

**Search for Dark Matter in Proton-Proton  
Collisions at a Center-of-Mass Energy of 13 TeV in  
the Higgs Boson associated b-anti-b quark channel**

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Submitted in partial fulfillment of the  
requirements for the degree  
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**COLUMBIA UNIVERSITY**

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# ABSTRACT

# Search for Dark Matter in Proton-Proton Collisions at a Center-of-Mass Energy of 13 TeV in the Higgs Boson associated b-anti-b quark channel

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## Part I

# Introduction

# Introduction

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## Part II

# The standard model and Dark Matter

## Chapter 2

# The standard model

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### 2.1 Introduction

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#### 2.1.1 Sample subsection

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## 2.2 Challenges

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### 2.2.1 Sample subsection

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## Chapter 3

# The Dark Matter

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### 3.1 Two-Higgs-doublet model

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#### 3.1.1 Sample subsection

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## **Part III**

# **The LHC and ATLAS experiment**

## Chapter 4

# The LHC

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### 4.1 The LHC: Instrument

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#### 4.1.1 The LHC layout

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#### 4.1.2 The LHC performance

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## 4.2 The LHC: Operation

### 4.2.1 The LHC accelerator

### 4.2.2 The LHC beam

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## Chapter 5

# The ATLAS experiment

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### 5.1 ATLAS detector system

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#### 5.1.1 Inner detector

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##### 5.1.1.1 Pixel detector

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#### 5.1.1.2 Semiconductor Tracker

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### 5.1.1.3 Transition Radiation Tracker

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### 5.1.2 Calorimeter

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### 5.1.2.1 Liquid Argon Calorimeter

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### 5.1.2.2 Tile Calorimeter

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### 5.1.3 Muon Spectrometer

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#### **5.1.3.1 Thin Gap Chambers**

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#### **5.1.3.2 Resistive Plate Chambers**

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#### **5.1.3.3 Monitored Drift Tubes**

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#### **5.1.3.4 Cathode Strip Chambers**

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### **5.2 Event reconstruction**

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### 5.2.1 Tracks

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### 5.2.2 Electrons

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### 5.2.3 Jets

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### 5.2.4 Missing transverse momentum

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### 5.2.5 Muons

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## 5.3 Event simulation

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### 5.3.1 Event generator

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### 5.3.2 Detector simulation

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## Part IV

Dark Matter search in the Higgs

Boson associated  $b\bar{b}$  decay

# Introduction

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## Chapter 7

# Boosted Xbb tagging

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### 7.1 Sample section

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#### 7.1.1 Sample subsection

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#### 7.1.2 Sample subsubsection

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## 7.2 Sample section

### 7.2.1 Sample subsection

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## Chapter 8

# Signal selection

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### 8.1 Sample section

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#### 8.1.1 Sample subsection

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#### 8.1.2 Sample subsubsection

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## 8.2 Sample section

### 8.2.1 Sample subsection

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## Chapter 9

# Background estimation

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### 9.1 Sample section

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#### 9.1.1 Sample subsection

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#### 9.1.2 Sample subsubsection

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## 9.2 Sample section

### 9.2.1 Sample subsection

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## Chapter 10

# Result

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### 10.1 Sample section

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#### 10.1.1 Sample subsection

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#### 10.1.2 Sample subsubsection

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## 10.2 Sample section

### 10.2.1 Sample subsection

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## Part V

# Conclusions

## Conclusions

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## Part VI

# Appendices



### A.1.2 Sample subsubsection

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## A.2 Sample section

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### A.2.1 Sample subsection

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## Analysis supplementary materials

### B.1 $pp \rightarrow H b \bar{b}$

### B.1.1 Sample subsection

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**B.1.2 Sample subsubsection**

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**B.2  $pp \rightarrow q\bar{q}b\bar{b}$** 

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**B.2.1 Sample subsection**

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## Part VII

# Bibliography

# Bibliography

- [Grosz and Sidner, 1986] Barbara Grosz and Candace Sidner. Attention, intention, and the structure of discourse. *Computational Linguistics*, 12(3):175–204, July-September 1986.