Atmospheric Monitoring with the LIDAR Network of the Pierre Auger Observatory

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HARDWARE AND OPERATION

FULLY STEERABLE FRAME

Alt-altazimuthal frame moved by two DC servomotors. Position is measured by two relative encoders with a 0.2° accuracy. Steering is controlled remotely by **Control Techniques MC-204** motion controller connected to a Unix machine **[1]**.

UV LASER SOURCE

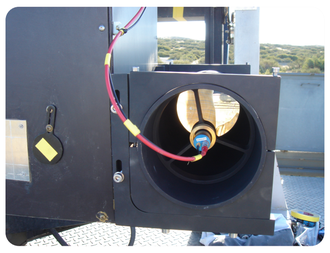
Lidars are operated with diode pumped solid state lasers by **Photonics Industries**. They generate the third harmonic of **Nd:YLF** at **351 nm** and are operated at a repetition rate of **333 Hz** and a per-pulse energy of about **100 µJ**. The laser wavelength is at the center of nitrogen fluorescence line spectrum.

OPTICAL RECEIVERS

4 parabolic mirrors (one for the short range, Ø = 20 cm; three for the long range, Ø = 80 cm).

PHOTOMULTIPLIERS AND DIGITIZATION

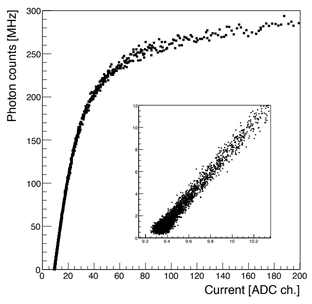
Hamamatsu R7400U-03 PMTs are operated at voltages between 770 and 950 V. Background suppression by means of a broadband UG-1 filter.
Signals are digitized by a **Licel TR40-160** three-channel transient recorder.
Current trace: amplified and digitized by a 12 bit, 40 MHz A/D converter with 16 k trace length.
Photon counting trace: a fast 250 MHz discriminator allows single photo detection (FWHM = 2 ns) **[2,3]**.



DATA ANALYSIS

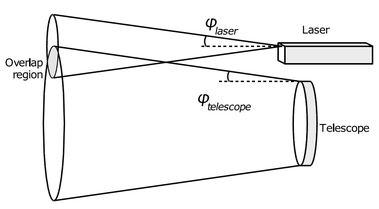
WIDE RANGE SOUNDINGS

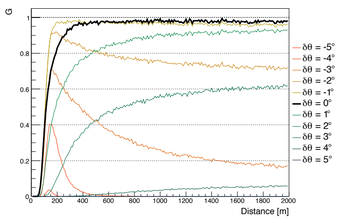
By combining analog and photon counting traces a dynamic range of more than 5 decades is achievable, corresponding to distances from 100 m up to 25-30 km. Signals are matched where the photon counting rate is between 0.5 and 10 MHz (region of proportionality).



OPTICS ALIGNMENT AND TESTS ON HORIZONTAL HOMOGENEITY OF THE ATMOSPHERE

Horizontal shots are firstly used to study optics alignment and stability. The percentage of signal seen by the optics as a function of distance (***overlap function***) is compared to simulations (raytracing Monte Carlo).

