



Summary of the Dijet Topology Group Parallel Session

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JTERM III
January 16, 2009



Agenda



● Morning Session (Dijets & Background)

10:30	CRAFT Analysis	Kwangzoo Chung (<i>University of Iowa</i>)
10:55	Inclusive Jet PT	David Mason (Fermilab)
11:20	Dijet Mass	Konstantinos Kousouris (<i>Fermilab</i>)
11:45	Dijet Ratio	Dan Miner (<i>University of Rochester</i>)
12:10	Dijet Angular Distribution	Agata Smoron (<i>UIC</i>)

● Afternoon Session (mainly Multijets)

13:30	Dijet Azimuthal Decorrelation	Cosmin Dragoiu (<i>UIC</i>)
13:55	Multijet QCD Studies	Sudaveep Bose (<i>Tata Institute</i>)
14:20	Multijet SUSY Studies	Burak Bilki (<i>University of Iowa</i>)
14:45	Multijet Resonance Search	Amitabh Lath (<i>Rutgers</i>)
15:10	Jet Shapes	Pelin Kurt (<i>University of Cukurova</i>)



Introduction



- We had two lively and interesting sessions.
 - Mainly the speakers attended, but there were a few others here and on EVO.
 - About 15 participants total
 - A nice mixture of new and established analyses.
 - Some new participants to the dijet topology group.
- There was a lot of material presented in 10 talks.
 - I can only show 1-2 slides for each talk in this summary.
 - There are a lot more results in the full talks on indico at <http://indico.cern.ch/conferenceDisplay.py?confId=46957>

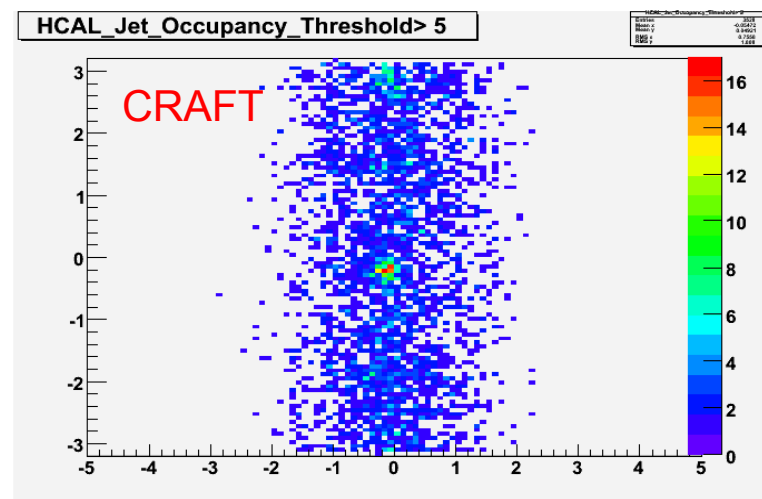
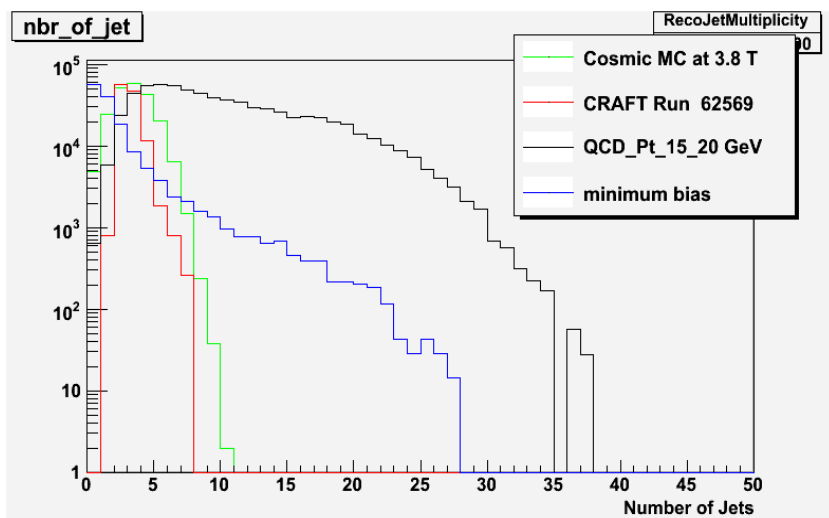
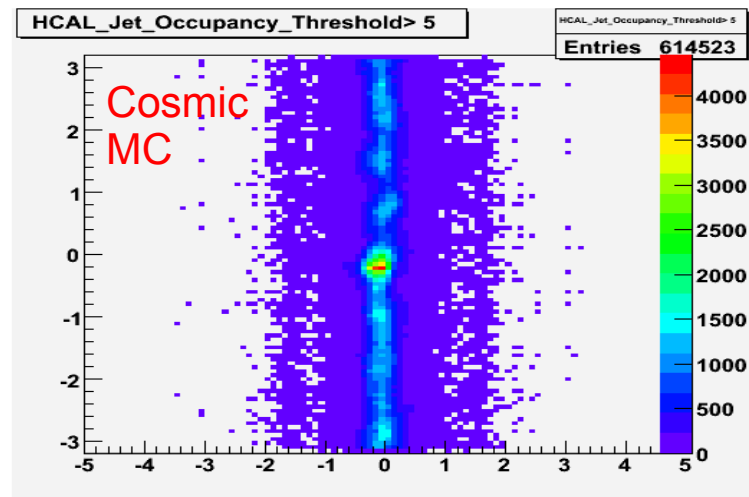


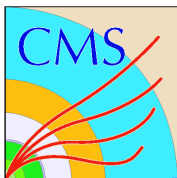
CRAFT Analysis

(Kwangzoo Chung & Kerem Cankocak)



- L1 jet triggers in CRAFT
 - ➔ Stable rate of 200 Hz.
- Cosmic Ray Studies Underway
 - ➔ Craft data comparisons with Cosmic Ray MC are beginning.
 - ➔ Concludes that correct pedestal calculation is crucial !



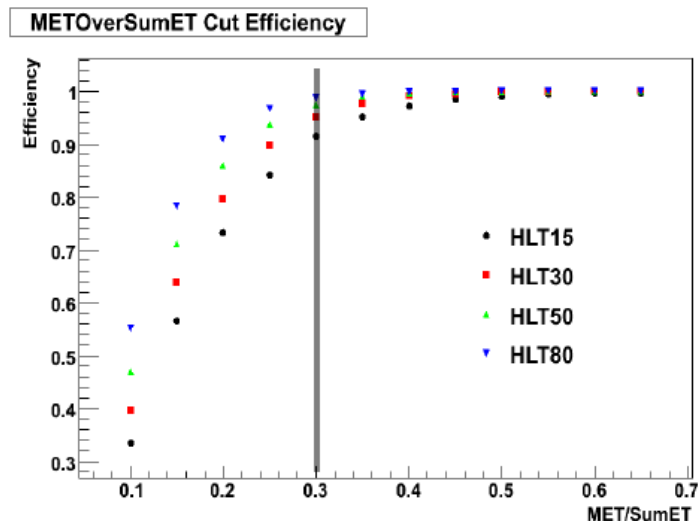
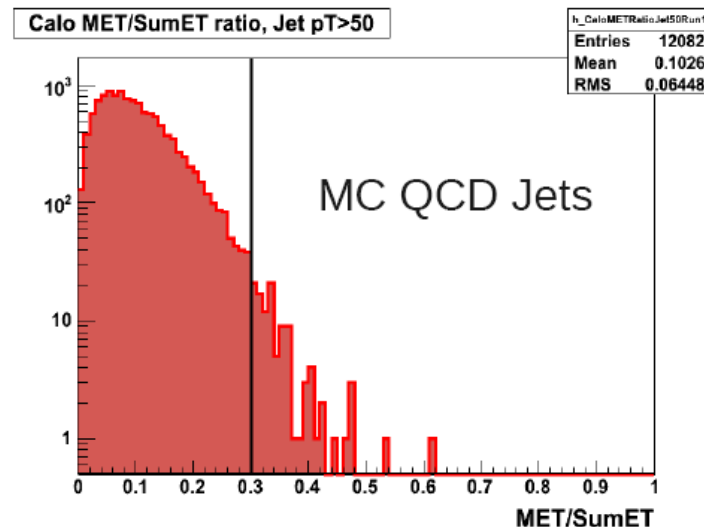


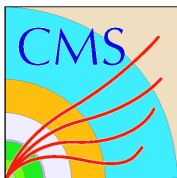
Inclusive Jet Cross Section

(Dave Mason & Pratima Jindal)



- Event cleanup using $MET/\Sigma E_T$
 - QCD jets will balance in p_T .
 - Backgrounds from cosmic rays, detector noise, and beam halo won't
 - These will be a significant background for the highest p_T jets.
 - We plan to employ a cut on MET/SET to reduce these backgrounds.
 - Previous studies indicated the selection $MET/\Sigma E_T < 0.3$ was more than 99% efficient for QCD and remove all the high p_T jets in global run data (noise and cosmic triggers).
 - Recent studies indicate lower efficiency in QCD so we may need to loosen this cut.



