LAGO
El Observatorio Latinoamericano Gigante
Current State and Future Perspectives

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LAGO @ Latin America, July 2020
The Latin American Giant Observatory (LAGO) Project

A very long baseline “array” of water Cherenkov detectors (WCD)

The LAGO Collaboration

- 99 members from 30 institutions in 11 countries: Argentina, Bolivia, Brasil, Chile, Colombia, Ecuador, Guatemala, México, Perú, Venezuela & España.

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

Academic goals:
- Train Latin American students in HE and Astroparticle physics
- Build a LA network of Astroparticle researchers
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How does it work?
- Non-centralized, collaborative network of institutions and scientists
- 3 working groups (physics, detectors, data)
- 11+1 members coordination committee, 1 P.I.
- Developments, expertise and data are shared across the network
- Primary objectives conducted by specific LAGO programs

Build a LA network of Astroparticle researchers
### LAGO Objectives ↔ LAGO Programs @ 3 WG

**WG: Physics - Detectors - Data**

#### LAGO-High Energy:
- Small arrays of WCD
- High energy components of GRB
- Low energy astroparticles

#### LAGO-Space Weather:
- Space Weather phenomena from ground level
- Possible connections: atmospheric physics
- Background radiation at ground (and flight) level

#### LAGO-Universities:
- Astrophysics and particle physics in undergraduate courses
- Muon decay
- Construction and characterization of particles detectors
- Detector physics and radiation-matter interactions
- Data analysis and statistic

#### LAGO-Virtual:
- Acquire, produce, collect and preserve LAGO data
- Integration with EOSC services
- Toolkit development → ARTI (integration of MAGCOS, CORSIKA and Geant 4)
Our detector: sWCD (Water Cherenkov Detector) as in smart

- Autonomous, reliable, simple and cheap detector
- Commercial tanks with 1.5 m² – 10 m² of detection area filled with purified water
- Inner coating of Tyvek (UV diffusive and reflective fabric)
- PMT + Digitizer board (own design)
- FPGA + Raspberry Pi: detector control, telemetry, data acquisition and on board data pre-analysis (including machine learning techniques)
- Upgrade of the electronics → STEMLab® (redpitaya) system

- Digitized signals by a 10-14 bits FADC at 40-100 MHz (10-25 ns)
- Temporal synchronization: GPS in PPS mode
- Station consumption: ≲ 8 W
Latest ‘news’ on LAGO

Some recent publications

XI LAGO Workshop and VII School: ’The physics of LAGO’

Performance of the LAGO Water Cherenkov detector optimization for space weather studies in the Antarctic

O.G. Morales Olivares\textsuperscript{1,2}, Hugo de León Hidalgo\textsuperscript{2}, Karen Salomé Caballé\textsuperscript{1}, Roberto Arose Reyer\textsuperscript{1}, Eduardo Moreno Barbosa\textsuperscript{2}, Arnulfo Zepeda Don César Álvarez Ochoa\textsuperscript{2}, Filiberto Huayllat Zahuastitil\textsuperscript{2}, Luis Rodolfo Pérez Sánchez\textsuperscript{2} for the LAGO Collaboration\textsuperscript{1,2}.

Water Cherenkov detector optimization for space weather studies in the Antarctic

Preliminary results of the design and development of the data acquisition and processing system for the LAGO Collaboration

R. Calderón-Ardila\textsuperscript{1,2}, A. Jaime-Motta\textsuperscript{2,3}, C. Sarmiento-Cano\textsuperscript{1,2}, M. Suárez-Durán\textsuperscript{1,2}, A. Vásquez-Ramírez\textsuperscript{1,2} for the LAGO Collaboration\textsuperscript{1,2}.

Modeling the LAGO’s detectors response to secondary particles at ground level from the Antarctic to Mexico

O. G. Morales Olivares\textsuperscript{1,2}, H. de León Hidalgo\textsuperscript{2}, K. Salomé Caballé\textsuperscript{1}, R. Arose Reyer\textsuperscript{1}, E. Morena Barbosa\textsuperscript{2}, A. Zepeda Don César Álvarez Ochoa\textsuperscript{2}, F. Huayllat Zahuastitil\textsuperscript{2}, L. Rodolfo Pérez Sánchez\textsuperscript{2} for the LAGO Collaboration\textsuperscript{1,2}.

To be sended for publication

In 1 week

Performance of water Cherenkov detectors to cosmic rays flux

C. Sarmiento-Cano\textsuperscript{1,2,5}, M. Suárez-Durán\textsuperscript{1,5}, R. Calderón-Ardila\textsuperscript{1,2,5}, A. Vásquez-Ramírez\textsuperscript{1,2}, A. Jaime-Motta\textsuperscript{1,2}, I. Sidelnik\textsuperscript{1,2,5}, L. A. Núñez\textsuperscript{2,5}, H. Asoy\textsuperscript{1,2,5}, S. de la Peña\textsuperscript{1}, for the LAGO Collaboration\textsuperscript{1,2,5,6}.
Projection of major activities separated in two groups

**Uniformization Goals**

- **End 2019**: New electronic design and characterization *(partially/done)*
- **Mid. 2020**: New electronic deployment at all the sites *(postponed-covid19)*
- **2020/21**: Central LAGO Data Repository and data analysis chain *(ongoing)*
- **2021**: Selection and deployment of new detectors in the region
- **2019/21**: Replacement and deployment of permanent detectors in Antarctica *(done)*

WCD of each site (diff. geometries) and most of the PMTs were donated by the Auger Observatory (failing and replacement is expensive).

**Academic objectives → 2 schools per year at different LAGO sites**

- **2019**: 2 schools (South America and North America) *(1@Perú - 1@BsAs)*
- **2020**: 2 schools (South America and Central America) *(postponed-covid19)*
  Replace with Virtual School on LAGO Data Analysis.
- **2021**: 2 schools (C-Amercia and S-America)
- **2022**: 2 schools (S-America)
- **2023**: 2 schools (S-America and C-America)

One school synchronized with the annual Collaboration meeting.

**MoU with Auger Collaboration**: data exchange *(joint analysis)* and technical support.

Need a stable and uniform operation of the current sites and the development of new sites. We foresee the need for a **common funding support for all the Observatory**, it is crucial in the development of the entire scientific program.

The core cost of all this development is estimated at the level of 1.5M US$ for the following 5 years.
Conclusions

- Ultra long baseline “array” of sWCD from Mexico to Antarctica
- High and low altitude sites across the Andean range: Background radiation, Space Weather and HE physics
- New sWCD with upgrade in the electronics and PMT replacement
- Full simulation chain: from primary flux to detector signals, on going multispectral data analyses (several papers this year)
- New sites along all LA (including Antarctica)

- Local to regional integration of Universities
- Student training in HE physics in LA with schools & experiments @ each site
- Very active LA community: several projects funded in many LA countries

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The LAGO Project: A Latin American network of astroparticle students and researchers