# THE CHERENKOV TELESCOPE ARRAY

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for the the CTA Consortium[2]

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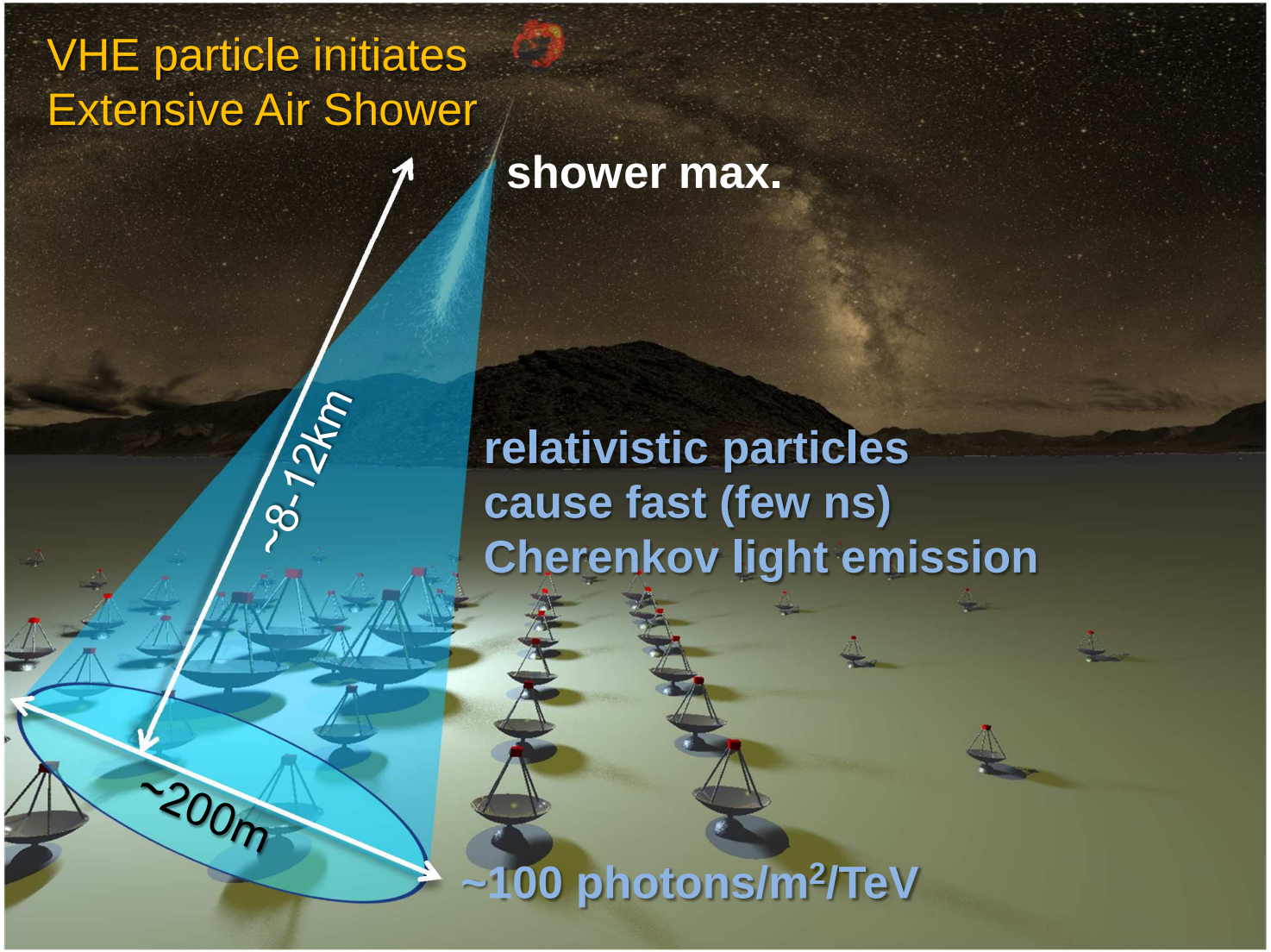
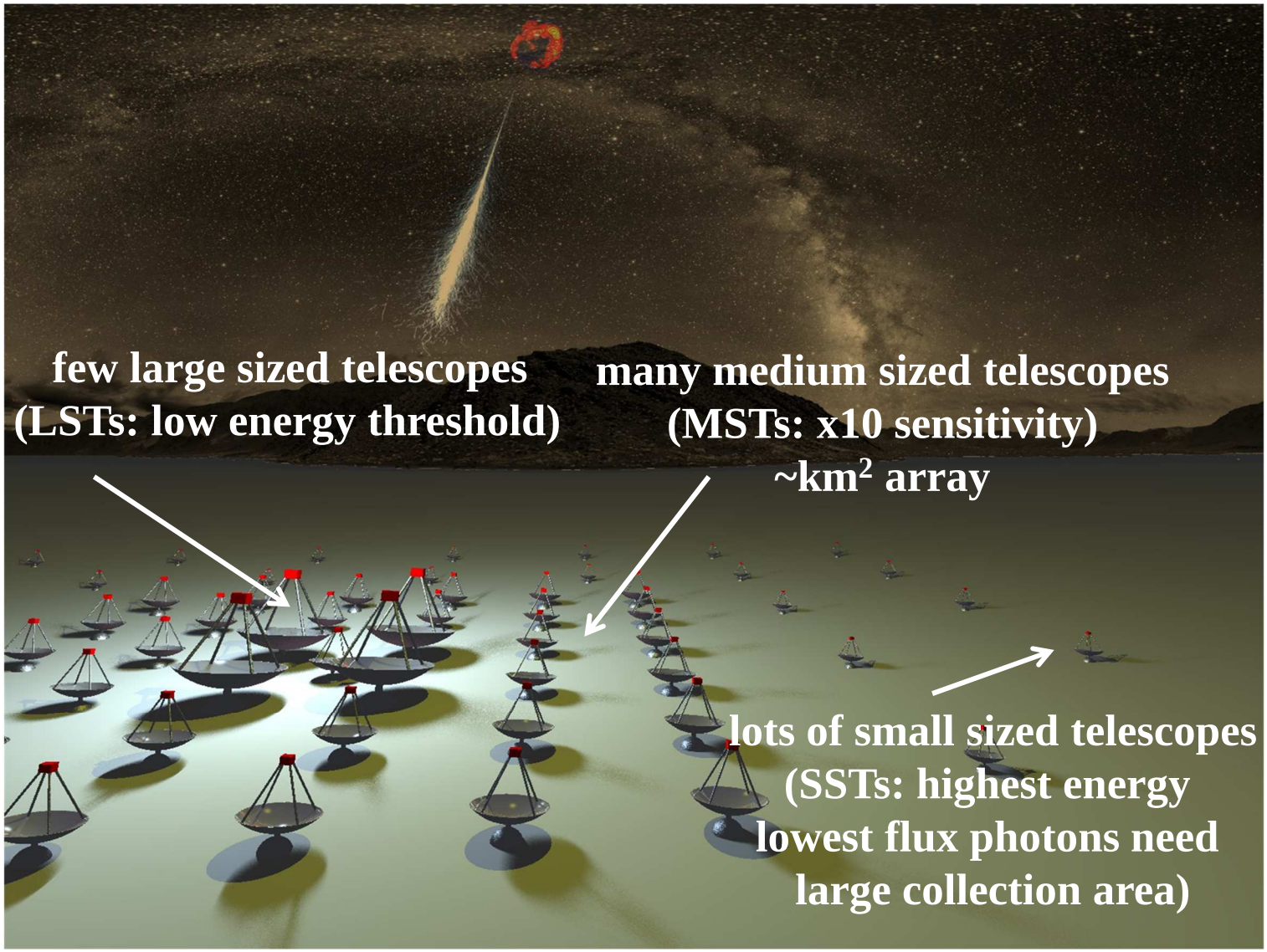
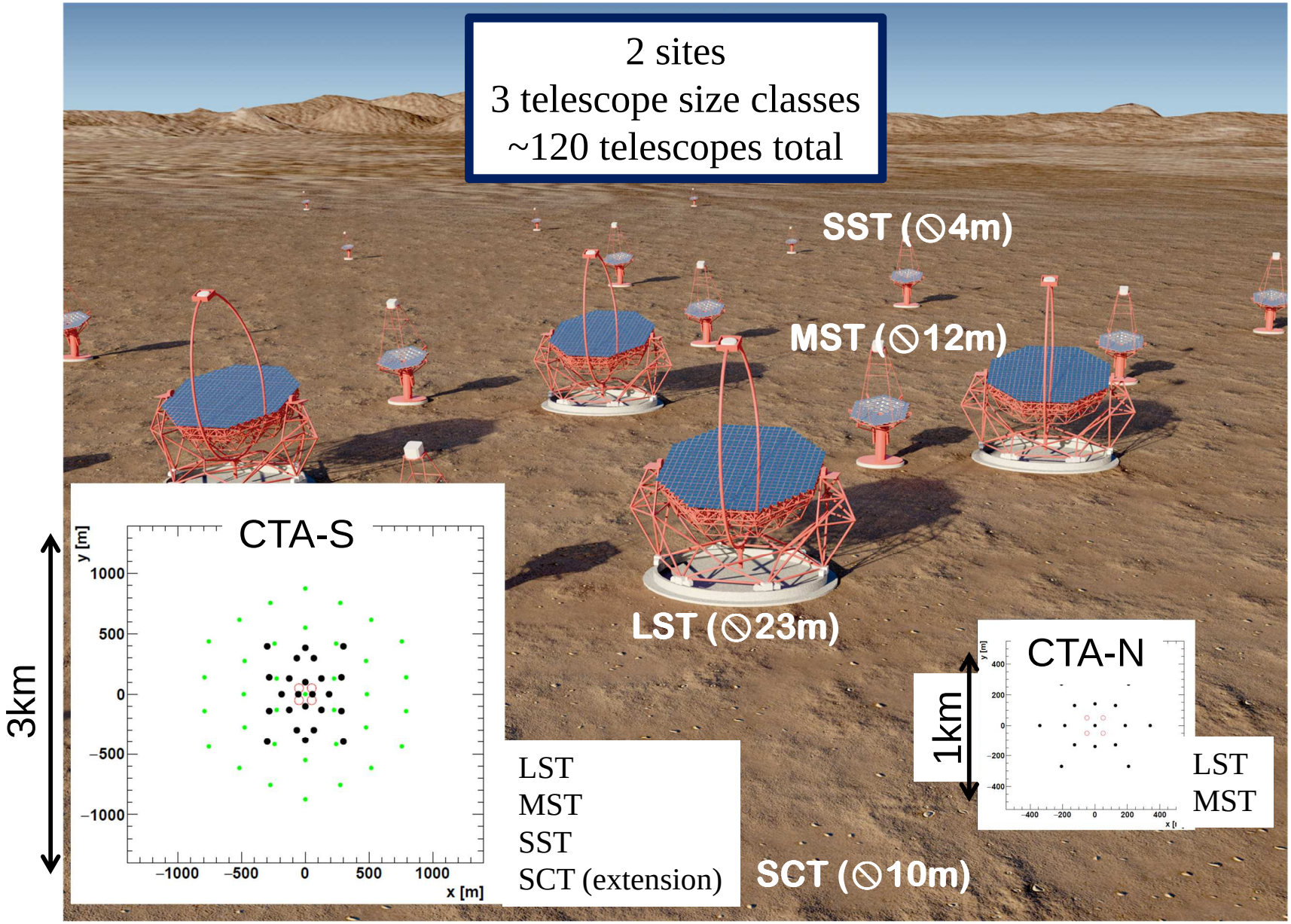
# TECHNIQUE


