

Measurement of $H \rightarrow b\bar{b}$ in Associated Production with the CMS Detector

by

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Abstract

We measured $VH \rightarrow b\bar{b}$ with the CMS Detector.

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Chapter 1

Introduction

1.1 Measurement of the Higg Cross Section

1.2 Motivation for the Measurement

1.3 Historic Context

[1]

1.4 Using the CMS Detector

Chapter 2

Theory

2.1 Higgs Boson

2.2 Associated Production

2.2.1 Production Mechanisms

2.2.2 Decay Channels of Vector Bosons

2.3 Characteristics of the Higgs

2.3.1 Energy Spectrum

2.3.2 Decay to $b\bar{b}$

2.4 Other Relevant Standard Model Processes

Chapter 3

The CMS Detector

3.1 Associated Production at the LHC

The LHC is a hadron collider.

Quark interactions can lead to Vector boson production, since the protons are at high energy.

Virtual vector bosons can radiate a Higgs.

This happens along with additional event stuff, caused by breaking apart the protons and pileup.

3.2 Observables of Associated Production

We can count charged leptons or infer neutrinos to tag vector bosons.

We are interested in Higgs to $b\bar{b}$.

3.3 Detector Requirements

We need to identify interesting particles, be able to reconstruct missing transverse momentum, and remove pileup.

3.3.1 Particle Types and Energies

3.3.2 Pileup Conditions at the LHC

3.4 Detector Design

3.4.1 Silicon Pixel Detector

3.4.2 ECAL

3.4.3 HCAL

3.4.4 Muon Chambers

3.5 Detector Performance

3.5.1 Test Beam Performance

3.5.2 Trigger

3.5.3 Online Calibration

3.6 Data Format

3.6.1 Event Reconstruction

3.6.2 Offline Calibration

Chapter 4

Simulation

4.1 Backgrounds to the Analysis

In order to effectively measure Higgs production, we need to be able to accurately estimate other events that end up in our selection.

4.2 Event Generation

We use different generators.

Details in Appendix C.

4.2.1 Tree Level Simulation

4.2.2 Parton Showers

4.3 Detector Simulation

4.4 Corrections to Simulation

4.4.1 Smearing

Muons

Electrons

Jets

4.4.2 Selection Efficiencies

4.4.3 Control Regions

Light Flavor Jets

Heavy Flavor Jets

$t\bar{t}$

Chapter 5

Event Selection

5.1 Object Definitions

Section 3.6.1 describes how detector responses are linked to possible physical particles. We want to remove false positives, so here are some tighter requirements for counting for event selection.

Once we have our objects defined, we can count them.

5.1.1 Muons

Muons can show up in weakly decaying jets, so we're only interested in isolated ones here.

5.1.2 Electrons

Electrons do the same thing as muons, but messier because the ECAL isn't as clean as the muon chambers.

5.1.3 Jets

Jets are messier still.

Pileup removal is a big deal here.

5.1.4 MET

MET is corrected.

5.1.5 Undesirable Particles

There are certain particles that we do not want present. We make very loose selections for those and veto on them.

Photons

Tau Leptons

5.2 Removal of QCD

We have some cuts across the board on our objects in order to remove events that are just QCD.

5.3 Categories of Vector Boson Decay

Now that we are ready to count, we can count leptons in order to characterise potential vector bosons.

5.3.1 0 Leptons

5.3.2 1 Lepton

5.3.3 2 Leptons

5.4 Topology of Higgs Decay

5.4.1 Resolved Jets

We reconstruct two b jets.

5.4.2 Boosted Jet

When the Higgs has very high p_T , the jet clustering algorithms can find both daughter particles as being part of a single jet.

Chapter 6

Analysis Results

6.1 Systematic Uncertainties

6.2 Combination Fit Method

6.3 Results

Chapter 7

Conclusions

Appendix A

Physics Calculations

Appendix B

Data Format

Appendix C

Generator Parameters

Appendix D

Data Card

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