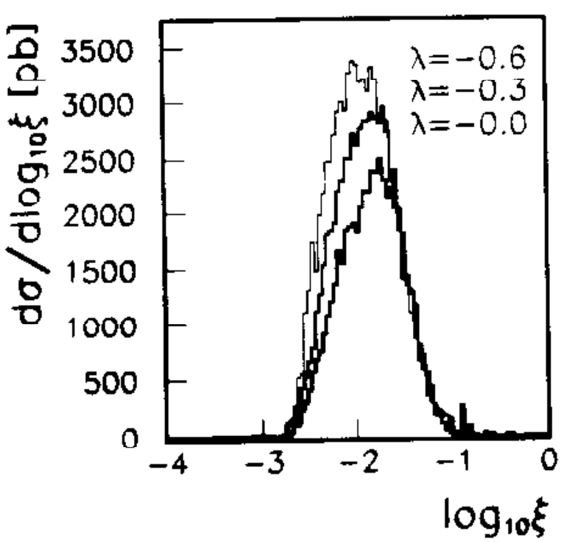
Calculation

- ◇ two programs
  - MEPJET (Mirkes and Zeppenfeld)
  - DISENT (Seymour and Catani)
- ◇ NLO dijet production calculated from pQCD matrix elements
- ◇ apply jet finder to momentum four vectors of outgoing partons
- ◇ we used:
  - Q^2 as factorization/renormalization scale
  - the MRSA parton distribution function
  - MRSA gluon parametrized as:

$$g(x, Q_0^2) = A_g x^\lambda (1-x)^\beta (1+\eta x) \text{ at } Q_0^2 = 4 \text{ GeV}^2$$

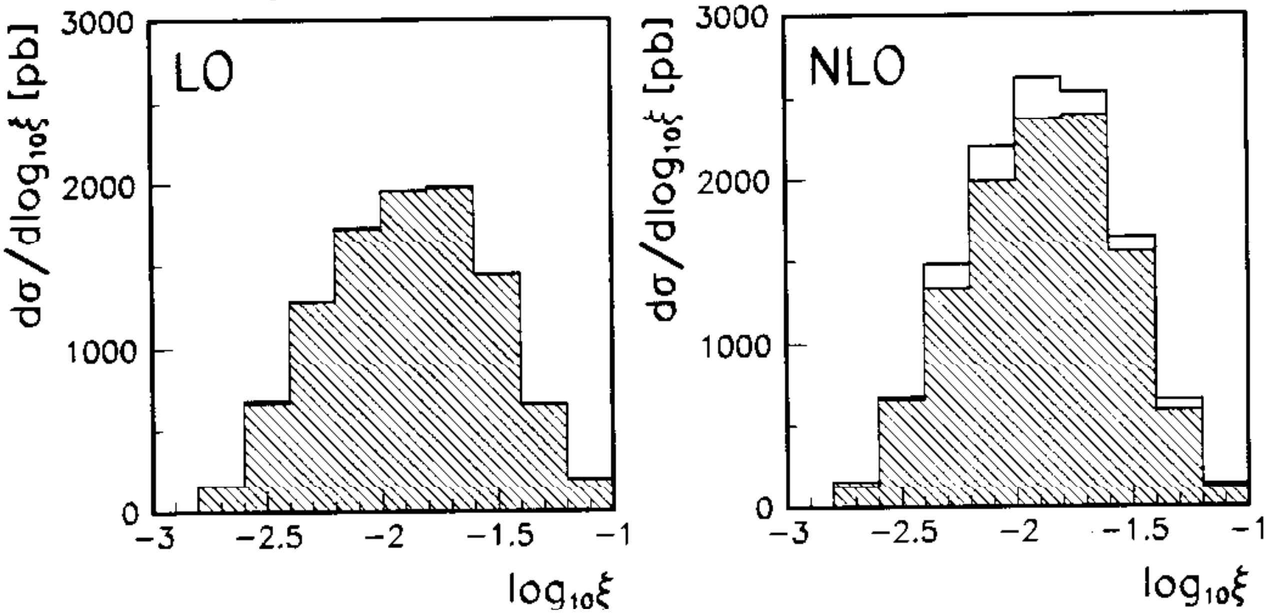
Variation of Calculated Dijet Cross Section with λ



The value of λ effects the total rate and the shape of the distribution.

Comparison of MEPJET and DISENT:

ξ distribution



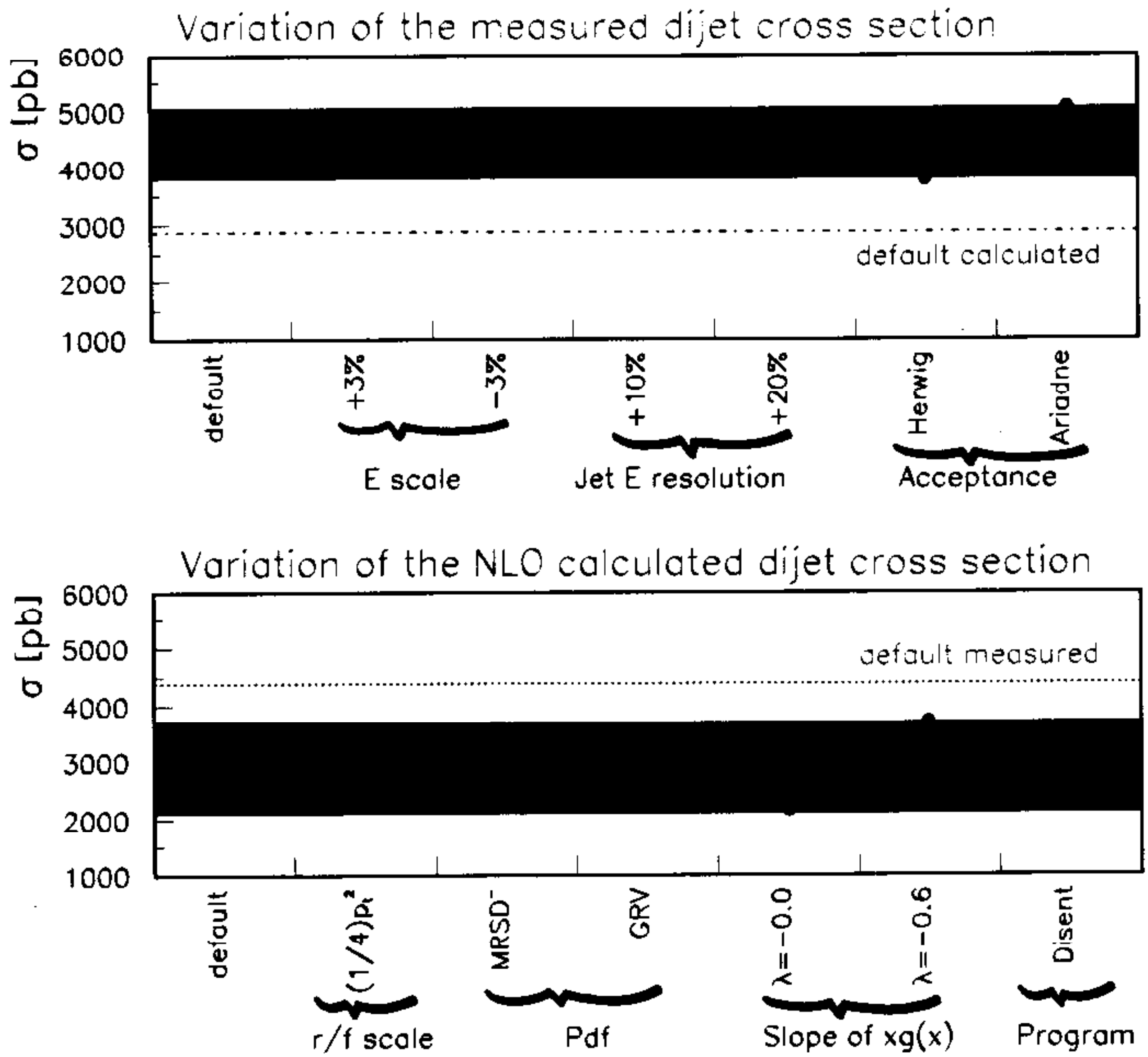
Disent LO = 2.04 ± 0.01 nb   Disent NLO = 2.25 ± 0.08 nb

Mepjet LO = 2.03 ± 0.00 nb   Mepjet NLO = 2.41 ± 0.05 nb

same input parameters
for both programs

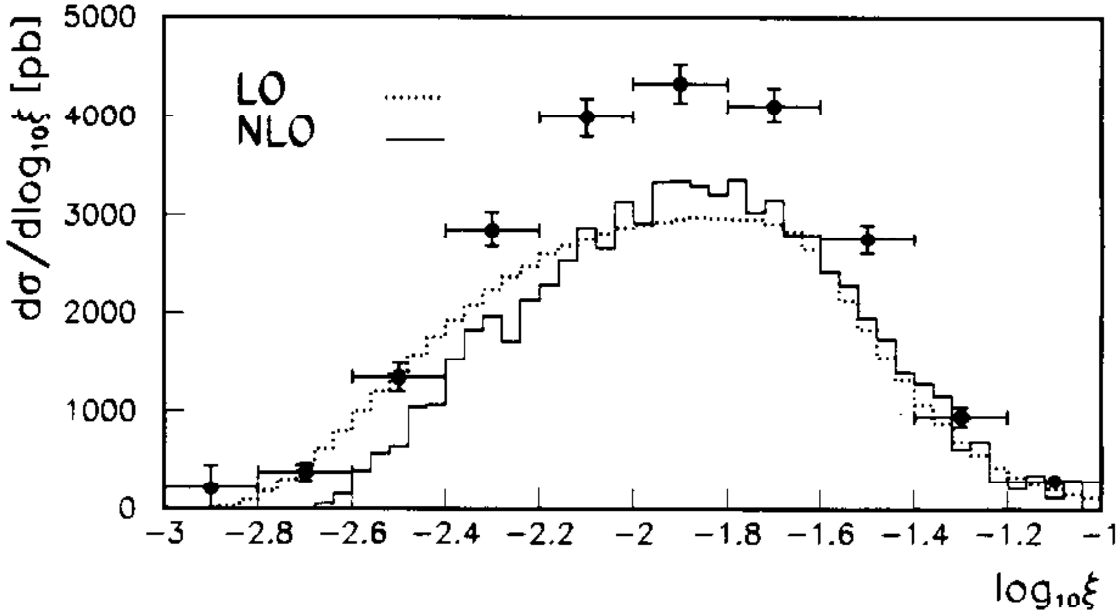
α_{QED} = fixed

$\alpha_s(LO)$ = 2loop



Variation of the measured dijet cross section
σ [pb]
6000
5000
4000
3000
2000
1000
default calculated
default
+3%
-3%
+10%
+20%
Herwig
Ariadne
E scale
Jet E resolution
Acceptance
Variation of the NLO calculated dijet cross section
σ [pb]
6000
5000
4000
3000
2000
1000
default measured
default
(1/4)p_t^2
MRSD⁻
GRV
λ=-0.0
λ=-0.6
Disent
r/f scale
Pdf
Slope of xg(x)
Program

Measured and Calculated Dijet Cross Sections



→ The NLO calculation describes well the shape of the measured cross section, but the calculated cross section is approximately 34% smaller than the measured one.

What we varied in the measurement:

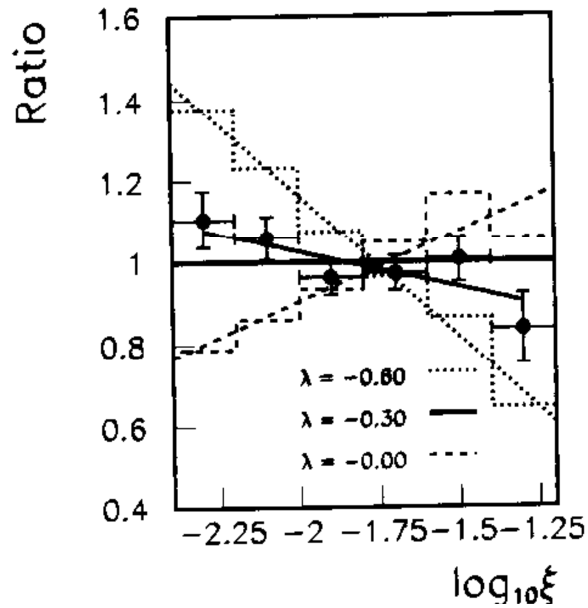
- calorimeter energy scale(±3%)
- jet energy resolution(10% 20%)
- Monte Carlo (Herwig Ariadne)

What we varied in the calculation:

- factorization/renormalization scale(P_T)
- input P.D.F.s (GRV,MRSD$^-$)

ZEUS 1994 - Preliminary

Extract λ from shape of cross section



$$\text{Ratio} = \frac{\sigma_{NORM}(\text{data}, \lambda=0.0, -0.3, -0.6)}{\sigma_{norm}(\lambda=-0.3)}$$

$$\lambda_{meas} = 0.38 \pm 0.04 \pm 0.18$$

at $Q^2 = 4\ \text{GeV}^2$

CONCLUSIONS FROM JETS?

PROBLEM: NLO PARTONS
$\neq$ PARTON SHOWER $\rightsquigarrow$ HADR LEVE

1. A MEASUREMENT OF THE CORRECTED DATA $d^4\sigma / dp_T\, d\eta\, dx\, dQ^2$ NOT YET AVAILABLE

"EXP^{I}AL AMBITION TO MEASURE α_s, $xg(x)$, "POWER CORRECTIONS"... NEED TO BE MORE MODEST"
[DAVID KOSOVER]

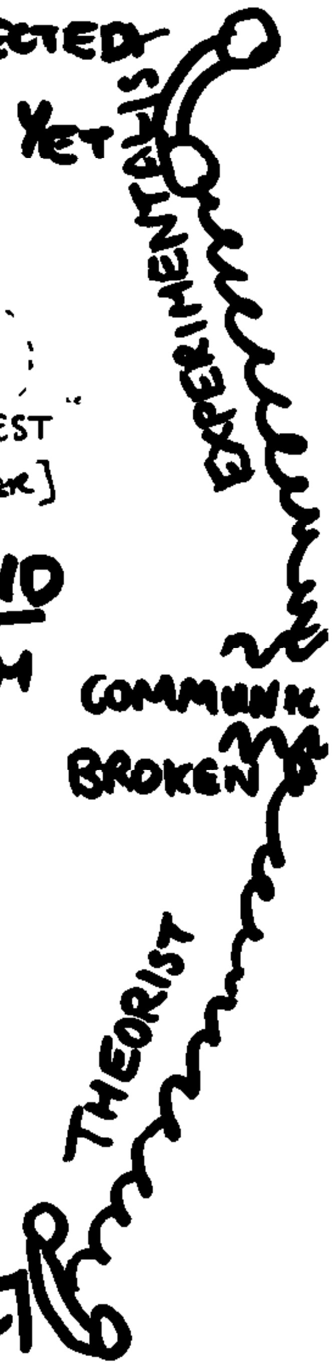
2. INTERNAL X-CHECK OF RATE **AND** SHAPE SUGGESTS RATES TOO HIGH IN CURRENT KINEMATIC REGIONS

IS THIS TELLING US:

(a) NNLO req^{d} — BOTH?
(b) UNIVERSAL POWER CORRECTION
(c) RESUMMATION

ARE NEEDED IN A GIVEN KINEMATIC REGION?

$\Rightarrow$ SIGNIFICANT DEBATE



The Daily Telegraph

FRIDAY, FEBRUARY 9, 1996

40p

Scientists challenge heart of the matter

By Robert Uhlig, Technology Correspondent

THE foundations of nuclear theory could be shaken by the discovery that quarks the fundamental sub-atomic building blocks, may not be the smallest particles of matter after all

In a report in today's *Science* magazine, American researchers say they found collisions between quarks in a particle accelerator were unexpectedly violent.

"This is just the sort of effect you would see if quarks were not fundamental particles, but had some sort of internal structure," William Carithers, of Fermi National Accelerator Laboratory, in Batavia, Illinois, told *Science*.

If this is true, then the finding would challenge the accuracy of the accepted theory for fundamental matter, a concept called the Standard Model.

But researchers say there may be explanations that are consistent with the widely accepted theory of matter. They are now sifting through the data for other, less earth-shattering explanations.

If the researchers reach the conclusion that quarks do have a sub-structure, they believe that the discovery could be a reprise of Sir Ernest Rutherford's turn-of-the-century discovery of the atomic nucleus.

"It might just mean that, just as in Rutherford's atom, there's a hard centre lurking within quarks," suggested Steve Geer, of Fermilab.

Professor Melvyn Shochet, former spokesman for the 444-member research team that made the observations, said that if quarks had a sub-structure, they would be "made up of something even smaller".

This would be "in the same way that a proton is made up of quarks", he said.

Quarks were named by Murray Gell-Mann in 1963 and are smaller than a trillionth of the thickness of a human hair.

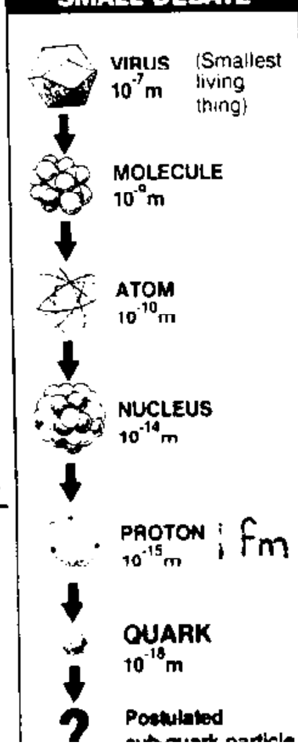
Researchers at Fermi announced in March that they had discovered the top quark, the last of six families of quarks thought to exist.

The half-dozen families are thought to be the smallest, most elemental form of matter.

Science said a paper reporting the finding has been submitted to Physical Review Letters, a major scientific journal.

But the study has not yet been subjected to peer review, a process in which other experts in the field crit-

SMALL DEBATE



*

⇒ JET PRODUCTIO[N]
AT LARGE E_T
[CDF EXPERIMENT

EXPLORING THE FEMTOUNIVERSE

Typical Theory Choices for each Experiment

DØ:

Program: JETRAD

Clustering: Snowmass, Rsep=1.3

μ_R, μ_F: $E_{Tmax} / 2$

CDF:

Program: EKS

Clustering: Snowmass, Rsep=2.0

μ_R, μ_F: $E_{Tjet} / 2$

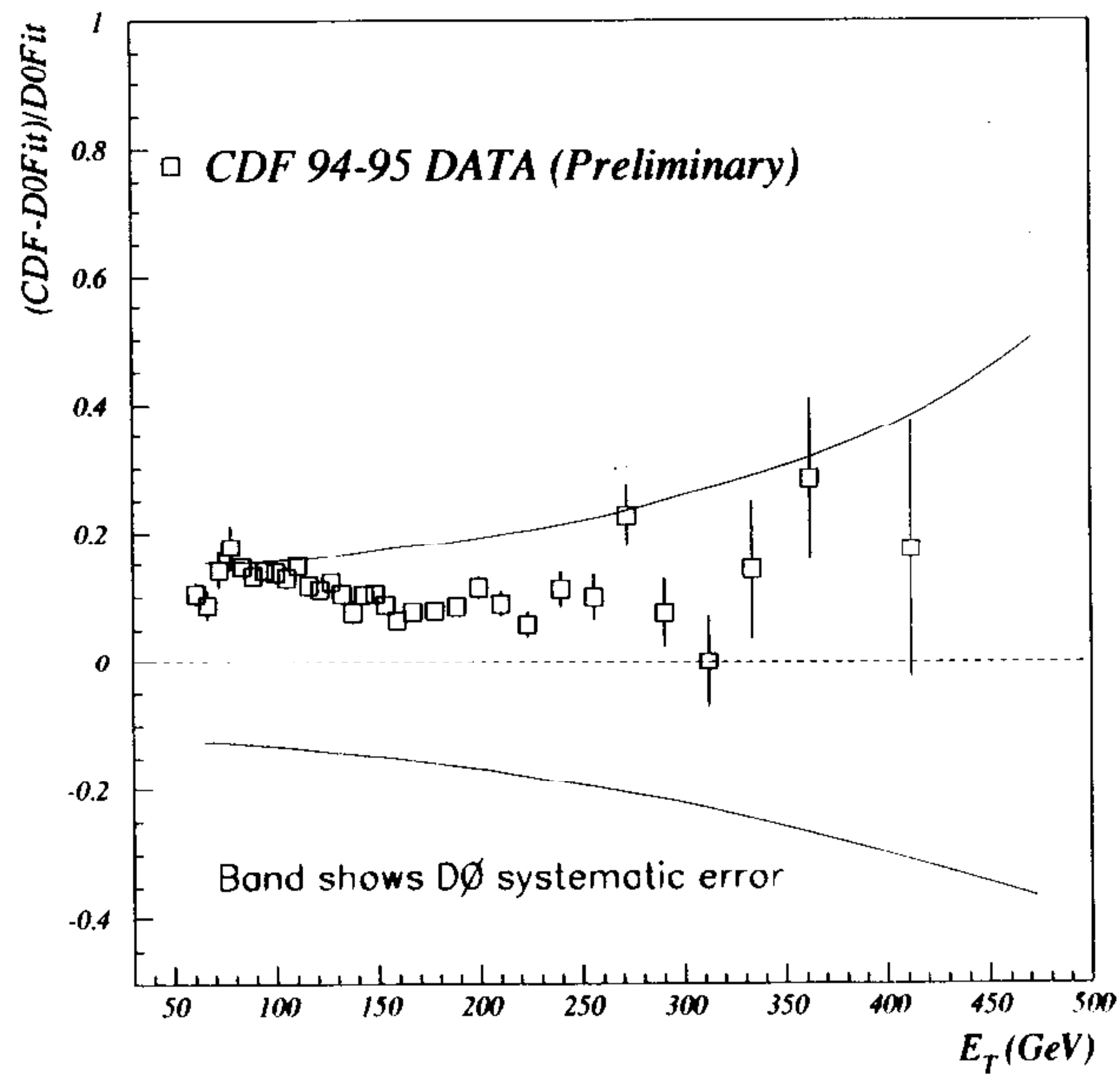
Comparison of Experimental Cross Sections

