cherenkov telescope array

The Cherenkov Telescope Array: an observatory perspective

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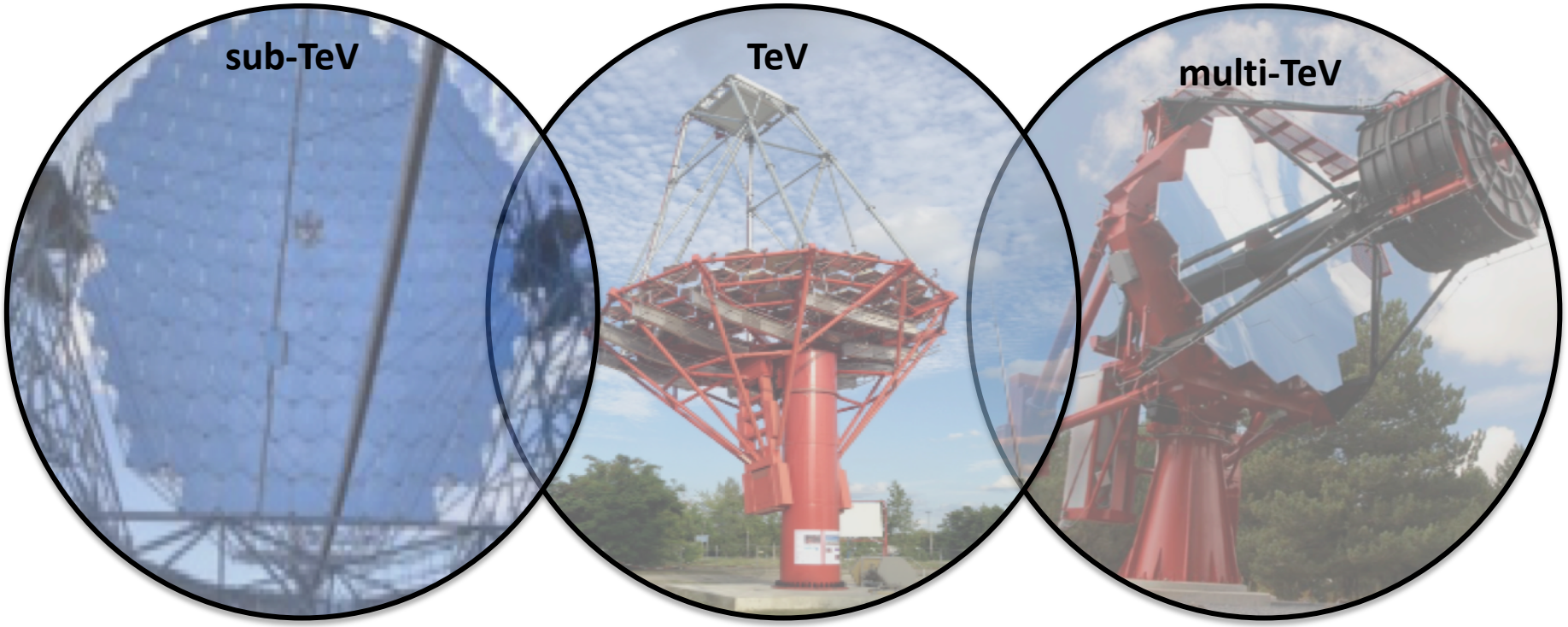
CTA: the Cherenkov Telescope Array

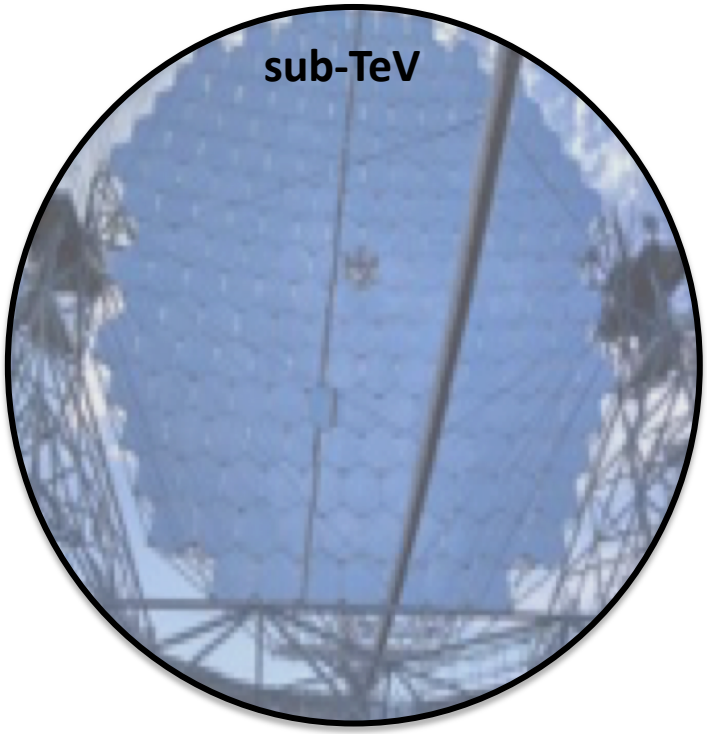
Next generation ground-based gamma-ray observatory

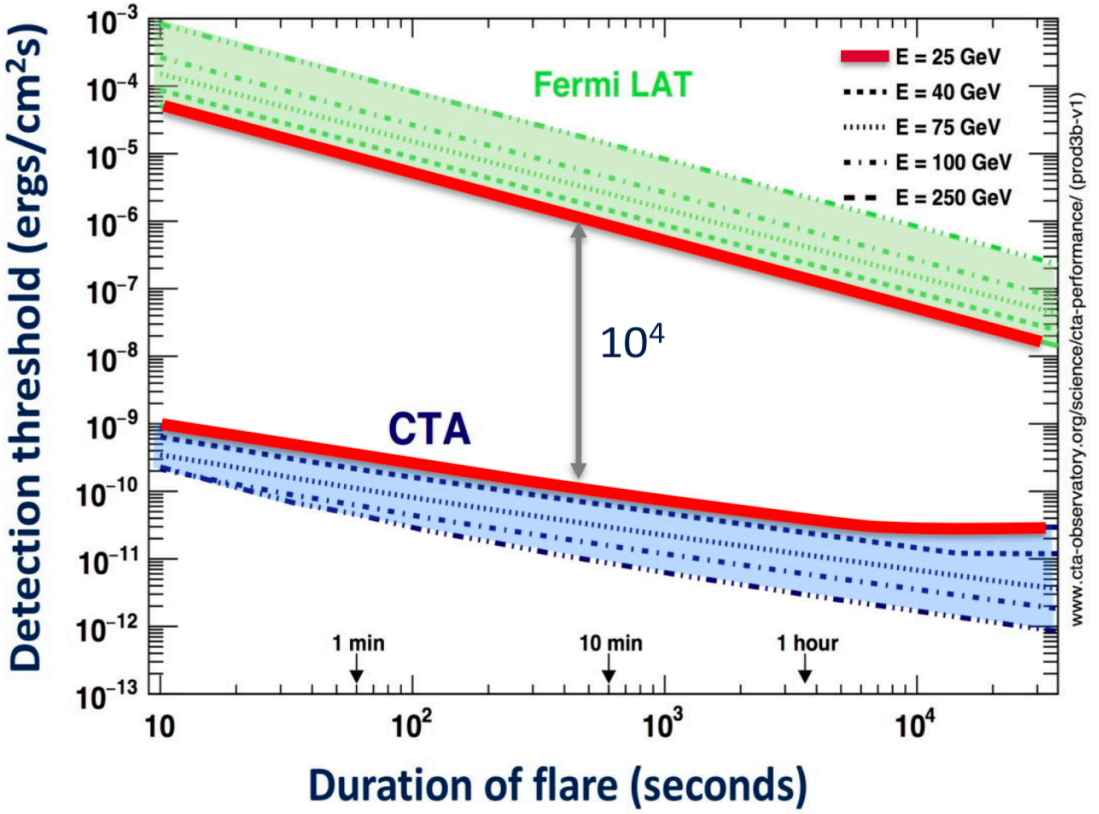
- Science cases and design drivers
- Performances
- Observatory & operations
  - Operations in a MWL/MM era

