

Status and Perspectives of the LAGO Project

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Paris, France

Édgar F. Carrera
✉ ecarrera@usfq.edu.ec

(for the LAGO Collaboration)

Universidad San Francisco de Quito



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May 27, 2014

What is LAGO?

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Let's start by what it means . . .

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Let's start by what it means ...

Latin **A**merican **G**iant **O**bservatory

What is LAGO?

Let's start by what it means ...

Latin American Giant Observatory

A little obnonioux, but let's see ...

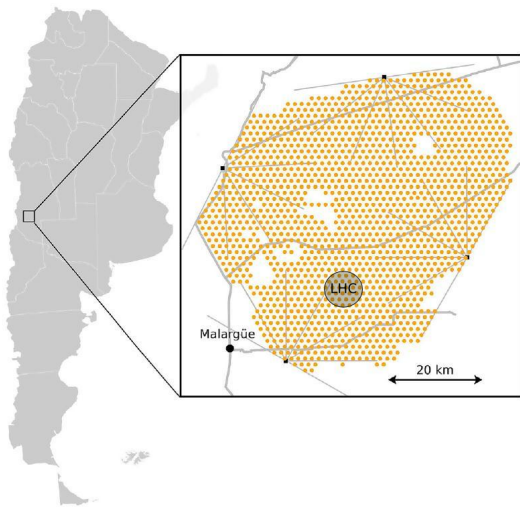
What is LAGO?

This is the **Large** Hadron Collider



What is LAGO?

This is the Pierre Auger Observatory



What is LAGO?

and the Latin American **Giant** Observatory



LAGO: Latin American Giant Observatory



- A very long baseline “array” of Water Cherenkov detectors (WCD)
- Formerly “The Large Aperture Gamma Ray Observatory”
- 9 Latin American countries

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The LAGO scientific goals

- Search for HE component of GRBs at ground level
- Study transient and long term Space Weather phenomena through Solar modulation (SM) of Cosmic Rays (CR)

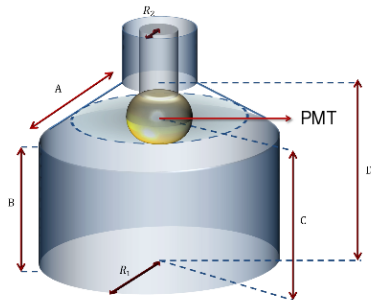
The *Latin American* Astroparticle Network

- Non-centralized, collaborative network of institutions
- Horizontal management
- Developments, expertise and data are shared across the network
- Open working groups



WCD: Water Cherenkov Detector

- Autonomous, reliable, simple and cheap detector
- Single particle technique or array mode
- Sensitivity to secondary charged particles and γ (mainly trough $\gamma \rightarrow e^+e^-$)
- Mostly commercial tanks with $1.5 \text{ m}^2 - 10 \text{ m}^2$ of detection area filled with purified water
- Inner coating of Tyvek (UV diffusive and reflective fabric)
- 8/9" PMT + Digitizer board (own design) + GPS + Temperature and Pressure sensor
- FPGA + Raspberry Pi: detector control, telemetry, data acquisition and on board data pre-analysis



- Digitized signals by a 10 bits FADC at 40 MHz (25 ns)
- Temporal synchronization: GPS in PPS mode
- Station consumption: $\lesssim 8 \text{ W}$
- Very low cost detector

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Astroparticles, witnesses of the extreme universe

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- Magnetic reconnection in the Magnetosphere
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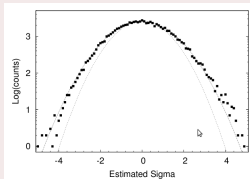
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Astroparticles, sources of background radiation

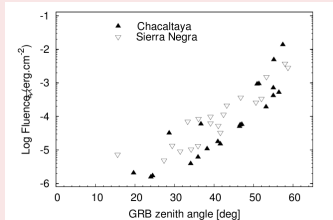
- Atmospheric radiation at ground and flight level

LAGO- γ Program on GRBs

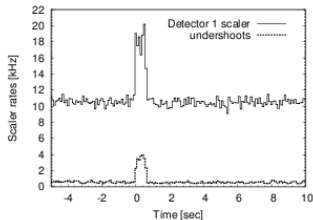
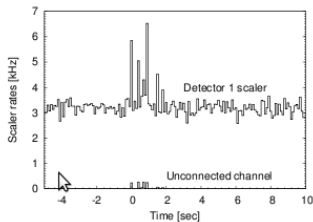
arXiv:0906.0814; arXiv:0906.0816; arXiv:0906.0820

