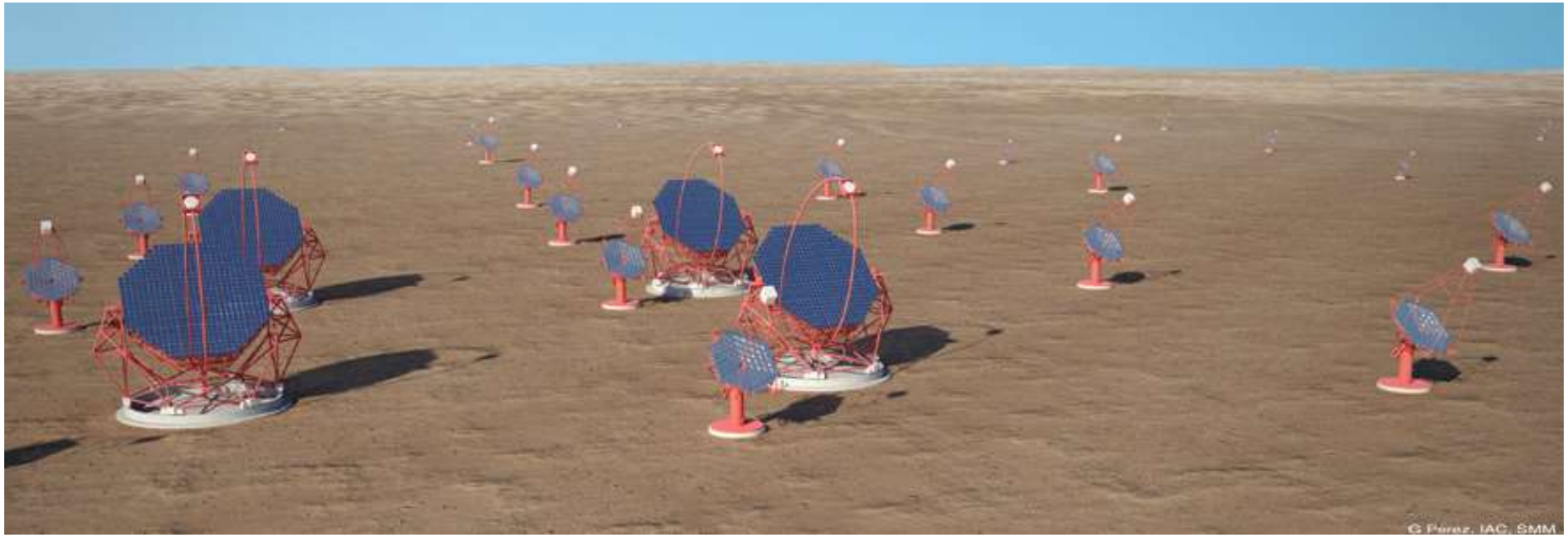
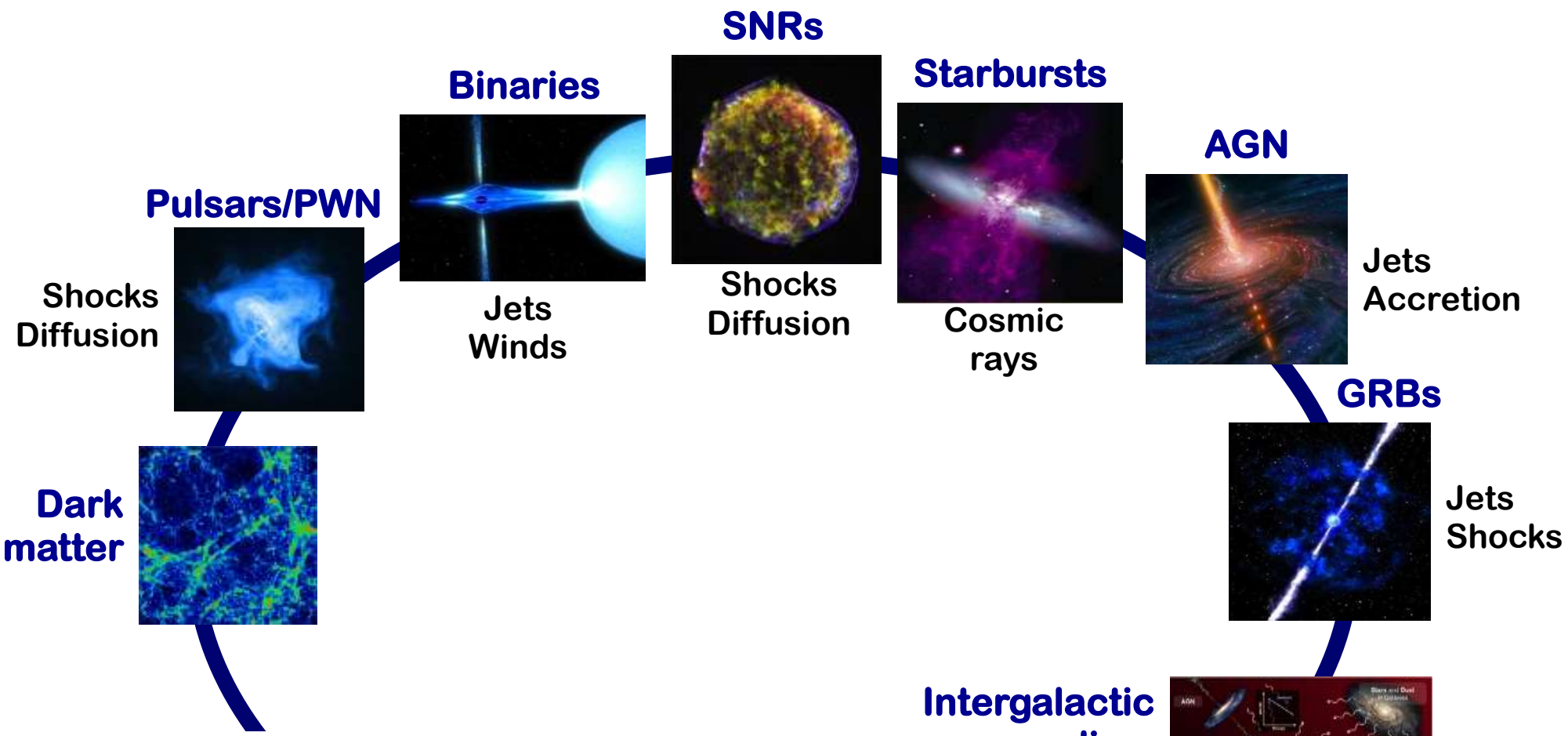
# The Cherenkov Telescope Array




An observatory for ground-based gamma-ray astronomy

**Jürgen Knödlseder**
**on behalf of the CTA Consortium**

# Astronomy with VHE gamma rays



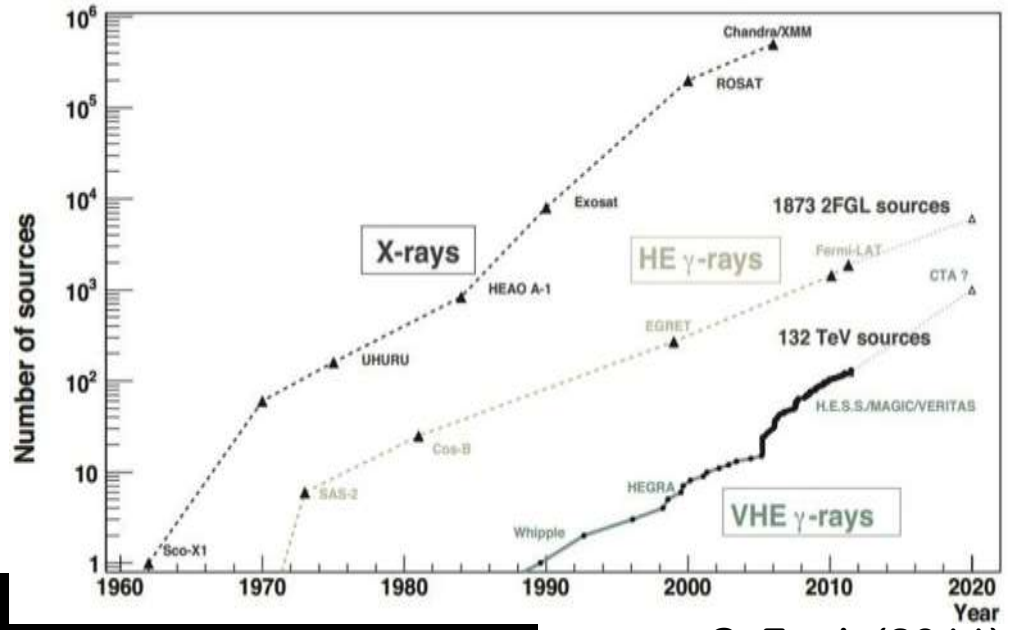

**VHE gamma rays probe**

Particle acceleration and propagation
Cosmic rays
Highest energy processes in a large variety of objects
Intergalactic medium
Dark matter and fundamental physics