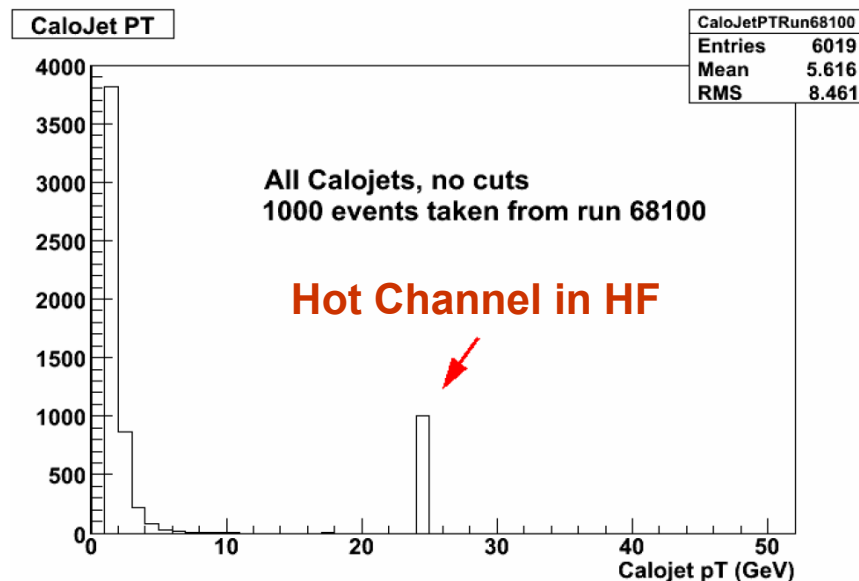
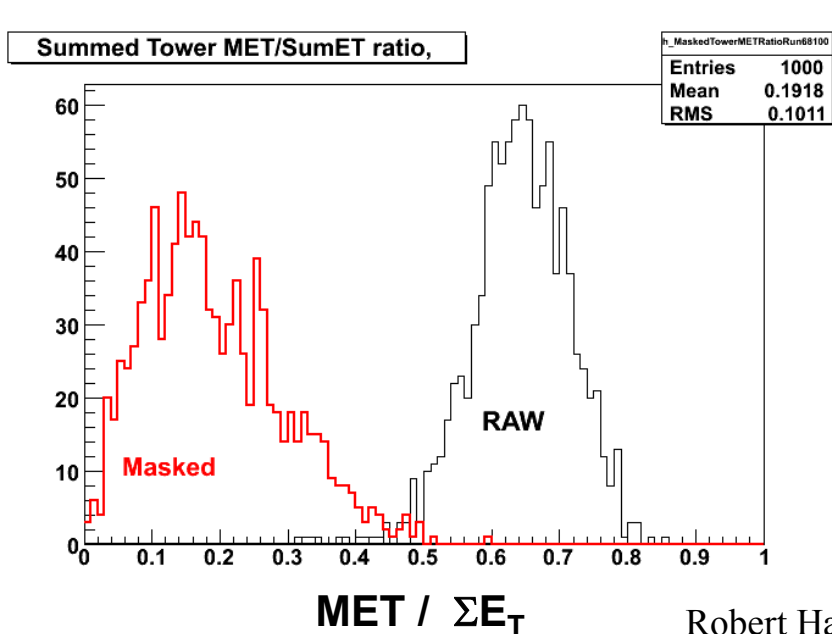


Inclusive Jet Cross Section

(Dave Mason & Pratima Jindal)



- Started studying $MET / \Sigma E_T$ in global run data again.
 - Run 68100 demonstrated a problem causing large MET.
 - Discovered that raw $MET / \Sigma E_T$ was unusually large for every event!
 - Only expected occasional large MET.
 - Caused by a single hot channel in the HF: 25 GeV P_T jet every event!
 - Masking the hot channel in the analysis offline improves $MET/\Sigma E_T$.
 - Cleanup will be required before we can even use MET to reject events!





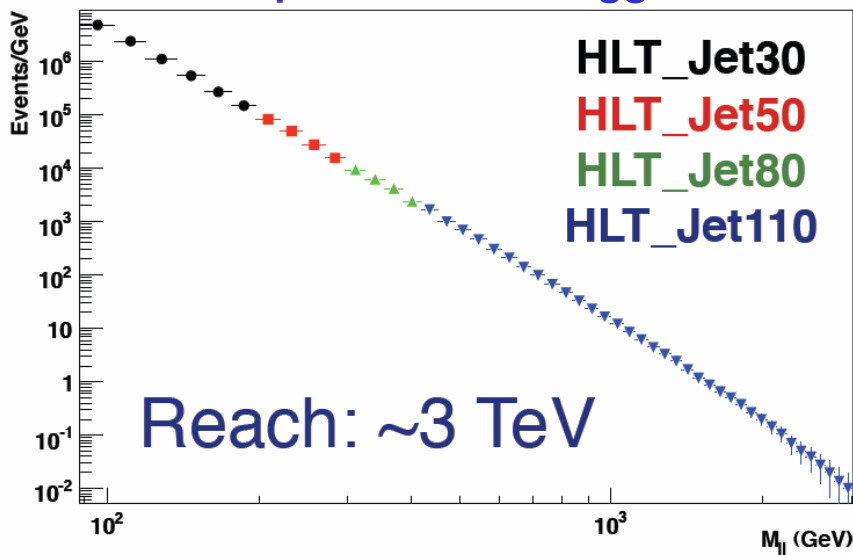
Dijet Mass

(Kostas Kousouris)

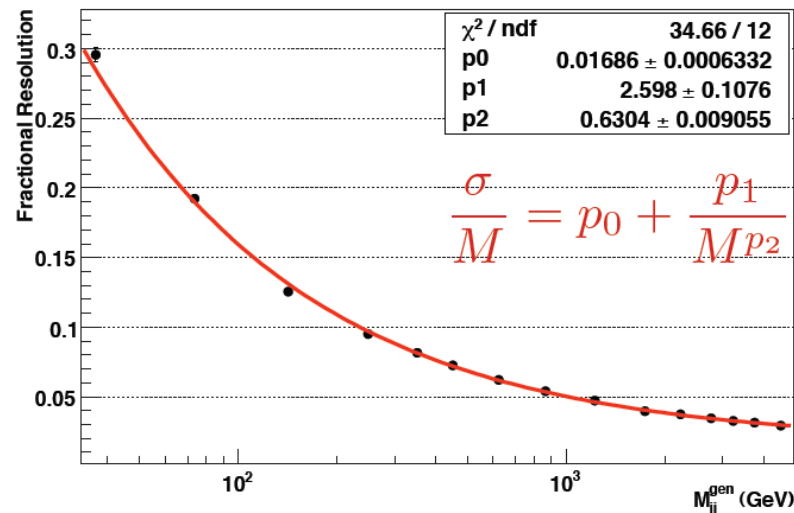


- Mass Spectrum Measurement
 - ➔ Pythia Summer08 fullsim at 10 TeV
 - ➔ Find two leading jets with $|\eta| < 1.3$
 - ➔ Correct jet energy vs η and p_T
 - ➔ Combine jet triggers for spectrum
 - ➔ Mass reach for 10 pb⁻¹ is 3 TeV
 - ➔ Resolution for SIScone R=0.7
 - ➔ Resolution unsmearing is small

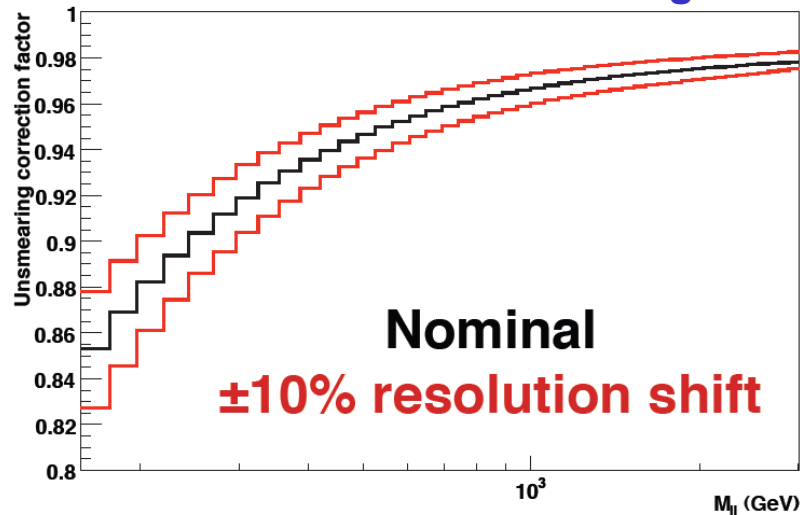
Spectrum and Triggers



Resolution



Resolution Unsmearing





Dijet Mass

(Kostas Kousouris)



