

Outline

0. Introduction

I. Measurement Principles and Instruments

Lecture I

II. Galactic Gamma-Ray Astronomy

III. Extragalactic Gamma-Ray Astronomy

IV. Outlook/Future

Lecture II



CTAO
Cherenkov Telescope Array Observatory

Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 29



Current IACT Instruments

VERITAS

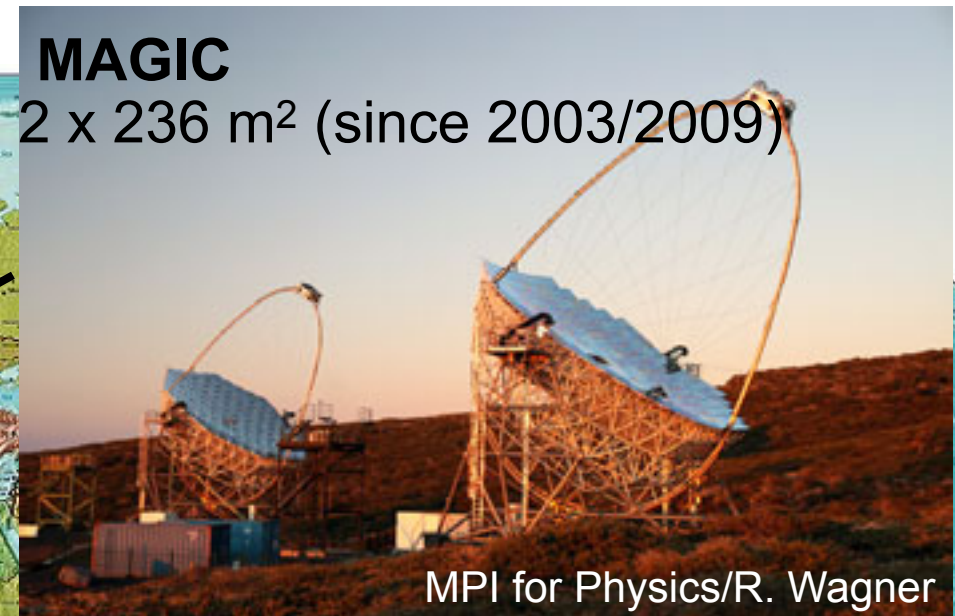
4 x 110 m² (since 2007)



VERITAS Coll.

MAGIC

2 x 236 m² (since 2003/2009)



MPI for Physics/R. Wagner

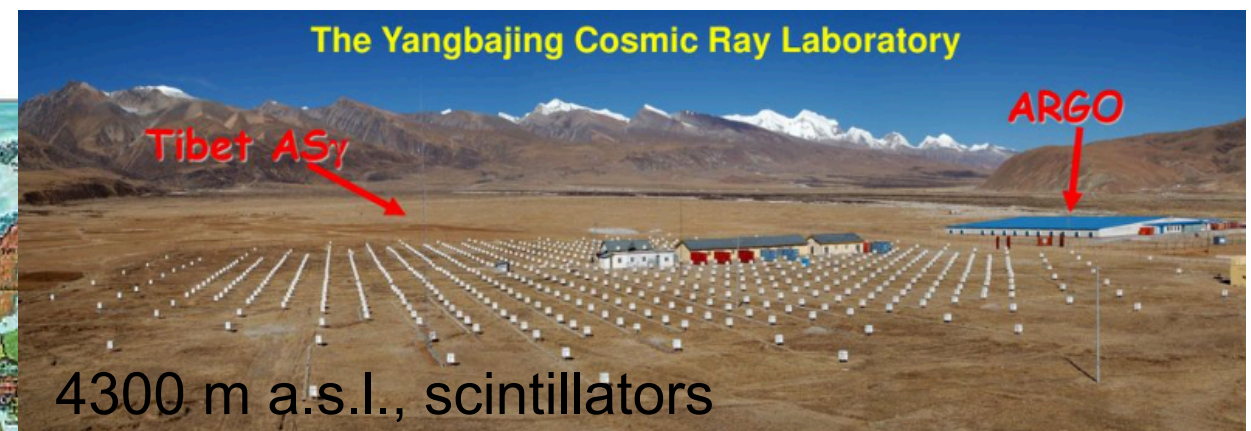
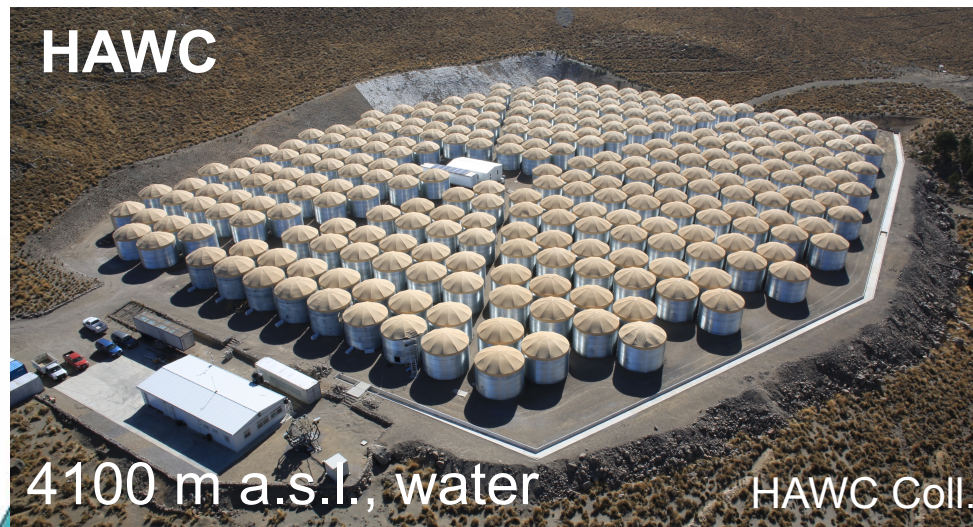
Effective area: ~10⁵ m²
Field of view: few degrees
Duty cycle: ~1000 hours/year
Background separation: imperfect
Angular resolution: <1'
Energy resolution: ~15%

H.E.S.S.



4 x 108 m² (since 2002)
1 x 614 m² (since 2012)

Current Particle Detector Array Instruments



Field of view: sky above detector

Duty cycle: 24/7

Background separation: modest

Angular resolution: $\sim 0.5^\circ$

Energy resolution: $\sim 50\%$

LHAASO

4410 m a.s.l.
water & scintillators

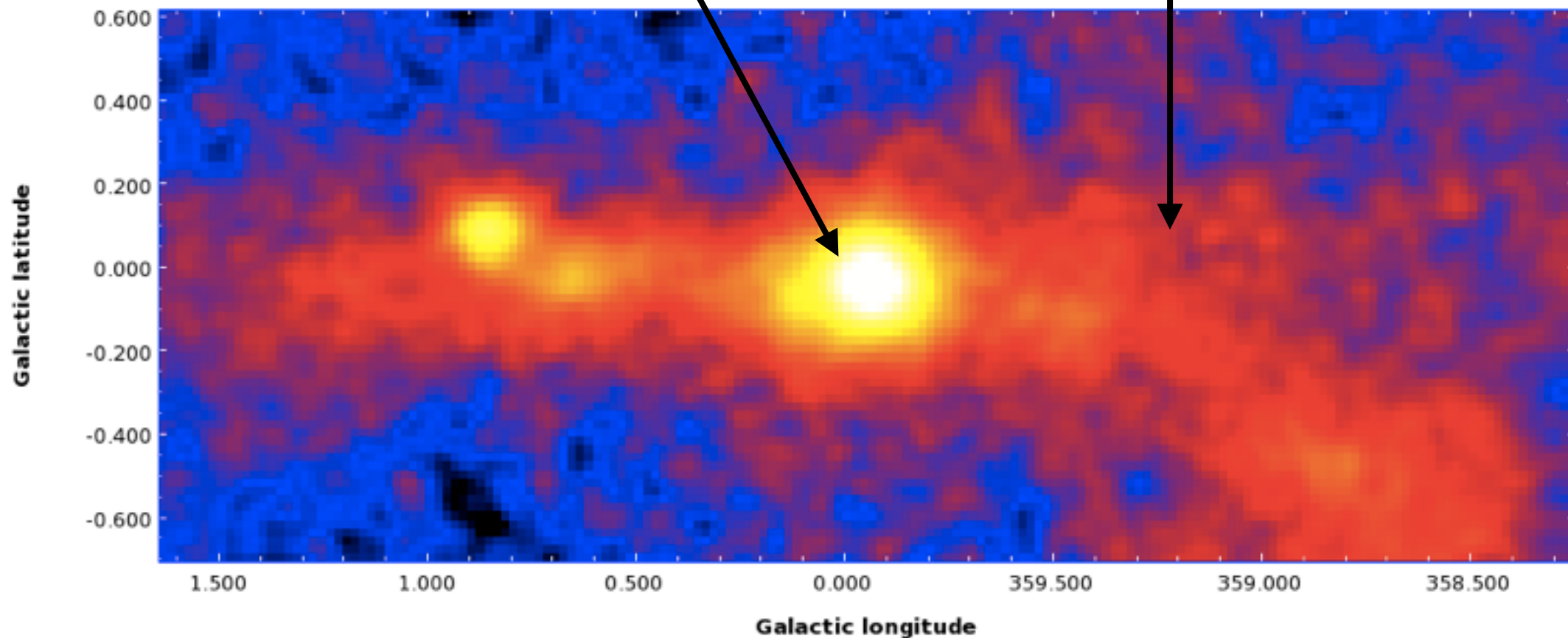
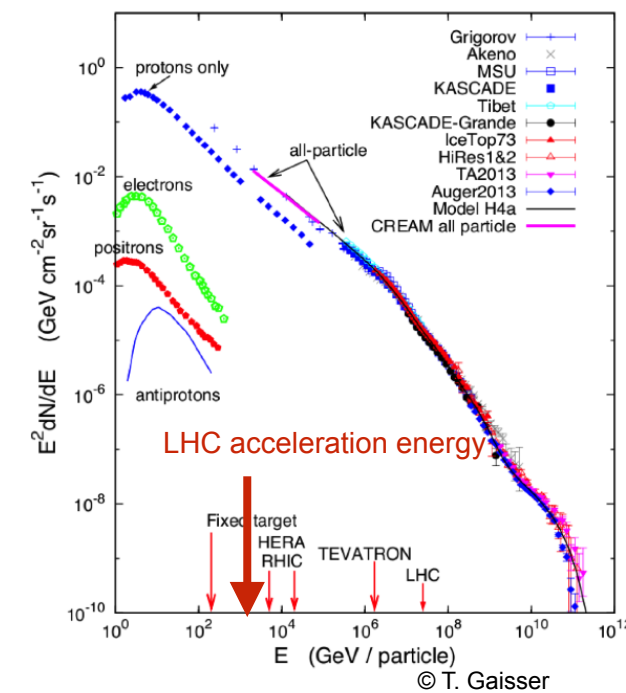
IHEP

III. Galactic Gamma-Ray Astronomy

Cosmic-ray accelerators:
gamma-ray sources

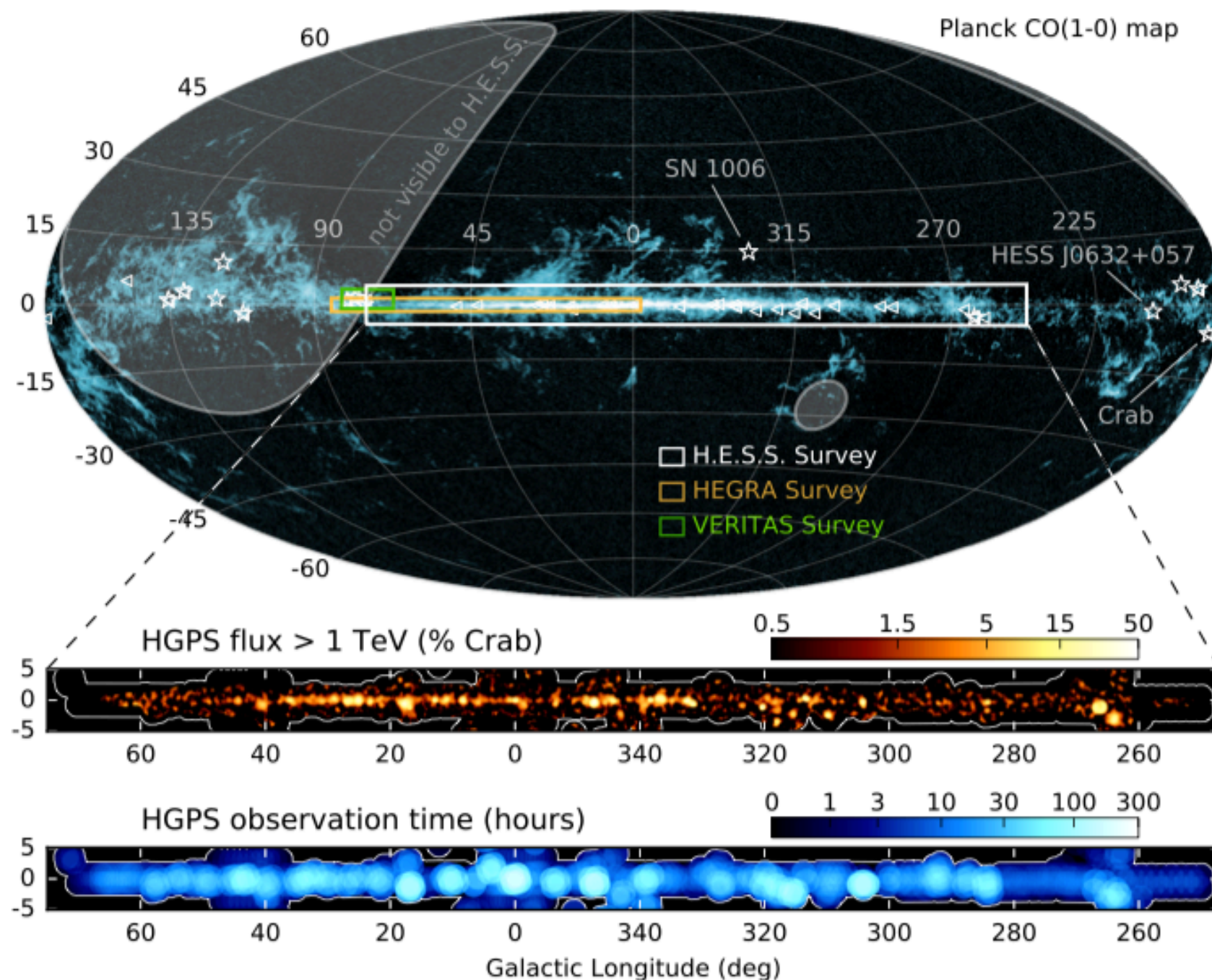
*with ≥ 30 TeV gamma-rays
probing CRs up to the knee*

Propagating cosmic rays:
diffuse gamma-ray emission



The View on our Milky Way

The H.E.S.S. Galactic Plane Survey

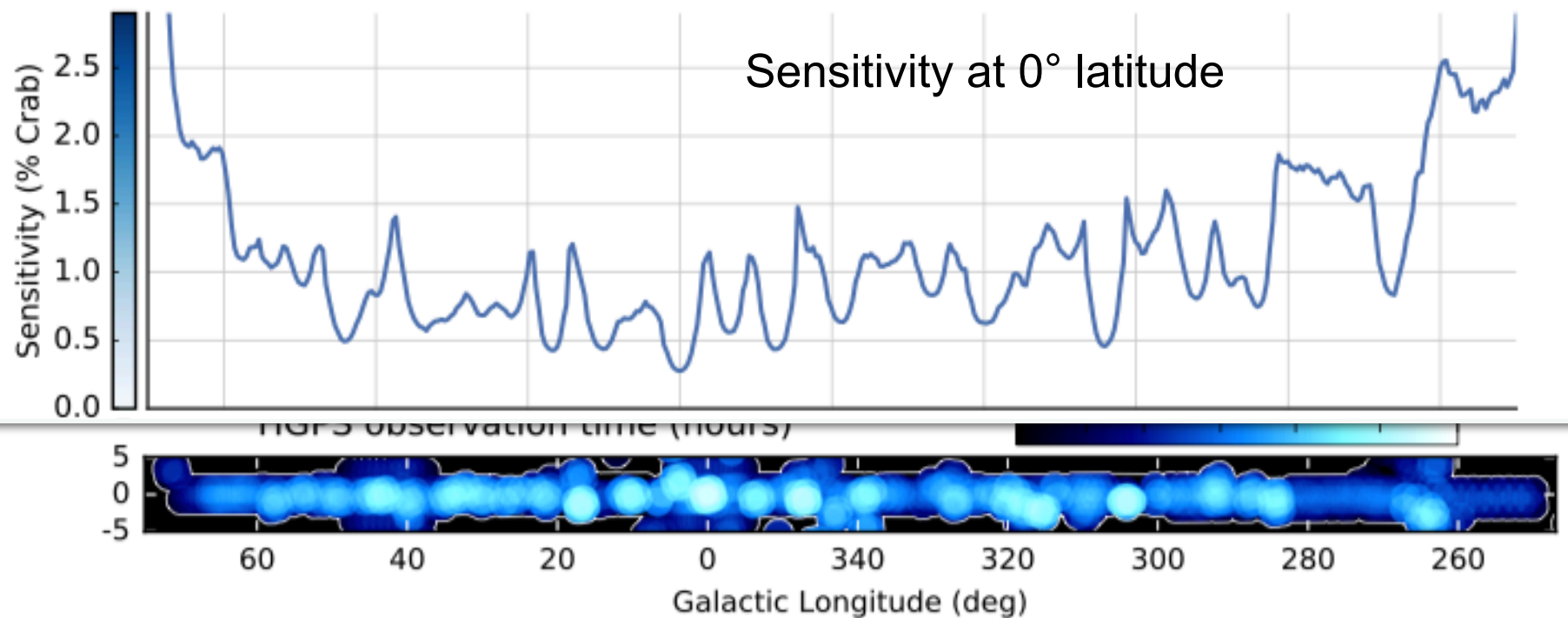
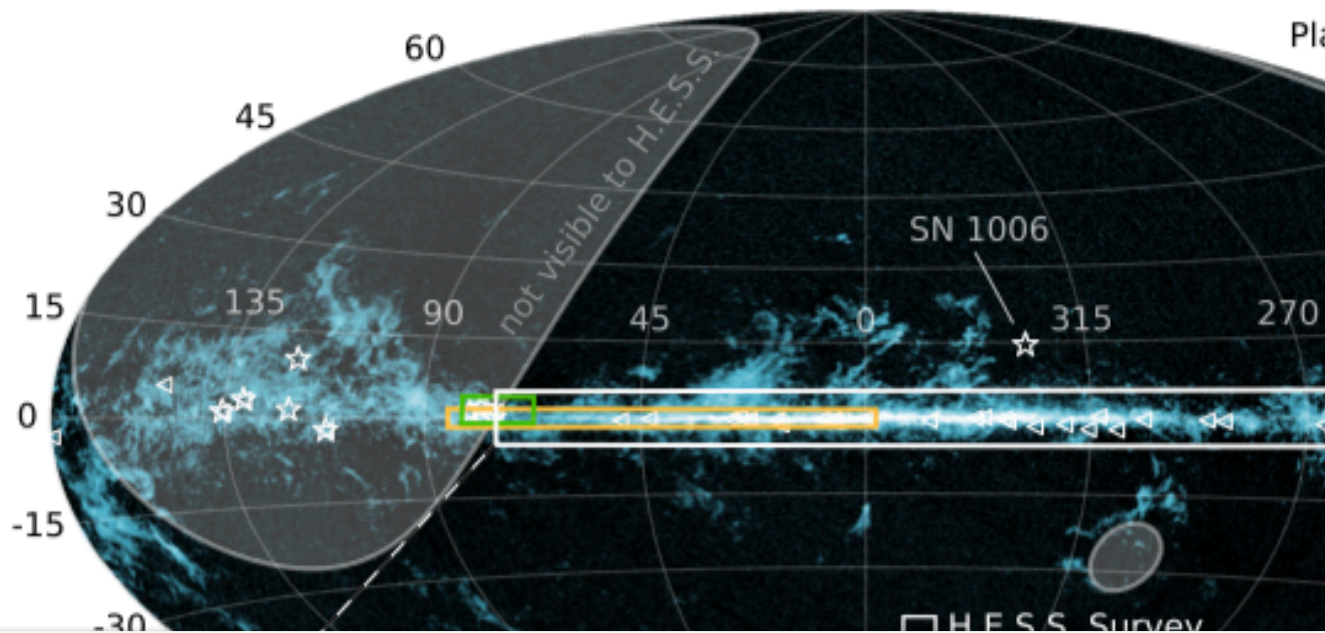
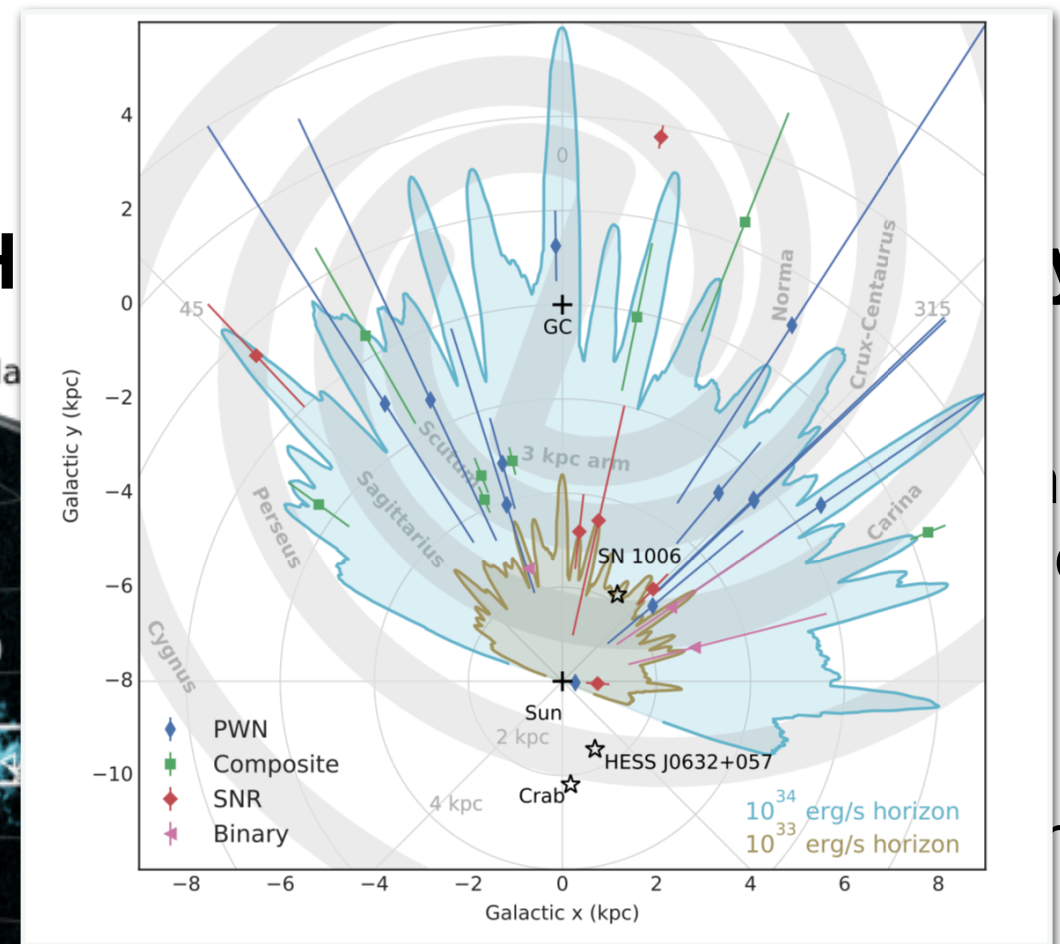


- Major effort of almost 10 years of pointed observations 2004 - 2013
- 2673 hours of high-quality data
- Covered area:
 $l = 250^\circ$ to 65° ,
 $|b| < 3^\circ$
- Inhomogeneous exposure

H.E.S.S. Collaboration, A&A 2018

The View on our Milky Way

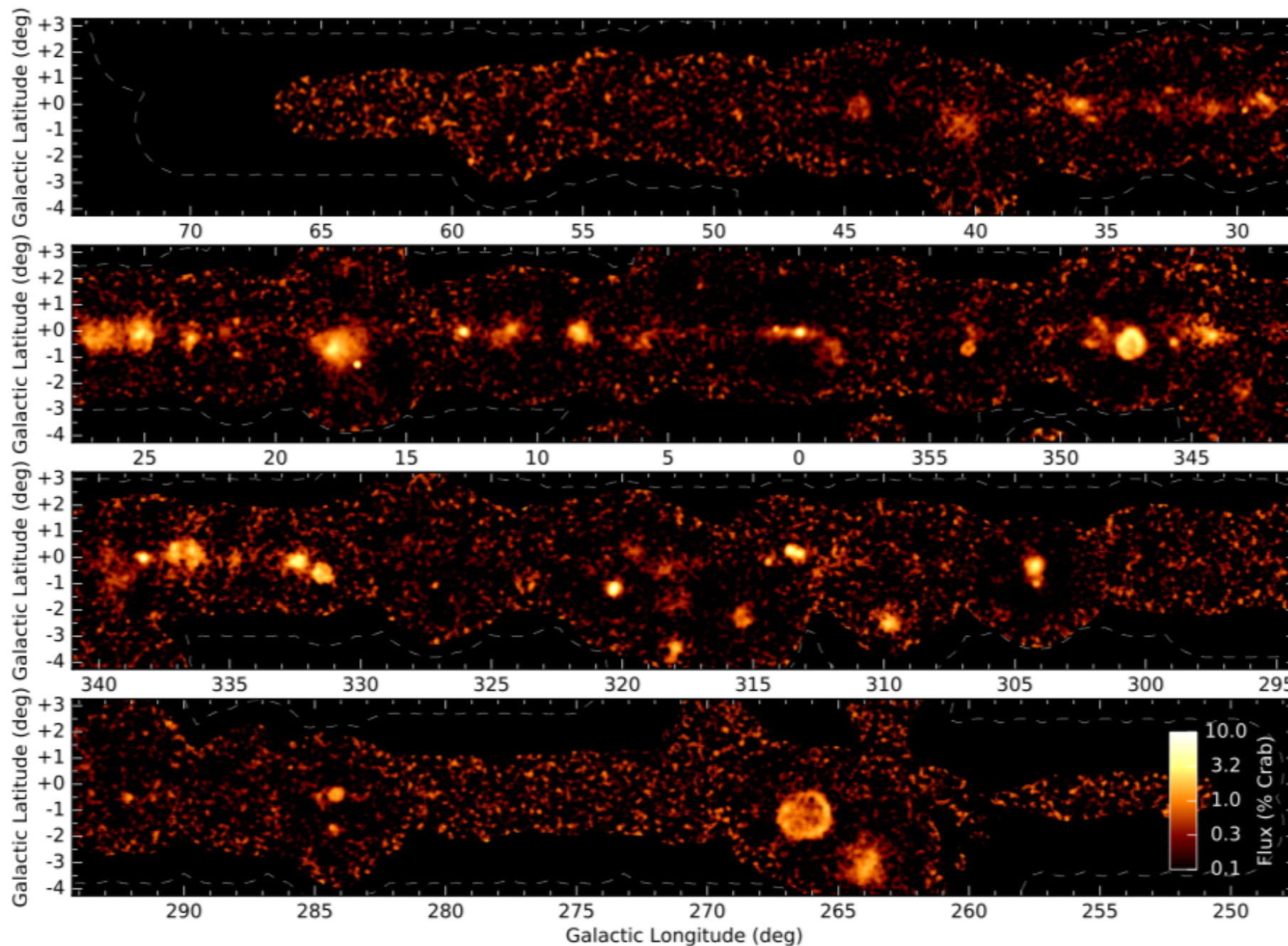
The H



- Covered area:
 $l = 250^\circ$ to 65° ,
 $|b| < 3^\circ$
- Inhomogeneous exposure

