LA Research infrastructure Cosmic Ray/Neutrino

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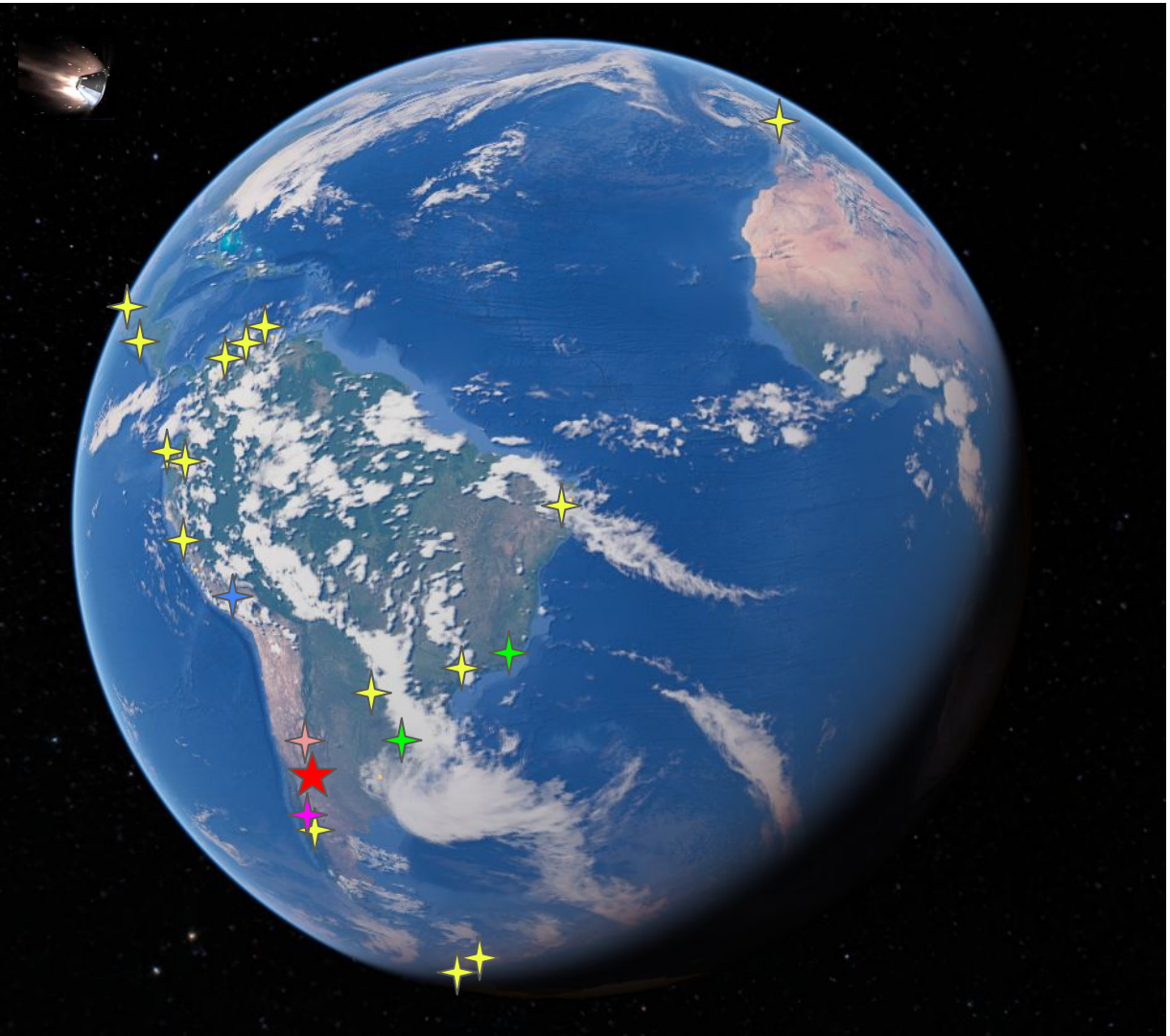
Ingo Allekotte (AUGER-CAB-Argentina)

Latin-American
Astro-particle
Physics Research
Network



Operational

- Pierre Auger Observatory
- LAGO: Latin American Giant Observatory
- CONNIE-Atucha: Coherent Neutrino-Nucleus Interaction Experiment

