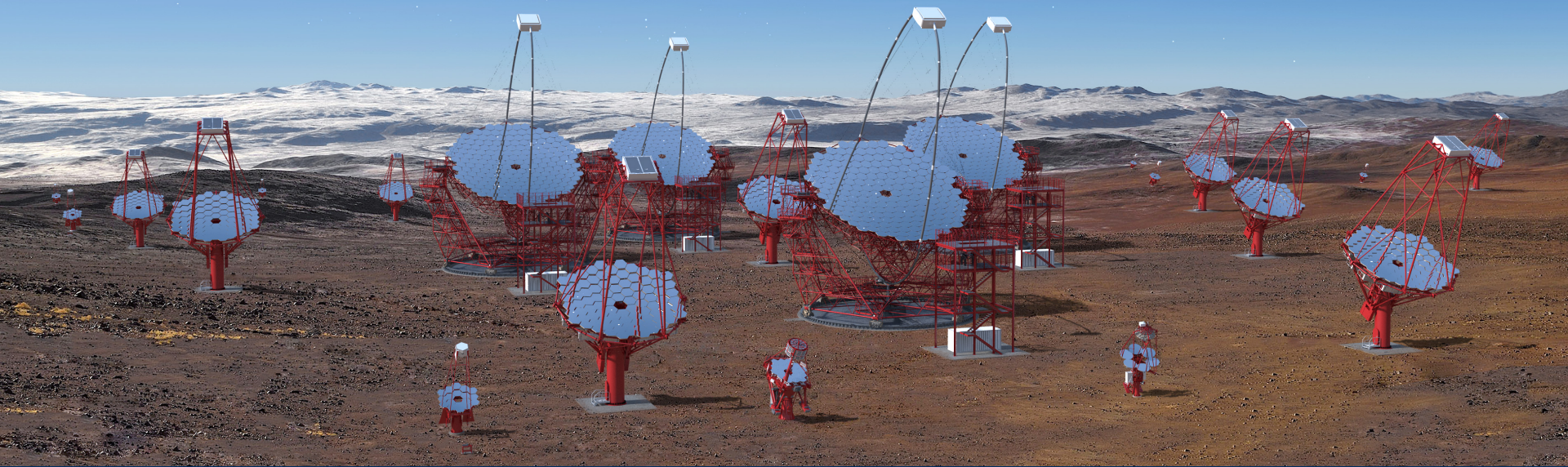


Il Cherenkov Telescope Array: un Osservatorio sull'Universo estremo



Stefano Vercellone (INAF – OA Brera)

