Report of Activities

By

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Abstract (First part of stance)

To obtain reliable calorimetric information from the fluorescence stations, the atmospheric conditions at the AUGER's site need to be monitored continuously during operation. One of the components of the observatory's atmospheric monitoring system is a set of four elastic backscatter lidar stations, one station at each of the fluorescence detector sites. In this part it will be described the design, current status, standard operation procedure, and performance of the lidar system of the Pierre Auger Observatory. Besides, a humble proposal for one extension to the lidar control system will be introduced. Activities done at the Malargue site.

Abstract (Second part of stance)

Up to now, the AIRES Montecarlo program does not have a subroutine to consider exotics, in this section it will be described the first attempt to write FORTRAN code to consider de reaction $\nu_{\mu}(k)+N(p)\rightarrow\mu(k')+X(p')$. These activities were done at Universidad Nacional de La Plata.

Introduction: (First part)

The Pierre Auger Observatory is a hybrid detector which combines a large surface detector (SD) array of area 3000 km2 and a system of four fluorescence telescopes (FD) at the same site.

While the SD provides the well-defined aperture and the 100 % duty cycle needed to achieve high statistics, the FD provides, for a subset of showers, the calorimetric information to calibrate the SD.

For the calibration to be meaningful, the properties of the calorimeter, (the atmosphere), must be well-known.
Particles in the atmosphere, Cherenkov radiation and the weather need to be factored into this calibration.

Fluorescence light from air showers is affected by the absorption and scattering on molecules and aerosols, and, in addition, some fraction of the Cherenkov radiation from the relativistic particles in the air shower cascade is scattered into the detector.

This Cherenkov light cannot be separated from the fluorescence light, and so the contamination by Cherenkov light needs to be modeled and subtracted to give an accurate energy estimate for the cosmic ray shower.

Moreover, the light transmission properties of the atmosphere are not constant over the large detector volume of the Pierre Auger Observatory, and equally important, they are not constant in time. Changing weather conditions inevitably mean changing transmission properties. Consequently, the properties of the atmosphere need to be monitored continuously.

The Pierre Auger Observatory has an extensive program to monitor the atmosphere within the FD aperture and measure atmospheric attenuation and scattering properties in the 300 to 400 nm sensitivity range of the FDs. Within this system, a central role is played by a system of four elastic backscatter lidar (light detection and ranging) stations, one at each fluorescence site.

The system is currently under construction, with three out of four stations operating. At each lidar station, a high-repetition UV laser sends short laser light pulses into the atmosphere in the direction of interest. The backscattered signal is detected as a function of time by photomultiplier tubes at the focus of parabolic mirrors. The laser and the mirrors are mounted on a steering frame that allows the lidar to cover the full azimuth and elevation.

For each hour of FD data taking, the four lidars perform a routine scan of the sky over each FD, providing a measurement of the aerosol scattering and absorption properties of the atmosphere. Furthermore, the lidar provides information about the height and coverage of clouds as well as their depth and opacity.

In addition to this routine operation, the lidar system is used for real time monitoring of the atmospheric homogeneity between the FDs and selected cosmic ray events. For example, if a high energy "hybrid" event is observed with the SD and one or more FDs, the routine scan is interrupted and the lidar scans the shower detector plane reported by the FD within a few minutes of the detection of the event. This procedure is called "shoot the shower" (StS) and allows for a rejection of events where the light profile from the track is distorted by clouds or other aerosol non-uniformities that are not characterized well by the average hourly aerosol measurements.

Operation

The lidar is active between the end of astronomical twilight of one day and the beginning of twilight the following day. In this way, a good signal-to-noise ratio is assured for the whole lidar dataset.

After the telescope cover is opened, an initialization procedure is executed to calibrate the incremental encoders used to determine the telescope position. A webcam located in the interior of the telescope cover is used to supervise that these tasks are executed correctly. In this way, before starting a run, the operator has information about the status of the telescope in real time and about the weather conditions of each site through the information being sent to the lidar web site.

