CTAO
Cherenkov Telescope Array Observatory

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Status of the Cherenkov Telescope Array Observatory

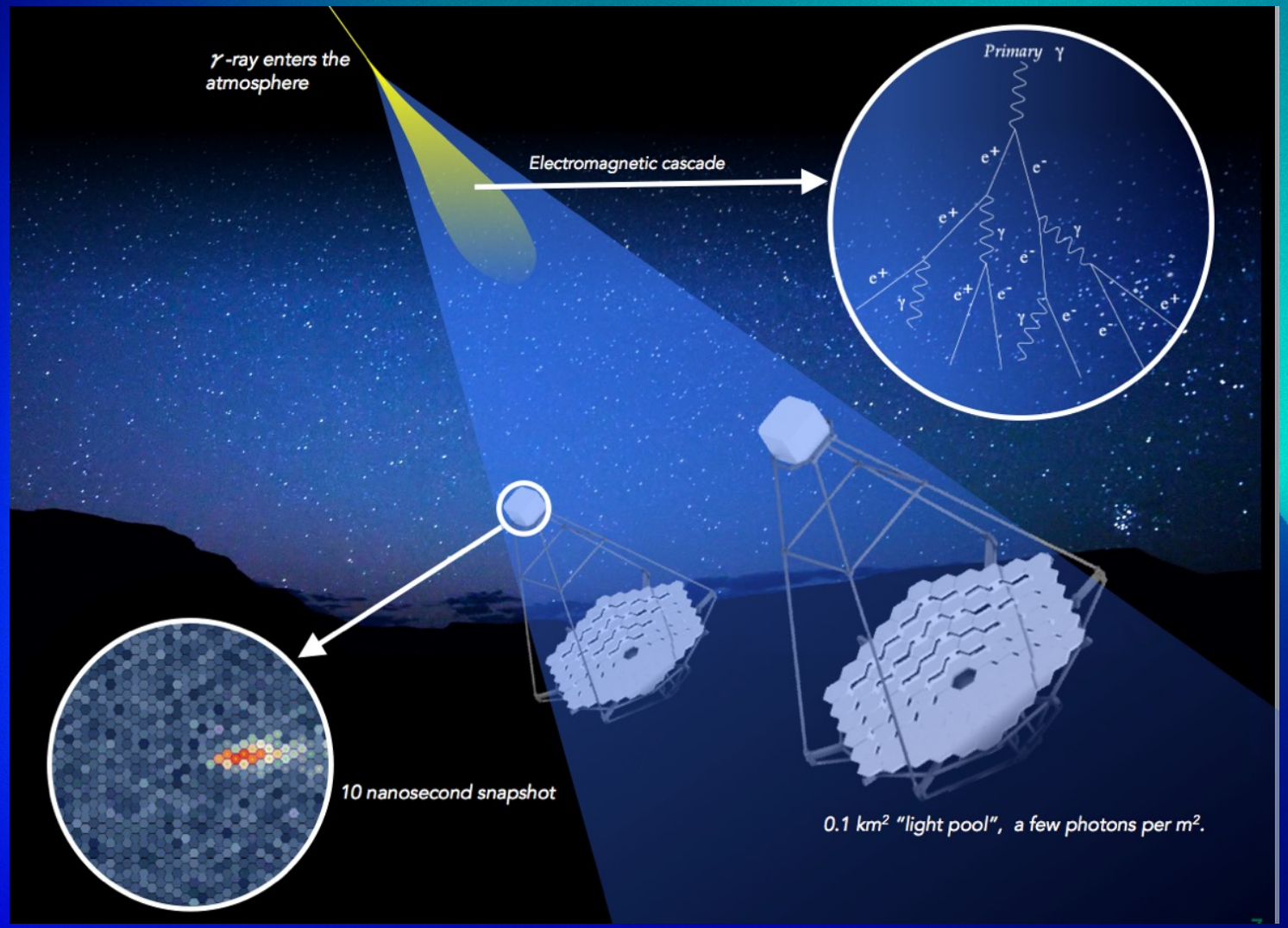
RICH2025, September 2025

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

The CTAO System

CTAO

Imaging Atmospheric Cherenkov Telescopes

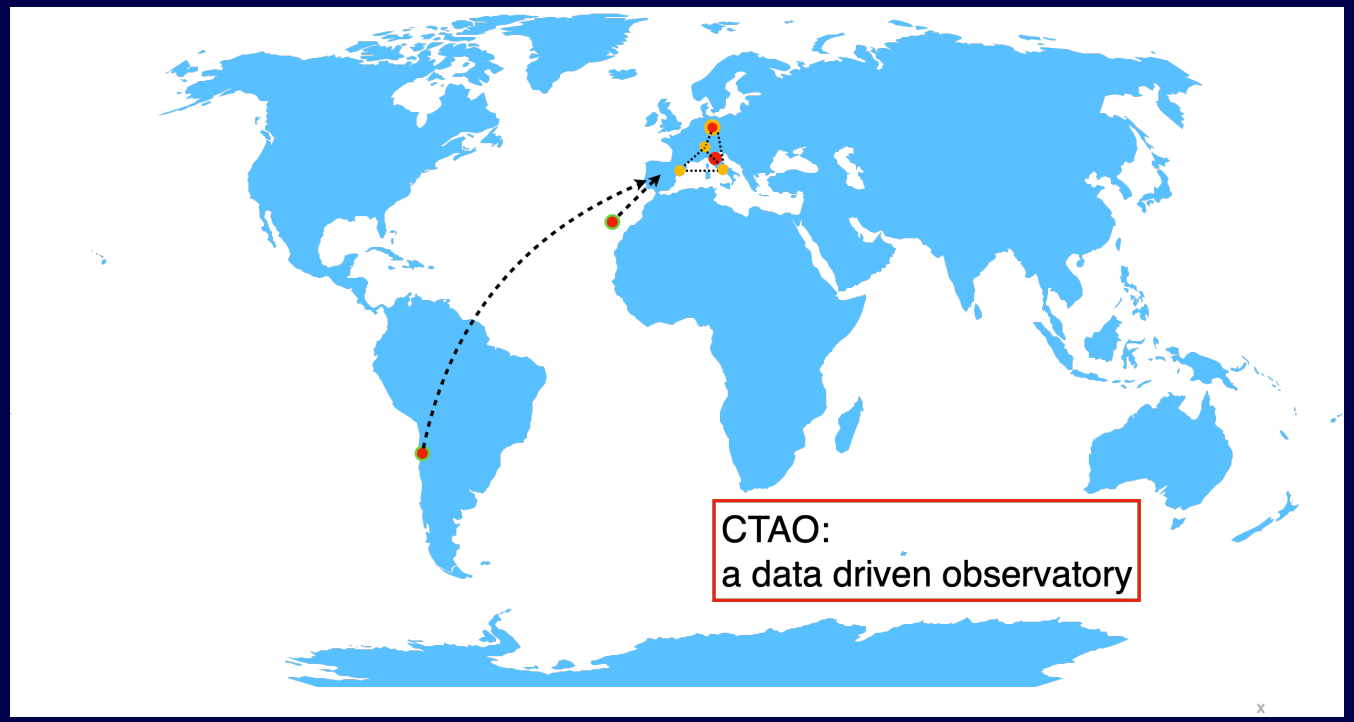


CTAO figures:

- Large collection areas (10^5 - 10^6 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

- The VHE sky is more populated than initially expected!

CTAO: A Distributed Facility



CTAO

Science Data Management Centre (site)

Headquarters (site)

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

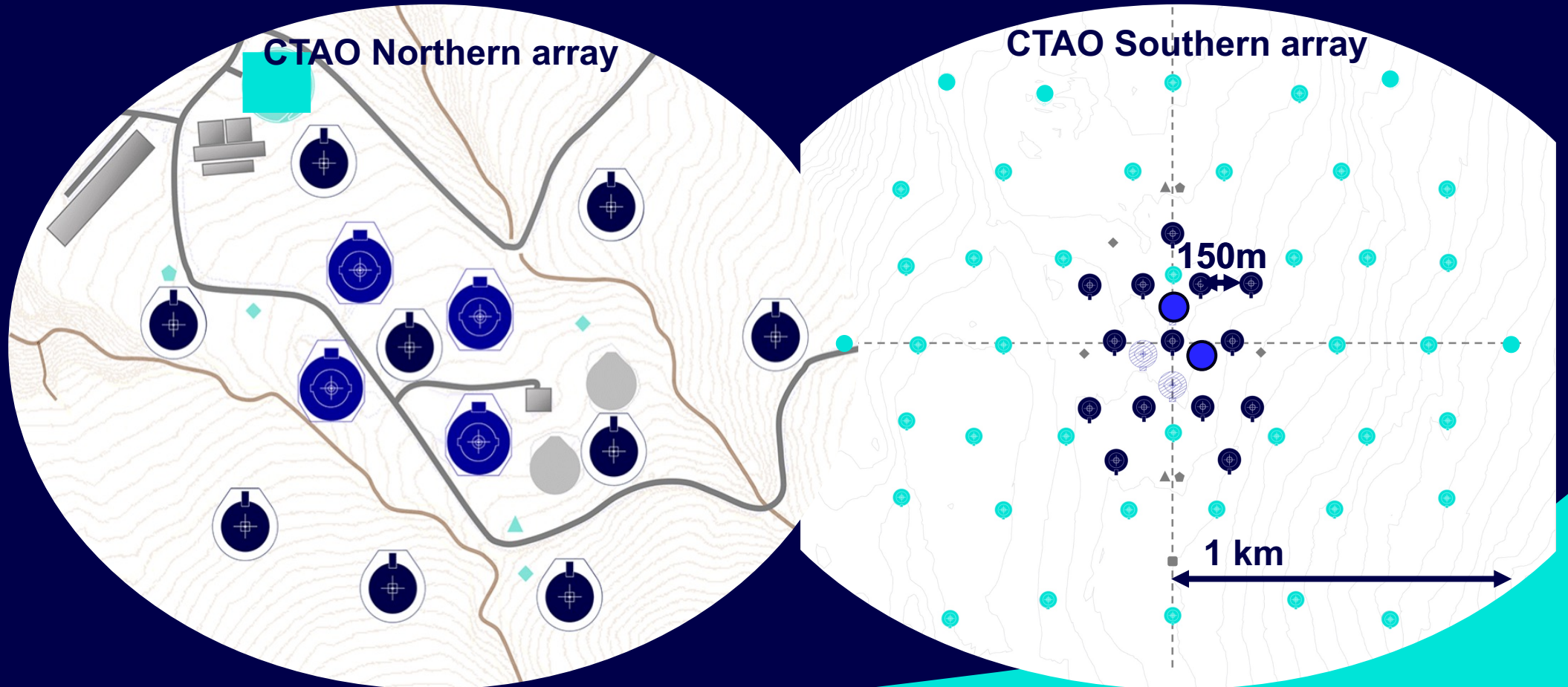
CTAO-South (site)
(or CTAO-South Station)
- CTAO-South Array (site)
- CTAO-South Operations Building (site)

