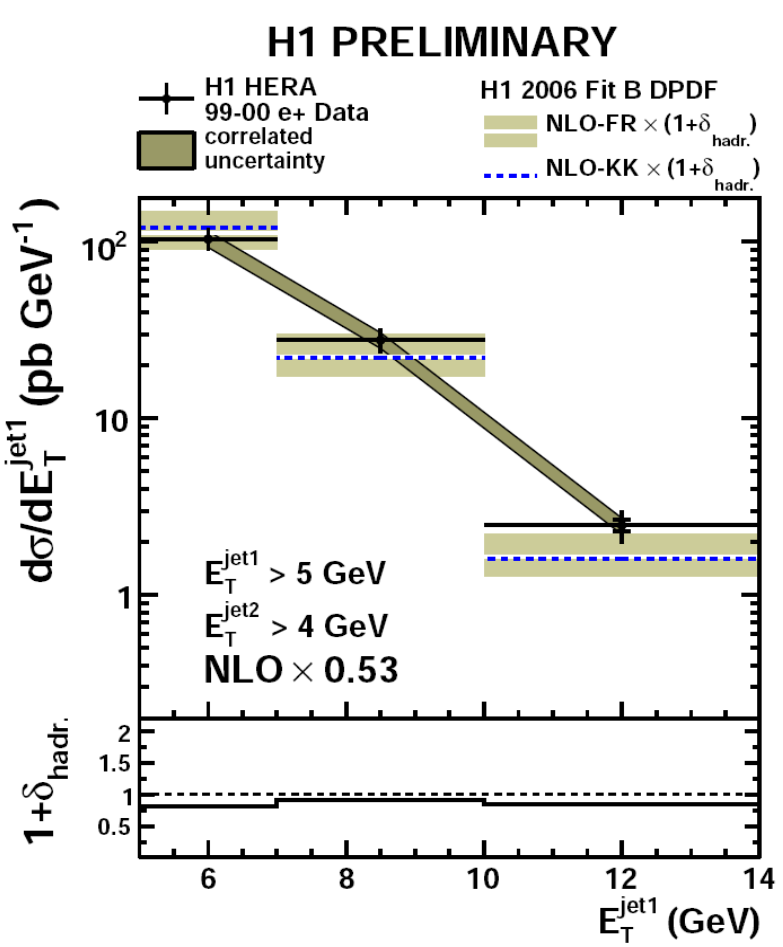
$$S^{FR}_{fit\ B} = \underline{0.54} \pm 0.01\,(stat.) \pm 0.10\,(syst.)\,^{+0.14}_{-0.13}\,(scale)$$

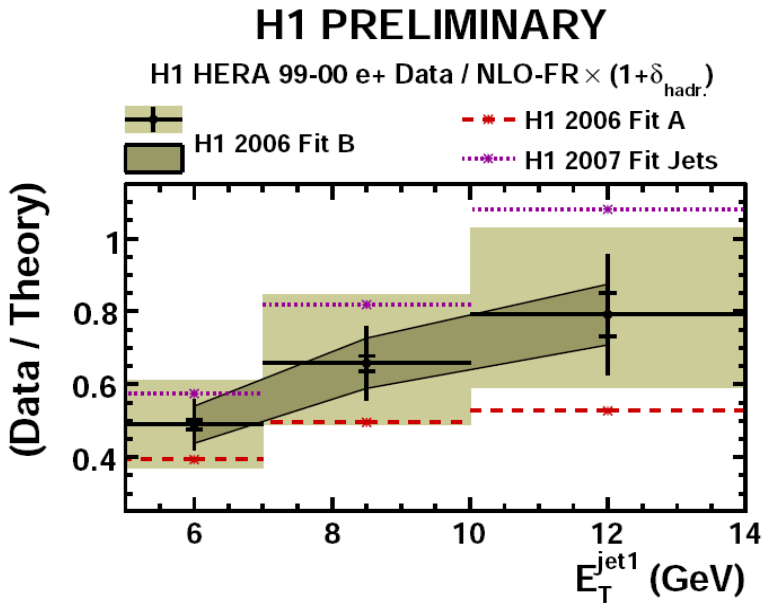
$$S^{KK}_{fit\ B} = 0.51 \pm 0.01\,(stat.) \pm 0.10\,(syst.)$$

