Southern Wide-Field Gamma-ray Observatory

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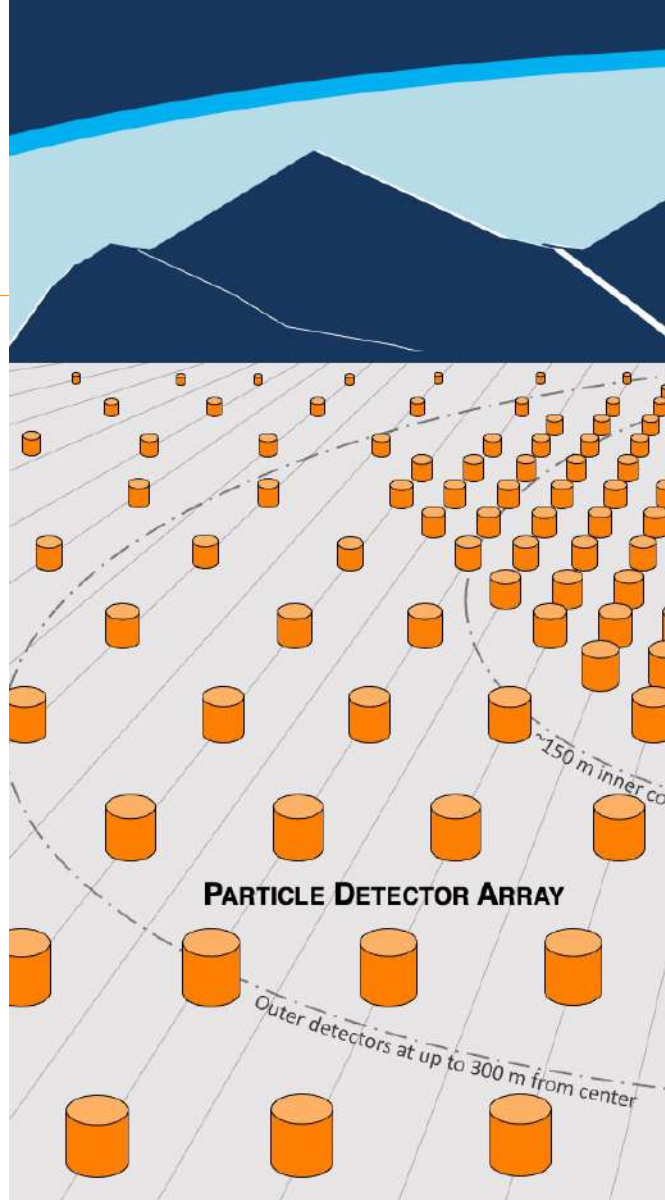
SWGO
The Southern Wide-field Gamma-ray Observatory

Content

- The field in context
- Introduction of SWGO
- Status of R&D
- Science Outlook



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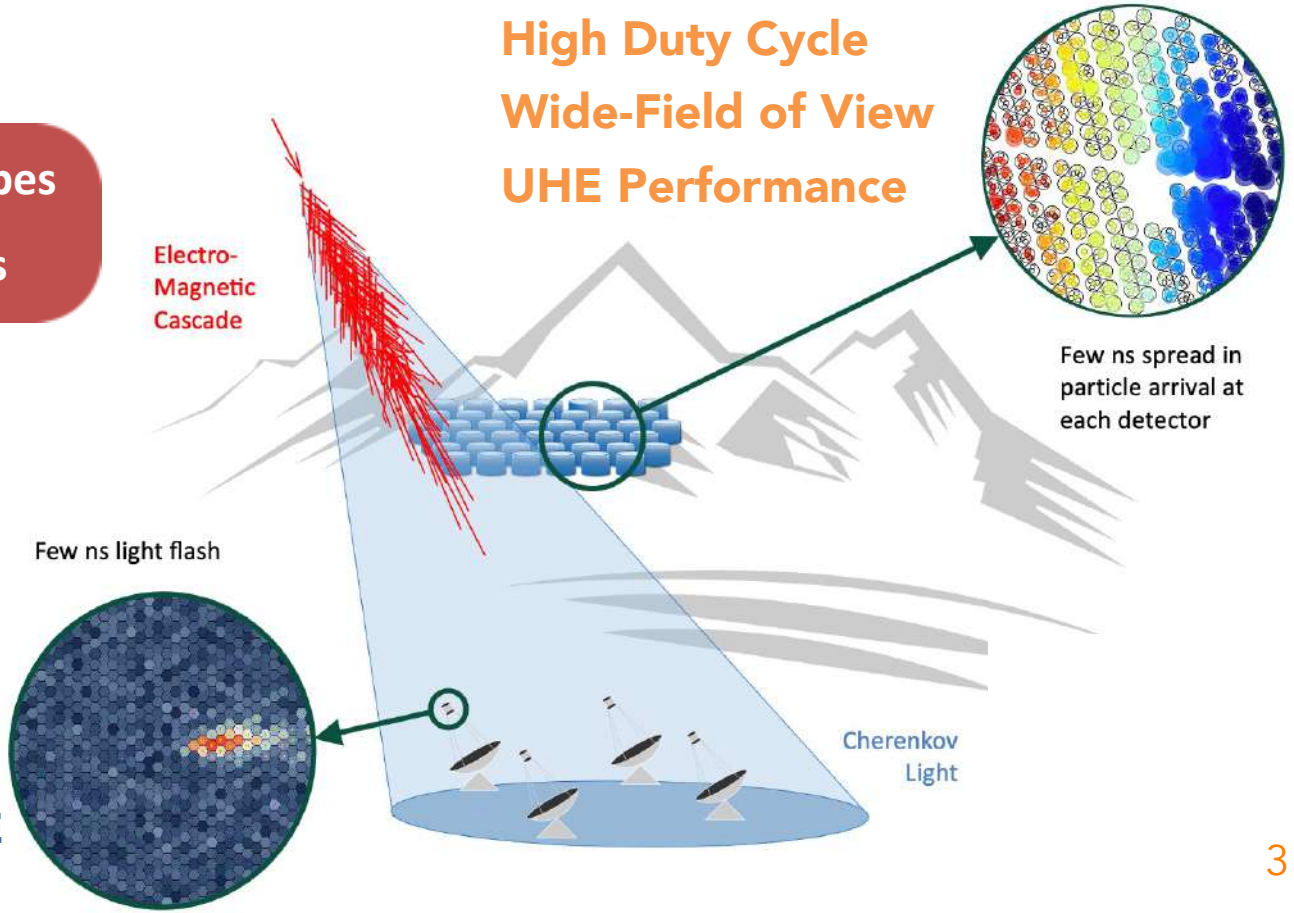
Ground-based gamma-rays

Two techniques

1. Air-Cherenkov telescopes
2. Altitude particle arrays

High Duty Cycle
Wide-Field of View
UHE Performance



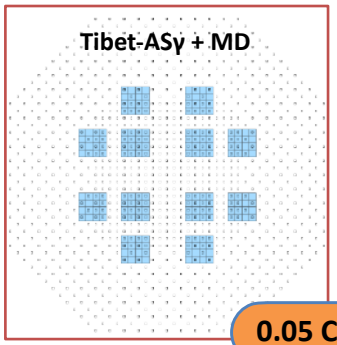
Low Duty Cycle
Pointing instruments
Precision Astronomy at VHE

— Meeting of Physics 2023 | Lima, Peru —

Larger and higher...

