JET SHAPES STUDIES

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OUTLINE

Jet Shapes at hadron level: Underlying Event

Jet shapes at detector level:

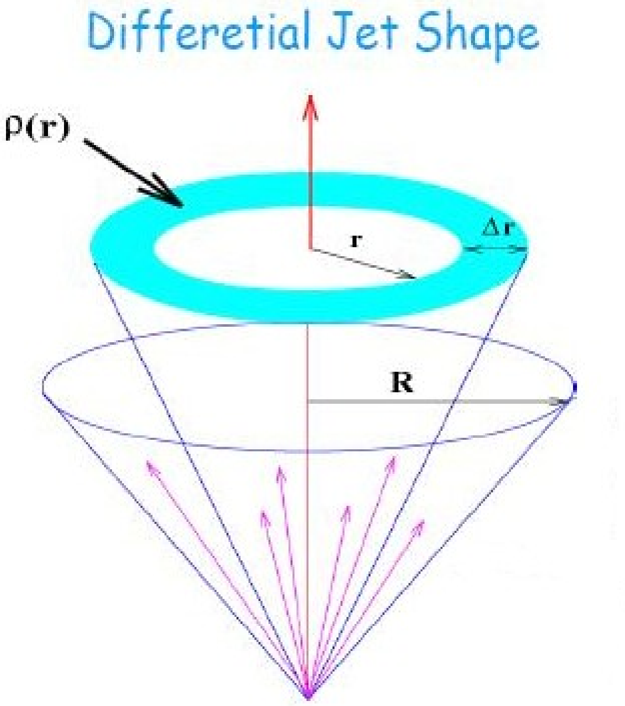
I. Different calorimeter constituents

II. Effects of jet calibration on shapes

III. Pile-up and dependence on N vertices using calorimeter constituents and tracks associated to jets

IV. Results using the Anti-Kt algorithm

INTRODUCTION



- Observables like the shape of the jets are sensitive to a detailed simulation of the showers in the calorimeter
- Being a ratio of energies one can measure it precisely using first data
- Jet Shapes are sensitive to the underlying event and to the presence of pile-up

$$\rho(r) = \frac{1}{\delta r} \frac{1}{Njets} \sum_{jets} \frac{PT(r-\delta r/2, r+\delta r/2)}{PT(0,R)}$$

$$r = \sqrt{\Delta\eta^2 + \Delta\varphi^2}$$

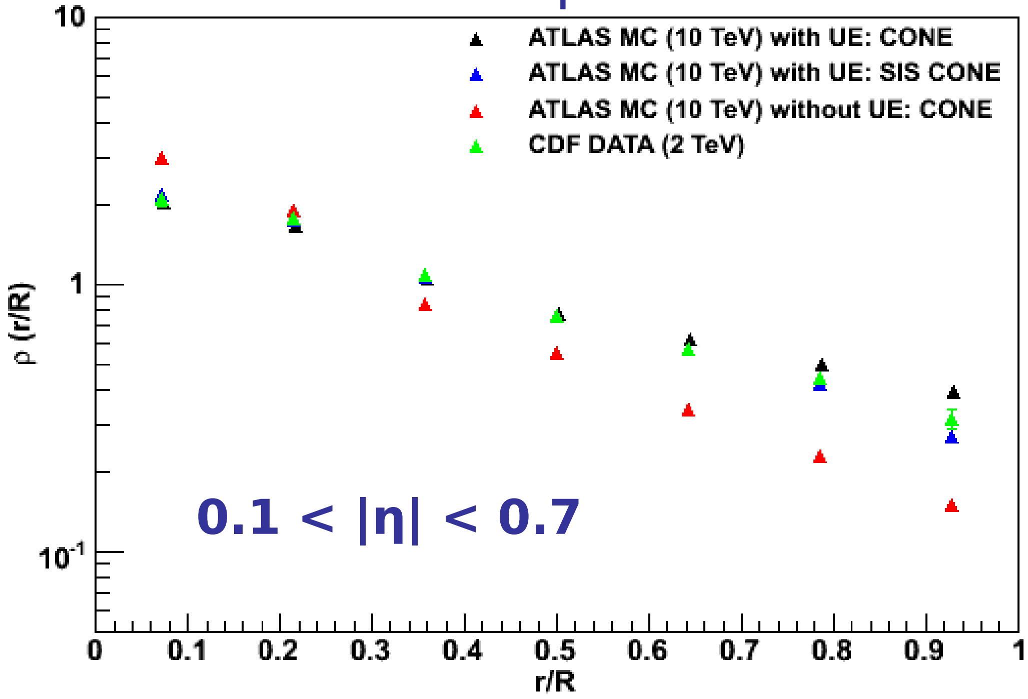
$0 \leq r \leq R = 0.7$

Differential Jet Shapes (Hadron Level)

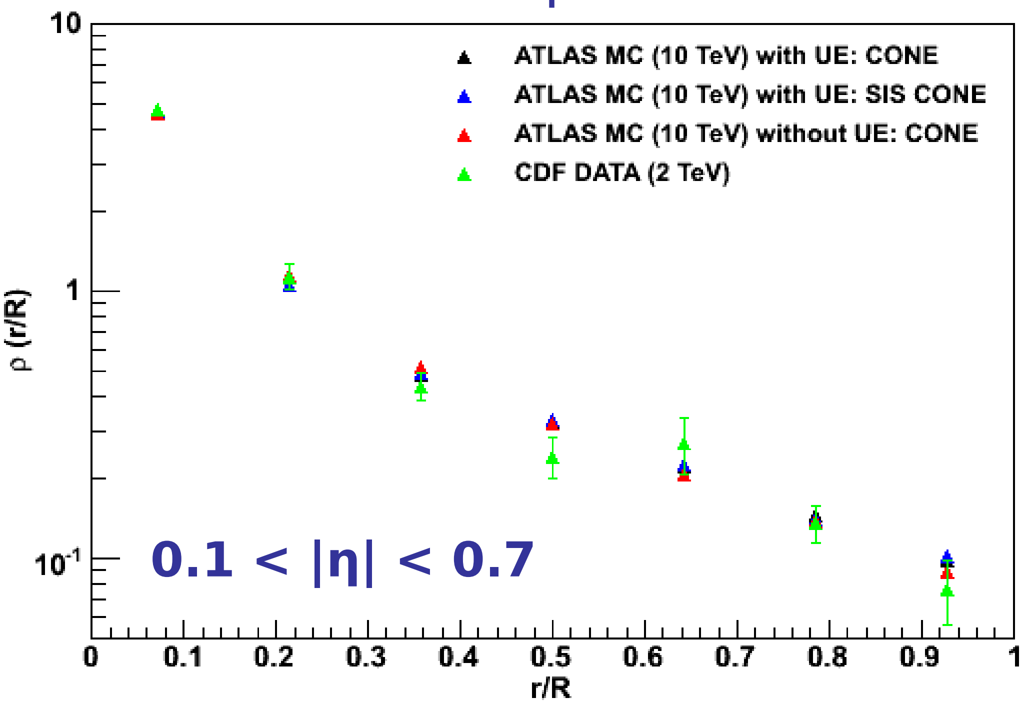
• Pythia MC di-jet samples (10 TeV) J0 to J6: 8 GeV < P_T hard < 1120 GeV with and withouth Underlying Event (UE)

