

Jet Reconstruction Algorithms & Performances at CMS

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OutLine

- Different approaches to reconstruct jets at CMS
- Different jet clustering algorithms
 - Definition
 - Performance
- Anti-kt jet: proposed by the JetMET POG
 - Definition
 - Performance
- Outlook & ToDoList

Three Different Approaches to Reconstruct Jets at CMS

- ❑ **Calorimeter jet** reconstruction based only on the energy deposits in the calorimeters
- ❑ **Jet-Plus-Track** algorithm which improves the energy measurement of calorimeter jets by exploiting the kinematics of tracks associated to them
- ❑ **Particle Flow** reconstruction which attempts to reconstruct and calibrate each particle individually combining the information from all sub-detectors prior to the formation of jets

Different Reconstruction Algorithms at CMS

❑ Iterative Cone

- An E_t -ordered list of input objects is created
- A cone of size R is cast around the leading object(seed) above a specified threshold
- The objects inside the cone are used to calculate a proto-jet using E_t -scheme :

$$E_t = \sum E_{ti}, \quad \eta = \frac{\sum E_{ti} \eta_i}{E_t}, \quad \phi = \frac{\sum E_{ti} \phi_i}{E_t}$$

- This proto-jet is used to seed a new proto-jet
- The procedure is repeated until the energy (less than 1%) and direction (0.01) of the proto-jet changes a bit between iterations

❑ Inclusive K_t

- A cluster-based jet algorithm
- Starts with a list of input objects
- For each object l and each pair (i,j) the following distances are calculated:

$$d_i = (E_{ti})^2 * R^2, \quad d_{ij} = \min\{(E_{ti})^2, (E_{tj})^2\} * R_{ij}^2$$

- The algorithm searches for the smallest d_i or d_{ij}
- If d_{ij} is minimum the objects i and j are merged and added to the list of input objects
- If d_i is minimum the object i is saved as a final jet
- The procedure is repeated until no more object is available
- For all final jets i and j we have $R_{ij} > R$

□ Seedless Infrared Safe Cone

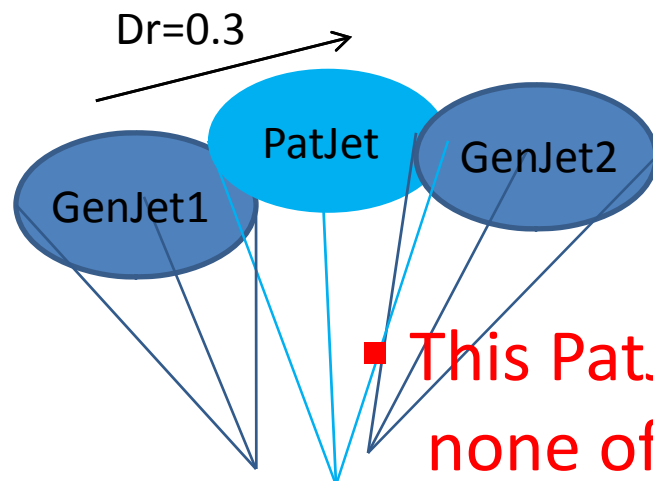
- In contrast to IC, SC searches for all possible stable cones
- The algorithm first finds all the stable cones
 - For a given particle i , loop over all particles j with $DR(i, j) < 2R$, find two circles determined by the pair i, j and test for their stability
 - For a given circle, its four-momentum is the sum of all the enclosed particles four-momenta
 - A circle is stable if the same set of particles is enclosed by the circle of radius R centered at its four-momentum
 - A stable circle is added to the list of proto-jets
- Then these stable cones are split/merged

Collinear Safety in Different Jet Algorithms

List of Objects	IC5 Jets	Kt4 Jets	Anti-Kt5
1- 130 GeV, 0 2- 200 GeV, 0.35 3- 70 GeV, 0.75	1- 400 GeV, 0.3	1- 70 GeV, 0.75 2- 330 GeV, 0.2	1- 330 GeV, 0.2 2- 70 GeV, 0.75
After Collinear Decomposition			
1- 130 GeV, 0 2- 120 GeV, 0.35 3- 80 GeV, 0.35 4- 70 GeV, 0.75	1-330 GeV, 0.2 2- 70 GeV, 0.75	1- 70 GeV, 0.75 2- 330 GeV, 0.2	1- 330 GeV, 0.2 2- 70 GeV, 0.75