VHE particle initiates
Extensive Air Shower
shower max.
~8-12km
relativistic particles
cause fast (few ns)
Cherenkov light emission
~200m
~100 photons/m²/TeV

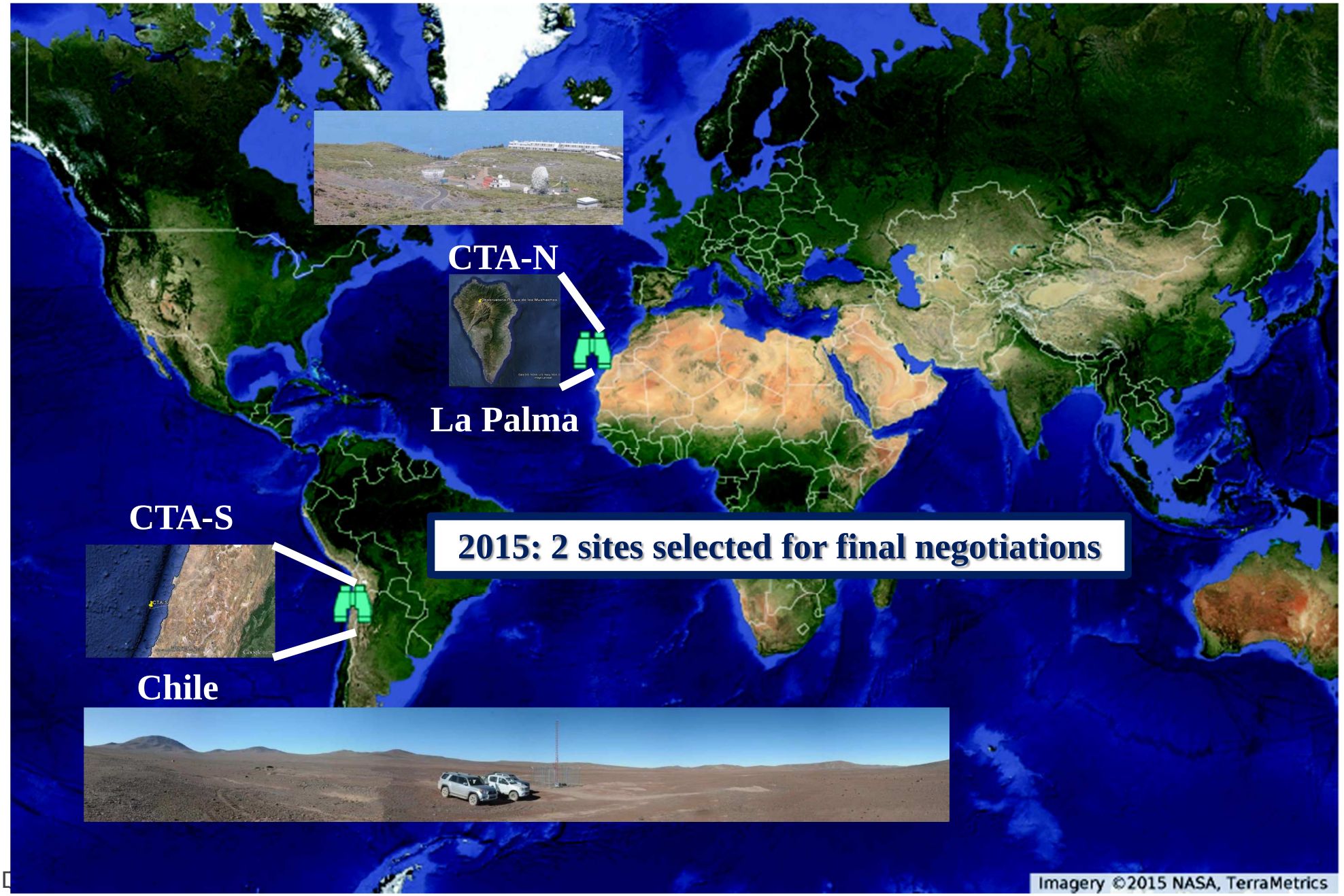
# CHERENKOV TELESCOPE ARRAY



# CTA OBSERVATORY



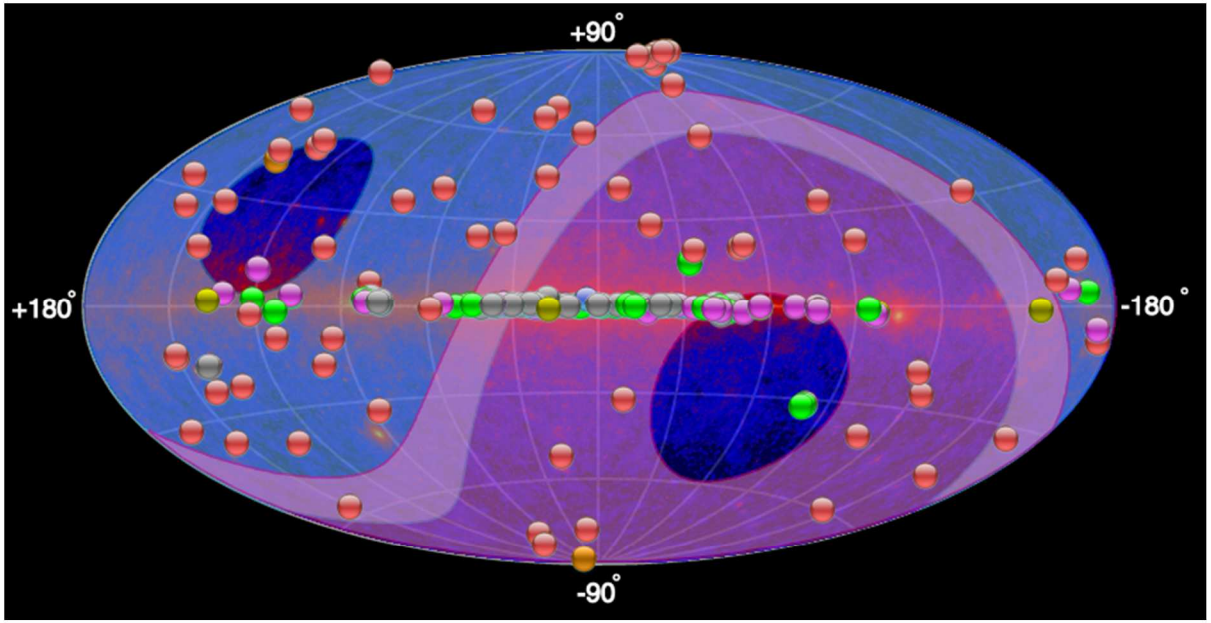
# CTA SITES


CTA-N
La Palma
CTA-S
Chile
2015: 2 sites selected for final negotiations
Imagery ©2015 NASA, TerraMetrics

# ALL SKY COVERAGE

**Source count evolution**

1989: 1 source (Whipple)
2000: 10 sources (Whipple/HEGRA/Durham)
2010: 100 sources (HESS, MAGIC, VERITAS)
2020: 1000 sources (CTA)?




http://tevcat.uchicago.edu/

Source Types

- PWN
- Binary XRB PSR Gamma BIN
- HBL IBL FRI FSRQ Blazar LBL AGN (unknown type)
- Shell SNR/Molec. Cloud Composite SNR Superbubble
- Starburst
- DARK UNID Other
- uQuasar Star Forming Region Globular Cluster Cat. Var. Massive Star Cluster BIN BL Lac (class unclear) WR

# LARGE SIZED TELESCOPE (LST)

## Science drivers

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

## Characteristics

23m diameter parabolic design
370 $m^2$ effective mirror area
28 m focal length
1.5 m mirror facets with active mirror control
