The Cherenkov Telescope Array observatory

A SENSITIVE PROBE OF EXTREME UNIVERSE

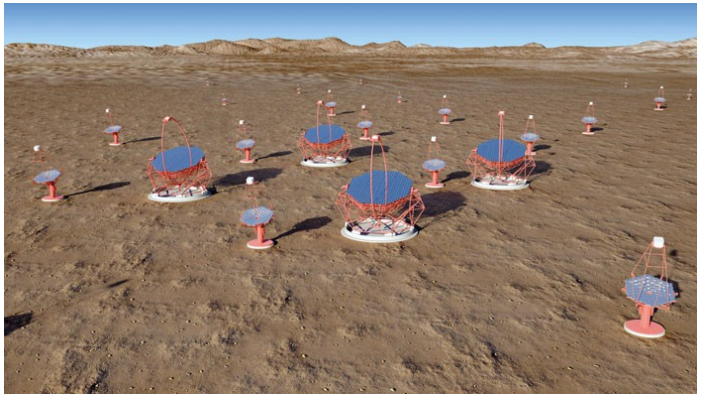
Mai 5, 2016

David Sanchez (LAPP) for the CTA Consortium

CTA : Next Generation

From 2-5 Tel arrays

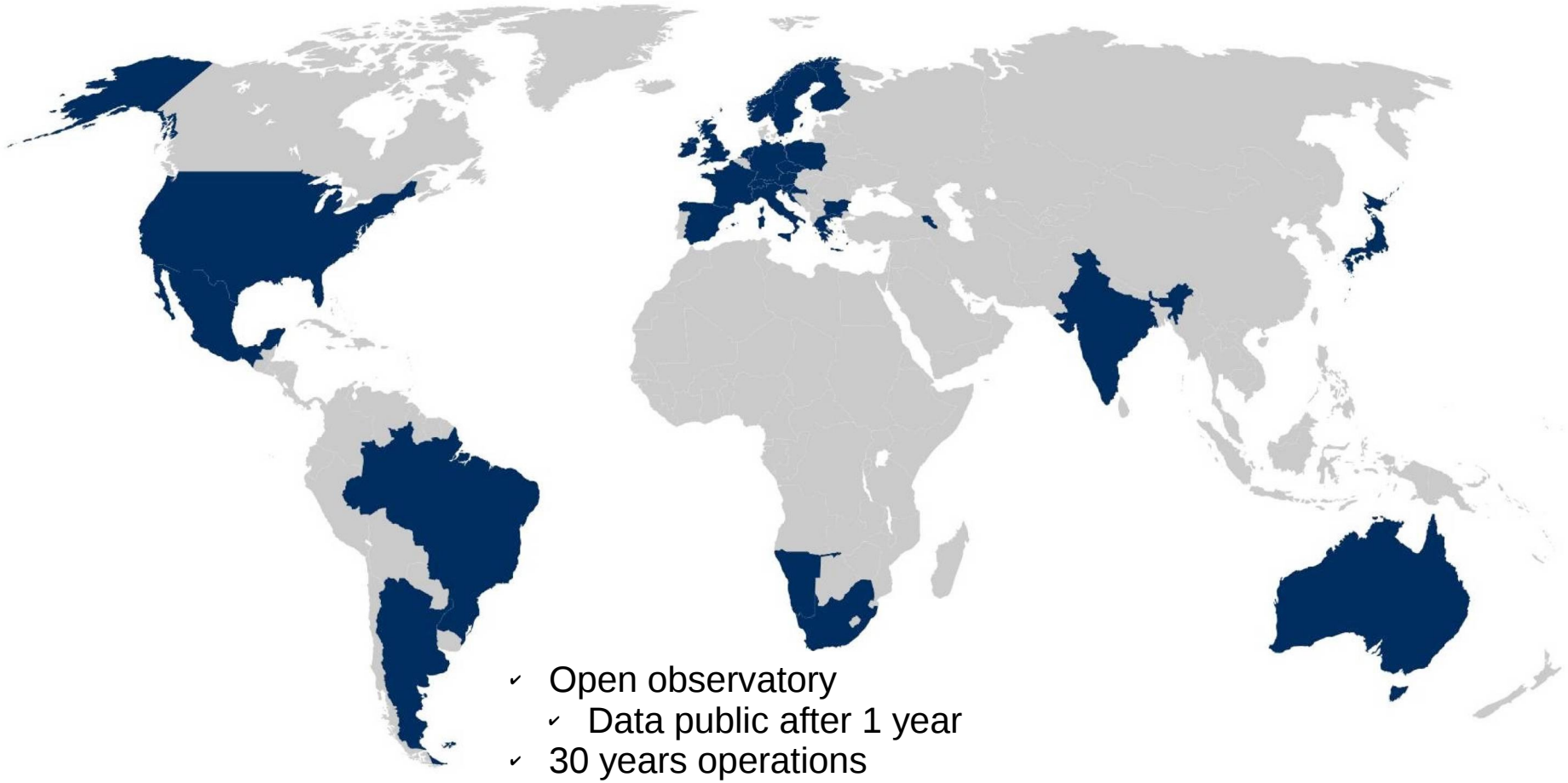




To ~ 100 telescopes

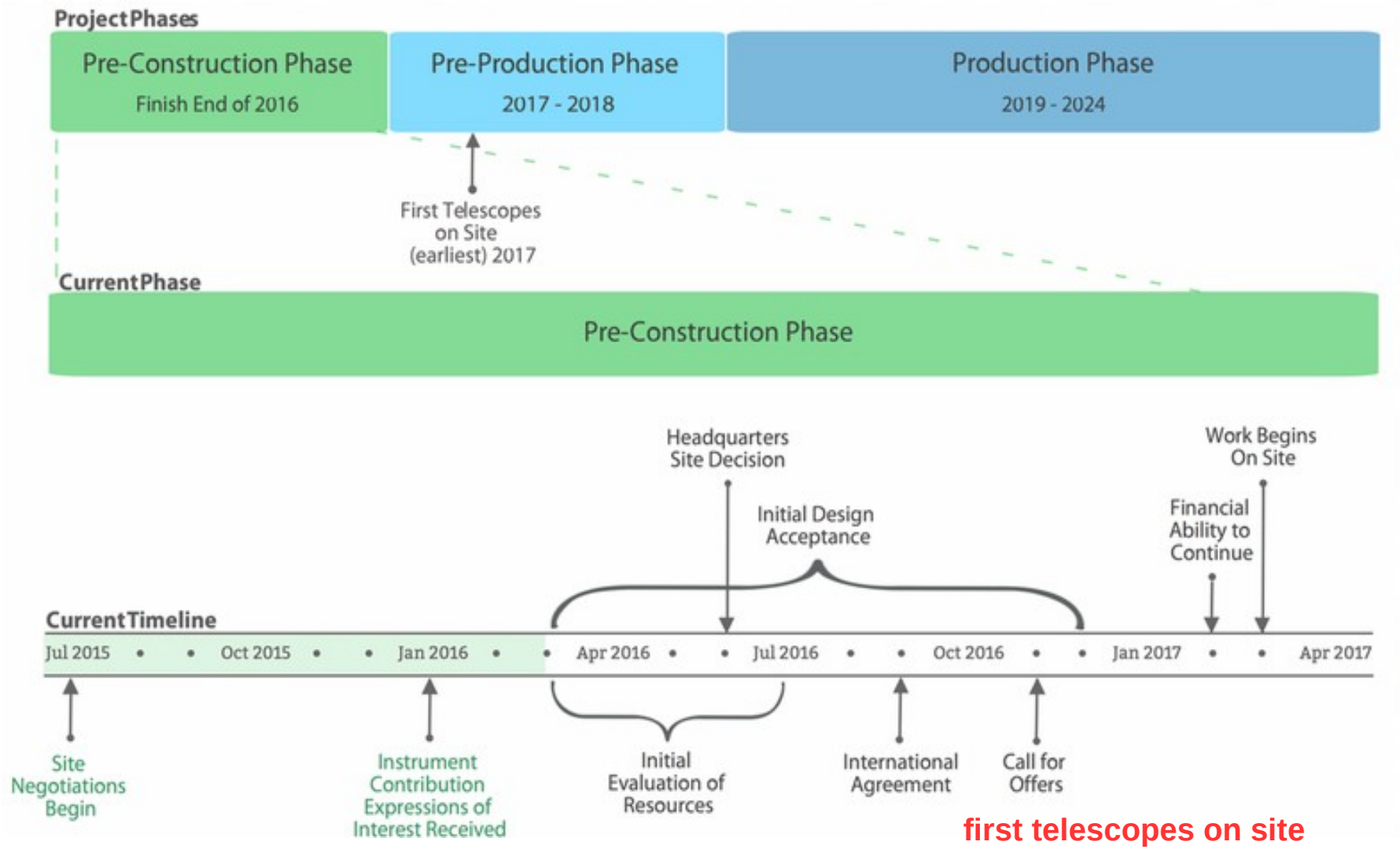
- Open observatory
  - Data public after 1 year
- 30 years operations
- 2 sites
- 32 nations, ~ €297M (construction costs)

CTA consortium



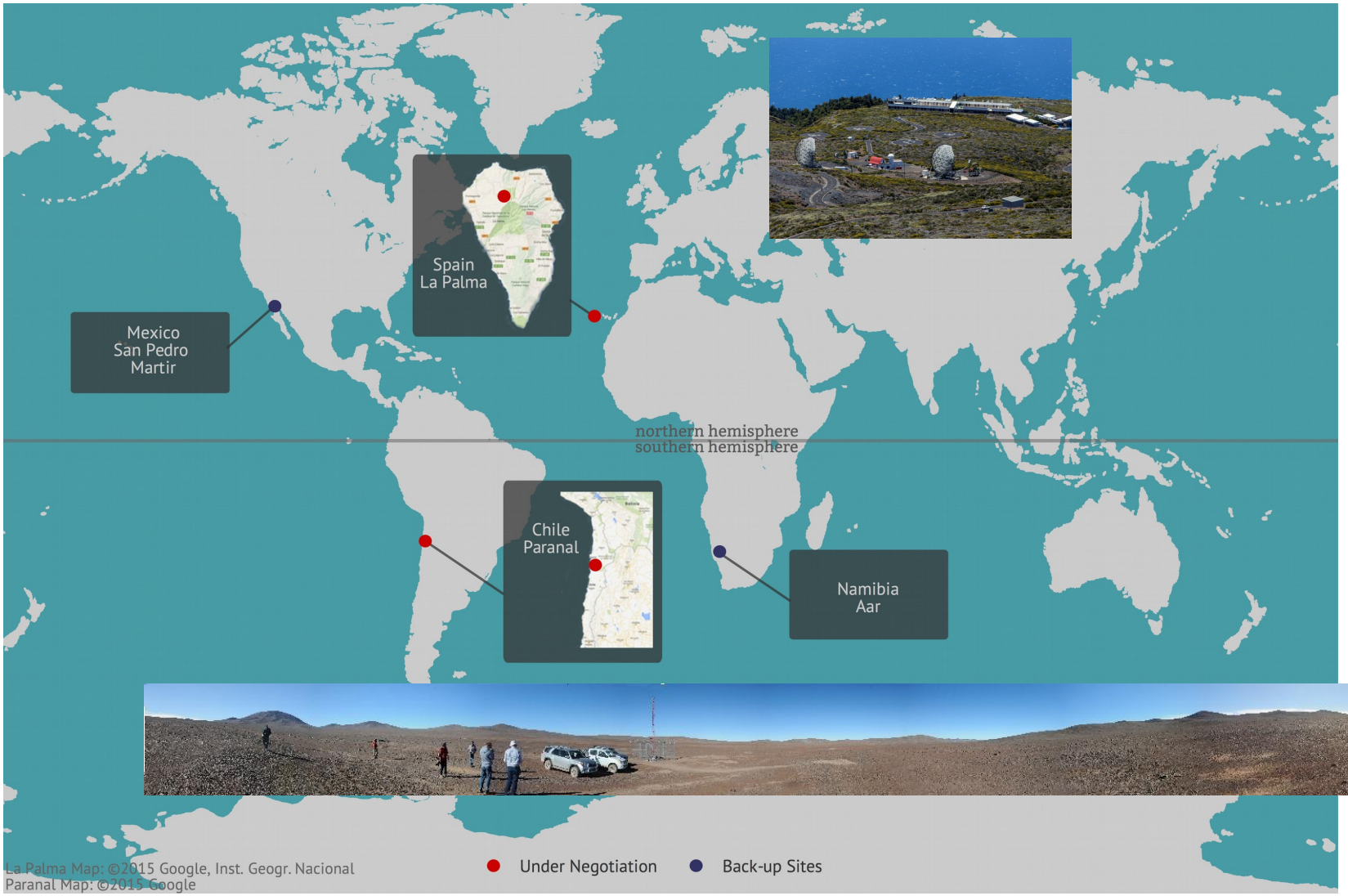
- Open observatory
  - Data public after 1 year
- 30 years operations
- 2 sites
- 32 nations, ~ €297M (construction costs)

