LAGO: the Latin American Giant Observatory, current status, projects and future perspectives.

Iván Sidelnik[1,2,3] on behalf of the LAGO Collaboration[4]

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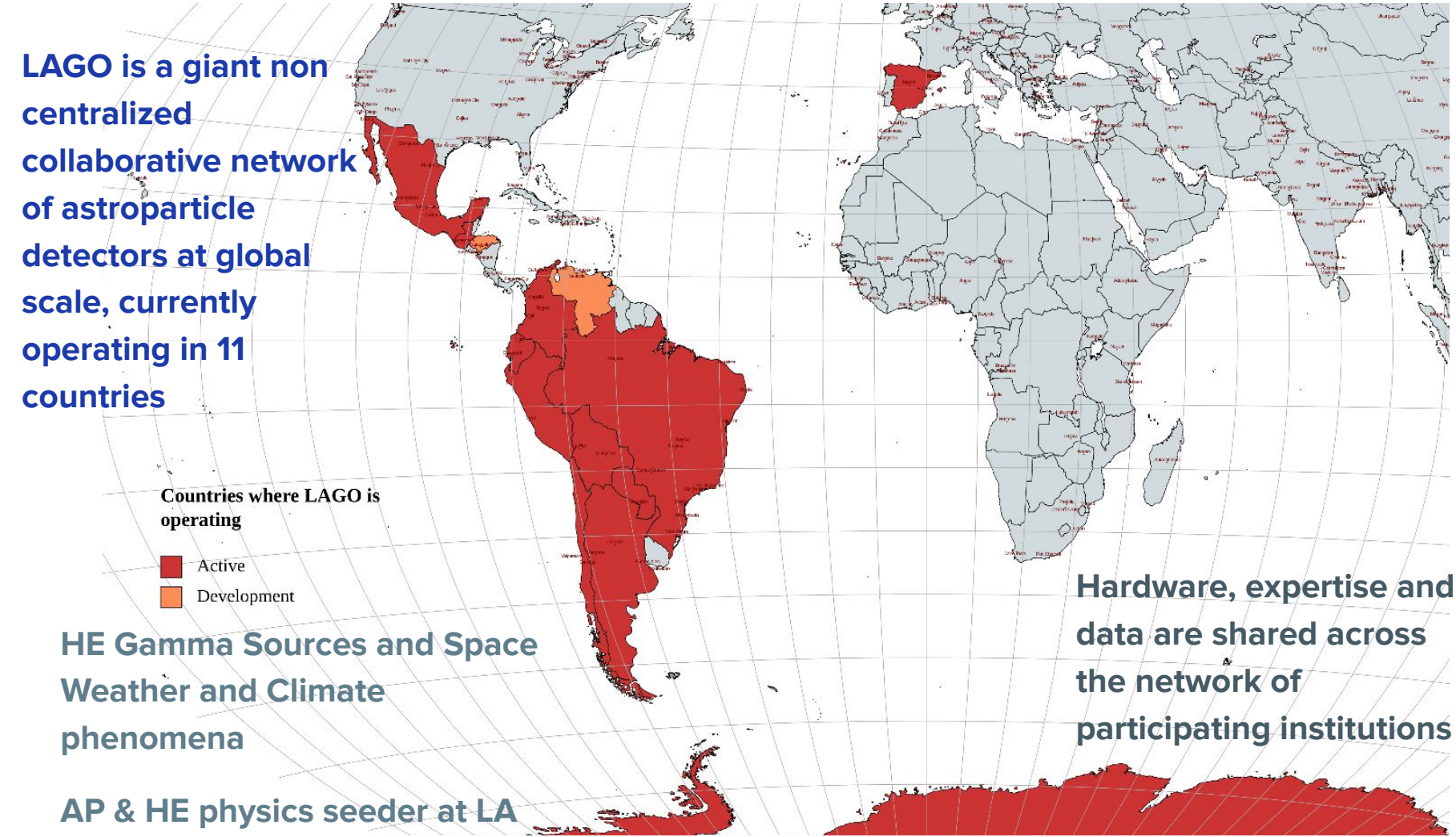
Latin America Giant Observatory
lagoproject.net

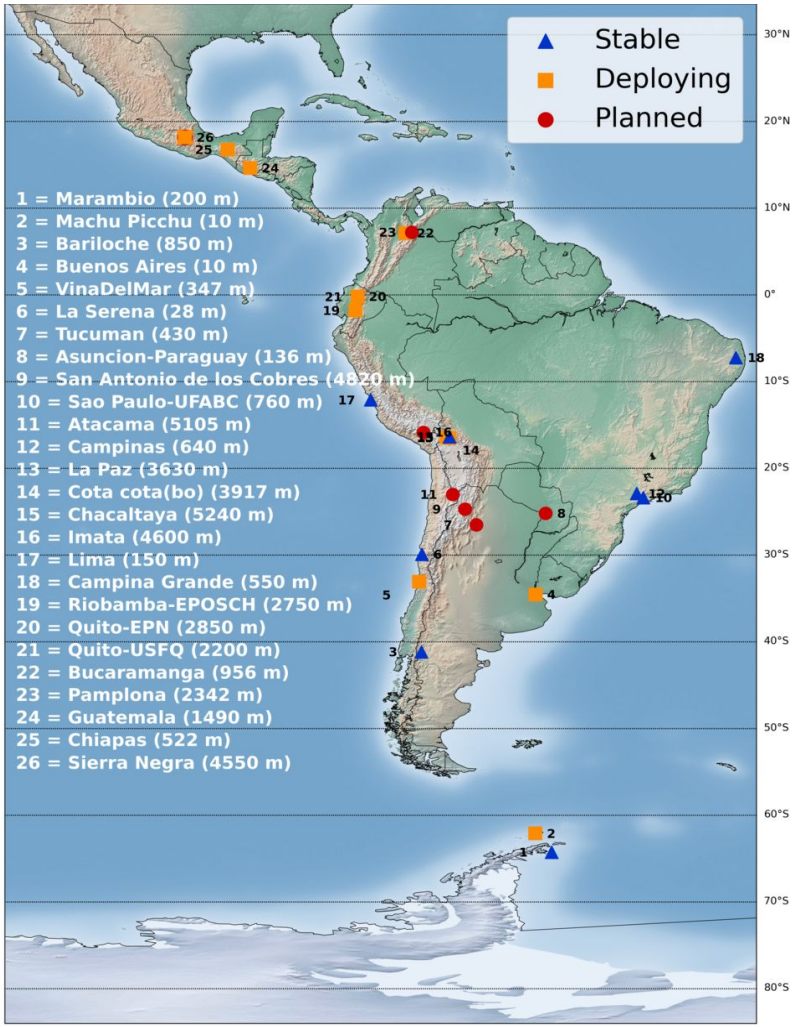
LAGO is a giant non centralized collaborative network of astroparticle detectors at global scale, currently operating in 11 countries