stefano.vercellone@brera.inaf.it

Outline



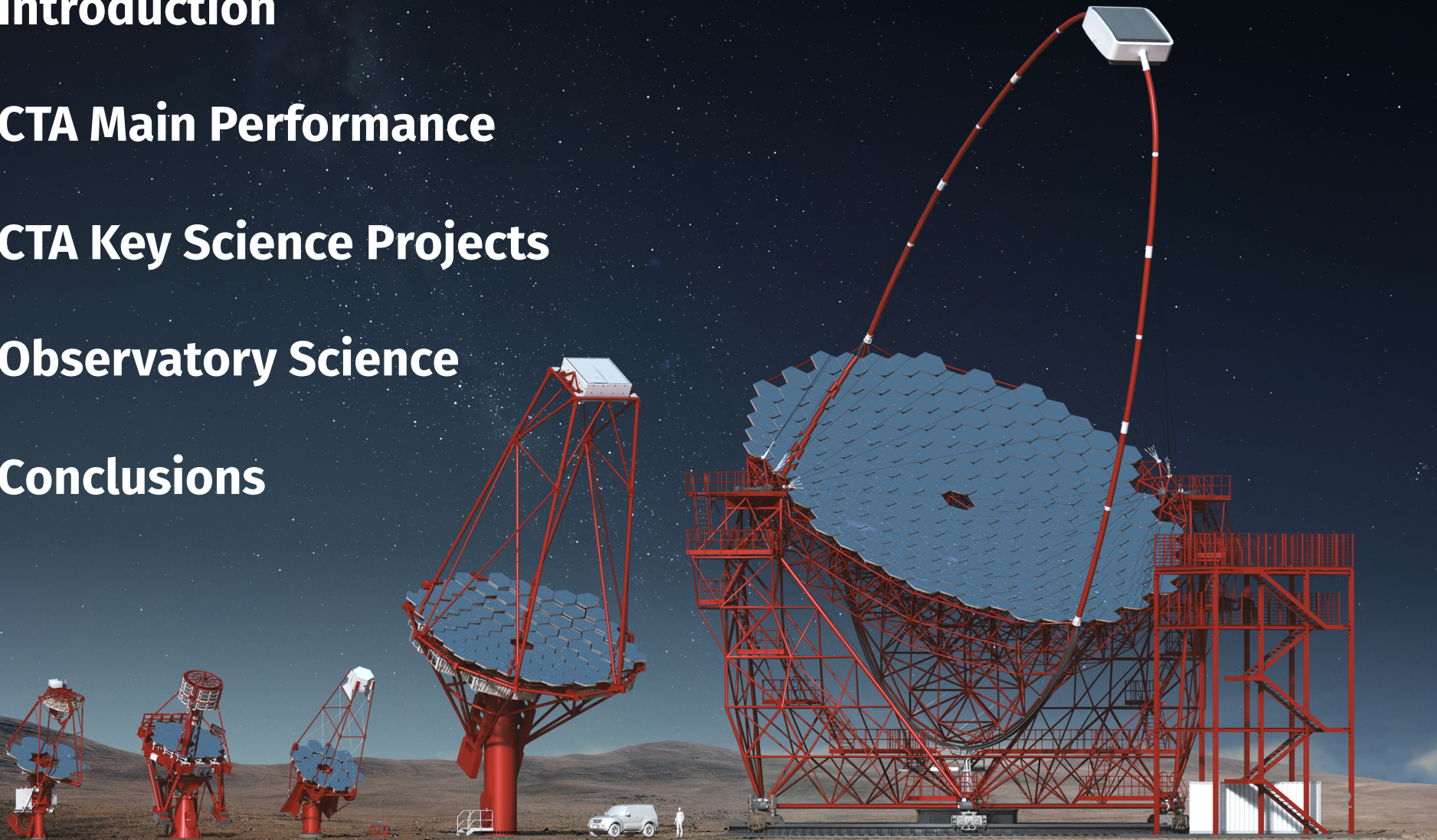
Introduction

CTA Main Performance

CTA Key Science Projects

Observatory Science

Conclusions



Outline



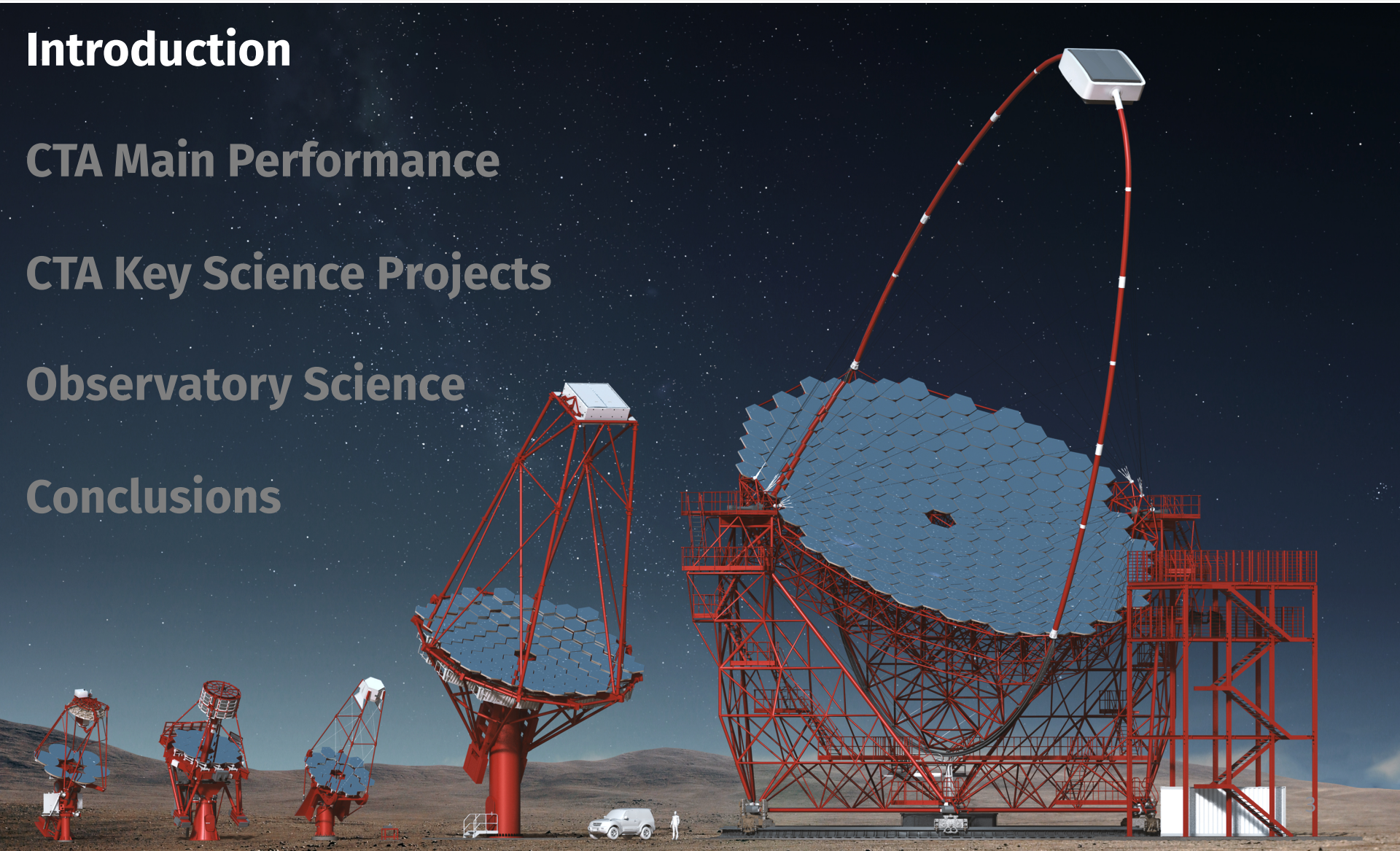
Introduction

CTA Main Performance

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Observatory Science

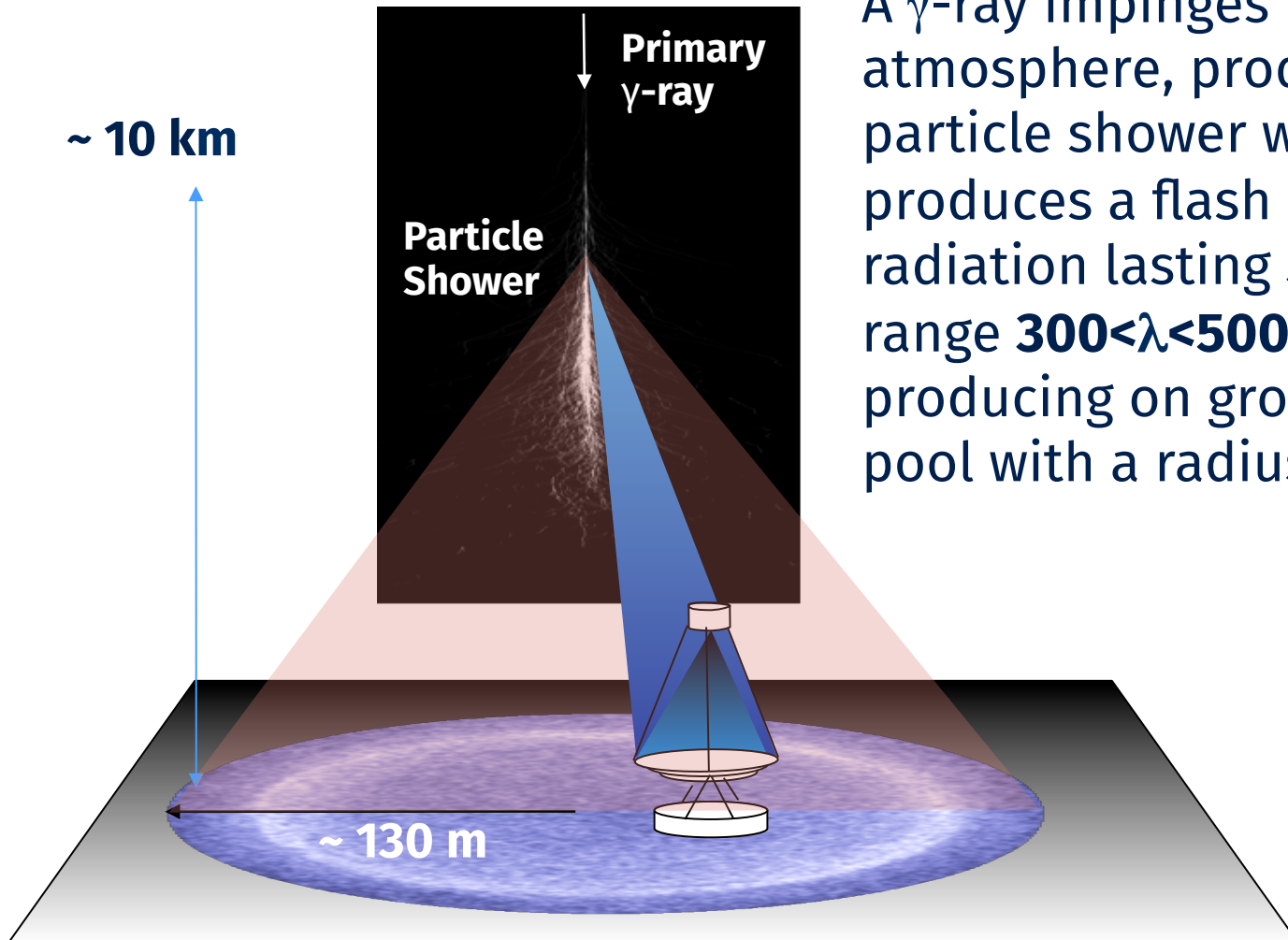
Conclusions



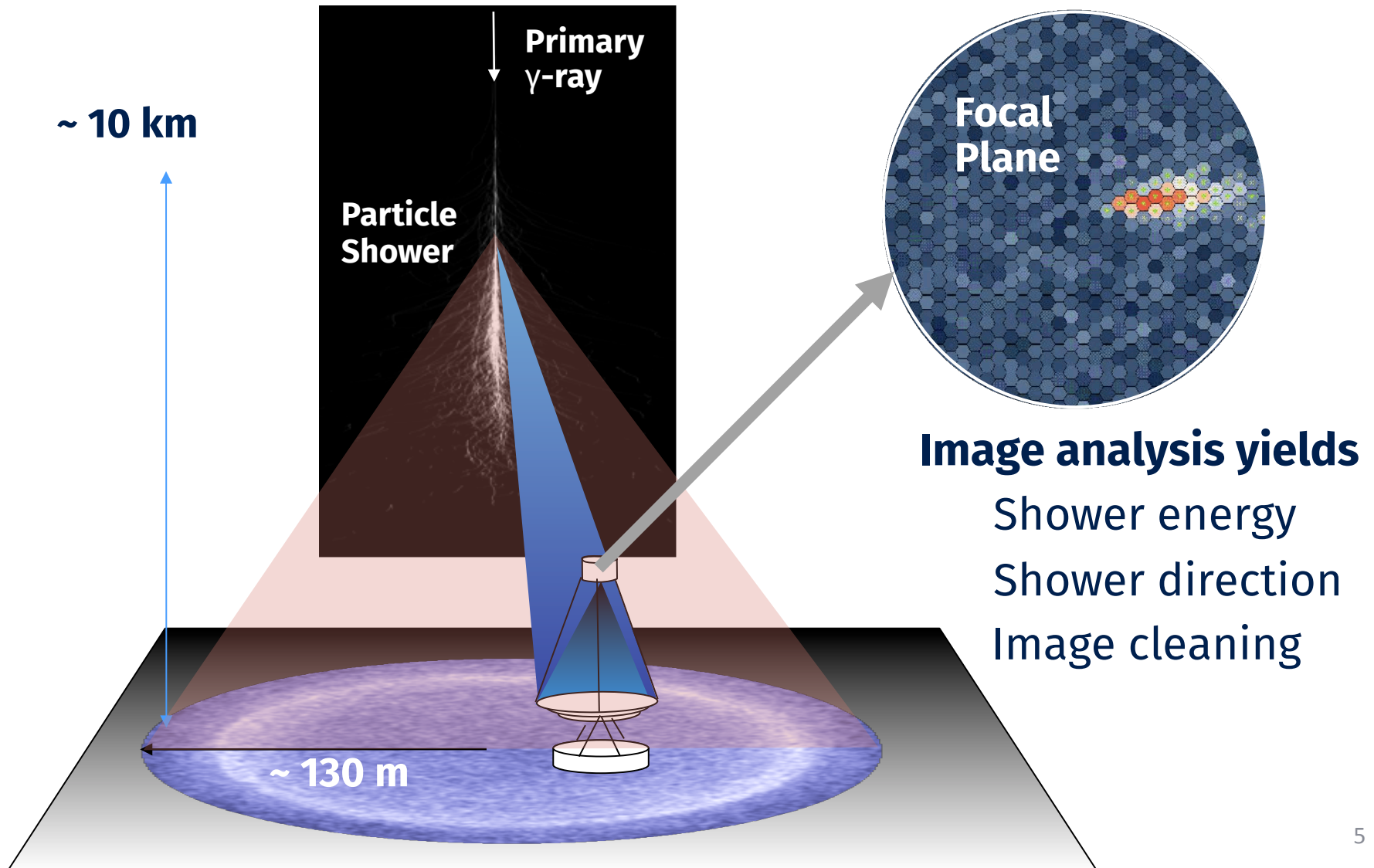
The Cherenkov Telescopes



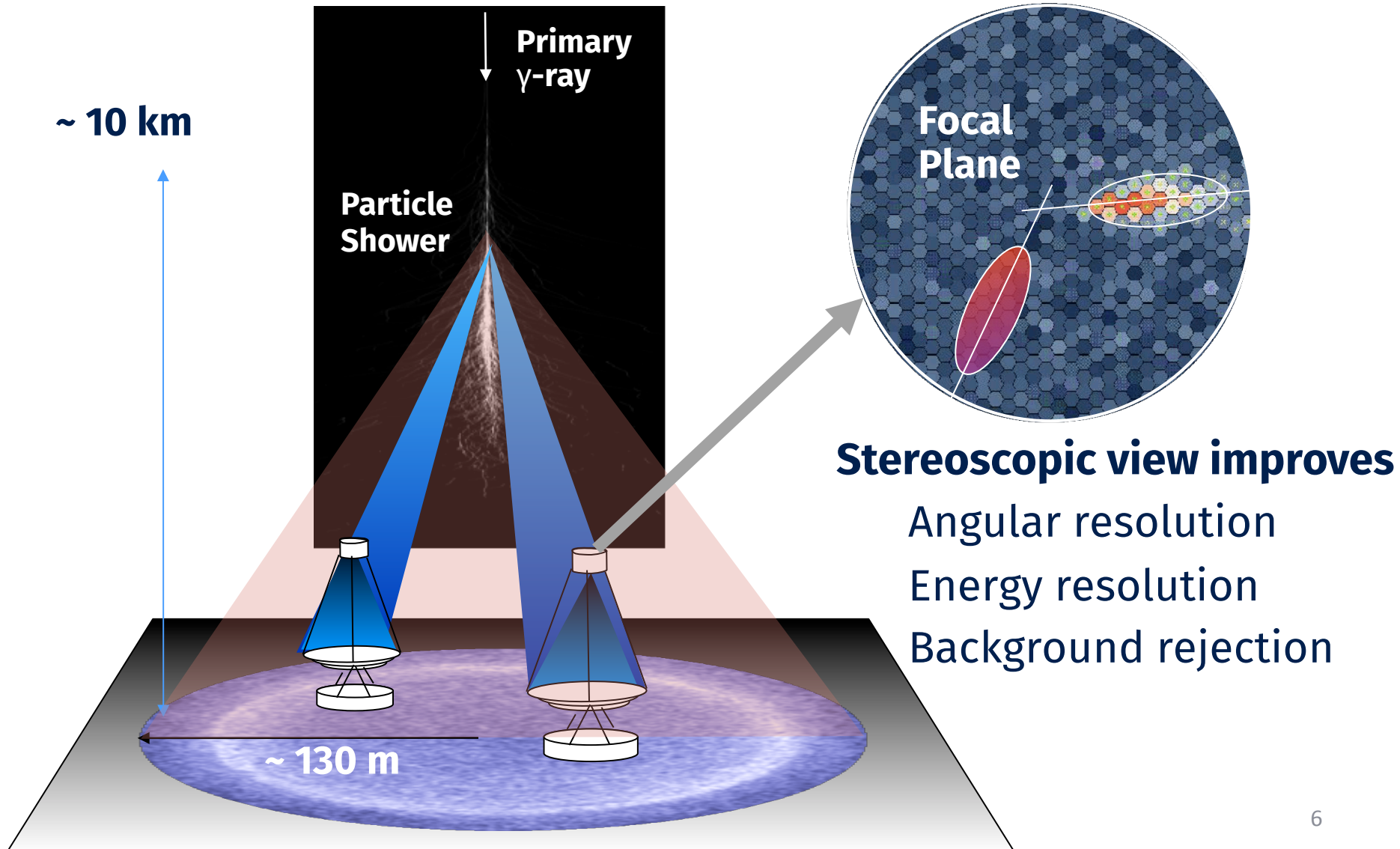
A γ -ray impinges the atmosphere, producing a particle shower which, in turns, produces a flash of Cherenkov radiation lasting **5-20 ns** in the range **$300 < \lambda < 500$ nm** and producing on ground a light pool with a radius of **~130m**.



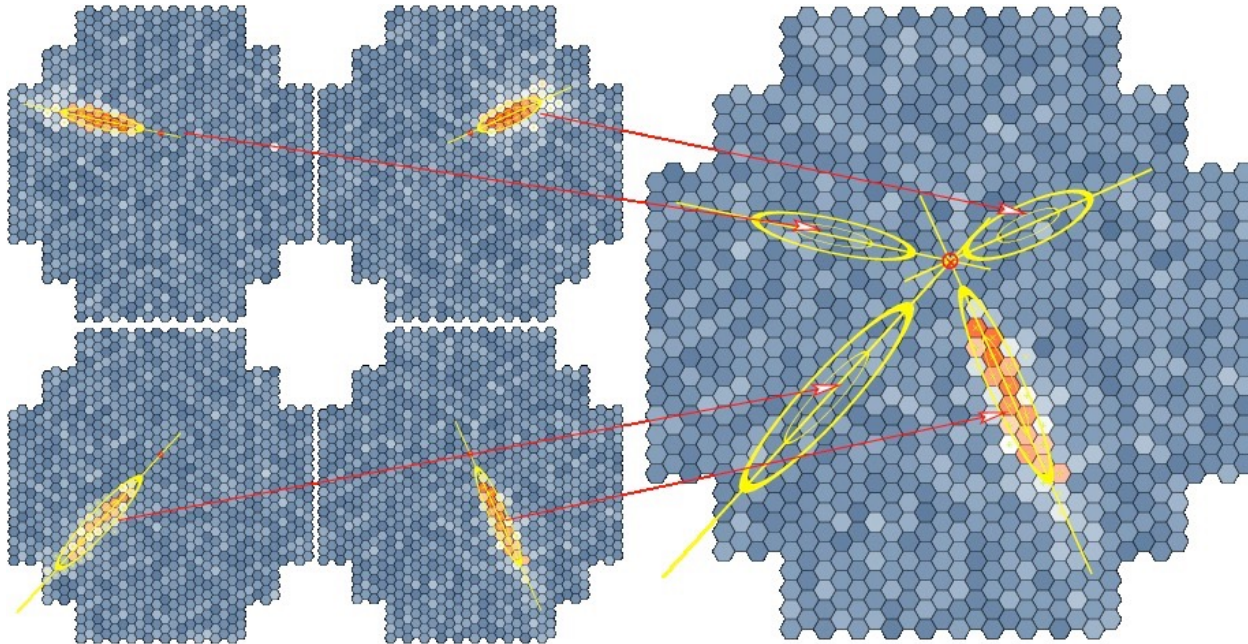
The Cherenkov Telescopes



The Cherenkov Telescopes



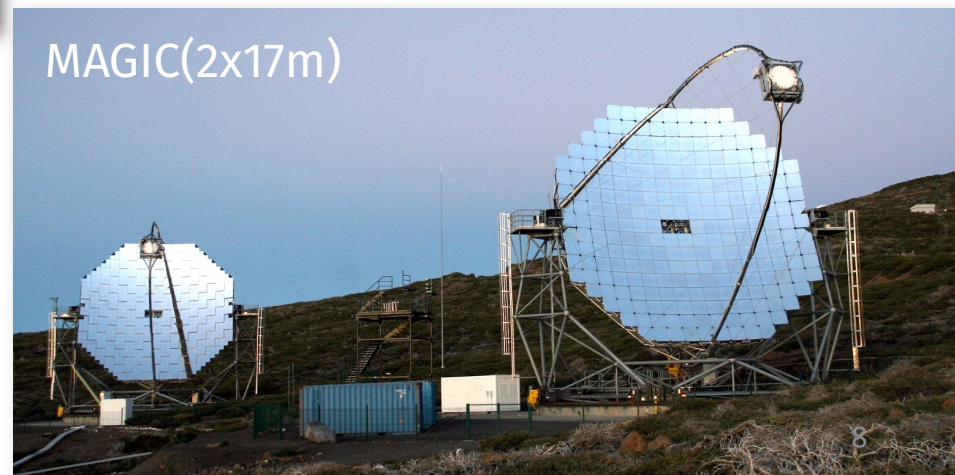
The Cherenkov Telescopes



The intersection of major axes on the common FOV gives source position on the sky.

**More on the Cherenkov technique, sources and physics in:
Hinton & Hofmann, 2009, ARAA, 47, 523**

The current IACT status



VHE high-level timeline



Hillas, 1985

445
CERENKOV LIGHT IMAGES OF EAS PRODUCED BY
PRIMARY GAMMA RAYS AND BY NUCLEI

A. M. Hillas
Physics Department
University of Leeds, Leeds LS2 9JT, UK.

ABSTRACT

It is shown that it should be possible to distinguish a shower from a point source on the basis of the width, orientation of the Cerenkov light images of the shower, the focal plane of a focusing mirror, even with a relatively coarse pixel size such as employed in the Mt. Hopkins d

1. Detection of point sources of cosmic rays

Certain X-ray binaries, pulsars and active galaxies appear to be point sources of TeV cosmic rays — presumed to be gamma-rays — have been detected by observing flashes of Cerenkov radiation in the upper atmosphere, but these do not stand against the intense isotropic background of ordinary proton showers. If the appearance of the Cerenkov flashes differs from classes of shower, such of the background might be rejected. paper. Gwiley et al. (1) describe the modification of the 10m the Whipple Observatory (Mt. Hopkins, Arizona) to record data Cerenkov image on a 0.5° grid, using 37 photomultipliers in the plane of the focusing mirror. (A central photomultiplier is a ring of 6 others, then by a further ring of 12, and another whole forming a hexagonal grid pattern.) Predictions of the this system to air showers will be presented. Even though the width of shower images are less than 0.5° , the image dimensions measured well enough to provide discrimination between types though the alignment of the short image with the source will clear than with finer angular resolution.

2. Simulation of Cerenkov image patterns

A 3-dimensional Monte-Carlo calculation is used to aid development. The computer program has been used previously investigations (2) and is much more detailed than is necessary ting Cerenkov processes, following particles down to an error (far below the Cerenkov threshold), although "thin sampling" to follow particles below $1/4000$ of the primary energy to real time. The model atmosphere is not isothermal. Hadronic collisions been simulated both by a radial scaling model with rising cross and by a model with increased production of low-energy secondary (relative to scaling) at high primary energies (though a less drastic than proposed by Mészáros and Wolfendale, for example, as the particles in the fragmentation region — high x — are larger. However, at TeV energies, there is little difference between the constrained by accelerator data, so the simulation results are put together in the presentations below.

Even though some loss of Cerenkov light by Rayleigh and a tertiary Rayleigh for (2), scattered light is assumed not to the spread of the image (size $<1^\circ$) in a clear mountain atmosphere.

provided by the NASA Astrophysics Data System

The basics

OG 9.5-3

The Astrophysical Journal, 342:379-385, 1989 July 1
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OBSERVATION OF TeV GAMMA RAYS FROM THE CRAB NEBULA USING THE ATMOSPHERIC CERENKOV IMAGING TECHNIQUE

T. C. WEEKS,¹ M. F. CRAWLEY,² D. J. FINLAY,³ K. G. GERR,¹ A. M. HILLAS,⁴ P. W. KWOK,² R. C. LAKE,⁵ D. A. LEWIS,¹ D. MACDONALD,¹ N. A. PORTER,² P. T. REYNOLDS,^{1,2} AND G. VACCANTI²

Received 1989 August 1; accepted 1989 December 9

ABSTRACT

The Whipple Observatory 10 m reflector, operating as a 37 pixel camera, has been used to observe the Crab Nebula in TeV gamma rays. By selecting gamma-ray images based on their predicted properties, more than 98% of the background is rejected; a detection is reported at the 9.0σ level, corresponding to a flux of 1.8×10^{-11} photons $\text{cm}^{-2} \text{s}^{-1}$ above 0.7 TeV (with a factor of 1.5 uncertainty in both flux and energy). Less than 25% of the observed flux is pulsed at the period of PSR 0531. There is no evidence for variability on time scales from months to years. Although continuum emission from the pulsar cannot be ruled out, it seems most likely that the observed flux comes from the hard Compton synchrotron spectrum of the nebula.

Subject headings: gamma rays: general — nebulae: Crab Nebula — pulsars — radiation mechanisms

1. INTRODUCTION

The observation of polarization in the radio, optical, and X-ray emission from the Crab Nebula is usually taken as confirmation of the synchrotron origin of the radiation and is a strong indication of the presence in the nebula of a mirror of relativistic electrons with energies up to 1 TeV. The presence of the radio pulsar, PSR 0531, near the center of the nebula provides a source for the on-going injection of relativistic electrons into this reservoir. The collision of the synchrotron-radiating electron with synchrotron-radiated photons within the nebula inevitably results in a hard photon spectrum (at some level) that extends from the X-ray into the gamma-ray energy range; the shape of the spectrum mirrors that of the soft photon spectrum but with greatly reduced intensity. The Compton synchrotron model of the nebula was first developed by Gould (1965) and was refined by Rieke and Weekes (1969) and by Grindlay and Hoffmann (1971). A strong flux of gamma rays was predicted with maximum luminosity in the 0.1–1.0 TeV energy range. The gamma-ray flux level depends on the strength of the nebular magnetic field, which is a free parameter in the model and is little constrained by observations at other wavelengths. However, based on equipartition arguments, it is estimated to be $\sim 10^{-5}$ G.

The observation of a flux of 0.14 TeV gamma rays from the Crab Nebula was reported by the Smithsonian group using the atmospheric Cerenkov technique (Weekes et al. 1972), based on observations that spanned 3 years. The detection was still only at the 3σ level. This demonstrates the weakness of the source and the lack of sensitivity of the technique. The detection of TeV gamma rays from the Crab Nebula by a confirmation of the Compton synchrotron model requires a direct measure of the magnetic field. This measure, which was conservatively interpreted as an upper limit, takes an average magnetic field of 3×10^{-5} G, or a radially symmetric field with $B_\parallel = 1 \times 10^{-5}$ G at a distance of 0.1 pc from the pulsar (Grindlay 1978).

¹ Harvard-Smithsonian Center for Astrophysics,
² St. Patrick's College, Maynooth,
³ University College, Dublin,
⁴ University of Leeds,
⁵ Iowa State University.

Weeks et al., 1989

>150 sources

Hinton & Hoffmann, 2009

Teraelectronvolt Astronomy

J.A. Hinton¹ and W. Hofmann²

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email: J.A.Hinton@leeds.ac.uk

²Department of Physics and Astronomy, Max Planck Institute für Kernphysik,
Heidelberg D-69029, Germany; email: werner.hofmann@mpi-kp.mpg.de

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0068-4146/09/050523-02\$12.00

Key Words

gamma-ray astronomy, high-energy astrophysics

Abstract

Ground-based γ-ray astronomy, which provides access to the TeV energy range, is a young and rapidly developing discipline. Recent discoveries in this wavelength have important consequences for a wide range of topics in astrophysics and astroparticle physics. This article is an attempt to review the experimental status of this field and to provide the basic formulae and concepts required to begin the interpretation of TeV observations.

