

Experimental Contributions

1.	Arik Kreisel	ZEUS	Production of Vector Mesons in DIS
2.	Agnieszka Kowal	ZEUS	Diffractive photoproduction of VM at large t
3.	Caroline Collard	H1	Measurements of DME for ρ mesons production at intermediate t
4.	Duncan Brown	H1	Photoproduction of J/ψ at high t
5.	Dirk Ryckbosh	HERMES	Electroproduction of ρ , ω and ϕ mesons at HERMES
6.	Jan Olsson	H1	Proton dissociative ρ production
7.	Tobias Golling	H1	Search for contribution of Odderon- γ fusion to π^0 production
8.	Karl-Heinz Hiller	H1	Measurement of photoproduction cross section with a leading proton
9.	Antonio Pellegrino	ZEUS	Measurement of the diffractive cross section in ep interactions at low Q^2
10.	Barbara Smalska	ZEUS	Diffractive results from the ZEUS Leading Proton Spectrometer
11.	Alberto Garfagnini	ZEUS	Leading baryon production in ep scattering
12.	Dino Goulianos	CDF	Diffraction in CDF: Run I results and plans for Run II
13.	Christophe Royon	D0	Run I results in diffraction in D0 and prospects for Run II
14.	Igor Vorobiev	L3/OPAL	Hadronic cross sections of untagged and double-tagged 2 photon events at LEP
15.	Taro Yamashita	ZEUS	Hadronic final states and 3-jet production
16.	Frank-Peter Schilling	H1	Diffractive jet production in DIS
17.	Irina Korzhavina	ZEUS	Study of D^* meson production in diffractive ep scattering at HERA

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+ crew

: Marco Gabbini

Sandro Bortini

Silvia Miglioranza

THANK

YOU

Report from the Diffractive Working Group

Experimental Results

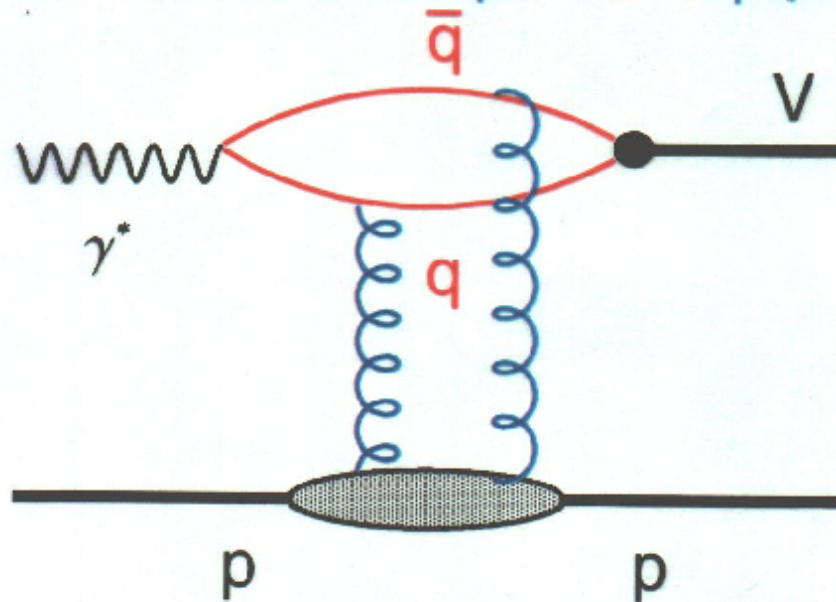
Halina Abramowicz, Jochen Bartels, Gerhard Knies
Bologna DIS01

Outline

- VM
 - σ_L/σ_T
 - pomeron trajectory $\alpha(t)$
 - $d\sigma/dt$
- Leading baryon production
 - Q^2 dependence of rates
- Hadronic final states and Jets
 - sensitivity to diffractive gluons
- Future
 - CDF, D0
 - scaling
 - LEP measurements

Exclusive vector meson in ep

Candidate for a hard process $\Rightarrow$ pQCD



Expectations:

- SU(4) restoration

$$\rho : \omega : \Phi : J/\psi = 9 : 1 : 2 : 8$$

If $q\bar{q}$ form small configuration $\Rightarrow$ resolves gluons

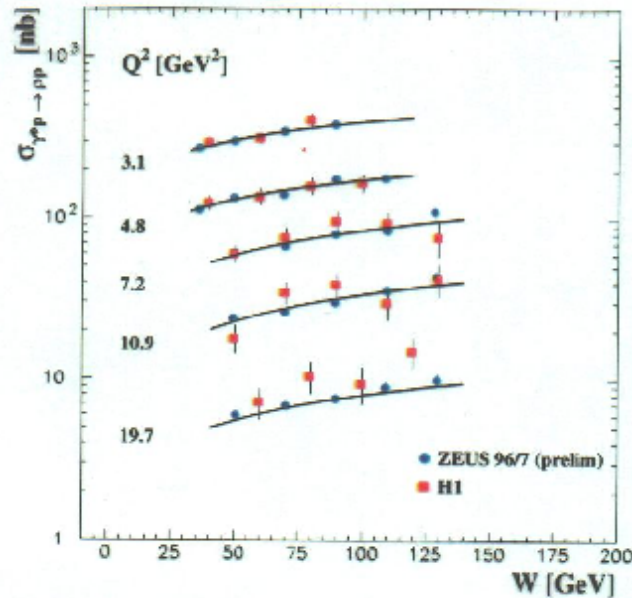
either γ_L^* or $V = c\bar{c}, b\bar{b}$

- $\sigma_L \sim \frac{\alpha_s^2}{Q^6} |xG(x, Q^2)|^2$
 - $\Rightarrow$ fast increase of $\sigma(\gamma^* p \rightarrow V p)$ with W^2
 - $\Rightarrow$ universality of t dependence $\sim e^{b_{2g}t}$
 - $b_{2g} \simeq 4 \text{ GeV}^{-2}$ and $\alpha'_P \simeq 0$
 - $\Rightarrow Q^2$ dependence slower than $1/Q^6$

- σ_T ?

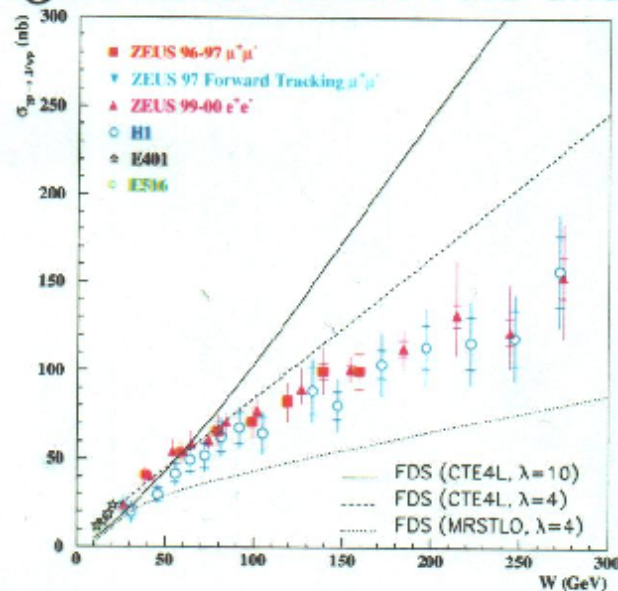
Update on exclusive vector meson

$$\gamma^* p \rightarrow \rho p$$



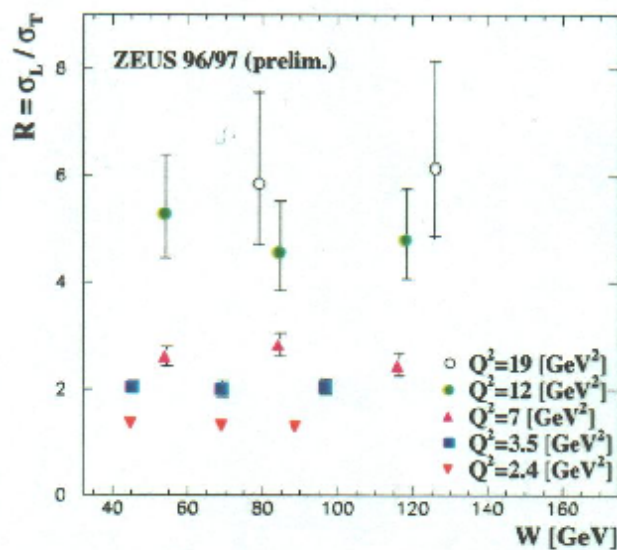
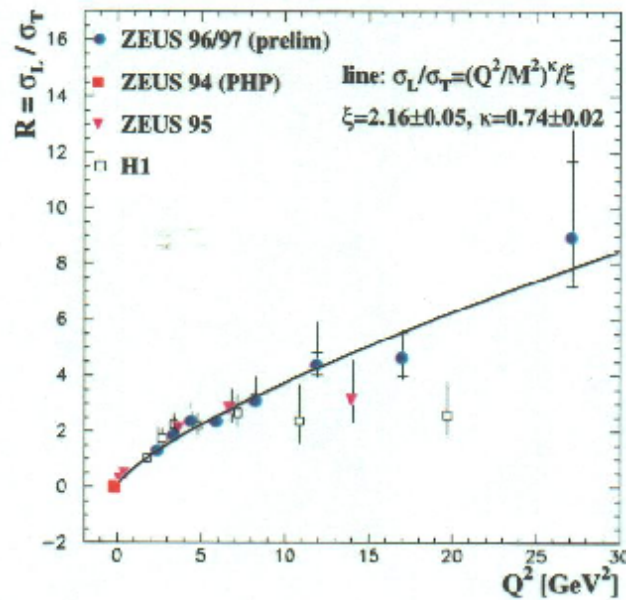
Good agreement between H1 and ZEUS

$$\gamma^* p \rightarrow \gamma/\psi p$$



Curves by Frankfurt, McDermott and Strikman

$$R = \sigma_L / \sigma_T \text{ in } \gamma^* p \rightarrow \rho p$$



σ_L dominates at high Q^2
 σ_T has the same W dependence - large sizes
 suppressed !!!

