Diffraction and the Pomeron

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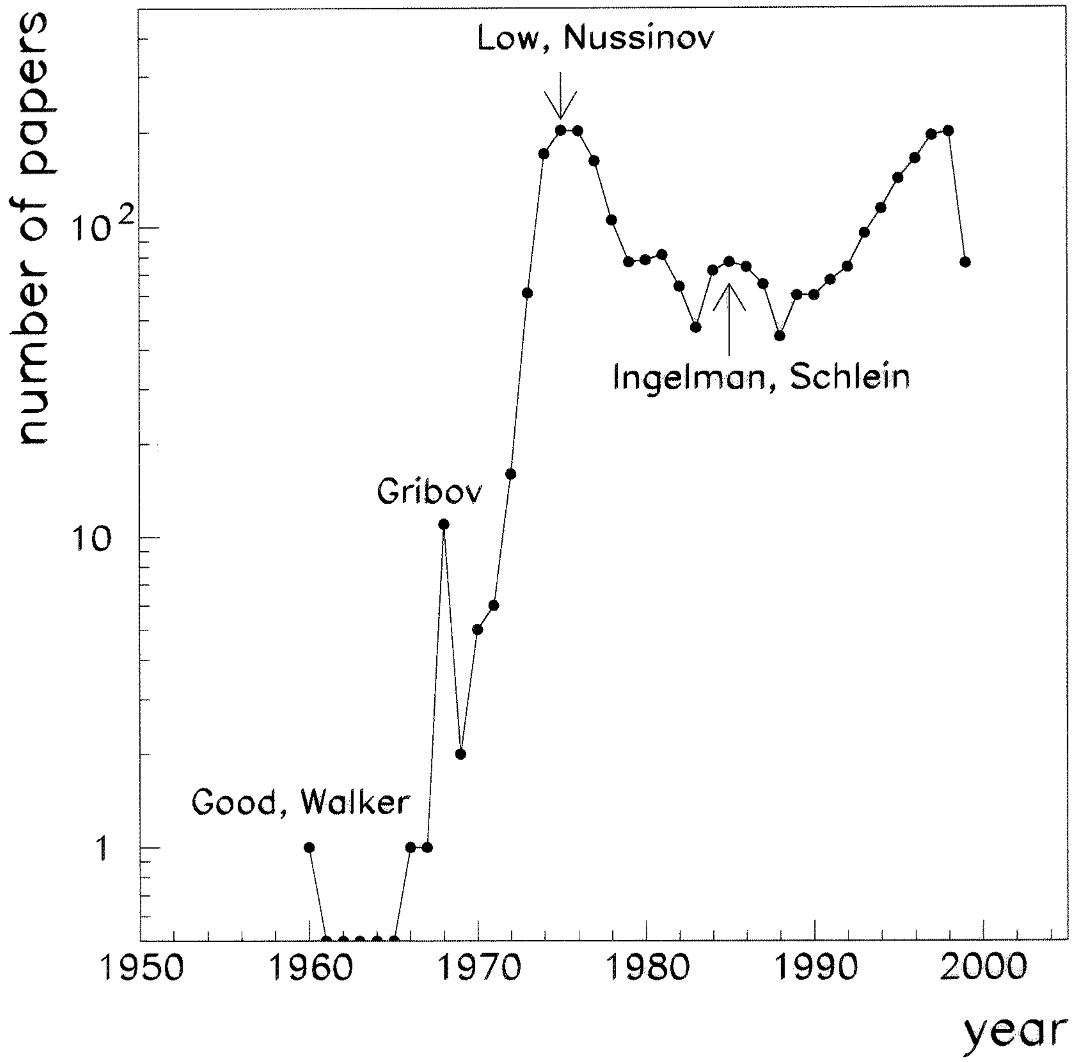
Stanford, August 1999

- Introduction
- Inclusive processes - diffractive parton distributions
- Exclusive production of vector mesons - hard diffraction
- Hard color singlet exchange
- Double gaps
- Conclusions

History of diffraction



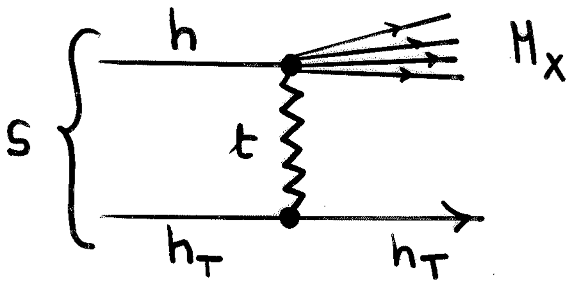
Good and Walker : different components of the projectile absorbed differently by target $\Rightarrow$ new physical states

Gribov : Reggeon calculus and the $\mathbb{P}$

Low, Nussinov : $\mathbb{P}$ in QCD $\approx$ 2 gluon exchange

Diffractive Scattering

definition by description



s – (center of mass energy)^2

t – (momentum transfer)^2

quantum numbers of the target are preserved

Coherence requires

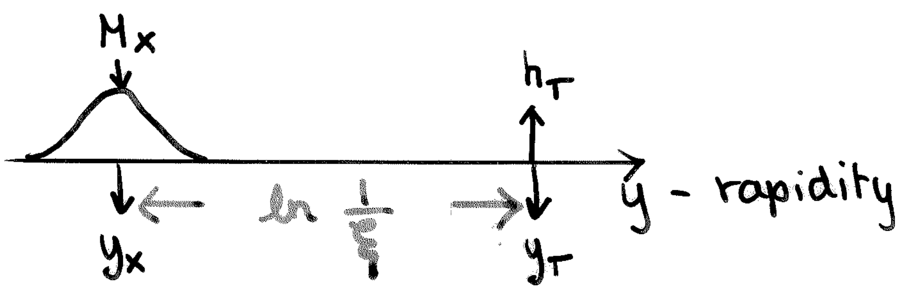
- $\sqrt{|t|} < \frac{1}{R_T}$ $\qquad R_T$ – radius of the target

$$f(t) \sim e^{-b|t|} \qquad b \approx \frac{R_T^2}{6}$$

- $$|t_{min}| = \left[\frac{(M_X^2 - m_T^2)\, m_T}{s}\right]^2 \approx \left(\frac{M_X^2}{s}\right)^2$$

$$x_{\mathbb{P}} \equiv \xi \equiv \frac{M_X^2}{s} < \frac{1}{R_T} \approx 0.15 \div 0.20$$

- presence of a large rapidity gap



$$\Delta y = y_T - y_X = \ln \frac{s}{m_T M_X} \simeq \ln \frac{1}{\xi} > 2$$

- In the t channel exchange of quantum numbers of vacuum $\Rightarrow$ Pomeron

Pomeron $\mathbb{P}$

- derived by Gribov in Reggeon calculus
  right most singularity in the complex
  angular momentum plane – universal
- named Pomeron by Gell-Mann
  Pomeranchuk theorem:
  for $s \to \infty$ $\quad \sigma(hh) = \sigma(h\bar{h})$
- parametrized by Donnachie and Landshoff
  $$\alpha_{\mathbb{P}}(t) = 1 + \varepsilon + \alpha' t$$
  $\varepsilon = 0.08$ (from σ_{tot} πp, Kp, pp, $\bar{p}p$)
  $\alpha' = 0.25$ GeV^{-2} (from elastic pp)

$\mathbb{P}$: universal Regge trajectory with quantum numbers of vacuum

Regge phenomenology: for $s \gg m, t$

$$\sigma_{tot}(ab) \sim s^{\alpha_{\mathbb{P}}(0)-1}$$

$$\frac{d\sigma_{el}}{dt}(ab \to ab) = \frac{\sigma^2_{tot}(ab)}{16\pi} e^{2(b_0^{el} + \alpha' \ln s)t}$$

$$\frac{d^2\sigma_D}{dt\, dM_X^2}(ab \to Xb) \sim \frac{1}{M_X^2}\left(\frac{s}{M_X^2}\right)^{2(\alpha_{\mathbb{P}}(t)-1)} \sim$$
$$\sim \frac{1}{M_X^2}\left(\frac{s}{M_X^2}\right)^{2(\alpha_{\mathbb{P}}(0)-1)} e^{2(b_0^{sd} + \alpha' \ln \frac{s}{M_X^2})t}$$

- σ_{el}/σ_{tot} & $\sigma_D/\sigma_{tot} \sim s^{\alpha_{\mathbb{P}}(0)-1}$ (unitarity limit?)
- shrinkage of the t slope
- large enhancement of $\frac{d\sigma_D}{dx_{\mathbb{P}}} \sim \left(\frac{1}{x_{\mathbb{P}}}\right)^{1+2\varepsilon}$

Diffraction and QCD

In QCD/QPM large rapidity gaps from ONE parton radiation are suppressed

$$P(\text{LRG} = \Delta y) \sim e^{-C_p(\alpha_s, \mu)\,\Delta y}$$

$\Rightarrow$ diffraction in QCD through interacting partons

Tests of our understanding of QCD dynamics

$\Rightarrow$ $\mathbb{P}$ in QCD $\equiv$ search for dynamical origin of rapidity gaps $\Rightarrow$ color singlet exchange

Simplest model of $\mathbb{P}$ = 2 gluon exchange
(Low, Nussinov)

Confusion: In QCD rapidity gaps are not universal
The $\mathbb{P}$ trajectory is universal in soft interactions

In the $\boxed{\text{unlucky case}}$ that we don't understand QCD dynamics the alternative is

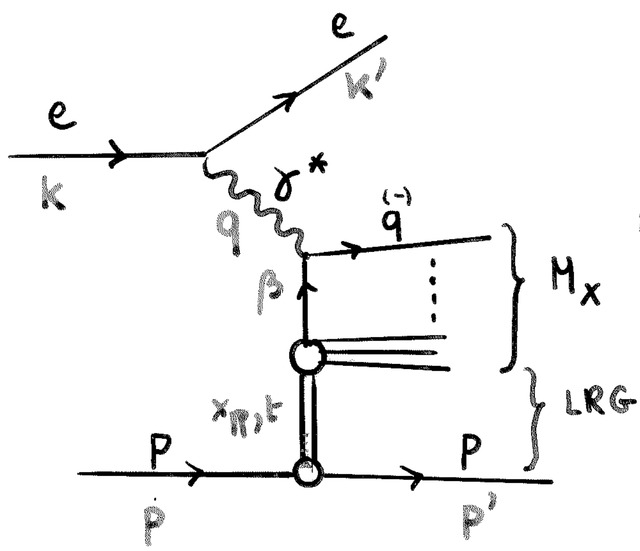
$\mathbb{P}$ à la Ingelman and Schlein, universal with partonic structure to be probed as that of hadrons $\Leftarrow$ partonic content of strong interactions

Diffraction at HERA

$$ep \rightarrow ep\,X$$

$E_e = 27.5$ GeV $\qquad E_p = 820$ GeV (H1, ZEUS)

$\qquad\qquad\qquad\qquad\quad E_p = m_p$ (HERMES)



$$Q^2 = -q^2 = -(k-k')^2$$
$$W = (q+p)^2$$
$$t = (p-p')^2$$
$$x = \frac{Q^2}{2p\cdot q}$$
$$y = \frac{p\cdot q}{p\cdot k}$$

Additional variables:

$$(\xi)\ x_{I\!P} = \frac{q\cdot(p-p')}{q\cdot p} = \frac{Q^2+M_X^2-t}{Q^2+W^2-m_p^2} \simeq \frac{Q^2+M_X^2}{Q^2+W^2}$$

→ fraction of the proton momentum transferred to the "exchange"

$$\beta = \frac{Q^2}{2(p-p')\cdot q} = \frac{Q^2}{Q^2+M_X^2-t} \simeq \frac{Q^2}{Q^2+M_X^2}$$

→ fraction of the "exchange" momentum carried by the quark

$$\beta \cdot x_{I\!P} = x$$

Diffractive structure function F_2^D

$$\frac{d^4\sigma(ep \to epX)}{dx_{I\!P}\, dt\, dx\, dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left(1+(1-y)^2\right) \frac{d^2 F_2^D(x_{I\!P}, t, x, Q^2)}{dx_{I\!P}\, dt}$$

(σ_L/σ_T neglected)

- QCD factorization holds for diffractive DIS (Collins, Berera & Soper, Trentadue & Veneziano)

$$\frac{d^2 F_2^D(x_{I\!P}, t, x, Q^2)}{dx_{I\!P}\, dt} = \sum_i \int dz\, \frac{d^2 f^D_{i/p}(x_{I\!P}, t, z, \mu^2)}{dx_{I\!P}\, dt}\, \hat{F}_i\left(\frac{x}{z}, \frac{Q^2}{\mu^2}\right)$$

$\uparrow$ diffractive parton distribution functions DPDF

$\uparrow$ hard scatt. same as for inclusive DIS (pQCD)