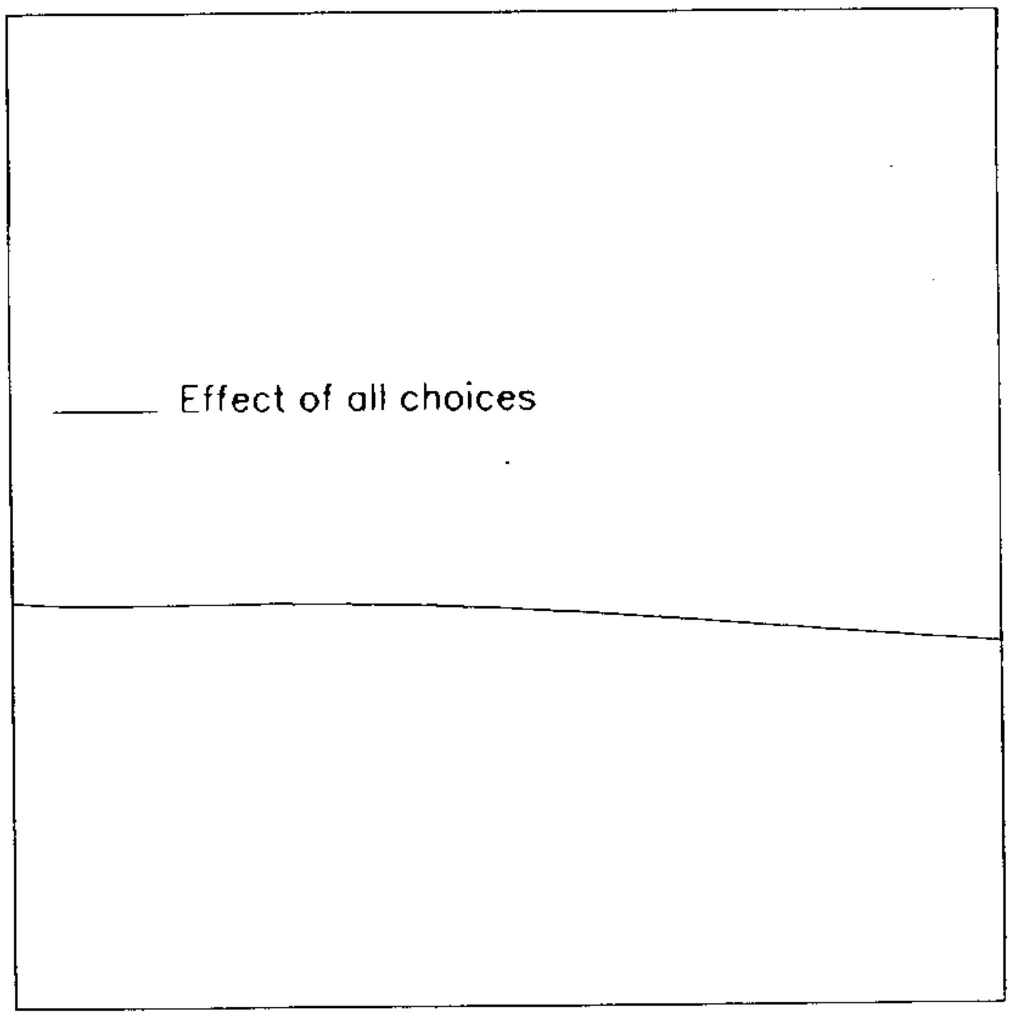
Repeat DØ analysis with CDF fiducial cuts

$$0.1<|\eta_{jet}|<0.7$$

Compare CDF 1B (1994-5) data w/ fit to DØ Cross Section

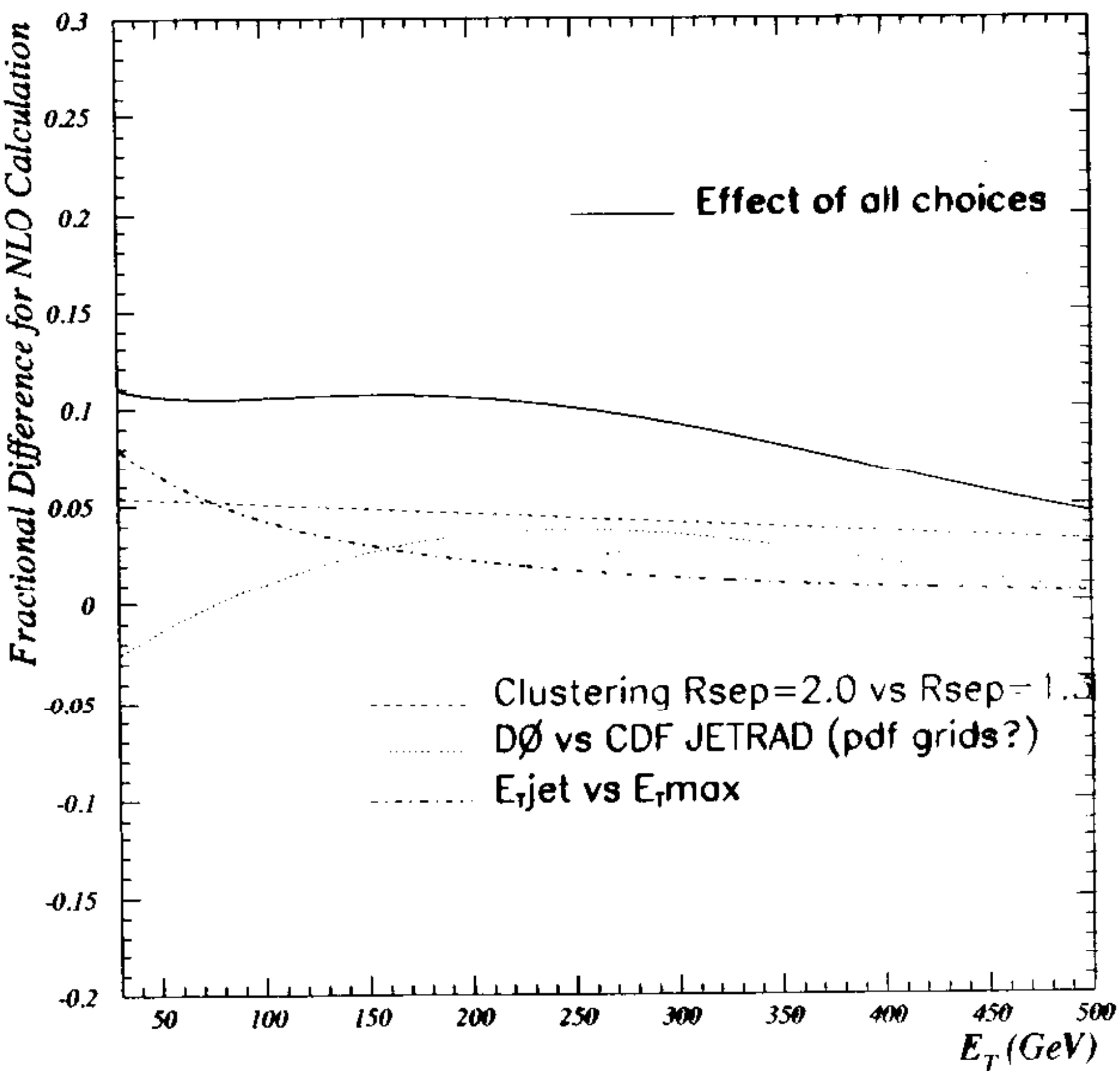
Preliminary




Effect of all choices

•Both experiments agree with respective theory choices in intermediate or full E_T range

•How do these choices add up?

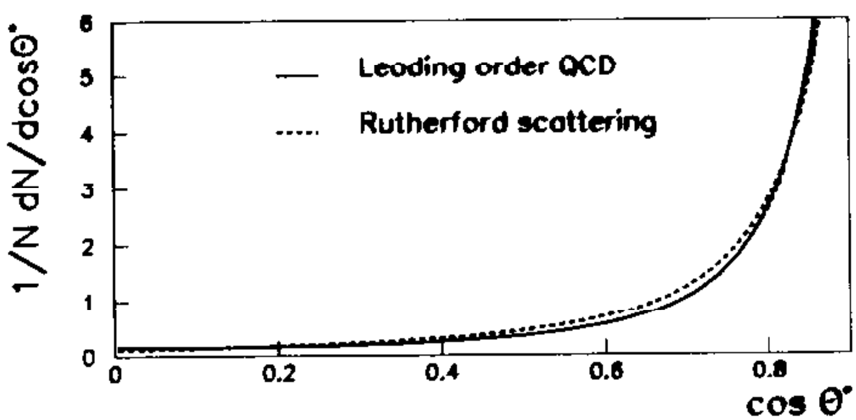


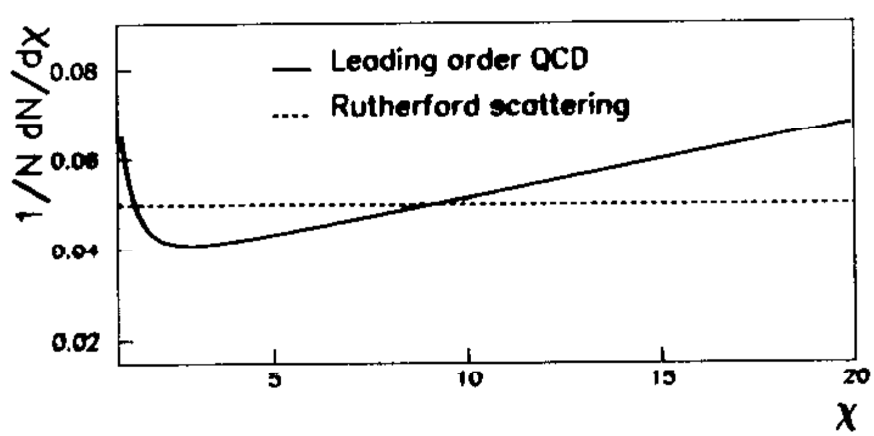
Dijet Angular Distribution

Measure: $$\frac{1}{N}\frac{dN}{d\chi} \text{ vs. } \chi$$ **for different mass bins**

$$\chi = e^{(|\eta_1-\eta_2|)} = \frac{1+\cos\theta^*}{1-\cos\theta^*}$$

χ flattens out the angular distribution and facilitates comparison with theory

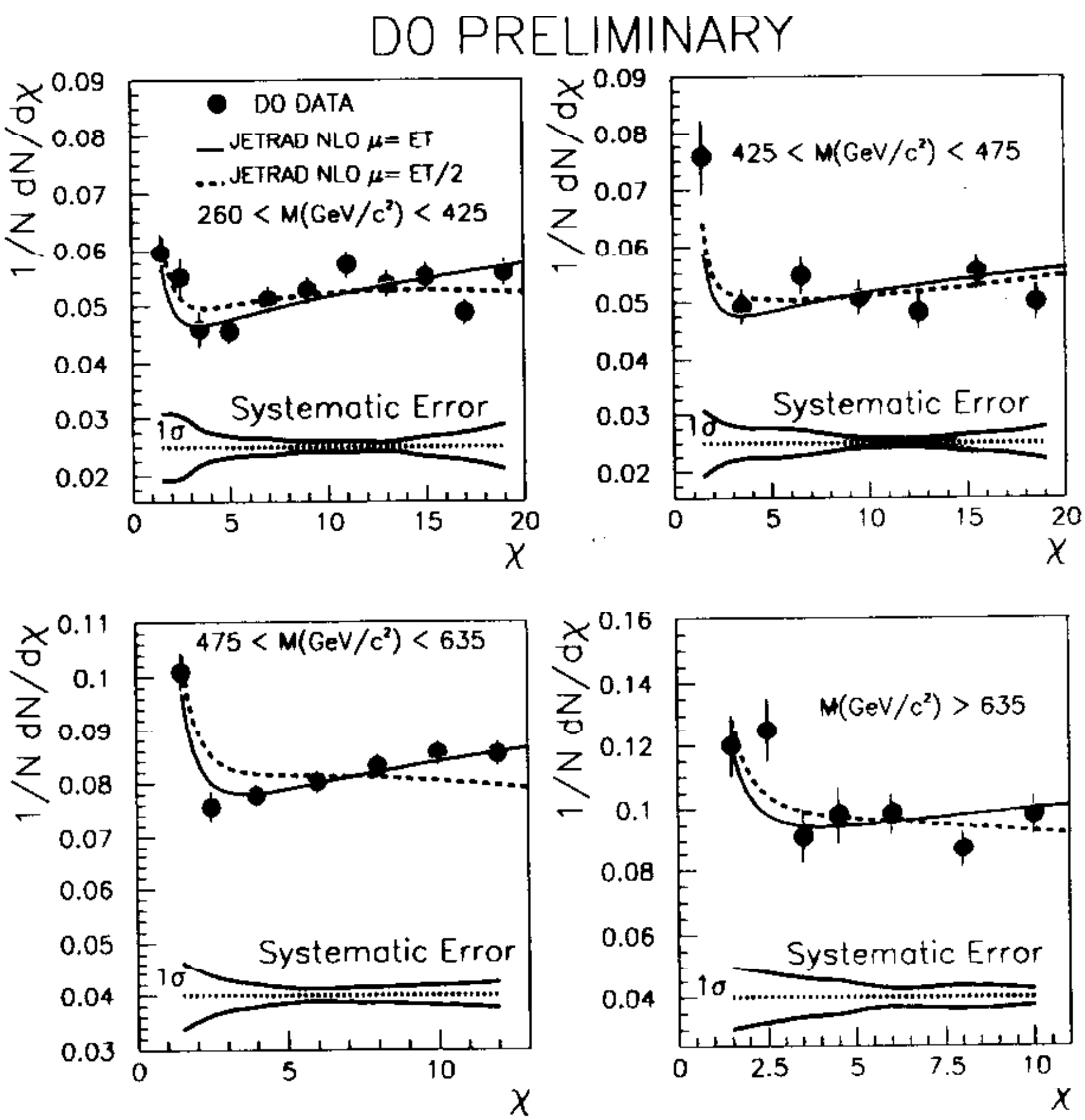




DØ Dijet Angular Distribution

Comparison w/ theory:

JETRAD NLO, CTEQ3M,
$\mu = E_T(MAX)$ or $E_T(MAX)/2$



Comparison sensitive to scale choice

Limits on Quark Compositeness

DØ

Bayesian 95% CL limit for Λ^+, each renorm. scale treated as different theory

DØ Preliminary

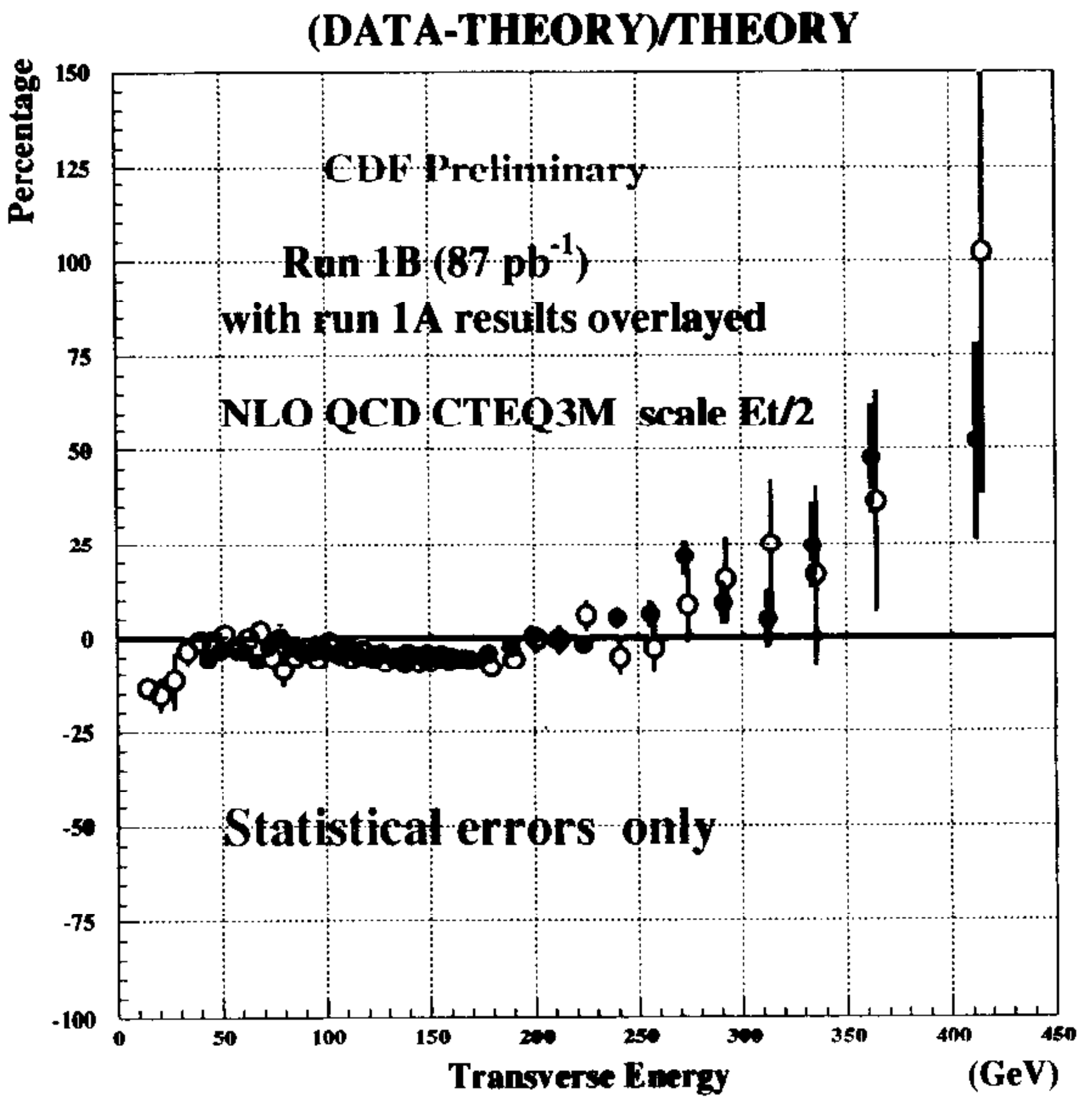
μ	prior	limit (TeV)
$E_T(max)/2$	$1/\Lambda^2$	2.2
$E_T(max)$	$1/\Lambda^2$	2.0
$E_T(max)/2$	$1/\Lambda^4$	2.0
$E_T(max)$	$1/\Lambda^4$	1.9

CDF

χ^2 95% CL limit for various compositeness models added to CTEQ2M, $\mu=E_T(max)$ NLO prediction

model	limit (TeV)
Λ_{ud}^+	1.6
Λ_{ud}^-	1.4
Λ^+	1.8
Λ^-	1.6

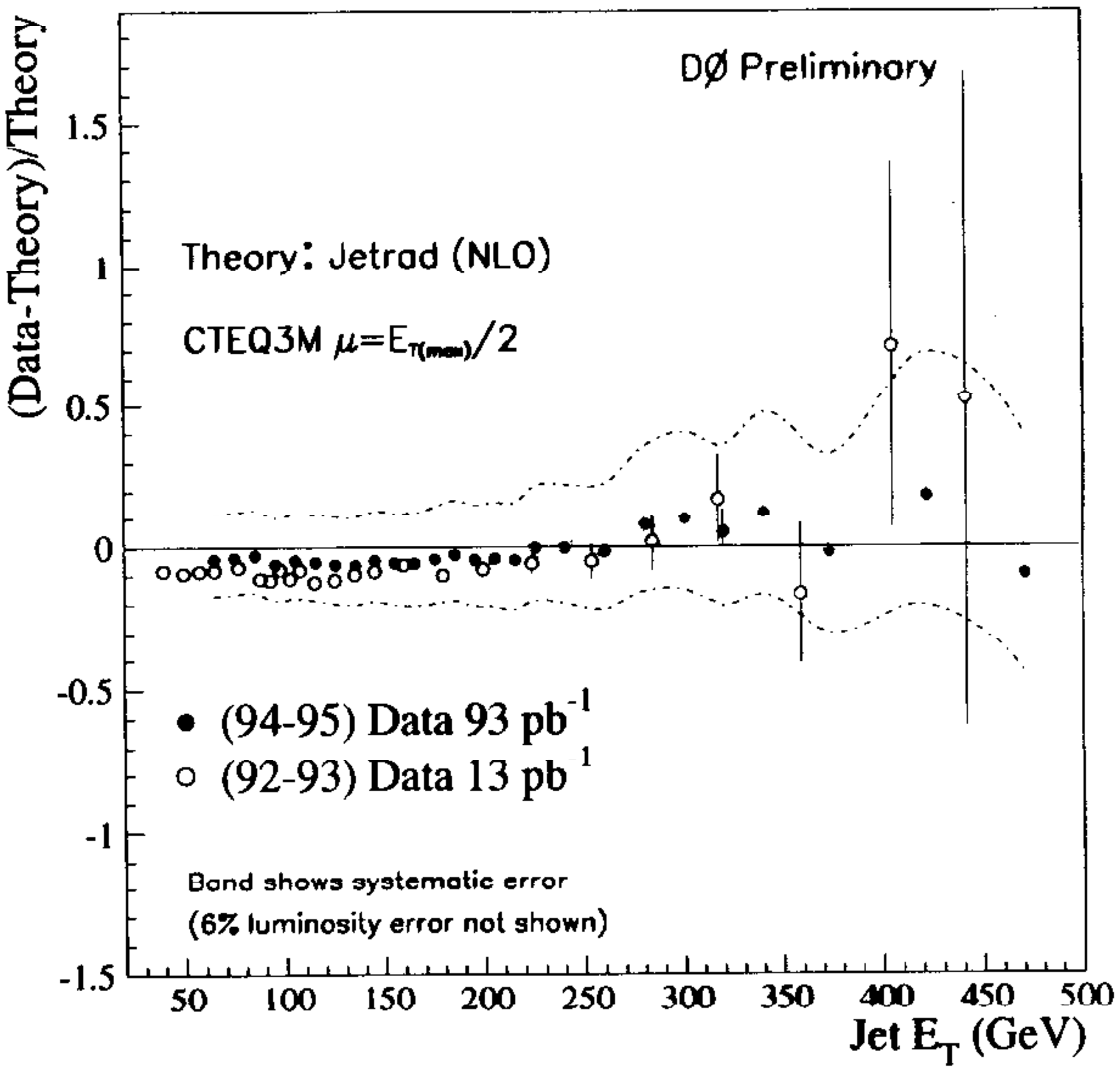
CDF Inclusive Jet Cross Section (1994-95)
$0.1 < |\eta| < 0.7$



