SWGO

Southern Wide-Field Gamma-ray Observatory

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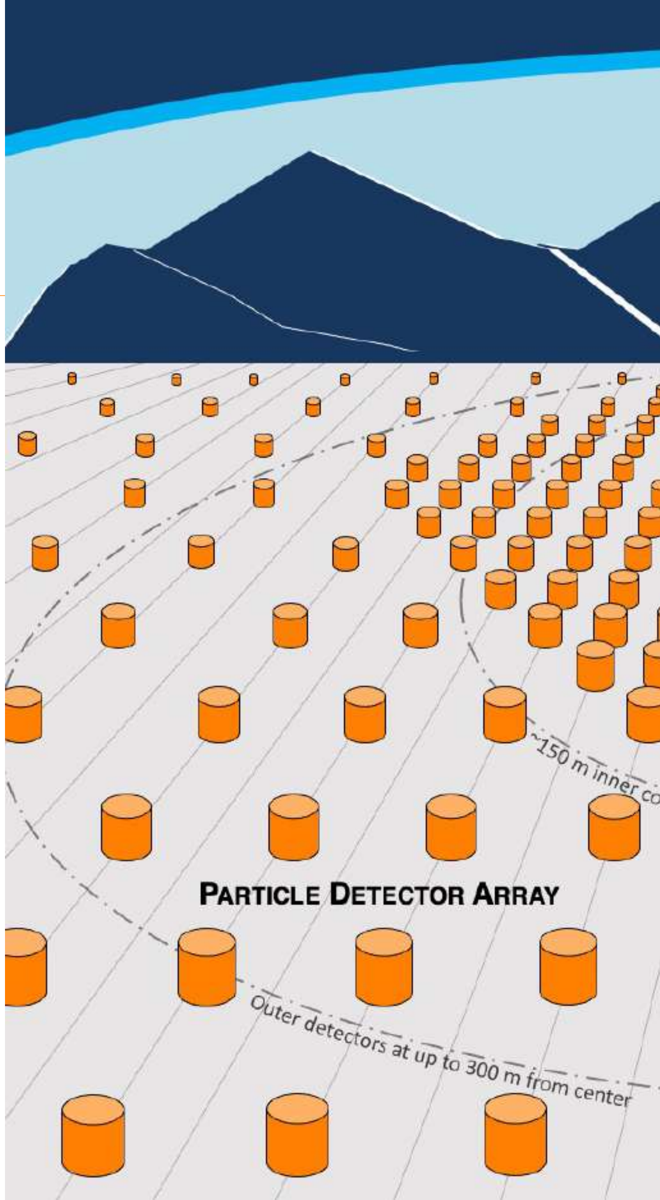
Content

