E_T^{miss} in first ATLAS data

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Summary. — In december 2009 ATLAS collected more than half a million of minimum bias events at center of mass energy of 900 GeV and 2.36 TeV. These events offer a good opportunity to test the performance of missing transverse energy (E_T^{miss}) reconstruction with up to 100 GeV total transverse energy per event. Resolution and tails of missing transverse energy distribution are in good agreement with the simulation. In this early stage, only calorimeter-based missing transverse energy is considered and all cell energies are calibrated at the electromagnetic (EM) scale.

1. – Data samples and event selection

In December 2009, collision candidate events were recorded at 900 GeV and 2.36 TeV proton-proton center-of-mass energy. These events were triggered by the Minimum Bias Trigger Scintillators and were recorded with stable beam, as well as nominal magnetic field conditions. In addition, only runs satisfying data quality criteria for the calorimeters and offline timing cuts were kept in order to remove non-collision backgrounds. This selection results in a sample of about 600,000 and 20,000 events at 900 GeV and 2.36 TeV proton-proton center-of-mass energy, respectively.[1]

Jets (if any) are reconstructed with the anti-k_t algorithm [2] of cone $R = 0.6$. Cleaning cuts to remove jets with energy coming mainly from problematic cells are applied.

The same trigger and event selection, as described for the data, are applied to the Monte Carlo simulation.

2. – Performance of the E_T^{miss} reconstruction

2˙1. *Reconstruction of* E_T^{miss}. – Due to the small number of muons in present data, E_T^{miss} can be reconstructed using only cells belonging to three-dimensional topological clusters (topocluster) [3] and is defined as:

$$
\begin{aligned}
E_x^{miss} &= -\sum_{i=1}^{N_{cell}} E_i \sin\theta_i \cos\phi_i,\\
E_y^{miss} &= -\sum_{i=1}^{N_{cell}} E_i \sin\theta_i \sin\phi_i,\\
E_T^{miss} &= \sqrt{(E_x^{miss})^2 + (E_y^{miss})^2},
\end{aligned}
\tag{1}
$$

where E_i, θ_i and ϕ_i are the cell energy, polar angle and azimuthal anglerespectively.

2˙2. *Performance of* $E_{\mathrm{T}}^{\mathrm{miss}}$ *in collisions*. – In soft proton-proton collisions, no true $E_{\mathrm{T}}^{\mathrm{miss}}$ is expected. Total transverse energies ($\sum E_{\mathrm{T}}$) up to 100 GeV are deposited in the calorimeter for minimum bias events in the present data set. Figures 1 shows the $E_{\mathrm{y}}^{\mathrm{miss}}$ distributions where the RMS is about 1.4 GeV and 1.8 GeV for 900 GeV and 2.36 TeV center-of-mass energy, respectively. The $E_{\mathrm{T}}^{\mathrm{miss}}$ distribution is also shown in Figure 1 for the two center-of-mass energies. $E_{\mathrm{T}}^{\mathrm{miss}}$ and its component distributions are found to be in good agreement with expectations from the Monte Carlo simulation. There are very few events with large reconstructed $E_{\mathrm{T}}^{\mathrm{miss}}$. In simulation, the event with $E_{\mathrm{T}}^{\mathrm{miss}}\sim$30 GeV is due to the presence of a high p_T jet, not balanced since the other jet in the event is poorly reconstructed because of detector acceptance. In data, the two events with $E_{\mathrm{T}}^{\mathrm{miss}}\sim$30 GeV are traced back to energy deposited in few cells out of time by at least two bunch crossings.

A more quantitative evaluation of the $E_{\mathrm{T}}^{\mathrm{miss}}$ performance can be obtained from a study of the $E_{\mathrm{x}}^{\mathrm{miss}}$ and $E_{\mathrm{y}}^{\mathrm{miss}}$ resolution as a function of the total transverse energy $\sum E_{\mathrm{T}}$ in the event. The resolutions observed in the ATLAS data at both centre-of-mass energies are presented as a function of $\sqrt{\sum E_{\mathrm{T}}}$ in Figure 2. A very good agreement between data and Monte Carlo is observed at both center-of-mass energies. The $E_{\mathrm{T}}^{\mathrm{miss}}$ resolution for data and MC increases with $\sum E_{\mathrm{T}}$ as $\sigma(E_{\mathrm{x}}^{\mathrm{miss}},E_{\mathrm{y}}^{\mathrm{miss}}) = 0.37 \times \sqrt{\sum E_{\mathrm{T}}}$.