1.3 km

2010s



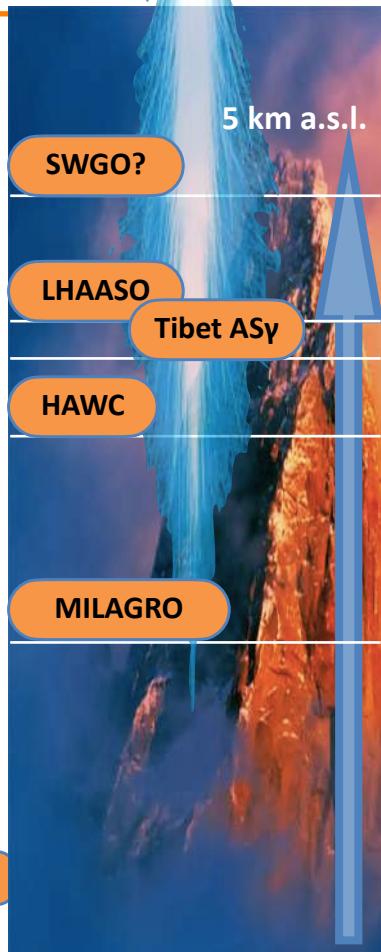
0.05 Crab

2000s

ARGO-YBJ

0.5 Crab

1.0 Crab



A new window for the UHE sky

HAWC

Major observational technique > 10s TeV

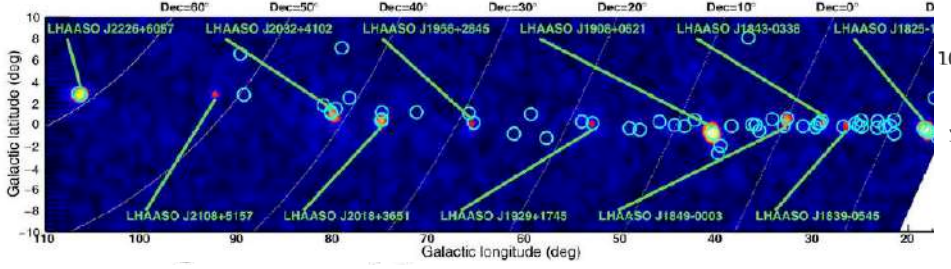
Ultrahigh-energy photons up to 1.4 petaelectronvo
from 12 γ-ray Galactic sources

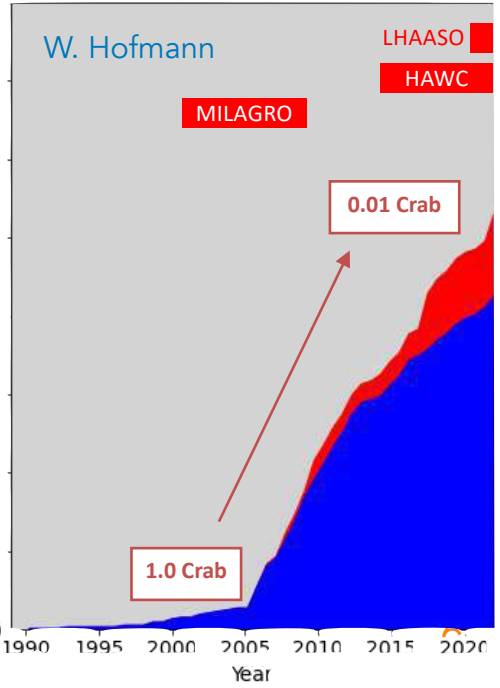
Zhen Cao ✉, F. A. Aharonian ✉, [...] X. Zuo