Time line



first telescopes on site expected in early 2017

South and North Sites



South and North Sites

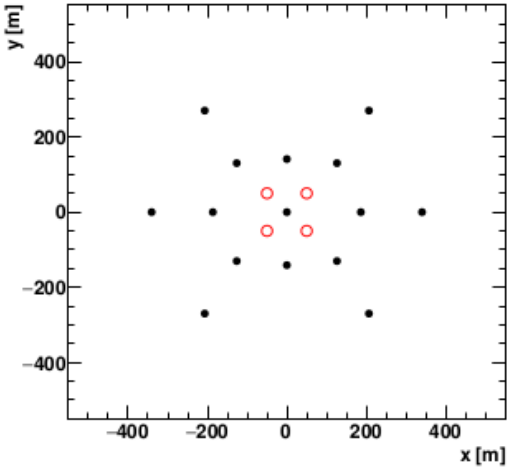
First stone at la Palma
October 9th

MPI director Masahiro Teshima

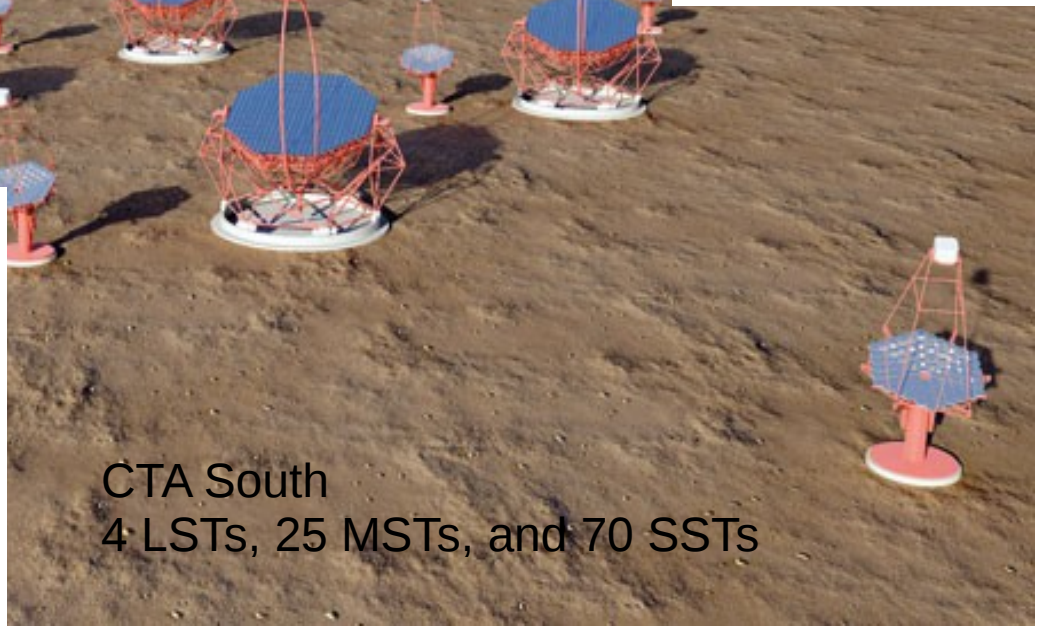
Site characterization instruments
on the Armazones site in Chile

