

DiJet Angular Distribution

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Outline

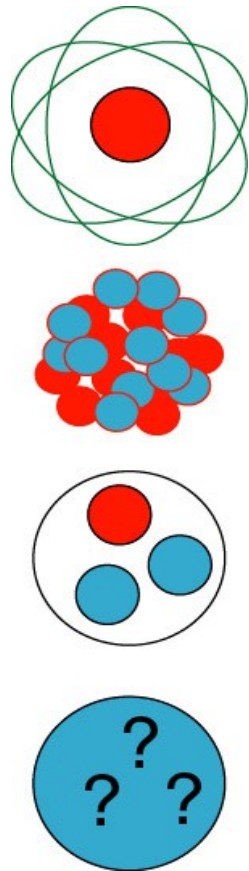
- Theory and motivation
- Methodology
- $D\bar{D}$ and CDF results from Run II
- CMS studies
- Summary

Motivation for the analysis

- The dijet angular distribution with respect to the beam direction probes the dynamics of the underlying process
- At small center of mass scattering angles the dijet angular distribution is similar to Rutherford scattering (t-pole exchange)
 - Many new physics models predict angular distributions that are much more isotropic
- Dijet angular distribution is relatively insensitive to the parton distribution function (PDF) and provides an excellent test of QCD and new physics processes like quark substructure and extra dimensions
- There has been no experimental evidence of quark compositeness so far
- LHC will explore physics at an unprecedented energy scale with collision energies approximately 7 times that of the Tevatron
- The existence of a quark substructure would appear as:
 - an excess of the high P_T jets compared to the QCD predictions
 - dijet angular distributions more isotropic than that expected from a point-like quark theory

Quark substructure searches

- There is a hypothesis that quarks are bound states of preons and that preons interact by means of a new strong interaction - metacolor
- Compositeness Scale:
 - $\Lambda = \infty \rightarrow$ point like quarks
 - $\Lambda = \text{finite} \rightarrow$ substructure at mass scale of Λ



$d\sigma \sim [\text{QCD} + \text{Interference} + \text{Compositeness}]$

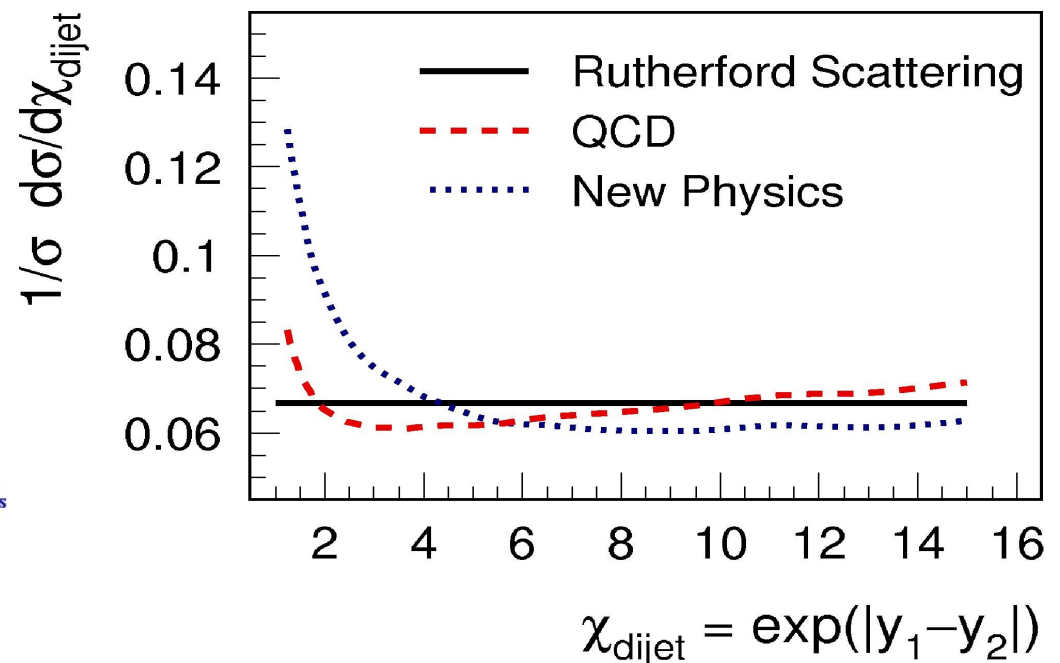
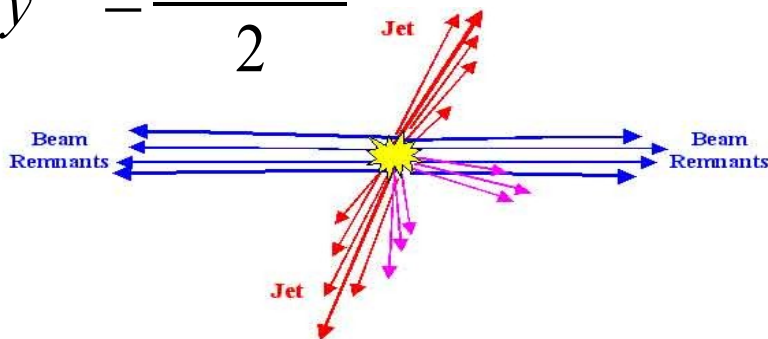
$$\begin{array}{ccc}
 \nearrow & \nearrow & \nwarrow \\
 \alpha_s^2(\mu^2) \frac{1}{t^2} & \alpha_s(\mu^2) \frac{1}{t} \frac{u^2}{\Lambda^2} & \left(\frac{u}{\Lambda^2} \right)^2
 \end{array}$$

