



cherenkov  
telescope  
array

# The CTA Observatory Construction Project – Status and Upcoming Industrial Opportunities

Big Science Business Forum 2022  
Session A2, Affiliated Big Science Organizations

**WOLFGANG WILD**  
Project Manager, CTAO GmbH





# What is CTA ?

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- CTA, the Cherenkov Telescope Array, is the next generation ground-based observatory for gamma-ray astronomy at very high energies
- It will initially have 65 telescopes at two sites, in the North and South
  - Much larger and more sensitive than existing instruments
- It is designed and built in a large international collaboration
- It will be the first open gamma-ray observatory
  - Previous and existing instruments are run as experiments
- Cherenkov radiation is electromagnetic radiation emitted when a charged particle passes through a dielectric medium at a speed greater than the phase velocity of light in that medium
  - Discovered 1934 by Pavel Cherenkov (1904-1990) – Nobel price winner

# The CTA Observatory (CTAO)

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- The CTA Observatory is the legal entity for construction and operation of the Cherenkov Telescope Array
- An interim legal entity for preparation of CTA construction was set up in Heidelberg (Germany)
- The final legal entity for construction and operation, a ***European Research Infrastructure Consortium (ERIC)***, is being set up under European Union law, in Italy
- The CTA Project Office and future Headquarters are located in Bologna (Italy), hosted by INAF
- The *Science Data Management Centre (SDMC)* will be located in Berlin-Zeuthen (Germany), hosted by DESY in a new building



