Algorithms for the DØ Calorimeter

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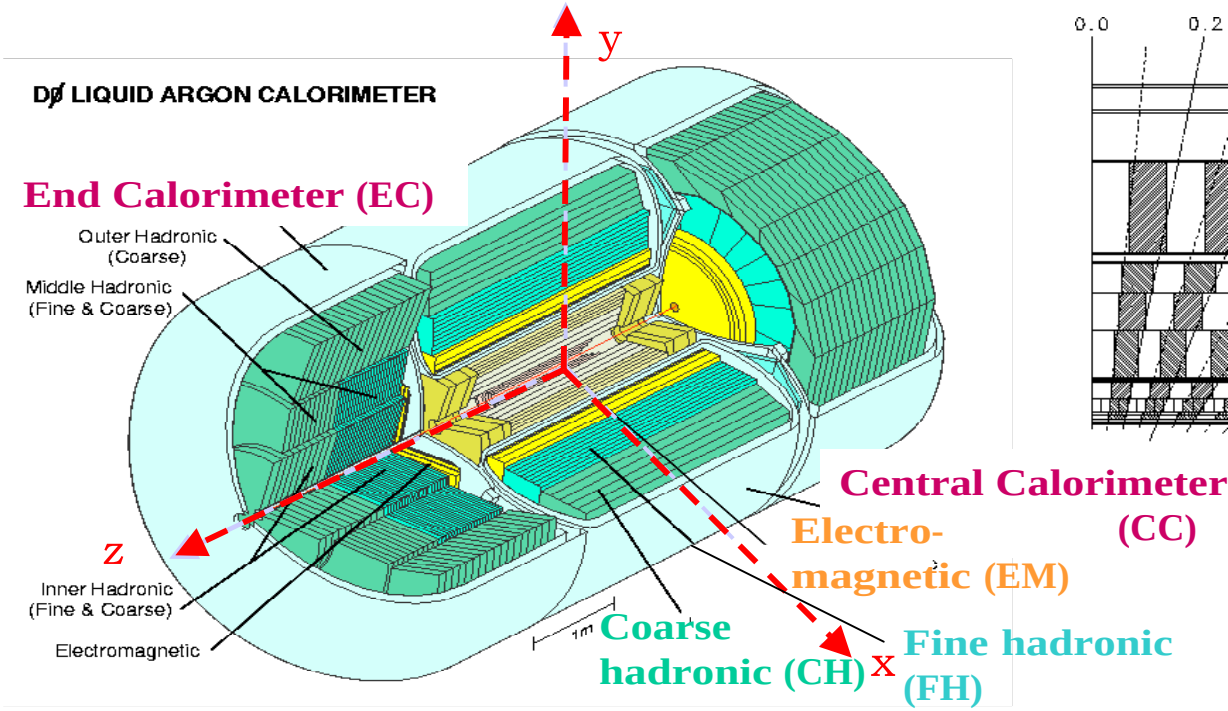
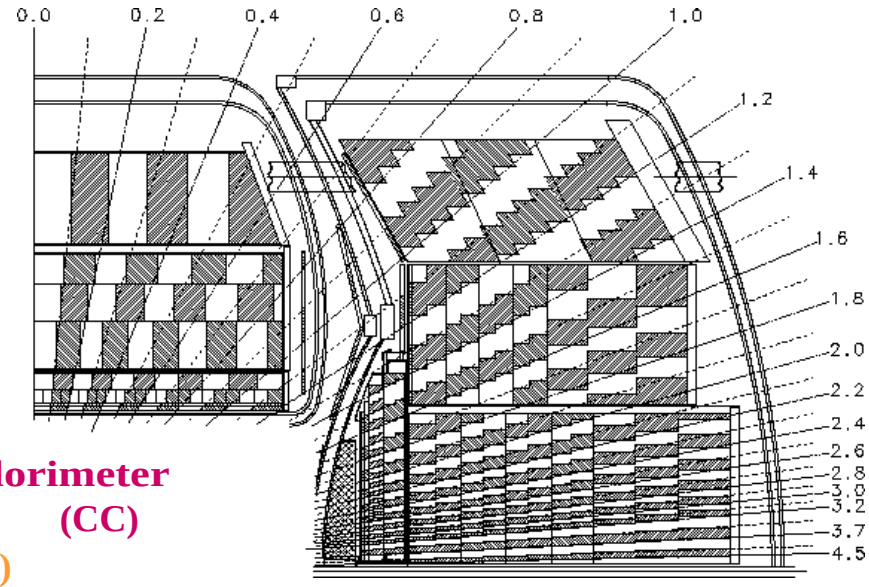
LPNHE – PARIS VI for the DØ collaboration

- Calorimeter short description
- Algorithms at the cell level
- Jets reconstruction
- Electromagnetic objects reconstruction
- Missing transverse energy

The DØ calorimeter



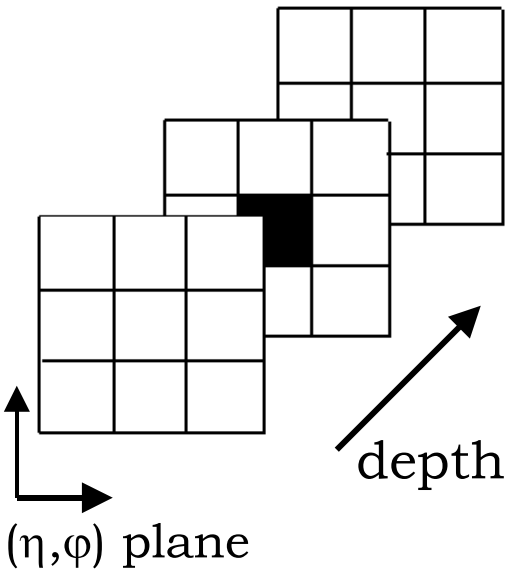


55000 cells
50 dead channels

- Liquid argon active medium and uranium absorber
- Hermetic with full coverage : $|\eta| < 4.2$; $\lambda_{int} > 7.2$ (total)
- Fine granularity of the calorimeter : for cells $\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$ (0.05x0.05 in third EM)
  Transverse segmentation (pseudo-projective towers) $\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$
- Fiducial volume : avoid region $\pm$ 0.02 around φ cracks and far from cryostat boundaries.

