cherenkov telescope array

an observatory for ground-based gamma-ray astronomy

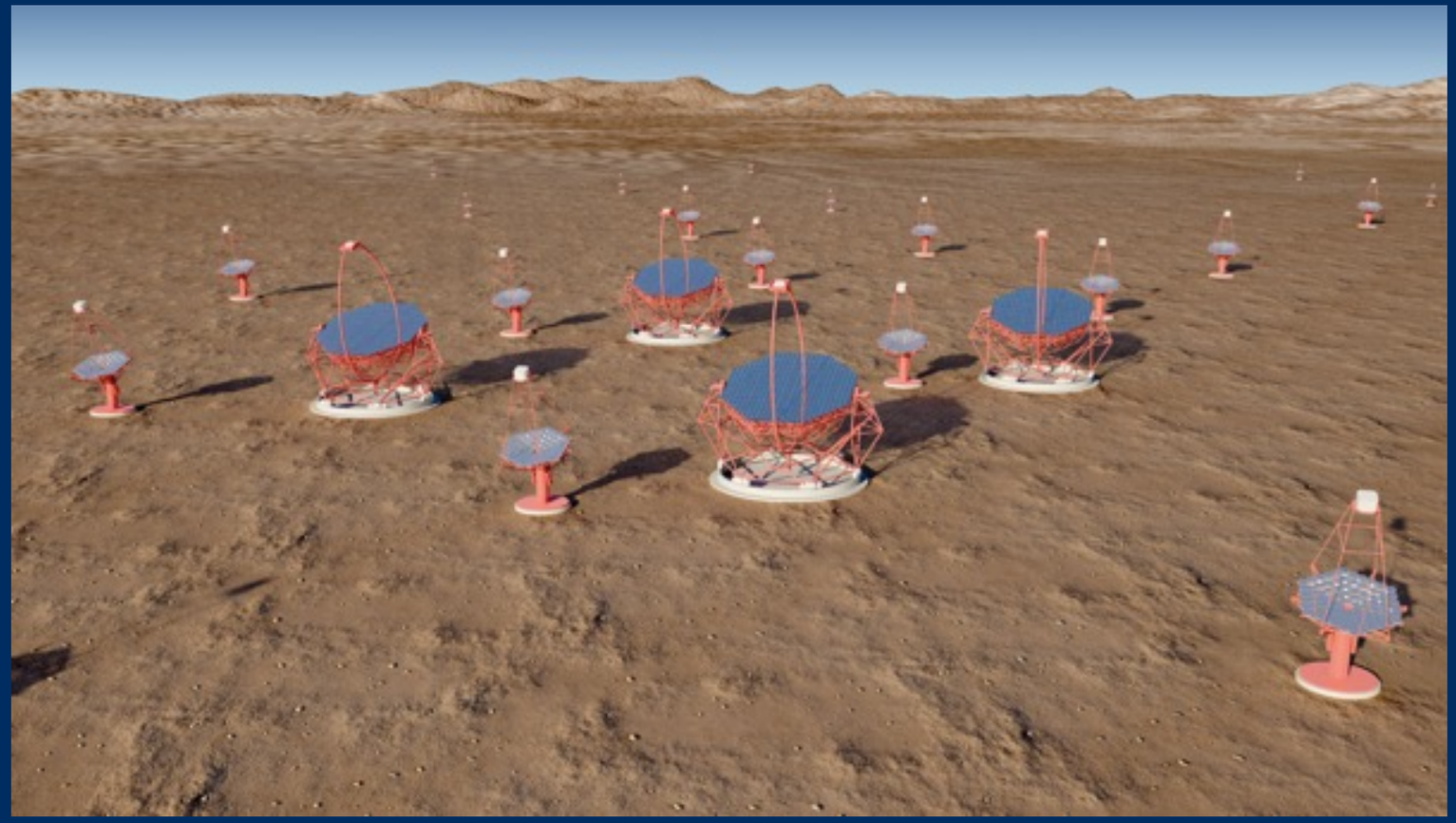
Status and perspectives of CTA

Daniel Mazin, ICRR U-Tokyo and MPI for Physics, Munich

Contents

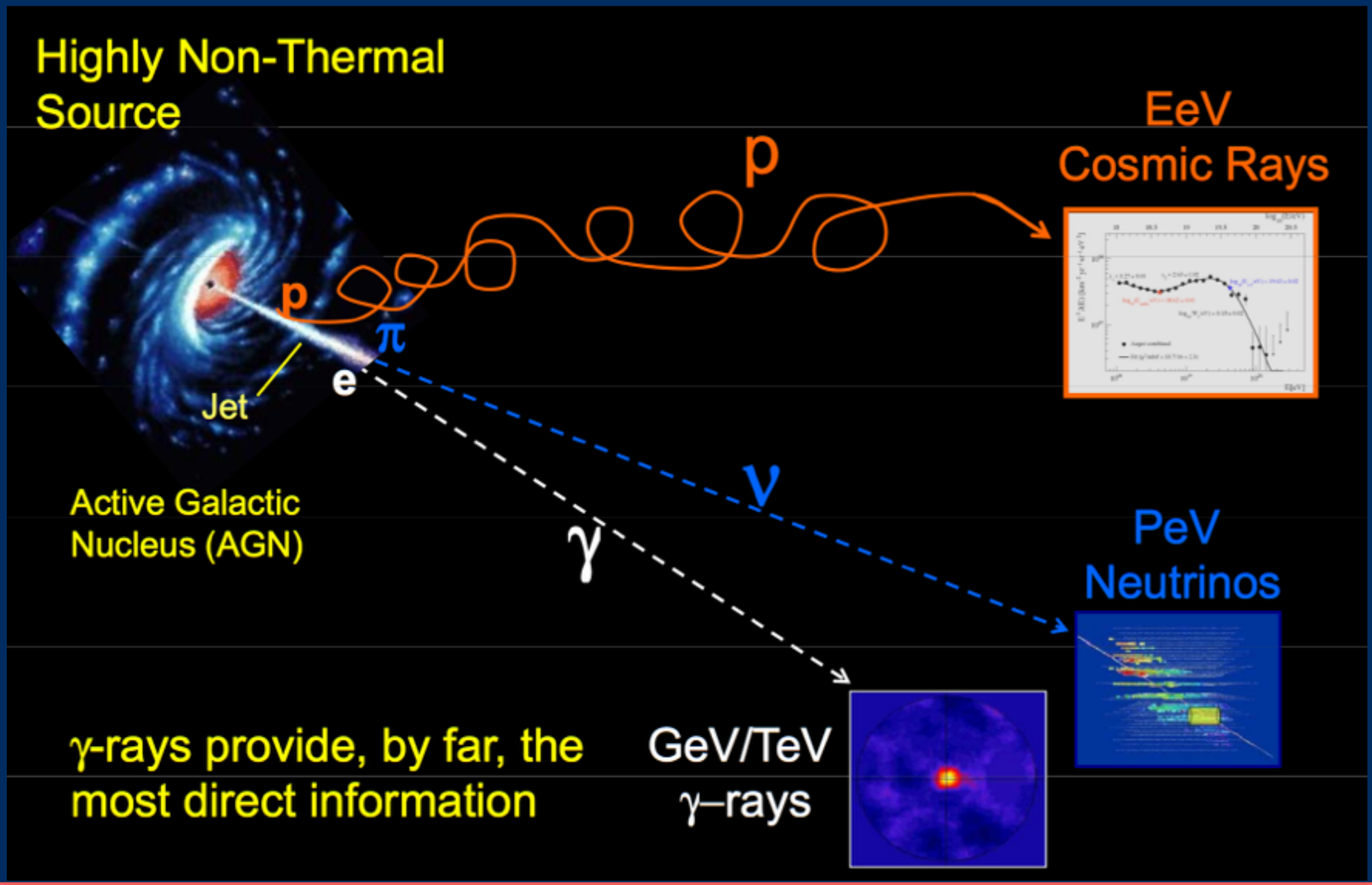
- Brief history
- IACT technique
- CTA
  - Principle
  - Organization
  - Sites
  - Telescopes
- Key Science Projects

