The Latinoamerican Giant Observatory (LAGO)

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AGENCIA ESPACIAL DEL PERU CONIDA

Innóvate Perú

Programa Nacional de Innovación para la Competitividad y Productividad

LAGO

The Latinoamerican Giant Observatory

LAGO (htt://lagoproject.org) is a very long baseline "array" of water Cherenkov detectors (WCD) at different altitude and latitude

It counts on 87 members from 25 institutions in 10 countries.

Scientific goals

- *Astroparticle physics to study the Extreme Universe*
- *Transient and long term Space Weather phenomena trough Solar modulation of Cosmic Rays (CR)*
- *Measurements of background radiation at ground level*

Academic goals:

- *Train Latin American students in High Energy and Astroparticle physics*
- *Build a Latin-American network of Astroparticle researchers*

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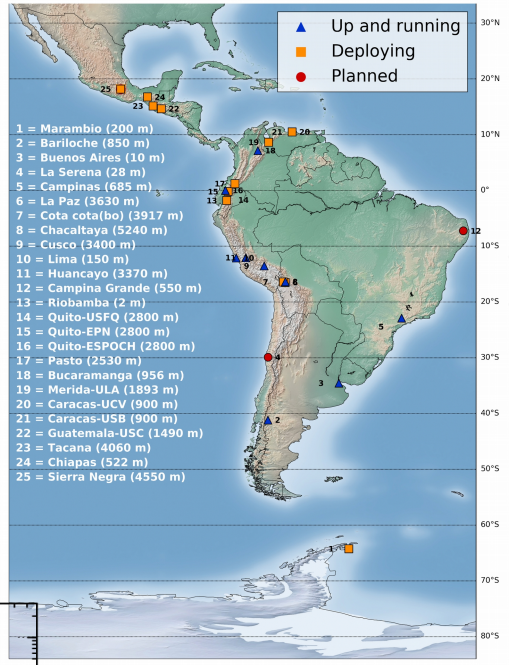
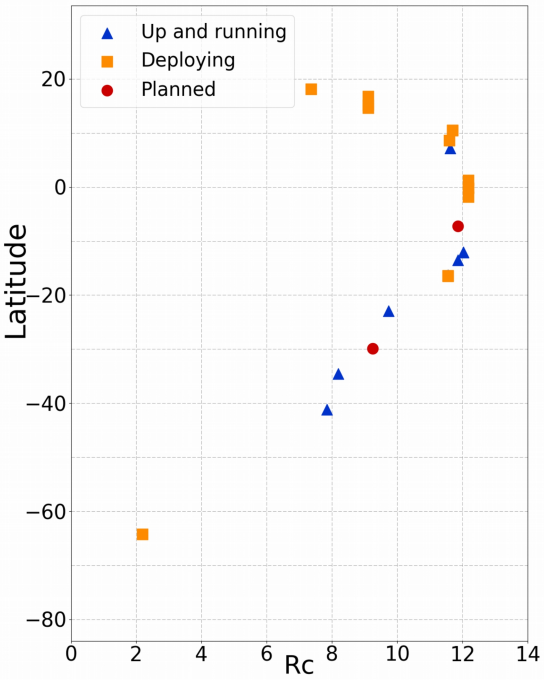
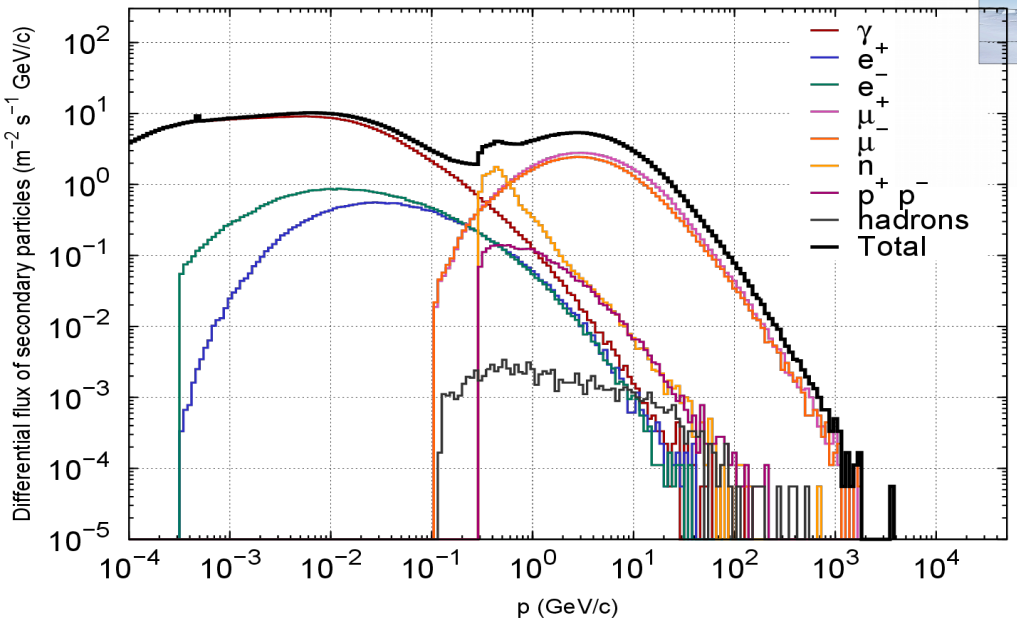
LAGO network