• Jets reconstructed with the ATLASCone and the SISCone algorithm, both with R = 0.7 and SMF=0.75

37 GeV < P_T < 45 GeV



304 GeV < P_T < 340 GeV



• Jets are narrower as the P_T increases

• Broader jets in samples with Underlying Event can be clearly seen at low P_T values

Comparison with CDF run II data: PRD 71, 112002 (2005) at hadron level (no detector effects)

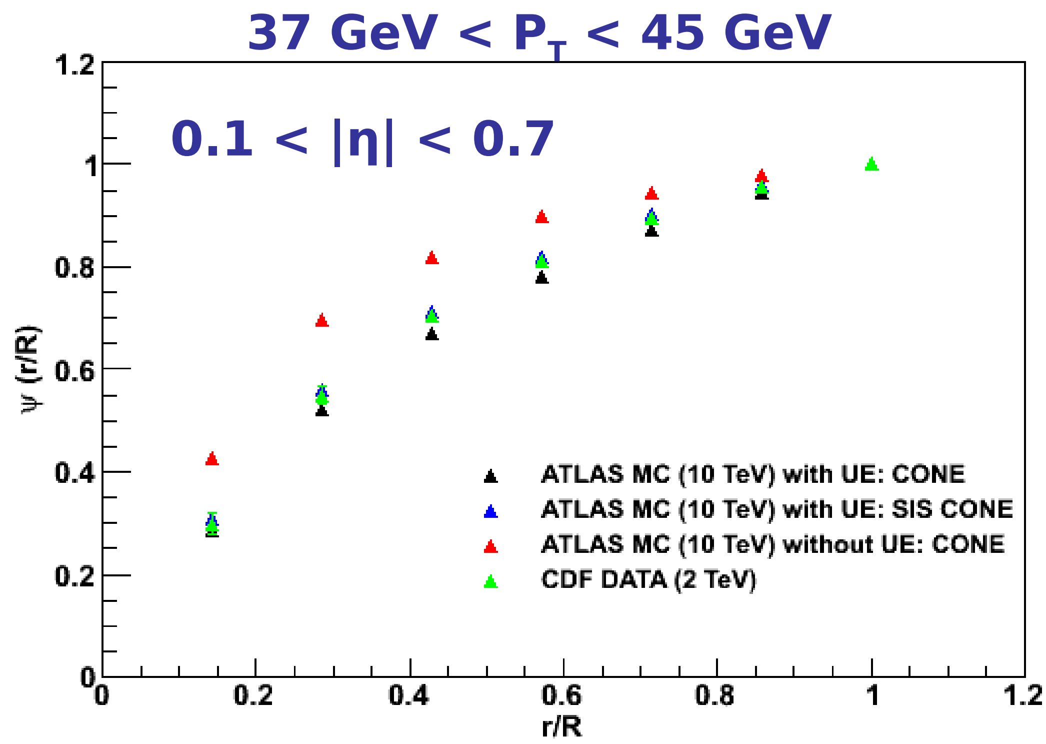
Integrated Jet Shape

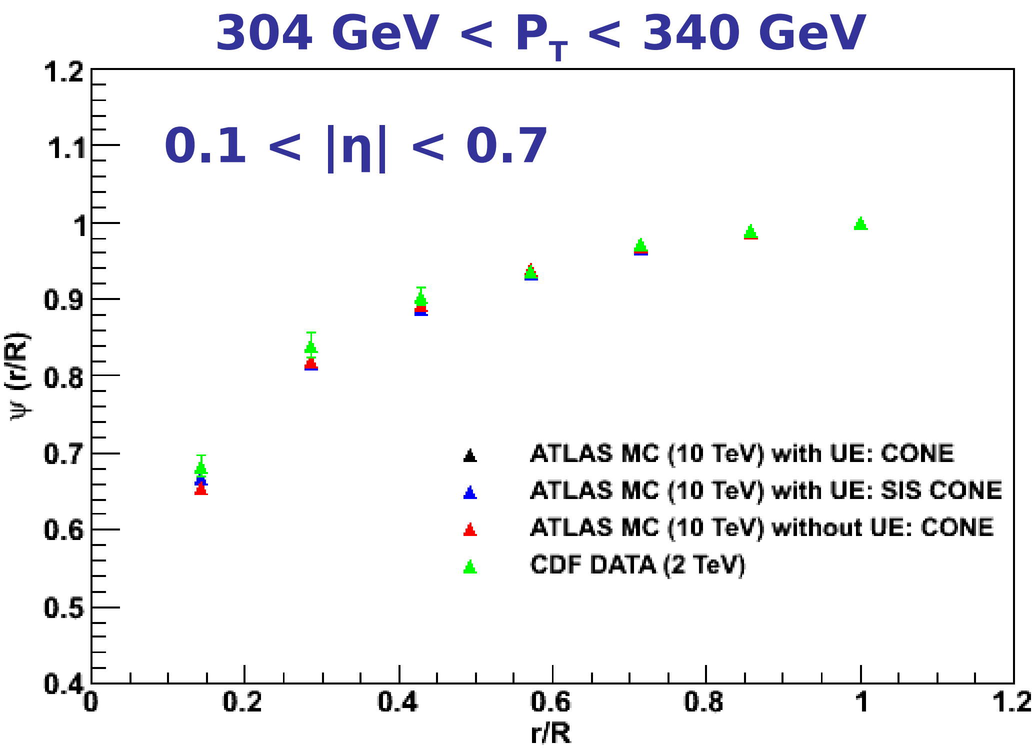
(Hadron Level)

