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Test of the Jet Reconstruction and Calibration analyzing the invariant mass of the W decay products
"Work in Progress"

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We have used simulated t-tbar events produced by Koji for the calibration note and the Lisbon workshop (June 2009) to study the reconstructed W mass with the goal of studying different versions of jet calibrations. Other studies of the W mass reconstruction have been carried out, most recently by Nabil Ghodbane (http://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=55272) and we obtain results which are similar.

The calculation of the W mass can be affected by several factors:

- **Input to the jet algorithm**
  Since noise treatment is different for each input the width of the W peak could be potentially different. There are three possible inputs:
    - topological clusters,
    - towers and
    - topo-towers.

  However in this document we will show only the difference between towers and topological clusters.

- **Jet Calibration**
  In the scheme proposed by the jet calibration task force, the jet energy scale should be set by applying the numerical inversion method and thus the value of the W mass would be set by this method. However the resolution may be affected by a particular calibration method. We will study the W mass distribution from the reconstructed jets after:
    - cell energy density calibration and
    - local cluster calibration to improve the resolution and
    - numerical inversion (to set the correct jet energy scale).
    -
- **Jet algorithm**
    - Volume/Area of the final jets. Depending on the jet algorithm and its parameters the number of constituents included in the jet volume changes and so the jet energy and W mass calculation.

Reconstruction details

The dataset name is:
user09.KojiTerashi.mc08.105200.T1_McAtNlo_Jimmy.recon.DPD_NOSKIM.e357_s462_r635_DPDMaker000164_p1

The calibration used is the default in the Athena release 15 for H1 and LC. The jet energy scale used is the numerical inversion calculated for the DPDs produced by Koji.

Calculation of W mass

We have reconstructed the invariant mass of the W decay products in the t-tbar events for the decay partons, reconstructed truth jets and reconstructed (& calibrated) jets:

a) **Parton level**

We use the primary partons in the generator list from the W decay. The status flag used to select these partons are as follows:

status = 3 (for Pythia)
status = 155 (for Acer)
status = 195 (for McAtNLO)

b) **Jet level**

   a. **Truth jets:** The truth jets are obtained from the MC particles running the same jet reconstruction algorithm as the reconstructed jets – we however use the collections written on the pDPD. We match the truth jets to the MC partons from the W decay and sum the 4^{th}-momenta of the matched truth jets to reconstruct the W.
   b. **Reconstructed jets:** We match them also to the MC partons of the W decay and sum the 4^{th}-momentum of the matched jets to reconstruct the W.

Instead of matching truth jets with reconstructed jets as it has been done before, we attempt to reduce possible biases by matching the reconstructed jets and the truth jets directly to the MC partons from the W decay. For the matching we set a cut on $\Delta\phi$ between the parton and the reconstructed/truth jet of 0.2 and a cut on $\Delta\eta$ of 0.1 (and apply these cuts separately rather than as a cut in ΔR).

Input to the Jet algorithm

The effect of the jet reconstruction input should be more evident in the width of the W mass distribution. Any differences on the mean value of the W mass peak are not a very indicative factor, since the calibration should correct it. We compare here the differences between using topological clusters and towers. In this case, the jets have been reconstructed using AntiKt with parameter 0.4 and calibrated using the Numerical inversion method.

Figure shows the invariant mass distributions of the jets with topological clusters as input; and Figure 22 shows the distributions using towers as input. Both inputs give about the same width for the W mass peak. Although using tower jets the width of the W mass peak is about 2% wider than using topological clusters, the difference is within the errors of the fit. Numerical inversion applied to topological cluster gives a similar value for the W mass than the truth jets. However, in the simulation, Numerical inversion applied to tower jets gives 80 GeV for the W mass. This is about 1 GeV higher than the mass reconstructed using truth jets. As we discuss below, we cannot unambiguously attribute this difference to the jet energy calibration scheme.

