

The Pierre Auger Observatory: science, cooperation & impact

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CLAF-MCTI High-Level Meeting
2023



CNEA - CONICET - UNSAM



PIERRE
AUGER
OBSERVATORY

The Pierre Auger Collaboration & Observatory

>400 scientists, technicians from
18 countries (82 institutions):

Argentina*, Australia, Belgium, **Brazil***,
Colombia, the Czech Republic, France,
Germany, Italy, **Mexico***, the Netherlands,
Peru, Poland, Portugal, Romania, Slovenia,
Spain, and the United States of America.

** founders members*



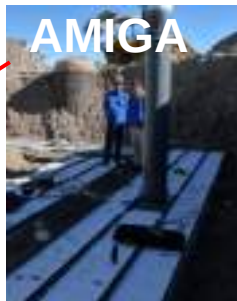
Latin-America

	Institutions	Researchers (OCL)	On-going PhD
Argentina	10	38	17
Brazil	13	17	6
Colombia	2	3	1
Mexico	5	8	-
Peru	1	2	-

More than 20% human resources from LA countries



The Pierre Auger Observatory



Coihueco

AERa

Loma Amarilla

Fluorescence Telescopes

Los Leones

Los Morados

XLF's

CLF's

[km]

COSTS

Construction 53 MUSD

Operation & Maintenance* 1,7 MUSD/year

*shared based on number of senior collaborators (Op. Cost List, OCL)

*local staff > 30 persons



- 1995 International Agreement
- 1999 Groundbreaking Ceremony
- 2001 Engineering Array
- 2004-2008 construction
- 2019 Celebration 20 years

The Pierre Auger Collaboration & Observatory

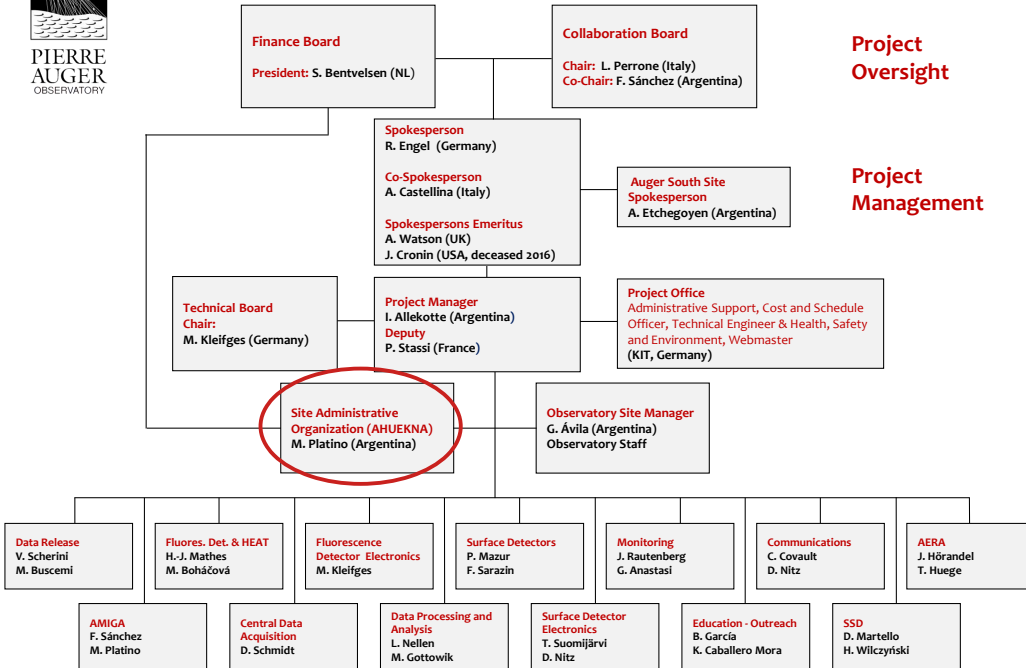
Management tasks

Science & performance tasks



AUGER Organization

(updated 2022-12-15)