Function: When talking about what they do

Geographical: When talking about location

Two Observation Stations, one Unique Observatory

Improved Alpha configuration

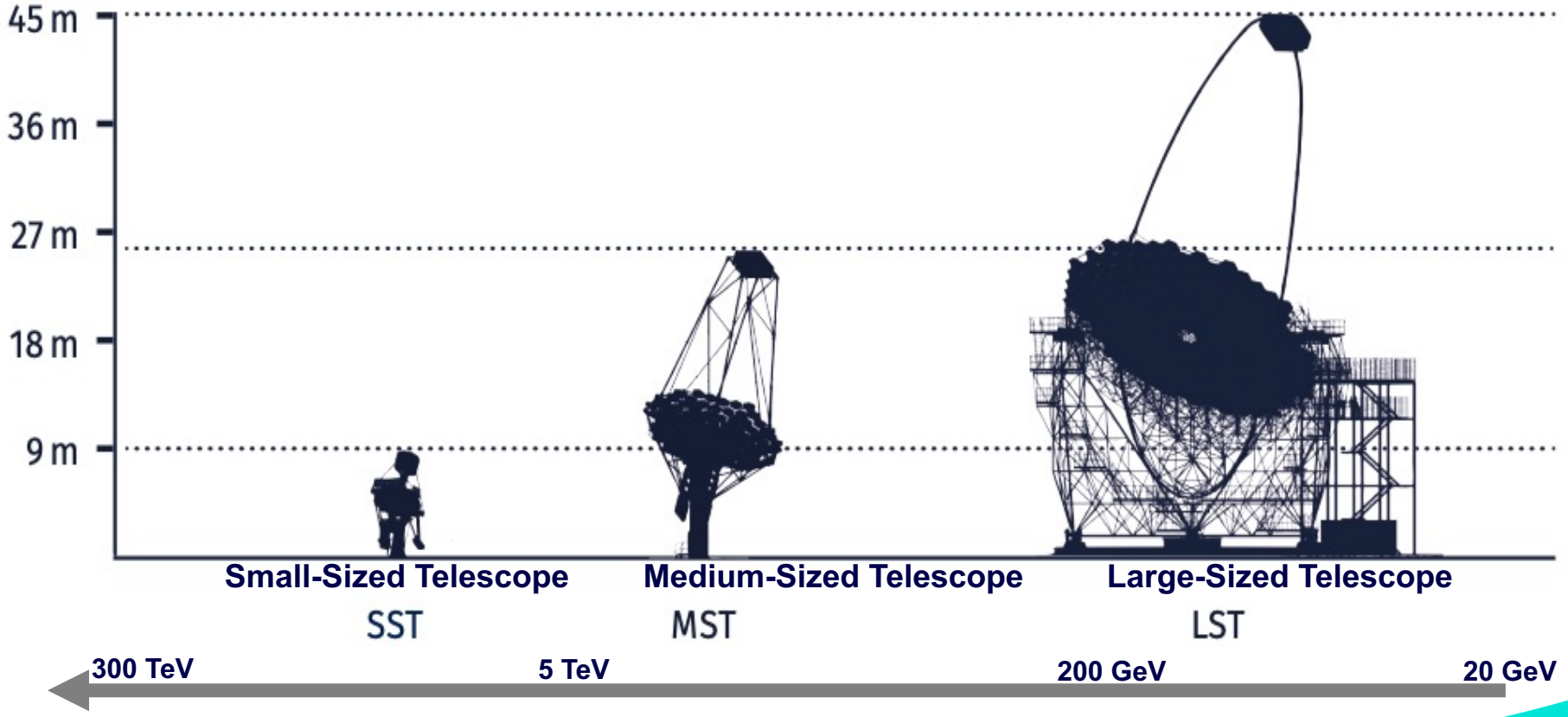


3 Telescope Designs

- 2-mirror Schwarzschild-Couder optical design
- 4.3 m ⌀ primary reflective surface
- SiPM camera: 2048 pixels (0.16 °)
- 8.8° FoV
- 17.5 tonne

- Davies-Cotton optical design
- 12 m ⌀ reflective surface
- PMT camera – 2 designs:
  - NectarCAM: 1855 pixels
  - FlashCam: 1764 pixels
- ~7° FoV
- 82 tonne

- Parabolic optical design
- 23 m ⌀ reflective surface
- PMT camera: 1855 pixels (0.1°)
- 4.3° FoV
- 100 tonne