Is located in Latinoamerica at 7 different (operational) sites with altitudes, ranging from sea level (Lima, Per u) up to 5200 masl (Chacaltaya, Bolivia), and latitudes, which span most of Latin America from 18◦590 N (Sierra Negra, M exico) to 41◦090 S (Bariloche, Argentina).







Secondary cosmic rays bacground simulation at each site:

- *Directional rigidity cut-off at each site.*
- *Primary flux at the top of the atmosphere (CORSIKA)*
- *Secondary flux at detector level.*

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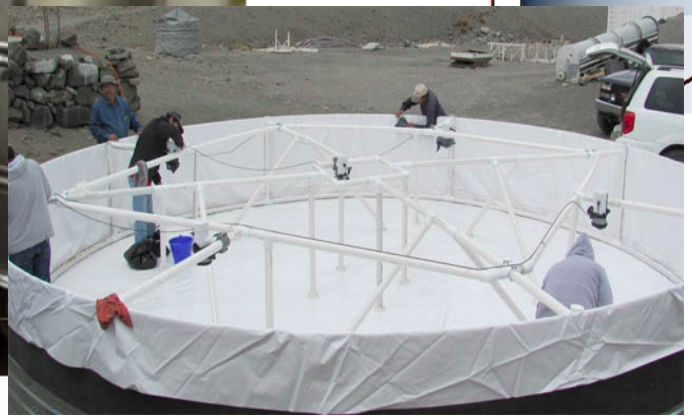
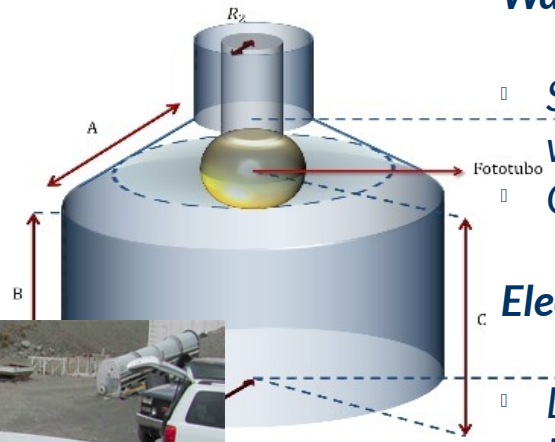


