JETS AND E_t FLOW IN DIFFRACTIVE PROCESSES

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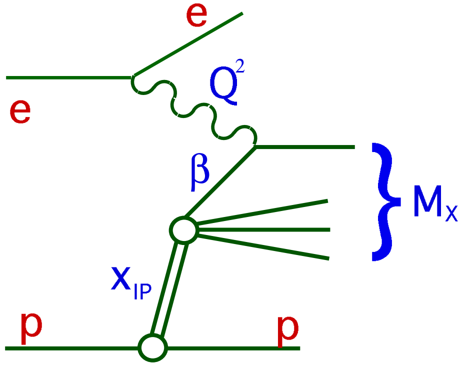
On behalf of

H1 and ZEUS Collaborations

- Introduction
- Physics Models
- Global event Shapes
- Dijets
- 3-Jets
- New QCD fits and the Final State
- Summary

Introduction: Diffractive Hadronic Final State

Kinematics



$$x_{I\!P} = \frac{q.(p-p')}{q.p} \simeq \frac{Q^2+M_X^2}{Q^2+W^2}$$

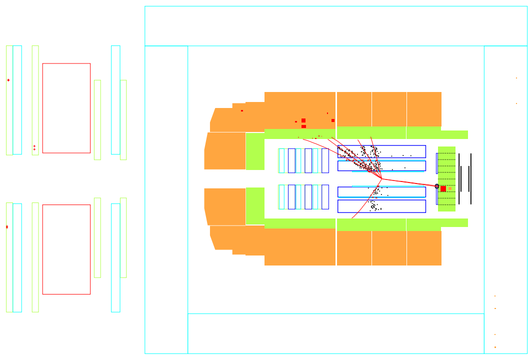
$$\beta = \frac{Q^2}{q.(p-p')} \simeq \frac{Q^2}{Q^2+M_X^2}$$

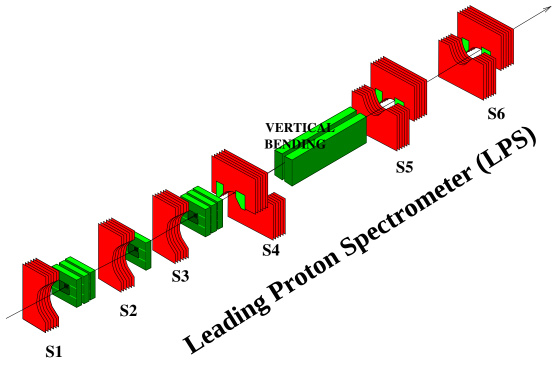
$$t = (p-p')^2$$

$$(x = x_{I\!P}\beta)$$

Methods of Selection

- Measure the Leading Proton
- Large Rapidity Gap (LRG)





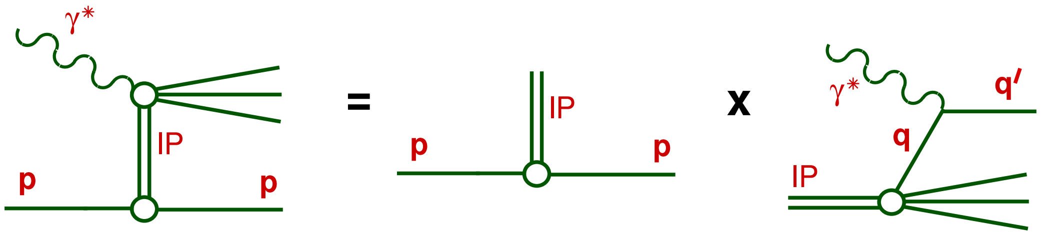
Aims

- Topology of the hadronic final state

$\longrightarrow$ nature of $I\!P$ exchange

- QCD factorisation and diffractive PDFs
- Test QCD calculations (high p_T)

Factorisable Pomeron Model - RAPGAP



$$\sigma(\gamma^* p \to Xp) \quad \sim \quad f_{\mathrm{IP}/\mathrm{p}}(x_{I\!P}, t) \quad \otimes \quad f_{q/\mathrm{IP}}(\beta, Q^2) \quad \otimes \quad \hat{\sigma}_{\gamma^* q}(\beta, Q^2)$$

Combine

QCD Hard Scattering Factorisation (Collins et al)

(Diffractive PDFs evolve in x, Q^2 via DGLAP)

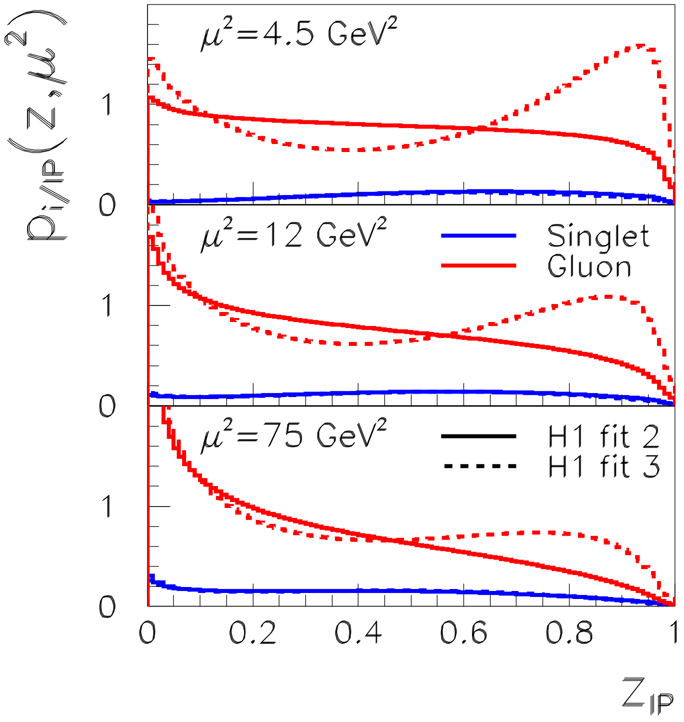
with

'Regge' Factorisation ($x_{I\!P}$, t flux)