DPDFs evolve in z and μ^2 following DGLAP equations as the proton PDFs

$z = x_{I\!P} \cdot \beta \quad \Rightarrow$ for fixed $x_{I\!P}$ evolution in β

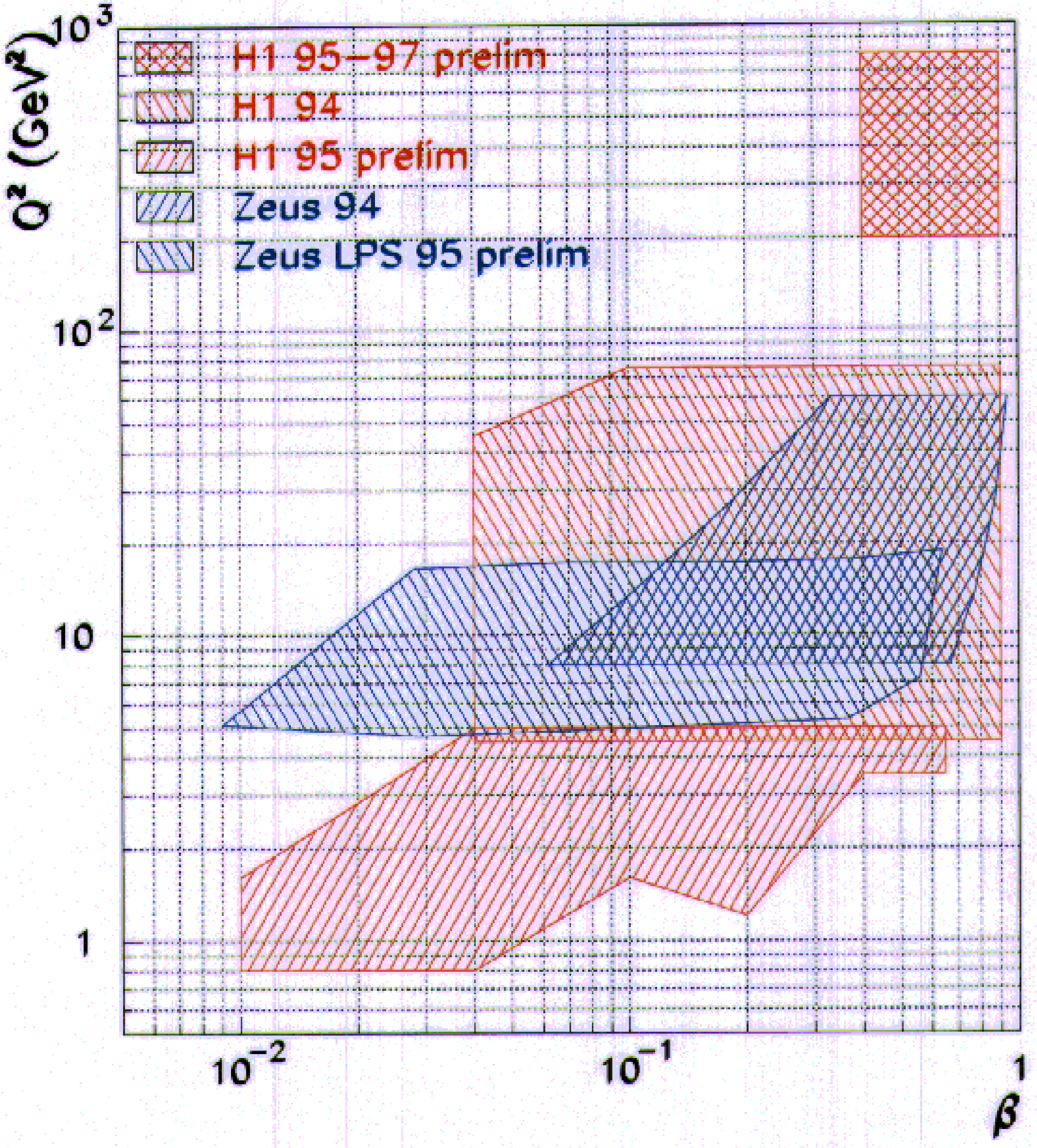
- If postulate Regge factorization (Ingelman & Schlein)

$$\frac{d^2 F_2^D(x_{I\!P}, t, x, Q^2)}{dx_{I\!P}\, dt} = f_{I\!P/p}(x_{I\!P}, t)\; F_2^{I\!P}(\beta, Q^2)$$

note: $F_2^{D(4)} \equiv \dfrac{d^2 F_2^D}{dx_{I\!P}\, dt}$

$F_2^{D(3)} \equiv \displaystyle\int dt\, \frac{d^2 F_2^D}{dx_{I\!P}\, dt}$

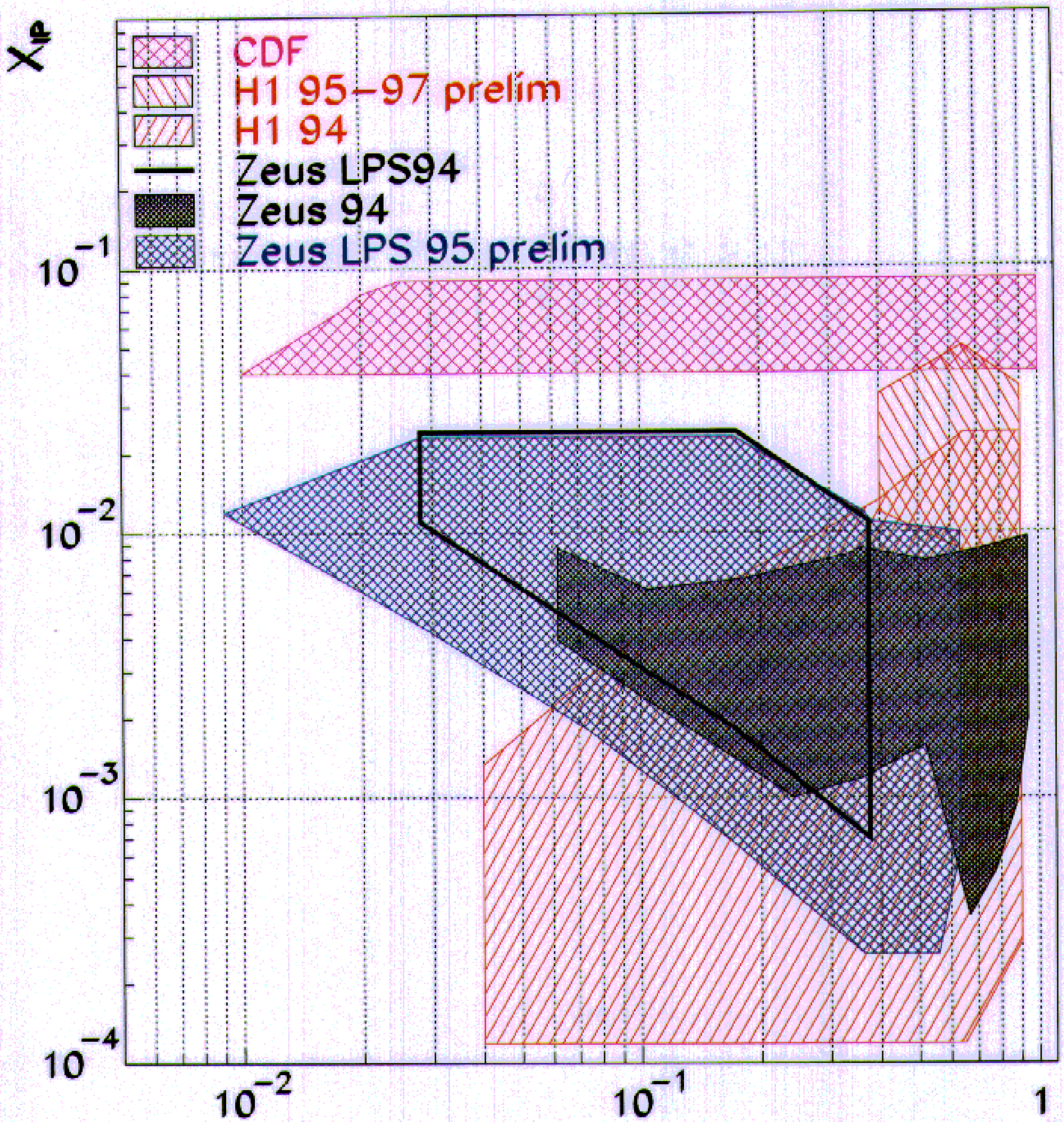
Diffractive Structure Function $F_2^{D(3)}$



$10^{-4} < x_{IP} \lesssim 0.05$

Large fraction of events with LRG

$10\% \div 15\%$



CDF
H1 95–97 prelim
H1 94
Zeus LPS94
Zeus 94
Zeus LPS 95 prelim
x_{IP}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-2}
10^{-1}
1
β

Energy dependence in $\gamma^* p$ - summary

Check Regge factorization: $x_{I\!P} F_2^{D(3)}(x_{I\!P}, \beta, Q^2) = \frac{C(\beta, Q^2)}{x_{I\!P}^{2\bar{\alpha}_{I\!P}-2}}$

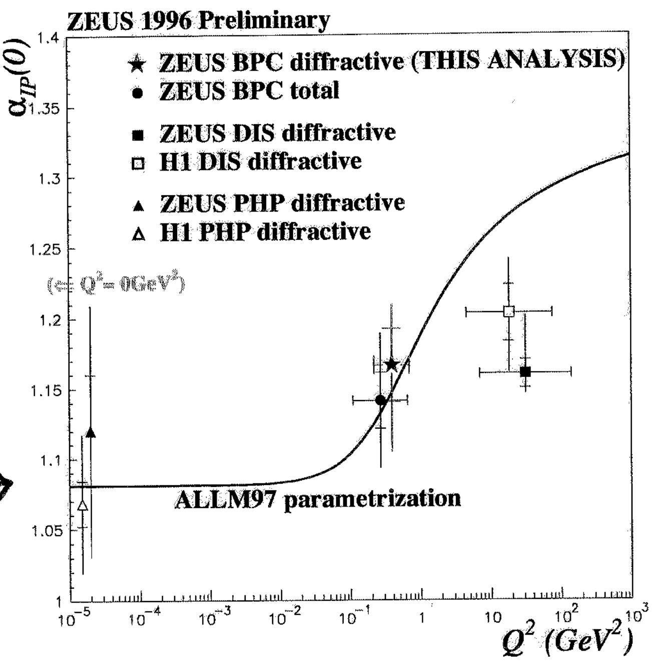
$$\alpha_{I\!P}(0) = \bar{\alpha}_{I\!P} + \frac{\alpha'_{I\!P}}{b}$$

b slope measured with ZEUS LPS - no Q^2 dependence found

$$b \simeq 7 \pm 1(\mathrm{stat}) \pm 1(\mathrm{syst})\ \mathrm{GeV}^{-2}$$

assume $\alpha'_{I\!P} = 0.25\ \mathrm{GeV}^{-2}$

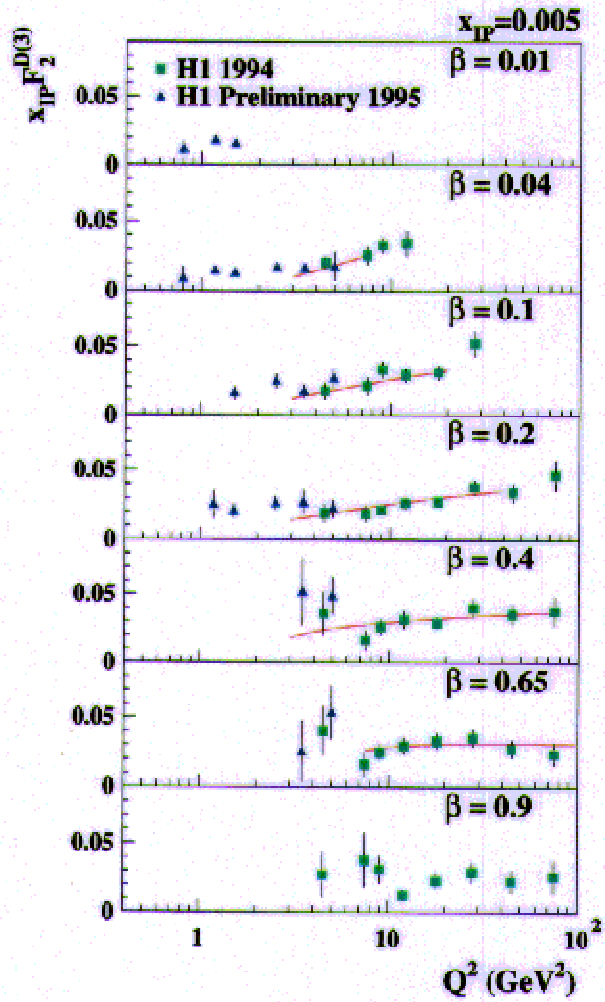
Donnachie Landshoff intercept

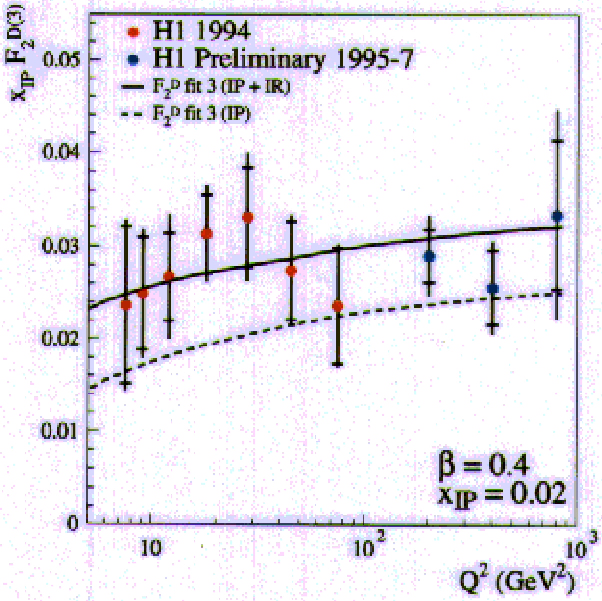


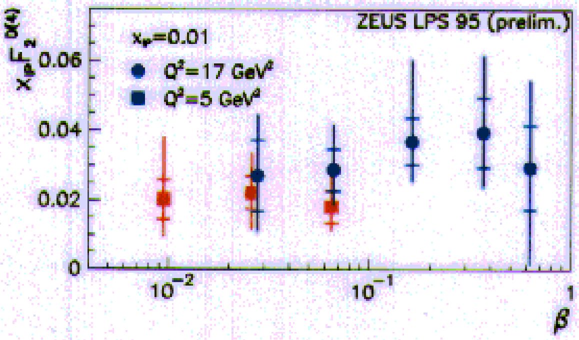
representation of the W dependence of inclusive DIS

- At low Q^2 data compatible with Regge phenomenology
- At high Q^2 diffractive cross section has the same W dependence as the inclusive cross section.
- Q^2 dependence of $\alpha_{I\!P}(0)$ requires more precise measurements

Update on $F_2^{D(3)}$





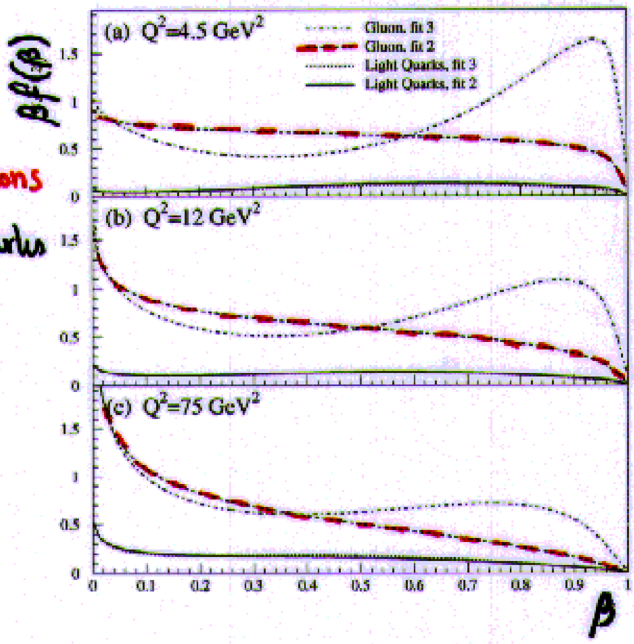


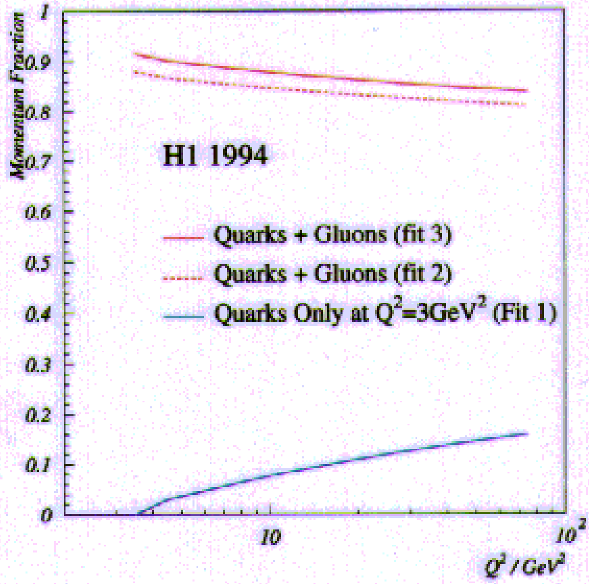
Very different from the proton case - for DGLAP evolution to hold large gluon content is required

