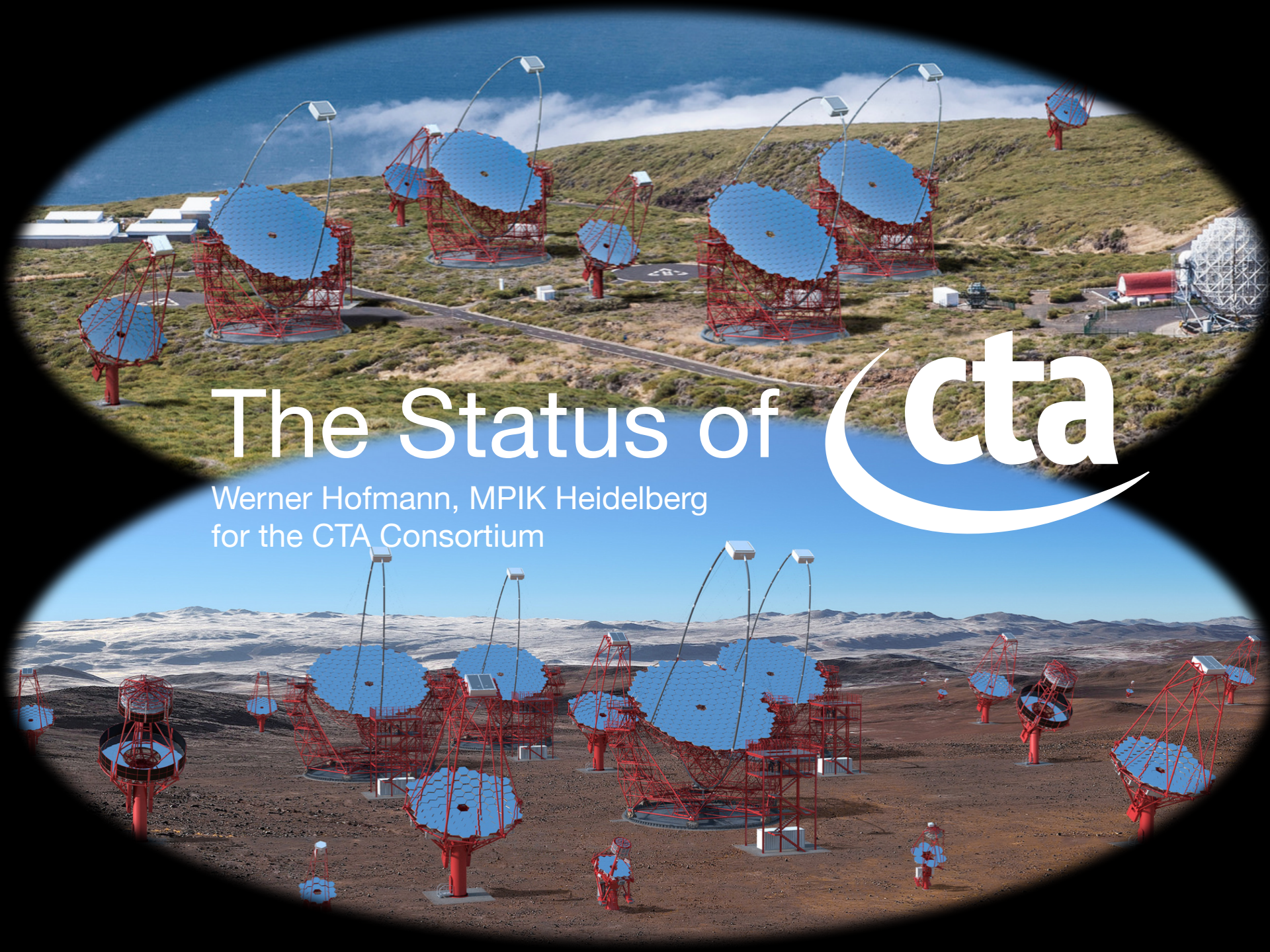


The Status of cta

Werner Hofmann, MPIK Heidelberg
for the CTA Consortium



COMMEMORATION DAY

FOR

PATRICK FLEURY

Hommage P. Fleury

3 months ago, here in Paris

12 septembre 2018
Paris
Fuseau horaire Europe/Paris

- Vue d'ensemble
- Ordre du jour
- Liste des contributions
- Inscription
- Liste des participants
- Acces
- Droit à l'image / Image righs
- Webcast

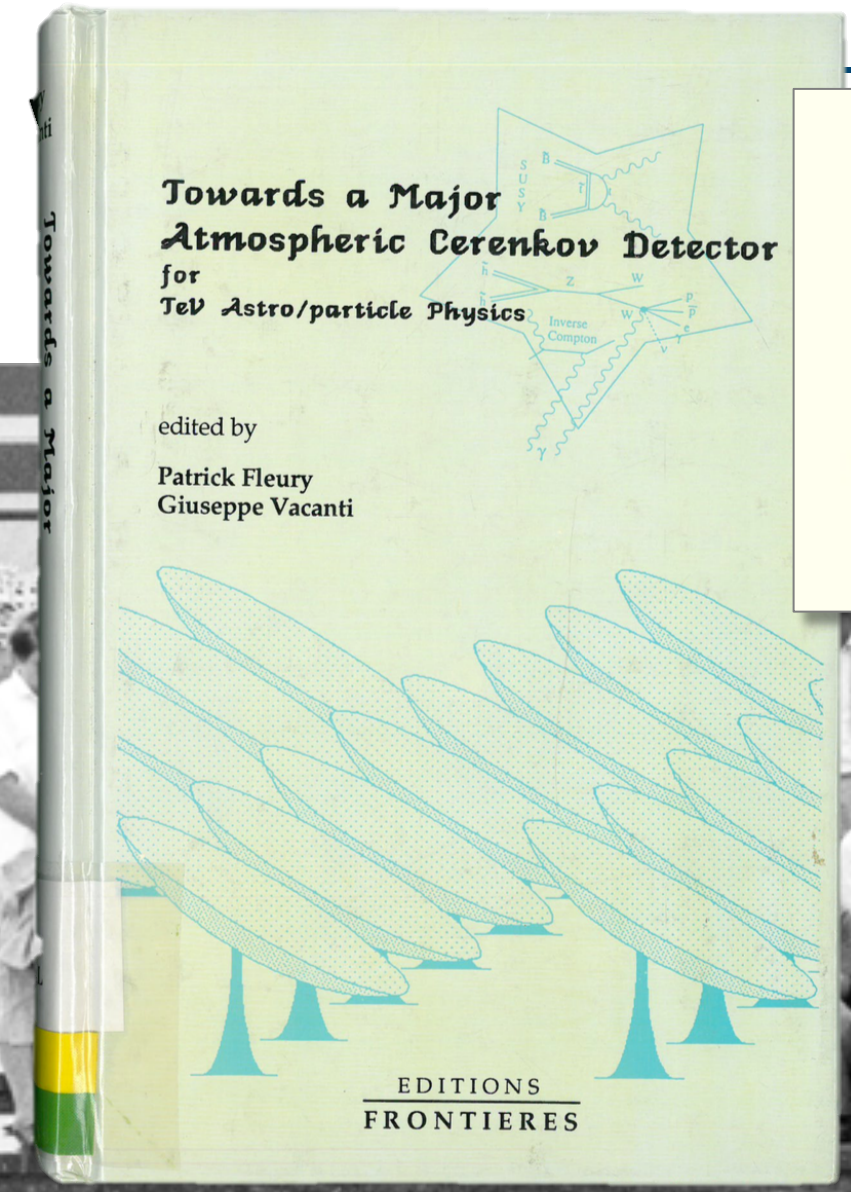
Contact

hommage.patrick@llr.in2...

Ce 12 septembre nous commémorerons Patrick Fleury, un physicien qui est né à la physique des hautes énergies avec le modèle des quarks et a disparu soixante ans plus tard, après avoir vu le boson de Higgs et surtout ces immenses bifurcations que sont les astroparticules et les ondes gravitationnelles. Il a été partie prenante de toutes ces aventures, et reconnu comme un pionnier. Il a été également associé à l'émergence du CERN, et en même temps un grand réformateur de son laboratoire, aujourd'hui connu comme le Laboratoire Leprince-Ringuet, qu'il a longuement dirigé. Ses collègues et amis parleront de ses contributions à ces domaines mais aussi de l'esprit de Patrick, de sa façon de voir, de ses engagements, de ce qu'il a été un entrepreneur plein de fougue, parfois d'emportement, et de perspicacité, de ce qu'il était un homme pas toujours simple mais empli d'humanité.

Cette commémoration comportera des présentations retraçant les étapes diverses de sa carrière et des témoignages évoquant sa riche personnalité. Quelques documents et photos seront mis à la disposition des participants.

THE 1992 PALAISEAU WORKSHOP



Following the observation of
TeV gamma ray emission from the Crab Nebula,
it seems desirable that a major program
be set forth by the international community
to develop TeV γ-Astronomy.

2005 Scientists propose CTA as Next Generation Facility for Ground-based Gamma-Ray Astronomy

2007 First Community Meeting on CTA

2007 Definition of the CTA Design Study

2008 CTA Consortium Established

2008 CTA included in the Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI)

2010 - 2014 CTA Preparatory Phase Supported by FP7 Grant from the European Commission

2010 Project Office Established in Heidelberg

2011 Publication of the “Design Concepts for the Cherenkov Telescope Array“

2012 Funding Agencies Sign Declaration of Intent – Beginning of CTA Pre-Construction Phase

2015 Consortium Grows to more than 1,500 Members from 32 Countries

06 2016 HQ and Data Management Centre Site Decisions

2016 North Site Hosting Agreements Finalized

11 2016 Memorandum of Understanding for Construction

03 2017 CTA Offices Open in Bologna

CTA becomes EFRI Landmark

2018 South Site Hosting Agreement Finalized

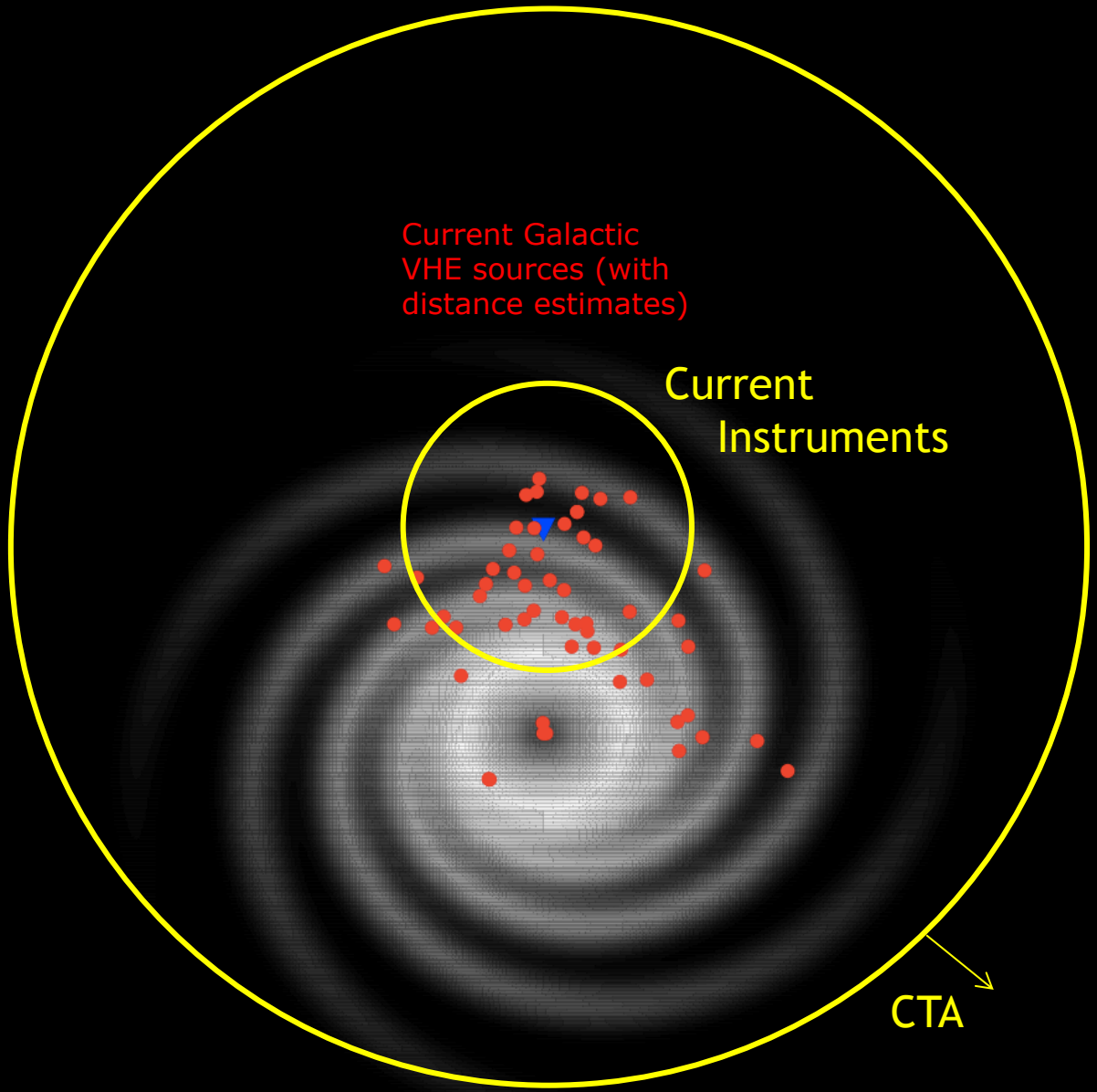
LST1

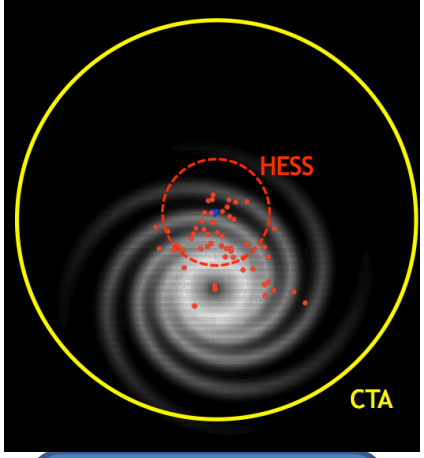
2020 European Research Infrastructure Consortium (ERIC) Established