- Theory & Experiment Uncertainties

- PYTHIA compared with LO & NLO

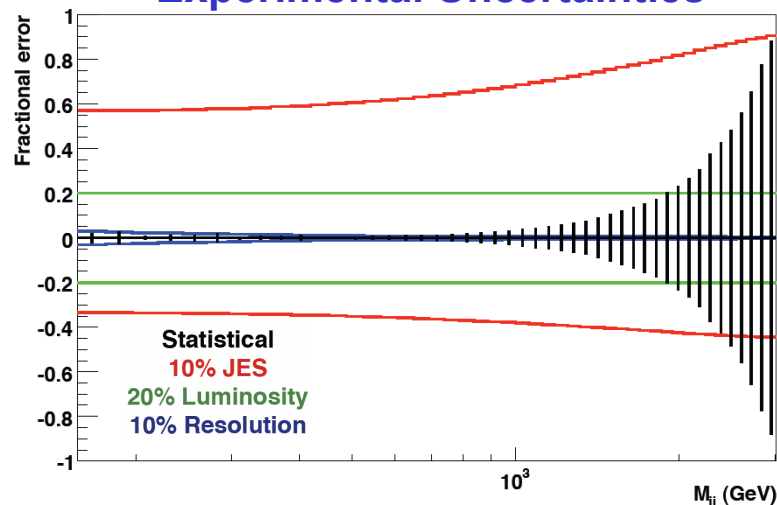
- K. Hatakeyama using NLOJET++

- ~20-40% variations due to hadronization and higher orders

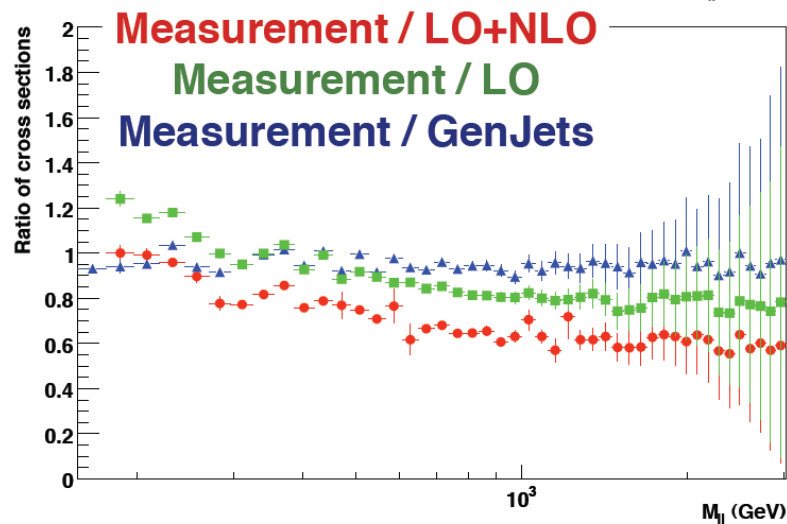
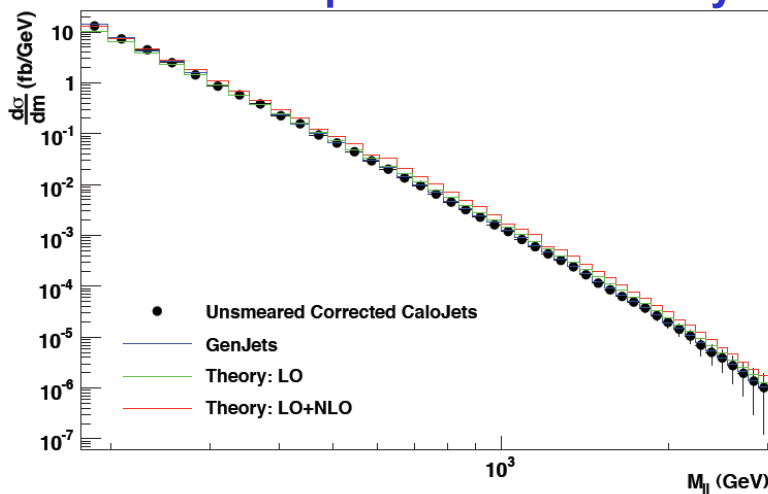
- Experimental error dominated by Jet Energy Scale

- Unsmearing uncertainty small.

Experimental Uncertainties



Corrected Spectrum and Theory



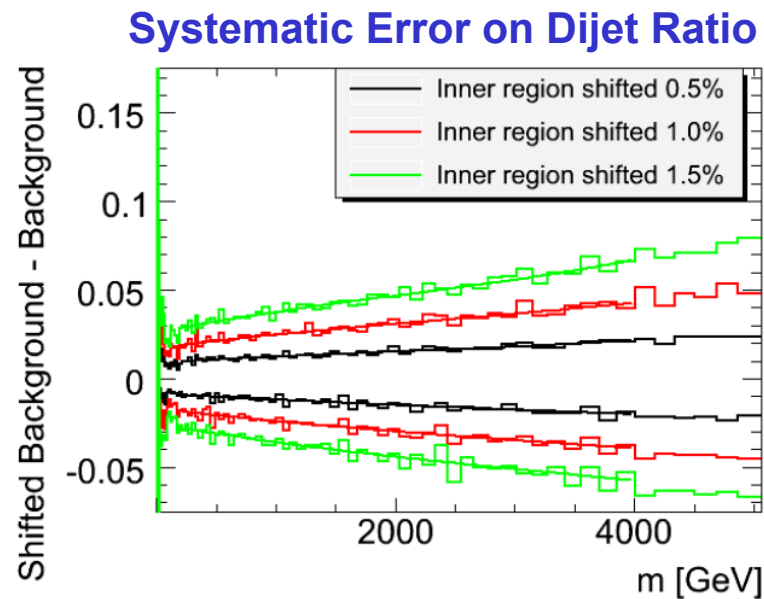
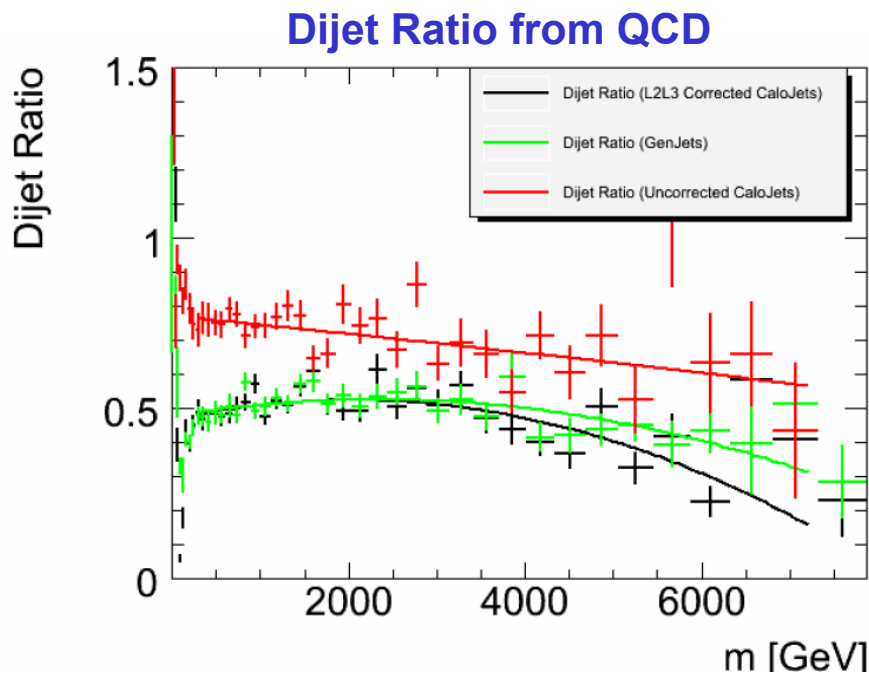


Dijet Ratio

(Daniel Miner)



- Dijet Ratio = $N(|\eta| < 0.7) / N(0.7 < |\eta| < 1.3)$
 - Small systematic uncertainties and sensitive to angular distributions
 - Same sample, algorithm and mass binning as dijet mass analysis.
 - Dijet ratio from corrected calojets agrees with GenJets and is ~ 0.5
 - Systematic uncertainty due to relative jet energy scale in barrel is small