Rafael Defavari, APOD

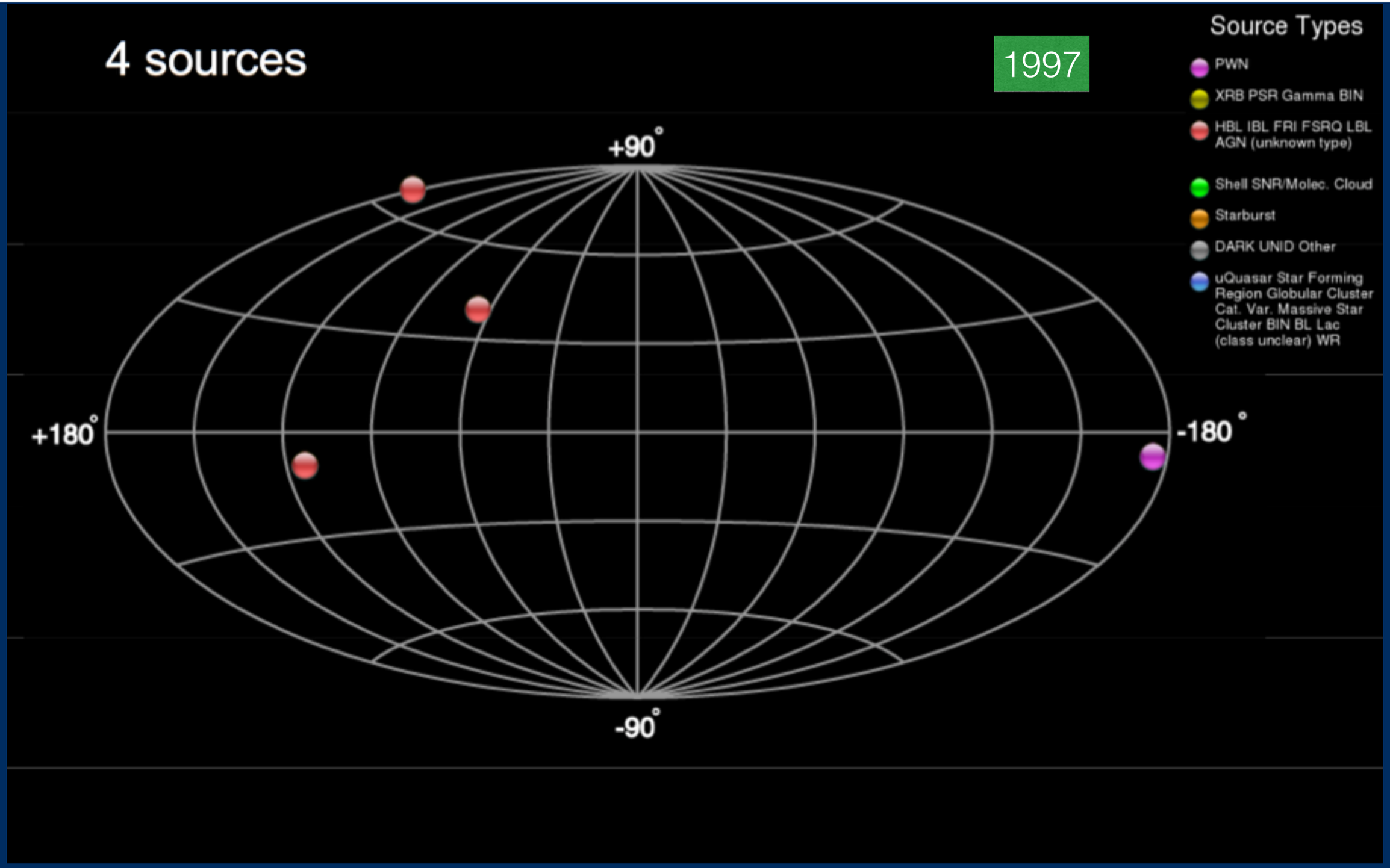


Motivation

cherenkov telescope array

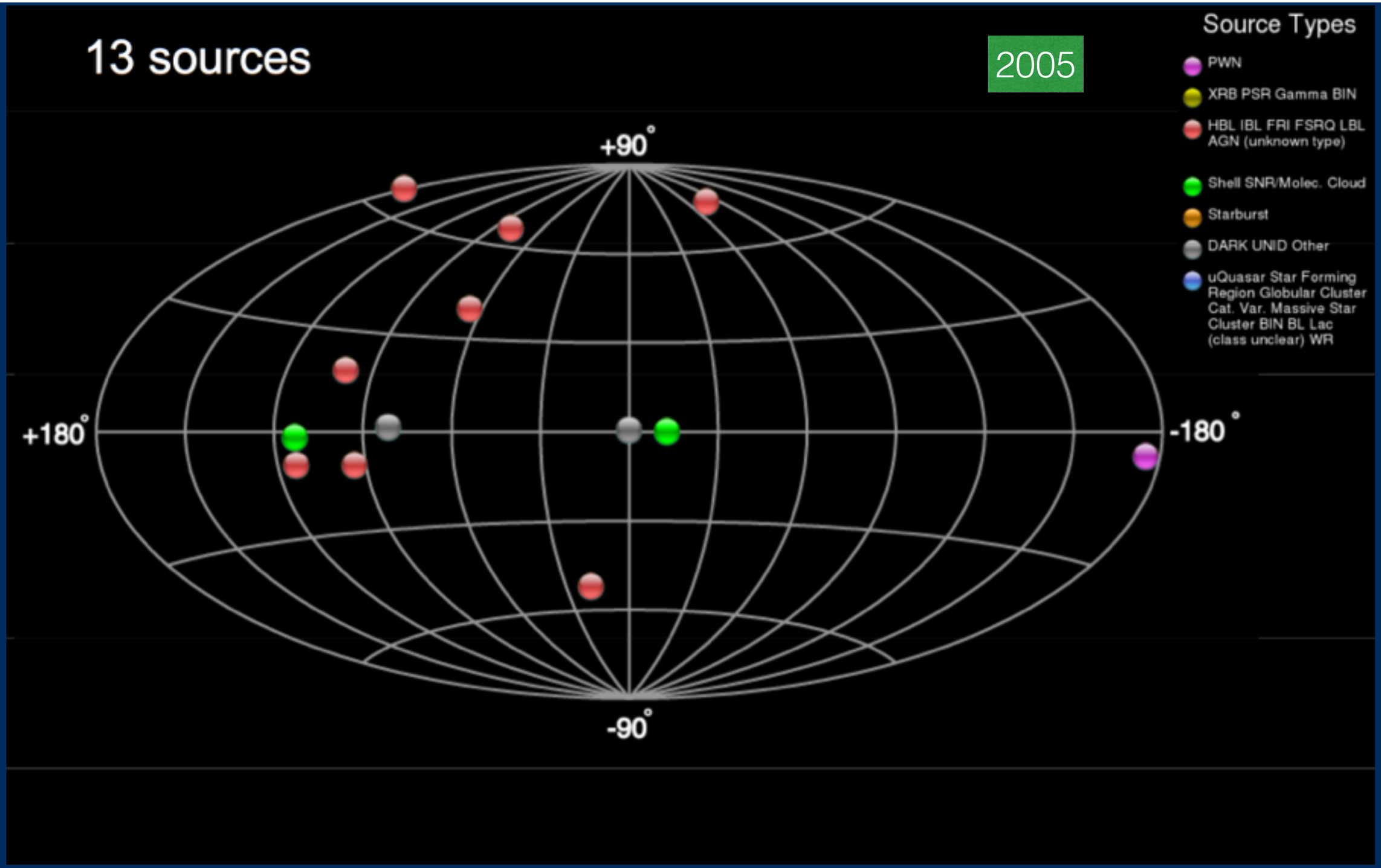


Brief history



Brief history

cherenkov telescope array



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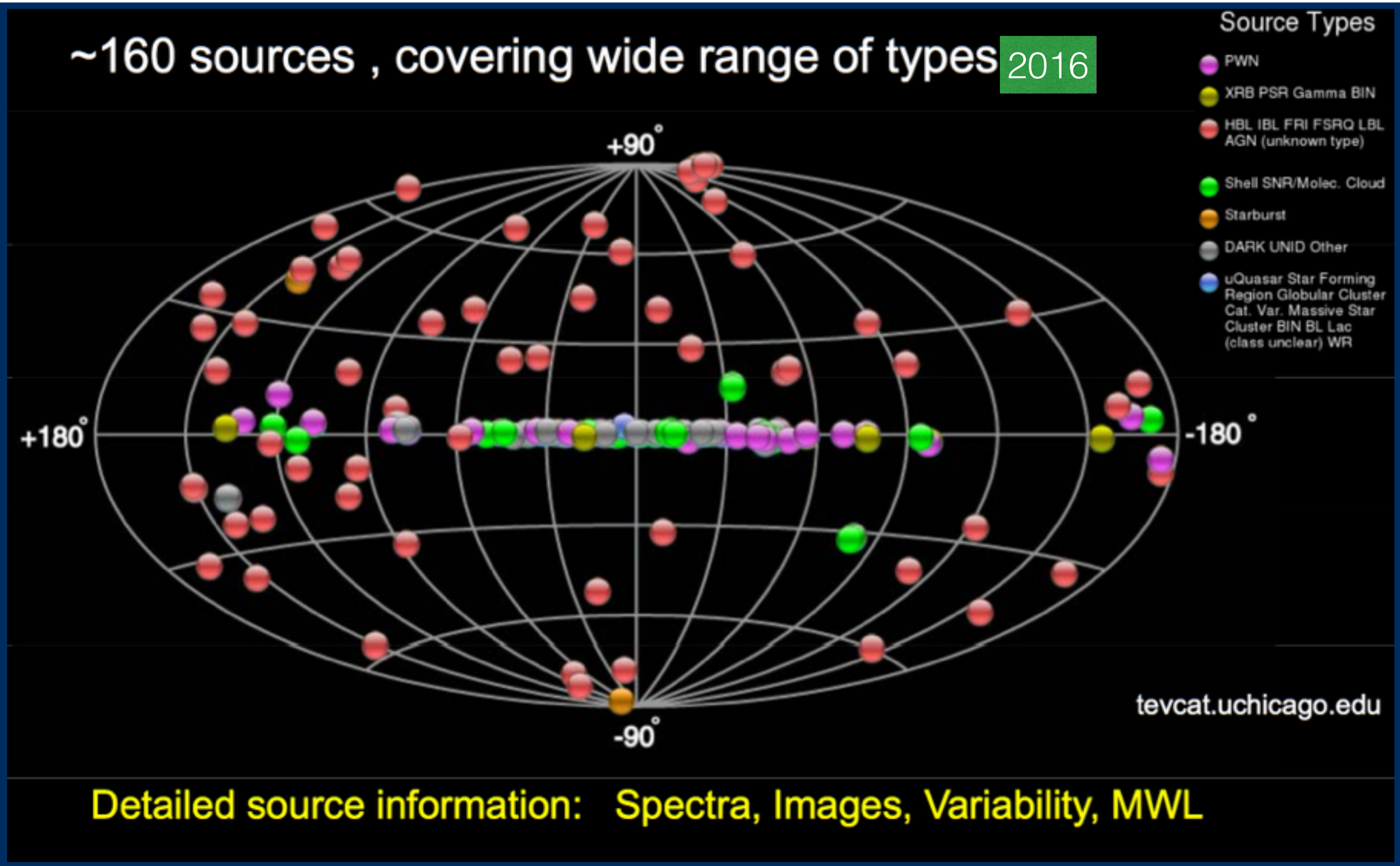
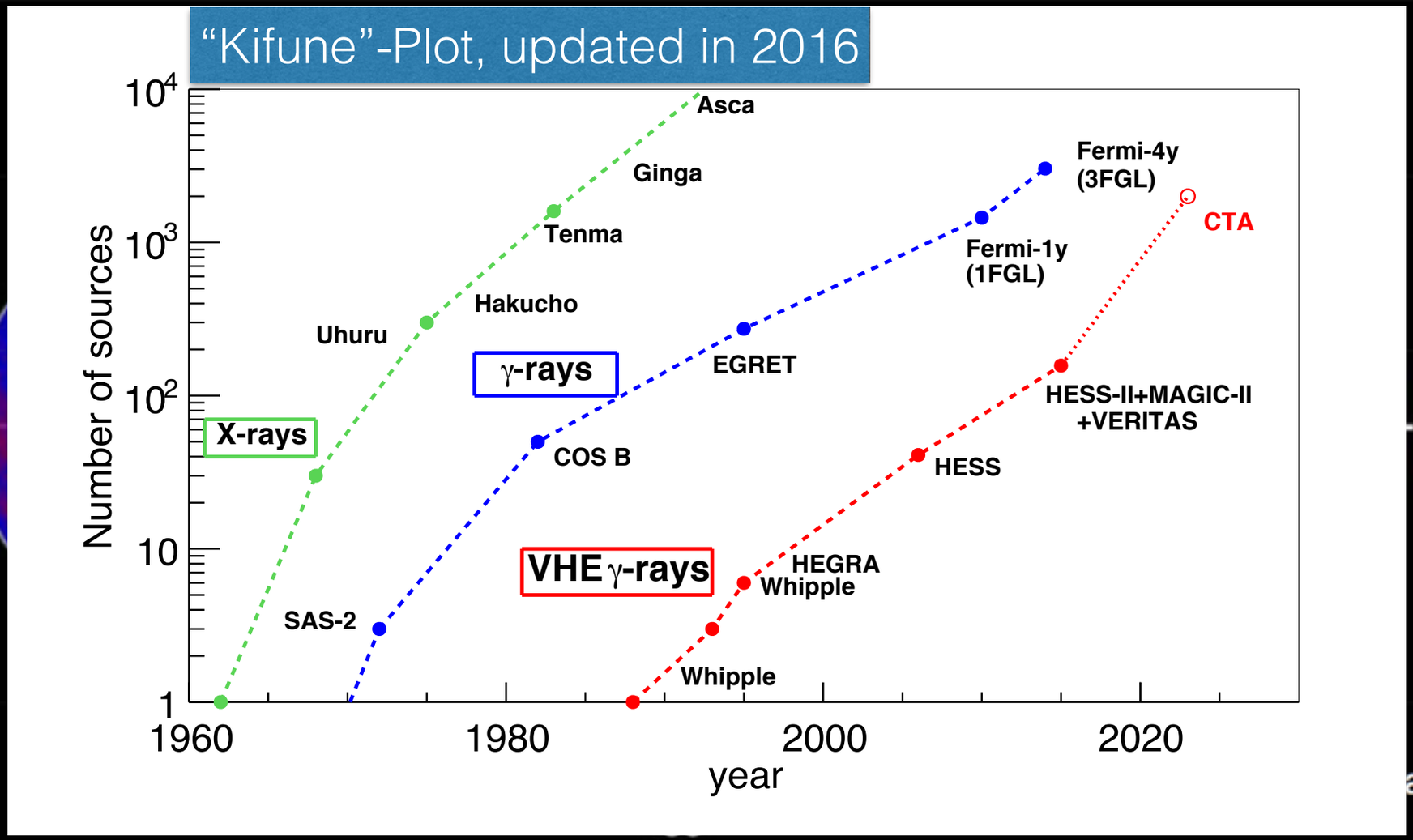
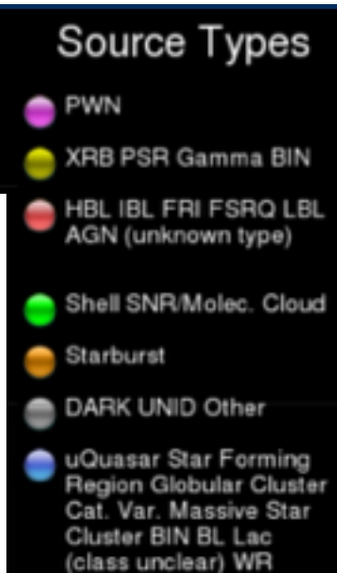


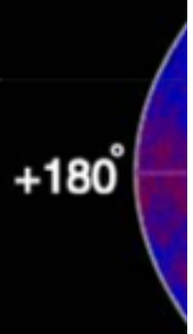
Brief history

cherenkov telescope array

~160 sources , covering wide range of types 2016





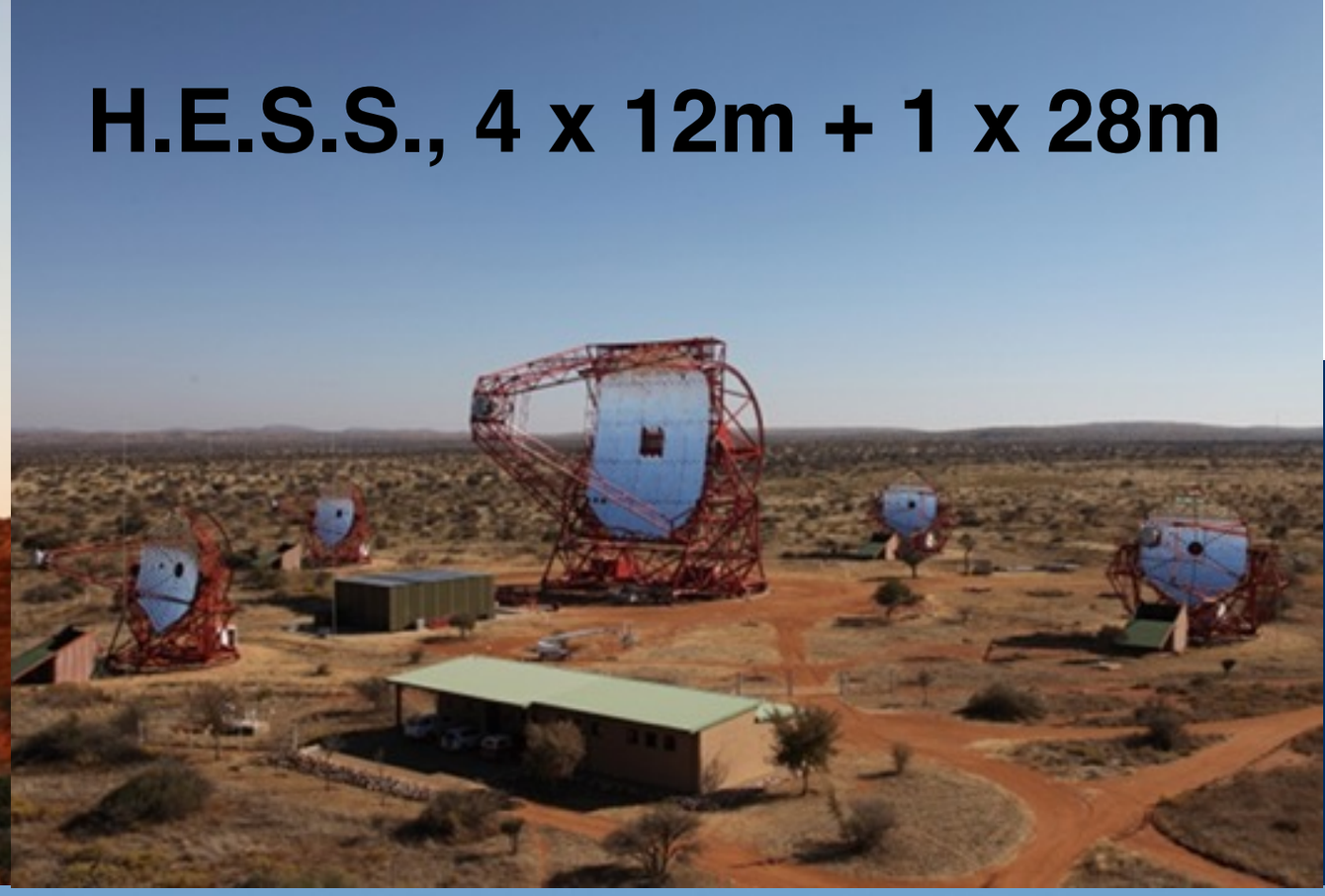


at.uchicago.edu

Detailed source information: Spectra, Images, Variability, MWL
+ FERMI-LAT map

MAGIC, 2 x 17m

H.E.S.S., 4 x 12m + 1 x 28m



VERITAS, 4 x 12m

see talks on Tuesday for details

Highly successful, but …

cherenkov telescope array

- Some key object classes still elusive, e.g.
  - Galaxy clusters as cosmological storehouses of Cosmic Rays
  - Very high energy emission from GRB
  - Dark Matter annihilation signatures
- Some key mechanisms remain to be understood, e.g.
  - Supernovae as sources of cosmic rays: do they provide sufficient peak energy & energy output?
  - Cosmic ray escape from accelerators and propagation
  - Energy conversion in pulsars
- Energy range & angular resolution of current instruments insufficient to probe details

What do we want?

cherenkov telescope array

- High sensitivity
  - 3 orders of magnitude dynamic range in flux, down to 1“mCrab”
- Wide spectral range
  - Over three decades, ~20 GeV to ~300 TeV 10-15% energy resolution
- Resolved source morphology
  - ~5’ angular resolution
  - 10-20” source localization
- Survey capability
  - H.E.S.S. Galactic Plane Survey:
    better than 2% Crab sensitivity, 77 sourced detected -> goal is 2mCrab
  - Extragalactic survey
- Well-resolved light curves
  - Minute-scale variability of AGN

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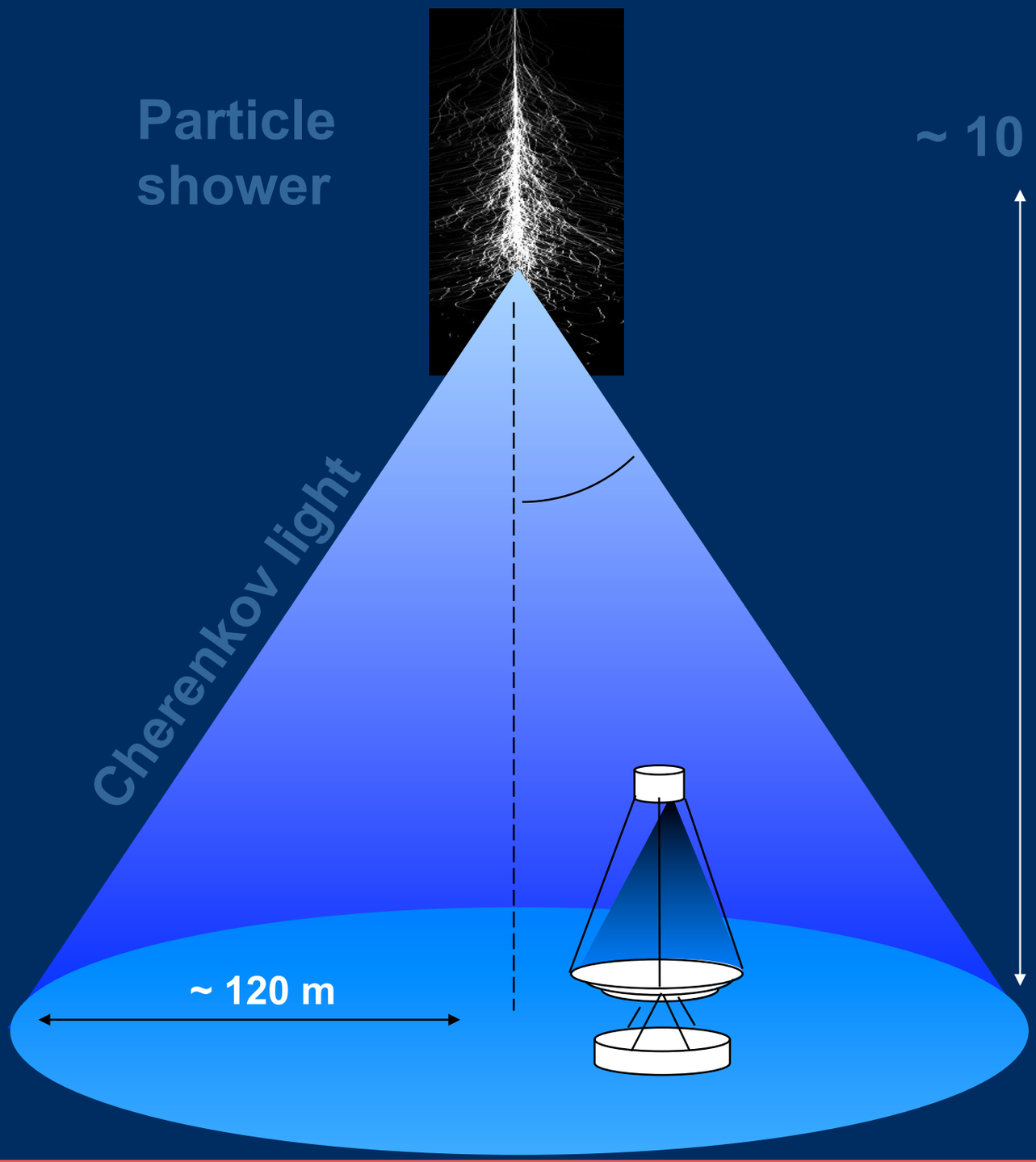
HOW?

Observation technique

cherenkov telescope array

Detection of gamma rays using
Imaging Atmospheric Cherenkov Telescopes



Observation technique

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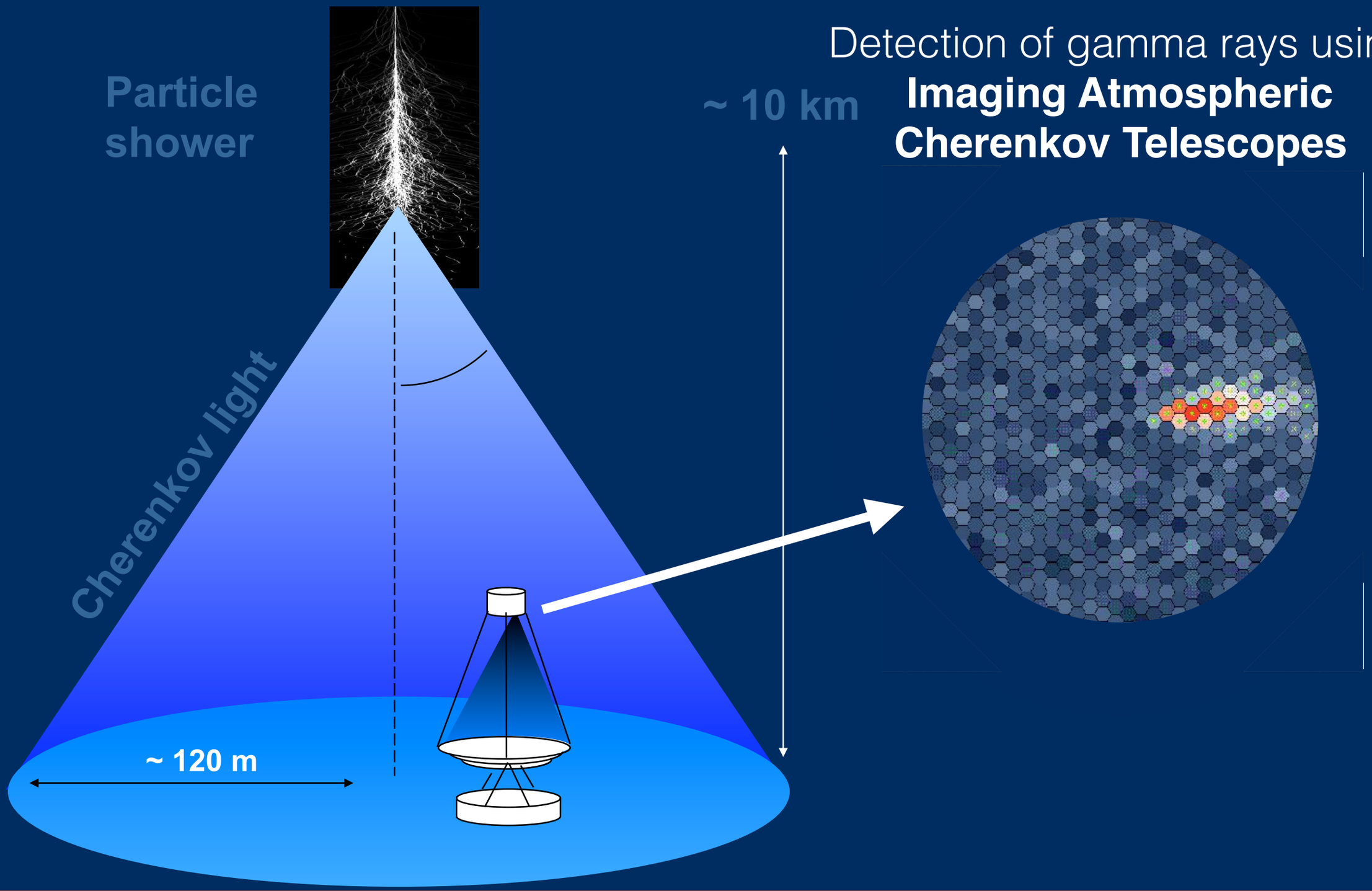
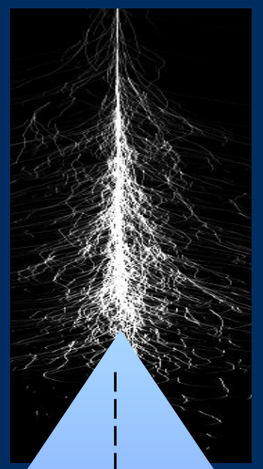


