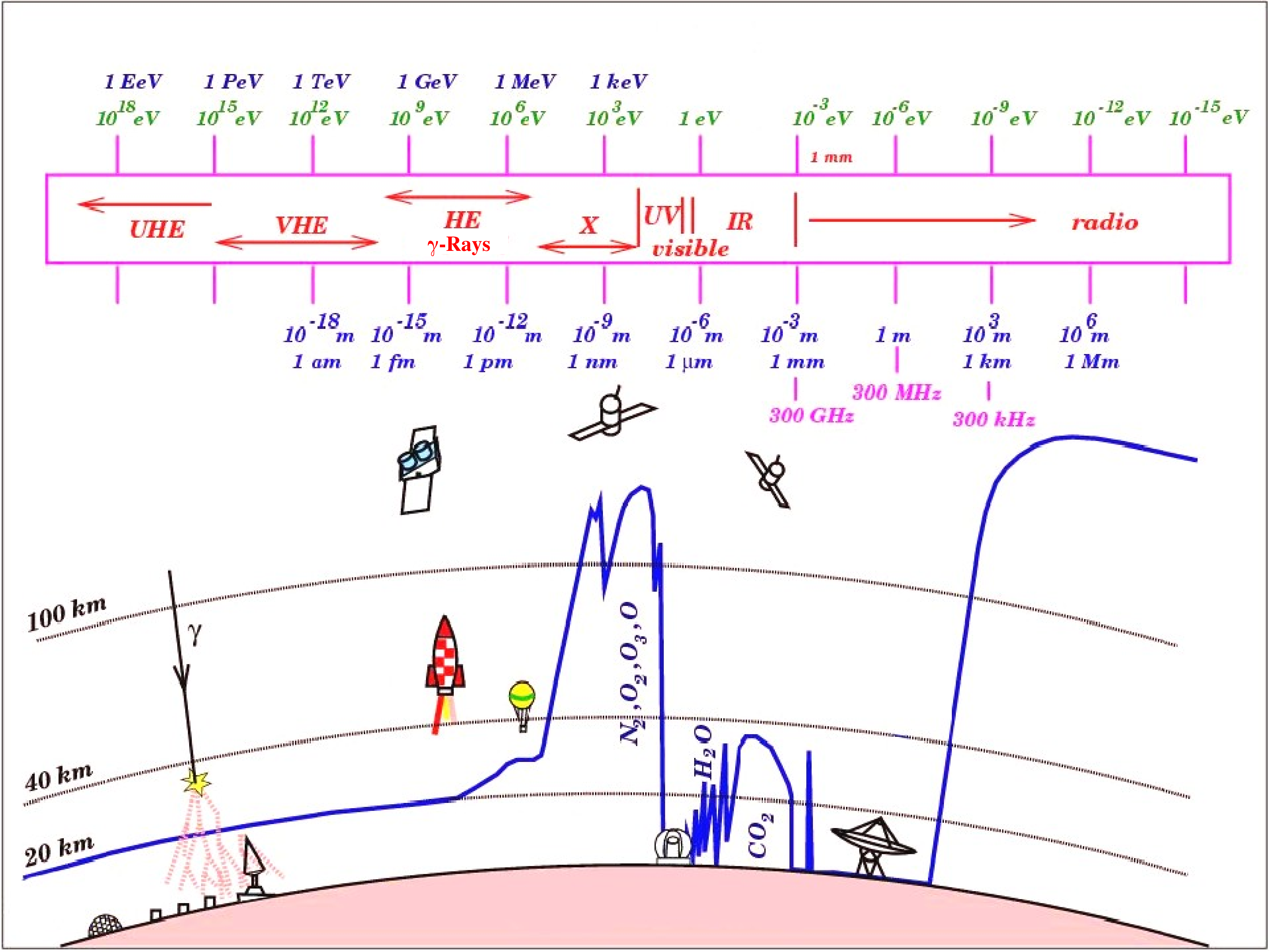
The future
Cherenkov Telescope Array

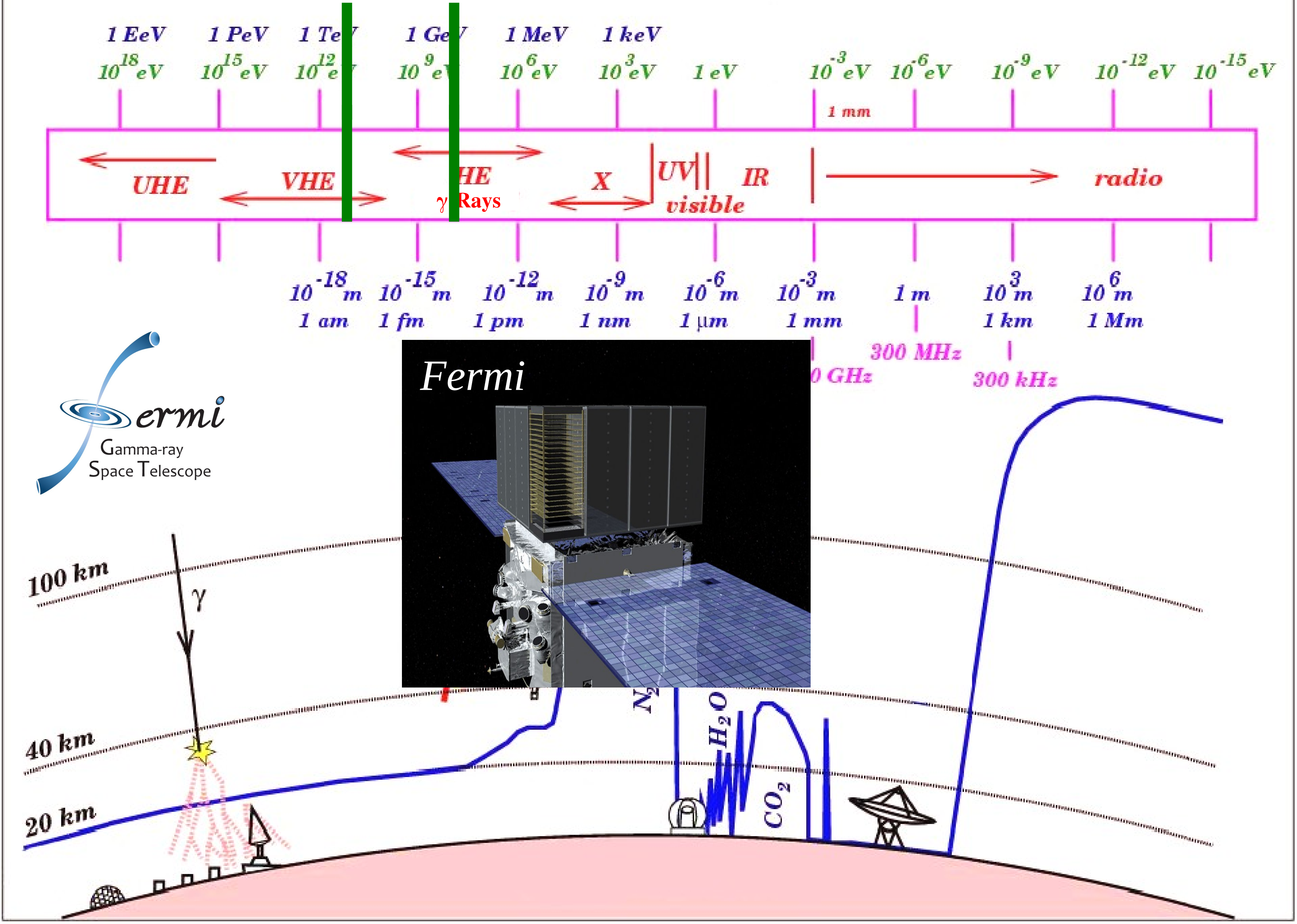
T. Hassan

Current γ-Ray detectors

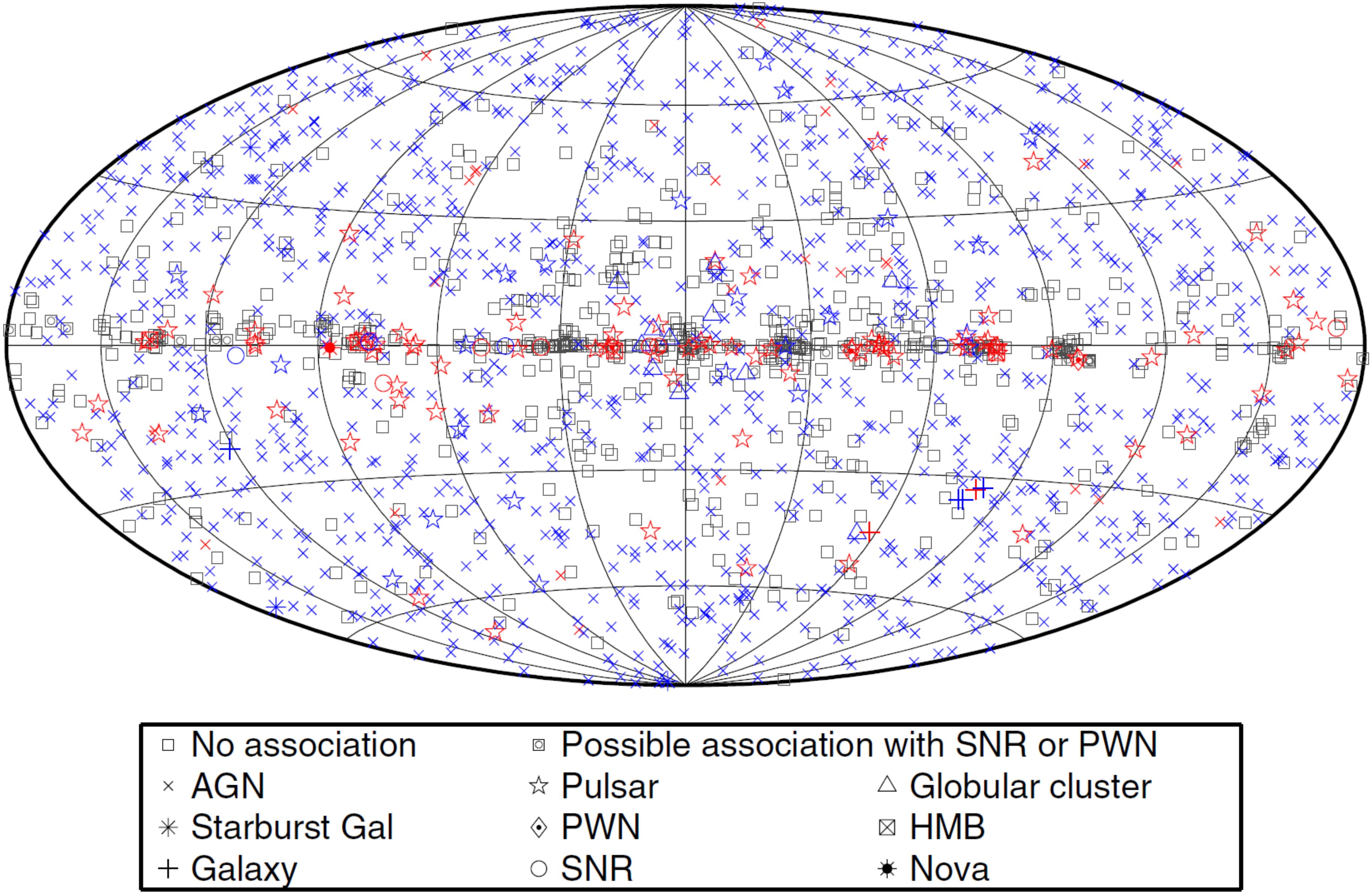


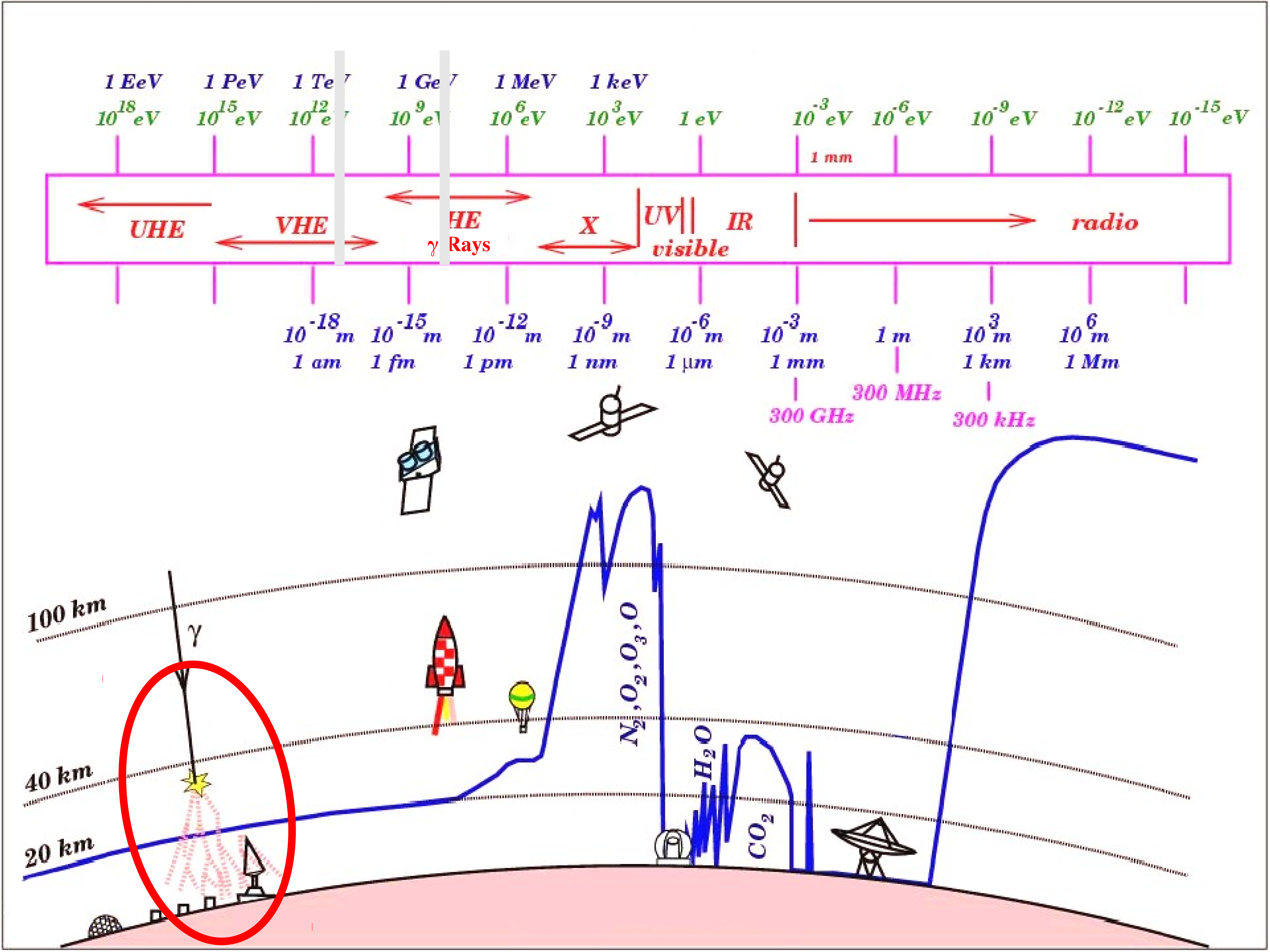
1 EeV
1 PeV
1 TeV
1 GeV
1 MeV
1 keV
10^{18} eV
10^{15} eV
10^{12} eV
10^{9} eV
10^{6} eV
10^{3} eV
1 eV
10^{-3} eV
10^{-6} eV
10^{-9} eV
10^{-12} eV
10^{-15} eV
1 mm
UHE
VHE
HE
γ-Rays
X
UV
visible
IR
radio
10^{-18} m
1 am
10^{-15} m
1 fm
10^{-12} m
1 pm
10^{-9} m
1 nm
10^{-6} m
1 μm
10^{-3} m
1 mm
300 GHz
1 m
300 MHz
10^{3} m
1 km
300 kHz
10^{6} m
1 Mm
100 km
γ
40 km
20 km
N_2, O_2, O_3, O
H_2O
CO_2