Nature **594**, 33–36 (2021) | Cite this article

8285 Accesses | 637 Altmetric | Metrics

LHAASO

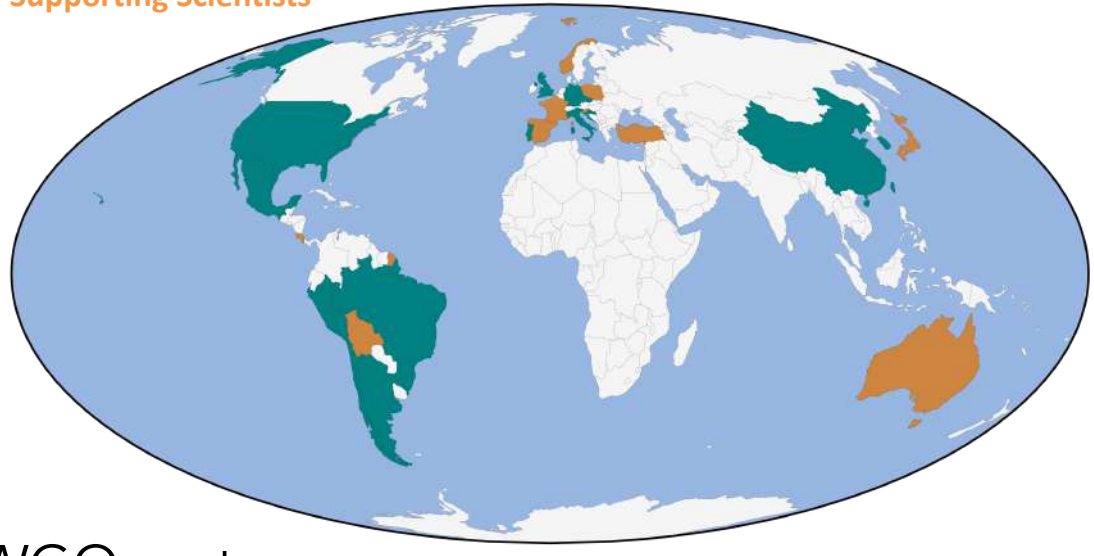


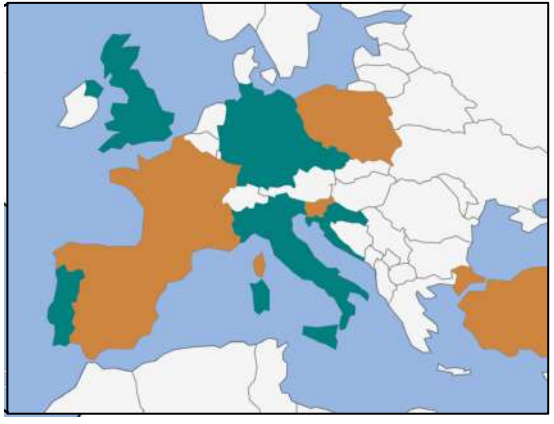


SWGO Collaboration

Member Institutes

Supporting Scientists





- SWGO partners
  - → 14 countries, 66 institutes*
  - → + supporting scientists

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

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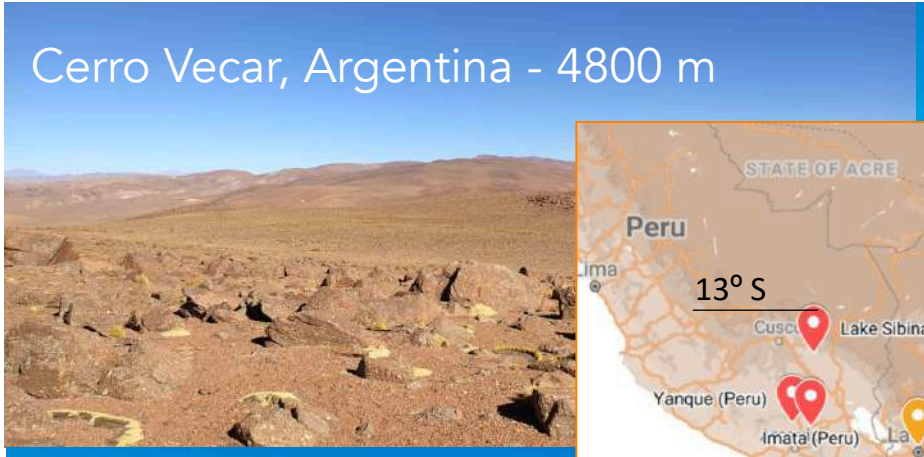
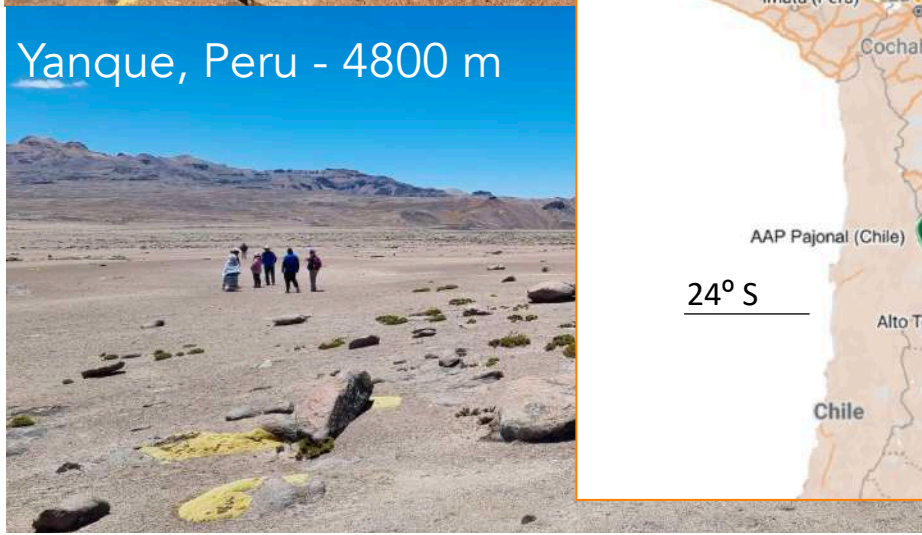
A Wide-field Gamma-ray Observatory in the South



A Wide-field Gamma-ray Observatory in the South

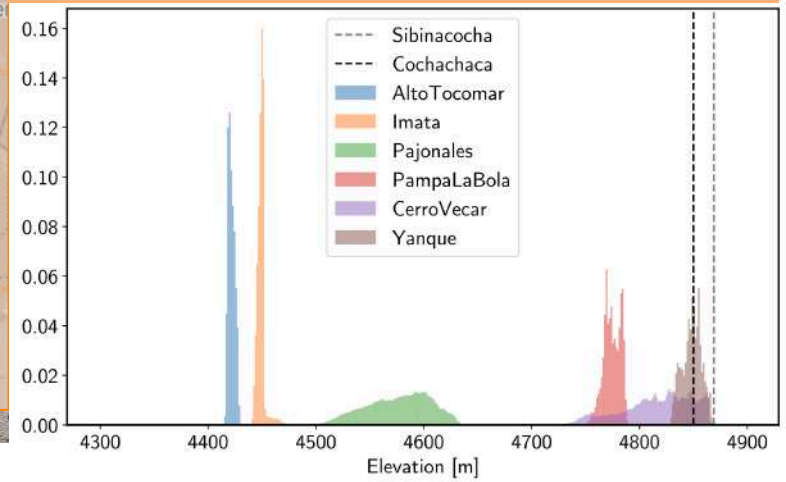
SWGO
The Southern Wide-field Gamma-ray Observatory



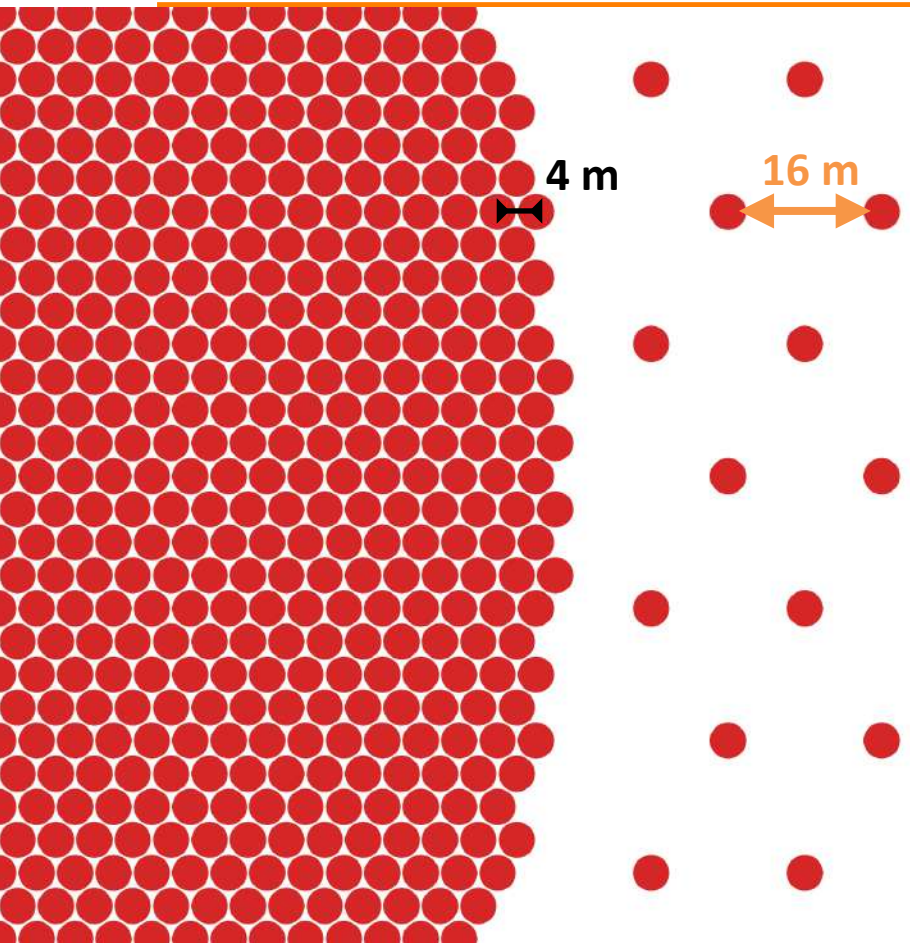
2020-21: Site Candidates

2022-23: Visits and Characterisation

2024: Site Selection



The baseline detector concept

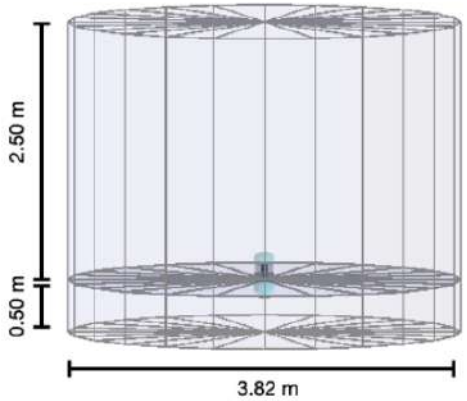


Core: Ø 320 m, FF = 80%
5,700 WCD units

Outer: Ø 600 m, FF = 5%
880 WCD units

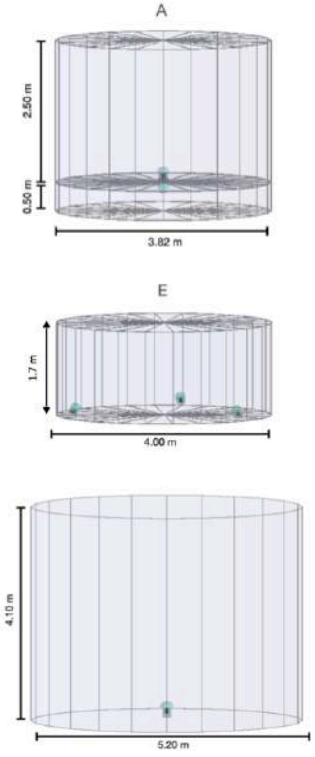
Altitude: 4,700 m a.s.l.

