SEARCH FOR CHARGINOS, NEUTRALINOS AND SLEPTONS IN OPPOSITE-SIGN DI-LEPTON FINAL STATES AT CENTER-OF-MASS ENERGY OF 13 TEV WITH THE CMS DETECTOR.

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This document presents two searches for physics beyond the Standard Model (SM), each using 35.9fb^{-1} of proton–proton collision data collected with the CMS detector at a center-of-mass energy of 13 TeV, at the CERN Large Hadron Collider (LHC). The two searches for new phenomena is targeting electroweak production of Supersymmetric (SUSY) particles, so called Charginos, Neutralinos and sleptons, in a production mode that results in two leptons of opposite-sign and same-flavor, large missing transverse momentum, p_T^{miss}.

The document contains a summary of the theoretical framework that make up the SM and SUSY, along with a comprehensive description of the CMS experiment at the LHC accelerator complex. The two searches presented in this thesis both target the production of electroweak SUSY particles, but are divided into two types, according to the production mode. The search for Charginos and Neutralinos result in final states where two or more jets resulting from hadronization are produced, while the search for the direct production of sleptons is chrarcterized by the fact that no hadronization is expected, and thus results in a final state without any jets. The search strategies thus differ slightly, and the two strategies are presented, along with a description of the SM background processes that govern these final states.

Since no excess of collision data is observed with respect to the predicted SM backgrounds in neither of the searches, a statistical interpretation of the results yielding

upper limits in the production cross sections on the SUSY particles, is performed. These limits greatly extend the limits set using 8 TeV collision data during the LHC Run 1.

Concluding remarks commenting on the current absence of evidence for physics beyond the SM (BSM) are given, and an outlook highlighting the unprecedented instantaneous luminosity expected at the LHC, and the window of opportunity for searches for BSM physics that it presents.

CHAPTER 1

PERFORMANCE OF MISSING TRANSVERSE MOMENTUM

At the forefront of SUSY physics program are searches where R-parity is conserved, resulting in the LSPs escaping detection. The existence of such particles can be inferred by the momentum imbalance in the transverse plane, $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$, with its magnitude denoted $p_{\mathrm{T}}^{\mathrm{miss}}$. When the LSPs are massive, the $p_{\mathrm{T}}^{\mathrm{miss}}$provides an excellent search tool for SUSY. But other sources can contribute to a large momentum imbalance. Any process with a leptonically decaying W-boson produces a neutrino that escape the detector similarly as the LSP. Additionally, as jets are complex objects to measure, and their energy are corrected through JECs, any over or undermeasurement in the jets can create $p_{\mathrm{T}}^{\mathrm{miss}}$. In order to perform a SUSY search, a deep understanding of the $p_{\mathrm{T}}^{\mathrm{miss}}$is needed to enable differentiation between the $p_{\mathrm{T}}^{\mathrm{miss}}$originating from LSPs, from SM neutrinos and from jet mismeasurements and detector inefficiencies. As the reconstruction of various physics objects is relying on the ability to successfully differentiate tracks from the primary vertex with tracks from overlapping bunch crossings in multiple pp collisions (pileup), the $p_{\mathrm{T}}^{\mathrm{miss}}$reconstruction as a result is very pileup dependent. A detailed study of the performance of two commonly used $p_{\mathrm{T}}^{\mathrm{miss}}$reconstruction algorithms is presented in this chapter, along with a specific study analyzing the performance of the algorithms under extreme pileup conditions, as is expected in the High Lumi phase of the LHC.

1.1 Missing transverse momentum and hadronic recoil in CMS

In collision events, the transverse momentum of the partons is small compared to the energy available in the center of mass, and does not depend on their longitudinal energy. A hypothesis is then made by considering that the initial transversal momentum of the system formed by the partons is zero. If particles escape detection, a transverse energy equilibrium is created and a missing transverse energy appears. The final states containing one or more neutrinos are therefore a significant missing energy corresponding to the vectorial sum of the neutrino momenta. In the absence of invisible particles, the missing transverse energy fluctuates around zero because of the noise of the detector. The resolution of the $p_{\mathrm{T}}^{\mathrm{miss}}$and the energy scale of the $p_{\mathrm{T}}^{\mathrm{miss}}$can then be studied from equilibrated energetic events, such as events containing a Z boson decaying to two electrons or two muons, or events containing a single photon. $p_{\mathrm{T}}^{\mathrm{miss}}$is defined as the negative vectorial sum of the particles in the event

$$\vec{p}_{\mathrm{T}}^{\mathrm{miss}} = -\sum \vec{p}_{\mathrm{T}} \tag{1–1}$$

and its magnitude is denoted $p_{\mathrm{T}}^{\mathrm{miss}}$. In CMS, two algorithms for the $p_{\mathrm{T}}^{\mathrm{miss}}$reconstruction are used, PF $p_{\mathrm{T}}^{\mathrm{miss}}$and Puppi $p_{\mathrm{T}}^{\mathrm{miss}}$.

1.1.1 PF $p_{\mathrm{T}}^{\mathrm{miss}}$reconstruction

The first and most commonly used reconstruction algorithm is PF $p_{\mathrm{T}}^{\mathrm{miss}}$, which is the magnitude of the negative of the vectorial sum of all PF candidates in an event:

$$\vec{p}_{\mathrm{T}}^{\mathrm{miss}} = -\sum_{i \in PF} \vec{p}_{\mathrm{T,i}} \tag{1–2}$$

1.1.2 Puppi $p_{\mathrm{T}}^{\mathrm{miss}}$reconstruction

Puppi [**?**]