SWGO
The Southern Wide-field Gamma-ray Observatory

www.swgo.org

CLAF-MCTI High Level Meeting

on

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

Rio de Janeiro, Brazil, April 20, 2023

Claudio O. Dib Venturelli
UTFSM & CCTVal, Chile
for the SWGO Collaboration

UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

CCTVal CENTRO CIENTÍFICO TECNOLÓGICO DE VALPARAÍSO

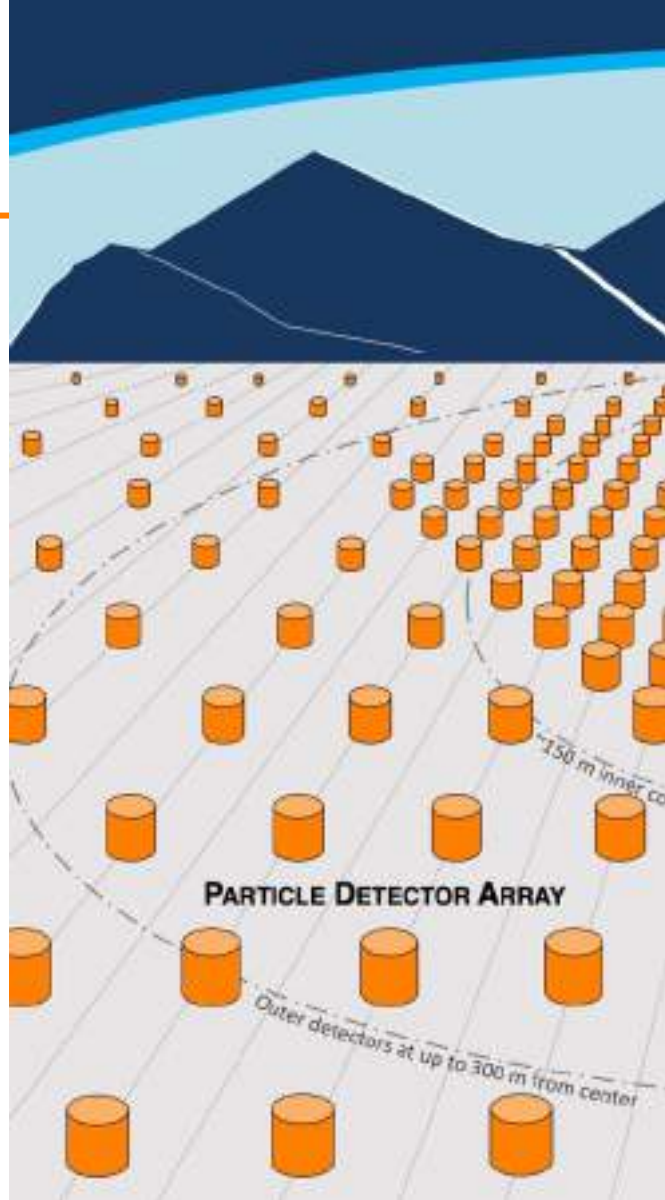
Content

SWGO:
Science, Technology, Collaboration.

1- The Science of SWGO

2- The Technology

3- The Collaboration



SWGO
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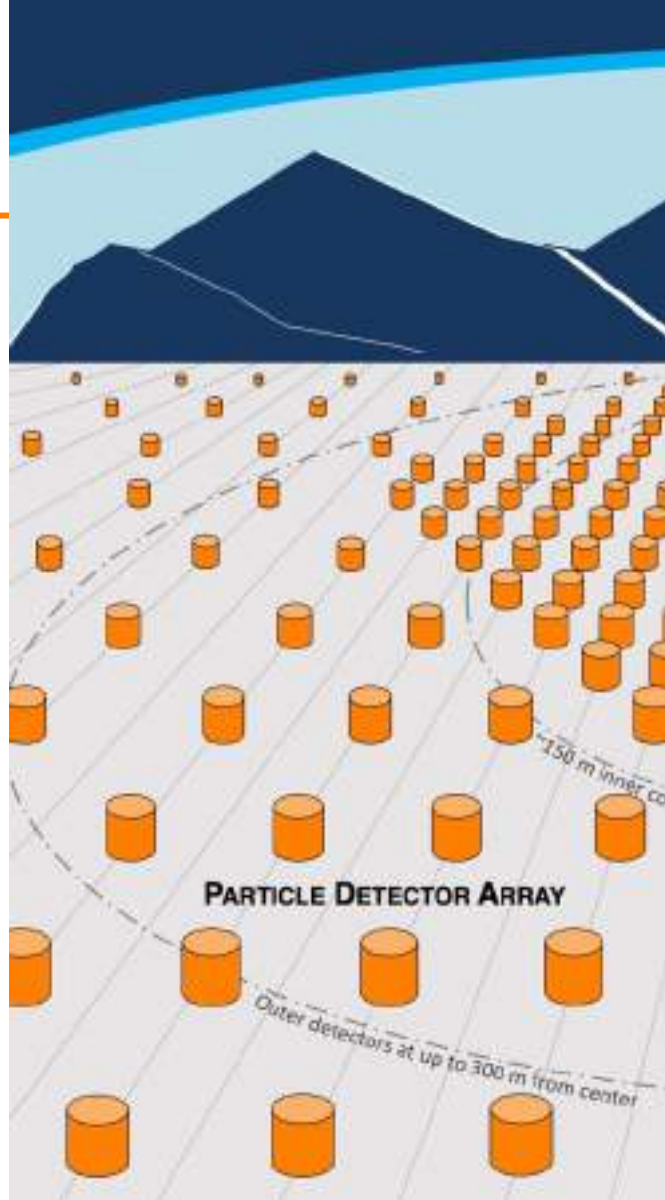
- The Science

  (why we do this)



The science

- **Why?** → to know and understand
  (the search for knowledge)

- We have observed **the heavens**
  and experience **visible light**
  … and wonder…
  for thousands of years

- But…. We are reaching
  real **understanding**
  in the last few hundreds of years

Credit: Richard Talcott, Astronomy Magazine

credit: Mark Garlick/Science Photo Library

The science

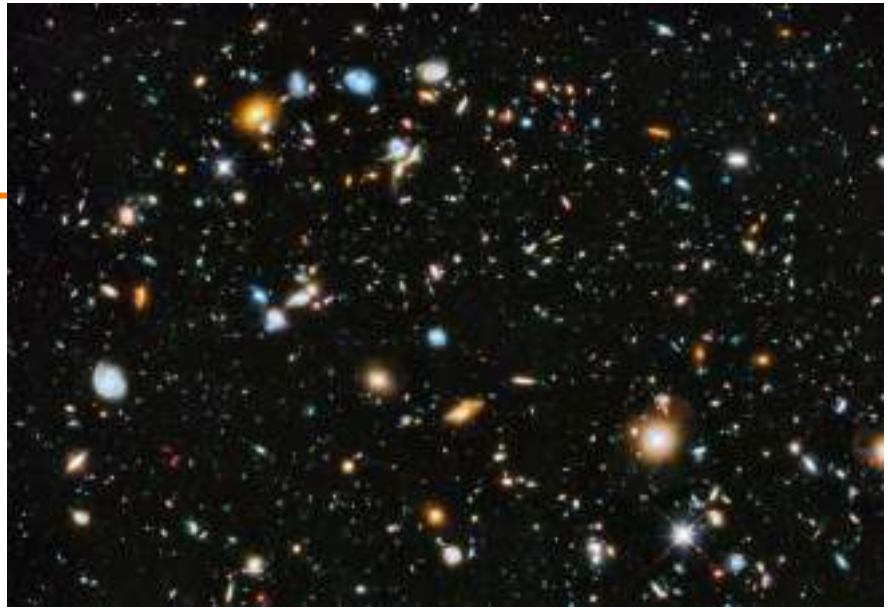
… And only in the last century we know about:

