DIJET ANGULAR DISTRIBUTIONS

Motivation

$\frac{1}{N}\frac{dN}{d\chi}$ $vs.$ χ **for different M_{jj} mass bins**

$$M_{jj}^2 = 2E_{T1}E_{T2}\left(cosh(\eta_1-\eta_2) - cos(\varphi_1-\varphi_2)\right)$$

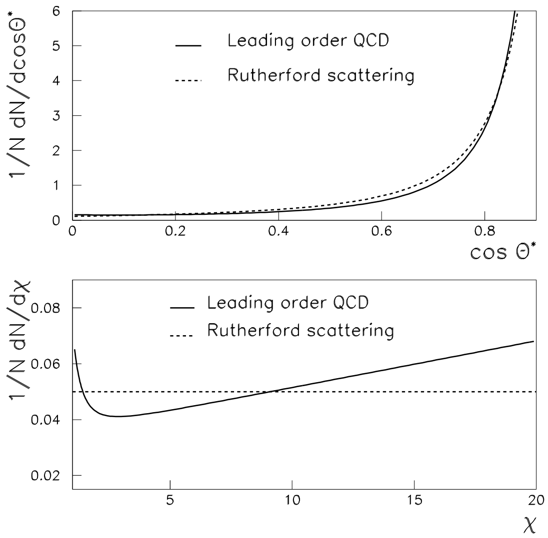
Other useful variables:

$\eta^* = \frac{1}{2}(\eta_1 - \eta_2) \Leftarrow \eta$ **of the CM system**

$\eta_{boost} = \frac{1}{2}(\eta_1 + \eta_2) \Leftarrow$ **Lab frame to CM frame**

$$\chi = e^{2|\eta|^*} = \frac{1+cos(\theta^*)}{1-cos(\theta^*)}$$

χ flattens out the angular distribution and facilitates comparison with theory

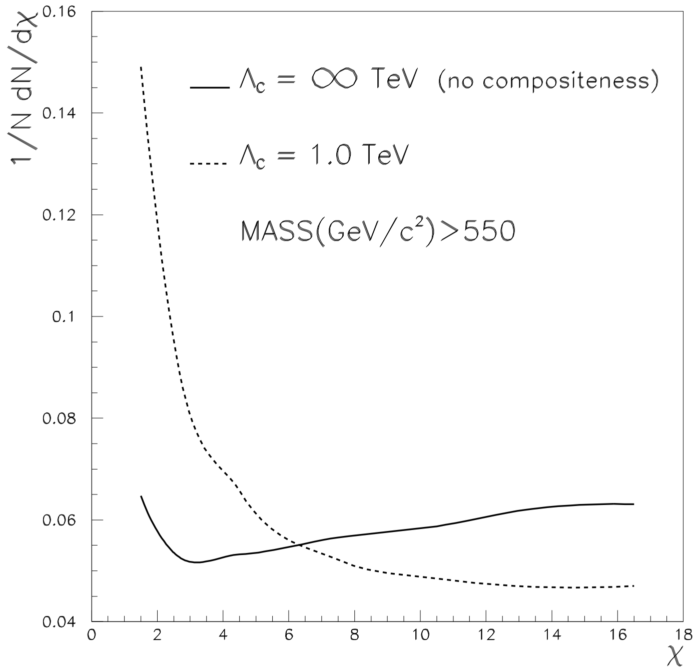


Direct test of QCD, since $dN/d\chi$ is insensitive to parton distribution functions

- **Shape of the angular distributions unaffected by boost of the system**

- **gg $\rightarrow$ gg, gq $\rightarrow$ gq, qq $\rightarrow$ qq produce similar angular distribution**

$dN/d\chi$ is sensitive to contact interactions introduced by compositeness models



Sample Selection

- **Fixed cone algorithm with a 0.7 cone size**
- **Events with two or more jets are selected**
- **Same jet triggers and cuts used in the inclusive jet analysis**

Large rapidity range: $|\eta| < 3$ and χ up to 20

Systematic Errors

- **Quality cuts and efficiency corrections**
- **Misvertexing in multiple $p\overline{p}$ interactions**
- **Biases in η like splitting–merging and other algorithm effects**
- **η dependence of the jet energy scale correction**
- **Jet energy resolution**

Each source contribute an average $1 - 2\%$ on the angular distribution

Limit on Quark Compositeness

- **We define:**

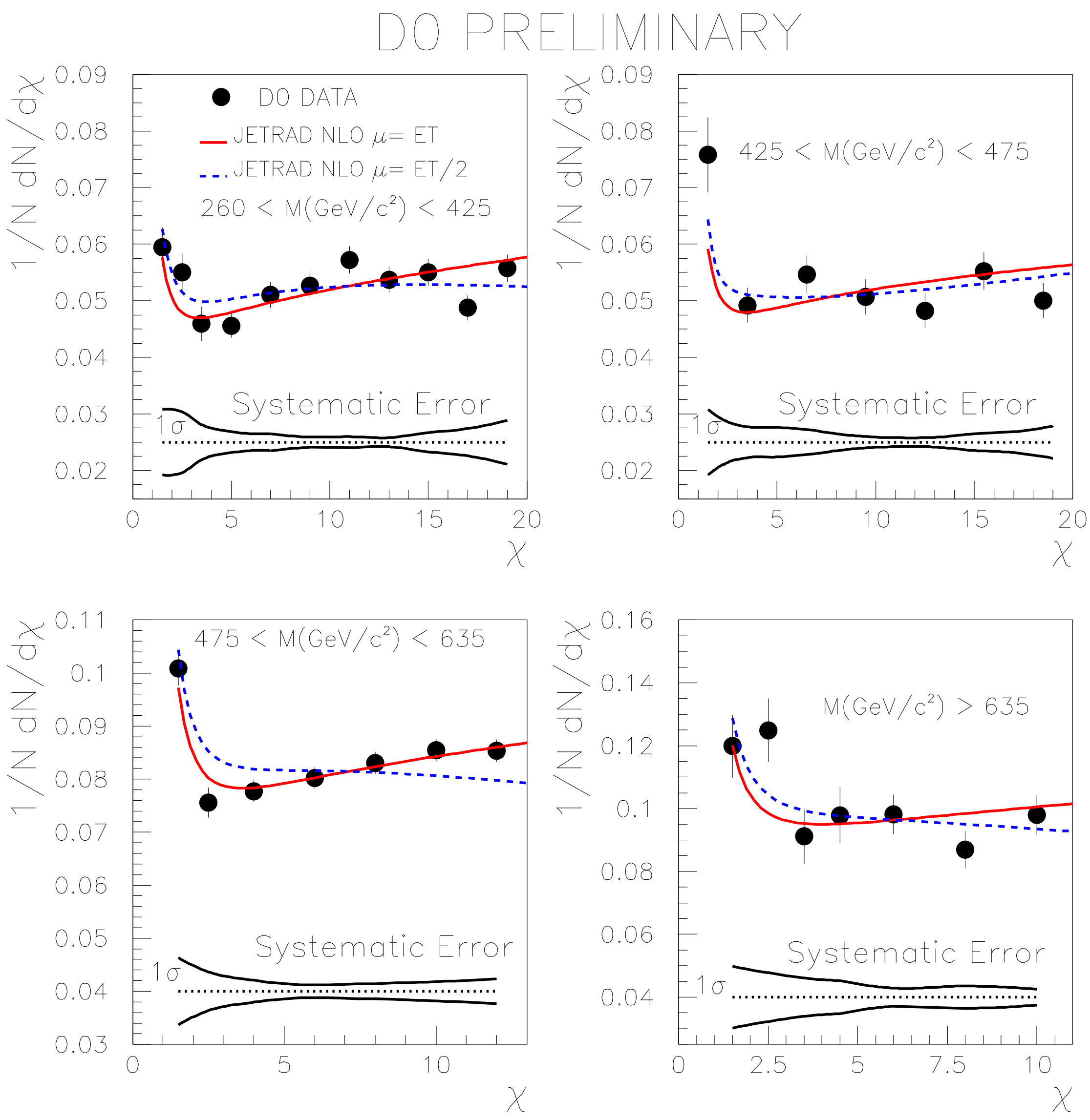
$$R_\chi = \frac{\#\, of\ events\ \chi < 4}{\#\, of\ events\ \chi > 4}$$

