Recent Dijet Measurements at DØ

Don Lincoln

Fermi National Accelerator Laboratory

for the DØ *Collaboration*

(in lieu of Mandy Rominsky or Nirmalya Parua)

DPF 2009

2009 Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2009)

26-31 JULY 2009

Wayne State University, Detroit, MI

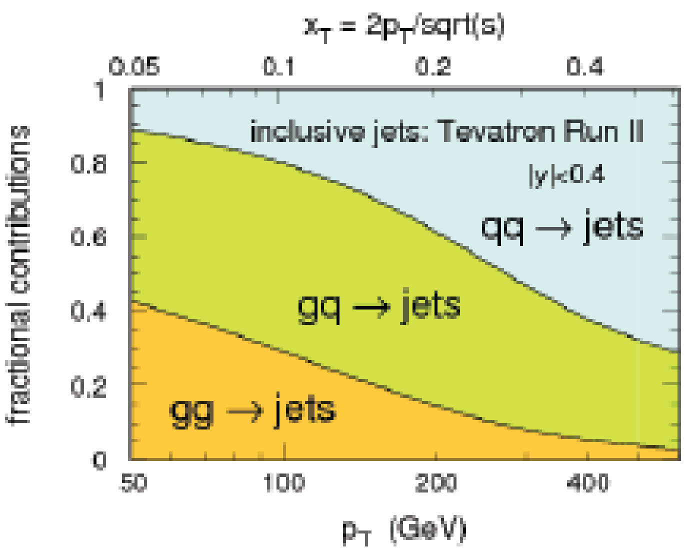
High PT Jet Physics

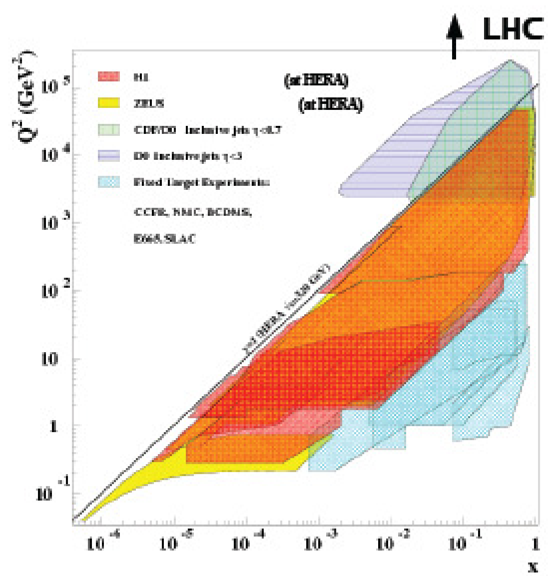
Jet production at a hadron collider is sensitive to:

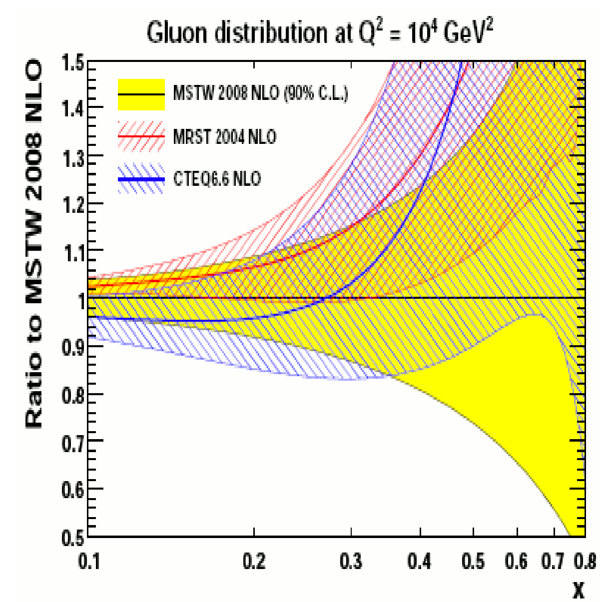
- Dynamics of interaction (QCD or "New Physics"?)
- Proton structure (PDFs)

Before we can use Tevatron jet data in PDF fits based on QCD matrix elements, we need:

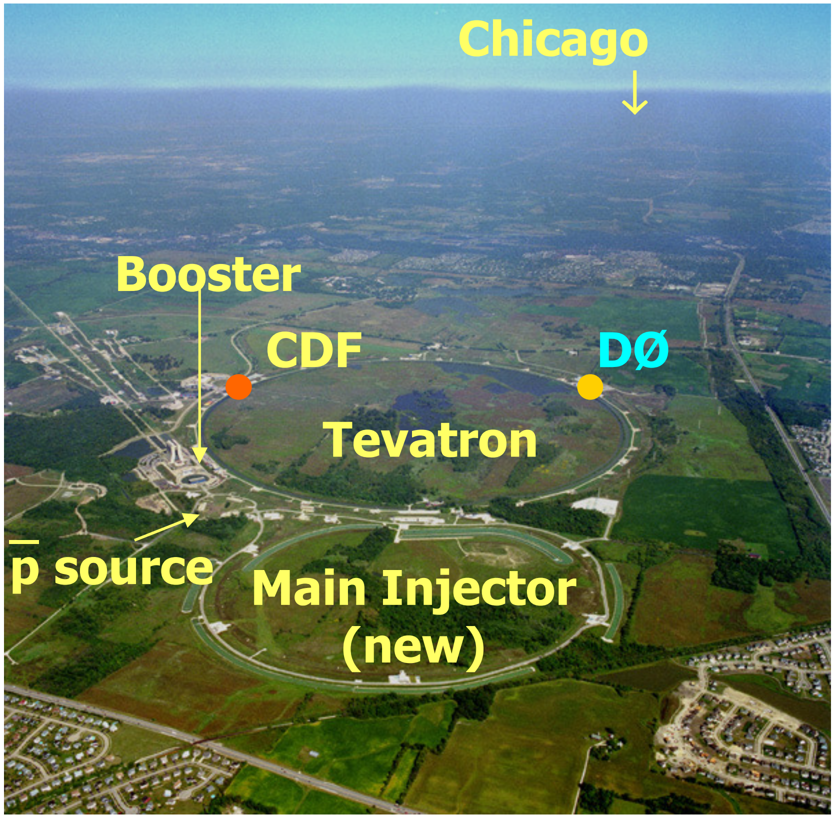
- Independent confirmation that jets are really produced by QCD