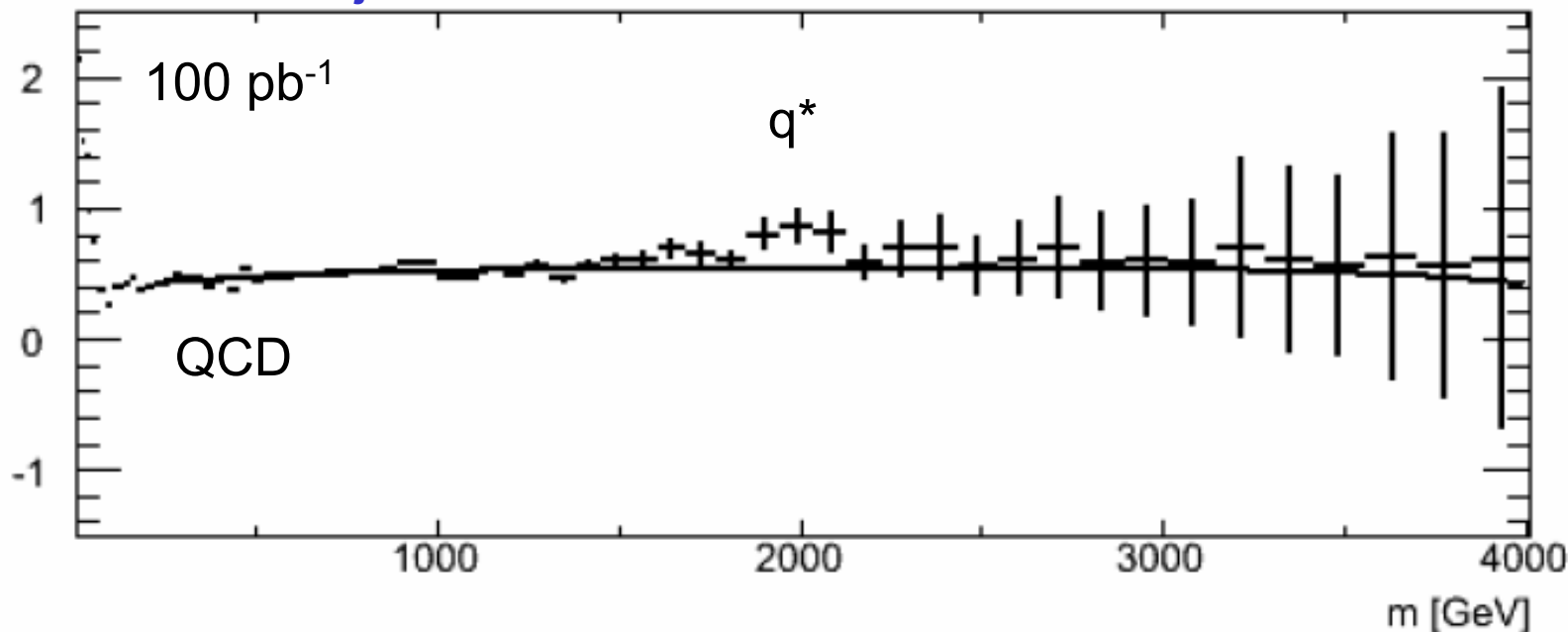
Dijet Ratio

(Daniel Miner)



- Dijet Resonances with Dijet Ratio
 - 2 TeV q^* resonance produced in summer08 fullsim sample
 - Pure signal has dijet ratio of 2, QCD has dijet ratio of 0.5
 - Combined signal and QCD has dijet ratio shown below
 - Statistical error bars are for 100 pb^{-1} ; points below fluctuate with MC statistics.
 - Signal shown is likely near the edge of our statistical sensitivity (work ongoing).

Dijet Ratio from QCD and 2 TeV Excited Quark





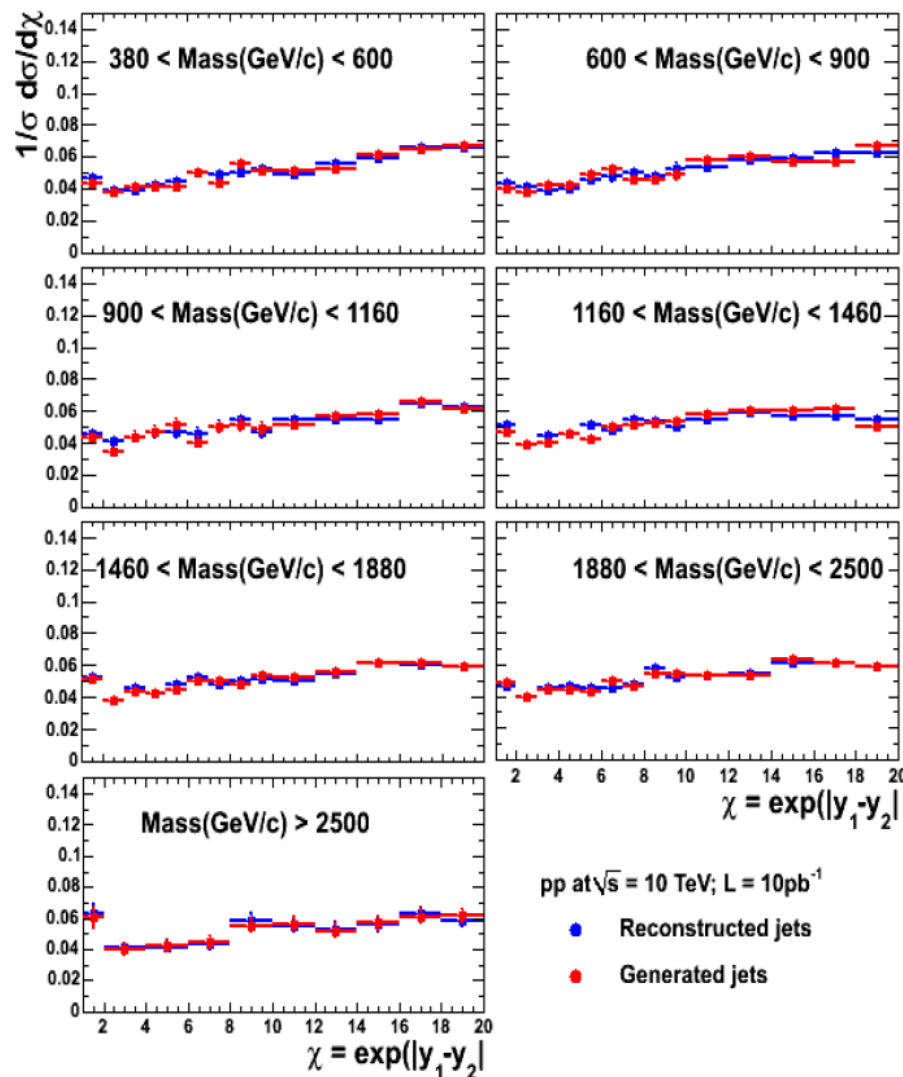
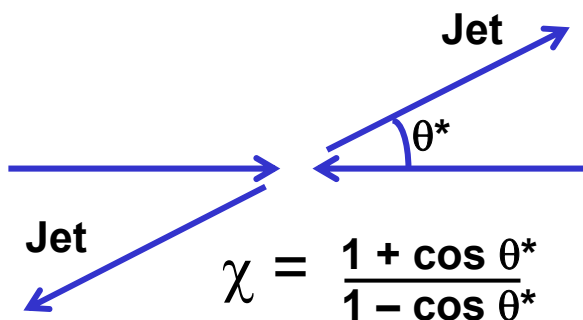
Dijet Angular Distribution

(Agata Smoron, Len Apanasevich, Nikos Varelas)



- Angular distribution $dN/d\chi$
 - From CSA08 samples
 - Uses data in barrel & endcap.
 - Reconstructed and generated distribution are in good agreements