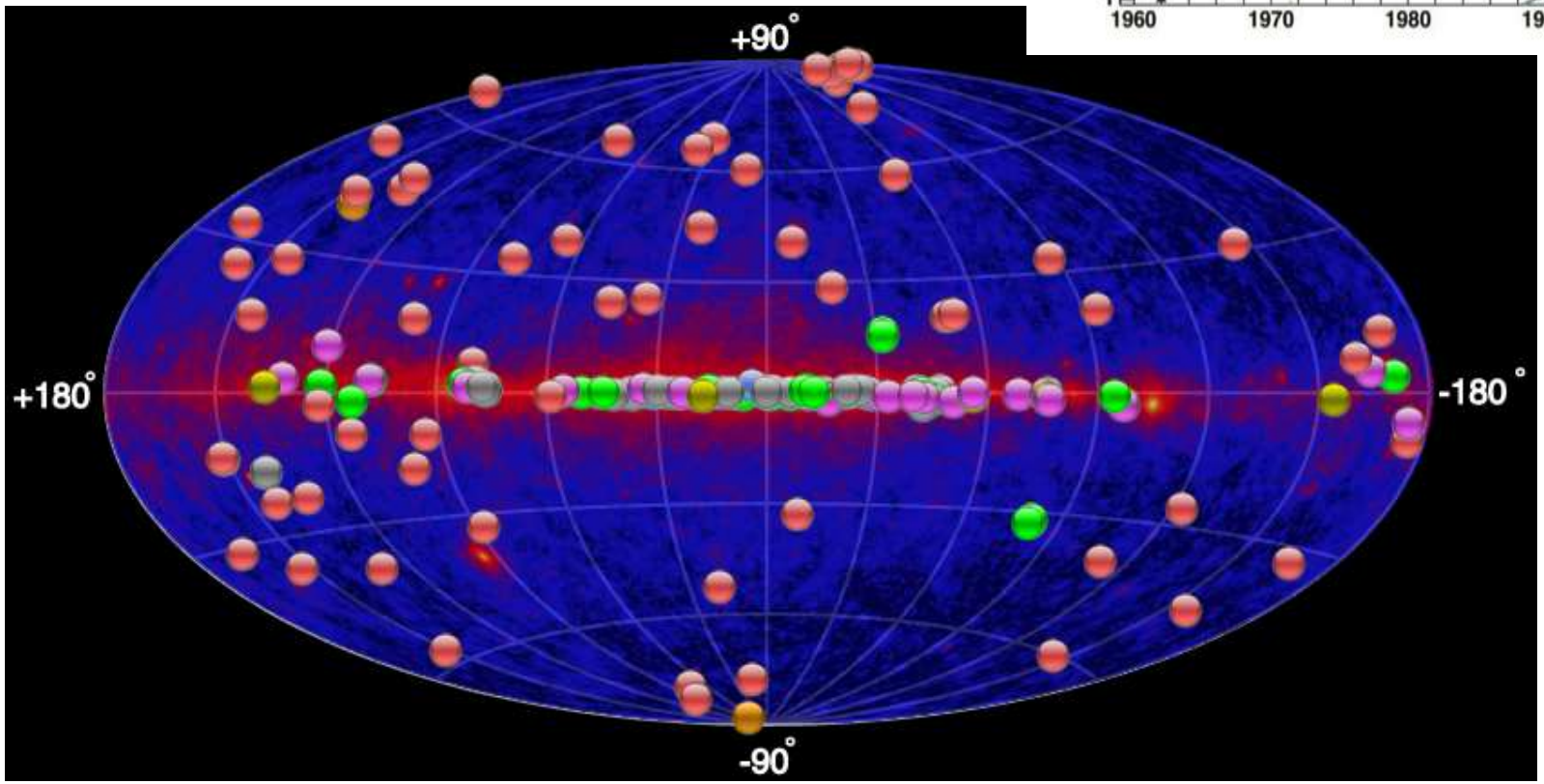
# The current VHE sky

## Source count evolution

2000: 10 sources (HEGRA)
2010: 100 sources (HESS, MAGIC, VERITAS)
2020: 1000 sources (CTA)?