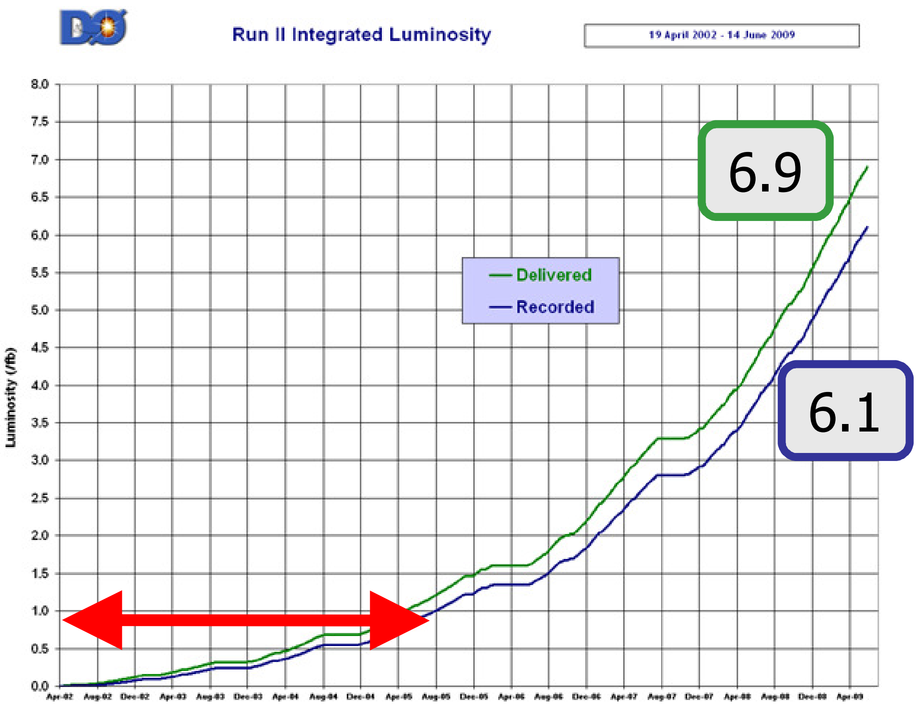




The Run II Tevatron



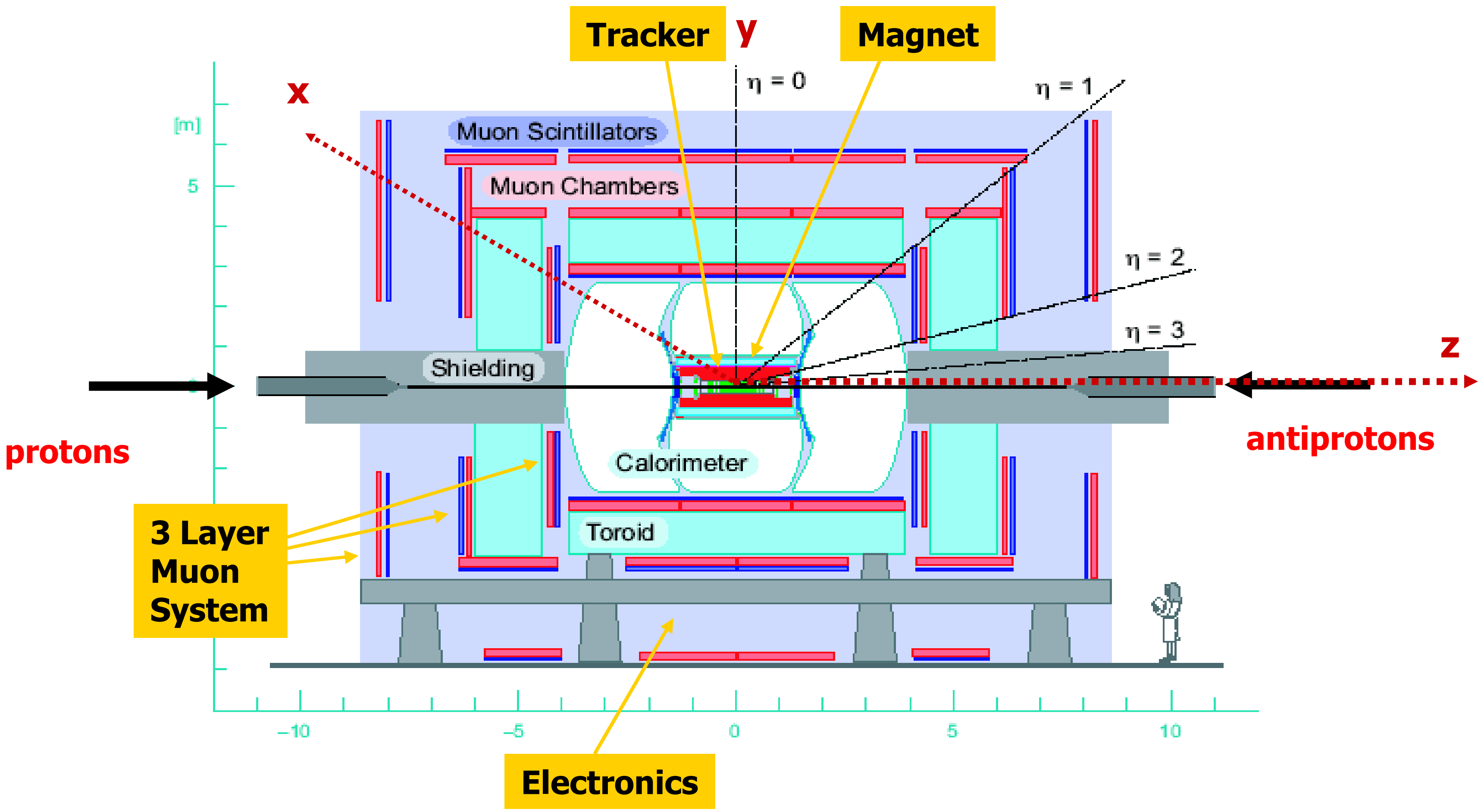
$p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV



Analyses presented here uses up to 0.7 fb^{-1} of luminosity

Nearly 6 fb^{-1} of luminosity recorded

DØ Detector



Tracker
y
Magnet
x
z
η = 0
η = 1
η = 2
η = 3
[m]
5
Muon Scintillators
Muon Chambers
Shielding
Calorimeter
Toroid
protons
antiprotons
3 Layer Muon System
Electronics
–10
–5
0
5
10

Data and Jet Selection

Data Set

~0.7 fb^{-1} of Luminosity is used by this analysis .

