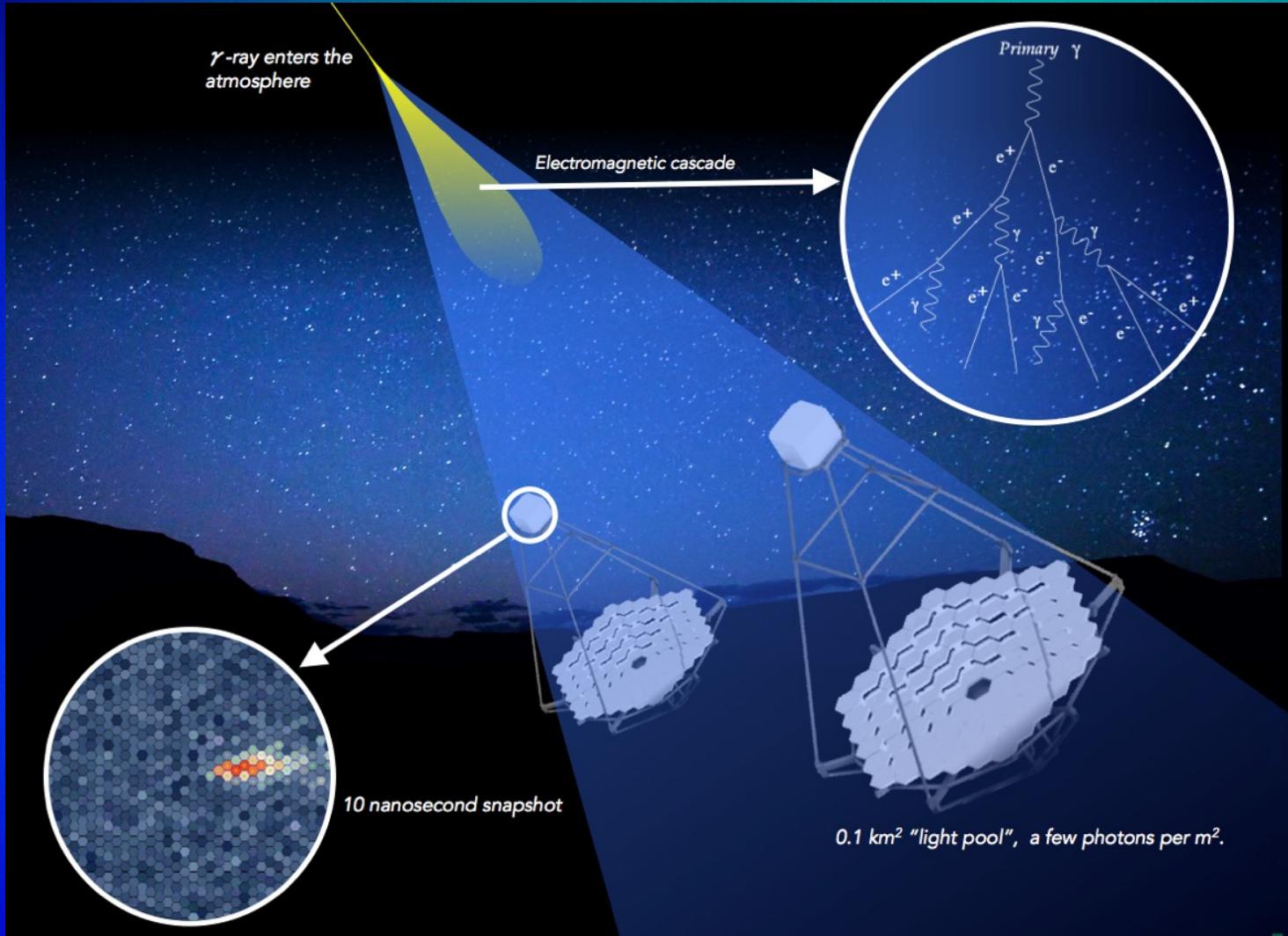


# The Cherenkov Telescope Array Observatory: Construction Progress, and the Spanish Contribution

XVII CPAN Days, Valencia, November 2025

Igor Oya, CIEMAT.  
CTAO Array Control and Data Acquisition Coordinator, Computing Deputy Coordinator.