Science cases and design



sub-TeV energies - Flare sensitivity

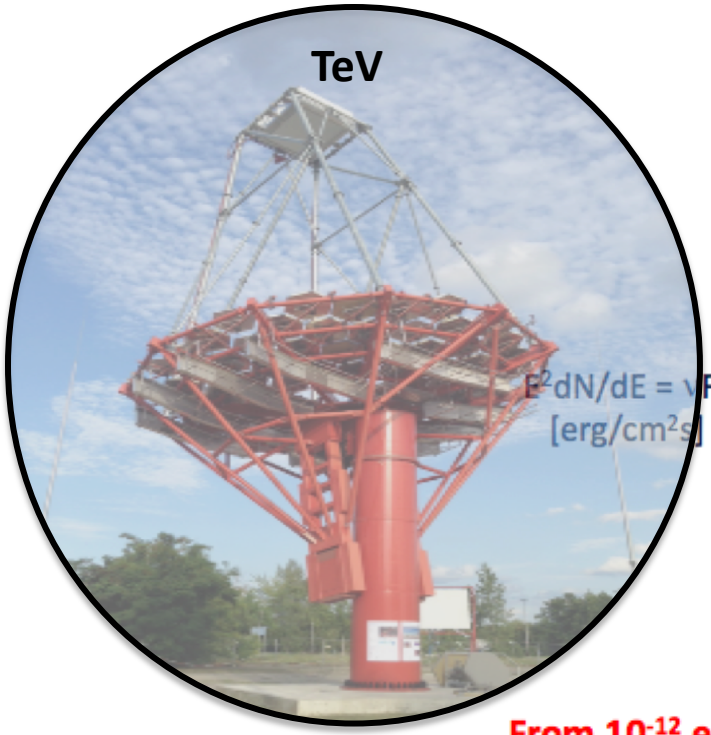


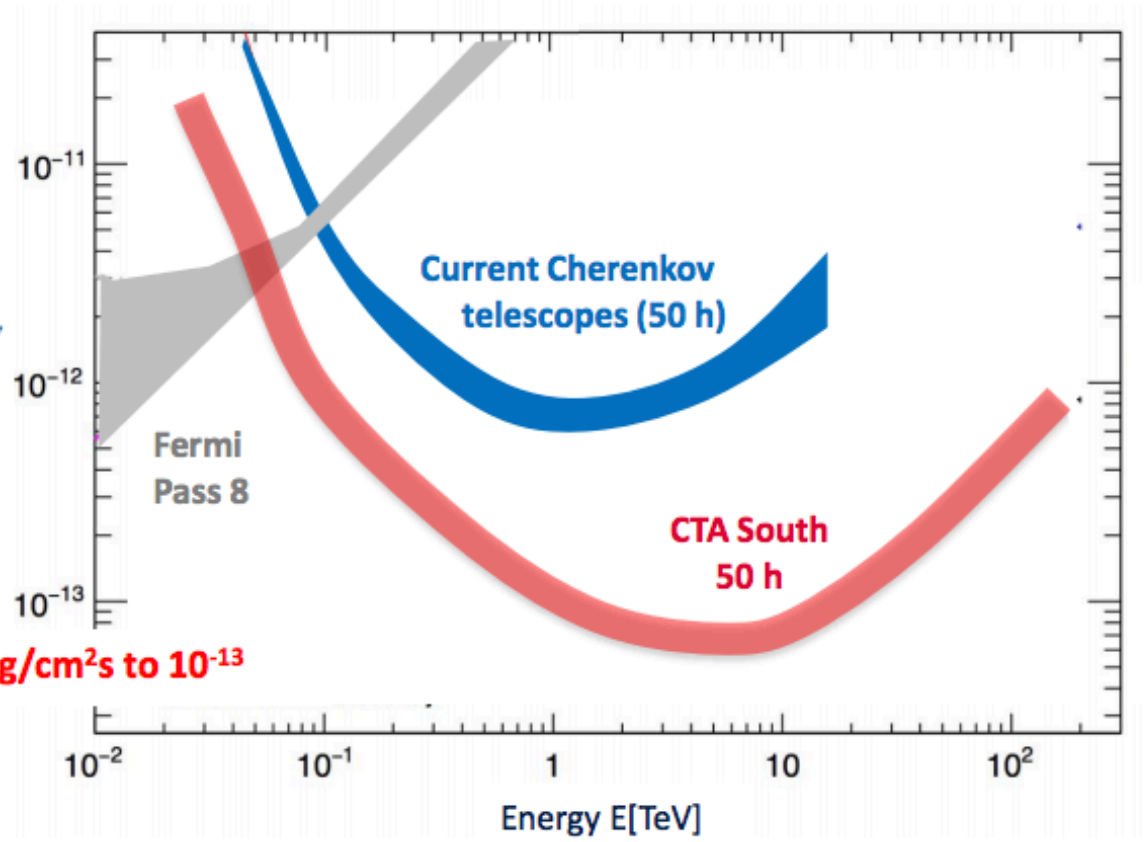


- Deepest sensitivity for short timescale phenomena

- **Time domain unexplored**
  → cosmological sources

TeV energies - Sensitivity (steady sources)



