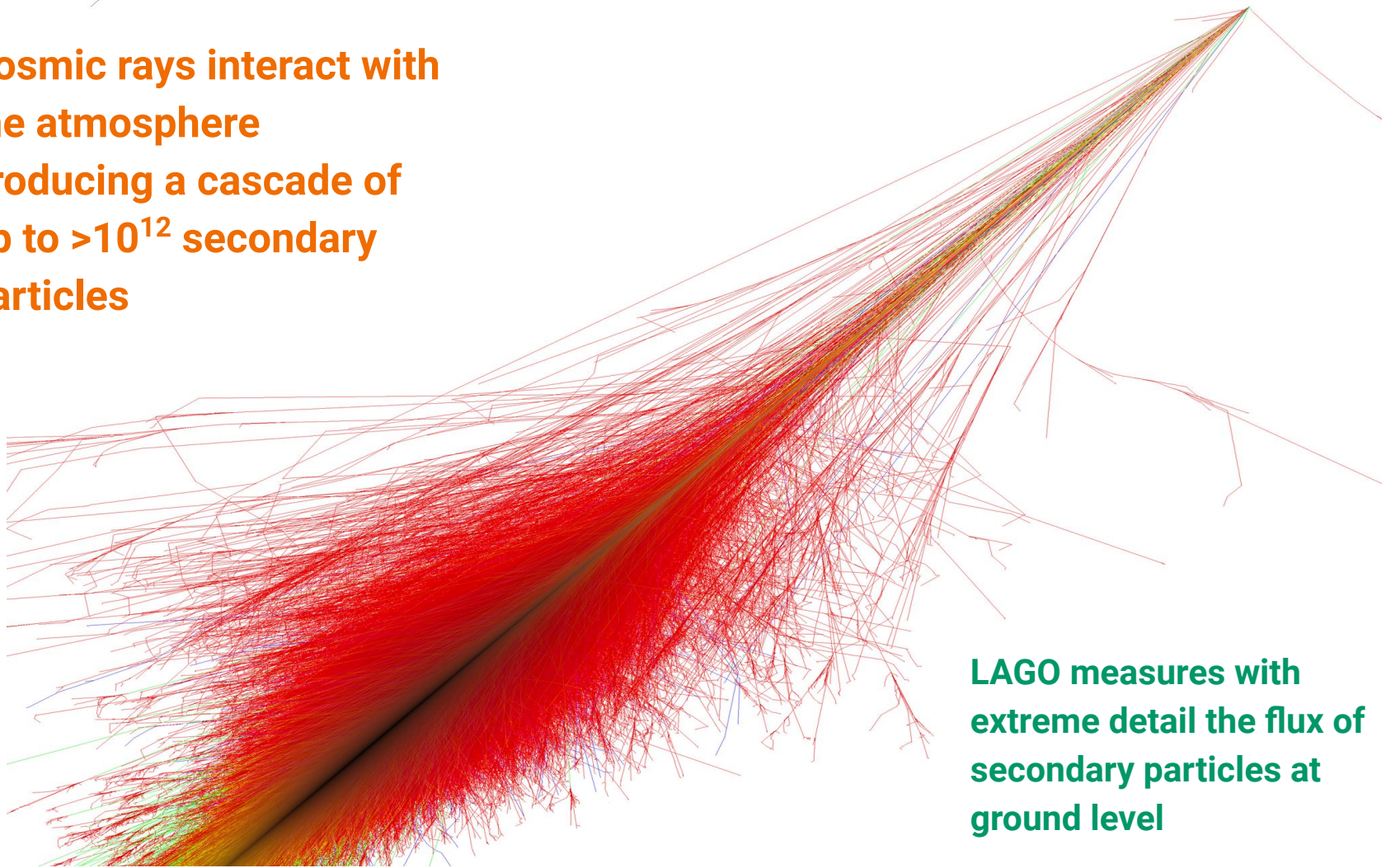
LAGO: Una iniciativa transcontinental para la explotación automática de capacidades de cálculo y almacenamiento

H. Asorey[1,2,3] on behalf of the LAGO Collaboration[4]

[1]CAB-CNEA/CONICET, Argentina [2]ITeDA&CAB-CNEA/CONICET/UNSAM, Argentina
[3]CIEMAT, Spain (temporarily)
[4]https://lagoproject.net
hernan.asorey@iteda.cnea.gov.ar

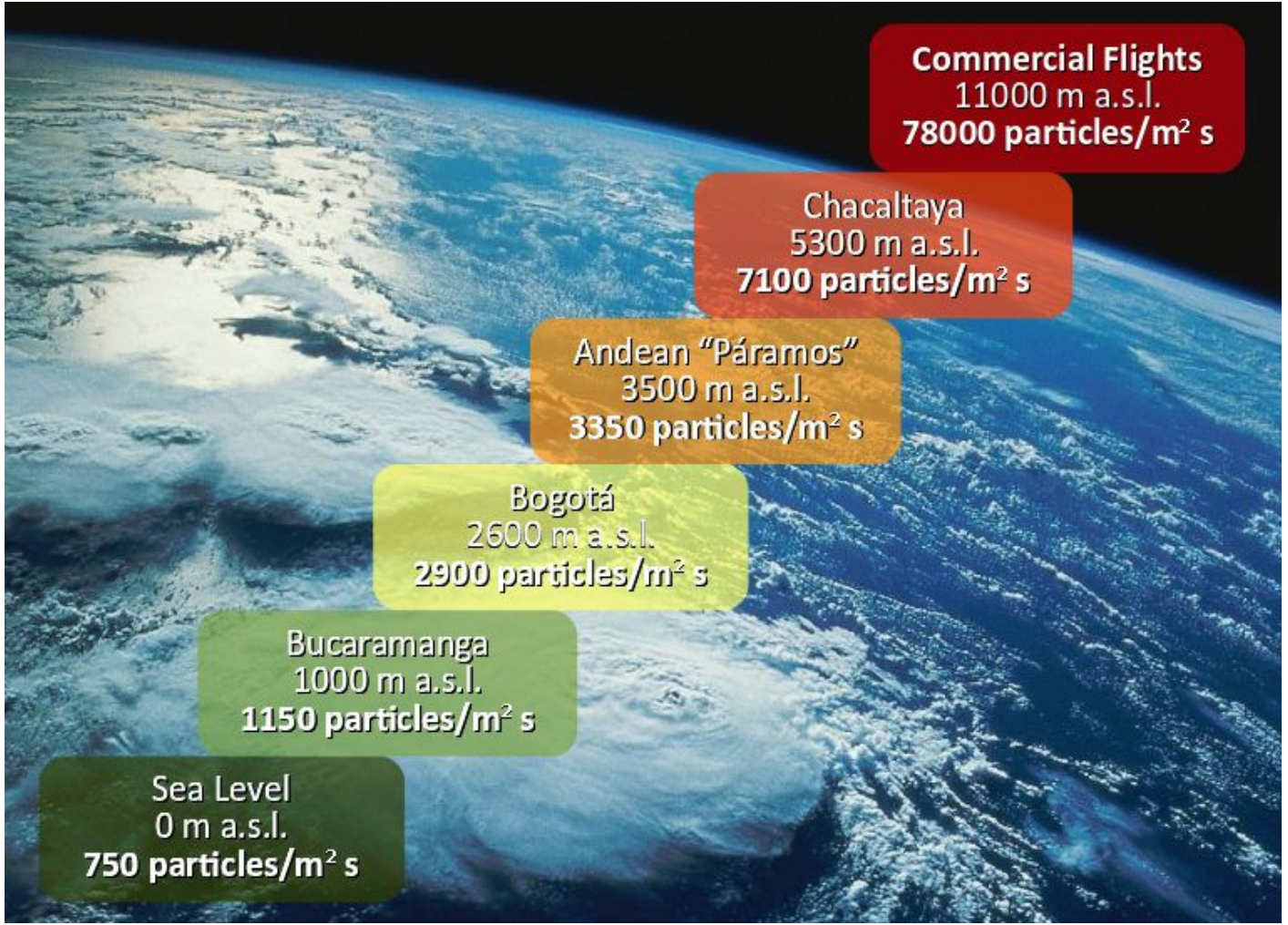
Latin America Giant Observatory
lagoproject.net