R_χ vs M_{jj} removes correlations and reduces the curve to a single number.

- **Apply the BAYESIAN method to compare the measured R_χ vs M_{jj} with theory.**

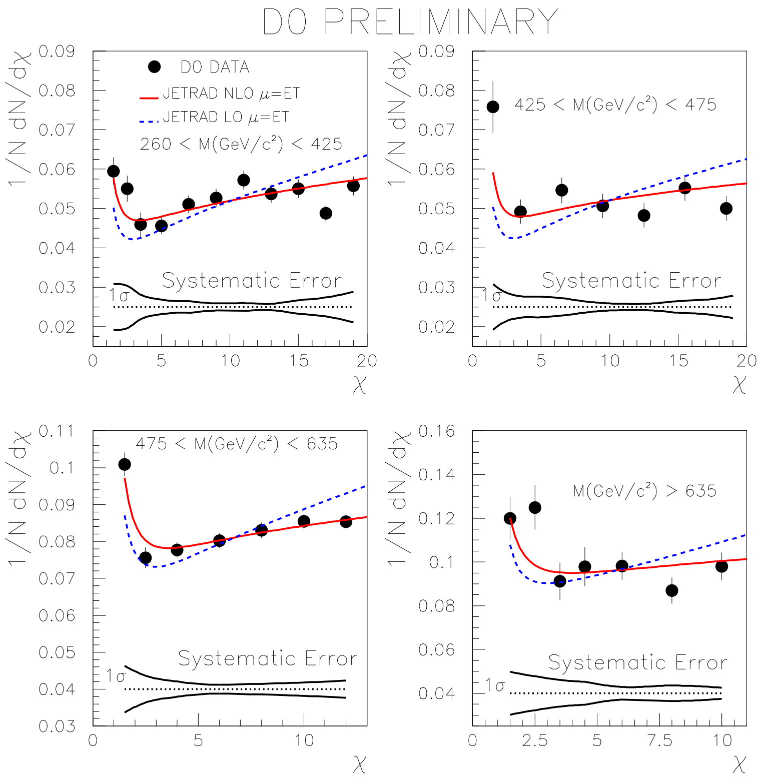
μ	**Prior Dist.**	**Limit on Λ_c**
$E_T/2$	$1/\Lambda^2$	2.2
E_T	$1/\Lambda^2$	2.
$2E_T$	$1/\Lambda^2$	1.9
$E_T/2$	$1/\Lambda$	2.4
$E_T/2$	$1/\Lambda^4$	2.0

Dijet Angular Distributions (μ scale comparison)



Dijet Angular Distributions (NLO and LO comparison)

$$\chi = e^{2|\eta|\star} = \frac{1+\cos\theta^\star}{1-\cos\theta^\star}$$

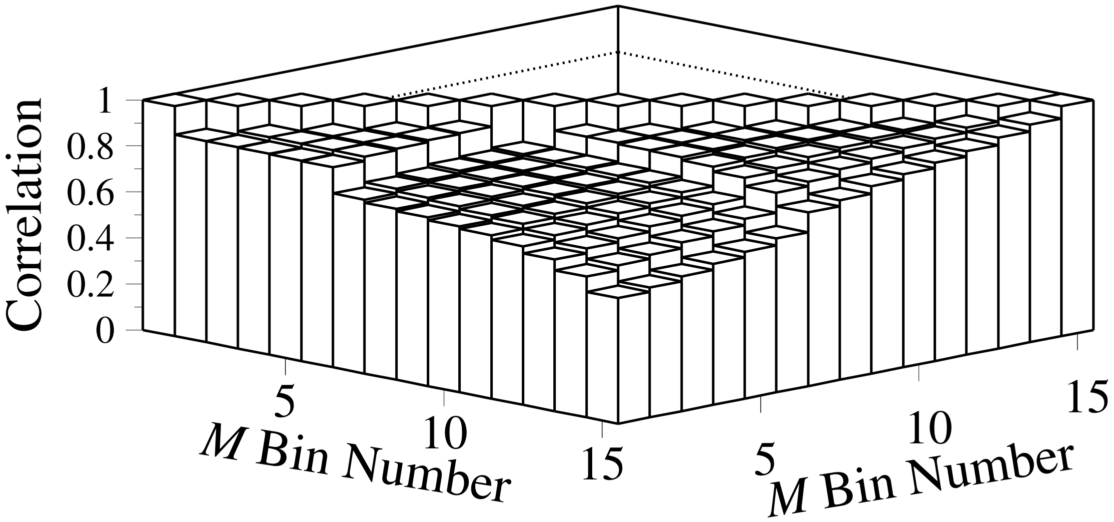


→ use χ because it flattens out angular distribution & facilitates comparison with theory

→ $dN/d\chi$ is insensitive to *pdf* choice
- shape is unaffected by boost of system

→ $dN/d\chi$ sensitive to contact interactions introduced by compositeness models

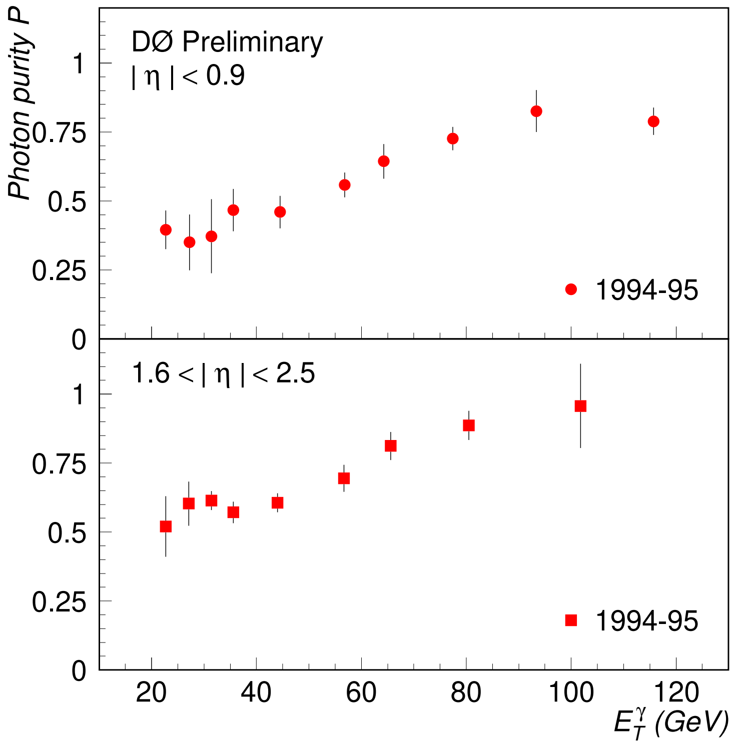
Limit on Compositeness: $\Lambda_c > 1.9$ TeV