# Imaging Atmospheric Cherenkov Telescopes



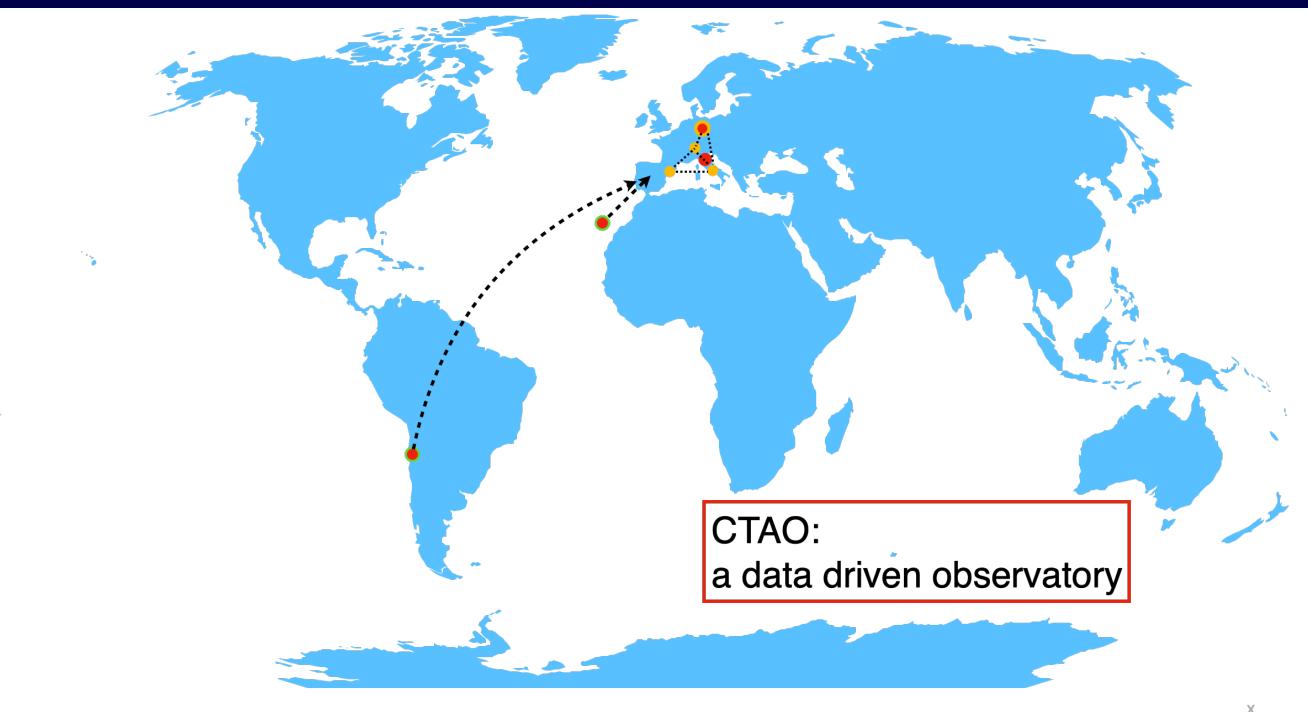
**CTAO**

## CTAO figures:

- Large collection areas ( $10^5 - 10^6 \text{ m}^2$ )
- Excellent background rejection power
- Wide energy range 20 GeV – 300 TeV
- Good energy (15 to 7%) and angular resolution (0.15 – 0.02 deg)
- Reaction to external science alerts and fast repositioning (30 s to point towards any direction in the sky)
- Real-time analysis and internal science alerts
- Big Data: 10s of PB/y of raw data
- The VHE sky is more populated than initially expected!

# CTAO: A Distributed Facility

CTAO



CTAO

Headquarters (site)

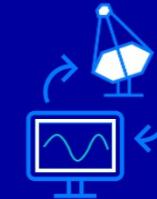


CTAO-South (site)  
(or CTAO-South Station)

- CTAO-South Array (site)
- CTAO-South Operations Building (site)



Science Data  
Management Centre  
(site)



CTAO-North (site)  
(or CTAO-North Station)

- CTAO-North Array (site)
- CTAO-North Low Elevation Office (site)

