Report of our DESY experience

Emma Prati and Francesco Tori

During the days between Friday, 19th October to Tuesday, 30th October we had the opportunity to learn how a researcher at the Deutsches Elektronen-Synchrotron (DESY) works; moreover we worked on a project funded by European Union in collaboration with our tutors Elisabetta Gallo and Andrea Cardini.

After being introduced to the basics of particle physics, following the instructions of Elisabetta, we started working with the program CMS Show, in order to study how event scanning works. In particular we wanted to understand the decay of different bosons. At first Elisabetta gave us a file of events containing possible Z bosons decaying into two muons or two electrons with opposite electric charge, so that we could start gaining confidence with the program. Then we were taught how to calculate the mass of the Z boson candidate with the invariant mass calculator. After scanning some events with the Z decays, we analyzed a collection of possible Higgs (H) to four leptons decays and we had to find, among 12 events, which ones included an H boson candidate. We also paid attention to the presence of the MET (Missing Transverse Energy), which is the visualization of the presence of neutrinos or the sum of various detector inefficiencies. This is calculated mathematically, as we know that the energy of the event must be the same of the two protons before the collision in the plane transverse to the beam. Hence the sum of the momenta in the transverse plane has to be zero, because of the energy conservation principle.

In another important part of our work we learnt how to make histograms through which we were able to better analyze some variables for signal or background events. First we were shown what is the difference between signal and background: for example, we know that an Higgs can decay into a tau+ and a tau- particles which then may decay into a muon, neutrinos and in jet and neutrinos, so at the end we have in the final state a muon, jets and MET. However two protons, after colliding, may produce some jets and a W boson, which then may decay into a muon and a neutrino, so at the end we have the same final state as before: we have a muon, jets and MET, but in this case they were not produced by a real Higgs boson. These events are called background.

Among some histograms of variables that we have chosen to represent the signal and the background events, we noticed that the most interesting variable was the transverse mass, as its characteristics were different compared to the other variables and the signal and the background were better distinguishable. Subsequently we understood how to optimize the area of our histograms with most signal as possible and least background, namely setting a cut on this variable. Here is why we applied different cuts and among those we chose the most suitable and useful one, by considering the highest value of the significance (which is defined as the number of signal events divided by the square root of the number of background events, after cuts.).

Finally, we have concluded our experience exposing to all the tutors, our teachers and our mates what we have done, with a short Powerpoint presentation.