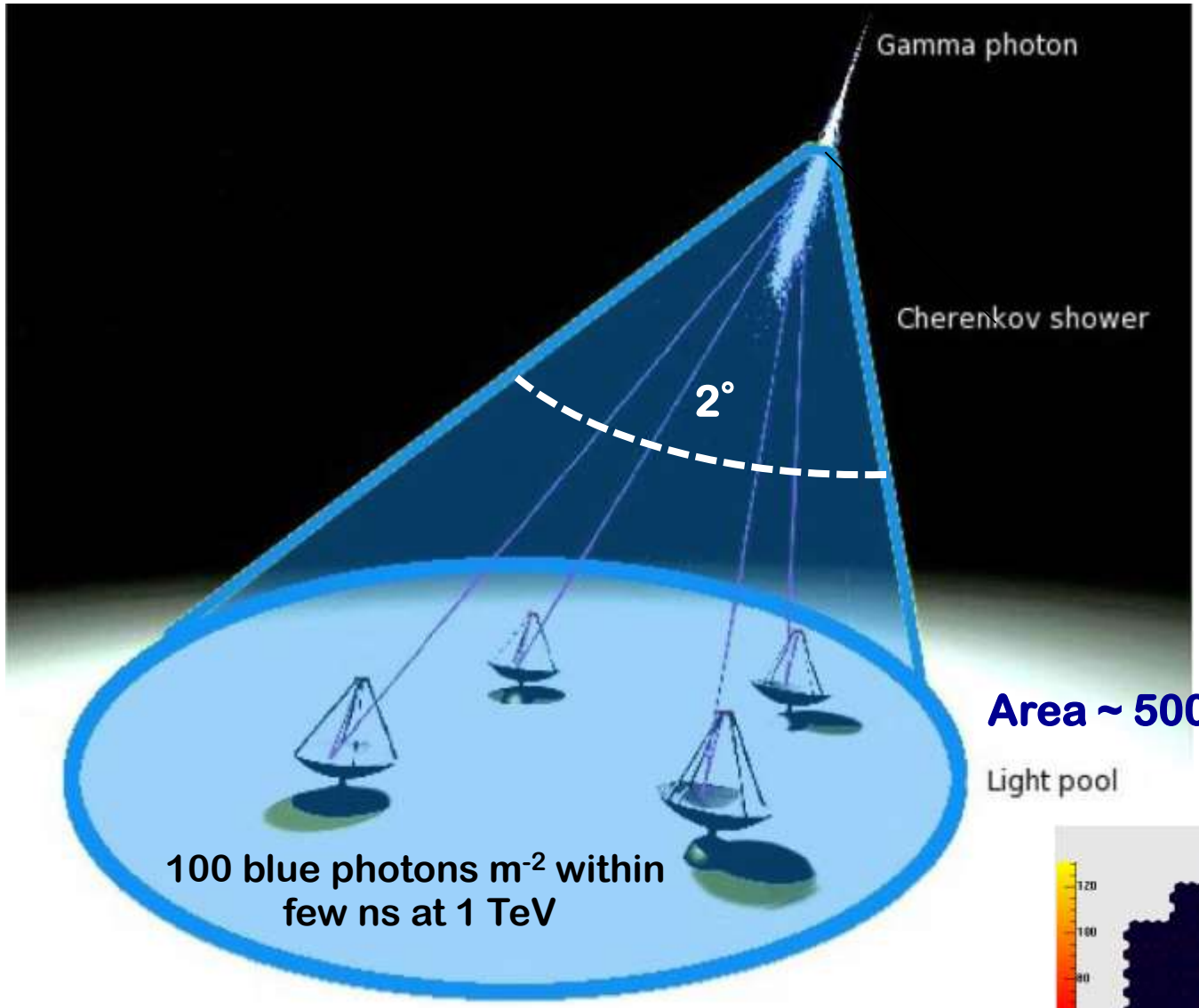


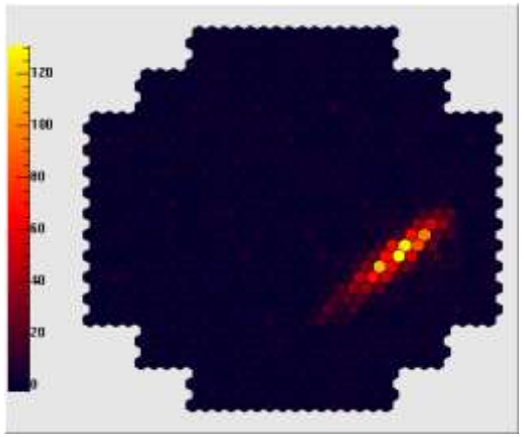

S. Funk (2011)



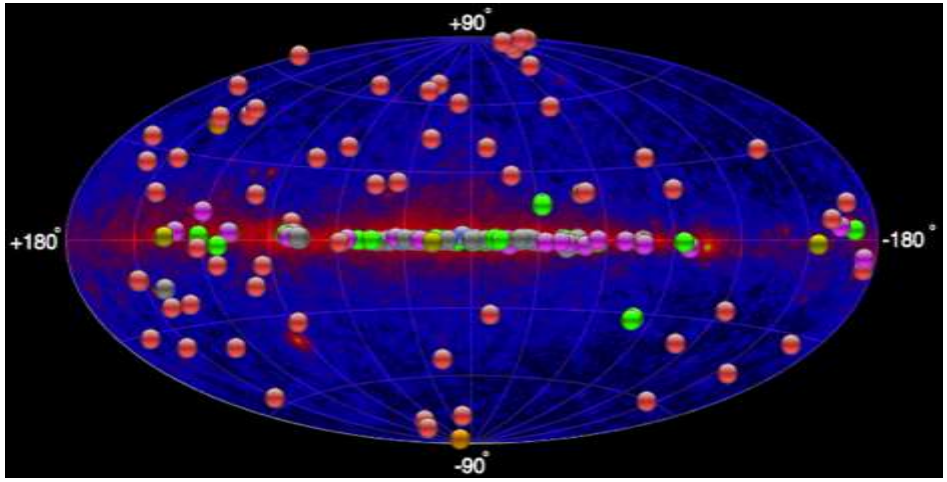

**TeVCat**
(S. Wakely, D. Horan)

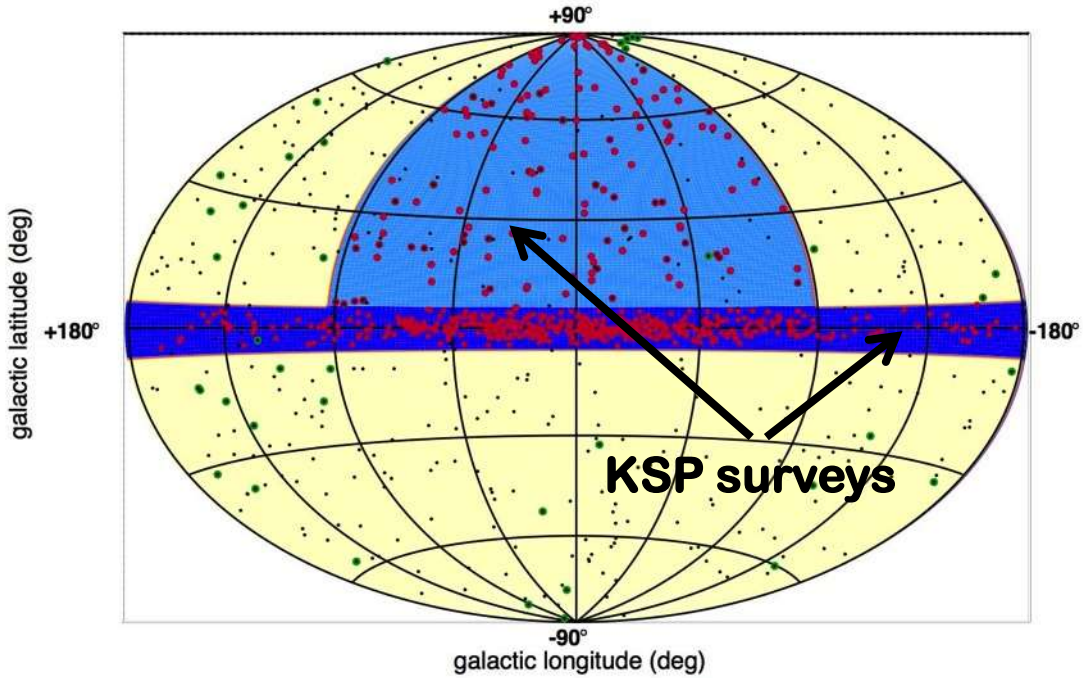
# Detecting VHE gamma rays

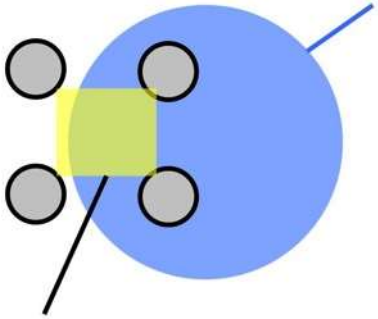


# From current arrays to CTA

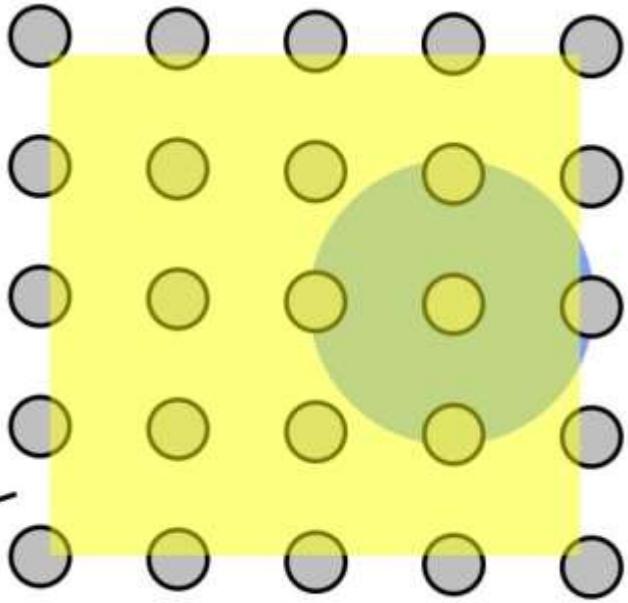


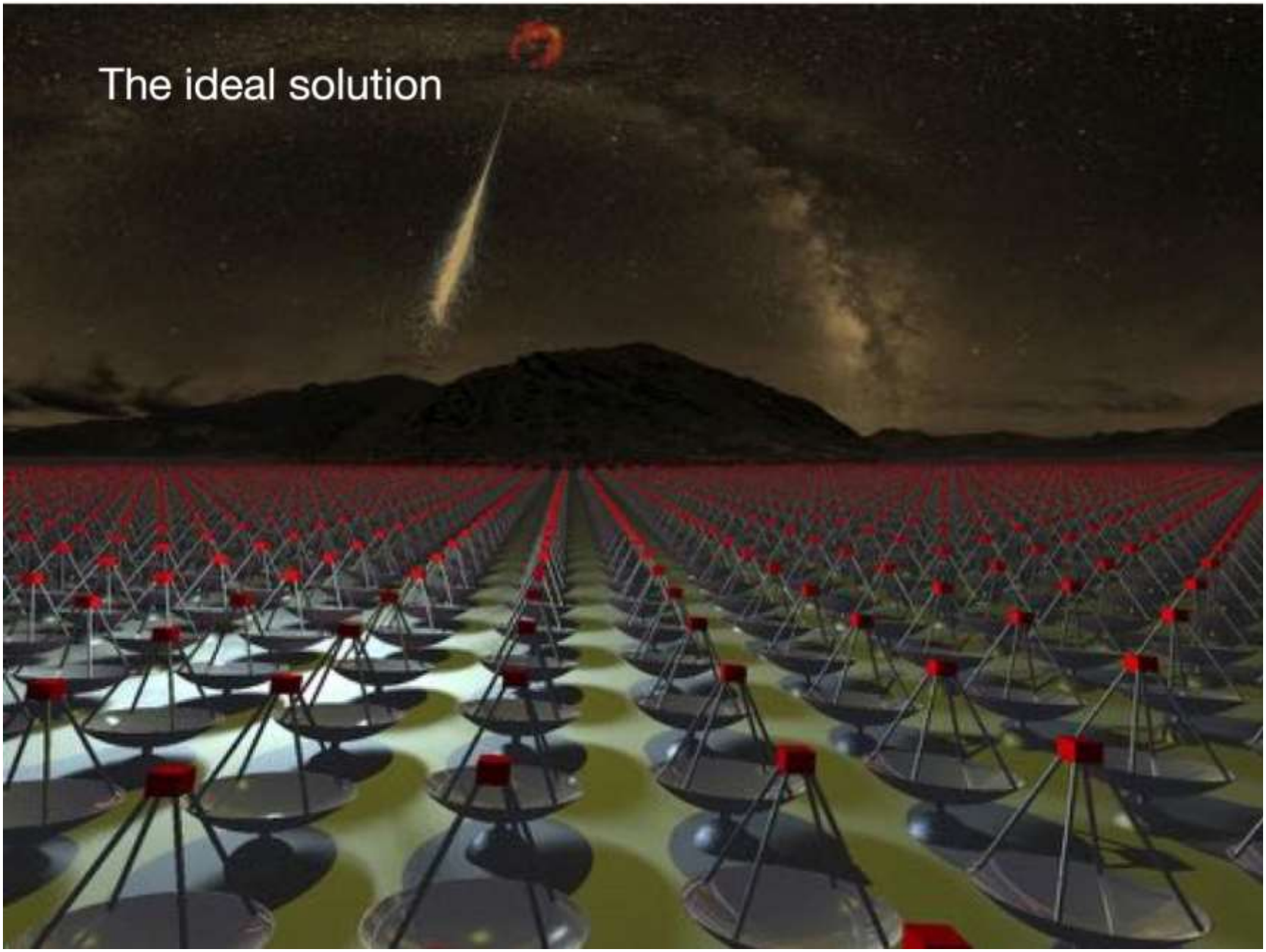
light pool radius
R ≈100-150 m
≈ typical telescope spacing

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



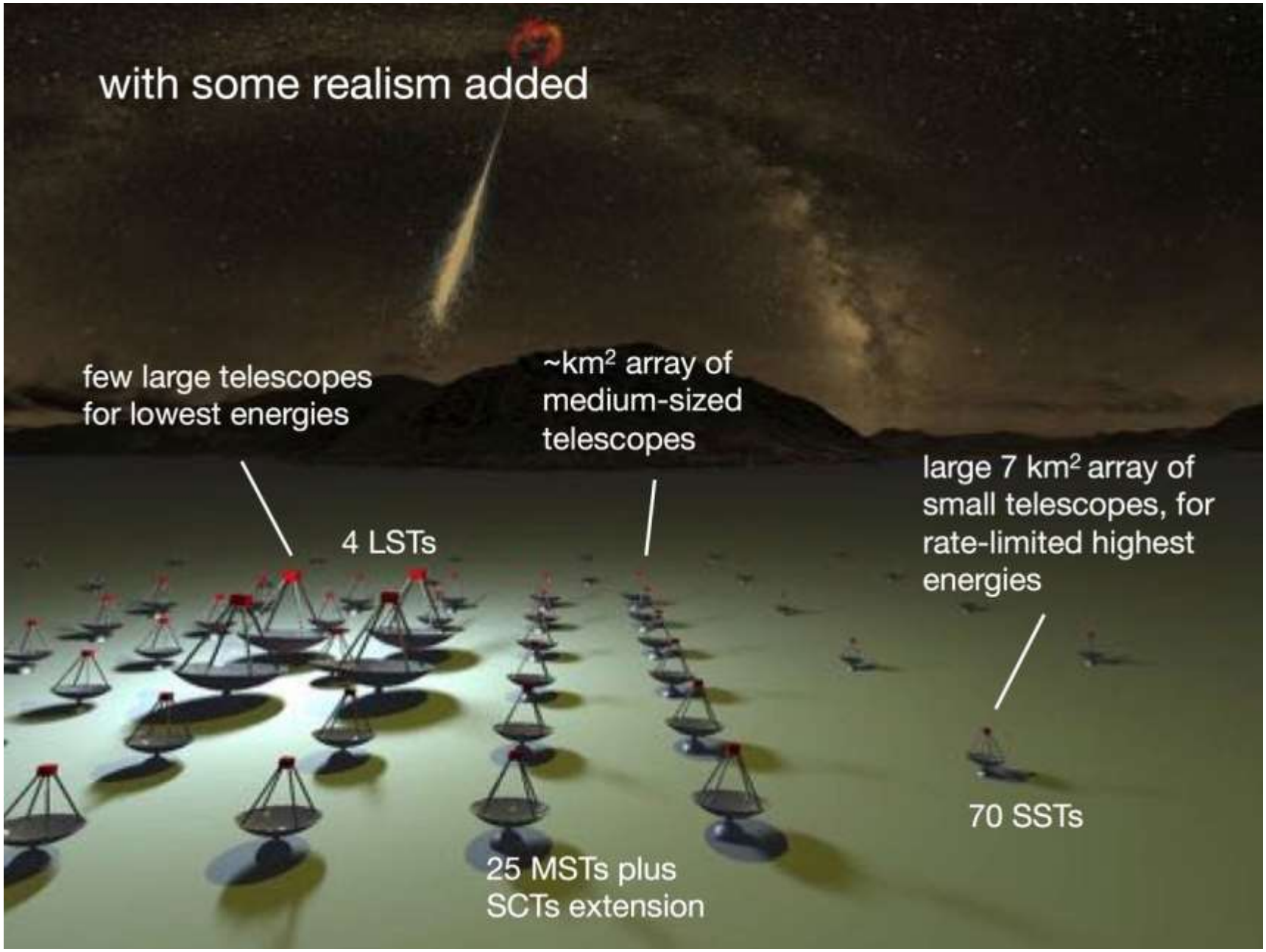
large detection area
more images per shower
lower trigger threshold