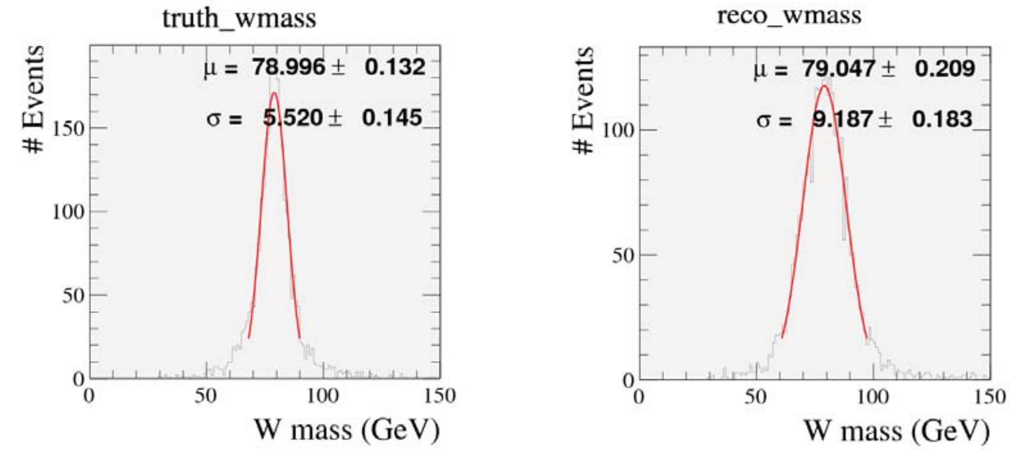

Figure 1: W mass for AntiKt4Topo using truth jets (left) and reconstructed jets from topological cluster and after numerical inversion calibration (right).

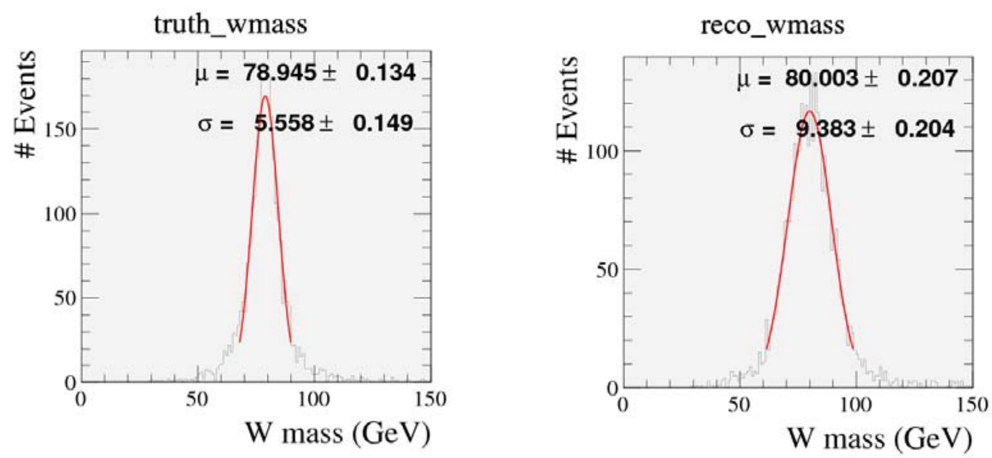

Figure 2: W mass for AntiKt4Tower using truth jets (left) and reconstructed jets from towers and after numerical inversion calibration (right).

Figure 3 shows the linearity (E^{reco}/E^{NTJ}) as a function of E^{NTJ} for tower and topo jets after numerical inversion. In both cases the average jet energy has been over estimated for low jet energies and approaches 1 for higher jet energies. Although we can think of plausible excuses (quark versus gluon jet, jet spectrum, out-of-cone energy) we don't understand this and it needs more study.

