Test of factorization in in DIS and γ-p at HERA

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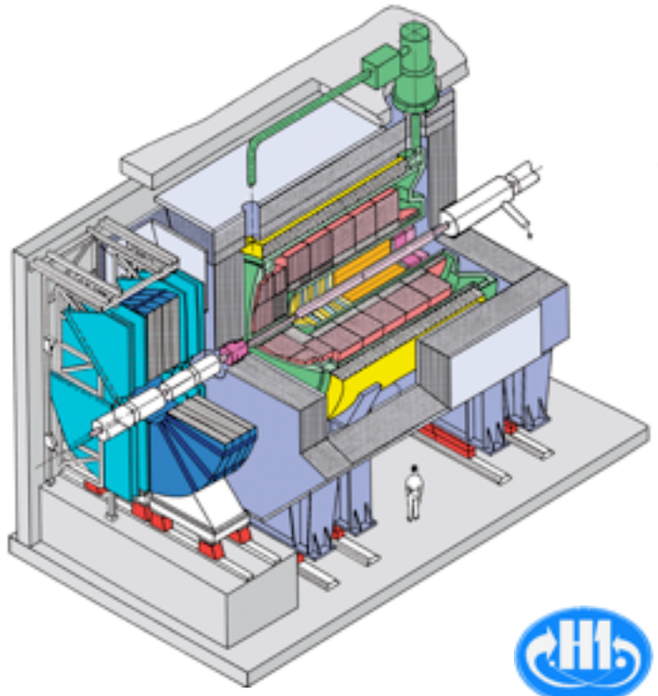
on behalf of the H1 Collaboration

15.9.2014
Diffraction 2014, Primošten, Croatia

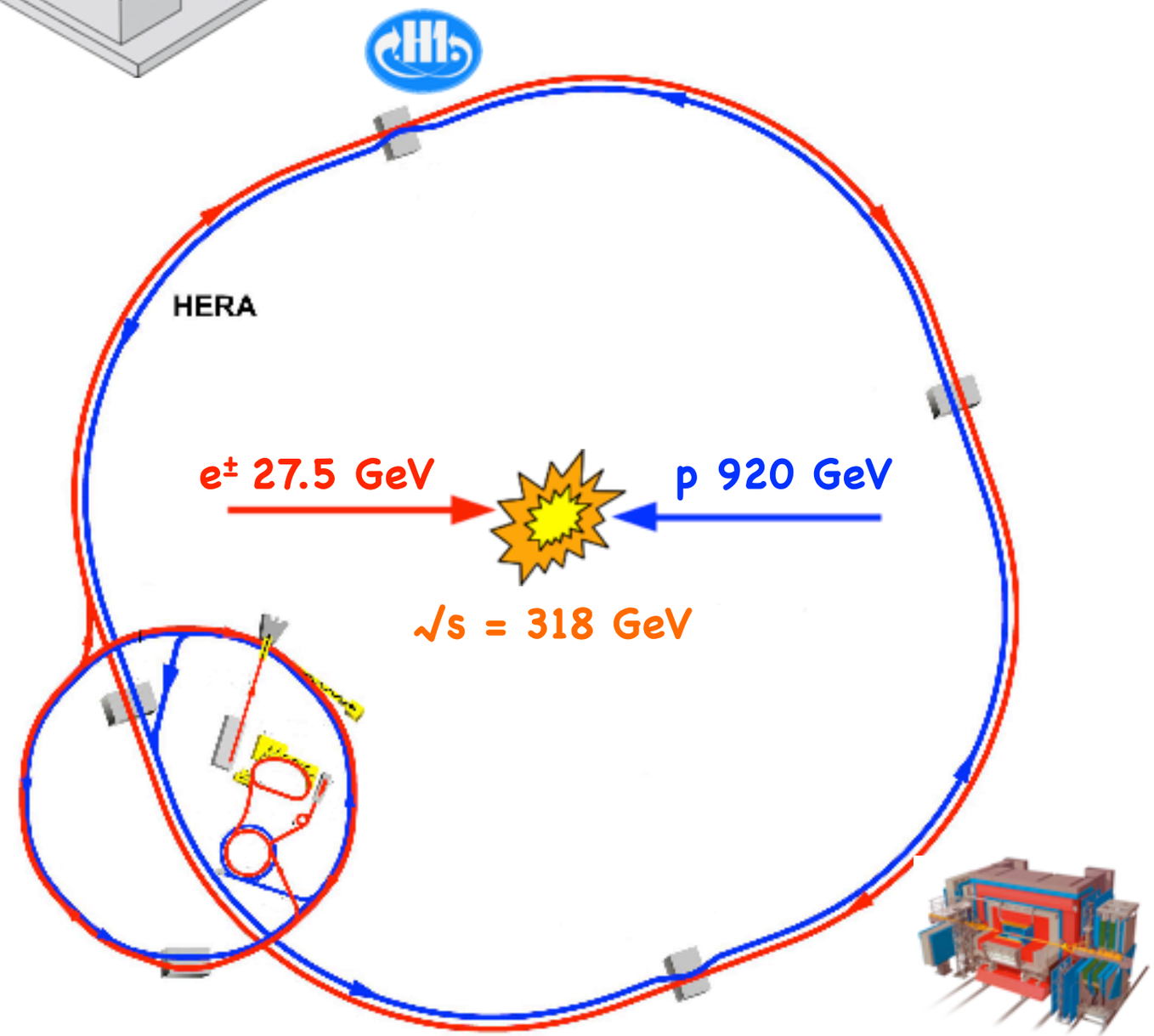


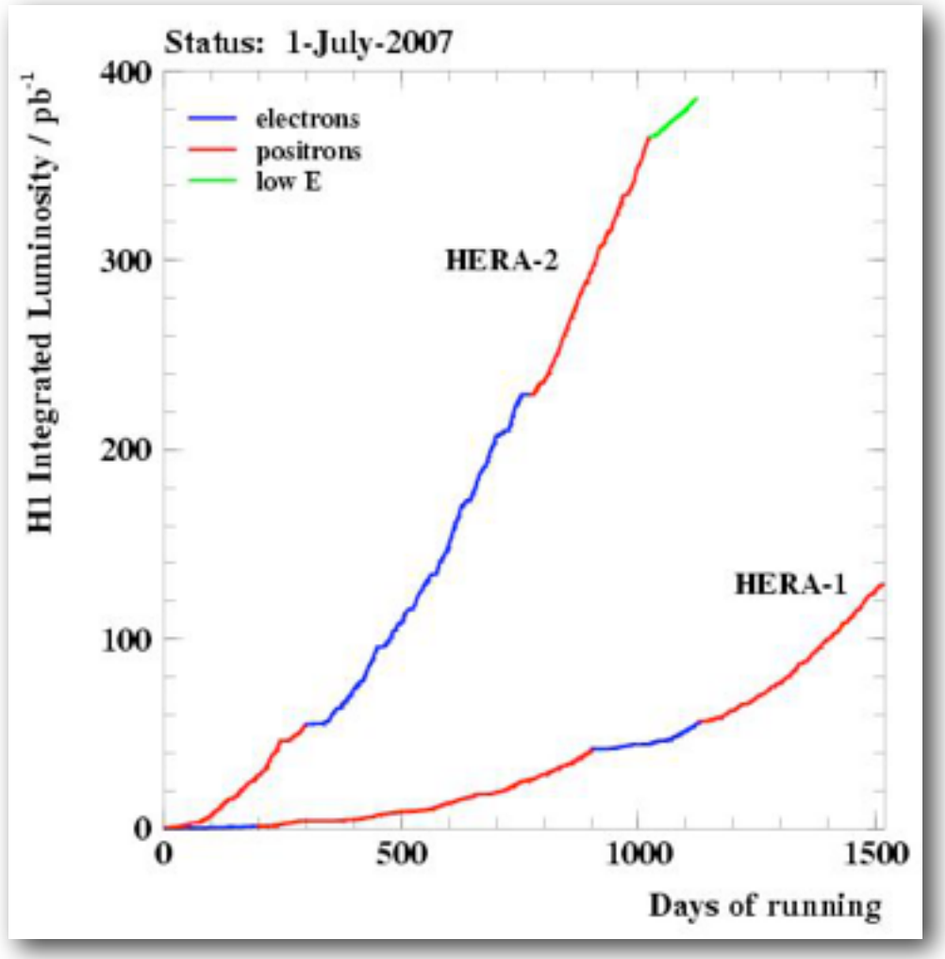
HERA

1992–2007

DESY, Hamburg, GE

H1 & ZEUS – 4π





Ep = 820-920 GeV

L_{int} = ~0.5 fb^{-1}/experiment

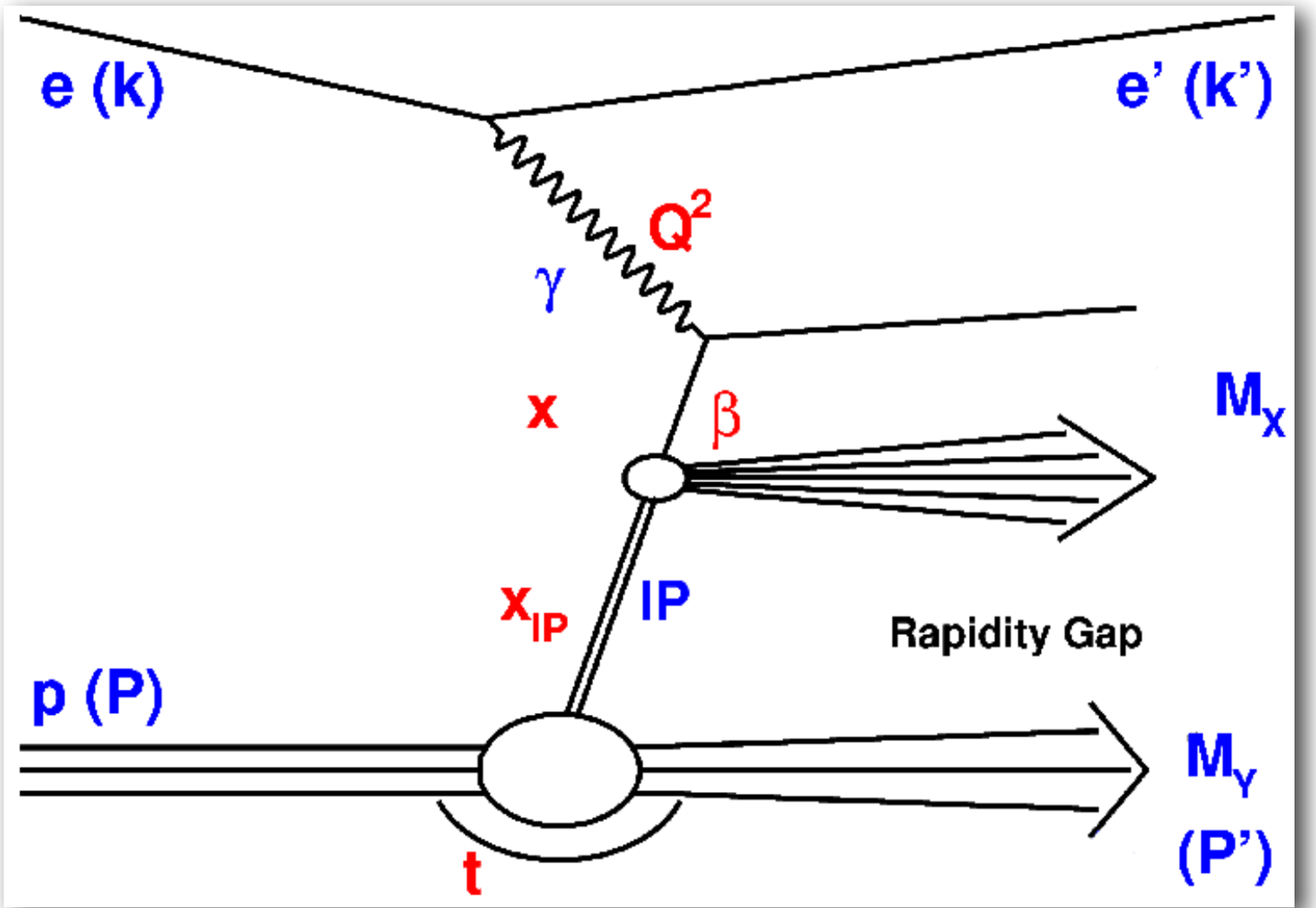
Ep = 460 GeV

L_{int} = 12.4 pb^{-1}

Ep = 575 GeV

L_{int} = 6.2 pb^{-1}

Diffractive kinematics



$Q^2 = -q^2 = (k - k')^2$

$x = Q^2 / 2Pq$

$x_{IP} = q(P - P')/qP = 1 - E'p/Ep$

$\beta = x/x_{IP}$

$z_{IP} = (Q^2 + M_{jj}^2)/x_{IP}ys$

$M_Y = m_p$ .... intact proton

$m_p \leq M_Y \leq 1.6$ GeV .... intact proton or proton dissociation

Collins factorisation, proven:

