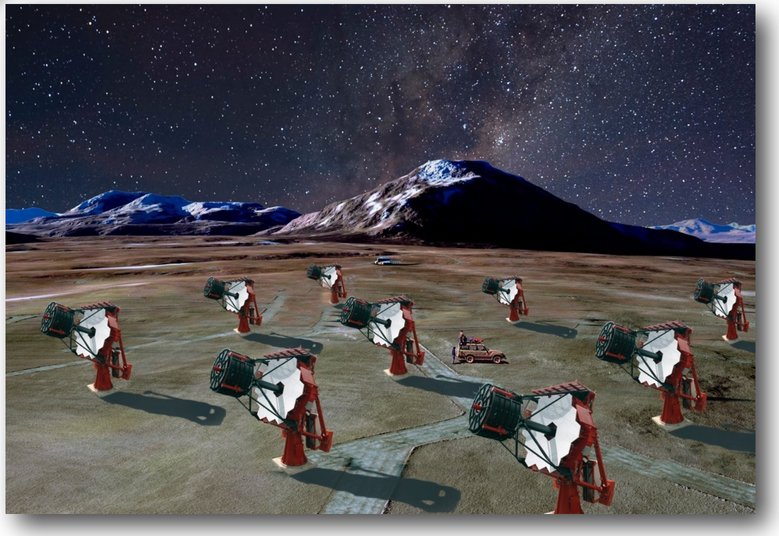


ASTRI Astrofisica con Specchi a Tecnologia Replicante Italiana

cta cherenkov telescope array

INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

Universidade de São Paulo
Instituto de Astronomia, Geofísica e Ciências Atmosféricas

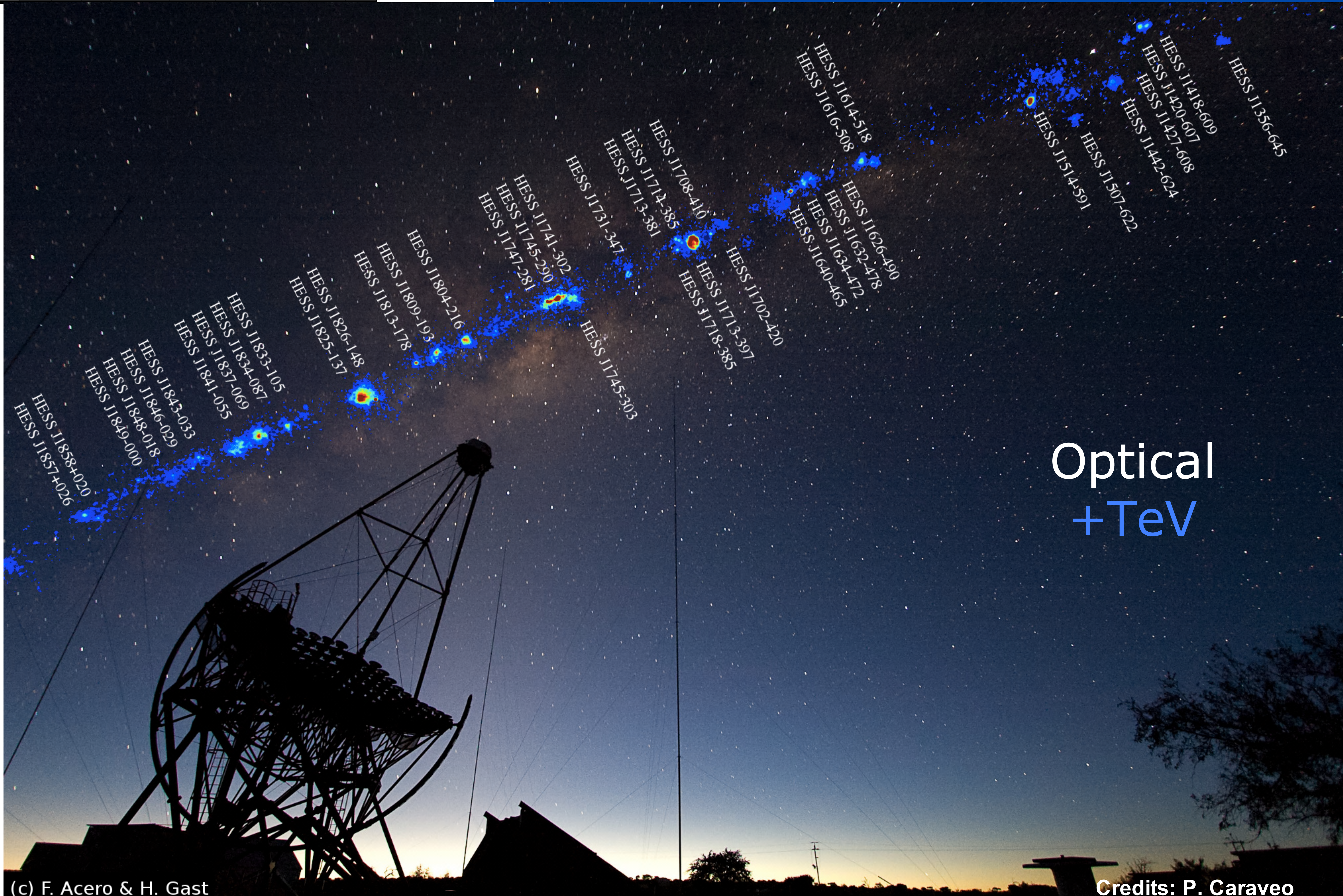
MIUR

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

The CTA and ASTRI Projects

A. Giuliani (INAF/IASF Milano)

The TeV Sky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HESS J1837-069
HESS J1834-087
HESS J1833-105
HESS J1826-148
HESS J1825-137
HESS J1813-178
HESS J1809-193
HESS J1804-216
HESS J1747-281
HESS J1745-290
HESS J1741-302
HESS J1745-303
HESS J1731-347
HESS J1713-381
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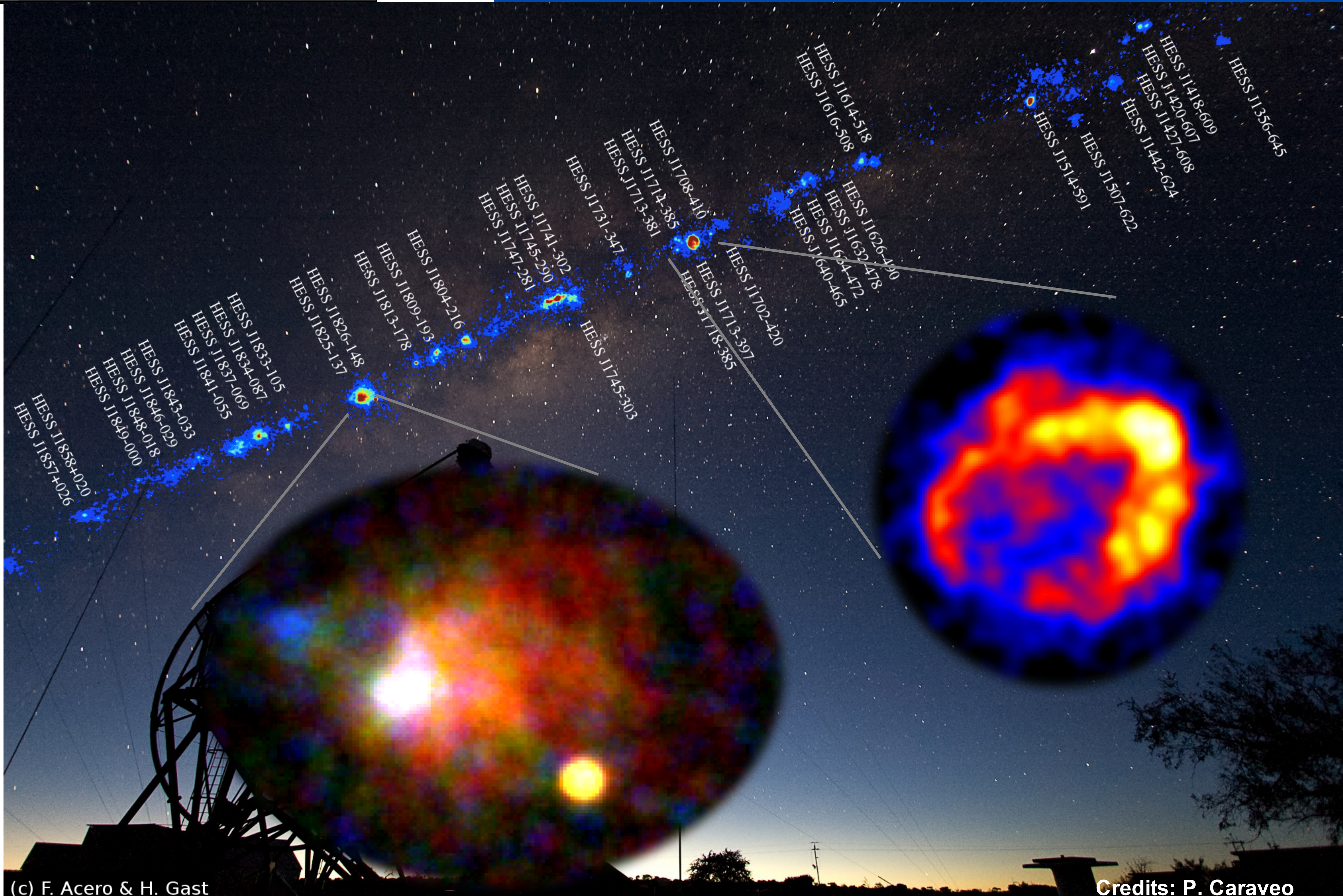
HESS J1708-410
HESS J1718-385
HESS J1713-397
HESS J1702-420
HESS J1640-465
HESS J1634-472
HESS J1632-478
HESS J1626-490
HESS J1616-508
HESS J1614-518
HESS J1514-591
HESS J1507-622
HESS J1442-624
HESS J1427-608
HESS J1420-607
HESS J1418-609
HESS J1356-645
Optical
+TeV
(c) F. Acero & H. Gast
Credits: P. Caraveo

The TeV Sky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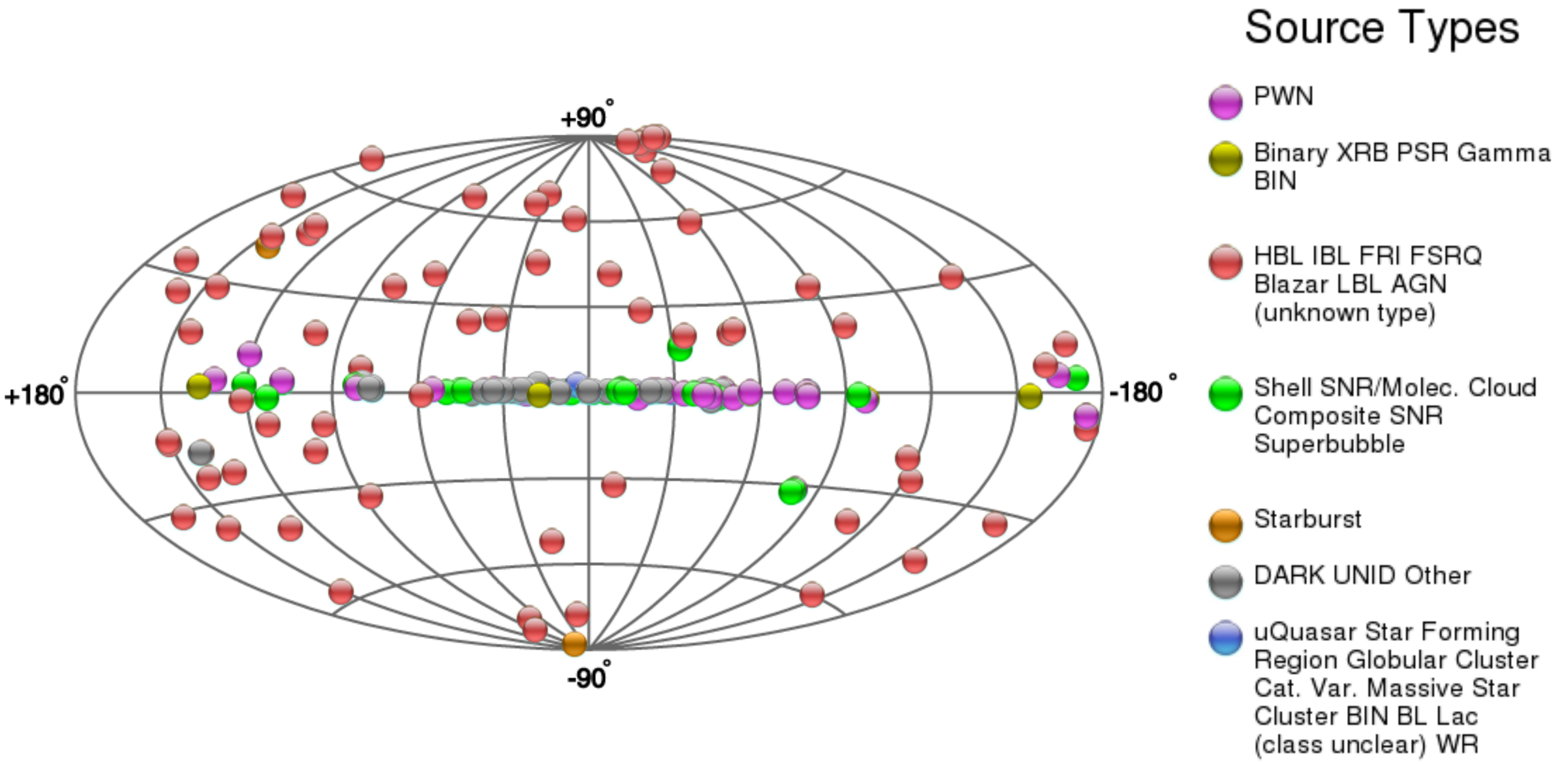
(c) F. Acero & H. Gast
Credits: P. Caraveo