Center of Momentum Frame



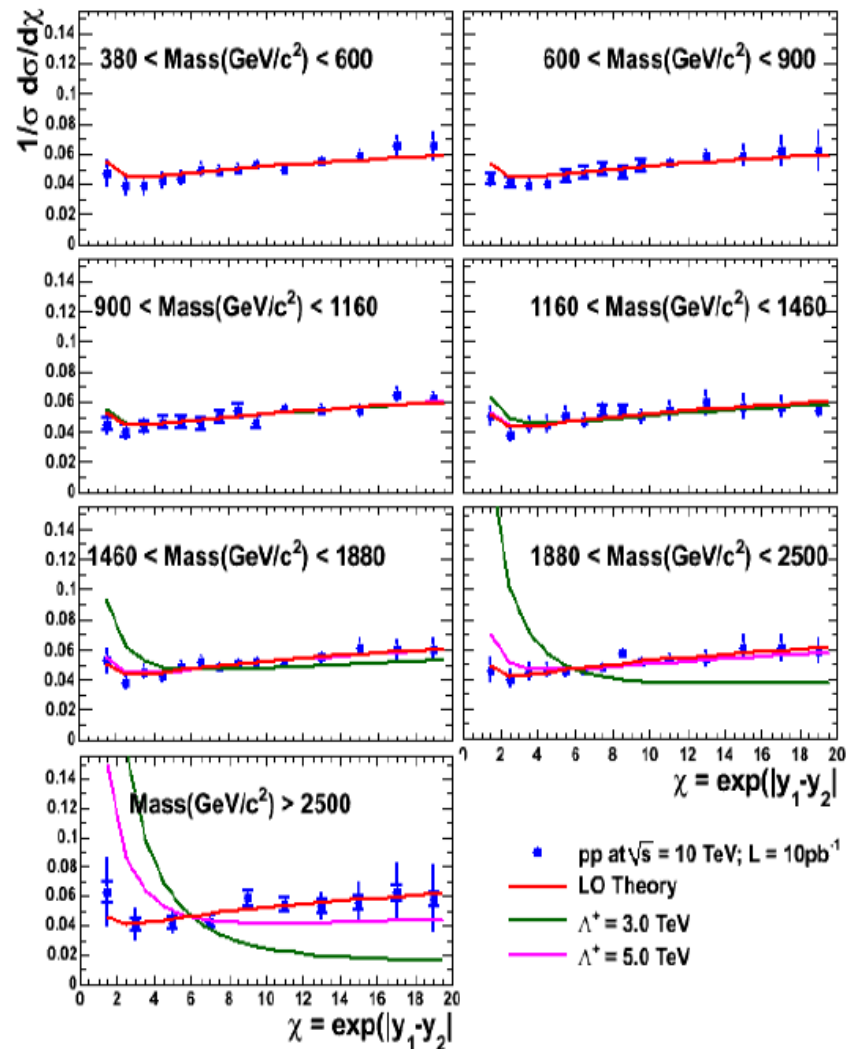


Dijet Angular Distribution

(Agata Smoron, Len Apanasevich, Nikos Varelas)



- QCD test
 - Statistical errors with 10 pb^{-1}
 - Early estimates of systematic errors are also shown
 - PYTHIA compares well with LO QCD
- Contact Interaction Search
 - Contact interaction is more isotropic than QCD
 - Produces more events at low χ .
 - Can clearly discover a $\Lambda^+ = 3 \text{ TeV}$ contact interaction with only 10 pb^{-1} at $\sqrt{s} = 10 \text{ TeV}$
 - Best D0 limit is $\Lambda^+ > 2.7 \text{ TeV}$ from the dijet ratio in run 1.
 - Preliminary CDF and D0 run 2 results using the angular distribution are not better . . .



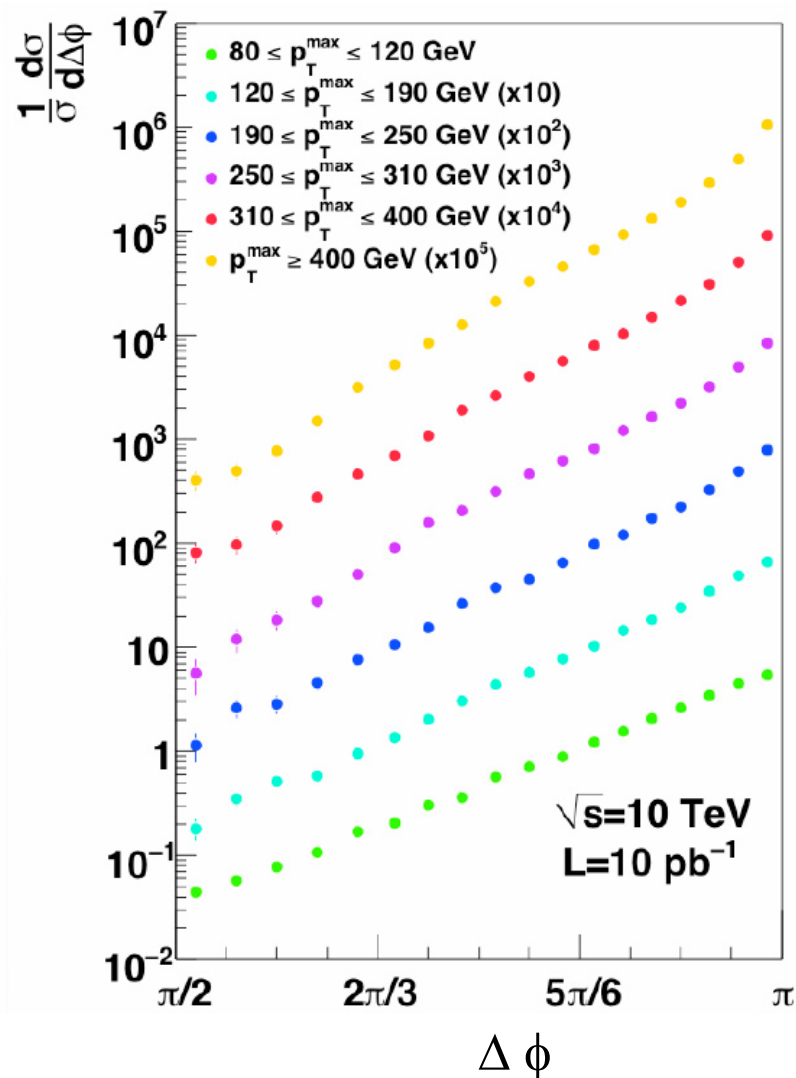


Dijet Azimuthal Decorrelation

(Cosmin Dragoiu, Len Apanasevich, Nikos Varelas)



- $\Delta\phi$ of the leading two jets
 - Sensitive to the presence of initial and final state radiation
 - Provides test of NLO QCD and a good measurement to tune the amount of radiation in the MC
- Analysis
 - CSA08 sample, SISCone $R=0.5$ jets.
 - Six p_T bins of the leading jet
 - No cut on the 2nd jet p_T
 - Requires $|y| < 1.1$ for both jets
- Systematics
 - Insensitive to CMS jet position resolution.
 - Some sensitivity to jet energy resolution for jet $p_T < 250$ GeV
 - Causes switching between 2nd and 3rd jet, giving smaller $\Delta\Phi$.



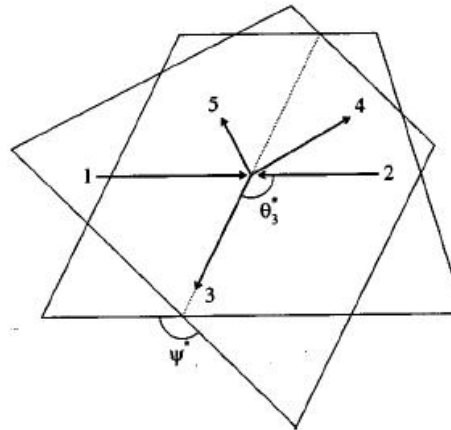


Multijet QCD Studies (Sudaveep Bose)