Triggers:

Use a single jet trigger with P_T thresholds of 15, 25, 45, 65, 95, 125 GeV

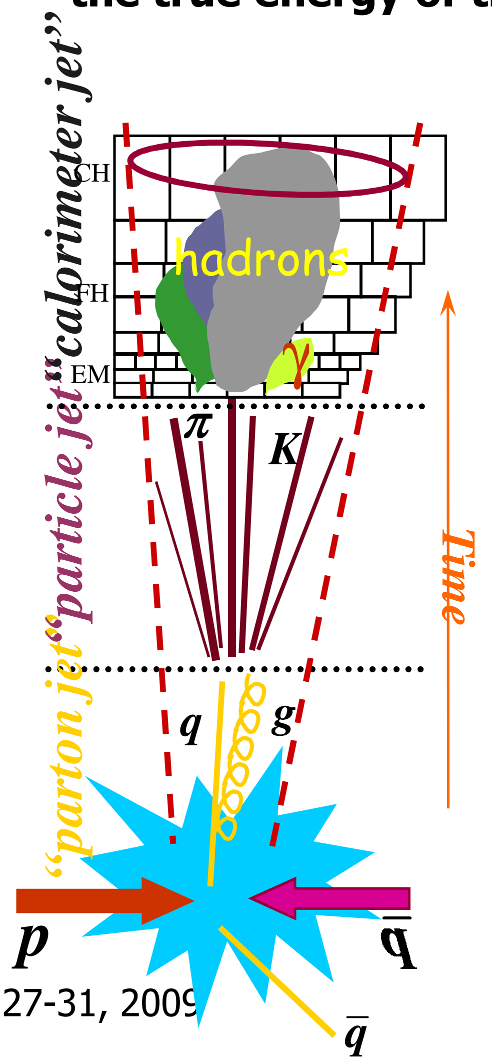
Dijet mass trigger with M_{jj} threshold of 250 and 430 GeV

Event Selection Criteria

- Required good performance of all relevant subdetectors
- Events were required to have not much missing transverse energy
- Events with central position of the Z vertex were accepted
- Required both leading jets to pass identification requirements

Jet Energy Scale

Aim is to go from measured energy in calorimeter using cone algorithm to the true energy of the particle jets



$$E_{ptcl} = \frac{E_{cal} - Offset}{(F_{\eta} \cdot R) \cdot S} \cdot k_{bias}$$

Offset correction takes into account electronic noise, pile-up, and multiple interaction

Response, R, is the calorimeter response to particle jets

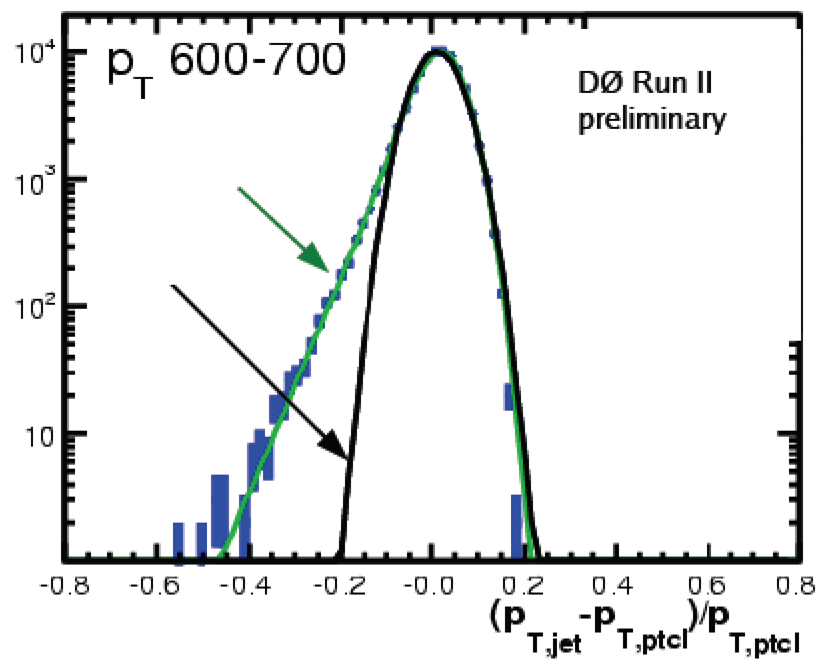
Showering correction, S, is the fraction of the shower contained within the cone

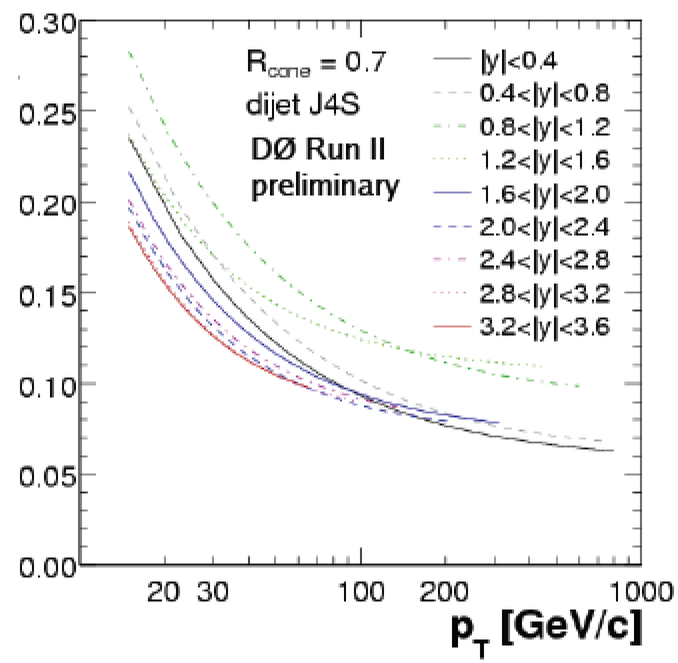
Jet PT resolution

P_T resolution is obtained from Dijet data using P_T asymmetry, and corrected for soft radiation and particle level imbalance.