- PDFs from H1 fits to $F_2^{D(3)}$

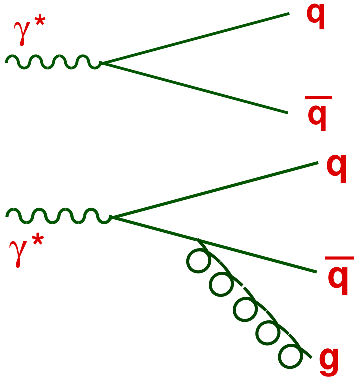
$\longrightarrow$ PDFs dominated by gluons

- Soft $\mathbb{P}$ remnant
- Subleading $\mathbb{R}$ exchange

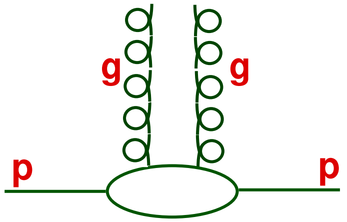


Colour Dipole Models: SATRAP, RIDI, BJLW

$\gamma^{\star} \longrightarrow q\bar{q}, q\bar{q}g$ in p rest frame



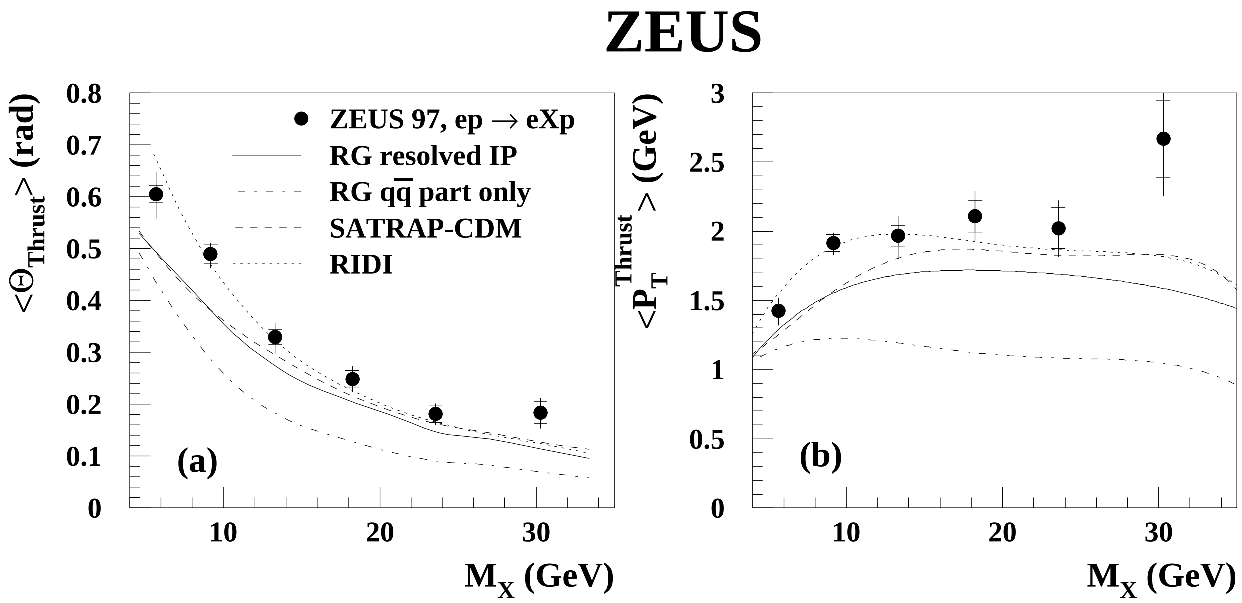
Partonic $\mathbb{P}$ - two gluon exchange

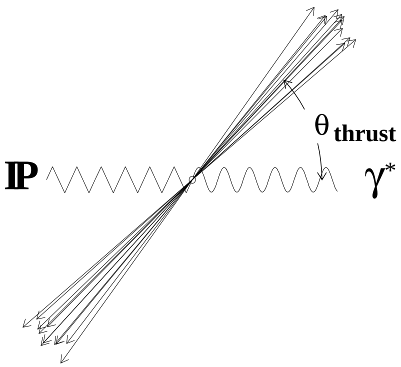


- Cross sections related to proton $g(x)$
- $q\bar{q}g$ dominate at high M_X
- High p_T diffractive final states

- SATRAP: Saturation Model
  - $\longrightarrow g(x)$ from parameterisation of $F_2(x, Q^2)$
  - $\longrightarrow$ strongly ordered k_T: $p_T^g \ll p_T^q$
- RIDI:
  - $\longrightarrow g(x)$ from PDF (CTEQ4M)
  - $\longrightarrow$ strongly ordered k_T: $p_T^g \ll p_T^q$
- BJLW:
  - $\longrightarrow g(x)$ from PDFs
  - $\longrightarrow$ unordered k_T

Global Event Shapes: Thrust Angle





- System more aligned with $\gamma^\star\mathbb{P}$ axis as M_x increases
- High level of $p_T^{\mathrm{thrust}} \simeq 2\ \mathrm{GeV}$
- Mostly produced in $q\bar{q}g$ type events

Additional source of k_T needed?