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



Ground-based gamma-rays

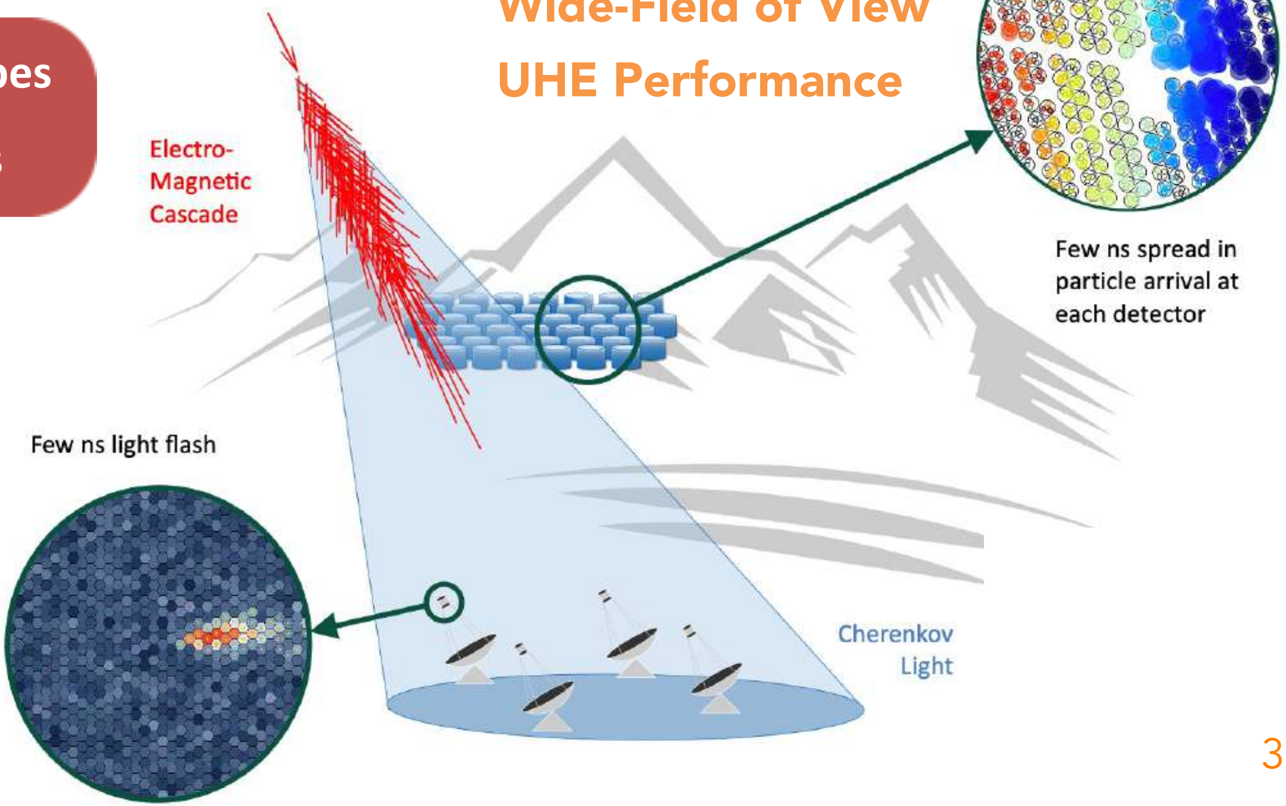
Two techniques

1. Air-Cherenkov telescopes
2. Altitude particle arrays

High Duty Cycle

Wide-Field of View

UHE Performance



Low Duty Cycle

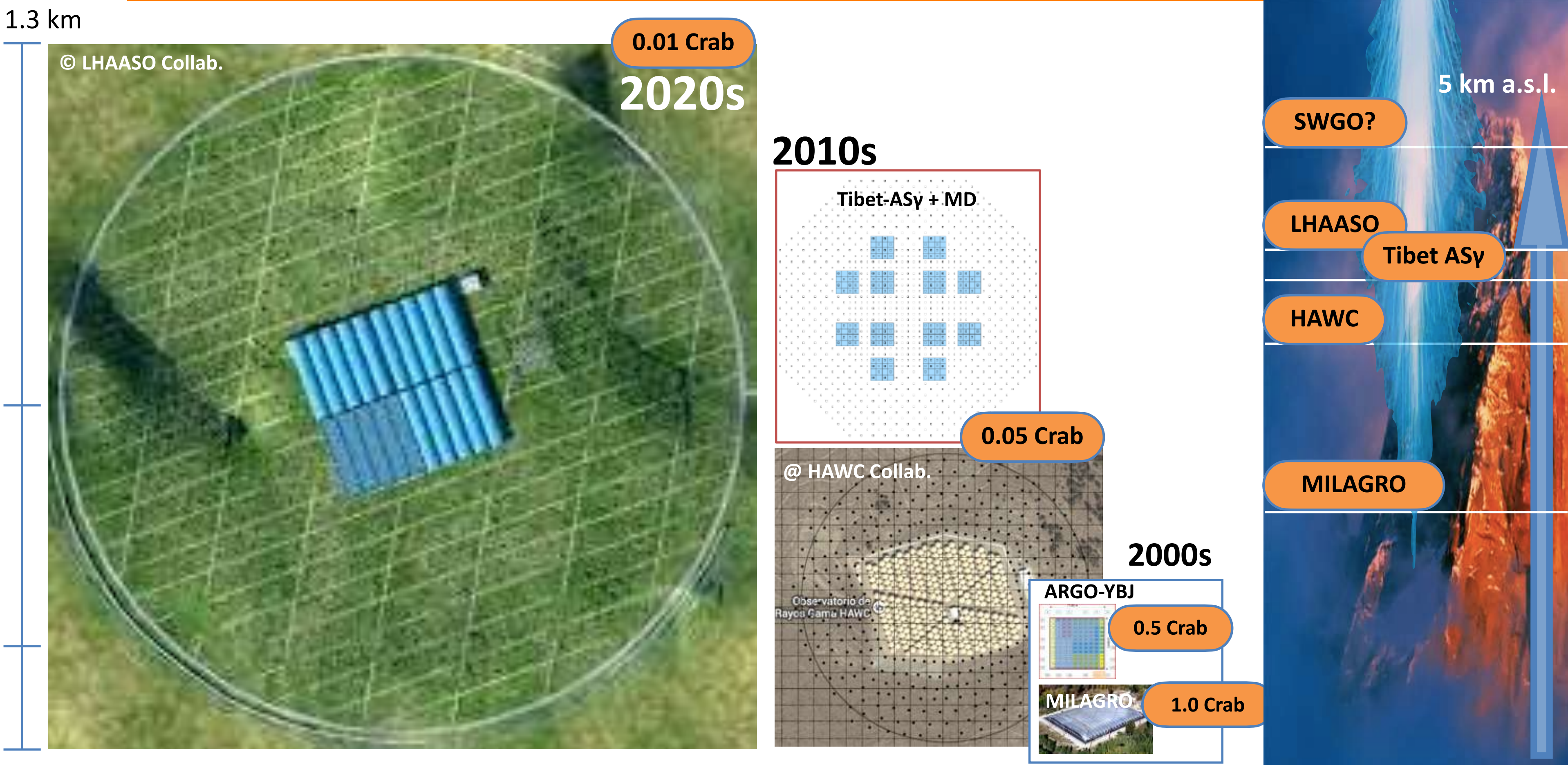
Pointing instruments

Precision Astronomy at VHE

Ground-based Gamma-ray Astronomy Network

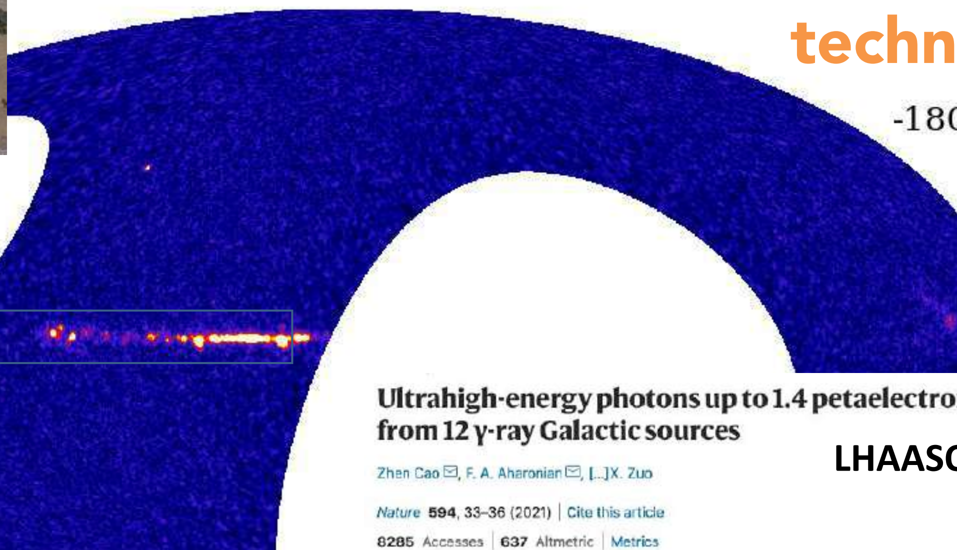
— TeVPA Naples | September 2023 —

Larger and higher...



A new window for the UHE sky

HAWC



Major observational technique > 10s TeV

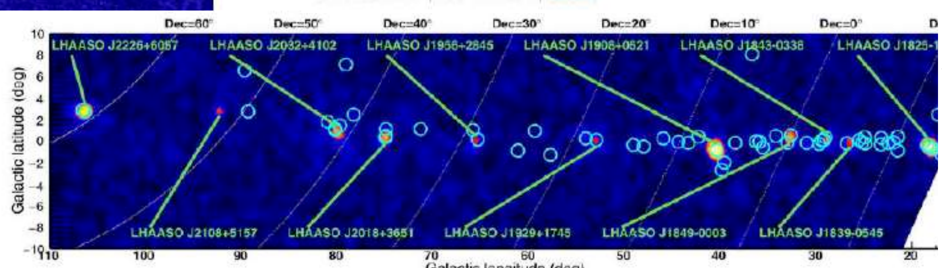
Ultrahigh-energy photons up to 1.4 petaelectronvo
from 12 γ-ray Galactic sources