4.5° field of view composed of 0.11° PMT pixels
Carbon-fibre arch structure (fast repointing)

## Array layout

South site: 4 LST
North site: 4 LST

## Status

Some elements prototyped
Prototype telescope under construction in La Palma (to become first full LST)

# MEDIUM SIZED TELESCOPE (MST)

## 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 with 0.18° PMT pixels

## Array layout

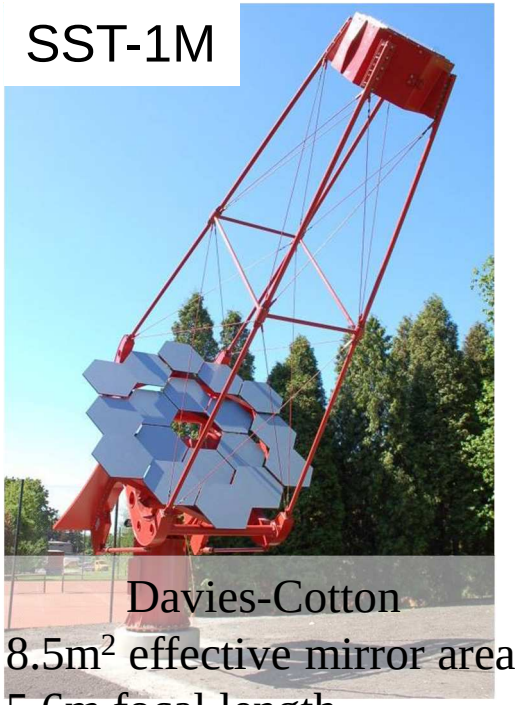
South site: 25 MST
North site: 15 MST

## Status

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

# SMALL SIZED TELESCOPE (SST)

SST-1M



Davies-Cotton
8.5m$^2$ effective mirror area
5.6m focal length
9 °fov 0.24°SiPM pixels

ASTRI

Schwarzchild-Couder
6m$^2$ effective mirror area
2.2m focal length
9.6 °fov 0.17°SiPM pixels

GCT

Schwarzchild-Couder
6m$^2$ effective mirror area
2.3m focal length
8.6 °fov 0.16°SiPM pixels

## Science drivers

Highest energies (> 5 TeV)
Galactic science, PeVatrons, Fundamental Physics (ALPs, LIV)

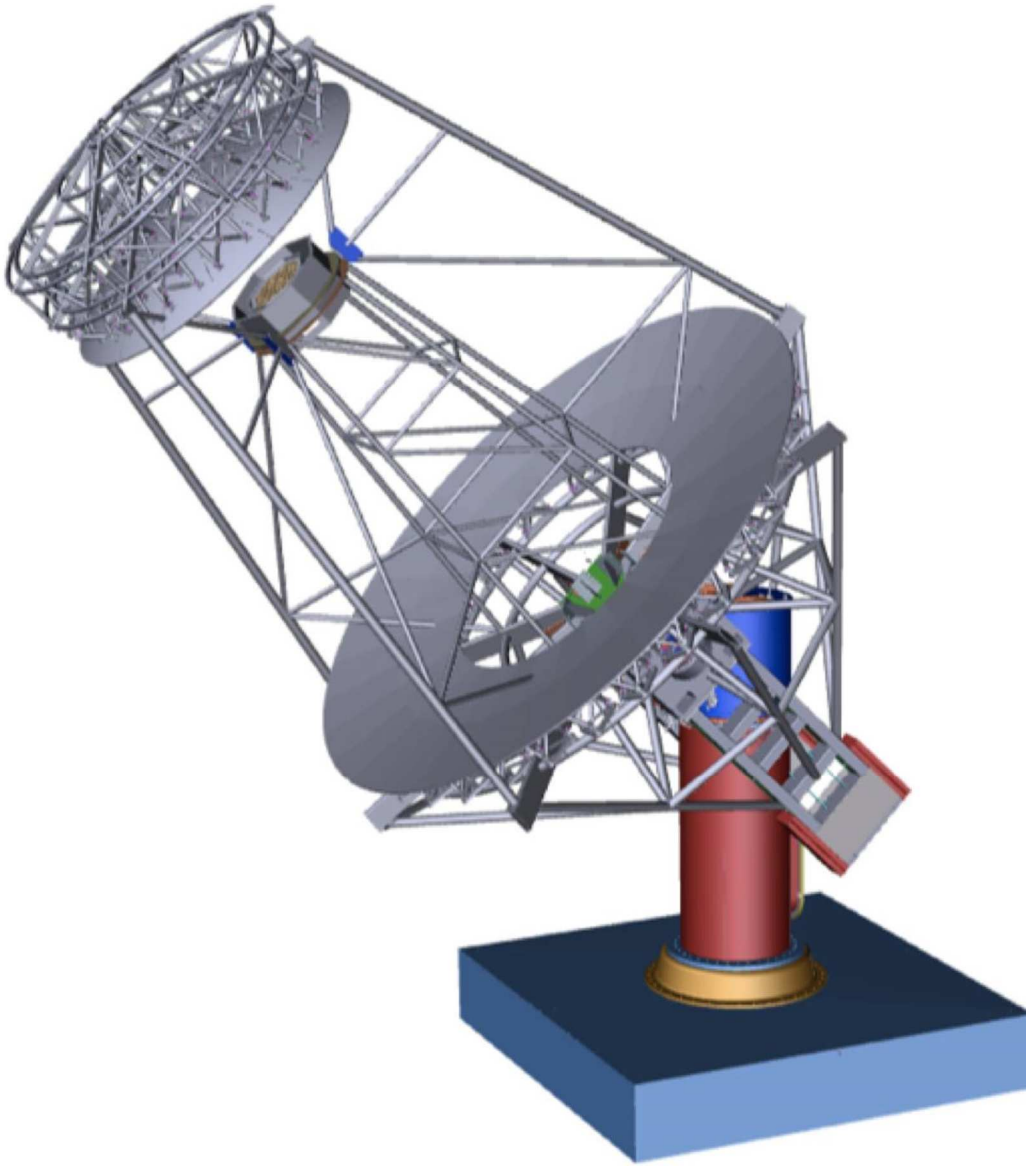
## Array layout

South site: 70 SST
North site: -

## Status

Prototypes in Krakow (SST-1M), Mt. Etna (ASTRI), Paris (GCT)

