D Soper
W. G. II

Diffractive DIS

$$e + p \to e + p + X$$

$$Q^2 \gg 1 \text{ GeV}$$

$$|t| \lesssim 1 \text{ GeV}$$

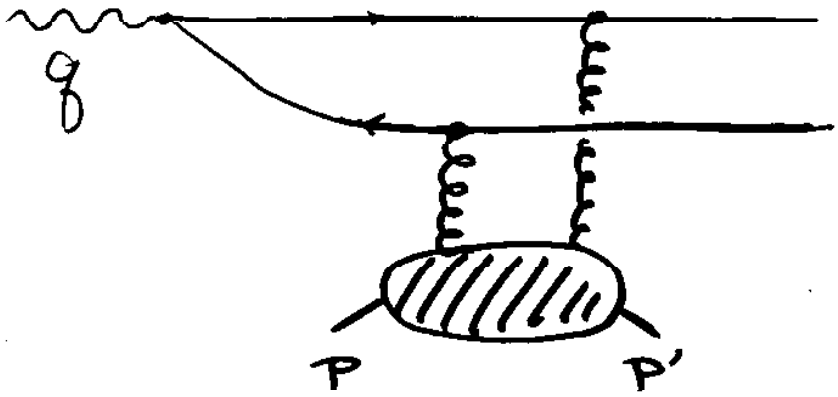
$$x_{\mathbb{P}} \ll 1$$

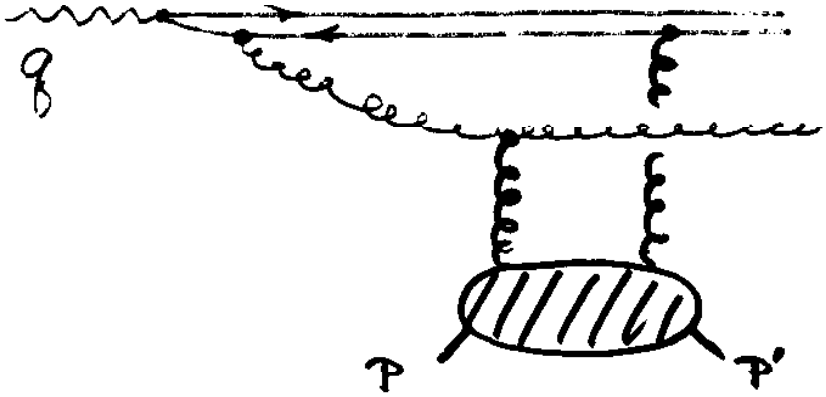
Can substitute a rapidity gap for direct observation of the final state proton

I will not mention "pomeron" for some time.

