

# CTAO status and perspective

Alicia López Oramas (Instituto de Astrofísica de Canarias)

On behalf of the CTAO Consortium

The logo for the Cherenkov Telescope Array Observatory (CTAO) features the letters 'CTAO' in a bold, white, sans-serif font. A small, stylized teal starburst is positioned between the 'A' and 'O'.

**CTAO**

Cherenkov Telescope Array Observatory

An aerial photograph of the Cherenkov Telescope Array Observatory (CTAO) site. Several large, circular, blue-tinted telescopes are scattered across a grassy, hilly landscape. The telescopes are mounted on metal frames and are partially covered with blue protective material. The background shows a clear blue sky and a distant mountain range.

## Cherenkov Telescope Array Observatory

Next-generation ground-based gamma-ray observatory

One observatory, two sites, three types of telescopes

A night-time photograph of the Cherenkov Telescope Array Observatory (CTAO) site. The telescopes are illuminated from below, creating a strong glow. The background is a dark, starry sky with a few bright stars visible. The telescopes are arranged in a grid-like pattern across a dark, flat landscape.

# Three types of telescopes

## Medium-Sized Telescope (MST)

Core energies

$E = 0.15 - 5 \text{ TeV}$

## Large-Sized Telescope (LST)

Lowest energies

$E = 0.02 - 0.15 \text{ TeV}$

## Small-Sized Telescope (SST)

Highest energies

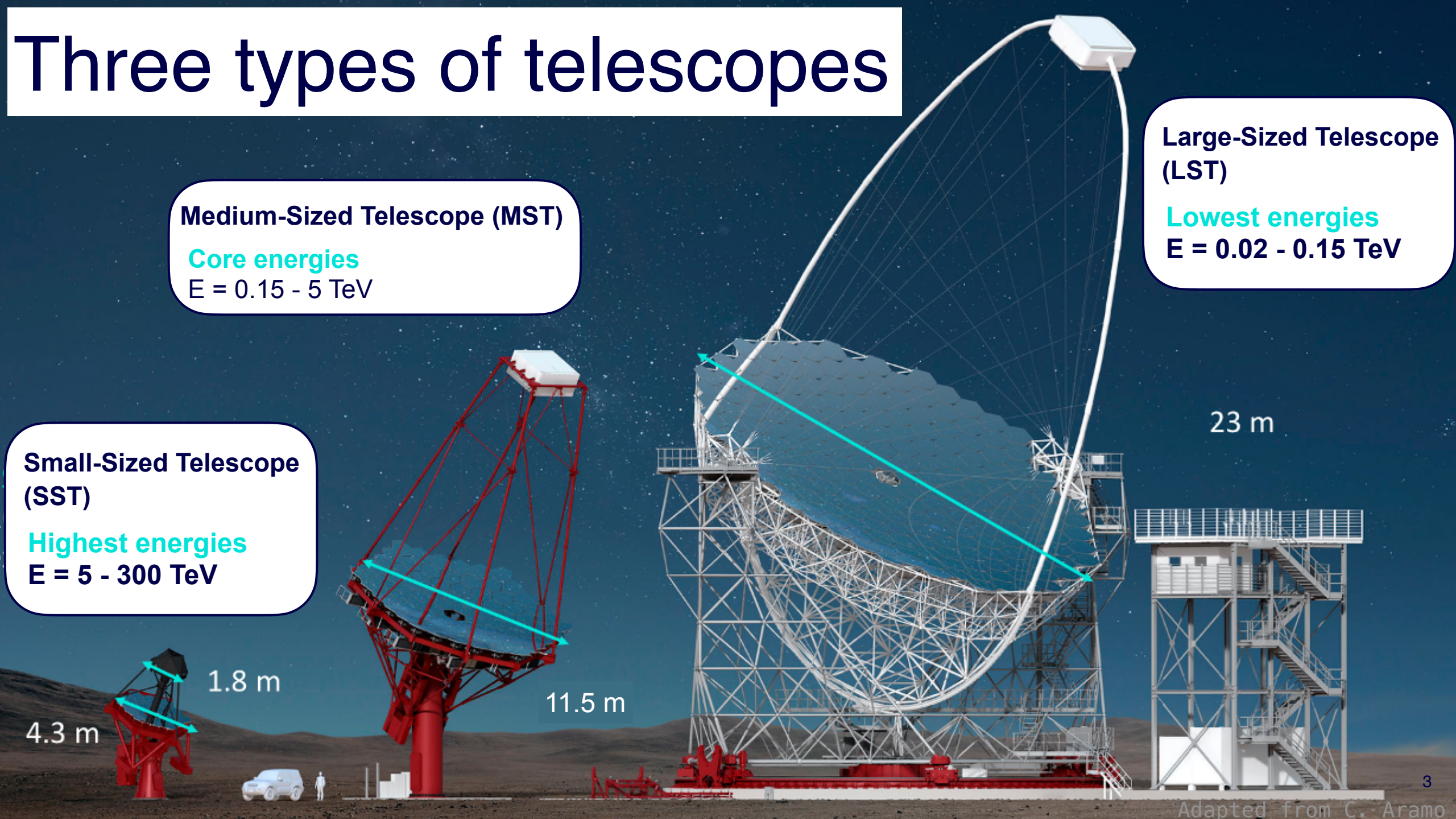
$E = 5 - 300 \text{ TeV}$

1.8 m

4.3 m

11.5 m

23 m



# Partners (In-kind Contributors)

Telescope construction | Software development |  
North Site Infrastructure

 | LST  
COLLABORATION

67 different institutions across  
twelve countries:  
Brazil, Bulgaria, Croatia,  
Czech Republic, France,  
Germany, Italy, Japan,  
Poland, Spain  
and Switzerland

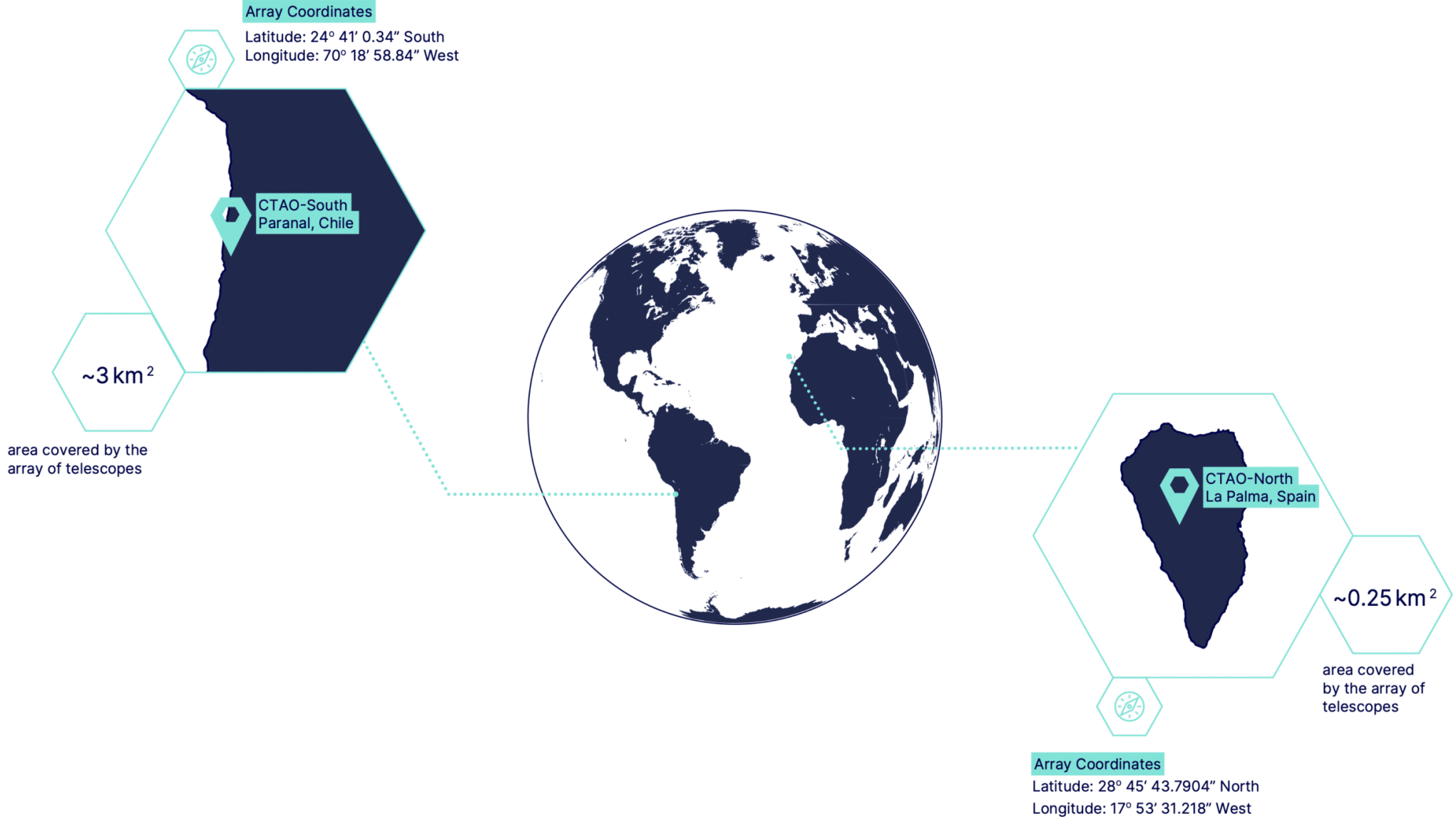
 | MST  
COLLABORATION

International collaboration of  
organizations from  
Austria, Brazil, France,  
Germany, Italy, Poland, Spain  
and Switzerland

 | SST  
COLLABORATION

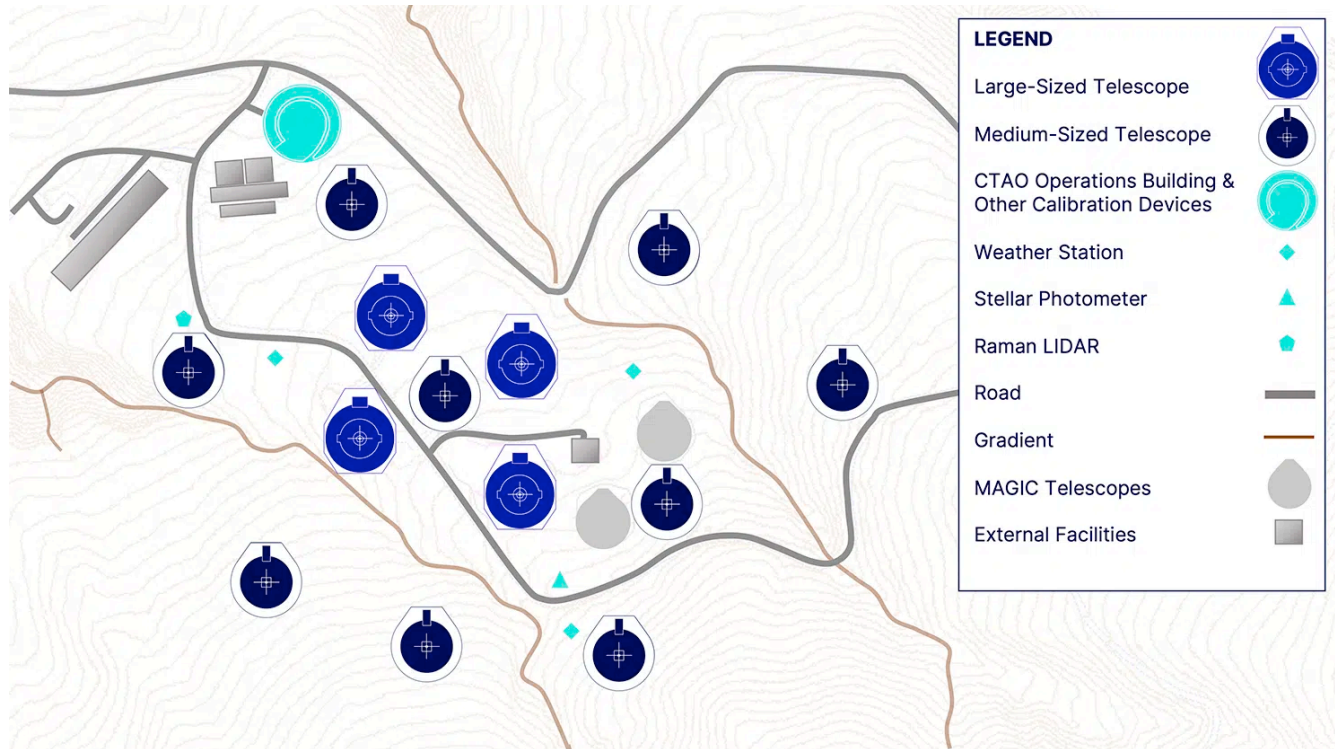
International collaboration of  
organizations from  
Australia, Brazil, France,  
Germany, Italy, Japan,  
Netherlands, Switzerland