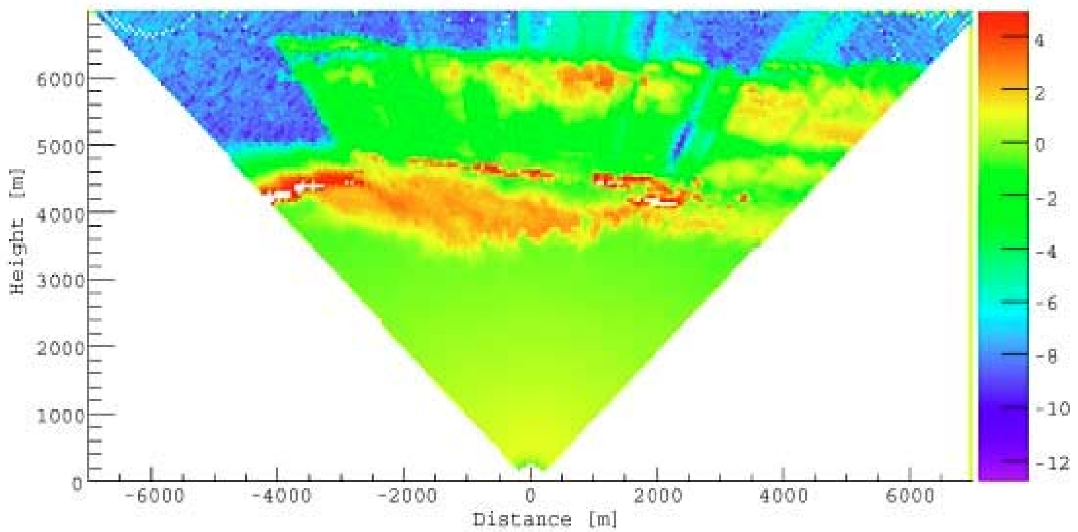
Following initialization, the system enters an operational mode called AutoScan. In AutoScan mode, the telescope performs a cycle of steering scripts, unless otherwise interrupted until the end of the night. When the laser is fired, the telescope position is determined by the coordinates contained in these scripts. There are four main steering strategies: three making up the AutoScan pattern and a fourth, shoot-the-shower, that periodically interrupts the AutoScan. These strategies are discussed below:

Continuous scans:

In this scan, the telescope is moved between two extreme positions with a fixed angular speed while the laser is shot.

The telescope sweeps the sky along two orthogonal paths, each of those with an aperture angle of 90~.

The purpose of these scans is to provide useful data for simple cloud detection techniques and to probe the atmosphere for horizontal homogeneity. An example of the data produced by this kind of scan is presented in the next figure.



Discrete scans:

The telescope is positioned at a set of particular coordinates. The angular distance between two subsequent points increments with a fixed step in θ (zenith angle of the telescope position).

The purpose of this angular distribution is to supply a constant step in height at a given horizontal distance from the lidar every time the telescope moves between two positions. Because the discrete shots increment in steps of equal height, and the telescope remains at the same coordinates for longer time periods than on the continuous scans, the data obtained from discrete scans are very useful to determine the vertical distribution of aerosols in the atmosphere.

Shoot the Shower:

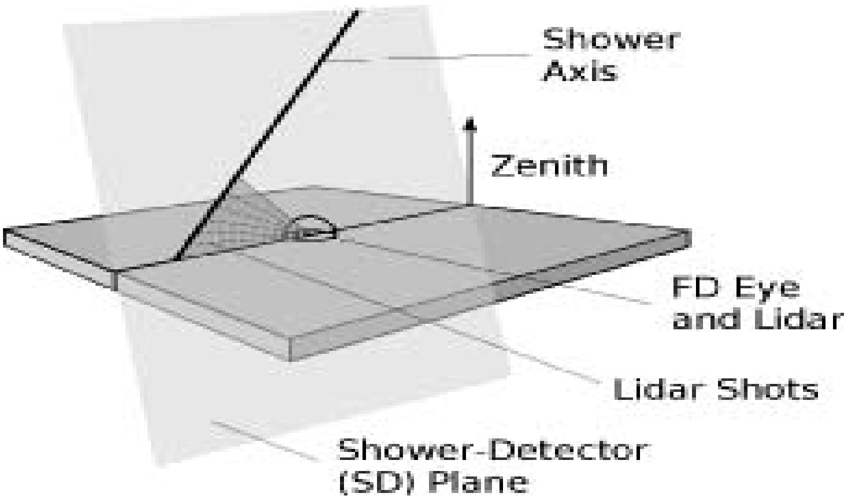
This rapid response mode is used to measure the atmospheric attenuation in the line of sight between the FD telescopes and a detected cosmic ray shower. This scanning mode suspends any of the previously mentioned sweeps.

The length of the lidar run depends on the length of astronomical twilight, which varies over the course of the year from less than five hours during the summer to almost fourteen hours during the winter. This has a direct impact on the amount of data generated by each station during a data acquisition run.

A primary design requirement of the lidar system is that it probes the atmosphere along the tracks of cosmic rays observed by the FDs.

This function, called shoot-the-shower (StS), exists to provide the FDs with atmospheric backscattering and absorption coefficients for showers of particular interest. StS is meant to compensate for unusual and highly localized atmospheric conditions that can affect FD observations at different times of the year. These include the presence of low and fast clouds, and low-level aerosols due to fog, dust, or land fires.

The basic operation of StS is depicted in the next figure. The axis of a cosmic ray air shower, when projected onto the field of view of an observing air fluorescence detector, defines a plane called the shower-detector plane, or SDP.



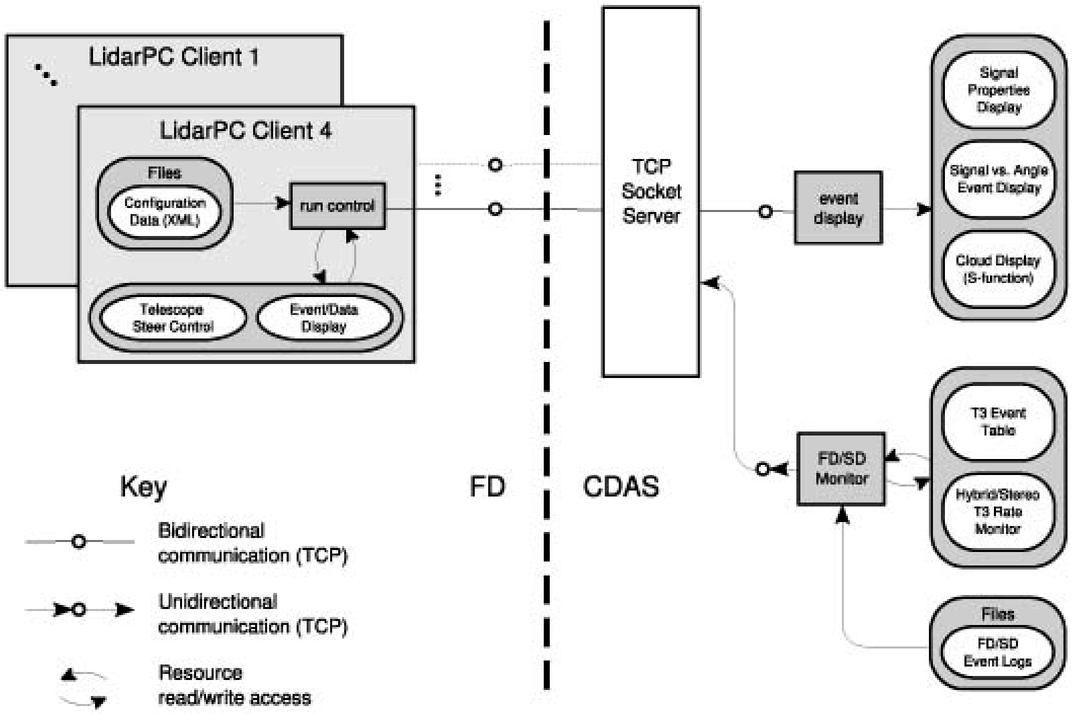
When a lidar station shoots the shower, it performs a series of laser shots within this plane, determining the atmospheric transmission between the shower segment and the FD. For a given shower, up to sixty shots may be taken, all within the FD field of view.