Weather station, Wifi router

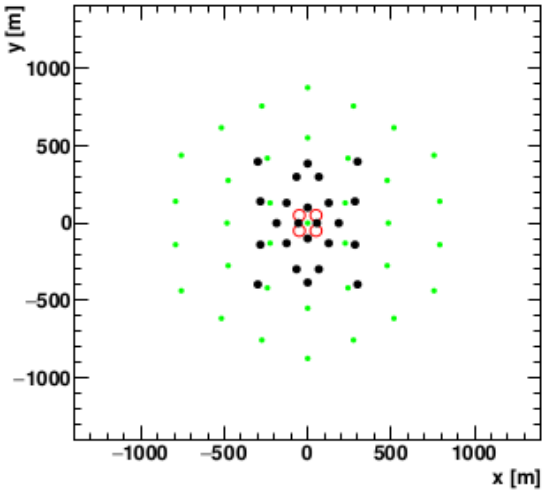
Array layout



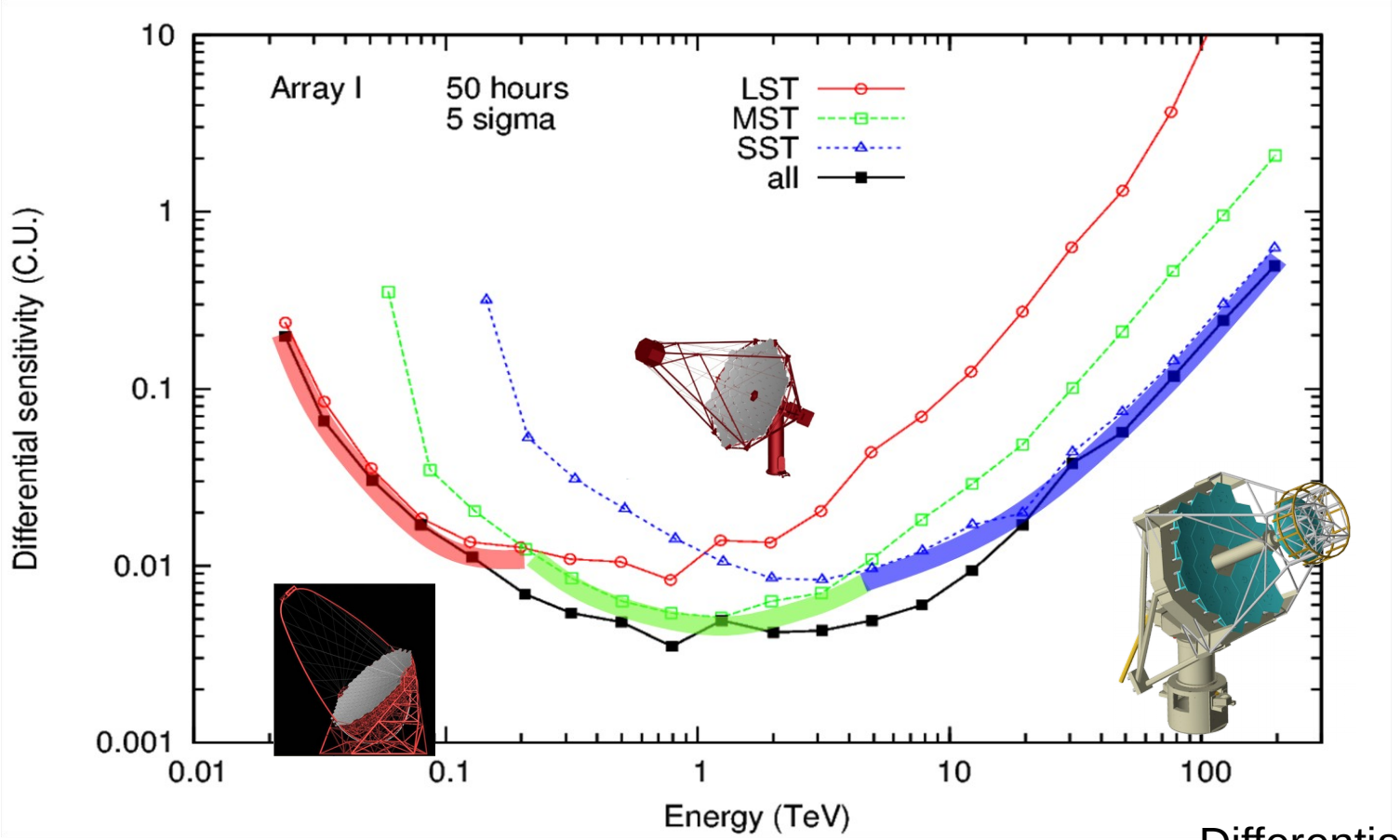
CTA North
4 LSTs and 15 MSTs



CTA South
4 LSTs, 25 MSTs, and 70 SSTs



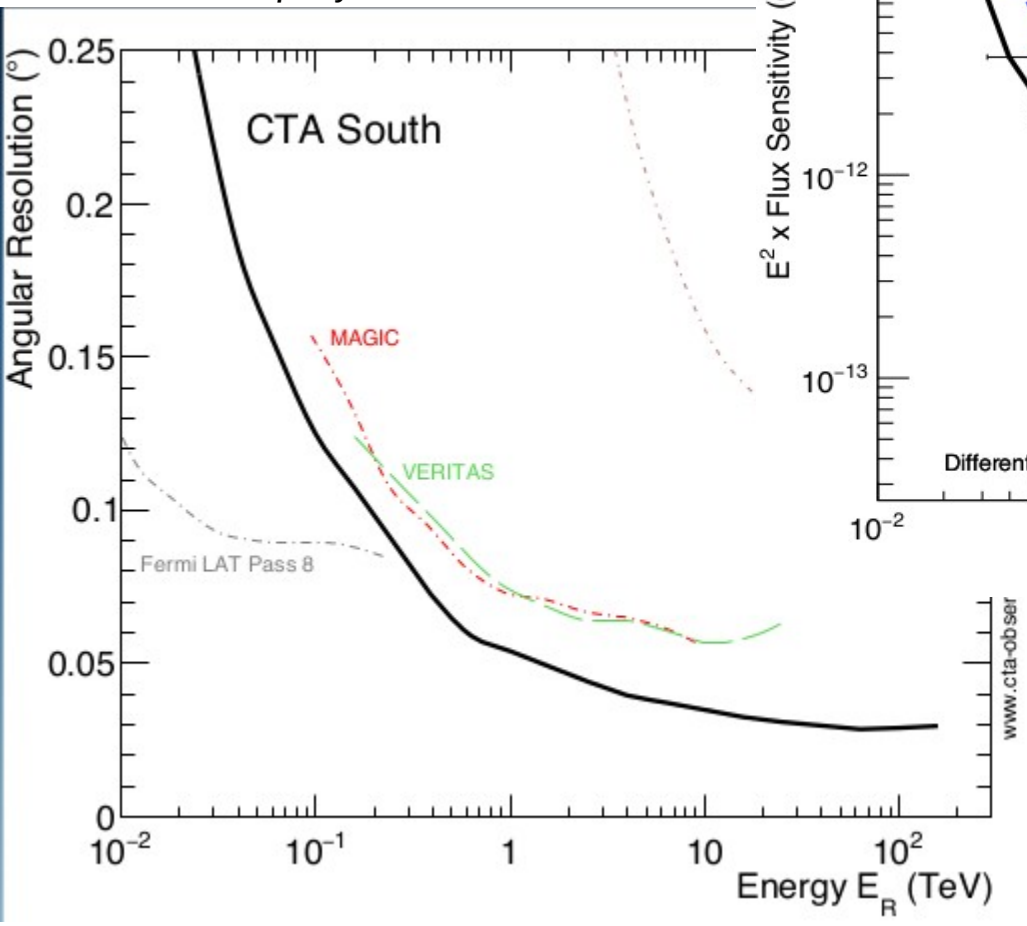
Expected sensitivity

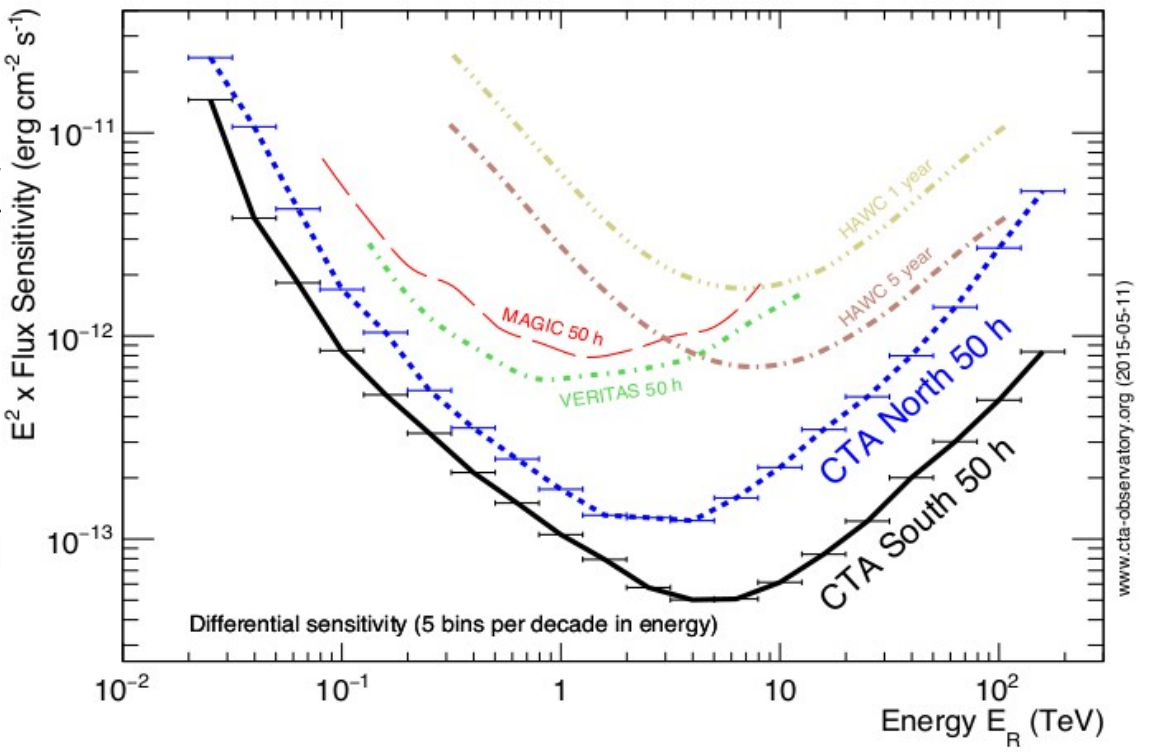


Differential flux sensitivity for 5σ detection per decade in energy

Expected sensitivity

Angular resolution expressed as the 80% containment radius of reconstructed γ rays



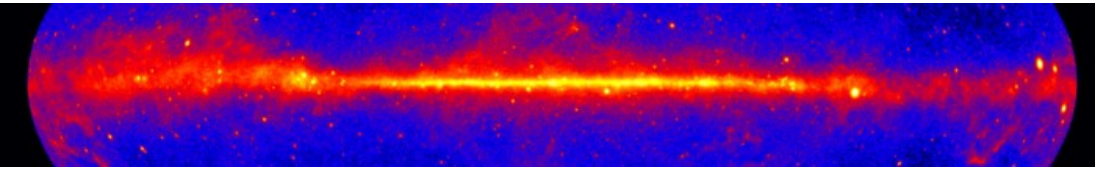


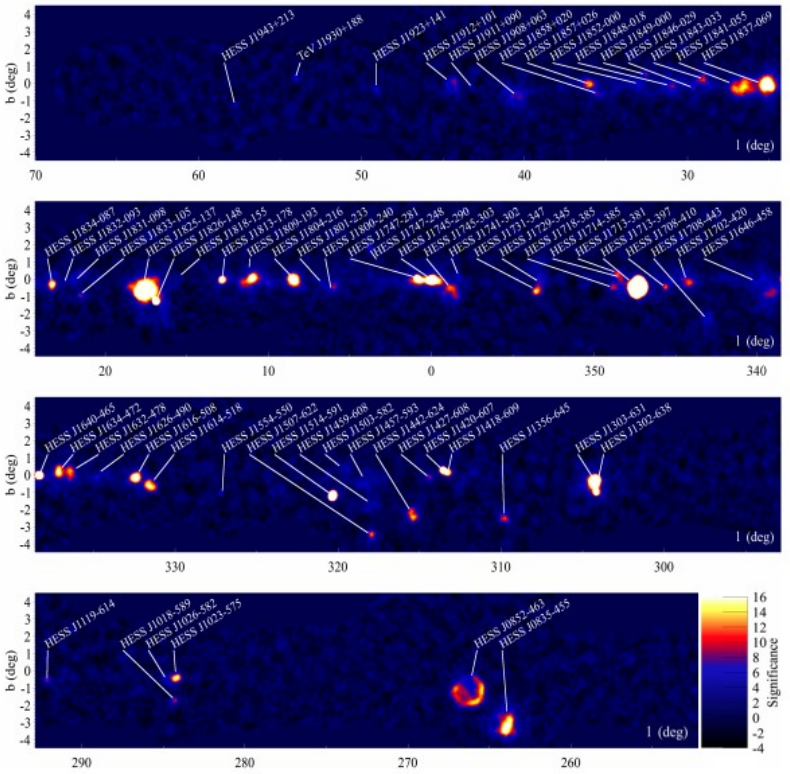
10 times better sensitivity

- Lower energy threshold
- Much more sensible ~10 TeV

A look at the Inner Galaxy

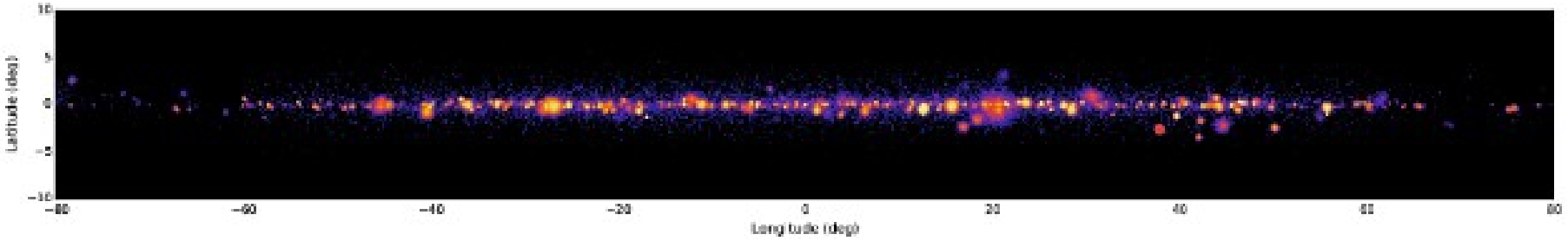
Fermi-LAT 5 years





HESS (ICRC 2013)

CTA simulation
(SNR and PWN populations as well as diffuse emissio)



Small Sized Telescope SST

Science drivers

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

Array layout Status

- South site: 70 SST
- None in North
- Prototypes in Krakow (SST-1M), Mt. Etna (ASTRI), Paris (GCT)

SST-1M

9 °fov 0.24°SiPM pixels

Davies-Cotton
8.5m² effective
mirror area

5.6m focal length

Inauguration of the **SST-1M telescope prototype** for the Cherenkov Telescope Array took place on **June 2, 2014** at the H. Niewodniczański Institute of Nuclear Physics Polish **Academy of Sciences (IFJ PAN) in Kraków**

Astri Telescopes

Schwarzchild-Couder
6m² effective mirror area
2.2m focal length
9.6 °fov 0.17°SiPM pixels

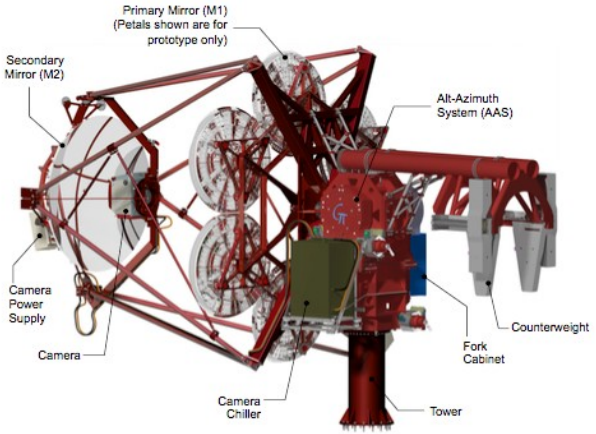
2014 September 24th

Inauguration of the ASTRI
SST-2M Prototype

Location: Mt Etna

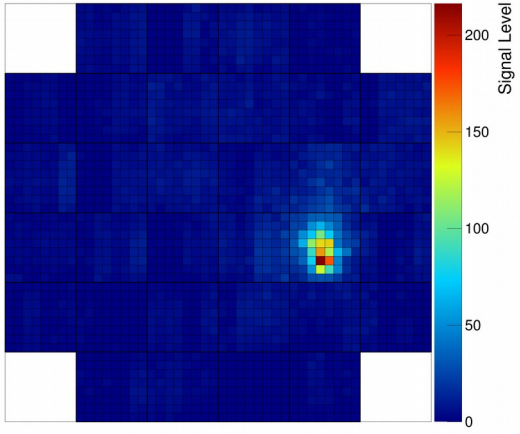
GCT

Schwarzchild-Couder
6m² effective mirror area
2.3m focal length
8.6 °fov 0.16°SiPM pixels

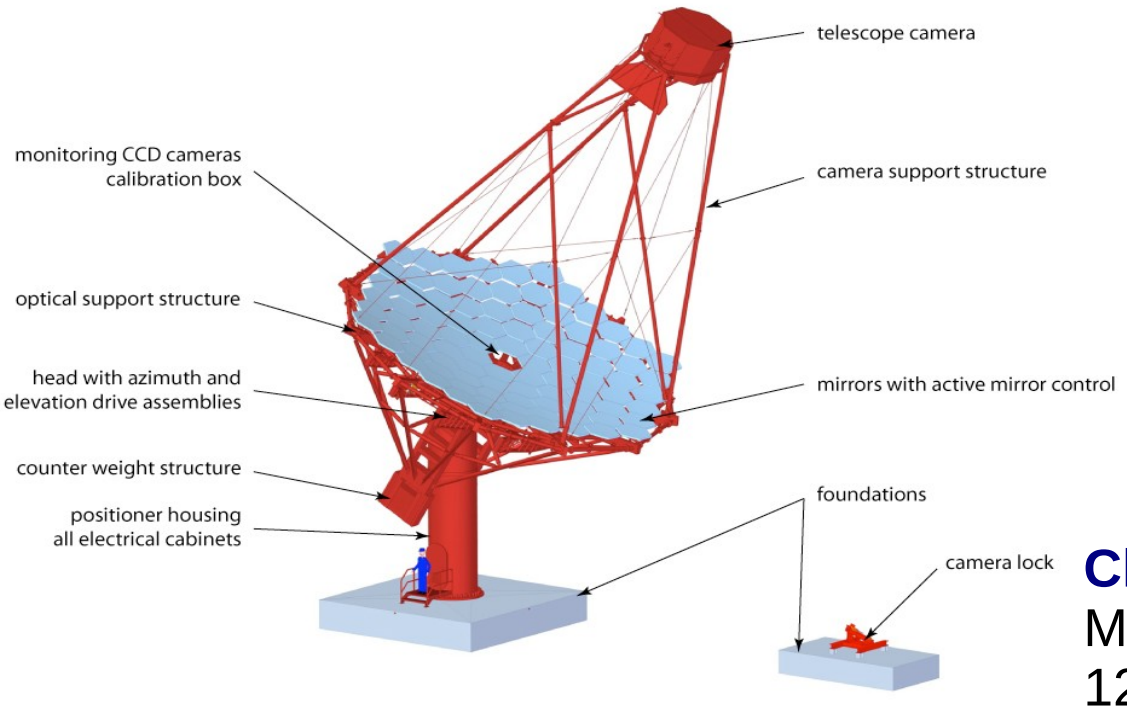


December 1st, 2015, l'Observatoire de Paris hosted the inauguration of the Gamma-ray Cherenkov Telescope (GCT) prototype.

