Diffractive Results from the Tevatron

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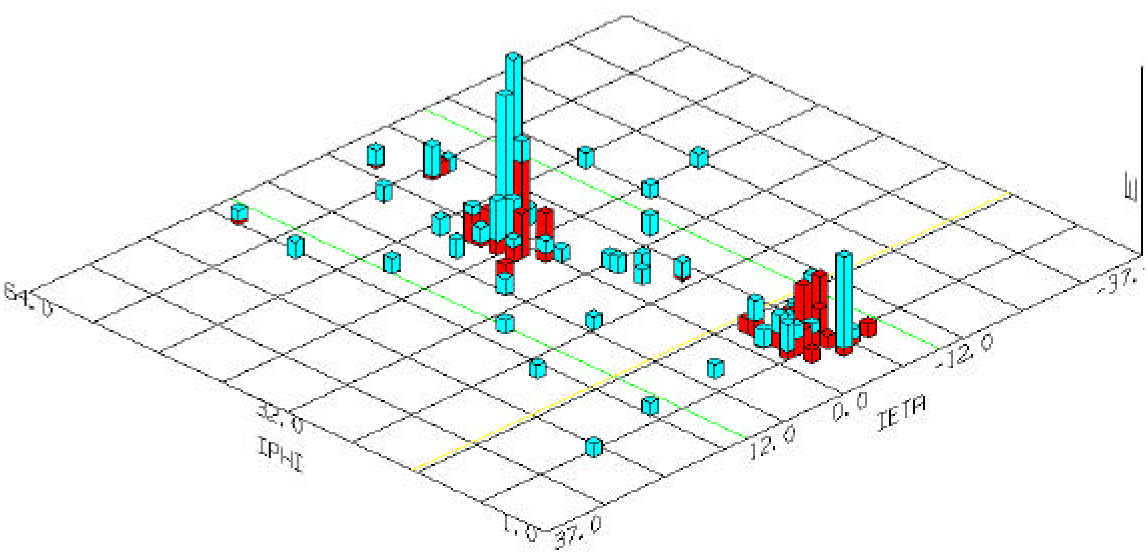
Lafex/CBPF
for the
D-Zero and CDF Collaborations

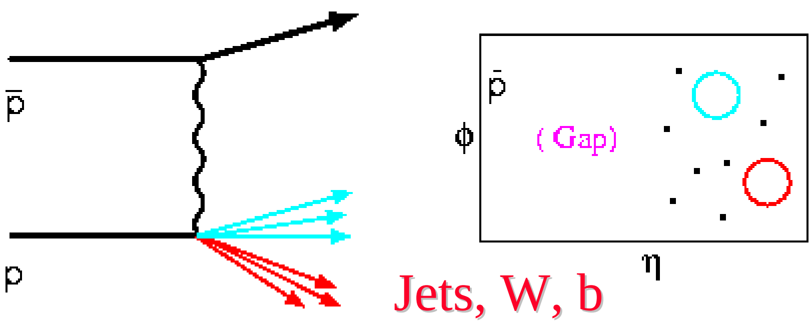


- Introduction
- Jet Production by Color Singlet Exchange
- Diffractive $b\bar{b}$ Production
- Diffractive Dijet and Pomeron Structure
- Double Pomeron Exchange
- Summary

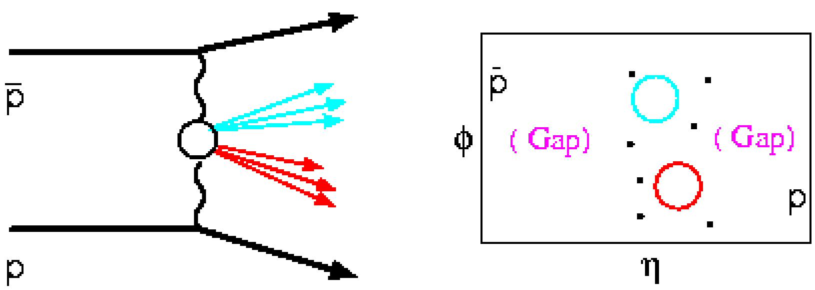
Introduction

Rapidity Gaps and Color-Singlet Exchange

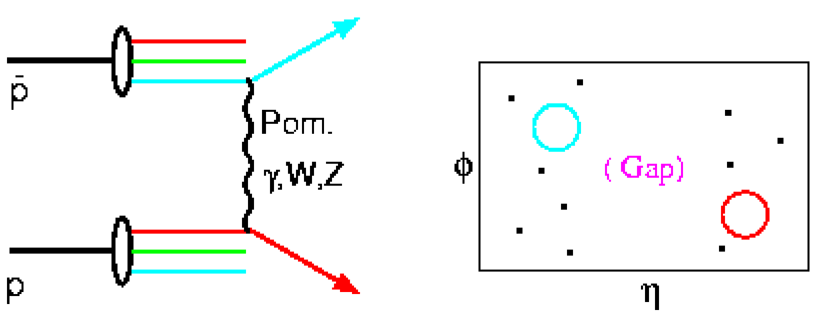
Hard Processes (jet production):



Hard Single Diffraction



Hard Double Pomeron



Hard Color-Singlet

Diffractive Signatures

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Rapidity Gap Tagging

- CDF Central: Tower E_T (EM + HAD) > 200 MeV
  - $|\eta| < 1.1$ Track > 300 MeV
  - Forward: $2.4<|\eta|<4.2$ E > 1500 MeV
  - $3.2<|\eta|<5.9$ BBC (Scint.) Hits

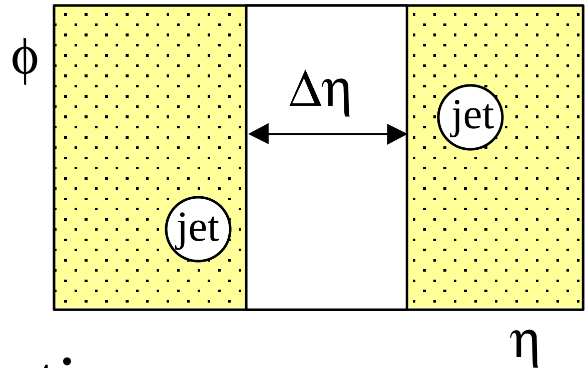
- DØ Central: Tower E_T (EM) > 200 MeV
  - $|\eta| < 1.0$ Track (No Threshold Cut)
  - Forward: $2.0<|\eta|<4.1$ E(EM) > 125 MeV
  - $3.0<|\eta|<5.2$ E(HAD) > 500 MeV
  - $2.0<|\eta|<4.1$ L0 (Scint.) Hits

CDF: BBC not used in Trigger → Can look for Diffractive anything

DØ: 94-96 Run removed L0 from selected Jet, W/Z Triggers used in veto to enhance SD, DPE Stats.