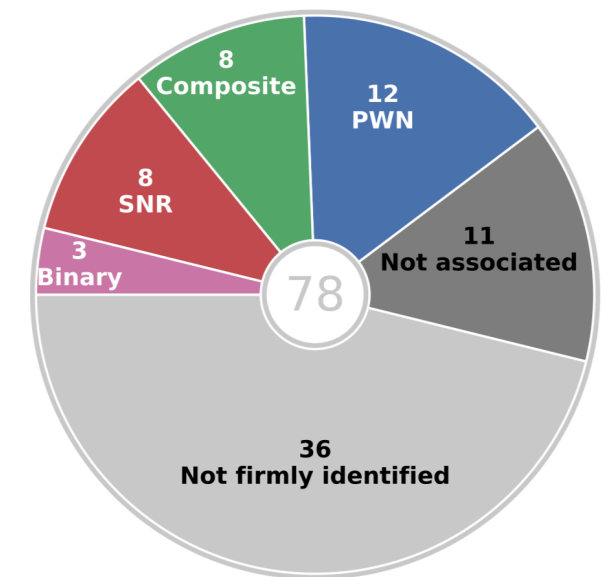
H.E.S.S. Collaboration, A&A 2018

The View on our Milky Way



H.E.S.S. Collaboration, A&A 2018

- Detection of 78 VHE sources along the plane,



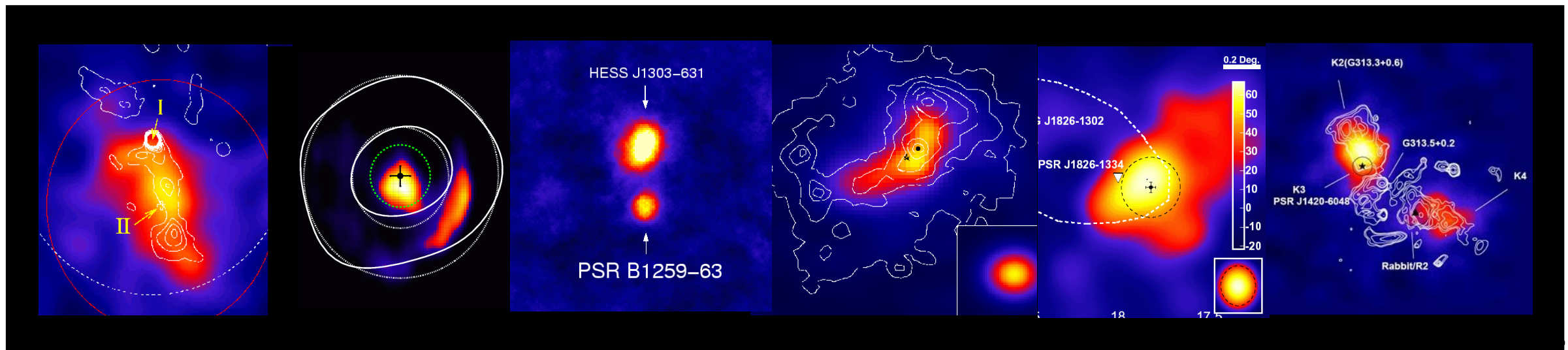
- And a component of large-scale diffuse emission
- Update of the HGPS catalogue in preparation (2HGPS)

Pulsar Wind Nebulae

Powerful winds driven by pulsars

Consisting of electromagnetic energy and highly relativistic particles

Wind interaction with ambient medium gives rise to a complex structure



Many known X-ray PWN identified as TeV emitters and almost all of the highest spin-down power radio pulsars have associated TeV emission

Efficient particle accelerators (leptonic emission)

Exist in many sizes, shapes, morphologies, distances to PSR

Many of our unidentified sources may be PWN

Supernova Remnants

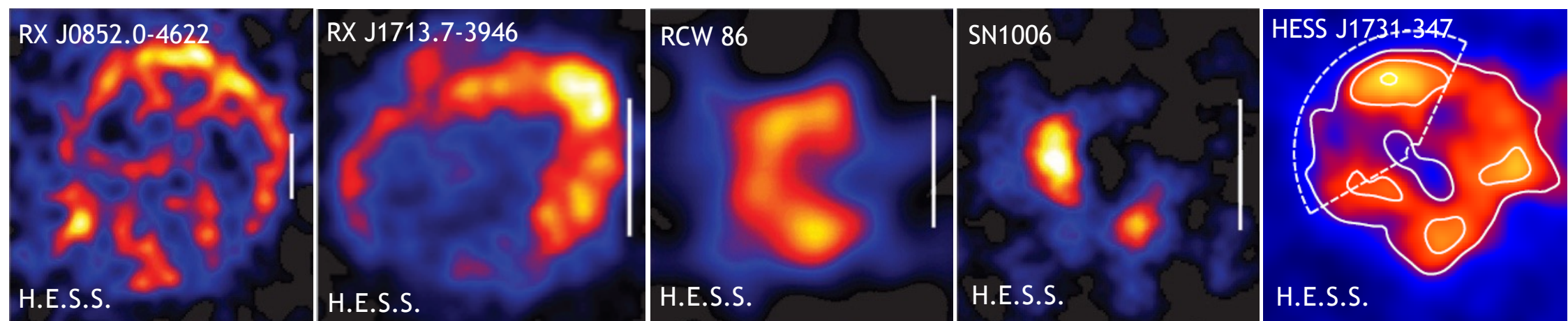
Shells created by a supernova explosion ($E \sim 10^{51}$ erg)

Consist of a mixture of supernova ejecta and shocked circumstellar medium

Initial velocities $> \sim 10,000$ km/s, young SNRs (~ 500 yr) ~ 2000 - 5000 km/s

Site of particle acceleration by 1st order Fermi mechanism

~ 250 Galactic SNRs identified as extended radio sources (Green's catalog)



Morphology

correlation with gas? $\rightarrow$ hadronic origin

correlation with radio? $\rightarrow$ leptonic origin

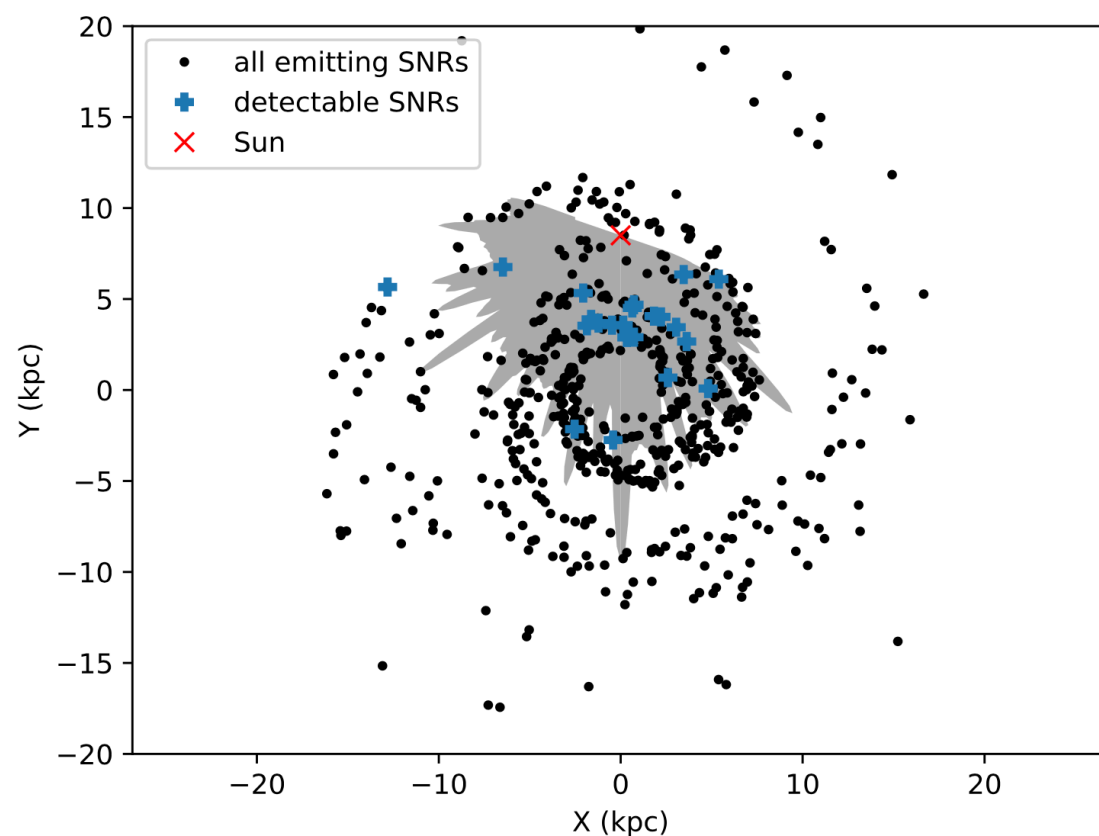
$\rightarrow$ angular resolution crucial!

*What are the accelerated particles?
Is emission leptonic or hadronic?*

Going from single sources to source populations

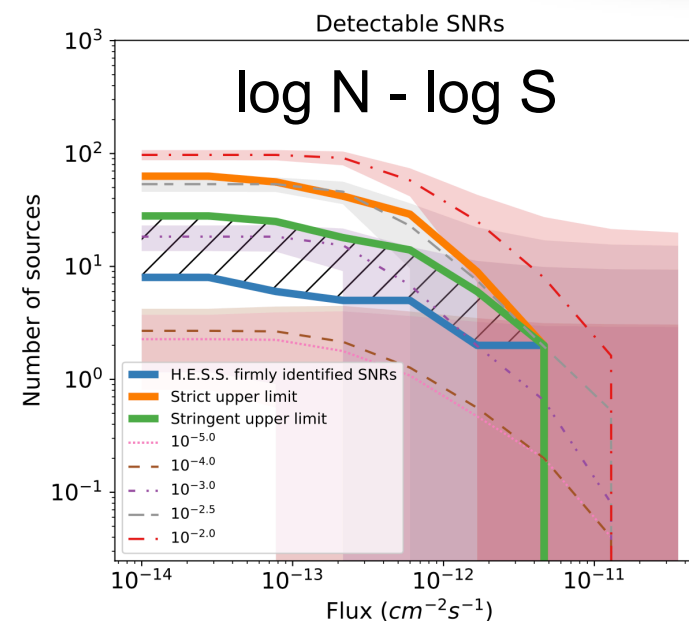
Only a small and biased subsample of sources visible

Requires population synthesis to derive population properties



1. Simulation of population
2. Determination of detectable subsample (detection threshold)
3. Comparison with data

→ preference for small fraction of electrons while having decent number of leptonic-dominated SNRs detected

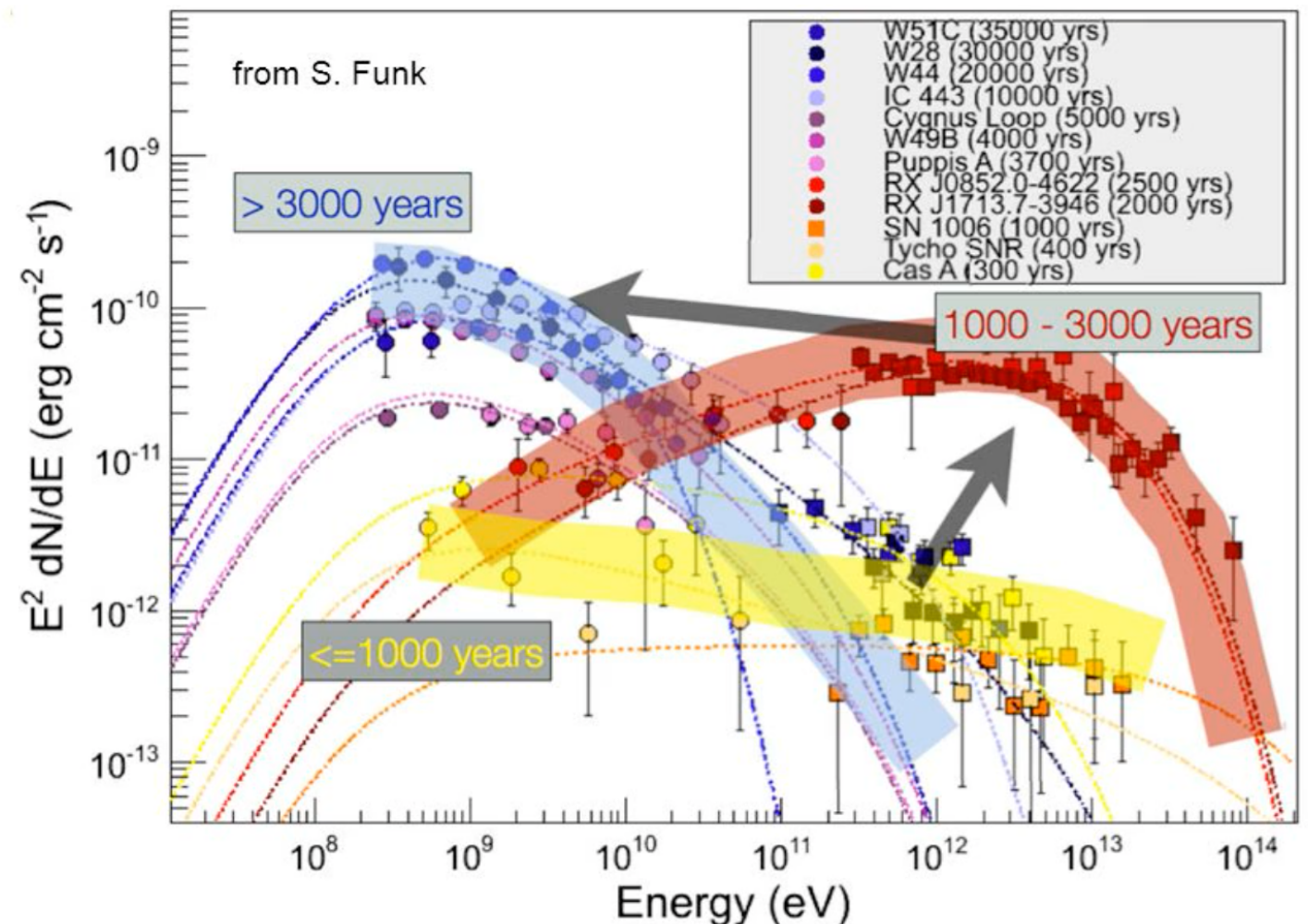
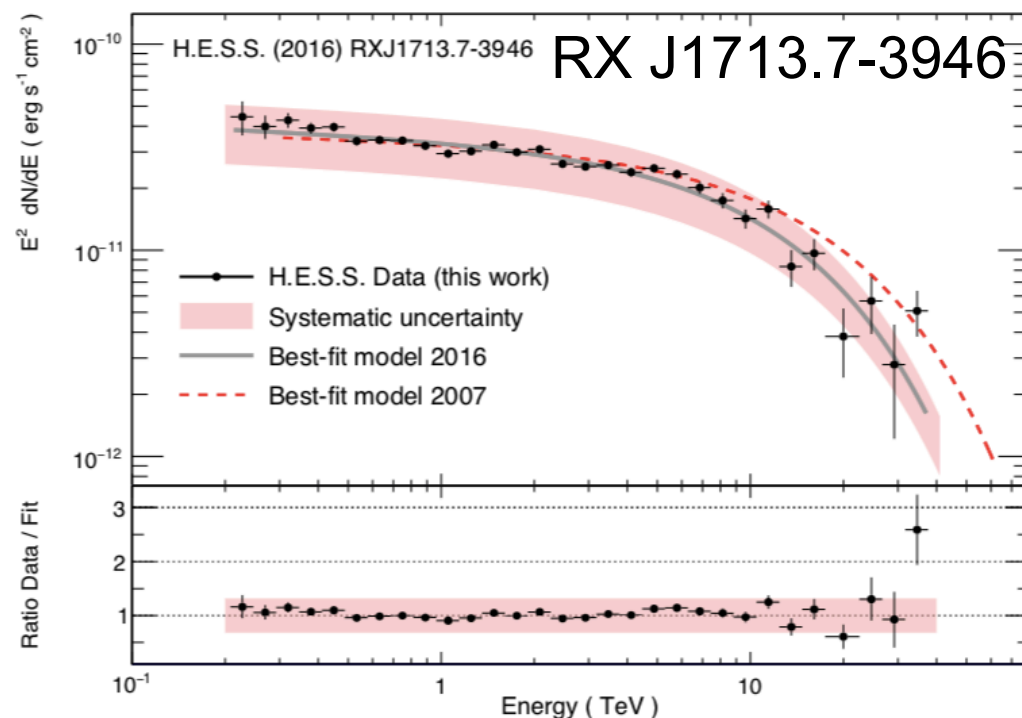


example:
variation of the e/p ratio:
 $10^{-2} - 10^{-5}$

Batzofin et al. 2024

Do SNRs accelerate cosmic rays up to the knee?

- Besides differentiation of leptonic vs hadronic, need spectral information!
- Most SNRs (and other sources as well) feature cutoffs at few TeV

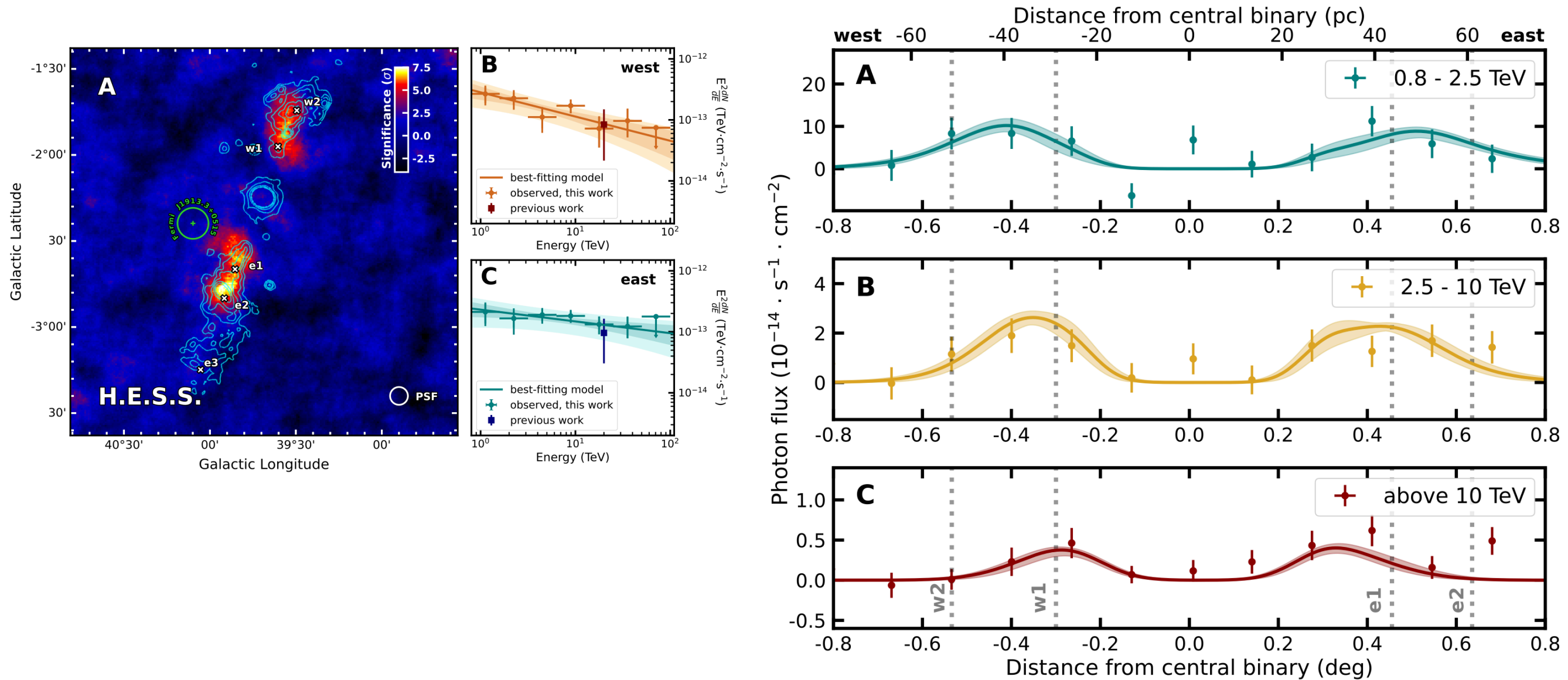


Could be timing problem...

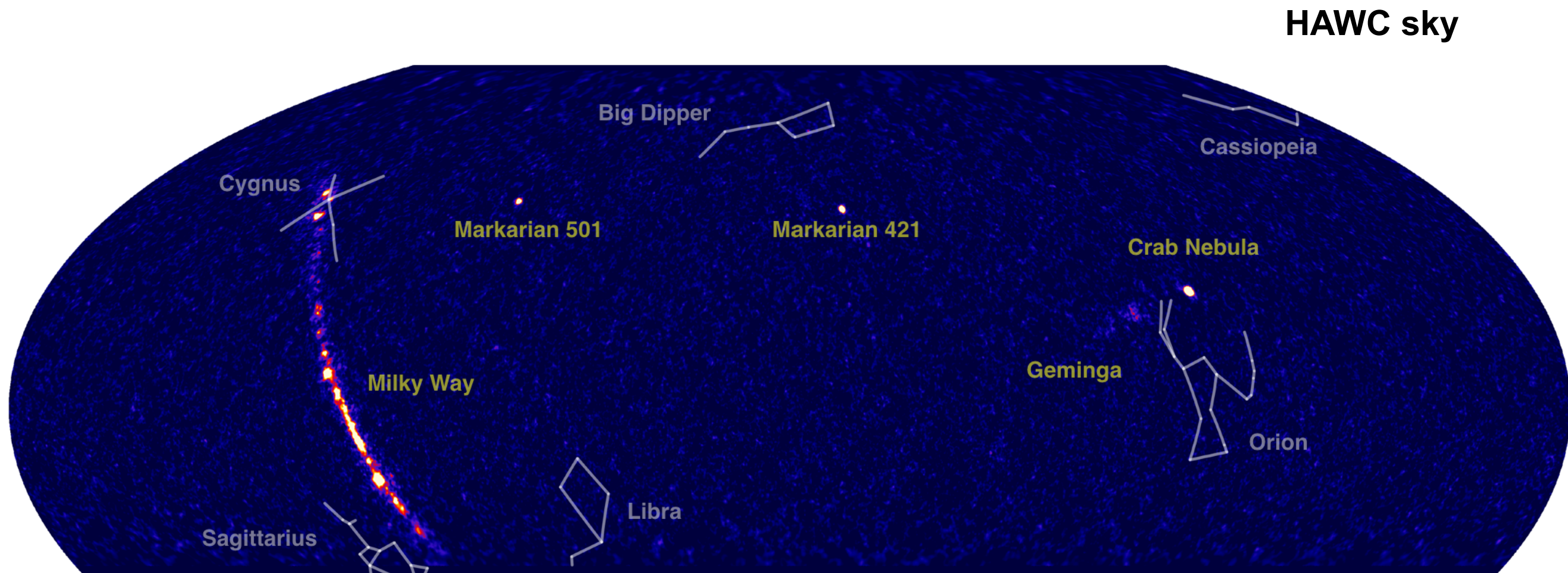
Acceleration and transport of relativistic electrons in the jets of the microquasar SS 433

H.E.S.S. COLLABORATION [Authors Info & Affiliations](#)

SCIENCE • 25 Jan 2024 • Vol 383, Issue 6681 • pp. 402-406 • DOI: 10.1126/science.adi2048

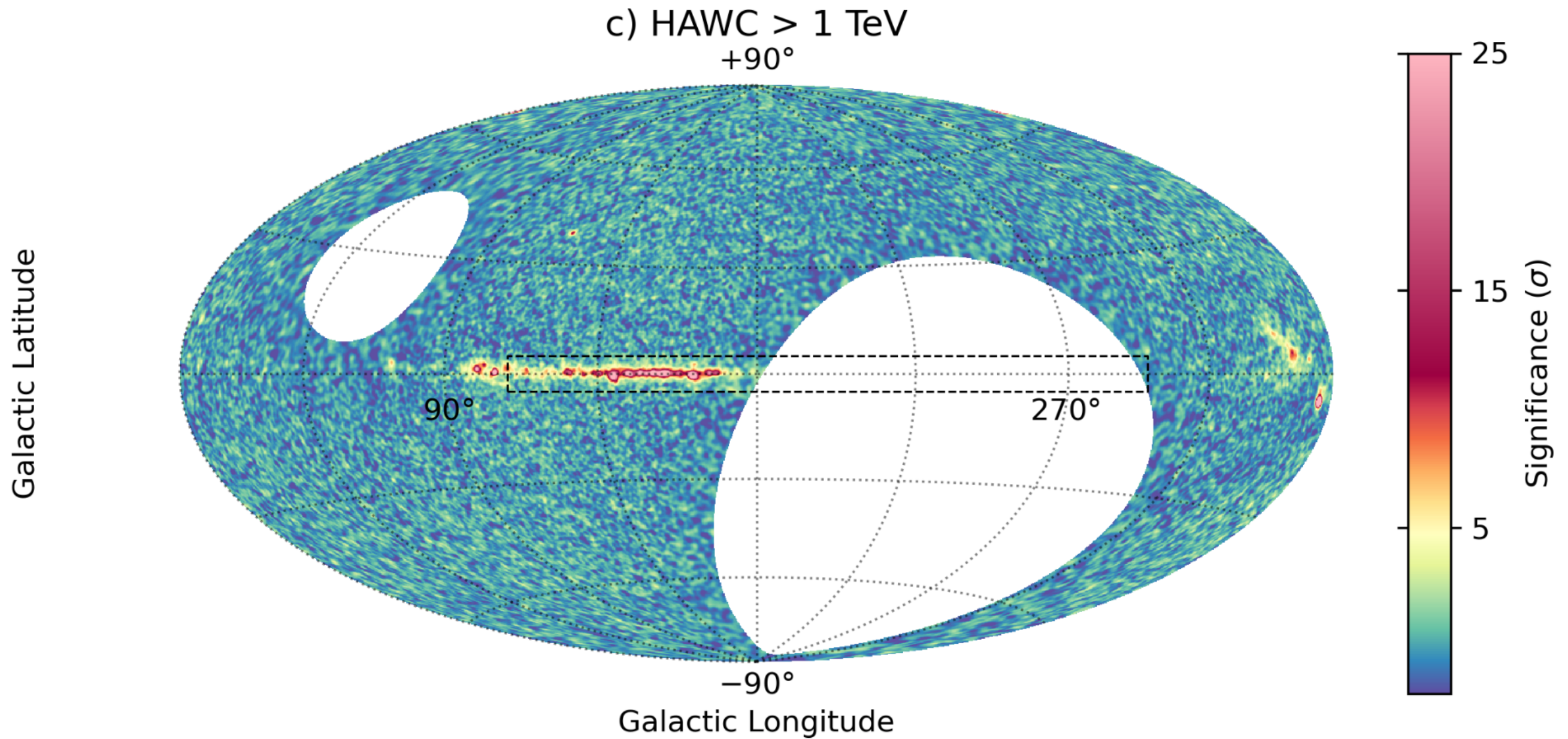


Particle Detector Arrays: The HAWC Sky

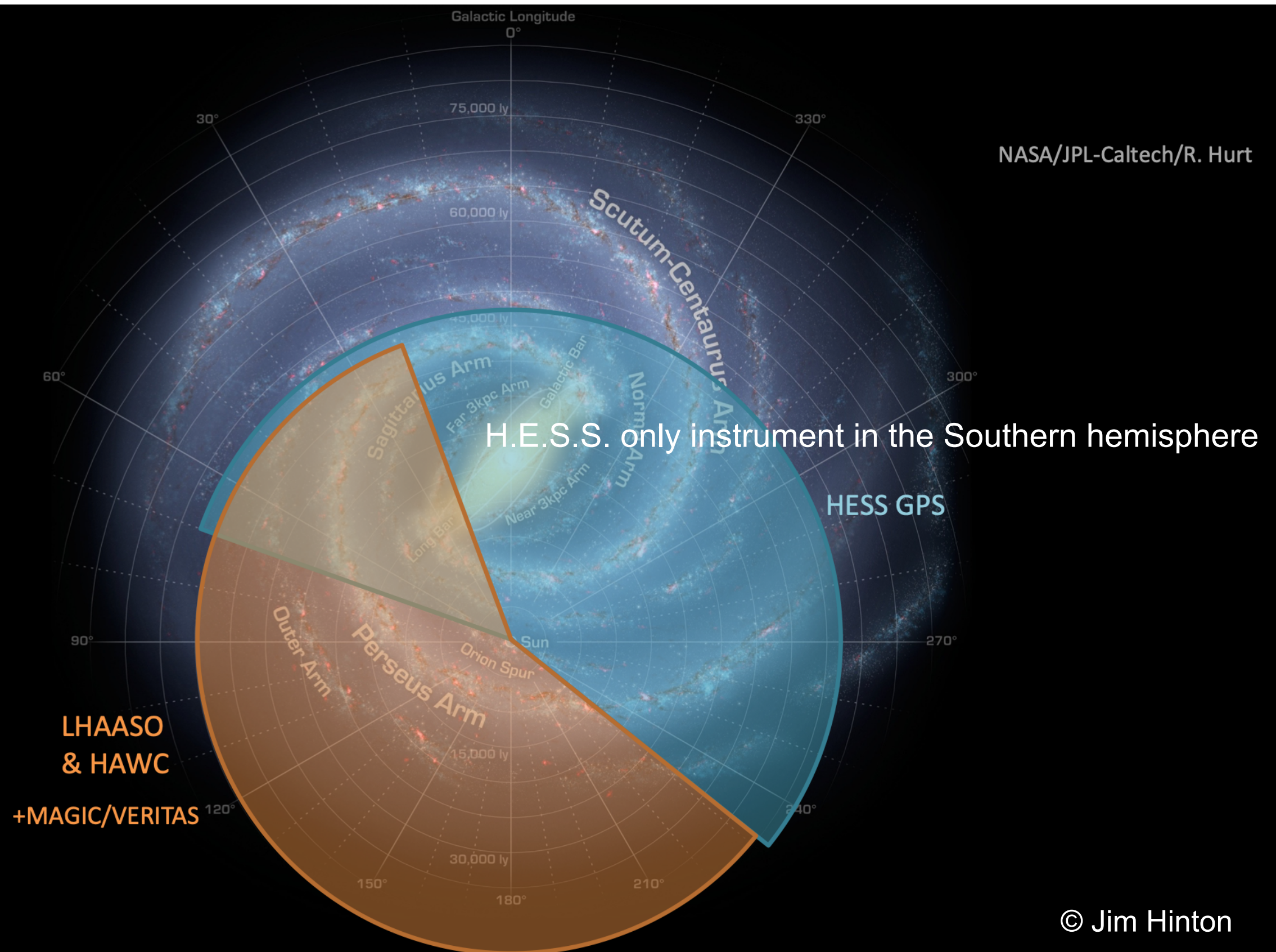


Beautiful view on the Northern Hemisphere

Particle Detector Arrays: The HAWC Sky



What we see....



