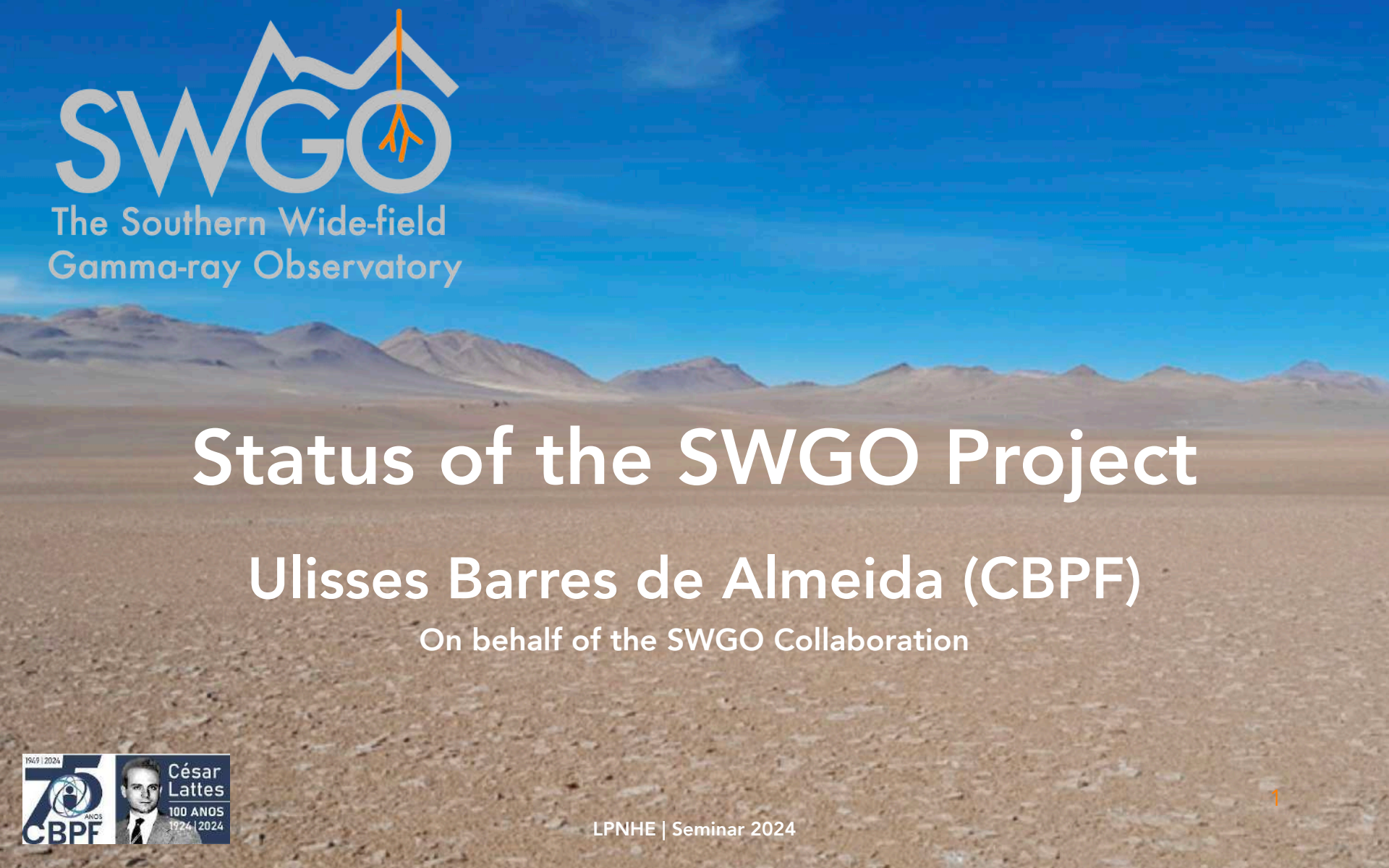


Status of the SWGO Project

Ulisses Barres de Almeida (CBPF)

On behalf of the SWGO Collaboration

Content

1. Gamma-ray Astronomy
2. The SWGO R&D
3. Site Selection
4. Next Steps

TeV-PeV Gamma-rays

Astrophysics & Cosmic-Rays

Origin of Cosmic-Rays
Astrophysical Neutrino Sources
Gravitational Wave Transients

Particle Acceleration and Propagation
High-Energy Astrophysical Sources

Multi-Messenger Astrophysics

Fundamental Physics from Space

Dark Matter
BSM model physics
Cosmology

© adapted from Jim Hinton

VERITAS

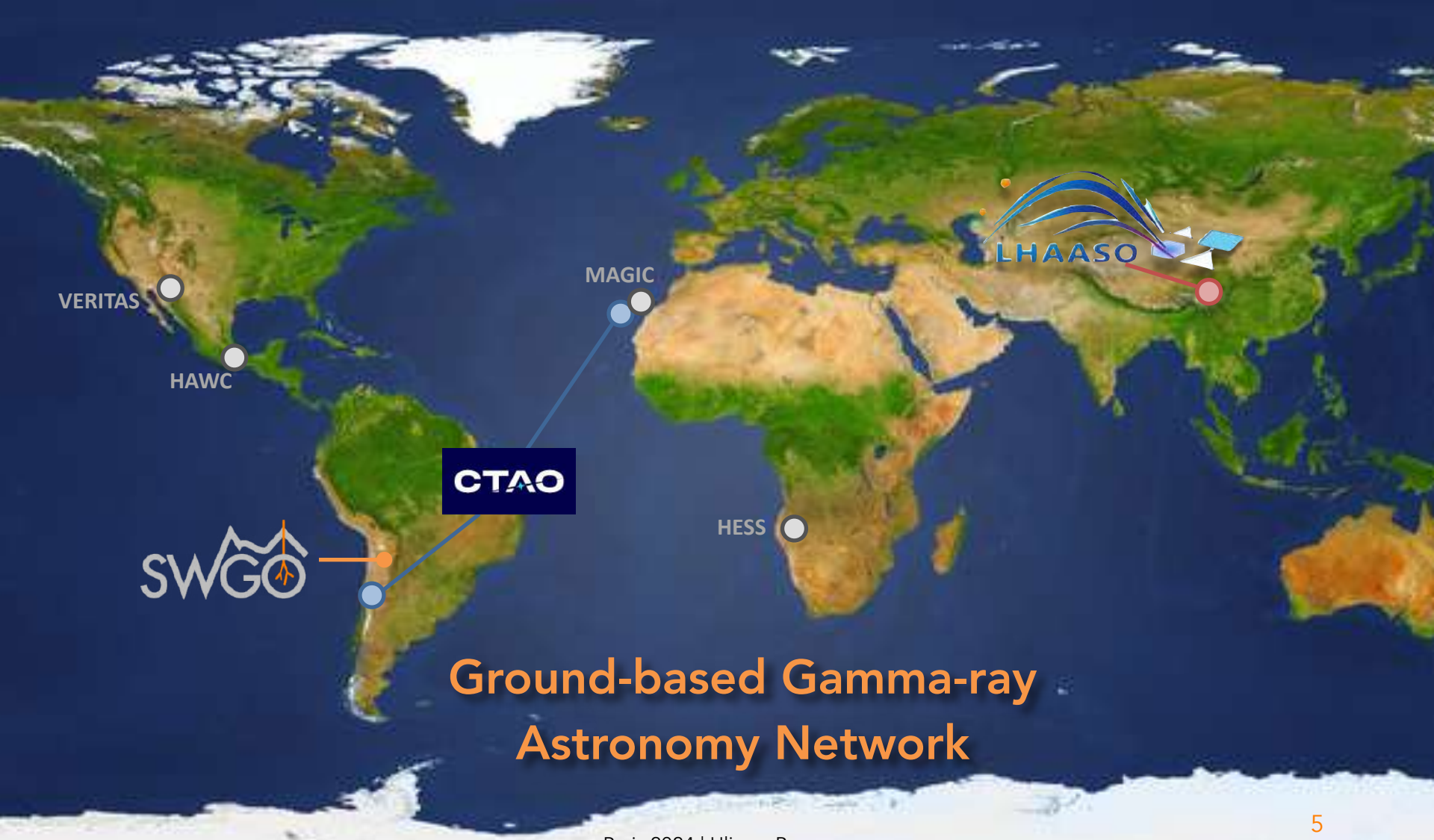
MAGIC

TIBET

HAWC

HESS

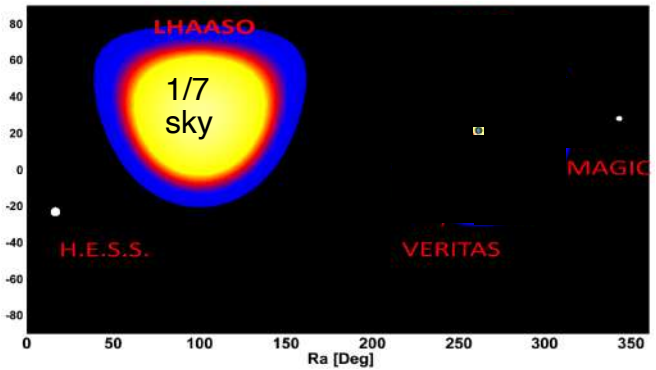
Ground-based Gamma-ray Astronomy Network



Ground-based Gamma-ray Astronomy Network

Ground-based Gamma-ray Astronomy Network

Ground-based Techniques

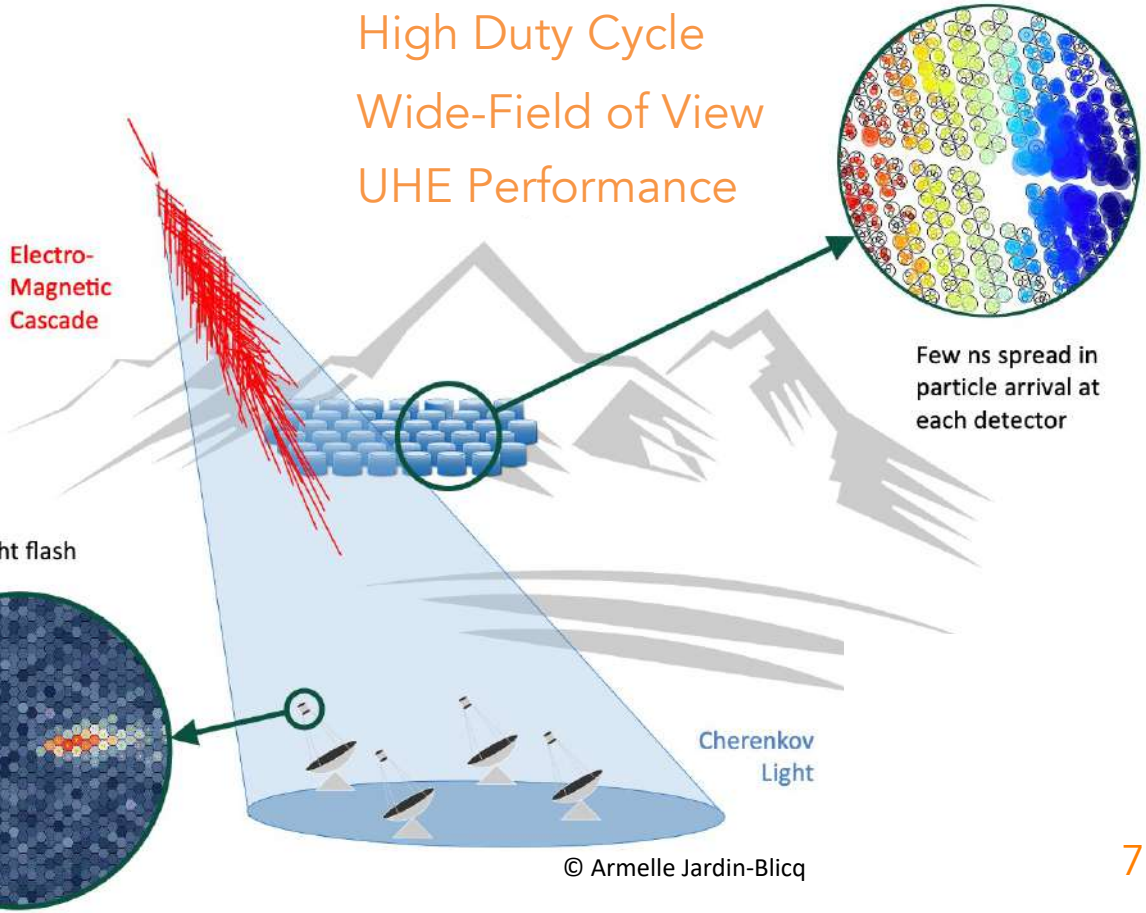


Air-shower particle arrays

High Duty Cycle

Wide-Field of View

UHE Performance



Air-Cherenkov Telescopes

Low Duty Cycle

Pointing instruments

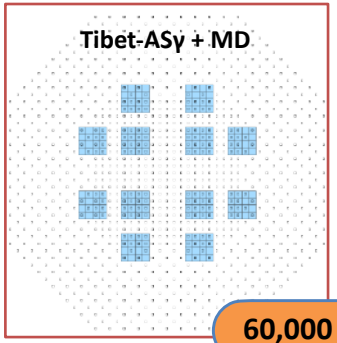
Precision Astronomy

© Armelle Jardin-Blicq

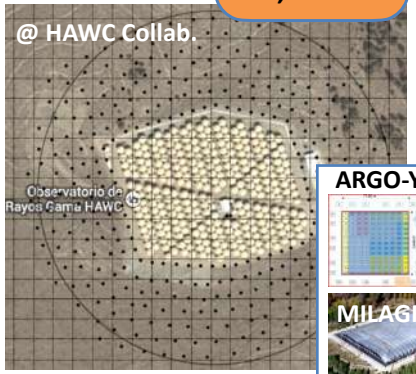
Larger and higher...