Methodology

It is convenient to plot the angular distribution as a function of the variable χ , defined below, since the QCD predictions are relatively flat in this variable

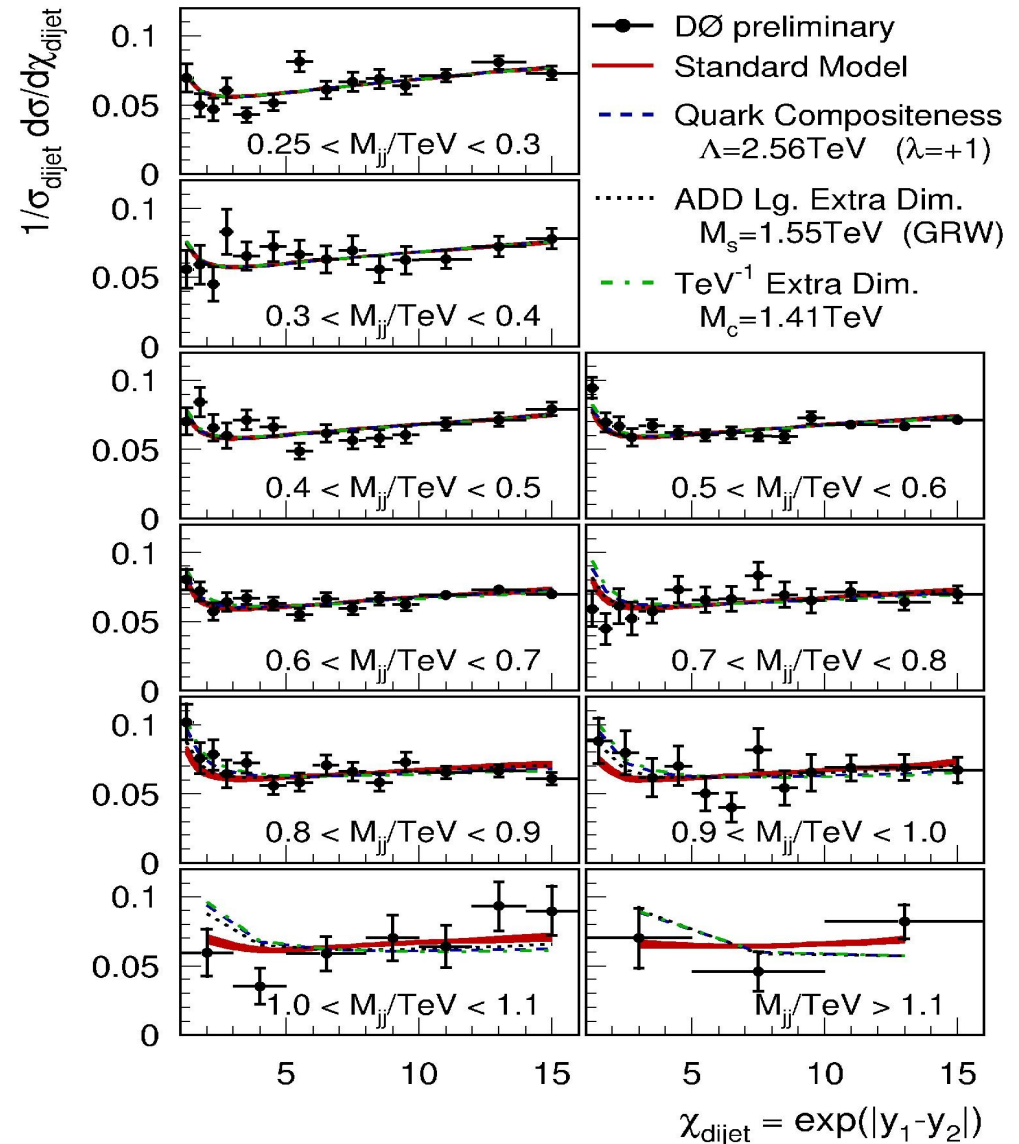
$$\chi = \frac{1 + \cos \theta}{1 - \cos \theta} = e^{2|y^{star}|}$$