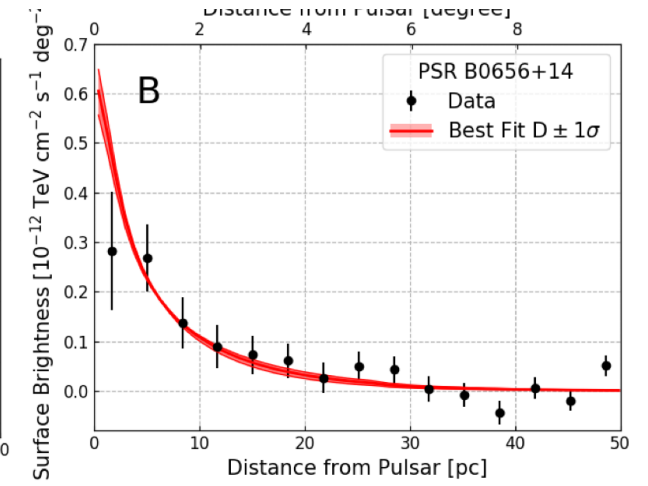
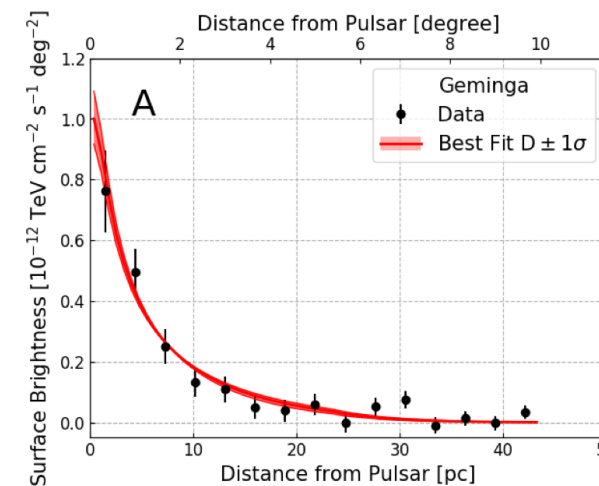
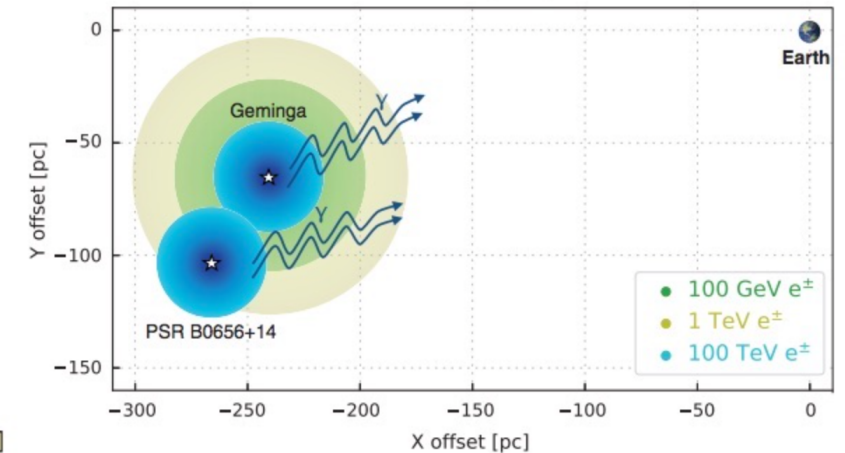
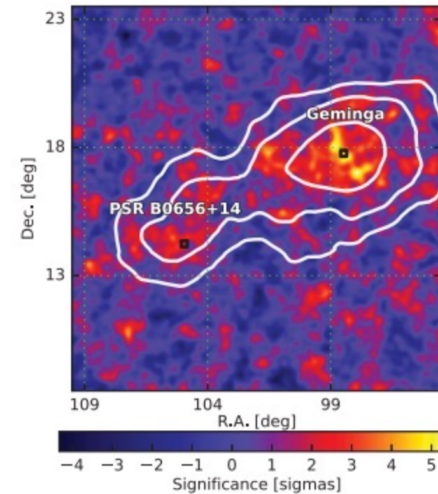
A Case for Particle Detector Arrays: Very Extended Sources

Geminga and **Monogem** pulsars surrounded by a spatially extended region (~ 20 pc) emitting multi-TeV gamma-rays

HAWC

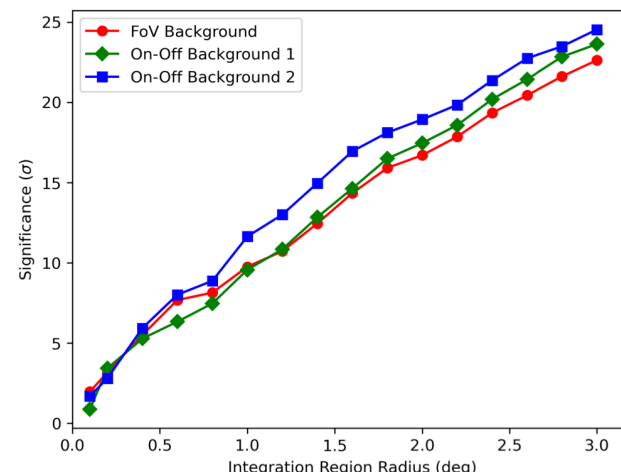
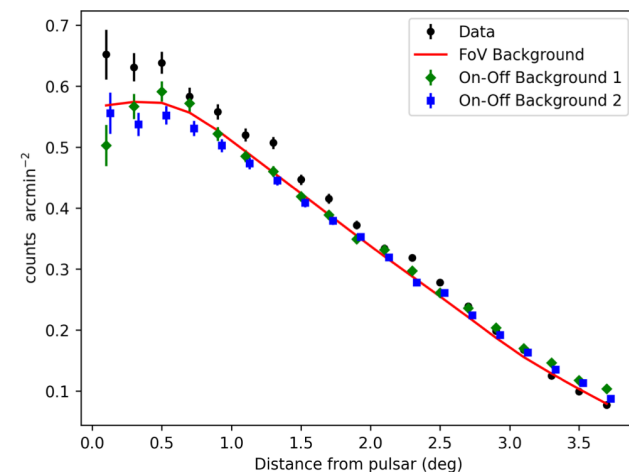
TeV halos as new source class

- Diffusion coefficient two orders of magnitude lower?
- H.E.S.S. results dependent on the applied background subtraction technique



HAWC Collaboration 2017

H.E.S.S.



H.E.S.S. Collaboration 2023

**Crucial for IACTs: subtraction of
the background of charged cosmic rays!**



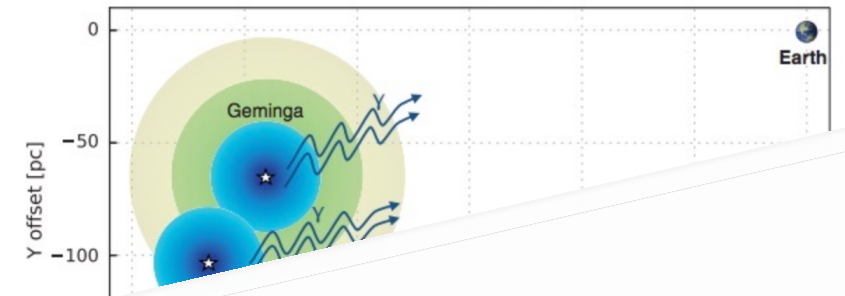
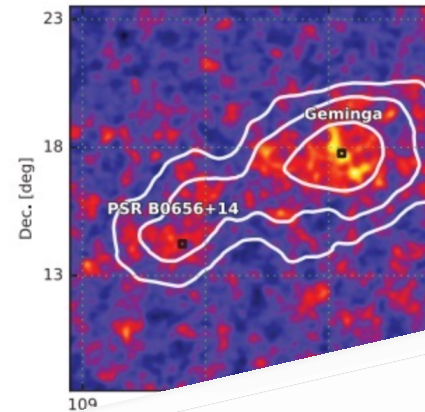
Example of a Very Extended Source

Geminga and **Monogem** pulsars surrounded by a spatially extended region (~ 20 pc) emitting multi-TeV gamma-rays

TeV halos as new source class

- Diffusion coefficient two orders of magnitude lower

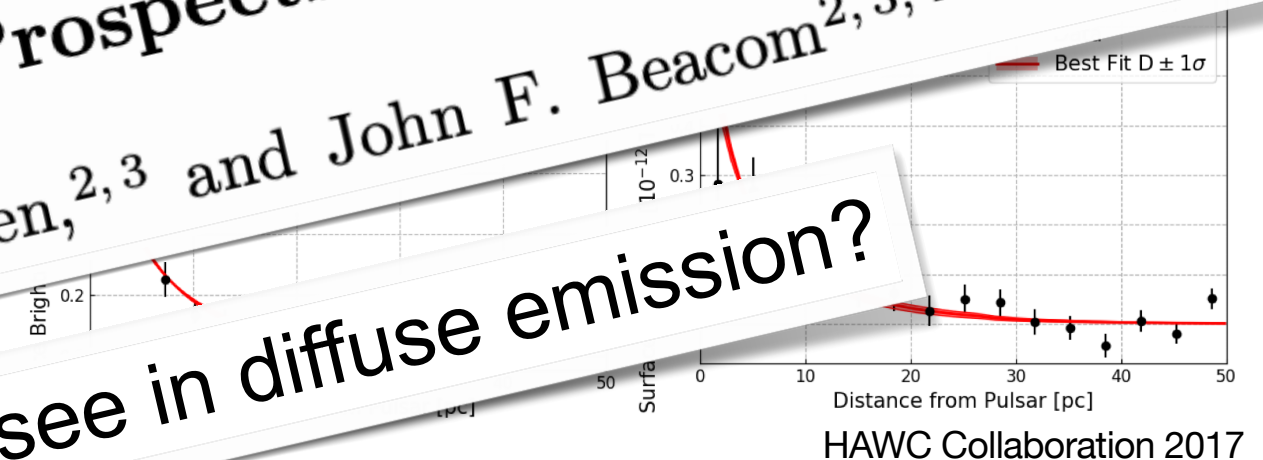
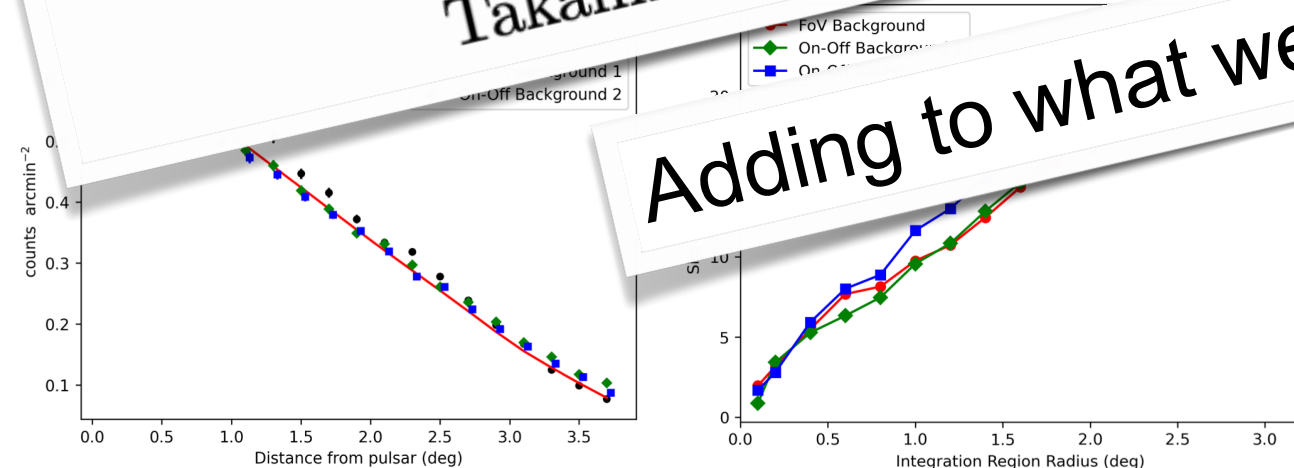
HAWC



TeV Halos are Everywhere: Prospects for New Discoveries
Takahiro Sudoh,^{1,2} Tim Linden,^{2,3} and John F. Beacom^{2,3,4}

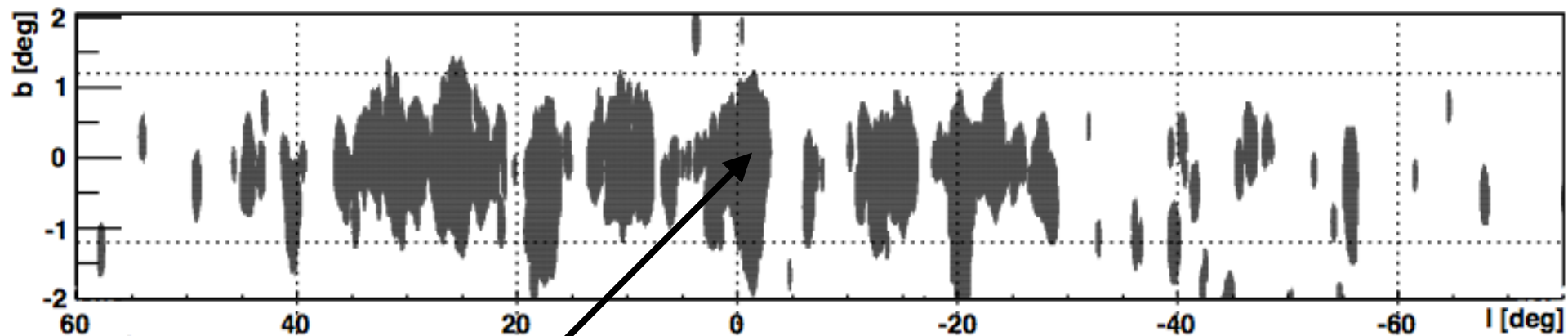
Adding to what we see in diffuse emission?

Crucial for IACTs: subtraction of the background of charged cosmic rays!



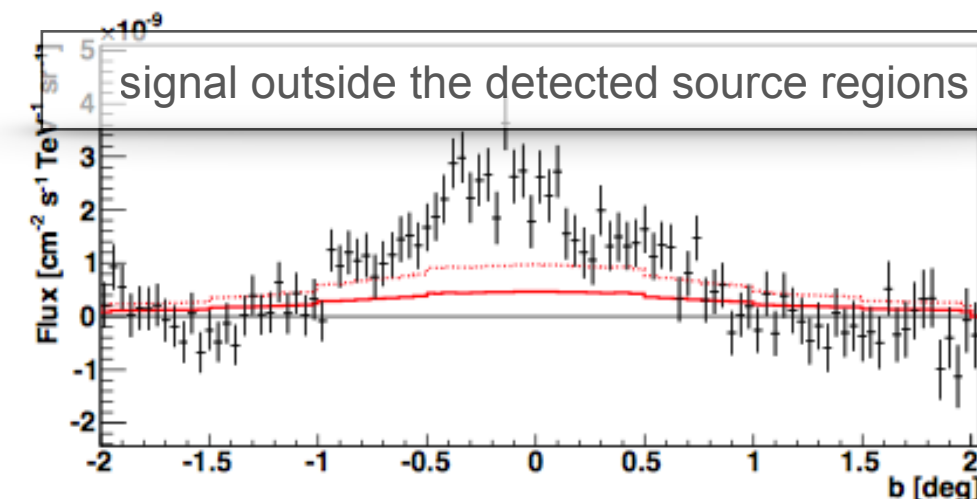
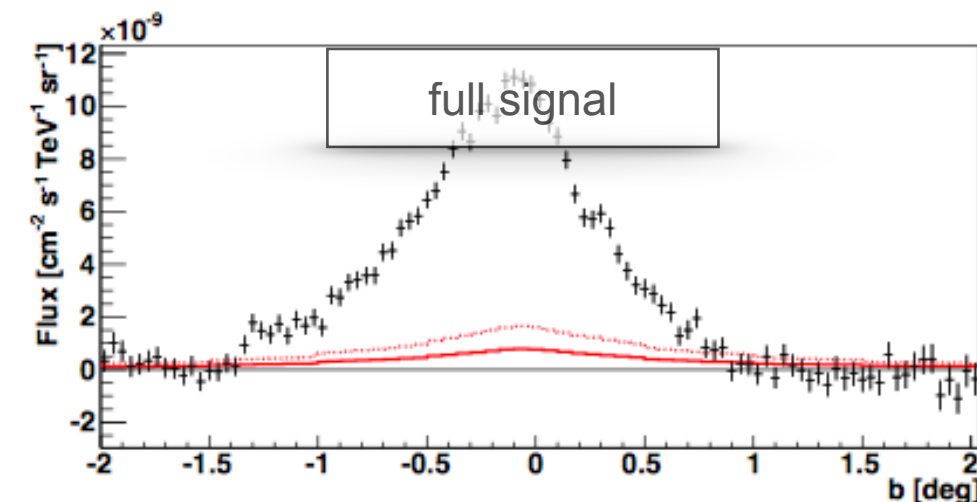
Diffuse Emission at TeV energies (IACTs)

- Complicated due to the bright sources everywhere



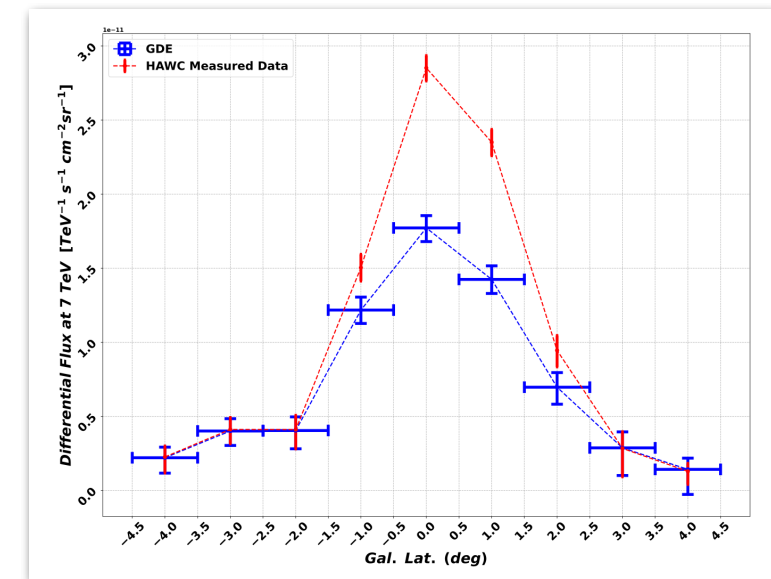
significantly detected γ -ray sources

- Accumulated large-scale signal outside source regions
- Affected by background subtraction
→ measurable only a relative excess
- Signal is mixture of
 - hadronic component from π^0 decay
 - inverse Compton component
 - unresolved gamma-ray sources

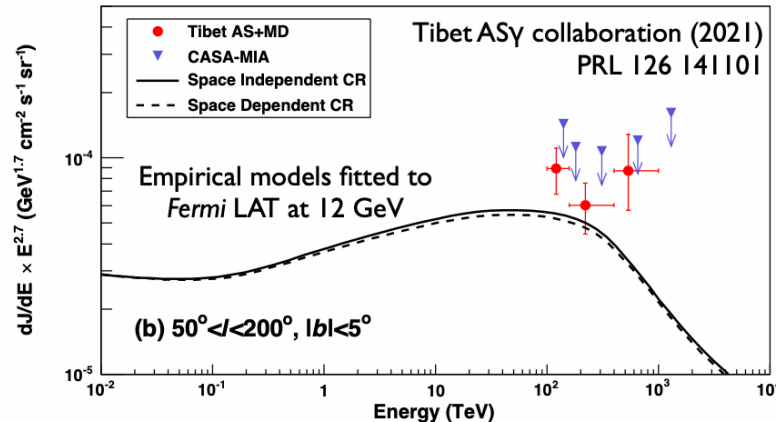
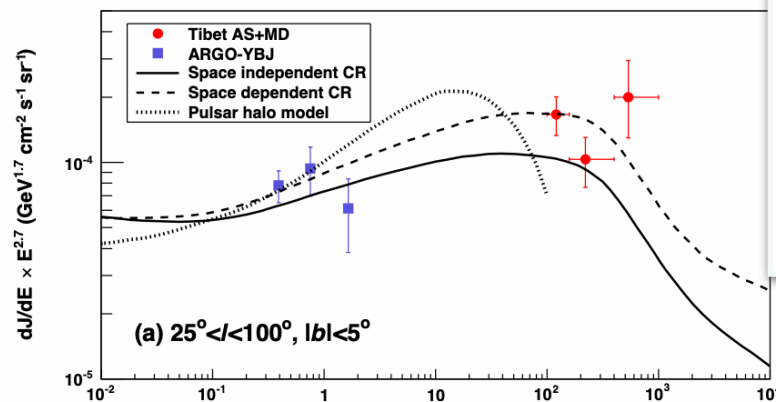
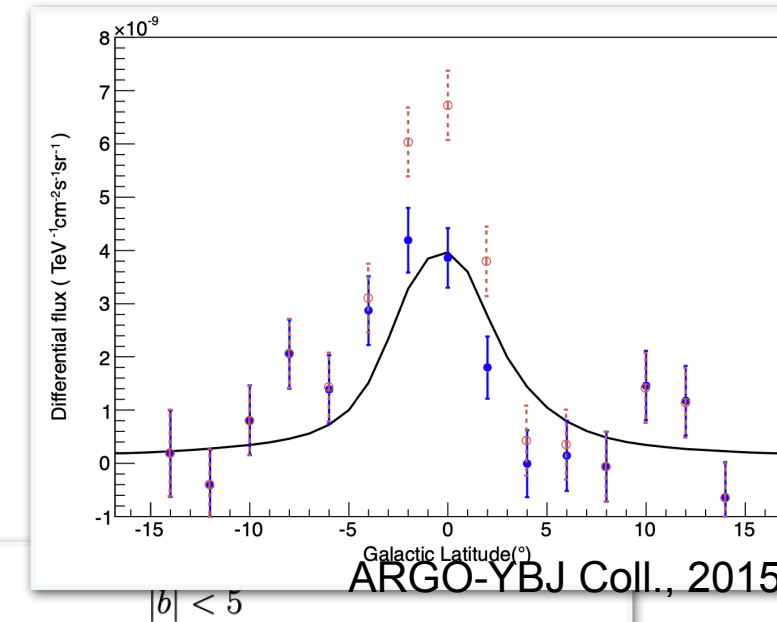
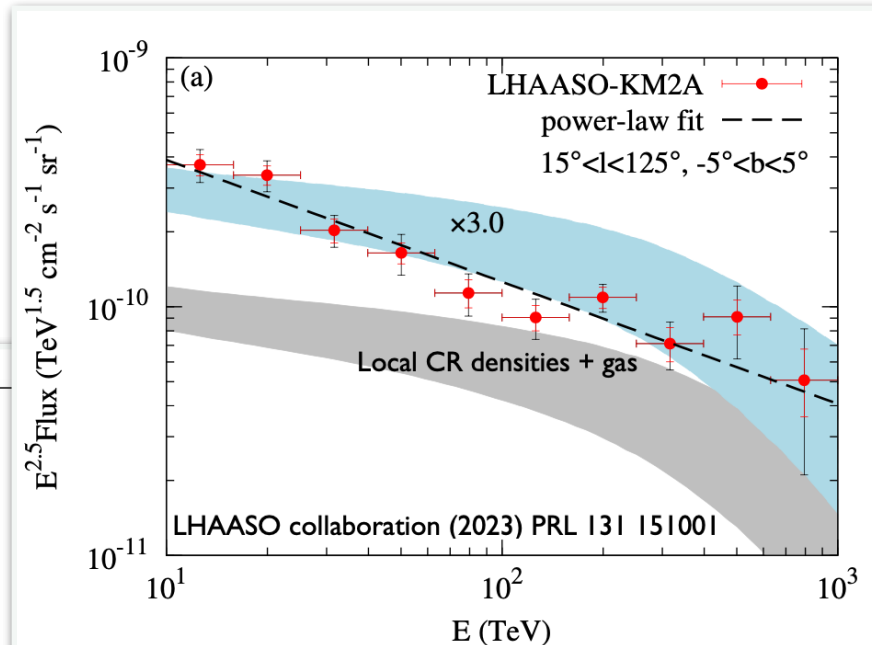


Diffuse Emission (Particle Detector Arrays)

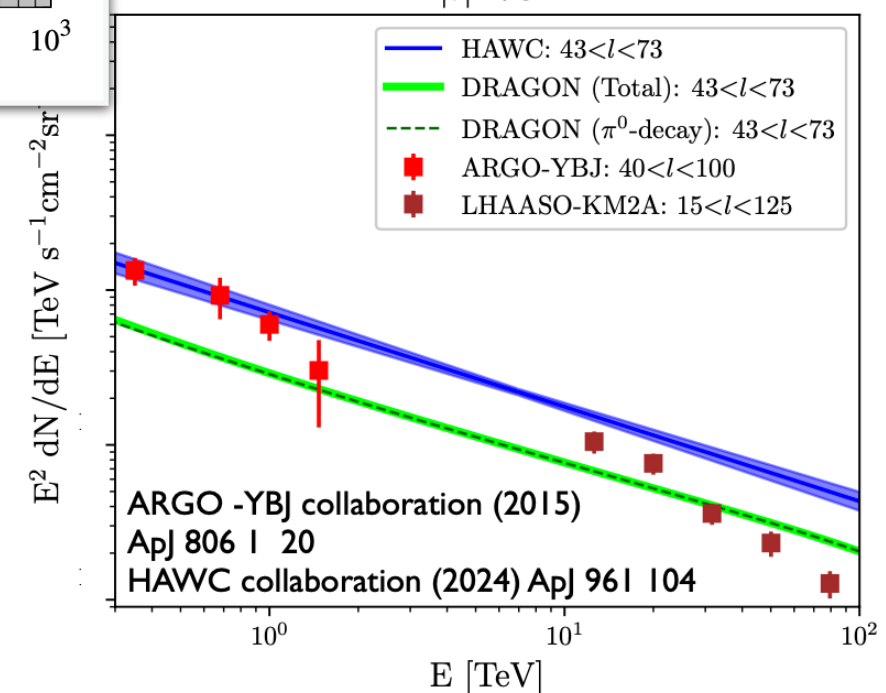
- Many recent measurements
- Careful in detail comparisons
→ different regions, different signal!
- Large contribution of diffuse emission to total emission



7 TeV diff. flux, $43^\circ < l < 73^\circ$
(HAWC 2023)



rin Egberts . Ground-Based Gamma-Ray



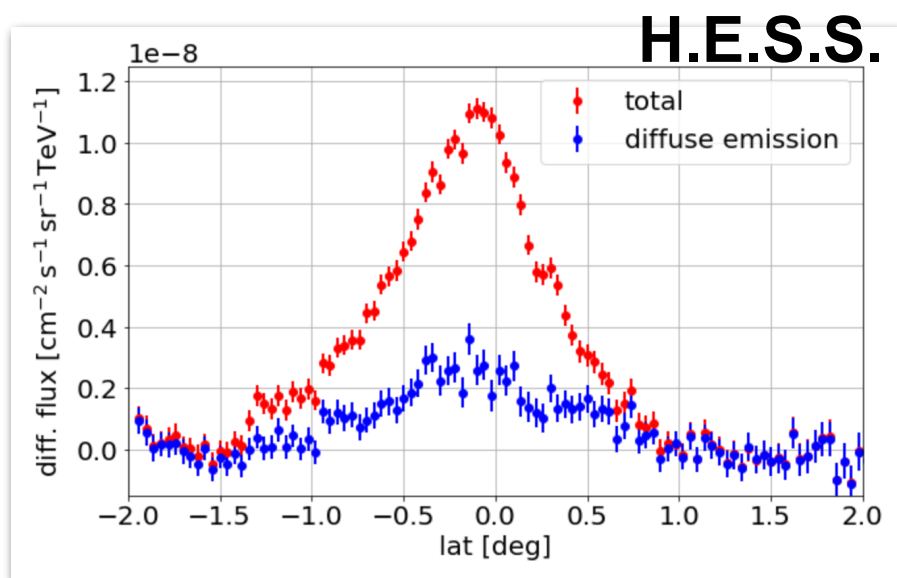
TeV sky dominated by sources or diffuse emission?