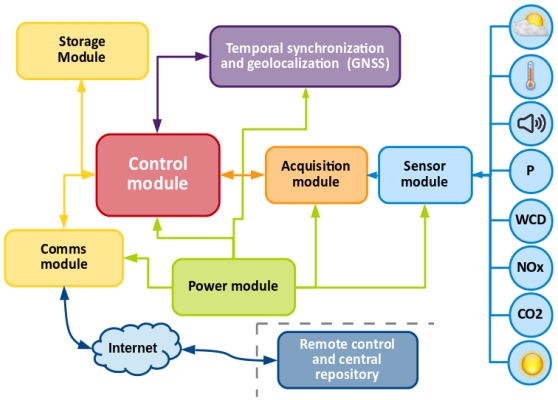


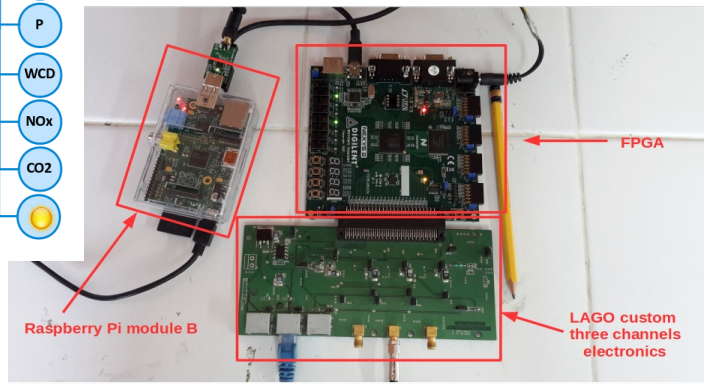
Water Cherenkov Detector

- Simple, releable, autonomoues and cheap water Cherenkov detector,
- One central large área Photomultiplier.

Electronics

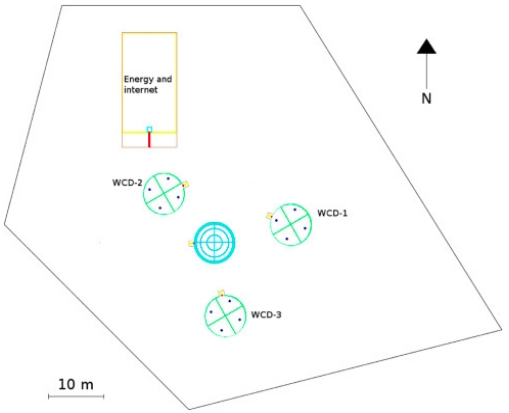
- Digitizer board (own design).
- FPGA + Raspberry Pi: detector control, telemetry, data acquisition and on board data pre-analysis.
- Digitized signals by a 10 bits FADC at 25 ns.
- Temporal synchronization: GPS in PPS mode





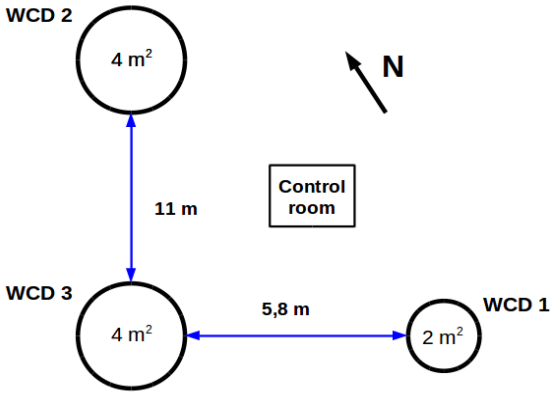
Control and Acquistion Station → Environment

- Sensors: Arduino-One&shield + environmental sensors (P, T, CO 2 , NO x , radiance, ...)
- Control (SBC Raspberry Pi): data conformation, pre-processing and station control
- GNSS: geo-localization and time synchronization.
- Comms: support standard protocols: WiFi, GPRS (2.5G-3G-3.5G), 4G-LTE



