Gamma Ray Astrophysics with CTA: Introduction

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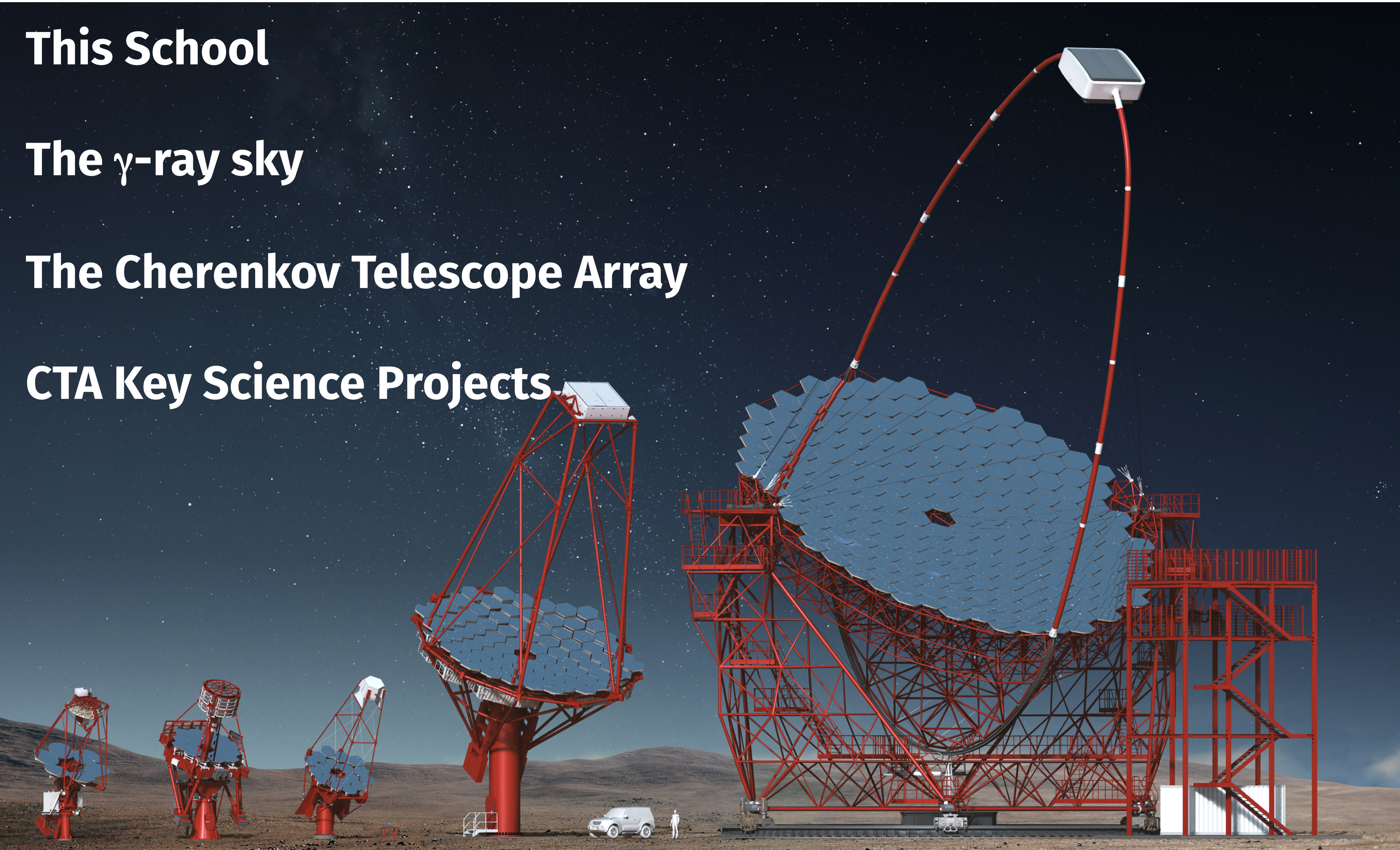
Outline

This School

The γ-ray sky

The Cherenkov Telescope Array

CTA Key Science Projects



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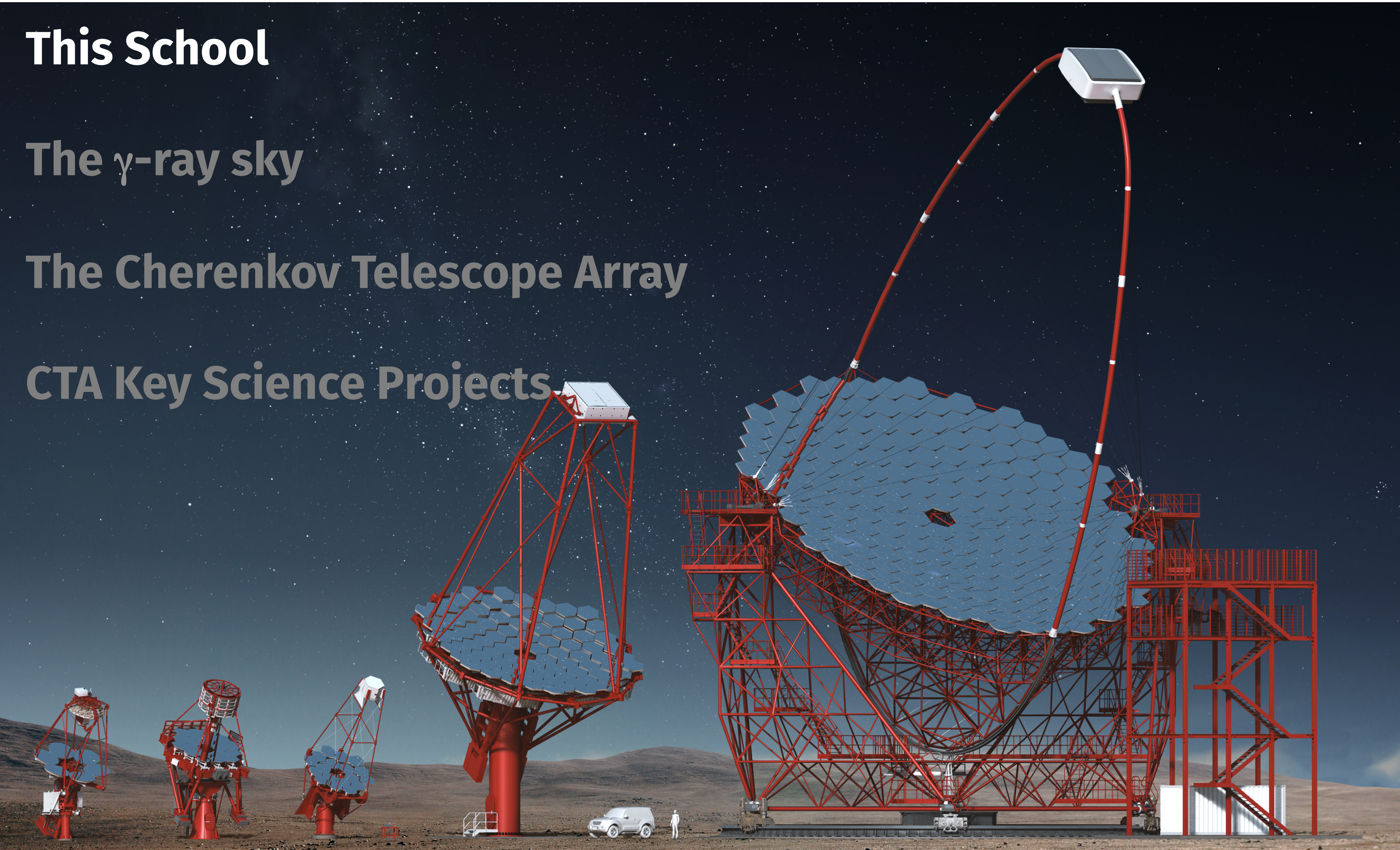

The School format

- **Morning**
  - Lectures on all the CTA scientific areas both in the galactic and in the extragalactic domains as well as in the fundamental physics one.
  - A multi-wavelength and multi-messenger approach will also be discussed.
  - A dedicated session will present also future gamma-ray missions concepts and their relation to CTA.

Details in the blue boxes

The School format

- **Lunch**
  - Free! Enjoy the Dolomites which are a UNESCO World Heritage Site!
- **Afternoon**
  - Hands-on activities
  - Contributed talks
  - Social activities

See talk by

F. Longo – *Hands-on session introduction*

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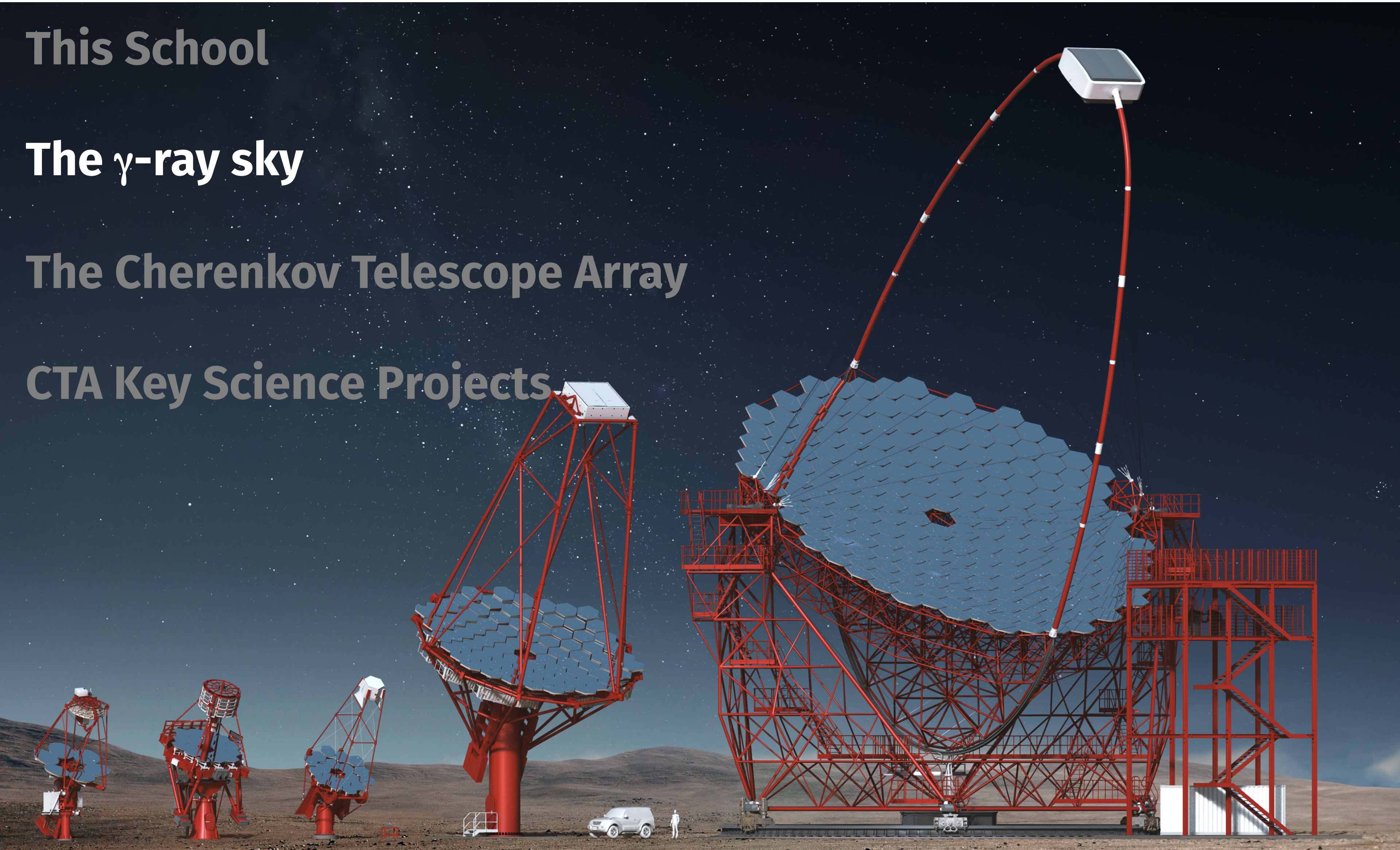
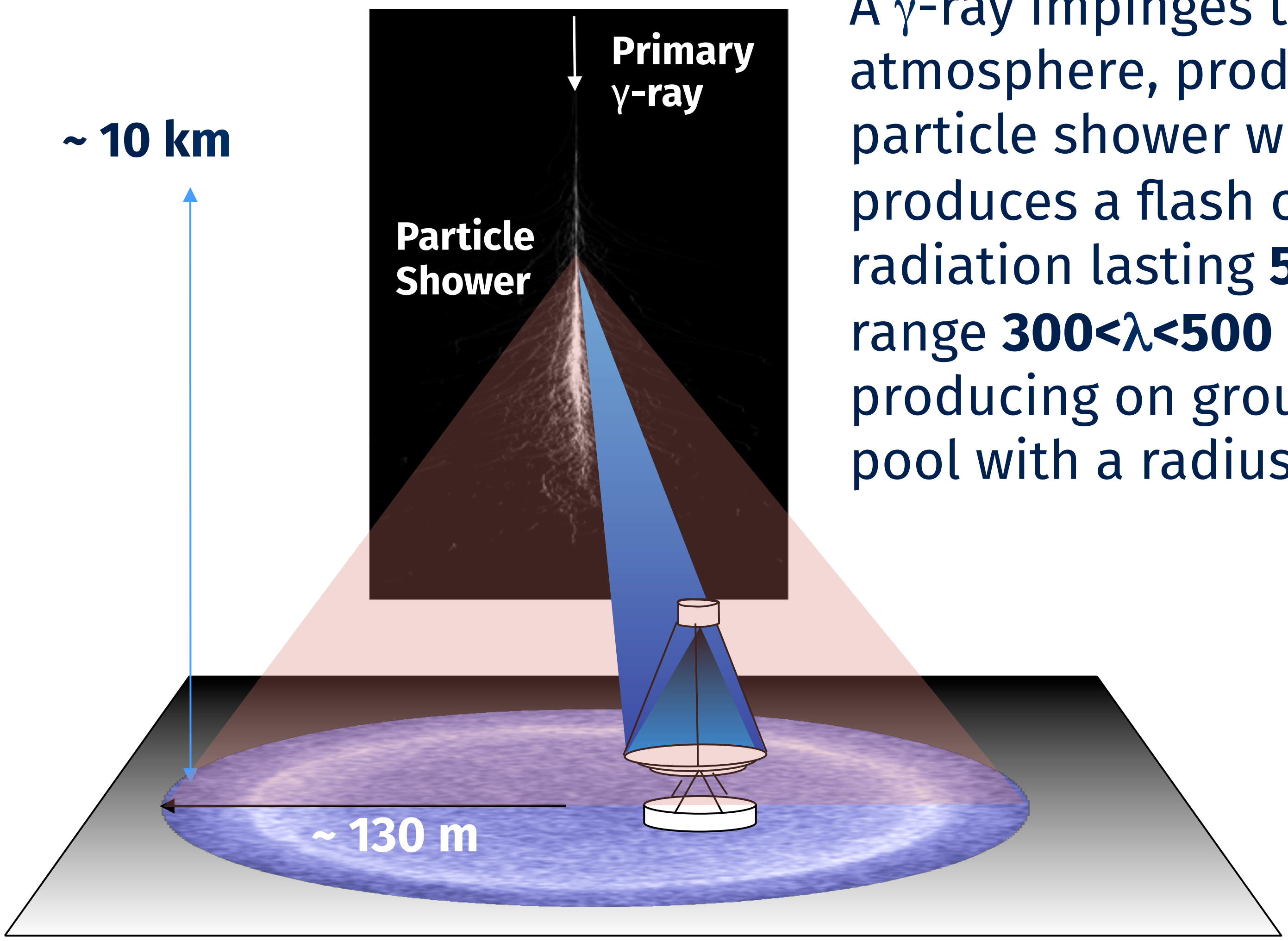


