Experimental Pile-up effects on Jets

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Mini-workshop 'Journée Jets'
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Outline

Reminder on Pile-up

How pile-up affect jets ?

- Calorimeter signal
- Jets objects

How to reduce pile-up effects ?

- Calorimeter level
- Other methods

Reminder on Pile-up at Atlas

2 main facts :

Up to **23** minbias interaction per bunch crossing

Slow LAr response : ~500 ns (25ns between bunch Xing)
(but bipolar & null integral shape can help)

Plus other difficulties :

High underlying event activity
Complex bunch structure of the beam

Pile-up effects evaluation

Match the **same objects** in **same events** w/wo pile-up

objects = cells, clusters, jets

match = DeltaR (+ depth position for clusters)

Compare physics quantities :

compute ratios Q(PU) / Q(noPU)

2 Luminosity condition:

low 10^{33} $cm^2 s^{-1}$

low $2x10^{33}$ $cm^2 s^{-1}$

Use Dijets samples at low (JF17) & high (J5) Pt

Simulation : 12.0.6, reco : 13.0.40

Reminder : topological clusters

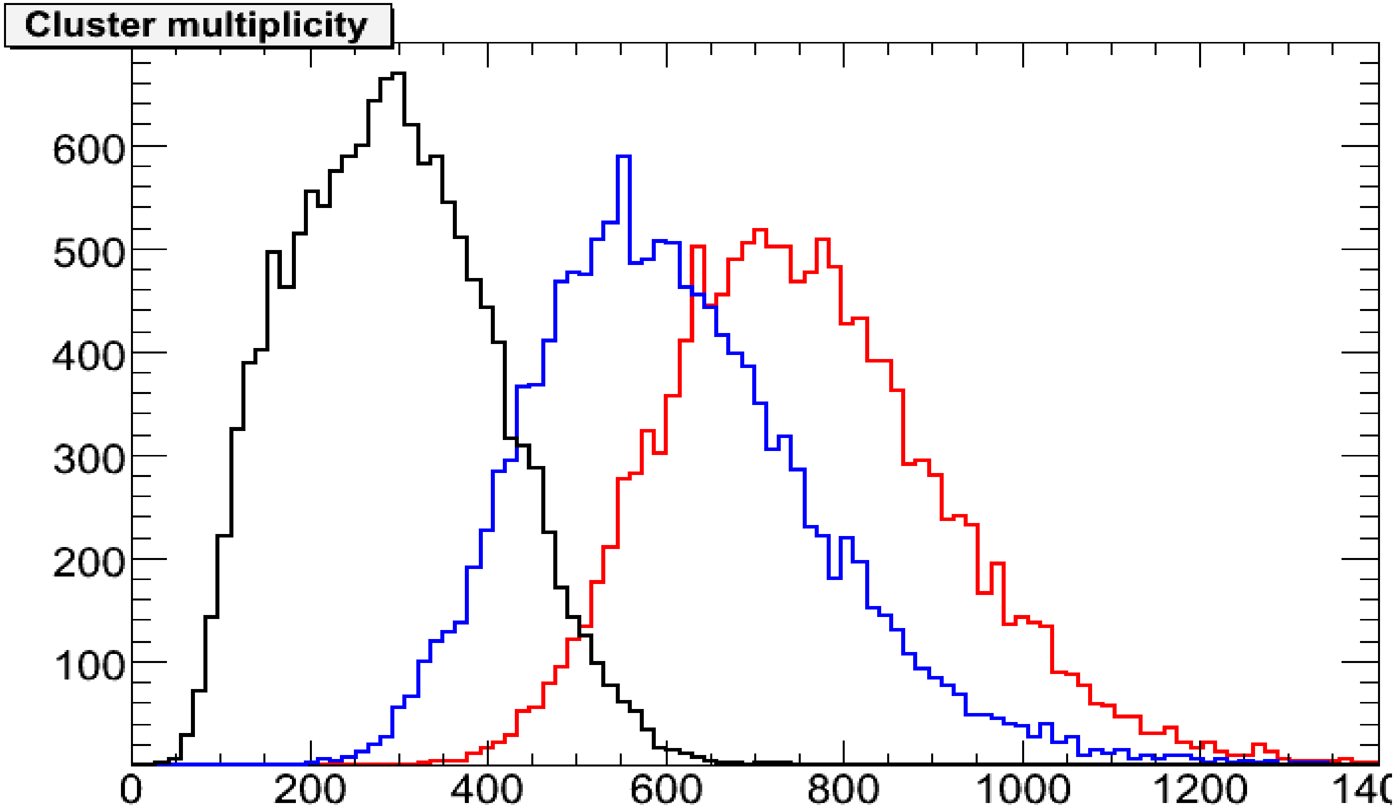
3D topological clustering

start with cells $|E| > \mathbf{4}\sigma$
expand neighbour cells $|E| > \mathbf{2}\sigma$
include border cells $|E| > \mathbf{0}\sigma$
(4/2/0 scheme)

- Take advantage of the fine granularity of the calo
- Intrinsic noise suppresion

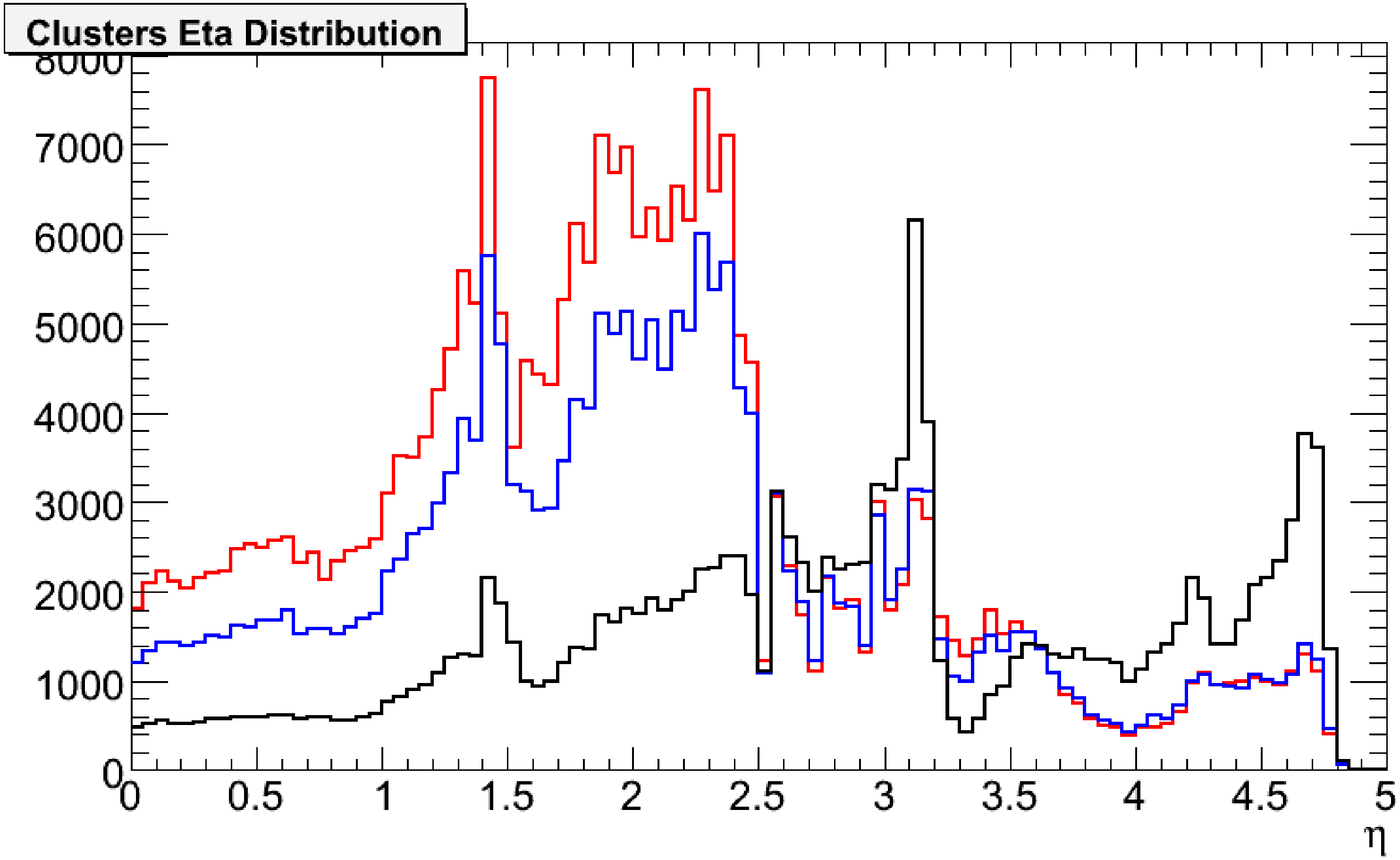
Then find jets on **calibrated** clusters