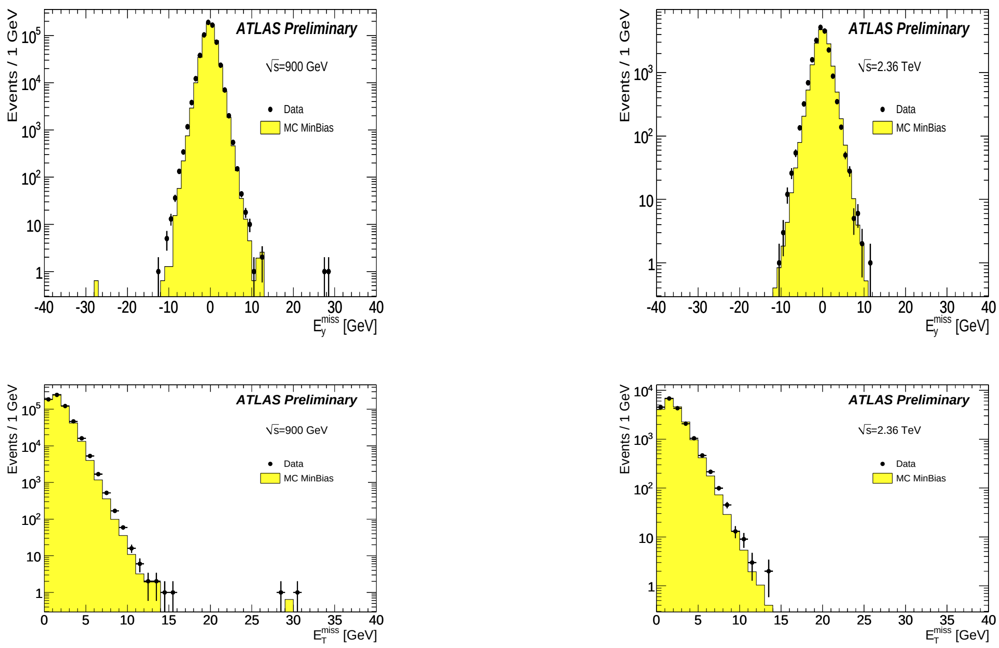

Fig. 1. – *Distribution of* $E_{\mathrm{y}}^{\mathrm{miss}}$ *(top) and* $E_{\mathrm{T}}^{\mathrm{miss}}$ *(bottom) as measured in data from minimum bias events (dots) at 900 GeV (left) and 2.36 TeV (right) center-of-mass energy. The expectations from Monte Carlo simulation are superimposed (histograms) and normalized to the number of events in data.*

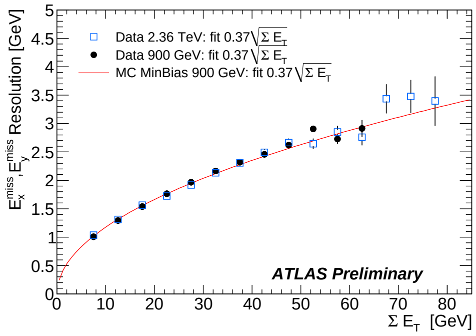

Fig. 2. – *E_x^{miss} and E_y^{miss} resolution as a function of the total transverse energy ($\sum E_T$) for minimum bias events. The line represents a fit to the resolution obtained in the Monte Carlo simulation and the full dots (open squares) represent the results with data at 0.9 (2.36) TeV. E_x^{miss}, E_y^{miss}, $\sum E_T$ are computed with topocluster cells at EM scale.*

3. – Conclusion

The missing transverse energy E_T^{miss} has been measured in first LHC collision events. The Monte Carlo simulation describes the data well. This is a result of the past work on detector and software commissioning. At this preliminary stage, E_T^{miss} is computed from cells in calorimeters calibrated at electromagnetic scale. With the minimum bias events at 900 GeV and 2.36 TeV center-of-mass energy, the E_T^{miss} resolution, calculated as the width variation of E_x^{miss} and E_y^{miss} as a function of $\sum E_T$ is in very good agreement with simulation and gives $\sigma(E_x^{miss},E_y^{miss}) = 0.37 \times \sqrt{\sum E_T}$. No large tails in the E_T^{miss} distribution are observed, either in data or in Monte Carlo simulation, few events with large reconstructed E_T^{miss} are understood.

REFERENCES

[1] ATLAS Collaboration, *Performance of the missing transverse energy reconstruction in minimum bias events at $\sqrt{s}$ of 900 GeV and 2.36 TeV with the ATLAS detector* , ATLAS-CONF-2010-008.
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[3] W. Lampl *et al.*, *Calorimeter clustering algorithms: Description and performance*, ATL-LARG-PUB-2008-002.
[4] ATLAS Collaboration, *Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics (Jet and E_T^{miss} chapter)*, CERN-OPEN-2008-020, ArXiV:0901.0512.