# Two array sites

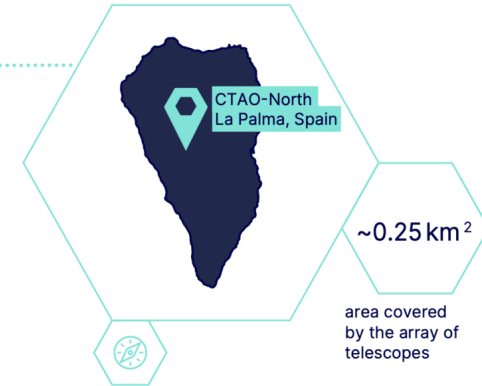


# CTAO-Northern Array

## Alpha Configuration



**CTAO**

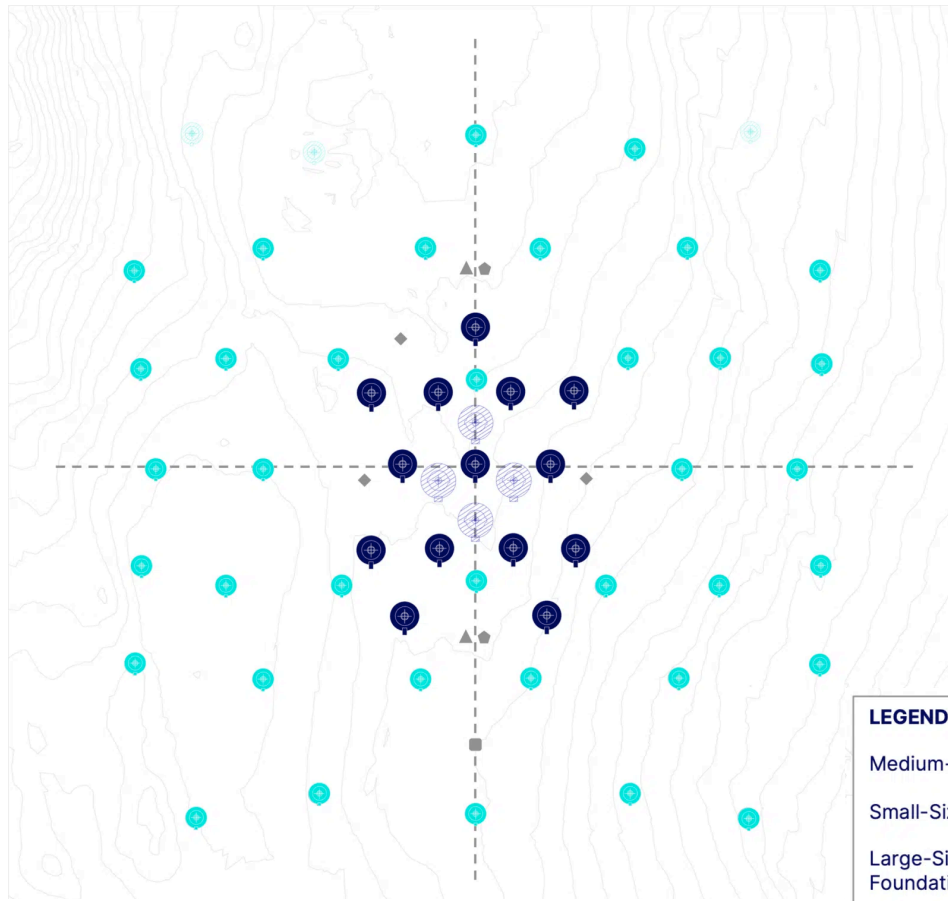


**Array Coordinates**  
Latitude: 28° 45' 43.7904" North  
Longitude: 17° 53' 31.218" West

- Located at Observatorio Roque de los Muchachos (ORM), Spain
- 4 LSTs+ 9 MSTs

# CTAO-Southern Array

## Alpha Configuration

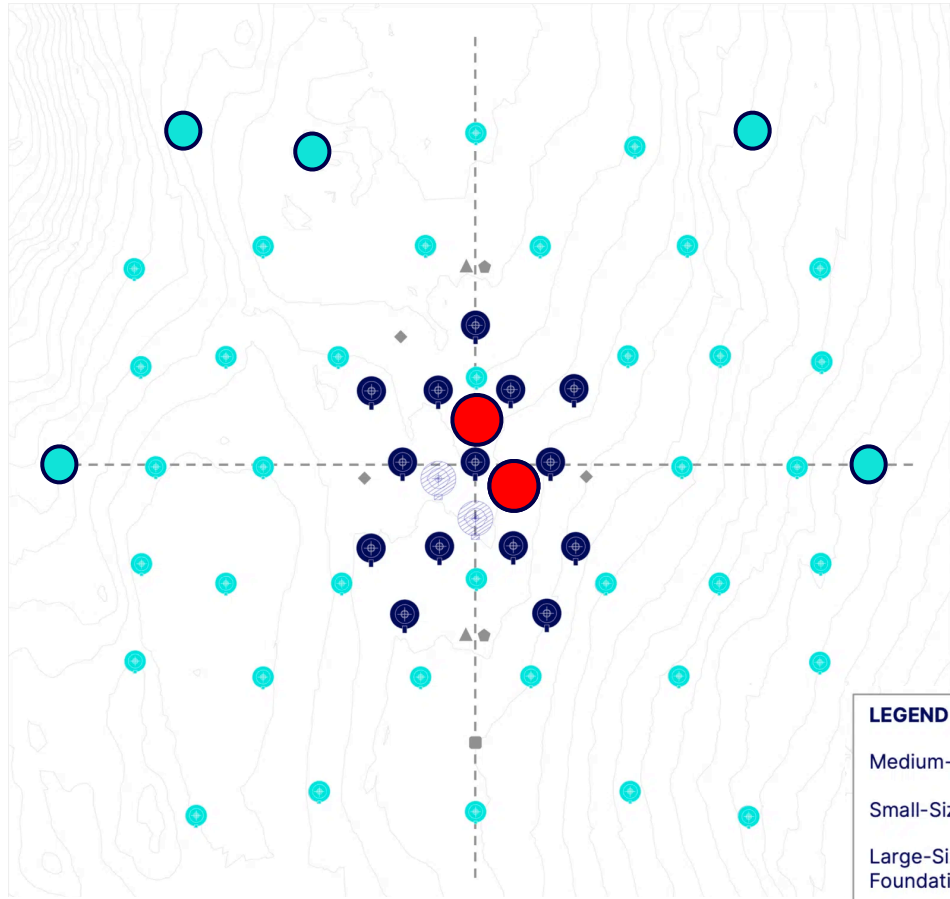


- Located at Atacama Desert, Chile
- 14 MSTs + 37 SSTs

LEGEND			
Medium-Sized Telescope (MST)		Weather Station	
Small-Sized Telescope (SST)		Stellar Photometer	
Large-Sized Telescope (LST) Foundation		Raman LIDAR	
SST Foundation		Other Calibration Devices	

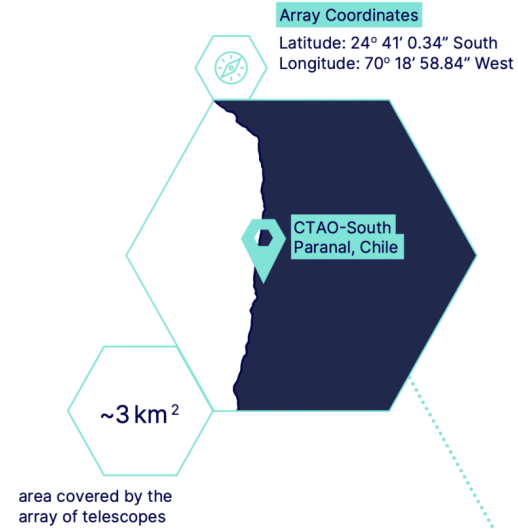
# CTAO-Southern Array

## Alpha Configuration+



LEGEND	
Medium-Sized Telescope (MST)	
Small-Sized Telescope (SST)	
Large-Sized Telescope (LST)	
SST Foundation	
Weather Station	
Stellar Photometer	
Raman LIDAR	
Other Calibration Devices	

Array Coordinates  
Latitude: 24° 41' 0.34" South  
Longitude: 70° 18' 58.84" West