The Cherenkov Telescopes



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<λ<500 nm** and producing on ground a light pool with a radius of ~**130m**.

The Cherenkov Telescopes

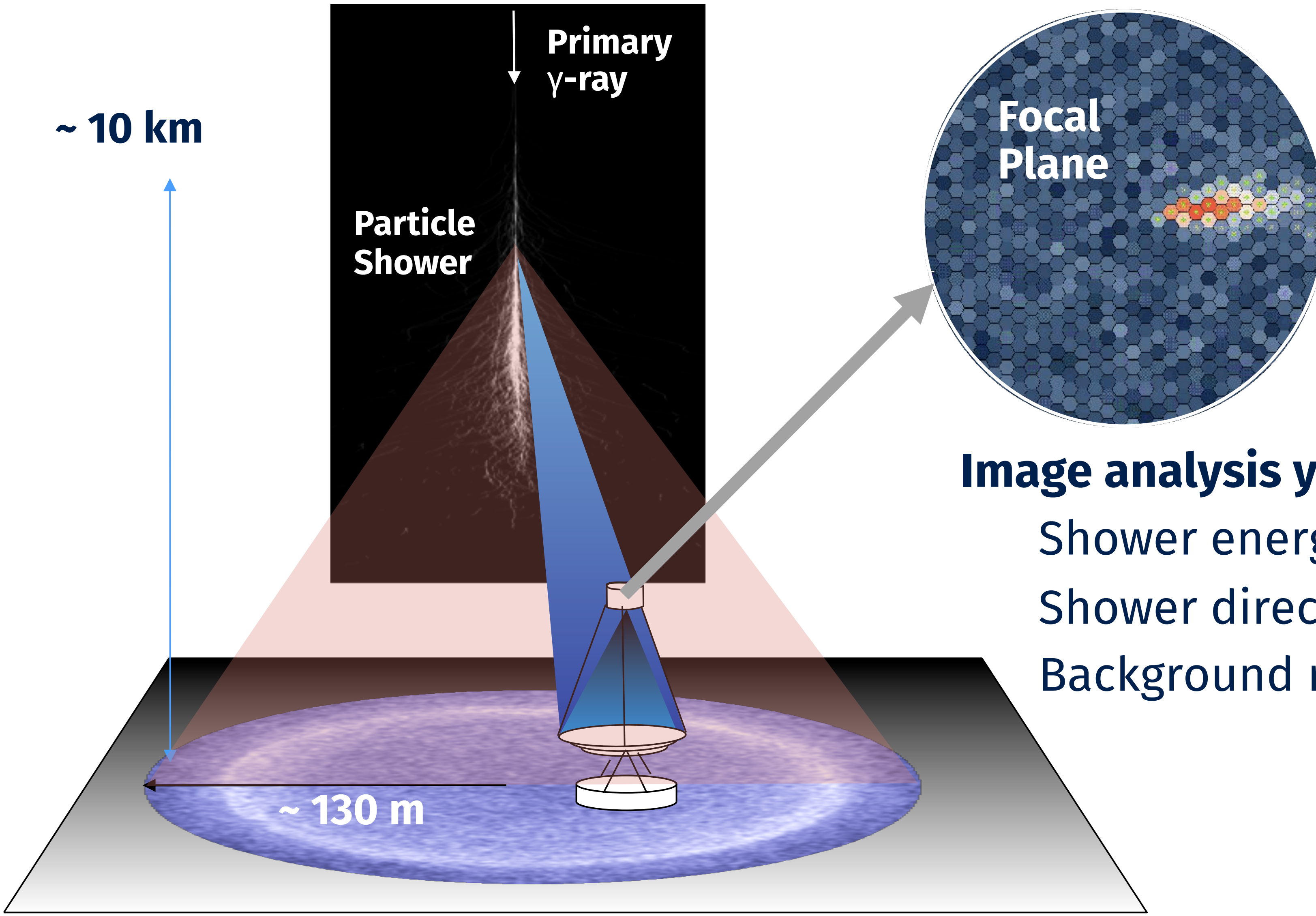
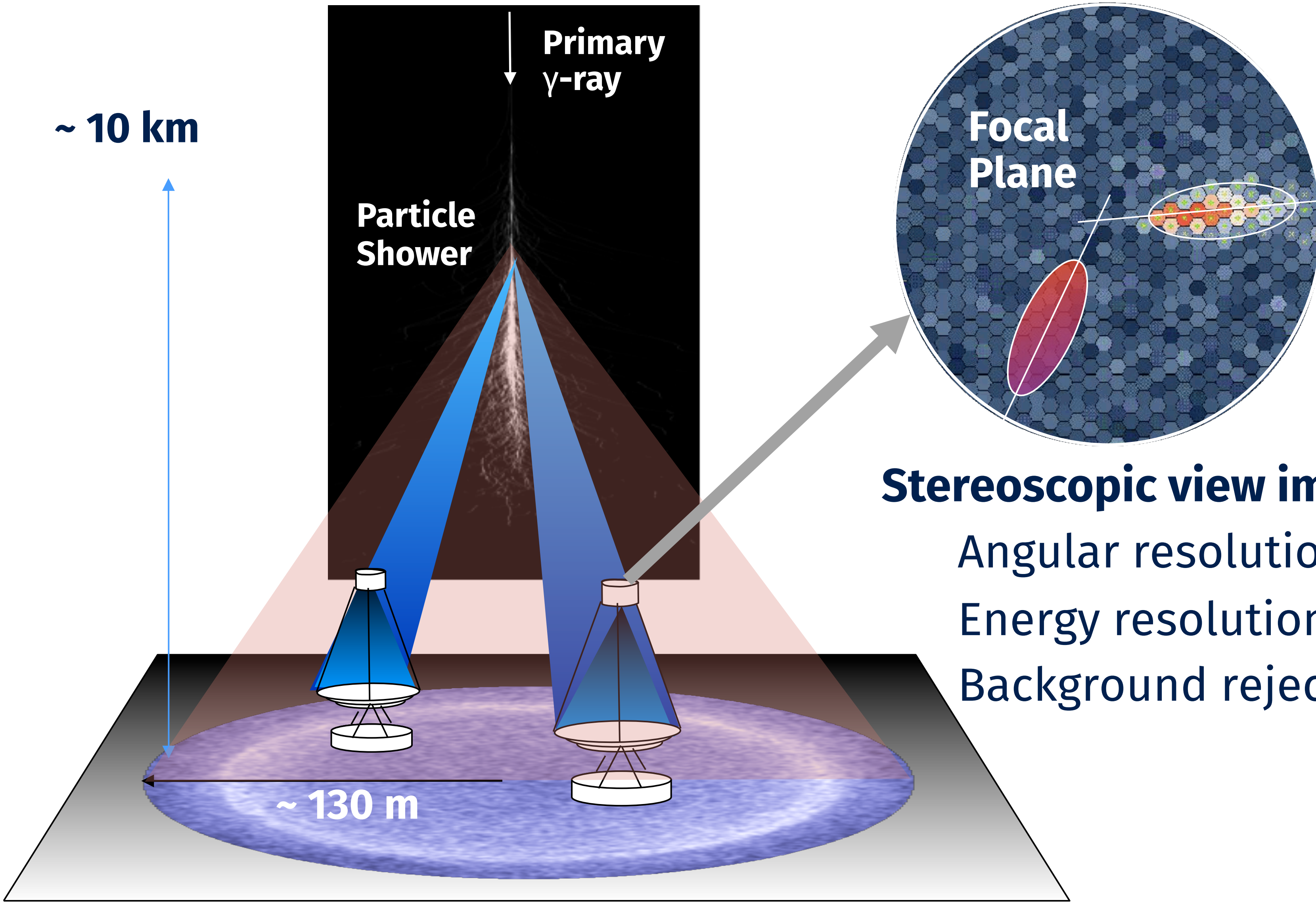


Image analysis yields

- Shower energy
- Shower direction
- Background rejection

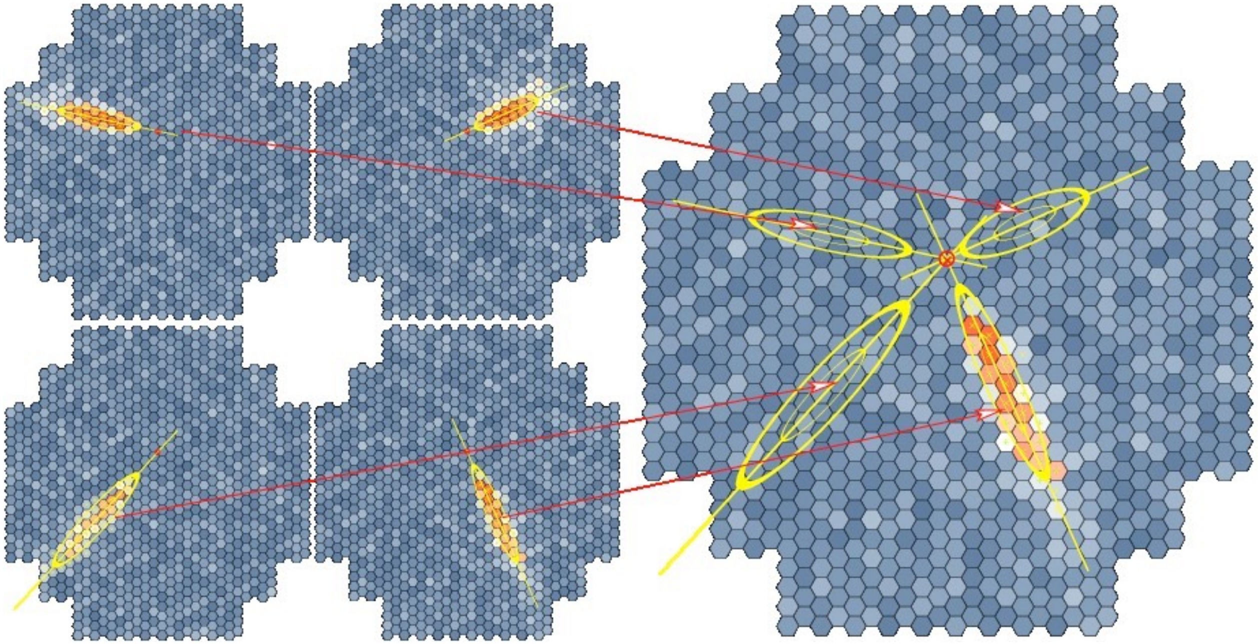
The Cherenkov Telescopes



Stereoscopic view improves

- Angular resolution
- Energy resolution
- Background rejection

The Cherenkov Telescopes

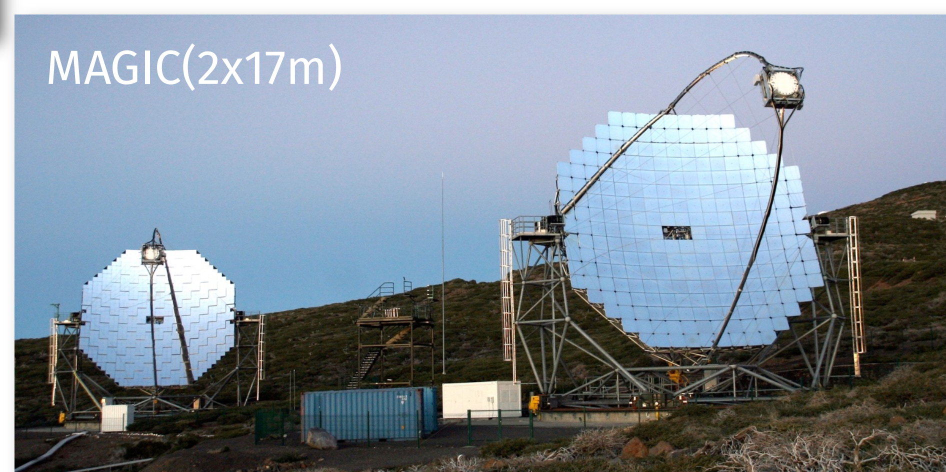


The intersection of major axes on the common FOV gives source position on the sky.