# SCT – AN MST 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**

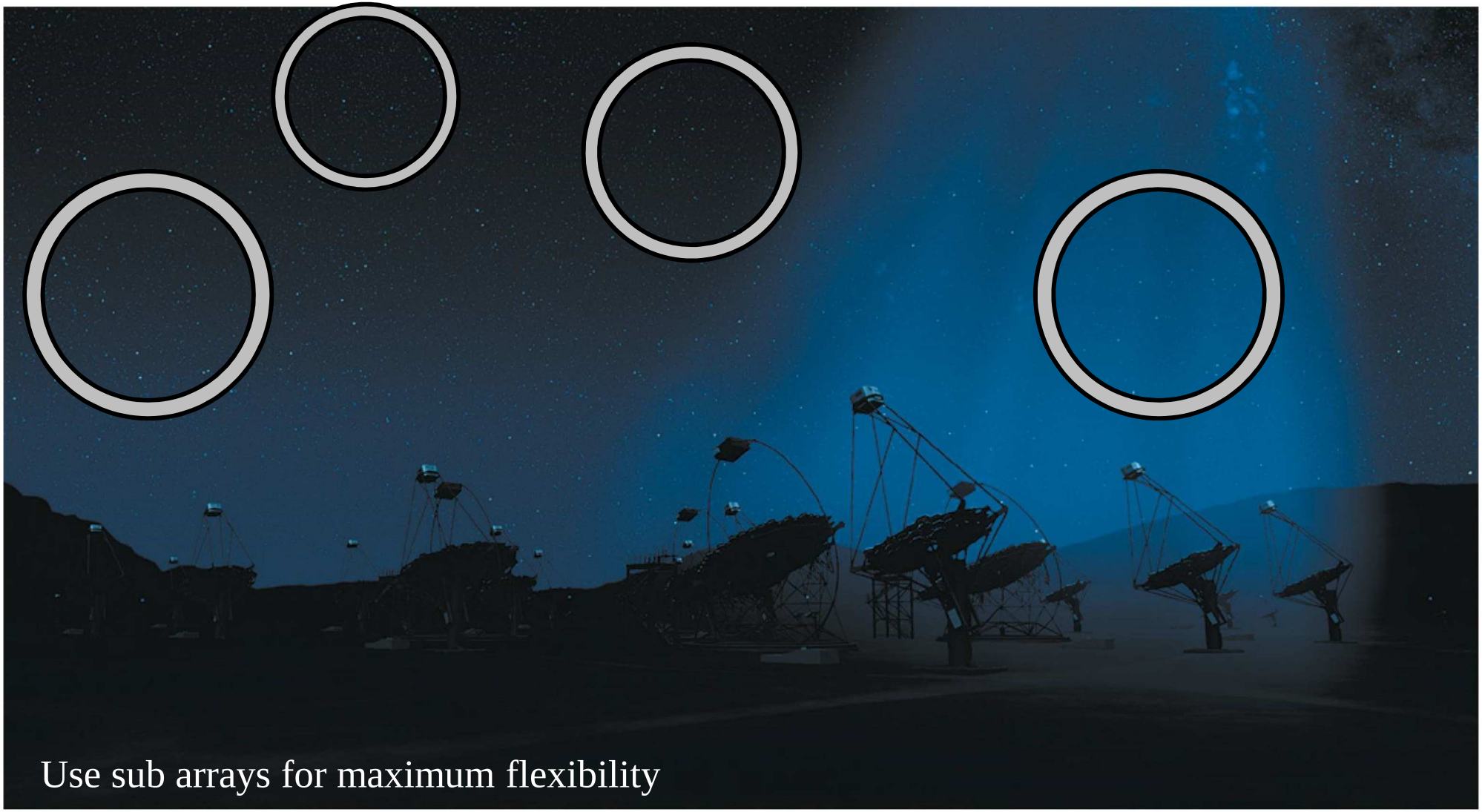
South site: 24 SCT
North site: -

**Status**

Prototype telescope, including camera, under construction on VERITAS site (Arizona)

# DEEP FIELD

# SOURCE MONITORING



# SURVEY

# EXPECTED PERFORMANCE

## Sensitivity gain

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

## FoV > 8°

- measure extended sources/diffuse emissions
- efficient survey of large fields

## Arcmin angular resolution

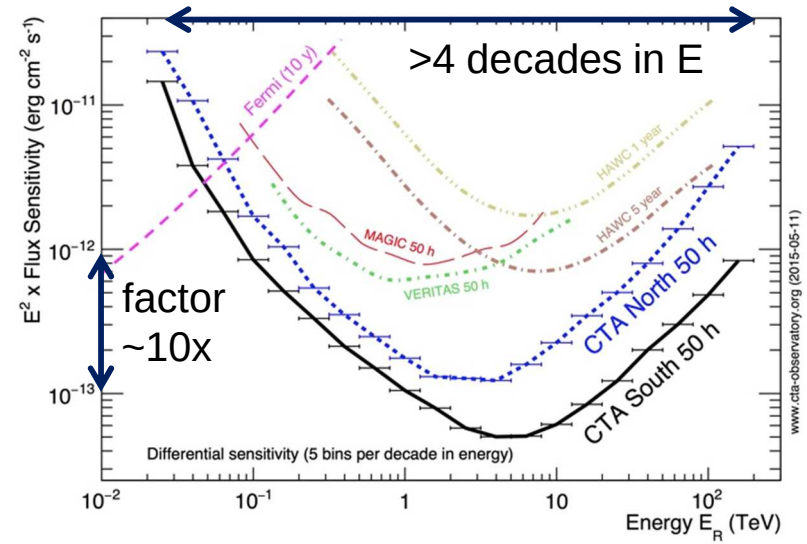
- resolve extended sources (SNR, starbursts)

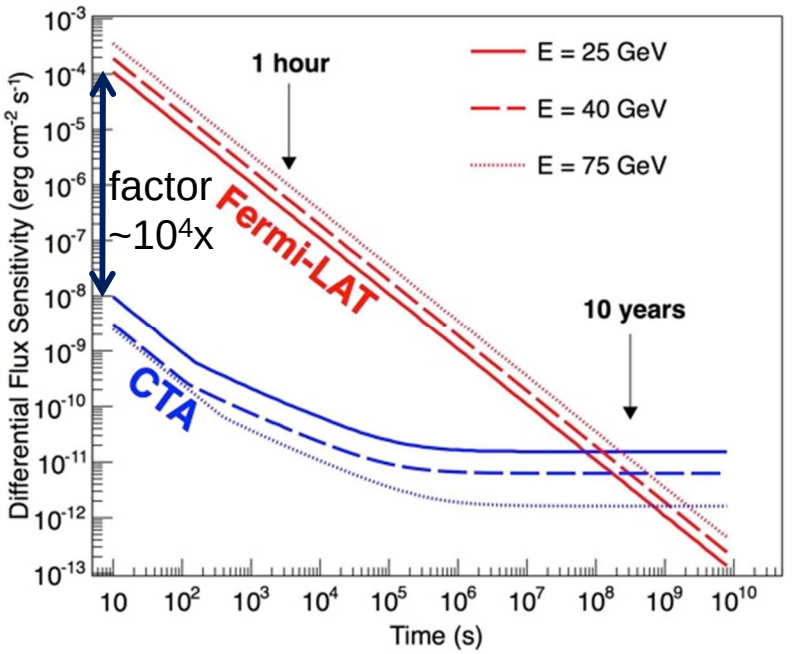
## Broad energy coverage

- < 100 GeV to reach higher redshifts
- > >10 TeV to search for PeVatrons
- enhanced energy resolution (eg DM lines)