Diffractive parton distributions

Input to DGLAP evolution from fit to data

— gluons
— quarks

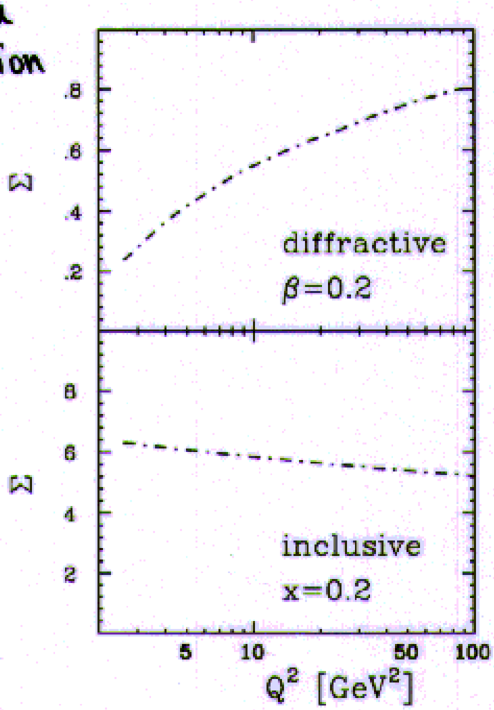




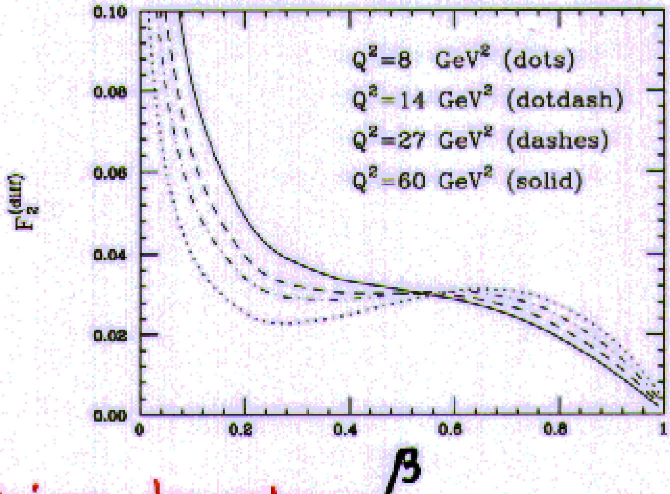
Difference in evolution

quark evolution

from Hautmann, Kunszt, Soper



Quark evolution



Diffractive scattering is driven by gluons

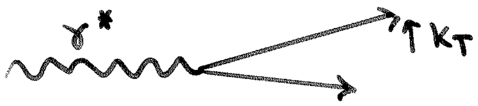
DPDF – convenient way to parametrize our lack of "knowledge"

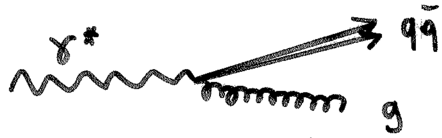
Models for diffractive DIS

In the target rest frame

(1) $\gamma^* \rightarrow q\bar{q}$ or $q\bar{q}g$ color dipoles

$\tau_{fluctuation} \sim \frac{1}{2mx}$ ($\sim$ 10 - 100 fm) at HERA





(2) the dipoles interact with the target T

If small transverse size - r (large relative k_t)

pQCD: $\sigma_{q\bar{q}T} = \frac{\pi^2}{3} r^2 \alpha_s(Q^2)\, x G_T\left(x, Q^2 \approx \frac{\lambda}{r^2}\right)$ color transparency

$\sigma_{q\bar{q}gT} \simeq \sigma_{ggT} = \frac{9}{4}\sigma_{q\bar{q}T}$

If Large transverse size - r (small relative k_t)

non-perturbative effects dominate

(3) diffraction = quasielastic scattering of dipoles

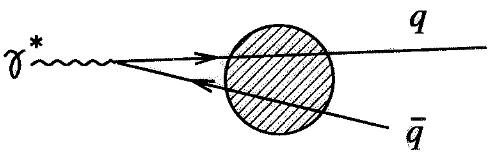
$$\left.\frac{d\sigma_D}{dt}\right|_{t=0} = \frac{\sigma^2_{dipole\,T}}{16\pi}$$

(4) fold in the wave function of γ^*_T and γ^*_L (pQCD)

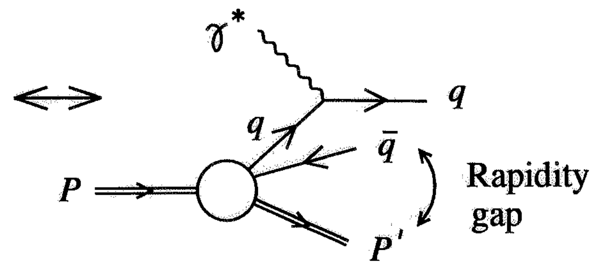
Essence of diffractive dynamics

Equivalence between γ^* fluctuations
and diffractive partons - (BHG)

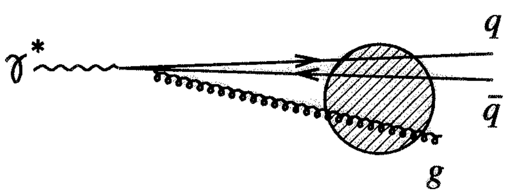
Target rest frame | Breit frame



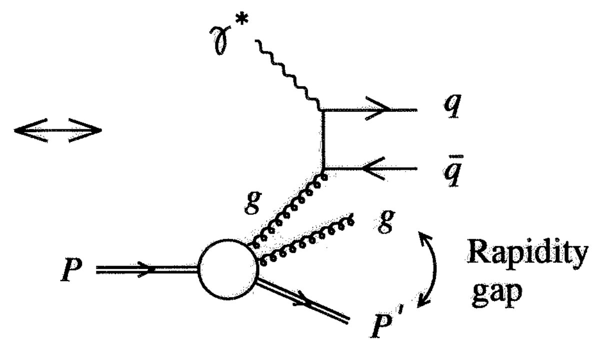
$\Longleftrightarrow$



a) quark distribution



$\Longleftrightarrow$

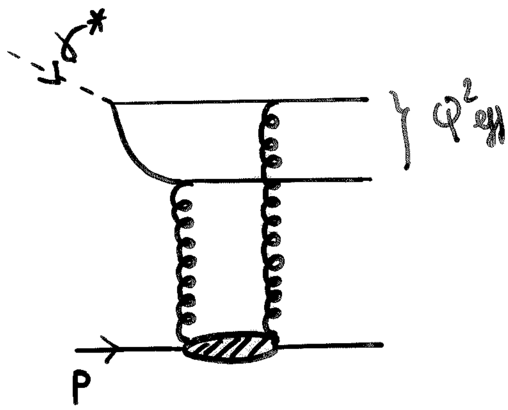


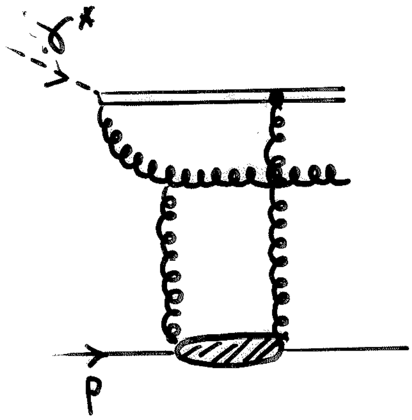
b) gluon distribution

Models differ in the treatement of the 'blobs'

- β distribution $\leftarrow$ photon partonic fluctuation
- $x_{I\!P}$ dependence $\leftarrow$ "blob"
- gluons dominate $\leftarrow$ $\sigma_{q\bar{q}g} > 2\sigma_{q\bar{q}}$

Models for diffractive DIS





2-gluon exchange models:

- assume dominance of small dipoles
- $x\,G(x, Q^2_{eff})$ to describe inclusive DIS

⇒ Bartels, Ellis, Kowalski, Wüsthoff [BEKW]

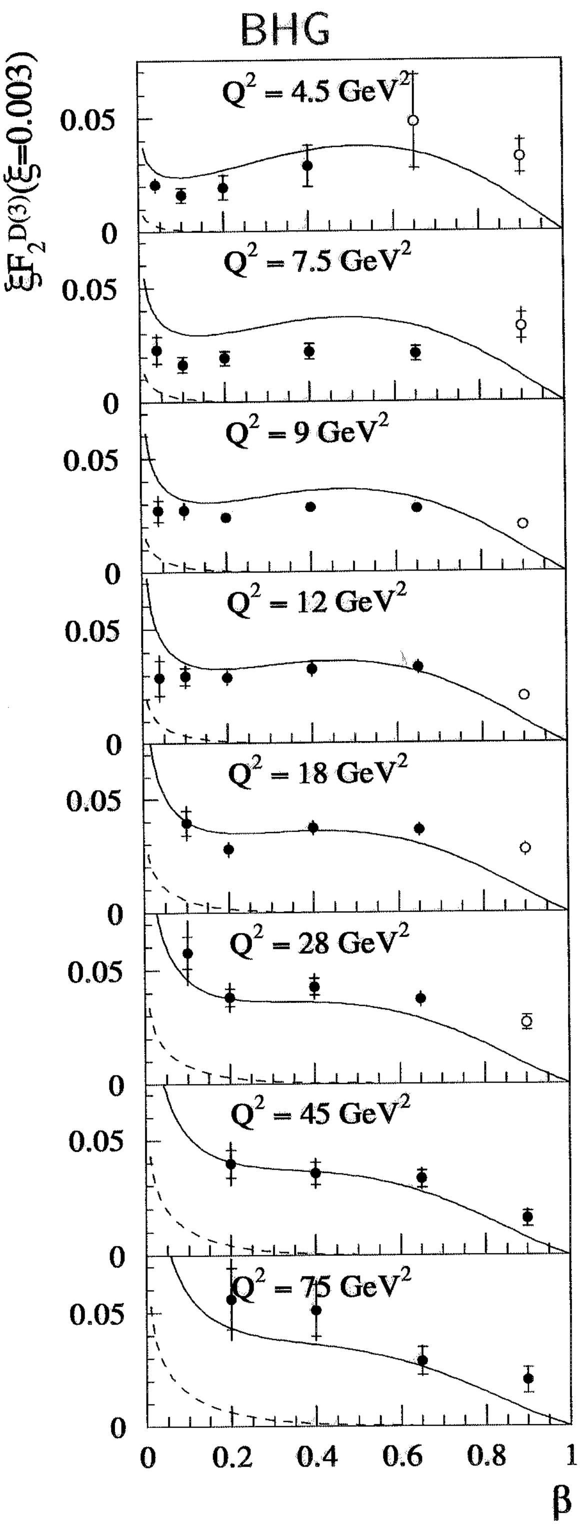
Gotesman, Levin, Maor (gluon ladder with screening)
Białas, Peschanski (BFKL ladder)
Ryskin
Nikolaev, Zakharov (parametrize dipole cross sections)

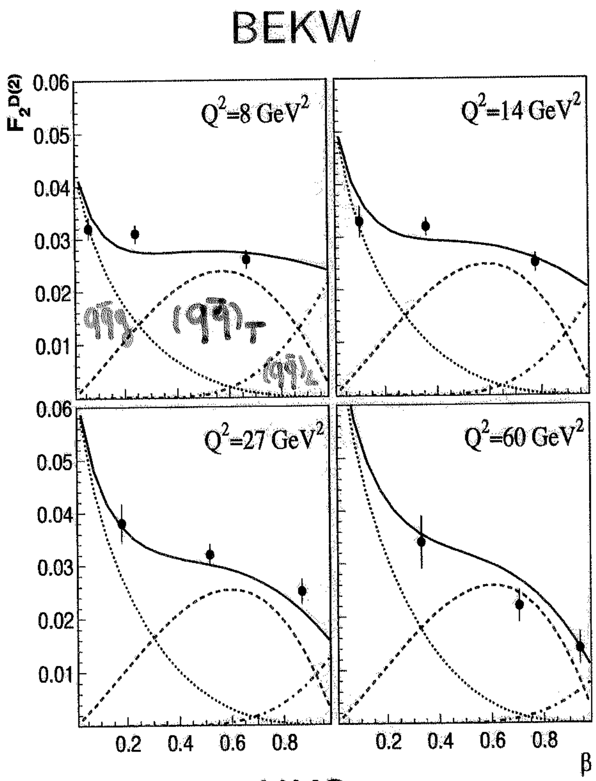
⇒ Hautmann, Kunszt, Soper (scattering of small target) [HKS]

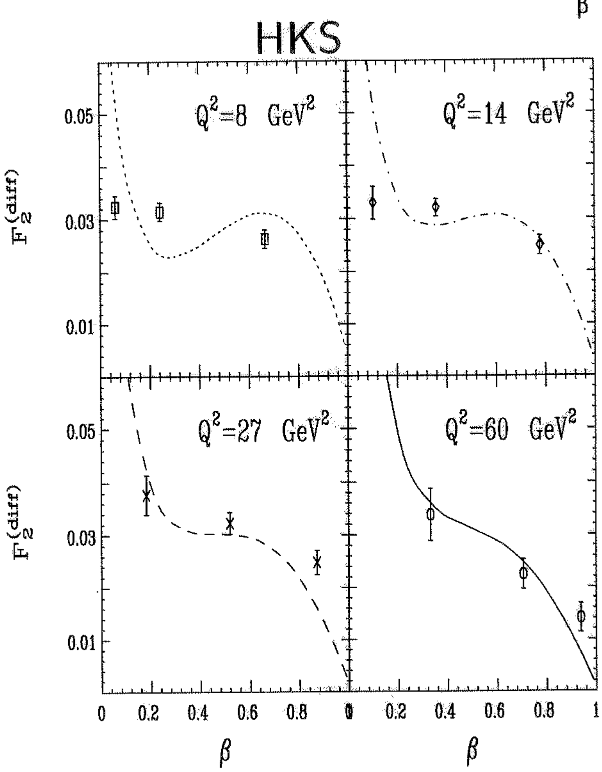
Semiclassical approximation:

