Precise measurements of the running weak, strong and electromagnetic couplings performed at the Large Electron-Positron Collider (LEP) indicates that these couplings fail to unify at high energy (see Figure \ref{fig:GUT} a) ~\cite{ALEPH,GUTLep}. In ~\cite{GUTLep}, it is stated that the minimal supersymmetric standard model (MSSM) is the only possibility, without an intermediate mass scale. The MSSM can raise the scale of the unification by introducing a particle called the gluino, the spin half partner of the gluon. The gluino partially cancel the asymptotic freedom effect of the gluon itself ~\cite{Wil}.

The MSSM and its particle content will be explained in section \ref{sec:mssmPartContect}.

The event reconstruction can fail due to the noisy detector cells and other kinds of detector problems. These can result in incorrectly reconstructed muons, jets and hence associatively MET.

The event reconstruction can fail due to the noisy detector cells and other kinds of detector problems. These can result in incorrectly reconstructed physics objects such as: muons, jets and hence MET. In CMS, the physics object groups related to the problem release event filters or cures for the falsely reconstructed objects.

Cleaning

Event cleaning: Filters

Secondary particles are produced in showers that are initiated by collisions of the beam with residual gas inside the LHC vacuum chamber or by interactions of the beam halo with limiting apertures.

The collisions of the beam with residual gas inside LHC cause showers of secondary particles. Additionally to these scattering effects, charged particles are deflected by the magnetic field of the beam optics. These particles are called beam halo particles and one of the main sources of the beam background of the LHC. In CMS, the beam halo algorithm considers the particles produced outside the CMS cavern and to detect events with beam halo it uses the timing information and hit topology in CSC, ECAL and HCAL subsystems.

This noise is originated from the Hybrid PhotoDiodes and Readout Boxes of the HCAL. The timing, pulse shape as well as the other readout errors are used to detect the noise.

The existence of noisy crystals in ECAL can lead to fake MET. The events, in which the noisy cells deposit high energy, are filtered.

This filter fires when there is a PF muon with too low quality and has large $\pt$. The quality of the muon is determined according to its tracking uncertainty, segment compatibility and other detector related features. This bad muon is required to have $\pt > 100$ GeV.

The events, where there is a muon but it fails to be a PF muon and it still contributes to PF MET calculation as a charged hadron candidate, are filtered. Here, as in the previous case, this muon is required to have $\pt > 100$ GeV. Moreover, it is required that the muon and the charged hadron traces are almost overlapping ($\Delta R(\mu, charged\, hadron)<$ 0.00001). In addition to this, their $\pt$s are needed to be very close to each other.

Unlike the other filters explained above this filter is applied to background simulation samples as recommended.

Ghost muon filters:

In the Re-reco data it is observed that there is an increase in events in the MET tail of Z$\rightarrow\mu\mu$ data. It is understood by the muon POG that there are duplicate muons in the events due to reconstruction failures. A recipe is applied to remove the muon and reconstruct the event again.

Additionally, two filters are recommended by the SUSY group:

One is to remove events with the ratio of PF MET to calorimeter MET is more than 5. The second is to remove events containing bad jets which have $\pt > 200$ GeV, muon energy fraction $>0.5$ and $\Delta\phi(met,jet)>\pi-4$.

The distributions are plotted after the baseline selection, requiring no b-tagged jets, at least five jets, minimum $\HT$ of 500 GeV, a minimum $\LT$ of 250 GeV and exactly one lepton with $\pt >$25 GeV. In the top row the number of jets (left) and $\HT$ (right) are shown, while in the bottom row $\LT$ and $\DF$ distributions are shown. The simulated background events are stacked on top of each other, and several signal points are overlaid for illustration without being stacked. The model T5qqqqWW (1.5,1.0) (T5qqqqWW (1.9,0.1)) corresponds to a gluino mass of 1.5 TeV (1.9 TeV) and neutralino mass of 1.1 TeV (0.1 TeV), respectively. The intermediate chargino mass is fixed at 1.25 TeV (1.0 TeV). The two benchmark signal models are scaled up by a factor of 10.

The distributions of main kinematic variables, also called control plots, are shown in this section. In all the control plots, the colored lines represent the signal models and the color filled stacked histograms display the background processes. Additionally, the black dotted distribution exhibits the observed data points requiring the triggers introduced in section \ref{sec:triggers}. In all the control plots, the events are cleaned by the filters discussed in section \ref{sec:filters}. The signal and background events are scaled by the luminosity factor and additional weights introduced in section \ref{sec:SF}. The Figure \ref{fig:nbtag} shows the n-btag distribution after the baseline selection (see section \ref{sec:BL}). The distribution of simulated signal events peaks at zero as expected. Clearly, one can see from this distribution that choosing events with zero b-tagged jets suppresses the $\ttbar$ background significantly.