Cluster multiplicity



black : 0 pile-up
blue : low pile-up
red : medium pile-up

Cluster Eta distribution



black : 0 pile-up
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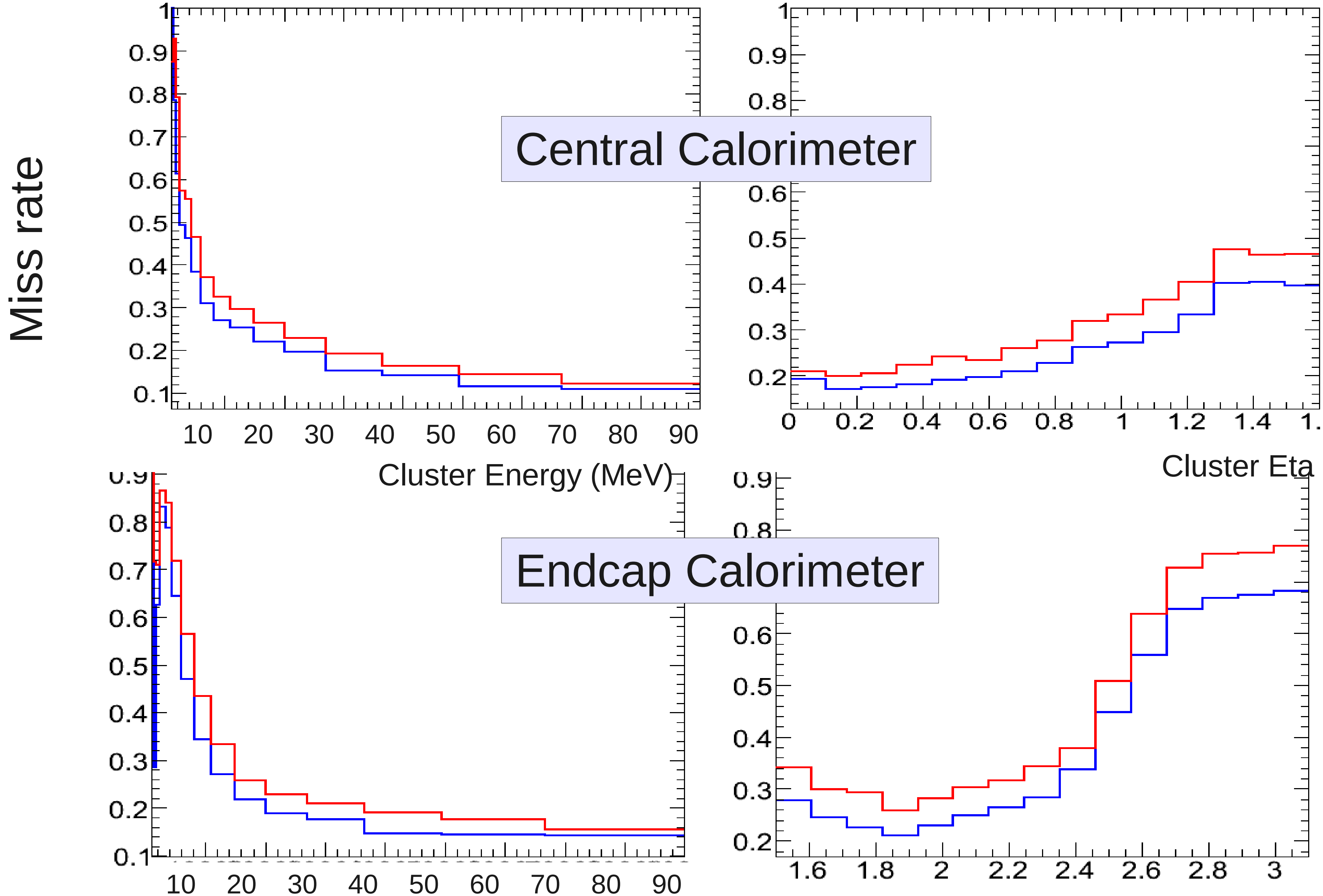
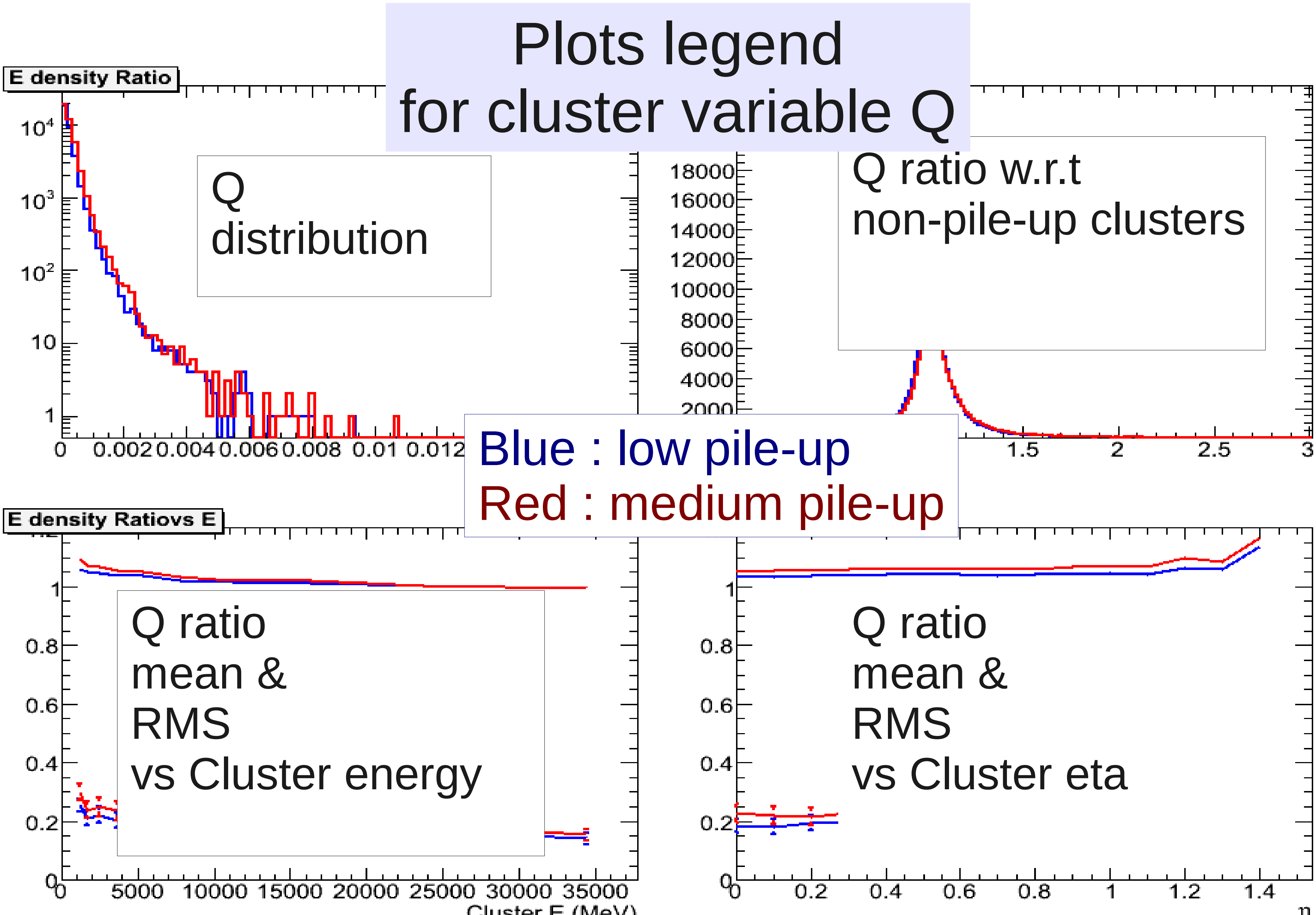
Missed signal rates

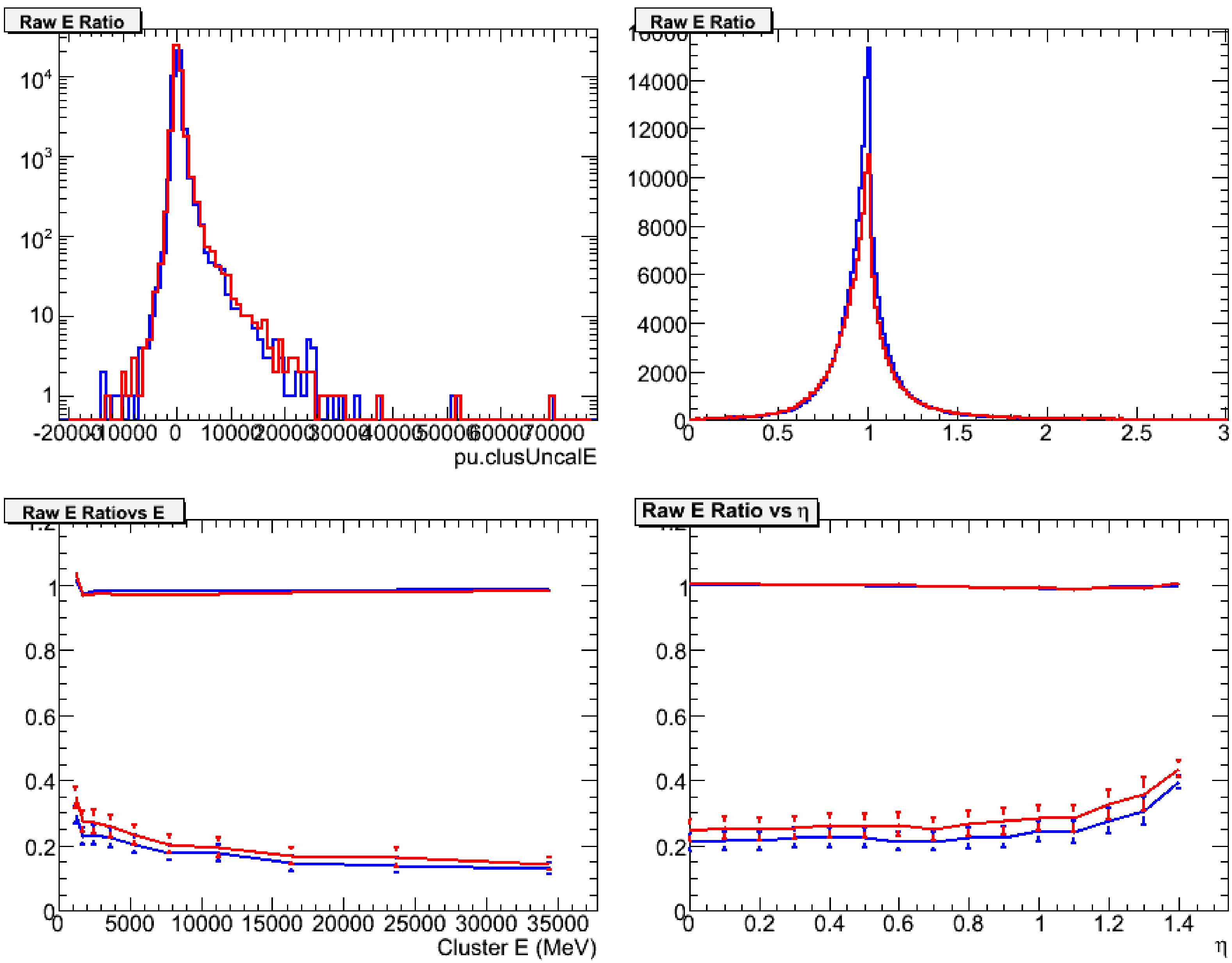
Rate of 'no match for nonPU cluster within DeltaR<0.1'