Off-line noise reduction : NADA

NADA : Neighborless Anomalous Deposit Algorithm

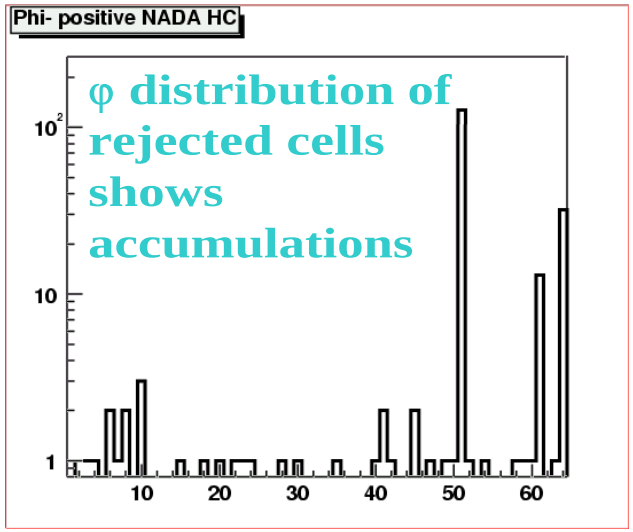


Purpose : Identify anomalous energy deposition in the calorimeter : the isolation of high E_T cells is checked by looking at their 3D neighbors.

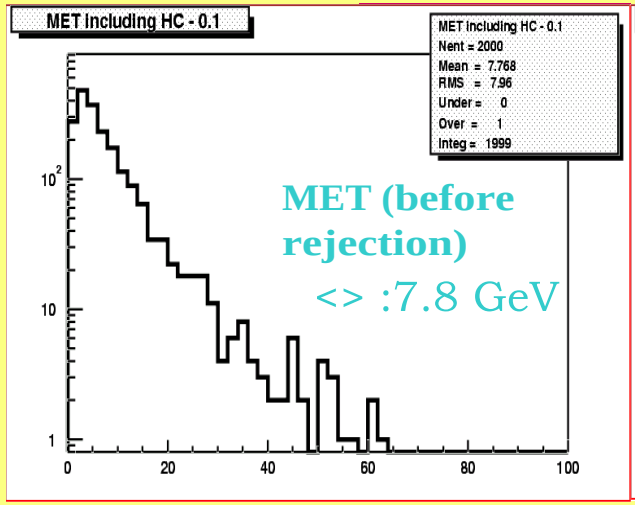
if $\begin{cases} E_{Tcell} < -1 \text{ GeV or } E_{Tcell} > 500 \text{ GeV} \\ \text{or} \\ 1 \text{ GeV} < E_{Tcell} < 500 \text{ GeV and } \Sigma E_{neighbors} < E_{cut}(E_T) \end{cases}$

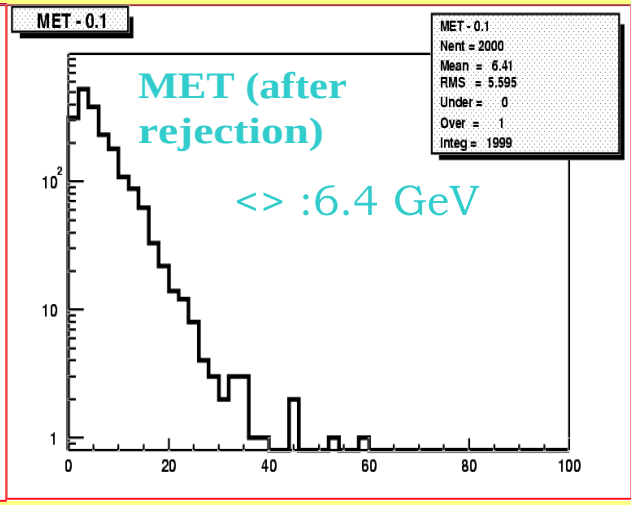
$\Rightarrow$ the cell is rejected

0.04 wrongly rejected cell per event



Effect of NADA on Missing Transverse Energy (MET)





Off-line noise reduction : T42

Purpose : improve the signal to noise ratio beyond the standard DØ zero-suppression (2.5σ) by rejecting isolated cells of low energy and cells of negative energy.

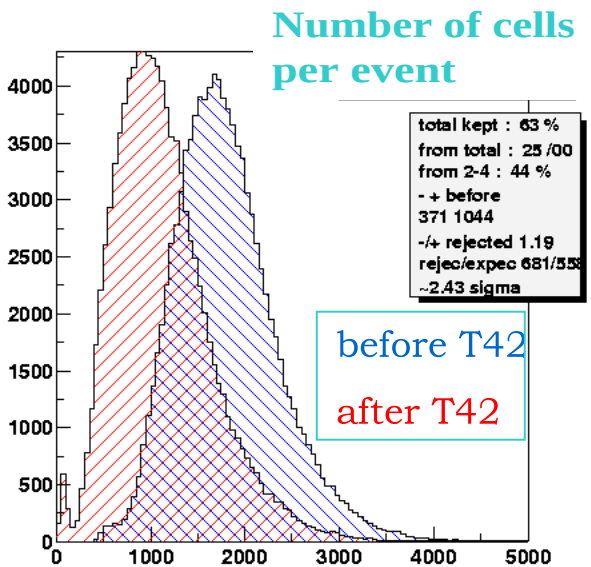
The algorithm T42 rejects :

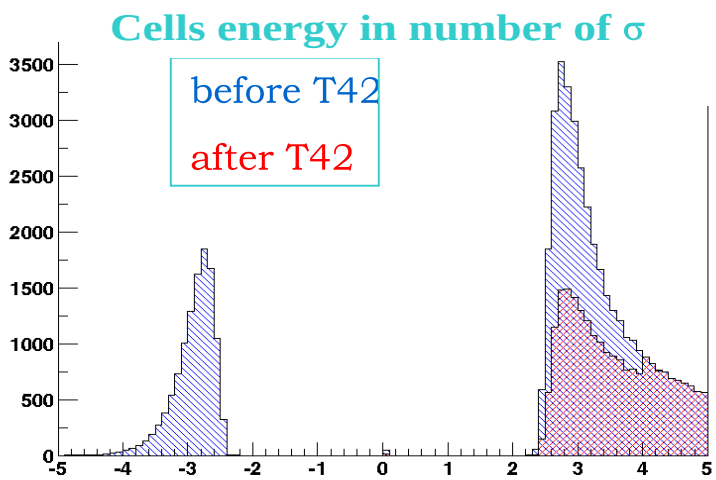
- all isolated cells with energy below 4σ of noise (*similar to* H1)
- all negative cells

It keeps :

- only high signal cells (with energy above 4σ)
- their significant 3D neighbors (between 2.5σ and 4σ)