Imaging Atm. Cherenkov Telescopes

Small fields of view

Angular resolution of $\lesssim 0.1$ deg

Larger instantaneous sensitivity
(put into perspective by small FoV
and low duty cycle)



1 TeV diff. flux, $-75^\circ < l < 60^\circ$ (H.E.S.S. 2014)

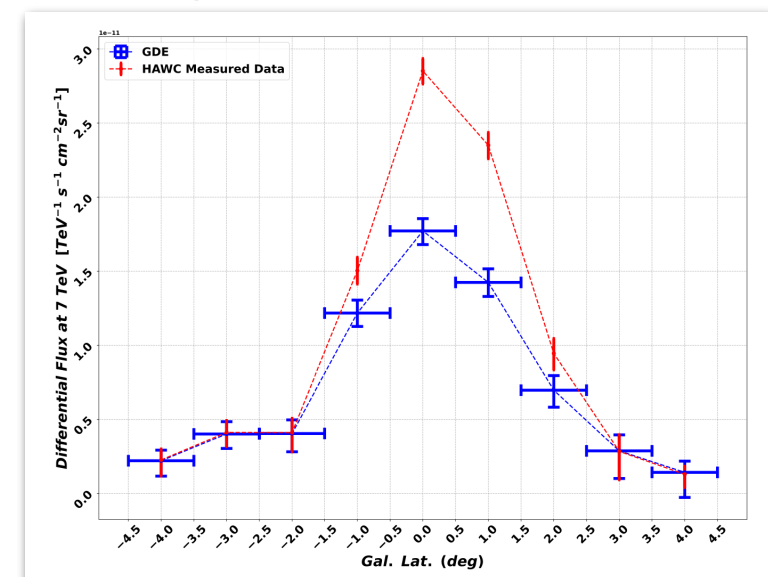
Particle Detector Arrays

Wide fields of view

Angular resolution of ~ 0.5 deg

Large duty cycle

HAWC



7 TeV diff. flux, $43^\circ < l < 73^\circ$
(HAWC 2023)

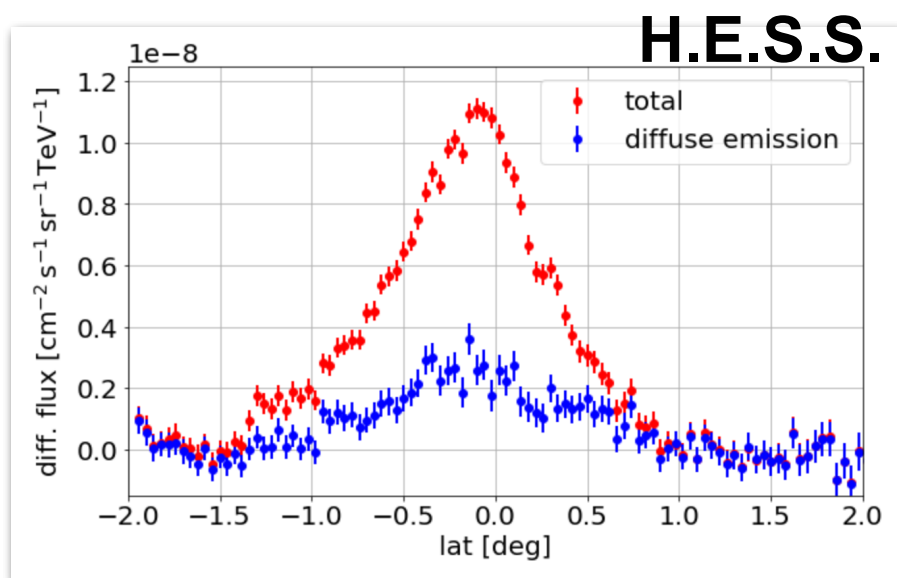
TeV sky dominated by sources or diffuse emission?

Imaging Atm. Cherenkov Telescopes

Small fields of view

Angular resolution of $\lesssim 0.1$ deg

Larger instantaneous sensitivity
(put into perspective by small FoV
and low duty cycle)



1 TeV diff. flux, $-75^\circ < l < 60^\circ$ (H.E.S.S. 2014)

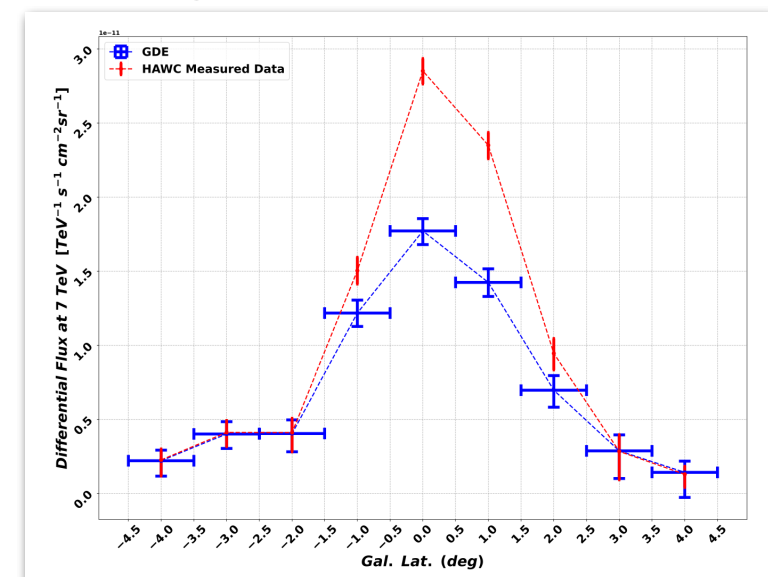
Particle Detector Arrays

Wide fields of view

Angular resolution of ~ 0.5 deg

Large duty cycle

HAWC



7 TeV diff. flux, $43^\circ < l < 73^\circ$
(HAWC 2023)

Causes double drawback for IACTs:

1. limits the **data set** and the region to be probed
2. renders **background estimation** from within FoV challenging

→ **underestimation of diffuse signal in IACTs**

TeV sky dominated by sources or diffuse emission?

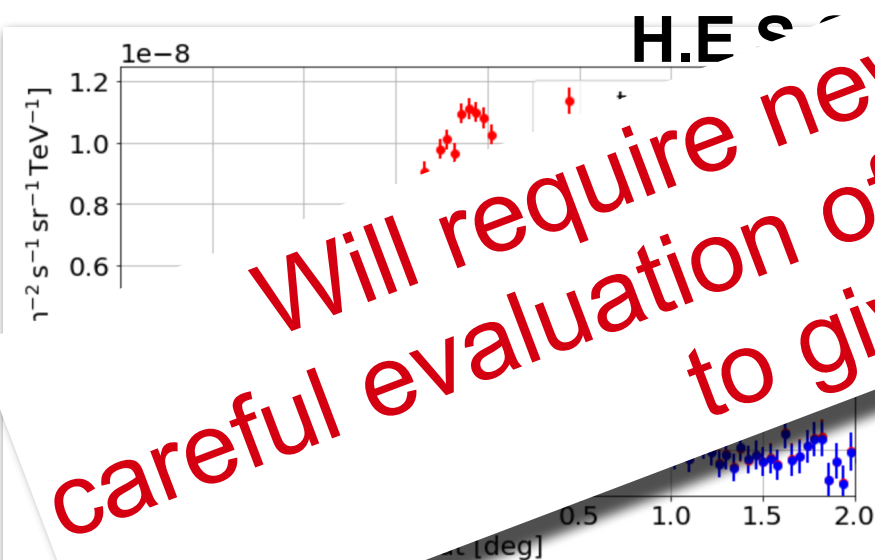
Imaging Atm. Cherenkov Telescopes

Small fields of view

Angular resolution of $\lesssim 0.1$ deg

Larger instantaneous sensitivity

(put into perspective by small FoV and low duty cycle)



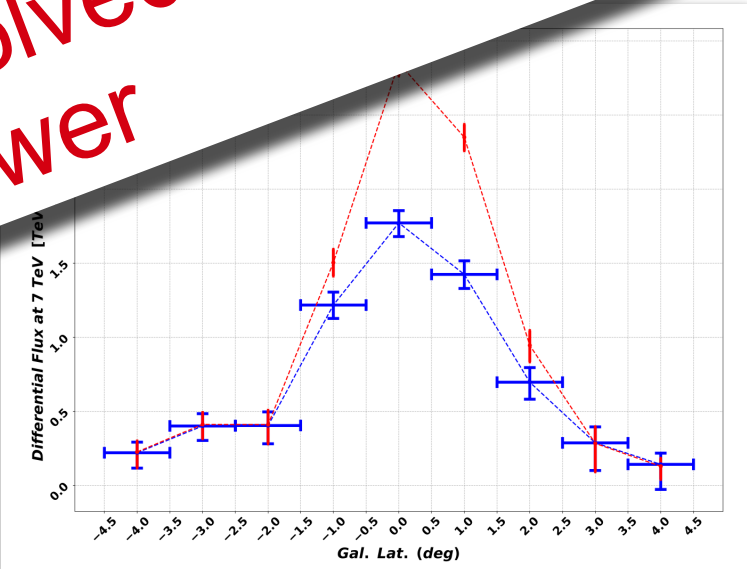
Will require new measurements and careful evaluation of the unresolved contribution to give final answer

diff. flux, $-75^\circ < l < 60^\circ$ (H.E.S.S. 2014)

Particle Detector Arrays

Wide fields of view

Angular resolution of ~ 5 deg



7 TeV diff. flux, $43^\circ < l < 73^\circ$
(HAWC 2023)

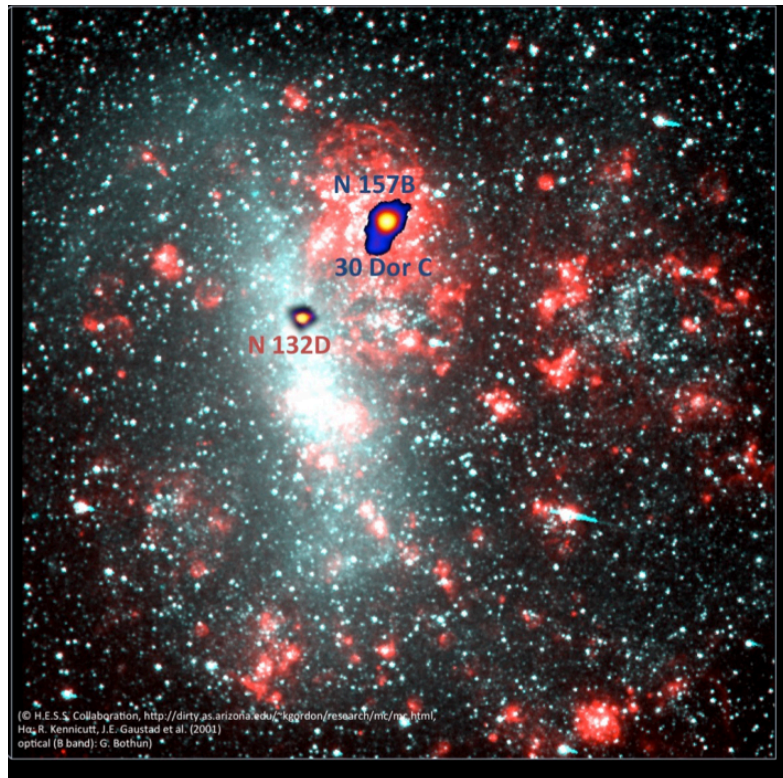
Helps not only in resolving structures
but also in the **discrimination of γ -ray sources**

measurable diffuse = truly diffuse + unresolved sources

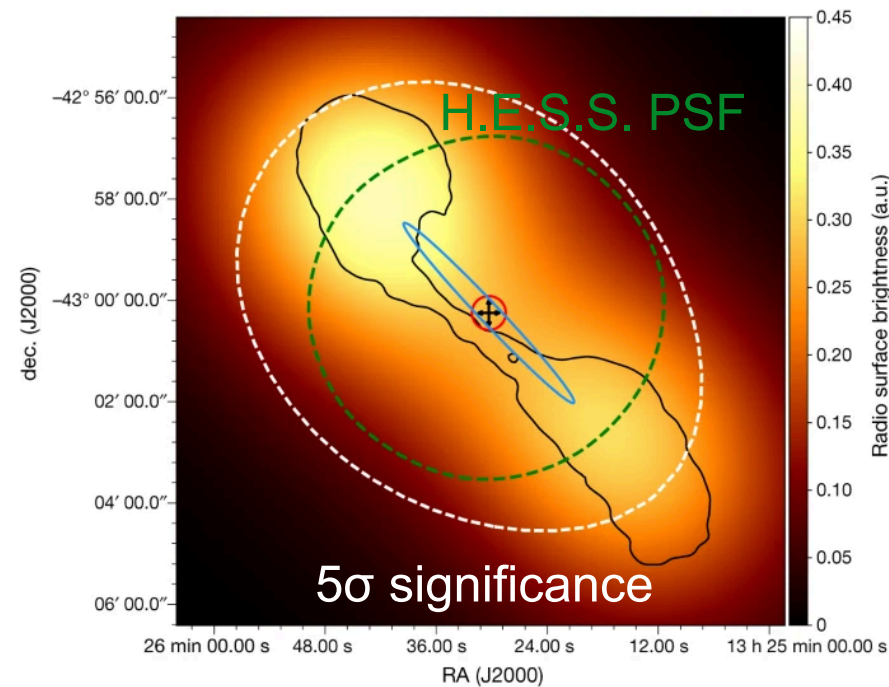
III. Extragalactic Gamma-Ray Astronomy

Distances get larger, angular scales smaller

LMC

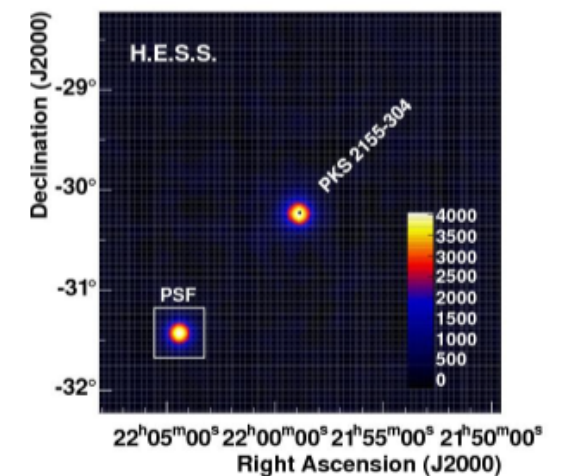


Cen A

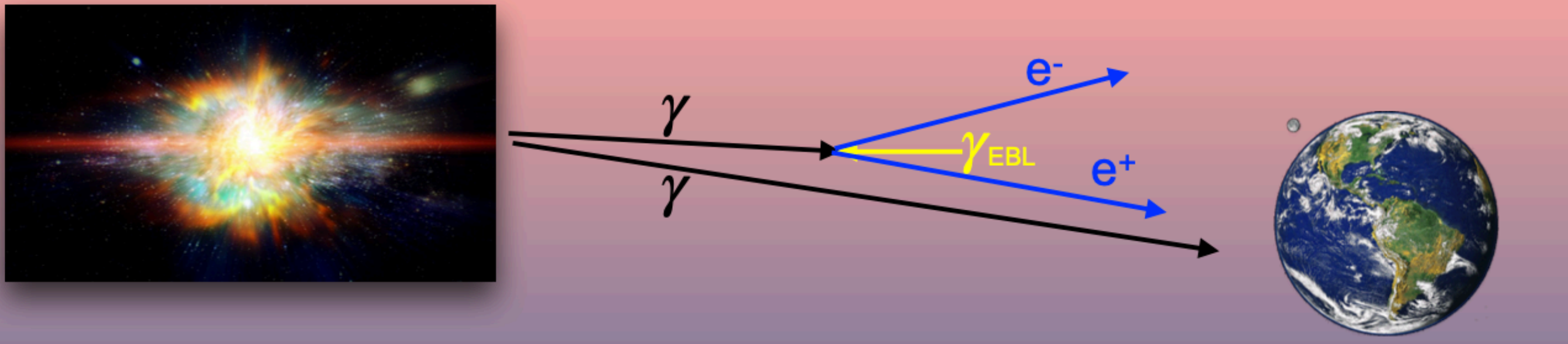


VLA radio surface brightness
(smoothed and as contours)

PKS 2155-304

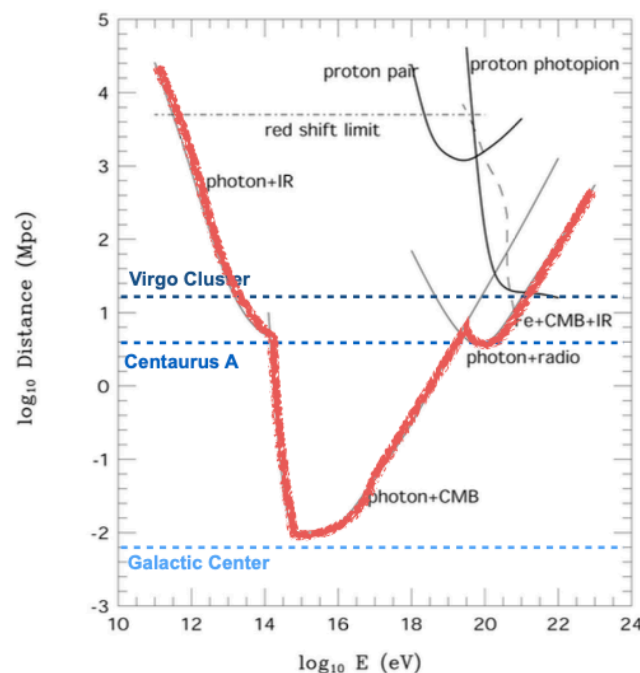


Observable energies are smaller as well



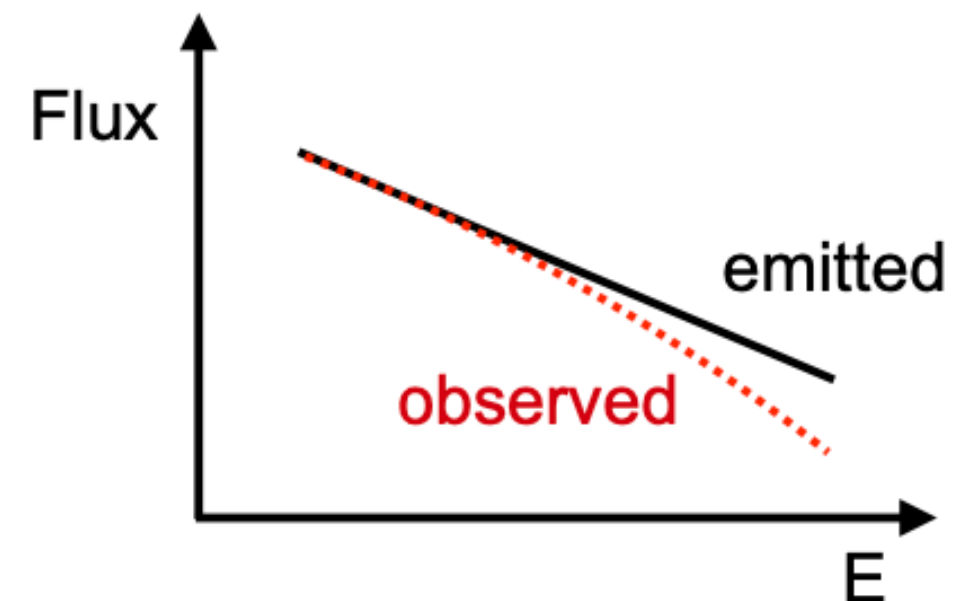
Absorption in extragalactic background light (EBL)

exponential flux decay, depending on gamma energy and EBL opacity (redshift)

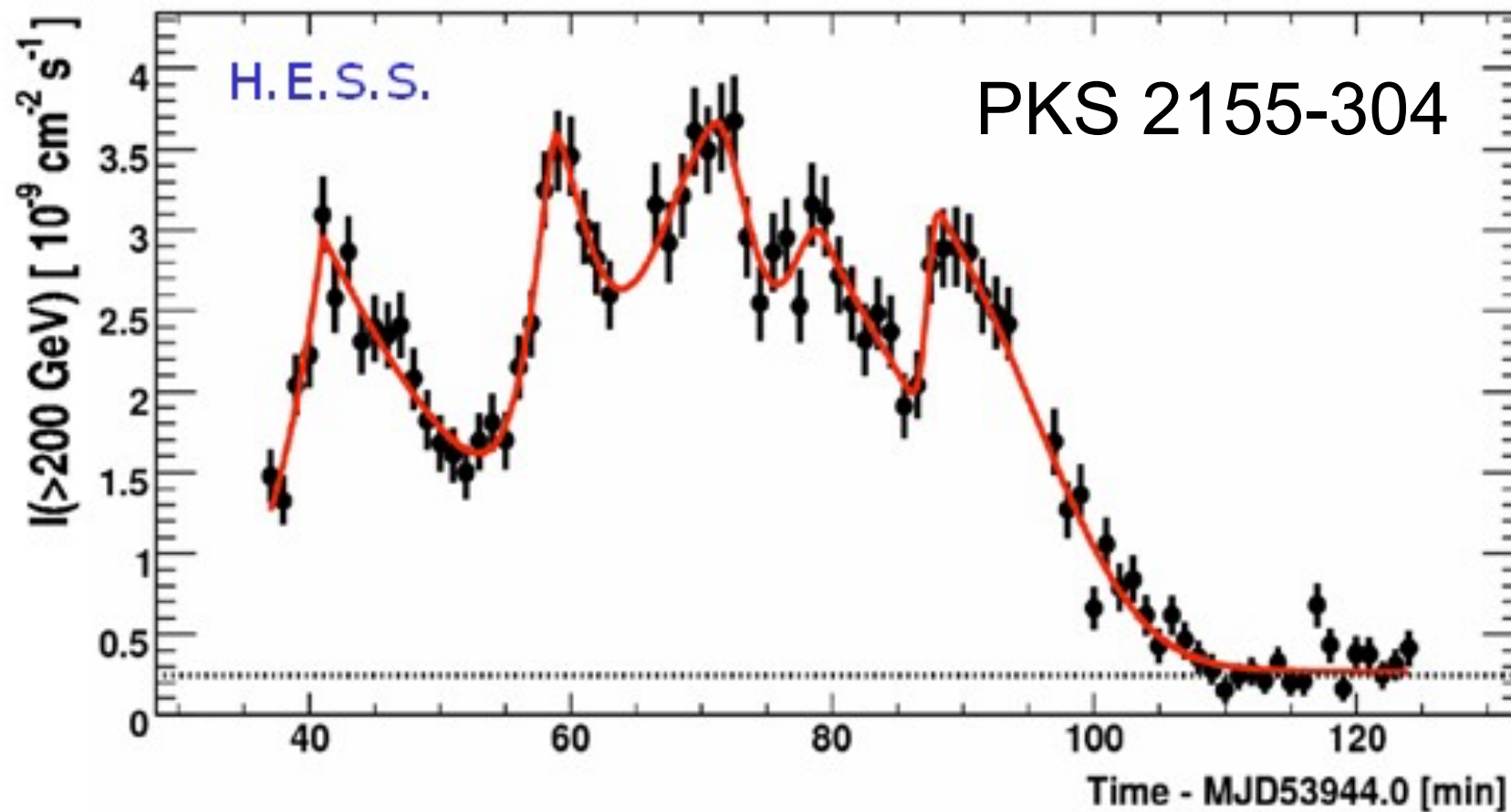


We see CR “PeVatrons” only in Galactic sources!

Gamma energies do not reflect maximum energy reached by the system



Time-Variability!

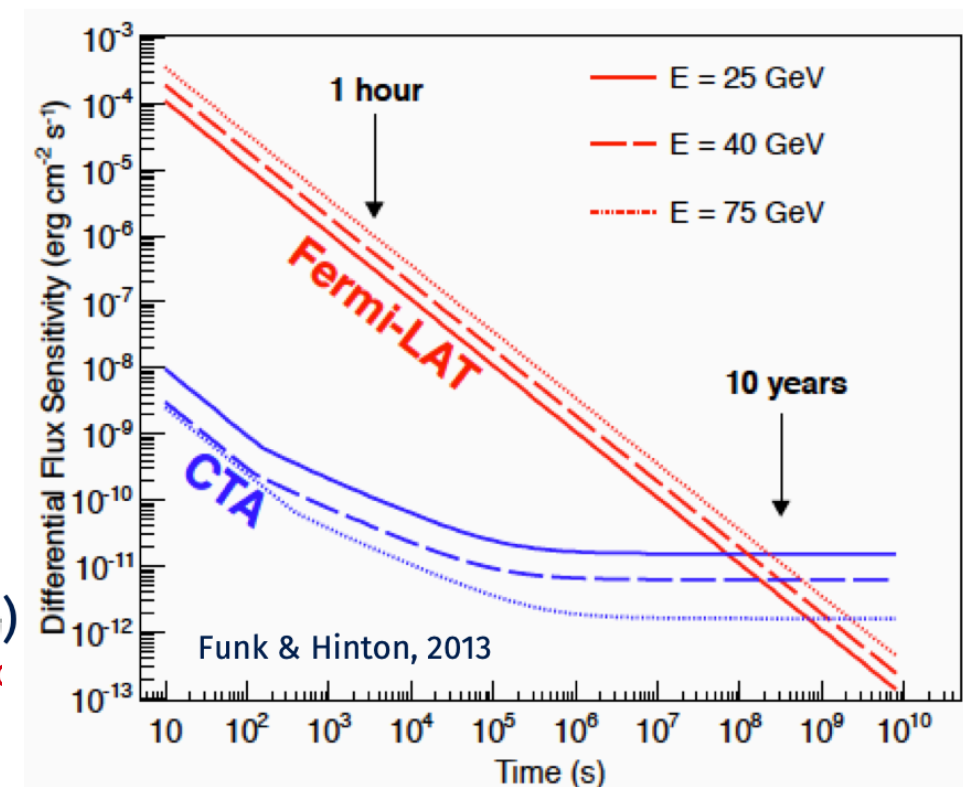


Emission increases by factor of 100

12 orders of magnitude higher energy output than the Crab nebula

Variability on time scales of few minutes

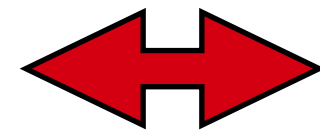
- Possibility to probe size of emission region
 - Timing as crucial observable
- Requires large instantaneous sensitivity



Sensitivity and Timing

Strong time variability, sometimes on very short scales
(e.g. short GRBs ~few seconds)
and unpredictable

Catching the event on short
time scales
→ **survey instruments**

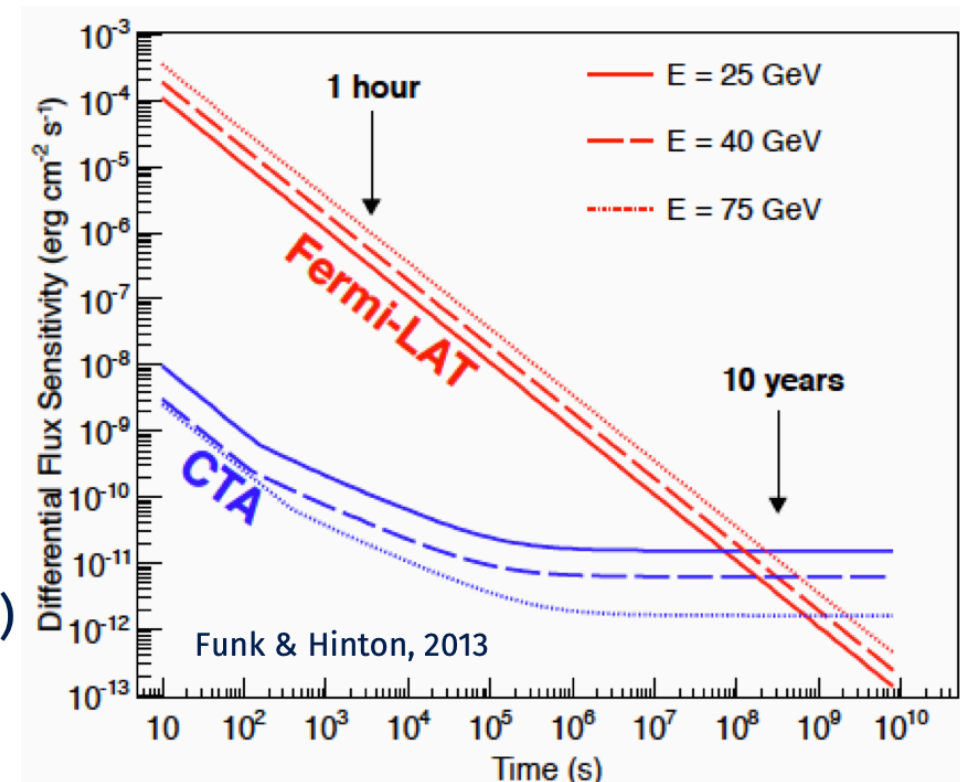


Trade off

Short signal
→ large instantaneous sensitivity
of **pointed instruments**

IACTs can typically
repoint in < 1 min
if observations are possible

Crucial:
Coordination with
other instruments for
triggering of observations

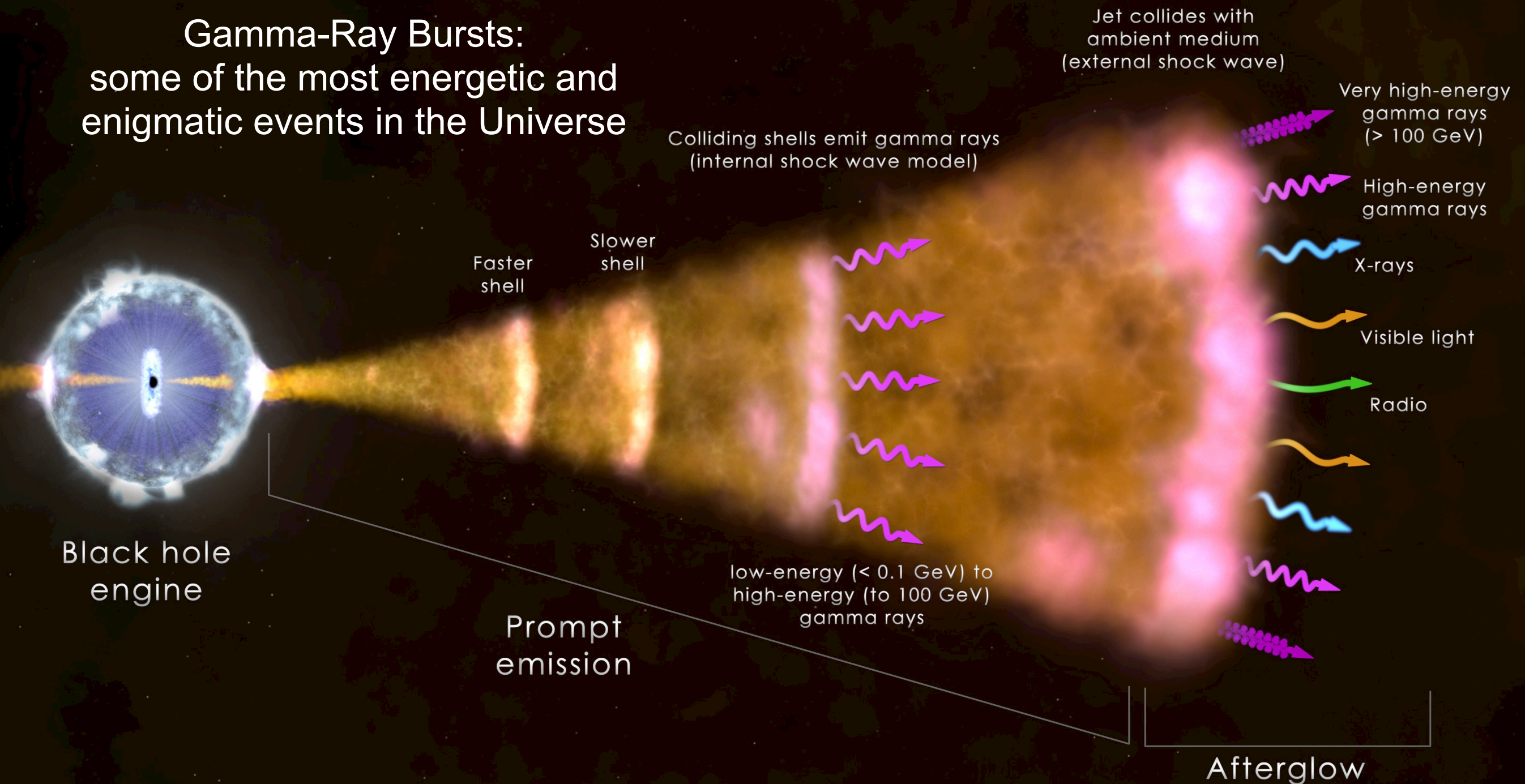


CTAO
Cherenkov Telescope Array Observatory

Kathrin Egberts . Ground-Based Gamma-Ray Astr

Transient Phenomena

Gamma-Ray Bursts:
some of the most energetic and
enigmatic events in the Universe



Ground-Based GRB Detections

All ground-based gamma-ray instruments
have been hunting GRBs for more than a decade

Then, in 2019...