## Time Domain Astronomy

- Coverage from seconds to years



# CTA SCIENCE

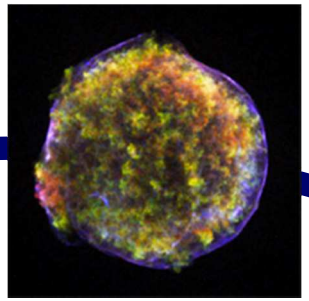
Shocks
Diffusion

**SNRs**

Jets
Accretion

**AGN**

**Starbursts**

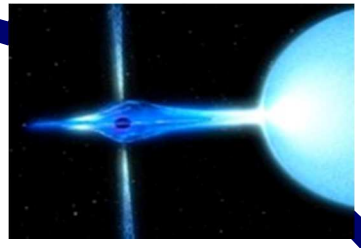


Cosmic rays

Shocks
Diffusion

**Binaries**

Jets
Accretion

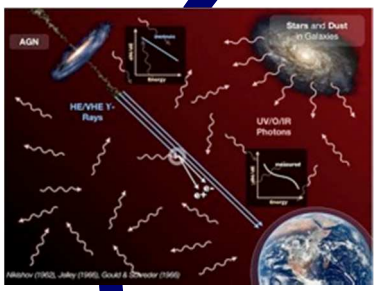


Jets
Winds

**Pulsars/PWN**

**Intergalactic medium**

Probes



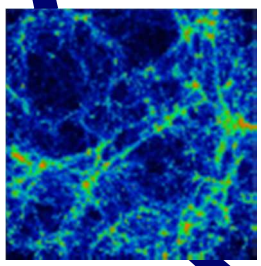

EBL
IGM

## CTA Themes

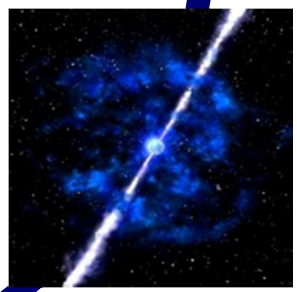
1. Understanding the origin of cosmic rays and their role in the Universe.
2. Understanding the nature and variety of particle acceleration around black holes.
3. Searching for the ultimate nature of matter and physics beyond the Standard Model.

WIMPs
ALPs

**Dark matter**

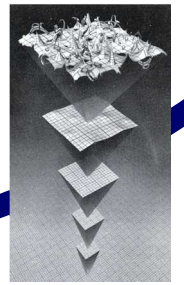


**GRBs**



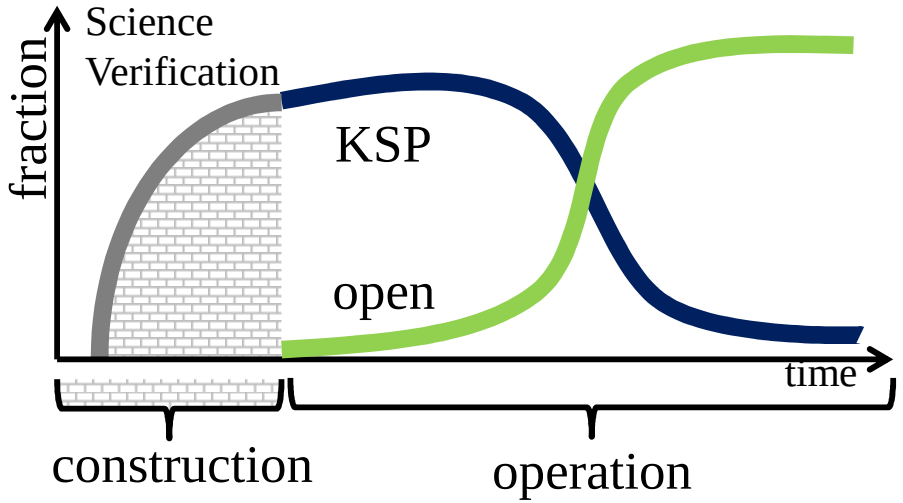
**LIV**

Probes



Jets
Shocks

# AN OPEN OBSERVATORY




**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.

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

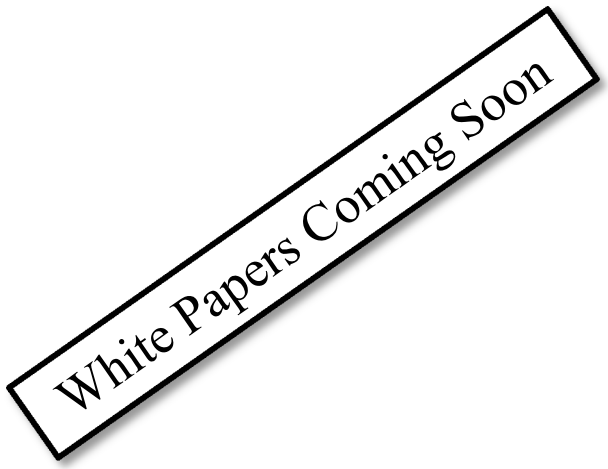
Proposal preparation & submission tools (TAC evaluation)
Calibrated, reconstructed & reduced event data (FITS)
Software to analyse data (Fermi-LAT like)
User documentation
Help Desk, Knowledge, Training

# KEY SCIENCE PROJECTS

Criteria:

- scale in terms of observing hours
- need for coherent approach across multiple targets/pointings
- technical difficulty of performing required analysis and hence reliance on consortium expertise

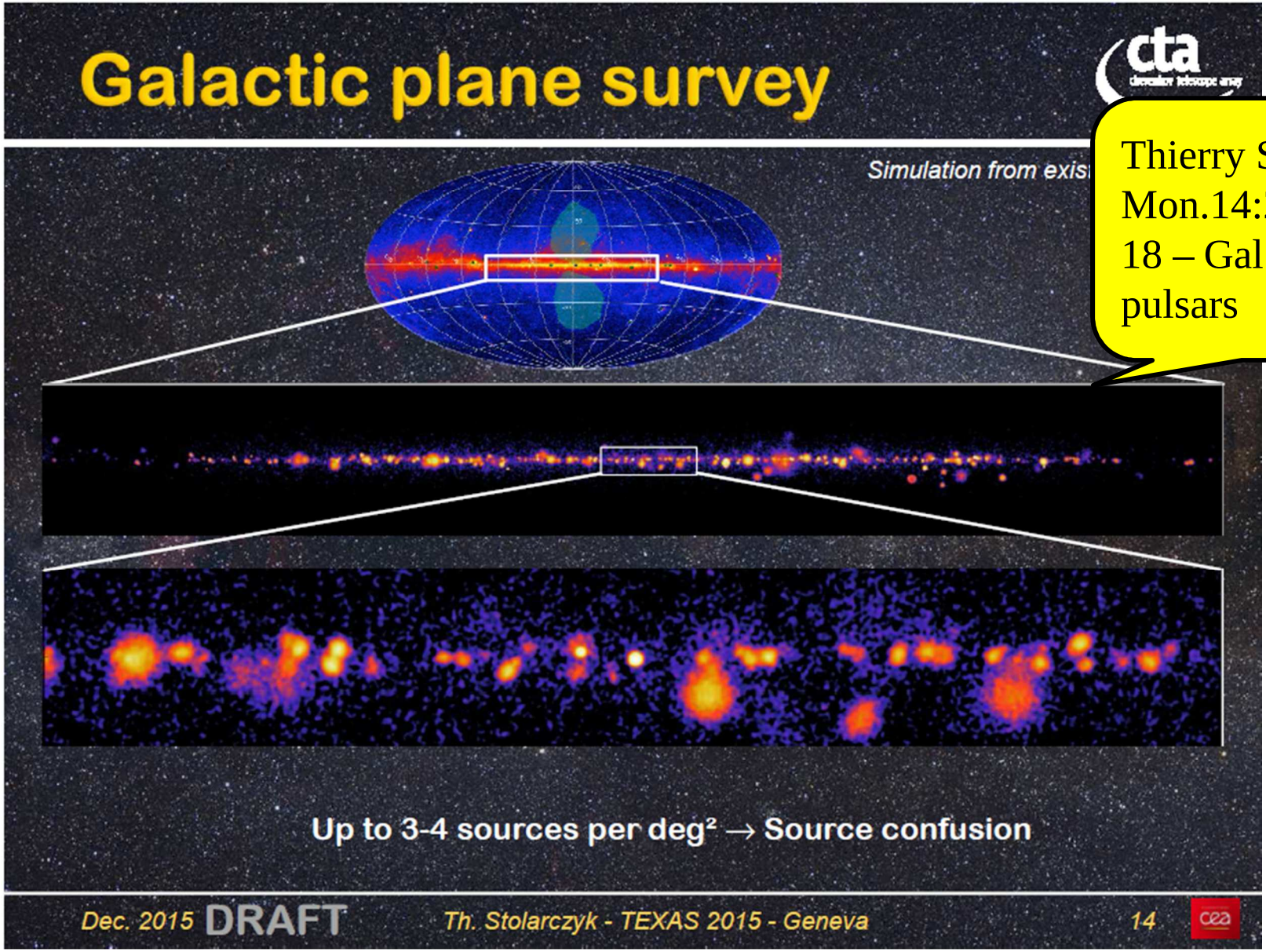
Will become legacy datasets of high value to the wider community