- include both small and large configurations
- represent the color field of the proton
- generate rapidity gap as a result of soft color interactions

β distribution and models

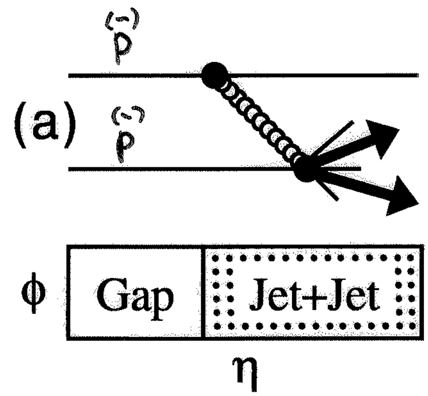




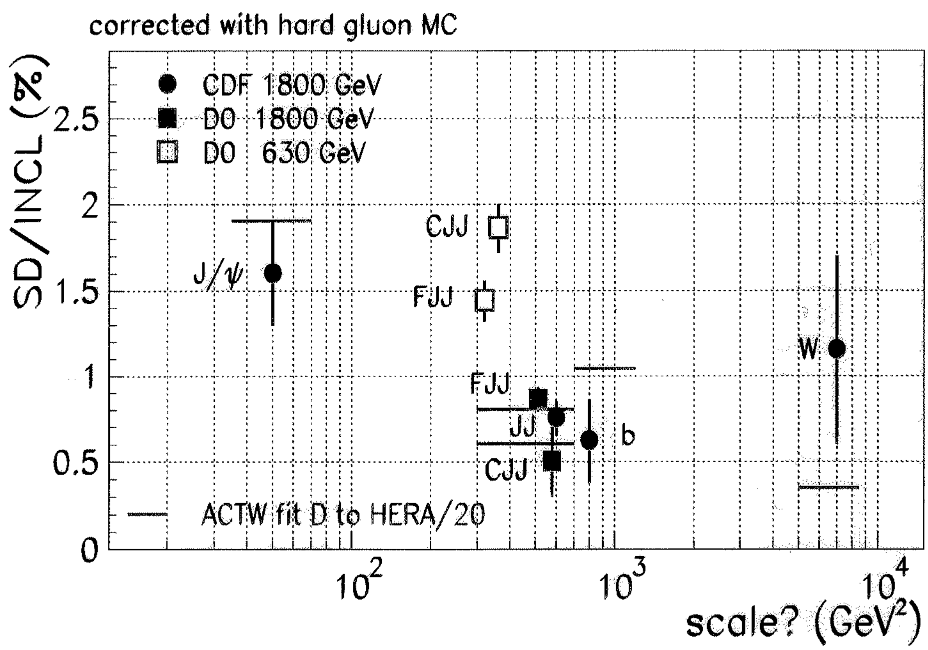


Diffraction in $p\bar{p}$ (FNAL)

QCD factorization cannot be proven for hadron-hadron diffractive scattering - non factorizable contributions identified (Collins)



$$R_{\text{sample}} = \frac{\text{single diff}}{\text{inclusive}} = \frac{\text{sample with LRG}}{\text{sample}}$$

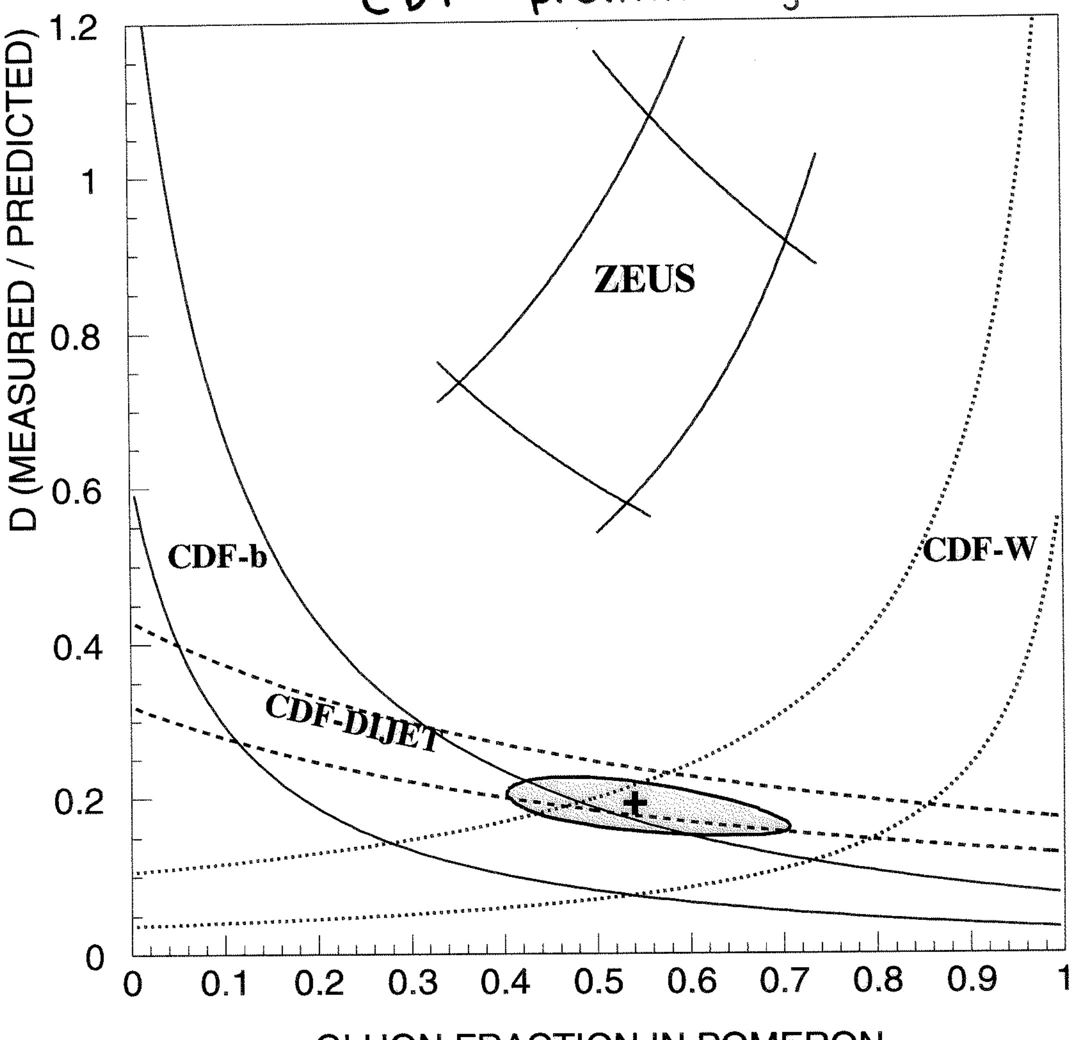


ACTW - Alvero, Collins, Terron, Whitmore

QCD factorization breaking

Rates smaller than expected from diffractive parton distributions of HERA

CDF preliminary

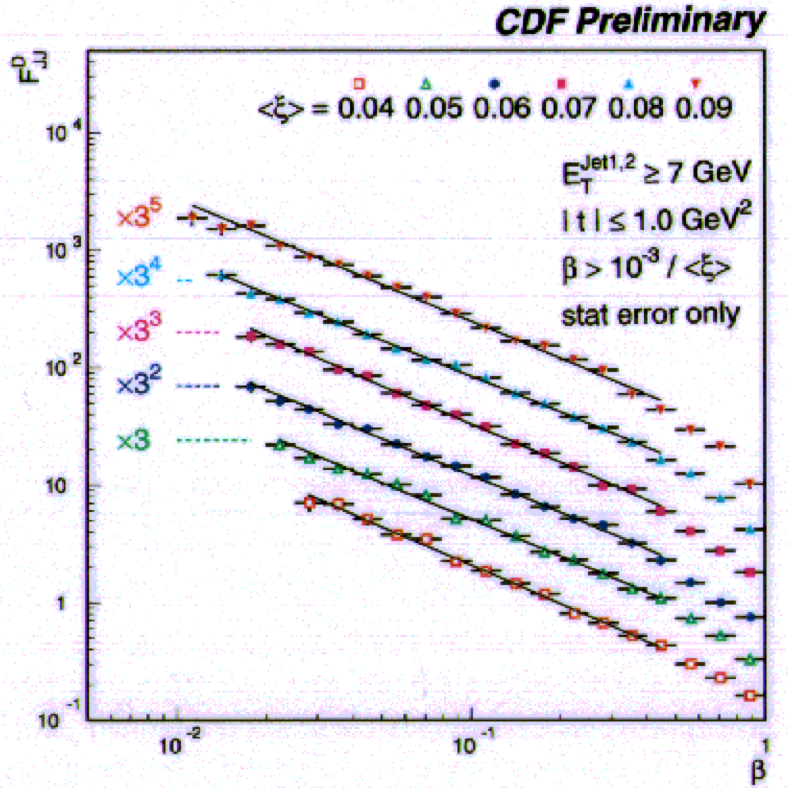


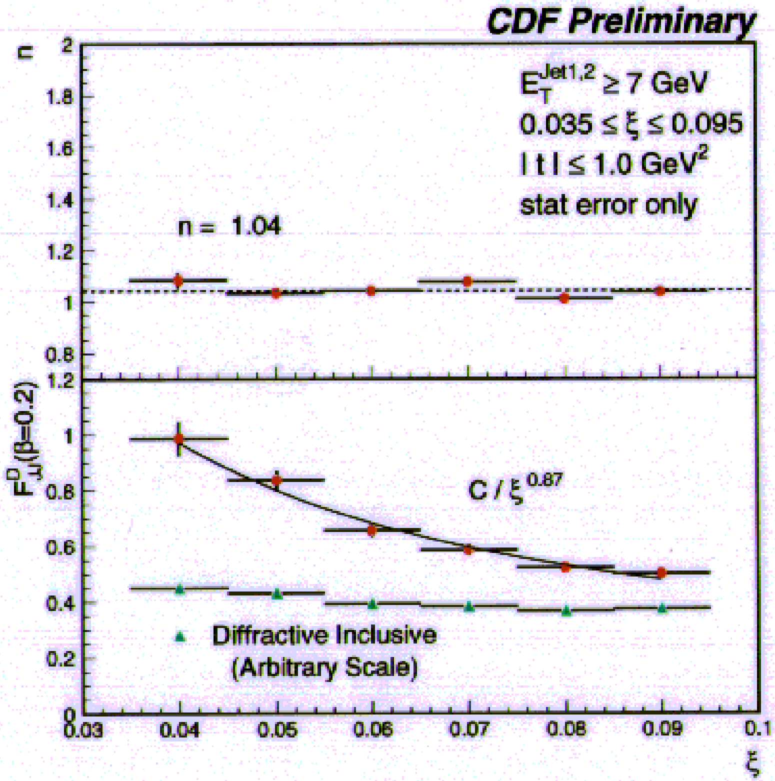
$$f_g = 0.54^{+0.16}_{-0.14}$$

$\bar{p}$ detected in Roman Pots + 2 jets

$F^D_{JJ}(\xi, x_{\bar{p}}) = R_{SD/ND}(x_{\bar{p}}) \cdot F_{JJ}(x_{\bar{p}}) \qquad F^{(D)}_{JJ}(x_{\bar{p}}) = x_{\bar{p}}\left[g^{(D)}(x_{\bar{p}}) + \frac{4}{9}\sum_i\left(q_i^{(D)}(x_{\bar{p}}) + \bar{q}_i^{(D)}(x_{\bar{p}})\right)\right]$

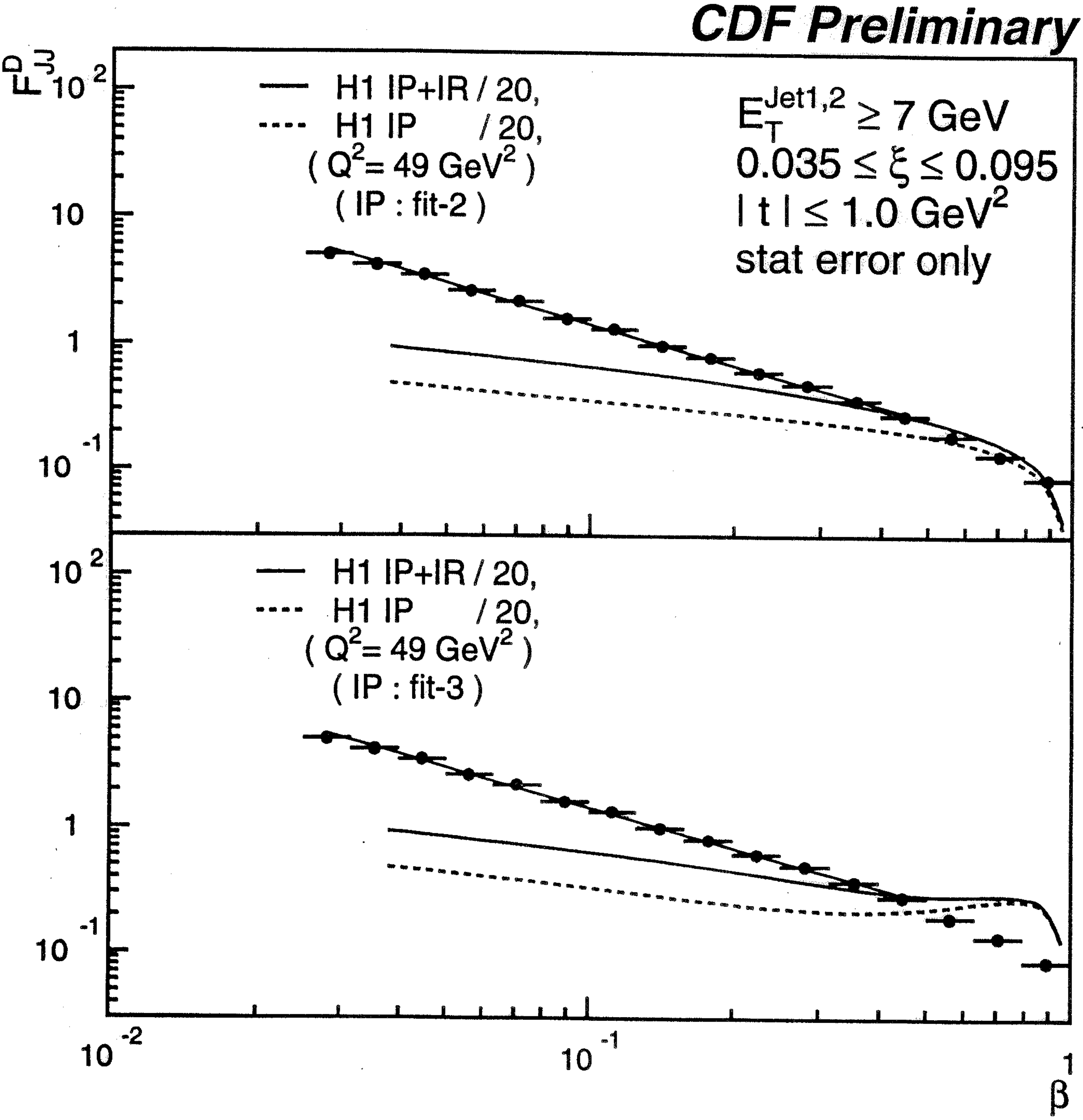
Diffractive Structure as a function of ξ & β





These distribution can be fitted to C/β^n in the region of $10^{-3}/\langle\xi\rangle < \beta < 0.5$.