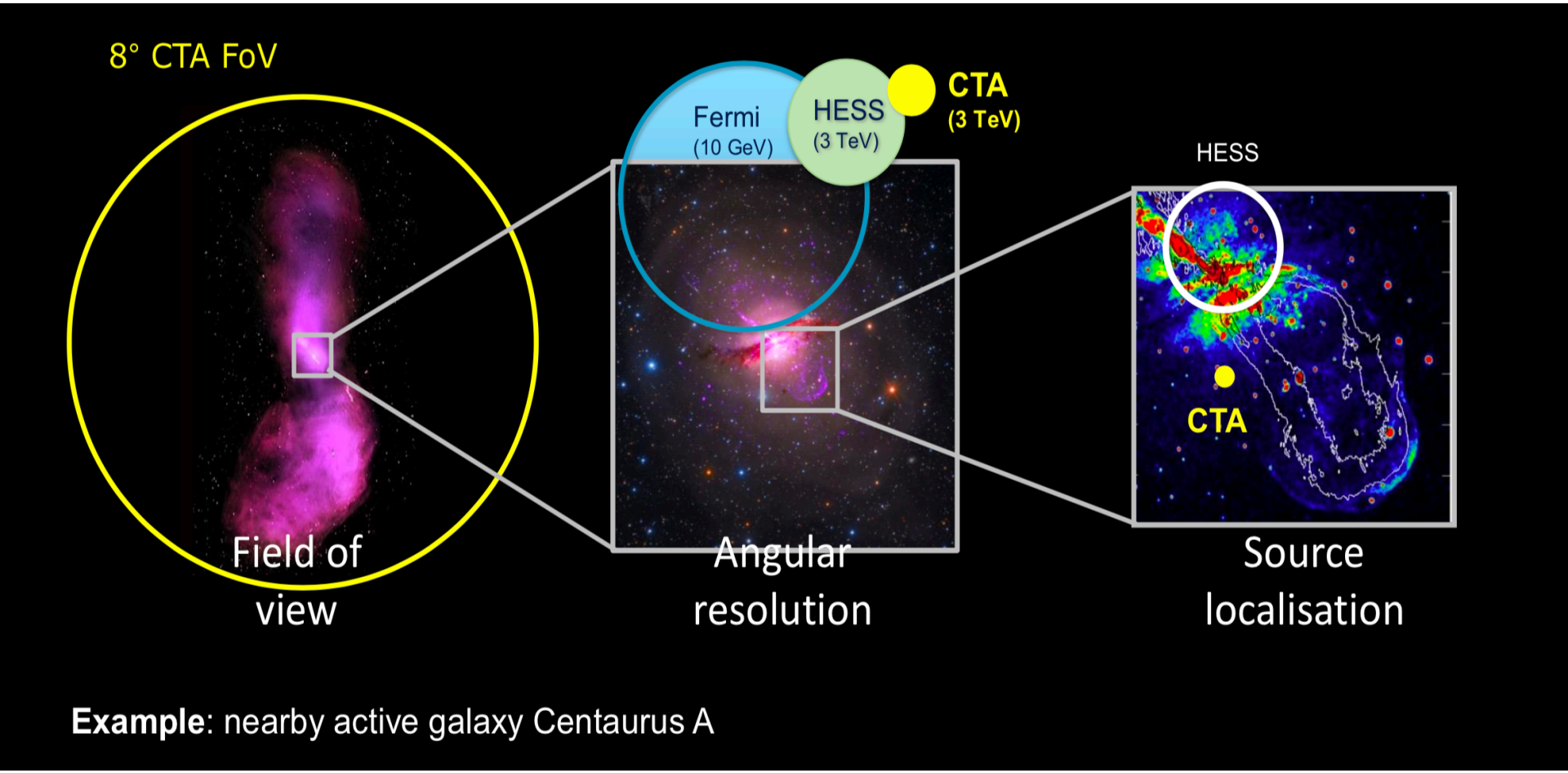


From 10^{-12} erg/cm^{2}s to 10^{-13}

- deepest sensitivity ever
- arcmin angular resolution
- large FoV

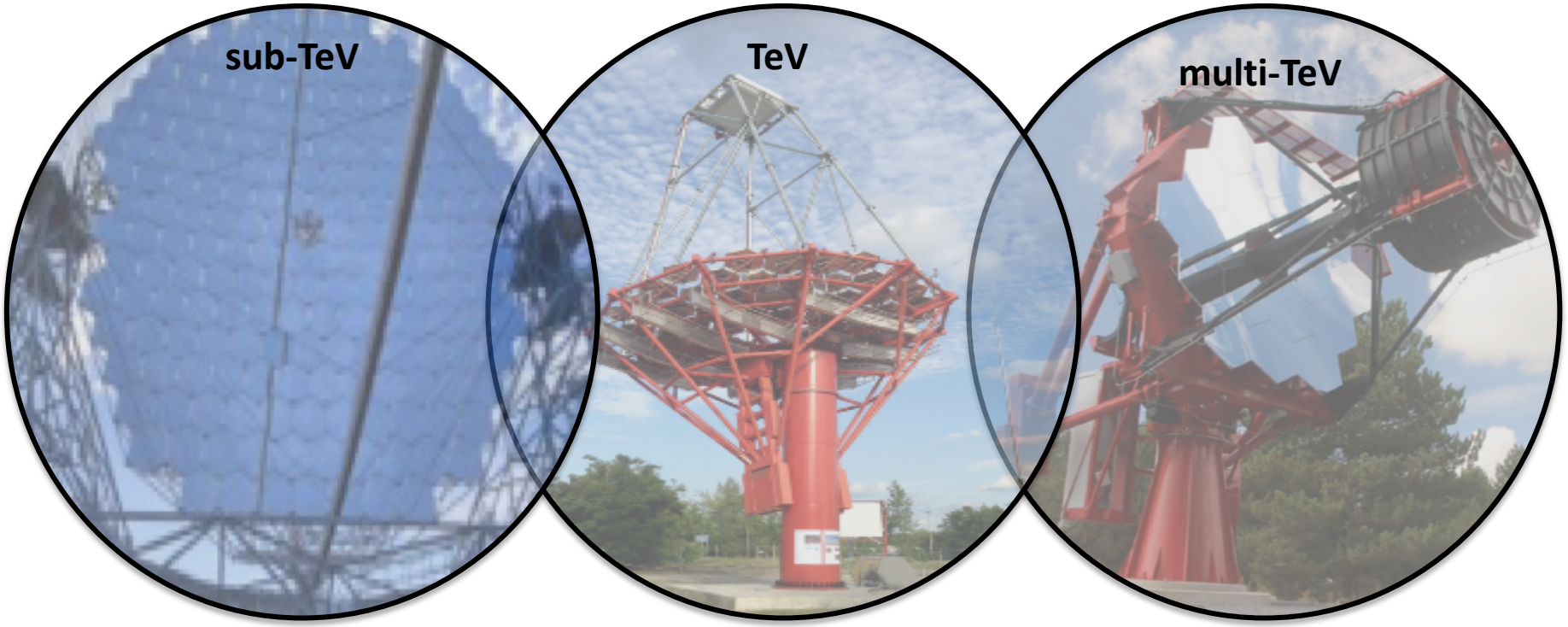
- Surveys & precision studies

TeV/multi-TeV energies - Resolving power



Example: nearby active galaxy Centaurus A

Science cases and design



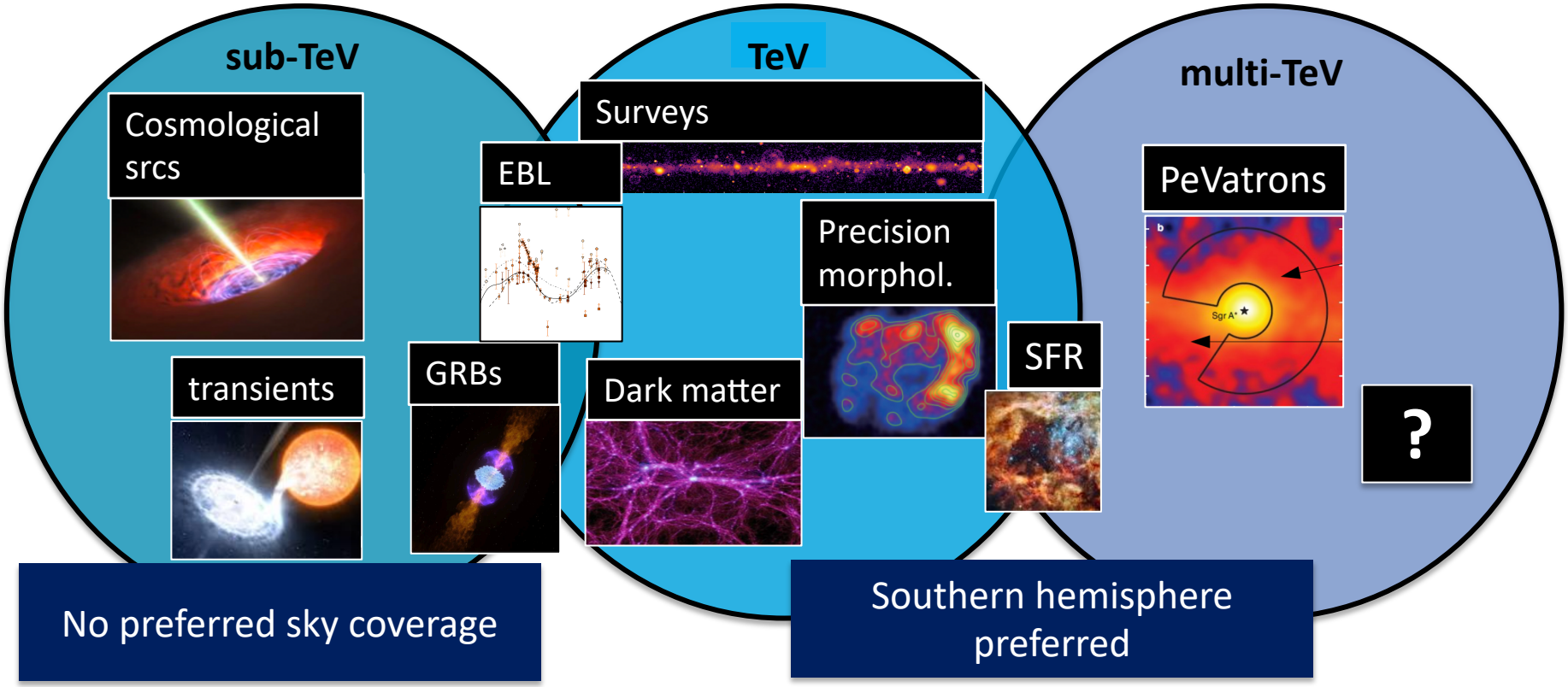
- Deepest sensitivity for short timescale phenomena
- deepest sensitivity ever
- arcmin angular resolution
- large FoV
- Precision measurements in a still little explored energy range