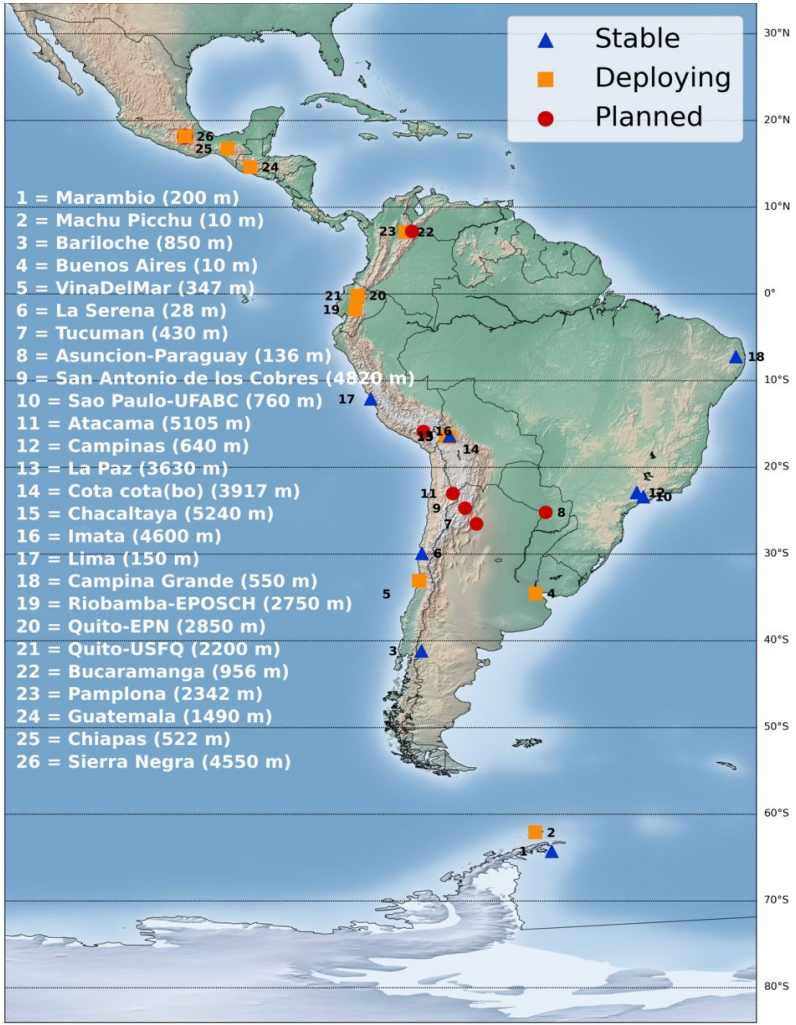
Cosmic rays interact with the atmosphere producing a cascade of up to >10^{12} secondary particles



LAGO measures with extreme detail the flux of secondary particles at ground level

Atmospheric reaction produces background radiation





The Latin American Giant Observatory

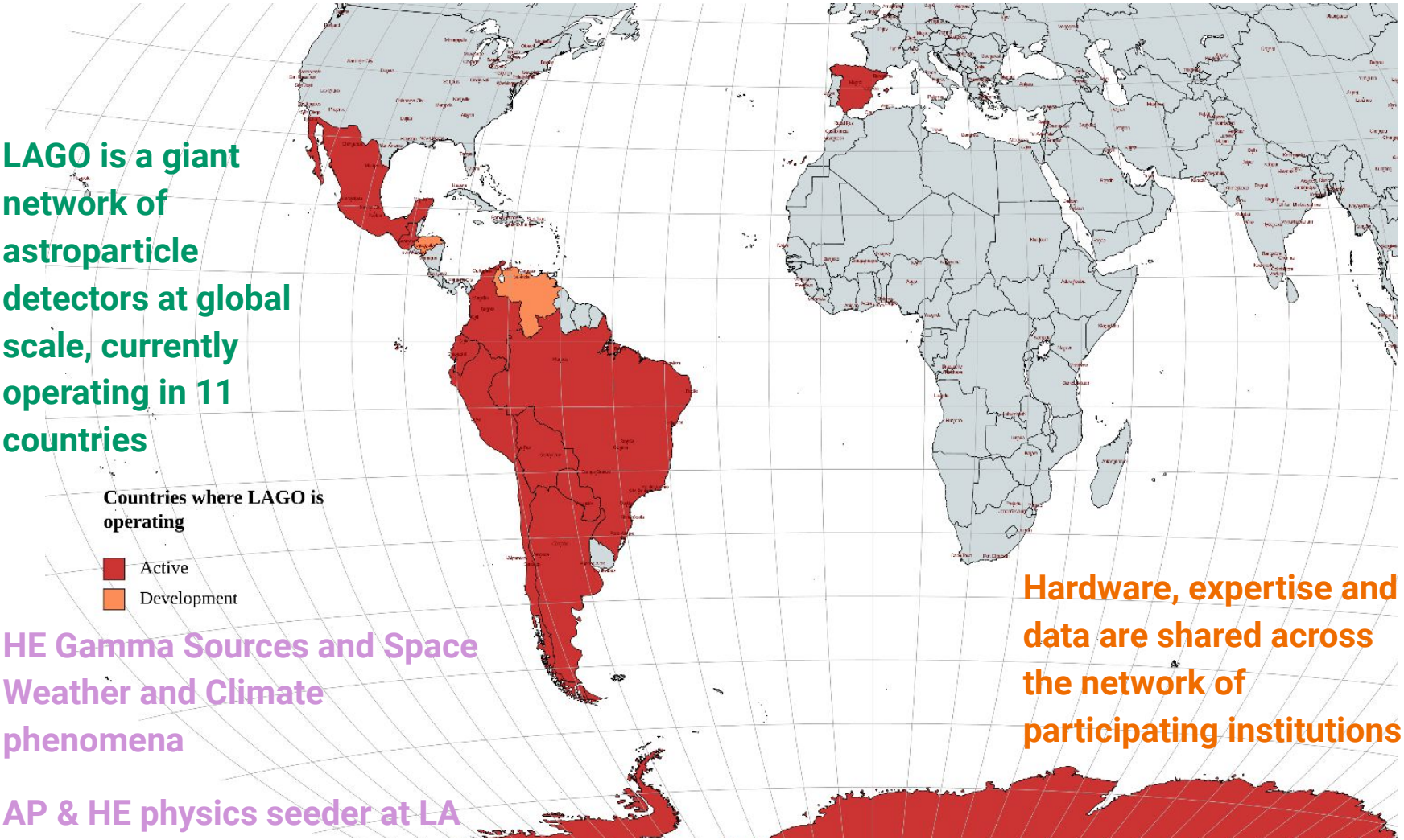
LAGO is an extended astroparticle observatory at continental scale: from México to Antarctica