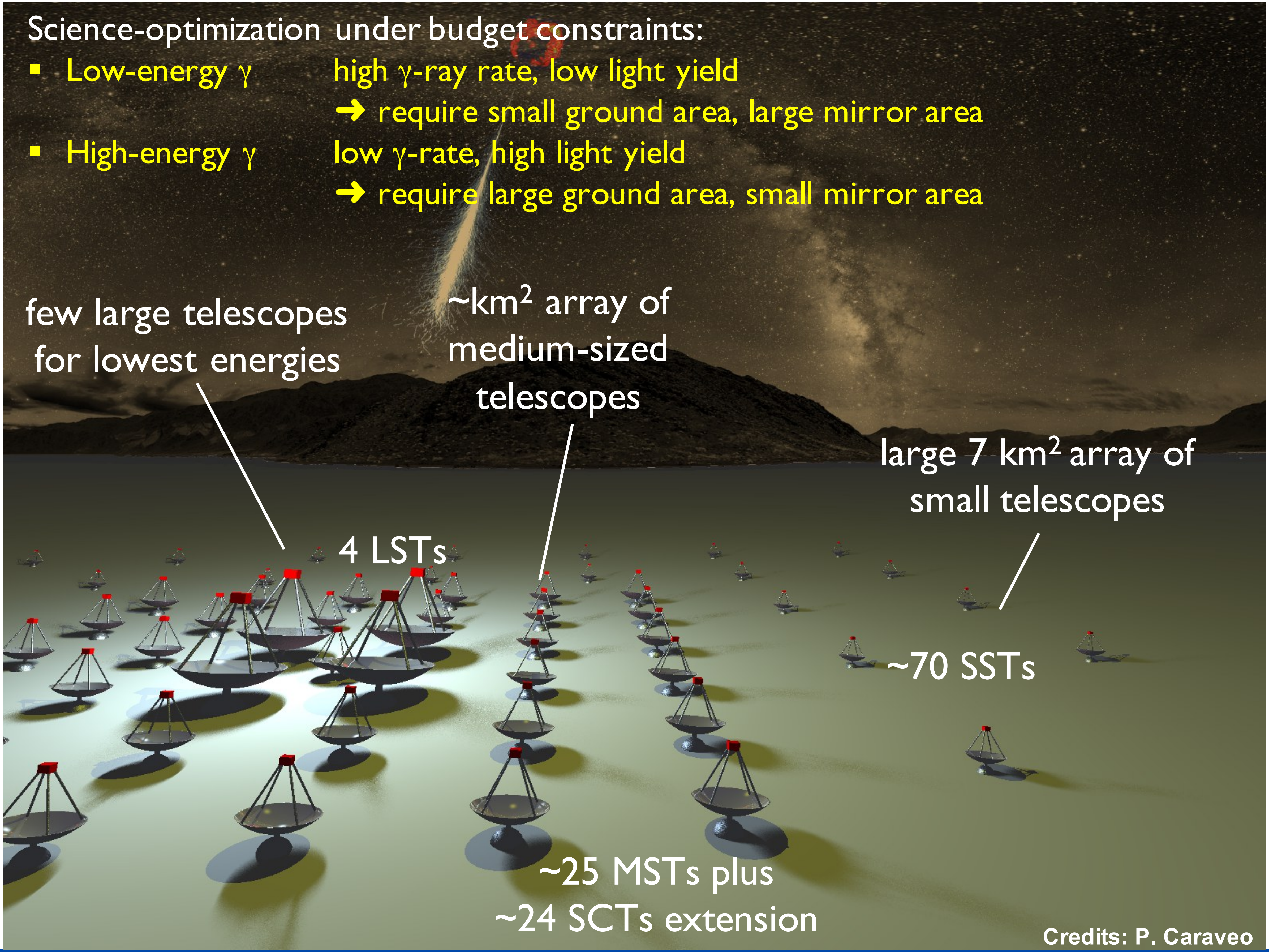
The TeV Sky



Credits: P. Caraveo

The Cherenkov Telescope Array

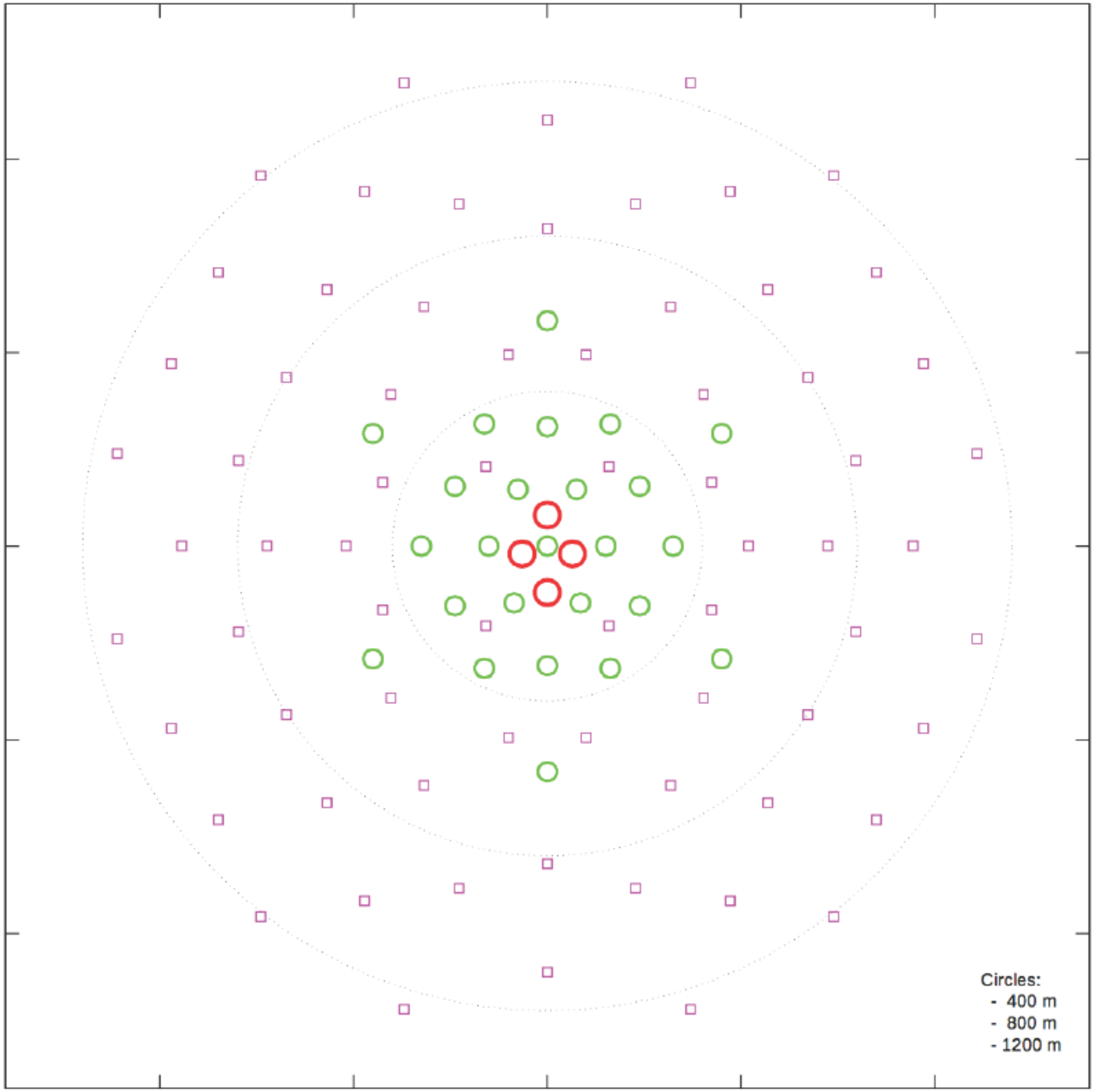
CTA Telescopes



Astrofisica con Specchi a Tecnologia Replicante Italiana

cta cherenkov telescope array

Final CTA Layout



4 LSTs, 25 MSTs, 70 SSTs

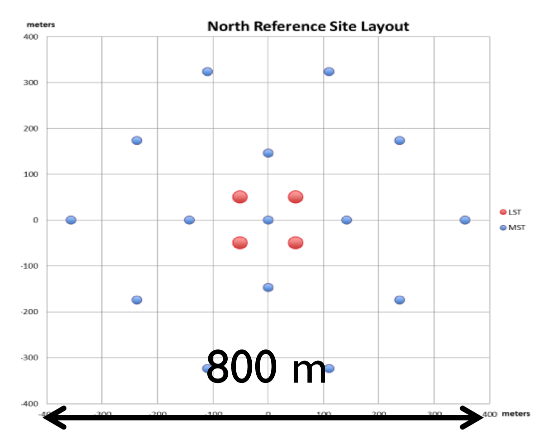
Type:

23-m LST
12-m MST
4-m SST

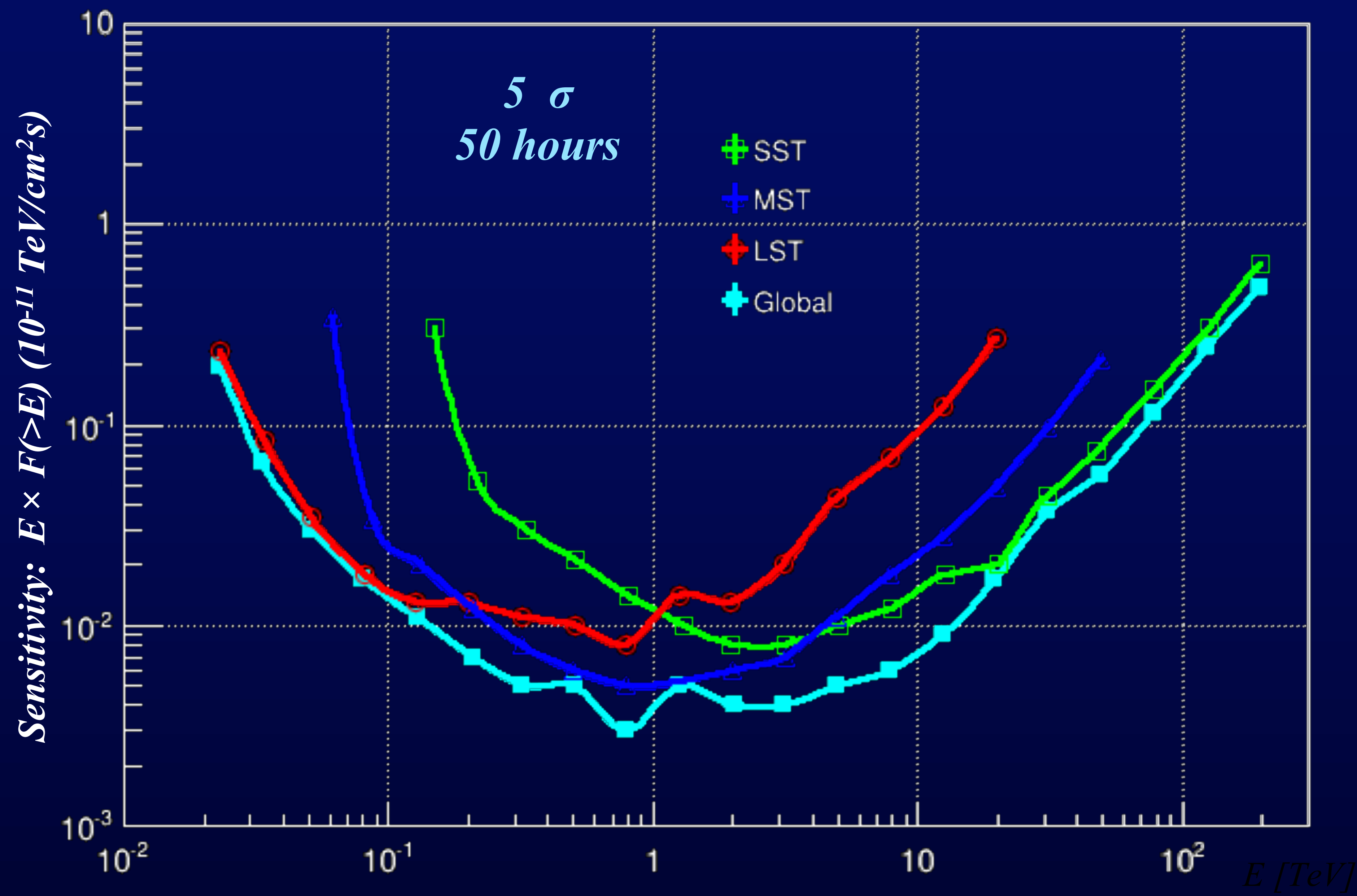
1000 m

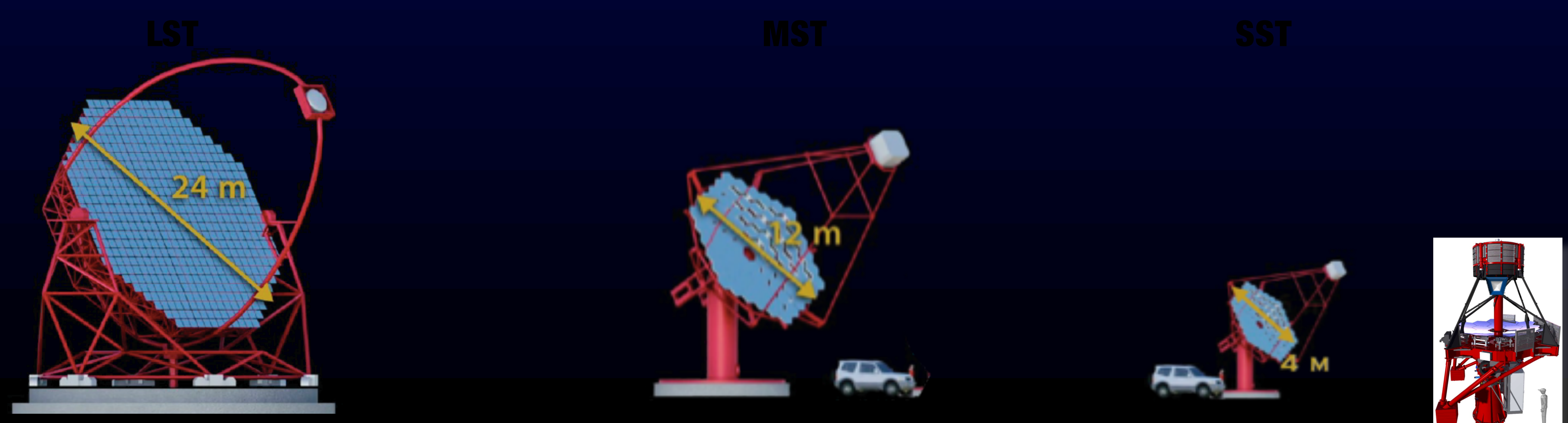
North (x) is up
West (y) is left

North site
4 large LST
15 medium MST

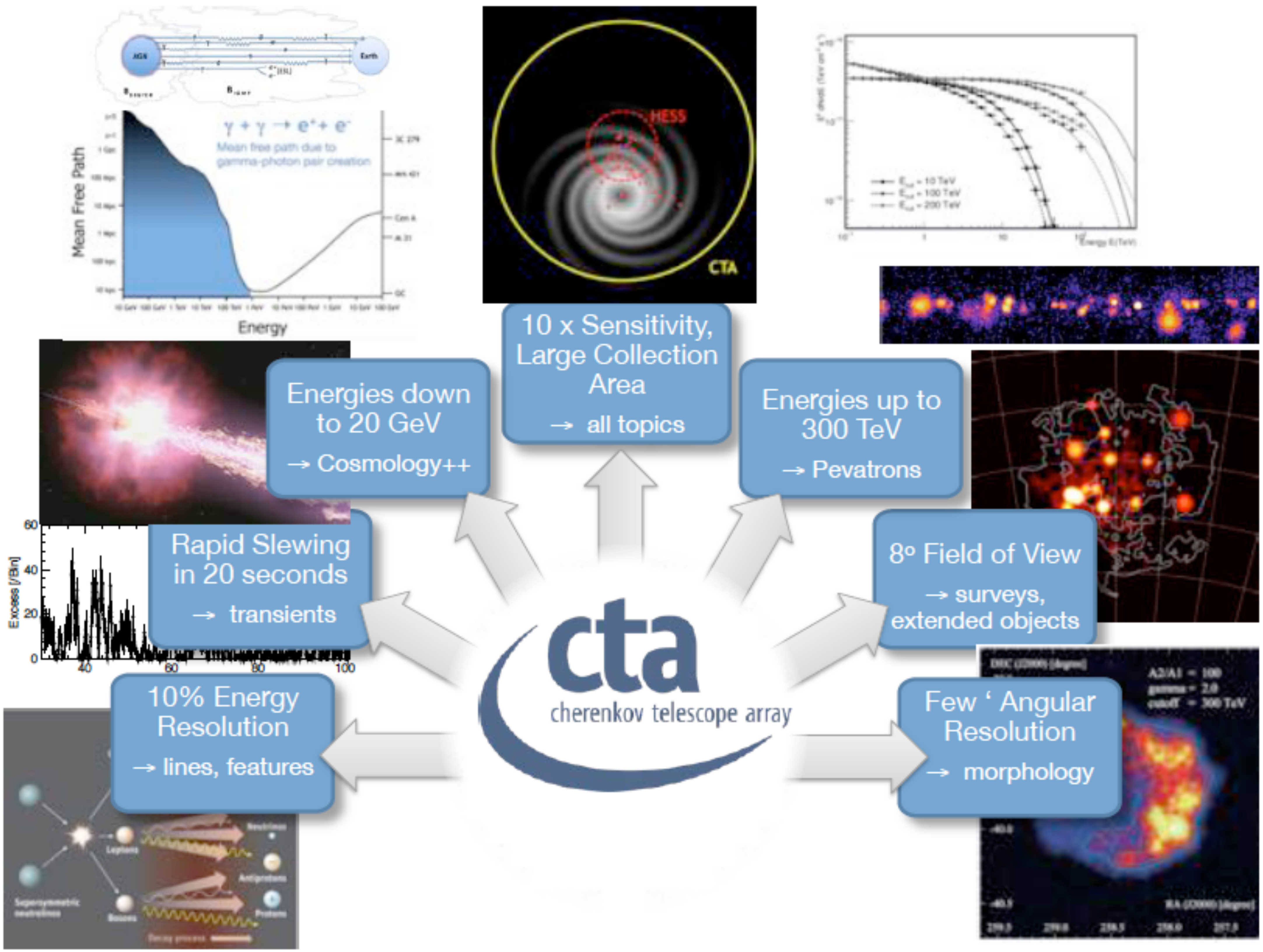


Credits: P. Caraveo


5 σ
50 hours
SST
MST
LST
Global
Sensitivity: E × F(>E) (10^-11 TeV/cm^2 s)
E [TeV]
10
1
10^-1
10^-2
10^-3
10^-2
10^-1
1
10
10^2