Project Oversight

Project Management

Detector Performance and Science Coordination

C. Berat, F.Salamida

L.Cazon, B.Dawson

CR Phenomenology D.Boncioli, E.Roulet <i>Astrophysical scenarios, magnetic fields, LIV,...</i>	Multimessenger K.-H.Kampert, E.Zas <i>Multi-wavelength observations, triggers, alerts, data sharing...</i>	Air Shower Physics R.Conceicao, T.Pierog <i>Muons and multiparticle production, new physics,...</i>	Cosmo-geophysics R.Colalillo, R.Mussa <i>Atmo phenomena, correlation with solar activity and space weather,...</i>
Energy Spectrum F.Fenu, V.Verzi <i>SD-vertical, SD-inclined, hybrid, radio</i>	Mass Composition E.Mayotte, A.Yushkov <i>Mass estimators and composition</i>	Neutral Particles J.Alvarez-Muniz, M.Niechciol <i>v and γ searches</i>	Arrival Directions L.Caccianiga, G.Golup <i>Large and intermediate scale anisotropy, point sources</i>
Calibration D.Schmidt, G.Salina, B.Pont <i>FD calib database, VEM/MIP, muon number...</i>	Monitoring G.Anastasi, J.Rautenberg <i>Definition and preparation of tools for performance checks</i>	Long Term Performance C.Bonifazi, R.Caruso <i>Detectors stability, operations, shifts report</i>	Atmospheric Conditions B.Keilhauer, L.Valore <i>Atmo database, VAOD, data monitoring,...</i>
Monte Carlo Simulations G.Isar, E.Santos <i>Shower and detector simulation libraries</i>		Analysis Foundations J.Bellido, T.Huege, M.Roth <i>High quality data for analysis</i>	
			Machine Learning J.Glombitza, N.N. <i>Deep learning methods, algorithms</i>

- The Observatory is governed and maintained by a cooperative and collaborative work between countries and members
- Ahuekna manages the handling of funds, imports, hiring and legal responsibilities.

The Pierre Auger Collaboration & Observatory

Management tasks

Science & performance tasks



AUGER Organization

(updated 2022-12-15)

Pillars of the Organization

- ✓ Design Report – Technical Design Report (scope, science, technology, management)
- ✓ Project Management Plan
- ✓ Bylaws of the Collaboration Board
- ✓ International Agreement (First renewal in 2015 and to be re-renewed 2025, AugerPrime)
- ✓ MoU with Institutions
- ✓ Local Executing Institution (Comisión Nacional de Energía Atómica, CNEA)
- ✓ Local Financial Institution (Created ad-hoc, Ahuekna)
- ✓ Agreement between Finance Board (funding agencies) with Ahuekna
- ✓ Agreements with landowners

Cosmo-geophysics
R.Colalillo, R.Mussa
Cosmic ray phenomena, correlation with solar activity and space weather,...

Arrival Directions
...Caccianiga, G.Golup
Large and intermediate scale anisotropy, point sources

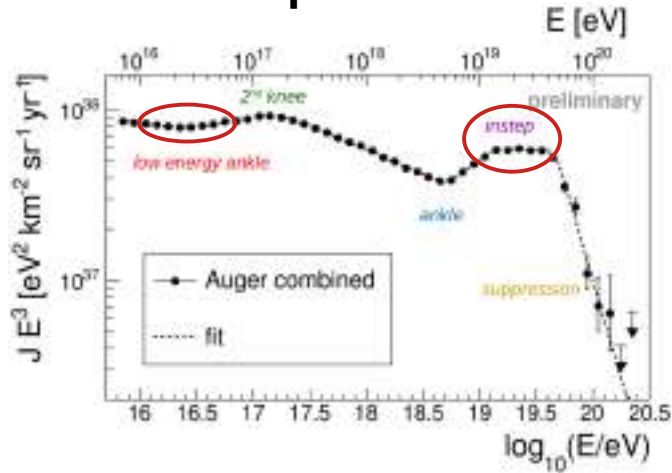
Atmospheric Conditions
B.Keilhauer, L.Valore
Atmo database, VAOD, data monitoring,...

