Algorithms for the DØ Calorimeter

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

- Liquid argon active medium and uranium absorber
- Hermetic with full coverage: $|\eta| < 4.2$; $\lambda_{\text{int}} > 7.2$ (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 $\varphi$ cracks and far from cryostat boundaries.

55000 cells
50 dead channels
**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.

\[
\text{if} \begin{cases} 
E_{T\text{cell}} < -1 \text{ GeV} \text{ or } E_{T\text{cell}} > 500 \text{ GeV} \\
1 \text{ GeV} < E_{T\text{cell}} < 500 \text{ GeV} \text{ and } \sum E_{\text{neighbors}} < E_{\text{cut}}(E_T)
\end{cases} \\
\Rightarrow \text{ the cell is rejected}
\]

0.04 wrongly rejected cell per event

**Effect of NADA on Missing Transverse Energy (MET)**

- MET (before rejection): $\sim 7.8$ GeV
- MET (after rejection): $\sim 6.4$ GeV

**CALOR 2004 - 1-April-2004**
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 algorithm 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 $\Delta R=0.3$ \[ \text{[Tower size = 0.1}\times0.1\text{ in } (\eta, \varphi)] \]

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 $E_T(tower)-E_T(cell) > 500$ MeV

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

Seeds are in the center of a $\Delta R$ cone which is iteratively drifted until it is stable.

$P_T$ jet $> 8$ GeV

If cones overlap ⇒ 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 (\( P_T(L1) \)). \( P_T(L1)/P_T\text{jet} > 0.4 \) (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

**Effect of L1 confirmation**
- L1 confirmation

**Efficiency for good jets after L1 confirmation**
- New jet-Id
- Old jet-Id

- **$P_T$ fraction of jets in the CH (CHF)**
- **$P_T$ fraction of jets in the EM (EMF)**

**Bad jets**
- CHF $< 0.4$

**Good jets**
- 0.05 $< \text{EMF} < 0.95$

**L1 confirmation**
- Efficiency for good jets after L1 confirmation
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

More in A. Kupco’s talk

CALOR 2004 - 1-April-2
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 $P_T$

Central Calorimeter

End Cap

Smeared Invariant mass distribution of good EM cluster (at least one track)

$Z \rightarrow e^+e^-$
- Data
- MC

MC smearing of 3.5 %

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: $\sim 82\%$ on MC for $P_T > 5$ GeV
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 $W\gamma$ production.**
Criteria for photons identification are:

$\sum P_T$ (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 $W\gamma$ production.
Reconstruction of Missing Transverse Energy

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

Quadartic sum of cells transverse energy $\equiv$ Visible Transverse Energy (VET)
$\sum \text{Transverse Energy} = 0 \Rightarrow \text{Missing Transverse Energy (MET)} = -\text{VET}$

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 and scalar transverse energy in W+dijets events used for Wbbar 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