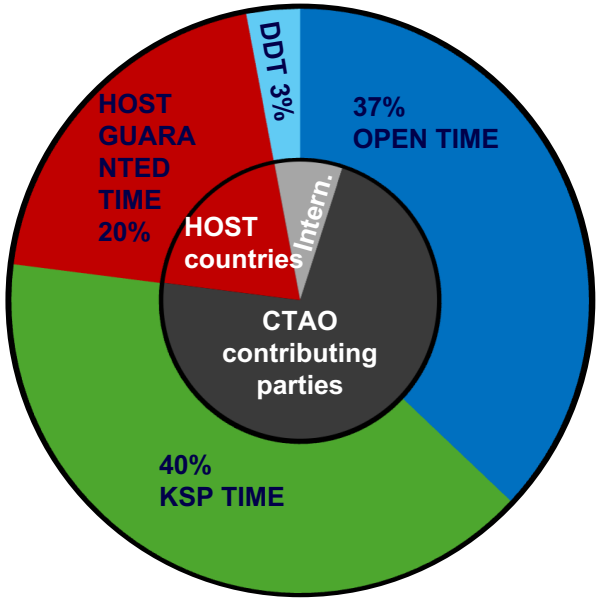


In addition, several array-level calibration and monitoring instruments

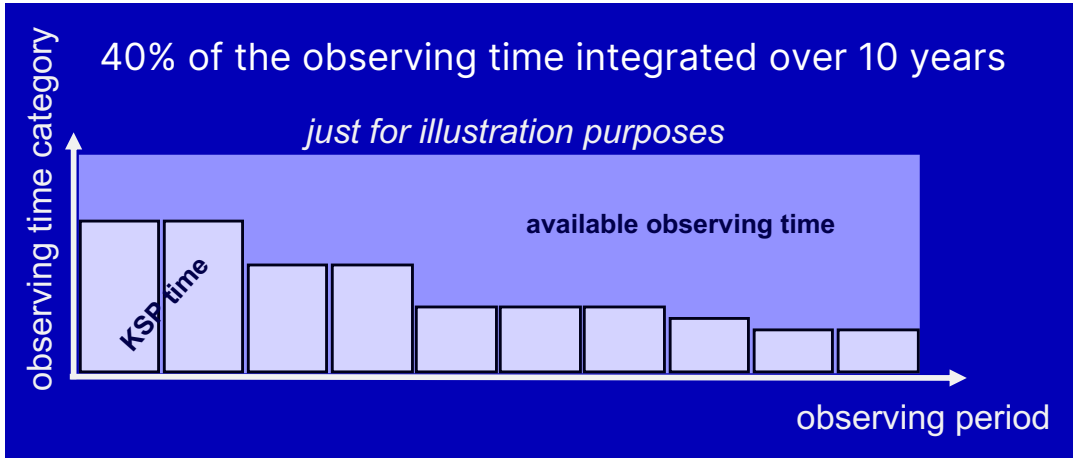
An Astronomical Observatory

An open, proposal-driven observatory

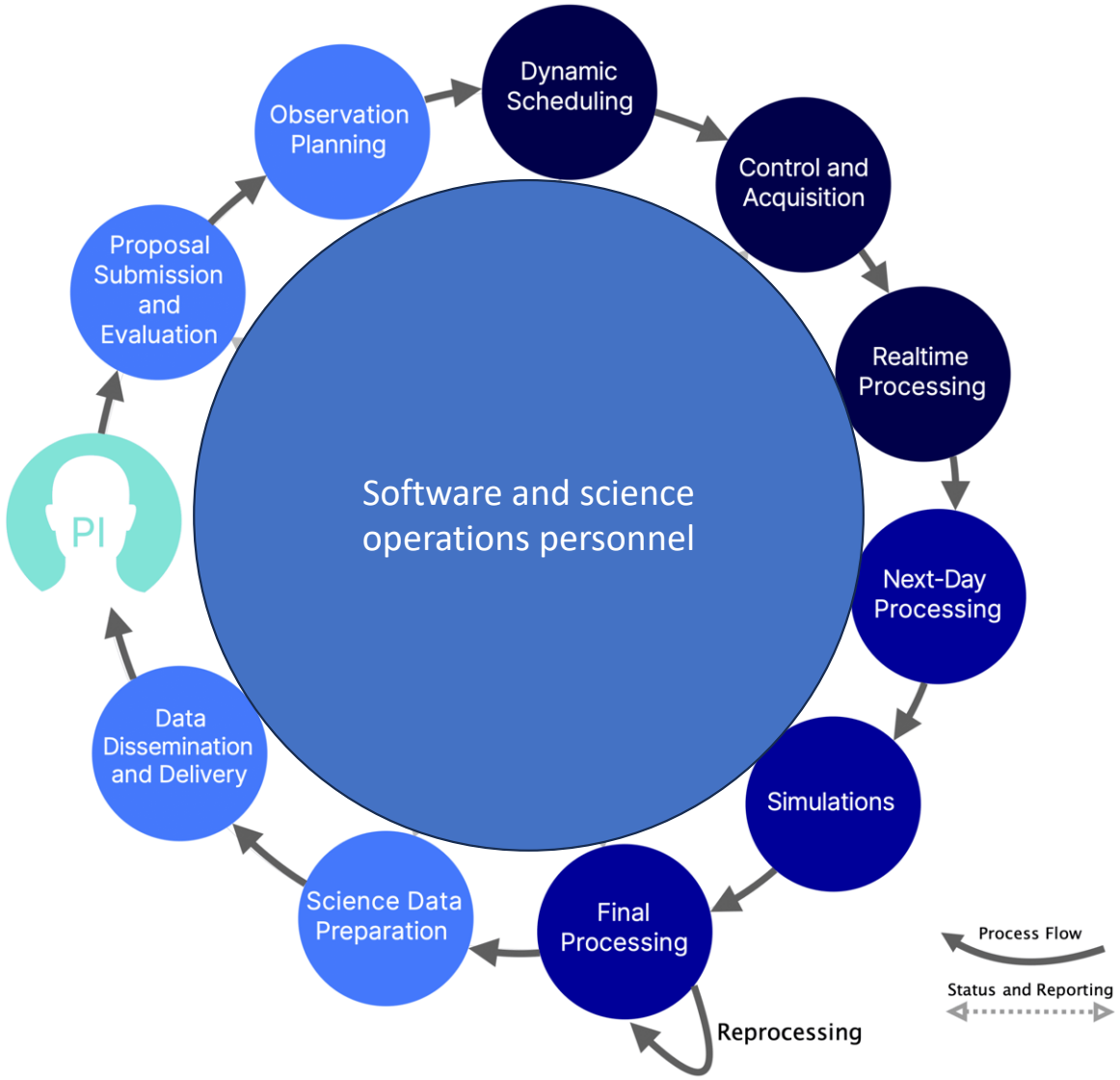
- Data with a proprietary period of 1 yr after that fully open
- KSPs are granted to contributors of the CTAO Construction Project, contingent upon the formation of the CTAO scientific collaboration.
- Key Science Projects (KSPs): observational projects requiring more than 300 hr, over more than one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



integrated over 10 yr



Science Operations



CTAO: Status

CTAO

CTAO – The ERIC Established

- CTAO European Research Infrastructure Consortium (ERIC) Established on January 7th, 2025
- The ERIC provides the CTAO with the legal stability and administrative advantages it needs to be sustainable in its worldwide operations and impact.

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

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

Founding Members of the CTAO ERIC

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

In addition:

- Japan - Strategic Partner
- Accession of Switzerland and Croatia as Founding Members is being processed.
- Australia, Brazil and possibly USA are on their way to join the project