Color-Singlet Studies

QCD color-singlet signal observed in ~ 1 % opposite-side events ($p\bar{p}$)



Publications

DØ: PRL 72, 2332(1994)
CDF: PRL 74, 885 (1995)
DØ: PRL 76, 734 (1996)
Zeus: Phys Lett B369, 55 (1996) (7%)
CDF: PRL 80, 1156 (1998)

New Results

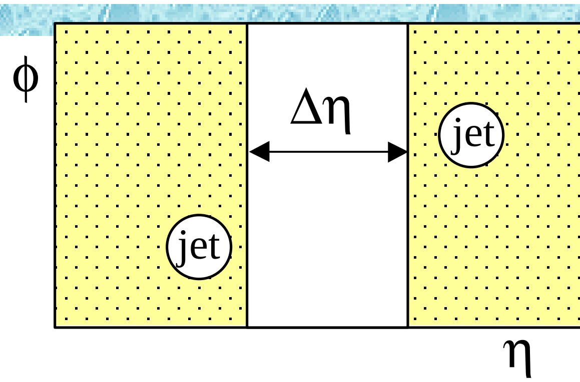
(Phys. Lett. B 440 189 (1998), hep-ex / 9809016)

✦Color-Singlet fractions at $\sqrt{s}$ = 630 & 1800 GeV

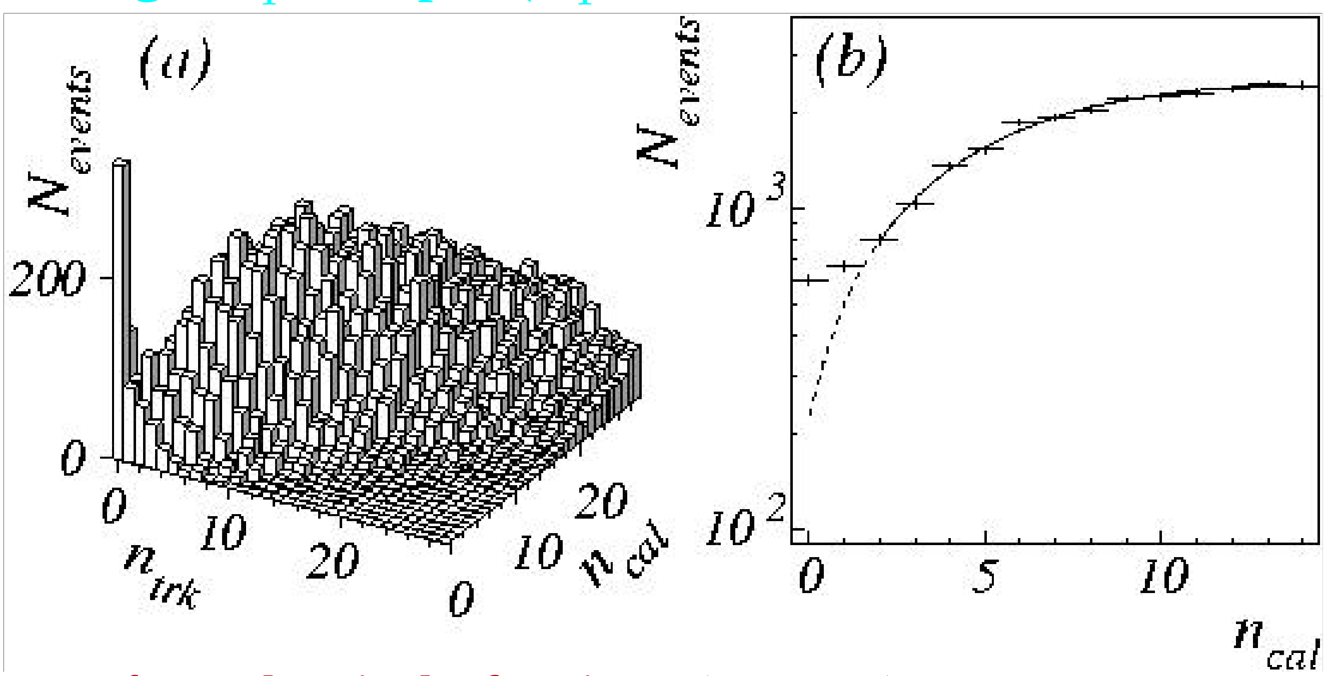
✦ Color-Singlet Dependence on: $\Delta\eta$, E_T, $\sqrt{s}$ (parton-x)

D0 Central Gaps

Count tracks and EM Calorimeter Towers in $|\eta| < 1.0$



High-E_T sample ($E_T > 30$ GeV, $\sqrt{s} = 1800$ GeV)



f_S = **color-singlet fraction** $=(N_{data} - N_{fit})/N_{total}$

$$f_S^{1800} = 0.94 \pm 0.04_{stat} \pm 0.12_{sys}\ \%$$

$E_T > 30$ GeV

(Includes correction for multiple interaction contamination. Sys error dominated by background fitting.)

