H1 Diffractive Dijets

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HERA/LHC Workshop

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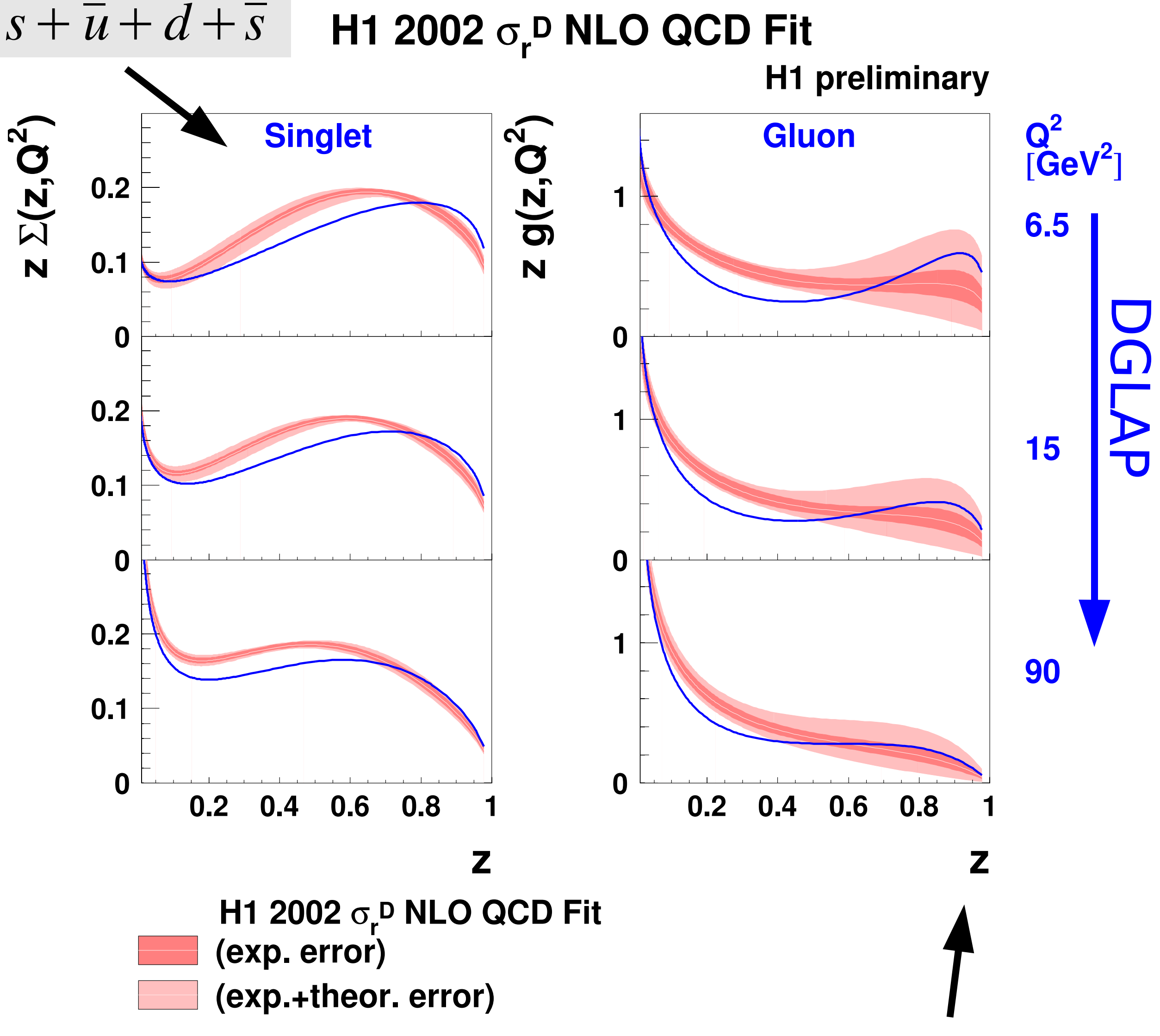
Diffractive parton content of proton

Quark singlet

$\Sigma = u + d + s + \bar{u} + \bar{d} + \bar{s}$

- gluons carry ≈80% of momentum

- large gluon uncertainty at high fractional momentum

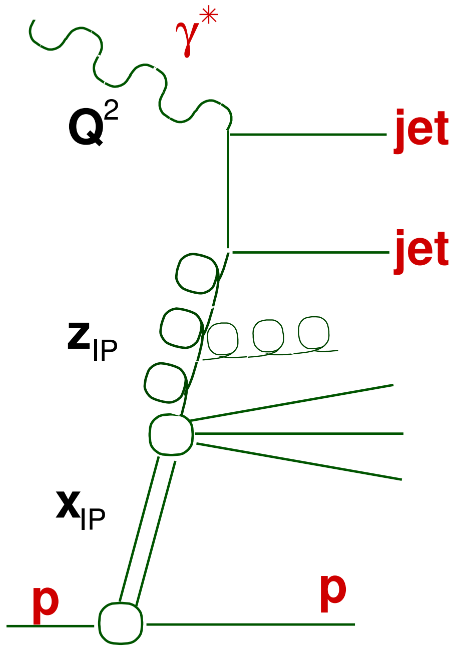


momentum fraction
w.r.t. diffr. exchange

Universal diffractive parton densities?

- diffractive parton densities describe inclusive *ep* collisions
- description of other processes?
    - more exclusive processes: jet production
    - diffractive $\mathrm{p}\,\bar{\mathrm{p}}$ collisions?
    - diffractive γp collisions?

→ Factorisation tests



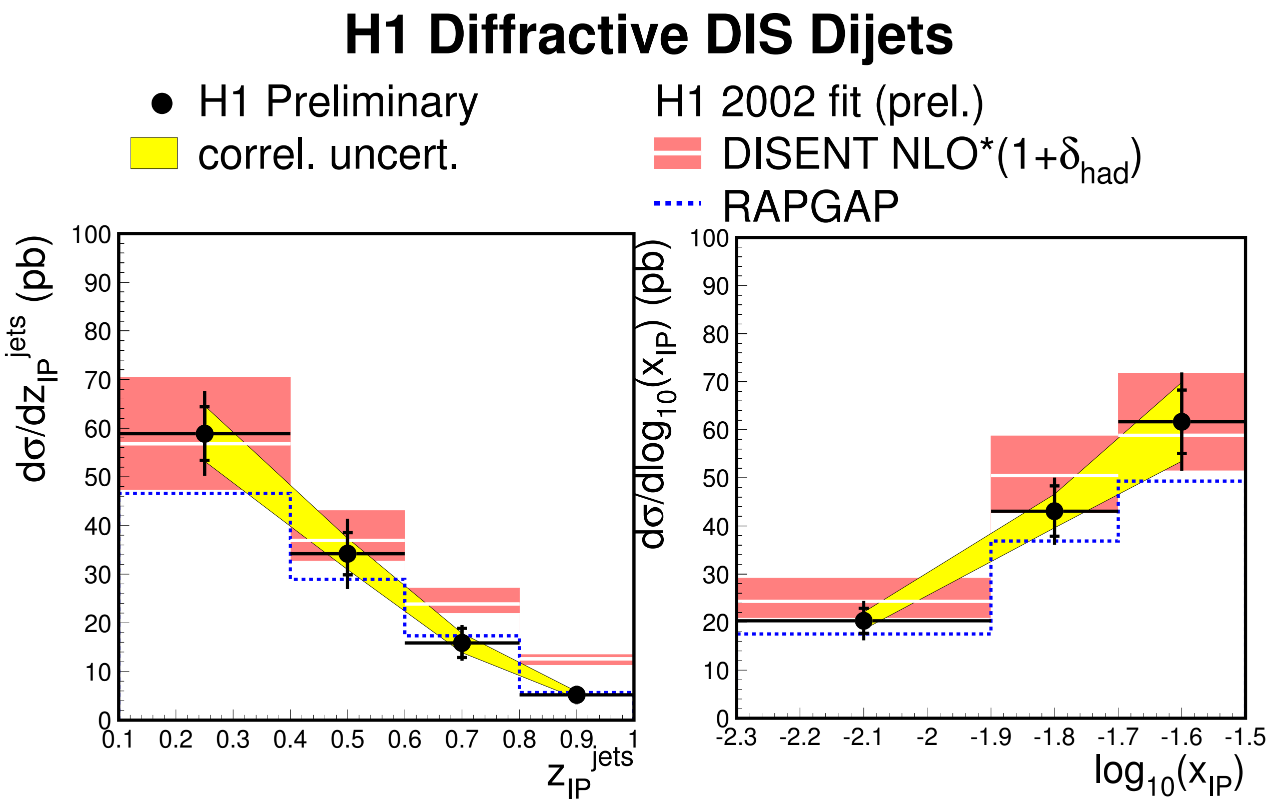
- sensitive to gluon
- NLO calculations: $O\left(\alpha_{\mathrm{em}}\alpha_{\mathrm{s}}\right)+O\left(\alpha_{\mathrm{em}}\alpha_{\mathrm{s}}^{2}\right)$
- no resolved virtual photon contribution