- First events few days before



Medium Sized Telescope



Science drivers

Mid energies (0.1–10 TeV)
DM, AGN, SNR, PWN, binaries,starbursts, EBL, IGM

Array layout

South site: 25 MST
North site: 15 MST

Characteristics

Modified Davies-Cotton design
12 m diameter, 90 m² effective mirror area
1.2 m mirror facets
16 m focal length
8° field of view with 0.18° PMT pixels

MST prototype

Status

Telescope prototyped (Berlin-Adlershof)

Prototype cameras under construction (2 types: NectarCAM & FlashCam)

Large Sized Telescope

Science drivers

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

Characteristics

23m diameter parabolic design
370 m² 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

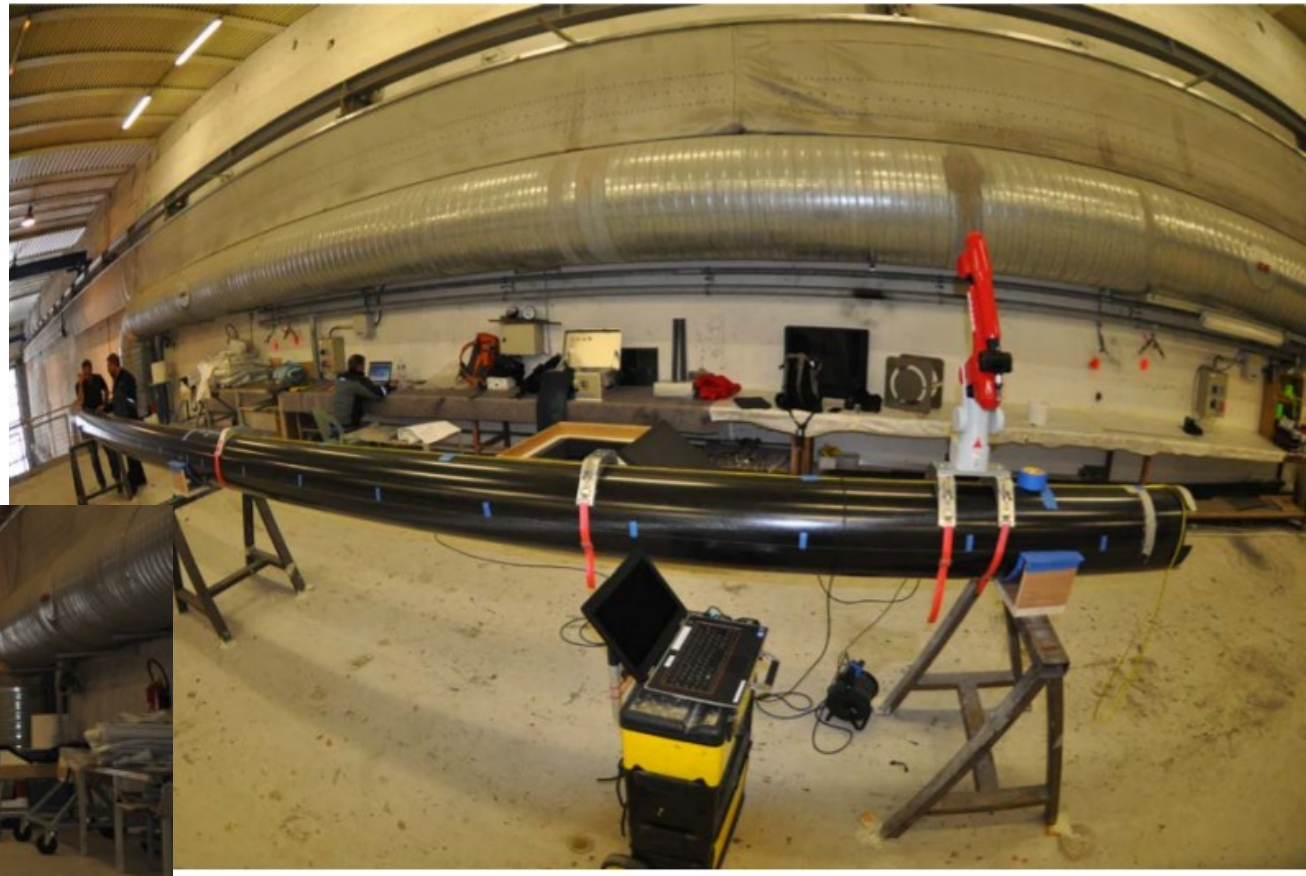
South site: 4 LST
North site: 4 LST

Status

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

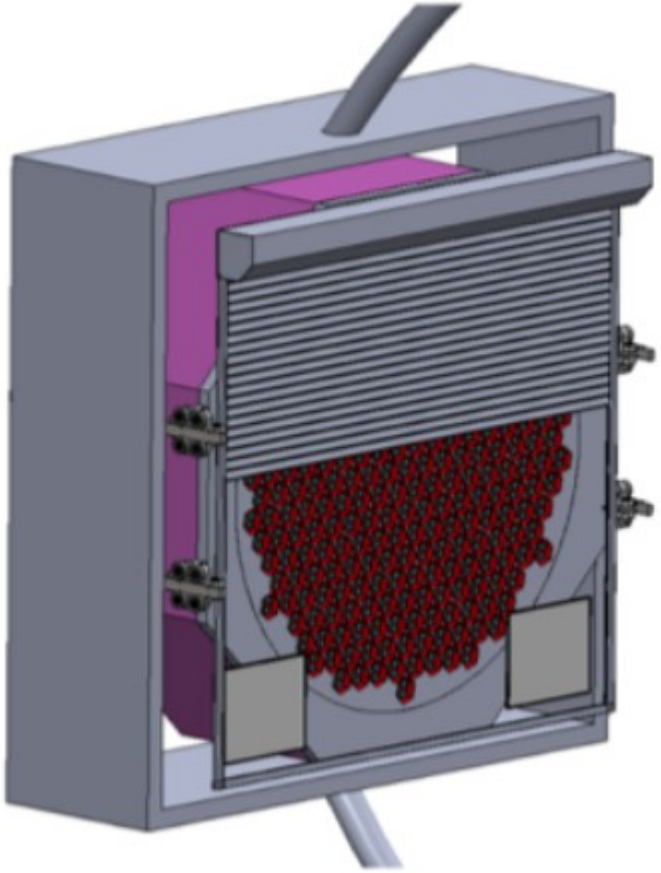
Large Sized Telescope

Production of the arch @ LORIMA



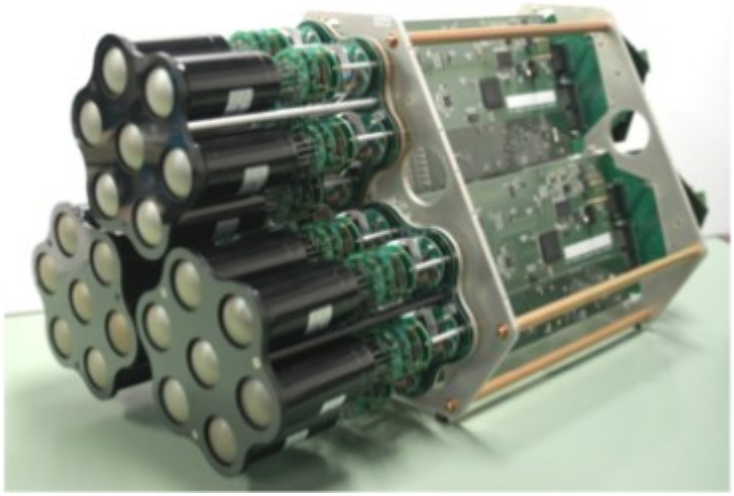
Courtesy of A. Fiasson (LAPP)