$$S^{FR}_{fit\ Jets} = 0.65 \pm 0.01\,(stat.) \pm 0.11\,(syst.)$$

$$S^{FR}_{fit\ A} = 0.43 \pm 0.01\,(stat.) \pm 0.10\,(syst.)$$

Differential cross sections in E_T^{jet1}



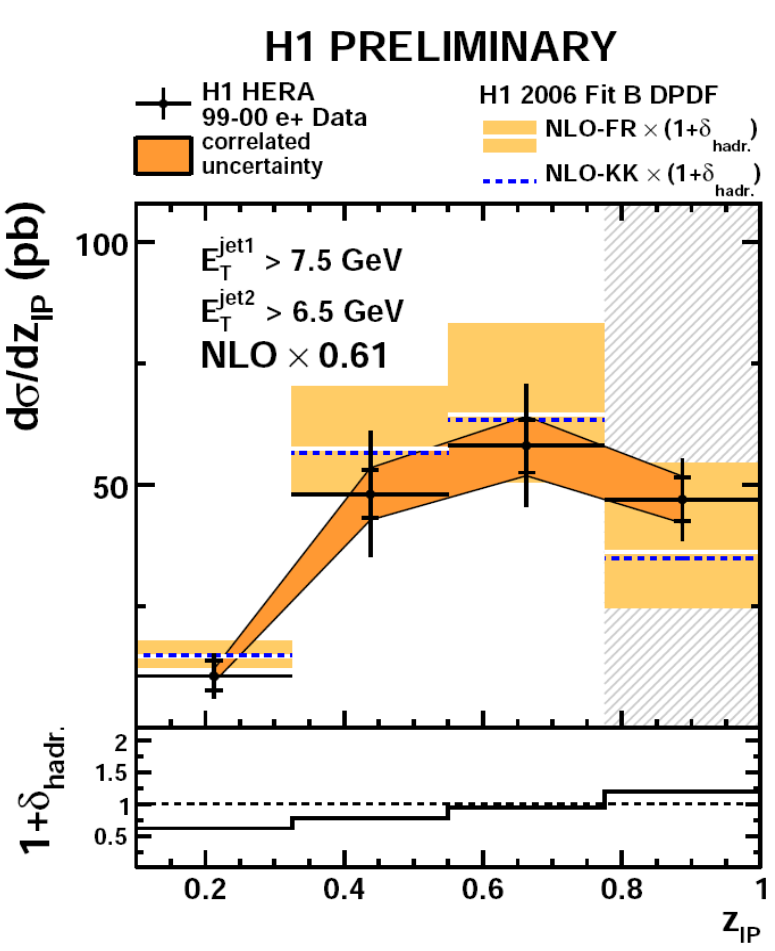


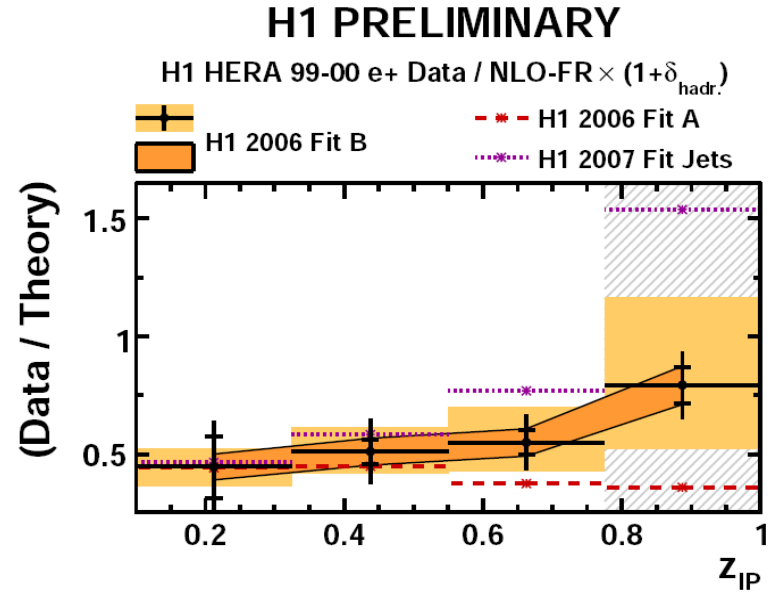
Another suggestion for harder E_T^{jet1} slope in data than NLO theory.

$5 < E_T^{jet1} < 7$ GeV
within uncertainties ratio ranges between **0.3 – 0.7**
(confirming previous H1 result).

$E_T^{jet1} > 7$ GeV
within uncertainties ratio is compatible with ~ **0.8**
(cf. previous ZEUS result)

higher E_T jets



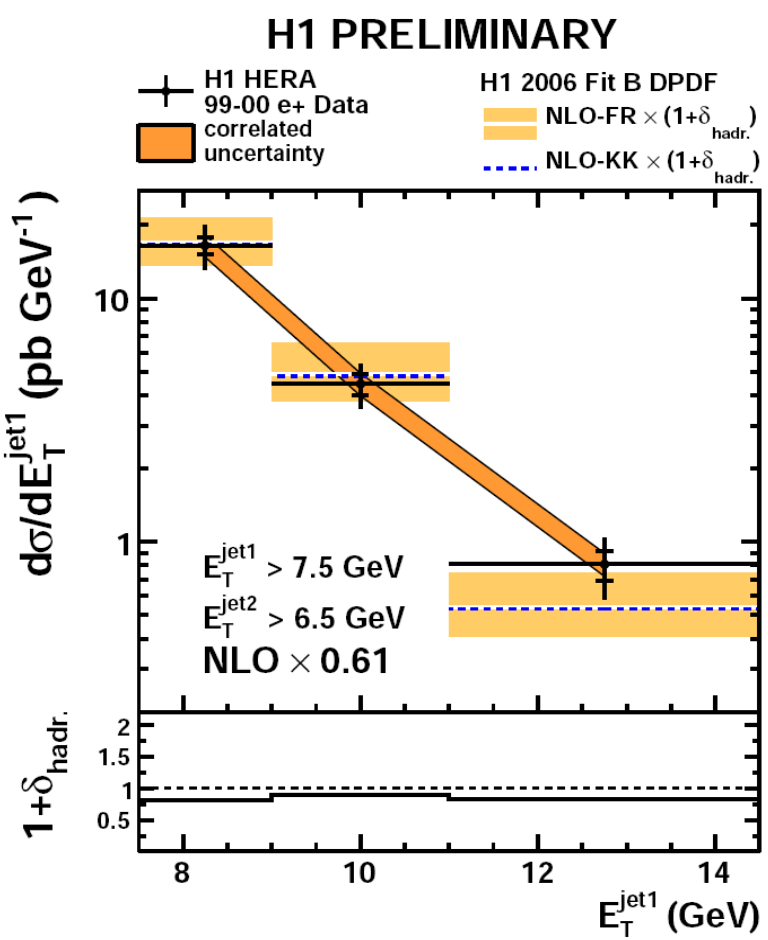


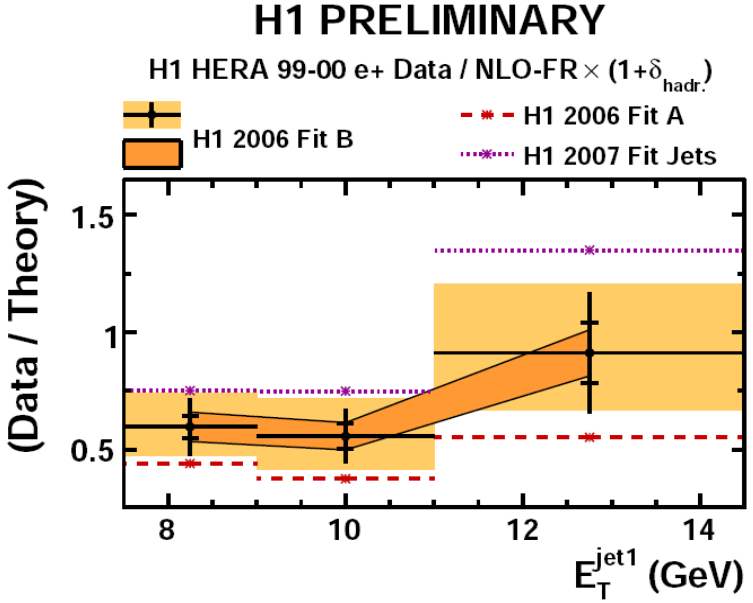
Analysis at Larger E_T z_{IP} dependence

Kinematics chosen as close as possible to ZEUS measurement.

The y range still different from ZEUS ($0.2 < y < 0.85$).

Here and for other variables Fit B continues to describe the shapes well.





Analysis at Larger E_T^{jet1} dependence

Larger integrated survival probabilities than for lower E_T cuts:

$$S^{FR}_{fit\ B} = 0.61 \pm 0.03\,(stat.) \pm 0.13\,(syst.)\,^{+0.16}_{-0.14}\,(scale)$$

