

Master's Thesis

Improving Event Reconstruction for Dileptonic Decays of Top Quarks Pairs Using Machine Learning

prepared by

Siemen Aulich

from Emden

at the DESY Hamburg



Course: M.Phy.1610: Development and Realization of Scientific Projects
in Theoretical Physics

Course period: 7th April 2025 until 4th December 2026

First referee: Prof. Dr. Stan Lai

Second referee: Dr. Katharina Behr

Abstract

Here the key results of the thesis can be presented in about half a page.

Keywords: Physics, Bachelor thesis

1. Introduction

2. Theoretical Background

2.1. The Standard Model of Particle Physics

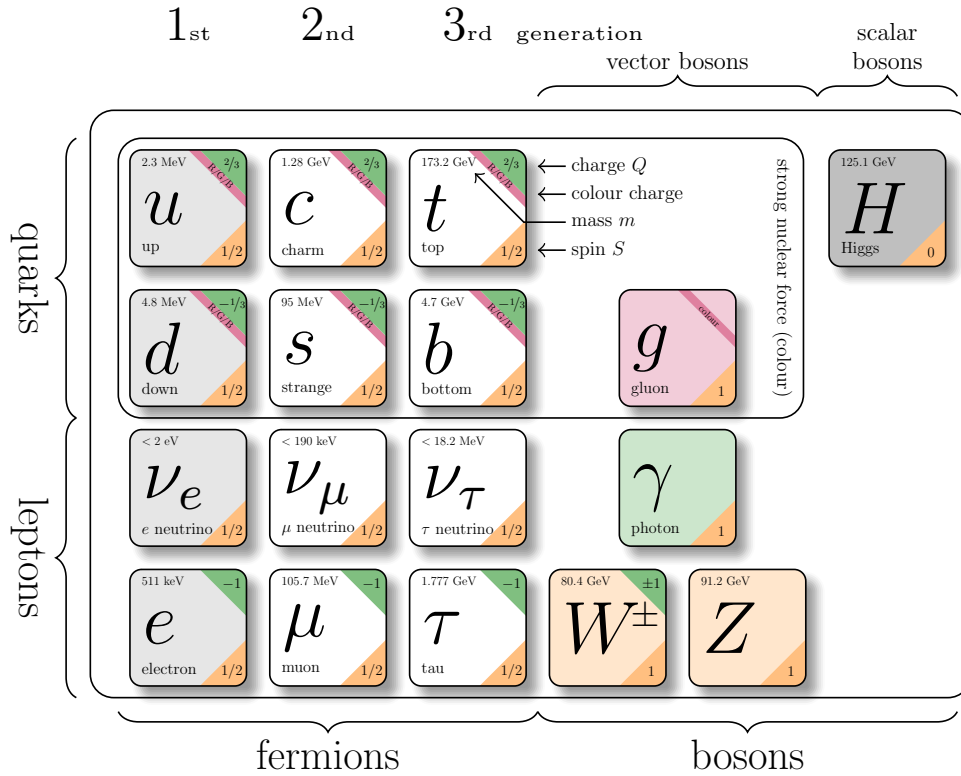


Figure 2.1.: The particles of the Standard Model. Particle properties taken from Ref. [1].

The Standard Model of Particle Physics (SM) provides the theoretical foundation describing three of the four elementary forces as well the particles making up the known matter. The Figure 2.1 shows a tabular overview of the known particle of the Standard Model. The SM classifies the elementary particles into fermions and bosons. Fermions are the building blocks of matter and have half-integer spin values. They are further divided into quarks and leptons. Quarks experience all four fundamental forces, while leptons do not participate in the strong interaction. Bosons are the force carriers of the fundamental interactions and have integer spin values. The photon, W and Z bosons, and gluons mediate the electromagnetic, weak, and strong forces, respectively. The Higgs boson is responsible for giving mass to other particles through the Higgs mechanism. Based on the coupling of the weak interaction, two particles are grouped into one iso-spin doublet. The iso-spin is the quantum number related to the weak interaction. Two quarks

2. Theoretical Background

form one doublet and one lepton and its corresponding neutrino form another doublet. Based on the different masses, two iso-spin doublets are grouped into what is called a generation. There are three generations of fermions, with each generation containing heavier particles than the previous one.

2.2. Top Quark Physics

The positive iso-spin partner of the third generation quark doublet is the top quark (t). With a mass of about $173 \text{ GeV}/c^2$ [1], it is the heaviest known elementary particle. Due to its high mass, the top quark has a very short lifetime of approximately $5 \times 10^{-25} \text{ s}$ [1], which is shorter than the timescale for hadronization.

3. Methodology

4. Results

5. Conclusion

A. Additional Plots

Bibliography

- [1] S. Navas et al. (Particle Data Group Collaboration), *Review of Particle Physics*, Phys. Rev. D **110**, 030001 (2024)

Danksagung

Dank. . .

Erklärung

nach §17(9) der Prüfungsordnung für den Bachelor-Studiengang Physik und den Master-Studiengang Physik an der Universität Göttingen: Hiermit erkläre ich, dass ich diese Abschlussarbeit selbständig verfasst habe, keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe und alle Stellen, die wörtlich oder sinngemäß aus veröffentlichten Schriften entnommen wurden, als solche kenntlich gemacht habe.

Darüberhinaus erkläre ich, dass diese Abschlussarbeit nicht, auch nicht auszugsweise, im Rahmen einer nichtbestandenenen Prüfung an dieser oder einer anderen Hochschule eingereicht wurde.

Göttingen, den 4. Dezember 2025

(Siemen Aulich)