1-10 m3 water Cherenkov detectors (WCD) deployed at **very different** altitudes and geomagnetic coordinates

The **time evolution of individual particles signals** registered at all the WCD are transferred and stored in a **central repository**

Simulated signals produced by EAS are calculated for **any detector** of **any type**, in any site **around the World** under **realistic time-evolving conditions**

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



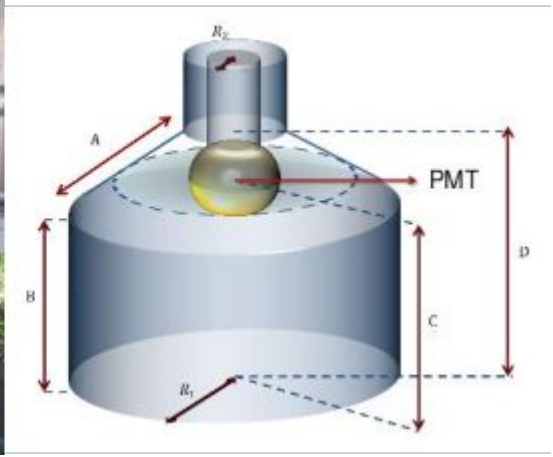
HE Gamma Sources and Space Weather and Climate phenomena

AP & HE physics seeder at LA

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

The Latin American Giant Observatory

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

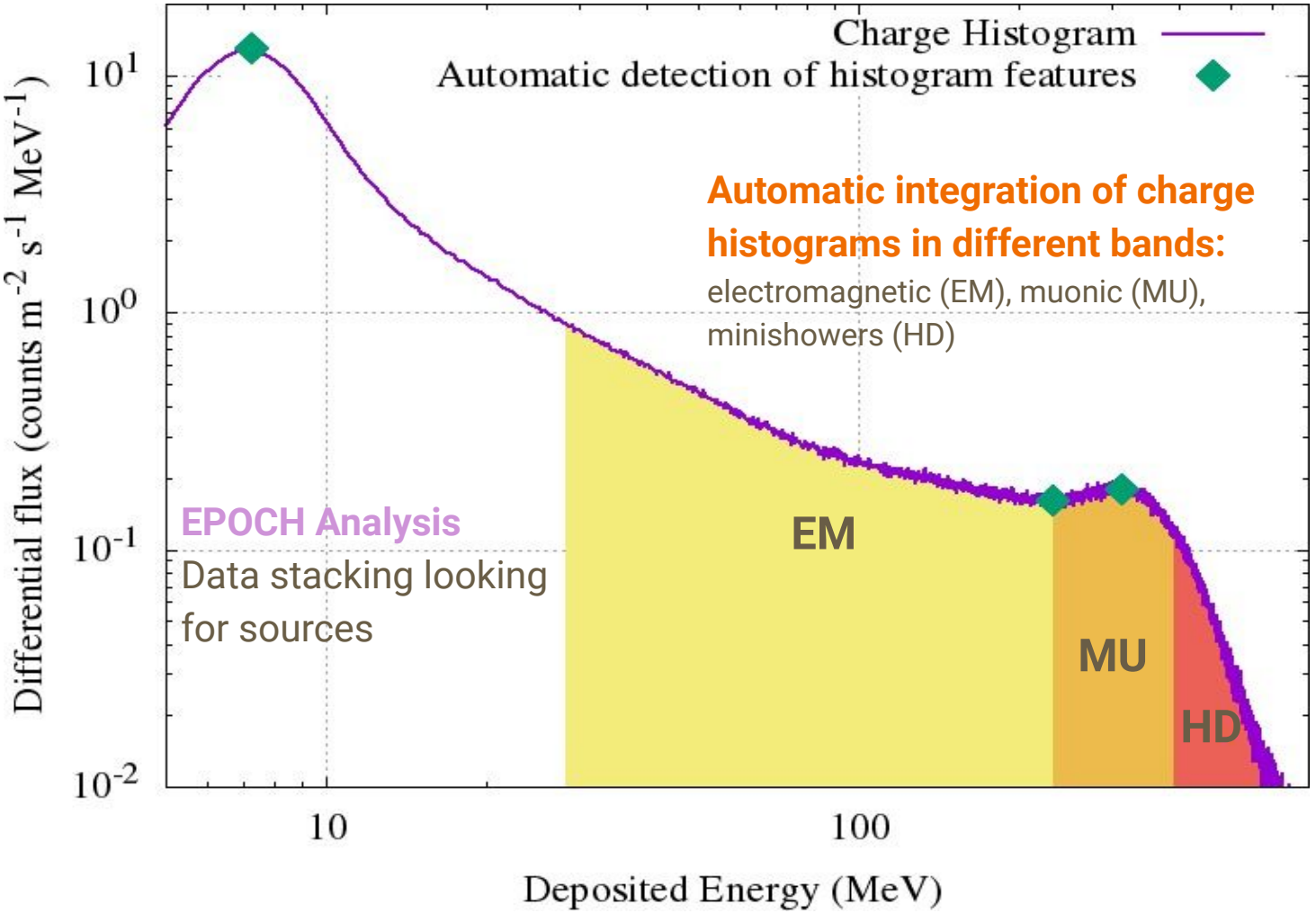
- Simultaneous measurements of secondaries at ground level
- Intensive simulation and data analysis frameworks