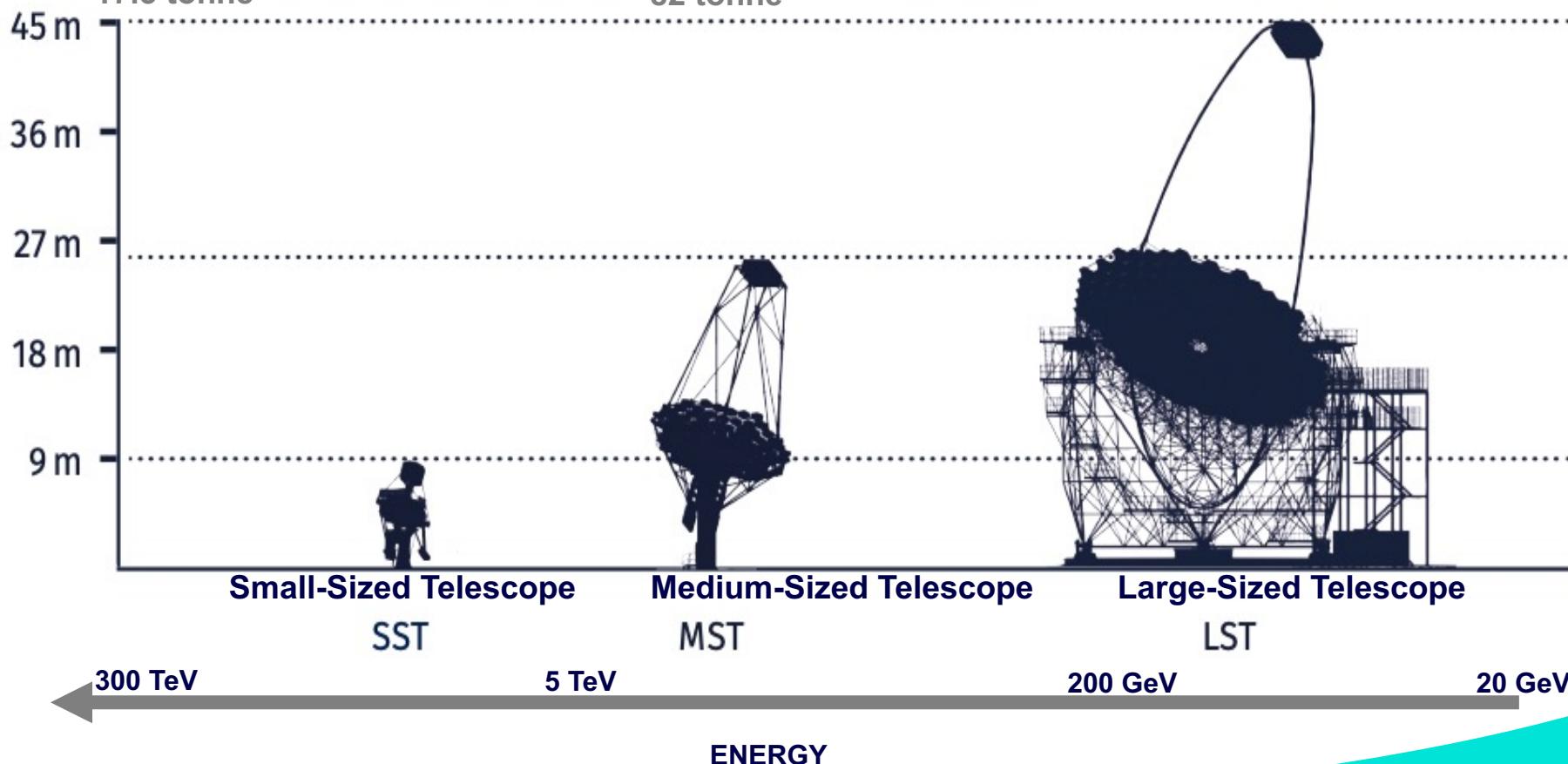


Function: When talking  
about what they do

Geographical: When talking  
about location

# 3 telescope designs

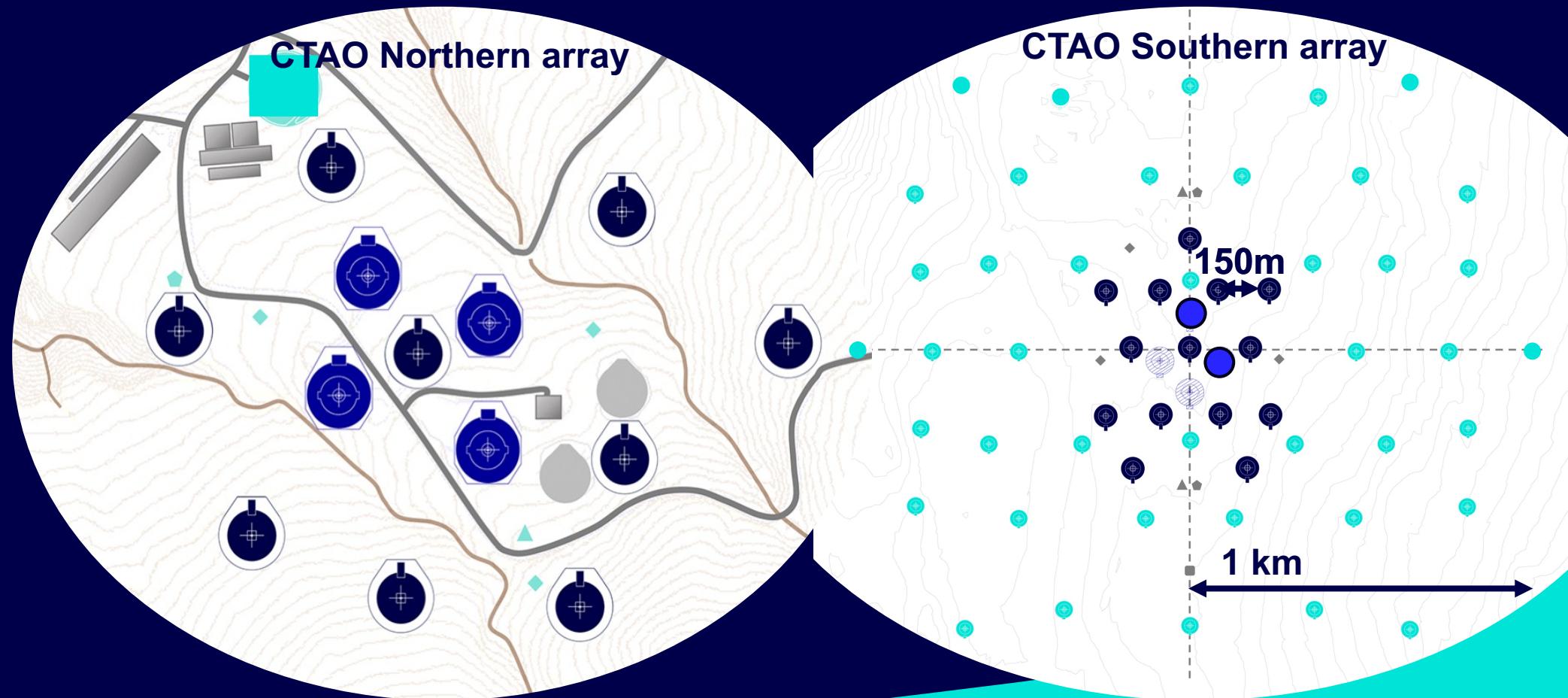
- 2-mirror Schwarzschild-Couder optical design
- 4.3 m  $\varnothing$  primary reflective surface
- SiPM camera: 2048 pixels (0.16 °)
- 8.8° FoV
- 17.5 tonne
- Davies-Cotton optical design
- 12 m  $\varnothing$  reflective surface
- PMT camera – 2 designs:
  - NectarCAM: 1855 pixels
  - FlashCam: 1764 pixels
- $\sim 7^\circ$  FoV
- 82 tonne
- Parabolic optical design
- 23 m  $\varnothing$  reflective surface
- PMT camera: 1855 pixels (0.1°)
- 4.3° FoV
- 100 tonne