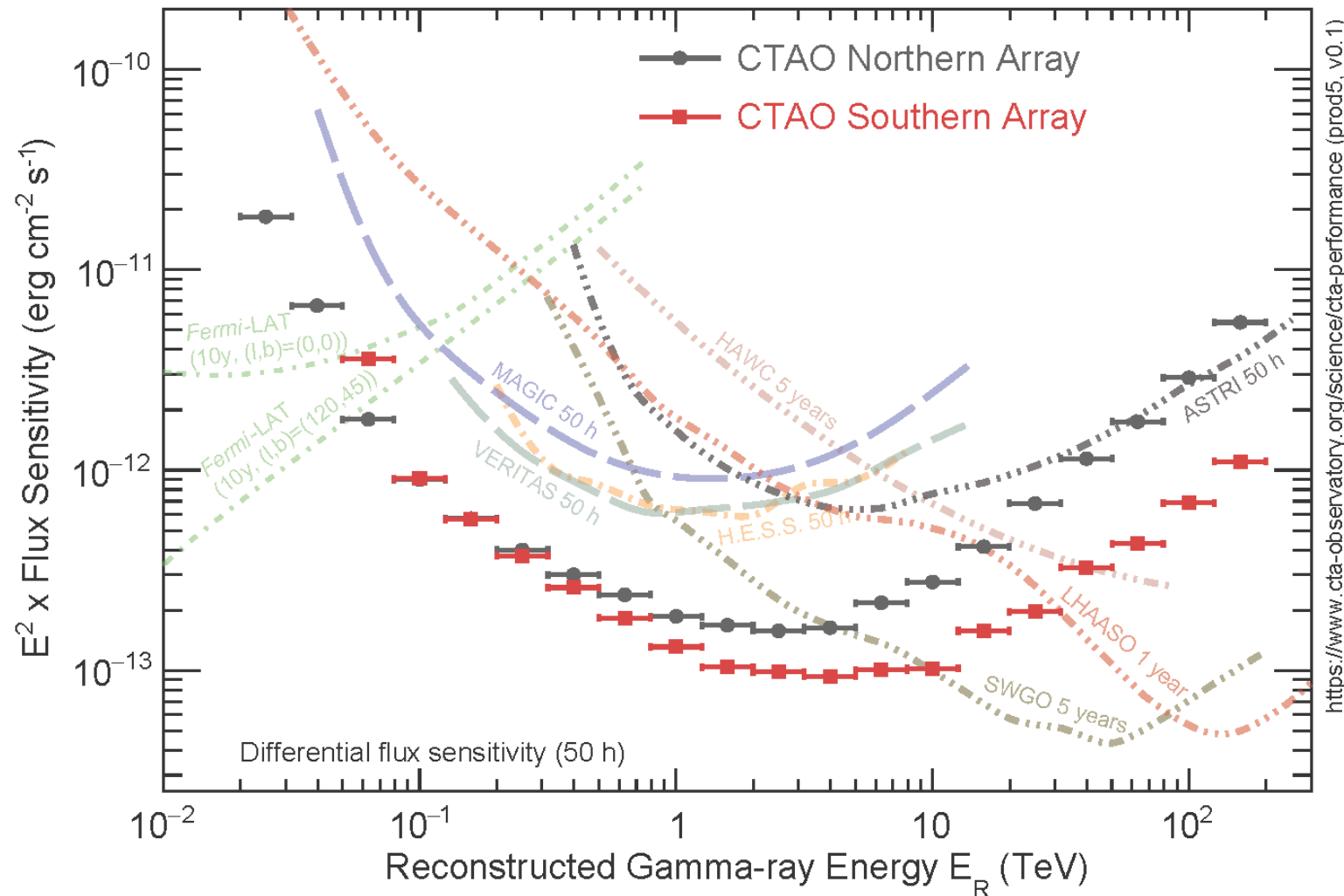


- Located at Atacama Desert, Chile
- 14 MSTs + 42 SSTs + 2 LSTs

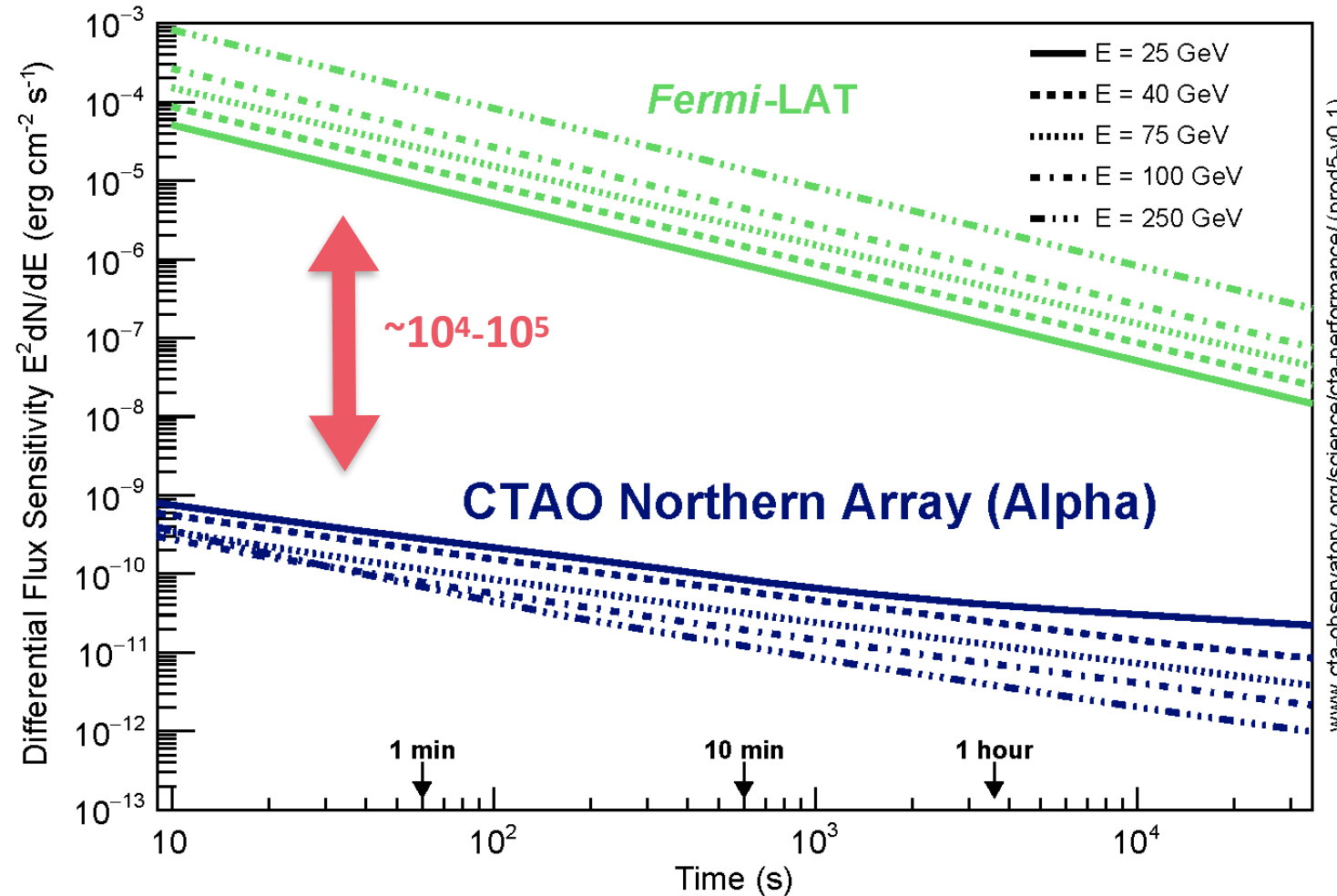
CTA+ (see talk by C. Aramo)



# Sensitivity



# Short-time Sensitivity



**Optimal for transient detection**

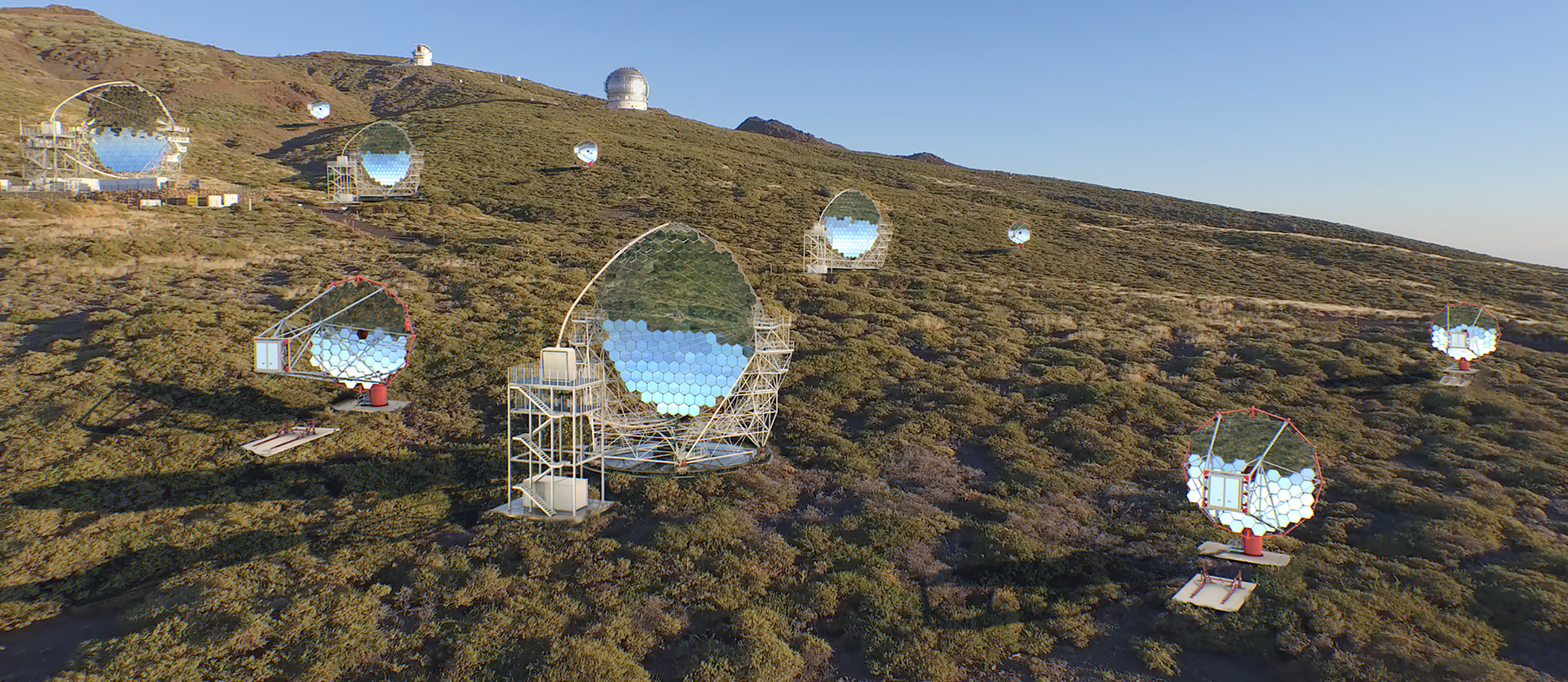
# Current Status

# CTAO-Northern Array

ORM, La Palma (Spain)

