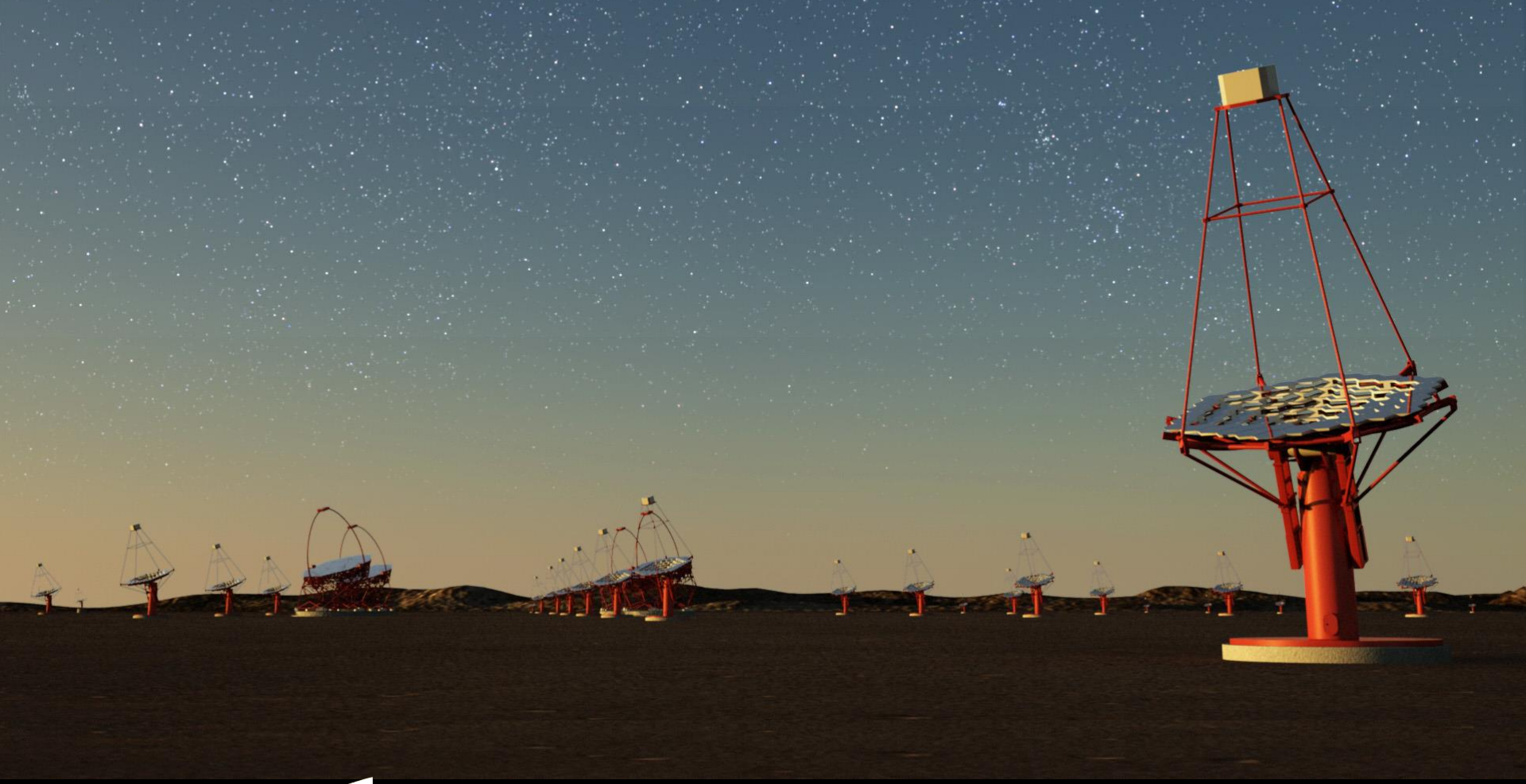
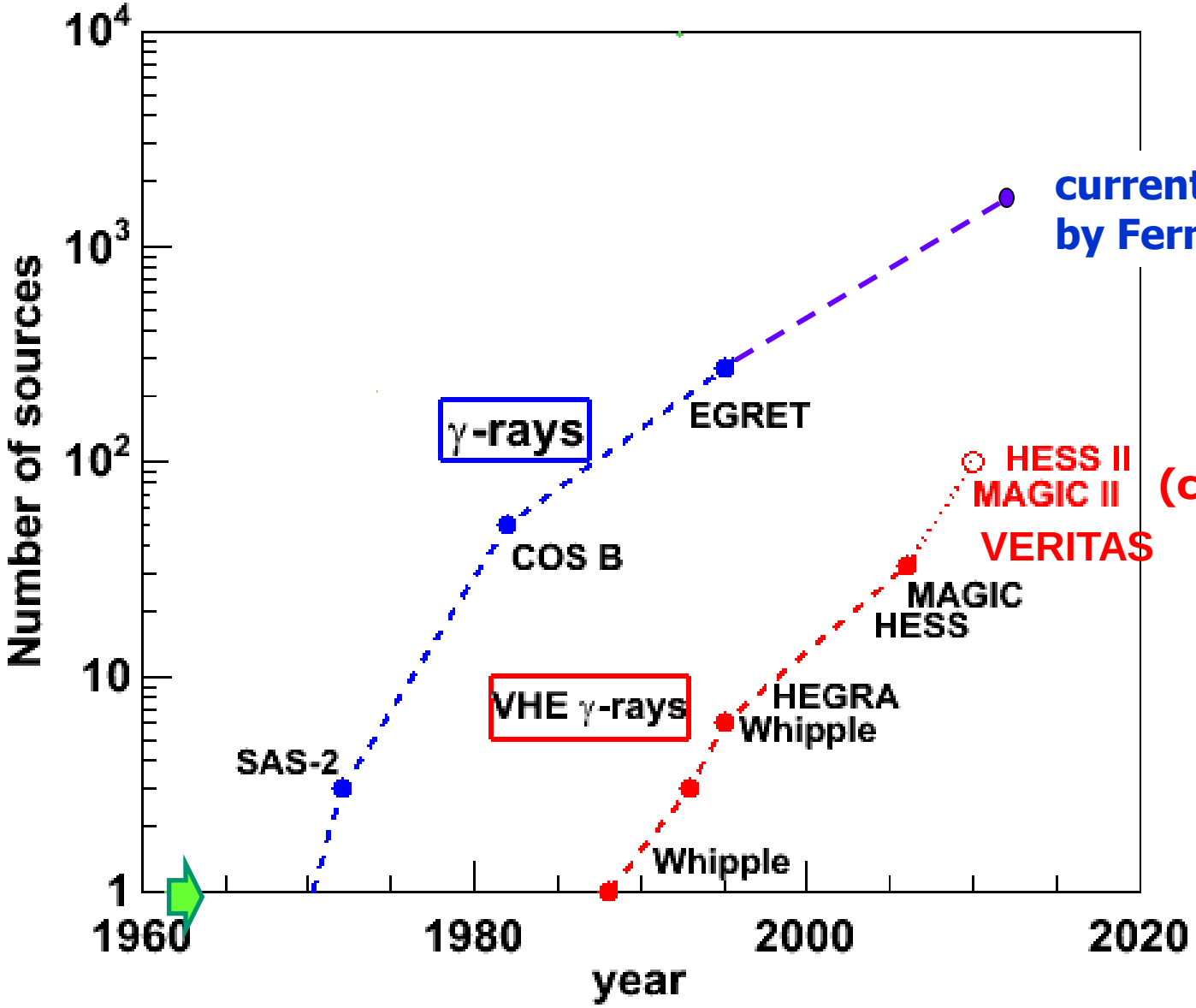