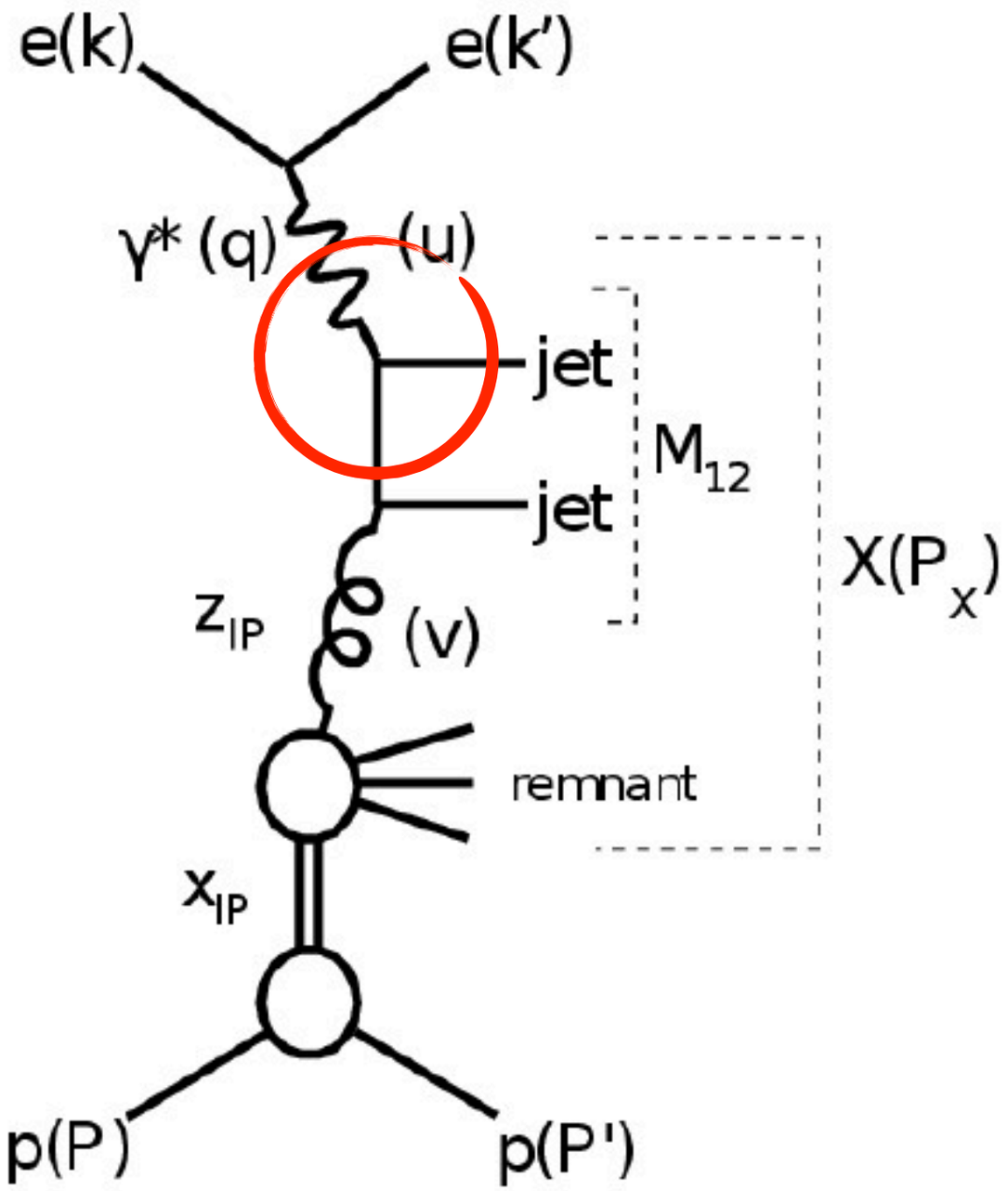
$$d\sigma^{ep\to eXp}(\beta, Q^2, x_{IP}, t) = \sum_i f_i^D(\beta, Q^2, x_{IP}, t) \cdot d\sigma^{ei}(\beta, Q^2)$$

Proton Vertex Factorisation, consistent with data:

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

Diffractive dijet production

direct, dominant for DIS



Diffractive dijet production

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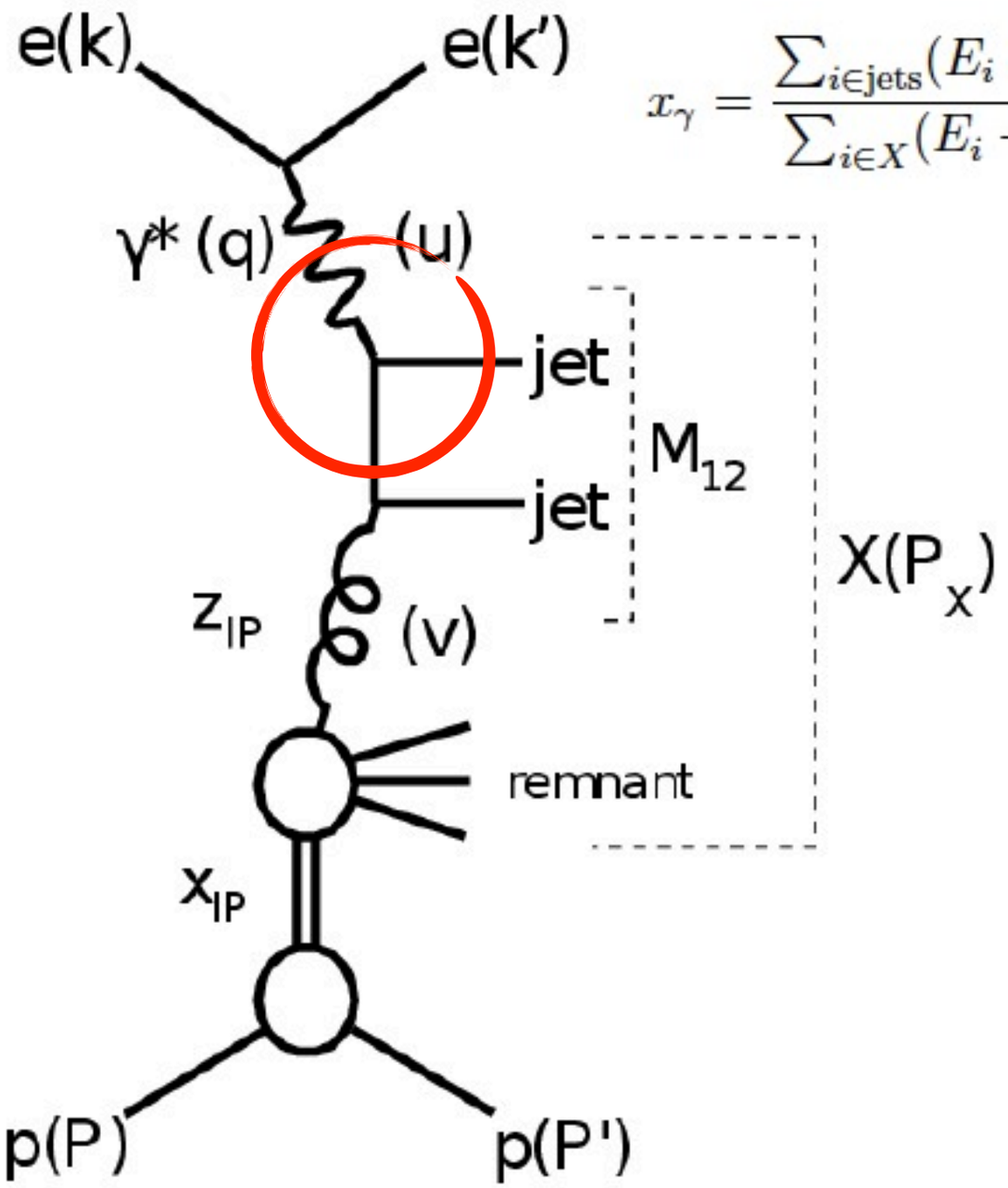
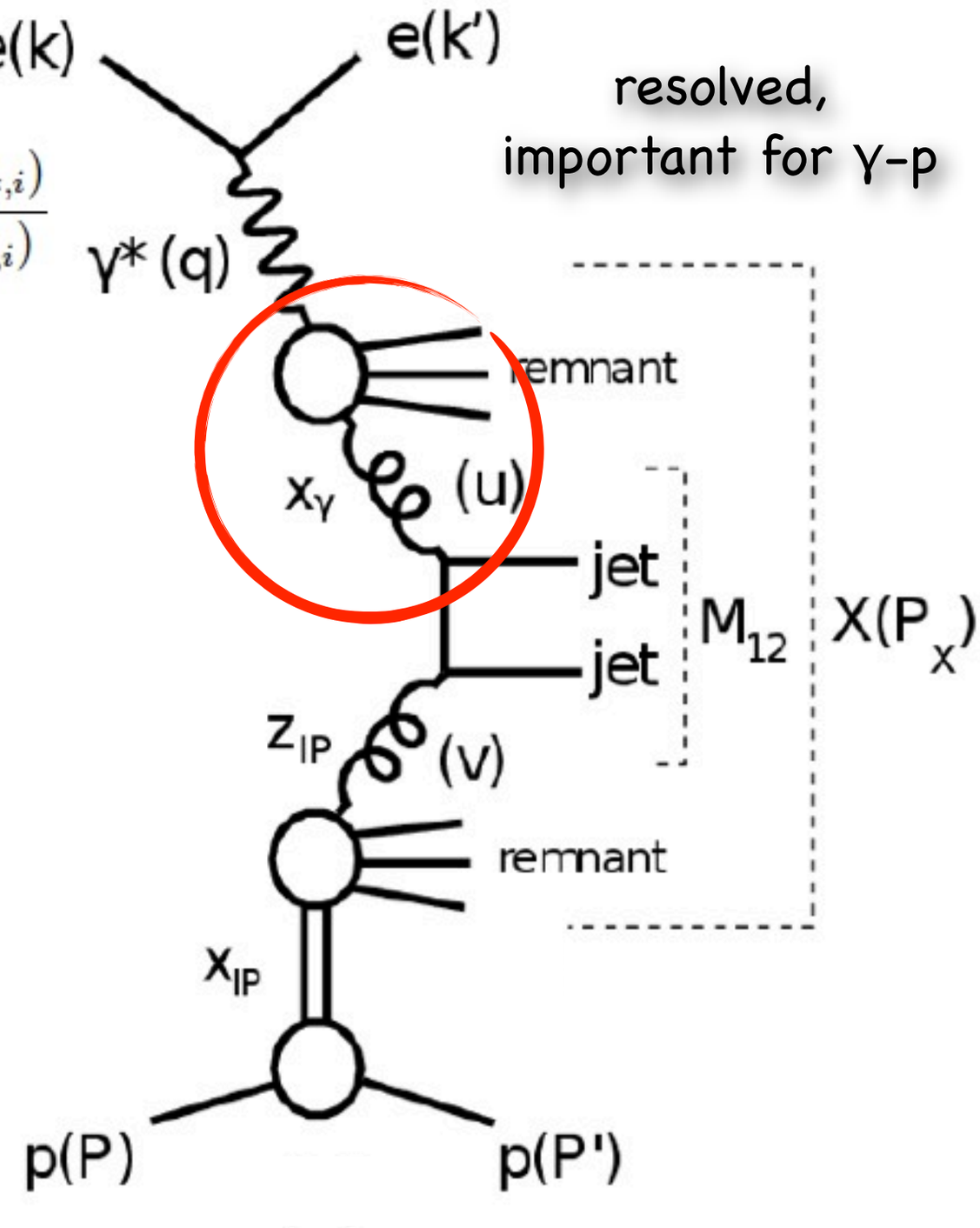


$$x_\gamma = \frac{\sum_{i\in\text{jets}}(E_i - P_{z,i})}{\sum_{i\in X}(E_i - P_{z,i})}$$

resolved,
important for γ-p



picture holds in LO

Diffractive dijet production

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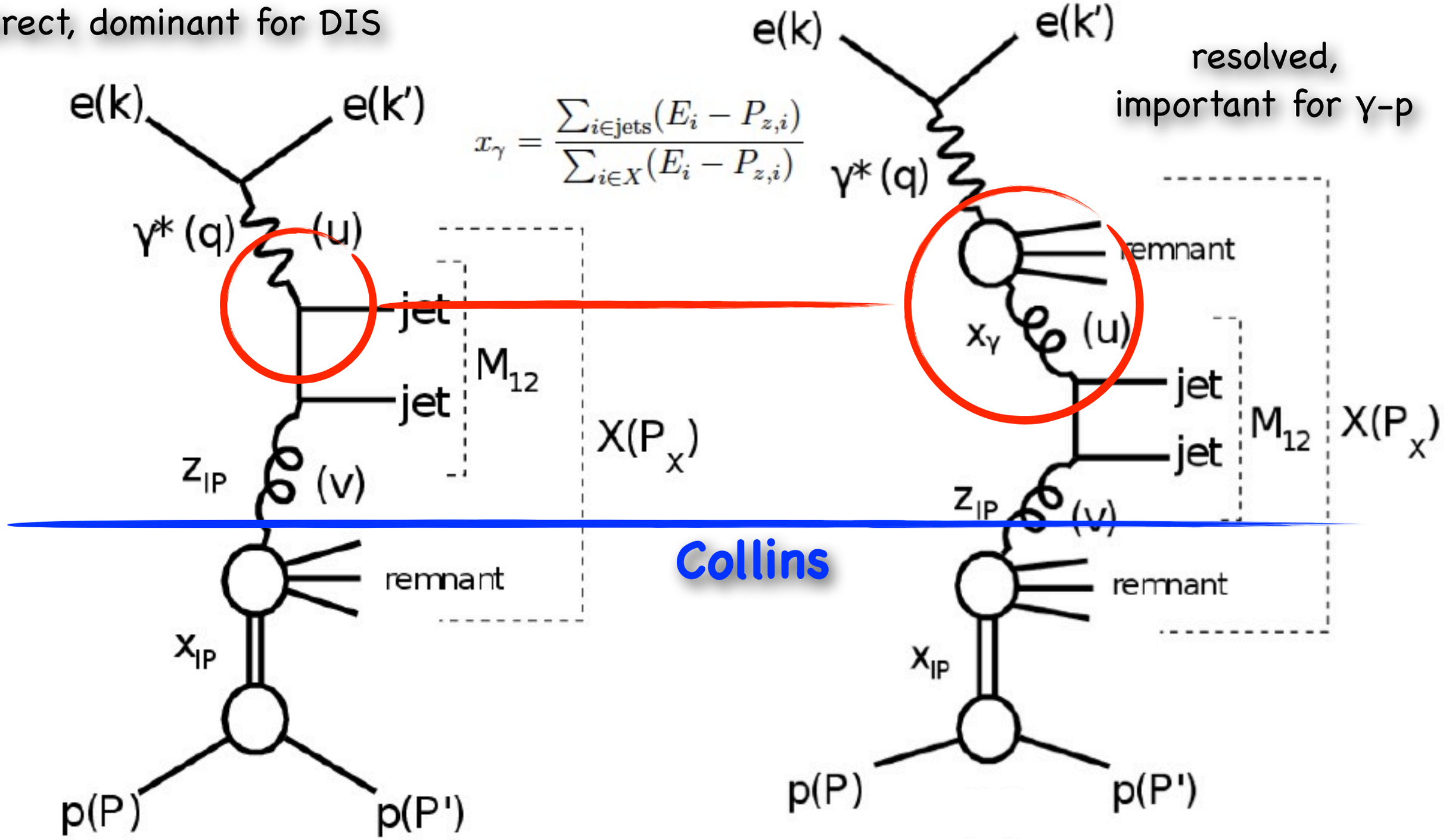