Luminosity Uncertainty ~ 10 %

Systematic errors not finalized, but expected to be similar to published results

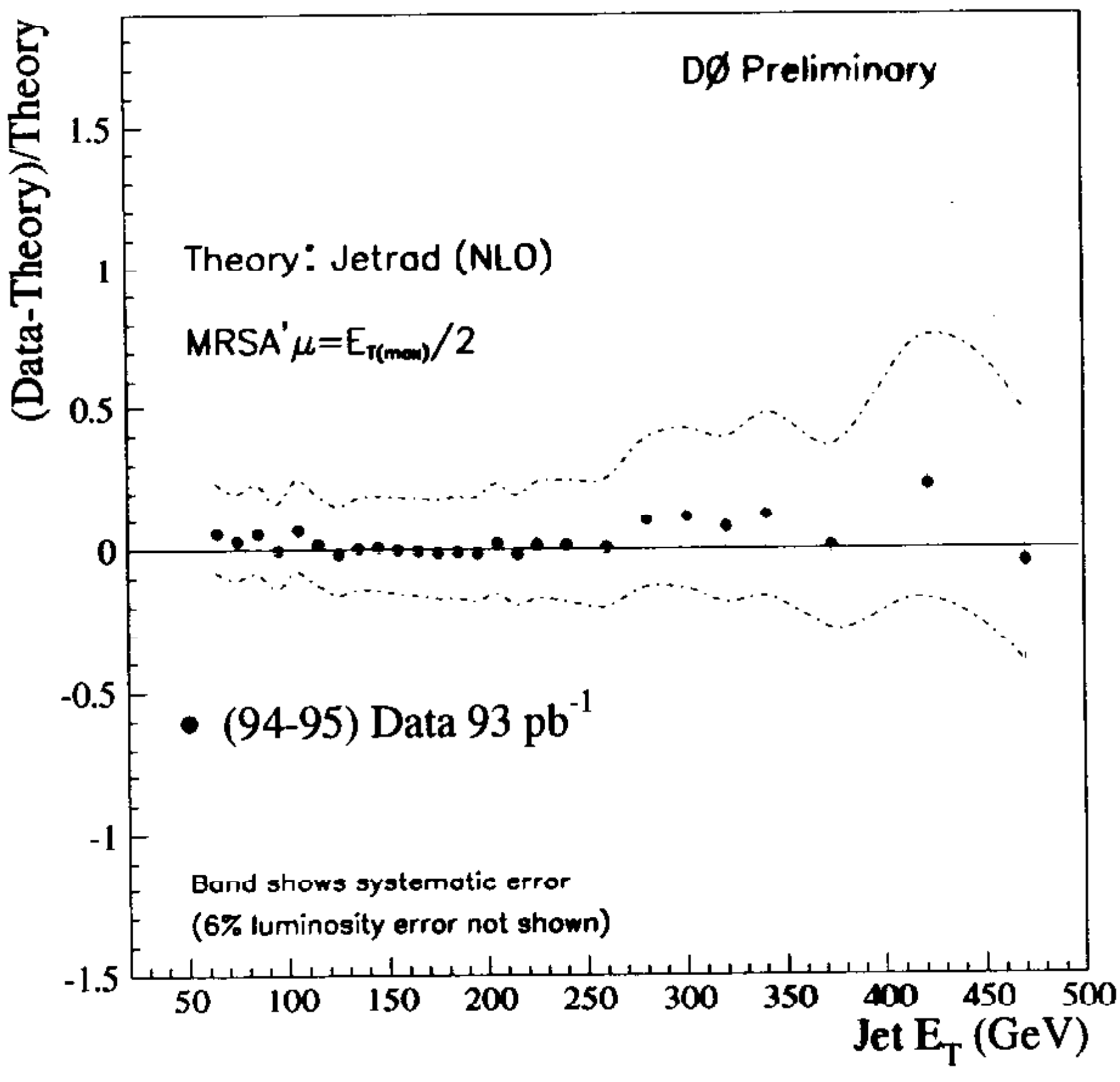
DØ Inclusive Jet Cross Section (1994-95) $|\eta| < 0.5$



•Good agreement w/ QCD

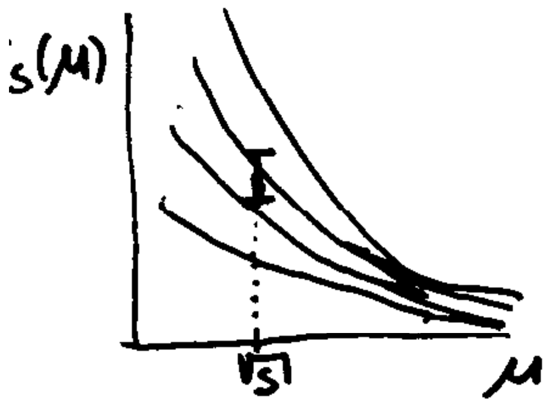
R.Hirosky DIS97 Chicago

DØ Inclusive Jet Cross Section (1994-95) $|\eta| < 0.5$



R.Hirosky DIS97 Chicago

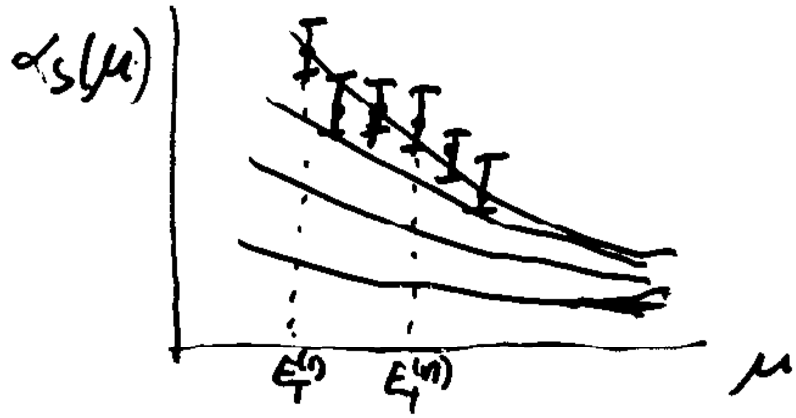
e^+e^-



FIXED $\sqrt{s}$

α_s DETERMINED BASED ON EVENT RATE

$p\bar{p}$



VARIABLE $\sqrt{\hat{s}} \propto E_T$

$\rightarrow \alpha_s$ DETERMINATION BASED ON BOT[H] NORMALIZATION (= EVENT RATE) AND EVOLUTION RATE. THESE TWO ARE CLOSELY CORRELATED (SHAPE & NORMALIZATION OF ONE JET INCLUSIVE DISTRIBUTION

$\Downarrow$

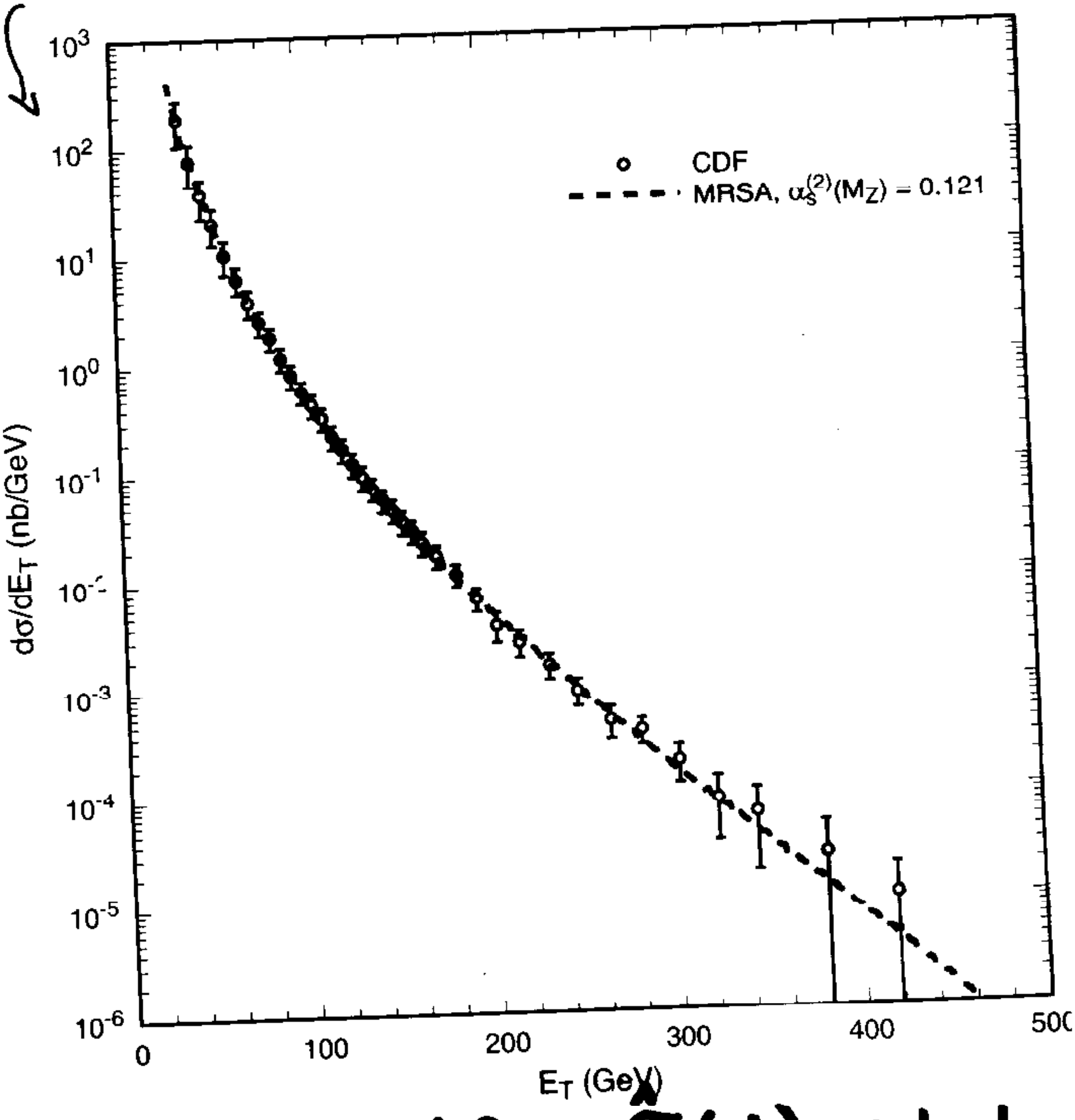
GIVES SEVERE CONSTRAINTS ON CONSISTENCY OF DATA WITH QC[D]

* THE DEPENDENCE OF THE ONE-JET INCLUSIVE TRANSVE[RSE] ENERGY DISTRIBUTION ON α_s IS QUITE COMPLICATE[D] TWO (COMPETING) EFFECTS:

1) α_s CHANGES THE NORMALIZATION
2) α_s CHANGES THE EVOLUTION RATE OF THE PDF'S (IE A SMALLER α_s GIVE MORE VALENCE QUARKS FOR HIGH Q^2 (FIG 8).

Jet Production Cross Section As A Function Of E_T

MEASURED OVER 8 ORDERS OF MAGNITUDE.

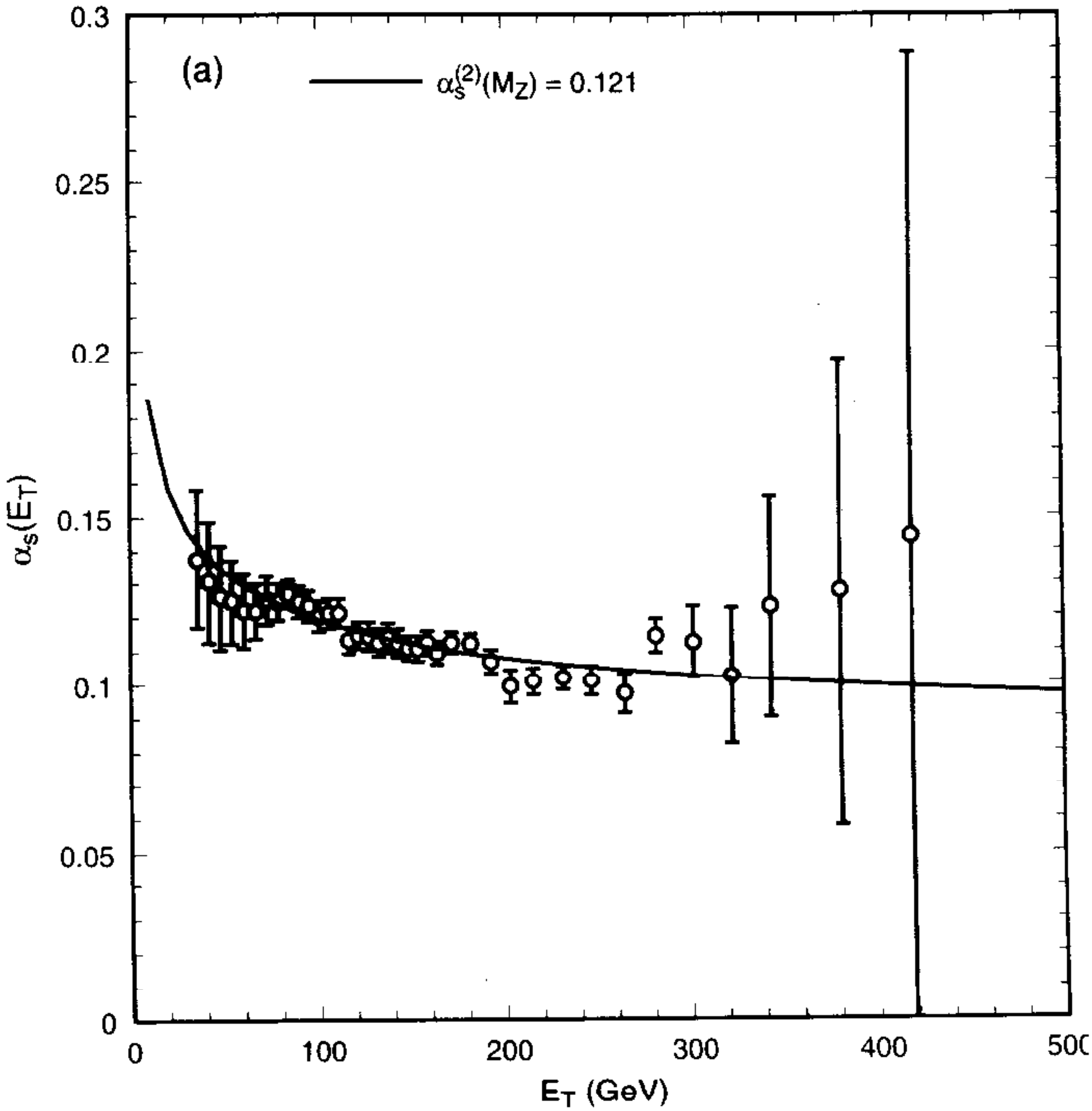


$$\sigma \sim \text{p.d.f} \otimes \hat{\sigma}(\alpha_s) \otimes \text{hadron}^{\underline{n}}$$

$$\Rightarrow \quad \alpha_s(M_Z) = 0.121 \pm \underset{(\text{STAT})}{0.001} \pm \underset{(\text{SYS})}{0.008} \pm \underset{(\text{THEORY})}{0.005}.$$

RUNNING OF $\alpha_s(E_T)$ OBSERVED IN SINGLE EXPERIMENT

~40 INDEPENDENT MEASUREMENTS AS A FUNCTION OF TRANSVERSE ENERGY



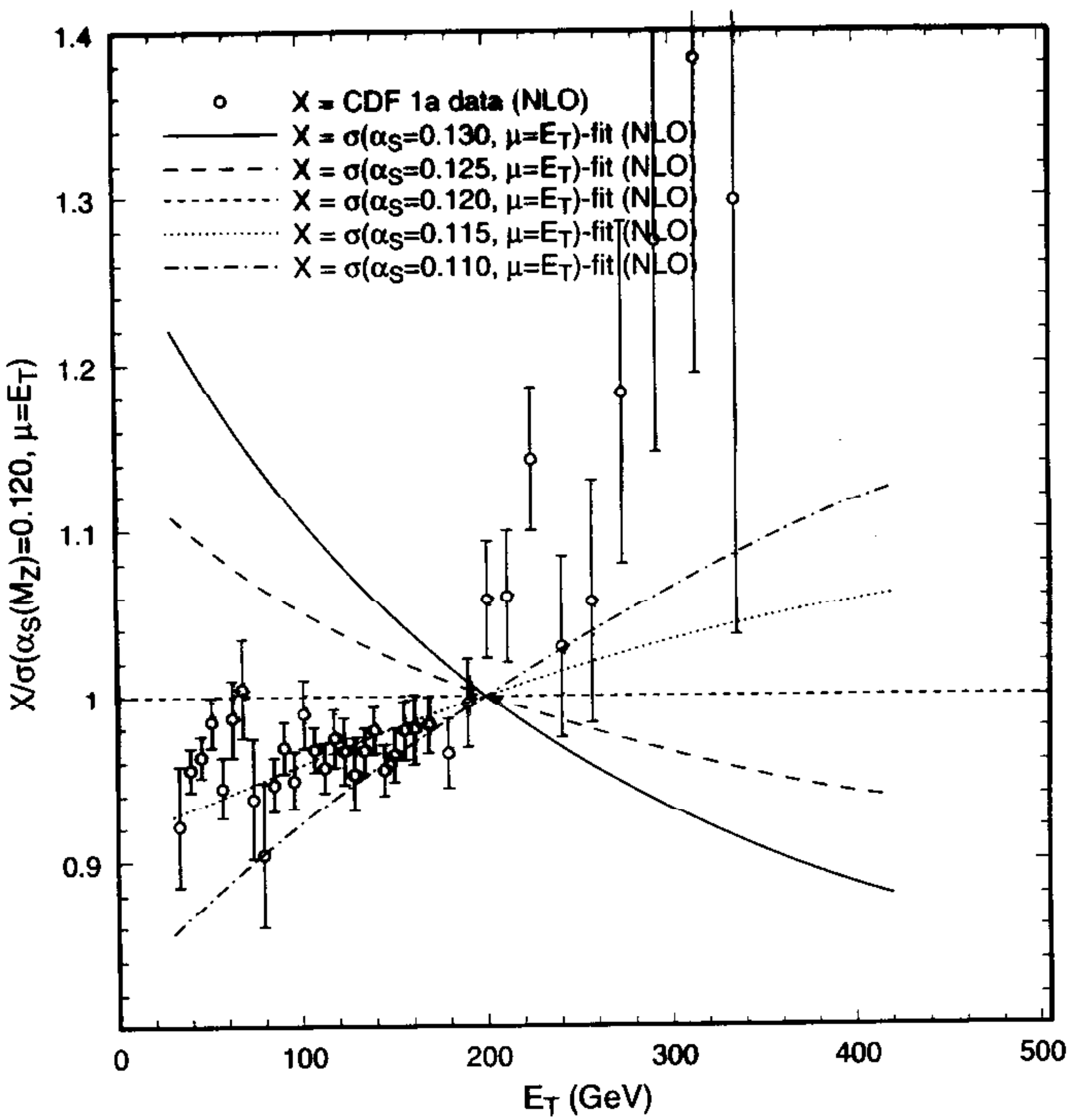
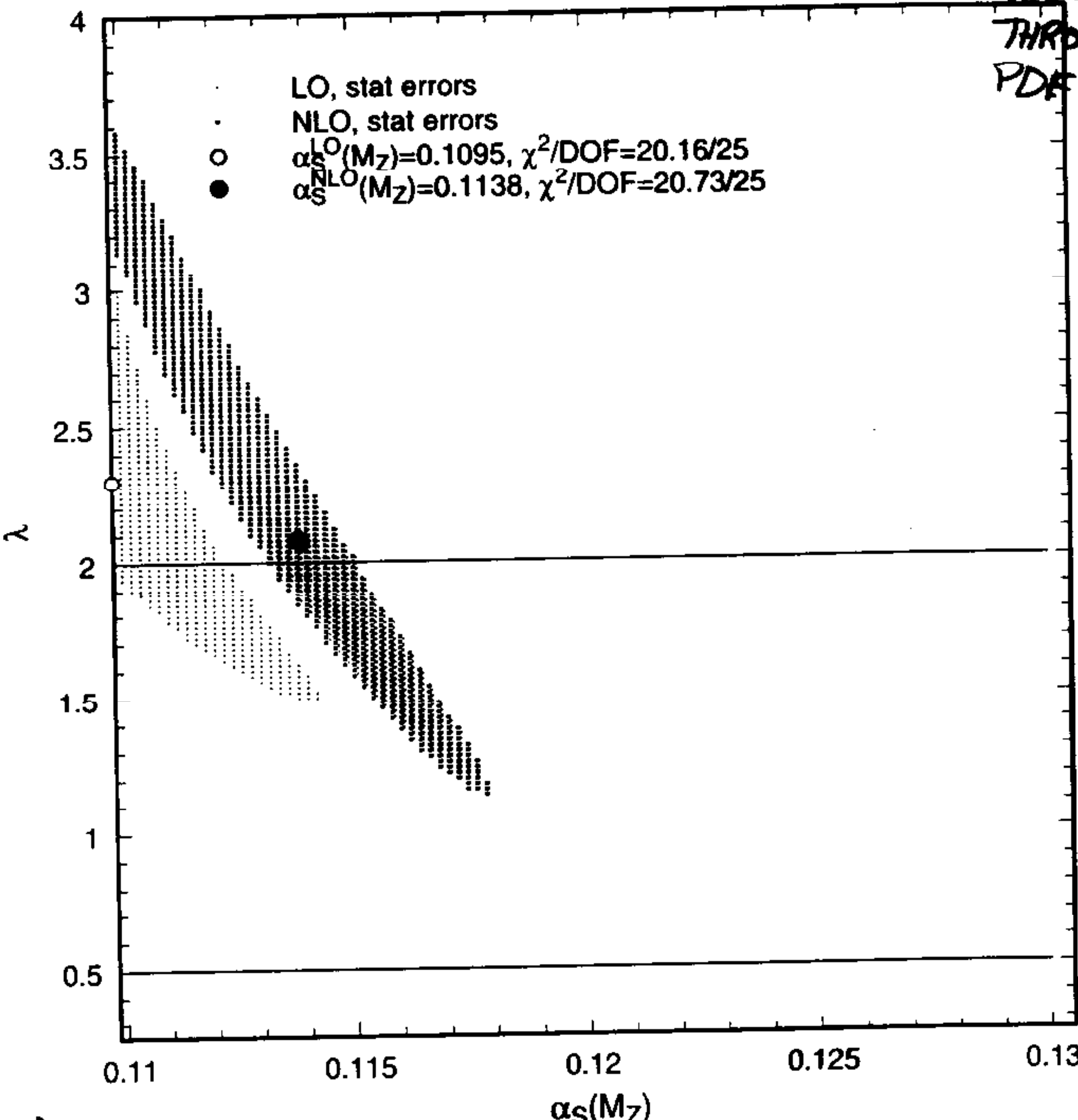

X = CDF 1a data (NLO)
X = σ(αS=0.130, μ=ET)-fit (NLO)
X = σ(αS=0.125, μ=ET)-fit (NLO)
X = σ(αS=0.120, μ=ET)-fit (NLO)
X = σ(αS=0.115, μ=ET)-fit (NLO)
X = σ(αS=0.110, μ=ET)-fit (NLO)
X/σ(αS(MZ)=0.120, μ=ET)
ET (GeV)
1.4
1.3
1.2
1.1
1
0.9
0
100
200
300
400
500

Fig 2.