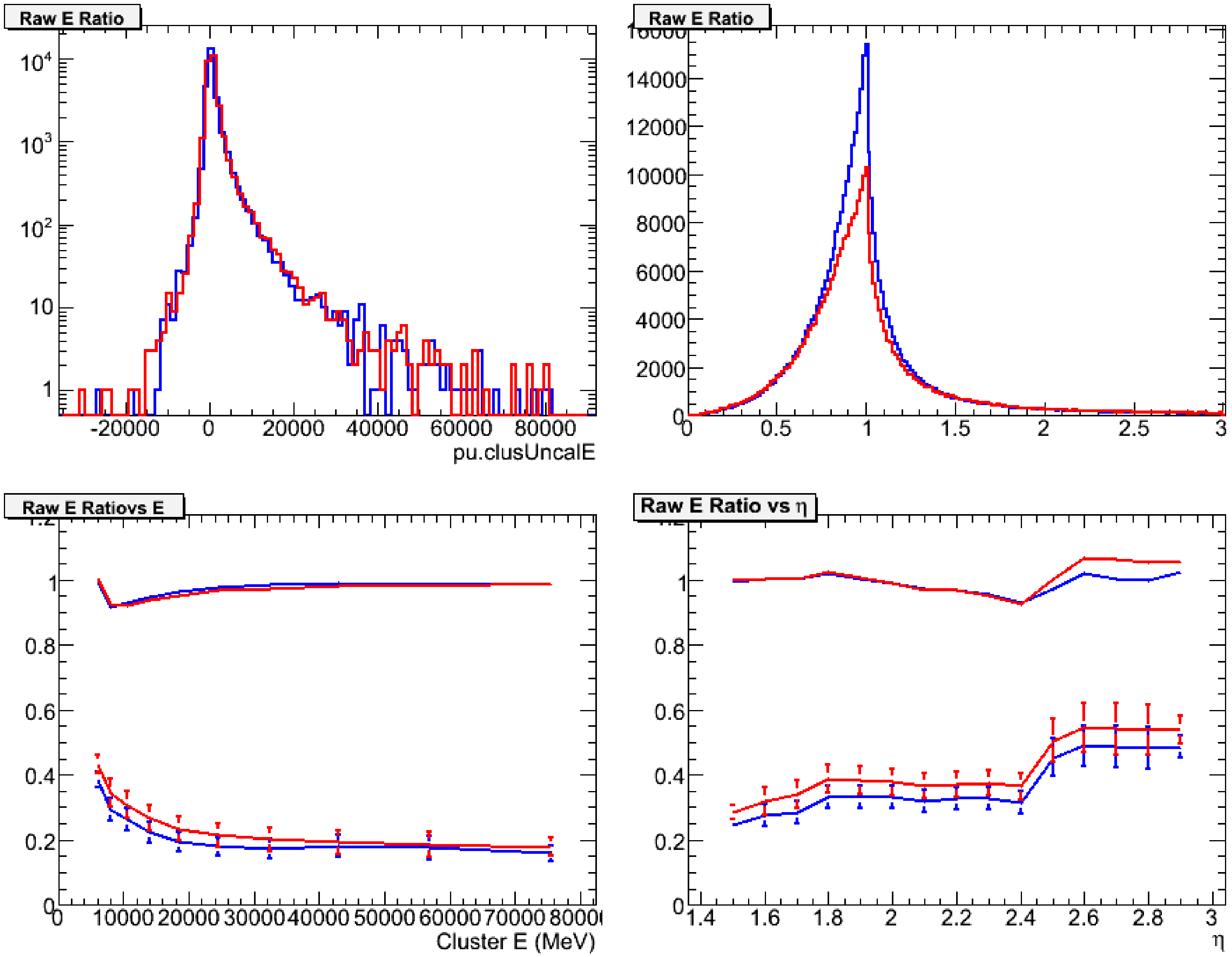
Comparing Clusters



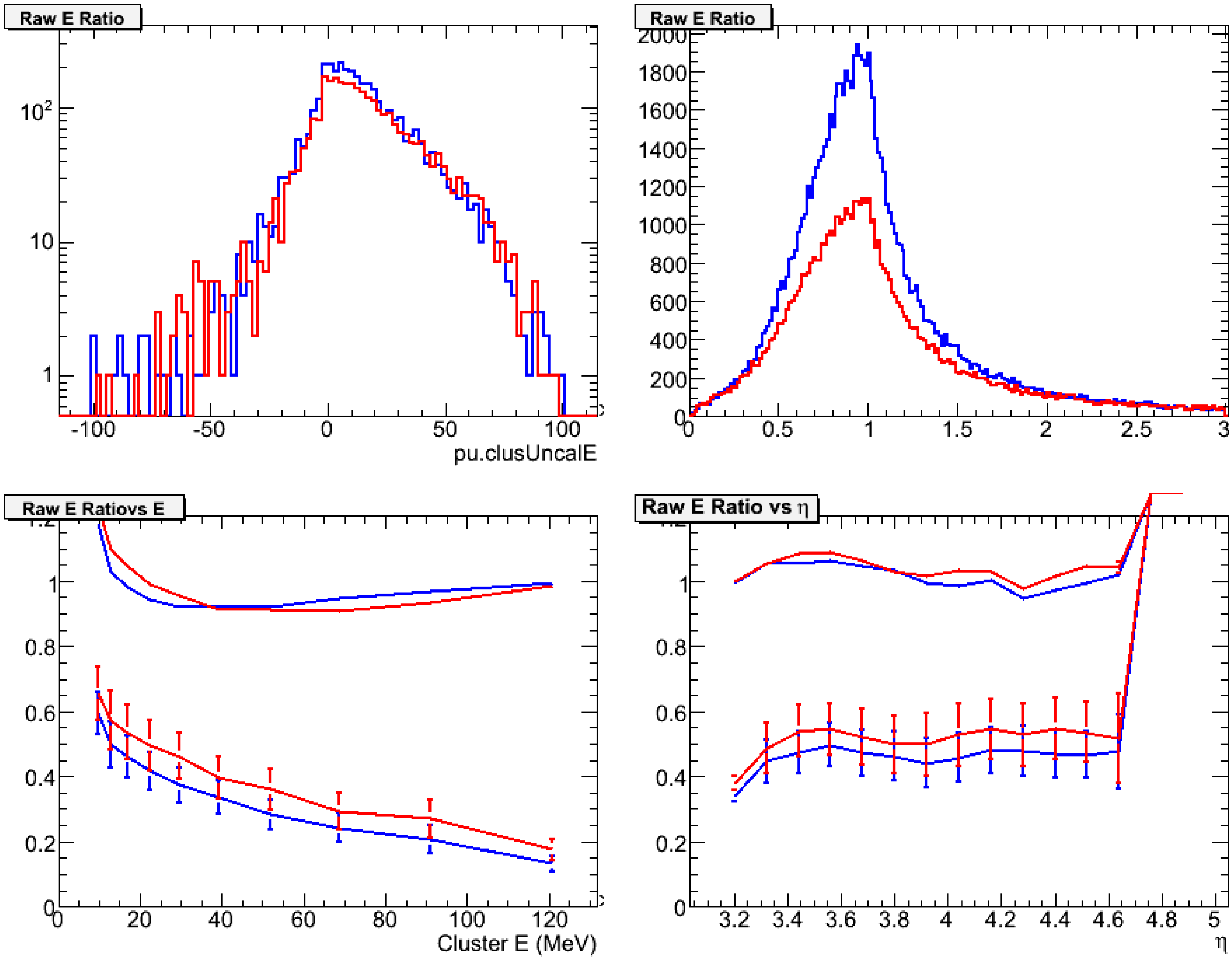
Energy in central region



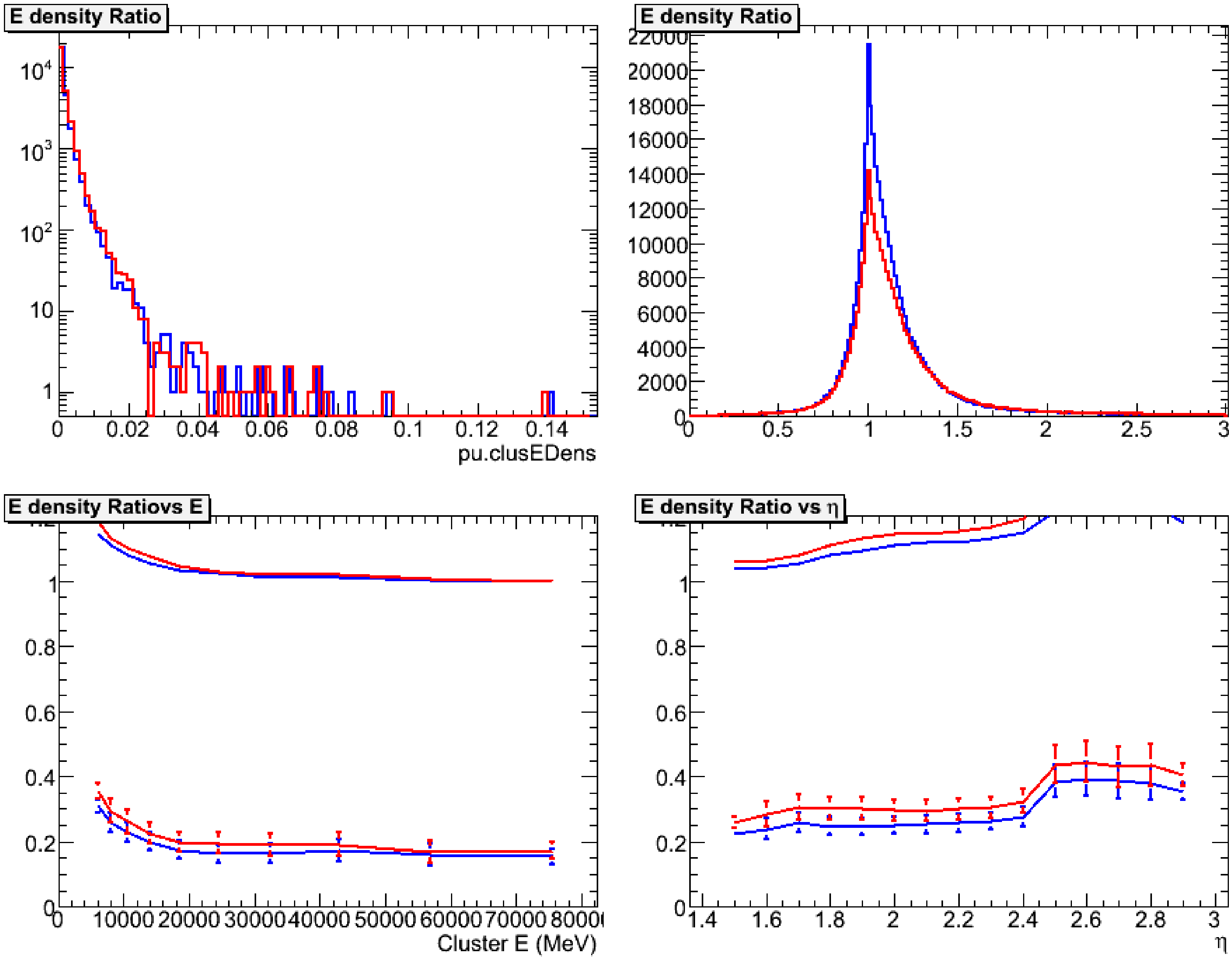
Energy in endcap region



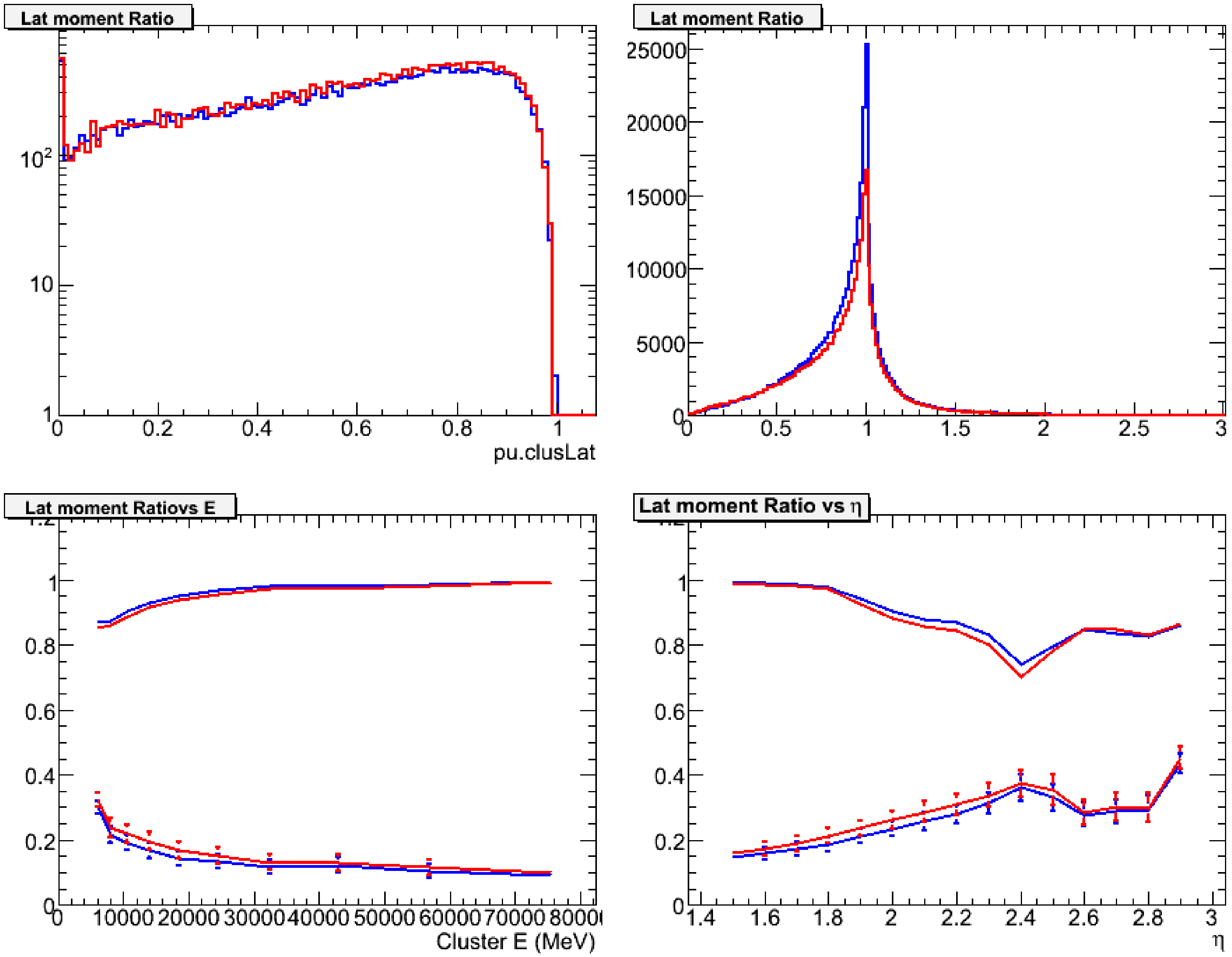
Energy in fcal region



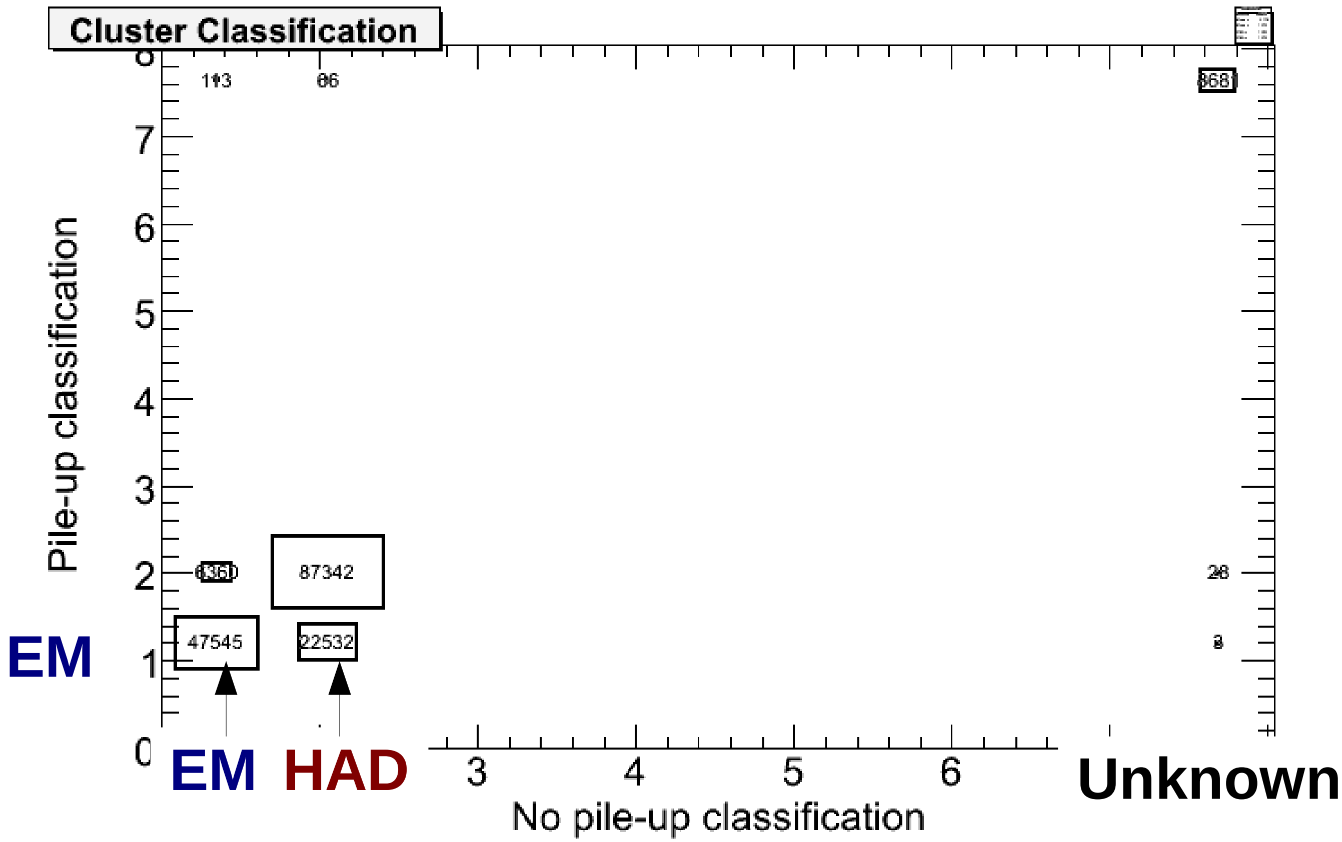
Energy Density in endcap region