$$y^{star} = \frac{|y_1 - y_2|}{2}$$



DØ results

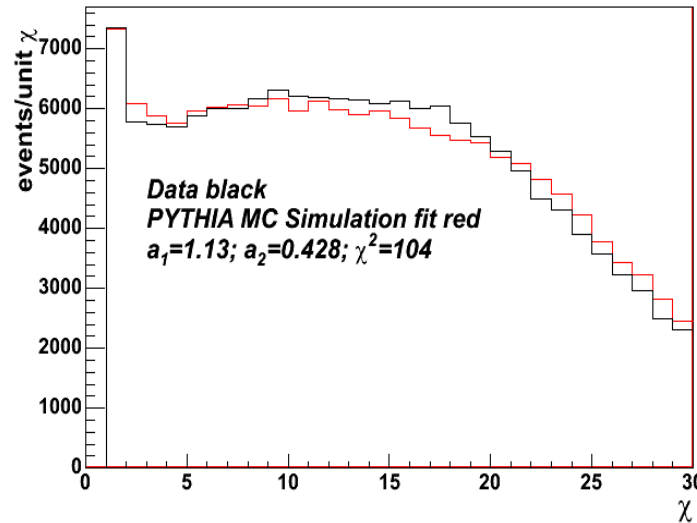
- DiJet angular distribution from the DØ experiment was compared to the NLO theory predictions with various choices of compositeness scale.
- The compositeness scale limit was $\Lambda > 2.5\text{-}2.8\text{ TeV}$ (several limits given depending upon the statistical approach used)
- No evidence of quark substructure was observed
- More details in DØ Note:
<http://www-d0.fnal.gov/Run2Physics/WWW/results/prelim/QCD/Q11/Q11.pdf>



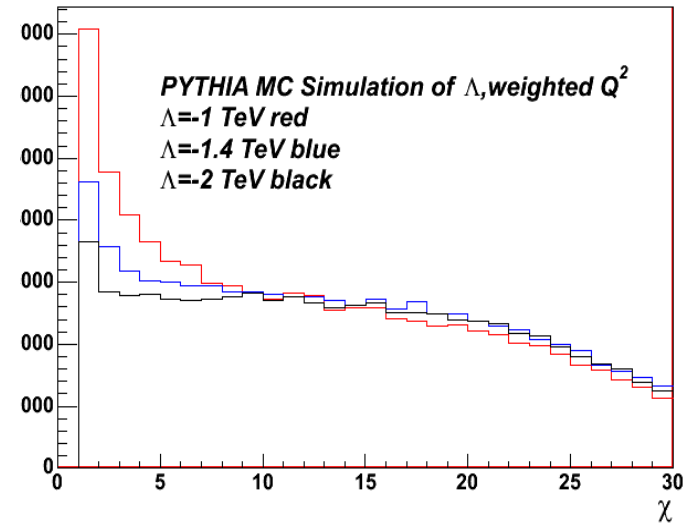
CDF results

- In CDF experiment the ratio of $R = \frac{1 \leq \chi \leq 10}{15 \leq \chi \leq 25}$ versus $(\text{mass})^4$ was plotted for various values of Λ to the default Monte Carlo
- No evidence of quark substructure was seen
- The compositeness scale limit was $\Lambda > 2.4 \text{ TeV}$
- More details can be found at: <http://www-cdf.fnal.gov/physics/new/qcd/QCD.html>

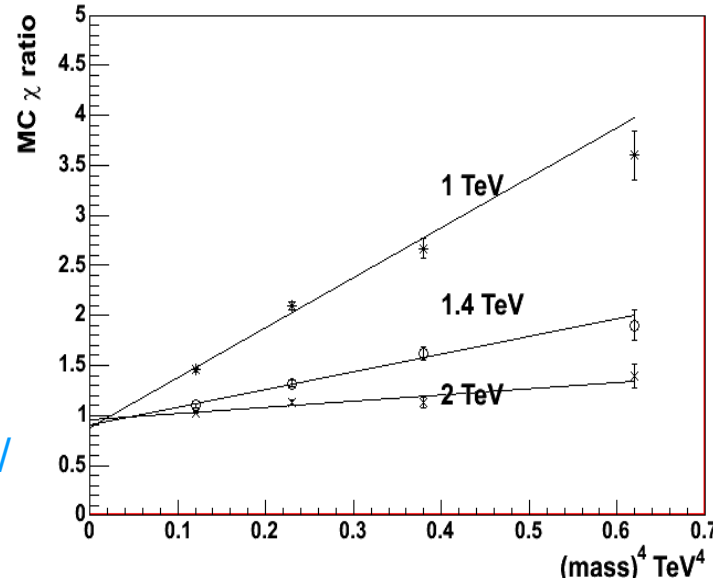
χ Dist MC fit to 1.1fb^{-1} data, 600 GeV mass, CDF Run2 Preliminary