1. **galaxies**

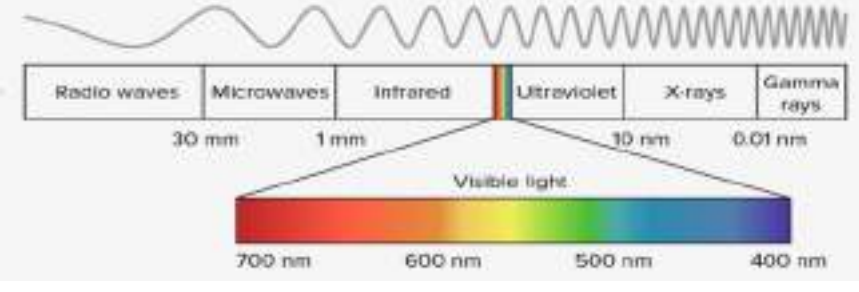
2. the expanding Universe

3. the **physics** of stars

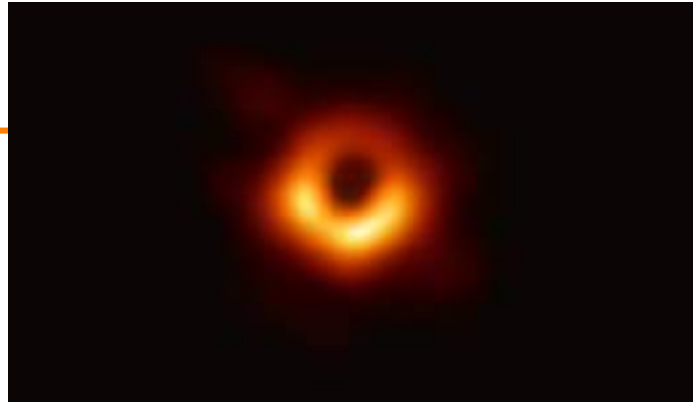
4. the **nature of light**
   as waves and particles



Hubble ultra deep field 2014
Credit: NASA, ESA, H.Teplitz and M.Rafelski (IPAC/Caltech), A. Koekemoer (STScI), R. Windhorst(ASU), Z. Levay (STScI)



The science



Radio astronomy: Event Horizon Telescope image of supermassive black hole at the center of M87 galaxy.

- And only in the last decades

we are discovering the invisible skies:

1. multi-wavelength astronomy
(radio, infrarred, visible, UV, X-rays, gamma rays)

2. multi-messenger astronomy
(gamma-rays, neutrinos, Gravitational waves)

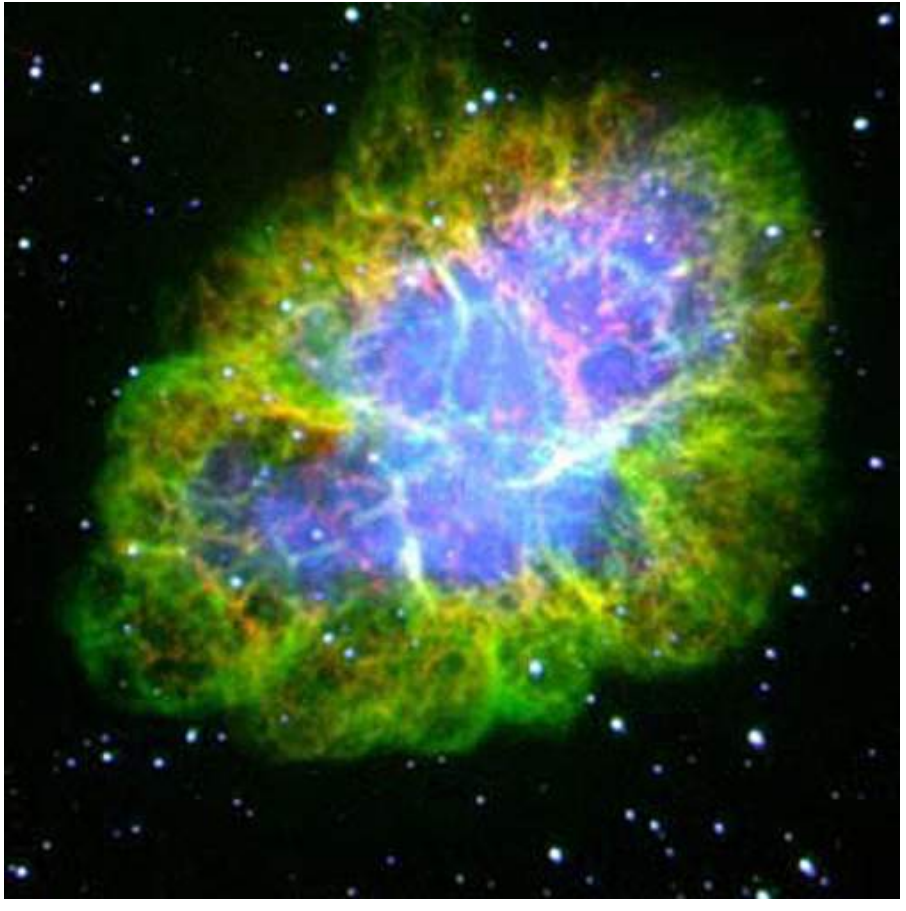
Visible light from gravitational wave source from neutron star mergers. Credit: ESO