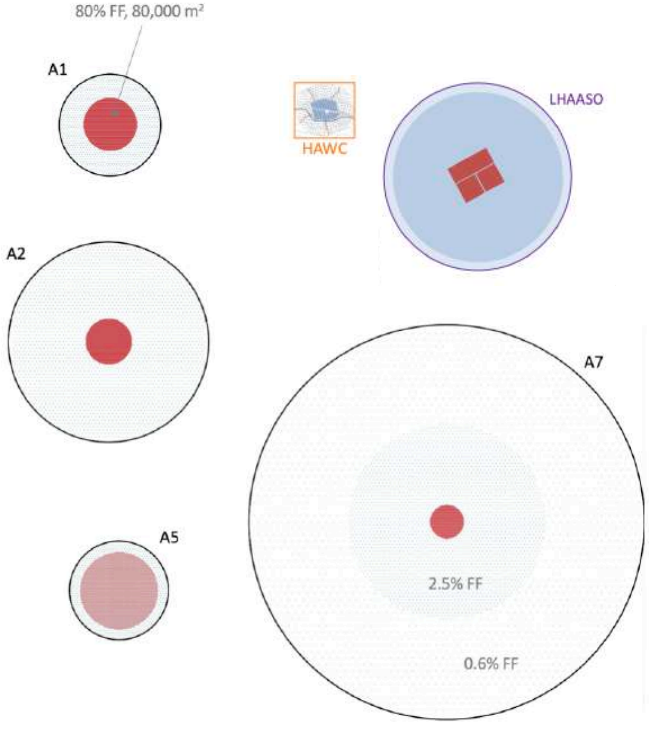
✧ muon counting



Analysis and Simulations

Simulation studies with different **WCD concepts** and **array configurations** to select most promising candidates





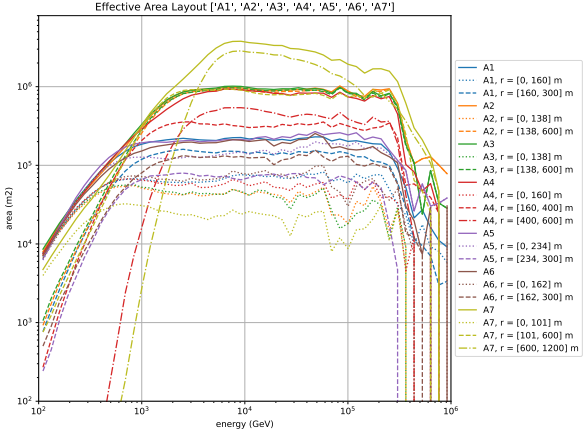
All layouts present in the SWGO simulation framework

CORSIKA — Simulation of extensive air showers

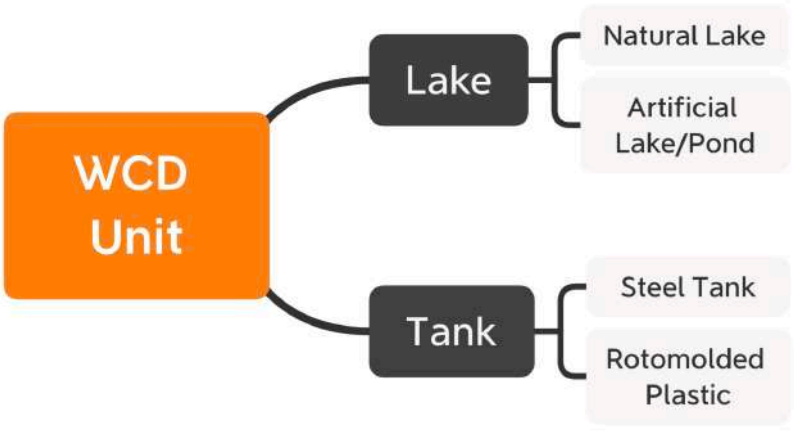
AERIE — Detector simulation

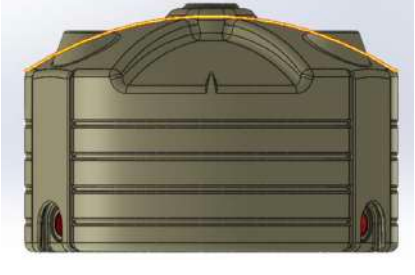
SWGO-RECO — Shower reconstruction

PYSWGO — High-level reconstructions (IRFs)



Exploring different WCD concepts





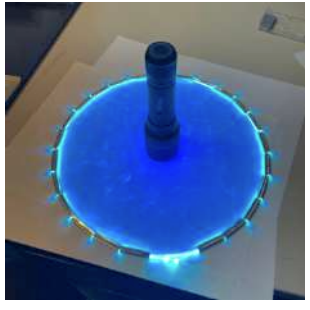
Several Prototypes

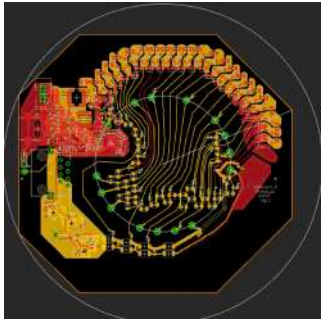
In construction - analysed in LAB

- taking data in the field

Detector options and prototyping

- Photodetectors
  - Detector
    - Large-area PMT
    - SiPM array
    - Multi-sensor
    - Distributed sensor
  - Light guide
    - None
    - Winston cone
    - WLS plate or fibres
- Electronics chain
  - Photodetector supply
    - Active base
    - Multi-channel HV
  - Digitiser
    - High-rate sampling
    - Medium-rate sampling + TDC
    - Time-over-threshold (ToT)
  - Clock distribution
    - White Rabbit
    - RapCal

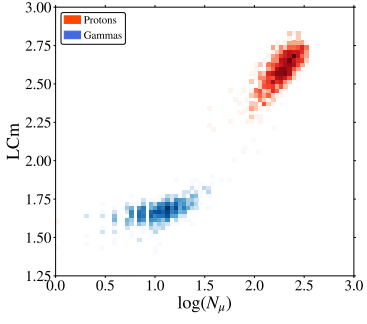




A next-generation observatory

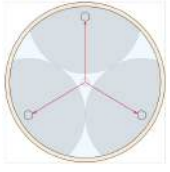
Development of new concepts and approaches

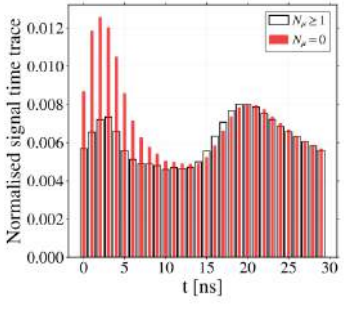
New gamma/hadron discrimination approaches



shower footprint azimuthal fluctuations

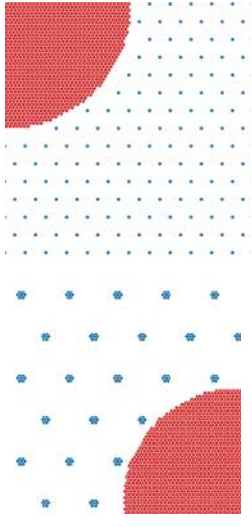
Novel surface detector concepts





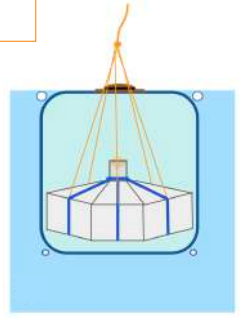
multi-PMT signal time trace for muon tag