Correlation
1
0.8
0.6
0.4
0.2
0
5
10
15
M Bin Number
5
10
15
M Bin Number

New DØ Measurement of the Direct Photon Cross Section

$95\ \mathrm{pb}^{-1}$ from 1994–95 run

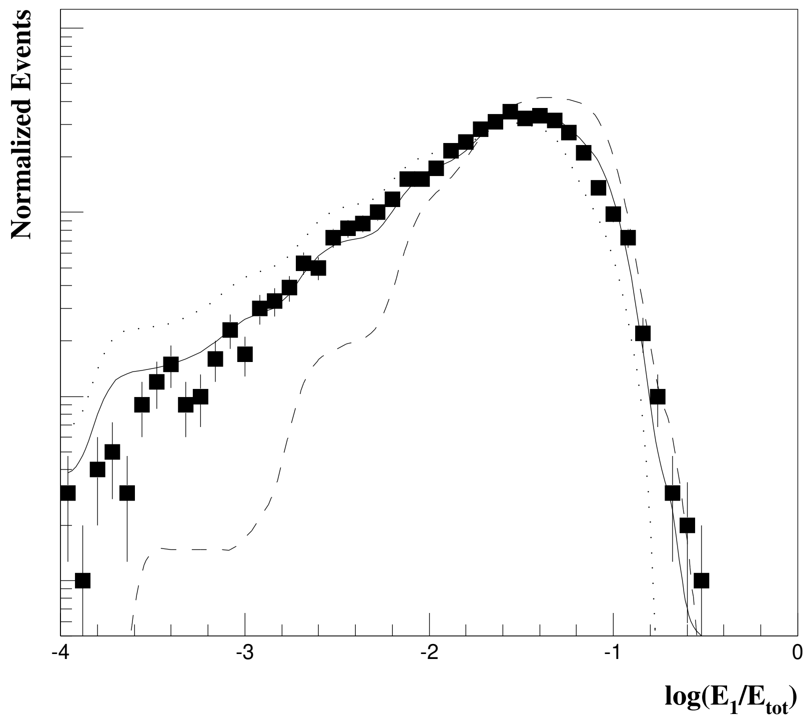
Photons are identified as isolated EM clusters in the calorimeter ($E_T < 2$ GeV in $R = 0.4$)



Fraction of true photons in the candidate sample is estimated using the energy deposited in the first $2X_0$ of the calorimeter: fit to `PYTHIA+GEANT` γ and jet samples.

Determination of the Photon Purity

Fraction of true photons in the candidate sample is estimated using the energy deposited in the first $2X_0$ of the calorimeter: fit to `PYTHIA+GEANT` γ (dotted line) and jets (dashed line).



Example fit for $33 < E_T^\gamma < 39$ GeV, $1.6 < |\eta^\gamma| < 2.5$.

Purity $= 0.57 \pm 0.04$.