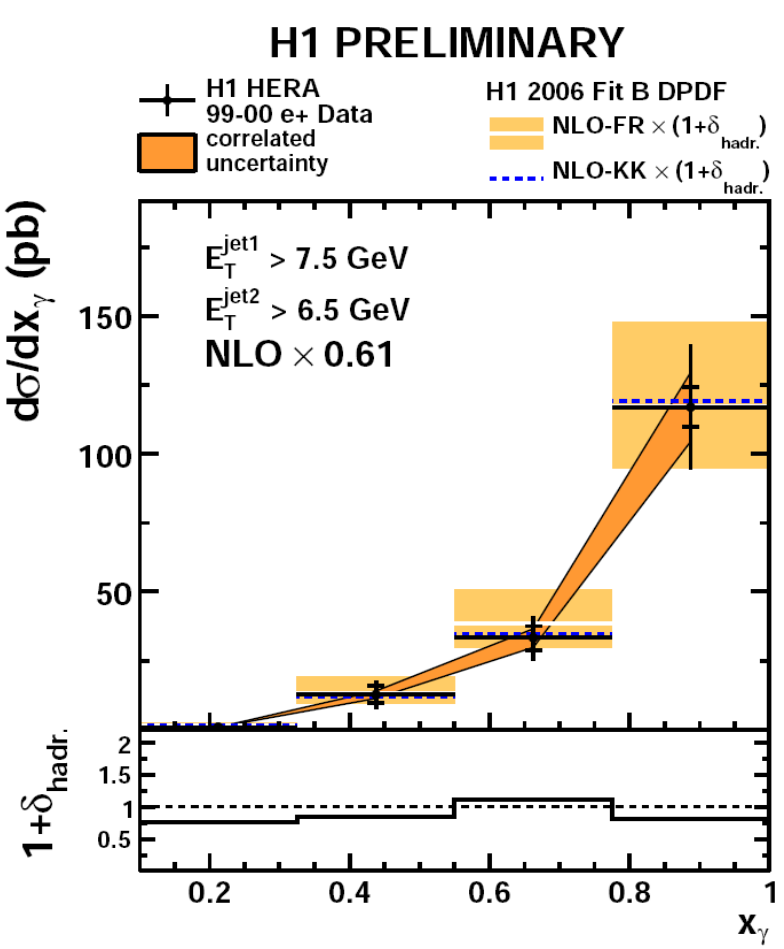
$$S^{KK}_{fit\ B} = 0.62 \pm 0.03\,(stat.) \pm 0.14\,(syst.)$$

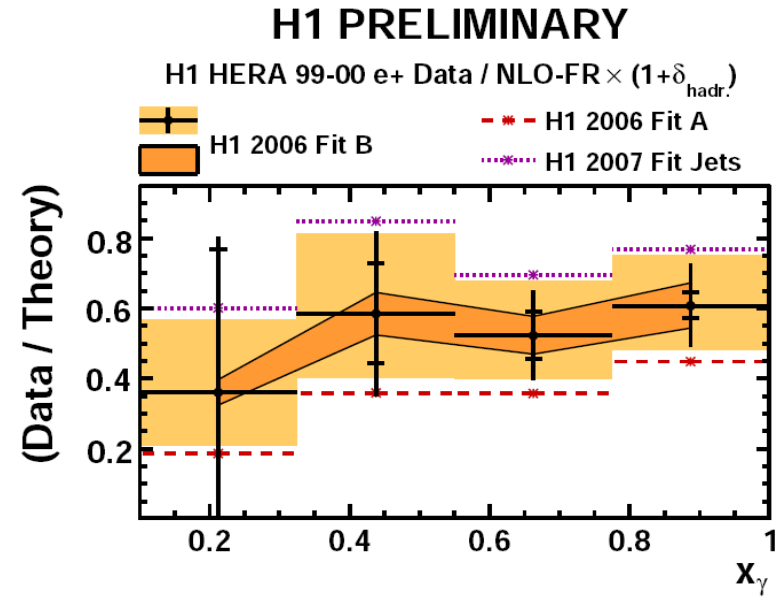
$$S^{FR}_{fit\ Jets} = 0.79 \pm 0.04\,(stat.) \pm 0.16\,(syst.)$$

$$S^{FR}_{fit\ A} = 0.44 \pm 0.02\,(stat.) \pm 0.09\,(syst.)$$

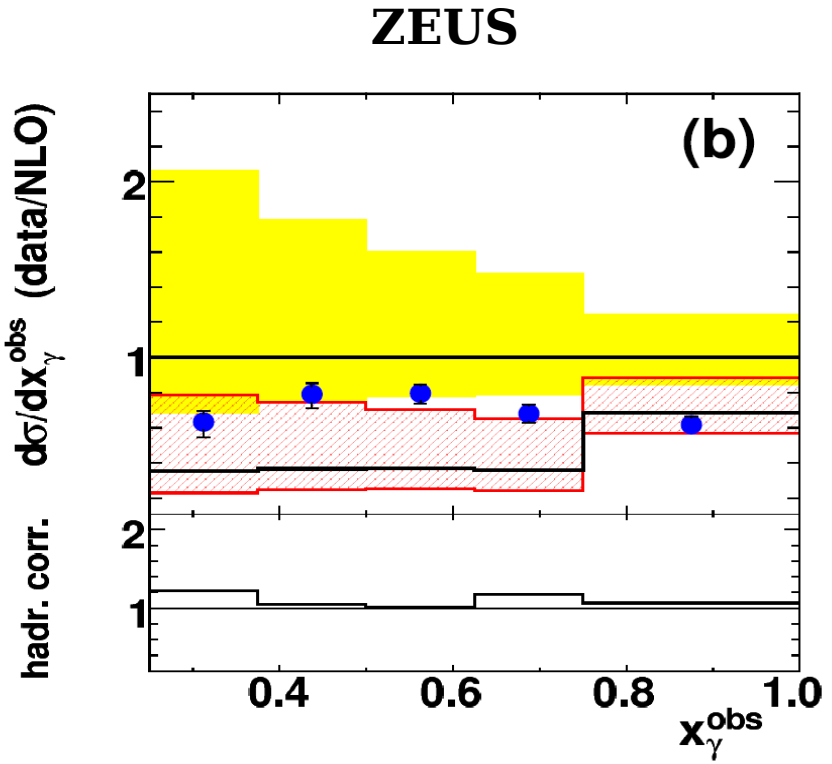
Similar survival probability range as to ZEUS in similar E_T range if data and DPDF uncertainties taken into account.

E_T dependence not excluded but cannot be independently verified.





Analysis at Larger E_T x_γ dependence



Within errors the suppression is the same for resolved and direct processes.

Summary

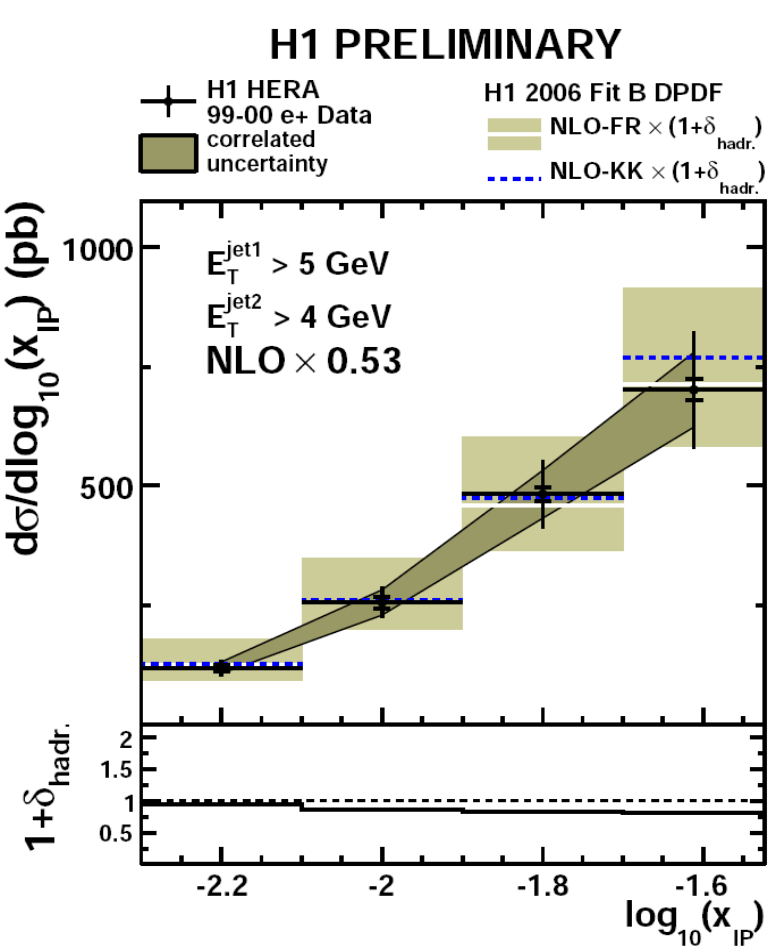
(1) New H1 data yield gap survival probability significantly less than unity in some regions (low E_T)