- **Time domain unexplored → cosmological sources**

- Surveys & precision studies

- **100 TeV range unexplored**
- **precision studies**

Science cases



- **Mainly CTA consortium involved in the definition of the science cases**

  (Science with CTA, CTA Consortium 2019 - https://doi.org/10.1142/10986)

Science cases

- **The science case is stronger than ever**
  - γ rays – neutrinos correlation as proof for the mechanisms at work in the most violent explosions in our Universe
  - Detection/non-detection of the electromagnetic counterparts of the GW
  - Pulsars as a potential new population of TeV emitters

Science cases

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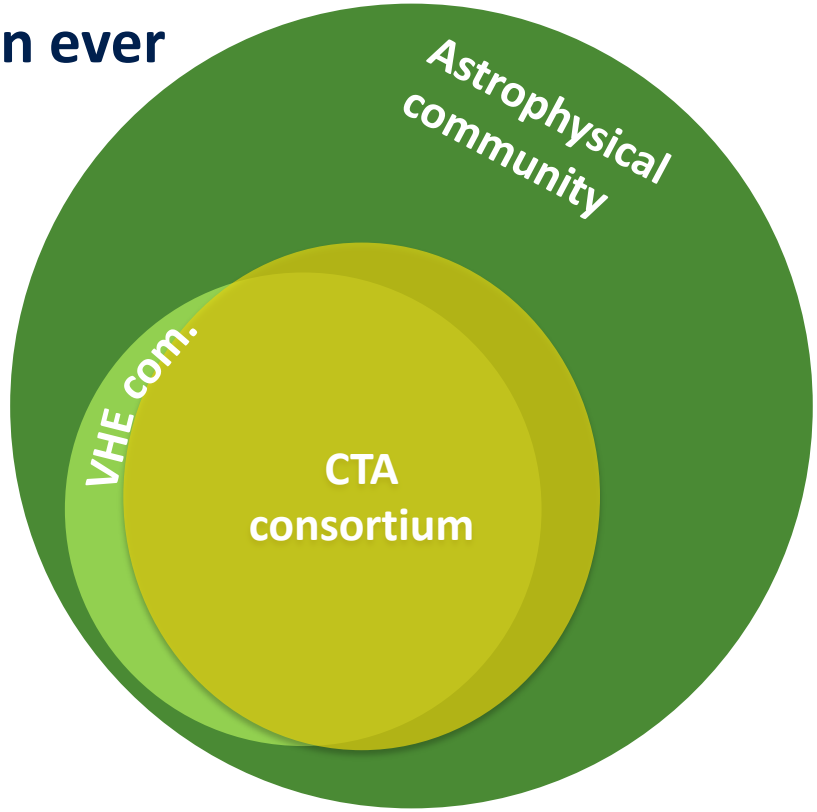


- **The advent of the multi-messenger has enlarged the interest in the overall astronomical community on the VHE astrophysics**

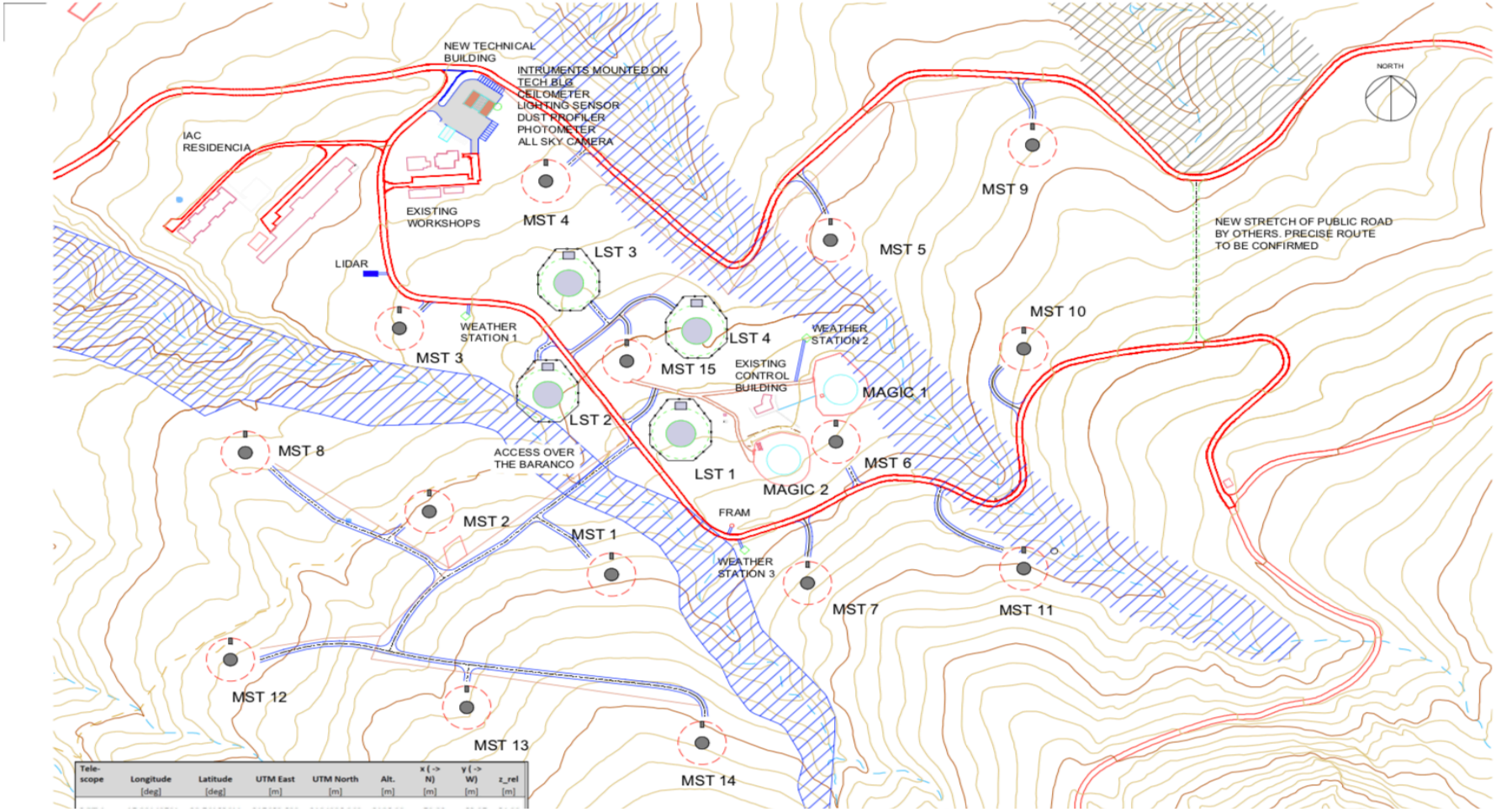
CTA Observatory

- **The first ground-based gamma-ray observatory**
  - **serve large user community in an open and fair way**
- **30 yr of lifetime**
  - Significant effort for maintenance and operations costs optimization
- **One legal entity**: CTAO GmbH in the process to become an **ERIC** with **HQ in Bologna (Italy)**
- **Two Telescope arrays, one Observatory**
  - Inter-site coordination
  - Uniform approach to scientific ops
- **The Science Data Mgmnt Center in Zeuthen (Germany)**
  - CTA is a software instrument

CTA Observatory

CTA-North site

- **4 LSTs + 15 MSTs (baseline configuration)**
  - **Focus on sub-TeV and TeV energy range**