# A next generation VHE facility



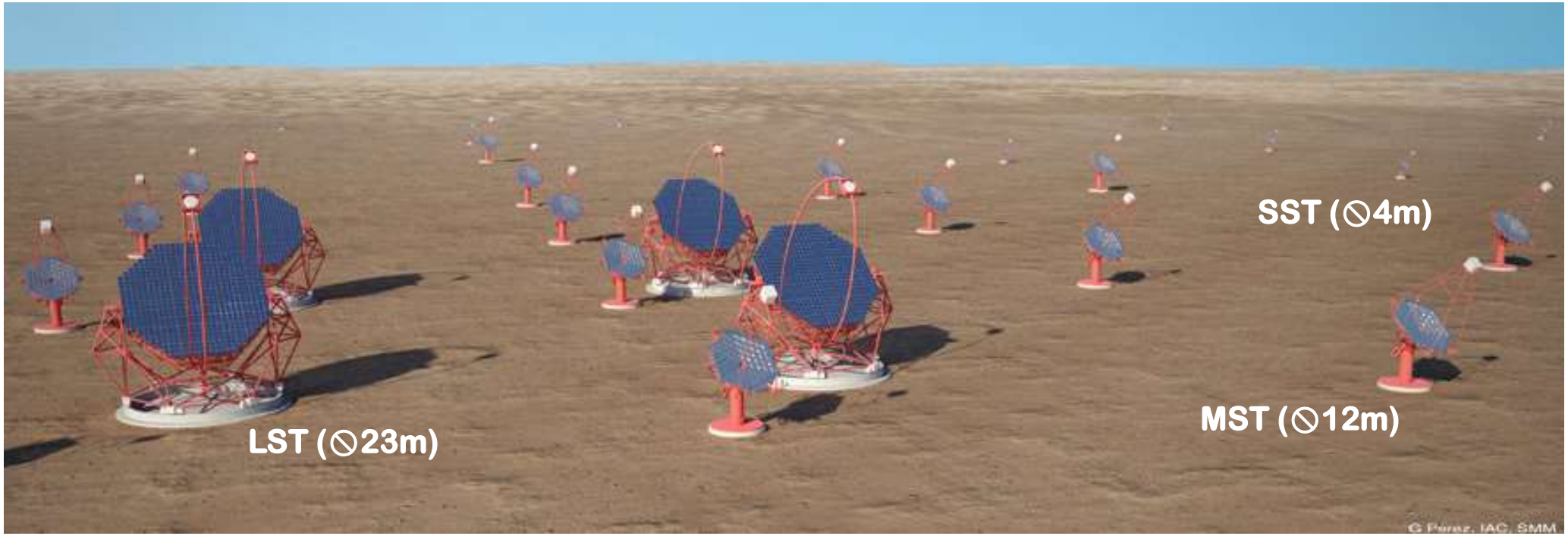

W. Hofmann

# A next generation VHE facility

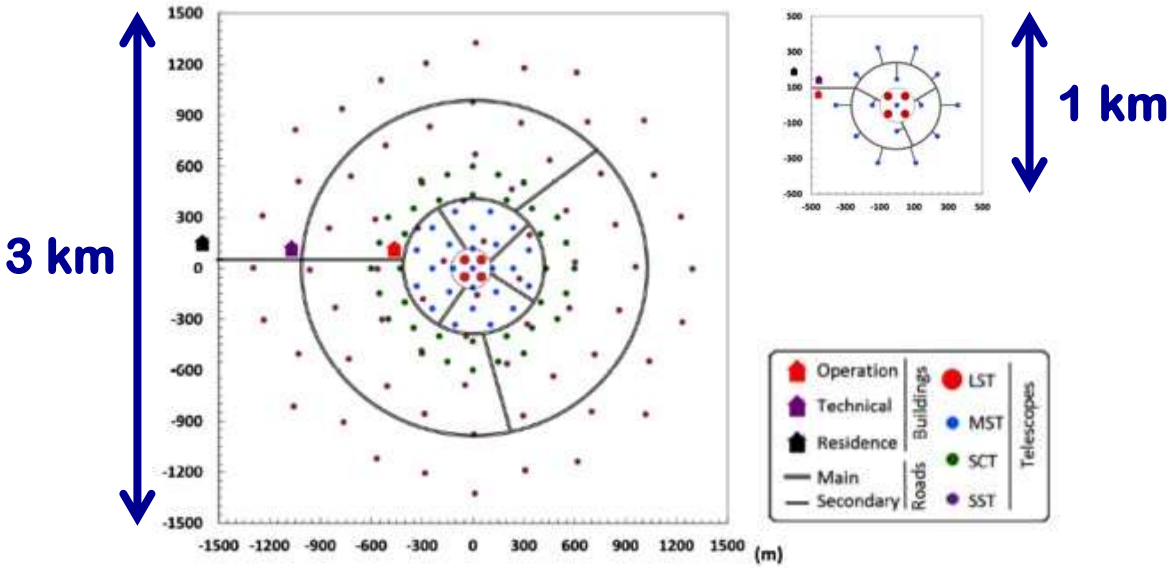



**W. Hofmann**

# The CTA Observatory



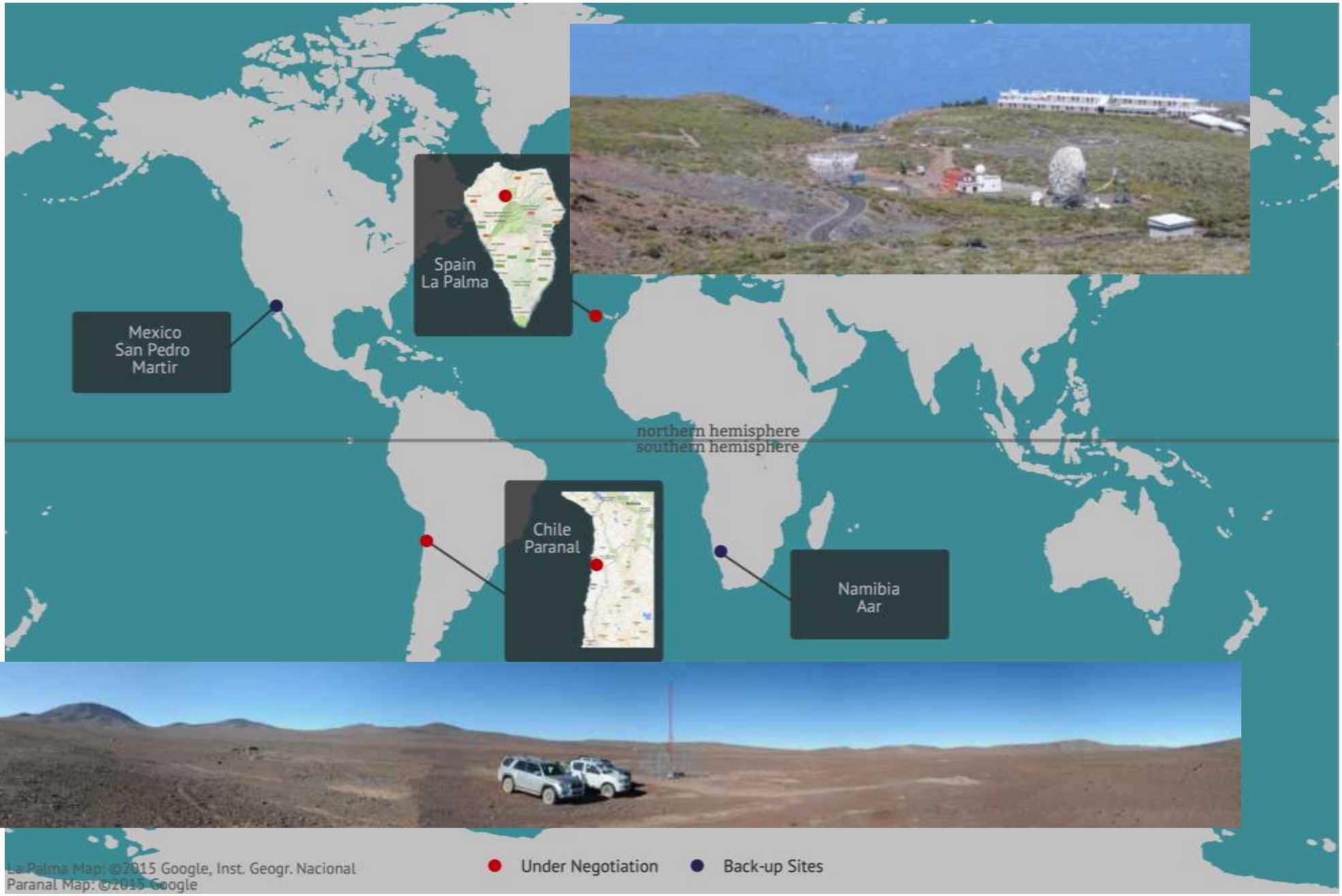

SCT (⌀10m)