The distributions exhibit reasonable MC-data agreement although it is not necessarily expected.

The multiplicities of jets and b-tagged jets display no difference between the signal scenarios, since the mass splitting has no effect on the decay topology.

The two selected signal benchmark models show differences in the distributions of $\HT$ and $\LT$, this is due to the gluino-neutralino mass splitting. In the non-compressed T5qqqqWW (1900,100) model, the quarks coming from the gluino decay have a large boost, resulting in high leptonic and hadronic energy scales. For the compressed region with T5qqqqWW (1500,1000) no such effect is observed, and the shape of the distributions look similar to the SM processes.

After the baseline selection, $\wJets$ and $\ttJets$ are the main background components.

The signal region of an analysis, is the reason

Generally, signal region is where it is expected to observe a deviation from SM background in the existence of SUSY scenario.

Naturally, this shape difference leads the high values of the $\DF$ as the signal region and the high values as the control region. The control region is used in the background estimation, which will be discussed in the next chapter.

To further enhance the sensitivity the phase space is subdivided in bins of $\njet$, $\HT$ and $\LT$.

Requiring no b-tagged jets in the final state leads to both $\wJets$ and $\ttJets$ background components to be equally important. Therefore, the $\Rcs$ strategy developed for this analysis takes into account the differences in $\Rcs$ values of these two components.

$\ttJets$ and QCD events are considered to be homogenous in charge.

Fractions of the background processes in the control regions ($f^{CR}\_i$) are calculated using likelihood fit of b-tag multiplicity distributions templates to data. The templates are obtained from simulation except the QCD events. The QCD multijet contribution in b-tag multiplicity bins is taken from the prediction. \\

$\wJets$ events display a charge asymmetry in $\Rcs$ due to polarization effects. To account for this, the fits are performed separately for each charge: positive or negative.

$\ttJets$ and QCD events are considered as homogenous in charge. Other background templates are also produced separately for positive and negative charged leptons.

Background compositions

It subtracted criteria

CERN accelerator complex

The LHC is currently the largest particle accelerator worldwide. It is primarily designed to collide protons at a centre-of-mass energy of 14 TeV. Operated by the European Organization for Nuclear Research – Conseil Européen pour la Recherche Nucléaire – (CERN) and located in the suburbs west of Geneva, Switzerland the accelerator complex lies between the

Jura mountains and Lake Geneva at depths ranging from 50 to 150 m. Originally build for the

LEP between 1984 and 1989, the tunnel consists of eight arcs and eight straight sections, with a total circumference of 27 km.

A particle accelerator is a machine that moves charged particles by using electromagnetic fields. Nowadays, accelerator machines are using changing electromagnetic fields to propel particles to nearly the speed of light.

The large hadron collider (LHC) is the world's largest particle accelerator and it is the last ring of the accelerator chain at CERN.

Mounted

An overview of the experimental setup used to collect data for this analysis is explained in the chapter. The chapter begins with a brief explanation of the Large Hadron Collider (LHC) including the pre-accelerator complex. The different components and subsystems of the Compact Muon Solenoid (CMS) will be discussed in Sec. \ref{sec:cms\_ex}. The chapter will end with a description of the event simulation tools in Sec. \ref{sec:simulation}.

LHC further future plans are constraint by the fixed ring size, thus the limited proton energy. Therefore the LHC proceeds in the direction of the intensity frontline.

The main challenge in this environment would be the development of new magnet system to handle with such an increase in number of protons per beam.

Coordinate system and the relevant kinematic variables

As it can be seen from the Fig. \ref{fig:CMS}, CMS detector is an onion shape detector meaning it incorporates successive layers.

The pseudorapidity is a version of rapidity, which is Lorentz invariant under longitudinal – along the beam axis - boosts. In the case where particle masses are negligible, rapidity converges to $\eta$.

The proton is a composite particle, which includes partons. Therefore, the proton-proton collisions are interactions of the corresponding partons. Furthermore, even though the energy of the incoming proton beams are symmetric, this condition does not necessarily need to be hold for individual partons.

MAGNET

As it can be understood from the name of the CMS experiment, the solenoid magnet is a crucial component of the detector. It has an important role in precise measurements of charged particles. It is designed to host the tracker and calorimeter systems at the same time providing a uniform axial magnetic field of 4T within its volume. Due to its unique design and not yet well-understood aging, it is currently being operated at slightly lower field strength of 3.8 T.

TRACKER

The main purpose of this component is the identification and measurement of tracks ascending from charged particles coming from the interaction vertices.

This detector system has several strict requirements in terms of detection efficiency, spacial resolution and radiation safety due to the large collision rates and high particle multiplicities.