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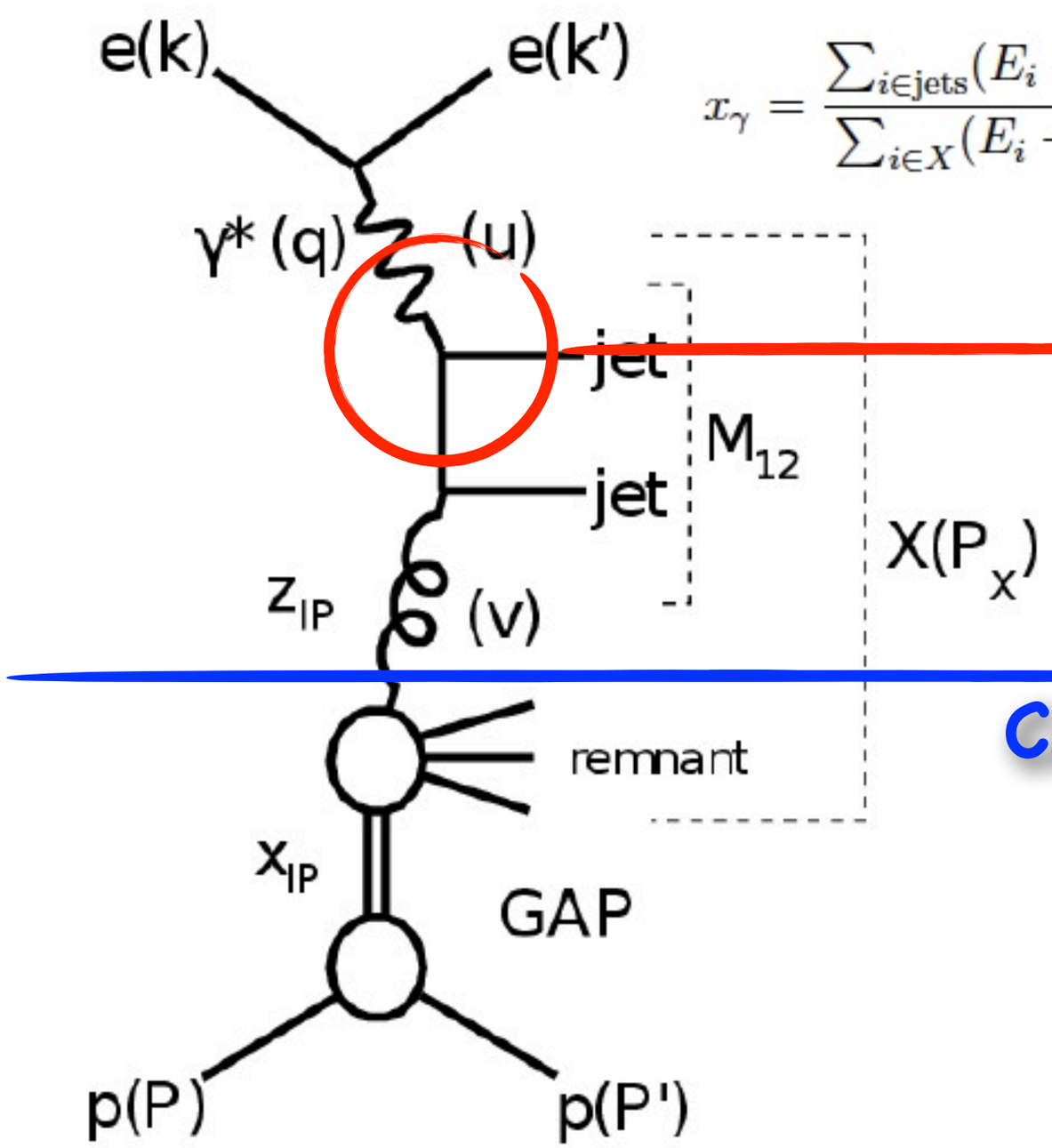
Diffractive dijet production

direct, dominant for DIS



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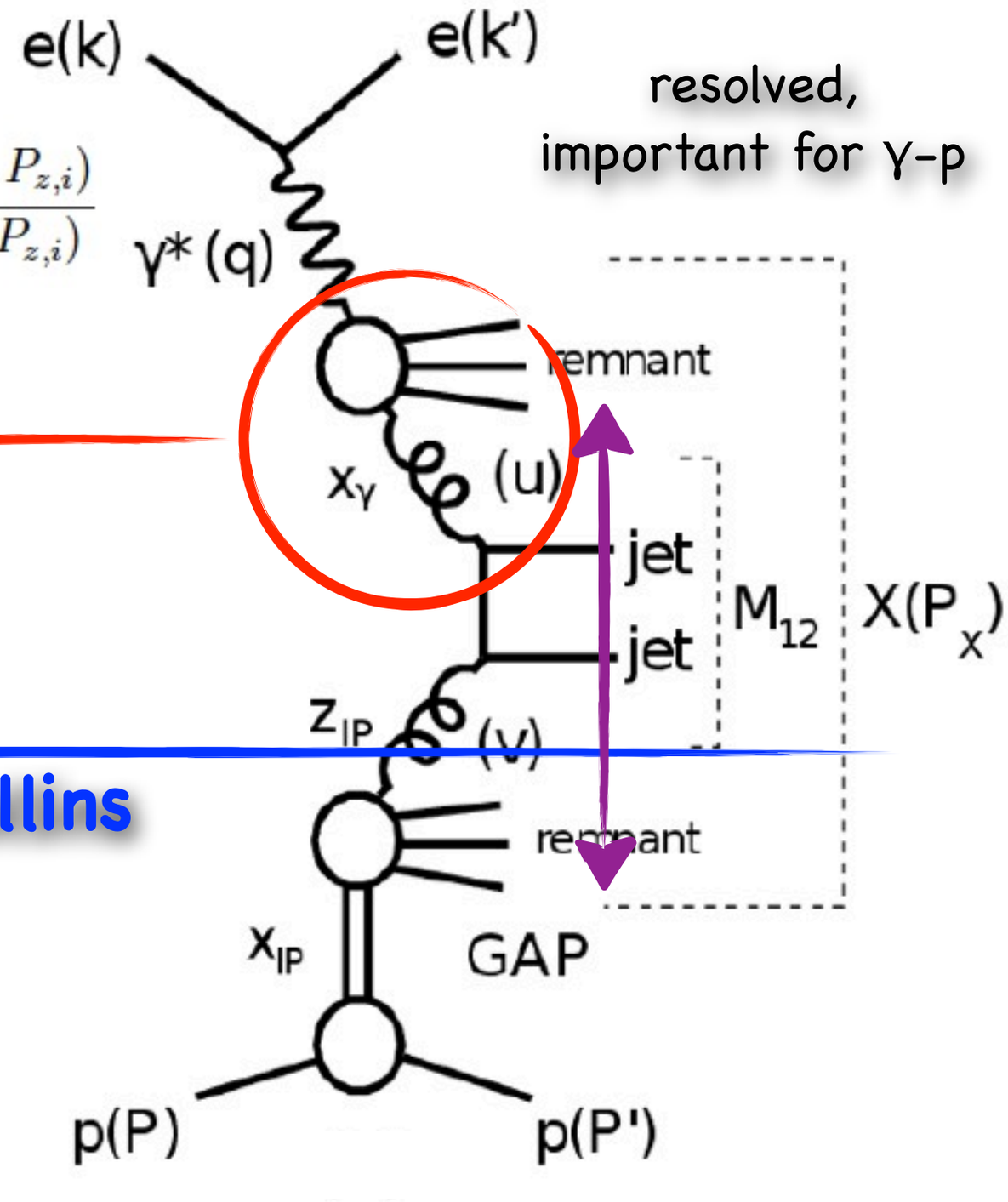


Collins

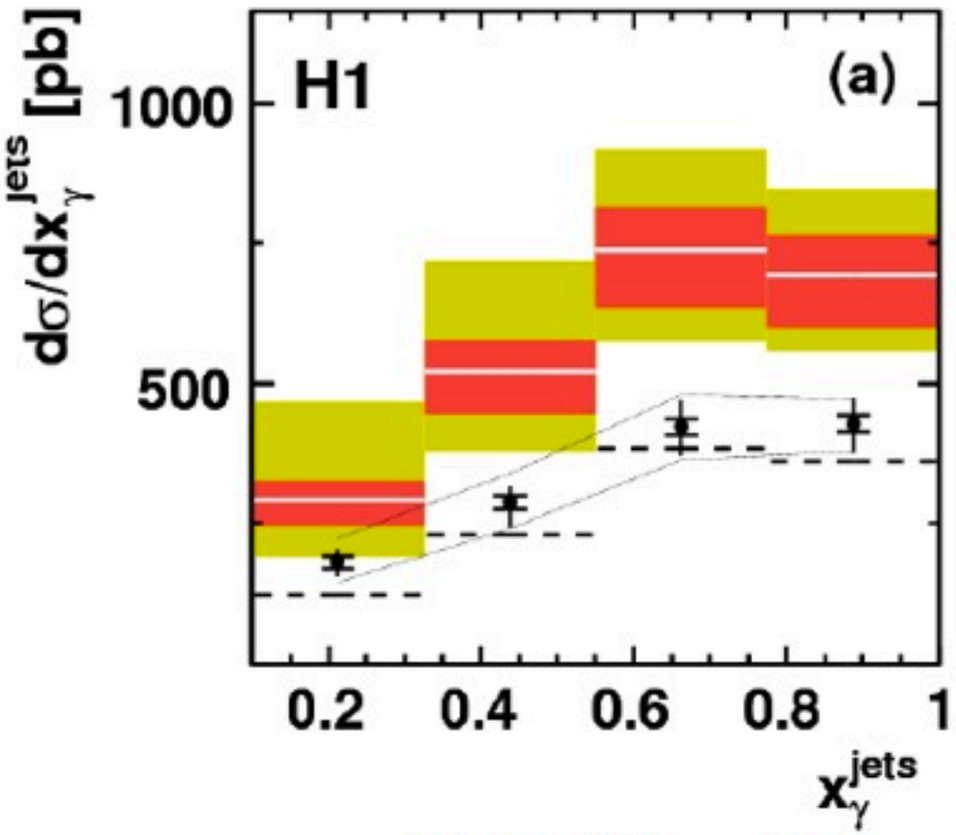
Will the photoproduction preserve factorization, or will additional remnants interaction destroy the rapidity gap signature?

picture holds in LO

Breaking(?)