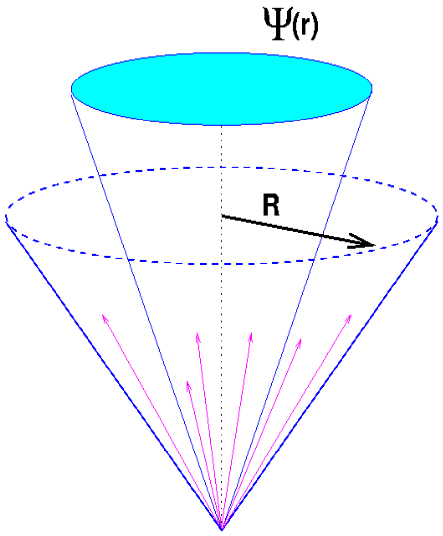
An alternative way to define shapes:

$$\Psi(r) = \frac{1}{Njets} \sum_{jets} \frac{PT(0,r)}{PT(0,R)}$$

where Ψ (R) = 1 by definition and the point at different r values are strongly correlated

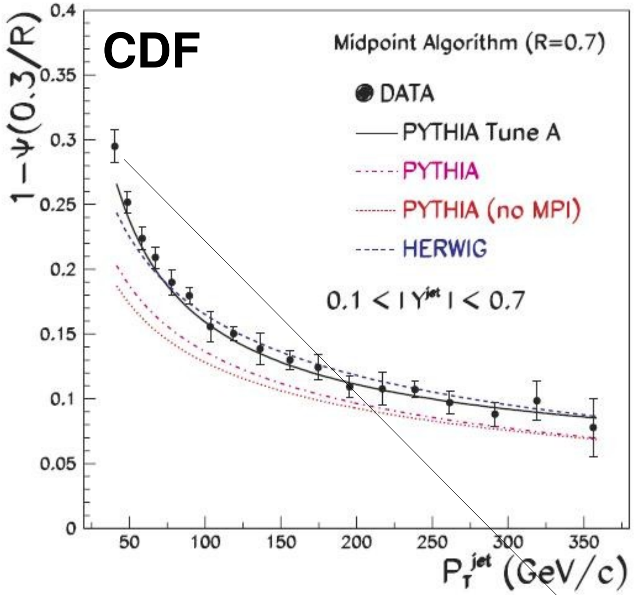






Same conclusions as in differential case

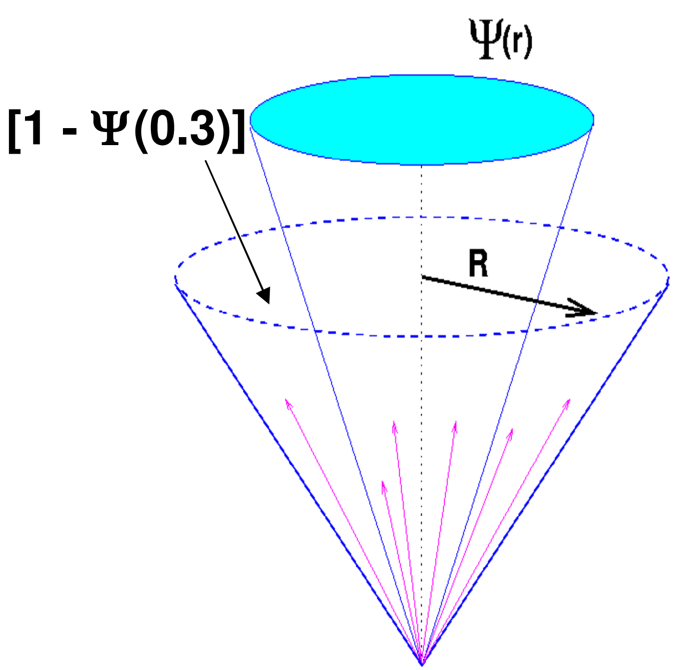
Summary Plot (Hadron Level)



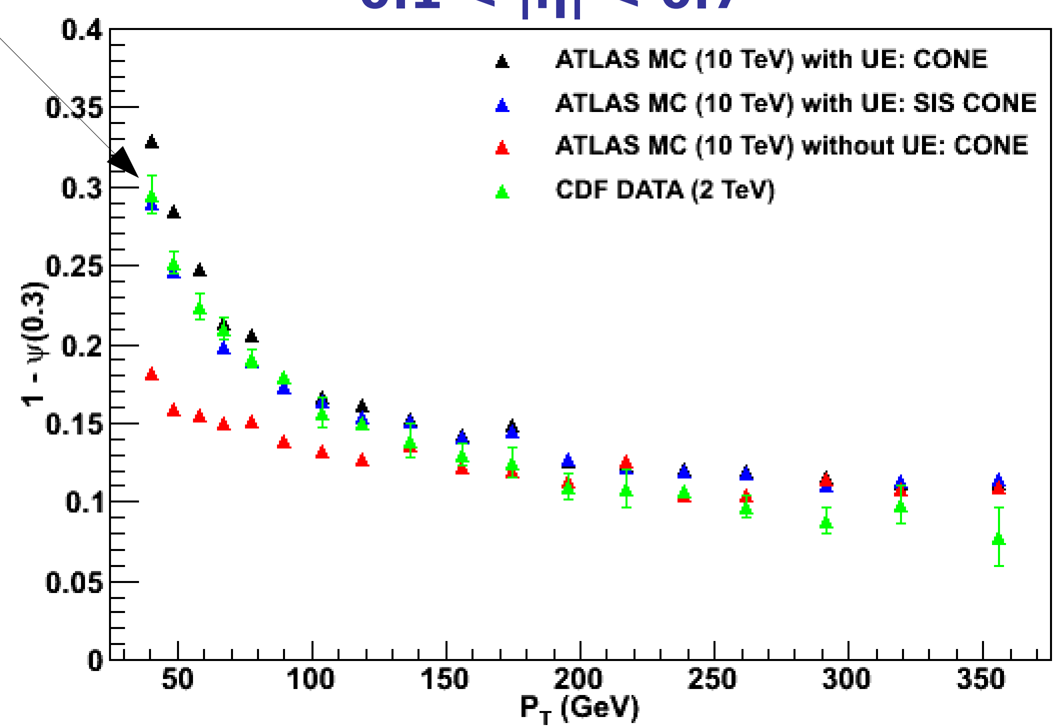
[1 - Ψ(0.3)] shows the activity in the outer part of the jet cone

This activity is larger in samples with Underlying Event (can be clearly seen in jets up to 120 GeV)

