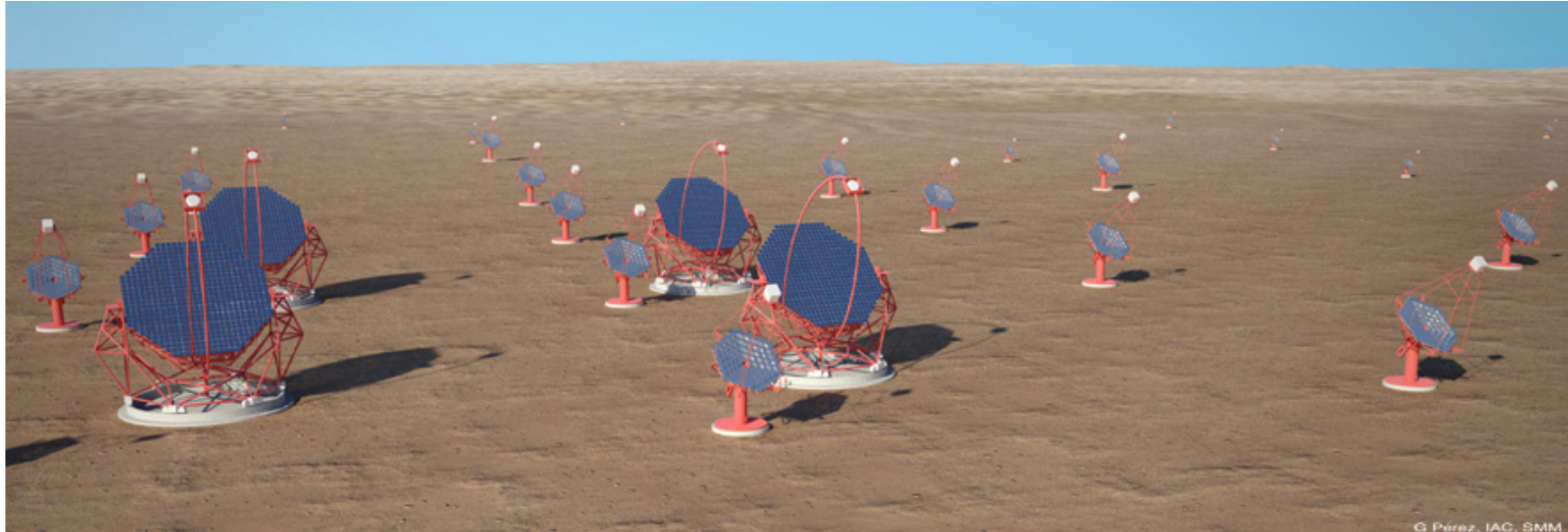
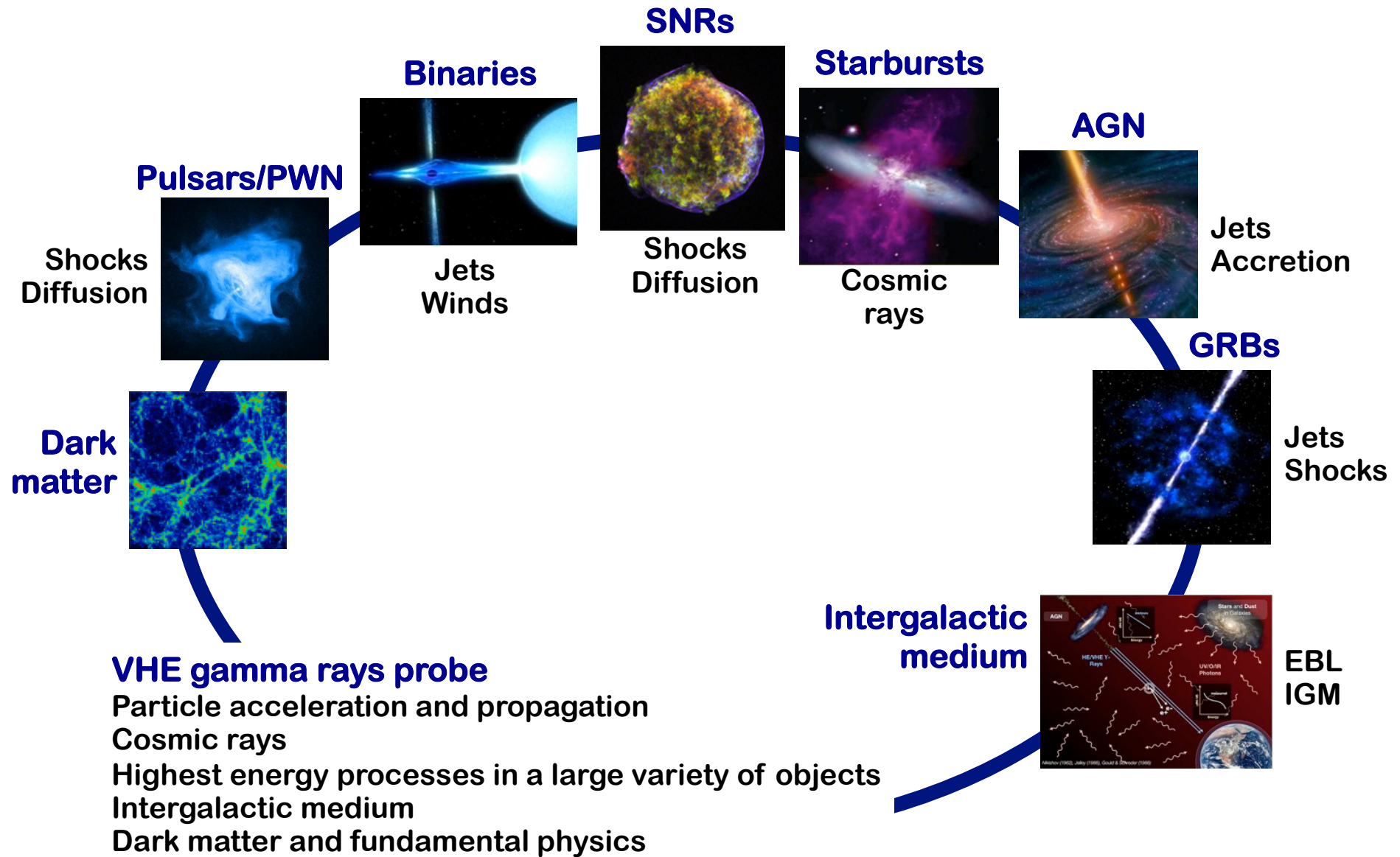


# The Cherenkov Telescope Array



An observatory for ground-based gamma-ray astronomy

**Jürgen Knödseder**

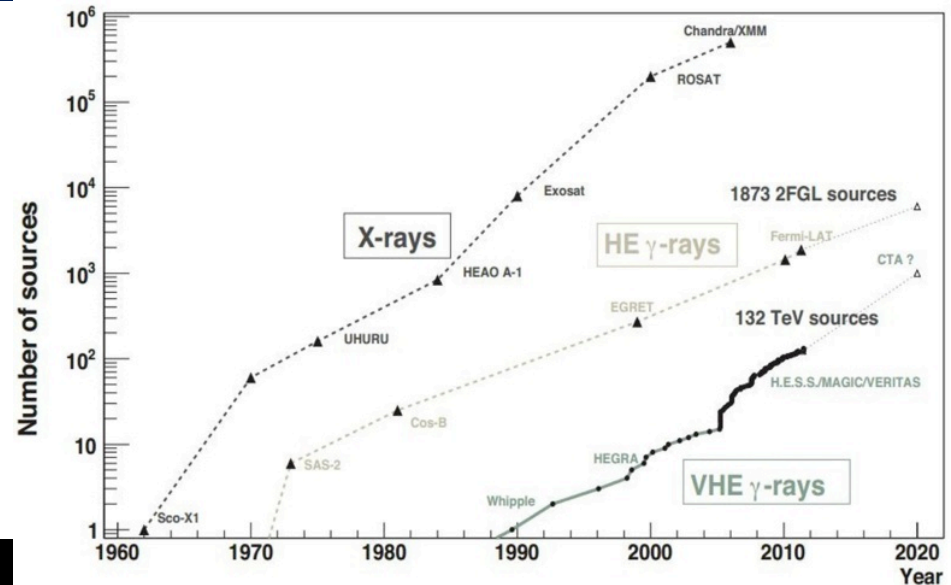


## Source count evolution

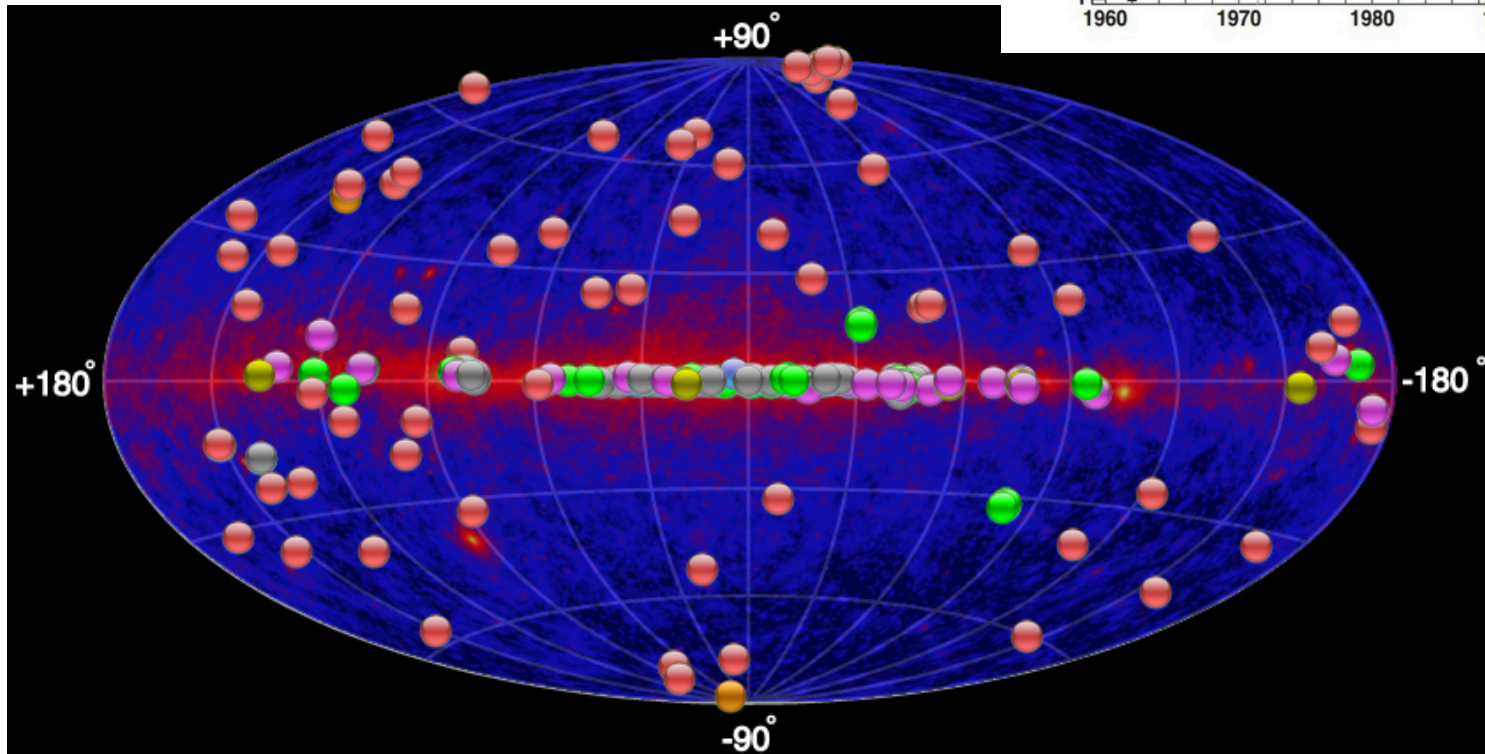
2000: 10 sources (HEGRA)

2010: 100 sources (HESS, MAGIC, VERITAS)

2020: 1000 sources (CTA)?