HE Gamma Sources and Space Weather and Climate phenomena

AP & HE physics seeder at LA

Hardware, expertise and data are shared across the network of participating institutions



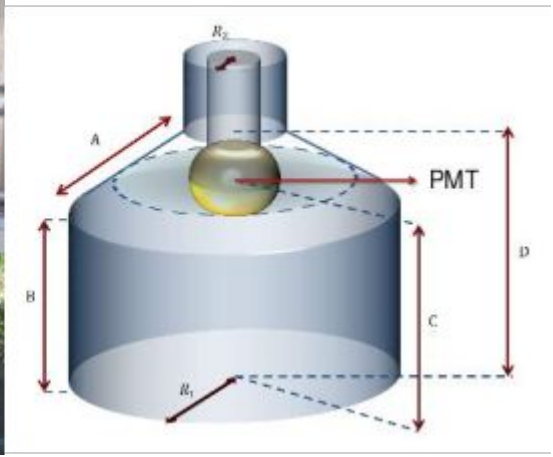
The Latin American Giant Observatory

LAGO is an extended astroparticle observatory at continental scale: from México to Antarctica

- **Scientific goals**
  - Astroparticle physics to study the extreme universe
  - Transient and long term space weather phenomena trough Solar modulation of Cosmic Rays
  - Measurement 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 and Cosmic Rays researchers

The Latin American Giant Observatory

Autonomous, reliable, simple, cheap and smart (based on SBC and COTS) WCD with a single PMT
(usually provided by LAGO in most of the participating countries)



New own designed electronic based on SteamLab RedPitaya
H. Arnaldi et al, IEEE2020

SaaS (Sensors as a Service) Concept
H. Asorey et al, PoS(ICRC2015)

LAGO Capabilities: Multi-spectral analysis

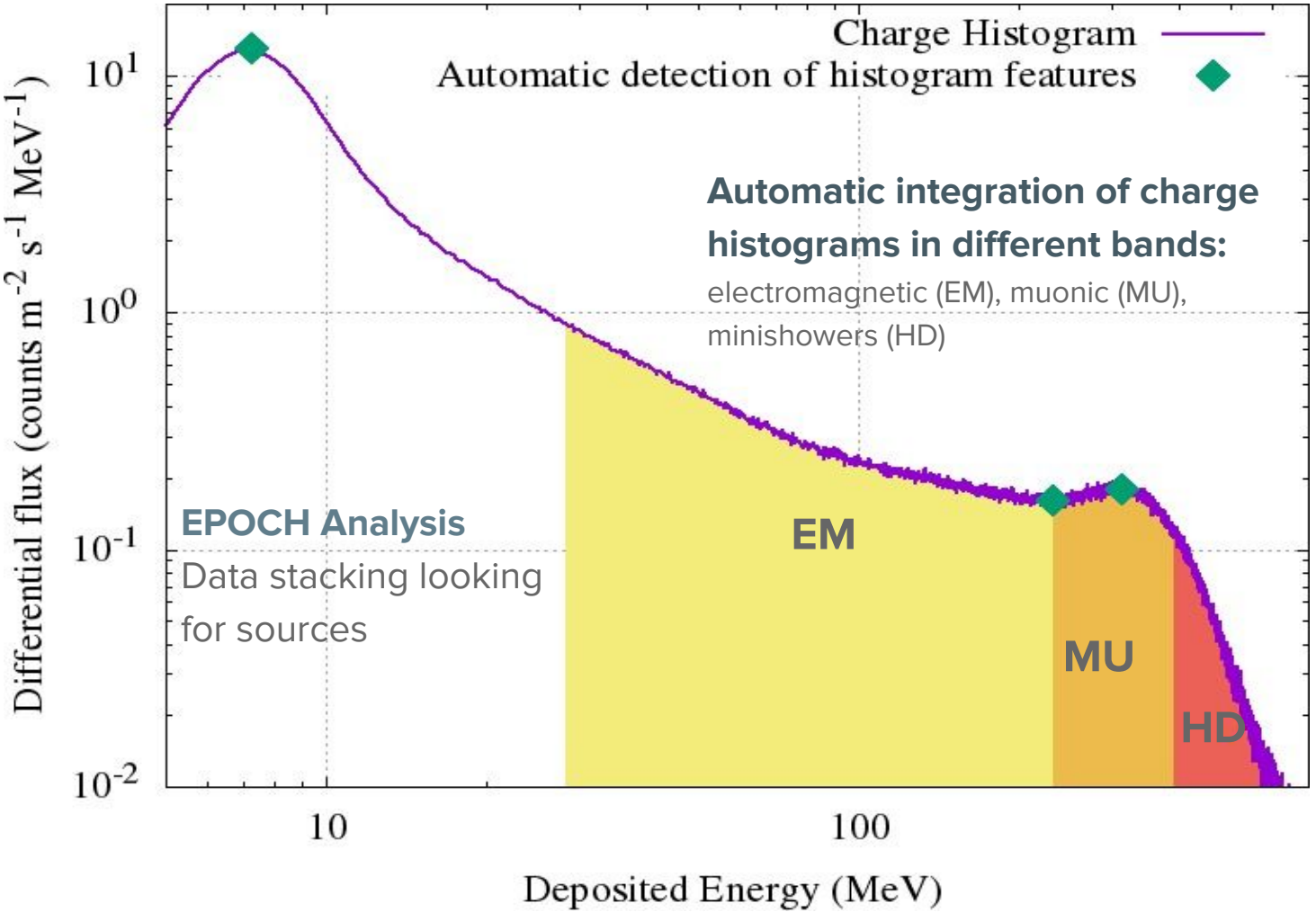
- Simultaneous measurements of secondaries at ground level
- Intensive simulation and data analysis frameworks