1.3 km

2010s



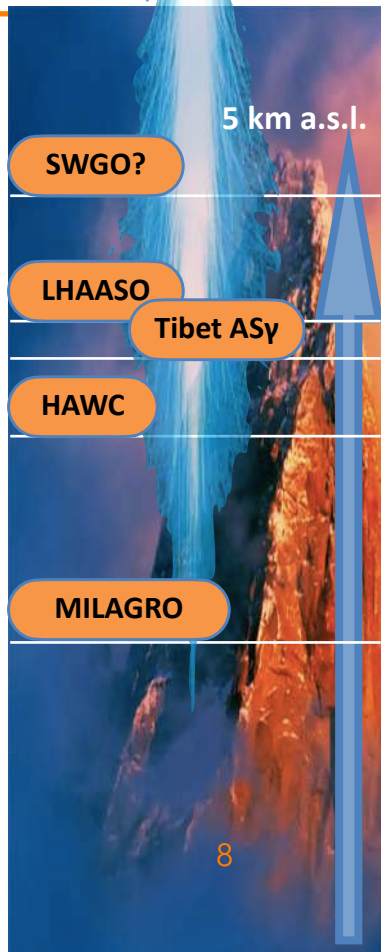
60,000 m²



2000s

ARGO-YBJ

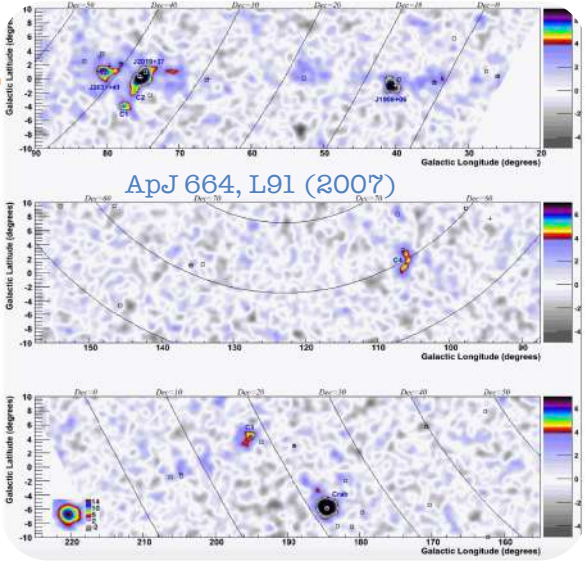
6,000 m²



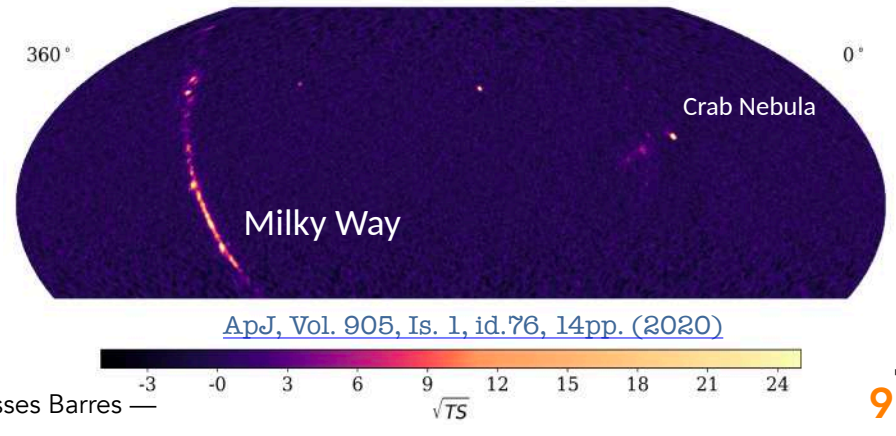
Surveys over the Years

© Petra Huentemeyer, IAU-GA 2024, FM12

- Milagro: 2000-2007,
  - → 8 sources at ~ 20 TeV (> 4.5 σ)
- HAWC: 3HAWC catalog (2015-2019)
  - → 65 sources detected at > 5σ
  - → 20 sources > 1° away from previously detected TeV sources
  - → 14 of these have potential counterpart in the 4th Fermi-LAT catalog
- LHAASO: 1st LHAASO Catalog (2020-2022)
  - → 90 sources at > 5σ
  - → 32 sources Unidentified sources
  - → 43 sources detected at > 5σ above 100 TeV
- 4HWC catalog of >2500 days upcoming, 2024



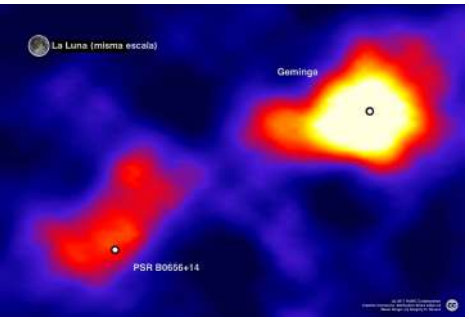
ApJ 664, L91 (2007)



ApJ, Vol. 905, Is. 1, id.76, 14pp. (2020)

Particle Detector Array Discoveries

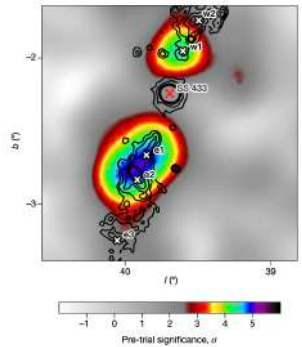
Extended Sources



PARTICLE ASTROPHYSICS

Extended gamma-ray sources around pulsars constrain the origin of the positron flux at Earth

Abeysekara *et al.*, *Science* **358**, 911–914 (2017) 17 November 2017



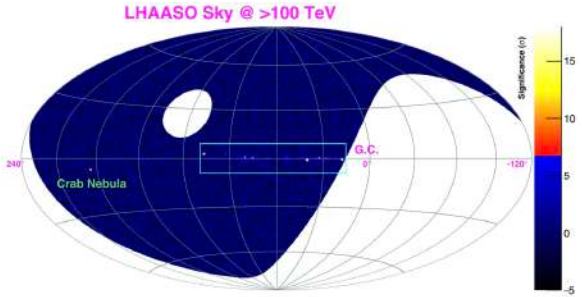
LETTER

Corrected: Publisher Correction

Very-high-energy particle acceleration powered by the jets of the microquasar SS 433

82 | NATURE | VOL 562 | 4 OCTOBER 2018

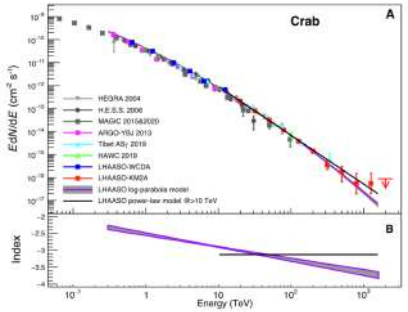
PeVatron Accelerators



Article

Ultrahigh-energy photons up to 1.4 petaelectronvolts from 12 γ-ray Galactic sources

34 | Nature | Vol 594 | 3 June 2021



RESEARCH

ASTROPARTICLE PHYSICS

Peta–electron volt gamma-ray emission from the Crab Nebula

Cao *et al.*, *Science* **373**, 425–430 (2021) 23 July 2021

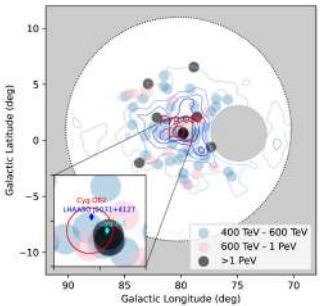
Article

An ultrahigh-energy γ-ray bubble powered by a super PeVatron

LHAASO Collaboration[1]

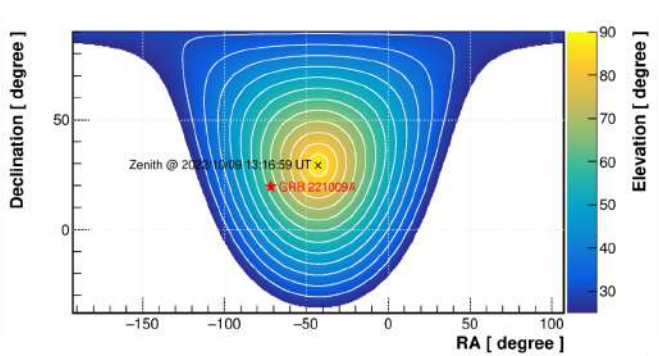
Science Bulletin

Volume 69, Issue 4, 26 February 2024, Pages 449-457



The BOAT Gamma-ray Burst

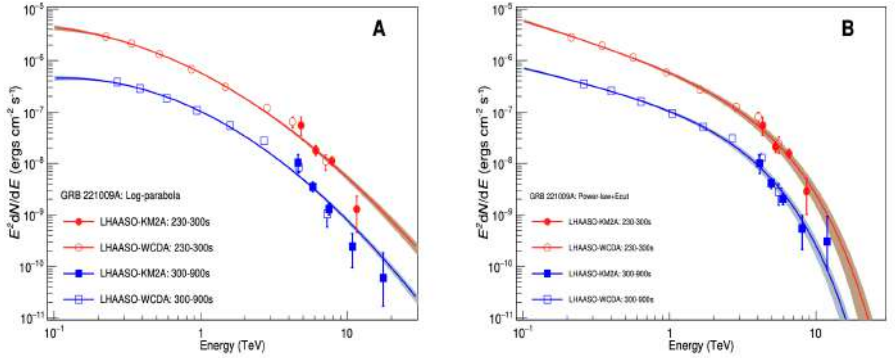
arXiv:2310.08845v1 [astro-ph.HE] 13 Oct 2023