# Two observation stations, one unique observatory

CTAO

*Improved Alpha configuration*



# CTAO – The ERIC Established

- CTAO European Research Infrastructure Consortium (ERIC) Established on January 7<sup>th</sup>, 2025
- The ERIC provides the CTAO with the legal stability and administrative advantages

## Members of the CTAO ERIC

- Austria
- Croatia
- the Czech Republic
- the European Southern Observatory (ESO)
- France
- Germany
- Italy
- Poland
- Slovenia
- Spain
- Switzerland

In addition, in process of joining the CTAO ERIC as Strategic Partners or Third Parties:

- Australia, Brazil, Japan, South Africa, and the United States

- Supported by the CTAO Consortium with ~1500 scientists around the world.
- The CTAO science collaboration establishment is in progress.



From left to right: Francisco Colomer, Chair of the CTAO ERIC Council; Eva Ortega, Secretary General of Research at the Spanish Ministry of Science, Innovation and Universities; and Ana María Aricha, Spanish Delegate at the CTAO ERIC Council. Credit: CTAO



Delegates from the CTAO ERIC Council in the inaugural meeting in Bologna, Italy. Credit: CTAO.

# CTAO: Construction Status



- Rapid development at the CTAO-N
  - LST-1 prototype in operation and producing science, with three more LSTs expected online in 2026
  - A Joint Commissioning Team of LST, software, and central organization members has been established for the LST-1 in La Palma.
- CTAO-S construction ramping up
- CTAO products in advanced stage:
  - Most telescopes and software/computing systems passed or are passing the Critical Design Reviews (CDR)
- System-level verification planned to begin after the individual telescopes have been verified and accepted, to be followed with early science



*On 2 July, a major contract, worth several million Euros, was signed between the CTAO's hosting partner, ESO (European Southern Observatory), and a consortium of Chilean companies for the construction of roads and telescope foundations for the CTAO's southern hemisphere array (CTAO-South)*

# CTAO-N as of today

LST-1 Operative



LST-2  
Structure, mirrors installed



LST-4  
Structure, mirrors and camera installed



LST-3  
Structure, mirrors installed



All LSTs will be ready by 2026. LSTs inauguration is being organised for mid October 2026 in La Palma

In addition:

- MST3 will be built soon
- Operation building: construction to start soon

Credit: CTAO LST Collaboration

# CTAO-S as of today

- Large-scale CTAO-S infrastructure works have started



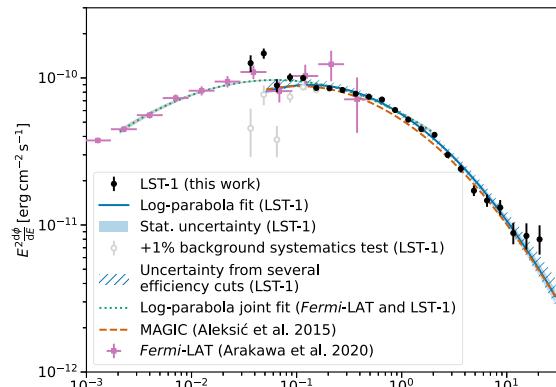
**In addition:**  
First SST and MST  
expected in 2026-  
2027

An intermediate data  
centre and control  
container to cover the  
gap until the  
operations building is  
in place (late 2028)

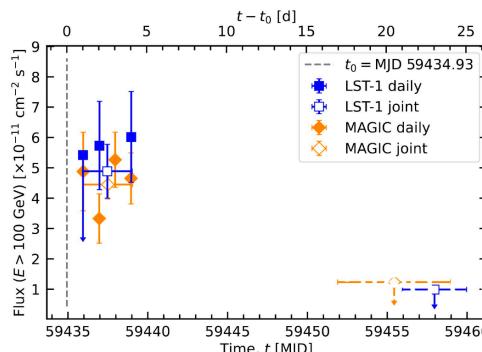
# LST1 – First Science Results

Credits to the CTAO LST collaboration

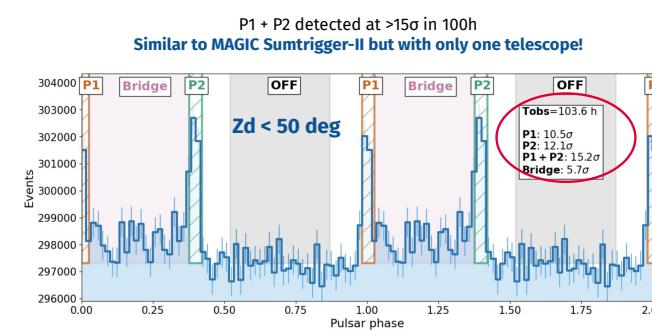
“LST-1 performance paper”  
[Abe et al. 2023](#)



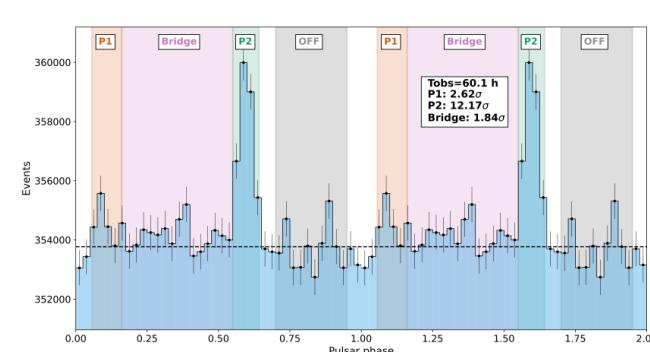
Nova RS Ophiuchi: First nova ever detected at VHE gamma rays  
[Abe et al. 2025b](#)