$$A = \frac{p_{T,1} - p_{T,2}}{p_{T,1} + p_{T,2}} \Rightarrow \frac{\sigma_{p_T}}{p_T} = \sqrt{2}\,\sigma_A$$

We took into account non-Gaussian tails for high P_T jets



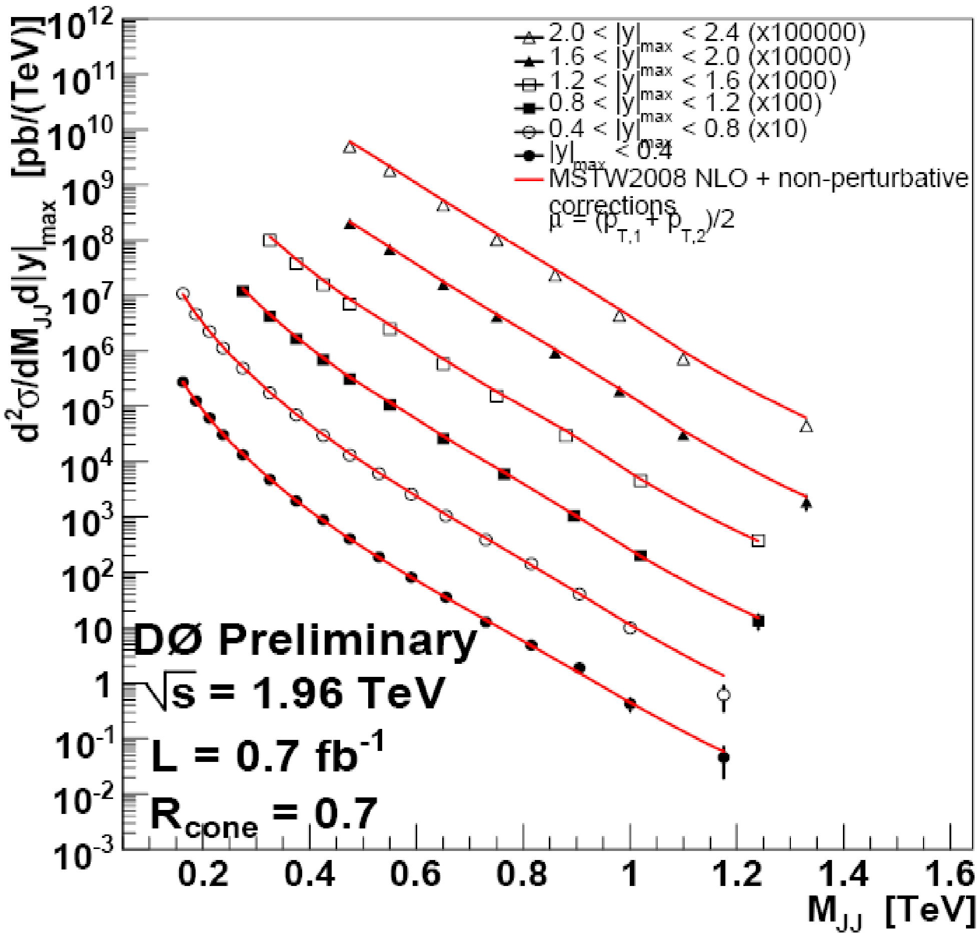


Data Correction

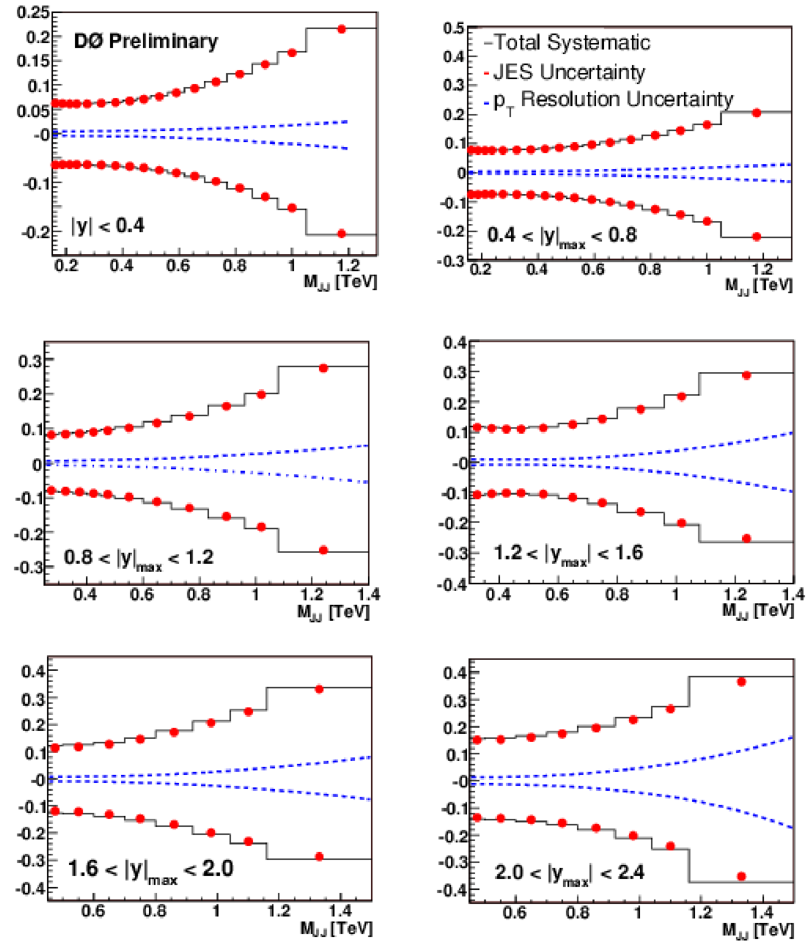
Correction and the uncertainties are determined using MC and data