# CTA Sites: Arrays, Headquarter, Data Center

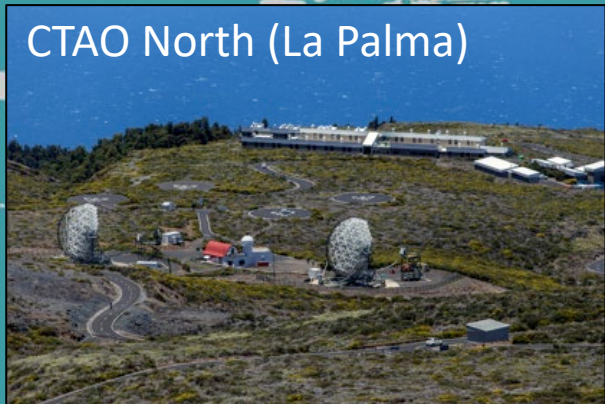


● Array Sites

● CTAO Offices

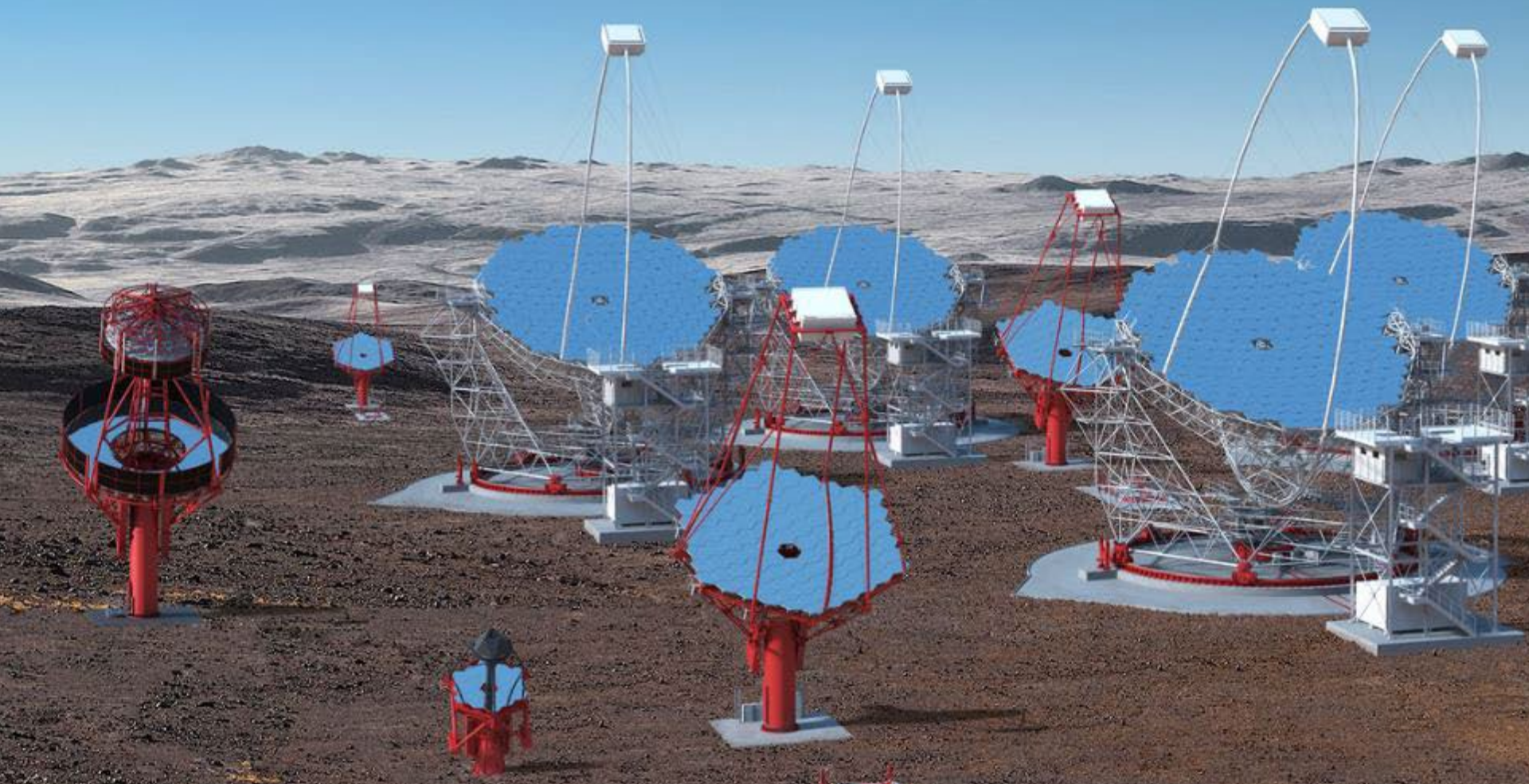
● Science Data Management Centre

# CTA Sites: Arrays, Headquarter, Data Center

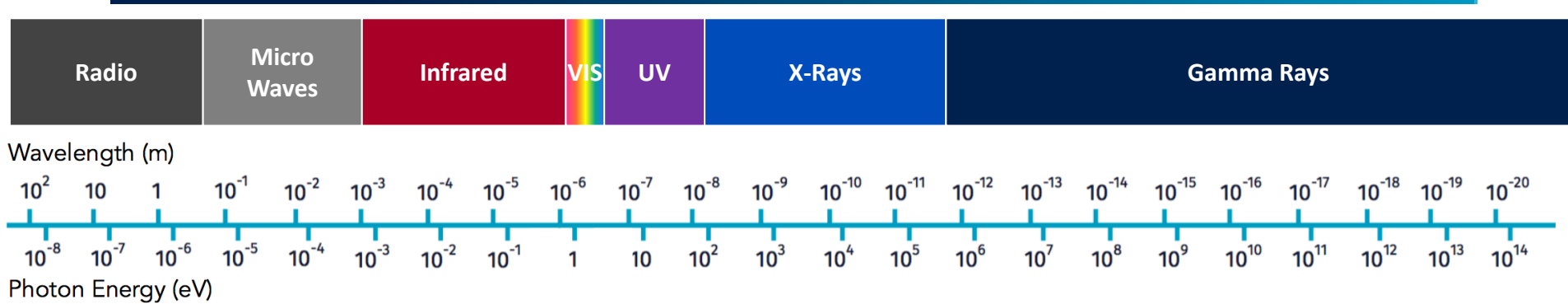


- Array Sites
- CTAO Offices
- Science Data Management Centre

# Why Gamma Rays?



# Waveband Coverage: a New Window



SKA

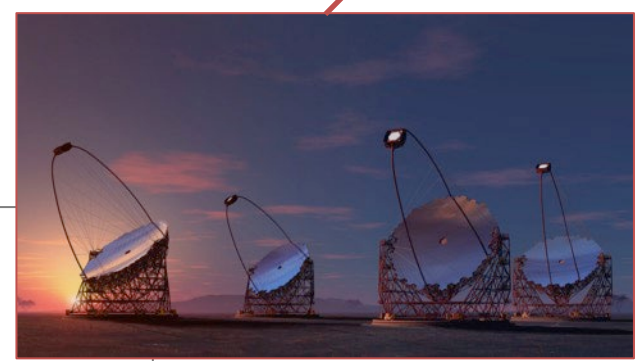
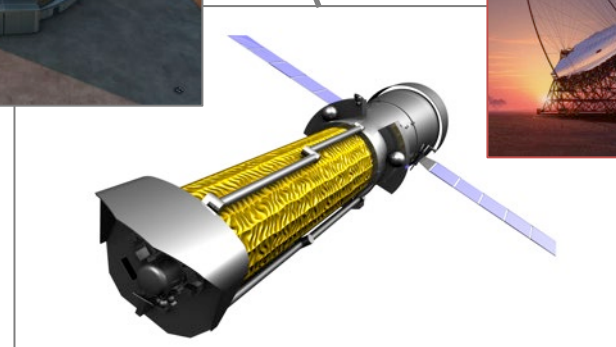
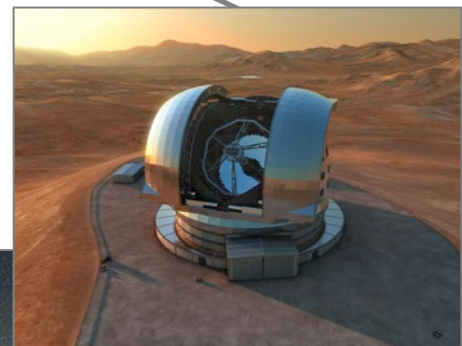
ALMA

