Search for New Physics in Events with Jets and Missing Transverse Momentum at the CMS Experiment

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Kristin Goebel geb. Heine

aus Gifhorn

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Vorsitzender des Promotionsausschusses:	Prof. Dr. bla
Leiterin des Fachbereichs Physik:	Prof. Dr. bla
Dekan der Fakultät für Mathematik, Informatik und Naturwissenschaften:	Prof. Dr. bla

Abstract

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Kurzfassung

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1 Introduction

blabla bla [1]

2 Theoretical Background

2.1 The Standard Model of Particle Physics

2.1.1 Shortcomings of the Standard Model

2.2 Supersymmetry

2.2.1 Searches for Supersymmetry at Collider Experiments

3 Experimental Setup

In order to probe the various aspects of the well-established standard model or search for hints of new physics beyond the SM, particle physics experiments preferentially make use of powerful particle accelerators where particles of a certain type are collided in order to probe the constituents of matter and interactions between them. The analyses presented in this thesis are all connected to the CMS experiment located at the Large Hadron Collider (LHC) at CERN near Geneva.
The first part of this chapter provides an introduction to the LHC. This is followed by an overview of the detector system of the CMS experiment. Afterwards the hitherto periods of collision data taking at the LHC are discussed together with an introduction to the generation of simulated events which are used in the analysis of real data events.

3.1 The Large Hadron Collider

The Large Hadron Collider [2,3] is a ring-accelerator designed to provide particle collisions of hadrons. It is built in the tunnel of the former LEP experiment 45 – 170 m below the ground and has a circumference of 26.7 km. The LHC is a particle-particle collider and thus composed of two rings with counter-rotating beams. The operation can be performed in different modes with either proton beams or heavy ions like e.g. lead [1].

Ref: LEP

3.2 The CMS Experiment

3.2.1 Coordinate System and Kinematic Variables

3.2.2 Inner Tracking System

3.2.3 Electromagnetic Calorimeter

3.2.4 Hadronic Calorimeter

3.2.5 Muon System

3.2.6 Trigger System

3.3 Data Taking and Event Simulation

[1] The studies presented in this thesis are all based on proton-proton collisions. Thus the operation with heavy ions is not discussed here.

4 Reconstruction Algorithms and Object Definition

4.1 Global Event Description with the Particle-Flow Algorithm at CMS

4.2 Reconstruction of Jets

4.2.1 Jet Algorithms

4.2.2 Jet Types at CMS

4.2.3 Jet Energy Calibration

4.3 Identification of Boosted Top Quark Decays

4.3.1 The CMS Top Tagger

4.3.2 The HEP Top Tagger

5 Measurement of the Jet Transverse-Momentum Resolution

5.1 Basic Concept of the Dijet Asymmetry Method

5.2 Apllication to Realistic Collision Events

5.3 Samples and Event Selection

5.3.1 Datasets and Triggers

5.3.2 Selection Criteria

5.4 Corrections to the Dijet Asymmetry

5.4.1 Correction for Additional Jet Activity

5.4.2 Correction for Particle-Level Imbalance

5.4.3 Results of the Corrections to the Asymmetry

5.5 Determination of the Data-to-Simulation Ratio of the Jet Transverse Momentum Resolution

5.6 Validation of the Method

5.6.1 Validation in Simulated Events

5.6.2 Validation of the Measured Data-to-Simulation Ratio

5.7 Systematic Uncertainties

5.8 Extension of the Method to the Forward Detector Region

5.9 Results

5.9.1 Comparison to Other Measurements

6 Search for New Physics in the Multijet and Missing Transverse Momentum Final State at $\sqrt{s} = 8$ TeV

6.1 Event Selection

6.1.1 Data samples and trigger

6.1.2 Event Cleaning

6.1.3 Baseline Selection

6.1.4 Exclusive Search Regions

6.2 QCD Background Estimation with the Rebalance-And-Smear Method

6.2.1 Rebalance Procedure using Kinematic Fits

6.2.2 Response Smearing

6.2.3 Validation Tests

6.2.4 Systematic Uncertainties

6.2.5 QCD Background Prediction

6.3 Estimation of Non-QCD Backgrounds

6.3.1 Invisible Z Background

6.3.2 Hadronic τ Background

6.3.3 Lost-Lepton Background

6.4 Results and Interpretation

7 Prospect Studies for a Search for Top Squarks in Events with Jets and Missing Transverse Momentum at $\sqrt{s} = 13$ TeV

7.1 Data samples

7.2 Top Tagging Efficiency Studies

7.2.1 Top Tag Efficiency

7.2.2 Misidentification Rate

7.3 Identification of Selection Criteria

7.4 Comparison of the Performance of Various Selections

7.5 Impact of Specific Assumptions in the Analysis

8 Conclusions

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