Search for supersymmetry in the single lepton final state in 13 TeV pp collisions with the CMS experiment

TECHNISCHE UNIVERSITÄT WIEN

Ece Asilar

Ausgeführt am Atominstitut der Technischen Universität Wien
in Verbindung mit dem Institut für Hochenergiephysik (HEPHY)
der Österreichischen Akademie der Wissenschaften

Doctor of Philosophy

August 2017

This thesis is dedicated to
someone
for some special reason

Acknowledgements

bla bla bla bla

Abstract

FIXME The Standard Model of particle physics is like an old family car: likable but also with problems, like the hierarchy and the lack of explanation of Dark Matter. Many extensions of the Standard Model provide solutions to these problems, and Supersymmetry seems to be one of the most promising ones. A search for Supersymmetry in events with a single electron or muon is performed on proton-proton collisions at a center-of-mass energy of 13 TeV. The data were recorded by the CMS experiment during Run 2 of the LHC, corresponding to an integrated luminosity of 36.5 fb-1. The analysis is designed to look for signatures of the two different decays of pair-produced gluinos, superpartners of Standard Model gluons. In one of them each gluino decays to top quarks and a neutralino via a three-body decay. In the other one, each gluino decays to two light quarks and an intermediate chargino, with the latter decaying to a W boson and a neutralino. In these models, the neutralino is considered to be the stable lightest supersymmetric particle, or LSP. Hence, It is a strong candidate of Dark Matter. The main search variable of the analysis is the azimuthal angle between the lepton and four-vector sum of the missing energy and lepton. The angle for leading background processes tend towards low values while the expected signal events do not show dependence, due to the large missing transverse energy contribution from LSP. Thus, the region with high (low) values of this angle is chosen to be signal (control) region. To further increase the sensitivity several signal rich search regions are defined, based on the number of (b)jets, the scalar sum of all jet transverse momenta, and the scalar sum of the transverse missing momentum and transverse lepton momentum. The Standard Model background is estimated with a data-driven approach using control regions where no signal contribution is expected. Low jet multiplicity sidebands are used to obtain signal to control region transfer factor. Since no significant deviation from the predicted Standard Model background is observed, exclusion limits on gluino and neutralino masses are obtained.

Contents

List of Figures

Abbreviations

ALICE A Large Ion Collider Experiment

ATLAS A Toroidal LHC Apparatus

BSM Beyond the Standard Model

CERN European Organization for Nuclear Research

CM Center of Mass

CMS Compact Muon Solenoid experiment

CMSSW CMS SoftWare framework

DAQ Data Acquisition

ECAL Electromagnetic Calorimeter

HCAL Hadron Calorimeter

HF Hadron Calorimeter (Forward)

LHC Large Hadron Collider

LHCb the Large Hadron Collider Beauty Experiment

LINAC Linear particle Accelerator

PDG Particle Data Group

QFT Quantum Field Theory

SM Standard Model

SUSY Super Symmetry

GUT Grand Unified Theory

Chapter 1

Introduction

Bla bla

Organisation of the thesis:
¿ itemize the chapters

Chapter 2

Supersymmetry

Supersymmetry is an extension of the Standard Model of Particle Physics .. This will be intro

2.1 Standard Model

continue StandardModel

2.1.1 Current Status of the Standard Model

Explain standard model particles

Explain interations

Explain interations

Maybe explain also latest experimental achivments supporting SM

2.1.2 Inadequacies of the Standard Model

Experimental and Theoratical puzzles..

Experimental and Theoratical puzzles..

2.2 Supersymmetry as a solution

2.2.1 Minimal Supersymmetric Standard Model

continue Minimal Supersymmetric Standard Model continue Minimal Supersymmetric Standard Model

2.2.2 Short History of SUSY searches at colliders

continue History of SUSY searches at colliders

Chapter 3

Experimental Setup

3.1 The LargeHadron Collider at CERN

3.1.1 The CERN accelerator complex

3.1.2 The future of the LHC

3.2 The Compact Muon Solenoid experiment at the LHC

3.2.1 Superconducting Magnet

3.2.2 Tracker

3.2.3 Electromagnetic Calorimeter

3.2.4 Hadron Calorimeter

3.2.5 Muon System

3.2.6 Trigger and Data Acquisition Systems

3.2.7 Data Tiers of CMS

RAW , RECO , AOD ...

3.2.8 Luminosity measurement

3.2.9 Future of CMS

upgrade plans.. pixel .. will help to motivate future of physics analysis

3.3 Event simulation

Describe madgrapgh , pythia .. will be short

Chapter 4

Object reconstruction and identification

4.1 Particle-Flow algorithm

4.2 Physics Object reconstruction

4.2.1 Primery vertices

4.2.2 Electrons

4.2.3 Muons

4.2.4 Jets

4.2.5 b tagged Jets

mention fake rate

4.2.6 Missing transverse energy

continue Missing transverse energy

Chapter 5

Event Selection

5.1 SUSY signature

kinematic variables DeltaPhi , HT , LT ....
Put inclusive plots which then will support baseline selection

5.2 Samples

5.2.1 Data Samples

Shortly explain triggers

5.2.2 MC Samples

5.3 Baseline selection

plots ele channel

plots mu channel

Chapter 6

Design of Search Regions

Explain MB , SB...

Plots MB , SB...

6.1 Signal Regions

6.1.1 Background and Signal composition in MB SR

6.2 Control Regions

6.2.1 Background composition in MB CR and SB SR/CR

continue background composition

6.2.2 Signal contamination in MB CR and SB SR/CR

Tell that It is negligible

supporting plots : Tell that It is negligible

Chapter 7

Background Estimation

7.1 R_{CS} method

refer background compositions from the previous chapter

RCS stability plots ...

7.1.1 R_{CS} method in ttbar events

Maybe mention: Previously : SB was 1 bjet events -¿ you studied the extension now It is btagged region explain kappas

Explain dilepton correction on kappa tt

shortly tell systemtics, will be expalin in details ...

7.1.2 R_{CS} method in w jets events

continue ..

addition of diboson contributions to WJets ...

other contribution from MC

7.2 QCD background estimation

keep short you did nothing

7.3 Validation of the background estimation

plots, table

explanation

Chapter 8

Systematic Uncertainties

8.1 Systematic Uncertainties on background estimation

8.1.1 Theoratical Uncertainties

- $\sigma()$
- $\sigma(t\bar{t})$
- $\sigma(others)$

8.1.2 Experimental Uncertainties

- Dilepton control sample
  will be long plots

text of dilep

- JES
- Tagging of b-jets
- W polarization

- nISR reweighting
- Pileup
- QCD

8.2 Systematic Uncertainties on signal modelling

- Trigger
- Pileup
- Lepton efficiency

- Luminosity
- ISR
- Tagging of b-jets

- JES
- Factorization/renormalization scale
- Reconstruction of MET

Chapter 9

Results and Interpretation

9.1 Results of background predition

plots...

9.2 Limit settings

explain cls

statistical tests

9.3 Interpretation

T5qqqqWW limit goes here

9.4 Comparison to other results

with plots will take at least 2 pages

with plots will take at least 2 pages

Chapter 10

Conclusion

Bitti

The End

Appendix A

Appendix

[]99

J. Beringer et al. (Particle Data Group), PR D86, 010001 (2012) http://pdg.lbl.gov
, last visited 09/07/2014