Under consideration:

- Dark Matter Programme
  - dSph
- Galactic Centre
  - synergy with dark matter prog.
- Galactic Plane Survey
  - catalogue, diffuse emission model, PeVatron candidate list, variable sources
- LMC Survey
- Extragalactic Survey
  - 25% sky catalogue
- Transients
  - synergies to MWL/MM partners
- Cosmic Ray PeV-atrons
- Star Forming Systems
  - from mol. clouds to starbursts
- Active Galactic Nuclei
  - long term monitoring, deep exposures of a few sources
- Galaxy Cluster
  - synergy to cosmic-ray/dark matter prog.
- Non-gamma-ray Science
  - Cosmic ray spectrum, electron spectrum, Intensity Interferometry

# GAL/SURVEY




Thierry Stolarczyk
Mon.14:20
18 – Gal. accel. & pulsars

# EXGAL

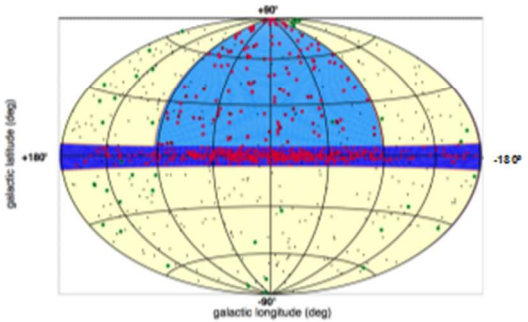
## Extragalactic Key Science Projects

**Active Galactic Nuclei**
- Long-term monitoring
- High quality spectra
- Flare Program

AGN physics
Cosmology
UHECRs
Fundamental physics

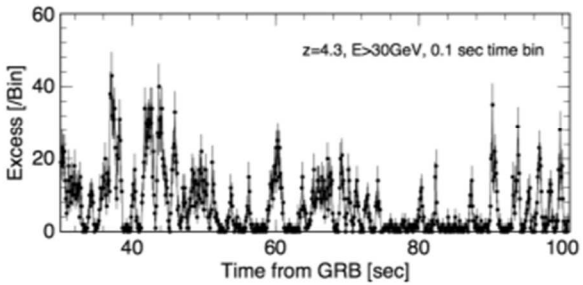
**Extra-Galactic Survey**
- Unbiased survey of ¼ of the sky

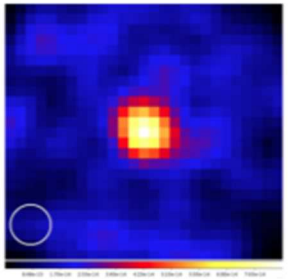
Population study and duty cycle
New and unknown sources




**Transients**
- Follow-up of external or internal triggers

Gamma-Ray Burst



**Galaxy Clusters**
- Deep observation of galaxy clusters

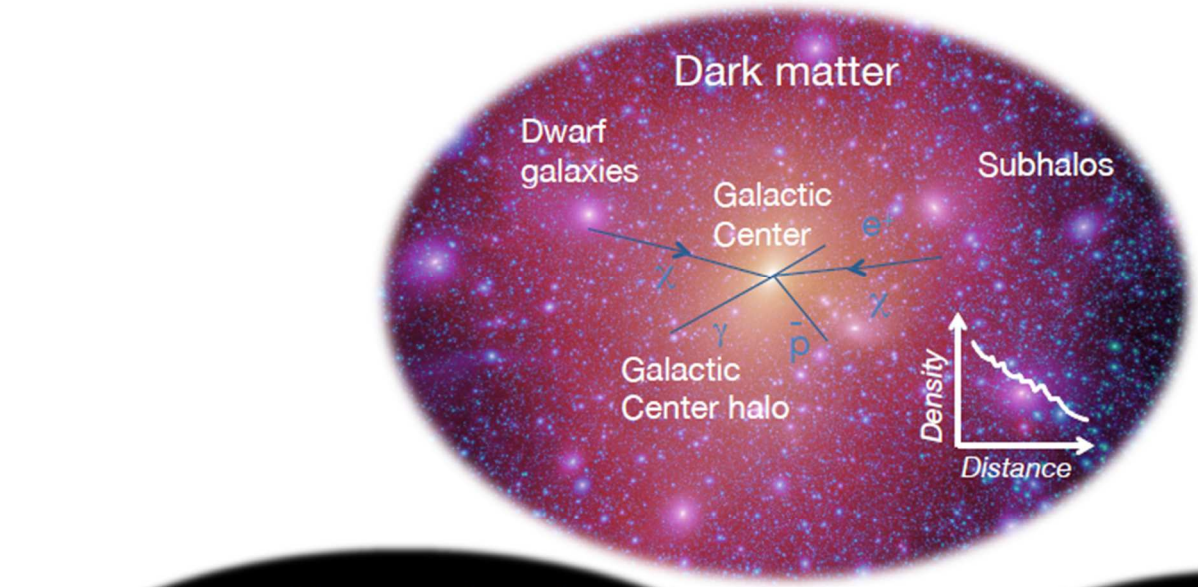
Probing cosmic ray in clusters

Lucie Gerard
Weds.16:15
19 – VHE&CR

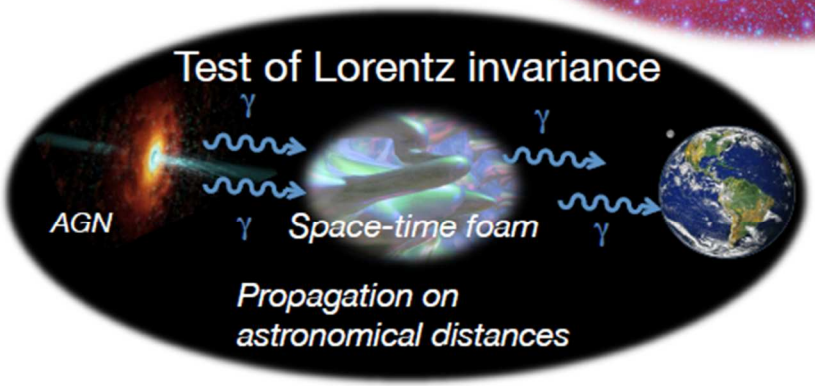
Lucie Gérard | ExtraGalactic Science with CTA | 2015/12/15 | Page 1