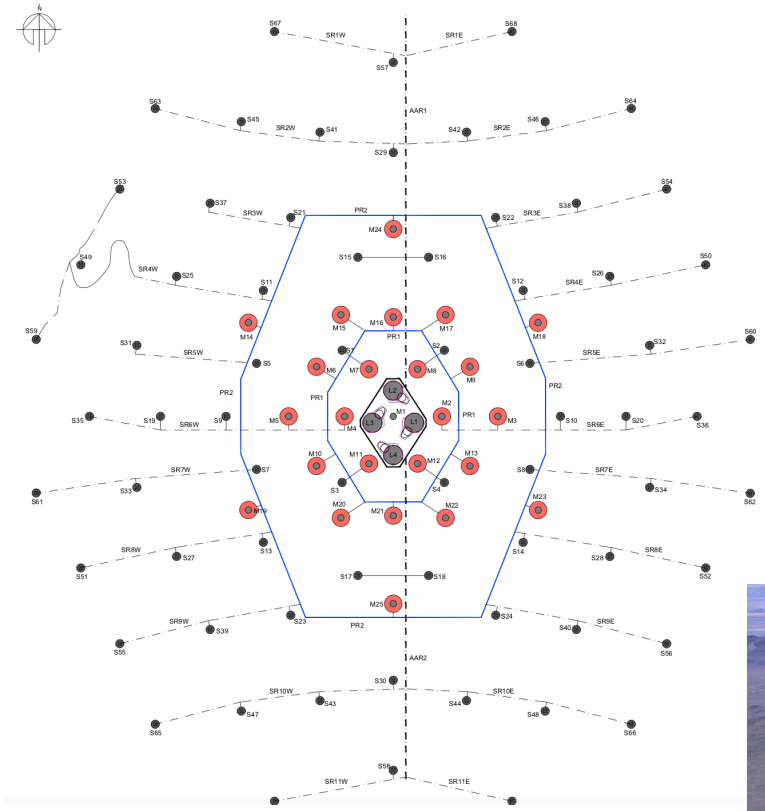


Tele-scope	Longitude [deg]	Latitude [deg]	UTM East [m]	UTM North [m]	Alt. [m]	x (-> N) [m]	y (-> W) [m]	z_rel [m]

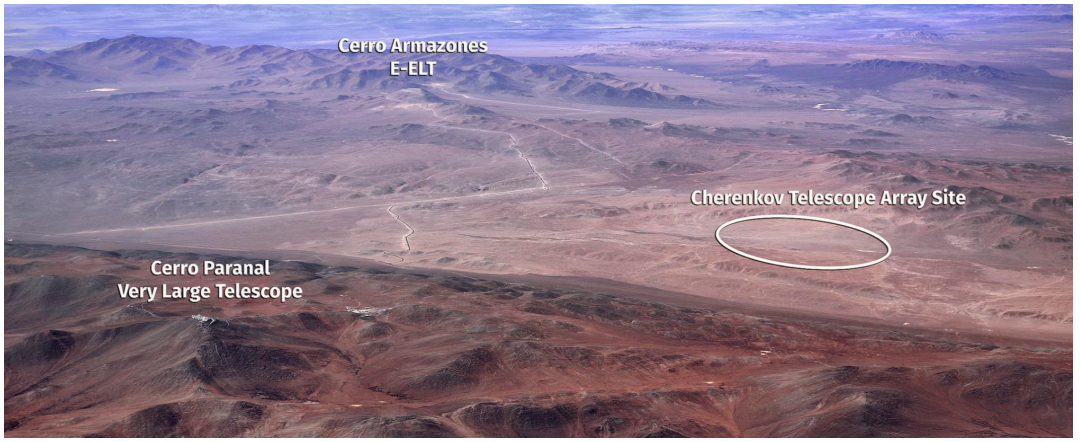
CTA-North site

CTA-South site

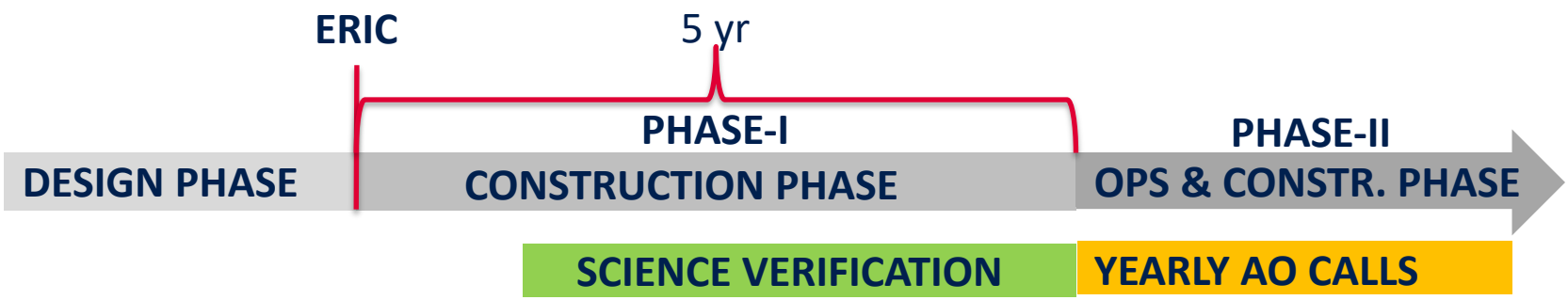
- 4 LSTs + 25 MSTs + 70 SSTs (baseline-configuration)



- Site agreement signed in Dec 2018
- Aim to start with site infrastructure construction soon



Project Status



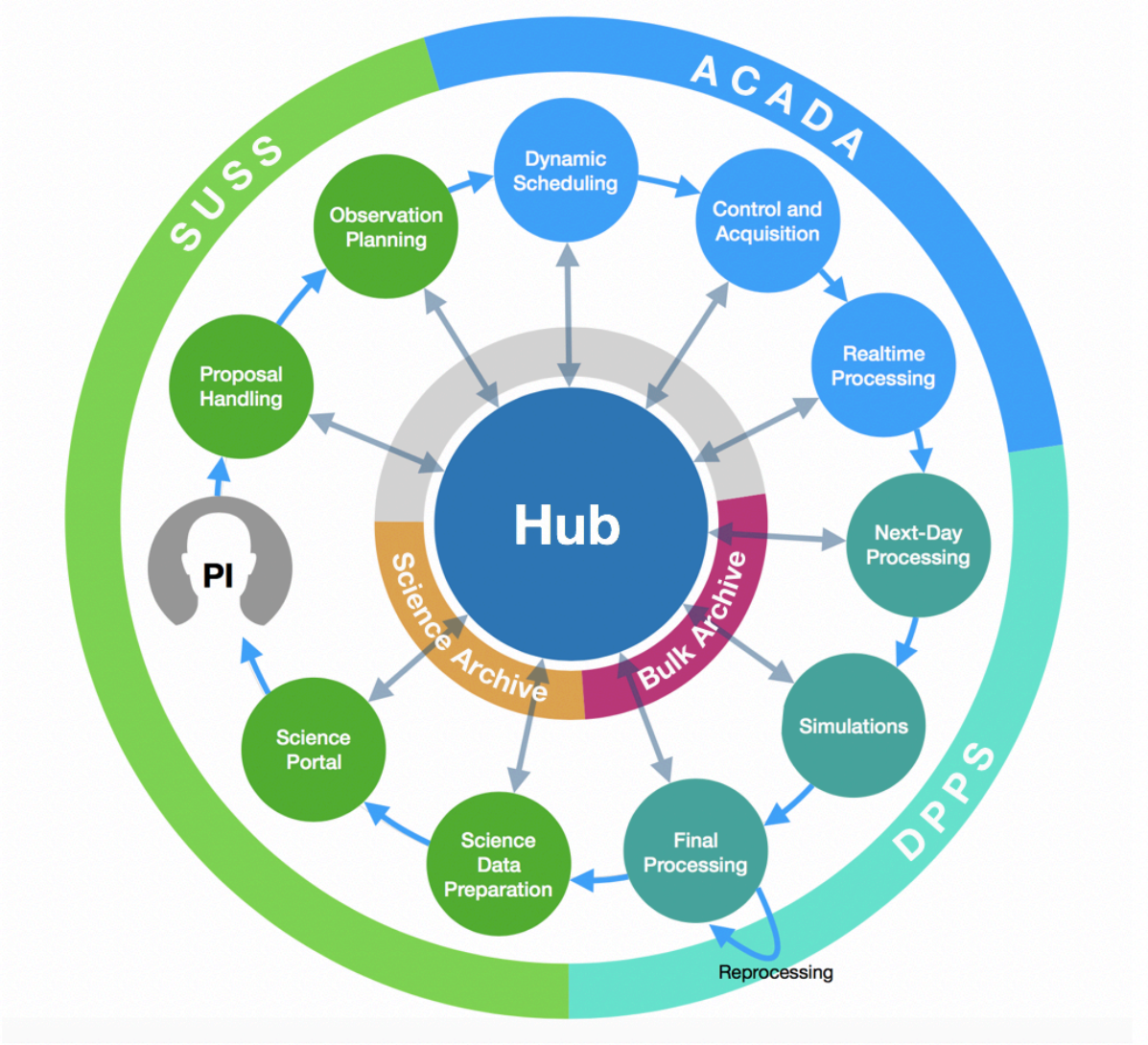
- **Phase-I: construction of a reduced-baseline configuration**
  - **a significant performance improvement wrt the currently running facilities**
    - guarantees high-impact science covering most of the science cases
    - guarantees a significant increase of the discovery space