To operate effectively, the lidar must shoot showers of importance to the overall detector analysis with a minimum of delay after each shower occurs and with minimum disruption to the normal operations of the FD.

Physics events are made available to the lidar by picking off the SD and FD data stream sent continuously to the observatory's Central Data Acquisition System (CDAS), located in the observatory's central campus. A program running in CDAS monitors incoming data, checks for hybrid and stereo events, and calculates StS trajectories. StS requests are sent to the lidar station data acquisition and control PCs (LidarPCs), which initiate the laser shots.

Communication between the lidar stations and CDAS, shown schematically in the next figure, occurs over the network links between the central campus and the four FD subnetworks. Each LidarPC listens on an open TCP port for StS requests from the FD/SD Monitor running in CDAS.

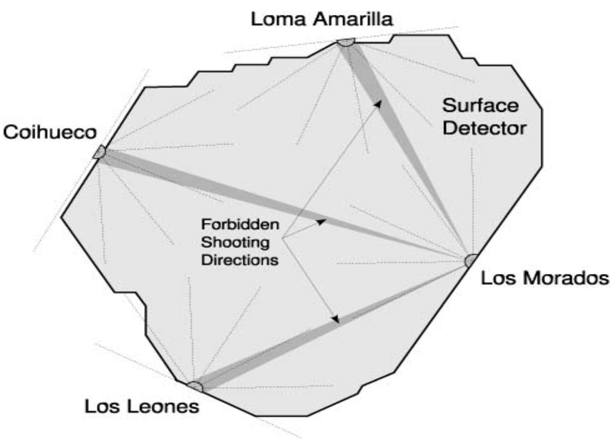
As the lidar shoots, it returns basic diagnostic information, such as shooting directions and PMT signal peaks, back to CDAS for display. A TCP socket server operating in CDAS manages the bidirectional flow of data packets between the central campus and the lidar stations. See next figure.



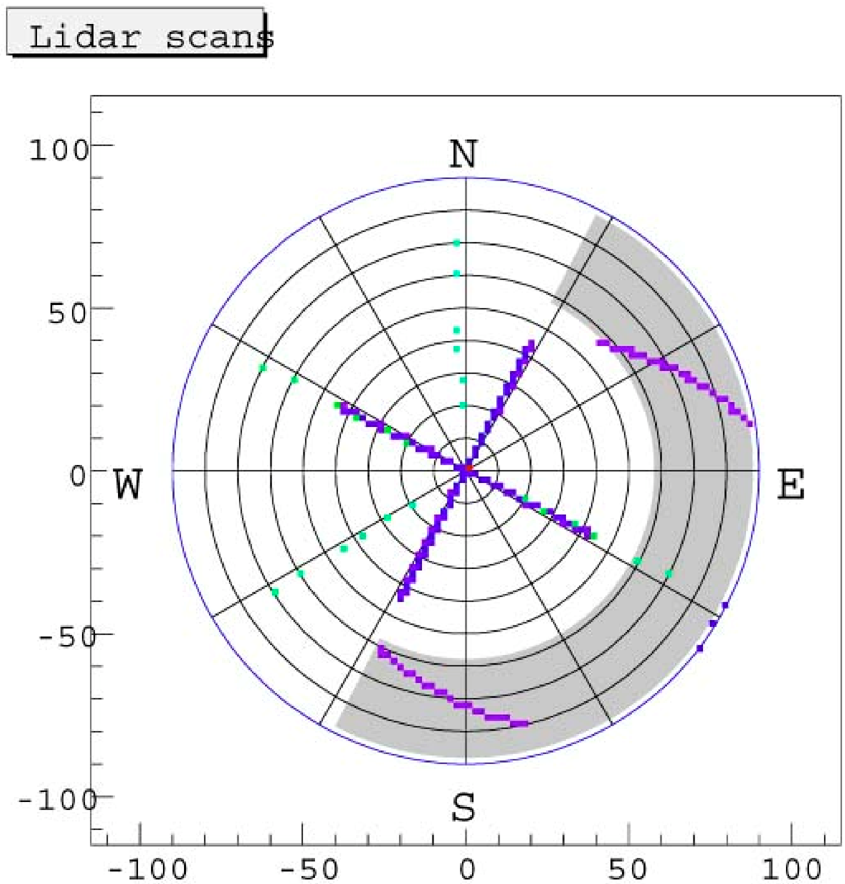
Lidars receiving StS requests from CDAS automatically stop the default shooting operation (AutoScan), move to the FD field of view, initiate the StS, and then resume the AutoScan when StS is complete. If the lidar receives a StS request while shooting another shower, the request is pushed into a queue for later processing.

