MET Performance in 2011 CMS Data

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Abstract

In this note we present the studies of the MET performance in the full dataset collected by CMS in 2011, corresponding to 4.6 fb-1. We show comparisons of MET distributions in data with simulation in events with Z-¿mumu, MET resolution and response in Z-¿mumu events as a function of pile-up (PU) multiplicity and qT. Additionally, an example of algorithms used by CMS to recover the performance of MET reconstruction in high PU events is shown.
MET Performance in 2011 CMS Data

CMS Collaboration
Content

• Detailed studies of the performance of the Missing Transverse Energy (MET) reconstruction published in [1]

• In this note we present the studies of the MET performance in the full dataset collected by CMS in 2011, corresponding to 4.6 fb⁻¹.
  – Comparison of MET distributions in data with simulation in events with $Z \rightarrow \mu\mu$
  – MET resolution and response in $Z \rightarrow \mu\mu$ events as a function of pile-up (PU) multiplicity and the Z boson transverse momentum $q_T$
  – An example of algorithms used by CMS to recover the performance of MET reconstruction in high PU events

• Events in low and high PU data-taking periods were analyzed
  – Referred to as Run 2011A and 2011B in the following
Z$\rightarrow$\(\mu\mu\) Event Selection

- Ideal test-bed to study the MET resolution
  - Clean final state, small background contributions
  - No intrinsic MET, only resolution effects

- Data is collected using double-muon triggers
  - Muons are required to satisfy the identification criteria listed in [2]
  - Two OS muons within |\(\eta\)|<2.1, \(P_{T\mu} > 20\) GeV, and 60<\(M_{\mu\mu}\)<120 GeV

- At least one of the muons isolated, isolation corrected for PU effects
  - \(I_{\mu} = \sum P_{T}^{charged}(\Delta z<2\text{mm}) + \max(P_{T}^{h0} + P_{Ty} - \Delta\beta, 0); \text{ where } \Delta\beta = 0.5 \cdot \sum P_{T}^{charged}(\Delta z>2\text{mm})\)
  - Isolation requirement: \(I_{\mu} < 0.10 \cdot P_{T\mu}\)

- The composition of the data samples is estimated using MC samples
  - MadGraph [3] samples for Z$\rightarrow$\(\mu\mu\), \(t\bar{t}\) and di-boson (WW, WZ, ZZ)
Event Reconstruction

- Events are reconstructed with the Particle Flow technique [5]
  - MET computed as the negative vectorial sum of all particles candidates

- MET reconstructed in simulated samples is corrected for JES:
  \[
  E_{x,\text{corr}} = E_{x,\text{raw}} + \Delta_x \\
  E_{y,\text{corr}} = E_{y,\text{raw}} + \Delta_y \\
  E_{T,\text{corr}} = \sqrt{E_{x,\text{corr}}^2 + E_{y,\text{corr}}^2} \\
  \Delta_i = \sum P_i^{\text{calibrated}} - P_i
  \]
  \(i=x, y\), and the sum extends over all jets with JES corrected momenta \(P_T > 10\ \text{GeV}\).
  - Jet energies are corrected by applying \(L1Fastjet, L2\) and \(L3\) corrections [6]

- Events containing signatures of instrumental noise are rejected from the analysis, as described in [1]
PU multiplicities in Run2011 and Run2011B

- About 70\% larger PU in Run2011B than in 2011A
  - Simulated events are reweighted to match PU in data
  - We use a “3D reweighting” to match the PU distributions in the colliding bunch, as well as the previous and next bunches (for out-of-time PU)
• MET distributions agree well between data and simulation
  – Simulation is corrected for jet energy scale. Additionally, jet energy resolution in simulation is smeared to match that observed in data [6].
MET response and resolution in $Z \rightarrow \mu\mu$

- The momentum of the $Z$ boson is denoted as $q_T$
- The transverse momentum $\sum$ of all particles’ $P_T$ except the boson: $u_T$
  - In a perfectly measured event $u_T$ would balance transvers momentum of the $Z$
  - $\vec{q}_T + \vec{u}_T + \vec{E}_T = 0$

- Determine the MET scale and resolution
  - The mean of the distribution of $-u_{\parallel}/q_T$ is a measure of the MET response
  - The RMS widths of $-u_{\parallel} - q_T$ and $u_{\perp}$ are used to measure the MET resolution
Recoil measured in $Z \to \mu\mu$ events

- Parallel and perpendicular recoil components agree well with the simulation.
  - Combined distributions in 2011A and 2011B are shown
MET response is close to unity after Type 1 MET corrections

- ~1-2% overestimation of the response is expected: larger fraction of quark jets than in the sample used to derive the JES corrections

- MET response is independent of PU multiplicity in the event
MET resolution VS $q_T$ in $Z\rightarrow \mu\mu$ events

- Good agreement between MC simulation and data
  - Difference at low $q_T$ indicates mis-modeling of the underlying event
- Resolution worsens in 2011B due to larger PU contribution
MET resolution VS NVtx in $Z \rightarrow \mu \mu$ events

- Resolution for fixed NVtx is worse in 2011B due to larger Out-Of-Time PU
- The distributions are fitted to extract $\sigma_{PU}$ which represents the degradation in resolution caused by PU events
  - PU introduces an additional smearing of $\sim 3$-4 GeV on MET resolution (in quadrature)
  - The "c" component of the fit represents average resolution in events with no PU
MET degradation in high PU events

- Degradation of MET performance in high PU significantly affects sensitivity of H→WW analysis
  - Rejection efficiency of the MET cut drops by a factor of ~10 for DY events

![Graph showing CMS preliminary, √s=7 TeV](image)

- Missing momentum from charged tracks (TrackMET) originating at PV [8]
  - min(TrackMET, PFMET) protects against large TrackMET in cases when missing neutral contribution is significant

- Much improved signal efficiency with the same background rejection efficiency
  - Efficiency of background rejection is independent of PU

the vertical line represents the cut value used in [7]
References