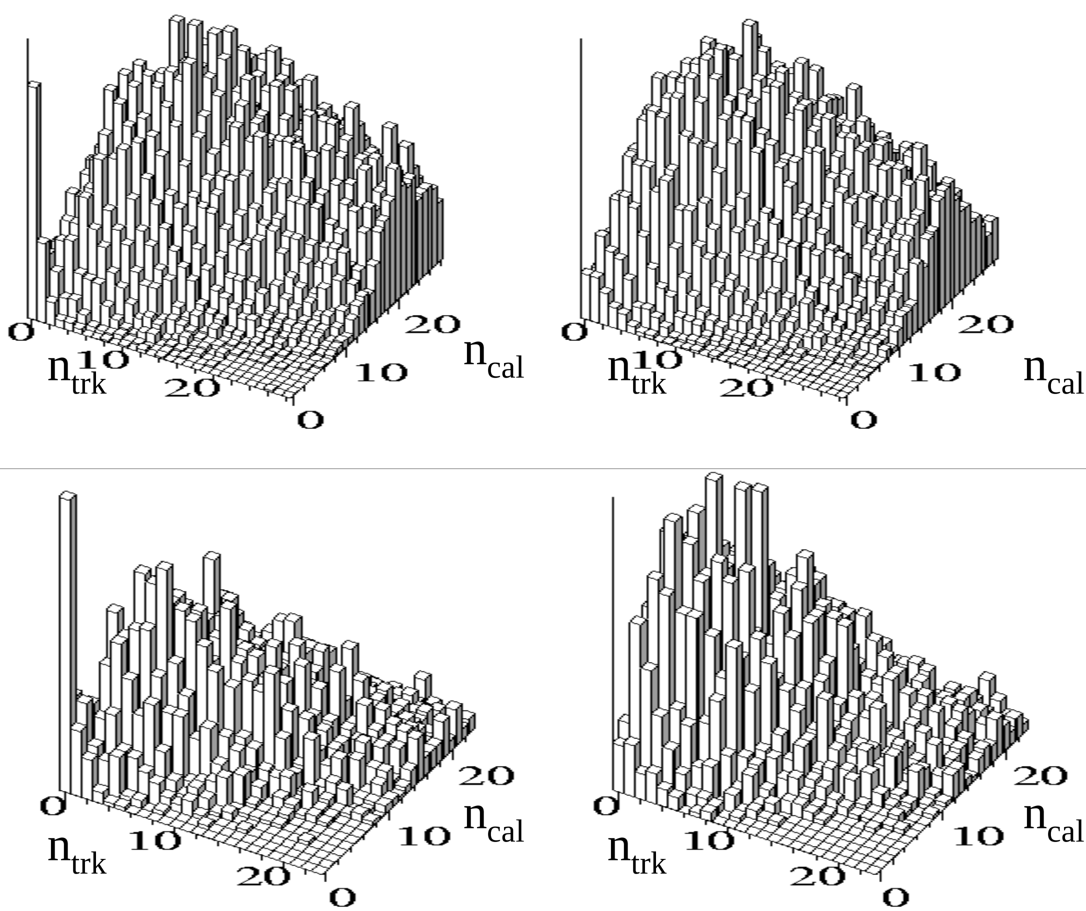
630 vs 1800

Jet $E_T > 12$ GeV, Jet $|\eta| > 1.9$, $\Delta\eta > 4.0$

Opposite-Side Data — Same-Side Data

1800 GeV:

630 GeV:



$$f_S^{\,1800} = 0.54 \pm 0.06_{stat} \pm 0.16_{sys}\ \%$$

$$f_S^{\,630} = 1.85 \pm 0.09_{stat} \pm 0.37_{sys}\ \%$$

Dzero Data $R^{630}_{1800} = 3.4 \pm 1.2$

Central Gap Fraction vs. √s

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D0:

f_S^{630} = 1.85 ± 0.09 ± 0.37

f_S^{1800} = 0.54 ± 0.06 ± 0.16

(stat) (sys)

CDF:

f_S^{630} = 2.7 ± 0.7 ± 0.6

f_S^{1800} = 1.13 ± 0.12 ± 0.11

(stat) (sys)

Ratio (630/1800)

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other types of printers.