- **Phase-II: operation of the phase-I configuration + construction towards the final baseline**

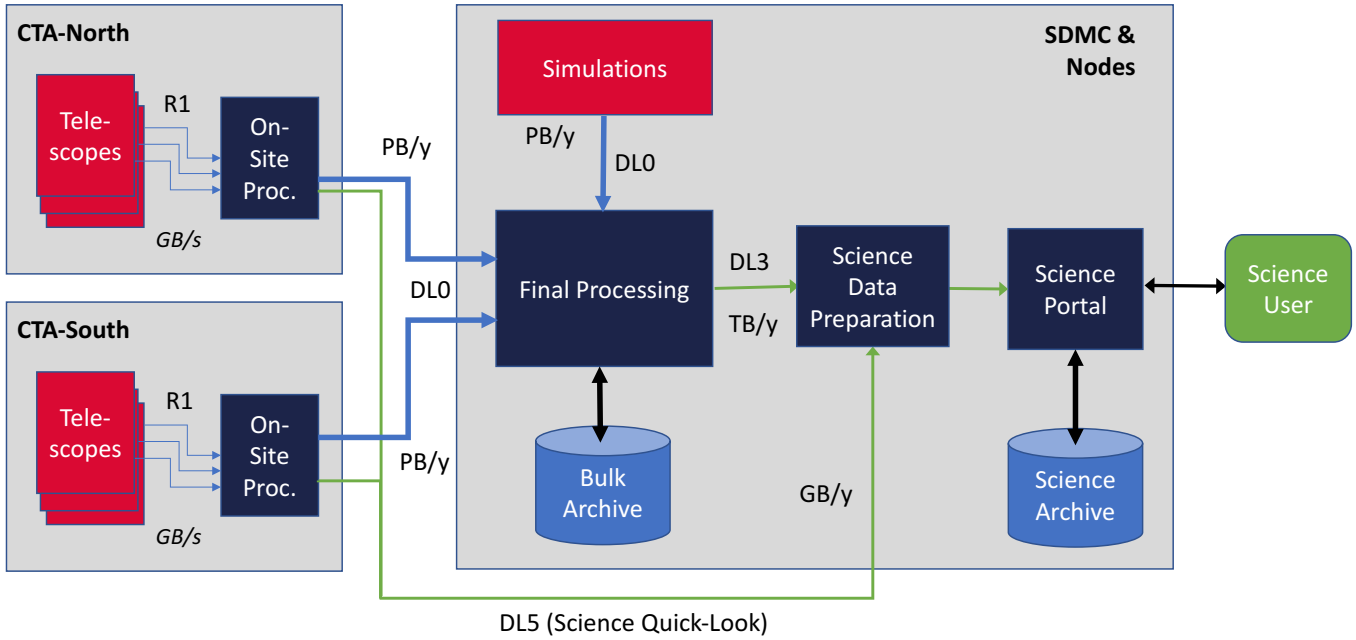
A proposal-driven observatory

- **Announcement of opportunity call every year**
  - **Proposal evaluation through a peer-review process**
  - **Each proposal** is associated to **one unique PI**
  - **After 1yr proprietary period data are open**
  - **Different data quality levels corresponding to distinct observing conditions**
- **Scientific proposals are classified in:**
  - **Regular PI proposals**
    - Tens to hundreds of hours of observation
  - **Key Science Projects**: large observation programs (from hundreds to thousands hr) that need to be addressed in a coherent fashion generating legacy data sets for the community
    - 40% of observation time devoted to KSPs for the first 10 yr
  - **Discretionary Director's Time (DDTs) proposals**

Overview on Science Operation Processes



Data Flow & Analysis Categories

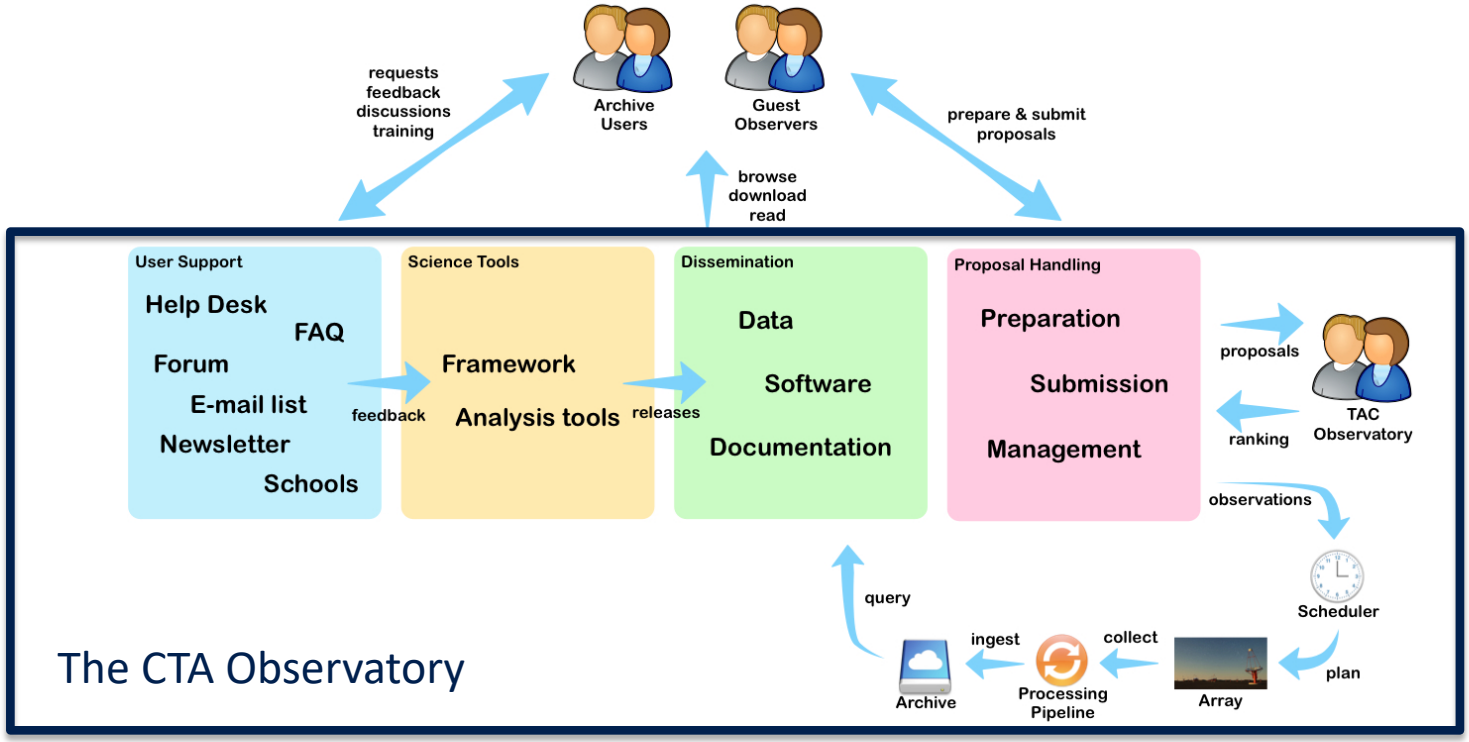


Three analysis categories

- ***Category A*: at the sites, **real-time**, generate internal science alerts**
- ***Category B*: at the sites, offline (e.g. next day) → Higher sensitivity than category A**
- ***Category C*: offsite, final analysis results with maximum sensitivity**