More on the Cherenkov technique, sources and physics in:

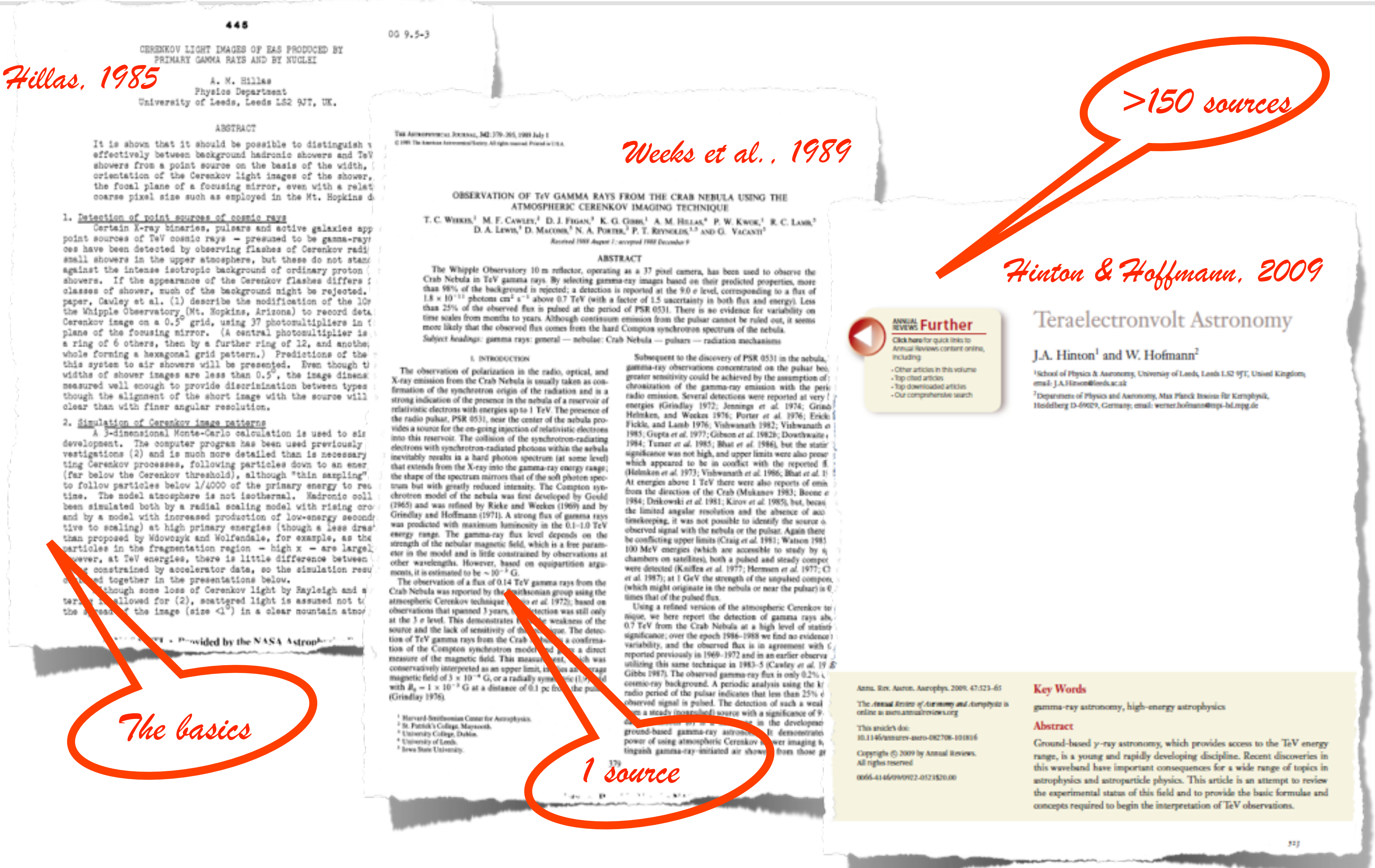
Hinton & Hofmann, 2009, ARAA, 47, 523

The current IACT status



Telescopes not to scale

VHE high-level timeline



HE & VHE view and future perspectives

See talks by

P. Caraveo – *High-energy γ-ray astrophysics*

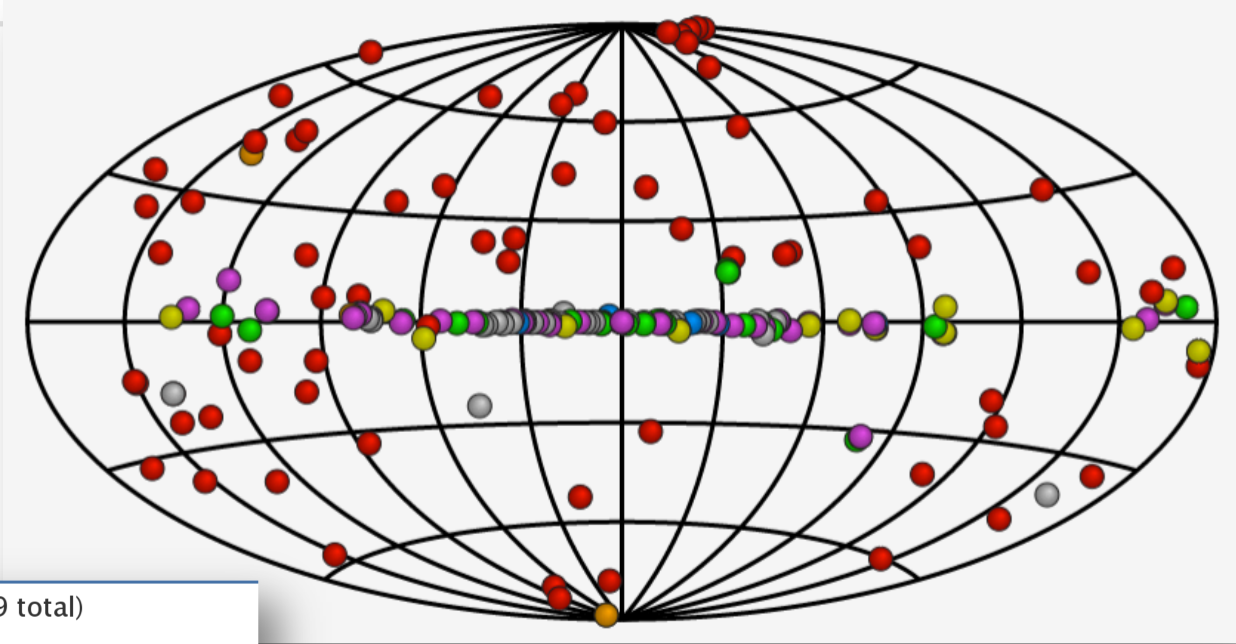
G. Ambrosi – *Future c-rays experiments in the CTA era*

M. Tavani – *Future γ-ray experiments in the CTA era*

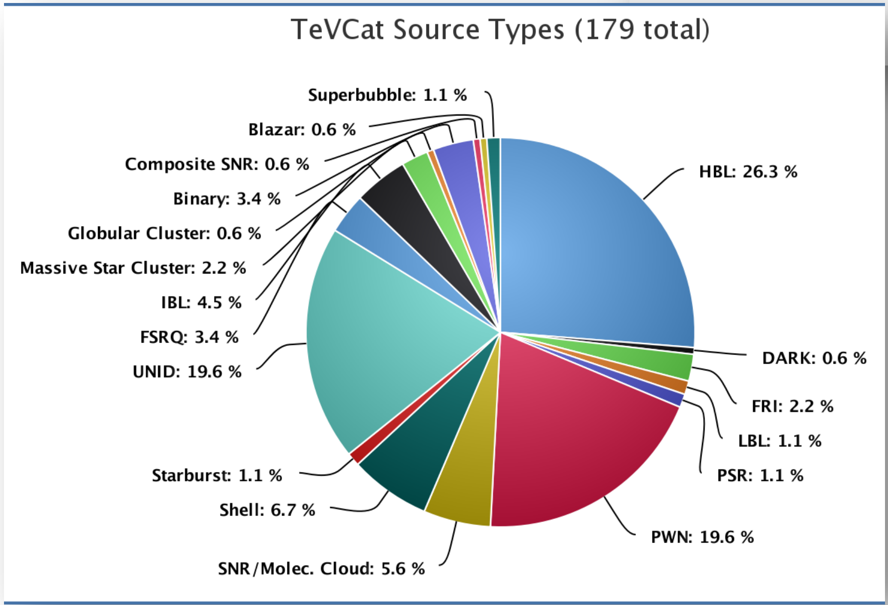
S. Funk – *VHE science after 10 years of CTA*

100 GeV – 50 TeV sky

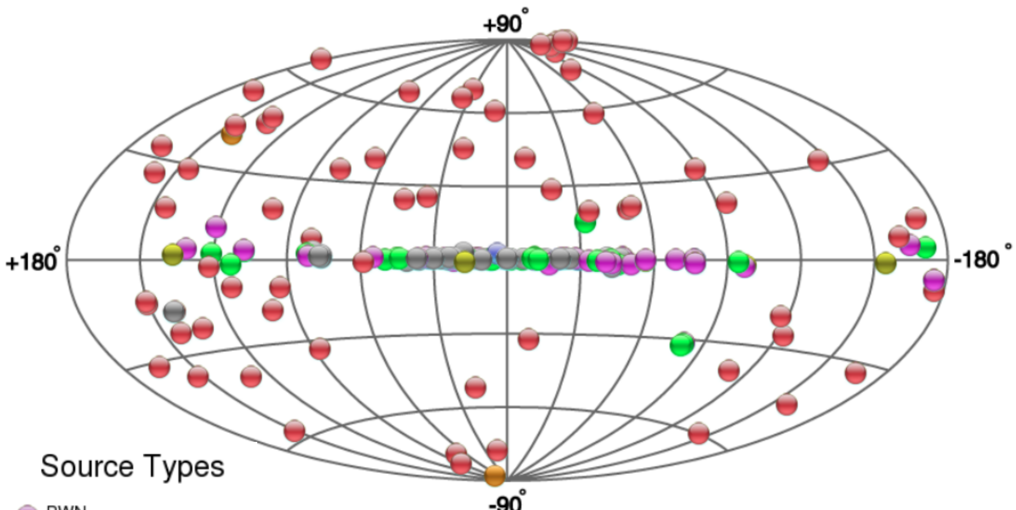
TeVCat 2
H.E.S.S., MAGIC, VERITAS
~180 sources
E>100 GeV