Eur. Phys. J C70 (2010)

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

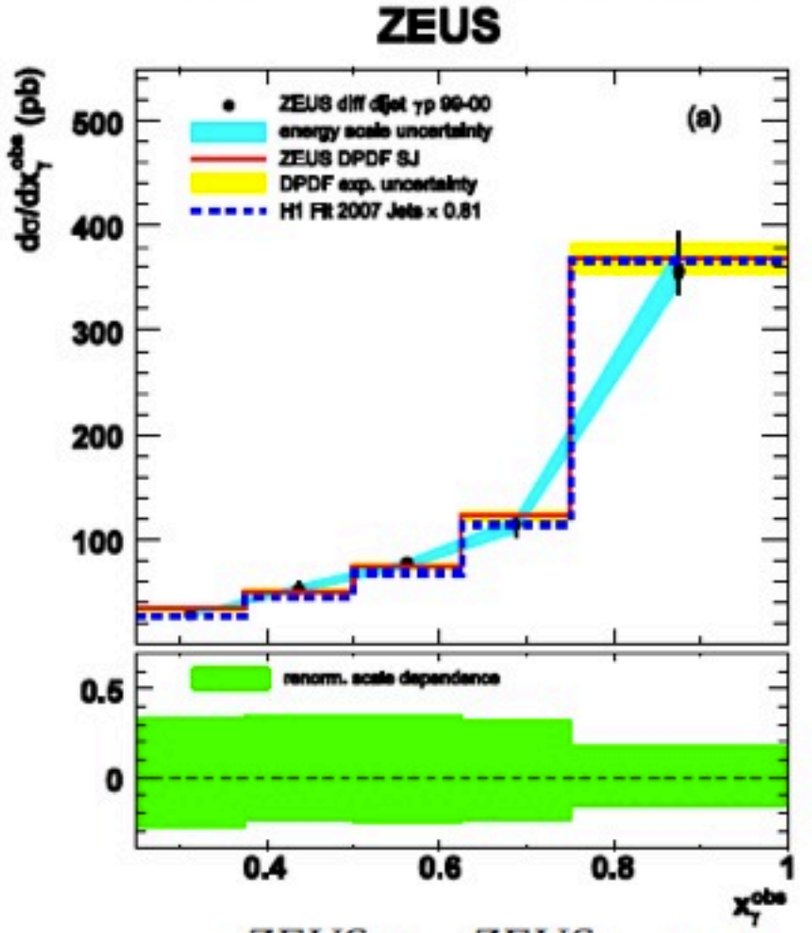


$\sigma^{H1}_{data}/\sigma^{H1}_{NLO} \approx 0.6$

LRG + electron tagger

Nucl. Phys. B 831 (2010)

$E_T^{\text{jet1(2)}} > 7.5(6.5)\,\text{GeV}$



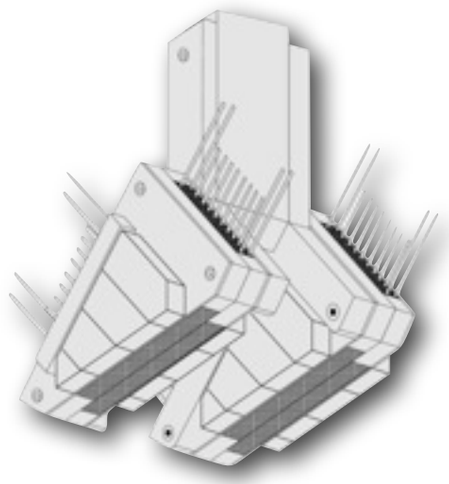
$\sigma^{ZEUS}_{data}/\sigma^{ZEUS}_{NLO} \approx 1.0$

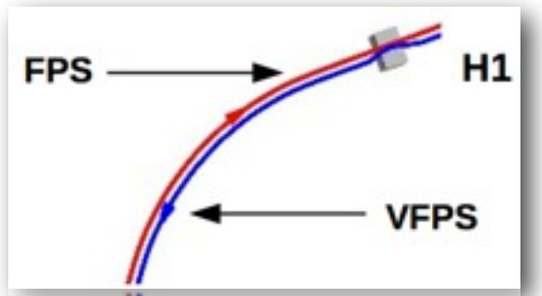
LRG + electron VETO

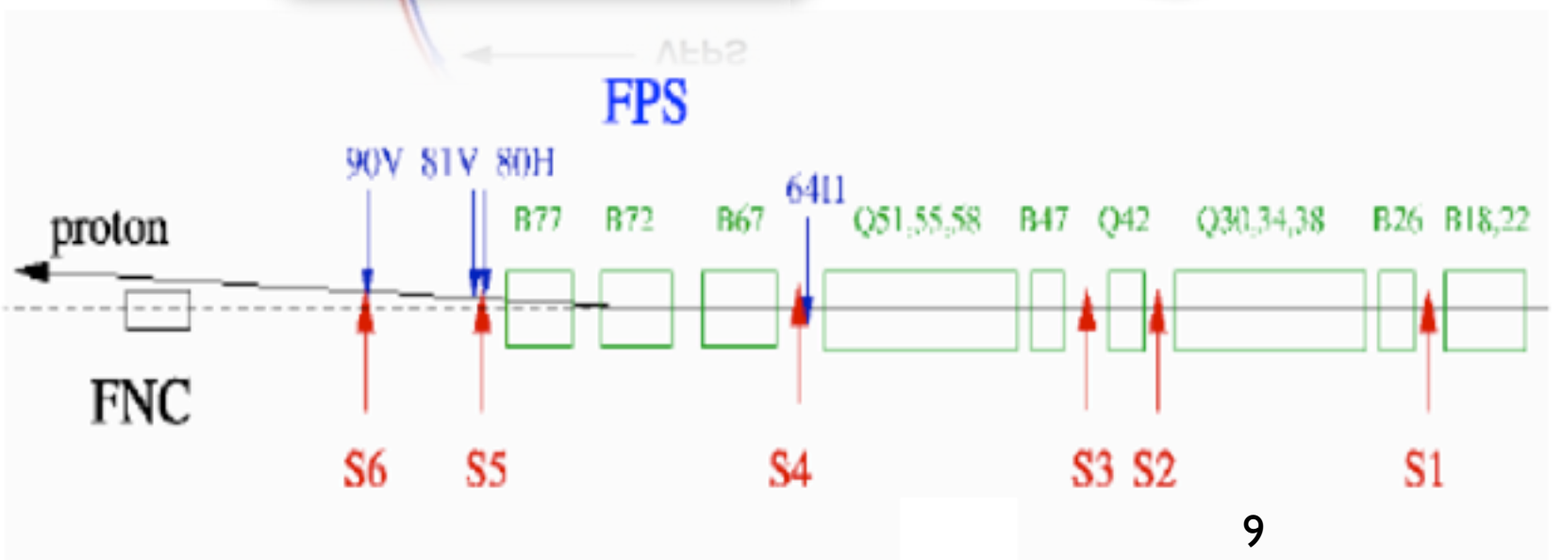
H1 and **ZEUS** did not converge on same answer ->
new and independent measurement by H1

Experimental Methods

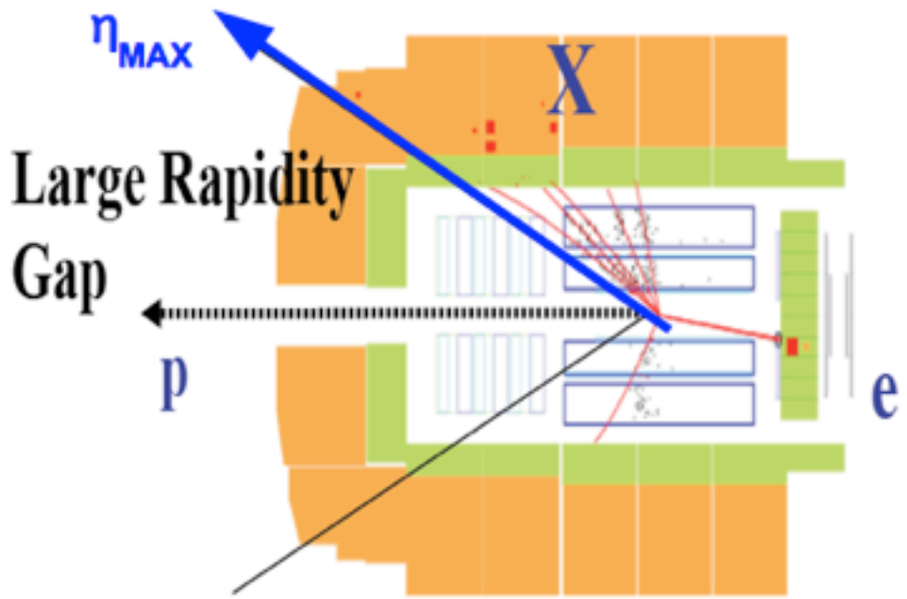
- **LRG method:**
  - no activity in forward part of the calorimeter
    - + high statistics
    - - proton dissociative background



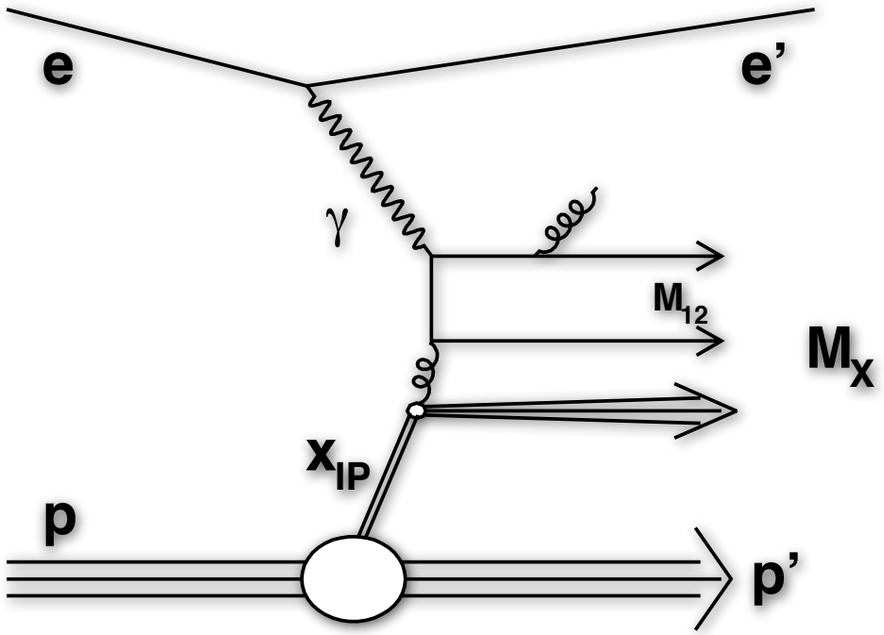




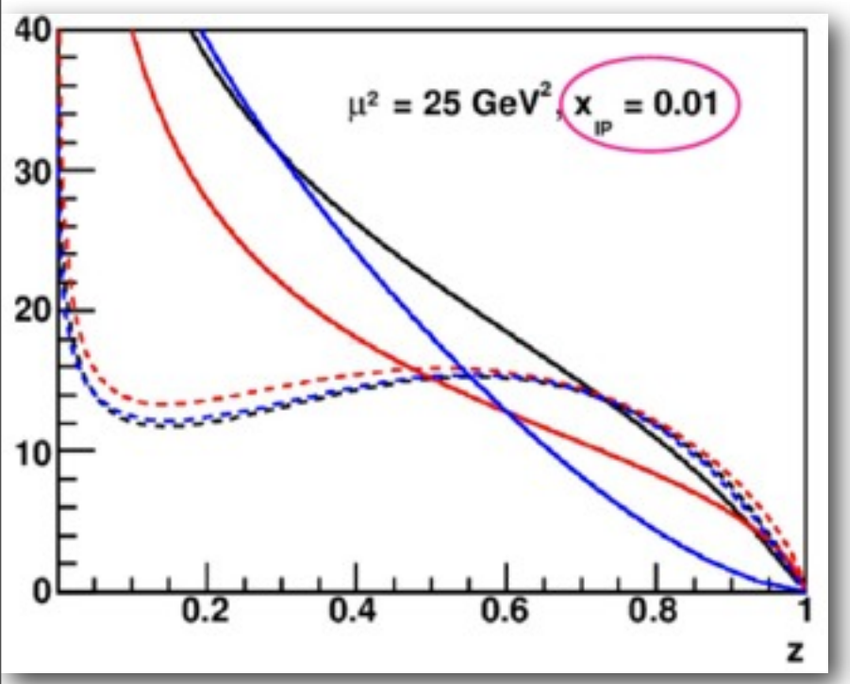
- **Proton Tagging:**
  - detection of the outgoing proton in forward proton spectrometers (PS) - FPS and VFPS
    - + direct extraction of diffractive variables, t dependence
  - + free of p-diss background
  - - small acceptance -> low stats

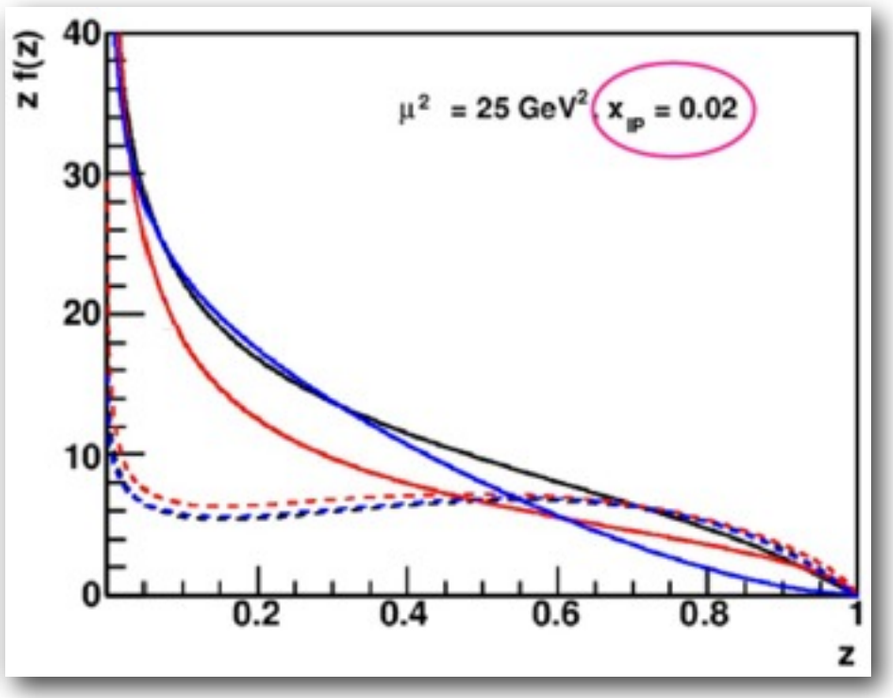


Diffractive PDFs



- extracted from inclusive DIS measurement
  - H1 2006 fit A & B
- diffractive jets constrain the gluon part of DPDF at high z
  - H1 2007 Jets, ZEUS SJ