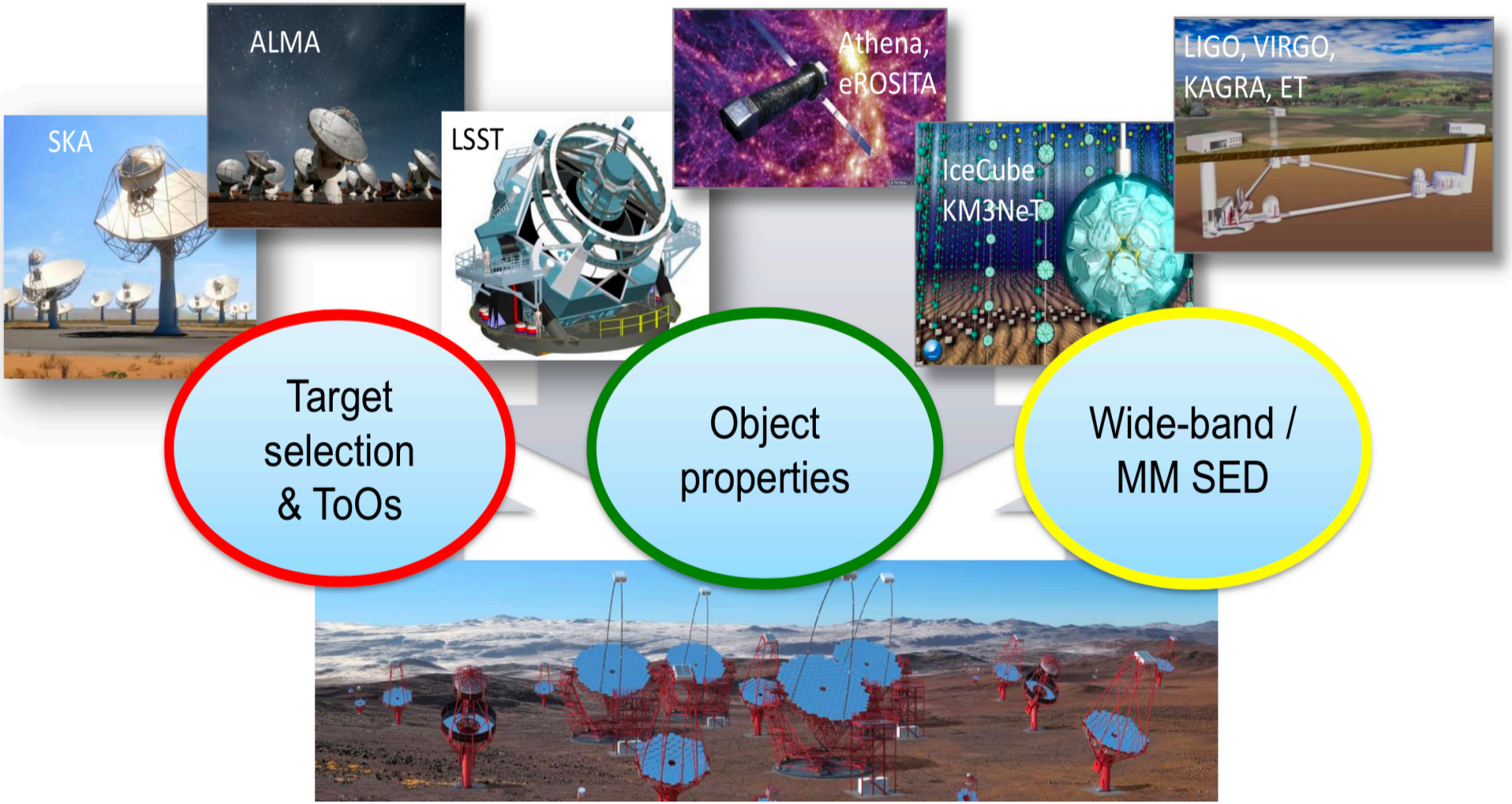
Science User Perspective

- **Science User get access to the analysis results**
  - on different timescales depending on the type of analysis
- Products and services are in the core of the **CTA Science Platform**
  - Access to results for PIs only via the CTA Science Platform



The CTA Observatory

Crucial: MWL & MM links



Archive MWL data

- **Catalogs for source associations**
  - **Radio, IR, optical, X-rays, gamma rays**
  - **State-of-art catalog of the currently running VHE facilities**
- **Radio surveys for the study of the diffuse emission**
- **Specific (non-flaring) source archival data**
  - **Crucial to disseminate our data in a standard format to favor the interoperability and MWL/MM analyses**

MWL/MM observational campaigns

- **MWL/MM campaigns are organized for**
  - Typical timescales days to months
  - expected exceptional events (periodic sources, transitioning sources, long-duration flaring states)
  - correlation studies (i.e. giant pulses, FRB counterparts ..)

- **They require fixed predefined timeslots**
  - policy defined by previous agreements

- Constant communication between the involved facilities to react to possible failures of the partners (bad weathers, technical problems…)

Target of Opportunity Observations

- **Monitoring ToOs**
  - Typical scheduling timescales **days to weeks**
  - **Monitoring** can be performed
    - **by different facilities** (it requires previous agreements)
    - **by a sub-array of CTA telescopes**

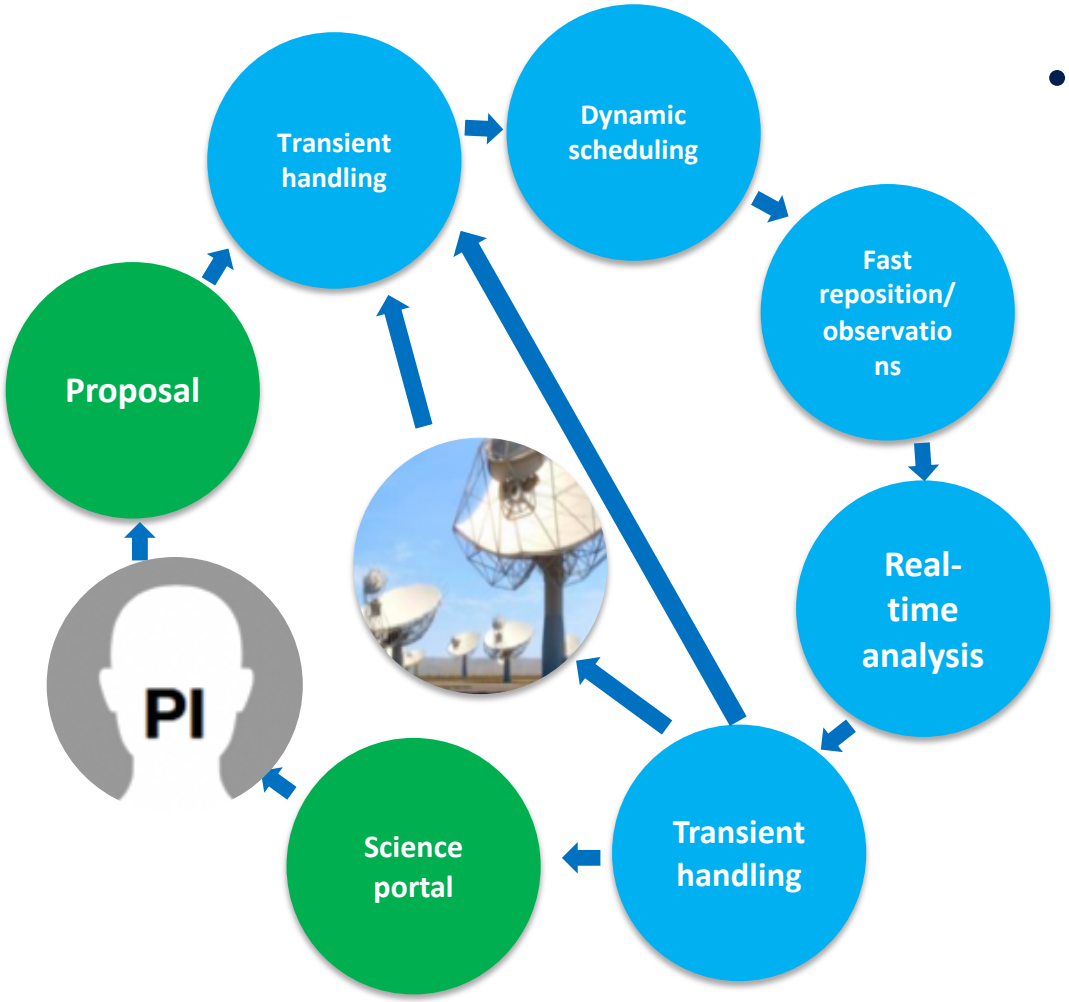
- **Offline ToOs**
  - Typical scheduling timescales **days to weeks**
  - **Request** to activate the corresponding proposal **sent on day timescale by the PI to the CTAO**, that schedules the observations off-site/off-line