Article

Teraelectronvolt emission from the γ -ray burst GRB 190114C

<https://doi.org/10.1038/s41586-019-1750-x>

Received: 10 May 2019

Accepted: 2 September 2019

Published online: 20 November 2019

MAGIC Collaboration*

Long-duration γ -ray bursts (GRBs) are the most luminous sources of electromagnetic radiation known in the Universe. They arise from outflows of plasma with velocities near the speed of light that are ejected by newly formed neutron stars or black holes (of stellar mass) at cosmological distances^{1,2}. Prompt flashes of megaelectronvolt-energy γ -rays are followed by a longer-lasting afterglow emission in a wide range of energies (from radio waves to gigaelectronvolt γ -rays), which originates from synchrotron radiation generated by energetic electrons in the accompanying shock waves^{3,4}. Although emission of γ -rays at even higher (teraelectronvolt) energies by other radiation mechanisms has been theoretically predicted^{5–8}, it has not been previously detected^{7,8}. Here we report observations of teraelectronvolt emission from the γ -ray burst GRB 190114C. γ -rays were observed in the energy range 0.2–1 teraelectronvolt from about one minute after the burst (at more than 50 standard deviations in the first 20 minutes), revealing a distinct emission component of the afterglow with power comparable to that of the synchrotron component. The observed similarity in the radiated power and temporal behaviour of the teraelectronvolt and X-ray bands points to processes such as inverse Compton upscattering as the mechanism of the teraelectronvolt emission^{9–11}. By contrast, processes such as synchrotron emission by ultrahigh-energy protons^{10,12,13} are not favoured because of their low radiative efficiency. These results are anticipated to be a step towards a deeper understanding of the physics of GRBs and relativistic shock waves.

Very high energy particle acceleration deep in the gamma-ray burst afterglow phase

H. Abdalla¹, R. Adam²⁷, F. Aharonian^{3,4,5}, F. Ait Benkhali³, E.O. Angüner¹⁹, M. Arakawa³⁸, C. Arcaro¹, C. Armand²², H. Ashkar¹⁷, M. Backes^{8,1}, V. Barbosa Martins³⁴, M. Barnard¹, Y. Becherini¹⁰, D. Berge³⁴, K. Bernlöhr³, E. Bissaldi^{45,44}, R. Blackwell¹³, M. Böttcher¹, C. Boisson¹⁴, J. Bolmont¹⁵, S. Bonnefoy³⁴, J. Bregeon¹⁶, M. Breuhaus³, F. Brun¹⁷, P. Brun¹⁷, M. Bryan⁹, M. Büchele³³, T. Bulik¹⁸, T. Bylund¹⁰, M. Capasso²⁶, S. Caroff¹⁵, A. Carosi²², S. Casanova^{20,3}, M. Cerruti^{15,43}, T. Chand¹, S. Chandra¹, A. Chen²¹, S. Colafrancesco²¹ †, M. Curyło¹⁸, I.D. Davids⁸, C. Deil³, J. Devin²⁴, P. deWilt¹³, L. Dirson², A. Djannati-Atai²⁸, A. Dmytriiev¹⁴, A. Donath³, V. Doroshenko²⁶, J. Dyks³¹, K. Egberts³², G. Emery¹⁵, J.-P. Ernenwein¹⁹, S. Eschbach³³, K. Feijen¹³, S. Fegan²⁷, A. Fiasson²², G. Fontaine²⁷, S. Funk³³, M. Füßling³⁴, S. Gabici²⁸, Y.A. Gallant¹⁶, F. Gaté²², G. Giavitto³⁴, L. Giunti²⁸, D. Glawion²³, J.F. Glicenstein¹⁷, D. Gottschall²⁶, M.-H. Grondin²⁴, J. Hahn³, M. Haupt³⁴, G. Heinzlmann², G. Henri²⁹, G. Hermann³, J.A. Hinton³, W. Hofmann³, C. Hoischen³², T. L. Holch⁷, M. Holler¹², D. Horns², D. Huber¹², H. Iwasaki³⁸, M. Jamroz³⁵, D. Jankowsky³³, F. Jankowsky²³, A. Jardin-Blicq³, I. Jung-Richardt³³, M.A. Kastendieck², K. Katarzyński³⁶, M. Katsuragawa³⁹, U. Katz³³, D. Khangulyan³⁸, B. Khélifi²⁸, J. King²³, S. Klepser³⁴, W. Kluźniak³¹, Nu. Komin²¹, K. Kosack¹⁷, D. Kostunin³⁴, M. Kreter¹, G. Lamanna²², A. Lemièrre²⁸, M. Lemoine-Goumard²⁴, J.-P. Lenain¹⁵, E. Leser^{32,34}, C. Levy¹⁵, T. Lohse⁷, I. Lypova³⁴, J. Mackey⁴, J. Majumdar³⁴, D. Malyshev²⁶, V. Marandon³, A. Marcowith¹⁶, A. Mares²⁴, C. Mariaud²⁷, G. Martí-Devesa¹², R. Marx³, G. Maurin²², P.J. Meinties³⁷, A.M.W. Mitchell^{3,42}, R. Moderski³¹, M. Mohamed²³.

H.E.S.S. Coll., Nature 2019

MAGIC Coll., Nature 2019



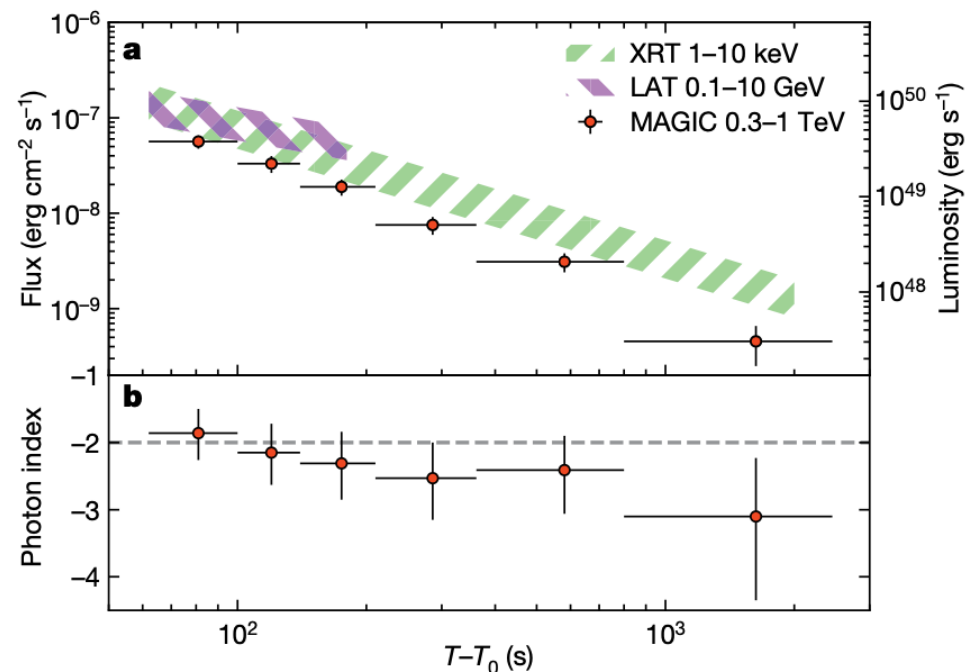
Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 56



Two Completely Different Cases

GRB190114C (MAGIC)

- Observations after 50 seconds
 - >300 GeV
(zenith of 60deg & partial moon)
 - >20 sigma in first 20 min of observations
- MAGIC Coll., Nature 2019

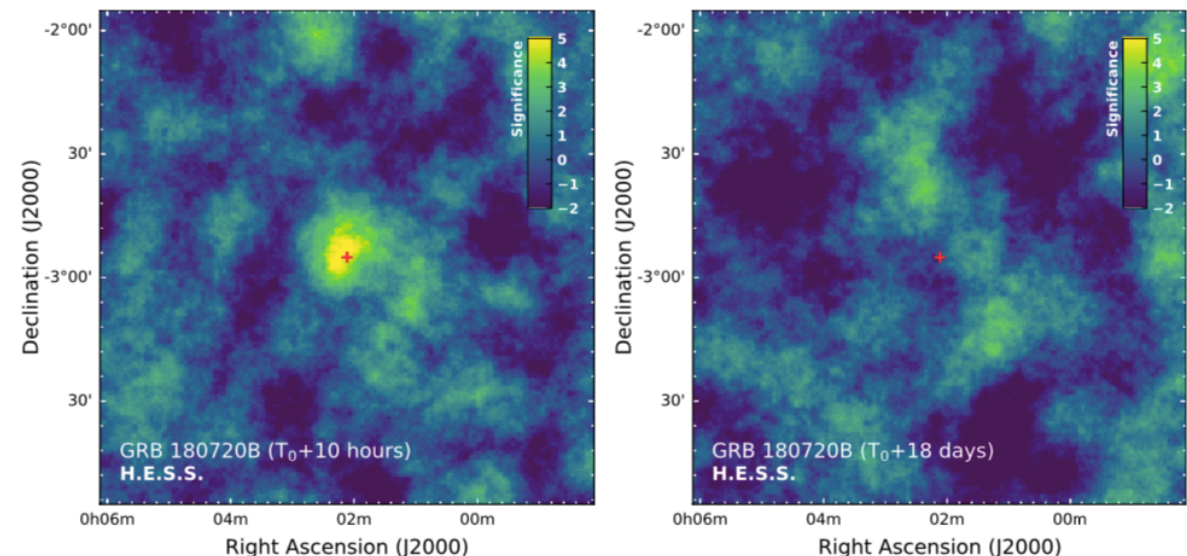


GRB180720B (H.E.S.S.)

- Observations after 10 hours
- 100 - 440 GeV
- 5 sigma accumulated over 2 hours

after 10 hours

after 18 days



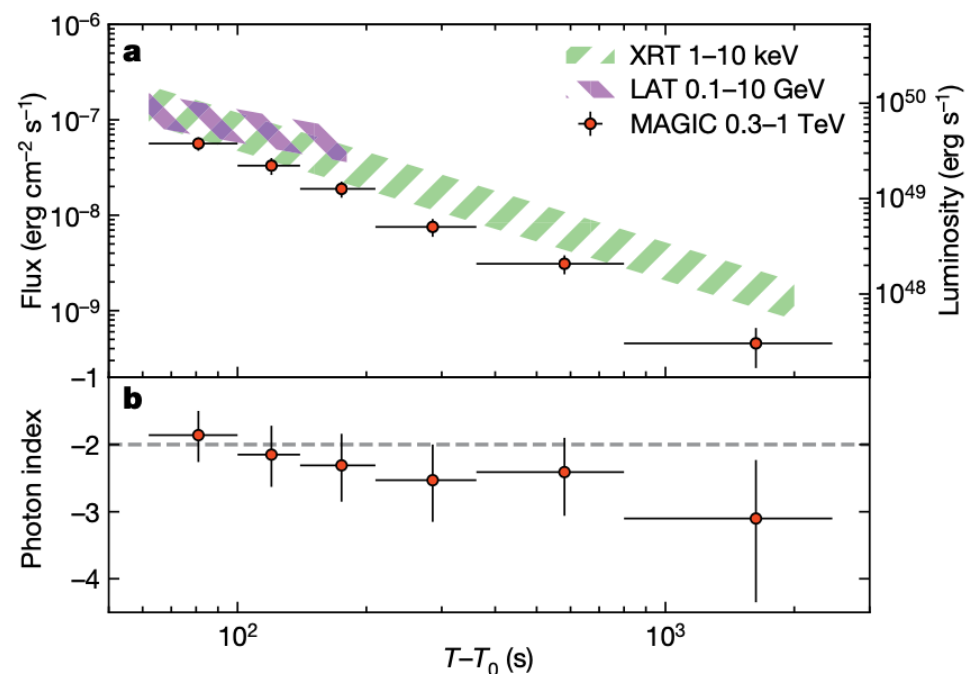
H.E.S.S. Coll., Nature 2019

→ Probing GRBs as extreme accelerators over a diverse range of timescales becomes possible!

Two Completely Different Cases

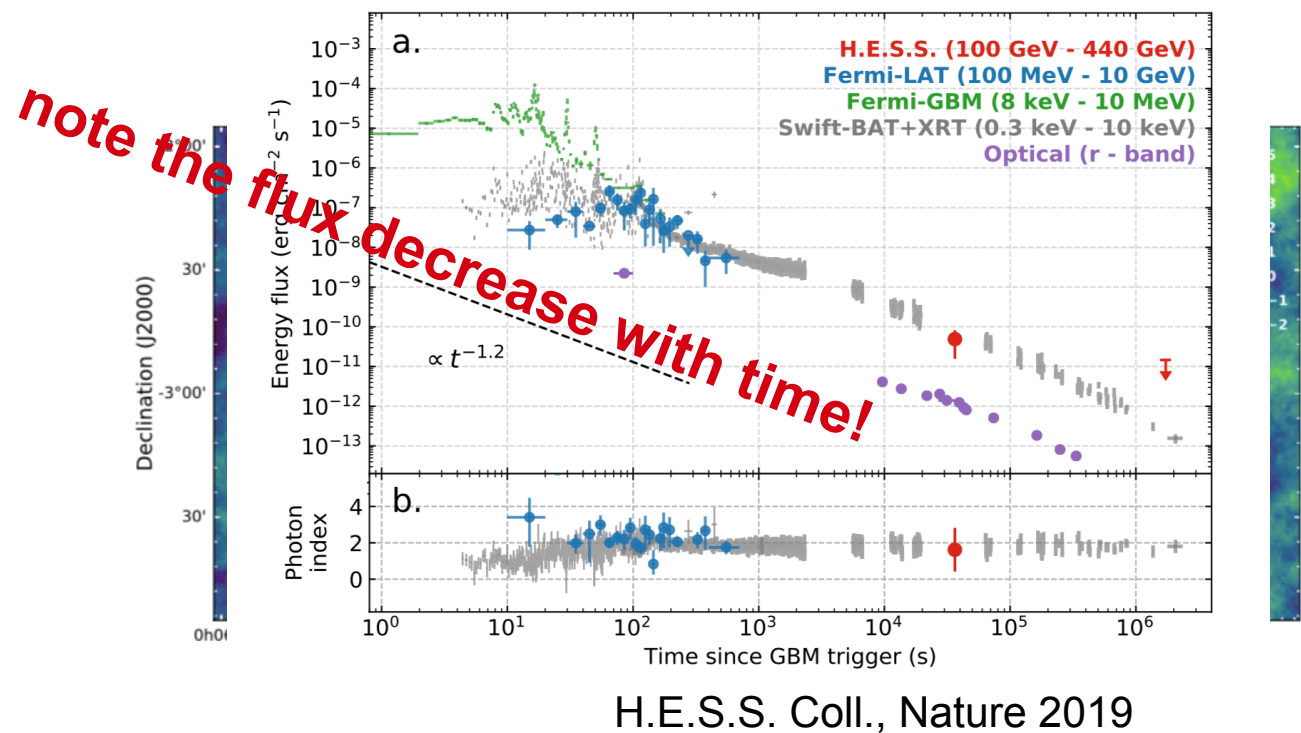
GRB190114C (MAGIC)

- Observations after 50 seconds
 - >300 GeV
(zenith of 60deg & partial moon)
 - >20 sigma in first 20 min of observations
- MAGIC Coll., Nature 2019



GRB180720B (H.E.S.S.)

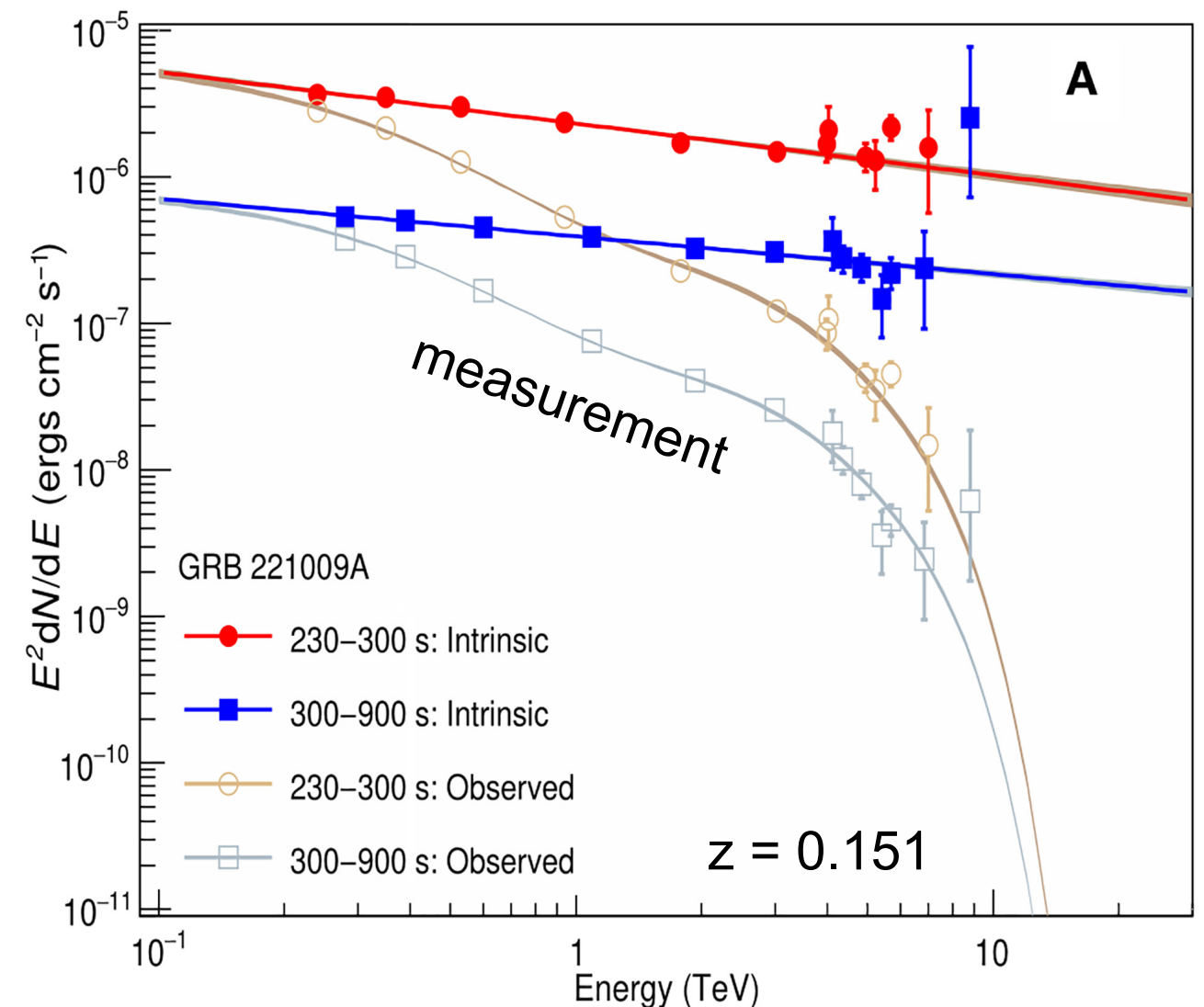
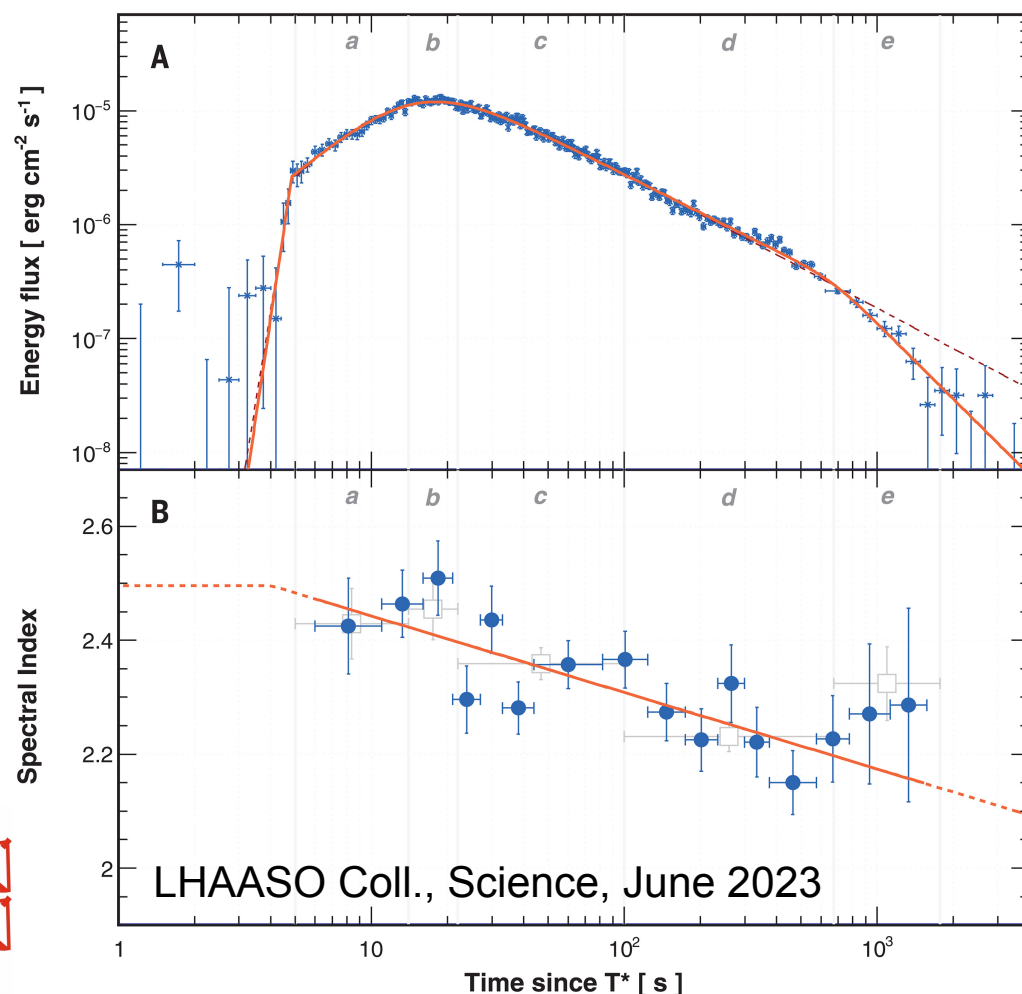
- Observations after 10 hours
- 100 - 440 GeV
- 5 sigma accumulated over 2 hours



→ Probing GRBs as extreme accelerators over a diverse range of timescales becomes possible!