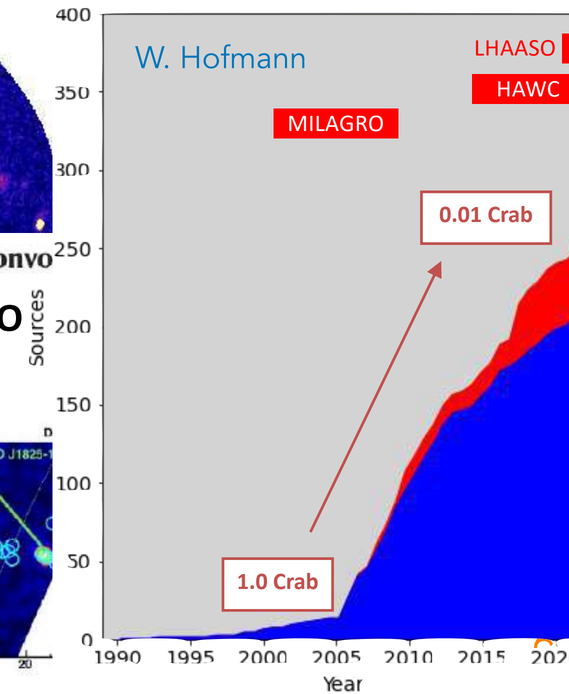
Zhen Cao, F. A. Aharonian, [...]X. Zuo

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

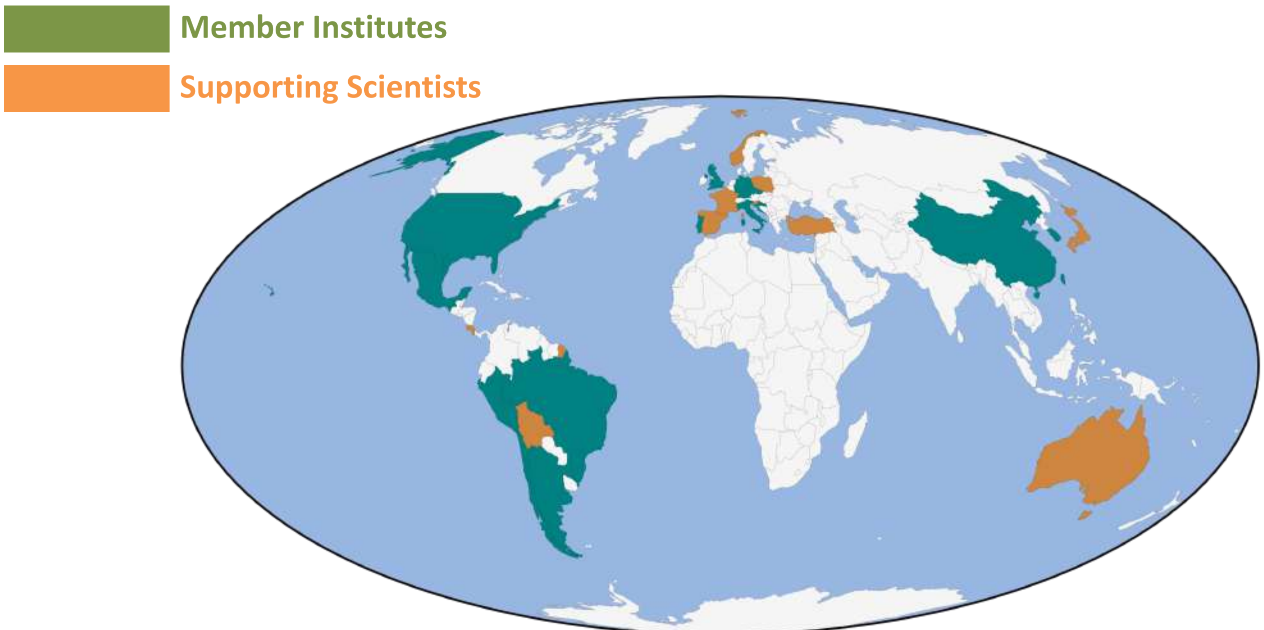
8285 Accesses | **637** Altmetric | Metrics

