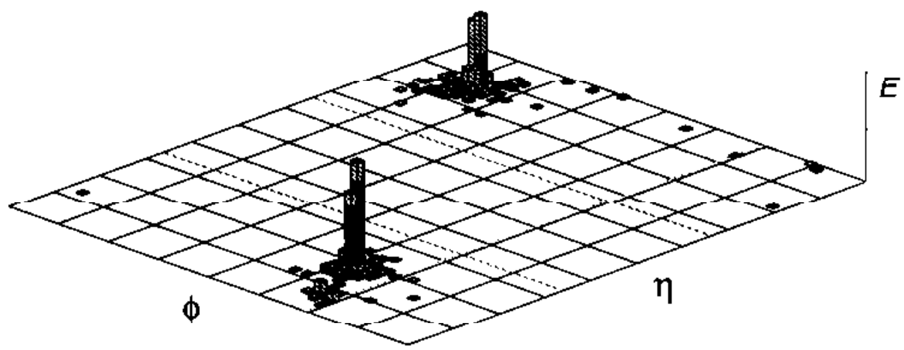
Probing Color-Singlet Exchange

(With rapidity gaps between jets)

Experimental updates from D-Zero

Jill Perkins

University of Texas - Arlington

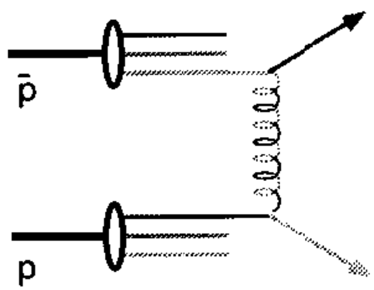


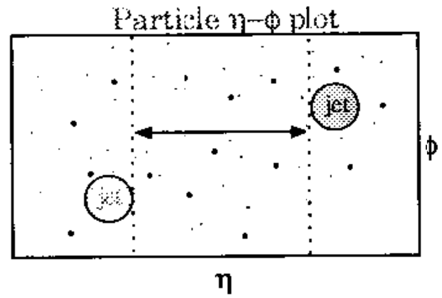
- Introduction
- Latest results from $\sqrt{s}$ = 630 and 1800
- Color-singlet theories/models
- Conclusions

DIS '97
April 15, 1997
Chicago, IL U.S.A.

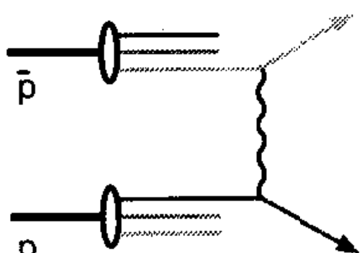
Measuring Color-Singlet Exchange

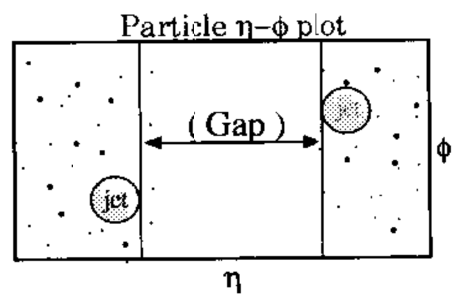
Color exchange $\Rightarrow$ particles between jets

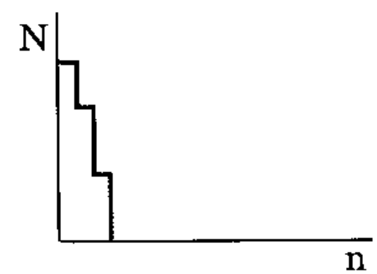




Color-singlet exchange $\Rightarrow$ rapidity gaps







Fraction of observable signal

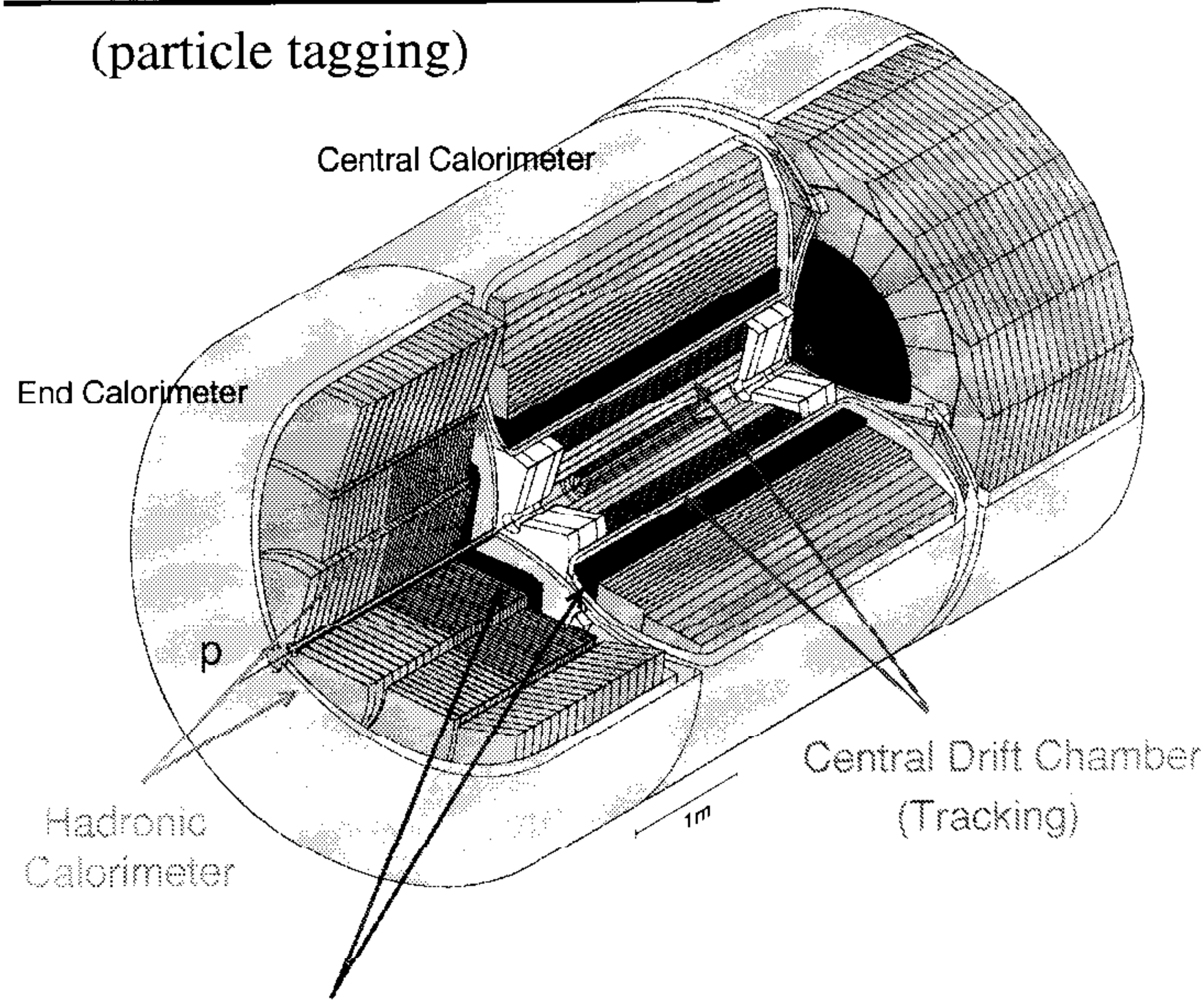
$$f_{gap} = S \bullet \frac{\sigma_{gap}}{\sigma}$$