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

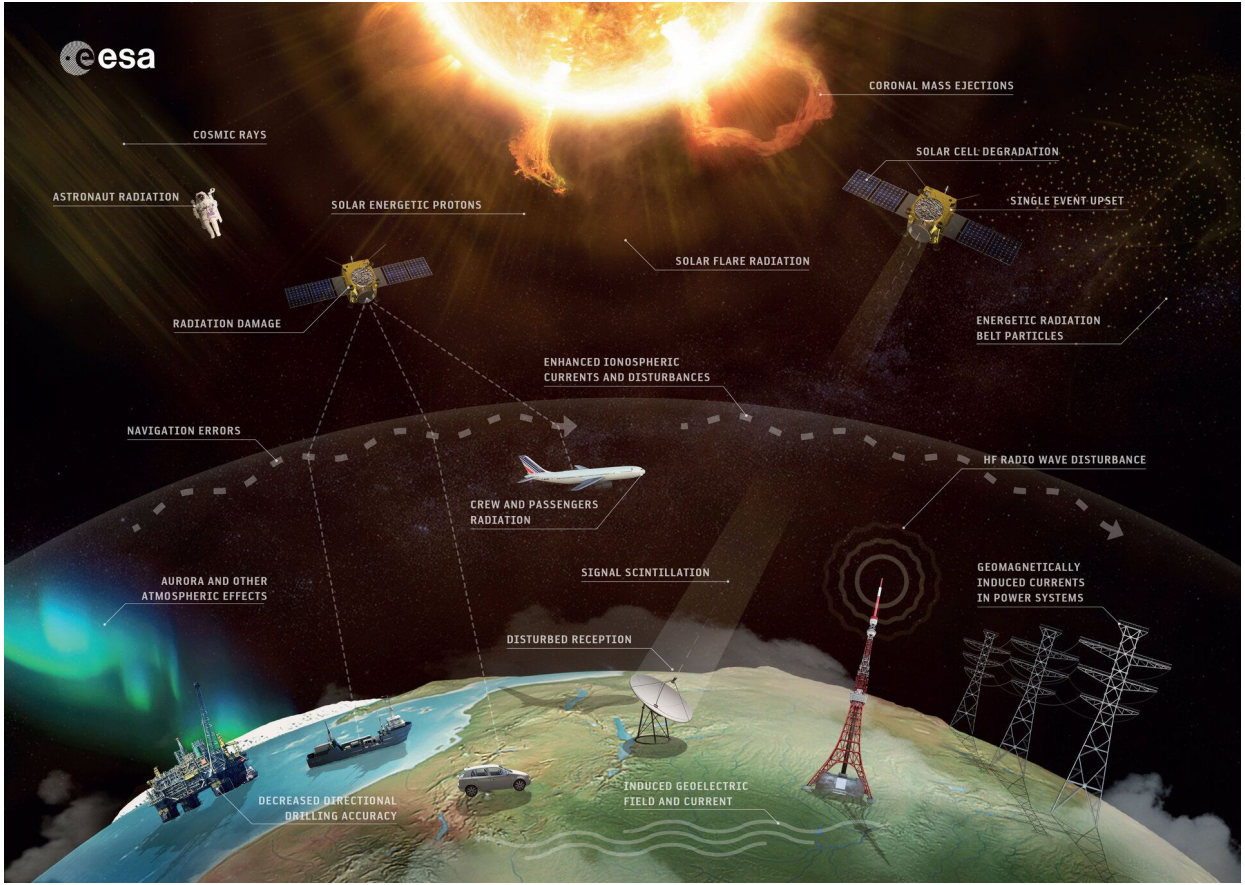

Charge Histogram
Automatic detection of histogram features
Automatic integration of charge histograms in different bands:
electromagnetic (EM), muonic (MU), minishowers (HD)
EPOCH Analysis
Data stacking looking for sources
EM
MU
HD
Differential flux (counts m-2 s-1 MeV-1)
Deposited Energy (MeV)
10
100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

LAGO SW

LAGO studies Earth-Sun connection

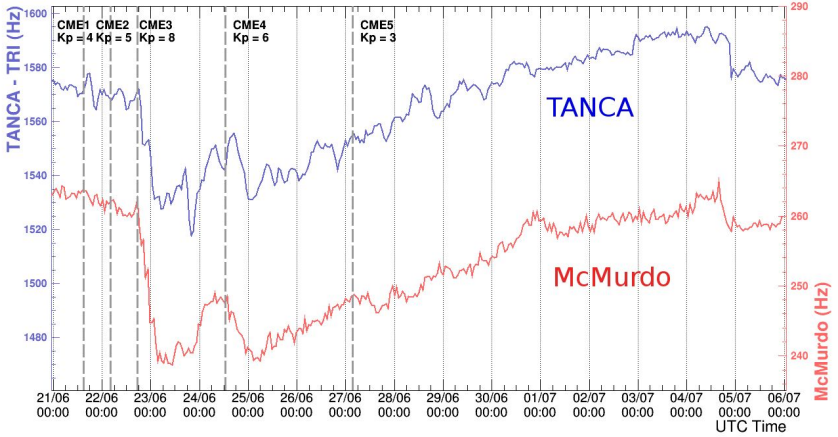
by measuring the time-evolving secondary signals from ground level. Atmospheric and geomagnetic conditions are continuously monitored