ELTs

Athena

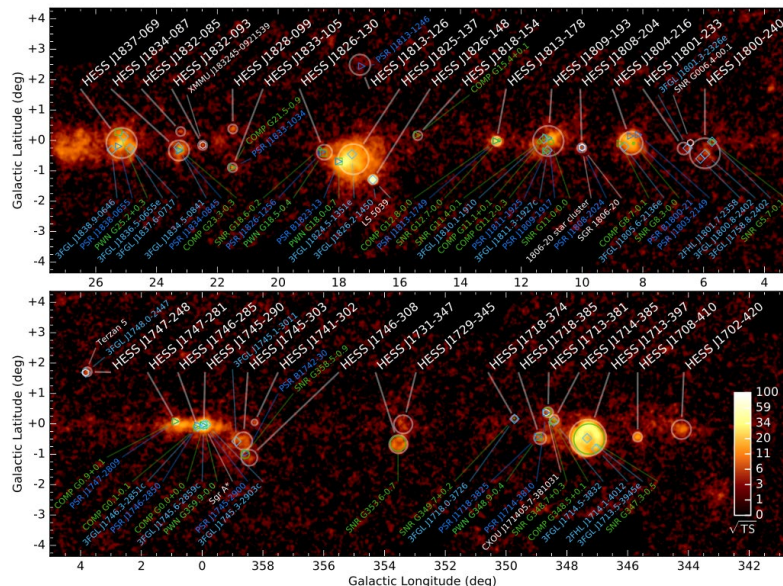
Major Astronomical Facilities

CTA



# Why gamma rays: a different sky

- Observation of gamma rays give access to the most energetic phenomena in the Universe
- Gamma ray astronomy is a young field with tremendous discovery potential
  - First astronomical gamma array detection in 1967 by a satellite
  - First ground-based gamma ray observations in early 1970s



H.E.S.S. Coll.  
A&A. Vol 612 (2018)

Shown here:  
central 40° of Galaxy





Optical

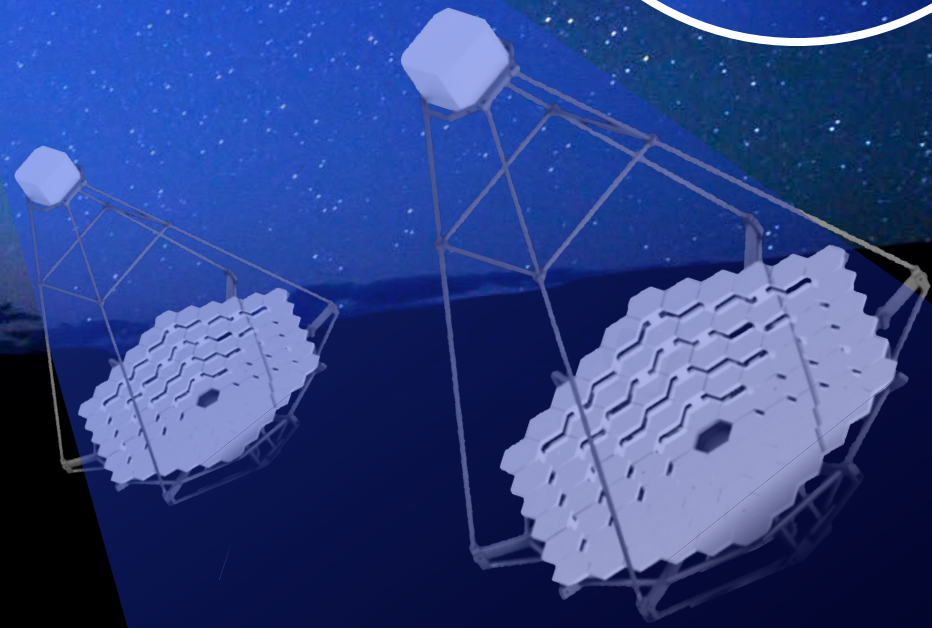


Optical  
+ Gamma rays



$\gamma$ -ray enters the atmosphere

Electromagnetic cascade



0.1 km<sup>2</sup> "light pool", a few photons per m<sup>2</sup>.

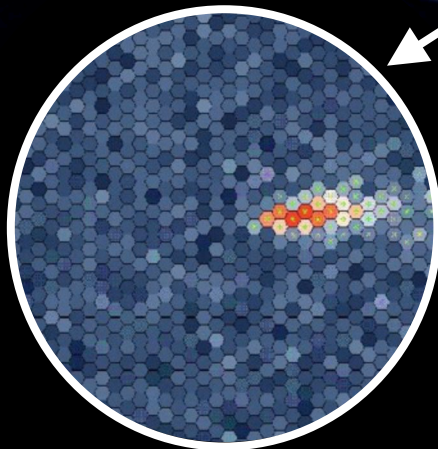
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Electromagnetic cascade