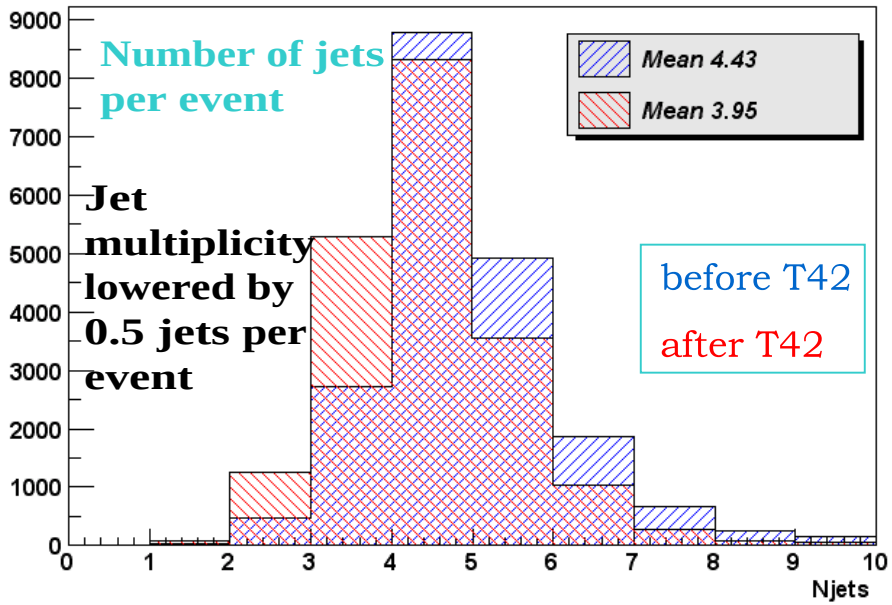
Allow to improve the missing transverse energy and the reconstruction of jets and e/γ at low energy

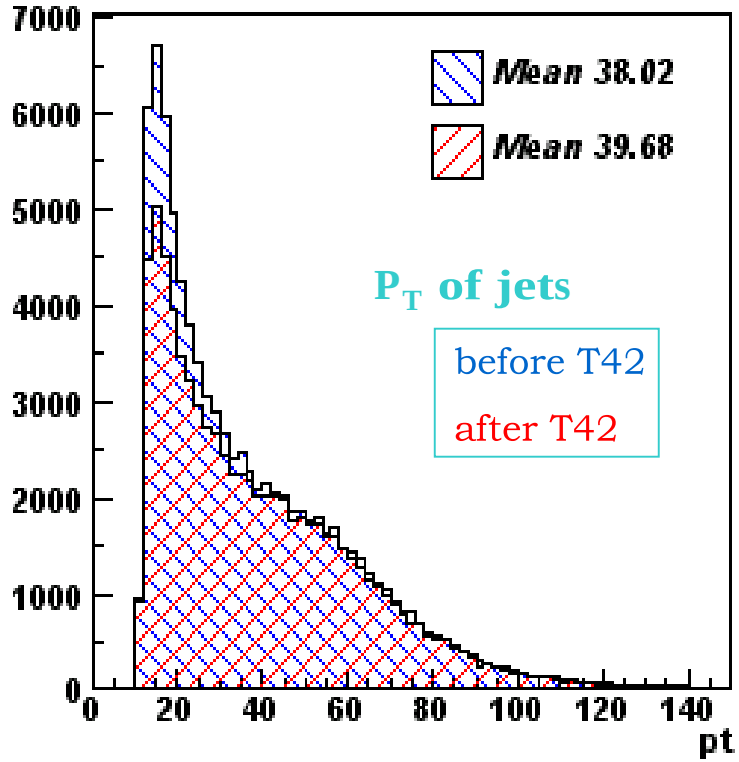




Effect of the T42 algoritm on jets

Sample of events used for top reconstruction in all-jets channel





T42 allows to reject low energy jets influenced by noise

Objects reconstruction

- Jets
- Electromagnetic objects
- Missing transverse energy

Jets reconstruction algorithm

Improved Legacy Cone Algorithm

- Pre-clustering = Input for clustering.

Simple cone algorithm : A first clusterisation is made around high E_T towers (> 500 MeV) in a cone of $\Delta R=0.3$ $\left[\textit{Tower size} = 0.1\times 0.1 \textit{ in } (\eta,\varphi)\right]$

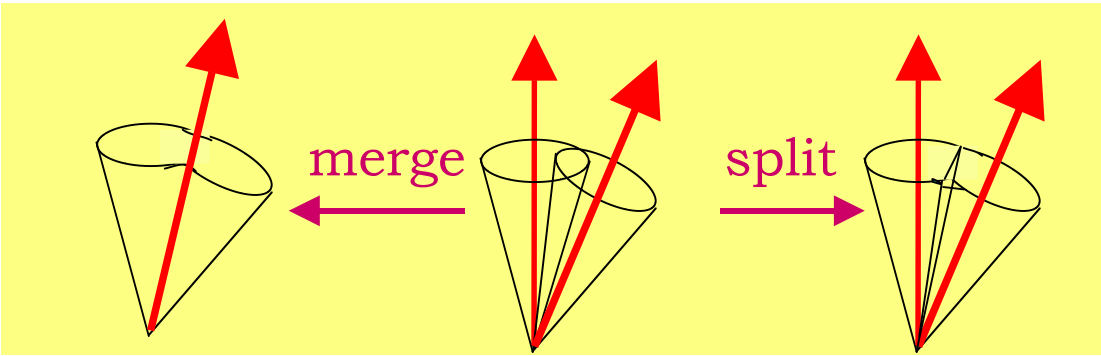
Rejection of fake clusters :
If the higher E_T cell of a tower is in the CH and if $E_{cell} < E_{threshold}$ then the tower is considered only if $E_T(\text{tower})-E_T(\text{cell}) > 500$ MeV

- Clustering : simple cone algorithm ($\Delta R=0.5$ or $\Delta R=0.7$)

Seeds are in the center of a ΔR cone which is iteratively drifted until it is stable.

P_T jet > 8 GeV

If cones overlap $\Rightarrow$ apply a split/merge algorithm.



Jets identification

Variables that help to reject fake jets.

- P_T fraction of jets in the CH : < 0.4
- P_T fraction of jets in the EM : 0.05 < EMF < 0.95
- Number of towers containing 90% of the jet energy : > 1
- P_T of the higher cell / P_T of the second higher cell : < 10
- Use the L1 information : around the center of a jet, sum the transverse energy of L1 towers within a cone (P_T(L1)).