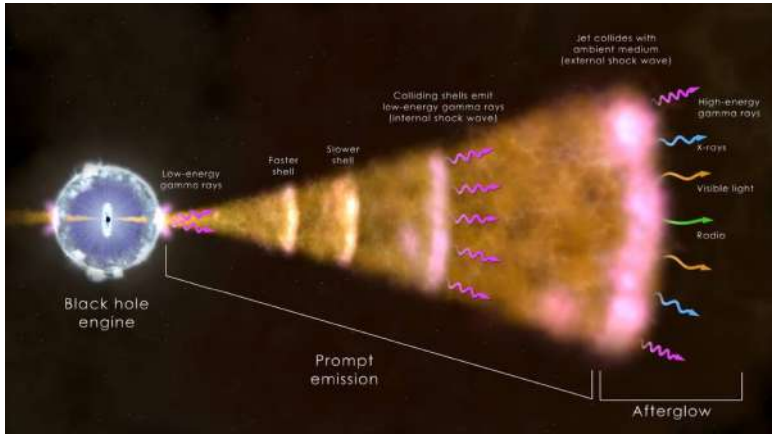


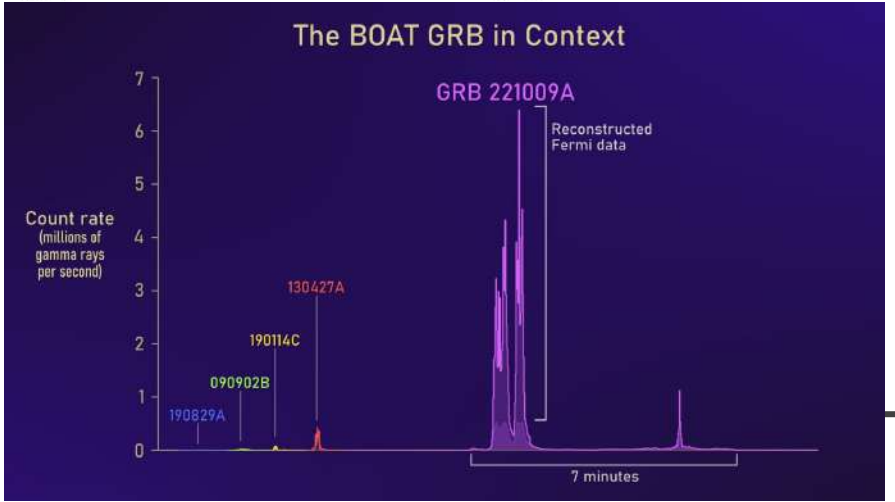
TITLE: GCN CIRCULAR
NUMBER: 32677
SUBJECT: LHAASO observed GRB 221009A with more than 5000 VHE photons up to around 18 TeV
DATE: 22/10/11 09:21:54 GMT
FROM: Judith Racusin at GSFC <judith.racusin@nasa.gov>

Yong Huang, Shicong Hu, Songzhan Chen, Min Zha, Cheng Liu, Zhiguo Yao and
Zhen Cao report on behalf of the LHAASO experiment

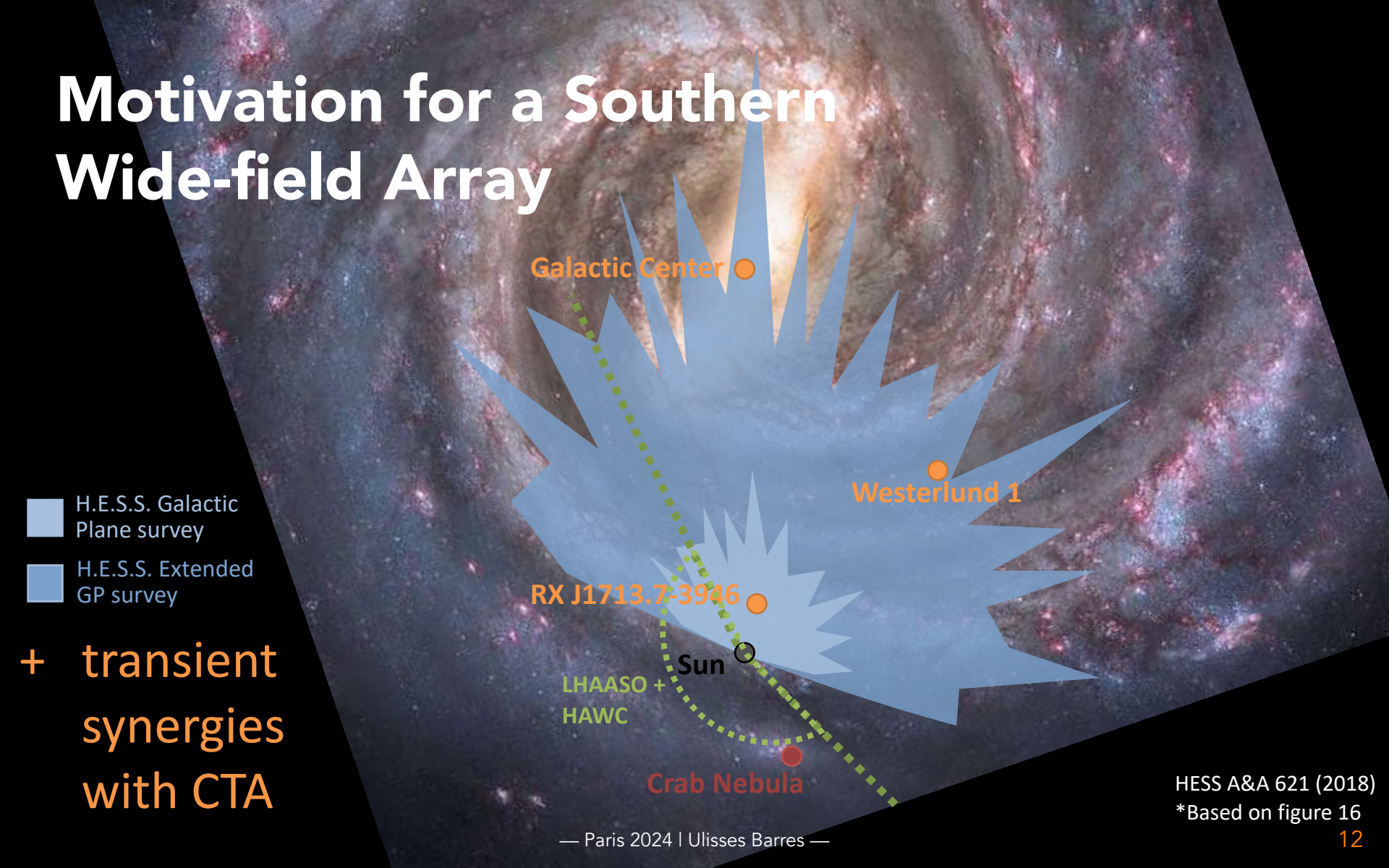
Very high energy gamma-ray emission beyond 10 TeV from GRB 221009A







Motivation for a Southern Wide-field Array



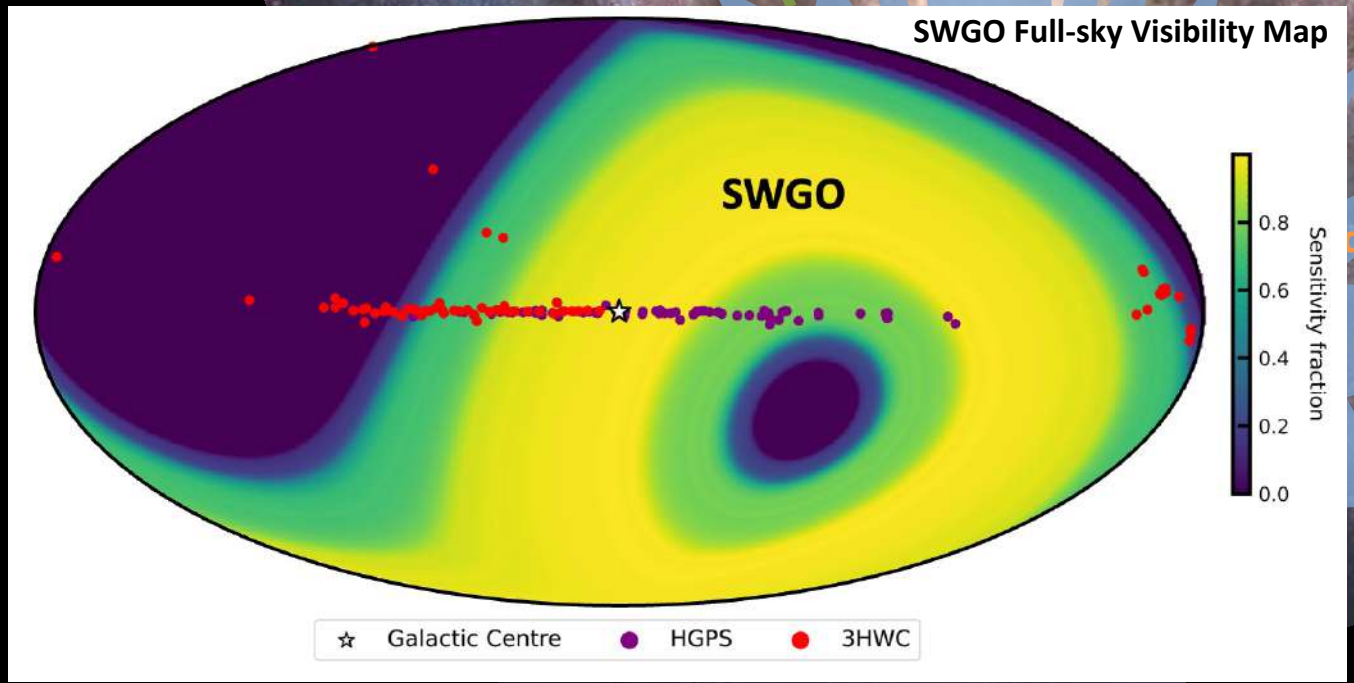
H.E.S.S. Galactic Plane survey

H.E.S.S. Extended GP survey

\+ transient synergies with CTA

HESS A&A 621 (2018)
*Based on figure 16

Motivation for a Southern Wide-field Array

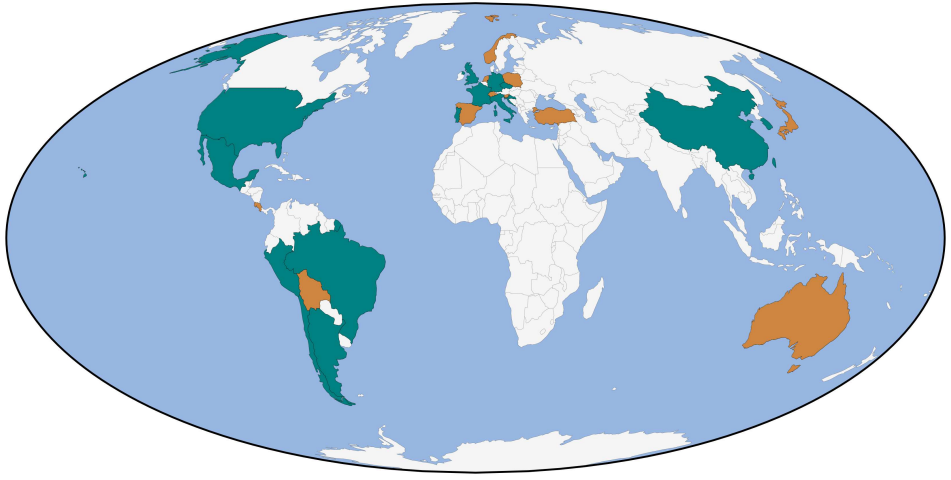


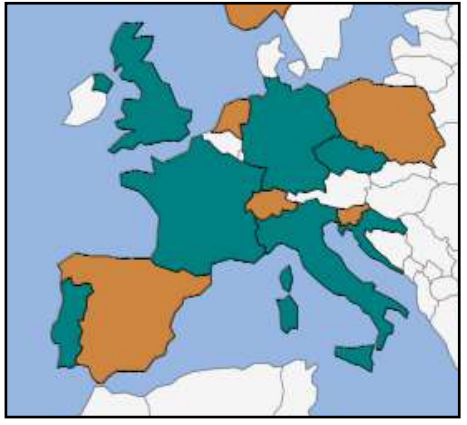
HESS A&A 621 (2018)
*Based on figure 16

SWGO Collaboration

Member Institutes

Supporting Scientists





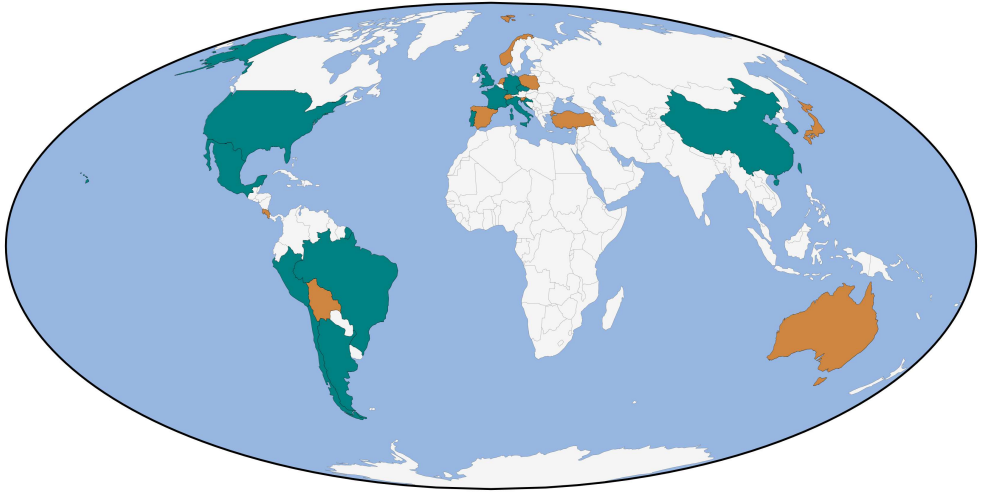
- SWGO partners
  - → 15 countries, over 90 institutes
  - → + supporting scientists