Observation technique

cherenkov telescope array

Particle shower

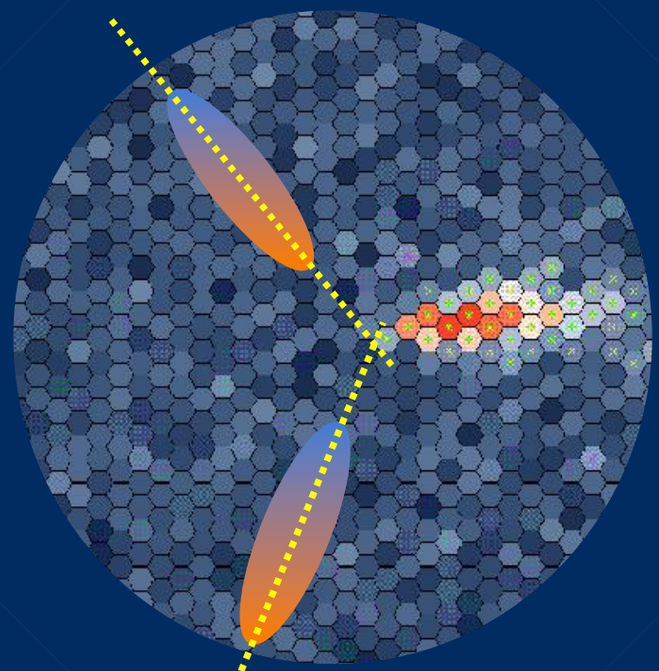


~ 10 km

Cherenkov light

~ 120 m

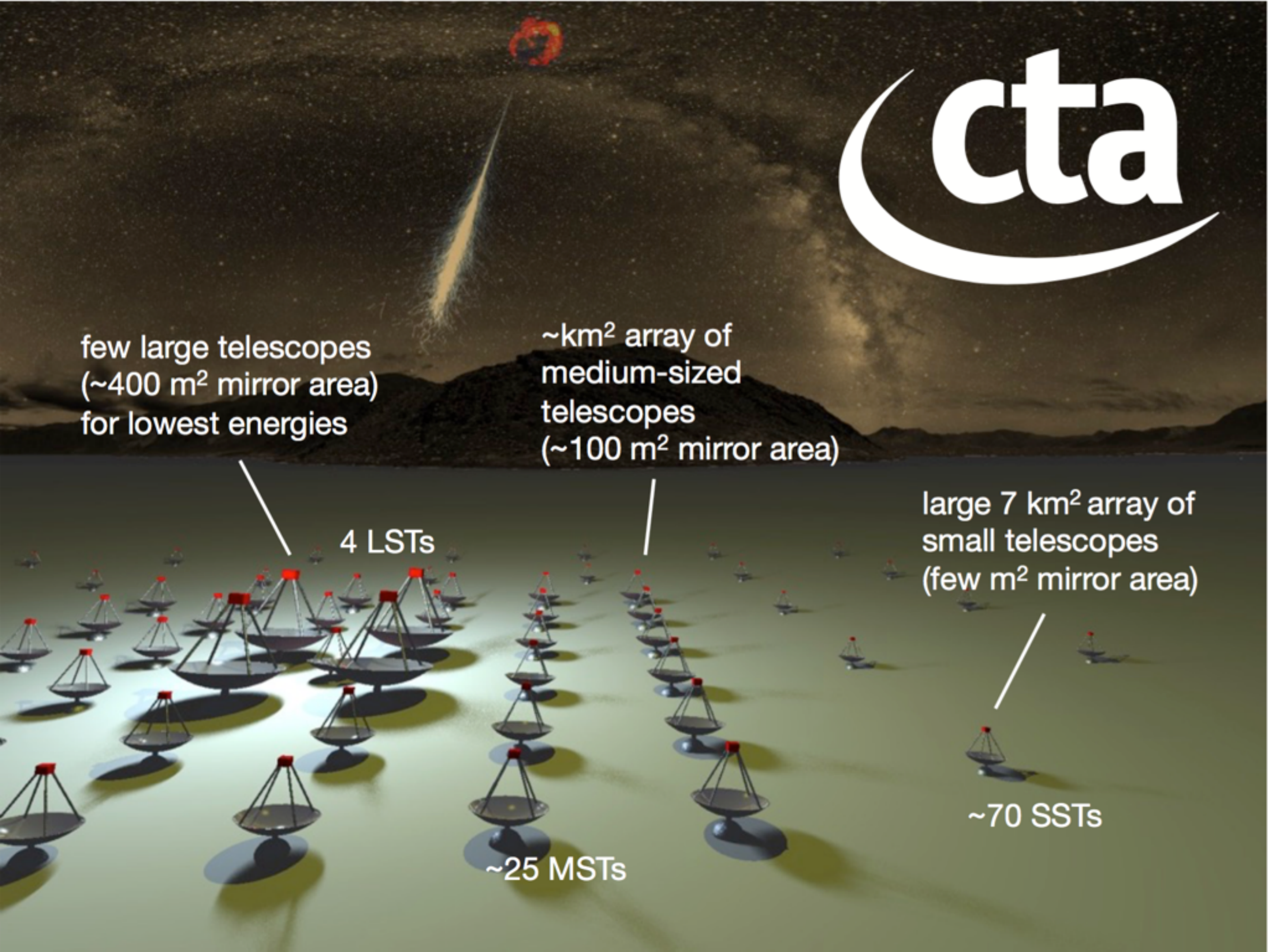
Detection of gamma rays using
Imaging Atmospheric Cherenkov Telescopes



stereoscopy:

- better background rejection
- better angular resolution
- better energy resolution

Simple minded approach


few large telescopes
(~400 m² mirror area)
for lowest energies
~km² array of
medium-sized
telescopes
(~100 m² mirror area)
large 7 km² array of
small telescopes
(few m² mirror area)
4 LSTs
~25 MSTs
~70 SSTs

WHY?

few large telescopes
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for lowest energies

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small telescopes
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4 LSTs

~25 MSTs

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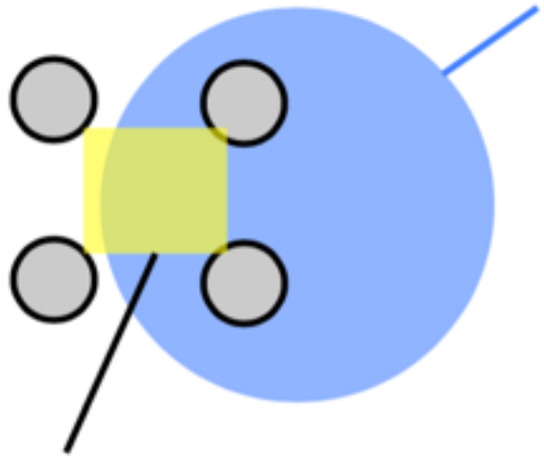
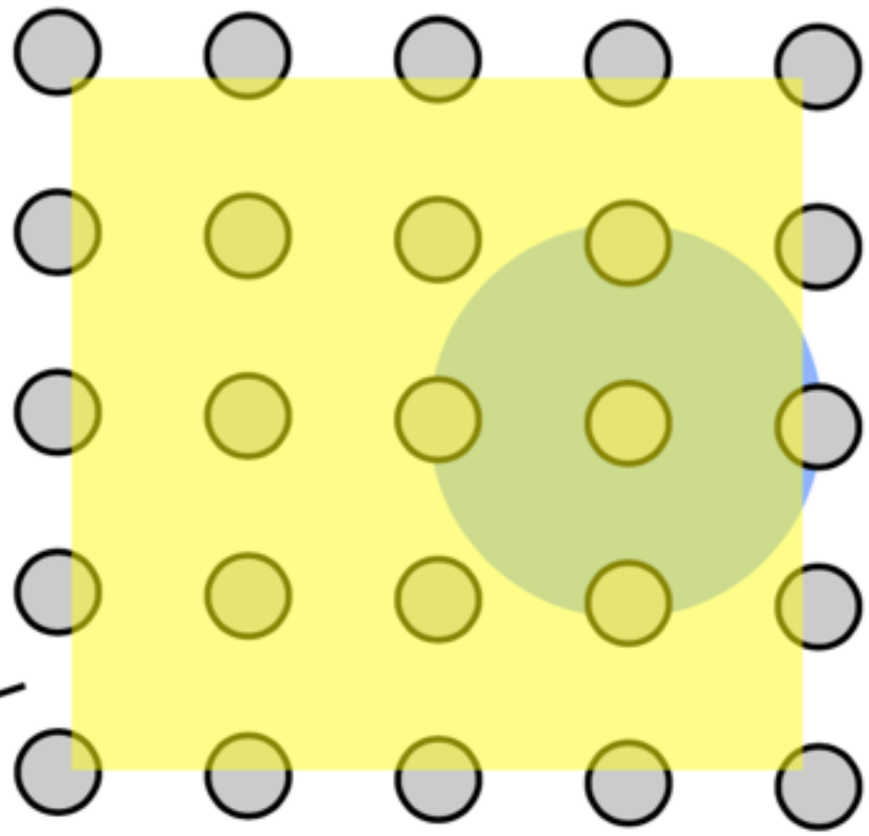
Cherenkov light pool



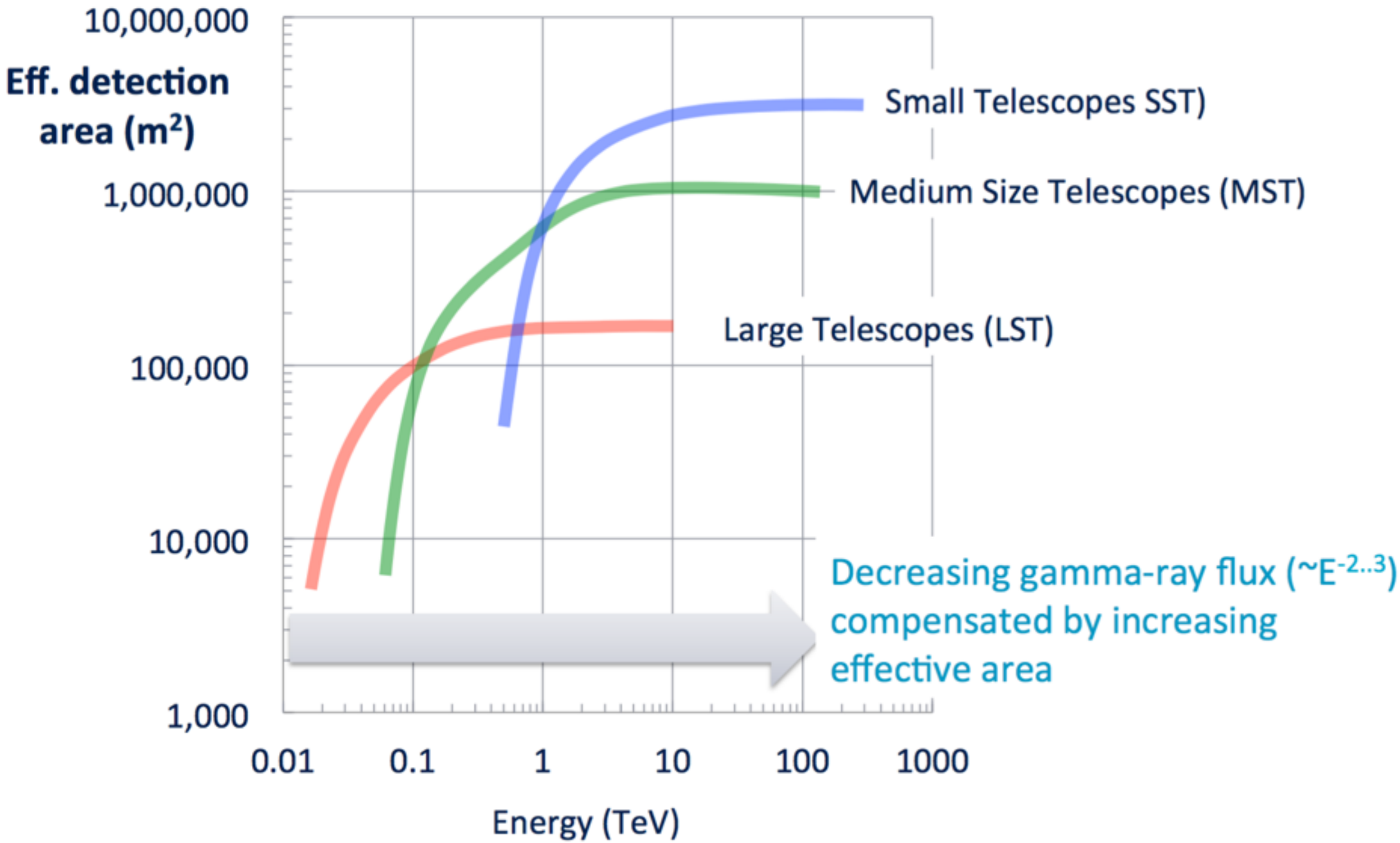
light pool radius
R ≈100-150 m
≈ typical telescope spacing