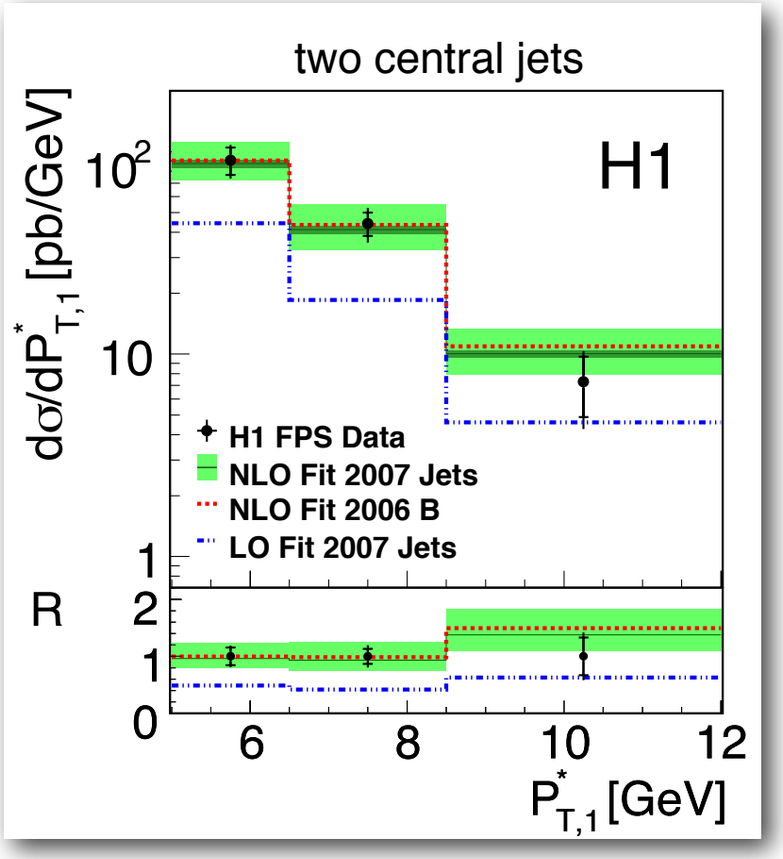
Gluon Densities
- H1 Fit B - z G(z)
- H1 Fit Jets - z G(z)
- ZEUS SJ - z G(z) × 1.2

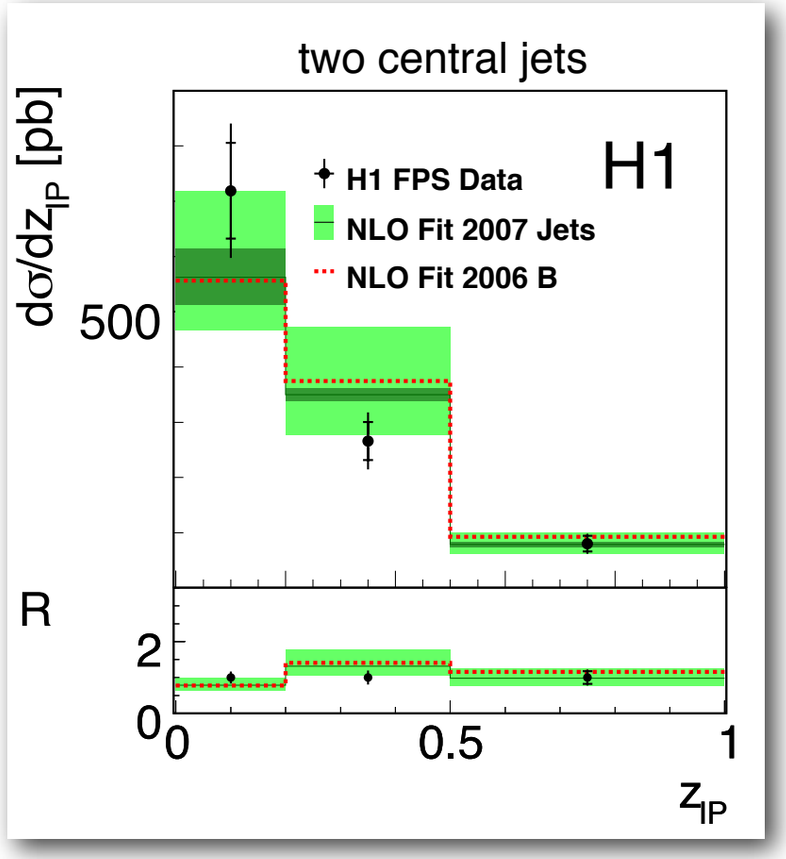
Quark Singlet Densities
- H1 Fit B - z Σ(z)
- H1 Fit Jets - z Σ(z)
- ZEUS SJ - z Σ(z) × 1.2

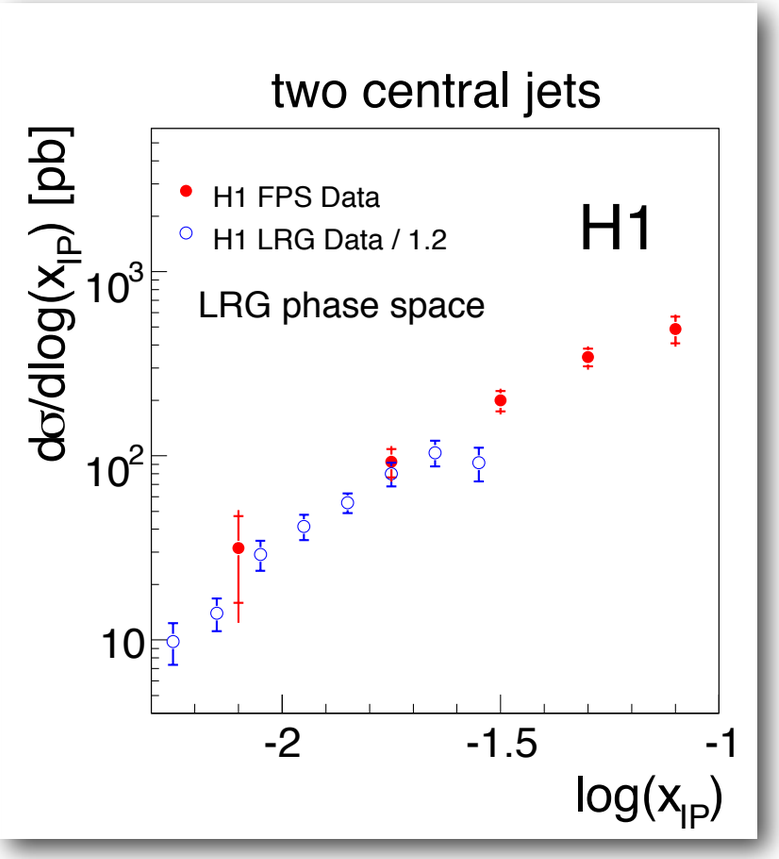
Dijets in DIS (1)

- measurement of di-jets in diffraction using the FPS detector (arXiv)
- comparison with NLO predictions (nlojet++) with H1 2006 Fit B and H1 2007 Jets implementation

$$4 < Q^2 < 110\ \mathrm{GeV}^2$$
$$0.05 < y < 0.7$$
$$x_{I\!P} < 0.1$$
$$|t| < 1\ \mathrm{GeV}^2$$
$$P^*_{T,1} > 5\ \mathrm{GeV}$$
$$P^*_{T,2} > 4\ \mathrm{GeV}$$
$$-1 < \eta_{1,2} < 2.5$$





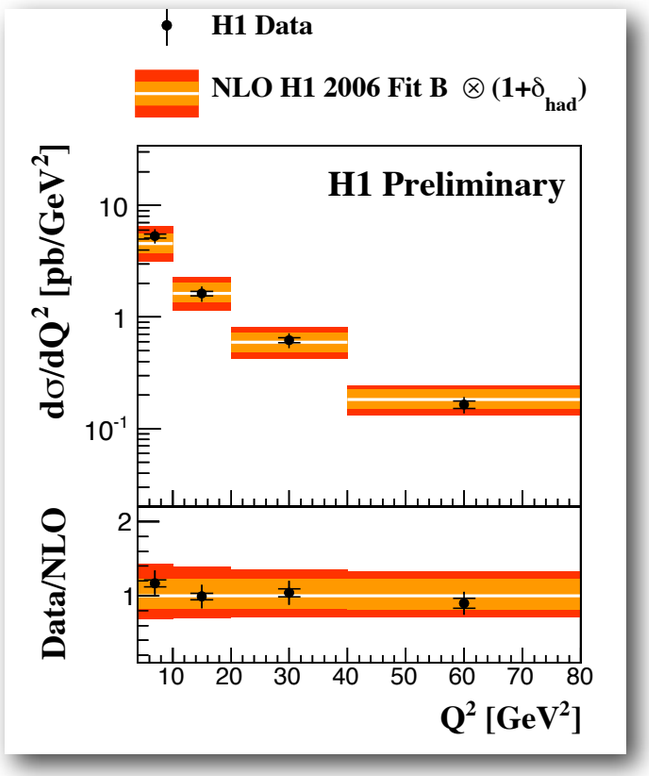


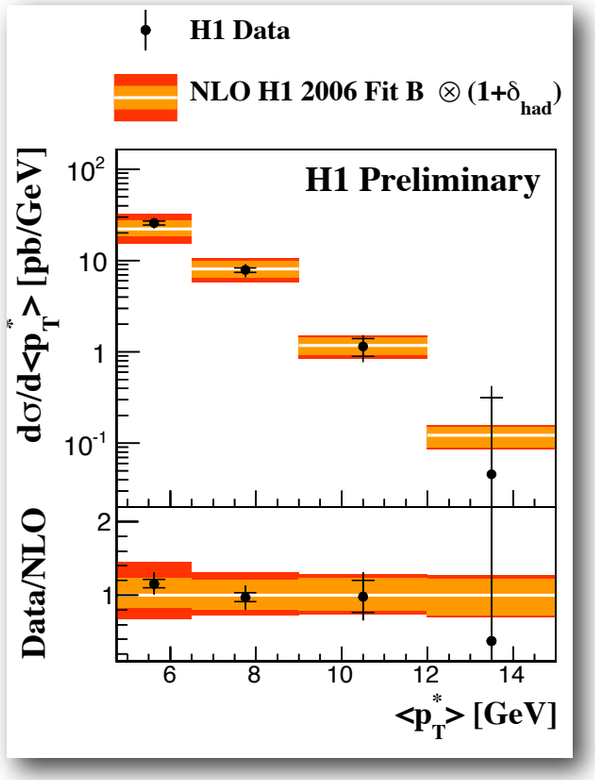
very good agreement between data and NLO QCD observed, consistency with old LRG measurement (HERA-I) shown

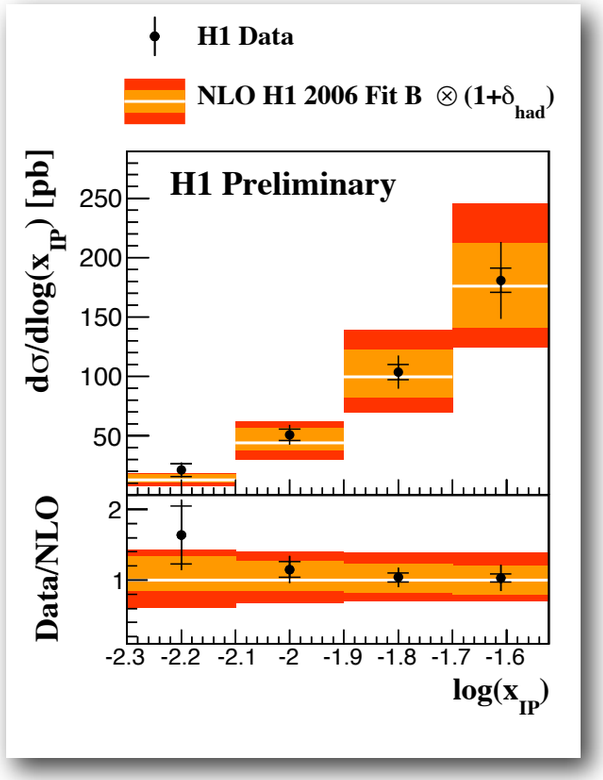
Dijets in DIS (2)

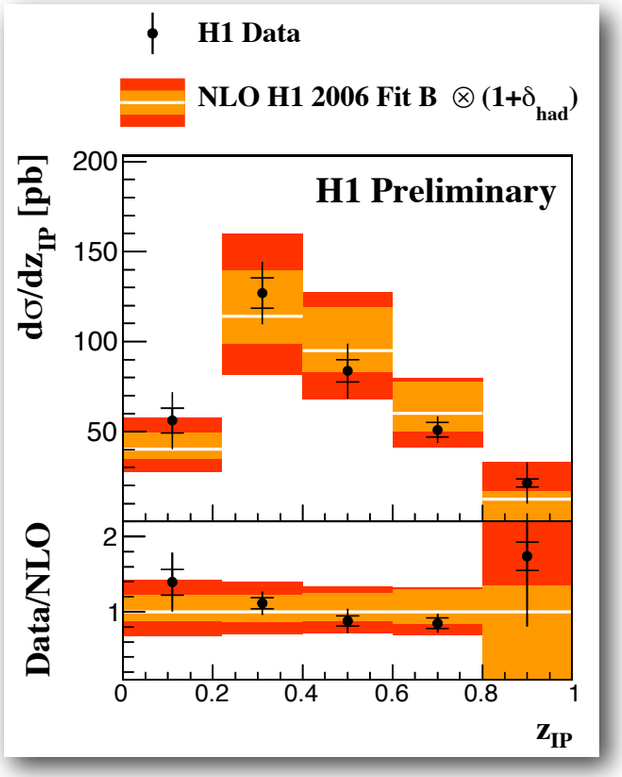
- analysis of full HERA-II statistics based on the LRG method is in preliminary stage
- comparison with NLO QCD with H1 2006 Fit B performed