300 GeV ← 100 MeV



Fermi-LAT detected γ-ray sources





1 EeV
1 PeV
1 Te
1 Ge
1 MeV
1 keV
10^{18} eV
10^{15} eV
10^{12} e
10^{9} e
10^{6} eV
10^{3} eV
1 eV
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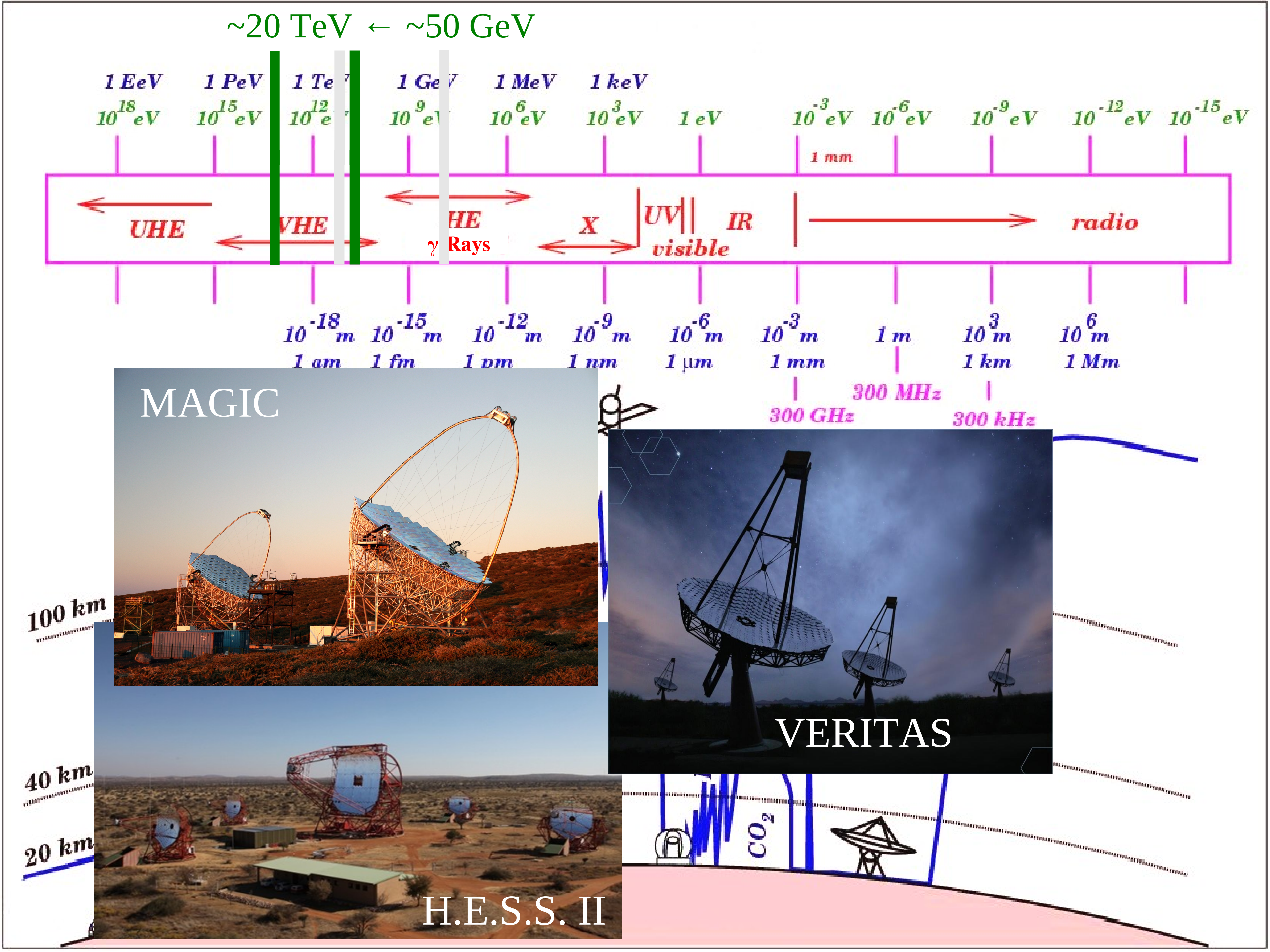
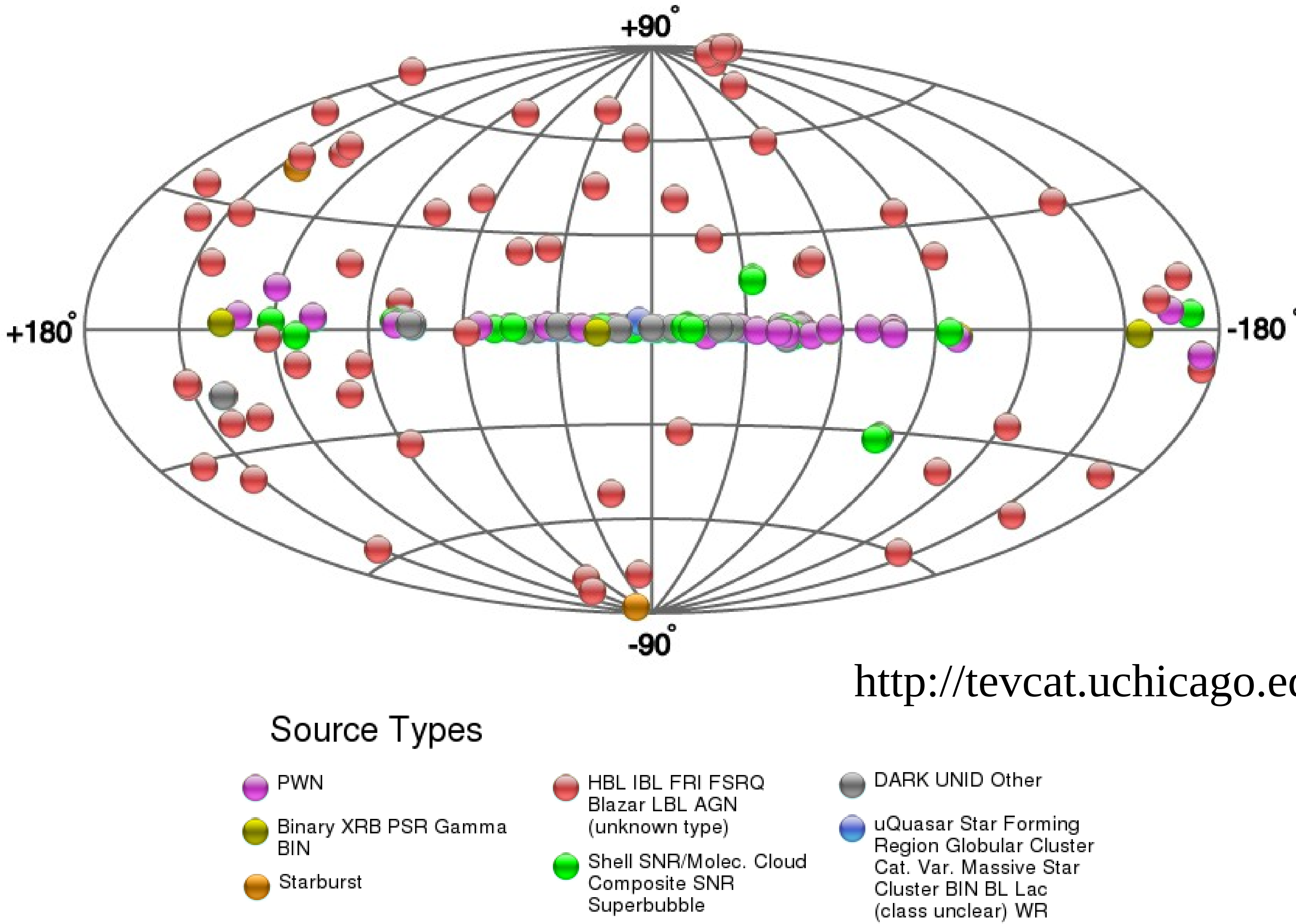
1 mm
1 m
10^{3} m
1 km
10^{6} m
1 Mm
300 GHz
300 MHz
300 kHz
100 km
40 km
20 km
γ
N_2, O_2, O_3, O
H_2O
CO_2