Alternative array layout configurations



Outer array configurations

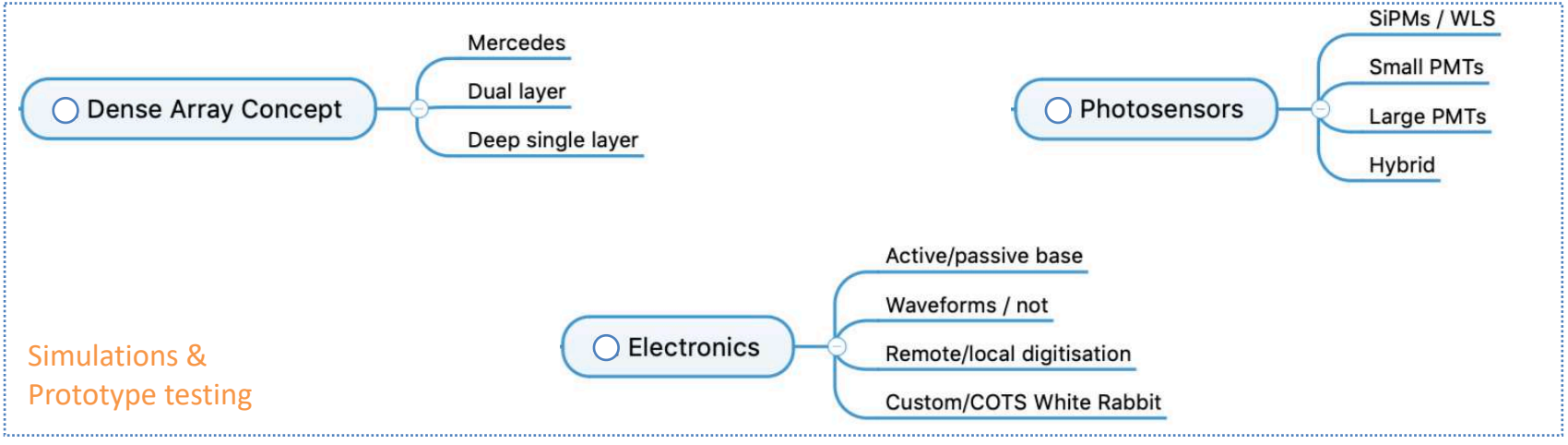
Novel WCD engineering solutions

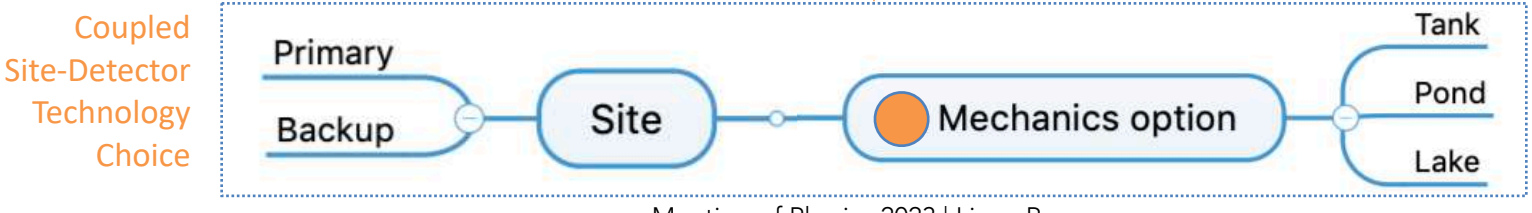


Double-layered bladders and thermally-insulated tanks

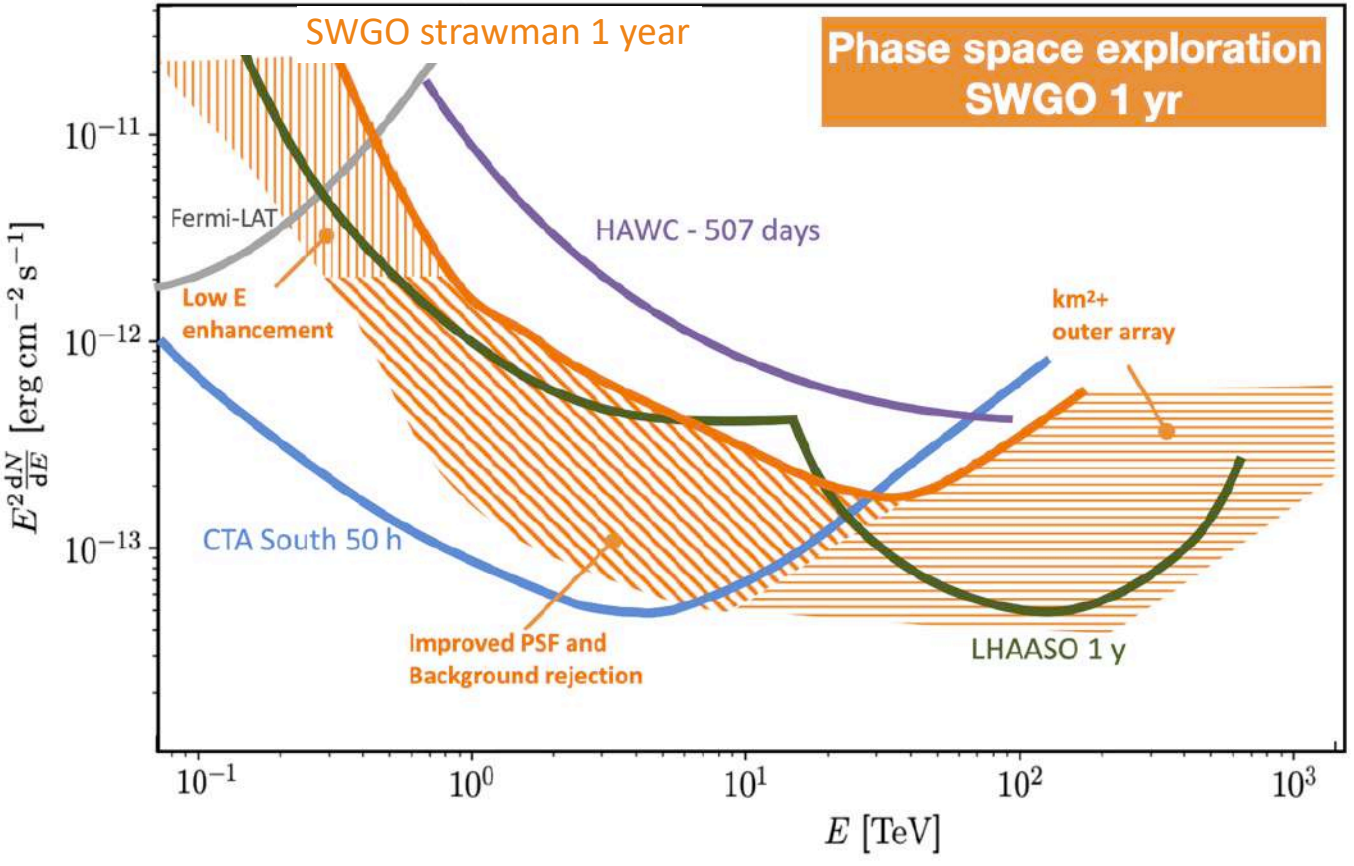
Decision phase has started!