Argentina
Brazil
Chile
China
Croatia
Czech Republic
France
Germany
Italy
Mexico
Peru
Portugal
South Korea
United Kingdom
United States

SWGO Collaboration LATAM

Member Institutes

Supporting Scientists



- Spokespersons
  - → Jim Hinton, MPIK (DE)
  - → Ulisses Barres, CBPF (BR)
  - → Petra Huentemeyer, MTU (USA)

Steering Committee LATAM:

AR: Adrian Rovero (IAFE)

BR: Ronald Shellard (CBPF)

Alberto Reis (CBPF)

→ Elisabete Dal Pino (IAG)

CH: Claudio Dib (UTFSM)

MX: Ibrahim Torres (INOAE)

PR: Luis Otiniano (CONIDA)

Unidad Astroparticulas

Países: Argentina Bolívia Brasil Chile Colômbia México Peru

Contact	Context	Objectives	Plan of Activities	National focal points	Eventos	Network

Contact: claf_astroparticulas@cbpf.br

Context

The successful observation of the sky at the highest energies (from 10 GeV to 10 PeV) with ground-based gamma-ray instruments is one of the greatest breakthroughs of Astroparticle Physics research in the past two decades. Currently, we are experiencing the transition to a new generation of instruments that promises to guide the field towards major future discoveries. These are global efforts to carry out large projects focused on the development of the observational techniques and to further explore the scientific potential of observations in the very- to ultra-high energy domains.

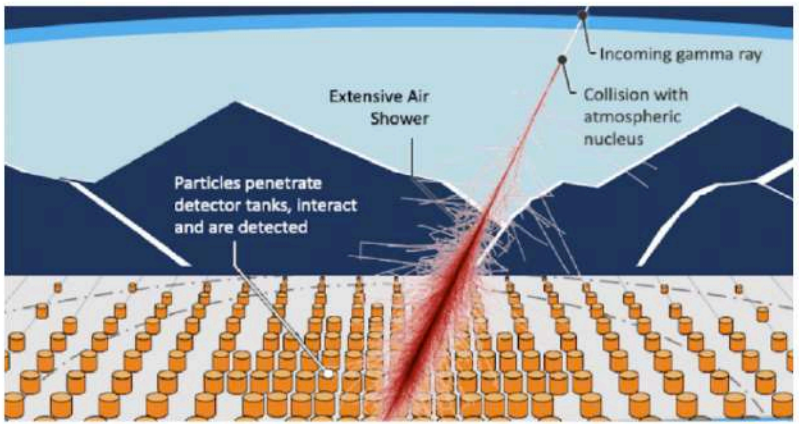
Latin America plays a central role as the prime geographic region for the installation of world-class ground-based gamma-ray experiments in the Southern Hemisphere. The continent has been recently chosen to host the southern site of the Cherenkov Telescope Array (CTA), in Chile, and selected as the continent for installation of the future Southern Wide-Field Gamma-ray Observatory (SWGO), following the presence of HAWC in Mexico. It also plays a long-standing leading role in the field of ultra-high-energy cosmic-rays, through the Pierre Auger Observatory (PAO), in Argentina, which is currently undergoing an upgrade. The continent is therefore about to concentrate the most important contingent of leading experiments in the field worldwide.

CLAF and MCTI High Level Seminar

Opportunities for the Latin-American Participation and Cooperation in Astro-Particle Physics and the Project SWGO

20 April 2023
CBPF, Rio de Janeiro, Brazil

Seminar Programme



The CLAF Astroparticle Physics Unit is a recently instated branch of CLAF for the development of this frontier field of experimental physics in Latin America. It will bring together scientists from all CLAF member states to set the future course of regional cooperation in this rapidly developing research area, for the benefit of scientific development and integration in the region.

Science Policy and Diplomacy

MCTI - Strategic Programmes
Prof. Marcia Barbosa, Secretary for Strategic Planning at MCTI / Brazil

Panorama of Science Cooperation in Latin America
Mr. Carlos Matsumoto, Acting Chief of International Cooperation, MCTI / Brazil

Account on CNPq Funding and Support of Pierre Auger (Remote)
Prof. Ricardo Galvão, President of CNPq / Brazil

Science Education and Capacity Building in Latin America (Remote)
Mr. Ernesto Fernández-Polcuch, Head for Latin America, UNESCO

Scientific Reports

Astro-particle Physics Landscape Worldwide and in Latin America
Prof. Carola Dobrigkeit Chinelatto, UNICAMP / Brazil

SWGO: Science, Technology and International Cooperation
Prof. Claudio Dib, UTFSM / Chile

The Pierre Auger Observatory: Science, Cooperation and Impact
Dr. Federico Sanchez, ITeDA / Argentina

Industrial Cooperation

Account on Industrial Impact of the Pierre Auger Observatory
Mr. Nelson Fromentini, CEO of ROTOPLASTYC / Brazil

Networks for Large Experiments: Impact and Regional Potential
Mr. Leandro Ciuffo, Director at RNP / Brazil

International Cooperation

European Science Cooperation in Latin America
Dr. Mario Pimenta, Presidente do LIP / Portugal (Remote)

European Science Cooperation in Latin America
Dr. Liviu Nicu, Director of CNRS South-America / France

European Science Cooperation in Latin America
Dr. Daniela Theuer, DWIH São Paulo / Germany

European Science Cooperation in Latin America
Dr. Andrea Chiavassa, INFN / Italy

Statements from Latin-American Delegates
Ambassador Julio Bravo Iubini, Chile (Remote)

Statements from Latin-American Delegates
Dr. Benjamin Marticorena, President of CONCYTEC / Peru (Remote)

Statements from Latin-American Delegates
Dr. Juan Pablo Paz, Vice-Minister of MinCyT / Argentina

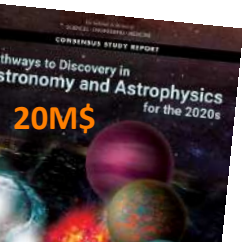
Statements from Latin-American Delegates
Dr. Alberto Etchegoyen, Representative of CONEA / Argentina

Project Status

		SWGO R&D Phase Milestones
2019 ✓	M1	R&D Phase Plan Established
✓	M2	Science Benchmarks Defined
2020 ✓	M3	Reference Configuration & Options Defined
✓	M4	Site Shortlist Complete
2022 ✓	M5	Candidate Configurations Defined
✓	M6	Performance of Candidate Configurations Evaluated
2024 ✓	M7	Preferred Site Identified
→	M8	Design Finalised
	M9	Construction & Operation Proposal Complete

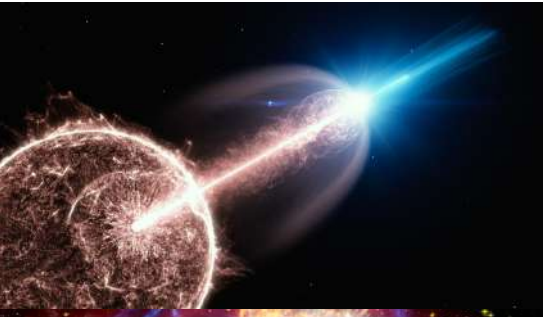
- R&D Phase
  - → Kick off meeting Oct 2019
  - → Planned completion 2025
    - ✓ Site and Design Choices made
    - ✓ Prototypes on site
- Preparatory Phase
  - → Detailed construction planning
  - → **Engineering Array in 2026**
- (Full) Construction Phase
  - → From 2027

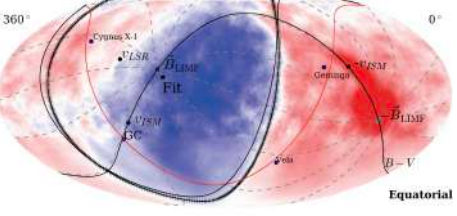
- Roadmaps
  - → US Decadal Review
  - → SNOWMASS, APPEC, Astronet



Science Drivers

White paper in preparation



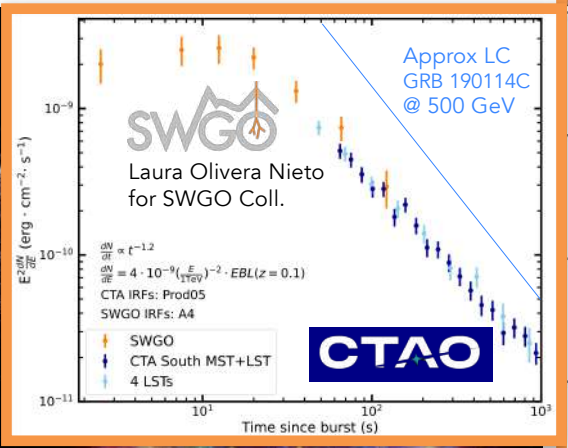


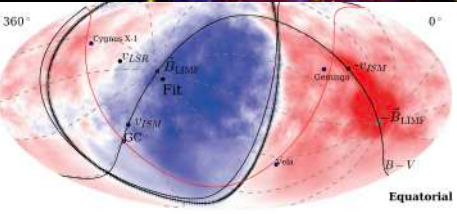
Science Case	Design Drivers
Transient Sources: Gamma-ray Bursts	Low-energy sensitivity & Site altitude[a]
Galactic Accelerators: PeVatron Sources	High-energy sensitivity & Energy resolution[b]
Galactic Accelerators: PWNe and TeV Halos	Extended source sensitivity & Angular resolution[c]
Diffuse Emission: Fermi Bubbles	Background rejection
Fundamental Physics: Dark Matter from Galactic Halo	Mid-range energy sensitivity Site latitude[d]
Cosmic-rays: Mass-resolved dipole/multipole anisotropy	Muon counting capability[e]

Science tools compatible with gammapy

Science Drivers

White paper in preparation





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Science tools compatible with gammapy

Science Drivers

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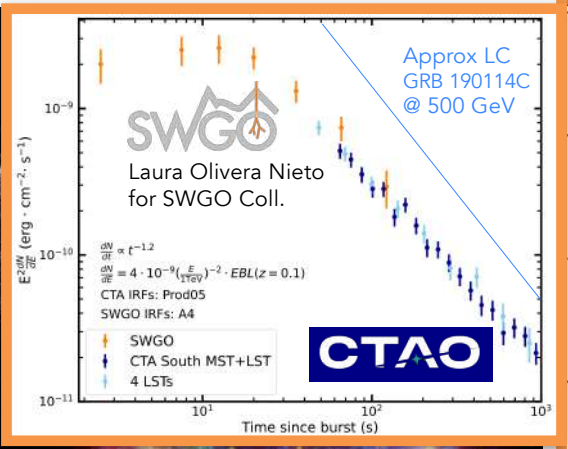