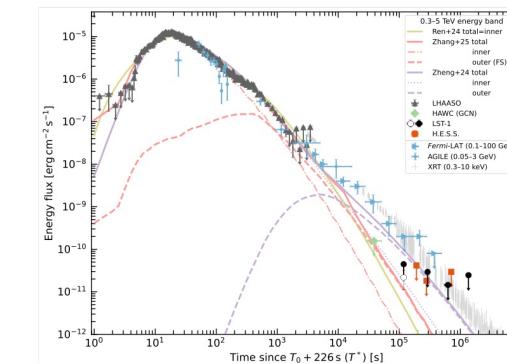
LST-1 observations of the Crab PSR  
[Abe et al. 2024](#)



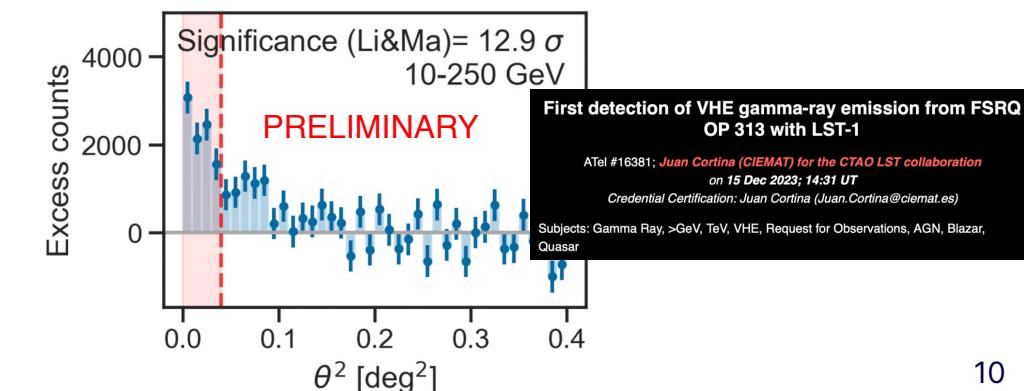
LST-1 observations of the Geminga PSR  
[Abe et al. 2025a, accepted](#)



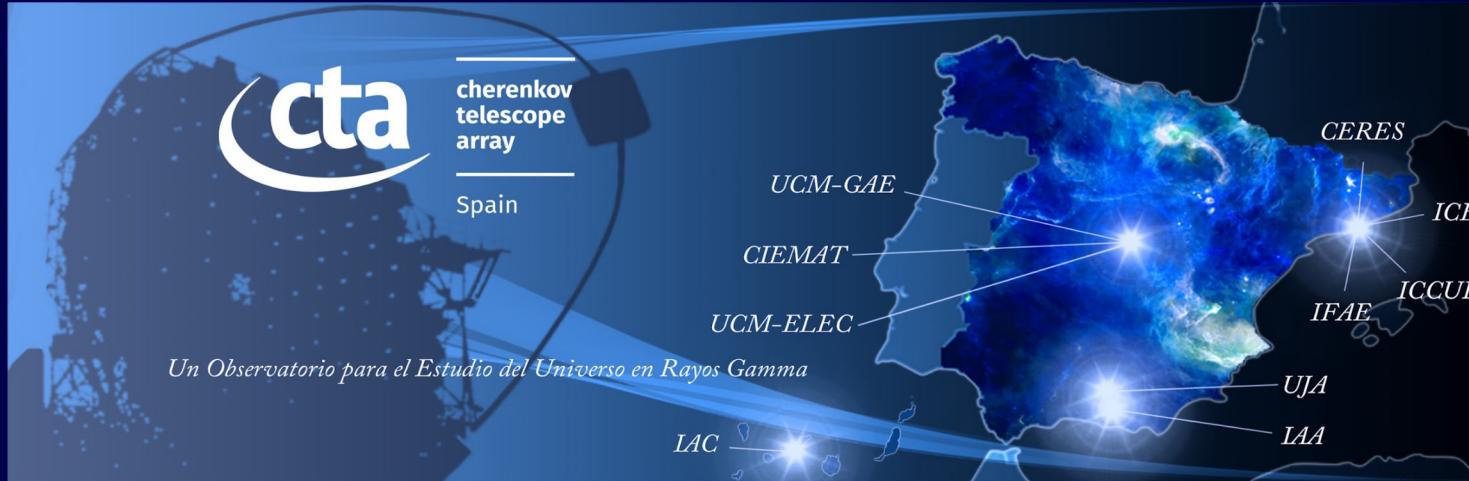
GRB221009A: The brightest of all time (“The BOAT”) GRB, 1 event every ~10<sup>3</sup> yrs  
[Abe et al. 2025c \(accepted\)](#)