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

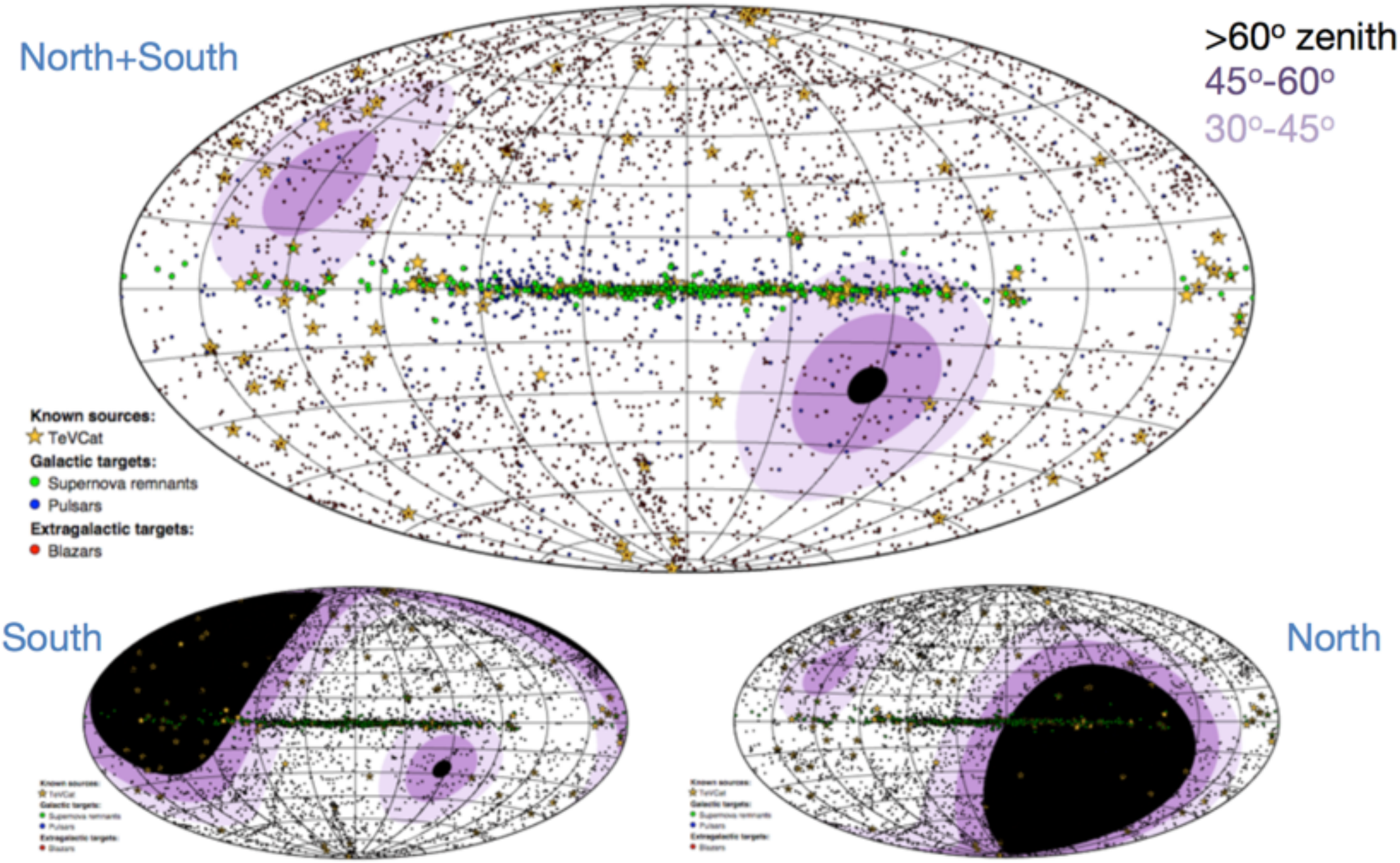


large detection area
more images per shower
lower trigger threshold

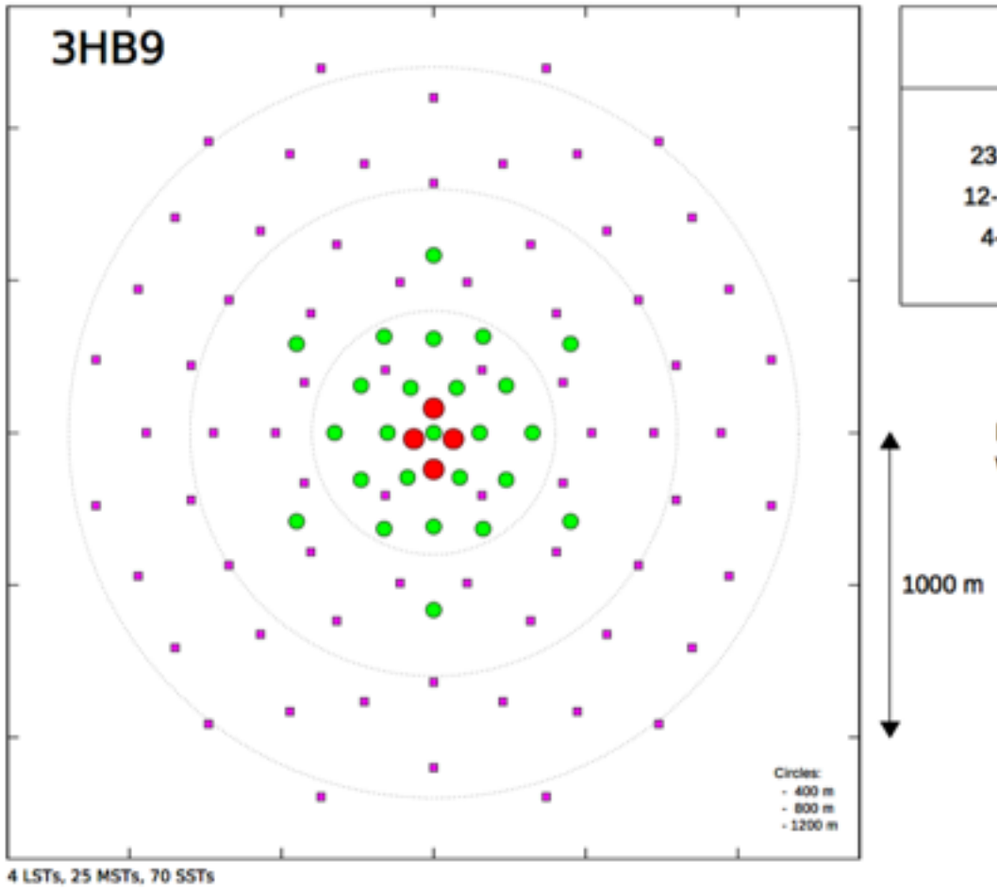
Cherenkov light pool

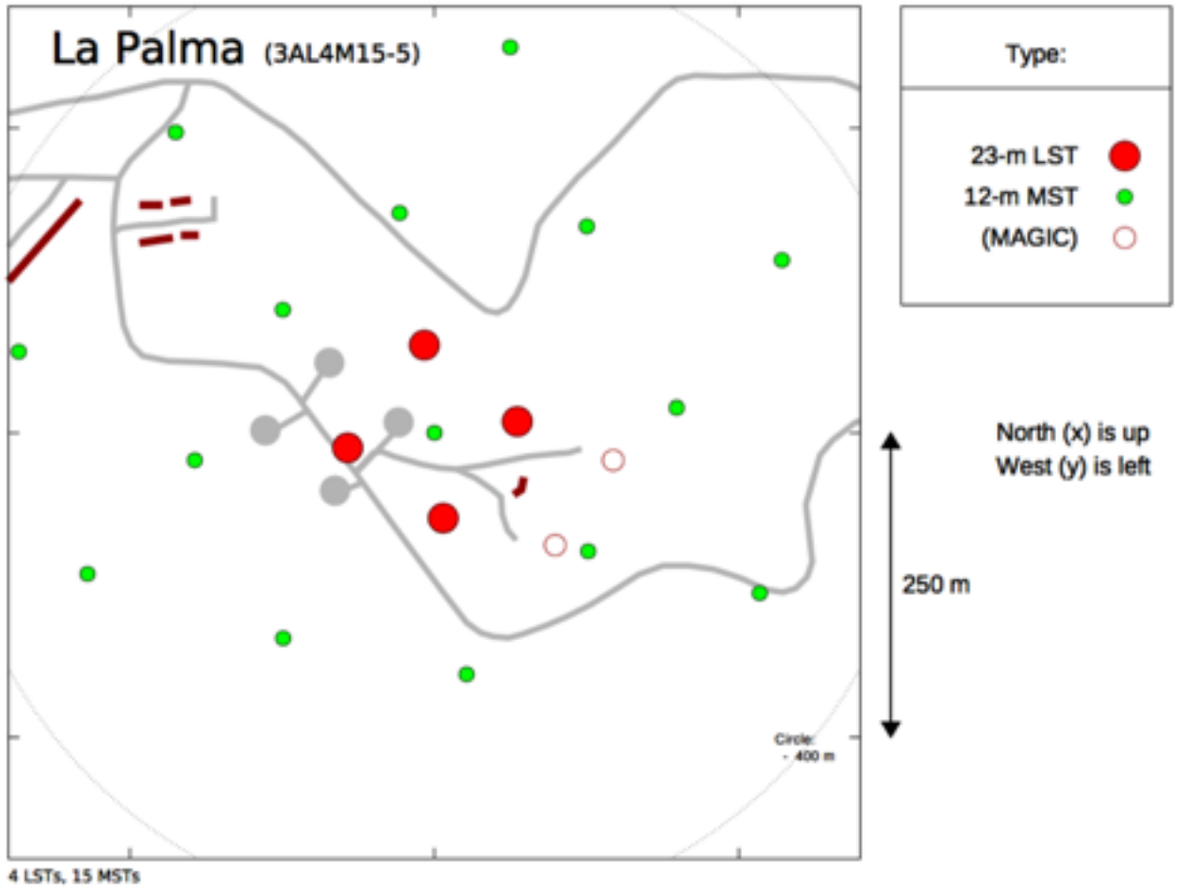


All sky coverage



Array layout (baseline)



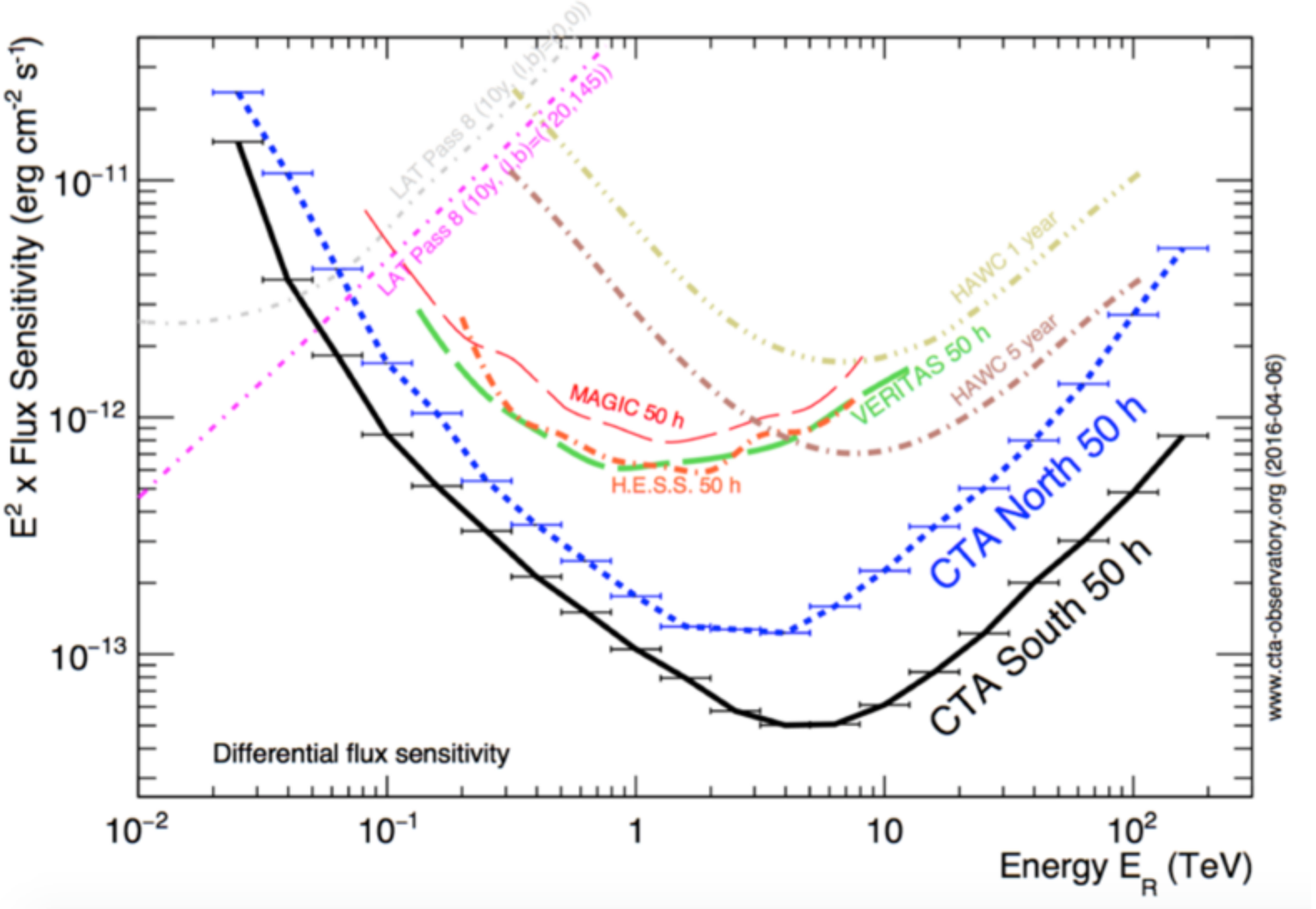


South:
4 LST
25 MST
70 SST

North:
4 LST
15 MST

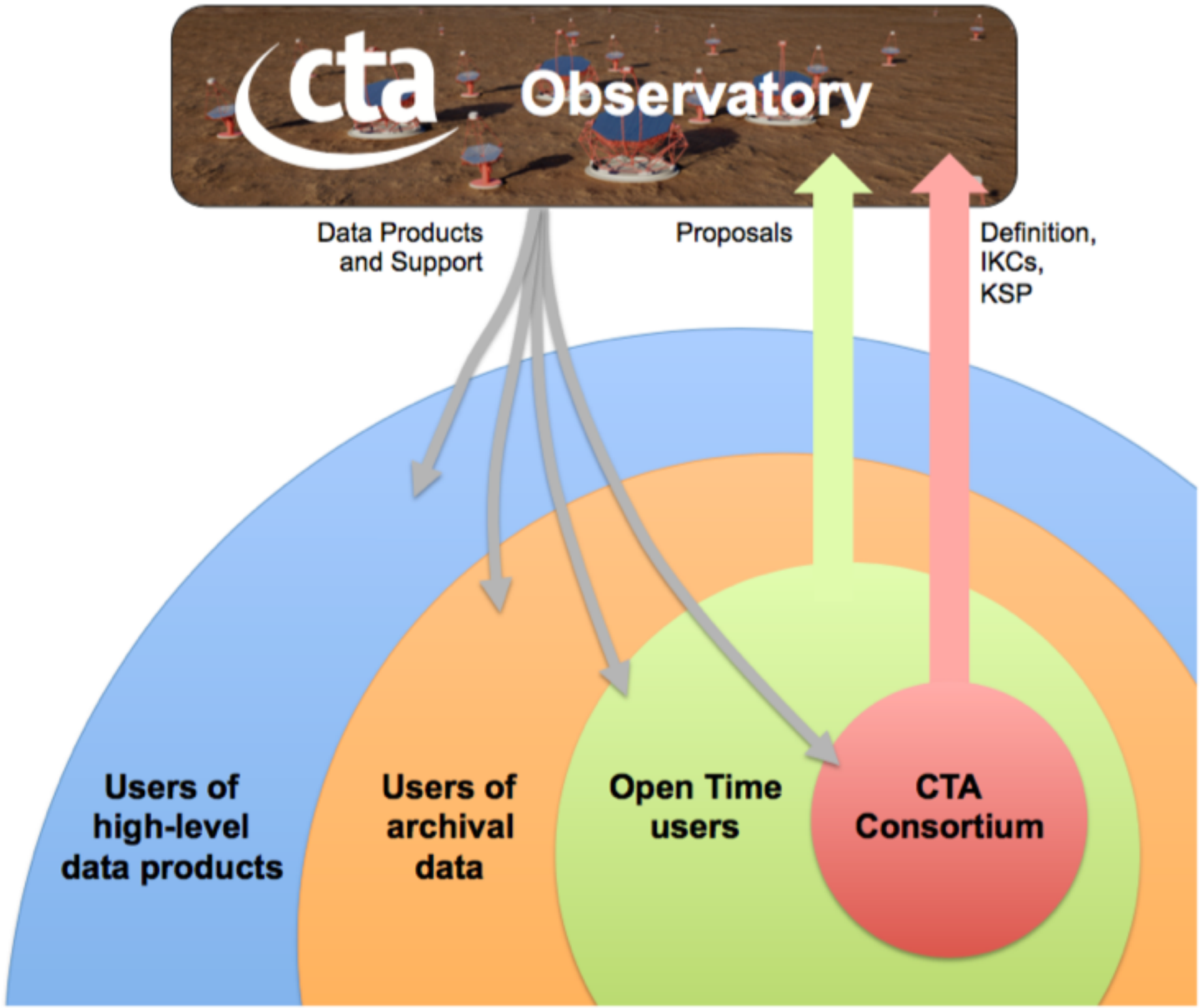
Sensitivity

cherenkov telescope array



Organization: observatory

cherenkov telescope array



Organization: observatory

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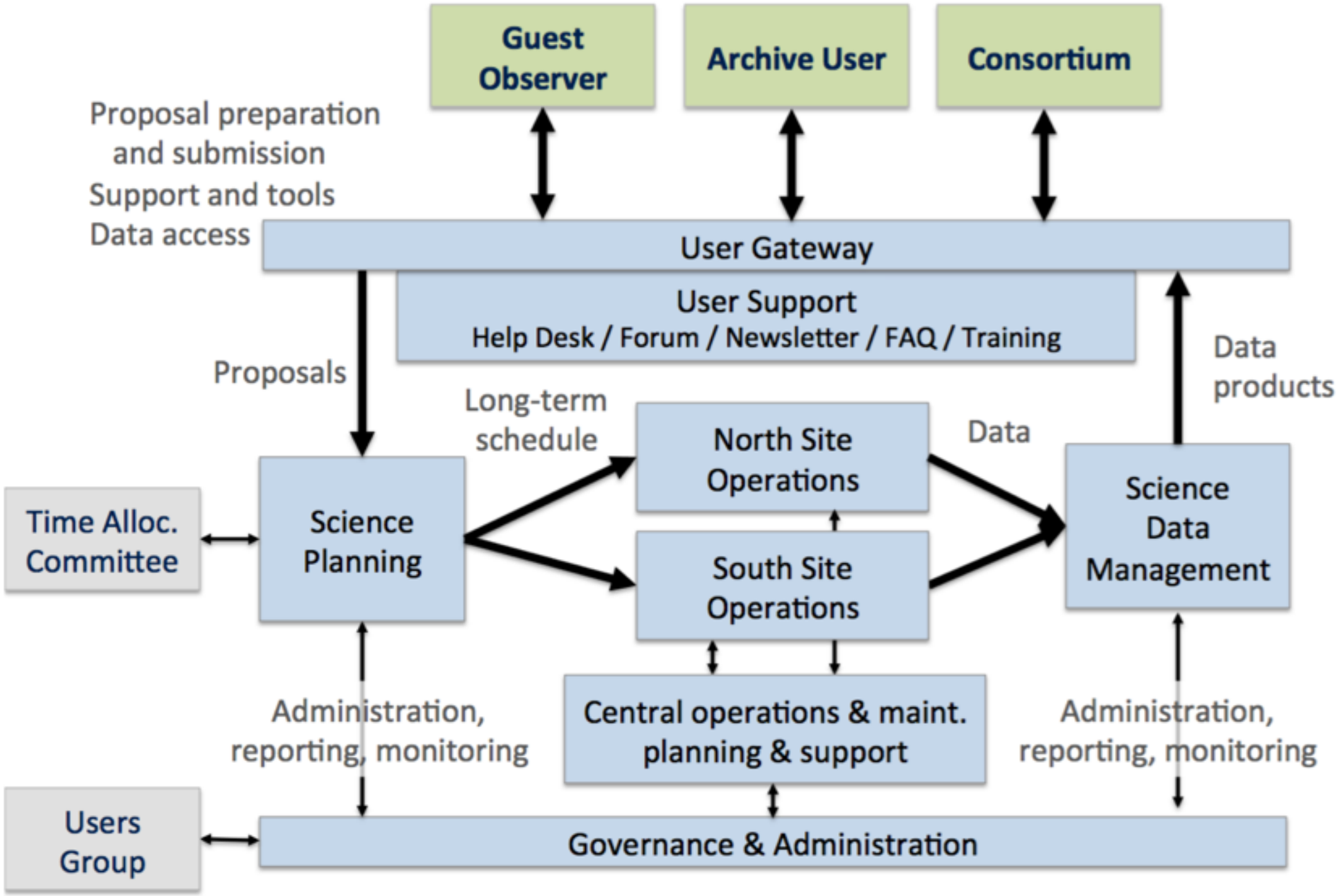
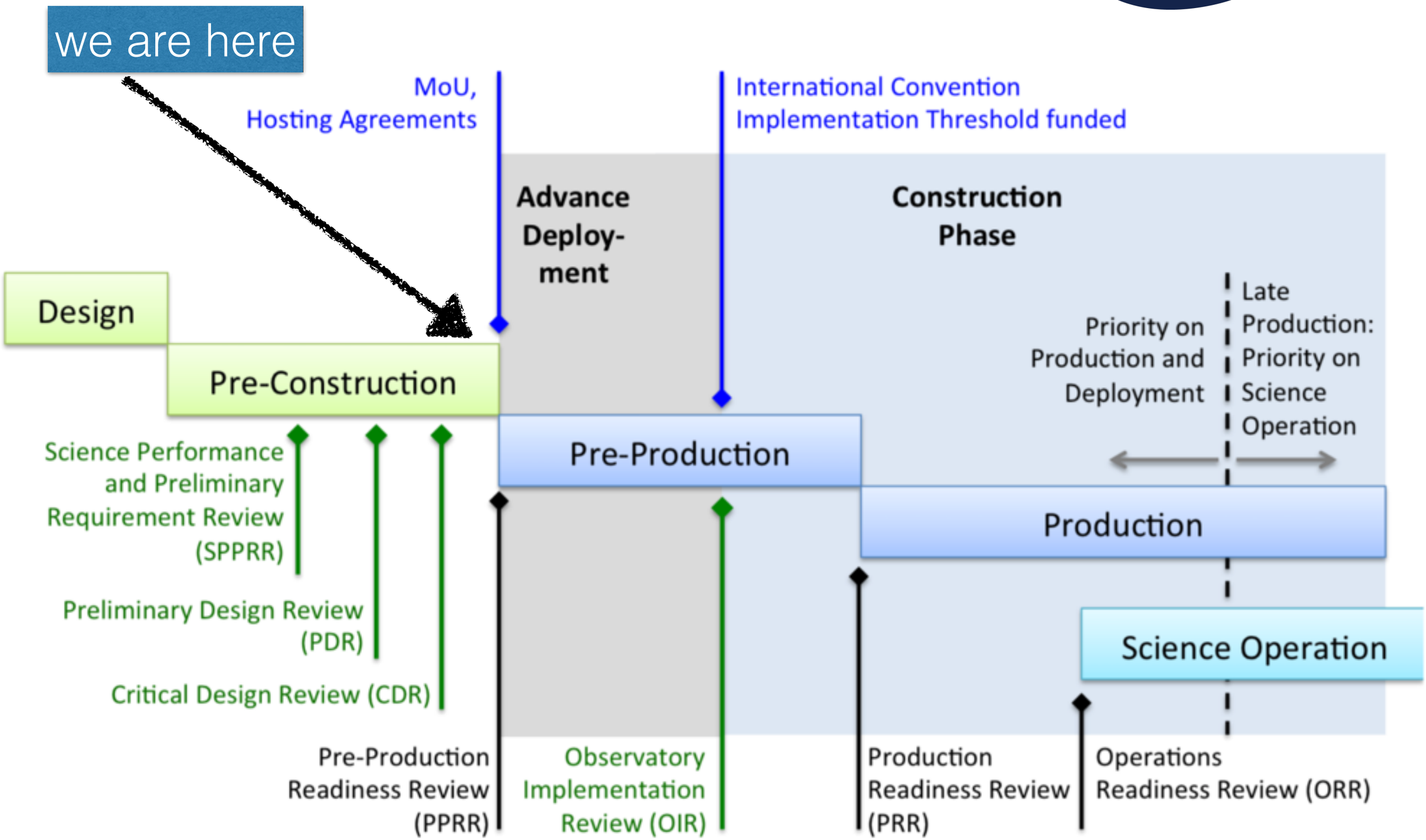