2020 First Pre-Production Telescopes on Site

2022 Beginning of Observatory Operations

2025 Construction Project Completion

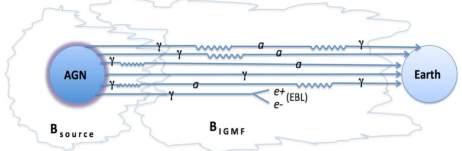

Current Galactic
VHE sources (with
distance estimates)
Current
Instruments
CTA

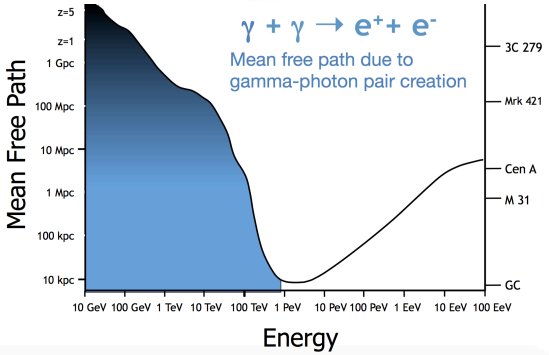


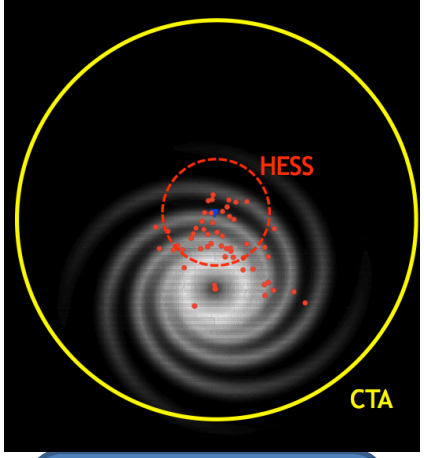
10 x Sensitivity, Large Collection Area

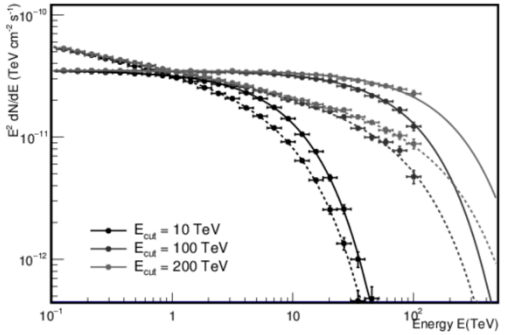
→ all topics

cta
cherenkov telescope array









Energies down to 20 GeV

→ Cosmology++

10 x Sensitivity, Large Collection Area

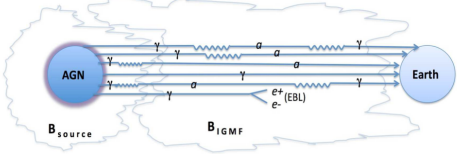
→ all topics

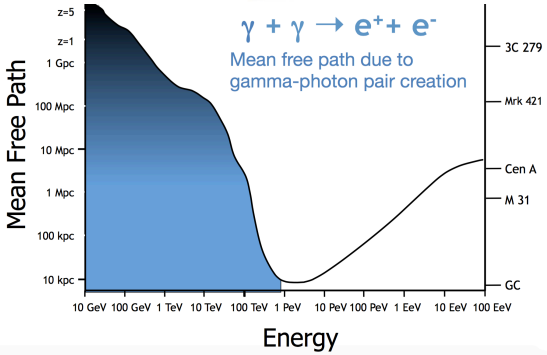
Energies up to 300 TeV

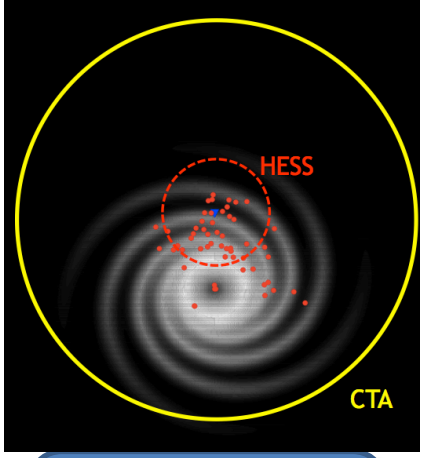
→ Pevatrons

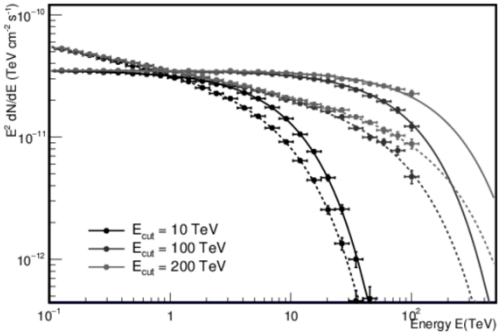
cta

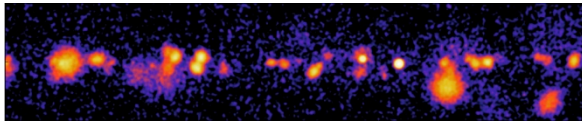
cherenkov telescope array



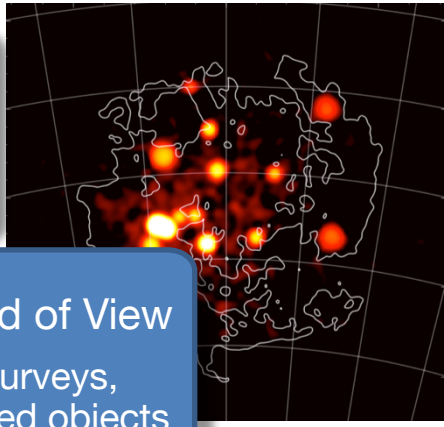


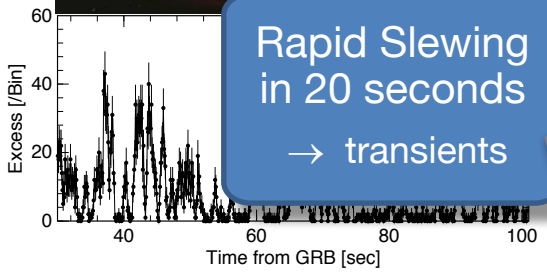












10 x Sensitivity, Large Collection Area → all topics

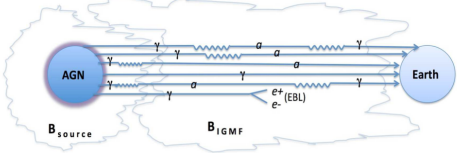
Energies down to 20 GeV → Cosmology++

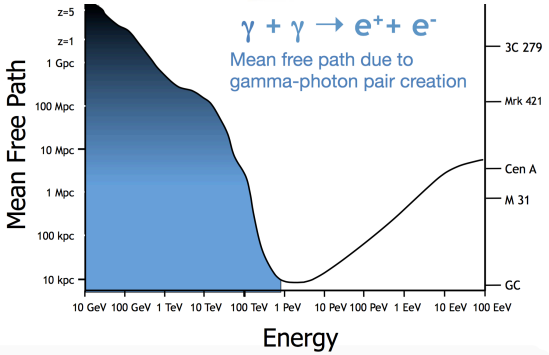
Energies up to 300 TeV → Pevatrons

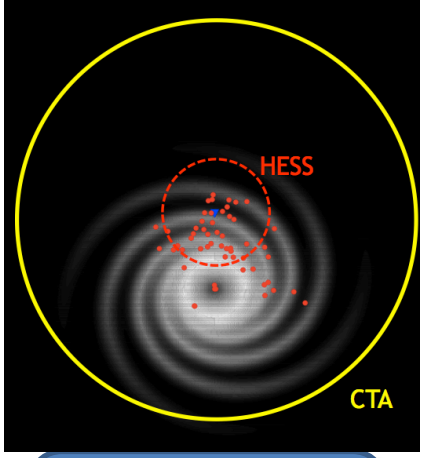
Rapid Slewing in 20 seconds → transients

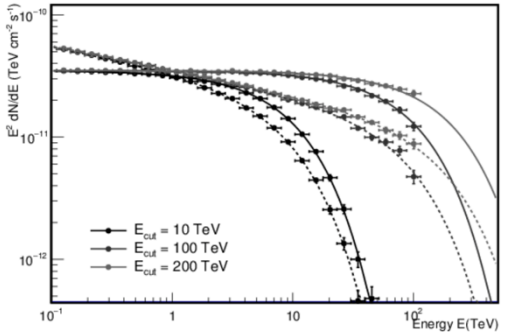
8° Field of View → surveys, extended objects

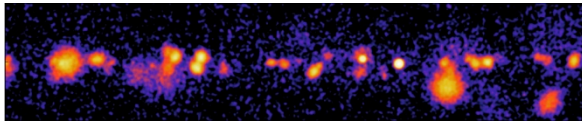
cta
cherenkov telescope array



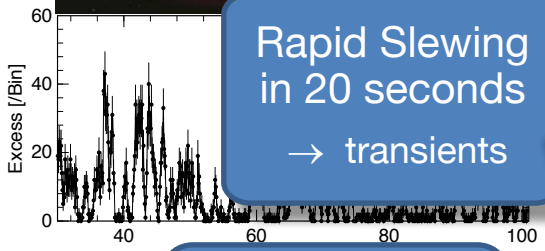


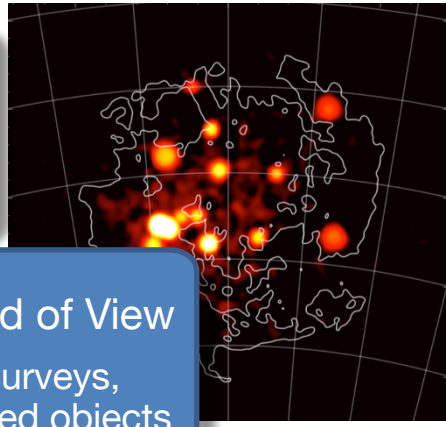












Energies down to 20 GeV
→ Cosmology++

10 x Sensitivity, Large Collection Area
→ all topics

Energies up to 300 TeV
→ Pevatrons

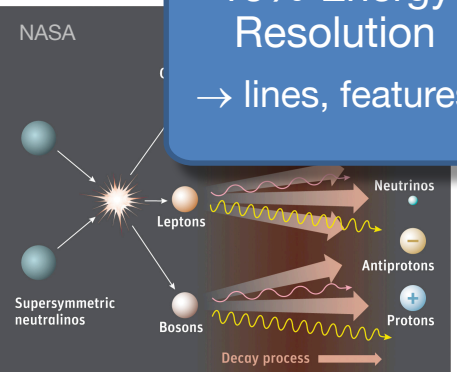
Rapid Slewing in 20 seconds
→ transients

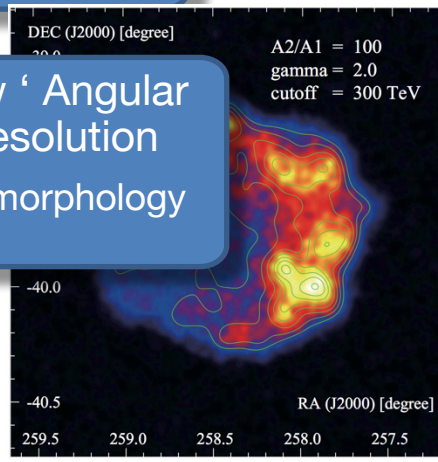
8° Field of View
→ surveys, extended objects

cta
cherenkov telescope array

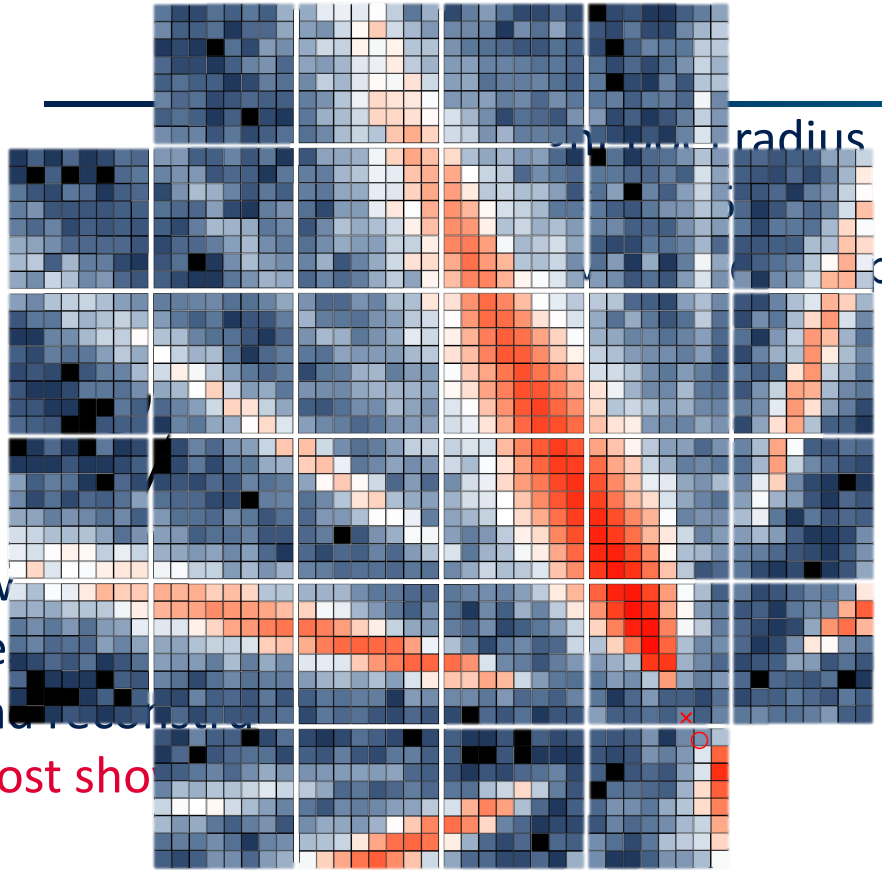
10% Energy Resolution
→ lines, features

Few ' Angular Resolution
→ morphology





FROM CURRENT ARRAYS TO CTA



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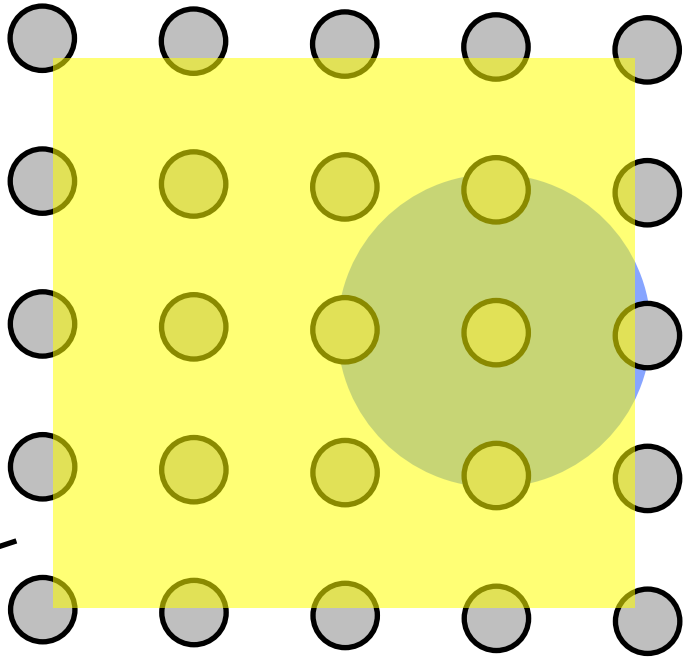


large detection area
more images per shower
lower trigger threshold

CHERENKOV TELESCOPE ARRAY

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

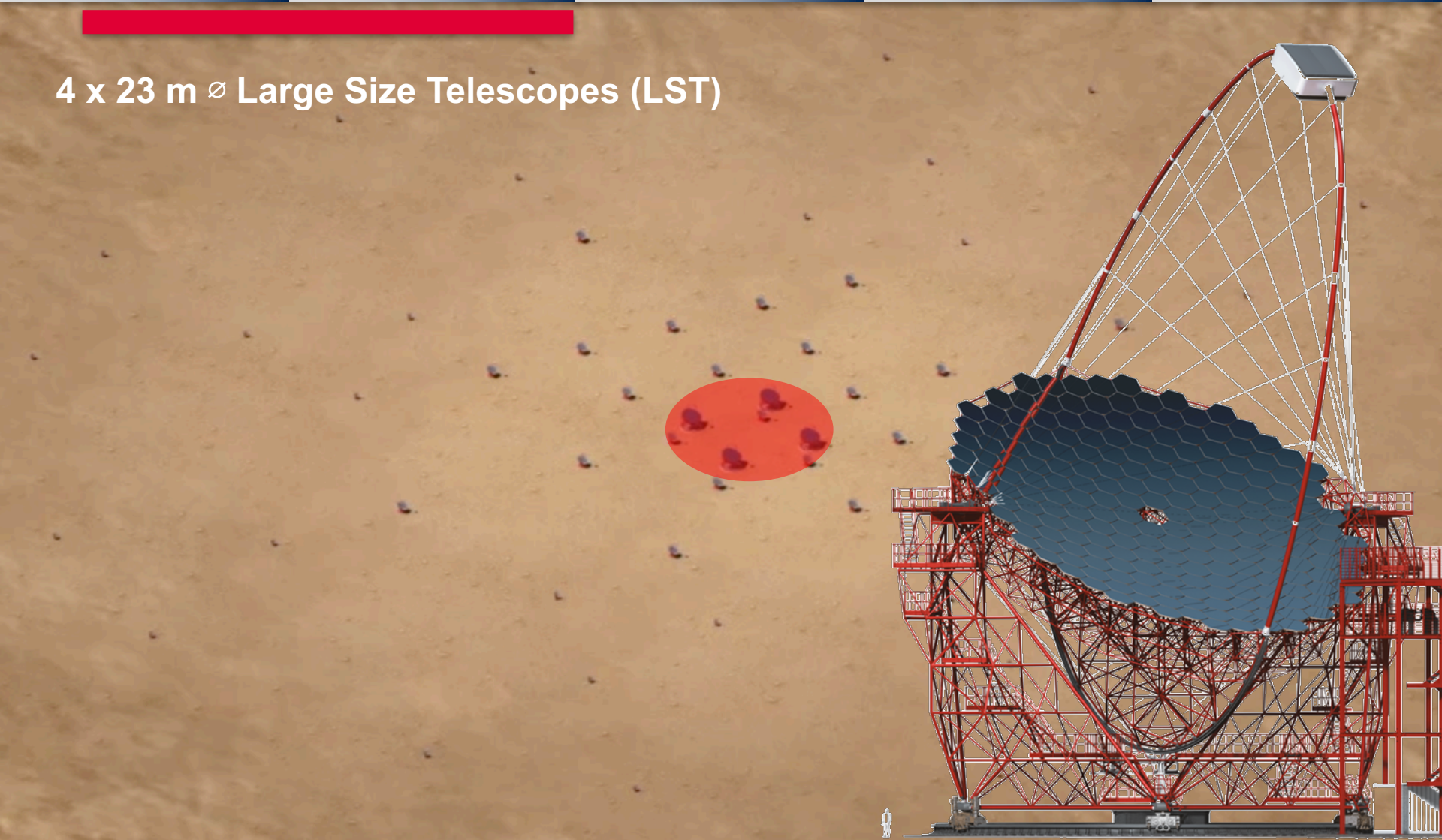


Southern array
of Cherenkov telescopes
- about 3 km across

CHERENKOV TELESCOPE ARRAY

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

4 x 23 m ⌀ Large Size Telescopes (LST)



CHERENKOV TELESCOPE ARRAY

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

25 x 12 m ⌀ Medium Size Telescopes (MST) (North: 15)





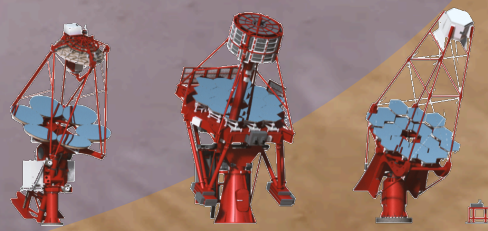
CHERENKOV TELESCOPE ARRAY

10 GeV	100 GeV	1 TeV	10 TeV	100 TeV

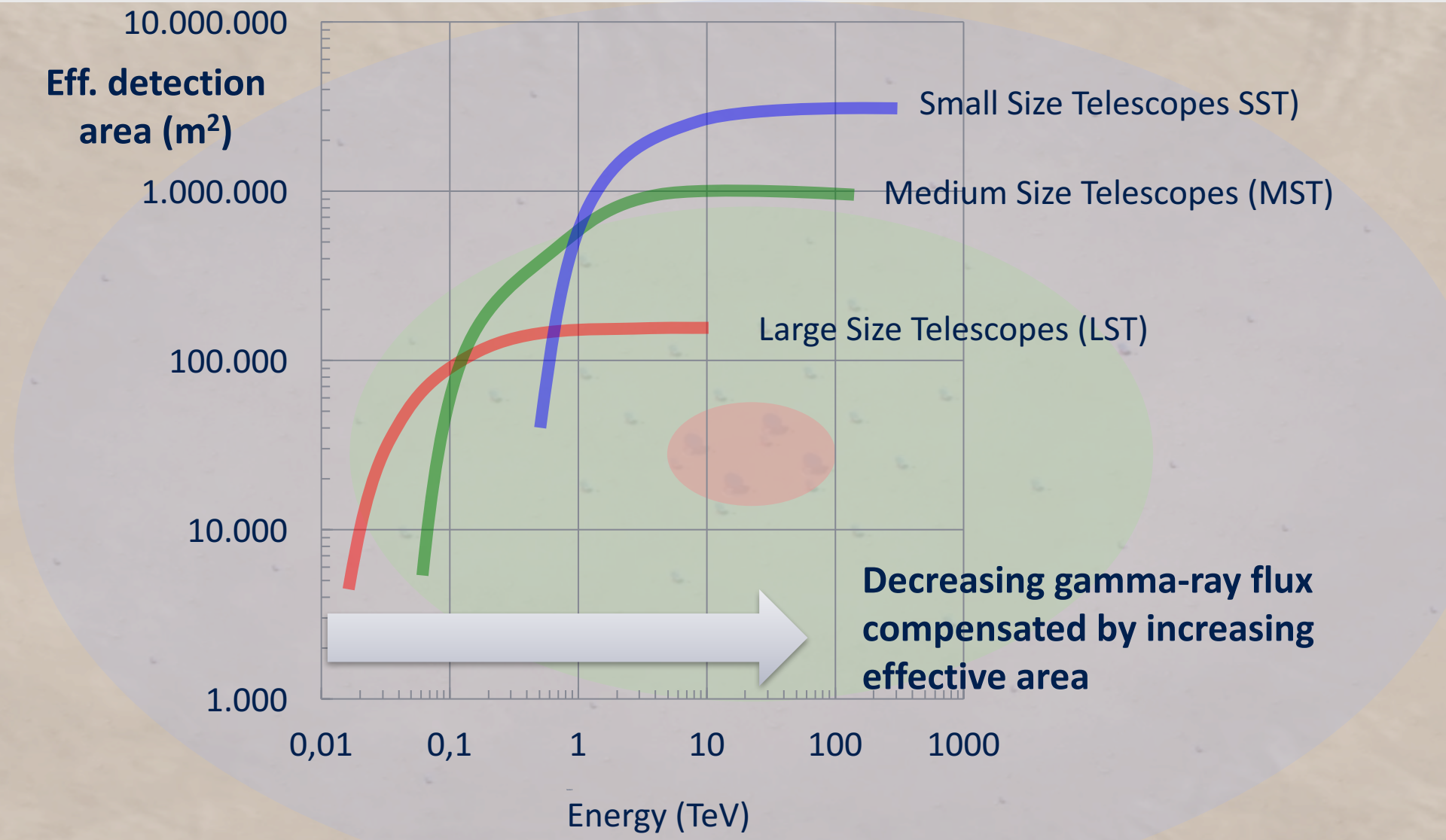
70 x 4 m ⌀ Small Size Telescopes (SST) **(South only)**

