ABSTRACT

SOMETHING ABOUT VECTOR BOSON SCATTERING

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SOMETHING ABOUT VECTOR BOSON SCATTERING

BY

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DEDICATION

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CHAPTER 1

INTRODUCTION

1.1 The Standard Model

The study of physics is fundamentally the study of how the universe and everything inside of it works. Naturally then, as physicists, we want to be able to explain everything we study in the most amount of detail we can, and to this end we develop models of the universe with as much explanatory power as possible. One of these such models for describing the fundamental interactions of our universe is named the Standard Model. This model attempts to understand the universe by understanding the interactions between elementary particles that the universe is comprised of.

The Standard Model was developed throughout the 1900's by many scientists contributing many different discoveries and theories. In the early part of the century after J. J. Thomson's 1897 discovery of the electron, Rutherford's 1918 discovery of the proton, and Chadwick's 1932 discovery of the neutron, the fundamental building blocks of matter seemed to have all been found [3]. We could explain the universe as being made up of atoms which were made up of the three smallest and most fundamental particles, the proton, neutron, and electron. It wasn't long though, before this simple model of the elementary particles was upended.

The 1930's through the 1950's saw a rapid expansion in the number of elementary particles proposed, predicted, and discovered. By 1960 the term "particle zoo" was used to describe the unwieldy amount of unique and seemingly fundamental particles. Much like Mendeleev organized the known elements into the periodic table, the particle zoo was in need of organization. In 1961 Gell-Mann proposed the Eightfold Way, a way to organize the particles of the zoo based on their properties. In 1964 Gell-Mann and Zwieg independently proposed the Quark Model to explain the substructure of the zoo's inhabitants, and 10 years later in 1974, when the J/ψ particle was discovered, the quark model won out as the best explanation for these particles [1].

In 1968 Glashow, Weinberg, and Salam combined the electromagnetic and weak interactions into a single electroweak theory, and in 1975 Pais and Treiman dubbed the electroweak theory with four quarks the "standard" model [2]. This model describes three of the four fundamental forces and how they govern the elementary particles that make up all matter. As the model and it's predictions grew so too did the number of particles included in the standard model.

At present, the model contains 6 quarks and their anti-quark counterparts, 6 leptons and their antiparticles, as well as 6 bosons[1]. As it currently stand's the Standard Model is our best framework for understanding the fundamental building blocks of our universe and their interactions.

1.1.1 Fermions

Fermions

[1] Presently there is no experimental evidence for a 7^{th} boson, the graviton, and it's associated standard model explanation for the 4^{th} fundamental force of gravity

1.1.2 Bosons

1.1.3 Electroweak Interactions

1.1.4 Quantum Chromodynamics

CHAPTER 2

VECTOR BOSON SCATTERING

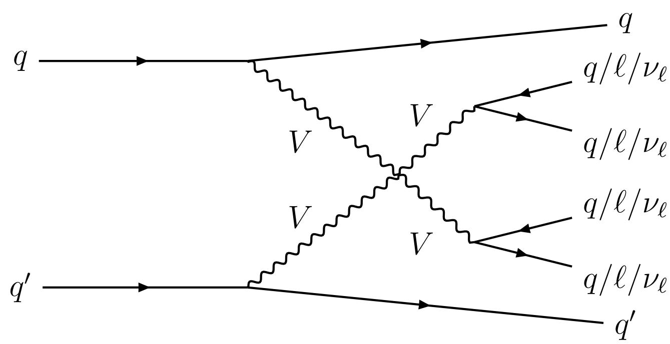

Figure 2.1: A basic quartic gauge coupling VBS process with the vector bosons decaying either hadronically, leptonically, or semi-leptonically

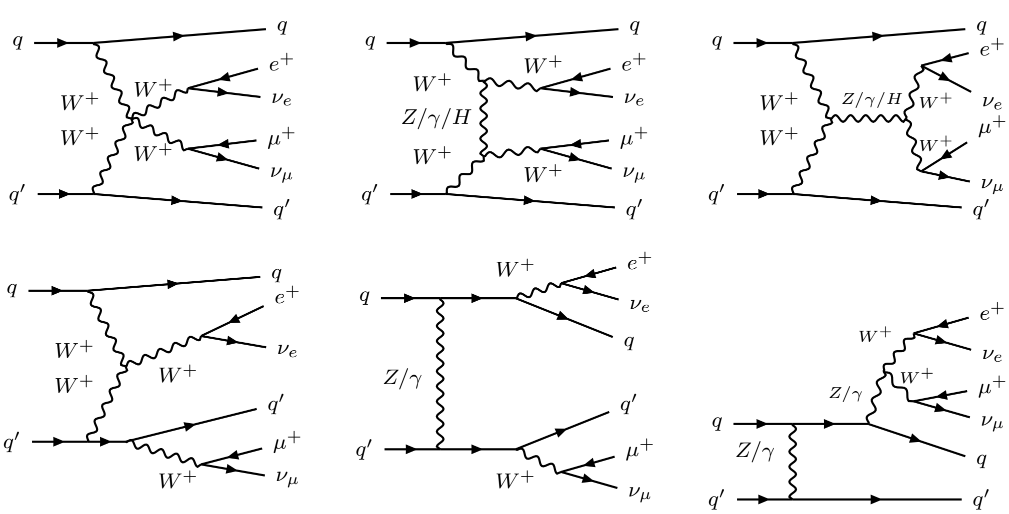

Table 2.1: Representative Feynman diagrams for VBS $pp \to e^+\nu_e\mu^+\nu_\mu jj$ and $pp \to e^+\nu_e\mu^-\bar{\nu}_\mu jj$ processes.

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CHAPTER 4

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CHAPTER 5

SIGNAL AND CONTROL REGIONS

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5.1.1 Top Background

5.1.2 W+jets Background

5.2 Signal Discrimination

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UNCERTAINTIES

CHAPTER 7

RESULTS

CHAPTER 8

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BIBLIOGRAPHY

[1] David Griffiths. *Introduction to Elementary Particles*. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2010. ISBN: 9783527406012.

[2] A. Pais and S. B. Treiman. "How Many Charm Quantum Numbers are There?" In: *Phys. Rev. Lett.* 35 (23 Dec. 1975), pp. 1556–1559. DOI: `10.1103/PhysRevLett.35.1556`. URL: `https://link.aps.org/doi/10.1103/PhysRevLett.35.1556`.

[3] James Trefil. *From Atoms to Quarks*. New York: Charles Scriber's Sons, 1980. ISBN: 0684164841.

APPENDIX A

STATISTICAL LEARNING TECHNIQUES

A.1 BDT

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APPENDIX B

ADDITIONAL PLOTS