Different wavelengths = different information

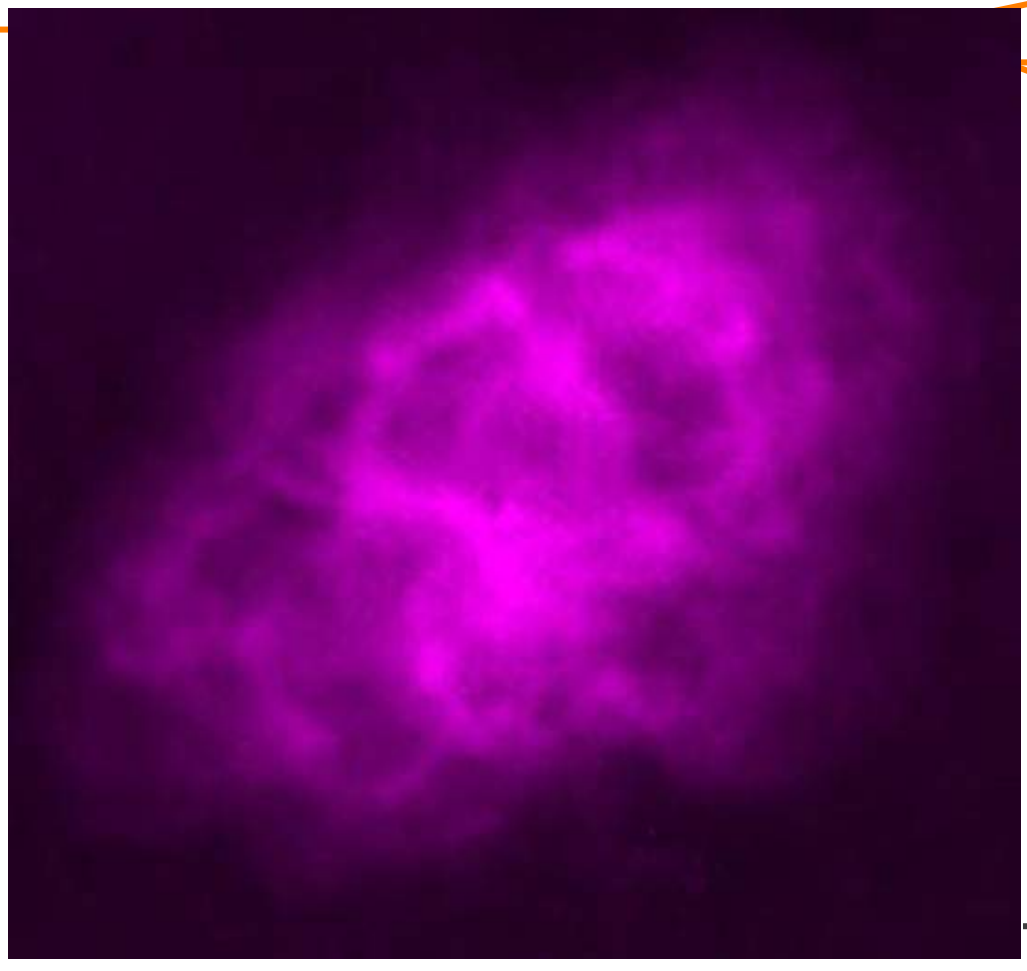
The Crab Nebula (Taurus A)

Remnant of a
Supernova explosion in 1054.