FLOATING NORMALIZATION! $\frac{1}{\sigma}\frac{d\sigma}{d\theta} \sim A + \alpha_s B$

ALL α_s-DEPN THROUGH PDF EVOLUTION

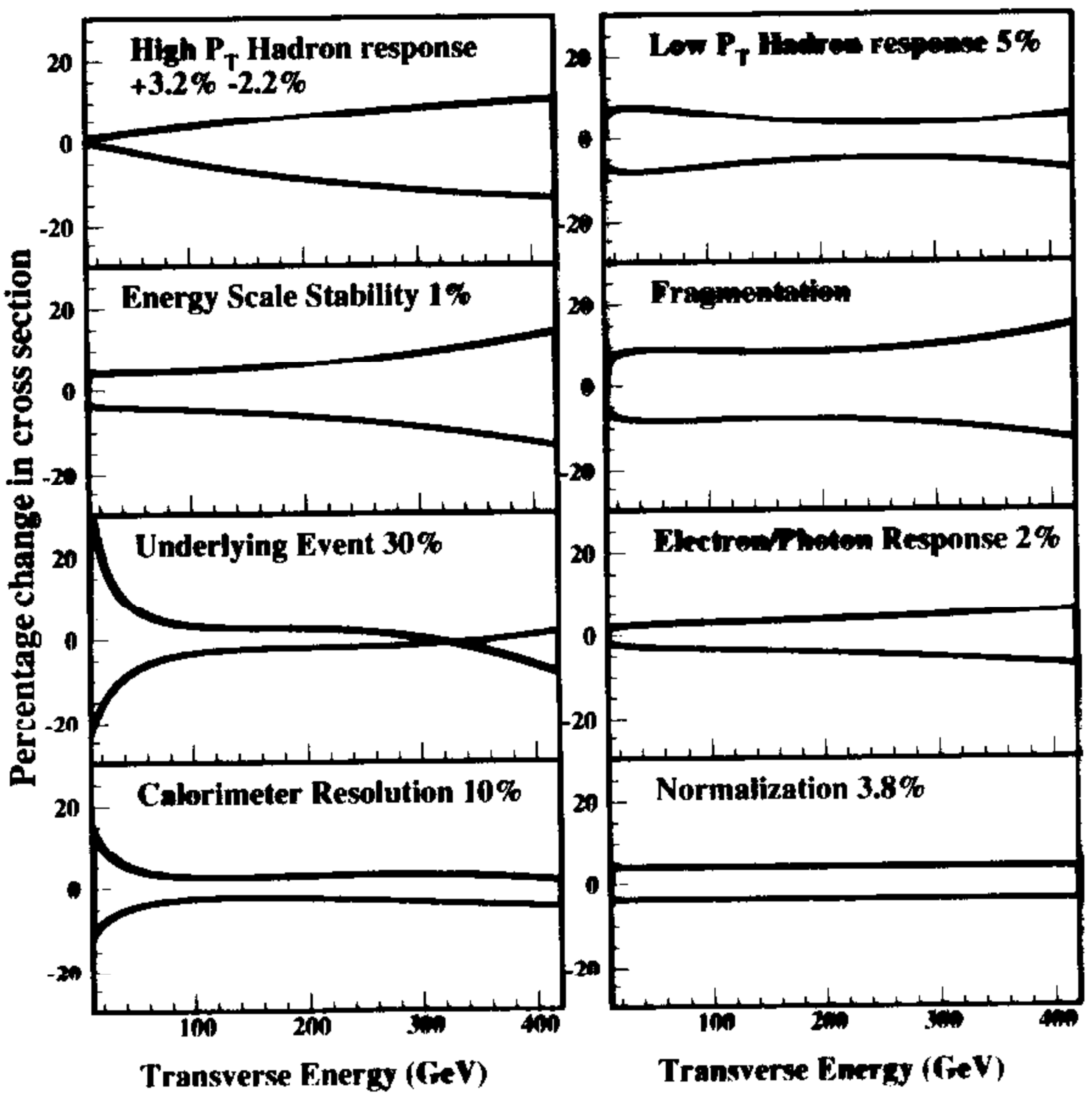


$\mu = \lambda E_T.$

$30\,GeV < E_T < 200\,GeV$

Systematic Errors

1)Evaluate change in Response Functions
2)Use new Response Functions to derive New Physics curve
3)Compare to "Standard Curve"



New CTEQ Global Analysis:

How Well do we know G(x,Q)?

at low to moderate x

Will study in two steps:

Impact of New and More Precise DIS data (1995):

HERA, NMC, E665 — significant

Impact of Inclusive CDF/D0 Jet data:

CDF (excluding low and high P_t regions) — 1st time

Phenomenological Sources of Uncertainties on G(x,Q):

Value of α_S

Will explore the range: $0.105 < \alpha_S(m_Z) < 0.125$

Parametrization of $G(x,Q_0)$

$$G(x,Q_0) = A\, x^B\, (1-x)^C\, P(x;\, D, \dots)$$

P(x; D, ...): functional form? $B_{gluon} = B_{sea\ quarks}$?

How many parameters?

Will compare:

(i) "minimal": $B_g = B_{s.q.}$; A - D (CTEQ3)

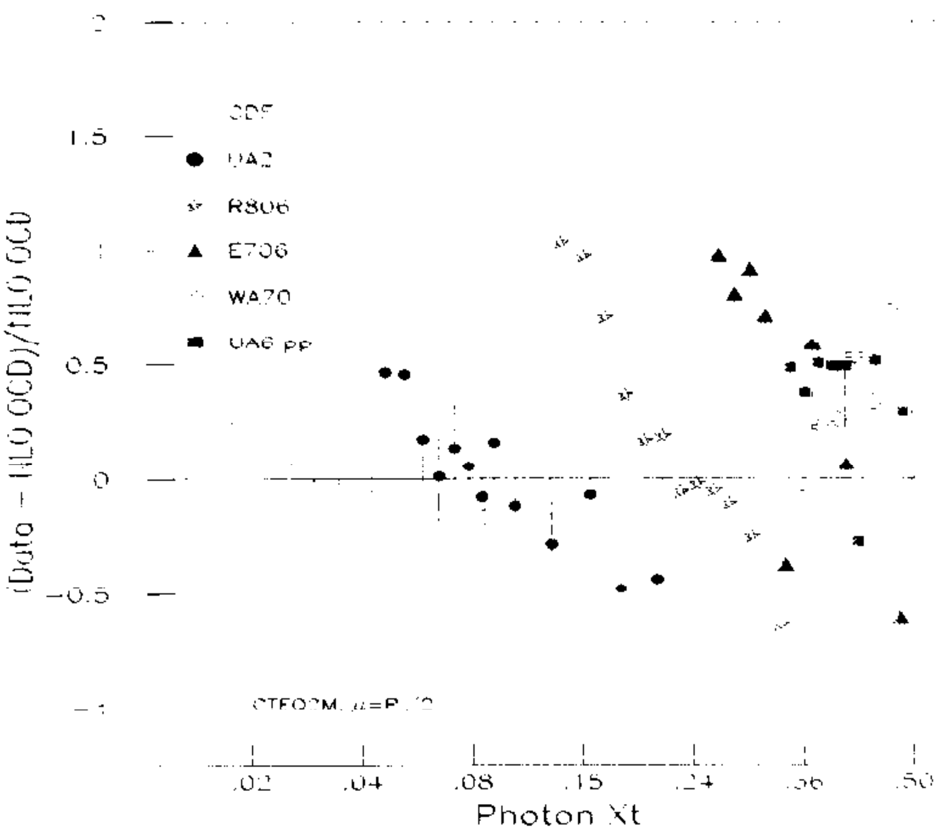
(ii) "2 + min" : $B_g \neq B_{s.q.}$; A - E (CTEQ2, MRSG, ..)

Data Selection: in particular, choice of "Q_{cut}"

$Q > Q_{cut}$ so that perturbative NLO QCD ("twist-two") theory will be applicable.

Will explore: $Q_{cut} = 2, 3, 4, 5$ GeV

A Global Study of Inclusive Direct Photon Production Data
(Huston et.al. CTEQ-407; Phys. Rev. D51, 6139 (95))



Global comparison of NLO QCD theory with fixed-target and collider data

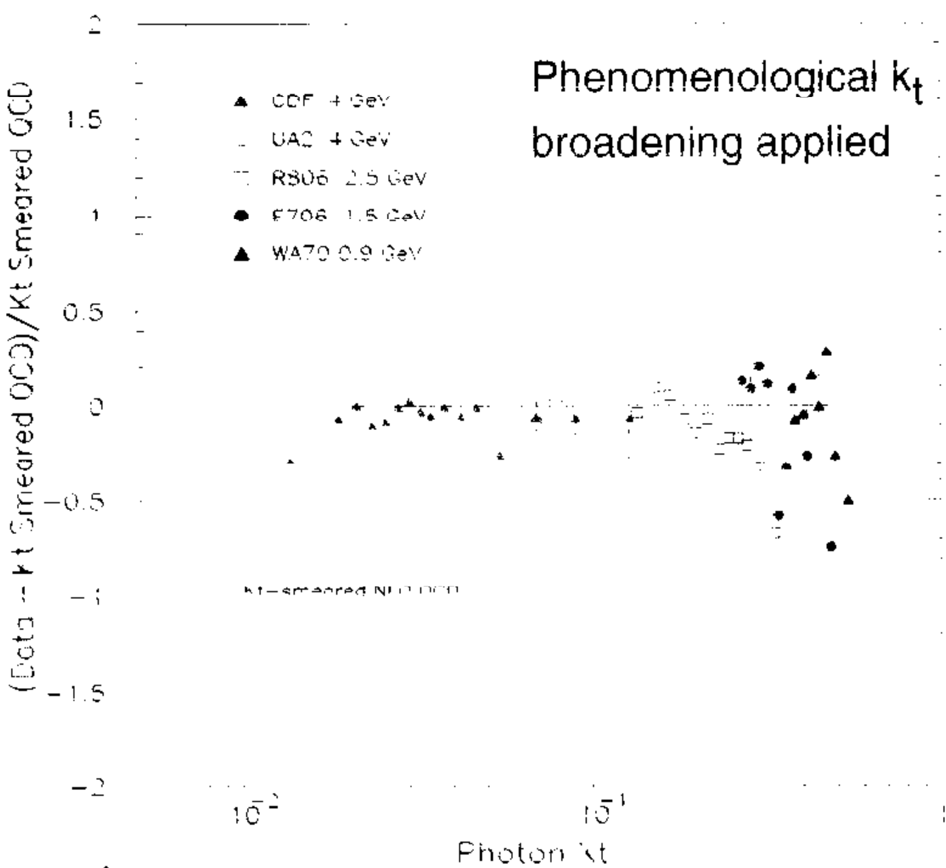
Pattern of deviation in the shape of P_t-distr. seen for all ranges of x_t

==>

not a PDF effect.

Pattern of observed behavior suggests energy-dependent broadening of transverse momentum of initial state partons, perhaps due to multi-gluon radiation

-- confirmed by shower MC calculations.



Phenomenological k_t broadening applied

HUNTING FOR BFKL ....."

BFKL - MOTIVATED MEASUREMENTS:

- INCREASED E_T FLOW $\Rightarrow$ LARGE HADRONISATION CORRECTIONS [H1, ZEUS OLD]

- JET ANGULAR DECORRELATION $\Rightarrow$ PREDOMINANT COHERENCE EFFECT [$\Rightarrow$ Dϕ]

- FORWARD JETS [$\Rightarrow$ H1, ZEUS]

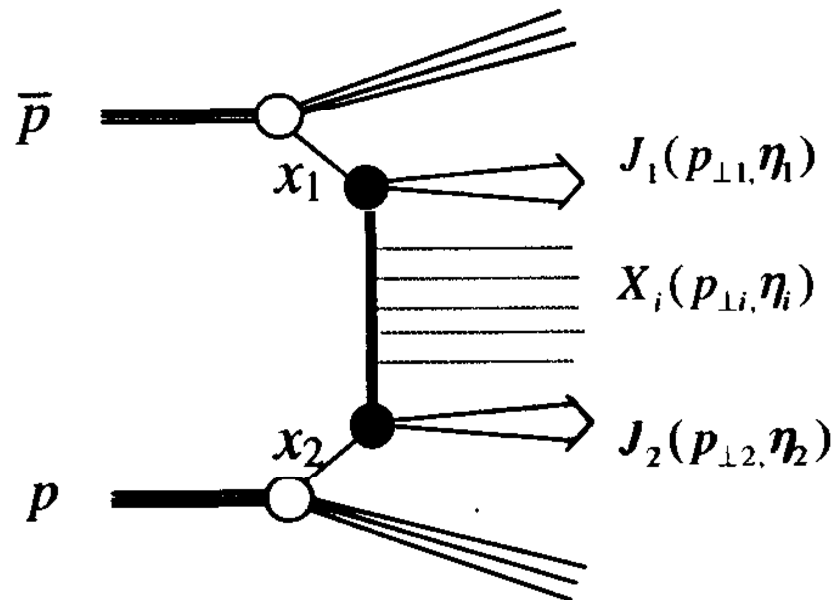
- CHARGED PARTICLE p_T [$\Rightarrow$ H1]

BFKL Dynamics at the Tevatron

- Inclusive dijet production at large rapidities

$$p + \overline{p} \to J_1(p_{\perp 1}, \eta_1) + J_2(p_{\perp 2}, \eta_2) + X$$

$$\sigma_{dijet} = x_1 P_1(x_1, Q^2) x_2 P_2(x_2, Q^2)\, \hat{\sigma}$$



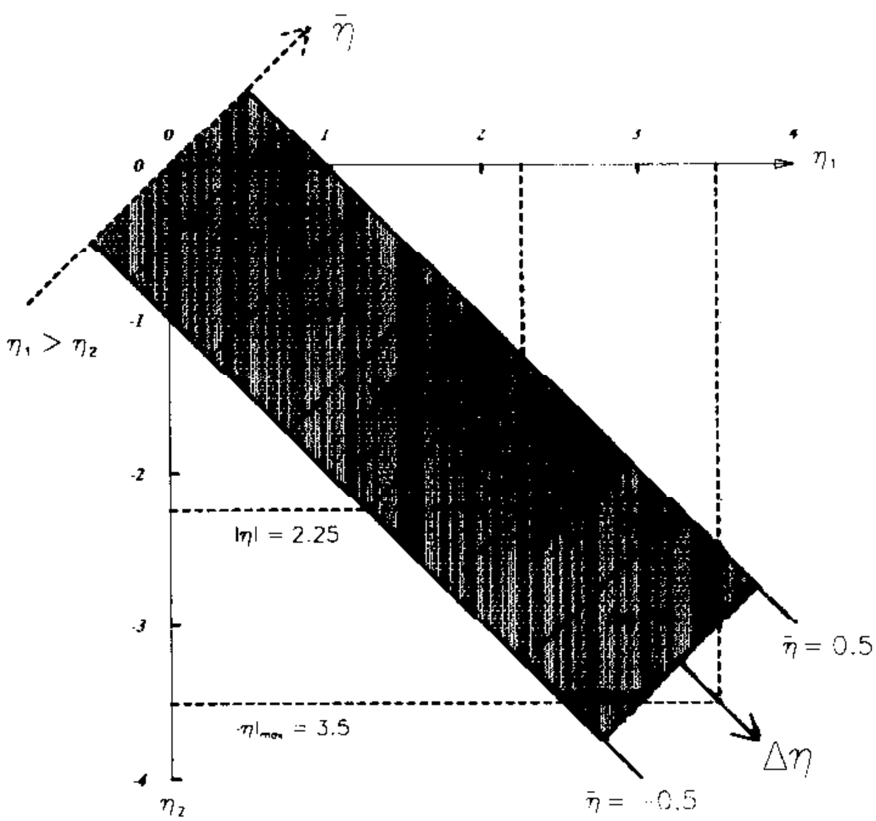
- Semi-hard region: $\Lambda_{QCD} << Q << \sqrt{\hat{s}} = \sqrt{x_1 x_2 s}$

$$\ln \frac{\hat{s}}{Q^2} \approx \eta_1 - \eta_2 = \Delta\eta >> 1$$

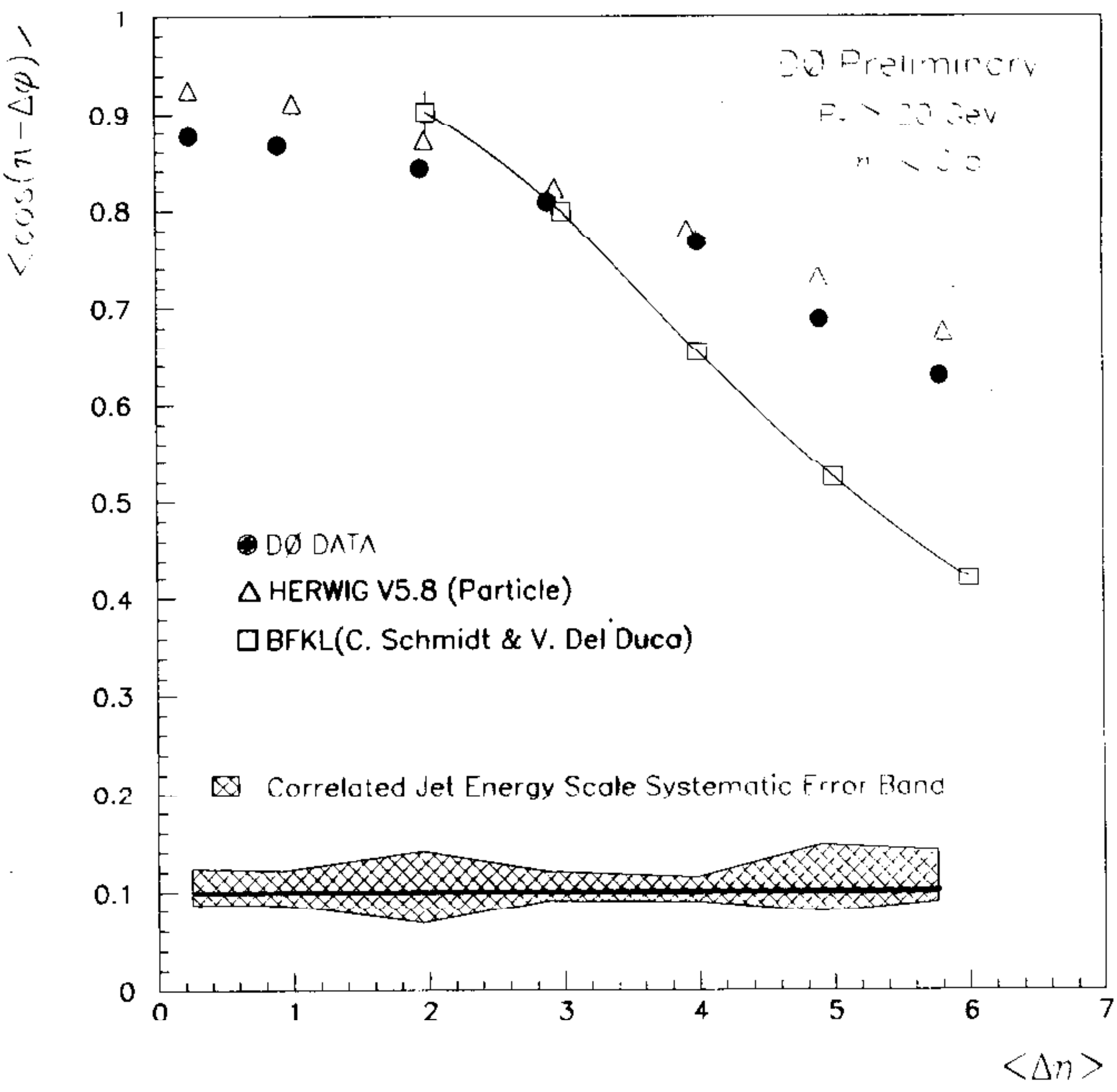
- Keeping large x_i allows these logarithms to factorize into the partonic cross section, $\hat{\sigma}$