P_T(L1)/$P_T$jet > 0.4 (0.2 in the intercryostat detector region)

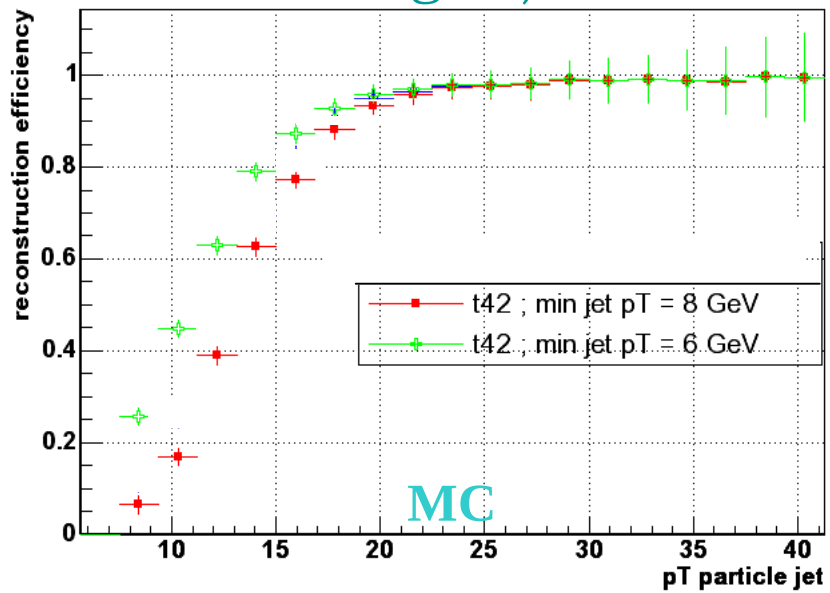
Independant readout path for trigger

Jet efficiency reconstruction+identification :