LST
24 m
MST
12 m
SST
4 M

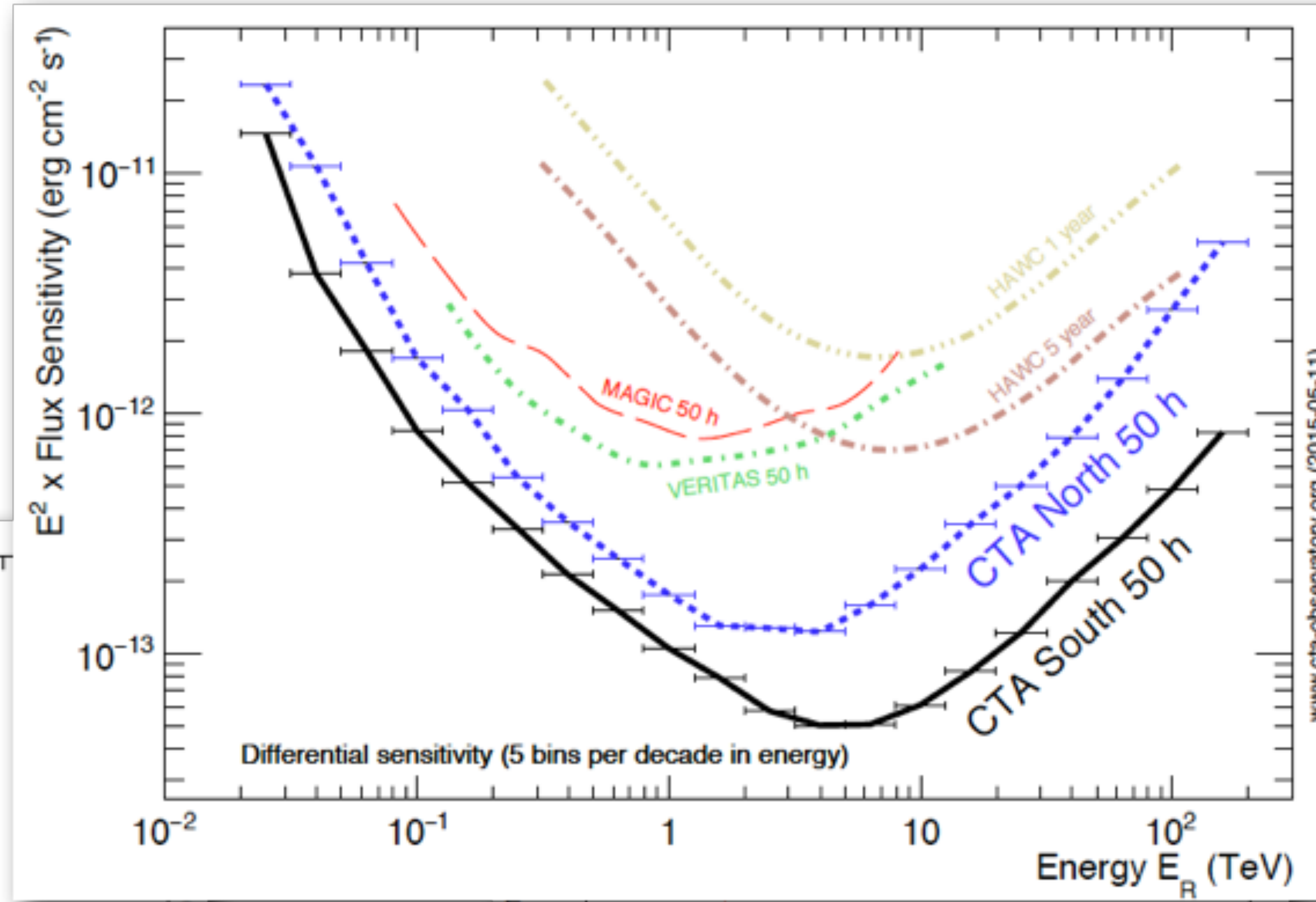
CTA Science Topics

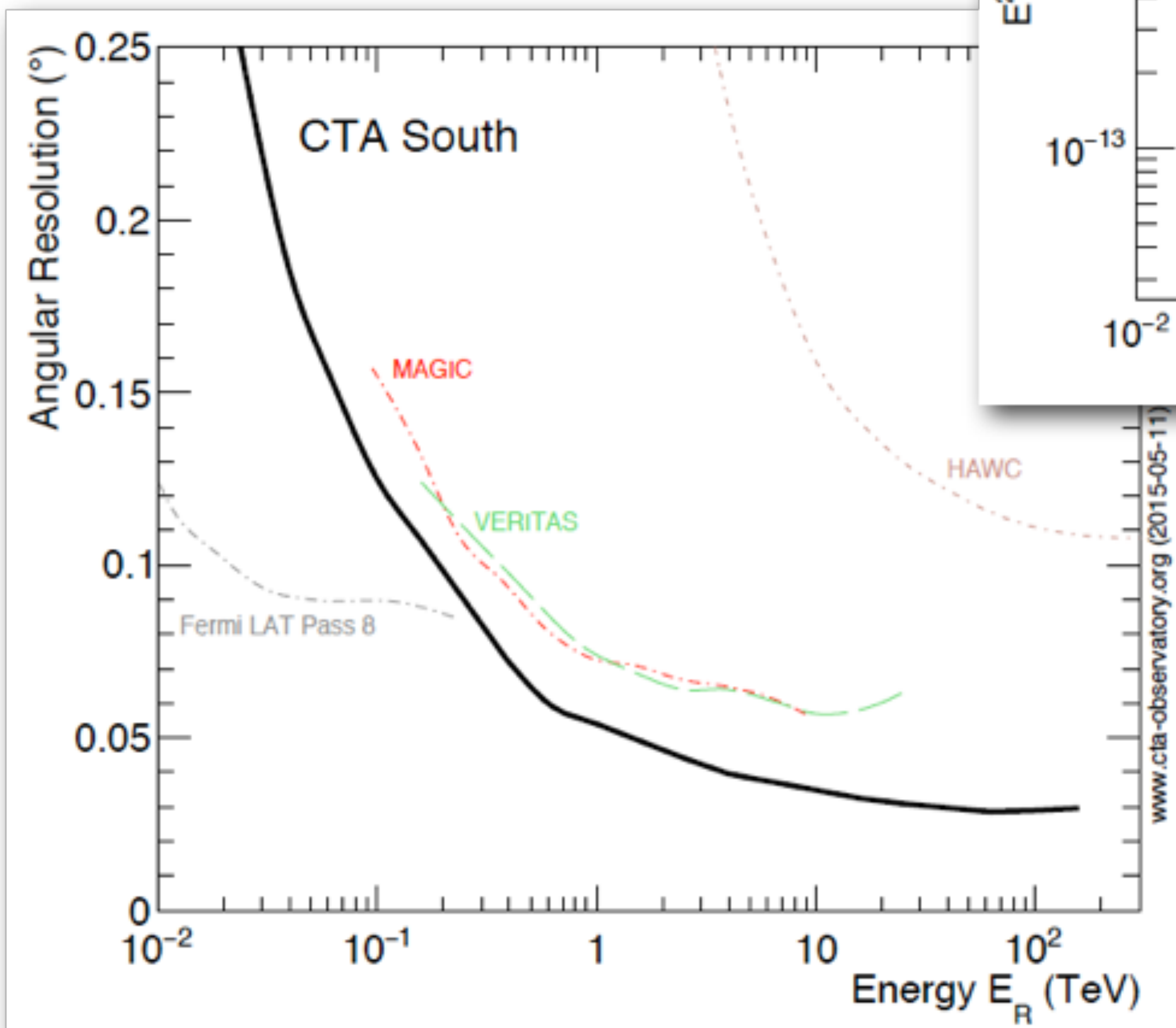


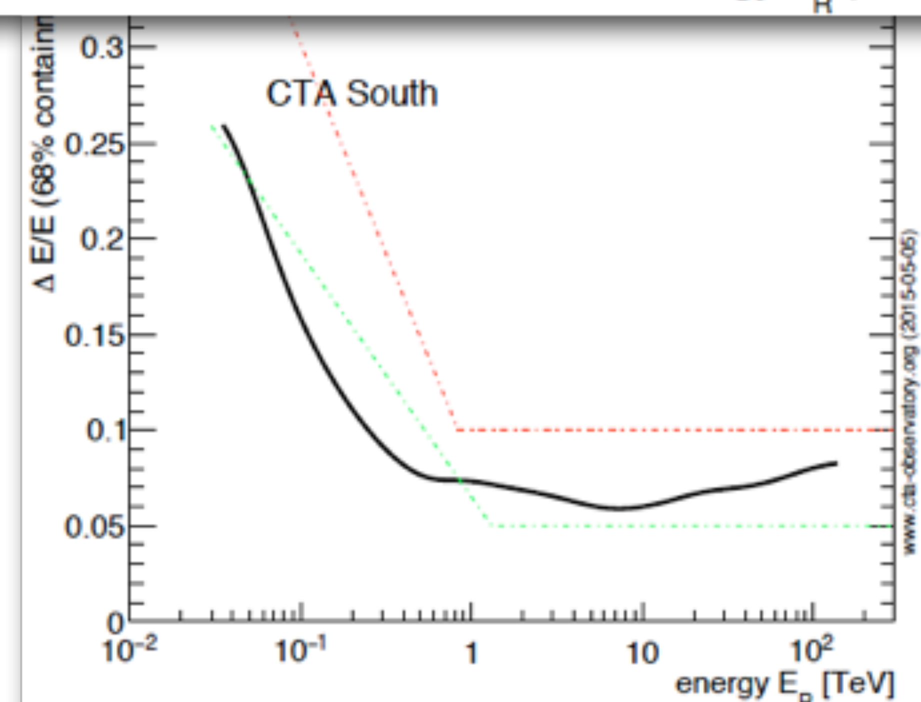
Credits: The CTA Consortium

CTA Performance

Credits: The CTA Consortium

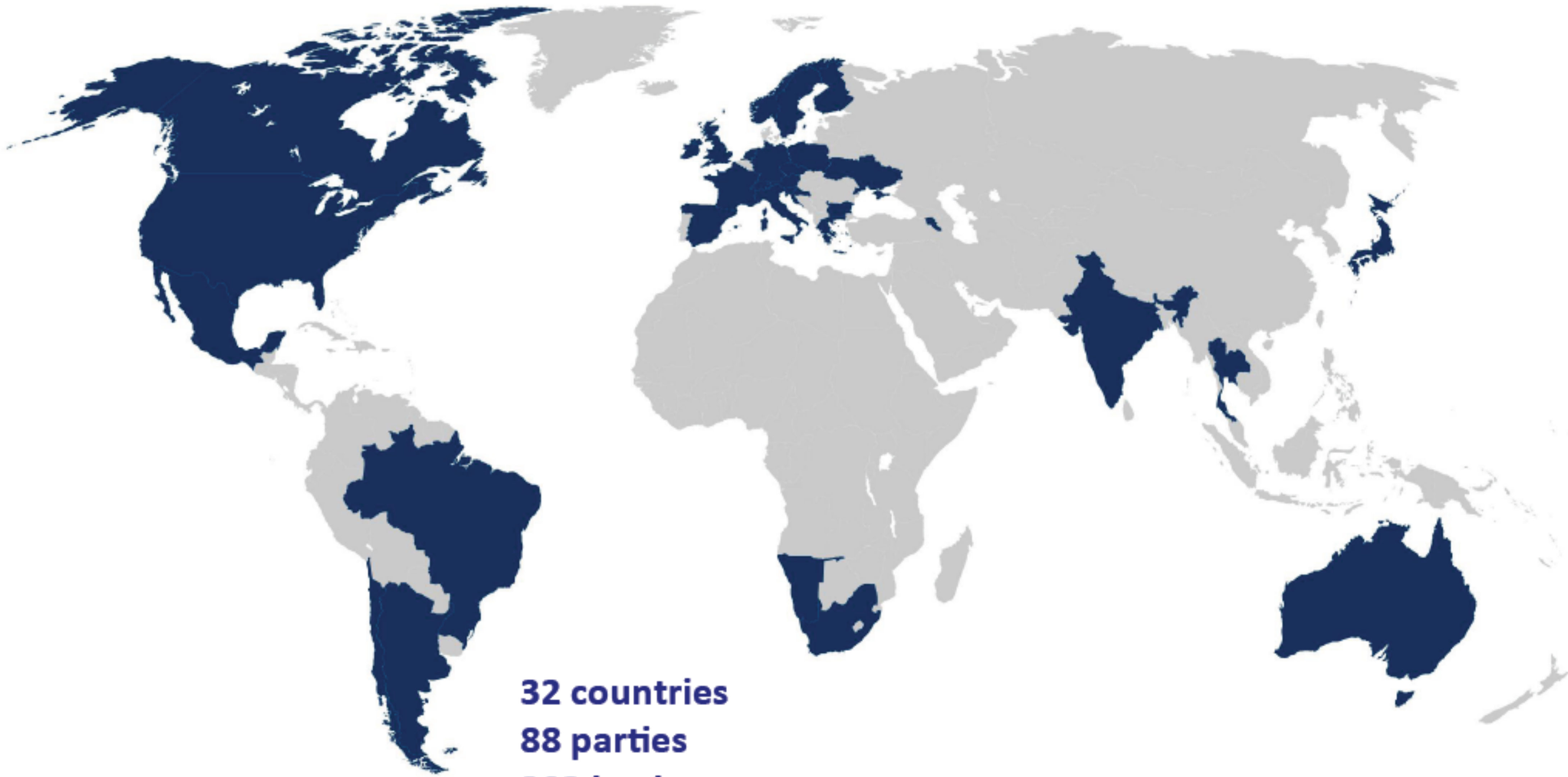






Consortium status

May 2016

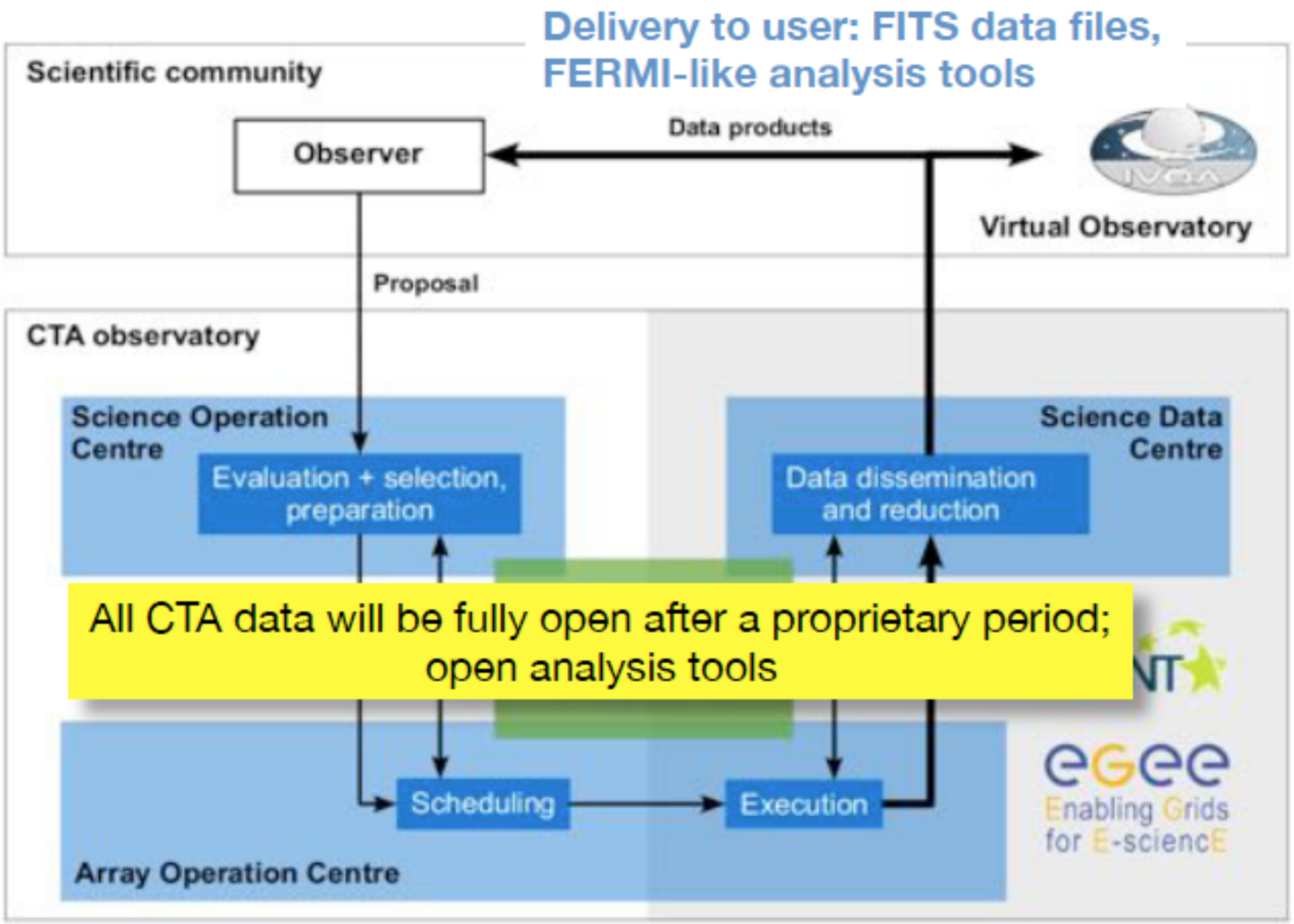


25

Credits: The CTA Consortium

CTA as an open Observatory

OPERATION AS OBSERVATORY



Credits: The CTA Consortium

CTA HQ in Bologna !

Credits: The CTA Consortium

NEWS RELEASE

FOR IMMEDIATE RELEASE
14 June 2016

Headquarters and Science Data Management Centre Sites Selected for World's Largest Gamma-Ray Detector

CTA Headquarters Building, Bologna
Download File: 1 MB
Credit: Bologna University Project Office
Description: Computer rendering image of some of the buildings of the new Bologna University–INAF Campus. The CTA-HQ will be mainly located on the third floor of the Bologna Observatory building.

CTA Science Data Management Centre Building, Zeuthen
Download File: 1 MB
Credit: Dahm Architekten & Ingenieure, Berlin
Description: Architectural rendering of new 1900 m^2 building complex on existing DESY campus.

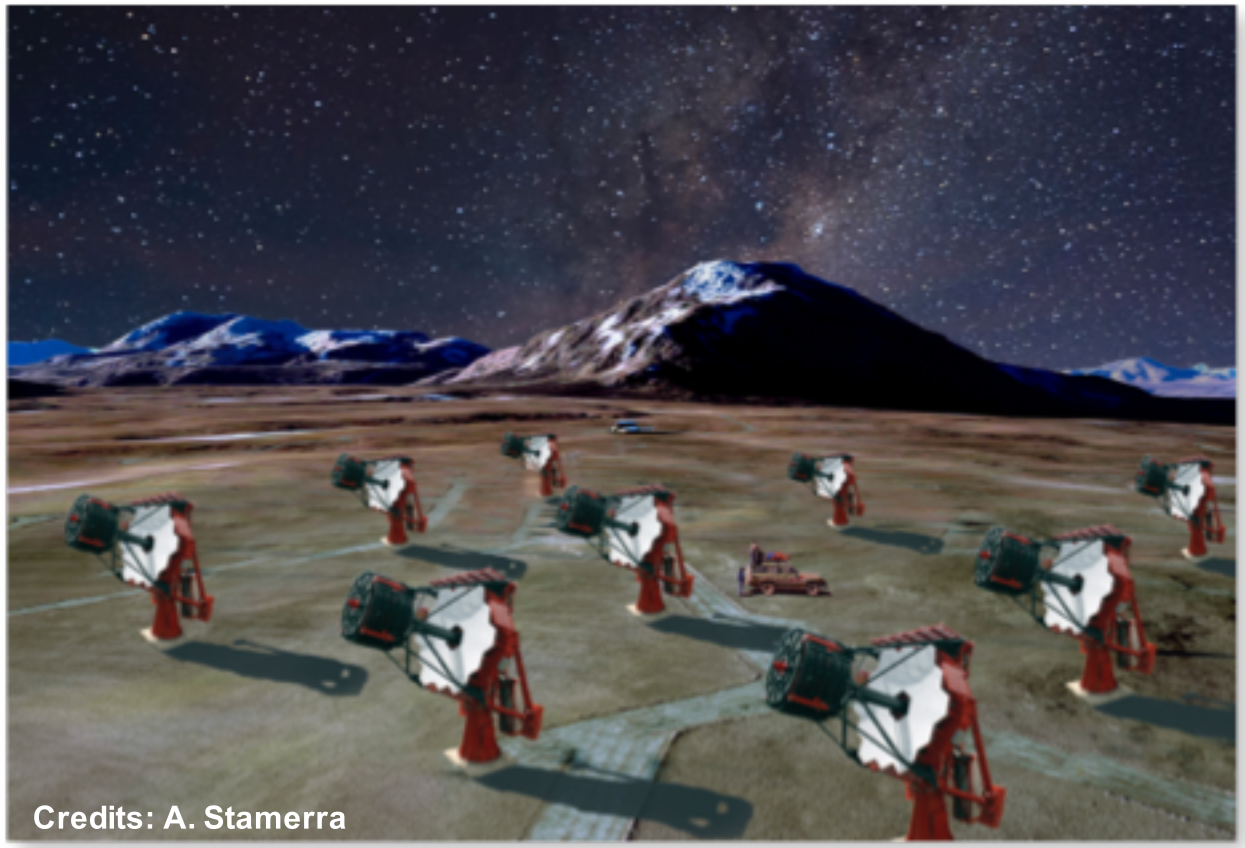
ASTRI end-to-end prototype

The ASTRI Project

The INAF-led **ASTRI Project** has two main goals:

- an **end-to-end prototype** of the **CTA small-sized telescope** in a dual-mirror, Schwarzschild-Couder configuration (ASTRI SST-2M), currently under commissioning at the INAF observing station on Mt. Etna (Sicily);
- an **ASTRI mini-array** of pre-production units composed of **nine small-sized telescopes** proposed to be installed at the chosen CTA Southern site in 2017.