$S \sim 10\% - 30\%$

Gap Survival, *(Bjorken, Gotsman et al.)*

DØ Calorimeter and Tracking

(particle tagging)



EM Calorimeter:

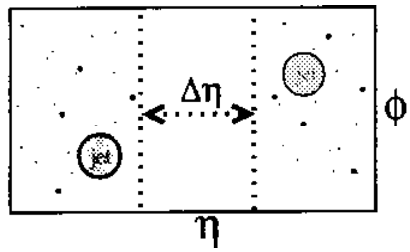
n_{cal} = # EM towers with $E_T > 200$ MeV

Tracking:

n_{trk} = # charged tracks ($|\eta| < 1.3$)

Color-Singlet Studies

- QCD color-singlet signal observed in opposite-side events (~ 1%).



Published results:

DØ: PRL 72, 2332 (1994)
CDF: PRL 74, 885 (1995)
DØ: PRL 76, 734 (1996)

Now looking at:

- $\Delta\eta$ dependence
- E_T dependence
- $\sqrt{s} = 630$ vs. 1800 at same η and E_T

$\Longrightarrow$ dependence on parton x values $\Longleftarrow$

also (not shown):

- Jet structure studies
- Multiplicities in other event regions

Data Selection

Collected during the 1994-1995 running period.

Online:

$\sqrt{s} = 1800$: high, medium, & low jet E_T triggers

$\sqrt{s} = 630$: low E_T trigger

Require 2 jets with:

$|\eta| > 1.6$, and

$\Delta\eta > 4.0$ (medium & high E_T triggers)

$\Delta\eta > 3.2$ (low E_T triggers)

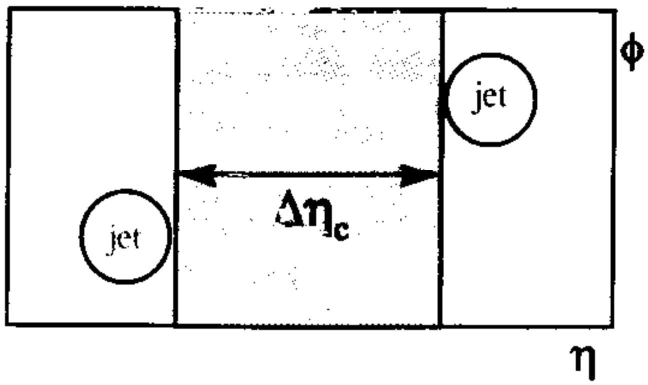
Offline:

- Require centered event vertex
- Cut events with spurious jets
- Require single interaction (includes luminosity cut)

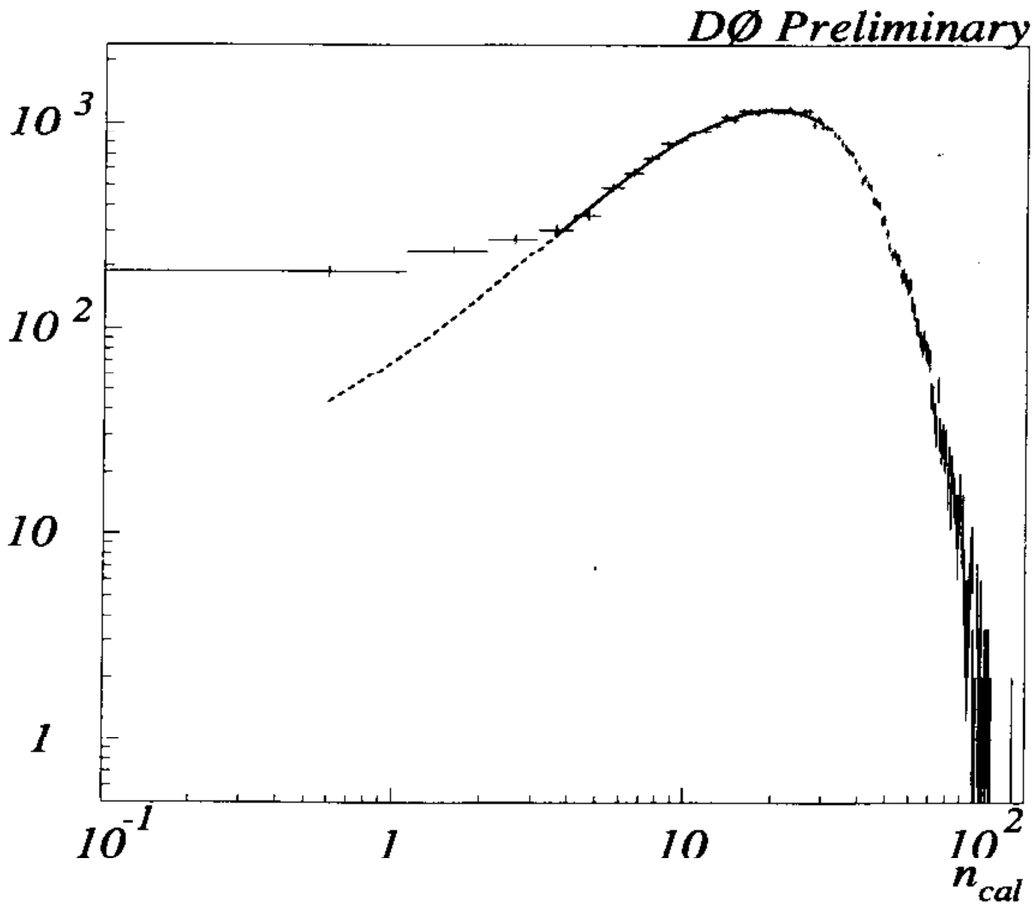
low E_T:	$E_T > 12$ GeV	20k events (1800)
		20k events (630)
medium E_T:	$E_T > 20$ GeV	35k events
high E_T:	$E_T > 30$ GeV	39k events