- The slope is almost constant over the measured ξ range.
- F^D_{JJ} is falling with ξ, $\propto 1/\xi^{0.87}$.



Disagreement both in shape and normalization with DPDF from HERA

Conclusions from studying diffraction in the presence of a hard scale:

- LRG (diffraction in QCD) are correlated with the presence of a large gluon component in the hard interaction

$$P^D_{g,q}(x,Q^2) = \frac{\int f^D_{g,q}\left(\frac{x}{x_{I\!P}}, Q^2, x_{I\!P}, t\right) dt\, dx_{I\!P}}{f_{g,q}(x,Q^2)}$$

$\Rightarrow$ (Frankfurt & Strikman) for $x < 10^{-3}$ $Q^2 = 4\ \text{GeV}^2$

$P^D_g \simeq 0.4$ (black body limit $P^D_g = 0.5$!!!)

$P^D_q \simeq 0.15$

- Unique situation – input distribution to DGLAP quasi-known

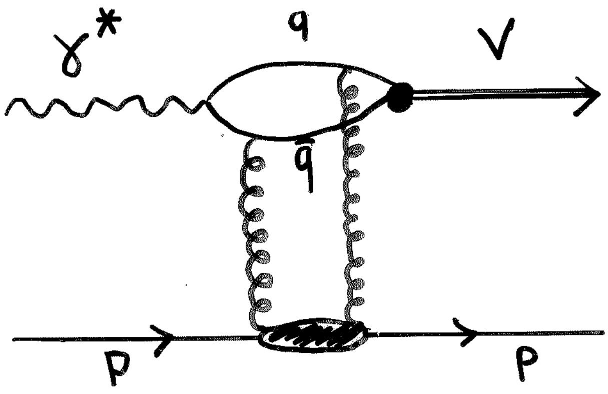
$\Rightarrow$ points to semi-hard nature of diffractive scattering in DIS
(absorption of large size $q\bar{q}$ configurations? proposed by Mueller, modeled by Wuesthoff & Golec-Biernat)

- Direct relation between diffraction with a hard scale in DIS and $p\bar{p}$ not expected in QCD

$\Rightarrow$ the factor 20 remains to be elucidated
(survival probability for a LRG – proposed by Bjorken, calculated by Levin, Gotsman, Maor)

Exclusive Vector Meson production in DIS

candidate for hard diffractive scattering
$\Rightarrow$ pQCD



Expectations:

- SU(4) restoration $\quad \rho : \omega : \varphi : J/\psi = 9:1:2:8$

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

$\Uparrow$

either γ^*_L

or

$V = c\bar{c}, b\bar{b}$

(factorization proven by Collins, Frankfurt Strikman)

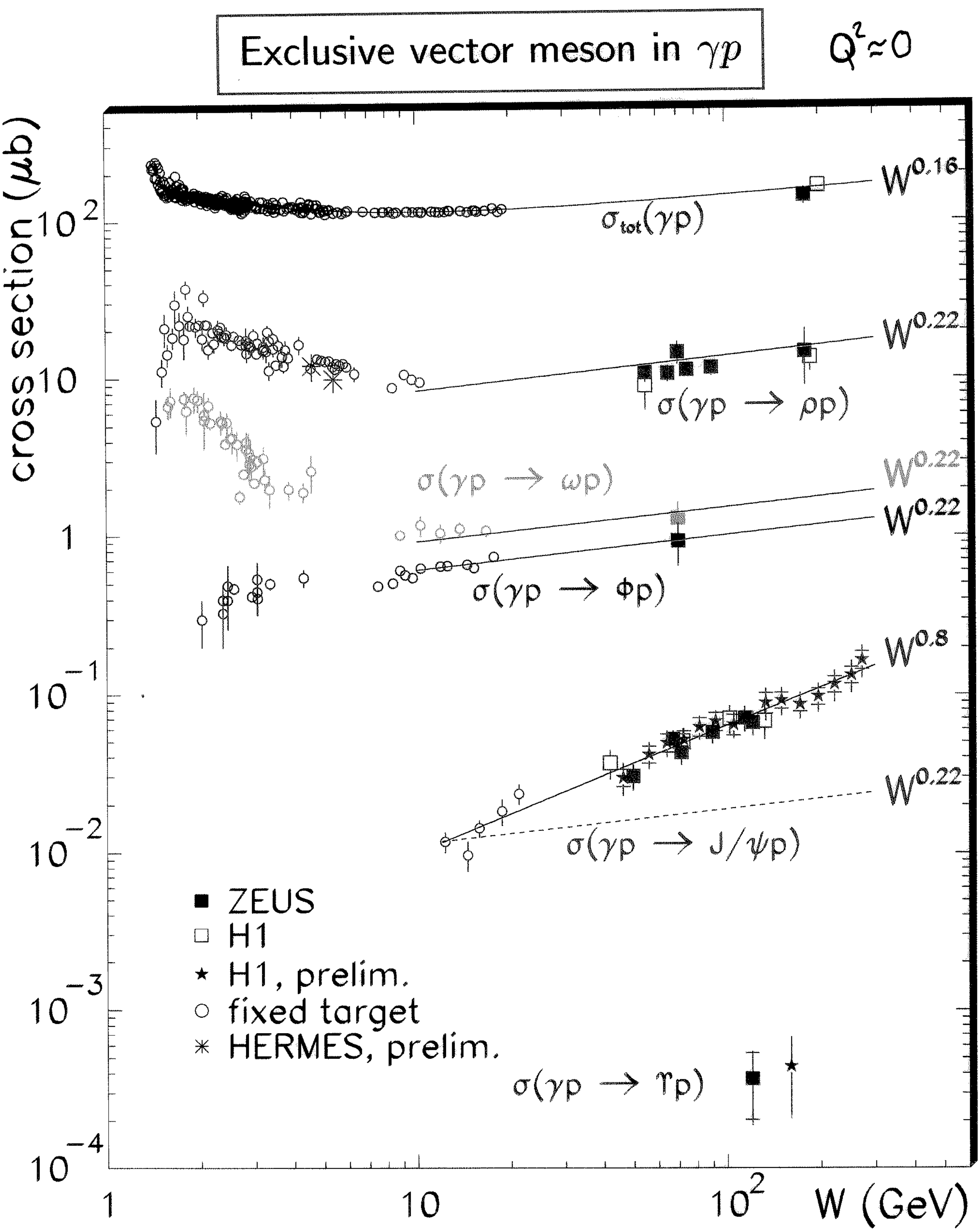
- $\sigma_L \propto \dfrac{\alpha_s^2(Q^2_{eff})}{Q^6} \left| x G(x, Q^2_{eff}) \right|^2$

$\Rightarrow$ fast increase of $\sigma(\gamma^* p \to V p)$ with $W^2 \sim \frac{1}{x}$

$\Rightarrow$ universality of t dependence $\sim e^{b_{2g} \cdot t}$

$b_{2g} \sim 4 \text{ GeV}^{-2} \qquad \alpha' \to 0$

$\Rightarrow$ Q^2 dependence slower than $\frac{1}{Q^6}$



Exclusive vector meson in γp
$Q^2 \approx 0$
cross section (μb)
$W^{0.16}$
$\sigma_{tot}(\gamma p)$
$W^{0.22}$
$\sigma(\gamma p \rightarrow \rho p)$
$\sigma(\gamma p \rightarrow \omega p)$
$W^{0.22}$
$W^{0.22}$
$\sigma(\gamma p \rightarrow \phi p)$
$W^{0.8}$
$W^{0.22}$
$\sigma(\gamma p \rightarrow J/\psi p)$
$\sigma(\gamma p \rightarrow \Upsilon p)$
ZEUS
H1
H1, prelim.
fixed target
HERMES, prelim.
W (GeV)

α' in hard processes

reminder:

$$\frac{d\sigma}{dt} \sim e^{bt}$$

$$b = b(W_0) + 4\alpha' \ln\left(\frac{W}{W_0}\right)$$

Interpretation of α' by Gribov:

diffusion of partons of the exchanged ladder in the impact parameter space (r)

Random walk

- number of steps $\sim \Delta y$
- in each step $\quad \Delta r \sim \frac{1}{k_t}$

$\Rightarrow$ apparent increase of the radius of the projectile

$$\Delta R^2 \sim \frac{\Delta y}{k_t^2}$$

soft partons: $\quad k_t \sim k_{t0}$ small $\rightarrow \alpha' \sim \frac{1}{k_{t0}^2}$

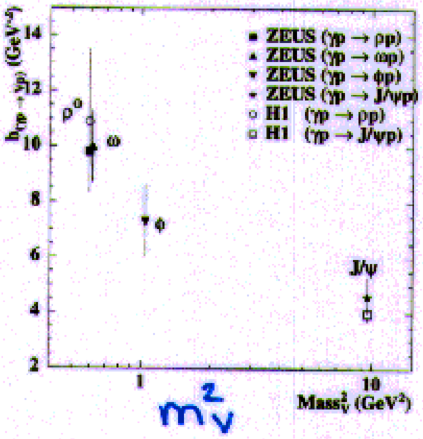
hard partons: $\quad k_t$ large $\quad \rightarrow \alpha' \rightarrow 0$