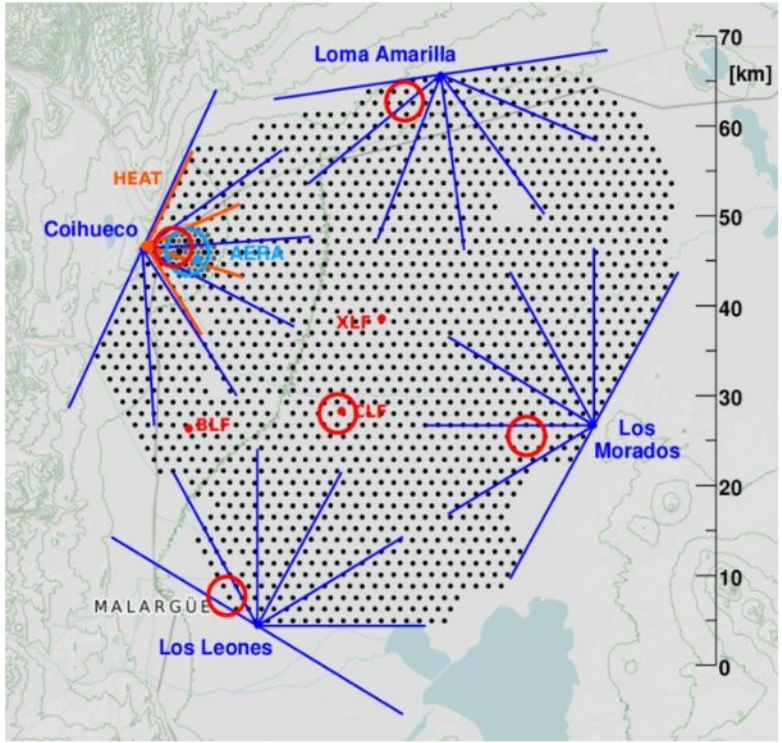
Planned

- HERON: Hybrid Elevated Radio Observatory for Neutrinos
- TAMBO:Deep-Valley Neutrino Observatory
- ANDES: Agua Negra Deep Experiment Site

Astroparticle cosmic ray/neutrino research infrastructure in Latin America

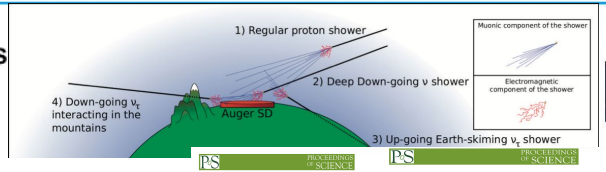
The Pierre Auger Observatory is by far the most important research infrastructure in Latin America for cosmic ray astrophysics and multimensager astrophysics

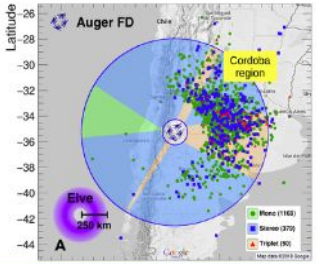
- Objective: study of cosmic rays of the highest energies.
- Area: 3000 km^2
- 1660 surface detectors
  - Water Cherenkov Detectors
  - Scintillators
  - Radio antennas
  - New electronics
  - Underground muon detectors (infill)
- 27 fluorescence telescopes
  - Atmospheric monitoring devices

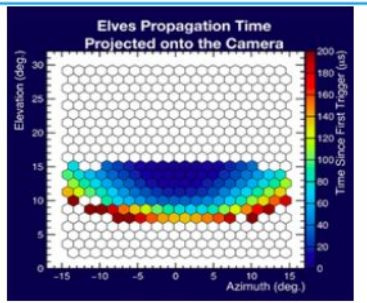


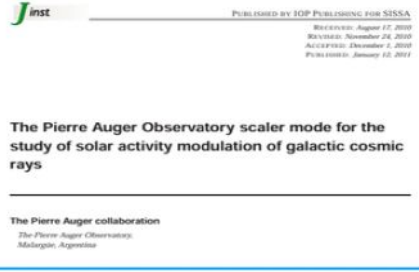
SCIENTIFIC IMPACT

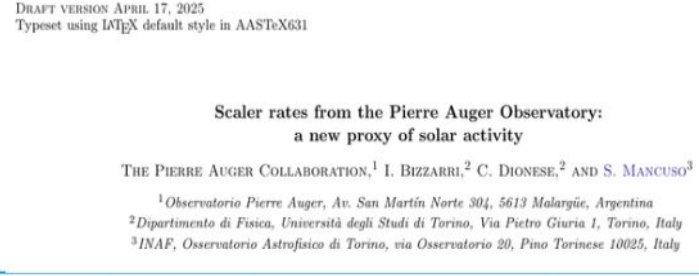
- From 2004 to 2025: 141 full-author list papers (+ 11 submitted) in refereed journals
- Hundreds of conference proceeding papers
- Papers on new subjects:
  - Scalers and solar activity (ICRC2025#943)
  - Atmospheric studies, ELVES, TGF's (ICRC2025#845,998)
  - Discoveries with FRAM telescope