CTAO

Cherenkov Telescope Array Observatory

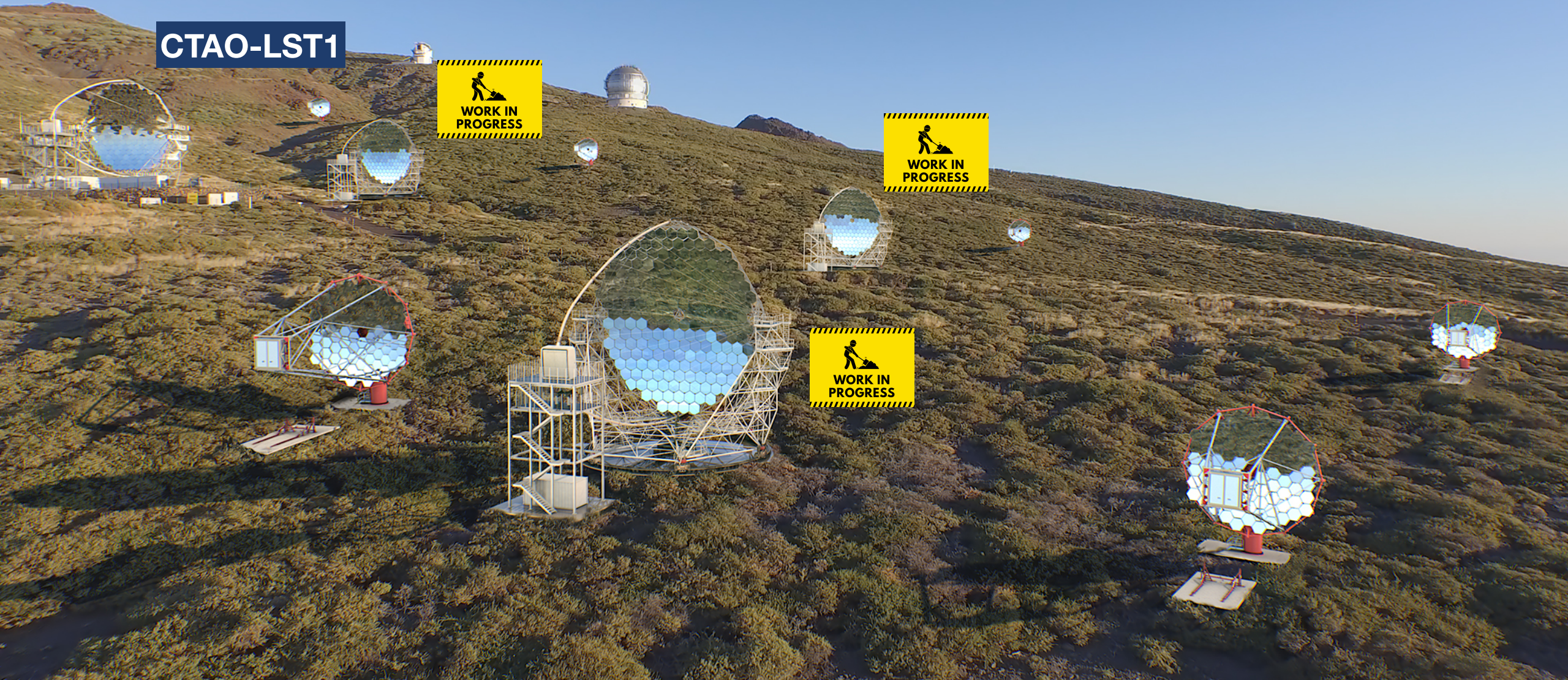


# CTAO-Northern Array

ORM, La Palma (Spain)



**CTAO-LST1**



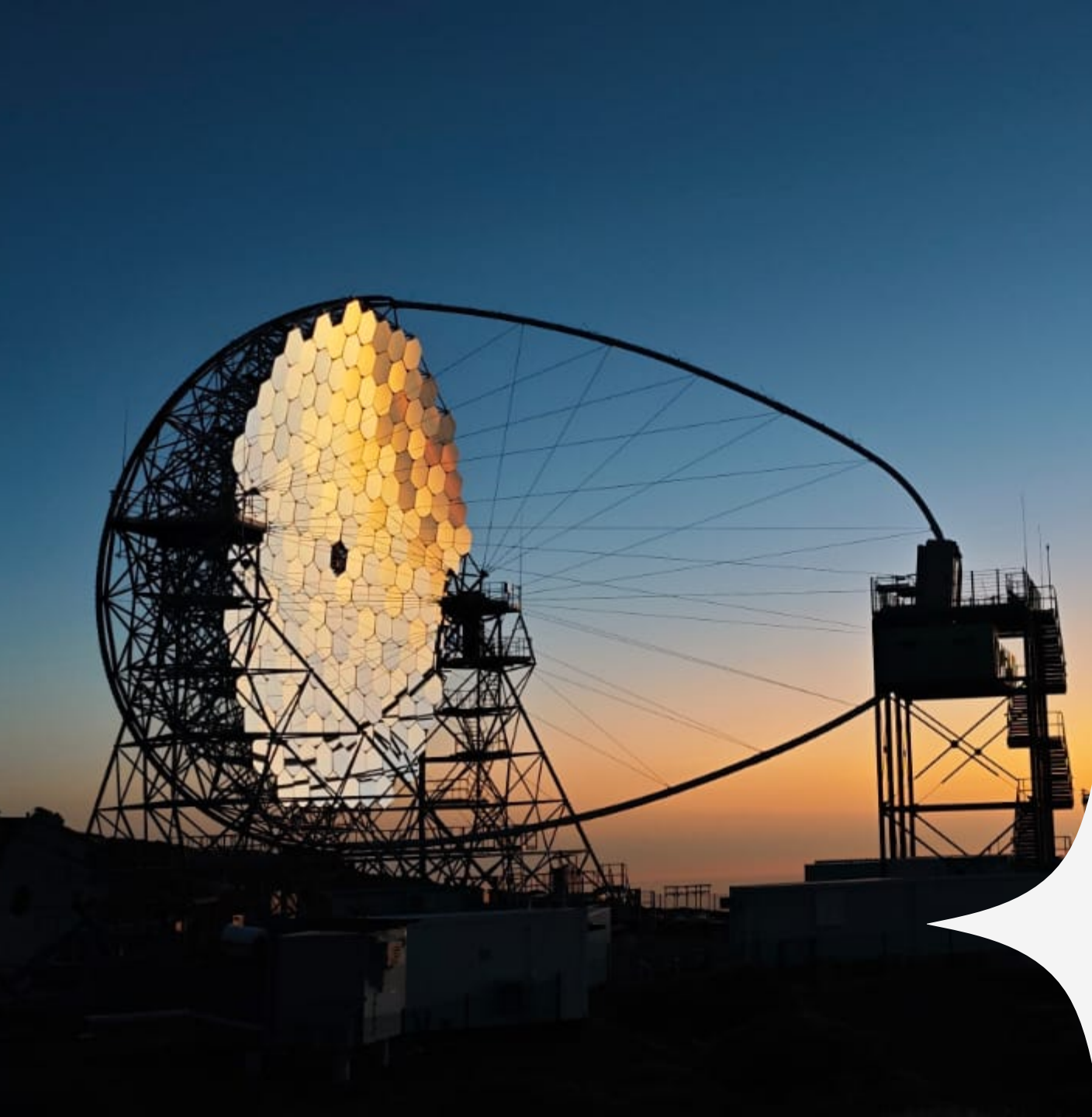
# CTAO-LST1

- Operational since 2018 at ORM
- Producing Scientific Results

[See talk by M. Teshima](#)

## Most recent scientific highlights

- Discovery of **OP313 at  $z=0.997$**
- (LST Coll, Otero-Santos, 11th Fermi Symposium 2024)
- **B.O.A.T. GRB 221009A at  $4\sigma$**
- (LST Coll, Aguasca-Cabot Gamma 2024)
- **Nova RS Oph 2021 outburst**
- (LST Coll, Aguasca-Cabot SEA 2024)



Most sensitive Cherenkov array worldwide by end of 2025

CTAO-LST1

CTAO-LST2

CTAO-LST3

CTAO-LST4

# CTAO-Southern Array

Paranal (Chile)





# CTAO-Southern Array

## Getting ready for construction



- Topographical Survey: complete
- Geotechnical study: nearly complete
- 23kV electrical Overhead Line: under negotiation
- 10 kV Power Conditioning System: Out for tender
- Array Roads and Telescope Foundations: Contract late this year



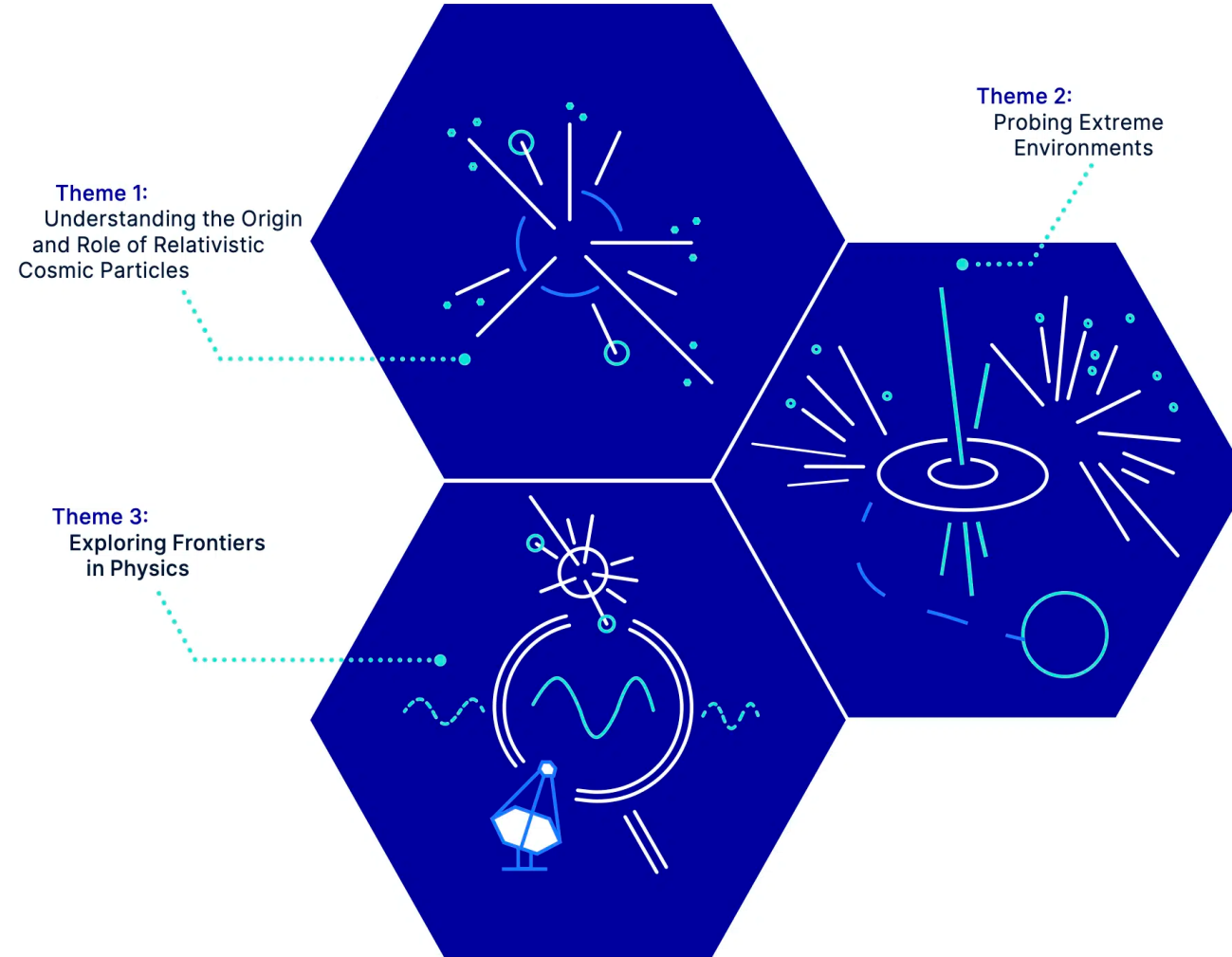
# Science Data Management Centre



- Science data processing and distribution
- Located in Zeuthen (near Berlin)
- Inauguration in October

# Science Perspectives

# Science Cases



# CTAO Consortium

- Created the CTAO concept
- Science exploitation
  - Key Science Projects (CTA Consortium, 2019)