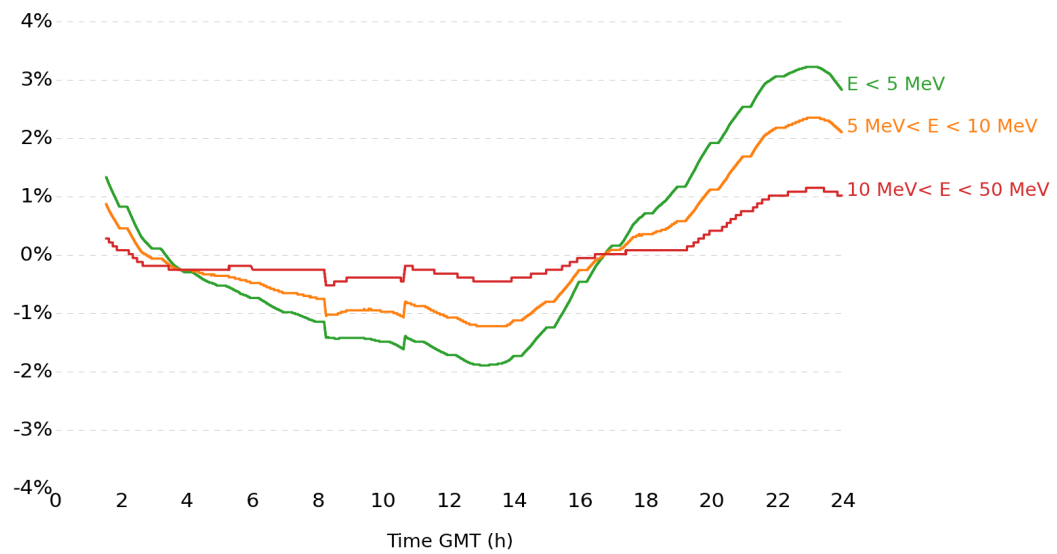
Sierra Negra (Mexico)

- *4 WCDs*
- *120 m2 detection qrea*
- *4550 masl*
- *Lowest RC 8.26 GV*
- *18.16 N 97,95 W*



Chacaltaya (Bolivia)

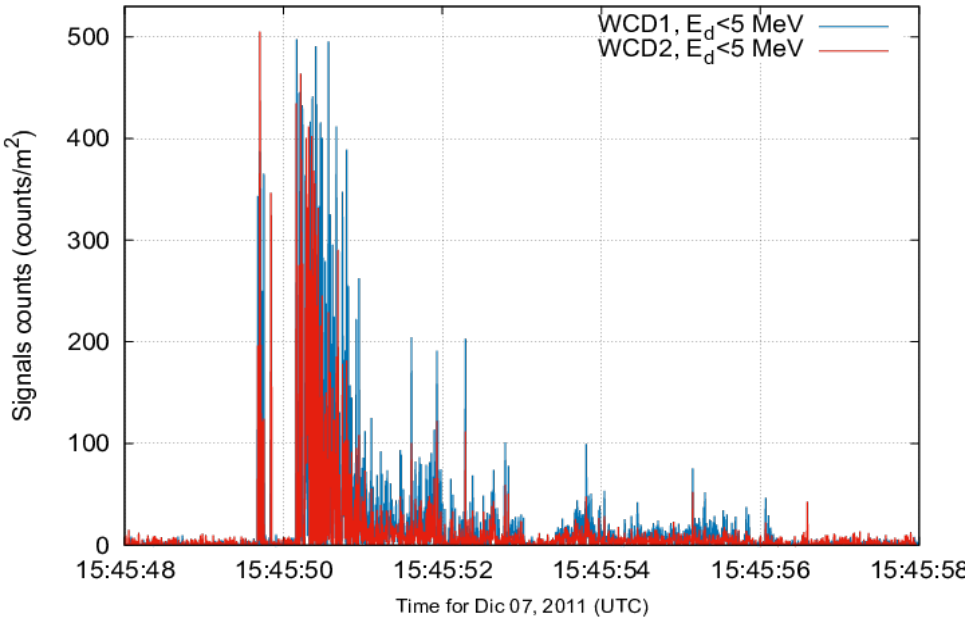
- *3 WCDs*
- *10 m2 detection area*
- *Highest place 5200 masl*
- *RC 11.87 GV*
- *16.35 N 68,13 W*



Solar (a) summation over the data gathered in the month of April of 2011 for the WCD1 detector at Chacaltaya.