- NLO scales = E_T(jet 1)

$4<Q^2<80$ GeV^2
$x_{IP}<0.03$
$E_T^{jet}(1)>5$ GeV
$E_T^{jet}(2)>4$ GeV
k_T jet algorithm

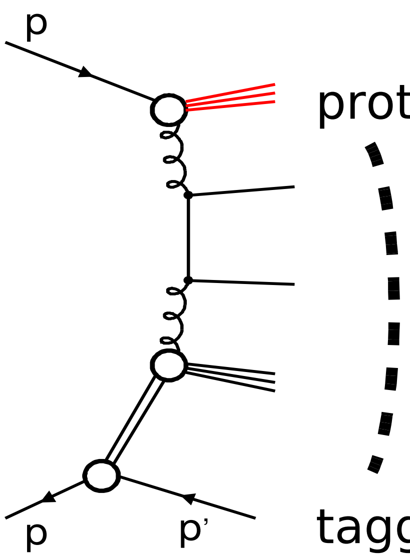
- NLO corrected for hadronisation using Monte Carlo RAPGAP: Lund string fragmentation

- good agreement except at high z_{IP}

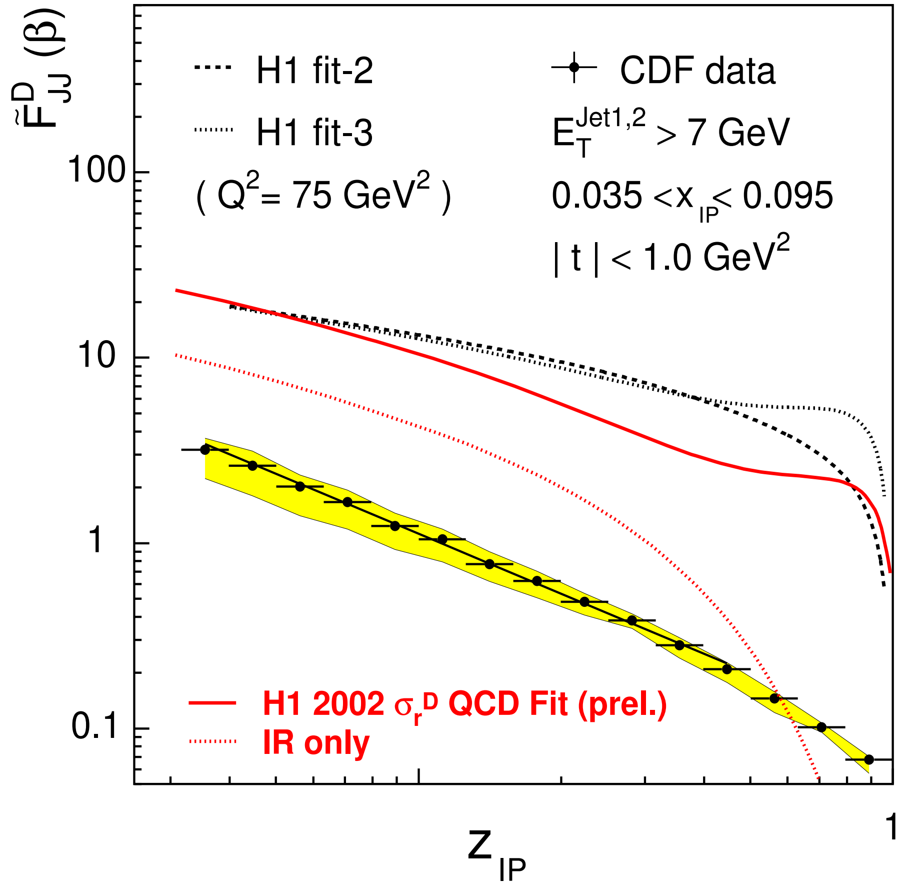


(a) (b)

Jets in $p\bar{p}$ collisions



Diffractive structure function of antiproton



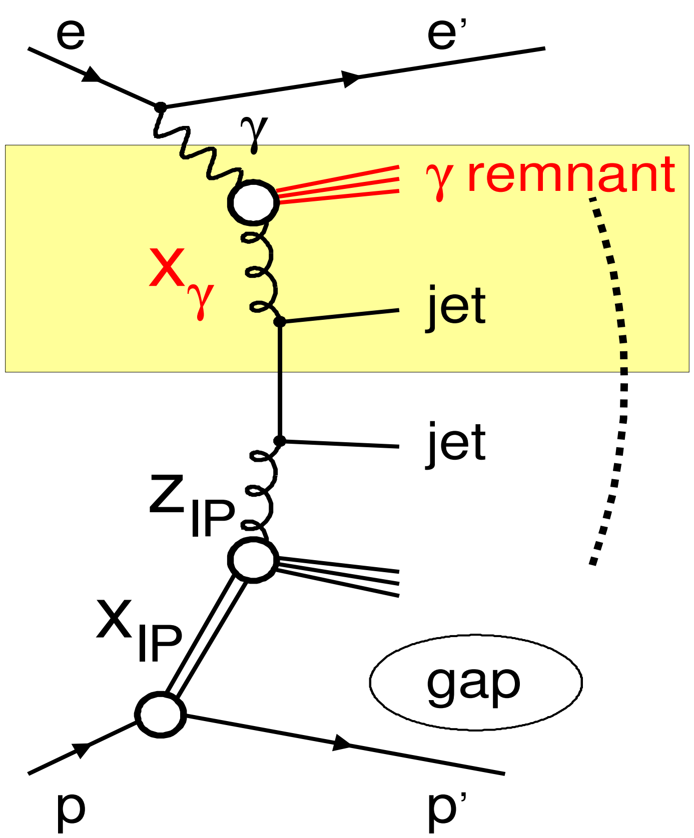
Leading Order comparison
with parton densities from HERA

- "gap survival probability"≈0.1
- rescattering due to second proton

γp collisions at HERA

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

- real photon source: bremsstrahlung from electron beam
- photon can fluctuate into $q\bar{q}$ + further gluon radiation, etc.
- a parton from this hadronic system can enter the hard scatter