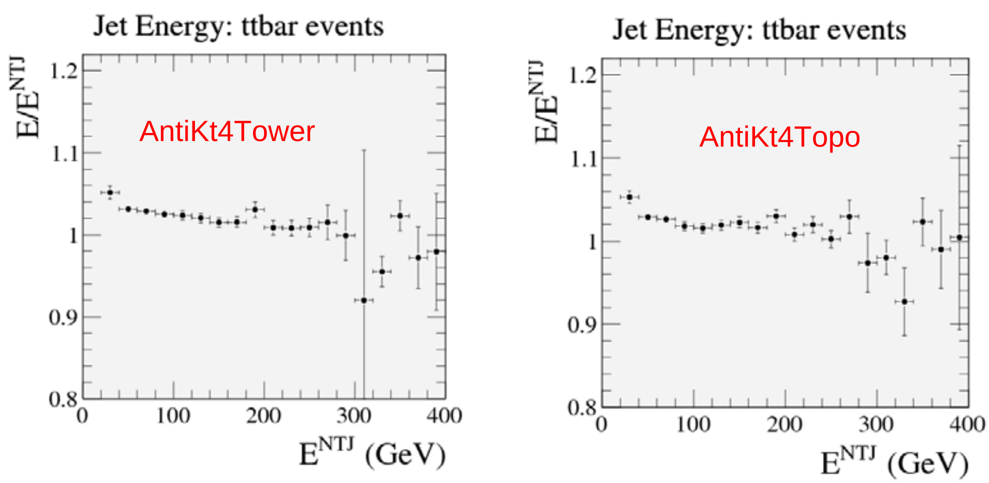

Figure 3: Linearity as a function of the truth jet energy for AntiKt4Tower jets (left) and AntiKt4Topo jets (right) calibrated using numerical inversion.

Jet calibration

We follow the same procedure now analyzing jets calibrated with cell energy density method and with local topo-cluster calibration (Figure 4):

a) AntiKt4H1TopoTower jets
b) AntiKt4LCTopo jets
c) Cone4H1Tower jets

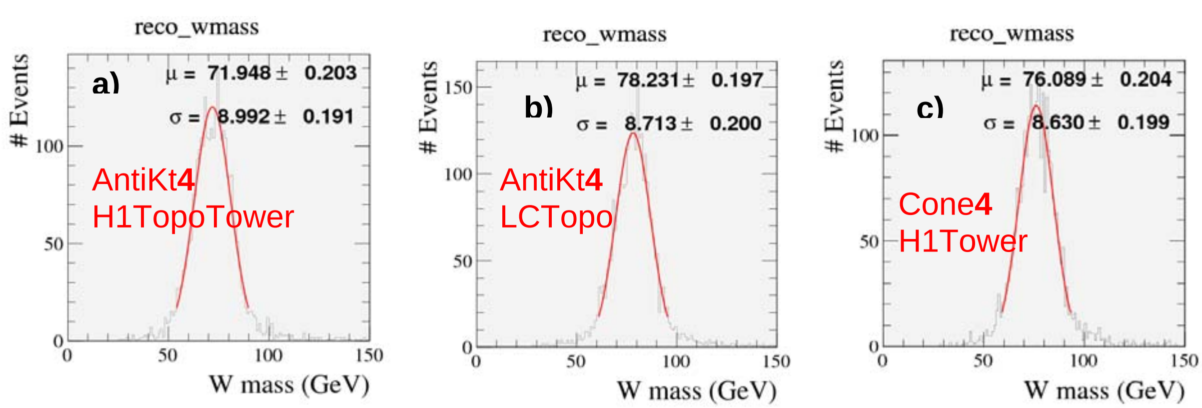

Figure 4: Invariant mass of the W decay products for: a) antiKt4H1TopoTower jets, b) AntiKt4LCTopo jets and c) Cone4H1Tower jets.

For the jet reconstruction algorithm with parameter 0.4 (either AntiKt or Cone) the width of the W mass peak is about the same for H1 or LC calibration. The average value of the peak should be set by the numerical inversion. We have also looked at the case of applying only numerical inversion and in this case the width of the distribution is only 6% wider than that obtained from either H1 or LC calibration.

Effect of the Jet algorithm: Jet size

In order to test the effect of the jet size we first looked at truth jets with two different cone sizes, 0.4 and 0.7. Then we calculate the W mass using the truth jets that match the partons and compare the result with the W mass obtained directly from the partons.