unlike the inclusive case

Shrinkage: α'_P in J/ψ and ρ production

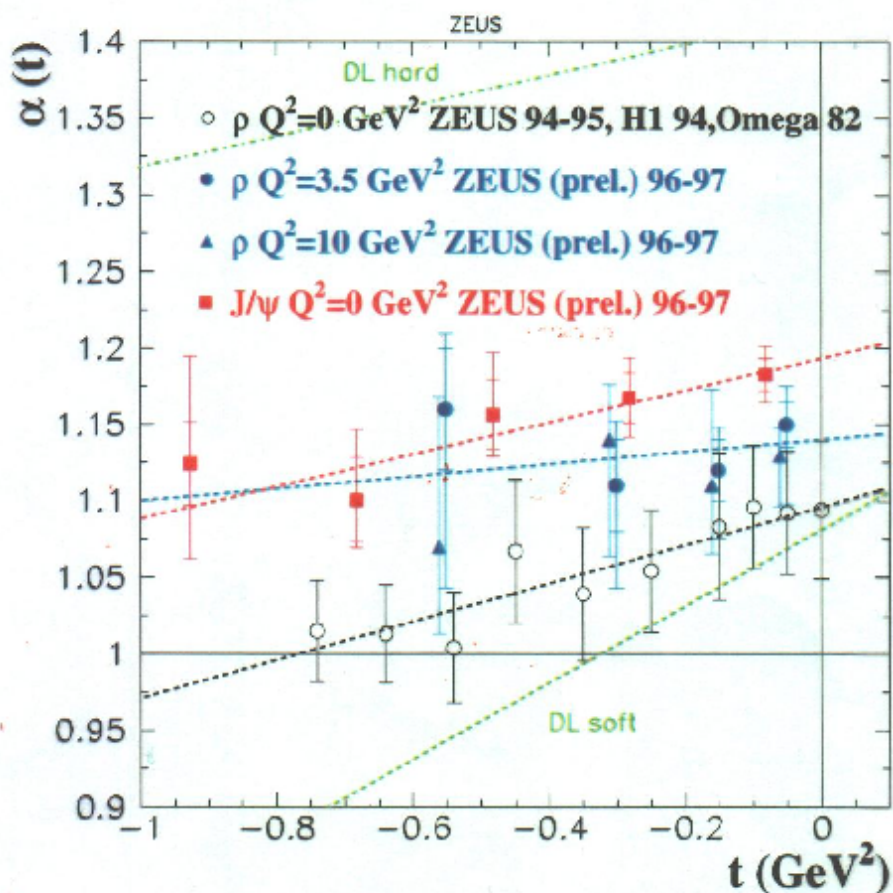
$$\frac{d\sigma}{dt} \sim e^{bt} \text{ with } b = b(W_0) + 4\alpha'_P \ln \left(\frac{W}{W_0} \right)$$

soft partons: $k_T \simeq k_{T0}$ and $\alpha'_P \sim \frac{1}{k_{T0}^2}$

hard partons: $k_T \simeq Q$ and $\alpha'_P \sim \frac{1}{Q^2}$

If pQCD occupies most of the phase space α'_P has to be small

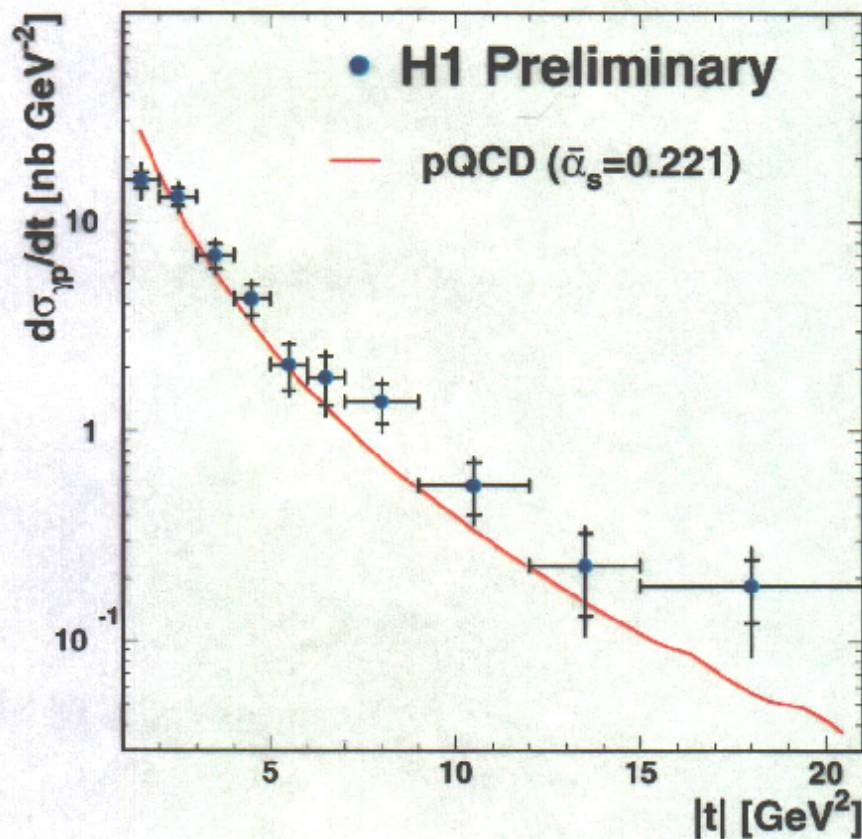
$$\text{for fixed } t: \frac{d\sigma}{dt} \sim W^{4(\alpha(t)-1)}$$



Non-universal trajectory

$$\gamma p \rightarrow J/\psi + Y$$

pQCD Comparison to Differential Cross Section



power law
dependence
at large t

$$50 < W_{\gamma p} < 160 \text{ GeV}$$

$$Q^2 < 1.0 \text{ GeV}^2$$

$$1.0 < |t| < 21.0 \text{ GeV}^2$$

⇒ BFKL Model describes the $|t|$ -behaviour.

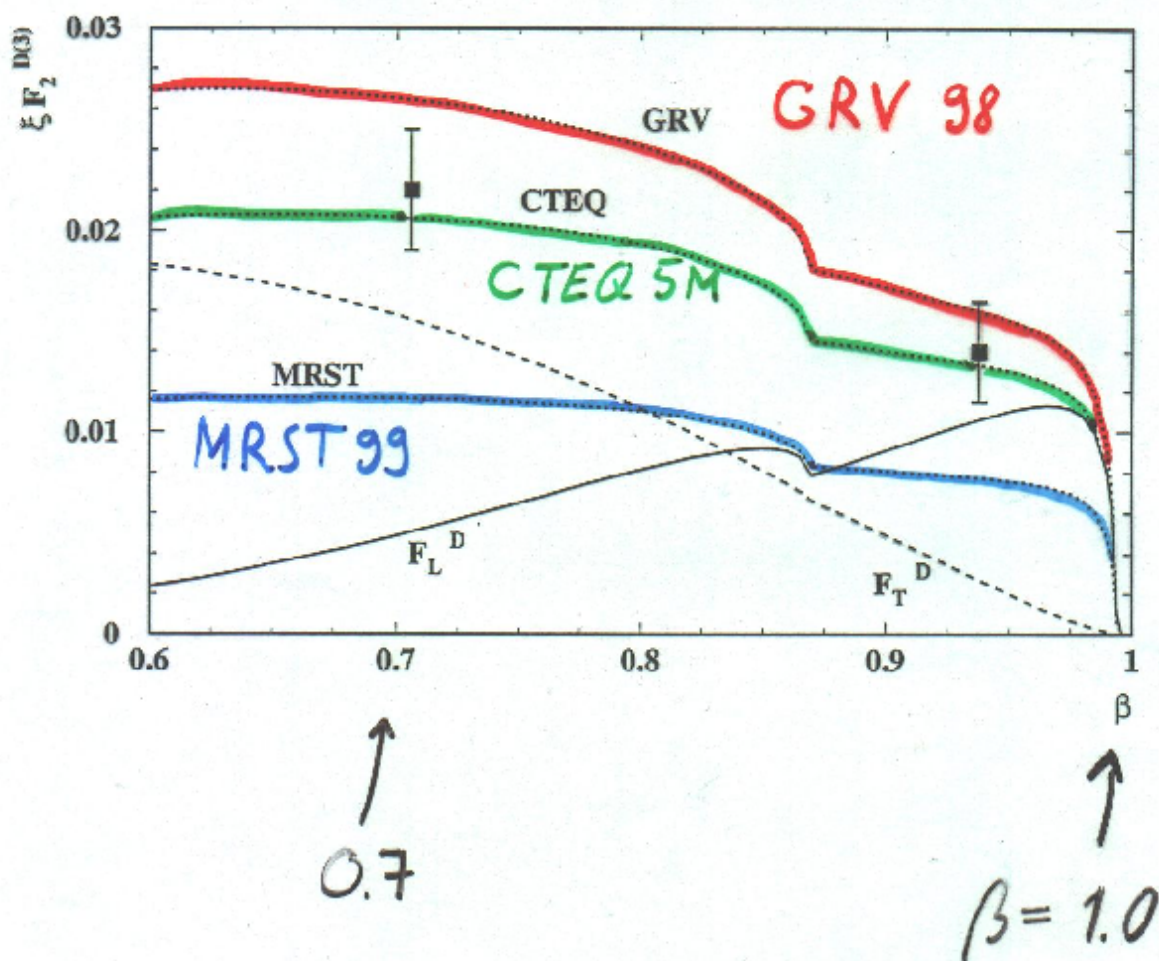
It might be possible to measure $\gamma p \rightarrow J/\psi + p$

⇒ Elastic amplitude in impact parameter space

NLO-prediction of

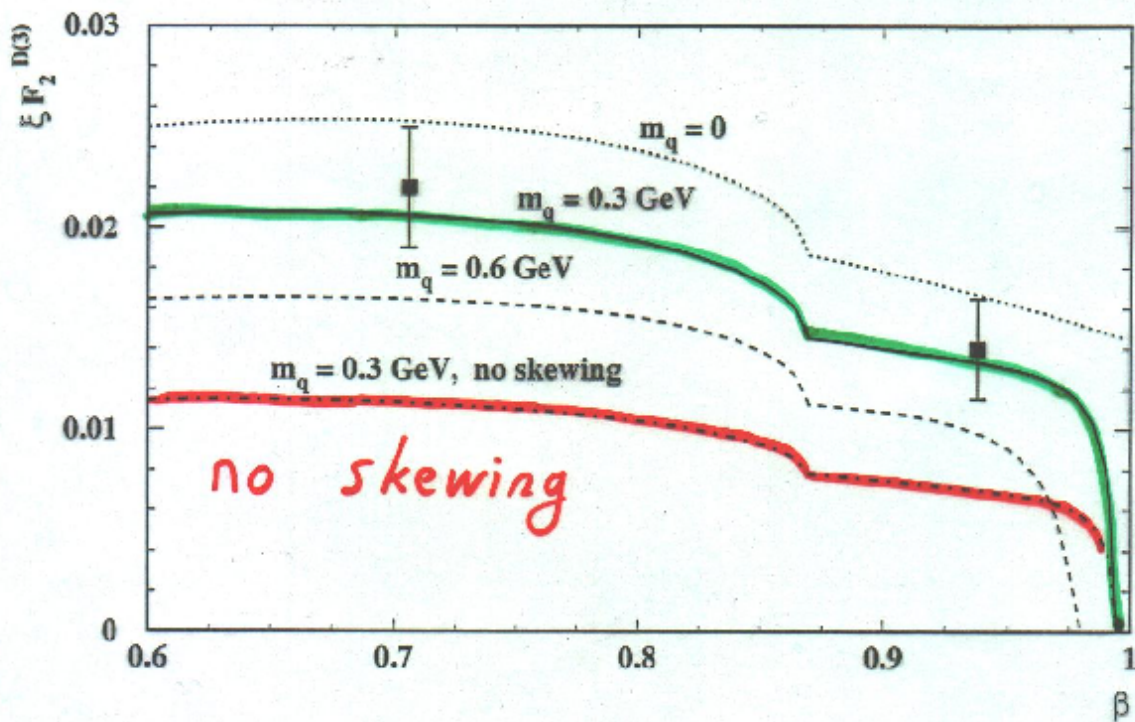
$F_2^{D(3)}(\beta, \xi, Q^2)$ at $Q^2 = 60 \text{ GeV}^2$,
 $\xi = 0.0042$