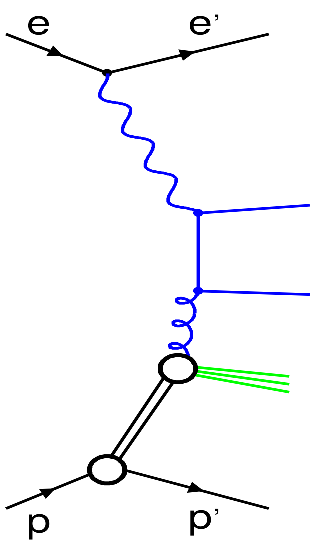


x_γ = photon momentum fraction entering hard scatter

“direct” and “resolved” photon interactions

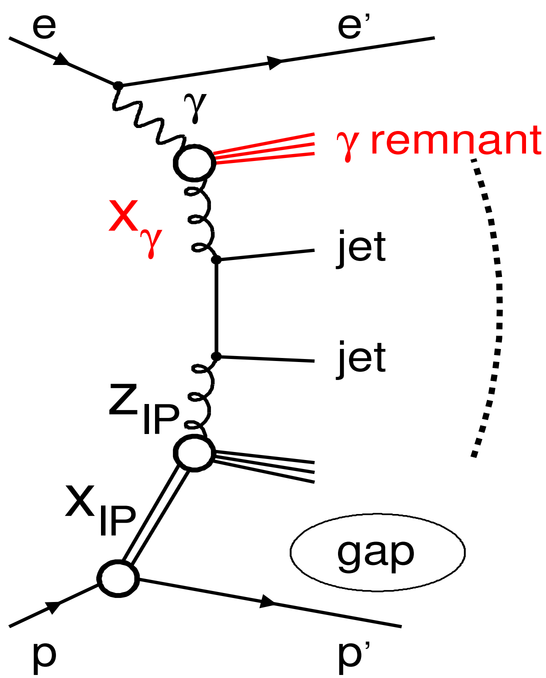
$x_\gamma = 1$	$x_\gamma < 1$

“direct”



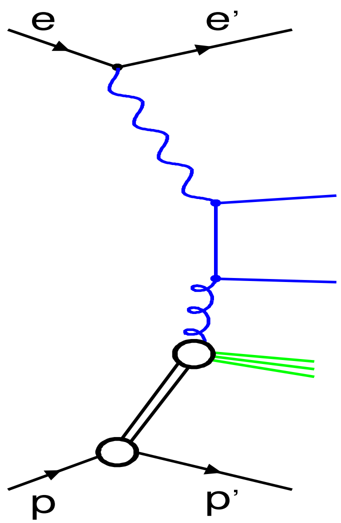
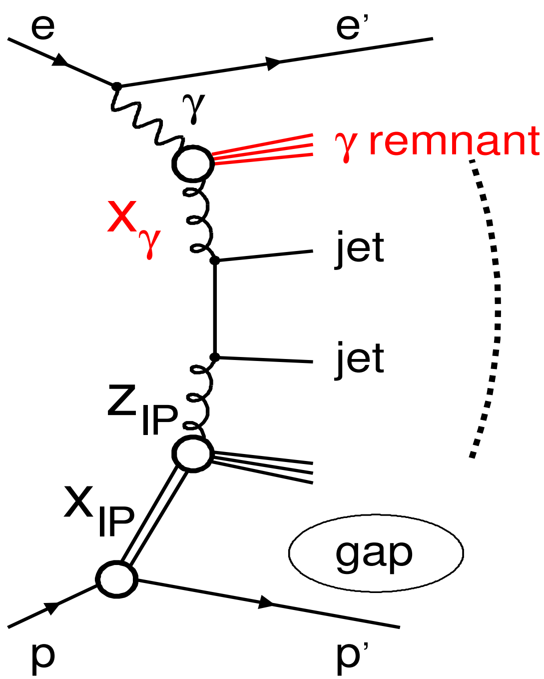
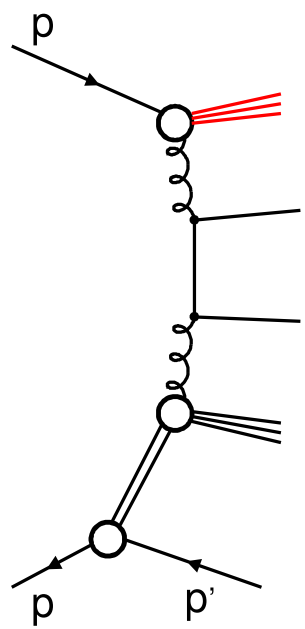
“ep-like”

“resolved”



photon remnant

“$p\bar{p}$-like”

ep	γp	$p\bar{p}$
		
	$x_\gamma < 1$: photon remnant $x_\gamma \approx 1$: no remnant	proton remnant
Factorisation works	Factorisation?	Factorisation broken

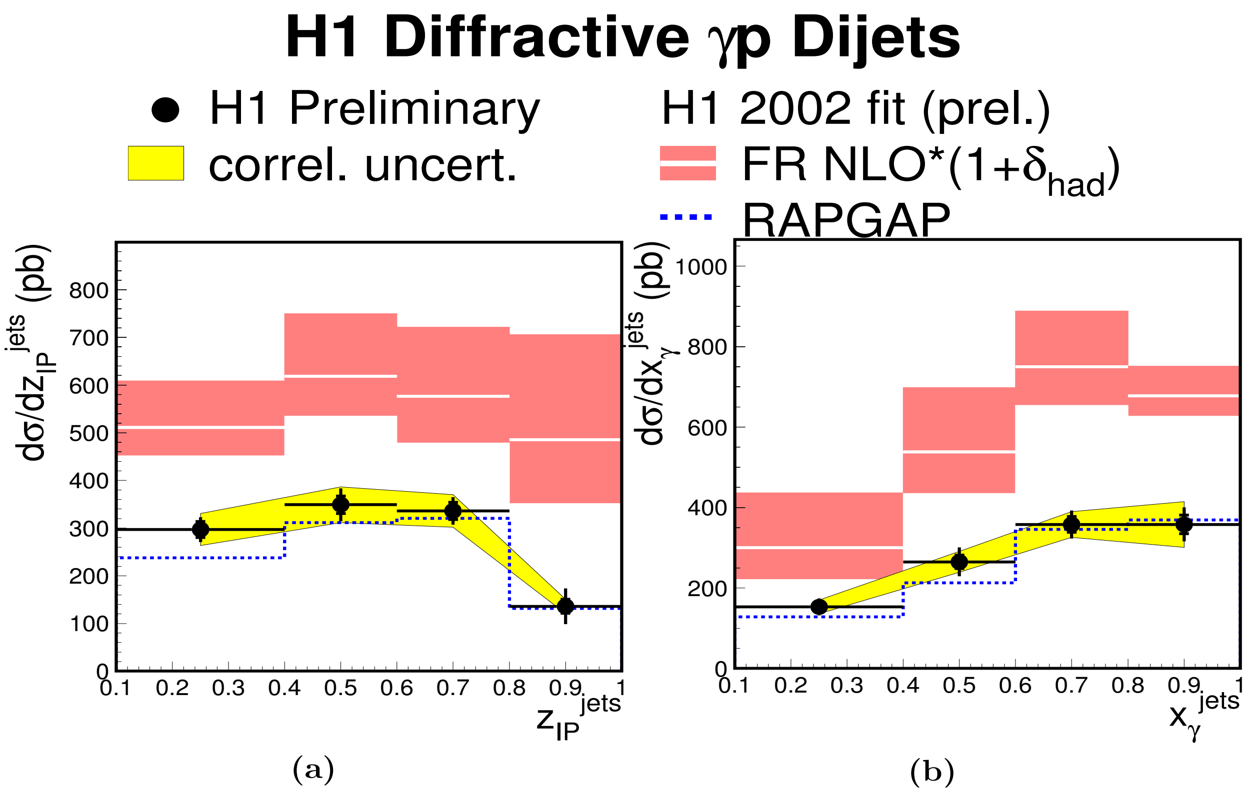
NLO calculation

- direct: $O(\alpha_{em}\alpha_s) + O(\alpha_{em}\alpha_s^2)$
- resolved: $O(\alpha_s^2) + O(\alpha_s^3)$

- NLO scales E_T(jet 1)