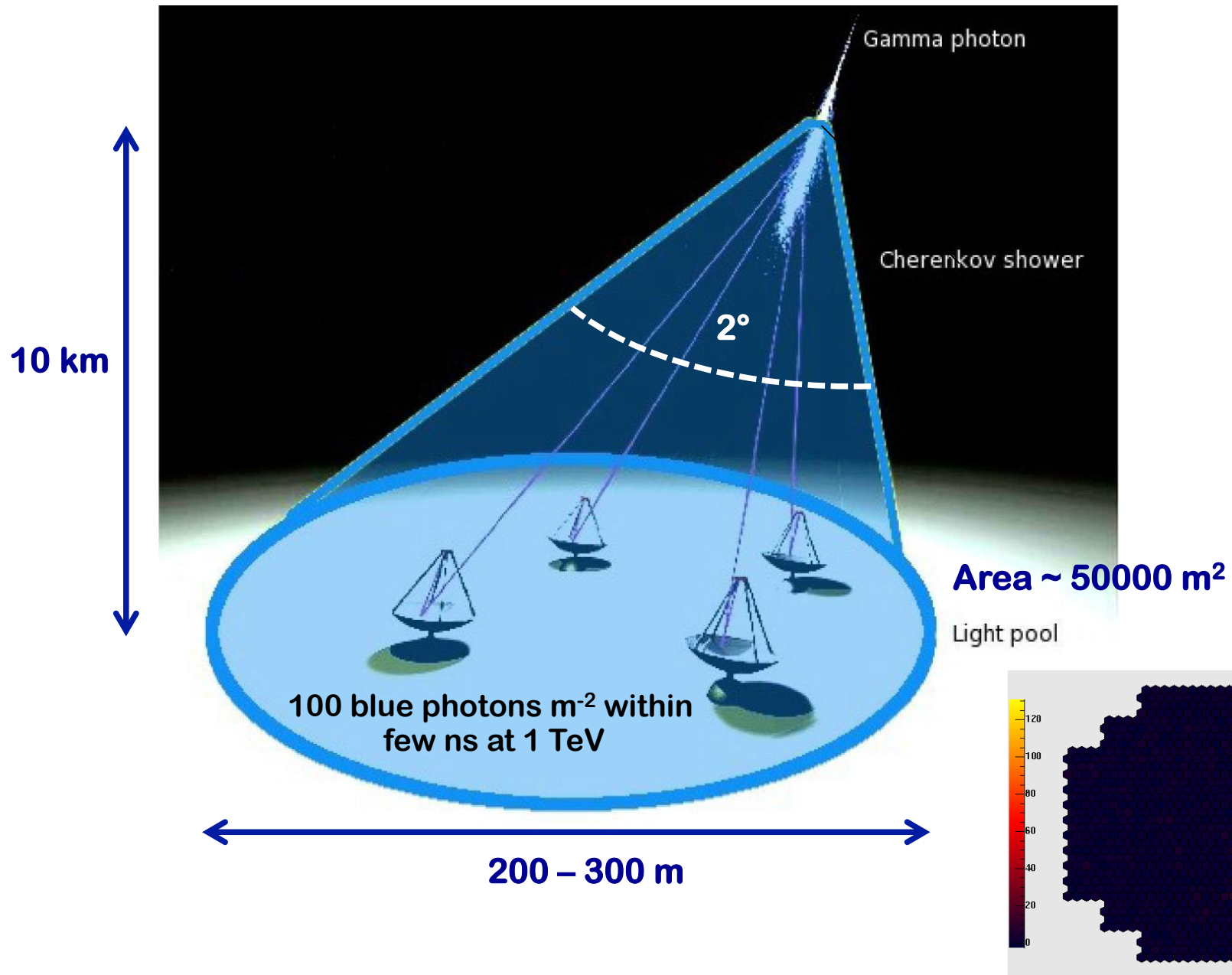


S. Funk (2011)

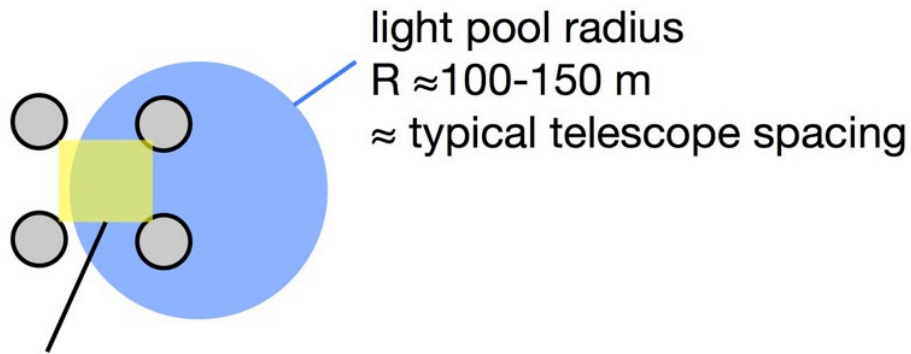
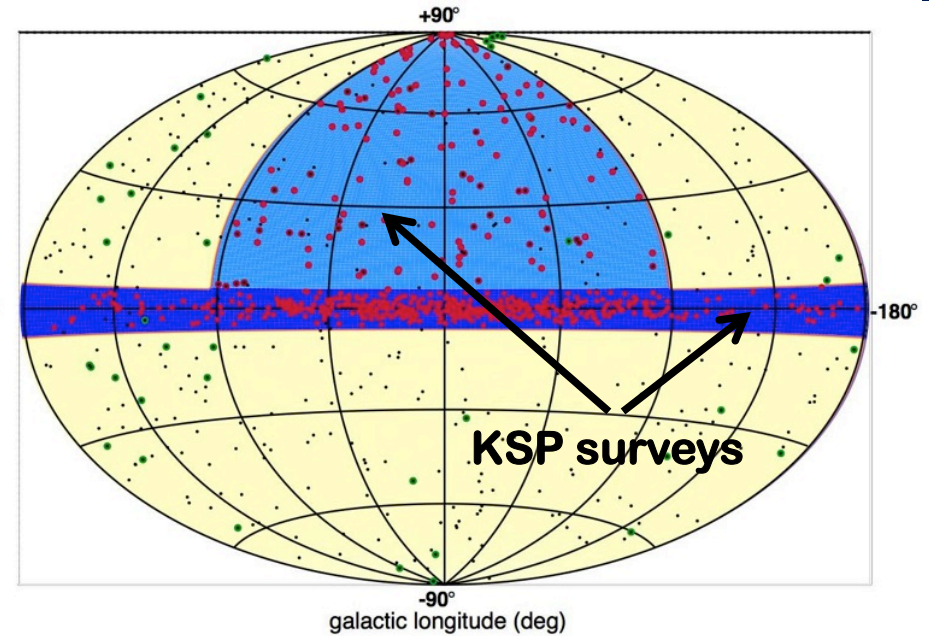
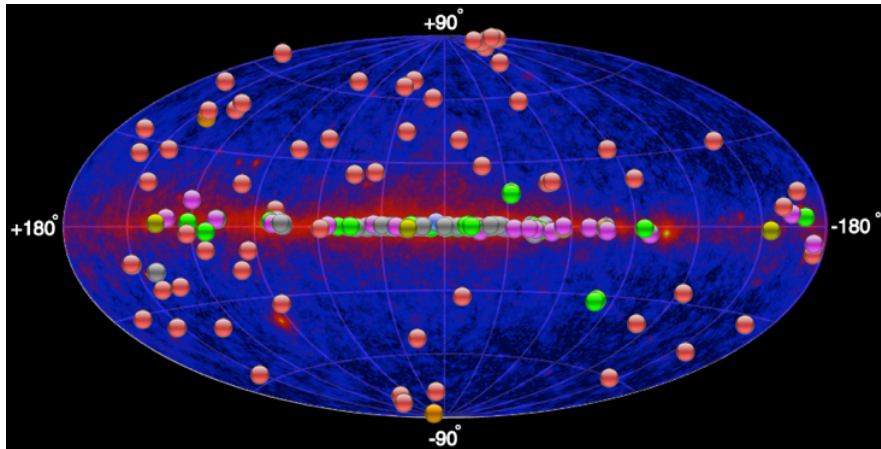


TeVCat  
(S. Wakely, D. Horan)