Lateral Moment in endcap region



Impact on cluster calibration

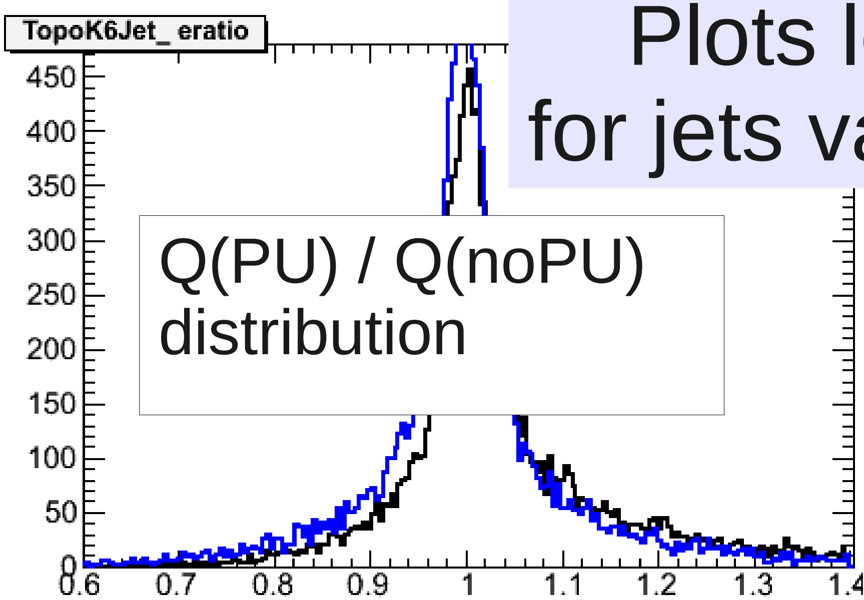


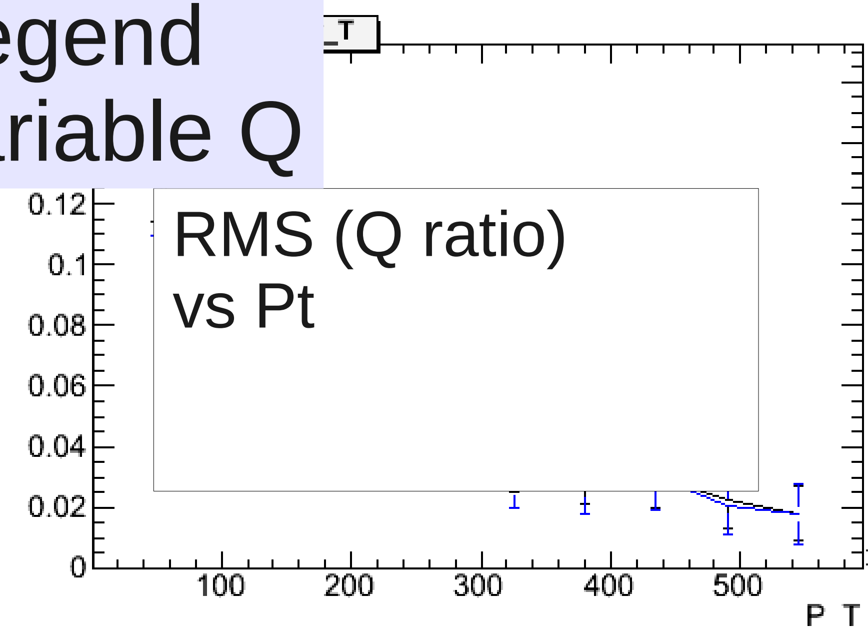
classification distribution

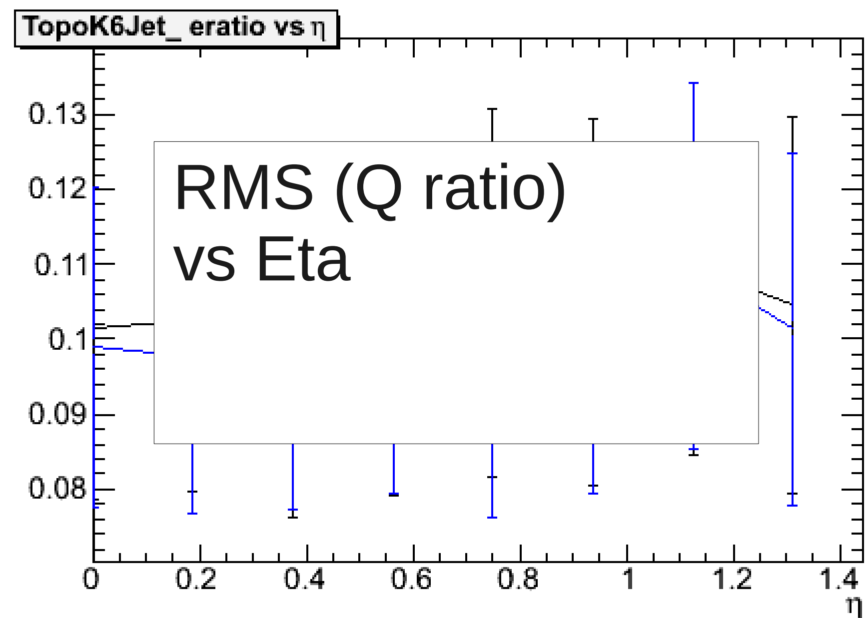
Mis-identification rate with low pile-up		Default Clustering
No Pile-up classification	**EM**	15%
	HAD	17%