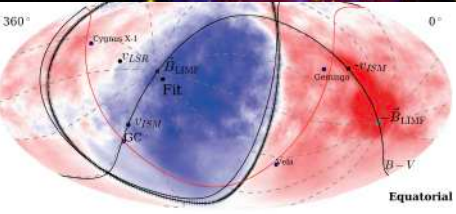

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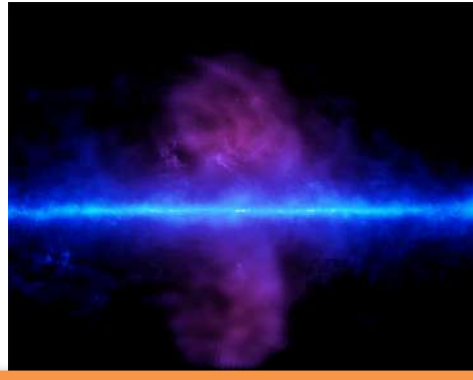
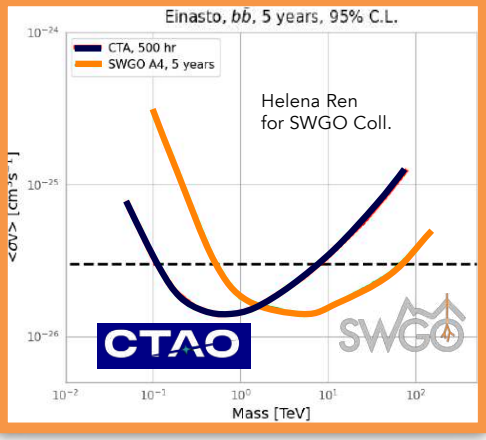
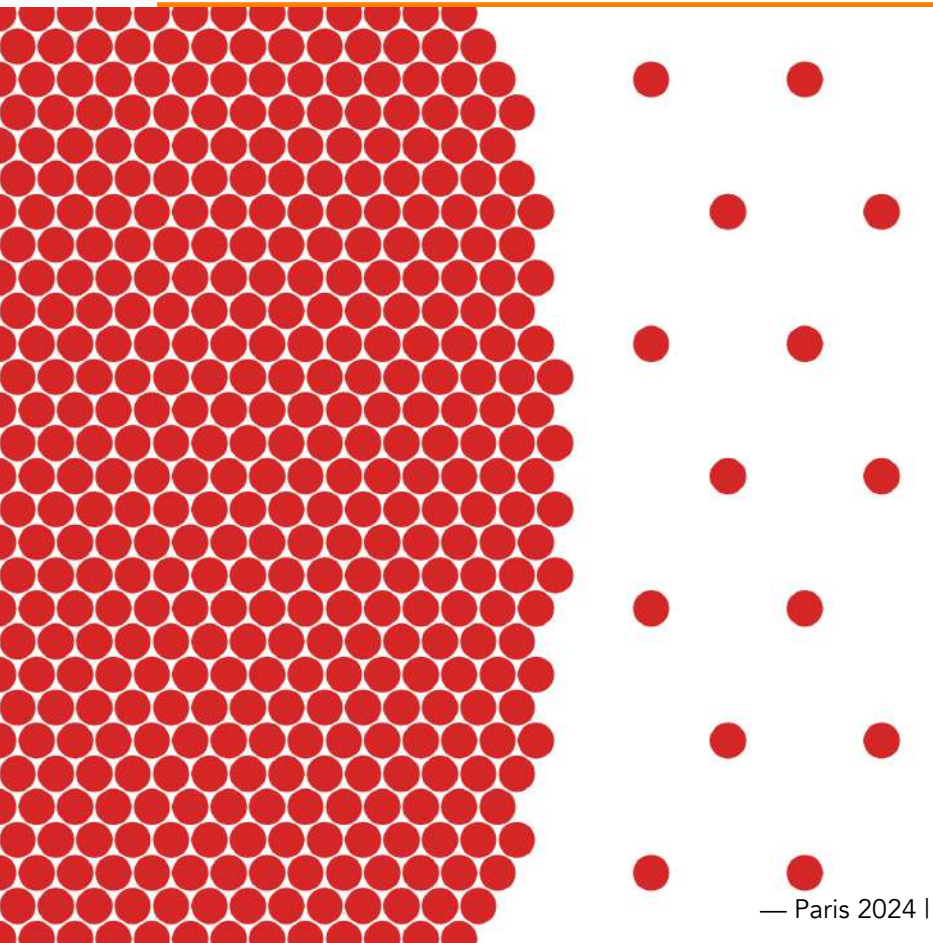




Science tools compatible with gammapy

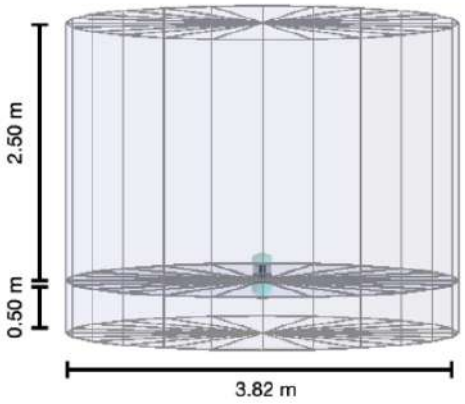
The reference detector concept



Layout: Core + Outer Array

Altitude: > 4,400 m a.s.l.

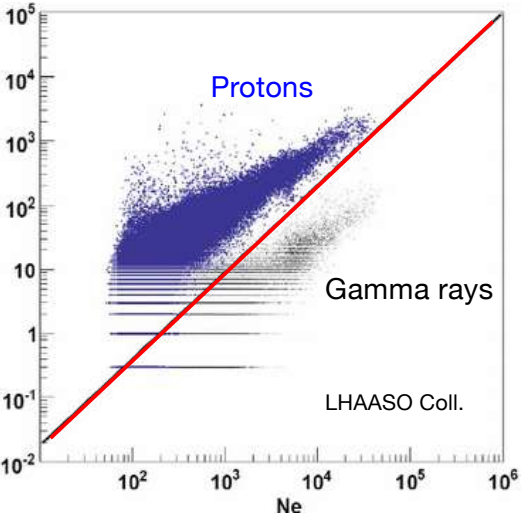
✧ muon tagging

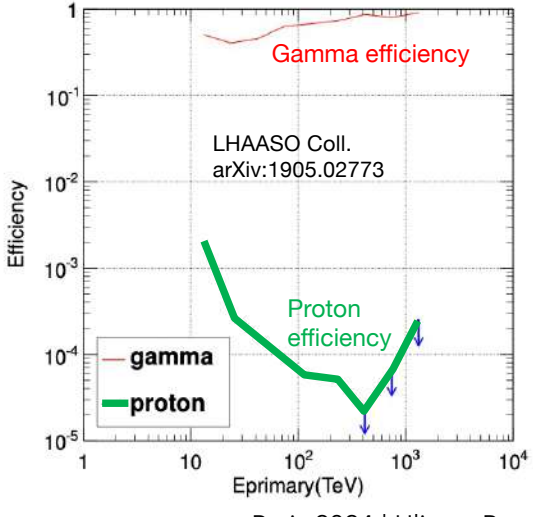


The reference detector concept

✧ Large muon detection areas are critical:

The case of LHAASO



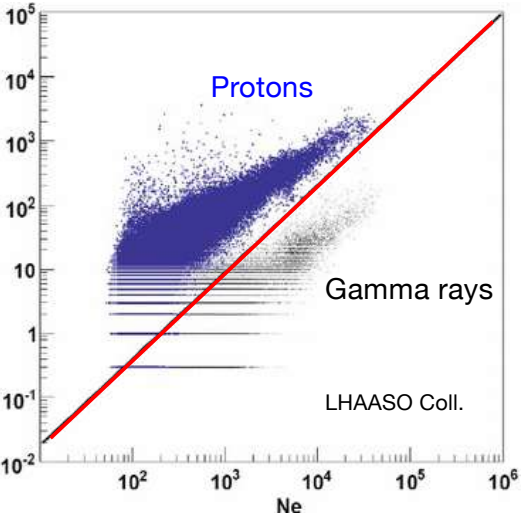


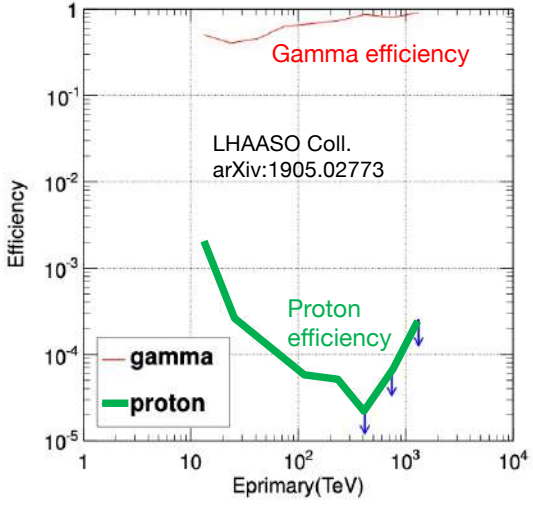
The reference detector concept

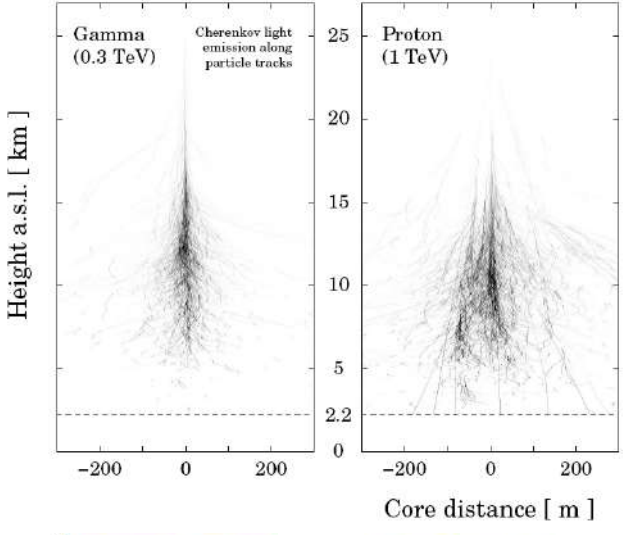
✧ Large muon detection areas are critical:

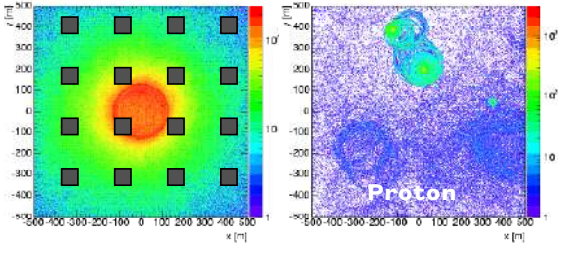
But not the only way to distinguish leptonic from hadronic showers….

The case of LHAASO



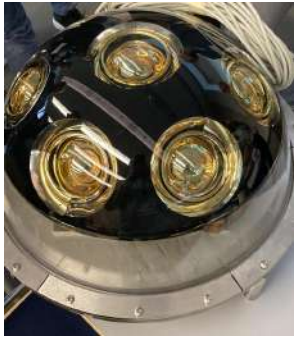






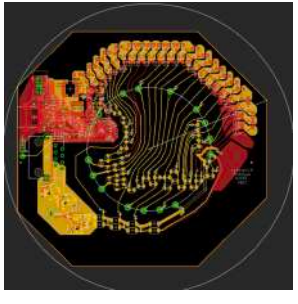
Exploring WCD technologies

Development of new concepts and approaches



PHOTOSENSORS

BLADDERS & LAKES



ELECTRONICS

WCD Unit

WCD tank development at CBPF

Based on decades-long Auger experience

Total of circa 1 MBRL invested.

New patent on rotomolding technology.

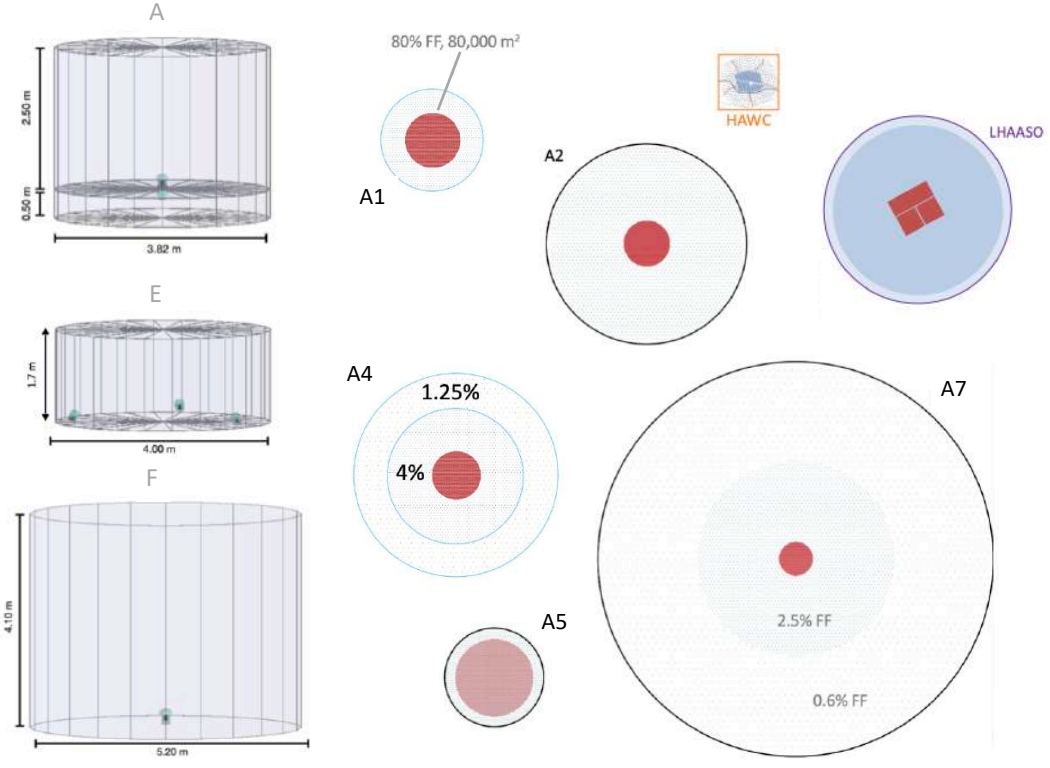
Immediate applications to the agribusiness.