# Detecting VHE gamma rays

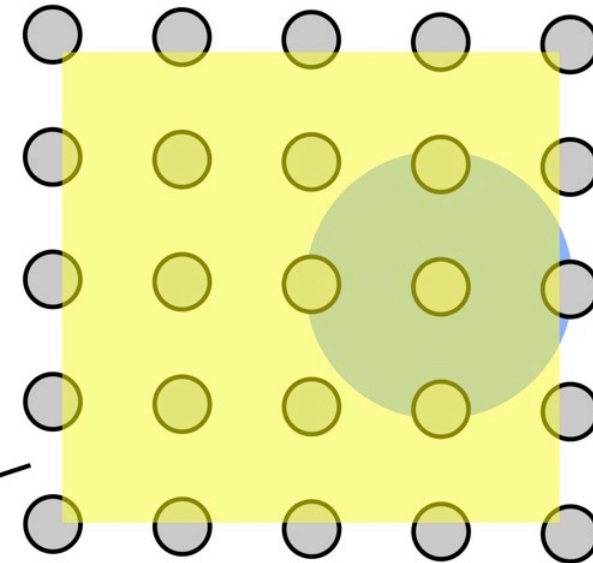


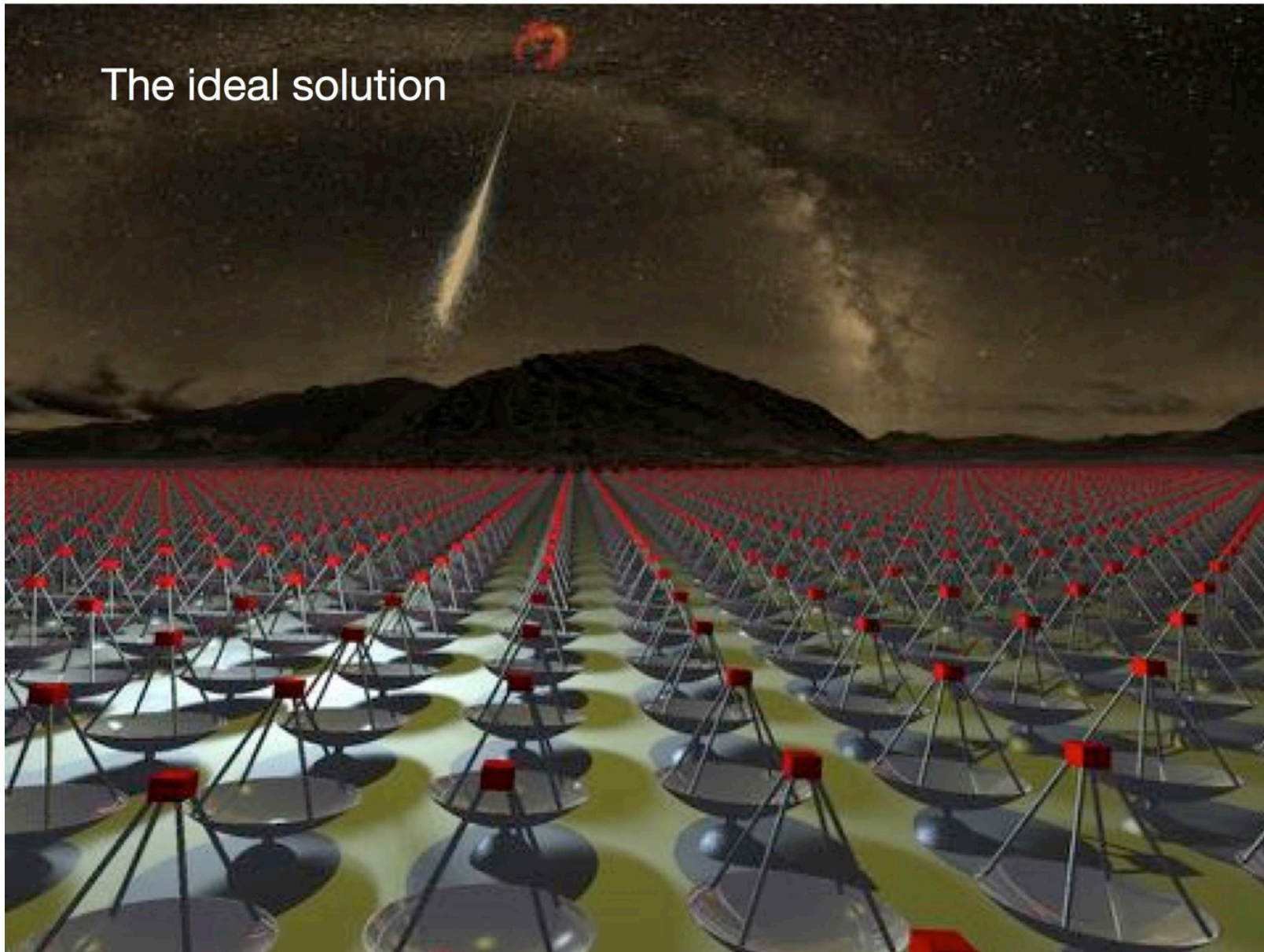
# From current arrays to CTA



Sweet spot for best triggering and reconstruction:  
 most showers miss it!

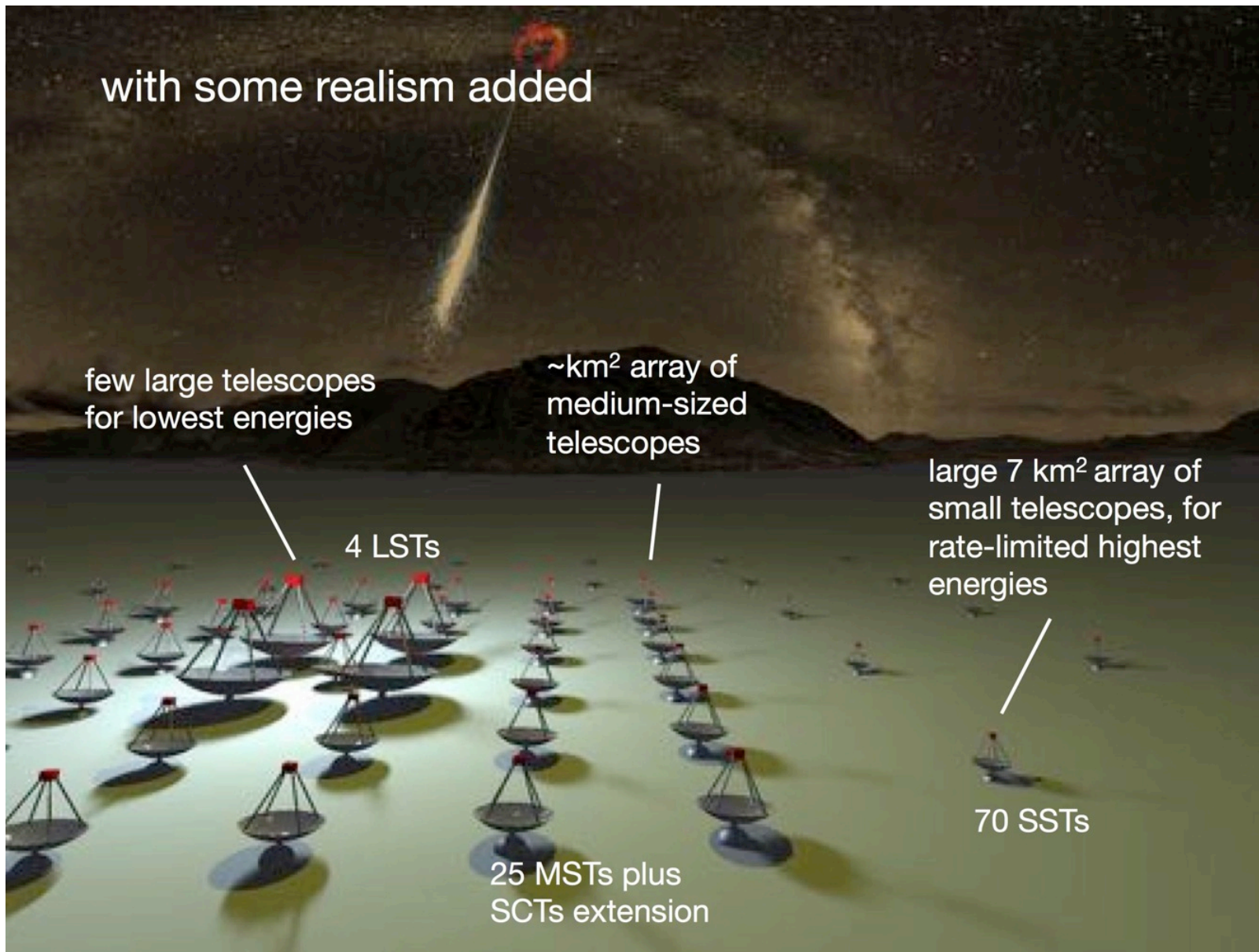
large detection area  
 more images per shower  
 lower trigger threshold





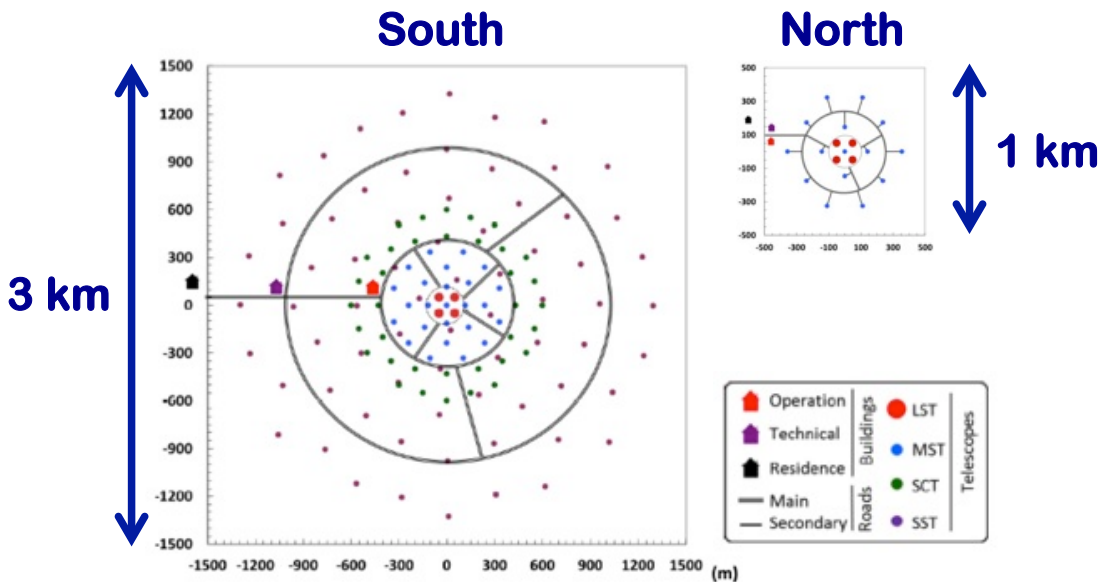
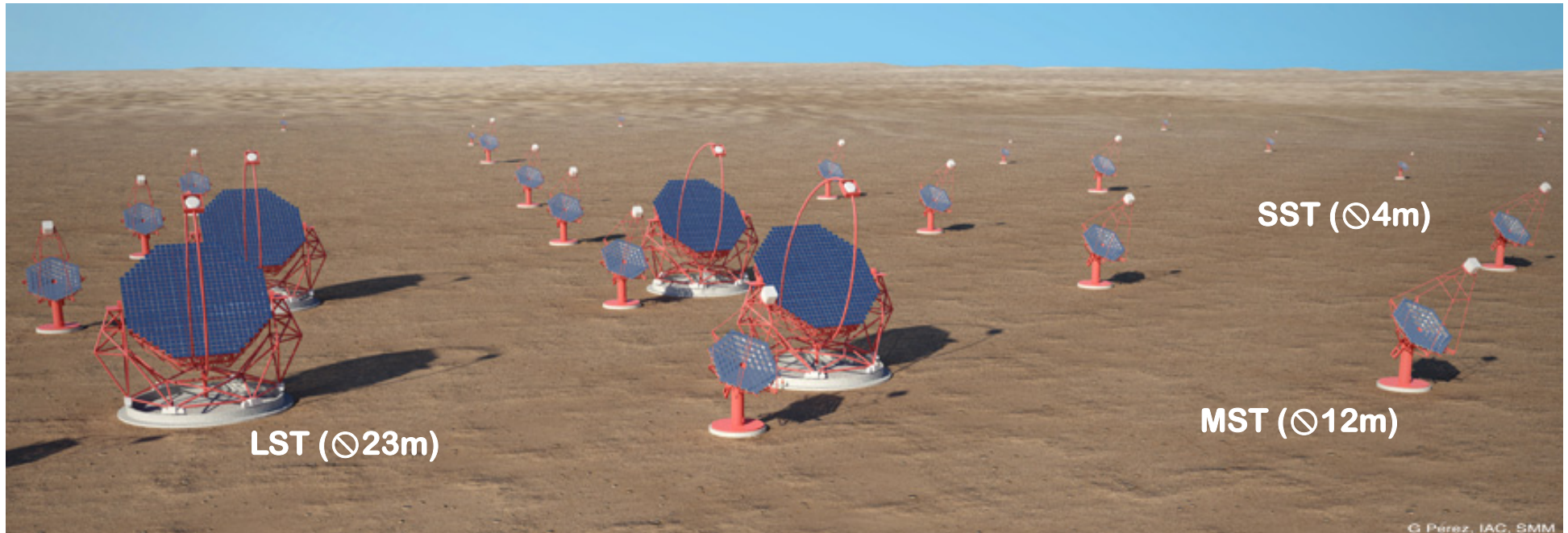
W. Hofmann