Compared to current IACT systems

- up to 20 x better sensitivity
- over 4 decades coverage in energy
- much larger field of view
- better resolution
- up to 400 x increased survey speed

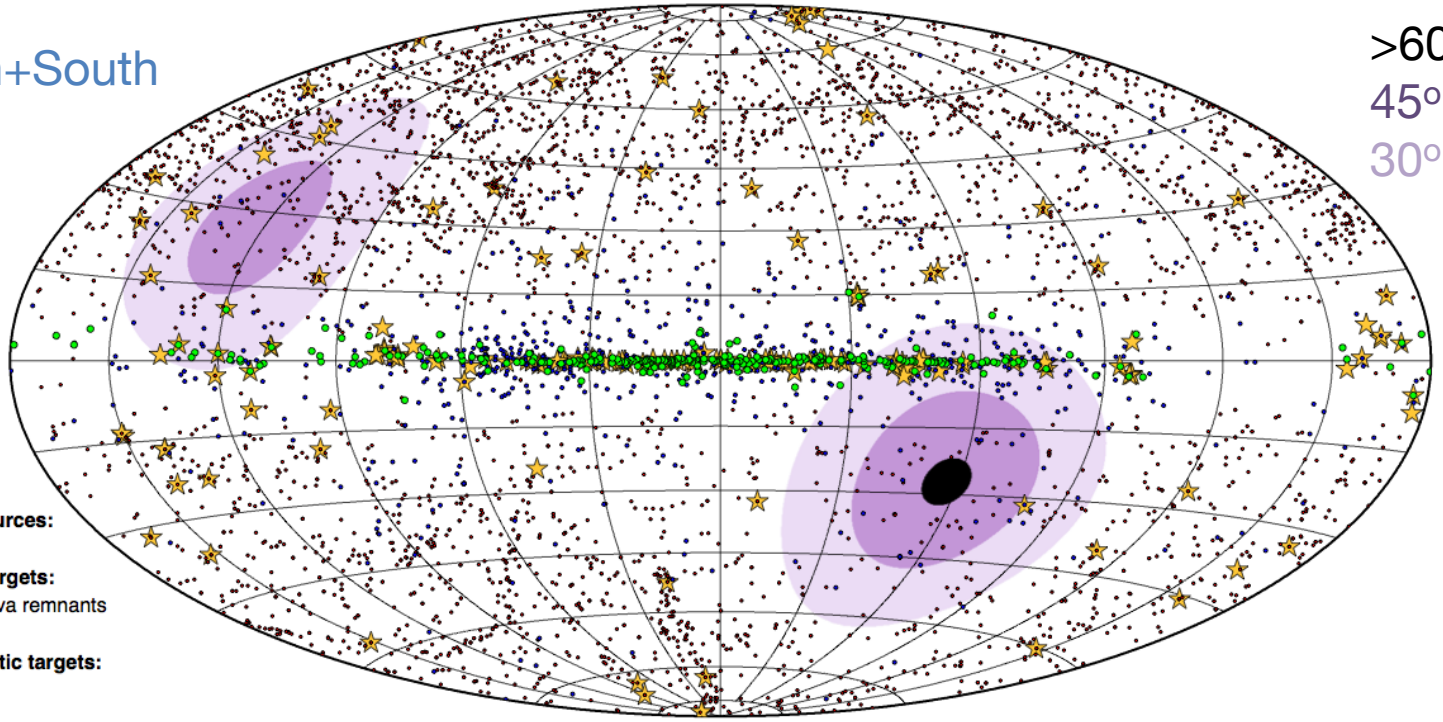


EFFECTIVE AREA FOR GAMMA-RAY DETECTION



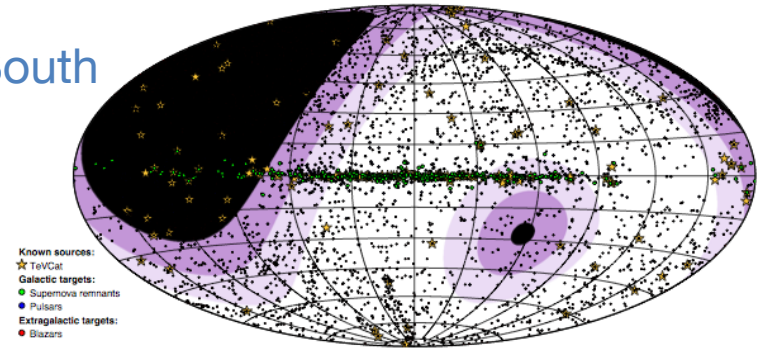
ALL-SKY COVERAGE WITH A NORTHERN AND A SOUTHERN SITE

North+South

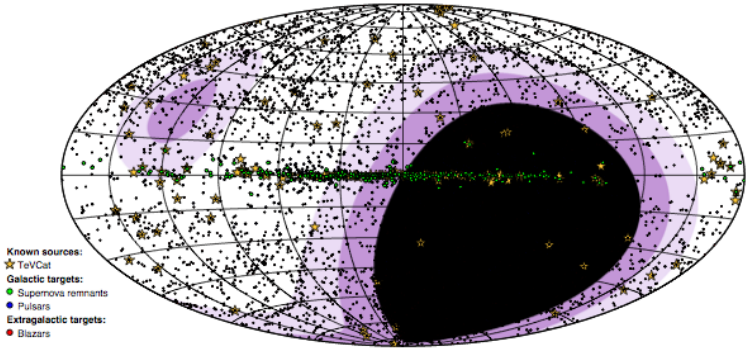


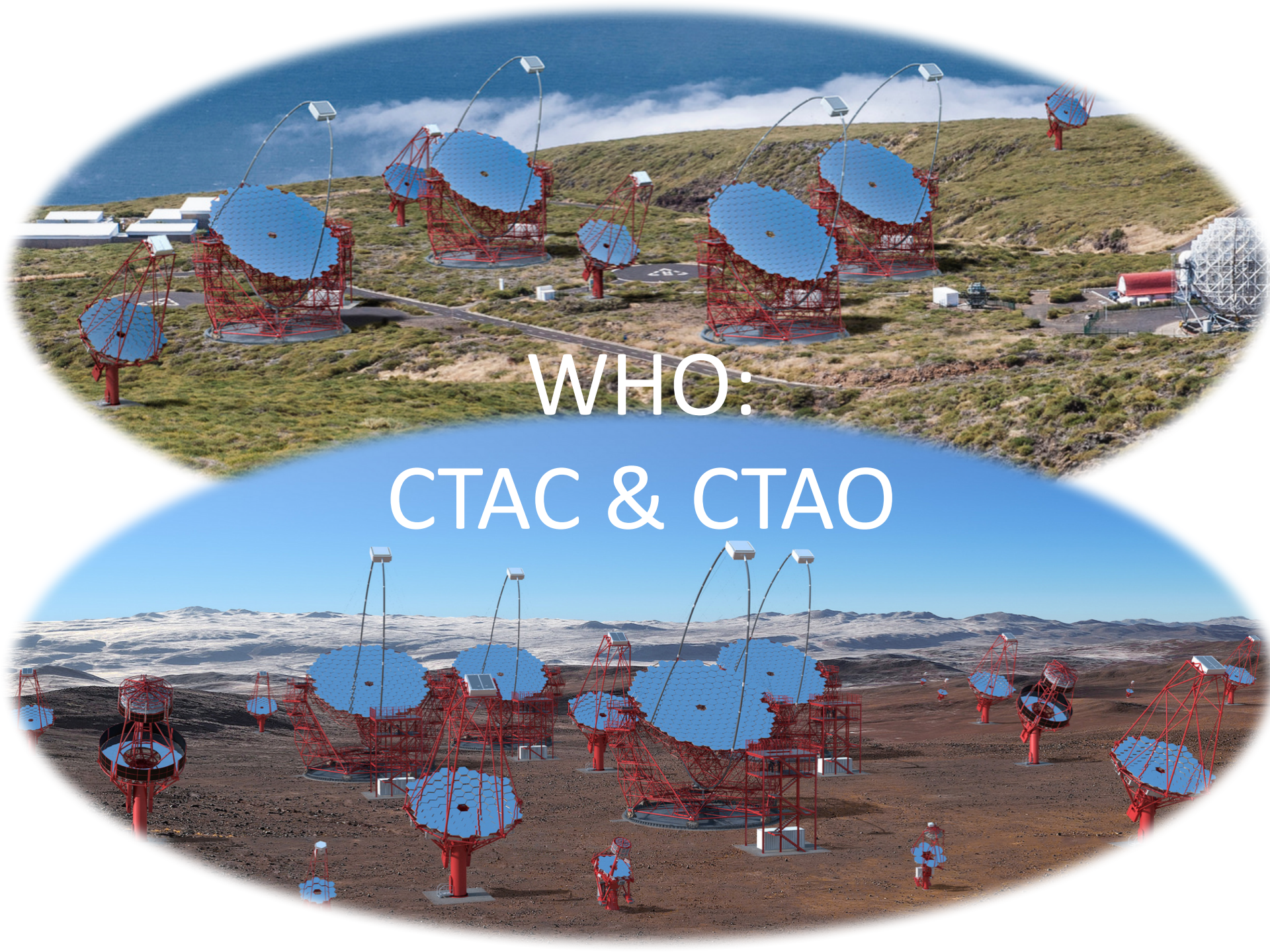
>60° zenith
45°-60°
30°-45°

South



North




WHO:
CTAC & CTAO

THE CTA CONSORTIUM (CTAC)

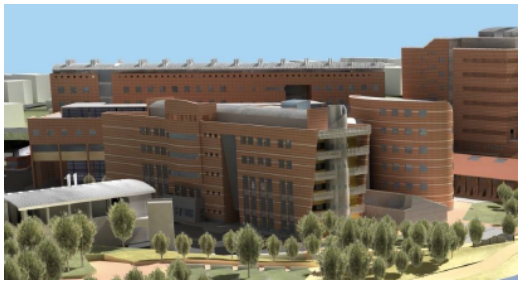


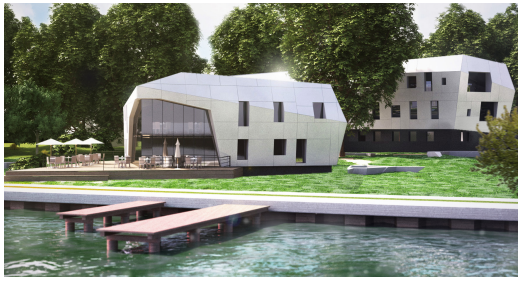
31 Countries
203 Institutes
1451 Members



THE CTA OBSERVATORY (CTAO)

- In 2014, the CTA Observatory GmbH was founded as interim legal entity, located at Heidelberg, under German law
  - To prepare the CTA implementation (select and prepare two array sites + Science Data Management Centre)
- The final legal entity for full construction, a *European Research Infrastructure Consortium* (ERIC), is being set up under European Union law (early 2020?)
- Bologna (Italy) selected as HQ; Project Office is moving to Bologna and is steadily growing
- The *Science Data Management Centre* (SDMC) will be built up at DESY in Berlin-Zeuthen (Germany), in a new building



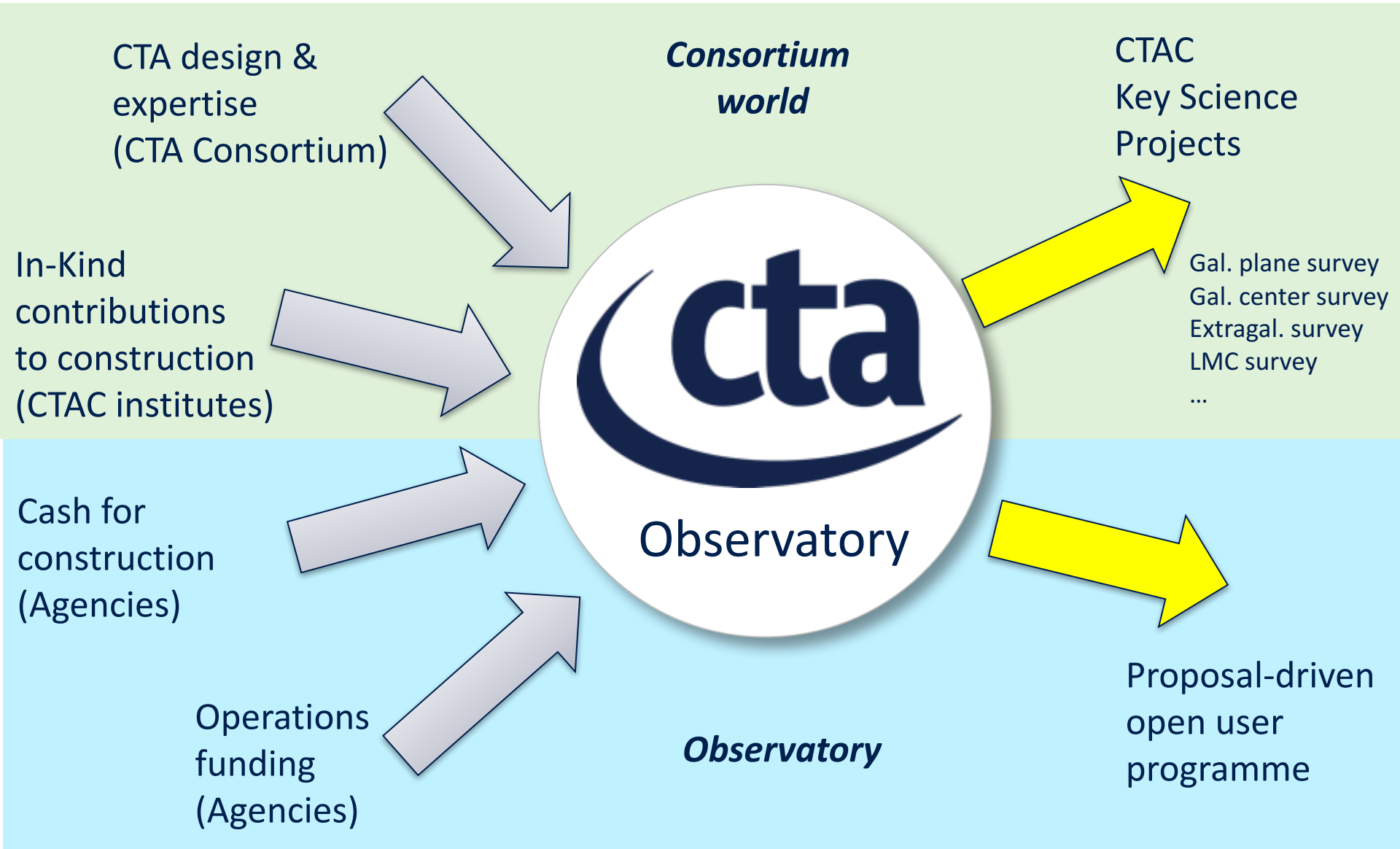


Artist's conception

CTA SITES: ARRAYS, HEADQUARTERS, DATA CENTER



CARE AND FEEDING OF THE CTA OBSERVATORY



CTA AS AN OBSERVATORY

- A Guest Observer Facility
  - For the **first time** in this waveband
    - Existing instruments are run as experiments
  - Annual cycles, TAC ranking, long-term schedule
  - Proposal preparation support, tracking, helpdesk +
  - Public science data archive
    - After proprietary period
- Two Telescope Arrays – one Observatory
  - Inter-site coordination
  - Uniform approach to science operations