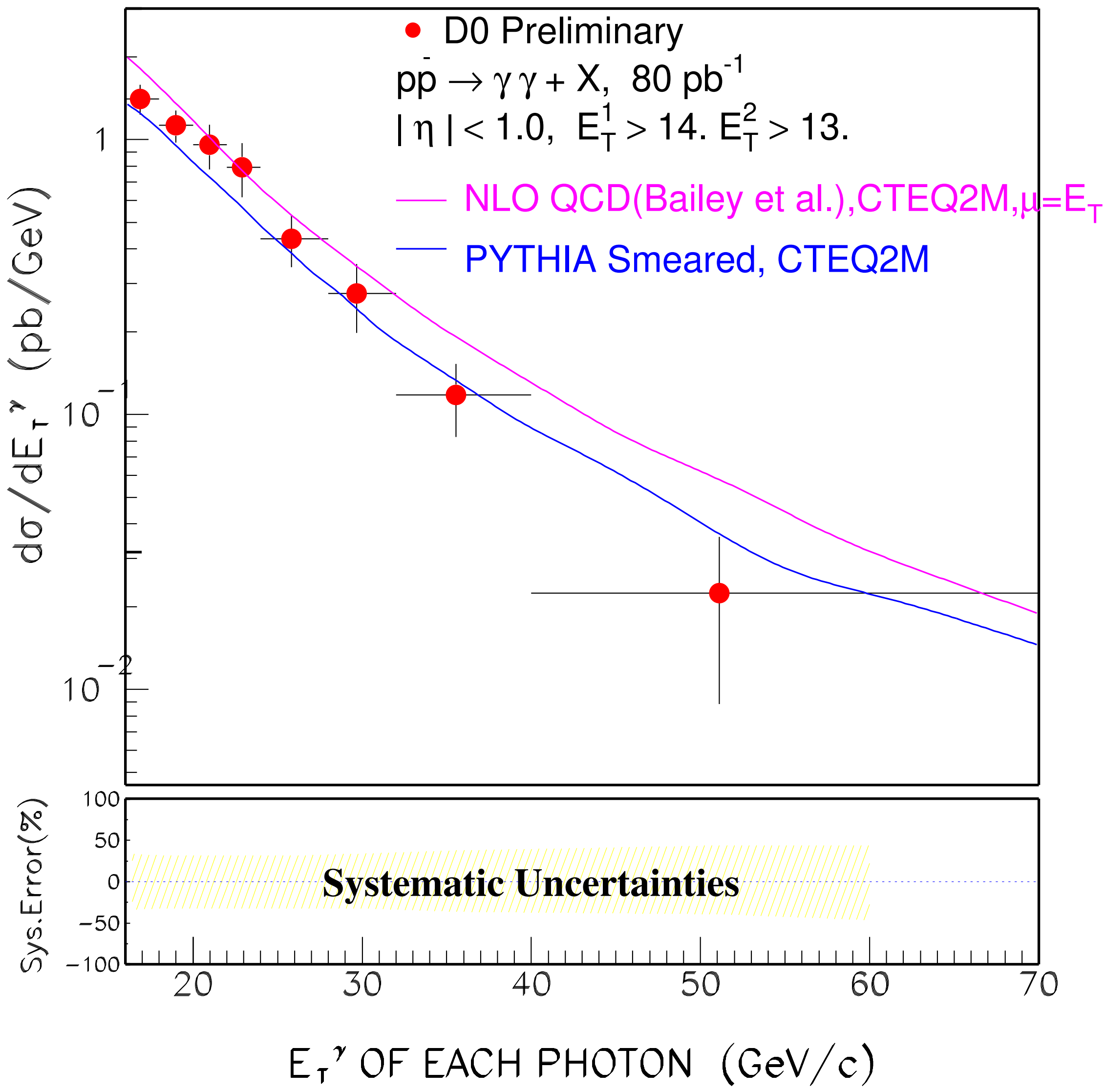
Comparison with Previous Measurements

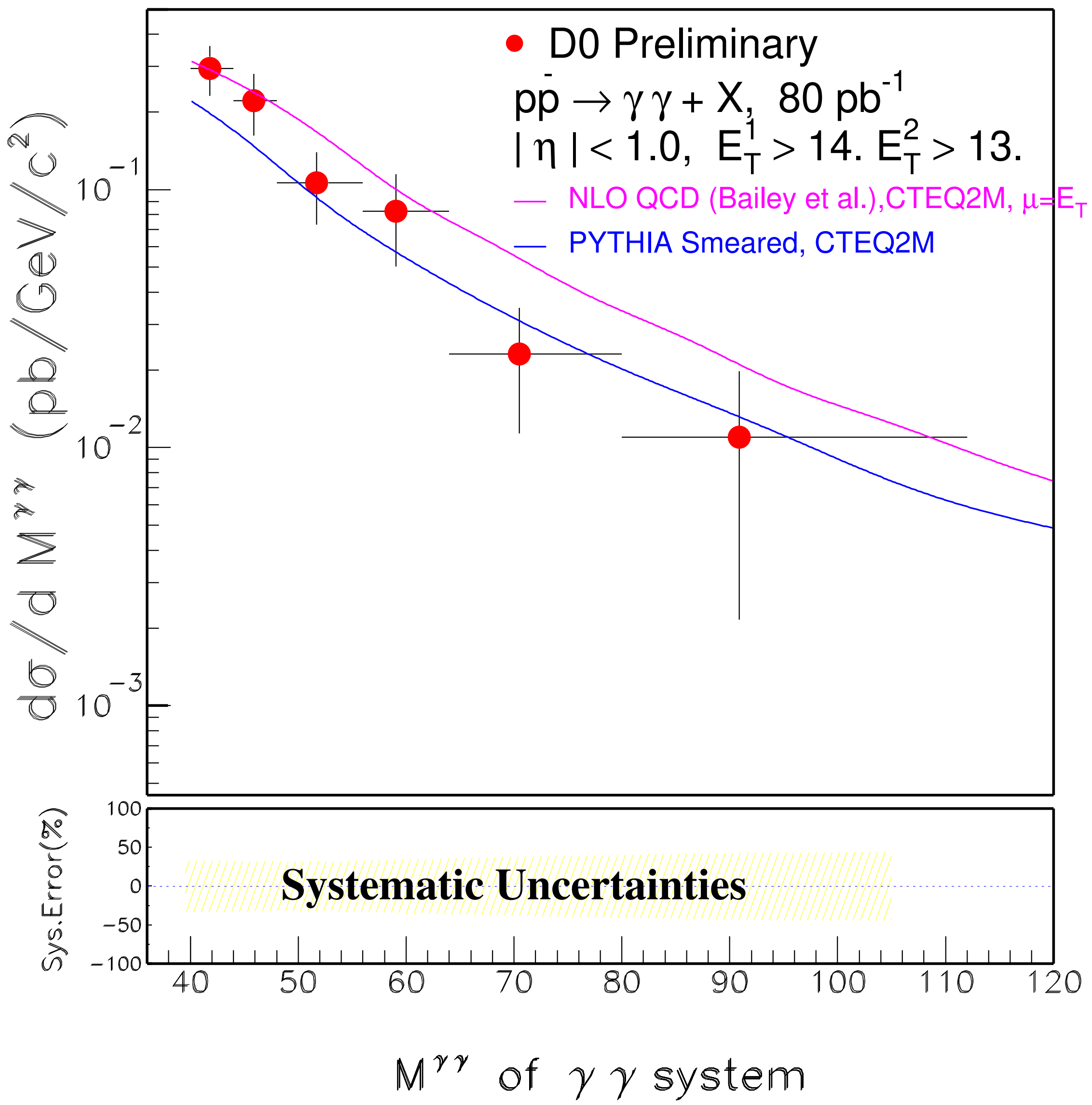
This new measurement is $\sim$ 25% (40%) higher than our published cross section from the 1992–93 data in central (forward) regions. [PRL 77 (1996) 5011]

- improved background modeling (PYTHIA jets in place of single π^0 and η mesons
- recalibrated calorimeter response
- improved acceptance estimate (calorimeter cracks)

Older data agrees with the new cross section if analyzed in a consistent manner.

When the new results are published we will include a reanalysis of the older data.


D0 Preliminary
$p\bar{p} \rightarrow \gamma\gamma + X$, 80 pb^{-1}
$|\eta| < 1.0$, $E_T^1 > 14.$ $E_T^2 > 13.$
NLO QCD(Bailey et al.),CTEQ2M,μ=E_T
PYTHIA Smeared, CTEQ2M
$d\sigma/dE_T^\gamma$ (pb/GeV)
Systematic Uncertainties
Sys.Error(%)
E_T^γ OF EACH PHOTON (GeV/c)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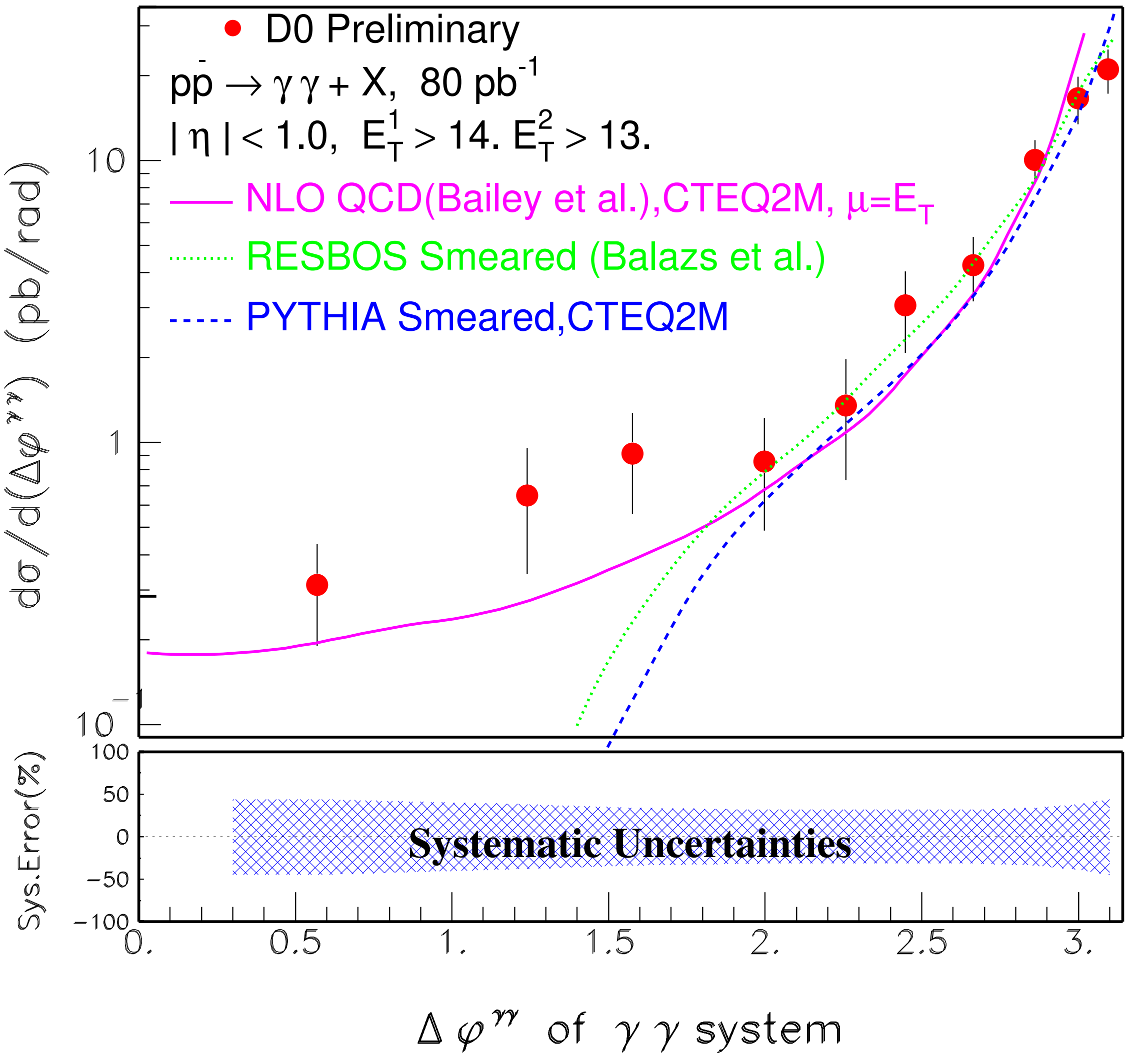
NLO QCD (Bailey et al.),CTEQ2M, $\mu=E_T$
PYTHIA Smeared, CTEQ2M
$d\sigma/dM^{\gamma\gamma}$ $(pb/GeV/c^2)$
Systematic Uncertainties
Sys.Error(%)
$M^{\gamma\gamma}$ of $\gamma\gamma$ system