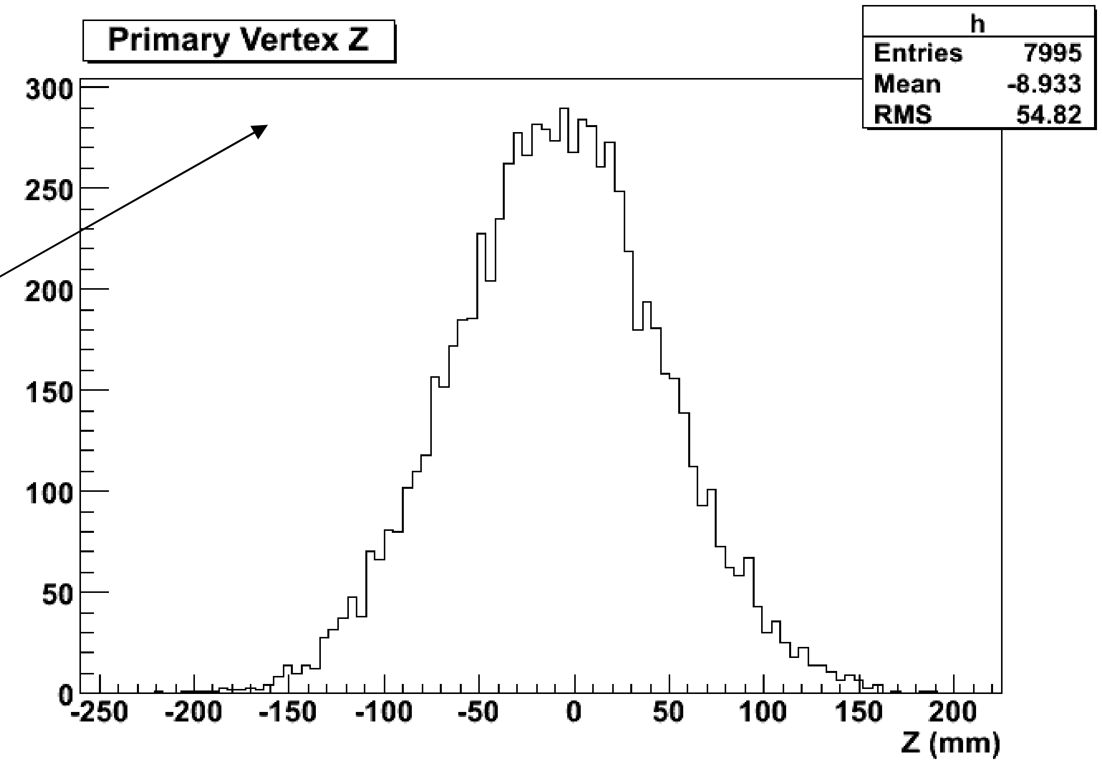
Despite of the different fraction of quark- and gluon-initiated jets in ATLAS and in CDF (for example, in the P_T region [37, 45] GeV, 80% of gluons in ATLAS vs 73% in CDF) SISCone matches CDF data at low P_T



0.1 < |η| < 0.7

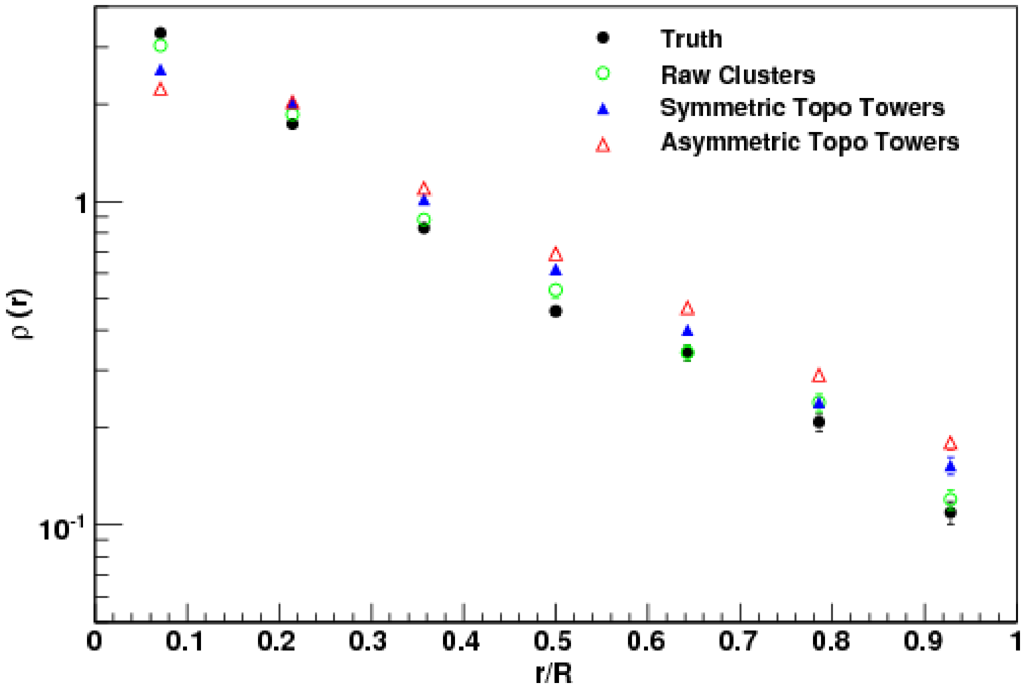


Jet Shapes at Detector Level



In Pythia full simulated samples used, the Beam Spot is displaced -9 mm in Z: **only events with |Z Vtx| < 4 cm are considered in all studies at detector level**

In each event, we choose the leading jet (**SISCone**) at hadron level whit |η| < 1.2 and 50 GeV < PT < 70 GeV



To perform a fair comparison, jets made with different calorimeter constituents are required to be matched to the Truth jet with ΔR < 0.1

- Shapes for Clusters similar to truth shapes
- Broader jets when made of TopoTowers, mainly when only cells with positive energy are use to build the towers (asymmetric)

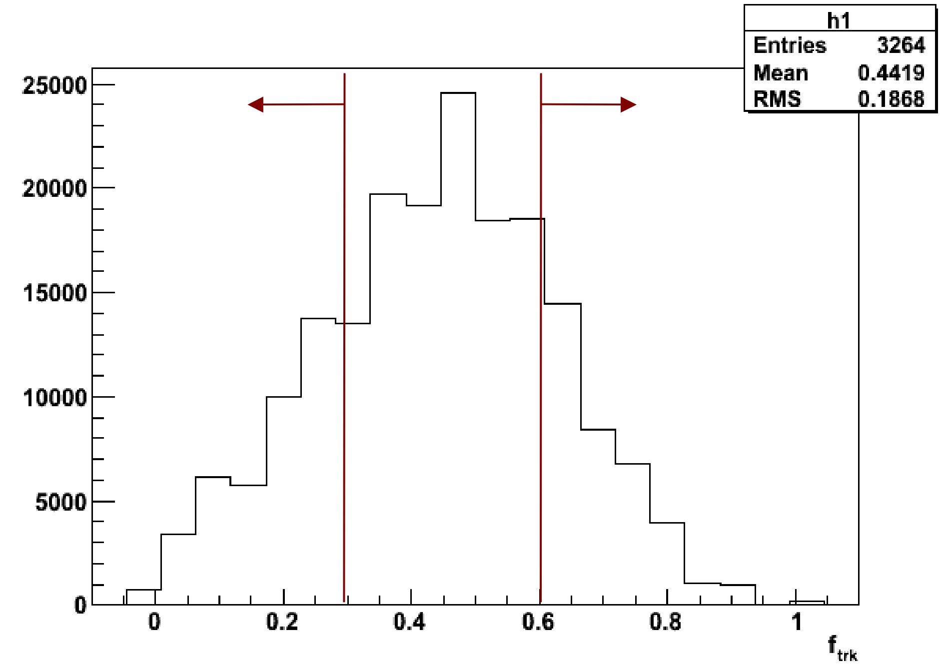
Effects of jet calibrations on jet shapes using f_{trk}