OP 313: the farthest AGN @ VHEs  
 $z=0.9973$



# Spanish contribution

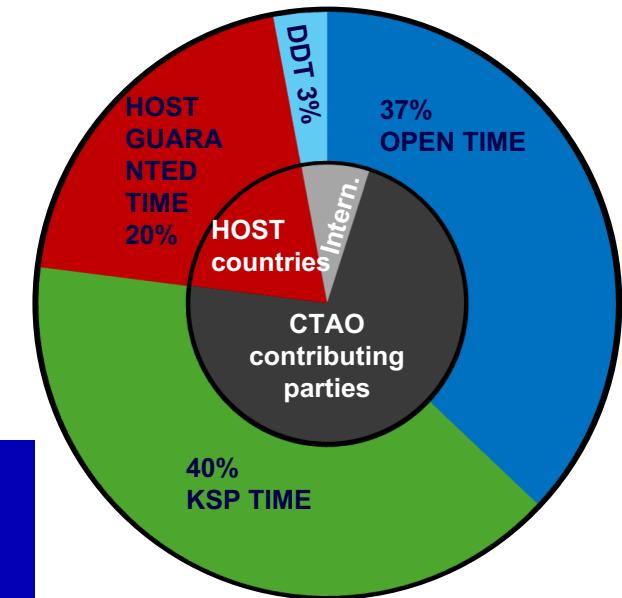
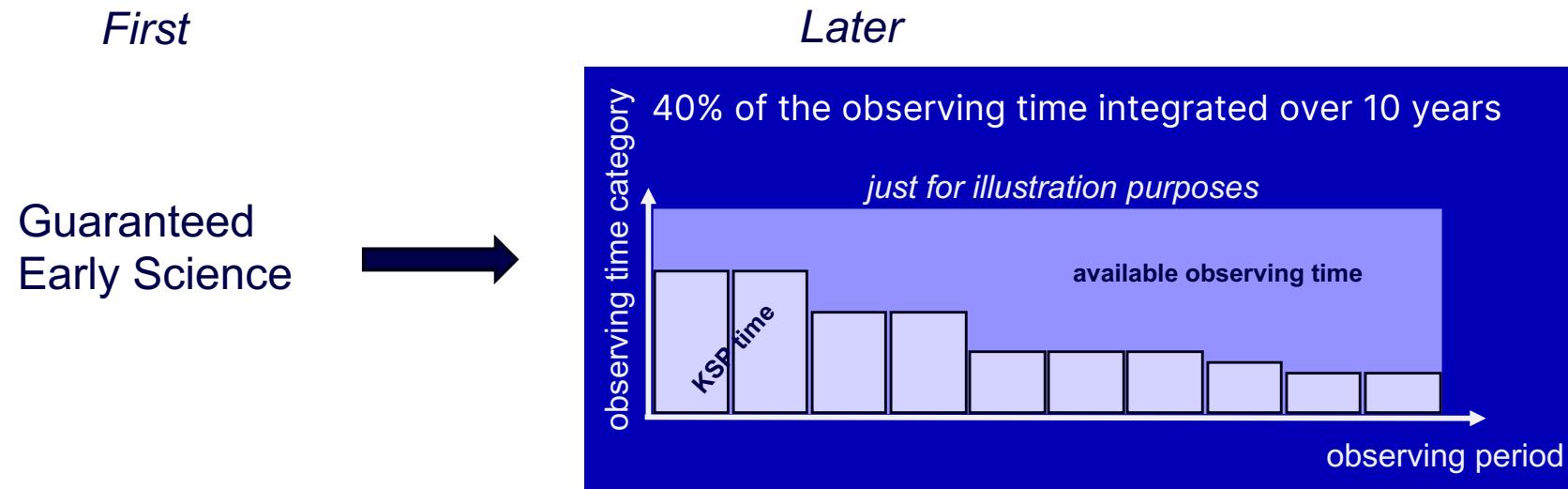


- Infrastructure of CTAO-North
- Design and funding of LST and MST structures and mechanics
- Data center of CTAO at PIC (1 out of 4 distributed data centers)
- Contribution to software systems: Array control system, scheduler, data reduction and analysis software
- Array Common Elements (ACE), Coordination, LIDAR, weather stations, etc.
- Cameras of LSTs and NectarCAM MSTs, including:
  - Structure and mechanics
  - Cooling
  - Power supplies and power distribution
  - Analog amplifiers
  - Trigger and Timing distribution system
  - Cabling
  - Camera Control
  - Assembly, Integration & Verification
  - R&D for Advanced LST SiPM-CAM