Connections

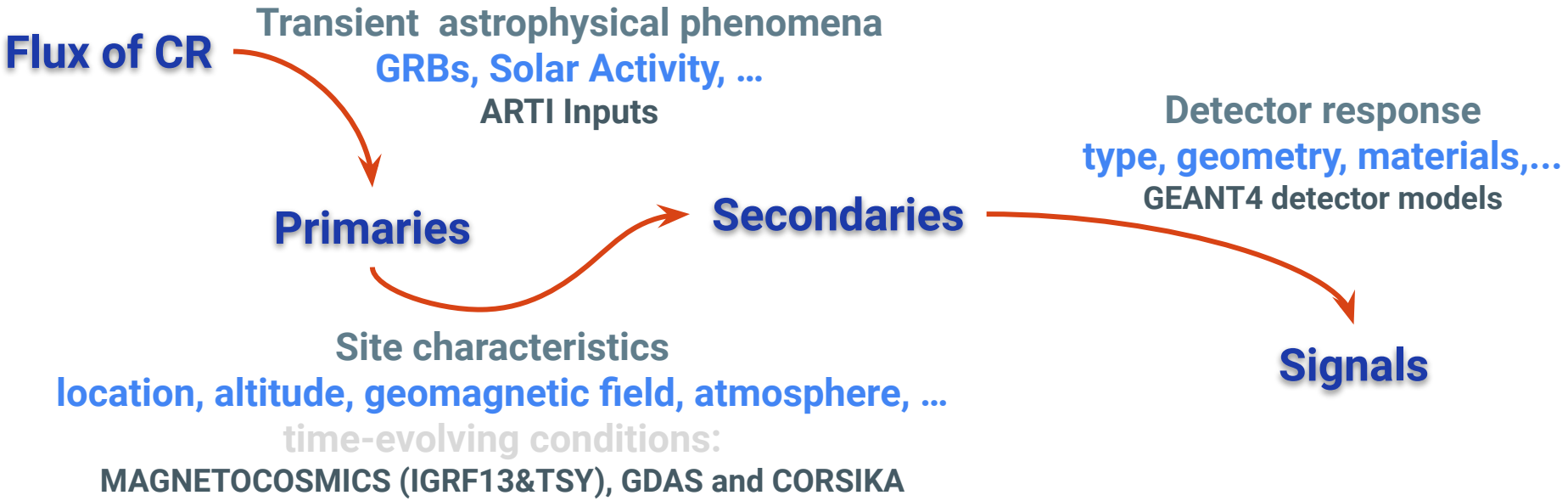
CR Flux	$\xrightarrow{\text{Astrophysics transients}}$	Modulated flux $\cdots$
$\cdots$ Modulated flux	$\xrightarrow{\text{Geomagnetic field}}$	Primaries $\cdots$
$\cdots$ Primaries	$\xrightarrow{\text{Atmospheric conditions}}$	Secondary particles $\cdots$
$\cdots$ Secondary particles	$\xrightarrow{\text{Detector response}}$	**Signals**

Synergy

Flux variation of signals at detector level$\Leftrightarrow$Transients


Charge Histogram
Automatic detection of histogram features
Automatic integration of charge histograms in different bands:
electromagnetic (EM), muonic (MU), minishowers (HD)
EPOCH Analysis
Data stacking looking for sources
EM
MU
HD
Differential flux (counts m-2 s-1 MeV-1)
Deposited Energy (MeV)
10
100
10^1
10^0
10^-1
10^-2