Same-side Events: 2 jets with $\eta_1 \bullet \eta_2 > 0$ (veto on SD)

Run 1b measurement of f



$E_T > 30$ GeV
$\Delta\eta_c > 2.6$



$$f = (\,0.84 \pm .06\ (stat) \pm .01\,(fit)\,)\ \%$$

$$f\,(|\eta| < 1) = (\,0.92 \pm .07\,(stat) \pm .03\,(fit)\,)\ \%$$

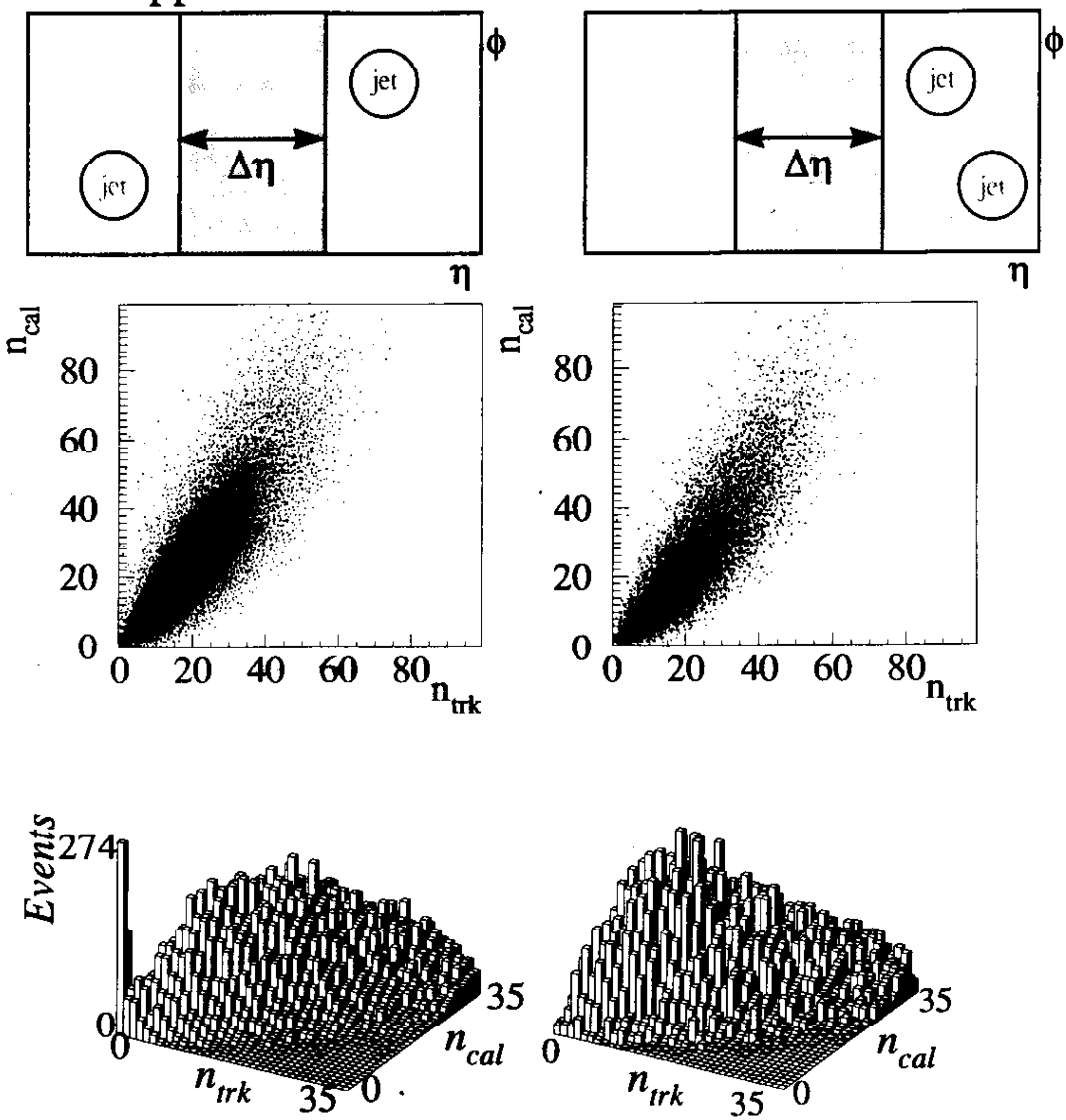
Compare to published fraction:

$$f\,(pub) = (\,1.07 \pm .10\,(stat\,)\,{}^{+.25}_{-.13}\,(syst)\,)\ \%$$

Calorimeter vs. Tracking

Plot calorimeter (n_{cal}) vs. tracking (n_{trk}) multiplicity for $|\eta| < 1.3$