Large Sized Telescope



View of the camera
field of view of 4.5 degrees
Weight below 2000 kg

3 clusters: PMTs + electronics



Data Management

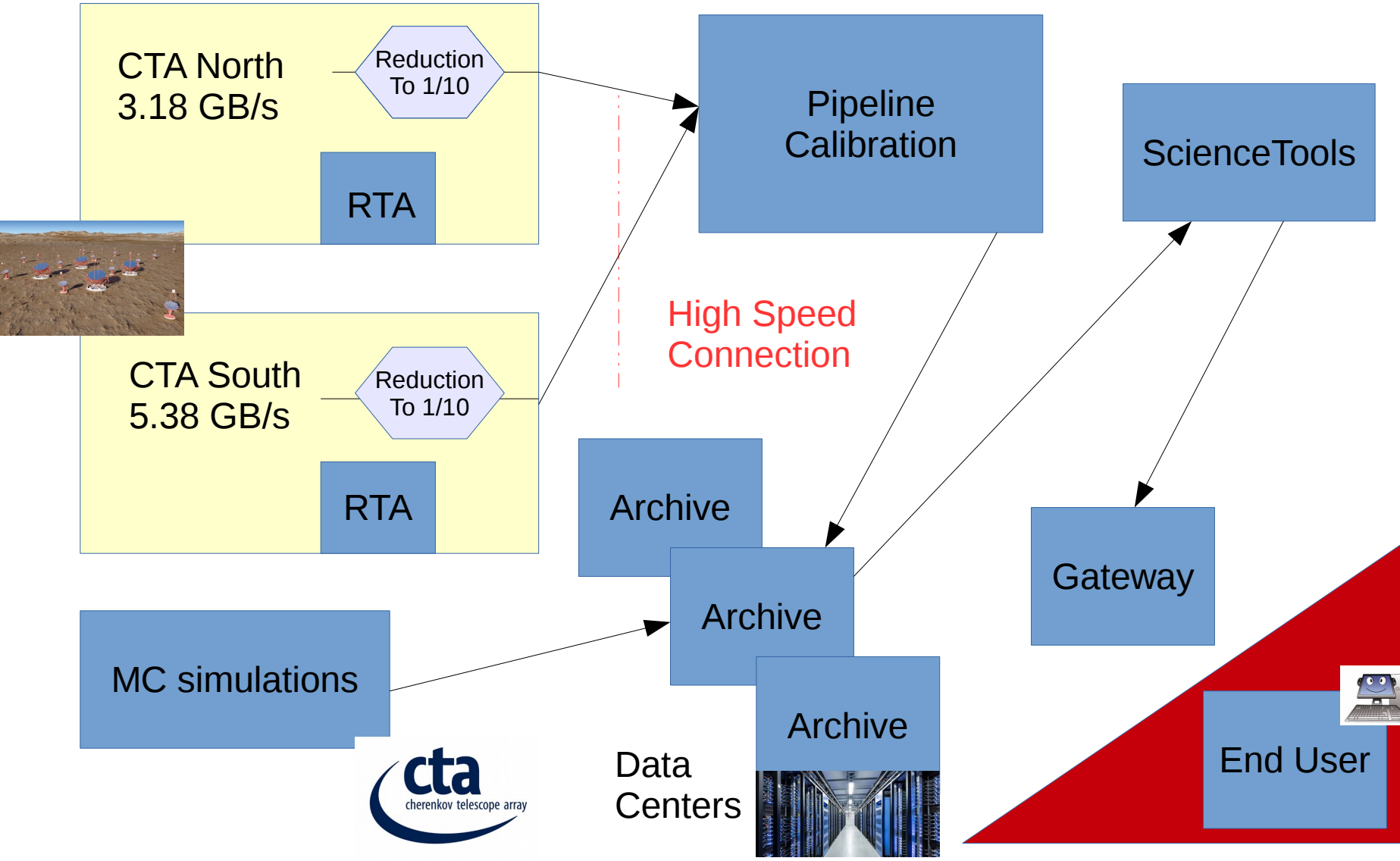
Challenges ahead

40 Pb per year of data
~2000 CPU cores to analyse data

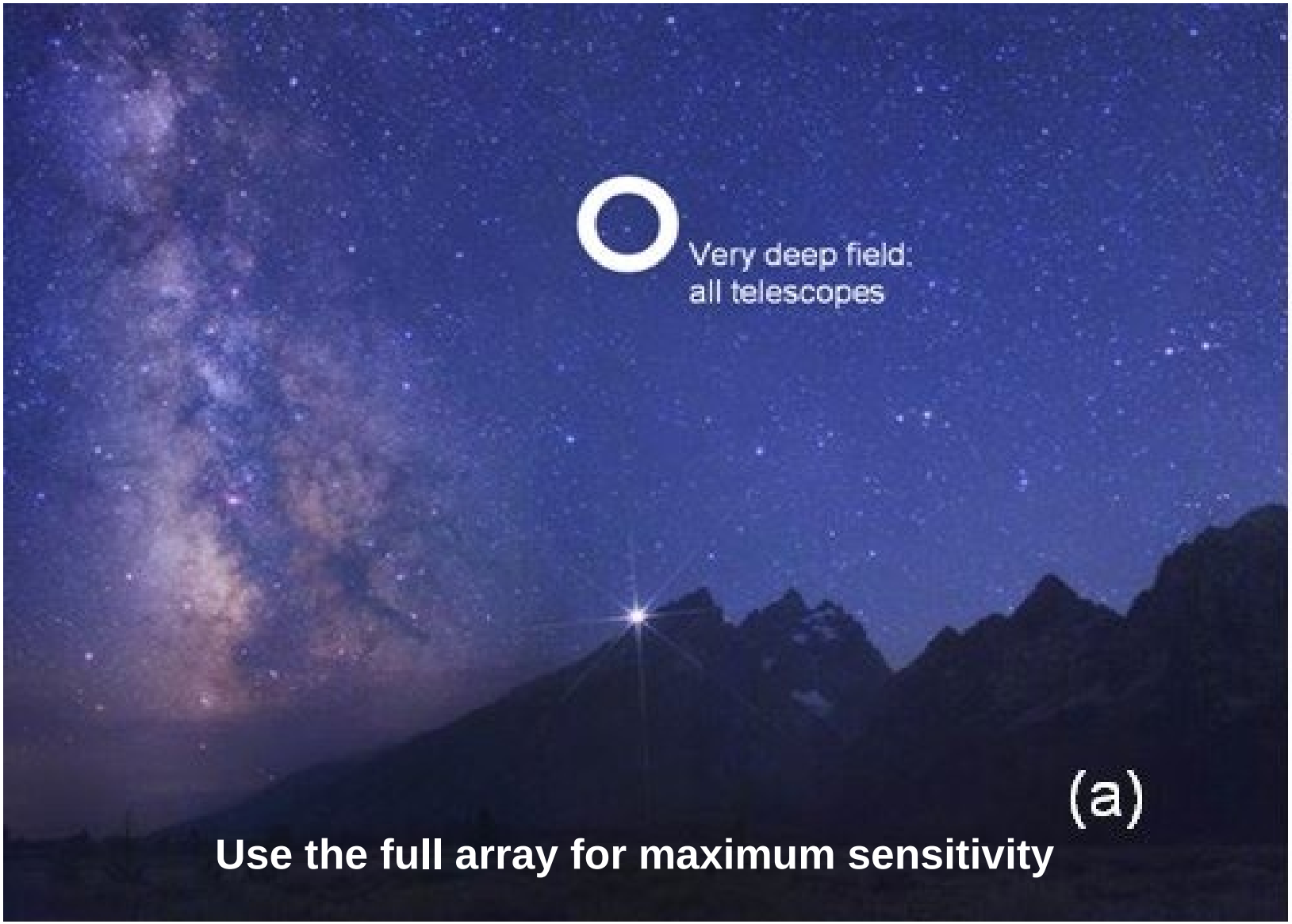
→

From Site to Data Centers
From Data Centers to you

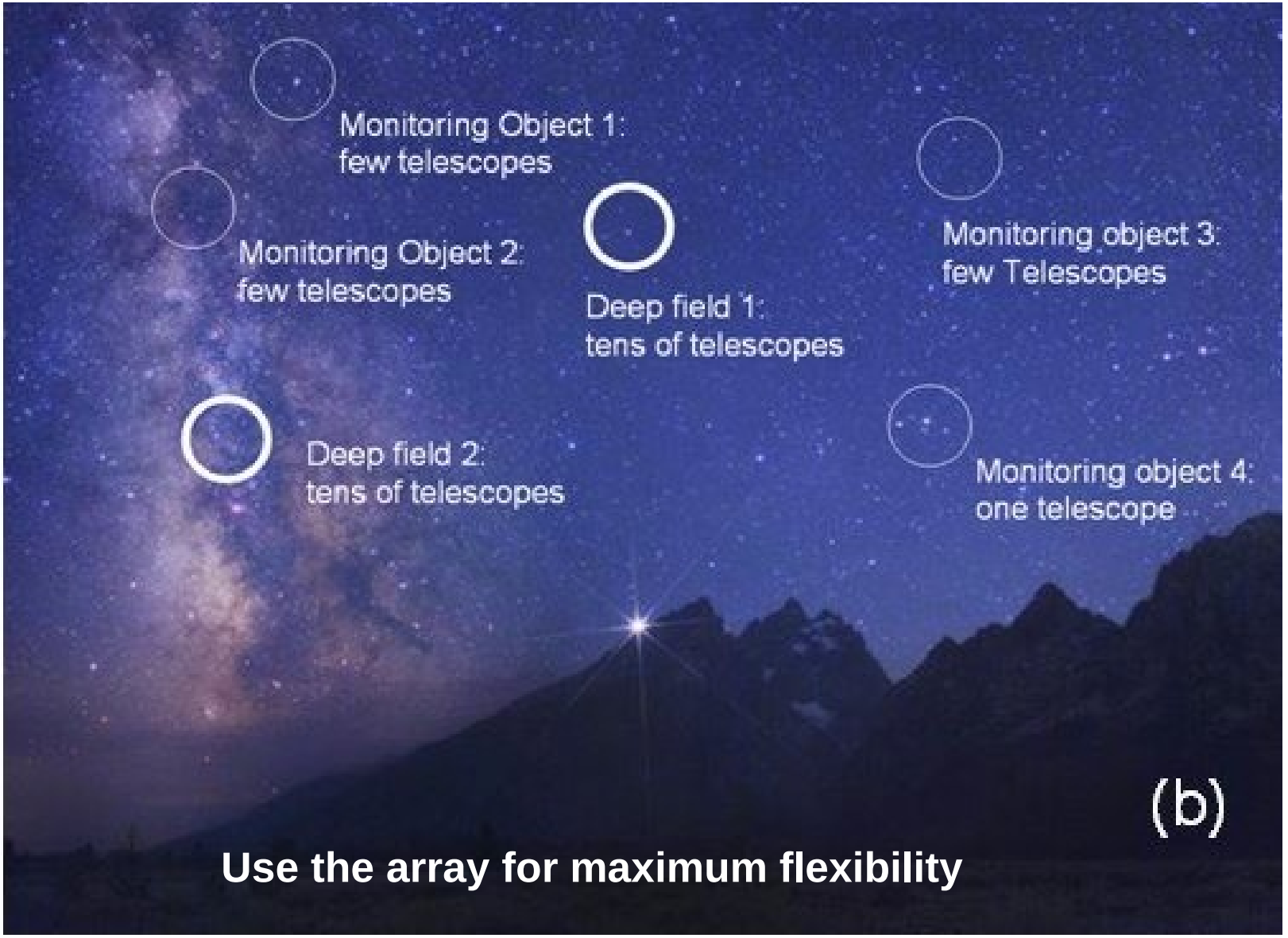
Data Management



Observation modes

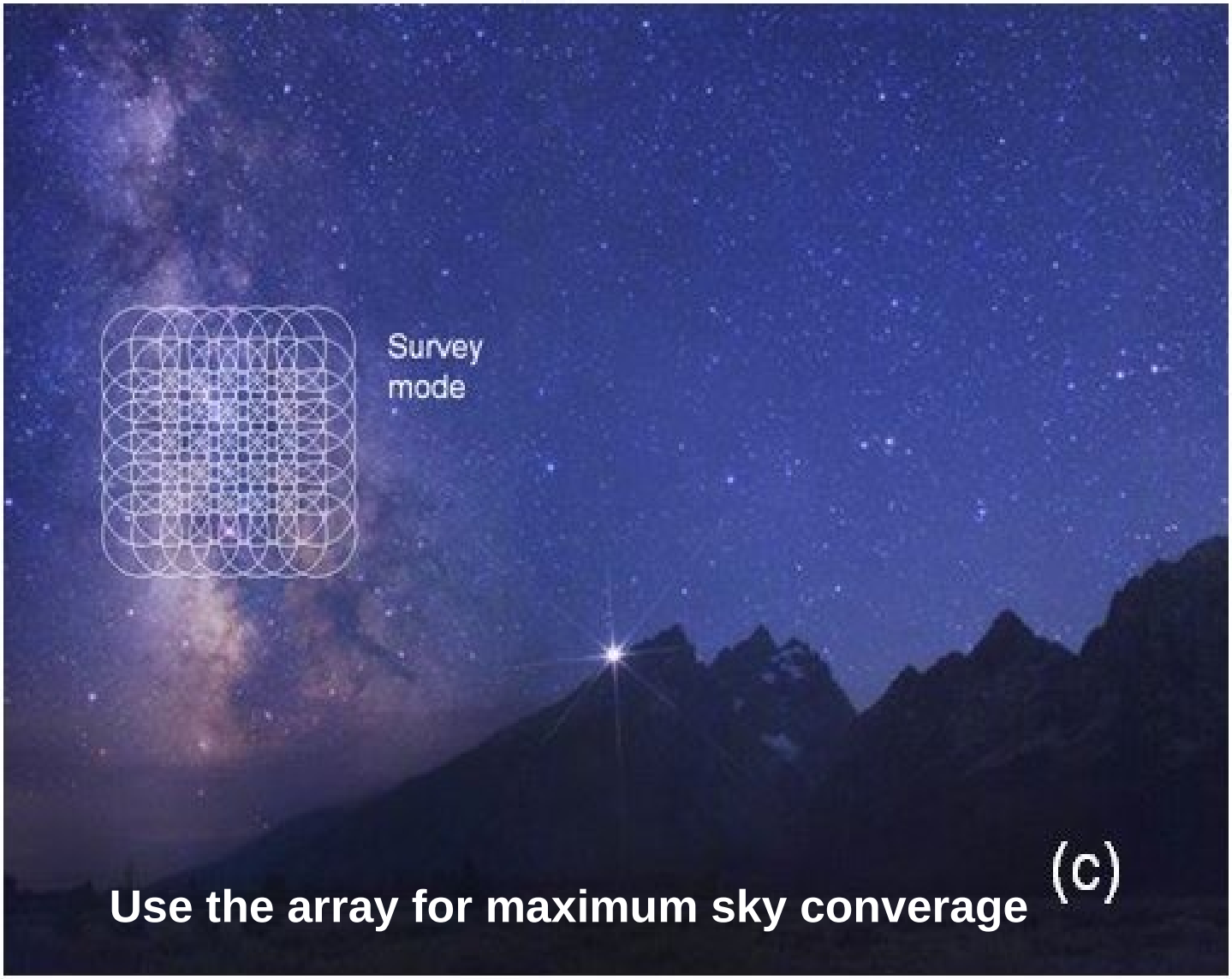


Observation modes



Use the array for maximum flexibility

Observation modes



Key Science Projects

Key Science Projects (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

Proposal-driven User Programme

Deep investigation of known sources

Follow-up of KSP discovered sources

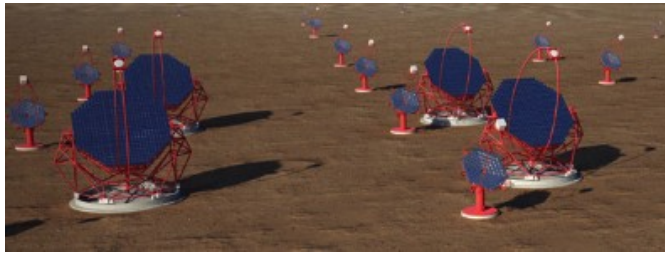
Multi-wavelength campaigns

Follow-up of ToOs from other wavebands or messengers

Search for new sources ...