Credits: T. Abegg



Credits: A. Stamerra

The ASTRI Project in a nutshell

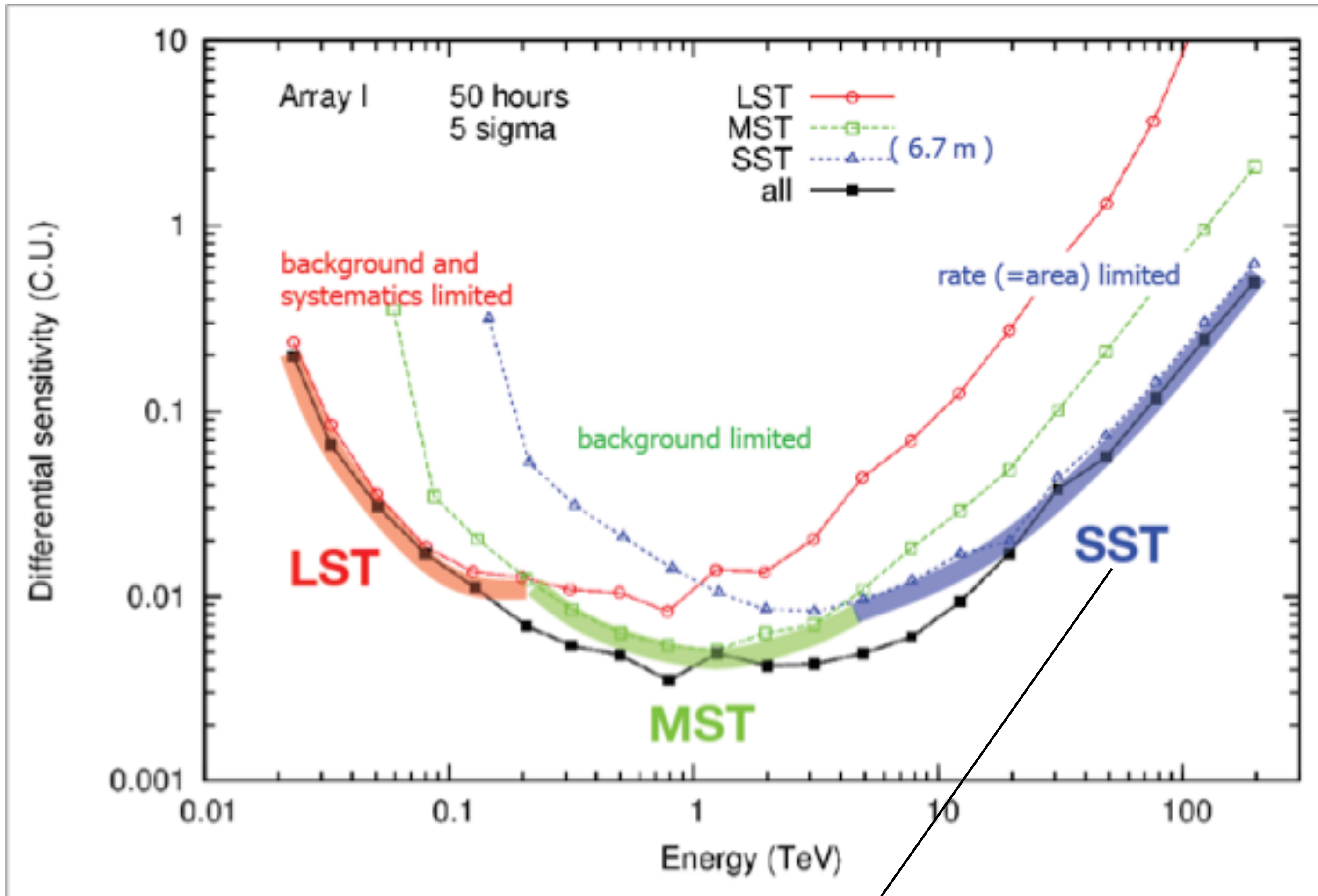
- **End-to-end SST-2M prototype**
  - Validation and commissioning of the prototype via Cherenkov astronomical observations

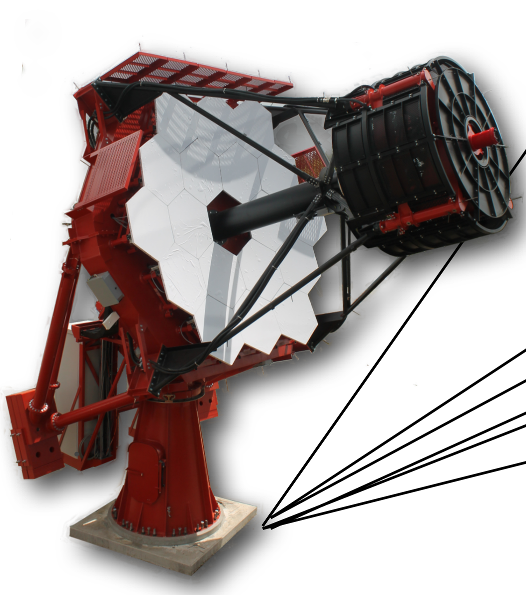
- **End-to-end implementation of a mini-array**
  - ≥ 9 SST-2M (pre-production) at the CTA southern site
  - Validation and commissioning of the ASTRI mini-array of pre-production CTA telescopes (including trigger and SW) via Cherenkov astronomical observations, first pre-production scientific data

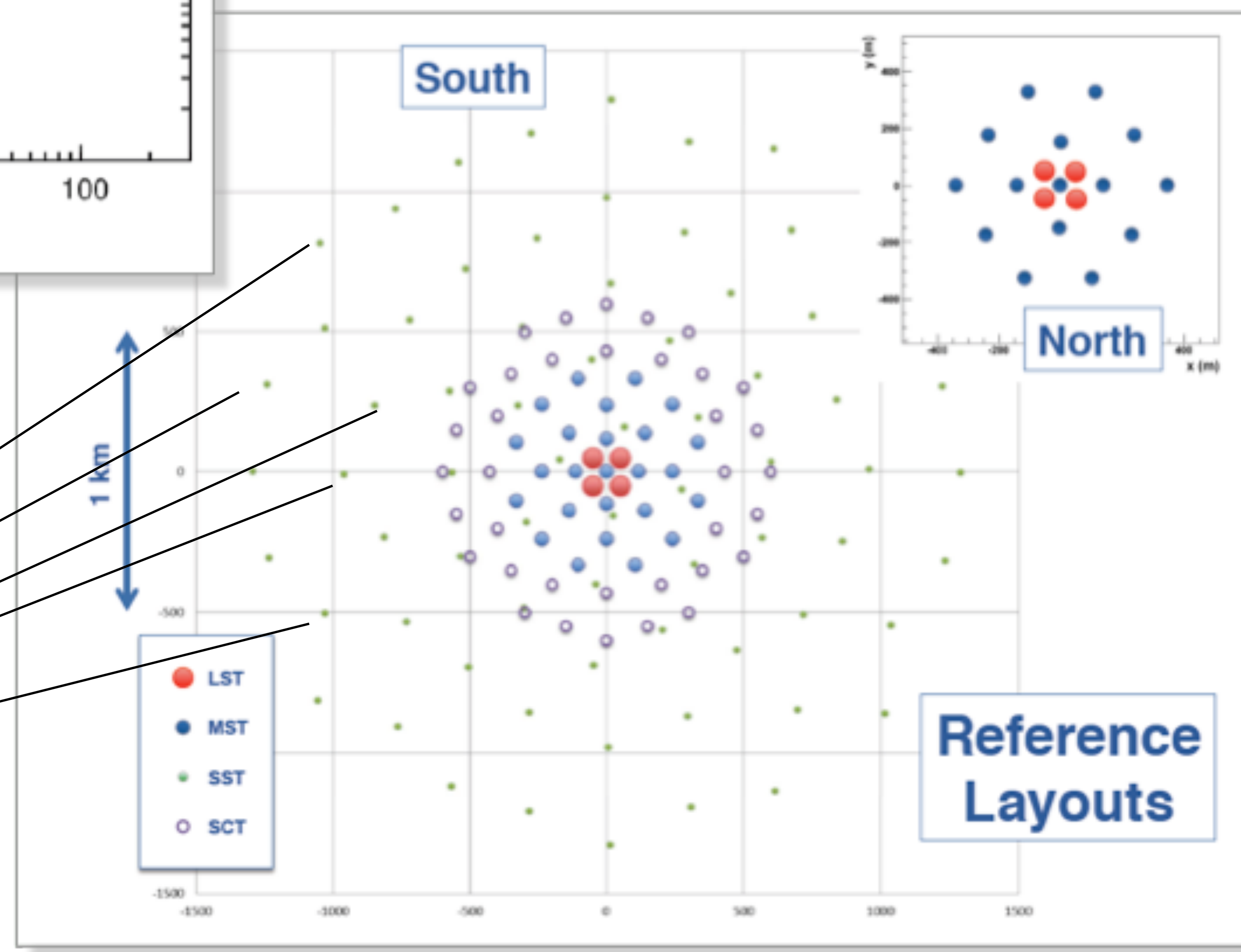
- **Aiming at the construction of 35 out of the 70 SST units** of the CTA southern array

Astrofisica con Specchi a Tecnologia Replicante Italiana

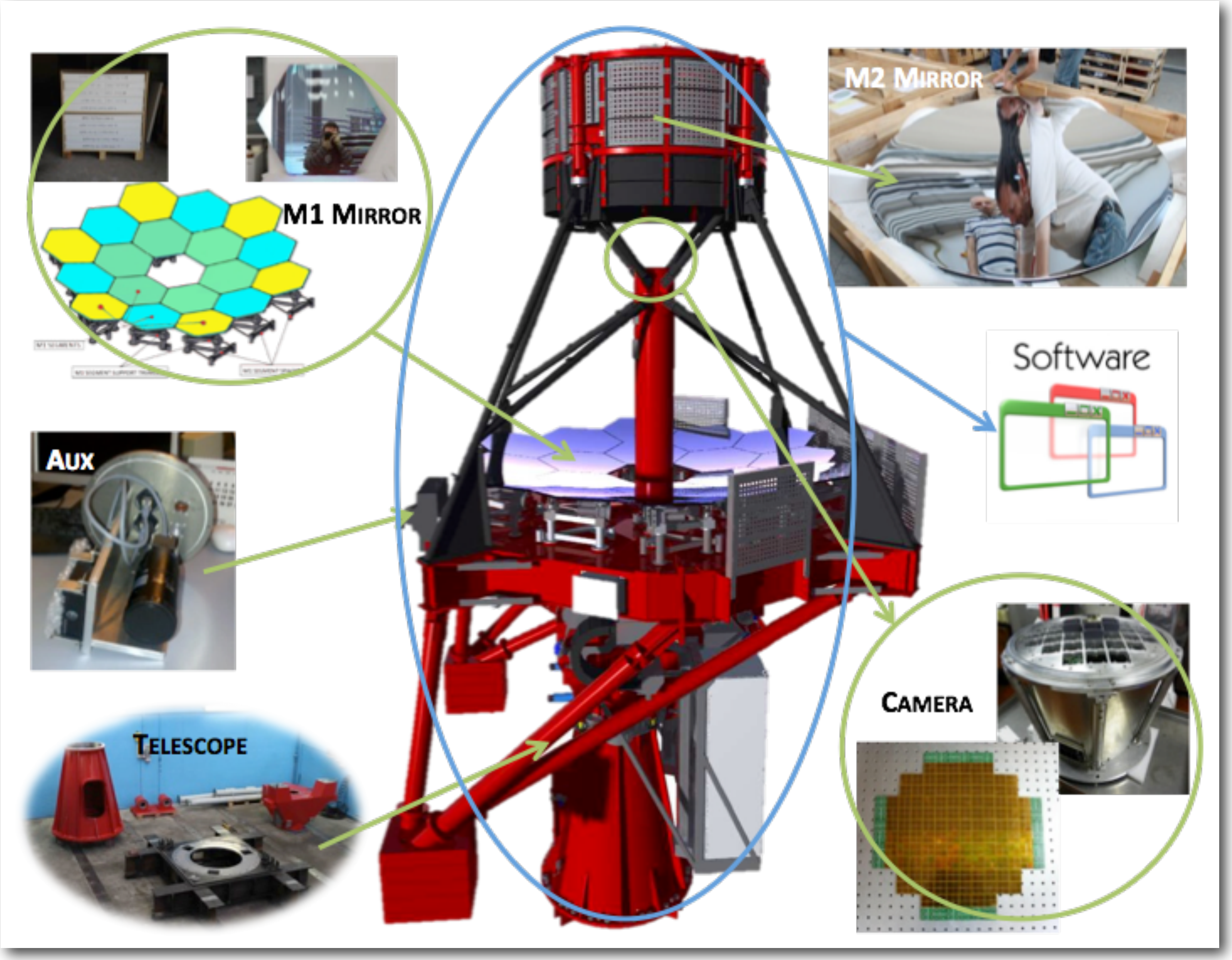
The ASTRI Project and CTA







ASTRI SST-2M end-to-end approach



The ASTRI SST-2M E2E prototype

★ Science !

We expect to detect **1 Crab flux level sources at 5-sigma in a few hours at E > 1 TeV**

More information:
Vercellone et al., 2015, arXiv:1508.00799
(and references therein)

ASTRI SST-2M **innovative solutions**:

Dual-mirror optical layout

first time for VHE IACTs;
reduces the plate-scale;
★ optimal PSF across the entire FoV.

SiPMs photo-detectors

small pixel-size;
★ can work during moonlight;
fast front-end and control electronics;

Wide field-of view (9.6°)

excellent for:
★ extended sources, surveys;
allows to extend the energy range above 100 TeV.

ASTRI SST-2M characteristics

Energy threshold

- 1 TeV

Telescope characteristics

- Primary mirror = ∅ 4.3m
- Optical design = Schwarzschild-Couder
- M1 type = Segmented (18, 3 coronae)
- Secondary mirror = ∅ 1.8m (2.2m RoC)
- M2 type = Monolithic
- M1-M2 distance = 3m
- Optical effective area = 6m^2
- F/D1 = 0.5, F = 2.15m

Camera characteristics

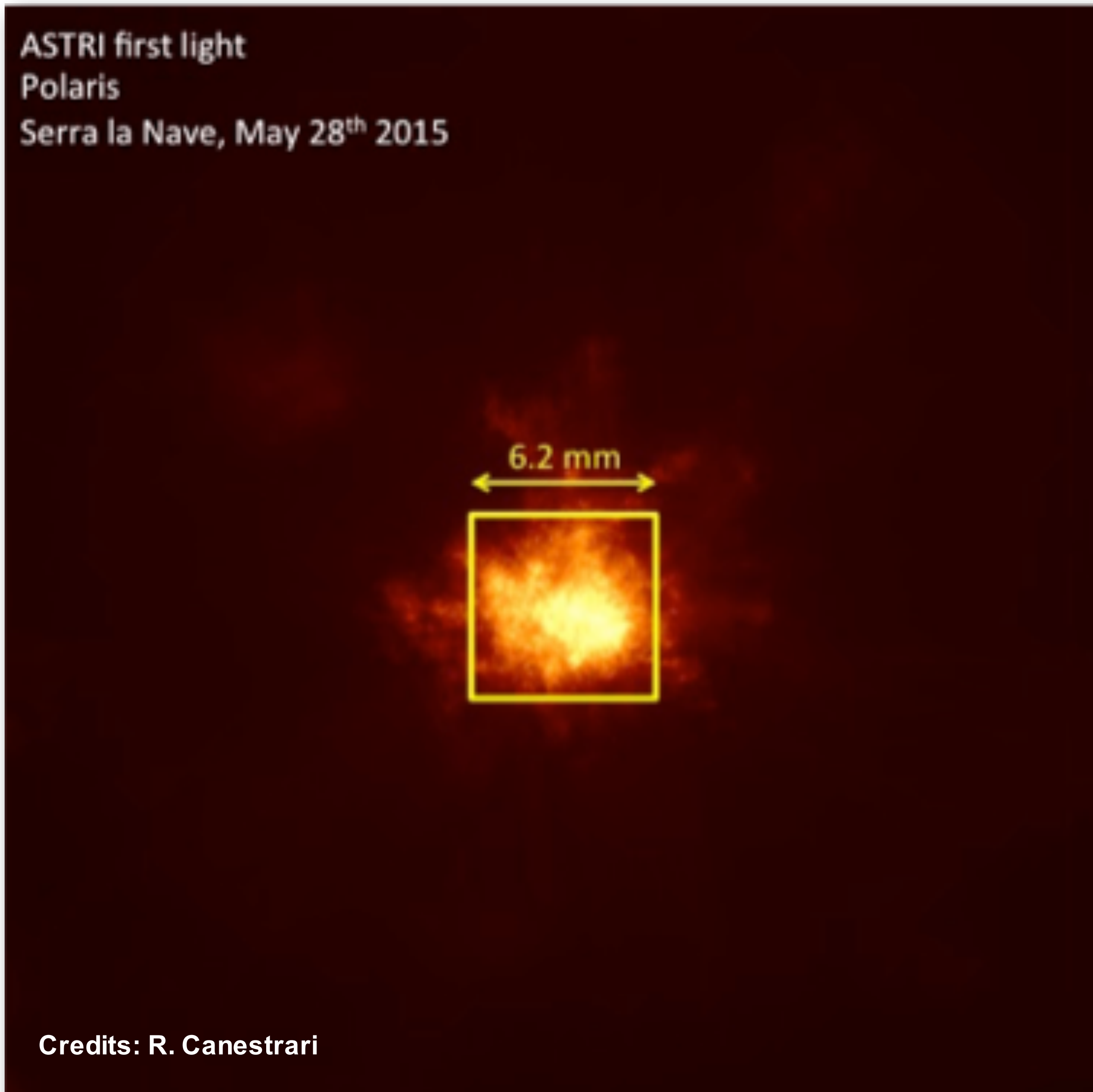
- Number of logical pixels = 1984
- Pixel = 0.17° (plate scale = 37.5mm/°)
- Field of View = 9.6°
- Sensors type = SiPMs

ASTRI SST-2M optical first light !