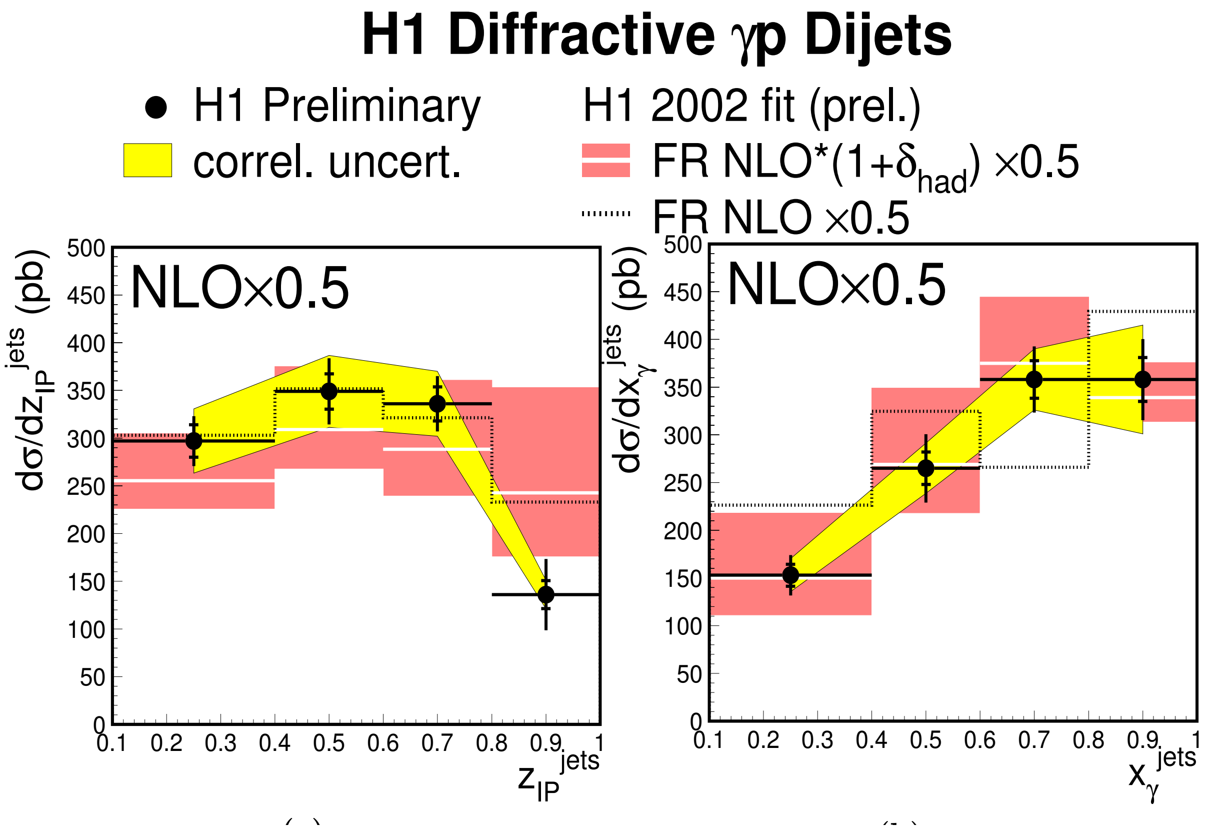
$Q^2 < 0.01$ GeV^2
$x_{IP} < 0.03$
$E_T^{jet}(1) > 5$ GeV
$E_T^{jet}(2) > 4$ GeV
k_T jet algorithm

Reggeon: 6%



NLO prediction too large → **Factorisation broken**

Suppression dependent on photon remnant energy?



- universal factor scale factor ≈0.5 needed
- suppressing entire NLO calculation (direct+resolved)
- no indication of dependence on x_γ

Fit of x_γ cross section

- χ^2 fit to x_γ distribution

$$\text{data}=a\,(x_\gamma^{(\text{jets})}>0.9)+b\,(x_\gamma^{(\text{jets})}<0.9)$$

≈direct ≈resolved

- Result:

a=0.47 ± 0.12
b=0.52 ± 0.15

- all variables reasonably well described

- error from data normalisation and NLO factorisation and renormalisation scale

- no indication of dependence on x_γ
- suppressing direct and resolved

The controversy...

- H1 and ZEUS analyses favor a global suppression of both direct and resolved photon processes
- This result is not embraced by some theorists: “direct should be unsuppressed”

Factorization Breaking in Diffractive Dijet Photoproduction

M. Klasen[1,2] and G. Kramer[2]

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[2] II. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg, Germany

Aug 2004

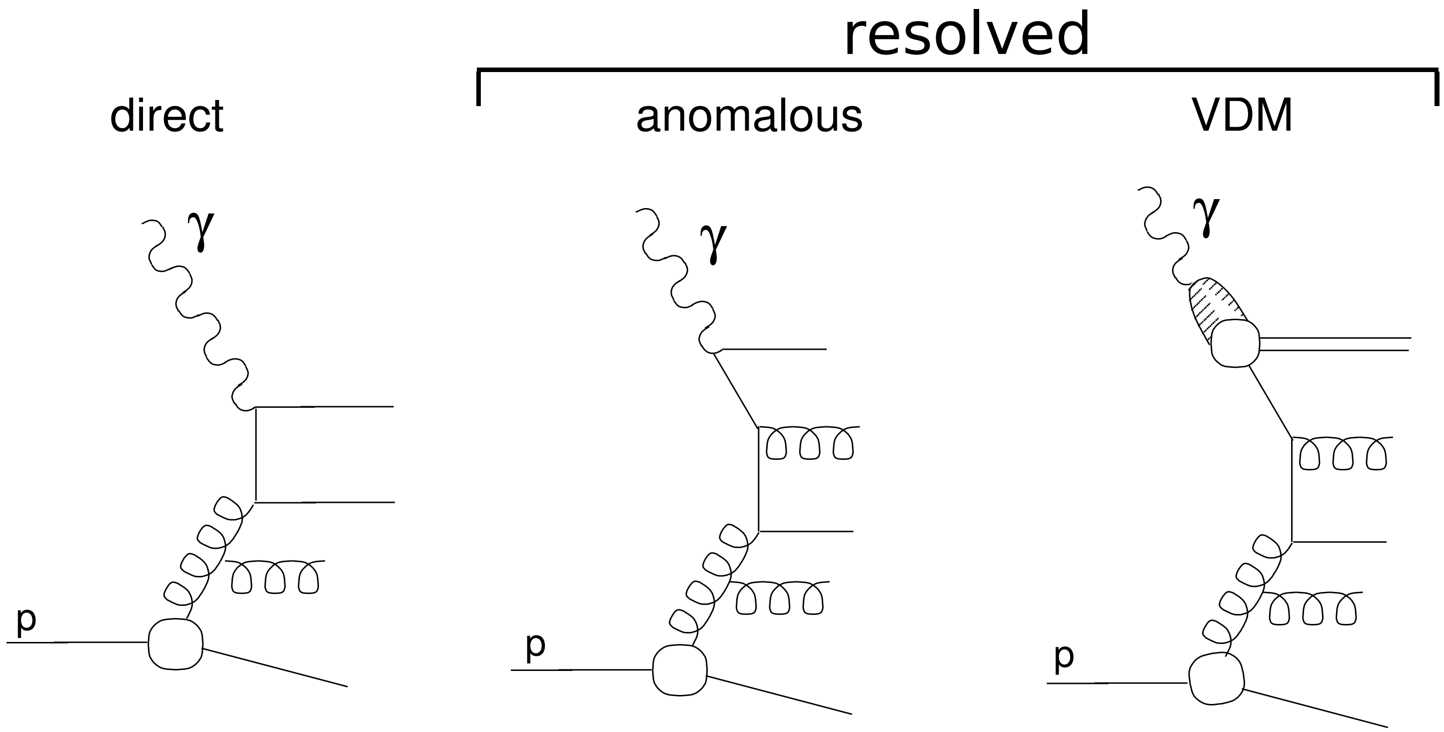
Date: October 13, 2004

Abstract. We have calculated the diffractive dijet cross section in low-Q^2 ep scattering in the HERA regime. The results of the calculation in LO and NLO are compared to recent experimental data of the H1 collaboration. We find that in LO the calculated cross sections are in reasonable agreement with the experimental results. In NLO, however, some of the cross sections disagree, showing that factorization breaking occurs in that order. By suppressing the resolved contribution by a factor of approximately three,

M Klasen and G Kramer claim that the measurements can be described by a suppression of only the resolved photon component by factor 0.34

- we have studied this possibility...

