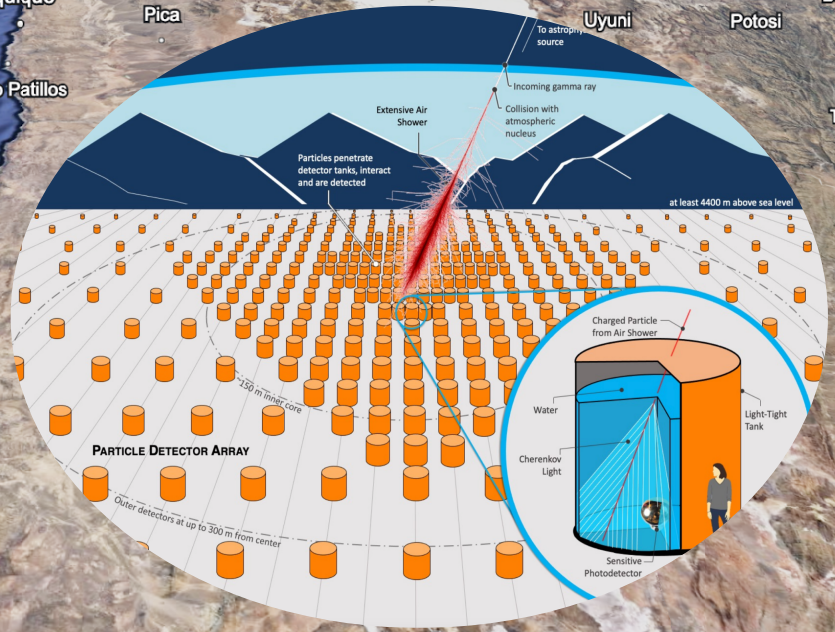
SWGO

The Southern Wide-field Gamma-ray Observatory

Alt 4,770 m – Lat 22.946 S – Long 67.6775 W

Hao Zhou for the SWGO Collaboration

Aug 28, 2025



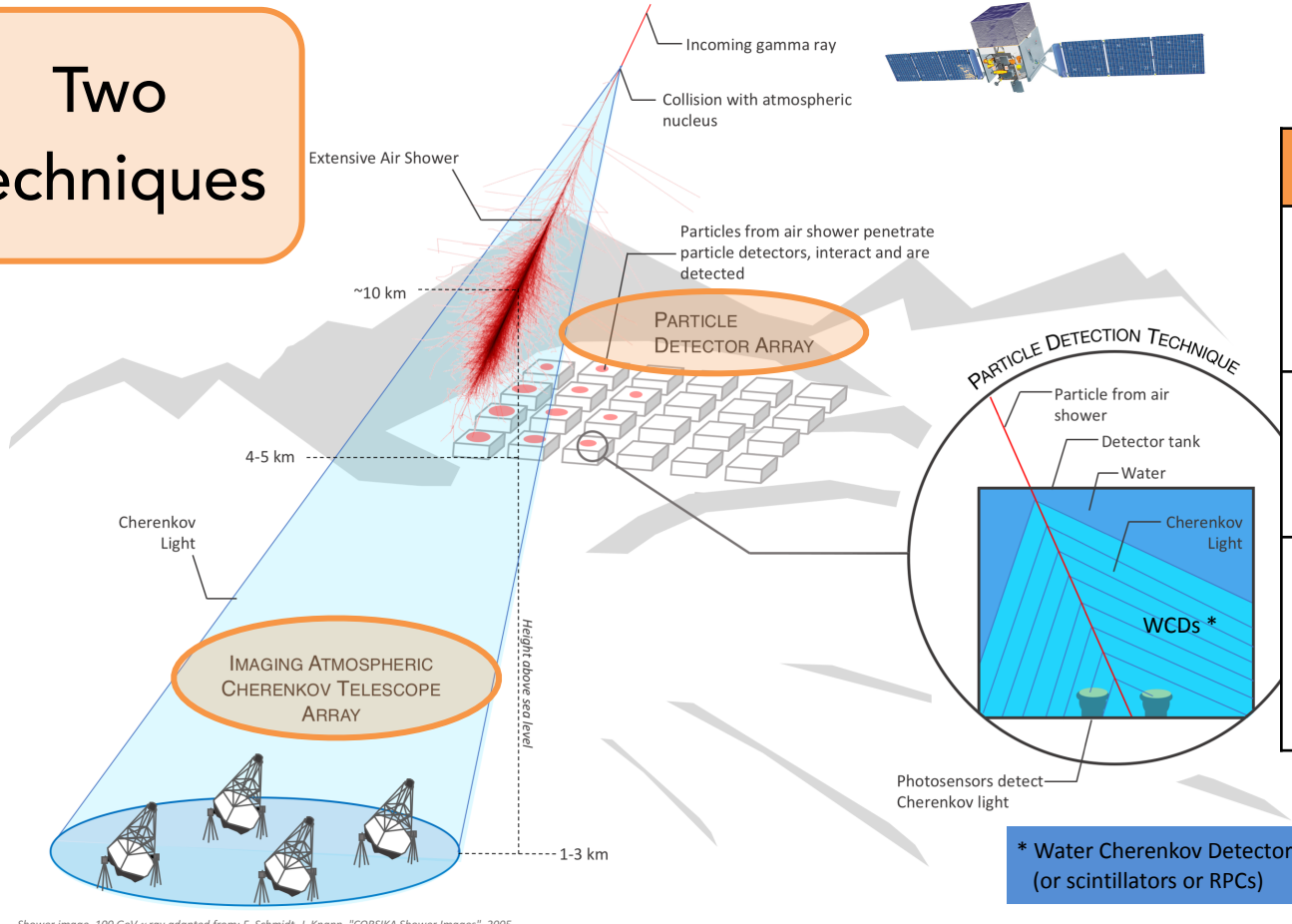
Layers

100 km

Camera:

Ground-Based Gamma-Ray Astronomy

Two techniques



Shower image, 100 GeV γ-ray adapted from: F. Schmidt, J. Knapp, "CORSIKA Shower Images", 2005, https://www-zeuthen.desy.de/~jknapp/fs/showerimages.html