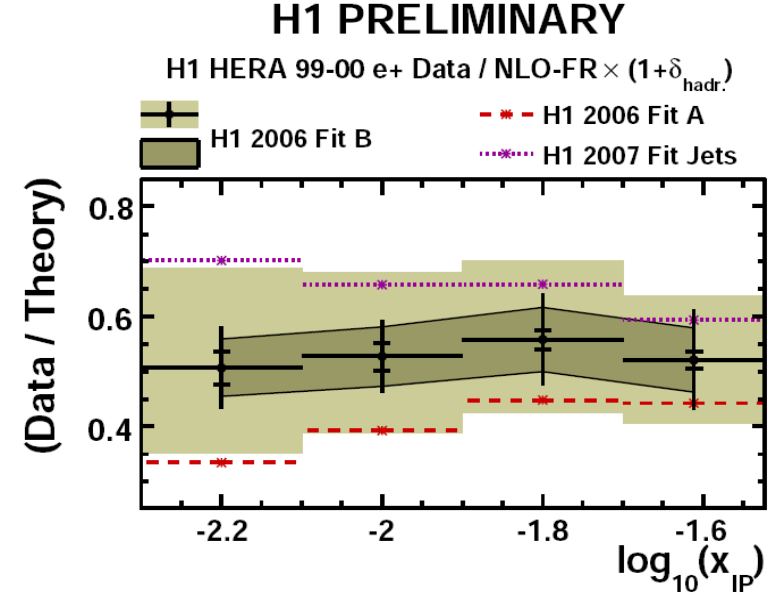
... but consistent with recent ZEUS data (at high E_T).

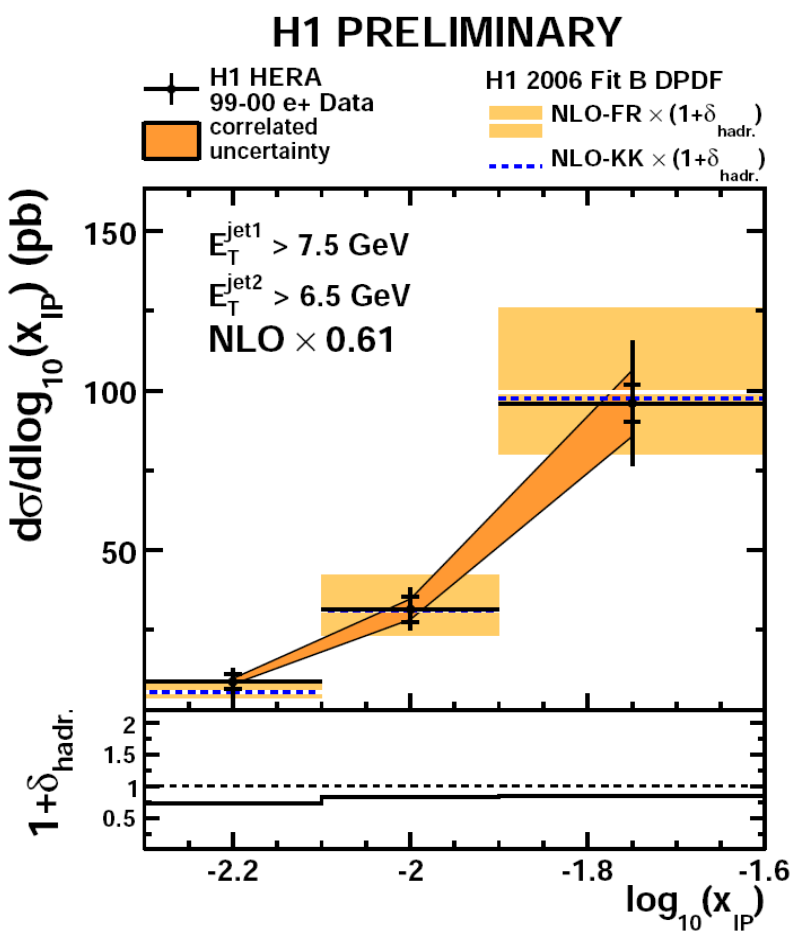
(2) Evidence that gap destruction becomes less likely if the jet kinematics is restricted into the range of higher E_T (weaker integrated suppression in the high E_T analysis).

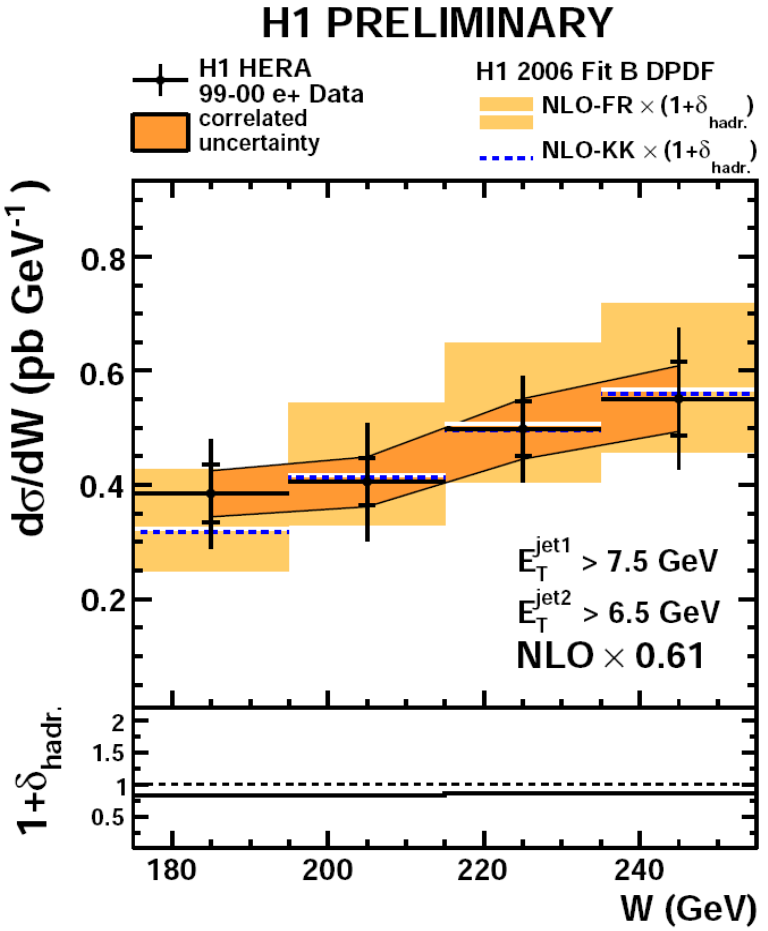
(3) In contrast to most expectations there is no evidence for any difference between the survival probability for the resolved and the direct processes.