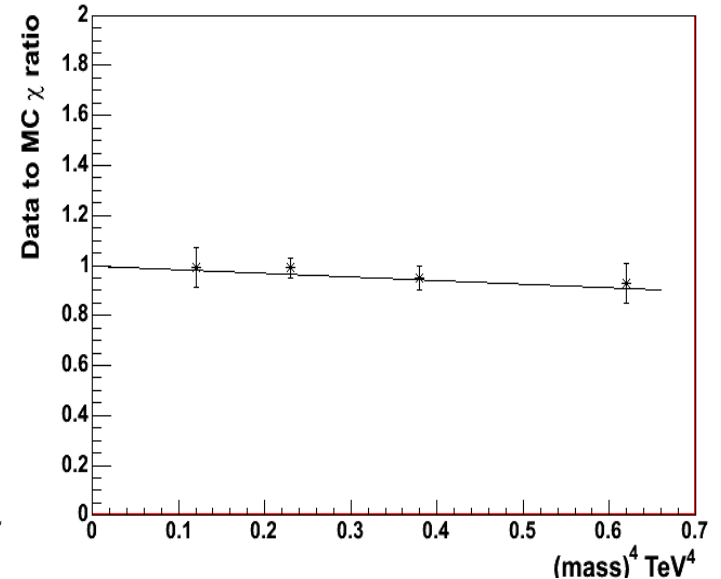
Dist varying Λ , 600 GeV mass, CDF Run2 Preliminary



MC χ ratios vs $(\text{mass})^4$, varying Λ , CDF Preliminary



Ratios of Data/(noqsub MC) vs $(\text{mass})^4$, CDF Preliminary



Dijet angular studies at CMS

- First preliminary results with the iCSA08 production samples
- We used single Jet PT trigger for 6 different thresholds in 7 different mass bins and scaled the results to correspond to an integrated luminosity of 10pb^{-1}
- Jets were reconstructed using Seedless Infrared Safe Cone with $R=0.7$ (SisCone7) jet algorithm
- We are currently working on reproducing the results with the newest Summer08 production samples