Opposite-side Same-side

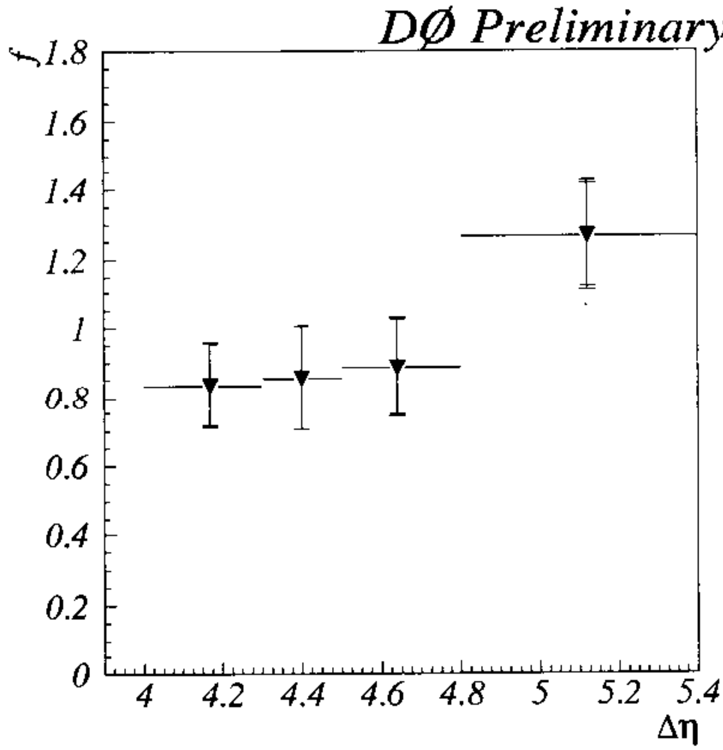


Fraction vs $\Delta\eta$

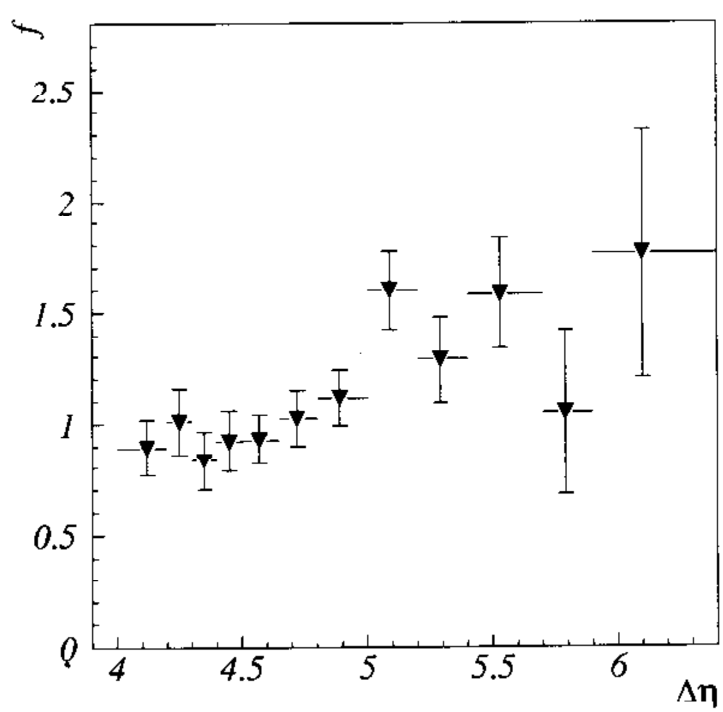
- Measure fraction as a function of separation of the leading jets

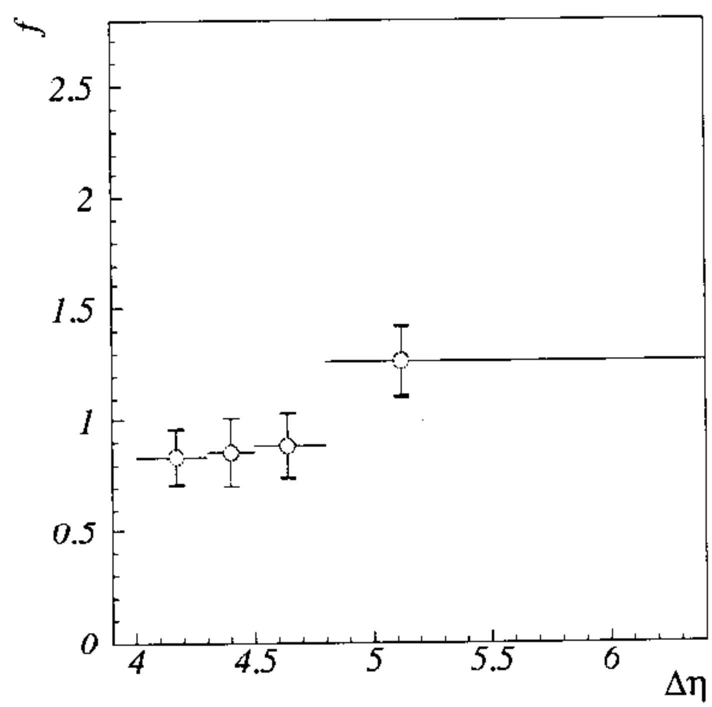
$E_T > 25$ GeV:

fit method



fraction with $n_{cal} = n_{trk} = 0$ (normalized to fit fraction)