Microscopic origin of diffractive DIS

- for this picture see talk of Nikolaev
- use proton rest frame

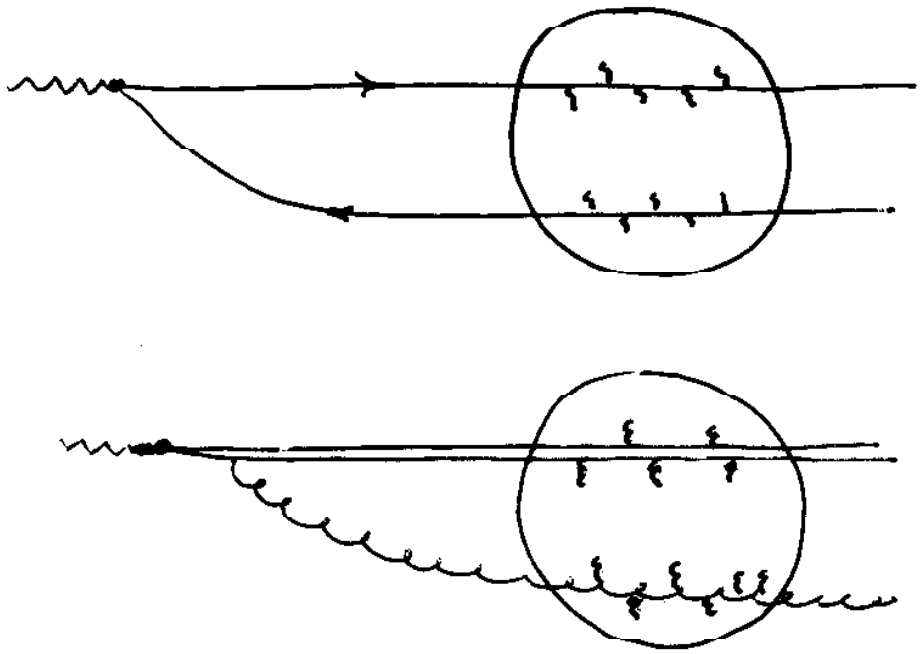




- Lots of predictions based on this
- see also talk of Wusthoff

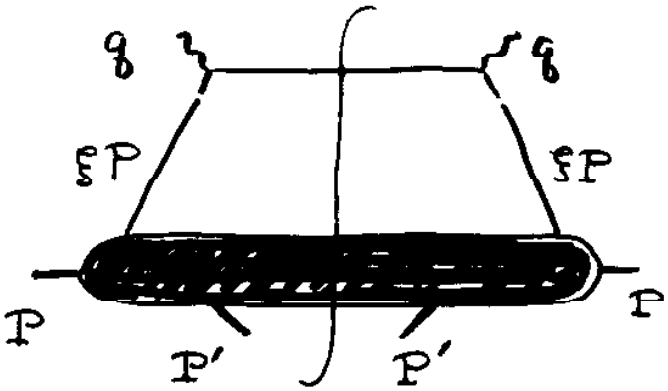
Another version

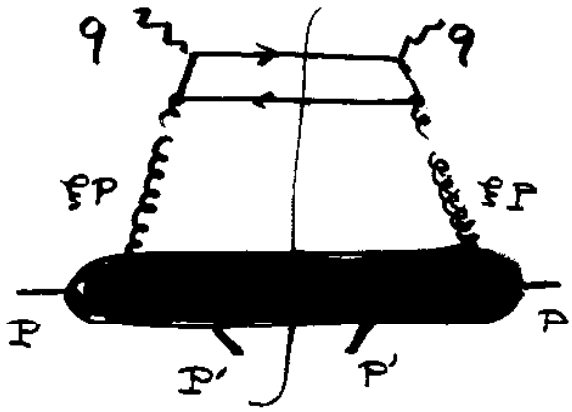
Buchmüller, Hebecker, Mc Dermott



Partons in the γ^* wave function rotated in color space by the soft color field of the proton

Diffractive Factorization in DIS





$$\frac{d F_2^{diff}(x, Q^2; x_{\mathbb{P}}, t)}{d x_{\mathbb{P}}\, dt} \sim$$

$$\sum_a \int_0^{x_{\mathbb{P}}} d\xi \; \frac{d f_{a/A}^{diff}(\xi, x_{\mathbb{P}}, t; \mu)}{d x_{\mathbb{P}}\, dt} \; \hat{F}_{2,a}\left(\frac{x}{\xi}, Q^2; \mu\right)$$

diffractive parton distribution functions (process independent)

usual calculated hard scattering function (process independent

Diffractive parton distributions

- must be determined from experiment
- have been determined from HERA experiments

  eg Whitmore talk
  (Alvero, Collins, Terron & Whitmore)

  - Regge form helps
  - Beware of $(1-\beta)Q^2 < M^2$

    $\beta \equiv \xi / x_{\mathbb{P}}$

    - see Bartels talk ; Nikolaev talk
  - lots of glue for $x_{\mathbb{P}} \ll 1$
  - often a big fraction of the available momentum is carried by a single gluon.

Diffractive factorization - comments

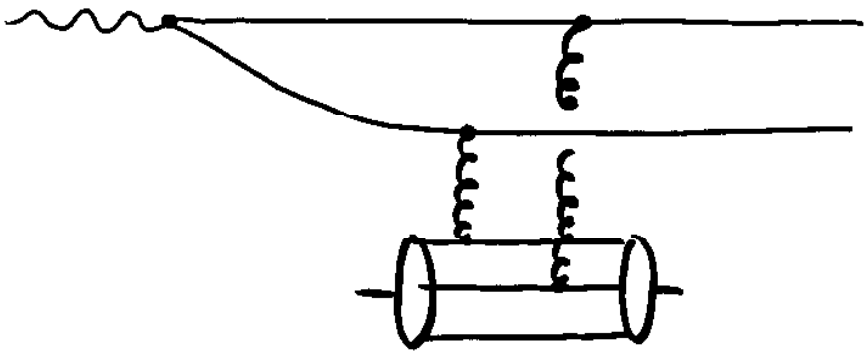
(from Berera & D.S. See Berera talk)

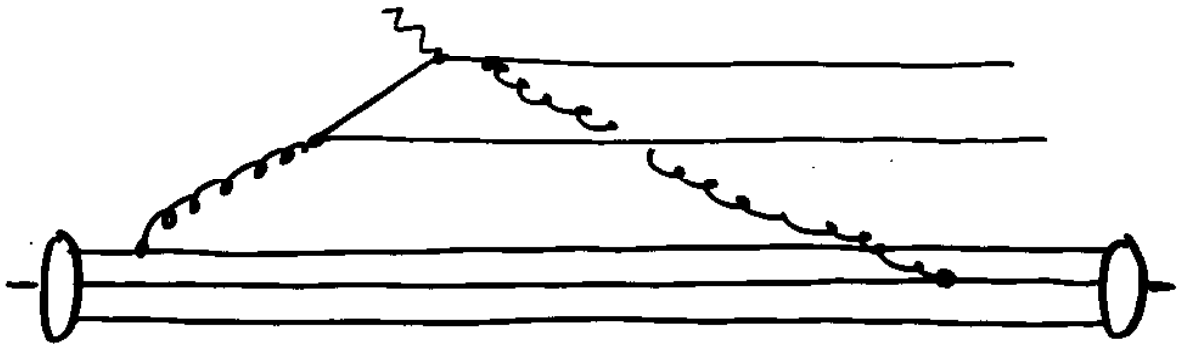
- This is Ingelman-Schlein minus Regge
- Cf Veneziano & Trentadue
- For lepton-hadron processes, diffractive factorization appears to be a consequence of QCD.
- Supported by 1-loop calculations of Graudenz.
- $df_{a/A}^{diff}(\xi, x_{\mathbb{P}}, t; \mu)/dx_{\mathbb{P}}\,dt$ has an operator definition
- Usual evolution equation follows from the factorization.