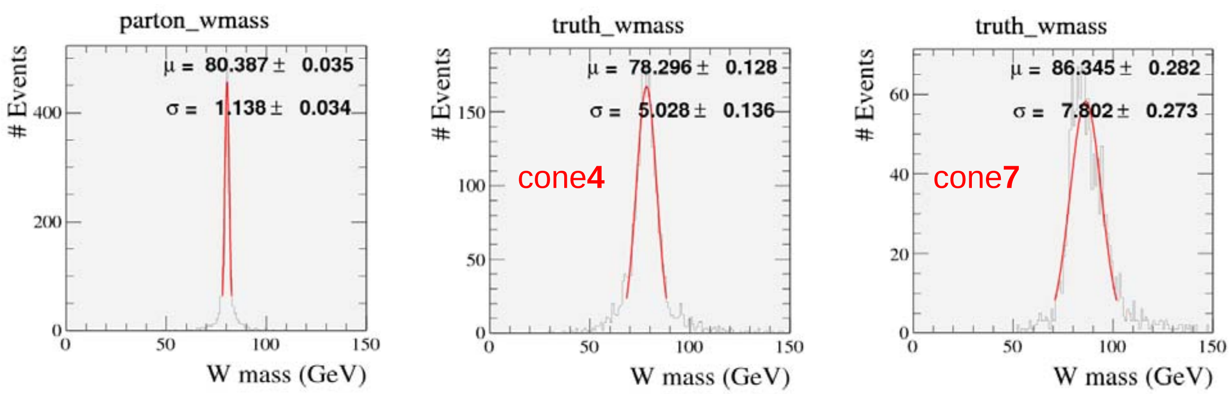

Figure 5: W mass for cone7H1Tower and cone4H1Tower, from parton (left) and truth particles (right).

Figure 5 (left) shows the W mass from the generator level partons; in the middle it shows the W mass from the truth jets reconstructed using Cone algorithm with parameter 0.4; and on the right, using Cone algorithm with parameter 0.7. We observe that wider jets result in an over estimation of the W mass while thinner jets underestimate it. Since our calibration is using the truth jets as the reference energy the same behavior will be expected in the reconstructed jets after calibration. This is observed in Figure 6, which shows the W mass peak using cone4H1Tower jets (left) and cone7H1Tower jets (right).

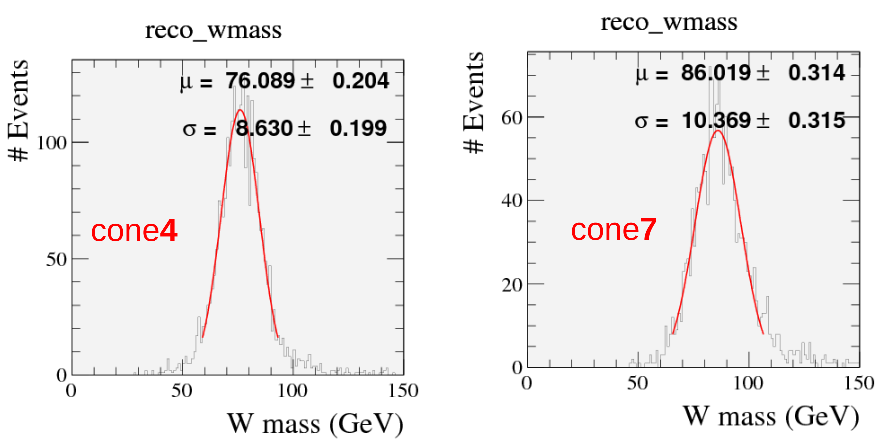

Figure 6: W mass for cone7H1Tower (left) and cone4H1Tower (right).

The mass change seen in the reconstruction of the W mass from truth jets is also seen in reco jets – although in the latter case the shift is ~10GeV rather than ~8GeV. Qualitatively we can understand this shift – for isotropic fragmentation we would expect the energy to increase faster than the momentum of the jet. We see a similar effect for AntiKt with the truth mass being reconstructed at ~86 GeV for D=0.6 (though our focus here is H1 since we were originally interested in studying cell weighting). The conclusion (not surprising after thinking about it) is that the jet algorithm itself plays a significant role in the determination of the W mass. Our comparison of jets at different radii (either cone or AntiKt), it has a potential impact in the range of 5 – 10%. We should also look at the effects of the energy scale and produce the plots for jets at the EM scale as well as at the EM scale with inversion.