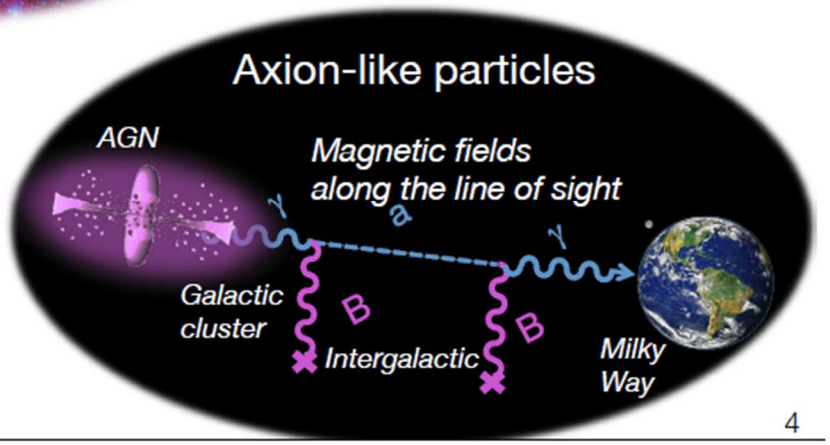
# FUNDAMENTAL

## DARK MATTER AND FUND. PHYSICS



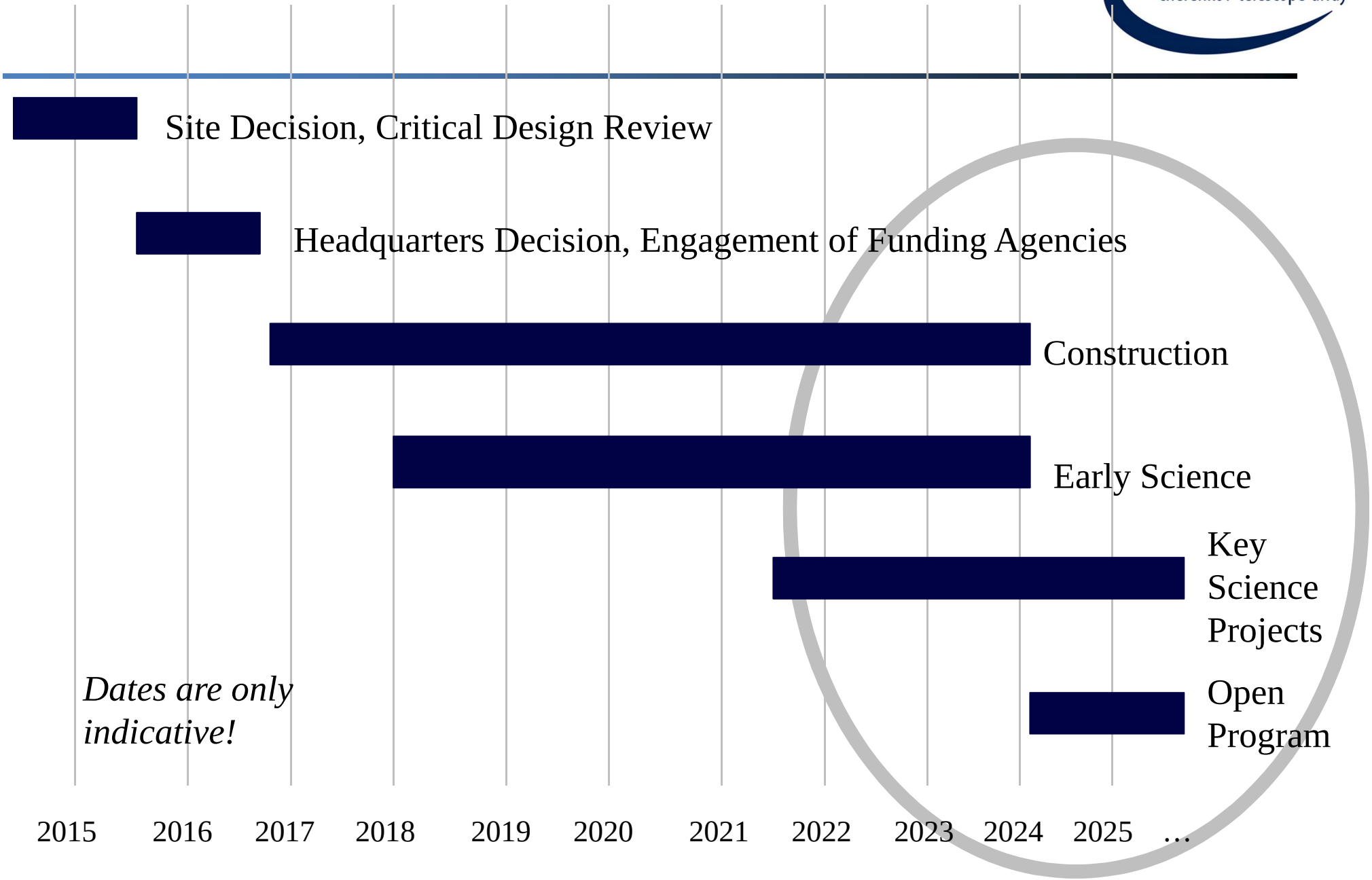

Emmanuel Moulin
Weds.16:40
05 – Dark Matter




E. Moulin, Texas Symposium, 13-18 December 2015 4

# CTA TIMELINE



# SUMMARY

CTA will be an open observatory comprising arrays of IACTs aiming to:

- Provide energy coverage for photons from 20 GeV to at least 300 TeV, providing reach to high redshifts and extreme accelerators.
- Increase the sensitivity level of current instruments by a factor ~10 at 1 TeV.
- Substantially improve angular resolution and field of view and hence ability to image extended sources.
- Significantly boost detection area, and hence photon rate, providing access to the shortest timescale phenomena.
- Provide access to the entire sky, with sites in two Hemispheres.
- Dramatically enhance surveying capability, monitoring capability, and flexibility of operation, allowing for simultaneous observations of objects in multiple fields,
- Serve a wide user community, with provision of data products and tools suitable for non-expert users.