Relation between the two pictures of diffractive DIS

talk of Hebecker

They are related by a Lorentz transformation





(Use gauge invariance, appropriate approximations to make sure this works)

The word "Pomeron" enters

Following Ingelman-Schlein, one proposes

$$\frac{d f_{a/A}^{diff}(\xi, x_{\mathbb{P}}, t; \mu)}{d x_{\mathbb{P}}\, dt}$$

$$= \frac{1}{8\pi^2} \left|\beta_A(t)\right|^2 x_{\mathbb{P}}^{-2\alpha(t)}$$

$$\times f_{a/\mathbb{P}}\left(\frac{\xi}{x_{\mathbb{P}}}, t; \mu\right)$$

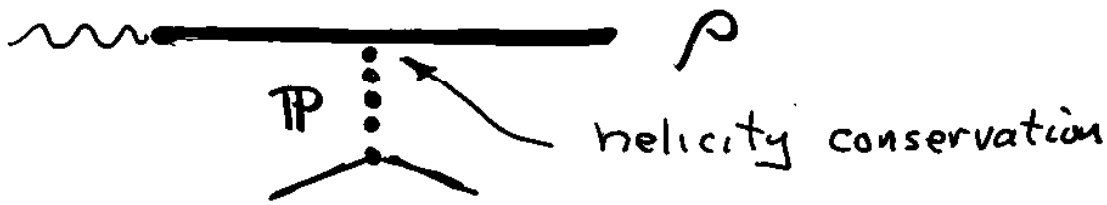
- Beware: if $x_{\mathbb{P}}$ is not small enough, one should add a term for the sub leading Regge trajectory
- exponent of $x_{\mathbb{P}}$ should be independent of $\beta = \xi / x_{\mathbb{P}}$.
- See following talk for how well this works.