Blind searches $\sigma - \delta$ 

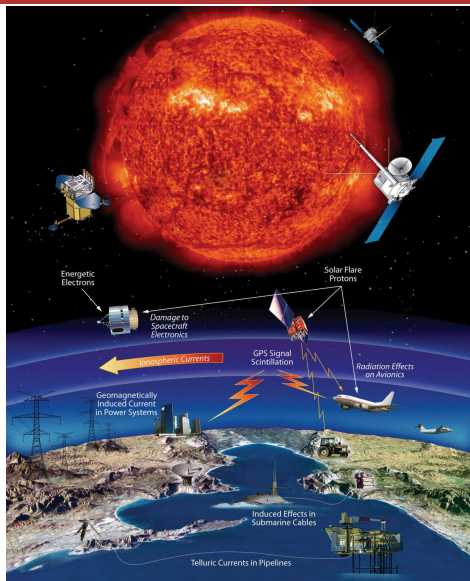
LAGO fluence limits



Candidate of GRB at Sierra Negra



Space Weather



Sun-Earth connection

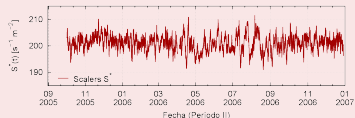
- Dynamic conditions in the Earth outer space environment:
 - Disruption of electrical power grids
 - Contribute to the corrosion of long pipelines
 - HF radio communications and GPS interferences
 - Operational anomalies and damage or degradation of critical electronics on spacecraft, satellites and even on board of commercial airplanes

WCD space weather oriented modes

H. Asorey [Pierre Auger Collab.], 31th ICRC Vol 7(2009)312; H. Asorey [Pierre Auger Collab.], 32th ICRC Vol 11(2011)462; S. Dasso & H. Asorey, [Pierre Auger Collab.], Adv. Sp. Res. 49:11(2012)1563

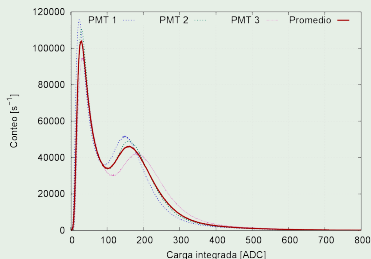
Counters

- Signal counting rate above a very low energy threshold



Histograms

- Charge histogram every 60 s
- WCD detector calibration



WCD space weather oriented modes

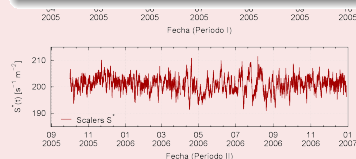
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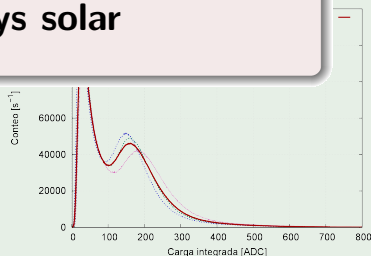
Objective

Study of galactic cosmic rays solar modulation



Histograms

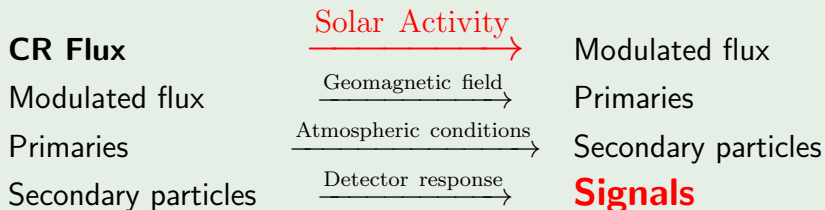
- Charge histogram every 60 s
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The LAGO Space Weather Program

via Solar modulation of low energy cosmic rays

Connections



Synergy

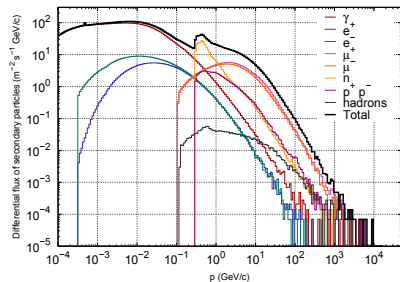
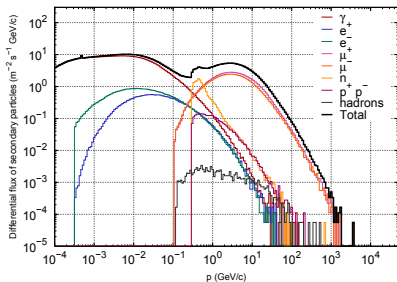
Flux variation of signals at detector level ⇔ **Solar Activity**