Wakely & Horan+16

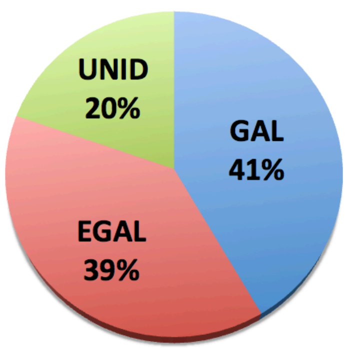


The Fermi sky above 50 GeV

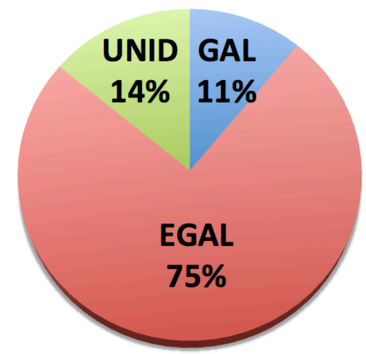


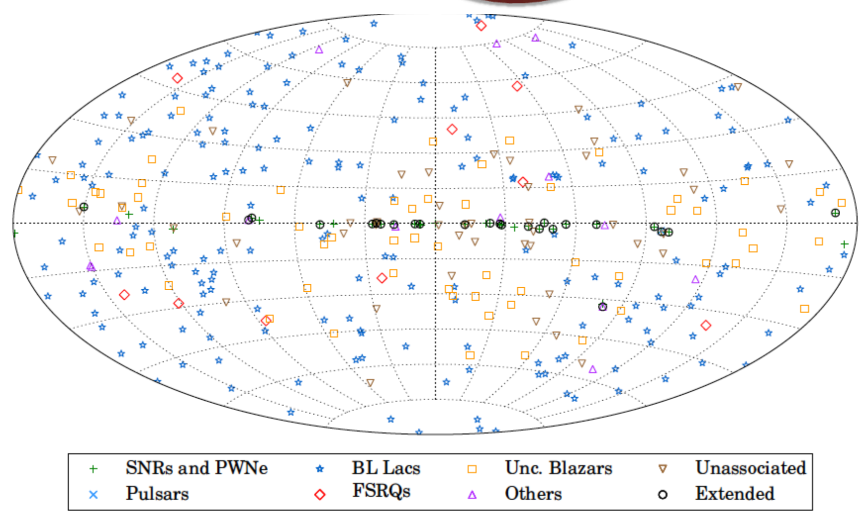
Wakely & Horan http://tevcat.uchicago.edu/

~180 TeVCat sources



360 *Fermi*-LAT sources E>50 GeV



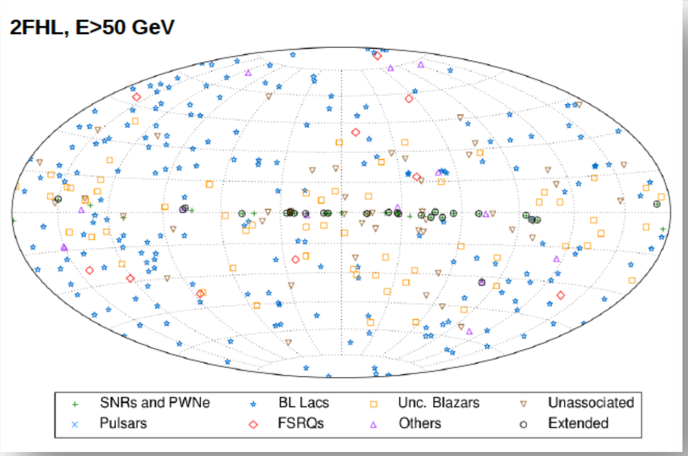


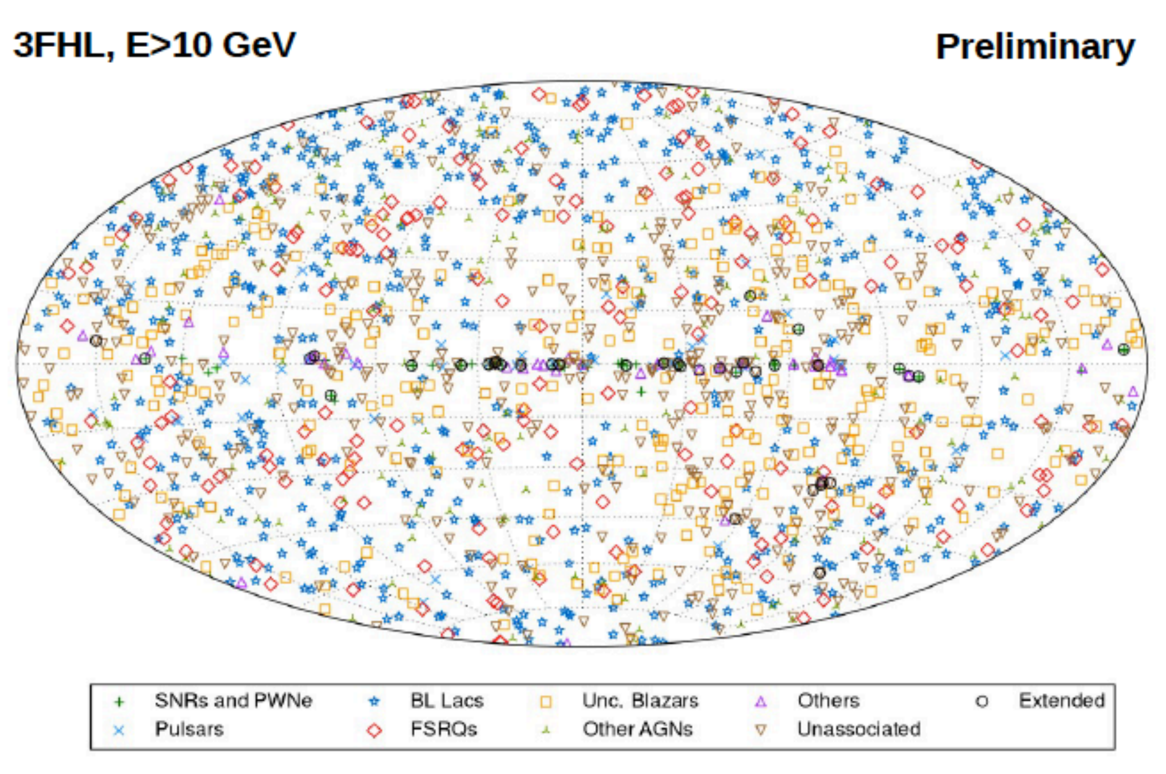
2FHL Ackermann+16

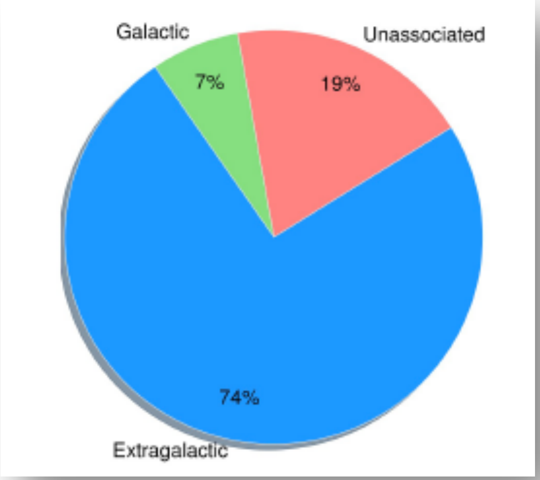
Only ~25% of the 2FHL sources have been previously detected by Cherenkov telescopes.

2FHL provides a reservoir of candidates to be followed up at very high energies.

Beyond 2FHL → 3FHL







3FHL, arXiv:1702.00664

10 GeV – 2 TeV

7 years of data

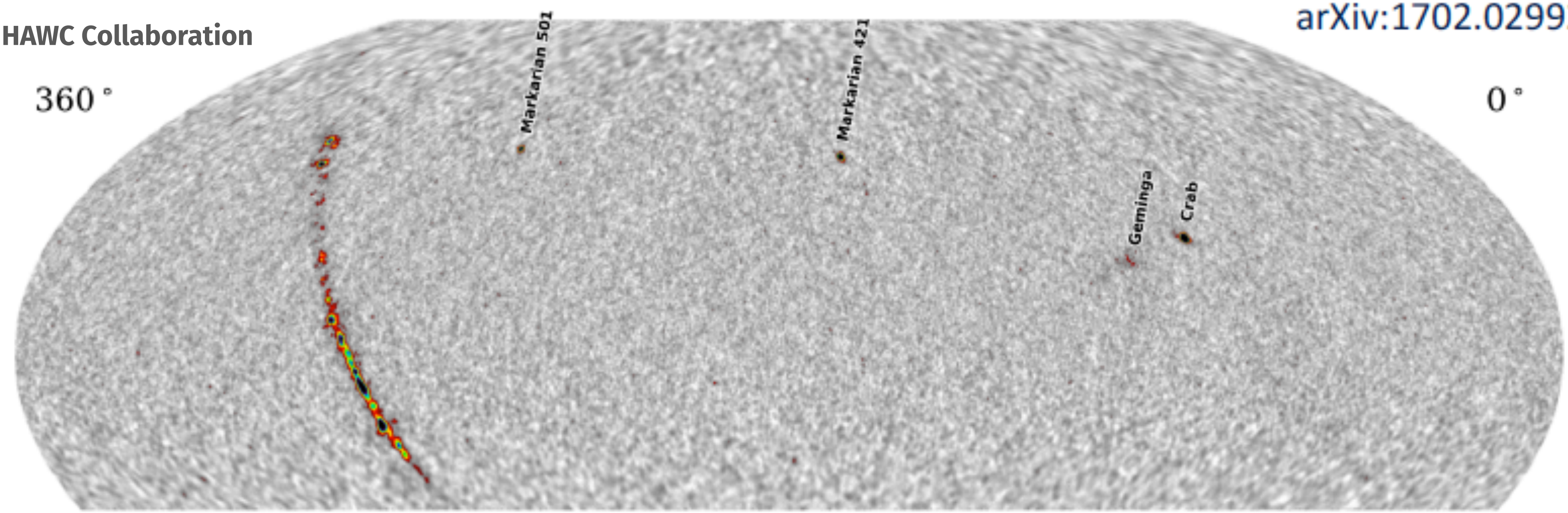
1556 sources

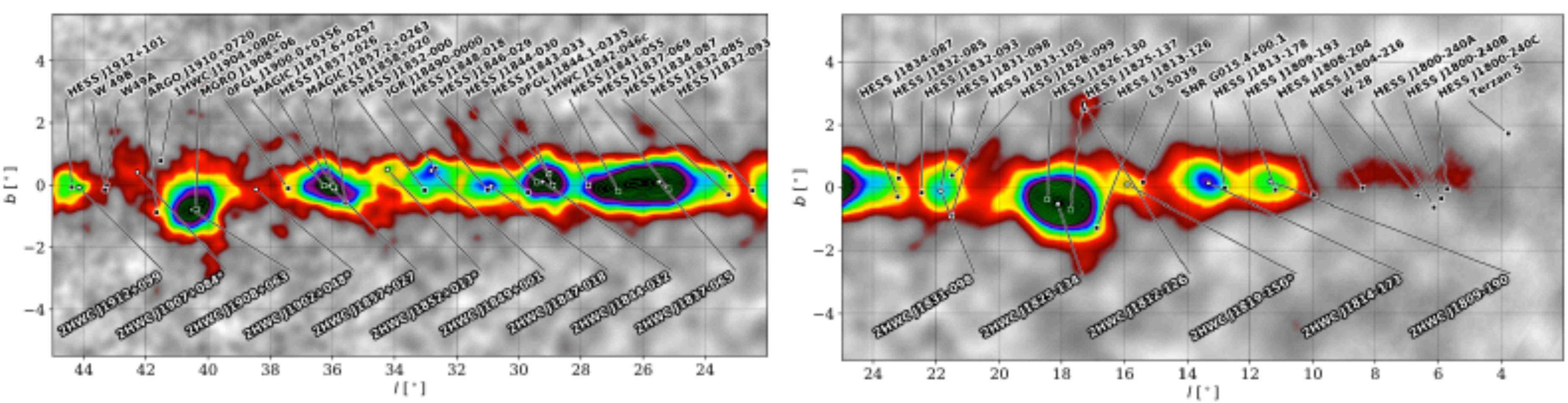
214 brand new (not in 1FHL/2FHL/3FGL)