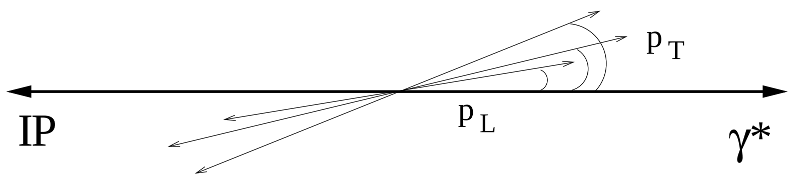
$$p_T^{\mathrm{Thrust}} = \frac{1}{2} M_X \sin\theta_{\mathrm{thrust}}$$

$$\text{Thrust } T = \max \frac{\sum_i |\vec{n}\cdot\vec{p}|}{\sum_i |\vec{p}|}$$

Global Event Shapes: Seagull Distribution

$$x_F = p_L / p_L^{max}$$

$$p_L^{max} = M_X / 2$$



- Asymmetry between $\mathbb{P}$ and γ

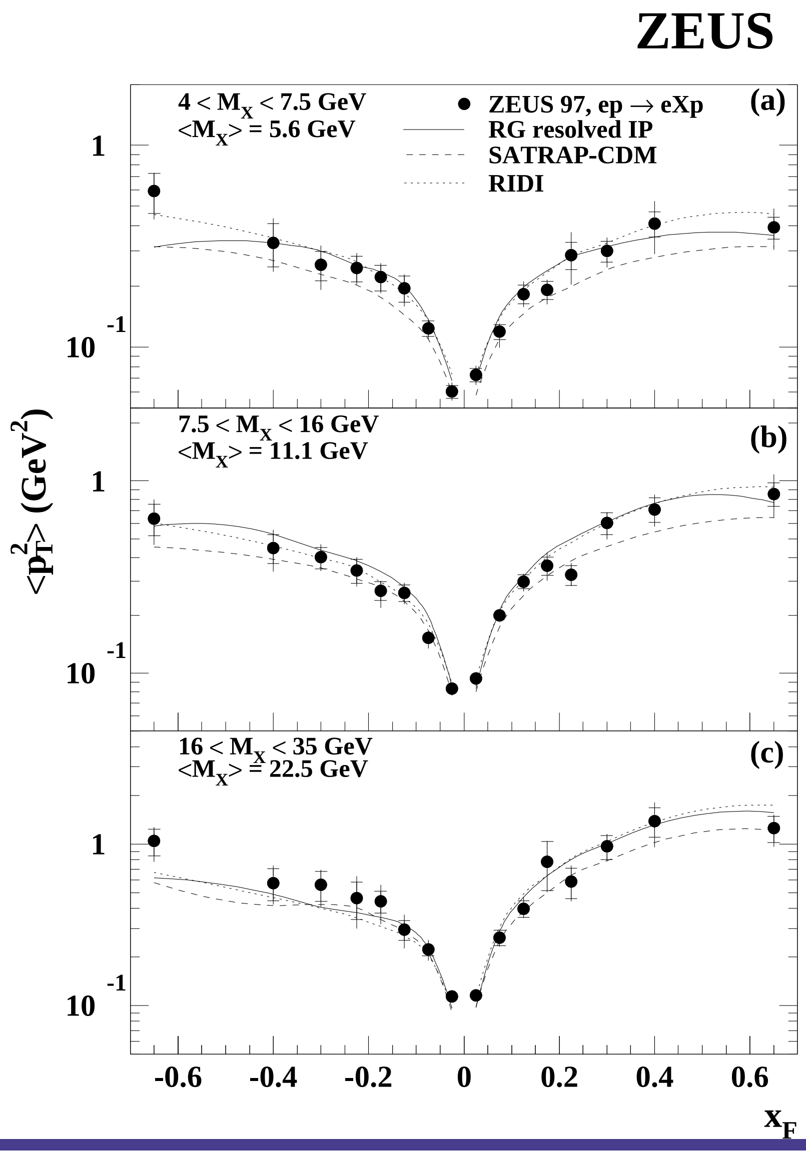
Increasing with M_X

- Described by resolved $\mathbb{P}$ (RAPGAP)

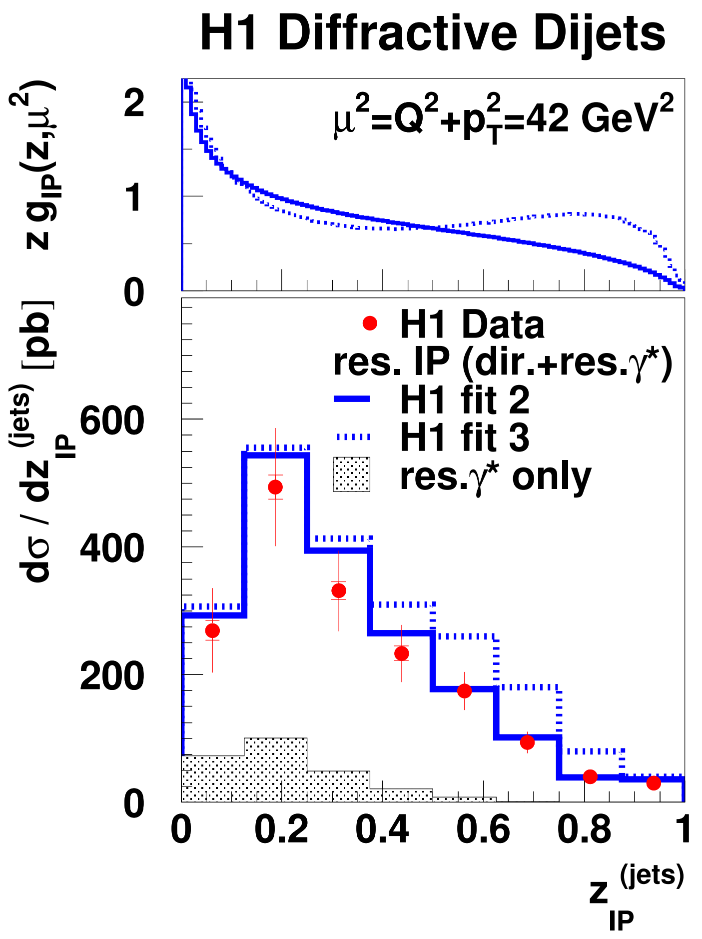
$\longrightarrow$ consistent with $\mathbb{P}$ remnant

- Described by 2 g exchange

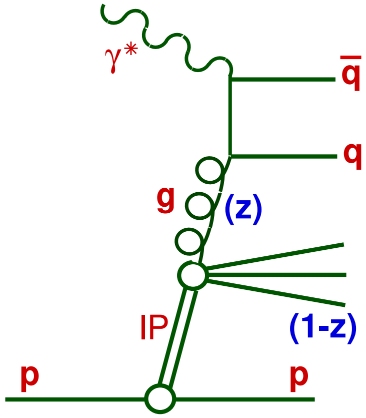
$\longrightarrow$ consistent with $q\bar{q}g$ final states



Dijet Production in Diffraction



Momentum fraction of exchange coupling with $\gamma^\star$



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

$\sim$ fraction of energy of the X system contained in the 2 jets.