- Jet pT resolutions
- Jet eta, phi resolutions
- Inefficiencies of jet selection quality criteria
- JES uncertainties
- Inefficiency due to Z-vertex selection criteria
- Muon/Neutrino corrections to jet energies

Dijet Mass Cross Section

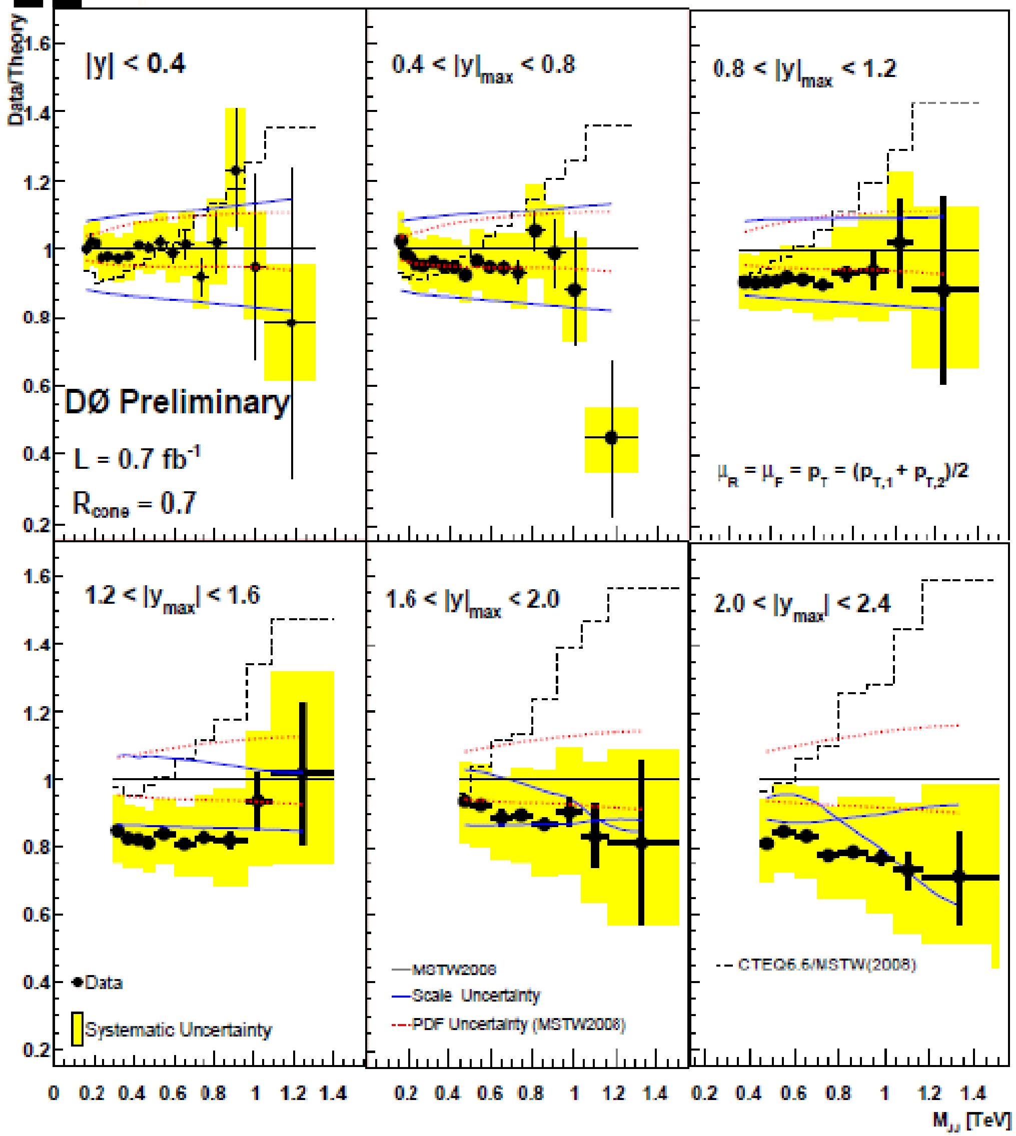


Unfolded Cross section



Systematic Uncertainties

Dijet Mass: Data Vs Theory



Theory:

NLO pQCD (fastNLO/NLOJET ++)