Not to scale

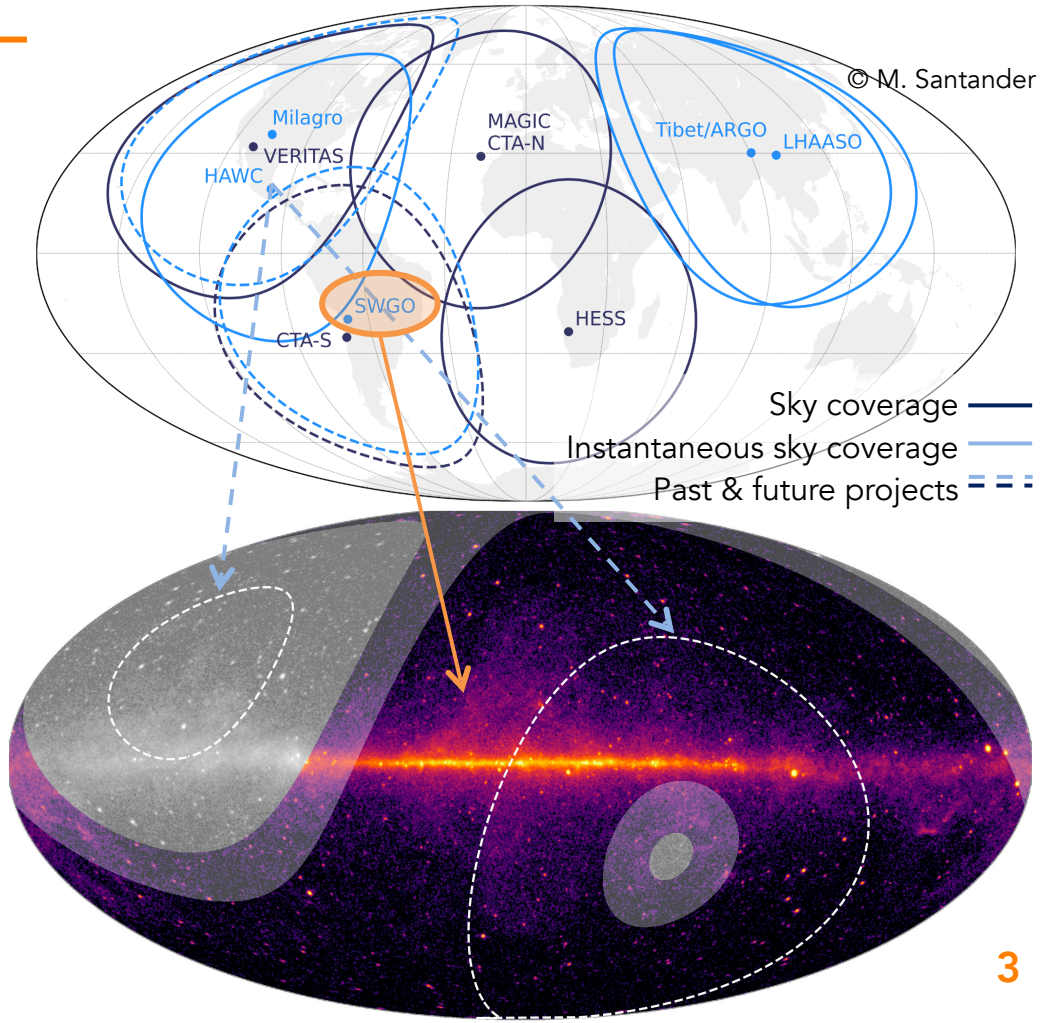
STRENGTHS

PDA	IACT
Wide FOV (~ 2 sr)	Good angular resolution (< 0.1°)
High Duty Cycle (>95 %)	Good energy resolution (10%)
Good UHE sensitivity	Good VHE sensitivity and low energy threshold

* Water Cherenkov Detectors (or scintillators or RPCs)

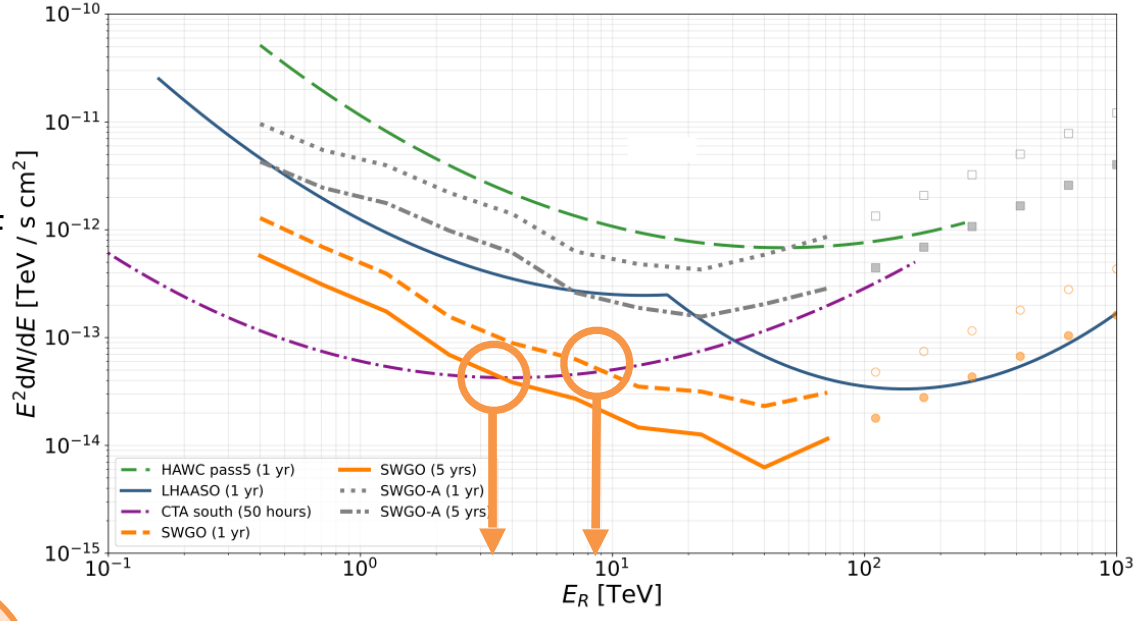
Particle Detection Array Qualities

- High duty cycle
  - ✓ Transients
- Wide field-of-view:
  - → Instantaneous: $\gtrsim$ 1.8 sr (~15% of the sky)
  - → Surveys: ~ 8.4 sr per day (~2/3 of the sky)
  - ✓ Extended, large-scale, unexpected emission
- Good Sensitivity, Angular & Energy Resolution $>$ 10 TeV
  - ✓ Highest energy accelerators



Particle Detection Array Qualities

- High duty cycle
  - ✓ Transients
- Wide field-of-view:
  - → Instantaneous: $\gtrsim$ 1.8 sr (~15% of the sky)
  - → Surveys: ~ 8.4 sr per day (~2/3 of the sky)
  - ✓ Extended, large-scale, unexpected emission
- Good Sensitivity, Angular & Energy Resolution $>$ 10 TeV
  - ✓ Highest energy accelerators



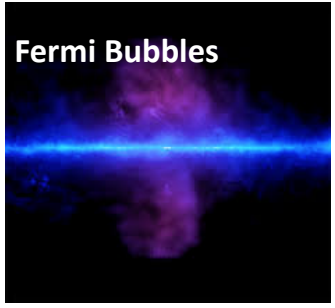
e-prints: arXiv:2506.01786vs2

Scientific Outlook

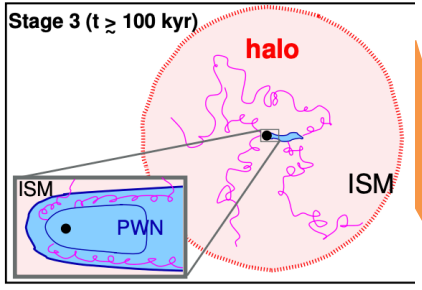
SWGO
The Southern Wide-field Gamma-ray Observatory