✓ **IC5 jet algorithm is not collinear safe!**

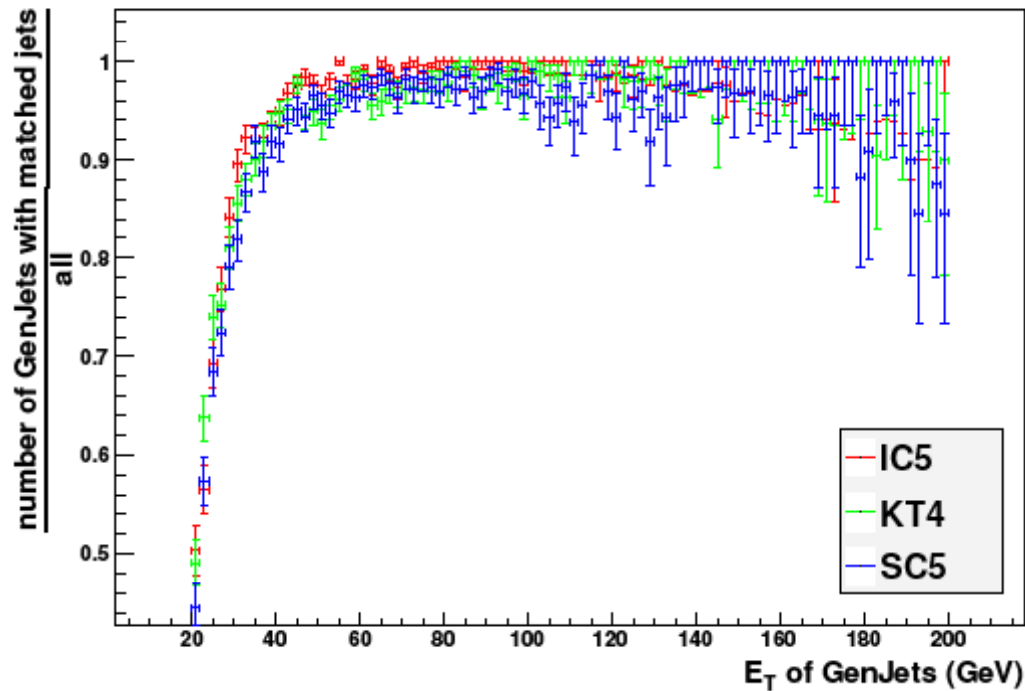
- Release: CMSSW_3_1_2
- DataSample: Semi Leptonic (e or m)TTbar events selected from RelValTTbar events at Gen Level
- To evaluate the performance of any jet reconstruction algorithm, a matching criteria should be defined
- GenJets are matched to PatJets such that no two GenJets are paired with PatJet in a distance less than 0.3 and vice versa



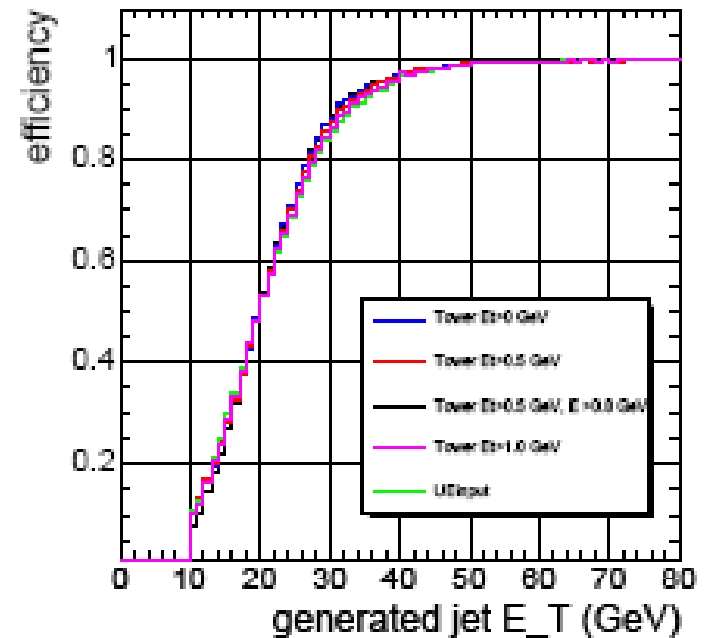
- This PatJet is not matched with none of GenJets!

Jet Reconstruction Efficiency Vs Et of GenJets

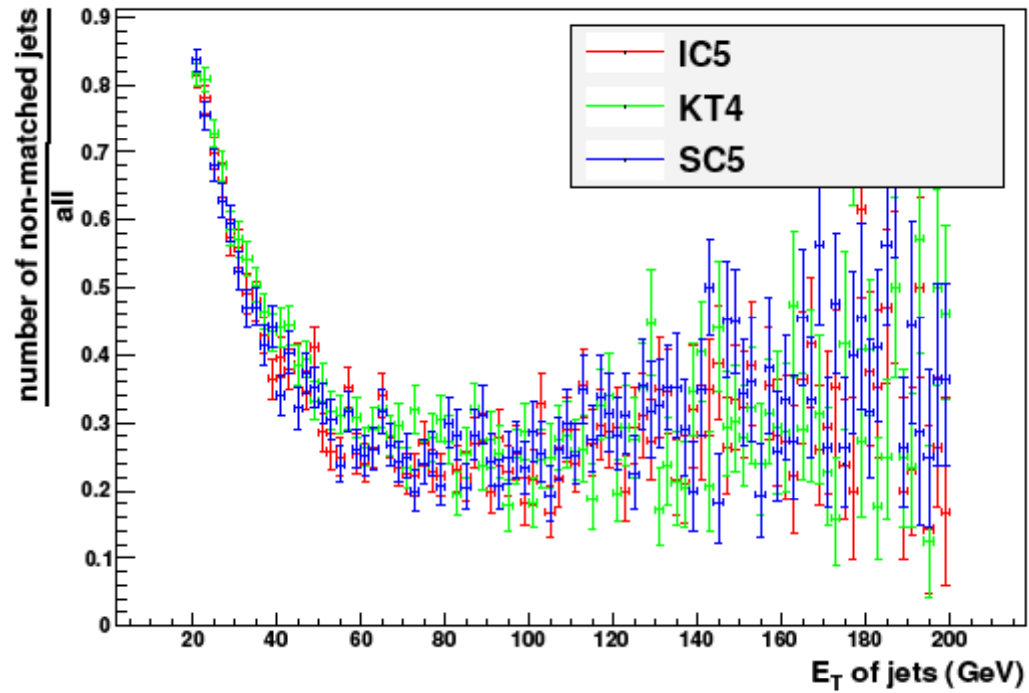
SemiLeptonic(electron or muon) TTbar sample