Science Topics with CTA

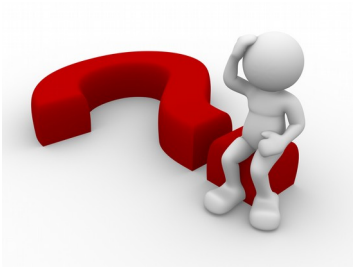
Theme 1: Cosmic Particle Acceleration



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

Theme 2: Probing Extreme Environments

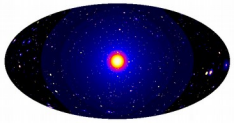
- Processes close to neutron stars and black holes?
- Particle acceleration in relativistic jets, winds and explosions?
- Exploring cosmic voids



Theme 3: Physics Frontiers – beyond the SM

- 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?

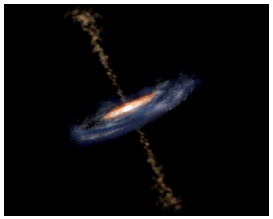
Science with CTA



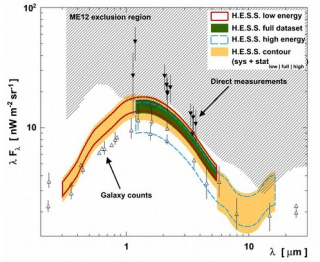
Dark Matter

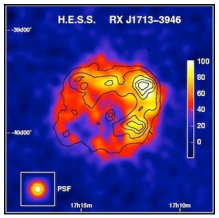
GRBs, ToO, etc..

EBL

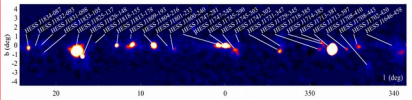


Blazars

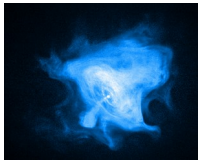




SNR, Pevatron



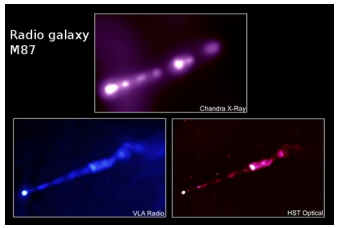
GPS

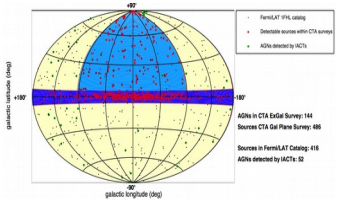


Redio Galaxies

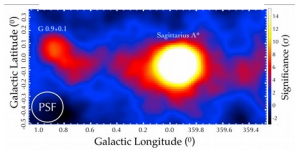
EGAL survey

Pulsar wind Nebulae





Galactic Center



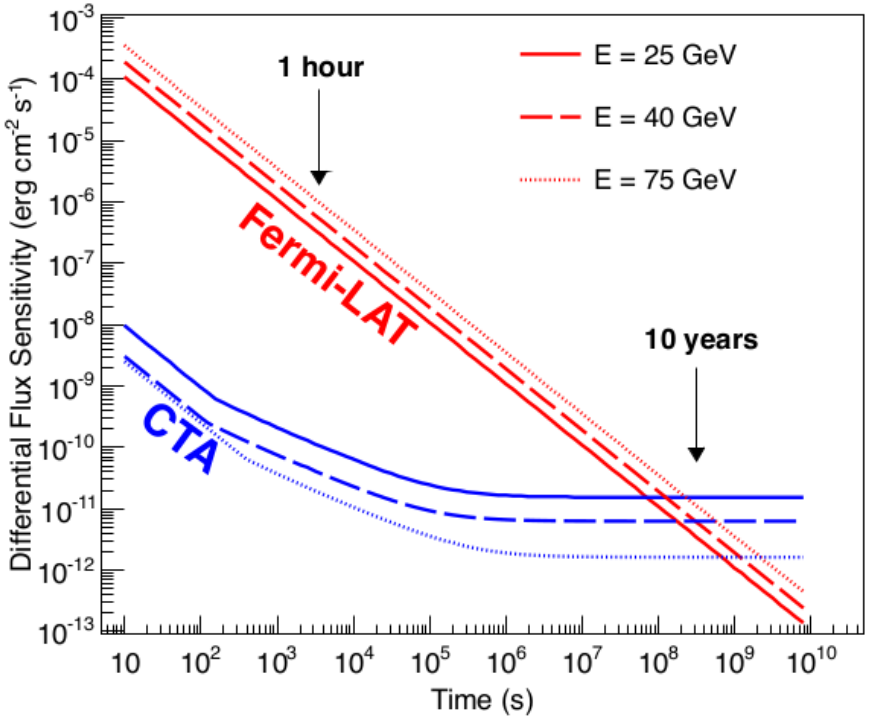
Transients, GRBs, GW

Gamma-ray bursts

Galactic Transients
High Energy Neutrino transients

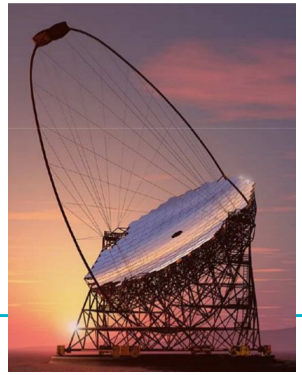
GW transients
Optical and radio transients

Serendipitous VHE transients



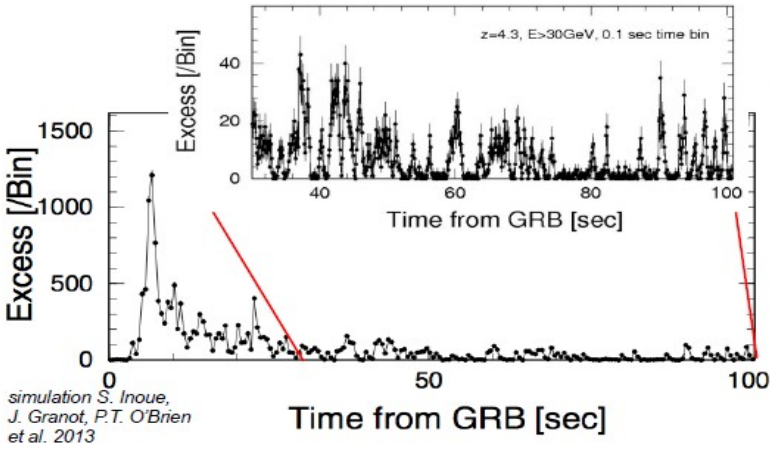
- ✔ Alerter system
- ✔ Real Time Analysis

→ LST : Fast slewing on target



GRBs simulation

Second Fermi–LAT GRB Catalog [in prep.]
→ ~100 GRBs, 6 yrs, 30 MeV – 300 GeV

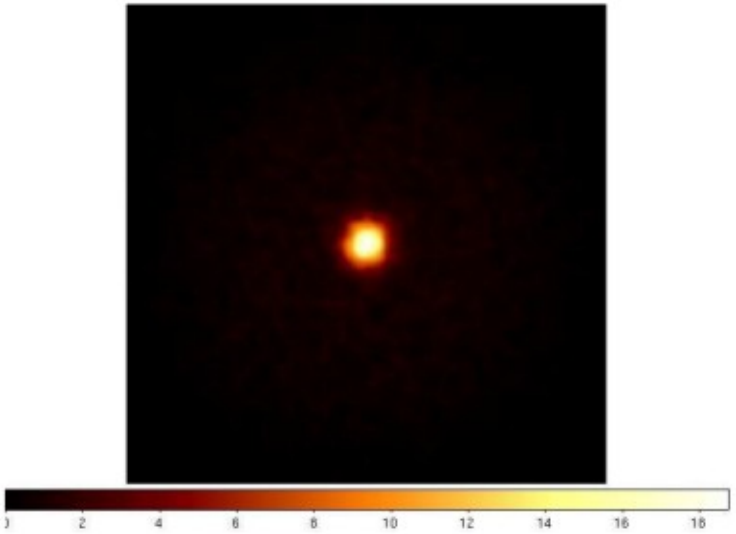


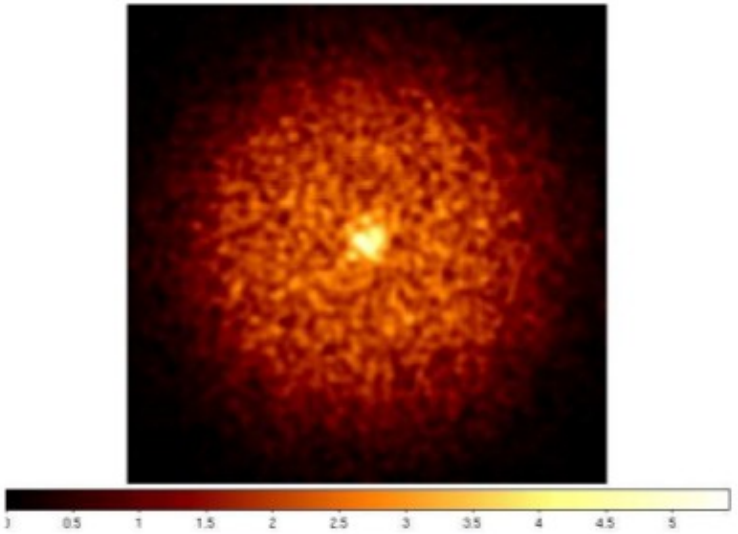
Simulated CTA gamma-ray burst light curve, based on the Fermi-LAT-detected GRB 080916C at
z =4.3

Extremely long GRB 130427A

1) 10 min @ 1 ks post trigger
2) 1 hour @ 10 ks post trigger

Simulation with ctools





Blazar Variablity

Short term variation:

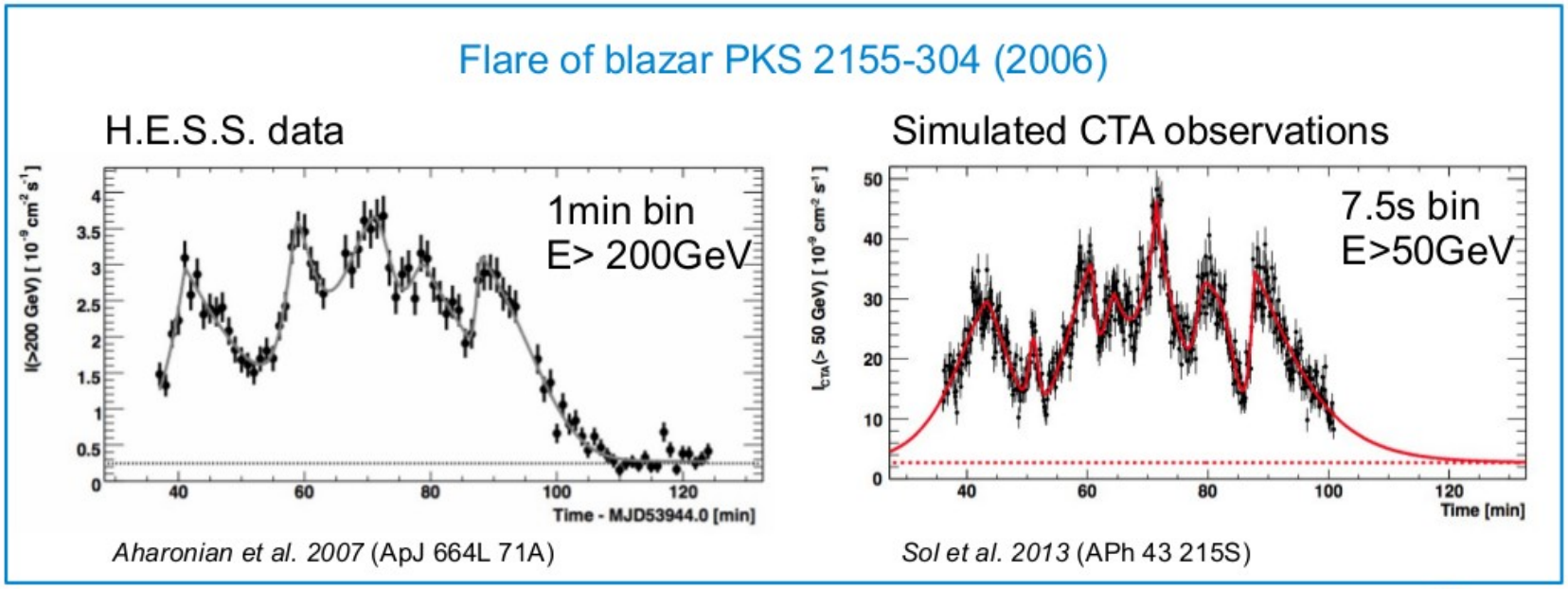
- Duty cycle?
- Size, location of the emission Region?