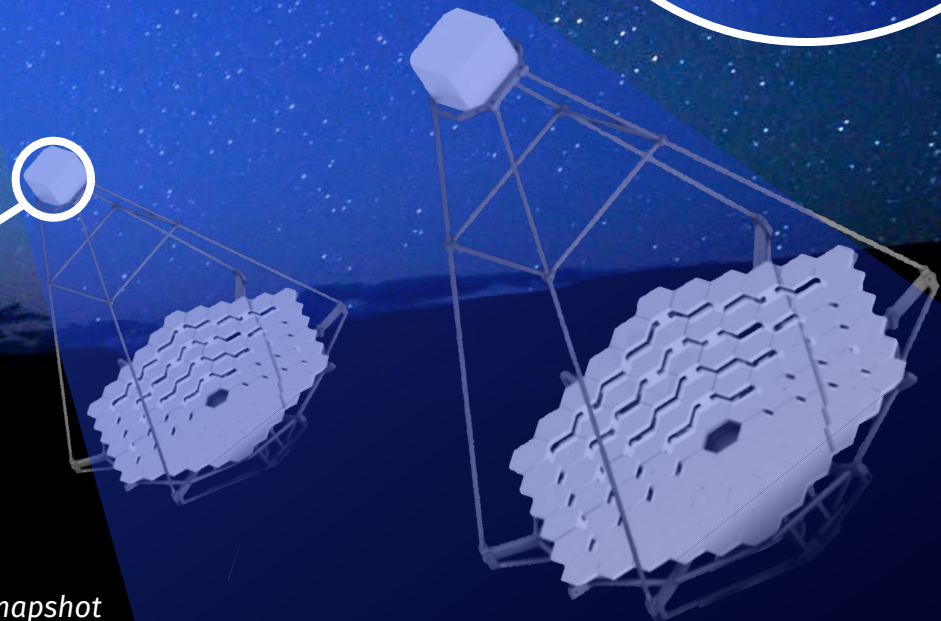


**CTA observational technique:**

- Detection of 10 nanosec flashes of blue light caused by the impact of gamma arrays in the upper earth atmosphere
- The "light pool" is detected simultaneously by the telescopes
- Trigger coincidence techniques separate the relevant events from background noise



10 nanosecond snapshot



0.1 km<sup>2</sup> "light pool", a few photons per m<sup>2</sup>.

# CTA Science Themes

## Theme 1: Cosmic Particle Acceleration

- How and where are particles accelerated?
- How do they propagate?
- What is their impact on the environment?



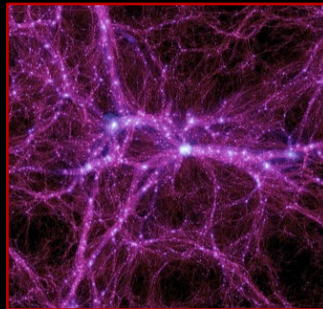
## Theme 2: Extreme Environments

- Close to neutron stars and black holes
- Relativistic jets, winds and explosions
- Cosmic voids



## Theme 3: Physics Frontiers

- What is the nature of Dark Matter?
- Is the speed of light constant?
- Do axion-like particles exist?



Sep 2017, 213 page volume, available at

<https://arxiv.org/abs/1709.07997>

and the CTAO web site

# CTA Technologies – One Page Summary



Imaging of very faint nano-second long blue light (Cherenkov) flashes requires:

- Three sizes of telescopes to cover the CTA energy range (0.02 to 300 TeV)
  - Large-Sized (23m, *LST*), Medium-Sized (12m, *MST*) and Small-Sized (4m, *SST*) Telescopes
- Very sensitive cameras with many pixels ( $\sim 10^3$ ), using photomultiplier tubes (PMTs) or silicon photomultipliers (SiPMs)
- Accurate (nano-second) timing & clock over the whole array
- Challenging calibration techniques and algorithms
  - Earth atmosphere is part of the detector!
- Substantial software development, “Big Data”
  - Expect 3.7 PB (reduced) raw data volume and  $\sim 4$  PB of data products per year