Event Selection and Analysis Cuts

- Single jet triggers: Inclusive: Et > 12 GeV
  Forward: Et > 12 GeV and $|\eta| > 1.6$
- Multiple $p\bar{p}$ interaction events and spurious jets removed
- Select analysis jets: Et > 20 GeV and $|\eta| < 3.5$
- Tagging jets at the extreme rapidities: $(\eta_1,\phi_1),(\eta_2,\phi_2)$
- Boost cut: $|\bar{\eta}| < 0.5$
- Forward trigger η efficiency cut: $\mathrm{Max}(|\eta_1|,|\eta_2|) > 2.25$

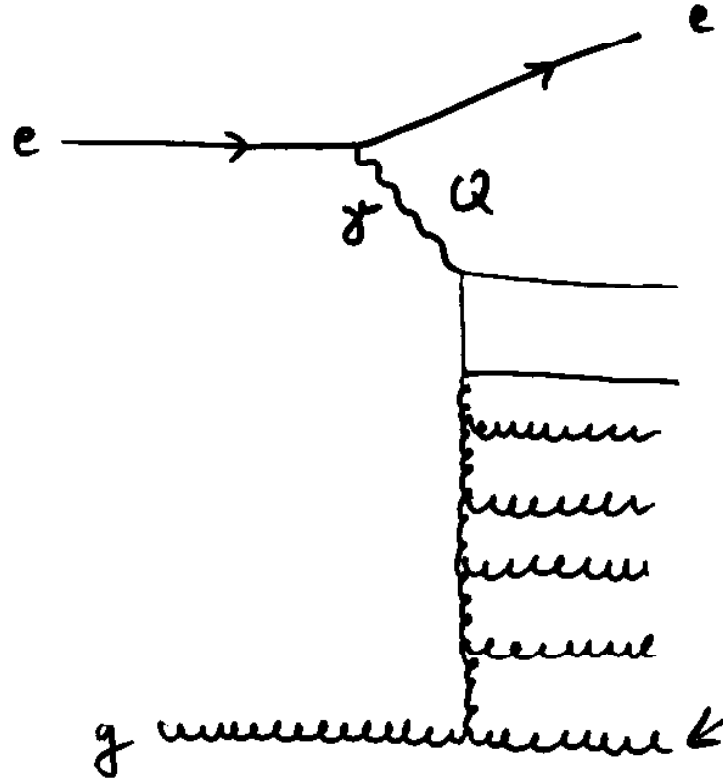


<cos(π-Δφ)> vs. Δη


DØ Preliminary
DØ DATA
HERWIG V5.8 (Particle)
BFKL(C. Schmidt & V. Del Duca)
Correlated Jet Energy Scale Systematic Error Band
<cos(π−Δφ)>
<Δη>
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7

Forward jets and BFKL dynamics

Isolate BFKL dynamics (gluon ladders) by tagging forward (Mueller-Navelet) jet



$$x = \frac{Q^2}{2p\cdot q}$$

$$p_T \approx Q$$

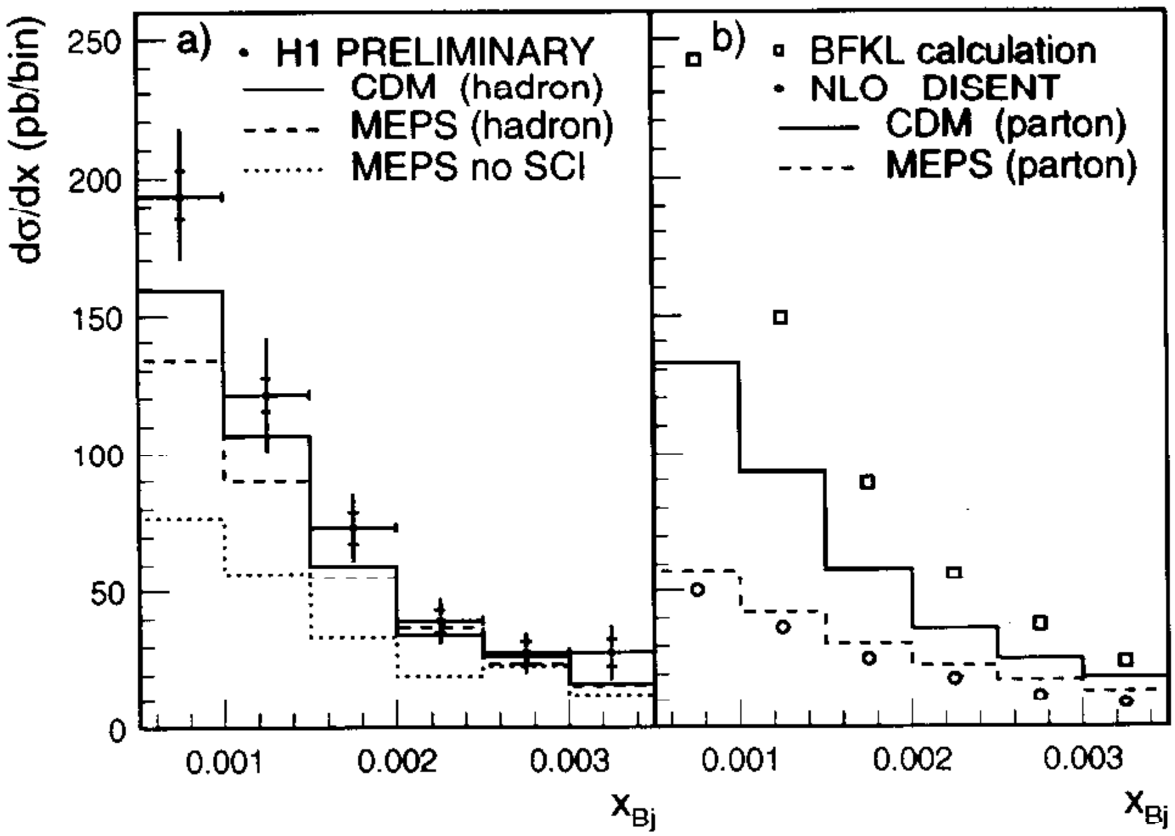
$$x_{jet} = \frac{p_z(\text{jet})}{E_p} \gg$$

BFKL prediction

$$\frac{\sigma_{BFKL}(x \ll x_{jet})}{\sigma_{\text{fixed order QCD}}} \sim \left(\frac{x_{jet}}{x}\right)^{\alpha_P - 1} \gg 1$$

Fixed order QCD is "background"

forward jets



	cone in lab R=1.
$E'_{el} > 11$ GeV	$E_{jet} > 28.7$ GeV
$160° < \vartheta_{el} < 173°$	$p_{\perp jet} > 3.5$ GeV
$y > 0.1$	$7° < \vartheta_{jet} < 20°$
	$0.5 < p^2_{\perp jet}/Q^2 < 2$

NLO, CDM, MEPS: MRS H parton densities

BFKL calculation: (normalization unknown)

Bartels, Del Duca, De Roeck, Graudenz, Wüsthoff

forward jets

- data is above all models
- closest model: CDM / MEPS fails
- BFKL (parton-level) calculation is above data
  - ⇝ large uncertainty for hadronization corrections (very large model dependence)
- NLO calculation not very predictive:

$$\frac{\sigma_{NLO}}{\sigma_{LO}} \simeq 6$$

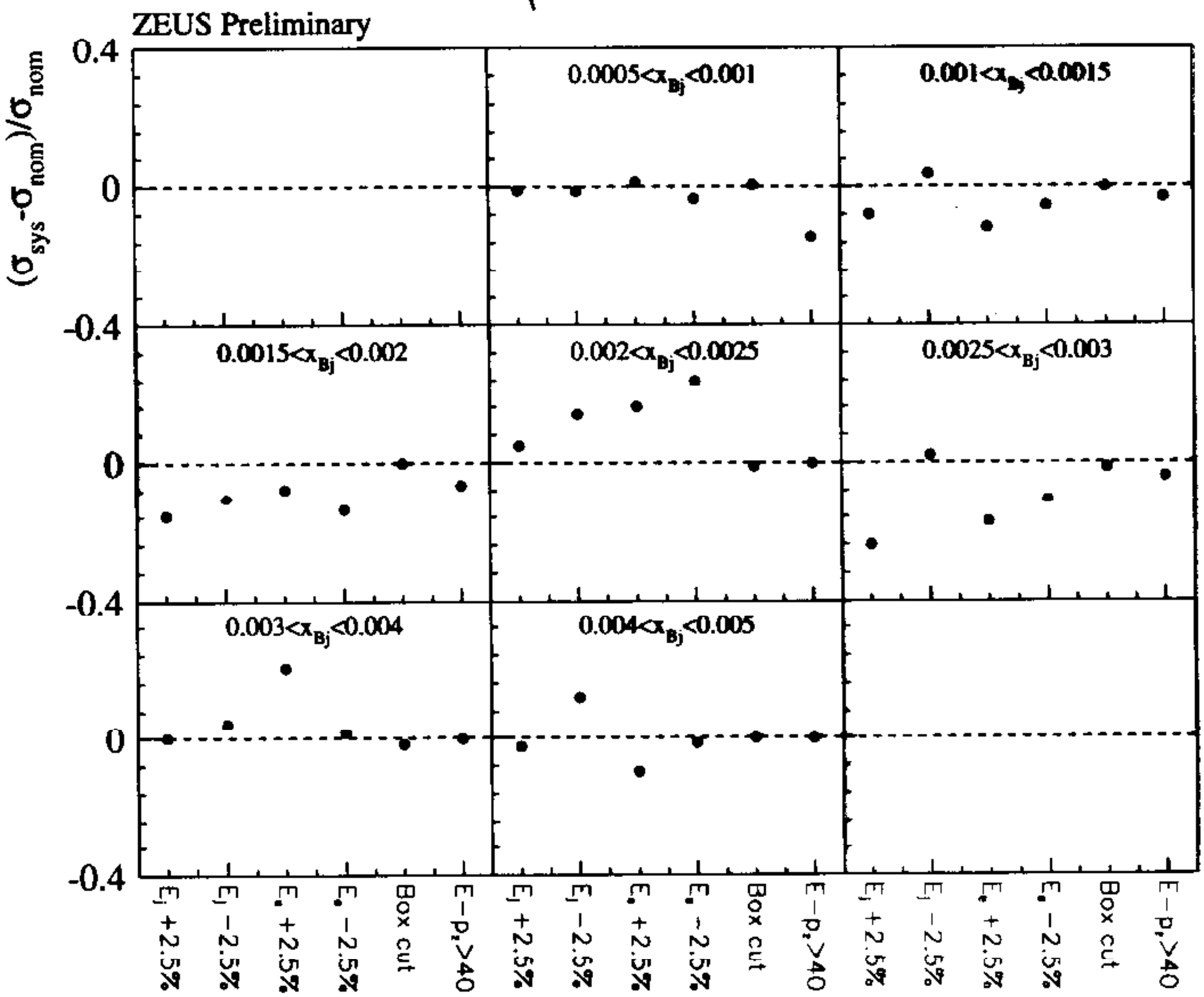
⇝ future prospects:

require higher transverse momentum to decrease hadronization effects!

Systematic Checks

- Vary (hadronic) calorimeter energy scale by ± 2.5%
- Vary electron energy by ± 2.5 %
- Change "box cut"
- Change $E - p_z$ cut

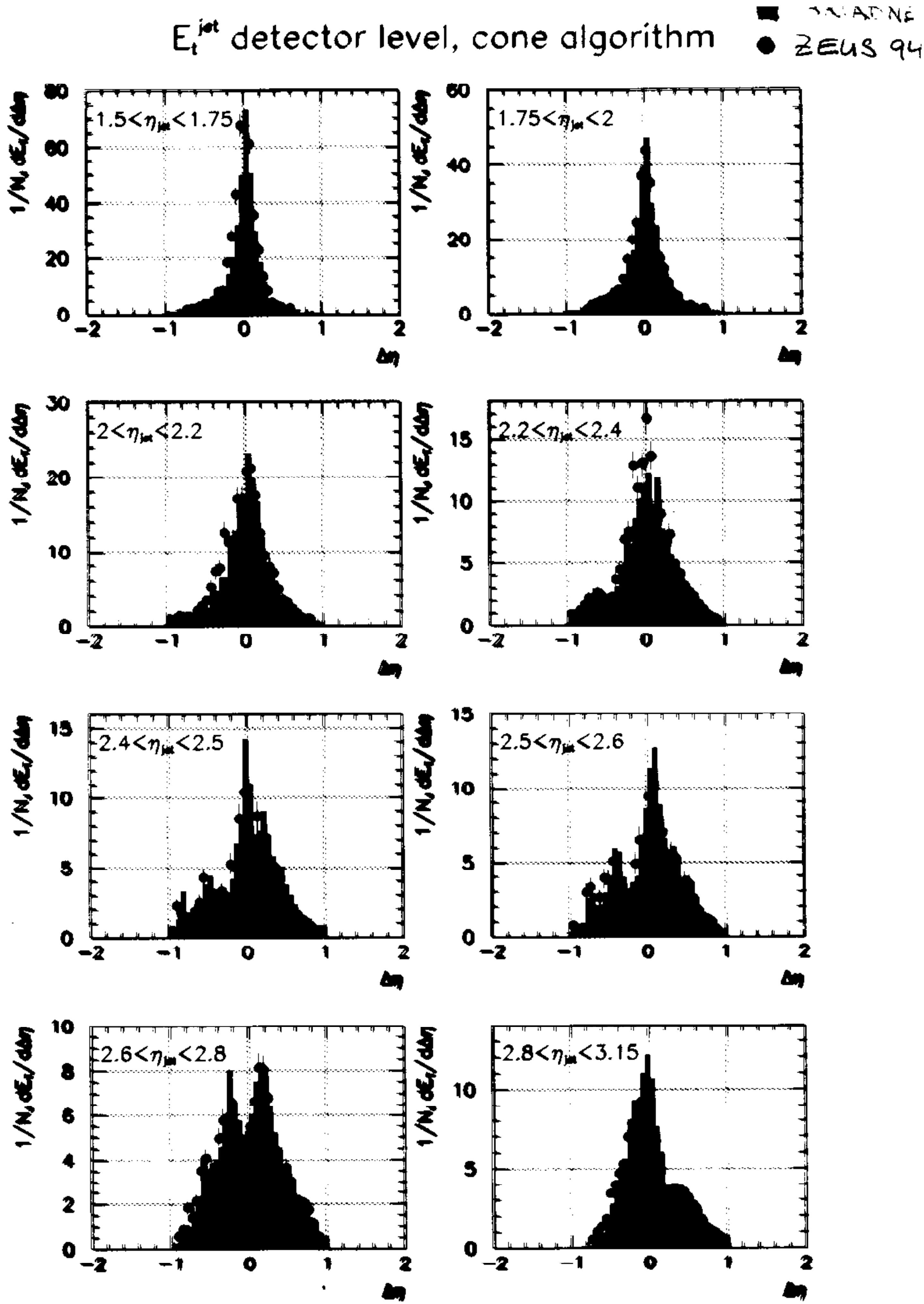
Relative Deviation from nominal cross section



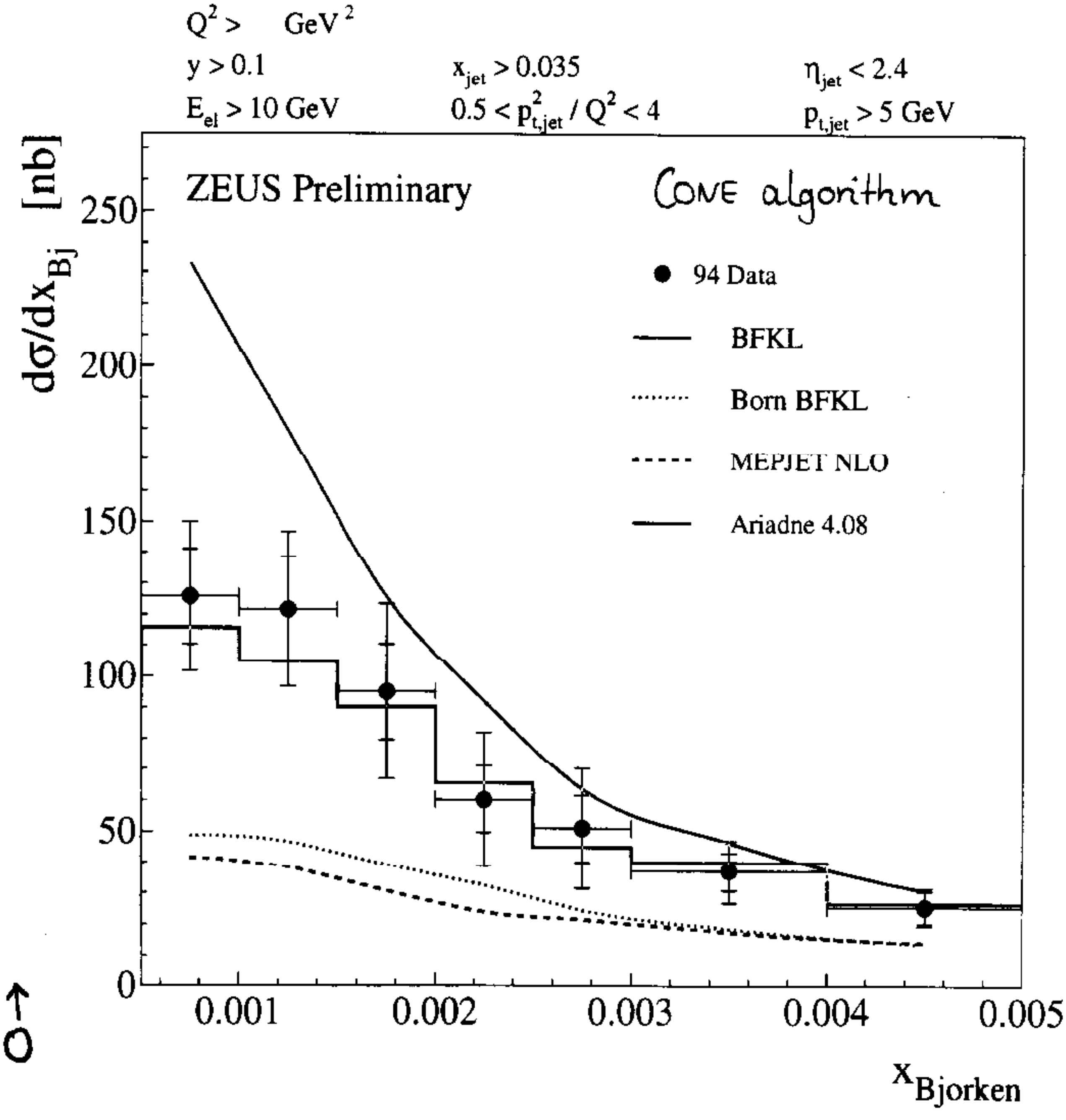
More systematic checks are needed:

- hadronization scheme
- parton density functions

⋮



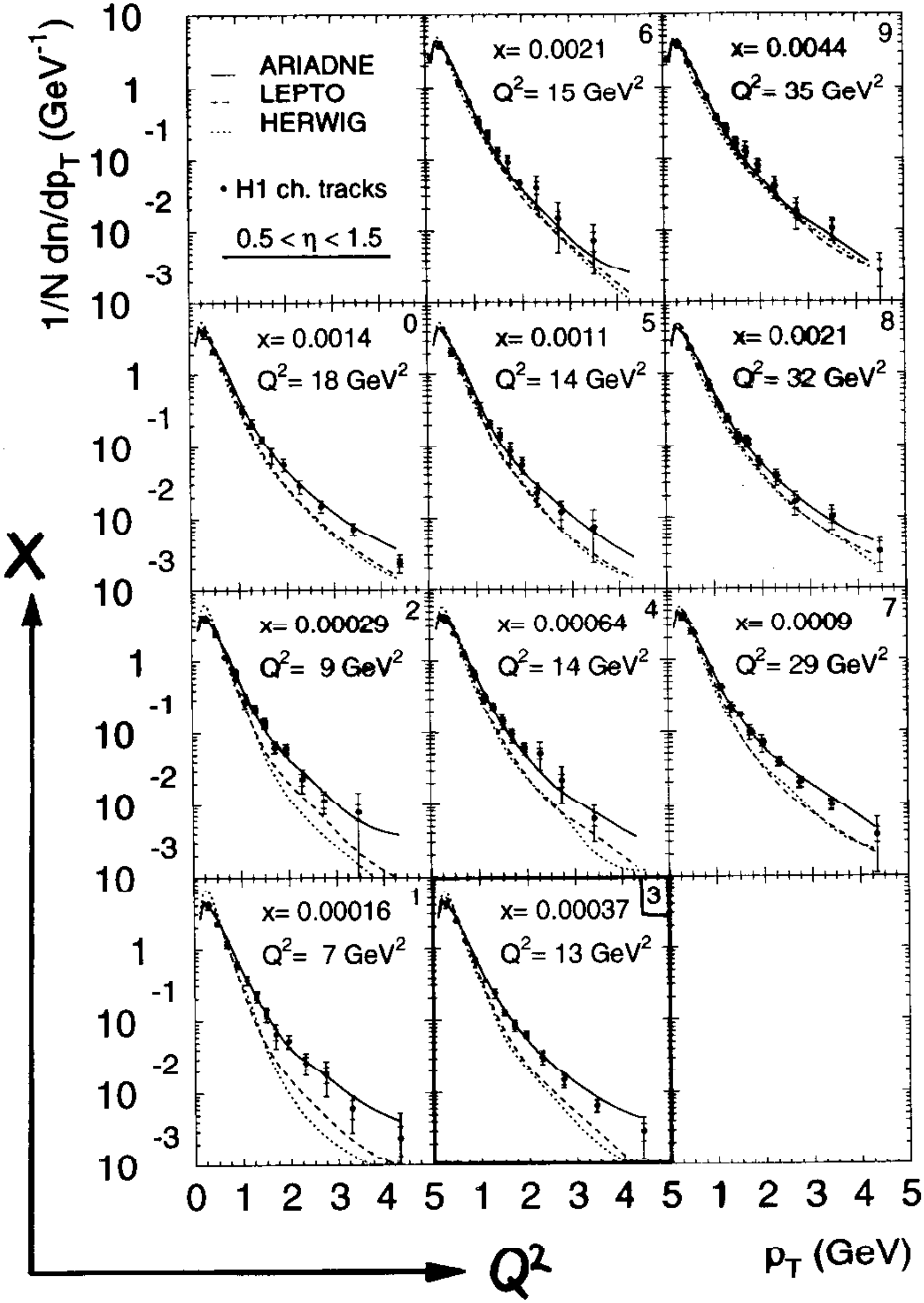
E_t^{jet} detector level, cone algorithm
ZEUS 94
$1.5<\eta_{jet}<1.75$
$1.75<\eta_{jet}<2$
$2<\eta_{jet}<2.2$
$2.2<\eta_{jet}<2.4$
$2.4<\eta_{jet}<2.5$
$2.5<\eta_{jet}<2.6$
$2.6<\eta_{jet}<2.8$
$2.8<\eta_{jet}<3.15$
$1/N_J\, dE_t/d\Delta\eta$
$\Delta\eta$