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

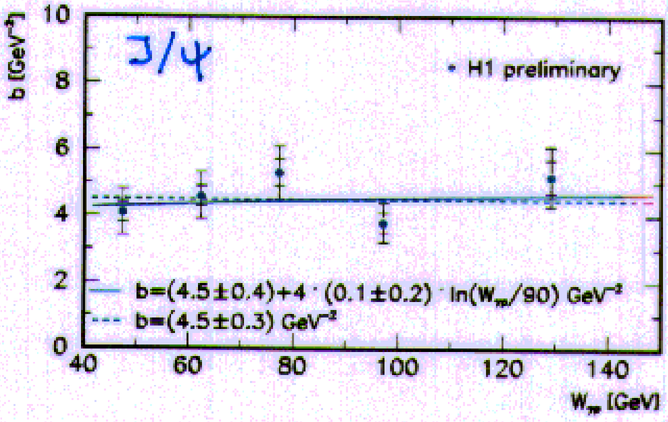
Shrinkage: $f(t)$ dependence on W

for fixed W assume $f(t) \sim e^{bt}$

b



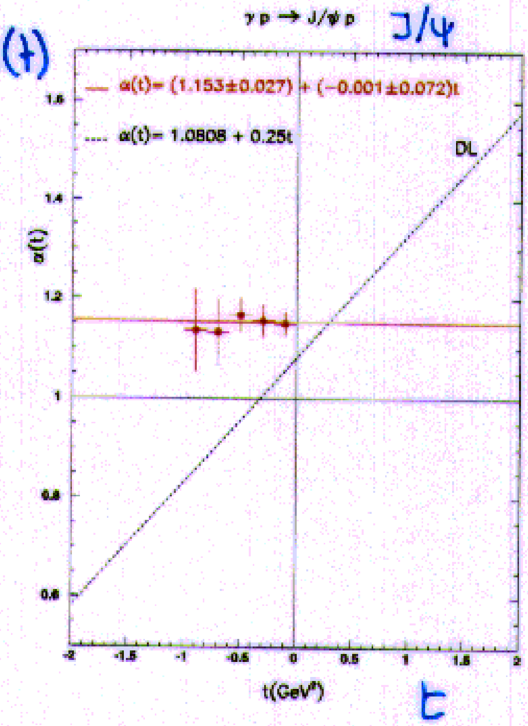
m_V^2

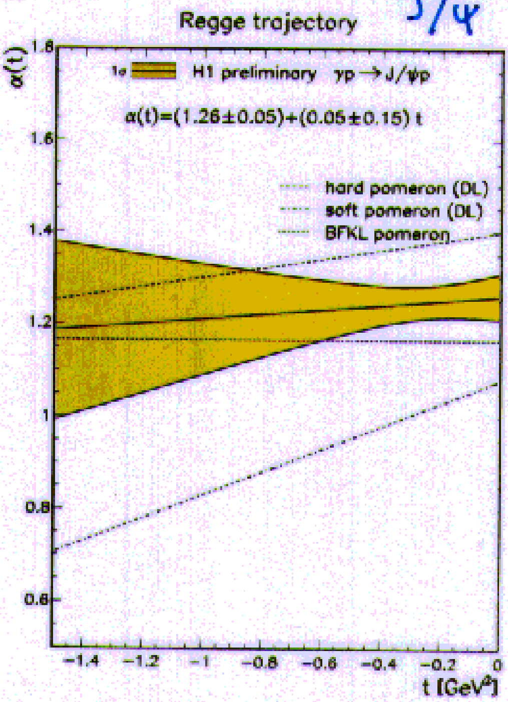


- The heavier the quark the smaller the hadron
- $b(W) \simeq$ const for J/ψ

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

$\alpha(t)$





t

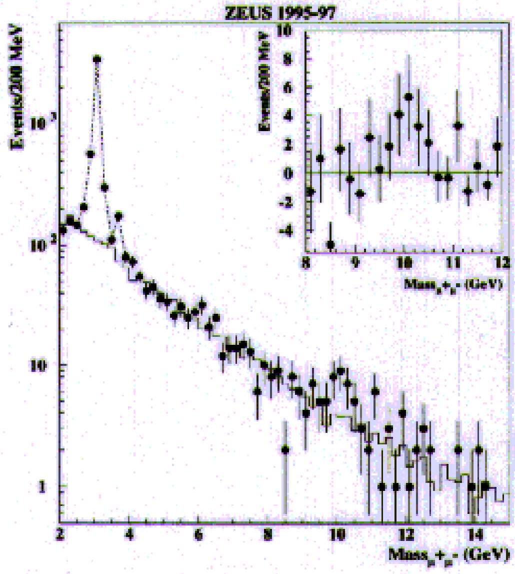
HERA + low energy PLB424(98)191

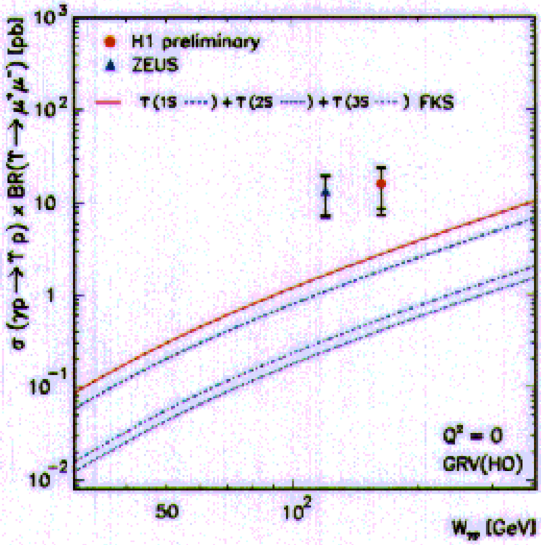
A. Levy

H1 data only

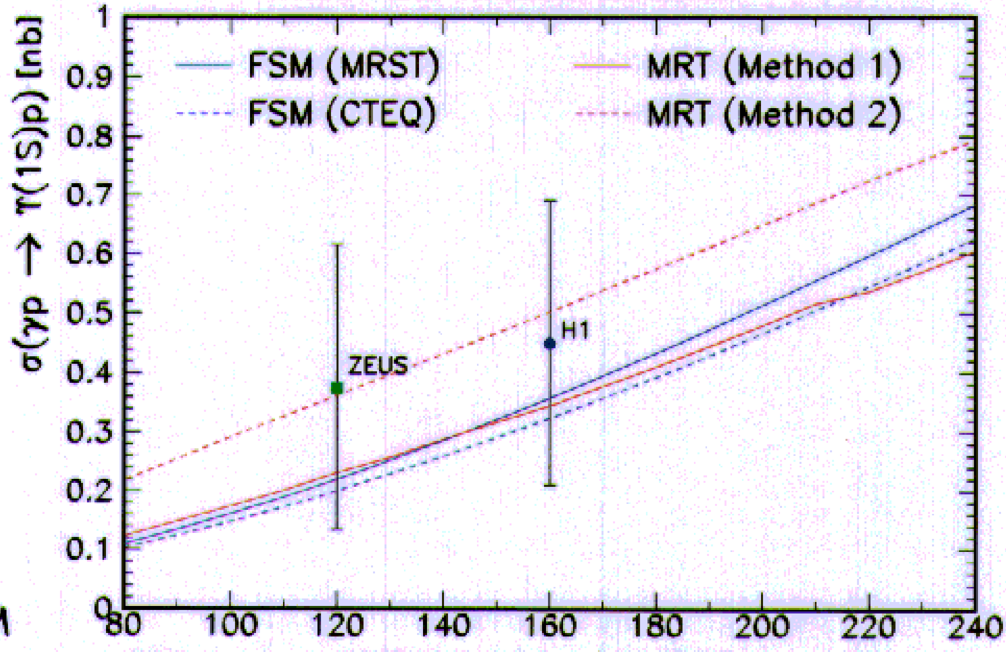
α' - small $\Rightarrow$ J/ψ photoproduction ($Q^2 \approx 0$) is a hard process

Exclusive Υ in γp





After the measurements:



FSM: hep-ph/9812316 (rev. 04/99) $W_{\gamma p}$[GeV]
MRT: hep-ph/9901420

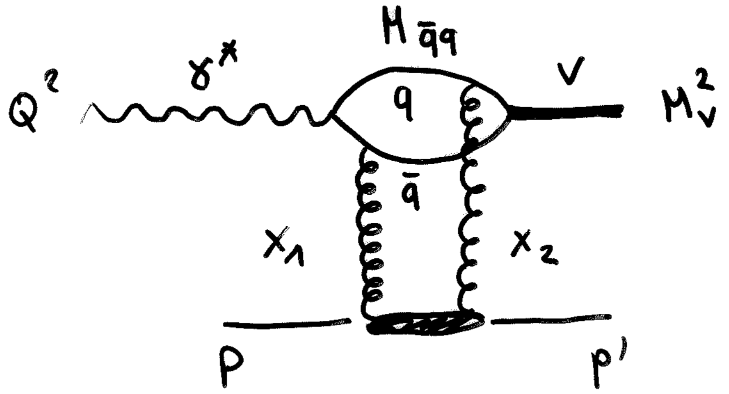
Frankfurt
Strikman } FSM
McDermott

Martin
Ryskin } MRT
Teubner

Important ingredients: skewed parton distributions

$\frac{\mathrm{Re}\,A}{\mathrm{Im}\,A} \neq 0$, large

Skewed parton distributions



for review see
X. Ji, J Phys G24(98)1181
A. Radyushkin, PLB449(99)81

$$x_1 = \frac{M_{q\bar{q}}^2 + Q^2}{W^2 + Q^2} \qquad x_2 = \frac{M_{q\bar{q}}^2 - M_V^2}{W^2 + Q^2}$$

$$\delta = x_1 - x_2 = \frac{M_V^2 + Q^2}{W^2 + Q^2} \neq 0$$

$$x g(x, Q^2) \longrightarrow x_2 g(x_1, x_2, Q^2)$$

enhancement factor

$$\left(\frac{x_2 g(x_1, x_2, Q^2)}{x g(x, Q^2)} \right)^2 \approx 2$$

Skewed parton distributions / off-diagonal / non-forward
probe of non perturbative effects
at the amplitude level

$\Rightarrow$ generalize other non-perturbative information
such as: parton densities
vector meson type distribution amplitudes
form factors

Real part of the scattering amplitude

$$\left.\frac{d\sigma_{el}}{dt}\right|_{t=0} = (1+\eta^2)\,\frac{\sigma_{tot}^2}{16\pi}$$

$$\eta = \frac{\mathrm{Re}\,A}{\mathrm{Im}\,A}$$

Gribov - Migdal relation

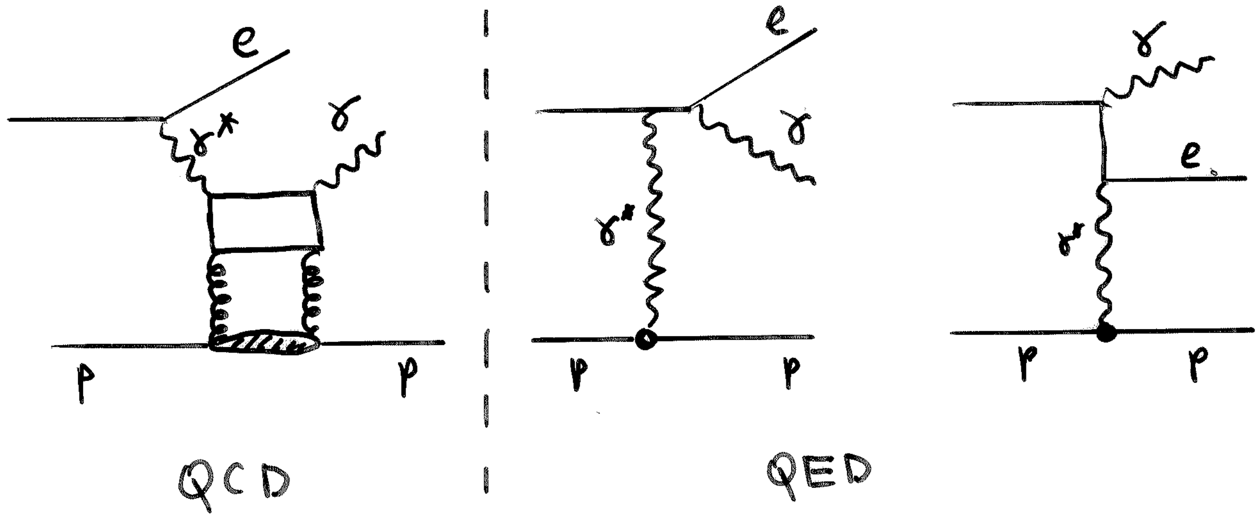
$$\eta \simeq \frac{\pi}{2}\,\frac{d\ln\sigma_{tot}}{d\ln W^2}$$

If $\sigma_{tot} \sim (W^2)^\alpha \quad \Rightarrow \quad \eta = \frac{\pi}{2}\alpha$

since $\alpha \neq 0$ $\quad \eta$ large

$$(1+\eta^2) \approx 1.5 \div 1.7$$

Deeply Virtual Compton Scattering

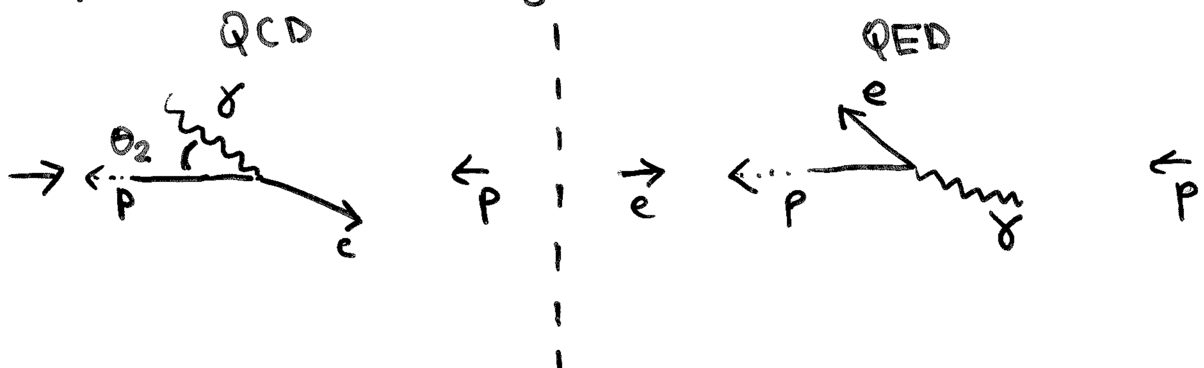


Interference

- measure skewed parton distributions without hadronic uncertainties
- measure Re (A_{QCD}) via interference with QED

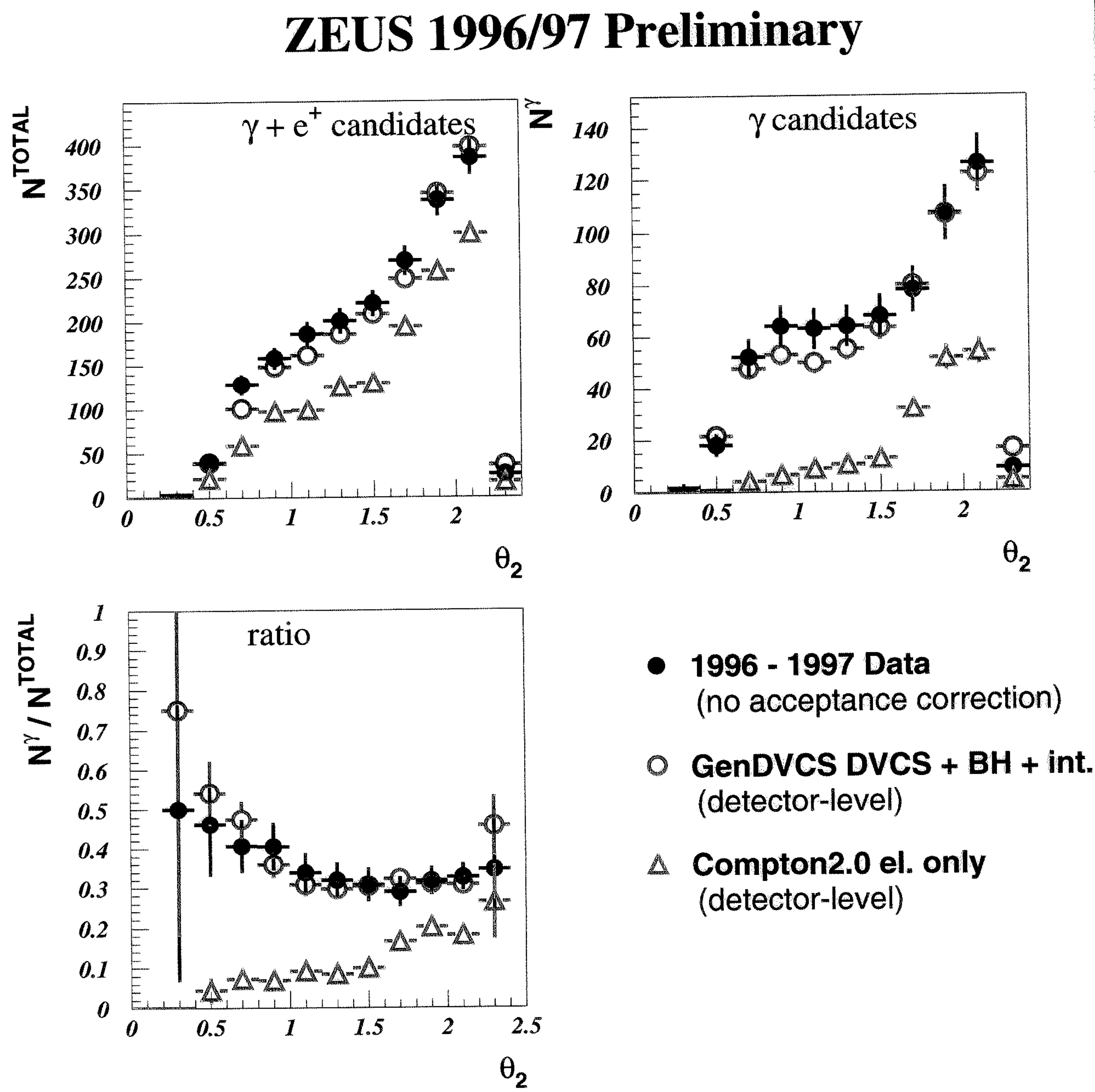
⇒ calculations by Frankfurt, Freund, Strikman
MC by Pat Saull

Experimental strategy:



Major difference when (e or γ) in the proton direction

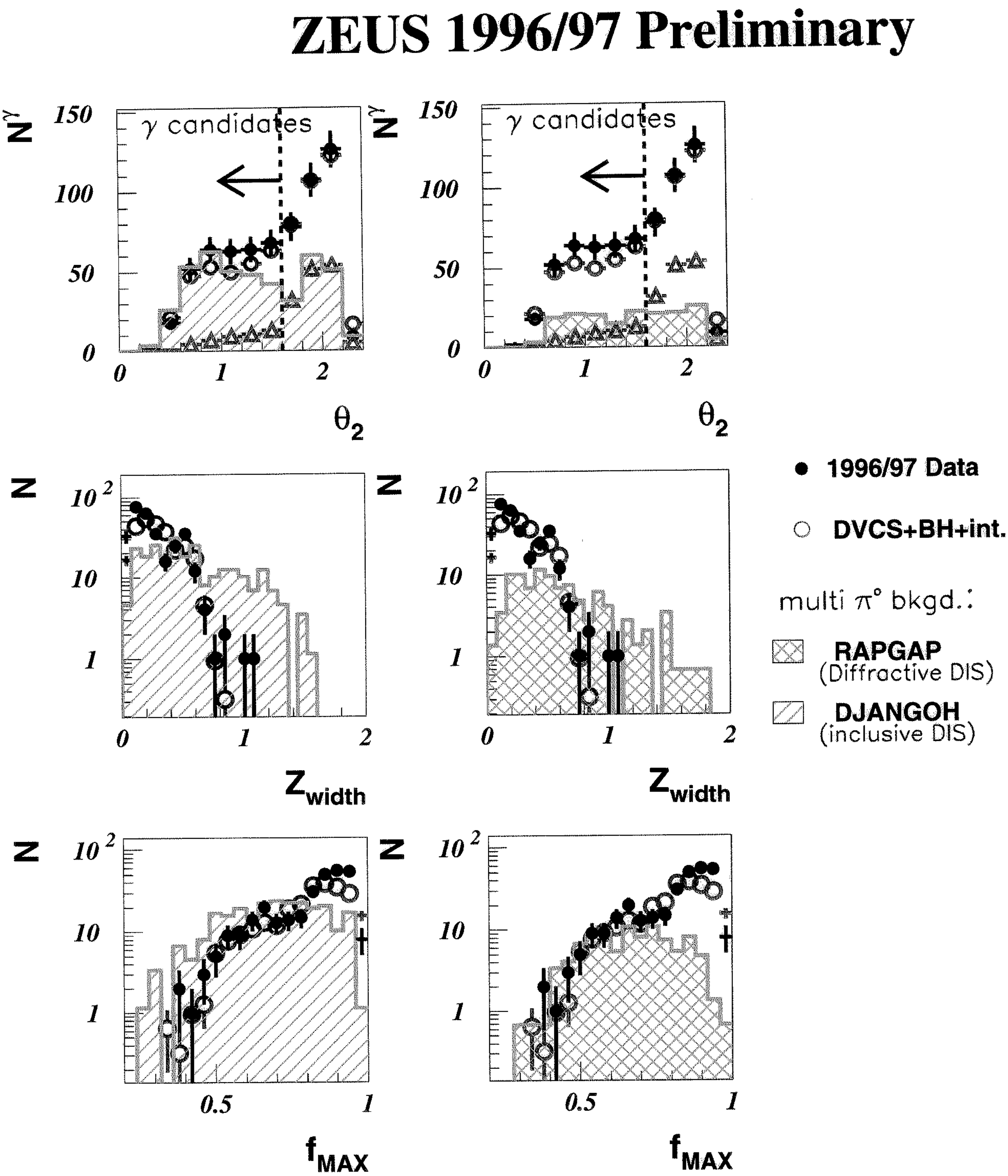
DVCS - θ_2 DISTRIBUTIONS



→ Appears to be clear signal for DVCS!

But, processes like $ep \to ep\pi^o$, $ep \to ep\pi^o\pi^o$, $ep \to ep\pi^o\eta$, ... potentially fake this signal.

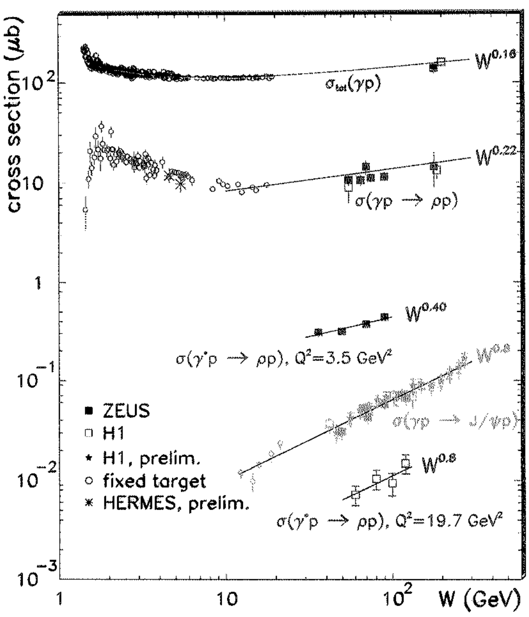
DVCS - γ CAND. SHOWER SHAPES



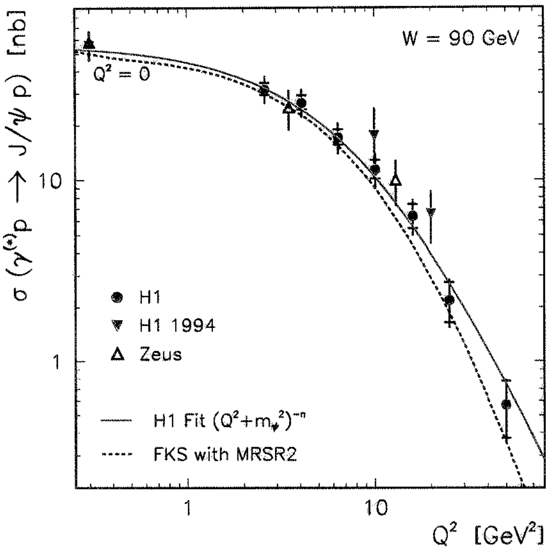
$\rightarrow \pi^o$ / η hypothesis cannot account for shower shapes.

Exclusive VM in $\gamma^* p$

W dependence

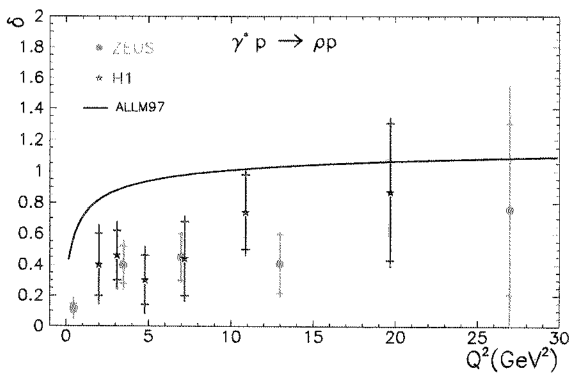


Q^2 dependence



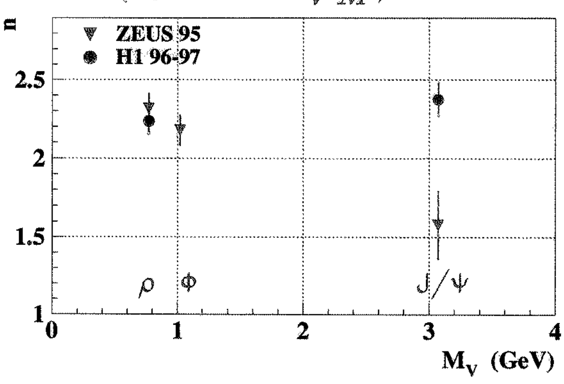
for fixed Q^2 fit

$$\sigma_{\gamma^* p}(W) \sim W^{4\delta}$$



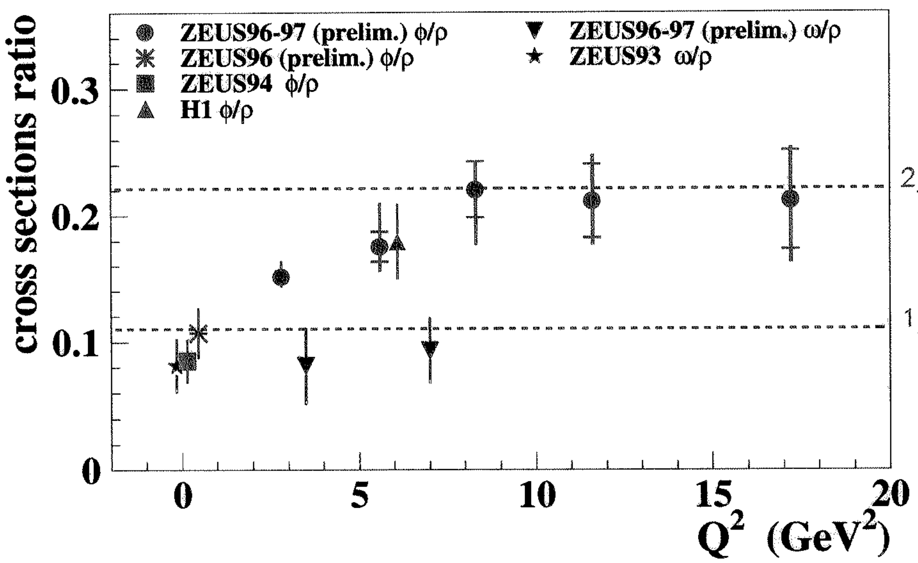
for fixed W fit

$$\sigma_{\gamma^* p}(Q^2) \sim (Q^2 + M_{VM}^2)^{-n}$$



$$\boxed{\rho : \omega : \phi : J/\psi \ ?}$$

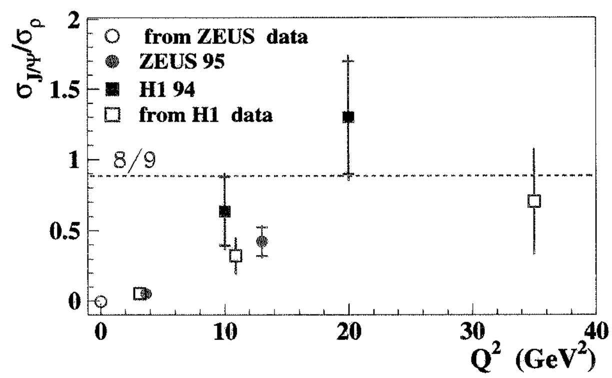
From γq coupling expect 9:1:2:8



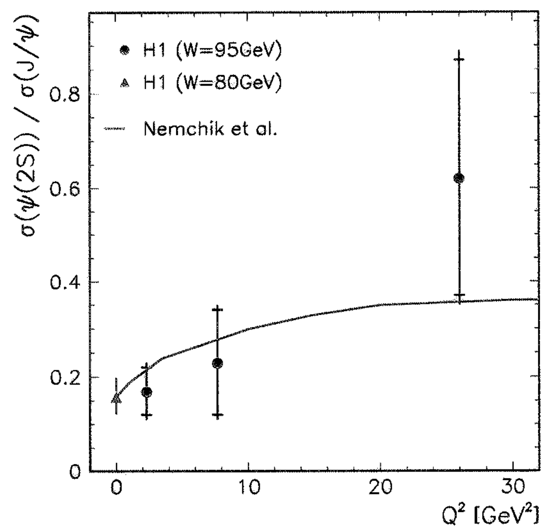
ϕ/ρ

ω/ρ

$J/\psi/\rho$



$\psi(2S)/J/\psi$



- democratic gluons
- $\psi(2S)$ wave function scanning

Conclusions from exclusive hard processes

Amazing success of perturbative QCD in terms of highly non-trivial

- W and Q^2 dependence
- universality of t distribution
- existence of DVCS
- cross section ratios for various VM states
- s-channel helicity non-conservation (not discussed)

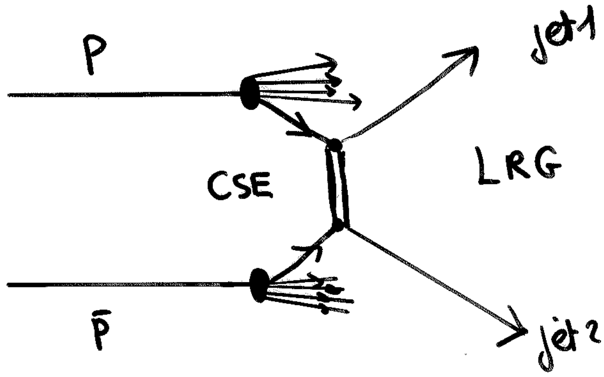
Immediate consequence of the role of the size of interacting "parton" states in determining the cross section = non-universality of LRG in QCD

Experimental dream – clean measurements

Expect:
- better understanding of VM wave functions
- low Q^2 gluonometer
- skewed parton distributions

High t Color Singlet Exchange

Proposed by Bjorken to study origin of LRG



Probe BFKL evolution?

$\Rightarrow$ evolution only in x, no k_t ordering

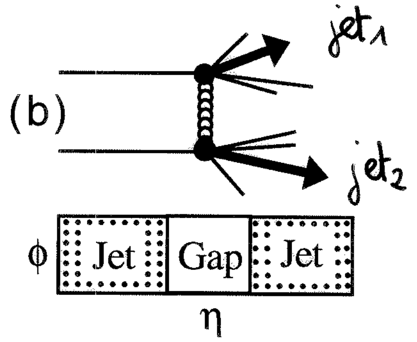
if
- $E_{T_1} \simeq E_{T_2}$ $\leftarrow$ no Q^2 evolution
- $\Delta\eta$ large $\leftarrow$ space for x evolution
- LRG requirement $\leftarrow$ BFKL gluon ladder $\equiv$ hard QCD $\mathbb{P}$omeron?