GRB 221009A - The Brightest Of All Times

- LHAASO detection >10 TeV
- ~ 3000 s after the trigger, $>64,000$ photons with energies between ~ 200 GeV and ~ 7 TeV
- EBL absorption by >2 orders of magnitude

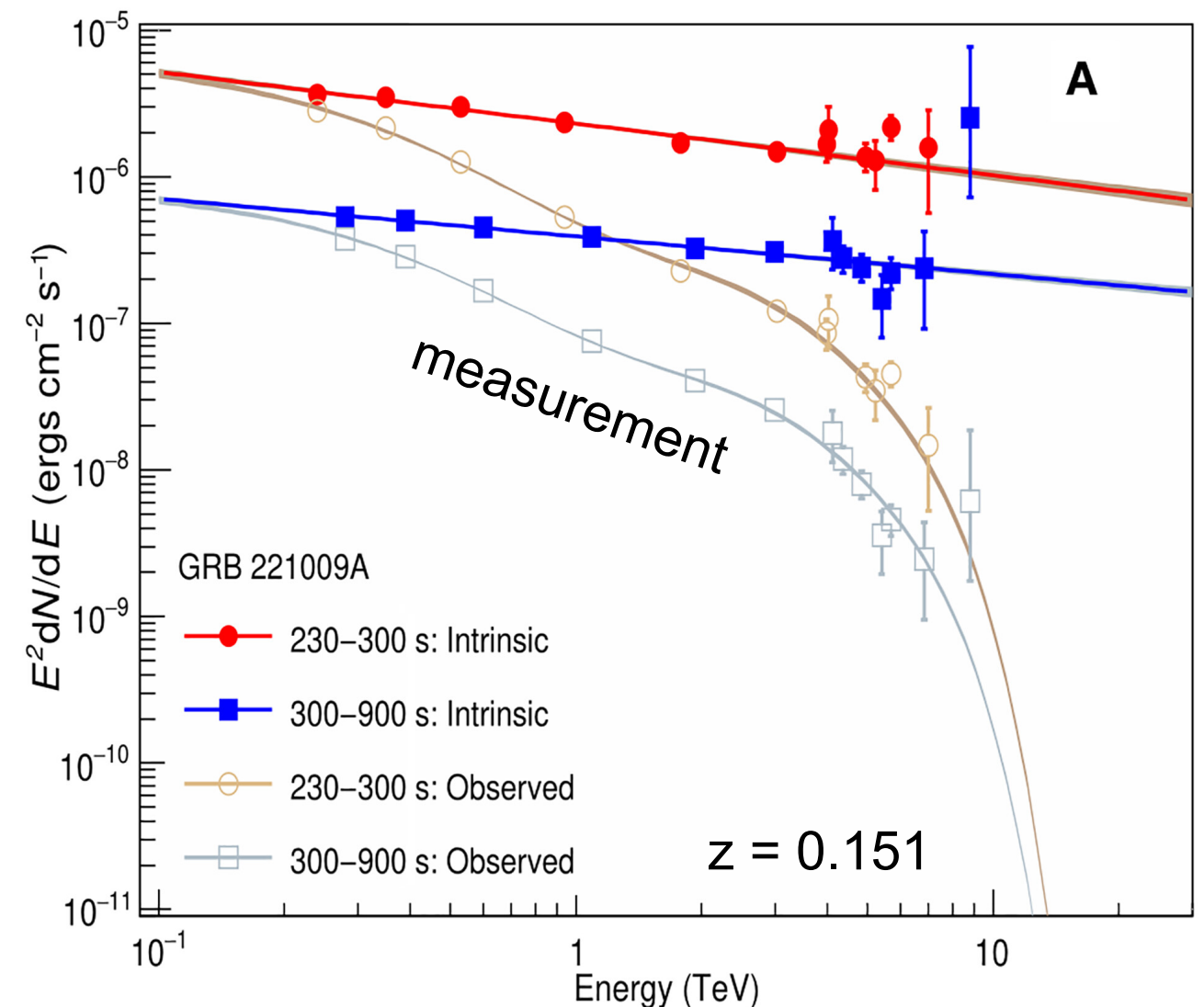
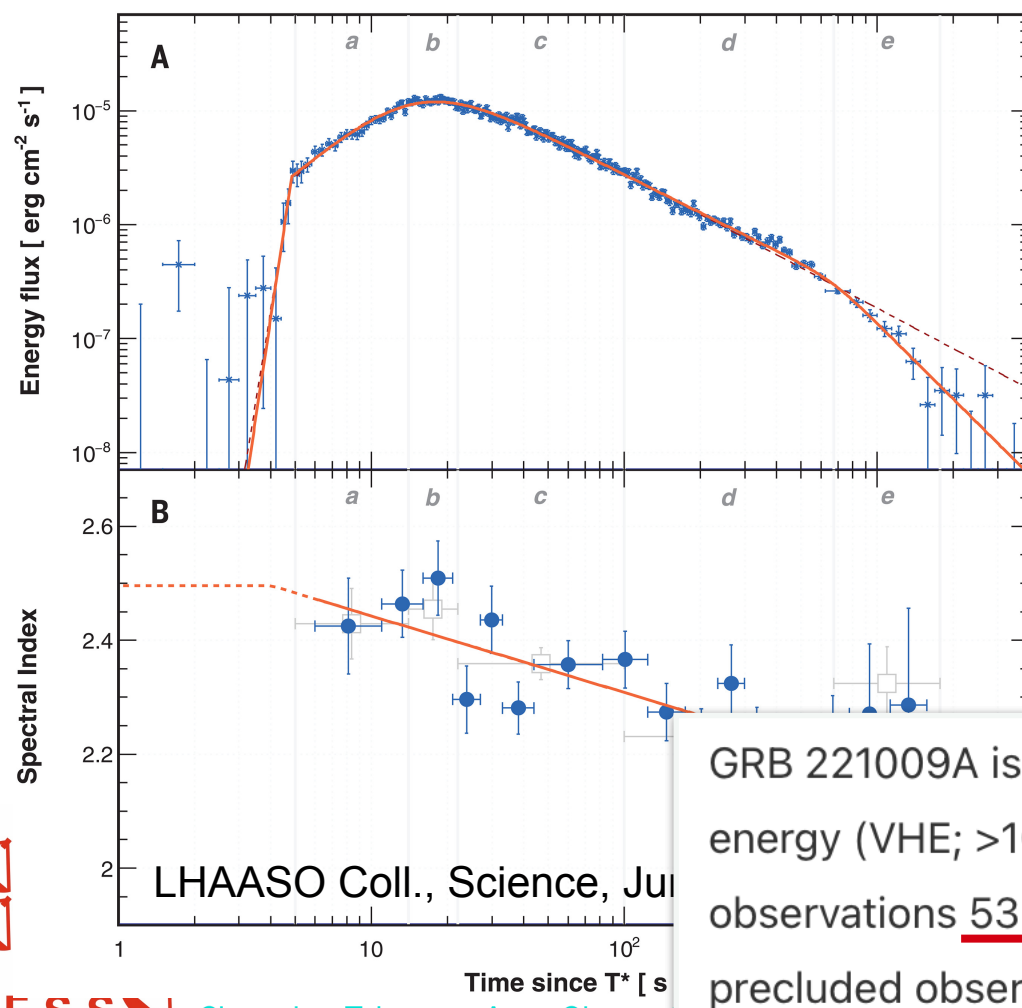


LHAASO Coll., Science, Nov 2023



GRB 221009A - The Brightest Of All Times

- LHAASO detection >10 TeV
- ~ 3000 s after the trigger, $>64,000$ photons with energies between ~ 200 GeV and ~ 7 TeV
- EBL absorption by >2 orders of magnitude



LHAASO Coll., Science, Nov 2023

IACTs:

GRB 221009A is the brightest gamma-ray burst (GRB) ever detected. To probe the very-high-energy (VHE; >100 GeV) emission, the High Energy Stereoscopic System (H.E.S.S.) began observations 53 hr after the triggering event, when the brightness of the moonlight no longer precluded observations. We derive differential and integral upper limits using H.E.S.S. data from



Multi-Messenger Astronomy

see Lecture by Fonteini Oikonomou

Neutrinos & Gravitational Waves

©DESY



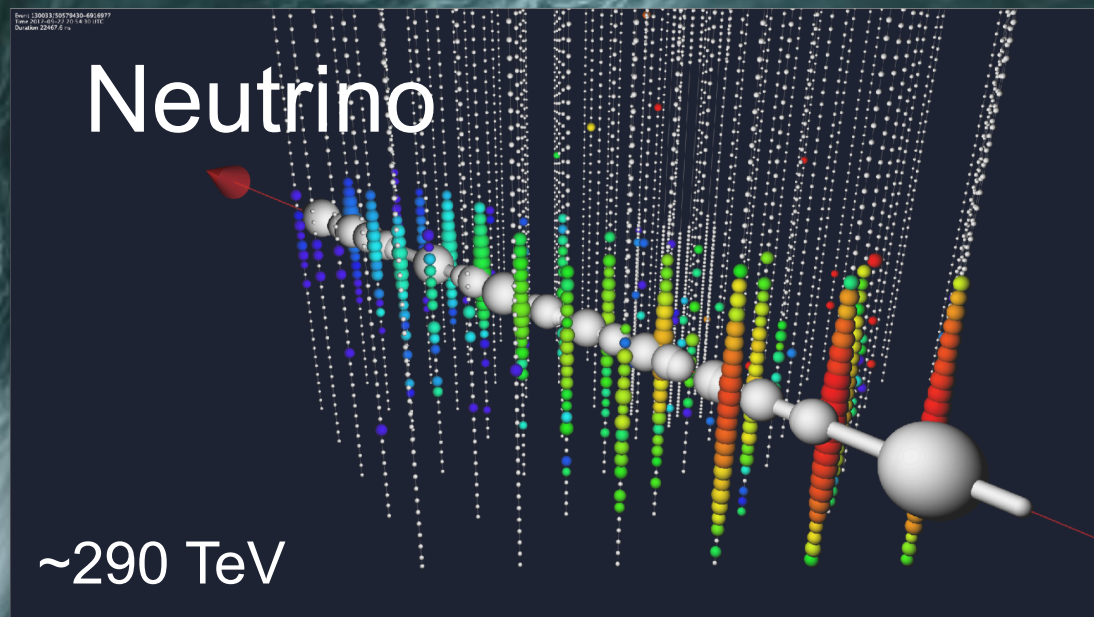
CTAO
Cherenkov Telescope Array Observatory

Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 61



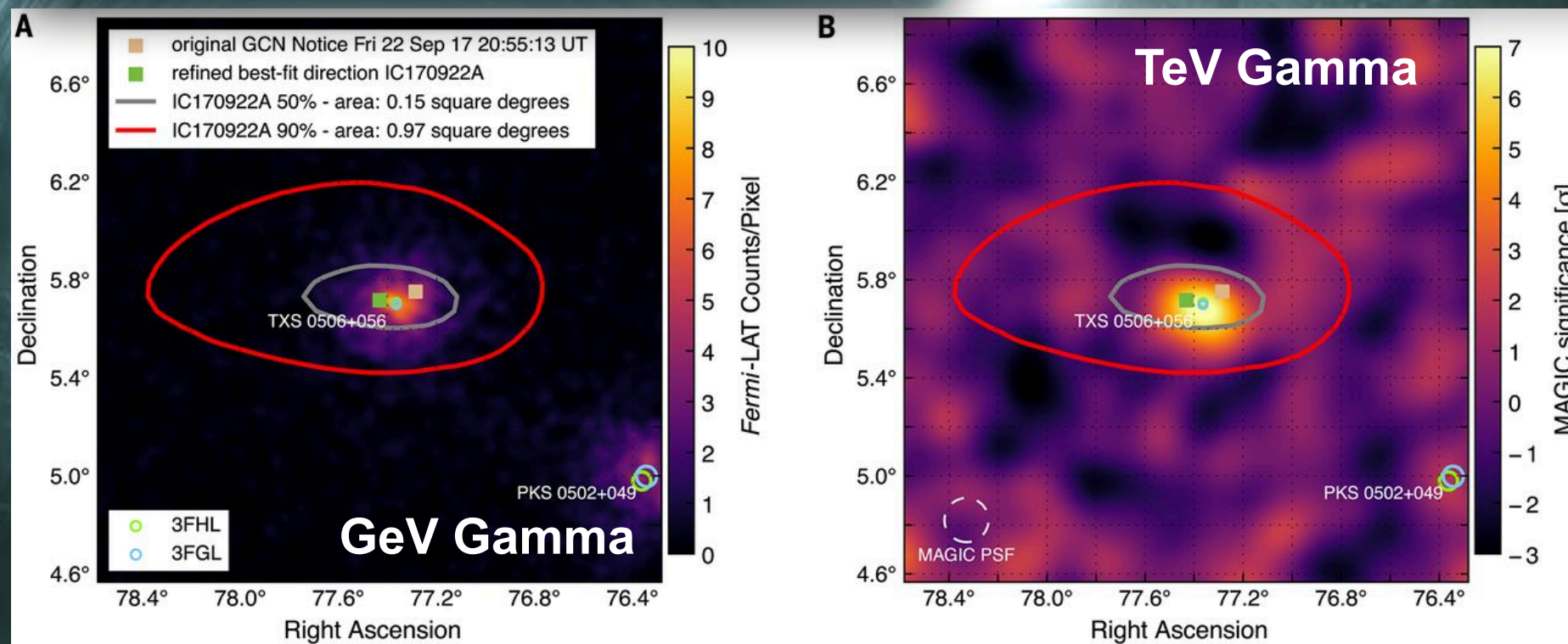
The Case of TXS 0506+056

see Lecture by Francis Halzen



A high-energy astrophysical neutrino in conjunction with a flaring blazar

- 4.1 σ (3 σ after trials) correlation
- First known source of HE neutrinos (& first extragalactic source of cosmic rays)

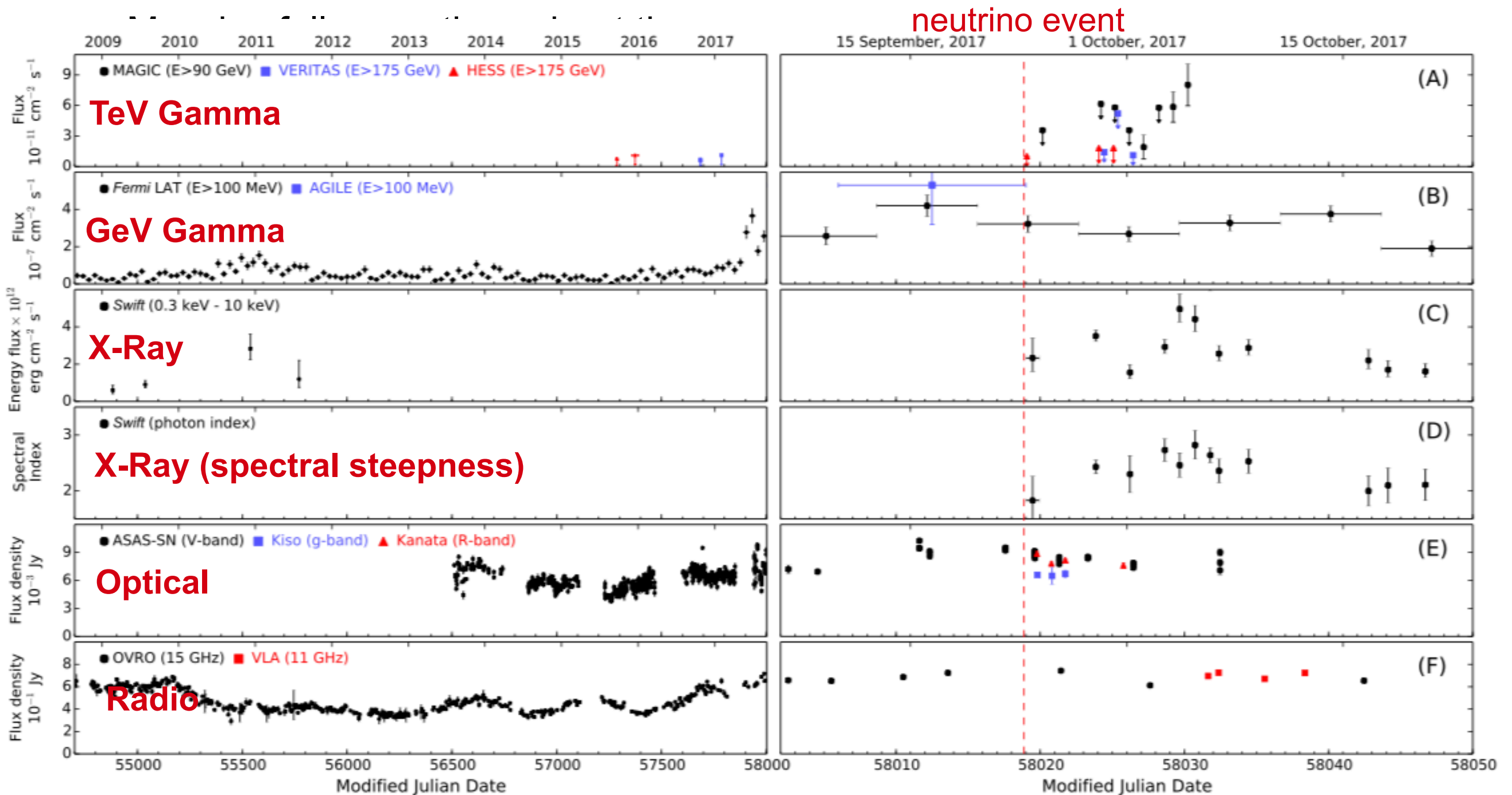


Beginning of neutrino multi-messenger astronomy

... together with a TeV detection!

©DESY

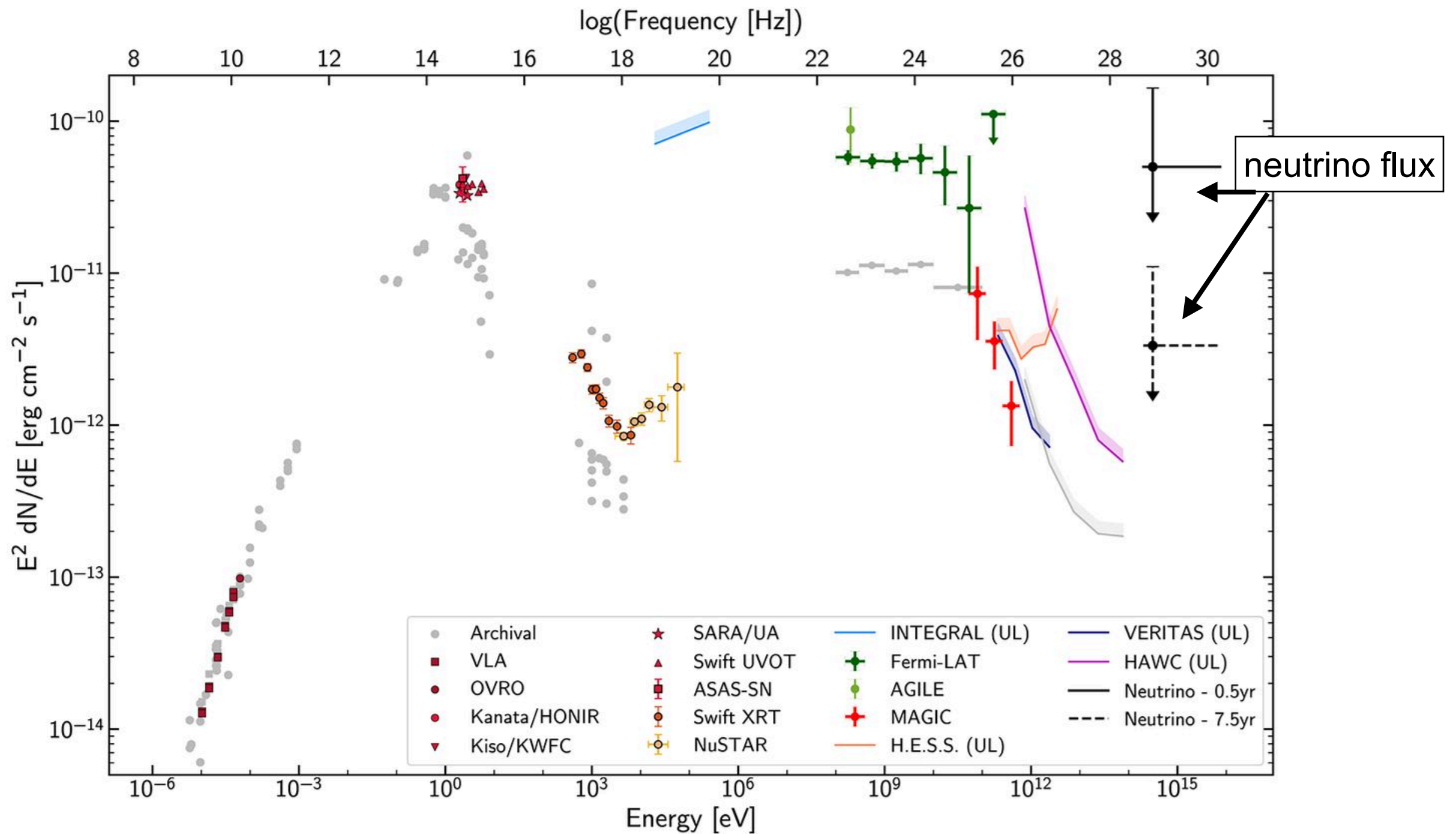
The Case of TXS 0506+056



IceCube et al., Science 2018



The Case of TXS 0506+056

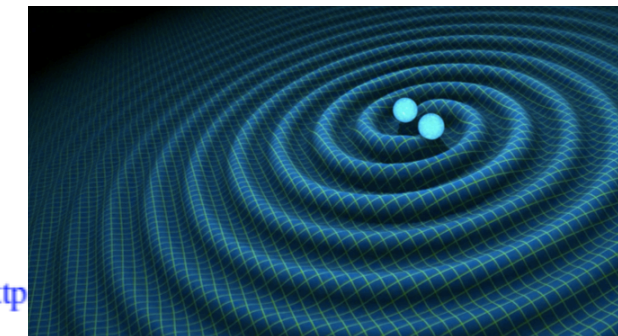


IceCube et al., Science 2018

The Era of Gravitational Wave Astronomy

The Case of GW 170817

See Lecture by
Simone Mastrogiovanni



http

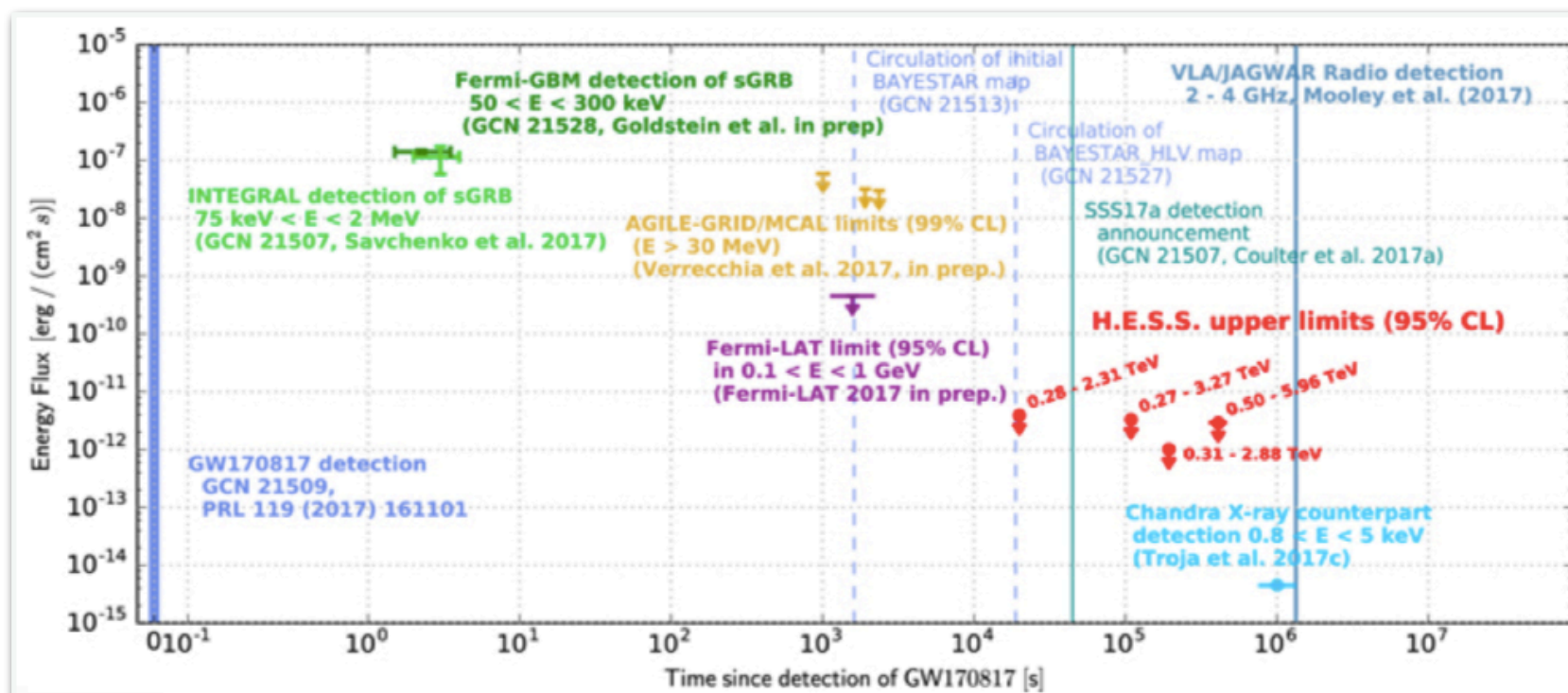


THE ASTROPHYSICAL JOURNAL LETTERS, 848:L12 (59pp), 2017 October 20

© 2017. The American Astronomical Society. All rights reserved.

OPEN ACCESS

Multi-messenger Observations of a Binary Neutron Star Merger*



Received 2017 October 3; revised 2017 October 6; accepted 2017 October 6; published 2017 October 16

collaboration, AstroSat Cadmium Zinc
laboration, The Swift Collaboration,
collaboration, The DLT40 Collaboration,
ATCA: Australia Telescope Compact
eeper, Wider, Faster Program), AST3,
EM, GROWTH, JAGWAR, Caltech-
onsortium, KU Collaboration, Nordic
ent Robotic Observatory of the South
Collaboration, IKI-GW Follow-up
AWC Collaboration, The Pierre Auger
dra Team at McGill University, DFN:
R, and SKA South Africa/MeerKAT

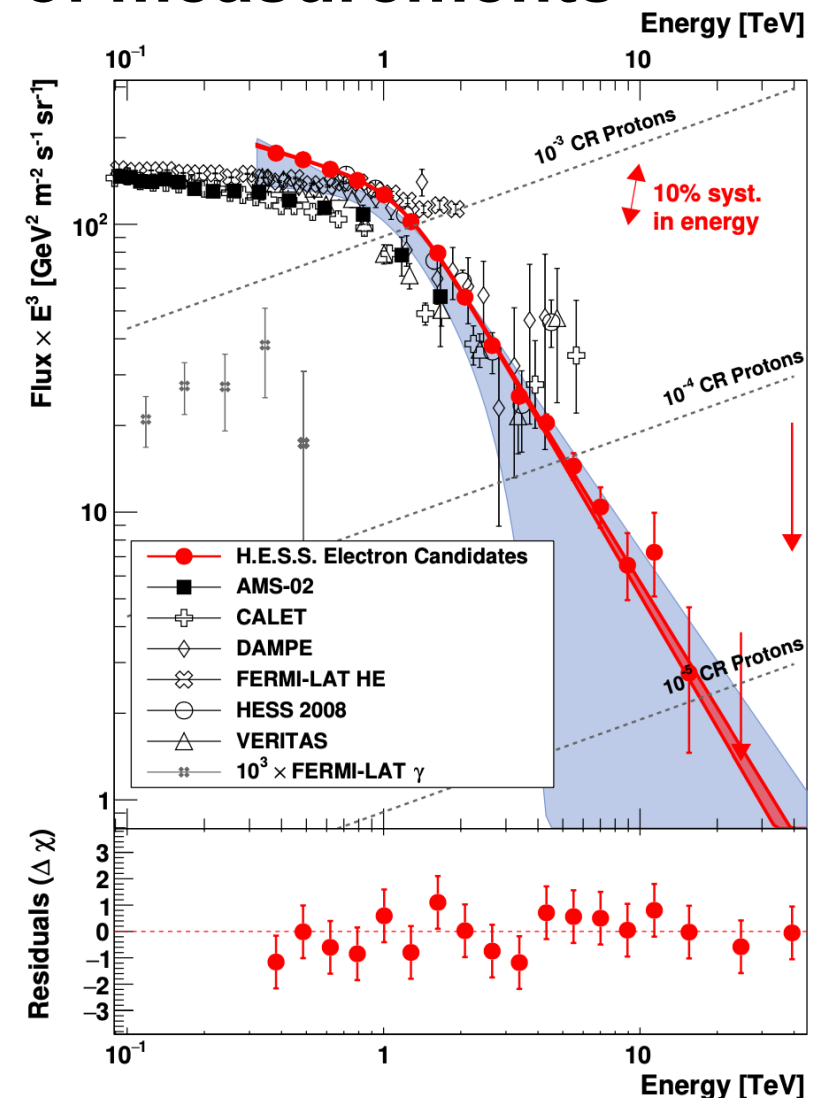
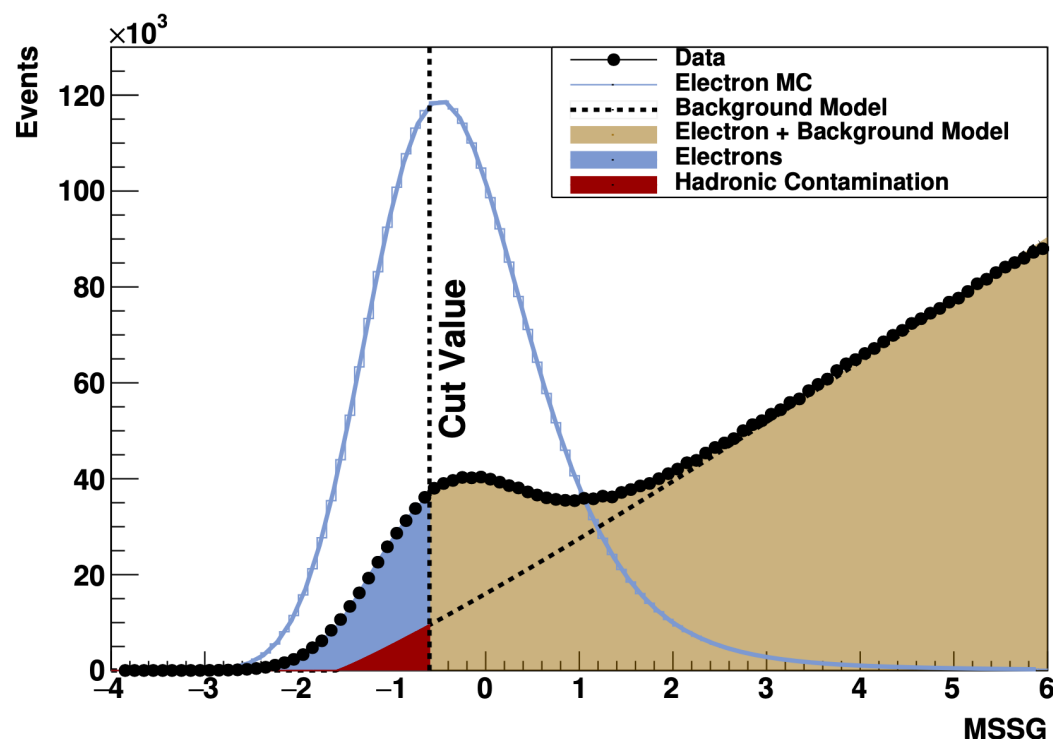
A remarkable example of international collaboration! >3500 authors
>70 observatories



Non-Gamma Science

Use the TeV instruments for other types of measurements

- Example: **cosmic-ray electrons**
- Due to their isotropy, very good separation power between hadrons and electrons required
- Can expand the measurable spectrum significantly beyond satellite capabilities