Machine Learning
Glombitza, N.N.
Learning methods, algorithms

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Science highlights

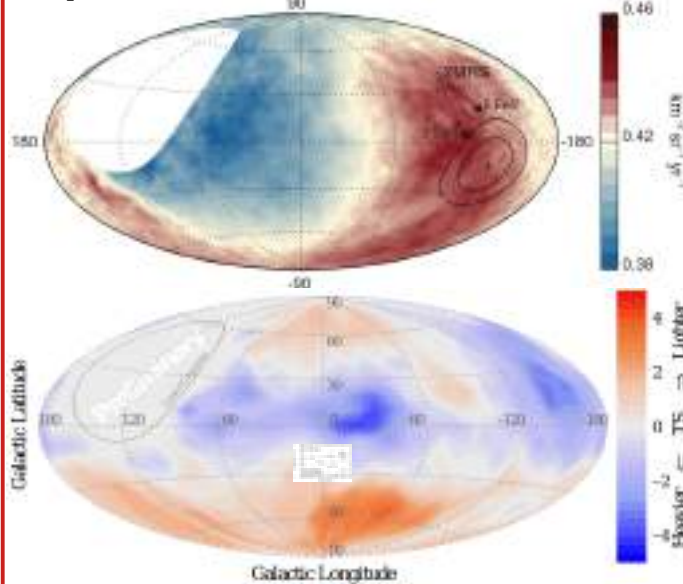
Combined spectrum



Features never seen before

New questions about the origin of these new features

Dipole in arrival directions



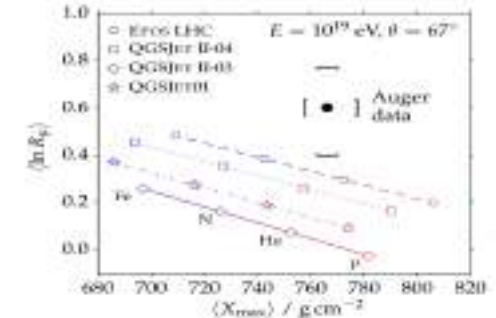
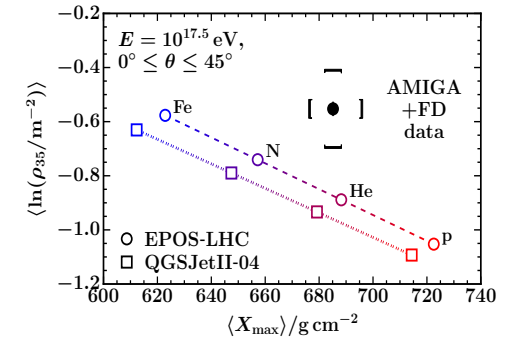
Dipole above 8 EeV suggesting extra-Galactic origin

Lighter elements from out the galactic plane (**charge particle astronomy**)

Auger Coll., Science 357 (2017)
 Auger Coll., ApJ. 868 (2018)
 Auger Coll., ApJ. 891 (2020)
 R. De Almeida, PoS(ICRC2021) 335

Auger Coll., Phys.Rev.D90 (2014) 122005
 Auger Coll., Phys.Rev.D96 (2017) 122003
 E. Mayotte, PoS(ICRC2021) 321

Hadronic physics



Muons observed in air showers are **not reproduced by hadronic models** tuned after LHC data.

Auger Coll., PRD. 91 (2015)
 Auger Coll., EPJ C. 751 (2020)

Auger Coll., Phys. Rev. D 102 (2020)
 Auger Coll., Phys. Rev. Lett. 125 (2020)
 Auger Coll., Eur. Phys. J. C 81 (2021)
 V. Novotny, PoS(ICRC2021) 324

