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Top quark studies in the ATLAS experiment at the Large Hadron Collider (LHC) at CERN

The top quark is the only known fundamental fermion with a mass on the electroweak scale. As a result, study of the top quark may provide an excellent probe of the sector of electroweak symmetry breaking, and new physics may well be discovered in either its production or decay. The LHC will be a "top quark factory", and a very large variety of top physics studies will be possible with the high statistics samples which will be accumulated.

The LPNHE group is involved in the ATLAS (Air Toroid Lhc Apparatus System) experiment, a worldwide collaboration, at the LHC collider at CERN (Geneva). The measurement of the top quark properties requires the designing of analysis schemes, in order to select the top quark decays from the background, to reconstruct the decay products, namely leptons and jets, with the best possible resolution, and to reduce as much as possible the sources of uncertainties. The LPNHE members have developed in the past years similar analysis schemes for the measurement of the top quark mass in the "lepton plus jets" channel and "dilepton" channel. In most cases, the precision in the measurement of the top quark properties will be limited by our knowledge of some of the ATLAS detector performances, such as the precision to which the particle energies are measured, or the efficiency with which we can identify some of these particles.

Introduction to data analysis

Data taking starting in 2007, ATLAS physics groups are producing datasets of interest, such as top quark events or Z bosons produced during the proton-proton collisions. The particles thus produced are transported in a program simulating the ATLAS detector response. The list of particles produced, primaries from the proton-proton collision and secondaries from the interaction with the detector material, are then reconstructed by dedicated algorithms. The results of these algorithms are written into files which can be analysed by the ROOT program, standard analysis program in particle physics allowing oriented object programming, histogram filling and visualisation.

I worked on such datasets simulating single particles (electrons, muons) or Z boson decays (into pairs of electrons or muons) in order to be more familiar with the use of these files, the way the reconstructed quantities can be retrieved, and of course ROOT program. The aim was to estimate the efficiency of the reconstruction of leptons, to reconstruct the invariant mass of the Z boson using different algorithms. This "training" period lasted about one month. Still many notions learnt at this moment ease the transition to the analysis program ($\sim$ 100k lines of ROOT macros).

Particle identification

The identification of electrons requires combining information from different detectors, the Inner Detector (namely the transition radiation tracker) and the electromagnetic calorimeter. Such method is particularly difficult in the environment at LHC. These studies require very good understanding of the characteristic features of electrons originating from various sources. In order to separate a signal from its background, the simplest approach consists of applying cuts to discriminating variables that use information from the inner detector (momentum measurement and transition radiation effect) and from the electromagnetic calorimeter (electromagnetic shower shape). The optimisation of the thresholds applied to each selection

required for the data recently produced, on which the ATLAS collaboration expects to write several notes beginning the end of 2006. My work on the optimization of thresholds as a function of the pseudo-rapidity and transverse momentum (First time done) has already been included in official ATLAS code which will eventually become part of ATHENA (ATLAS offline software framework). I am already including this part of my work in my final report and a presentation on this subject is planned to take place at CERN during the month of september.

I am currently understanding the identification of muons and jets. Since the LPNHE group is working mostly on the electromagnetic calorimeter (*i.e.* for photon and electron reconstruction), this part will naturally take less time than studies on electrons.

After understanding the identification of muons and jets I will work with the lepton plus jet sample which is one of the samples I will use while performing my studies on the Top quark.

Once I have completed my Complementary Training period at LPNHE I will present my work at my home institution in Venezuela (Universidad de Los Andes, Mérida, Venezuela) as my undergraduate research project which is the last requisite I need to fulfill in order to graduate. My advisor, Frédéric Derue will attend my presentation, thanks to HELEN, which does not have a precise date yet but I estimate it will take place between the last week of november to the second of december of the present year.

Other various activities

During the first 3 months of my complementary training I have learnt how to use a several computing tools which are mandatory for the work I am performing, namely basic Linux console commands, C++ programming language, LaTeX syntaxis and basic ROOT commands (the object oriented data analysis framework used).

It is undeniable that working with such a large collaboration has enabled me to improve my communication skills not only in English, but also in French. As the matter of fact the LPNHE paid for a short period of French lectures as a way for me to learn the basics.

I have been once at CERN and I will probably go again during the month of september. The purpose of my trip was to attend 2 meetings of the Top quark group. The first meeting was held by Top Quark France but most of the Top quark collaboration was present in the second meeting. I also had the chance to visit the ATLAS detector cavern.

Regular group and laboratory meetings, as well as a few presentations have taken place at LPNHE in the past months, of which I have attended several always on particle physics topics.

My advisor has provided me with basic material on the Standard Model as well as on the parts of the ATLAS detector (mostly electromagnetic calorimeter), which I have been studying progressively.

Personal Judgement

I can only be grateful for this wonderful oportunity I have been given to explore an area of physics I was not familiar with. It has been an enriching experience to work at LPNHE Paris in many ways. Not only have I had the opportunity to learn new things but also to meet many people belonging to the ATLAS collaboration and the lab provided me a means to travel to CERN for meetings as well as to visit the detector's cavern. The working atmosphere surpassed my expectations.

If ever a problem occurs or I have a difficulty while working my advisor and HELEN's Interlocutor for the IN2P3 are always there to help me with great patience.