# CTAO-South Site, ESO (Chile)

## CTAO-South in the Atacama desert


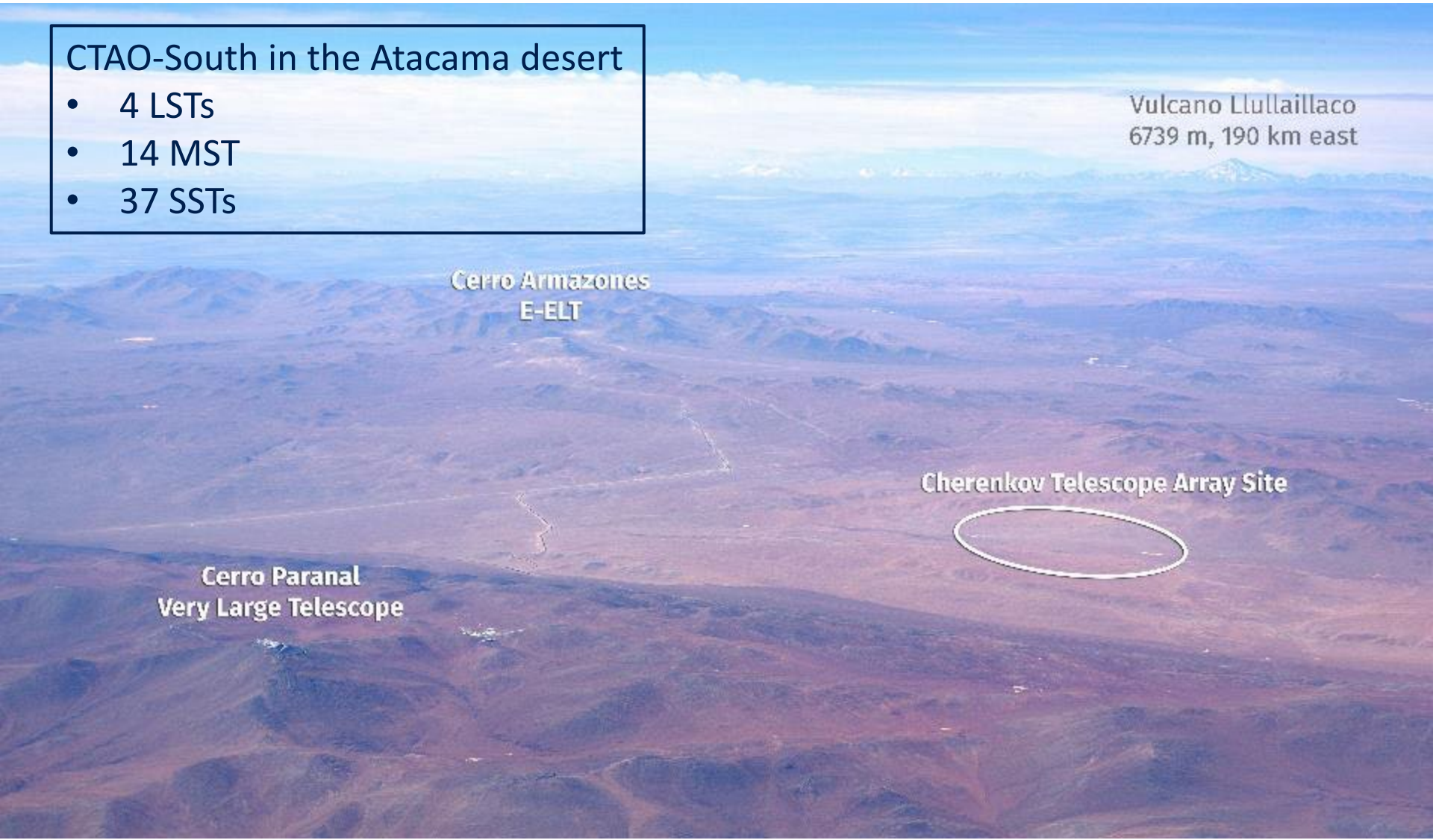
- 4 LSTs
- 14 MST
- 37 SSTs

Vulcano Lullillaco  
6739 m, 190 km east

Cerro Armazones  
E-ELT

Cerro Paranal  
Very Large Telescope

Cherenkov Telescope Array Site

A white oval outline on the desert floor, indicating the proposed site for the Cherenkov Telescope Array.





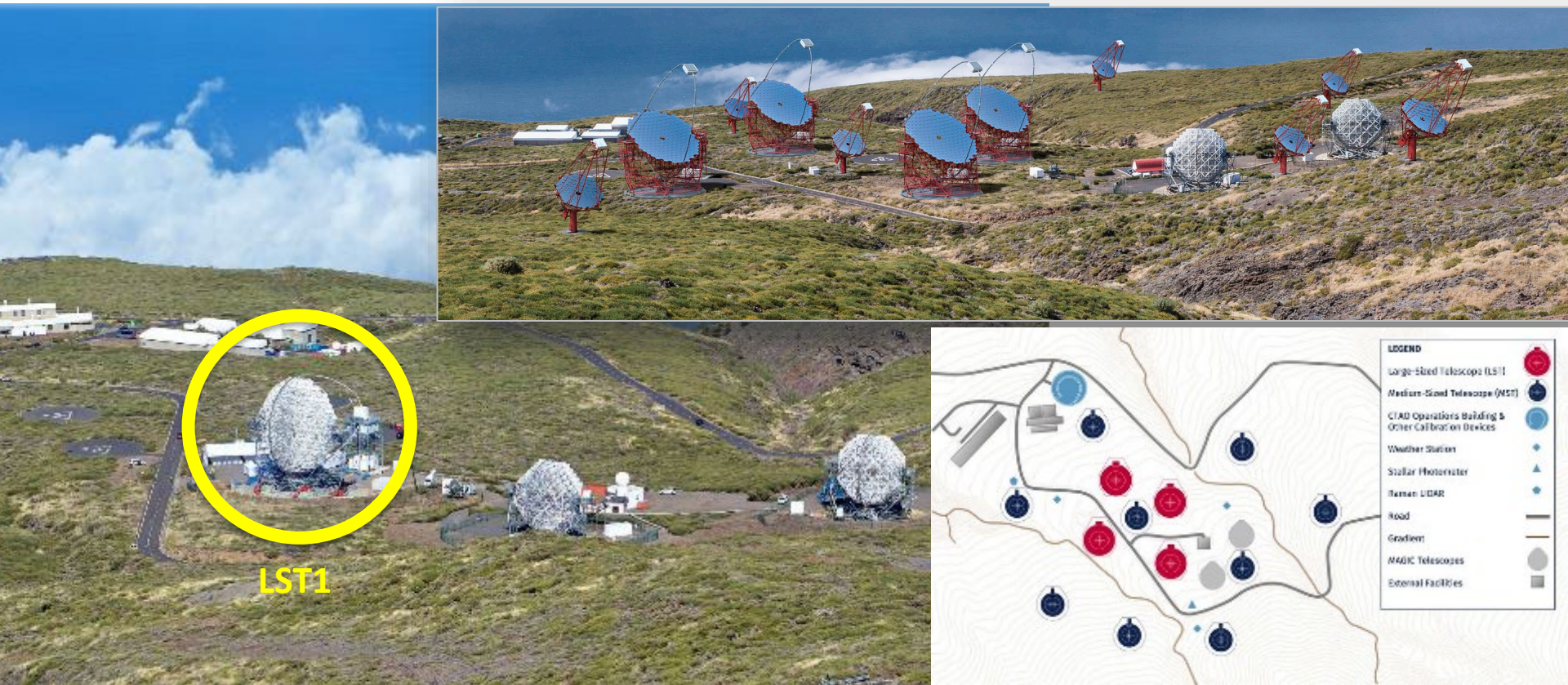
# CTAO-South Site, Atacama Desert (Chile)