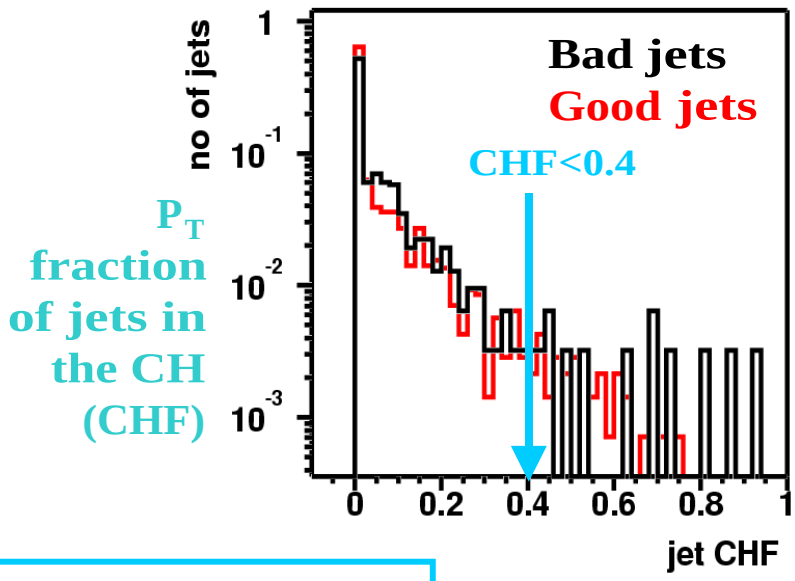
95 % ± 5 % on data for P_T>20 GeV

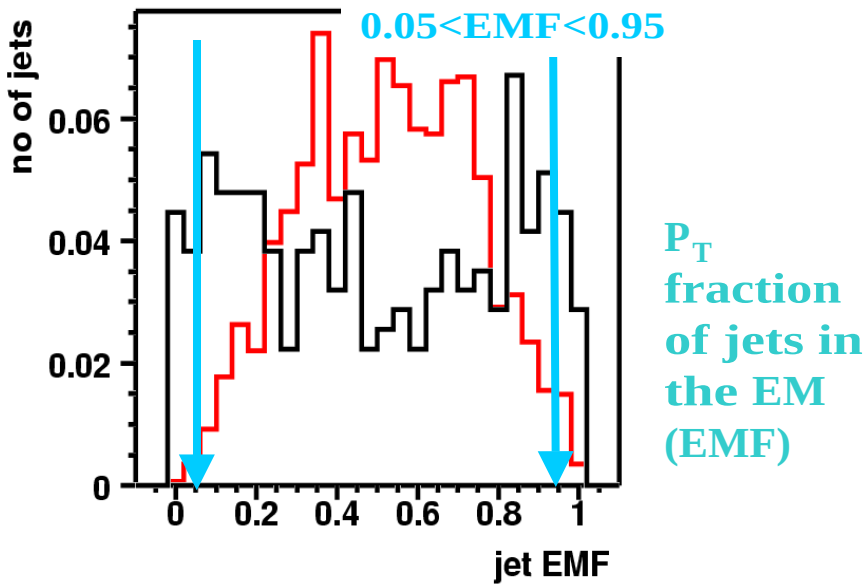
95 % on MC for P_T>20 GeV

98 % on MC for P_T>25 GeV



Variables for jets identification



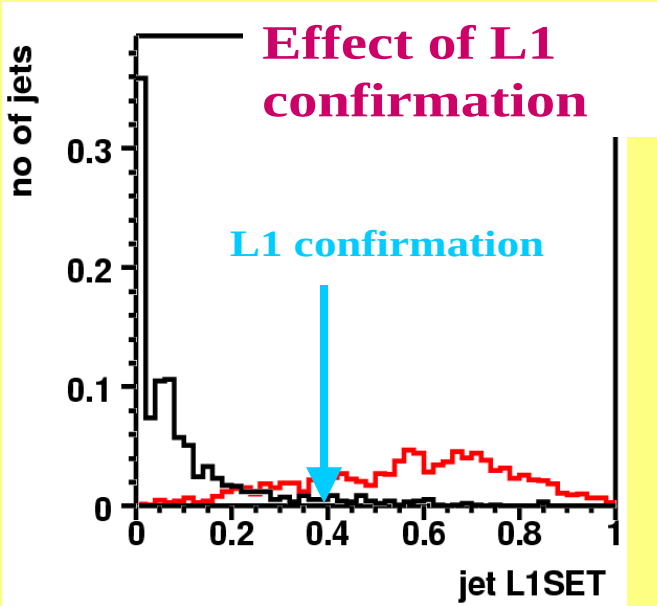


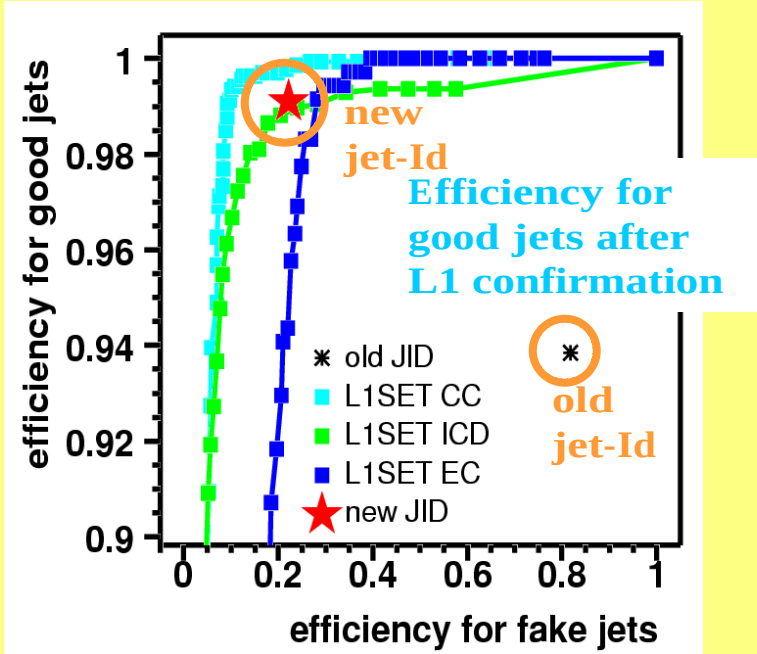
Good jets sample:

di-jet event

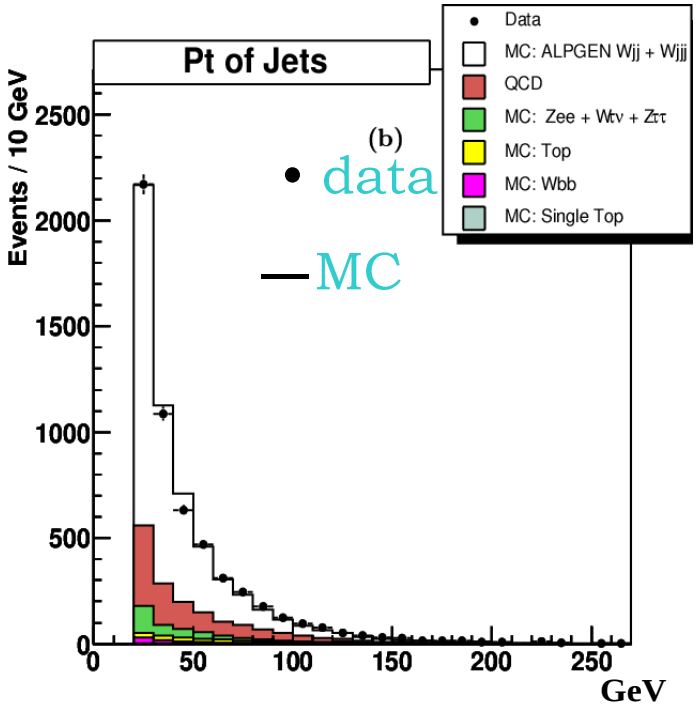
Fake jets sample:

events with more than 5 jets



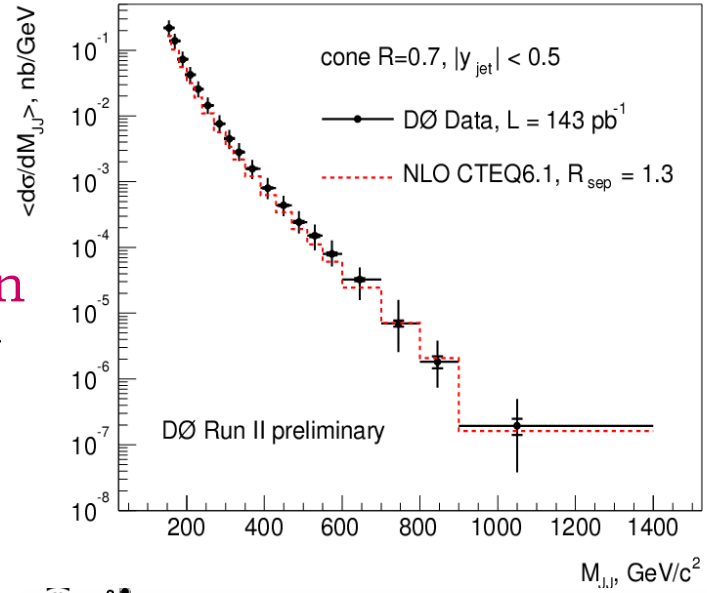


Jets in DØ RunII analysis

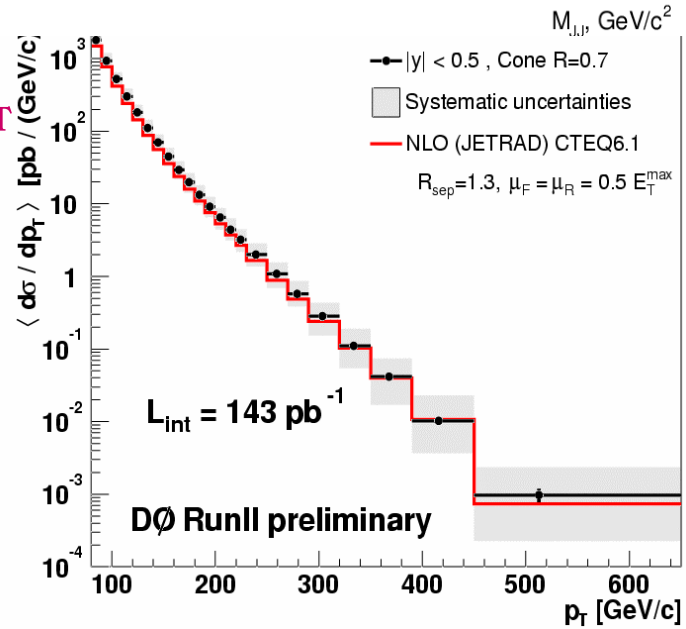


Data – MC comparison for jets P_T in W+dijets events used for $Wb\bar{b}$ studies
cone = 0.5

Dijet mass cross section data/theory comparison
cone = 0.7



Inclusive jet P_T cross section data/theory comparison
cone = 0.7



More in A. Kupco's talk

Reconstruction of high P_T electrons

The algorithm is simple cone algorithm :
Electromagnetic clusters are obtained by adding towers within a cone of $\Delta R<0.2$ around seeds (≡ towers of higher transverse energy ($P_T>0.5$ GeV)).
Cluster criteria is : P_T(cluster)>1.5 GeV and EMF>0.9.