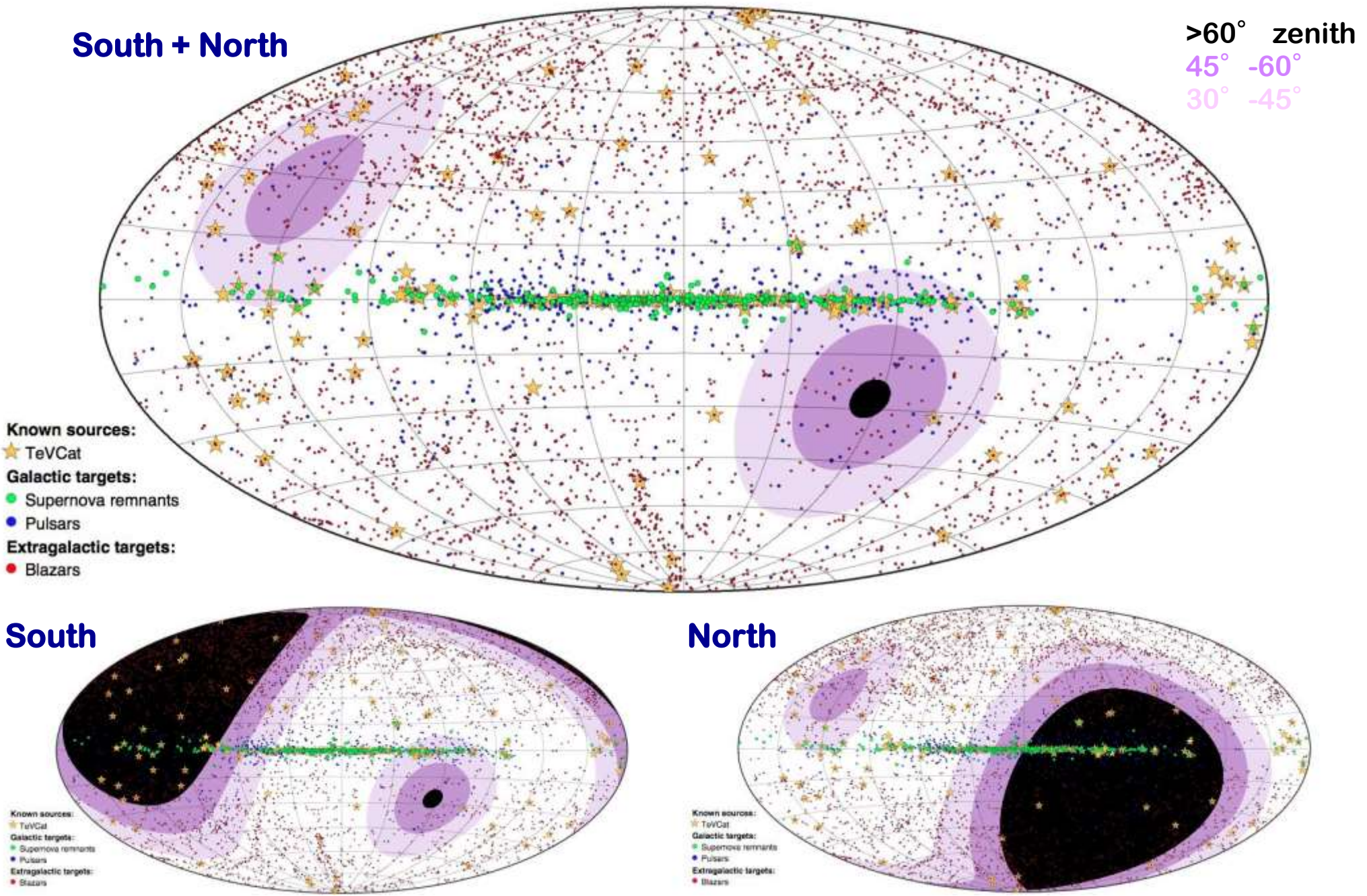

## Characteristics

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

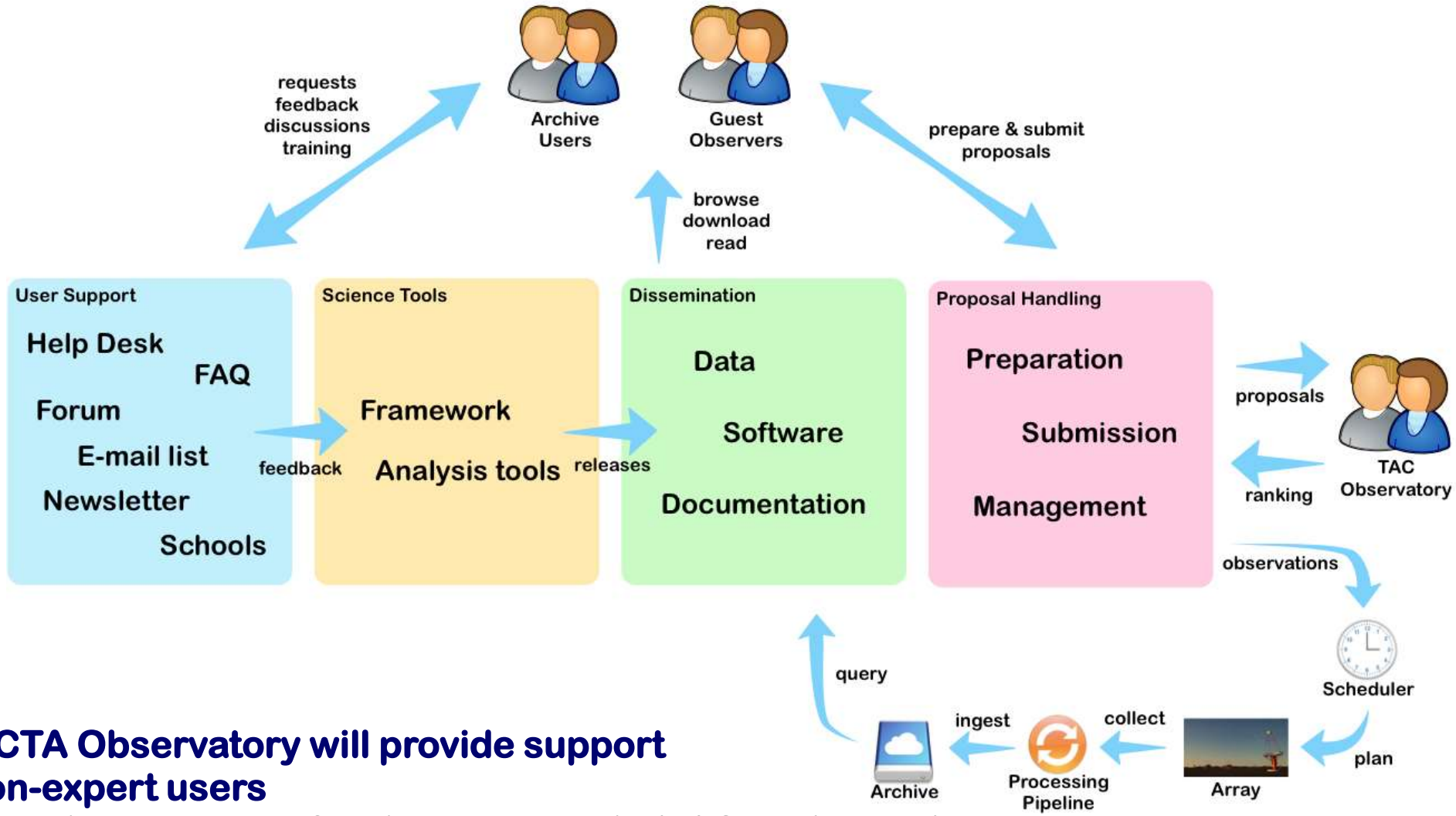
# CTA sites


Spain
La Palma
Mexico
San Pedro
Martir
northern hemisphere
southern hemisphere
Chile
Paranal
Namibia
Aar
Under Negotiation
Back-up Sites
La Palma Map: ©2015 Google, Inst. Geogr. Nacional
Paranal Map: ©2015 Google

# All-sky coverage



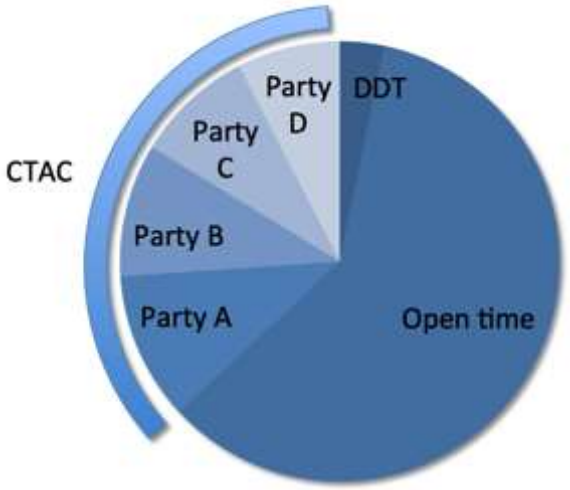
# CTA - an open observatory




**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 Observing Time

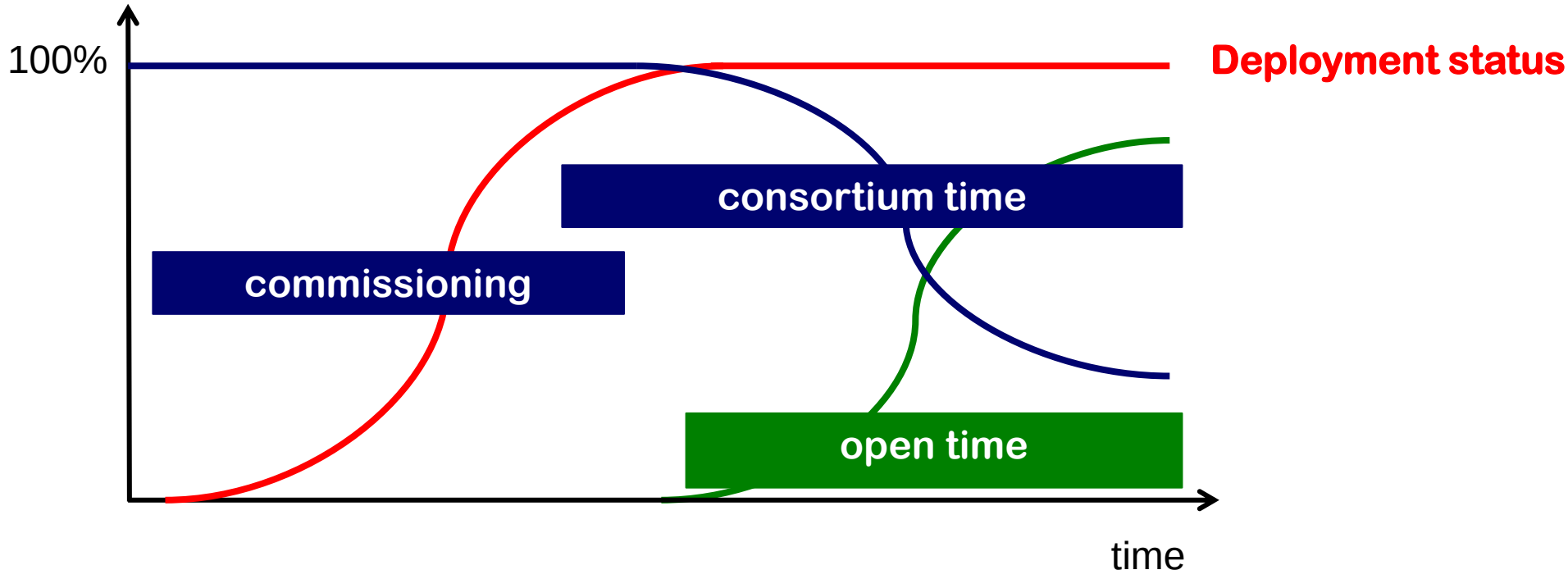



**Current assumptions**

**CTA parties pool the observing time in:**

- **Open time (for scientists of party countries)**
- **Consortium time (Key Science Projects)**

