HELEN Project Report
1st June to 1st September
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PART I – Research Project

CMS Event Generation and Reconstruction for WW Scattering Analysis

Introduction

The Higgs boson is the only particle of the standart model that has not being observed yet and the main objective of the LHC is to find it. As the mass of the W is due to the Higgs and the WW scattering diverges in case there's no Higgs, the W fusion process (figure 1) is very sensitive to the characteristics of the Higgs.

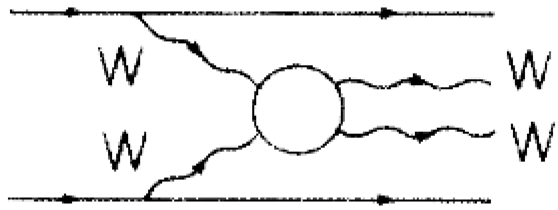

Figure 1

As the Ws lifetime is extremely short, all we can detect are it's decay products. The present project analyses the channel involving scattering of two Ws of the same sign, decaying into two muons and two (anti)neutrinos (figure 2). This choice suppresses the background giving a good signal to background ratio. CMS detector was designed to detect muons with high momenta with a good resolution and have a good missing Et resolution. Nevertheless the two neutrinos in the event brings a further difficulty for the Ws reconstruction.

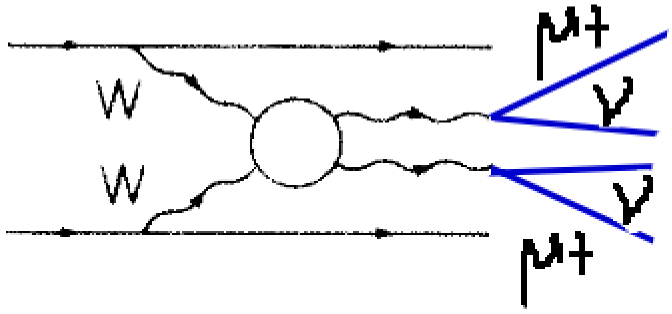

Figure 2

To simulate this processes I used a Monte Carlo generator called PHANTOM, that evaluates events of O(alfaem6). It differs from PYTHIA because it evaluates the complete matrix elements, taking into account also the interferences between the different Feymann diagrams, which alter considerably the results.

There generated data samples corresponded to two scenarios, one with a Higgs mass of 500MeV/c2 and another without the Higgs.

The project was developed in the following steps:

1 - Theoretical study of WW scattering. Specially the following paper:
hep-ph/0512219
Boson-boson scattering and Higgs production at the LHC from a six fermion point of view: four jets + lν processes at $\O(\alpha_{em}^6)

2 – Generated two monte carlo samples with five hundred thousands (500.000) events each. These samples contains all processes of the type: qq -> qqvvmu+mu+ in O(alfa_{em}6). The first with Higgs mass equal of 500MeV/c2 and the second with non Higgs scenario.

The monte carlo samples were analyzed using ROOT, a C++ framework designed for physics analysis. More specifically it was used a class called TSelector, which make loops trough the events of a tree (or chain), objects wherein are the generated data.

3 – Search for good cuts in momenta, pseudorapidity and other characteristics of the events, aiming at: (1) separate the processes involving W fusion from the background; and (2) search for good discriminating variables which maximizes the differences between the 500GeV Higgs from the non Higgs scenario.

Good cuts were found.

4 – After the cuts studies, the next step was to simulate the passage of the particles through the detector. First, the partonic level monte carlo events were hadronized and decayed through CMKIN, which uses Pythia hadronization and decay models.

5 – After the hadronization, the detector effects were simulated using FAMOS(FAst MOnte Carlo Simulation), a program that uses parametrizations of the detector response to simulate it's response. The output format of FAMOS is very similar to what one would obtain with a full GEANT simulation and reconstruction of the events.

Conclusion

These were the basic tools learned during the development of this analysis project. The analysis will evolve into a full simulation, digitalization, reconstruction and statistics treatment of data and we intend to write a CMS analysis note until the end of the year.

PART II – Study Project

Summer Courses

Meanwhile the analysis project was developing, I attended the CERN summer lectures, from 5th July to 11th August, which are listed below:

Introduction to particle physics	Close, F.
Accelerators	Gilardoni, S. e Metral, E.
Detectors	Ullaland, O.
Introduction to puclear physics	Chomaz, P.
Antimatter in the lab	Landua, R.
Fundamental concepts in particle physics	Ross, G.
Astroparticle Physics	Palanque-Delabrouille, N
Neutrino Physics	Gomez-Cadenas, J-J
Seminar on LHC upgrade	De Roeck, A.
The Standart Model	Pich, A.
Introduction to Eletronics	De la Taille, C.
Introduction to Cosmology	Sarkar, S.
Beyond the Standart Model	Kiritsis, E.
ROOT	Brun, R.
Introduction to Statistics	Cowan, G
Physics at Hadronic colliders	Jakobs, K.
From raw data to Physics results	Jacobsen, R.
From Heavy-Ion collisions to Quark Matter	Lourenco, C.
The GRID	Mendez Lorenzo, P
CP Violation	Hocker, A.

Visiting to detectors

Visiting CMS and ATLAS.

Conclusion

The HELEN project had a great importance for my formation as a physicist. It gave me the opportunity to learn how the research at the frontier of knowledge of particle physics is done. It also showed the need of an international collaboration, large investment and a large number of researchers to be able to do research on fundamental particles.