La Plata National University
Visit Report

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1 Introduction

AIRES is a computer simulation package designed to model the atmospheric development of air showers produced by ultra high energy cosmic rays, the simulated distributions of charged particles at the ground level are used to search for signatures to distinguish between vertical and inclined showers, between hadron produced showers and electromagnetic produced ones, between different primary energies, among others.

The number of particles involved in an air shower, depending on primary energy, is a huge one, so it is hard to follow the particles one by one to simulate a complete shower, AIRES uses a statistical sampling technic called "Thinning", in this manner a sample of the secondary particles are taken, with this sample AIRES estimates the weighted average behavior of the number of particles, energies, spatial and time distribution, etc. Several parameter are involved in the shower simulation, the most important of which have been carefully analyzed in order to see the influence in shower development, but some of them, which are mainly technical ones, important for the simulation but rather obscure for the physics, are not yet as well studied as the physical ones.

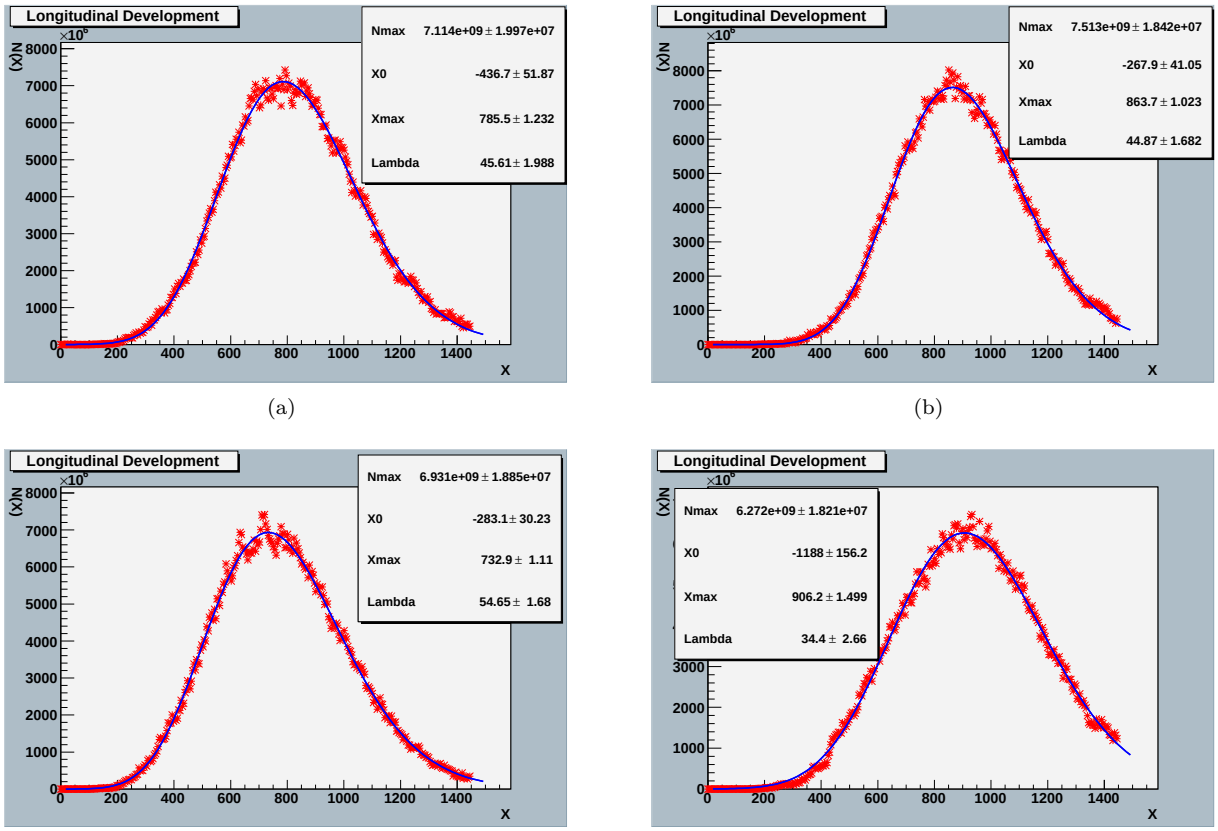
With the HELEN project support, a two weeks visit to La Plata National University, at Argentine, was realized. The visit to the AIRES and Auger project team was developed with the aim to establish a work plan to realize in the near future.

Sergio Sciutto suggested to look for the effect of some parameters in the shower simulation, specially the ThinningWFactor, which is related with the way the statistical sample is taken, so it is possible that statistical fluctuation appear due to the sampling variations.

2 Activities

Some showers were simulated at the very gross thinning relative energy of 10^{-4}, which were used to test the ROOT scripts to read the lateral distribution files of several simulated showers (in this test five hundred showers were used), fit every data set against the Gaisser-Hillas functions, obtaining the physical parameters X_{Max} and N_{Max}, and filling the histograms of the X_{Max} distributions, obtaining from this distribution the mean and the standard deviation. It is a need to simulate a large number of showers for every case, in order to reduce the statistical shower to shower fluctuations and to be able to see the real differences due to the ThinningWFactor variations.