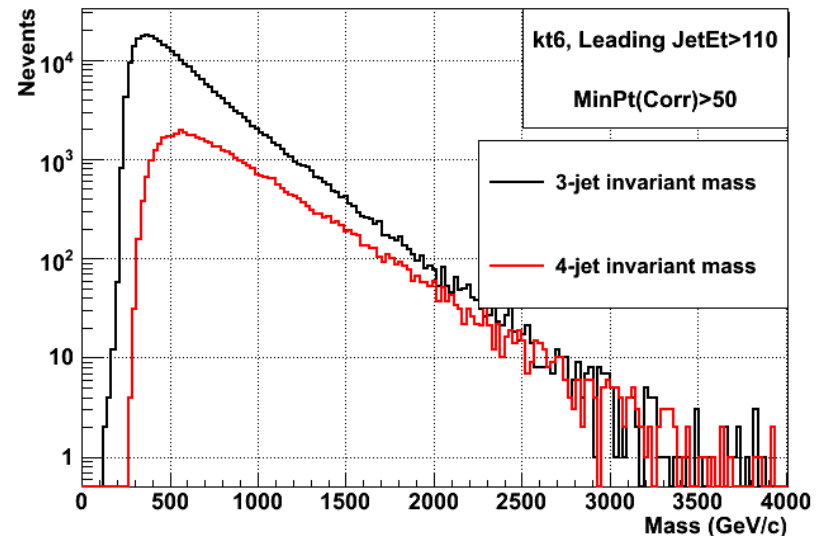
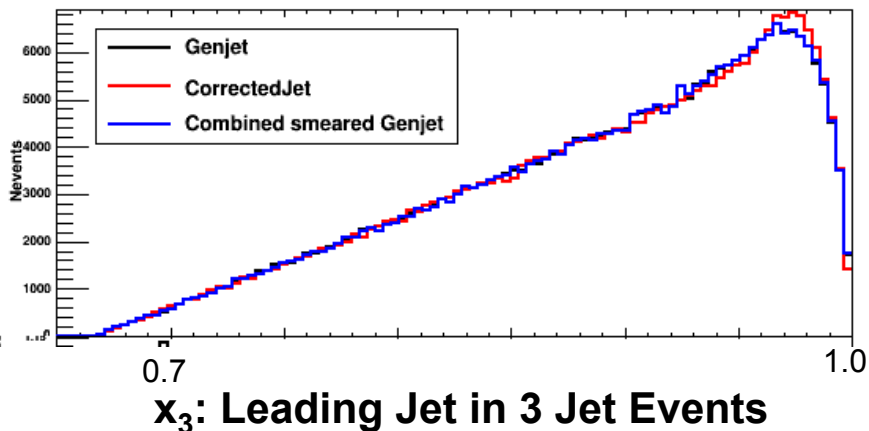
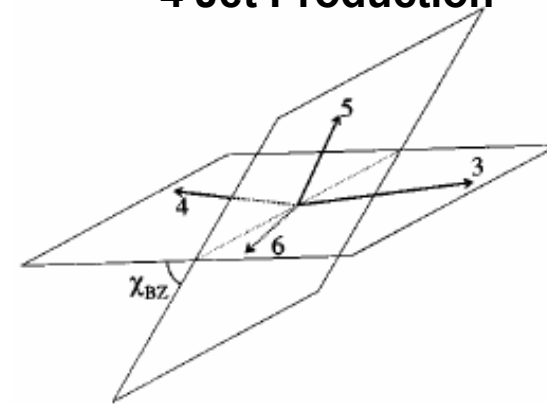


- Full analysis of 3 and 4 jet system underway
 - Scaled energies of jets in the CM frame: $x_i = 2E_i/\text{Mass}$
 - All angles.
 - Requires lead jet $p_T > 110$ GeV and every other jet to have $p_T > 50$ GeV
 - Currently studying systematic effects.

3 Jet Production



4 Jet Production



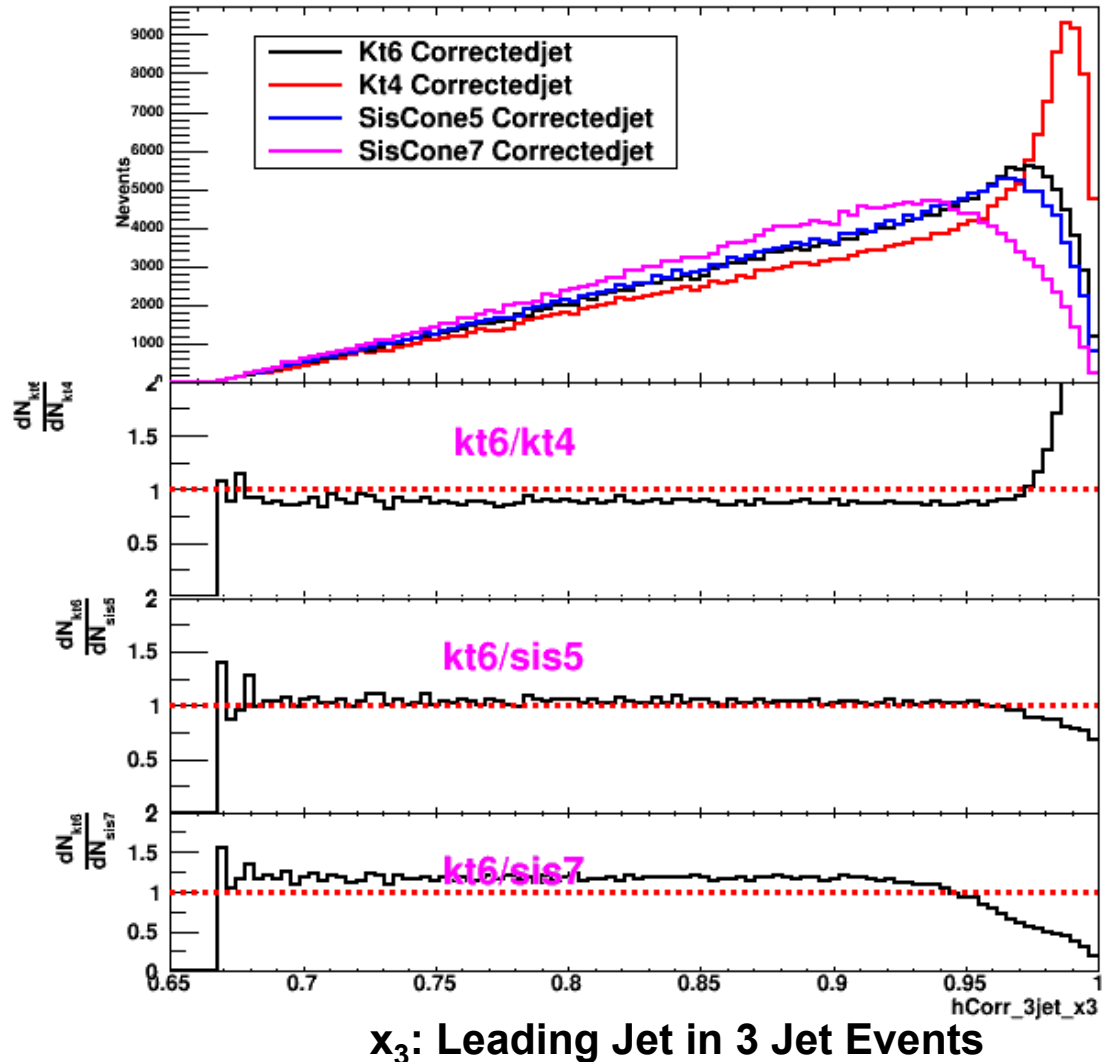


Multijet QCD Studies (Sudaveep Bose)



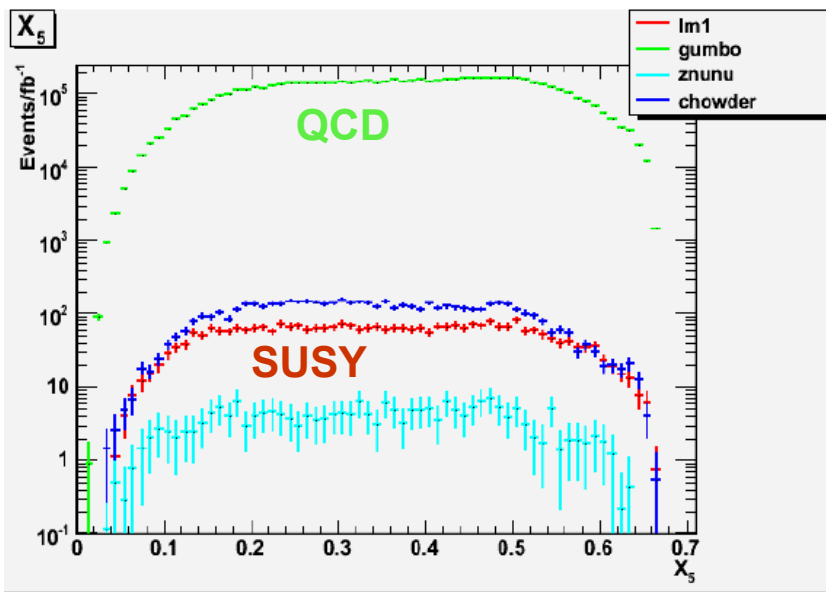
- Algorithm Dependence

- Scaled energies after jet corrections are sensitive to jet algorithm choice
- Some unexpected results on correspondence between K_T and Siscone
 - Here K_T with D parameter 0.6 looks like Siscone with $R=0.5$
 - For Dijet system K_T with D parameter 0.4 looks like Siscone with $R=0.5$

