MET Performance in 2012 Run A CMS Data

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Abstract

This note includes plots indicating the current state of the MET performance in 2012 for Data and MC.
MET Performance in 2012 Run A CMS Data

CMS Collaboration
Content

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

• In this note we present studies of the MET performance in the $\sqrt{s} = 8$ TeV dataset collected by CMS in Spring 2012 (2012 Run A), corresponding to 0.7 fb$^{-1}$ (the integrated luminosity of the full 2012 ICHEP dataset = 5.1 fb$^{-1}$; the full dataset has on average higher pile-up (PU) multiplicities)
  – 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 multiplicity and the Z boson transverse momentum $q_T$

• Results presented in this note extend Study of MET performance in 2011 data documented in [2]
Comparing 2011 and 2012 data

NOTE: when comparing MET resolution in 2011 and 2012 data, it is important to keep in mind that not only PU conditions changed, but also

• Improved the ECAL and HCAL energy reconstruction to reduce the effects of out-of-time pileup interactions
  • HCAL: 100ns time window in 2011, 50ns time window in 2012.
  • ECAL: Reject out-of-time energy deposits not only in the barrel but also in the endcap

• Specific MET corrections against PU applied in 2012 ("Type-0" and "systematic x/y shift" corrections)
Z→μμ 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 [3]
  – Two OS muons within |η|<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
  – $I_\mu=\sum P_T^{charged}(\Delta z<2\text{mm})+\max(P_T^{h0}+P_T^\gamma-\Delta\beta, 0)$; where $\Delta\beta=0.5\sum P_T^{charged}(\Delta z>2\text{mm})$
  – Isolation requirement: $I_\mu<0.10\cdot P_T^\mu$

• The composition of the data samples is estimated using MC samples
  – MadGraph5 samples for Z→μμ, tt and di-boson (WW, WZ, ZZ)
  – PYTHIA6.4 samples for QCD multi-jet production
Event reconstruction

- Events are reconstructed with the Particle Flow technique [4]
  - 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 \textit{L1Fastjet}, \textit{L2} and \textit{L3} corrections [5]

- Events containing signatures of instrumental noise are rejected from the analysis, as described in [1]
PU multiplicities in 2012 compared to 2011

- About 30% increase in PU in 2012 Run A compared to end of 2011 data-taking (2011 Run B)
  - 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)
- Larger difference in PU multiplicity for full 2012 wrt. full 2011 dataset
• 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 [5].
• Small degradation in Resolution due to PU
MET response and resolution in $Z \rightarrow \mu \mu$

- The momentum of the $Z$ boson is denoted as $q_T$
- The transverse momentum $\Sigma$ of all particles’ $P_T$ except the boson: $u_T$
  - In a perfectly measured event $u_T$ would balance transverse 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 $-u||/q_T$ is a measure of the MET response
  - The RMS widths of $-u||-q_T$ and $u_\perp$ are used to measure the MET resolution
Recoil measured in $Z \rightarrow \mu\mu$ events

Parallel and perpendicular recoil components agree well with the simulation.
MET response in $Z\rightarrow\mu\mu$ events

CMS preliminary, $\sqrt{s}=8$ TeV $L = 0.7$ fb$^{-1}$

- MET response is close to unity after Type 1 MET corrections
  - $\sim$1-2% overestimation of the response is expected: larger fraction of quark jets than in the sample used to derive the JES corrections
MET resolution VS NVtx in $Z \rightarrow \mu \mu$ events

- Resolution for fixed NVtx is better in 2012A due to changes in energy reconstruction (see page 3)
- 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$2.5-3.5 GeV on MET resolution (in quadrature)
  - The "c" component of the fit represents average resolution in events with no PU
References