Picture:
The Crab Nebula
in visible light

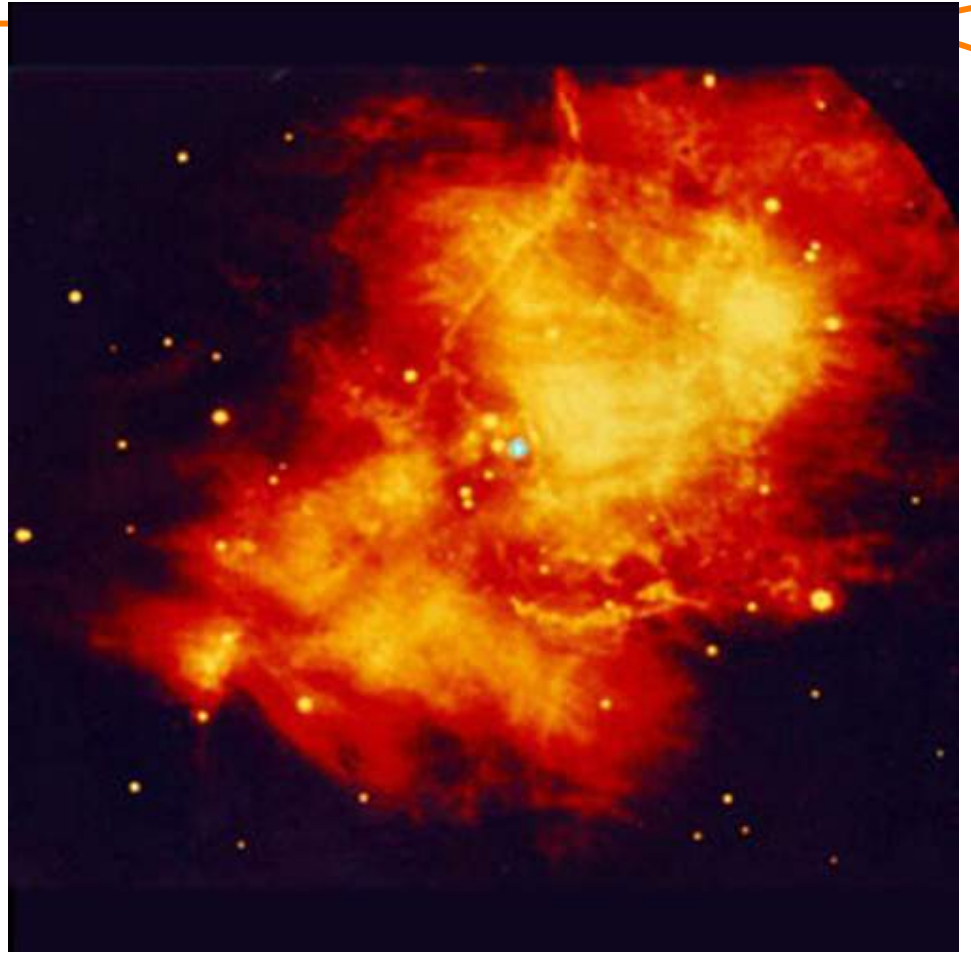


Different wavelengths = different info



Picture:
The Crab Nebula
in radio frequencies

Different wavelengths = different info

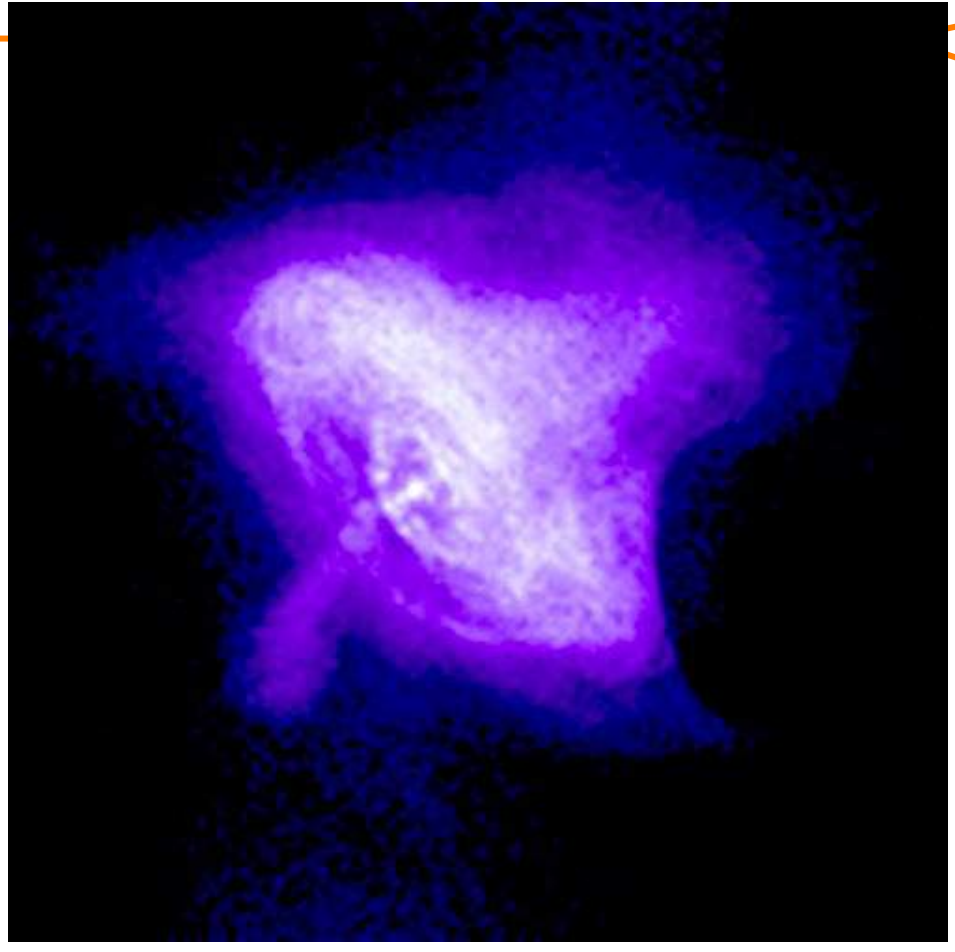


Picture:
The Crab Nebula
in IR (infrared light)

Different wavelengths = different info

Picture:
The Crab Nebula
in UV (ultraviolet light)

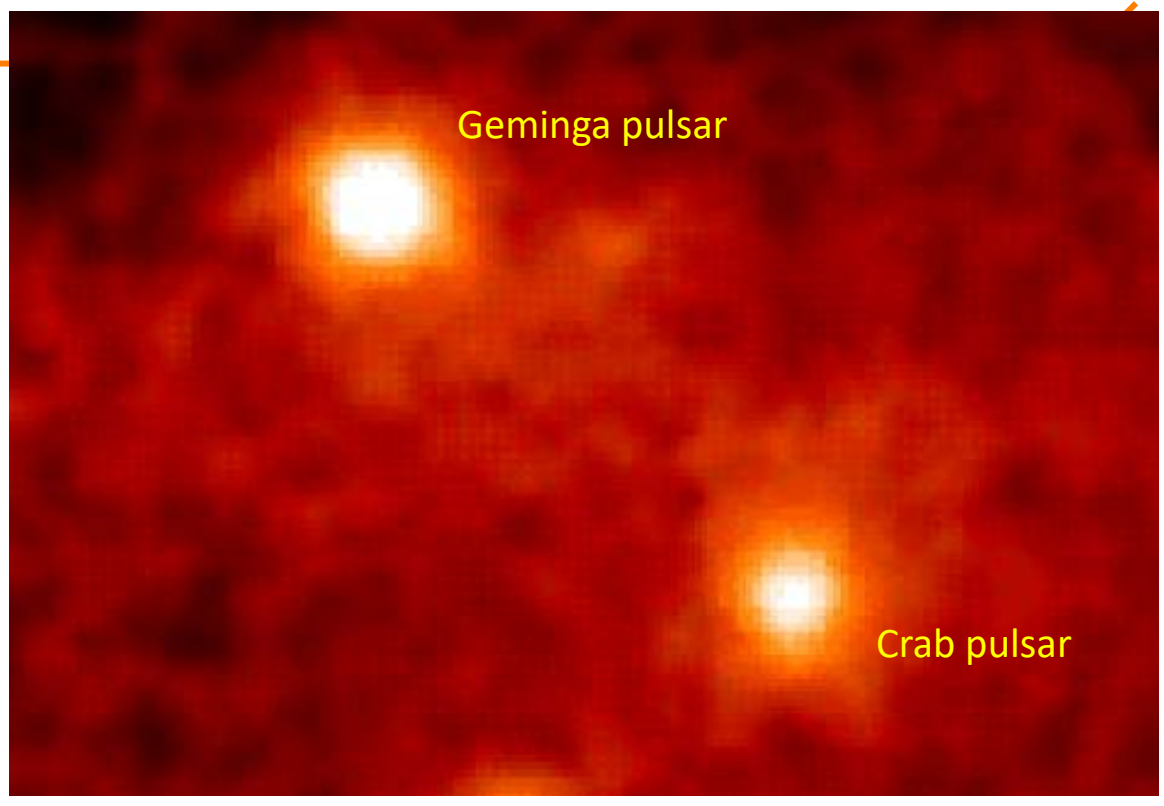
Different wavelengths = different views



Picture:
The Crab Nebula
in X rays

Different wavelengths = different views

Picture:
The Crab Nebula
in Gamma rays



Two pulsars in Gamma Rays.
Credit: NASA, Compton Gamma Ray Observatory

Gamma-ray exploration:

Gamma rays…

- are produced in the **most violent processes** of the Cosmos
- belong to the realm of **High Energy Physics**

→ **Multidiscipline:** Astro-particle physics

Active Galactic Nuclei

© H. Ford (JHU)/NASA

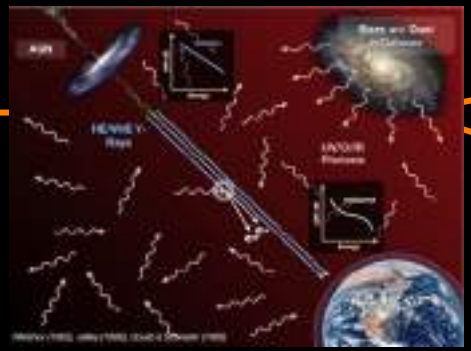
Starburst Galaxies

© NASA/STScI

Gamma-Ray Bursts

© NASA/SWIFT

Extragalactic Background Light & Dark Matter

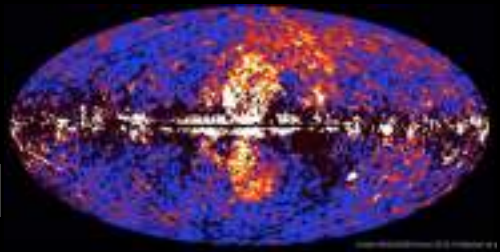


© Martin Raue 2011

Gamma-Ray* Sources

* (also sources of cosmic rays, neutrinos & gravitational waves)

Windows Into the Non-Thermal Universe



Super Nova Remnants

© X-ray: NASA/CXC/SAO; Optical: NASA/STScI;
Infrared: NASA/JPL-Caltech/Steward/O.Krause et al.