Duty-cycle

Deep View @ large scale



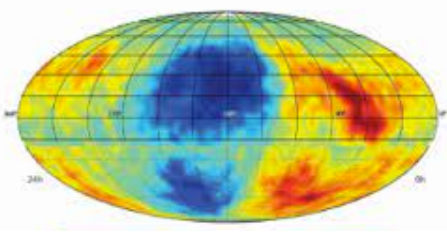
Wide-field



Halos

Survey + Discovery

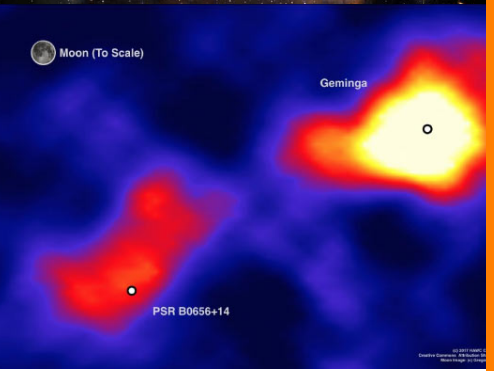
High-Energy Sensitivity

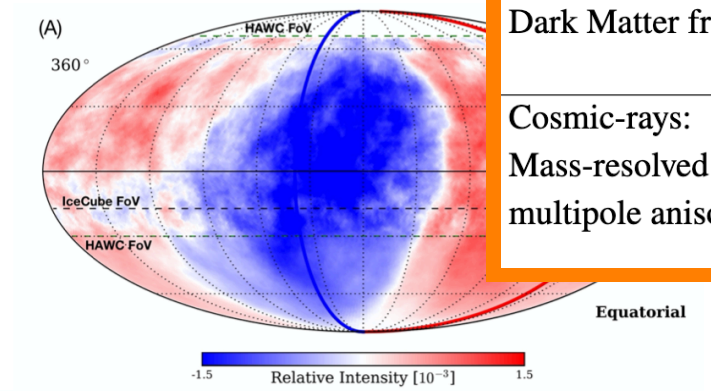


Cosmic rays

Science

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 GC Halo	Mid-range energy sensitivity Site latitude[d]
Cosmic-rays: Mass-resolved dipole / multipole anisotropy	Muon counting capability[e]



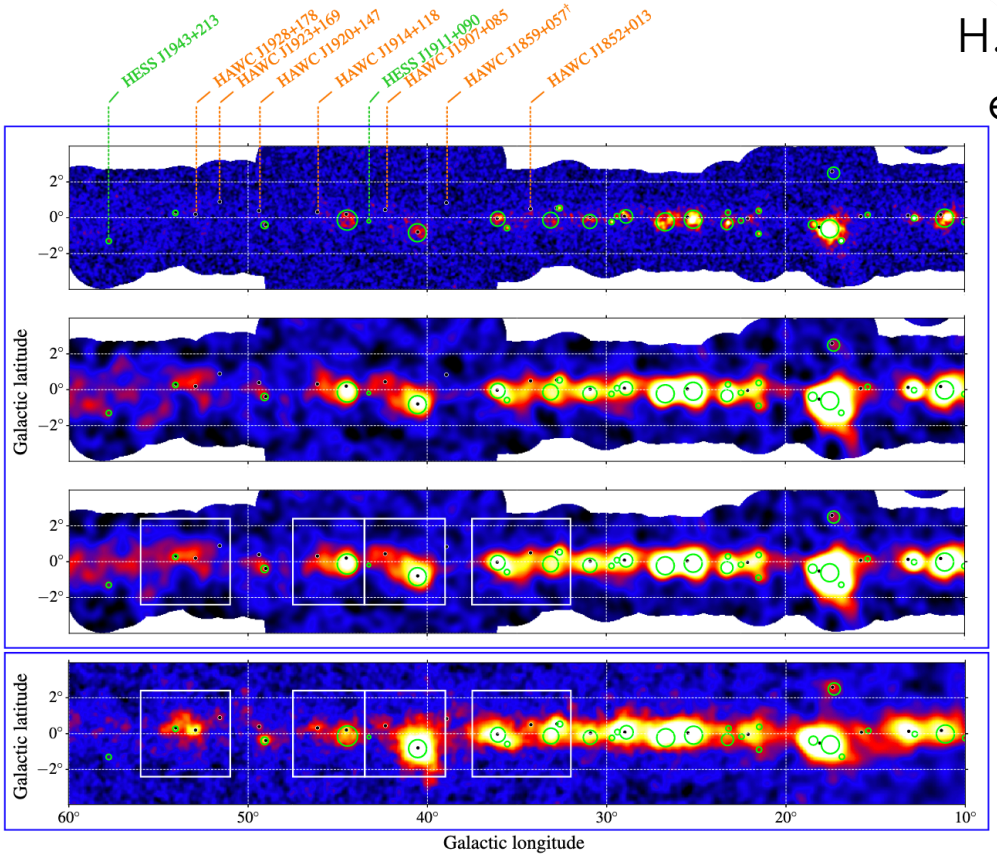


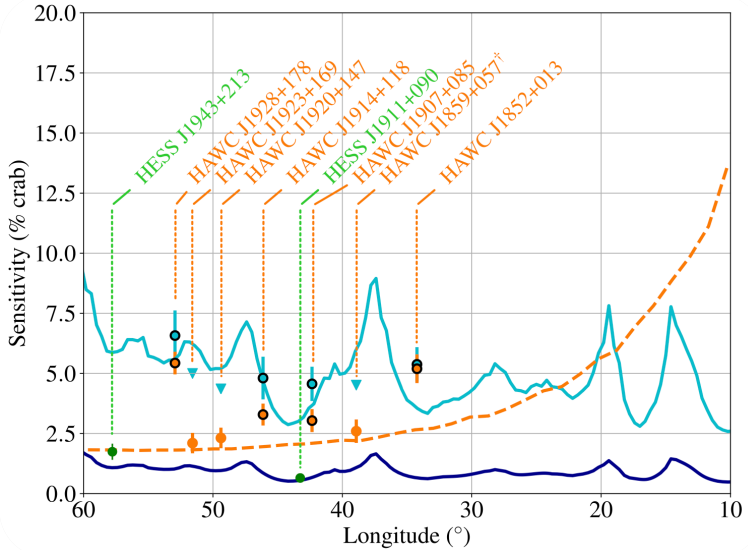
PRELIMINARY DESIGN TARGETS

- $E_{th} \rightarrow 100$ GeV
- $E_{res} < 20\%$
- $\Theta_{res} \sim 0.1°$
- CR_{res} @ 10^{-4}

Example of Complementarity with IACTs

H.E.S.S. confirmed the gamma-ray emission of four HAWC sources among seven previously undetected by IACTs