1 source

100 GeV – 50 TeV sky

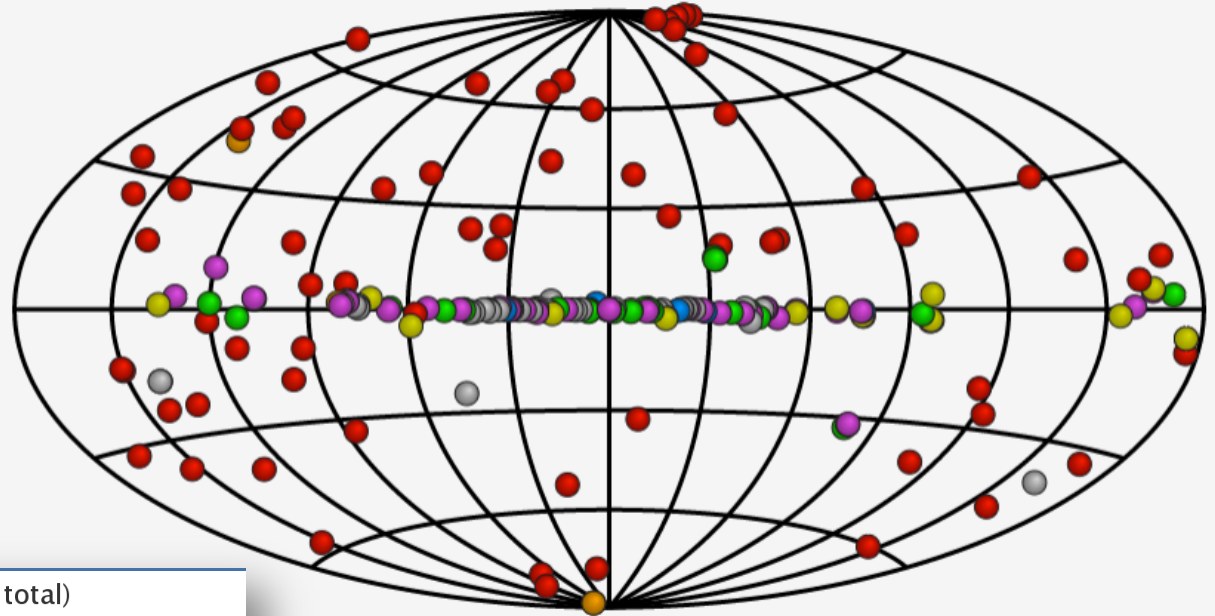


TeVCat 2

H.E.S.S., MAGIC, VERITAS

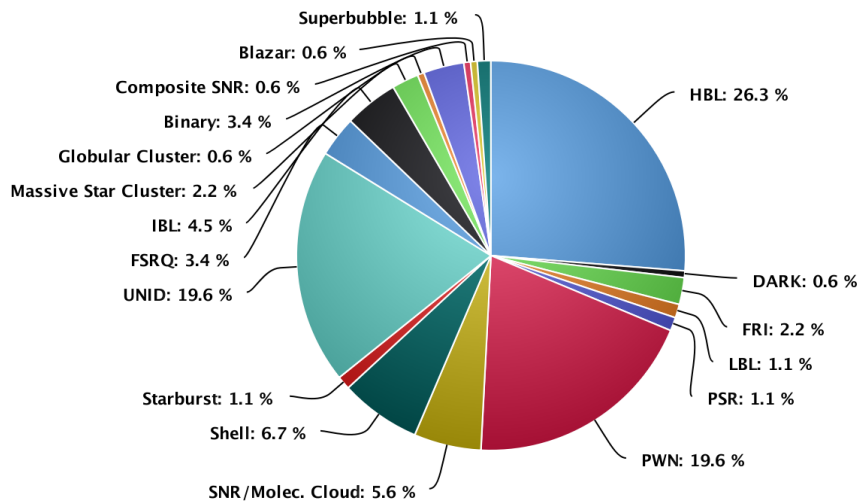
~180 sources

$E > 100$ GeV



Wakely & Horan+16

TeVCat Source Types (179 total)



Outline



Introduction

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Two sites (North and South) for a whole-sky coverage

Operated as an open Observatory

A factor of 5-20 more sensitive w.r.t. the current IACTs depending on the energy band

A few large size telescopes to cover the range 20 - 150 GeV

~km² array of medium size telescopes for the 0.15 - 5 TeV domain

~4km² array of small size telescopes, sensitive above 5 TeV up to 300 TeV

4 LSTs [N & S]

15 MSTs [N]
25 MSTs [S]
(24 SCTs [S])

70 SSTs [S]

Where to find us



High-level timeline and proposed layout



Project Phases

Pre-Construction

Current Phase

Pre-Production

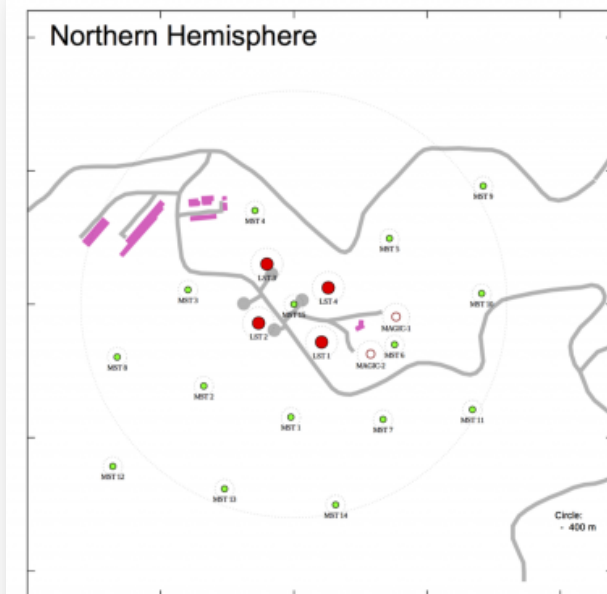
2019-2021

Production

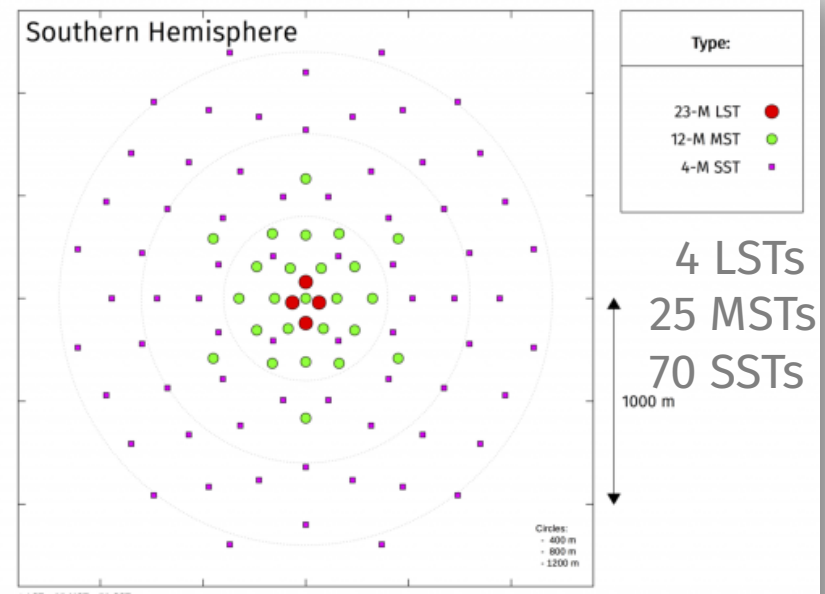
2021-2025



First Pre-Production
Telescopes on Site

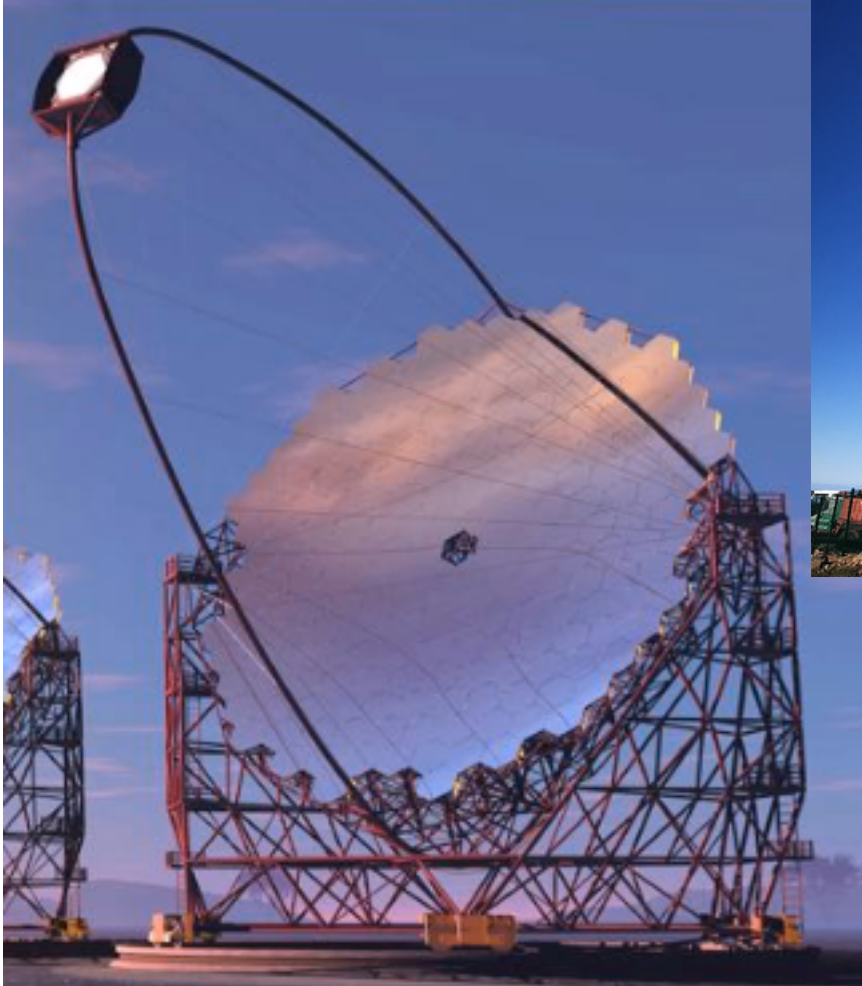


4 LSTs, 15 MSTs



4 LSTs, 25 MSTs, 70 SSTs

Large Size Telescope



- La Palma LST-1 prototype operational in 2018.
- <http://www.lst1.iac.es/webcams/>

Medium Size Telescope Prototype



https://www-zeuthen.desy.de/cta_cam/photogallery/content/index.html



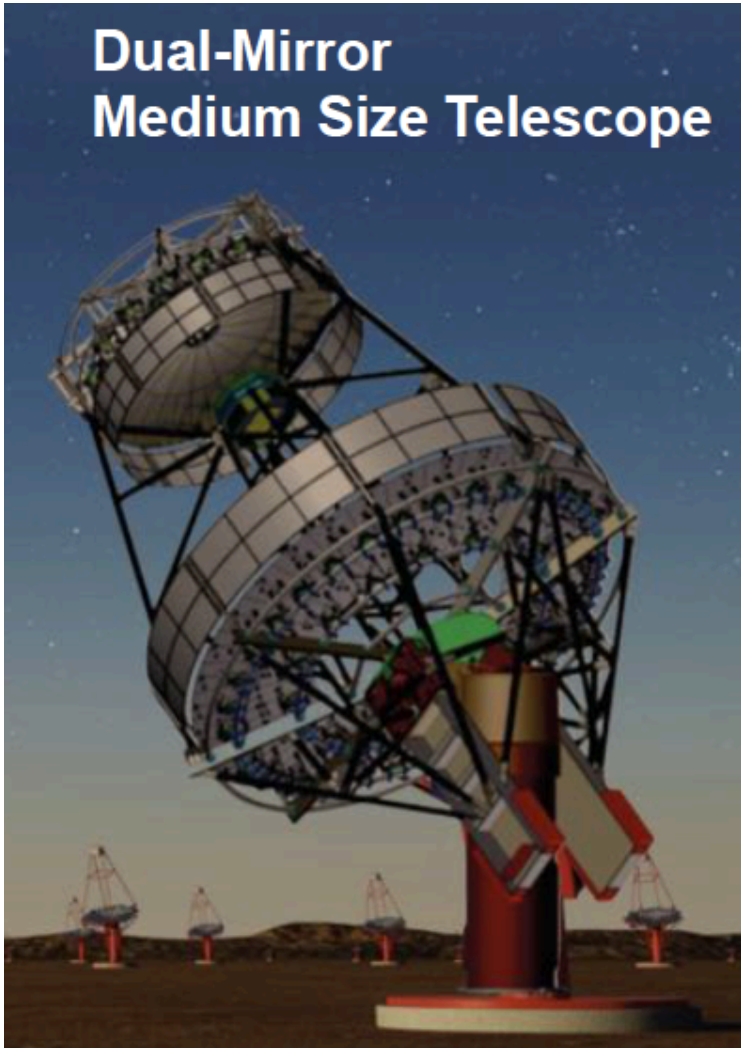
Prototype
Berlin-Adlershof

Credits: The CTA Consortium

Dual-mirror MST prototype



Dual-Mirror Medium Size Telescope



Small size telescope prototypes



ASTRI: Etna is an astronomical site...

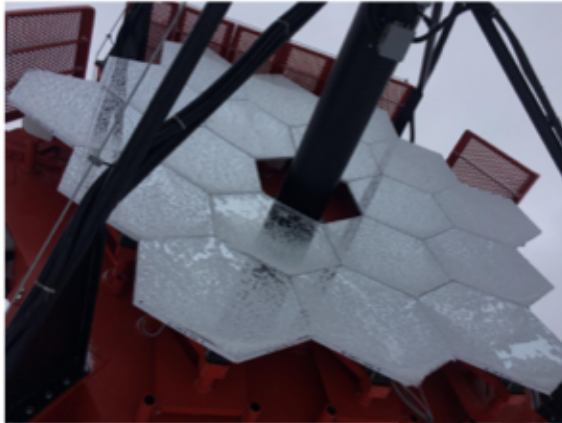


Credits: Pareschi

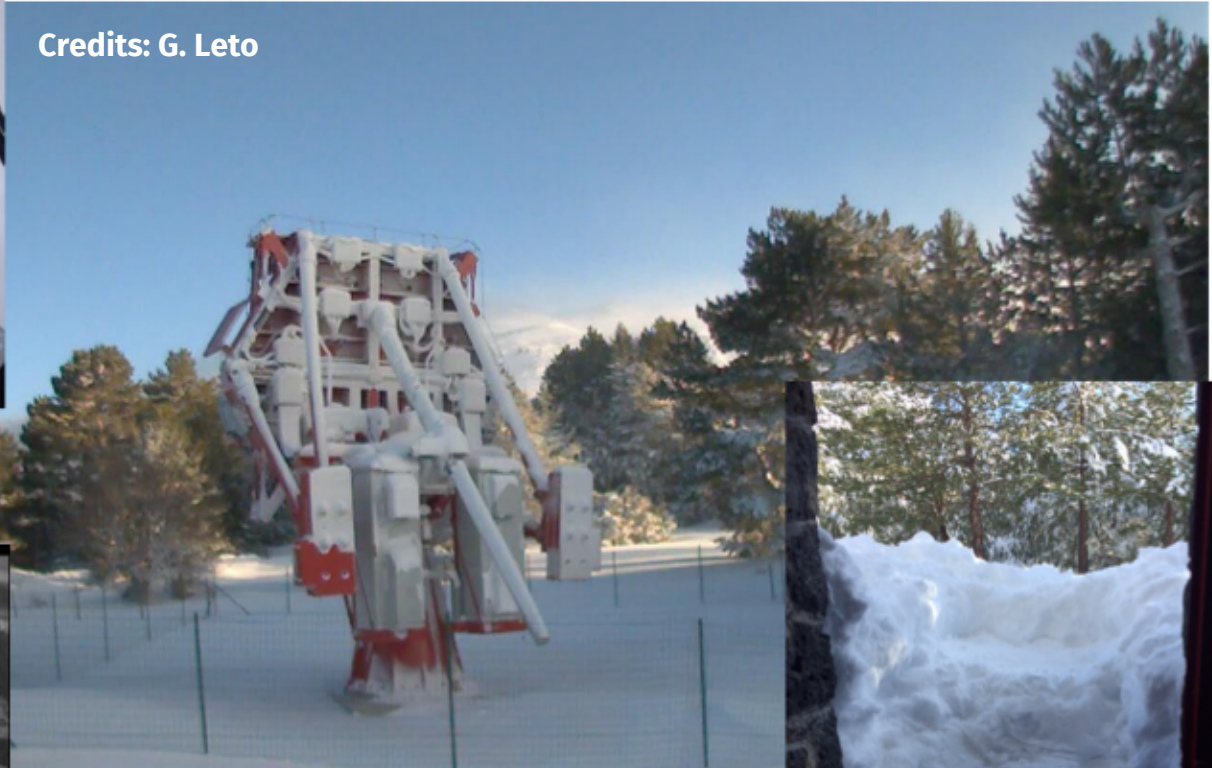
... in a peculiar environment...