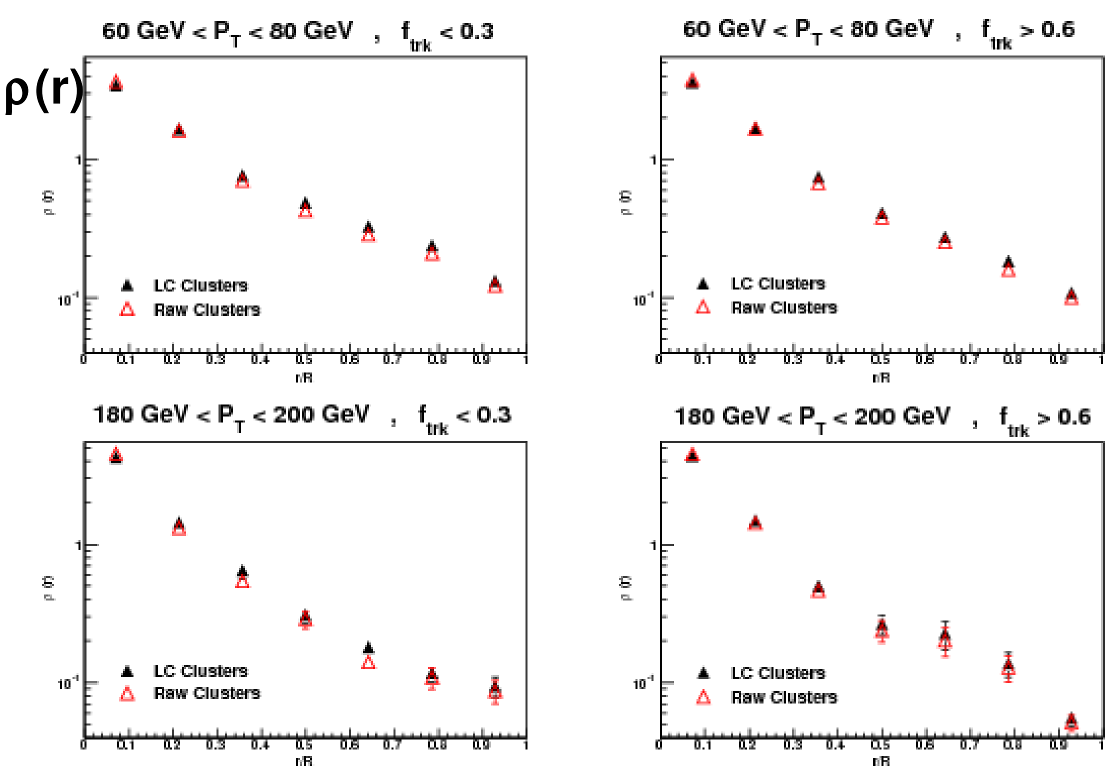
$$f_{trk} = \left(\sum \vec{P}\right)_T^{tracks} / P_T^{truth}$$

Leading jet in each event when $|\eta| < 1.2$

Tracks selected

- Tracks matched to the jet
- $|Z\ track - Z\ vertex| < 3.5$ mm
- Pt > 1 GeV
- nHits (B-layer+SCT+Pixel)>6
- nHits (TRT) > 0
- qual/NDofF < 3



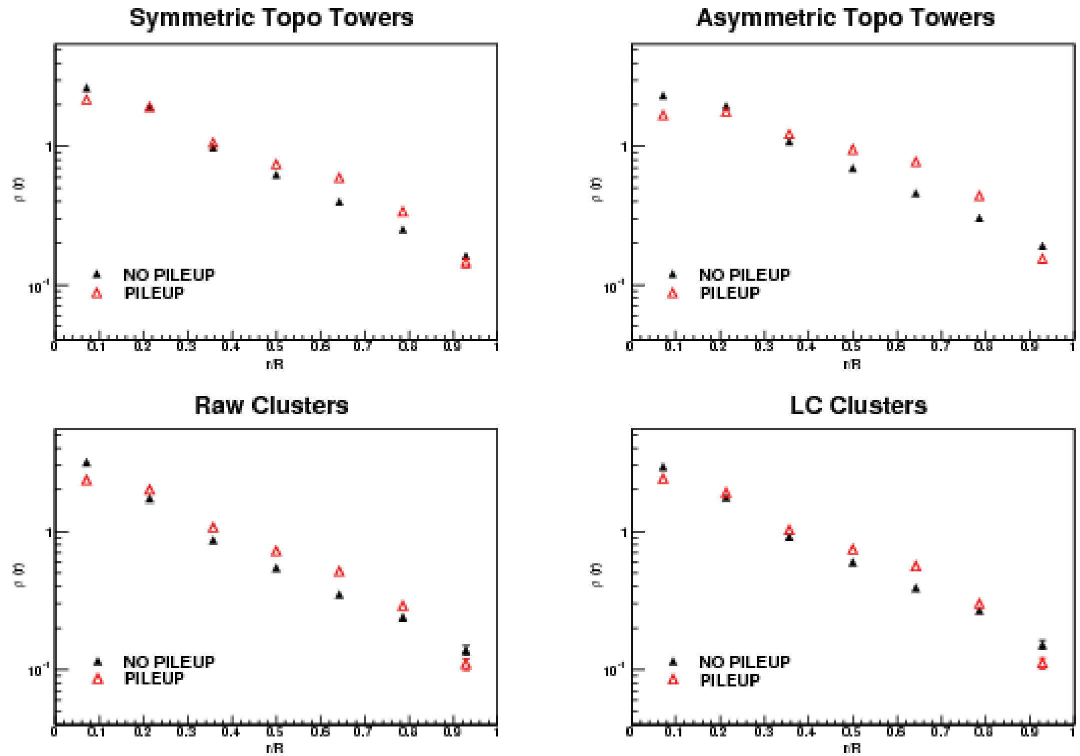


Smaller f_{trk} → more π^0 → smaller hadronic component (ftrk < 0.3)