Impact on jets

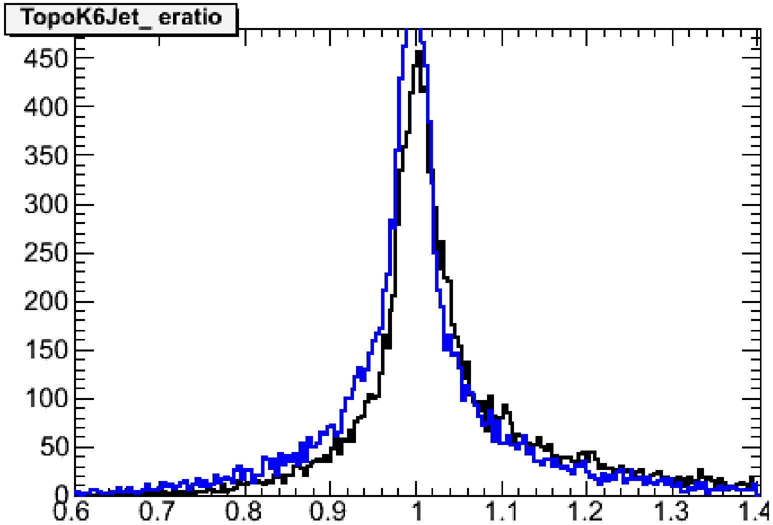
Plots legend
for jets variable Q

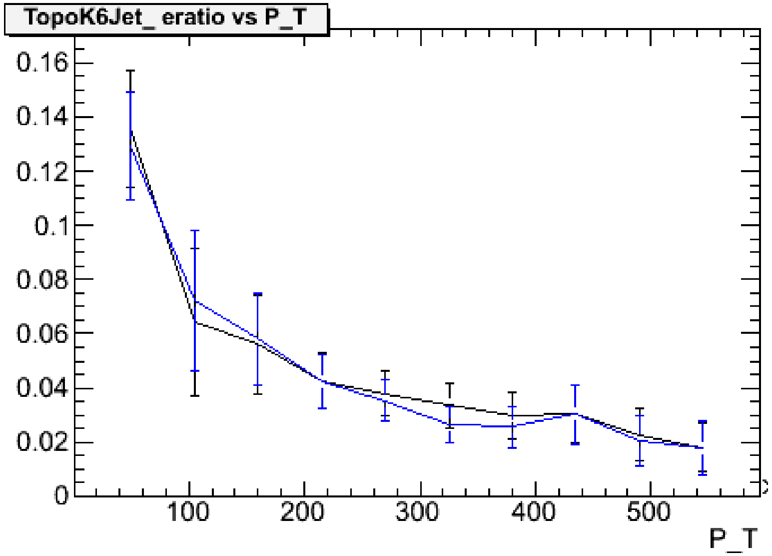






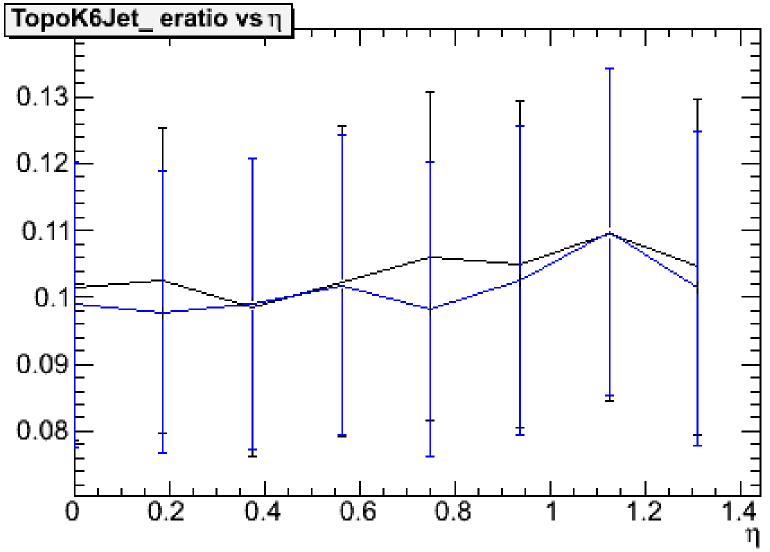
Impact on Energy – jet size



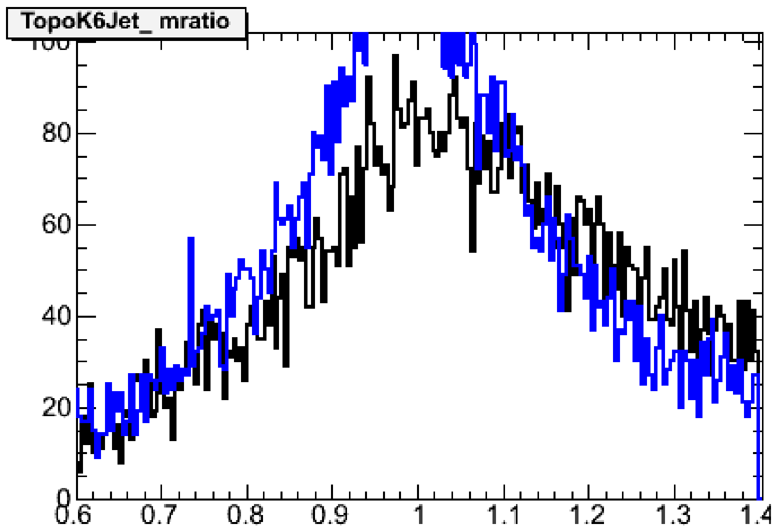


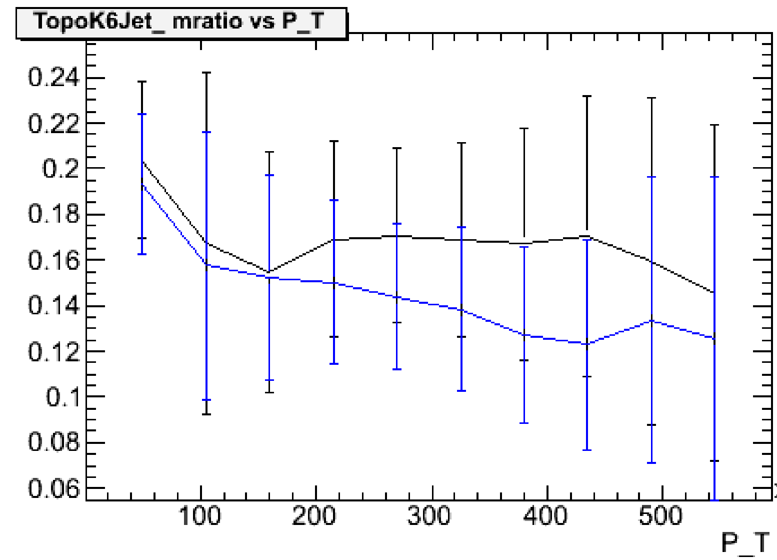
Low luminosity
Central Calorimeter

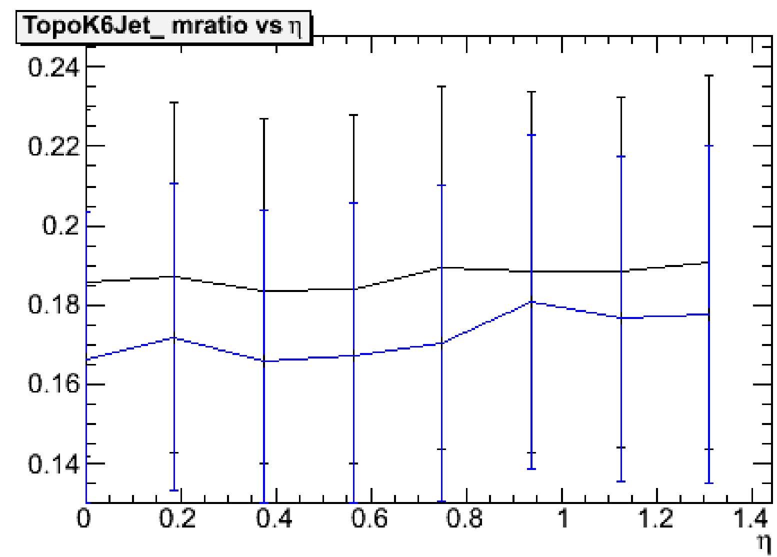
— Topo Kt jet 0.3
— Topo Kt jet 0.6



Impact on Mass – jet size







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Central Calorimeter

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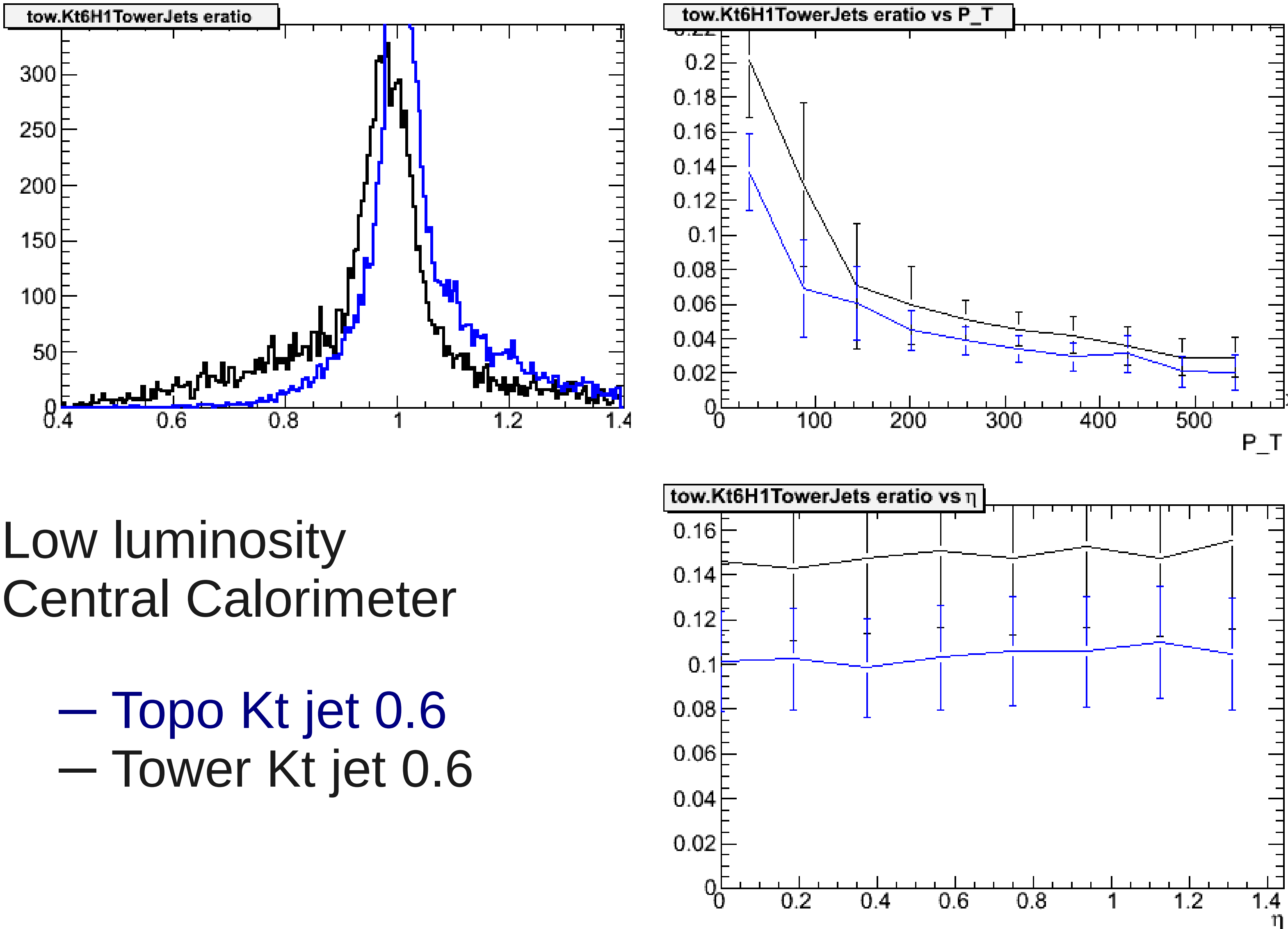