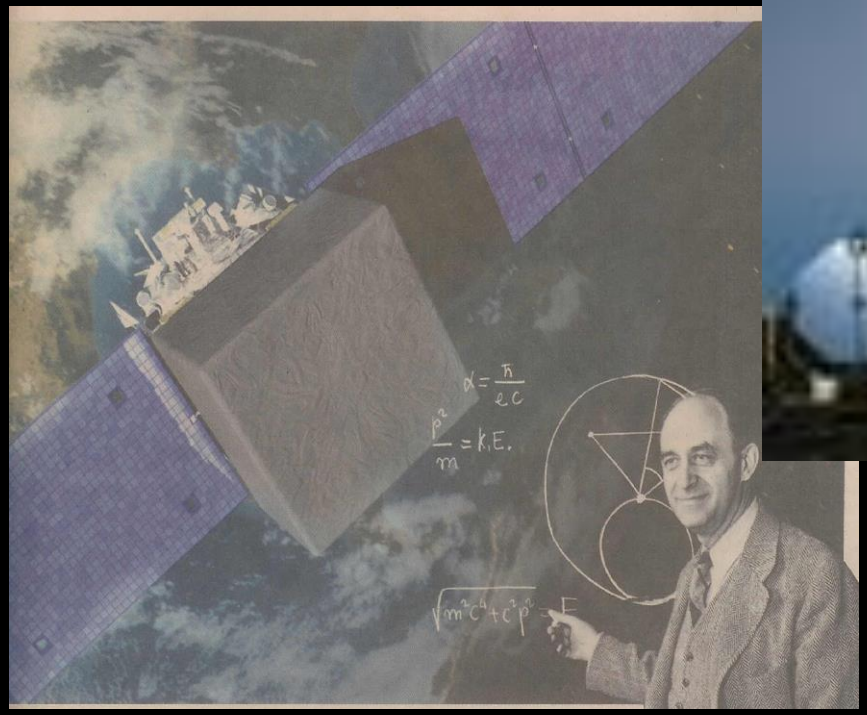
cherenkov telescope array

Patrizia Caraveo
INAF-IASF

4 decades of γ-ray astronomy from space and from the ground

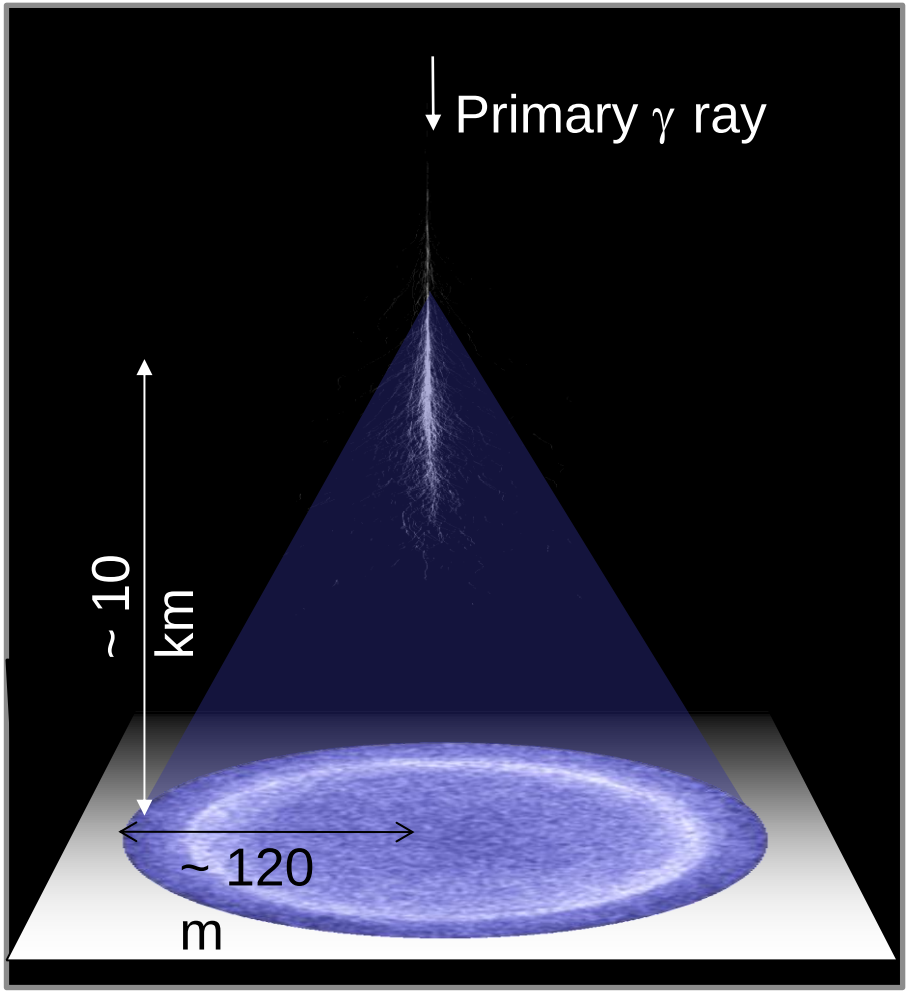


3 Our tools

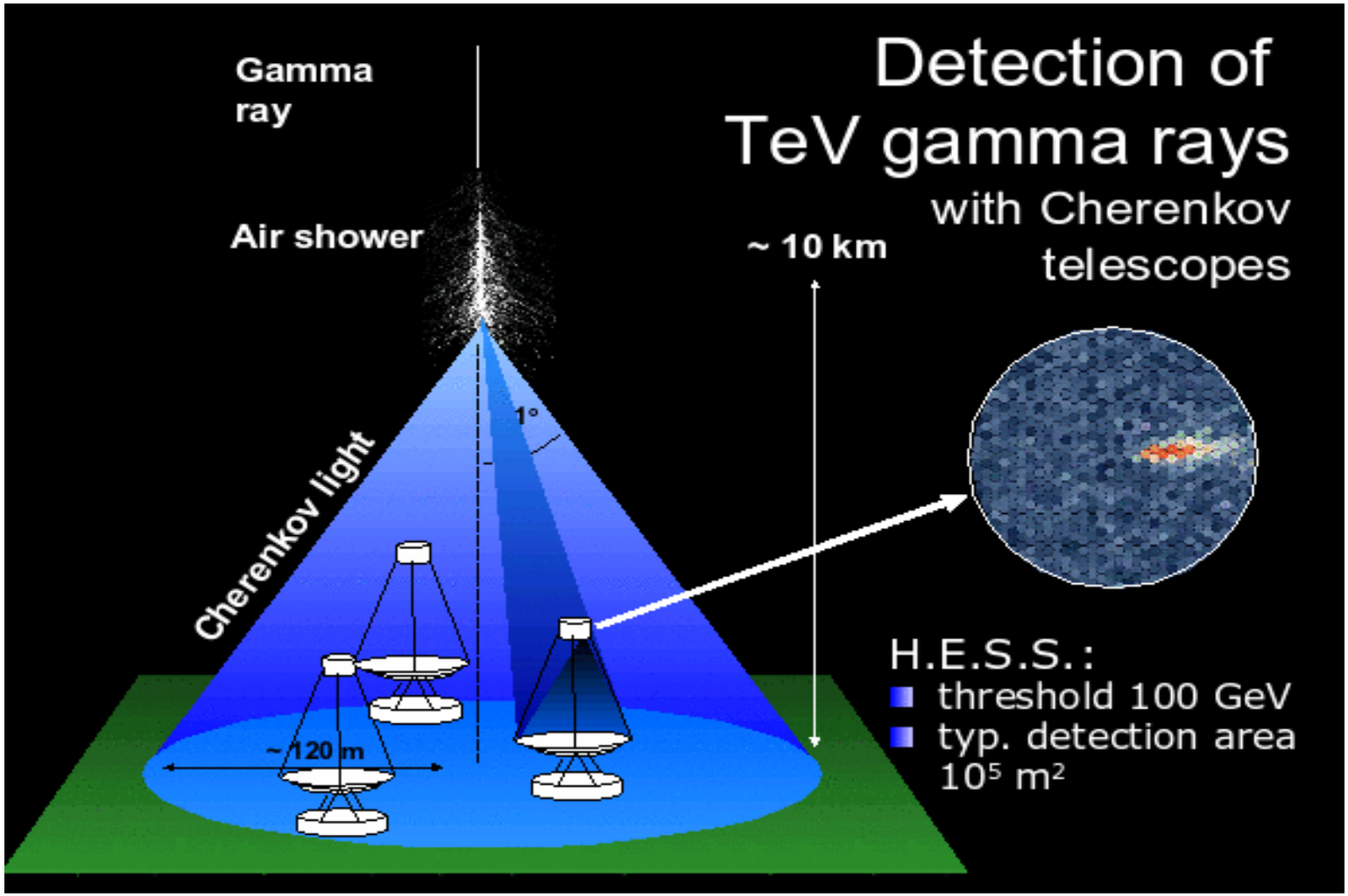


Detecting Cherenkov radiation from EM showers

- Air at STP, rad. length X_0 ~ 330 m, refractive index n ~ 1.0003, Moliere radius r_M ~ 65 m.
- VHE gamma causes shower with max. at height ~ 10 km.
- Cherenkov light production threshold for $e^{\pm}$ is E_c ~ 20 MeV (STP).
- Total $e^{\pm}$ path length above E_c ~ 10^4 km for 1 TeV photon.
- Get ~ 20 Cherenkov photons/m in wavelength range l = 300...400 nm.
- Cherenkov angle ~ 1°: at low shower particle energy, multiple scattering causes further spreading.
- Light pool radius ~ 120 m.



Stereoscopic Cherenkov imaging




(c) F. Acero & H. Gast

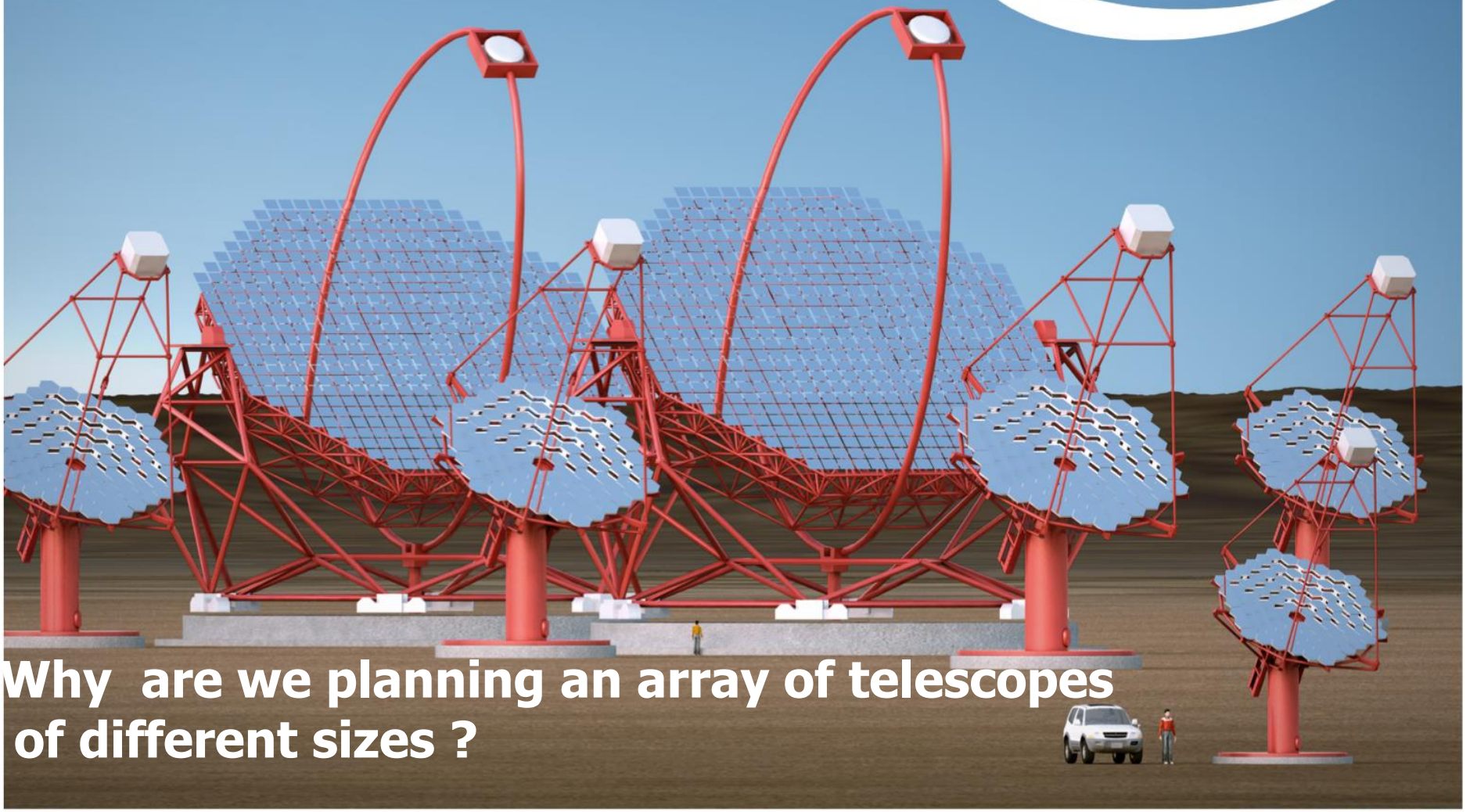
KEY SCIENCE ISSUES

cta
cherenkov telescope array

- Where and how are particles accelerated in our Galaxy and beyond?
- What makes black holes of all sizes such efficient particle accelerators?
- What do high-energy gamma-rays tell us about the star formation history of the Universe or the fundamental laws of physics?
- What is the nature of dark matter?
- The flaring sky: short-timescale phenomena at very high energies?