- High p_T jet production sensitive to shape and size of $\mathbb{P}$ gluon distribution

Dijet Production

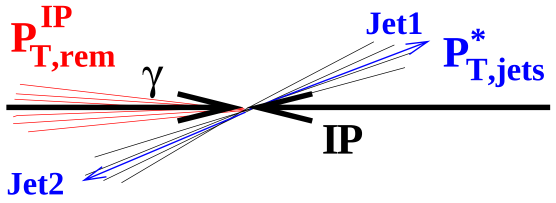
- $x_{I\!P} < 0.01$

avoid $I\!R$ contribution

- Resolved $I\!P$ good description
- BJLW describes data well

$\longrightarrow$ Require large $q\bar{q}g$ contribution

- $p_{T,\mathrm{rem}}^{I\!P}$: p_T of "$I\!P$ remnant"

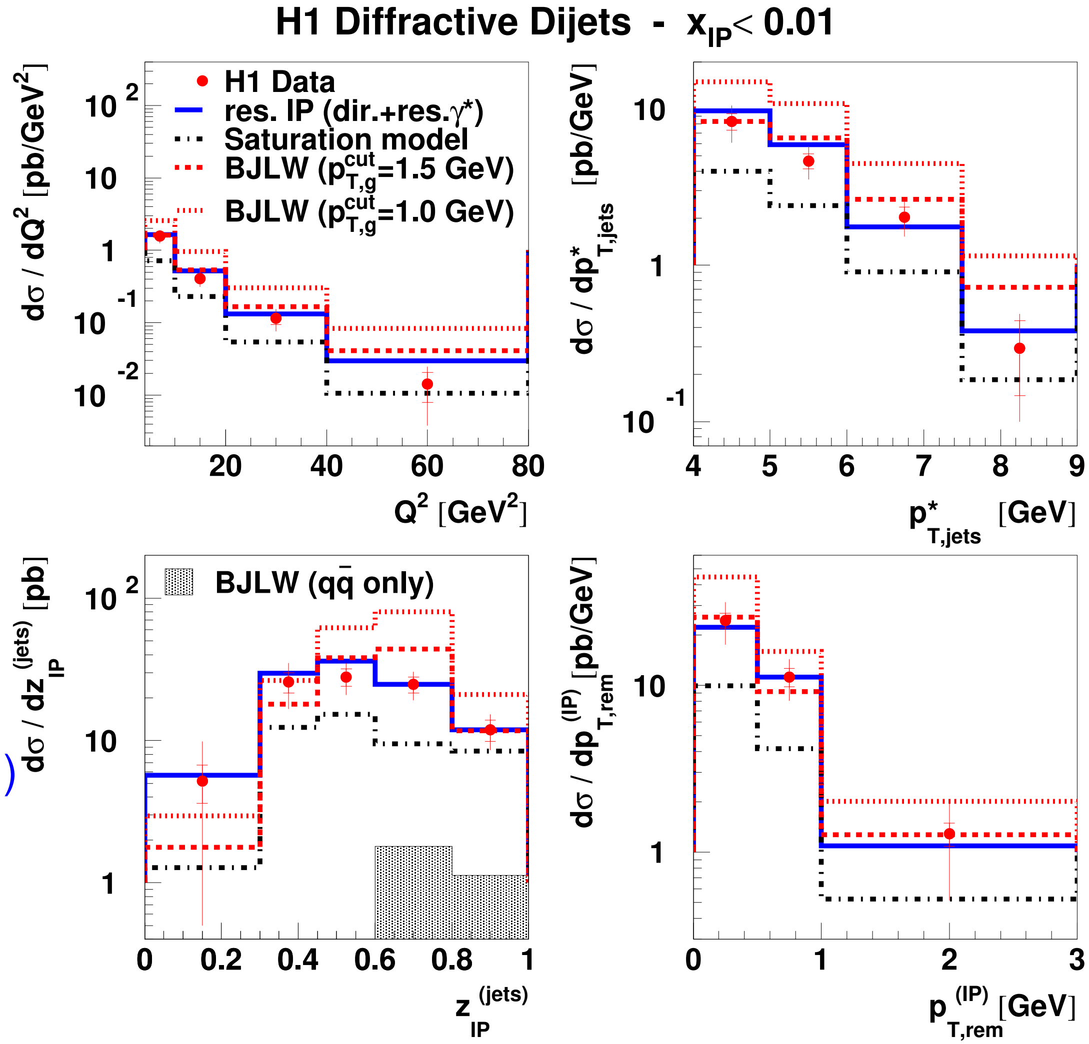


- Saturation model (with $p_T^g \ll p_T^q$)