First optical light with a Schwarzschild-Couder telescope ever!

Performed without optimal mirror alignment

CTA requirements on PSF fully met !

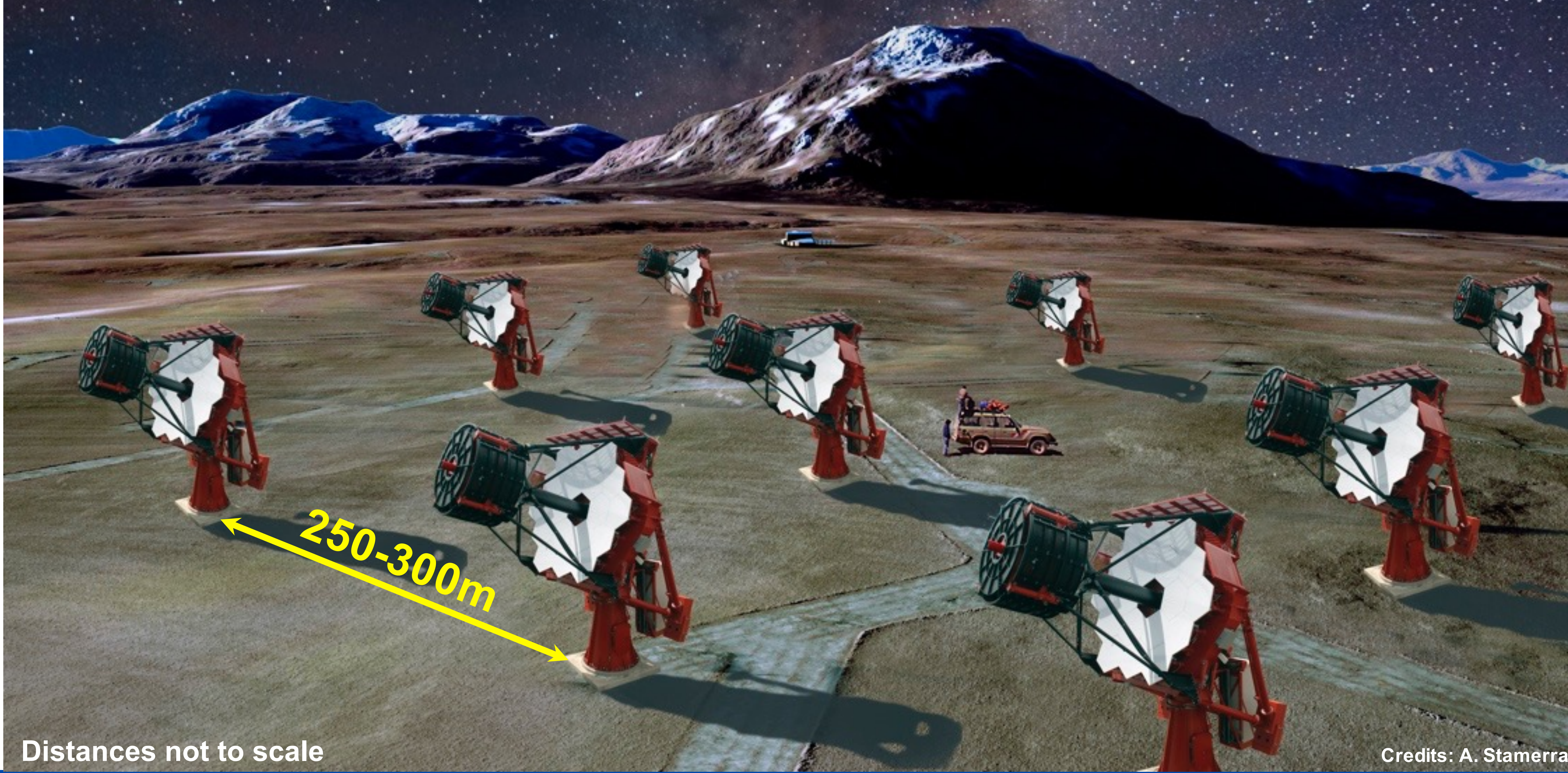


“Optical Camera” equipped with a 36mm x 36mm CCD (about 1º FoV)

ASTRI mini-array of pre-production CTA telescopes

Led by INAF in collaboration with:

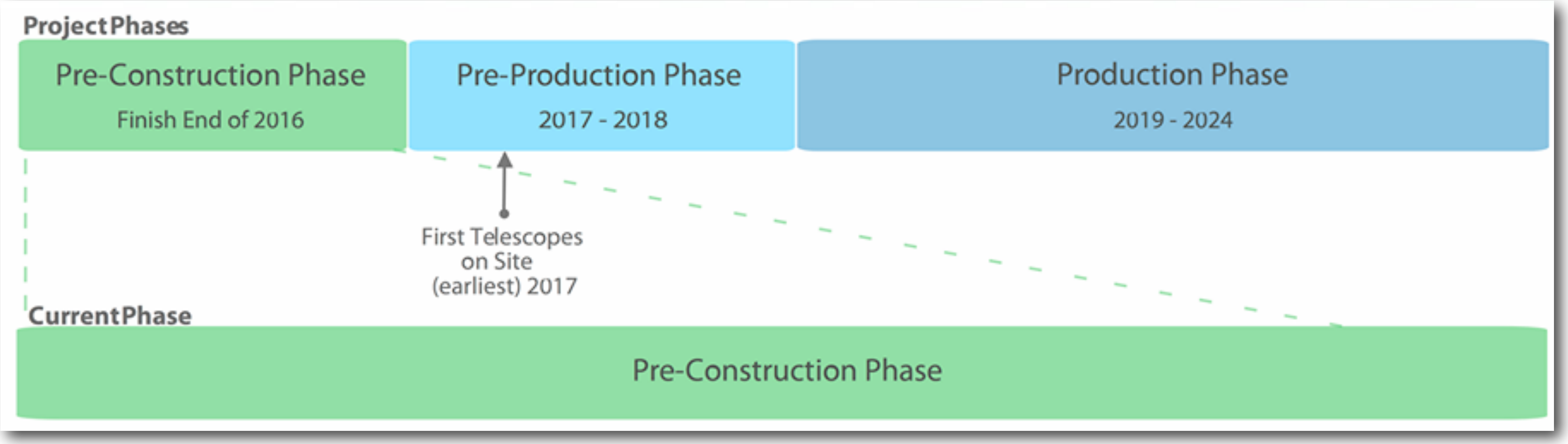
- Universidade de São Paulo & FAPESP, Brazil
- North-West University, South Africa
- INFN (trigger facility and SW)



Distances not to scale

Credits: A. Stamerra

CTA phases and pre-production telescopes



Pre-Production phase: deployment of pre-production telescopes on final official CTA array sites in order to **assess aspects of mass production** and final engineering issues.

With the Pre-Production telescopes, CTA will be competitive with, or superior to the best current instruments and should therefore start science operation.

We can foresee that (e.g.) during the Pre-Production phase at the **southern site** we will have about 2-3 MST, 3 GCT, 3 SST-1M, **and 9 ASTRI units.** This set of telescopes will allow us to obtain performance figures (e.g., the differential sensitivity) much better than the ones reported in the following slides.

The ASTRI mini-array - Rationale

The aim is to **test both the SST-2M technological and scientific performance** at energies above a few TeV by means of **prolonged pointings.**

Galactic science ➔ choose sky regions containing multiple targets.

Extra-galactic science ➔ select a few promising targets.

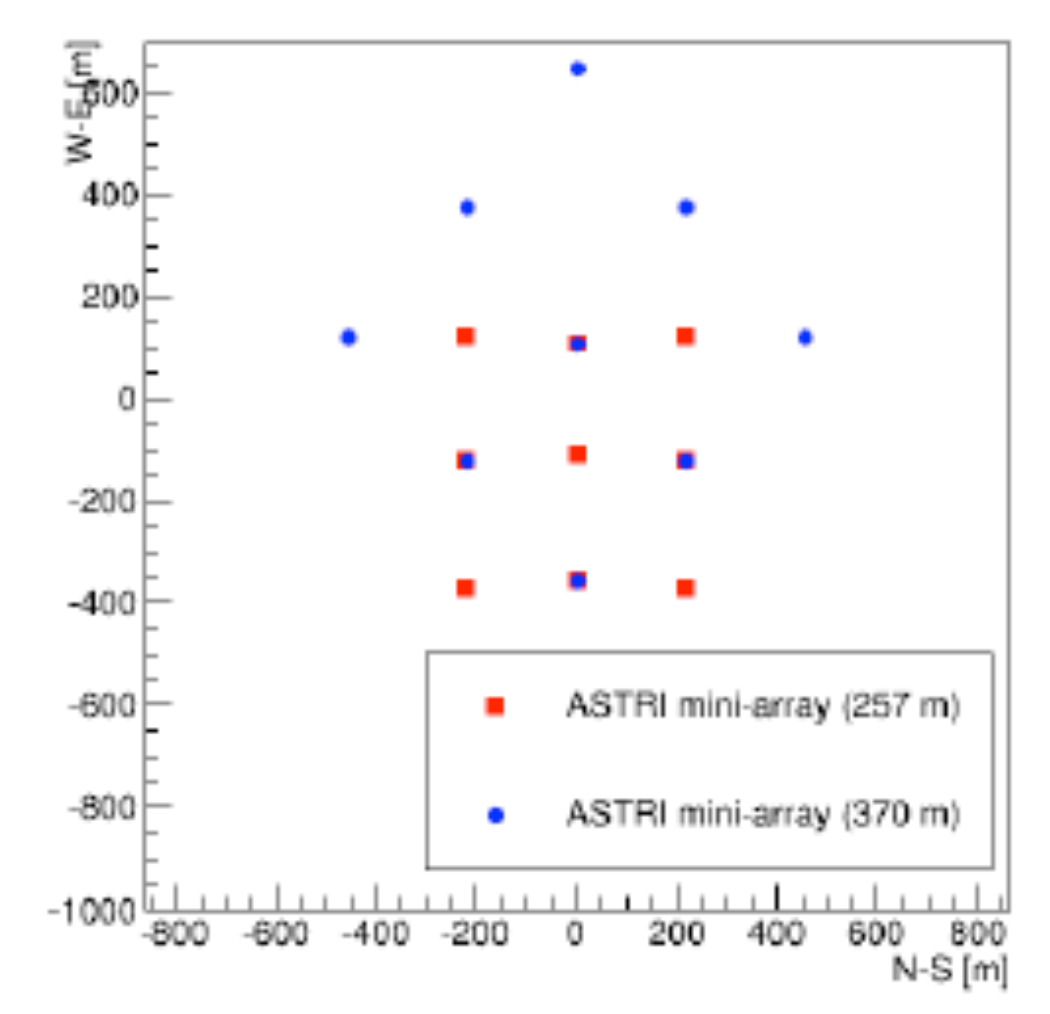
Fundamental Physics ➔ nearby blazars, GC, and dSphs.

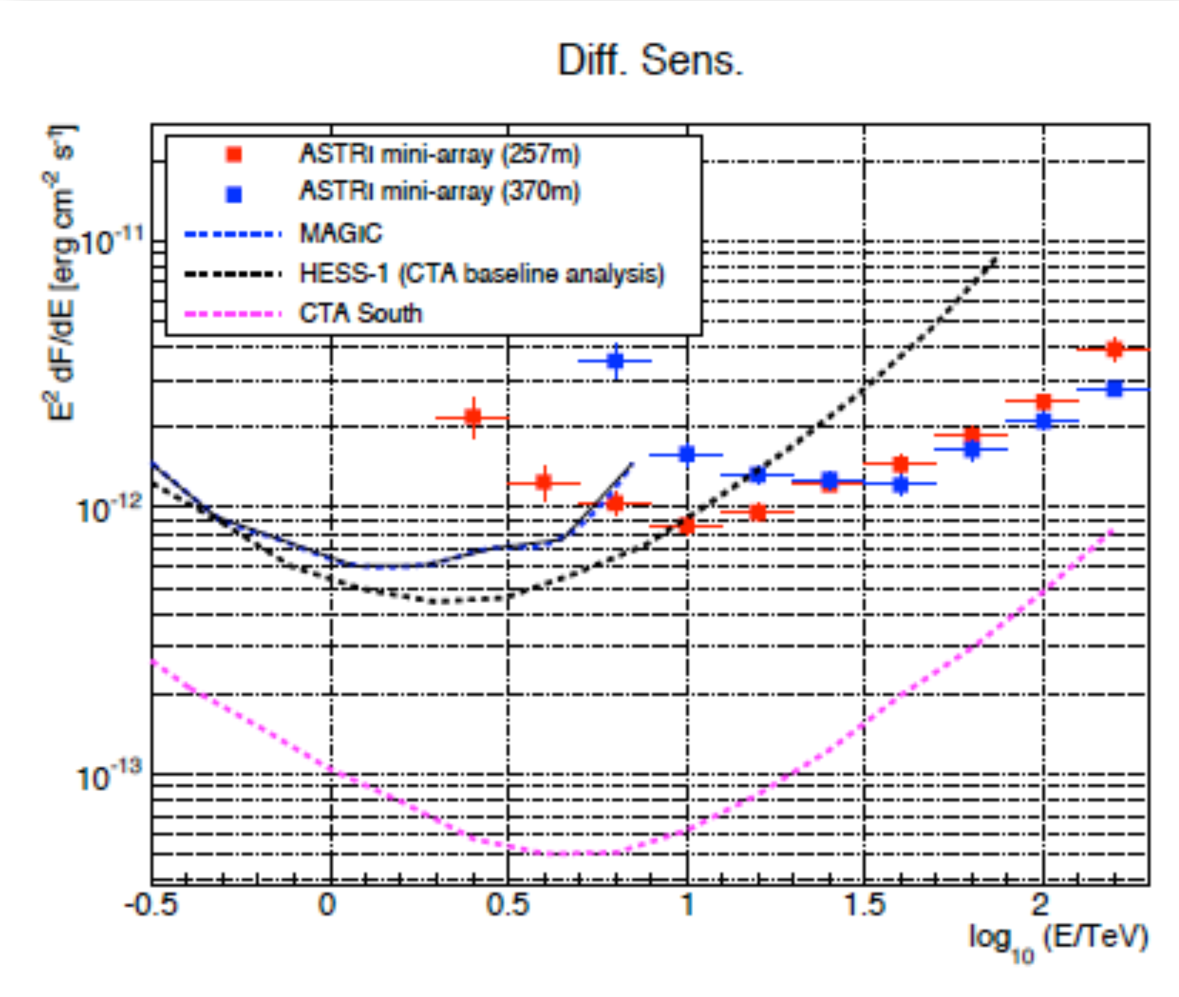
Synergies with facilities dedicated to transient follow-ups are of paramount importance.

The ASTRI mini-array performance (1)

Monte Carlo activities cover (at least) the following topics:

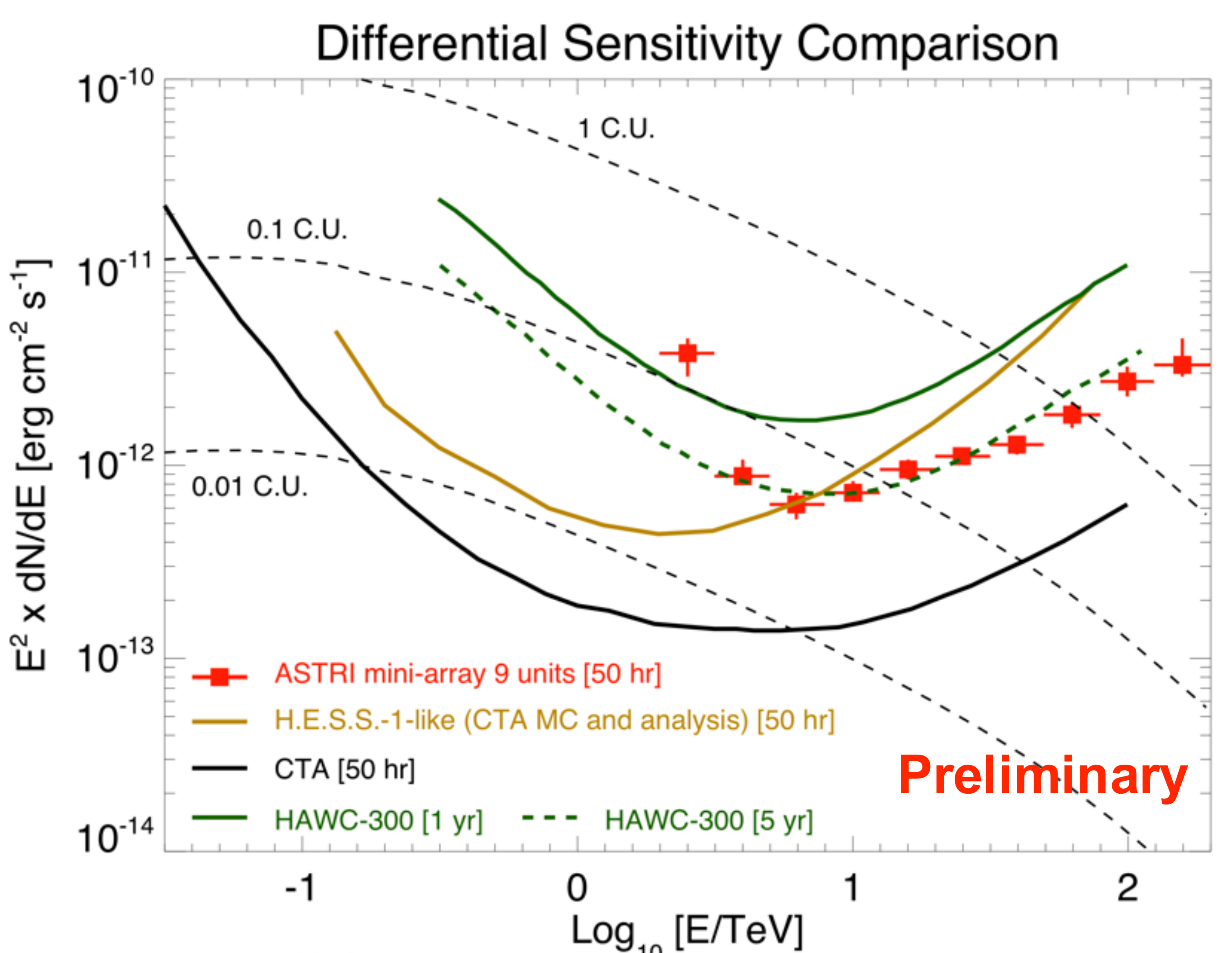
- investigation of the mini-array performance
- optimisation of the SST array layout
- production of the IRFs for the scientific simulations





Di Pierro et al., 2016, TAUP Proc.

