Dissertation

Automated optimization of sensitivity in a search for VBF Higgs pair production with four b-quarks in the final state with the ATLAS detector

For the attainment of the academic degree doctor rerum naturalium

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Abstract

I am an abstract.

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Chapter 1

Theory

The Standard Model of Particle Physics Standard Model (SM) is the current theory that describes three of the four fundamental forces, namely the electromagnetic, strong, and weak forces, with the exception of gravity. Over the last decades it has been probed with remarkable precision. Nonetheless there are observational phenomena that lie beyond its scope.

The SM is based on symmetry principles and is described by a lorentz-invariant quantum field theory Quantum Field Theory (QFT). This qft is renormalizable and invariant under local gauge transformations belonging to the non-abelian gauge group

$$G = SU(3)_C \otimes SU(2)_L \otimes U(1)_Y, \tag{1.0.1}$$

leaving the equations of motions invariant under transformations within this group. $SU(3)_C$ is the special unitary group of rank 3 representing the color symmetry within Quantum Chromodynamics Quantum Chromodynamics (QCD) descibing the strong interactions. $SU(2)_L \otimes U(1)_Y$ exhibits the unification of the weak and electromagnetic interaction into the electro-weak force of $SU(2)_L$ left-chiral fermions of the weak force and right-hand $U(1)_Y$ fermions with hypercharge Y of the electromagnetic force. The following describes the particle content of the SM and gives a brief overview of the qft's used to describe aforementioned forces. The content of this chapter draws inspiration primarily from [1–3].

Appendix A

Acronyms

CERN Organisation européenne pour la recherche nucléaire

ATLAS A Toroidal LHC Apparatus

SM Standard Model

QFT Quantum Field Theory

QCD Quantum Chromodynamics

QED Quantum Electrodynamics

EWSB electroweak symmetry breaking

VEV vacuum expectation value

LHC Large Hadron Collider

HL-LHC High Luminosity LHC

ID Inner Detector

SCT semiconductor tracker

TRT transition radiation tracker

ITk Inner Tracker

IBL insertable b-layer

EM electromagnetic

LAr liquid argon

MS muon spectrometer

RPCs resistive plate chambers

TGCs thin gap chambers

MDTs monitored drift tubes

CSCs cathod strip chambers

HLT high level trigger

RoI region of interest

L1 Level-1

PDF Parton Distribution Function

DGLAP Dokshitzer–Gribov–Lipatov–Altarelli–Parisi

MC Monte Carlo

MPI multi-parton interaction

PS parton shower

ME matrix element

ISR initial state radiation

FSR final state radiation

4FS four-flavour scheme

5FS five-flavour scheme

NLO next-to-leading order

Bibliography

[1] W. Hollik, "Quantum field theory and the standard model," (2010), arXiv:1012.3883 [hep-ph] .

[2] D. Griffiths, *Introduction to elementary particles* (John Wiley & Sons, 2020).

[3] M. Thomson, *Modern particle physics* (Cambridge University Press, 2013).

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Frederic Renner