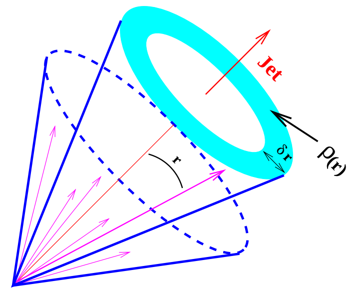
too low

k_T ordering / Higher order QCD

contributions important



Three Jet Production: Jet Shapes

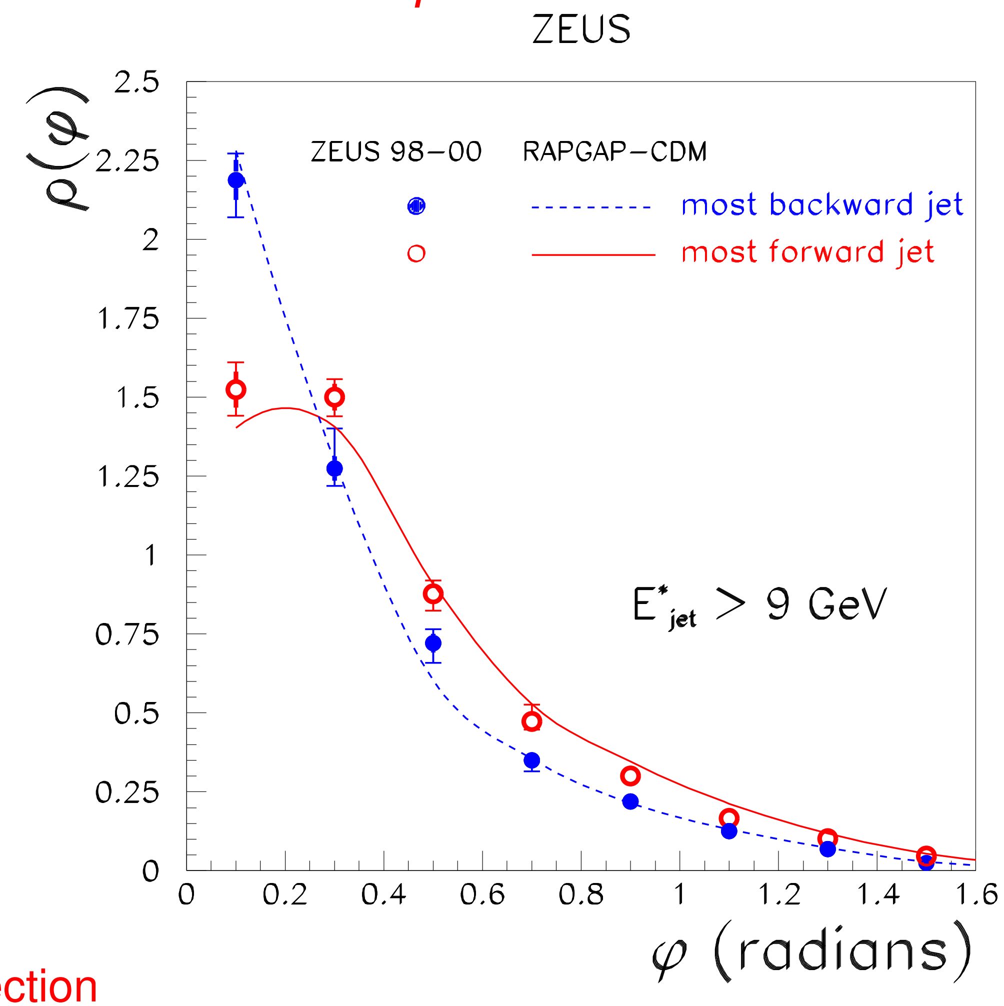


- jet shape of most forward and most backward jet

g **$q\bar{q}$**

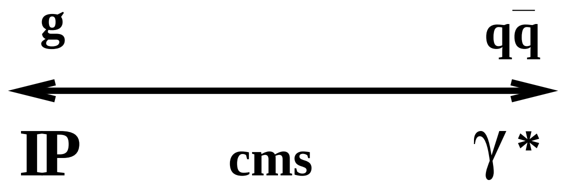
$\mathbb{P}$ **cms** **γ^***

- Jet in $\mathbb{P}$ direction broader than jet in γ direction
- Consistent with g initiated jet in $\mathbb{P}$ direction



Three Jet Production: $p_T^\star$ of Most Forward Jet

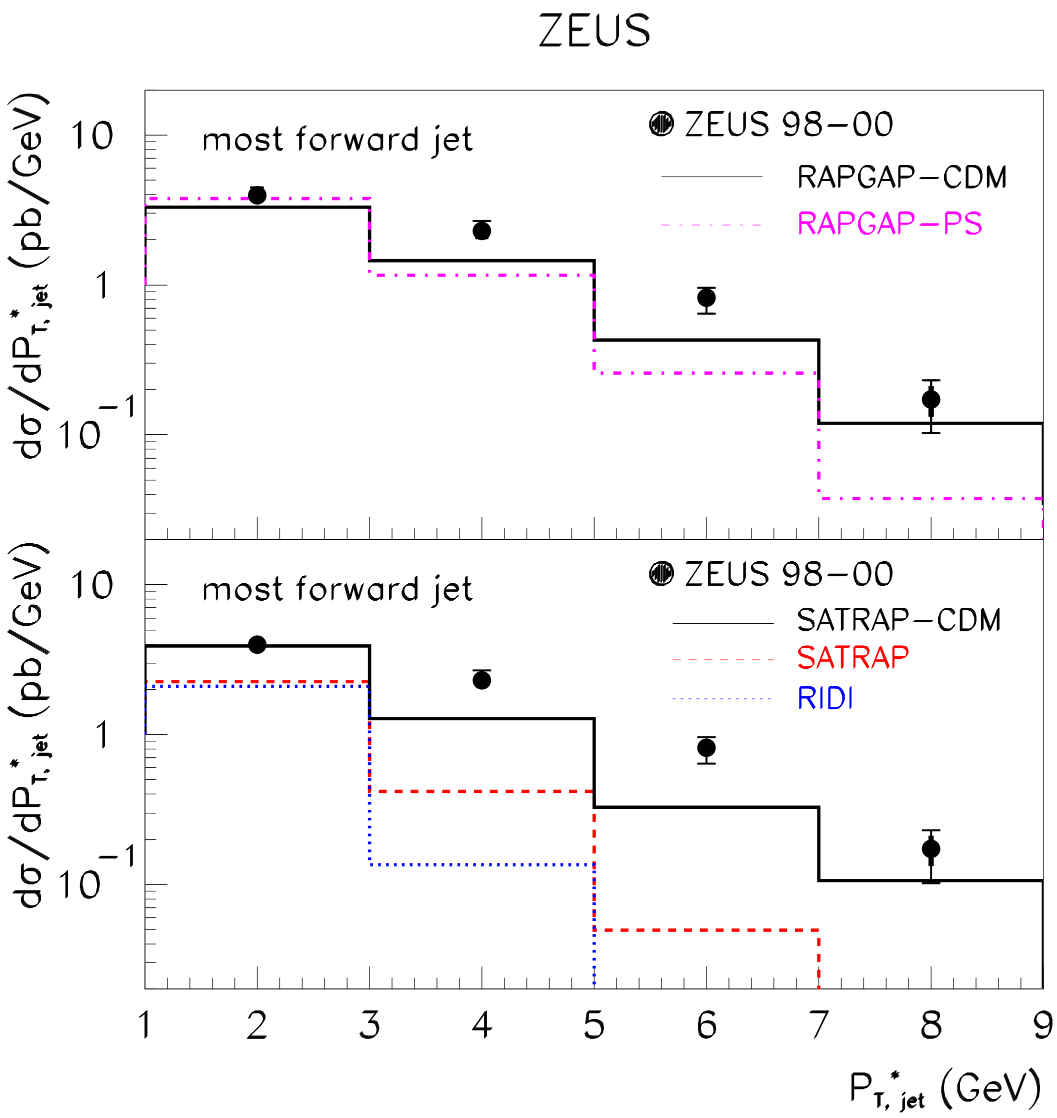
- Forward jet is the "$\mathbb{P}$ remnant"