# CTAO-North Site (IAC, La Palma, Spain)



- Observatorio Roque de los Muchachos, IAC, Canary Islands (Spain)
  - In total 4 LSTs and 9 MSTs
  - First LST in commissioning
  - Further 3 LSTs in production, infrastructure construction to start soon



# Prototype Large-Sized Telescope (LST-1)

- 23m LST prototype built and being commissioned on La Palma (Spain)
- By a collaboration of 30+ institutes in 11 countries
- No damage to telescope after 78-day volcano outbreak on La Palma
- Three more LSTs to be built in the coming years



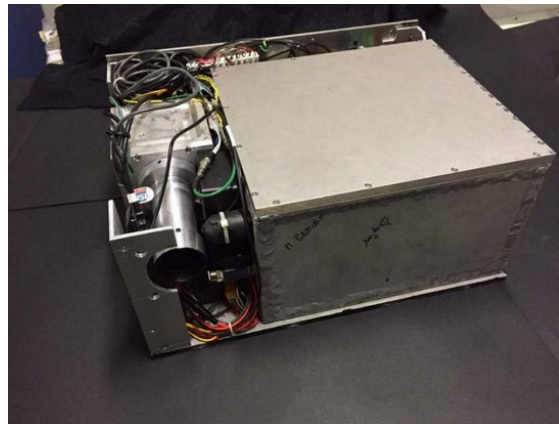
# LST-2 to 4 Production (I)

- Progress in tenders and procurement
  - Structure and mechanism in various stages of production, various parts already shipped to La Palma, production distributed (IAC, LAPP, MPP, INFN.....)
  - CFRP arch tubes and cables in production



# LST-2 to 4 Production (II)

- Mirrors and cameras progressing well
  - 600+ mirrors and AMC boxes (Japan) in La Palma
  - 1200+ AMC actuators (MPP) in production (completed in 2023)
  - Camera mechanics (IAC) finished for LST2, LST3 and in production for LST4
  - Camera integration done by industry
  - Calibration Boxes plus spare (INFN) before 2023
  - 3 Embedded Controller ECCs (LAPP) ready





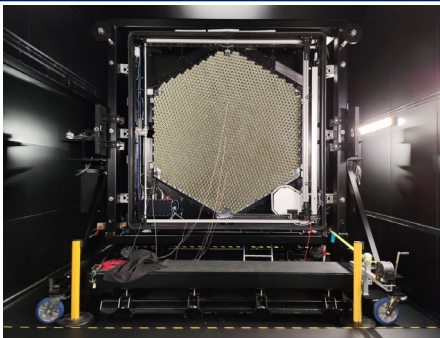
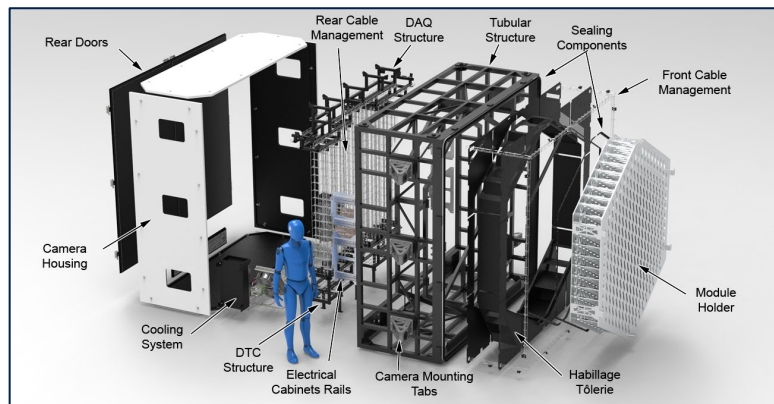
# LSTs for CTAO-South