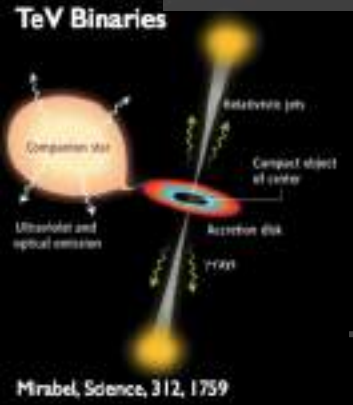
Pulsar Wind Nebulae

Purple Crab © NASA

Pulsars & Lorentz Invariance

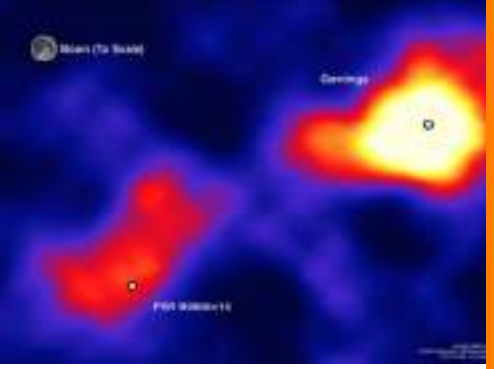
© NASA/Fermi

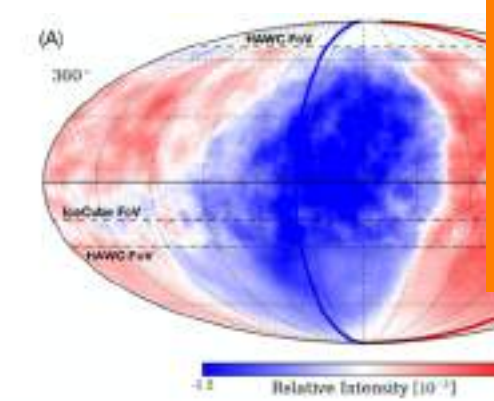
Binary Systems



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}

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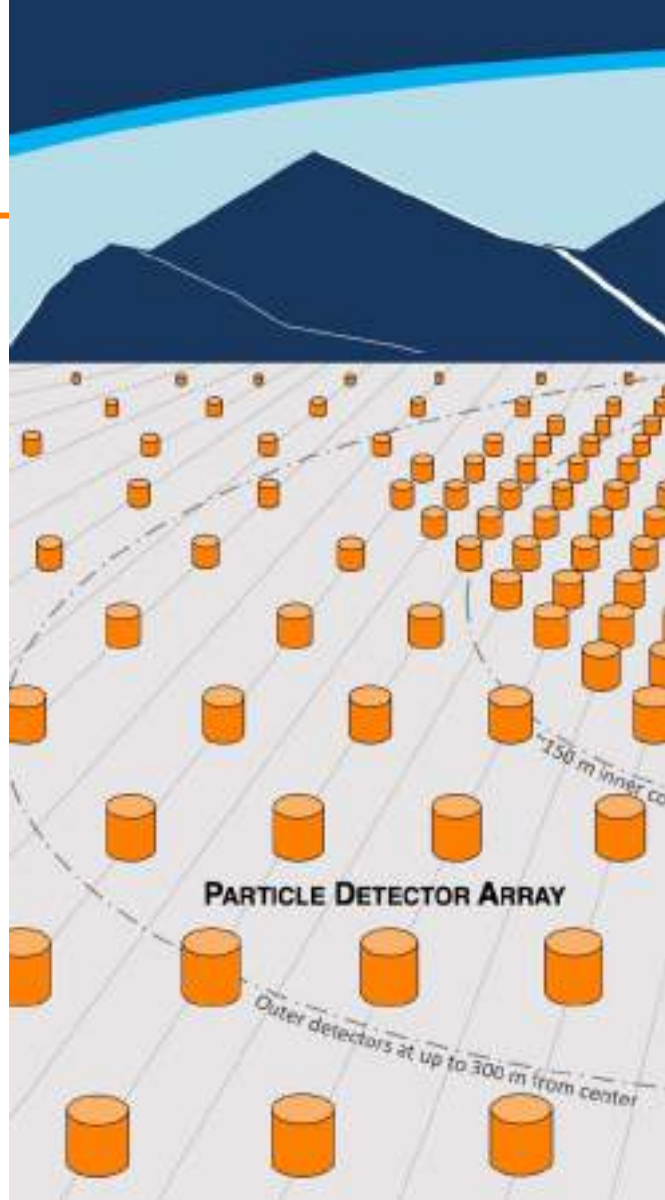
- The Technology

  (what tools we use)



Technology = the tools

The atmosphere is **opaque** to gamma rays, so…

How do we detect Gamma rays?

- For energies below a few 10's of GeV:

→ **Use Satellites.**

- but for E > 100 GeV cannot use satellites…

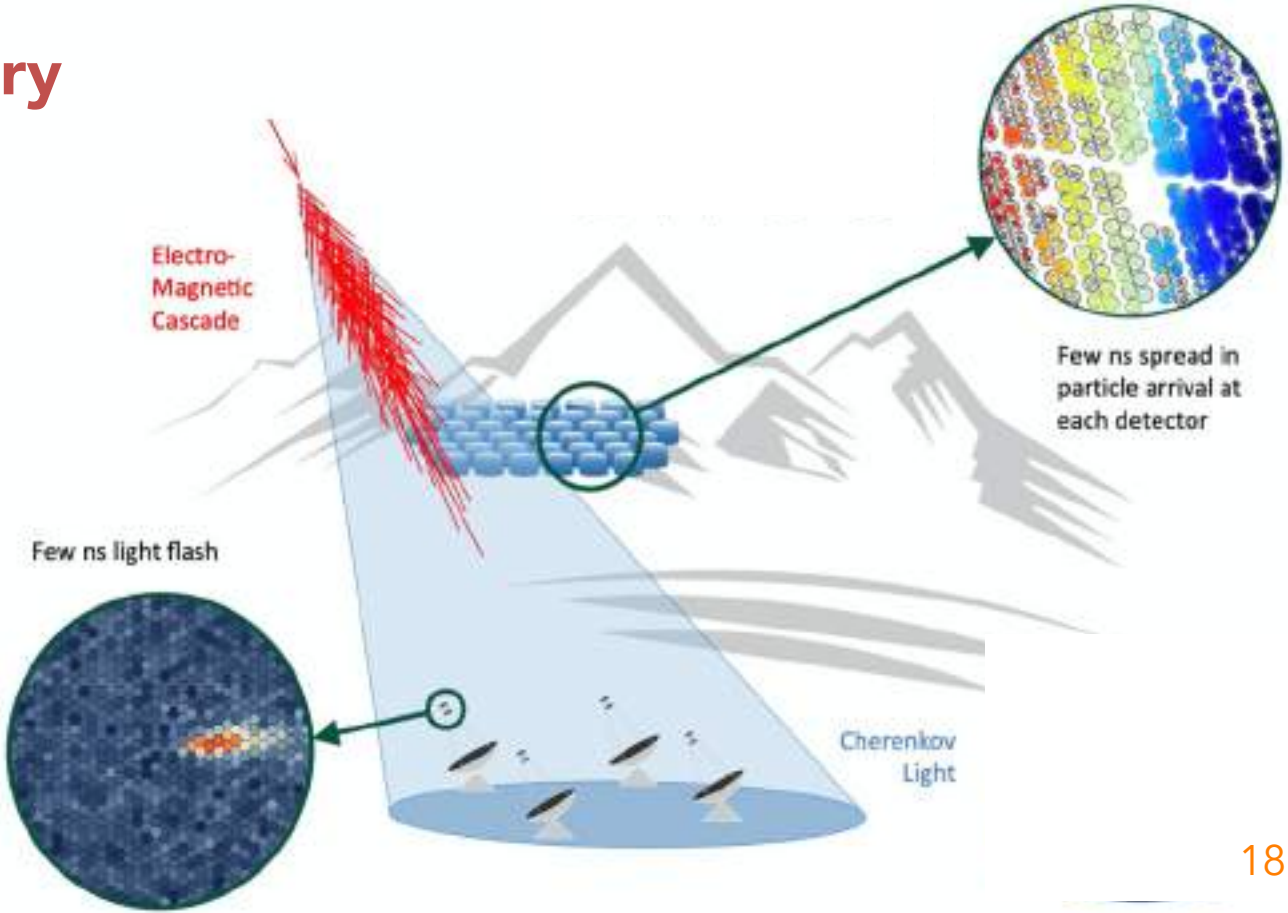
Fermi Gamma Ray Space Telescope
Credit: NASA.