Higher f_{trk} → less π^0 → larger hadronic component (ftrk > 0.6)

Same shapes for Raw/LC Clusters → calibrations are not distorting jets internal structure

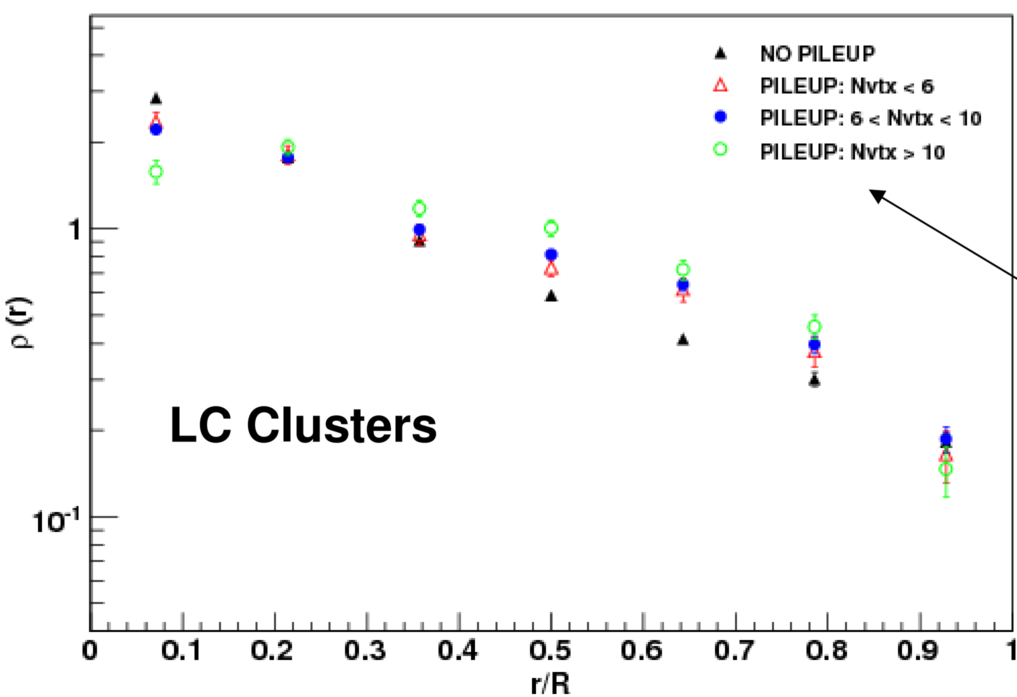
Jet shapes in events with pile-up



Phytia MC J2 sample: 35 GeV - 70 GeV

Calorimeter jets (only leading in each event) when 50 GeV < P_T < 70 GeV and $|\eta| < 1.2$

Jets get broader in the presence of pile-up (size of the effect similar for different constituents)

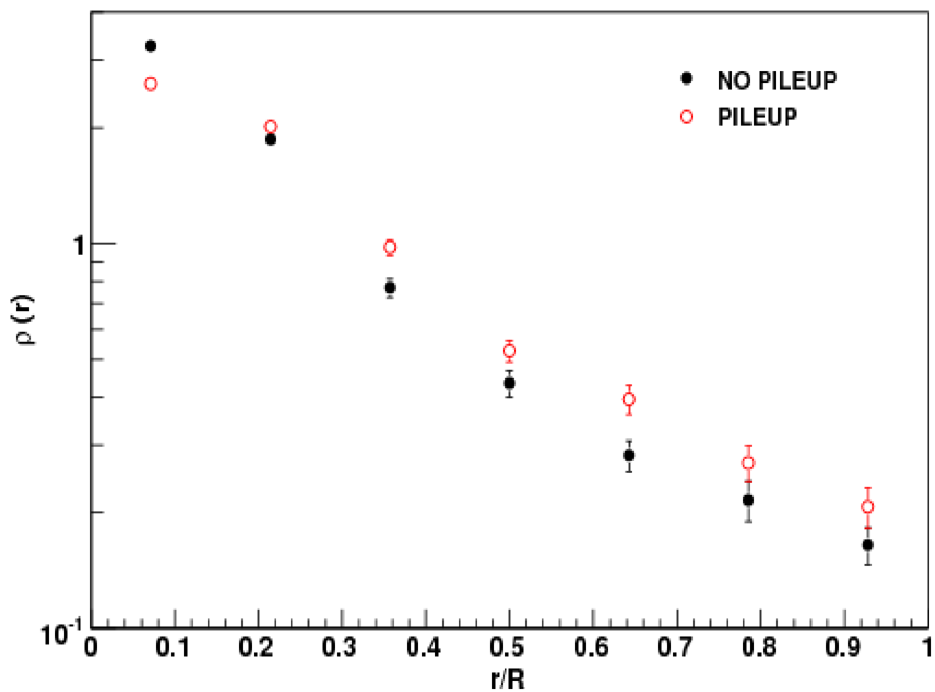


Pile-up events are expected to have multiple vertices and a correlation between the primary vertex multiplicity and shapes is expected:

→ Jets get broader as the Nvtx increases (demostrating sensitivity to pile-up)

Jet shapes using tracks

Calorimeter leading jet in each event when $|\eta| < 1.2$ and 50 GeV < P_T < 70 GeV