PDF MSTW2008

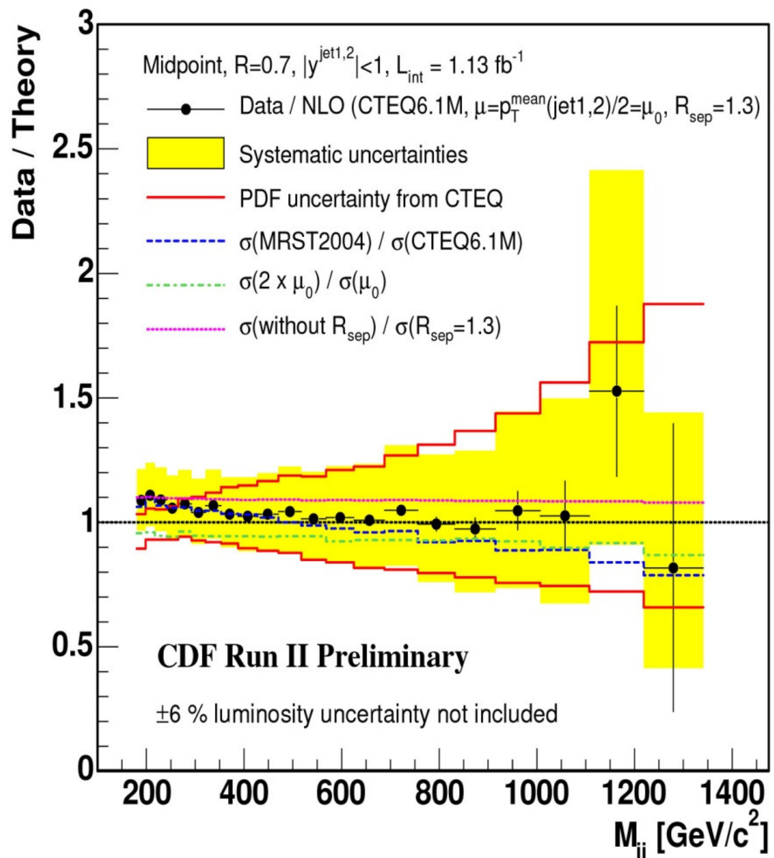
$\mu_r = \mu_f = <pT>$

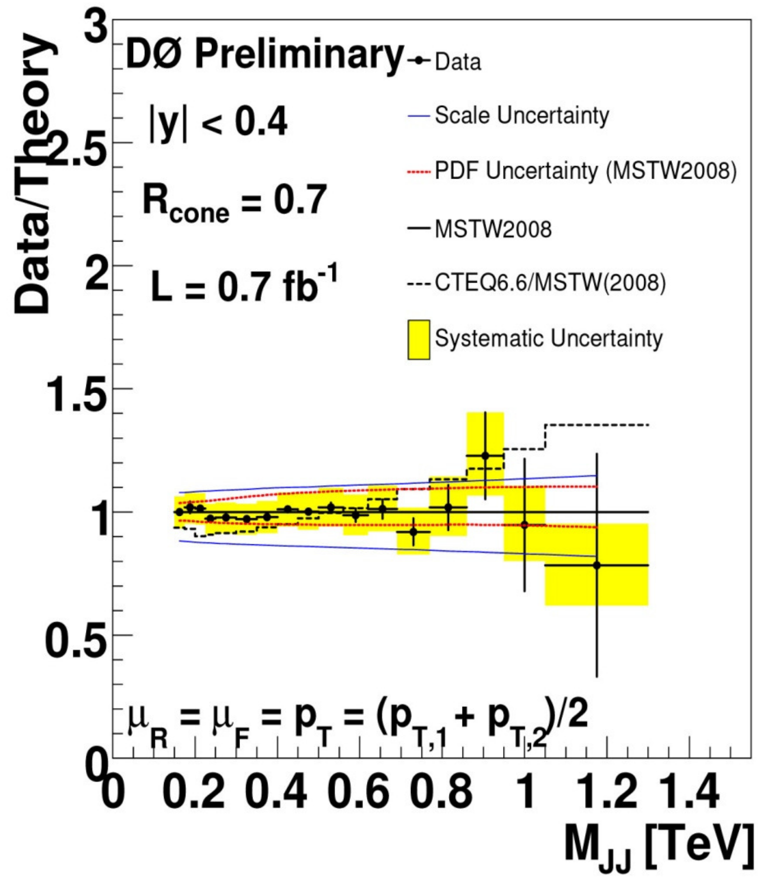
Good agreement between data and theory

Prefers smaller high x gluon than recent PDFs

Note MSTW2008 uses D0 inclusive jet measurement

DZero/CDF Comparison



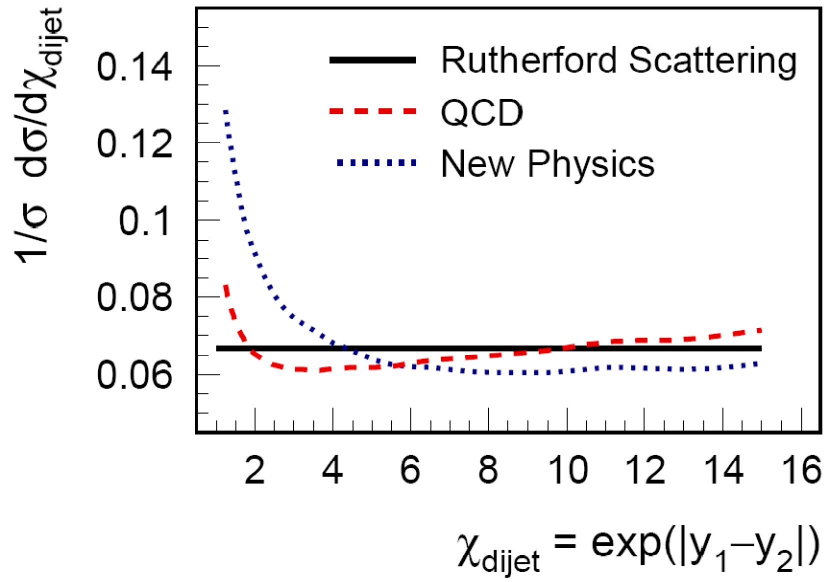


Unfair comparison

- CDF 1.13 fb-1, |y| < 1
- Dzero, 0.7 fb-1, |y| < 0.4

Just for systematics comparison. DZero will have a hard time improving on this.

Dijet Angular Distributions



→ χ is an excellent variable to disentangle QCD from "New Physics"

- Normalized distributions
- Reduction of experimental and theoretical uncertainties