D0 Preliminary
$p\bar{p} \rightarrow \gamma\gamma + X$, 80 pb^{-1}
$|\eta| < 1.0$, $E_T^1 > 14.$ $E_T^2 > 13.$
NLO QCD(Bailey et al.),CTEQ2M, $\mu = E_T$
RESBOS Smeared (Balazs et al.)
PYTHIA Smeared,CTEQ2M
$d\sigma/d(\Delta\varphi^{\gamma\gamma})$ (pb/rad)
10
1
10^{-1}
Sys.Error(%)
100
50
0
-50
-100
Systematic Uncertainties
0.
0.5
1.
1.5
2.
2.5
3.
$\Delta\varphi^{\gamma\gamma}$ of $\gamma\gamma$ system

Color Coherence

In QCD: Interference of soft gluon radiation emitted along color connected partons.

Intrajet Coherence

- Angular Ordering of sequential branchings in a partonic cascade
- *Hump-backed* shape of particle spectra

Interjet Coherence

String or Drag effect in multijet hadronic events

Shower Development

"Traditional Approach"

- Shower develops according to pQCD into jets of partons until a scale of Q_0 ~ 1 GeV.
- Thereafter, non-perturbative processes take over and produce the final state hadrons

"Local Parton Hadron Duality (LPHD) Approach"

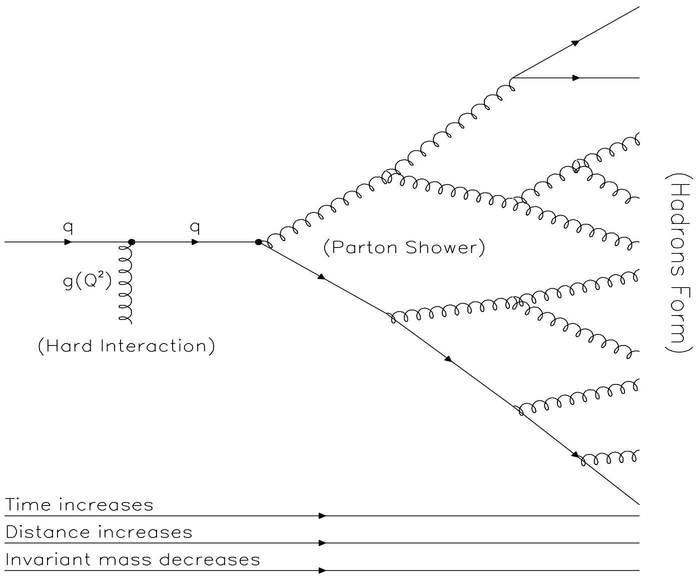
- Parton cascade is evolved further down to a scale of about Q_0 ~ 250 MeV.

33

- No hadronization process.

  Hadron spectra = Parton spectra

- Simplicity. Only two essential parameters (Λ_{QCD} and Q_0) and an overall normalization factor

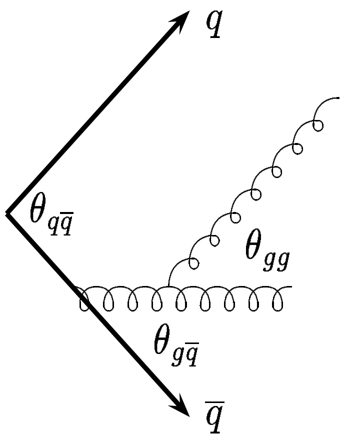


Intrajet Coherence

- Color Coherence (CC) effects in partonic cascades

- Angular Ordering Approximation

uniform *decrease* of successive emission angles of soft gluons as partonic cascade evolves away from the hard process



$$\theta_{gg} < \theta_{g\bar{q}} < \theta_{q\bar{q}}$$

Intrajet Coherence

Theoretical Framework:

- Analytic Approach:

PQCD + LPHD → **DLA, MLLA...**

LPHD → at low evolution scales the hadronic distributions are expected to be proportional to the partonic ones

PQCD → Resummed analytical calculations (DLA, MLLA) incorporate leading coherence effects

- MC Approach:

Perturbative: Include CC effects probabilistically by means of AO for both initial and final state evolutions

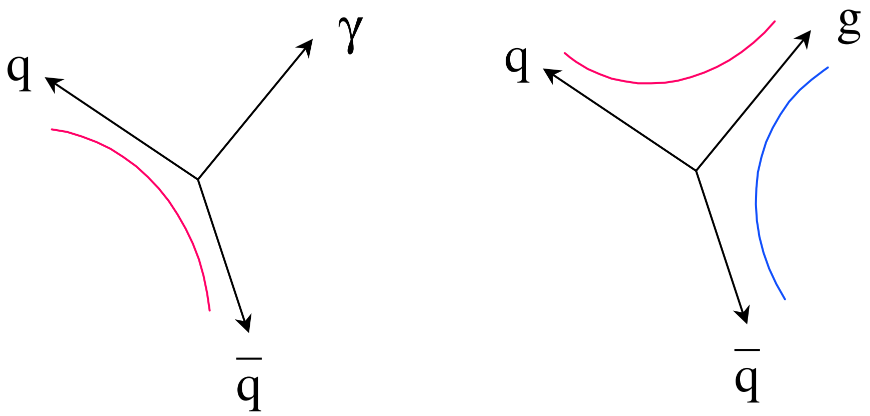
Non-Perturbative: Use phenomenological models to simulate the non-perturbative hadronization stage, e.g. the LUND string model or the cluster fragmentation model.