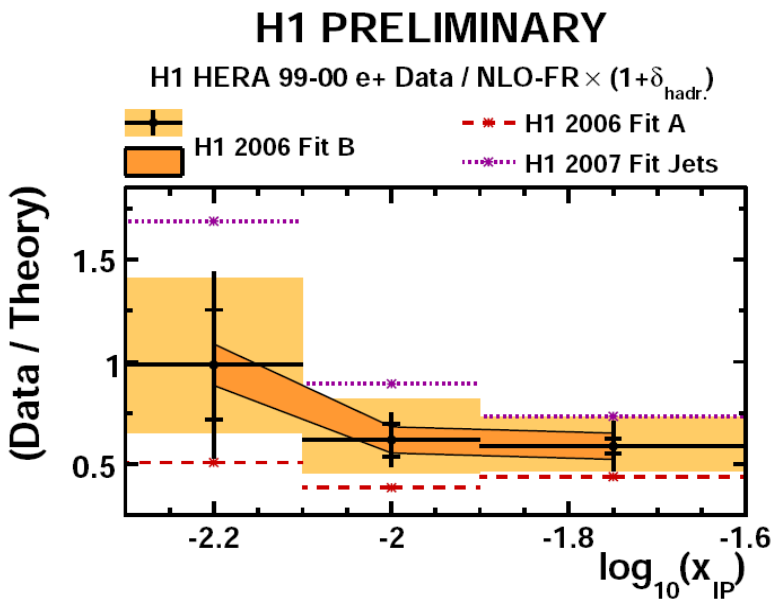
Further plots from both analyses

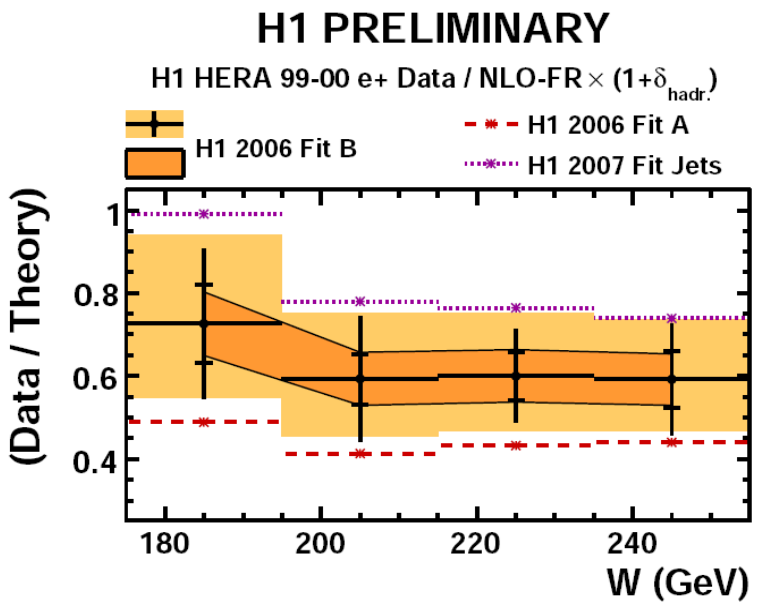

H1 PRELIMINARY
H1 HERA
99-00 e+ Data
correlated
uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δ hadr.)
NLO-KK × (1+δ hadr.)
dσ/dlog10(xIP) (pb)
1000
500
E T jet1 > 5 GeV
E T jet2 > 4 GeV
NLO × 0.53
1+δhadr.
2
1.5
1
0.5
-2.2
-2
-1.8
-1.6
log10(xIP)

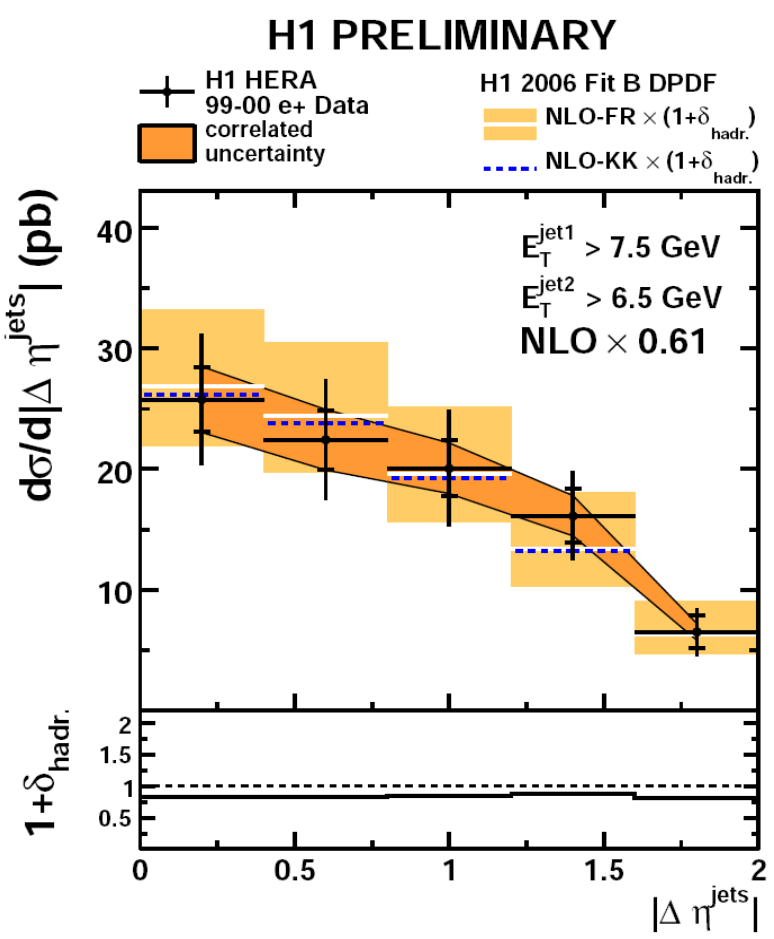

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δ hadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
0.8
0.6
0.4
-2.2
-2
-1.8
-1.6
log10(xIP)