- The vertical axis represent the percentage of change form the middle value of each sub-channel in the solar or sidereal time analysis.

Potential candidate signals for the event registered on Wed Dic 07 15:47:02.378 UTC 2011. The registered signals in 5 ms temporal bins.



- *Transient events or long term solar modulation effects can be measured simultaneously at places having different geomagnetic rigidity cut-offs and atmospheric reaction levels.*
- *Producing real time, high resolution and high quality data of the flux of secondary particles at each site of the LAGO detection network..*
- *This program is intensively supported by a complex chain of simulations that accounts for geomagnetic and atmospheric effects and the different detectors response.*

Heliosphere ***Magnetosphere***

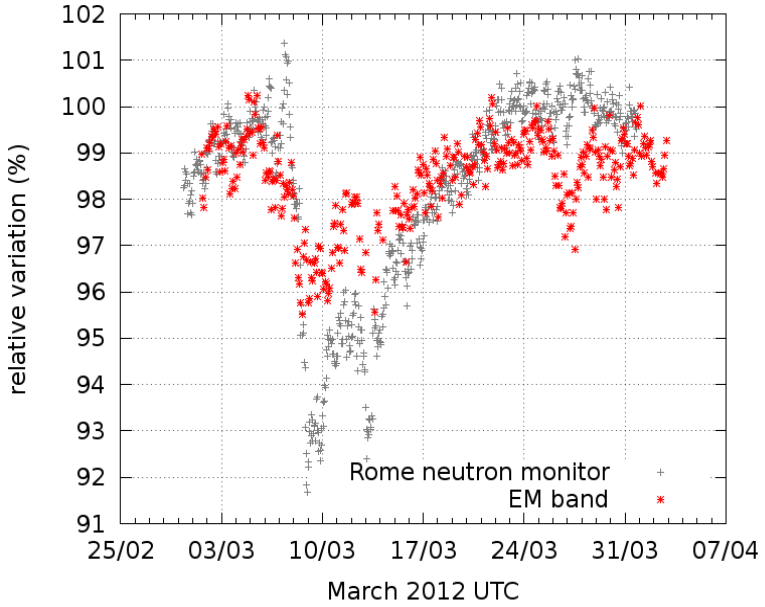
GCR Flux **−−−−−→** ***Modulated Flux*** **−−−−−→** ***Primaries*** **→ • • •**