Tracks selected

- Tracks matched to the jet
- |Z track – Z vertex| < 3.5 mm
- Pt > 1 GeV
- nHits (B-layer+SCT+Pixel)>6
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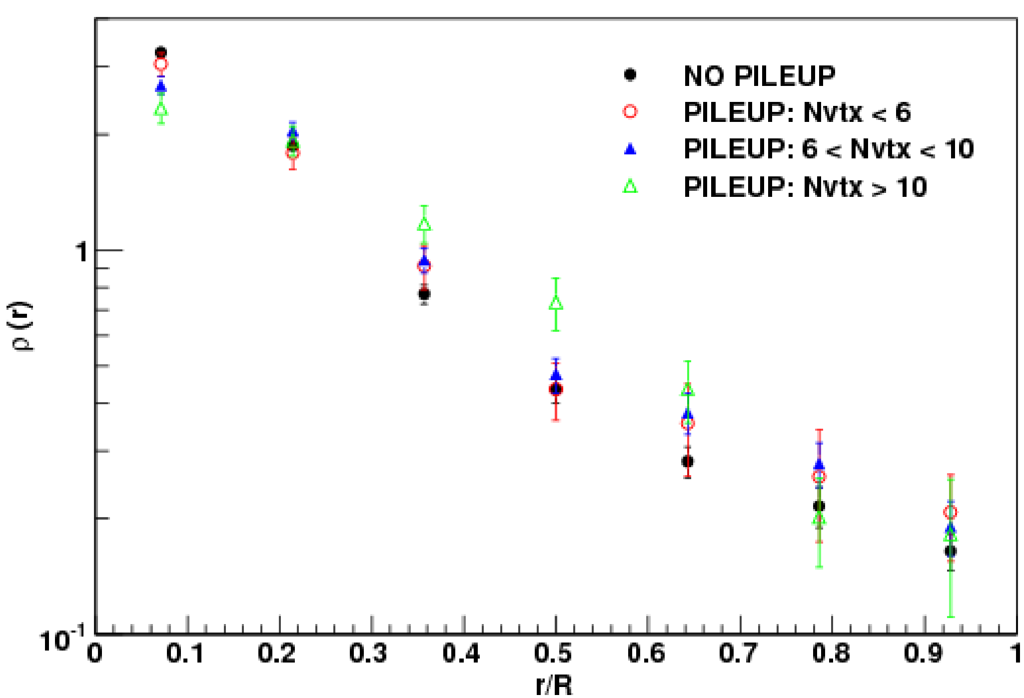
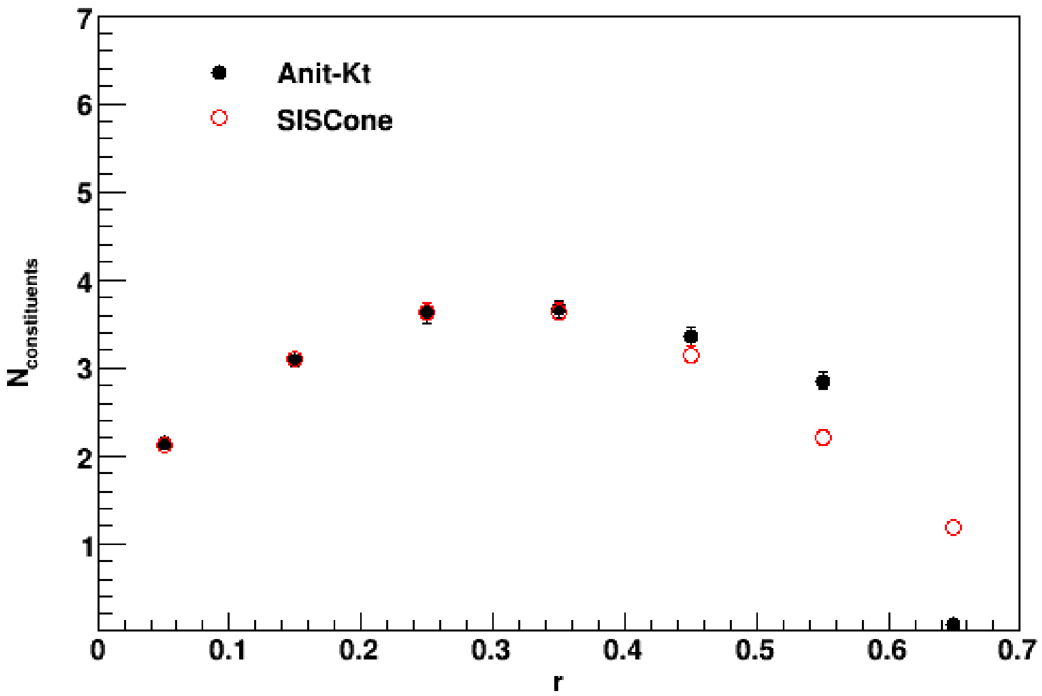


- Shapes calculated with tracks are broader in the presence of pile-up
- As before, broader jets as the primary vertex multiplicity increases

Jet shapes using Anti-Kt

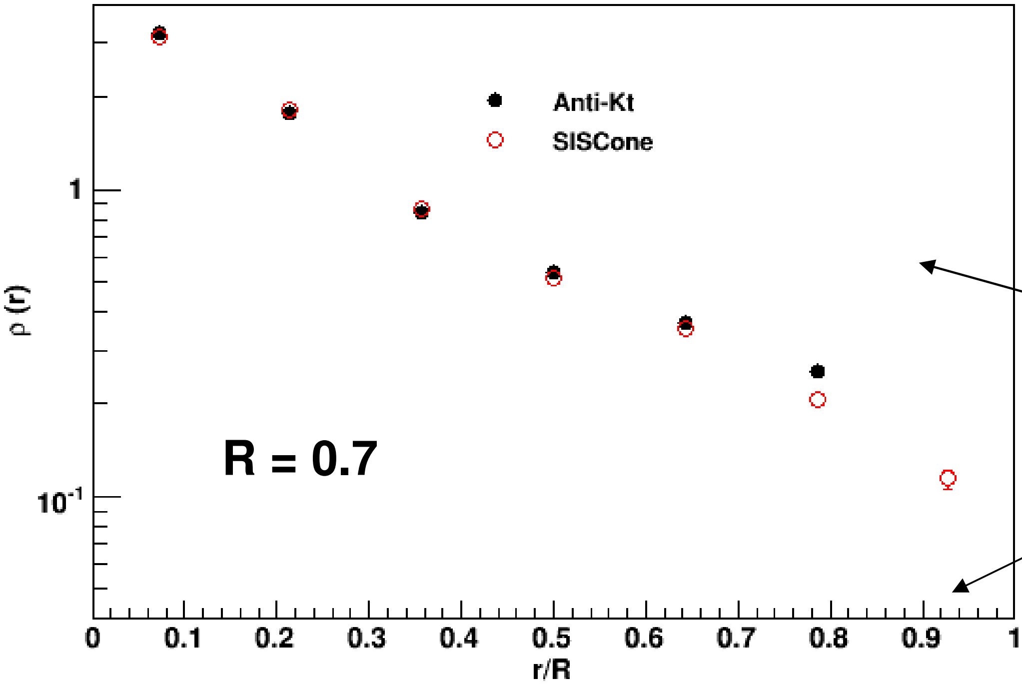
1) NO PILE-UP:

Calorimeter leading jet in each event when |η| < 1.2 and 50 GeV < P_T < 70 GeV (SISCone and **Anti-Kt with D = 0.6** jets matched with ΔR < 0.1)



Average number of constituents (LC Clusters) in the different jet annulus

There are almost no constituents in the last annulus of Anti-Kt jets



Looking at the average number of constituents one can see that jets reconstructed with the Anti-Kt algorithm are more conical and have a radius of around 0.6