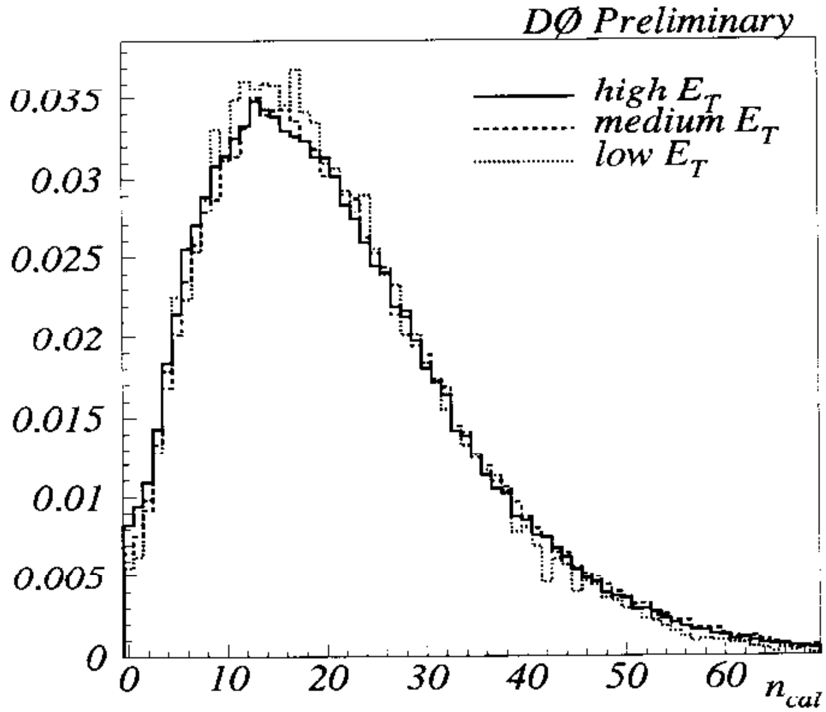


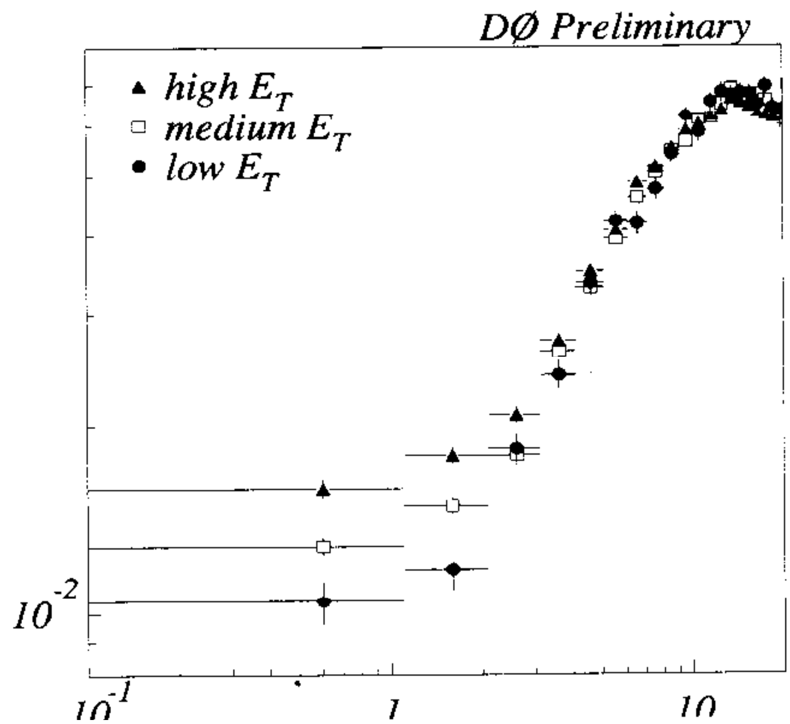


f
2.5
2
1.5
1
0.5
0
4
4.5
5
5.5
6
Δη

Multiplicity for different Jet E_T

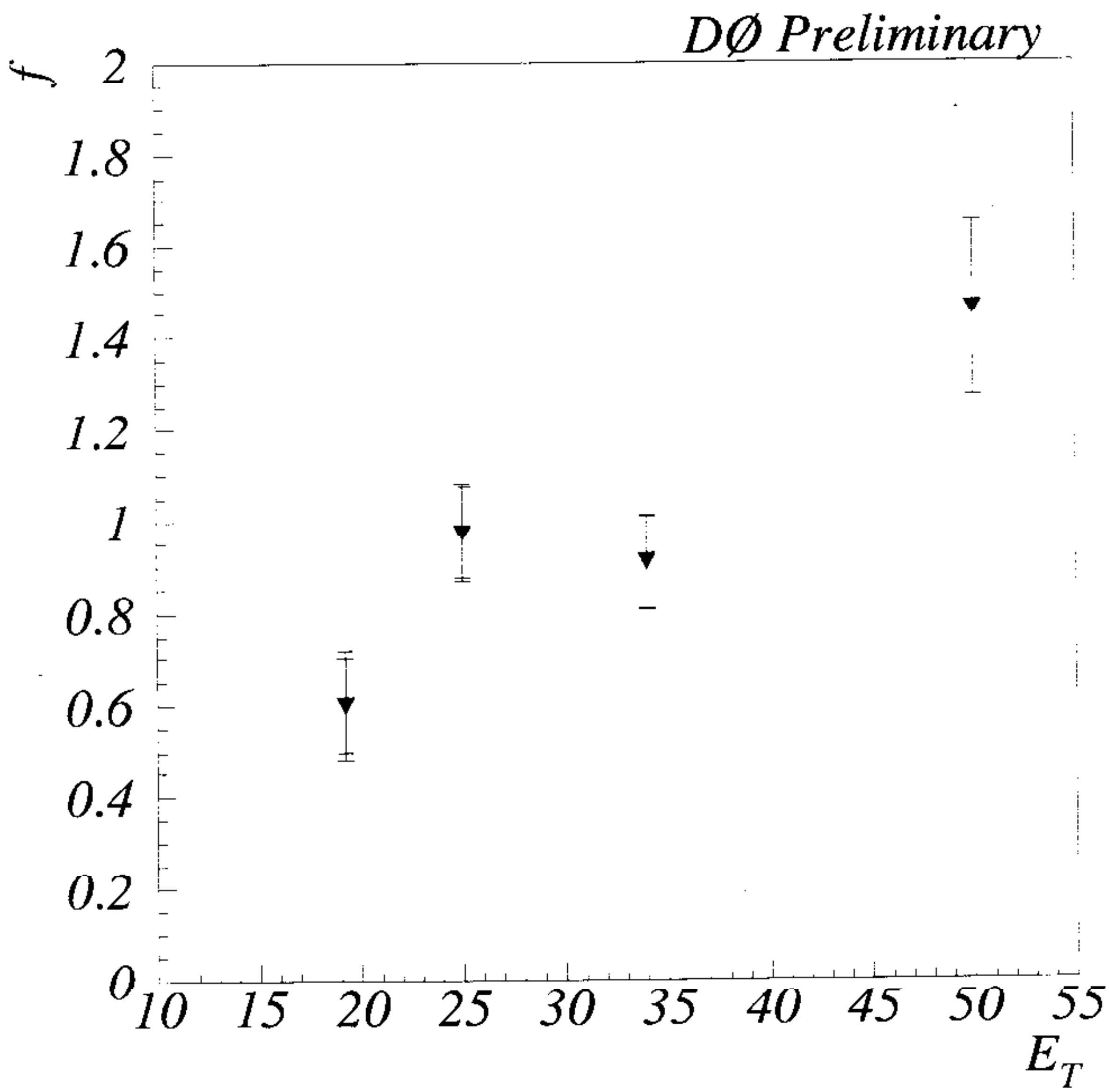
Multiplicity in $|\eta| < 1$:



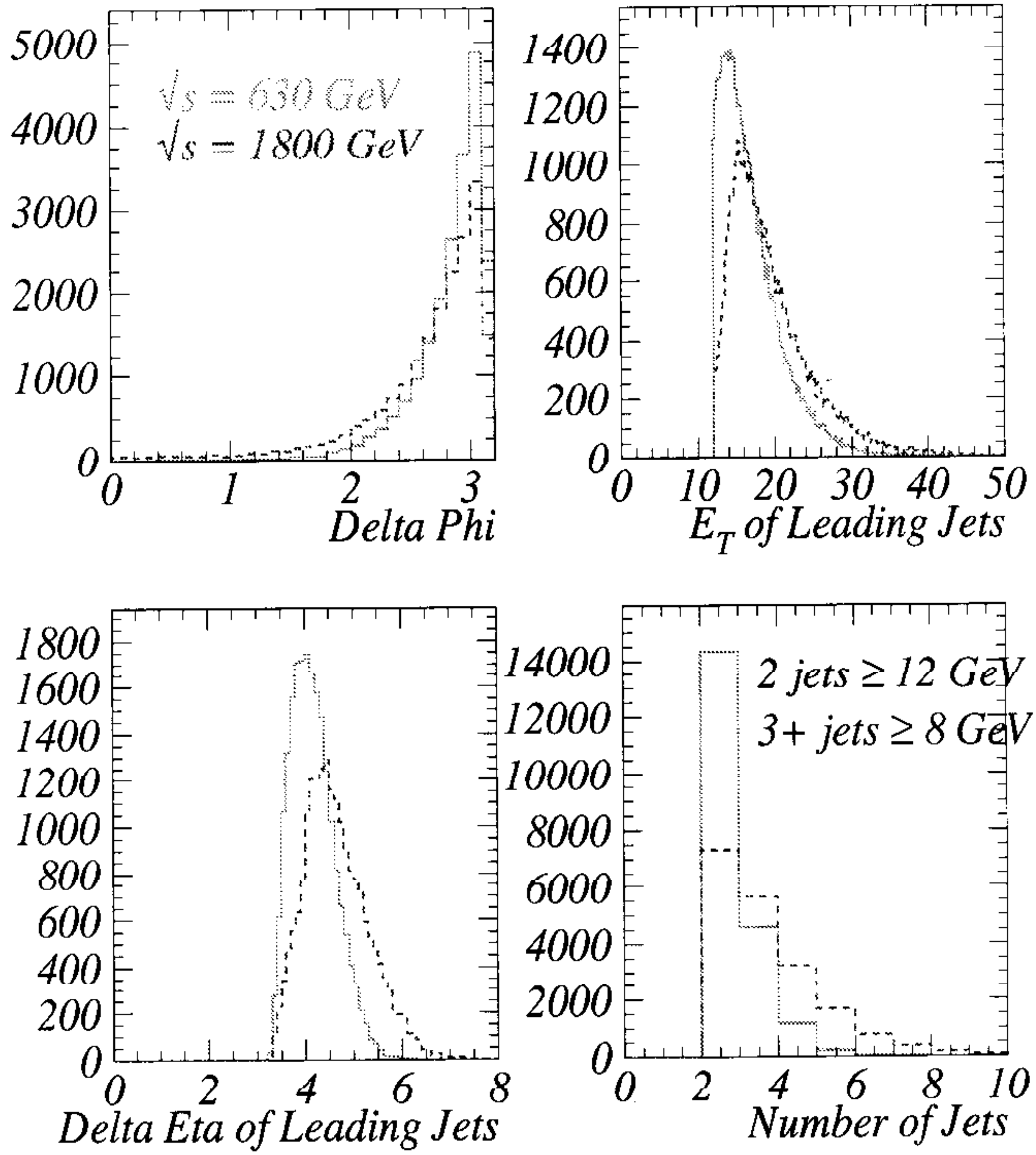


Fraction vs. Jet E_T

- Measure fraction as a function of leading jet E_T



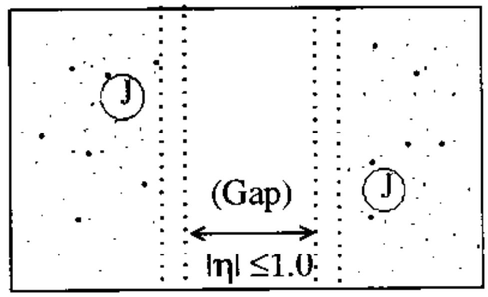
Data Characteristics



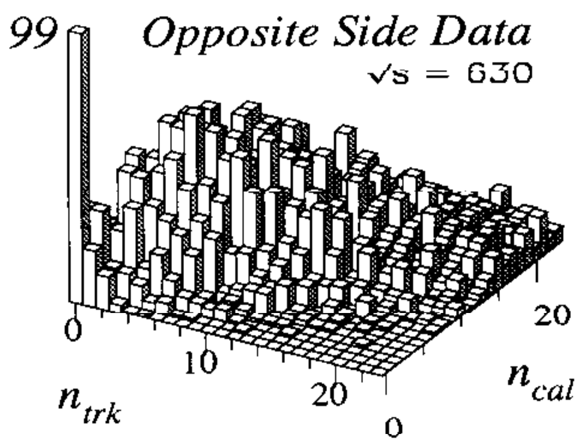
630 vs. 1800

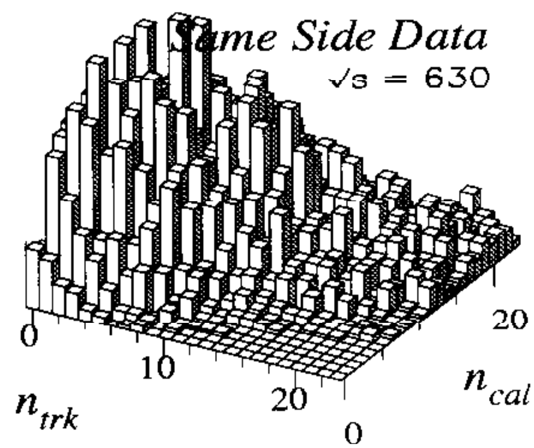
Opposite Side Data:

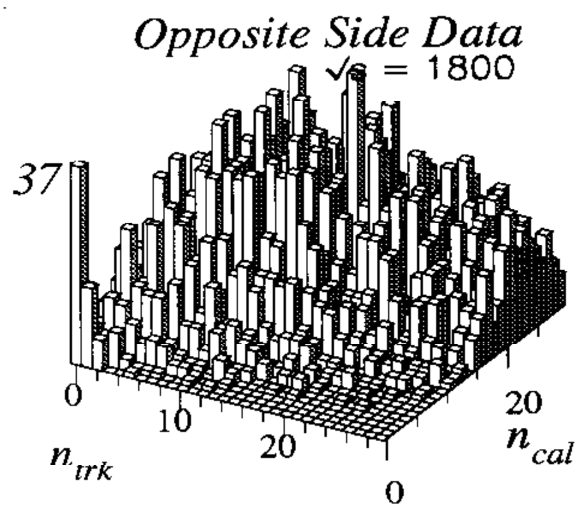
- 2 Jets, $E_T > 12$ GeV
- Jet $|\eta| \geq 1.9$
- N_{EM} $|\eta| \leq 1.0$

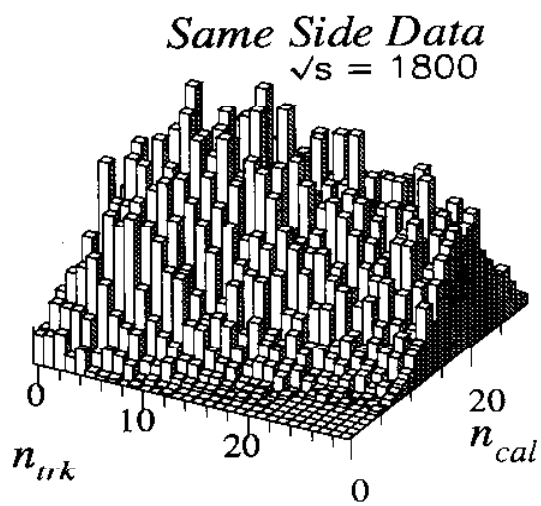


DØ Preliminary

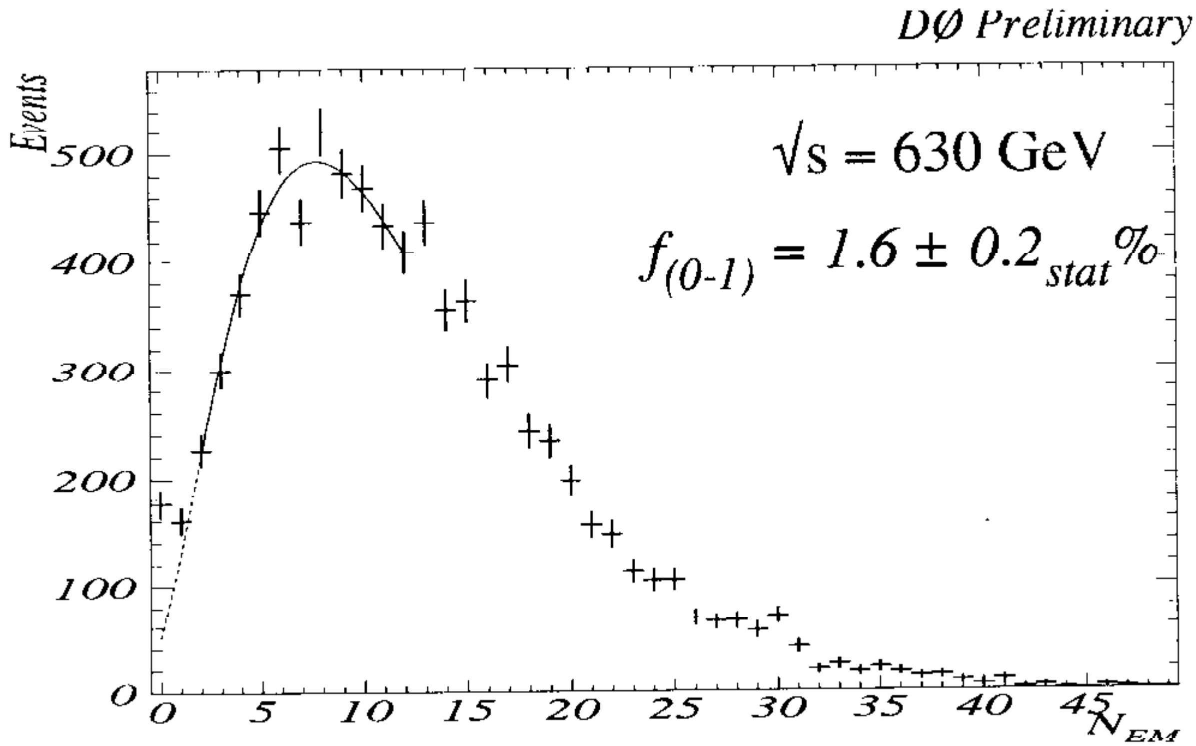


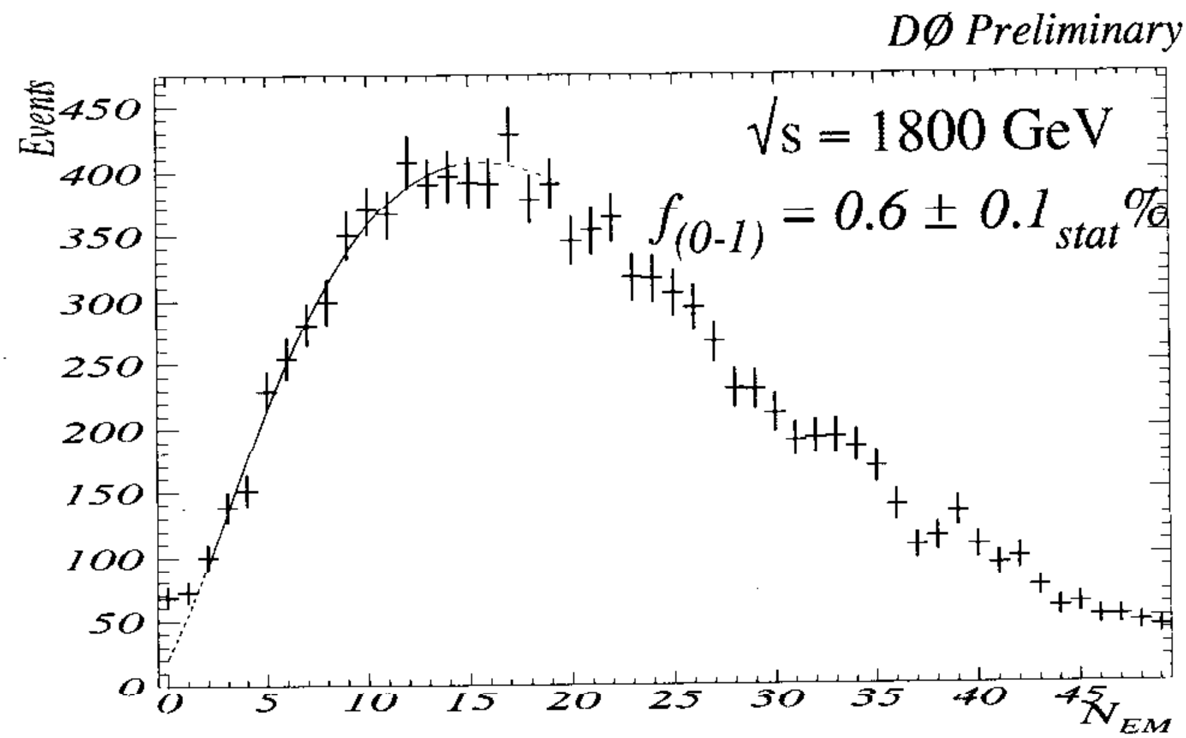






Calorimeter Multiplicities





$$R^{630}_{1800} = \frac{f_{630}}{f_{1800}} = 2.6 \pm 0.6_{stat}$$

Two Gluon Color Singlet Model

(Bjorken, Chehime et al., Del Duca/Tang)

Simple perturbative two gluon model *(Bj)*

- First prediction of strongly-interacting color-singlet exchange (1993).
- Coupling to gluons enhanced over quarks by 9/4 (relative color factors)
- At LO, R^{630}_{1800} depends on x_{Bj} through pdfs
  - $f_{gap} \sim 1\%$
  - f_{gap} falls with E_T
  - f_{gap} falls with $\Delta\eta$
  - $R^{630}_{1800} < 1$

LLA BFKL *(Del Duca / Tang)*

- BFKL dynamics affect fraction
  - f_{gap} falls steeply with E_T
  - f_{gap} rises at large $\Delta\eta$

U(1) Gauge Boson

(Carone / Murayama)

U(1) gauge boson (γ_B) couples only to baryon number (quarks, and not gluons)

- ✧ Constrainted to be strongly interacting, low mass boson (α_B< 0.2, m_B>20 GeV)
- ✧ As yet unobserved but could explain experimental rapidity gap fraction
- ✧ At LO, R^{630}_{1800} depends on x_{Bj} through pdfs

  - ⇨ Can choose parameters (α_B,m_B,E_T) such that f_{gap} ~ 1%
  - ⇨ f_{gap} rises with E_T
  - ⇨ f_{gap} rises with $\Delta\eta$
  - ⇨ $R^{630}_{1800} > 1$

Soft Color Rearrangement

(Eboli / Gregores / Halzen)

Non-perturbative "rearrangement" of color flow randomly "bleaches" color.