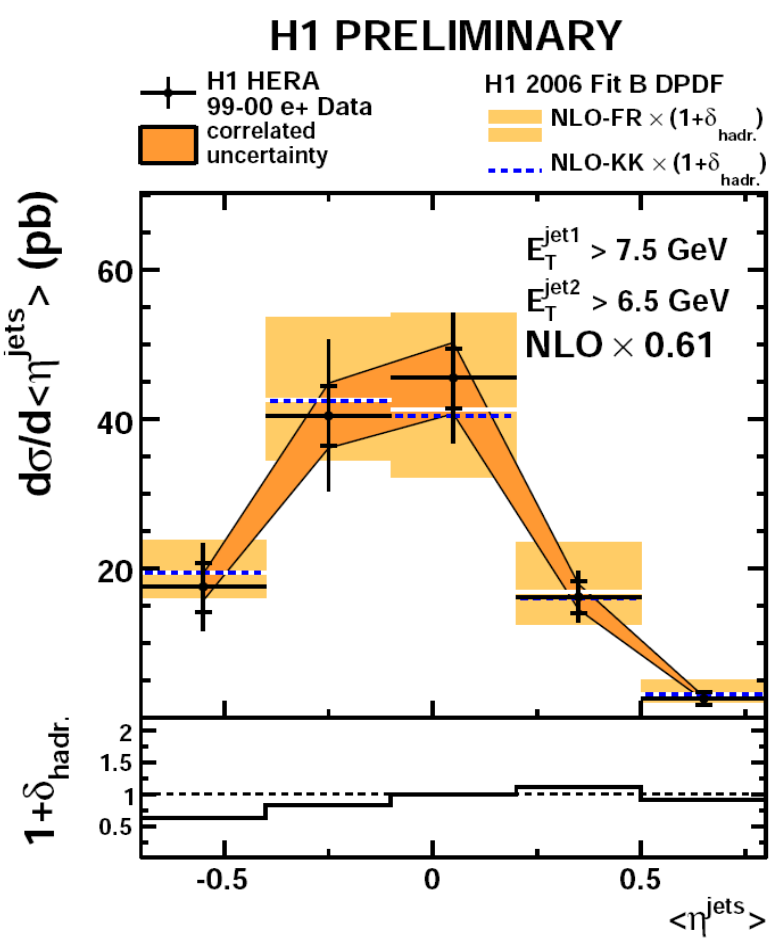

H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δhadr.)
NLO-KK × (1+δhadr.)
dσ/dlog10(xIP) (pb)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
1+δhadr.
log10(xIP)

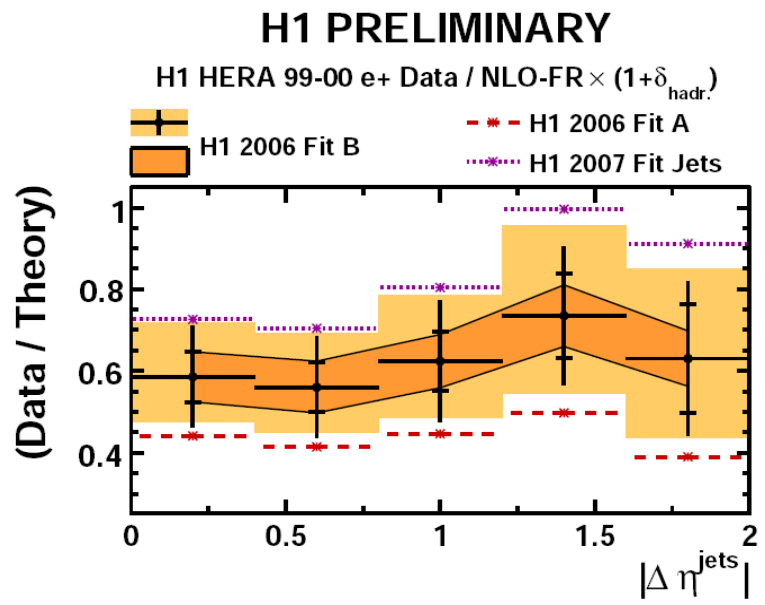

H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δhadr.)
NLO-KK × (1+δhadr.)
dσ/dW (pb GeV-1)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
1+δhadr.
W (GeV)

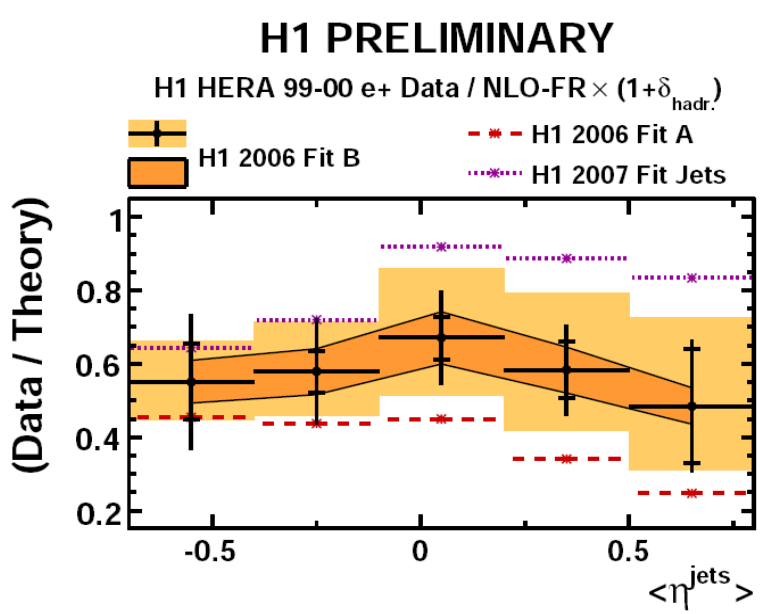

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δhadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
log10(xIP)

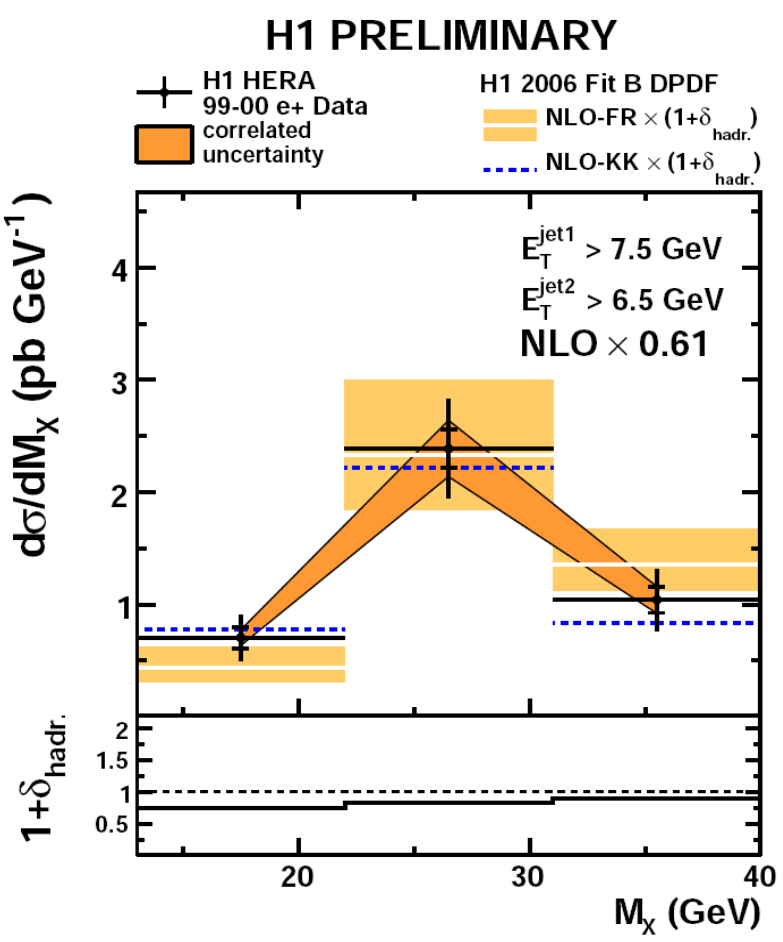

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δhadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
W (GeV)

