Rediscoerving the Higgs Boson

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Shortly after the big bang, it is theorized that matter and energy within the still expanding universe organized itself into some of the first fundamental particles. To explain why some of these indivisible particles exhibit mass and others do not, Physicists developed the theory of the Higgs Field. This theory subsequently lead to the formulation of several new Bosons, previously unknown to the standard model - the last of which to be confirmed is the Higgs Boson. In 2012 a team at CERN conducted a series of experiments in an attempt to experimentally validate the existence of the particle. Need to finish this abstract!

Introduction- The *Standard Model of Particle Physics* is the accepted theory that governs humanity's understanding of sub-atomic world. Its is composed of multiple kinds of invisible quarks, leptons, and Bosons, each of which represent the universe at it's most fundamental level [5]. Collectively, the particles in the standard model describe the strong nuclear force, weak nuclear force, electromagnetic force, as well as how the particles all interact with each other. While is consistent within it's own theory, has shown experimental validity, holds incredible predictive prowess, the standard model is still an incomplete theory of particle physics [2, 4].

The Standard model leaves open may questions such as how some some particles have experimentally shown the properties of having mass, whereas other particles do not. Modern theories about this indicate that in the time immediately after the big bang, several of the fundamental particles were formed, but did not interact gravitationally - as if they had no mass [2]. In the mid-twentieth century, English Physicist Peter Higgs proposed that some time after the formation of the universe, a scalar field, dubbed *The Higgs Field* was created. Higgs proposed that it was the particles interaction with this field that gives that allows for the particles to exhibit mass [1, 2].

Applying this theory to the electroweak force model lead to the formulation of the W and Z Gauge Bosons, which have been subsequently experimentally confirmed [1]. However, the theory consequently gave rise to another previously unknown particle in the standard model: The *Higgs Boson*. Despite having a place in the Standard Model, the theory is unable to provide a prediction for the mass of the new Boson [1, 4]. Decades of consideration has provided an estimate of the mass to be as low at 114 GeV/c^2 to almost 1 TeV/c^2. [1]

This large range of masses makes the search for the Higgs boson a very difficult process. We must systematically analyze data across this range and understand that the particle cross section may vary widely as well. To account for this the CERN detection apparatus was designed to process data over the large range of masses, and across five different decay modes. These decay modes model the Higgs Boson as decaying into one of five different pairs of elementary particles being :

$$\begin{aligned} \text{Higgs Boson to Photons} &\qquad H \to \gamma\gamma \\ \text{Higgs Boson to Z Bosons} &\qquad H \to ZZ \\ \text{Higgs Boson to W Bosons} &\qquad H \to W^+W^- \\ \text{Higgs Boson to tau} &\qquad H \to \tau^+\tau^- \\ \text{Higgs Boson to Botton Quarks} &\qquad H \to b\bar{b} \end{aligned} \tag{1}$$

Need to finish this intro. Why are the decays important? What do they mean????

Methods- In this paper, we explore a simplified reimplementation of parts of the Compact Muon Solenoid (CMS) Higgs to four lepton analysis as explored in CERN's publication which documents the details of the discovery of the Higgs Boson. Given the high volume of collected data, we use elected to use the ROOT software tool which is an open-source data analysis framework that allows for the processing of high-volumes of experimental data [6]. The analysis code we run to mimic the Higgs discovery does not use the original analysis code, and instead opts for a more simple and condensed version which skips some of the more advanced computations.

Discussions- The confirmation of the discovery of the Higgs Boson particle represents an enourmous milestone in the development of the Standard Model and particle physics as a whole. The existence of the this Boson particle is further support of the predictive power of the theories built into the standard-model and allows us to gain a new view on the properties of mass at the subatomic level. Additionally, the support of the Higgs field

Conclusions- The 2012 CERN search for the Higgs Boson particle using proton-proton collisions at $sqrts = 7$ and 8 TeV. The search was conducted over five different decay modes. Above the expected background, a mass near 125 GeV was detected indication the production of a new particle.

Our results are a simplified reconstruction of the data processing phase of the CERN experiemnt. This will be finished shortly!

No experimental conclusion yet!

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