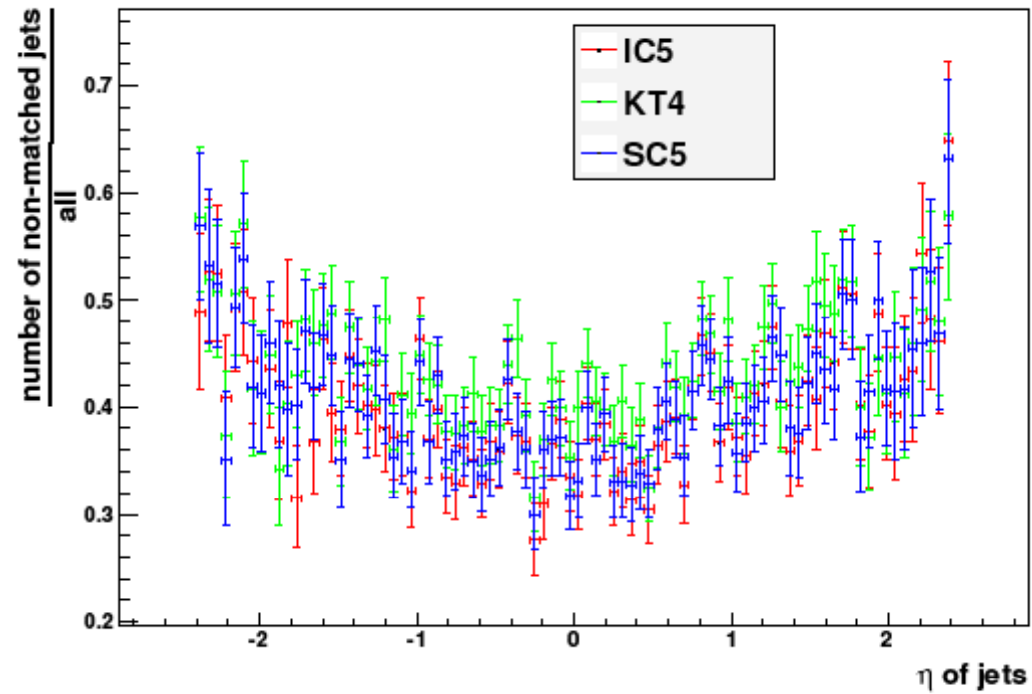
QCD DiJet sample



Instrumental Background Rate Vs Et of Jets

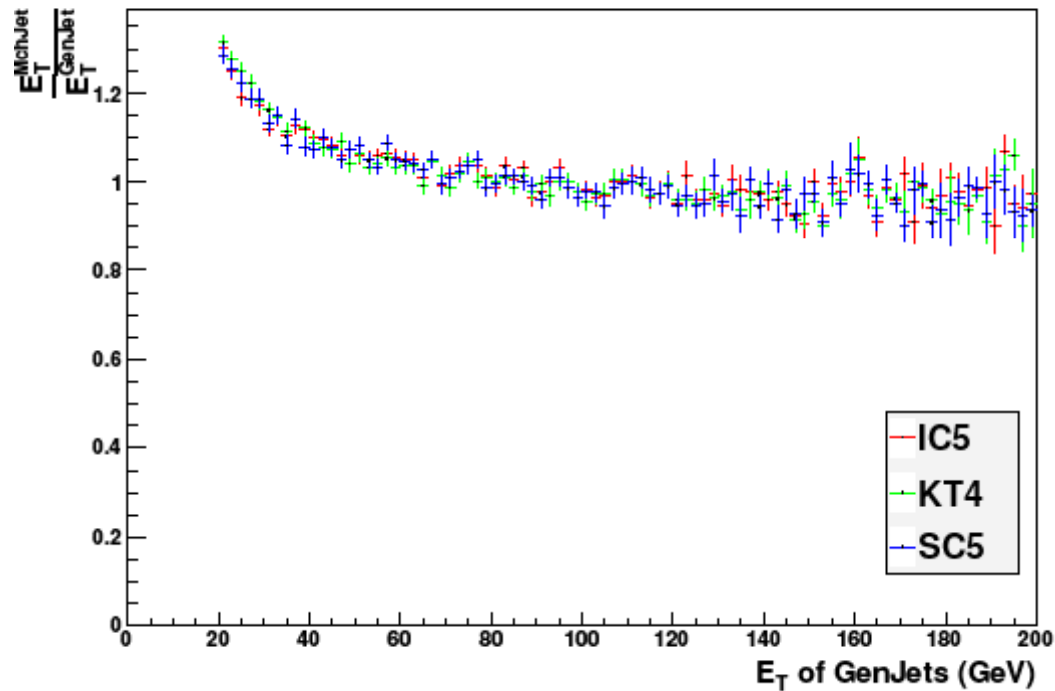


Instrumental Background Rate Vs η of Jets

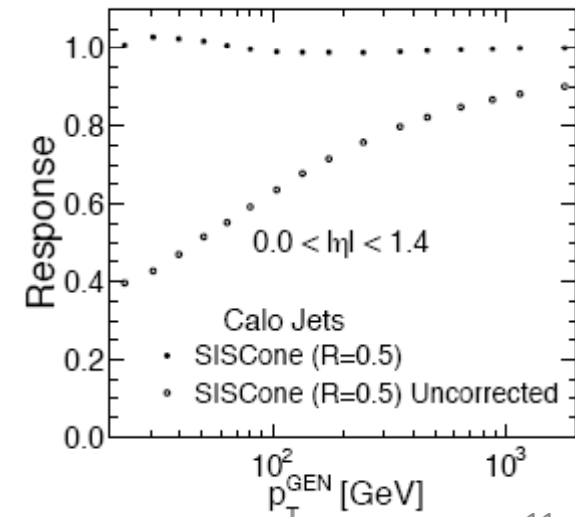