Rotoplastyc

Carazinho, Rio Grande do Sul

A next generation observatory

Comprehensive **simulations of 13 configurations** completed; several **reconstruction** and **γ/hadron** separation passes.



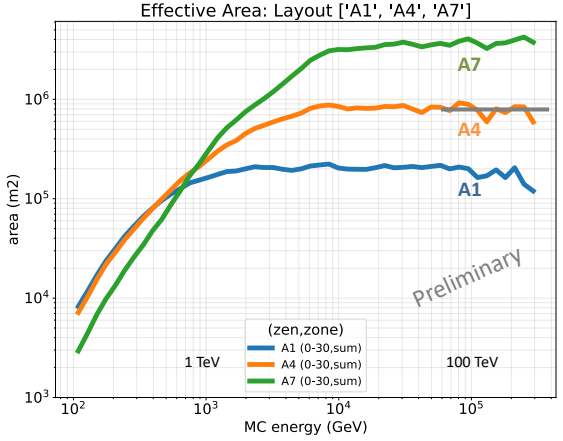
All layouts present in the SWGO simulation framework

CORSIKA — Simulation of extensive air showers

AERIE — Detector simulation

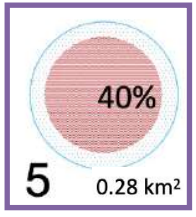
SWGO-RECO — Shower reconstruction

PYSWGO — High-level reconstructions (IRFs)

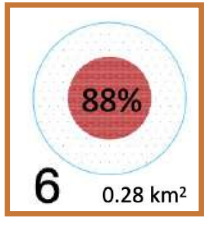


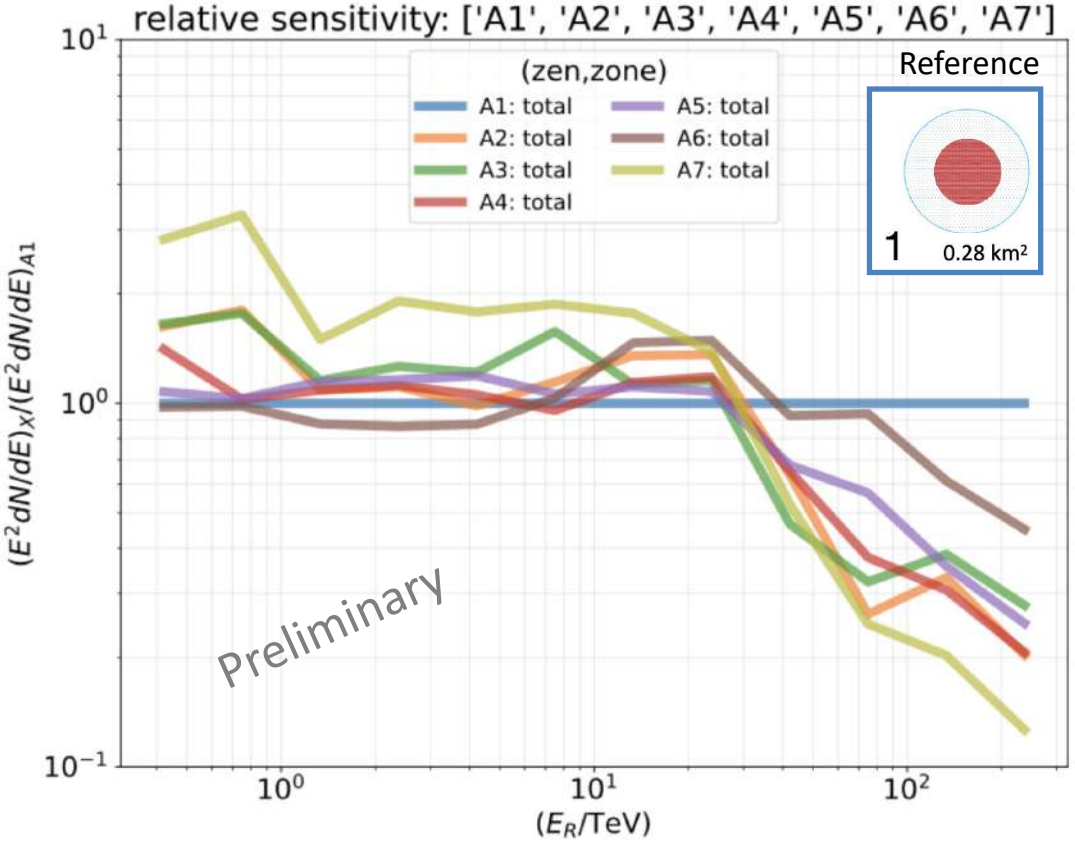
LHAASO approx

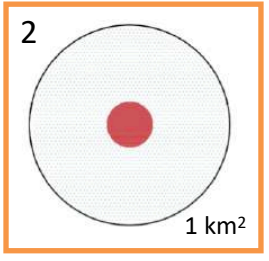
A next generation observatory



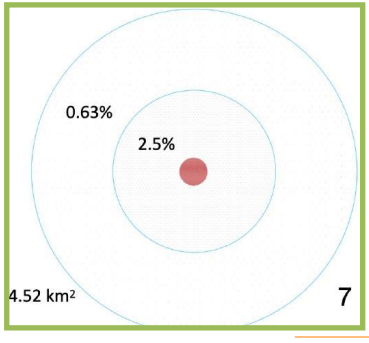
Exploring trade-off between core footprint and fill-factor.



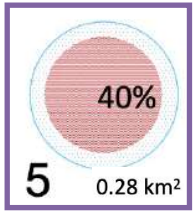




Exploring very large areas and low fill-factors



A next generation observatory



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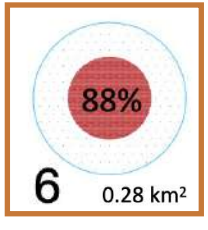
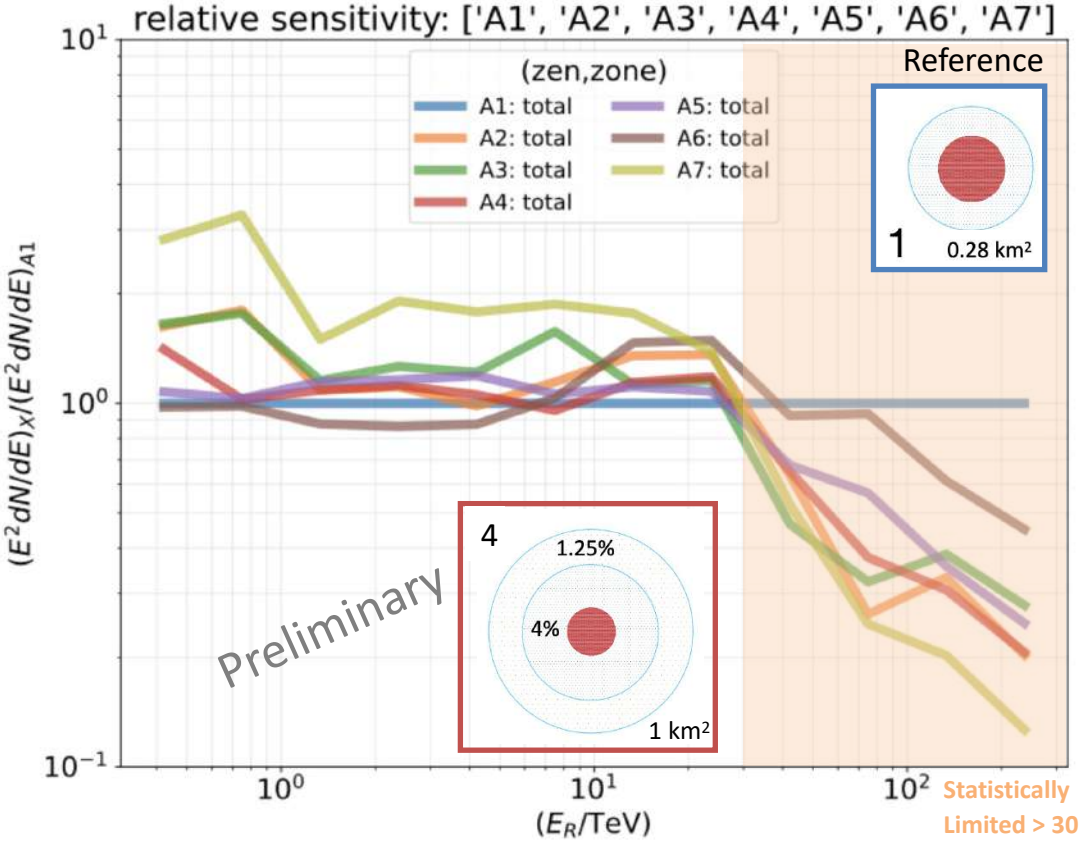
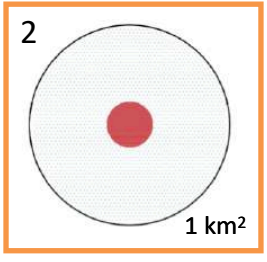
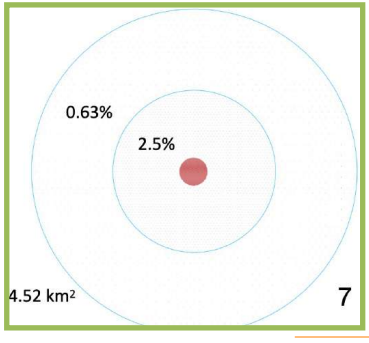