The ASTRI mini-array performance (2)



Vercellone et al., 2016

Limiting flux

slightly better than current generation of IACT above few (~10) TeV for an array composed by 9 telescopes

Angular resolution

a few (4-5) arcmin

Energy resolution

of the order of 10-15 %

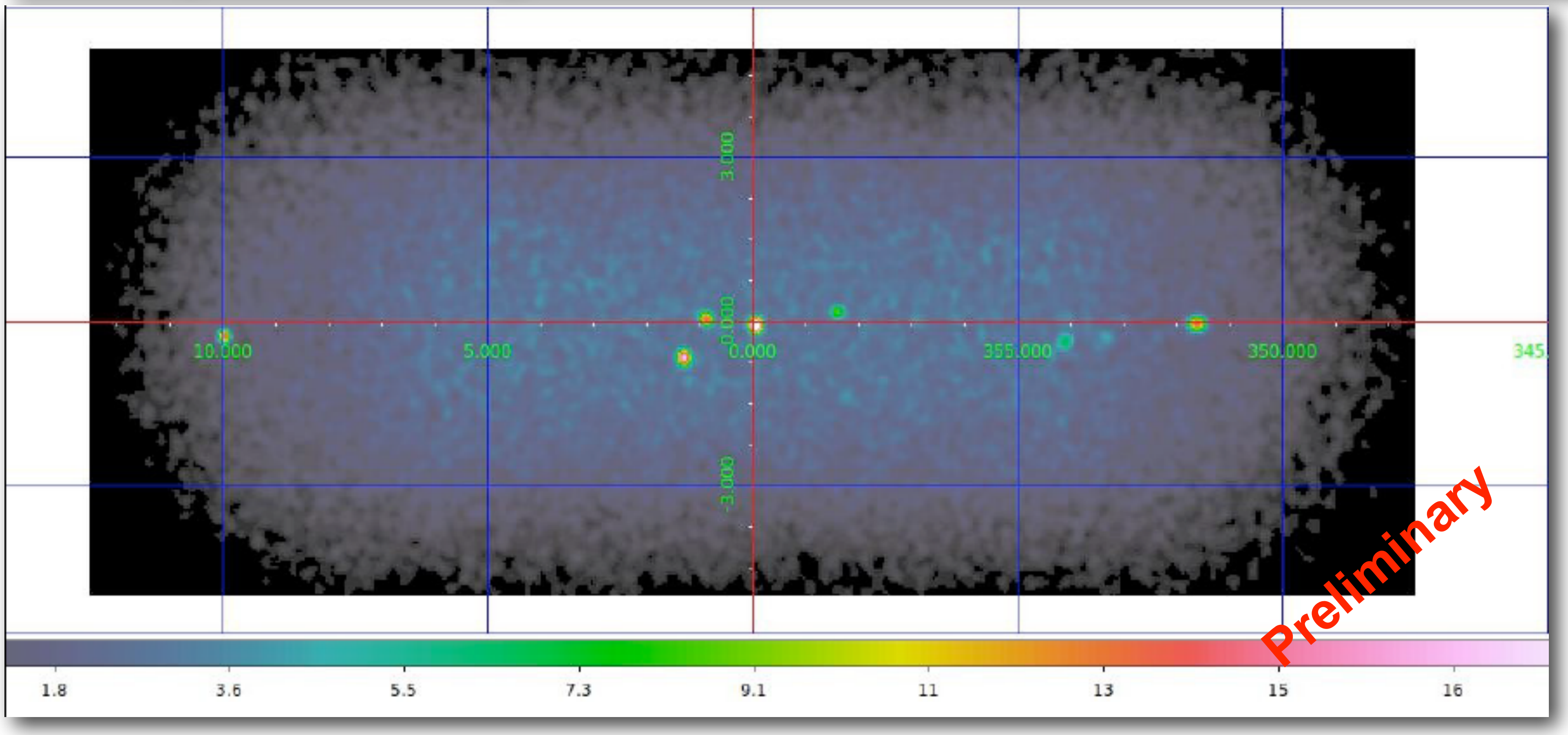
ASTRI SST pre-production CTA telescopes will have a better sensitivity at E >10 TeV for extended sources with respect to currents IACTs.

The ASTRI mini-array - Simulations

We developed a fast scientific simulator, ***ASTRIsim***, which can simulate both point-like and extended sources, and which makes use of the IRFs computed by the full Monte Carlo code.

A catalogue of Cherenkov sources has been compiled, which is used as a standard input for the *ASTRIsim* tool.

The *ASTRIsim* output is fully compliant with the standard CTA analysis tools (*Ctools*). Dedicated analysis tools (spectra, significance,...) have also been developed and integrated in the *ASTRIsim* SW suite.



ASTRI mini-array simulation of the Galactic Center ~240 hr, 5 pointings.

Giuliani et al., 2016

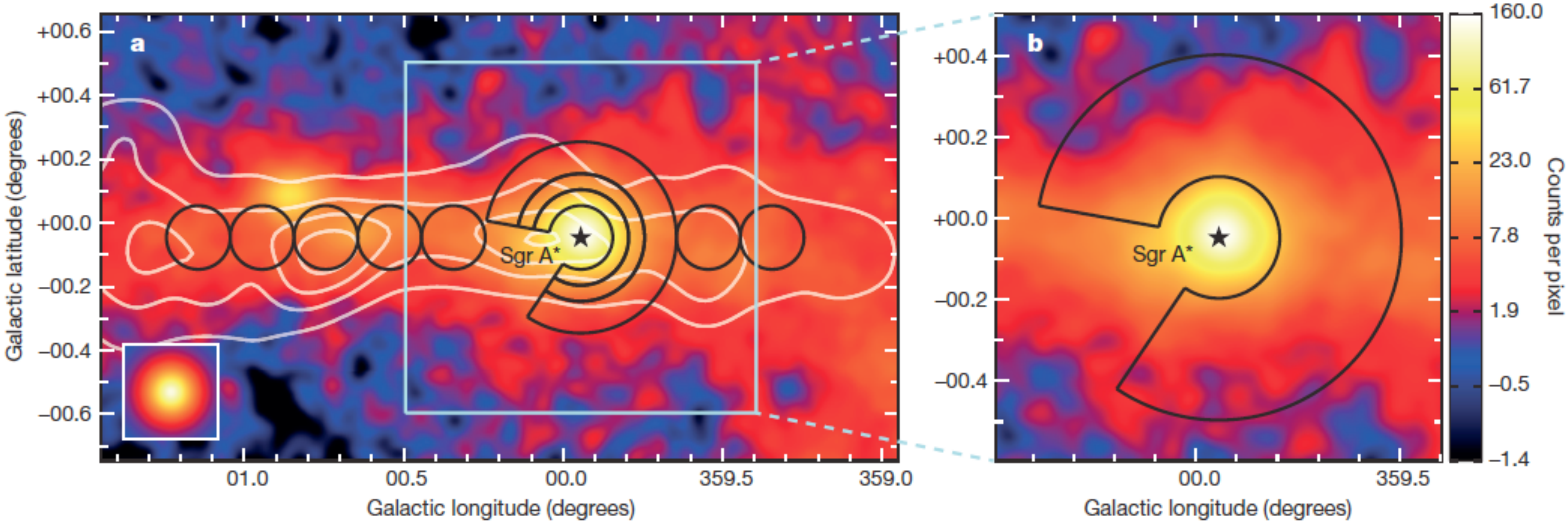
Hot result !

LETTER

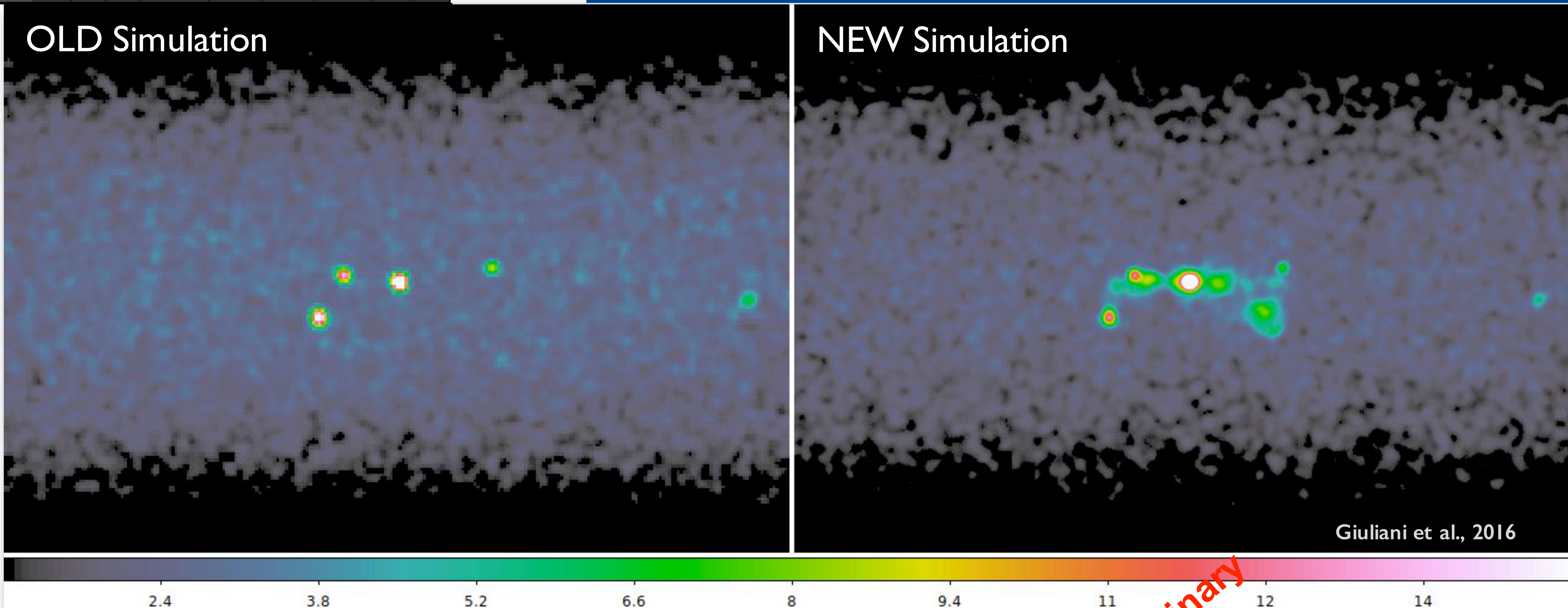
doi:10.1038/nature17147

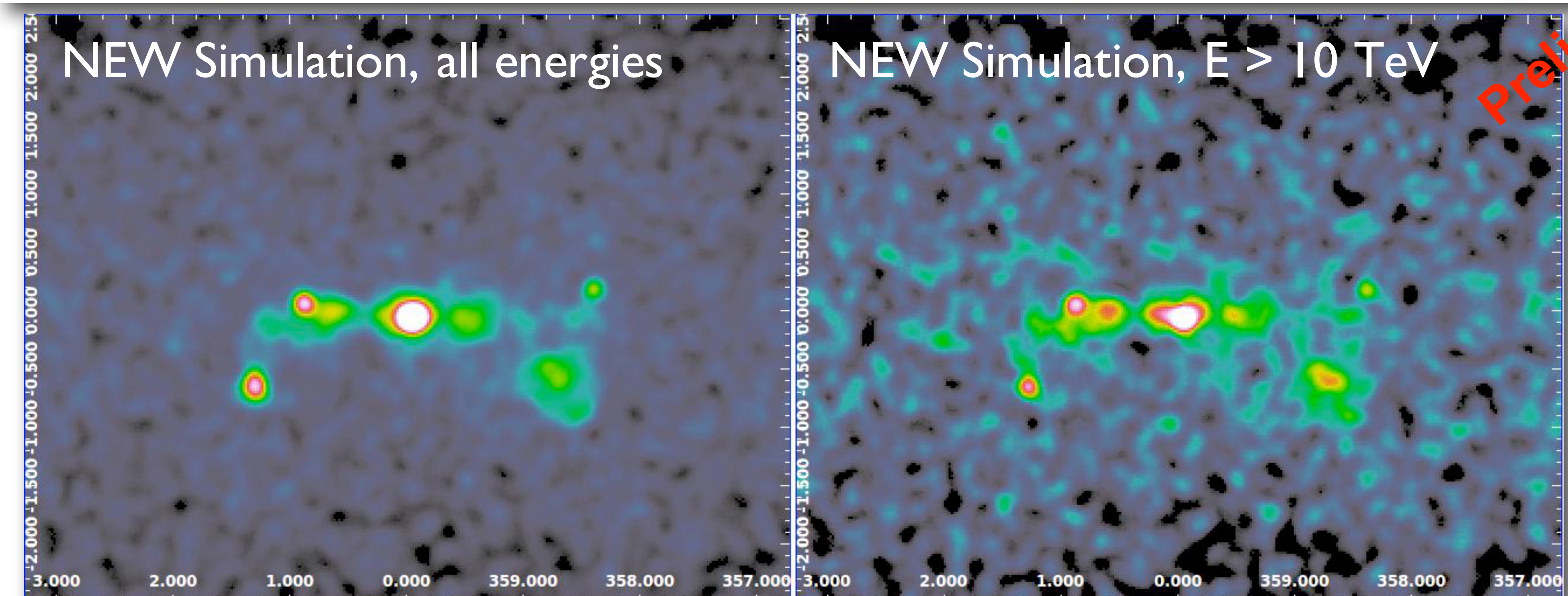
Acceleration of petaelectronvolt protons in the Galactic Centre

HESS Collaboration*



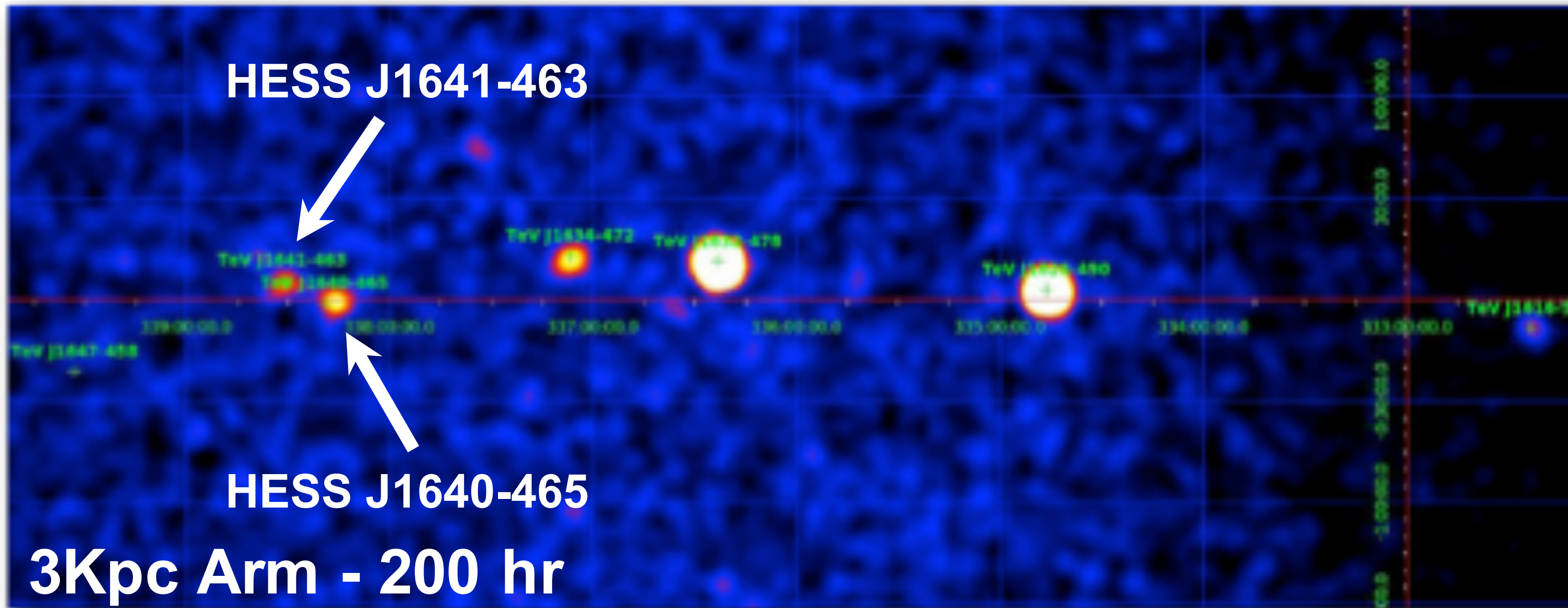
ASTRI mini-array and the Galactic Center