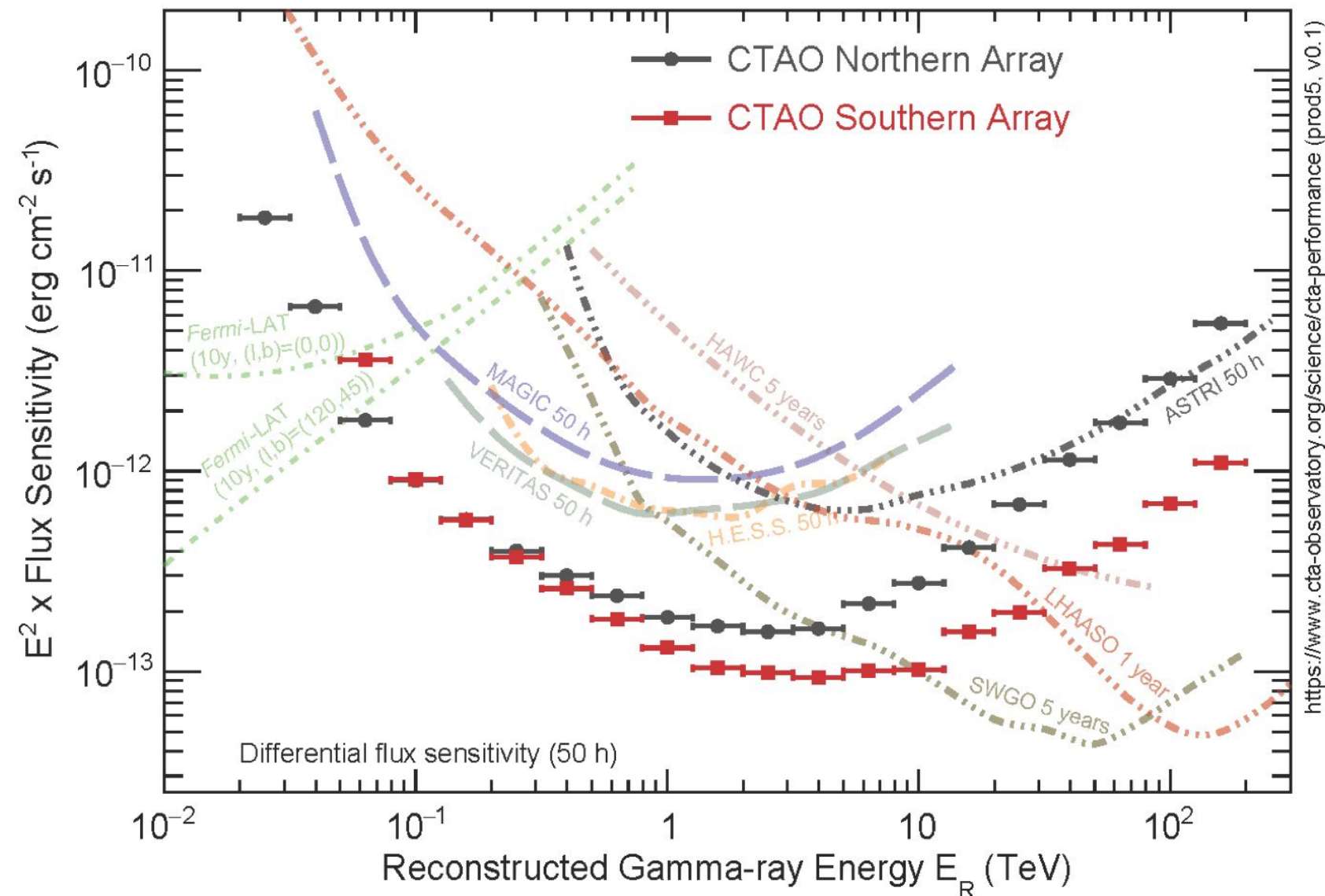


H.E.S.S. Coll., submitted to PRL

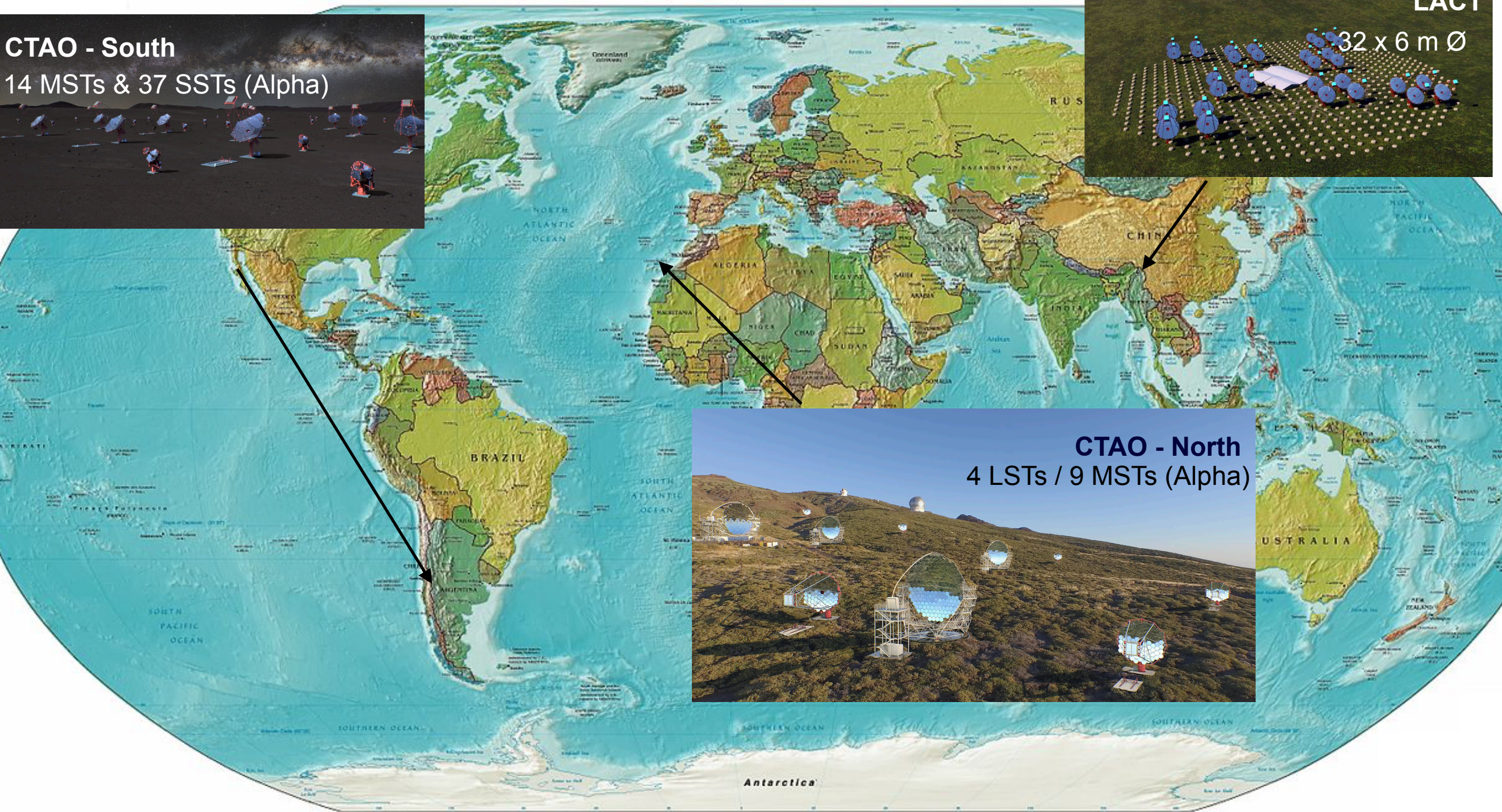
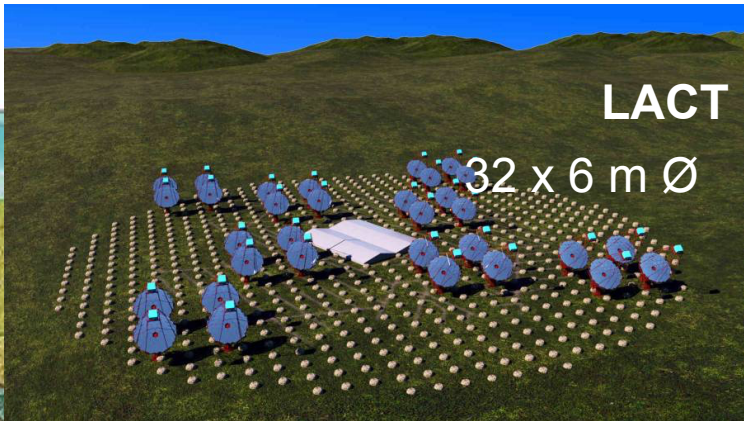
- Also other cosmic-ray measurements (e.g. proton, iron)
- Measurements of EBL in blazar absorption
- Stellar interferometry...

IV. Outlook

New experiments are around the corner: planning or construction phase



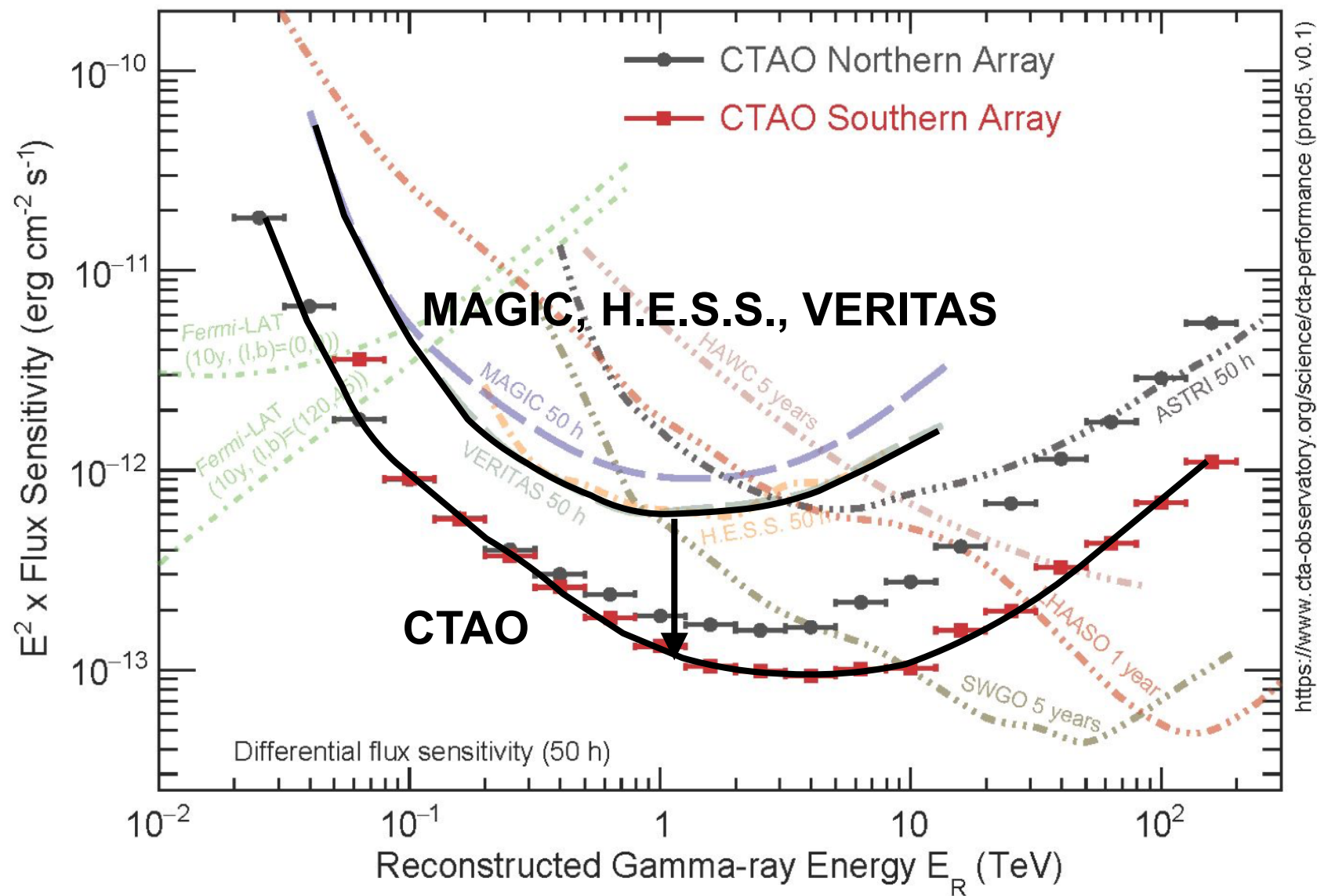
Next-Generation IACT Instruments



The next generation: CTAO & SWGO

IACTs

H.E.S.S., MAGIC, VERITAS → CTAO

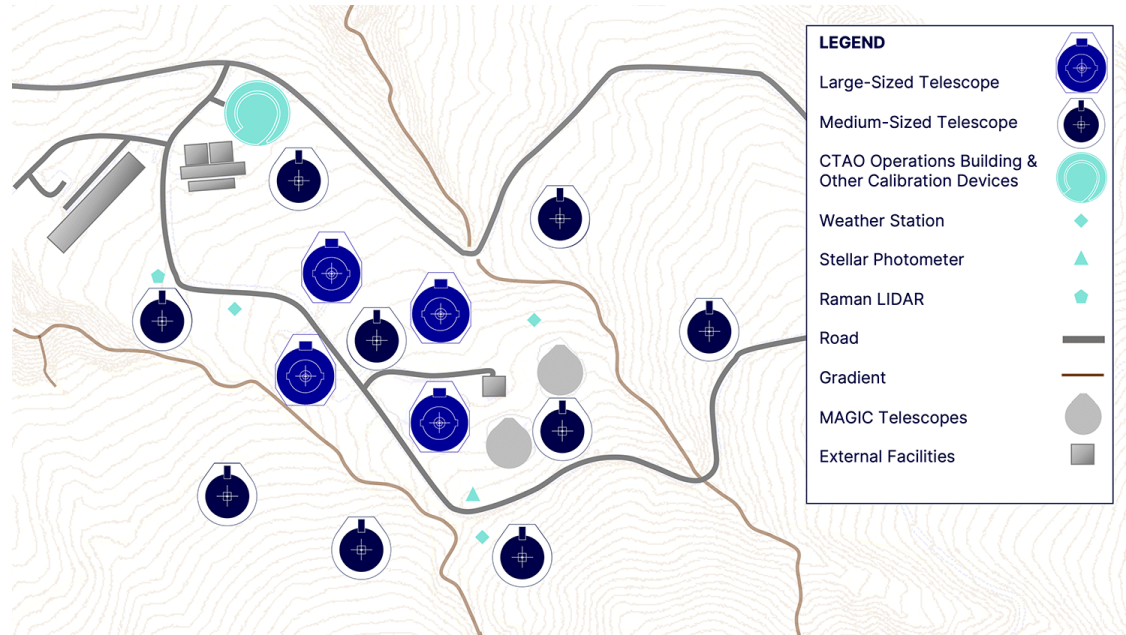


Order of magnitude increase in sensitivity!

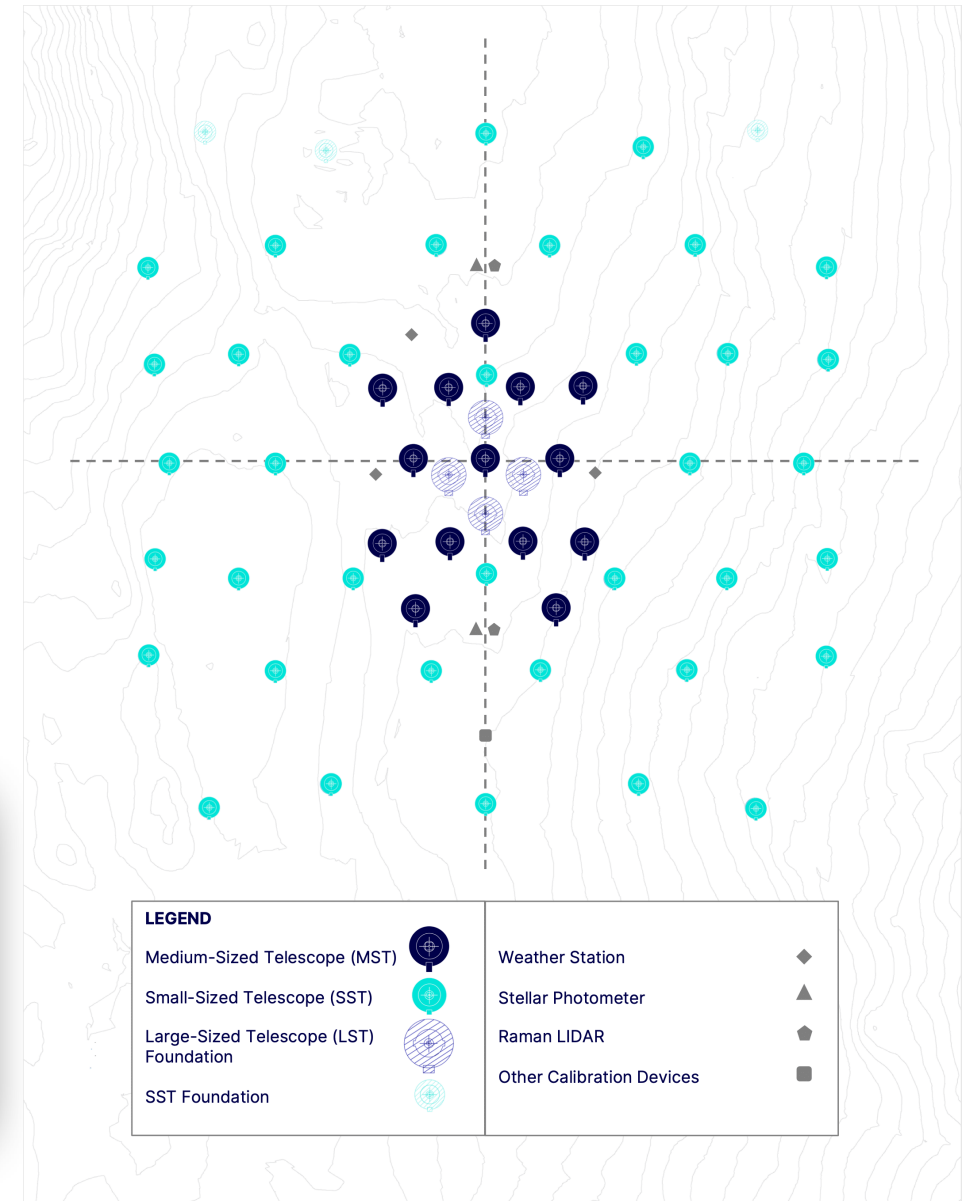


CTAO: an observatory with two sites (and a headquarter and a data centre)

La Palma



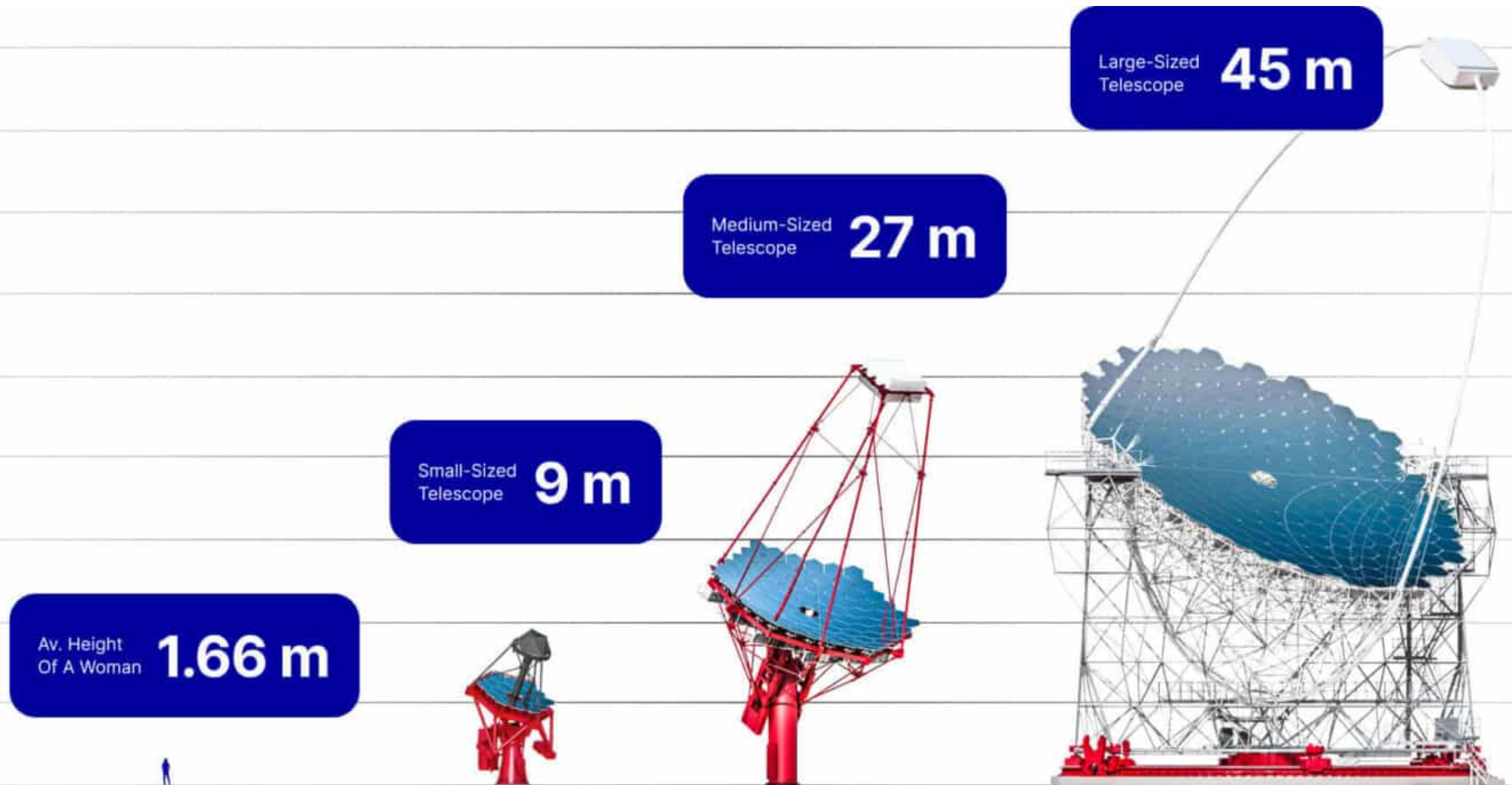
Chile



Two sites in La Palma and Chile for full sky coverage
Proposal-driven observatory
Wider energy coverage, better angular resolution,
larger field of view

The Cherenkov Telescope Array Observatory

Different telescopes for a larger dynamical range



Small-Sized Telescopes (SSTs)

Optimised for high energies

Many telescopes to increase statistics

In Chile for view on Galactic plane



	Small-Sized Telescope (SST)
Energy range (in which sensitivity is optimized)	2 TeV – 300 TeV
Number of SST telescopes	37 (South)
Optical design	Modified Schwarzschild-Couder
Primary reflector diameter	4.3 m
Secondary reflector diameter	1.8 m
Effective mirror area (including shadowing)	>5 m ²
Focal length	2.15 m
Total weight	17.5 t
Field of view	8.8 deg
Number of pixels	2048
Pixel size (imaging)	0.16 deg
Photodetector type	SiPM
Telescope readout event rate (before array trigger)	600 Hz
Telescope data rates (readout of all pixels; before array trigger)	2.55 Gb/s
Positioning time to any point in the sky (>30° elevation)	70 s
Pointing precision	<7 arcseconds
Observable sky	Any astrophysical object with elevation > 24 degrees

Medium-Sized Telescopes (MSTs)

	Medium-Sized Telescope (MST)
Energy range (in which sensitivity is optimized)	80 GeV – 50 TeV
Number of MST telescopes	14 (South) 9 (North)
Optical design	Modified Davies-Cotton
Reflector diameter	11.5 m
Effective mirror area (including shadowing)	88 m ²
Focal length	16 m
Total weight	89 t
Field of view (FlashCam / NectarCAM)	7.5 deg / 7.7 deg
Number of pixels (FlashCam / NectarCAM)	1764 / 1855
Pixel size (imaging)	0.17 deg
Photodetector type	PMT
Telescope readout event rate before array trigger (FlashCam / NectarCAM)	>6 kHz / >7.0 kHz
Telescope data rates (readout of all pixels; before array trigger)	12 Gb/s
Positioning time to any point in the sky (>30° elevation)	90 s
Pointing precision	<7 arcseconds
Observable sky	Any astrophysical object with elevation > 20 degrees

Central energy range

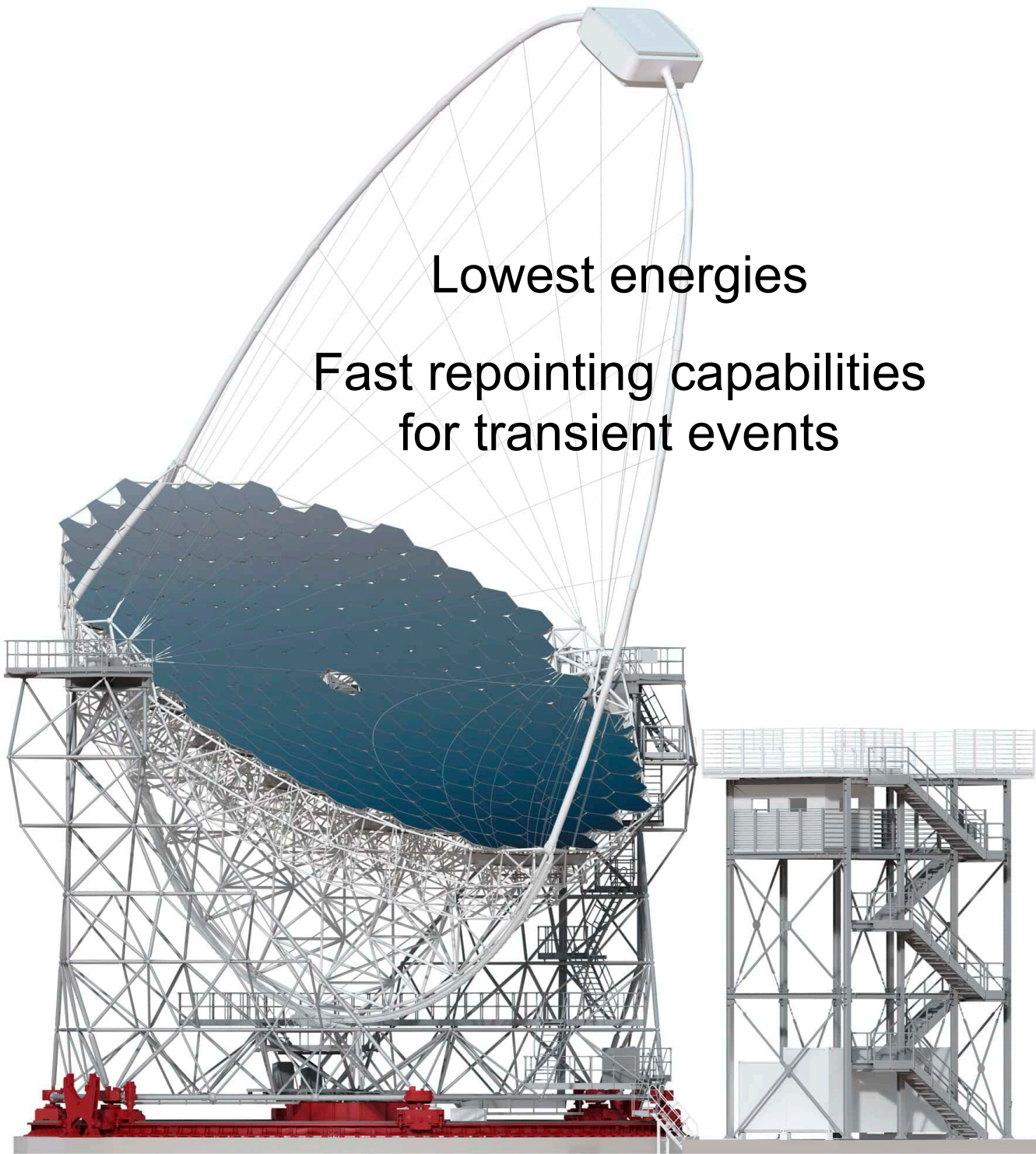
Large field of view

CTAO workhorse



Large-Sized Telescopes (LSTs)

	Large-Sized Telescope (LST)
Energy range (in which sensitivity is optimized)	20 GeV – 3 TeV
Number of LST telescopes	4 (North)
Optical design	Parabolic
Primary reflector diameter	23.0 m
Effective mirror area (including shadowing)	370 m ²
Focal length	28 m
Total weight	103 t
Field of view	4.3 deg
Number of pixels	1855
Pixel size (imaging)	0.1 deg
Photodetector type	PMT
Telescope readout event rate after array trigger	>7.0 kHz
Telescope data rates (readout of all pixels; before array trigger)	24 Gb/s
Positioning time to any point in the sky (>30° elevation)	30 s
Pointing precision	<14 arcseconds
Observable sky	Any astrophysical object with elevation > 24 degrees



La Palma, June 2026

CTAO Northern Site



CTAO
Cherenkov Telescope Array Observatory

Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 75



CTAO Southern Site



[from I. Ora, ACADA F2F meeting Catania 2026 - Ricardo Bastias, drone flight from April 2026]