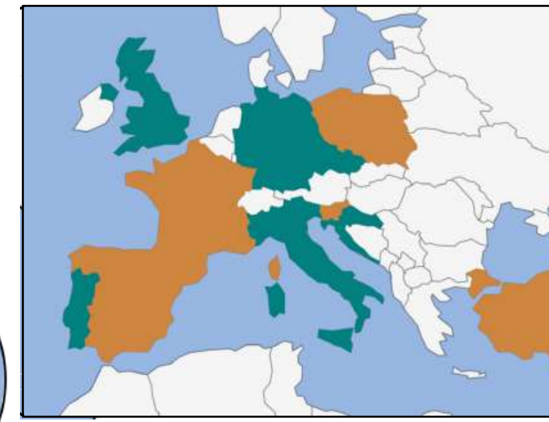
LHAASO





SWGO Collaboration





- 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

A Wide-field Gamma-ray Observatory in the South


Cerro Vecar, Argentina - 4800 m


Pampa La Bola, Chile - 4770 m


Yanque, Peru - 4800 m

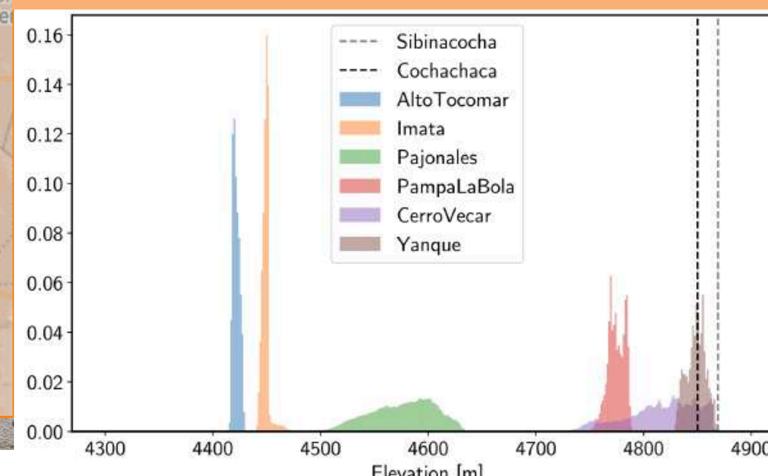

Sibinacocha, Peru - 4900 m

A Wide-field Gamma-ray Observatory in the South

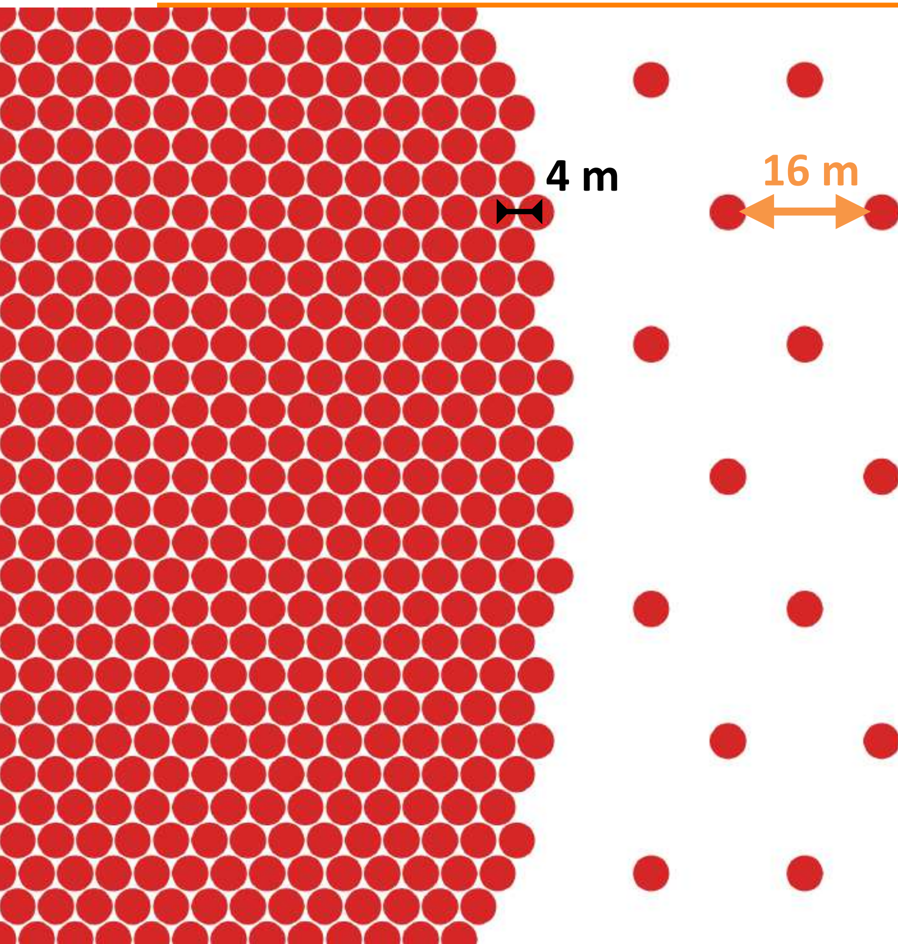
2020-21: Site Candidates

2022-23: Visits and Characterisation

2024: Site Selection



The baseline detector concept

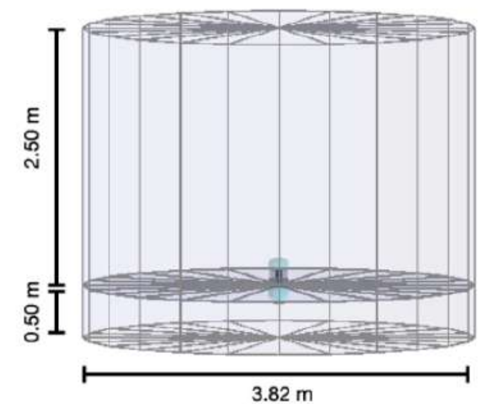


Core: Ø 320 m, FF = 80%
5,700 WCD units

Outer: Ø 600 m, FF = 5%
880 WCD units

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

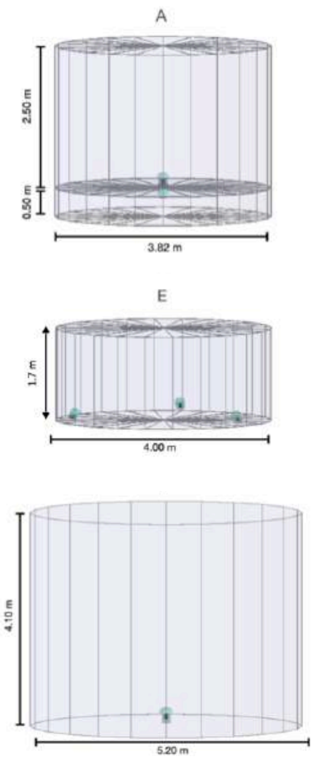
✧ muon counting

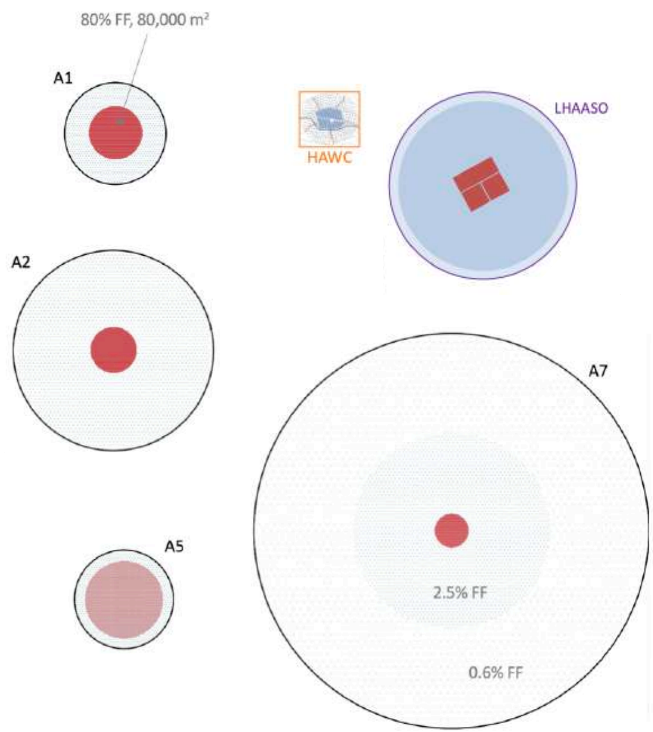


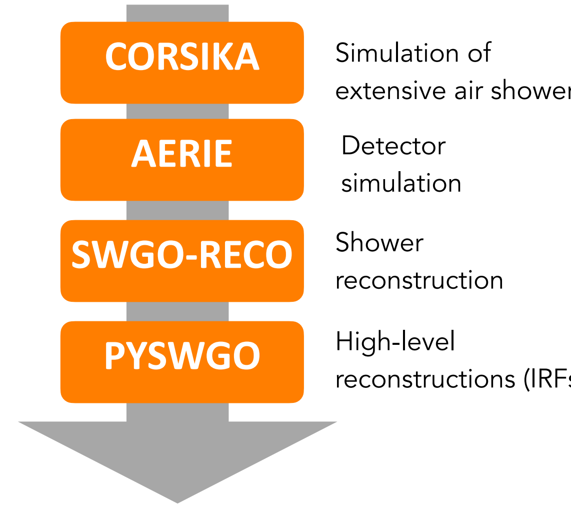
Analysis and Simulations

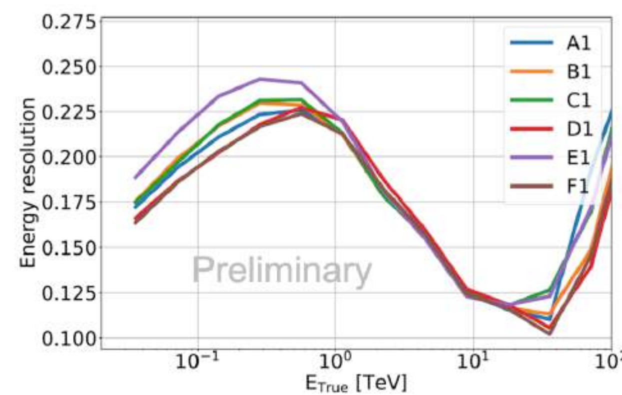
Simulation studies with different **WCD concepts** and **array configurations** to select most promising candidates