# A next generation VHE facility

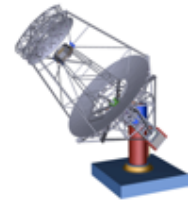


W. Hofmann

# The CTA Observatory



SCT (10m)

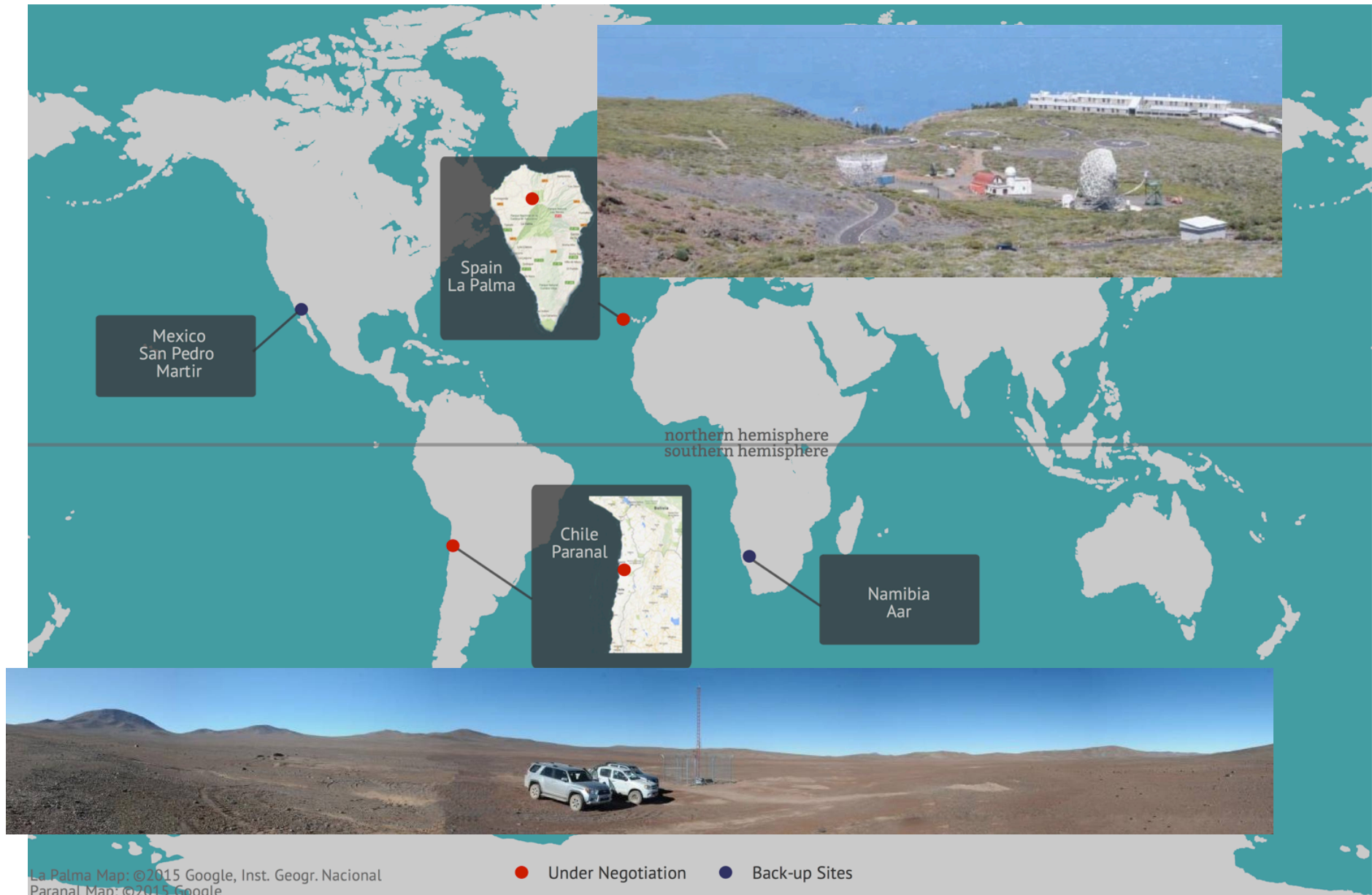


## Characteristics

- 2 sites (north & south)
- 3 telescope size classes
- About 120 telescopes in total
- South U.S. extension with about 25 SCT telescopes