... where Winter may be severe...



Credits: G. Leto



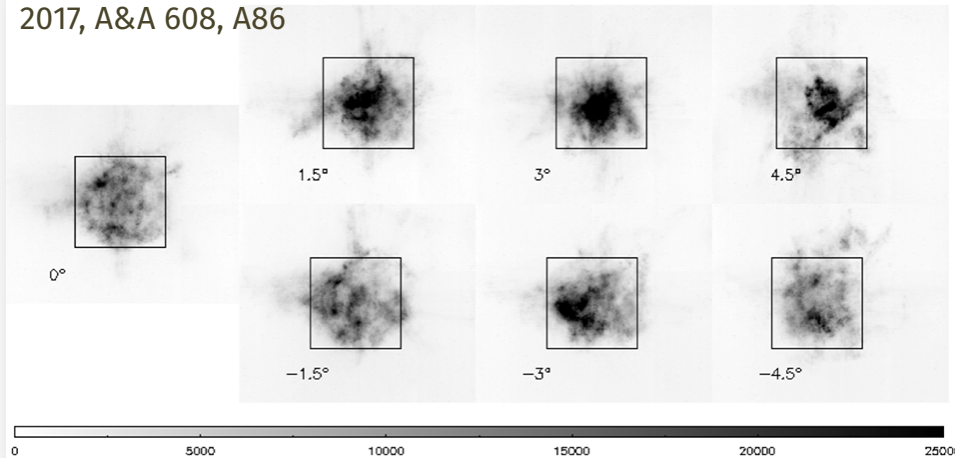
Winter 2014- 2015



... which we pass in full colours !

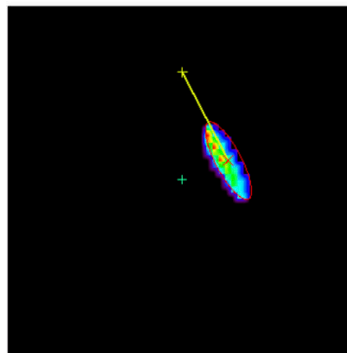


Giro, Canestrari, Sironi et al.
2017, A&A 608, A86

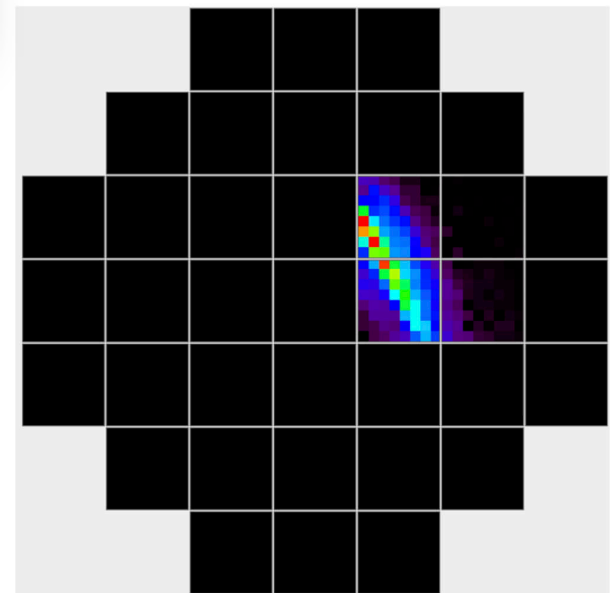


First ever optical characterization
of a Schwarzschild-Couder
telescope up to 4.5° off-axis.

First Cherenkov light
acquired by the ASTRI
camera of a shower
generated by cosmic rays
in the Earth's
atmosphere.



Credits: ASTRI Team, May 2017



The Cherenkov Telescope Array

(South Site)



The Cherenkov Telescope Array

(South Site)



4 x 23 m \varnothing Large Size Telescopes (LST)
~20 GeV to ~ 1 TeV range



The Cherenkov Telescope Array

(South Site)



25 x 14 m \varnothing Medium Size Telescopes (MST)
~100 GeV to ~10 TeV range

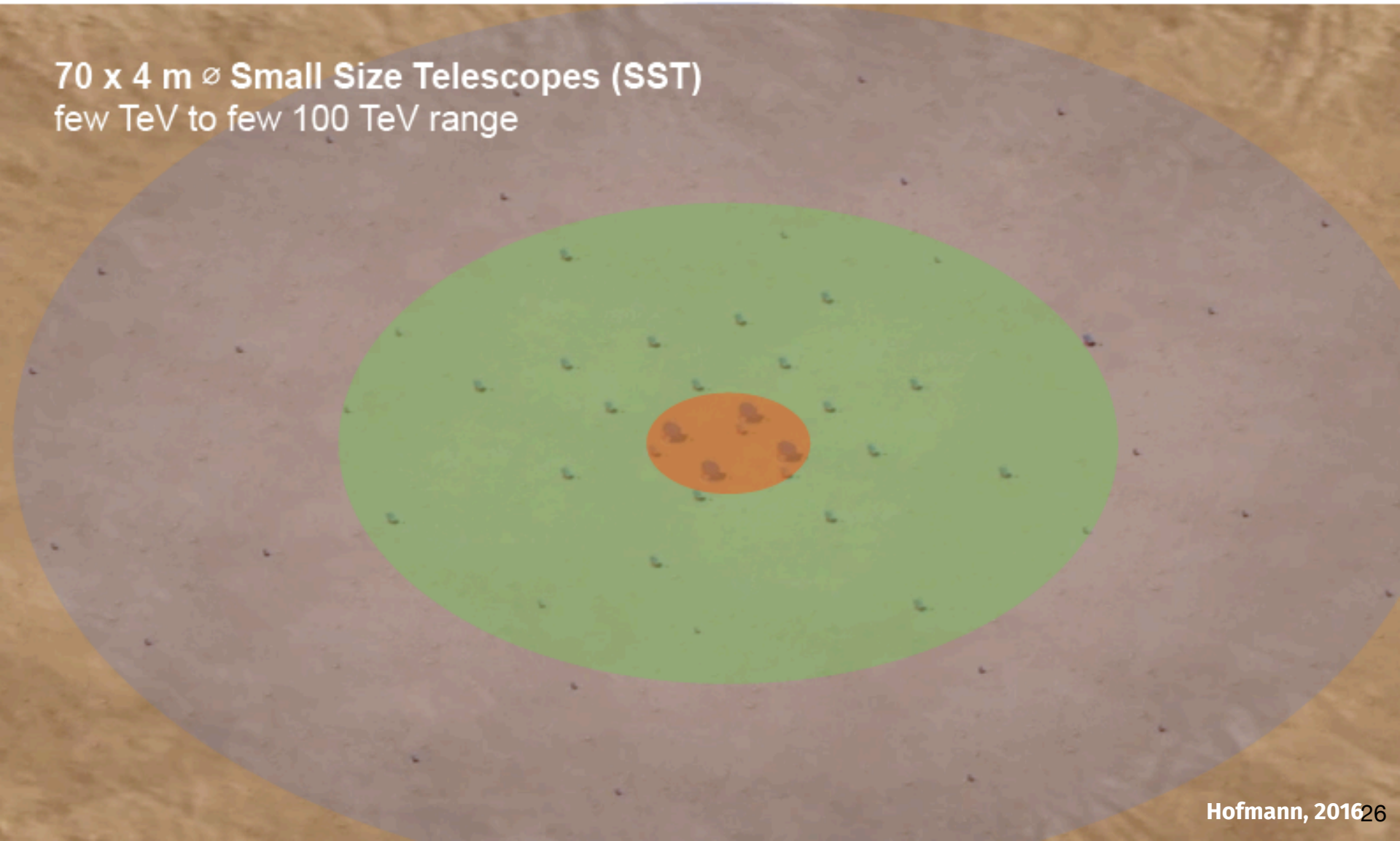


The Cherenkov Telescope Array

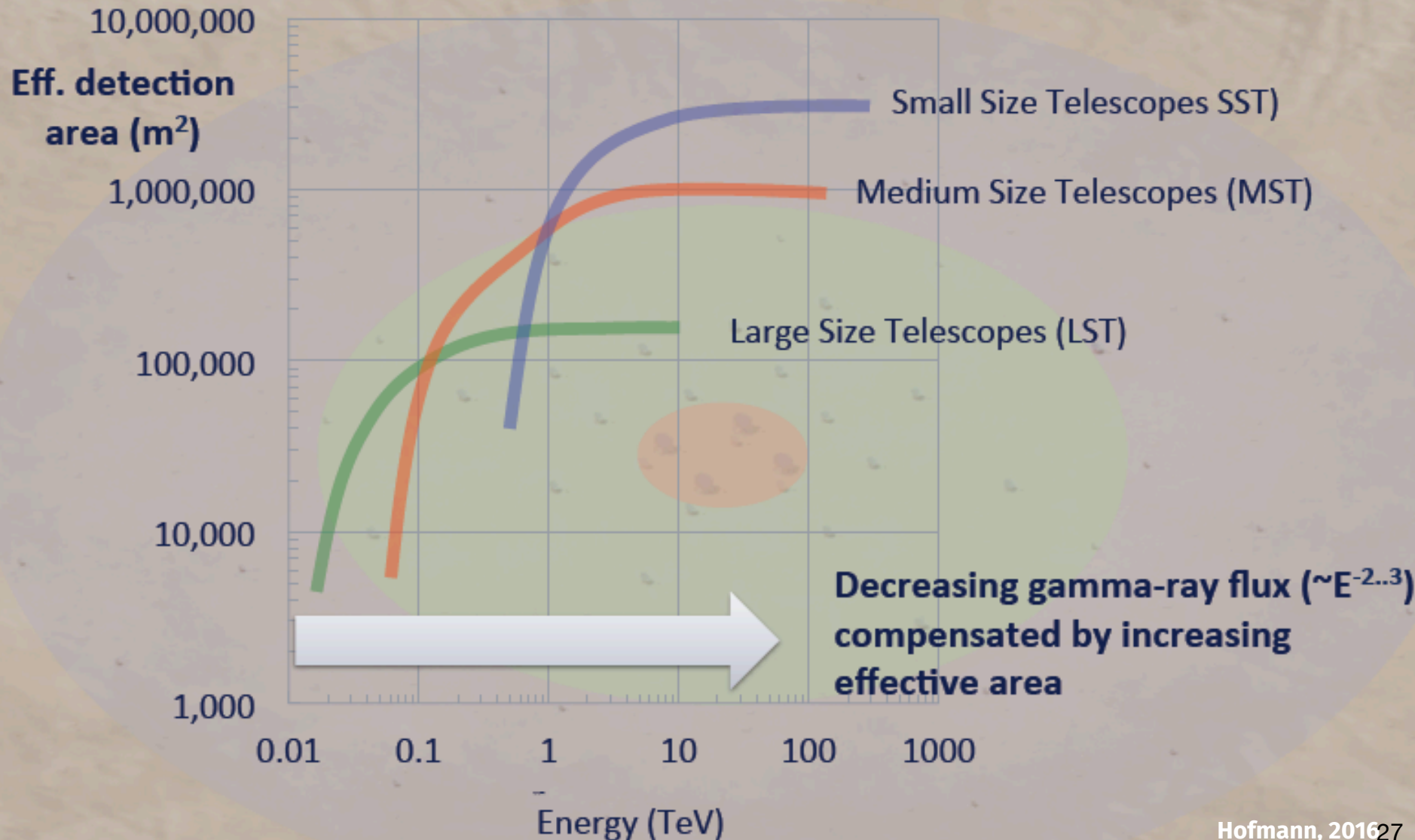
(South Site)



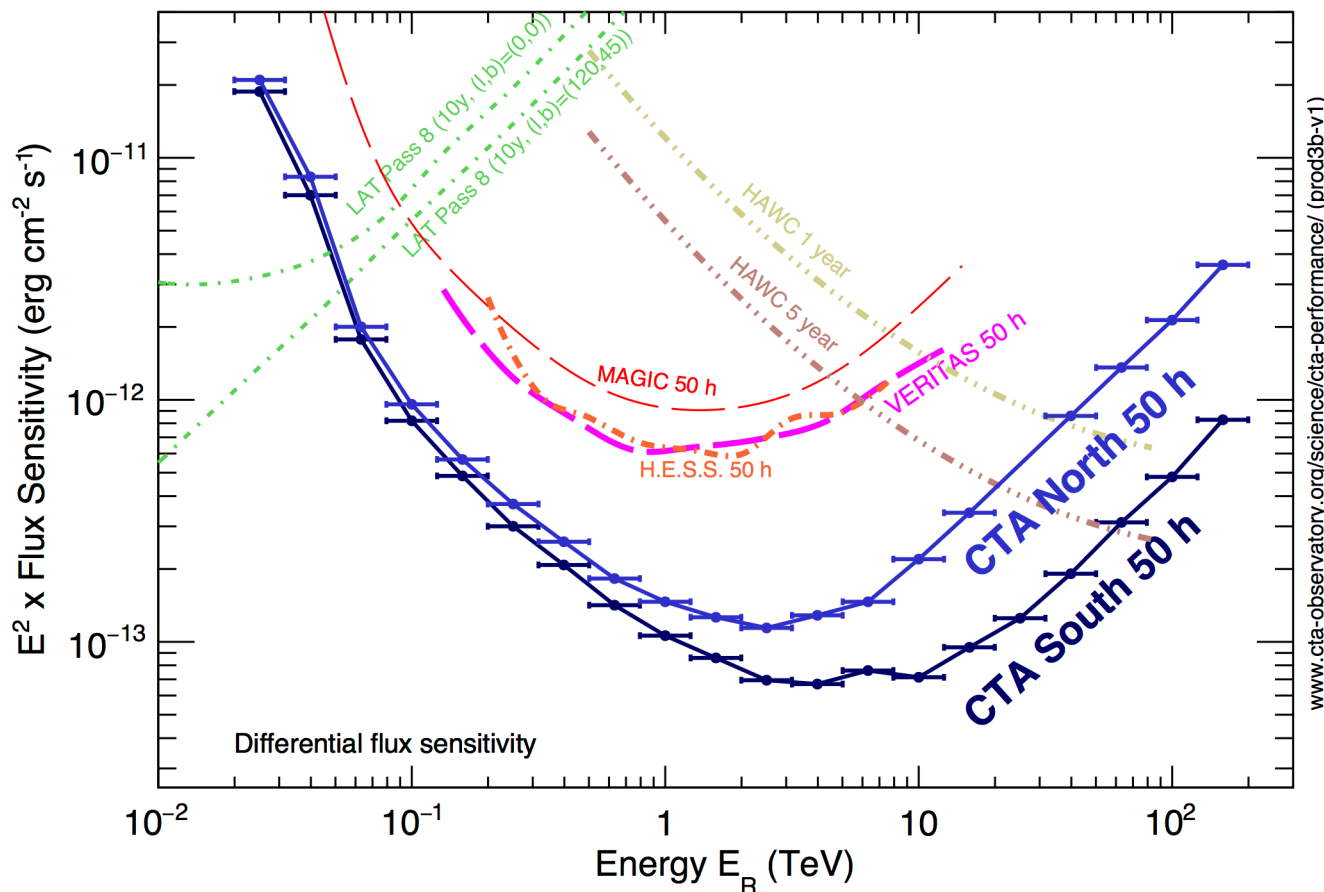
70 x 4 m \varnothing Small Size Telescopes (SST)
few TeV to few 100 TeV range