compared to ZEUS data



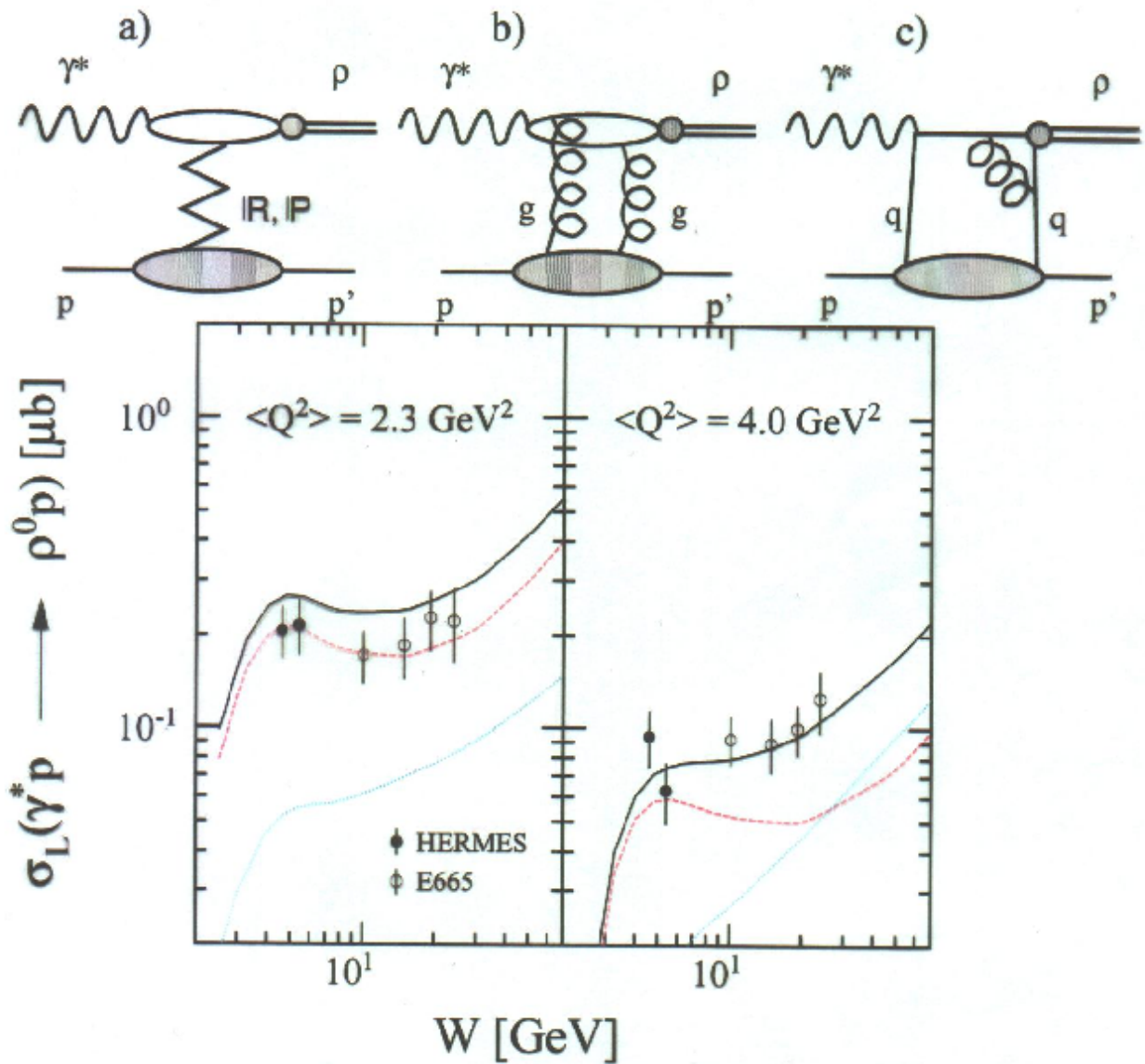
→ strong sensitivity on the
 input gluon distribution

"skewing effects" in the NLO -
prediction of $F_2^{D(3)}$



→ skewing very important (like in τ production)

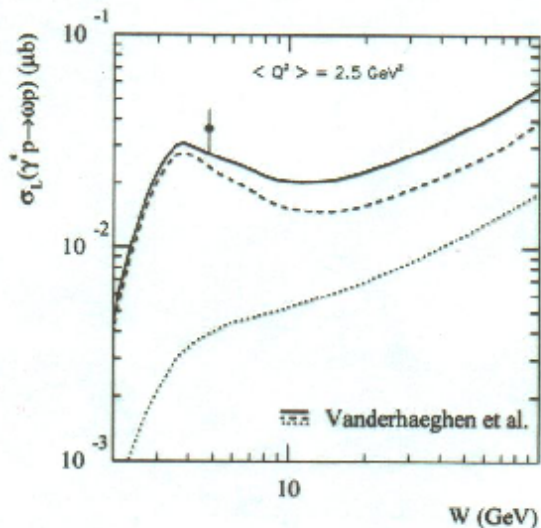
VM-production



b) 2-gluon exchange:
dots

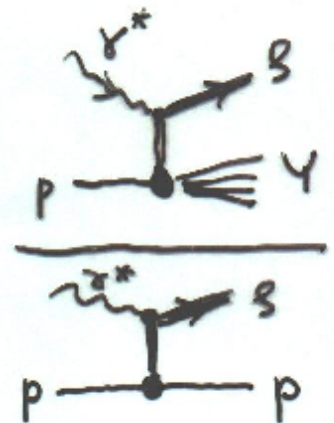
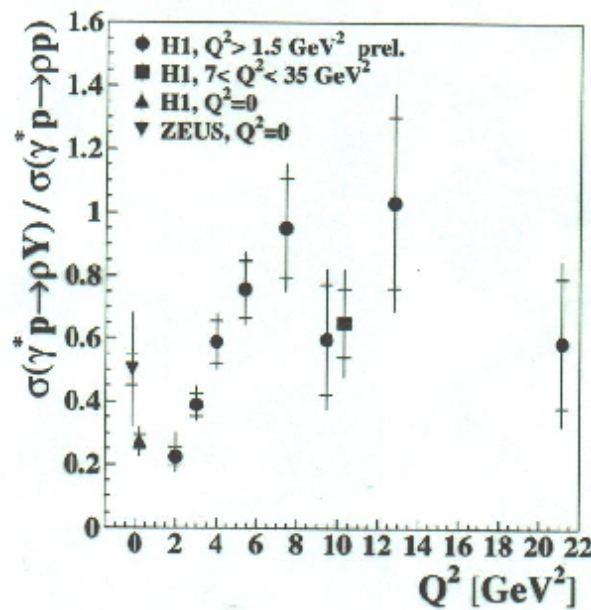
c) quark-exchange:
dashes

Vanderhaeghen et al
PRD60(1999)094017

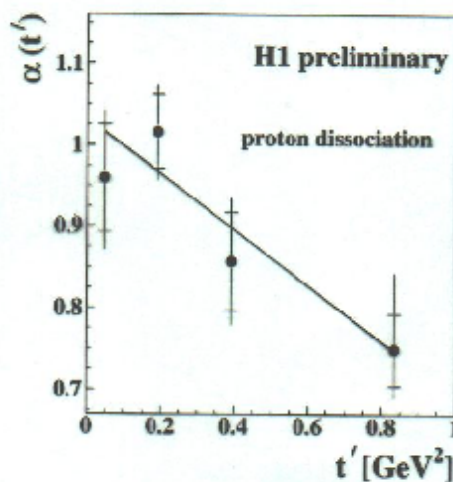


The proton vertex and Q^2 dependence

$$\text{Ratio} = \gamma^* p \rightarrow \rho Y / \gamma^* p \rightarrow \rho p$$



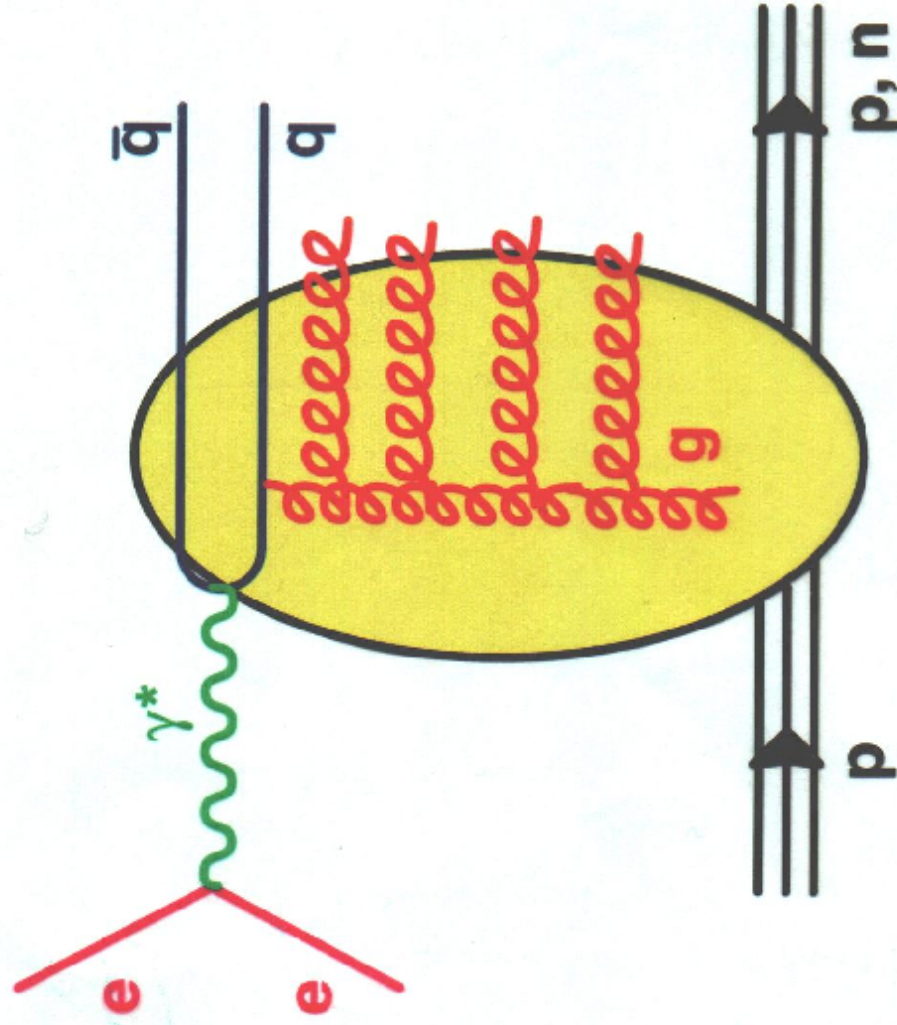
corresponding trajectory, $\langle Q^2 \rangle = 3.8 \text{ GeV}^2$



$$\alpha' = 0.34 \pm 0.08^{+0.12}_{-0.08}$$

Introduction

Study of leading baryon production at small t in hadronic interactions $\Rightarrow$ soft process
At HERA, at small x :



Scales of the reaction:

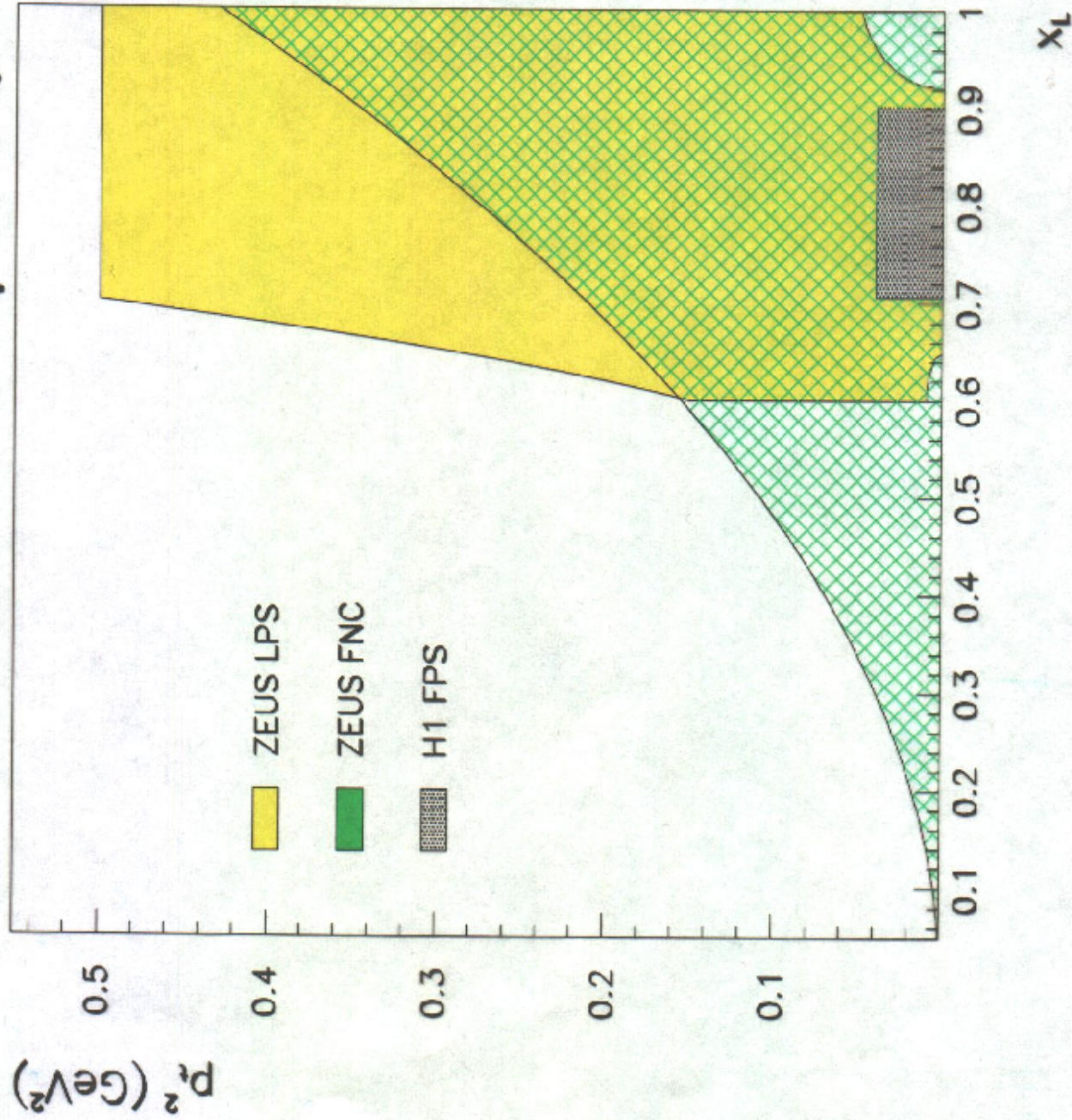
$$Q^2 = 0.1 - 1000 \text{ GeV}^2$$

$$p_t^2 < 0.5 \text{ GeV}^2$$

hard $\longleftrightarrow$ soft

$$(x_L = E_{p,n}/E_{\text{beam}}, p_t^2)$$

Kinematic plane (baryon)



Protons

ZEUS LPS: (FULL RANGE $0.6 < x_L < 1$)

- $0.6 < x_L < 0.97$
- $p_t^2 < 0.5 \text{ GeV}^2$

H1 FPS:

- $0.7 < x_L < 0.9$
- $p_t^2 < 0.04 \text{ GeV}^2$

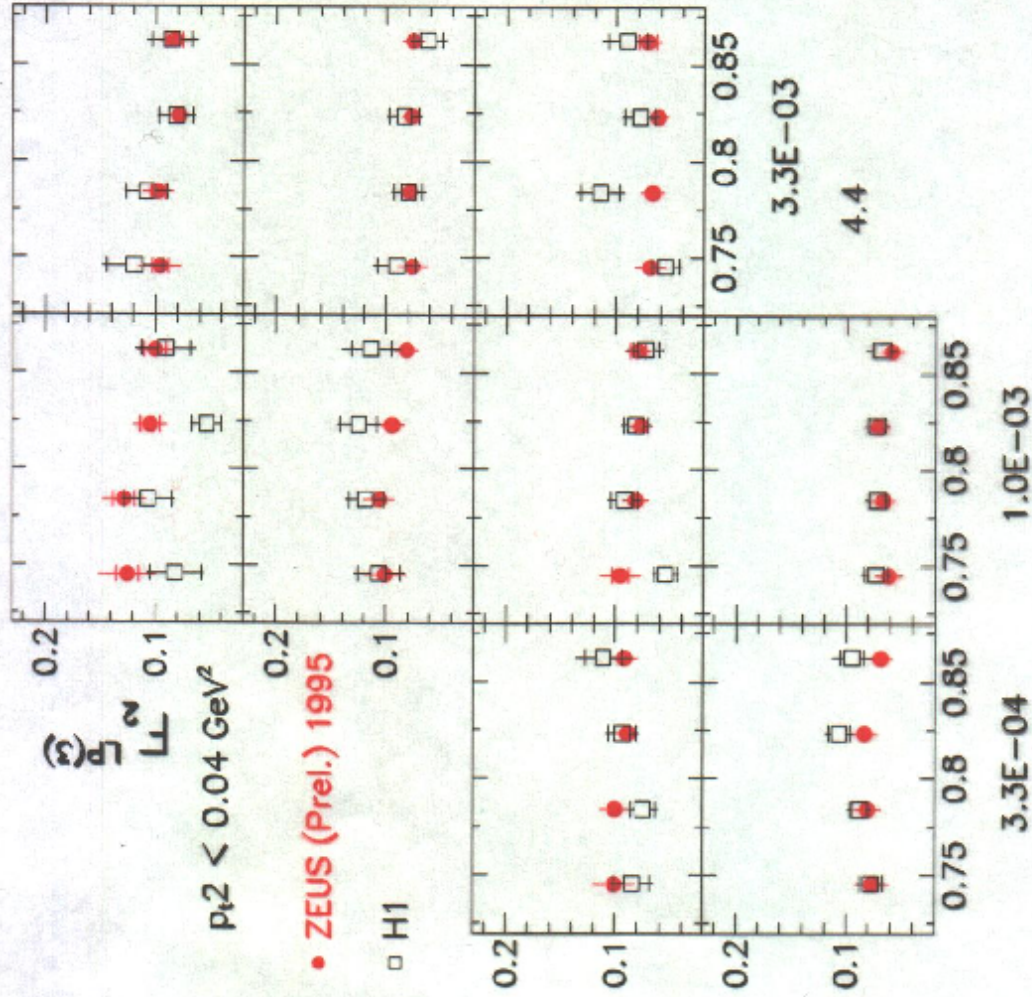
Neutrons

ZEUS FNC:

- $\theta_n < 0.8 \text{ mrad}$
- $p_t^2 < (0.66 x_L)^2$

F₂^{LP(3)} ZEUS-H1 comparison

ZEUS



Restricting the kinematic range to H1 FPS:

- $p_t < 200 \text{ MeV}$
- $0.7 < x_L < 0.9$
- $2 < Q^2 < 50 \text{ GeV}^2$
- $6 \cdot 10^{-5} < x < 6 \cdot 10^{-3}$



reasonable agreement between the measurements



Leading baryons

$$ep \rightarrow eXp(n)$$

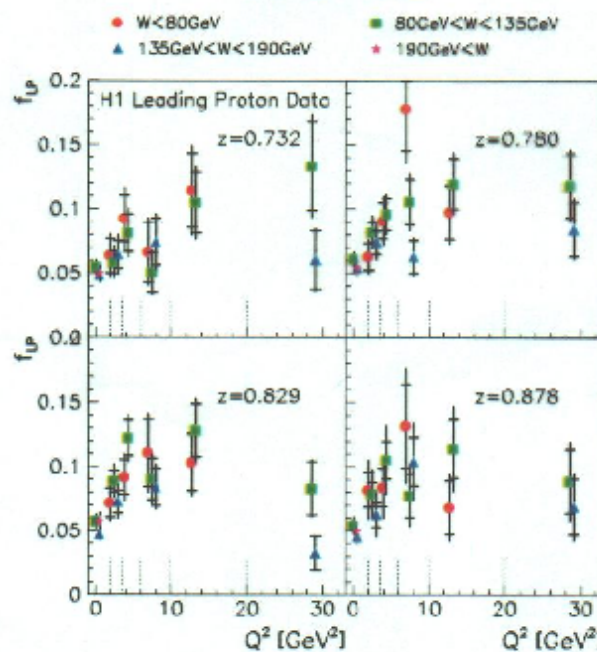
$$x_l = E_{p(n)} / E_{\text{beam}}$$

after integrating over p_t define (exp. dep.)