0.1 – 100 TeV sky

HAWC Collaboration

arXiv:1702.02992





HE & VHE sky

See talks by

G. Barbiellini – *10 years of AGILE*

L. Latronico – *The HE view of the γ-ray sky with Fermi*

S. Casanova – *Recent results from HAWC*

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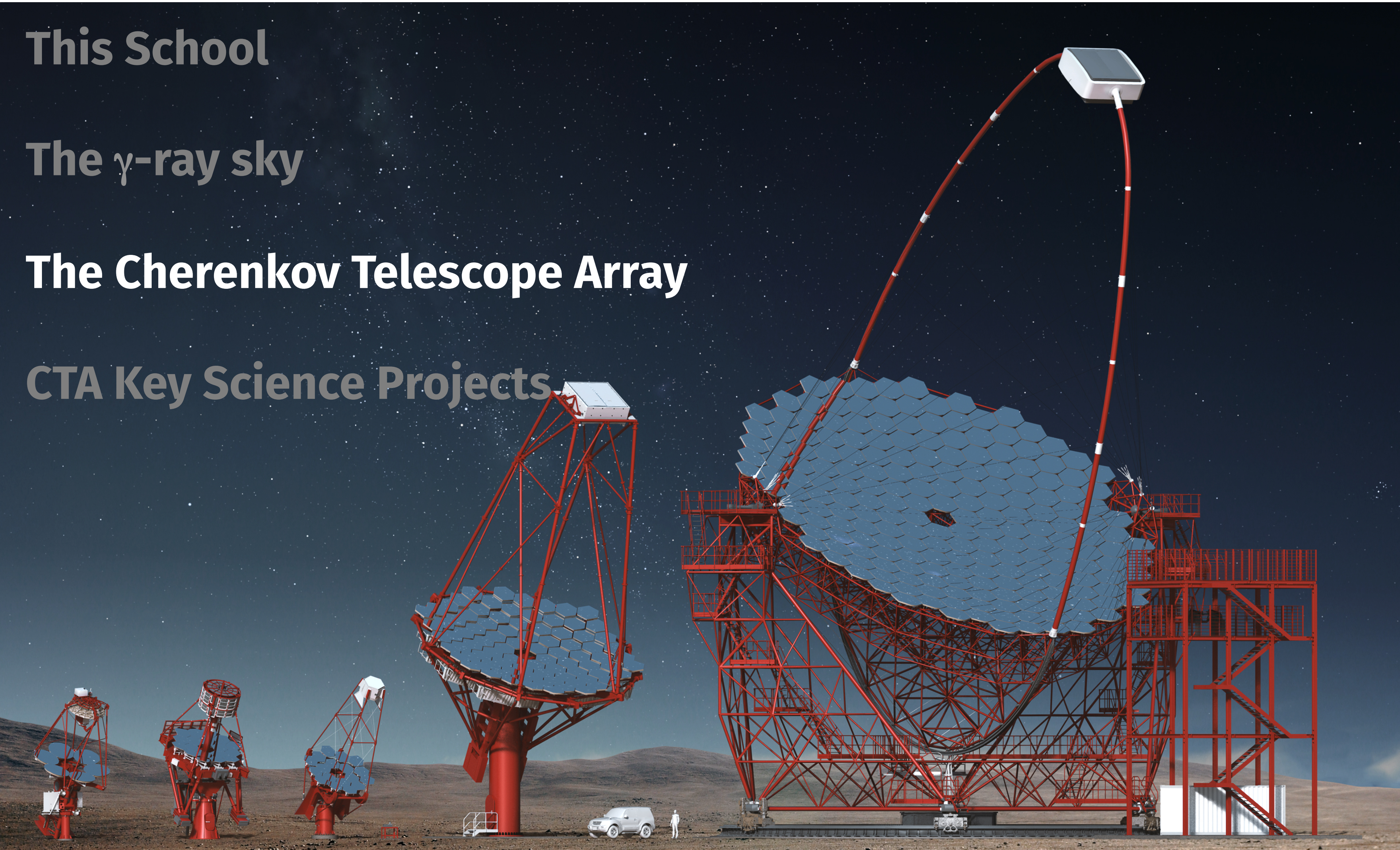

How to improve w.r.t. current IACTs ?

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A long time ago in a galaxy far,
far away….

How to improve w.r.t. current IACTs ?

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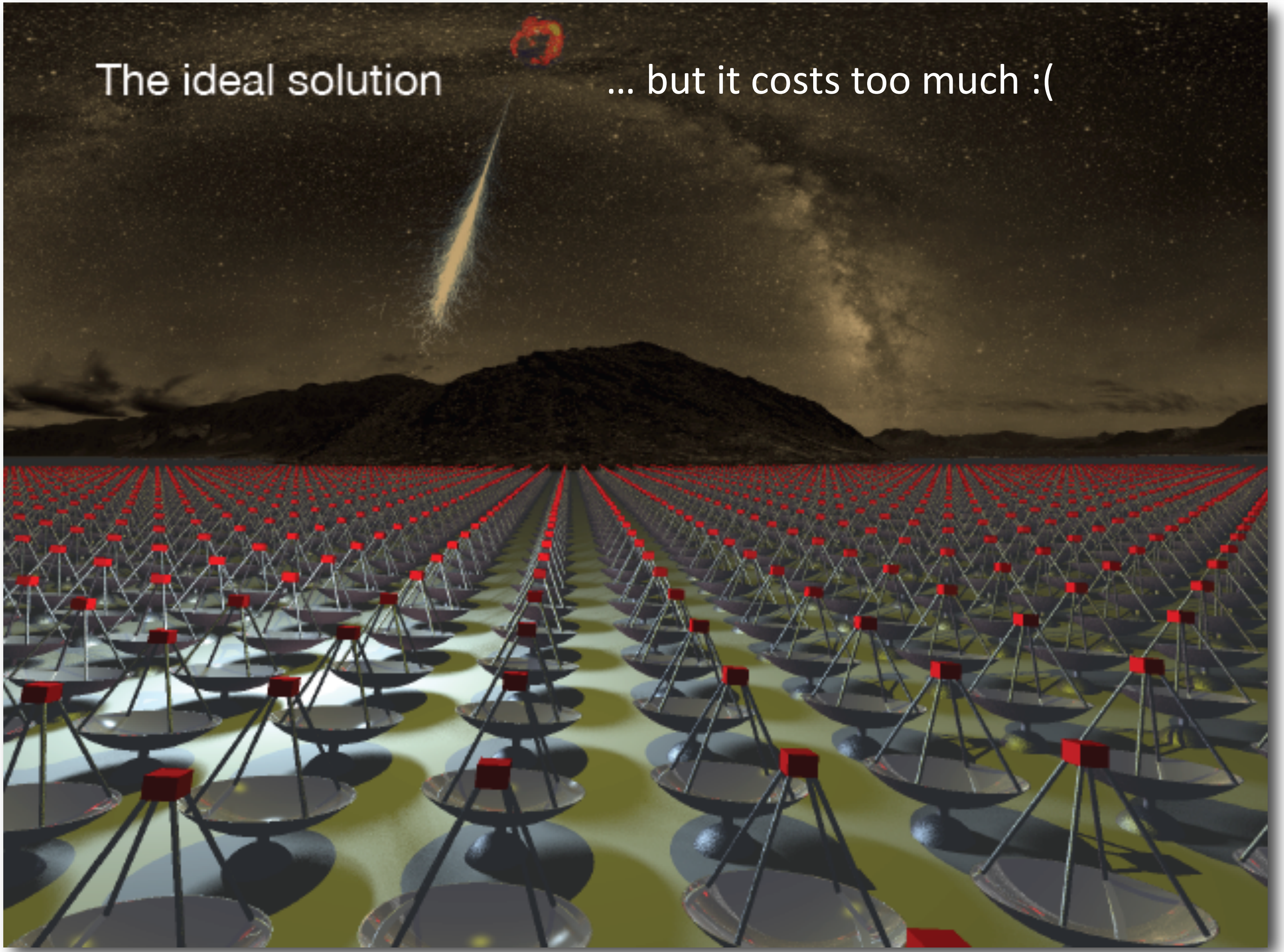
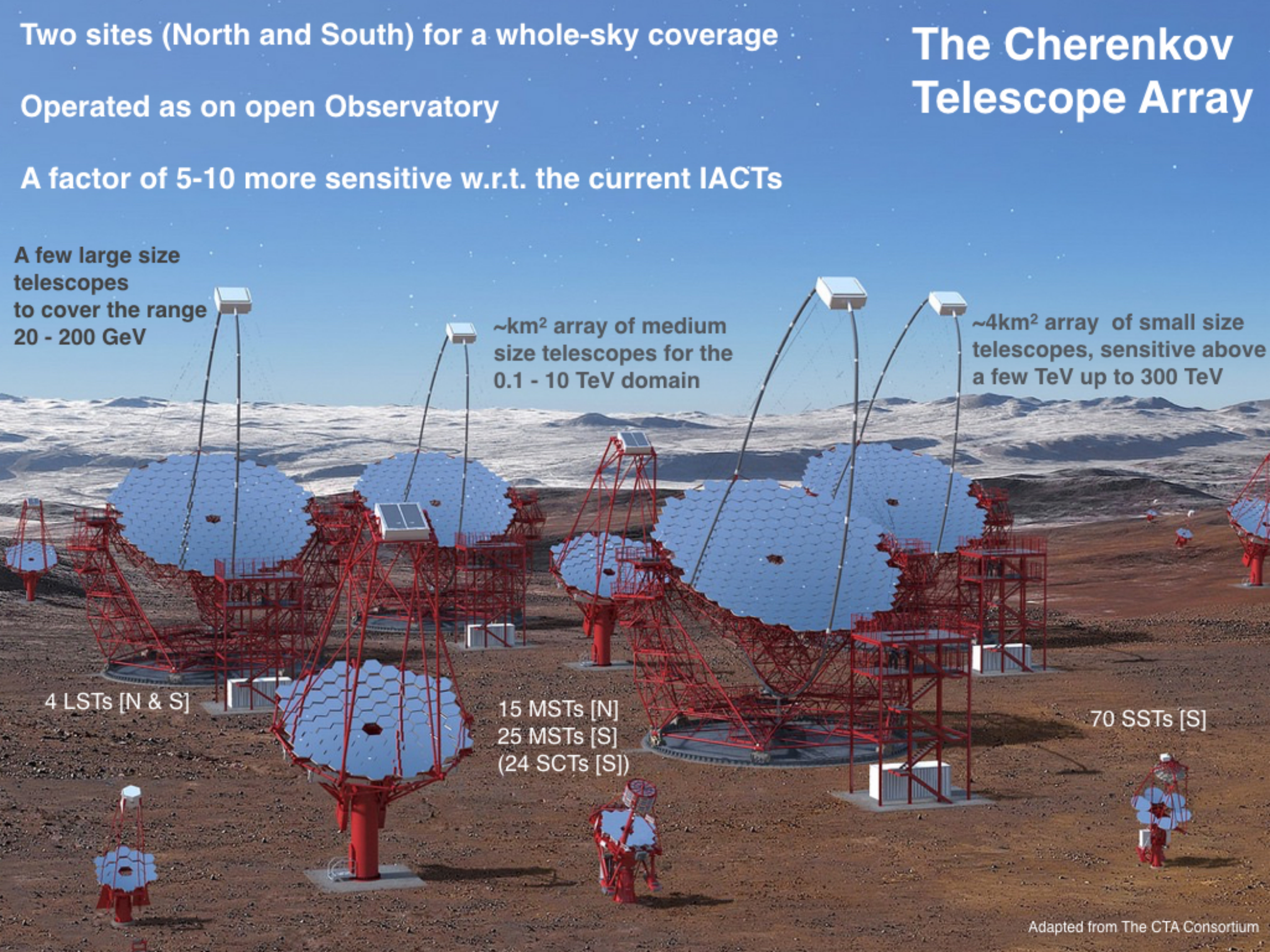
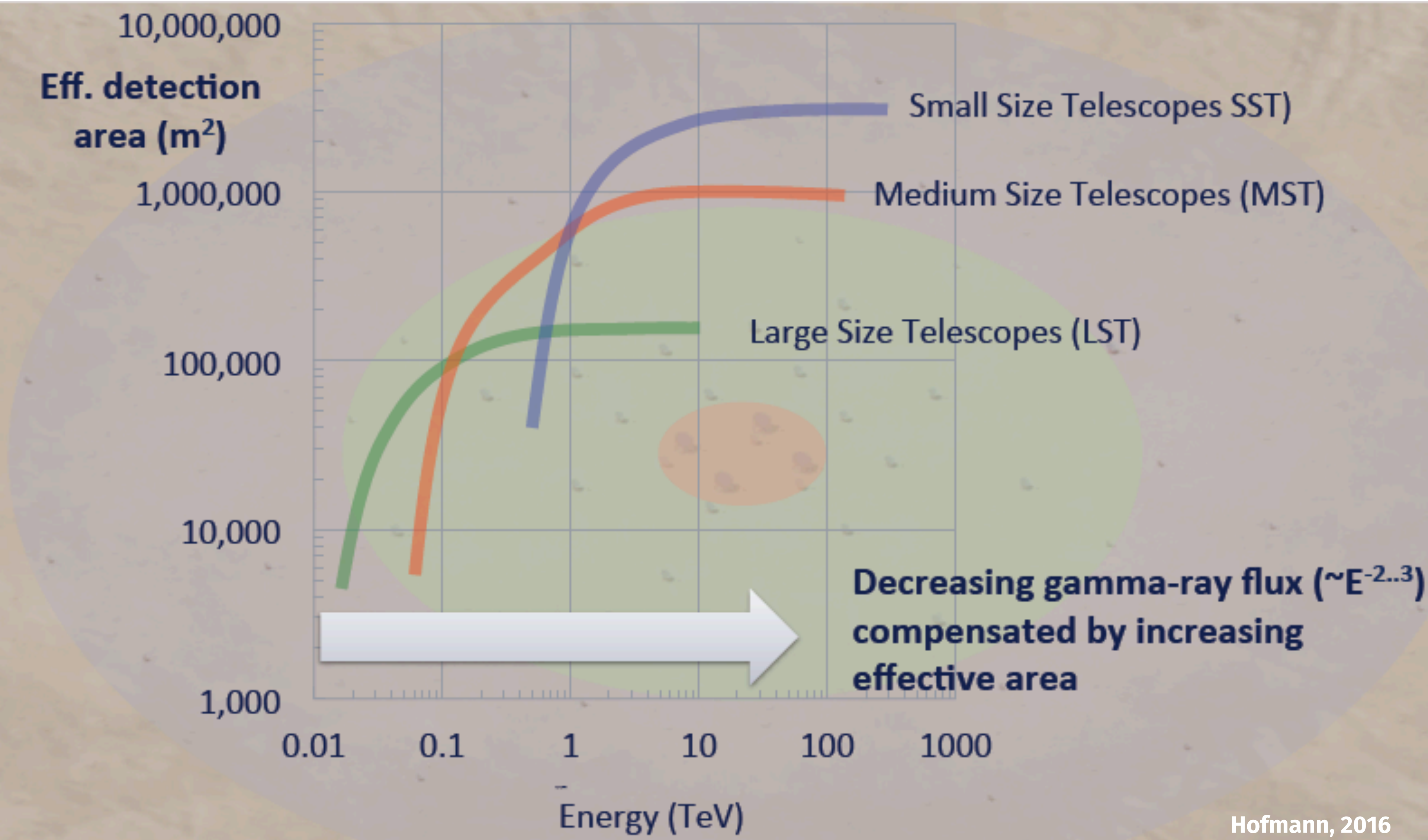