Jet Response Vs Et of GenJets

SemiLeptonic(electron or muon) TTbar sample

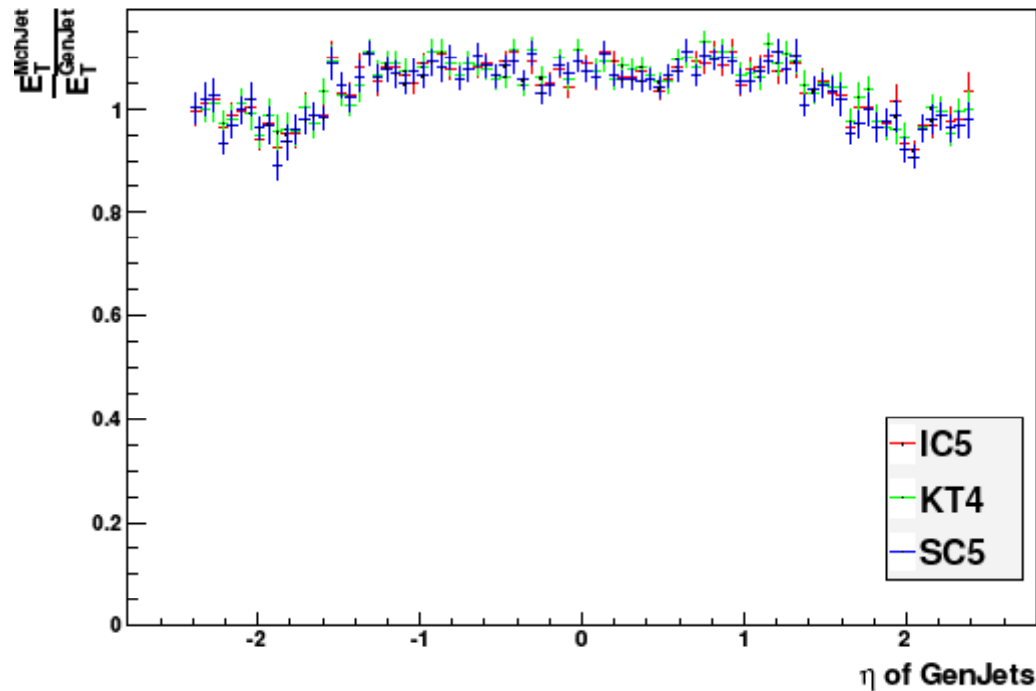


CMS AN -2009/067
QCD DiJet sample

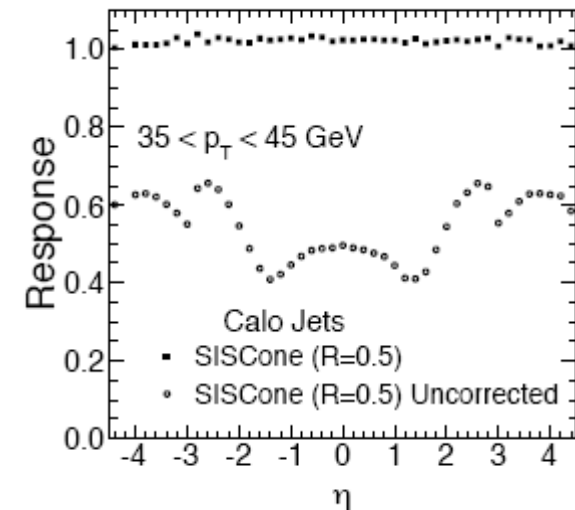


Jet Response Vs η of GenJets