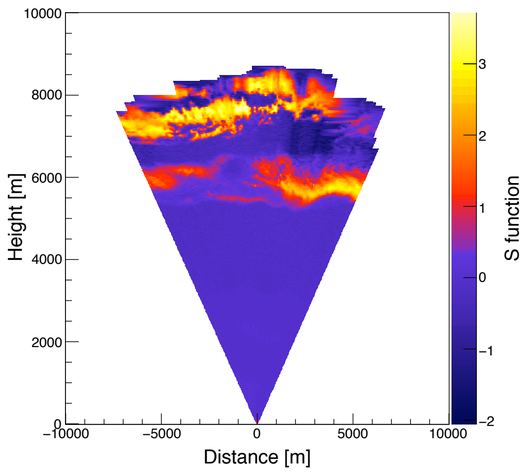


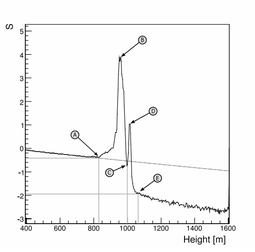


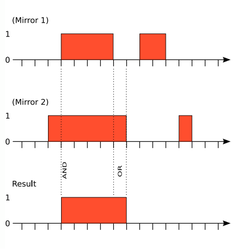
Horizontal shots are also used to extract the aerosol extinction coefficient at ground $\alpha_{aer}(0)$.

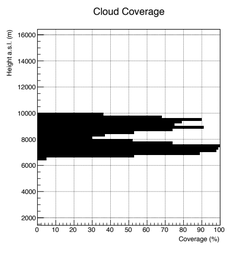
CLOUD DETECTION

From **continuous sweeps** an edge detection algorithm is used to extract the mean cloud coverage, the altitude and thickness of cloud layers, and their opacity.

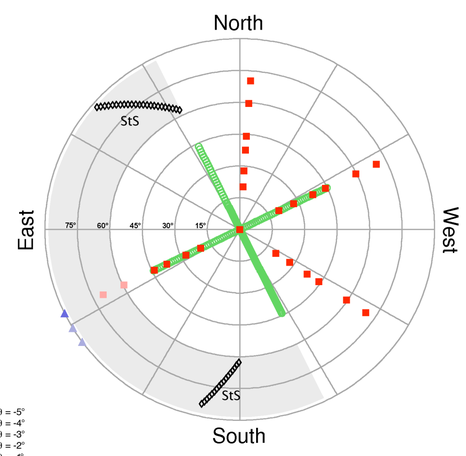


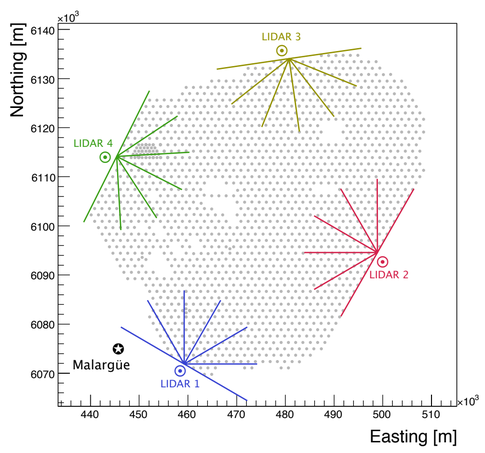






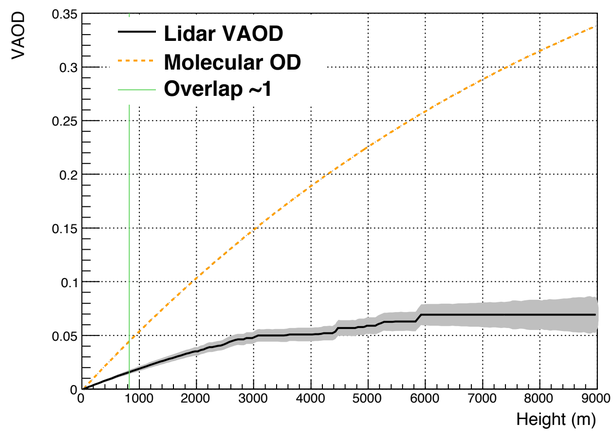
Lidars perform **periodic scans** following a hourly sequence formed by horizontal shots▲, continuous sweeps○, and scans at discrete angles■.





VERTICAL AEROSOL OPTICAL DEPTH (VAOD)

The atmosphere opacity due to aerosol scattering is calculated by using a multi-angle technique on discrete scans. The molecular contribution to the total scattering is evaluated with our local monthly models and then subtracted. The VAOD in the region of partial overlap is interpolated by using the horizontal shots [4,5].