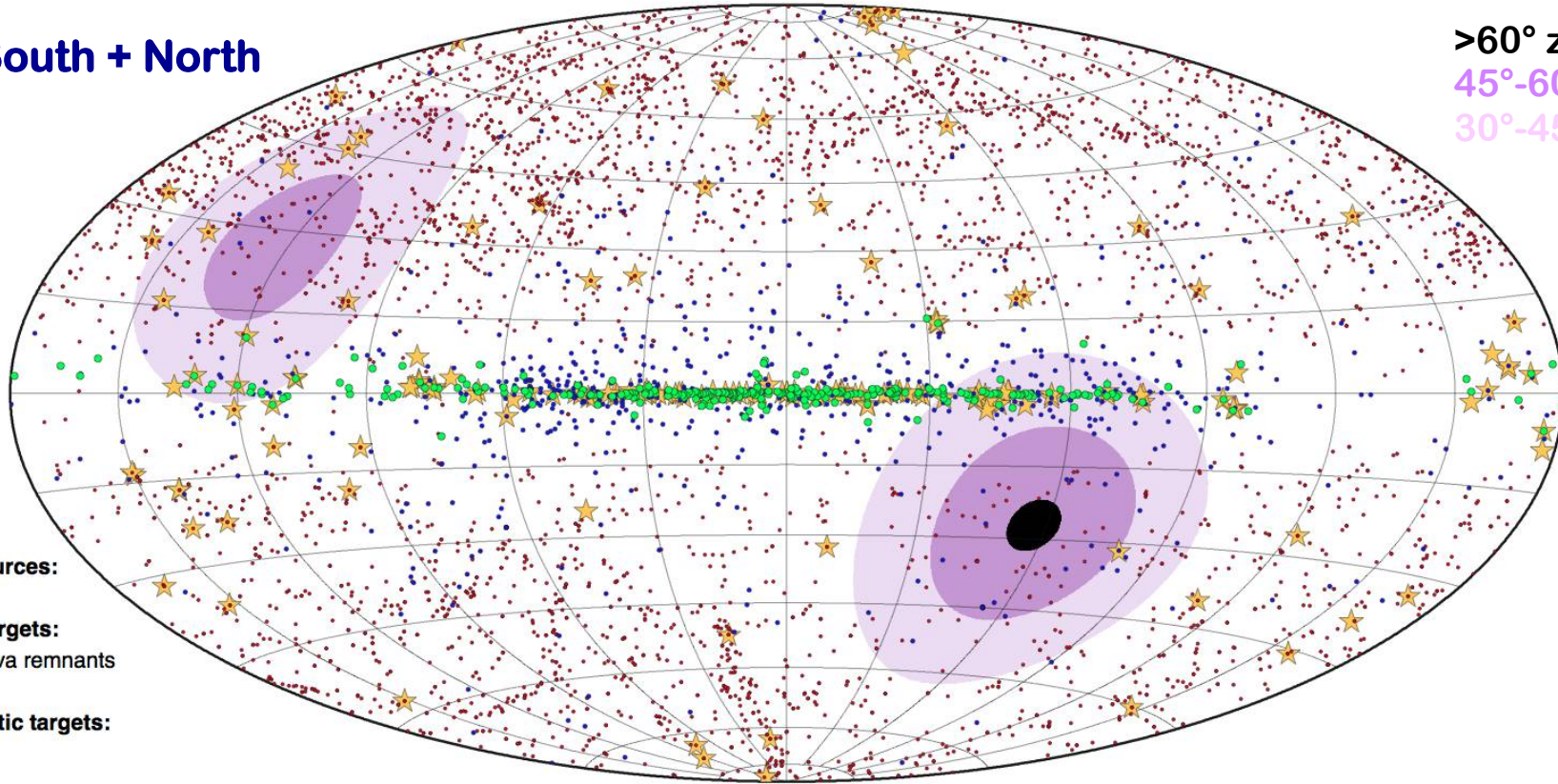


# CTA sites



## South + North

>60° zenith  
45°-60°  
30°-45°



**Known sources:**

★ TeVCat

**Galactic targets:**

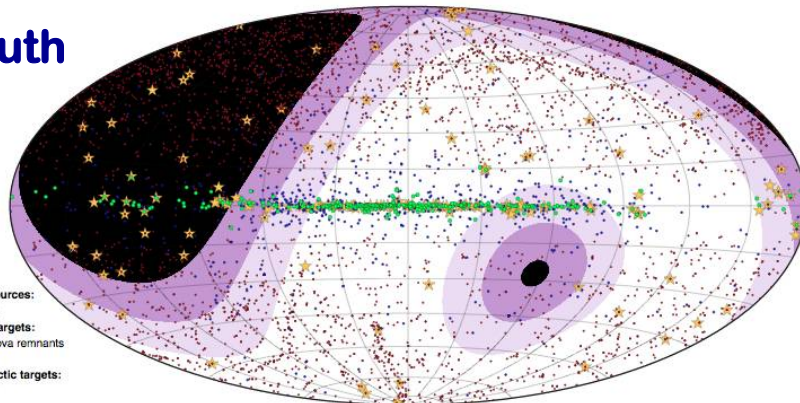
● Supernova remnants

● Pulsars

**Extragalactic targets:**

● Blazars

## South



**Known sources:**

★ TeVCat

**Galactic targets:**

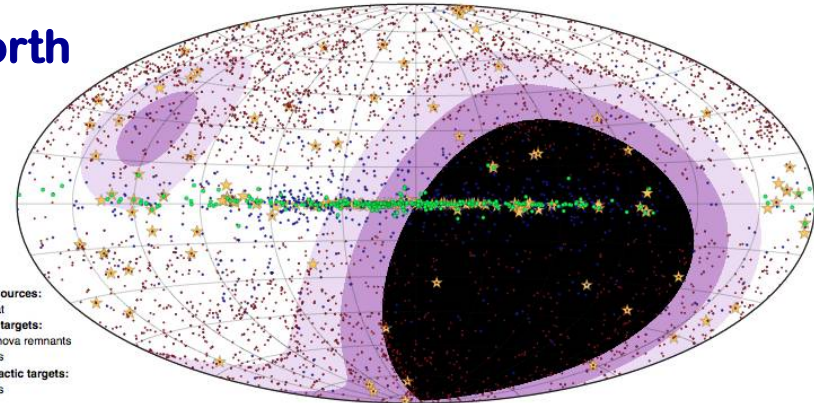
● Supernova remnants

● Pulsars

**Extragalactic targets:**

● Blazars

## North



**Known sources:**

★ TeVCat

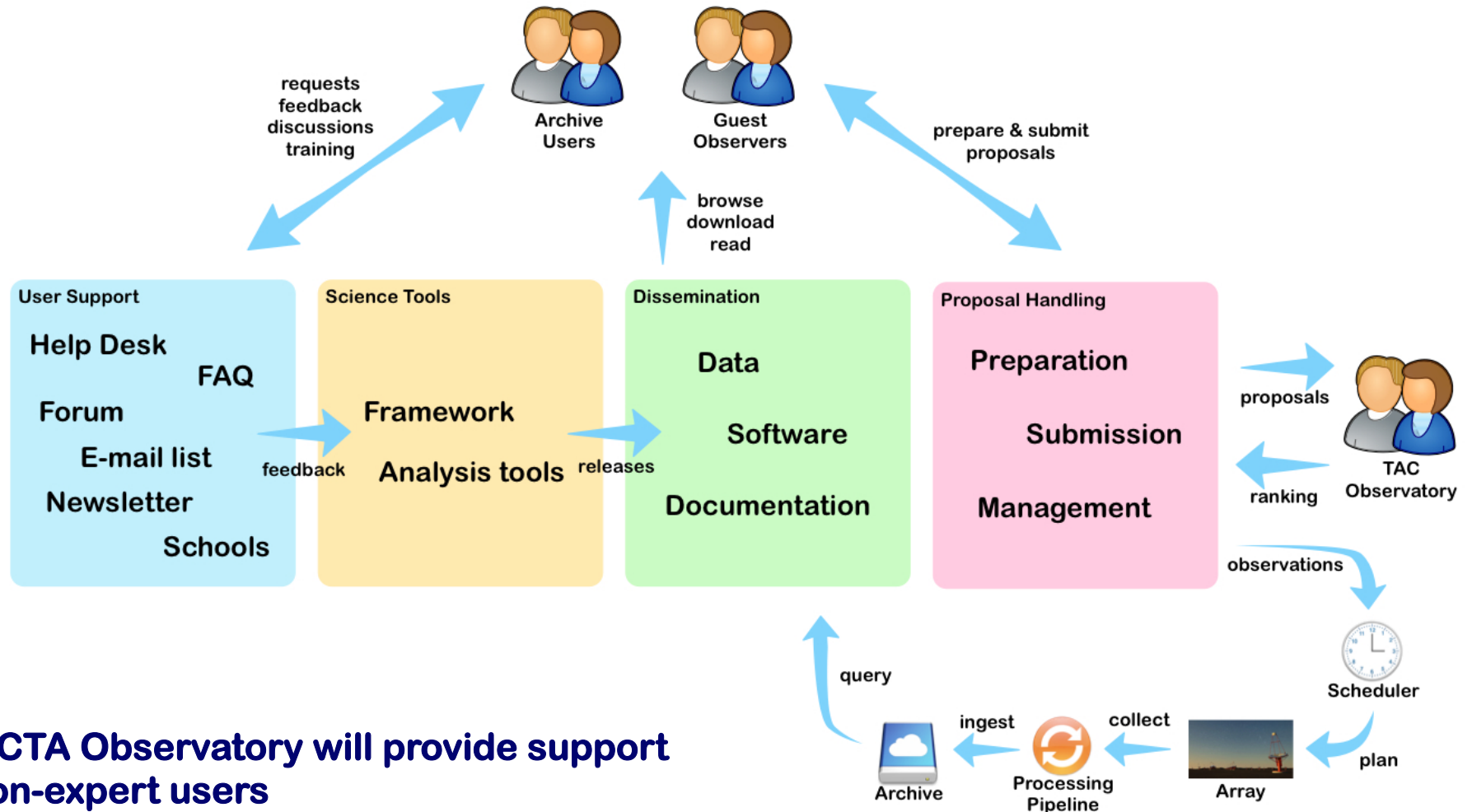
**Galactic targets:**

● Supernova remnants

● Pulsars

**Extragalactic targets:**

● Blazars



**The CTA Observatory will provide support to non-expert users**

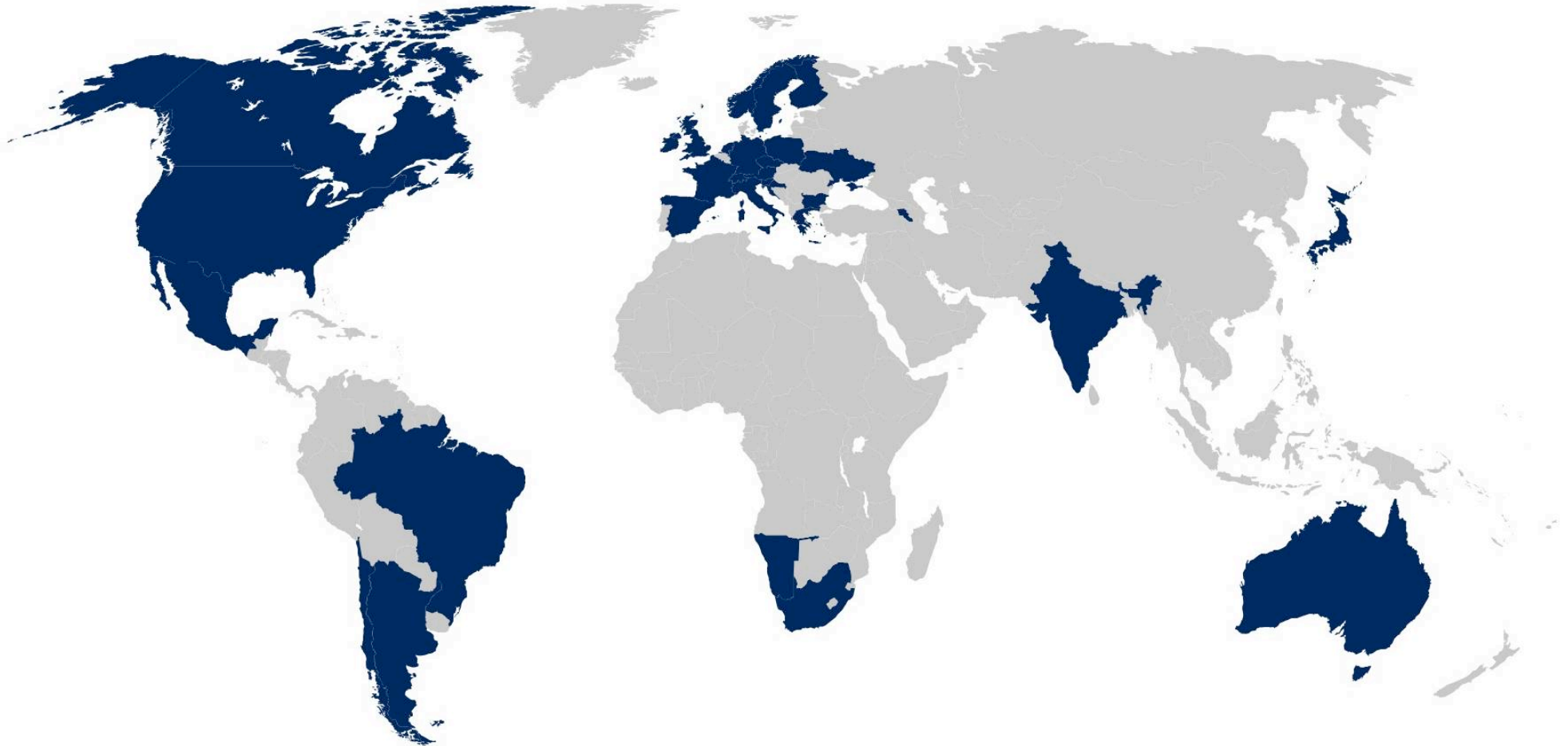
Proposal preparation & submission tools (TAC evaluation)

Calibrated, reconstructed & reduced event data (FITS)

Software to analyse data (Fermi-LAT like)

User documentation

Help Desk, Knowledge, Training



## CTA Consortium members status

1281 members  
413 FTE

## CTA Consortium members come from

31 countries  
91 parties  
194 institutes



## Science drivers

Lowest energies ( $< 200$  GeV)  
Transient phenomena  
DM, AGN, GRB, pulsars

## Characteristics

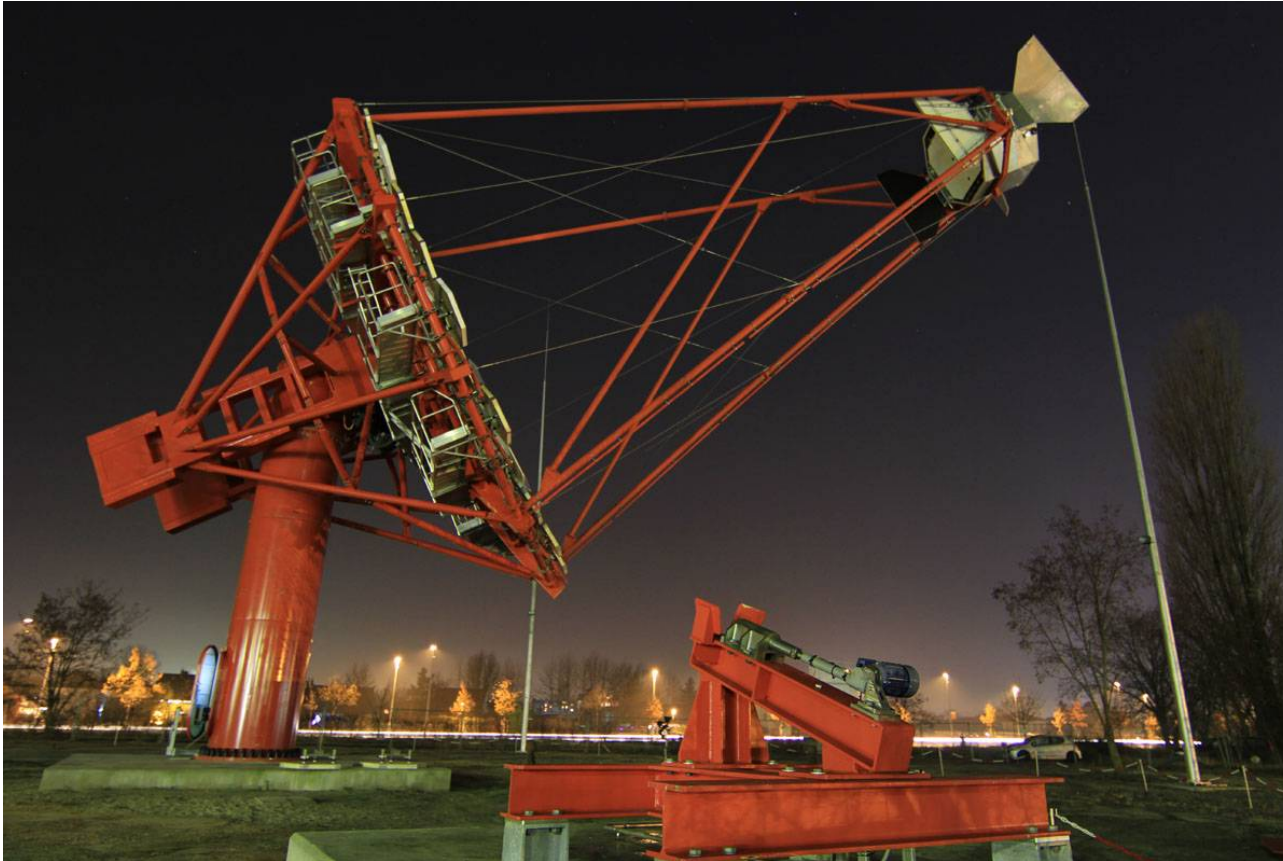
Parabolic design  
23 m diameter  
370 m<sup>2</sup> effective mirror area  
28 m focal length  
1.5 m mirror facets  
4.5° field of view  
0.11° PMT pixels  
active mirror control  
Carbon-fibre arch structure (fast repointing)