In the figures 1 the shower to shower fluctuations are shown, note the X_{Max} fluctuation on the fit results.



(a) (b)

(c) (d)

Figure 1: Shower to shower fluctuations.

In figures 2 the X_{Max} distribution of the five hundred simulated showers is shown for some values

of ThinningWFactor, there are some variation, but an equal mean is statistically consistent. Another

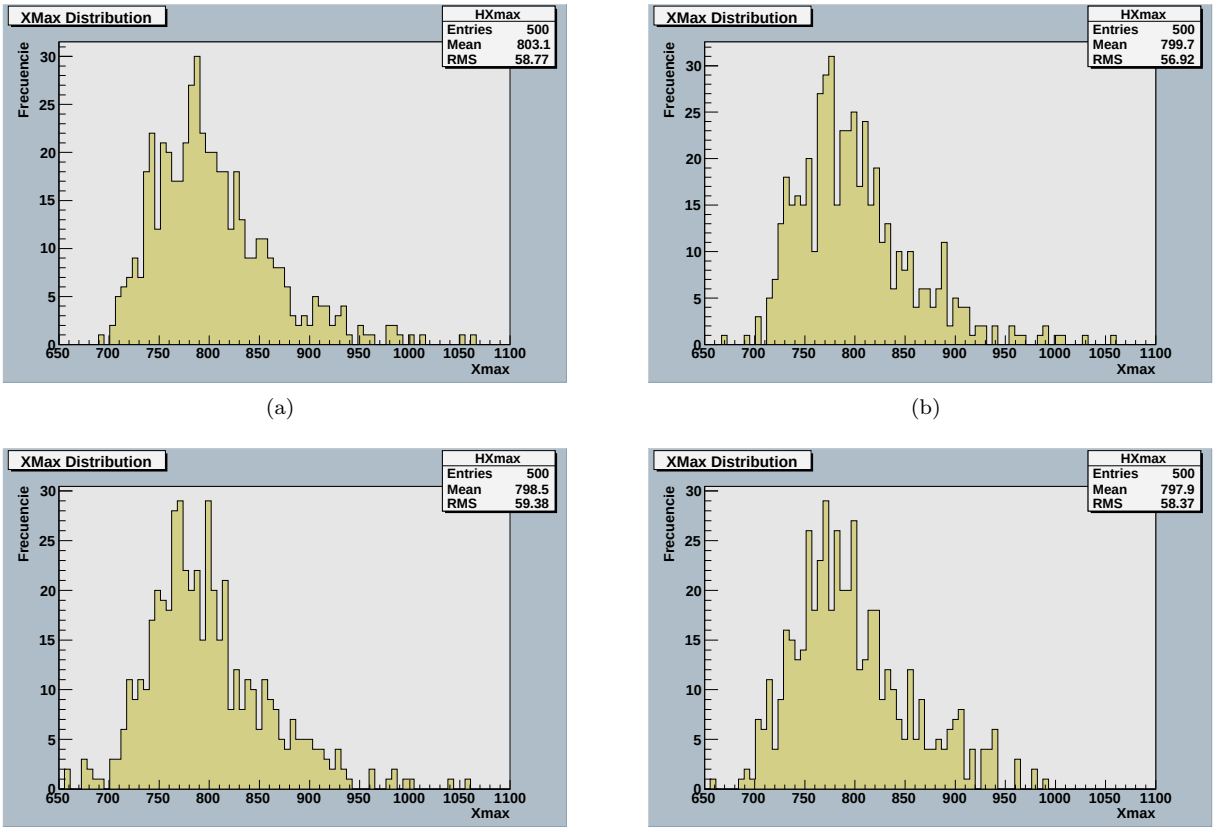


Figure 2: X_{Max} distribution of 500 shower, with ThinningWFactor 2,4,6, and 8 respectively.

subject have been taken in account, to look for the effect of the variations of the atmospheric depth limits on integrating the Gaisser-Hillas function to calculate the total number of charged particles, which is important to calculate the total fluorescence radiation produced by the shower.

3 Work Plan

The simulation of showers will be repeated taking realistic thinning energy values, in order to have some significative figures to tell real effects from statistical fluctuations, a wider range of the ThinningWFactor should be covered, and the integral limits effect on the integral of Gaisser-Hillas will be analyzed.

A short period of one week is considered to start the simulation, this time is required to install AIRES

in some SUN-Blade workstations, which will be dedicated partially to the showers simulation.

After that, a two weeks period is considered to run some sets of showers to reproduce the preliminary reported results, but with a thinning relative energy of 10^{-6} or 10^{-7}.

And then, a one month period to finish the showers simulation, to extract the X_{Max} distribution and to analyze the results, including the integral variations of the Gaisser-Hillas function.

Besides the showers simulation, a brief plan to engage some undergraduate students of computer science on scientific software applications and development was discussed. This work includes developing didactic material to teach some physical processes to non physical science students, this material will also be useful to teach physics to elementary student. The main idea is to work on animations of physical processes, so simulation of those processes are required, this didactic material should be reviewed by experienced researchers on particle physics and simulations from La Plata National University and CINVESTAV-IPN.

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