ARTI, the LAGO simulation framework

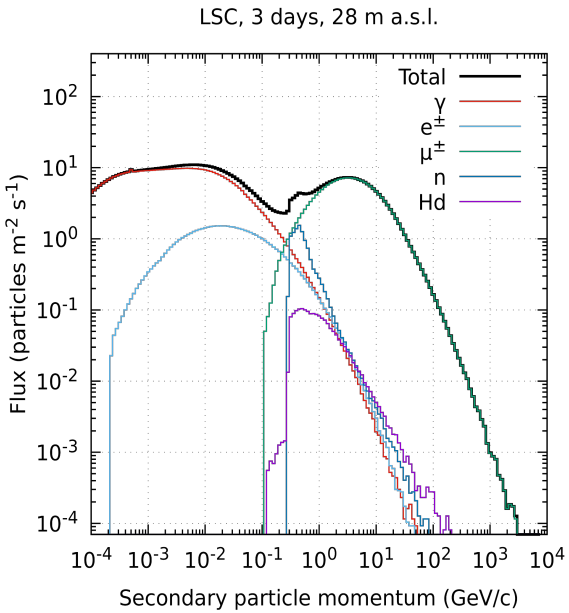


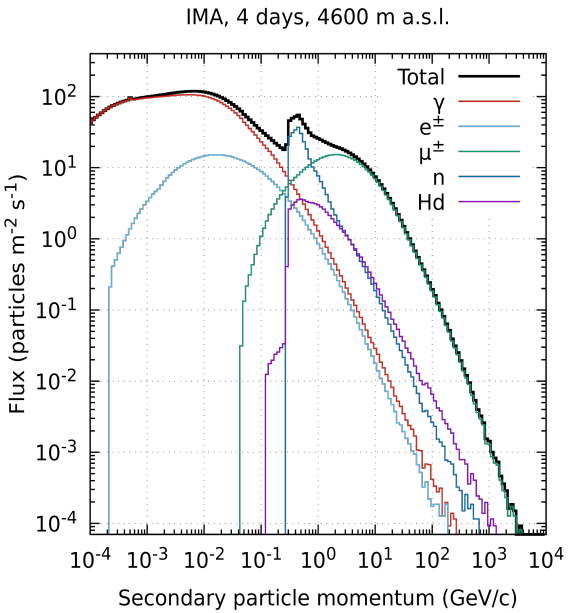
ARTI inputs —do_sims→ **S0: raw Corsika** —do_showers→ **S1: secondaries** —do_signals→ **S2: signals**

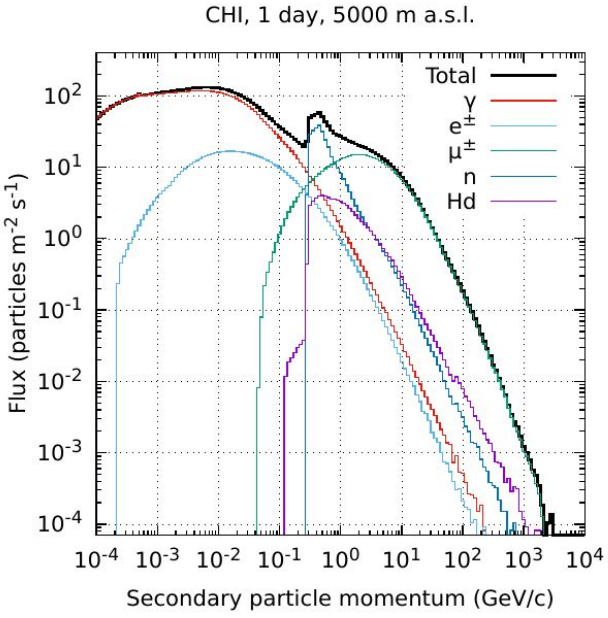
The EOSC-Synergy cloud services implementation for the Latin American Giant Observatory (LAGO), H. Asorey et al, PoS(ICRC2021)261 ,

A novel cloud-based framework for standardized simulations in the Latin American Giant Observatory, A. J. Rubio- Montero, et. al., WSC '21

ARTI, the LAGO simulation framework





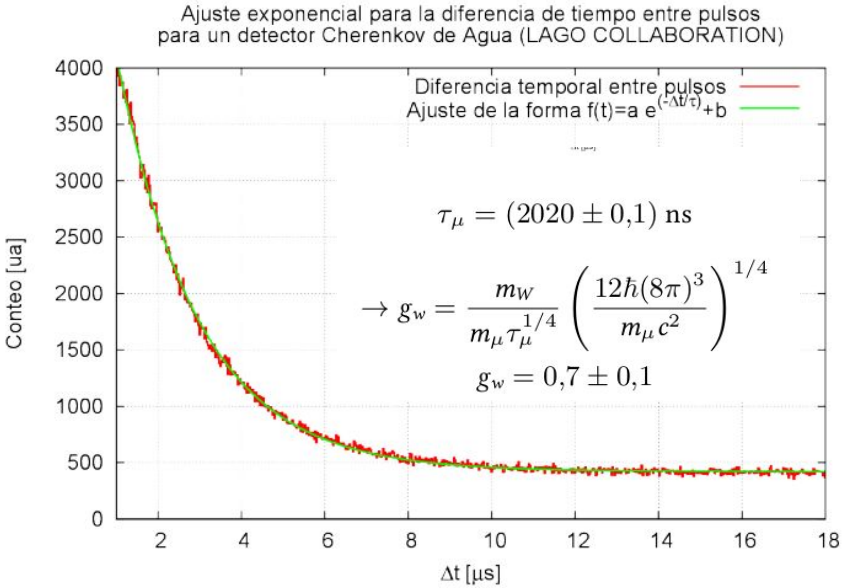


Detailed flux of of secondary particles at detector level for all LAGO sites and other locations **around the World.**

The EOSC-Synergy cloud services implementation for the Latin American Giant Observatory (LAGO), H. Asorey et al, PoS(ICRC2021)261

A novel cloud-based framework for standardized simulations in the Latin American Giant Observatory, A. J. Rubio- Montero, et. al., WSC '21

LAGO Universities



Experimental, astro-ph & hep-ph courses availables

Muon decay: electroweak theory, python, data analysis, simulations, detector physics, statistics, ...

H. Asorey et al, Rev. Bras. Ensino Fís. 40 (4)

Yearly LAGO workshop and AP&HE physics schools (combined mode since 2012!)