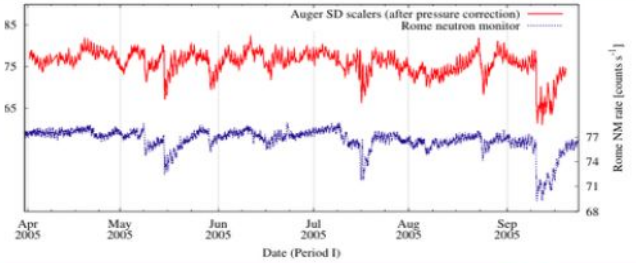












INFRASTRUCTURE FOR SCIENCE PROJECTS

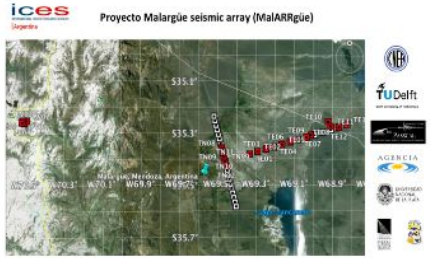
Available infrastructure, land access, trained technicians

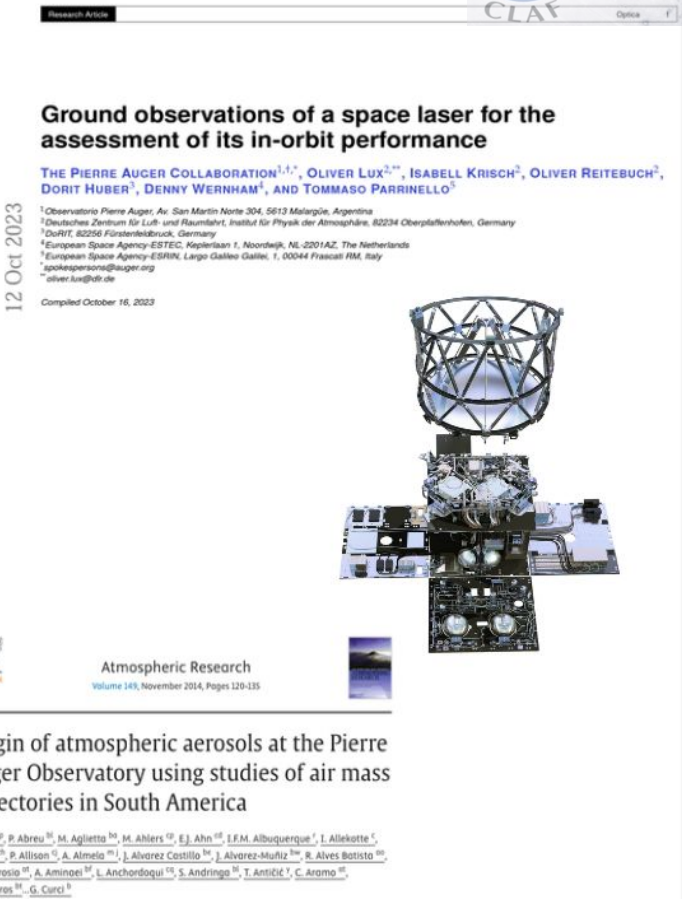
- AERA radio-array
- MIDAS, EASIER, AMBER GHz CR radio-detection
- FAST single-pixel FD
- AEOLUS satellite calibration
- EarthCare satellite (ICRC2025#226)
- GRAND prototypes (ICRC2025#1138)
- IceCube prototypes (ICRC2025#428)

- Reflector cones for CONAE (satellite calibration)

- Installation and maintenance of arrays of seismic sensors

- Instruments for aerosol studies




Research Article

Ground observations of a space laser for the assessment of its in-orbit performance

The Pierre Auger Collaboration[1,†,*], Oliver Lux[2,**], Isabell Krisch[2], Oliver Reitebuch[2], Dorit Huber[3], Denny Wernham[4], and Tommaso Parrinello[5]