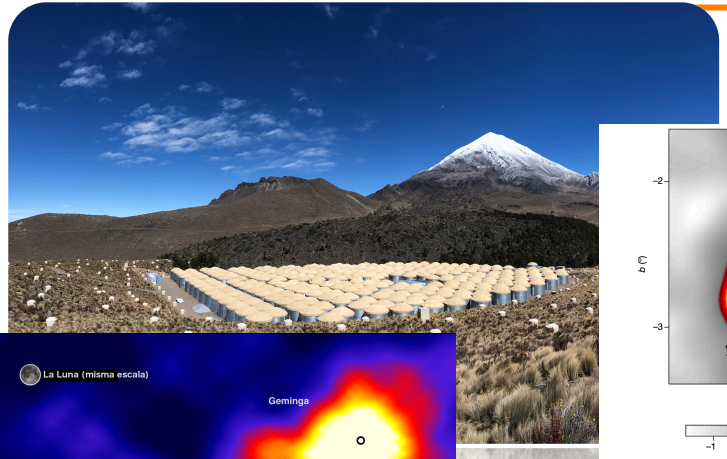


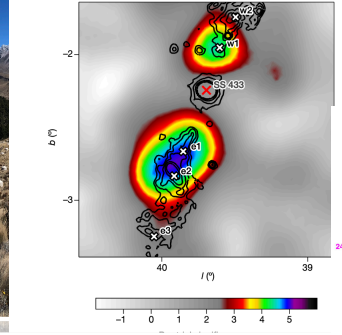


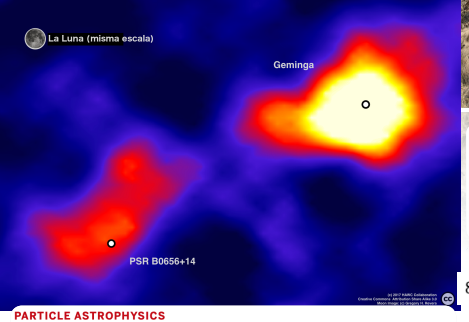
ApJ 917 (1) 6 (2021)

Northern Hemisphere PDA Discoveries

SWGO
The Southern Wide-field Gamma-ray Observatory







LETTER

Corrected: Publisher Correctic

https://doi.org/10.1038/s41586-018-0565-5

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

82 | NATURE | VOL 562 | 4 OCTOBER 2018

PARTICLE ASTROPHYSICS

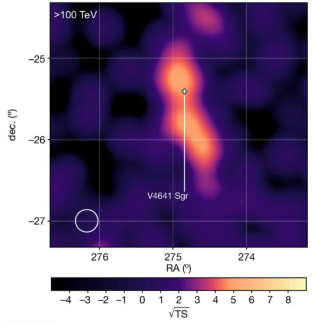
Extended gamma-ray sources around pulsars constrain the origin of the positron flux at Earth

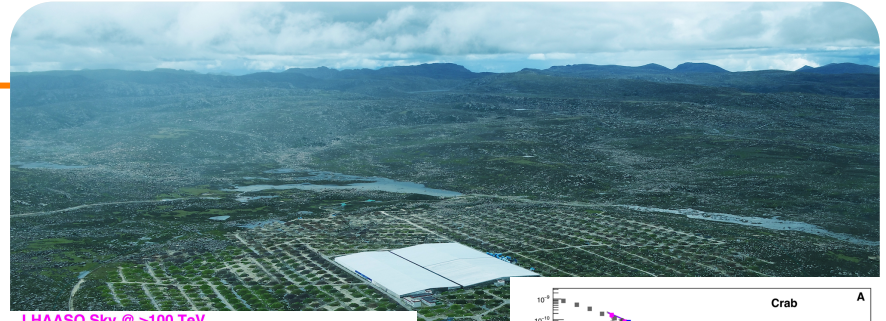
Abeysekara *et al.*, *Science* **358**, 911–914 (2017) 17 November 2017

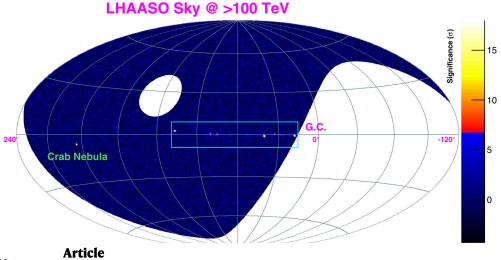
Article | Published: 16 October 2024

Ultra-high-energy gamma-ray bubble around microquasar V4641 Sgr

Nature | Vol 634 | 17 October 2024 | **557**



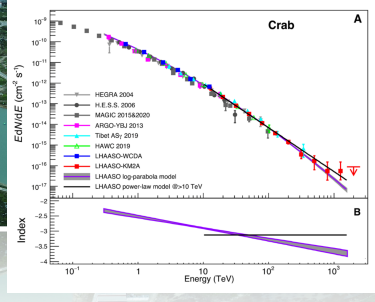




Article

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

34 | Nature | Vol 594 | 3 June 2021

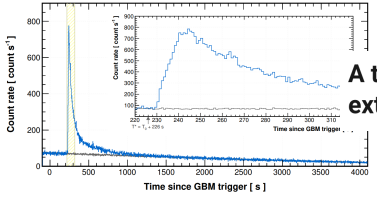


RESEARCH

ASTROPARTICLE PHYSICS

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

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



A tera–electron volt afterglow from a narrow jet in an extremely bright gamma-ray burst

SCIENCE • 8 Jun 2023 • Vol 380, Issue 6652 • pp. 1390-1396


Ground-based Gamma-ray
Astronomy Network
VERITAS
HAWC
MAGIC
LHAASO
cta
HESS
SWGO

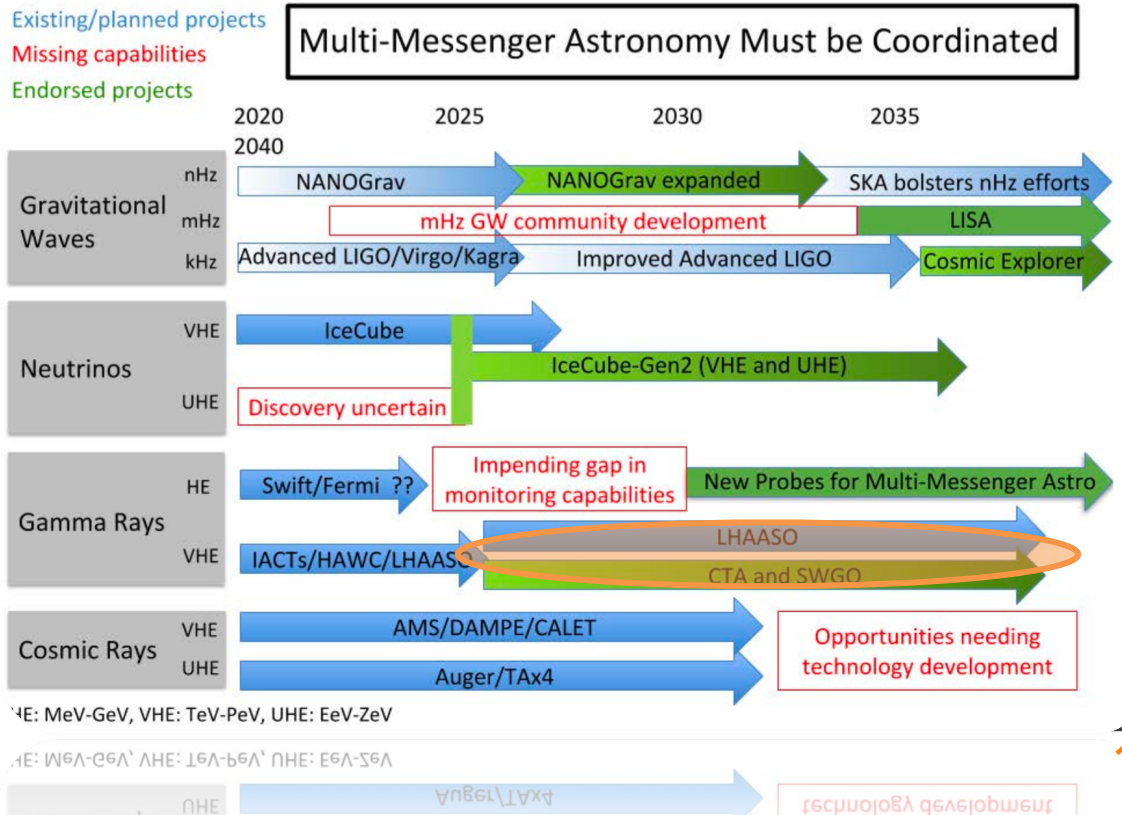
Multi-messenger Network

Gamma-Ray Messenger

"[...] the Cherenkov Telescope Array (CTA) and the **Southern Wide-Field Gamma-Ray Observatory (SWGO)** [...] will be valuable themselves - gamma rays reveal processes that longer-wavelength photons cannot - and will greatly enhance the returns of neutrino and gravitational-wave observatories."
– Astro2020 Report