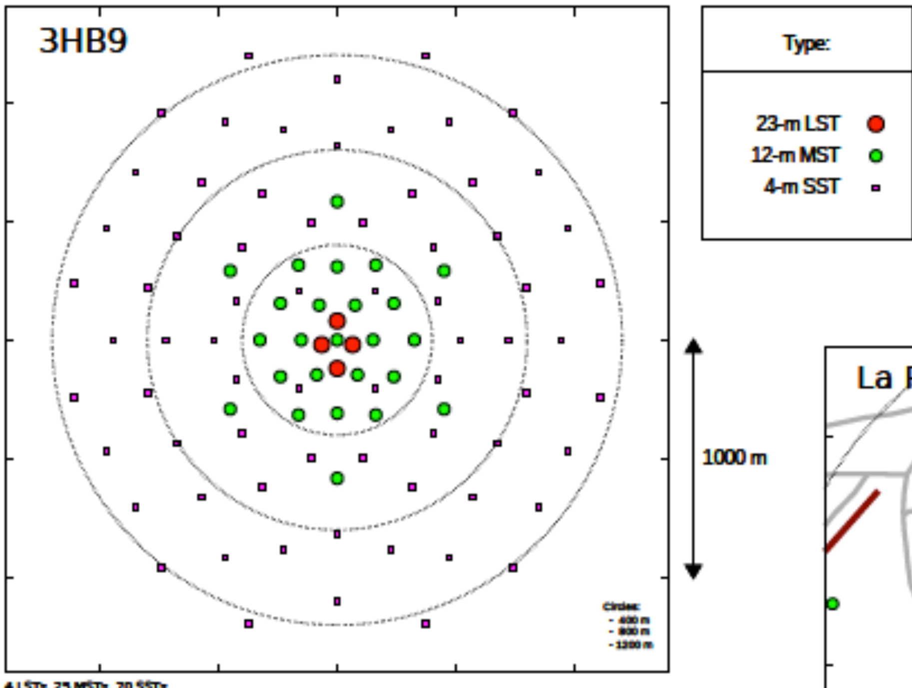

Two sites (North and South) for a whole-sky coverage
Operated as on open Observatory
A factor of 5-10 more sensitive w.r.t. the current IACTs
The Cherenkov Telescope Array
A few large size telescopes to cover the range 20 - 200 GeV
~km² array of medium size telescopes for the 0.1 - 10 TeV domain
~4km² array of small size telescopes, sensitive above a few TeV up to 300 TeV
4 LSTs [N & S]
15 MSTs [N]
25 MSTs [S]
(24 SCTs [S])
70 SSTs [S]
Adapted from The CTA Consortium

Effective area for gamma-ray detection

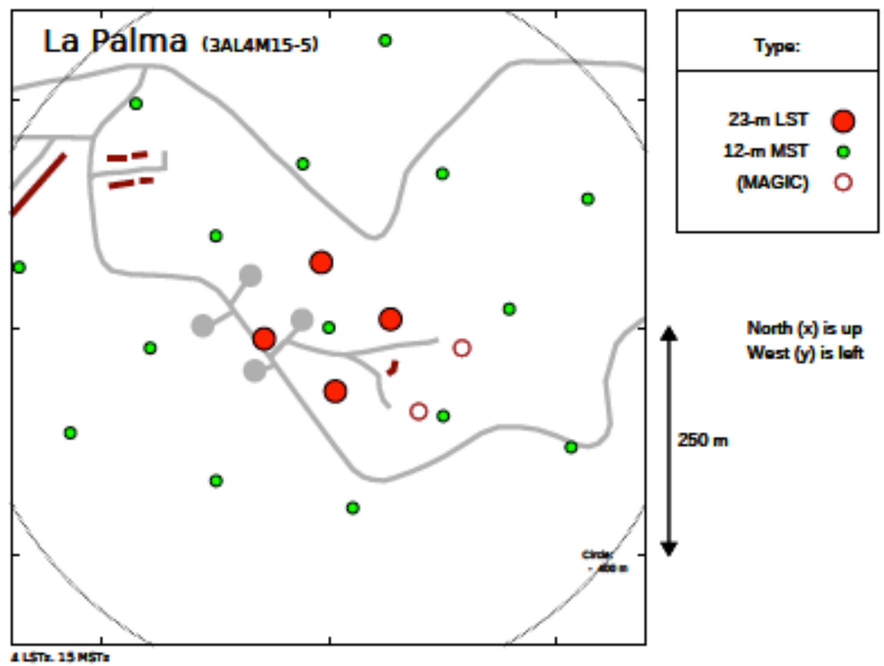


Hofmann, 2016

CTA Telescope layout



North:
4 LST
15 MST

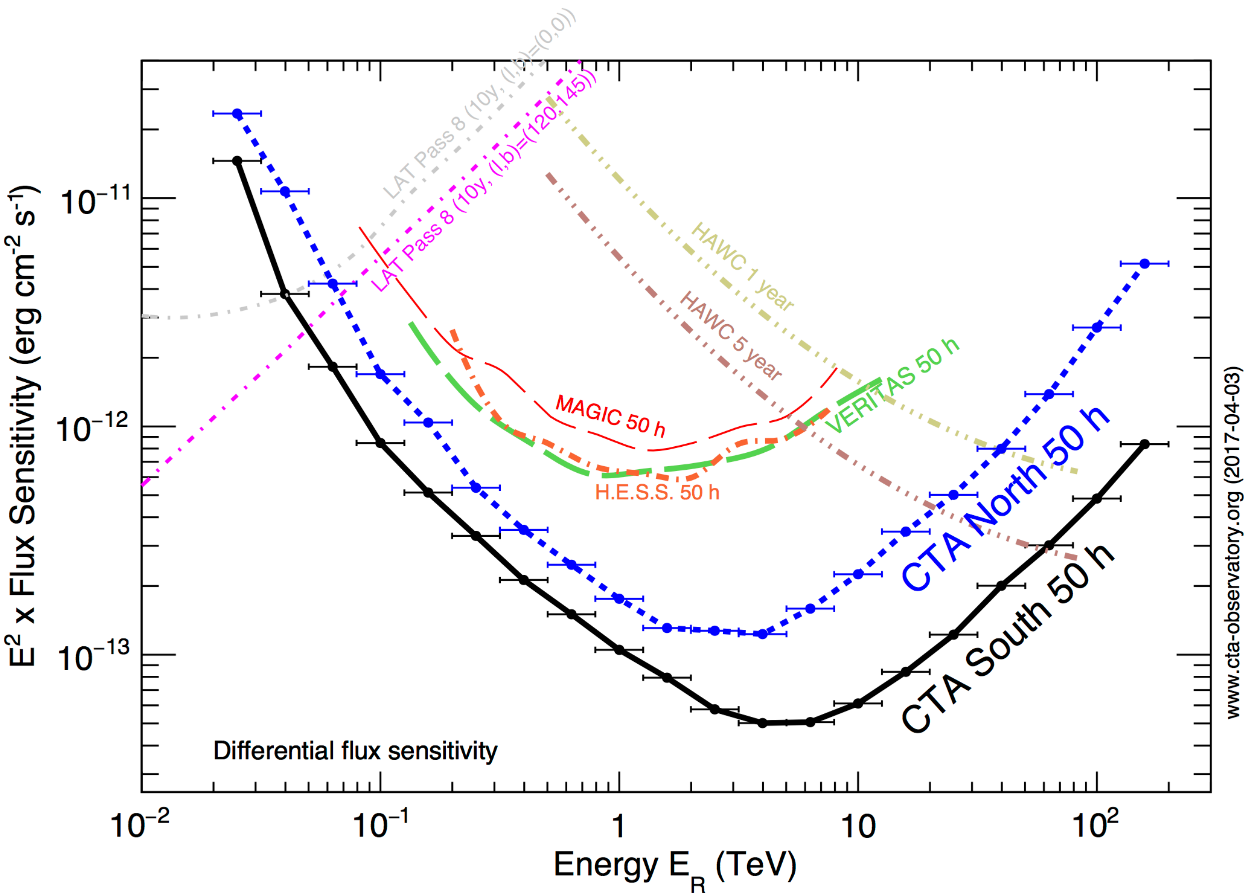


South:
4 LST
25 MST
70 SST

Credits: The CTA Consortium

CTA Performance

Differential Sensitivity

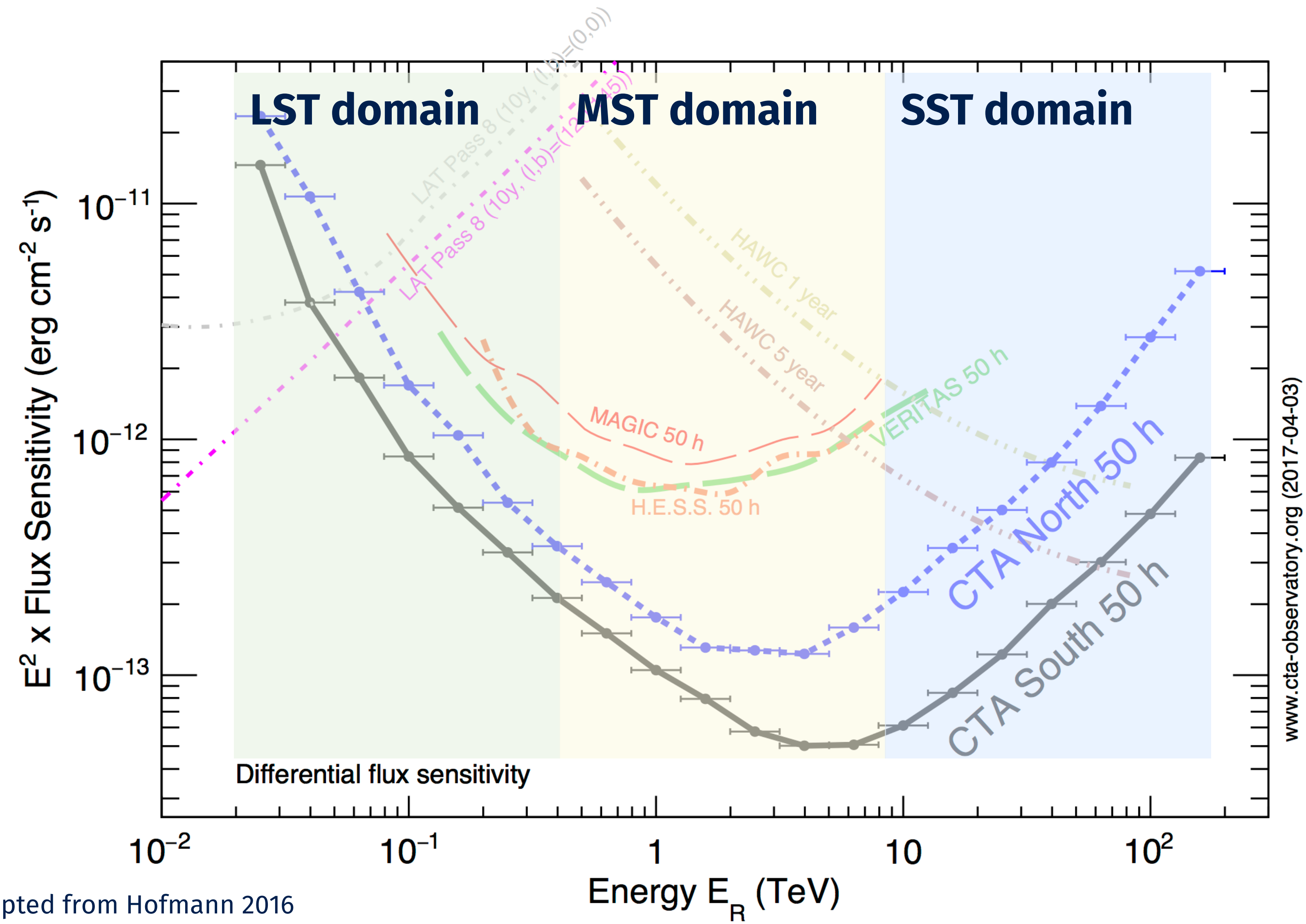


A factor of **5-10 improvement** in sensitivity in the domain of **about 100 GeV to some 10 TeV.**