Phases


we are here
MoU,
Hosting Agreements
International Convention
Implementation Threshold funded
Advance Deploy-ment
Construction Phase
Design
Pre-Construction
Priority on Production and Deployment
Late Production: Priority on Science
Operation
Science Performance and Preliminary Requirement Review (SPPRR)
Pre-Production
Production
Preliminary Design Review (PDR)
Science Operation
Critical Design Review (CDR)
Pre-Production Readiness Review (PPRR)
Observatory Implementation Review (OIR)
Production Readiness Review (PRR)
Operations Readiness Review (ORR)

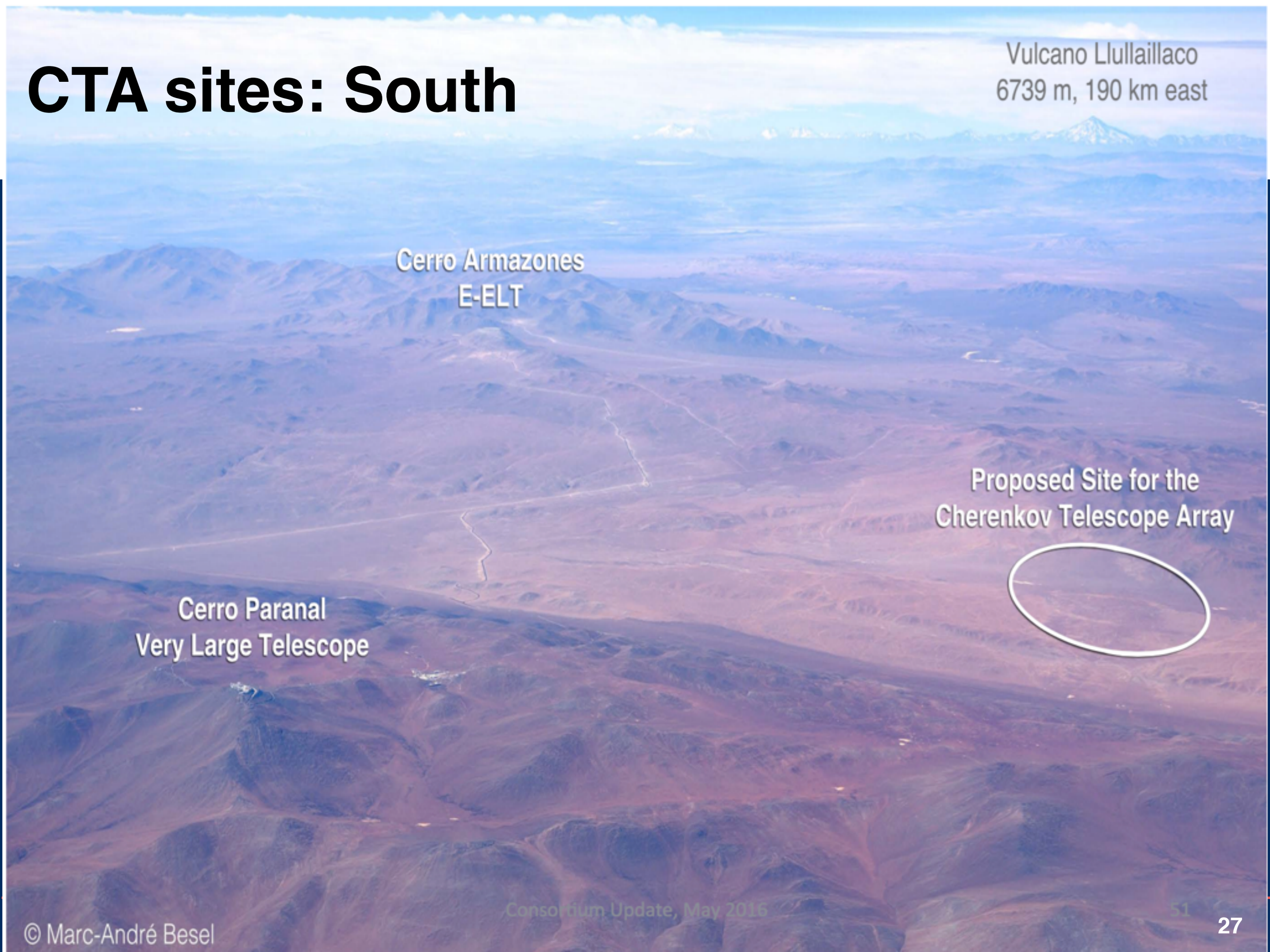
CTA sites

cherenkov telescope array

Site negotiations successfully completed with IAC, La Palma, Spain

Site negotiations progressing with ESO, Chile

CTA sites: South

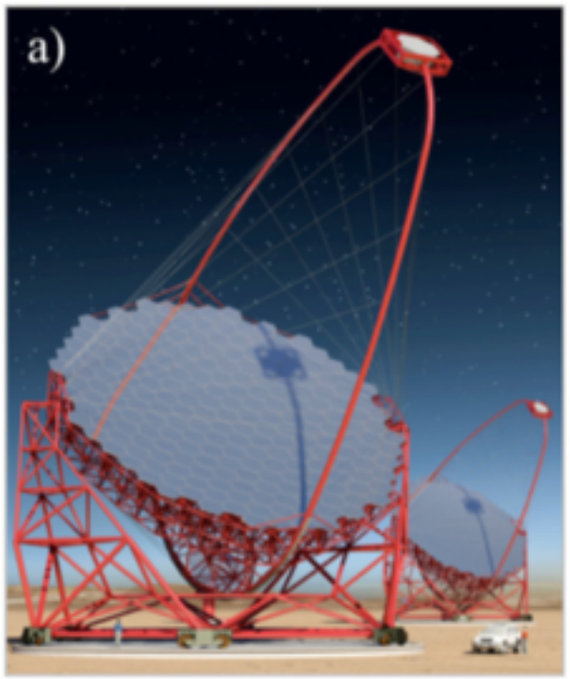


CTA sites: North

Roque de los Muchachos Observatory, La Palma, Spain

CTA Telescopes

cherenkov telescope array



LST corner stone ceremony

cherenkov telescope array

Oct 2015

LST prototype status (La Palma)

cherenkov telescope array

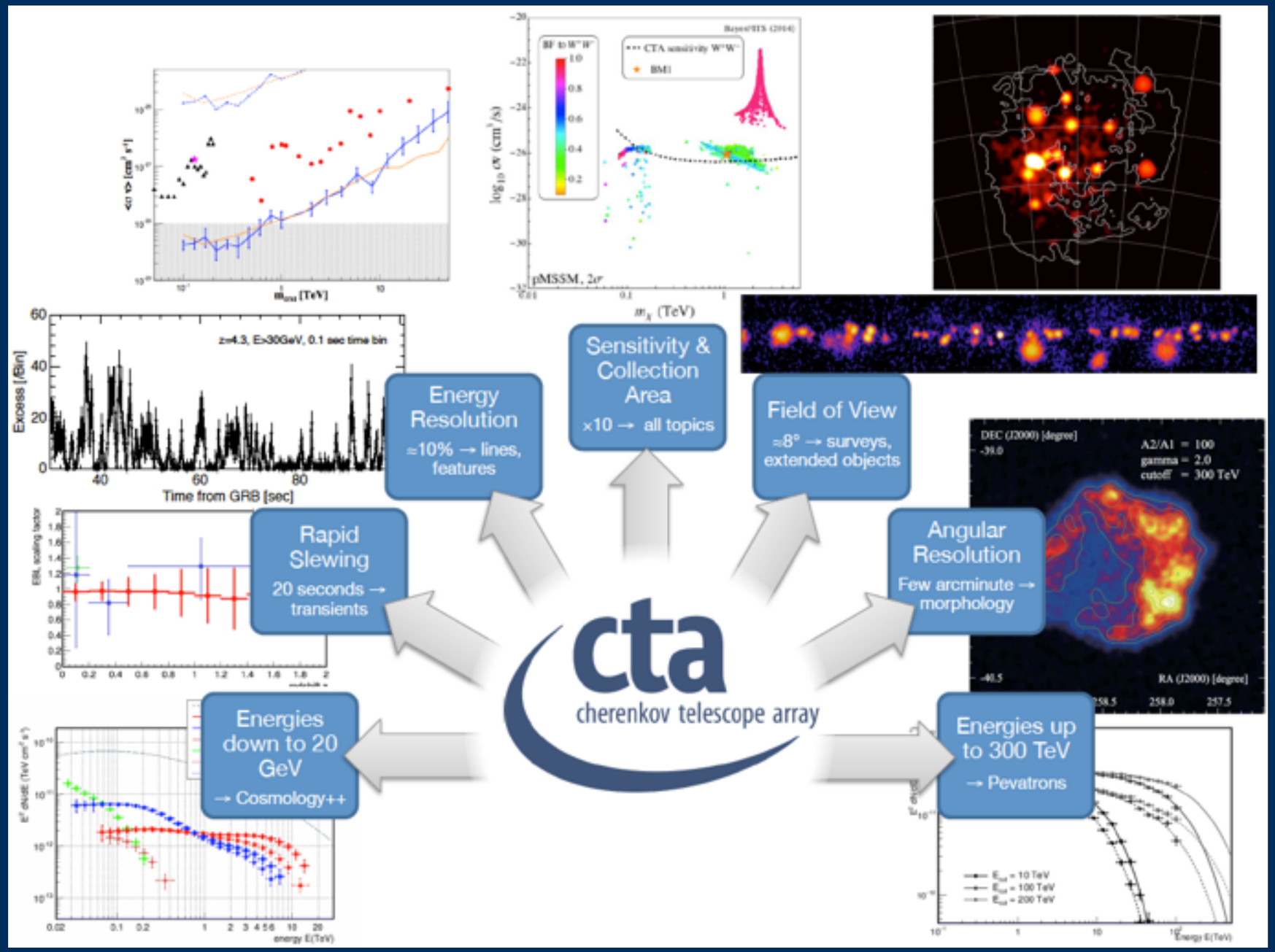
Oct 2016

@Daniel Mazin

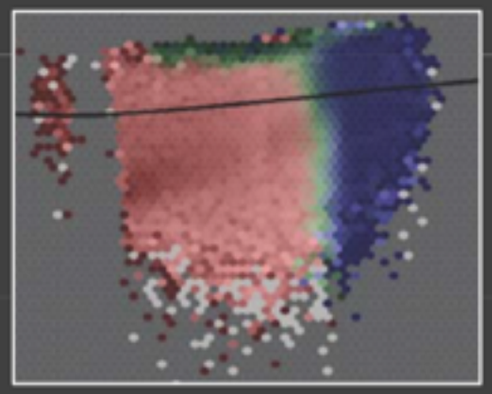
CTA Key Science Projects

cherenkov telescope array

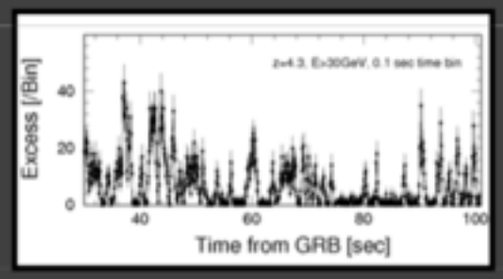
- Theme 1: Understanding the Origin and Role of Relativistic Cosmic Particles
- Theme 2: Probing Extreme Environments
- Theme 3: Exploring Frontiers in Physics



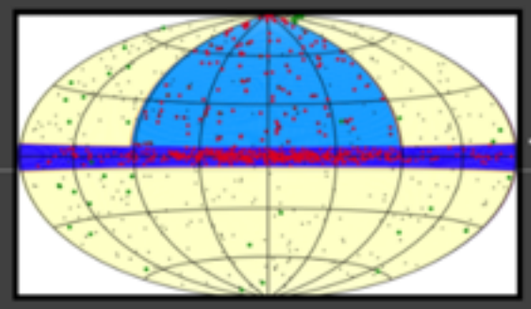
Key Science Projects (KSPs)



Dark Matter Programme



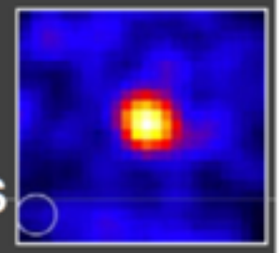
Transients

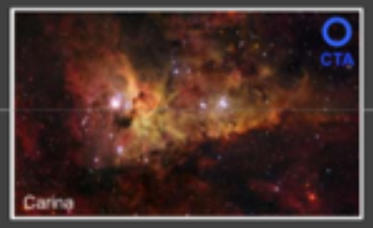


ExGal Survey

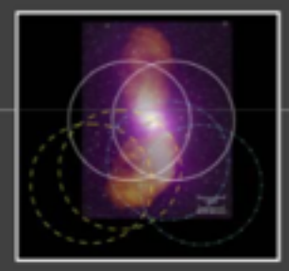
Extragalactic

Galaxy Clusters

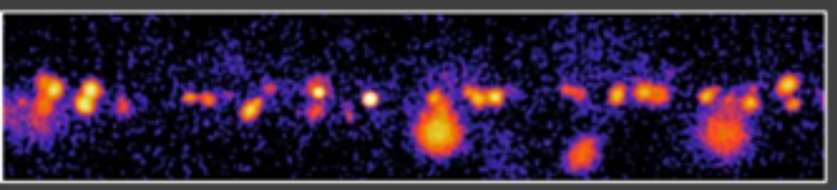




Star Forming Systems

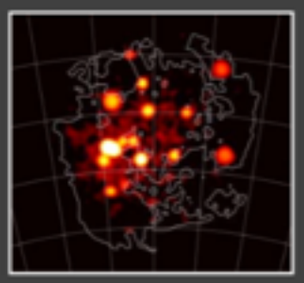


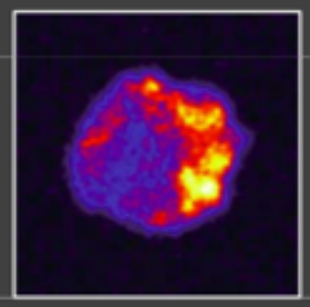
AGN



Galactic Plane Survey

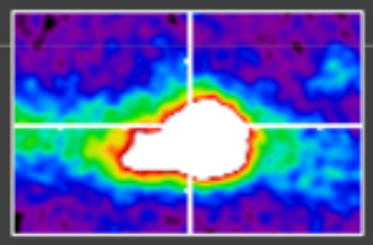
LMC Survey





PeVatrons

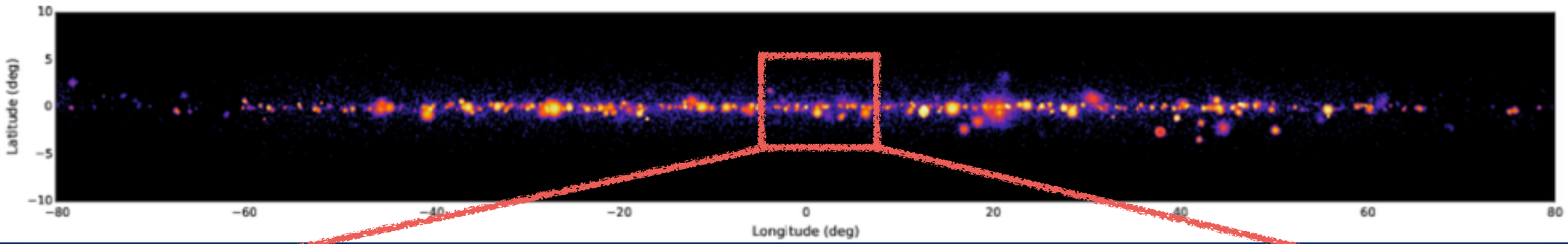
Galactic Centre



cta cherenkov telescope array

Galactic Plane Scan

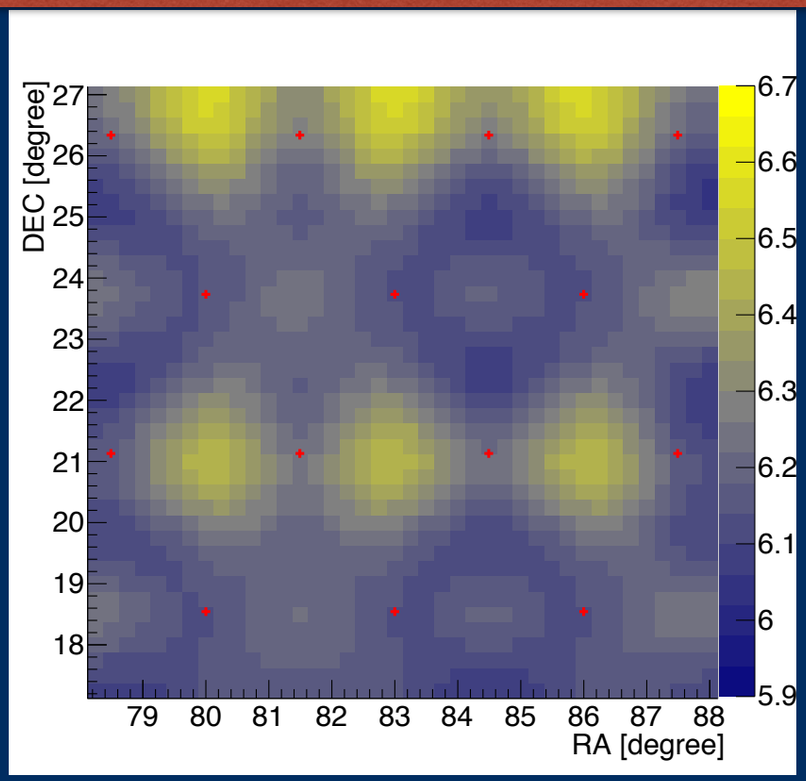
- Simulated Galactic Plane Scan and a zoom in the inner 10 deg
- Sensitivity: 1-3 mCrab (factor 5 better than H.E.S.S)



