Impacts of the higgs boson

In 1964, theoretical physicists Robert Brout, Francois Englert and Peter Higgs sought to answer the multitude of unanswered questions regarding the existence of particle mass. The ‘ Higgs mechanism’ they proposed involved a Higgs field and particle or ‘ boson’ which provided elementary particles with inertial mass (Gray & Mansoulie, 2018). Often referred to as the ‘ god particle’, the Higgs boson has no connection to religion (Greene, 2012). The moniker originates from Nobel Laureate, Leon Letterman, who claims that publishers convinced him that ‘ The God Particle’ was a much more suitable title compared to its original name, the ‘ Goddamn Particle’ (Greene, 2012): an acknowledgement to the elusive and unstable nature of the particle. The European Organisation of Nuclear Research (CERN) developed a powerful particle collider: The Large Hadron Collider (LHC), and experimentally confirmed the existence of the Higgs boson (Gray & Mansoulie, 2018). This discovery reformed the fundamental perception and understanding of many pre-existing ideas and theories in physics and can potentially unlock a plethora of opportunities and profoundly impact the lives of future generations. However, effective regulation of the use and research of resulting technological advancements is a necessity.

In the early 1960s, physicists observed symmetric patterns from collected data from the particle colliders at the time, and formed a theory describing electromagnetic and nuclear interactions (Greene, 2012). These patterns enabled scientists to form simple and elegant equations that could accurately model their results. However, only massless particles were supported, contrasting to real particles, which possess mass. Brout, Englert, and Peter Higgs proposed a solution to this discrepancy: the Brout-Englert-

Higgs (BEH) mechanism. Higgs proposed that empty space is suffused with an invisible field, that provides resistance to moving objects (Greene, 2012).

The LHC was utilised by CERN to achieve conclusive data that confirmed the existence of the Higgs field in 2012. This collider, about 29 km in circumference, accelerates protons to relativistic speeds (0. 9999c) with 27 km long superconducting magnets, and incites head on collisions between such protons (The Large Hadron Collider, 2019). The energy of these collisions can disturb the Higgs field enough that we may isolate and hence detect the existence of the boson (Greene, 2012). These particles are highly unstable and rapidly decay into familiar sub-atomic particles, such as protons or neutrons. However, through a regression-type analysis, physicists can reconstruct the process that produced such a particle (Greene, 2012).

While a seemingly simple concept, this process is a monumental challenge. With protons colliding 500 million times each second, detecting a faint signature of a decaying Higgs boson amongst the ‘ chaotic maelstrom’ of particle processes is incredibly difficult. Physicist Brian Greene described this feat (Greene, 2012):

“ comparable to hear a tiny, delicate, over the thundering, deafening din of a NASCAR race.”

However, over time, scientists were able to devise sophisticated techniques and advanced technology to develop mammoth detectors that could surround the collision point and capture the particle detritus (Greene, 2012). These detectors quantified ‘ signal events’ throughout these collisions and sent this data to super-computers for further analysis (Sutter, 2017).

Unlike all other subatomic particles which spin at a rate (half or one) dictated by its identity, the Higgs boson is unique, as it is the first discovered particle that has a ‘ zero’ spin (Greene, 2012). The discovery of the Higgs boson confirms the plausibility of numerous previous ideas that rely upon such characteristics. An example is the Big Bang Theory of cosmology, where physicists and mathematicians were unable to explain what would have driven the rapid expansion of space. However, the Higgs boson can now provide an explanation, as enough of a spin-less object in a tiny region of space yields a repulsive gravitational push that would drive everything apart (Greene, 2012).

To fund this project, immense funding from CERN member countries, including Germany, the UK, Italy, France and Spain was required, with 4. 75 billion USD required to construct the LHC alone (Knapp, 2012). Taking over a decade to construct, the LHC was stopped for repairs from September 2008 to November 2009. 20% of these expenses are paid by CERN: approximately $5. 5 billion per annum (Knapp, 2012). Due to the complex computational power required to analyse the collected data and the cooling required to operate the super-conductor magnets, electricity and power costs are a significant contribution of CERN’s expenses (Sutter, 2017). The total cost of running the LHC every year runs to about $1 billion per year. Additionally, experts estimate that over $13. 25 billion USD was required to find the Higgs Boson (Knapp, 2012). Further funding was received from other large institutions, universities and observer governments. With such significant expenses, it may be argued that such investments without a tangible impact is uneconomical and would be better spent on more immediate causes.

Additionally, a gargantuan amount of power is required to power the LHC: approximately enough electricity to power 60, 000 standard households (What powers the Large Hadron Collider?, n. d.). Like many other facilities, the LHC is dependent upon harmful fossil fuels to function.

While the societal impacts of the discovery of the Higgs Boson particle are obscure, the analysis of an analogous historical discovery from the 1920-30s illuminates the myriad of opportunities that this discovery may bring (Greene, 2012). When the subject of quantum mechanics was discovered and experimentally confirmed, it was commonly felt that these mechanisms were equally as abstract and theoretical. Today, we realise that modern society is heavily reliant upon such mechanics, and that by harnessing an understanding of molecules, atoms and other subatomic particles, we have developed the technological wonders that are ubiquitous throughout society. Quantum mechanics has allowed us to manipulate electrons through metal wires, giving rise to complex integrated circuits that power online servers, security and banking networks, and medical equipment that are saving lives around the world (Greene, 2012). Through this comparison, we see that practical applications of science are born through theoretical discoveries.

Whilst research of the Higgs boson may yield numerous benefits, physicists may have stumbled across the Higgs ‘ doomsday’. Measured at approximately 126 times the mass of a proton, mathematical calculations show that it is the exact mass required to maintain the delicate stability of the Universe (Dickerson, 2014). Renowned physicist Stephen Hawking and others believe that this delicate balance will inevitably collapse and destabilise the Universe (Dickerson, 2014). A quantum fluctuation or change in energy can cause ‘ quantum tunnelling’, which can create a vacuum in outer space. This void can be described as a ‘ bubble’, and can expand at the speed of light, causing catastrophic damage across the Universe. However, many scientists argue that the probability of such an event occurring is less than one in a googol (Dickerson, 2014), and such a small probability should not hinder scientific progress. The lack of understanding regarding other fundamental parts of physics such as dark matter, it’s interactions with particles, and the idea of supersymmetry handicaps our analysis and understanding of the implications of the Higgs mechanism. Further investigation into such fields may uncover a method of stabilising dangerous quantum events, Lykken says. Due to our preliminary understanding of events that can trigger quantum fluctuations and quantum tunnelling, research must be continued to further our understanding of these events.

It can be concluded that provided sufficiently rigorous in experimentation and regulation, the positive implications of Higgs boson research far outweigh the potentially harmful effects.

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Appendix:

The recommended YouTube video, various other news articles, economic and scientific reports and the CERN website were referenced for the writing of the paper. Out-dated (more than 10 years) sources were avoided, due to the contemporary and theoretical nature of the topic. It was acknowledged that news articles may accommodate a writer’s bias, and a wide range of news articles from various organisations were used to present a balanced, neutral discussion.