Very High Energy Gammas:
produce particle showers in the atmosphere

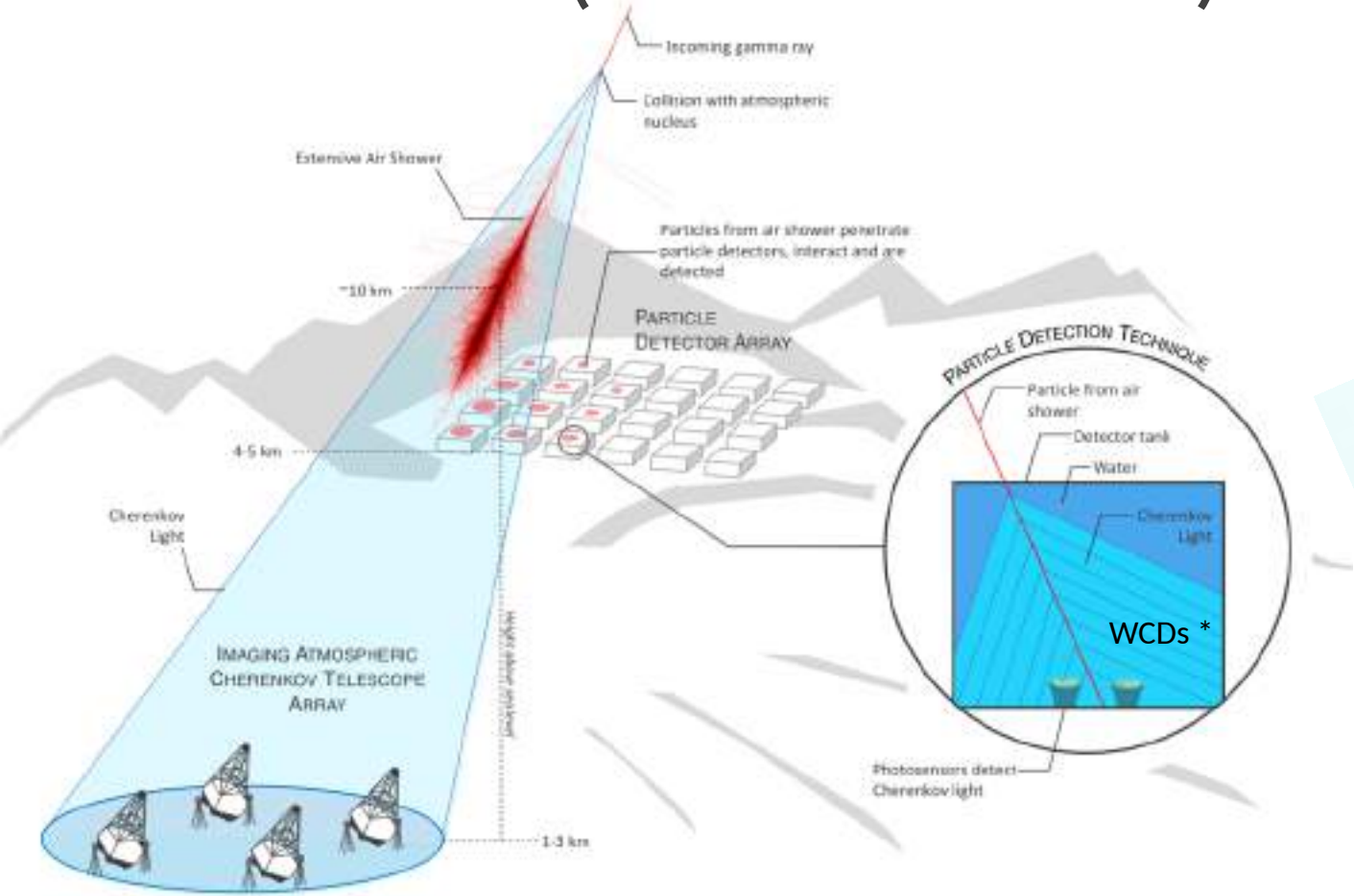
Two complementary Techniques:

a) Air Cherenkov Telescopes (e.g. CTA)

b) Particle Detectors at ground level (e.g. SWGO)