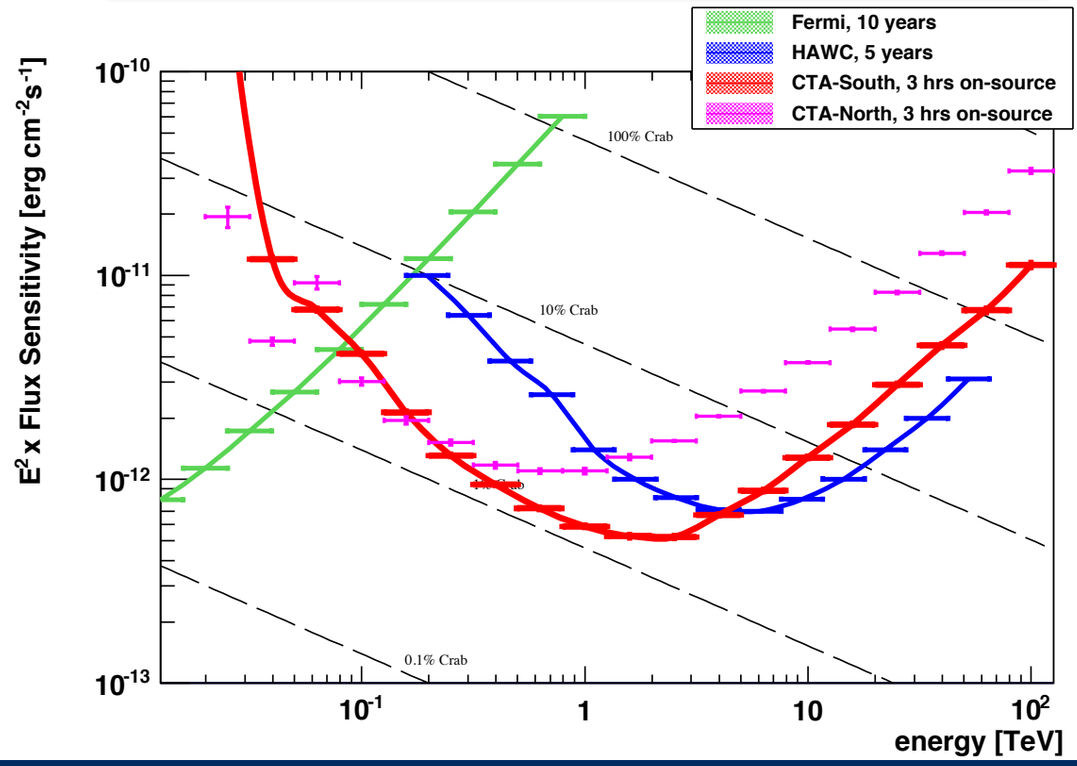
Extragalactic Survey

cherenkov telescope array

integral sensitivity map in mCrab

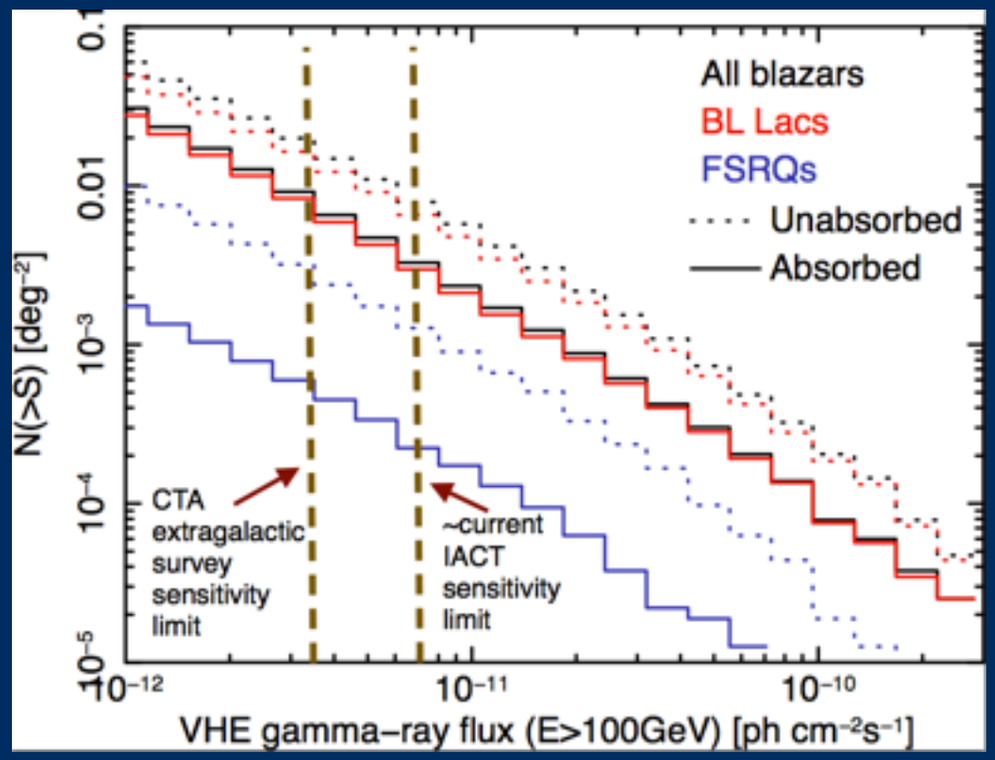


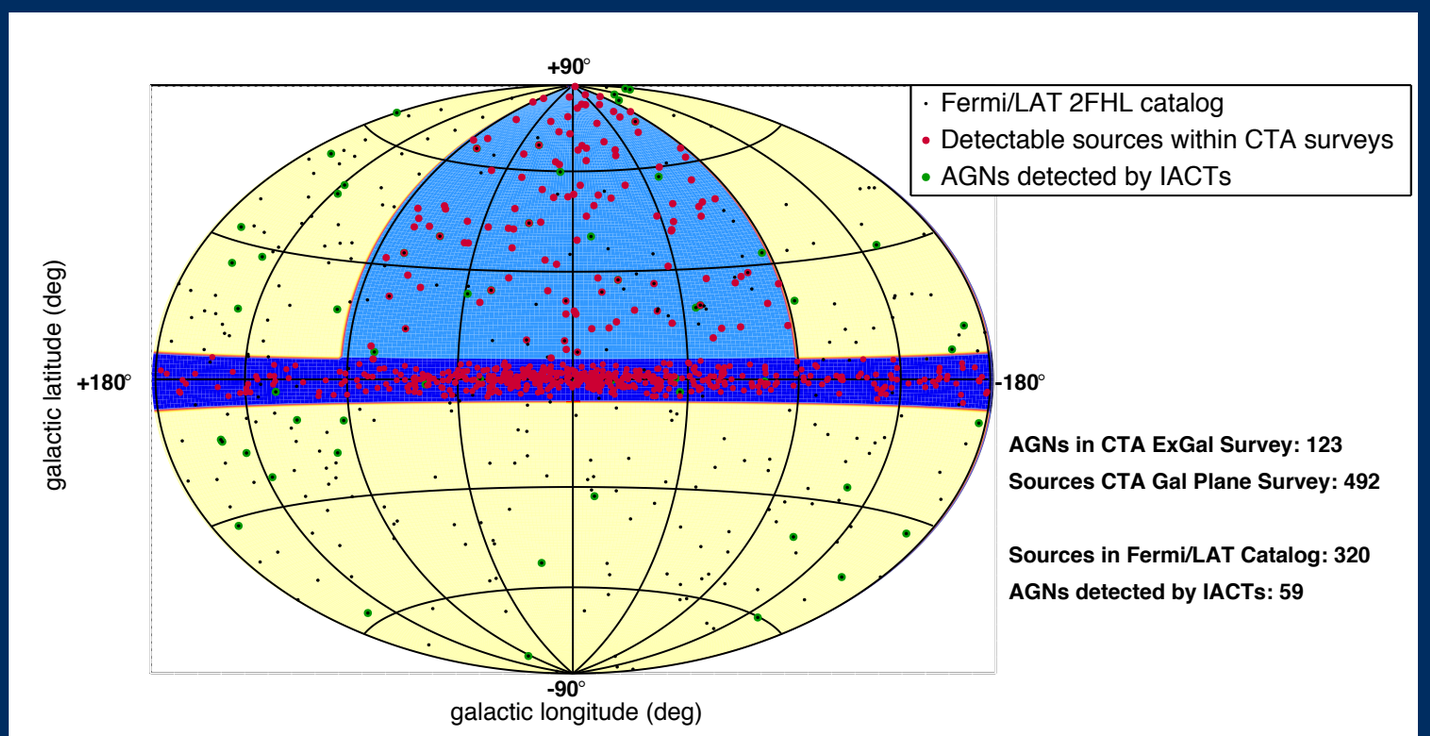
differential sensitivity of the survey



- Blind survey over 25% of the sky (~10,000 deg^2)
- Overall sensitivity of 6mCrab at energies above 100 GeV
- each field to be observed for few hours, revisit few times over two years to access source variability / persistence
- Divergent pointing is being explored as a possibility

Extragalactic Survey

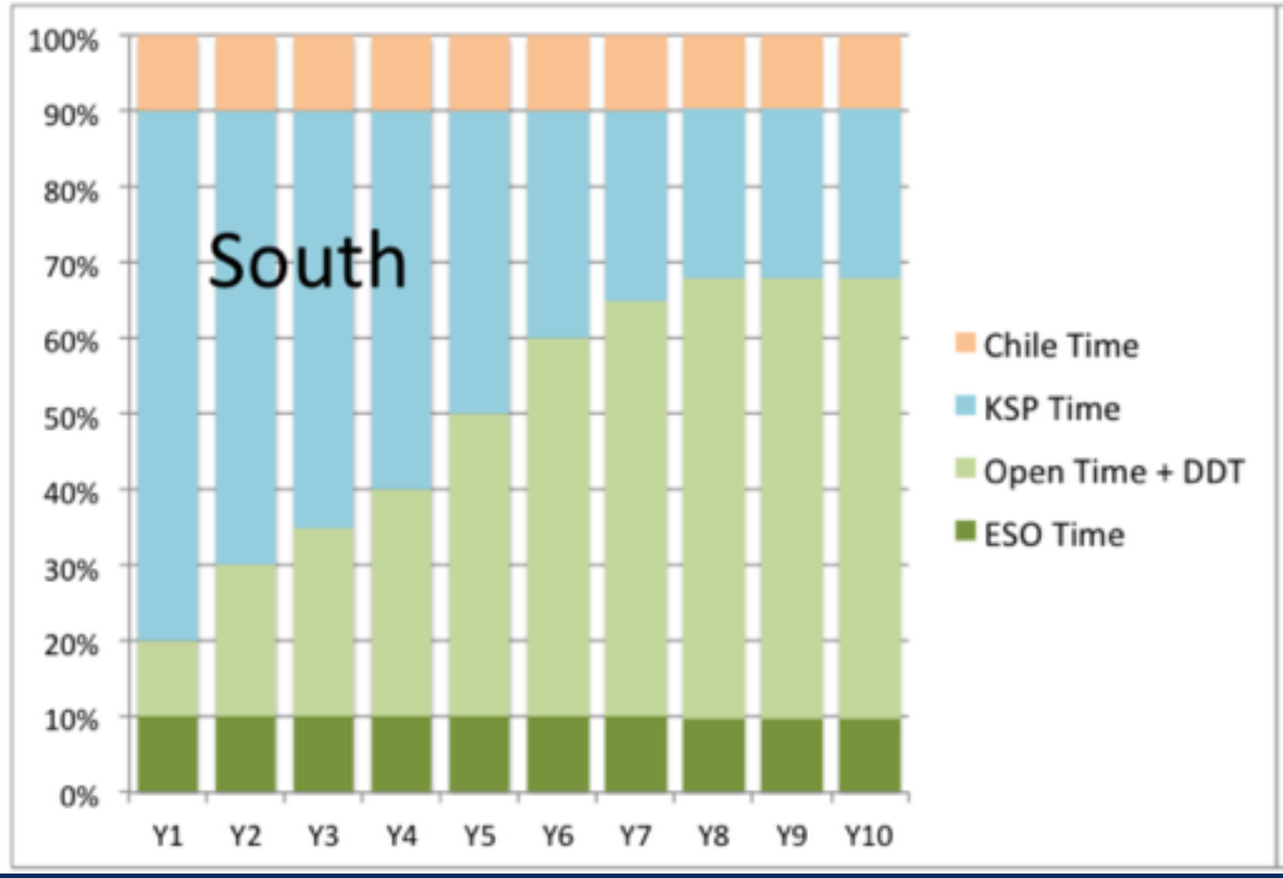


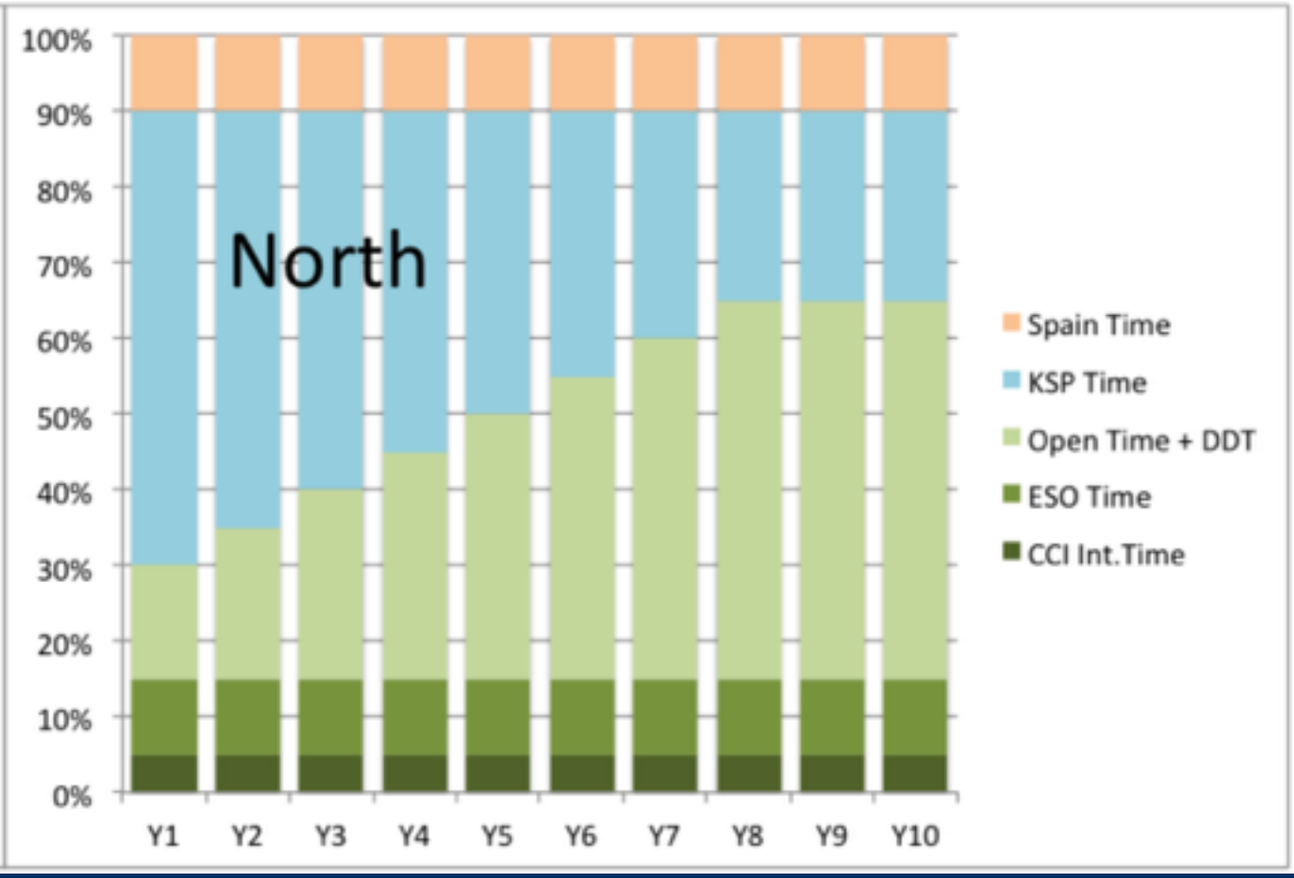


- Expect to detect about 100-150 sources (currently about 20 VHE sources in 25% of the extragalactic sky discovered): this will be enough to construct Luminosity Function
- Hope to find dark emitters: not seen by Fermi/LAT because of hard spectrum and too weak for current IACTs