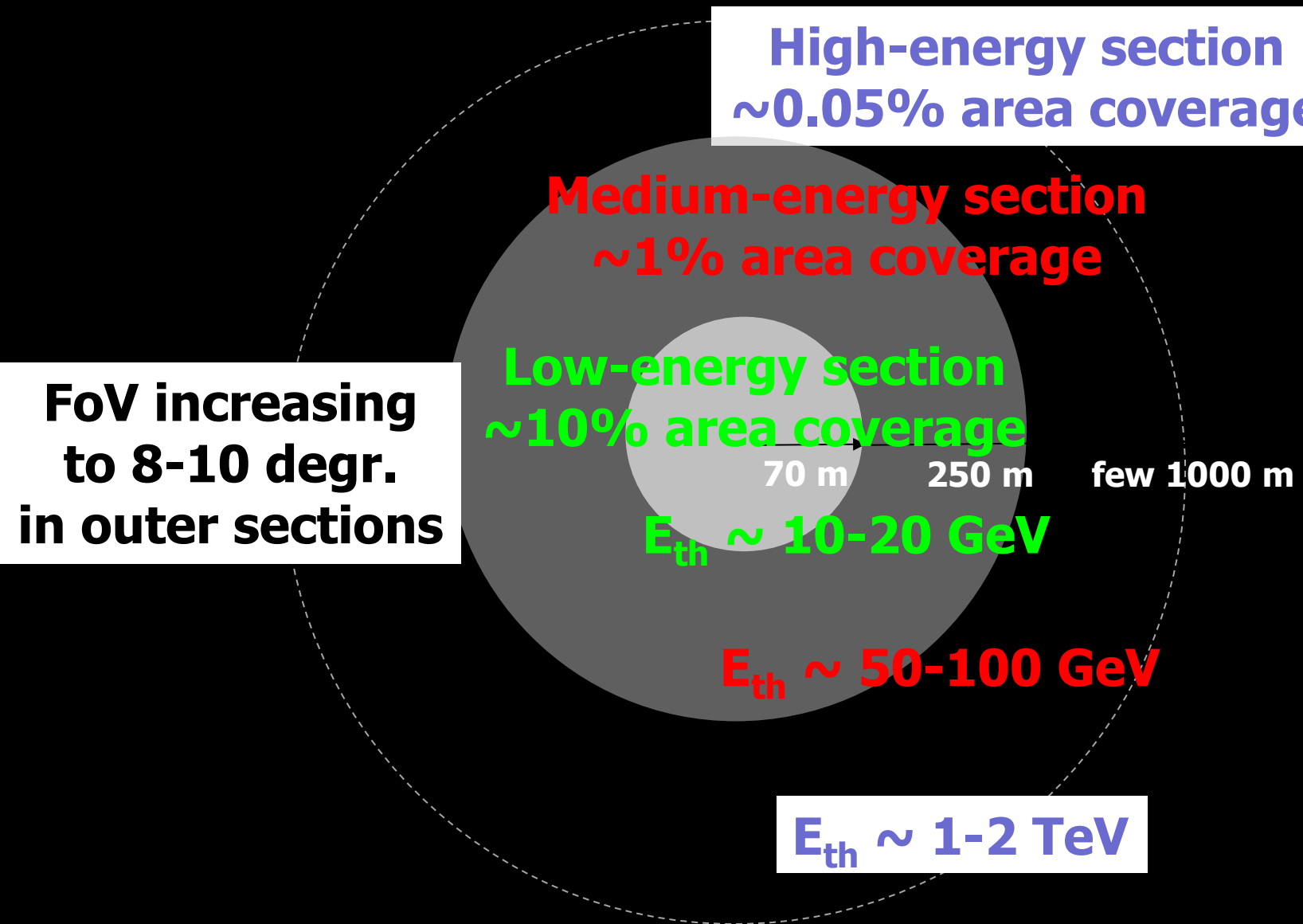
CTA – A NEW WINDOW ONTO THE VIOLENT UNIVERSE

cta
cherenkov telescope array

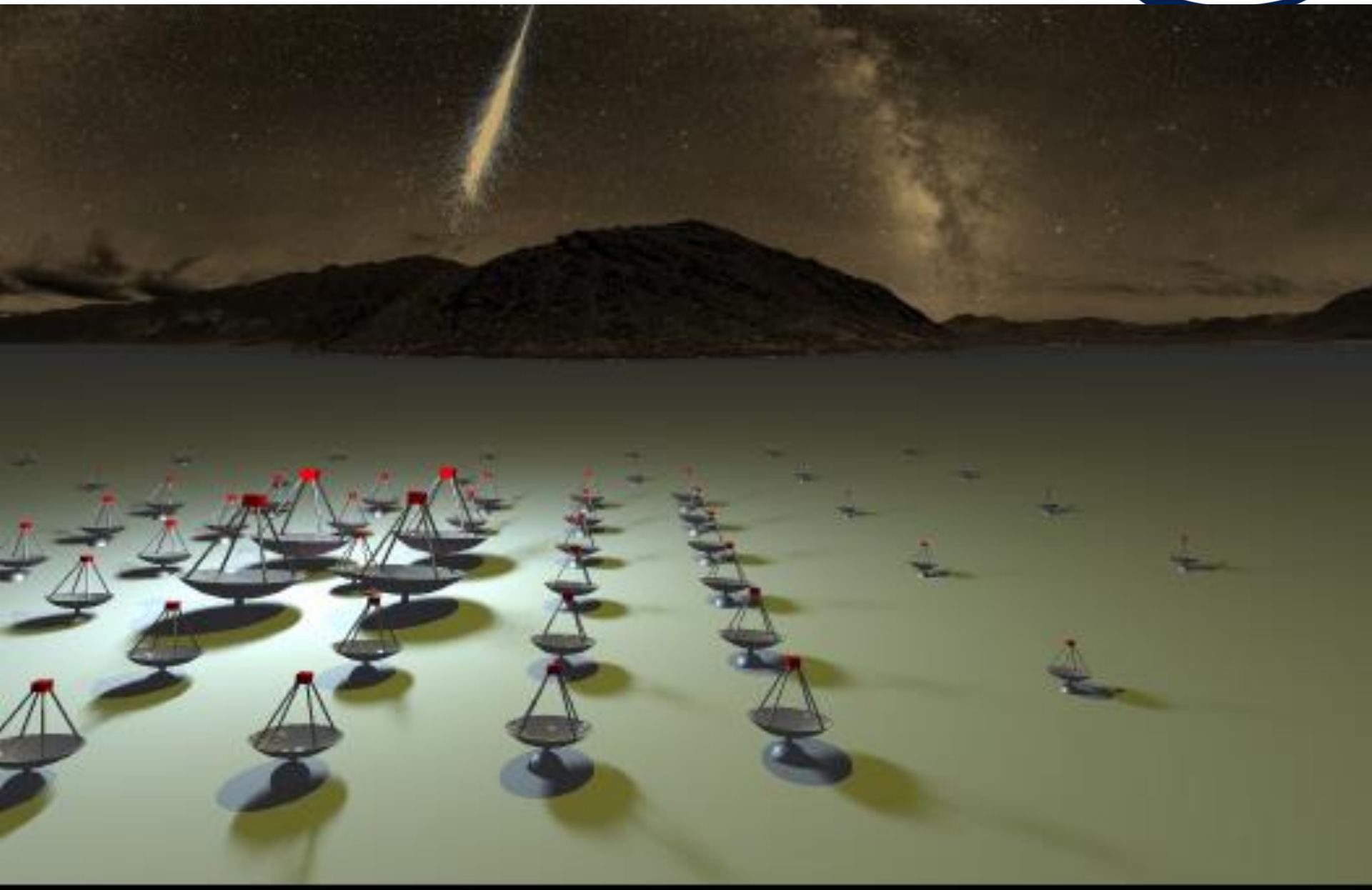


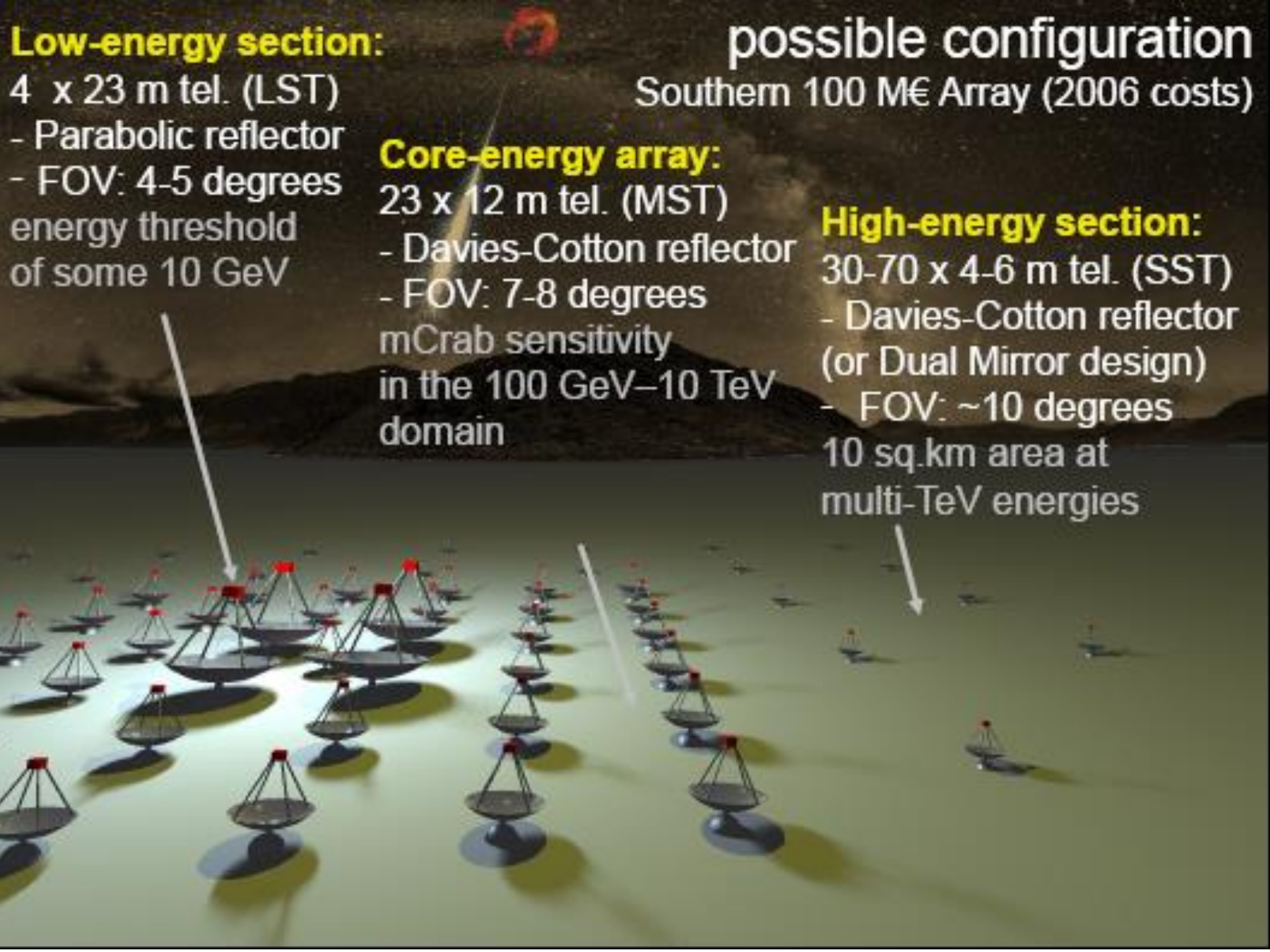
Why are we planning an array of telescopes of different sizes ?