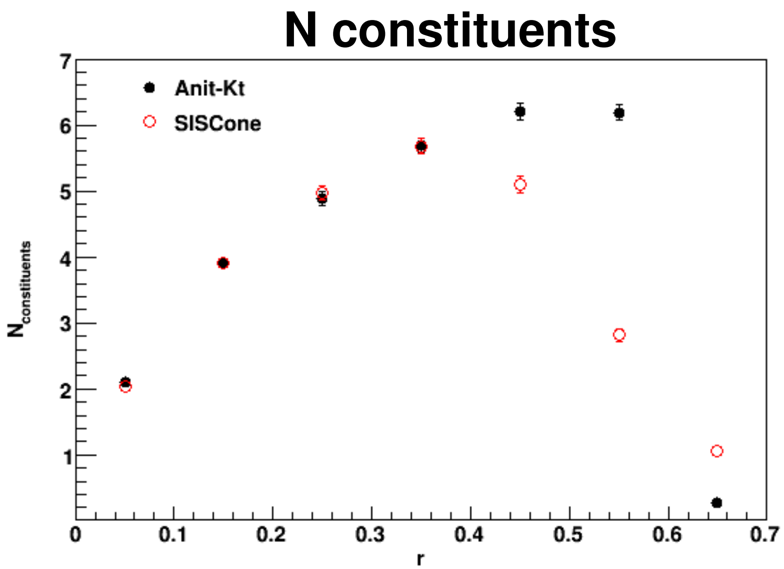
The differences among the jet algorithms are reflected in the shapes

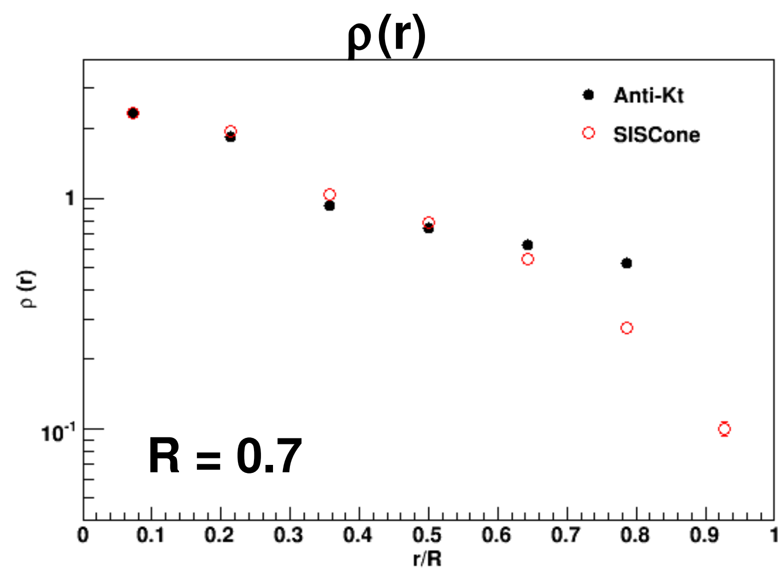
(in last Anti -Kt annulus the value is ~10^{-2})

2) PILE-UP:

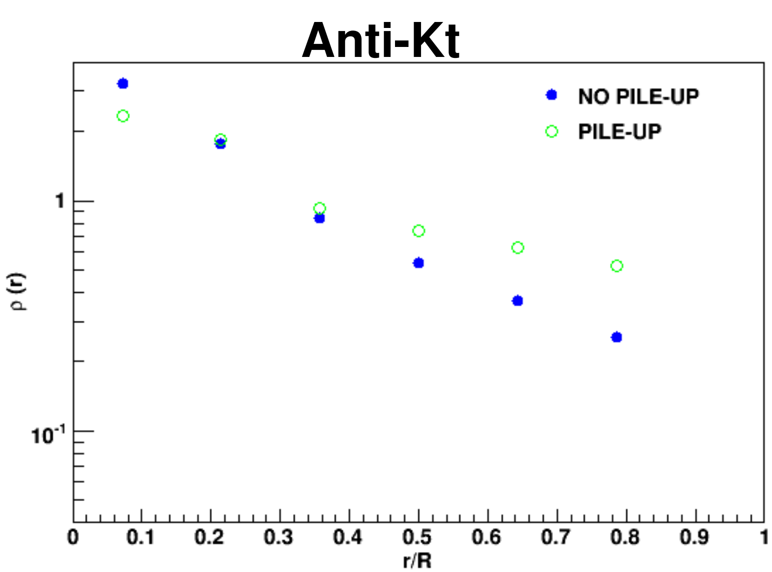
- When adding pile-up, the differences among the two algorithms increase
- Anti-Kt jets present a more stable geometry. This might help to implement energy corrections

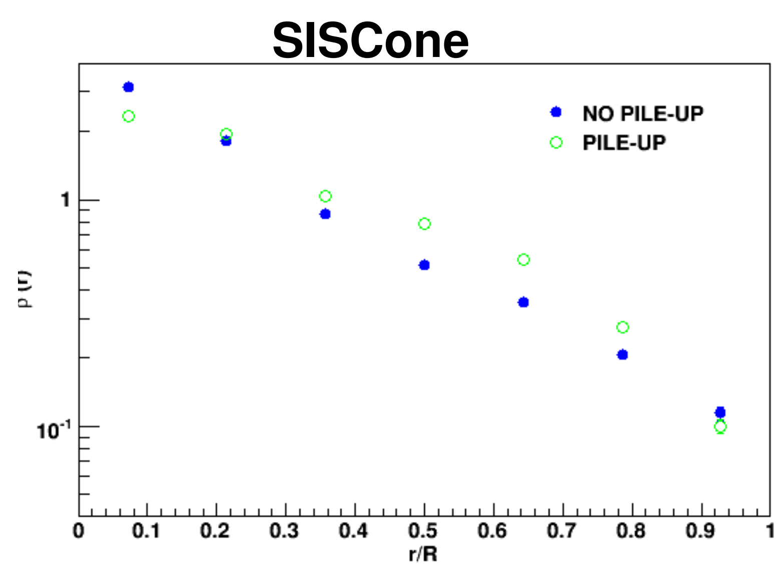
Anti-Kt vs SISCone in pile-up events





No pile-up VS pile-up





CONCLUSIONS

- Sensitivity of jet shapes to Underlying Event and Pile-up has been demonstrated
- Jet Shapes are robust against calibration (Raw and LC Cluster jets depending on f_{trk})
- As expected, jets reconstructed with the Anti-kt algorithm are more conical than those reconstructed with the SISCone
- ATLAS note in preparation