Time distribution

- Plausible scenario is shown below
- Start with early science (mainly transients and bright objects) in 2018
- Full array aimed for 2021





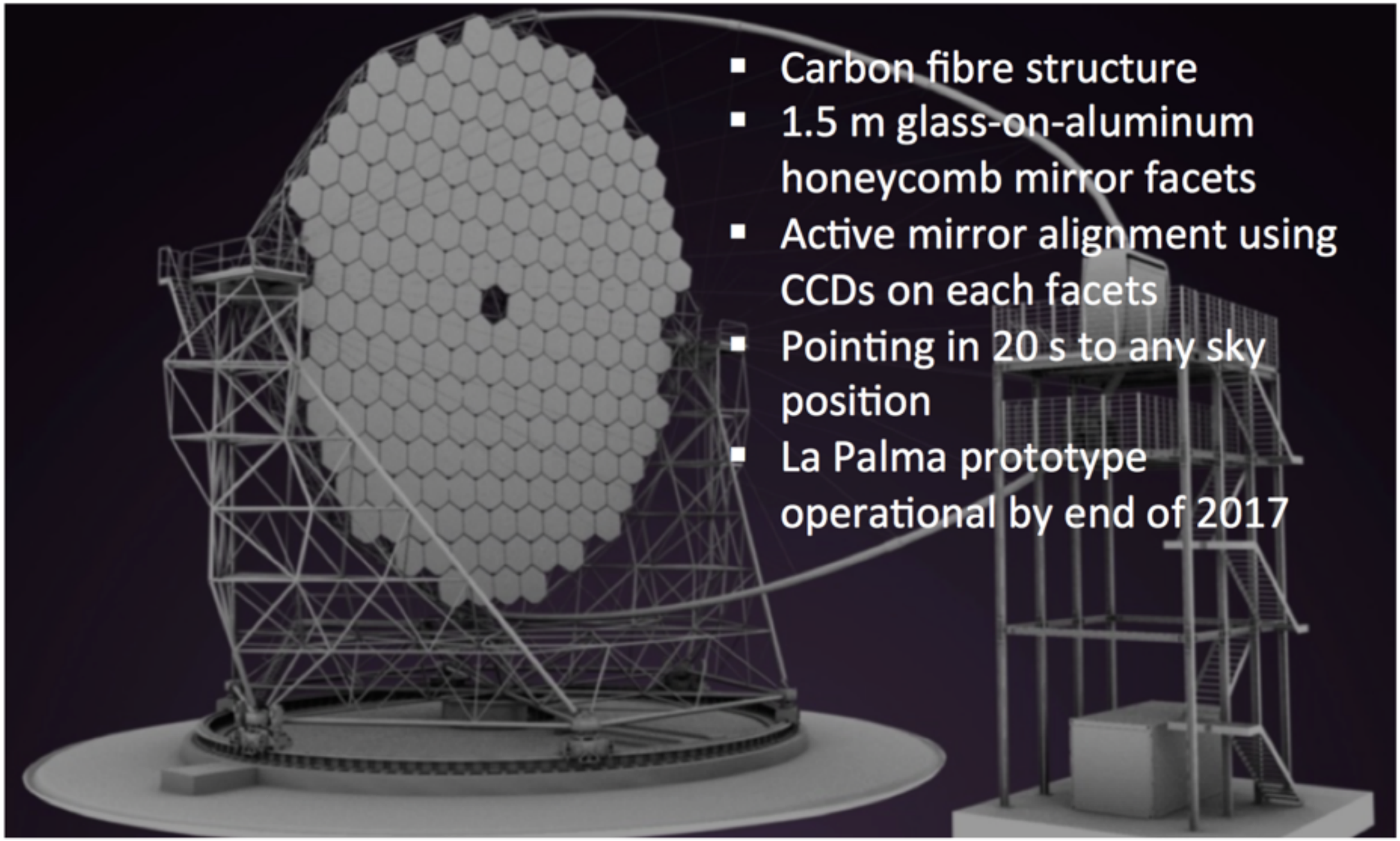
Summary

- Gamma ray astronomy is in booming phase
- CTA is the logical successor of the current instruments
- CTA will be the first ground based Cherenkov observatory
- CTA site selection finished in North, almost finished in South
- Several prototype telescopes are being built
- First science in 2018, full array 2021

backup

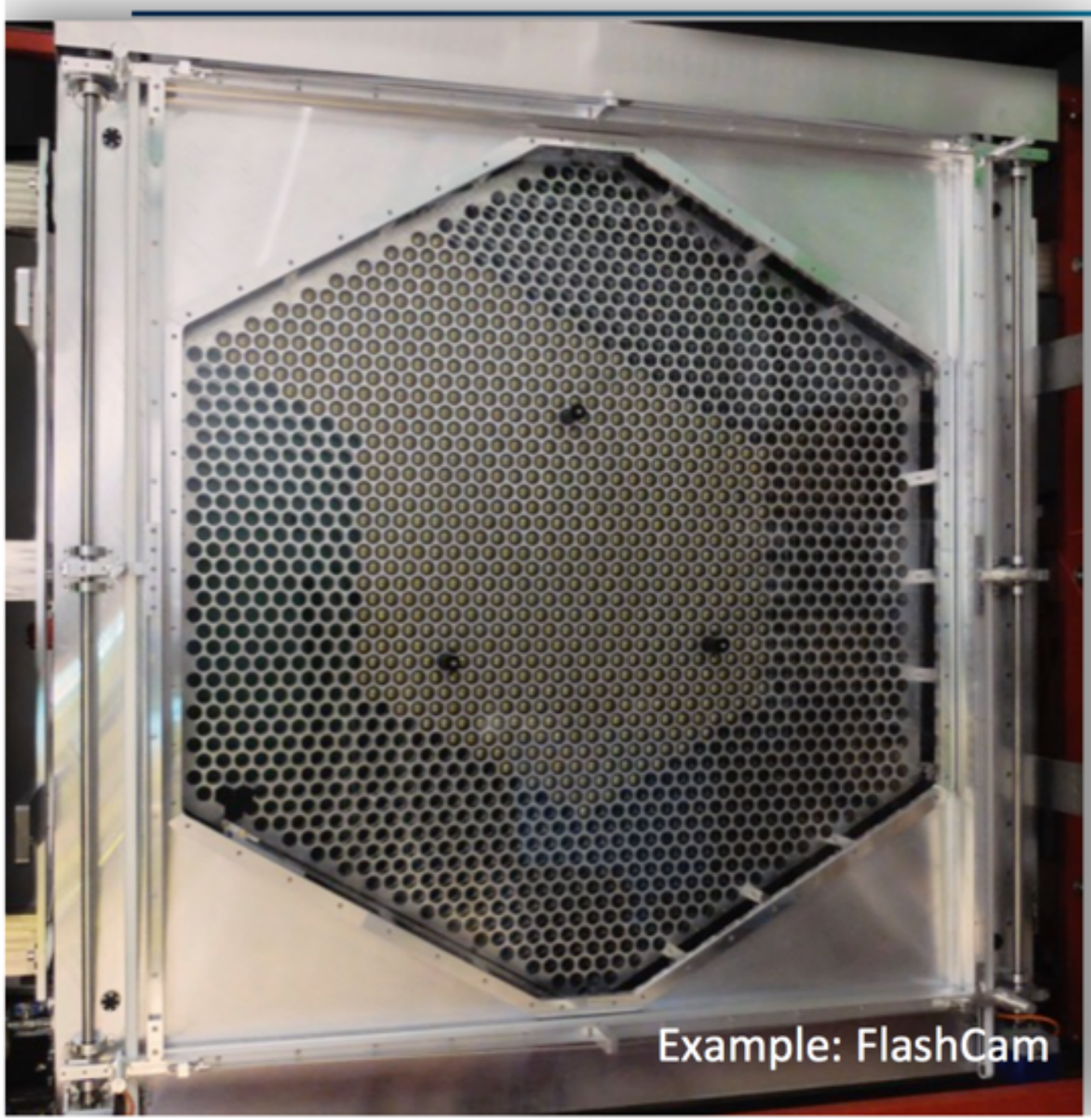
cherenkov telescope array

Large Size Telescope

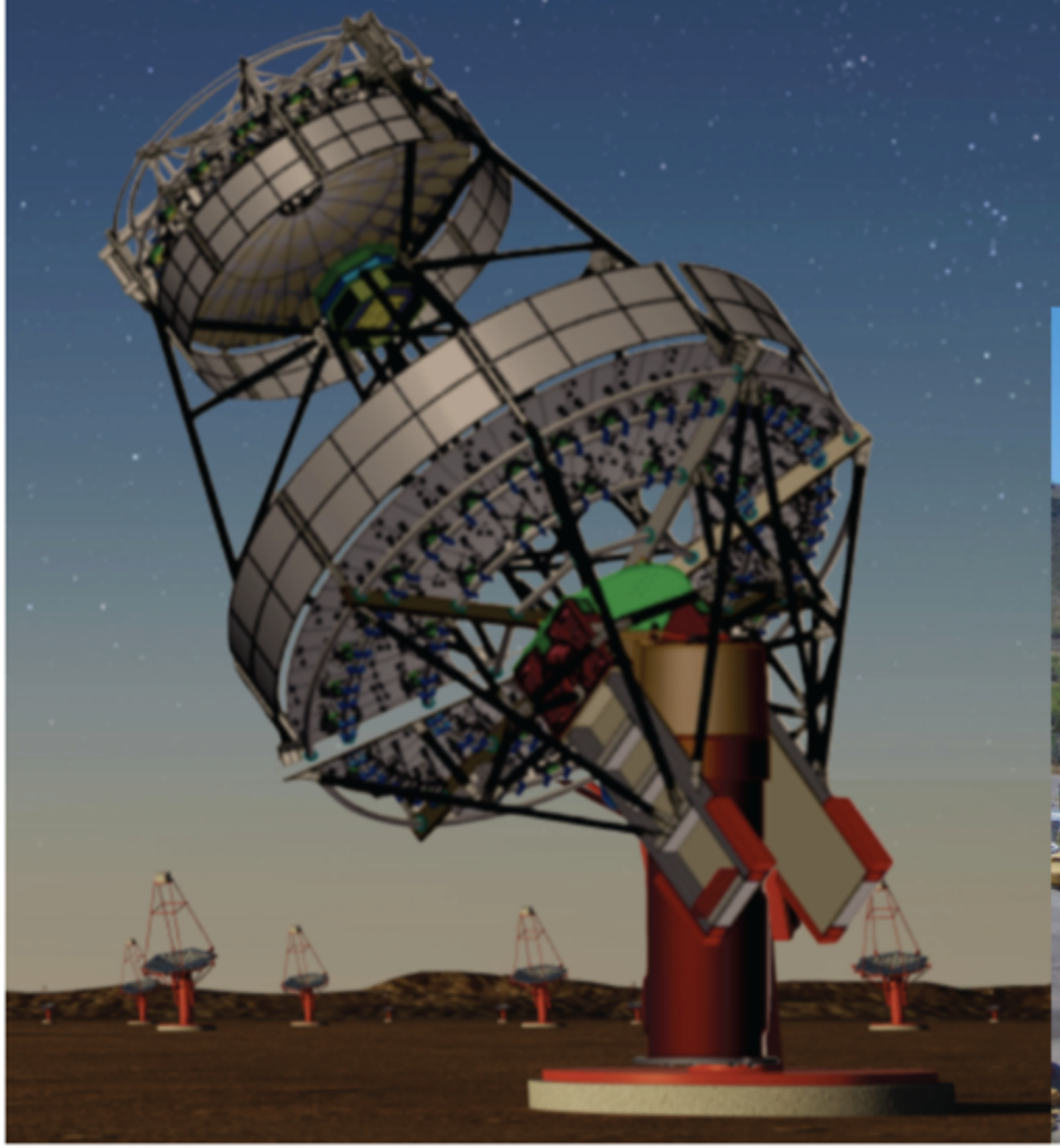


Medium Size Telescope Prototype

Focal Plane “Cameras” with Integrated Electronics

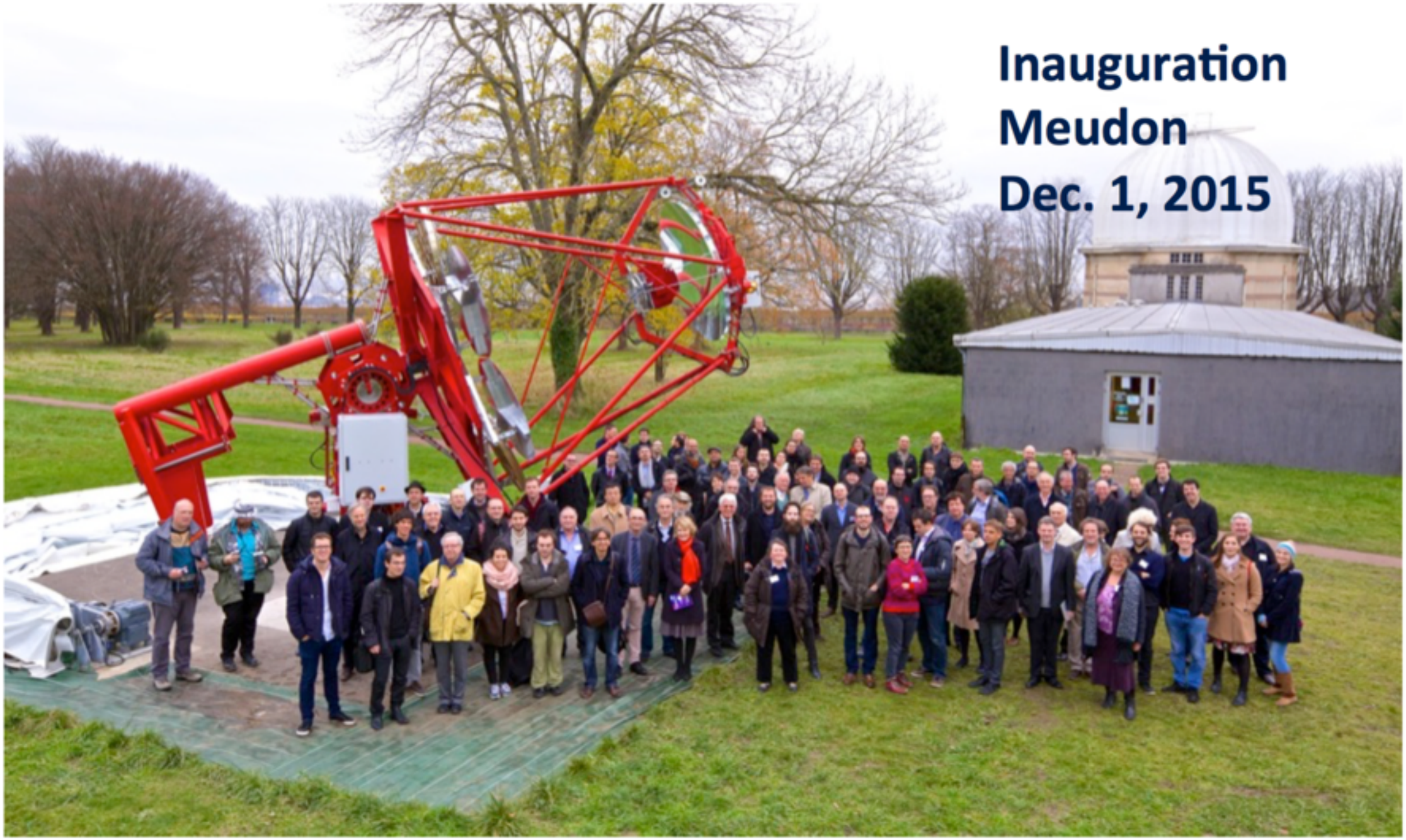


Dual-Mirror Medium Size Telescope



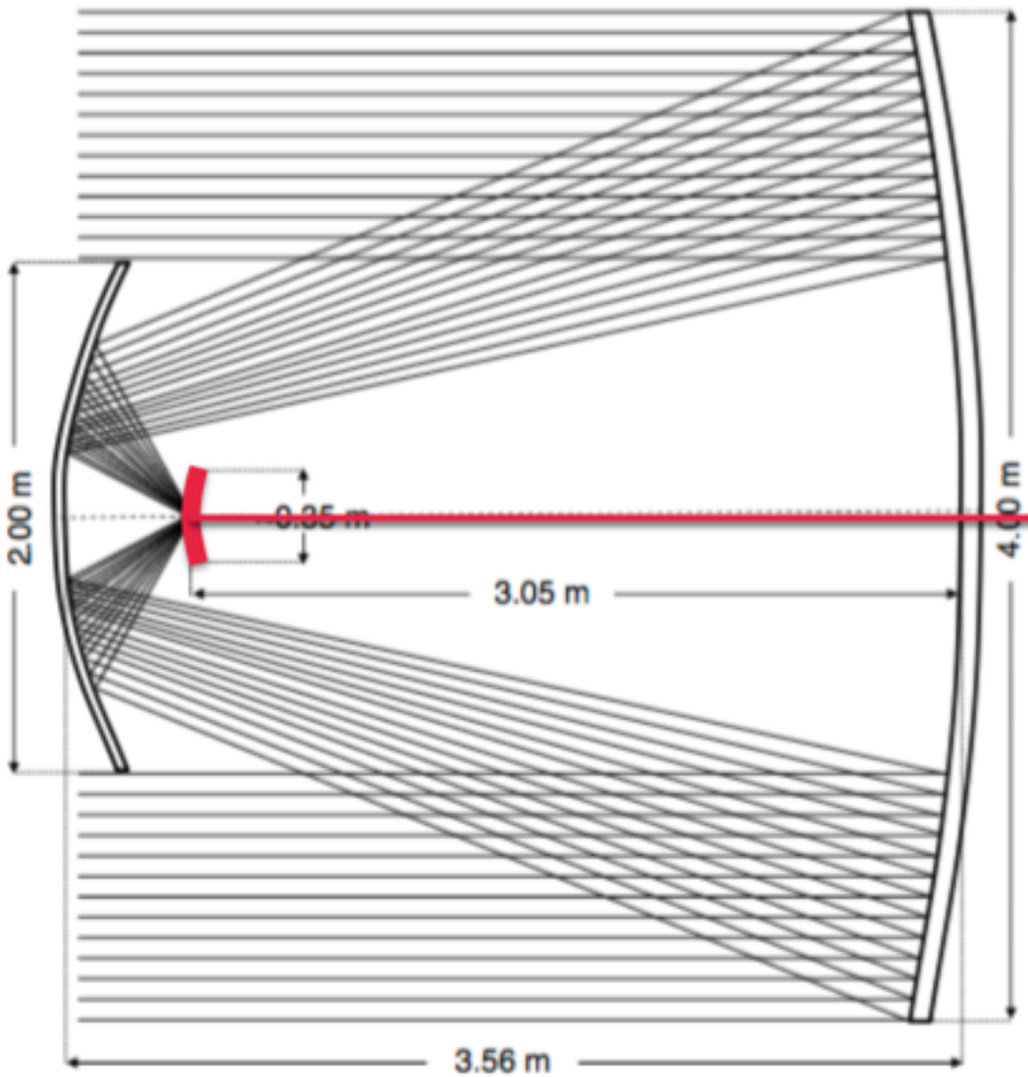
9.7 m primary
5.4 m secondary
5.6 m focal length, f/0.58
11328 x 0.07° SiPMT pixels