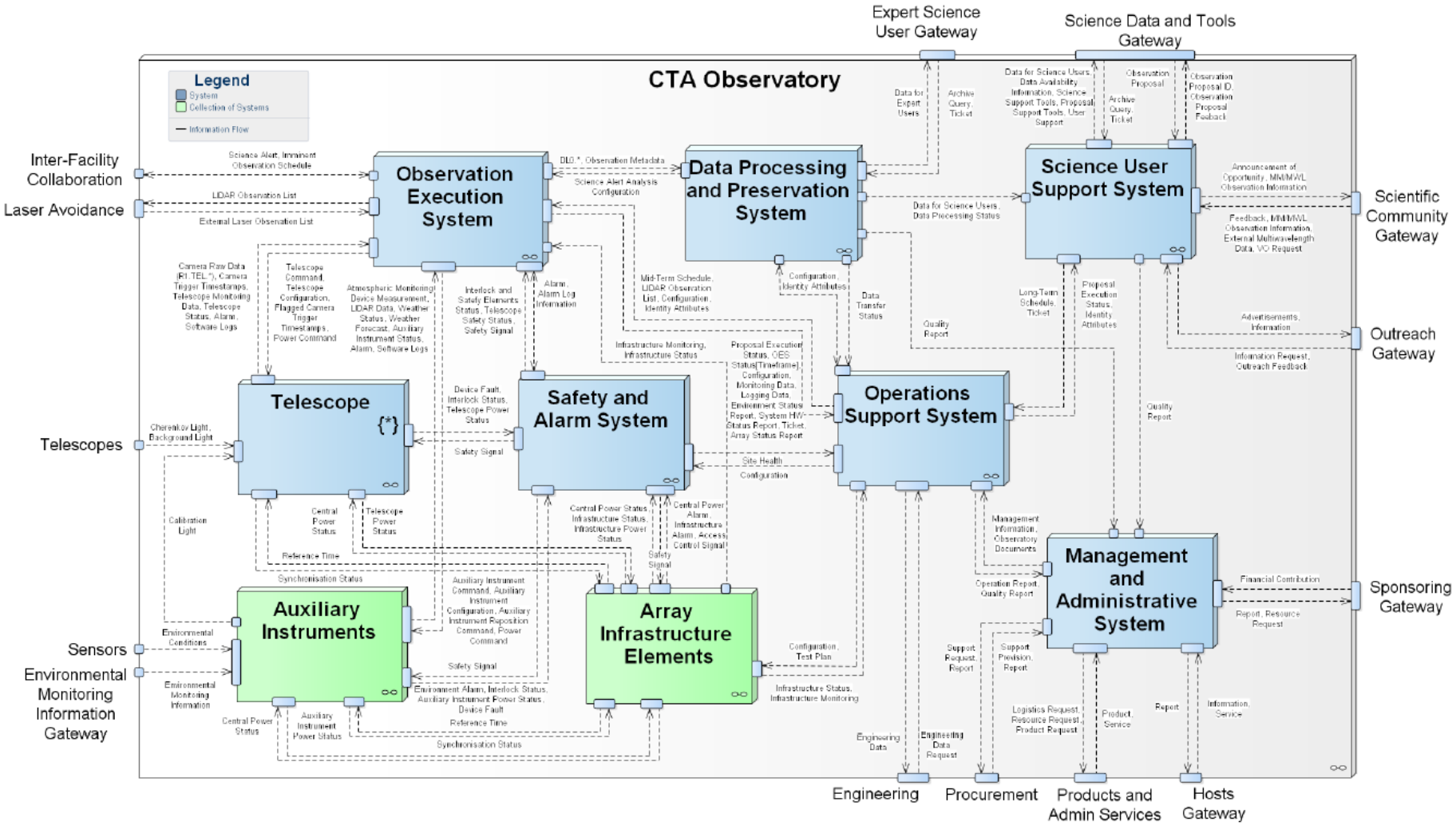
CTA OBSERVATORY

- Users will receive their data fully calibrated in FITS format, and be provided analysis tools
- After a one-year proprietary period, data are open
- During 1st decade, available observation time split roughly evenly between Key Science Projects (in particular surveys) and open time

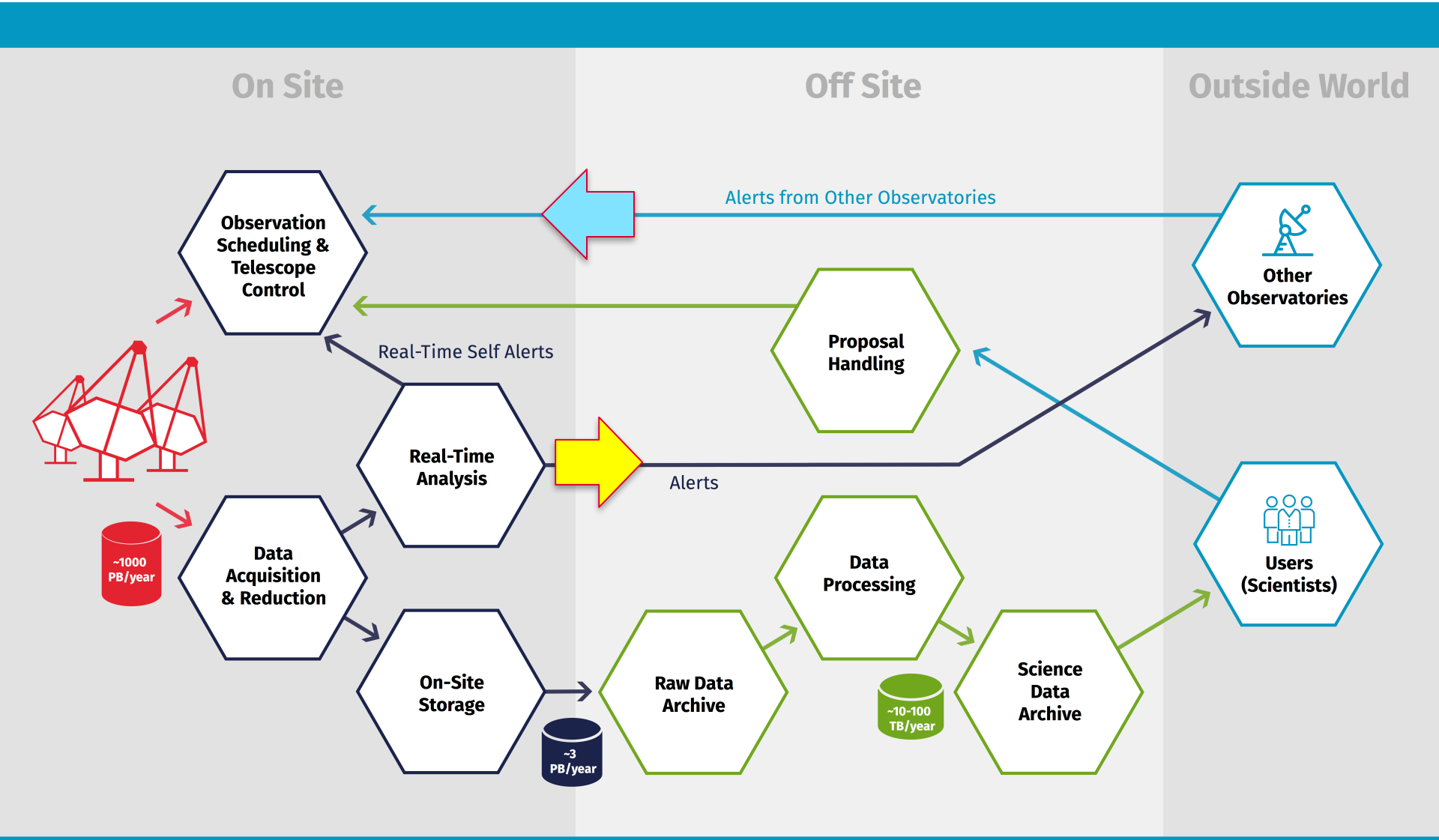
Timeline

- 2020 First pre-production telescopes on site
- 2022 Beginning of Observatory operations
- 2025 Construction project completion

CTA SYSTEM ARCHITECTURE

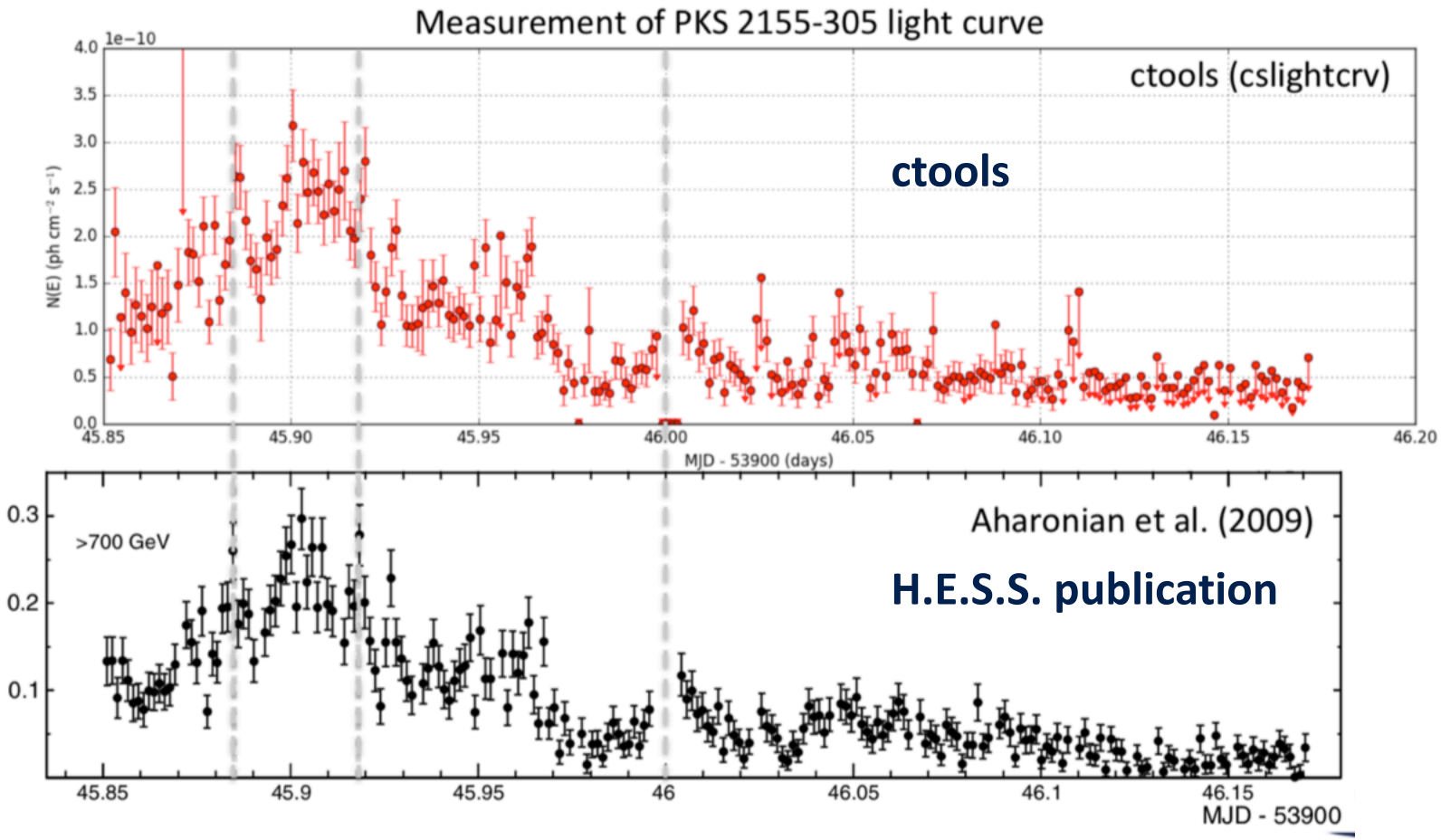


CTA SYSTEM ARCHITECTURE & INFORMATION FLOW



TEST OF USER TOOLS

Using public HESS data on PKS 2155-flare, released in CTA-like format




SITES

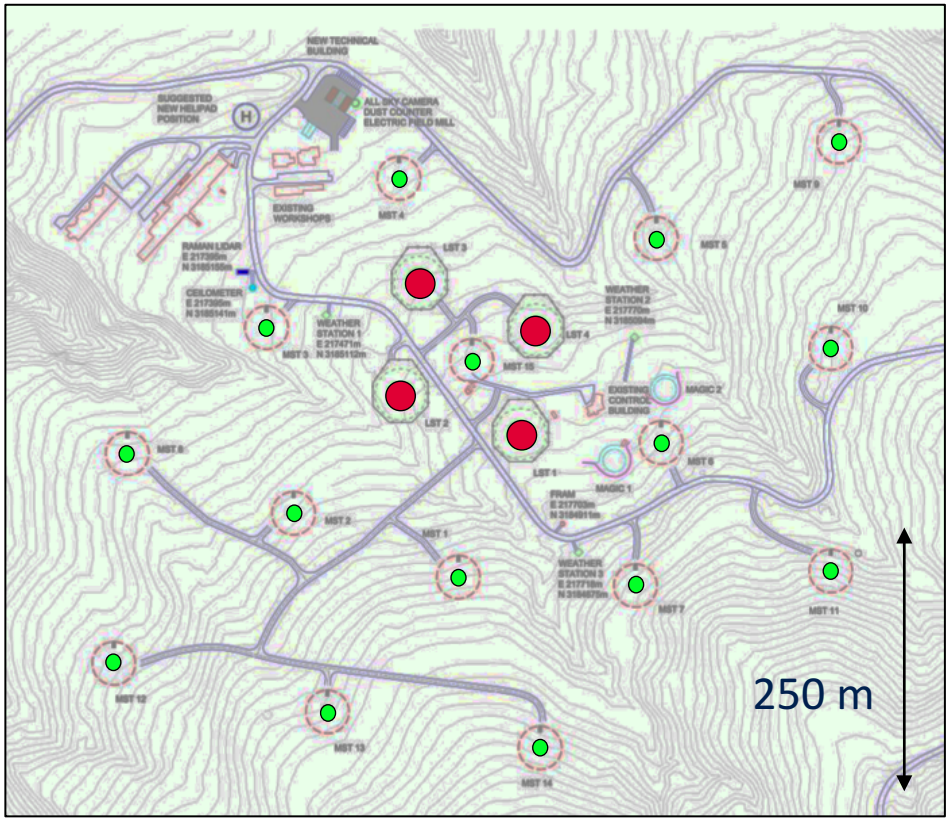
CTA SITES: NORTH

Observatory
Roque de los Muchachos
La Palma, Spain

Selected July 2015
Agreement signed Sept. 2016







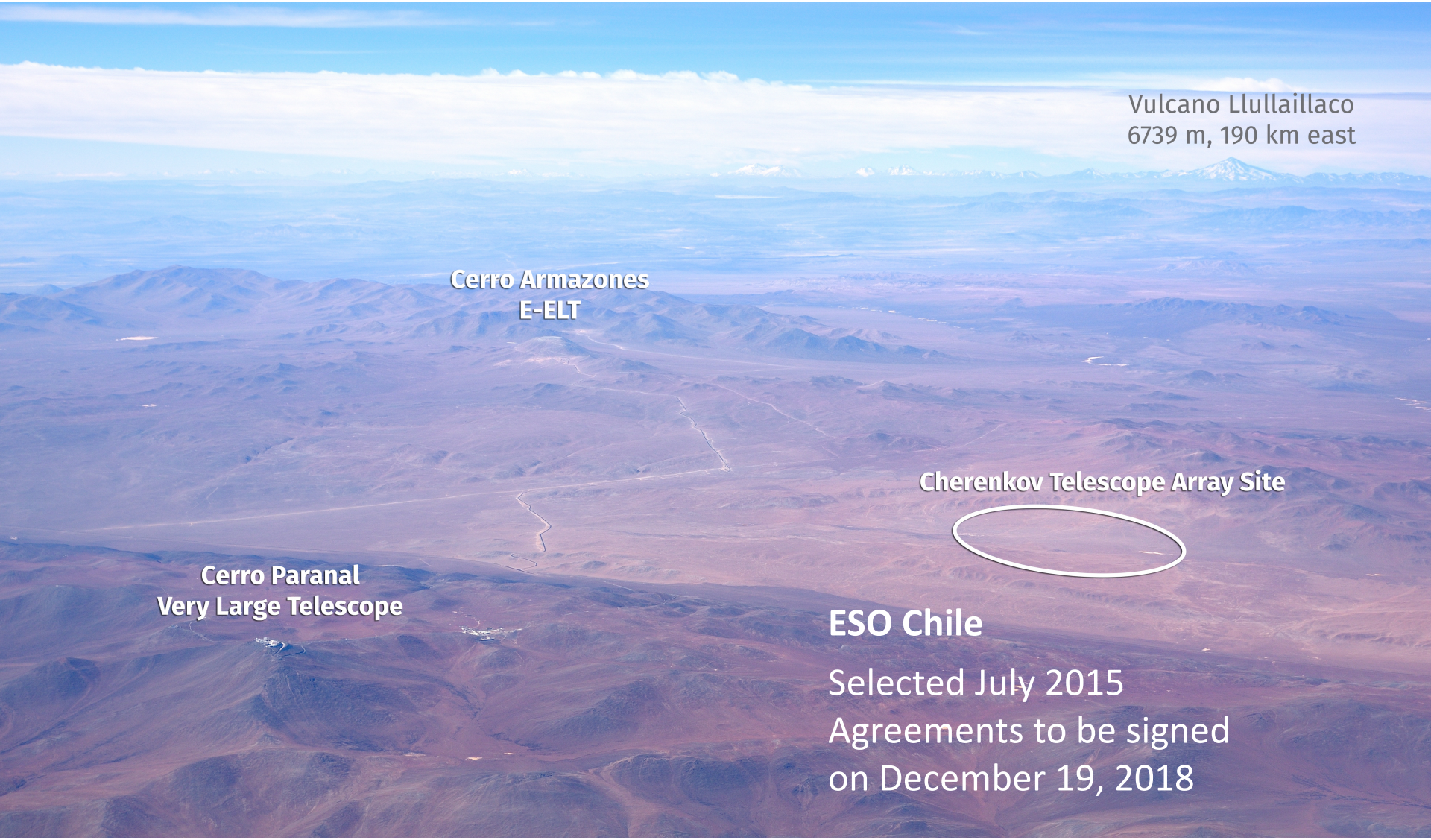
Steps:

1) LST Prototype (LST1)
2) Remaining 3 LST + 1 MST
3) Remaining 14 MST

Infrastructure implementation being procured



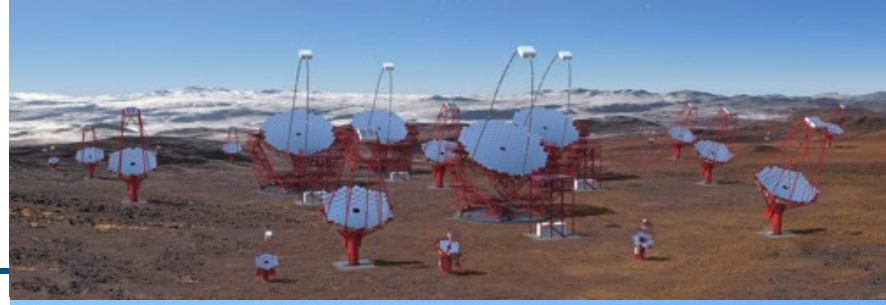
CTA SITES: SOUTH



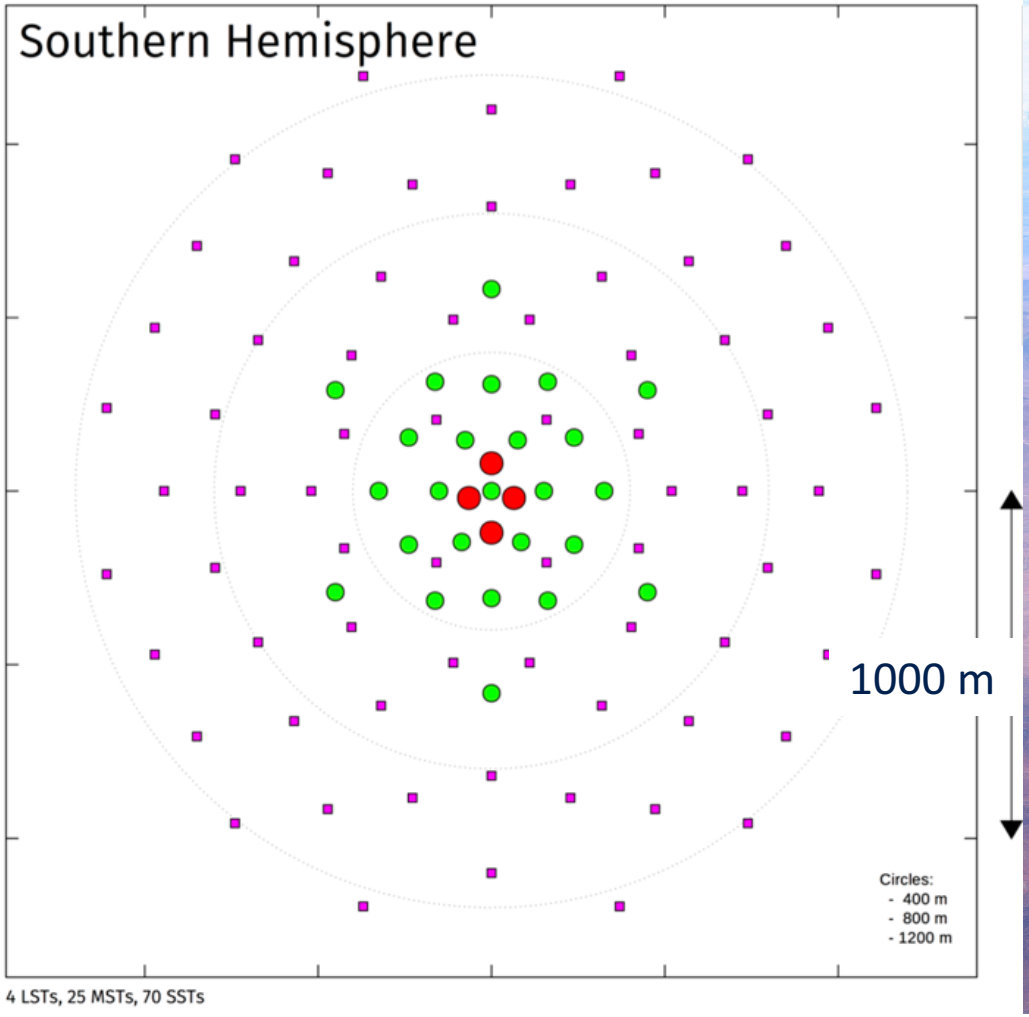
ESO Chile

Selected July 2015
Agreements to be signed
on December 19, 2018

CTA SITES: SOUTH



4 LSTs, 25 MSTs, 70 SSTs



Vulcano Llullaillaco
6739 m, 190 km east

Cherenkov Telescope Array Site

ESO Chile

Selected July 2015
Agreements to be signed
on December 19, 2018



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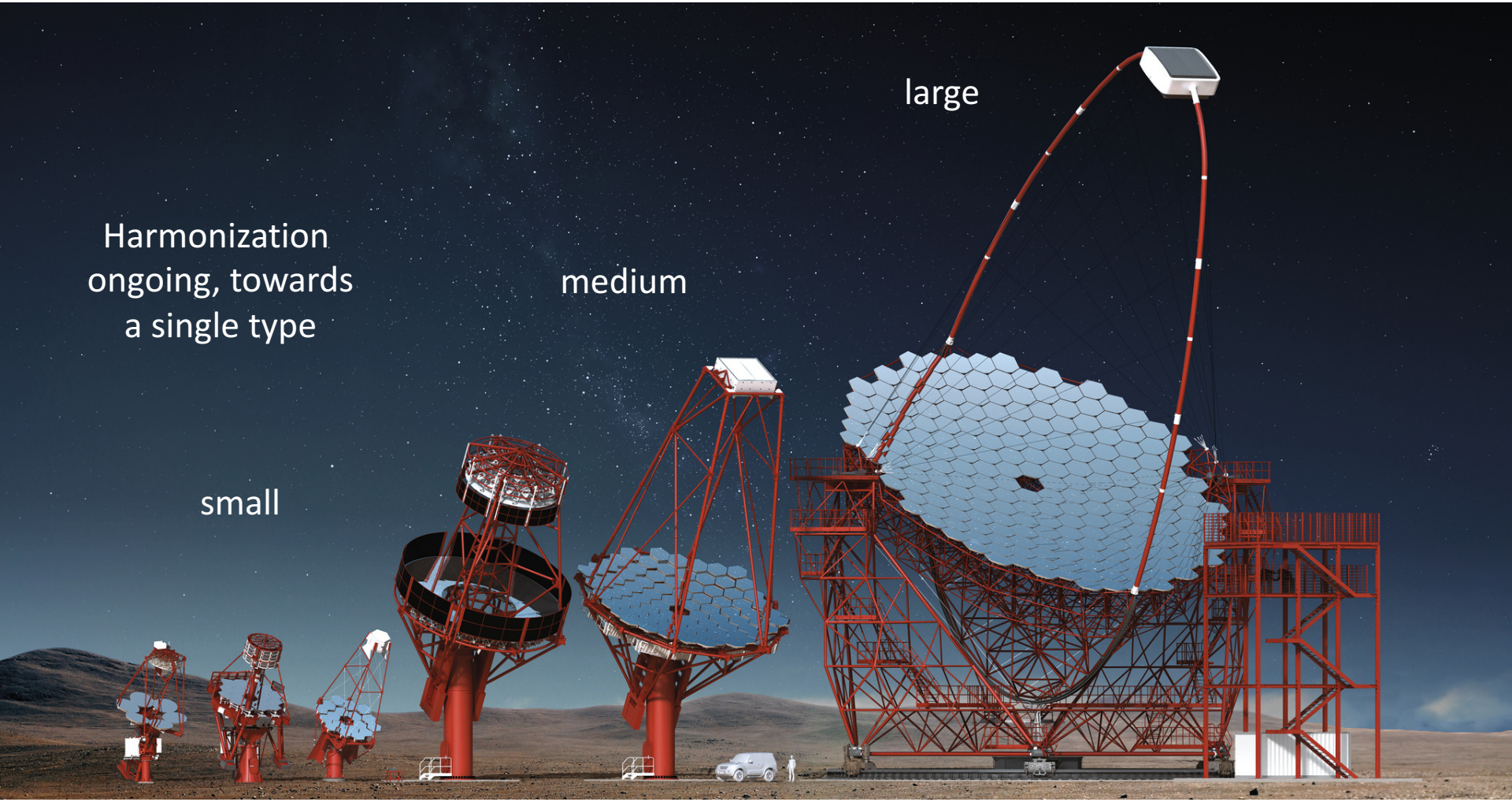
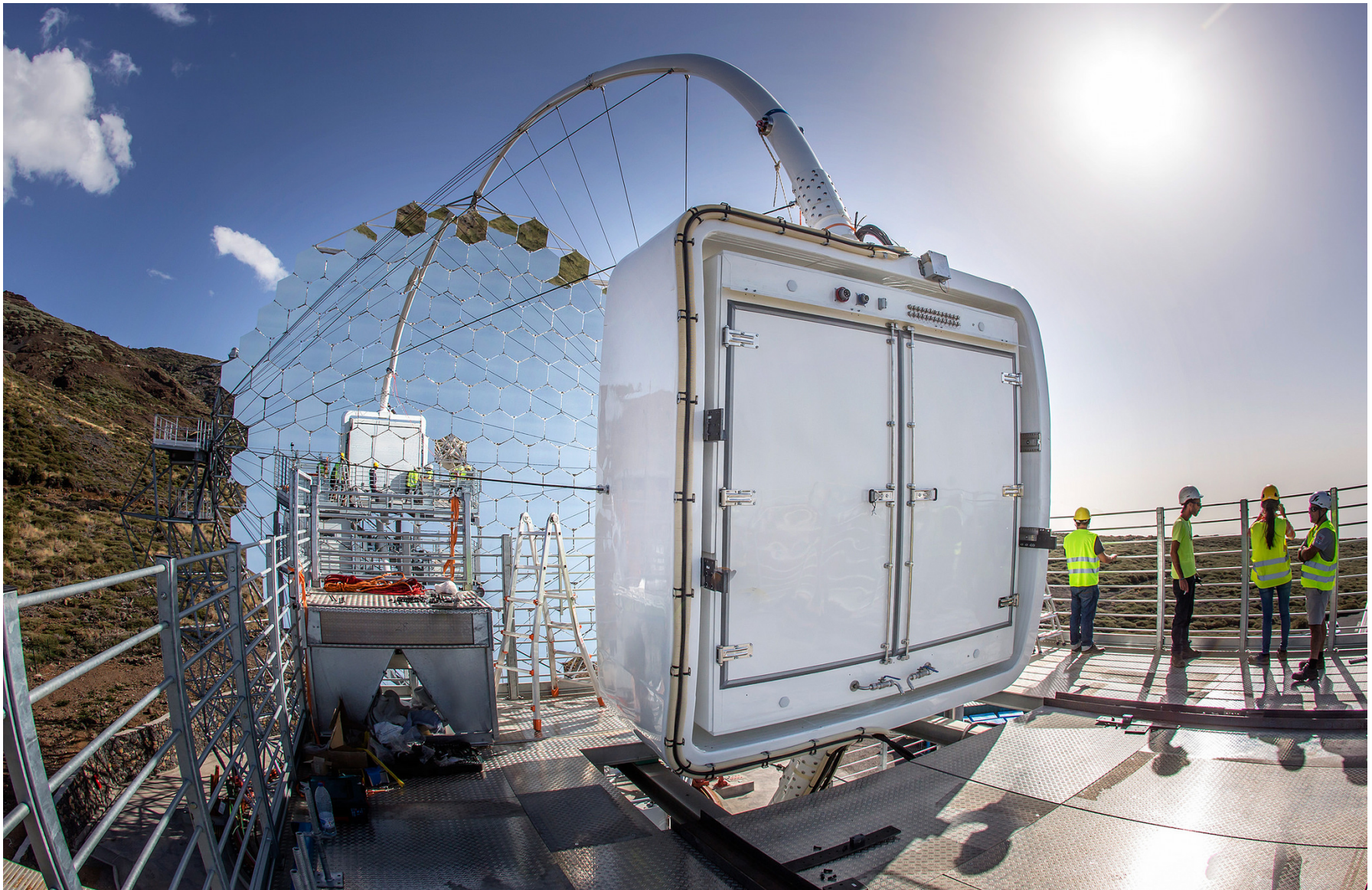
CTA TELESCOPE PROTOTYPES



LST1 INAUGURATION
OCTOBER 10, 2018



GROUND BREAKING
OCTOBER 9, 2015




CAT



INAUGURATION CEREMONY





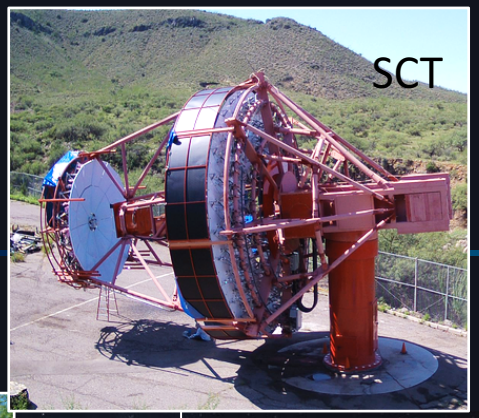
LST1



TELESCOPES

	Large-Sized Telescope (LST)	Medium-Sized Telescope (MST)			Small-Sized Telescope (SST)		
		FlashCam	NectarCam	SCT	ASTRI	GCT	SST-1M
Required energy range	20 GeV – 3 TeV	80 GeV – 50 TeV			1 TeV – 300 TeV		
Energy range (in which subsystem provides full system sensitivity)	20 GeV – 150 GeV	150 GeV – 5 TeV			5 TeV – 300 TeV		
Number of telescopes	4 (South) 4 (North)	25 (South) 15 (North)			70 (South) 0 (North)		
Optical design	Parabolic	Modified Davies-Cotton		Schwarzschild-Couder	Schwarzschild-Couder		Davies-Cotton
Primary reflector diameter	23.0 m	11.5 m		9.7 m	4.3 m	4.0 m	4.0 m
Secondary reflector diameter	--	--		5.4 m	1.8 m	2.0 m	--
Effective mirror area (including shadowing)	370 m^2	88 m^2		41 m^2	8 m^2	8.9 m^2	7.5 m^2
Focal length	28 m	16 m		5.6 m	2.15 m	2.28 m	5.6 m
Total weight	103 t	82 t		80 t	19 t	11 t	8.6 t
Field of view	4.3 deg	7.5 deg	7.7 deg	7.6 deg	10.5 deg	8.3 deg	8.8 deg
Number of pixels in Cherenkov camera	1855	1764	1855	11328	2368	2048	1296
Pixel size (imaging)	0.1 deg	0.17 deg	0.17 deg	0.067 deg	0.19 deg	0.17 deg	0.24 deg
Photodetector type	PMT	PMT	PMT	SiPM	SiPM	SiPM	SiPM
Telescope readout event rate (before array trigger for MSTs and SSTs)	>7.0 kHz (after LST array trigger)	>6 kHz	>7.0 kHz	>3.5 kHz	>0.3 kHz	>0.4 kHz	0.6 kHz
Telescope data rates (readout of all pixels; before array trigger)	24 Gb/s	12 Gb/s			2 Gb/s		3.2 Gb/s
Positioning time to any point in the sky (>30° elevation)	30 s	90 s			60 s		
Pointing precision	<14 arcseconds	<7 arcseconds		<10 arcseconds	<7 arcseconds		
Observable sky	Any astrophysical object with elevation > 24 degrees						