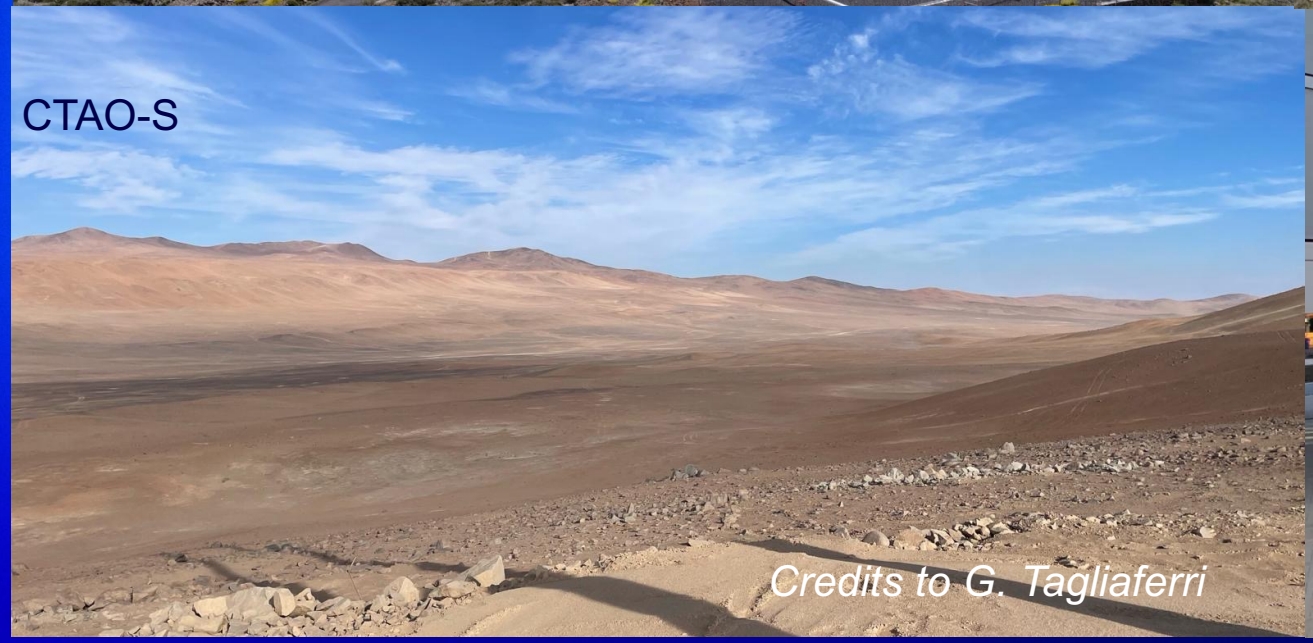
CTAO - Sites

CTAO-N

Credit: CTAO LST Collaboration

CTAO Central Organization personnel as in 10.2024

CTAO-S



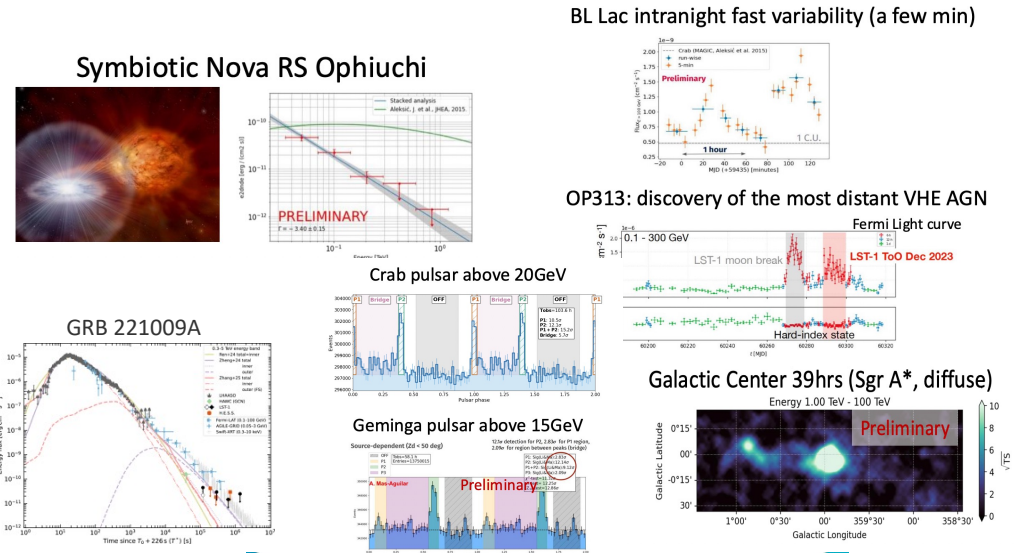
Credits to G. Tagliaferri

SDMC@Zeuthen

Credits to DESY

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
  - Technical building tender
  - Soon first MST
- CTAO-S construction ramping up
  - Large infrastructure tenders
  - Telescopes to start arriving in 2026
  - Intermediate data centre and control container
- 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
- Central organization staff significantly reinforced