Diffractive vector meson production

$$\gamma + p \to V + p$$

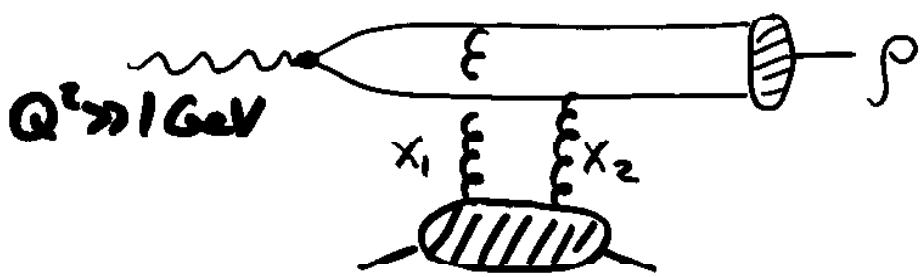
$\hookrightarrow \rho, \omega, J/\psi$

Use Regge theory



Connect this to

$$\gamma^* + p \to V + p$$



- See talks of Radyushkin & Freund for progress in understanding

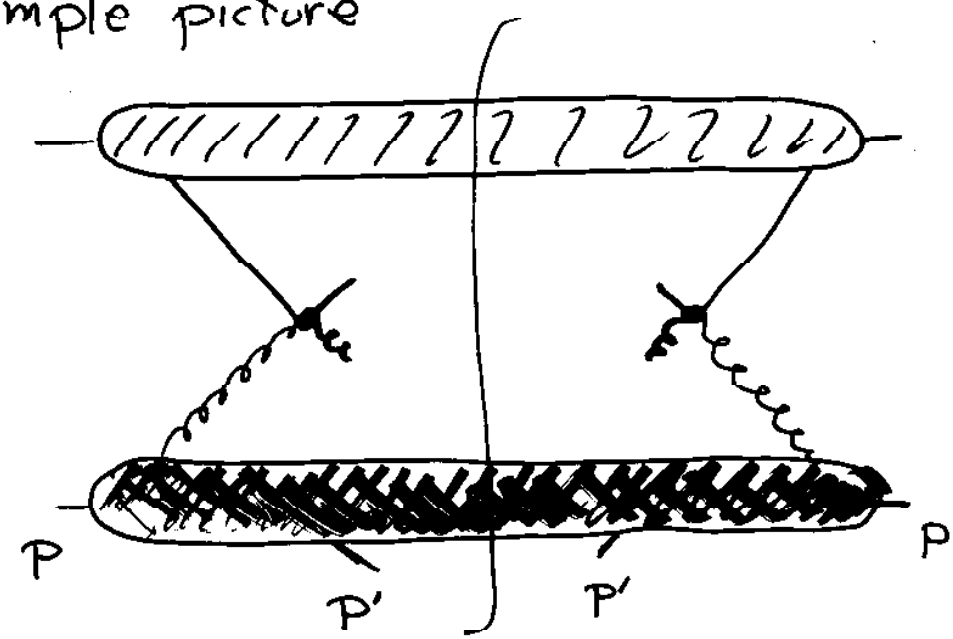
$$f(x_1, x_2) \sim g(x)$$

Hard diffraction in $\bar{p}p$

eg $p + \bar{p} \to p + \text{jets} + X$

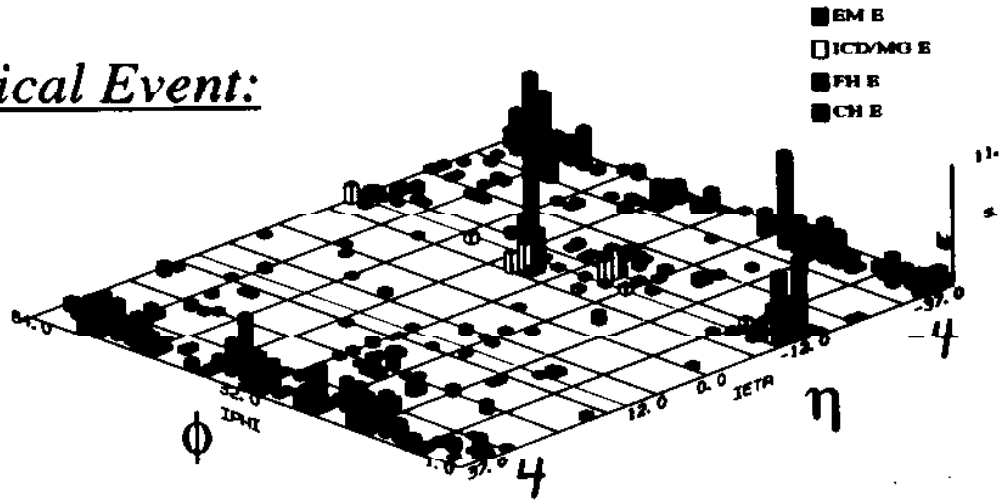
(can substitute rapidity gap for direct observation of the final state proton)

Simple picture

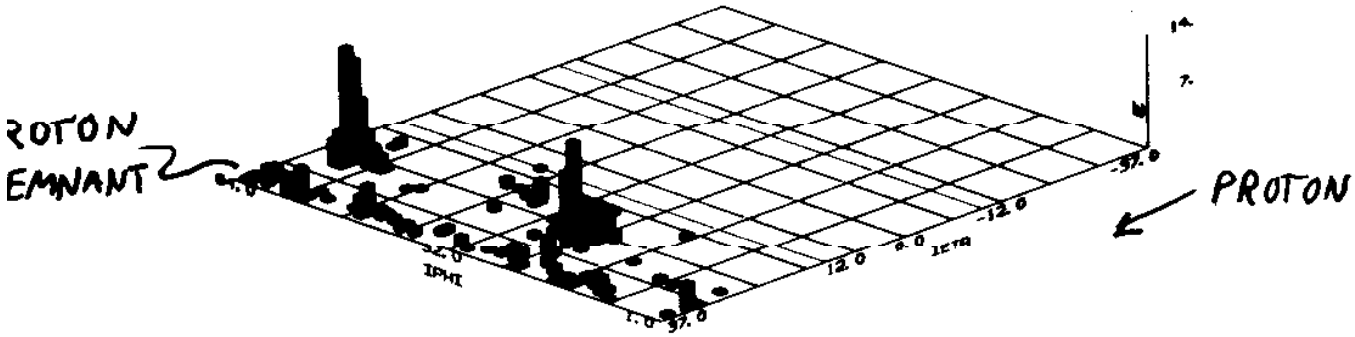


DØ Dijet Events: η–ϕ Legos

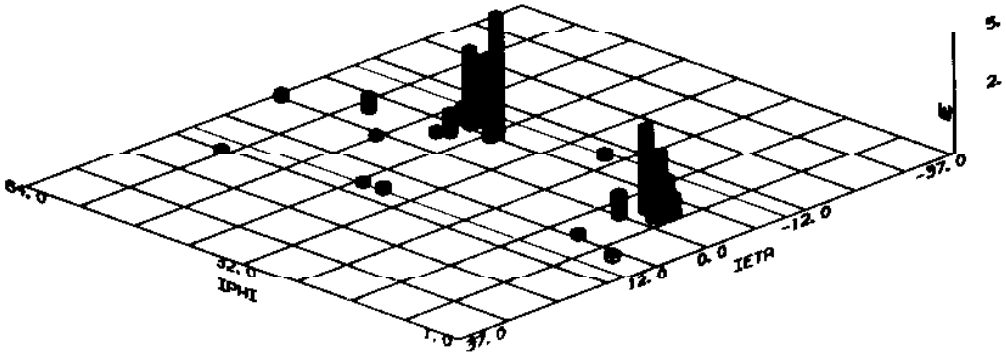
Typical Event:



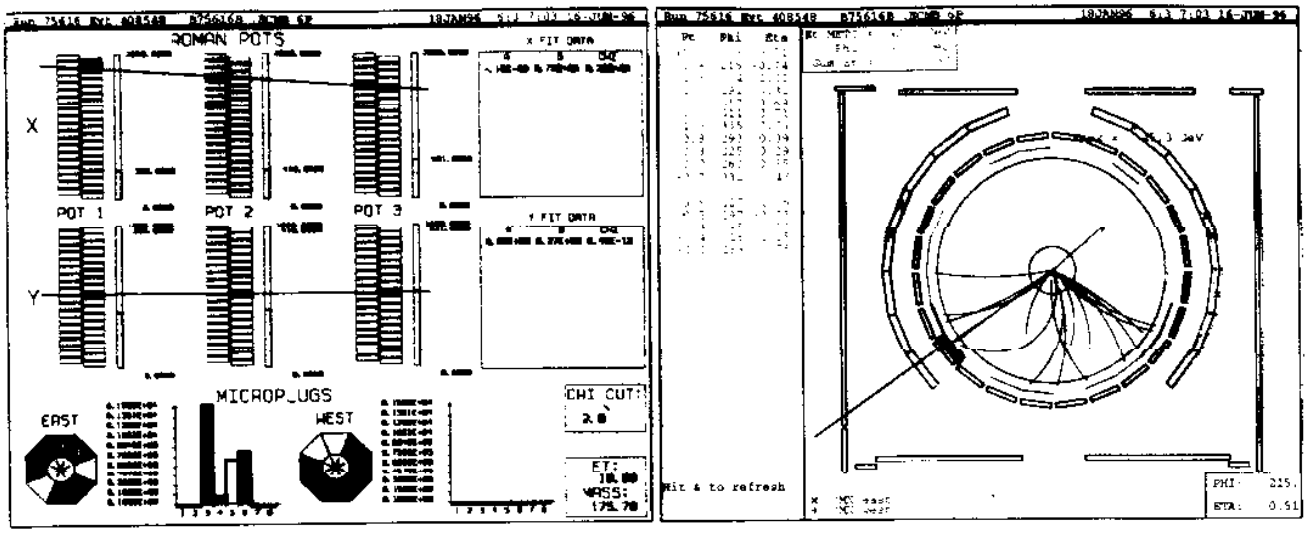
HSD topology:

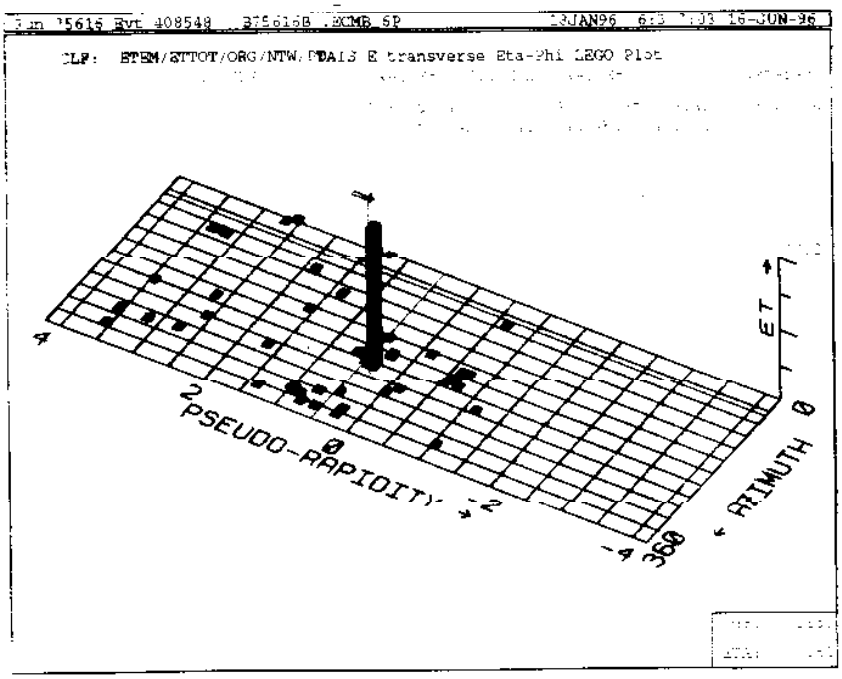


HDPE topology:



Diffractive W Candidate Event





Diffractive Hard Scattering in $p\bar{p}$ Collisions

	CDF	DØ	NO Suppression *
$\frac{\text{Diffractive W}}{\text{Inclusive W}}$	$(1.15 \pm 0.55)\%$		9.4 %
$\frac{\text{Diffractive Jets}}{\text{Inclusive Jets}}$	$(0.75 \pm 0.10)\%$		16 %
		$(0.67 \pm 0.05)\%$	10 %
$\frac{\text{Diffractive c, b}}{\text{Inclusive c, b}}$	$(0.18 \pm 0.03)\%$		?
$\frac{(\text{Diffractive})^2 \text{ Jets}}{\text{Inclusive Jets}}$	$(2.7 \pm 0.7) \times 10^{-6}$	$\sim 10^{-6}$	?

* Theory based on diffractive factorization with no suppression, using HERA data. Alvero, Collins, Terron & Whitmore

gluons favored by 7 to 3

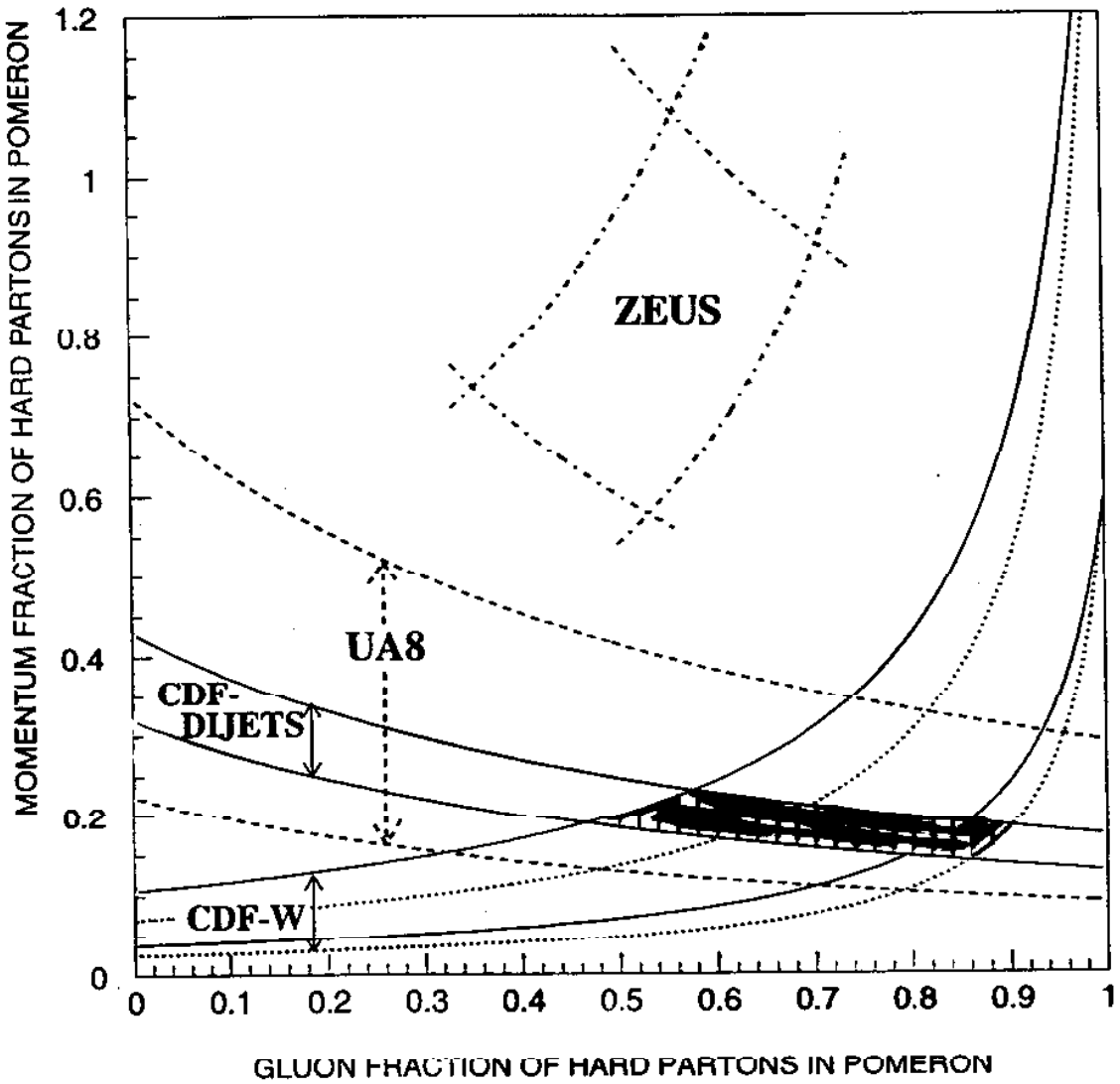
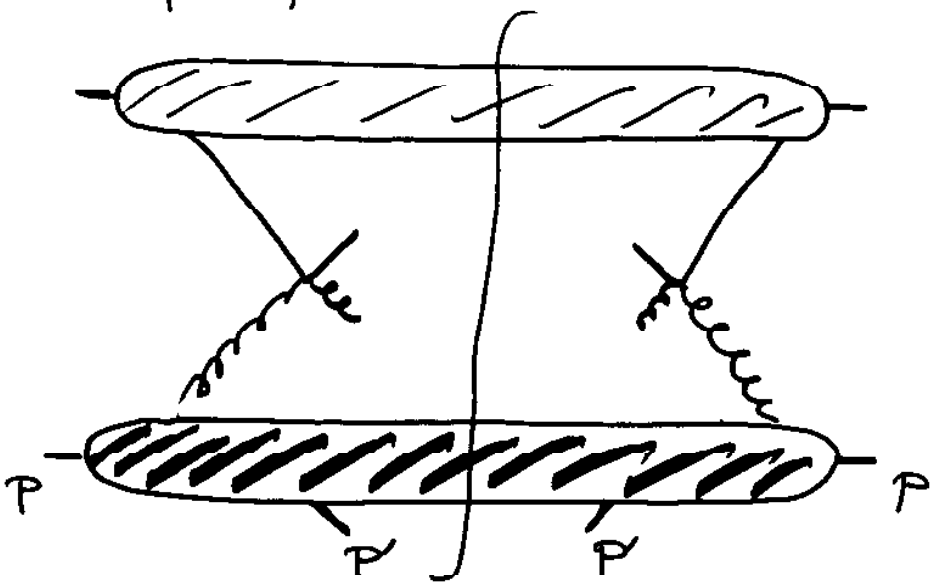
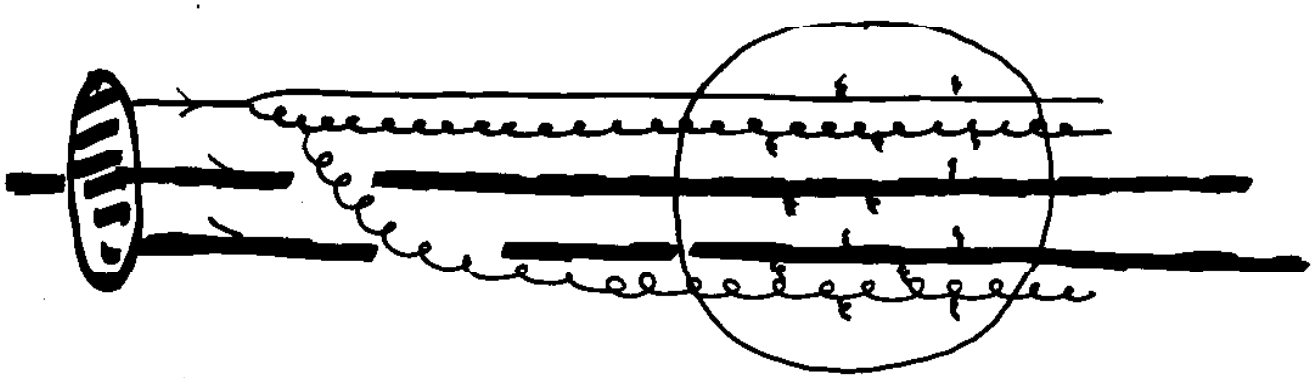