SemiLeptonic(electron or muon) TTbar sample

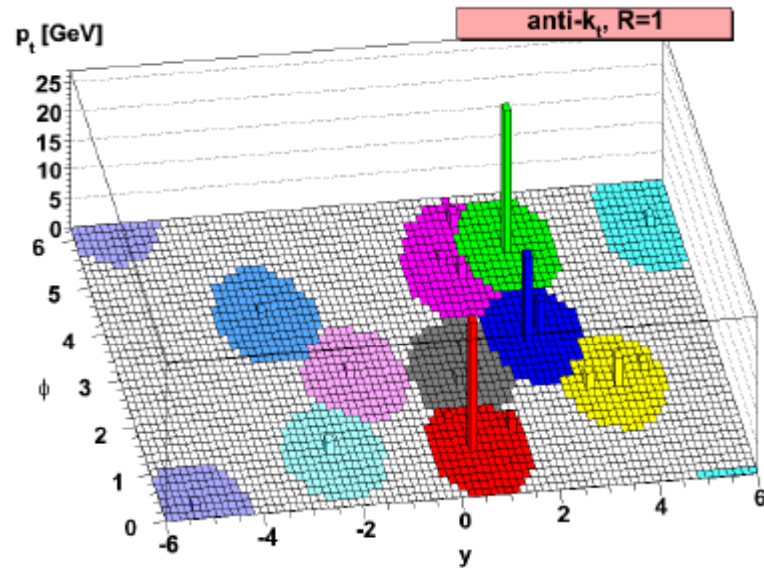
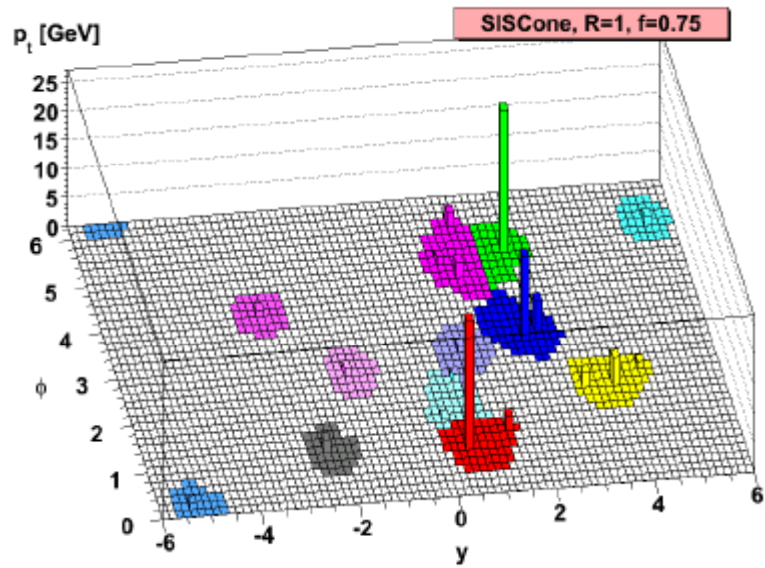
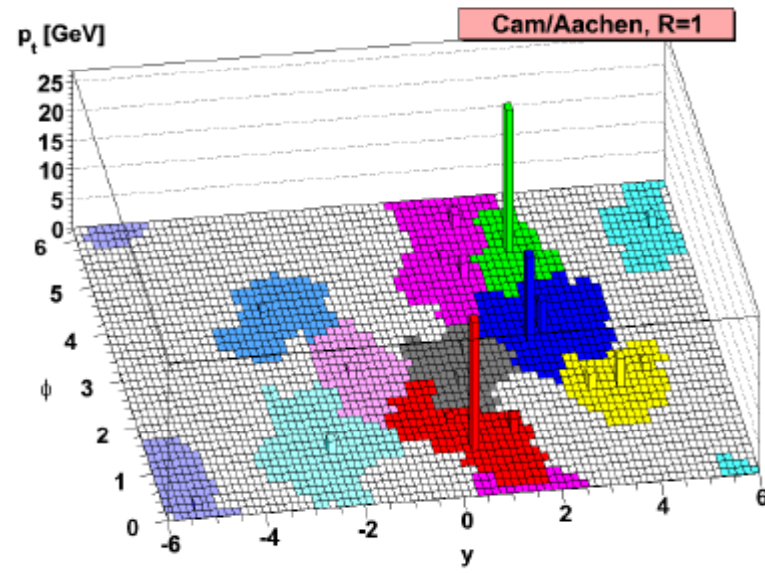
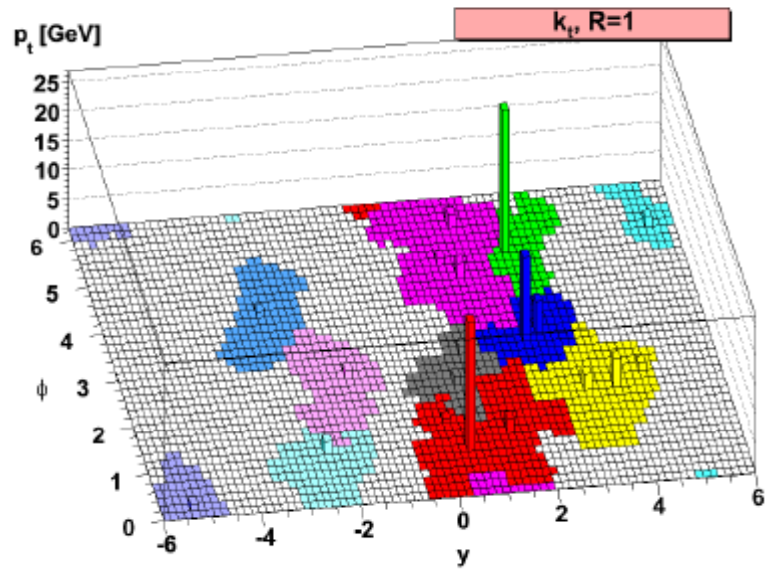