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- The Italian institutes INAF & INFN were granted about 70 M€ for a/o enhancing CTAO- South with LSTs, more SSTs and calibration equipment
  - Funded by the Italian Italian National Recovery and Resilience Plan (PNRR)
- Formal project kick-off on 1 Jan 2023
  - After which the industrial procurement phase will start
- Challenging timeline imposed by PNRR rules
  - Industrial activities to be completed by the end of 2025
- Procurements will be carried out according to European Rules but also aiming to preserve the know-how developed by INAF, INFN and other international groups involved in CTAO telescope development
- Contact persons/Principal Investigators
  - LST-South: Angelo Antonelli (INAF)
  - SST: Gianpiero Tagliaferri (INAF)
  - General: Giovanni Pareschi (INAF)

# Medium-Sized Telescope (MST)

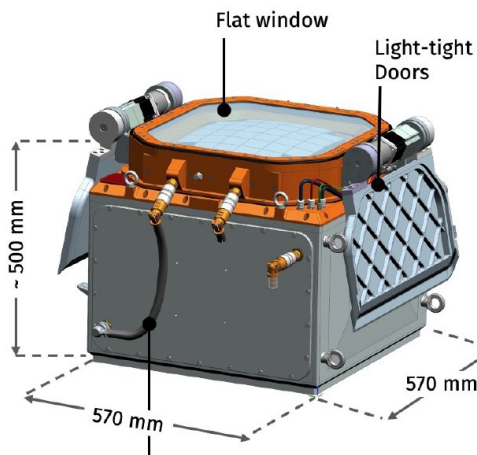
- 14m prototype MST has been built and tested in Berlin (Germany)
  - Telescope structure from DESY (Germany)
  - Cameras from MPIK (Germany) and CEA (France)
- Now ramping up for series production for the North and South sites





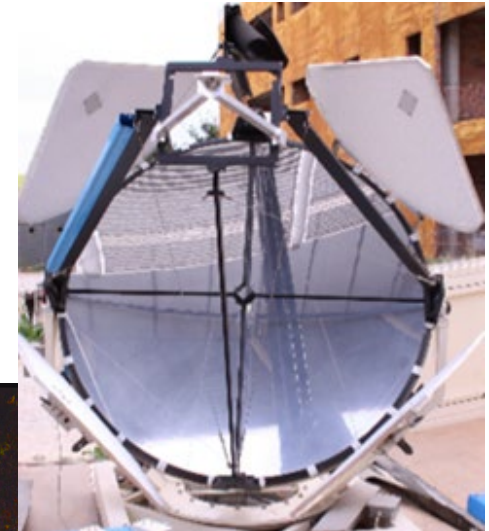
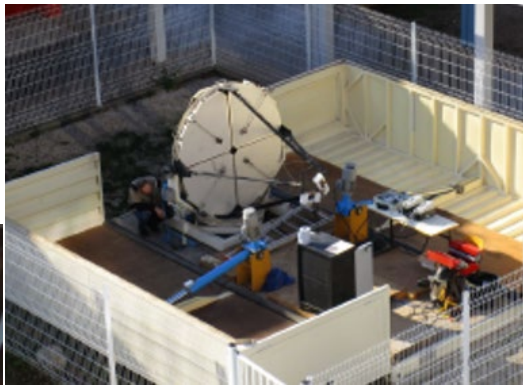
# Small-Sized Telescope (SST)

- 4m dual-mirror prototype built and tested at Mt. Etna, Sicily
- Precursor SSTs being built in Tenerife (ASTRI mini-array of 9 telescopes)
- 40+ SSTs to be built at CTAO-South in Chile
  - SST design for Chile to be finalized
  - Telescope structures to be tendered by INAF (Italy)
  - Cameras from consortium led by MPIK (Germany)



# CTA Calibration and Monitoring

- The CTA Observatory will install calibration and weather monitoring equipment at both array sites
- This includes LIDARs, All-Sky cameras, illuminators and weather towers
  - Some custom-made by scientific institutes, some industry-made





# CTAO & In-kind Contributions

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- Most of the CTA Observatory will be built with *in-kind contributions* (IKC) from participating scientific institutions in 10+ countries
  - Most of the industrial procurement done by these institutions
  - Various prototypes of telescopes and cameras have been built
- The CTAO is the central entity for construction & operation
  - Develops the system concept and subsystem requirements
  - Receives sub-systems & CTAO-North infrastructure as in-kind contributions
  - Procures / builds the CTAO-South infrastructure
  - Integrates sub-systems into the overall observatory system
  - Manages the software development
  - Will operate the observatory