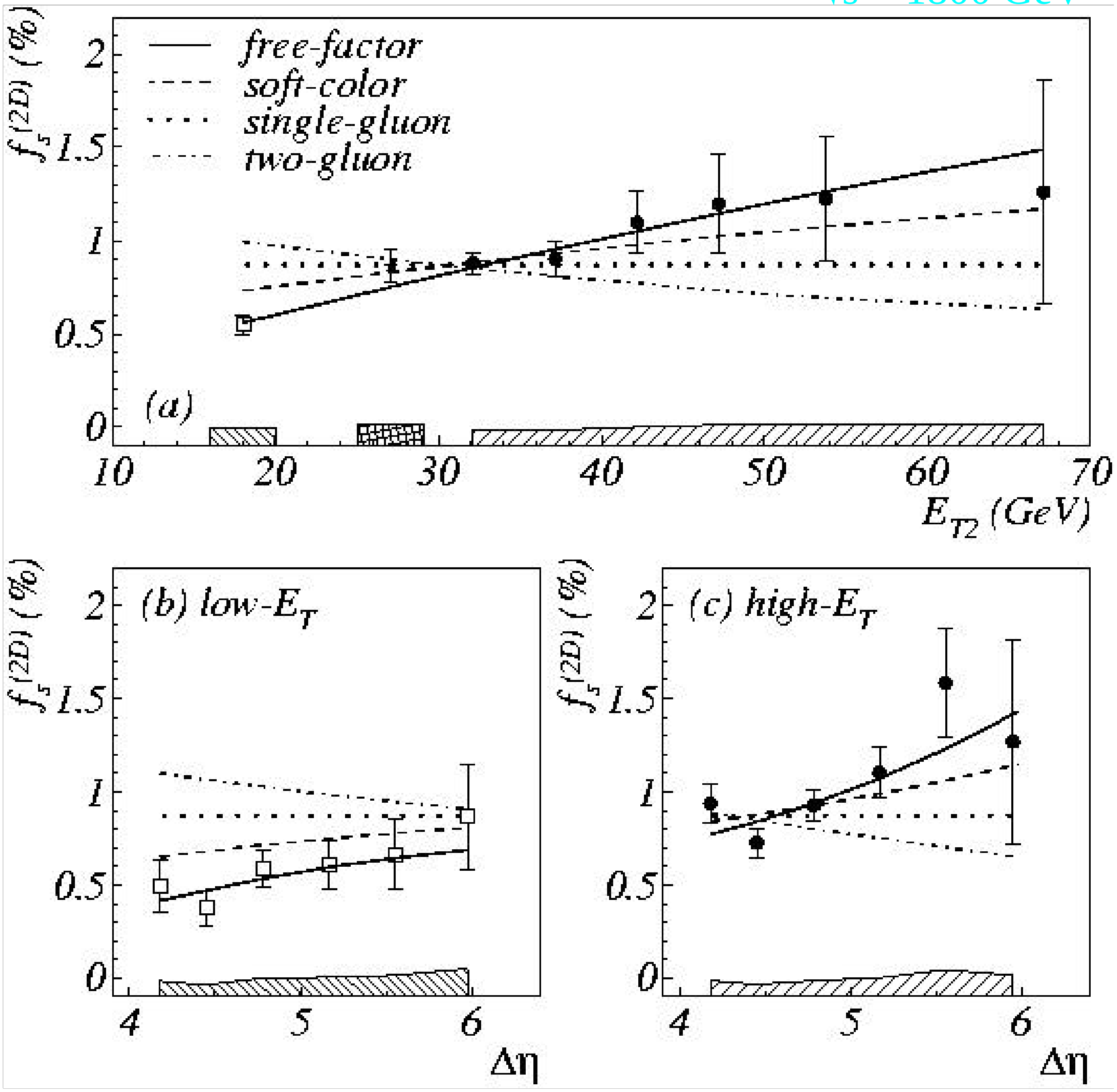
CDF: 2.4 ± 0.9

D0: 3.4 ± 1.2

Model Fits to DØ Data

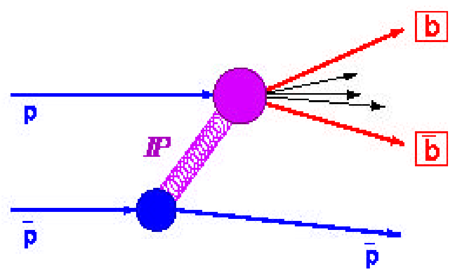
Using *Herwig 5.9*

√s = 1800 GeV



"Free-factor" and "Soft-Color" models describe data well

Diffractive $b\bar{b}$ Production *CDF*



Data (1800 GeV)

Inclusive High p_T Electron Trigger

$9.5 < p_T^e < 20\, GeV$

$\eta^e < 1.1$

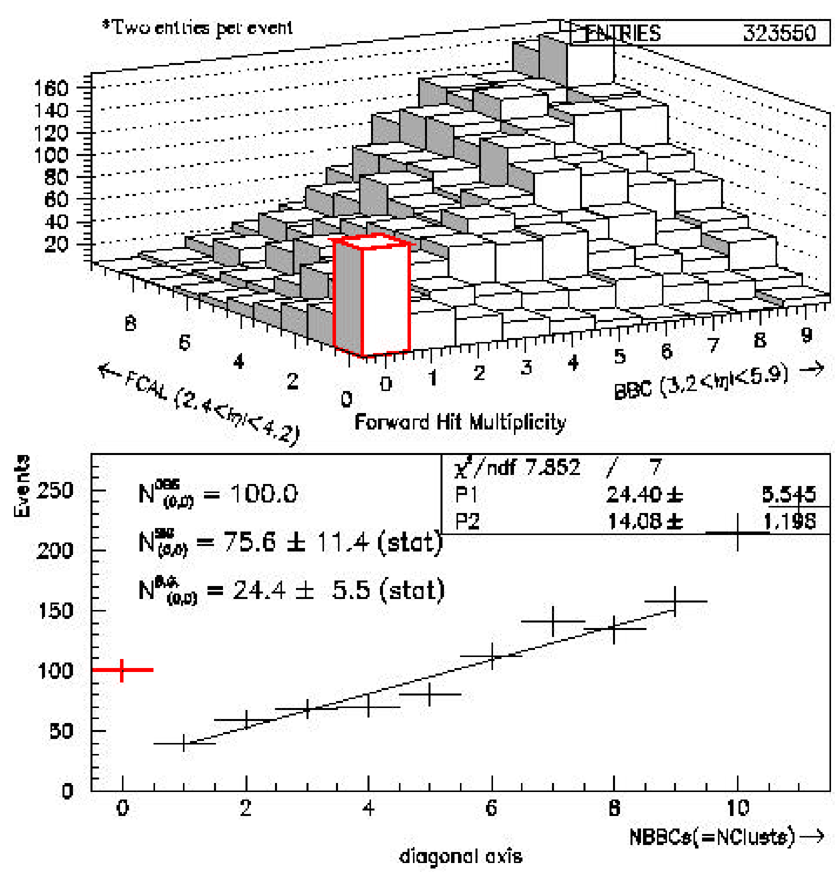
γ conversion and W electrons rejected.

(162,000 electron candidates.)

⇒ Count BBC hits and FCAL towers.

(Search for Rapidity Gap Signal.)

Diffractive Event Signal in electron sample



Combined Fit of Diffractive Candidates

Combined result of PTREL and IP fit

Simultaneous p_T^{rel} and IP fits to diffractive candidates. (unbinned likelihood function)

All-electron sample

N(b)=71600+-526(stat)+-4867(syst)
F(b)=44.4+-0.3(stat)+-3.0(syst)%

$\Rightarrow$

$b\bar{b}$ fraction in diffractive candidates.