All layouts present in the SWGO simulation framework

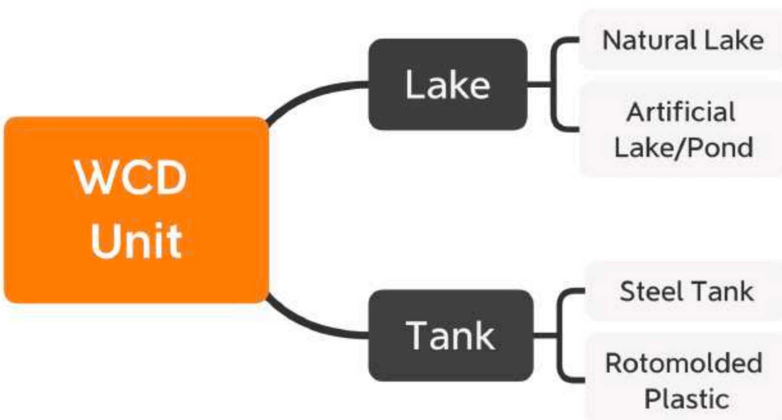


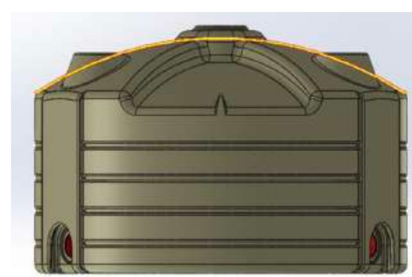






Exploring different WCD concepts





Several Prototypes

In construction - analysed in LAB

- taking data in the field

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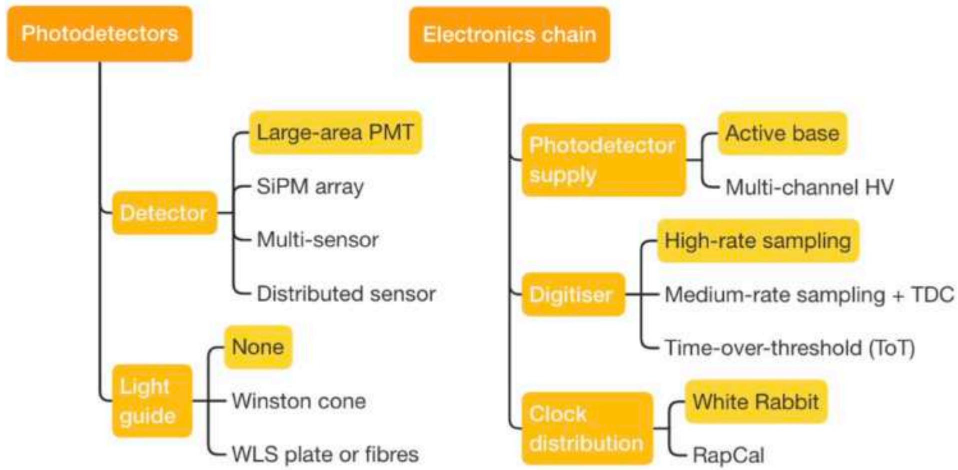
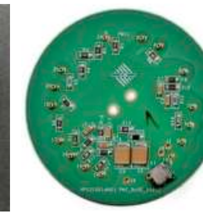
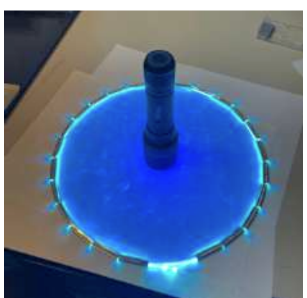
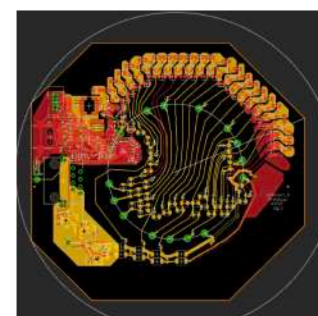
Detector options and prototyping





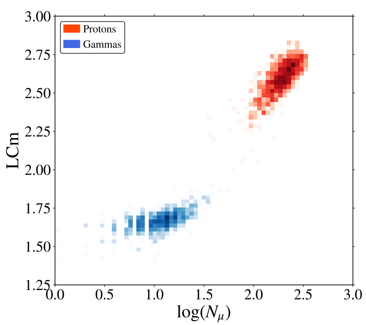




A next-generation observatory

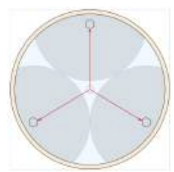
Development of new concepts and approaches

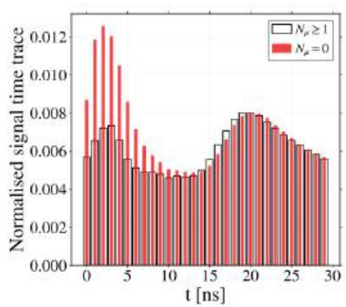
New gamma/hadron discrimination approaches



shower footprint azimuthal fluctuations

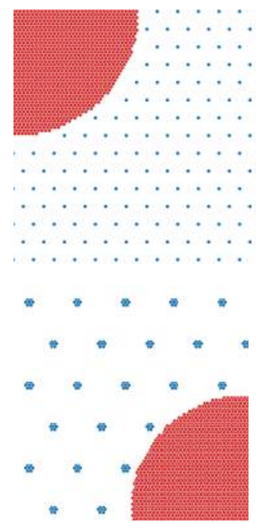
Novel surface detector concepts





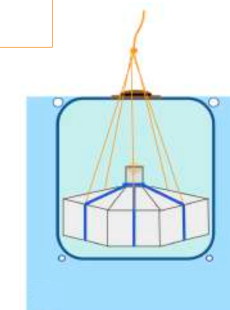
multi-PMT signal time trace for muon tag