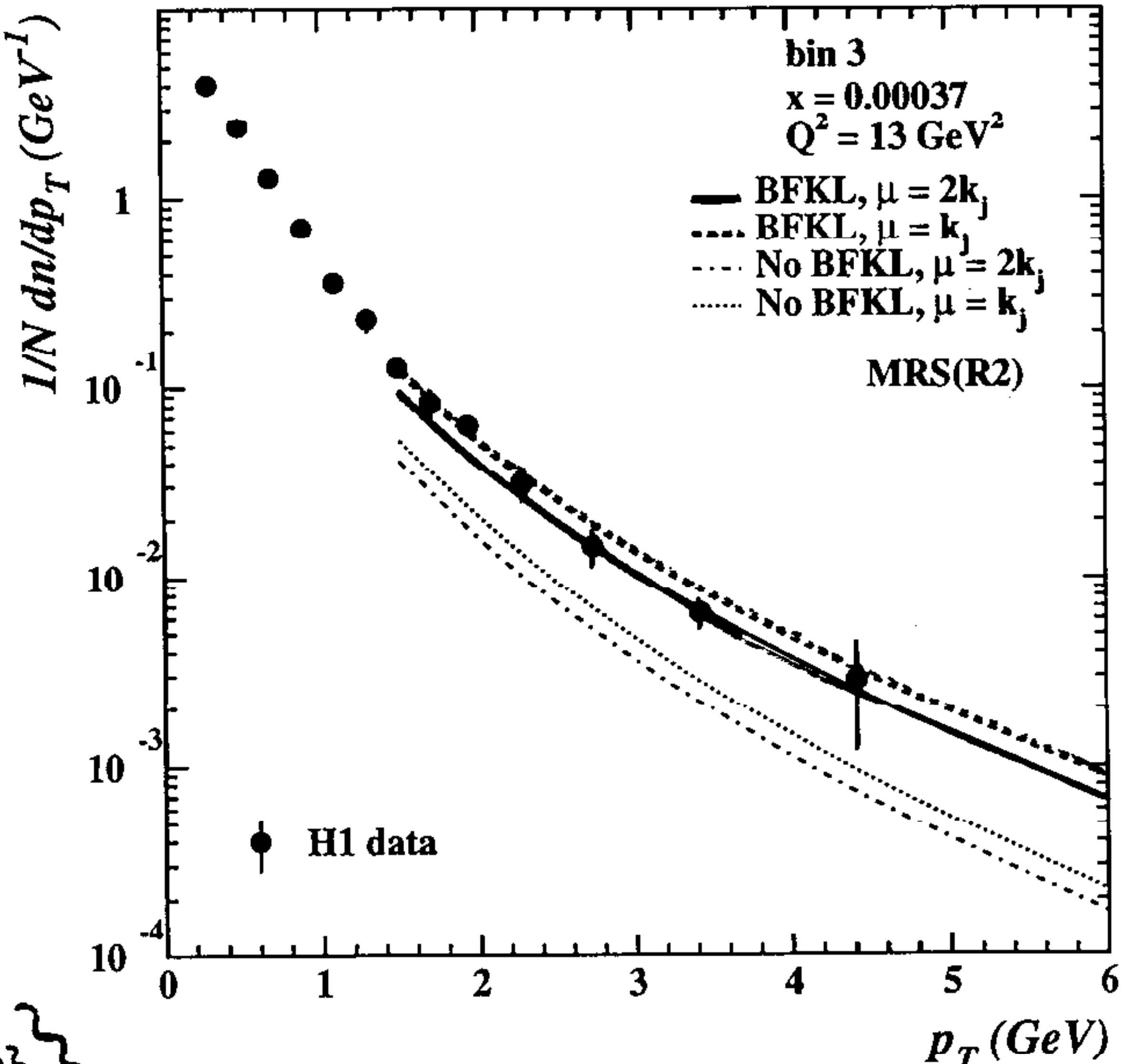
Q^2 > GeV^2
y > 0.1
x_jet > 0.035
η_jet < 2.4
E_el > 10 GeV
0.5 < p^2_t,jet / Q^2 < 4
p_t,jet > 5 GeV
ZEUS Preliminary
Cone algorithm
94 Data
BFKL
Born BFKL
MEPJET NLO
Ariadne 4.08
dσ/dx_Bj [nb]
x_Bjorken
O →

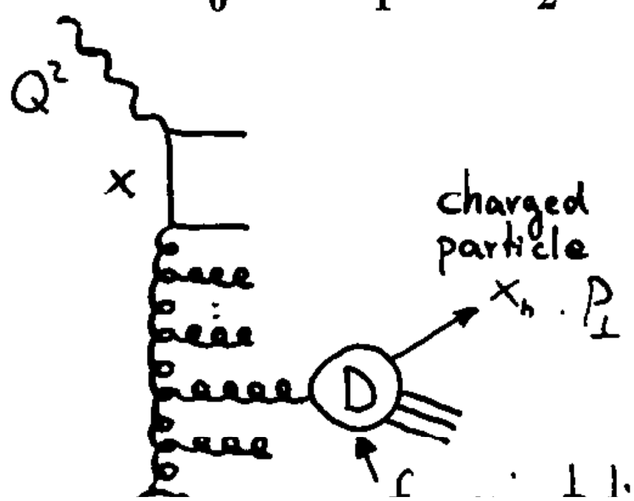
transverse momentum spectra of charged particles

Nucl. Phys. B 485 (1997) 3



Absolute prediction for the charged particle spectrum





Kwiecinski, Lang, Martin

(normalization taken from calc. for H1-forward jets)

GENERAL COMMENTS ... EMERGING FROM THE GROUP.

$e^+e^- \to$ LEP II : STILL "BEAUTIFUL AGREEMENT WITH QCD" $\Rightarrow$ SET OF WELL-DEFINED UNIVERSAL(?) VARIABLES

$K_T \gtrsim$ CONE $\gg$ JADE FROM THEORY
$R_{SEP} \simeq 1.3$

DIFFERENTIAL TWO JET RATE $\equiv$ WELL-BEHAVED EVENT SHAPE VARIABLE $\Rightarrow$ INTEGRATE JET AND EVENT SHAPE ANALYSES

AGREEMENT OF ARIADNE WITH ~ ALL HERA DATA $\Rightarrow$ SUCCESS OF DIPOLE MODEL $\Rightarrow$ NEXT STEP: LINKED DIPOLE CHAIN MODEL AVAILABLE SOON.

TEVATRON / HERA JET DATA PUSHING QCD TO ITS LIMIT: QCD IS FAILING?...

(NEVER SEEN SO MANY NLO QCD CURVES NOT FITTING THE DATA)

GENERAL COMMENTS... CTD.

GENERALLY LOW E_T AT HERA, SO VARIOUS WAYS OUT FOR THEORY

TEVATRON: SYSTEMATIC ERROR CORRELATION MATRIX REQ^{D} FOR INCLUSIVE JET DATA EAGERLY AWAITED.

W + JET DATA: WAYS OUT AT LOW E_T, BUT FOR $E_T \sim 50$ GeV?

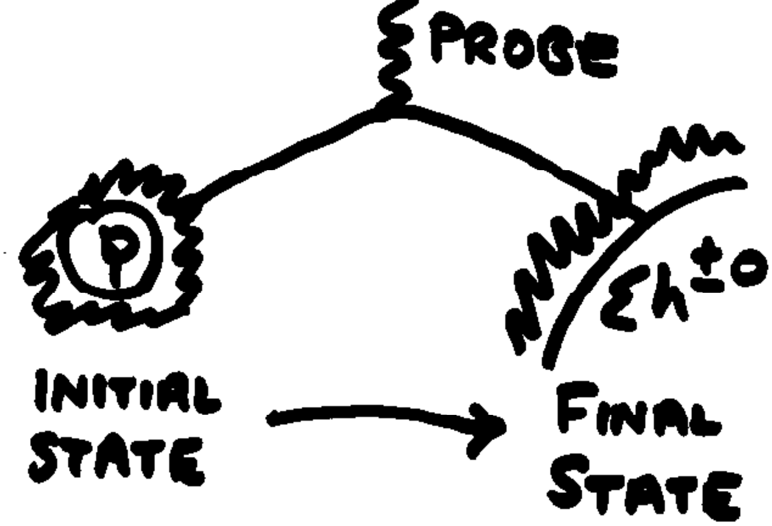
.... A MYSTERY (TO THIS GROUP..)

(MAYBE ARTHUR CONAN DOYLE SHOULD HAVE BEEN ASKED TO INVESTIGATE THIS ONE...)

CONCLUSIONS

INITIAL SURPRISE? "QCD WORKS WELL" DOWN TO LOW Q^2, E_T, η...
BASED ON COMPARISONS TO LO CALC$\underline{\text{N}}$S WITHIN MODELS / MONTE CARLO'S

NOW, THEORETICAL DEVELOPMENTS OF NLO CALC$\underline{\text{N}}$S $\Rightarrow$ CHINKS IN THE ARMOUR OF QCD...
NOT SEEN IN e^+e^-.....



SOMETHING MISSING?

THE MORE WE LEARN, THE LESS WE KNOW CAN TAKE FOR GRANTED...

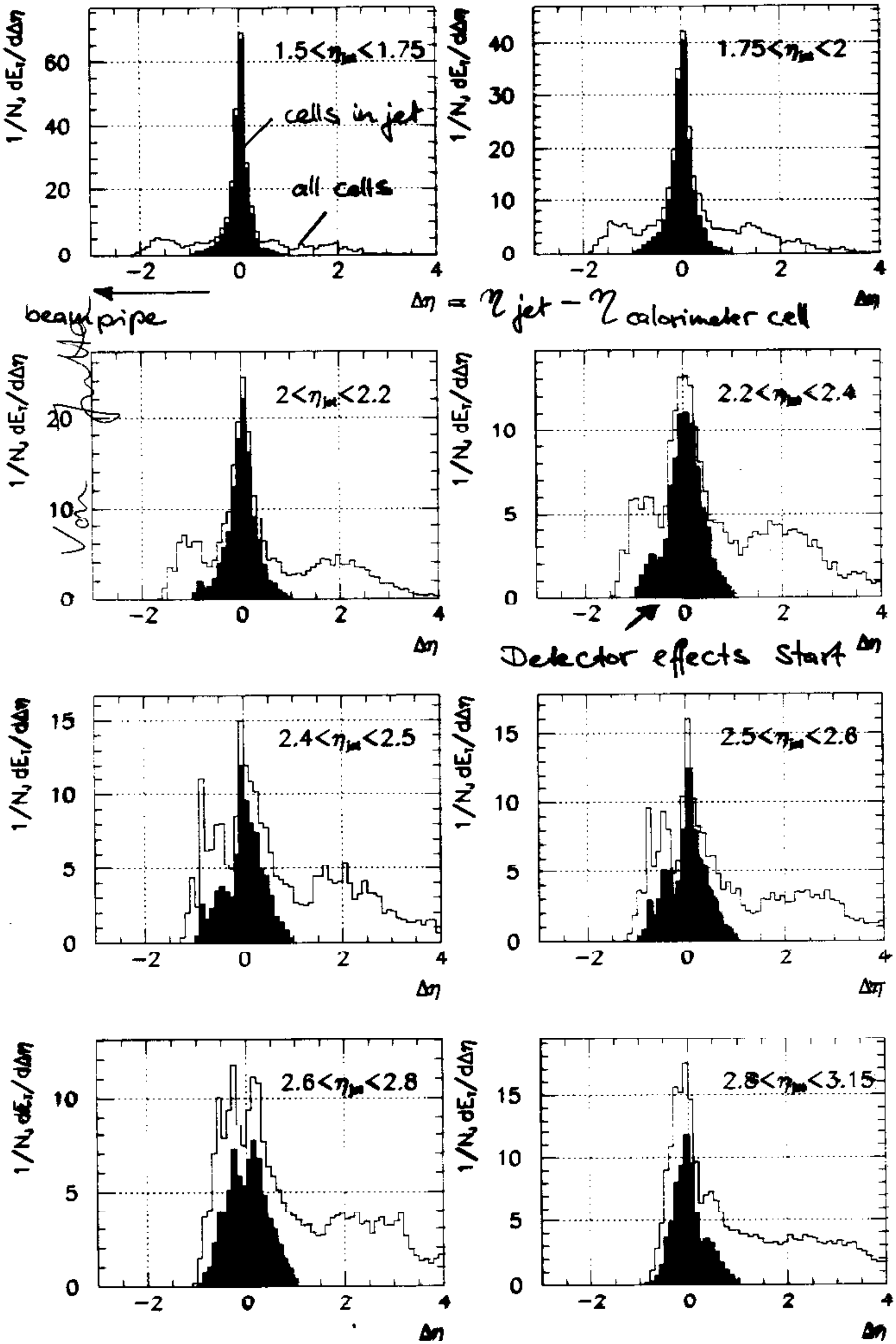
MANY THANKS ...

TO CO-CONVENORS: EDDI DE WOLF
NIKOS VARELAS
DIETER ZEPPENFELD

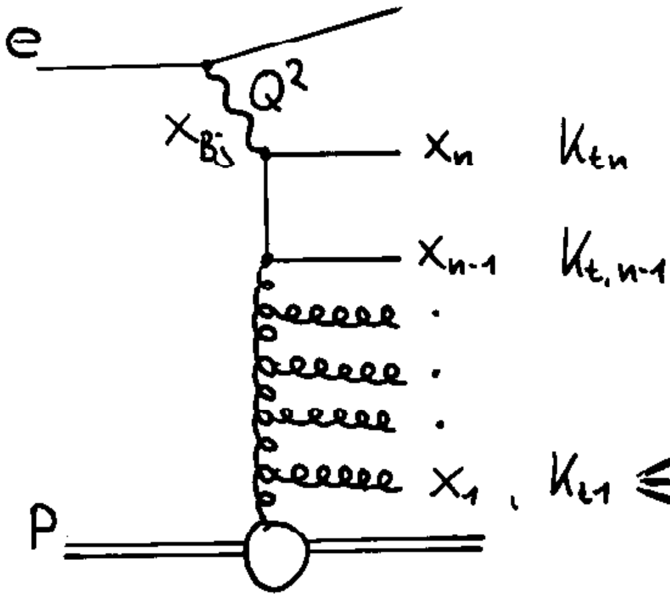
TO ALL THE SPEAKERS

AND ALL THOSE WHO CONTRIBUTED TO THE DISCUSSION WITHIN THE WORKING GROUP

E_t^{jet} detector level, cone algorithm, ARIADNE - 1



forward jet production



$\Leftarrow$ $\boxed{\text{forward jet}}$

DGLAP: $k_{t,n}^2 \gg k_{t,n-1}^2 \gg \dots \gg k_{t,1}^2$ $\qquad x_n < x_{n-1} < \dots < x_1$

BFKL: no k_t-ordering $\qquad x_n \ll x_{n-1} \ll \dots \ll x_1$

- $k_t^2 \simeq Q^2 \Rightarrow$ suppress phase space for DGLAP

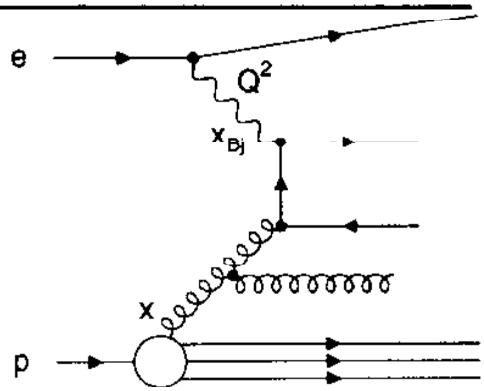
- $x_{jet} = \dfrac{E_{jet}}{E_p}$ large $\qquad x_{Bj}$ small

$\Rightarrow$ maximize phase space for BFKL evolution

$$\sim \left(\frac{x_{jet}}{x_{Bj}} \right)$$

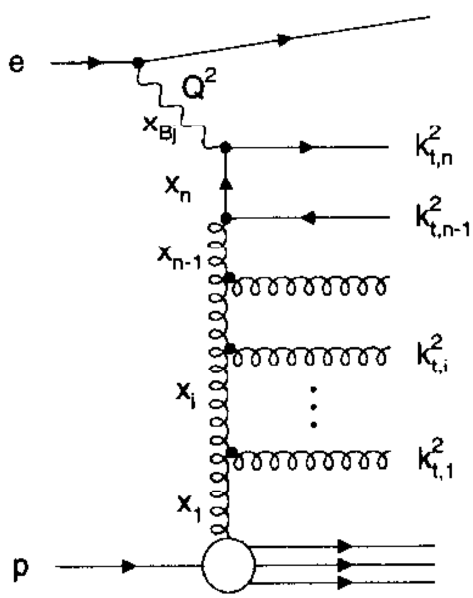
high $p_\perp^*$ hadr. final states

fixed order α_s



NLO

resummation of leading logarithms



DGLAP $\left(\alpha_s \ln \frac{Q^2}{Q_0^2}\right)^n$

$$K_{t,1} \lll K_{t,2} \lll \cdots \lll K_{t,n}$$

$$x_1 > x_2 > \cdots > x_n$$

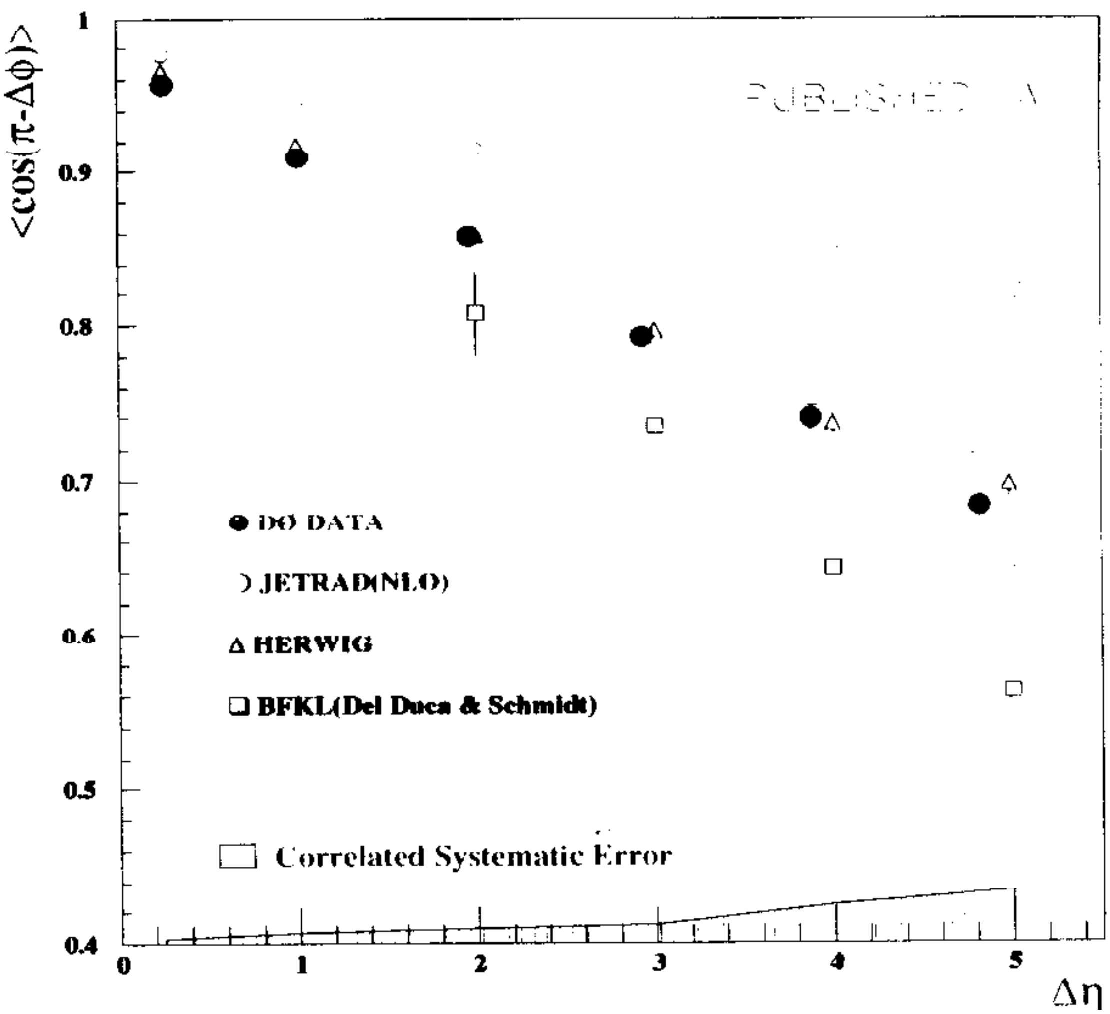
BFKL $\left(\alpha_s \ln \frac{1}{x}\right)^n$

$$K_{t,i} \sim K_{t,i+1}$$

$$x_1 \gg x_2 \gg \cdots \gg x_n$$

(should become relevant at small x)