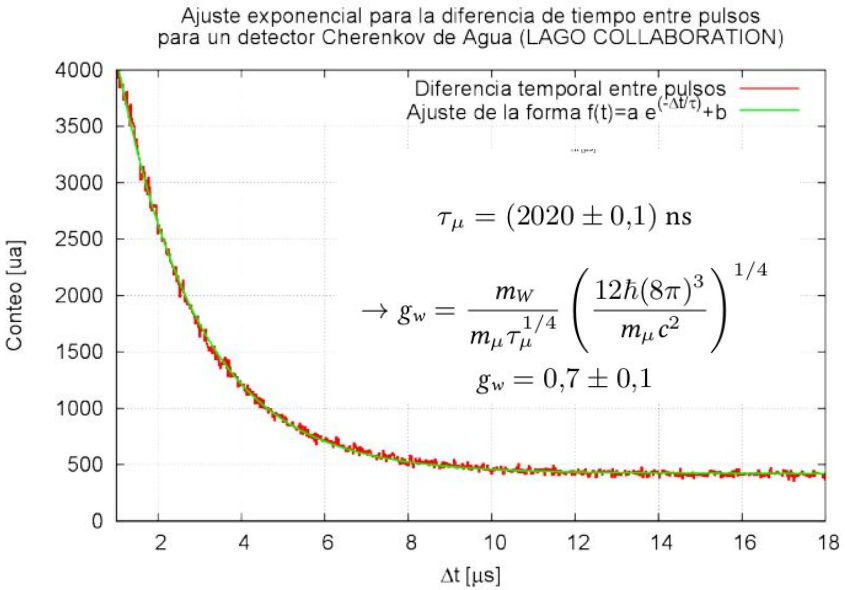
More than 400 participating students in total

Last in person meeting - Dec. 2019 - @ CAC - Bs As

Yearly LAGO workshop and AP&HE physics schools

Next edition Feb. 2022 @ Tucuman, Argentina

LAGO Universities



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H. Asorey et al, Rev. Bras. Ensino Fís. 40 (4)

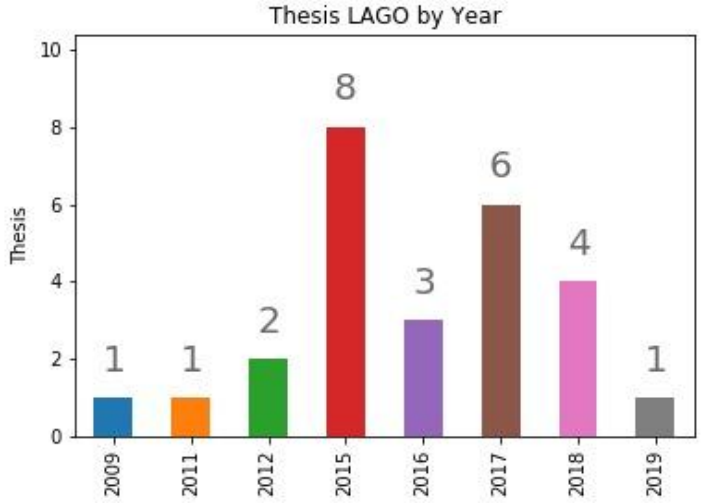
LAGO Universities

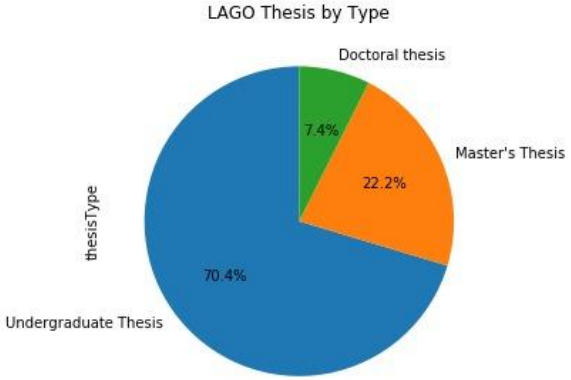
The Latin American Giant Observatory (LAGO)

Home | About | Publications | Activities | News | Contact

LAGO Thesis

Title	Author [*Director*]	Thesis Type	School	Year
Caracterización de perfiles atmosféricos para la cadena de simulación de la colaboración LAGO	Grisales-Casadiegos, J. [ ]	Undergraduate thesis	Escuela de Física, Universidad Industrial de Santander, Bucaramanga, Colombia	2019
Estimación de la respuesta de un detector Cherenkov de agua al fondo de rayos cósmicos en Bucaramanga(956 m s.n.m)	Jaimes-Motta, A. [ ]	Undergraduate thesis	Escuela de Física, Universidad Industrial de Santander, Bucaramanga, Colombia	2018
Procedimiento de instalación, calibración y sincronización del arreglo de detectores cherenkov de agua (guane), para la detección y estudio de rayos cósmicos en Bucaramanga	Hernández-Barajas SP, León-Carreño YF. [ ]	Undergraduate thesis	Escuela de Ingeniería Eléctrica, Electrónica y de Telecomunicaciones , Universidad Industrial de Santander, Bucaramanga, Colombia	2018