Experimentally: how to define LRG

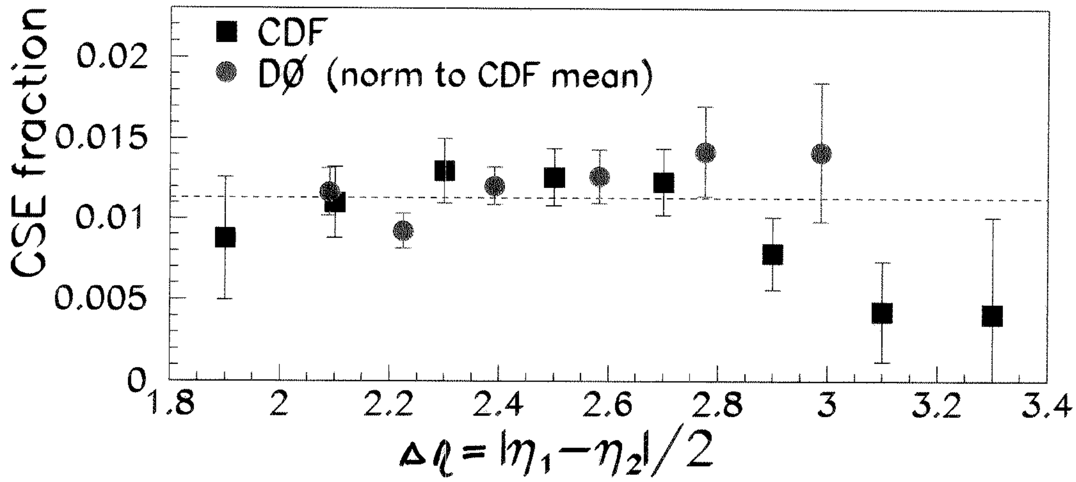
Theoretically: LRG survival probability (multi parton interactions)

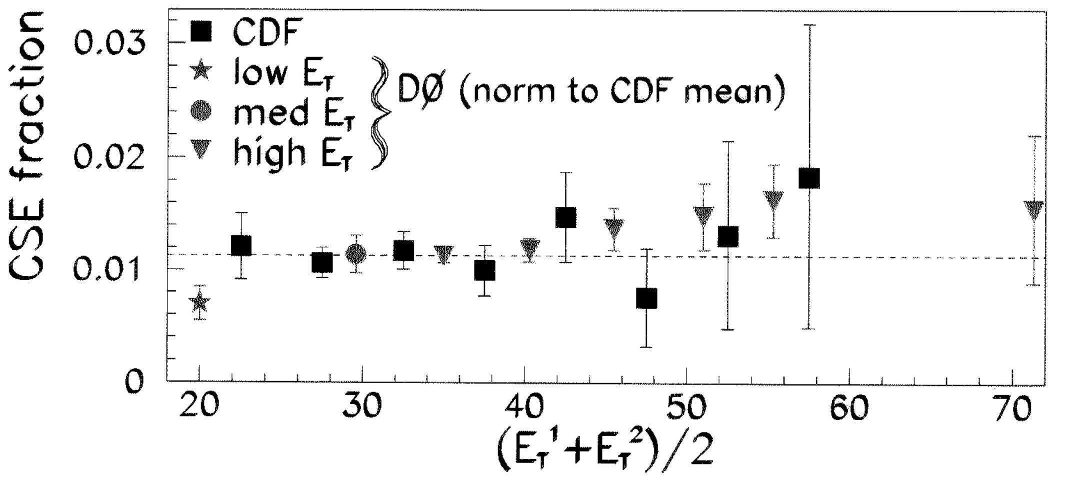
High t color singlet in $p\bar{p}$ (FNAL)

color singlet exchange
CSE

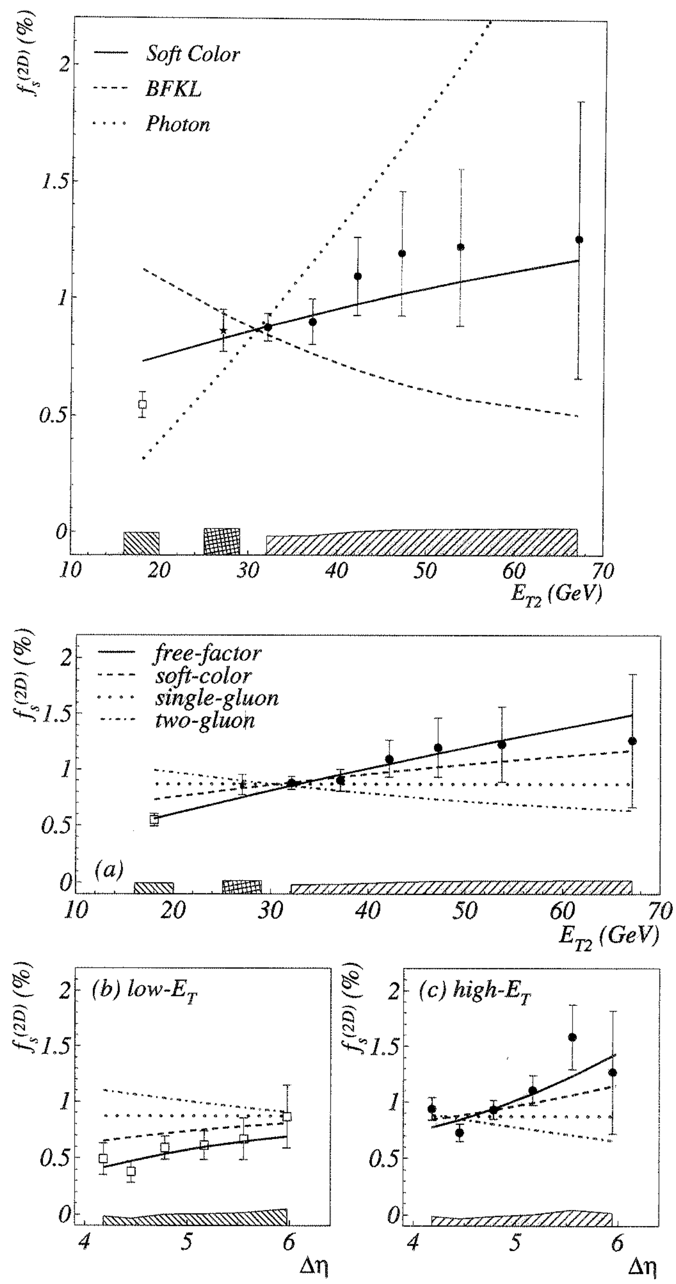


enhance
LRG of perturbative
origin ?





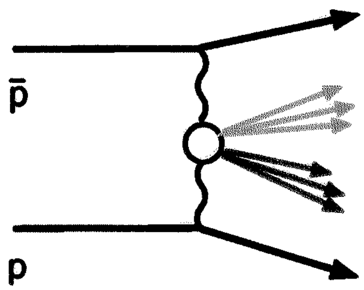
Origin of large t color singlet in $p\bar{p}$

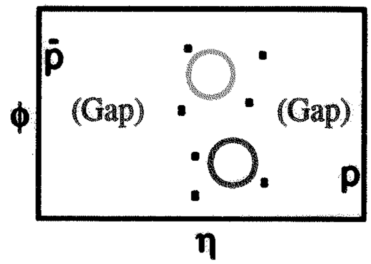


The color singlet exchange seems to couple predominantly to quarks

Double Gaps at 630 GeV

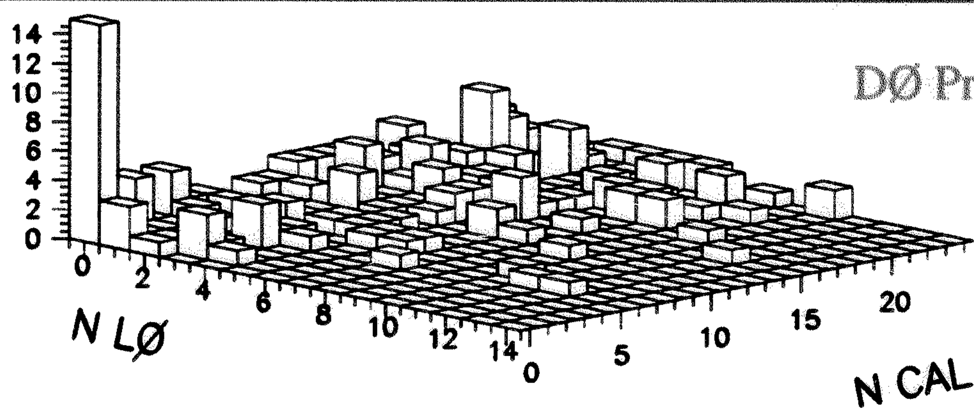
$|\text{Jet } \eta| < 1.0$, $E_T > 12$ GeV



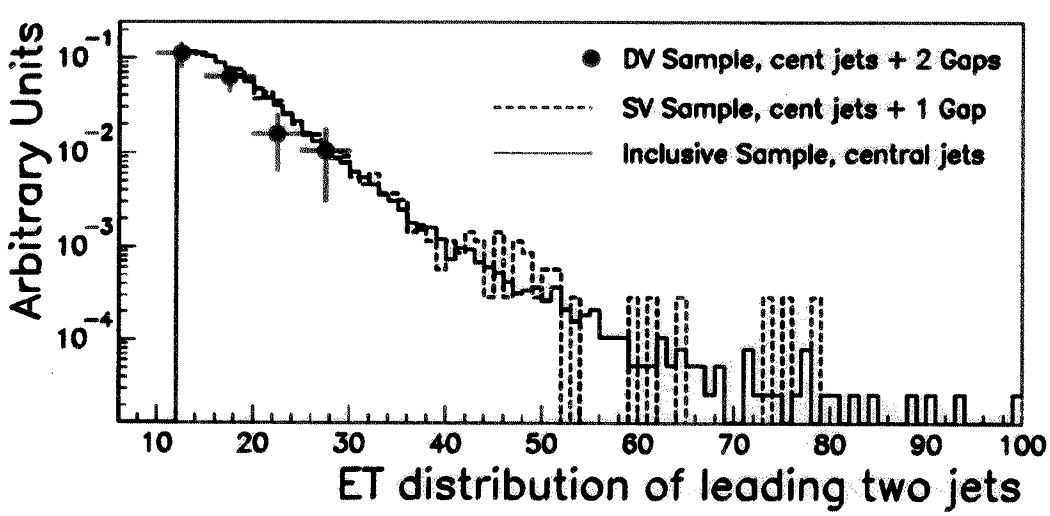


Gap Region
$2.5 < |\eta| < 5.2$

Demand gap on one side, measure multiplicity on opposite side



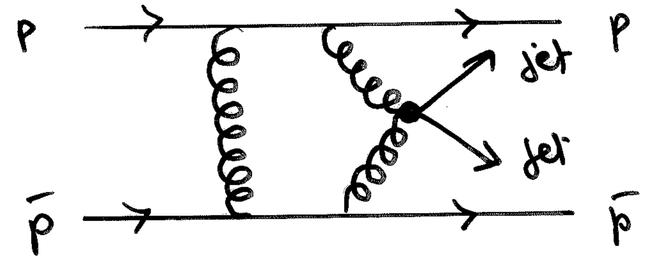
DØ Preliminary



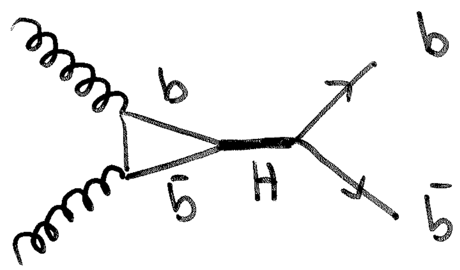
Motivation for double gaps

(of M. Albrow)

Non factorizable double $\mathbb{P}$ exchange

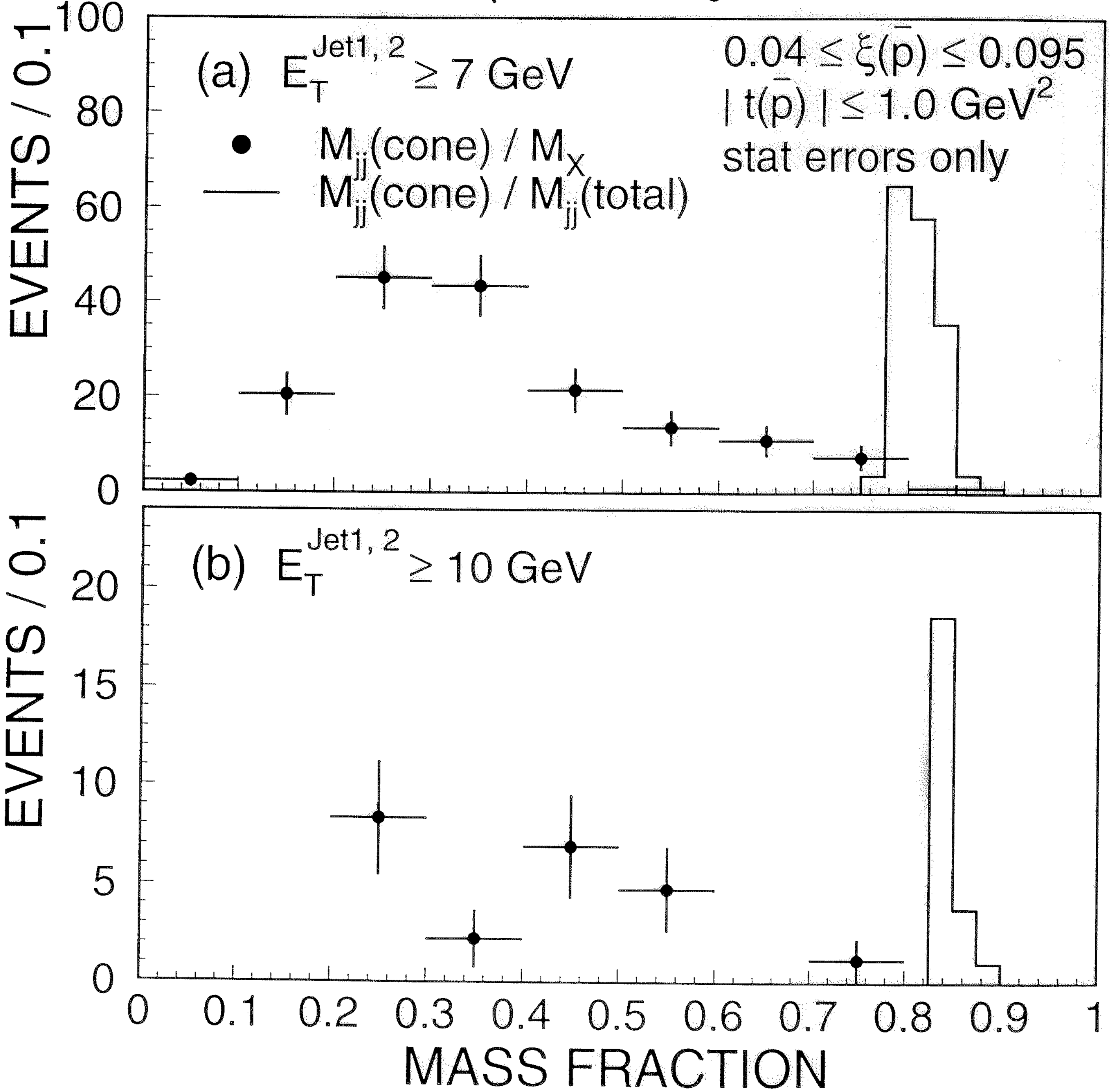


Search for Higgs in a missing mass experiment



$p\bar{p} \to p\bar{p}$ H

CDF preliminary



Summary

- Expanded understanding of QCD dynamics at high energy
- "New" language in terms of sizes of interacting states - interplay between hard and soft contributions
- Many features of the theoretical expectations and of the data to explore
- Important implications for scattering off nuclear target

WHY?

Citation from L. Frankfurt:
"It may allow us to produce in LAB new form of (partonic dense matter) in a controlled manner !!!"