To minimize the FD dead-time introduced by StS, the lidar software cuts on event size, reducing the number of requests to several per FD site per night. A further reduction in the rate is achieved by rejecting events caused by known artificial light sources in the detector, such as other lidar stations.

In addition, the intensity of the high-repetition laser means that the lidar must carefully avoid incidents of cross fire into other unvetoed FD buildings durin StS. Therefore, angular windows of approximately 5~ in azimuth and 10~ in zenith are defined around each FD; the lidar is forbidden from entering these windows during StS. The angular windows are drawn in the next figure.

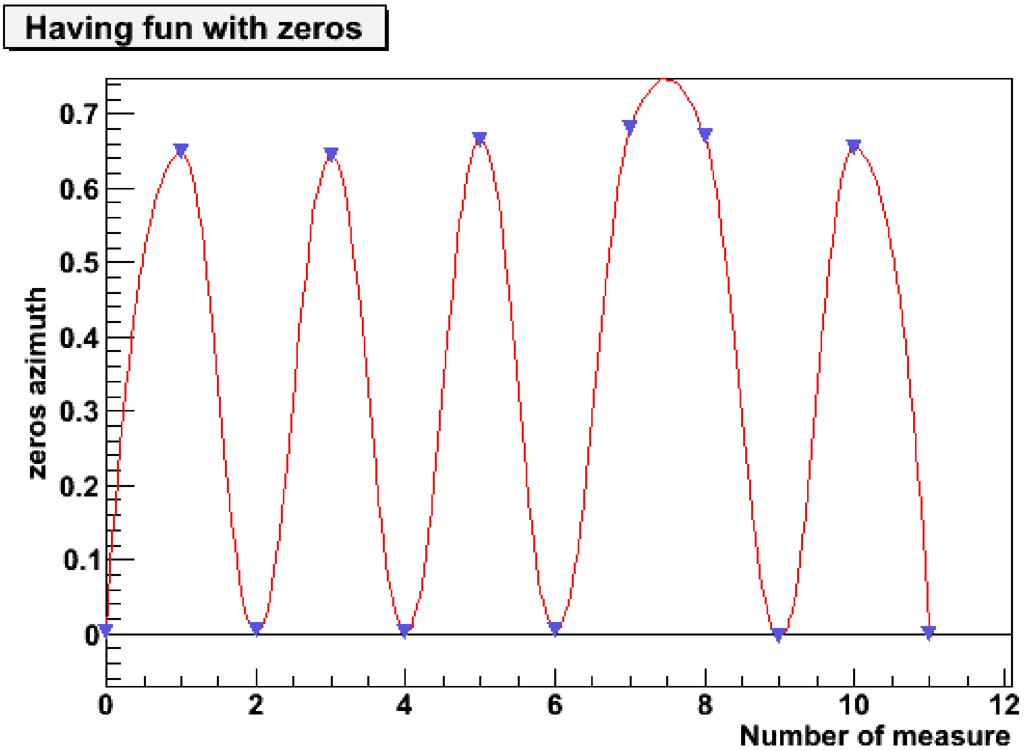


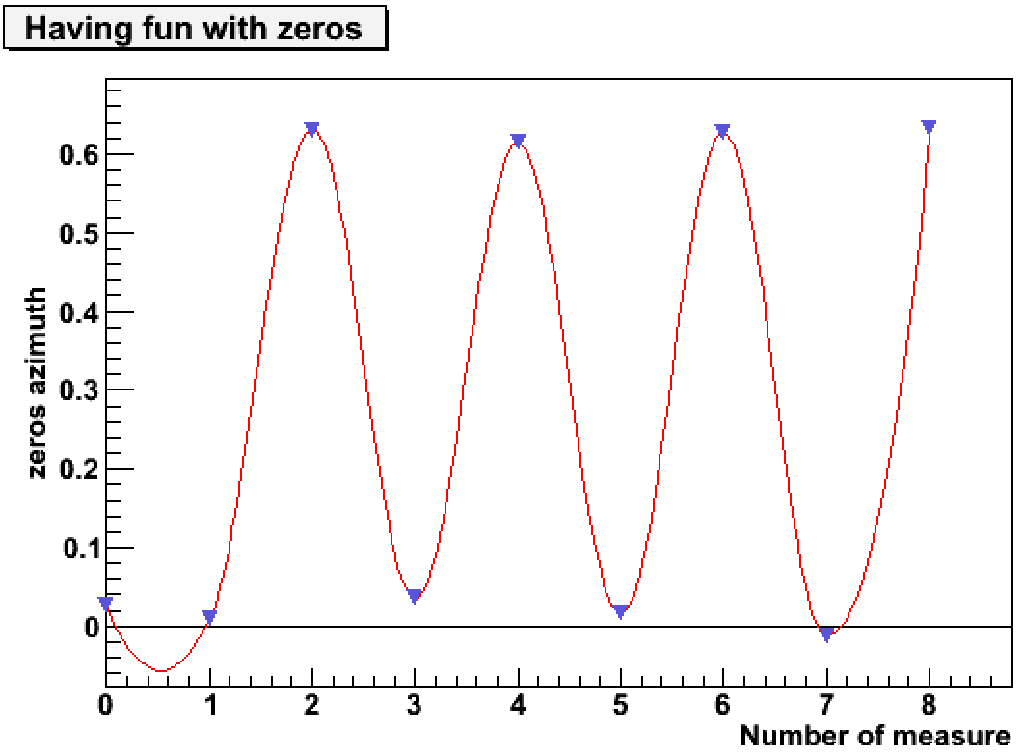
The next figure shows the scans described above. The green dots are a set of discrete scans, the blue dots are the continuous scan and the purple dots are the shoot the shower scan.