- dominant $p_T^\star < 3\ \mathrm{GeV}$

- sensitivity to higher order QCD processes

- RIDI: large $p_T^{\star,\mathrm{jet}}$ missing

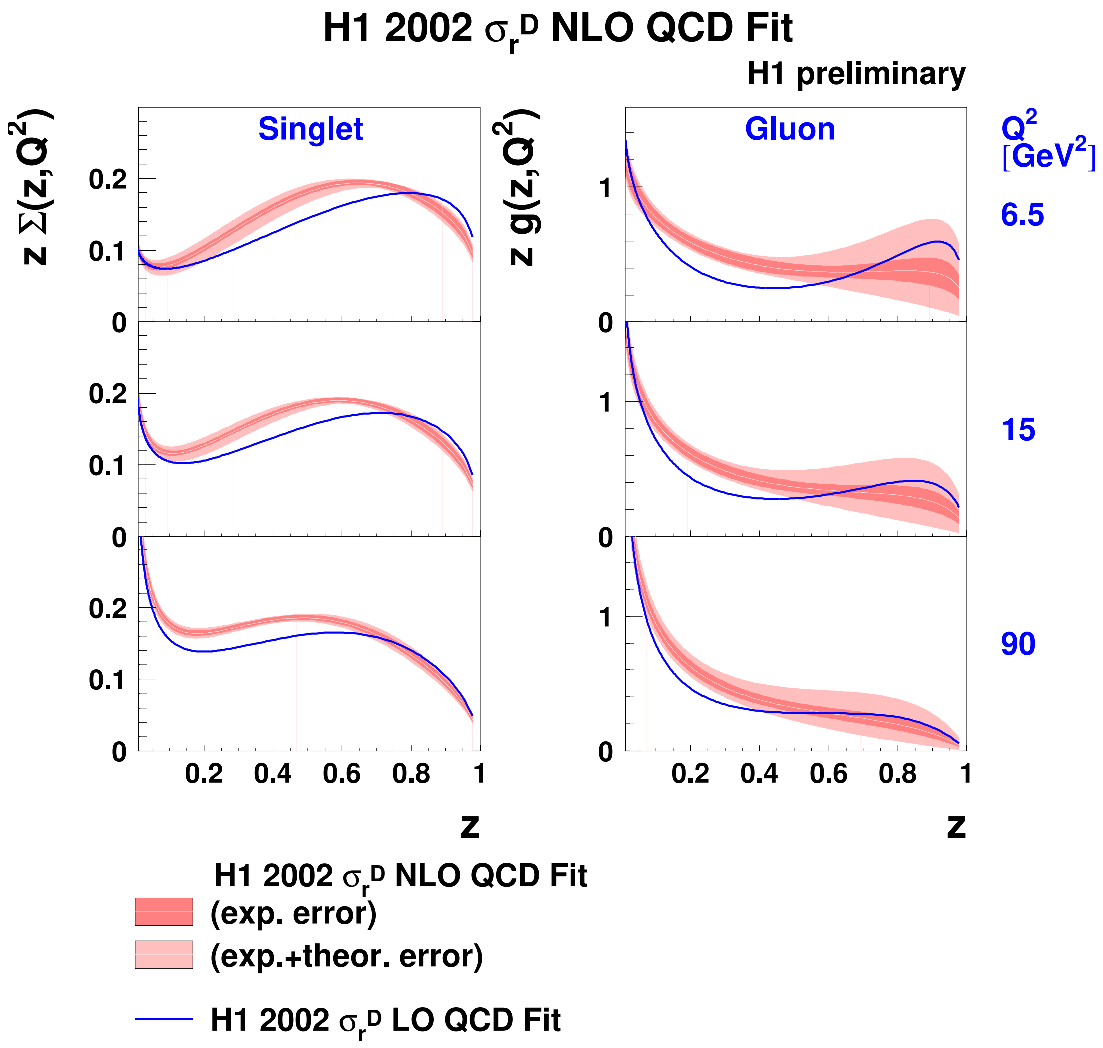


New H1 QCD Fits and The Final State

- New LO and NLO QCD fits to 1997 H1 $F_2^{D(3)}$ data
- First evaluation of experimental and theoretical uncertainties
- LO gluon density around 30% lower than 1994 fit