26 thesis / 44 publications / 15 astroparticle schools in LA

efficiency: (scientific production / investment) tends to infinity

I. Sidelnik for LAGO, LAS4RI forum, 2020

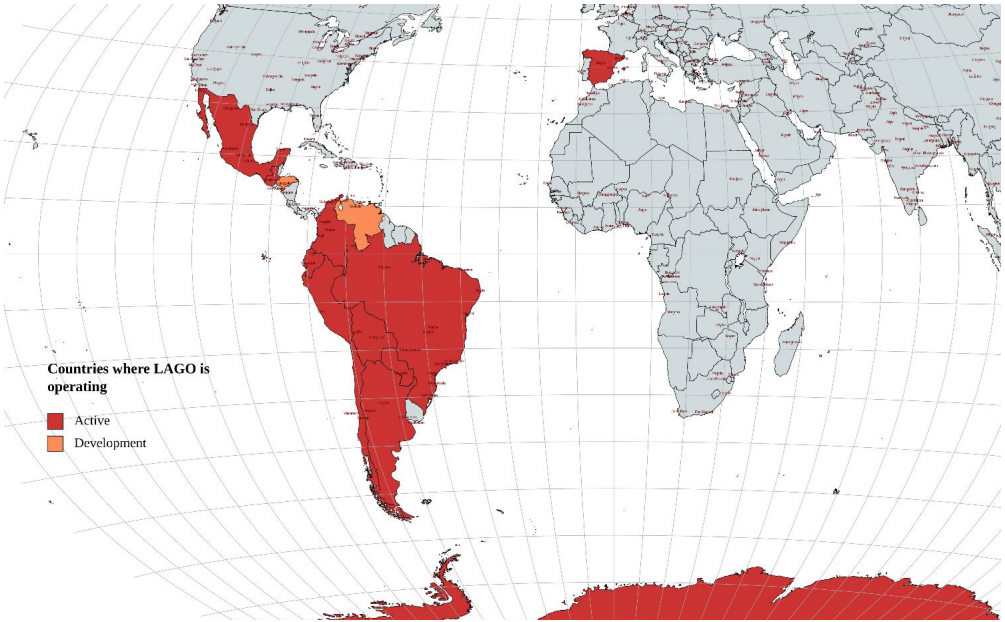
LAGO Virtual

Own designed hierarchical data analysis and virtualized docker-based tools

Measured: 2 TB/year-detector. 4 quality levels: L1: raw data, L2: preliminary, L3: Data Quality, L4: High Quality

Simulated: Up to 1 PB (estimated), EOSC-Synergy thematic service lead by CIEMAT: S0: raw data, S1: simulated and modulated particles at ground, S2: simulated signals at detector level.

Data is transferred to the central repository and is mirrored to several sites (+ each site has its own local data)



H. Asorey, Red Clara symposium, 2021

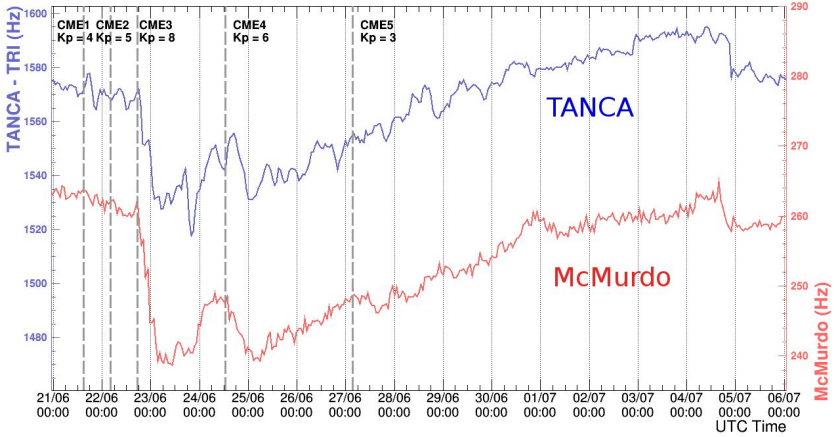
LAGO SW

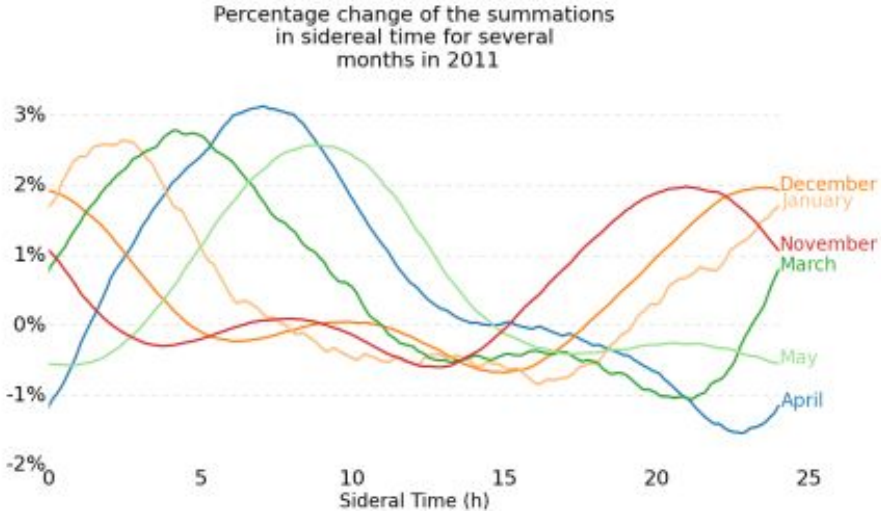
LAGO studies Earth-Sun connection by measuring the time-evolving secondary signals from ground level. Atmospheric and geomagnetic conditions are continuously monitored