**All data will become fully public after a proprietary period (typically one year)**

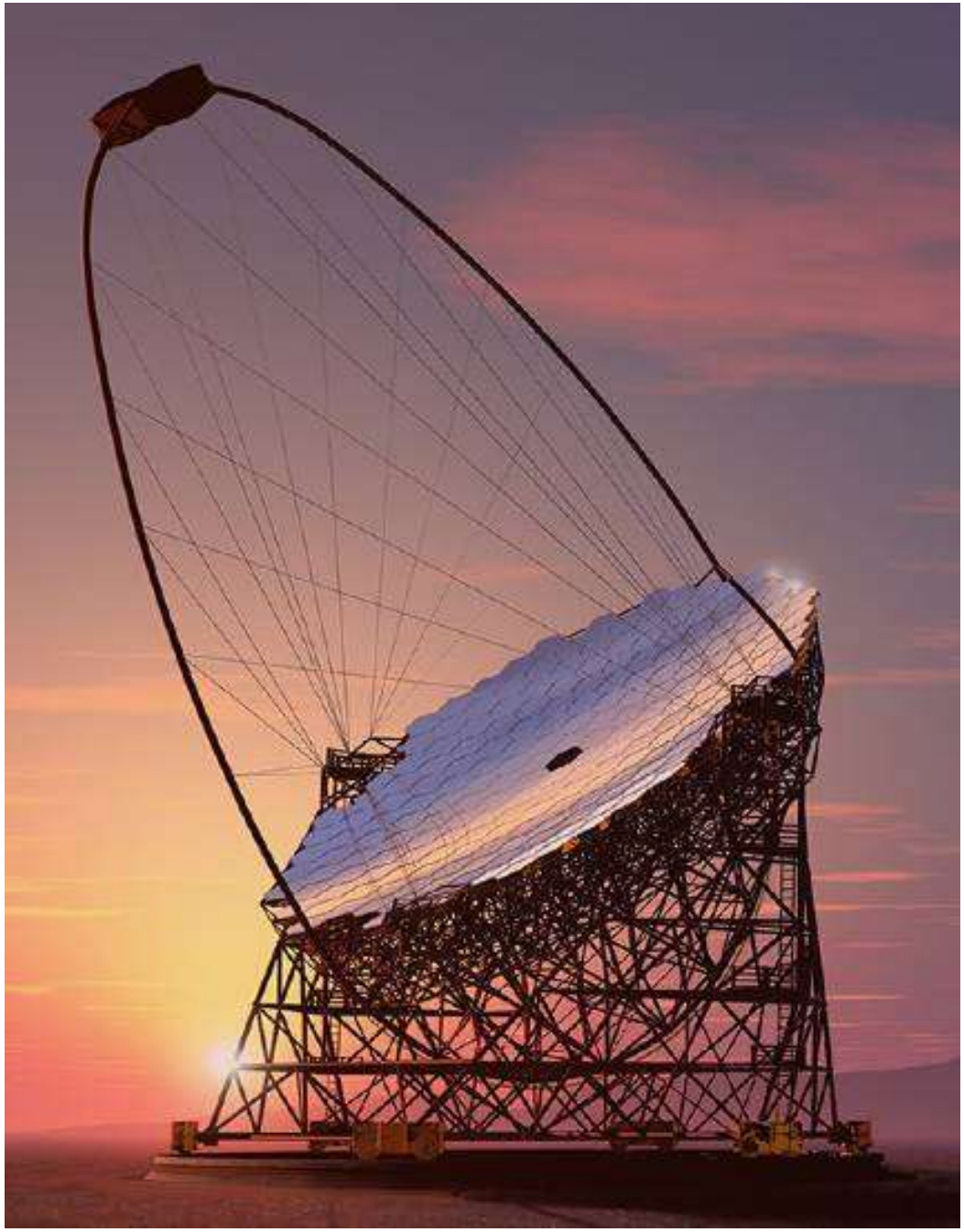


# CTA consortium

**CTA Consortium members status**
1281 members
413 FTE

**CTA Consortium members come from**
5 continents
31 countries
91 parties
194 institutes

# Large size telescopes



## Science drivers

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

## Characteristics

Parabolic design
23 m diameter
370 $m^2$ 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 dish & arch structure (fast repointing)

## Array layout

South site: 4 LST
North site: 4 LST

## Status

Some elements prototyped
First full telescope construction starts in October in La Palma

# Medium size telescopes

## 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 $m^2$ 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)

# Small size telescopes

## SST 1M

## ASTRI

## GCT

## Science drivers

Highest energies (> 5 TeV)
Galactic science, PeVatrons

## Array layout

South site: 70 SST
North site: -

# SST 1M

## Characteristics

Davies-Cotton design
4 m diameter
8.5 $m^2$ 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

# ASTRI

## Characteristics

Schwarzschild-Couder design
4.3 m primary diameter
1.8 m secondary diameter (monolithic)
6 $m^2$ 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

# GCT

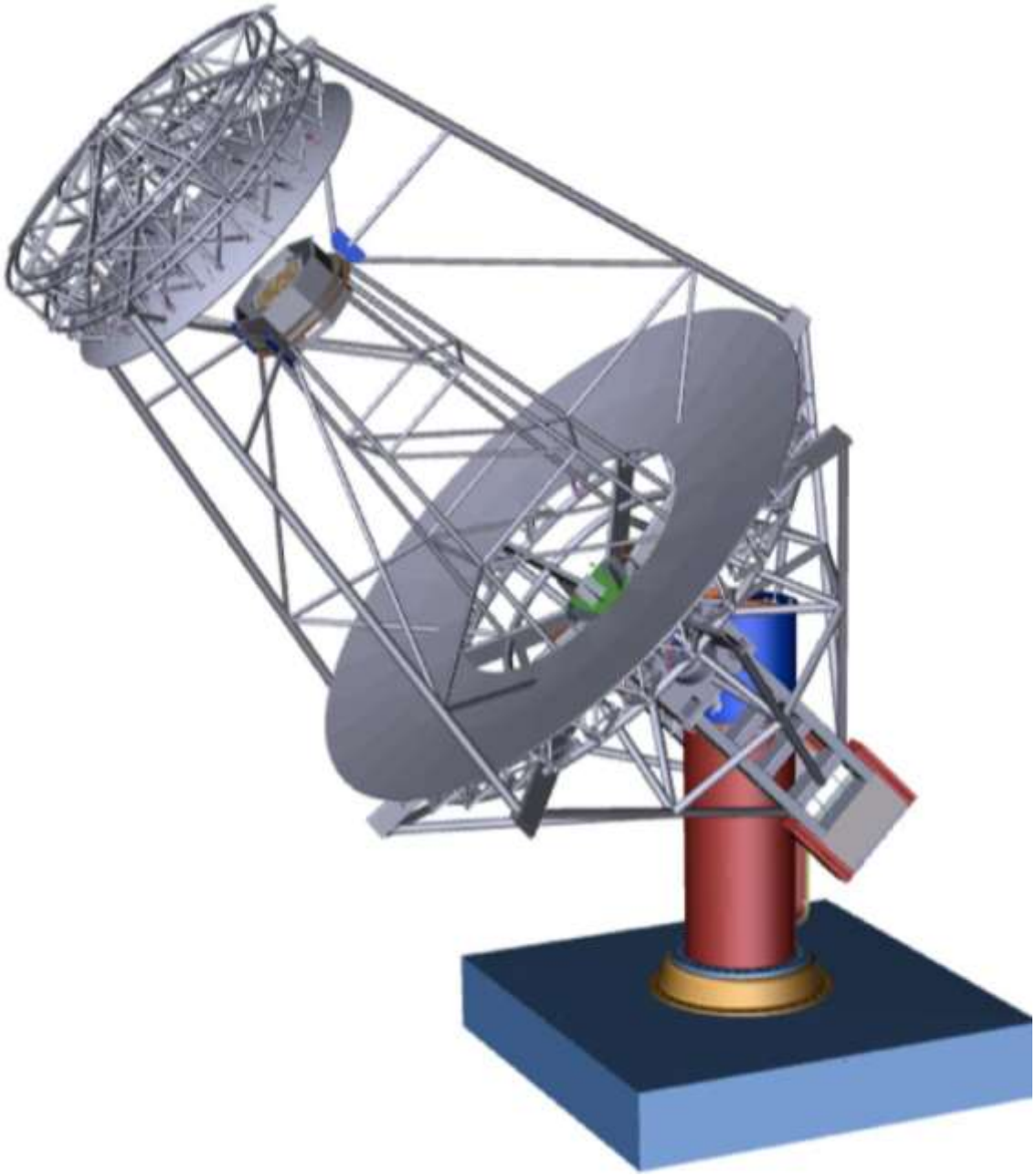
## Characteristics

Schwarzschild-Couder design
4 m primary diameter
2 m secondary diameter
6 $m^2$ 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)
Mirrors coming soon
Camera prototype under construction

# Medium size telescopes (extension)



## 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 $m^2$ 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

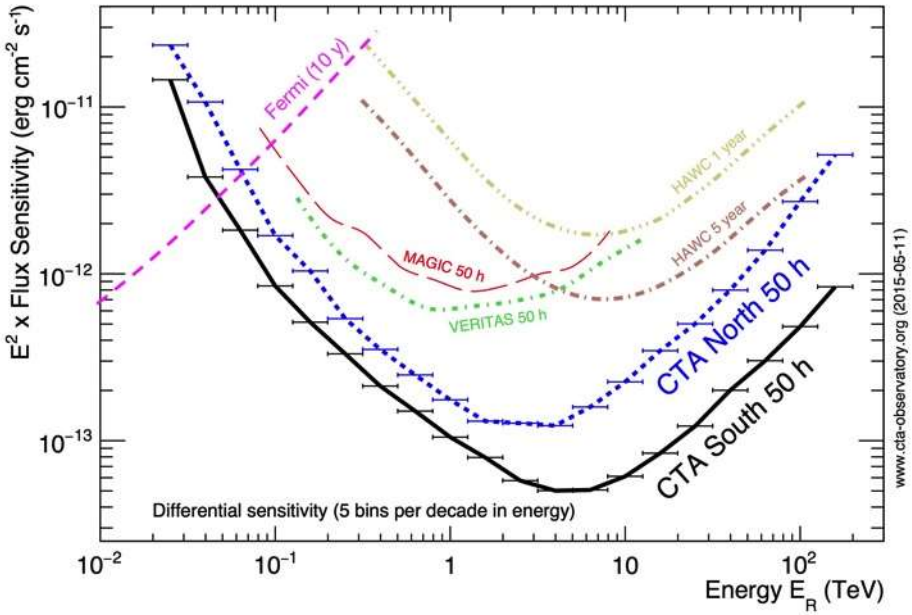
# Expected performance

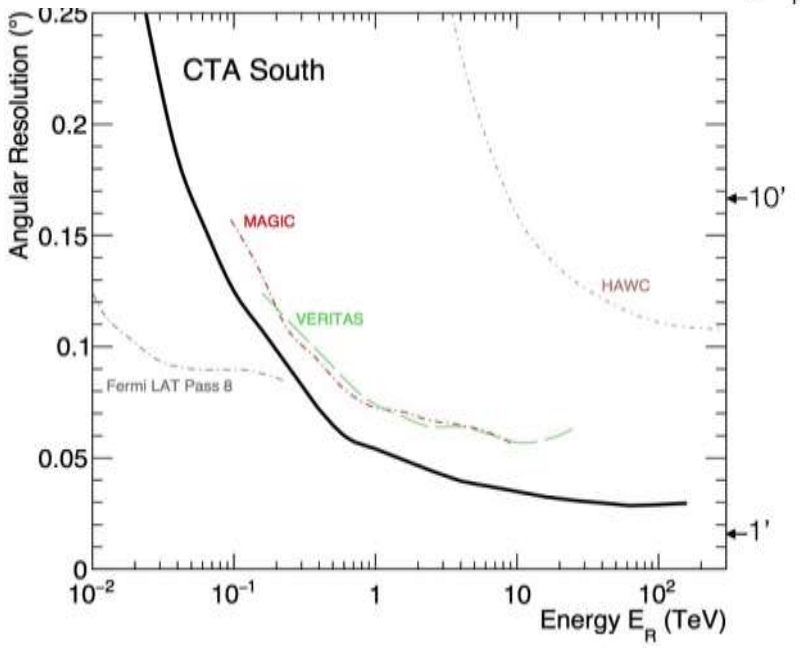
## Sensitivity gain
- access VHE populations across entire Galaxy
- sample fast variability (AGN, GRB)