[1]Observatorio Pierre Auger, Av. San Martin Norte 304, 5613 Malargüe, Argentina
[2]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Physik der Atmosphäre, 82234 Oberpfaffenhofen, Germany
[3]DoRIT, 82256 Fürstenfeldbruck, Germany
[4]European Space Agency-ESTEC, Keplerlaan 1, Noordwijk, NL-2201AZ, The Netherlands
[5]European Space Agency-ESRIN, Largo Galileo Galilei, 1, 00044 Frascati RM, Italy
[*]spokespersons@auger.org
[**]oliver.lux@dlr.de

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12 Oct 2023

Atmospheric Research
Volume 149, November 2014, Pages 120-135

Origin of atmospheric aerosols at the Pierre Auger Observatory using studies of air mass trajectories in South America

A. Aab[ap], P. Abreu[bi], M. Aglietta[bn], M. Ahlers[ar], E.J. Ahn[ad], I.F.M. Albuquerque[r], I. Allekotte[c], J. Allen[ch], P. Allison[ci], A. Almela[m,l], J. Alvarez Castillo[bx], J. Alvarez-Muñiz[bw], R. Alves Batista[bo], M. Ambrosio[at], A. Aminaei[af], L. Anchordoqui[cs], S. Andringa[bi], T. Antičić[y], C. Aramo[at], F. Arqueros[bt], G. Curci[b]

A Science Hub to test new scientific instrumentations

- LAGO Project (https://lagoproject.net): Latin-American collaboration to install WCDs and measure low energy cosmic radiation at different latitudes and altitudes

- Muonography projects, detector development

METEORED

El Tiempo en...

Buenos Argentina

Tiempo Noticias Videos Avisos Radar Mapas Satélites Modelos

Entrevista: meteorología espacial por argentinos en la Antártida

Conversamos con los doctores en física Adriana Gulisano y Sergio Dasso, especialistas en meteorología del espacio, para que nos cuenten como se estudian los rayos cósmicos alrededor del mundo, y los detalles del primer detector argentino en la Antártida.

Científicos argentinos en la Base Marambio. De izquierda a derecha: Tech Omar Areso, Dr. Adriana María Gulisano, Dr. Sergio Dasso, Ing. Matías Pereira en la base Marambio.

The LAGO Collaboration

LAGO is an Auger Observatory spinoff collaboration with 83 members from 25 institutions at 10 LA countries & Spain

Scientific goals:

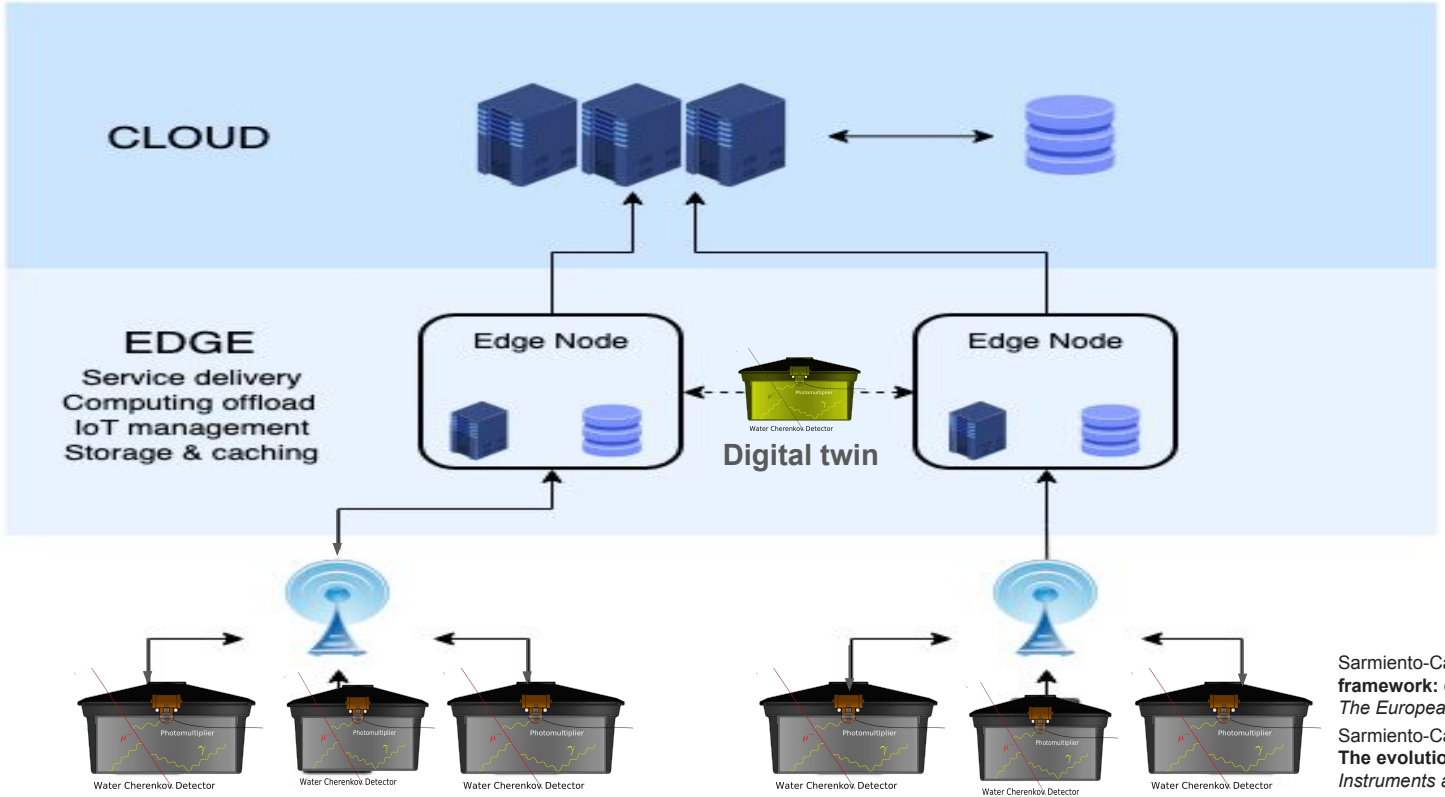
- Astroparticles up to the Cosmic Ray knee
- Study transient and long term Space Weather
- Applications of Cosmic Rays (Muography/Moisture)