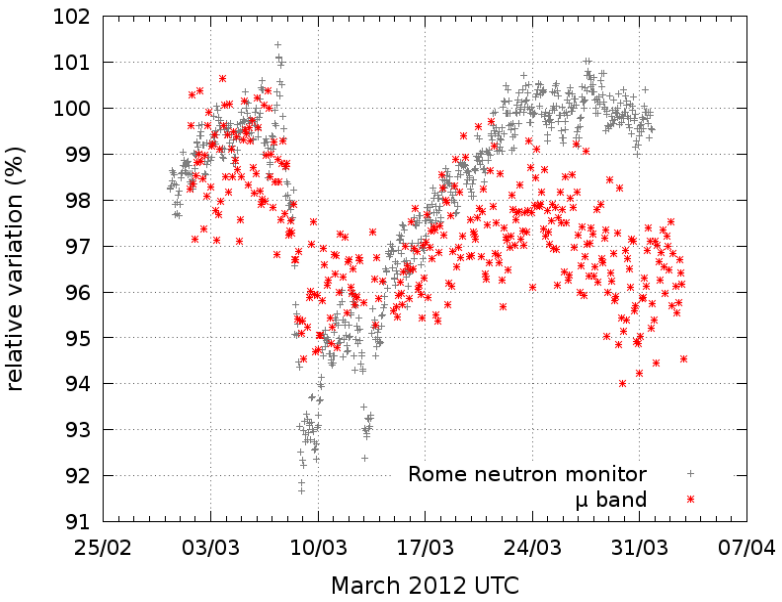
Atmosphere ***Detector response***

• • • → ***Primaries*** **−−−−−→** ***Secondary*** **−−−−−→** ***Signals.***

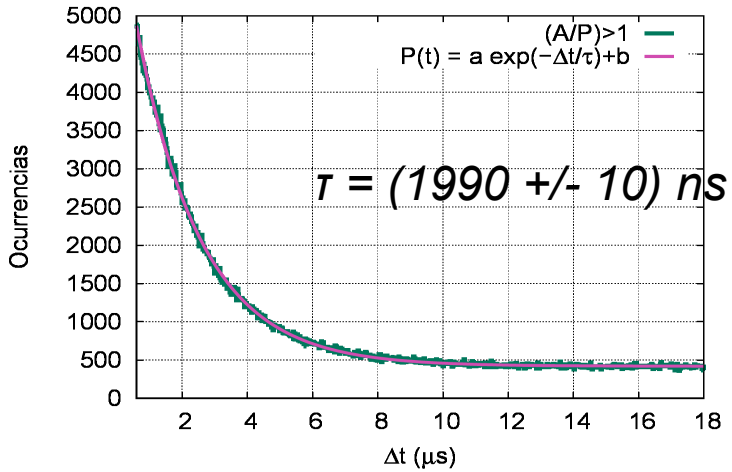
Flux variation of signal at detector level **−−−−−−−−→** ***Solar Activity***

08/March/2012: Forbush event ← single LAGO detector





Results of Multi-Spectal Analysis of the Forbush Decrease of March 8th, 2012 measured in a single 1.8 m 2 WCD installed in Bariloche, Argentina (red stars), compared with measurements of the Rome neutron monitor (gray pluses), in two bands: EM-band (left), and μ-band (right).



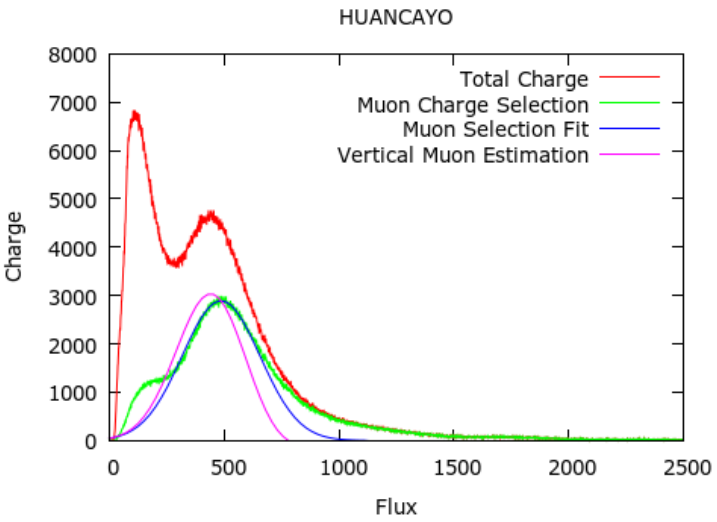
Training Courses held in 8 academic institution in Latinoamerica