CTAO
Cherenkov Telescope Array Observatory

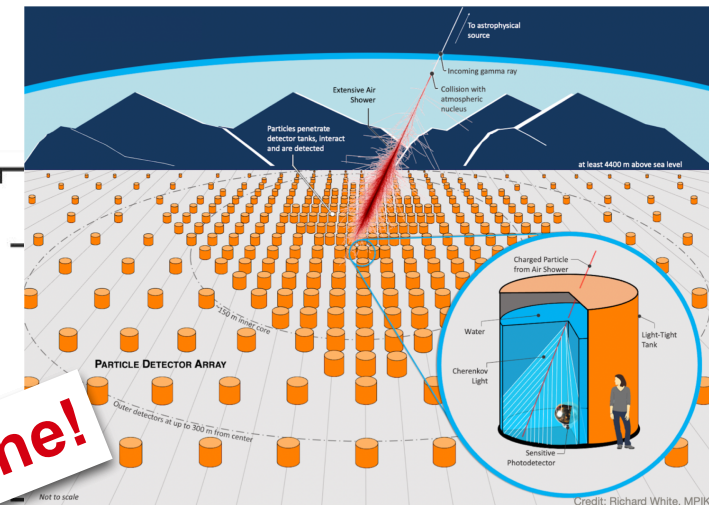
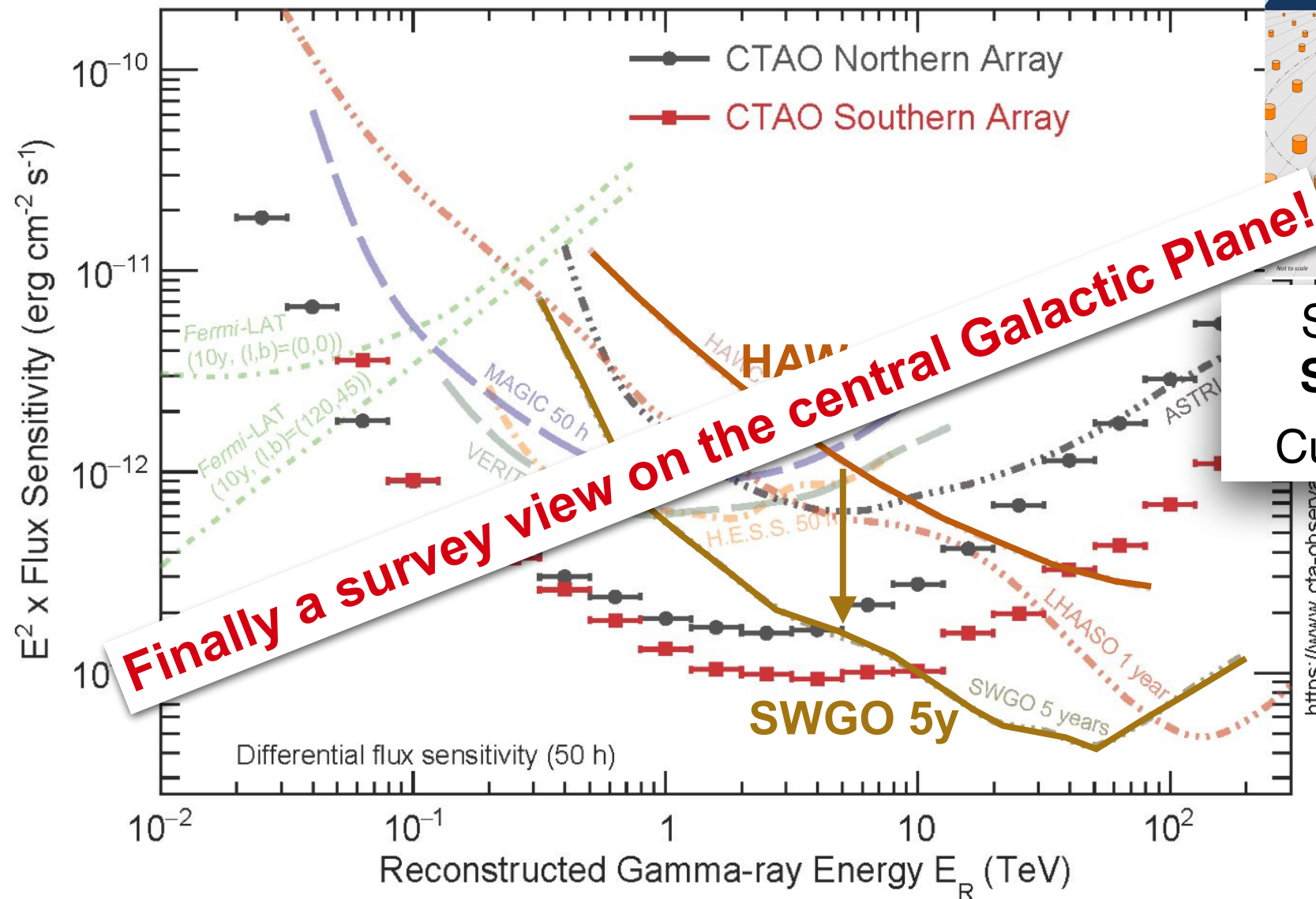
Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 76



The next generation: CTAO & SWGO

PDA's

HAWC → SWGO



Site in the Andes in the
Southern hemisphere
Currently in design phase

SWGO

Order of magnitude increase in sensitivity!



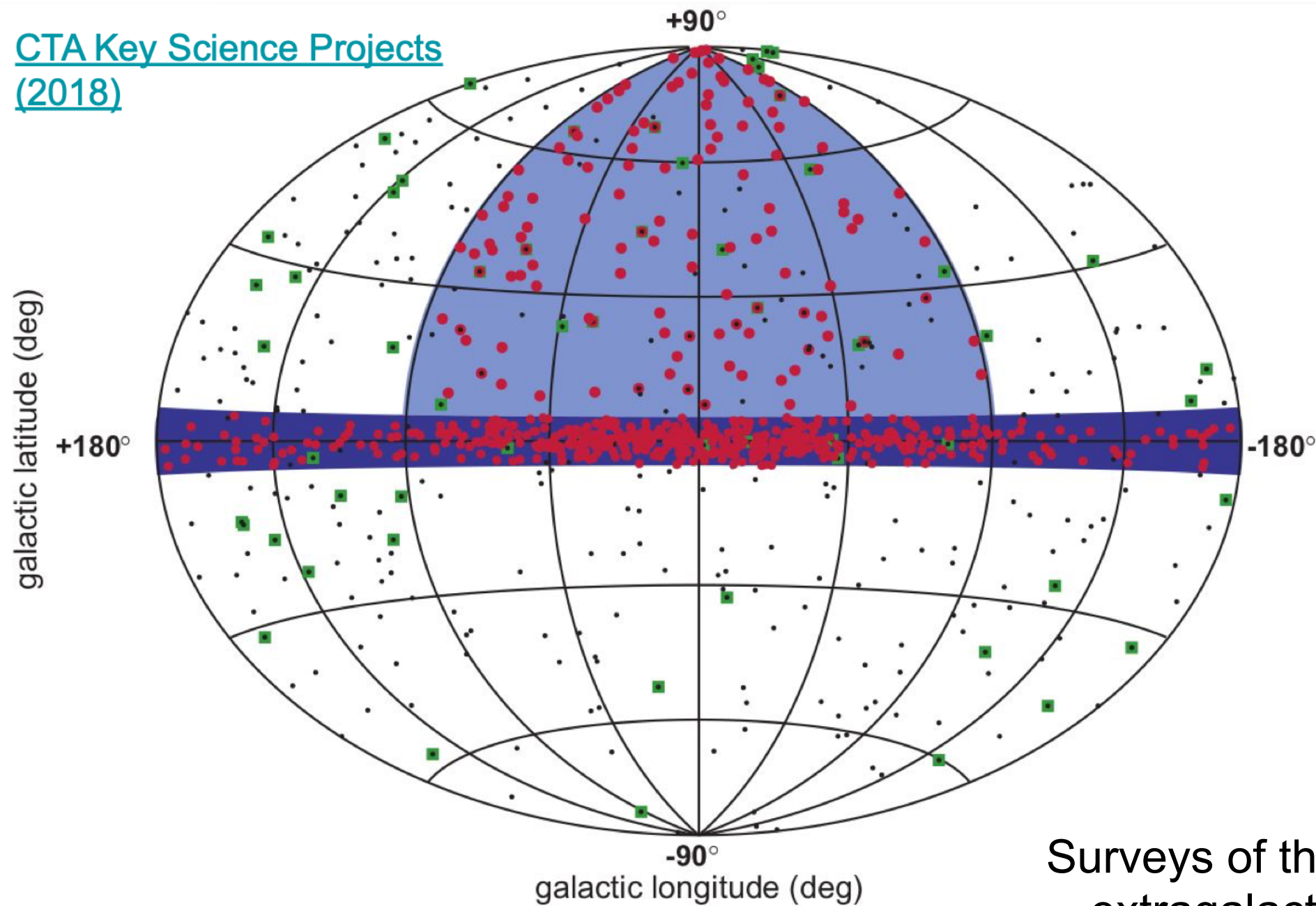
CTAO
Cherenkov Telescope Array Observatory

Kathrin Egberts . Ground-Based Gamma-Ray Astronomy . Erice . August 2026 77



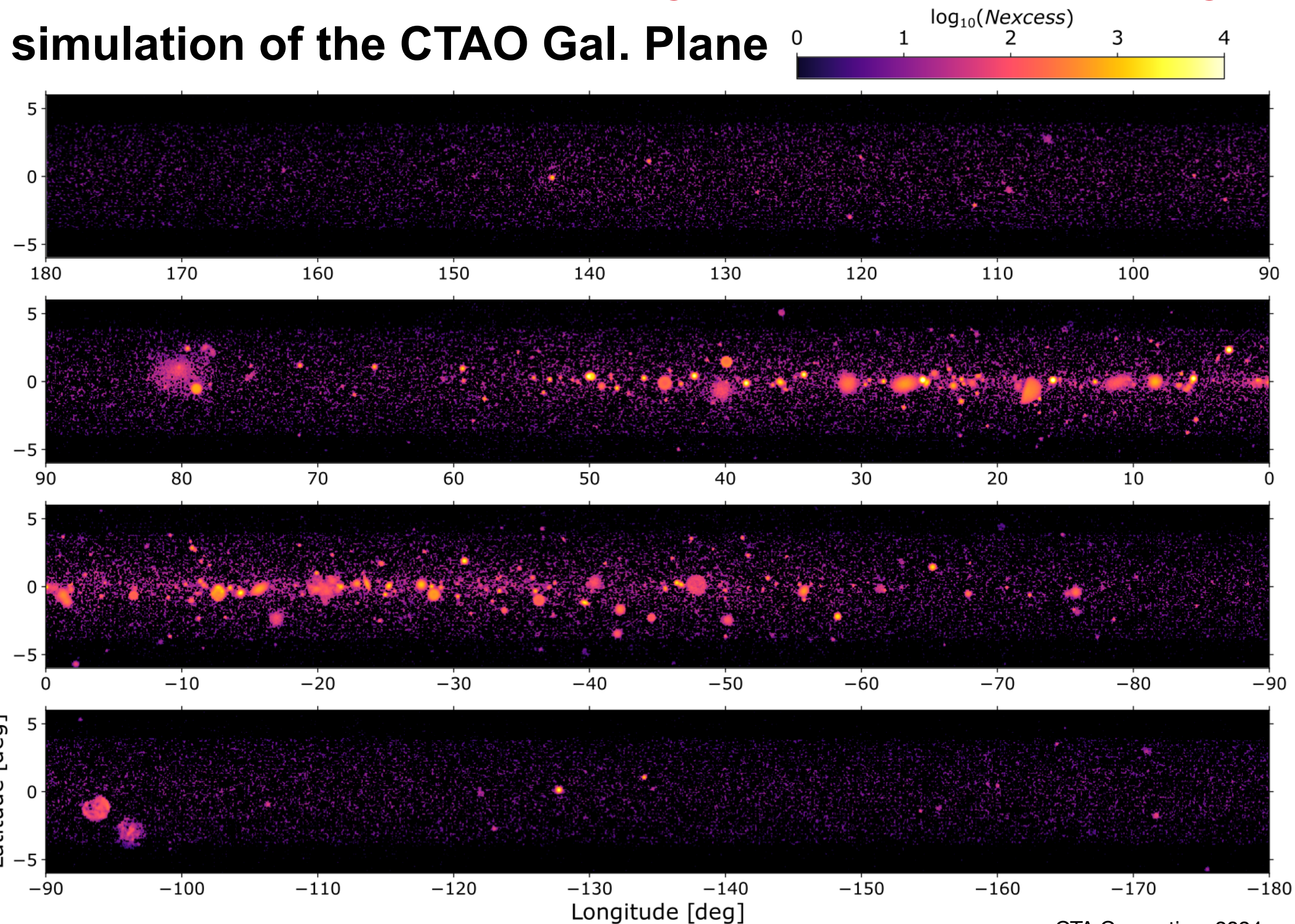
CTAO: the Key-Science-Project Surveys

[CTA Key Science Projects \(2018\)](#)



Surveys of the Galactic and extragalactic (25%) sky

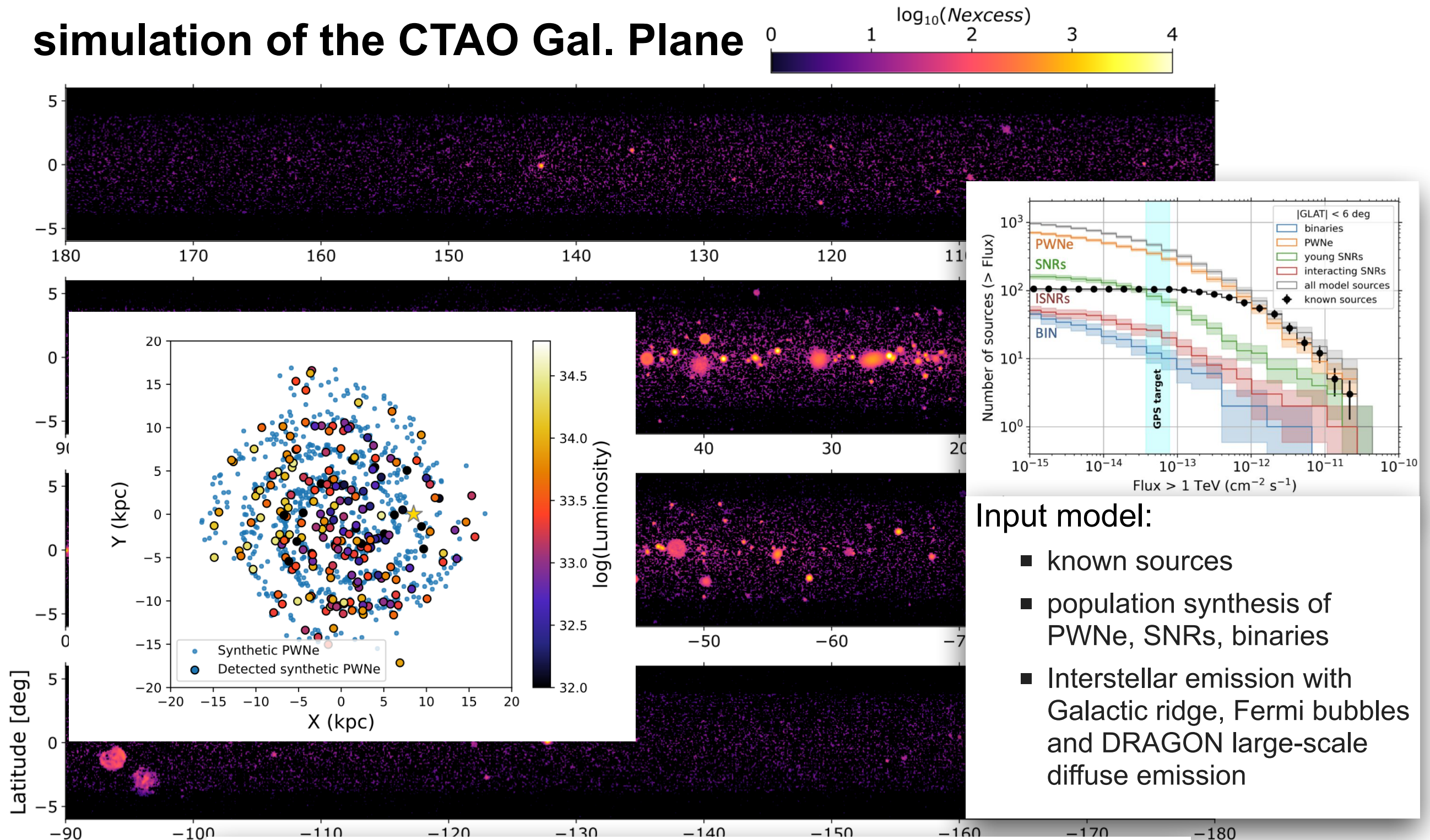
CTA Galactic Plane Survey: Performance Study



CTA Consortium 2024

CTA Galactic Plane Survey: Performance Study

simulation of the CTAO Gal. Plane

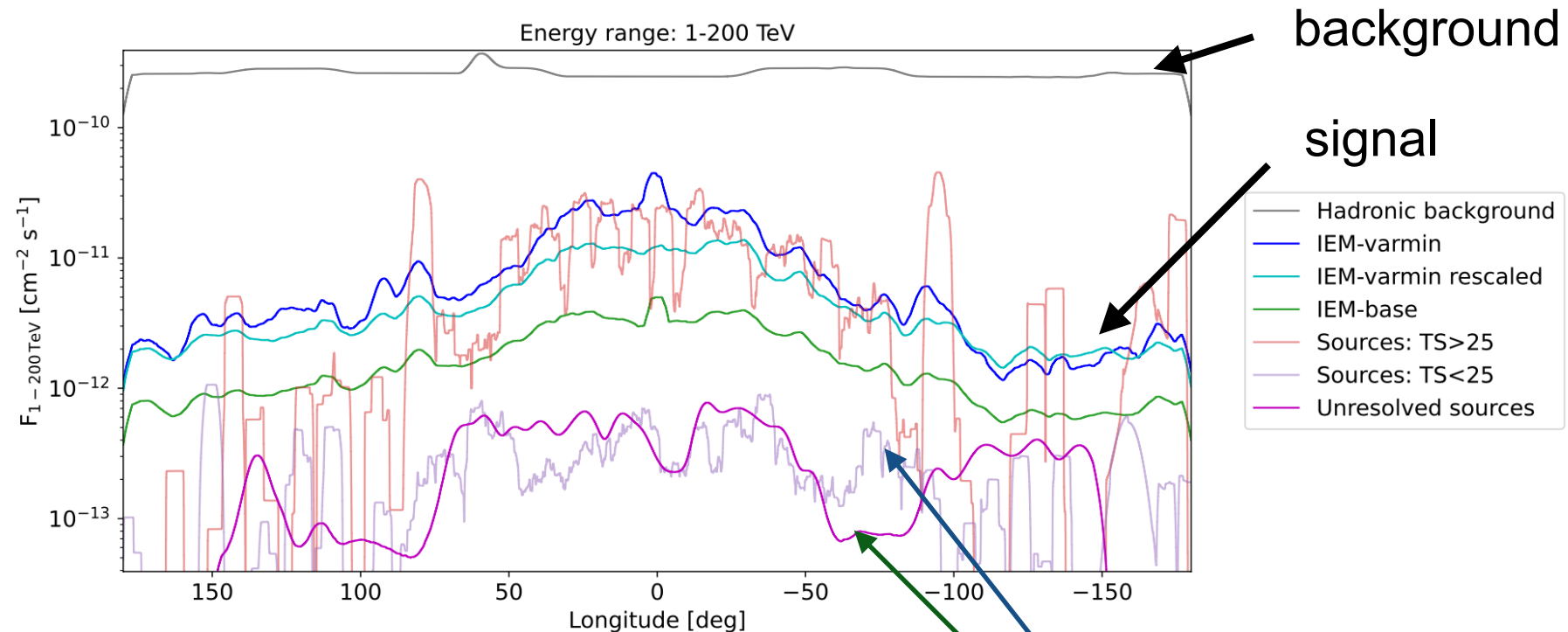


Input model:

- known sources
- population synthesis of PWNe, SNRs, binaries
- Interstellar emission with Galactic ridge, Fermi bubbles and DRAGON large-scale diffuse emission

Source count increase by factor of 5-7, probing the entire Milky Way

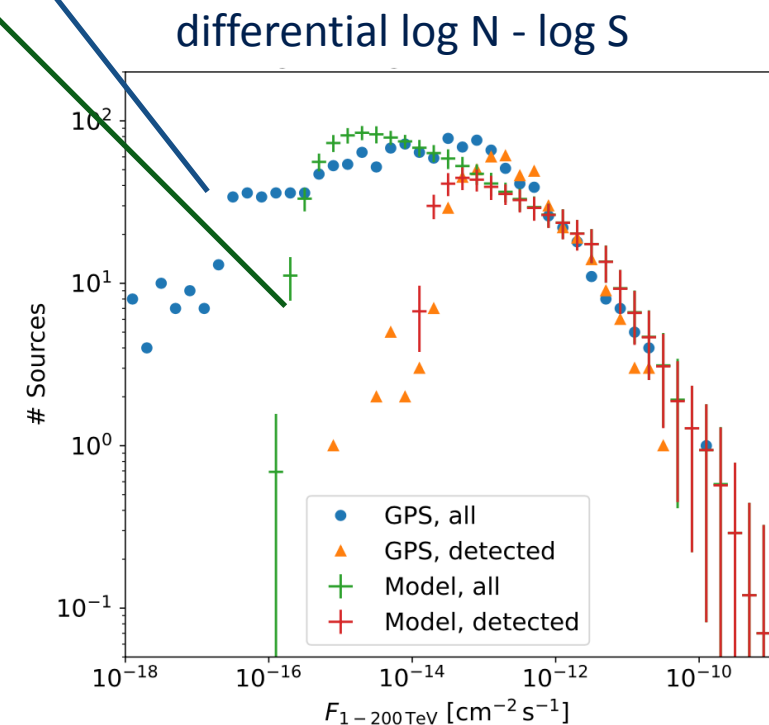
Large-Scale Diffuse Emission in the CTAO Era



Possibility to significantly detect large-scale diffuse emission

Background estimation facilitated by larger fields of view

Contribution of unresolved sources can be estimated by deriving population properties

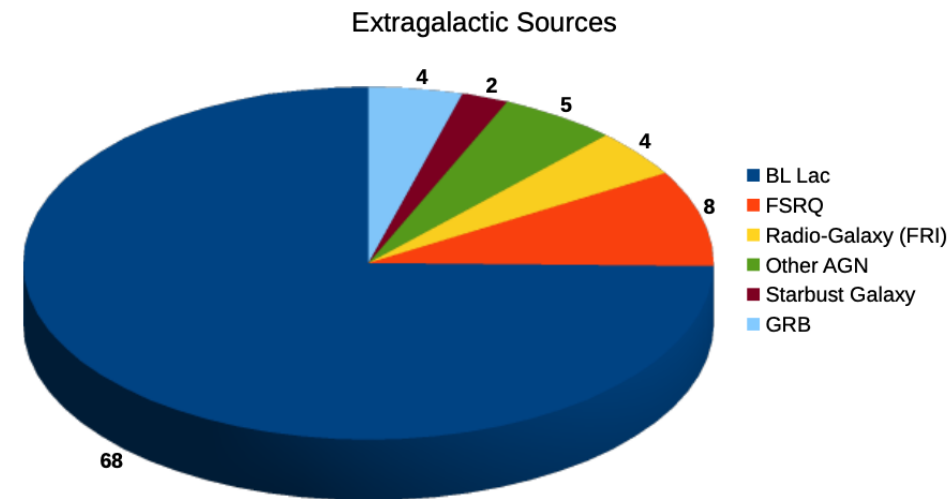
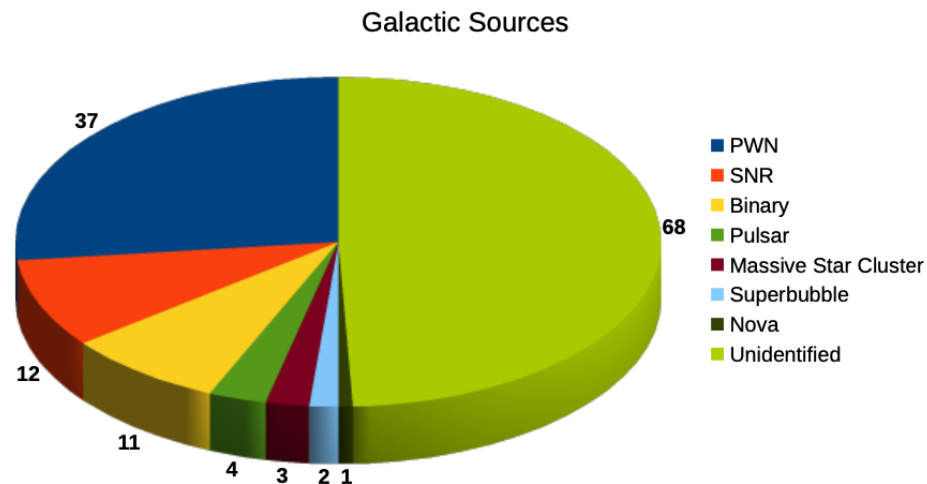
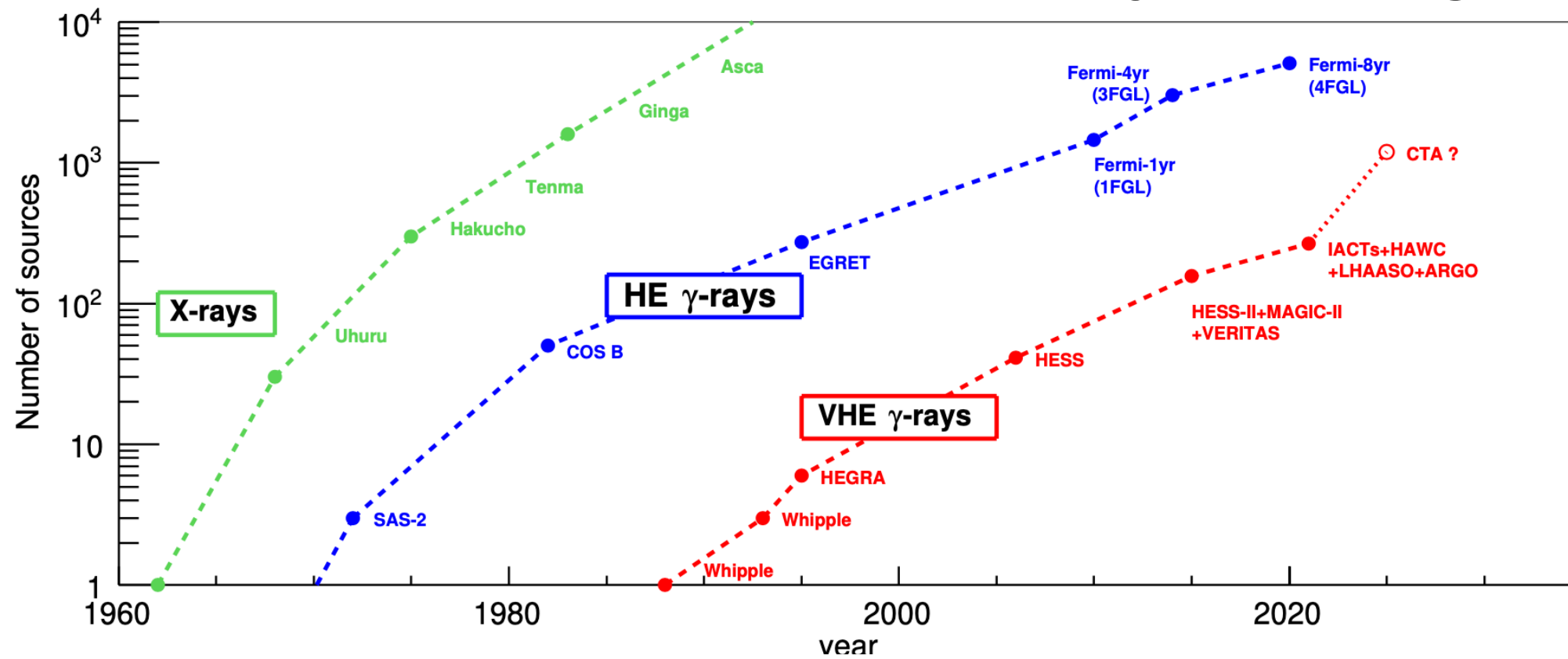


Conclusion

- Gamma-rays at VHE and UHE are a crucial probe to study cosmic-ray accelerators to highest energies
- Current generation of ground-based detectors have shown that there is an **incredible diverseness and richness in the gamma-ray sky**
- Discovery space at the sensitivity limit, new detections, population studies, in-depth understanding of our Milky Way - with the **tenfold sensitivity of next-generation instruments** in reach
- **Coverage of both hemispheres** guarantees extragalactic as well as Galactic science to be ideally explored
- **Strong complementarity** between particle detector arrays and imaging atmospheric Cherenkov telescopes

TeV Observations

A rapidly developing field



with a large variety in sources!

Mathieu de Naurois (2021)



Thank you!