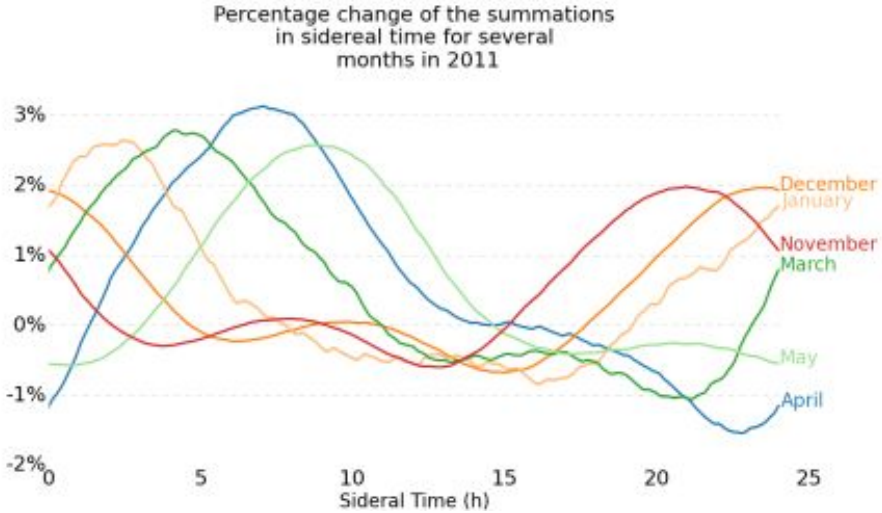
H. Asorey et al, PoS(ICRC2015)142

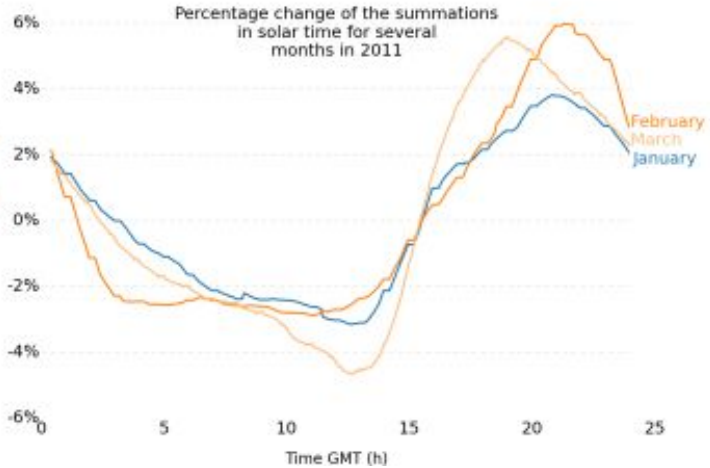


LAGO SW

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

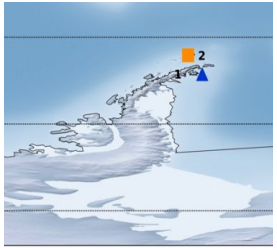


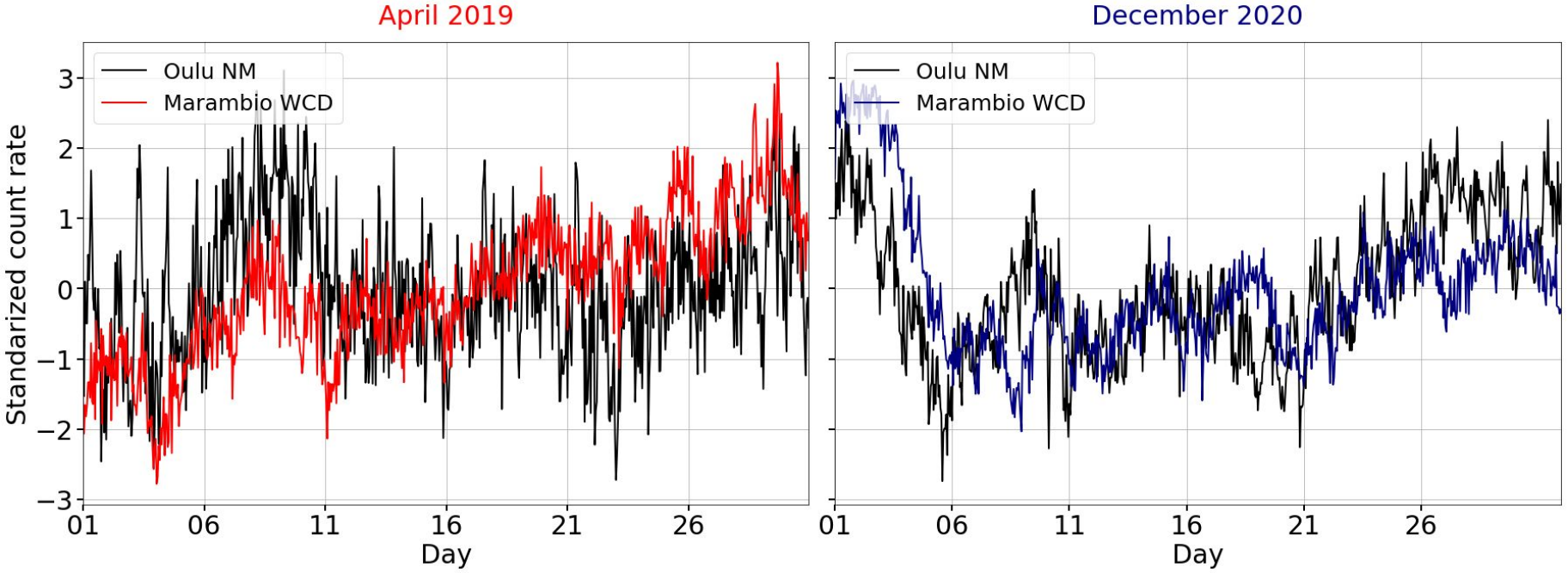




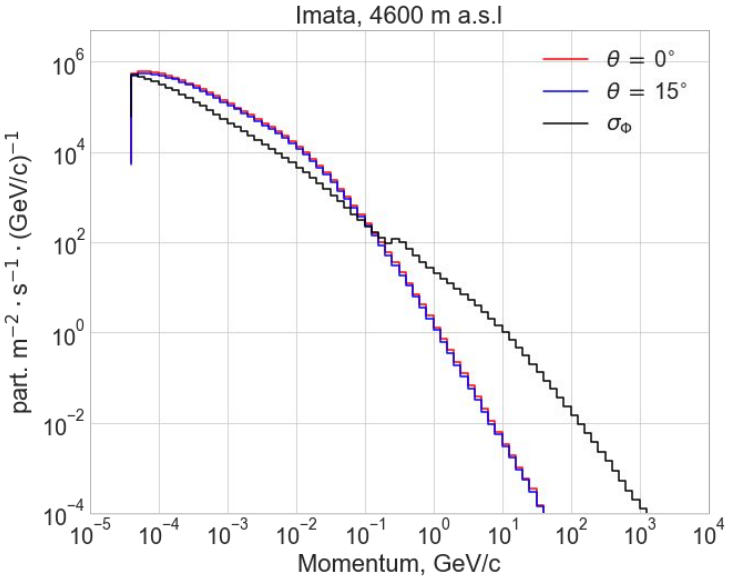
LAGO SW

Long term analysis for space climate at low rigidity sites: LAGO observations at the Antarctica Peninsula (N. Santos et al, PoS(ICRC2021)304)



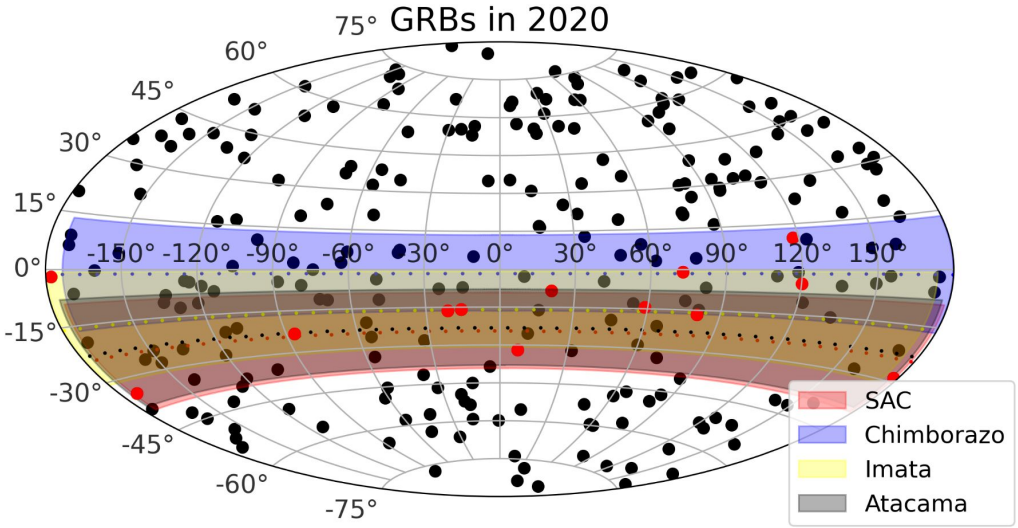


LAGO HE program



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

FOV overlapped by design for simultaneous measurements

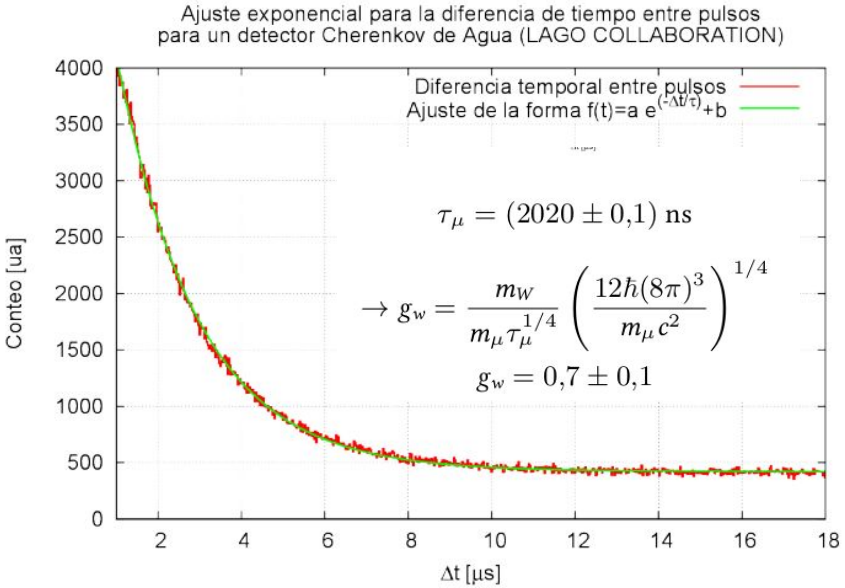


LAGO Capabilities for detecting high energy component of GRBs and Gamma Sources

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

LAGO Universities

Yearly LAGO workshop and AP&HE physics schools (hybrid mode since 2012!). More than **400 participating students in total**
Next edition Feb. 2022 @ Tucuman, Argentina



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)

LAGO Universities

The Latin American Giant Observatory (LAGO)