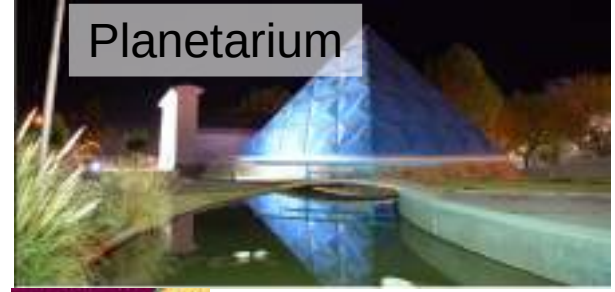
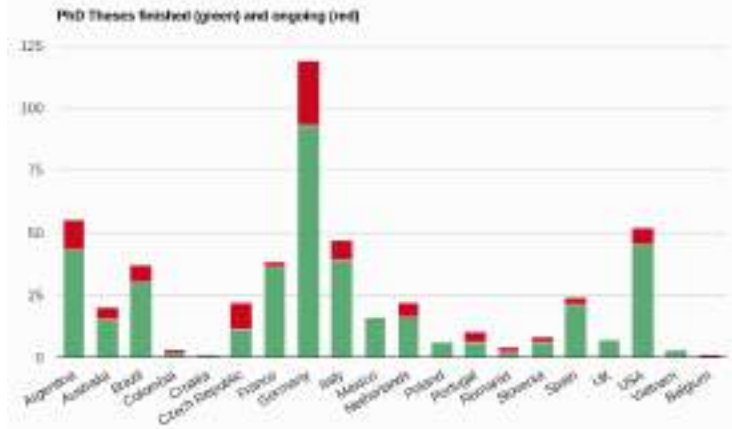
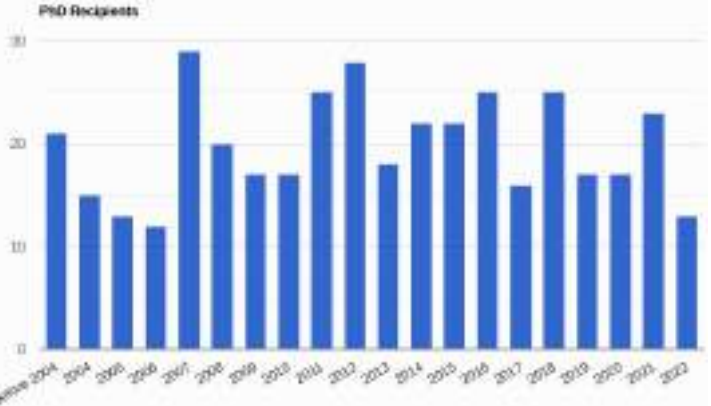
The Pierre Auger stakeholders & beneficiaries

Stakeholders

- International scientific community
- Scientists, engineers, technicians of the project
- Sponsors, financing agencies

Beneficiaries

- Local population / Project staff / Landowners
- Political authorities
- International/Local providers (incl. services)
- Visitors



- Science fair
- Visitor Center (10k/year)
- Master Classes
- ...

The future: AugerPrime, a **multi**-hybrid observatory

Motivations

1. Elucidate the **origin of UHECR**
2. Open a **new brach for astronomy**: charge particle astronomy
3. Study **fundamental physics and hadronic interactions**

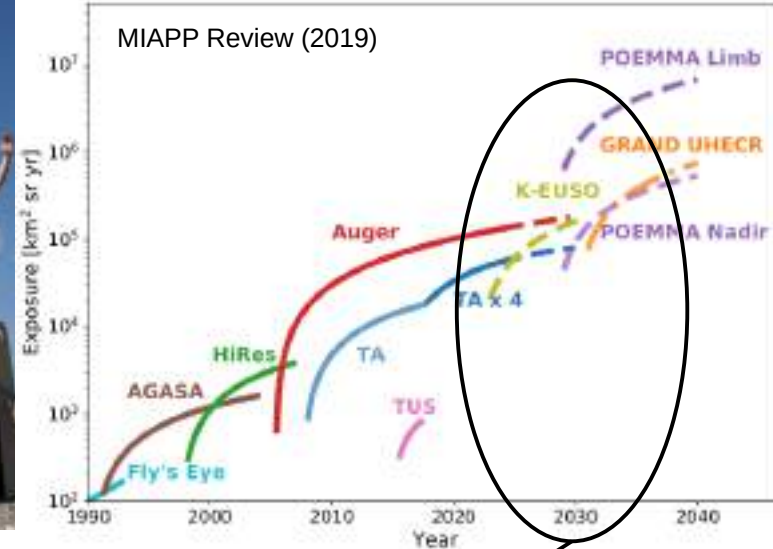


On each Water-Cherenkov station (WCD) over 3000 km²

1. Additional **surface scintillators (SSD)** on top of WCD
2. 3x **faster electronics (UUB)**
3. Additional **small-area PMT (sPMT)** for WCD
4. Addiotinal **radio antennas (RD)**

In the Infill region (23.1 km²)

5. The **Underground Muon Detector (UMD)**



The **largest operative exposure detector** with unprecedented composition sensitivity from **3x10^{16.5} eV to 4x10¹⁹ eV**

Conclusions

1. Building, operating and maintaining a large scientific infrastructure is a highly cooperative and collaborative endeavor.
2. Commitment of local community (scientific, civil, political) is of outmost importance.
3. Large international project can be successfully built and operated in our region boosting local scientific communities and fostering science and technology in Latin-America.

Thanks