$4 < Q^2 < 80\ \mathrm{GeV}^2$
$0.1 < y < 0.7$
$p^*_{T,1} > 5.5\ \mathrm{GeV}$
$p^*_{T,2} > 4.0\ \mathrm{GeV}$
$-1 < \eta_{1,2} < 2$
$x_{I\!P} < 0.03$
$\lvert t \rvert < 1\ \mathrm{GeV}^2$
$M_Y < 1.6\ \mathrm{GeV}$







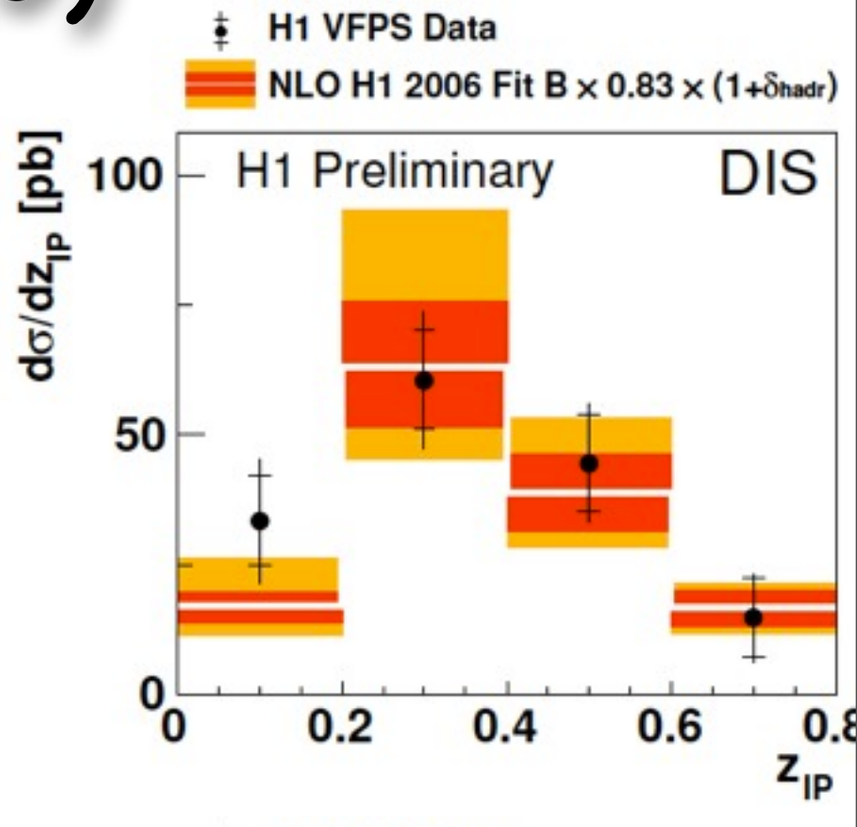


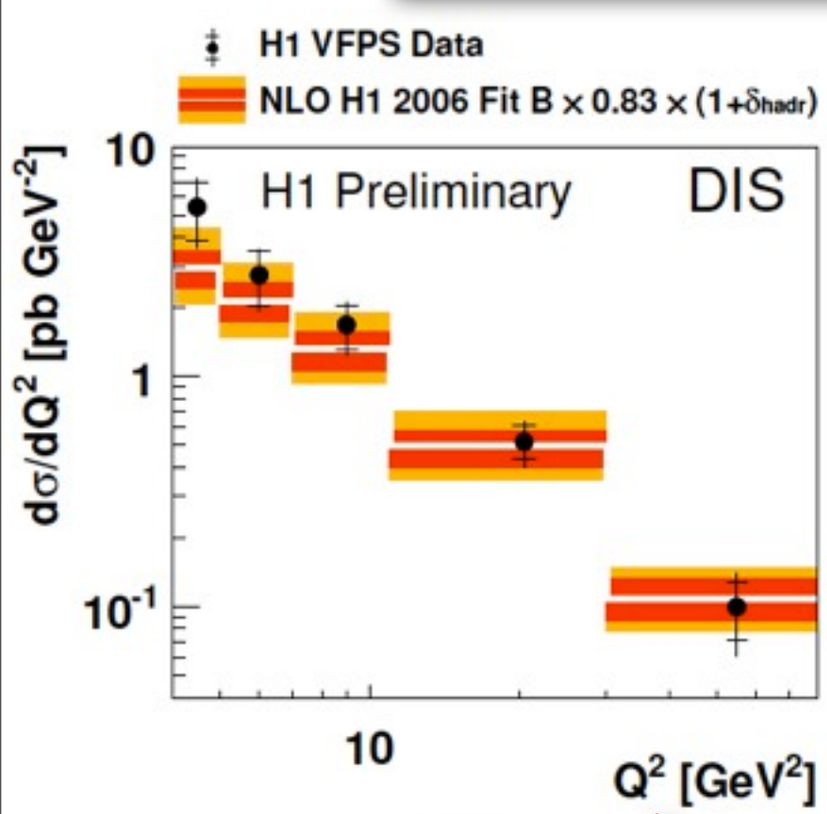
very good agreement between data and NLO QCD observed

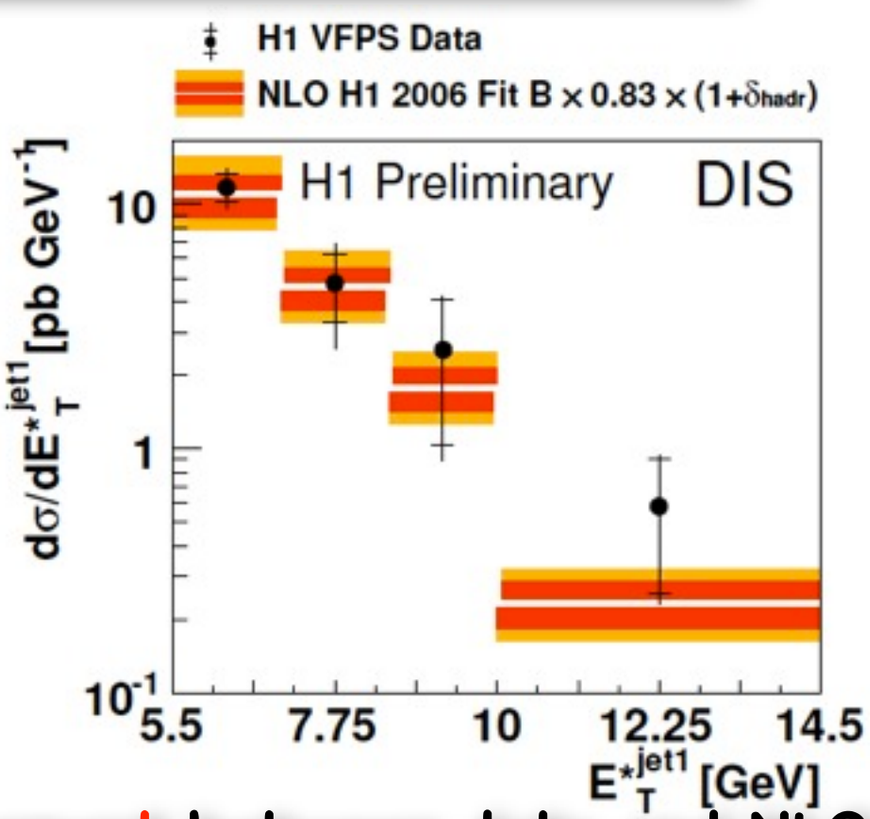
Dijets in DIS (3)

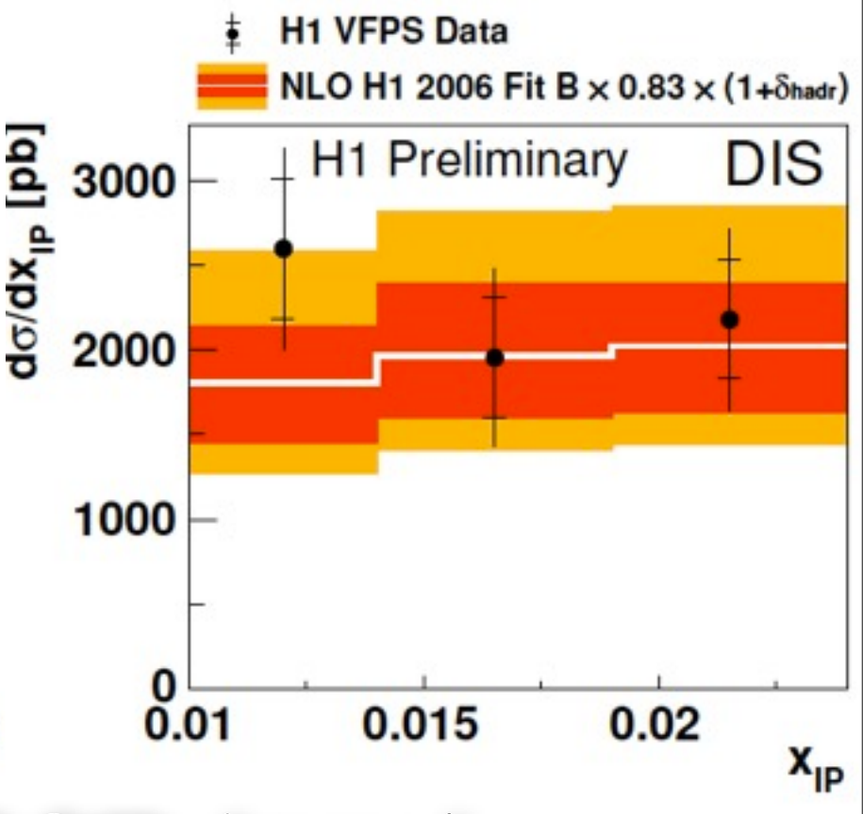
- analysis of events with proton tagged in VFPS
- comparison with NLO QCD (nlojet++) with H1 2006 Fit B performed, "validation region" of the γP analysis
- $\mu_{r,f} = \sqrt{(E_{Tj}^2 + Q^2/4)}$ **$4 < Q^2 < 80$ GeV^2**

$0.2 < y < 0.7$	
$E_T^{*\mathrm{jet1}} > 5.5\,\mathrm{GeV}$	$E_T^{*\mathrm{jet2}} > 4.0\,\mathrm{GeV}$
$-1 < \eta^{\mathrm{jet1}} < 2.5$	$-1 < \eta^{\mathrm{jet2}} < 2.5$
$\lvert t\rvert < 0.6\,\mathrm{GeV}^2$	$0.010 < x_{I\!P} < 0.024$
$z_{I\!P} < 0.8$	









very good agreement between data and NLO QCD observed

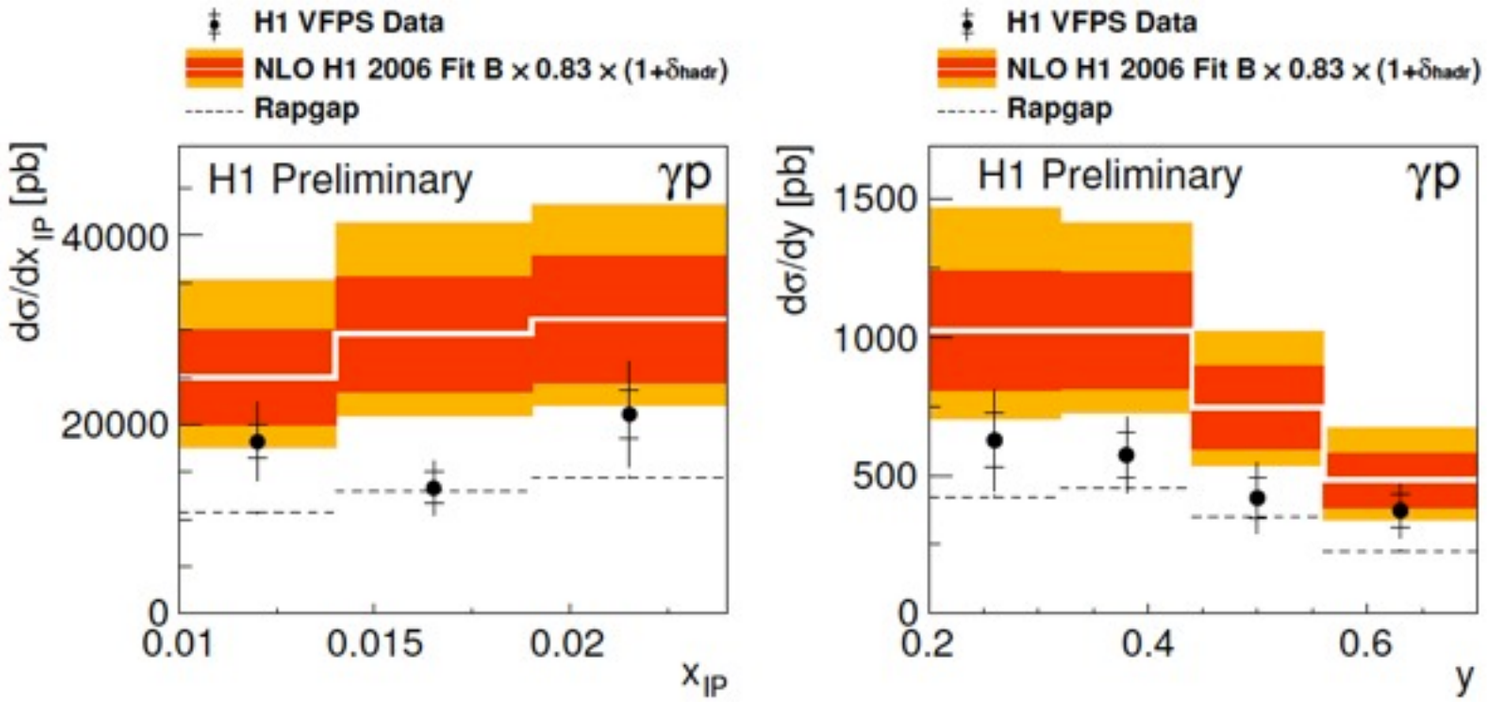
Dijets in γP (1)