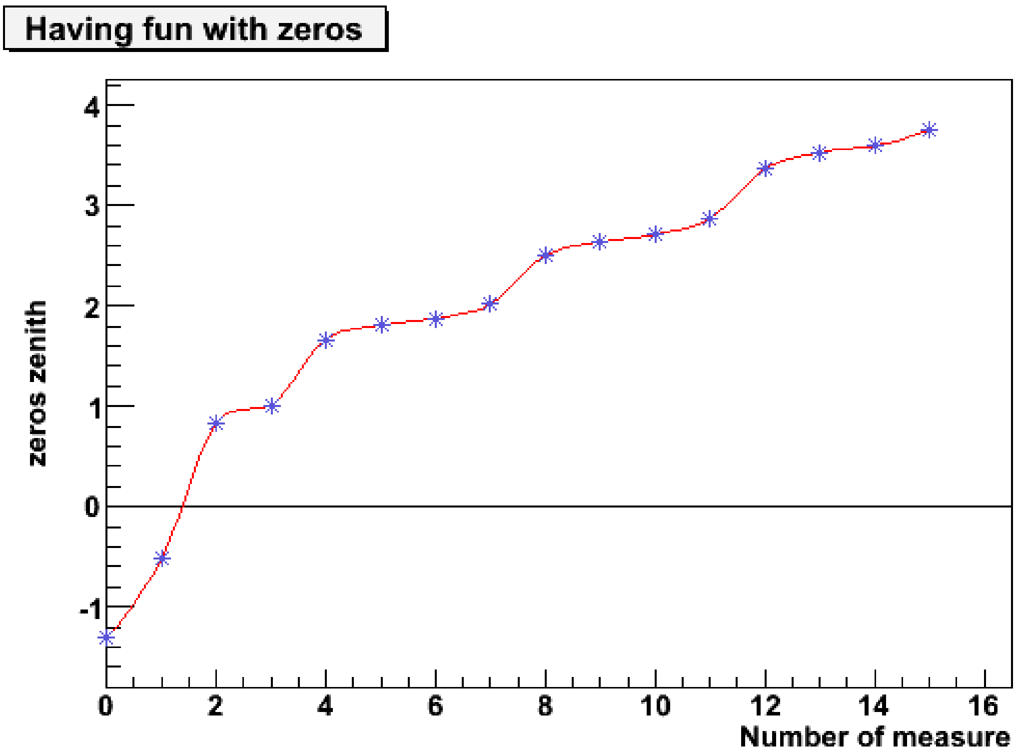


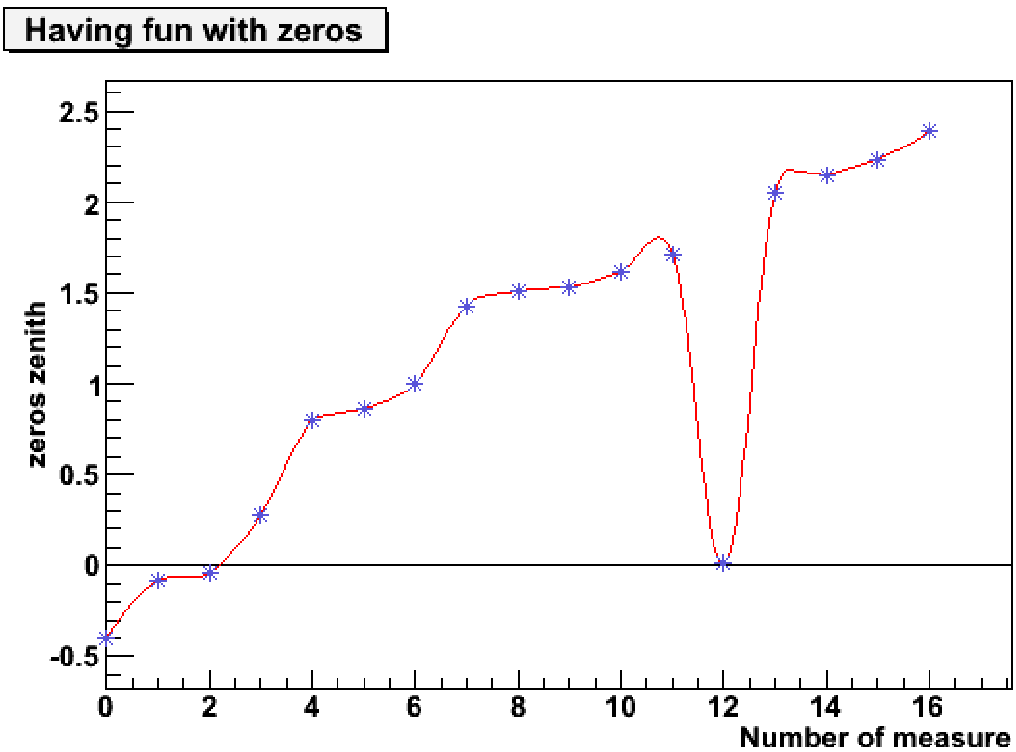
During the shift times, special care has to be taken with the encoders that set the lidar position to zero in azimuth and zenith.