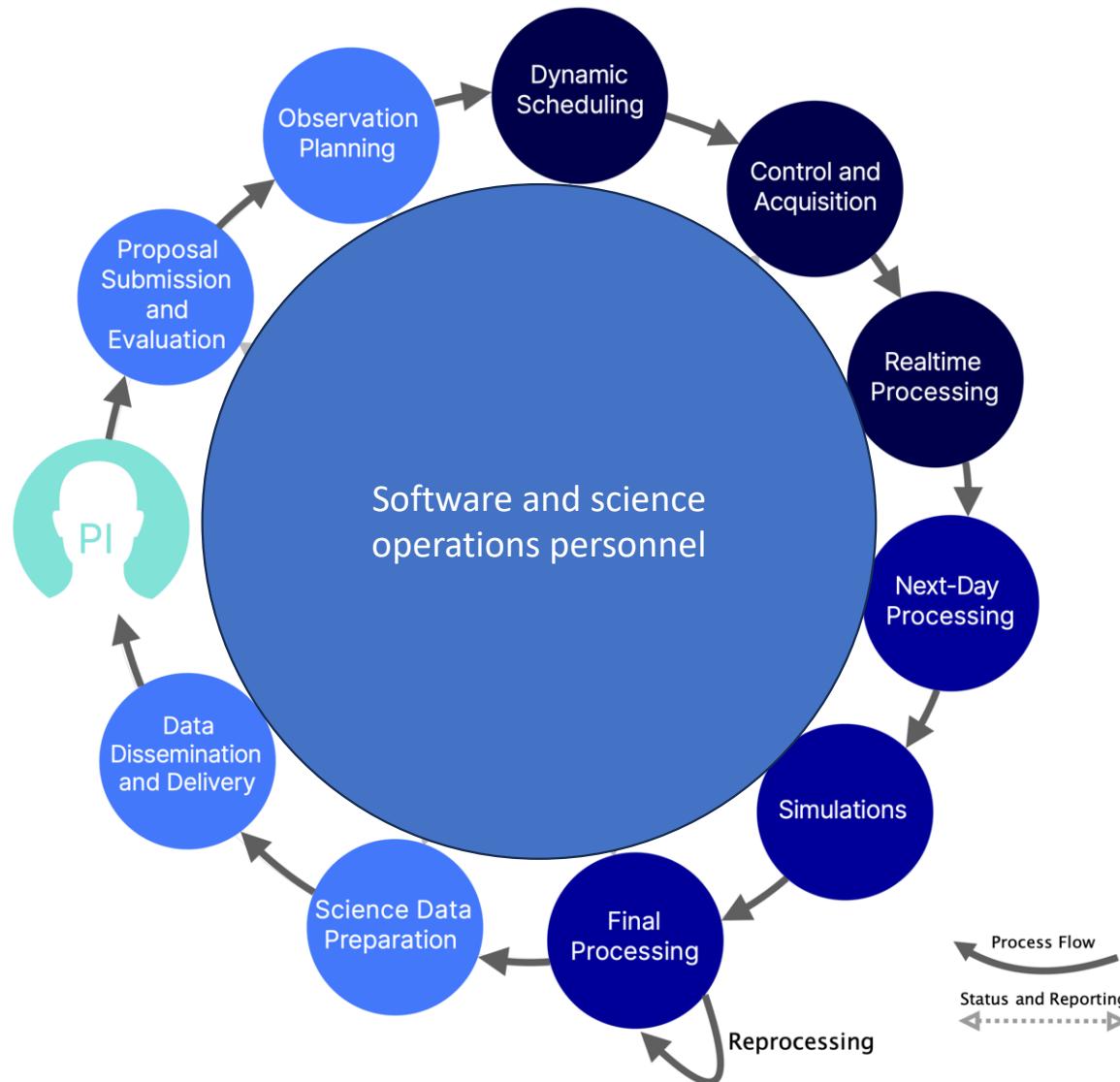
# An Astronomical Observatory

## An open, proposal-driven observatory

- Data with a proprietary period of 1 yr after that fully open
- KSPs are granted to contributors of the CTAO Construction Project, contingent upon the formation of the CTAO scientific collaboration.
- Key Science Projects (KSPs): observational projects requiring more than 300 hr, over more than one observing period with the aim of delivering legacy data sets and gamma-ray catalogues, on key science cases promising major breakthroughs.