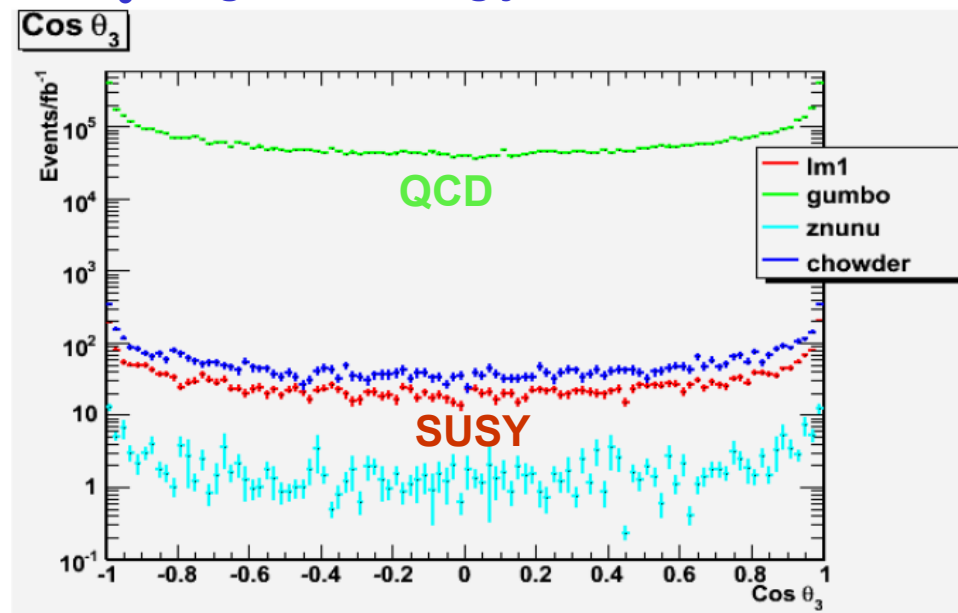


- Comparison of the Multijet variables for SUSY & Background
 - ➔ Hoping to find additional variables to help isolate signal
 - ➔ All the standard multijet variables look similar for SUSY & Background

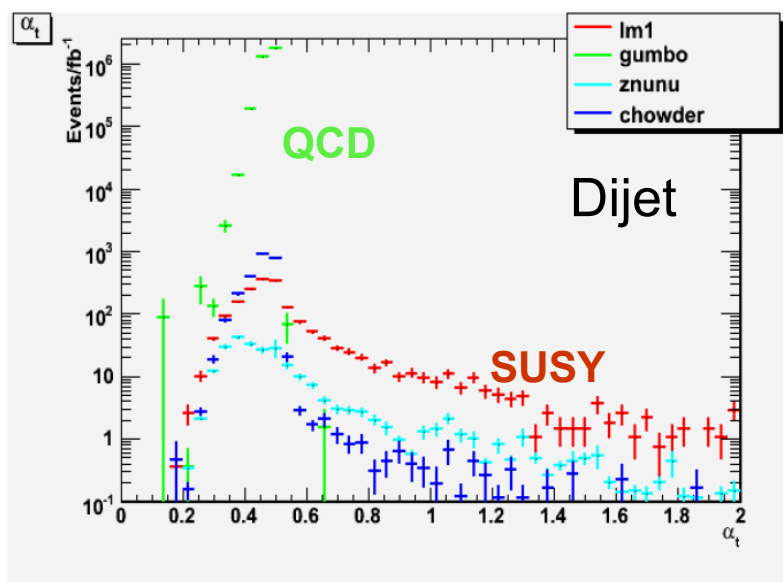
x_5 : Least Energetic Jet in 3 Jet Events



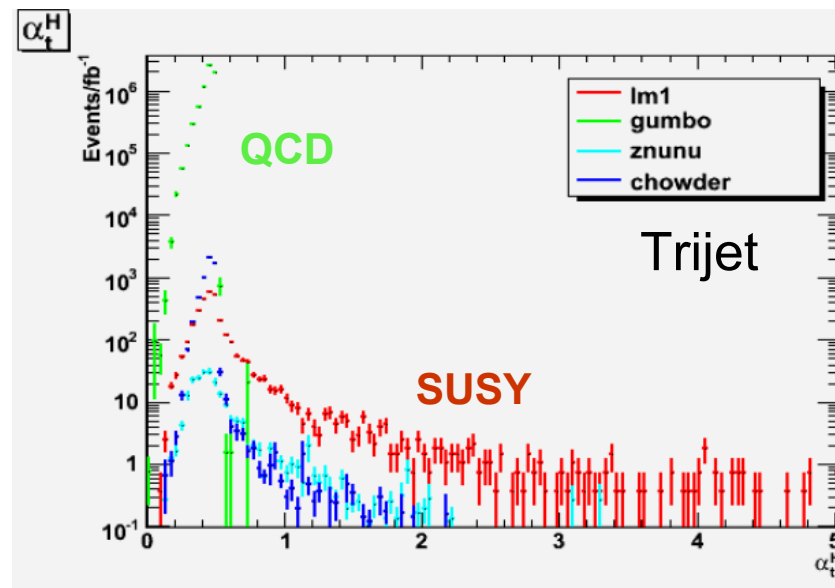
$\text{Cos } \theta_3$: Angle of leading jet in 3 Jet Events



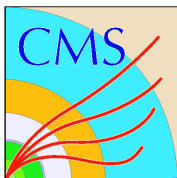
- α and α_T variable for multijet system
 - The variable α and α_T for dijets has been shown to discriminate SUSY from QCD without using MET.
 - This can be extended to the multi-jet system (3 or greater).
 - By combining the smaller jets to get a dijet system.
 - Many methods of combining the smaller jets were studied.



$$\alpha_T = E_{T2} / M_T$$



α_T using hemispheres

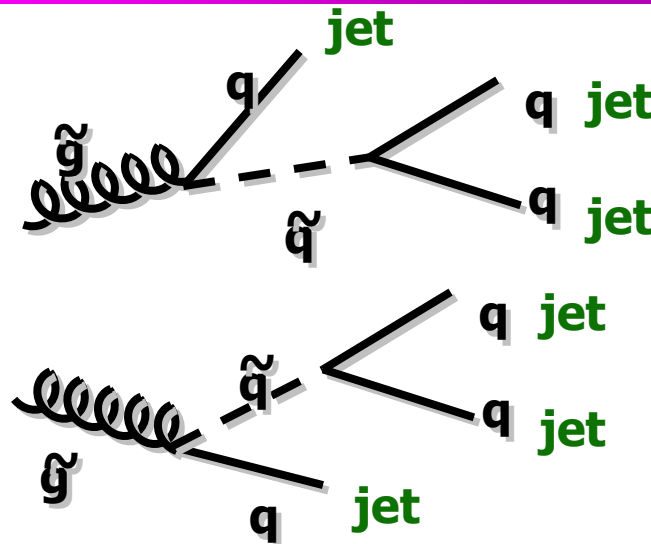


Multijet Resonances

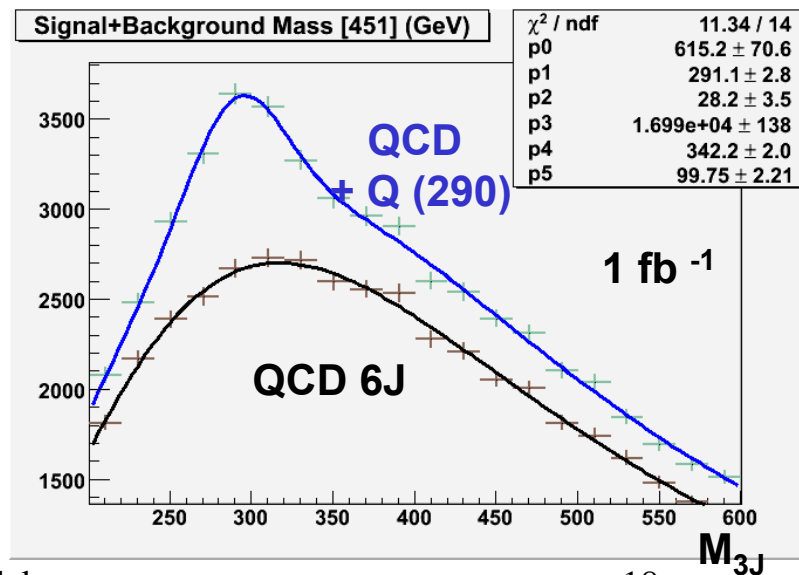
(Amitabh Lath)

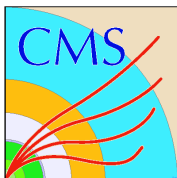


- Pair production of particles Q
 - Each Q decays to 3 jets.
 - $pp \rightarrow Q Q \rightarrow 3j+3j = 6j$
 - Modeled with PYTHIA gluino pair production followed by r-parity violating decays (No MET)
 - They investigate a few masses for Q
 - Model QCD background with Alpgen