$$r = \sigma(x, Q^2, x_l) / \sigma(x, Q^2)$$

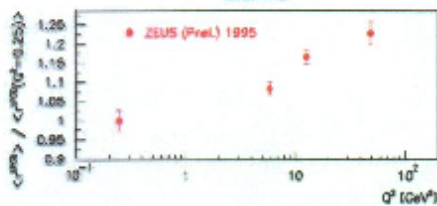
FPS - H1

leading
proton



LPS

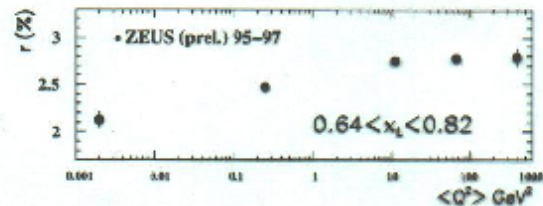
ZEUS



leading proton

FNC

ZEUS

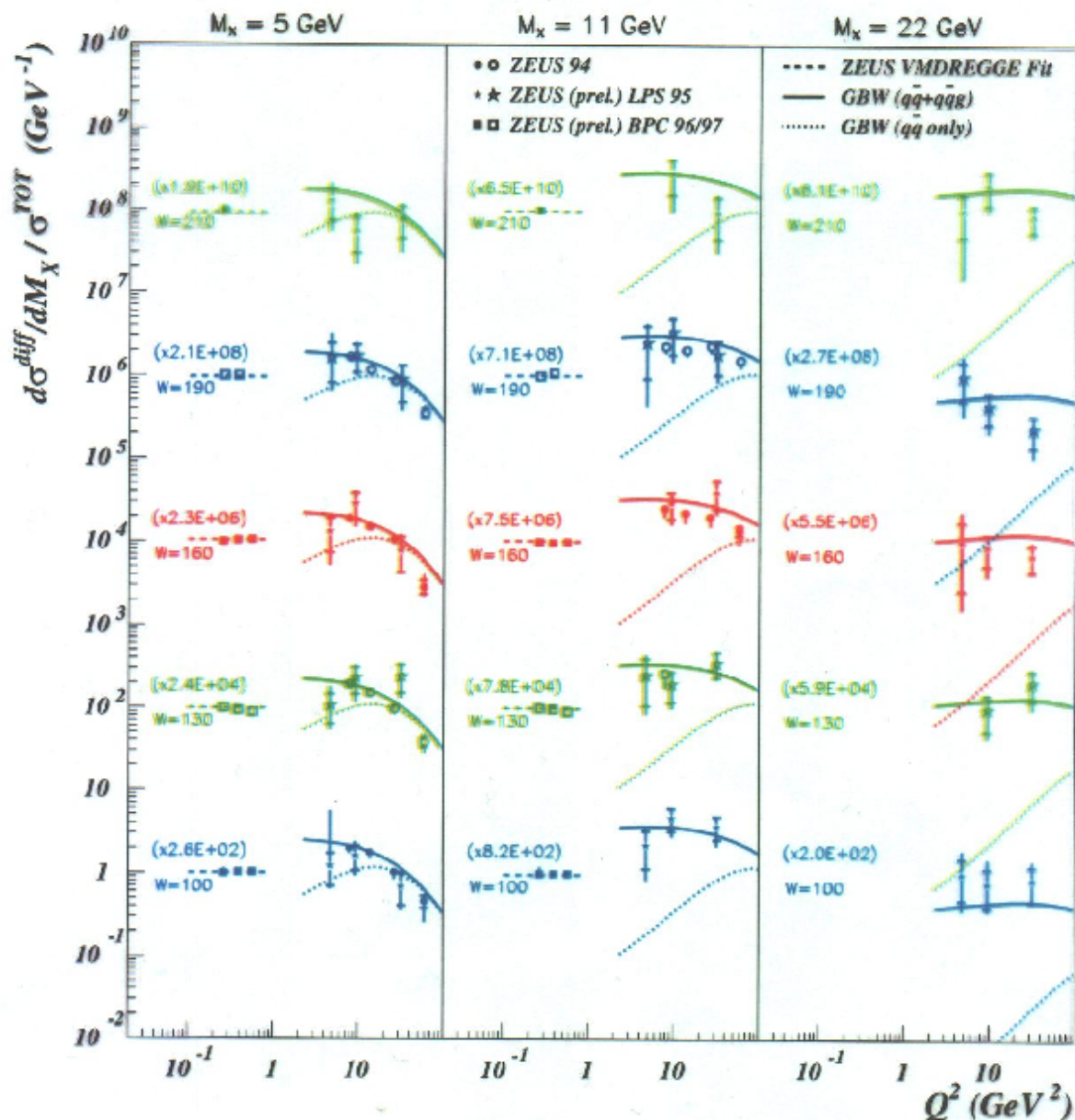


leading neutron

The photon vertex and Q^2 dependence

$$r = \sigma^{\text{diff}}(Q^2, W, M_X) / \sigma(Q^2, W)$$

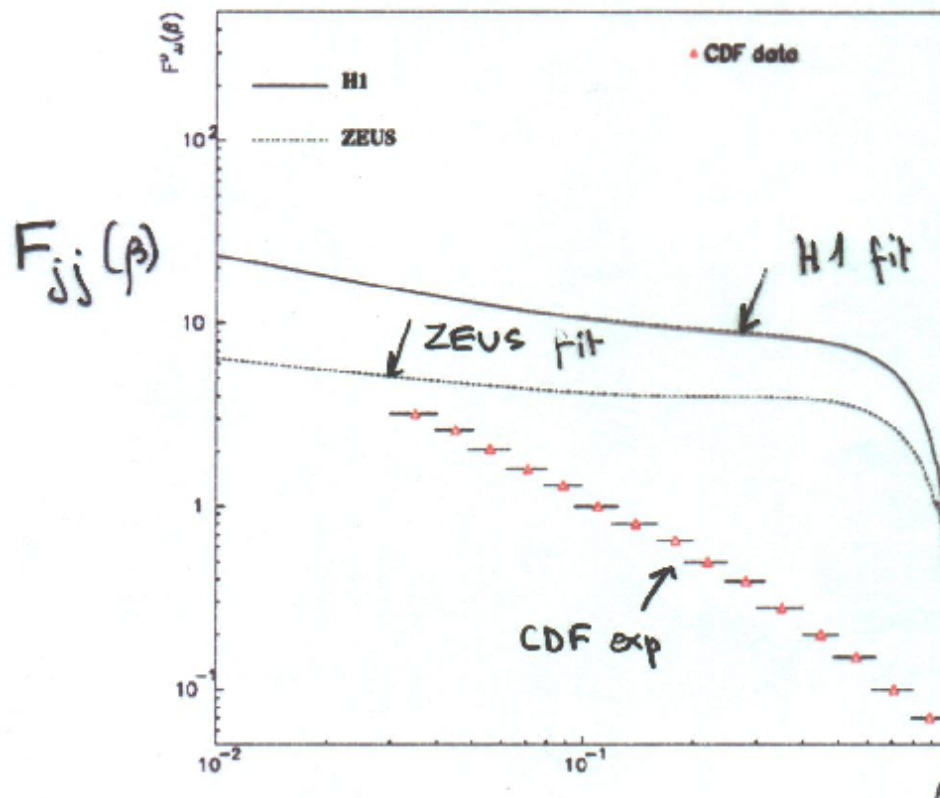
ZEUS



Extrapolation to Tevatron

Test factorization breaking between HERA and the Tevatron

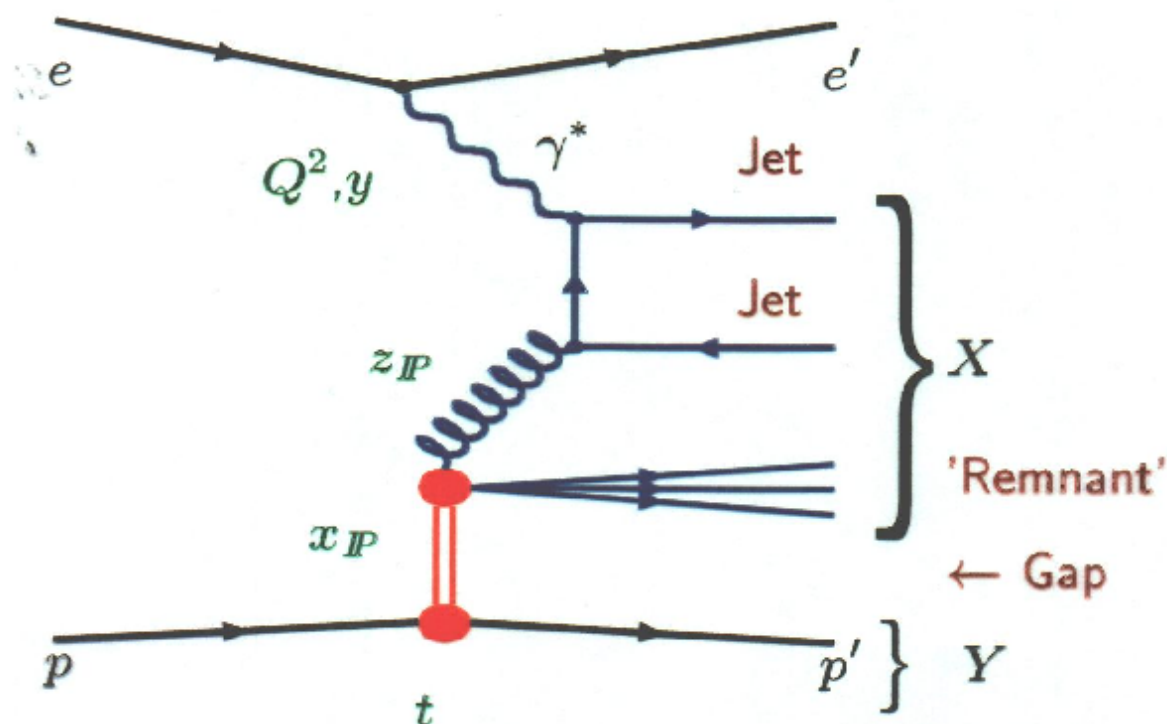
Thus, we need Extrapolations of the H1 and ZEUS QCD fits to the recent CDF diffractive jet cross-section measurements



ZEUS data are compatible with factorization at low β

NOTE : the extrapolation to the CDF domain suffers from large uncertainties $\rightarrow$ more precise data needed

Kinematics



Q^2, y

– Usual DIS variables

M_X

– Invariant mass of X system

M_{12}

– Invariant mass of two leading jets

$$x_P \approx \frac{Q^2 + M_X^2}{Q^2 + W^2}$$

– Momentum fraction carried by colourless exchange

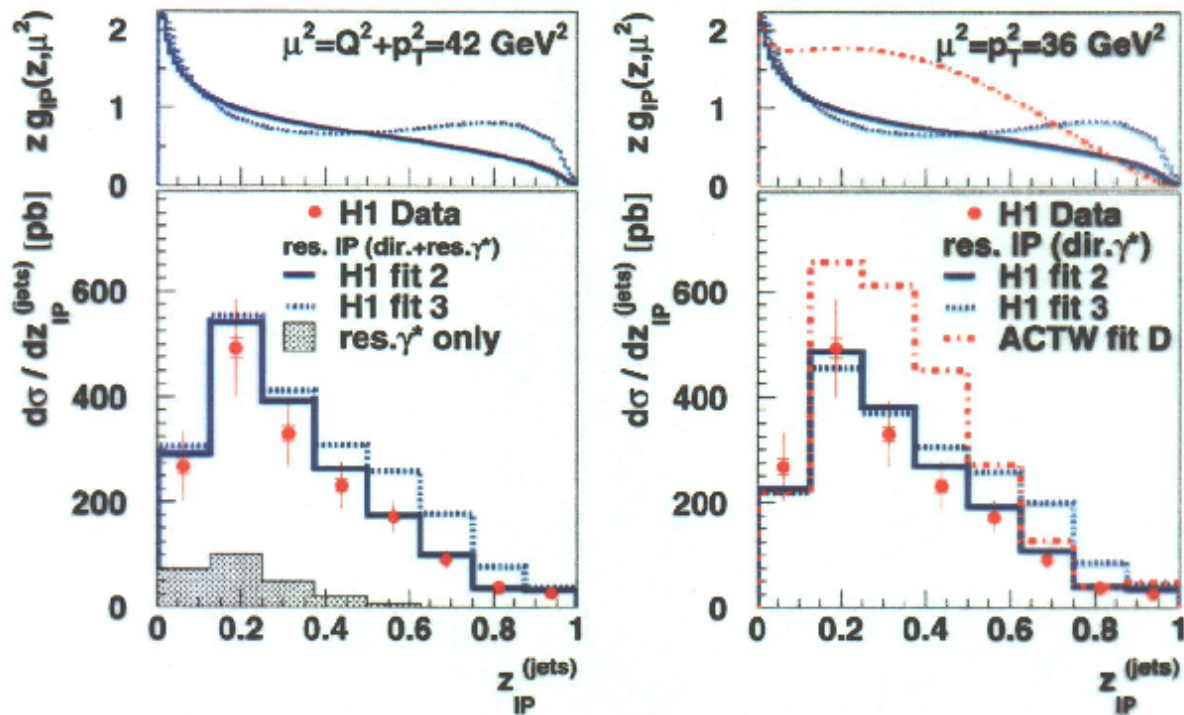
$$z_P^{(jets)} \approx \frac{Q^2 + M_{12}^2}{Q^2 + M_X^2}$$

– Momentum fraction of exch. entering hard scattering

Diffractive Gluon Distribution

Dijets directly constrain shape and normalization of g^D :

H1 Diffractive Dijets



[res. γ^* , R and quark contributions small]