A series of steps to decide on detector elements by end 2024

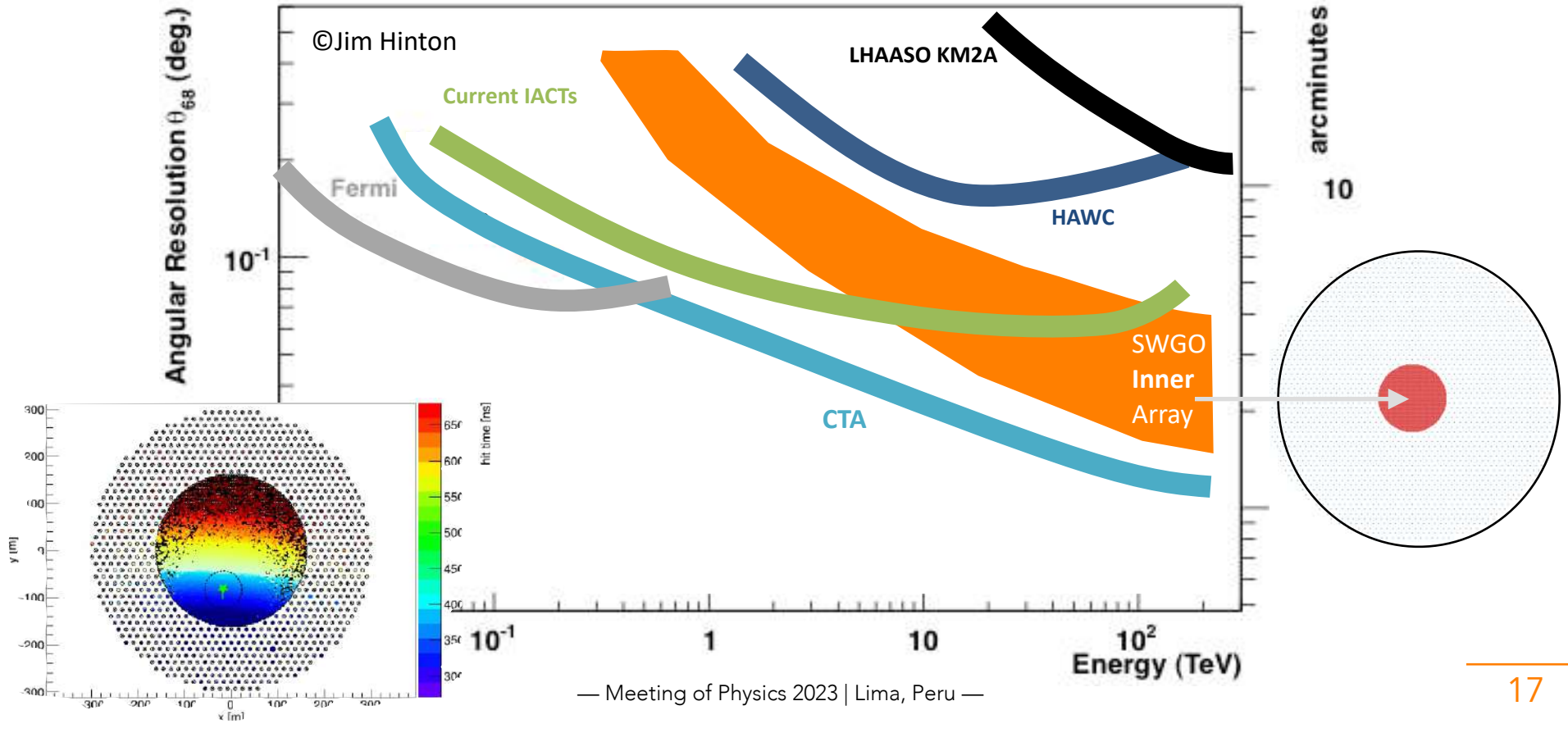




SWGO foreseen sensitivity



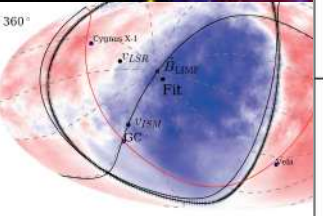
SWGO Performance Goal
Angular Resolution



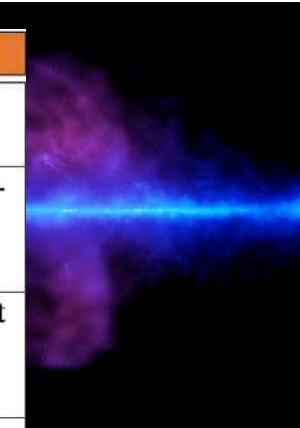
Science

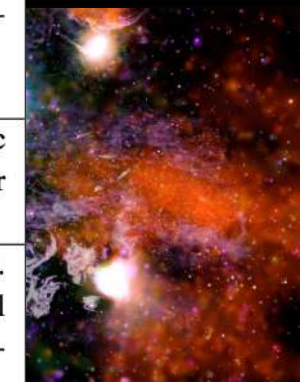
6 core benchmark science cases

First IRFs in production for performance expectations



Core Science Case	Design Drivers	Benchmark Description
Transient Sources: **Gamma-ray Bursts**	Low-energy Site altitude	Min. time for 5σ detection F(100 GeV)= 10^{-8} erg cm^{-2} s^{1}
Galactic Accelerators: **PeVatron Sources**	High-energy sensitivity Energy resolution	Maximum exp-cutoff energy detectable 95% CL in 5 years for: F(1 TeV)= 5 mCrab, index= −2.3
Galactic Accelerators: **PWNe and TeV Halos**	Extended source sensitivity Angular resolution	Max. angular extension detected at $5\,\sigma$ in 5-yr integration for: F(>1 TeV)= 5×10^{-13} TeV cm^{-2} s^{1}
Diffuse Emission: **Fermi Bubbles**	Background rejection	Minimum diffuse cosmic-ray residual background level. Threshold: $< 10^{-4}$ level at 1 TeV.
Fundamental Physics: **Dark Matter from GC Halo**	Mid-range energy sensitivity Site latitude	Max. energy for $b\bar{b}$ thermal relic cross-section at 95% CL in 5-yr, for Einasto profile.
Cosmic-rays: **Mass-resolved dipole** **Multipole anisotropy**	Muon counting capability	Max. dipole energy at 10^{-3} level. Log-mass resolution at 1 PeV – goal is $A = 1, 4, 14, 56$; Maximum multipole scale > 0.1 PeV.