## FoV > 8°
- measure diffuse emissions
- efficient survey of large fields

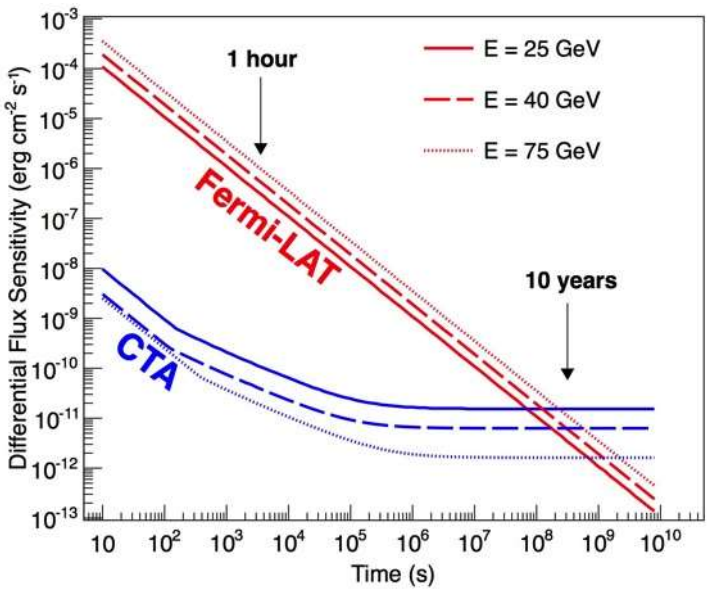
## Arcmin angular resolution
- resolve extended sources (SNR, starbursts)

## Broad energy coverage
- < 100 GeV to reach higher redshifts
- > 10 TeV to search for PeVatrons



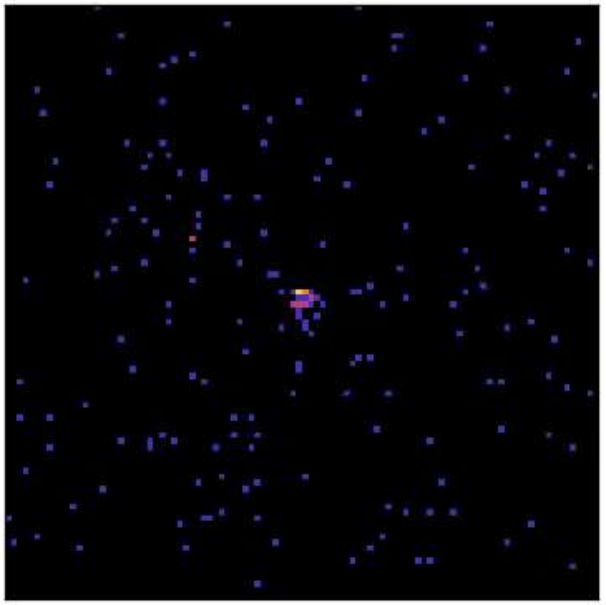



# Time - domain astronomy



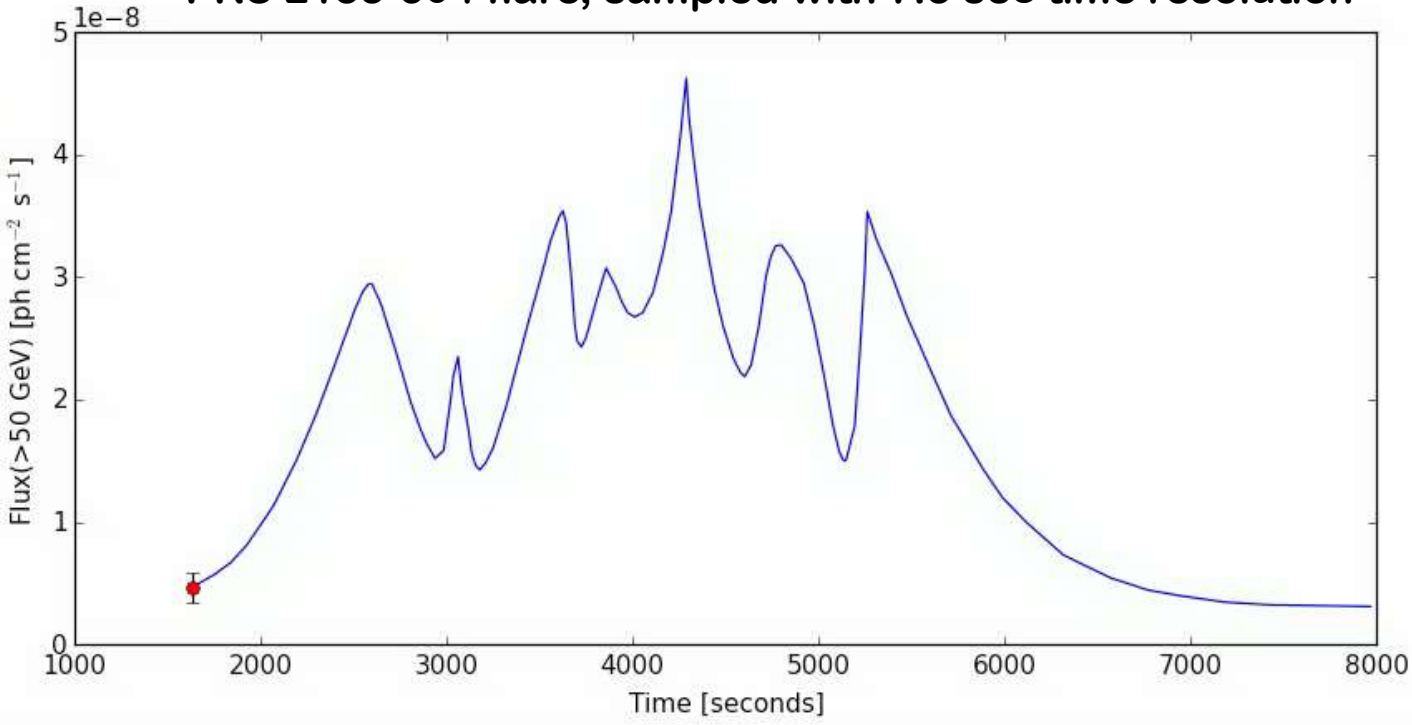

## CTA as a transient factory

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

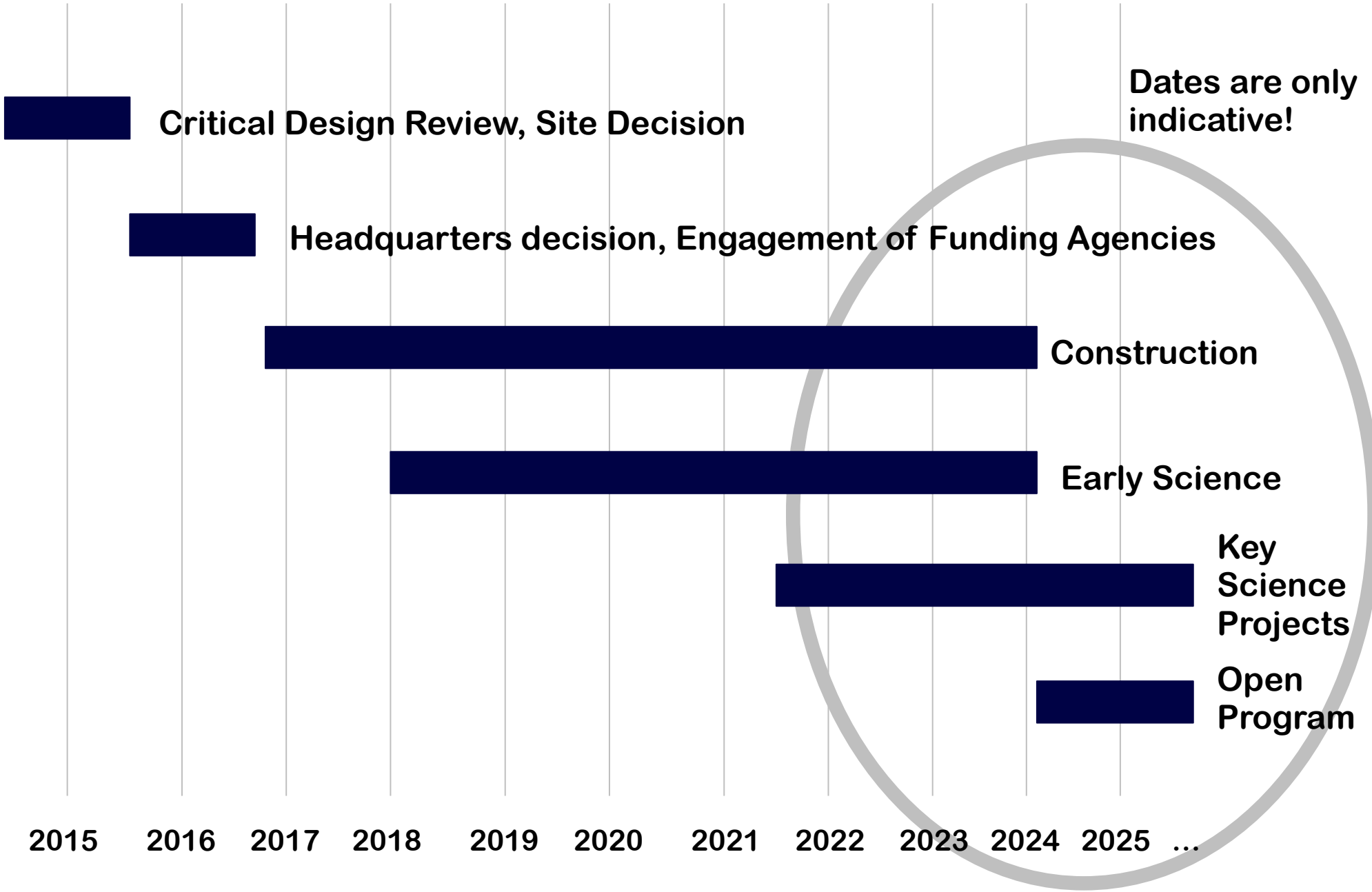


## Example: PKS 2155-304

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



# CTA Calendar



# CTA Key Science

## 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

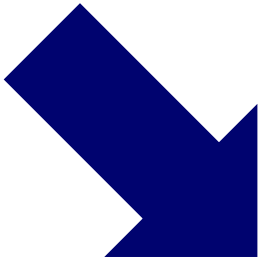
## Physics frontiers – beyond the Standard Model

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?