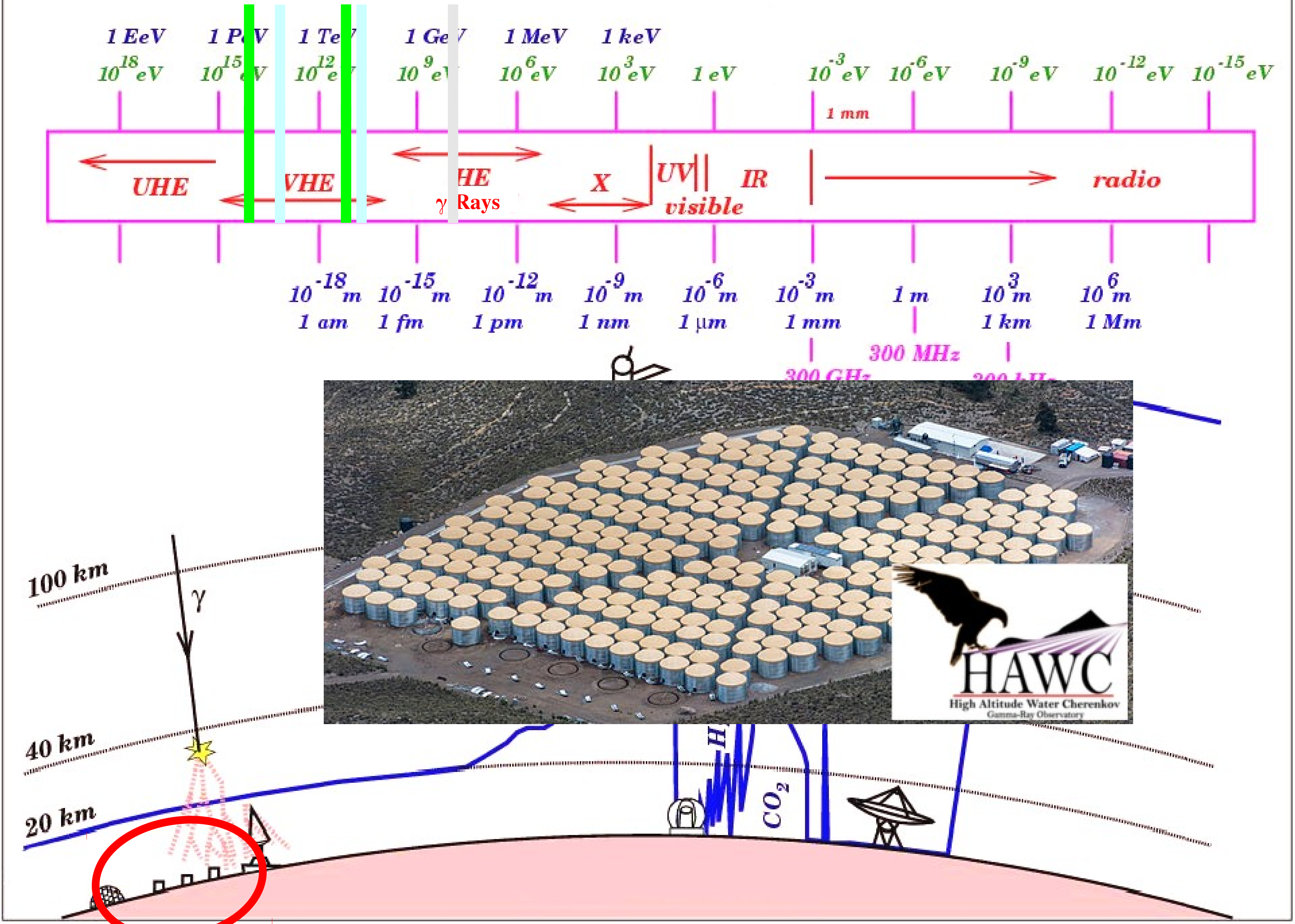

~20 TeV ← ~50 GeV
1 EeV
1 PeV
1 MeV
1 keV
10^18 eV
10^15 eV
10^6 eV
10^3 eV
1 eV
10^-3 eV
10^-6 eV
10^-9 eV
10^-12 eV
10^-15 eV
1 mm
UHE
VHE
HE
γ Rays
X
UV
visible
IR
radio
10^-18 m
10^-15 m
10^-12 m
10^-9 m
10^-6 m
10^-3 m
1 m
10^3 m
10^6 m
1 fm
1 pm
1 nm
1 μm
1 mm
1 km
1 Mm
300 GHz
300 MHz
300 kHz
100 km
40 km
20 km
CO2
MAGIC
VERITAS
H.E.S.S. II