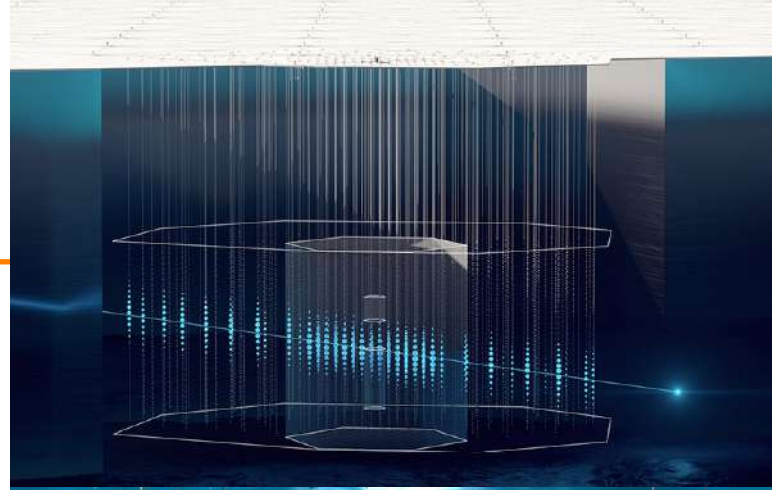


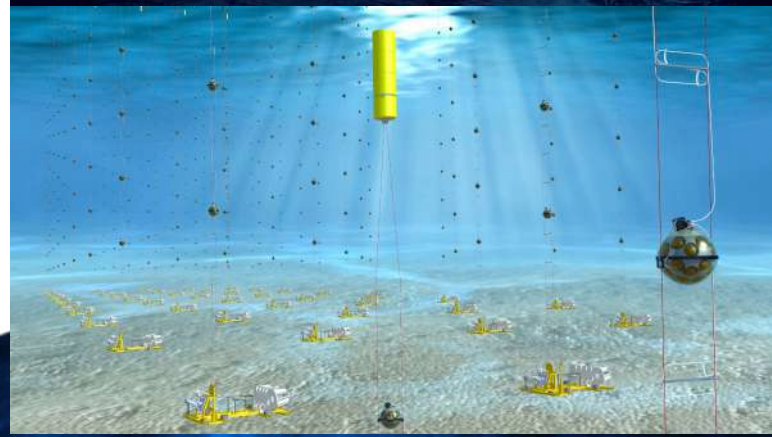


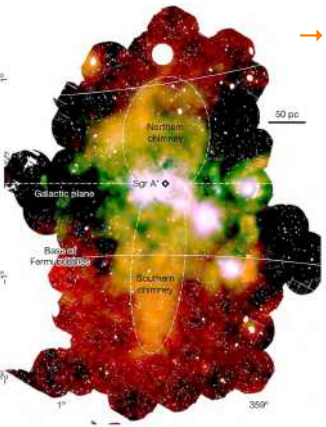
SWGO
The Southern Wide-field Gamma-ray Observatory

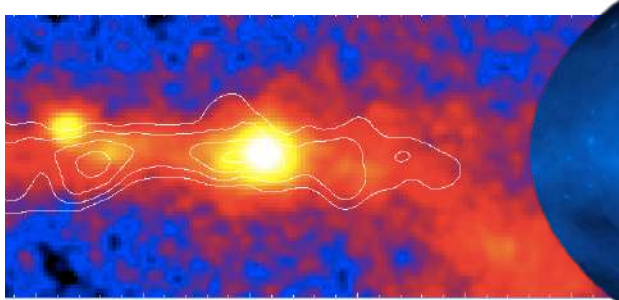
UHE Synergies

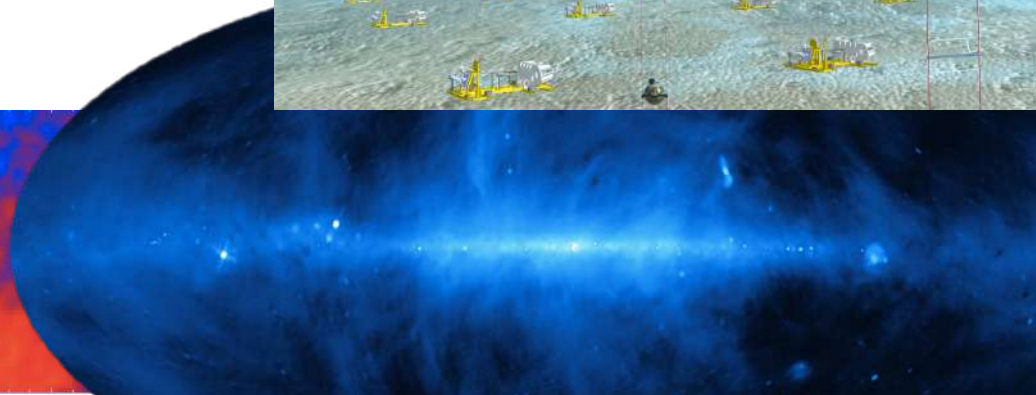
- SWGO+LHAASO
  - → **Full sky map of TeV-PeV γ emission**
- Strongly complements new generation of **neutrino instruments**
  - → Mapping out diffuse emission / separating IC from pion decay emission, Dark Matter search +++
    - → Nearby transients/flares











Transients with SWGO

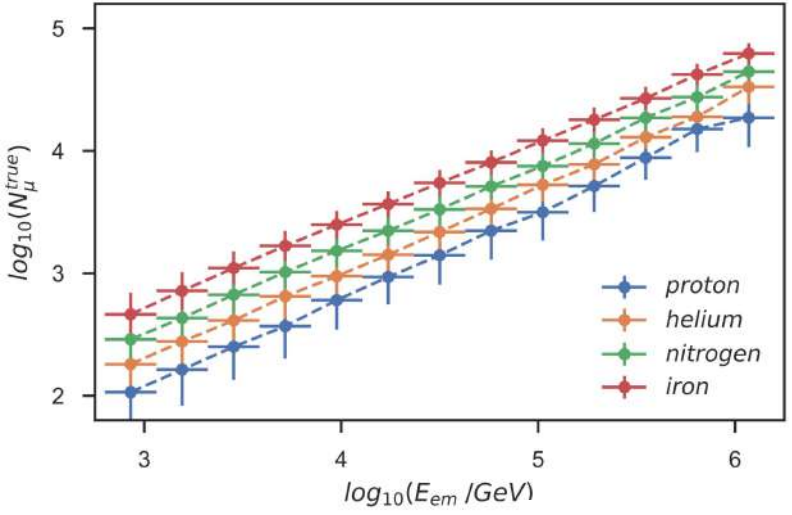
- Short-timescale sensitivity of ground-particle detectors is much worse than IACTs at low E! But room for improvement < 1 TeV

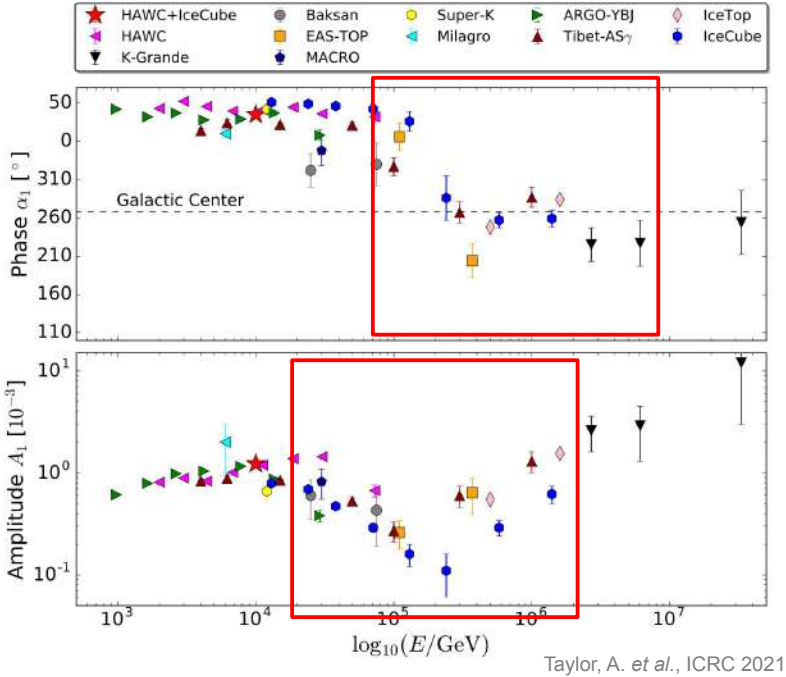
- And a number of other advantages…
  - → **100% duty cycle** → higher rate and monitoring capability of transients → bridging the gap with satellite facilities
  - → **Serendipitous view** - observation of onset / prompt emission of GRBs
  - → **A trigger instrument**!
    - ✓ Blind searches and offline checks for afterglow triggers
      - Critical synergy with IACTs and other MWL + MM instruments

✧ **SWGO can bring the 10s deg² error boxes (GBM, GW) down to ~ deg²**

Cosmic rays

- Charged cosmic ray physics at the knee
  - → **Mass-resolved anisotropy studies**
- Measuring μ-content with WCDs
  - → Tagging of single muons at detector unit