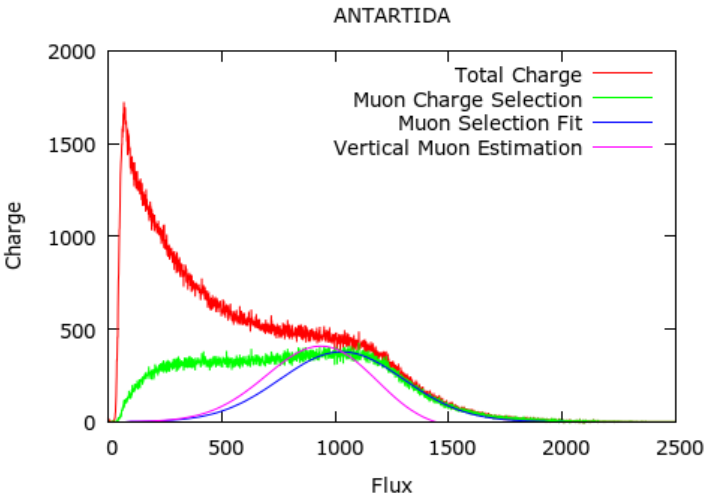
- *Transport and Fenomenology of cosmic rays*
- *Simulation on EAS and background.*
- *WCD detector construccion and data adquisition*
- *Data análisis*

Academic Program

Peruvian Detectors:

Huancayo detector (up): 2,4 m diameter – 0,9 m height, and the other in Peru's Antarctica Camp (right): 1,2 m diameter - 1 m height.