Alternative array layout configurations



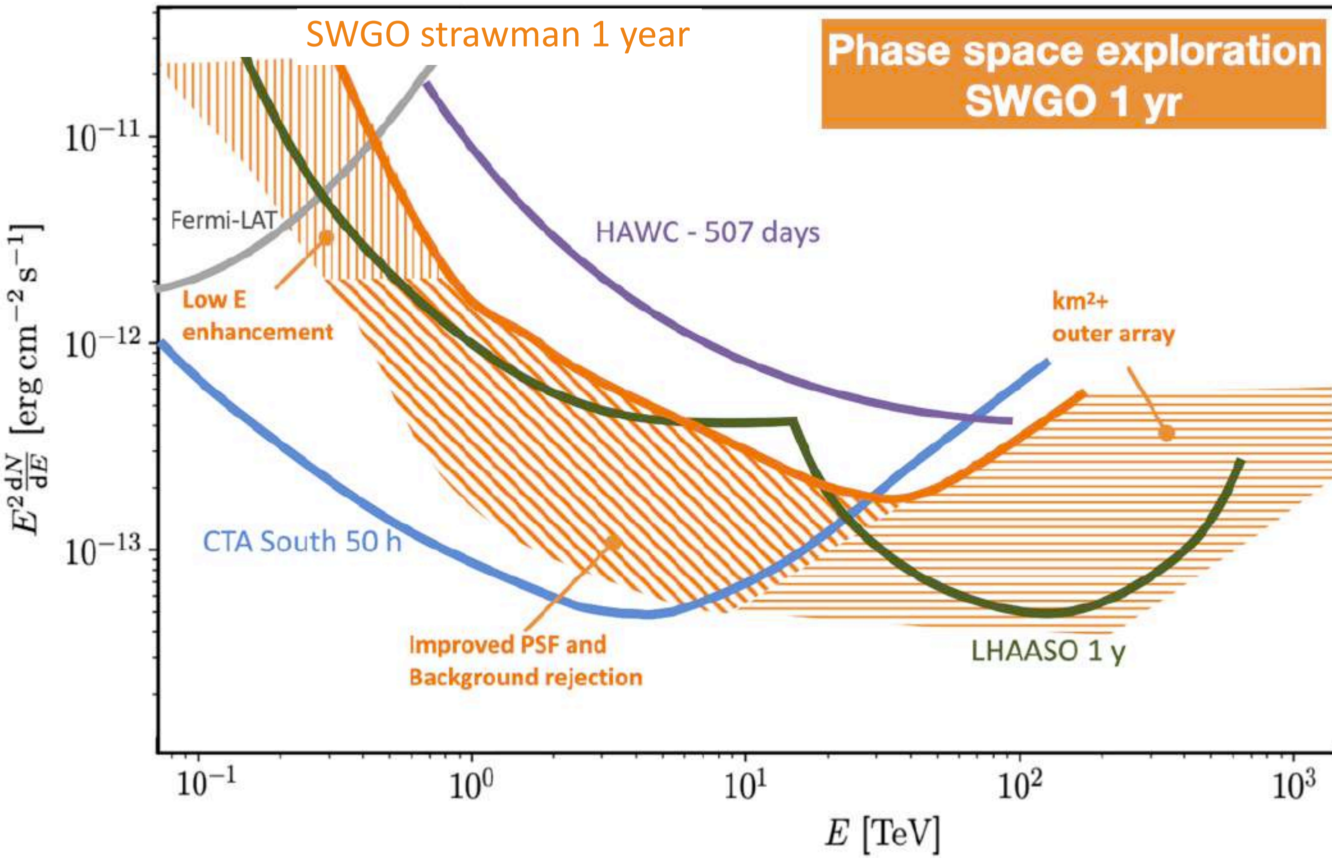
Outer array configurations

Novel WCD engineering solutions

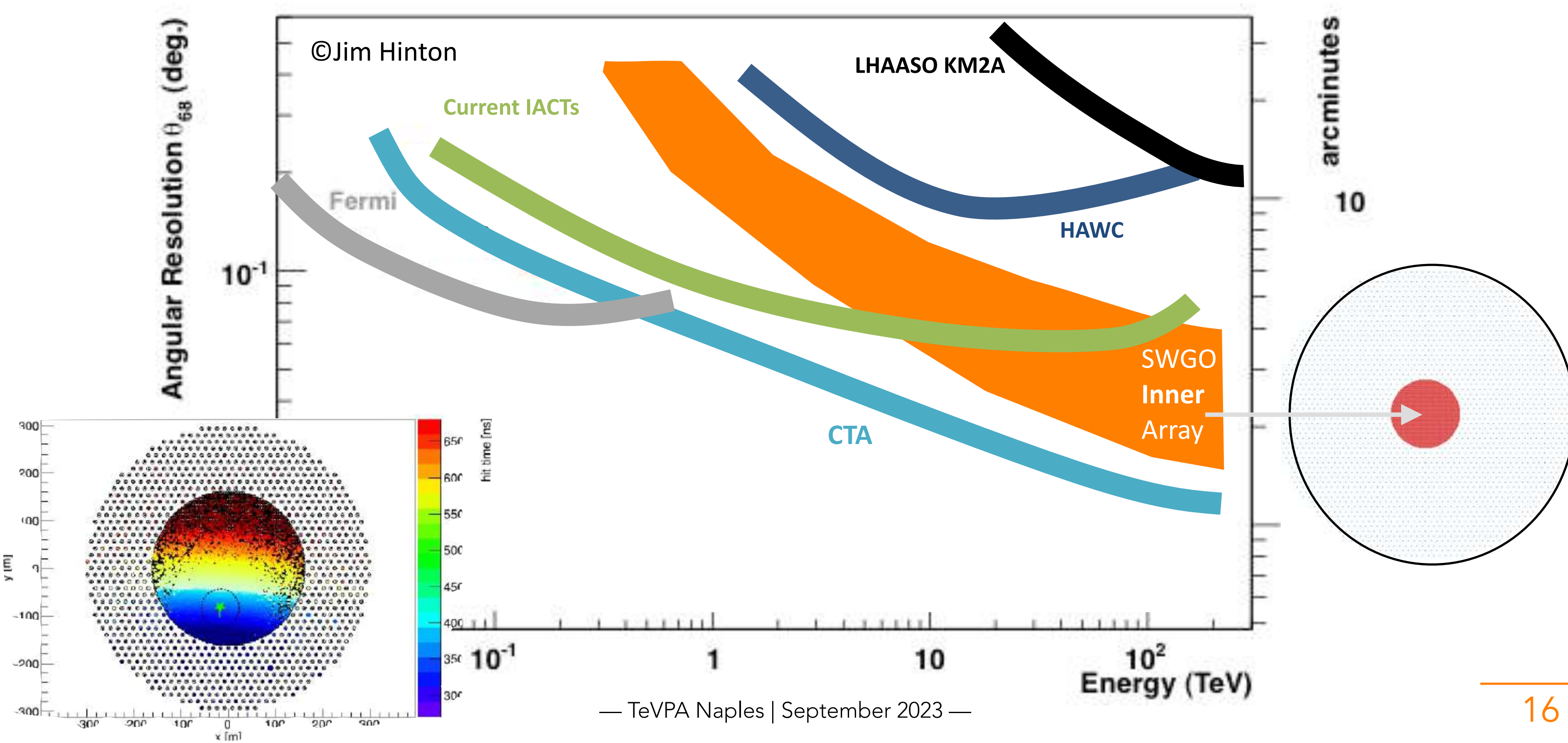


Double-layered bladders and thermally-insulated tanks

SWGO foreseen sensitivity



SWGO Performance Goal
Angular Resolution



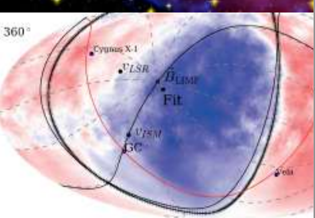
Science

6 core benchmark science cases

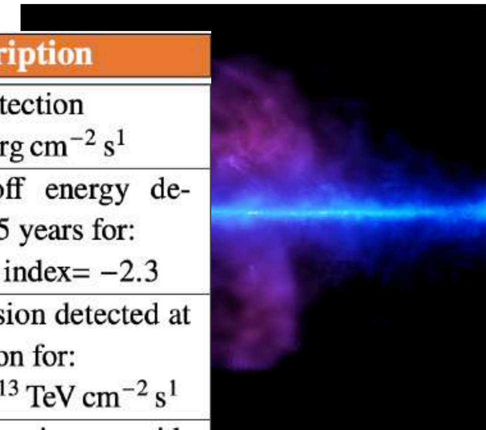
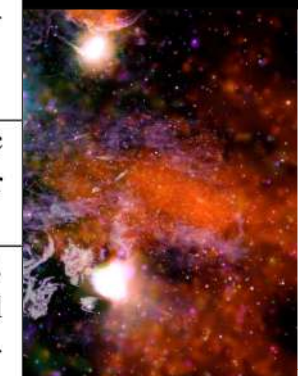
The Southern Wide-field Gamma-ray Observatory

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 $F(100\,\text{GeV}) = 10^{-8}$ 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: $F(1\,\text{TeV}) = 5$ 