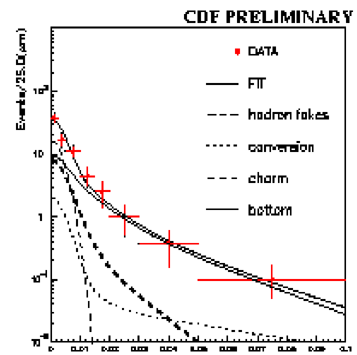
$\mathrm{F(b)} = 44.1 \pm 10.2(stat.)\,\%$

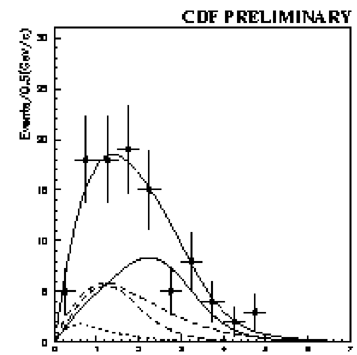
Number of $b\bar{b}$ events :

$\mathrm{N(b)} = 44.4 \pm 10.4(stat.)$

Diffractive candidates

(simultaneous PTREL+IP fit)





$\Rightarrow$

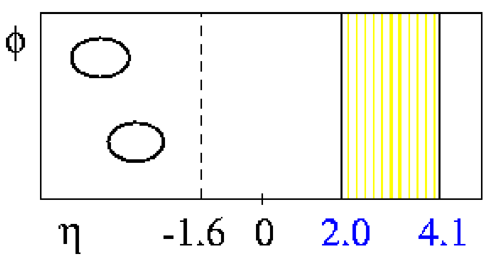
The Ratio of Diffractive to Non-Diffractive $b\bar{b}$ Production :

N(b)=44.4+-10.3(stat)+-3.0(syst)
F(b)=44.1+-10.2(stat)+-3.0(syst)%

$$R_{b\bar{b}}(9.5 < p_T^e < 20\,GeV, |\eta^e| < 1.1, gap) = 0.26 \pm 0.08(stat.) \pm 0.04(syst.)\,\%$$

(NO Gap Acceptance Correction)

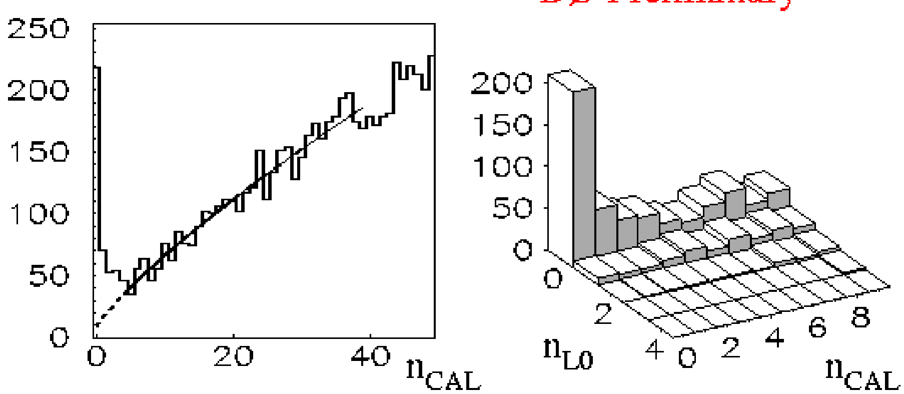
DØ Hard Diffraction at 1800 and 630 GeV



2 Jets: ET>12 GeV, |η|>1.6
Gap Interval: 2.0 <|η|< 4.1
Opposite Jets

DØ Preliminary

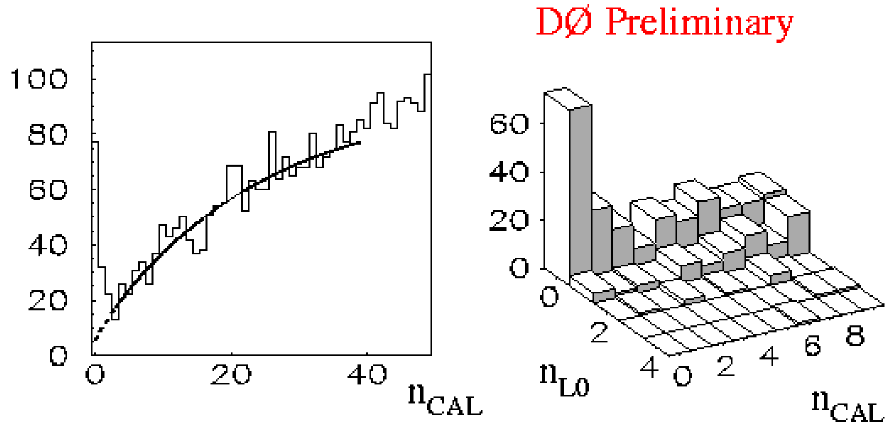
1800GeV



1800 Gap fraction: (0.76±0.04±0.07)%

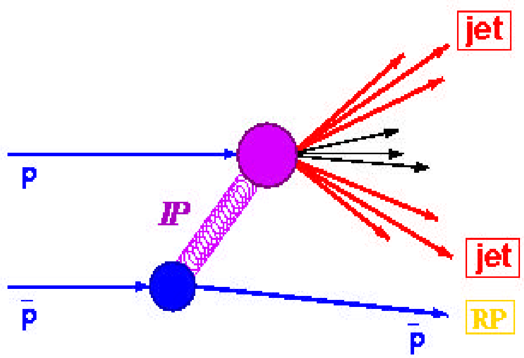
DØ Preliminary

630GeV



630 Gap fraction: (1.11±0.11±0.20)%

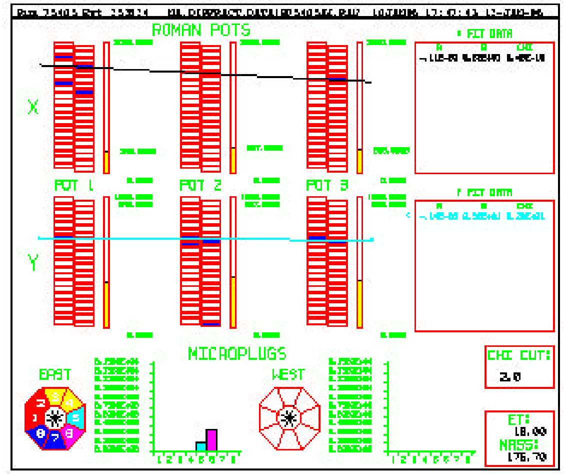
Diffractive Dijets with Roman Pot *CDF*

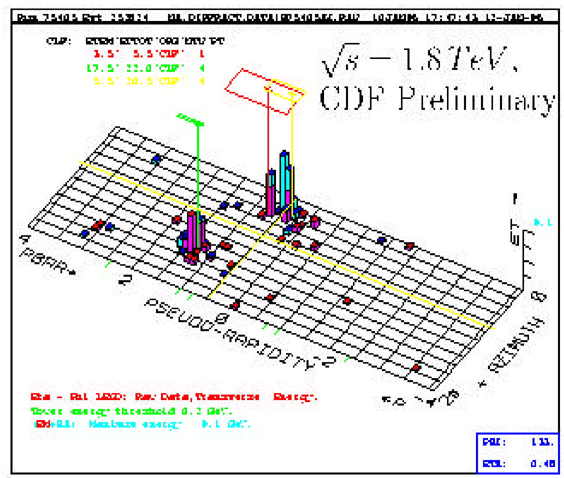


Dijets

⇒ hard process on the parton level.

