University of Delhi

Department of Physics & Astrophysics

PhD Thesis

Search for Anomalous Gauge Coupling through Vector Boson Scattering with the CMS Experiment at the LHC and Development of the GEM Detectors for Muon System

---

by Ram Krishna Sharma

Advisor: Dr. Md. Naimuddin

Contents

1

Introduction

"Particle physics is a modern name for the centuries old effort to understand the basic laws of physics."

– Edward Witten

Everybody is excited to know about the behaviour of nature around us, e.g. we are standing on earth but where the earth is standing, how it comes into existence, why there are lots of stars, and so on. These are the general questions asked by every human being. Answers and explanations to all these question at deeper level will lead us to the one of branch of fundamental physics known as "*particle physics*". As the name infers it deals with the particles (the fundamental particles) of matter and the interactions among them.

In the last century a theory was developed to describe the fundamental particles and their interactions and is known as the Standard Model (SM) of particle physics. Up to now this theory is well tested and with the discovery of the Higgs boson [1, 2] the spectrum of particles predicted by it is complete. Now the next important task is to study rigorously the precision measurement and test the deviation in the SM prediction, specially in the electroweak sector [3].

As the electroweak gauge bosons $W^{\pm}$, Z and γ, through mixing, represents the SM sector coupled strongly to the Electroweak Symmetry Breaking (EWSB). And the Higgs discovery give faith that the ultimate EWSB should be much like the simple Higgs mechanism. Thus, to study the hidden structure, if any, of EWSB beyond the Higgs, one of the best way to look carefully the electroweak gauge bosons.

In this thesis the study of one of such channel where an interaction vertices have four bosons, known as quartic gauge coupling, is studied through vector boson scattering process. Also a model interpretation is done with George-Machak model which gives us doubly charged Higgs. Further as we know that to perform these studies at very fundamental level we need a very sophisticated accelerator to accelerate the particles and to collide them and a detector to capture the remnants. Only this way one can perform the studies in experimental particle physics.

The one of such accelerator, LHC, and its one of main purpose detector Compact Muon Solenoid (CMS) is described in chapter **??**, while the brief introduction of the SM and the Vector Bososn Scattering (VBS) is explained from experimental point of view in chapter **??**. In continuation the experimental work done in described in chapter **??** along with the results. Also with time and to look for rare process along with to increase the production rate of the existing process such as vector boson scattering with time and latest available technology we should upgrade our detector. In this thesis the performance of one of such detector, Gas Electron Multiplier (GEM), is described in chapter **??**. This detector is going to be installed during Long Shutdown-2 (2019-2020) in CMS detector to improve the triggering and tracking of muons in higher pseudo-rapidity region. Also, in the same chapter the characterization of one of basic ingredients of GEM detector, known as GEM foil, is described which is fabricated by an Indian company named Micropack Pvt. Ltd.

Appendices

Bibliography

[1] S. Chatrchyan et al. "Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC". In: *Physics Letters B* 716.1 (2012), pp. 30–61. DOI: 10.1016/j.physletb.2012.08.021.

[2] Georges Aad et al. "Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC". In: *Phys. Lett. B* 716 (2012), p. 1. DOI: 10.1016/j.physletb.2012.08.020. arXiv: 1207.7214 [hep-ex].

[3] M. Baak et al. "Study of Electroweak Interactions at the Energy Frontier". In: (Oct. 24, 2013). arXiv: http://arxiv.org/abs/1310.6708v1 [hep-ph].