Interjet Coherence

- **Interjet coherence deals with the angular structure of particle flow when three or more partons are involved**

- **e^+e^- interactions:**

First observations of final state color coherence effects in the early '80's (**"string"** or **"drag"** effect)



$e^+e^- \rightarrow q\,\bar{q}\,\gamma$ $e^+e^- \rightarrow q\,\bar{q}\,g$

Depletion of particle flow in region between q and $\bar{q}$ jets relative to that between q and g jets.

Recent Results

Intrajer Coherence

☞ Hump-backed plateau

☞ Invariant charged hadron energy spectrum

☞ Angular multiplicity fluctuations in hadronic Z decays (L3 Analysis - CERN-EP/98-23) - not shown -

Interjer Coherence

☞ Multijets

☞ Particle flow in W+Jets events

☞ Color reconnection effects in $e^+e^- \rightarrow q\bar{q}g$ events

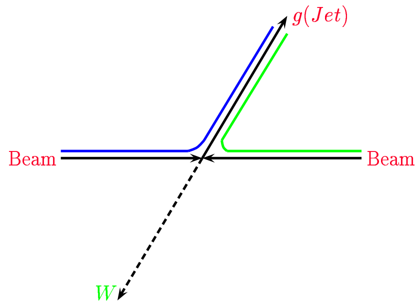
- Experimental issues:

★ Can Color Coherence effects survive hadronization process?

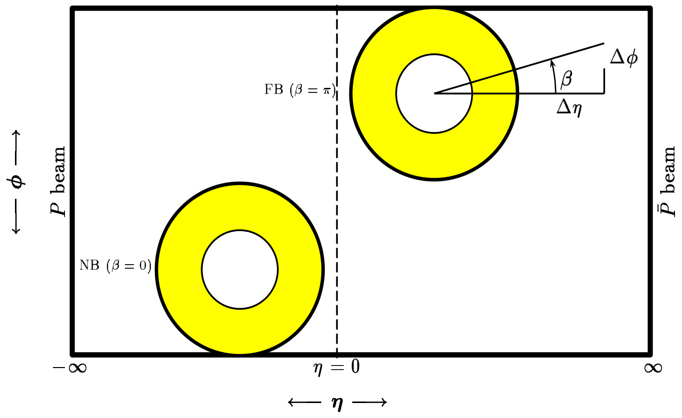
★ What is relative importance of perturbative vs. non-perturbative contributions?

W+Jet Analysis

Compare pattern of soft particle flow around jet to that around (colorless) *W*



Calorimeter view:



- In each annular region, measure number of calorimeter towers (~ particles) with $E_T > 250$ MeV
- Plot $N^{TWR}{}_{JET} / N^{TWR}{}_{W}$ vs. β
- Annuli "folded" about ϕ symmetry axis

  β range: $0 \rightarrow \pi$ (to improve statistics)

  $\beta = 0 \rightarrow$ "near beam", $\beta = \pi \rightarrow$ "far beam"

Search disks: R(*inner*)=0.7, R(*outer*)=1.5

$$\beta = \arctan(\mathrm{sign}(\eta_{W,Jet})\, \Delta\phi / \Delta\eta)$$

W + Jet - Monte Carlo Samples

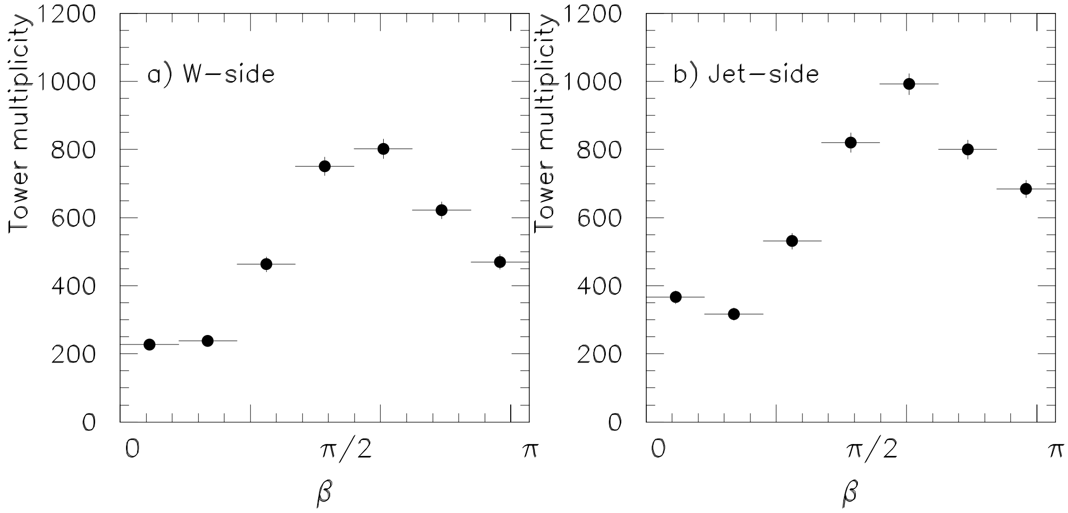
- **PYTHIA v5.7 Monte Carlo**
  - Full detector simulation
  - Mimic noise by overlaying pedestal data
  - 3 samples with different color coherence:

"Full coherence":	AO + String Fragmentation
"Partial":	No AO + String Fragmentation
"No coherence":	No AO + Independent Frag.

- **Analytic Predictions by Khoze and Stirling**
  - MLLA + LPHD
  - $q\bar{q}$–>Wg and qg–>Wq processes
  - hep-ph/9612351