⇒ good probe to pomeron structure.





We measure:

$\xi = P_{IP}/P_p$ with RP.

$\beta = P_{g,q}/P_{IP}$

$$= \frac{E_{T1} \cdot e^{-\eta_1} + E_{T2} \cdot e^{-\eta_2}}{2 \cdot \sqrt{\xi} \cdot P_{beam}}$$

with dijets.

$\Longrightarrow$ β shape : structure of the pomeron.

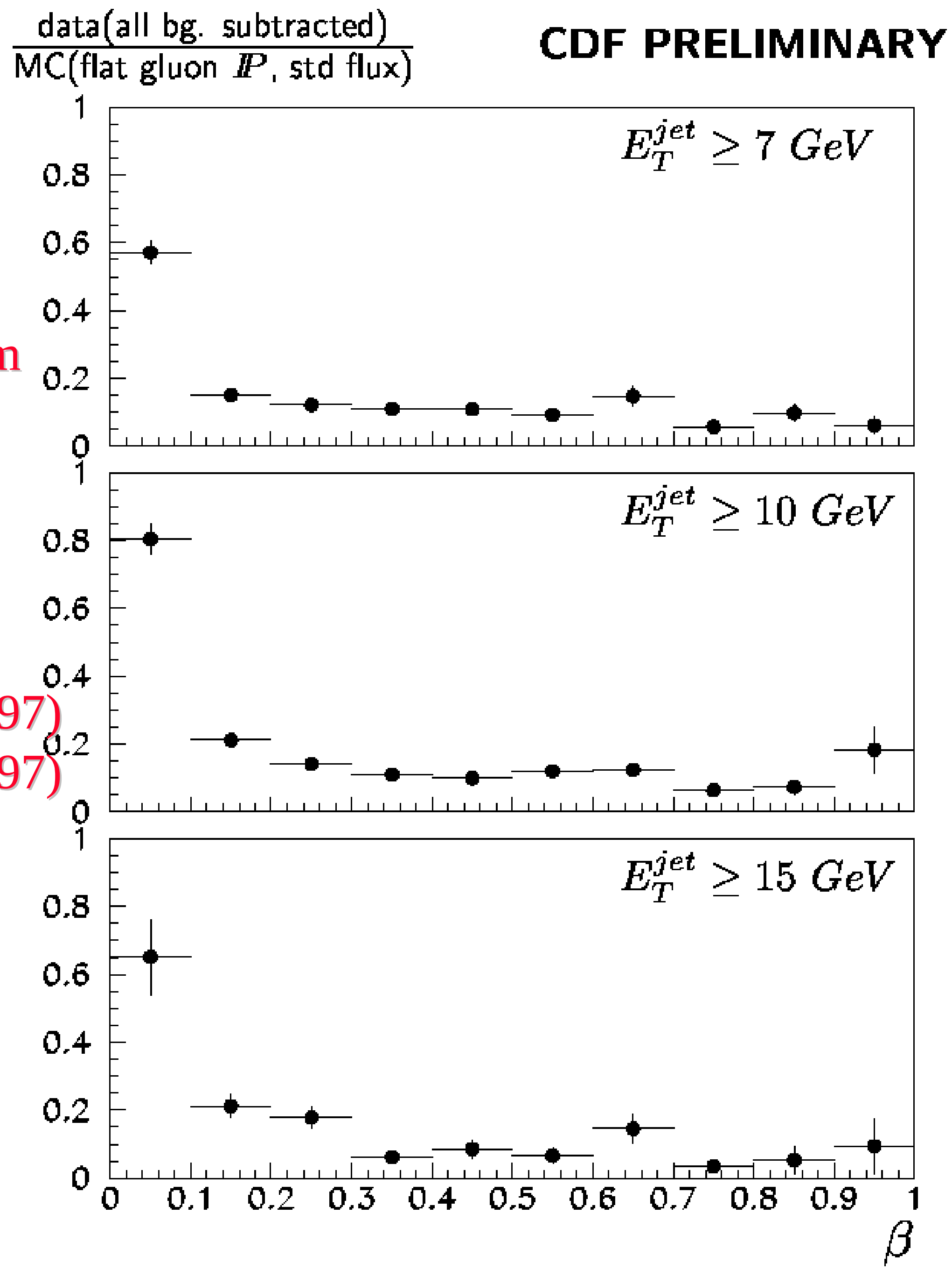
Rate : pomeron flux factor dependence.

Diffractive Dijets

Ratio Data(all bg. subtr.) to MC simulations using a flat gluon $I\!P$ and a standard flux

$0.05 < \xi < 0.1 \quad -1.0 < t < t_{min} \quad \sqrt{s} = 1800$ GeV

(stat. err. only)



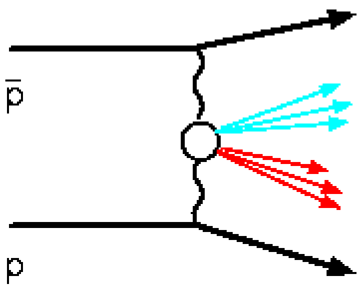
Discrepancy from Standard Flux Predictions for $\beta \geq 0.2$ agrees with previous results:

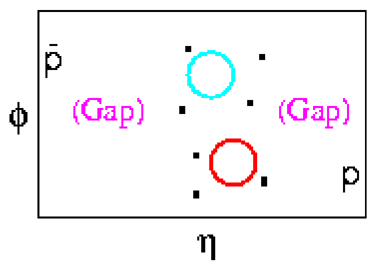
PRL 78,2698(1997)

