Refined reconstruction and calibration of the missing transverse energy in the ATLAS detector

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In a collider event the missing transverse energy, $E_{\mathrm{T}}^{\mathrm{miss}}$, is defined as the momentum imbalance in the plane transverse to the beam axis, where momentum conservation is expected. Such an imbalance may signal the presence of either weakly interacting particles, particles missing detection or any problem in the detector. So, an optimal $E_{\mathrm{T}}^{\mathrm{miss}}$ evaluation, including the setting of its absolute scale, is crucial for the study of many physics channels in the Standard Model such as W and $t\bar{t}$ production or for discovery of Higgs bosons decaying to WW or to $\tau\tau$, SUSY and extra dimensions [1].

The measurement of $E_{\mathrm{T}}^{\mathrm{miss}}$ in the ATLAS detector makes use of the full event reconstruction including contributions from energy deposits in the calorimeters and muons reconstructed in the muon spectrometer. The calorimeter cells are associated with a reconstructed and identified high-p_{T} parent object in a chosen order: electrons, photons, hadronically decaying τ-leptons, jets and muons and they are calibrated according to the physics object to which they belong. Cells in topological clusters not associated with any such objects are also added in the $E_{\mathrm{T}}^{\mathrm{miss}}$ calculation. The $E_{\mathrm{T}}^{\mathrm{miss}}$ configuration which gives the best performance uses muons reconstructed in the spectrometer, electrons properly calibrated, photons at the electromagnetic scale, jets reconstructed from clusters calibrated using local hadronic calibration to correct for the effect of non-compensation in the calorimeter and for dead material effects and, if $p_{\mathrm{T}} > 20$ GeV, scaled to the jet energy scale, and energy deposition in calorimeter cells not contained in reconstructed objects improved with track information (for further details on this configuration and comparison with other configurations see Ref. [2]).

The $E_{\mathrm{T}}^{\mathrm{miss}}$ performance has been evaluated using data collected in pp collisions at a centre-of-mass energy of 7 TeV in 2010 for different physics channels.

The Z events are useful to study $E_{\mathrm{T}}^{\mathrm{miss}}$ performance because of their clean event signature and the relatively large cross-section. For these events no genuine $E_{\mathrm{T}}^{\mathrm{miss}}$ is expected. Figure 1 (top left) shows the $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution for $Z \to ee$ events: the Monte Carlo simulation (MC) describes data well and no large tails are observed. Tails are compatible with either signal candidates, including $t\bar{t}$, WW and WZ diboson events, all involving real $E_{\mathrm{T}}^{\mathrm{miss}}$, or events in which the $E_{\mathrm{T}}^{\mathrm{miss}}$ vector is close to a badly measured jet in the transverse plane.

In events containing leptonic W decays genuine $E_{\mathrm{T}}^{\mathrm{miss}}$ is expected due to the presence of the neutrino, therefore the $E_{\mathrm{T}}^{\mathrm{miss}}$ scale can be checked. Figure 1 (top right) shows the linearity in MC, defined as $(E_{\mathrm{T}}^{\mathrm{miss,True}} - E_{\mathrm{T}}^{\mathrm{miss}})/E_{\mathrm{T}}^{\mathrm{miss,True}}$, as a function of $E_{\mathrm{T}}^{\mathrm{miss,True}}$. The mean value of this ratio is expected to be zero if the reconstructed $E_{\mathrm{T}}^{\mathrm{miss}}$ has the correct scale. Except for the bias observed at low $E_{\mathrm{T}}^{\mathrm{miss,True}}$, up to 40 GeV, due to the finite $E_{\mathrm{T}}^{\mathrm{miss}}$ resolution, the linearity is better than 1% in $W \to e\nu$ events, while there is a non-linearity up to about 3% in $W \to \mu\nu$ events.

Another quantitative evaluation of the $E_{\mathrm{T}}^{\mathrm{miss}}$ performance can be obtained from a study of the E_x^{miss}, E_y^{miss} resolution as a function of ΣE_{T}. Figure 1 shows the $E_{\mathrm{T}}^{\mathrm{miss}}$ resolution, which follows an approximately stochastic behaviour as a function of ΣE_{T}, in different physics channels for data (bottom left) and for MC (bottom right). The agreement between different channels and data-MC is reasonably good, taking into account the different topologies.

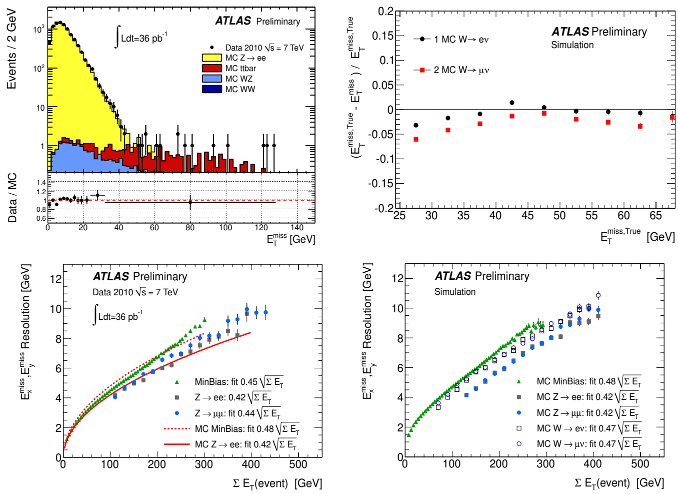

Figure 1: Main results for the $E_{\mathrm{T}}^{\mathrm{miss}}$ performance in 2010 data (left plots) and in MC simulation (right plots). Further details in the text.

References

[1] The ATLAS Collaboration, CERN-PH-EP-2011-114, arXiv:1108.5602 [hep-ex]

[2] The ATLAS Collaboration, ATLAS-CONF-2011-080