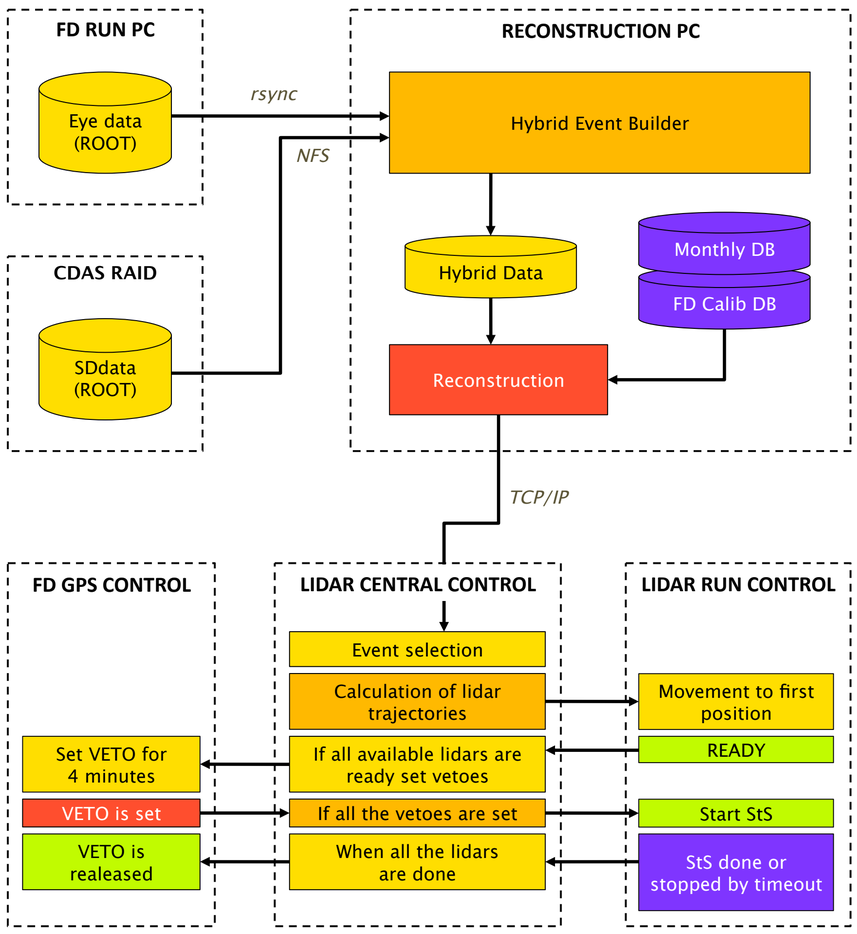
SHOOT THE SHOWER (StS)

SAMPLING THE ATMOSPHERE FOR THE MOST ENERGETIC COSMIC RAYS

A fast and precise online reconstruction of extensive air showers detected by both surface array and fluorescence detector (hybrid events) has been designed. Events are merged and built within 10 minutes. Event main parameters are then broadcasted through the network.

The lidar central control selects these events by applying different quality cuts. For those events that pass the cuts, it orders the lidars to shoot simultaneously along the reconstructed shower track. Fluorescence detectors are vetoed during this operation.

These scans are meant to give a better description of the atmosphere for various classes of events of particular interest, selected with cuts on energy, depth of shower maximum, and profile quality.



REFERENCES

[1] R.Mussa *et al.*, NIM A 518 (2004) 183
[2] A. Filipcic *et al.*, Proc. 28th ICRC (2003) 461
[3] S.Y.BenZvi *et al.*, NIM A 574 (2007) 171
[4] D.Veberic *et al.*, Astropart. Phys. 18 (2003) 501
[5] A.S.Tonachini, PhD Thesis (2007)
http://www.to.infn.it/~tonachin

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