Array layout: 3 Zones

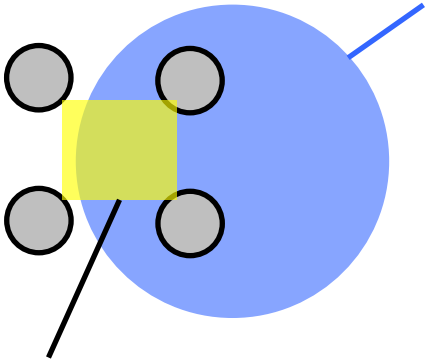


FoV increasing to 8-10 degr. in outer sections



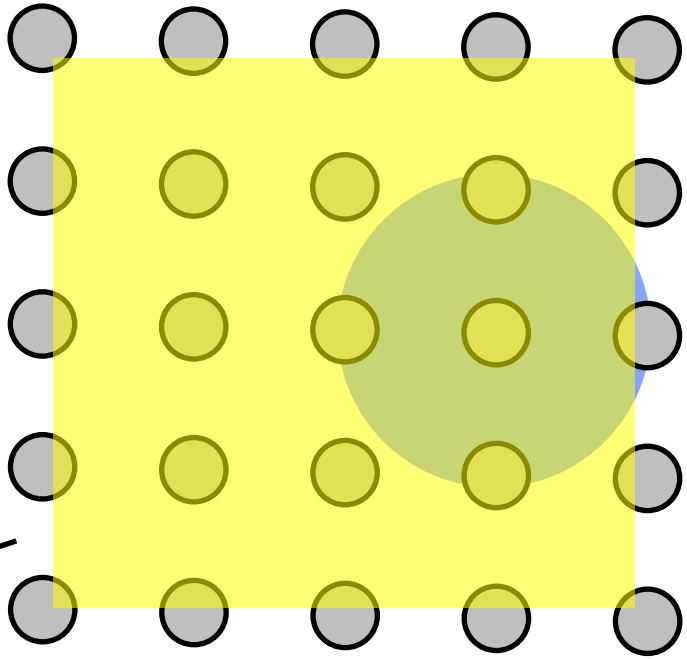

possible configuration
Southern 100 M€ Array (2006 costs)
Low-energy section:
4 x 23 m tel. (LST)
- Parabolic reflector
- FOV: 4-5 degrees
energy threshold
of some 10 GeV
Core-energy array:
23 x 12 m tel. (MST)
- Davies-Cotton reflector
- FOV: 7-8 degrees
mCrab sensitivity
in the 100 GeV–10 TeV
domain
High-energy section:
30-70 x 4-6 m tel. (SST)
- Davies-Cotton reflector
(or Dual Mirror design)
- FOV: ~10 degrees
10 sq.km area at
multi-TeV energies

Why so many telescopes?



light pool radius
R ≈100-150 m
≈ typical telescope spacing

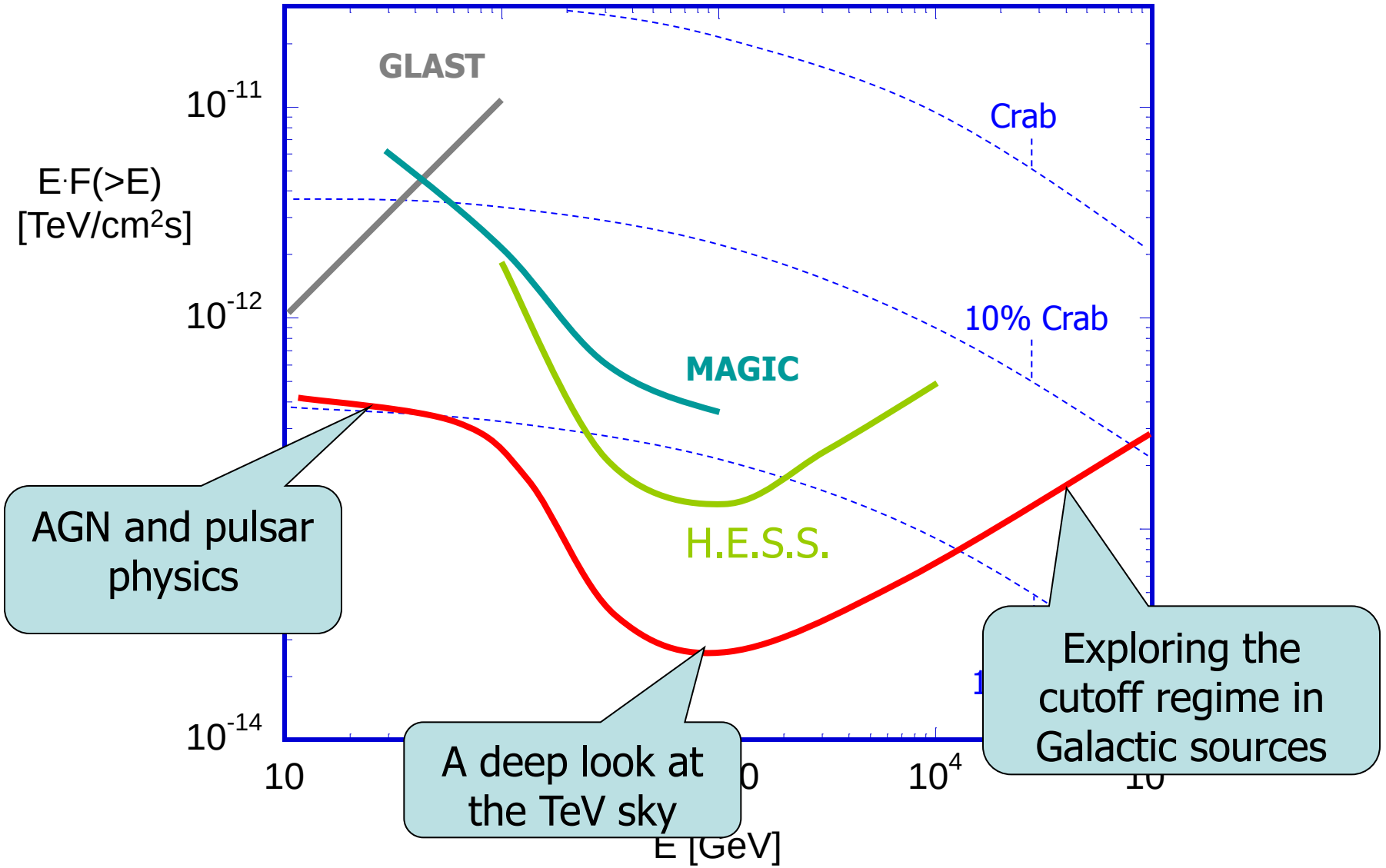
Sweet spot for
best triggering
and reconstruction:
most showers miss it!