Acceptance studies

As shown before $\chi = e^{2y^{star}}$

where $y^{star} = \frac{|y_1 - y_2|}{2}$ and

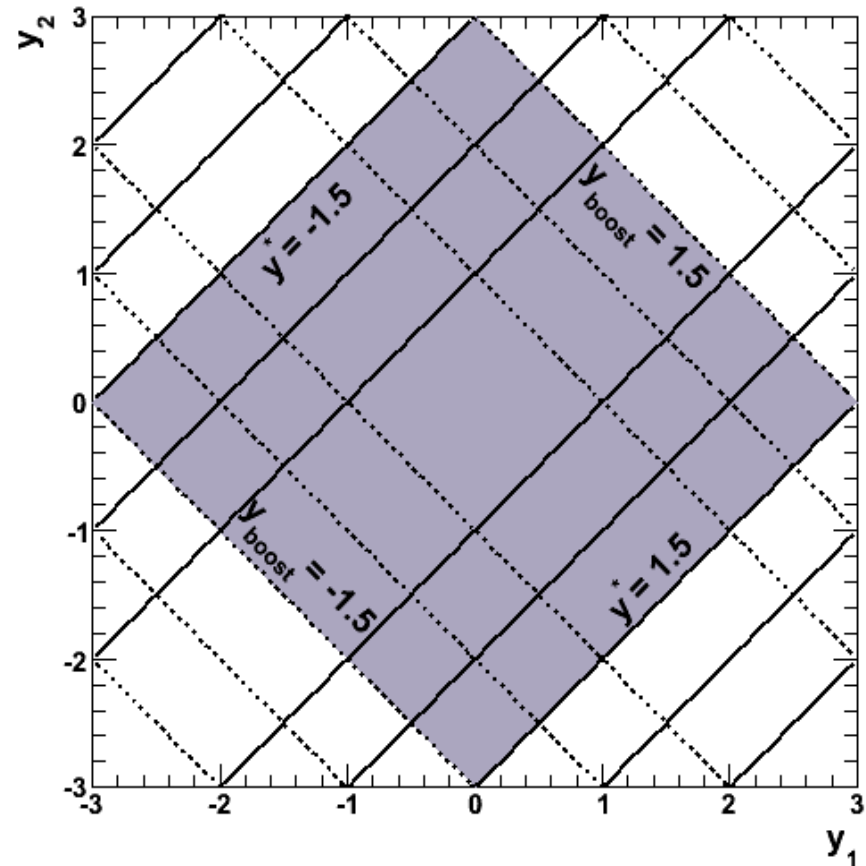
$$y_{boost} = \frac{|y_1 + y_2|}{2}$$

Limit on y_{boost} is set by

$$|y_{boost}| + |y^{star}| < |y_{max}|$$

Two cuts were

investigated: $y_{max} = 3.0$ and $y_{max} = 2.0$

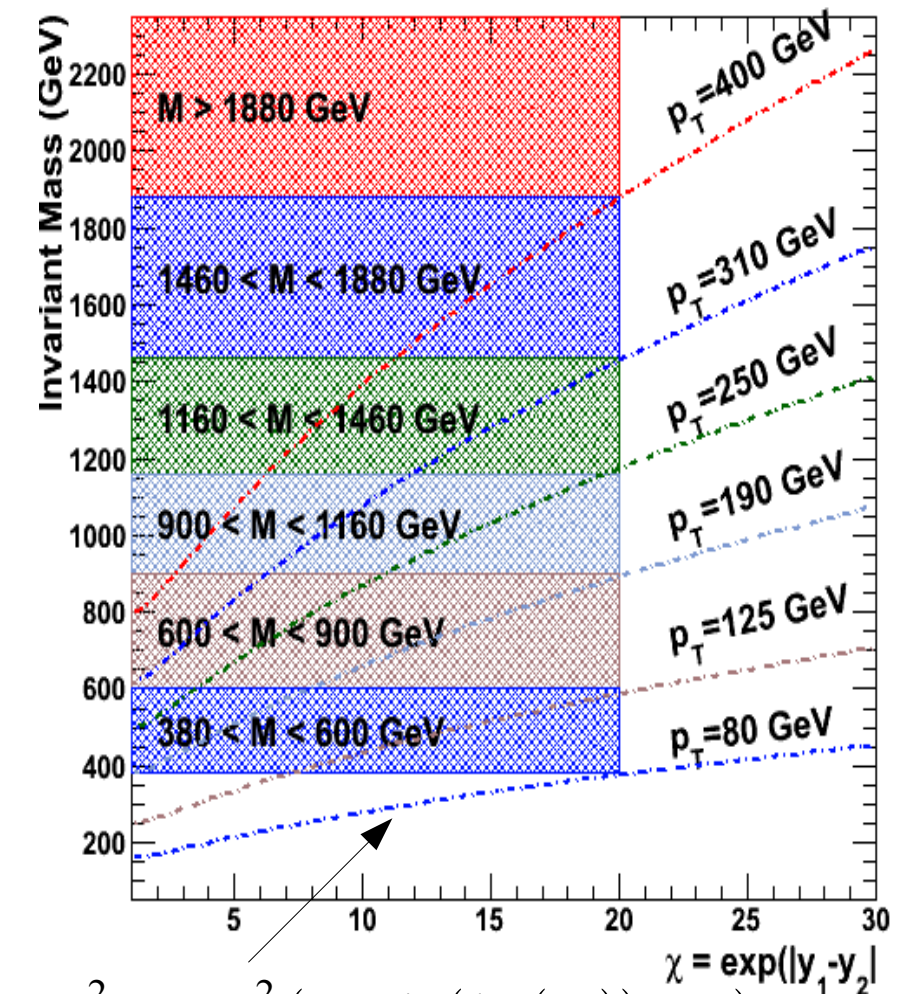


Mass bins: data-driven approach

- We only used events where single jet trigger is fully efficient
- Each dijet mass bin only uses data from a single trigger path
- Shape analysis:

– Observable:

$$\frac{1}{\sigma} \frac{d\sigma}{d\chi}$$

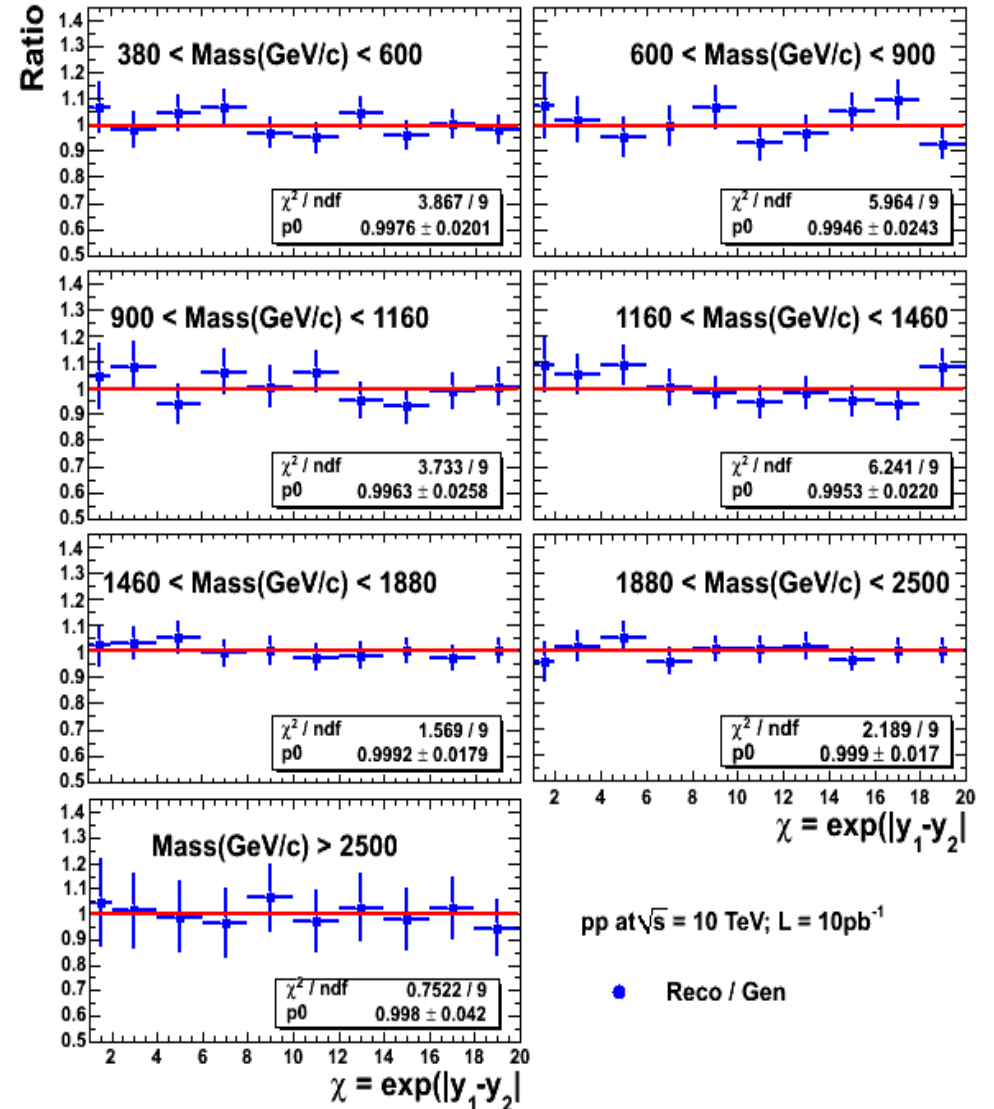
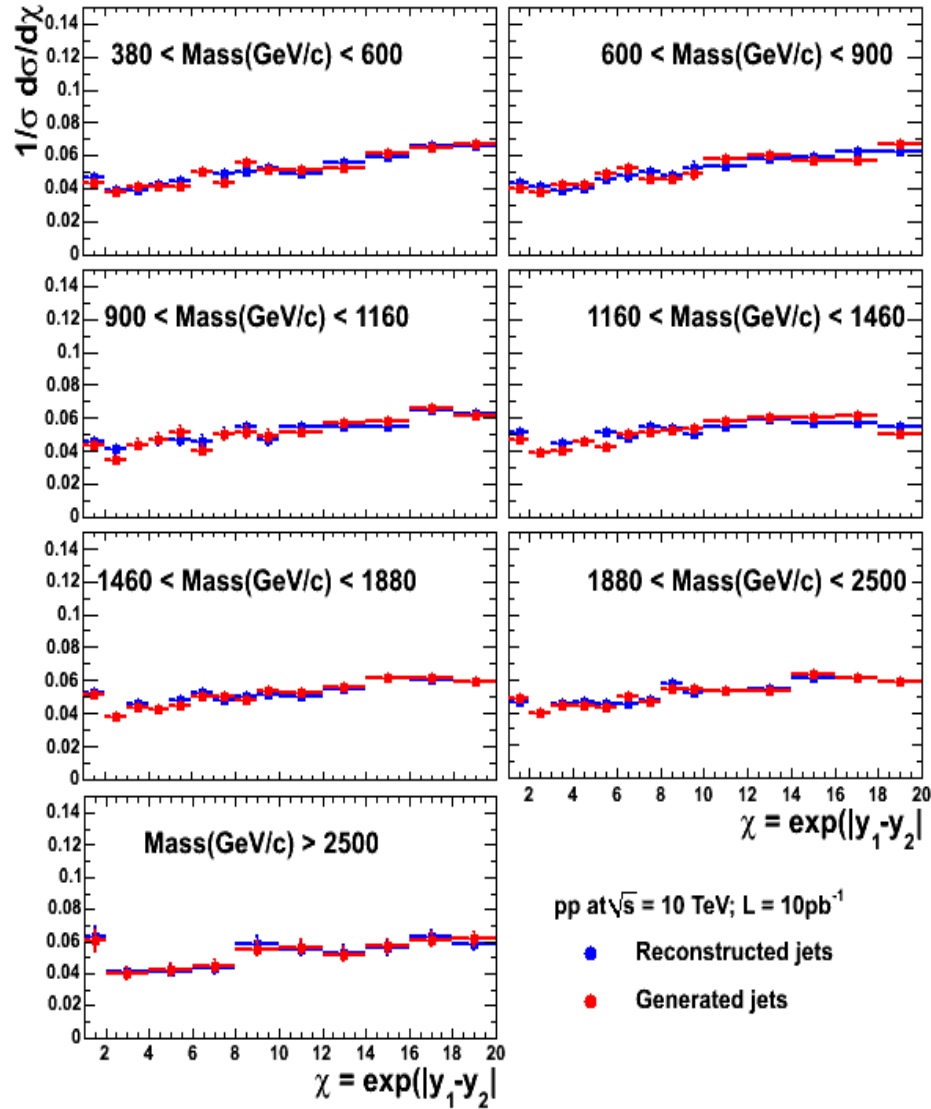