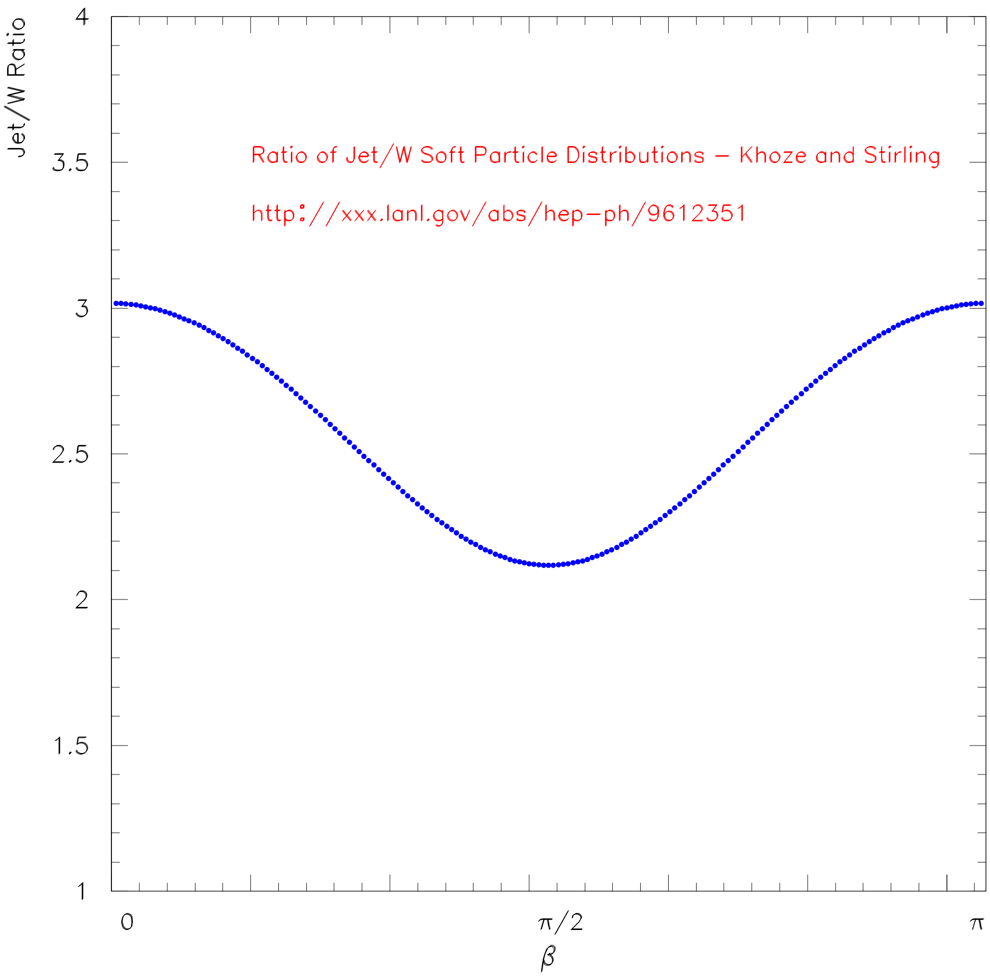
W+Jet Results

D0 Preliminary



Number of towers (E_T > 250 MeV)

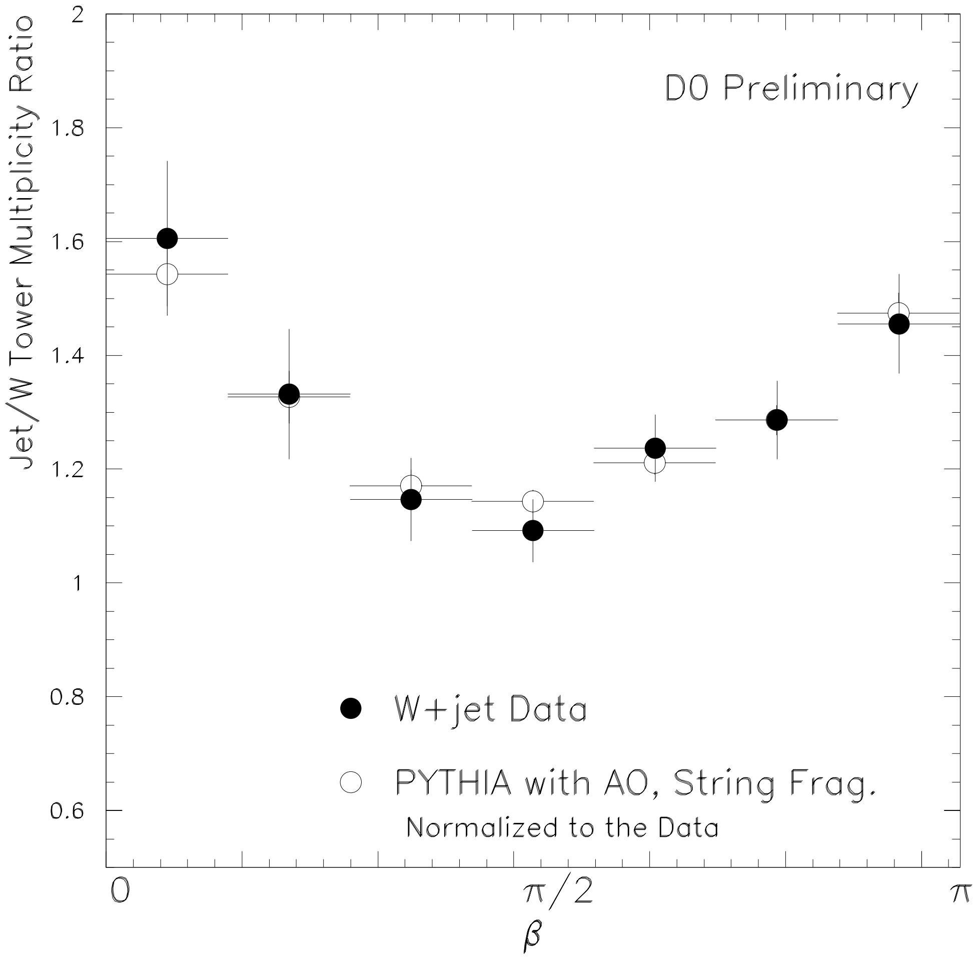
MLLA+LPHD Predictions



W + Jet - D0 Preliminary Results

Comparison to Pythia (Sample I, full coherence)

Angular ordering + String fragmentation

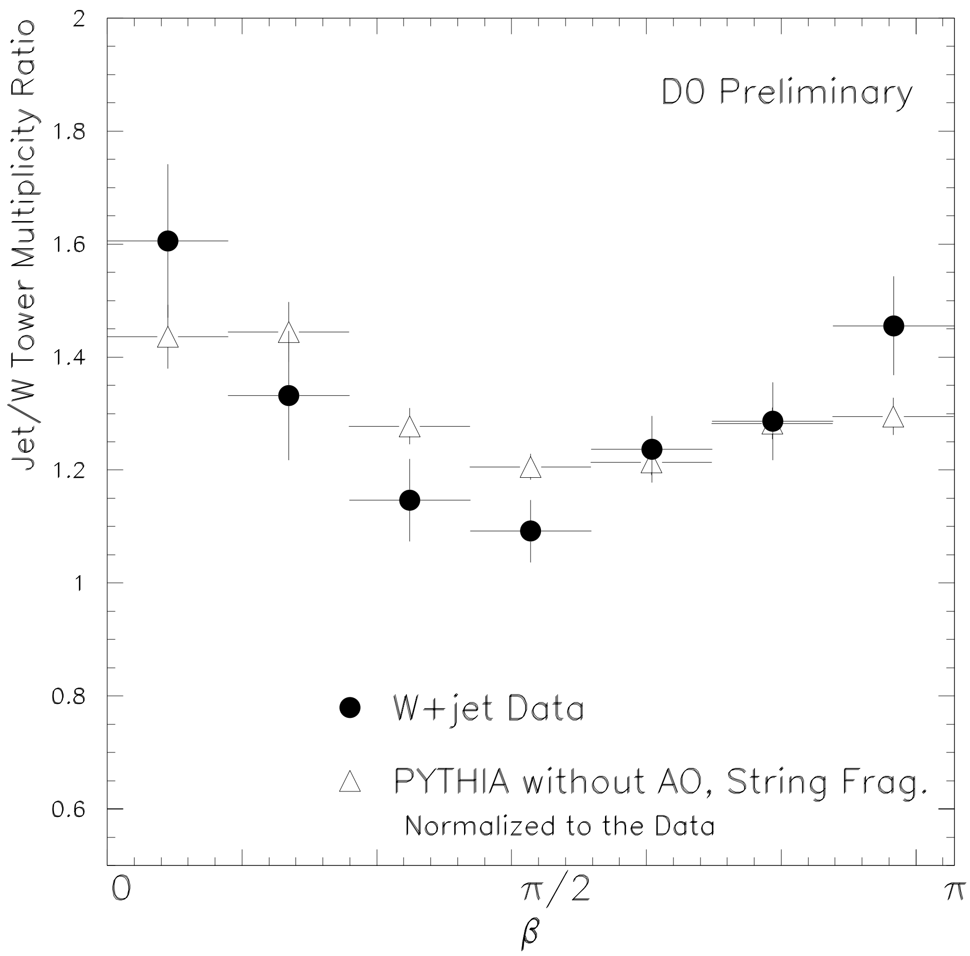


Monte Carlo normalized to data.