CMS AN -2009/067
QCD DiJet sample



Anti-kt Jet Algorithm

- Define:
 - $d_i = (E_{Ti})^{2p}$,
 - $d_{ij} = \min\{(E_{Ti})^{2p}, (E_{Tj})^{2p}\} * R_{ij}^2 / R^2$
- R_{ij} is defined in (y, ϕ) space not (η, ϕ)
 - $p=1$: Kt algorithm
 - $p=0$: Cambridge/Aachen algorithm
 - $p=-1$: Anti-kt algorithm
- Soft particles tend to cluster with hard ones long before they cluster among themselves
- Key feature: Soft particles do not modify the shape of the jet, while hard particles do
 - jet boundary is resilient w.r.t. soft radiation
 - jet boundary is flexible w.r.t. hard radiation

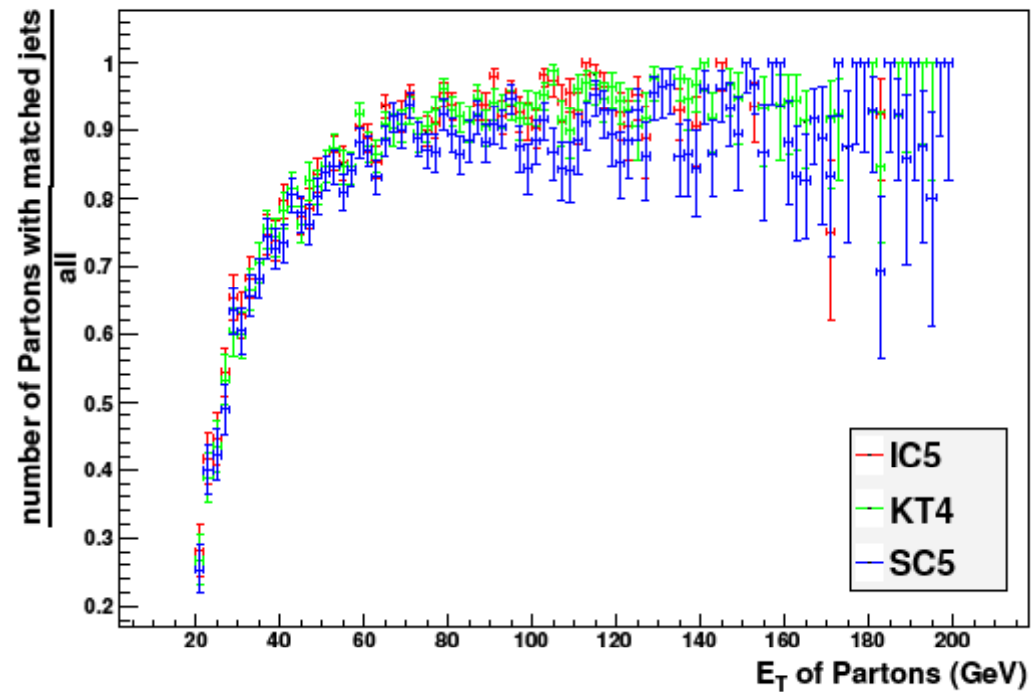


OutLook & ToDoList

- Run on more statistics based on CMSSW_3_3_X using AK
- Learn the JEC strategies at CMS
- JER
 - What is it
 - How to calculate
 - Where do they enter
 - How are they applied
- Optimizing cuts on jets E_t and η for the further use in my analysis
- Jet-Parton matching or Jet-GenJet matching, which one is the best way to do the matching?