EFFECTIVE AREA FOR GAMMA-RAY DETECTION



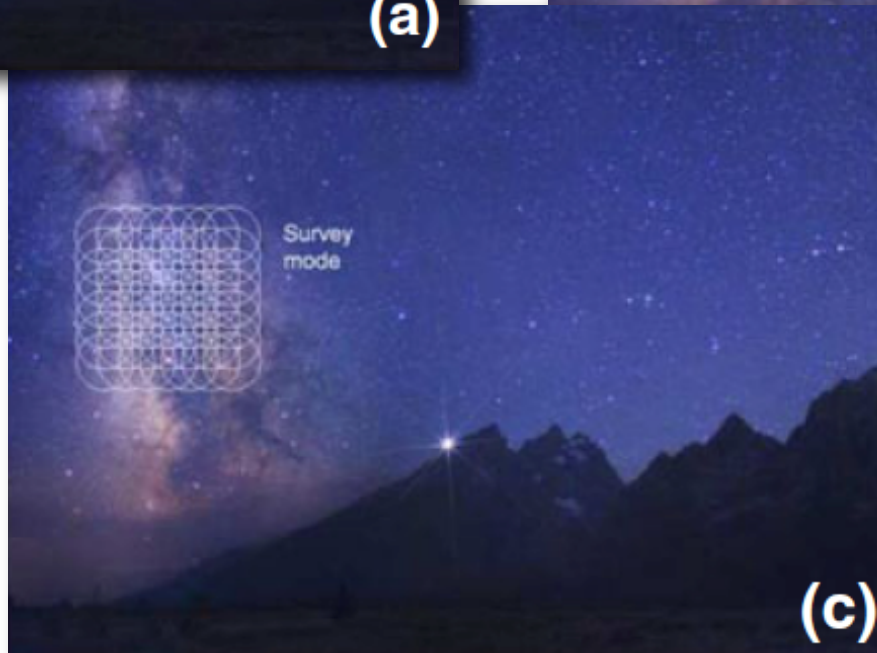
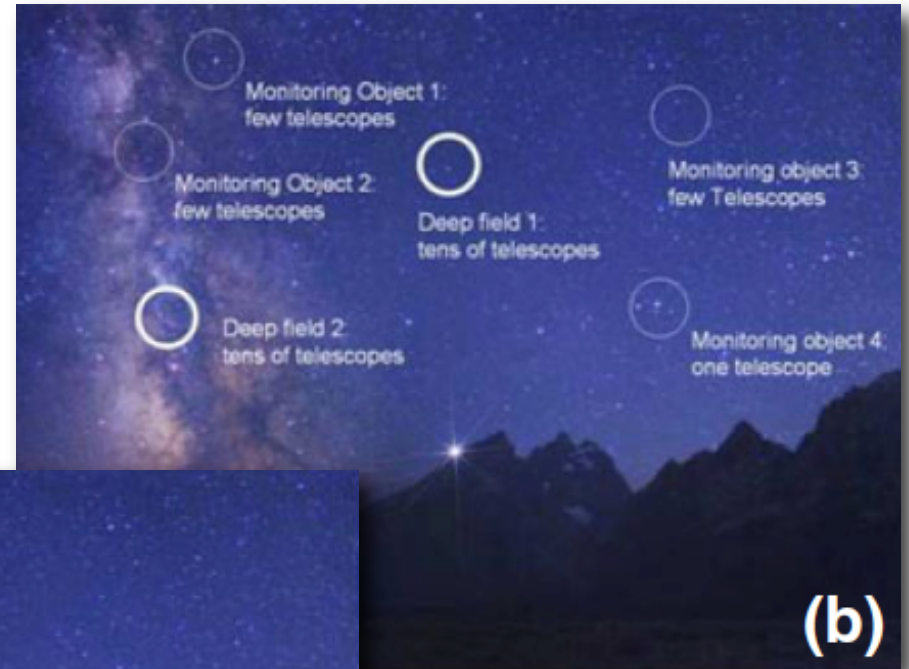
Differential Sensitivity



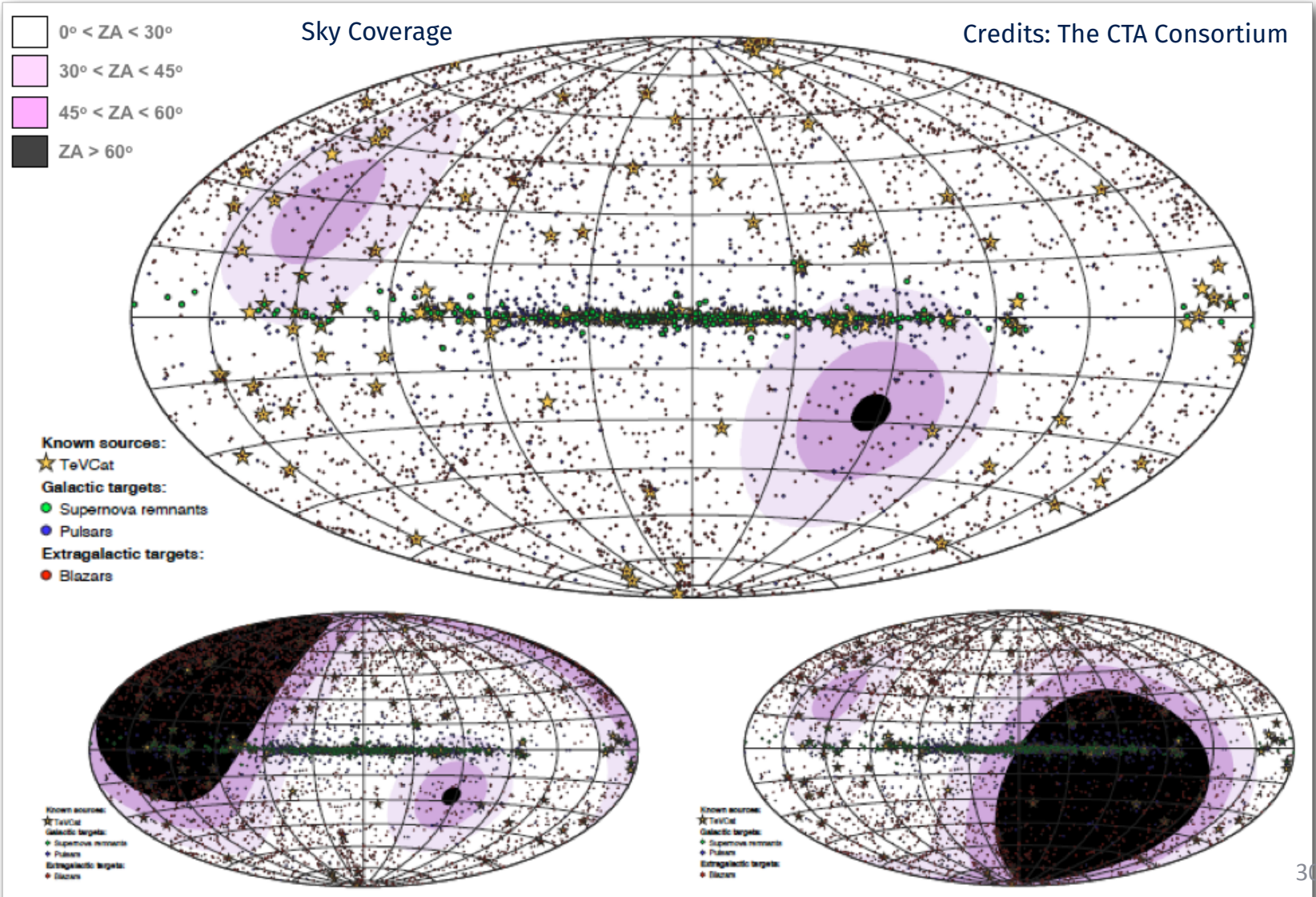
A factor of **5-20 improvement** in sensitivity depending on energy, relative to current IACTs.

Extension of the accessible energy range from **well below 100 GeV** to **above 100 TeV**.

CTA Possible Observing Strategy



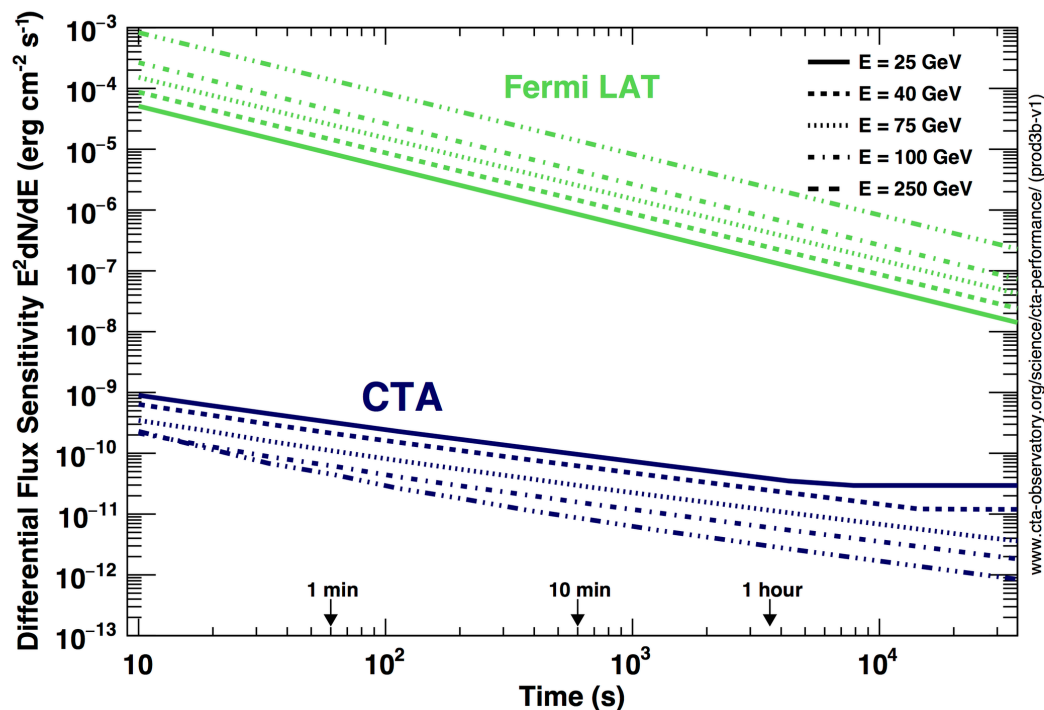
CTA as an *all-sky* Observatory



CTA as a *transient factory*



- **Huge advantage over Fermi** in energy range of overlap for ~minute to ~day timescale phenomena
 - Explosive transients
 - AGN flares
 - Binary systems
- **Disadvantage over Fermi**
 - Limited FoV (compared to Fermi)
 - Prompt reaction to external trigger is critical



Outline



Introduction

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Science Themes

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

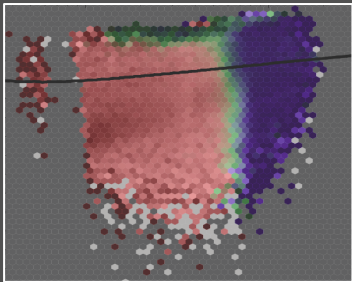
- Processes close to neutron stars and black holes?
- Processes in relativistic jets, winds and explosions?
- Exploring cosmic voids

Theme 3: Physics Frontiers – beyond the SM

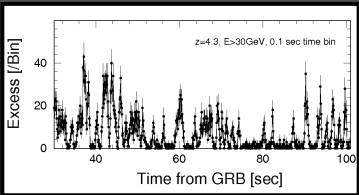
- What is the nature of Dark Matter? How is it distributed?
- Is the speed of light a constant for high energy photons?
- Do axion-like particles exist?

CTA Observing Programme

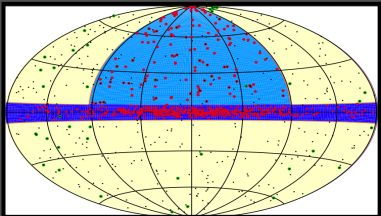
- Core Programme (baseline CTA)
 - **9 Key Science Projects (KSPs)** and **1 DM Programme**
 - Focused on **major legacy projects**: surveys & population studies (providing legacy data-sets), large classes of sources, and a few iconic objects
 - Large potential for **guest observer proposals** – building on results from the KSP surveys



Dark Matter Programme

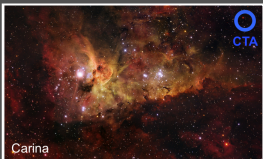
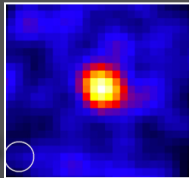


Transients



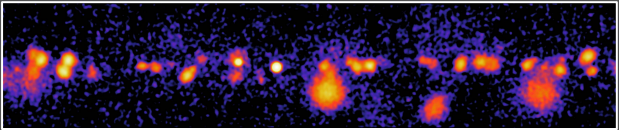
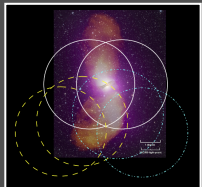
ExGal Survey

Galaxy Clusters



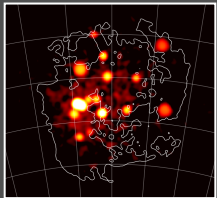
Star Forming Systems

AGN



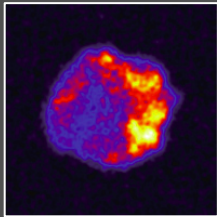
Galactic Plane Survey

LMC Survey

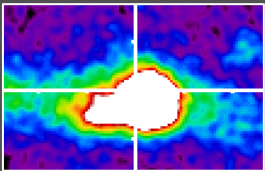


Galactic

PeVatrons



Galactic Centre Survey



Mapping Science → Observations

Theme	Question	Dark Matter Programme	Galactic Centre Survey	Galactic Plane Survey	LMC Survey	Extra-galactic Survey	Transients	Cosmic Ray PeVatrons	Star-forming Systems	Active Galactic Nuclei	Galaxy Clusters
1 Understanding the Origin and Role of Relativistic Cosmic Particles	1.1 What are the sites of high-energy particle acceleration in the universe?		✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓	✓✓
	1.2 What are the mechanisms for cosmic particle acceleration?		✓	✓	✓		✓✓	✓✓	✓	✓✓	✓
	1.3 What role do accelerated particles play in feedback on star formation and galaxy evolution?		✓		✓				✓✓	✓	✓
2 Probing Extreme Environments	2.1 What physical processes are at work close to neutron stars and black holes?		✓	✓	✓			✓✓		✓✓	
	2.2 What are the characteristics of relativistic jets, winds and explosions?		✓	✓	✓	✓	✓✓	✓✓		✓✓	
	2.3 How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?					✓	✓			✓✓	
3 Exploring Frontiers in Physics	3.1 What is the nature of Dark Matter? How is it distributed?	✓✓	✓✓		✓						✓
	3.2 Are there quantum gravitational effects on photon propagation?						✓✓	✓		✓✓	
	3.3 Do Axion-like particles exist?					✓	✓			✓✓	

DM



KSPs



- **KSPs are sets of observations** addressing multiple science questions within CTA themes.
- **Check-marks** → impact of each KSP on a particular science question.
- **The DM Programme** has a transversal nature (GC, LMC, Galaxy Clusters).

Science with the Cherenkov Telescope Array

Science with CTA

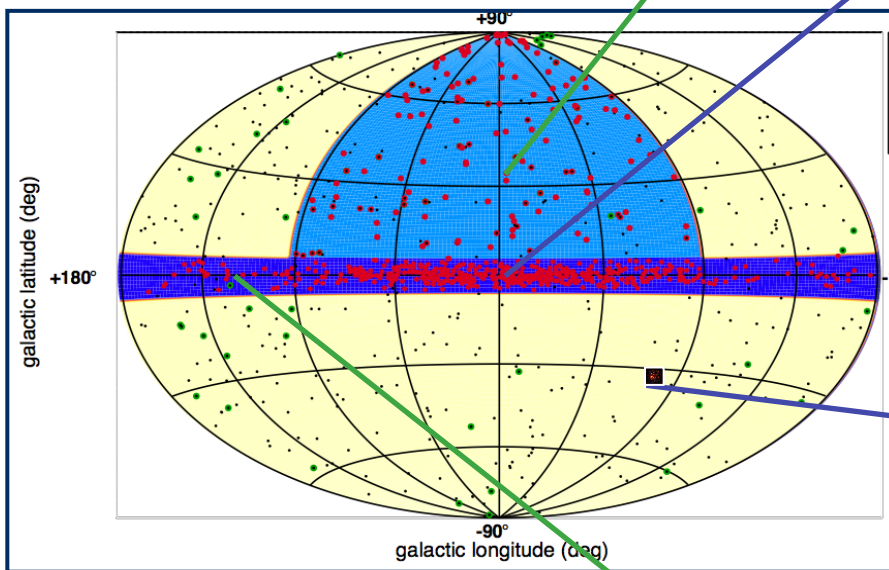
[arXiv:1709.07997](https://arxiv.org/abs/1709.07997)

To be published as a
book & open-access
online version by World
Scientific.