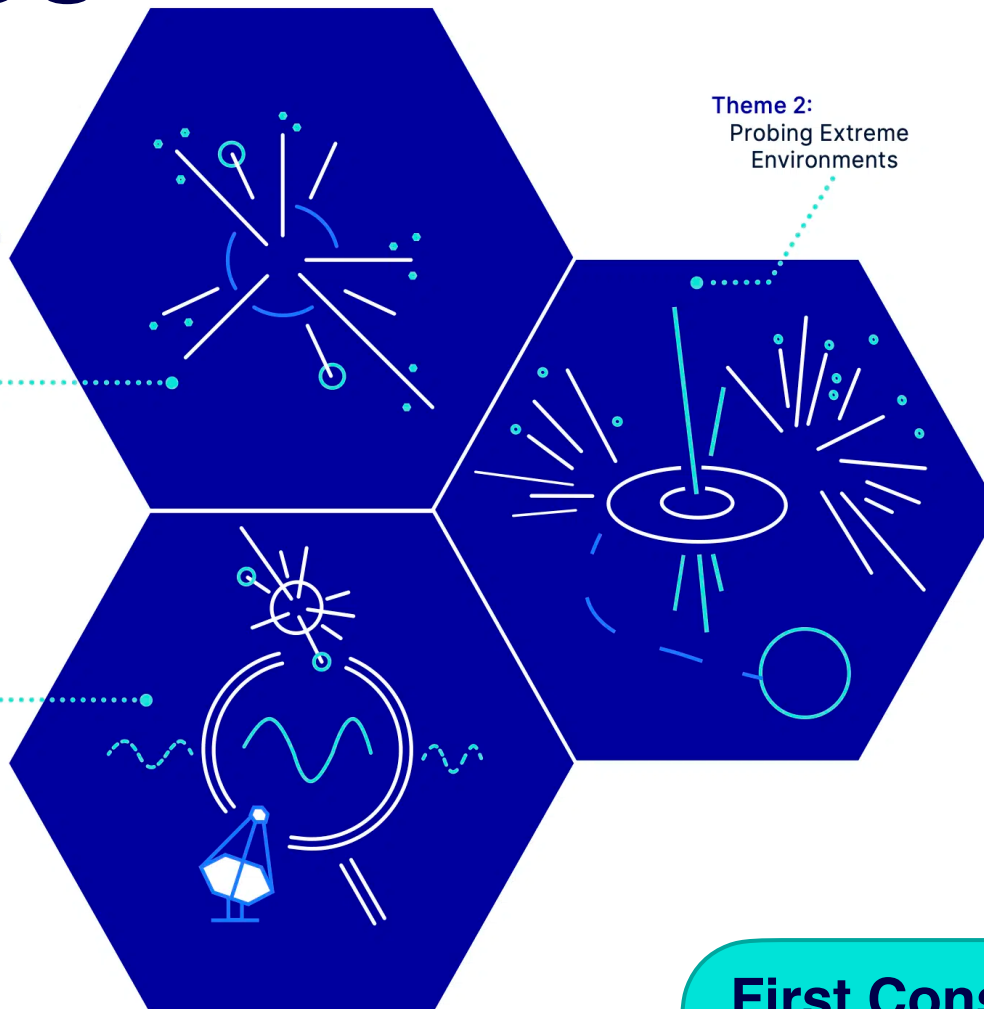
+1500 members  
~ 200 institutes  
25 countries



# Science Cases

- Cosmic rays
- PeVatrons
- Star-forming regions

Theme 1:  
Understanding the Origin  
and Role of Relativistic  
Cosmic Particles



- Galactic Plane Survey
- Extragalactic Survey
- LMC Survey

- Dark matter
- Fundamental physics

- Galactic Centre
- Transients
- AGNs
- Galaxy Clusters

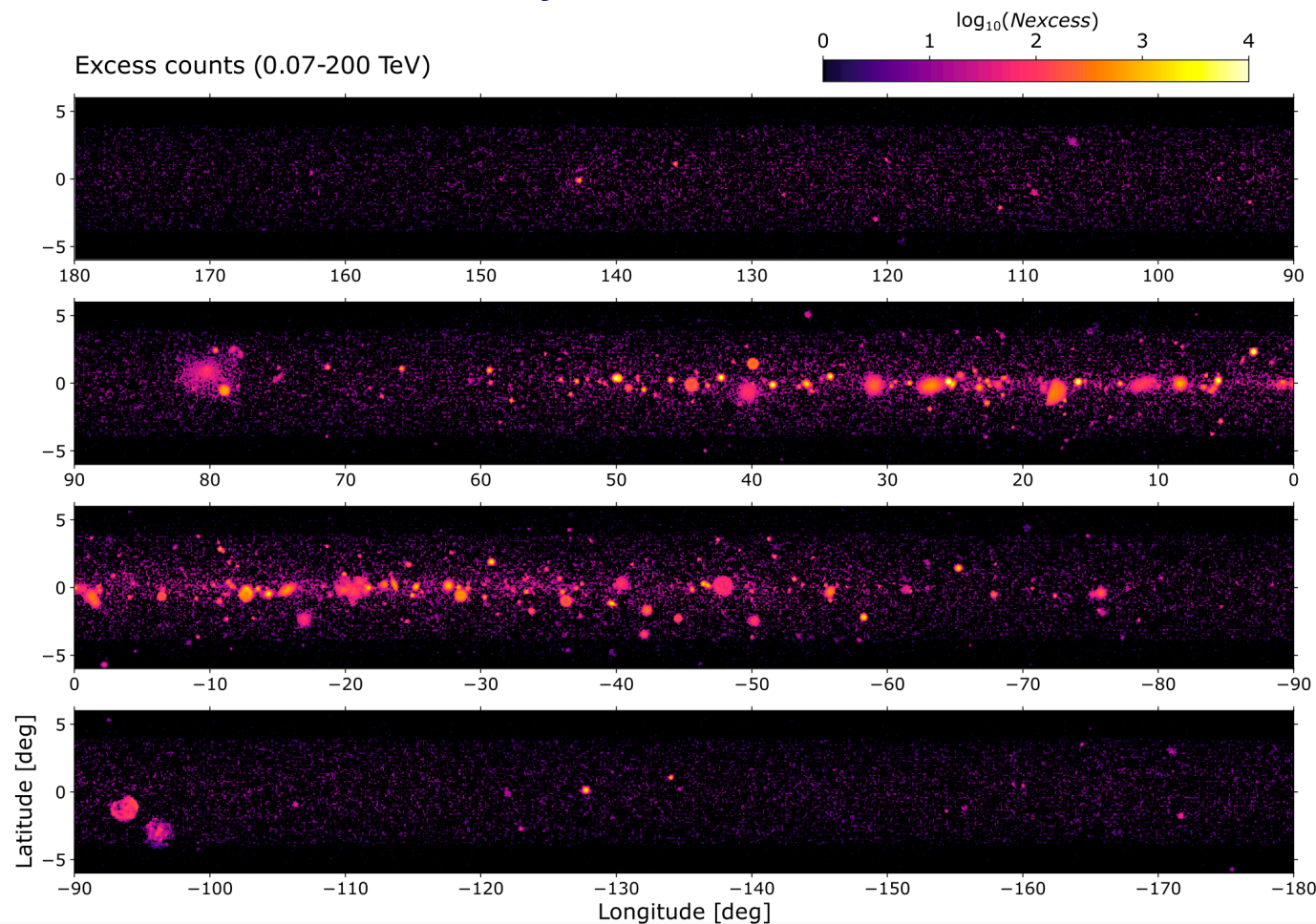
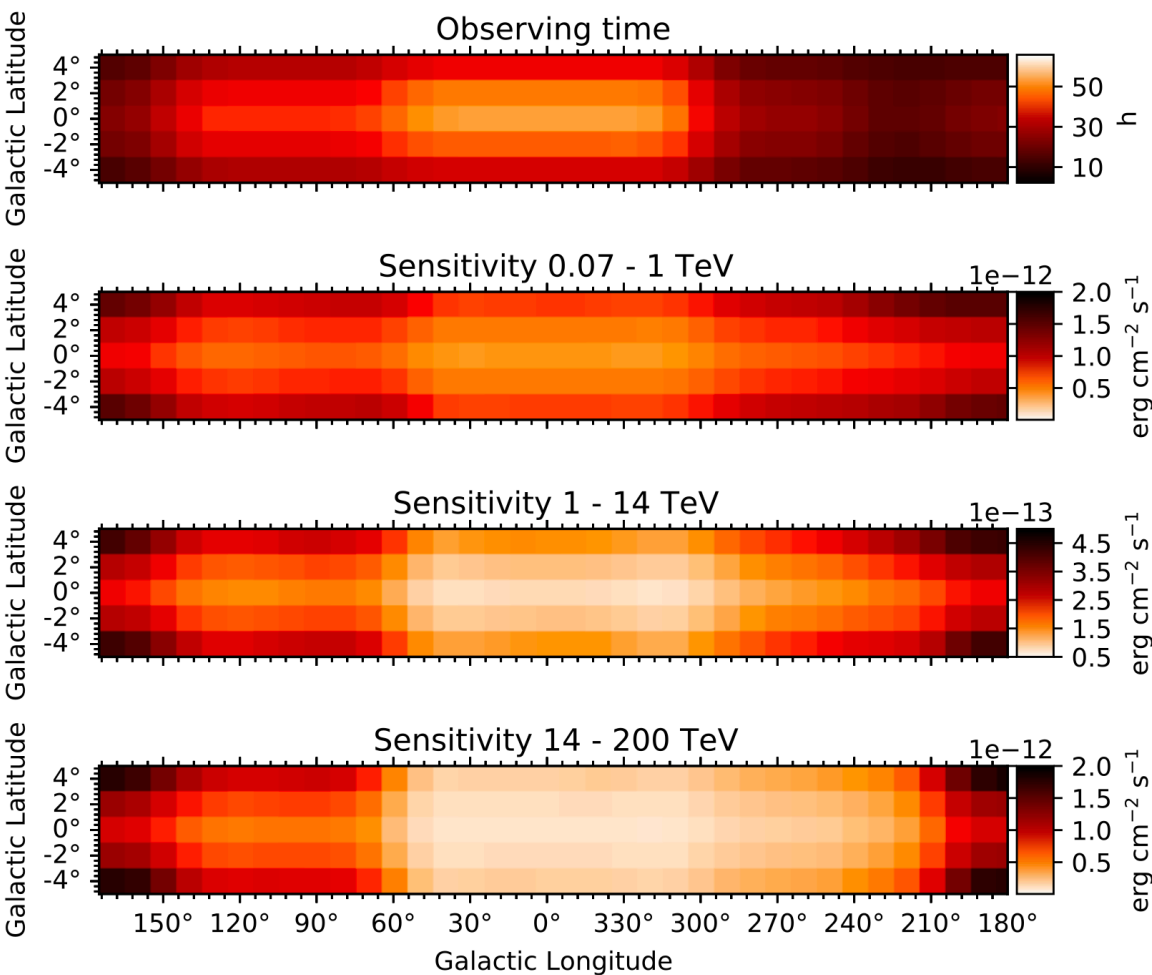
- **Key Science Projects:** multi-purpose observations designed to **efficiently address the science questions of CTAO** (CTA Consortium, 2019)

**First Consortium papers on KSPs already published**  
(Abdalla et al. 2021, Acharyya et al. 2023, Acero et al. 2023, Abe et al. 2024)

# Galactic Science

# Survey of the Galactic Plane

- Total of 1620 hours spread over ten years
- Potential to increase the number of Galactic VHE emitters by a  $\sim$  factor of five