$\longrightarrow$ Consistent within errors

- Lower $\mathbb{R}$ contribution



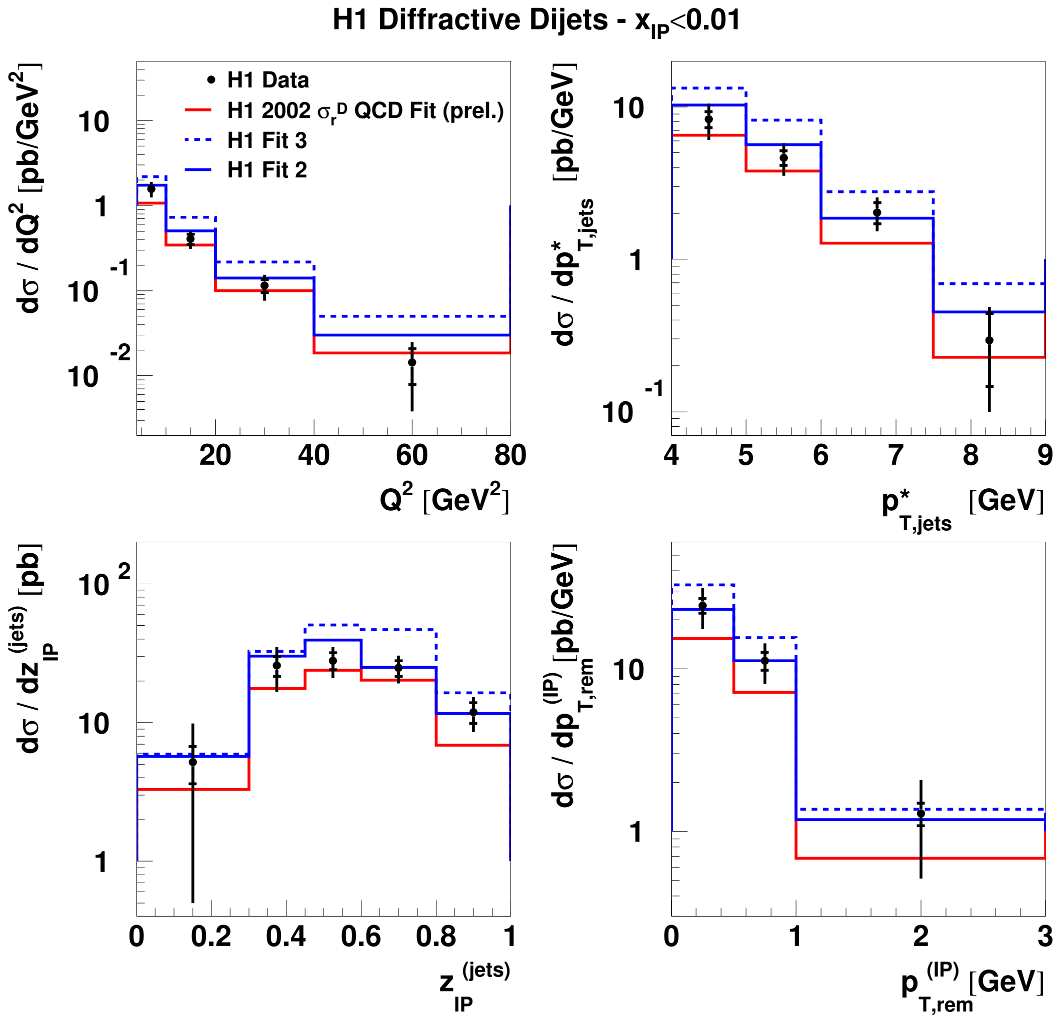
New H1 QCD Fits and Dijets

- Comparison with old and new LO QCD fits
- Shape remains well described
- Normalisation consistent with data when combined with uncertainties in

$\longrightarrow$ model parameters and scales

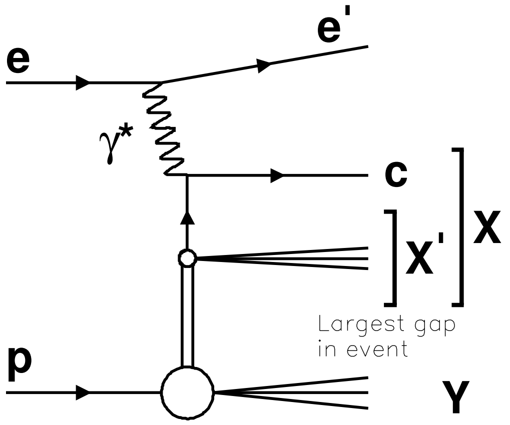
$\longrightarrow$ PDFs

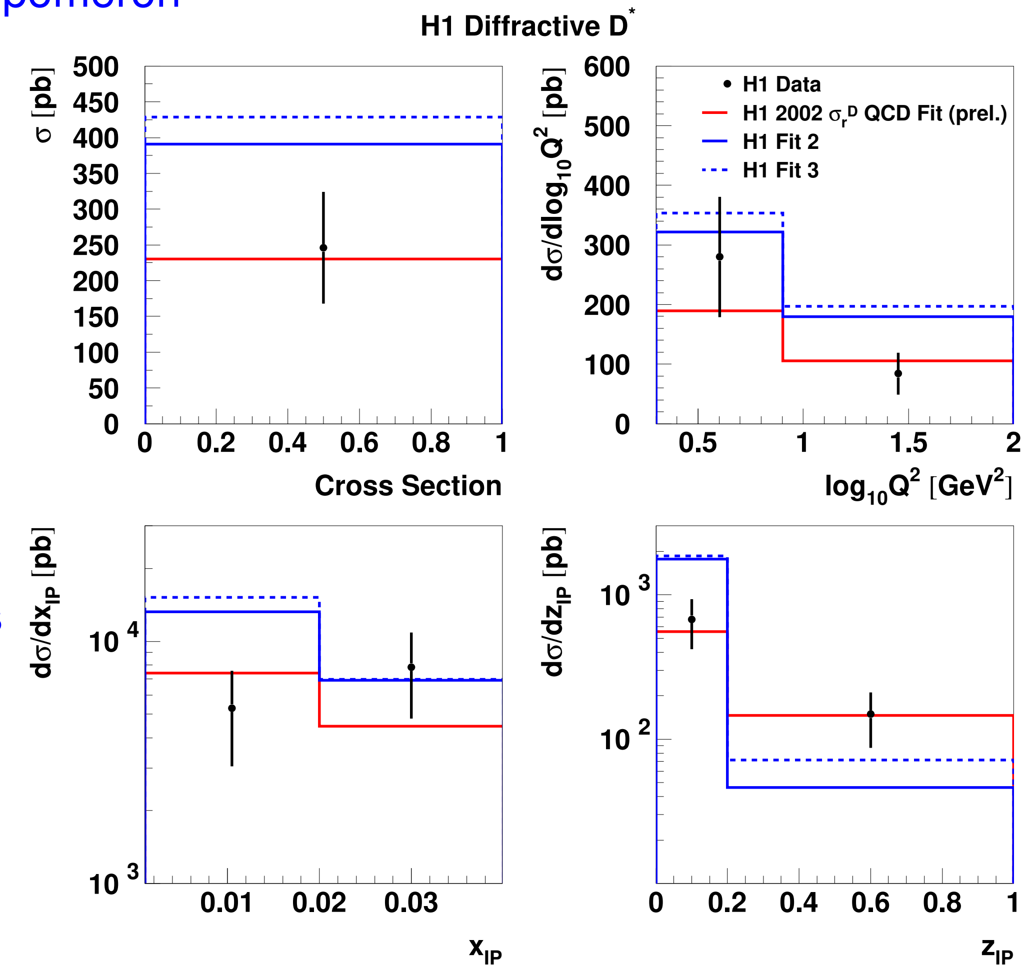
$\longrightarrow$ higher order QCD effects