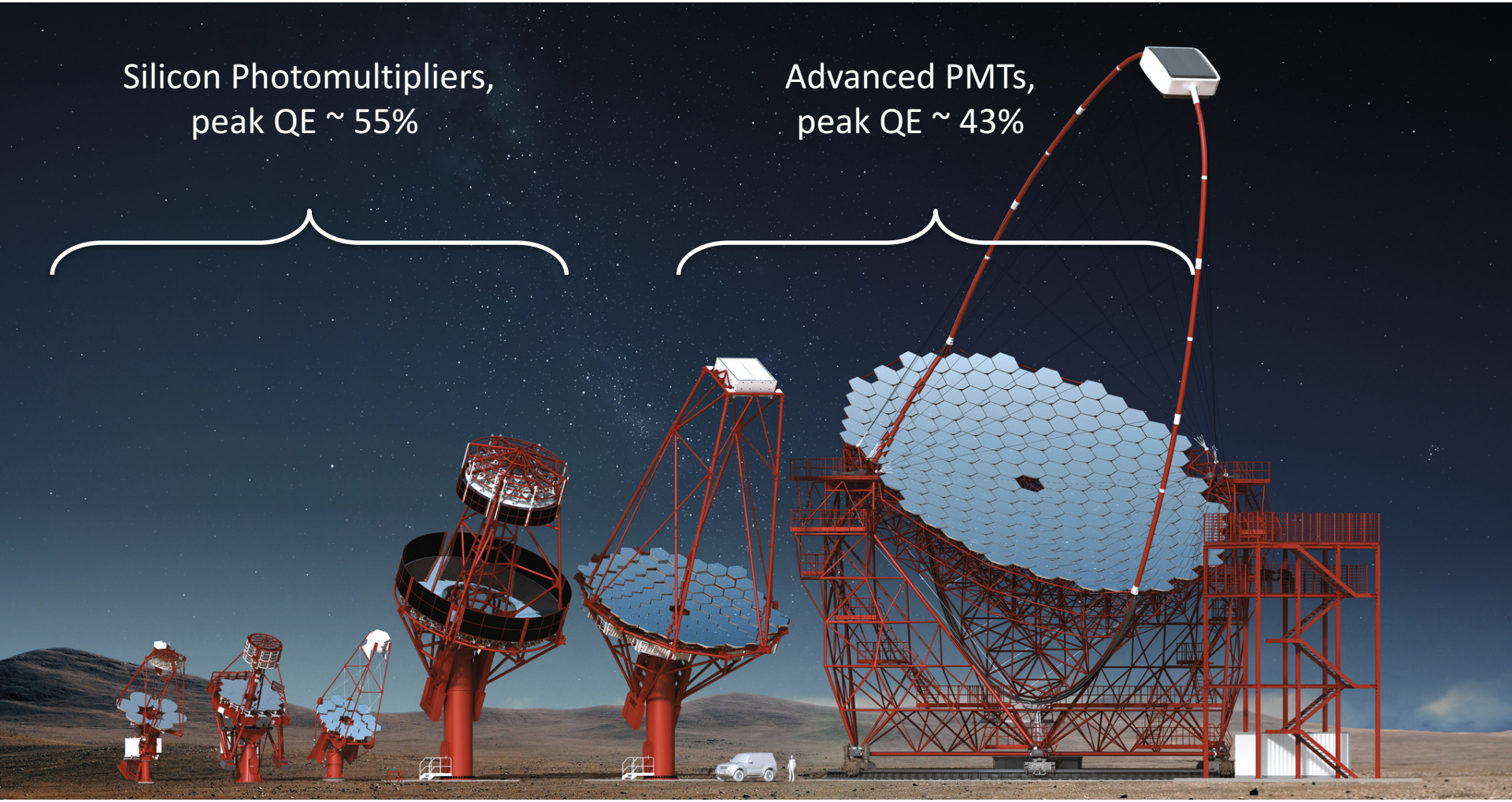




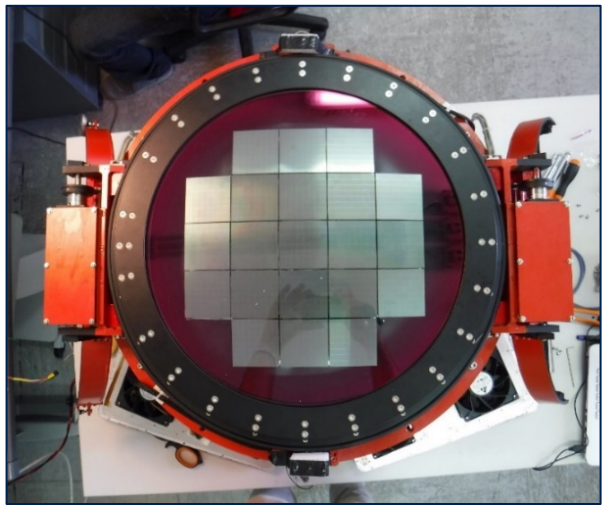
Prototype Telescopes



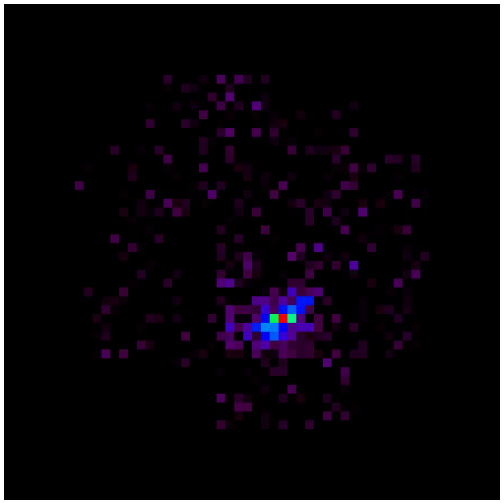
CTA TELESCOPE PROTOTYPES



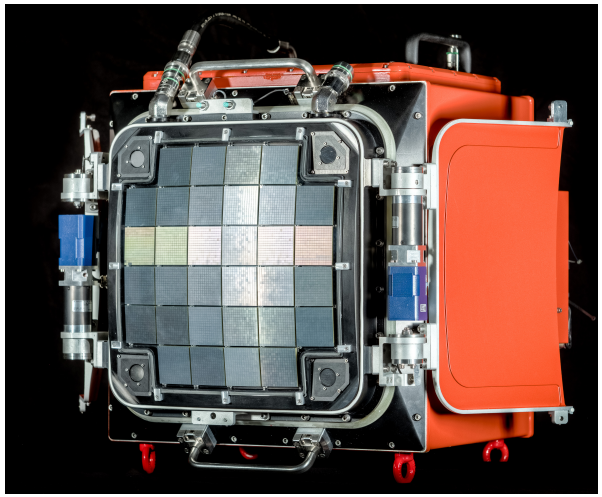
CAMERAS & SHOWER IMAGES



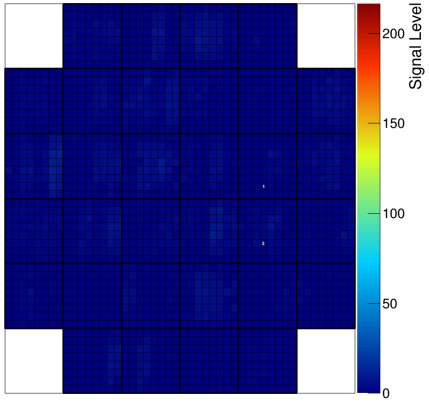
30 cm



ASTRI
SST

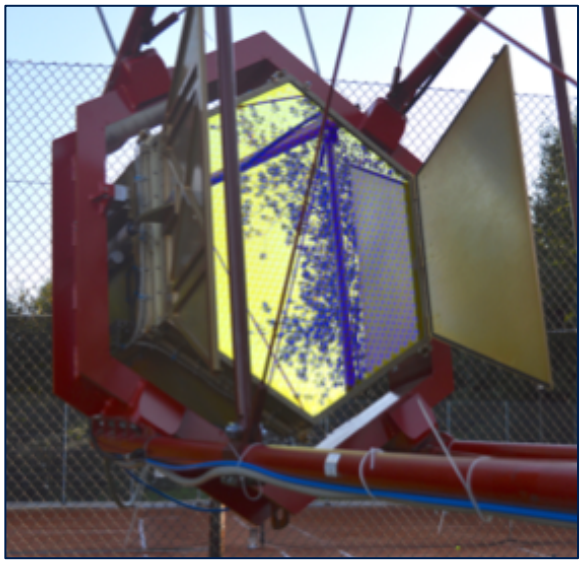


30 cm

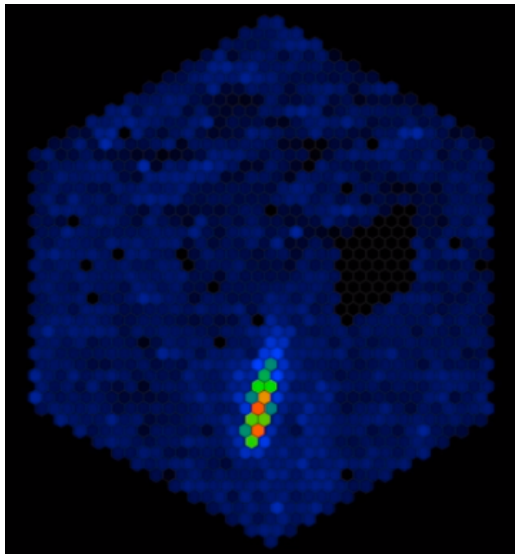


CHEC
SST

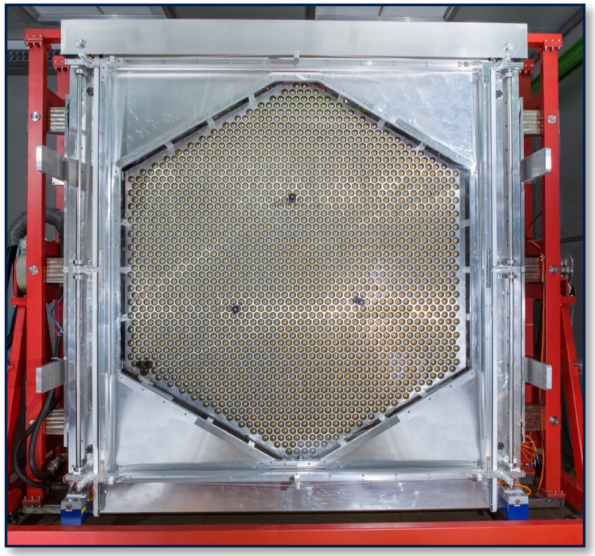
CAMERAS & SHOWER IMAGES



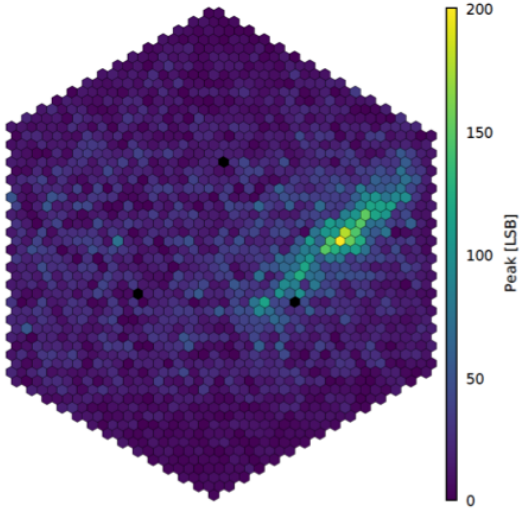
90 cm



SST-1M



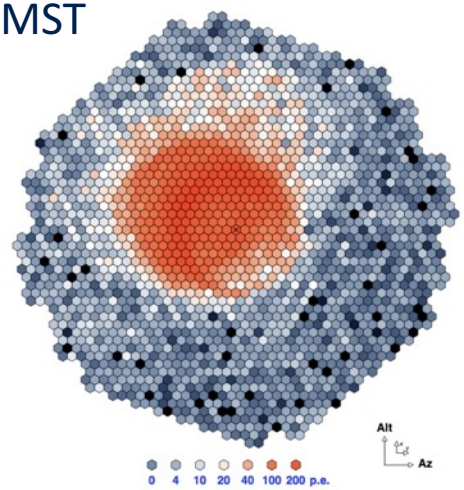
3 m



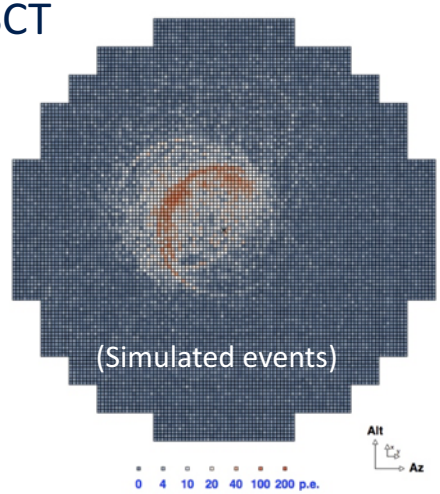
MST
FlashCam

MEDIUM SIZED SCHWARZSCHILD COUDER TELESCOPE (SCT)

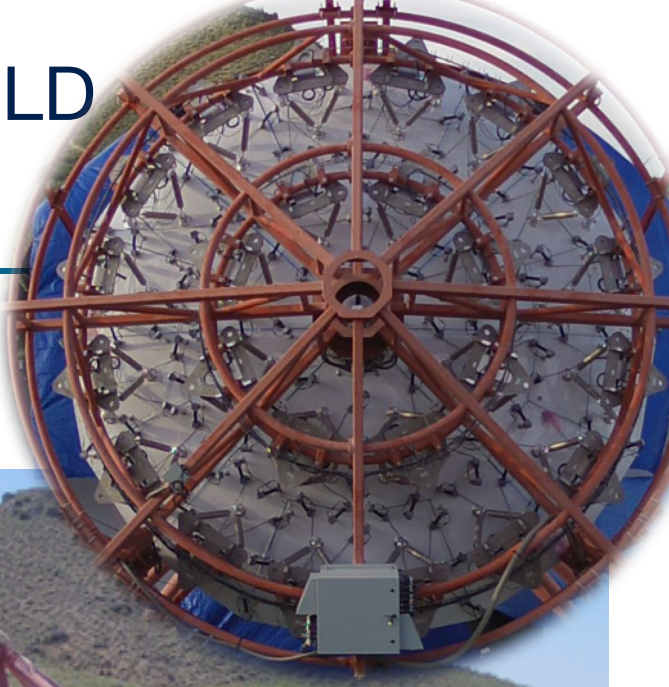
Single-mirror MST

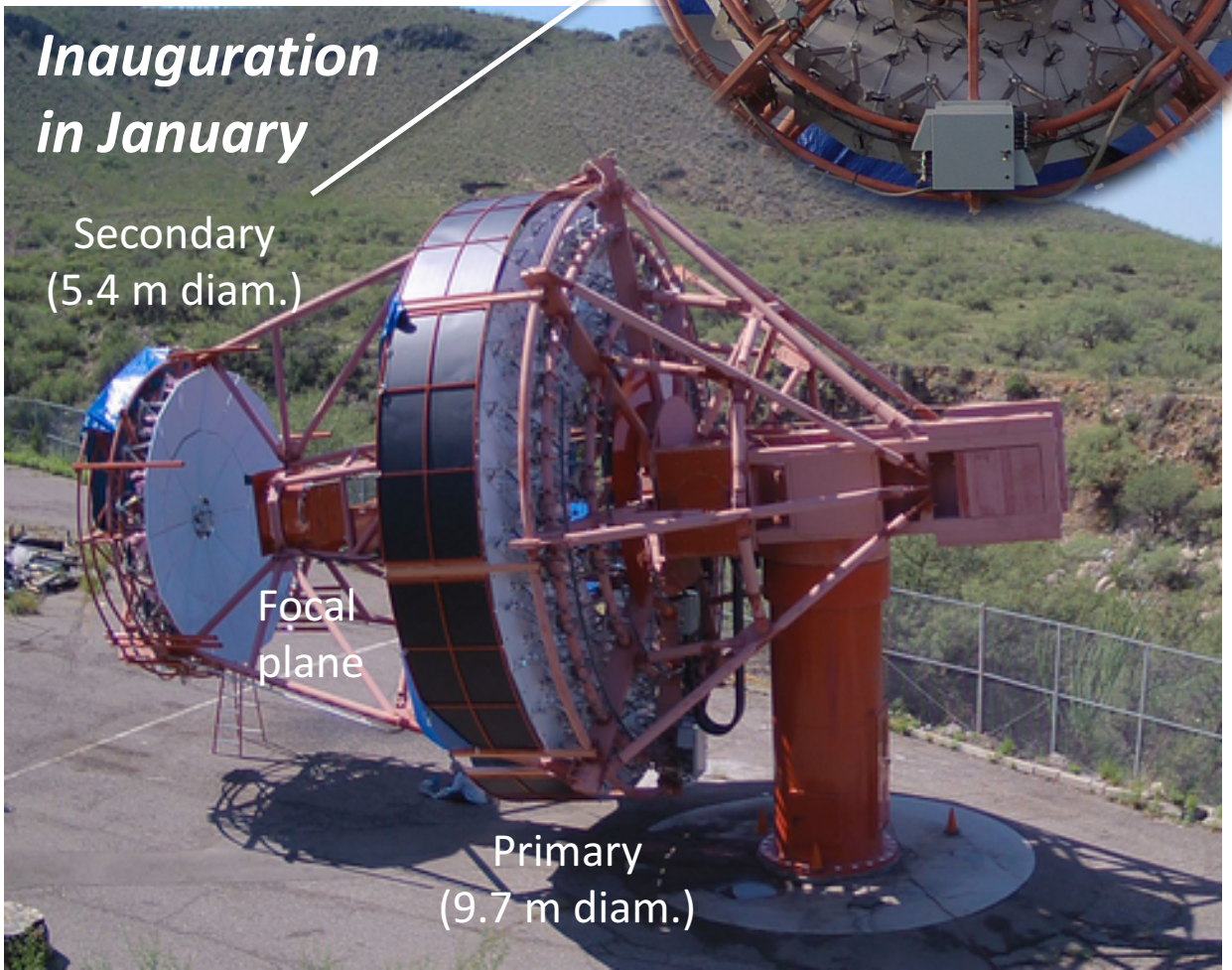


Dual-mirror SCT



Back side of secondary mirror





TELESCOPE SIMULATIONS

Input


ASTRI - Astrofisica con Specchi a Tecnologia Replicante Italiana

Code: ASTRI- | Issue: 1 | DATE: 19-OCT-17 | Page: 1

OPTICAL PARAMTERS FOR ASTRI CHILE DEMONSTRATORS MC MODEL

Prepared by: Name: G. Sironi Signature: Date: 19/10/2017

Approved by: Name: G. Pareschi Signature: Date: 19/10/2017

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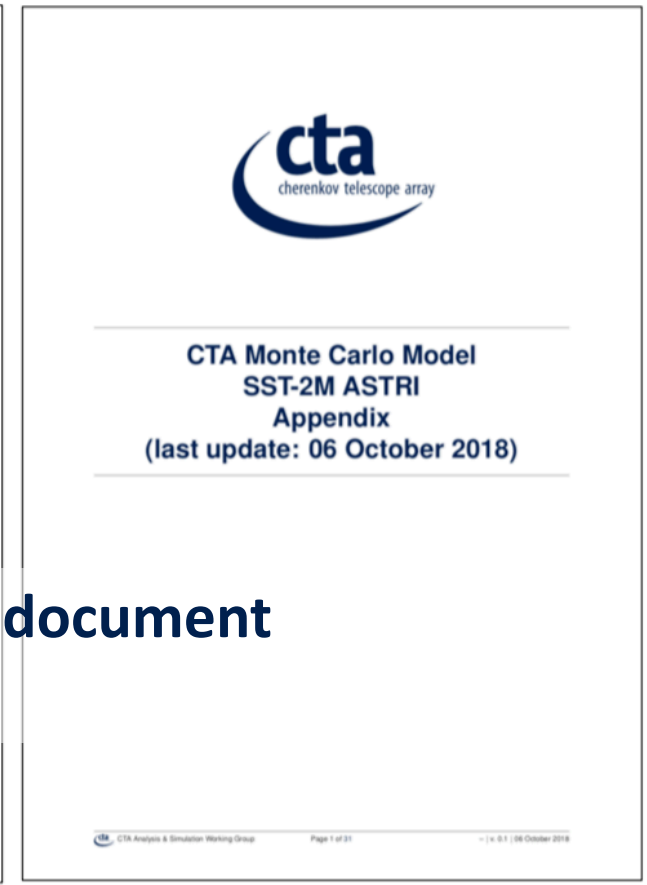
Parameters used in simulation


cherenkov telescope array

MC parameter description:
SST-2M ASTRI

CTA Analysis & Simulation Working Group Page 1 of 51 DOC-MC-PAR-DESC | v. 1.0 | 12 October 2018

