Measurement of Dijet Angular Distributions in pp collisions at √s = 7 TeV with the CMS detector

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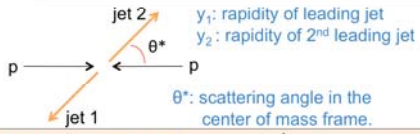
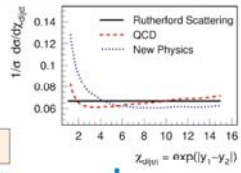
Dijet Angular Distribution



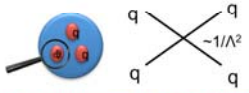
y_1: rapidity of leading jet
y_2: rapidity of 2nd leading jet

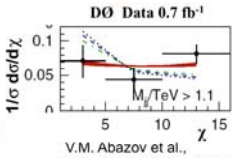
θ*: scattering angle in the center of mass frame.

Dijet angular distribution: $\chi = e^{2|y^*|} = \exp(|y_1 - y_2|)$



Test perturbative QCD NLO predictions ⟷ Probe quark substructure Signal: Contaction Interaction





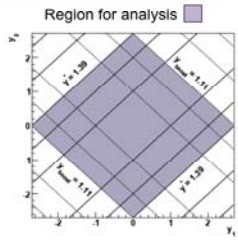
V.M. Abazov et al., PRL 103, 191803 (2009)

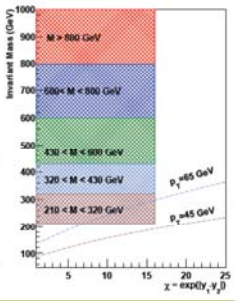
- Measurements at the Tevatron:
  - No evidence of quark substructure.
  - Exclusion limits on compositeness of quarks for a Contact Interaction scale Λ < 2.8 TeV - 3 TeV (depending on statistical method).
- Exclusion limit from ATLAS: Λ < 3.4 TeV (arXiv:1009.5069v1 [hep-ex]).

Phase Space and Event Selection

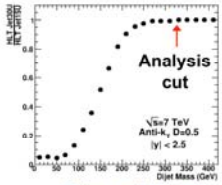
- Event selection:
  Beam coincidence, Clean event, Good vertex, Jet Id applied.
  Calorimeter Jets with Cone size 0.5.
- Restrict measurement within |y|<2.5
  $y_{boost} = 0.5*|y_1+y_2| < 1.11$
  $y^* = 0.5*|y_1-y_2| < 1.39$ (or χ<16)

Region for analysis



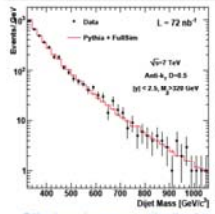


- Measure dijet angular distributions in 5 bins of dijet mass (M).
- Choose mass bin borders where trigger >99% efficient.



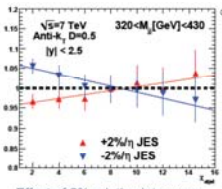
Trigger efficiency

Data/MC comparison and Systematic Uncertainties



Dijet invariant mass distribution

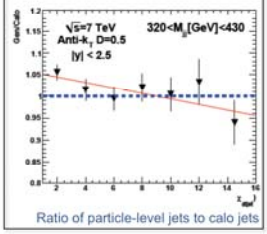
- Data-MC comparison
  - Pythia MC gives good description of dijet mass in analysis phase space.



Effect of 2% relative jet energy scale uncertainty vs. η on χ_{dijet}

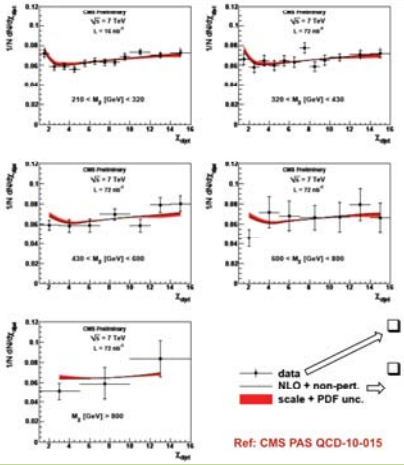
- Leading systematic uncertainty is relative jet energy scale: 2%×|η|
- Small uncertainties from absolute jet energy scale and jet position and energy resolutions .
- All effects < ±5%

- Use ratio of particle-level jets to calorimeter jets for unfolding.
- Correction factor for unsmearing < ±3%.
- Currently applying full size of correction factor as a systematic uncertainty.



Ratio of particle-level jets to calo jets

Dijet Angular Distributions with Data



Ref: CMS PAS QCD-10-015

- Distributions corrected to particle level.
- Reach as high as 1.54 TeV in Invariant mass.
- No significant deviation of data from NLO QCD prediction.

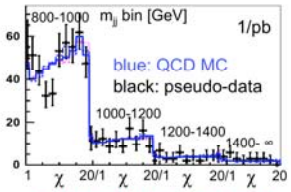
- **Data**: unsmeared ± statistical (ticks) ± systematic uncertainties
- **Theory**: NLO pQCD prediction with non- perturbative corrections (MPI and hadronization) ± Scale + PDF uncertainty

Setting Limit on Contact Interaction

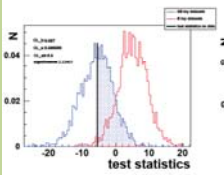
- Test QCD versus QCD+CI hypothesis
- Use log likelihood ratio test statistics.

$$Q = -2\ln\left(\frac{L_{QCD+CI}}{L_{QCD}}\right)$$

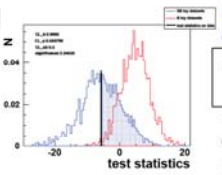
- Input: NLO χ distributions with each M_{jj} bin normalized to data.
- Construct test statistics with and without systematic uncertainties



Sample input for the likelihood



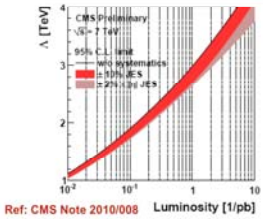
No systematic uncty.



10% JES uncertainty

- Using CL_s approach to set exclusion limits.
- ✓ Criterion for exclusion: $1-CL_s > 95\%$
- CL_s calculated using toy-MC experiments.
- Implementation using *RooStats HybridCalculator*.

Expected Exclusion Limits



Ref: CMS Note 2010/008

- Plots shows the expected exclusion limits as a function of luminosity without systematic uncertainties (line) and with an uncertainty of 10% on the absolute jet energy scale (colored band) and with an uncertainty of 2% per unit of η on the relative jet energy scale (gray band) using CLs.
- With an integrated luminosity of ~2 pb⁻¹ the analysis is expected to be competitive with the Tevatron limit (Λ> 2.8-3 TeV).

Updated Analysis Summary

- Analysis has been recently updated with 6.7/pb of luminosity.
- Dijet Invariant Mass reach has gone beyond 2 TeV.
- The last mass bin for χ distributions has been extended up to M_{jj} > 1800 GeV.
- Current Exclusion Limit on Contact Interaction Scale from LHC data stand well beyond theTevatron limit.
- Analysis plan for publication is to use the full 7 TeV p-p collision data collected by CMS in 2010 with an expected integrated luminosity of ~30 pb⁻¹.