Photon interactions



- direct and anomalous parts connected:

  LO anomalous and NLO direct of same order α_s

  S Frixione:

  separating direct and resolved is unphysical and ill-defined

  e.g. leads to huge scale uncertainties of separated parts

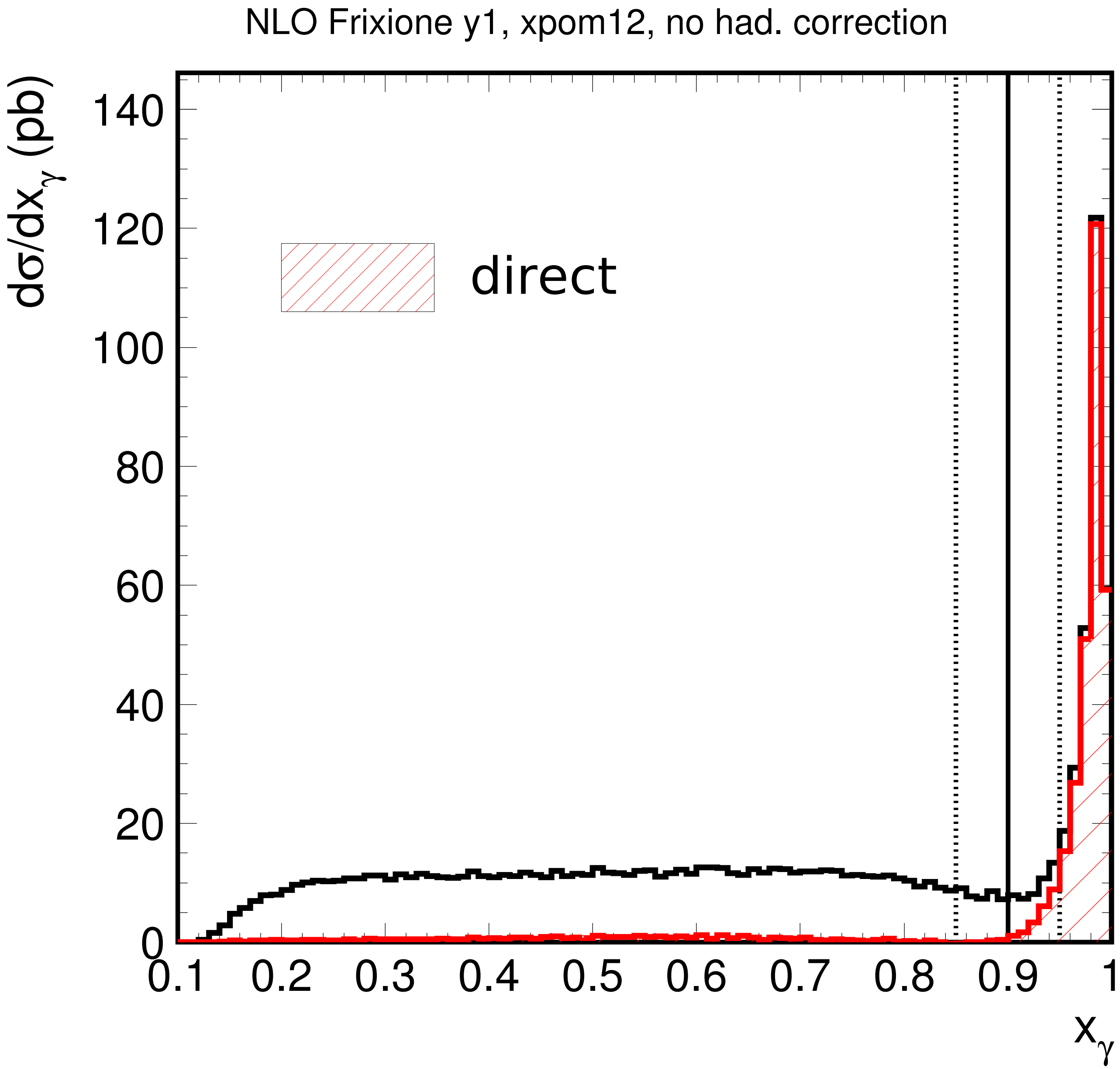
→ cannot scale only resolved by 0.34

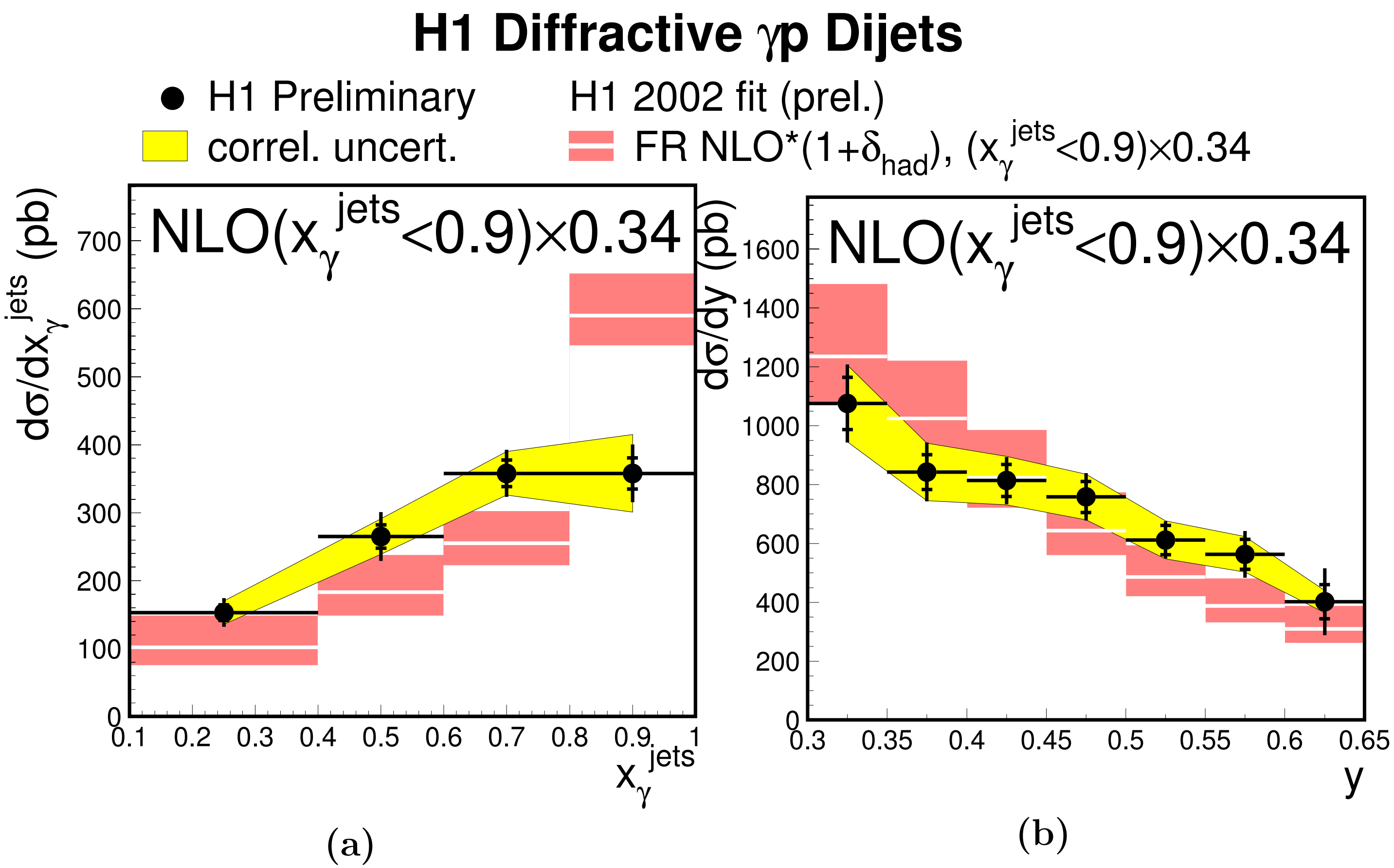
"Experimental definition of resolved"