large detection area
more images per shower
lower trigger threshold

Possible CTA sensitivity

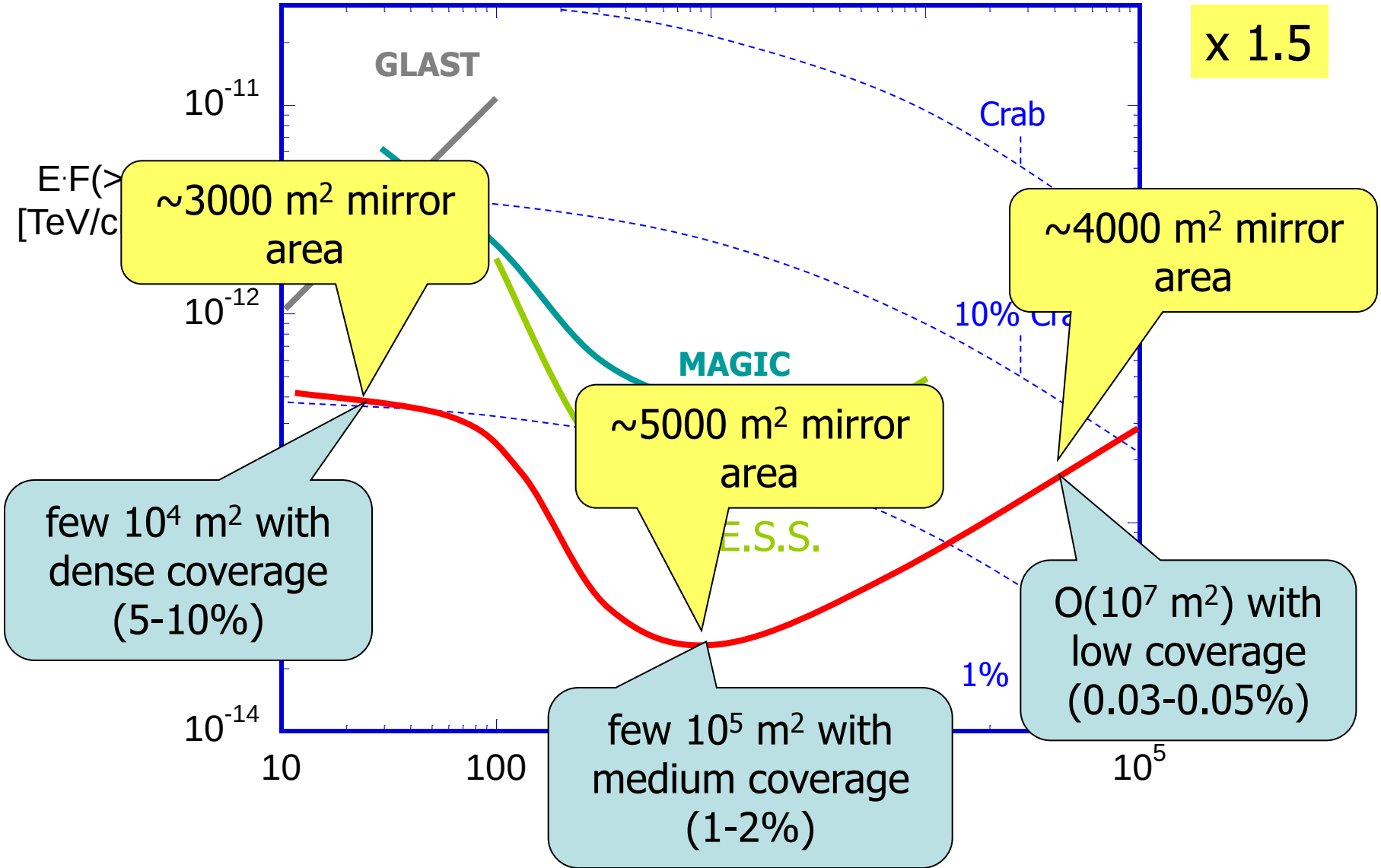
An advanced facility for ground-based high-energy gamma ray astronomy



Possible CTA sensitivity

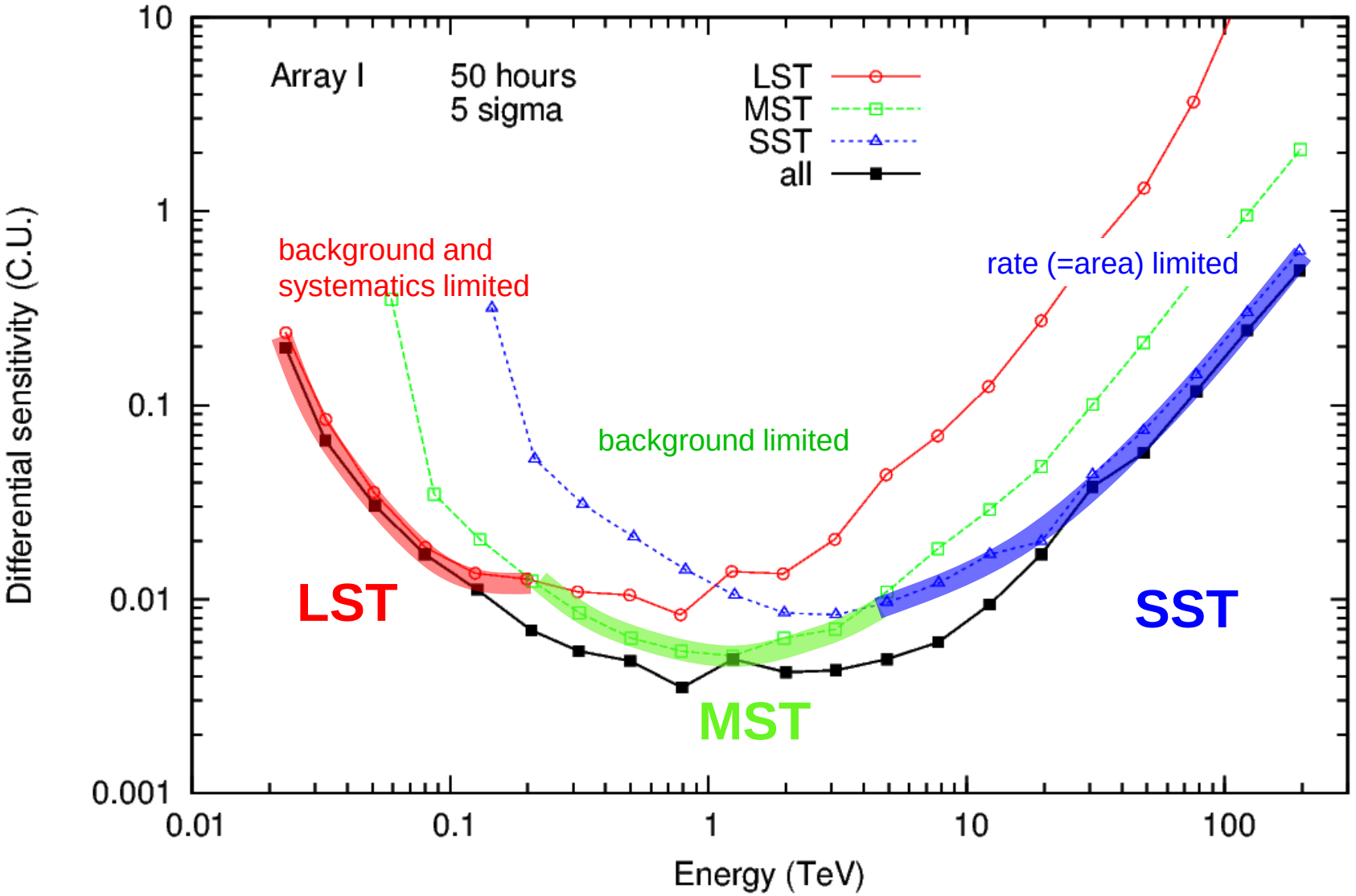
CTA

An advanced facility for ground-based high-energy gamma ray astronomy



Sensitivity (in units of Crab flux)

for detection in each 0.2-decade energy band



LARGE 23 M TELESCOPE
OPTIMIZED FOR THE RANGE BELOW 200 GEV

cta
cherenkov telescope array

400 m^2 dish area
27.8 m focal length
1.5 m mirror facets

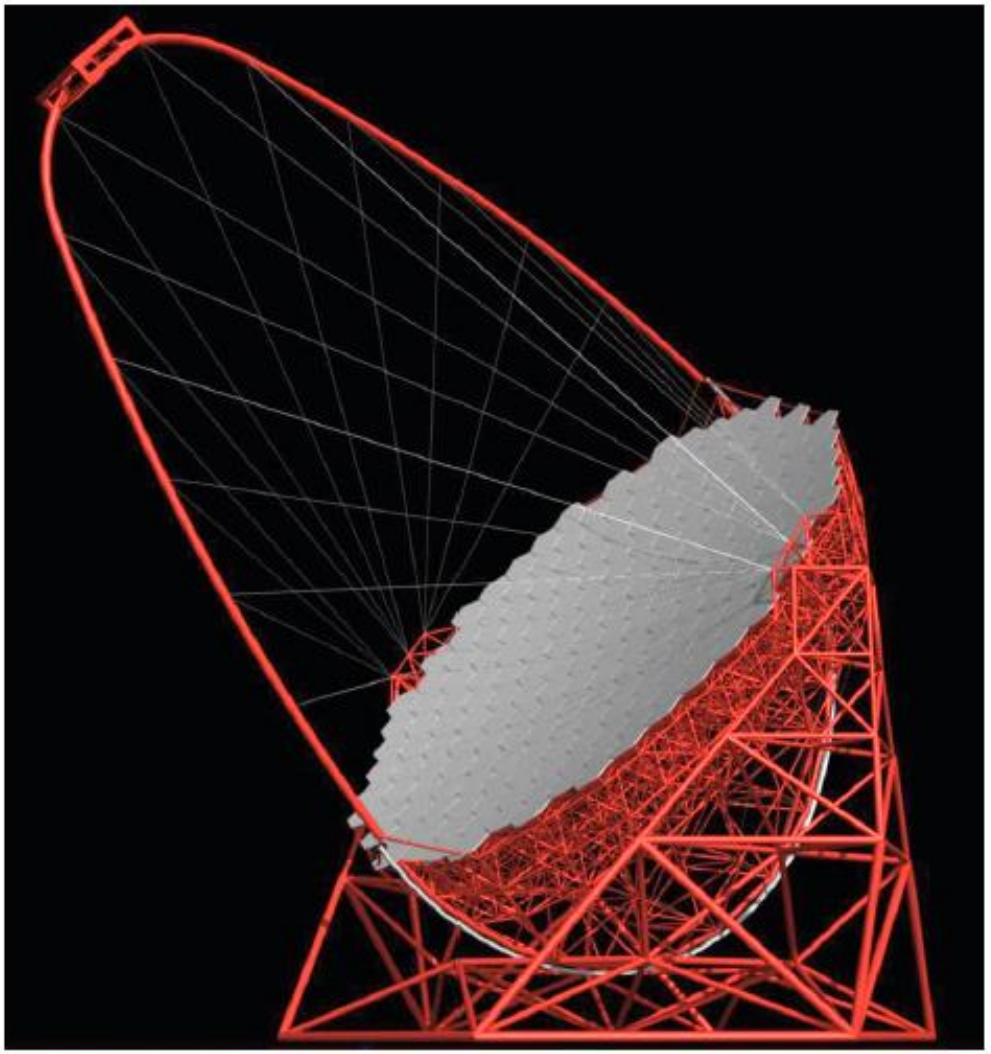
4.5° field of view
0.1° pixels
Camera ∅ over 2 m