The Survey KSPs

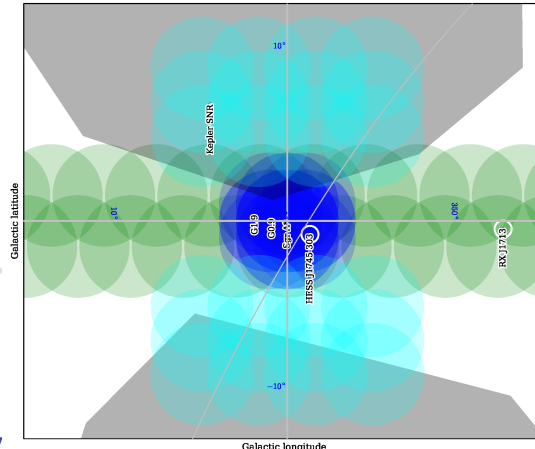
Extragalactic Survey:

Unbiased survey of $\frac{1}{4}$ sky to ~ 6 mCrab
VHE population study, duty cycle
New, unknown sources; 1000 h



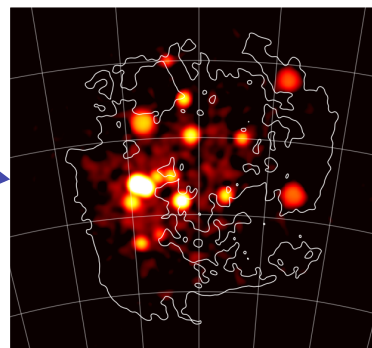
Galactic Plane Survey:

Survey of entire plane to ~ 2 mCrab
Galactic source population: SNRs, PWNe, etc.
PeVatron candidates, early view of GC, 1620 h



Galactic Centre Survey:

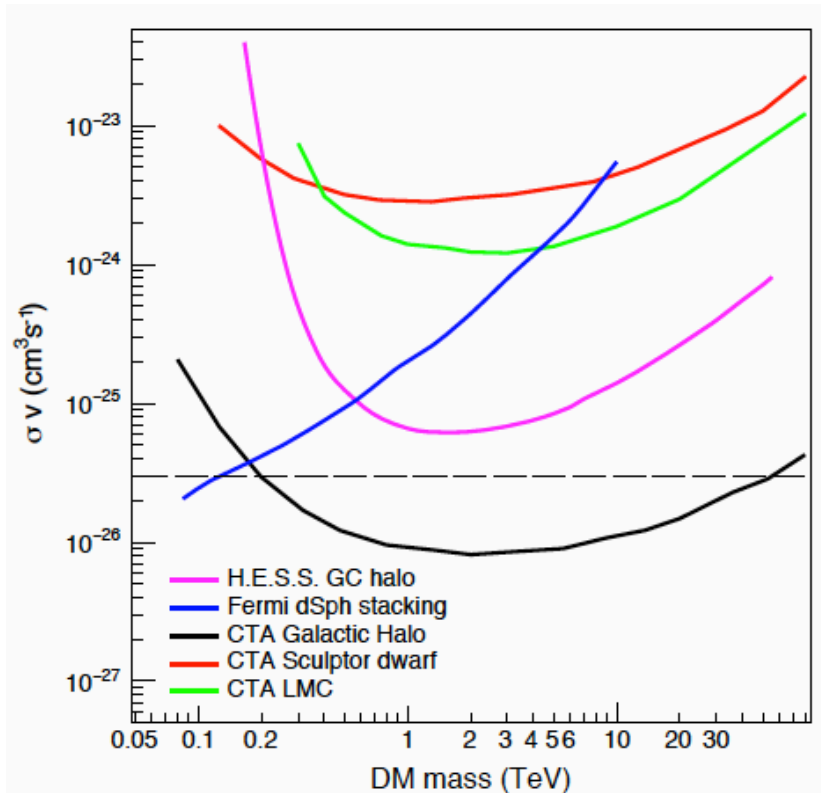
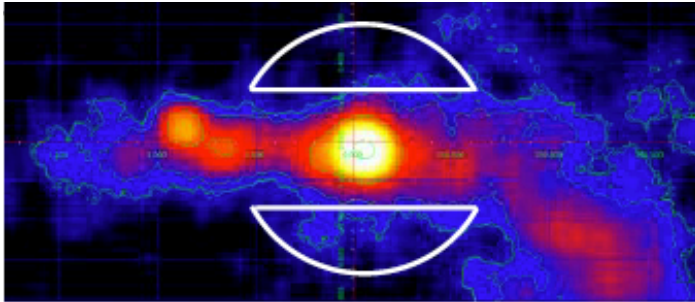
ID of the central source
Spectrum, morphology of diffuse emission
Deep DM search; base of the Fermi Bubbles
Central exposure: 525 h, $10^\circ \times 10^\circ$: 300 h



Large Magellanic Cloud Survey:

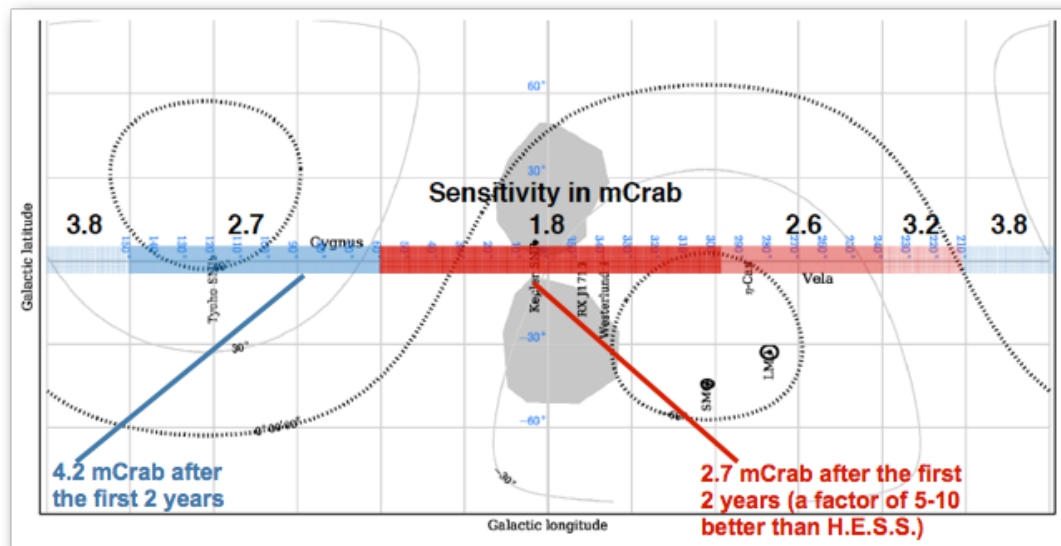
Face-on satellite galaxy with high SFR
Extreme Gal. sources, diffuse emission (CRs)
DM search; 340 h in six pointings

The Dark Matter Programme

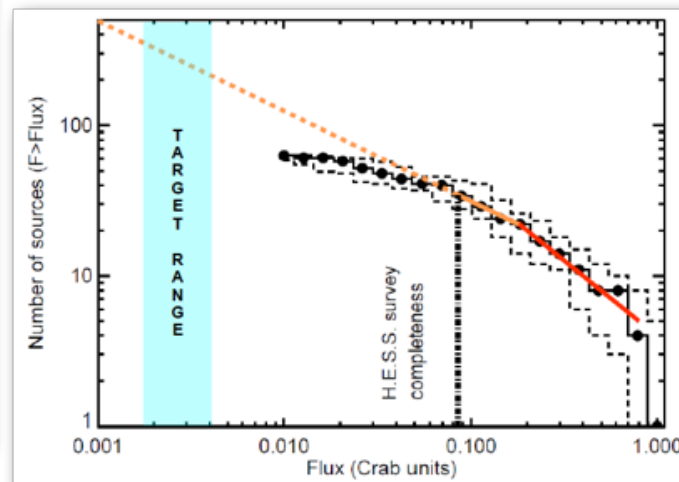


- **Key target: Galactic Centre halo**
 - Deep observation (525 h) to reach canonical thermal cross-section for wide WIMP mass range
- **Complementary observations**
 - Dwarf Sph. Galaxies (100 h)
 - LMC (340 h)
 - Perseus Gal. Cluster (300 h)
 - Expect strategy to evolve with new information

Galactic Plane Survey



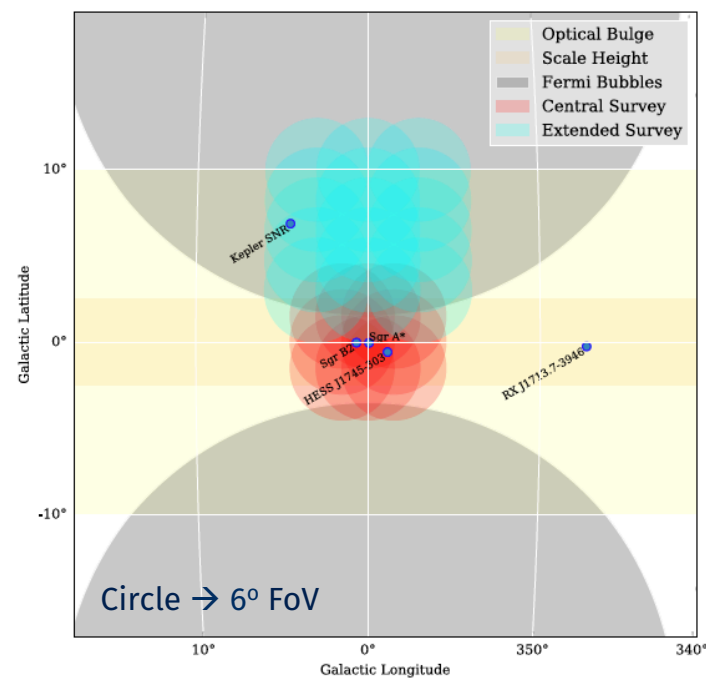
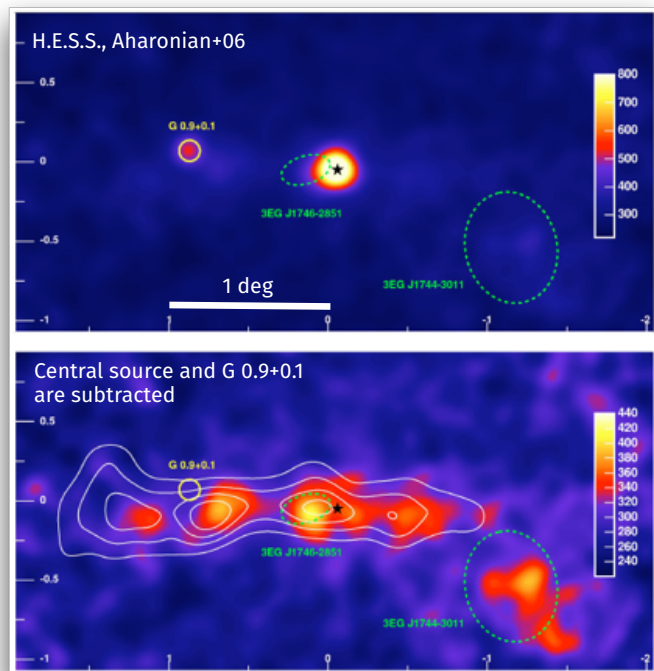
The CTA Consortium



Expected results

- Discovery of new and unexpected phenomena in the Galaxy
- **Discovery of PeVatron candidates → origin of cosmic rays**
- **Detection of many new VHE sources O(300 – 500), particularly PWNe and SNRs**
- Measurement of the large-scale diffuse VHE gamma-ray emission
- **Discovery of new VHE gamma-ray binaries**
- **Production of a multi-purpose legacy data set**
- The GPS will produce and periodically release sky maps and catalogues

Galactic Centre Survey



Expected results

- **Determination of the nature of the central source**
- **A detailed view of the VHE diffuse emission**
- Resolving new, previously undetectable sources
- **Search for variability in the VHE source near Sgr A***
- Studying the interaction of the central source with neighbouring clouds

The CTA Consortium



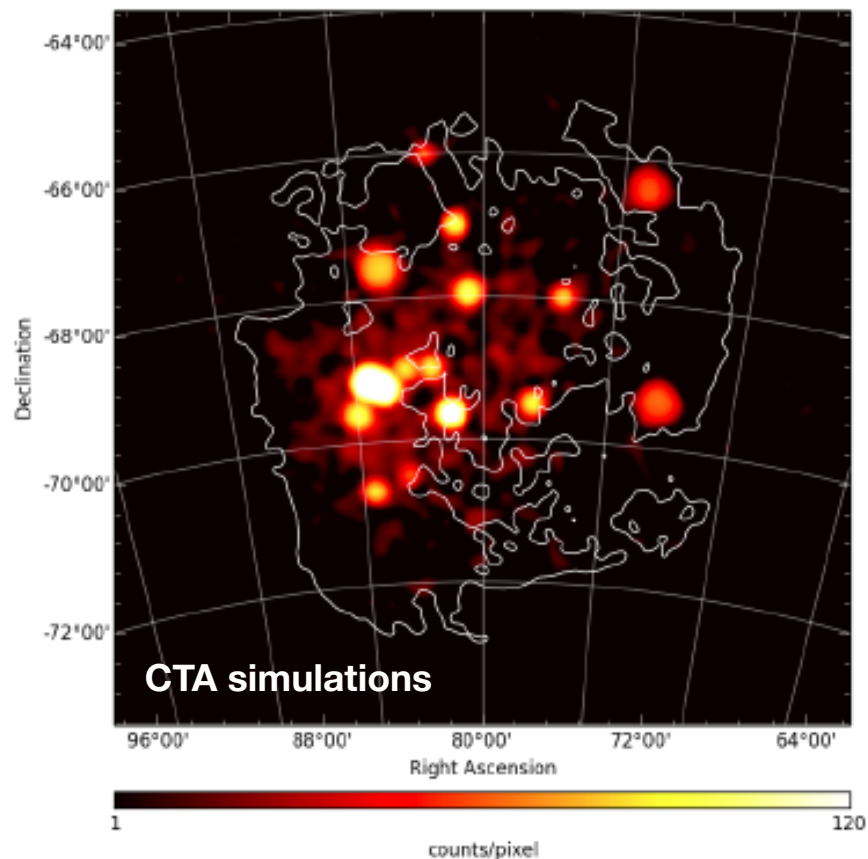
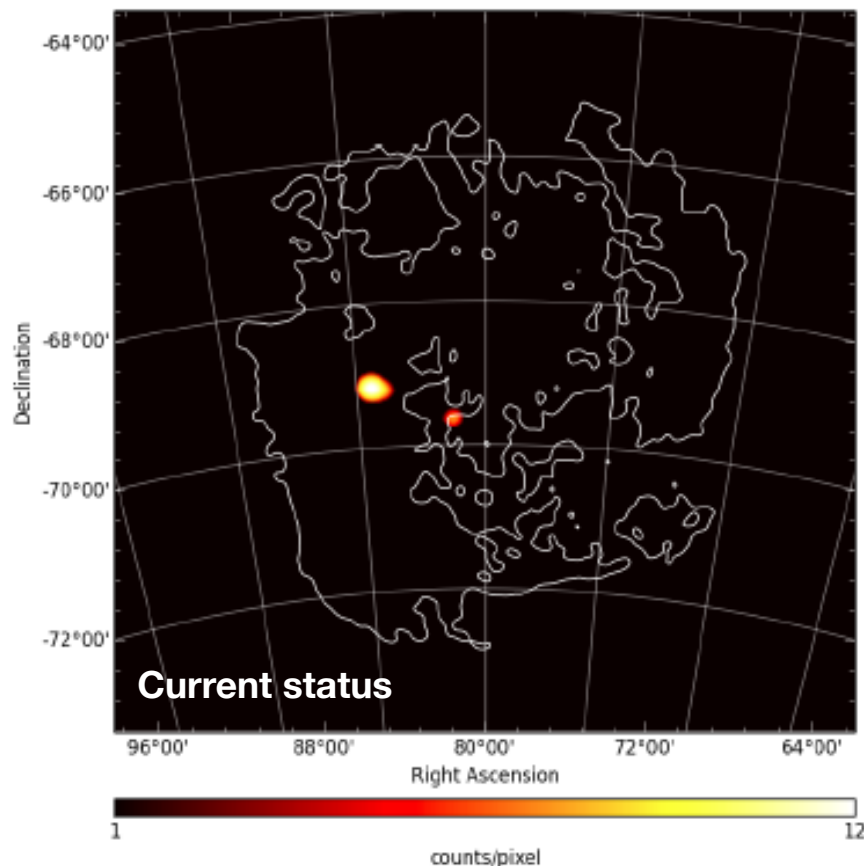
Credits: Schaefer 2015

The **Large Magellanic Cloud (LMC)** is one of the nearest **star-forming galaxies**, at a distance of 50 kpc ($\pm 2\%$ \rightarrow important for source energetics).