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: $F(>1\,\text{TeV}) = 5 \times 10^{-13}$ 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.

Transients with SWGO

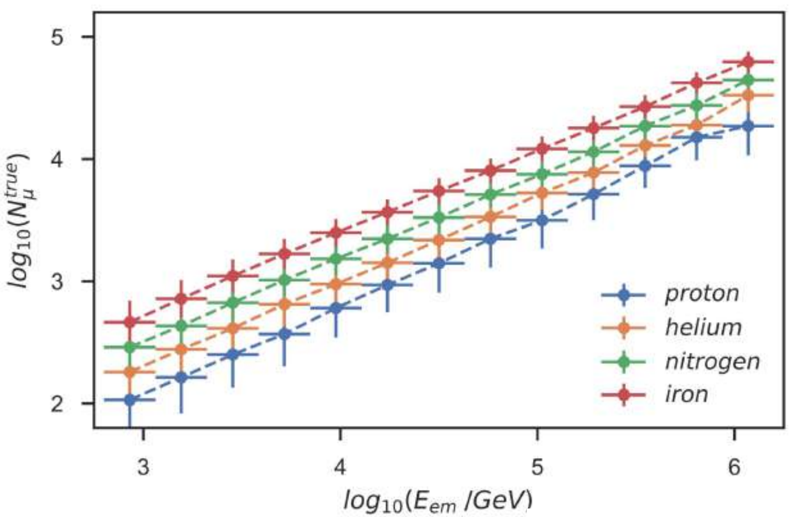
- Short-timescale sensitivity of ground-particle detectors is much worse than IACTs at low E! But room for improvement < 1 TeV

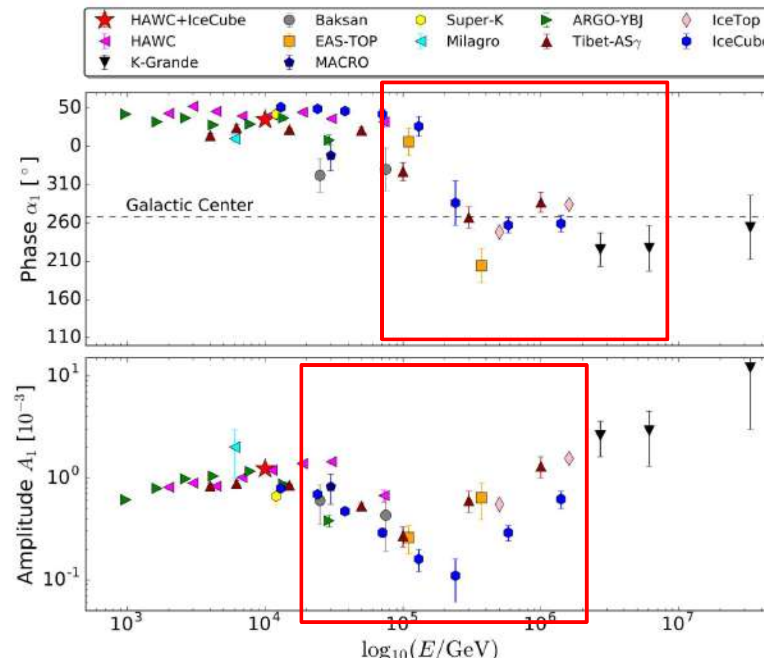
- And a number of other advantages…
  - **100% duty cycle →** higher rate and monitoring capability of transients → bridging the gap with satellite facilities
  - **Serendipitous view** - observation of onset / prompt emission of GRBs
  - **A trigger instrument**!
    - Blind searches and offline checks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