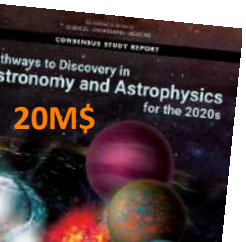
Taylor, A. *et al.*, ICRC 2021

Status & Plan

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

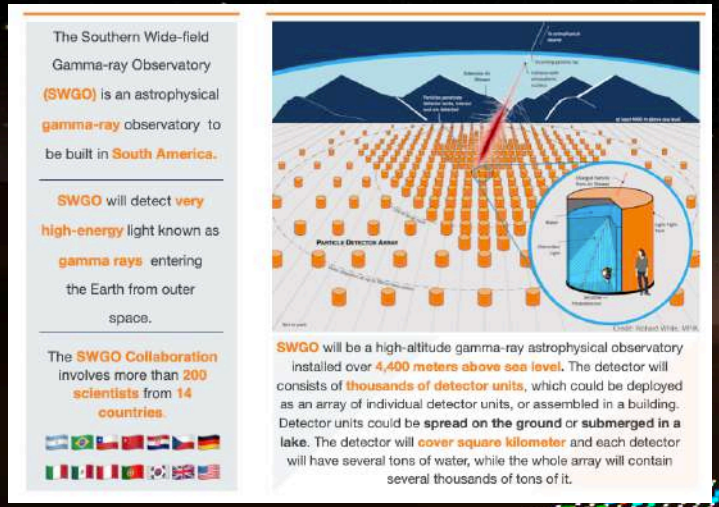
- R&D Phase
  - → Kick off meeting Oct 2019
  - → Expected completion 2024
    - ✓ Site and Design Choices made
  - → Then:
- Preparatory Phase
  - → Detailed construction planning
  - → **Engineering Array**
- (Full) Construction Phase
  - → From 2027

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



Outreach and Communication

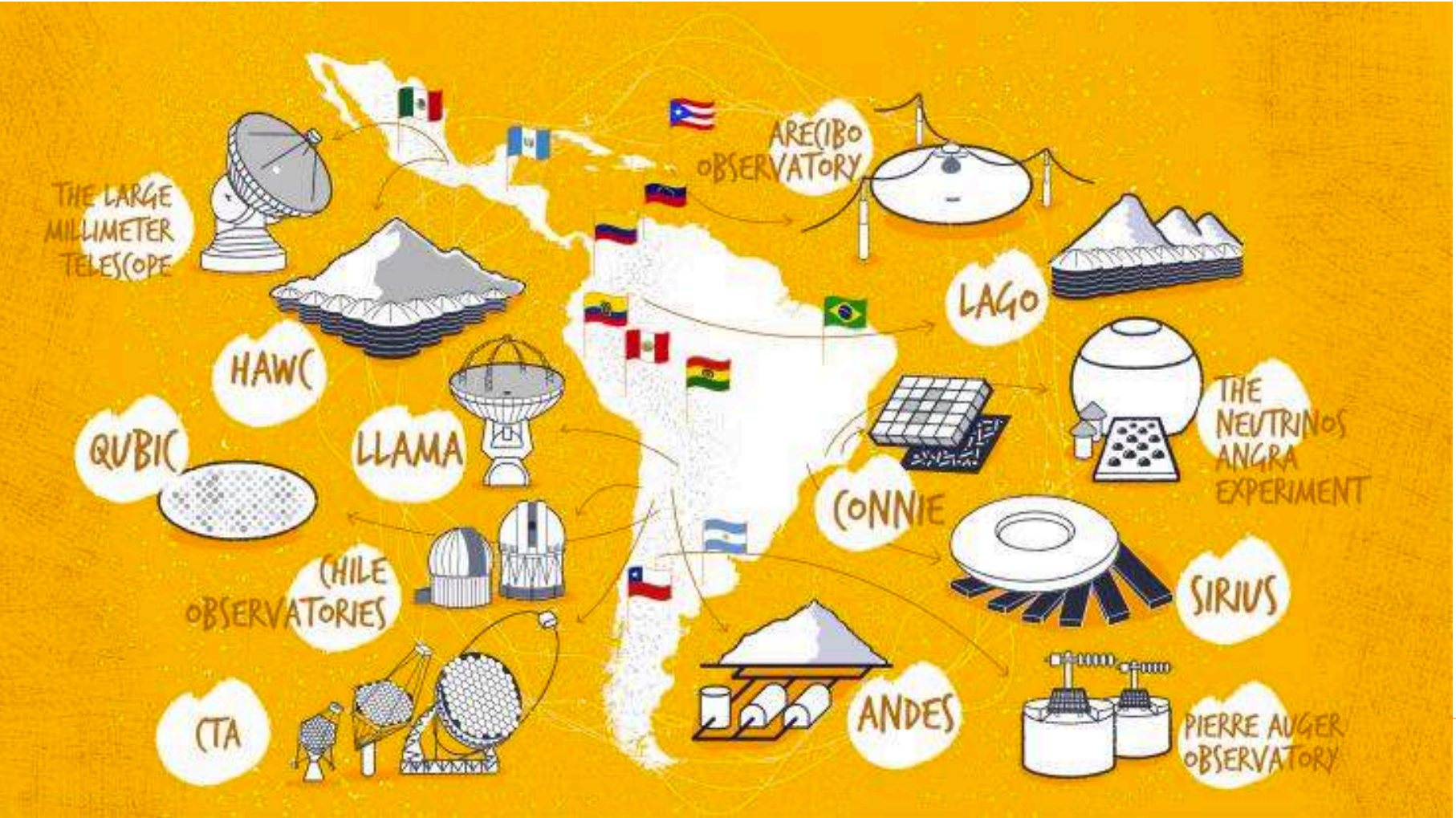
Production of poster and flyers in several languages



3D event display visualizer of SWGO

https://wminho.lip.pt/swgo/

Astroparticle Physics in Latin-America

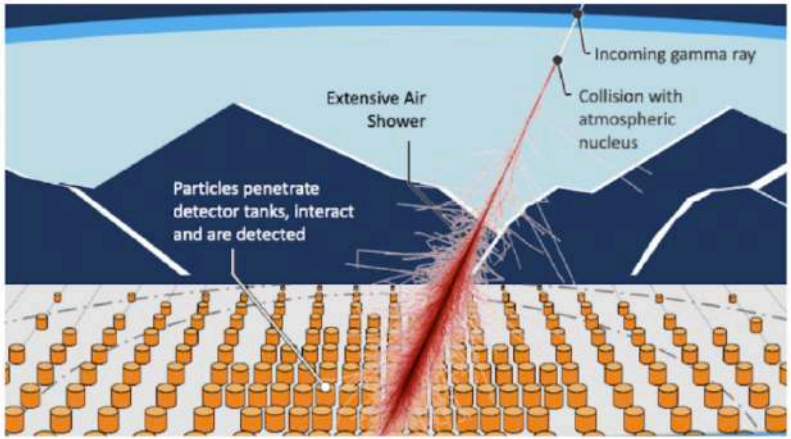


CLAF and MCTI High Level Seminar

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

Summary

- SWGO is deep into the R&D phase: decision phase has started!
- Engineering array at few-% scale planned after CDR, in 2026+
- **Science and performance goals**
  - → New window for PeVatron astronomy in the southern hemisphere
  - → Wide-energy range coverage 100 GeV - 1 PeV
  - → Sensitivity for transient phenomena below 1 TeV
  - → Crucial mass-resolved CR data at the knee region
- A key instrument for MM astrophysics for the next decades!

Thank you!

SWGO acknowledgements