"The **combination of CTA and LHAASO/ SWGO provides an integrated observational capability that maximizes the scientific opportunities** for all-sky multi-messenger astronomy."
– Astro2020 Report

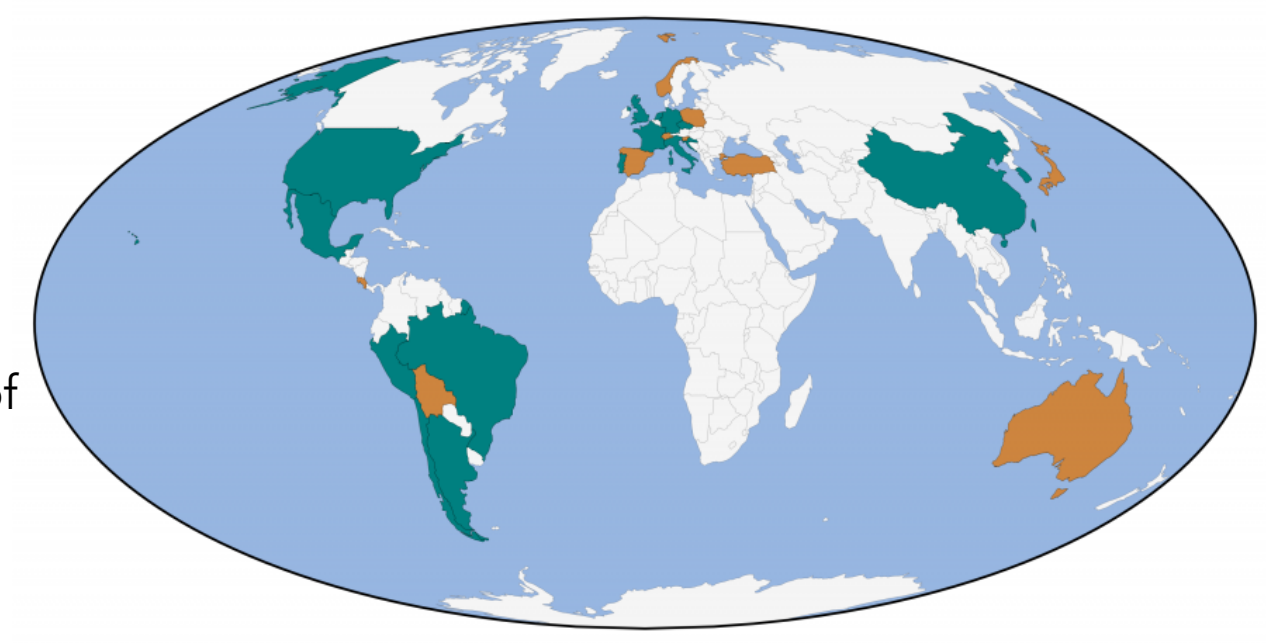
"... the Southern Wide-field Gamma-ray Observatory (SWGO) ... **will have unprecedented sensitivity to the highest energies and [is] critical to carrying on the legacy of science at the forefront of particle and astroparticle physics."**
– Report of the Topical Group on Cosmic Probes of Fundamental Physics for Snowmass 2021



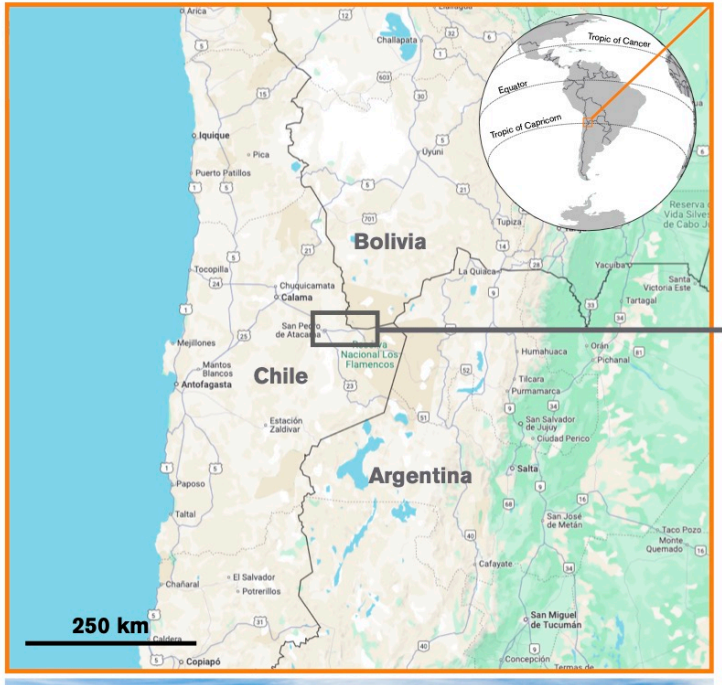
A Global Collaboration

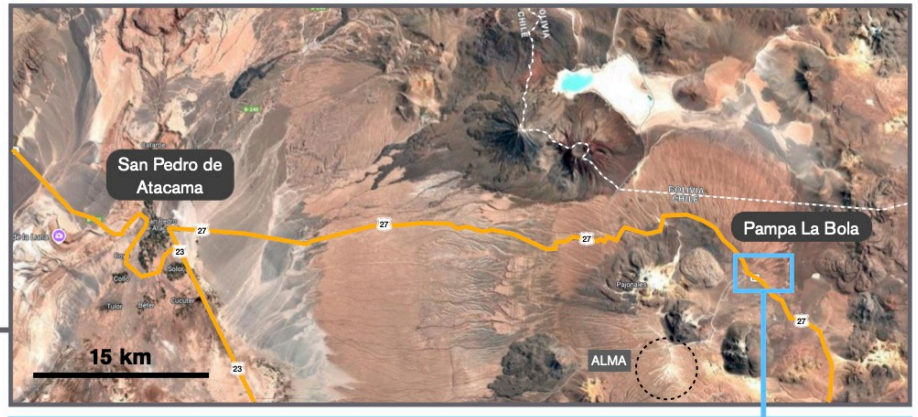
- A growing project: 41 institutions in July 2019 → > 90 institutions/16 countries now!