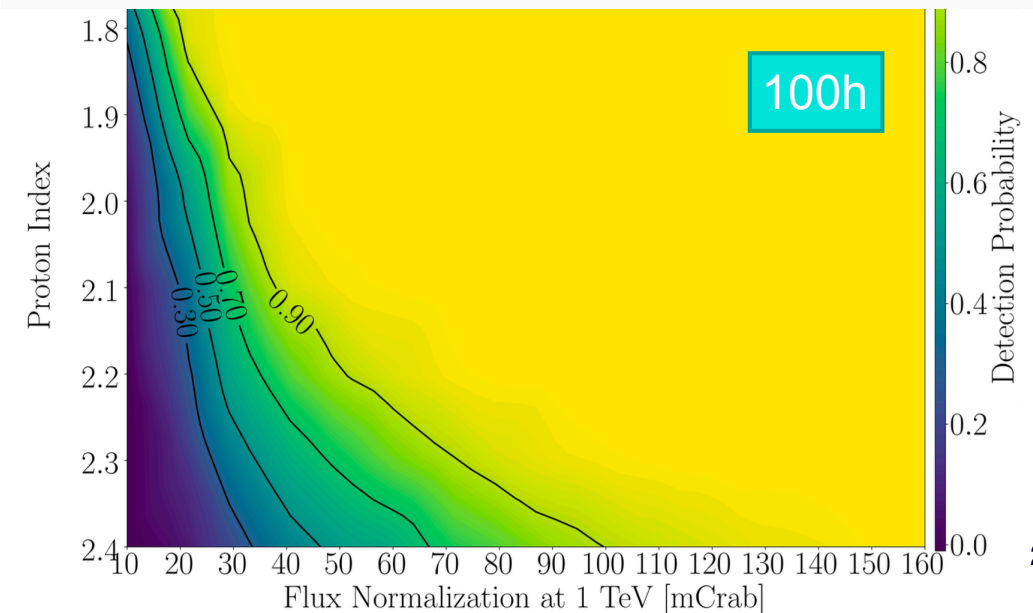
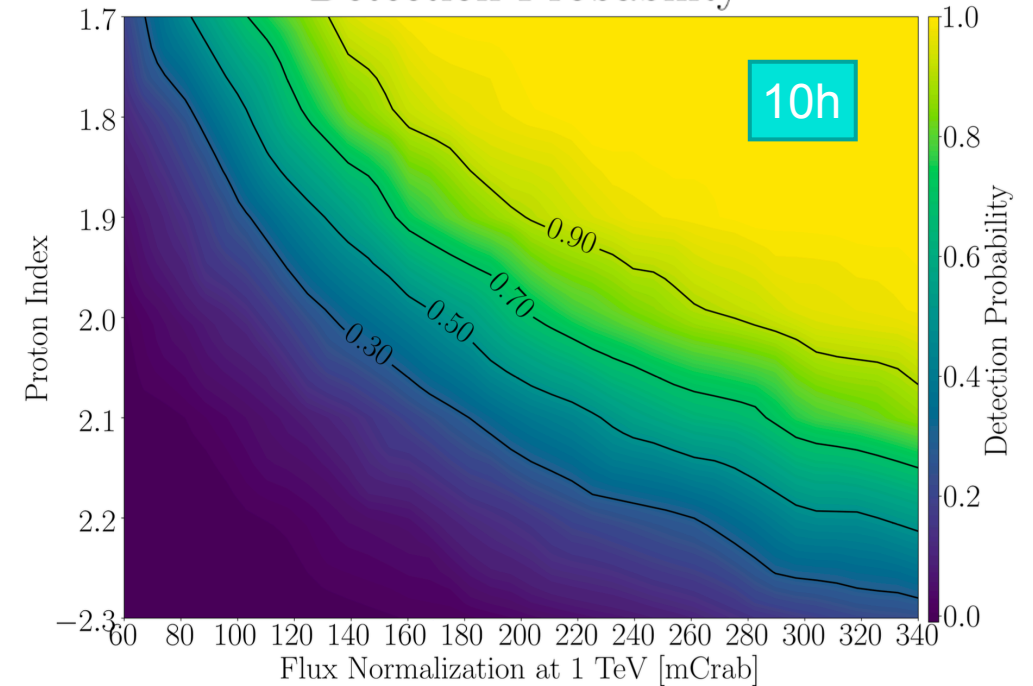




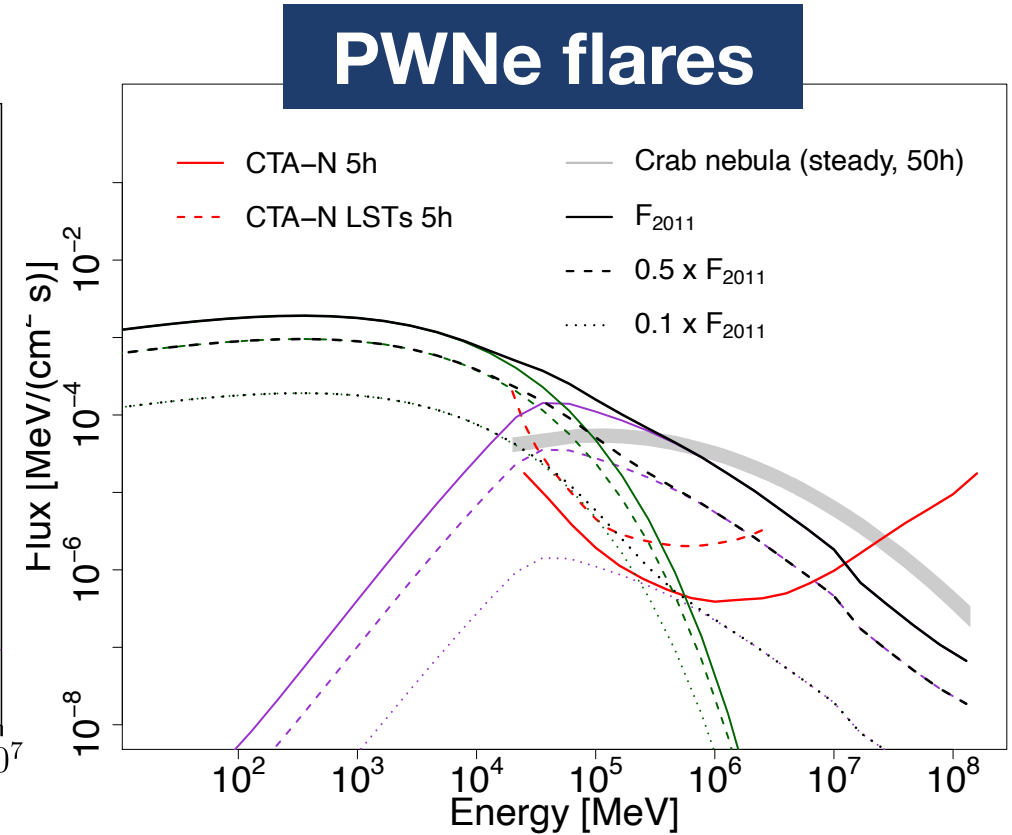
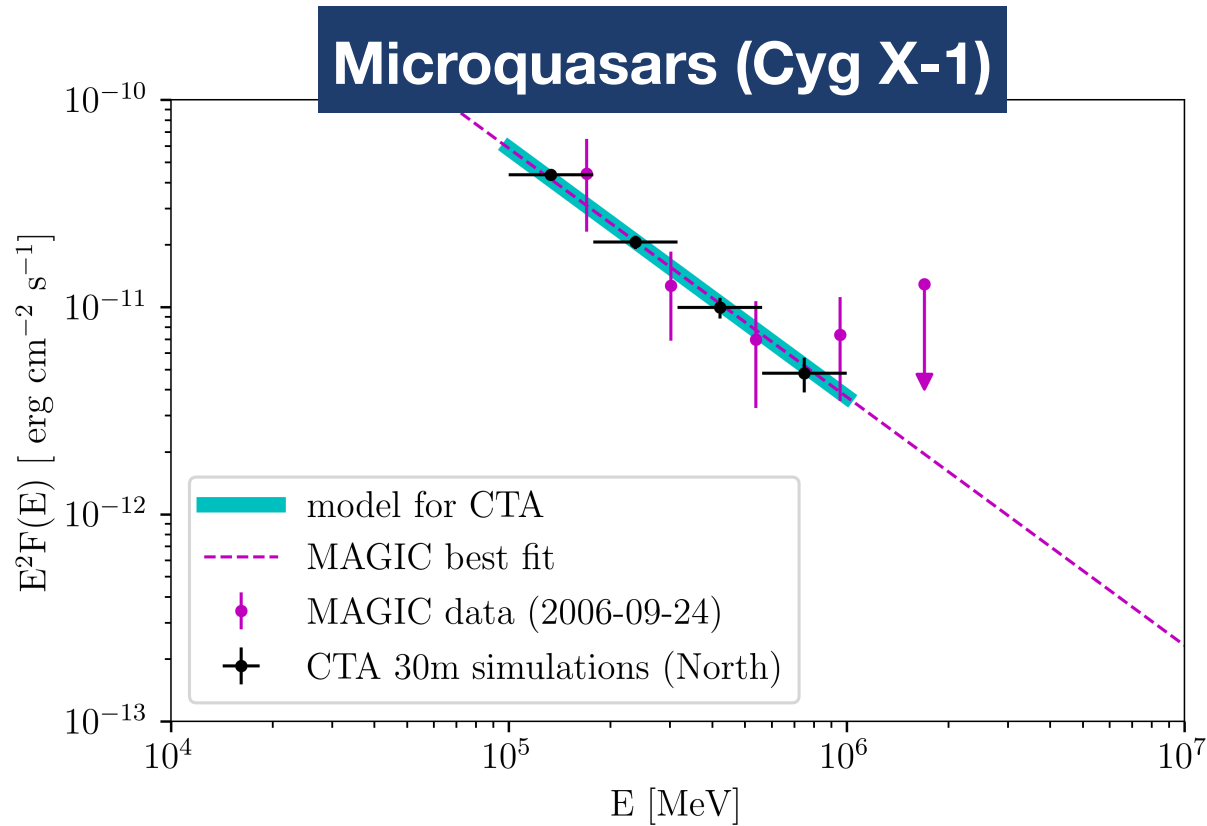
# PeVatrons

- Can CTAO identify hadronic PeVatrons?
  - **GPS: limited spectral sensitivity** to search for PeVatrons in scanning mode (~10h)
    - Detection if they have **hard proton spectra and are point like**
  - **Deep observations  $O(100)h$**  in the case of soft sources ( $\Gamma_p \gtrsim 2.3$ )
    - Could be done with SSTs during moontime with x2 time

$E_{c,proton} = 3 \text{ PeV}$   
Detection Probability



# Galactic transients



- Detection of transient emission from i.e.:
  - Microquasars
  - Crab Nebula (flares)
  - Novae