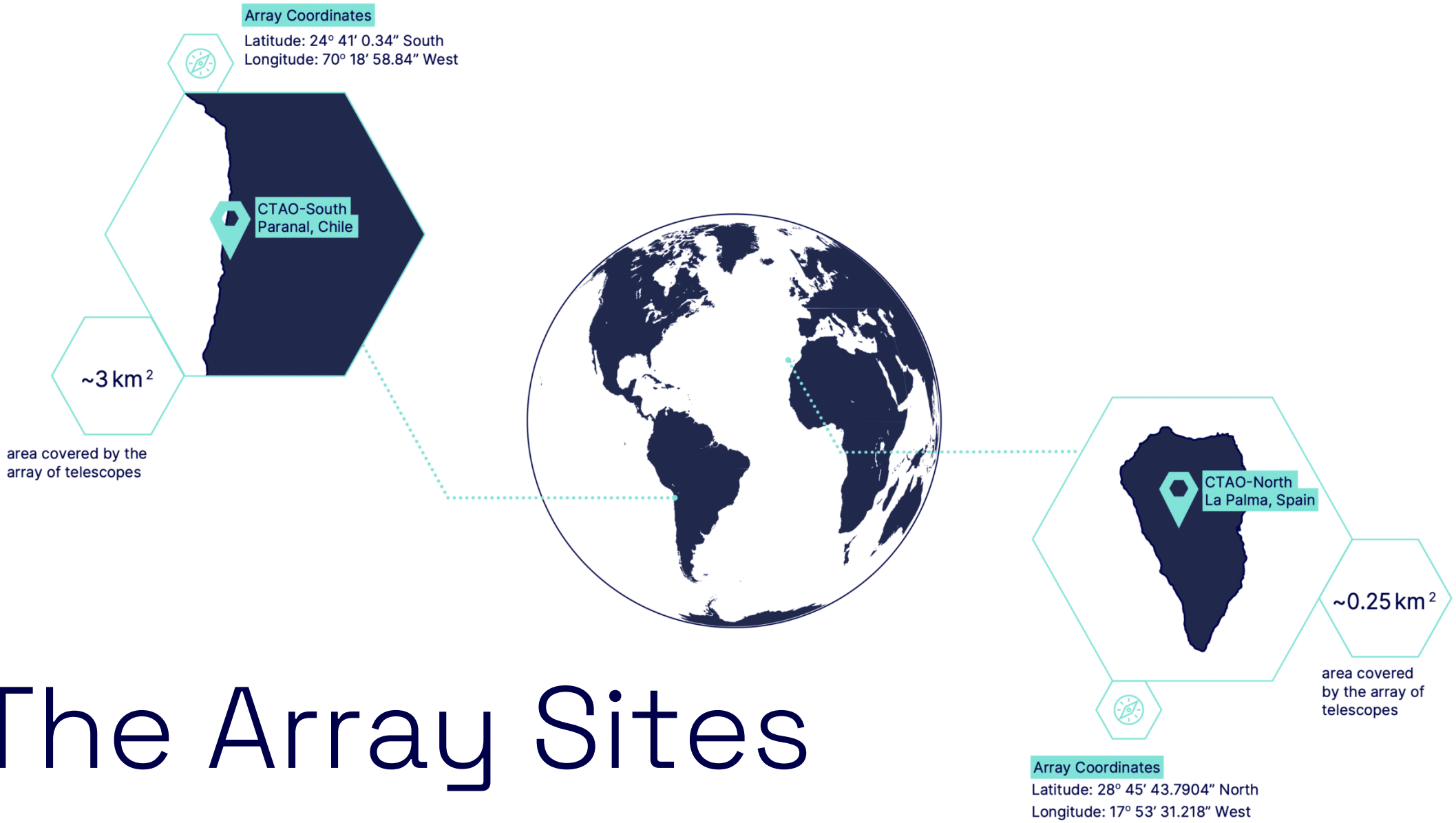
Credits to M. Teshima & the CTAO LST collaboration