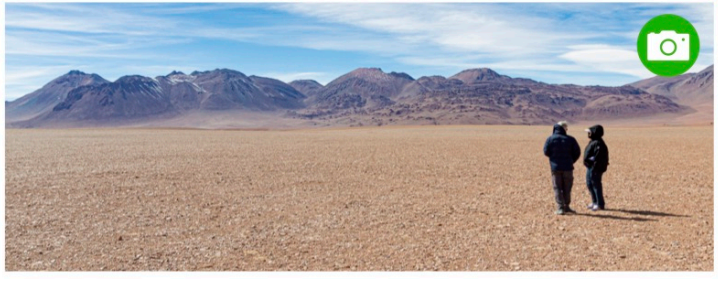
- History:
  - ✓ **Nov 2019:** First SWGO Collaboration Meeting
  - ✓ **Sep 2022:** Site Shortlist Complete
  - ✓ **Apr 2024:** Performance of Candidate Configurations Evaluated
  - ✓ **Jul 2024:** Preferred Site Identified

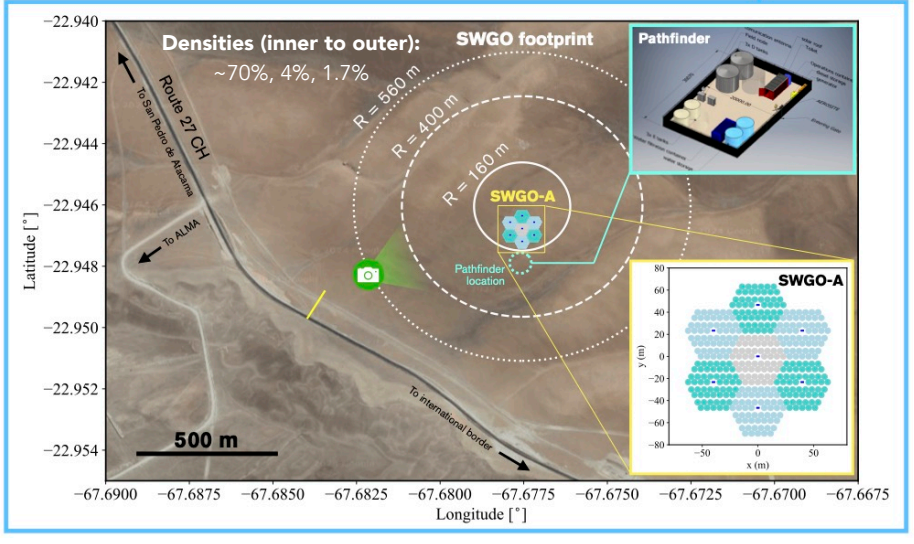


The Site & Layout









Map data: Google 2025
Satellite imagery: Landsat/Copernicus 2025
Illustration: M. Santander.

Inner Array Design & 1st Stage: SWGO-A

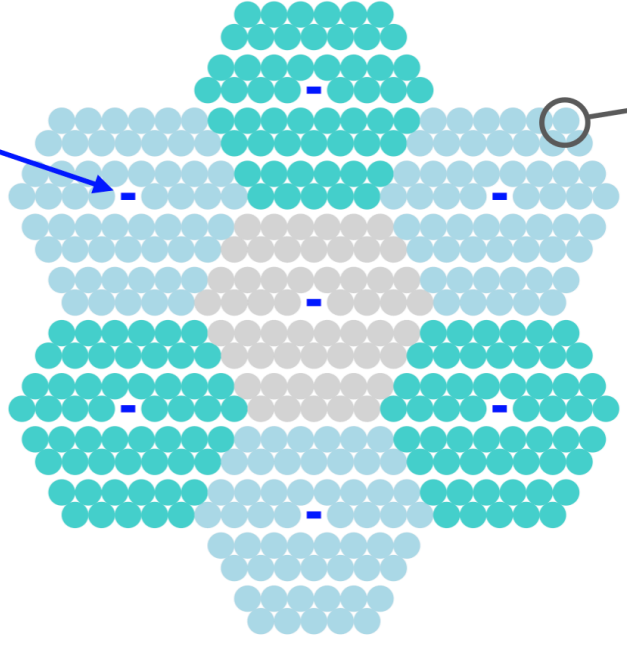
(A)

SWGO-A field node

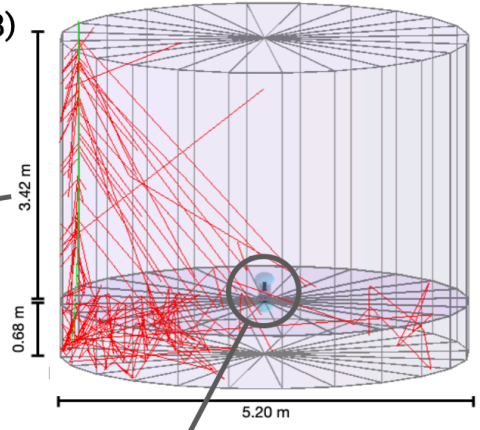
(C)

SWGO-A test tank at HAWC

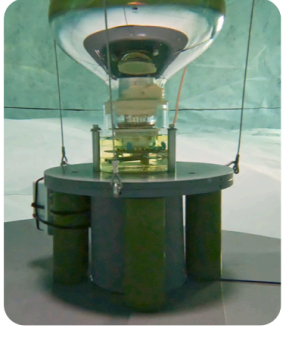
Array Layout of SWGO-A



(B)



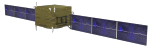
(D)