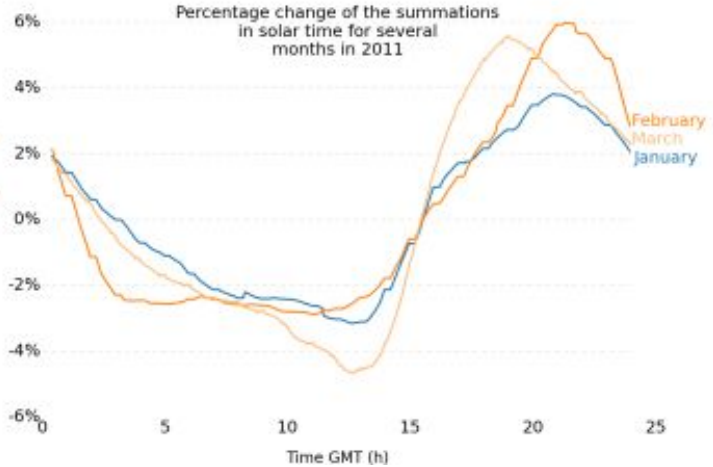
Antarctic dedicated SW sites

LAGO SW

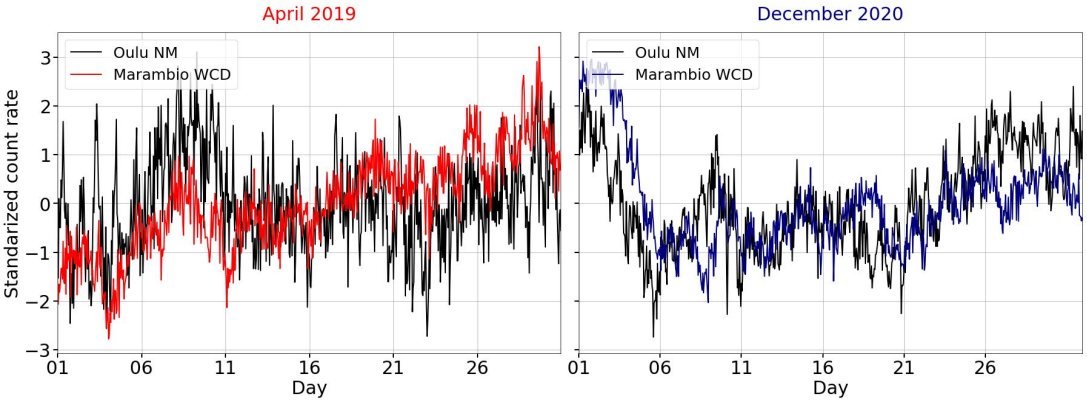
Intensive data analysis to detect secular and transient Solar Wind and Magnetosphere interaction: Forbush decreases (iCMEs) and Solar daily modulation (R. Aguiar et al, PoS(ICRC2021)1267)

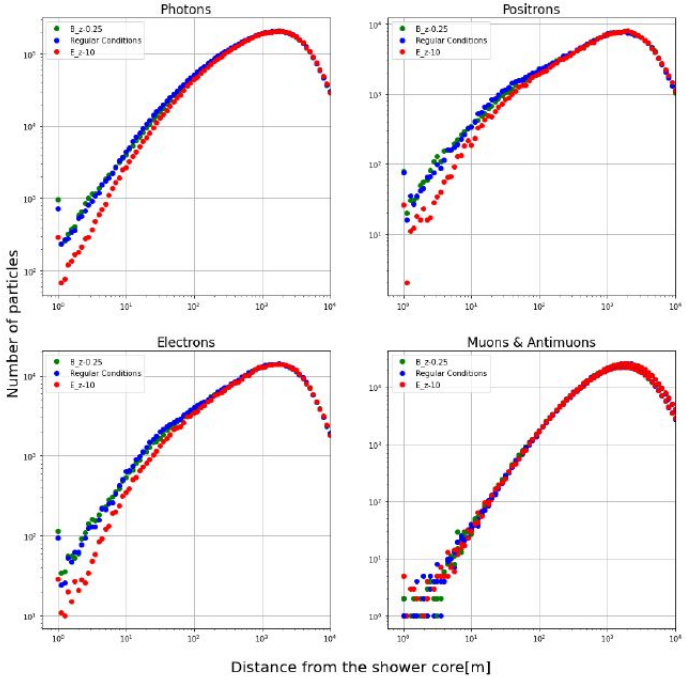






LAGO SW





Long term analysis for space climate at low rigidity sites: LAGO observations at the Antarctica Peninsula

Observations of the cosmic ray detector at the Argentine Marambio base in the Antarctic Peninsula

N. Santos et al, PoS(ICRC2021)304

Seismic activity could produce changes in local geoelectric and geomagnetic fields E and B

Study of the effect of seismically-induced geoelectric and geomagnetic fields on secondary particle detection at a LAGO site.

Diego Alberto Coloma Borja et al, PoS(ICRC2021)929

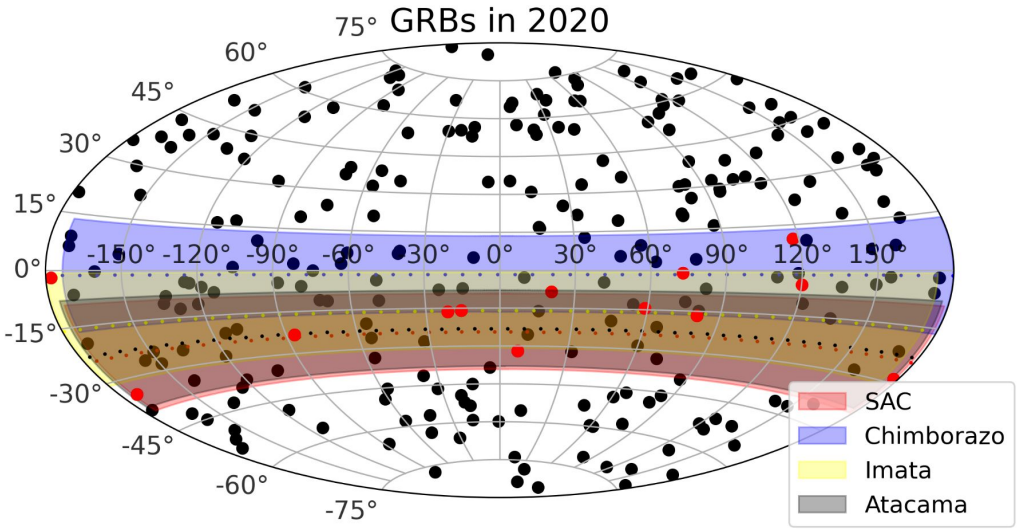
LAGO HE program

Small arrays of WCD at very high altitude sites (<4500 m asl)

FOV overlapped by design for simultaneous measurements

New high altitude sites projects!