Carbon-fibre structure

Active damping
of oscillations,
active mirror control

4 LSTs on each site

➜ Masahiro Teshima



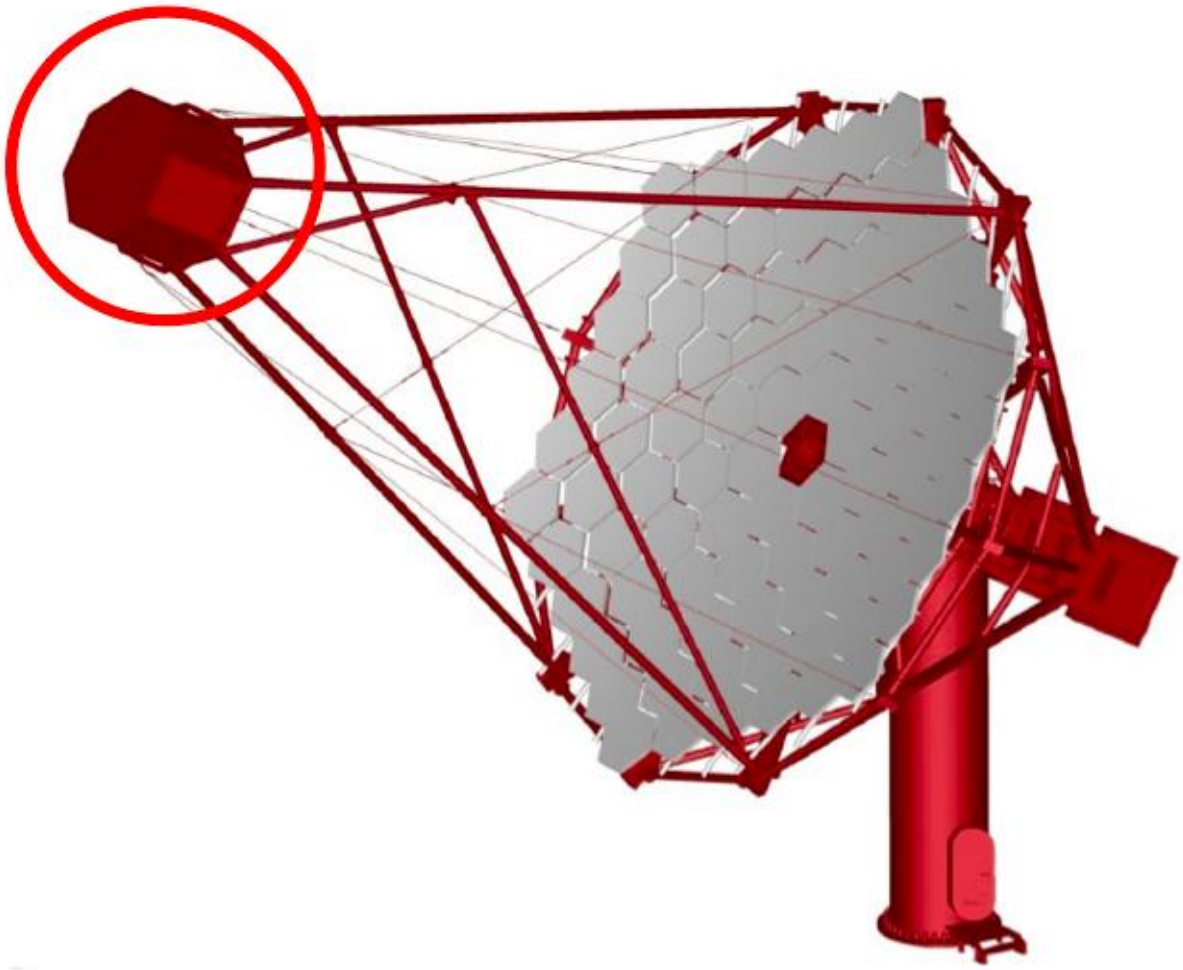
MEDIUM-SIZED 12 M TELESCOPE
OPTIMIZED FOR THE 100 GEV TO ~10 TEV RANGE

cta
cherenkov telescope array

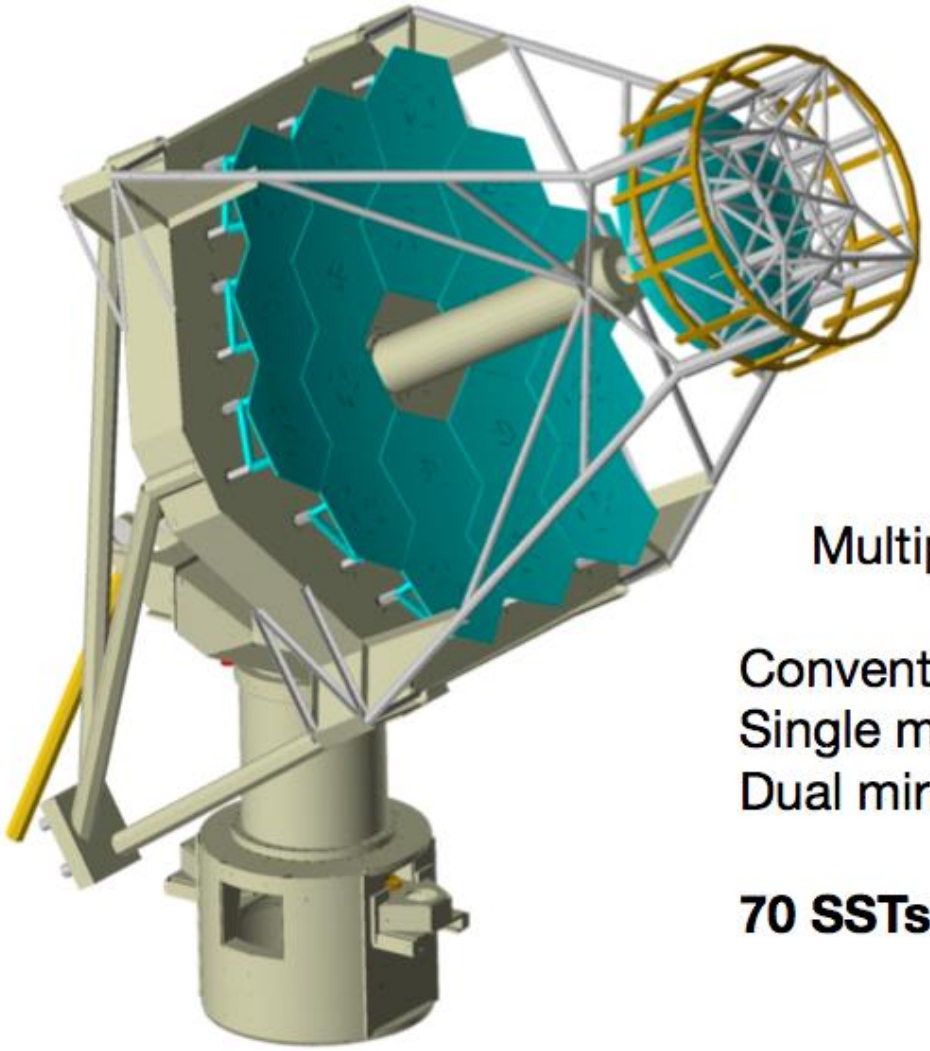
100 m^2 dish area
16 m focal length
1.2 m mirror facets

7-8° field of view
~2000 x 0.18° pixels

25 MSTs on South site
15 MSTs on North site



SMALL TELESCOPE
OPTIMIZED FOR THE RANGE ABOVE 10 TEV

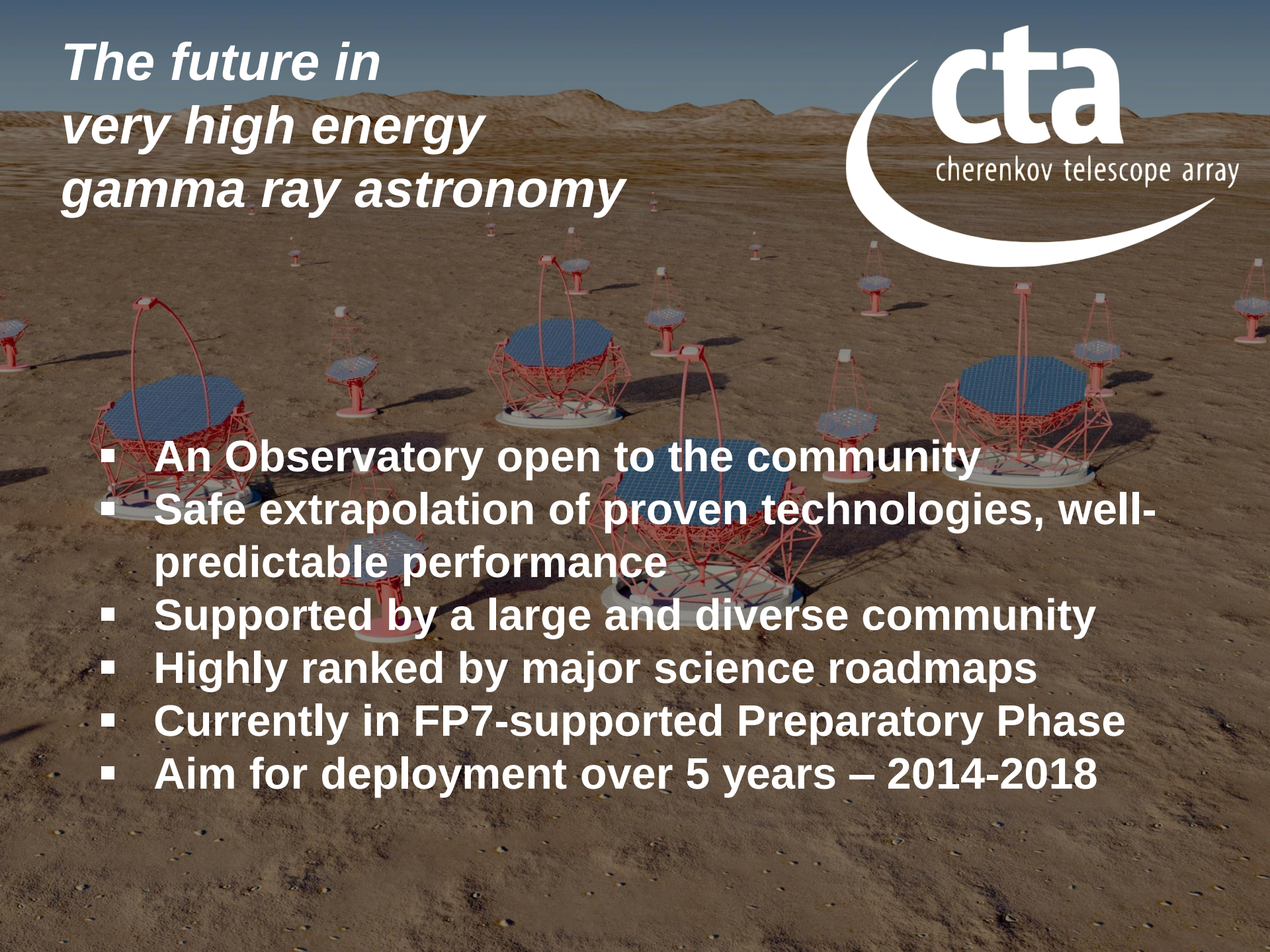


ASTRI Design
4.3 m mirror
9.6° foV
0.25° pixels

Multiple options under study:

Conventional single mirror, PMT camera
Single mirror, silicon sensor camera
Dual mirror optics, silicon & MAPMT camera

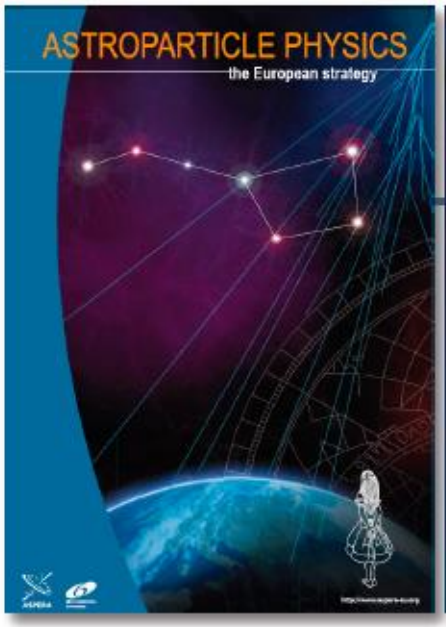
70 SSTs on Southern site

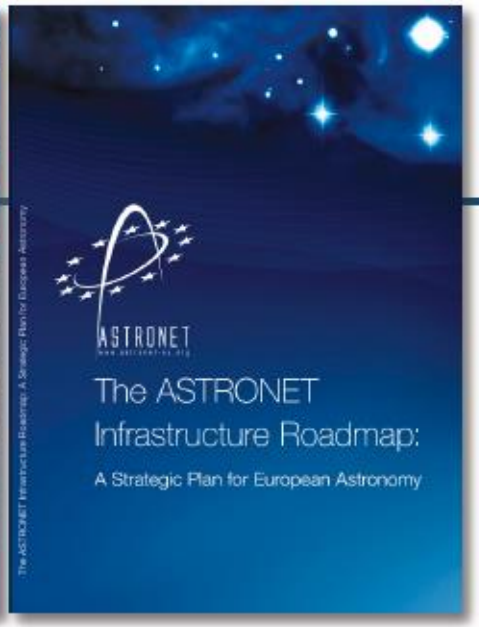


The future in very high energy gamma ray astronomy

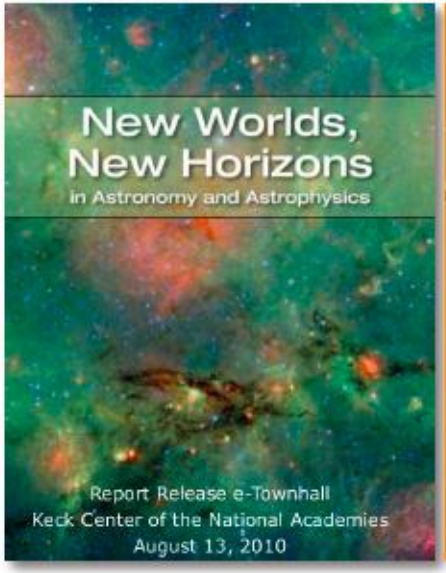
cta
cherenkov telescope array

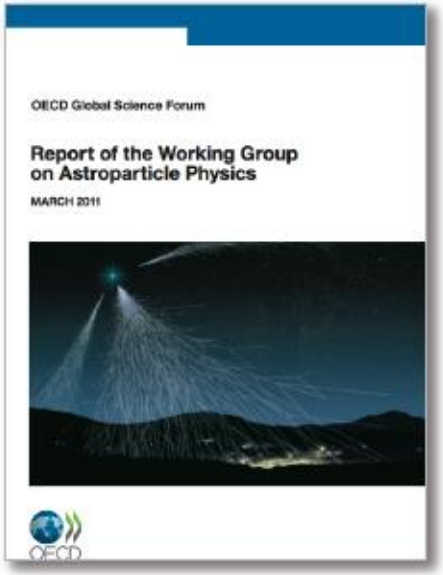
- **An Observatory open to the community**
- **Safe extrapolation of proven technologies, well-predictable performance**
- **Supported by a large and diverse community**
- **Highly ranked by major science roadmaps**
- **Currently in FP7-supported Preparatory Phase**
- **Aim for deployment over 5 years – 2014-2018**





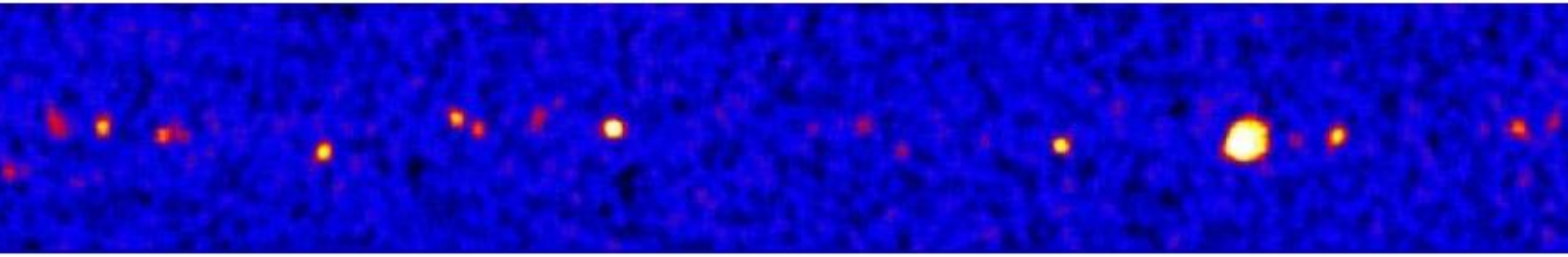
RECOMMENDED BY NATIONAL AND INTERNATIONAL ROADMAPS …



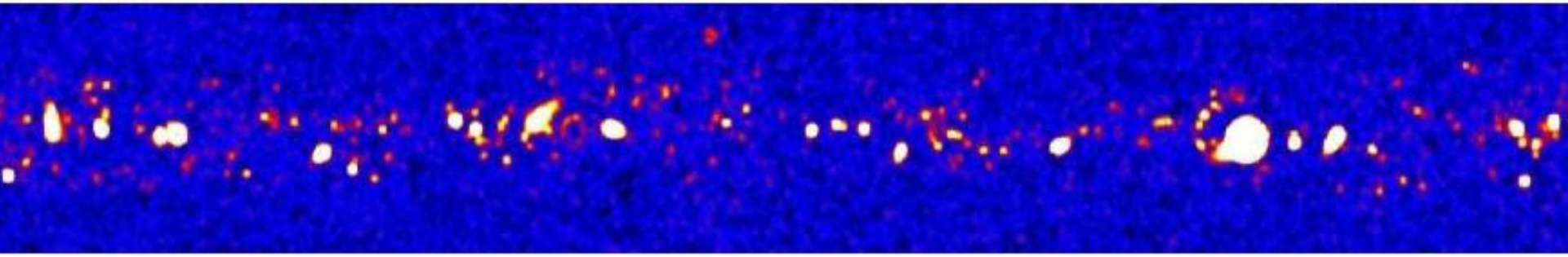


Example: Galactic Plane Survey

H.E.S.S.

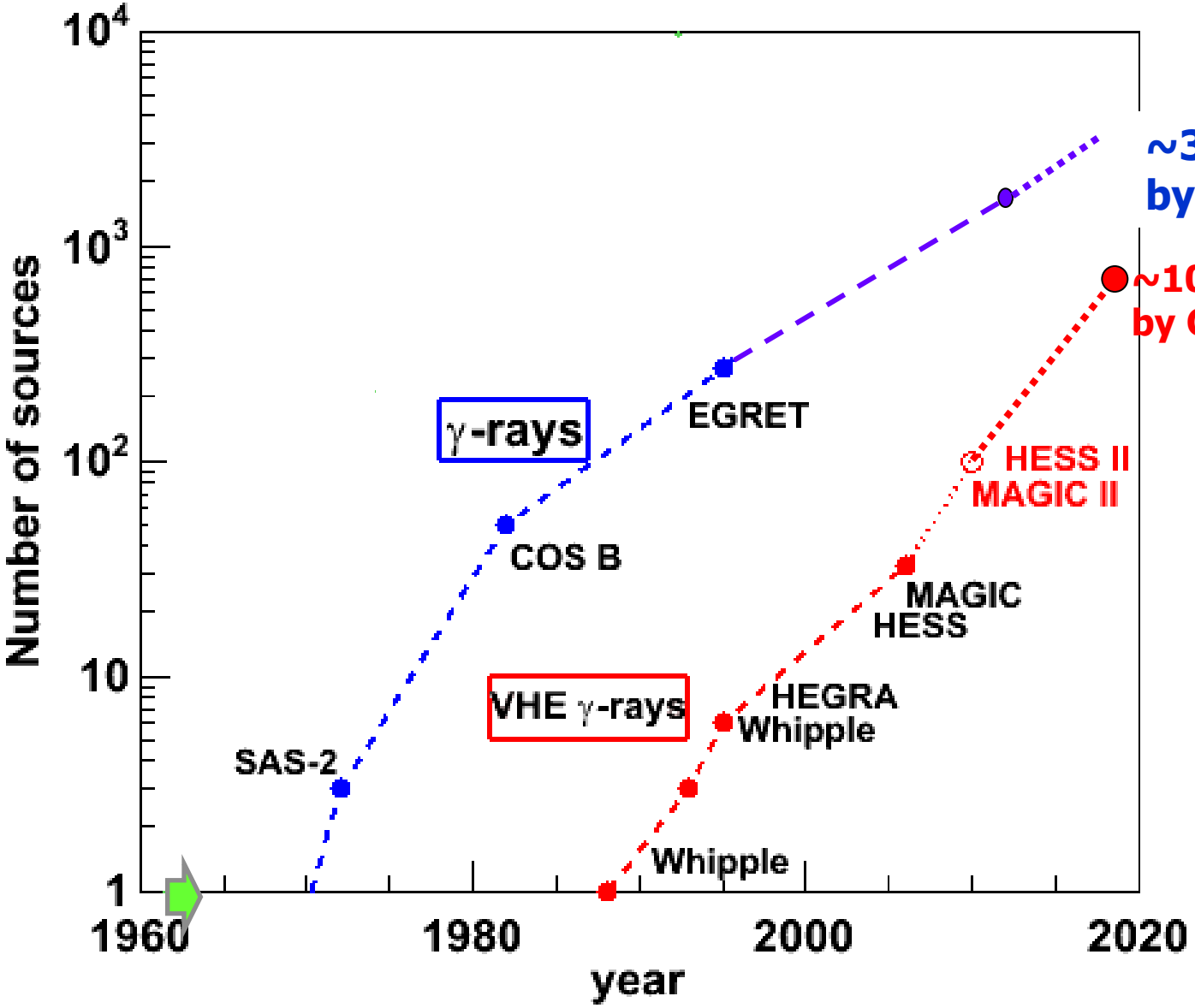


CTA, for same exposure



expect ~1000 detected sources

The next decade of γ-ray astronomy



by whom ?