Academic goals:

- *Capacity Building in HECAP Erasmus/CyTED*
- *Build a Latin-American network of Astroparticle researchers*

- Instrumentation
- Simulation framework
- Training in AstroParticle

LAGO Edge Computing Program



Collaboration level

Institutional level

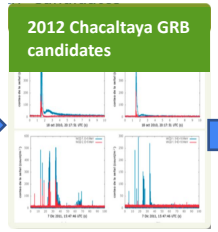
Field level

Sarmiento-Cano, & LAGO Collaboration. (2022). **The ARTI framework: cosmic rays atmospheric background simulations**. *The European Physical Journal C*, *82*(11), 1019.

Sarmiento-Cano, C. et al (2026). **From a network to a networking: The evolution of the Latin American Giant Observatory.** *Nuclear Instruments and Methods in Physics Research Section A*, 171328.

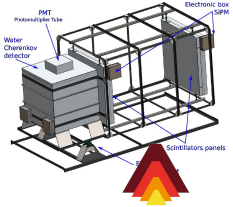
2011 first WCD

2012
Chacaltaya GRB Analysis



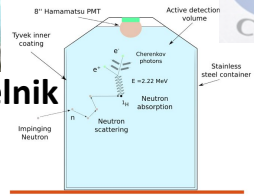
2015
LAGO Space Weather
Auger Member

Volcano Muon Tomography



MuTe

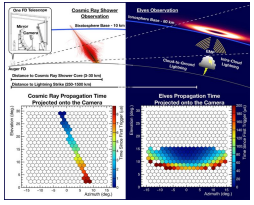
Ivan Sidelnik



Precision agriculture with cosmic rays

Roberto Mussa
Piera Ghia

ELVES & lighting analysis

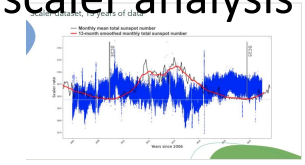


Xavier Bertou

Hernán Asorey

CosmoGeophysics

Long/short term scaler analysis

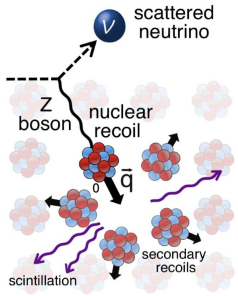


Ronald Cintra Shellard

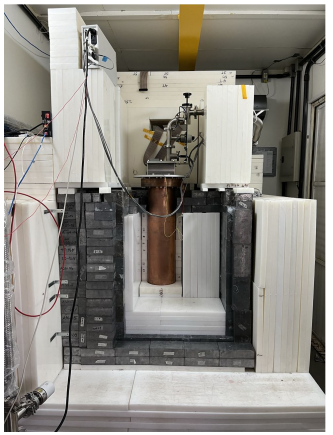
Sinergy Auger and LAGO observatories influence in Colombian Astroparticle Physics