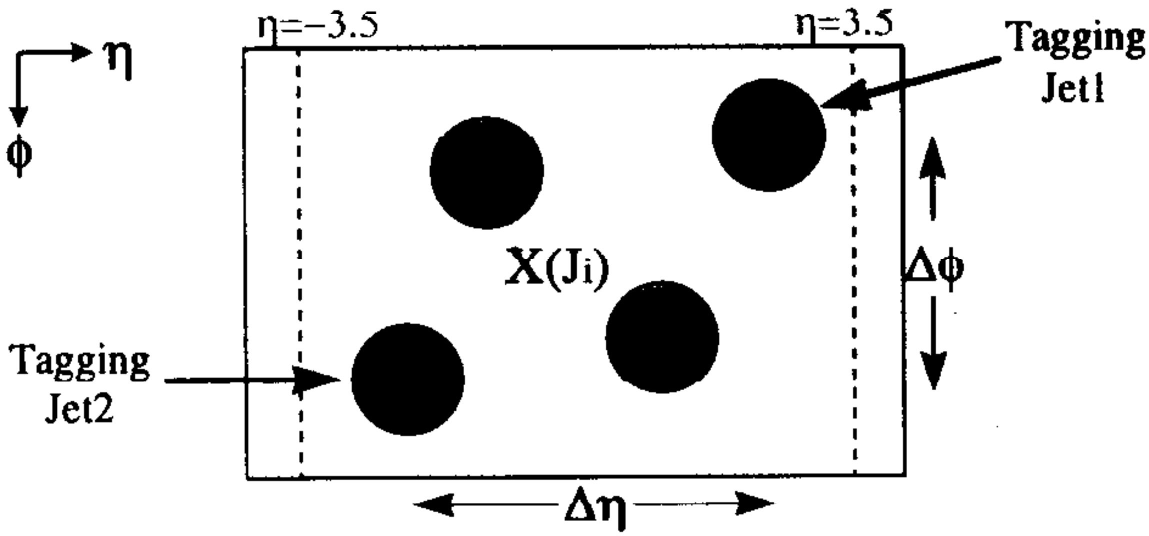
Published 1A Result: PRL, 77, 595 (1996)



	1A	1B	COMMENT
ET THRESHOLD CUT	Asymmetric Max(Et1,Et2) > 50 Min(Et1,Et2) > 20	Symmetric Min(Et1,Et2) > 20	Lower Symmetric Et cut
MAX Δη	5	6	Extended

Event topology and Analysis variables

- Inclusive dijet: $p+\overline{p} \rightarrow J_1(\eta_1,\phi_1)+J_2(\eta_2,\phi_2)+X(J_i)$



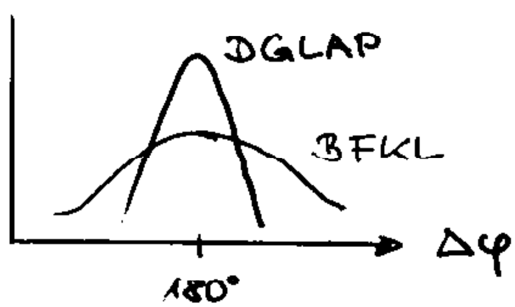
Rapidity ordering: $\eta_1 > \eta_i > \eta_2$

- Analysis variables:

$\Delta\eta = \eta_1 - \eta_2$	Rapidity interval
$\Delta\phi = \phi_1 - \phi_2$	Separation in azimuth
$\overline{\eta} = (\eta_1 + \eta_2)/2$	Rapidity boost

Possible Manifestations of BFKL Dynamics in Hadronic Final States

- Increased transverse energy flow
- Increased forward jet cross section
- Jet angular decorrelation



All these effects are based on the "non ordering" of the transverse momenta.

W/Z +Jets Production at the Tevatron

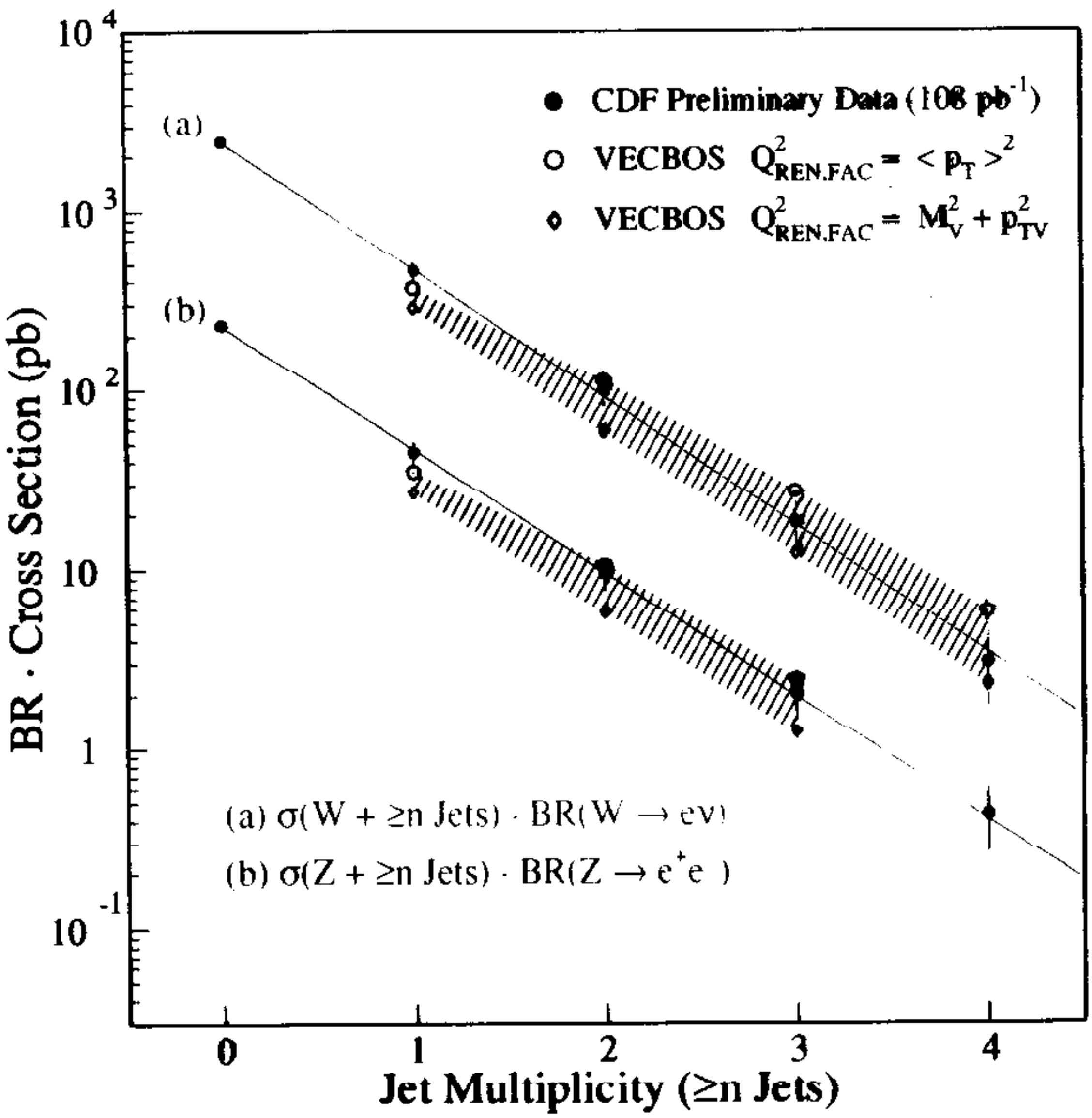
Tacy Joffe-Minor
Northwestern University

for the DØ Collaboration

5th International Conference on
Deep Inelastic Scattering and QCD

April 14-18,1997

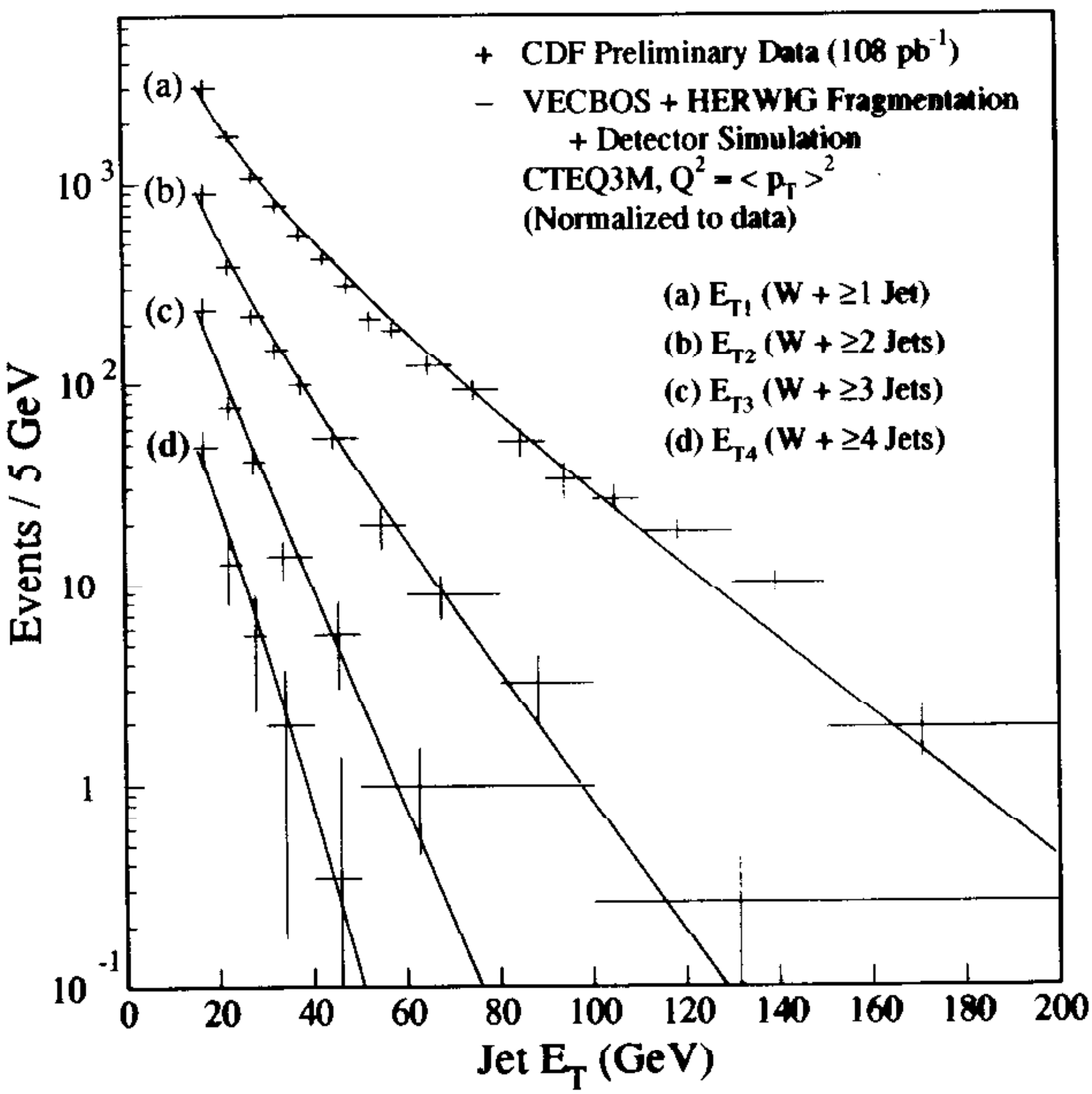
W/Z + ≥N Jet Cross Sections



Z+ n jet cross sections from F. Abe *et al.*, PRL 77, 448.

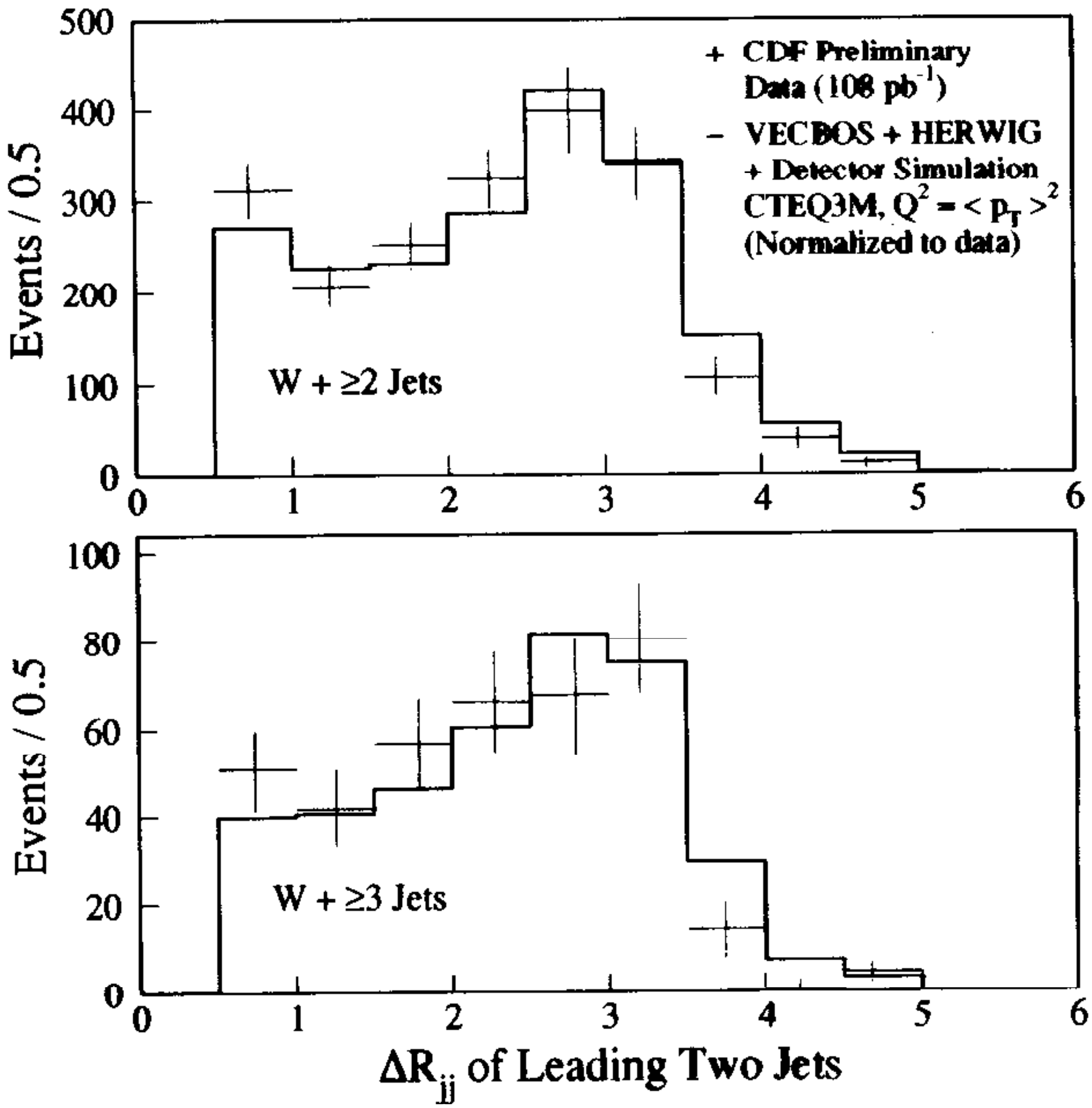
Jet E_T Distributions

* shape comparisons



Error bars include statistical uncertainties and background subtraction systematics.

ΔR_{jj} Comparisons

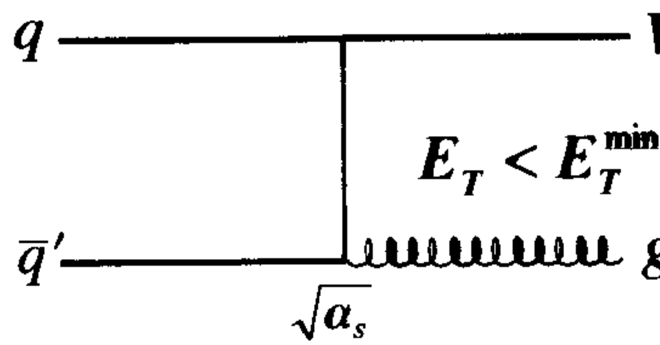


W/Z + N Jets Conclusions

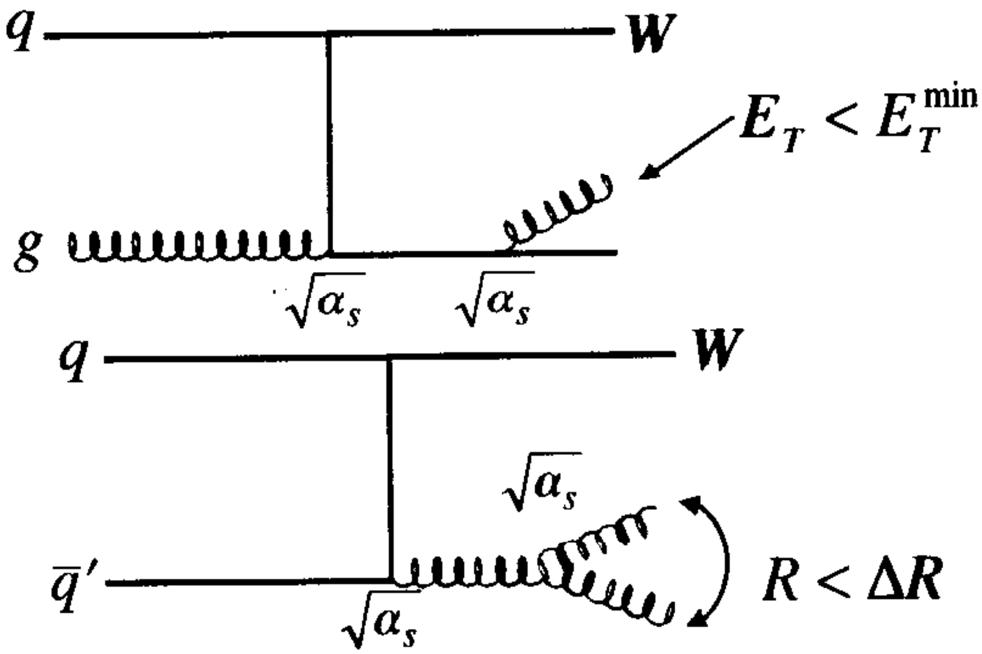
- New W + $\geq$ N Jets cross sections measured at CDF.
- Cross sections are 1.7 times larger than theory ($Q^2 = M_W{}^2 + p_{TW}{}^2$)
- W and Z data exhibit similar jet distributions
- Jet production observables (E_T, M_{jj}, ΔR_{jj}) are well produced by theory (up to a scale factor).
- Herwig parton shower model produces jet E_T spectra which agree with data. Some disagreement of other jet variables.