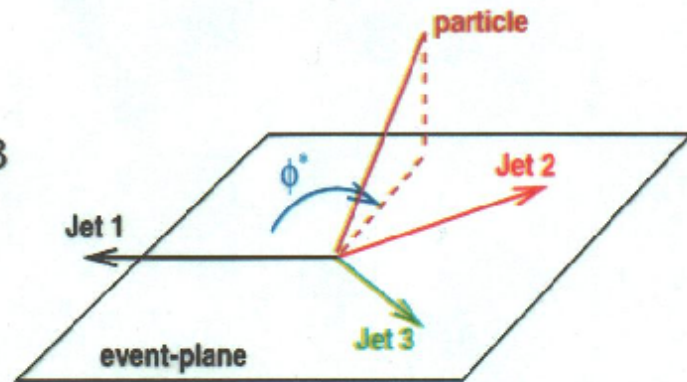
- H1 fit 2: very good agreement with data
- H1 fit 3: overshoots at high z_P
- ACTW-D: too high

⇒ Strong support for fully factorizable diffr. PDF's in DIS which are gluon-dominated with momentum distr. flat in z

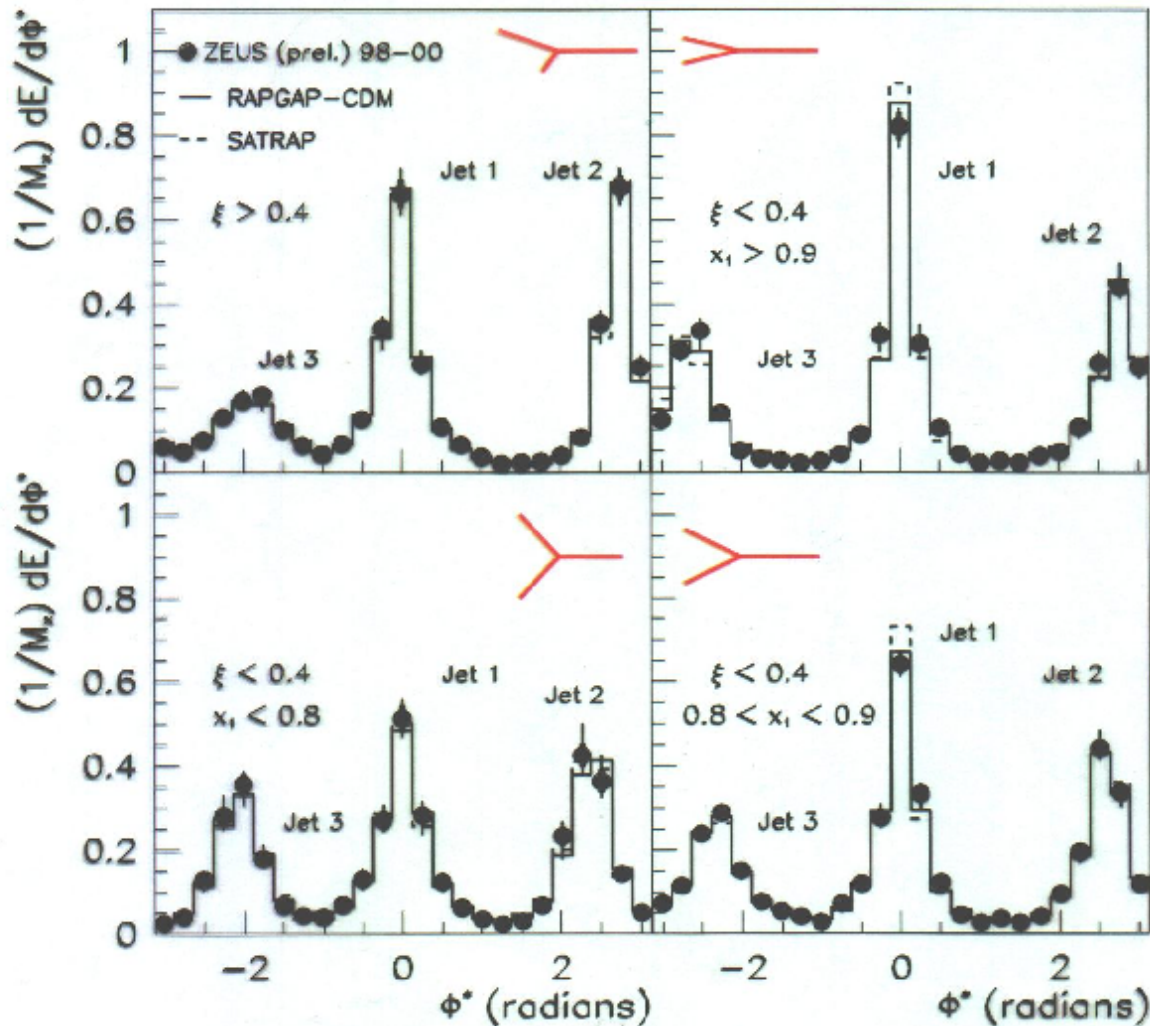
Proton rest frame picture: $q\bar{q}g \gg q\bar{q}$ states

Energy flow in the 3-jet plane

$$E_{\text{jet1}} \geq E_{\text{jet2}} \geq E_{\text{jet3}}$$

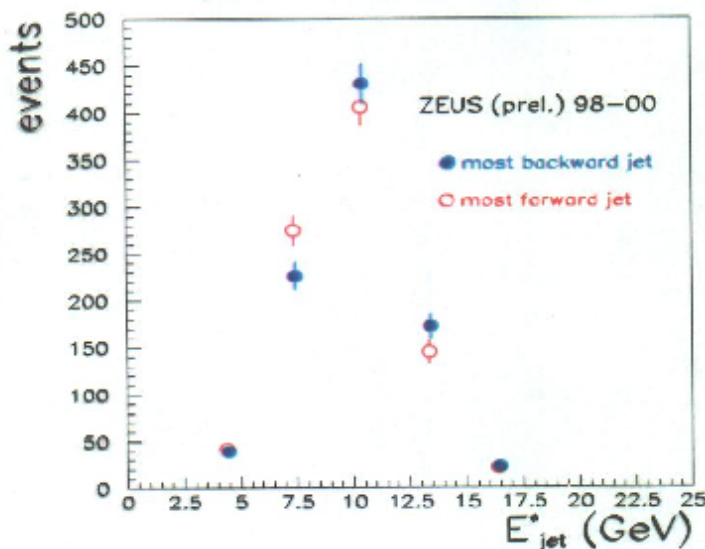
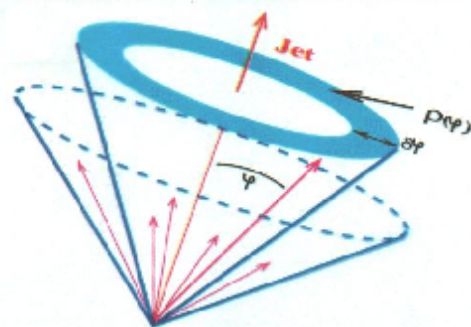
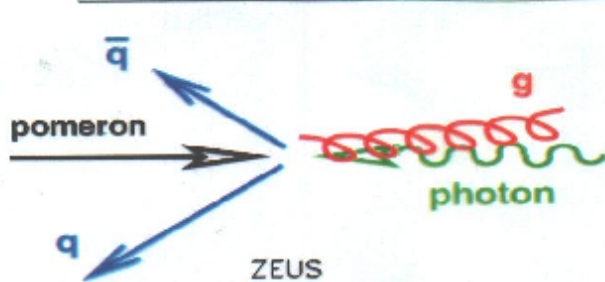


ZEUS



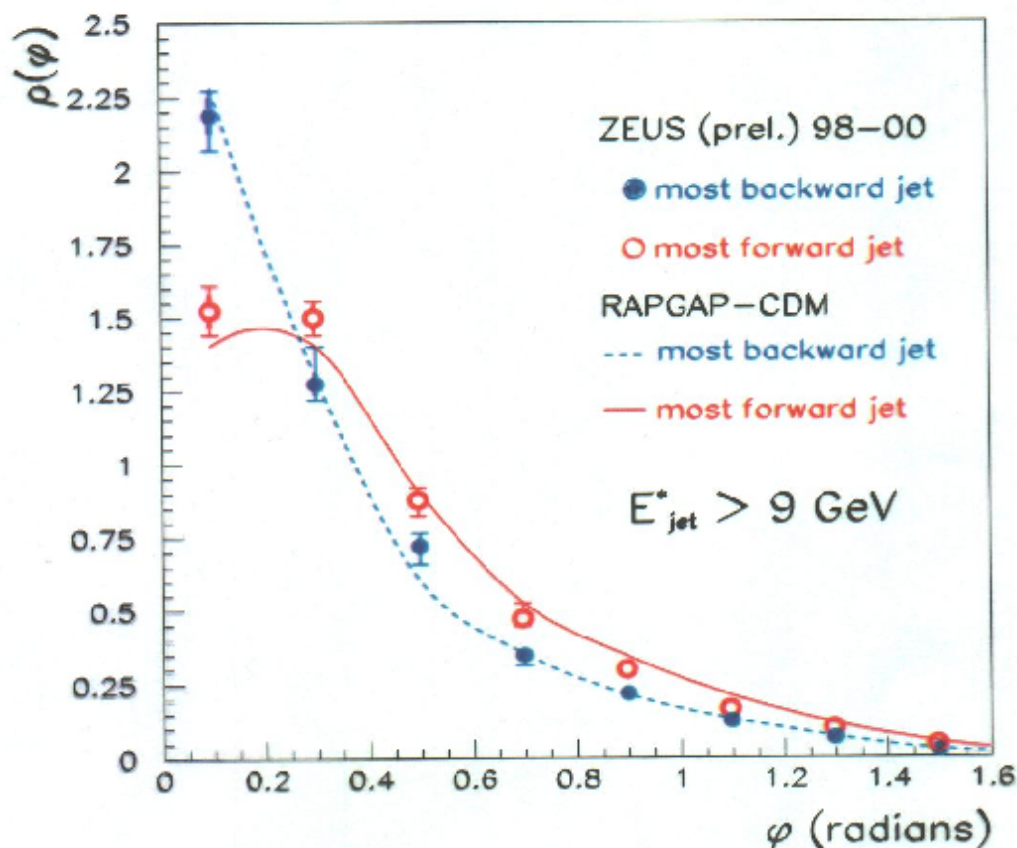
- **Clear 3-jet structure** is seen in all (x_1, ξ) region
- Energy flow in the plane is well described by RAPGAP (CDM) and SATRAP

Jet shape in diffractive DIS 3jet events



$$\rho(\varphi) = \left\langle \frac{1}{\delta\varphi} \frac{E_{jet}^{(\varphi \pm \delta\varphi/2)}}{E_{jet}} \right\rangle$$

~ Same E_{jet} distribution
most forward / backward jet



- Most forward jet is broader than most backward jet
- Data are described by the model where g is emitted to the $\mathbb{P}$ side and one of q is emitted to the γ side.
⇒ Supports the picture

