UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Fisica e Astronomia "Galileo Galilei"

Corso di Laurea in Fisica

Tesi di Laurea

Predictive learning applied to muon chamber monitoring

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Anno Accademico 2020/2021

To the strength, the courage, the perseverance,
the passion, the love you infused in me.
To you.

Abstract

Cose in inglese

Sommario

Ho fatto cose per 5 mesi e non funziona niente ma i grafici sono belli check them out!

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Chapter 1

Introduction

Particle Physics, also known as High Energy Physics (HEP), is the branch of physics that studies the nature of the particles that constitute matter and radiation. Its development can be located starting from the second half of the 19^{th} century and, since then, theoretical physicists have been working on models that can accurately predict and describe the outcome of experiments. The model that better describes the experimental results is the Standard Model (SM), although it is common knowledge among the HEP community that SM is not complete. As a matter of fact, it does not describe General Relativity in terms of quantum field theories, does not give specifics about neutrino masses and does not explain the existence of dark matter. These facts show that there are as yet undiscovered physical laws and that our understanding of the world at its most fundamental level is lacking.

In order to interrogate experimental data in the search for New Physics (NP), scientists have come to realize that employing a model-dependent approach (i.e. searching for specific NP models) has a critical disadvantage: a statistical test which is designed to be sensitive to one specific hypothesis is typically insensitive to data departures of a different nature from the one expected. This means that if new physics is present in the data, but not predicted by the specific NP model that is being tested, it would not be discovered. A modern approach that overcomes the difficulties underlined above is the so-called model-independent approach. We define a certain approach as "model-independent" if we are not testing any specific physical model against our data. The main reason for which we demand a model-independent approach is the advantage of sensitivity to a large variety of new physics scenarios.

In the realm of HEP, Machine Learning (ML) techniques have been used since early 2000 (traditionally known as Multivariate Analysis) in many crucial tasks, such as event classification, track reconstruction and particle identification. In recent years, a Deep Learning algorithm has been developed in order to search for New Physics beyond the Standard Model. Such algorithm outlines a model-independent approach by exploiting Neural Networks (NN) with multiple hidden layers.

Although the above algorithm (which we will call the "NPL algorithm") looks promising in finding discrepancies, hidden within our datasets, between collected data and SM predictions, the same approach can be embraced to perform data quality monitoring tasks. The main topic of this work is, in fact, the application of this Deep Learning algorithm to constantly check whether the detector is collecting High Quality data (i.e. the detector is working as expected) or data acquisition is compromised in some way. We would like to emphasize the importance of being able to accurately discriminate High-Quality (HQ) data from Low-Quality (LQ) data: while the former is our gold mine, in which we hope to find answers to the unresolved questions above, the latter is a complete waste of time. Lastly, we remind that our approach to Data Quality Monitoring is model-independent. Thus, in this field of application, we are not asked to make assumptions on how data could be affected if the detector stops collecting HQ data. We, therefore, find ourselves with a remarkable sensibility towards a large variety of LQ data acquisitions and, due to the methodology of the approach and the structure of the algorithm itself, no occurrences of type II errors.

Chapter 2

The Algorithm

Chapter 3

Experimental Setup and Datasets

Chapter 4

Running the Algorithm on Low Level Features

Chapter 5

Conclusions

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