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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ABSTRACT

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Acknowledgments

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Dedication text

Part I

Introduction

Chapter 1

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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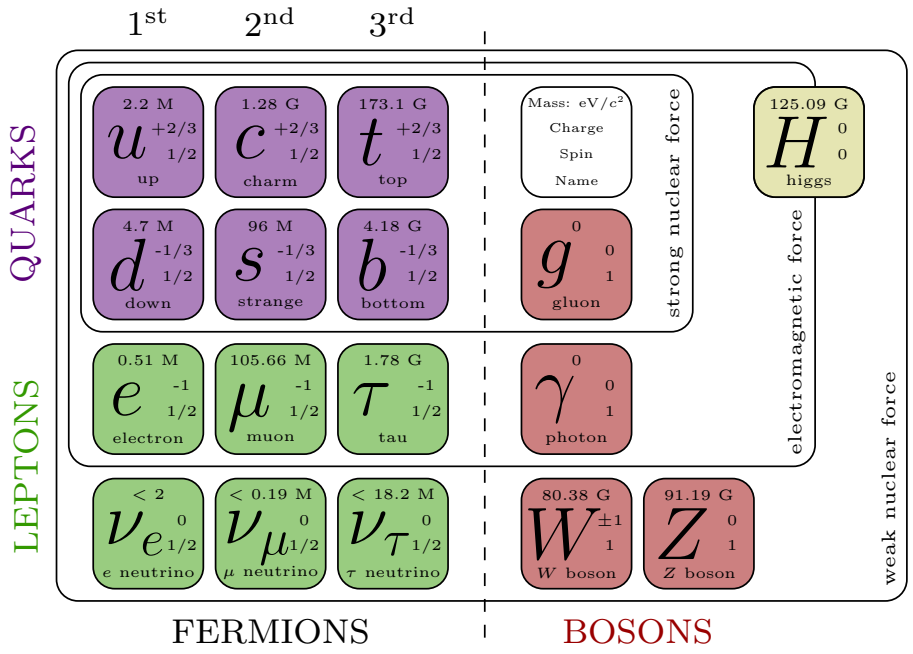

Figure 2.1: Particles of the Standard Model of particle physics

$$
\begin{aligned}
L = & -\frac{1}{4}B_{\mu\nu}B^{\mu\nu} - \frac{1}{8}tr(F_{\mu\nu}F^{\mu\nu}) - \frac{1}{2}tr(G_{\mu\nu}G^{\mu\nu}), (Gauge\,terms) \\
& + \begin{pmatrix} \bar{\nu}_L & \bar{e}_L \end{pmatrix} \bar{\sigma}^{\mu} i D_{\mu} \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} + \bar{e}_R \sigma^{\mu} i D_{\mu} e_R + \bar{\nu}_R \sigma^{\mu} i D_{\mu} \nu_R, (Lepton\,dynamical\,terms) \\
& - \frac{\sqrt{2}}{\upsilon}[\begin{pmatrix} \bar{\nu}_L & \bar{e}_L \end{pmatrix} \phi M^e e_R + \bar{e}_R \bar{M}^e \bar{\phi} \begin{pmatrix} \nu_L \\ e_L \end{pmatrix}], (Electron, muon, Tau\,mass\,terms) \\
& - \frac{\sqrt{2}}{\upsilon}[\begin{pmatrix} -\bar{e}_L & \bar{\nu}_L \end{pmatrix} \phi^* M^{\nu} \nu_R + \bar{\nu}_R \bar{M}^{\nu} \phi^T \begin{pmatrix} -e_L \\ \nu_L \end{pmatrix}], (Neutrino\,mass\,terms) \\
& + \begin{pmatrix} \bar{u}_L & \bar{d}_L \end{pmatrix} \bar{\sigma}^{\mu} i D_{\mu} \begin{pmatrix} u_L \\ d_L \end{pmatrix} + \bar{u}_R \sigma^{\mu} i D_{\mu} u_R + \bar{d}_R \sigma^{\mu} i D_{\mu} d_R, (quark\,dynamical\,terms) \\
& - \frac{\sqrt{2}}{\upsilon}[\begin{pmatrix} \bar{u}_L & \bar{d}_L \end{pmatrix} \phi M^d d_R + \bar{d}_R \bar{M}^d \bar{\phi} \begin{pmatrix} u_L \\ d_L \end{pmatrix}], (Down, strange, bottom\,mass\,terms) \\
& - \frac{\sqrt{2}}{\upsilon}[\begin{pmatrix} -\bar{d}_L & \bar{u}_L \end{pmatrix} \phi^* M^u u_R + \bar{u}_R \bar{M}^u \phi^T \begin{pmatrix} -d_L \\ u_L \end{pmatrix}], (Up, charm, top\,mass\,terms) \\
& + \bar{D_{\mu}}\phi D^{\mu}\phi - m_h^2[\bar{\phi}\phi - \upsilon^2/2]^2/2\upsilon^2, (Higgs\,dynamical\,and\,mass\,terms)
\end{aligned}
\tag{2.1}
$$