✧ **SWGO can bring the 10s deg^2 error boxes (GBM, GW) down to ~ deg^2**

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

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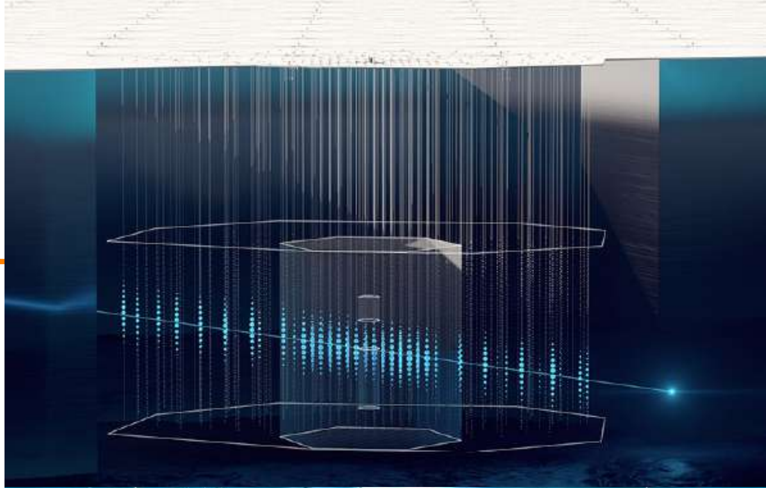
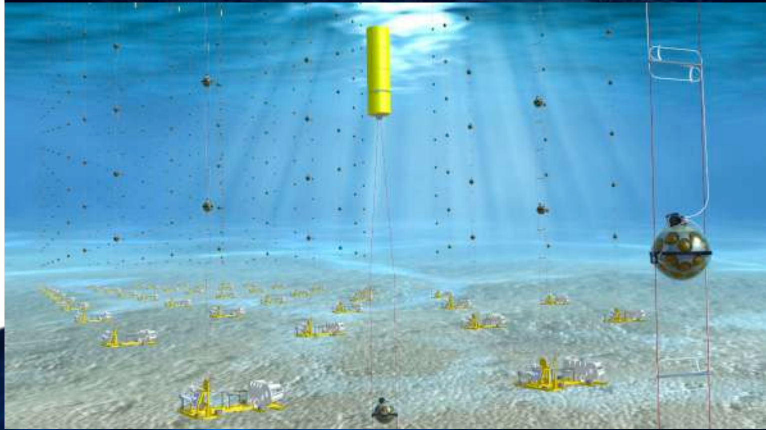
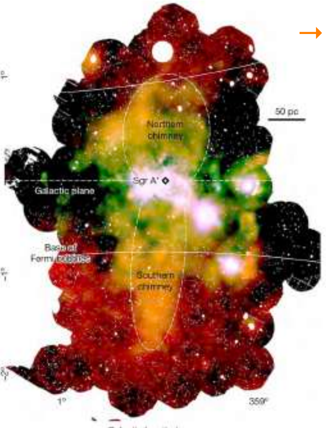
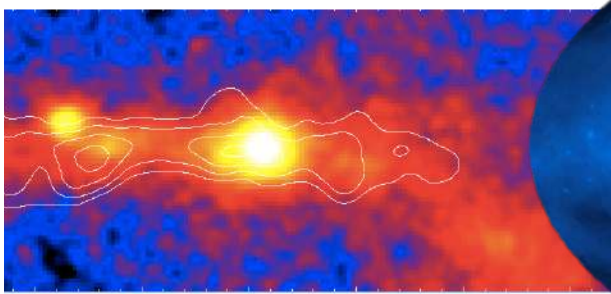
Neutrino Synergies

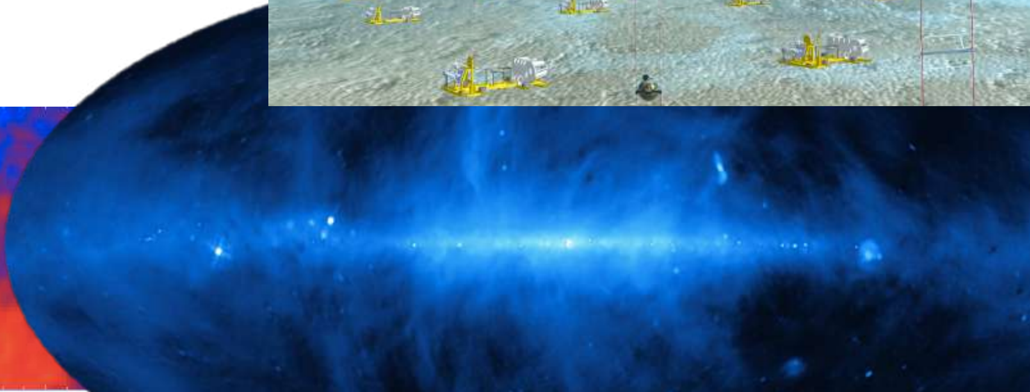
- SWGO+LHAASO
  - **Full sky map of TeV-PeV γ emission**
- Strongly complements new generation of **neutrino instruments**
  - Mapping out diffuse emission / separating IC from pion decay emission, Dark Matter search +++
    - Nearby transients/flares









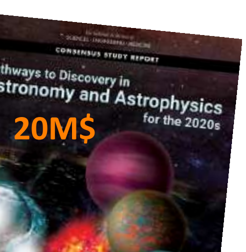


Status & Plan

		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
  - 2027+

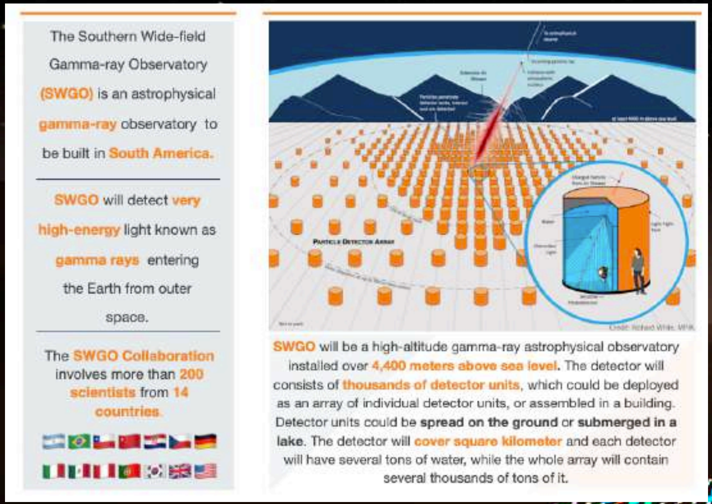
- Roadmaps
  - US Decadal Review
  - SNOWMASS, APPEC, Astronet



SWGO
The Southern Wide-field Gamma-ray Observatory
Event display developed by:

Outreach and Communication

Production of poster and flyers in several languages


The Southern Wide-field Gamma-ray Observatory (SWGO) is an astrophysical gamma-ray observatory to be built in South America.

SWGO will detect very high-energy light known as gamma rays entering the Earth from outer space.

The SWGO Collaboration involves more than 200 scientists from 14 countries.

SWGO will be a high-altitude gamma-ray astrophysical observatory installed over 4,400 meters above sea level. The detector will consists of thousands of detector units, which could be deployed as an array of individual detector units, or assembled in a building. Detector units could be **spread on the ground** or **submerged in a lake**. The detector will cover square kilometer and each detector will have several tons of water, while the whole array will contain several thousands of tons of it.

3D event display visualizer of SWGO


SWGO será el primer observatorio de **rayos gamma** a gran altitud que proveerá una cobertura amplia de una gran porción de cielo del Sur.

Créditos: Richard White, MPIK

Imagen del cielo en rayos gamma visto actualmente por HAWC y por futuras observaciones de SWGO.

SWGO complementará instrumentos actuales y futuros como HAWC, LHAASO y CTA; un esfuerzo mundial de detección de multi mensajeros para revelar los misterios de los fenómenos astrofísicos más extremos.

SWGO detectará los rayos gamma de las **más altas energías** provenientes del espacio, permitiendo estudiar objetos cósmicos extremos como **agujeros negros super masivos** y **remanentes de supernova**, así como investigar la naturaleza de la **materia oscura**.

SWGO también tiene como objetivo desarrollar una **buena relación** con el país anfitrión y la comunidad local.

¿Te gustaría saber más?

CONTACTO:
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www.swgo.org

SWGO
The Southern Wide-field Gamma-ray Observatory

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

Summary

SWGO
The Southern Wide-field Gamma-ray Observatory

- SWGO is deep into the R&D phase
- Engineering array at few-% scale planned after CDR, in 2024+
- **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