Its activity is attested by more than 60 supernova remnants, dozens to hundreds of HII regions, bubbles and shells observed at various wavelengths.

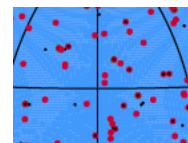
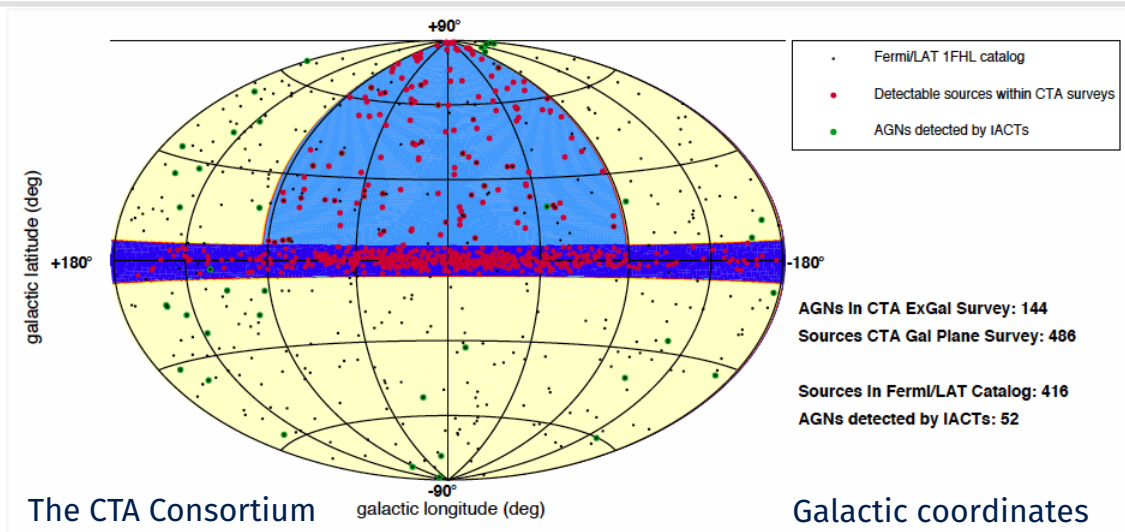
It is a unique place to obtain a resolved, global view of a star-forming galaxy at TeV energies.

LMC Survey



Simulation includes currently detected sources, plus ten point-like sources with $L_{(E > 1 \text{ TeV})} \sim 10^{34} \text{ erg s}^{-1}$, and a handful of regions enriched in cosmic rays.

Extra-galactic Survey



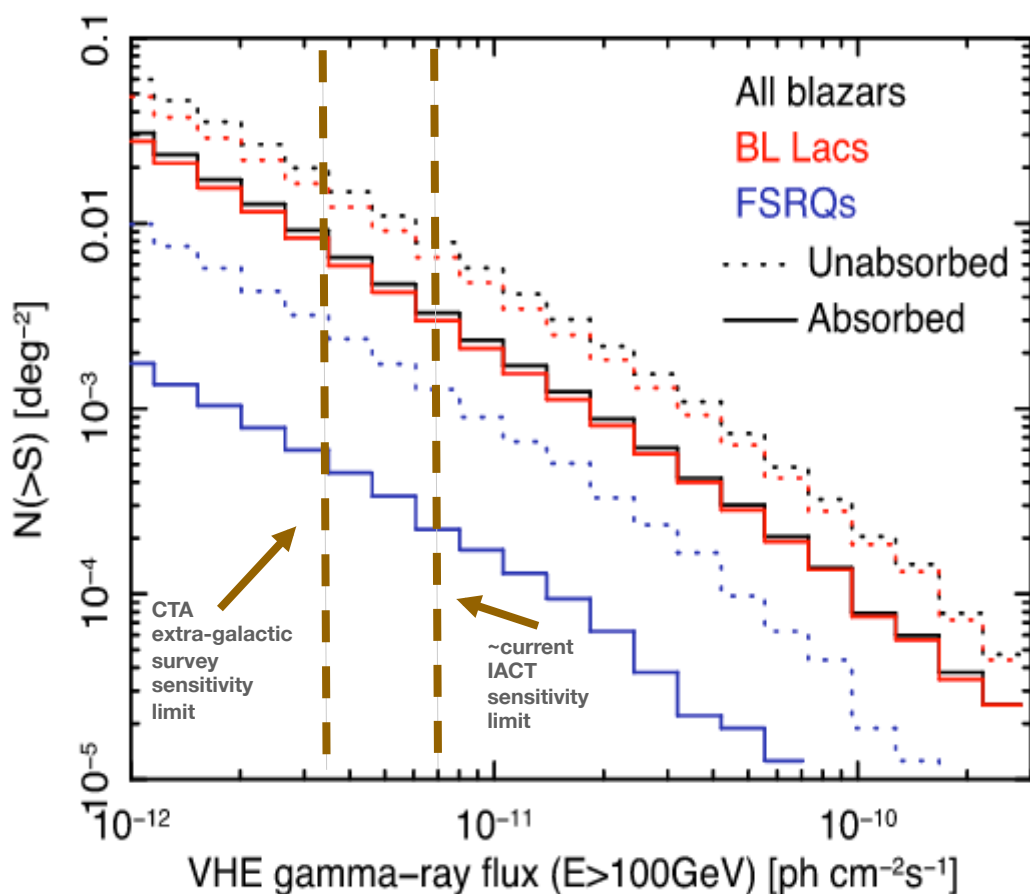
1/4 of the sky ($\sim 10^4 \text{ deg}^2$)
Limiting flux $\sim 5 \text{ mCrab}$

The survey would connect with the Galactic Plane Survey ($|b| < 5^\circ$) over Galactic longitude $-90^\circ < l < 90^\circ$.

Several highly interesting regions such as the Virgo & Coma clusters, the Fermi Bubbles (North) and Cen A (South) will be covered by the proposed survey. The EGAL survey will be useful to investigate dark matter sub-halos.

Current simulations suggest that a wide-field, shallow survey should detect more sources than a narrow-field, deep survey (given an equal survey time).

Extra-galactic Survey



Padovani & Giommi (2015)

Padovani & Giommi (2015) derived the expected number of blazars on the sky in the GeV–TeV domain.

With the 5 mCrab sensitivity during the proposed survey, **CTA should detect around 100 sources in 10,000 deg².**

Multi-messenger Astrophysics window is open !

The cover of the September 28, 2017 issue of the journal Nature. The main title 'nature' is in a large, yellow, serif font at the top. Below it, in smaller white text, is 'THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE'. The central headline is 'ANATOMY OF A KILONOVA' in large, white, sans-serif capital letters. To the right of this headline, in smaller white text, is 'Aftermath of the merger between two neutron stars' and 'PAGES 38, 64, 67, 71, 75, 80 & 85'. The background image is a dramatic, high-energy astronomical scene showing a bright, glowing object, likely a kilonova, with a bright jet of light extending from it. At the bottom of the cover, there are three smaller headlines: 'HEALTH LESSONS FROM SILICON VALLEY', 'MOLECULAR ECOLOGY EVOLUTION IN ACTION', and 'GENOMICS CHROMOSOME COMPLEXITY'. Each of these has a small icon and a page number.

nature

THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

ANATOMY OF A KILONOVA

Aftermath of the merger between two neutron stars
PAGES 38, 64, 67, 71, 75, 80 & 85

HEALTH LESSONS FROM SILICON VALLEY
Former founder seeks tech disruption for biomedicine
PAGE 23

MOLECULAR ECOLOGY EVOLUTION IN ACTION
Tracing mutations in decaying generations of bacteria
PAGES 42 & 45

GENOMICS CHROMOSOME COMPLEXITY
The architecture that guides the construction of the genome
PAGES 30 & 31

Detection of a gravitational wave event following a GRBs onset and its MWL follow-up

TITLE: GCN CIRCULAR
NUMBER: 21916
SUBJECT: IceCube-170922A - IceCube observation of a high-energy neutrino candidate event
DATE: 17/09/23 01:09:26 GMT
FROM: Erik Blaufuss at U. Maryland/IceCube <blaufuss@icecube.umd.edu>

First-time detection of VHE gamma rays by MAGIC from a direction consistent with the recent EHE neutrino event IceCube-170922A

ATel

Credential

Subjects: Optical, Gam

Fermi-LAT detection of increased gamma-ray activity of TXS 0506+056, located inside the IceCube-170922A error region.

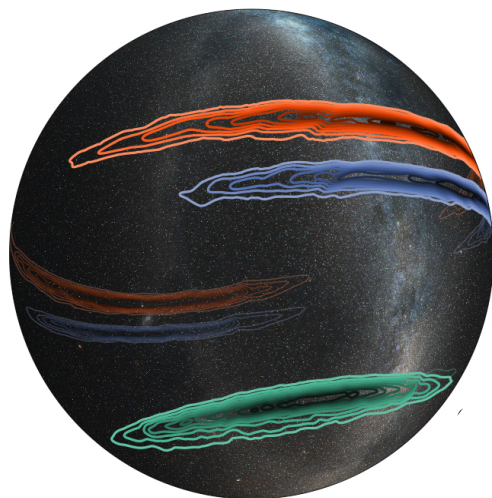
ATel #10791; *Yasuyuki T. Tanaka (Hiroshima University), Sara Buson (NASA/GSFC), Daniel Kocevski (NASA/MSFC) on behalf of the Fermi-LAT collaboration on 28 Sep 2017; 10:10 UT*

Credential Certification: David J. Thompson (David.J.Thompson@nasa.gov)

Subjects: Gamma Ray, Neutrinos, AGN

Possible association of an extra-galactic source with an IceCube neutrino event.

Transients



Credits: The LIGO Scientific Collaboration

Transients are a diverse population of astrophysical objects. Some are known to be prominent **emitters of high-energy gamma-rays**, while others are sources of non-photonic, multi-messenger signals such as cosmic rays, **neutrinos and/or gravitational waves** (GW → MoU already signed).

Priority	Target class	Observation times ($\text{h yr}^{-1} \text{ site}^{-1}$)			
		Early phase	Years 1–2	Years 3–10	Years 1–10
1	GW transients	20	5	5	
2	HE neutrino transients	20	5	5	
3	Serendipitous VHE transients	100	25	25	
4	GRBs	50	50	50	
5	X-ray/optical/radio transients	50	10	10	
6	Galactic transients	150	30	0(?)	

Follow-up priority	Target class	Detected @ HE	Trigger	Rate (yr^{-1})	Urgency	Activity duration	Obs. time (h) /night	Total time (h)	Site
1	Magnetar giant flares	–	MeV	0.1	1 min	1–2 d	Max. 1	10	A/B
2	PWN flares: Crab nebula	Y	HE	1	1 d	5–20 d (HE)	4	50	S&N
3	HMXB microquasars: Cyg X-3	Y	HE/X-ray	0.5	1 d	50–70 d (HE)	Max. 1	50	N
	Cyg X-1	Y	HE/X-ray	0.2	1 d	1–10 d ?	Max. 1	30	N
4	Unidentified HE transients	Y	HE	1	1 d	?	2	20	A/B
5	LMXB microquasars	?	X-ray/radio	1	1 d	Weeks	2	20	A/B
6	Novae	Y	HE/opt.	2	1 d	Weeks	2	20	A/B
7	Transitional pulsars	Y	Radio/opt.	0.5	1 d	Weeks	2	20	A/B
8	Be/X-ray binary pulsars	N	X-ray	1	1 d	Weeks	2	20	A/B