CONNIE-Atucha: Coherent Neutrino-Nucleus Interaction Experiment

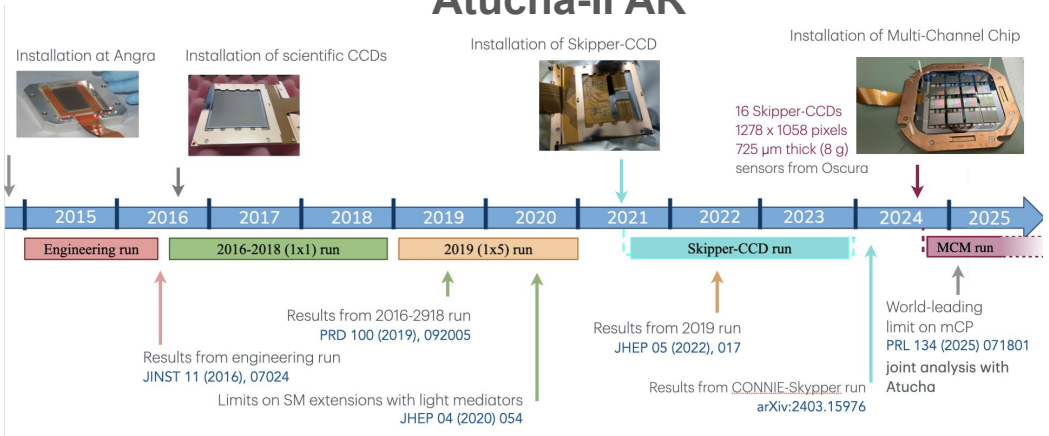
- Brazil (**Angra 2**) and Argentina (**Atucha-II**) possess nuclear power reactors with high-intensity neutrino sources.
- CONNIE and Atucha-II are designed to search for and measure coherent elastic neutrino–nucleus scattering of **reactor antineutrinos on silicon**.
- CONNIE-Atucha-II main achievement is pushing the threshold down to **15 eV scale!!**, which is best for **light mediators**.
- Atucha-II & CONNIE helped set a millicharge limit reaching about **ε ~ 10^{-6}** for masses near **1eV** world leading limit.