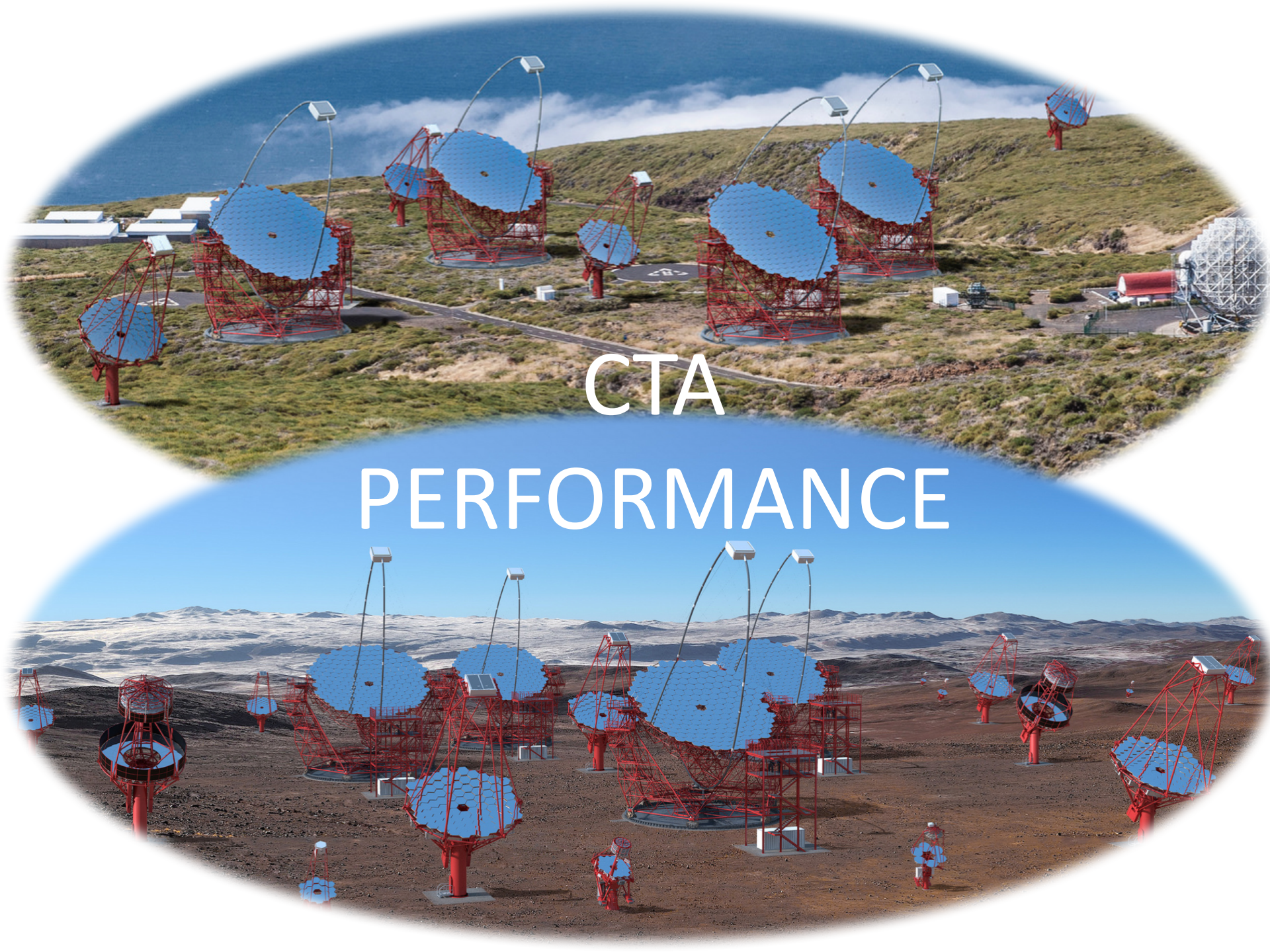
Telescope model description


cherenkov telescope array

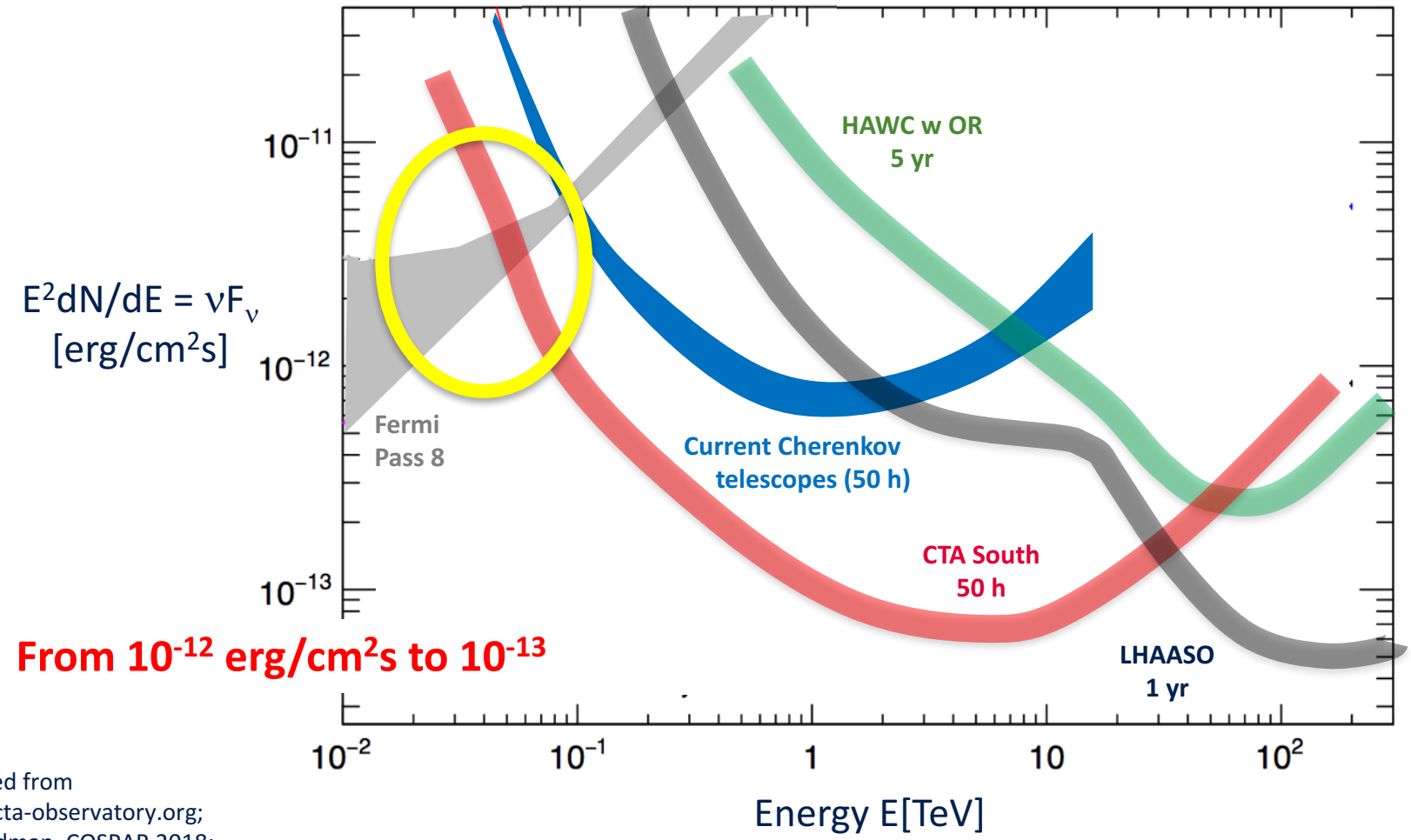
CTA Monte Carlo Model
SST-2M ASTRI
Appendix
(last update: 06 October 2018)

CTA Analysis & Simulation Working Group Page 1 of 31

Huge effort to improve, validate, document telescope simulations


CTA
PERFORMANCE

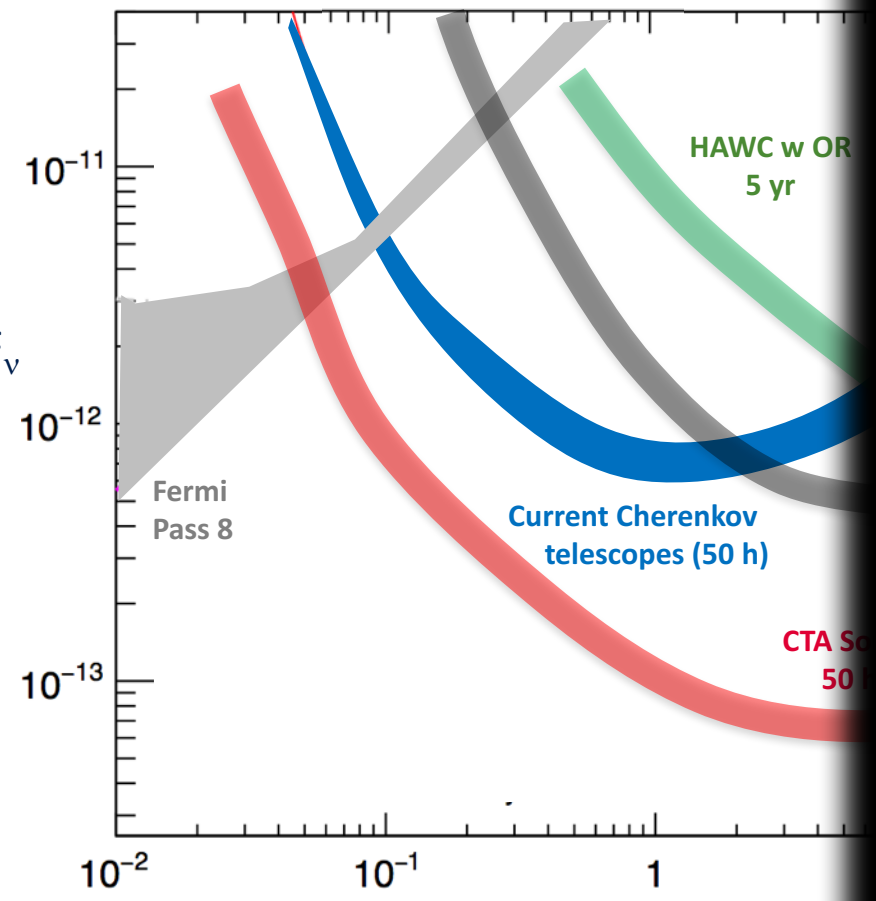
SENSITIVITY (STEADY SOURCES)



From 10^{-12} erg/cm^{2}s to 10^{-13}

adapted from
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

SENSITIVITY (STEADY SOURCE

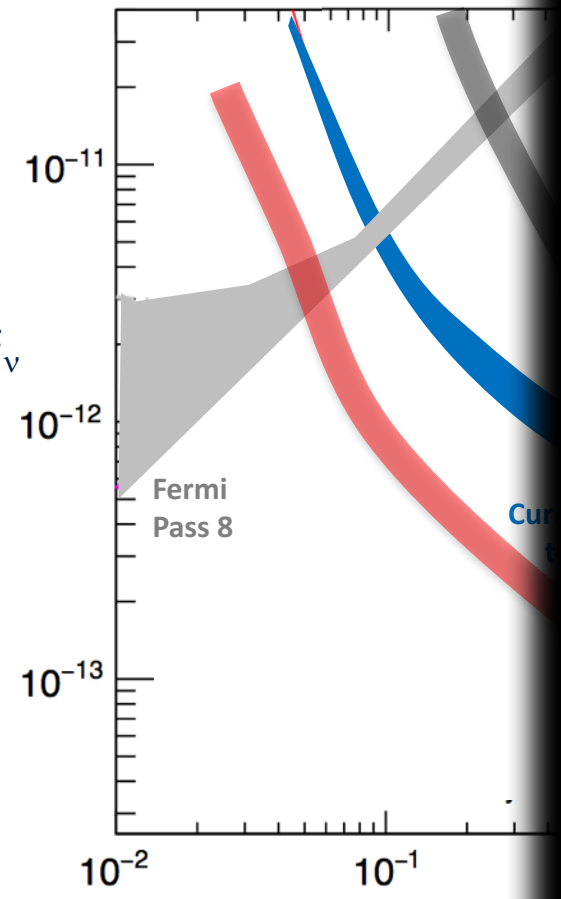


Redshift z=0.1

adapted from
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

SENSITIVITY (STEADY

$E^2dN/dE = \nu F_\nu$
$[erg/cm^2s]$

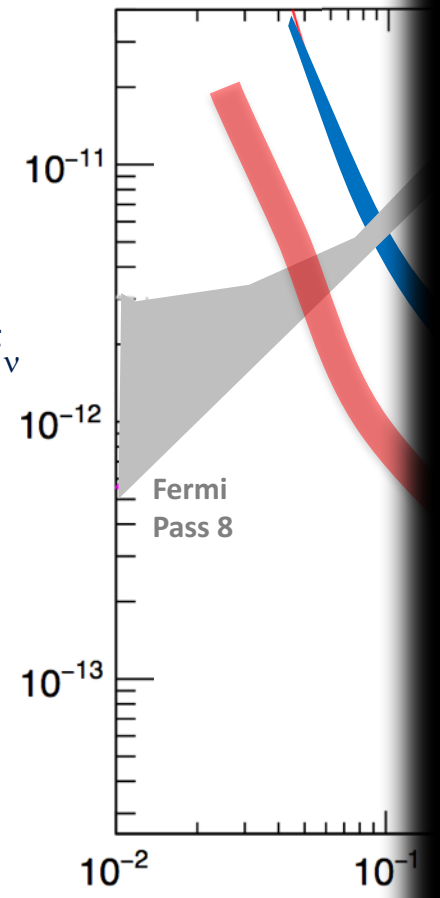


Redshift z=0.3

adapted from
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

SENSITIVITY (STEA

$E^2dN/dE = \nu F_\nu$
$[erg/cm^2s]$

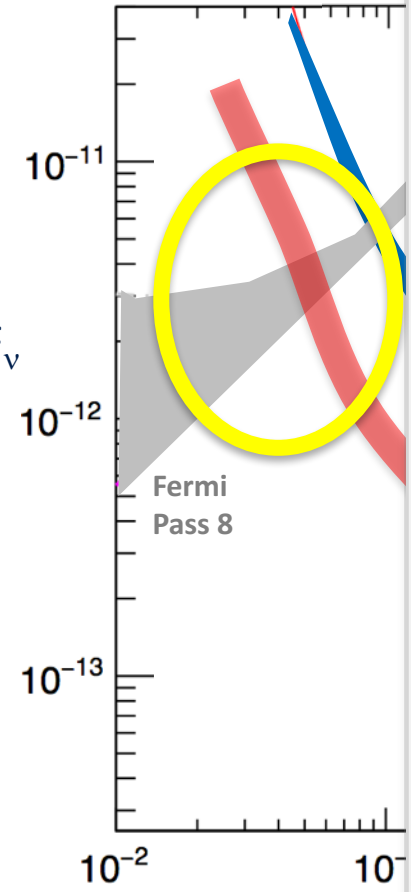


Redshift z=1

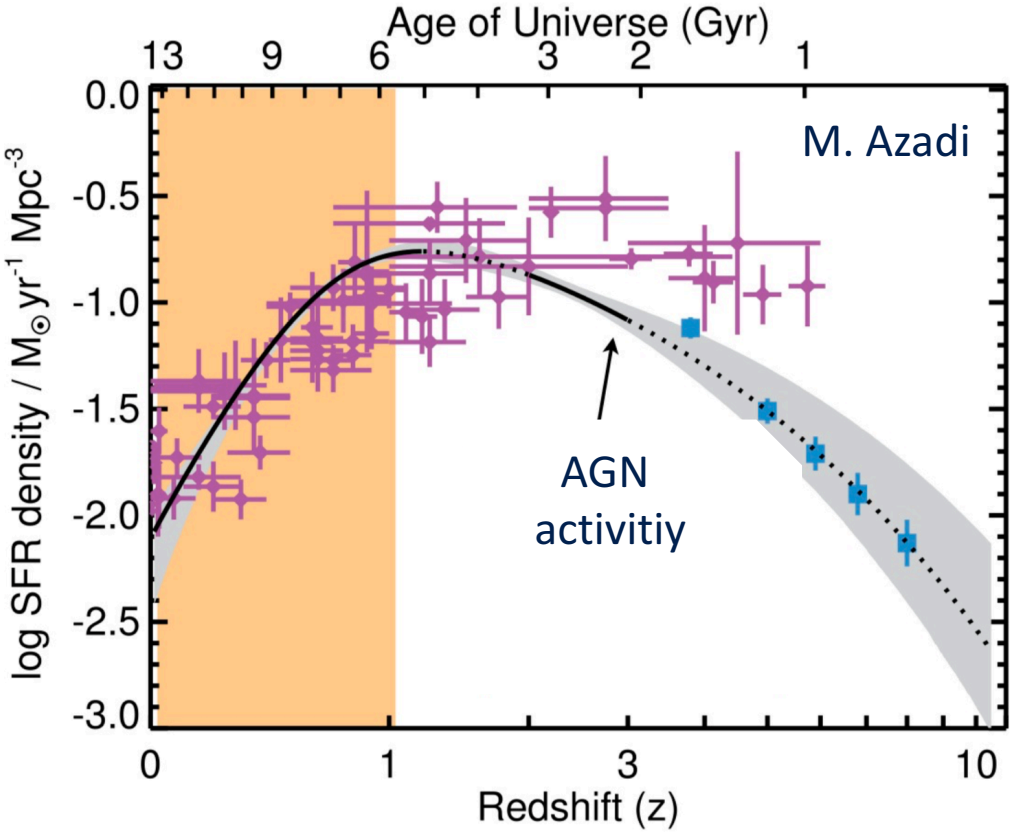
adapted from
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

SENSITIVITY (STEA

$E^2dN/dE = \nu F_\nu$
$[erg/cm^2s]$

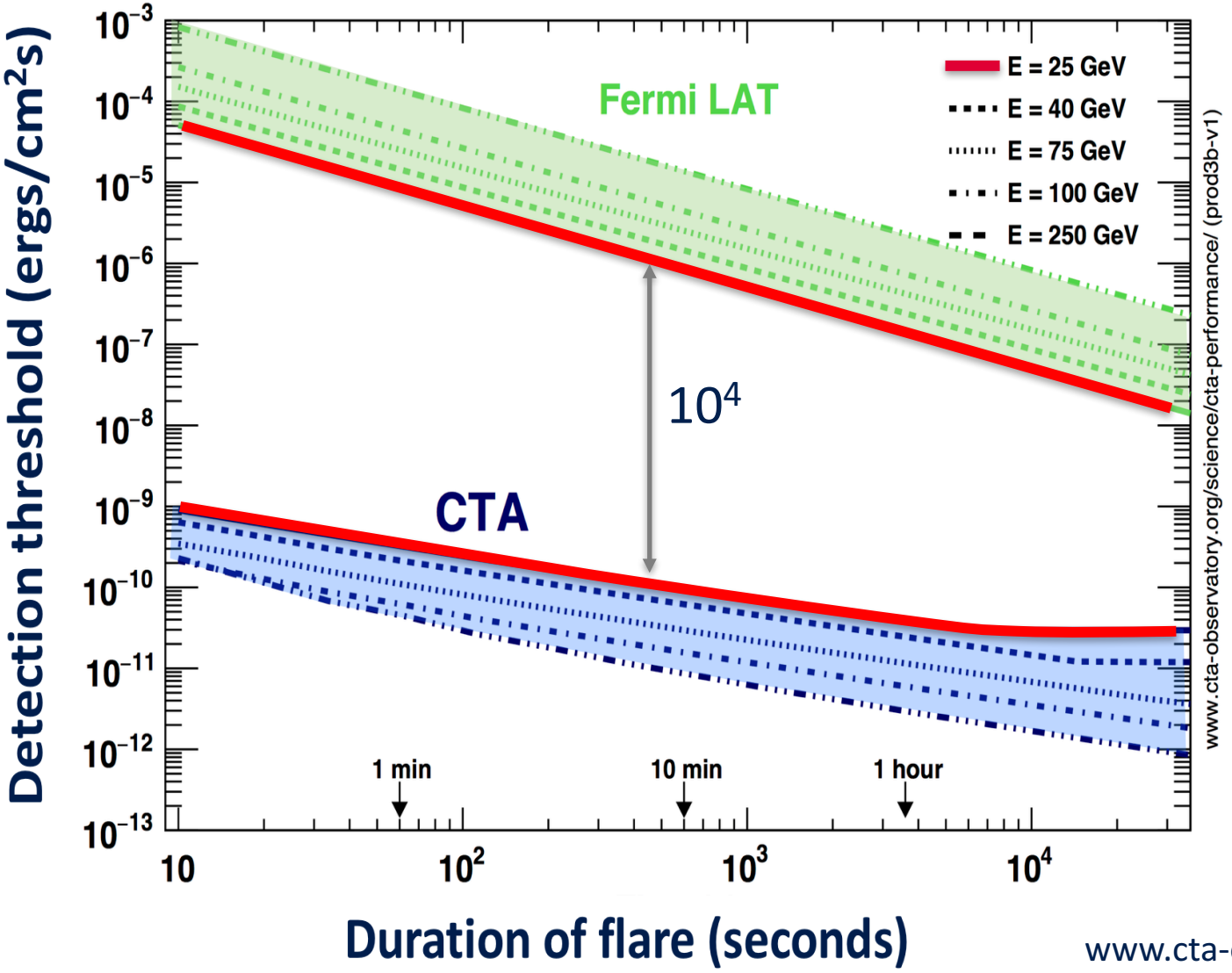


Much information
in the time domain
(transients)