Current γ-Ray detectors

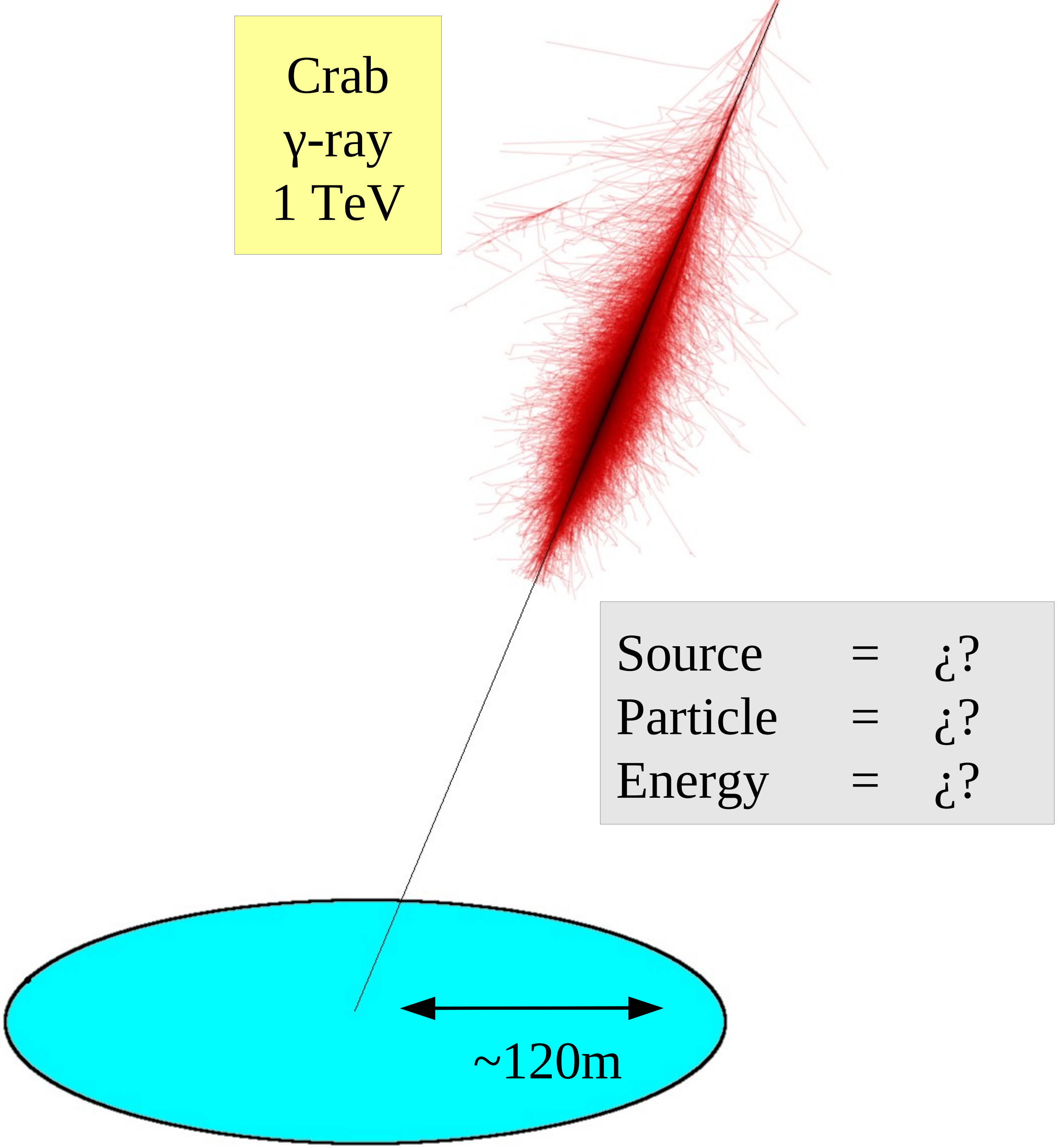


http://tevcat.uchicago.edu/

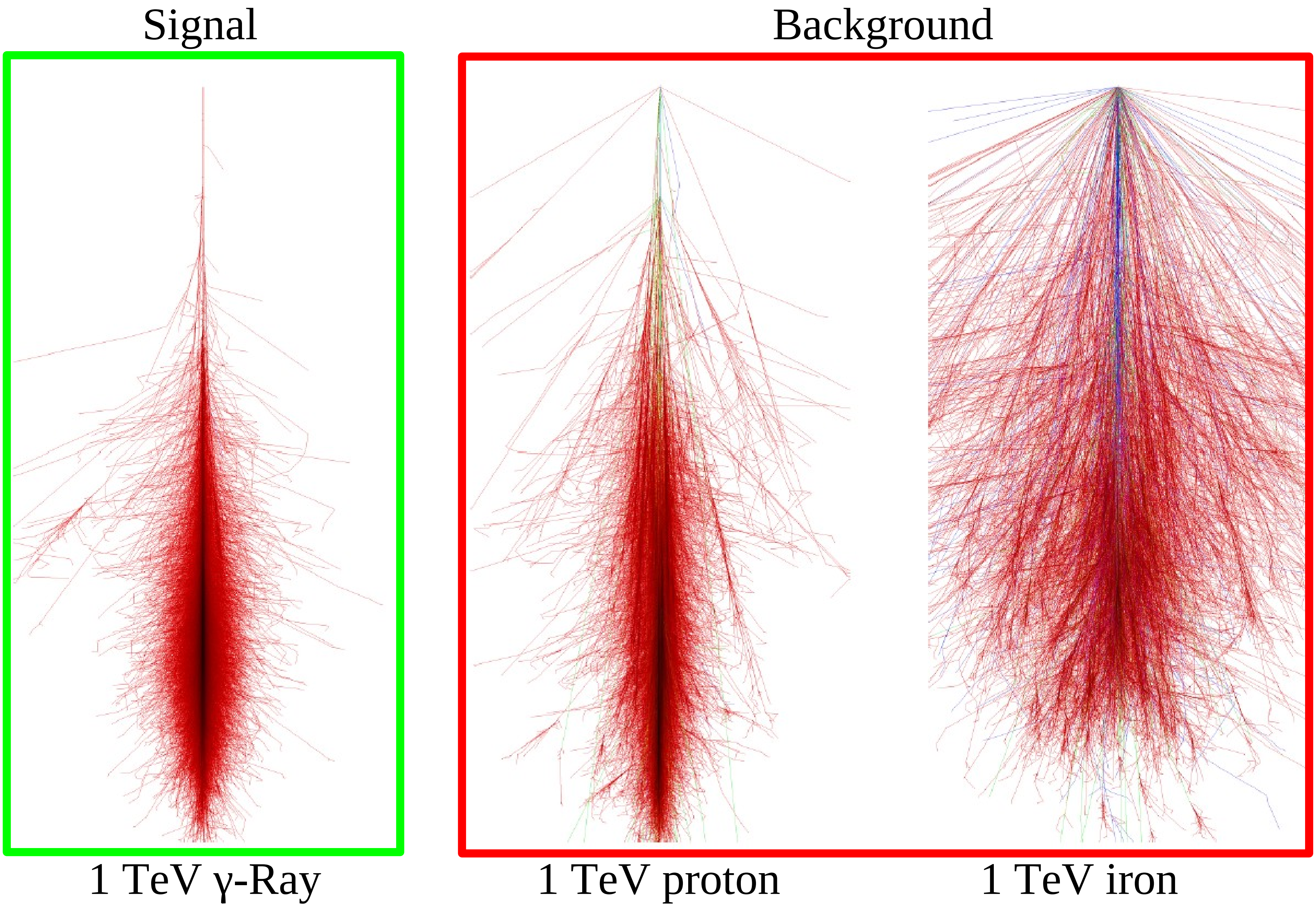
~100 TeV ← ~300 GeV



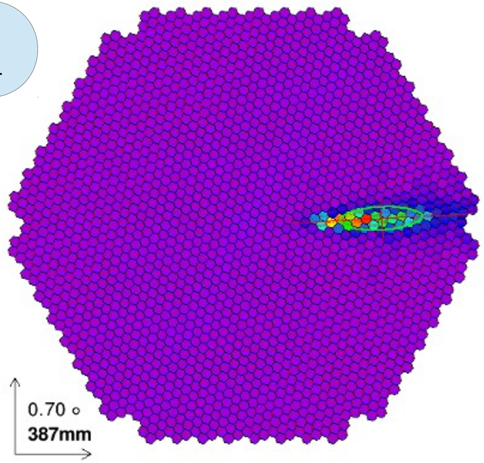
Imaging Atmospheric Cherenkov Telescopes (IACT) principle