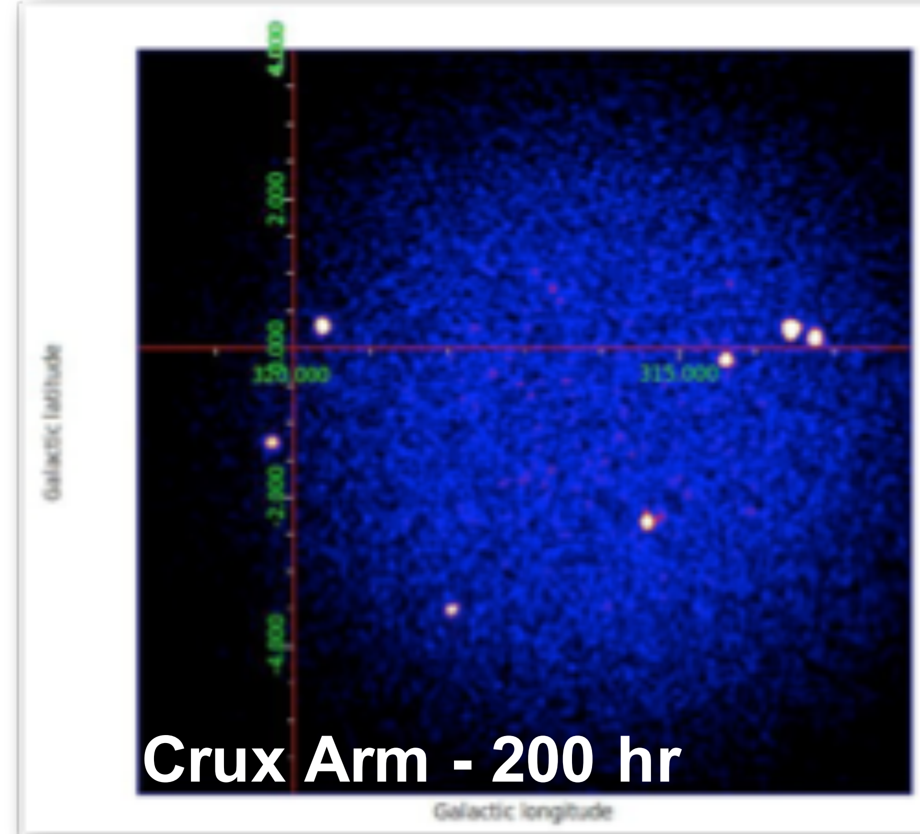


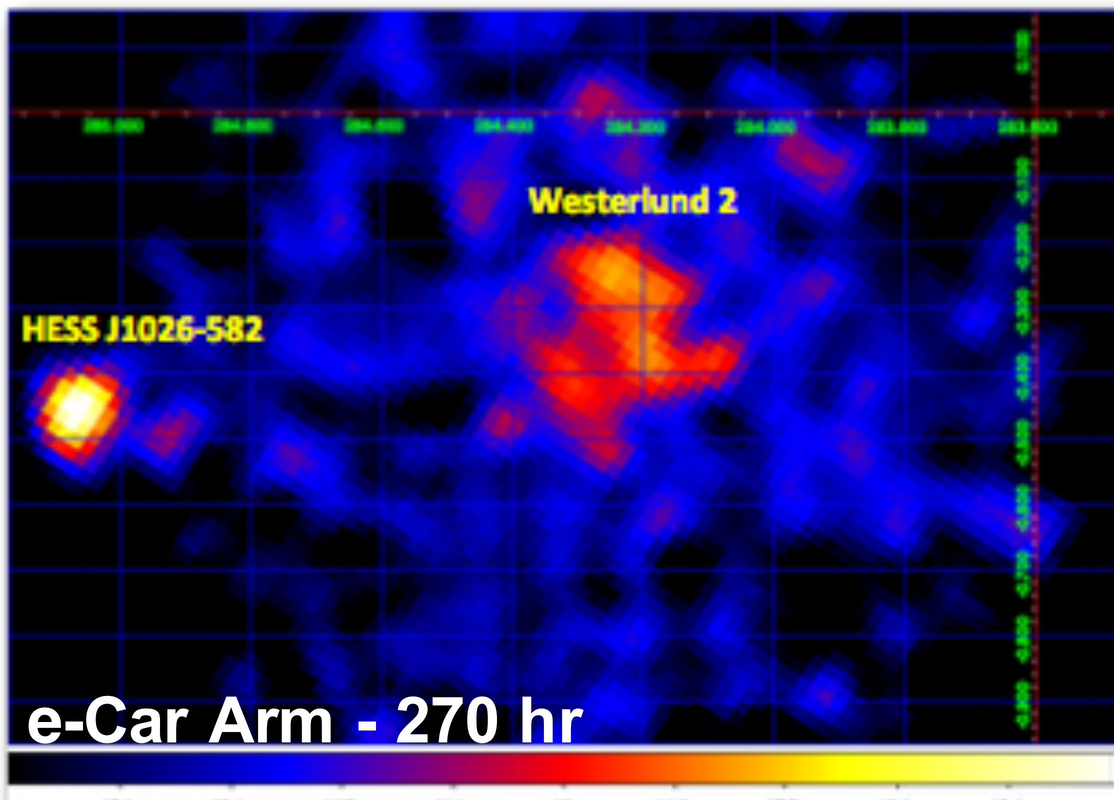


ASTRI mini-array simulation of the Galactic Center ~240 hr, 5 pointings.

The wide field of view and our Galaxy







Preliminary

Deep observations of Galactic Arms
Simulation based on the current performance of the ASTRI mini-array of pre-production CTA telescopes (by means of a dedicated SW).

SNR, PWN

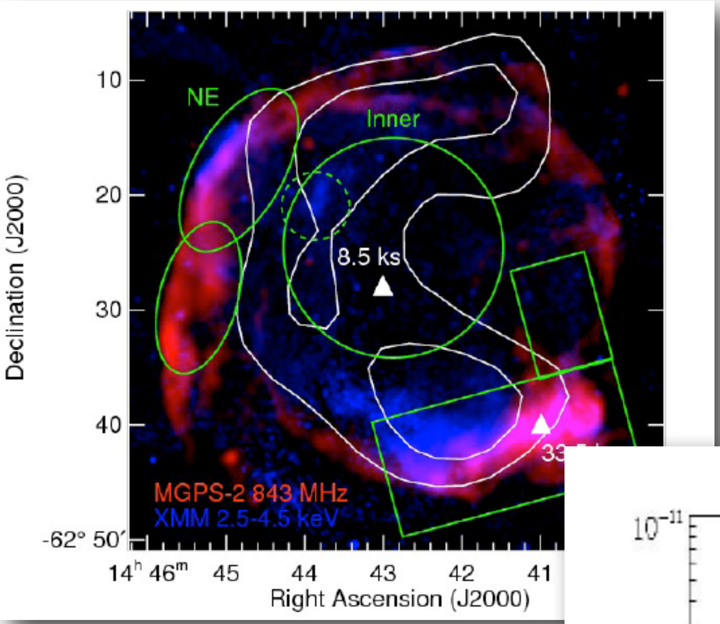
SNR RCW 86

Fairly young SNR (2000 yrs)

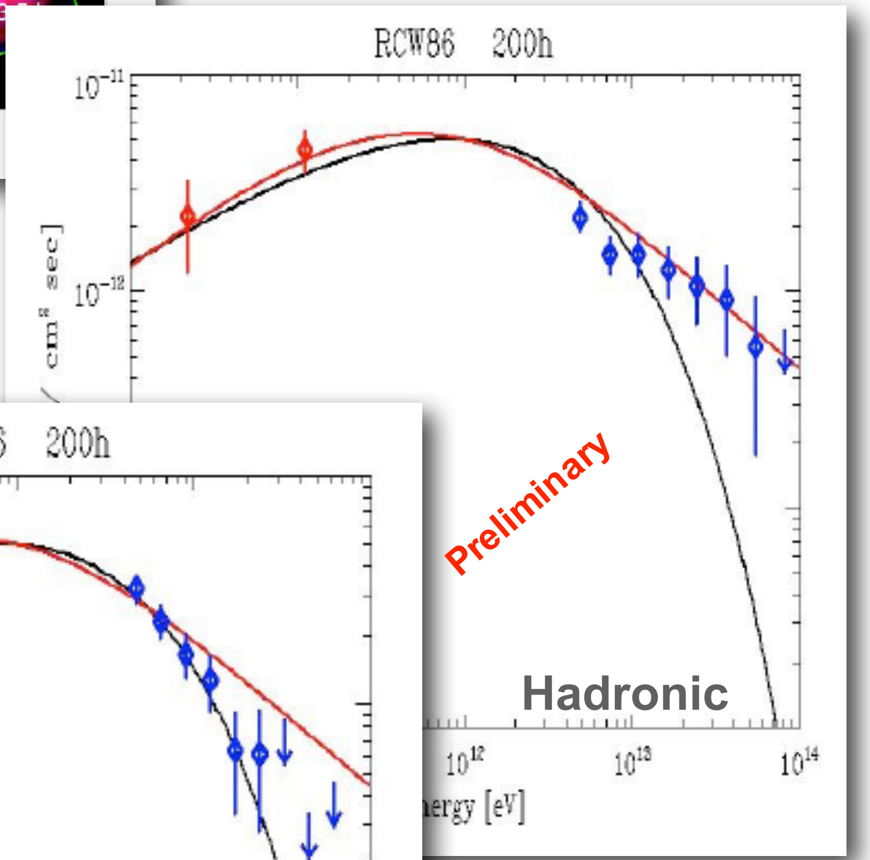
Seen in Radio, X, GeV (*Fermi*), TeV (H.E.S.S.)

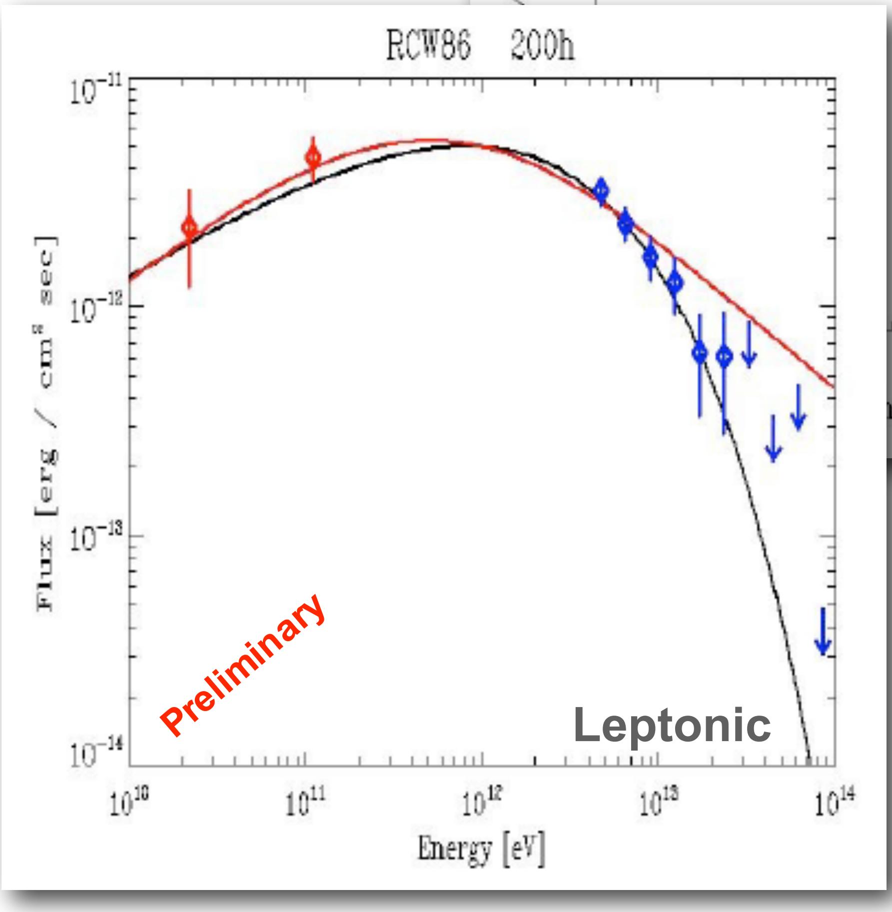
Debated origin:
interacting source with molecular clouds or
RX J1713-like source ?

ASTRI mini-array (blue points, simulated data) can discriminate between hadronic and leptonic scenario and (if hadronic) look for VHE(~5x10^{14} eV) CRs



Giuliani et al, in prep.



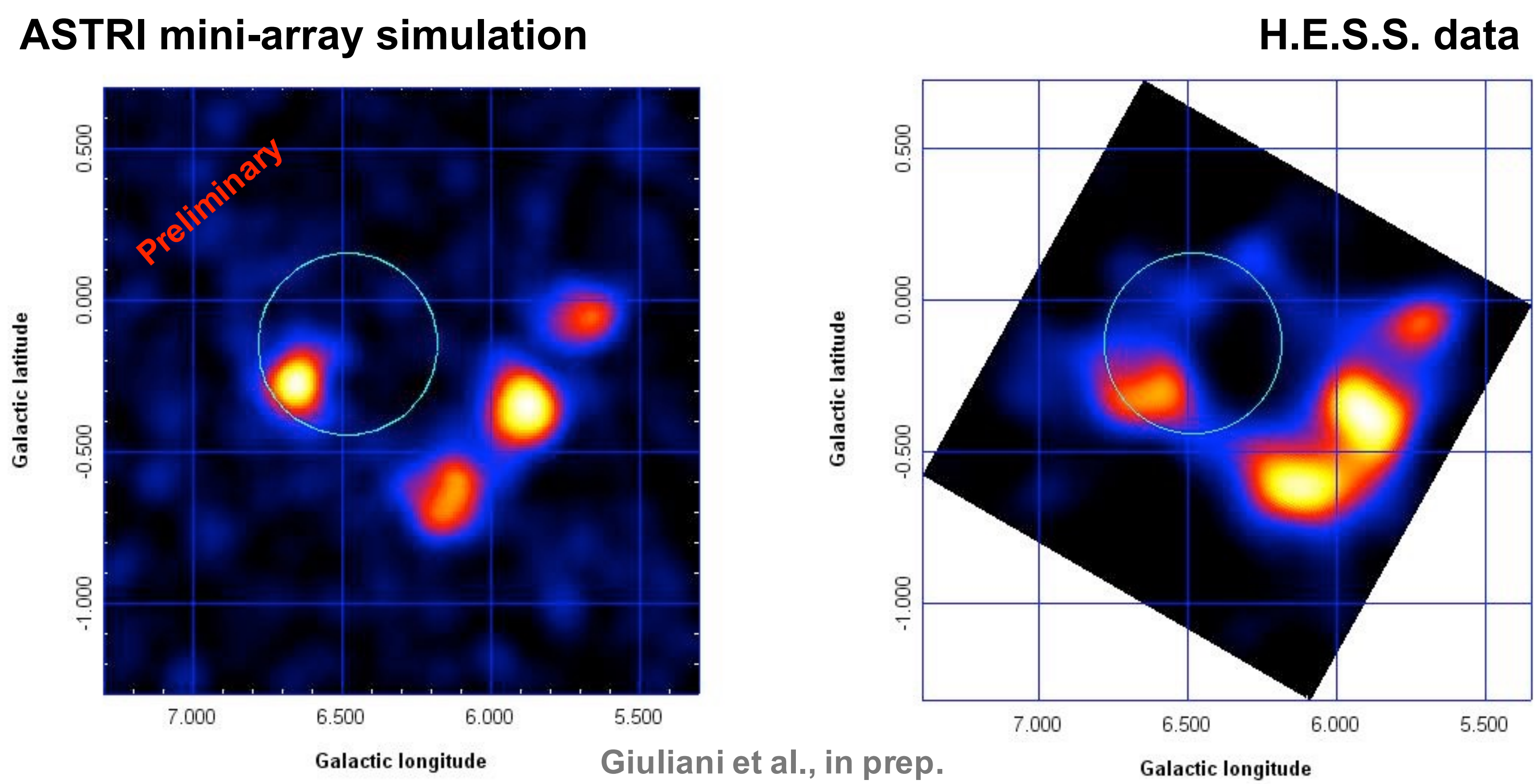


SNR W 28

Evolved SNR interacting with a giant molecular cloud (MC), very bright at TeV energies

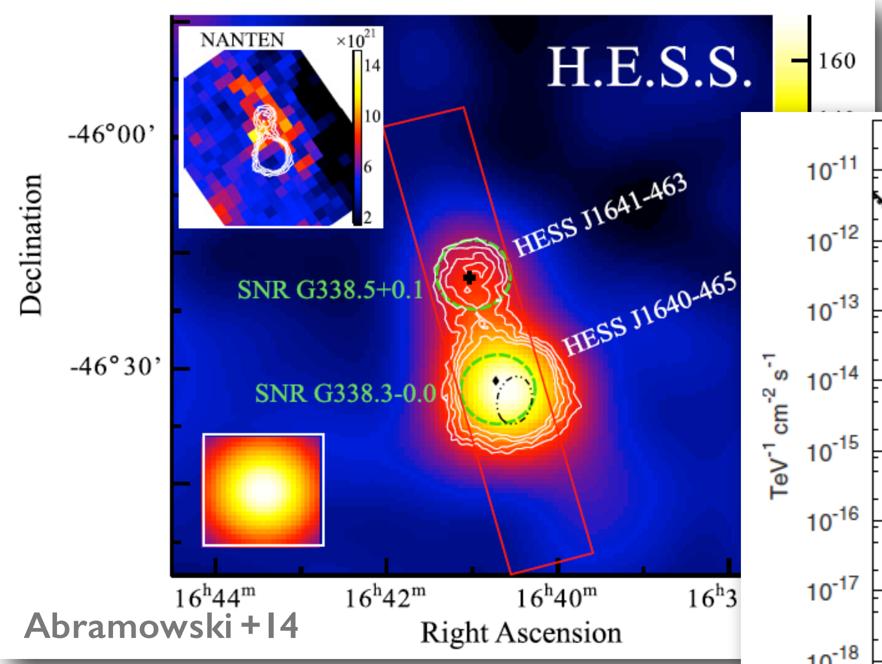
H.E.S.S. resolved this source in almost 4 point-like sources near the MC

ASTRI mini-array can better resolve the source and study the diffusion of CR far from the SNR shell (blue circle)