## Array layout

South site: 4 LST  
North site: 4 LST

## Status

Some elements prototyped  
First full telescope under construction in  
La Palma



## Science drivers

Mid energies (100 GeV – 10 TeV)  
DM, AGN, SNR, PWN, binaries,  
starbursts, EBL, IGM

## Characteristics

Modified Davies-Cotton design  
12 m diameter  
90 m<sup>2</sup> effective mirror area  
1.2 m mirror facets  
16 m focal length  
8° field of view  
0.18° PMT pixels

## Array layout

South site: 25 MST  
North site: 15 MST

## Status

Telescope prototyped (Berlin-Adlershof)  
Prototype cameras under construction (2 types: NectarCAM & FlashCam)

**SST 1M**



**ASTRI**



**GCT**



## Science drivers

Highest energies ( $> 5$  TeV)  
Galactic science, PeVatrons

## Array layout

South site: 70 SST  
North site: -



## Characteristics

Davies-Cotton design

4 m diameter

8.5 m<sup>2</sup> effective mirror area

5.6 m focal length

9° field of view

0.24° SiPM pixels

## Status

Prototype telescope built in Krakow

Camera prototype under construction





## Characteristics

Schwarzschild-Couder design

4.3 m primary diameter

1.8 m secondary diameter (monolithic)

6 m<sup>2</sup> effective mirror area

2.2 m focal length

9.6° field of view

0.17° SiPM pixels

## Status

Prototype telescope built on mount Etna

Camera prototype under construction



## Characteristics

Schwarzschild-Couder design

4 m primary diameter

2 m secondary diameter

6 m<sup>2</sup> effective mirror area

2.3 m focal length

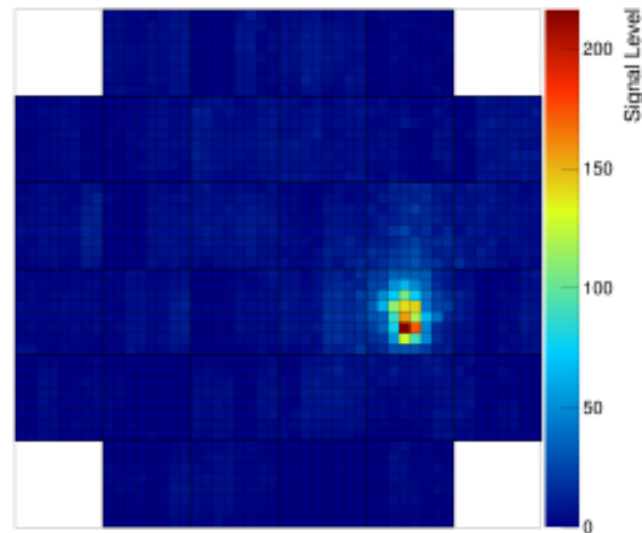
8.6° field of view

0.16° SiPM pixels

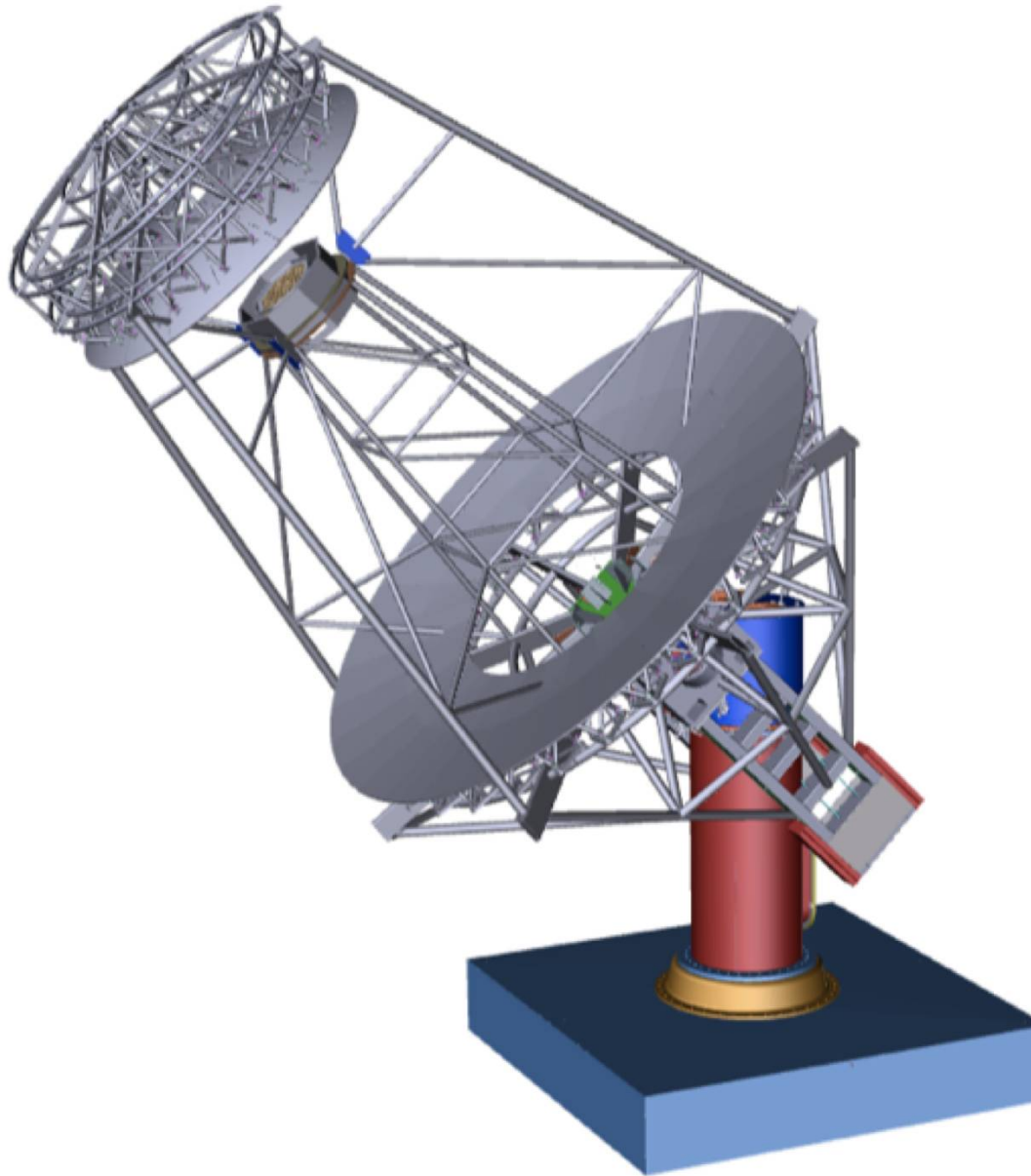
## Status

Prototype telescope structure built in Meudon (near Paris)

Inaugurated using a MAPMT-based CHEC camera



First CTA light



## Science drivers

Mid energies (200 GeV – 10 TeV)  
DM, AGN, SNR, PWN, binaries,  
starbursts, EBL, IGM

## Characteristics

Schwarzschild-Couder design  
9.7 m primary diameter  
5.4 m secondary diameter  
40 m<sup>2</sup> effective mirror area  
5.6 m focal length  
8° field of view  
0.07° PMT pixels

## Array layout

South site: 24 SCT  
North site: -

## Status

Prototype telescope, including camera,  
under construction on VERITAS site

## Sensitivity gain

- access VHE populations across entire Galaxy
- sample fast variability (AGN, GRB)

## FoV > 8°

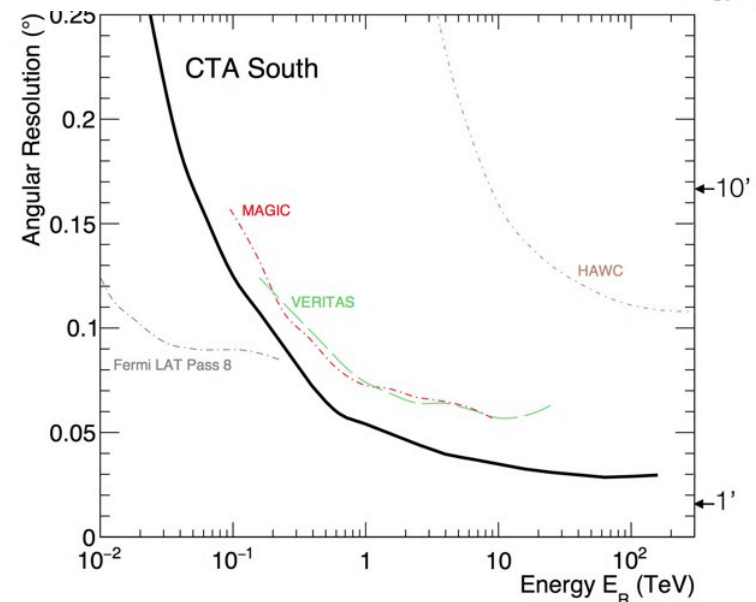
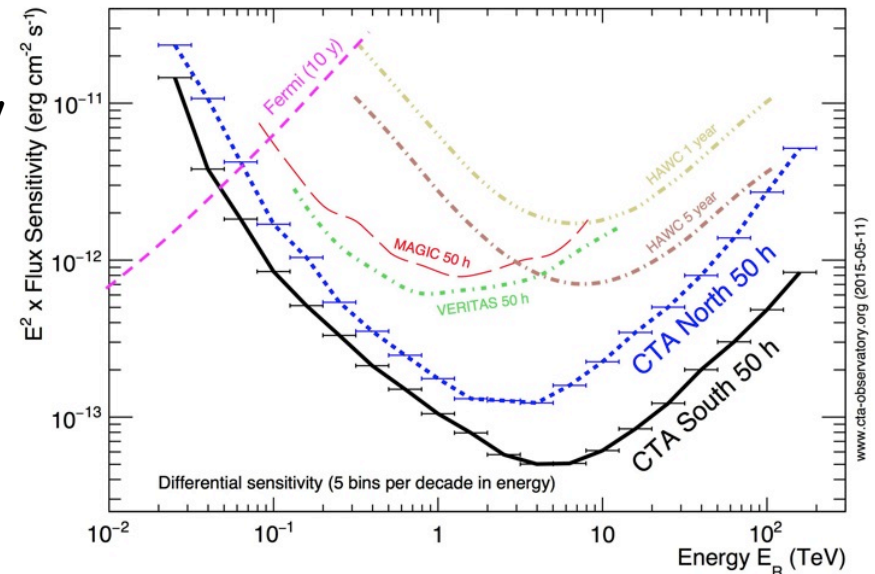
- measure diffuse emissions
- efficient survey of large fields