The estimators used to identify electrons are :

- Isolation of the cluster : Energy between cones $\Delta R<0.2$ and $\Delta R<0.4$ must be low : $\Delta E<E*0.15$
- The shower shape probability is evaluated on data (using 7 variables) and compared to the simulation.
- Track matching ($\chi 2$ probability must be reasonable)

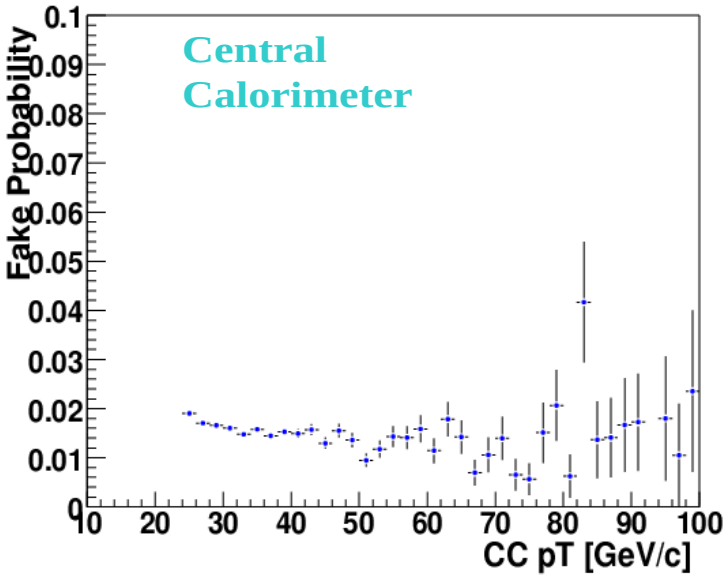
Cut on a Likelihood using 8 variables for electrons track matching.

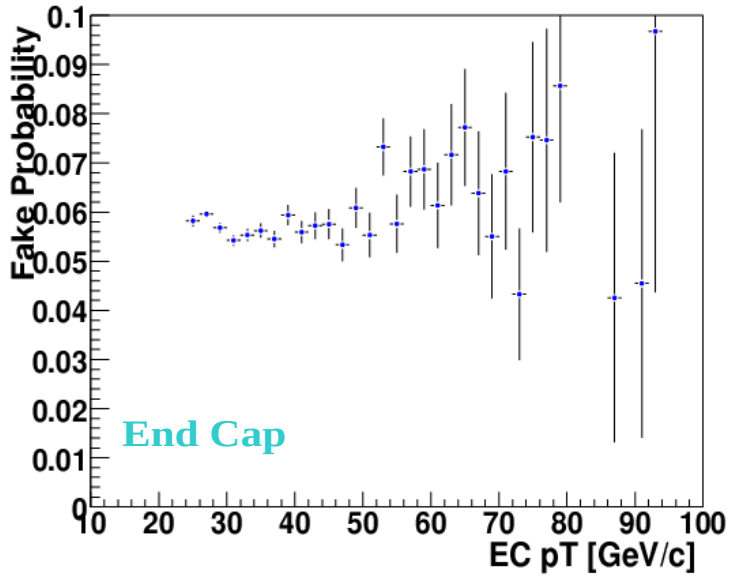
The variables include the 3 estimators and E_T/P_T, the DCA, the number of tracks in a cone $\Delta R<0.05$, the total PT of tracks in a cone $\Delta R<0.4$ around a candidate track and the number of CPS strip hits per electromagnetic energy.

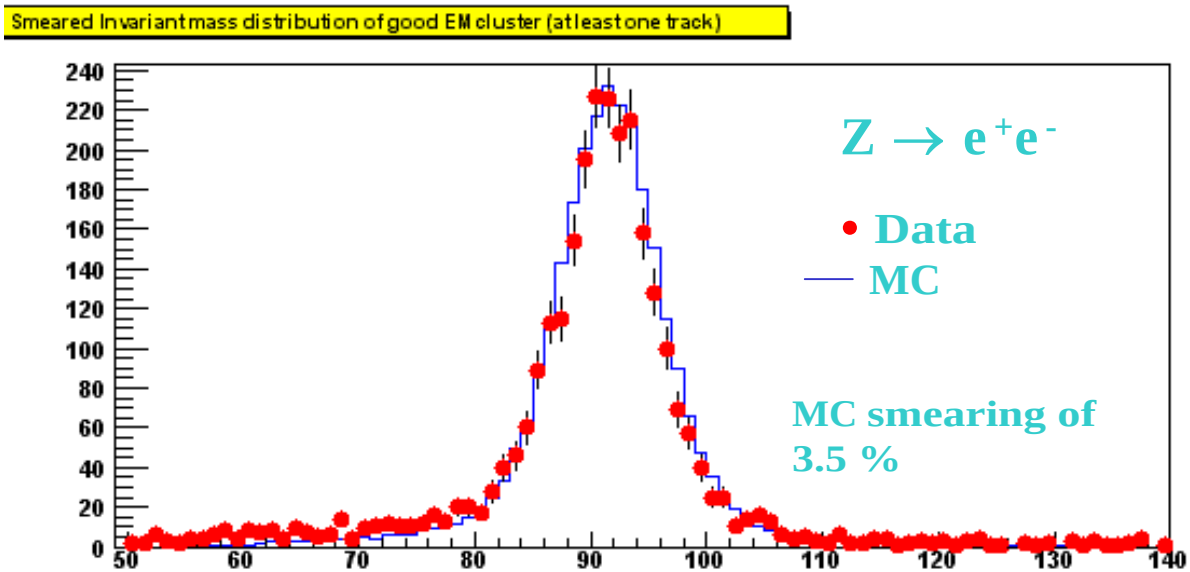
Electron identification efficiency : (92.7±0.2) % on data in CC
(91.2 ±0.6) % on data in EC

Electron reconstruction

Probability for a fake electron to have a track matched to it as function of P_T







Z mass resolution

Data :

3.8 % in CC – 3.1 % in EC

MC :