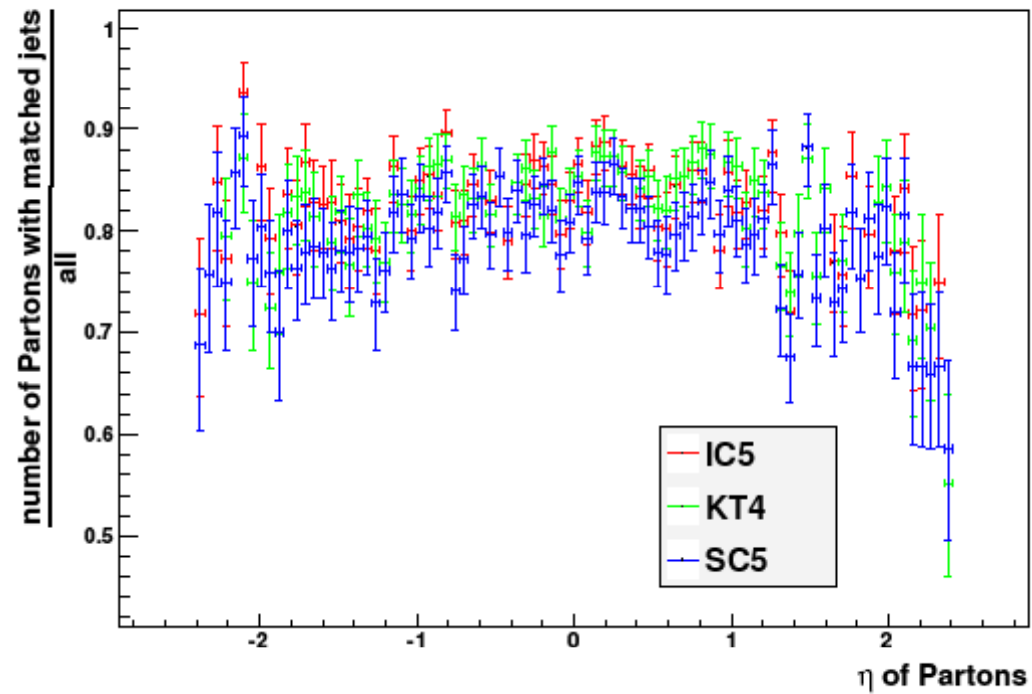
Jet Reconstruction Efficiency Vs Et of Partons