A set of subroutines in C++ and ROOT were written to verify that the zero position was reach correctly. The next four figure show the results obtained.









From the last figures we realized that the lidar did not reach the zero position as was expected. These plots helped to measure the right signal by substracting the false zero.

The activities as shifter were scheduled for working one week for the Surface Detector and tree weeks for the Fluorescence Detector.

The work for the Surface Detector consisted mainly in doing water deployments at la pampa amarilla.

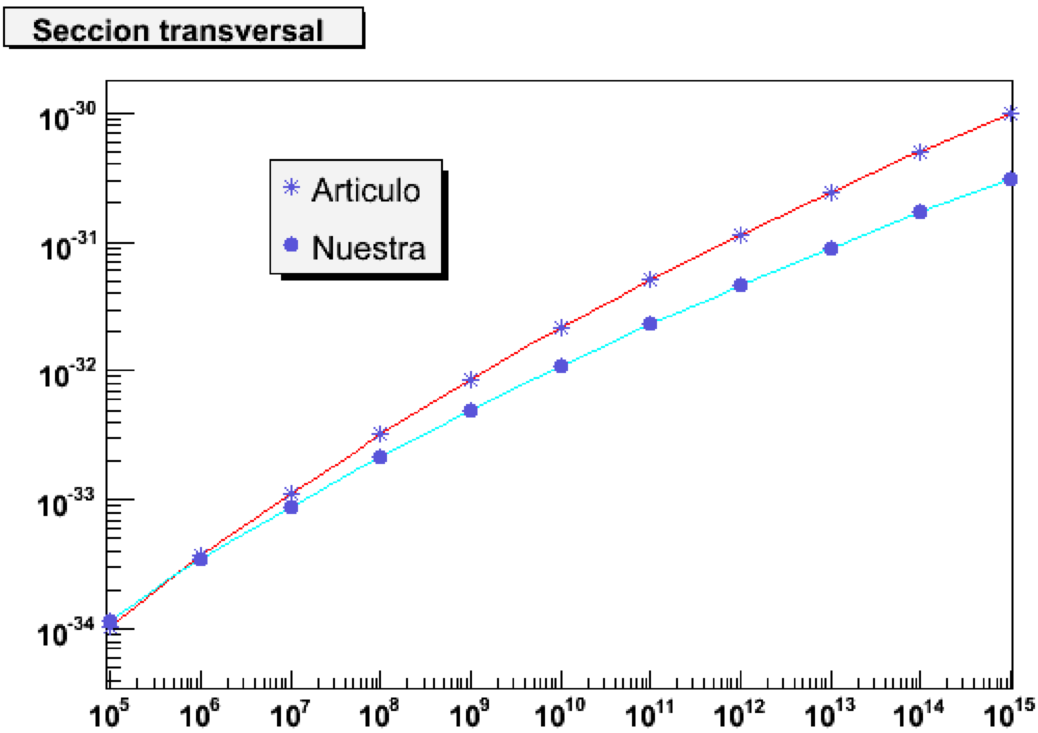
Introduction: (Second part)

For the second month I was working with Professor Sergio Sciuto from Universidad Nacional de La Plata.

The work at UNLP consisted in calculating the Asymptotic neutrino-nucleon cross section for the process

$$\nu_{\mu}(k) + N(p) \rightarrow \mu(k') + X(p')$$

The result compared to that in hep-ph/0512259 is shown in the next figure.



Further work

The next step will be calculate the mean free path as described in hep-ph/0512259

$$\lambda(E) = (\sum_i [n_i \sigma(z_i, E)])^{-1}$$

With these we will be able to extend the AIRES program with a toy model for simulating what we called the double bang i.e. the double interaction of one neutrino with the atmosphere.

References

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[3] A. Filipcic, M. Horvat, D. Veberic, D. Zavrtanik, and M. Zavrtanik, Astropart.Phys. 18 (2003) 501.
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