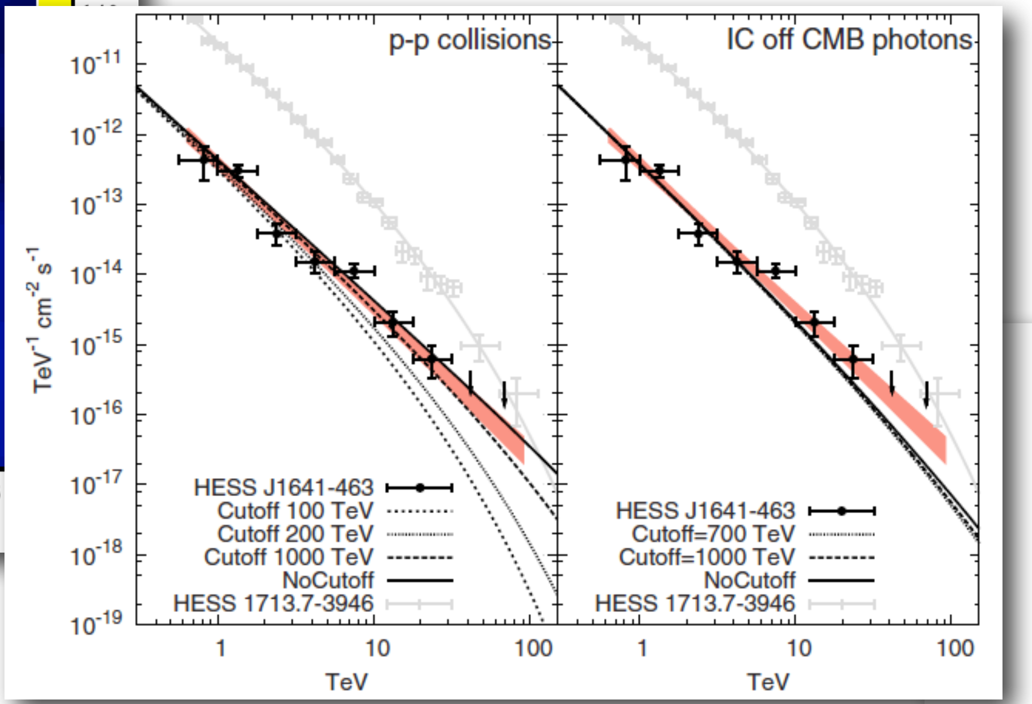


Giuliani et al., in prep.

gamma-ray UNID: HESS J1641-463

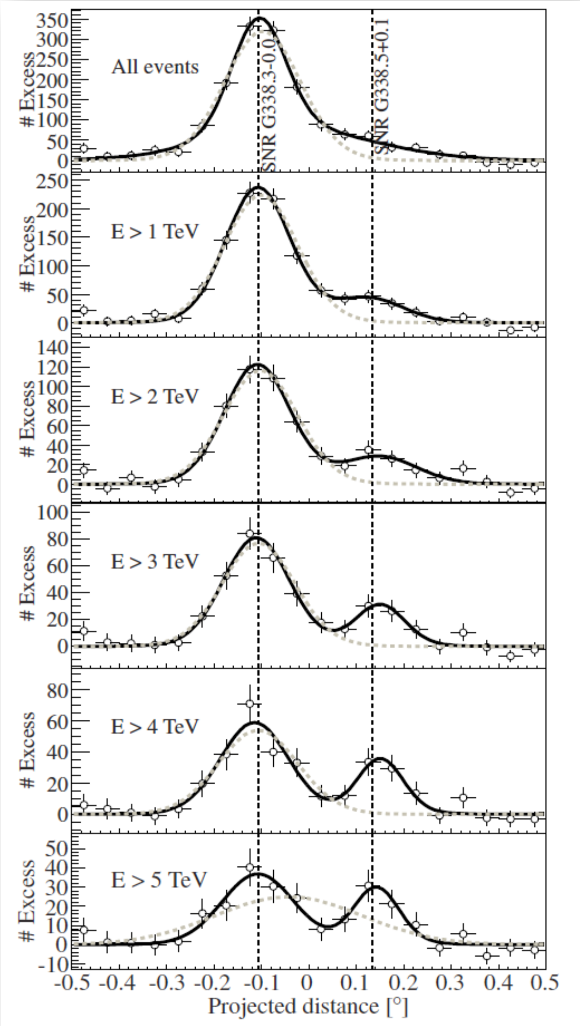


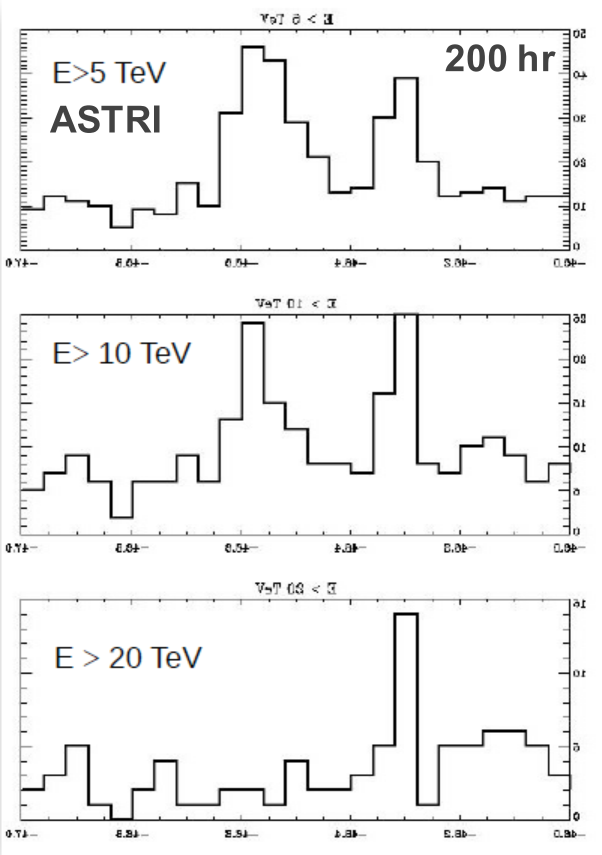
Abramowski+ 14



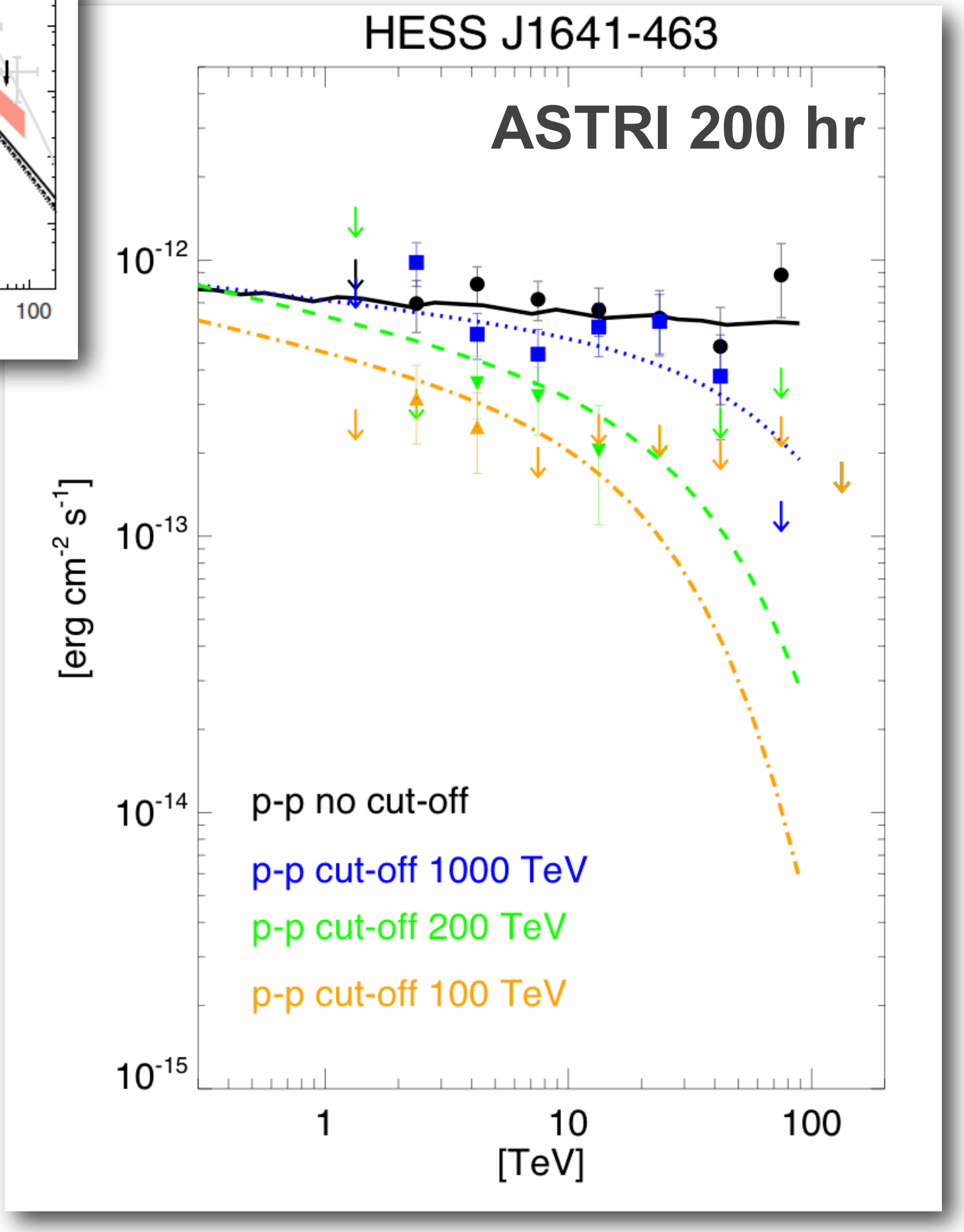
Hard source Ph. Index~2.1
Uncertain nature

Simulations by the ASTRI Science Team

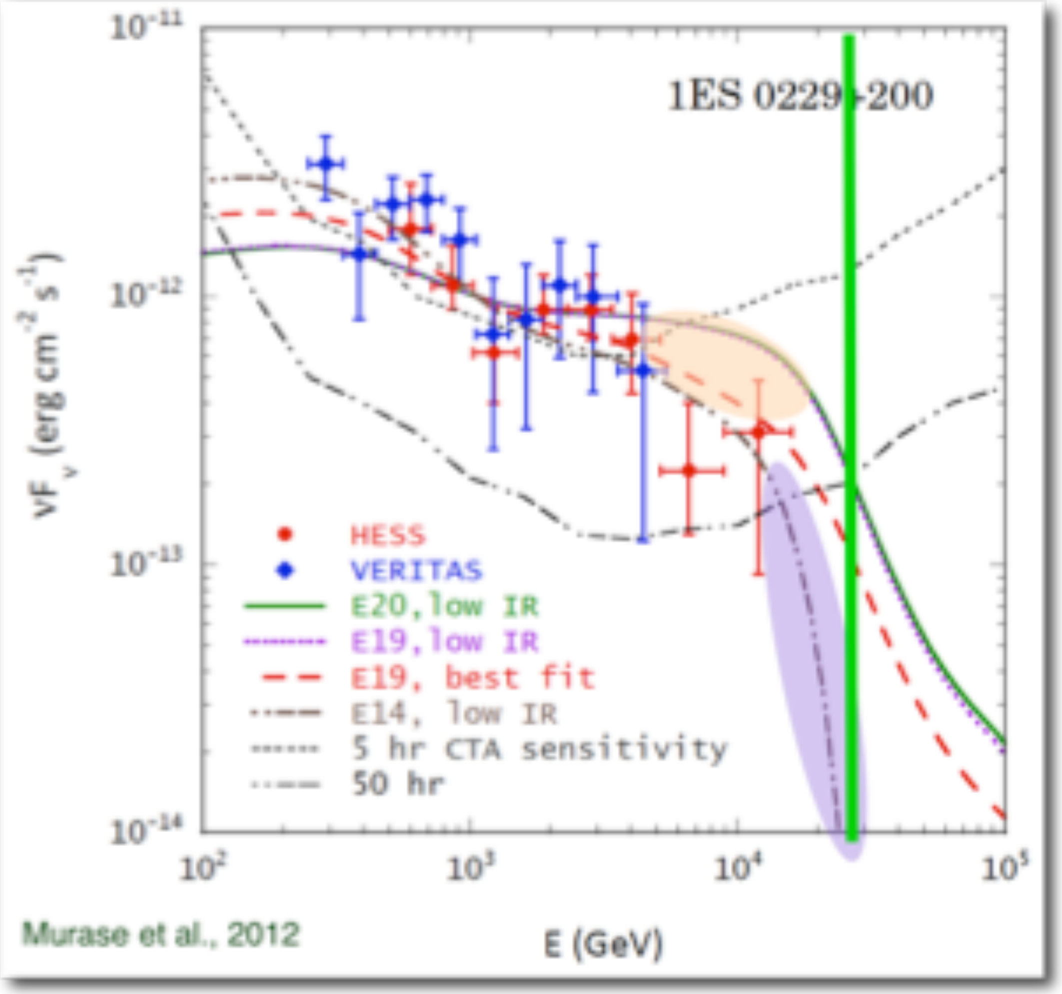




Preliminary



Extreme BL Lacs: probes of emission mechanisms



E-HBLs are characterized by:

- extremely low radio luminosity;
- luminous and hard X-ray emission;
- synchrotron peak above 10 keV;
- low variability at TeV energies.

1ES 0229+200 E-HBL SED can be fit by both the **gamma-ray-induced cascade** and **proton-induced cascade** emissions.

At higher energies, however, UHECR-induced cascade emission becomes harder than gamma-ray-induced cascade emission.

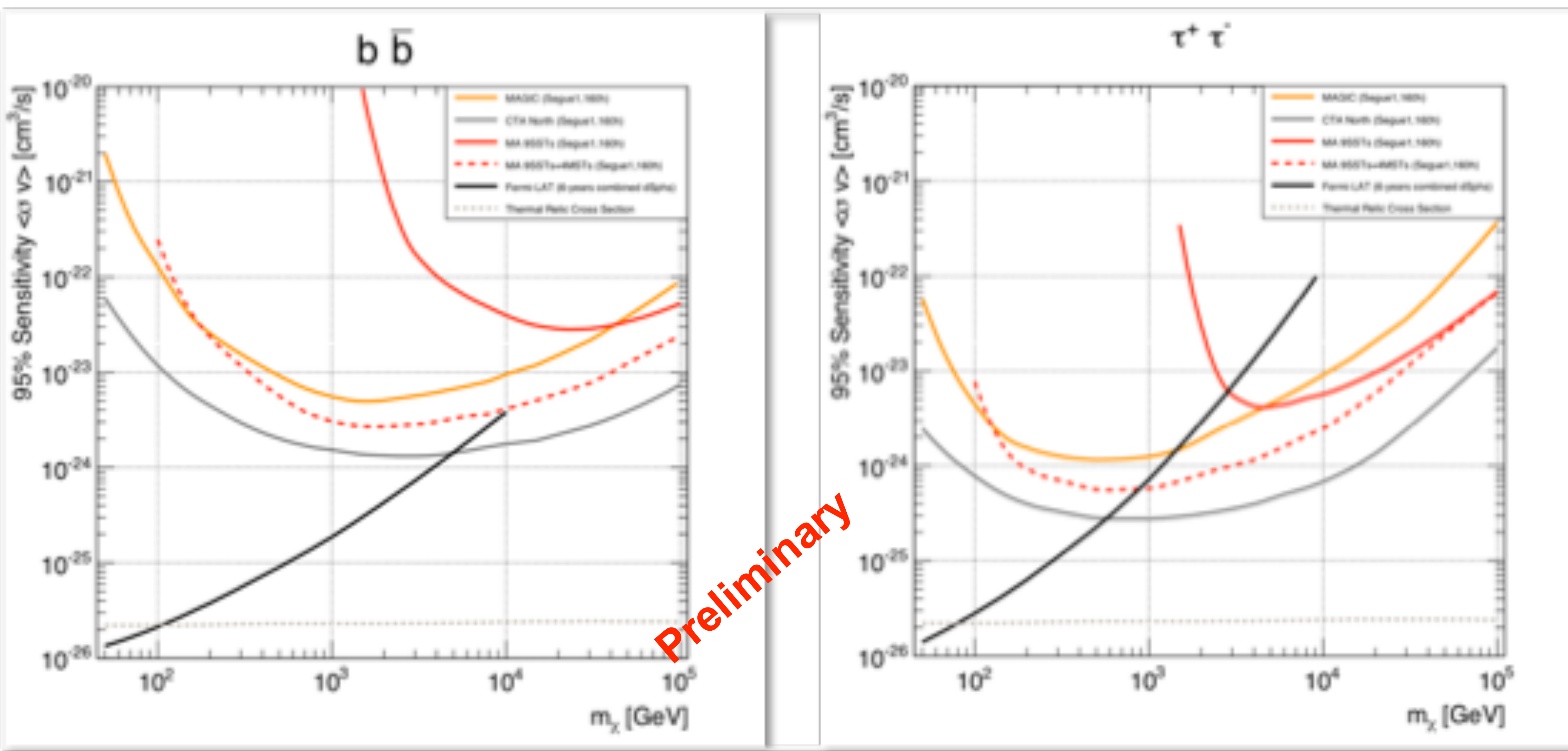
A detection of >25 TeV gamma-rays is consistent with an hadronic gamma-ray emission

Indirect search of DM in dSphs

Segue 1: 160 hr on target

- Ultra-faint dSph Galaxy, 23 kpc from Earth
- M ~ 6×10^5 M$_\odot$, M/L ~ 3400 M$_\odot$/L$_\odot$
- Einasto DM profile
- J-factor=1.1×10^{19} GeV^2 cm^{-5}

The combination of 4 MSTs with 9 SSTs may allow us to obtain interesting limits on DM studies.



Summary

- **The ASTRI SST-2M prototype**, currently in the Commissioning phase, will perform scientific observations in Fall 2016.

- **The ASTRI mini-array** will constitute one of the *pre-production* set of telescopes for the whole CTA array, allowing us to investigate innovative technological solutions.

- **CTA early science** performed by means of ASTRI mini-array observations of a few selected sky regions will allow us to obtain several solid detections during the first year.

- **Excellent synergies** with other pre-production CTA telescopes (SSTs, MSTs, LSTs) and with several observing facilities from 2017 and beyond.

http://www.brera.inaf.it/astri/

Credit: R. Canestrari