- cut in physical quantity to separate direct and resolved

$x_\gamma > 0.9$: 85% of direct
5% of resolved

→ scaling $x_\gamma < 0.9$ is
≈ equivalent to
scaling only resolved





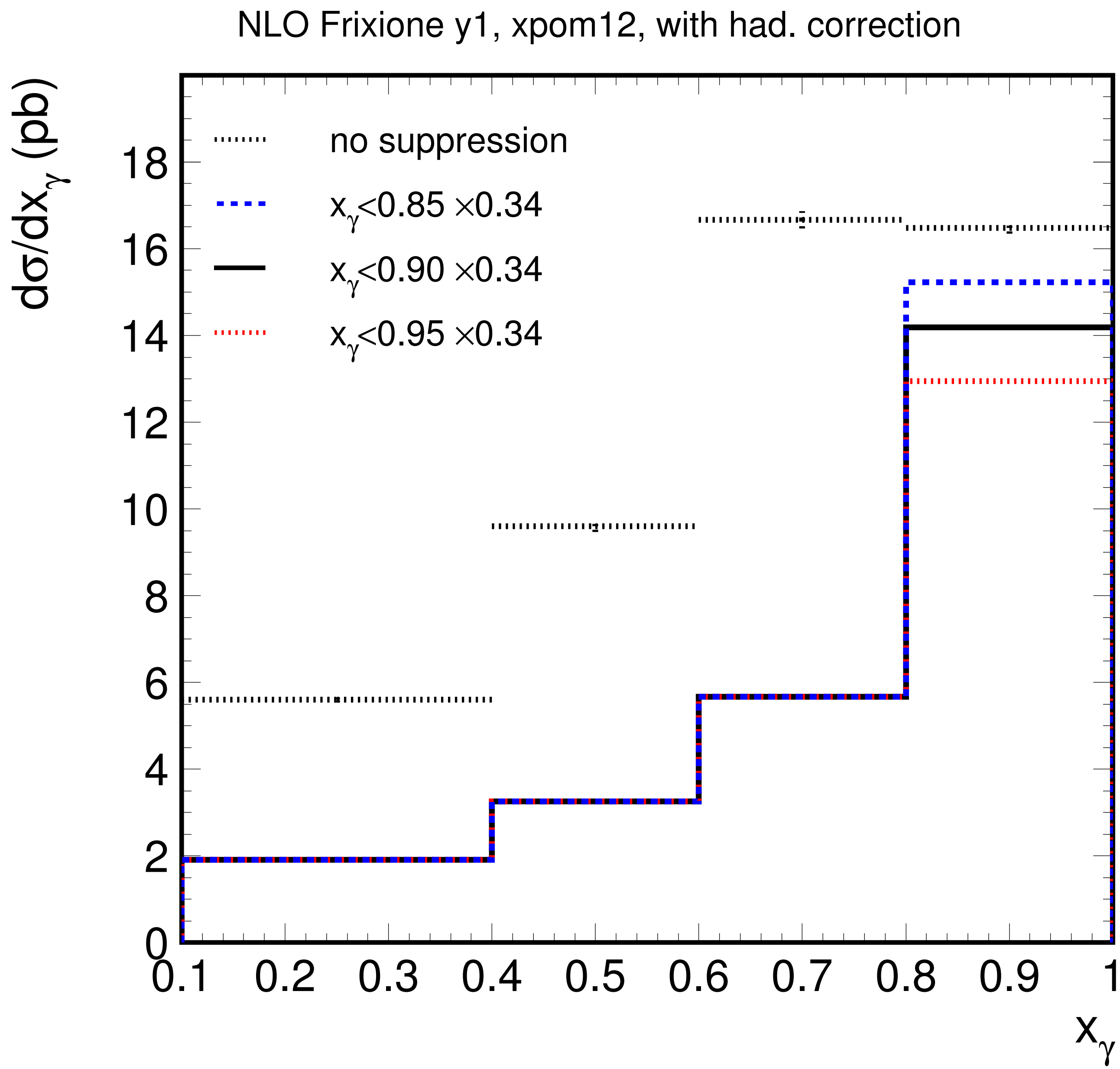
Factor 0.34 from Kaidalov et al.

