The Compact Muon Solenoid Experiment
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Missing Transverse Energy measurement in CMS experiment

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Abstract

The typical methods for measuring missing transverse energy (MET) in an event in CMS experiment at LHC are presented. Tools for calculating the MET uncertainty and correction are studied.

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Measurement of Missing Transverse Energy in CMS Experiment

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Keywords: MET, tools

1 Introduction

Particles that go undetected inside a detector are the main cause of missing transverse energy or MET or E_T^{miss} . By definition,

$$\vec{E}_T^{miss} = - \sum_{i \in visible} \vec{p}_T^i \quad (1)$$

where $\vec{p}_T^i$ is the transverse momentum of the i^{th} detected particle, like muons, electrons or hadrons produced by hadronization of quarks and gluons. The momentum imbalance due to detector resolution and sensitivity of the detector to various identified particles must be scrutinised thoroughly before relevant physics interpretation. In practice, the MET is corrected for the potential effects of the detector measurements and details of event reconstruction algorithms.

2 CMS Detector

CMS detector [1] consists of four detector subsystems: tracker, electromagnetic calorimeter (ECAL), hadronic calorimeter (HCAL) and muon system. The Tracker reconstructs the tracks of charged particles and measures the transverse momentum (p_T). The ECAL and HCAL measure the energy deposits from charged and neutral particles via electromagnetic and hadronic interactions. The Muon system is used for the detection of muons and measuring their momenta, it is the outermost part of the detector.

3 E_T^{miss} Corrections and Uncertainties

The simulated and reconstructed top pair production events are studied, as the inclusive final state consists of leptons, jets and genuine E_T^{miss} : $t \rightarrow Wb$,

$W \rightarrow qq'$ or $W \rightarrow l\nu$. The estimate of E_T^{miss} is affected by energy thresholds for calorimeter response and the non-linearity of calorimeters. For example, the jet energy corrections applied to each of the measured jet momentum in an event are incorporated in the calculations via the following relation:

$$\vec{E}_T^{miss} = - \sum_{j \in jet} \vec{p}_T^{j, JEC} - \sum_{i \in uncl.} \vec{p}_T^i \quad (2)$$

All the particles in a particular event can be divided into two parts: some are clustered into jets while the others remain unclustered. The p_T of the unclustered particles are not corrected by the jet energy correction factor.

The E_T^{miss} uncertainty is the resultant of the uncertainties in the measurement of four-momenta of particles in various detector components. For example: the unclustered energy part of E_T^{miss} , which is not associated with well reconstructed objects, has the following contributions: charged hadron, neutral hadron, photons and forward particles. Effect of each component uncertainty on E_T^{miss} can be seen from Fig. 1.

Fig. 1. Typical E_T^{miss} distribution from Drell-Yan events [2] and variations in fractional change in E_T^{miss} observed in $t\bar{t}$ simulation.

4 Future Work

Identification of physics processes like W production, $t\bar{t}$ production as well as search for various beyond Standard Model physics phenomena requires presence of significant E_T^{miss} in the event. Efforts are being made to improve the E_T^{miss} measurements in the high pileup environment as foreseen in upcoming LHC runs.

References

1. The CMS Collaboration, The CMS experiment at the CERN LHC, JINST3:S08004, 2008
2. The CMS Collaboration, CMS PAS JME-016-004