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

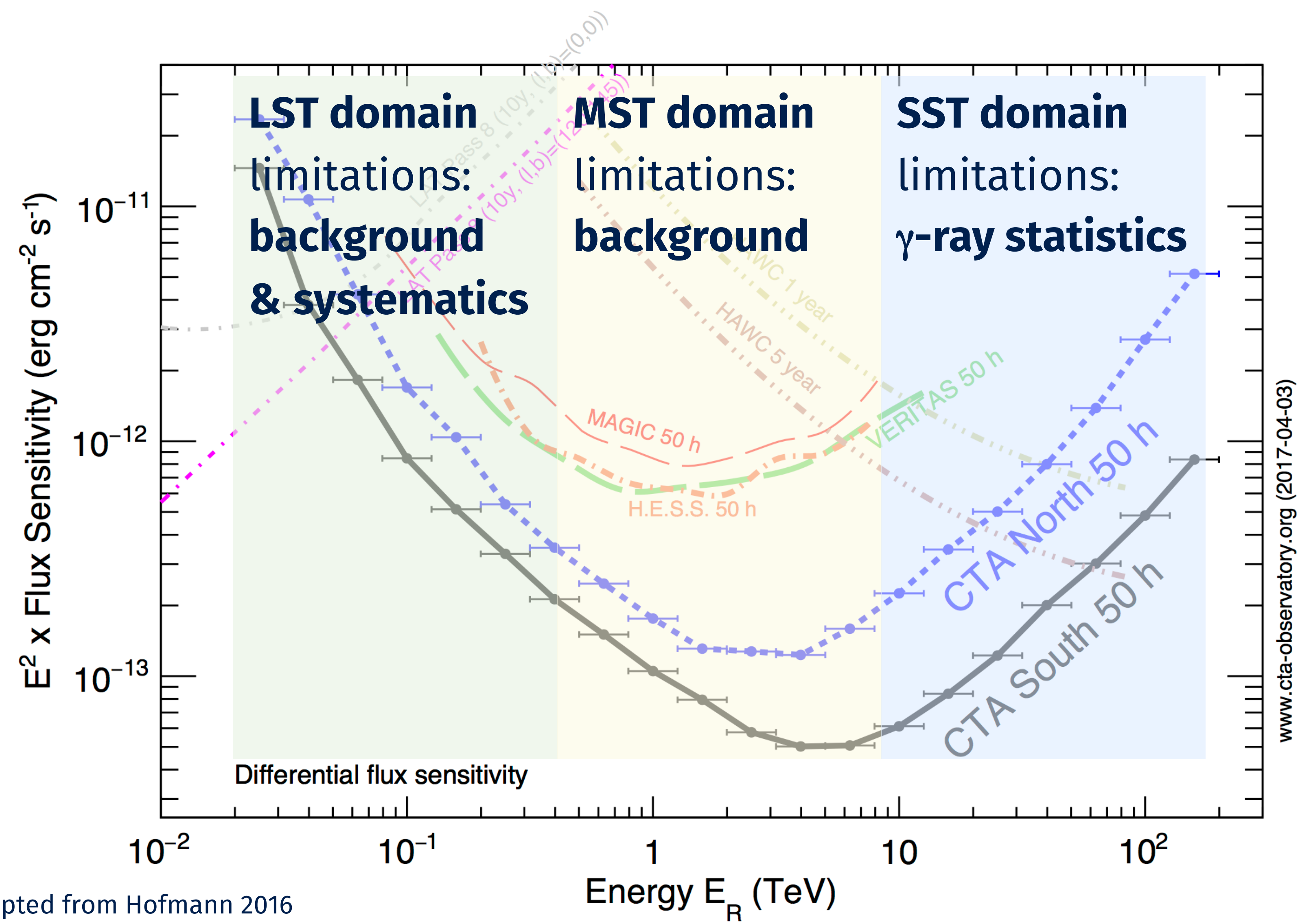
Credits: The CTA Consortium

CTA Performance



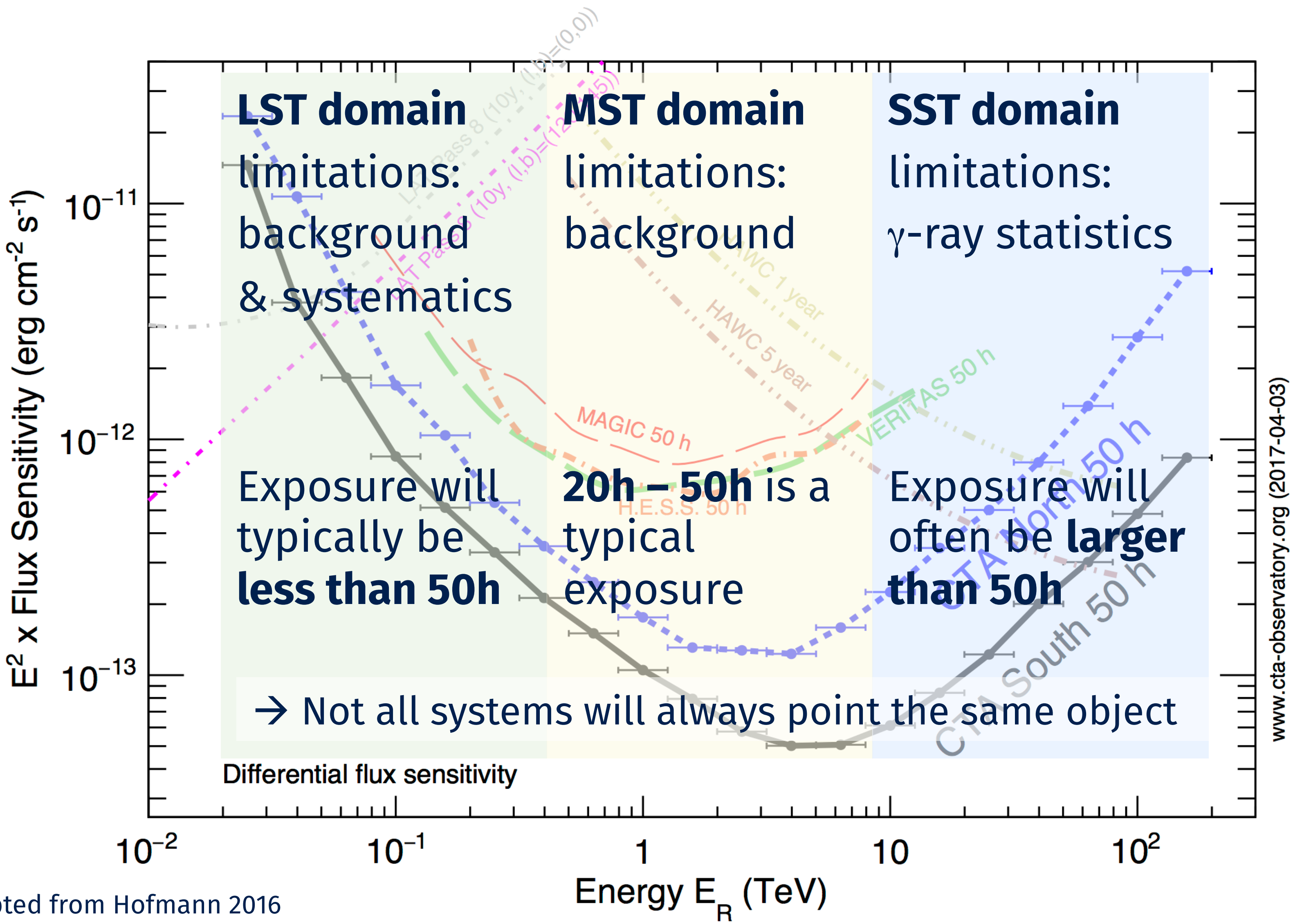
Adapted from Hofmann 2016

CTA Performance



Adapted from Hofmann 2016

CTA Performance



LST domain
limitations:
background
& systematics

MST domain
limitations:
background

SST domain
limitations:
γ-ray statistics

Exposure will typically be **less than 50h**

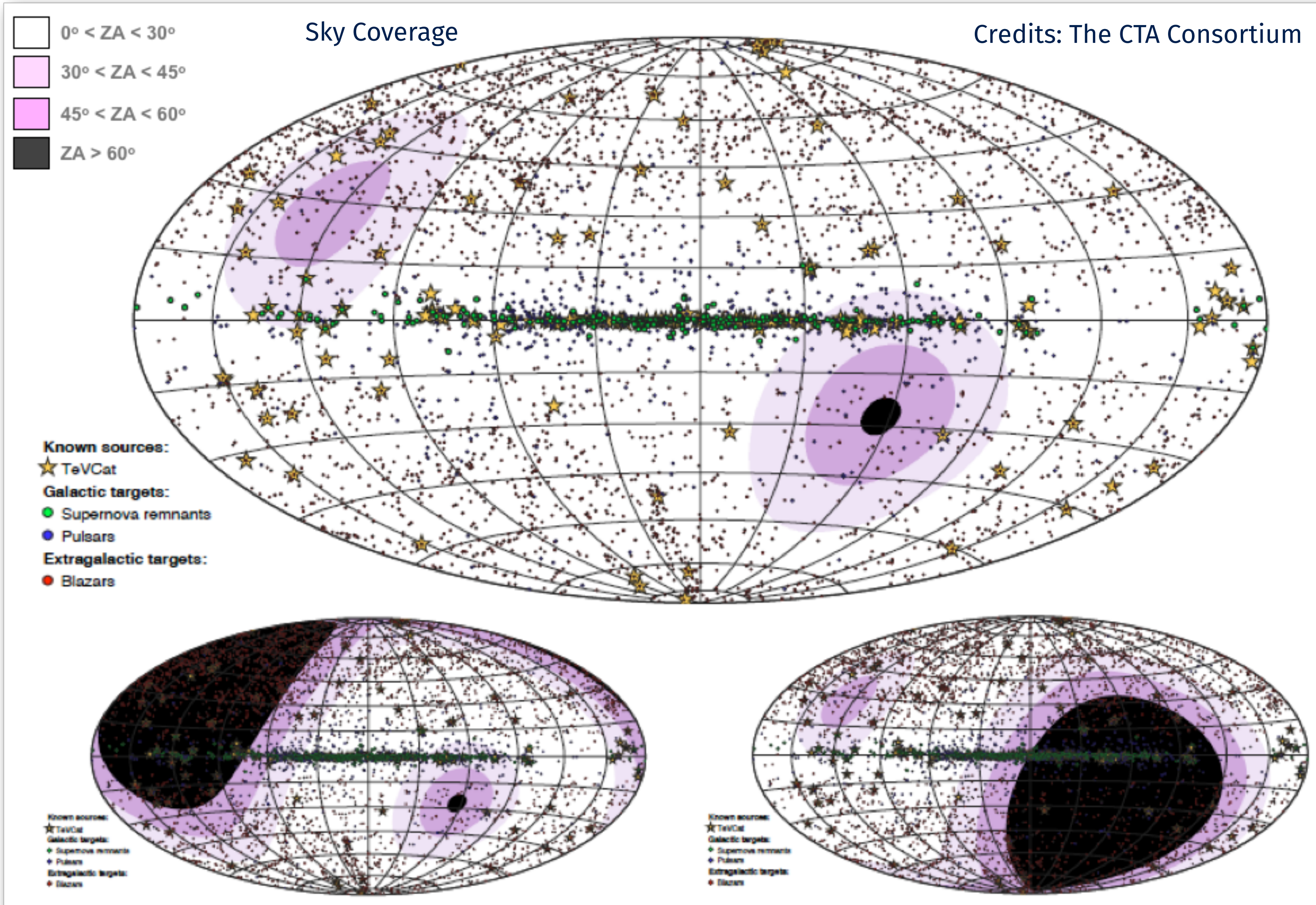
20h – 50h is a typical exposure

Exposure will often be **larger than 50h**

→ Not all systems will always point the same object

Adapted from Hofmann 2016

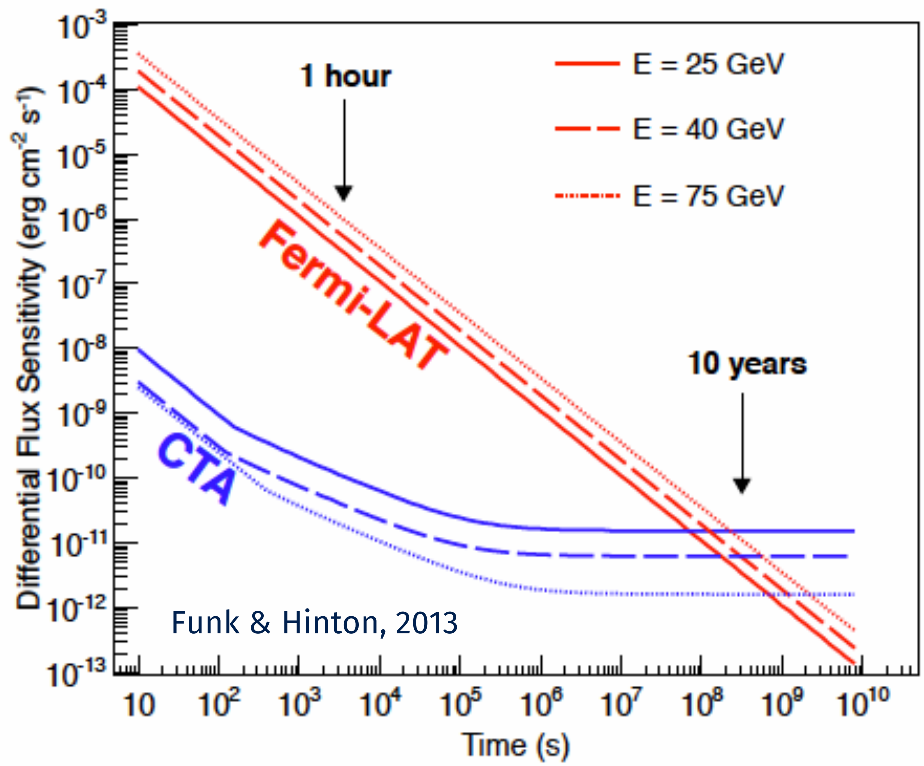
CTA as an *all-sky* Observatory



CTA as a *transient factory*

- **Huge advantage over Fermi** in energy range of overlap for ~minute to ~week timescale phenomena
  - Explosive transients
  - AGN flares
  - Binary systems