Dual-PMT unit deployed in dual bladder

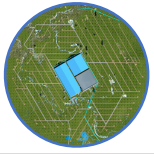
e-prints: arXiv:2506.01786vs2

Outer Array Designs



< 1m²

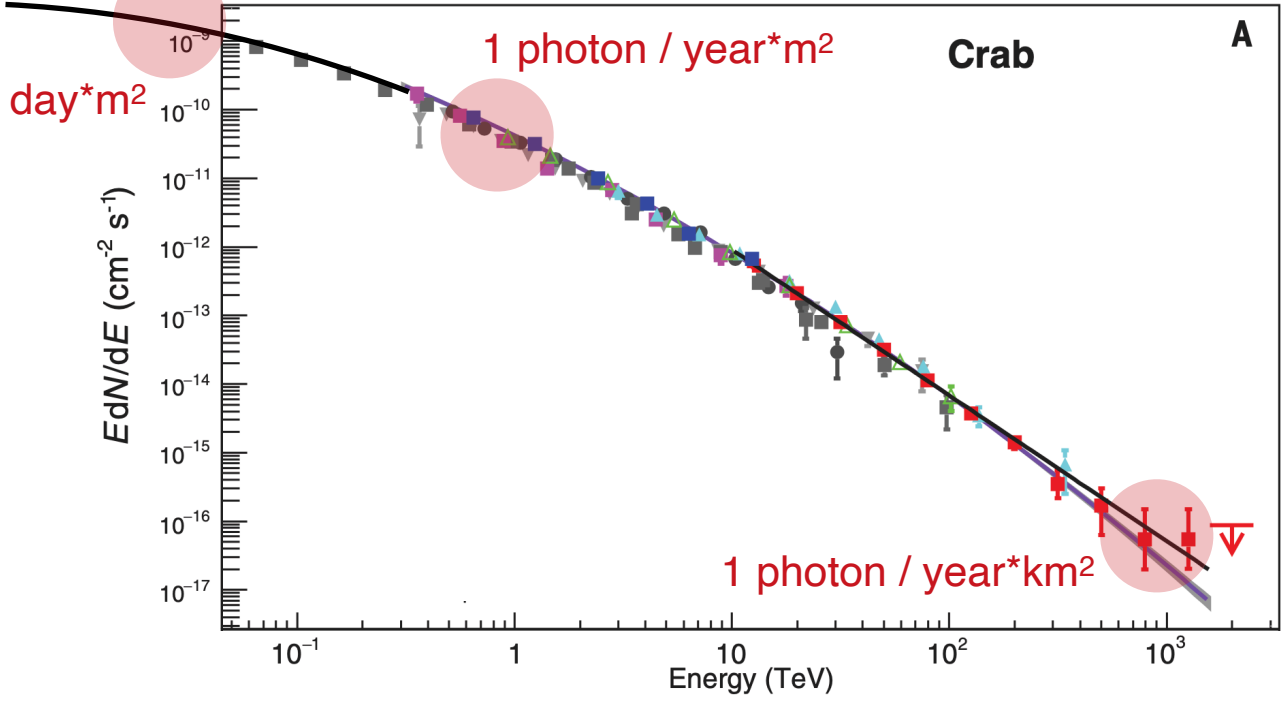
~10⁵ m²



>10⁶ m²

1 photon / day*m²

1 photon / year*m²

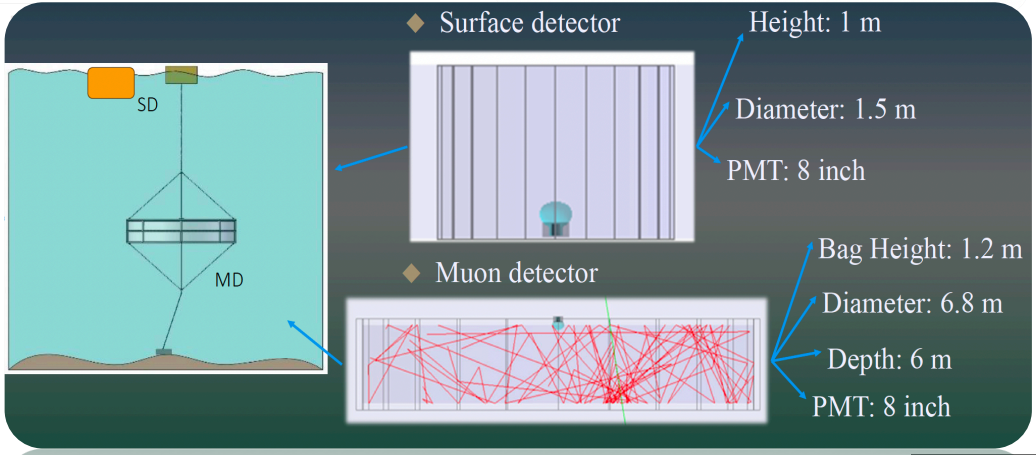


1 photon / year*km²

Outer Array Designs

Under Consideration:

1. Inner-array like design
2. Roto-molded HDPE tanks + multi-PMT modules
3. Possible UHE extension in a lake



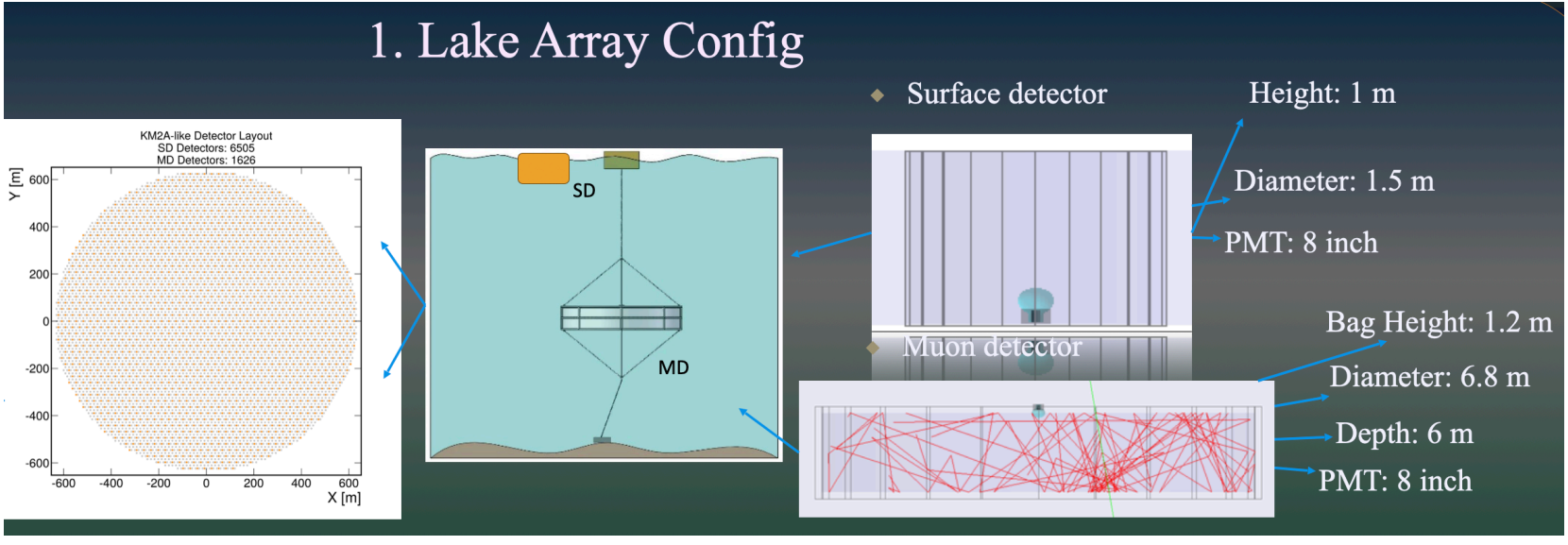
Deployment of Lake Array

Under Consideration:

1. Muon detectors are essential for gamma/hadron separation
2. Lake water provides good shielding of $e^{\pm}$ for free

Deployment of Lake Array

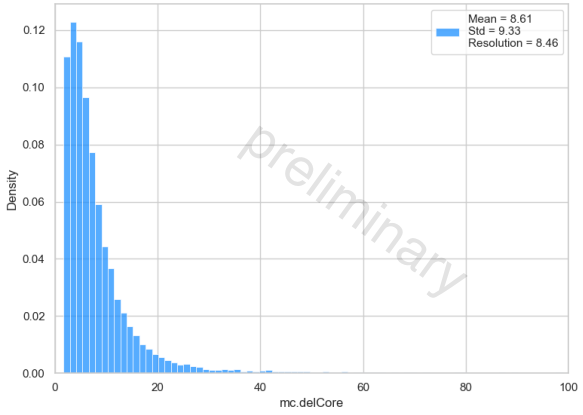
1. Muon detectors deployed five meters underwater
2. Smaller surface water Cherenkov detectors (SDs) floating on the lake surface