# Major CTAO Partners

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Significant hard- and software in-kind contributions are planned from the major CTA Observatory partners, including the following:

- **Italy** – INAF, INFN
- **Germany** – DESY, MPIK (Heidelberg), MPP (Munich)
- **France** – CNRS, CEA, OBSPM
- **Spain** – IAC, CIEMAT, IFAE, PIC, ICE/CSIC, UAB
- **Japan** – University of Tokyo
- **Switzerland** – University of Geneva
- **Czech Republic** – Institute of Physics of the Academy of Sciences
- **Slovenia** – University of Nova Gorica
- **UK** – UKRI
- **Austria** – Leopold Franzens Universität
- **The Netherlands** – NWO

# Major Technology Expertise/distribution (*non exhaustive...*)

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- Mirror technologies
  - France
  - Italy
  - Poland
  - Czech Republic
- Telescope structures
  - Italy
  - Germany
  - France
  - Poland
- Cherenkov cameras
  - France
  - Spain
  - Japan
  - Germany
  - Italy
  - UK
  - Netherlands
- Control systems
  - France
  - Italy
  - Germany
  - Slovenia
- Calibration technologies
  - Czech Republic
  - Slovenia
  - Germany
  - Italy
  - Spain
  - France
- Electronics
  - Various countries



# Procurement Key Points

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- No central CTA procurement scheme
  - Infrastructure South procured by CTAO, mostly via ESO (*it includes power distribution*)
  - Some (smaller) items procured directly by CTAO
- CTA has a high percentage of In-Kind Contributions
  - Procurement money is spent by the IKC institutions
  - Some contracts were / will be awarded to industry, other may involve scientific institutions together with industrial partners
- Public funding
  - All relevant procurements within Europe will have to follow European Tendering rules
- No geographical Fair Return rule
  - Distribution “plays” some role (often dealt with via generation of international consortia)

# Invitation to Tender (CTAO gGmbH)

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- CTAO gGmbH has to comply with EU Directive 2004/18/EC and special German provisions for public procurement, including
  - Principles applied are non-discrimination and equal treatment, competition, transparency, best value-for-money.
  - Based on this legal framework internal procurement procedures are established.
- Contract value of €30.000 - €221.000 > National Call for Tender (German law applies – publication on portal [www.bund.de](http://www.bund.de)).
- Contract value of over €221.000 > European Call for Tenders (EU Procurement Directive n. 24/2014 applies – publication on OJEU/Ted portal).
- For information about procurement at CTAO gGmbH: [ctao-procurement@cta-observatory.org](mailto:ctao-procurement@cta-observatory.org)

# Invitation to Tender (IAC, ESO, IKC)

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- IAC
  - All the information about contracts and tender calls is published at the IAC Contractor's profile available through the Spanish Public Sector Contracting Platform:  
[https://contrataciondelestado.es/wps/portal/!ut/p/b0/04\\_Sj9CPykssy0xPLMnMz0vMAfljU1JTC3Iy87KtClKL0jJznPPzSooSSxLzSIL1w\\_Wj9KMyU5wK9CPT\\_3d2Cc8vNLUvNHw31C3JzHqHrum6M/](https://contrataciondelestado.es/wps/portal/!ut/p/b0/04_Sj9CPykssy0xPLMnMz0vMAfljU1JTC3Iy87KtClKL0jJznPPzSooSSxLzSIL1w_Wj9KMyU5wK9CPT_3d2Cc8vNLUvNHw31C3JzHqHrum6M/)
- ESO
  - In general tendering process largely based on most competitive compliant tender and where possible and carried out within the ESO Member States
  - Information about ESO procurement:  
<https://www.eso.org/public/industry/cp.html>
- In-Kind Contributors
  - Those interested in opportunities with the IKC teams are encouraged to contact the regional industry contacts listed on the CTAO webpage  
<https://www.cta-observatory.org/project/industry/#1535533438154-65d5d2fa-6b2f>



# Announcement

This evening at 18:45 hrs there will be a Round Table (in Spanish) “EL UNIVERSO QUE VEREMOS” at the Instituto de Astrofísica de Andalucía, with representatives from ESO, SKAO and CTAO

**EL UNIVERSO QUE VEREMOS**  
5 DE OCTUBRE | 18:45h  
INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA (IAA-CSIC)  
Entrada libre

STREAMING: [YOUTUBE.COM/IAAUDC](https://www.youtube.com/IAAUDC)

**cta** Chileno Telescope Array

**Wolfgang Wild**  
PROJECT MANAGER DE CTAO

**Immaculada Figueroa**  
MINISTERIO DE CIENCIA E INNOVACIÓN

**IAA** INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA

**Xavier Barcons**  
DIRECTOR GENERAL DEL ESO

**SKAO**

**Philip Diamond**  
DIRECTOR GENERAL DEL SKAO

**MODERA:**  
Isabel Márquez  
DIRECTORA CIENTÍFICA DEL PROYECTO SEVERO OCHOA

**IAA** INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA **CSIC** **cta**

Thank You !

cta OBSERVATORY