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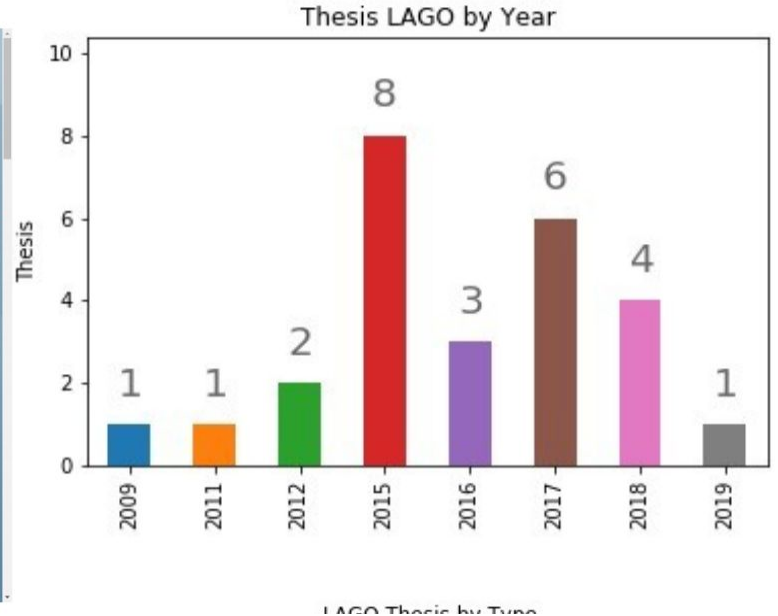
LAGO Thesis

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

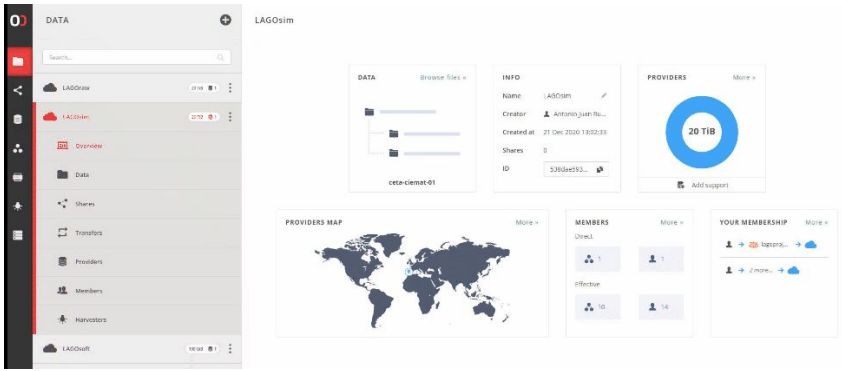
efficiency: (scientific production / investment) tends to infinity

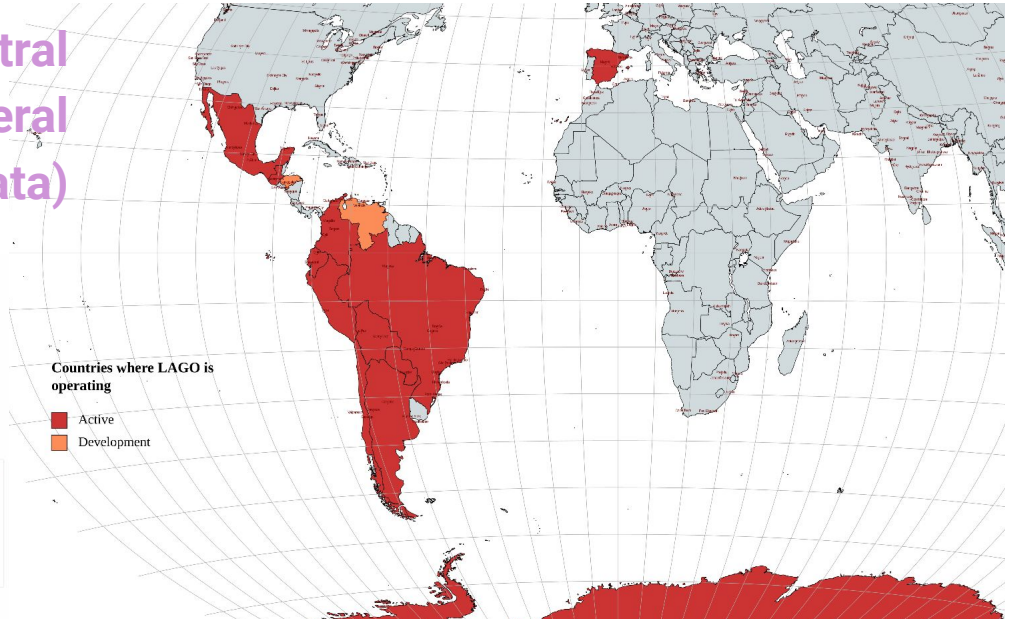
I. Sidelnik for LAGO, LAS4RI forum, 2020

LAGO Virtual

DART and FAIR protocols implemented in all the LAGO datasets. Data transfer and storage at central repositories. Supported by RedCLARA (LA) and EOSC (EU). **Routing throughout RedCLARA links had to be assured.**