Follow up of external triggers
Regular monitoring of 80 AGNs of different classes and different redshifts

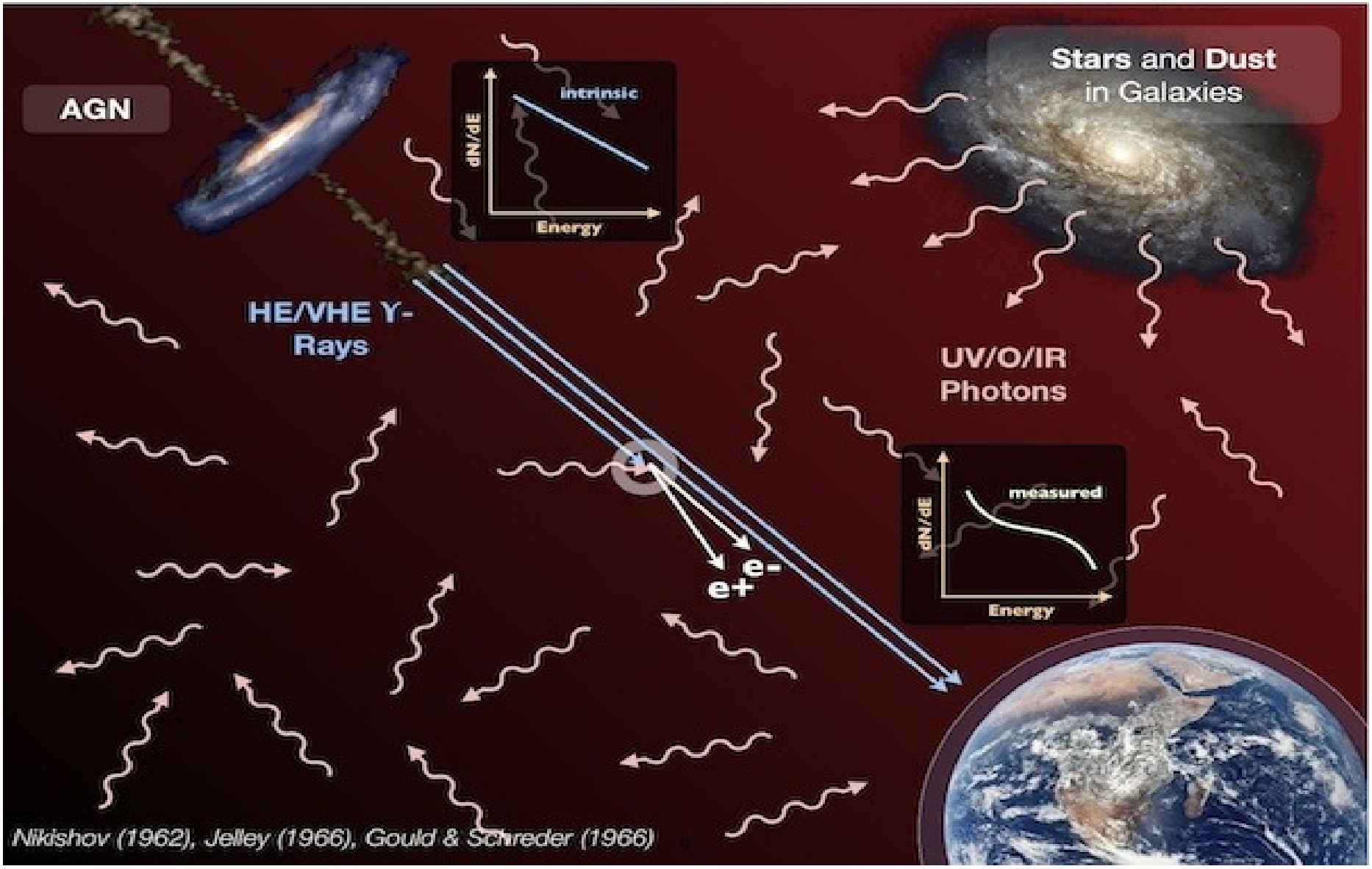
Long term variation:

- Quasi periodicity?
- Acceleration and cooling mechanisms?
- Break in the power spectra?

Regular observation of 15 VHE AGN of different classes
Light curves over 10 years minimum and time resolved spectra



Extragalactic Background light



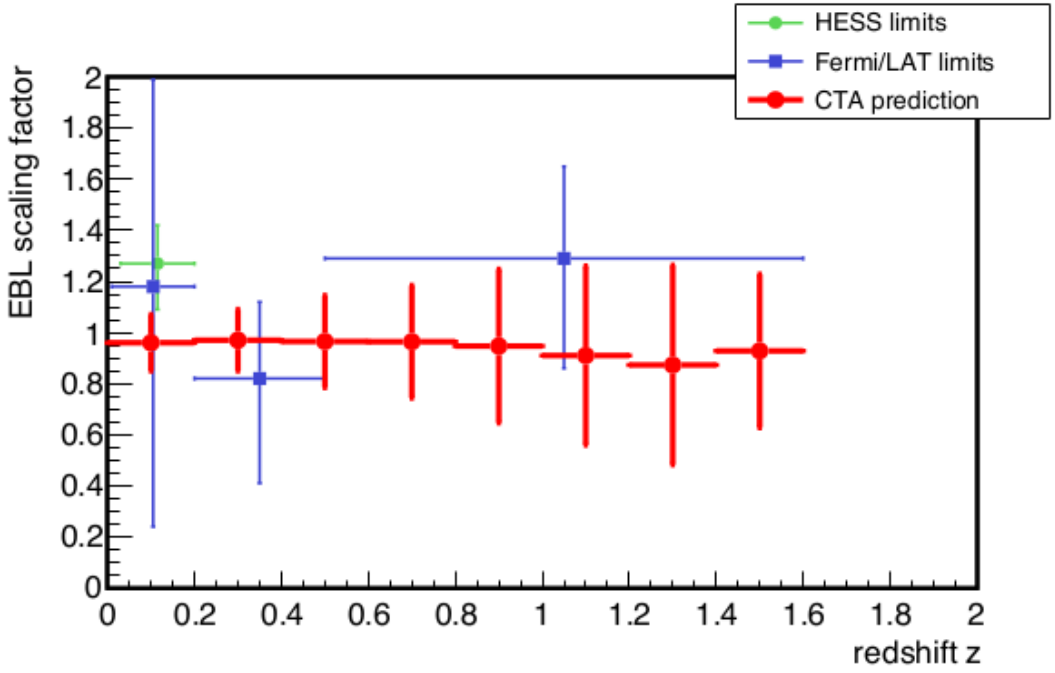
Extragalactic Background light

Extragalactic Background Light:

- measurement of EBL at z=0 with precision of 20%
- characterize the evolution up to z=1

Strategy:

- Steady blazars at low z
- At high z, **AGN flare programm**



Inter-Galactic Magnetic Fields

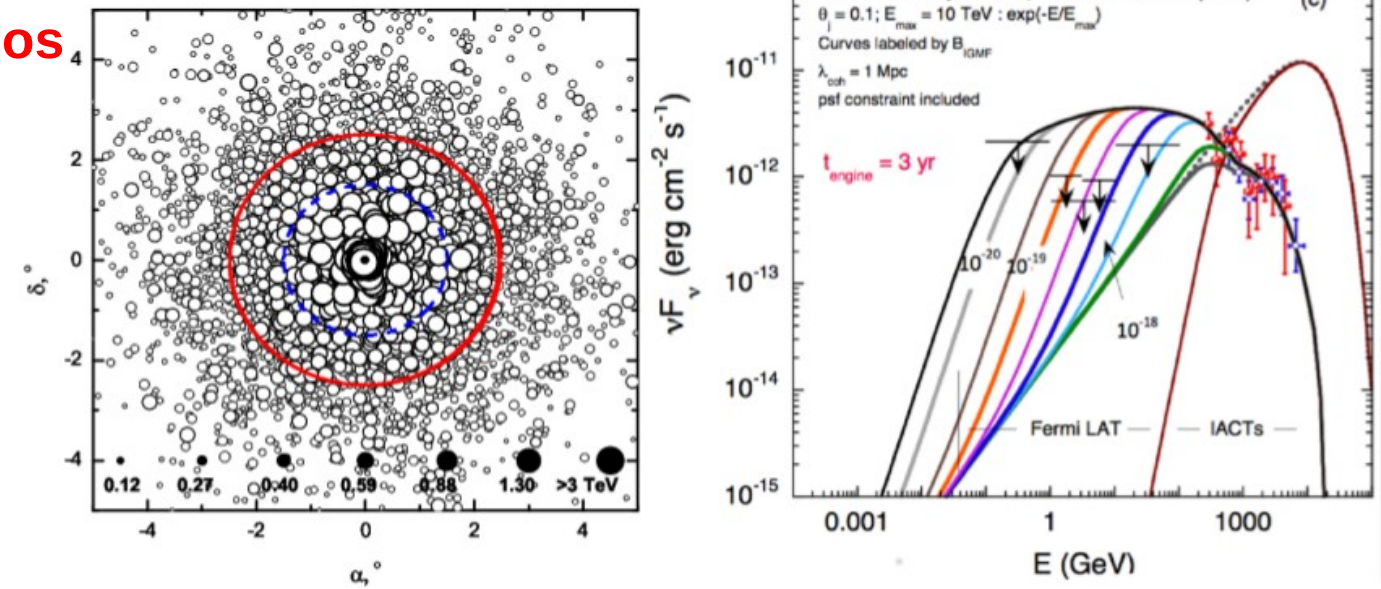
Inter-galactic magnetic fields:

- Lower limit or detection?
- Imaging analysis:
  - “pair halos” (IGMF > 10 -16 G)
- Time resolved spectra:
  - “pair echoes” (IGMF < 10 -16 G)

Simulation D. Mazin (CTA Science Case)

pair echoes

pair halos



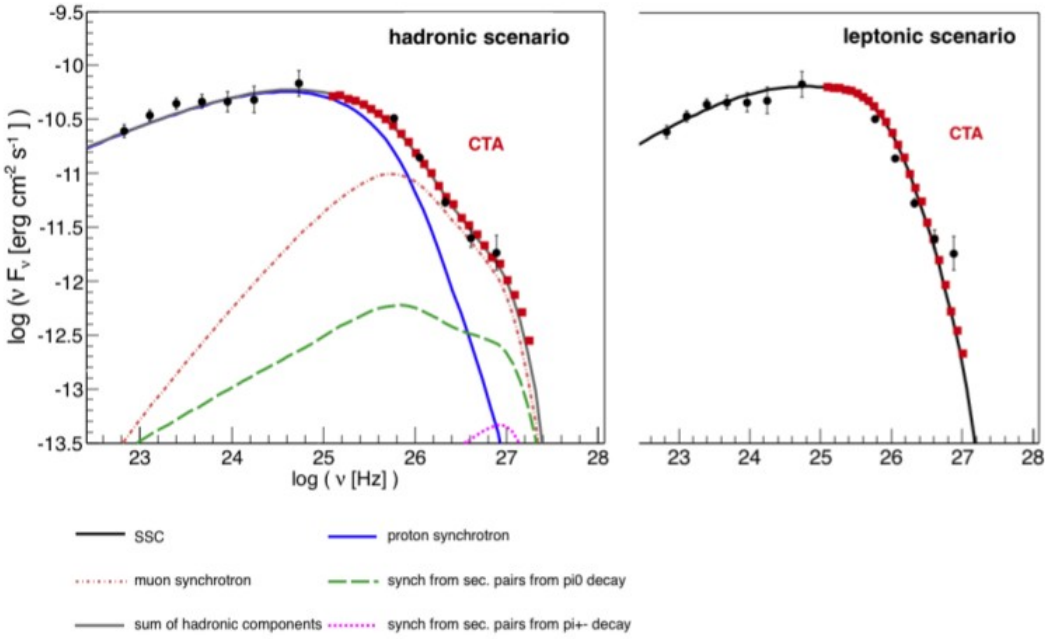
The arrival directions of primary and secondary gamma-rays (black circles) from a source at a distance D=120 Mpc with an IGMF strength of 10 14 G.