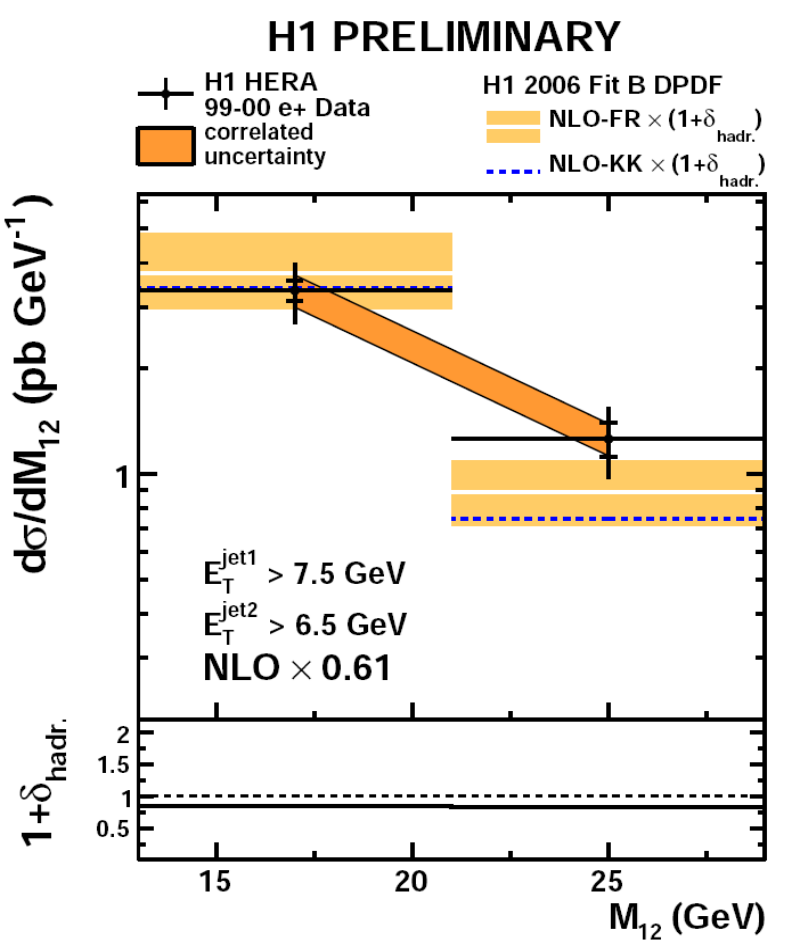

H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δ hadr.)
NLO-KK × (1+δ hadr.)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
dσ/d|Δ η^jets| (pb)
1+δ hadr.
|Δ η^jets|

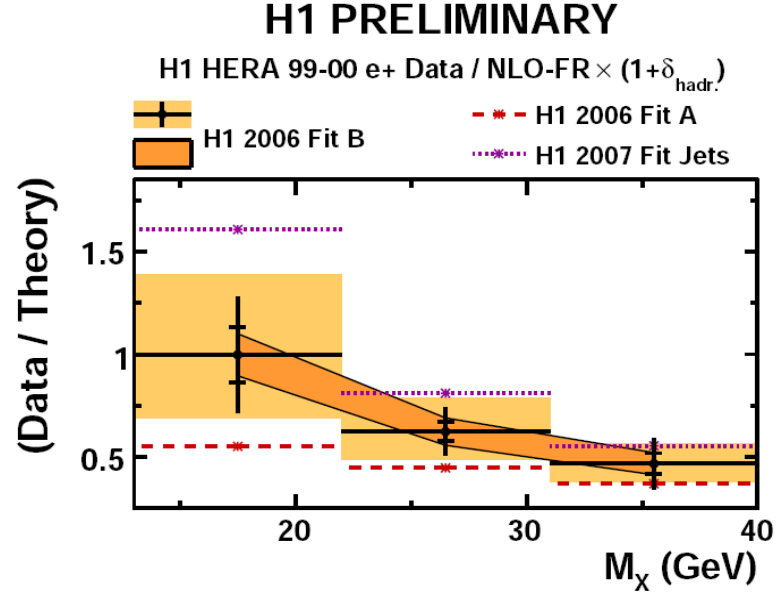

H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δ hadr.)
NLO-KK × (1+δ hadr.)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
dσ/d<η^jets> (pb)
1+δ hadr.
<η^jets>

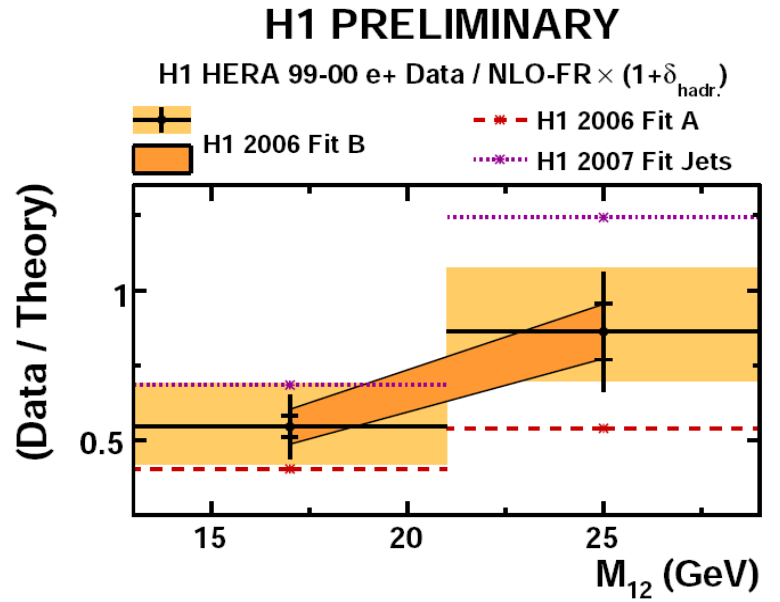

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δ hadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
|Δ η^jets|


H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δ hadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
<η^jets>


H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δhadr.)
NLO-KK × (1+δhadr.)
dσ/dMX (pb GeV-1)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
1+δhadr.
MX (GeV)