Crab
γ-ray
1 TeV
Source = ¿?
Particle = ¿?
Energy = ¿?
~120m

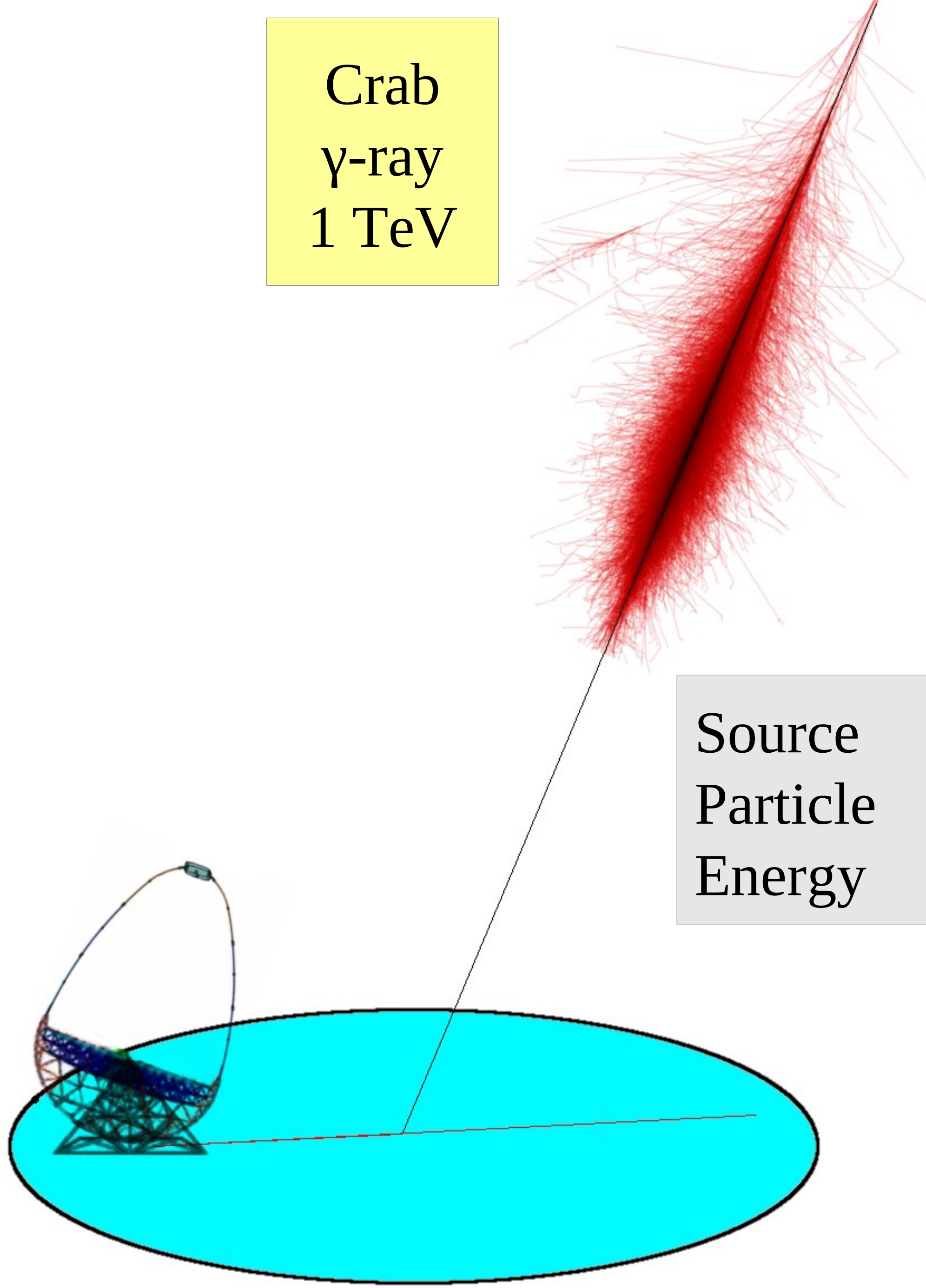
Main background sources



1

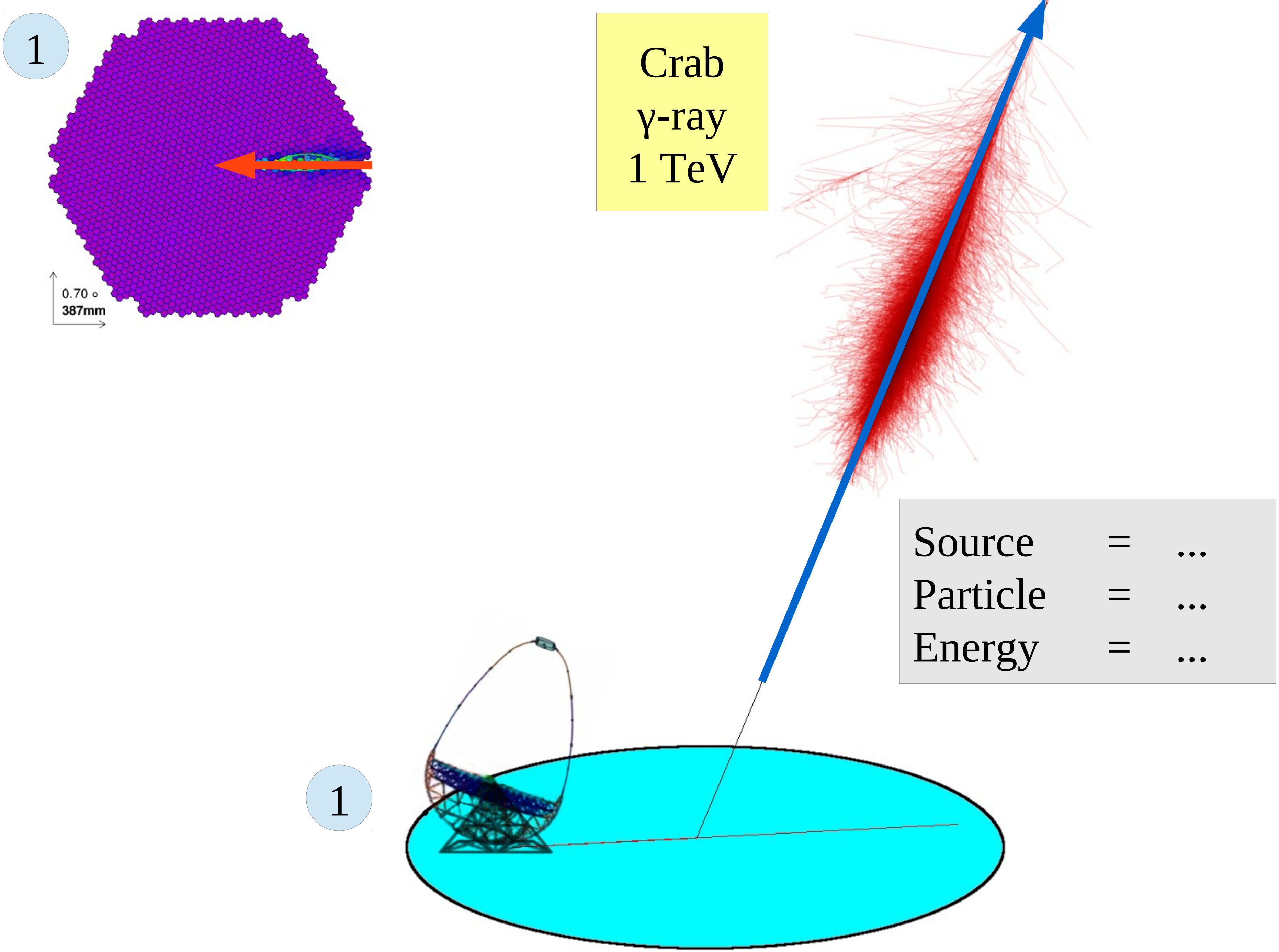