Target of Opportunity Observations

- **Externally generated real-time ToOs (GRBs, SGRs, Novae, AGNs…)**
  - **Automatic handling of alerts on ~second timescales**
  - The alert system shall have a **memory of the alerts during day-time**
  - **Alert priorization will be a must in the era of transient factories**

- **Internally generated real-time ToOs**
  - **Serendipitous detection in the FoV detected by the real-time analysis on ~minute timescales**
  - **Fast communication of the results to the other Observatories to enable follow-up observations**
  - **expected rate low, but identified events with high impact**

CTA as a transient facility



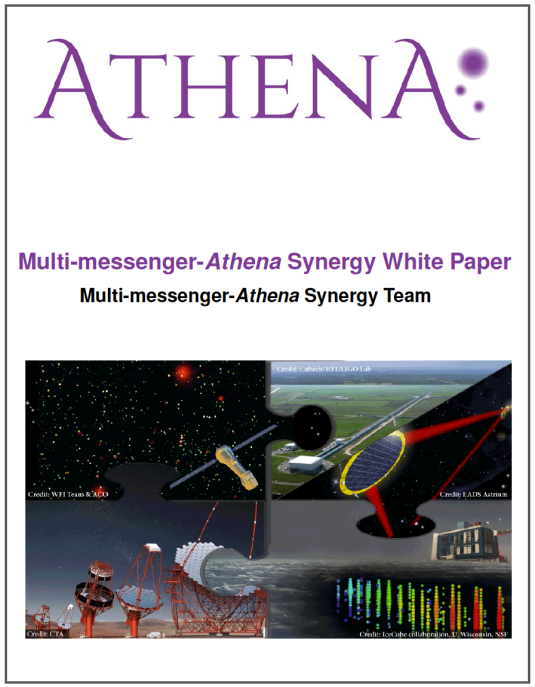
- **handling of any reaction to internal and external alerts by CTAO**
  - All functions planned to be compatible with **international standards to ensure interoperability**

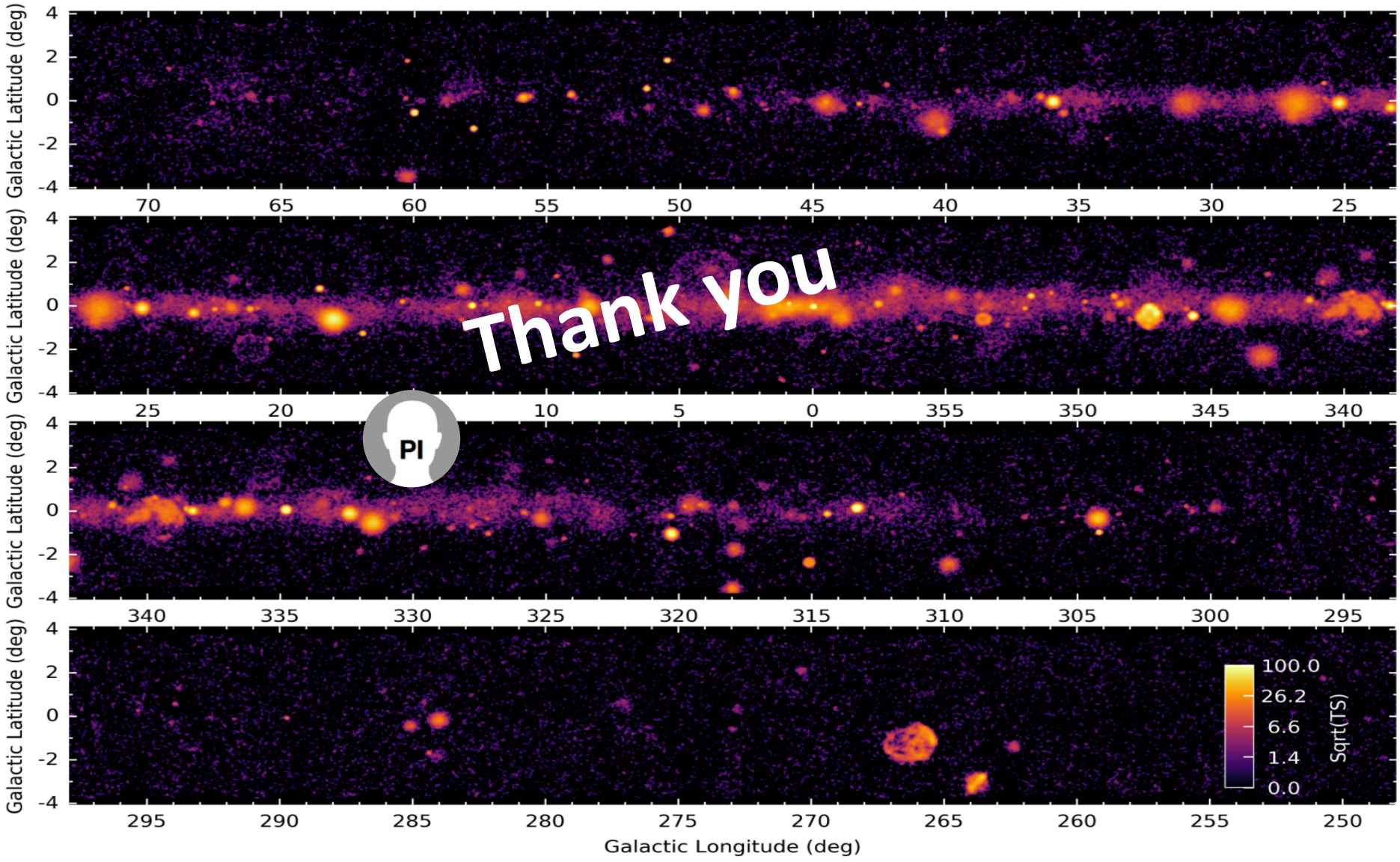
Synergies with other facilities

- **MoU CTAO-SKAO about to be signed**
  - Exchange of internal documents (data policies, architectures, ops concepts,…)
  - White paper CTA-SKA synergies

- **MoU CTAO-EGO signed in 2016**

- A series of white/yellow papers exploring the synergies with future observatories
  - Theseus
  - Athena




Galactic Latitude (deg)
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Thank you
PI
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