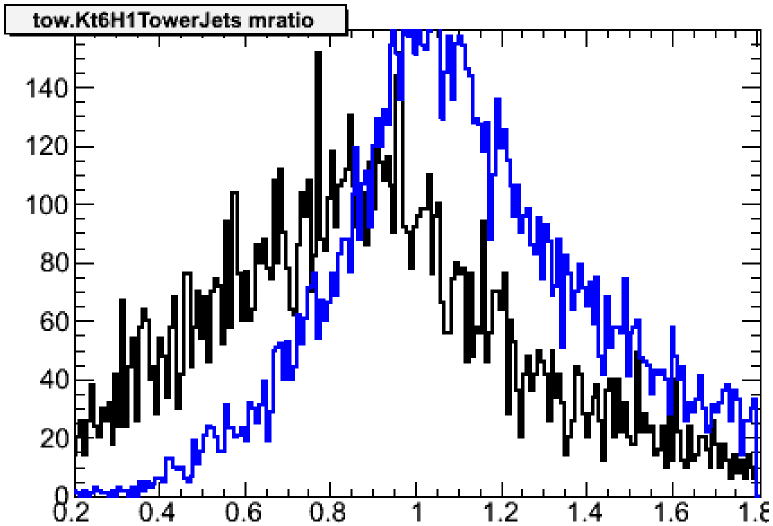
Impact on Energy – jet input

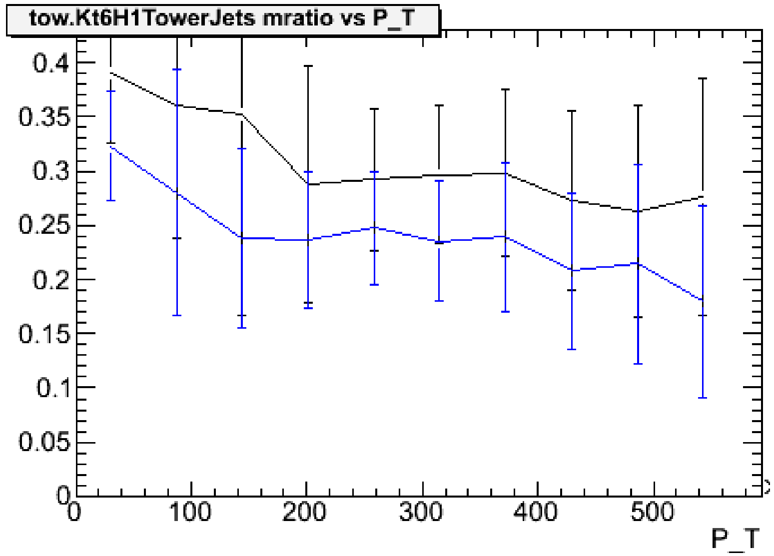


Low luminosity
Central Calorimeter

— Topo Kt jet 0.6
— Tower Kt jet 0.6

Impact on Mass – jet input





Low luminosity
Central Calorimeter

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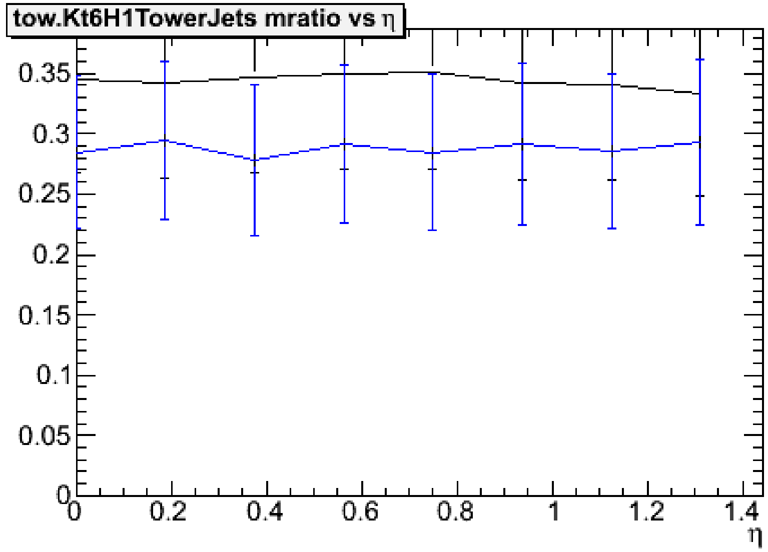


Impact on clusters

Energy fluctuation ~20%, more at low Pt
Other variables also affected
strong impact on classification

Impact on jets

Energy fluctuation 12% to 4%, strong dependance on Pt, Eta
Mass fluctuation > 15% !
Tower jets clearly more affected than cluster jets

What solutions ?