$Q^2 < 2\ GeV^2$

- analysis repeated with same conditions except for Q^2

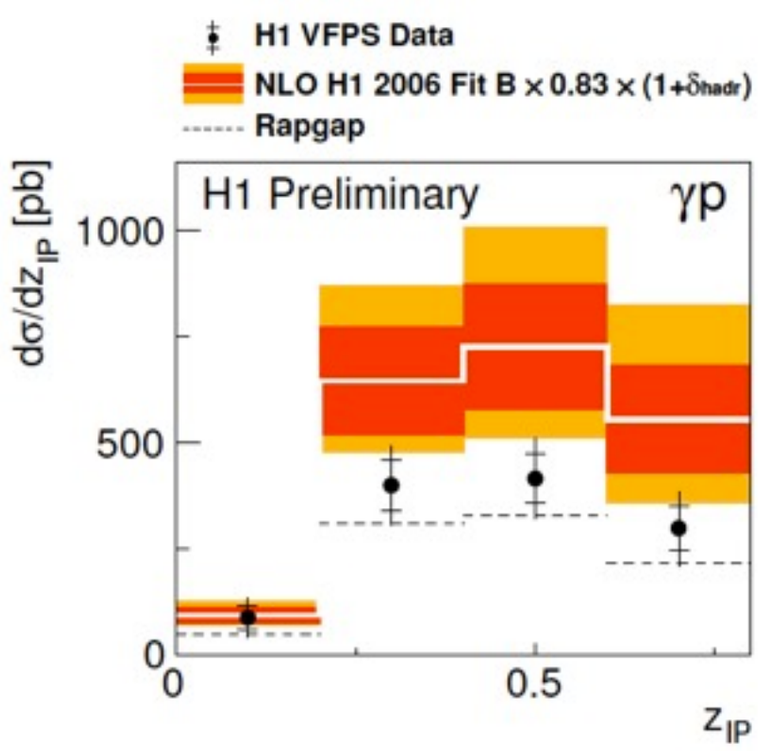
$0.2 < y < 0.7$	
$E_T^{*\mathrm{jet1}} > 5.5\,\mathrm{GeV}$	$E_T^{*\mathrm{jet2}} > 4.0\,\mathrm{GeV}$
$-1 < \eta^{\mathrm{jet1}} < 2.5$	$-1 < \eta^{\mathrm{jet2}} < 2.5$
$\lvert t\rvert < 0.6\,\mathrm{GeV}^2$	$0.010 < x_{I\!P} < 0.024$
$z_{I\!P} < 0.8$	

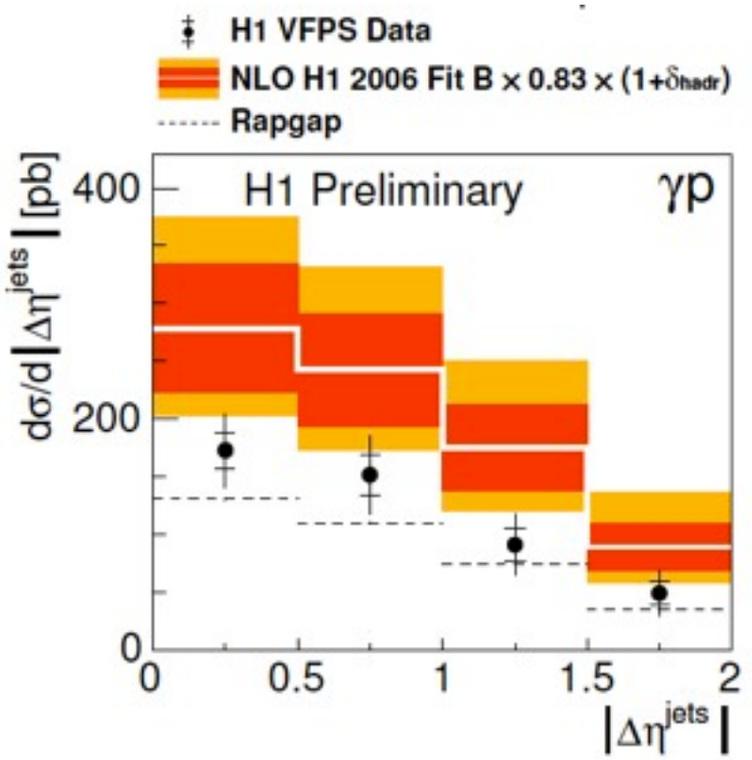
- NLO QCD: Frixione et. al. (x-check with Klasen&Kramer)
  - $\mu_{r,f} = \sqrt{(E_{Tj}^2+Q^2/4)}$
- DPDF: H1 2006 Fit B
- γPDF: GRV HO



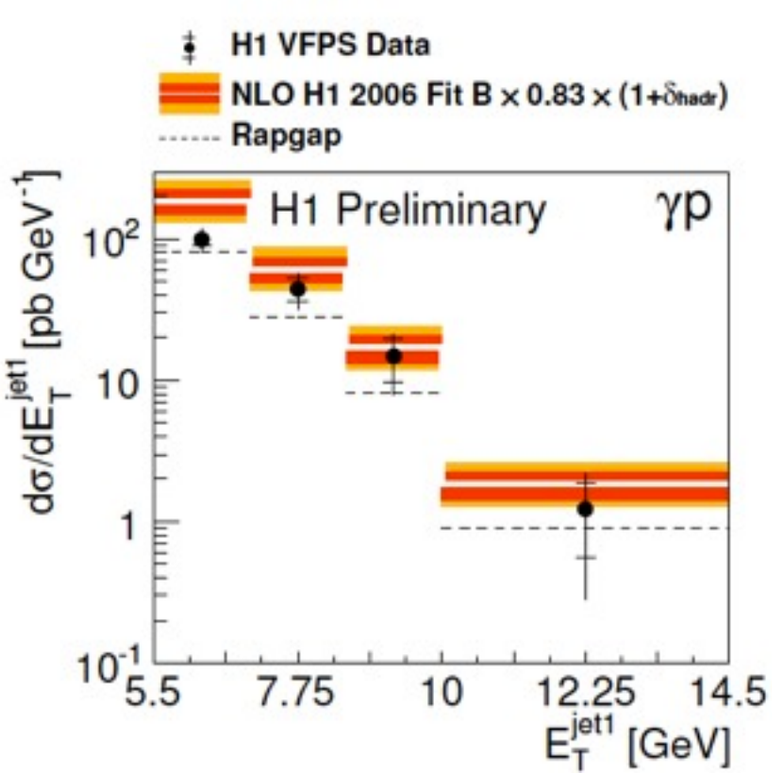
Data over-predicted by MC

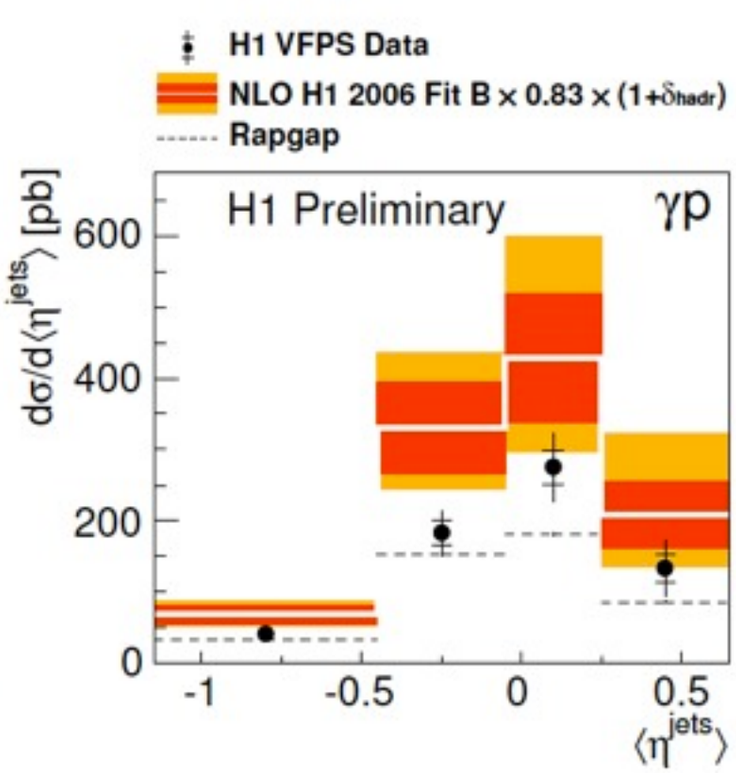
Dijets in γP (2)

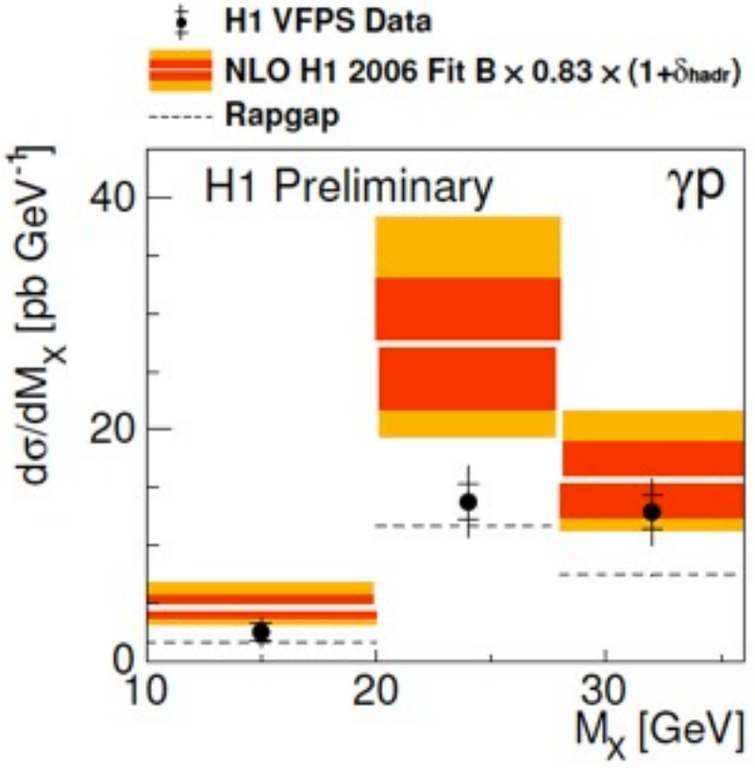




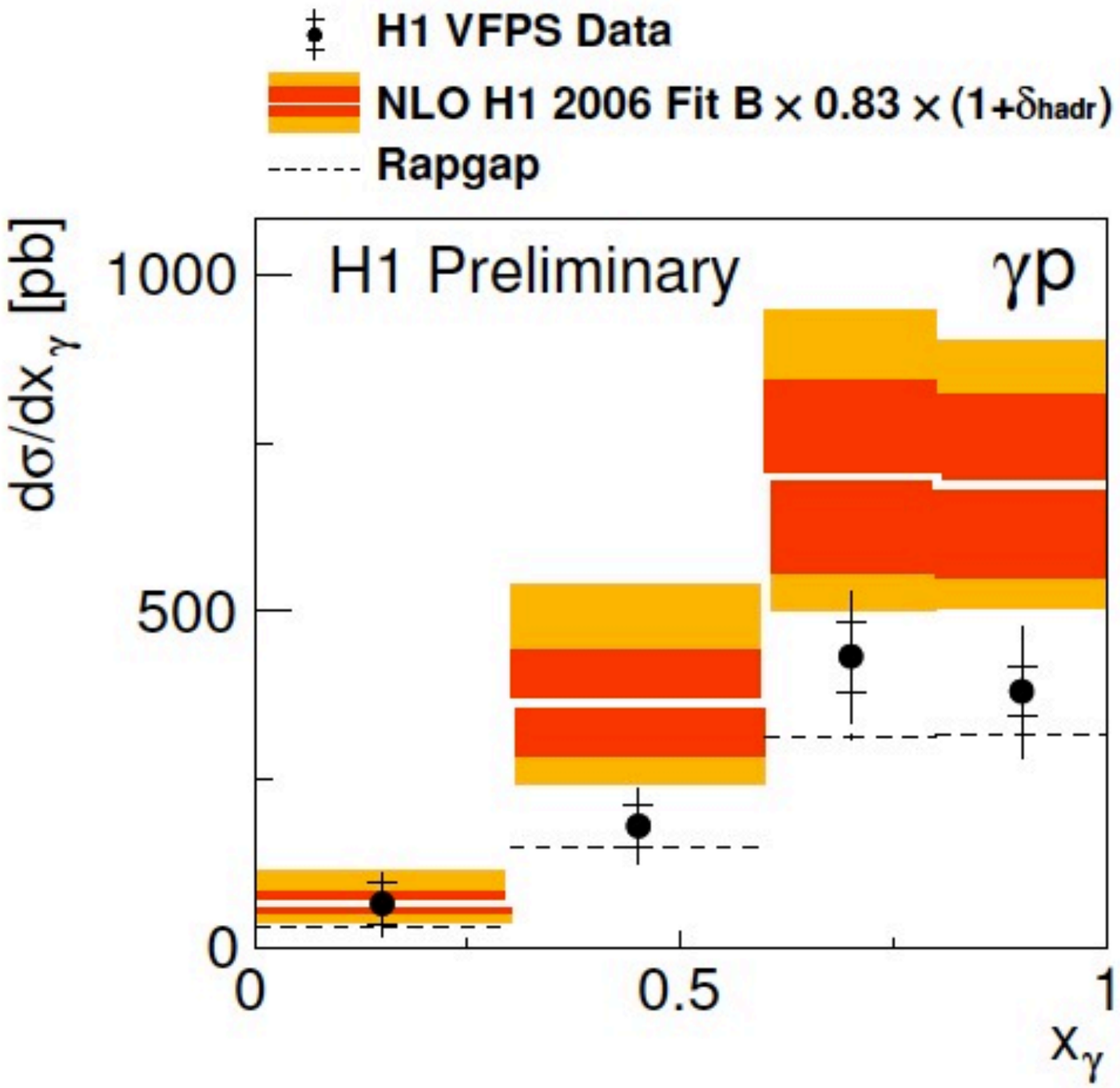
- data over-predicted by NLO
- hint visible for E_T^{jet1} (could explain non-observation of ZEUS), suffers from large uncertainties