FIG. 5. Momentum fraction versus gluon fraction of hard partons in the pomeron evaluated by comparing measured diffractive rates with Monte Carlo predictions based on the standard pomeron flux and assuming that only hard pomeron partons participate in the diffractive processes considered. Results are shown for ZEUS (dashed-dotted), UA8 (dashed) and the CDF-DIJET and CDF-W measurements. The CDF W result is shown for two (dotted) or three (solid) light quark flavors in the pomeron . The shaded region is used in the text to extract the quark to gluon fraction of the pomeron and the standard flux discrepancy factor.

The simple picture



This simple picture (diffractive factorization) should be wrong when we have hadron-hadron collisions



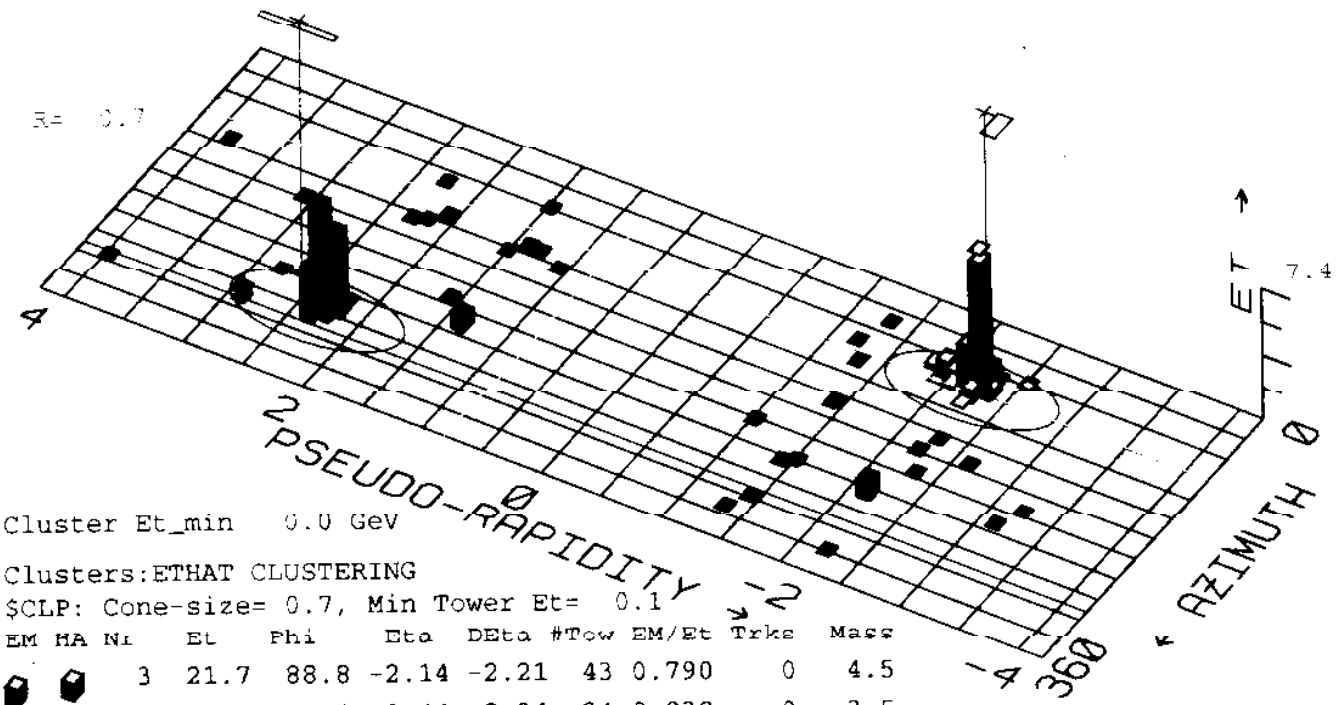
We should expect a survival probability

$S < 1$

Jet-Gap-Jet event

Run 61511 Evt 315901 HATTI.DST FWDJET_CCK496.DST;1 18AUG94 23:46:37 10-AUG-96

CLF: ETEM/ETTOT/ORG/NTW/PTAIS E transverse Eta-Phi LEGO Plot
17.5/ 17.5/CLF/ 4 Max tower E= 7.4 Min tower E= 0.20 N clusters=
12.0/ 14.5/CLF/ 6
METS: Etotal = 284.6 GeV, Et(scalar)= 47.6 Ge
Et(miss)= 4.4 at Phi= 288.0 Deg.



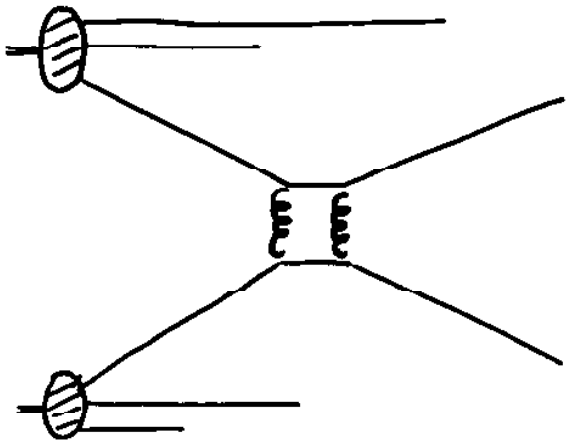
Cluster Et_min 0.0 GeV

Clusters:ETHAT CLUSTERING
$CLP: Cone-size= 0.7, Min Tower Et= 0.1

EM	HA	Nt	Et	Phi	Eta	DEta	#Tow	EM/Et	Trks	Mass
		3	21.7	88.8	-2.14	-2.21	43	0.790	0	4.5
		2	17.8	270.8	2.44	2.34	24	0.938	0	3.5

PHI: 90.
ETA: 0.82

Jet - Gap - Jet (DØ)



color 1

$$\frac{\left[(\text{Jet-Gap-Jet})/(\text{Jet-Jet})\right]_{630\,\text{GeV}}}{\left[(\text{Jet-Gap-Jet})/(\text{Jet-Jet})\right]_{1800\,\text{GeV}}} = 2.6 \pm 0.6$$

Two-gluon model $\Rightarrow$ $R = 0.8$

Soft color rearrangement model

$\Rightarrow R = 2.2$