Calorimeter level improvement :

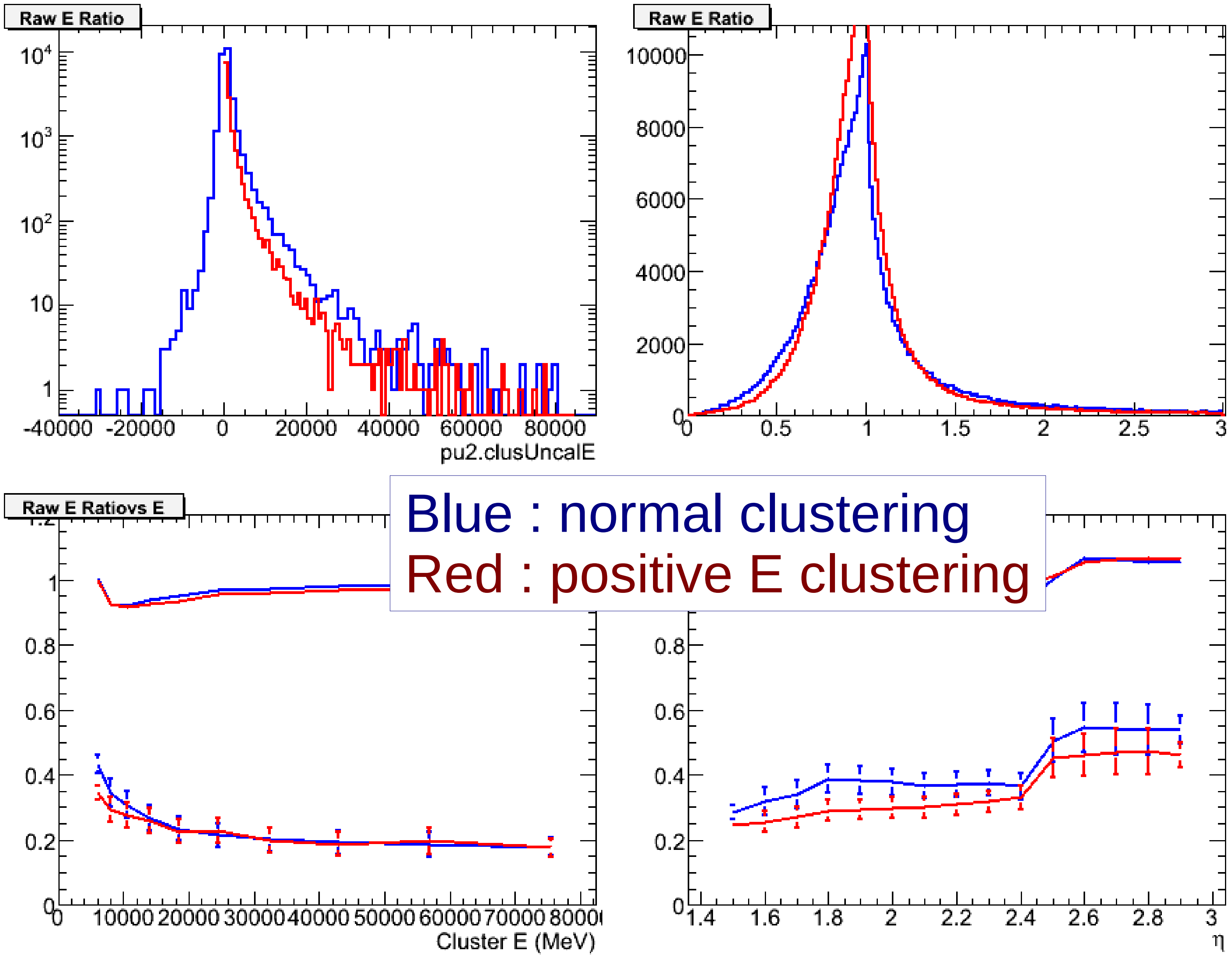
- Calorimeter time
  - only in-time cells -> marginal improvement at low lumi
- Tune the 'sigmas' ?
  - s depends on eta, luminosity
- Assymetric cuts
  - cancel biais using bipolar shape
- Only positive cells + biais substraction

Negative energy == noise
less fluctuation ? (c.f. next slide)

Offset substraction

needed anyway (we use clusters with E>0)
Important to measure MinB with early data

Energy in endcap region



Blue : normal clustering

Red : positive E clustering

Jet Level improvement

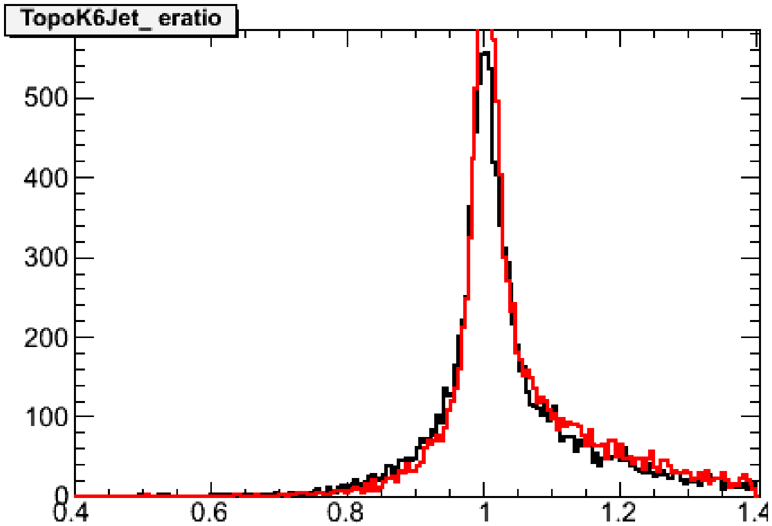
Choice of Jet algorithm

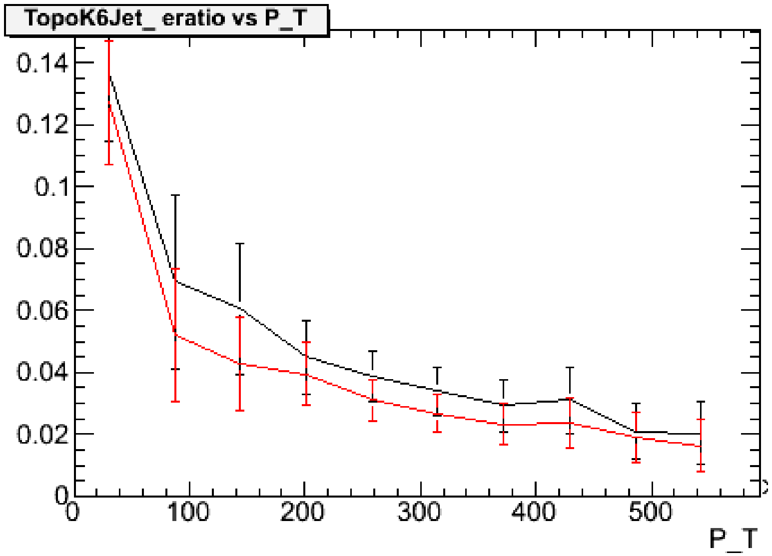
- prefer small size
- AntiKt performs better (c.f. next)

Jet Area

Jet Tracks

Impact on Energy – AntiKt





Low luminosity
Central Calorimeter

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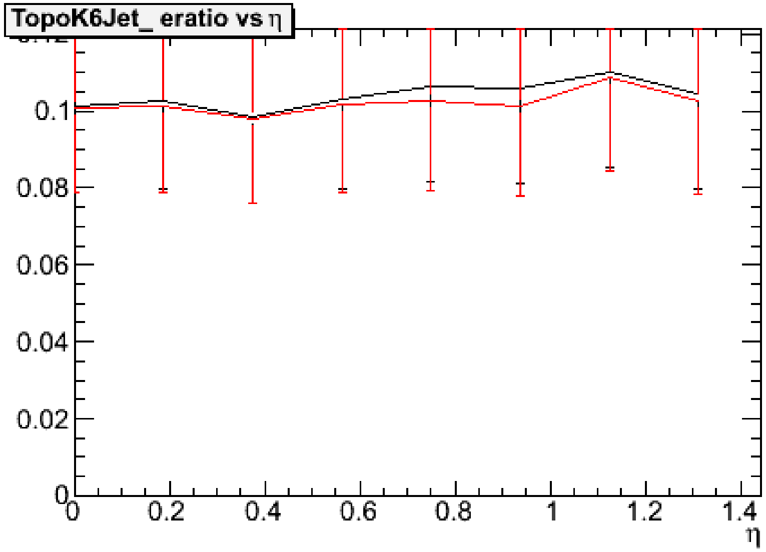
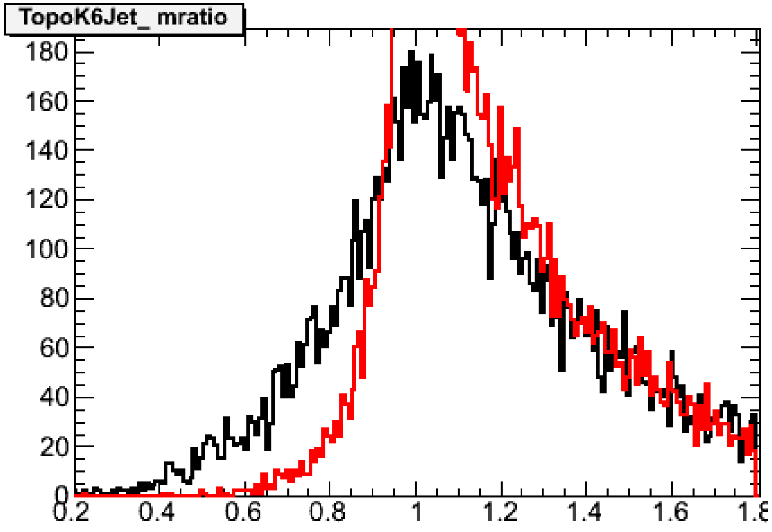
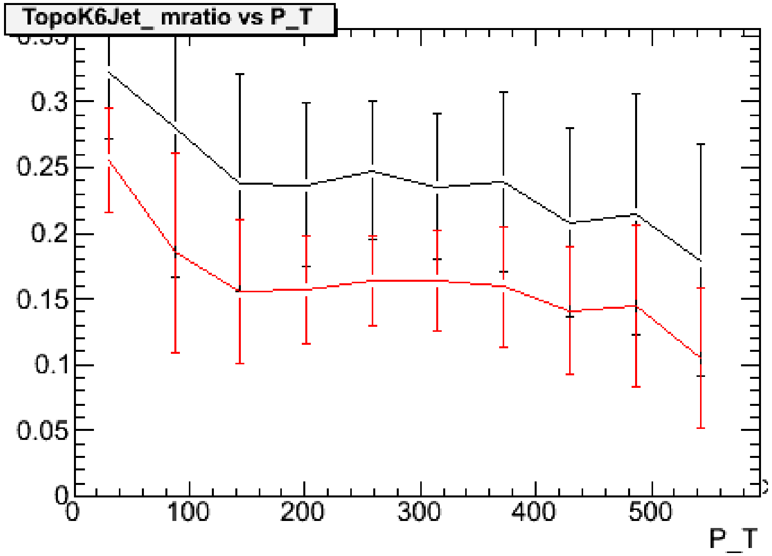
— Topo Kt jet 0.6