COMMUNITY

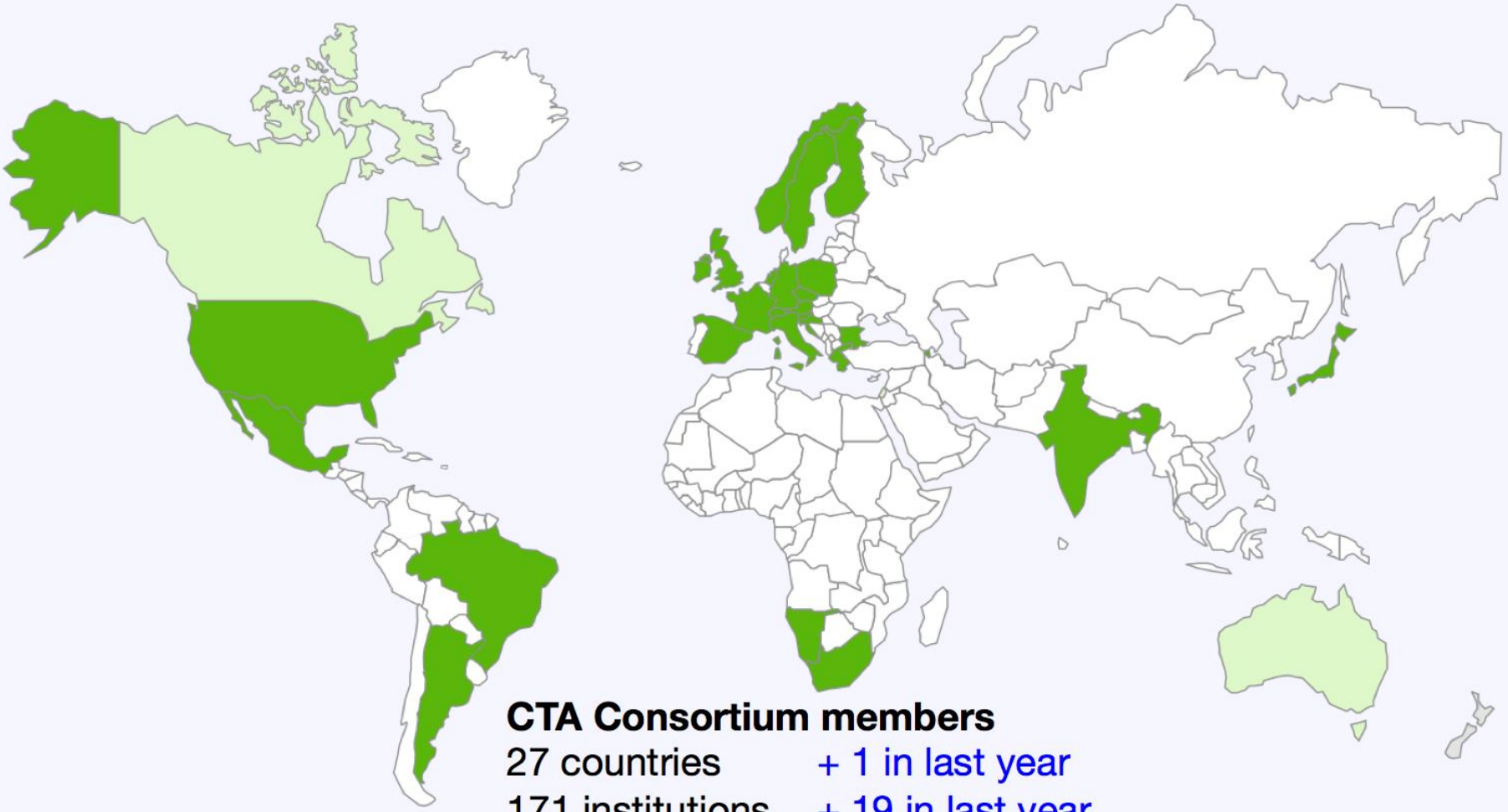
CURRENTLY ENGAGED IN CTA

(subset of future user community)

Members (27 countries)

interested to join

Canada, Australia, Israel

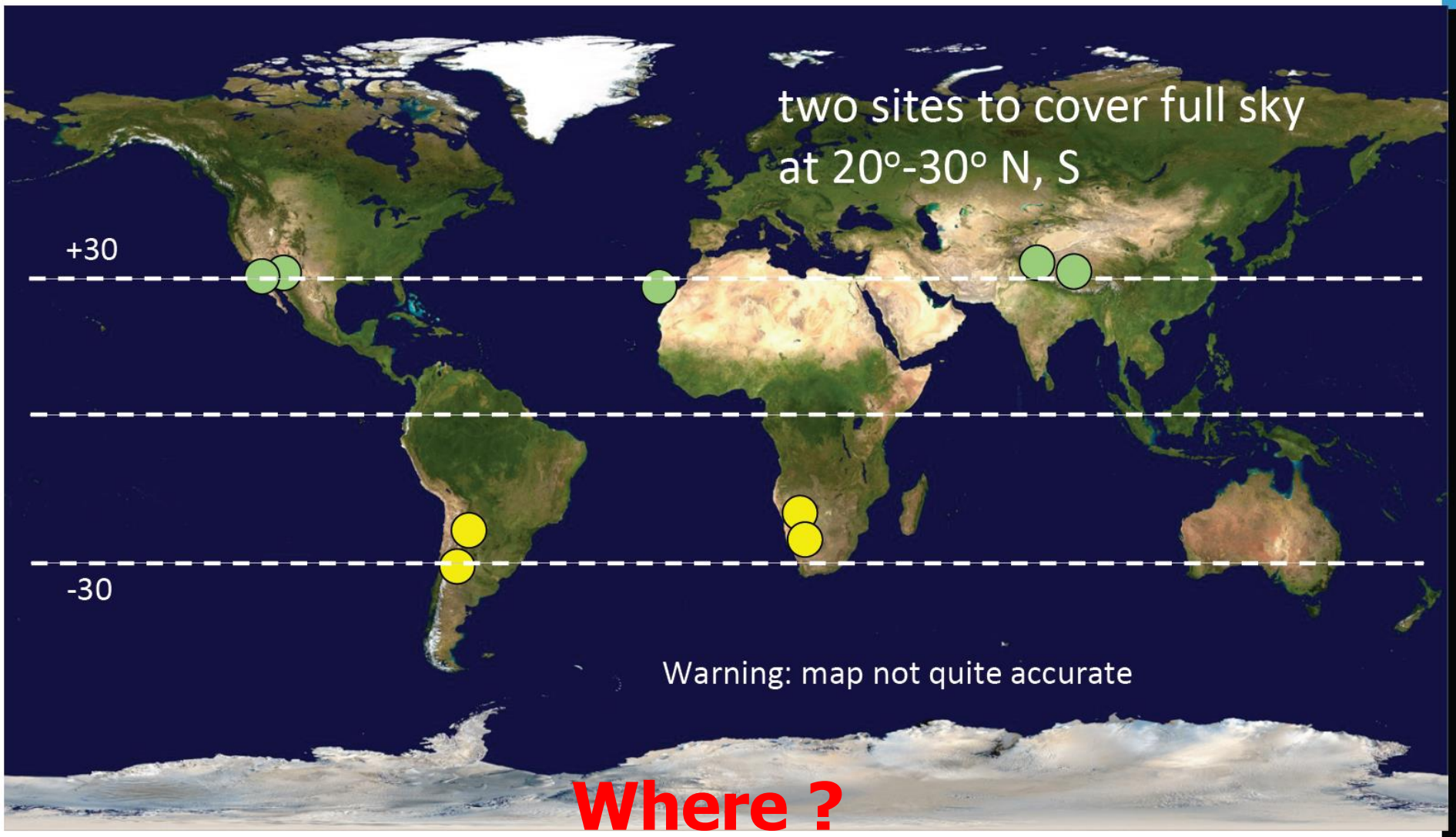


CTA Consortium members

27 countries	+ 1 in last year
171 institutions	+ 19 in last year
1058 persons	+ 198 in last year

SITE CANDIDATES

Working towards quantifying
site-dependent differences
in performance and cost



TELESCOPES

	SST "small"	MST "medium"	LST "large"	SCT "medium 2-M"
Number	70 (S)	25 (S) 15 (N)	4 (S) 4 (N)	36 (S)
Spec'd range	> few TeV	200 GeV to 10 TeV	20 GeV to 1 TeV	200 GeV to 10 TeV
Eff. mirror area	> 5 m^2	> 88 m^2	> 330 m^2	> 40 m^2
Field of view	> 8°	> 7°	> 4.4°	> 7°
Pixel size ~PSF θ_{80}	< 0.25°	< 0.18°	< 0.11°	< 0.075°
Positioning time	90 s, 60 s goal	90 s, 60 s goal	50 s, 20 s goal	90 s, 60 s goal
Availability	> 97% @ 3 h/week	>97% @ 6 h/week	>95% @ 9 h/week	>97% @ 6 h/week
Target capital cost	420 k€	1.6 M€	7.4 M€	2.0 M€

CTA TIMELINE

"By signing this Declaration of Intent, the signatories – Ministries and Funding Agencies – wish to express their common interest in participating in the construction and operation of CTA."

So far signed by

Argentina
Austria
Brazil
France
Germany
Italy
Japan
Namibia
Poland
South Africa
Spain
Switzerland
UK

SCIENCE DEFINITION

Seeing the High-Energy Universe with the Cherenkov Telescope Array
- The Science Explored with the CTA

Special issue of “Astroparticle Physics” in press

Overview articles &
case studies

350+ pages