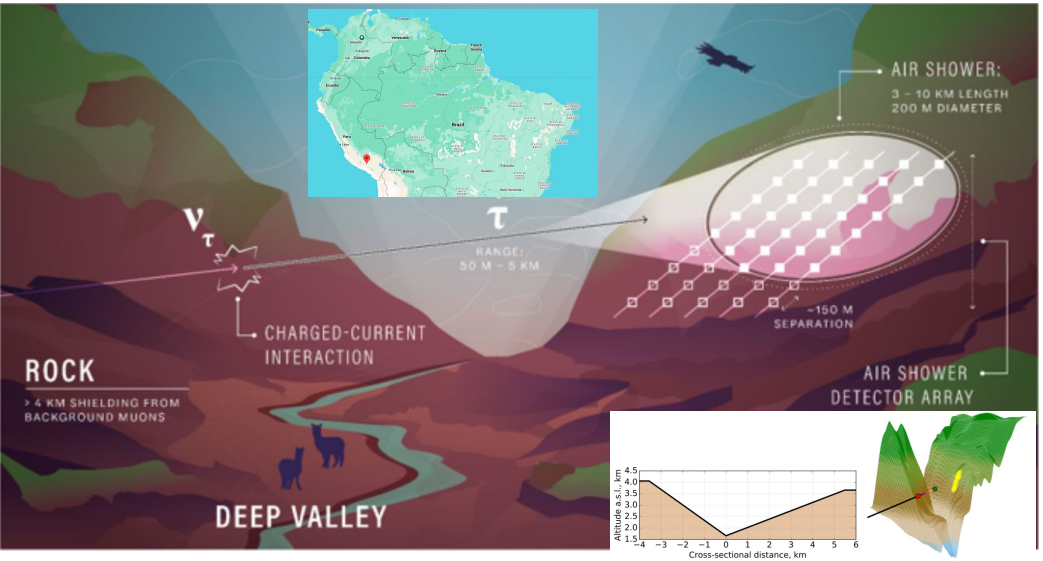


Angra2 BR



Atucha-II AR



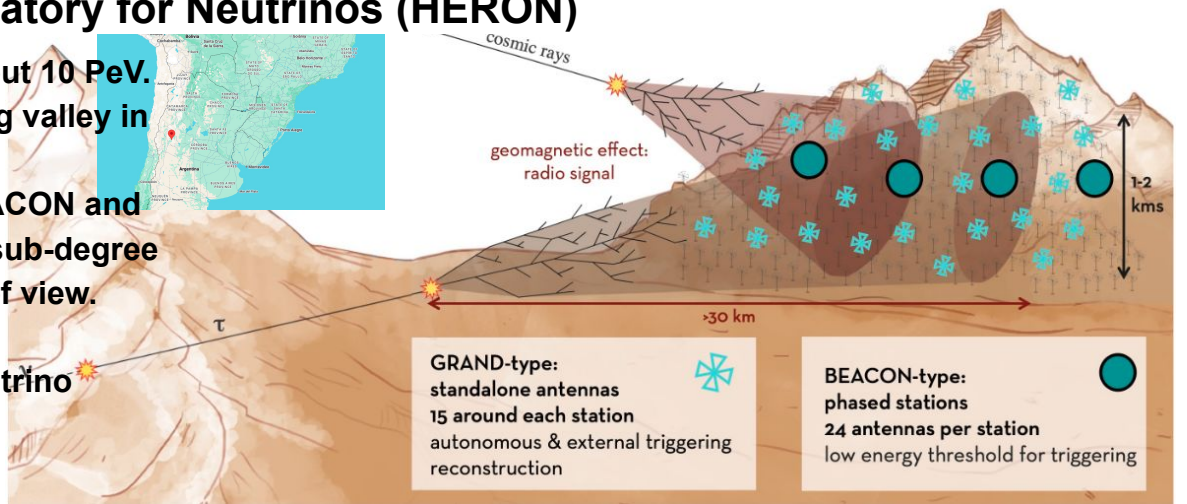


Tau Air Shower Mountain-Based Observatory (TAMBO)

- The observatory will be located in a deep canyon in Peruvian andes.
- It will comprise an array of water-Cherenkov and plastic scintillator air-shower detectors to detect a high-purity sample of astrophysical, Earth-skimming tau neutrinos about 10 PeV

The Hybrid Elevated Radio Observatory for Neutrinos (HERON)

- For ultra-high-energy neutrinos above about 10 PeV.
- It is planned at 1,000m across a 72 km-long valley in Argentina's San Juan province.
- It combines two radio techniques, the BEACON and GRAND prototypes, with high sensitivity, sub-degree angular resolution, and a wide daily field of view.
- It can be operated as part of the global multimessenger network to search for neutrino bursts from candidate cosmic-ray sources



ANDES - Agua Negra Deep Experiment Site

Agua Negra Tunnel Features

- Altitude: 3600m asl Chile, 4085m asl Argentina
- Two parallel tunnels: 14 km long, 60m separation
  12 m diameter (2 lanes each)

Deepest point: 1750 m depth. Slope 3%.

ANDES as multidisciplinary research facility

- Neutrino Physics
  - host double beta decay experiments
  - large neutrino detector (similar to KamLAND / Borexino)
  - focused on low energies (solar / SN / geoneutrinos)
- Dark Matter
  - opposite weather induced modulations
  - new detector technologies
- Nuclear Astrophysics
- Geophysics:
  - enhanced sensitivity to local and global events
  - link of seismograph networks (Chile-Argentina)
- Biology: low radiation measurements (see DULA Bio workshop 2015)

There is no Tunnel yet!

Views of the Agua Negra pass


Rayo cósmico
Núcleo atmosférico
Componente electromagnética
Componente hadrónica
Componente muónica
Neutrinos
That's all Folks!

ARTI Simulation framework

Eur. Phys. J. C (2022) 82:1019

Sarmiento-Cano, & LAGO Collaboration. (2022). **The ARTI framework: cosmic rays atmospheric background simulations**. *The European Physical Journal C*, *82*(11), 1019.

Taboada, A., et al.. (2022). **Meiga, a dedicated framework used for muography applications.** *Journal of Advanced Instrumentation in Science*.

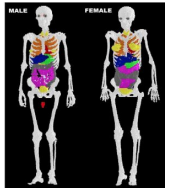
Files used by CORSIKA for simulation setup

MAGCOS uses CORSIKA to produce a corrected flux

Perl language | **Root & C++**

1 Input | 2 Steering files | 3 Corsika | 4 MAGCOS | 5 Geant4

Bash interface | **Fortran & C++**

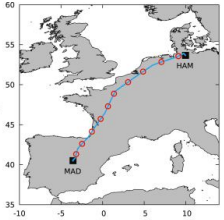


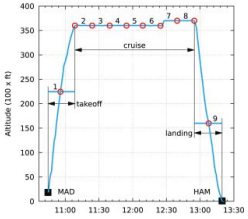
Initial conditions as energy interval, zenith, azimuth and geomagnetic field.