# CTA SYNERGIES

**Fermi**

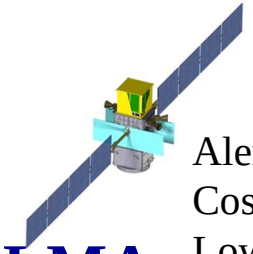
Alerts

**Athena**

Cosmic rays / SNR
Jet-disk connection

**SVOM**

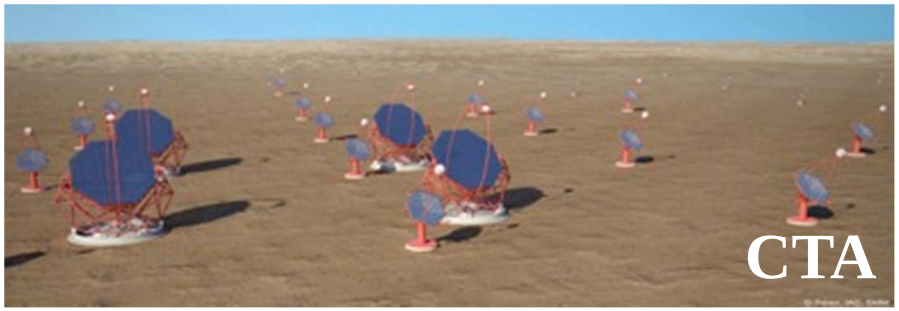
**ASTROGAM**



Alerts
Cosmic rays
Low-energy coverage

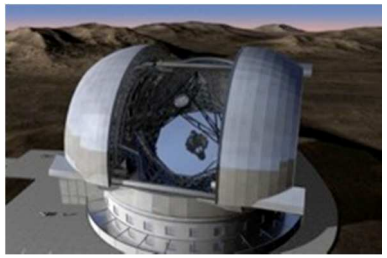
**HAWC**

Survey, Alerts



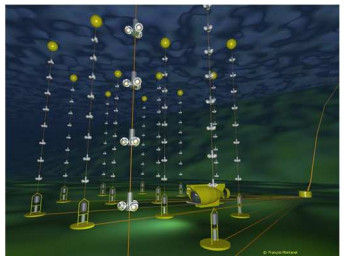

**ALMA**

ISM ionisation
BH jet imaging



Transient Factories,
Surveys…

**Icecube, KM3NET**



neutrino alerts

**Virgo/LIGO**

GW alerts

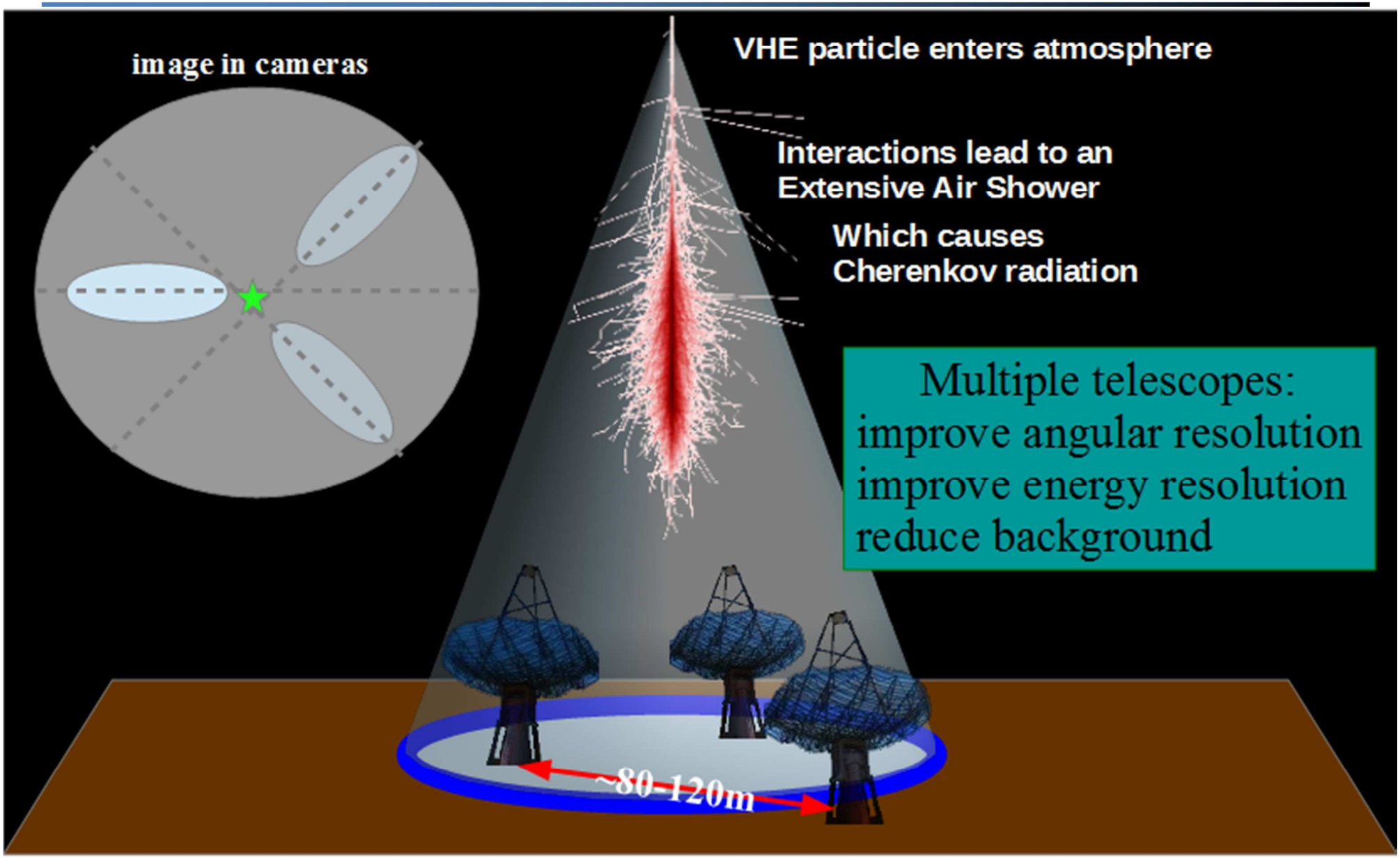
**SKA, LOFAR**

Broad band coverage
Alerts

# BACKUP

# VHE (E>10GeV) photons are best detected with Imaging Atmospheric Cherenkov Telescopes

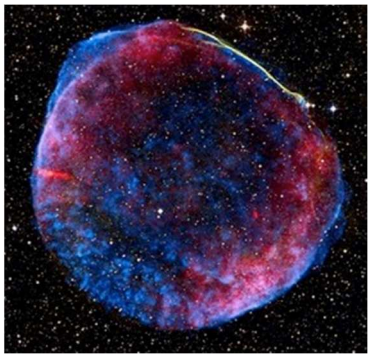
$\gamma$



# CTA SCIENCE THEMES

## 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?

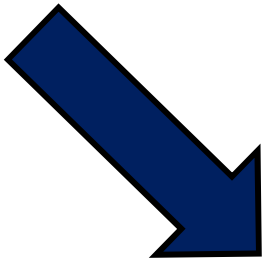
# CTA SCIENCE PROGRAMME

**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

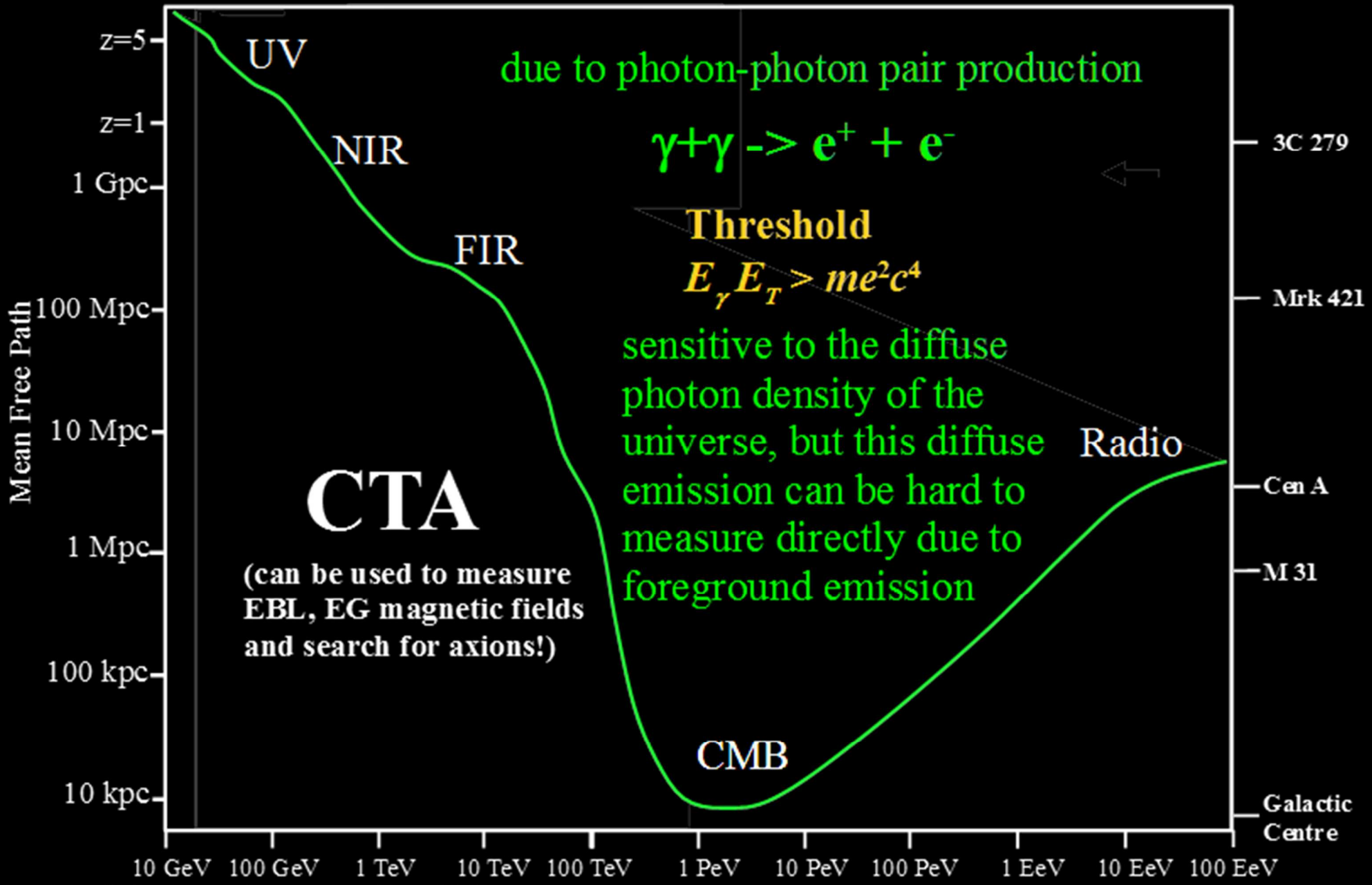
Multi-wavelength campaigns

Follow-up of ToOs from other wavebands or messengers

Search for new sources

…

# The γ-ray Horizon



# 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° MAPM/SiPM pixels

## Status

Prototype telescope structure built in Meudon (near Paris)
Inauguration Dec. 2015