# CTA Science Programme

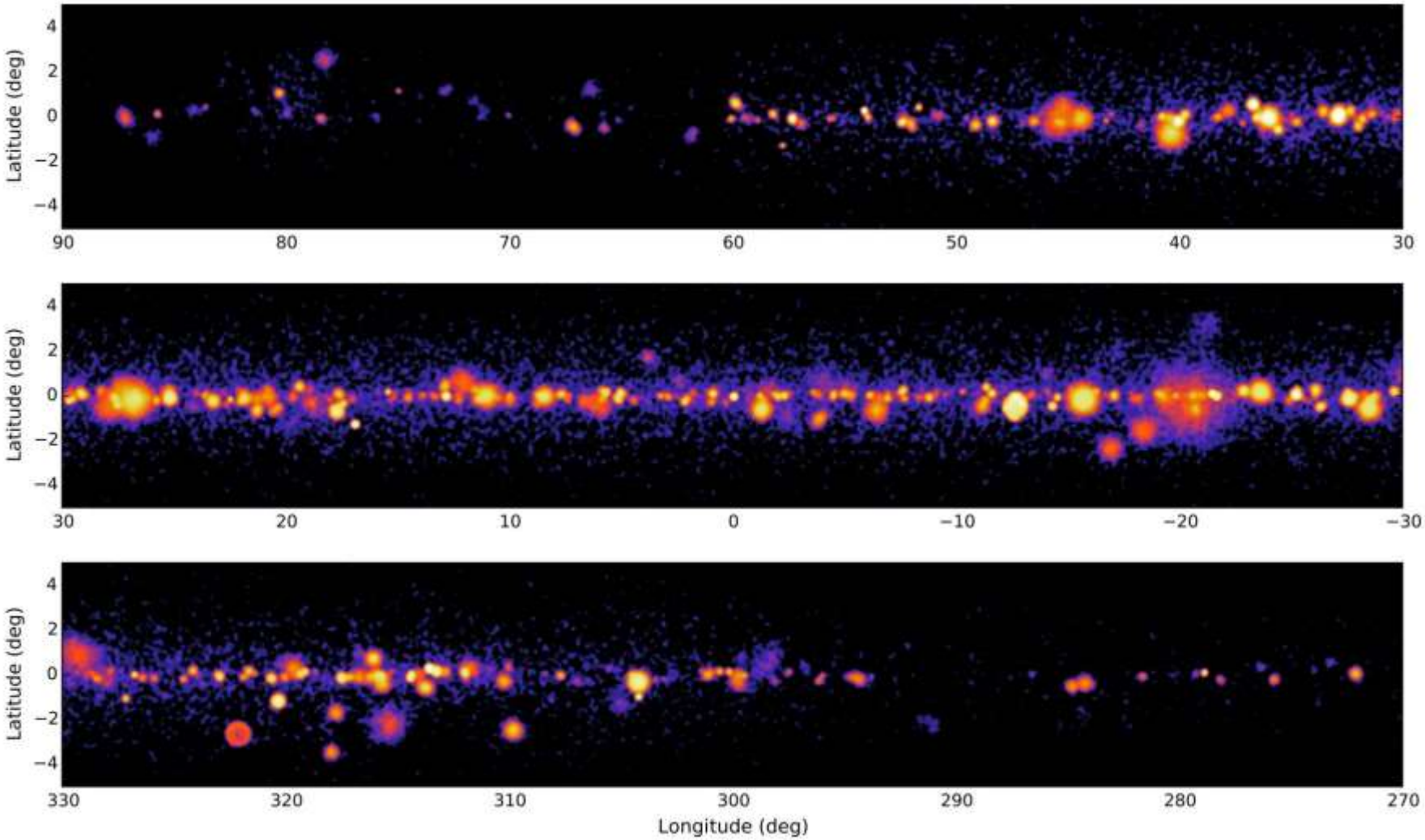
**Key Science Programmes (executed by consortium)**
Ensure that important science questions for CTA are addressed in a coherent fashion and with a well-defined strategy
Conceived to provide legacy data sets for the entire community

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
…

# KSP example: surveys




**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° x10° 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

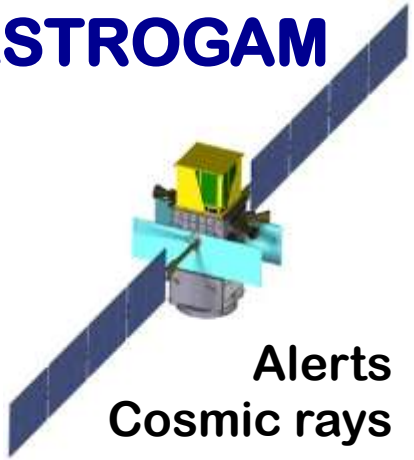
## Virgo/LIGO

GW alerts

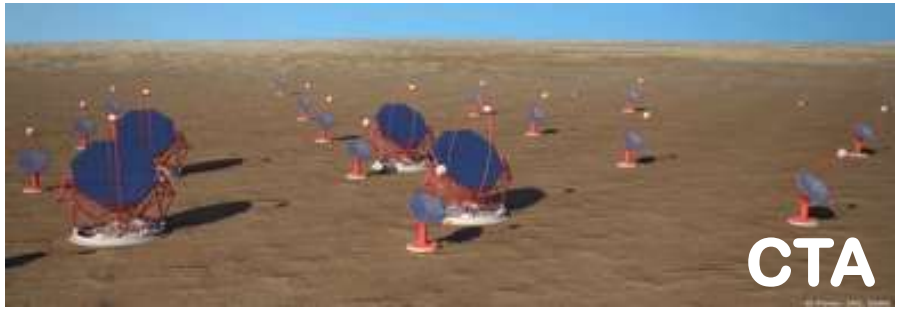
## SVOM

Alerts

## ASTROGAM



Alerts
Cosmic rays
Low-energy coverage




## ALMA

ISM ionisation
BH jet imaging

## Fermi

Low-energy coverage
Alerts

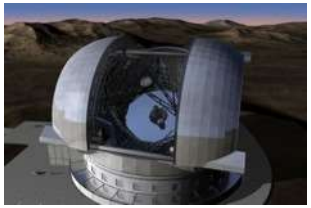
## HAWC

Sky survey
Alerts

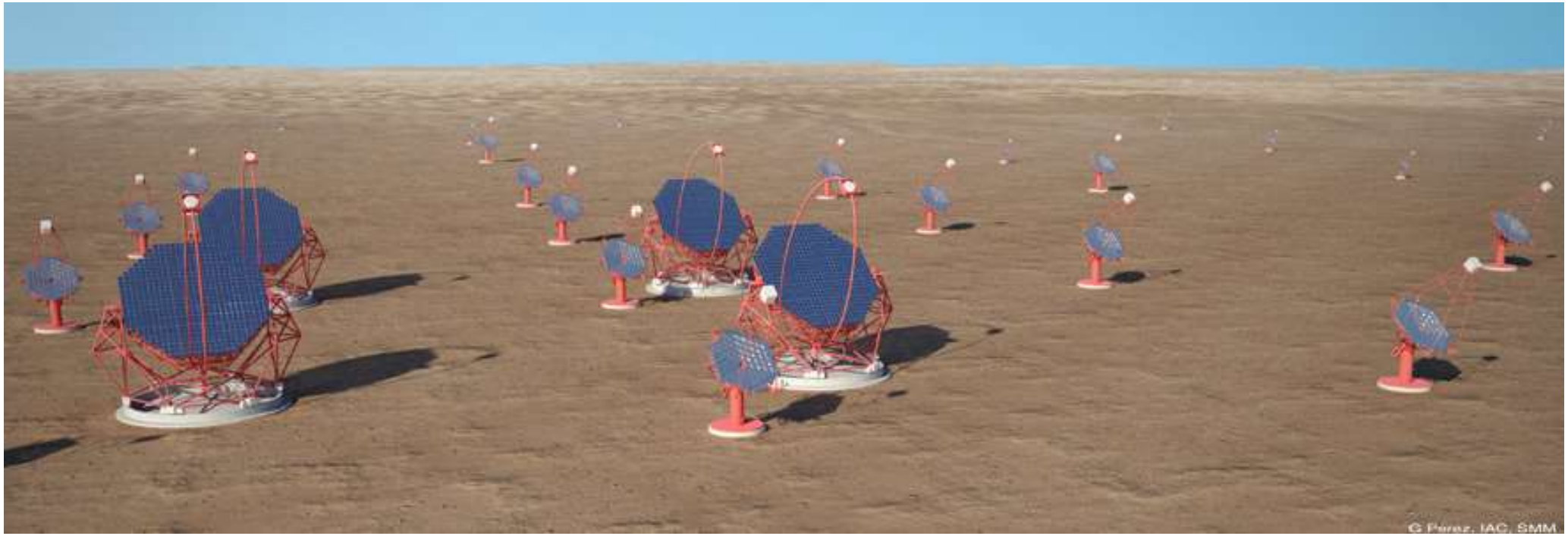
## Athena

Cosmic rays / SNR
Jet-disk connection

…



# Take home message




**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**