Event shapes in diffractive DIS

Proton is tagged using **Leading Proton Spectrometer (LPS)**

$$4 < Q^2 < 150 \text{ GeV}^2, \quad 70 < W < 250 \text{ GeV}$$

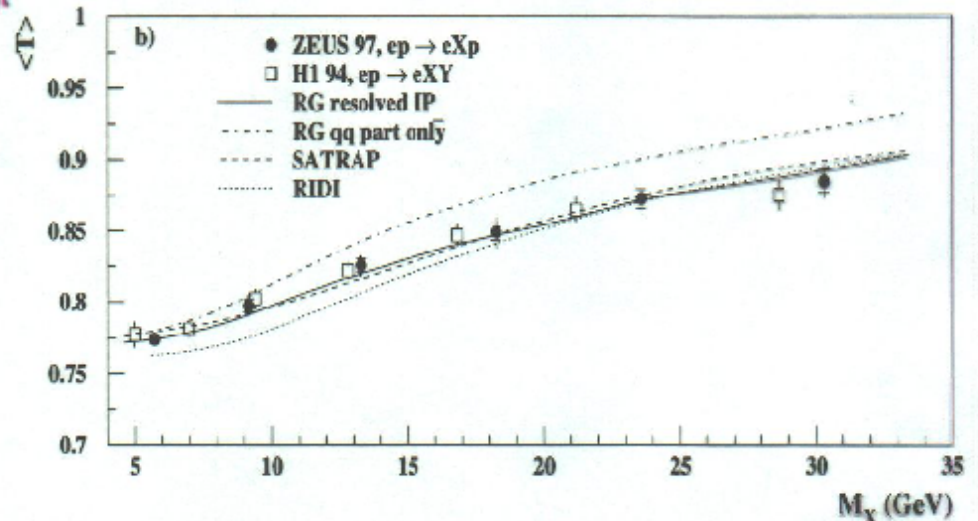
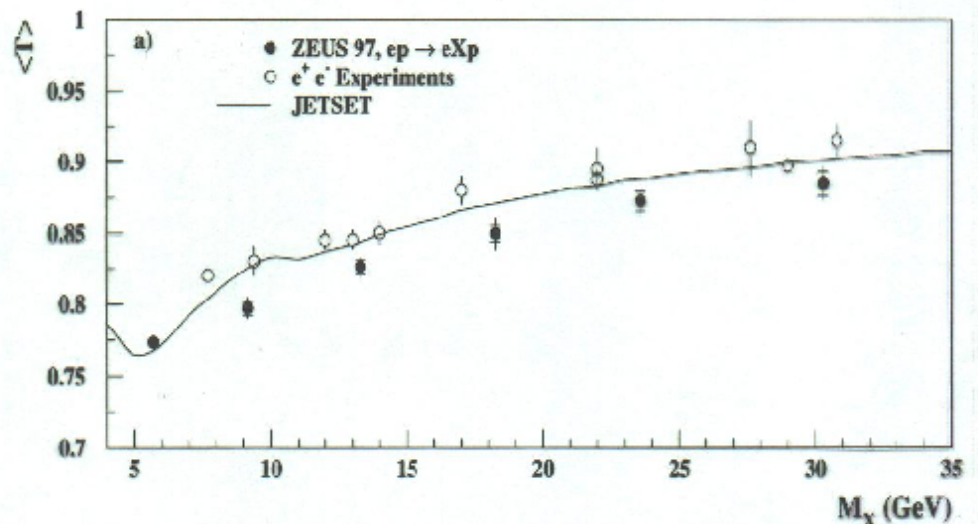
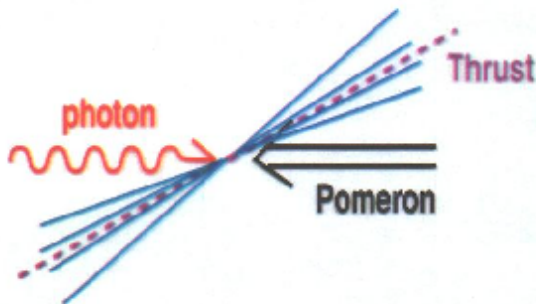
$$0.0003 < x_P < 0.03, \quad 4 < M_X < 35 \text{ GeV}$$

$$13.8 \text{ pb}^{-1}, \quad \text{CMS of hadronic system (X)}$$

Mean thrust value ($\langle T \rangle$) as a function of M_X

$$T(\hat{n}) = \frac{\sum_i |\hat{n} \cdot p_i|}{\sum_i |p_i|}$$

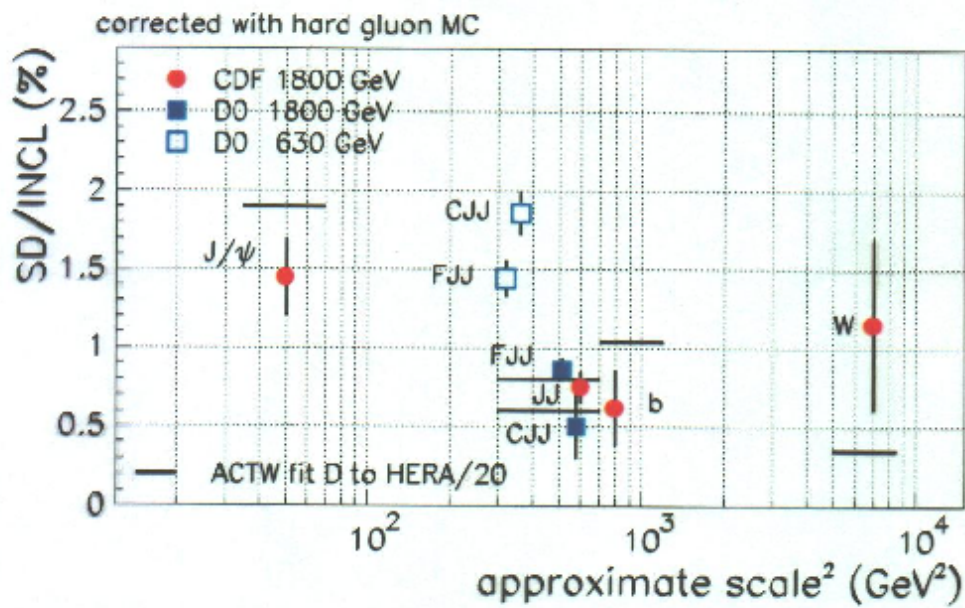
($\hat{n} : \max T(\hat{n})$)



- $\langle T \rangle$ now **agrees with H1**
 $\Leftarrow$ **Definition of HFS changed** such that short life time particles such as D^+ are decayed.
- $\langle T \rangle$ becomes **larger as M_X increases**
- $\langle T \rangle$ in diffraction is **smaller than in e^+e^-**
- Resolved pomeron model (RAPGAP) describes data
 $q\bar{q}$ part only is too narrow $\sim e^+e^-$
 $\Rightarrow$ **Importance of $q\bar{q}g$ contribution in diffraction**

FNAL present and future

Present



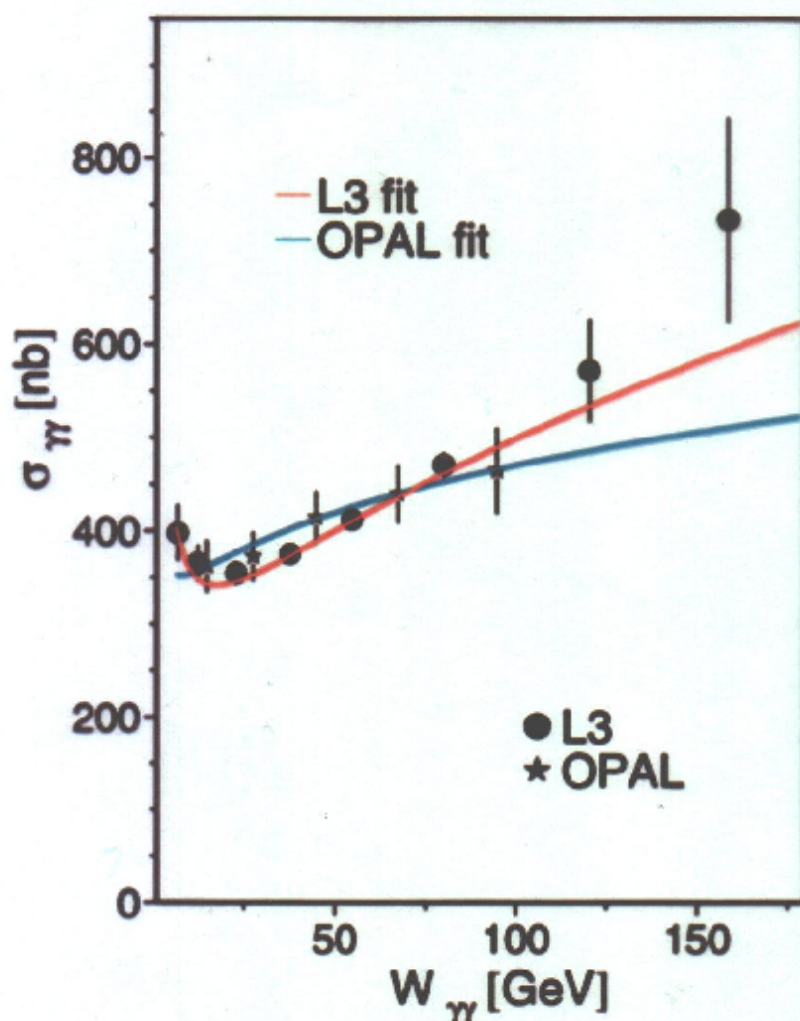
Future

- CDF upgrades the present leading proton spectrometer
- D0 installs a new leading proton spectrometer



Total $\sigma_{\gamma\gamma}$: DL fit

Average of Pythia and Phojet
Statistic and detector related systematic errors only



- Fit with Donnachie and Landshoff parametrisation (Phys. Lett., B296 (1992) 227):
$$\sigma_{\gamma\gamma} = As^\epsilon + Bs^{-\eta}, \quad s = W_{\gamma\gamma}^2$$
- Universal fit (PDG 2000):
 $\epsilon = 0.093 \pm 0.002, \quad \eta = 0.358 \pm 0.015, \quad A, B \text{ free}$
- OPAL fit, $\eta = 0.34$ fixed, A, B free
 $\epsilon = 0.101^{+0.025}_{-0.019} \quad 10 < W_{\gamma\gamma} < 110 \text{ GeV}$
- L3 fit to 183–202 GeV data, $\eta = 0.358$ fixed, A, B free
 $\epsilon = 0.225 \pm 0.021 \quad 5 < W_{\gamma\gamma} < 185 \text{ GeV}$



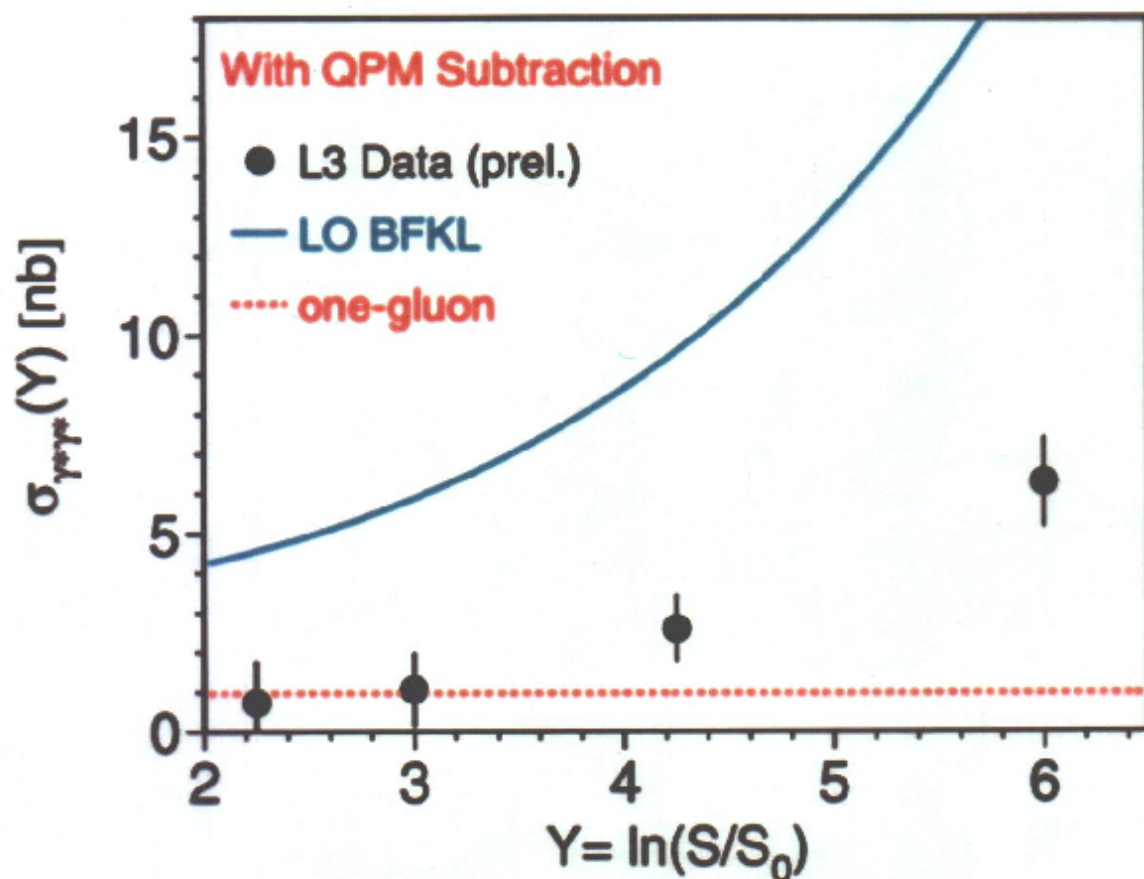
Double Tag: $\sigma_{\gamma^*\gamma^*}$ (L3)

➤ **L3 :**

☐ $\sigma_{ee} = \mathcal{L}_{TT} \times \sigma_{\gamma^*\gamma^*}$

☐ Subtract the QPM contribution.