AGN spectra

High-frequency peaked blazars:

- Leptonic or hadronic origin of the Emission?
- Signature of the interaction of gamma-ray with the photon fields?
- Separate intrinsic features from propagation effects (wide range of redshift and source classes)

PKS 2155-304 : Exposure time assumed for the simulations (33 hr)



Extragalactic Survey

Blind survey of 25% of the sky with sensibility ~ 5mCrab. 1000h in 3 years

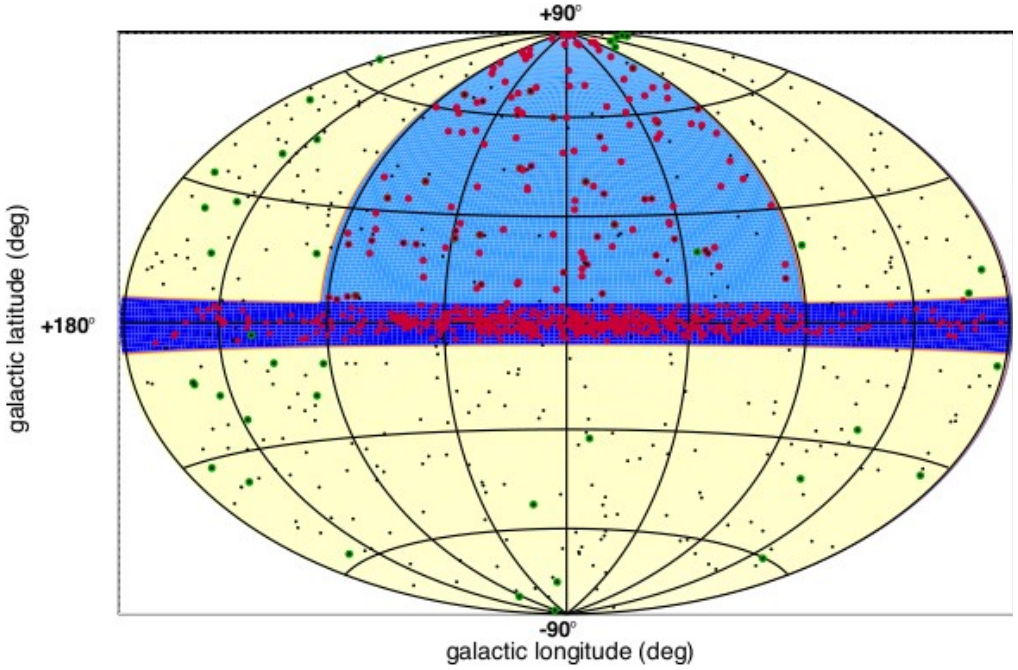
Aims:

- unbiased determination of log N-log S of the gamma-ray AGNs
- Measurement of the nearby (z<0.2) BL Lacs luminosity function
- Probing the AGN unification scheme and the Blazar sequence

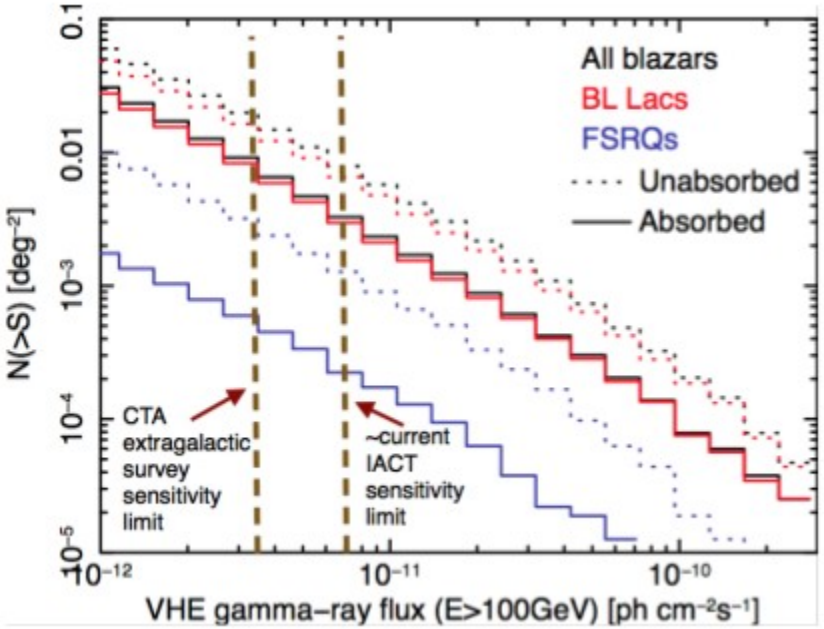
- Discovery of extreme blazars peaking in the ←100 GeV - 1 TeV region
- Serendipitous detection of fast flaring sources

- New sources classes such as Seyfert galaxies
- Dark sources with no astrophysical counterpart
- Study of large scale anisotropies in the electron spectrum at energies between 100 GeV and few TeV.

Extragalactic Survey



Proposed region of the extragalactic survey in Galactic coordinates



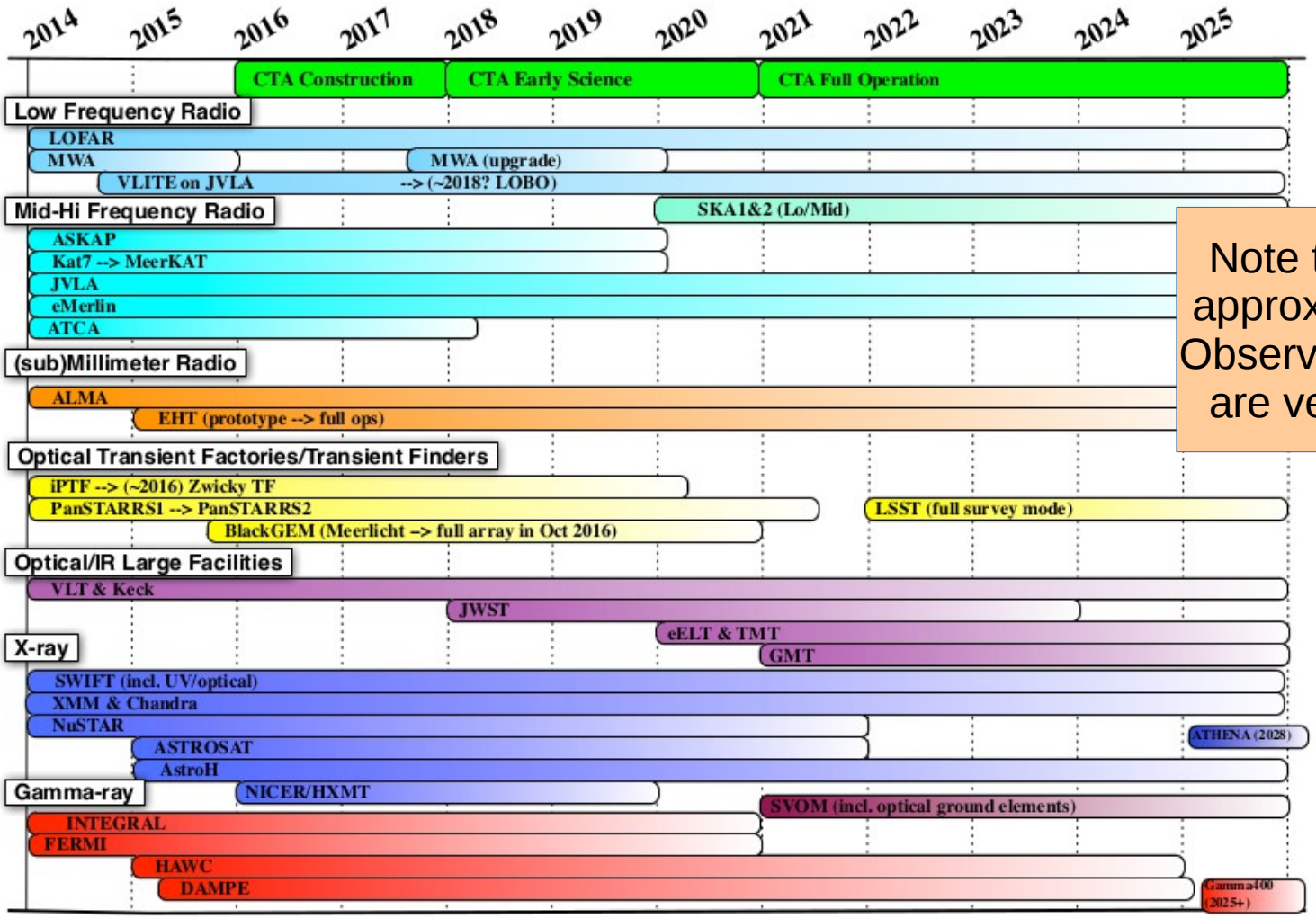
Simulated log N - log S distribution
5 mCrab sensitivity → around 100 sources in 10,000 deg²

30-150 foreseen detections from Fermi or UV-Xray extrapolations

Shallow survey vs deep survey

observing a four times narrower field for, consequently, four times longer time would result in a detection of about 50% less sources.

Synergies with CTA



Note that this is an approximate picture. Observatory timelines are very uncertain.

Conclusions

CTA Status

- **2 sites (South and North) selected** for discussion
- Telescope prototypes **being build**
- First telescopes (LST @ Lapalma) **expect to take data in 2017**

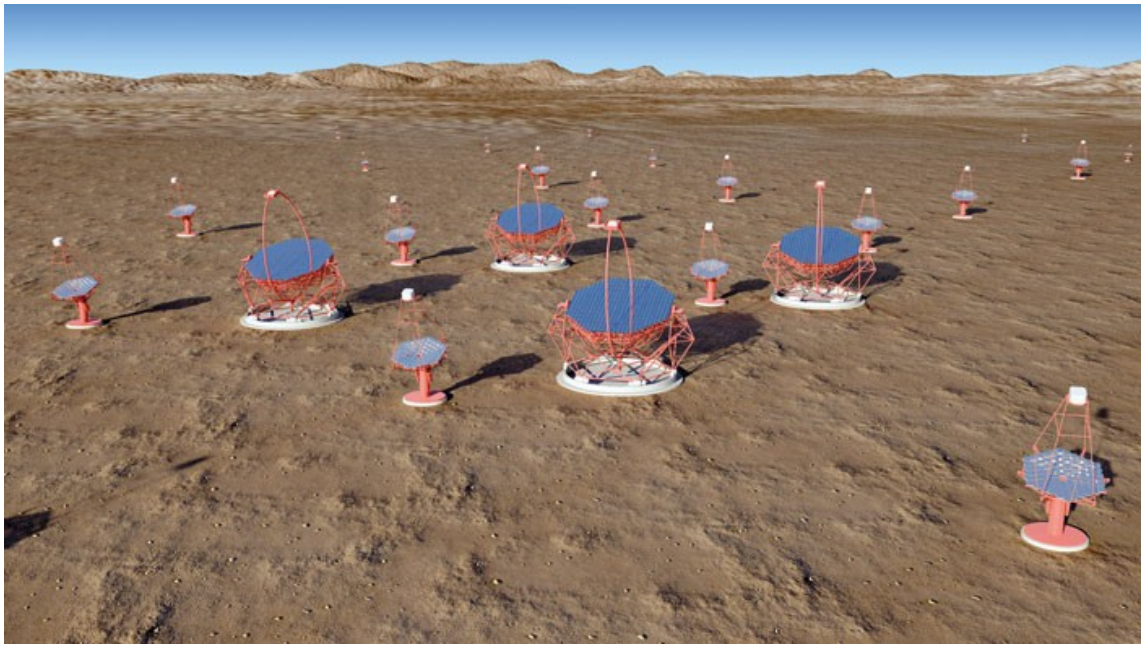
Key Science Projects

- Extragalactic KSPs explore CTA science themes in a coherent manner
- **Data release to public after proprietary time (1 year)**
- Strong Guest Observer program with ~50% of observing time over the first 10 years
- Legacy of use for the entire astronomical community
  - **Catalogues,Maps, Light curve**

Conclusions II

Acces of DATA

- CTA is an observatory
- Open to Proposal
- Propriatary period of 1 year
- Data public after + IRFs + Science tools



Thanks