2.3 % in CC – 1.6 % in EC

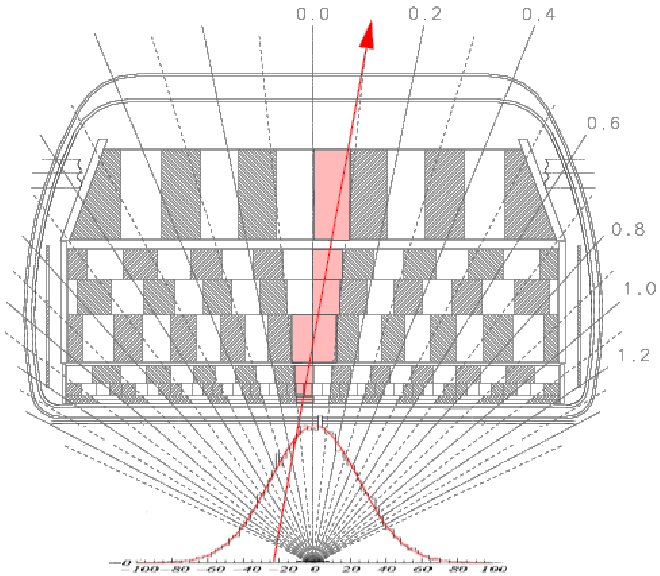
Reconstruction of low P_T electrons

The road method :

Developed for non-isolated and low P_T electrons

Each reconstructed track of P_T>2 GeV is extrapolated in the calorimeter

The road is reconstructed with cells in a cylinder around the track extrapolation (use the calorimeter granularity).

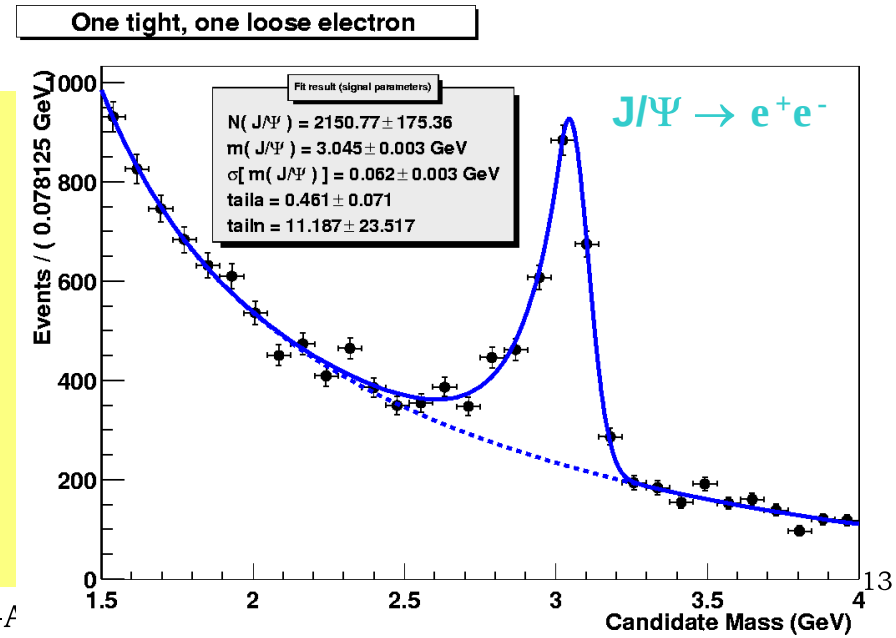


Discriminating variables :

- Electromagnetic fraction :
EMF > 0.85

- E/p :
0.6 < E_T(3 first EM layers)/P_T(track) <1.05

Efficiency : ~82 % on MC for P_T>5GeV



Photons reconstruction

Photons are reconstructed with same method as high P_T electrons (simple cone algorithm). They differ from electrons by the absence of a track.

Photon identification using pre-shower detector/calorimeter matches and vertex pointing are under development.

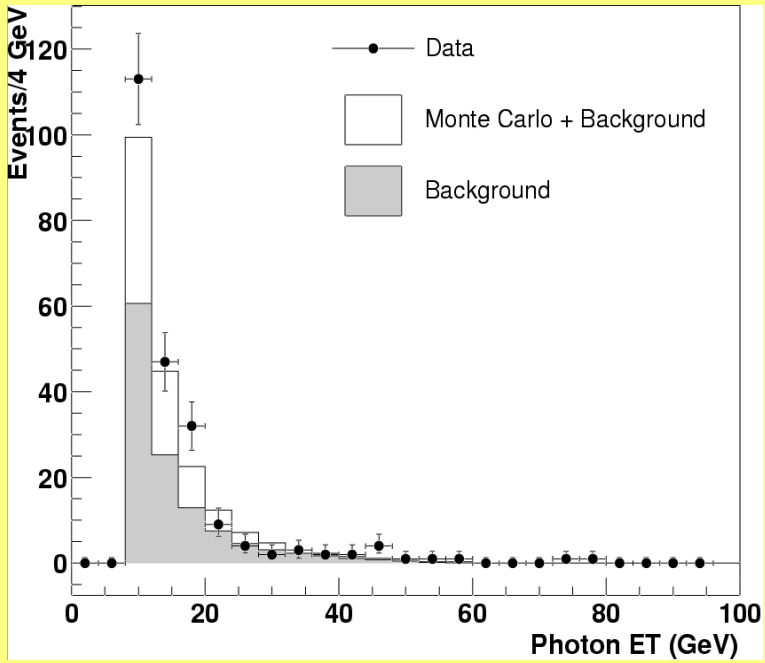
Currently, tighter criteria are adjusted by analysis groups.

Example of studies of Wγ production.
Criteria for photons identification are :

ΣP_T (tracks in the cone $\Delta R<0.4$) < 3 GeV

Photons are reconstructed in the central calorimeter

P_T(photon) > 8 GeV



Transverse energy of photons for studies of Wγ production.