CTAO Consortium (subm) arXiv:2405.04469

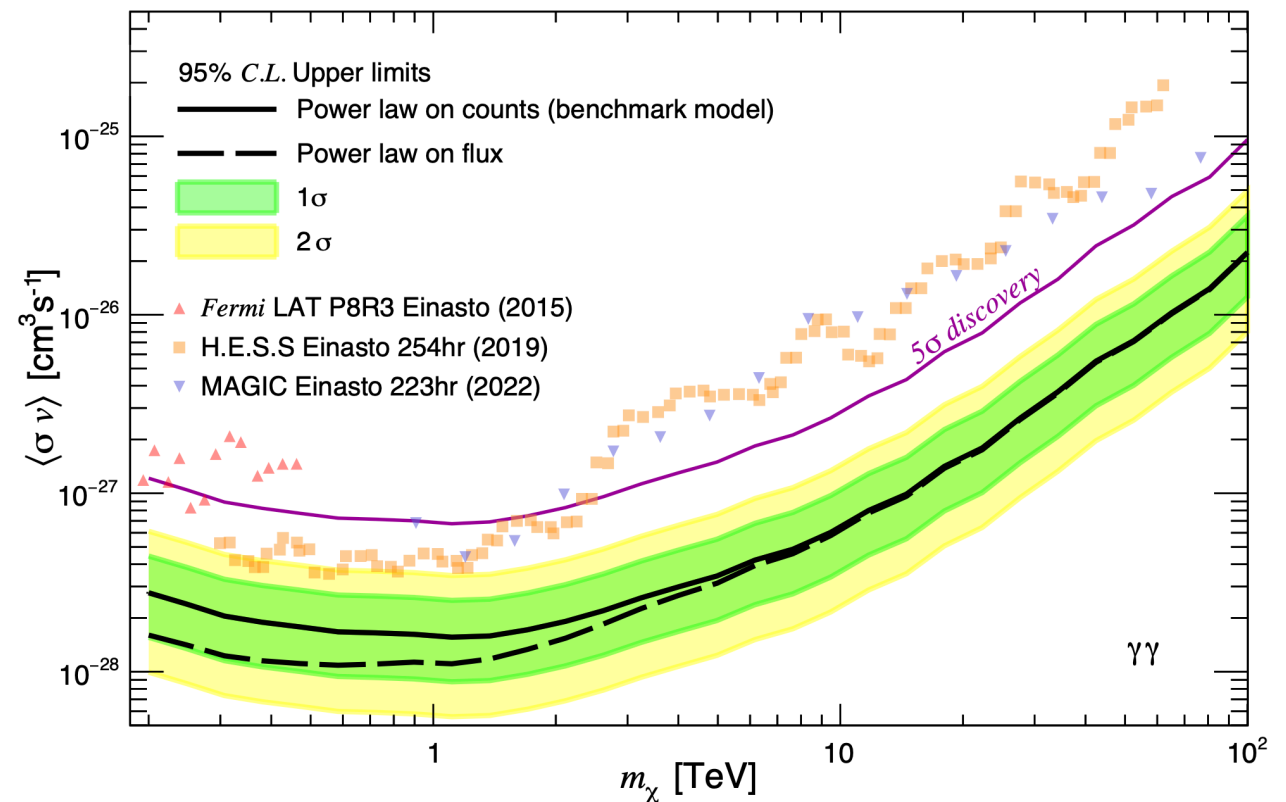
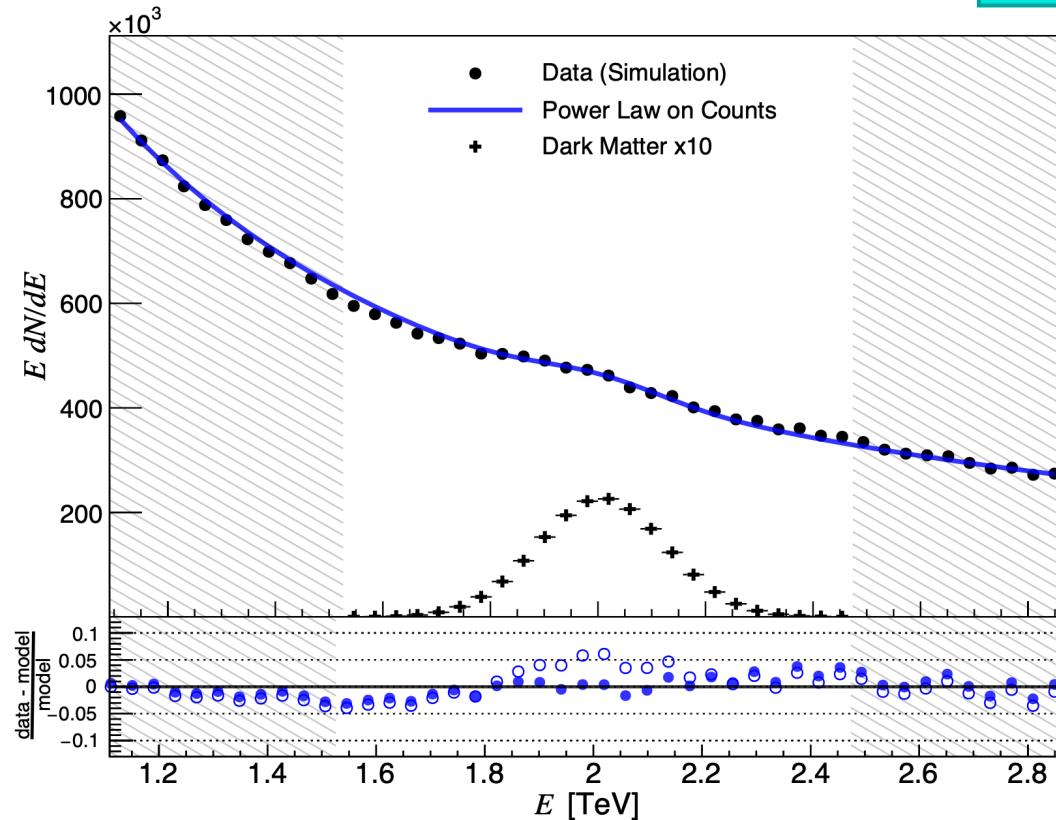
# Dark Matter

# DM line searches

- Gamma-ray signals -> annihilating or decaying dark matter
- Galactic centre (500h) and dwarf spheroidal galaxies (600h)

## Galactic Centre

CTAO Consortium (2024)




# Perseus Galaxy Cluster


- Goal: Detect diffuse emission



**Dark Matter  $\gamma$ -ray searches in Galaxy Clusters: status and prospects**



Co-funded by the European Union



Judit Pérez Romero  
[judit.perez@unq.si](mailto:judit.perez@unq.si)



RICAP 2024 – Indirect DM Detection  
26/09/2024

AI generated image combining different algorithms interpreting:  
"Gamma-rays from dark matter"

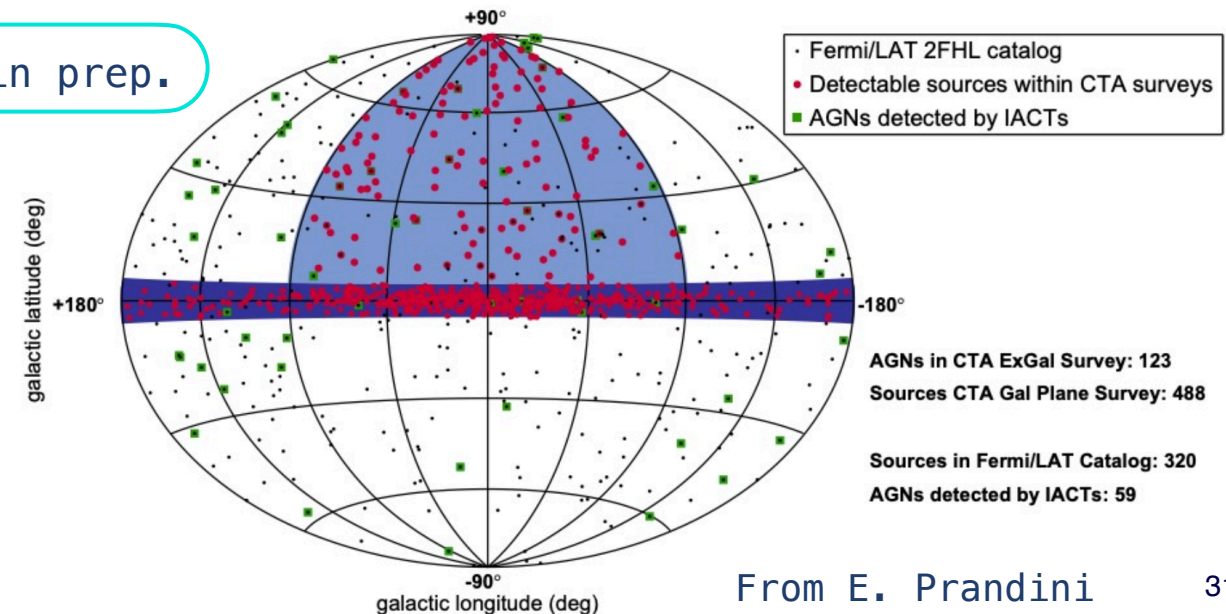
**See talk by J. Pérez-Romero**

CTAO Consortium (accepted in JCAP), 2309.03712

# Extragalactic Science

# Active Galactic Nuclei (AGNs) (+ Cosmology/Fundamental Physics)

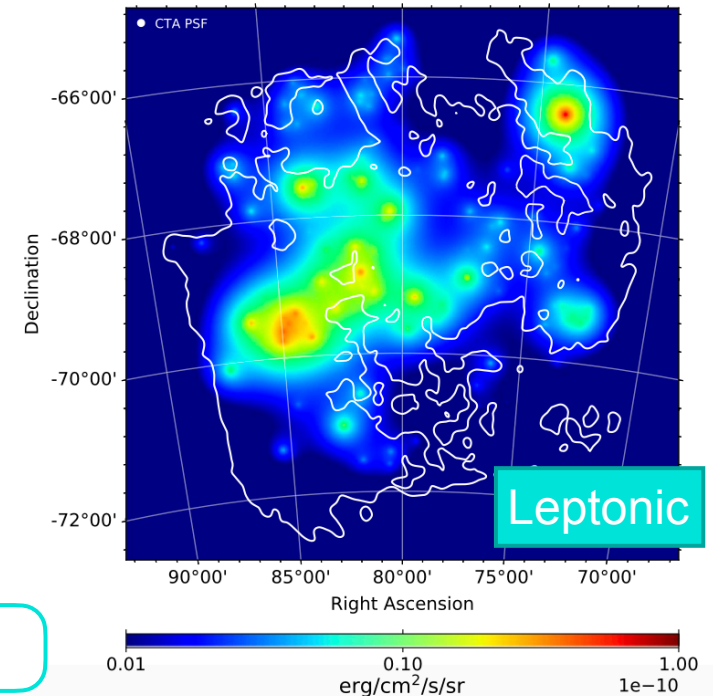
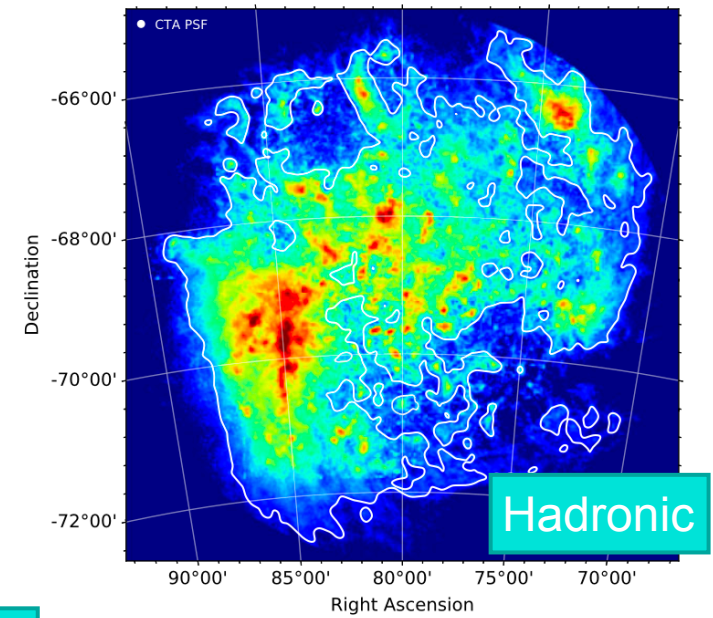
- **AGN population:** of gamma-ray emitting, jetted AGNs CTAO Consortium in prep.
- **Variability:** potential to discriminate between different scenarios CTAO Consortium in prep.
- **Gamma-ray propagation:** EBL, IGMF, ALPs, and LIV constraints CTAO Consortium (2021)
- **Redshift determination:** goal is to measure the redshift of blazars taking advantage of large and small worldwide facilities (Non-consortium papers)
- **EGAL survey:** 1000h , 2y CTAO Consortium in prep.
  - Including key targets:
    - Virgo and Coma clusters
    - CenA
    - Fermi bubbles