- Selection for $M_Q = 290$ GeV
 - Six jets with $p_T > 60$ GeV & $|\eta| < 3$
 - $\Sigma p_T (6J) > 600$ GeV
 - Form all pairs of 3 jets
 - Require each Q decay be boosted
 - $\Sigma p_T (3J) > M_{3J} + 200$ (combinatorics)
 - Convincing $s/\sqrt{b} = 15$ for 1 fb^{-1}
 - Marginal $s/\sqrt{b} = 5$ for 100 pb^{-1}



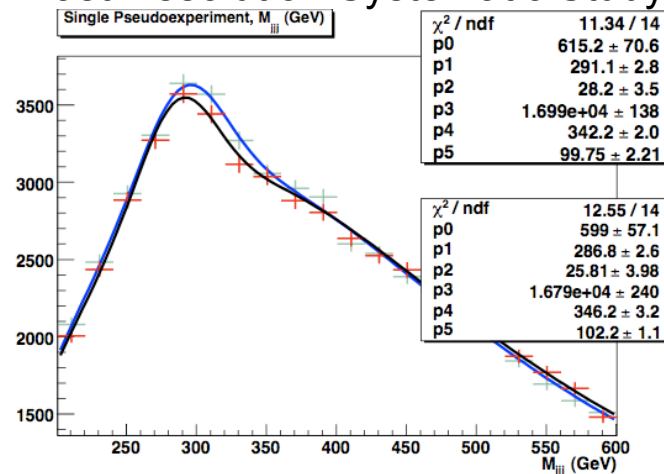


Multijet Resonances (Amitabh Lath)

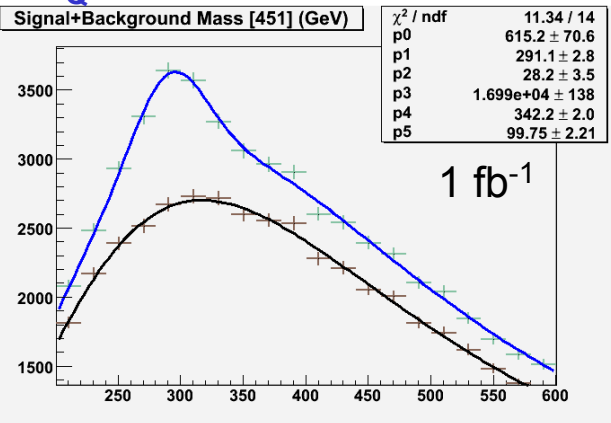


- Higher mass resonances also give signals over QCD
 - However currently need to tailor the cuts for each resonance in order to beat down the combinatorics.
- Also studying systematic uncertainties on QCD & jet resolution

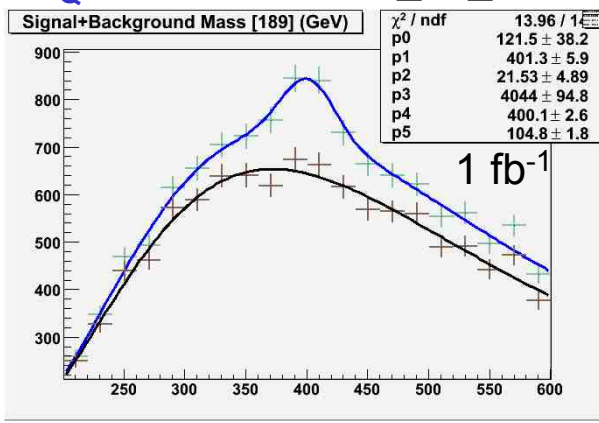
Jet Resolution Systematic Study



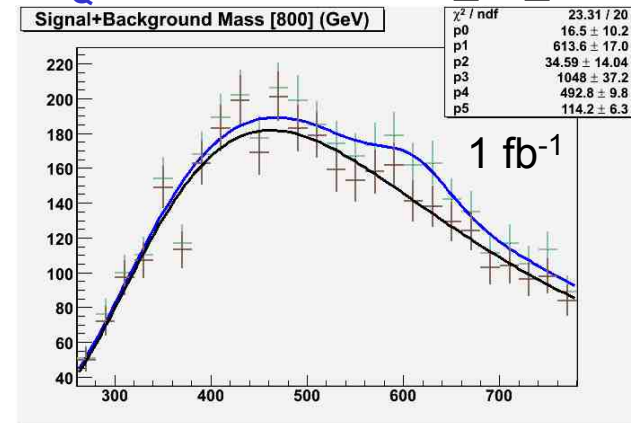
$M_Q=290$ Cuts: 600_60_200



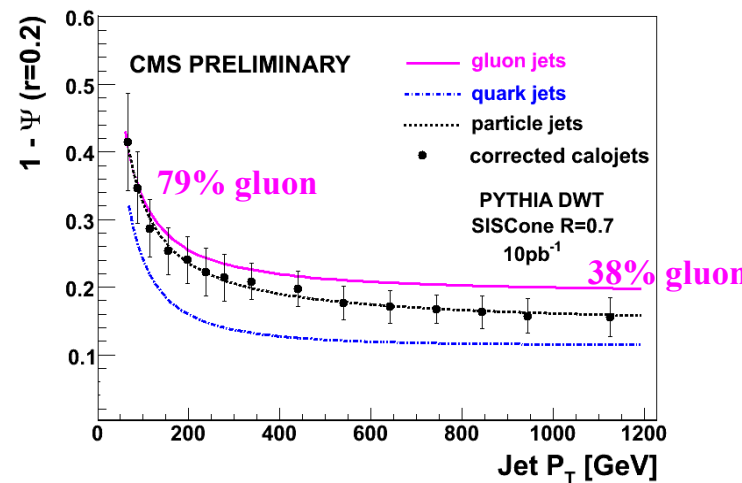
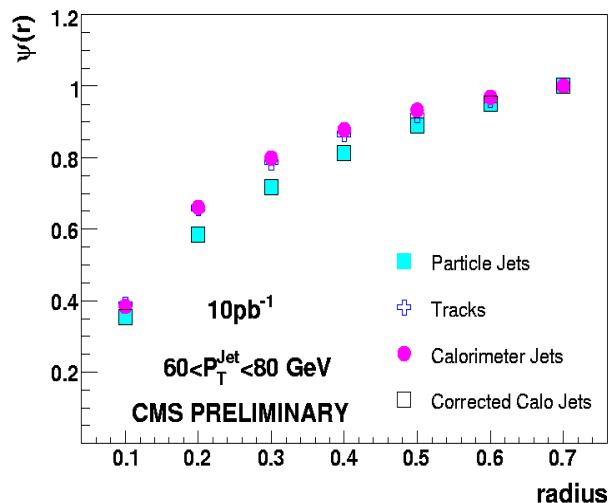
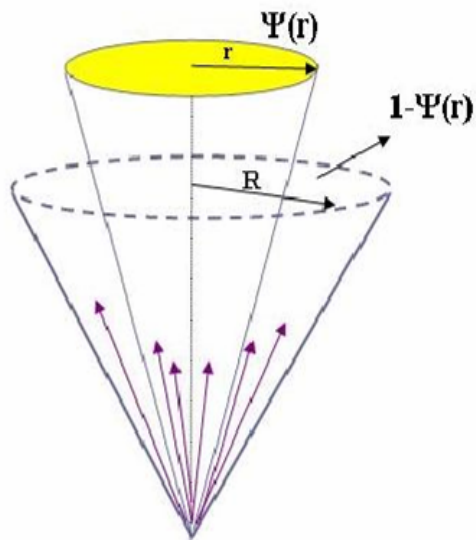
$M_Q=420$ Cuts: 700_90_200



$M_Q=660$ Cuts: 1100_90_300



- Presentation of mature and approved CMS analysis.
 - $\Psi(r)$ = average fraction of jet energy in a cone of radius r .
 - Jet shapes are in good agreement for GenJets and Corrected Jets
 - After generic jet corrections and special jet shape corrections.
 - The jet shape gets narrower with increasing jet p_T
 - Partly because parton showers are more collimated with increasing p_T .
 - Partly because the number of gluon initiated jets decreases.
 - Much more in the talk, including new results from NLOJET++.





Conclusions



- CMS has been studying the classic QCD tests and searches for new physics with dijets.
 - Inclusive Jet p_T
 - Dijet Mass Measurements.
 - Dijet Angular Measurements.
- CMS is just beginning to study multijet physics.
 - Basic QCD tests, searches for resonances and supersymmetry.
- But there is still a lot to do and all topics need help!!
 - We welcome new ideas and new people.
 - Join us at Dijet Topology Group meetings alternate Tuesdays at 1:30.
 - We are integrated into the CMS JetMET, QCD and Exotica groups.
 - We have a proven record of getting results approved at CMS.
 - Pick an analysis and get involved !