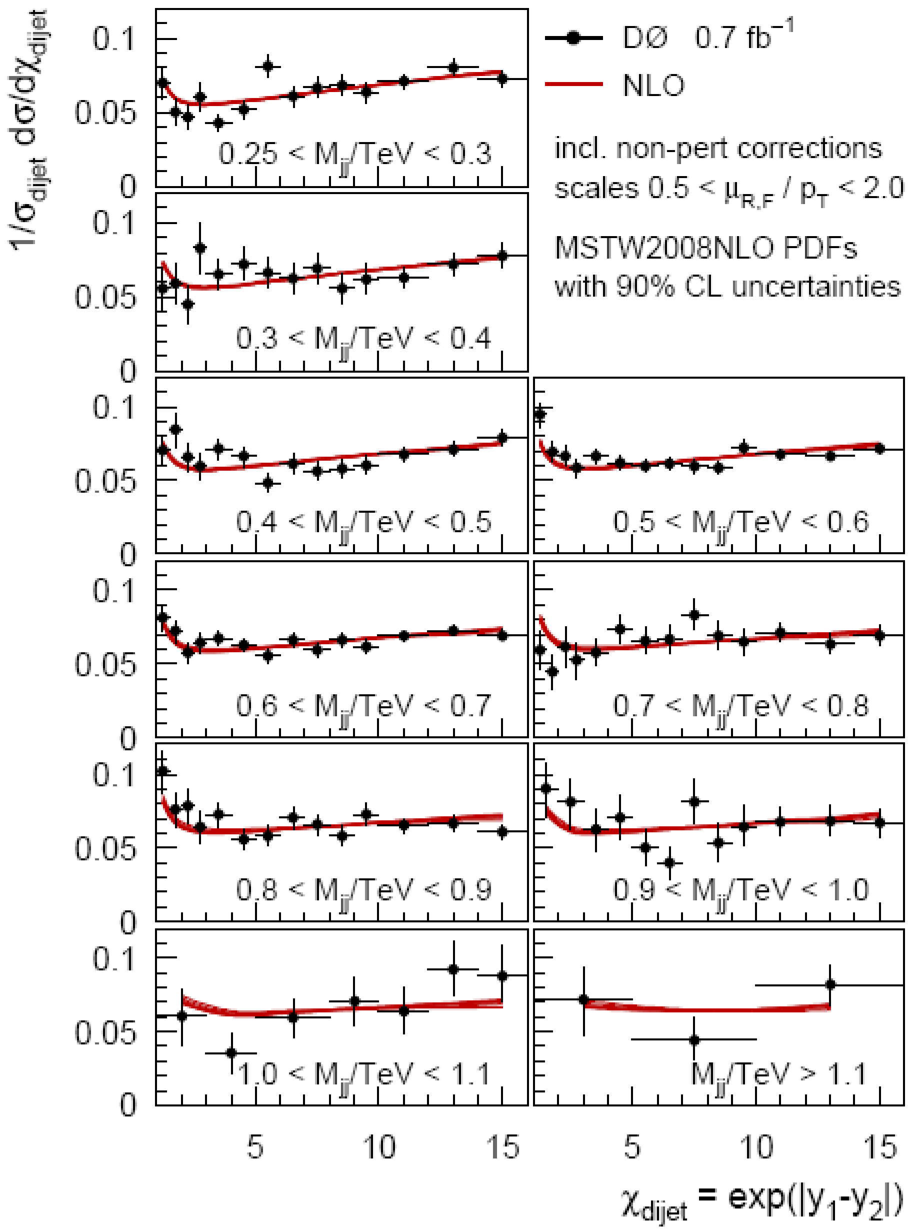
Phase space for the analysis:

Mjj >0.25 TeV

χ <16

Yboost = 0.5*(y1+y2) <1 => |y | < 2.4

Results – chi vs. pQCD



Data points include both stat and syst uncertainties

→ Data are well described by PQCD
(χ^2 ~ 127)

→ Theory uncertainties (PDFs and scales) are very small

13

New Physics Models

Quark Compositeness:

Symmetries in groups of particles like atoms or hadrons have often been explained by substructure.

Hypothetically quarks could also be made of other particles.

Parameters : the energy Scale Λ, and interference term λ

ADD Large extra dimension:

This model assumes that extra dimensions exist in which gravity is allowed to propagate.

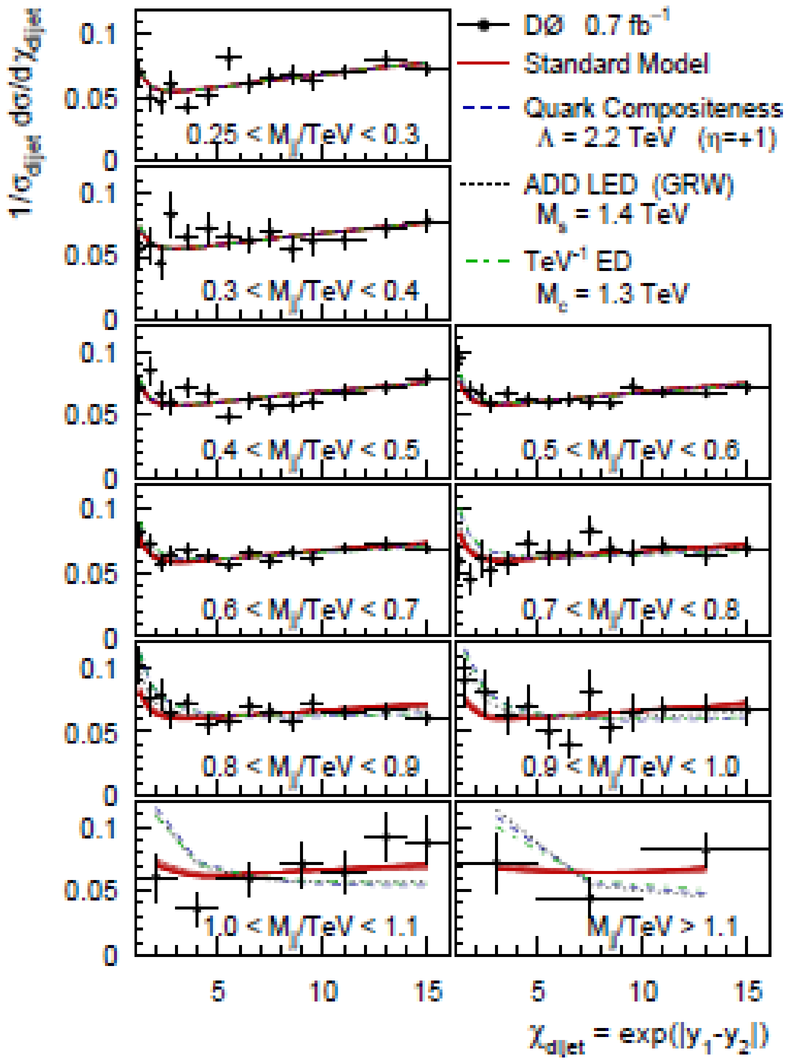
Parameter: Planck scale M_s and number n of large extra dimensions