Outline



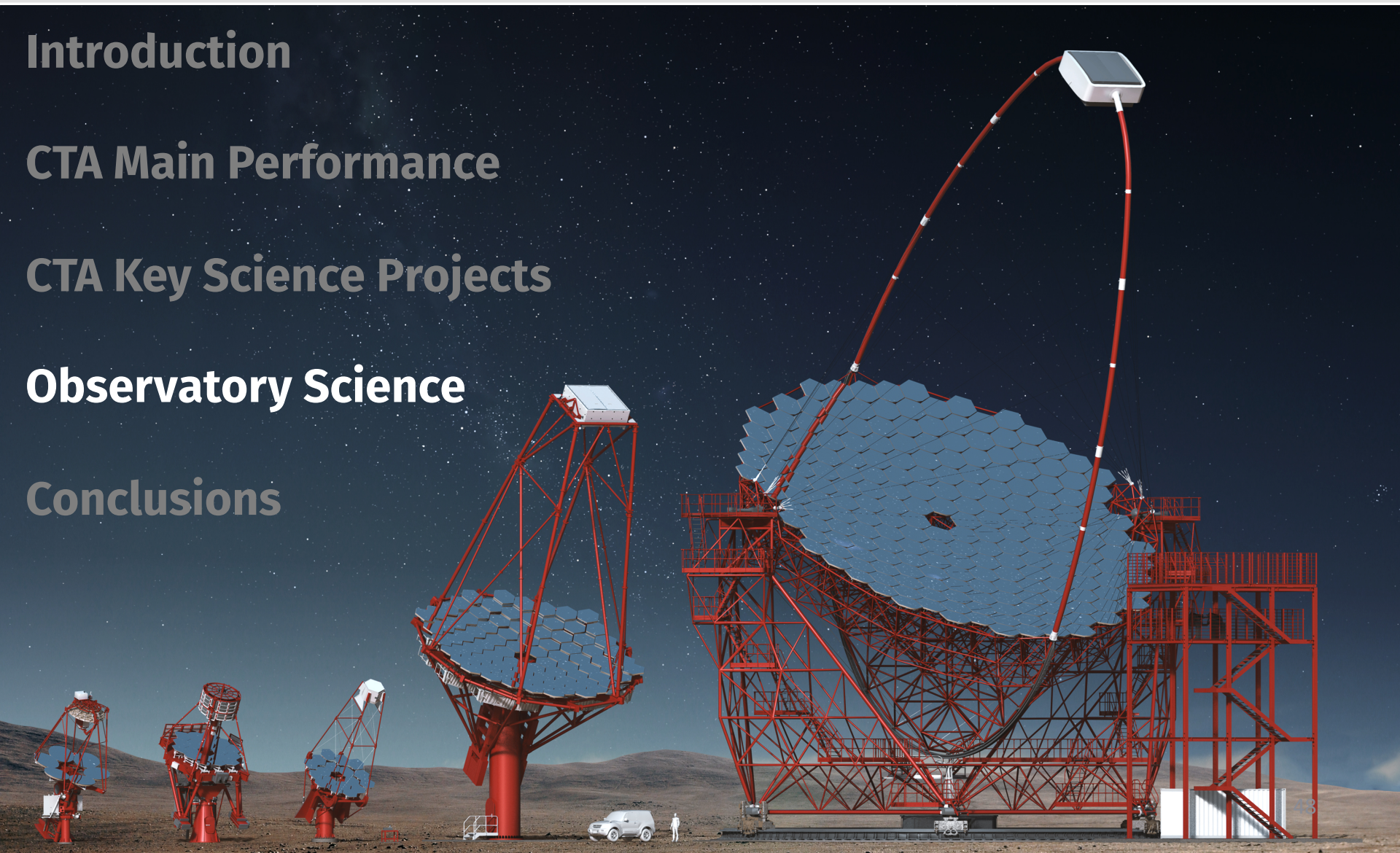
Introduction

CTA Main Performance

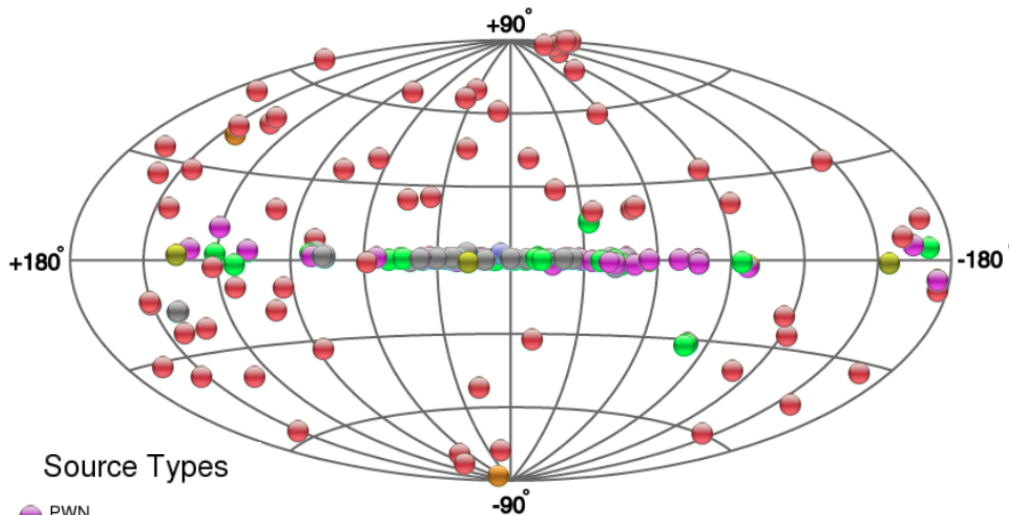
CTA Key Science Projects

Observatory Science

Conclusions



The sky above 50 GeV

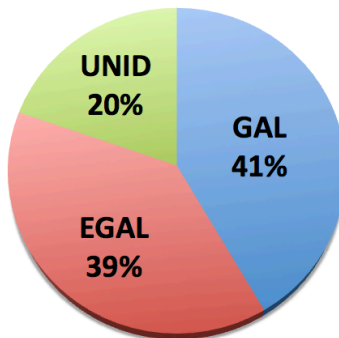


Source Types

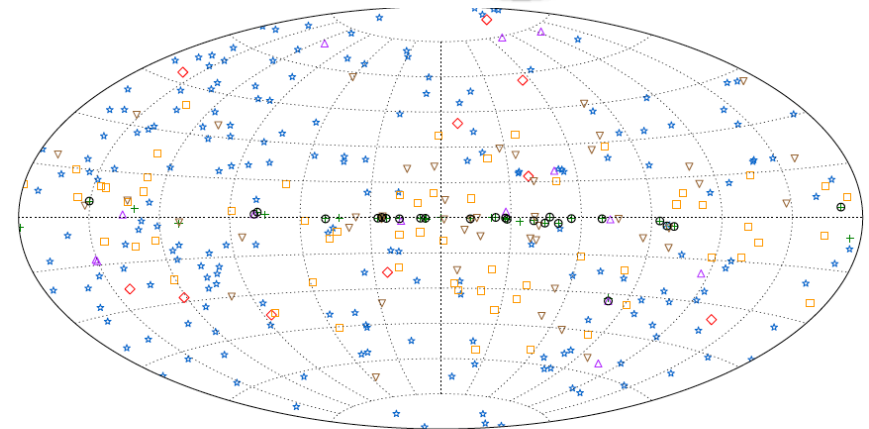
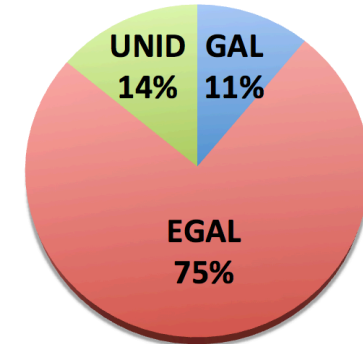
- PWN
- Binary XRB PSR Gamma BIN
- HBL IBL FRI FSRQ
Blazar LBL AGN
(unknown type)
- Shell SNR/Molec. Cloud
Composite SNR
Superbubble
- Starburst
- DARK UNID Other
- uQuasar Star Forming
Region Globular Cluster
Cat. Var. Massive Star
Cluster BIN BL Lac
(class unclear) WR

Wakely & Horan <http://tevcat.uchicago.edu/>

~180 TeVCat sources



360 *Fermi*-LAT sources $E > 50$ GeV



+	SNRs and PWNe	★	BL Lacs	□	Unc. Blazars	▽	Unassociated
×	Pulsars	◇	FSRQs	△	Others	○	Extended

2FHL Ackermann+16

Only ~25% of the 2FHL sources have been previously detected by Cherenkov telescopes.
2FHL provides a reservoir of candidates to be followed up at very high energies. 49

0.1 – 100 TeV sky

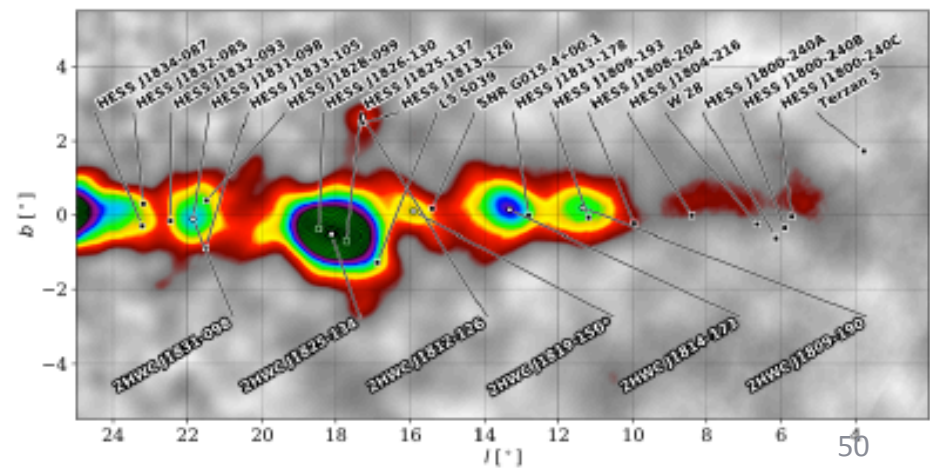
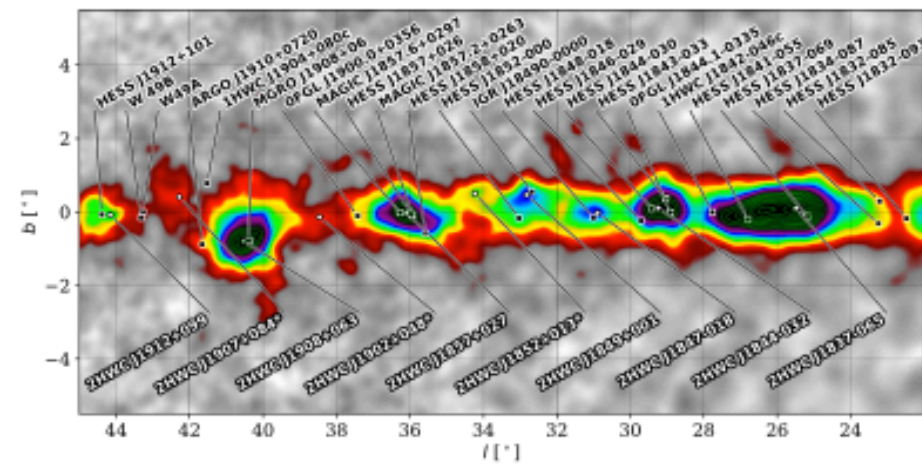
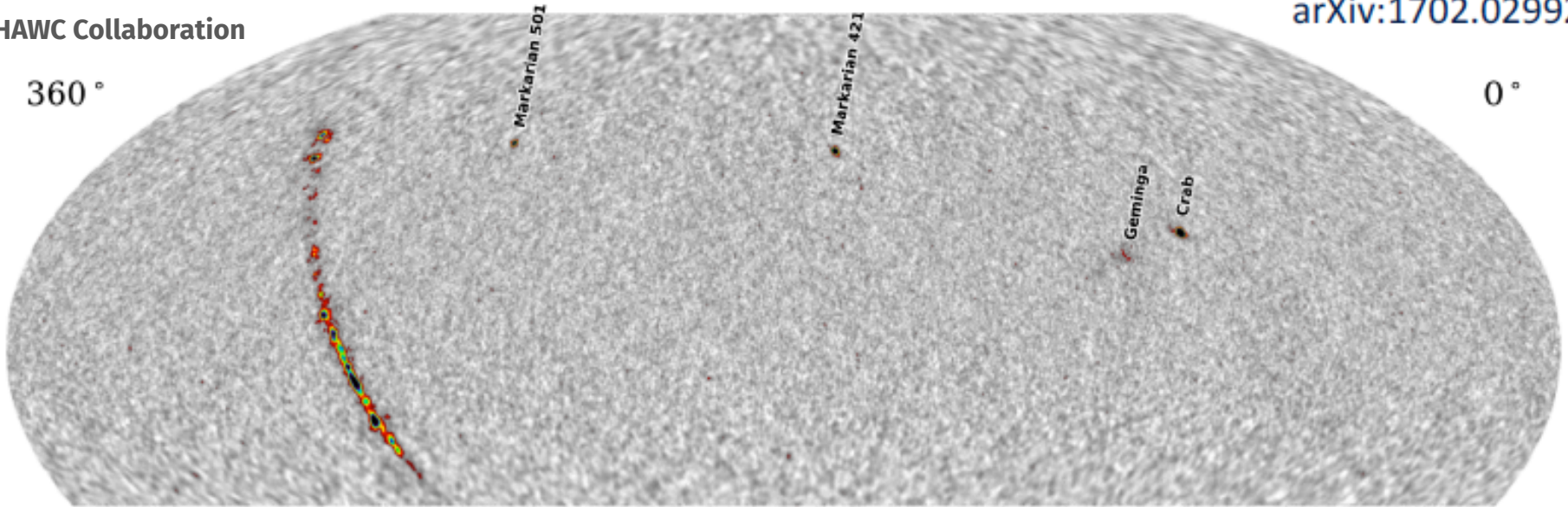


HAWC Collaboration

arXiv:1702.02992

360°

0°



KSPs vs. proposal-driven programs



Key Science Projects

- 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 and extragalactic surveys

- Deep investigation of known sources
- Follow-up of KSP discovered sources
- Multiwavelength campaigns
- Follow-up of ToOs from other wavebands / messengers
- Search for new sources
- ...

Proposal-Driven User Programme

Outline



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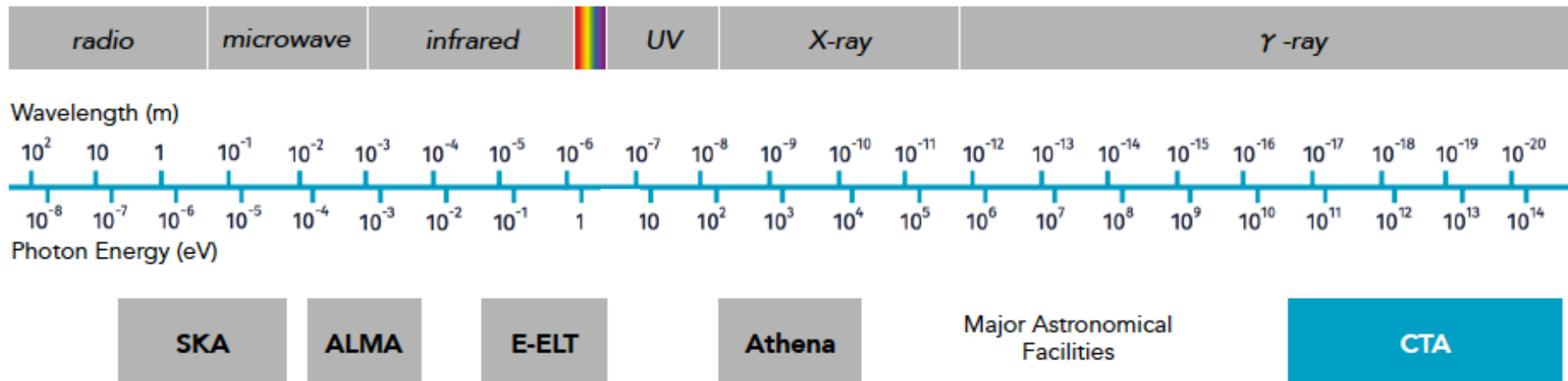
CTA Key Science Projects

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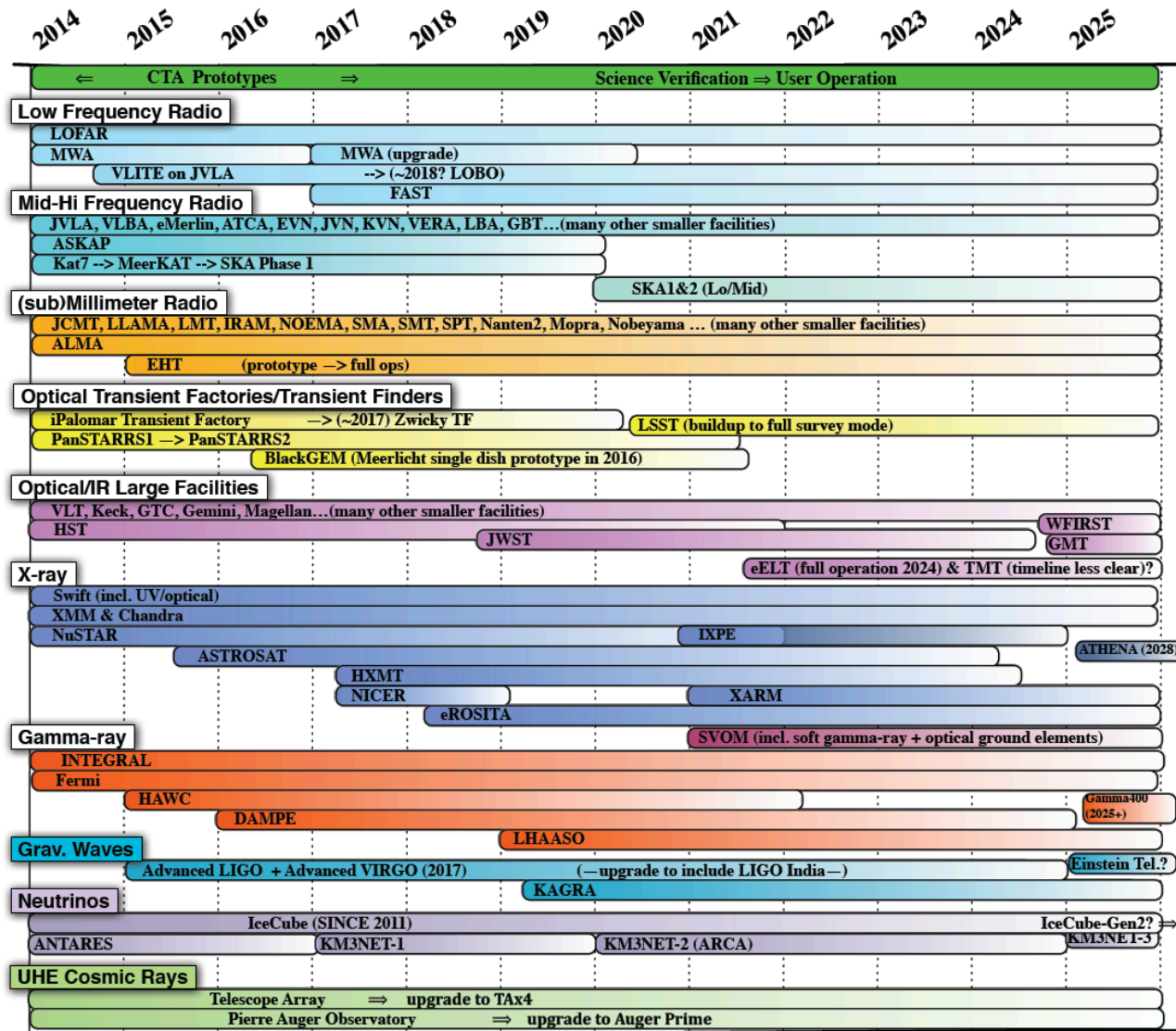
Synergies during CTA operation



These are just a few of the MWL facilities available during the CTA era.

Next slide shows...

Synergies during CTA operation



CTA Main webpage



<https://www.cta-observatory.org/>

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- **Tera-electronVolt Astronomy**
 - Hinton and Hofmann, Annual Review of Astronomy and Astrophysics, 47, 523 (2009)
- **Seeing the High-Energy Universe with the Cherenkov Telescope Array - The Science Explored with the CTA**
 - Edited by Hinton, Sarkar, Torres and Knapp, Astroparticle Physics Volume 43, Pages 1-356 (March 2013)
- **CTA Contributions to the 2017 ICRC Conference**
 - [<https://arxiv.org/html/1709.03483>]
- **Science with the Cherenkov Telescope Array**
 - Edited by Hinton, Ong and Torres, arXiv:1709.07997

Summary



CTA will be an **Observatory** open to the scientific community.

Science will focus on cosmic particle acceleration, extreme environments, and physics beyond the standard model.

Proprietary time (significant fraction in the first years) will be articulated in **Key Science Projects**.

Large potential for **Guest Observer proposals** – e.g., building on results from the KSP surveys.

CTA will have important **synergies** with many of the new generation of astronomical and astro-particle observatories.

Thanks !

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