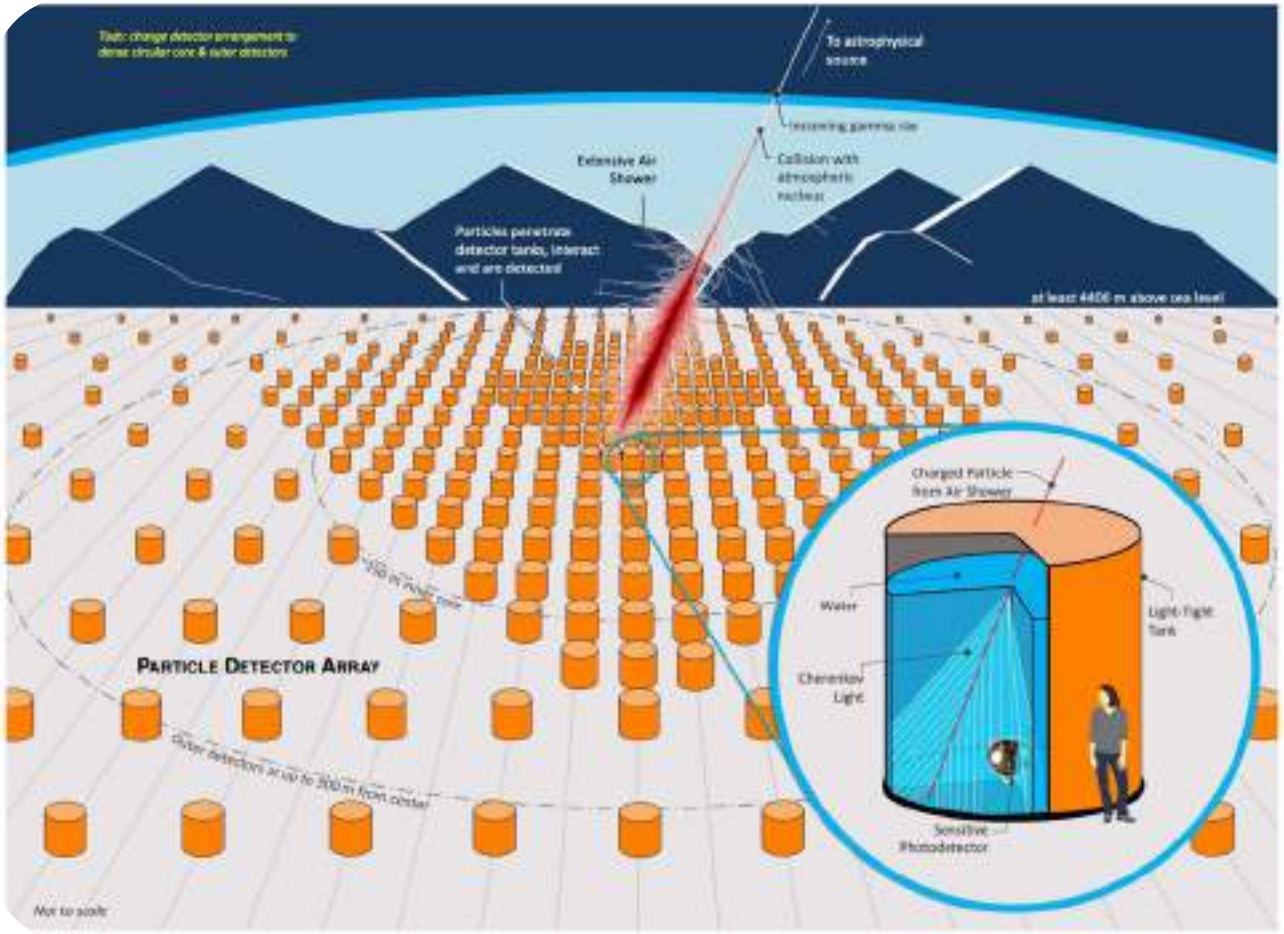
Cherenkov radiation (in air and in water)

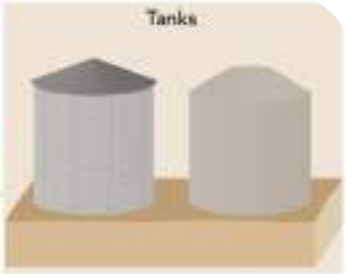


Made by H. Seldon, wikipedia.org/public domain

Past & Current
VHE Gamma-Ray Observatories

Detector Array at high altitude





Site Options

Two requirements:

1. **Southern Hemisphere**

2. **Ground at high altitude.**

Bolivia 4.7k

High Altitude Gamma-ray Observatory in the South

Chile 4.8 k

Country	Elevation	Location:
Peru	4900	Laguna Sibinacocha
Peru	4450	Imata
Peru	4450	Yanque
Argentina	4800	Cerro Vecar
Argentina	4450	Alto Tocomar
Chile	4700	ALMA Pampa La Bola
Chile	4400	AAP Pajonales
Bolivia	4700	ALPACA area

Shortlisting: Fall 2022
Site visits: October 2022
Site selection: Fall 2023

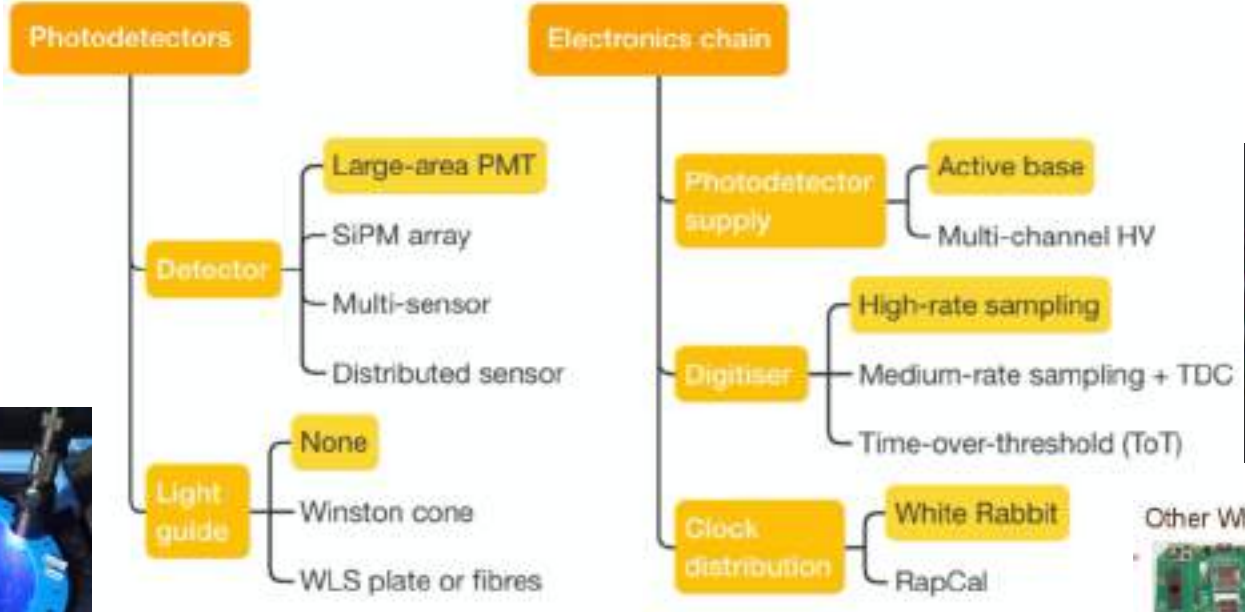
Argentina 4.8 k

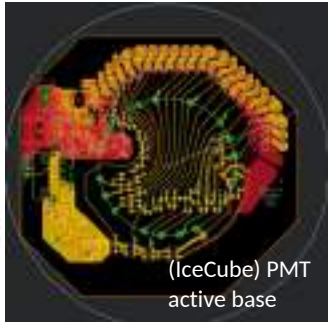
Peru 4.9 k

Novel detector technology: electronics, data acquisition, signal processing, artificial (and natural) intelligence, etc…