TeV^{-1} Extra Dimensions:

Instead of graviton exchange of virtual Kaluza-Klein excitations is considered

Parameter : compactification scale M_c

χ vs. New Physics



→ New Physics models change shape
→ Effects depends on dijet mass
→ Data prefers Standard Model

Limits on New Physics

Set Limits to

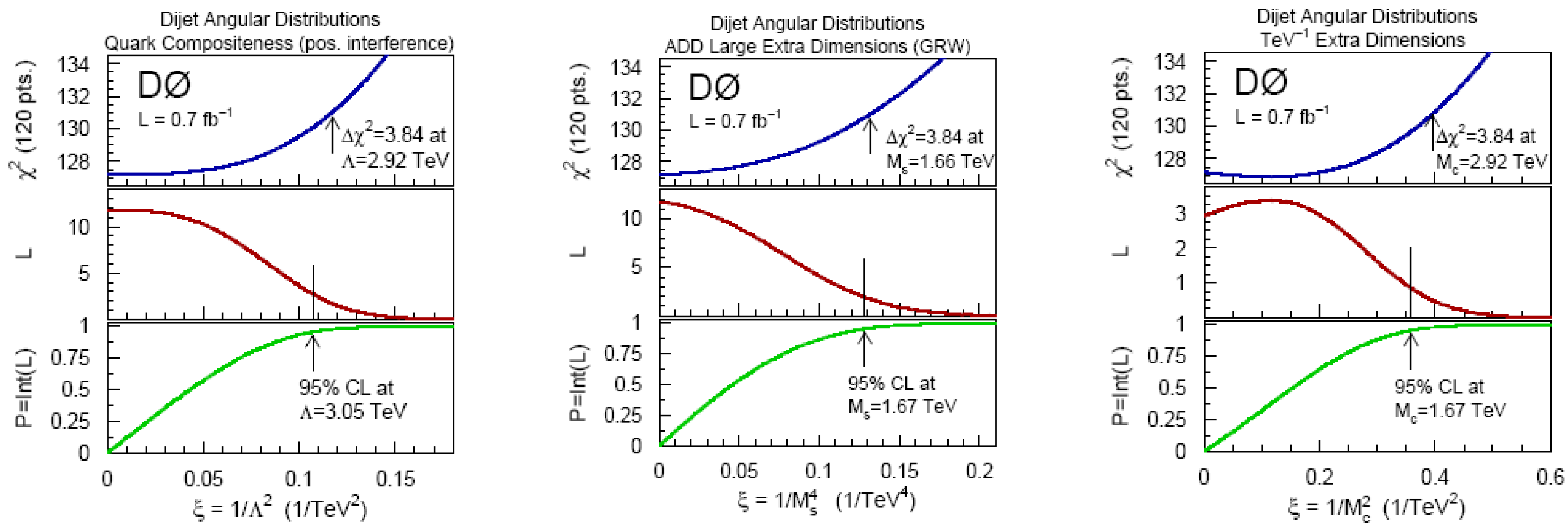
- Quark Compositeness (scale Λ)
- ADD Large Extra Dimensions (scale Ms, n)
- TeV-1 Extra Dimensions (scale Mc)

Matrix Elements taken from following references

- Quark Compositeness – Contact Interactions
  P. Chiappetta, M. Perrottet, Phys. Lett. B 253: 489 (1991)
- ADD Large Extra Dimensions
  D. Atwood, S. Bar-Shalom, A. Soni, Phys. Rev. D 62 (2000)
- TeV-1 Extra Dimensions
  K. Cheung, G. Landsberg, Phys. Rev. D 65 (2002)

$$\sigma_{\rm NP}^{\rm NLO} = \sigma_{\rm QCD}^{\rm NLO} \cdot \frac{\sigma_{\rm NP}^{\rm LO}}{\sigma_{\rm QCD}^{\rm LO}} = \sigma_{\rm NP}^{\rm LO} \cdot \frac{\sigma_{\rm QCD}^{\rm NLO}}{\sigma_{\rm QCD}^{\rm LO}}\,.$$

Limits on New Physics



Bayesian 95% C.L Limits:

(prior flat in ξ)	3.06	1.67	1.67
(prior flat in ξ^2)	2.84	1.59	1.55

Limits on New Physics

Model (parameter)	Prior flat in NP Lagrang. Exp.	Prior flat in NP Lagrang. Obs.	Prior flat in NP x-section Exp.	Prior flat in NP x-section Obs.	$\Delta\chi^2 = 3.84$ criterion Exp.	$\Delta\chi^2 = 3.84$ criterion Obs.
Quark comp. (Λ)						
$\eta = +1$	2.91	3.06	2.76	2.84	2.80	2.92
$\eta = -1$	2.97	3.06	2.75	2.82	2.82	2.96
TeV^{-1} ED (M_C)	1.73	1.67	1.60	1.55	1.66	1.59
ADD LED (M_S)						
GRW	1.53	1.67	1.47	1.59	1.49	1.66
HLZ $n = 3$	1.81	1.98	1.75	1.89	1.77	1.97
HLZ $n = 4$	1.53	1.67	1.47	1.59	1.49	1.66
HLZ $n = 5$	1.38	1.51	1.33	1.43	1.35	1.50
HLZ $n = 6$	1.28	1.40	1.24	1.34	1.25	1.39
HLZ $n = 7$	1.21	1.33	1.17	1.26	1.19	1.32

For all models considered we set the most stringent direct limits to date

Summary and Outlook

- Presented most precise double differential dijet mass spectrum
- And normalized χ distributions in 10 mass bins using 0.7 fb^{-1} of data collected by the D0 detector.
- Results are in good agreement with QCD.
- Most stringent direct limits on quark compositeness and extra spatial dimension models are presented