W + Jet - D0 Preliminary Results

Comparison to Pythia (Sample II, partial coherence)

NO angular ordering + String fragmentation

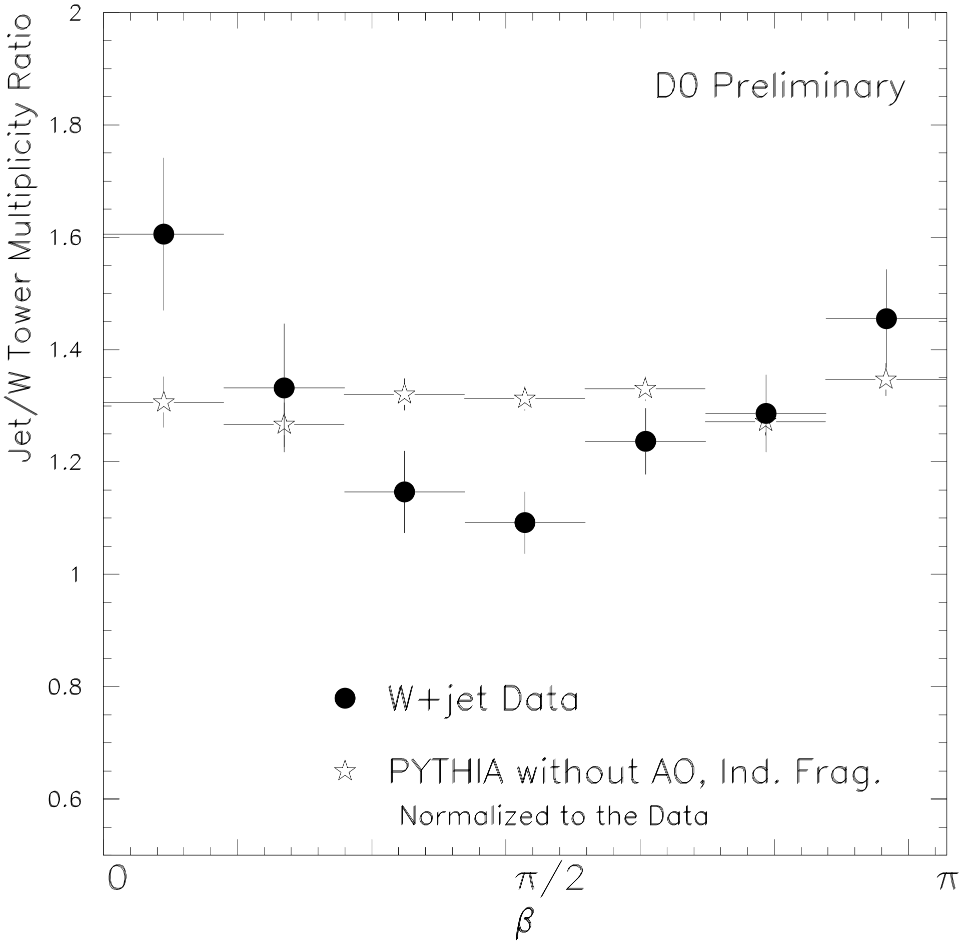


Monte Carlo normalized to data.

W + Jet - D0 Preliminary Results

Comparison to Pythia (Sample III, No coherence)

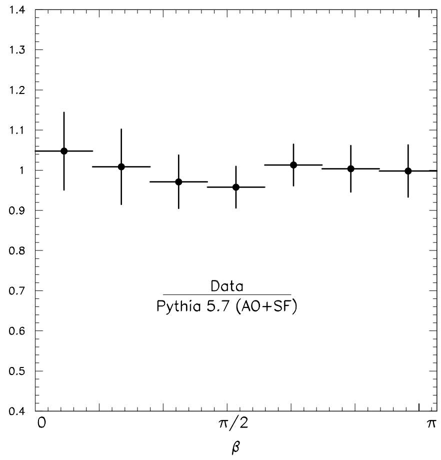
NO angular ordering + Independent fragmentation



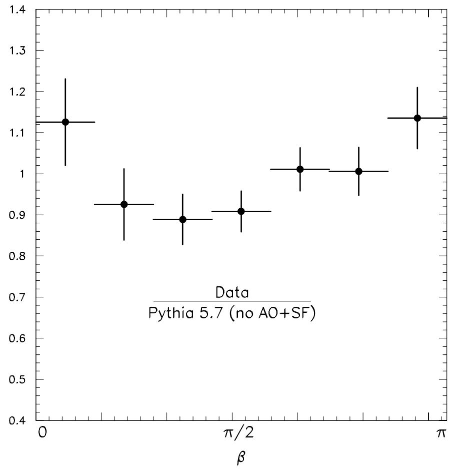
Monte Carlo normalized to data.

W + Jet - D0 Preliminary Results

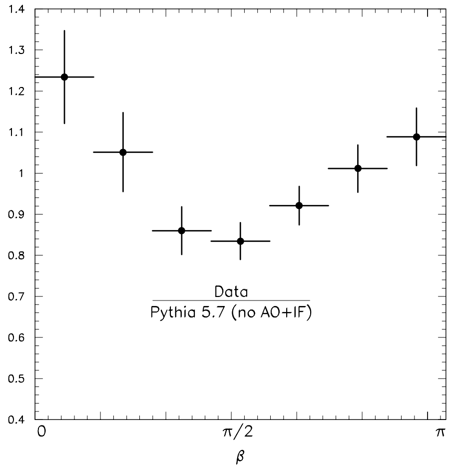
Data / PYTHIA ratios



AO + SF



~~AO~~ + SF



~~AO~~ + IF

Jet Shape Analysis
Test of QCD

- jet shape due to:
  - -- gluon radiation
  - -- fragmentation
- measure E_T flow in jets as a function of distance $R = (\Delta\eta^2 + \Delta\phi^2)^{1/2}$ from jet axis
- measure dependence of jet shape on E_T (D0 & CDF) and η (D0) of jets
- compare data to QCD predictions:
  - -- leading log shower Monte Carlo - HERWIG
  - -- NLO calculations
    - > parton level - no fragmentation
    - > 1 gluon radiating gives shape to jet
    - > first order prediction that jet shape can be calculated

D0 Jet Shape

Central vs Forward