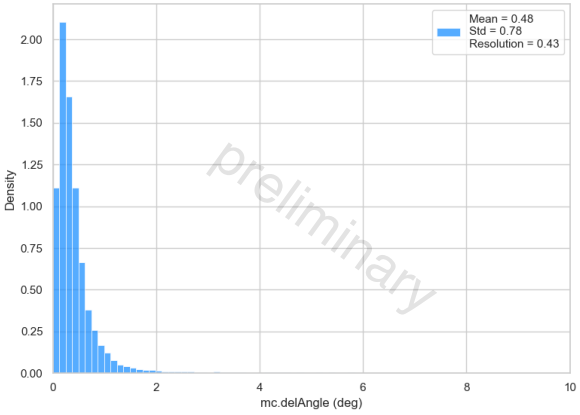
Deployment of Lake Array

1. Use LHAASO-KM2A as a reference layout
2. Preliminary reconstruction shows similar performance as LHAASO-KM2A

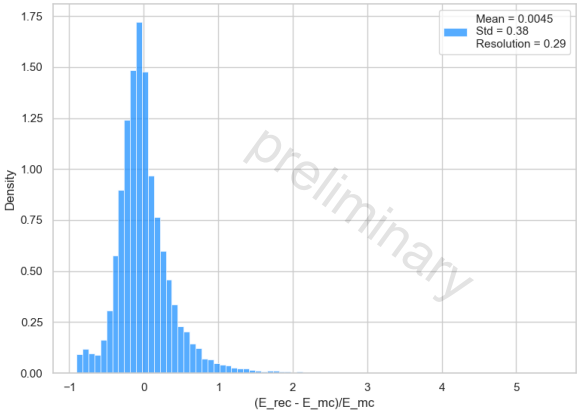
Core Reso



Angular Reso

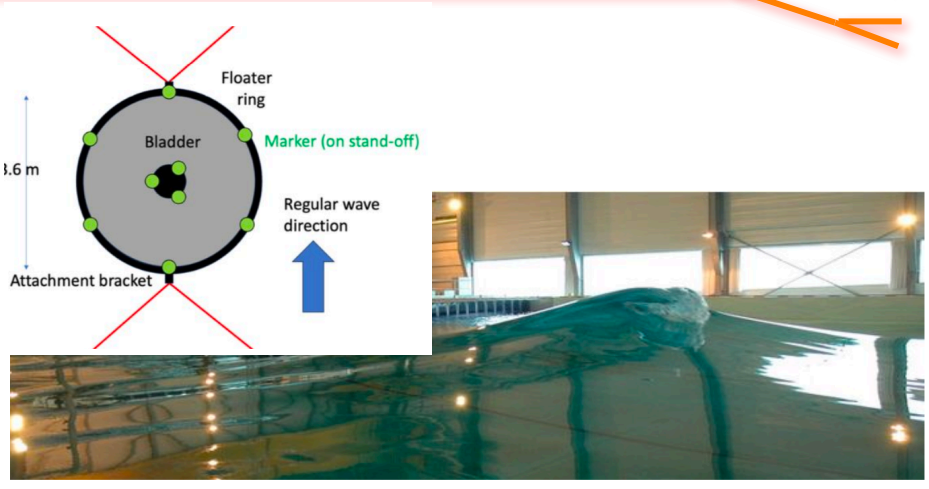


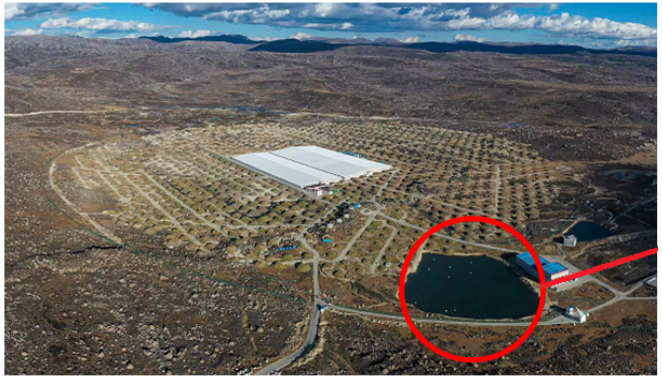
Energy Reso

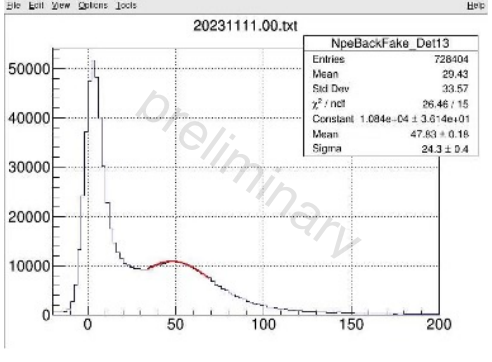


Prototyping Activities

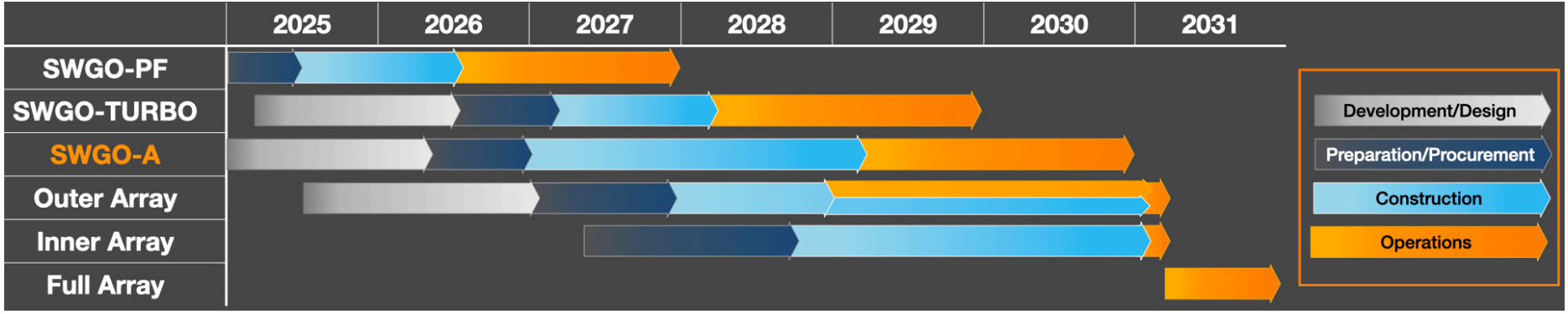
1. Wave test at Nantes, France
2. Prototyping in an artificial lake at the LHAASO site







Staged Plan



- First presence: Pathfinder – SWGO-PF
- Additional Component (already funded): The Utility for Radio Beam-formed Observations – SWGO-TURBO

SWGO
The Southern Wide-field Gamma-ray Observatory

Summary & Outlook

- SWGO is now moving toward construction after an intense 5-year design phase

- SWGO will
  - → become the most sensitive ground-based wide-field instrument at tens of TeV
  - → have synergies with CTAO, IceCube, KM3Net, LVK, and other instruments and contribute crucially to multi-messenger astronomy
  - → provide particle physics constraints at TeV energies
  - → tackle key science topics through observations of the Galactic Center/bright Galactic sources
  - → probe transient gamma-ray emission with full sky coverage together with HAWC and LHAASO

SWGO members and guests at the site of the project, Pampa La Bola
(12th Collaboration Meeting, San Pedro de Atacama, 5-9 May, 2025)

Thank You!