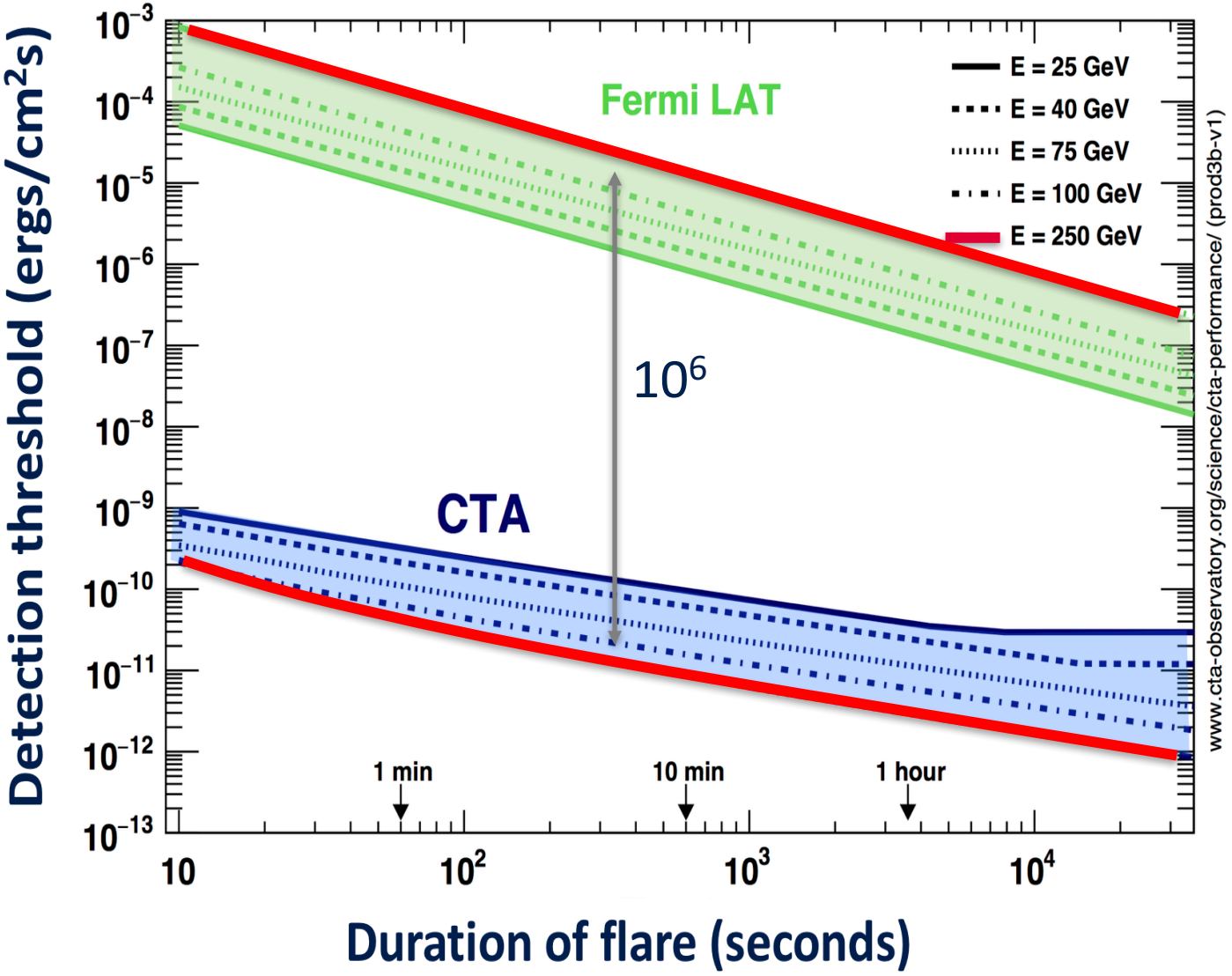


adapted from
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

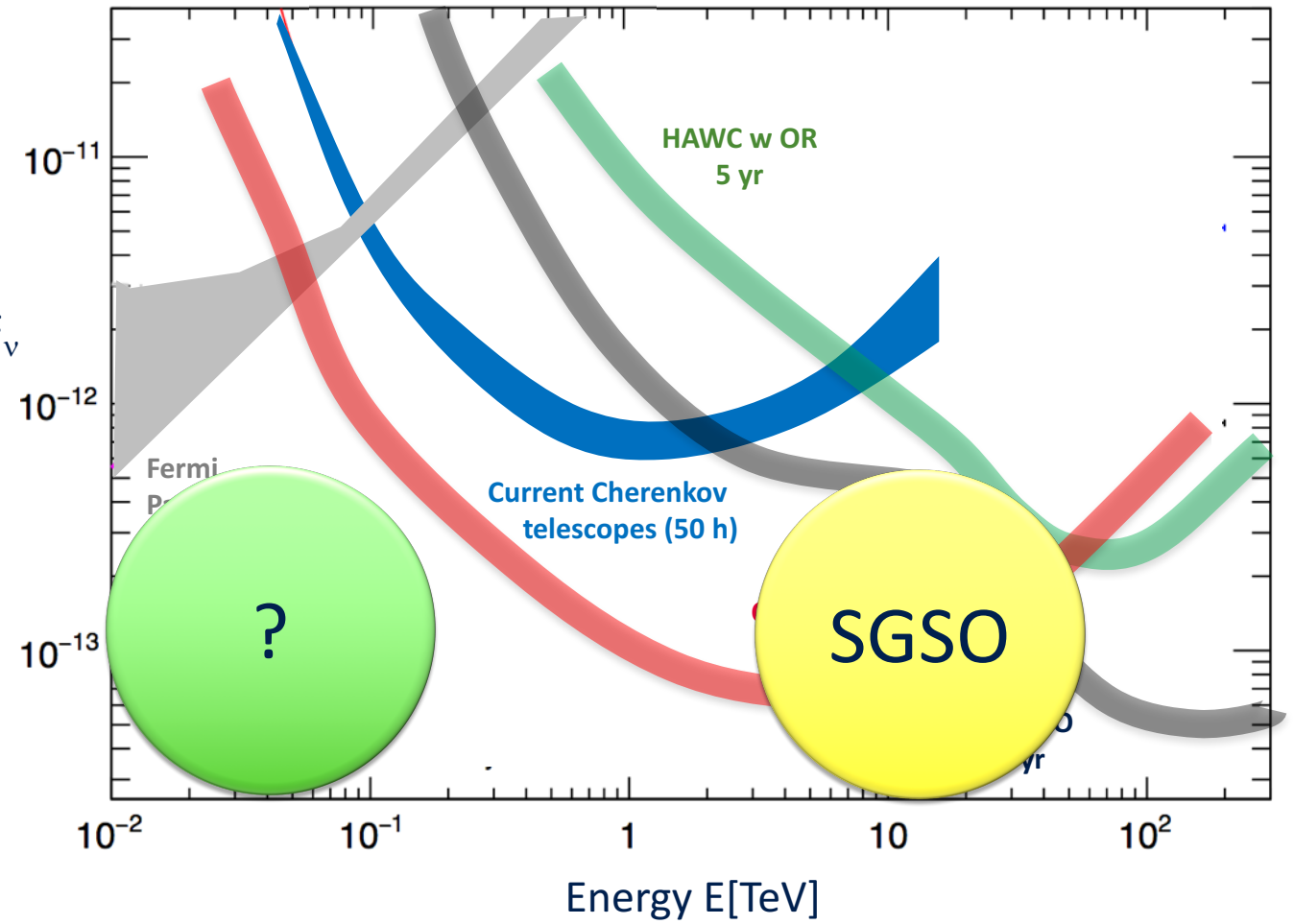
FLARE SENSITIVITY **(25 GEV)**



FLARE SENSITIVITY (~300 GEV)



SENSITIVITY (50 H)



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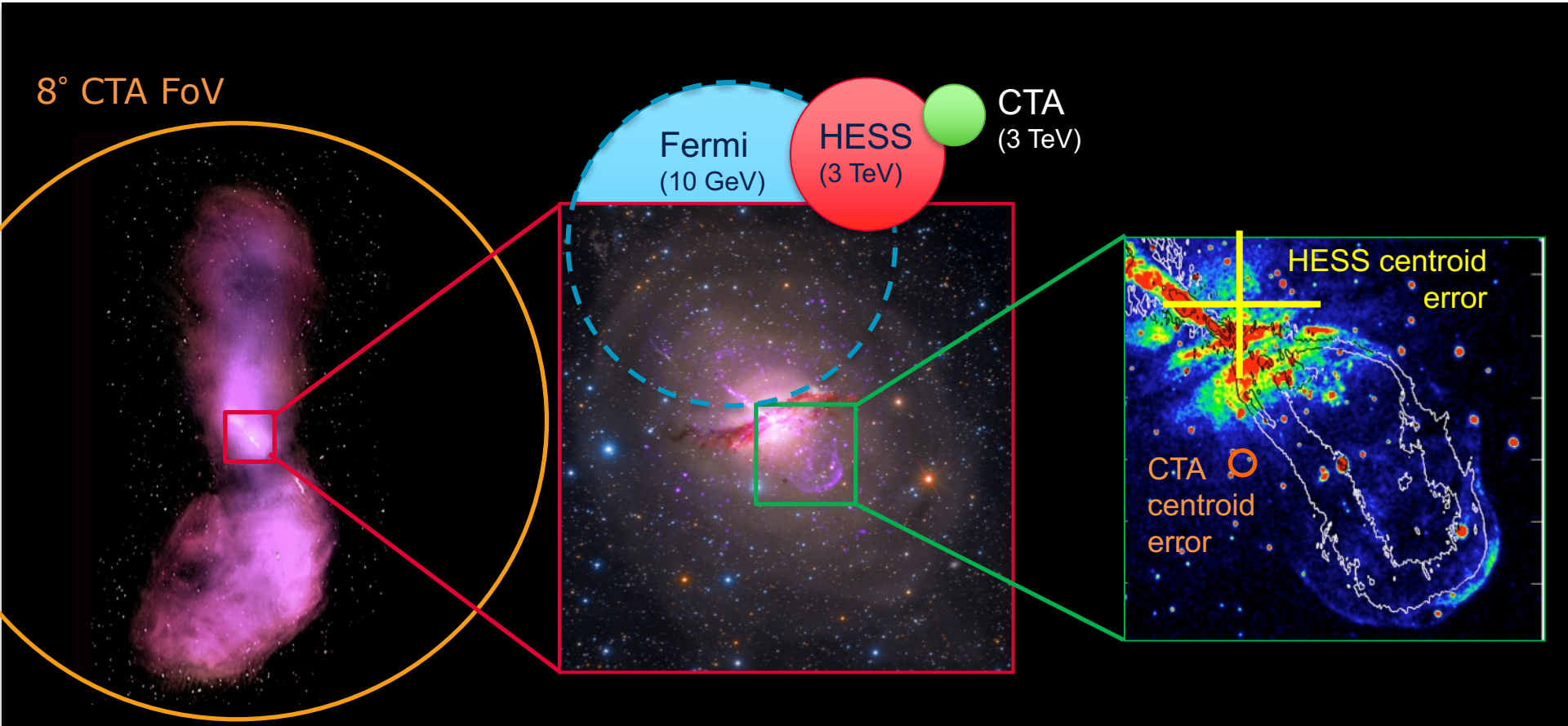
www.cta-observatory.org;
J. Goodman, COSPAR 2018;
Z. Cao, La Palma 2018

RESOLVING POWER

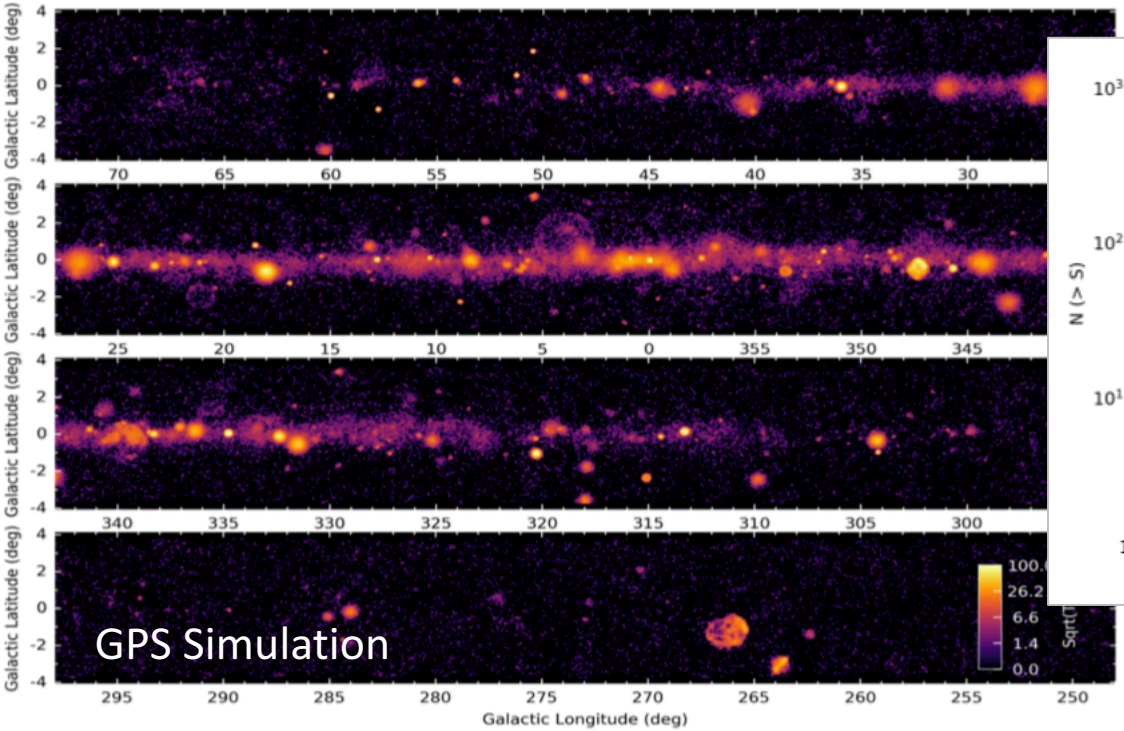


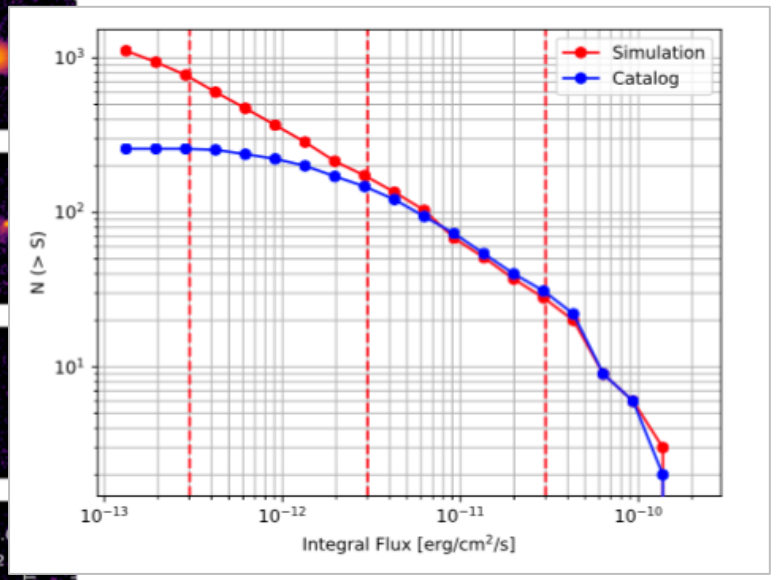
- **Example**: nearby active galaxy Centaurus A

DC1 DATA CHALLENGE

Simulated high-level data from the first 3 years of CTA operations, in particular

- Galactic Plane Survey / Galactic Center Survey (2445 h, 4941 pointings)
- Extragalactic Survey (500 h, 1271 pointings)
- AGN monitoring (960 h, 1920 pointings)

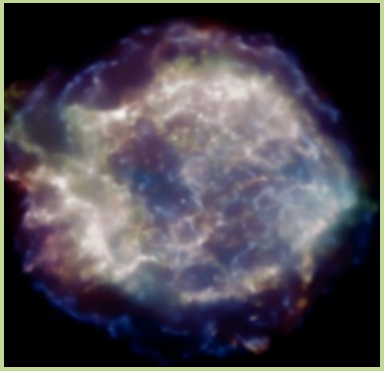


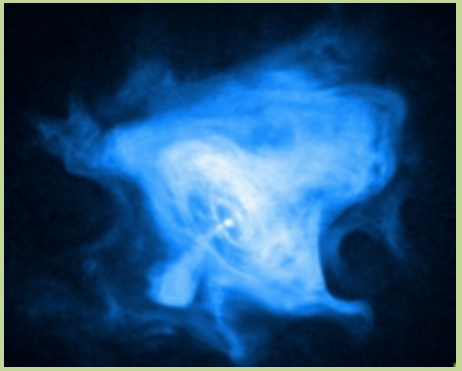


First catalog pipelines

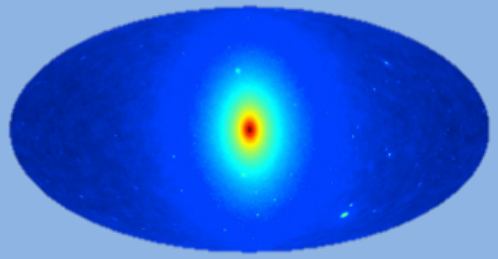
CTA SCIENCE

In-depth understanding
of known objects and
their mechanisms





Expected discoveries
of new object classes





The fun part:
Things we haven't thought of

?