Simulations (underway)

Detailed simulation chain

- Determine rigidity cut-off at each site $R(\varphi, \lambda, \theta, \phi)$ (underway)
- Primary flux at the top of the atmosphere (CORSIKA sims for each site (φ, λ, h))
 - Measured spectra for all nuclei $1 \leq Z_p \leq 26, 1 \leq A_p \leq 56$
 - $(R(\theta, \phi) \times Z_p) \leq (E_p/\text{GeV}) \leq 10^6, 0^\circ \leq \theta \leq 90^\circ$
 - Integrated primary flux: $\sim 5.8 \times 10^6 \text{ hour}^{-1} \text{ m}^{-2}$ ($\gtrsim 5$ hours at each site)
- Secondary flux at detector level
- Detector response (underway): simple detector simulation & detailed GEANT4 model

Simulated flux at detector level



Bariloche (BRC, 850 m a.s.l.)

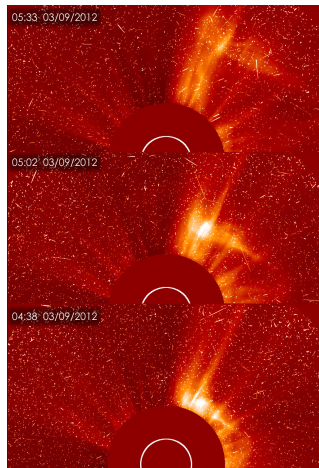
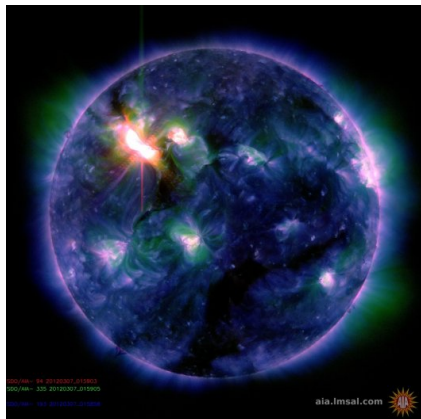
- $800 \text{ part. seg}^{-1} \text{ m}^{-2}$
- EM:MU:NE:HD = 0.767 : 0.209 : 0.020 : 0.004

Chacaltaya (CHA, 5240 m a.s.l.)

- $7100 \text{ part. seg}^{-1} \text{ m}^{-2}$
- EM:MU:NE:HD = 0.900 : 0.052 : 0.038 : 0.010

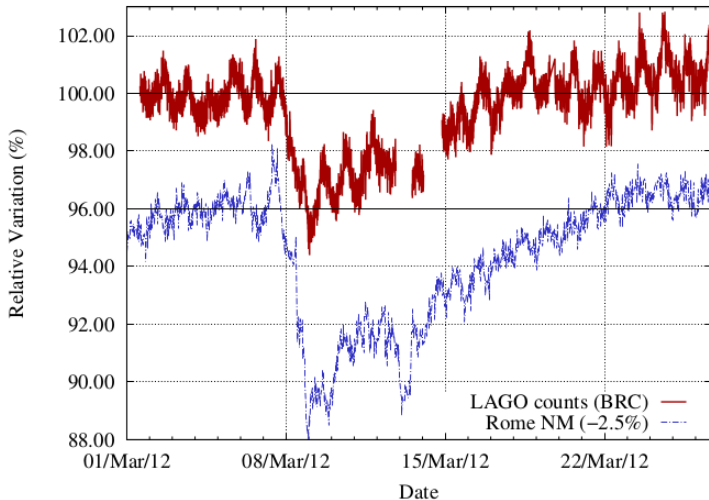
March/2012: Solar eruptive event

07/March: X5.4 major solar flare + Halo CME/iCME towards earth + Geomagnetic storm



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

LAGO-BRC: 1.8 m² WCD detector



Lago Summary

- **LAGO-Gamma:**
 - Detection of the high energy component of GRBs.
 - None seen so far; expanding sites and improving detectors.
- **LAGO-Solar:**
 - Cosmic ray solar modulation
 - Possible connections with physics of the atmosphere
- **LAGO-Academic :**
 - Astrophysics and particle physics in undergraduate courses
 - Atmospheric radiation background
 - Data analysis and statistic
 - Muon decay
 - Detector physics
 - Interaction of radiation with matter
 - Construction and characterization of detector
- **LAGO-Virtual:** Collaborative repository of high capacity for data analysis, simulations and storage
- **Regional integration in Latin America:**
 - More than 80 scientists and students from nine latin american countries