# Large Magellanic Cloud Survey

- 340 h survey
- Including prospects for the detectability of:
  - young remnant SN 1987A
  - star-forming region 30 Doradus
  - Known point sources
- Potential detection of extra half dozen sources (PWNe, SNRs)
- DM annihilation

1 TeV



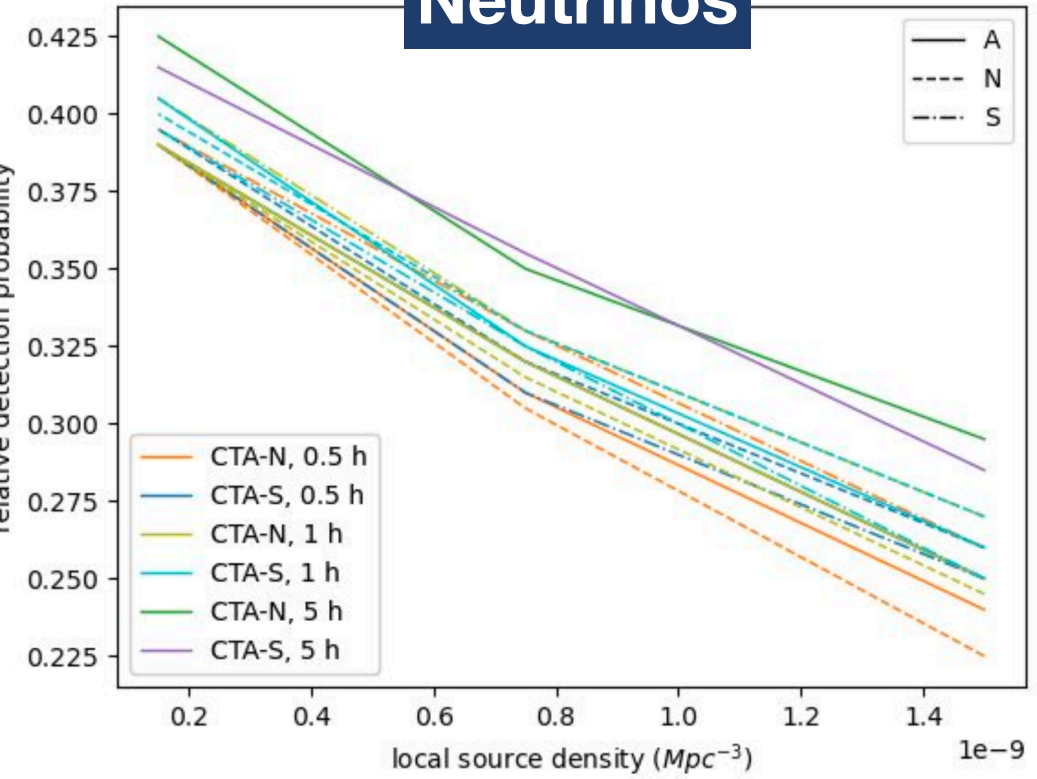
CTAO Consortium (2023)



# Transient & Multi-messenger: GRBs, neutrinos and gravitational waves

CPs in prep

## Neutrinos



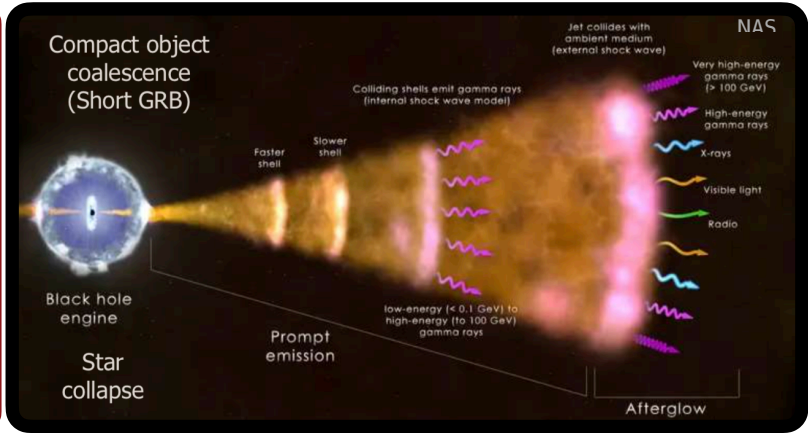
## GRBs

**Population**

Monte Carlo  
Calibrated on Fermi-  
GBM & Swift data

1000 GRB – 44 yr

Swift bright GRBs,  
 $P(15-150 \text{ keV}) > 2.6 \gamma$   
 $\text{cm}^{-2} \text{ s}^{-1}$



**Detection Analysis**

SoHAPPY with

A Python package for gamma-ray astronomy

Th. Stolarczyk

## GWs

See talk by A. Stamerra

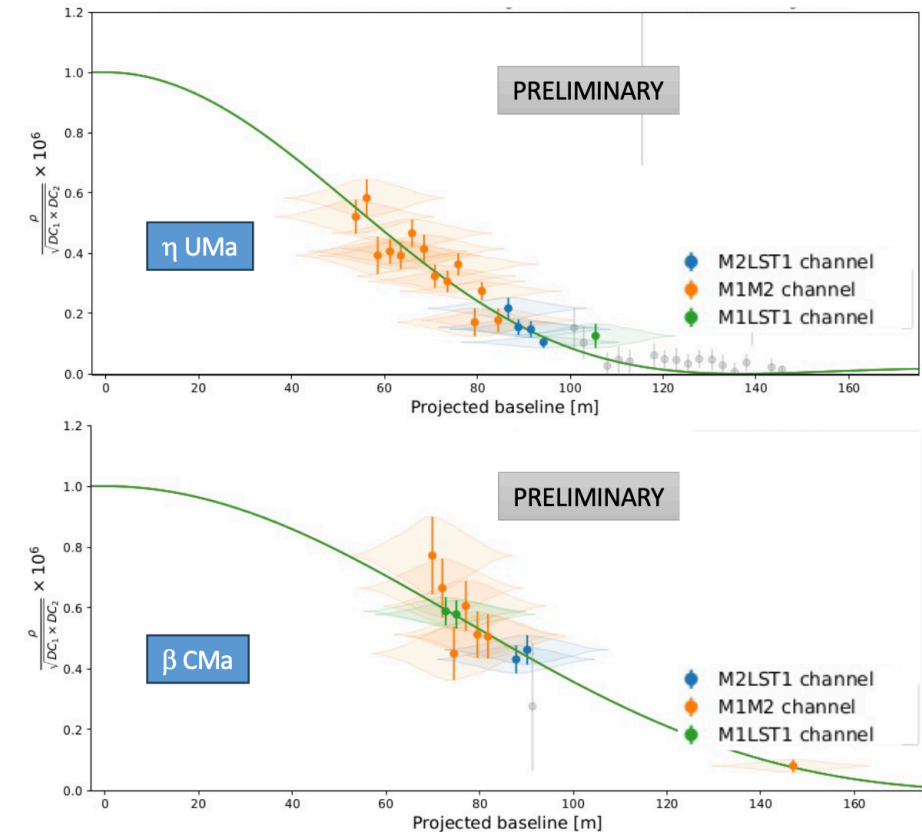
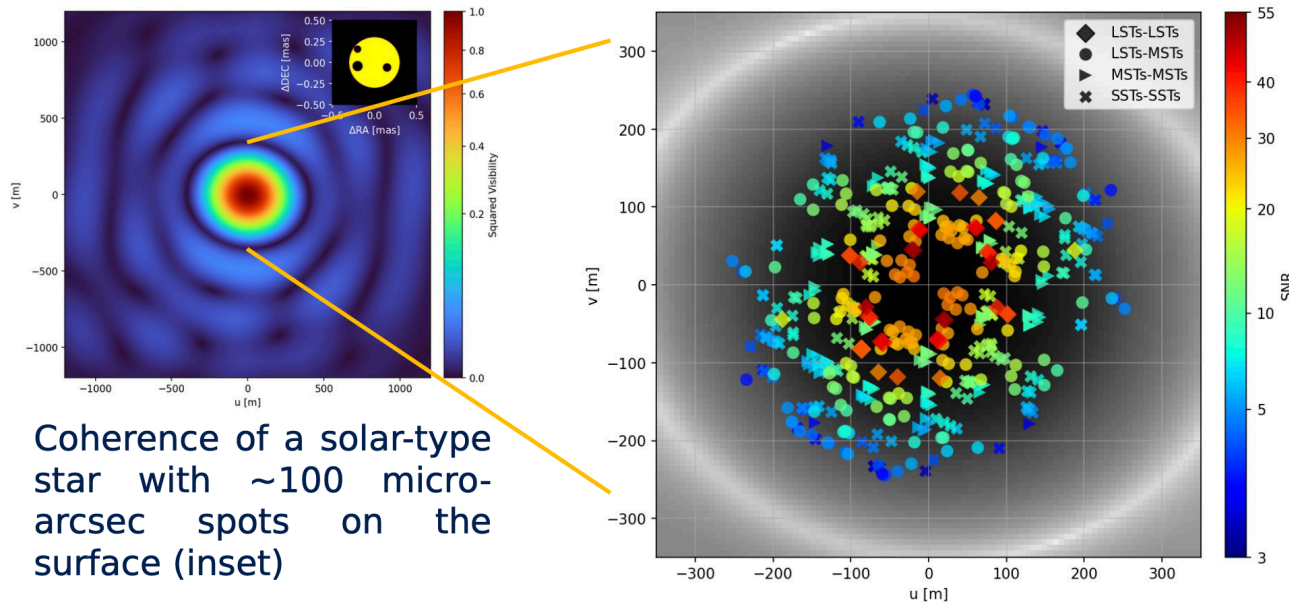
0. Sergijenko et al. 2024

# Bonus: Intensity Interferometry

# Stellar II

White paper in prep.

- Not a KSP but high interest in the community
- submas measurements of star's diameters
- Novae, fast rotators, binaries...



J. Cortina, CTA0 Symposium

# Take-home message

- **CTAO is happening!**
  - The first VHE observatory
  - Improved sensitivity, short-time sensitivity for transient detection
  - LST1 producing good science, LST2-LST4 coming soon
- Open a **new era in VHE astrophysics**
  - New research lines
  - Rich Science Program and wealth of new discoveries
  - Multi-wavelength and multi-messenger synergies



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On behalf of the CTAO Consortium



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la Unión Europea  
NextGenerationEU



Plan de Recuperación,  
Transformación  
y Resiliencia



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