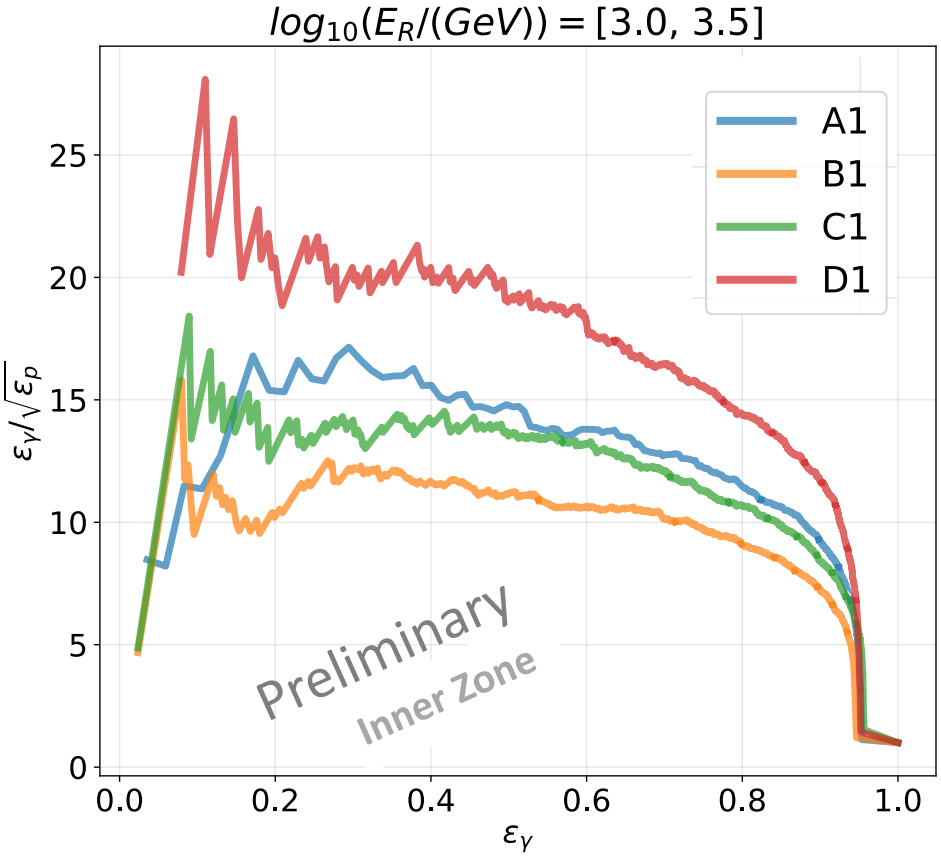
Statistically Limited > 30 TeV



Exploring very large areas and low fill-factors



A next generation observatory

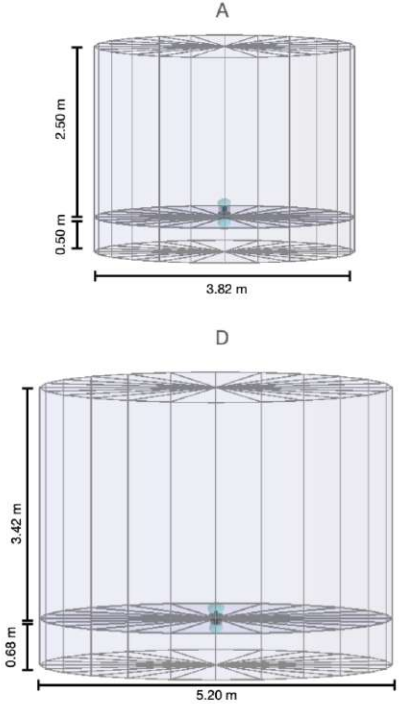


Double-layer WCD unit concept

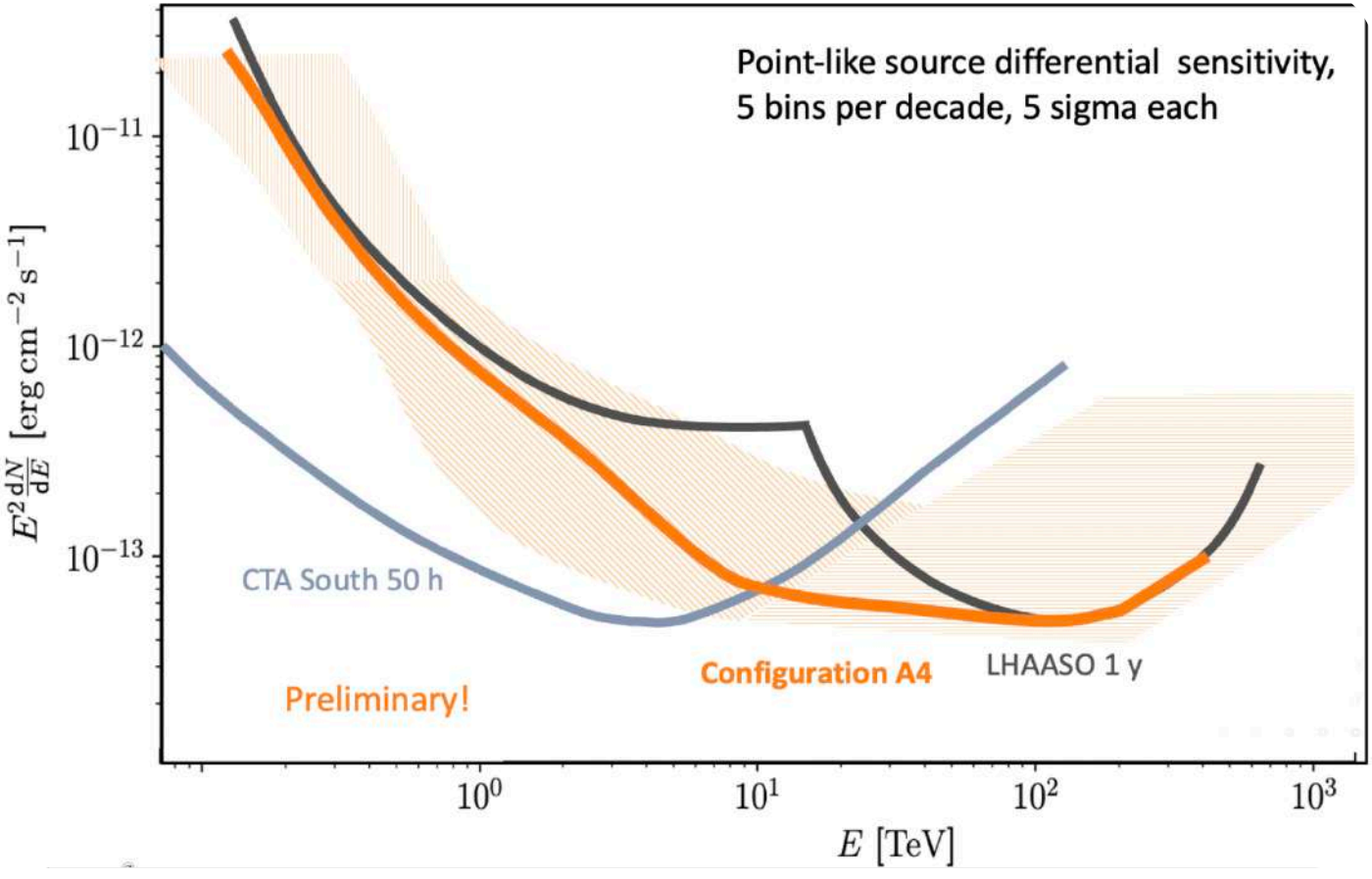
Cost-effective γ/hadron separation

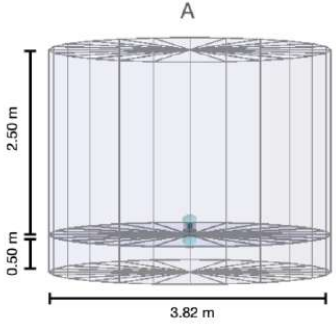
Large background rejection power > 1 TeV

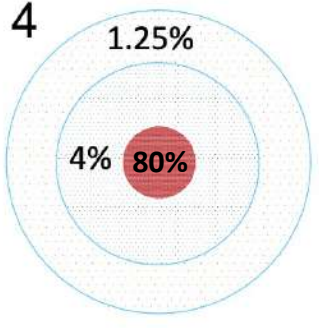
>400, with 50% gamma efficiency



Expected Sensitivity



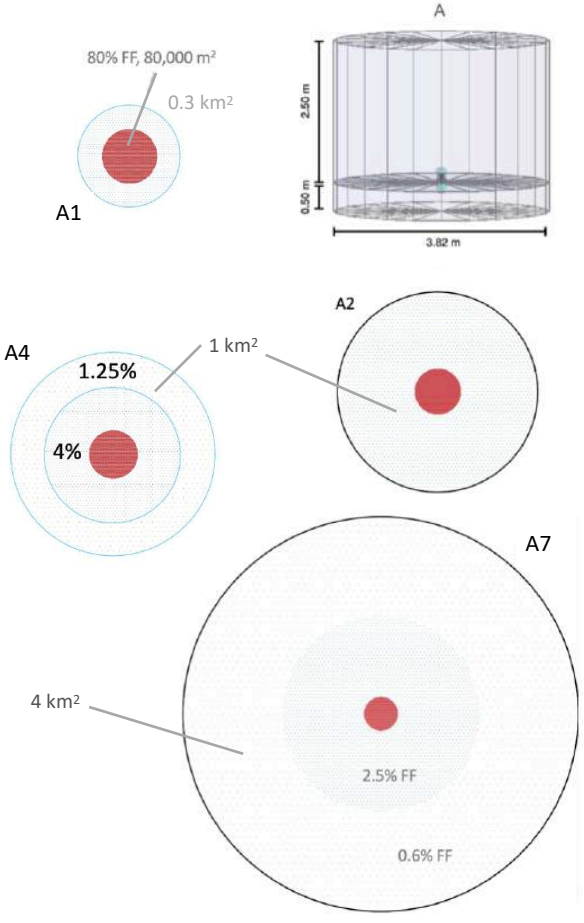


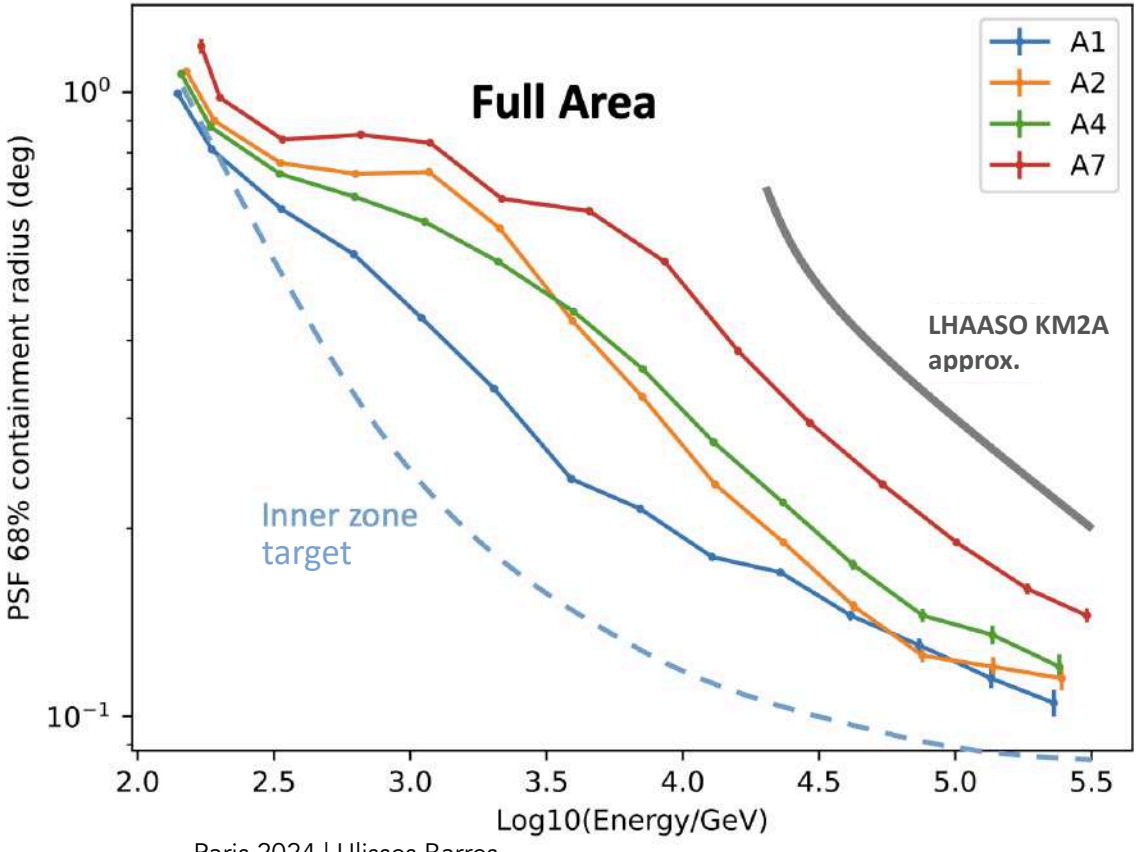


At 4,700 m a.s.l.