Phys.Lett. B567 (2003) 61

disfavored

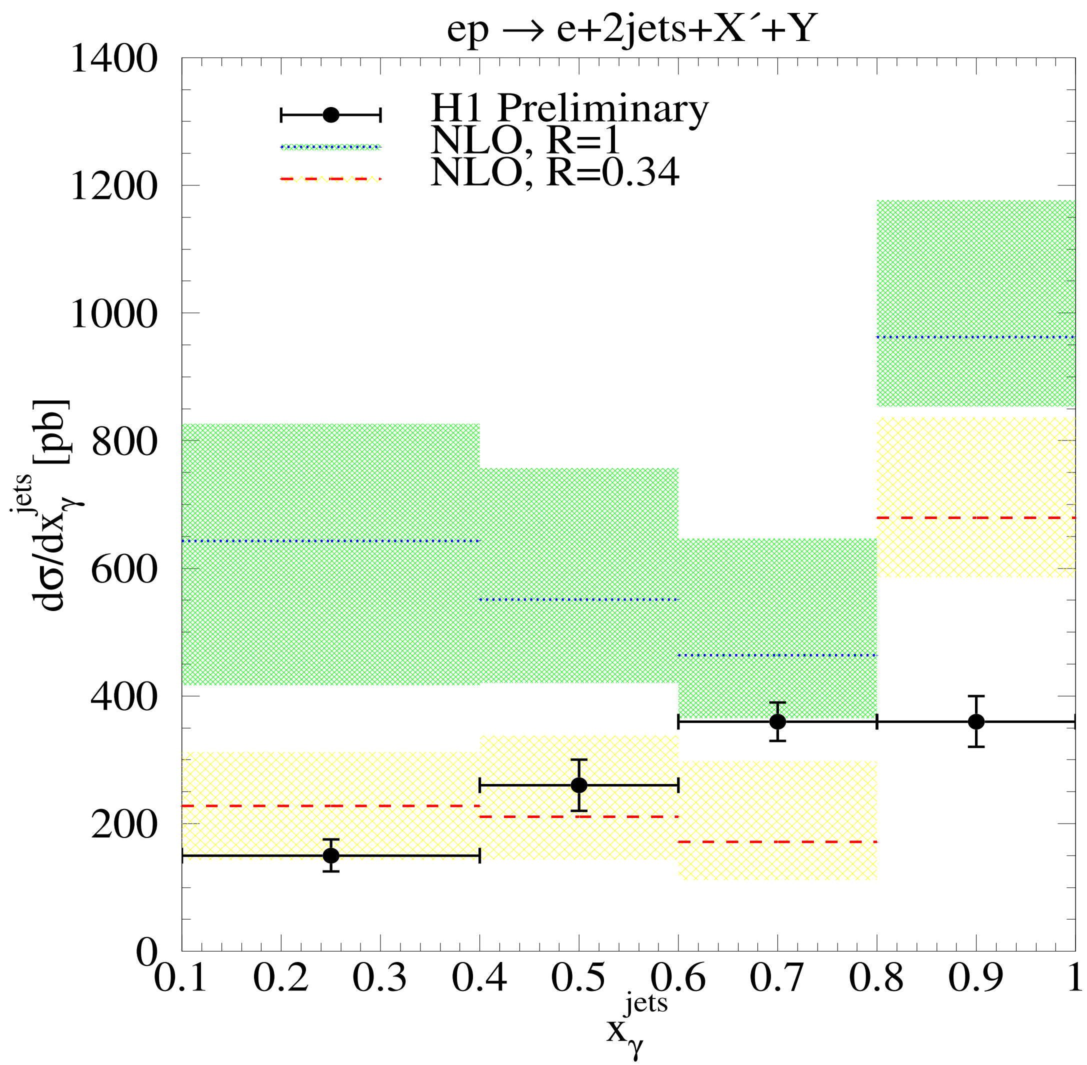
Variation of cut $x_\gamma > 0.9$

- variation of cut between 0.85..0.95 changes highest x_γ bin by ±10%



Klasen/Kramer calculation

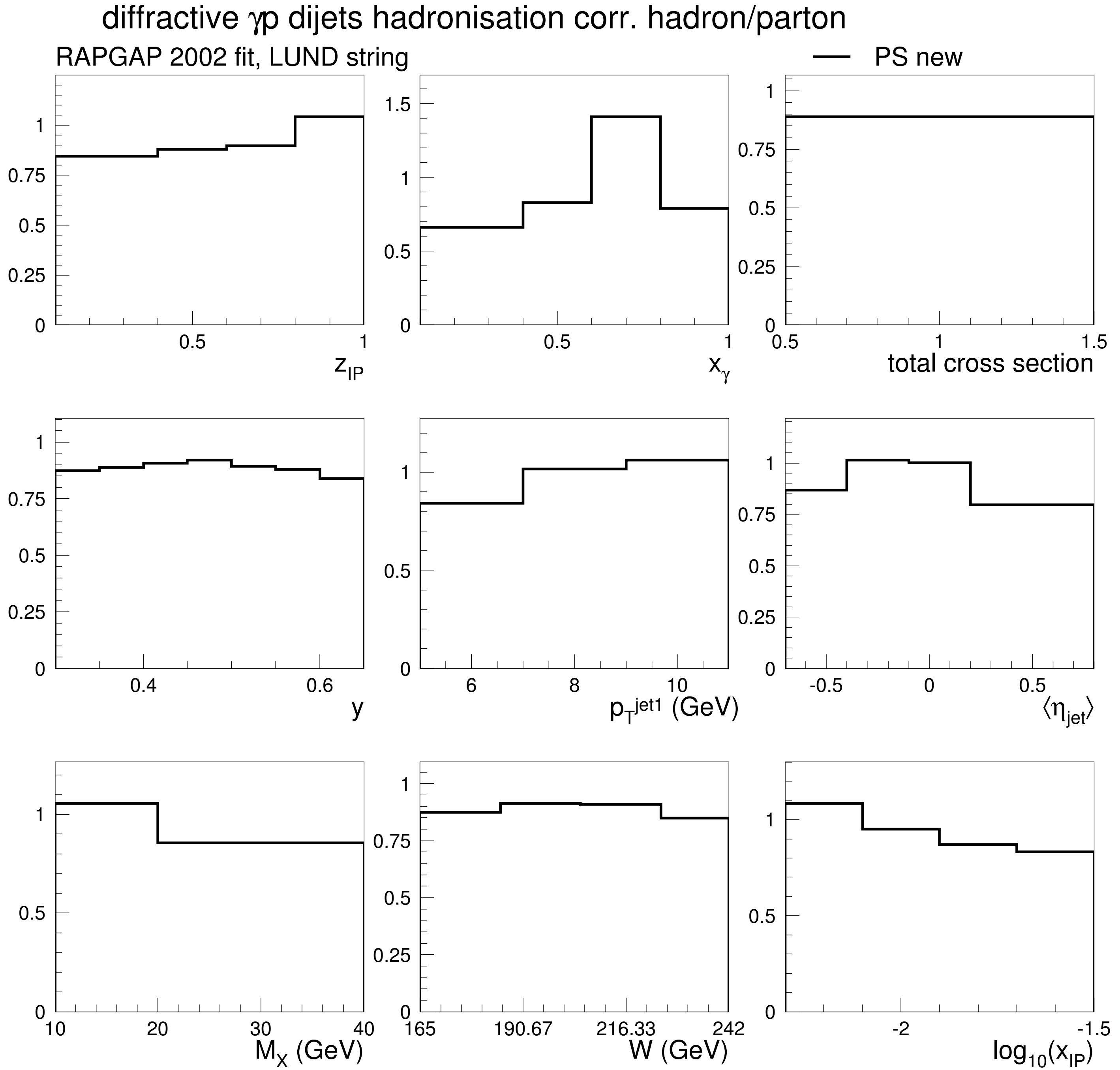
- from August paper
- no hadronisation corrections



Hadronisation Corrections

$$C_{had} = \frac{\text{hadron XS}}{\text{parton XS}}$$

Monte Carlo RAPGAP:
Leading order ME
+ Parton showers
+ Lund string
  fragmentation



Klasen/Kramer with hadronisation

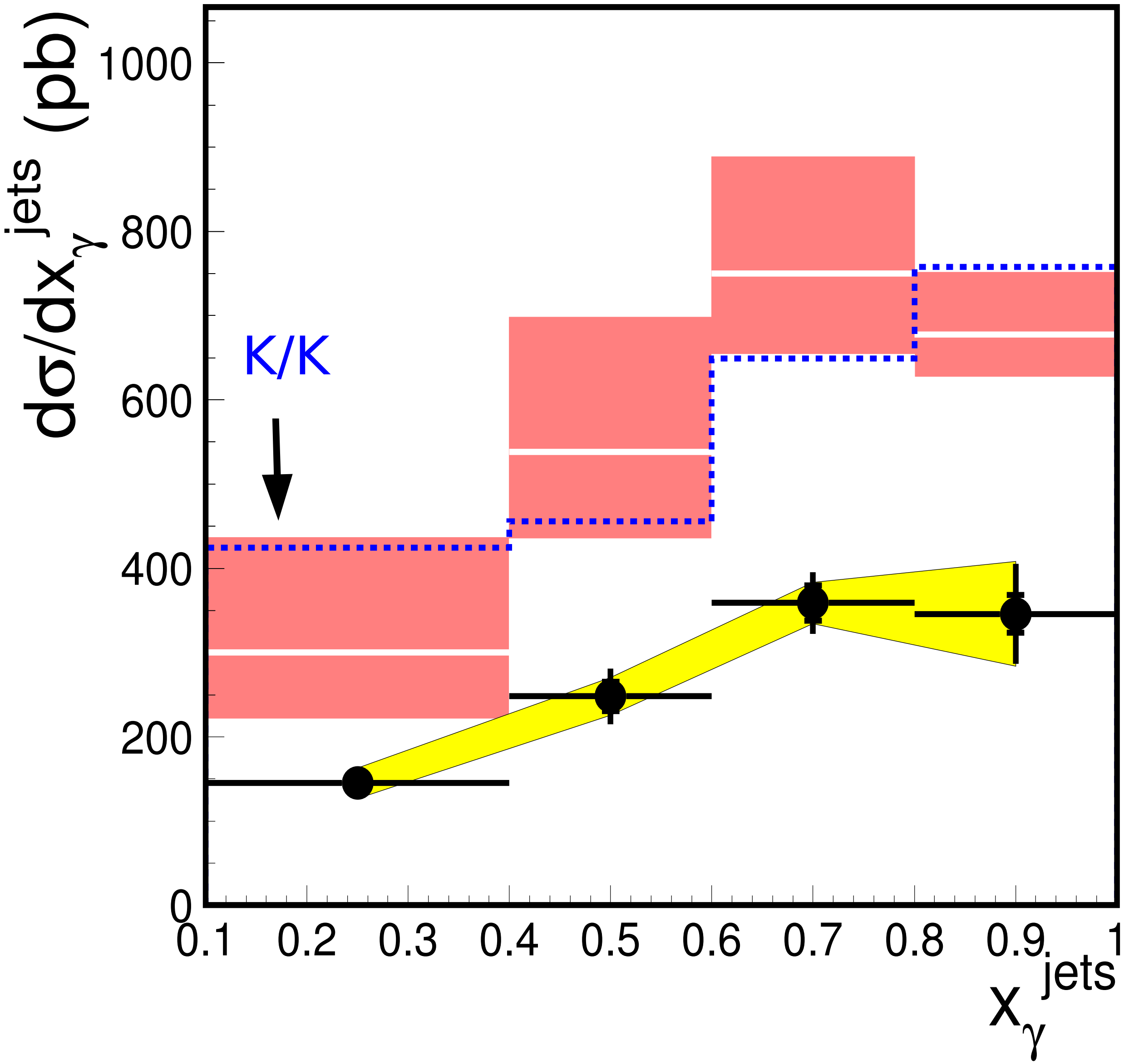
- hadronisation correction applied:

  NLO x C_{had}

- comparison with Frixione program:

  different shape

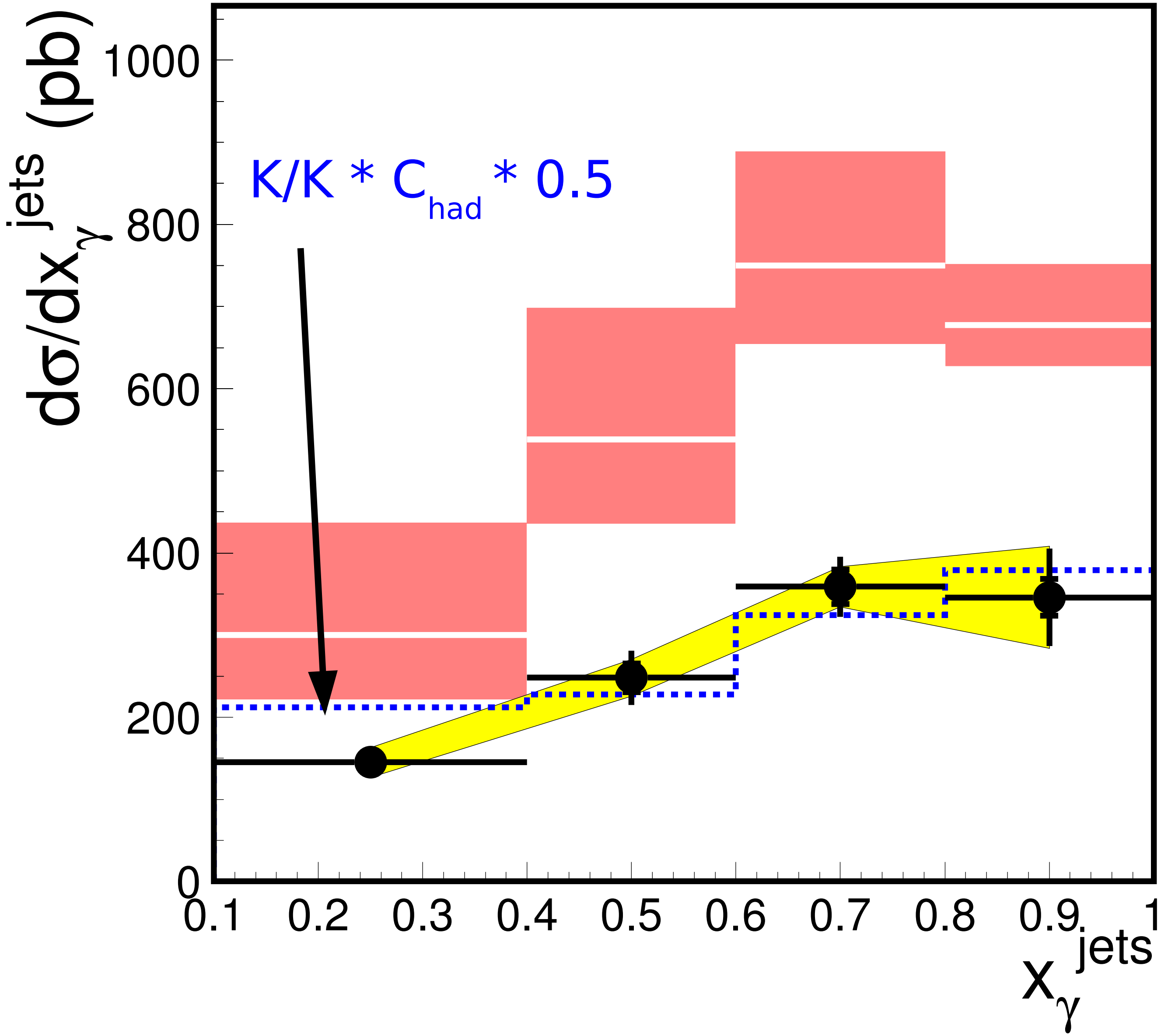
  ~15% difference



- with hadronisation

- scaled entire NLO calculation by 0.5

good description



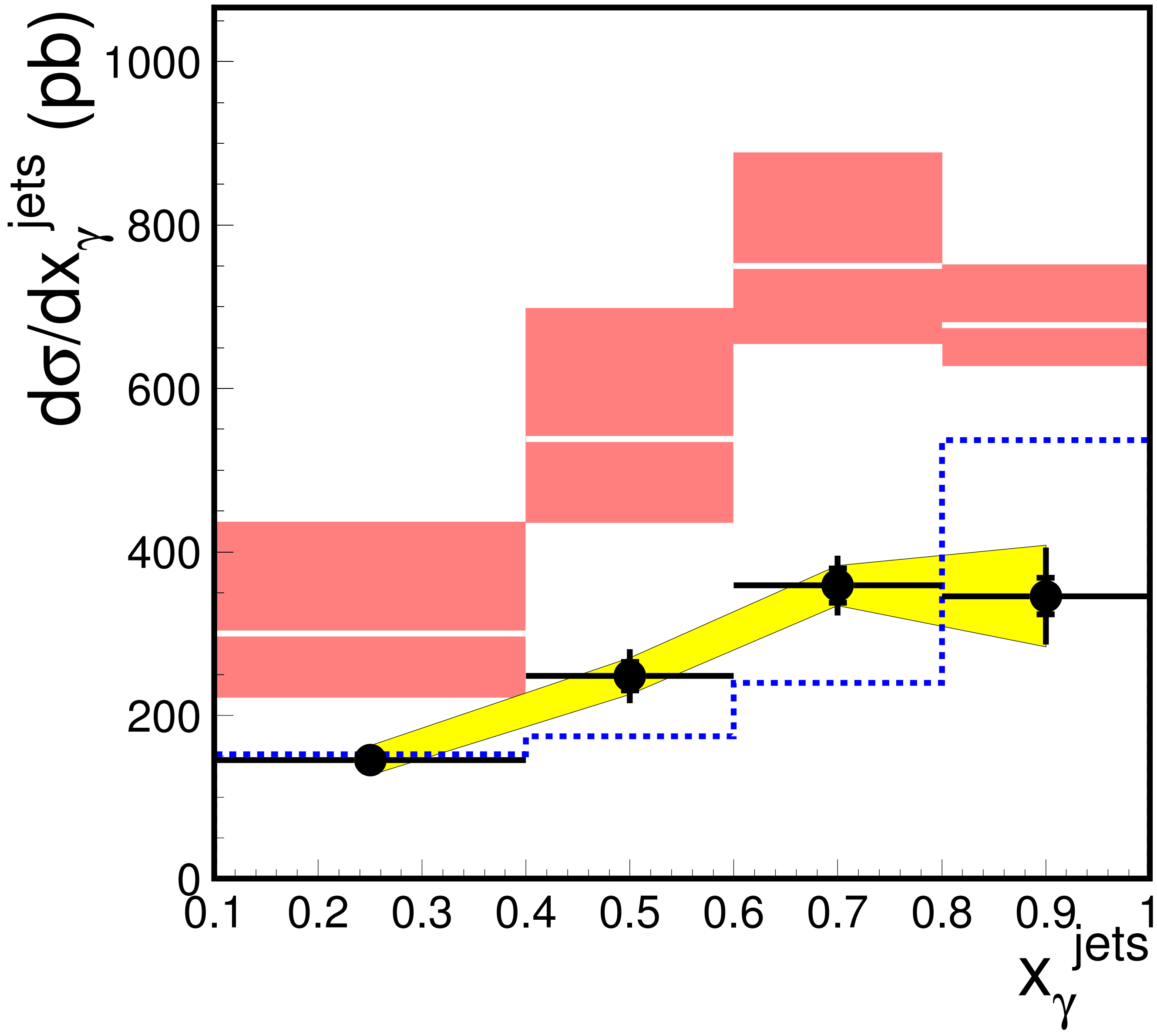
K/K resolved*0.34

- with hadronisation

- scaled resolved NLO calculation by 0.34

disfavored

shape not described



Conclusions

- global suppression is favored
  (for H1, ZEUS, and Klasen/Kramer)

- hadronisation correction critical