Master Advanced Lab Course
Universität Göttingen – Fakultät für Physik

Report on the experiment KT.HIP

Higgs physics with the ATLAS experiment

Name:	Eric Bertok
Email:	eric.bertok@stud.uni-goettingen.de
Conducted on	19th April 2018
Assistant:	K. Abeling
Copy of document requested:	☐ yes ☑ no
Unterschrift:	

Submission

Date:	Signature of assistant:

Review

Date:	Name of examiner:
Points:	Signature:
Mark:	

Contents

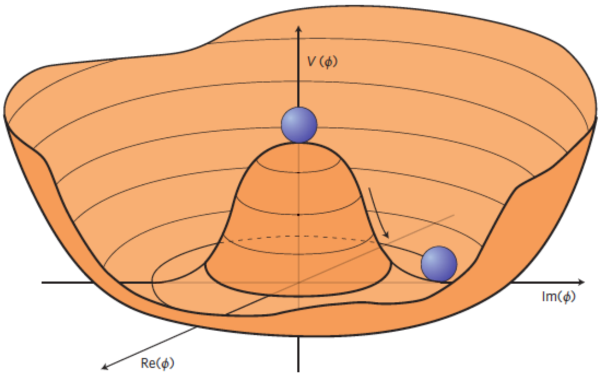

Figure 1: The mexican hat potential for the scalar Higgs boson. The symmetric state at $\Phi = 0$ is spontaneously broken and a new vacuum state is chosen in a random direction, leading to mass [**?**].

1 Introduction

2 Theory

2.1 A summary of the Standard Model

The Standard Model (SM) is the combination of different theories governing three of the four known fundamental forces (electromagnetic, weak and strong interactions), as well as all known elementary particles and their interaction. It consists of 6 quarks making up the hadrons, 6 leptons, as well as 4 gauge bosons acting as force carriers for the interaction between the other particles. The interactions are fixed by the principle of local gauge invariance. The last puzzle piece - the Higgs boson - has recently been found at the LHC. It gives mass to the other particles by the Higgs mechanism, a form of spontaneous symmetry breaking. The Standard model has been a great success, having made predictions for new physics as well as confirming these predictions with great accuracy. An example of this is the theory of quantum-electro-dynamics, which has been confirmed to an astounding precision [cite]. Despite the great success, the Standard Model is a rather ad-hoc combination of different ideas without a unifying underlying theoretical principle. It features 26 free parameters, namely the fermion masses, the coupling strengths of the fundamental forces, mixing angles of quarks and neutrinos and parameters specifying the Higgs mechanism [**?** , p. 500]. Therefore, it is desired that all four forces would unify into a "Great Unified Theory" (GUT). There are other obvious shortcommings of the SM: Gravity is not part of the SM, meaning that general relativity is not compatible with it, although being much weaker than the other forces, it can be neglected in particle experiments. Furthermore, dark matter is not described by the SM. Furthermore, the mass of the Higgs boson does not have the right mass order of magnitude at very high energy scales due to loop corrections, a problem known as the "hierarchy problem" [**?** , p. 505].

2.2 Beyond the Standard Model

Several ideas exist for an extension of the SM. Supersymmetry is an attempt to both unify the electroweak and strong force as well as solving the hierarchy problem. In supersymmetry, every elementary particle would have a corresponding super-partner, called a "sparticle". So far, no super-partners have been found [**?**]. Also, there would be the need for 5 different Higgs bosons. There is also a possibility of extra space-like dimensions that are hidden from us, which would be a possible explanation for the weakness of gravity. A prominent theory of quantum gravity - string theory - predicts these extra dimensions. In an experiment, these extra dimensions could manifest as a large amount of missing energy [**?**]. Additionally, neutrino masses need to be explained. A prominent idea is that neutrinos are majorana particles, namely particles being their own antiparticles.

2.3 The Higgs mechanism

The Higgs mechanism is needed in the SM to give rise to massive gauge bosons and fermions.

3 Experimental setup and methods

4 Analysis

5 Discussion