Impact on Mass – AntiKt





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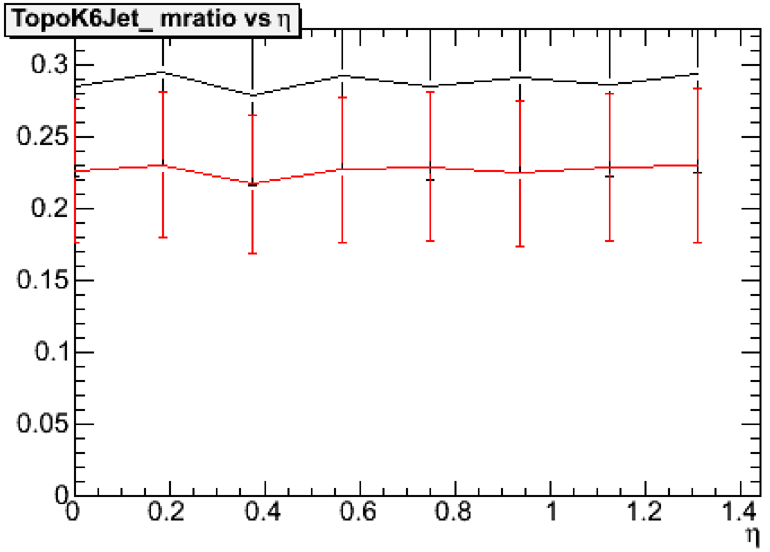
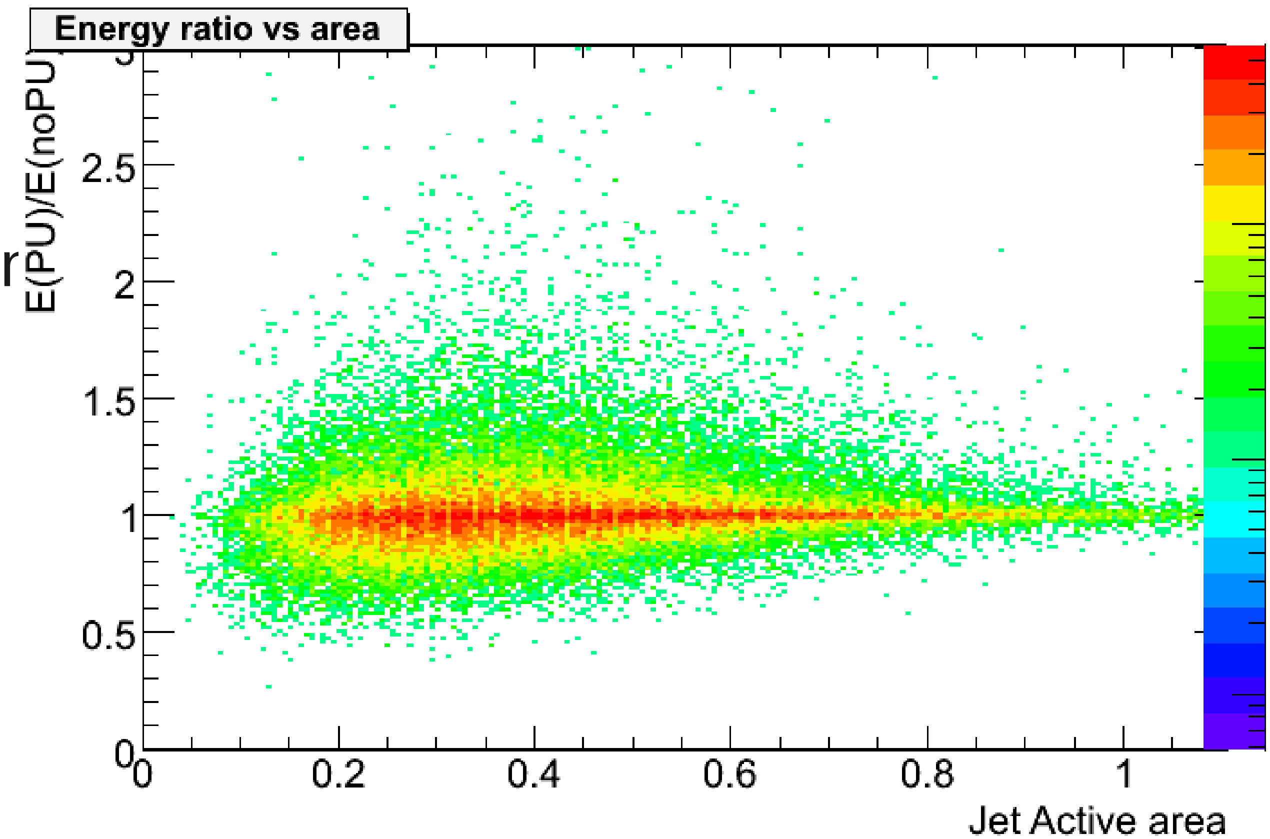


Jet Area

Several ways of computing areas :

- FastJet Active area
- Convex Hull Area
- 2nd angular moments

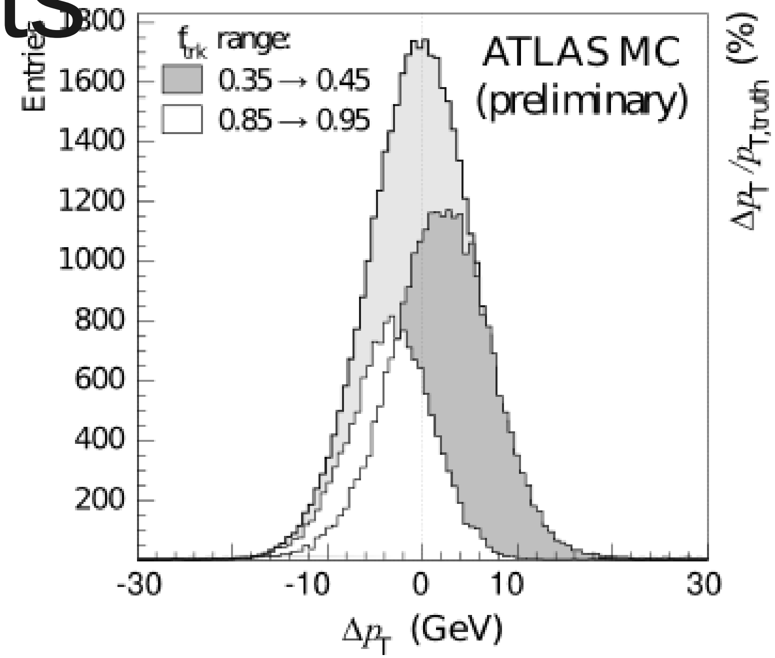


First look :
no direct correlation between fluctuations & areas

Lots more to do...

Ratio **Pt/Area** interesting discrimant for pile-up jets

Track Jets

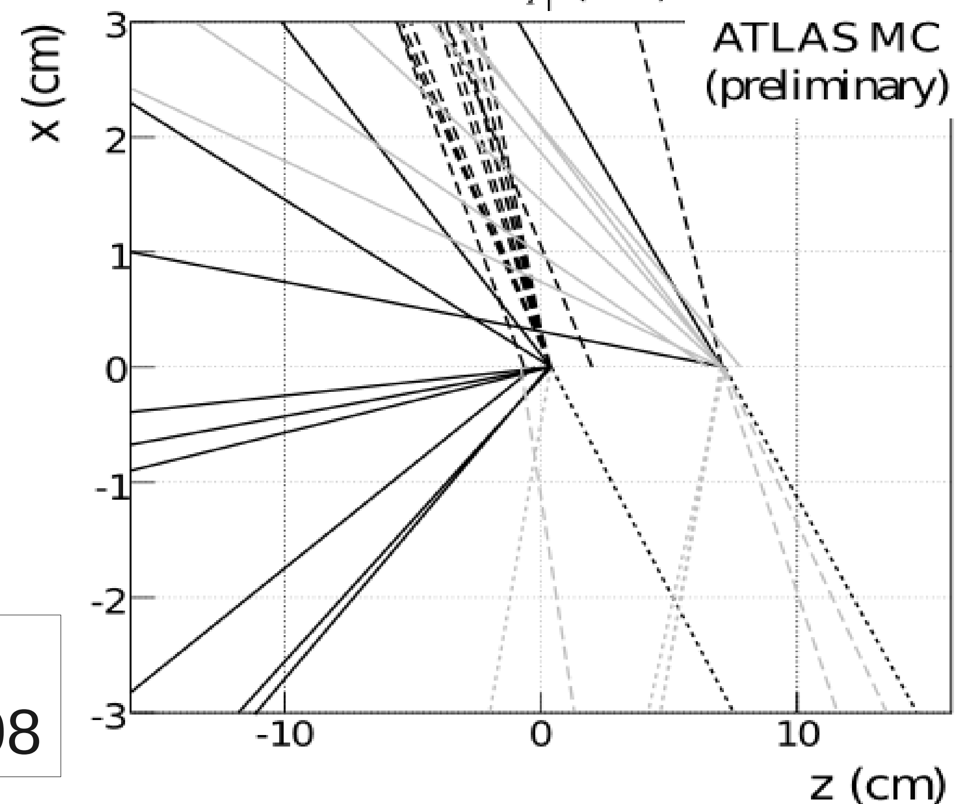


<u>Atlas allows jet finding on tracks</u>

Match tracks jets with calo jets

$$f_{trk} = \frac{Pt_{track}}{Pt_{calo}}$$

Correct energy scale according to f



Use tracks vertices :

- Adds a 3rd dimension to jet finding
- Use vertex assignment to reject PU jets

Work from A. Schwartzman et. al.
See note ATL-COM-PHYS-2008-008

Conclusions

Pile-up has an important effects on calorimeter objects

Even at low luminosity :

- Energy fluctuation ~4% to ~15% for jets
- More on clusters (impact also missing Et)

Several level of corrections can be applied

- Calorimeter : clustering
- Jet : algorithm, area, track jets

Work on this topics is starting...

First step with early data : measure MinBias !