Output: Binary files and pre-analysis files.

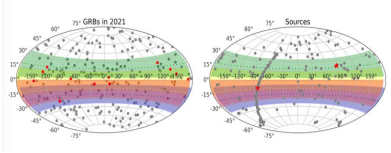
Output: Distribution of photoelectrons & Charge histogram

MuTe



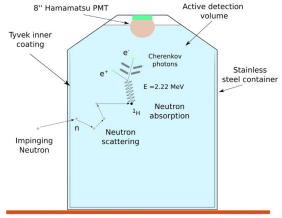


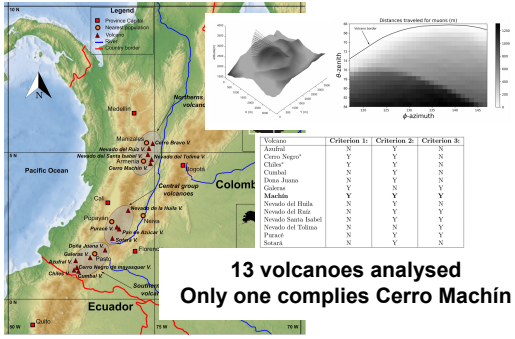
Asorey, H., Suárez-Durán, M., & Mayo-García, R. (2023). **ACORDE: A new application for estimating the dose absorbed by passengers and crews in commercial flights**. *Applied Radiation and Isotopes*, *196*, 110752.



Sidelnik, I.,& LAGO Collaboration. (2023). **The capability of water Cherenkov detectors arrays of the LAGO project to detect Gamma-Ray Burst and high energy astrophysics sources.** *Nuclear Instruments and Methods in Physics Research 1056*, 168576.

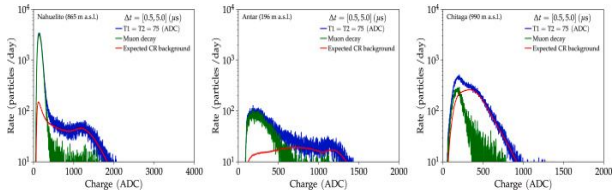
Country	Site	Altitude [m asl]	Latitude [deg]	Longitude [deg]
Sierra Negra	SNG	4,550	18.2 N	97.9 W
Chimborazo	CHI	5,000	1.5 S	78.8 W
Imata	IMA	4,600	15.9 S	71.1 W
Atacama	ATA	5,100	23.0 S	67.8 W
S. A. de los Cobres	SAC	4,500	24.2 S	66.3 W





Volcano	Criterion 1:	Criterion 2:	Criterion 3:
Azufral	N	Y	N
Cerro Negro*	Y	Y	N
Chiles*	Y	Y	N
Cumbal	Y	Y	N
Doña Juana	N	Y	N
Galeras	N	Y	N
Machín	**Y**	**Y**	**Y**
Nevado del Huila	N	Y	N
Nevado del Ruiz	N	Y	N
Nevado Santa Isabel	N	Y	N
Nevado del Tolima	N	Y	N
Puracé	N	Y	N
Sotará	N	Y	N

13 volcanoes analysed
Only one complies Cerro Machín



Otiniano, L.,& LAGO Collaboration. (2023). **Measurement of the muon lifetime and the Michel spectrum in the LAGO water Cherenkov detectors as a tool to enhance the signal-to-noise ratio.** *Nuclear Instruments and Methods in Physics Research 1056*, 168567.

Betancourt, J., et al. (2025). **Enhanced water Cherenkov detector for soil moisture detection.** *arXiv preprint arXiv:2509.08562*.

Sarmiento-Cano, C., et al. (2026). **Water Cherenkov Detectors in Precision Agriculture: A Novel Approach for High-Resolution Soil Moisture Monitoring**. arXiv preprint arXiv:2601.17595.

Vesga-Ramírez, A., et al (2020). **Muon Tomography sites for Colombian volcanoes.** *ANNALS OF GEOPHYSICS*, *63*(6).

Martínez-Rivero, R. A., et al (2025). **Muon imaging of hydrotreatment reactors.** *Journal of Applied Physics*, 138(24).