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



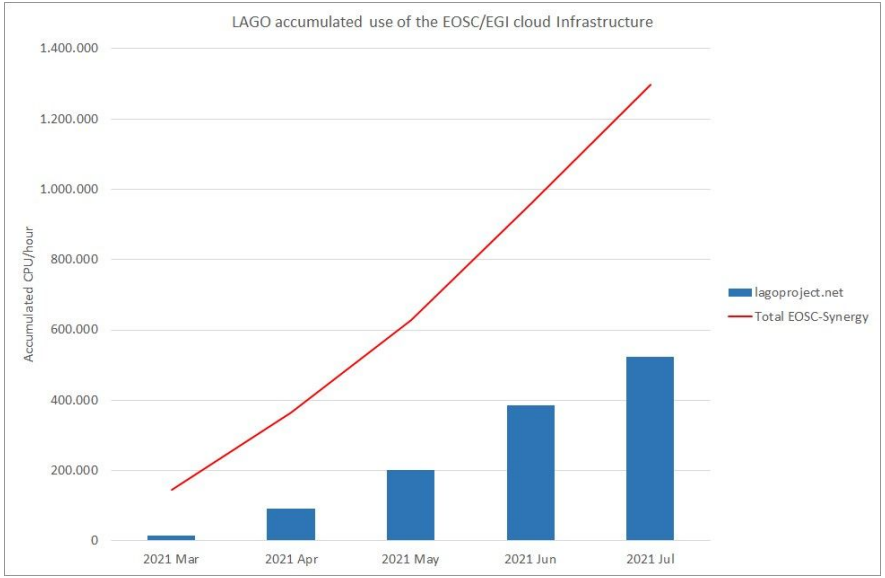


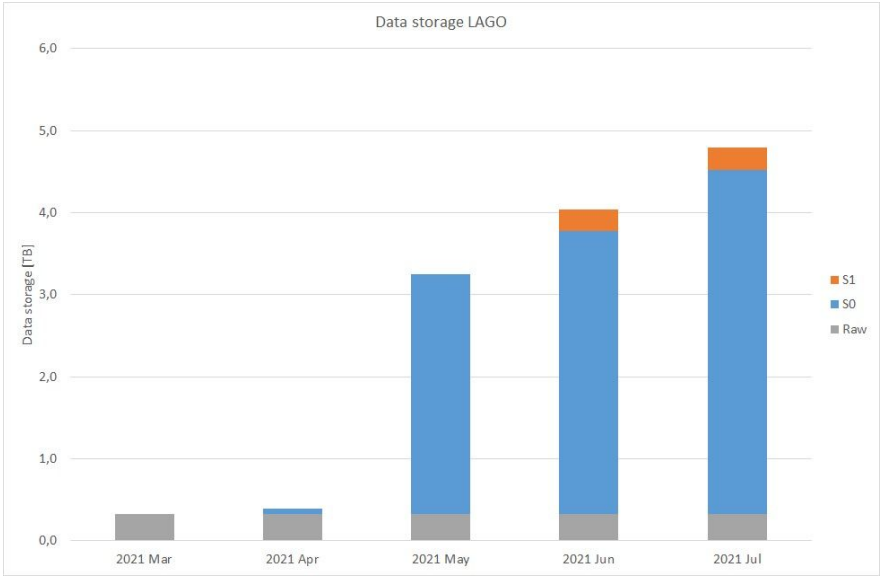
LAGO Virtual

Own designed hierarchical data analysis and virtualized docker-based tools

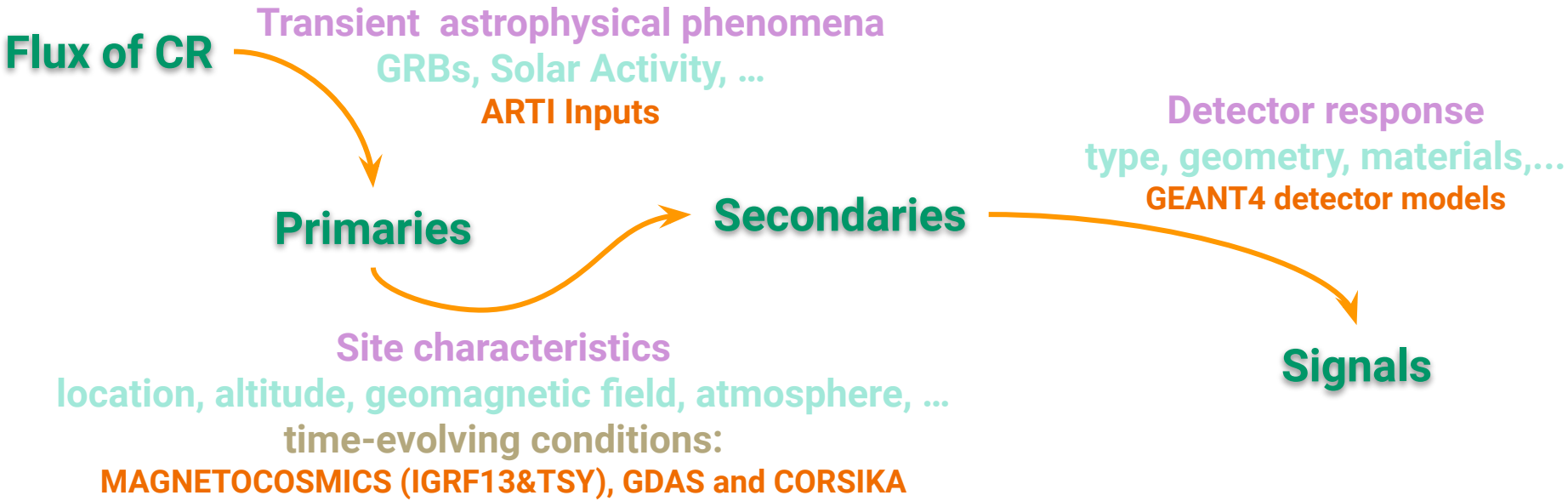
Measured: 2 TB/year-detector. 4 quality levels: L1: raw data, L2: preliminary, L3: Data Quality, L4: High Quality

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.





ARTI, the LAGO simulation framework



ARTI inputs → S0: raw Corsika → S1: secondaries → S2: signals

do_sims do_showers do_signals

EOSC-Synergy

European Open Science Cloud expanding the capacity and capabilities of EOSC by leveraging the experience, effort and resources of national publicly-funded digital infrastructures

Main objectives:

- Produce standardized computational mechanisms and tools for
  - production of simulated data (ARTI)
  - curation and analysis (ANNA) of measured and simulated data (ARTI)
- Enable open data and open science standards
  - open data: Findable, Accessible, Interoperable, Re-usable data
- Enable data and resources long-term sustainability

Cloud-based ARTI at EOSC-Synergy

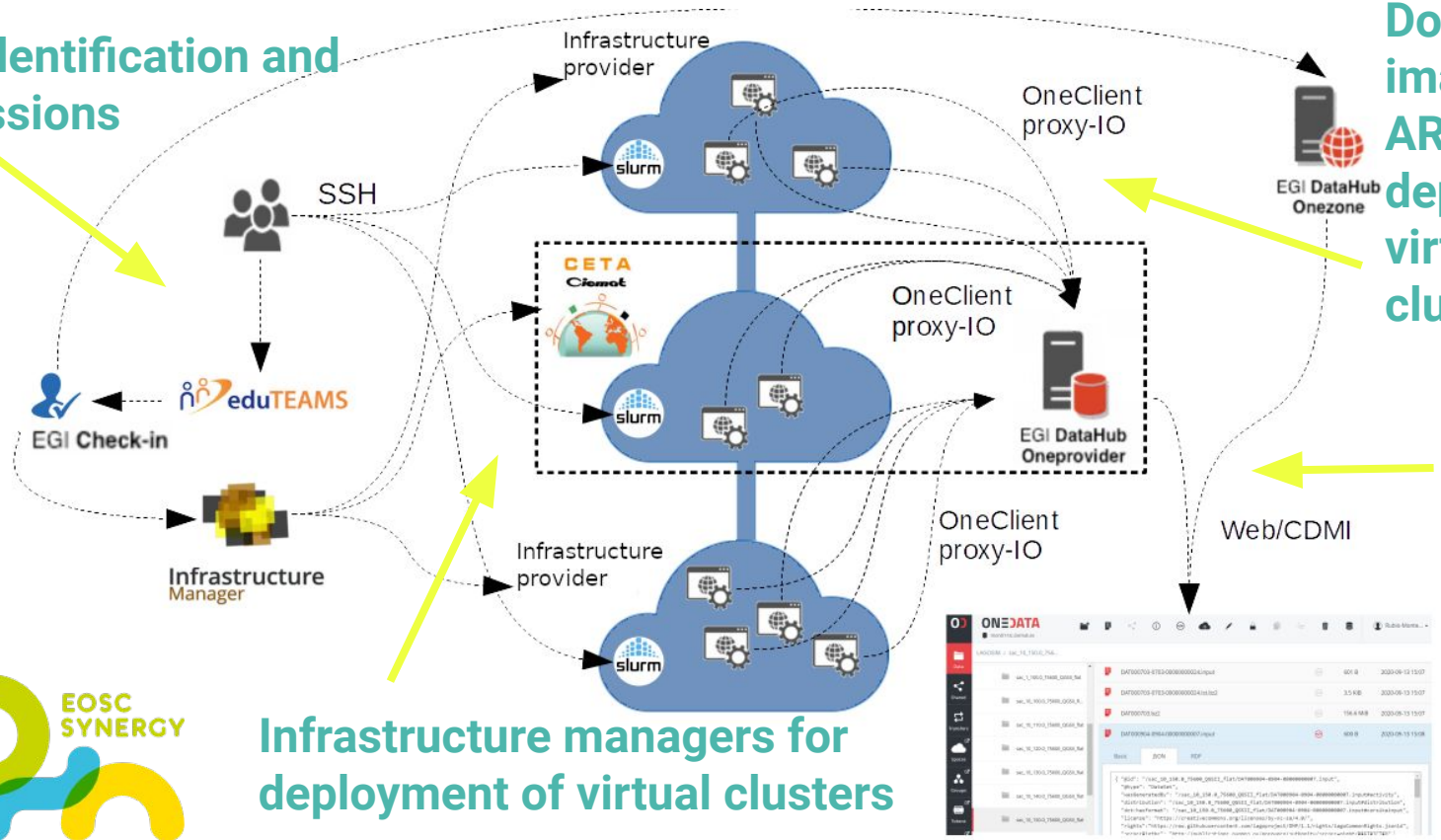
Partially funded by the EOSC-SYNERGY Horizon2020 RI project 857647.