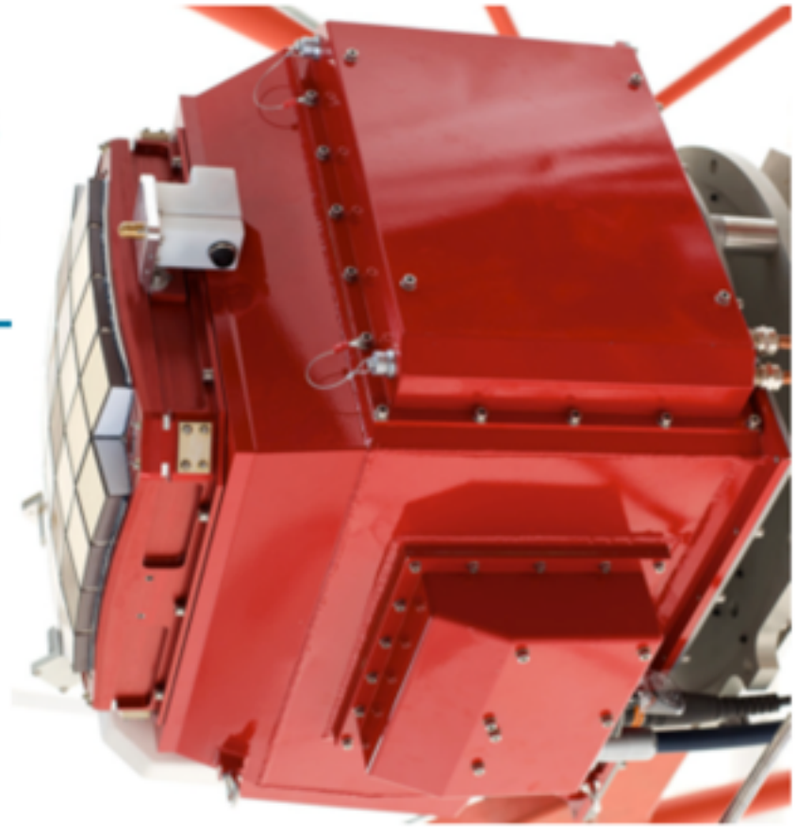
GCT Small Size Telescope

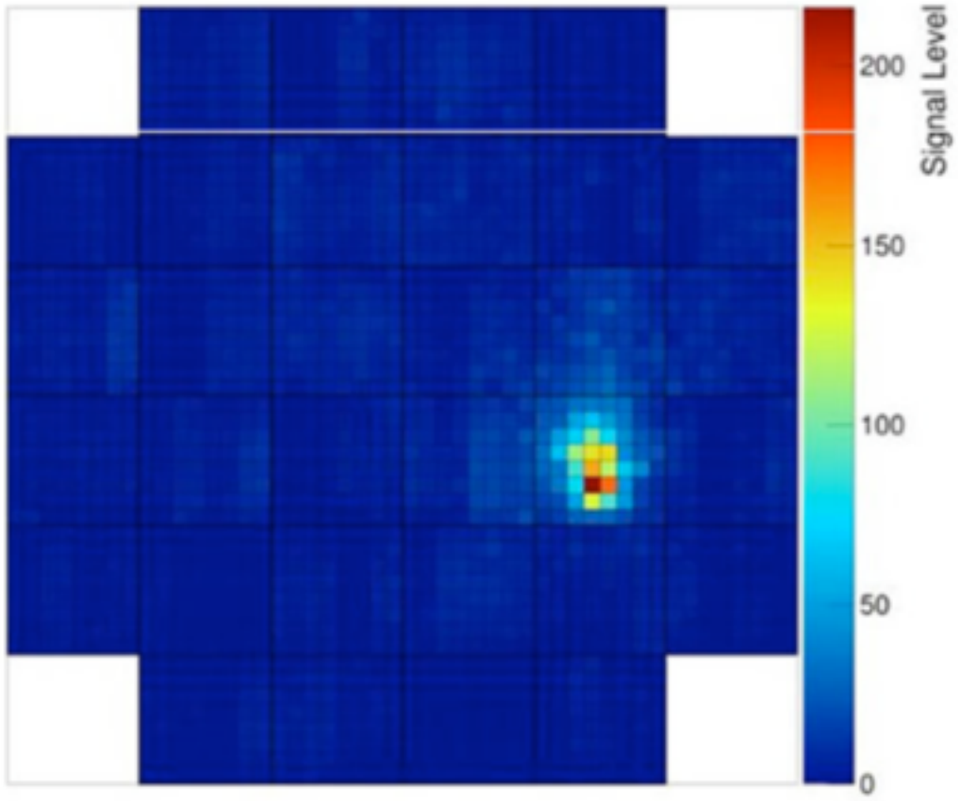


Inauguration
Meudon
Dec. 1, 2015

First Ever Cherenkov Images from a Dual Mirror Telescope







ASTRI Small Size Telescope

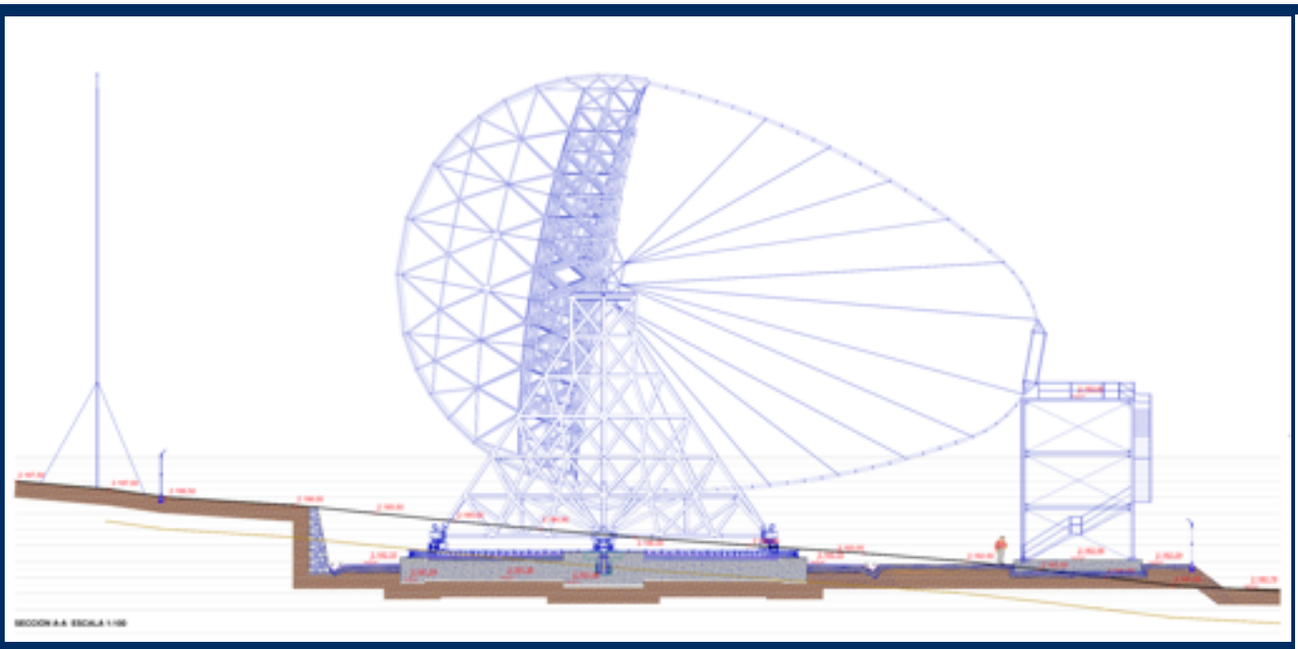
Single-Mirror Small Size Telescope

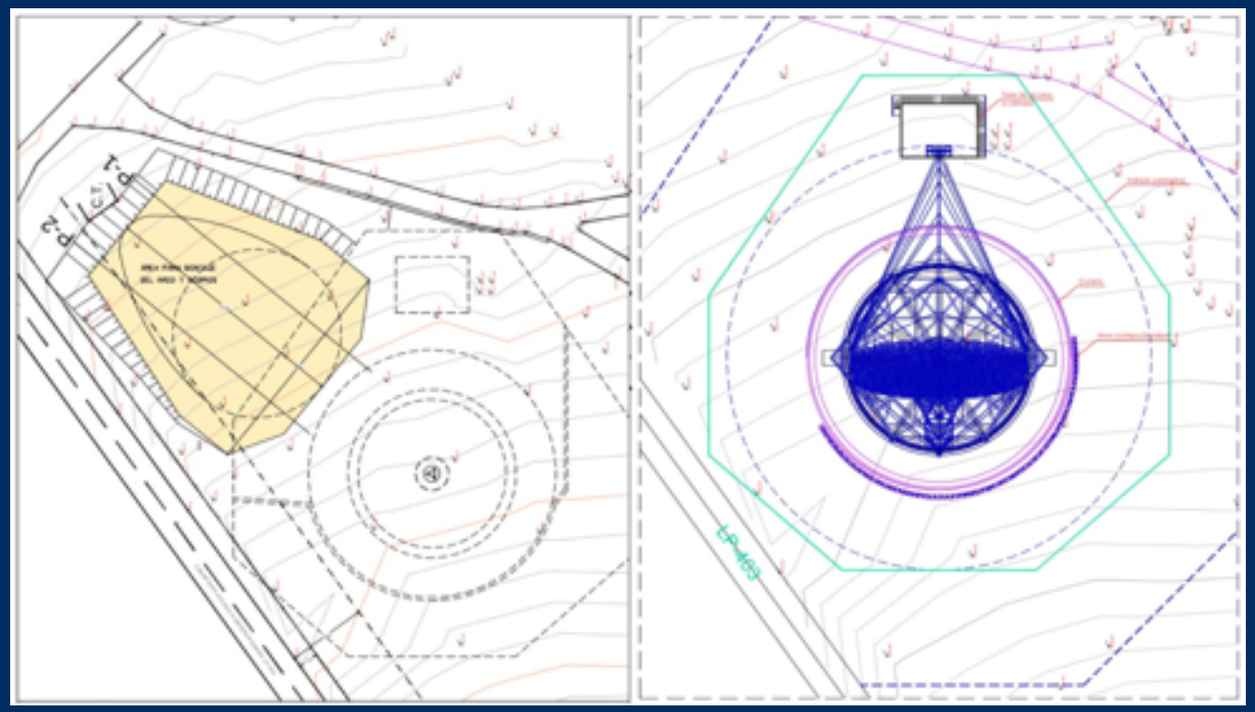
Telescope parameters

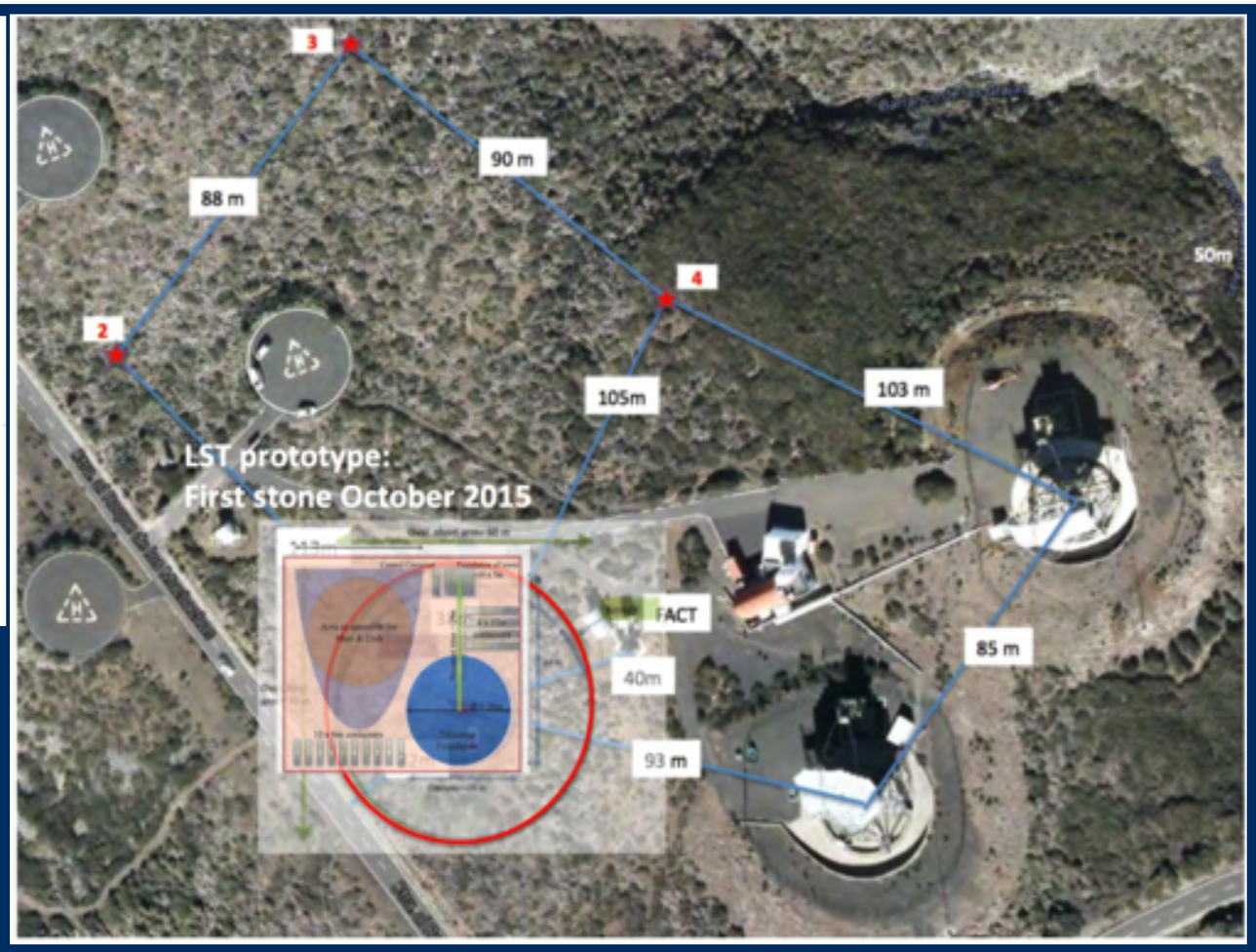
cherenkov telescope array

Telescope	Large	Medium		Small		
	LST	MST	SCT	SST-1M	ASTRI SST-2M	GCT SST-2M
Number North array	4	15	TBD		0	
Number South array	4	25	TBD		70	
Optics						
Optics layout	Parabolic mirror	Davies-Cotton	Schwarzschild-Couder	Davies-Cotton	Schwarzschild-Couder	Schwarzschild-Couder
Primary mirror diameter (m)	23	13.8	9.7	4	4.3	4
Secondary mirror diameter (m)	–	–	5.4	–	1.8	2
Eff. mirror area after shadowing (m^2)	368	88	40	7.4	6	6
Focal length (m)	28	16	5.6	5.6	2.15	2.28
Focal plane instrumentation						
Photo sensor	PMT	PMT	silicon	silicon	silicon	silicon
Pixel size (degr.), shape	0.10, hex.	0.18, hex.	0.07, square	0.24, hex.	0.17, square	0.15-0.2, square
Field of view (degr.)	4.5	7.7/8.0	8.0	9.1	9.6	8.5 - 9.2
Number of pixels	1855	1764/1855	11328	1296	1984	2048
Signal sampling rate	GHz	250 MHz / GHz	GHz	250 MHz	S&H	GHz
Structure						
Mount	alz-az, on circular rail	alt-az positioner	alt-az positioner	alt-az positioner	alt-az positioner	alt-az positioner
Structural material	CFRP / steel	steel	steel	steel	steel	steel
Weight (full telescope, tons)	100	85	~85	9	15	8
Max. time for repositioning (s)	20	90	90	60	80	60

Site for LST1: Foundation







- start of civil works in July 2016 (or June if possible)
- position change asked by MAGIC collaboration would require a new permission process from the beginning. Will not change the position.