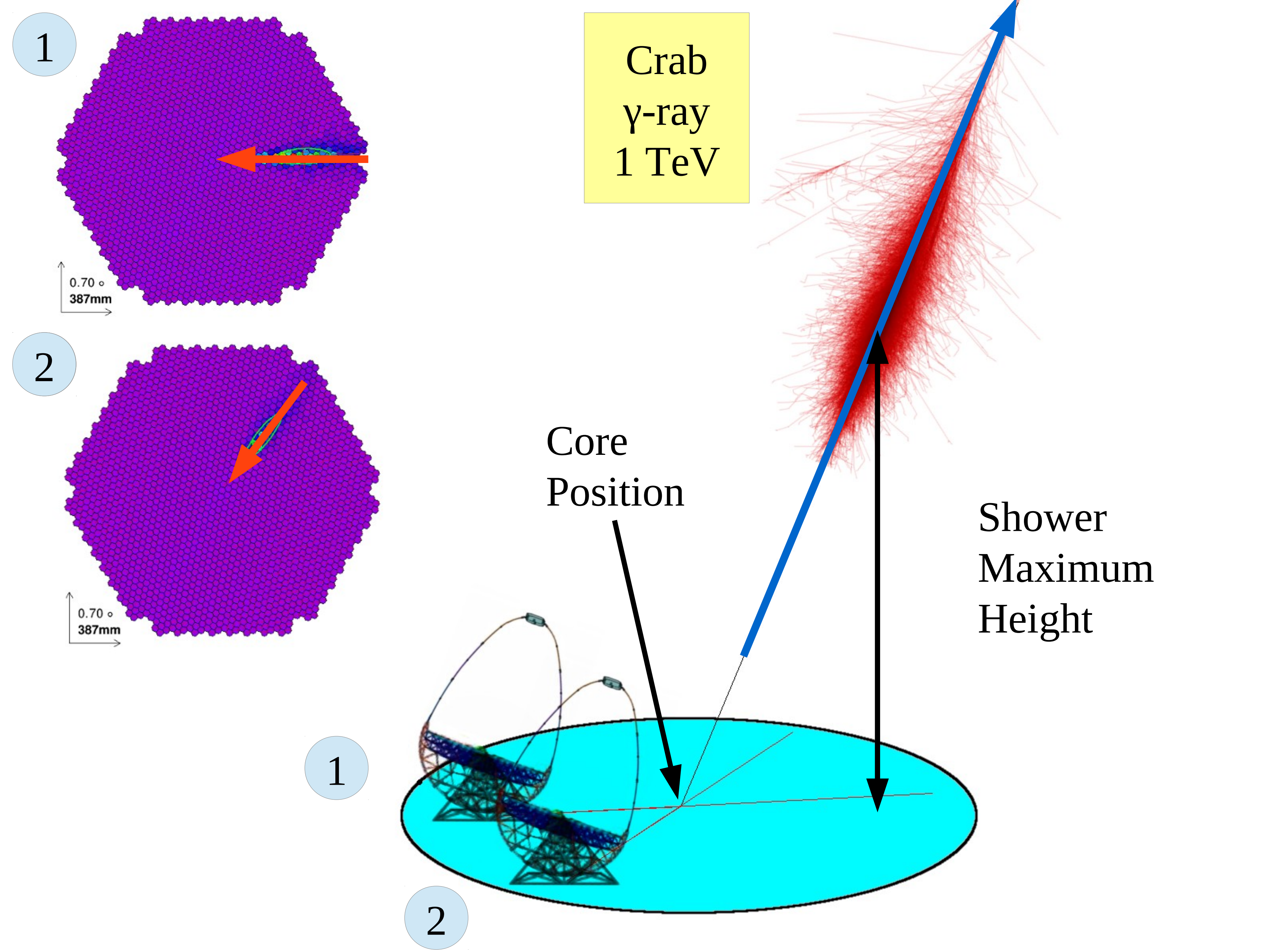
Crab
γ-ray
1 TeV



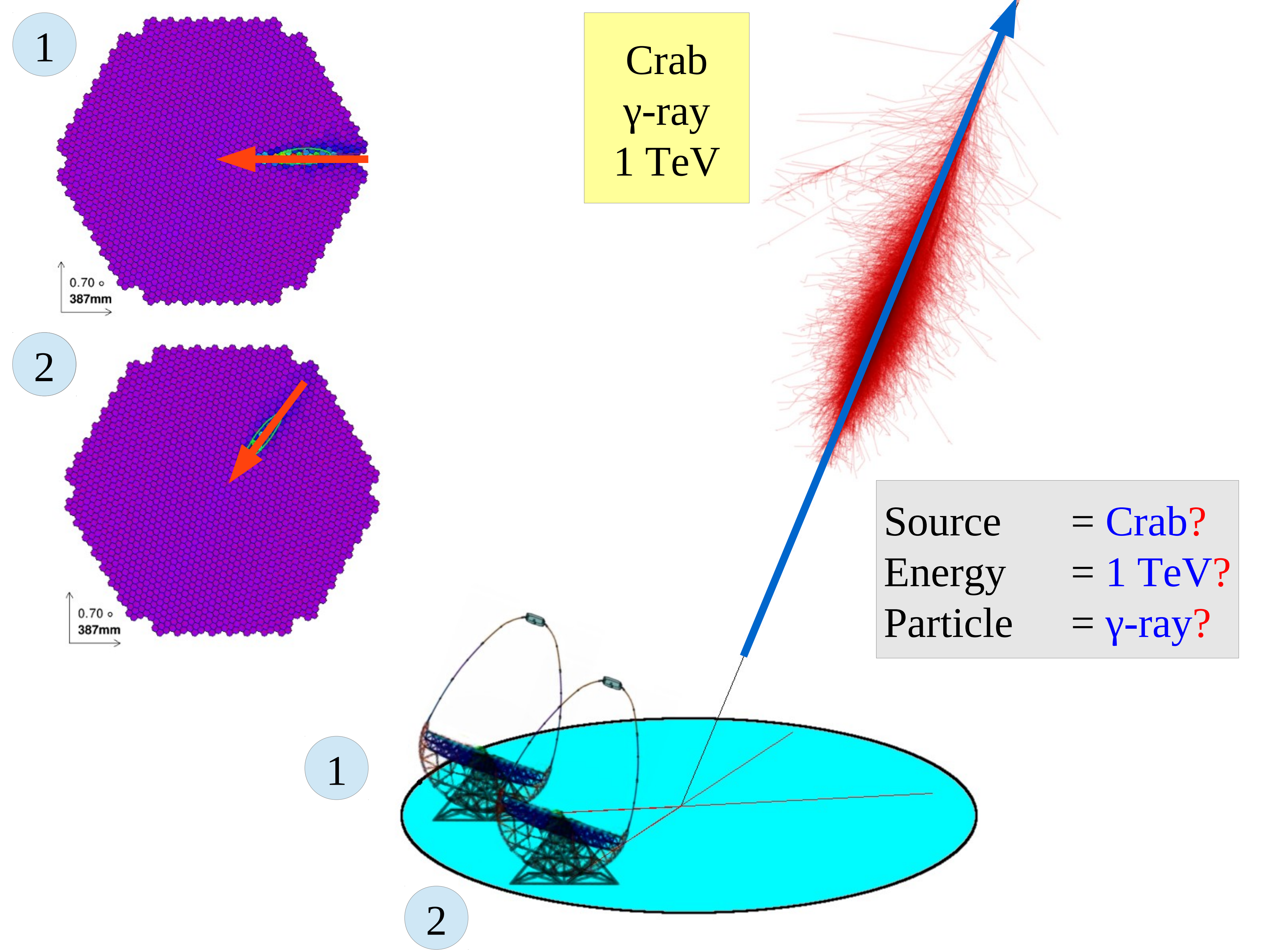
1

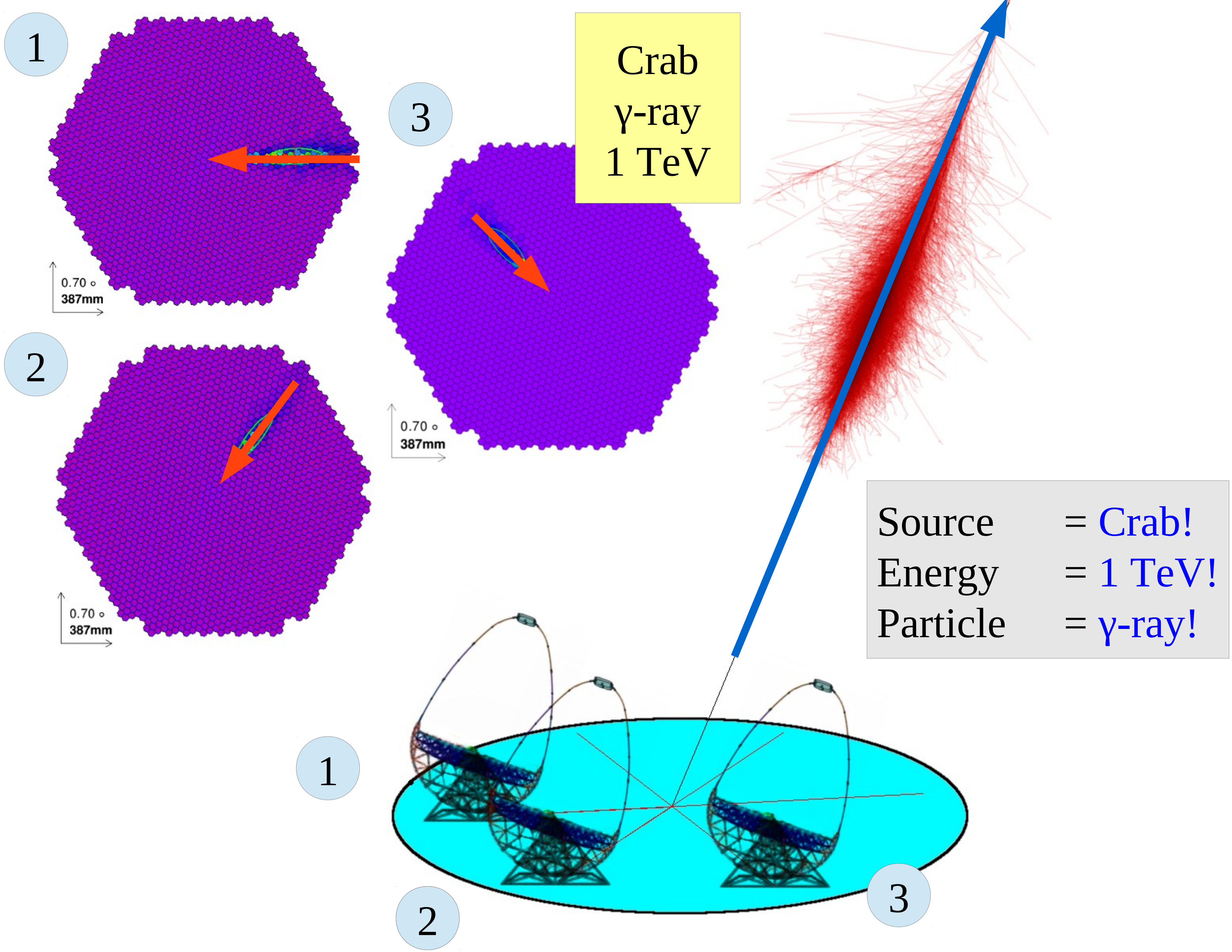
Source = ¿?
Particle = ¿?
Energy = ¿?