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),

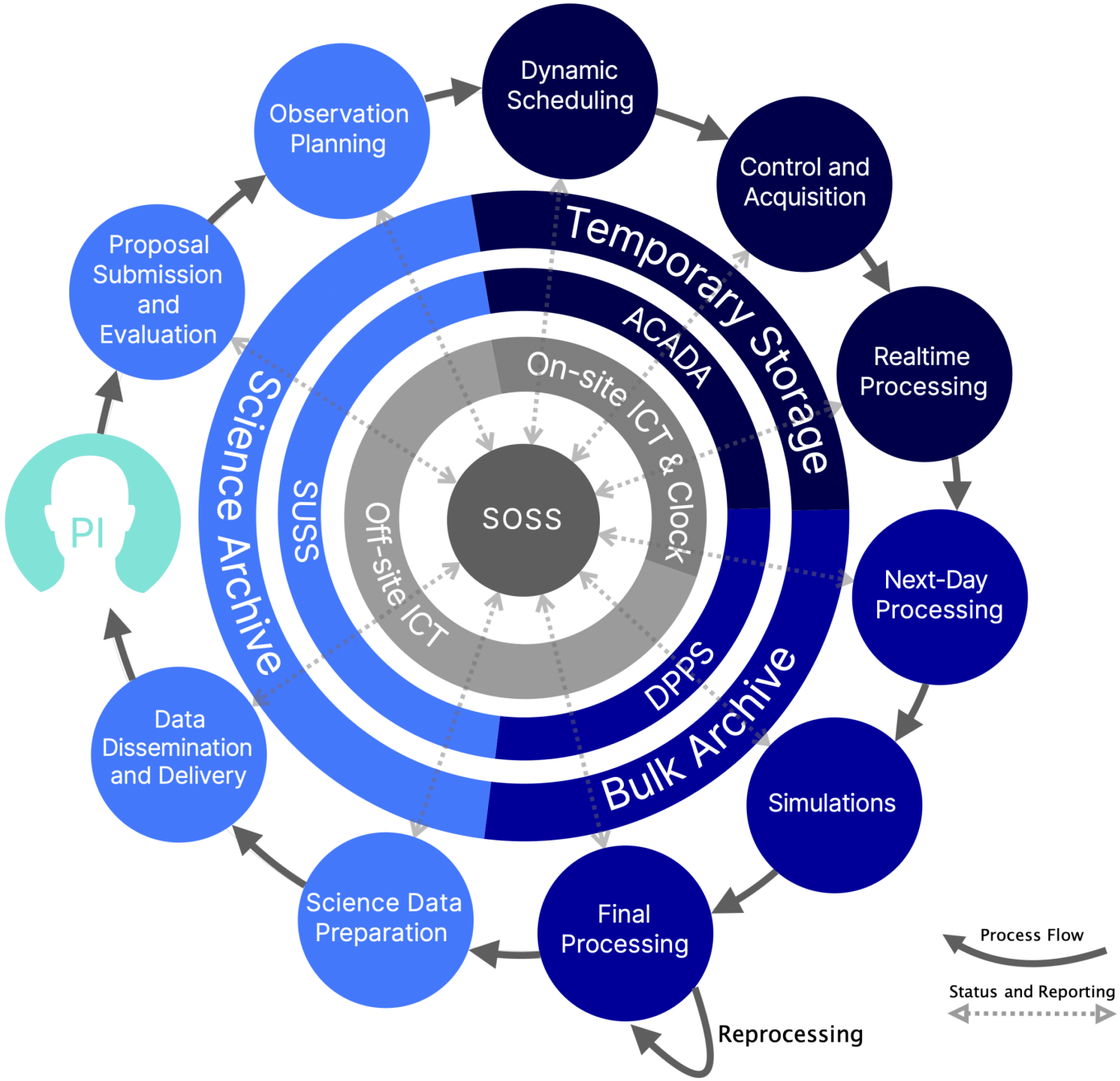
CTAO: Array Operations

CTAO

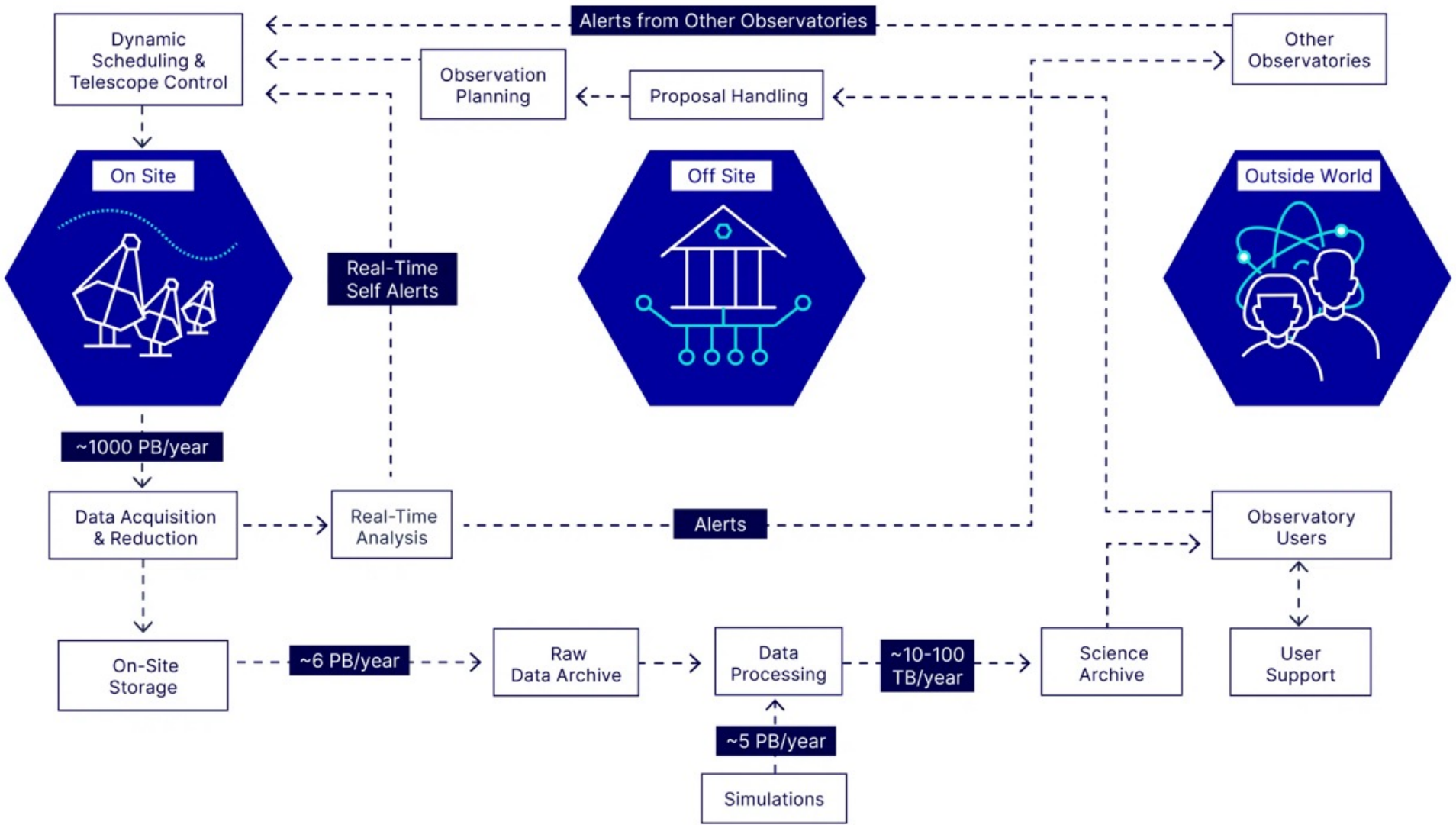
The Array Sites



The Science Operations of CTAO – And the Computing Systems



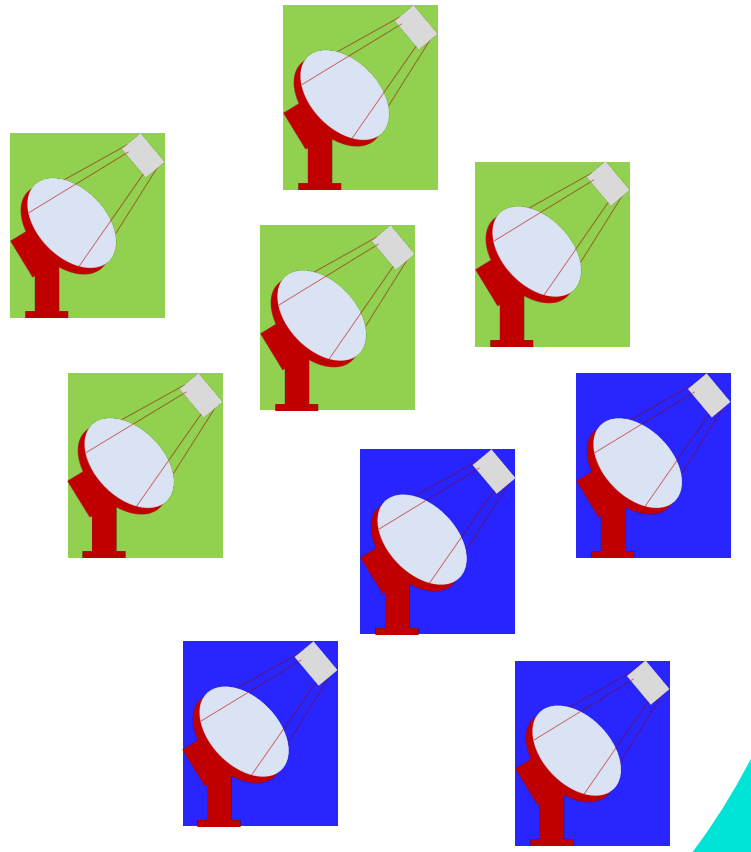
CTAO – Data Flow



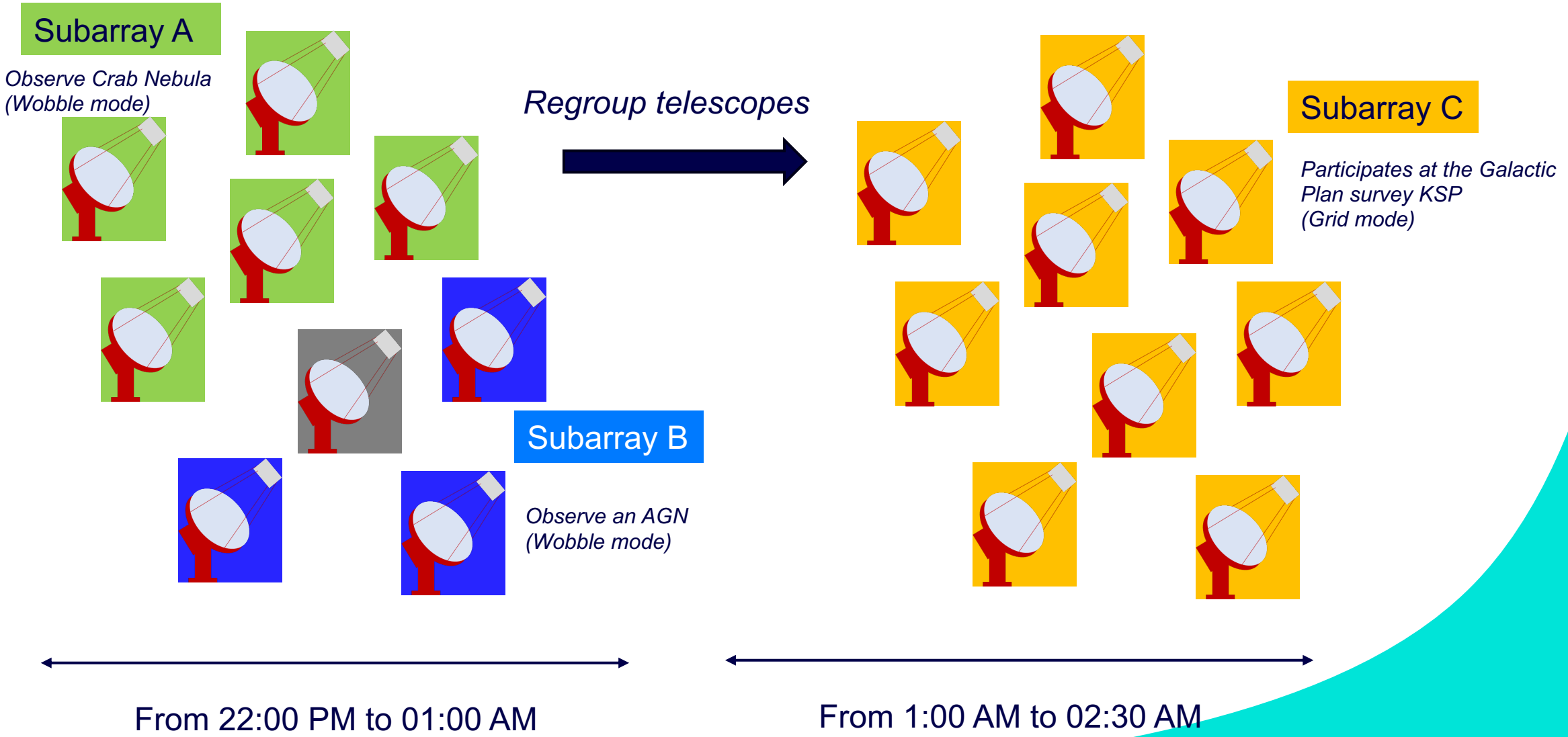
- Control 60+ telescopes
- BIG DATA project, generate hundreds of petabytes (PB) of data in a year (at least 6 PB after compression)
- Two sites and four off-site data centres

Telescopes During the Night

- Support different “telescope subarray” configurations for at each site – up to 8 operating simultaneously
- Telescopes operating within the same subarray point towards the same target, and use the same subarray-level trigger instance
- Allocation and operation of subarrays will be managed dynamically
- Transients such as gamma-ray bursts (Science Alerts) will cause the schedule to be adapted on the spot (~s timescales), and reconfigure subarrays
- Array common elements operating concurrently with the telescope subarrays
- Whole operations supervised by the Array Control and Data Acquisition (ACADA) system



Example of Subarray Operations



Calibration Operations

- The calibration of the CTAO system is fundamental for optimal performance.
- At the individual Cherenkov telescope level
  - Camera Calibration (internal flashers)
  - Pointing calibration (different methods, bending/pointing models), and offline corrections
- External telescope calibration - Illuminator :
  - Specially dedicated laser flasher for camera calibration
  - Point to individual telescope for external calibration
  - 2(4) North (South) per site to cover all telescopes
- Atmosphere characterization & Env. Monitoring (Array Common Elements ACEs):
  - LIDARs [Remote Sens. 2025, 17(6)]
  - Stellar Photometer (FRAM) [https://www.epj-conferences.org/10.1051/epjconf/201714401012]
  - All-sky Camera, Ceilometers [https://www.epj-conferences.org/10.1051/epjconf/20158903007]
- Laser safety in observatories – Laser Traffic Control Systems (LTCS) must be considered in online scheduling.

Conclusions and Outlook

- CTAO-N in development in La Palma
  - One LST operative, and another three LSTs being commissioned in CTAO-N
  - Technical building construction to start soon
  - 1st MST to come soon, the rest will follow
- CTAO-S
  - Large tenders for site infrastructure
  - 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
- **Exciting times ahead: CTAO early science is around the corner**