Dijets in γP (3)

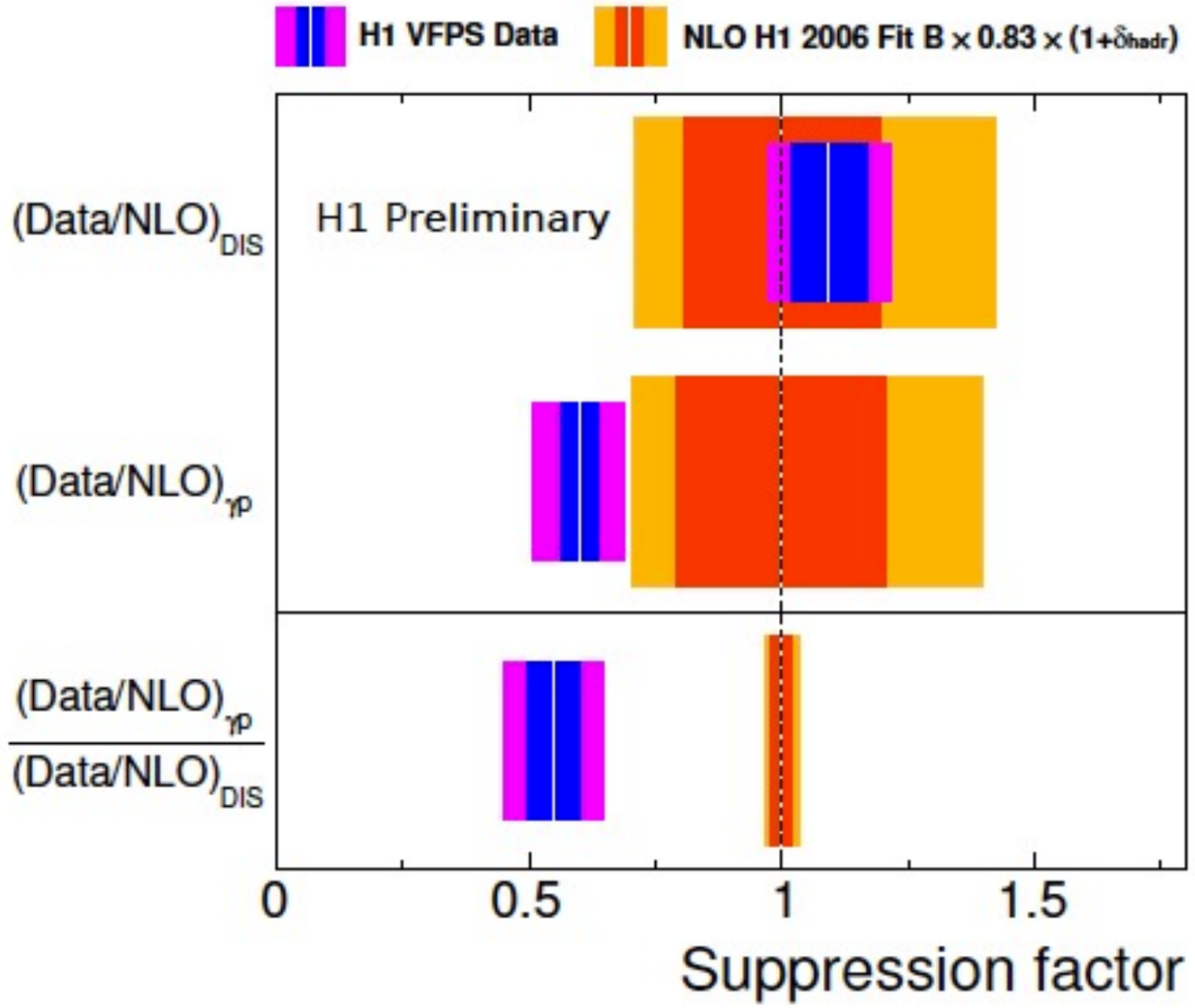


- naively, x_γ-> 1 (direct) should not show any suppression
- resolved component expected to be suppressed
- surprisingly, suppression is observed almost **independently** on x_γ

problem with rather large uncertainties solved by...

Dijets in γP and DIS (1)

- double-ratio of data/NLO cancels most of systematics uncertainties
- integrated result:



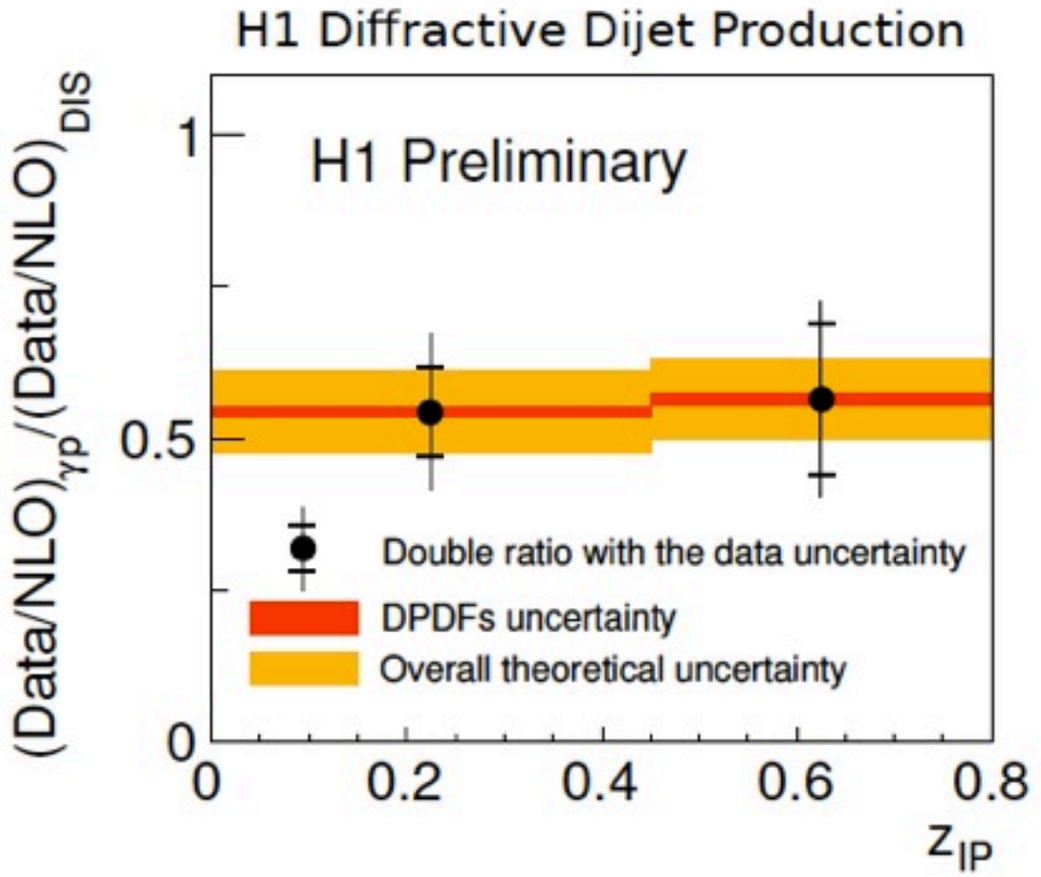
$$\frac{(\mathrm{DATA/NLO})_{\gamma p}}{(\mathrm{DATA/NLO})_{\mathrm{DIS}}} = 0.55 \pm 0.10\,(\mathrm{data}) \pm 0.02\,(\mathrm{theor.})$$

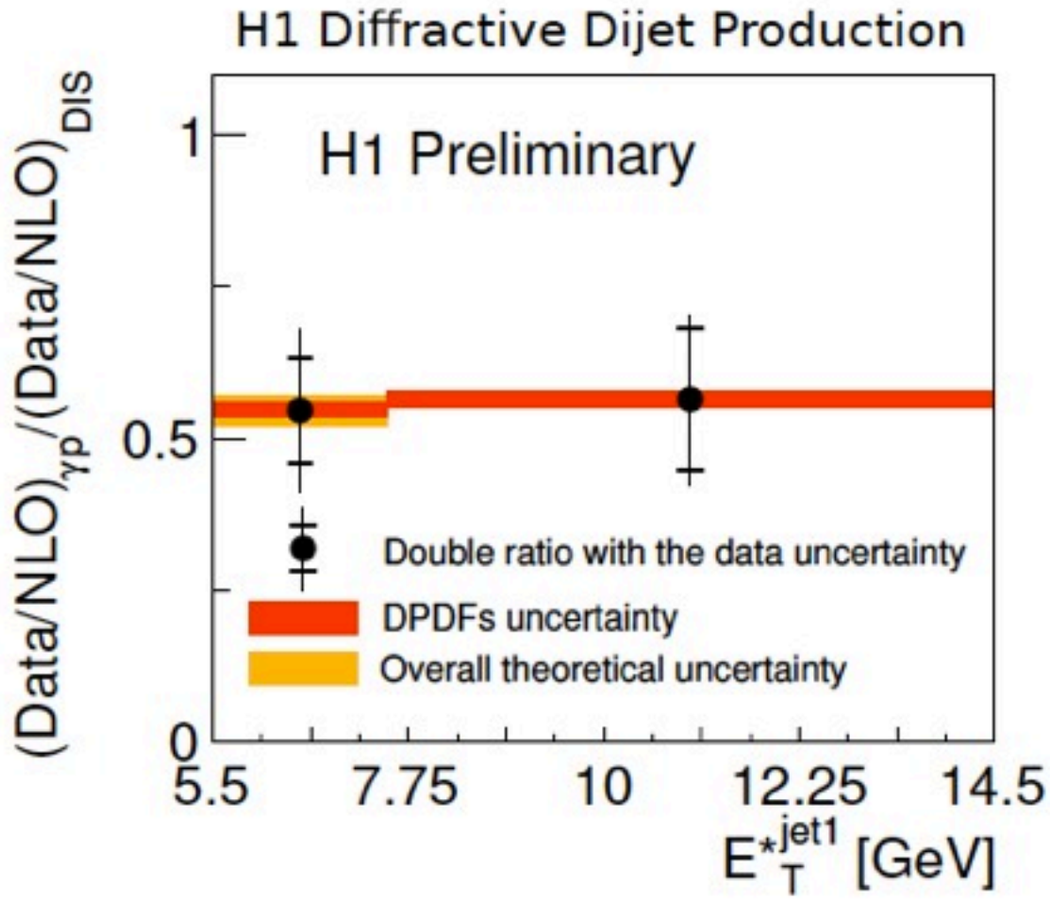
Factorization breaking in diffractive photoproduction observed with sufficient statistical precision

not due to proton dissocoation

Dijets in γP and DIS (2)

- double-ratio of data/NLO cancels most of systematics uncertainties
- binning driven by DIS statistics
- data/NLO:
  - DIS: ~1.07 x PHP: ~0.61





statistically significant deviation from unity, constant in E_T^{jet1} as well as z_{IP}

summary

- new preliminary results on diffractive dijets from the H1 Collaboration (shutdown 2007!) presented
- in **DIS**, all independent measurements are **consistent** with Proton Vertex Factorization
- in **Photo-Production**, deviation from unity in the double ratio is consistent with **factorization breaking**:

$$\frac{(\mathrm{DATA/NLO})_{\gamma p}}{(\mathrm{DATA/NLO})_{\mathrm{DIS}}} = 0.55 \pm 0.10\,(\mathrm{data}) \pm 0.02\,(\mathrm{theor.})$$

- stay tuned for final publications (coming SOON)

backup

Cross Sections

	PHP	DIS
Data	$242 \pm 15\,(\text{stat.}) \pm 33\,(\text{syst.})\,\text{pb}$	$29.7 \pm 2.0\,(\text{stat.}) \pm 2.7\,(\text{syst.})\,\text{pb}$
NLO QCD	$400^{+140}_{-90}(\text{scale}) \pm 80\,(\text{DPDF})\,\text{pb}$	$27.2^{+10.2}_{-5.9}(\text{scale}) \pm 5.3\,(\text{DPDF})\,\text{pb}$
Data/NLO	$0.60 \pm 0.08\,(\text{data}) \pm 0.21\,(\text{theor.})$	$1.09 \pm 0.10\,(\text{data}) \pm 0.40\,(\text{theor.})$