The definition of derivative operators in the Eq 2.1 is:

$$D_\mu \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} = [\partial_\mu - \frac{ig_1}{2} B_\mu + \frac{ig_2}{2} W_\mu] \begin{pmatrix} \nu_L \\ e_L \end{pmatrix} \tag{2.2}$$

$$D_\mu \nu_R = \partial_\mu \nu_R, \quad D_\mu e_R = [\partial_\mu - ig_1 B_\mu] e_R$$

$$D_\mu \begin{pmatrix} u_L \\ d_L \end{pmatrix} = [\partial_\mu + \frac{ig_1}{6} B_\mu + \frac{ig_2}{2} W_\mu + igG_\mu] \begin{pmatrix} u_L \\ d_L \end{pmatrix} \tag{2.3}$$

$$D_\mu u_R = [\partial_\mu + \frac{i2g_1}{3} B_\mu + igG_\mu] u_R, \quad D_\mu d_R = [\partial_\mu - \frac{ig_1}{3} B_\mu + igG_\mu] d_R$$

$$D_\mu \phi = [\partial_\mu + \frac{ig_1}{2} B_\mu + \frac{ig_2}{2} W_\mu] \phi \tag{2.4}$$

2.1.1 Sample subsection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

2.2 Challenges

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

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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3.2 Simplified model

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Part III

The LHC and ATLAS experiment

Chapter 4

The LHC

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4.1 The LHC: Instrument

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

4.1.1 Machine layout

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

4.1.2 Machine performance

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

4.2 The LHC: Operation

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

4.2.1 Machine accelerator

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

4.2.2 Machine 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

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.2 Event reconstruction

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.2.1 Tracks

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5.2.2 Electrons

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.2.3 Jets

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.2.4 Missing transverse momentum

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.2.5 Muons

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.3 Event simulation

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.3.1 Event generator

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

5.3.2 Detector simulation

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

Part IV

Dark Matter search in the Higgs Boson associated $b\bar{b}$ decay

Chapter 6

Introduction

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6.1 MC samples

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

Chapter 7

Boosted Xbb tagging

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

7.1 Sample section

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7.1.1 Sample subsection

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7.1.2 Sample subsubsection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

7.2 Sample section

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7.2.1 Sample subsection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

Chapter 8

Signal selection

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8.1 Event Triggers

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

8.2 Baseline selection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

8.2.1 Sample subsection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text

sample text. Sample text sample text sample text.

8.3 Signal region

TODO, MC simulation in signal region, Pie chart + table. No data.

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

8.3.1 Sample subsection

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Chapter 9

Background estimation

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9.1 Backgrounds from top and W decays

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9.1.1 Sample subsection

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9.1.2 Sample subsubsection

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

9.2 Backgrounds from neutrinos in Z decays

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9.2.1 Sample subsection

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9.3 Backgrounds from QCD multi-jet

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

Chapter 10

Result

TODO, background predictions in signal region, stack chart and table.

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

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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sample text. Sample text sample text sample text.

10.2 Sample section

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10.2.1 Sample subsection

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Part V

Conclusions

Chapter 11

Conclusions

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Part VI

Appendices

Appendix A

The ATLAS detector service work

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A.1 Sample section

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A.1.1 Sample subsection

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A.2 Sample section

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A.2.1 Sample subsection

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Appendix B

Analysis supplementary materials

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B.1 $pp \to Hb\bar{b}$

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B.1.1 Sample subsection

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B.2 $pp \to q\bar{q}b\bar{b}$

Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text. Sample text sample text sample text.

B.2.1 Sample subsection

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Part VII

Bibliography

Bibliography

[Alves *et al.*, 2012] Daniele Alves, Nima Arkani-Hamed, Sanjay Arora, Yang Bai, Matthew Baumgart, Joshua Berger, Matthew Buckley, Bart Butler, Spencer Chang, Hsin-Chia Cheng, Clifford Cheung, R Sekhar Chivukula, Won Sang Cho, Randy Cotta, Mariarosaria D'Alfonso, Sonia El Hedri, Rouven Essig, Jared A Evans, Liam Fitzpatrick, Patrick Fox, Roberto Franceschini, Ayres Freitas, James S Gainer, Yuri Gershtein, Richard Gray, Thomas Gregoire, Ben Gripaios, Jack Gunion, Tao Han, Andy Haas, Per Hansson, JoAnne Hewett, Dmitry Hits, Jay Hubisz, Eder Izaguirre, Jared Kaplan, Emanuel Katz, Can Kilic, Hyung-Do Kim, Ryuichiro Kitano, Sue Ann Koay, Pyungwon Ko, David Krohn, Eric Kuflik, Ian Lewis, Mariangela Lisanti, Tao Liu, Zhen Liu, Ran Lu, Markus Luty, Patrick Meade, David Morrissey, Stephen Mrenna, Mihoko Nojiri, Takemichi Okui, Sanjay Padhi, Michele Papucci, Michael Park, Myeonghun Park, Maxim Perelstein, Michael Peskin, Daniel Phalen, Keith Rehermann, Vikram Rentala, Tuhin Roy, Joshua T Ruderman, Veronica Sanz, Martin Schmaltz, Stephen Schnetzer, Philip Schuster, Pedro Schwaller, Matthew D Schwartz, Ariel Schwartzman, Jing Shao, Jessie Shelton, David Shih, Jing Shu, Daniel Silverstein, Elizabeth Simmons, Sunil Somalwar, Michael Spannowsky, Christian Spethmann, Matthew Strassler, Shufang Su, Tim Tait, Brooks Thomas, Scott Thomas, Natalia Toro, Tomer Volansky, Jay Wacker, Wolfgang Waltenberger, Itay Yavin, Felix Yu, Yue Zhao, and Kathryn Zurek and. Simplified models for LHC new physics searches. *Journal of Physics G: Nuclear and Particle Physics*, 39(10):105005, sep 2012.

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