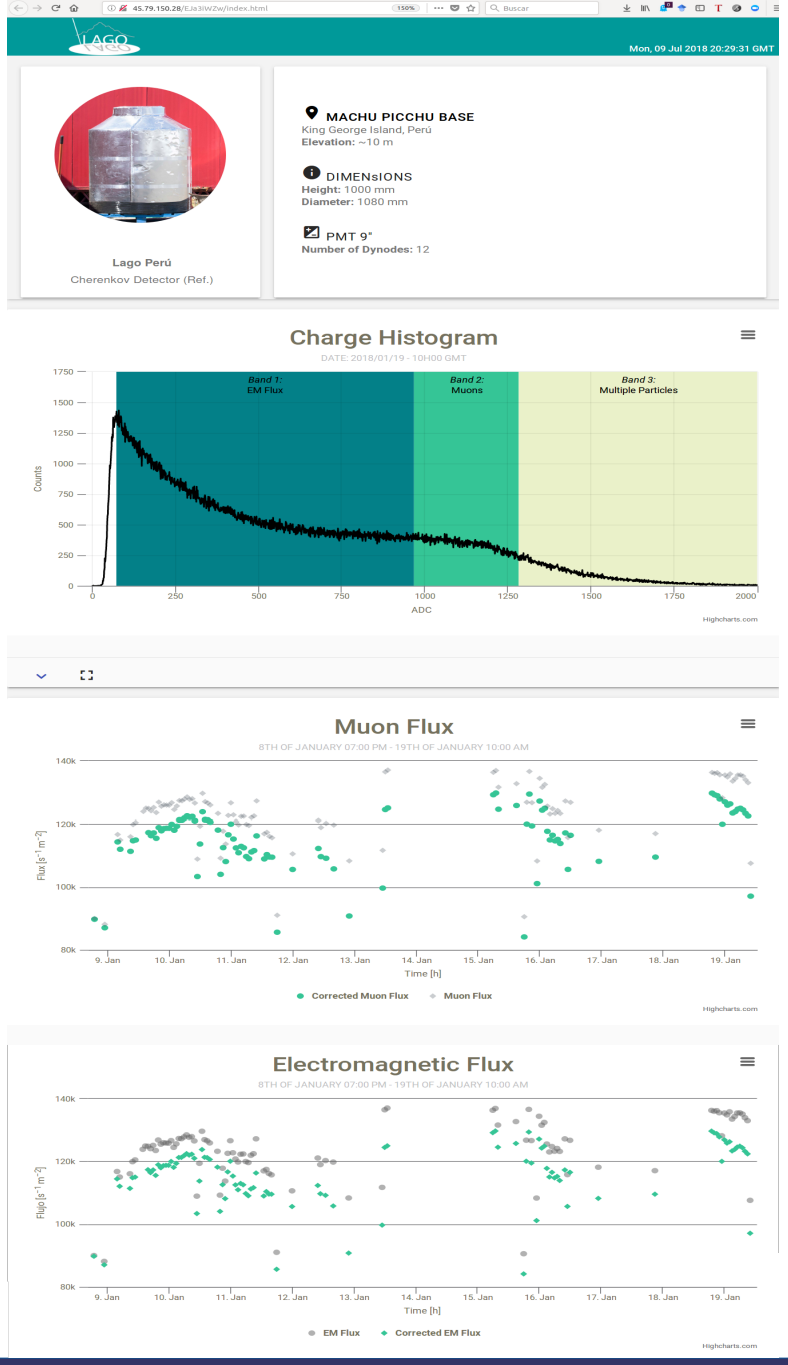




- **New calibration method**

- Two Steps calibtarion process:
- 1. Perform a selection of muons in the total charge spectrum (we choose between two consecutive pulses the one with the highest charge).
- 2. Adjust a gaussian to this secondary distribution an apply equation:
- **$F(q) + q\,F'(q)/\alpha \approx VEM(q)$**
- in order to estimate VEM(q).

Peru contribution to LAGO projecto: Web Monitor



Data obtained on January 2018 during the Peruvian campaign at the Antarctic, the data is corrected by pressure.

The new calibration method is simple and fast enought to calculate the muon region of the total charge spectrum hourly. This allows monitoring the detector status in real time.

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Thanks for your attention

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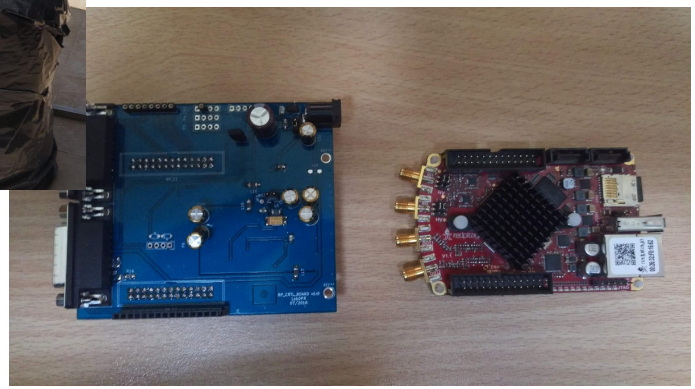
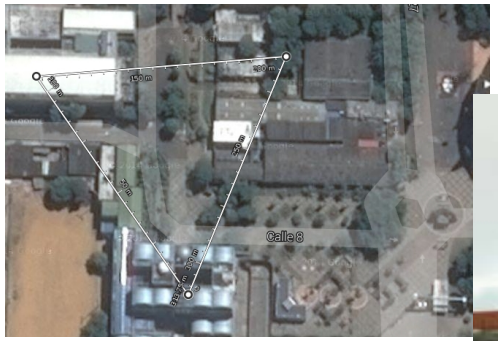
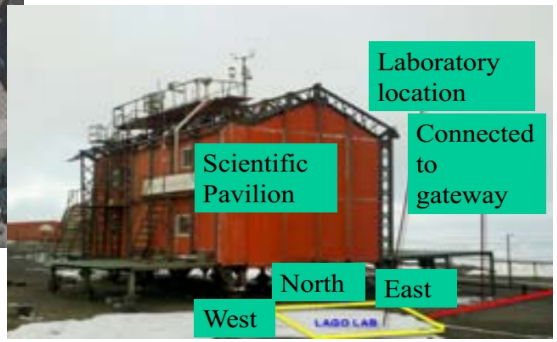


- *Autonomuos estation throught solar power.*
- *Upgrade of electronics from 40 Mhz to 100 Mhz.*
- *Arrays of WCD: towards detection of mid energy showers.*
- *Antartic permanent station.*





Perspectives