New QCD Fits and Diffractive D^* Production

- Directly sensitive to gluon content of pomeron





- Comparison with new and old LO fits
- Cross section in better agreement

$\longrightarrow$ Similar normalisation uncertainties as in dijets

- Shapes continue to be described

New H1 QCD Fits and CDF Dijets

- CDF Roman Pot diffractive dijet data
- From diffractive / inclusive dijet ratio,

$$\tilde{F}^D_{JJ} = \frac{N^{\rm diff}}{N^{\rm incl}}(x_{\bar{p}}) \left\{ x_{\bar{p}} g(x_{\bar{p}}) + \frac{4}{9}\left[q(x_{\bar{p}}) + \bar{q}(x_{\bar{p}})\right] \right\}_{\bar{p}}$$

- Comparison with $\mathbb{P}$ partons from F_2^D

(standard $\mathbb{P}$ flux folded in)

$$\tilde{F}^D_{JJ} \propto \left\{ \beta g(\beta) + \frac{4}{9} x \left[q(\beta) + \bar{q}(\beta)\right] \right\}_{\mathbb{P}} \otimes f_{\mathbb{P}/p}(\xi)$$

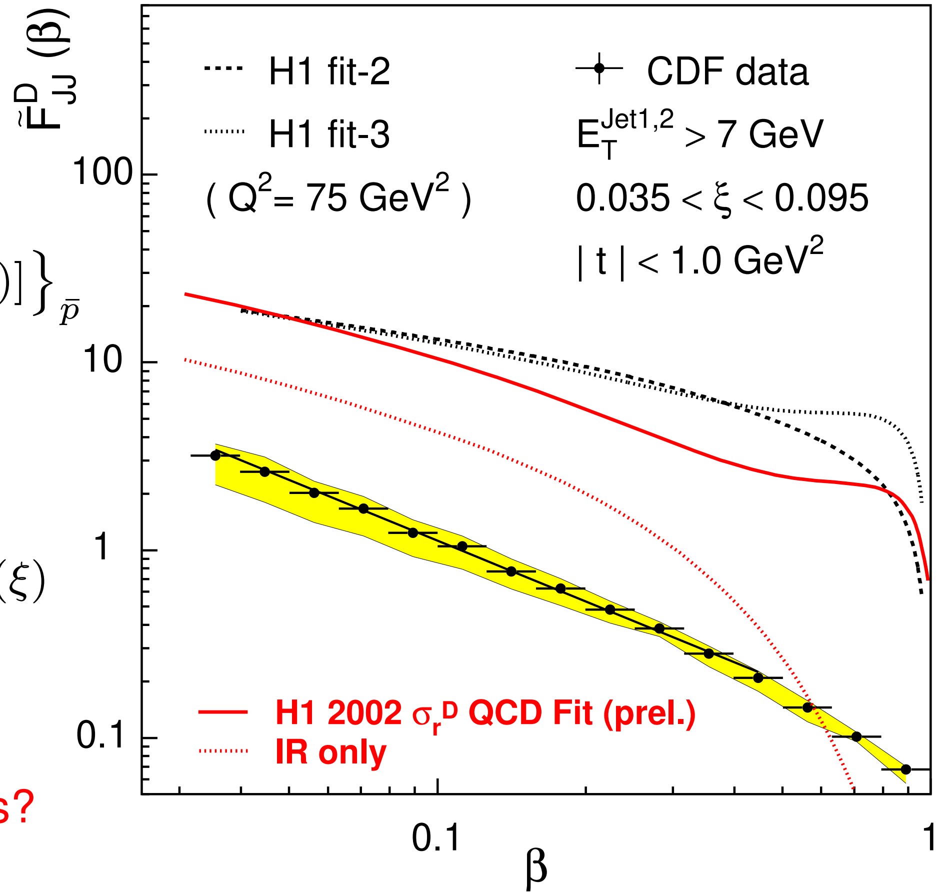
- Normalisation difference remains

$\longrightarrow$ destruction of gap by spectator interactions?

- Shape better described

$\longrightarrow$ Constant gap survival probability?

- $\mathbb{R}$ 50% at low β



Summary

- Diffractive Final state measurements well described by

1. Resolved $\mathbb{P}$ model with large gluon content of the $\mathbb{P}$
2. pQCD dipole models with inclusion of qqg at large M_X.

- Jet Measurements sensitive to

$\longrightarrow$ normalisation and shape of gluon distribution

$\longrightarrow$ k_T ordering and higher order QCD effects

- Evidence for a gluon remnant from the $\mathbb{P}$

- New H1 LO and NLO QCD partons obtained (with errors!)

$\longrightarrow$ Agreement with Dijets and D^* cross sections within normalisation uncertainties

- HERA II will allow a complete pQCD description of the diffractive final state?