SemiLeptonic(electron or muon) TTbar sample

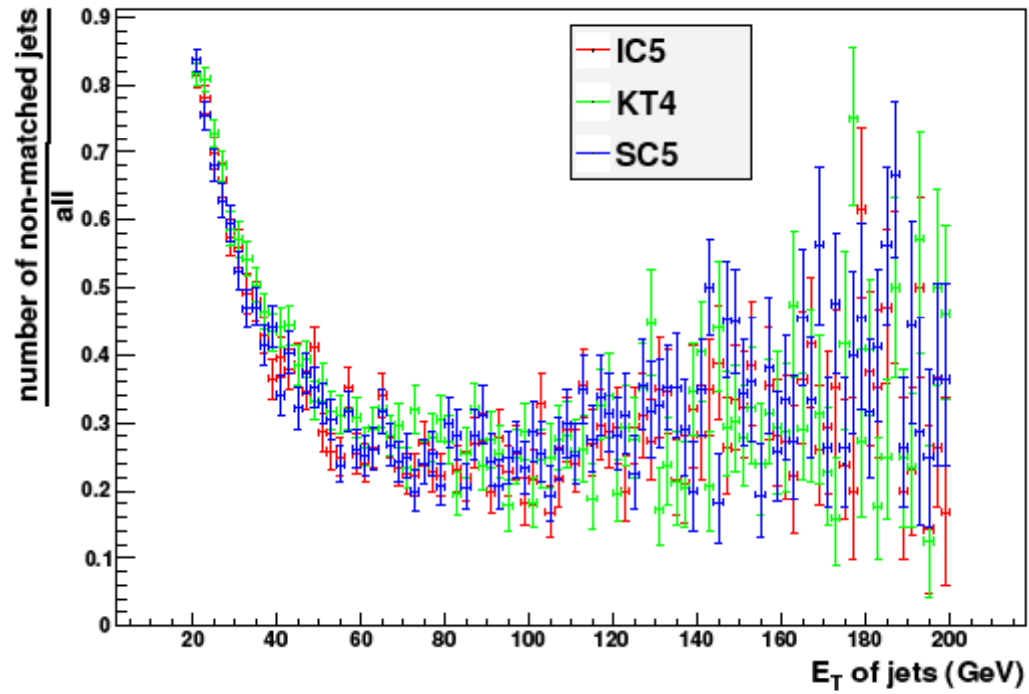


Jet Reconstruction Efficiency Vs η of Partons

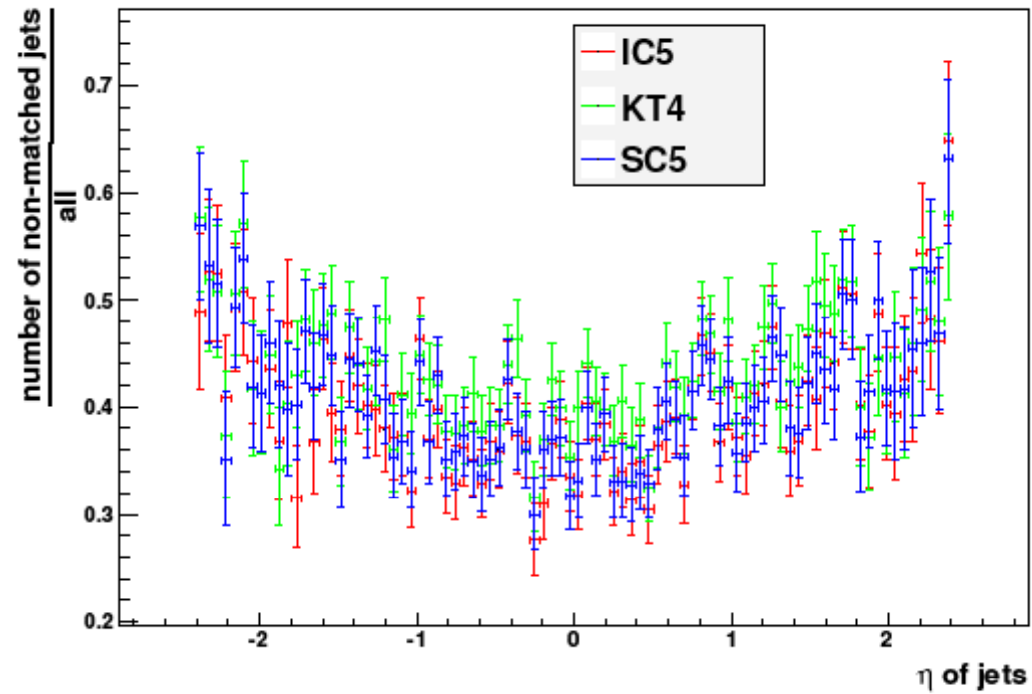
SemiLeptonic(electron or muon) TTbar sample



Instrumental Background Rate Vs Et of Jets

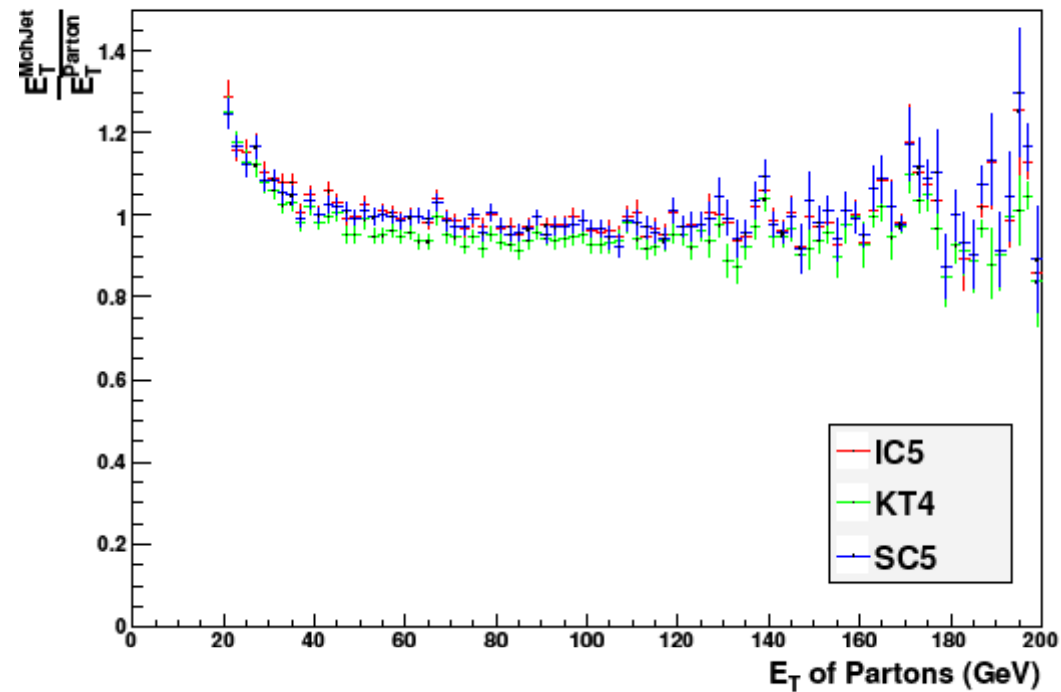


Instrumental Background Rate Vs η of Jets



Jet Response Vs Et of Partons

SemiLeptonic(electron or muon) TTbar sample



Jet Response Vs η of Partons

SemiLeptonic(electron or muon) TTbar sample