- **Disadvantage over Fermi**
  - Limited FoV (compared to Fermi)
  - Prompt reaction to external trigger is critical



CTA

See talks by

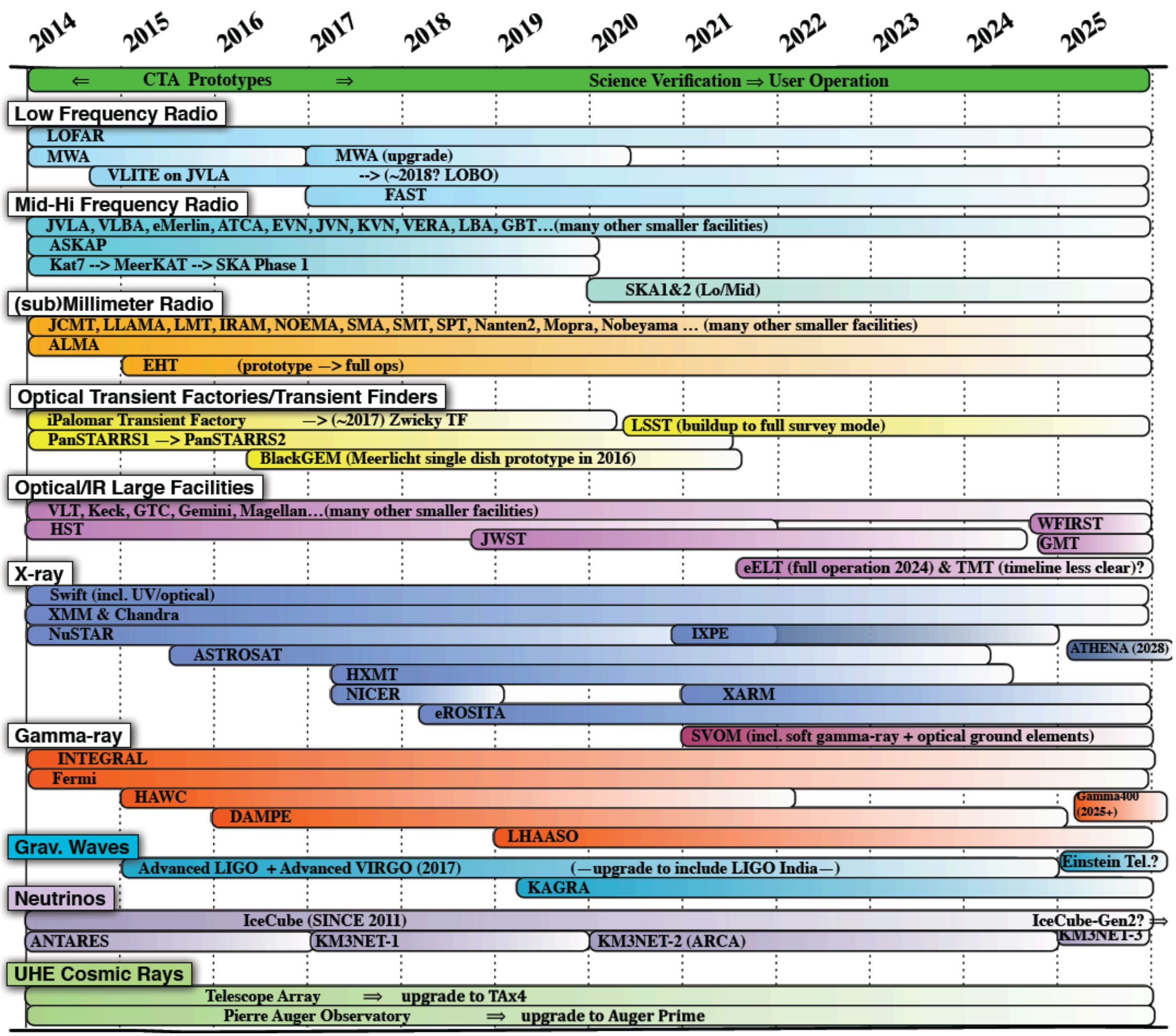
M. Martinez – *Overview of the CTA*

M. Teshima – *LST status*

S. Schlenstedt – *MST status*

G. Pareschi – *SST status*

Synergies during CTA operation



CTA and MWL synergies

See talks by

F. De Palma – *The Galaxy as seen by Fermi*

G. Tagliaferri – *X-ray astrophysics and CTA*

F. D'Ammando – *Optical observations and CTA*

M. Giroletti – *CTA and SKA synergies*

K. Satalecka – *Neutrinos counterparts at VHE*

B. Bertucci – *Cosmic-ray studies in the CTA era*

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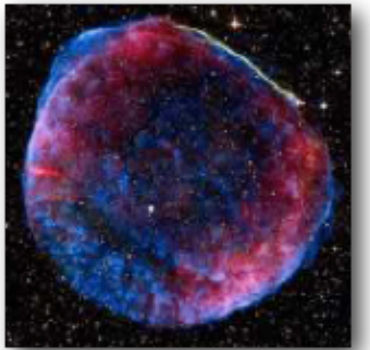
CTA Main Scientific Themes

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?

Adapted from J. Knödlseder.
More information on Astroparticle Physics, Vol. 43, 1-356 (2013) & CTA Contributions to the 2015 ICRC Conference [arXiv:1508.05894]

CTA Key Science Projects

The criteria used for selection of the baseline KSPs

1. **Excellent scientific case and clear advance** beyond the state of the art;

2. **Production of legacy data-sets** of high value to a wider community;

3. **Clear added value of doing this as a KSP** rather than as part of the Guest Observer Programme:
    1. the **scale of the project** in terms of observing hours - very large projects will be difficult to accommodate in the open time early in the lifetime of the observatory;
    2. the need of a **coherent approach** across multiple targets or pointings;
    3. the **technical difficulty** of performing the required analysis and hence reliance on consortium expertise.

cta

Science with CTA

Will become a regular book / a special issue journal.

CTA Key Science Projects

1. Dark Matter Programme
2. Galactic Centre Survey
3. Galactic Plane Survey
4. Large Magellanic Cloud Survey
5. Extragalactic Survey
6. Transients
7. Cosmic-ray PeVatrons
8. Star-forming Systems
9. Active Galactic Nuclei
10. Cluster of Galaxies
11. Non-Gamma-ray Science

CTA science and KSPs

See talks by

G. Brunetti – *Galaxy clusters with CTA*

G. Van Eldik – *The Galactic survey at VHE*

A. Giuliani – *Galactic science with CTA*

D. Mazin – *Survey of the extra-galactic sky*

F. Tavecchio – *Extra-galactic sky with CTA*

E. Bissaldi – *GRB studies with CTA*

B. Patricelli – *Search for GW counterparts with CTA*

A. Morselli – *Dark matter studies with CTA*

M. Roncadelli – *Axion-like particles and CTA*

CTA PHYS Working Group

The **PHYS WG is composed of ~350 members**, while SWGs are composed as follows (note that one can register for more than one SWG and numbers are rounded)

Registrations are always open for CTA Consortium members!

https://portal.cta-observatory.org/_layouts/people.aspx?MembershipGroupId=989

Galactic	~160
Cosmic Rays	~130
Extra-galactic	~150
Transients	~150
Dark matter and exotic physics	~100
Intensity Interferometry	~ 25
MWL Transverse WG	~ 70

Next meeting

CTA PHYS WG Face-to-Face Meeting

Restricted | Europe

18-20 September 2017
Max-Planck-Institut für Kernphysik
Europe/Berlin timezone

- Overview
- Call for Abstracts
- Timetable
- Author List
- Book of Abstracts
- Registration
- Conference Fee
- Accomodation
- Venue
- Travel info
- Conference dinner
- Participant List

Local Organizers

Roberta.Zanin@mpi-hd....
sabrina.casanova@mpi-...

Starts 18 Sep 2017 08:00
Ends 20 Sep 2017 19:00
Europe/Berlin

Max-Planck-Institut für Kernphysik
Otto-Hahn-Hörsaal, Library building
Saupfercheckweg 1
69117 Heidelberg
Germany

Stefan Funk
Stefano Vercellone

Materials

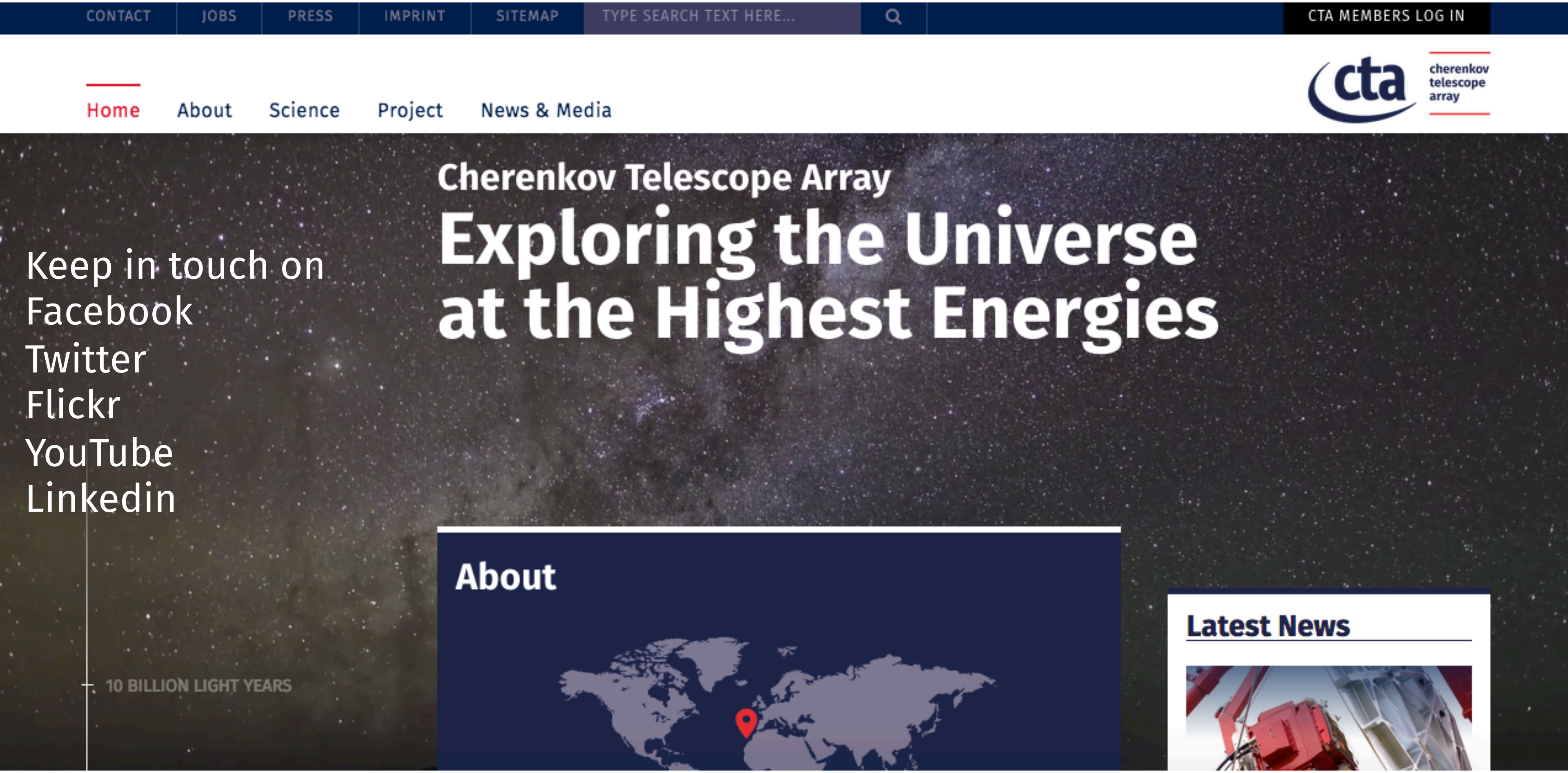
MPI 19.9.2017_Menü.pdf

Registration
Registration for this event is currently open.
Register now

The call for abstracts is open
You can submit an abstract for reviewing.
Submit new abstract

CTA Main webpage

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



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And now... let's have fun !