189 - 208 GeV



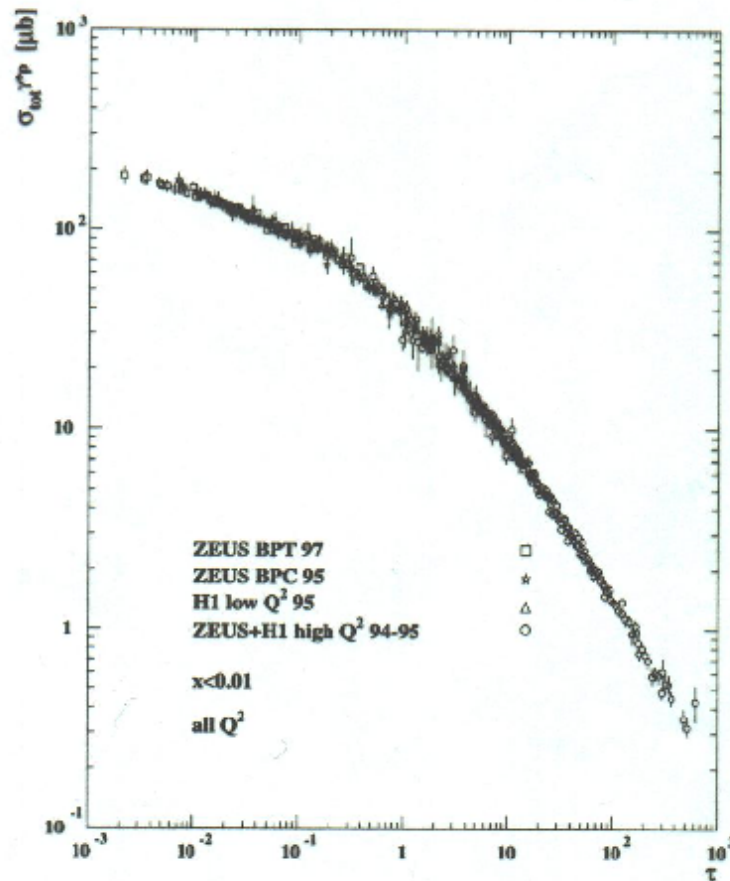
Geometric scaling

The assumption that the dipole cross section

$$\hat{\sigma}(x, r) = \hat{\sigma}(r/R_0(x))$$

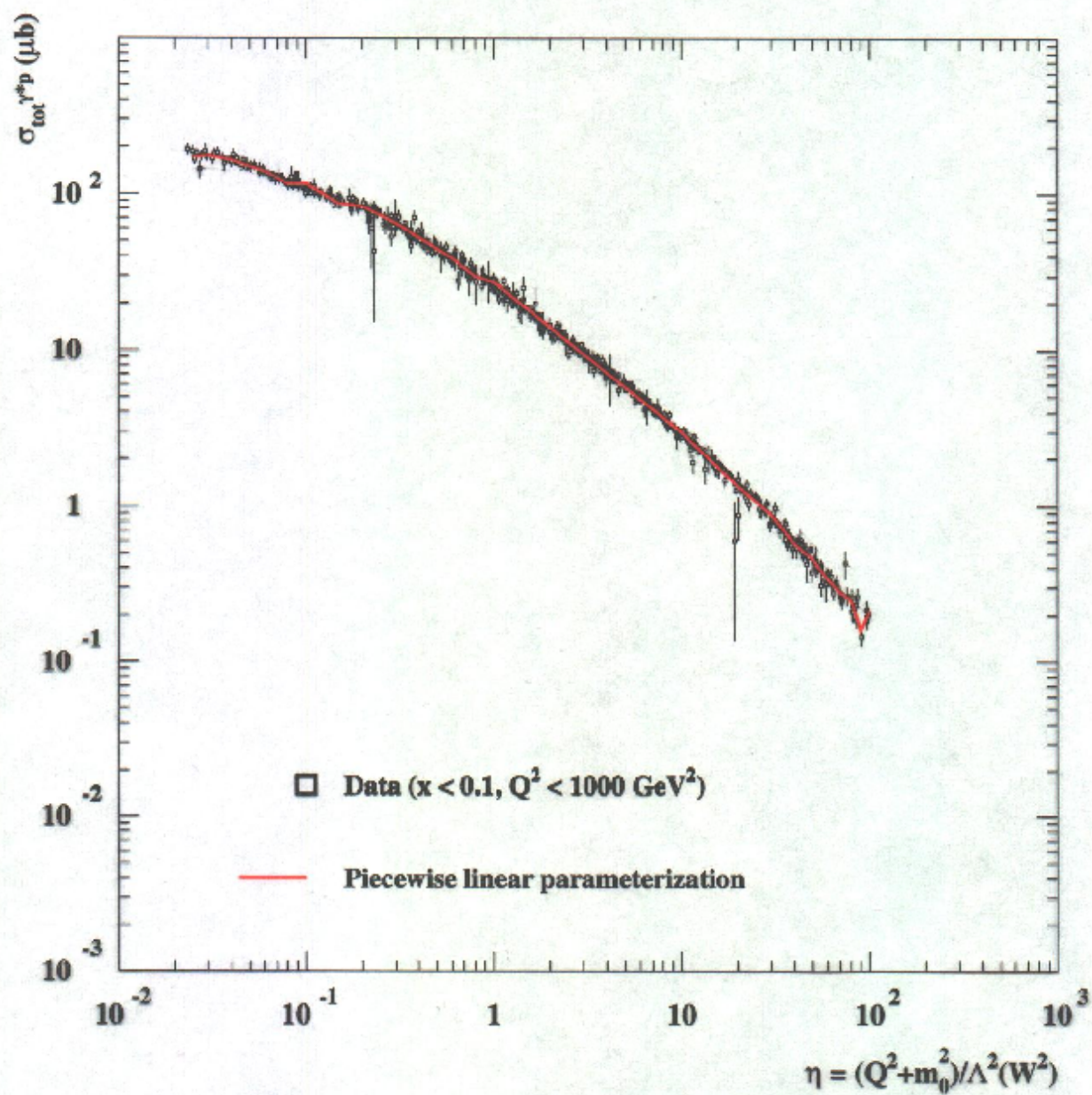
leads to a **new scaling** at small x

$$\sigma^{tot}(x, Q^2) = \sigma^{tot}(\tau = Q^2 R_0^2(x))$$



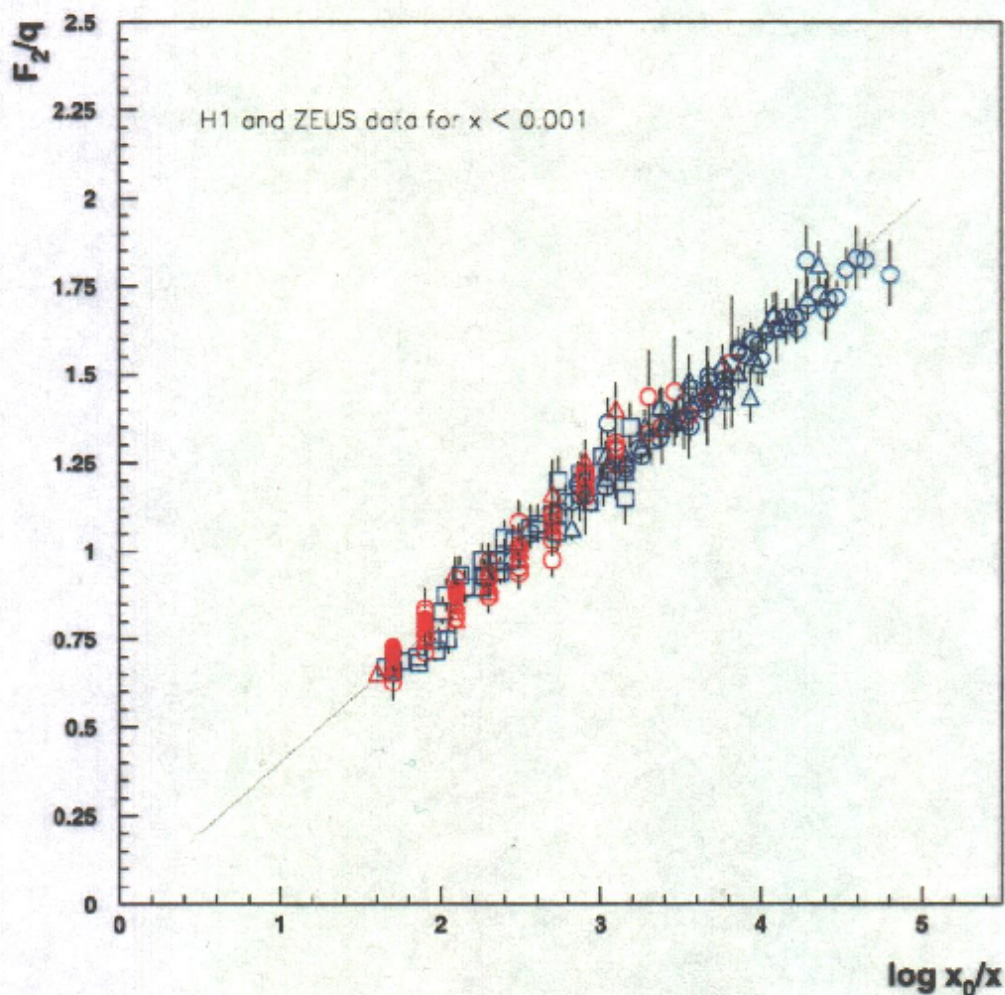
(Staśto, G-B, Kwieciński, hep-ph/0007192, PRL 86 (2001) 596.)

D. Schildknecht



Properties of the observable F_2/q

- Plot F_2/q of old and new data for $x < 0.001$ and all Q^2



- Confirm the empirical fact : $F_2/q \sim \log (1/x)$ and no visible Q^2 -dependence