User identification and permissions

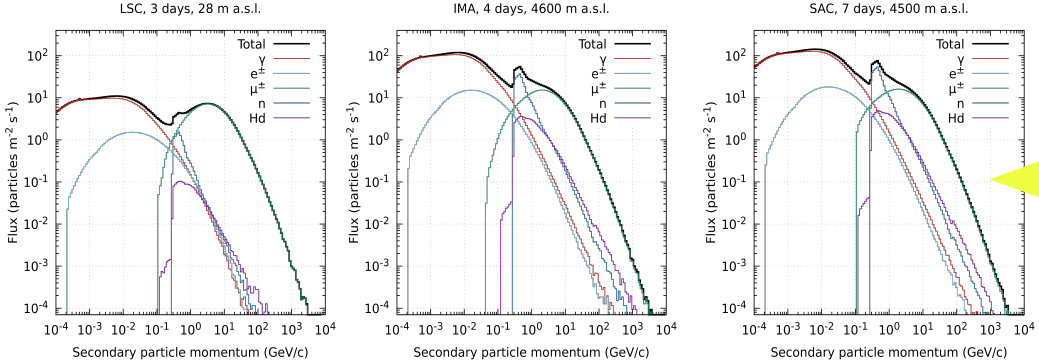
Docker images of ARTI deployed at virtual clusters

FAIR compliant data and metadata stored at cloud servers

Infrastructure managers for deployment of virtual clusters



1st run: >10^{11} sim EAS in 150 kh·proc (now 500 kh·proc & 4TB)

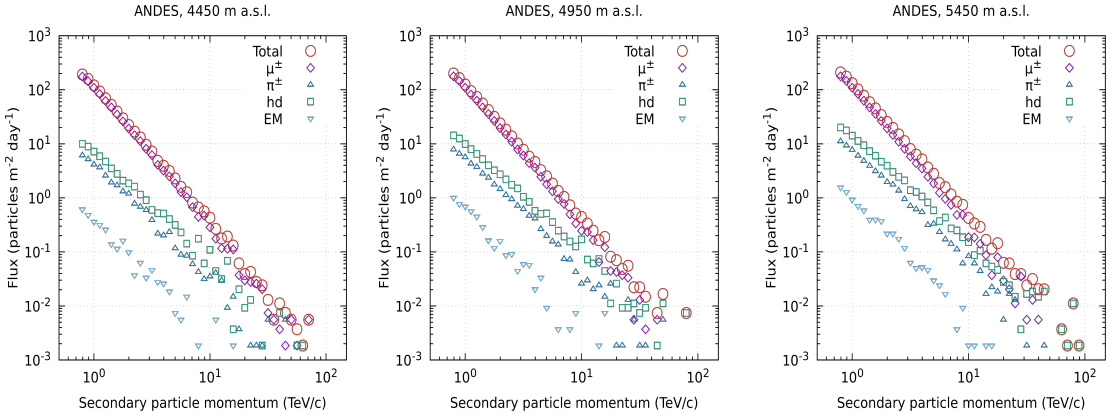


New detectors, integrated dose and better shieldings

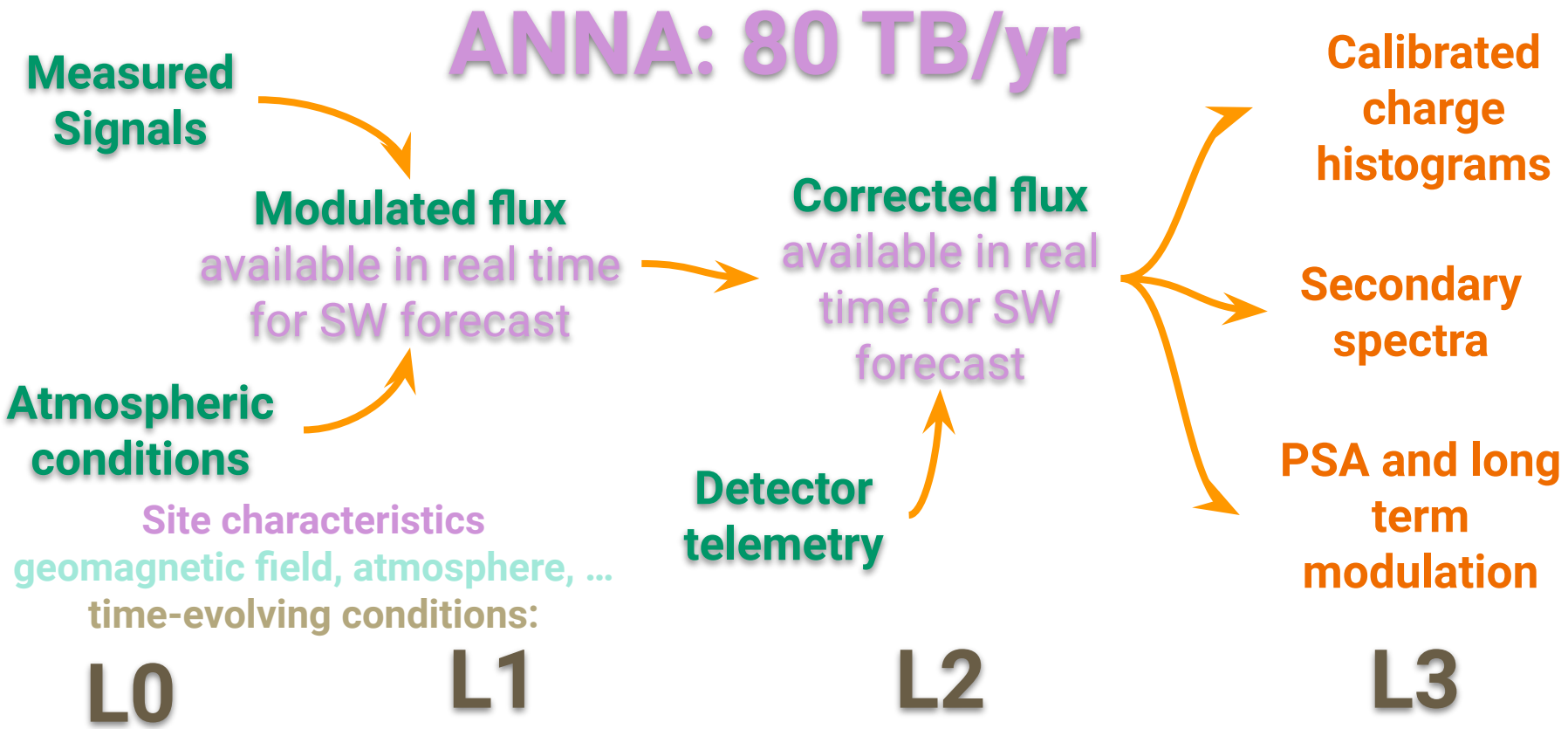
Detailed flux of of secondary particles at detector level for all LAGO sites and other locations **around the World.**

Muography and Underground LABs: One-year averaged flux of high-energy secondary particles at ground (p_s > 800 GeV/c)

Reference muon flux for underground laboratories and muography studies



Next: Measured data analysis and storage




Muchas gracias