- ✧ Dynamics determined by single hard gluon exchange
- ✧ Gap produced by additional soft color flow
- ✧ Quark initiated processes are statistically favored due to fewer color combinations
- ✧ Spectator interactions may create gaps
- ✧ At LO, R^{630}_{1800} depends on x_{Bj} through pdfs
  - ➪ $f_{gap} \sim (1/9)^2$
  - ➪ f_{gap} rises with E_T
  - ➪ f_{gap} rises with $\Delta\eta$
  - ➪ $R^{630}_{1800} > 1$

Comparison to Theory

(DØ Preliminary)

Ratio of 630/1800 for $E_T = 20$ GeV, $\Delta\eta > 4$

$$R_{1800}^{630} = 2.6 \pm 0.6^{(stat)}$$

$$R_{1800}^{630} = \begin{cases} 0.8 & (2-\text{gluon}) \\ 2.2 & (\text{soft color}) \\ 2.5 & (\text{U(1)boson}) \end{cases}$$

Possible rise in measured $f(E_T)$, $f(\Delta\eta)$ with x

$$f(E_T) \begin{cases} \text{falls for two - gluon models} \\ \text{rises for soft color / U(1)} \end{cases}$$

$$f(\Delta\eta) \begin{cases} \text{falls for simple two - gluon} \\ \text{rises for LLA BFKL} \\ \text{rises for soft color / U(1)} \end{cases}$$

Conclusions

D0 has measured color-singlet fraction:

- ✧ 630 GeV and 1800 GeV same E_T,η
- ✧ $f(E_T)$ and $f(\Delta\eta)$ at 1800 GeV
- ⇨ The measured fraction rises with initial parton *x* value. Many systematic studies are underway.
- ⇨ *Inconsistent* with two gluon color-singlet model, including LLA BFKL
- ⇨ *Possibly consistent* with
  - ✧ a strongly-interacting gauge boson (γ_B) coupling only to quarks
  - ✧ soft color rearrangement model prefering initial quarks

- ⇨ However, higher order effects need to be investigated...need input from theorists!