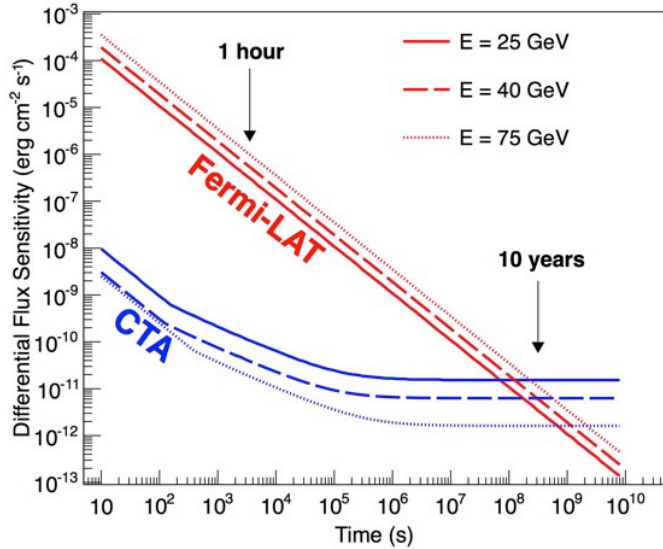
## Arcmin angular resolution

- resolve extended sources (SNR, starbursts)

## Broad energy coverage

- < 100 GeV to reach higher redshifts
- > 10 TeV to search for PeVatrons



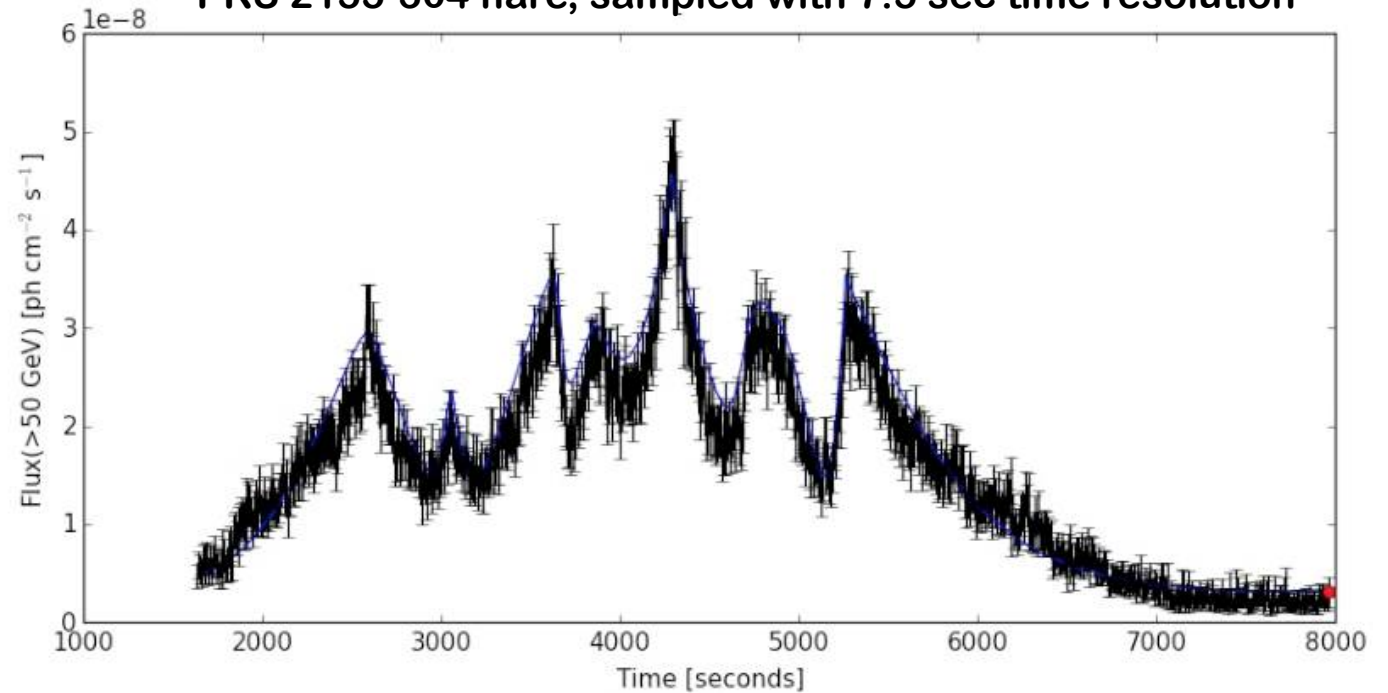
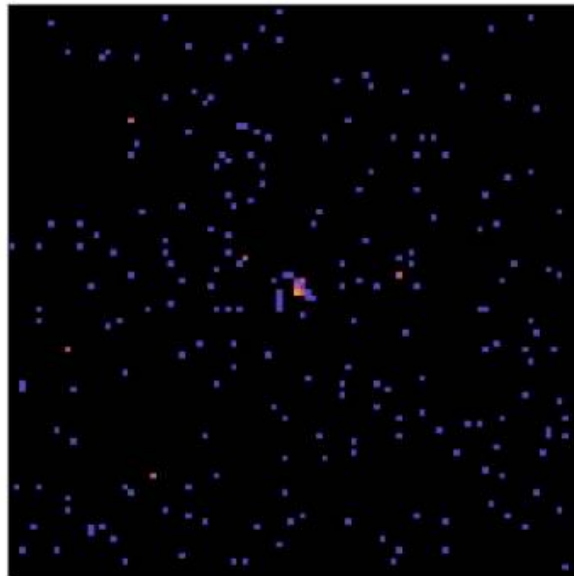


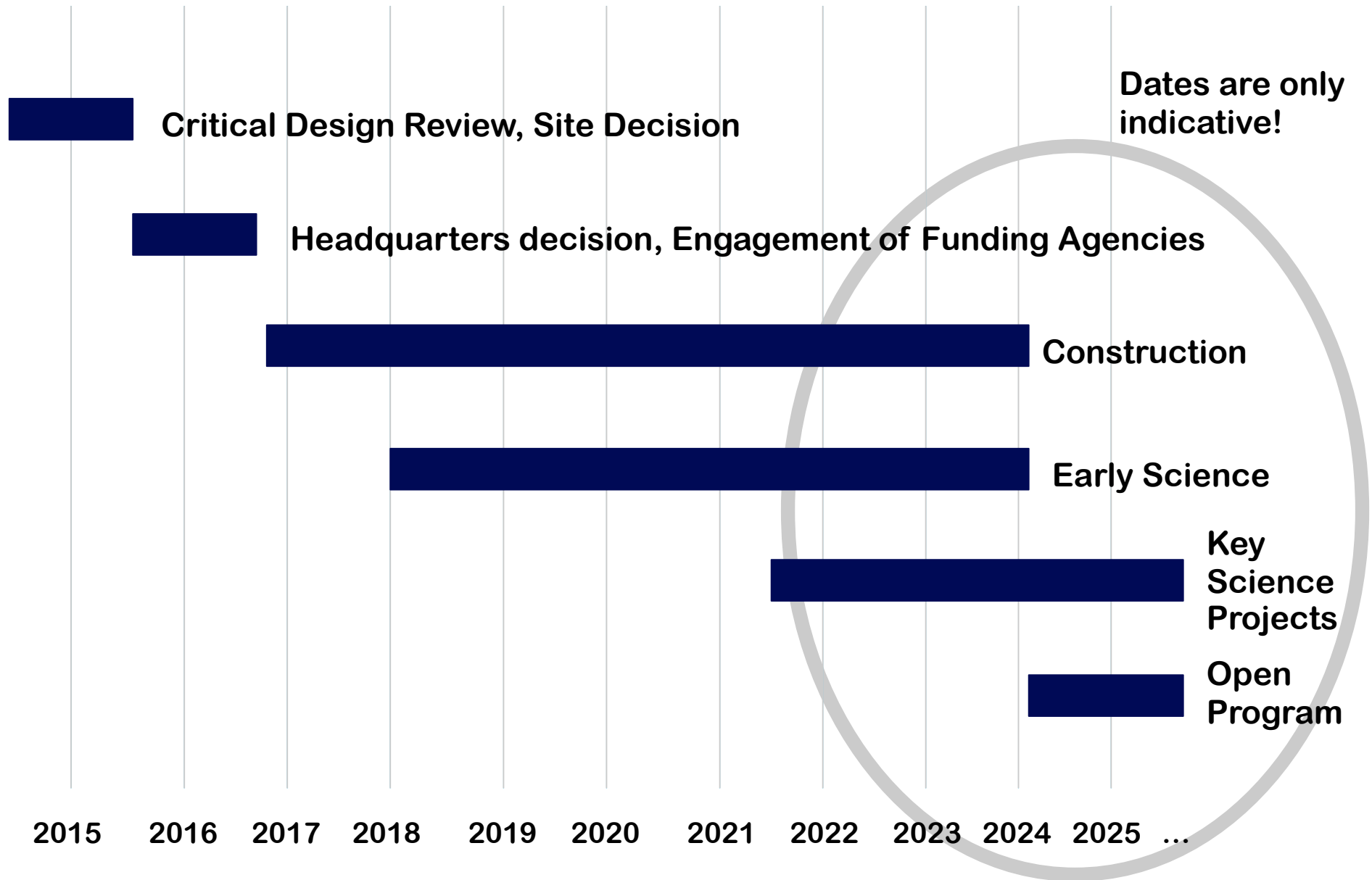
## CTA as a transient factory

Huge advantage over Fermi-LAT in energy range of overlap for seconds to week timescale phenomena

## Example: PKS 2155-304

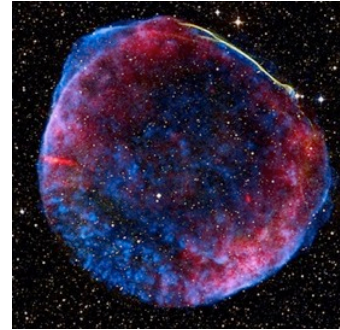
PKS 2155-304 flare, sampled with 7.5 sec time resolution





## Cosmic Particle Acceleration

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



## Probing Extreme Environments

Processes close to neutron stars and black holes?  
Processes in relativistic jets, winds and explosions?  
Exploring cosmic voids



## Physics frontiers – beyond the Standard Model

What is the nature of Dark Matter? How is it distributed?  
Is the speed of light a constant for high-energy photons?  
Do axion-like particles exist?