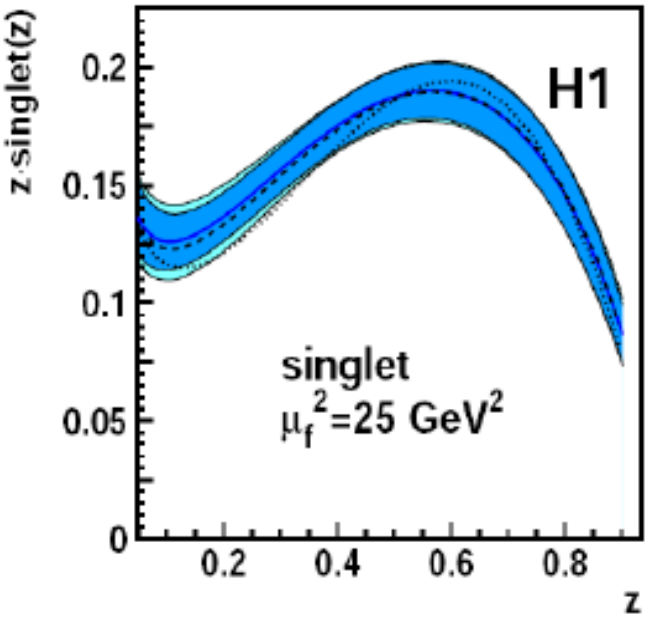

H1 PRELIMINARY
H1 HERA 99-00 e+ Data
correlated uncertainty
H1 2006 Fit B DPDF
NLO-FR × (1+δhadr.)
NLO-KK × (1+δhadr.)
dσ/dM12 (pb GeV-1)
E_T^jet1 > 7.5 GeV
E_T^jet2 > 6.5 GeV
NLO × 0.61
1+δhadr.
M12 (GeV)

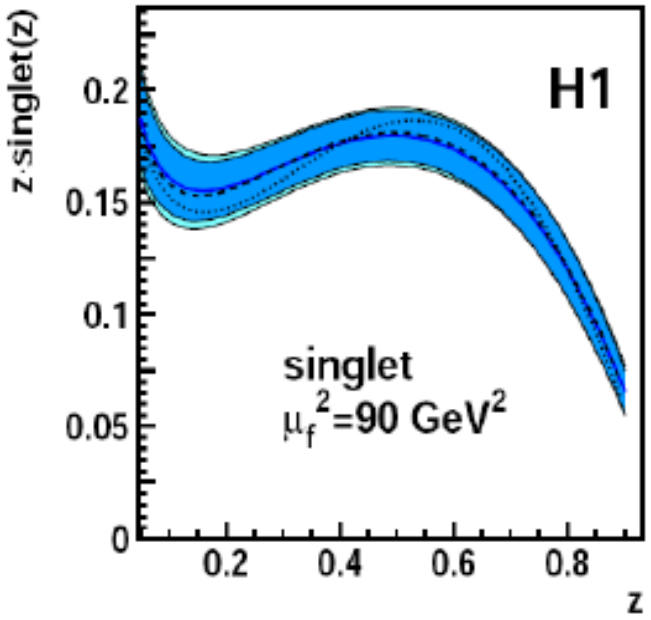

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δhadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
MX (GeV)

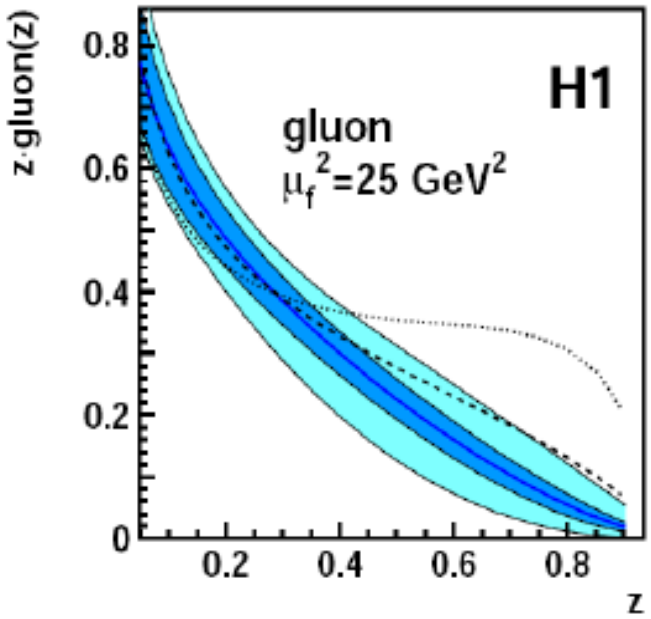

H1 PRELIMINARY
H1 HERA 99-00 e+ Data / NLO-FR × (1+δhadr.)
H1 2006 Fit B
H1 2006 Fit A
H1 2007 Fit Jets
(Data / Theory)
M12 (GeV)

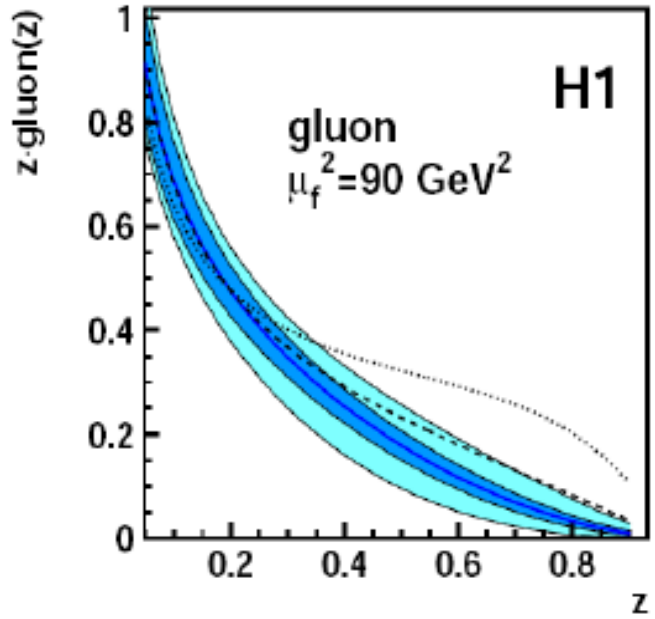
Backup

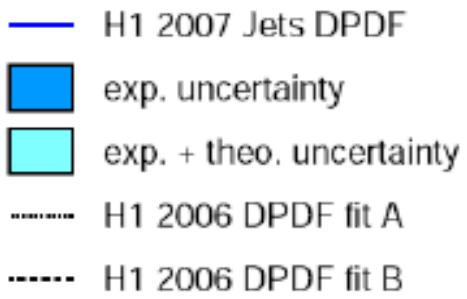
DPDF Fits


H1
singlet
μ_f^2=25 GeV^2
z·singlet(z)
z


H1
singlet
μ_f^2=90 GeV^2
z·singlet(z)
z


H1
gluon
μ_f^2=25 GeV^2
z·gluon(z)
z


H1
gluon
μ_f^2=90 GeV^2
z·gluon(z)
z


H1 2007 Jets DPDF
exp. uncertainty
exp. + theo. uncertainty
H1 2006 DPDF fit A
H1 2006 DPDF fit B