PRL 79,2636(1997)

Double Gaps at 1800 GeV

$|\text{Jet } \eta| < 1.0$, $E_T > 15$ GeV

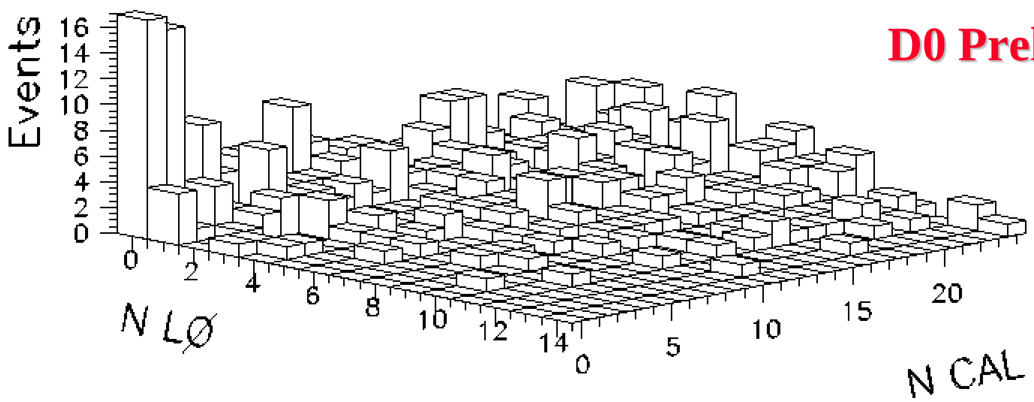


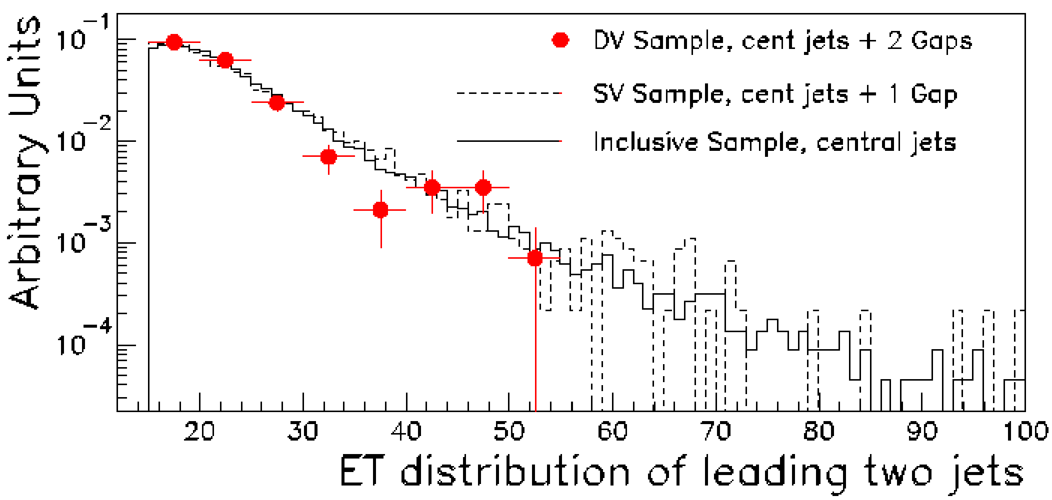


Gap Region
$2.5 < |\eta| < 5.2$

Demand gap on one side, measure multiplicity on opposite side

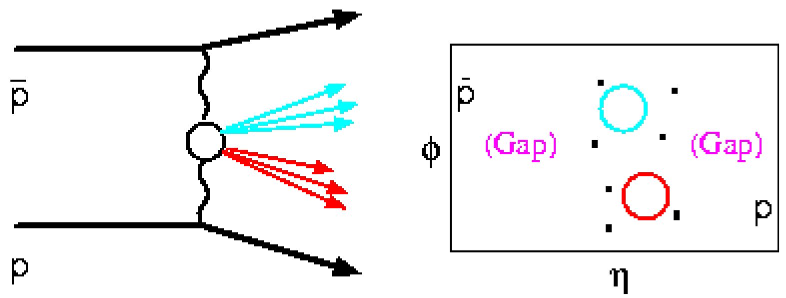
D0 Preliminary





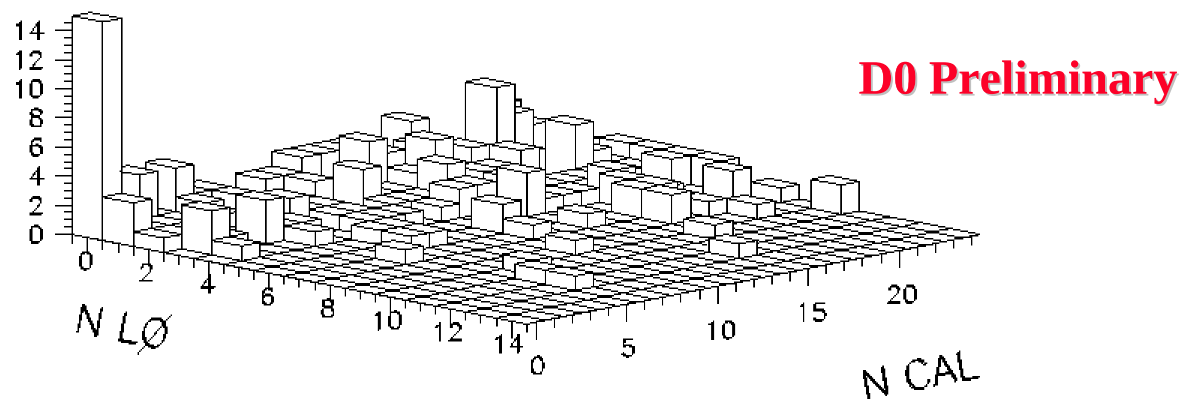
Double Gaps at 630 GeV

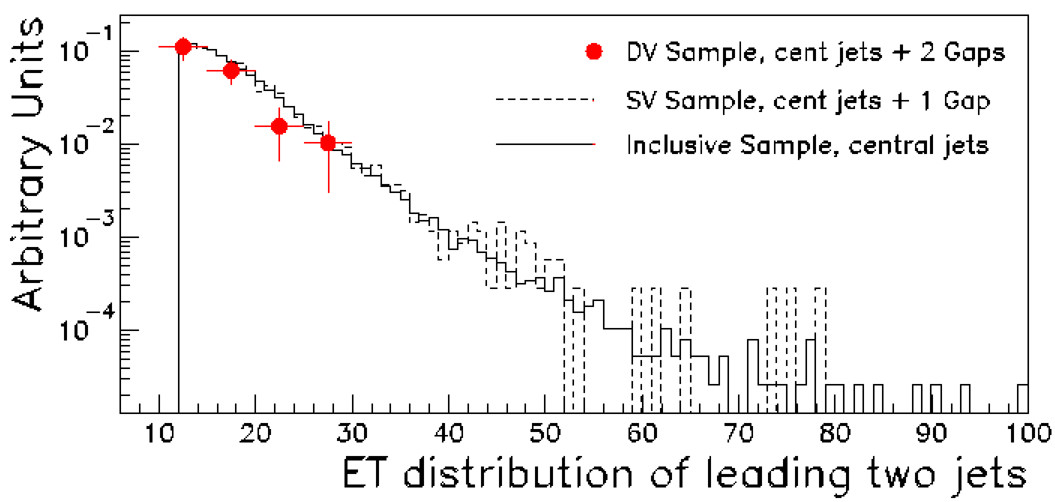
|Jet η| < 1.0, E_T>12 GeV



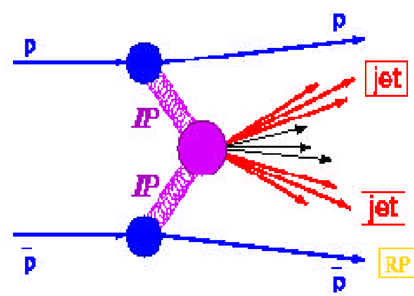
Gap Region
2.5<|η|<5.2

Demand gap on one side, measure multiplicity on opposite side





Dijets in Double Pomeron Exchange *CDF*



Dijets in DPE

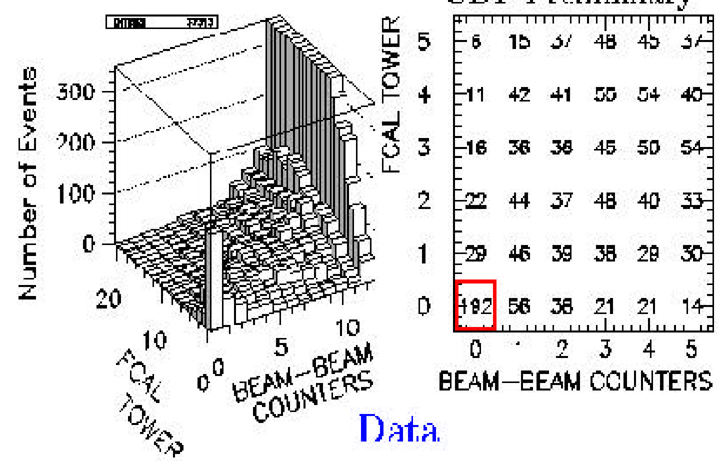
$\Rightarrow$ another possible probe to pomeron structure.

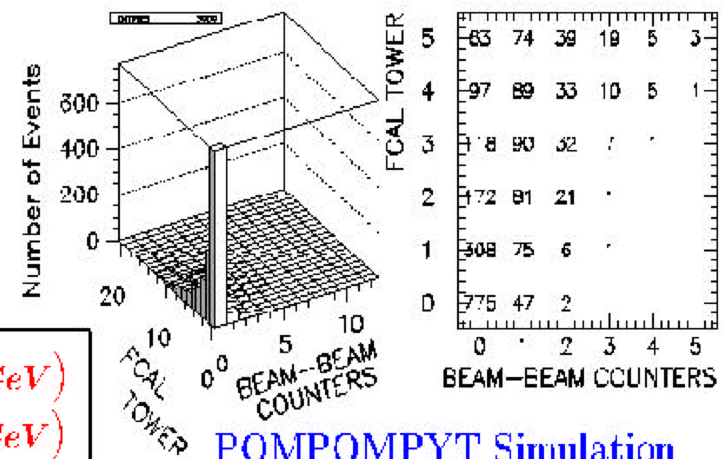
DPE Process

$\rightarrow$ Expect LOW multiplicity on the proton side.

$0.04 < \xi < 0.095$, $|t| < 1.0\,GeV^2$

Dijet $E_T > 7\,GeV$ (NO ULE energy stable)





Gap Excess Event Fraction $R_{\frac{GJJP}{JJP}}$:

$0.36 \pm 0.05(stat.) \pm 0.03(syst.)_{fit}\,\%$ $(E_T > 7\,GeV)$

$0.26 \pm 0.09(stat.) \pm 0.04(syst.)_{fit}\,\%$ $(E_T > 10\,GeV)$

Conclusions

- **D0 and CDF Measure Color-Singlet Fractions**

D0: Same E_T, η

$f_S^{630} = 1.85 \pm 0.09 \pm 0.37$

$f_S^{1800} = 0.54 \pm 0.06 \pm 0.16$

(stat) (sys)

CDF: Same η, Diffn't E_T (~Same x)

$f_S^{630} = 2.7 \pm 0.7 \pm 0.6$

$f_S^{1800} = 1.13 \pm 0.12 \pm 0.11$

(stat) (sys)

- **D0 and CDF $f_S(E_T)$, $f_S(\Delta\eta)$ Show Somewhat Different trends but are not obviously inconsistent**
- **D0 Favors a Soft Color Rearrangement Model (preferring initial quark states) Over Two-Gluon Color Singlet Models**

- **Hard Diffraction Observed and Measured in Many Channels -- ≈ 1% of Forward Dijets Have Opposite Side Gap**

- **Studies of Pomeron Structure, Flux in Progress**

- **Excess of Jet Events with Double Pomeron Topology Observed**

- **Jet E_T Distributions ≈ Same for QCD, SD, DPE!**

- RunII detectors will open new opportunities on this field.