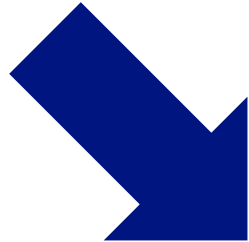


## **Key Science Programmes (executed by consortium)**

Ensure that important science questions for CTA are addressed in a coherent fashion and with a well-defined strategy

Conceived to provide legacy data sets for the entire community

Example: galactic, extragalactic and LMC surveys



## **Proposal-driven User Programme**

Deep investigation of known sources

Follow-up of KSP discovered sources

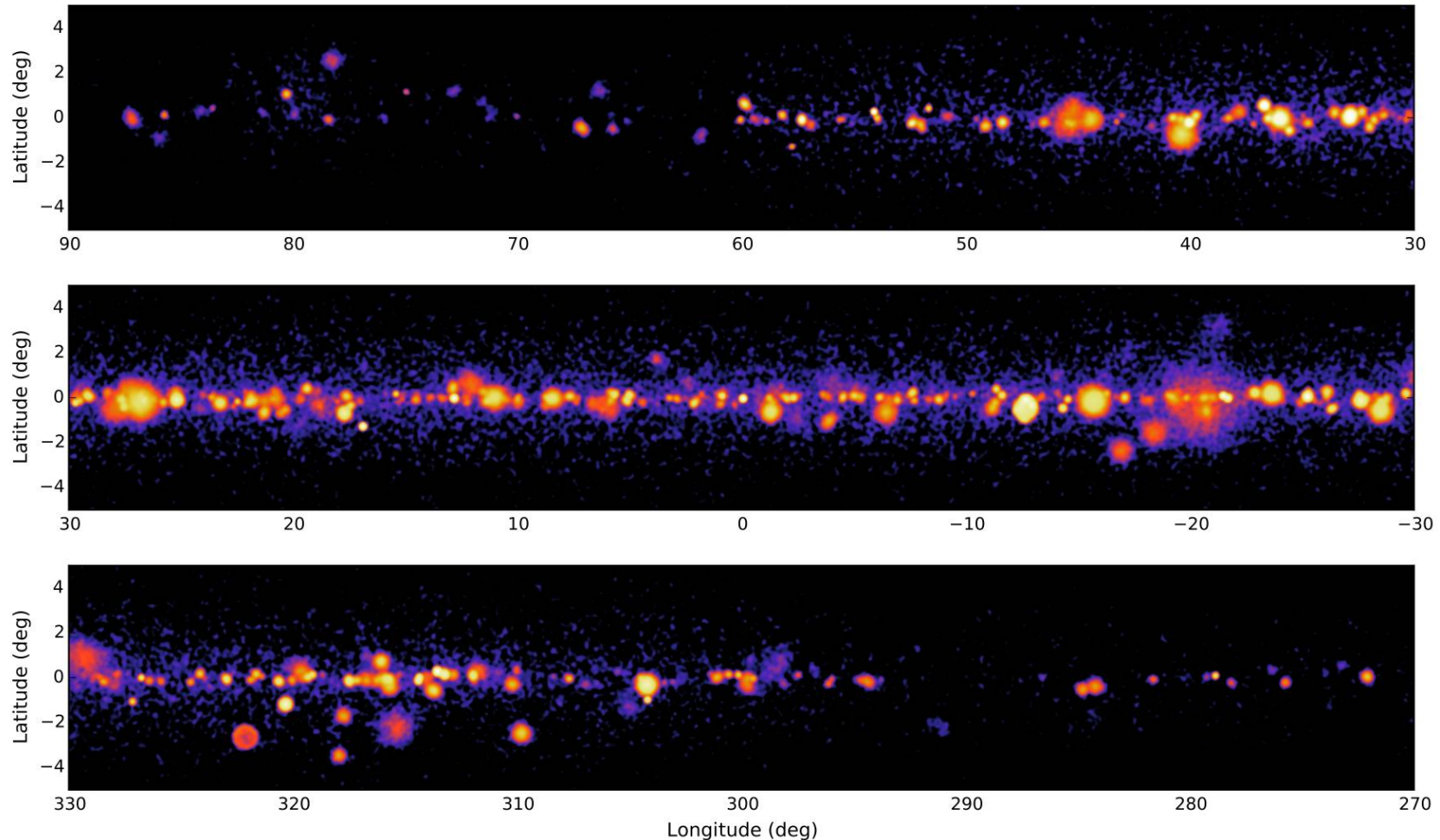
Multi-wavelength campaigns

Follow-up of ToOs from other wavebands or messengers

Search for new sources

...





## **Planned surveys: a deep view of the high-energy Universe**

Full galactic plane (1020 h)

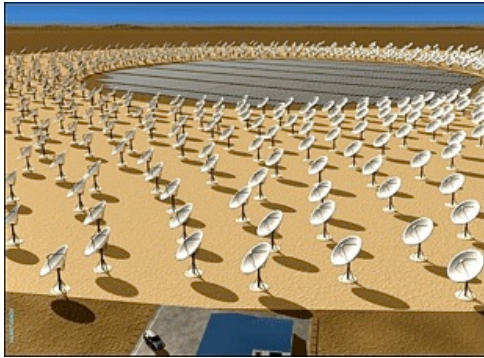
Deep survey of the Galactic Centre region (300 h on  $10^\circ \times 10^\circ$  region, 525 h on GC)

The Large Magellanic Cloud (340 h)

One-pi extragalactic survey down to 6 mCrab (1000 h)

# CTA Synergies

## SKA, LOFAR



Broad band coverage  
Alerts

## Virgo/LIGO



GW alerts

## SVOM



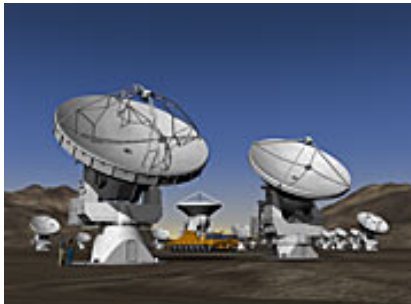
Alerts

## ASTROGAM

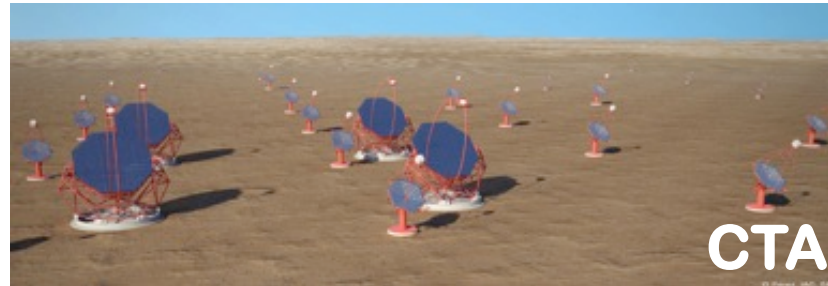


Alerts  
Cosmic rays  
Low-energy coverage

## ALMA



ISM ionisation  
BH jet imaging



CTA

## Fermi



Low-energy coverage  
Alerts

## HAWC

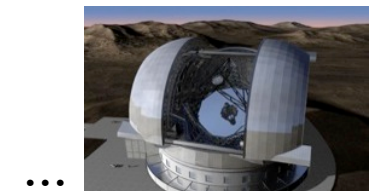


Sky survey  
Alerts

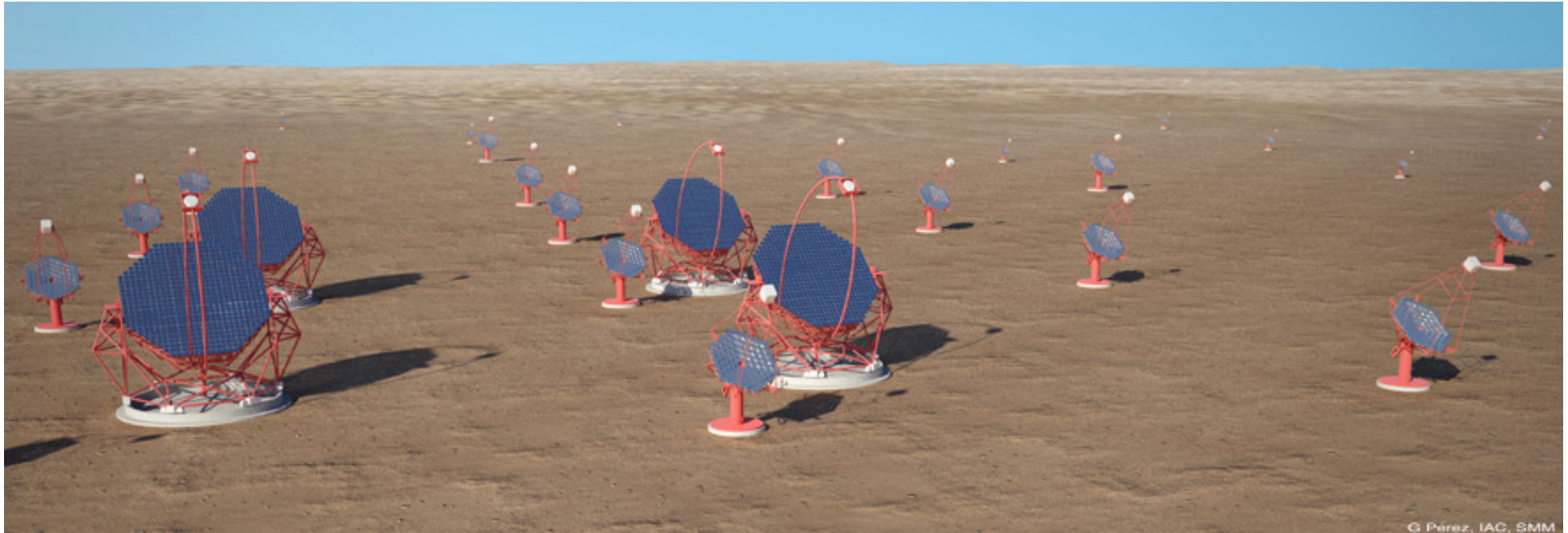
## Athena



Cosmic rays / SNR  
Jet-disk connection



...



**CTA will be a major research infrastructure for high-energy astronomy for the next decades**

**CTA science focuses on cosmic particle acceleration, extreme environment, and physics beyond the established horizon**

**A broad range of synergies exists with other scientific domains, and CTA will reach well beyond the traditional high-energy community**