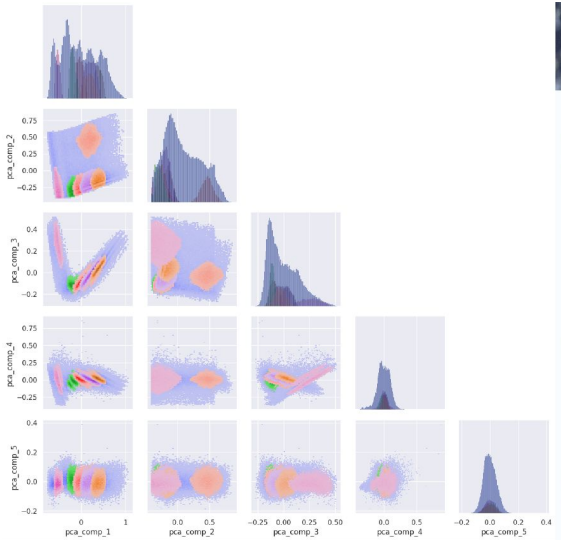
- Mt. Chimborazo @ Ecuador (ESPOCH) [Just started]
- Atacama @ Chile (Apex site) [application for funding ongoing]
- Imata @ Perú [application for funding ongoing]
- San Antonio de los Cobres @ Argentina

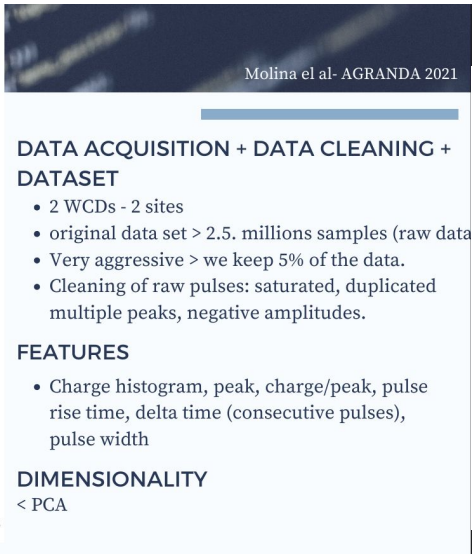


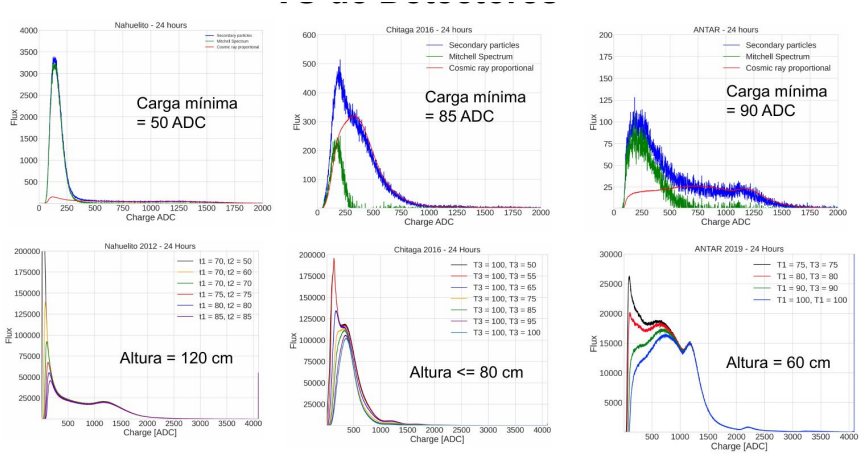
LAGO Capabilities for detecting high energy component of GRBs and Gamma Sources

C. Sarmiento-Cano et al, PoS(ICRC2021)929

LAGO ML program and Michel spectrum







Machine Learning program at the LAGO Collaboration

M. Graciela Molina et al, AGRANDA meeting 2021

Michel spectrum calculation from water Cherenkov detector data of the LAGO Observatory

L. Otiniano et al

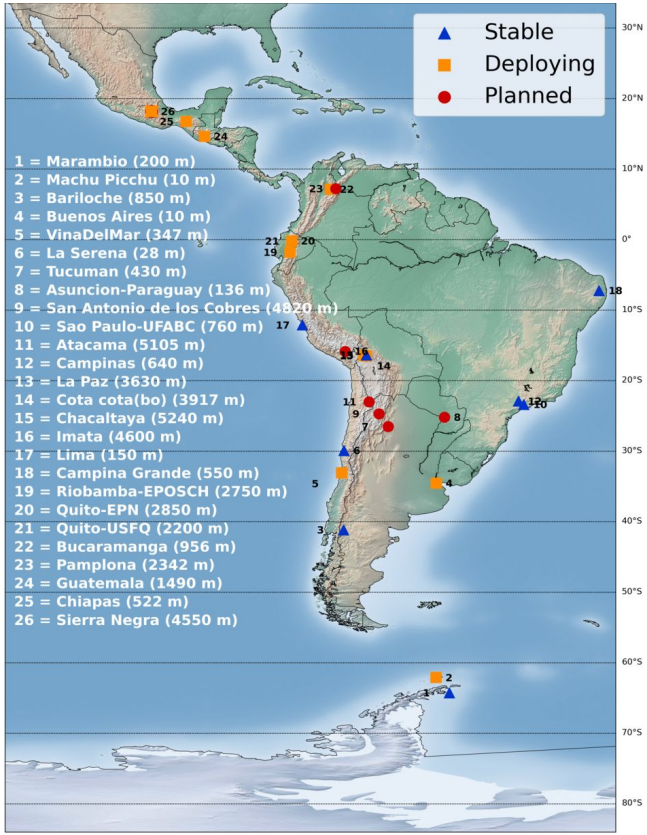
Conclusion

- LAGO major activities
- Long base WCD array from Mexico to Antarctica
- High and low altitude sites that allow us to perform space weather, high energy physics and background radiation measurements
- Complete simulation chain from the primary cosmic rays flux to signal at the WCD
- Multispectral analysis
- New sites @ latin america with projects and fund requested

- Local and regional integration of universities and institutes
- Student training in high energy physics @LA: schools and experiment @ different sites
- Very active LA community with several project funded and ongoing @ different institutions

LAGO constitutes a Latin American network of students and researchers in astroparticle and high energy physics

¡Gracias!



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