DØ: R^{10} and NLO

W+0 Jets:



W+1 Jet:

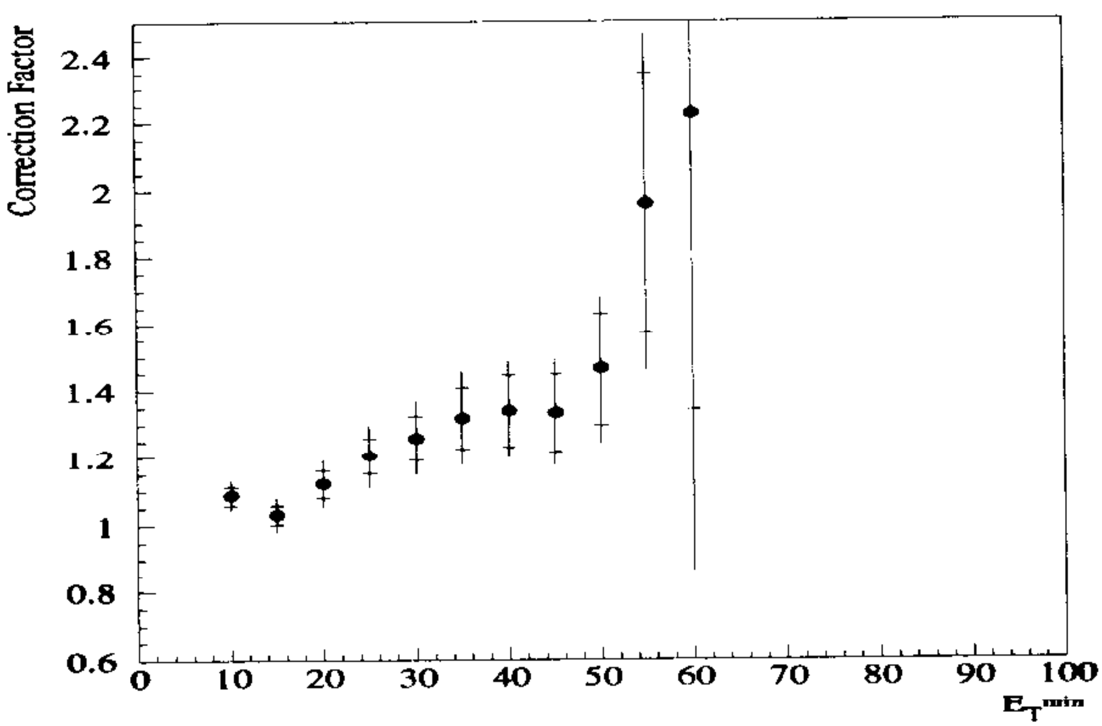


$$\boxed{R^{10} = \frac{\sigma(W + 1Jet)}{\sigma(W + 0Jets)}}$$

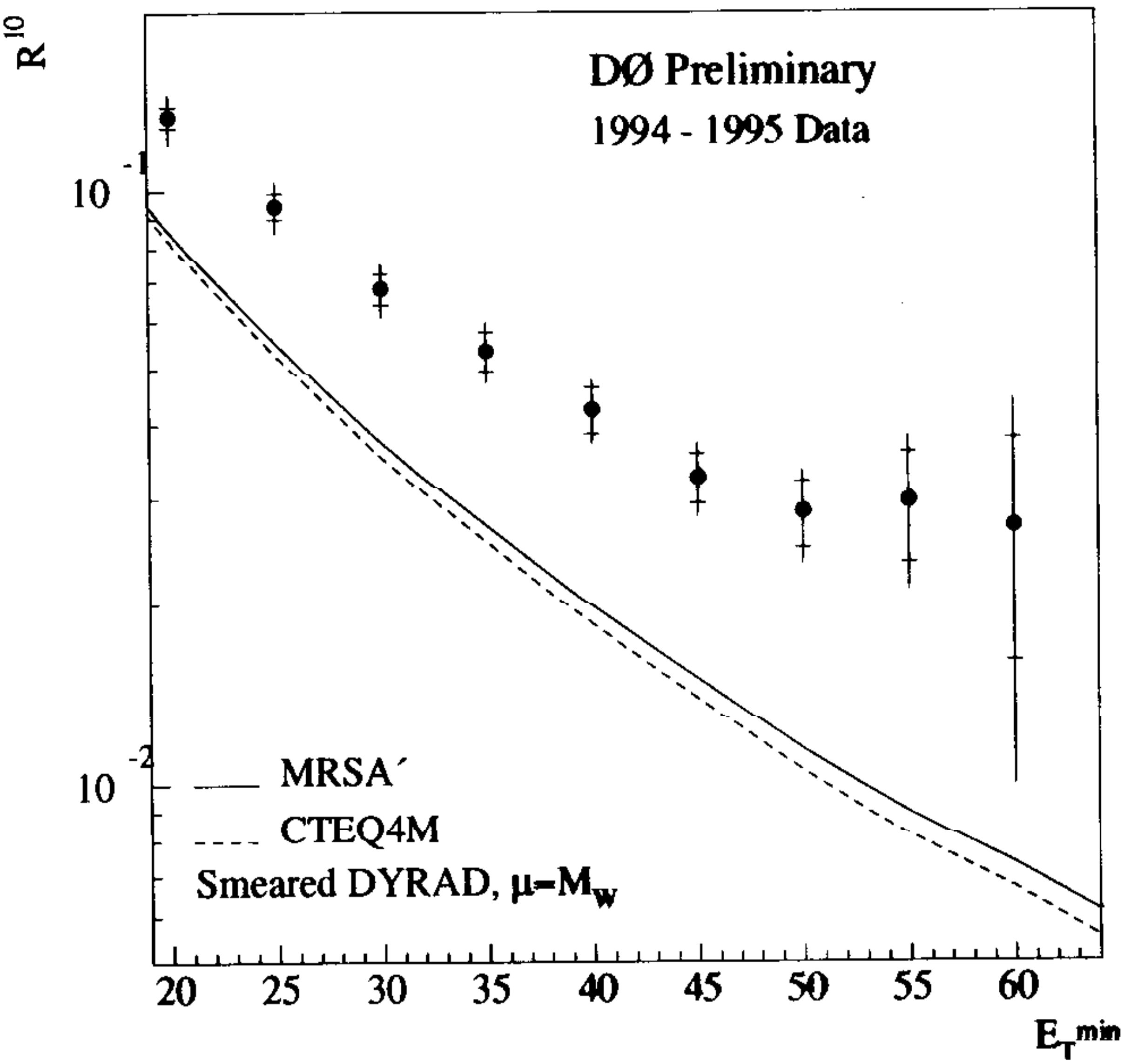
* NLO calculations use the DYRAD Monte Carlo. (Giele, Glover, Kosower, NPB403, 1993)

Data Corrections

* Hadronic energy calibration
  * ±5% error for E_T^{min}=25 GeV
* Electromagnetic energy calibration
* Electron efficiency correction
  * ±5% error for E_T^{min}=25 GeV
  * depends on jet multiplicity and jet E_T
  * trigger and off-line cut efficiencies

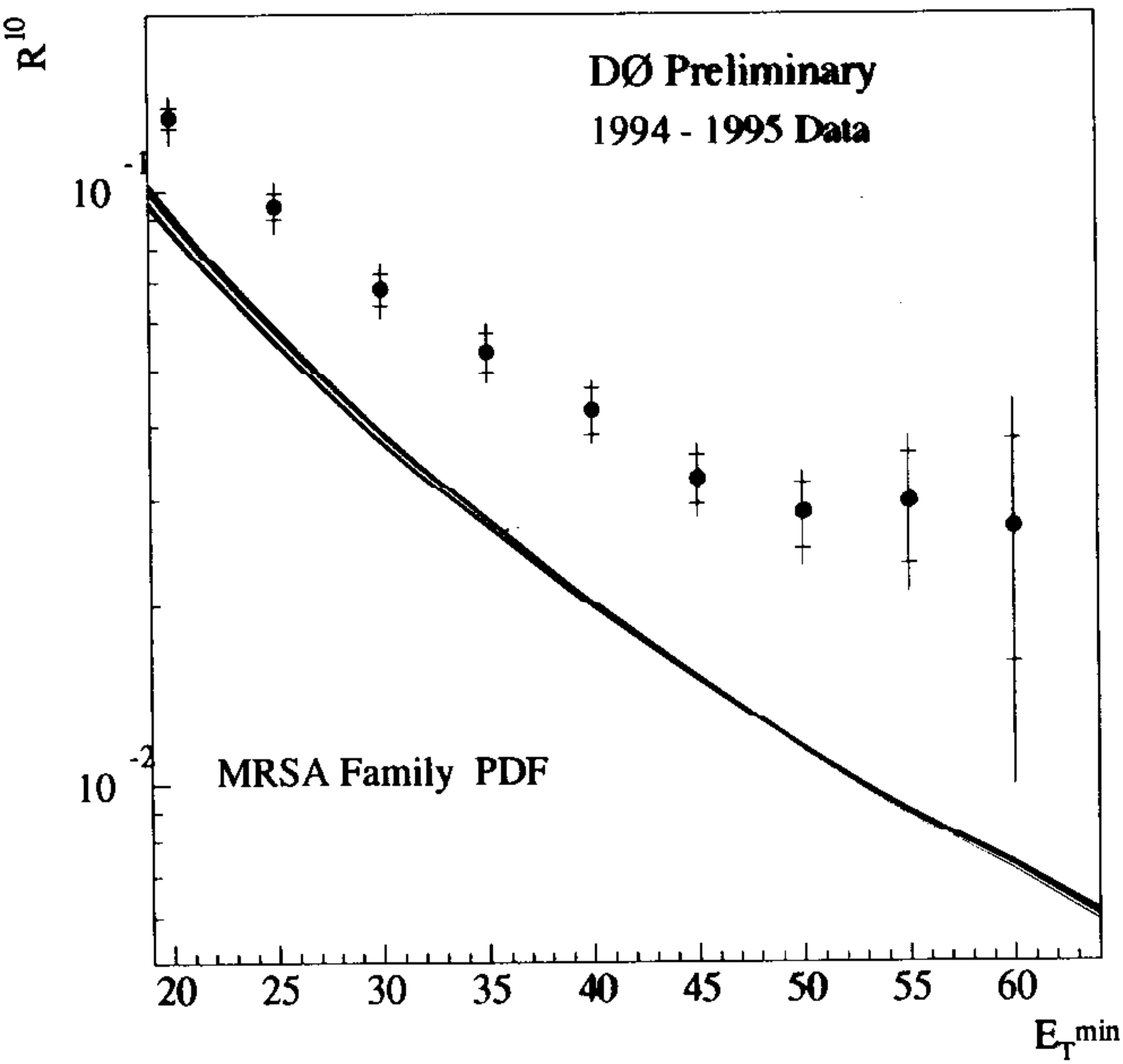


R^{10} vs. E_T^{min}



* inner error is statistical only
* outer error bar is statistical and systematic added in quadrature

R^{10} versus E_T^{min} with MRSA′ Family

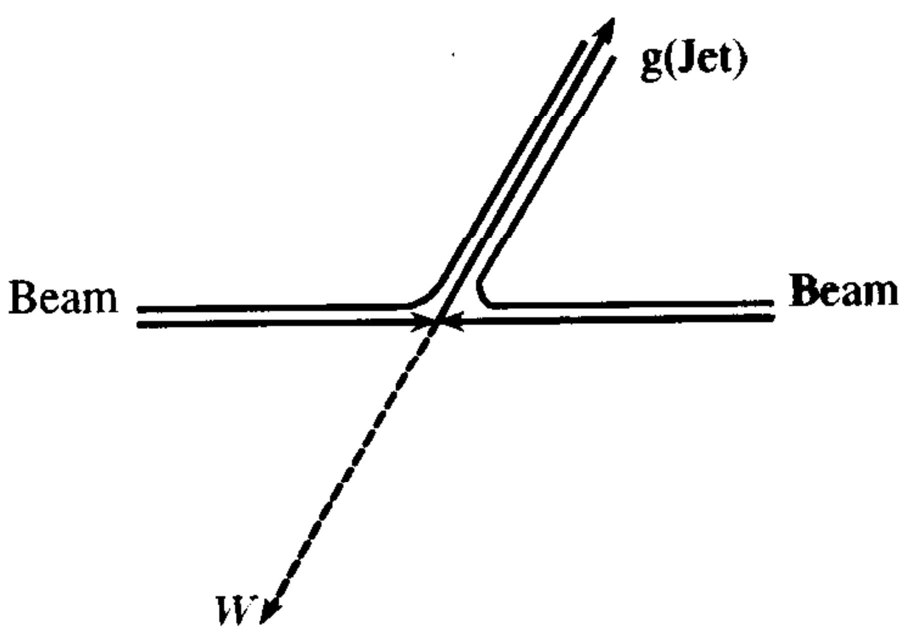


Other Studies for R[10]

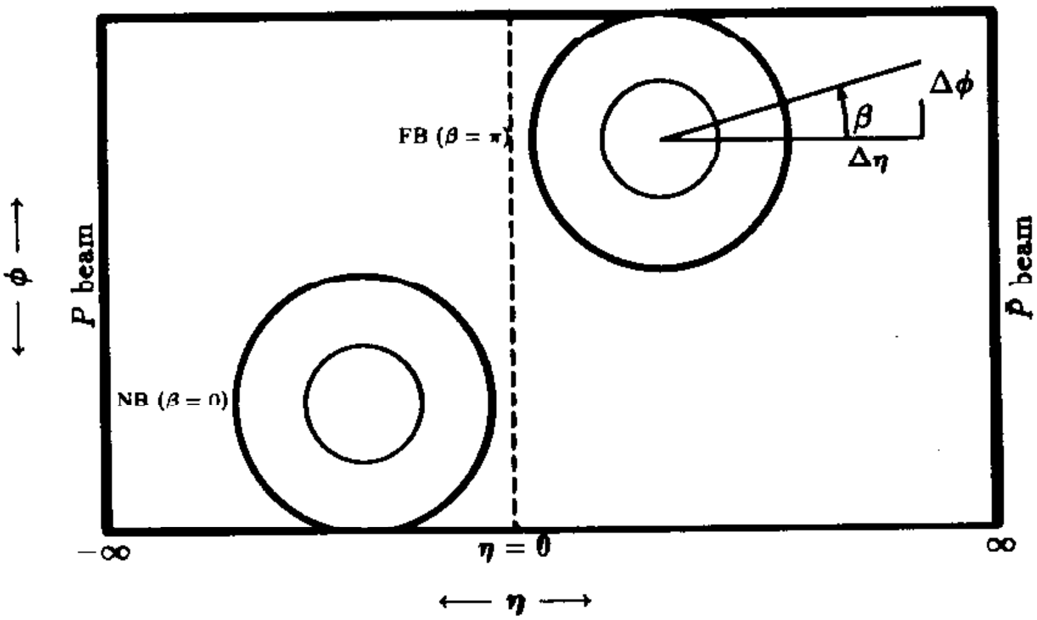
* DYRAD does reproduce the total W cross section measured at DØ.
* DYRAD agrees with the 630 GeV result from UA2.
* UA2 and DØ are at different center of mass energies and therefore are sensitive to different x regions of the PDF's and different mixtures of partons in the proton.
* DYRAD μ–scale has been varied from $M_W/2$ to $2*M_W$ with very little change in the NLO result.

Color Coherence

* Use W+Jets event
* compare pattern of soft particles around the jet and the W (colorless)
* $W \rightarrow e\nu$ events: W does not contribute to particle production



Color Coherence Method

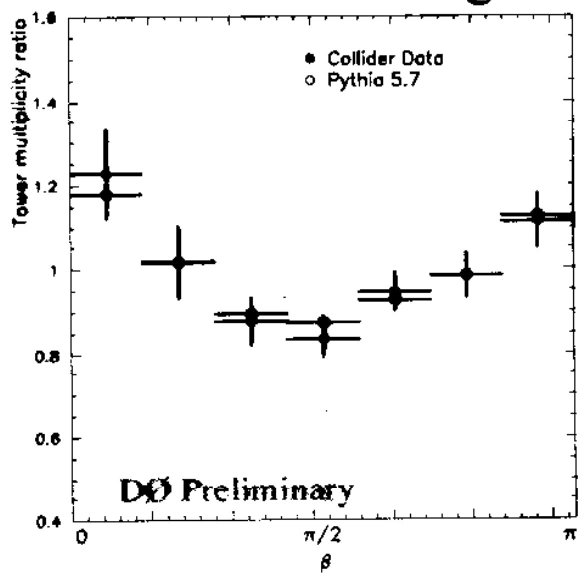


* Count number of towers with E_T>250 MeV in each annular region
* plot $N_{Jet}^{Tower} / N_{W}^{Tower}$ versus β
  * β=0 - "near" beam; β=π - "far" beam
  * $\beta = \arctan(\mathrm{sign}(\eta_{W,jet})\, \Delta\phi/\Delta\eta)$
  * search disk: R^{inner}=0.7, R^{outer}=1.5
* fold about φ axis to improve statistics

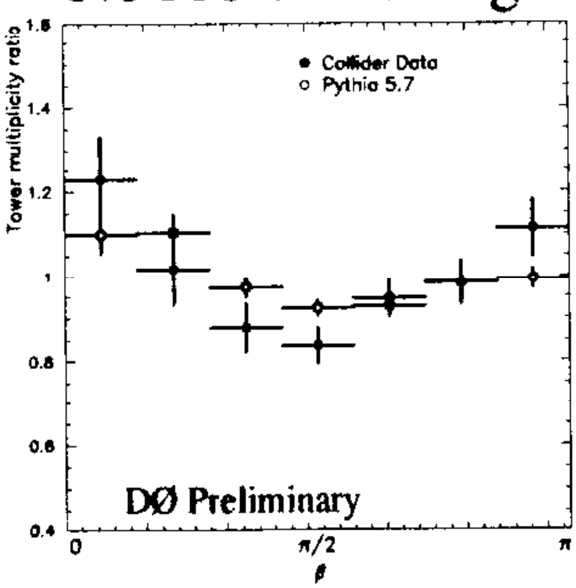
Data Compared to Pythia

* tower multiplicity ratio versus β
* Patterns are normalized to compare shapes

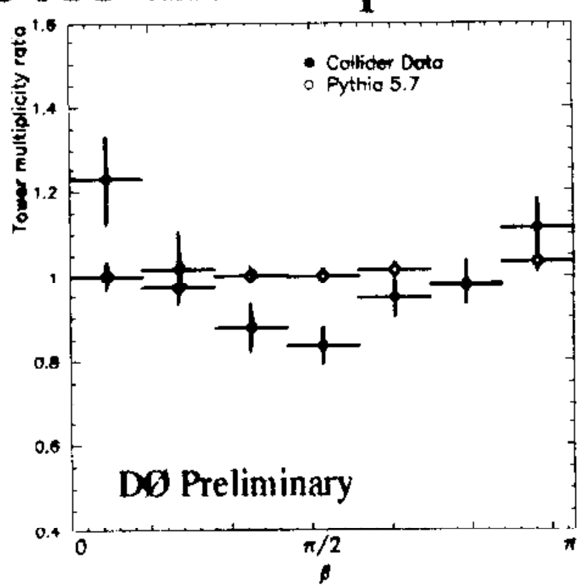
AO and string



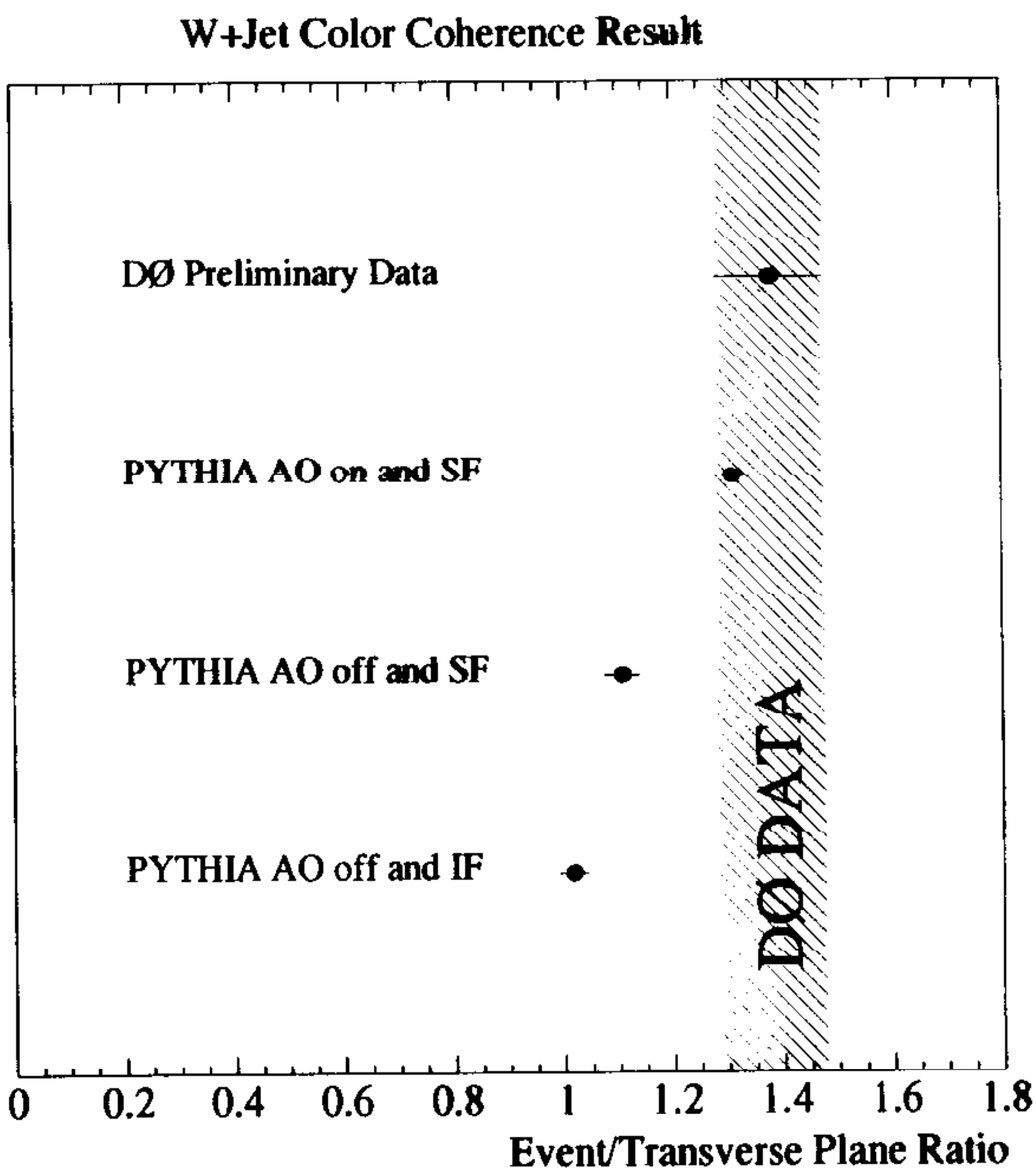
No AO and string



No AO and independent



Comparison to PYTHIA



* average multiplicity ratio at $\beta=0$ and $\beta=\pi$
* divide $\beta=0$ ratio by $\beta=\pi/2$ ratio

Overview

* Properties of jets in W/Z + $\geq$ N Jets events from CDF
  * W + $\geq$ N Jets cross sections measured for N = 1 to 4
  * Comparison of jet E_T, M_{jj}, ΔR_{jj}, distributions to QCD predictions
* Measurement of the ratio (W+1 Jet)/(W+0 Jets) at DØ
* Color Coherence Measurements in W+Jets events at DØ

* All analyses use $W^{\pm} \rightarrow e^{\pm}\nu$ events

Parameters by Experiment

Parameter	CDF	DØ
electron E_T	20 GeV	25 GeV
missing E_T	30 GeV	25 GeV
Jet cone	0.4	0.7
Jet E_T	15 GeV	20 GeV (R^{10}) 10 GeV (CC)
Monte Carlo	LO (VECBOS) + gluon shower	NLO (Dyrad) (Pythia)