$$M^2 = 2 p_T^2 (\cosh(\ln(\chi)) + 1)$$

assuming $p_{T_1} = p_{T_2}$

Comparison with GenJets

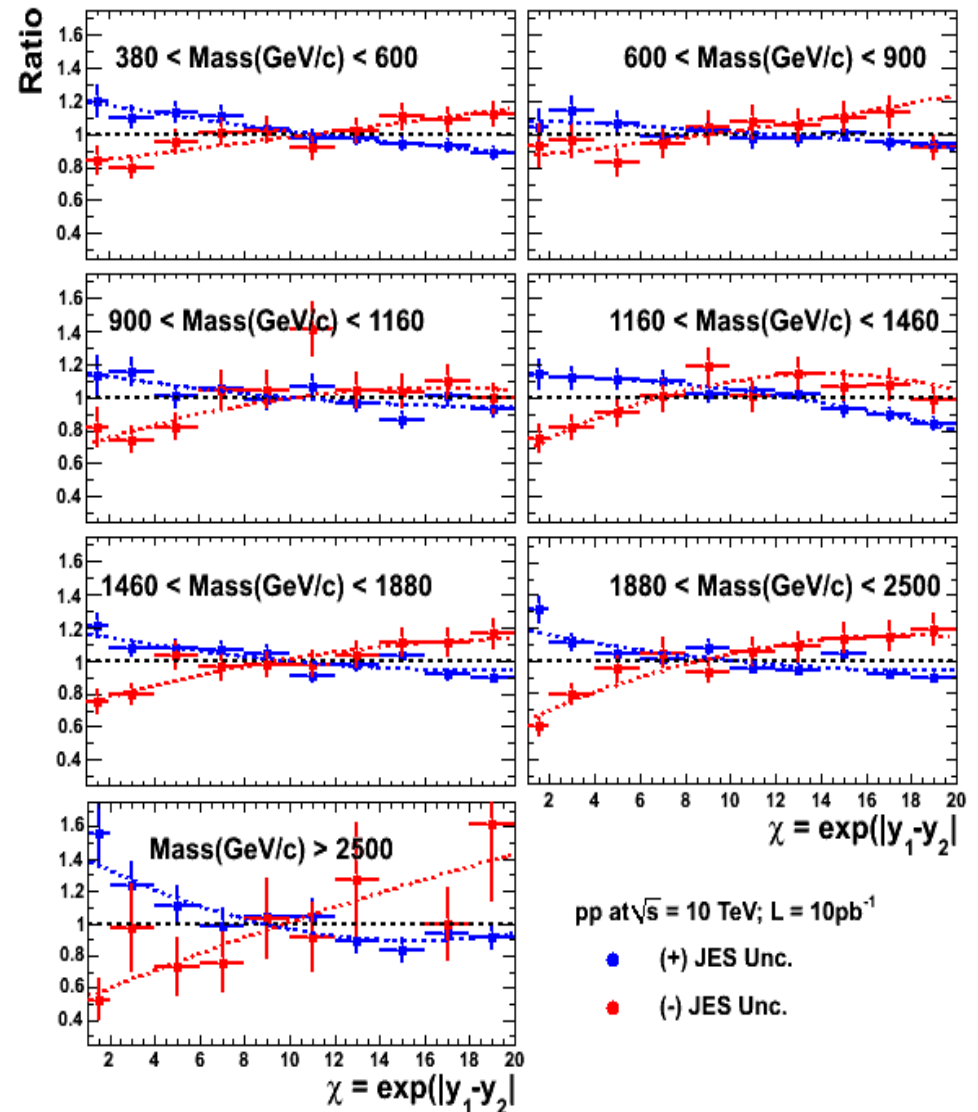
No resolution unsmearing performed



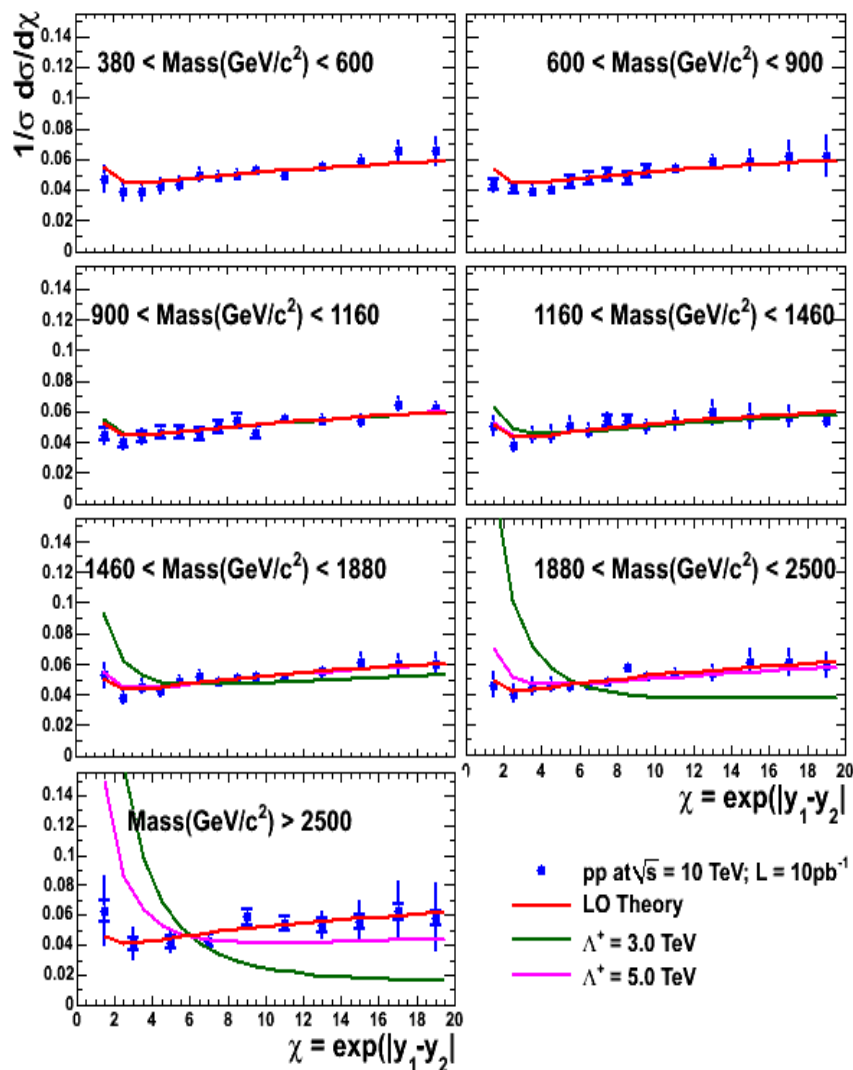
Uncertainty due to energy scale

Rough first guess for energy scale uncertainty with 10 pb^{-1} data:

- Barrel
 - 10% for $p_T < 100 \text{ GeV}$
 - Then linearly increasing to 20% @2TeV
- Endcaps
 - Barrel uncertainty plus additional 10% to 100 GeV
 - Extrapolate to 20% @1 TeV
- Forward
 - Barrel uncertainty plus additional 15% @100 GeV
 - Extrapolate to 30 % @ 500 GeV



Comparisons to theory



- No resolution unsmearing performed
- 5% systematic uncertainty due to energy scale added in quadrature to the statistical error
- LO calculations:
 - Scale: $\mu_R = \mu_F = p_T$
 - Pdf: CTEQ6L
 - Two choices of compositeness scale shown:
 - $\Lambda = 3.0$ TeV
 - $\Lambda = 5.0$ TeV

Summary

- Dijet angular distribution probes the hard scatter of QCD dynamics and signatures of new physics
- First look of dijet angular distributions @ 10 TeV was done with the iCSA08 MC sample
- Currently we are working on refining the analysis with the Summer08 samples, studying correlation of systematic uncertainties and developing the methodology to extract the compositeness limits