Target Angular Resolution

Unprecedented for wide-field instrument

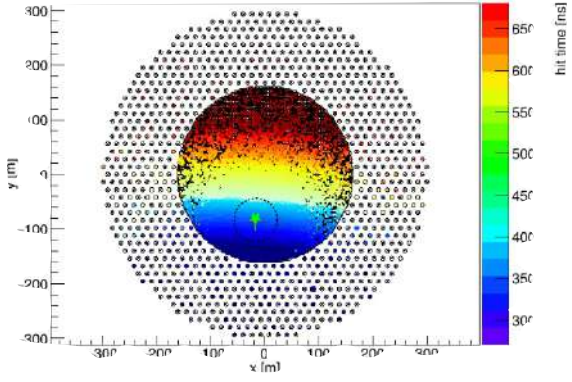


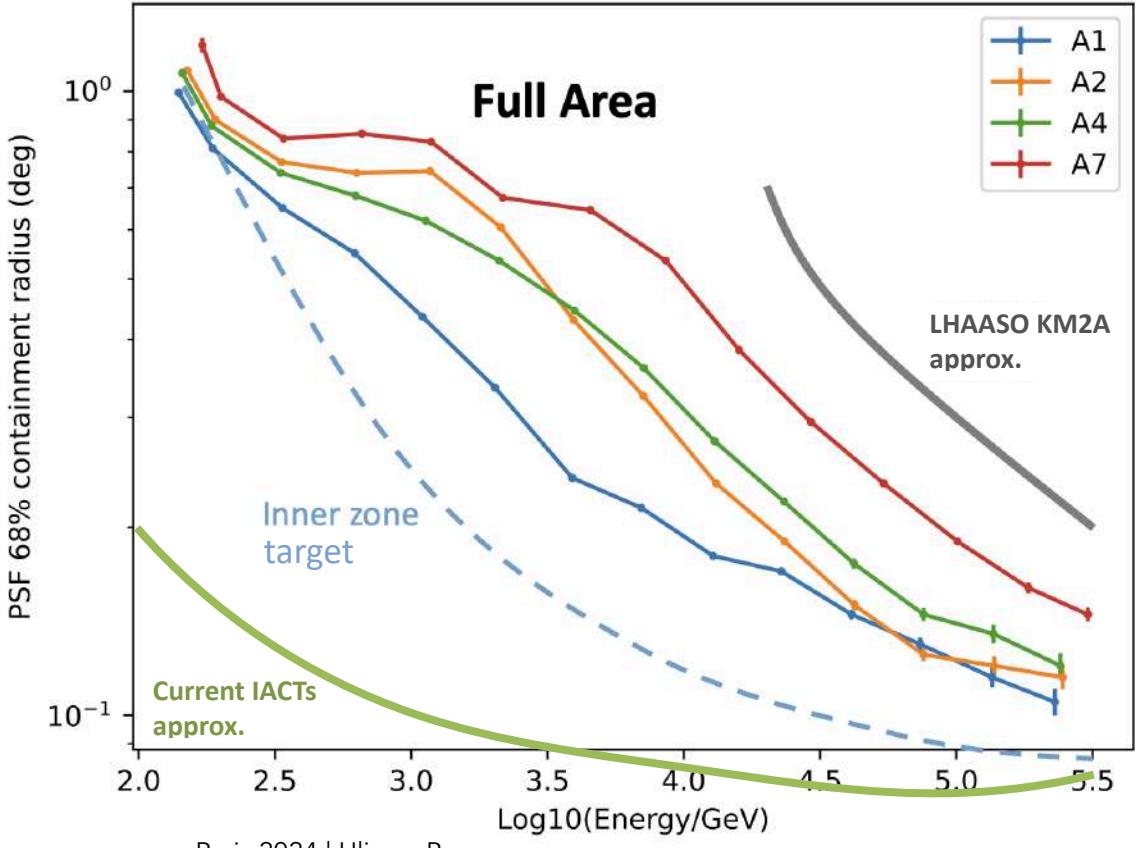


Target Angular Resolution

Unprecedented for wide-field instrument

Angular reconstruction methods still being refined





Site Search

- Candidate Sites in Argentina, Chile and Peru
  - → Latitudes between 14° and 24° South
  - → Elevations between 4,400 and 4,850 m a.s.l.
- Minimum available area 1 km^2
- Solution for water provision / availability
- Site visits took place in Oct-Nov 2022
  - → At the first available opportunity after the COVID-19 Pandemic

Shortlisted Sites

- All sites extremely flat with < 2% slope
- Shortlisting criteria included
  - → Science performance (array footprint + altitude)
  - → Site preparation and construction costs
  - → Construction and operations risks
  - → Environmental impact
  - → Social impact
- Engagement with local communities among priority factors in evaluation

Visão Geral
Tabela de Horários
Lista de Contribuição
Minha Conferência
Minhas contribuições
Registro
Lista de participantes
Remote connection
Accommodation
Restaurants nearby

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+5521995804456

Rio SWGO Site Selection Meeting.

The meeting will be held at CBPF, in Rio de Janeiro, Brazil, from 30th to 31st July, 2024.

Registration to the meeting is required only for confirmed in-person participants, for organisational purposes. The open sessions of the meeting will be accessible to the entire collaboration without the need of registration.

Site Selection

- Preferred and back-up site announced on 12th August
- Pampa La Bola, Atacama Astronomical Park (Chile)

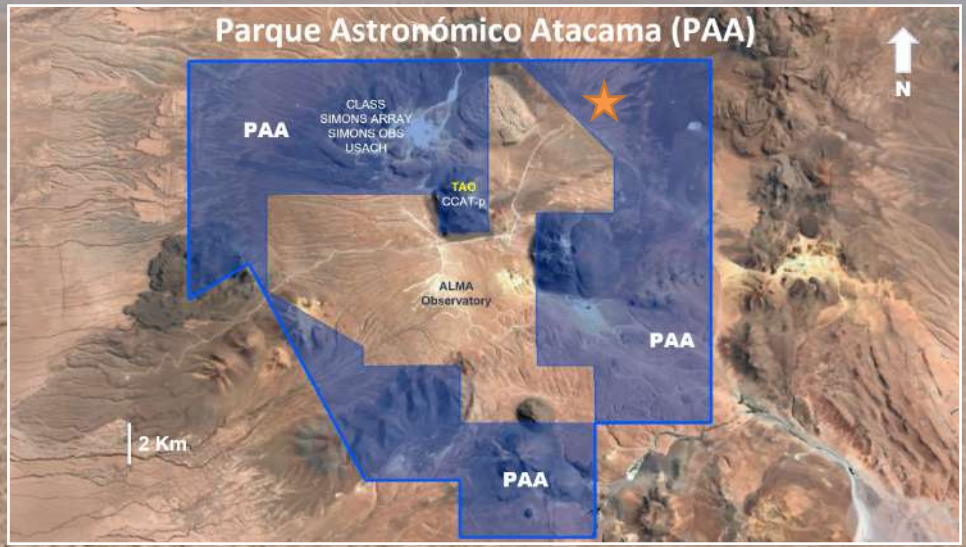
Site Selection

- Preferred and back-up site announced on 12th August
- Pampa La Bola, Atacama Astronomical Park (Chile)

CBPF, 30-31 Julho de 2024

Site Selection

- Preferred and back-up site announced on 12th August
- Pampa La Bola, Atacama Astronomical Park (Chile)
  - Vast plateau at 4,770 m a.s.l.
  - 23° South, 68° West
  - Available area superior to 1 km^2
  - At the international road Chile-Argentina
    - ✓ Few km from ALMA
    - ✓ 40 min from San Pedro de Atacama
    - ✓ 2 hours from Calama (airport)



Site Selection

- Pampa La Bola, Atacama Astronomical Park (Chile)

Towards Construction

Construction phase aimed to start 2026

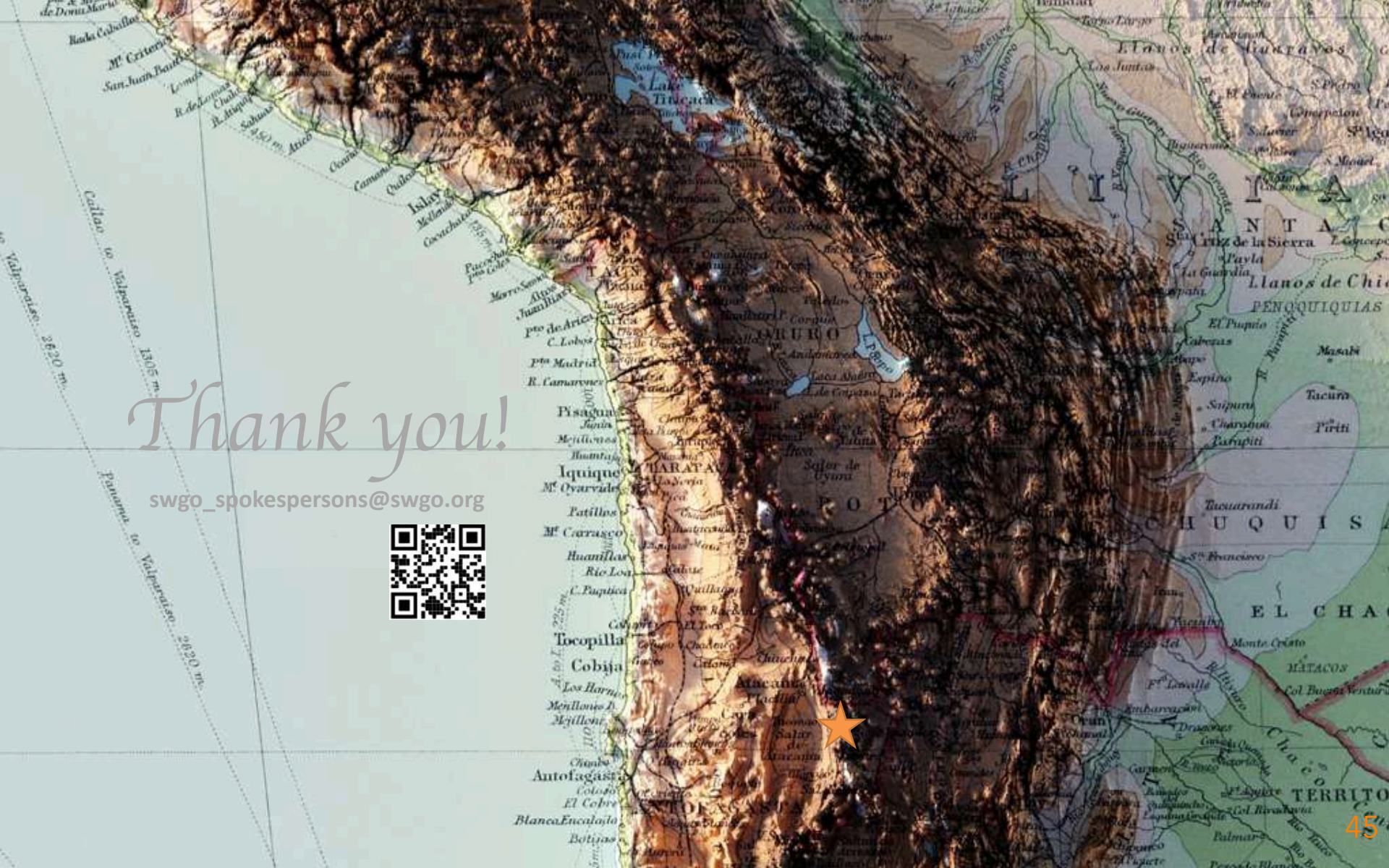
- SWGO will place a request to NSF for the first (SWGO-A) stage.
  - → SWGO-A will work as a core seed of SWGO and is expected to have superior performance to HAWC
  - → Current timeline foresees construction to start in 2026, and budget 20 MUSD
- The SWGO Collaboration aims to place funding requests for construction of the Outer Array in parallel to SWGO-A
  - → Shallow rotomolded tanks developed by Brazil/CBPF are considered as the primary WCD unit design
  - → Multi-PMT modules developed in Italy/INFN are the nominal photosensor solution for instrumenting the CBPF WCD units.
- The Array electronics is being developed by Germany/MPIK

Summary

- SWGO is approaching the conclusion of its R&D Phase, and has recently announced the observatory site.

- SWGO will be an international, multi-agency project
  - → Steering committee composed of 15 associated countries
  - → Spokesteam reflects the strong participation of Europe, North and South America
  - → *Brazil, through CBPF/MCTI contribution, is in position to lead the outer (PeV) array*

- SWGO will be the first km^2-scale wide-field gamma-ray observatory in the Southern Hemisphere
  - → Open a new observational window in astronomy, with unprecedented sensitivity
  - → Large opportunities for synergies with neighboring CTAO, including transients


Thank you!
swgo_spokespersons@swgo.org