Reconstruction of Missing Transverse Energy

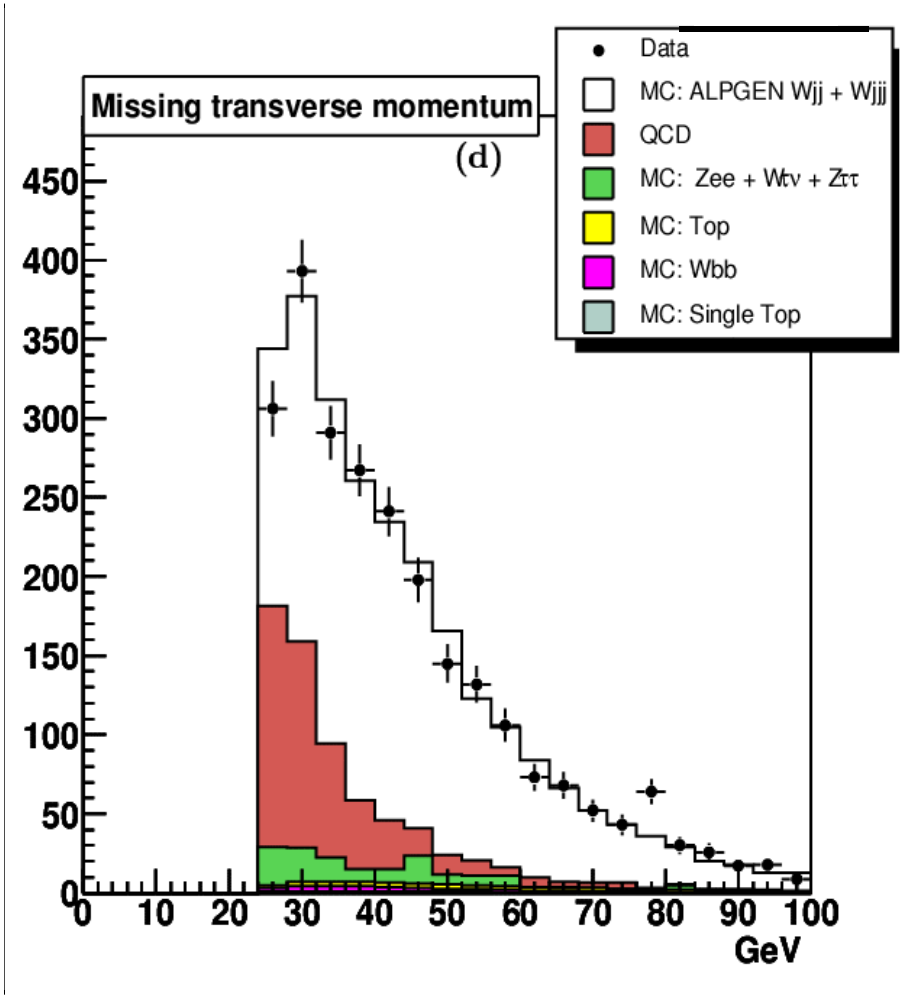
Purpose : identify a particle which doesn't interact in the detector (such as ν)

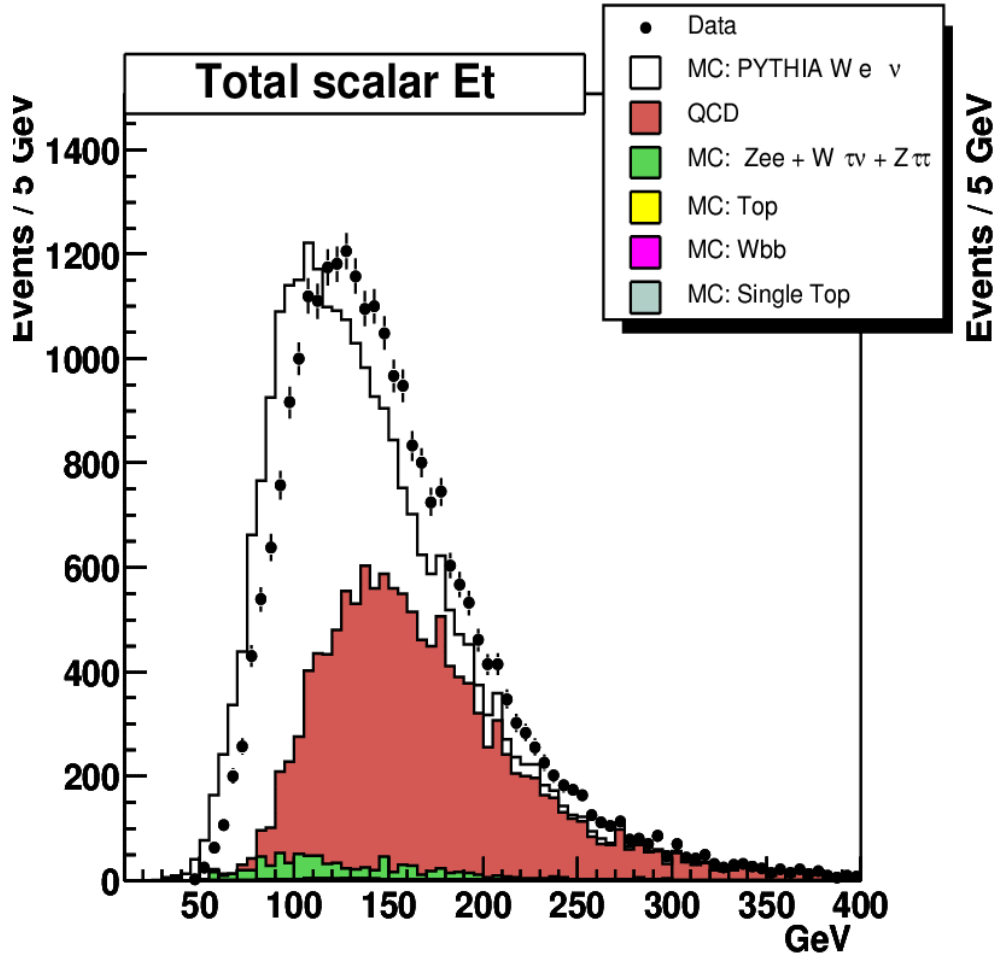
Quadratic sum of cells transverse energy $\equiv$ Visible Transverse Energy (VET)

ΣTransverse Energy = 0 $\Rightarrow$ Missing Transverse Energy (MET) = -VET

VET is computed with all cells excepted those from CH
The CH part of jets is added to VET
The bad jets are removed from VET
VET is corrected from electromagnetic scale and jet energy scale
Muons transverse energy is removed from MET.

Missing Transverse Energy





Missing transverse energy and scalar transverse energy in W+dijets events used for $Wb\bar{b}$ studies

Conclusion

- For the jets, standard cone algorithm is used with 0.5 and 0.7
Reduction of main systematics will come from improved jet energy scale.

- Electrons reconstruction/identification well understood for high P_T physics

Further efforts on low energy and non-isolated electrons

- Use pre-shower detector information to improve photon identification

- Improved missing transverse energy from off-line noise treatment

Improvements are still to come

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