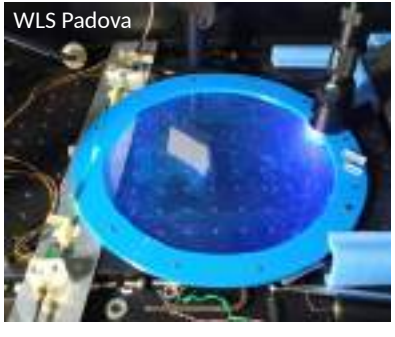
PMT module
MPIK

HAWC
Bladders





(IceCube) PMT
active base



WLS Padova

PMTs
Naples

HyperK-style
multi-PMT

SWGO
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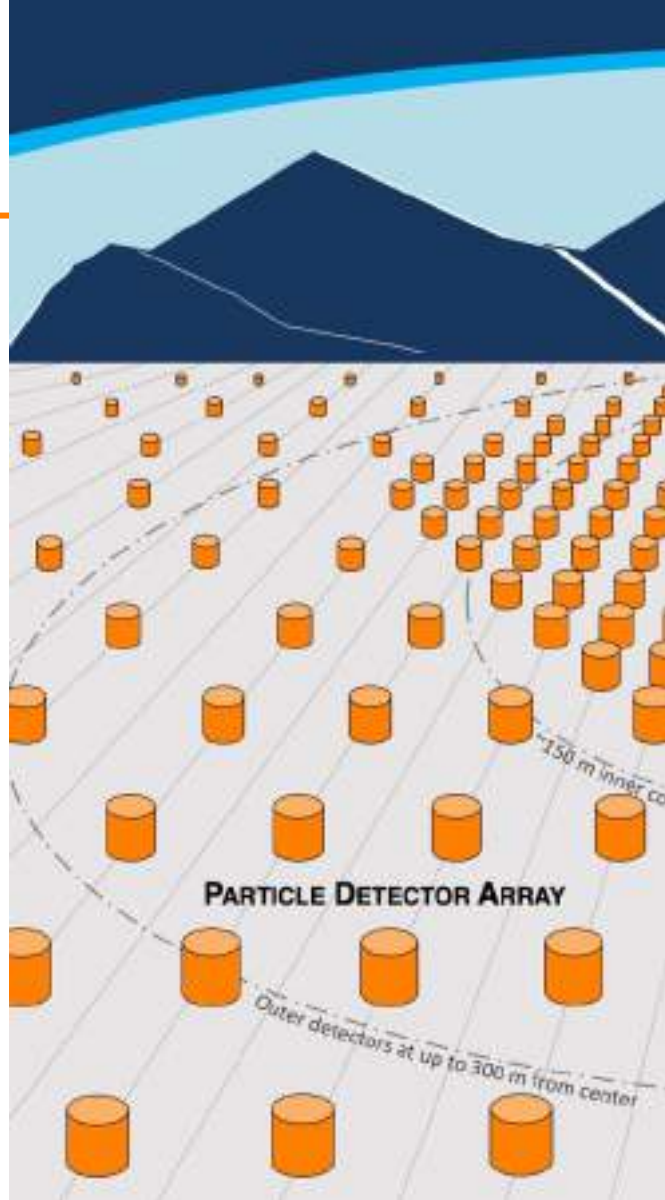
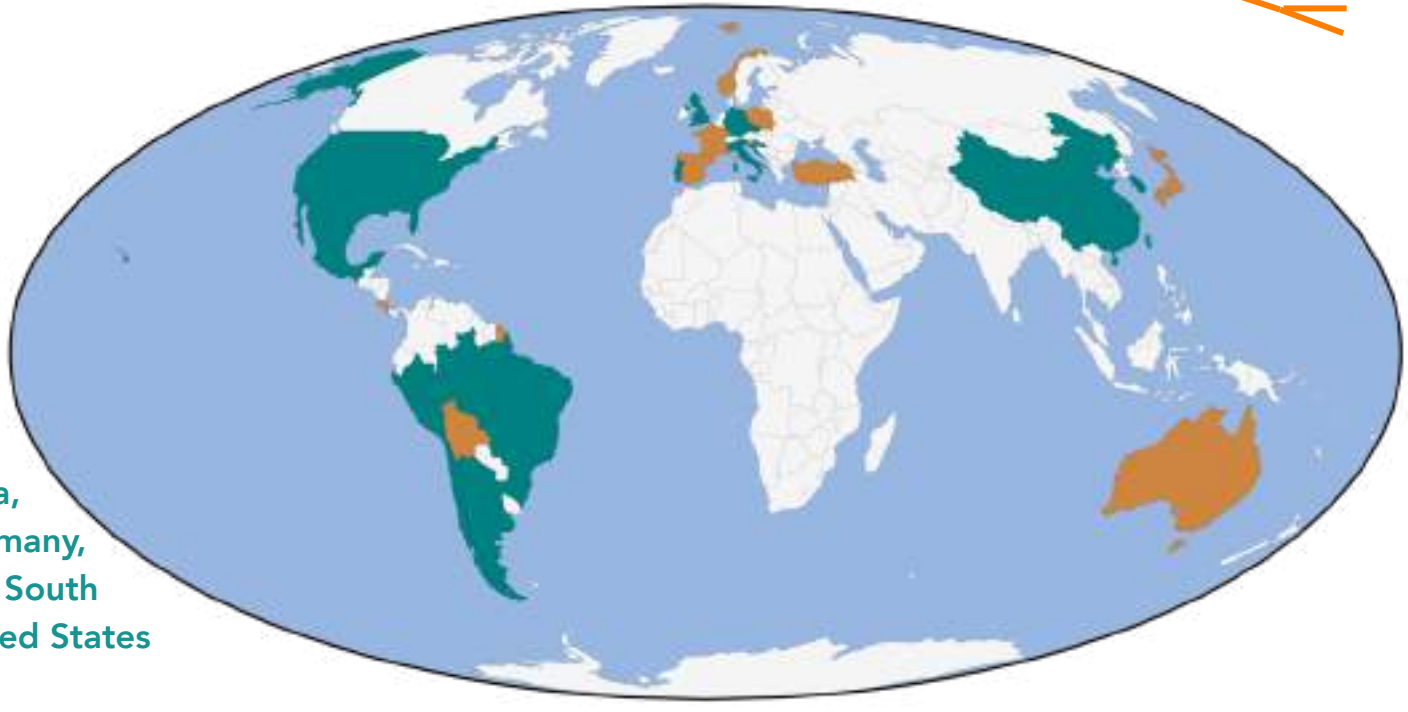
- The Collaboration

  (how we work)



The SWGO Collaboration

- Spokespersons
  - → Jim Hinton (Germany), Petra Huentemeyer (USA), Ulisses Barres (Brazil)



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

Supporting Scientists
Australia, Bolivia, Costa Rica, France, Japan, Poland, Slovenia, Spain, Switzerland, Turkey

- >70 institutions in14 countries

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The SWGO Collaboration

- >70 institutions in14 countries (~30 institutions of 5 countries from LA)

- SWGO is a **Collaboration** of specialists from **Latin America** and **the World** (not just an international Observatory in Latin America).

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The SWGO Collaboration

- >70 institutions in14 countries

- **Collaboration:**
  - → Diversity of talents.
  - → Formation and training of **diverse** and **highly specialized** local experts in science, instrumentation, big data, etc.

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The SWGO Collaboration

Progress is achieved
when we face **BIG CHALLENGES**.

→BIG CHALLENGES are complex:
They require **many disciplines**.

→To attract and retain talent:
need **Local Scientific Infrastructure**

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Summary

- SWGO is a key instrument for **Multimessenger Astrophysics**
- Major **Astroparticle Research Facility in Latin America**
- **BIG CHALLENGE of Science and Technology**
- **Scientific Collaboration of Latin America and the World**

SWGO
The Southern Wide-field Gamma-ray Observatory

Thank you

Backup slides

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
    - ü Site and Design Choices made
  - → Then:
- Preparatory Phase
  - → Detailed construction planning
  - → **Engineering Array**
- (Full) Construction Phase
  - → 2026+