# Science Operations



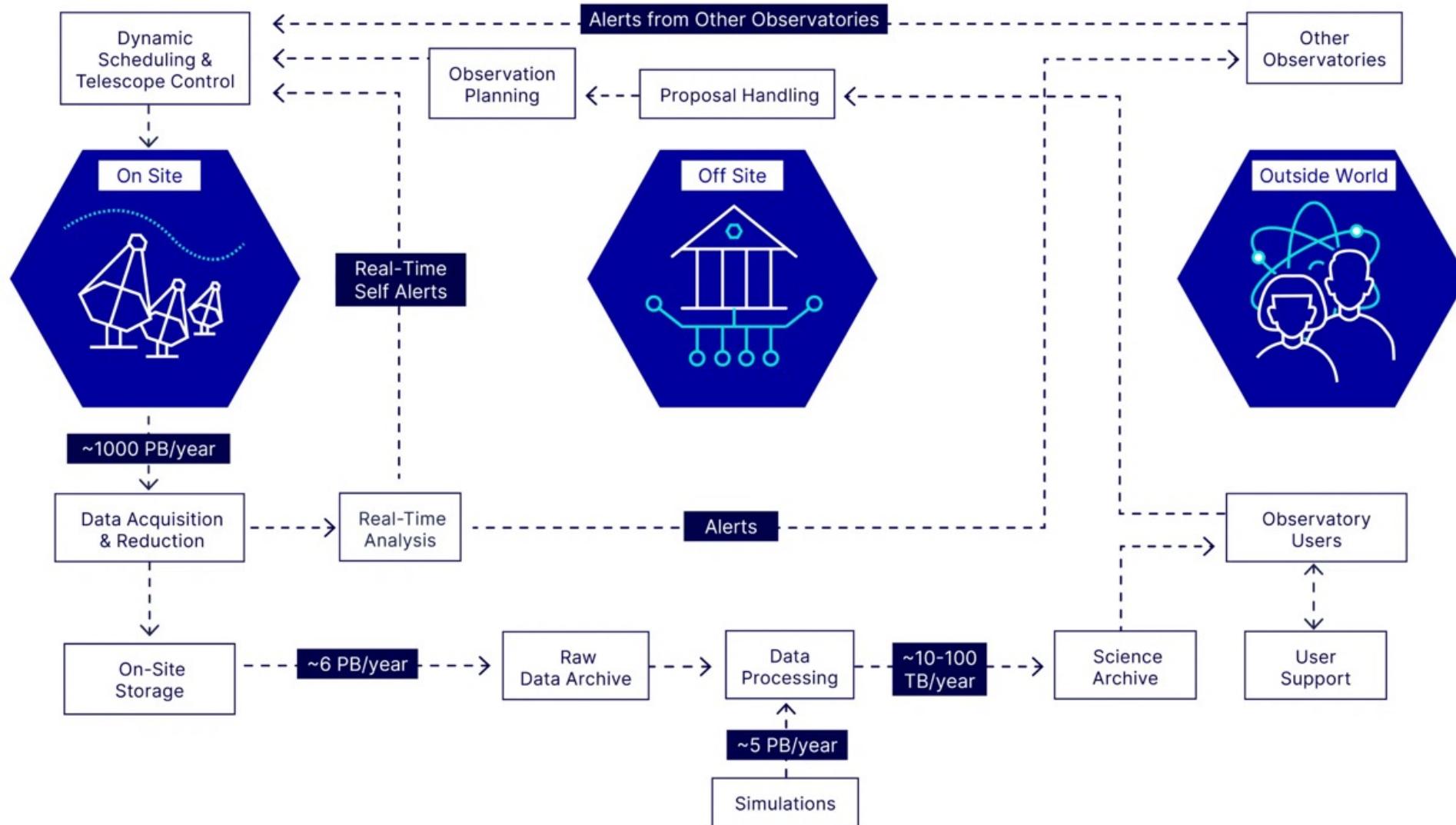
Operate as proposal-driven observatory

# Conclusions and Outlook

- CTAO-N in development in La Palma
  - One LST operative, and another three LSTs being commissioned in CTAO-N
  - Technical building and 1<sup>st</sup> MST construction to start soon
- CTAO-S
  - Large tenders for site infrastructure awarded → construction has started
  - First MSTs and SSTs expected to go online in 2026
  - Setting up an intermediate data centre and control container
- Software to support array operations, analysis and calibration progressing steadily, with the first official versions already released and tested
- Early science exploitation phase will arrive within the next few years after the first groups of telescopes have been commissioned and integrated into the arrays
- Significant Spanish contribution in CTAO Telescopes, Array Common elements, infrastructure, software and computing infrastructure
- Exciting times ahead: CTAO early science is around the corner

# Backup

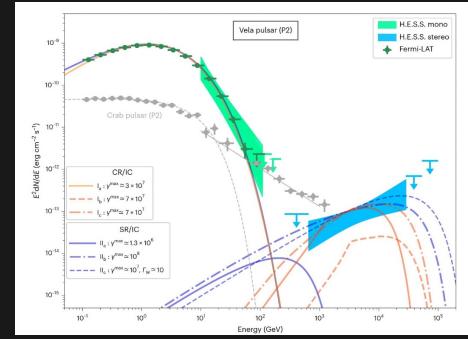
# CTAO - Data Flow



- Control 60+ telescopes
- BIG DATA project, generate hundreds of petabytes (PB) of data in a year (at least 6 PB after compression)
- Two sites and four off-site data centres

# Science cases of the VHE astronomy

H.E.S.S. coll. *Nature* 2023



## sub-TeV

- **Transients**
- **Cosmological sources**
- **Pulsars**

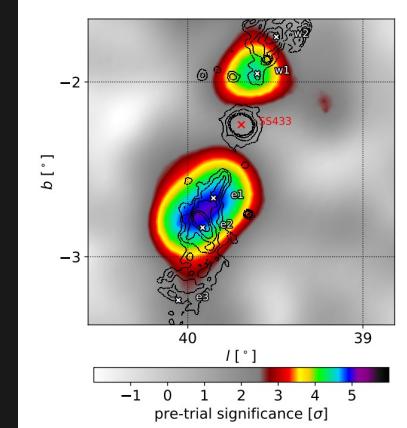
## TeV

- **EBL**
- **Dark Matter**
- **diffuse emission**
- **morphological studies**
- **surveys**

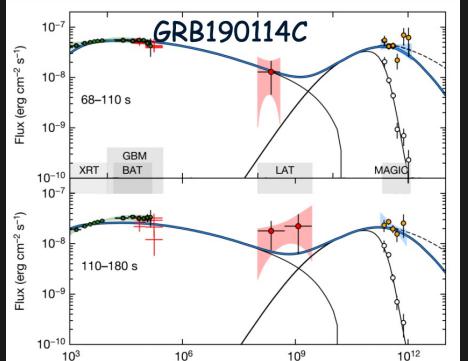
## multi-TeV

- **PeVatrons**
- **SFRs**

HAWC coll. *Nature* 2018



MAGIC coll. *Nature* 2020



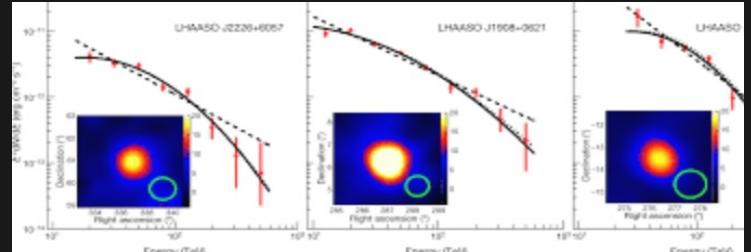
20 GeV

500 GeV 1 TeV

10 TeV

300 TeV

LHAASO coll. *Nature* 2021



GPS VERITAS + H.E.S.S.