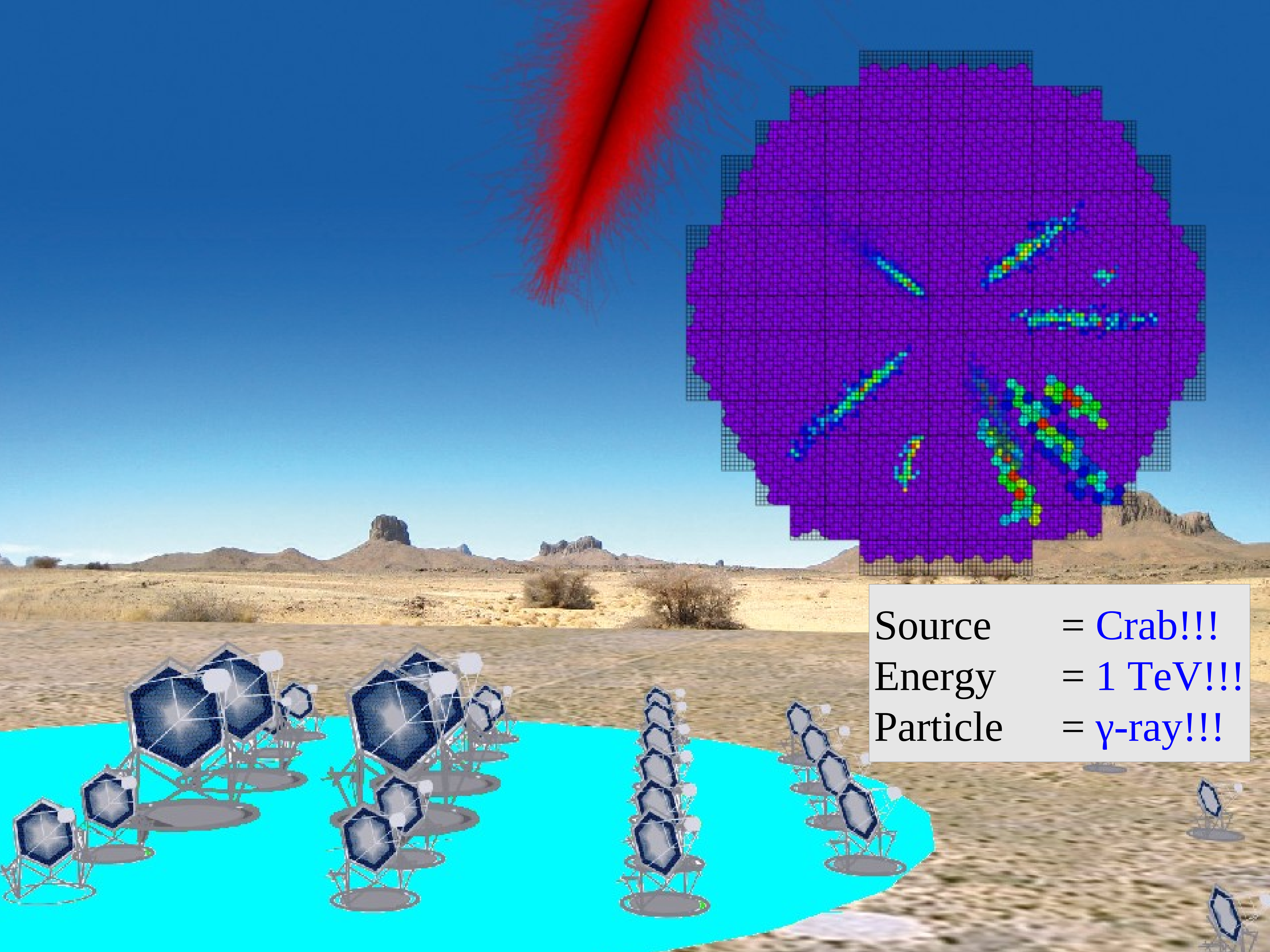

1
0.70 °
387mm
Crab
γ-ray
1 TeV
Source = ...
Particle = ...
Energy = ...
1



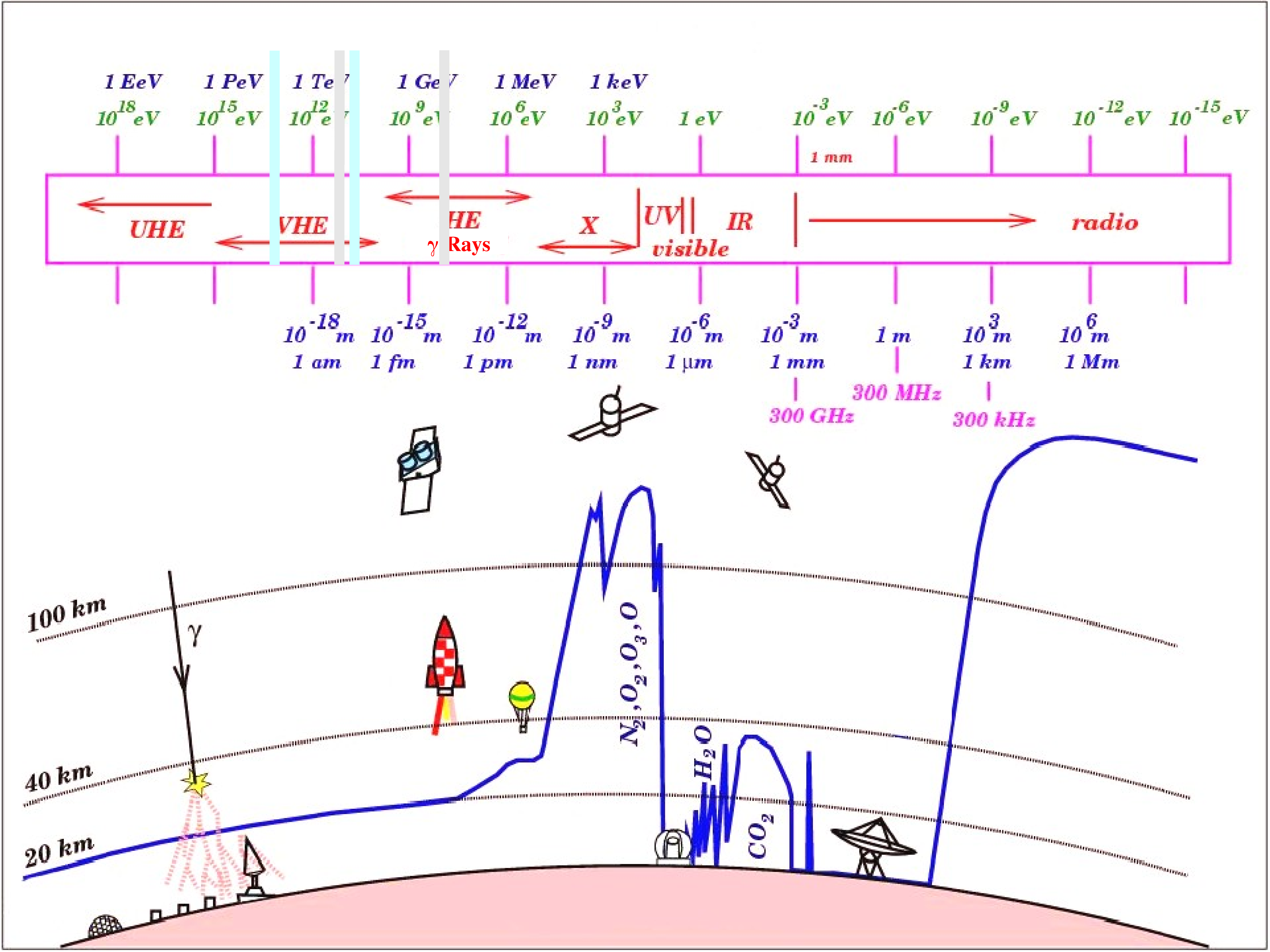
1
0.70 ∘
387mm
2
0.70 ∘
387mm
Crab
γ-ray
1 TeV
Core
Position
Shower
Maximum
Height
1
2


1
0.70 ∘
387mm
2
0.70 ∘
387mm
Crab
γ-ray
1 TeV
Source = Crab?
Energy = 1 TeV?
Particle = γ-ray?
1
2


1
3
Crab
γ-ray
1 TeV
0.70 ∘
387mm
2
0.70 ∘
387mm
0.70 ∘
387mm
Source = Crab!
Energy = 1 TeV!
Particle = γ-ray!
1
2
3


Source = Crab!!!
Energy = 1 TeV!!!
Particle = γ-ray!!!

Future γ-Ray detectors



1 EeV
1 PeV
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1 GeV
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10^{18} eV
10^{15} eV
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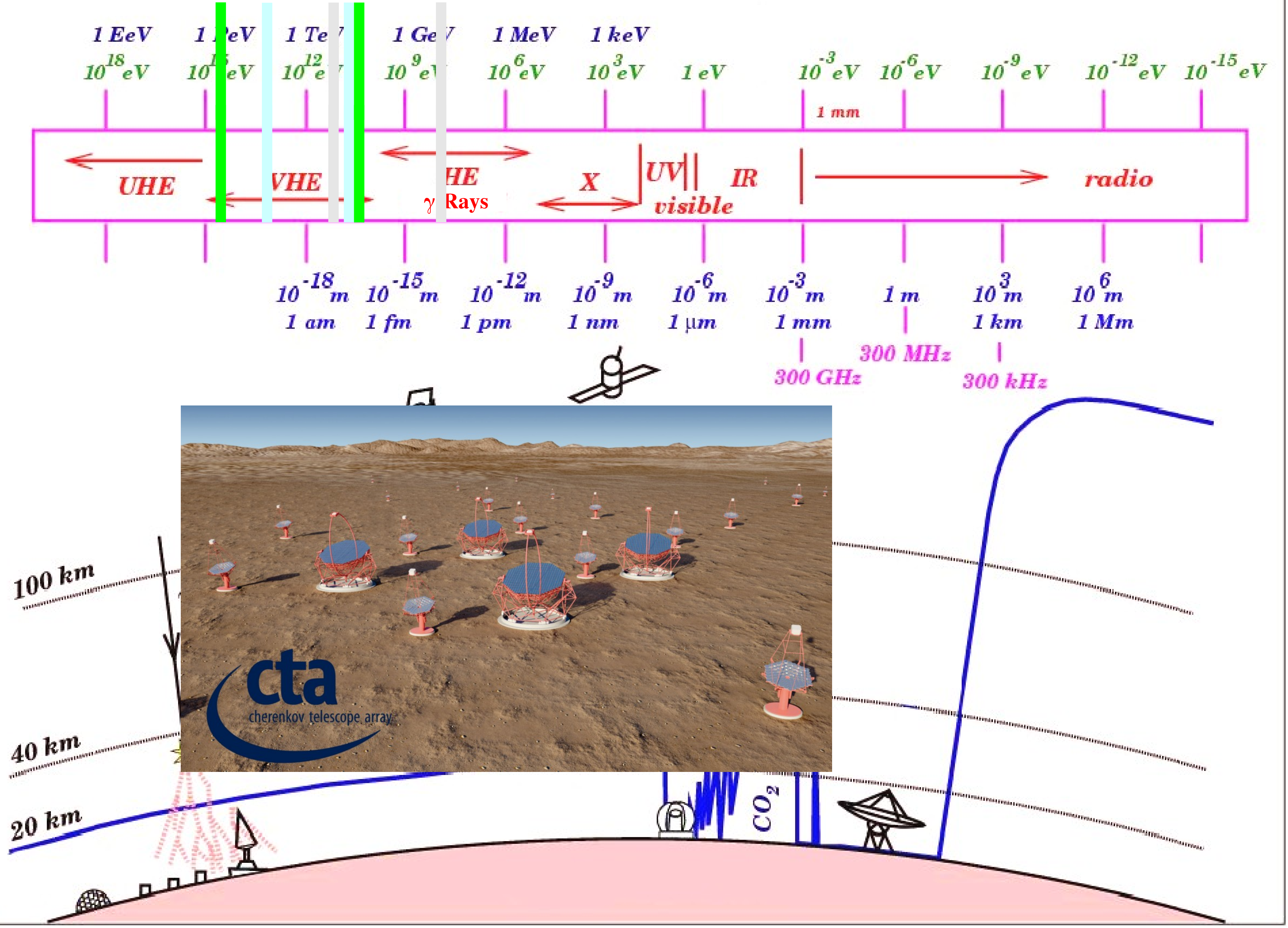
10^{9} eV
10^{6} eV
10^{3} eV
1 eV
10^{-3} eV
10^{-6} eV
10^{-9} eV
10^{-12} eV
10^{-15} eV
1 mm
UHE
VHE
HE
γ Rays
X
UV
visible
IR
radio
10^{-18} m
10^{-15} m
10^{-12} m
10^{-9} m
10^{-6} m
10^{-3} m
1 m
10^{3} m
10^{6} m
1 am
1 fm
1 pm
1 nm
1 µm
1 mm
1 km
1 Mm
300 GHz
300 MHz
300 kHz
100 km
40 km
20 km
γ
N_2, O_2, O_3, O
H_2O
CO_2

~300 TeV ← ~20 GeV



CTA: The Cherenkov Telescope Array

- The next generation of IACTs, expected to improve on the sensitivity of current instruments by an order of magnitude

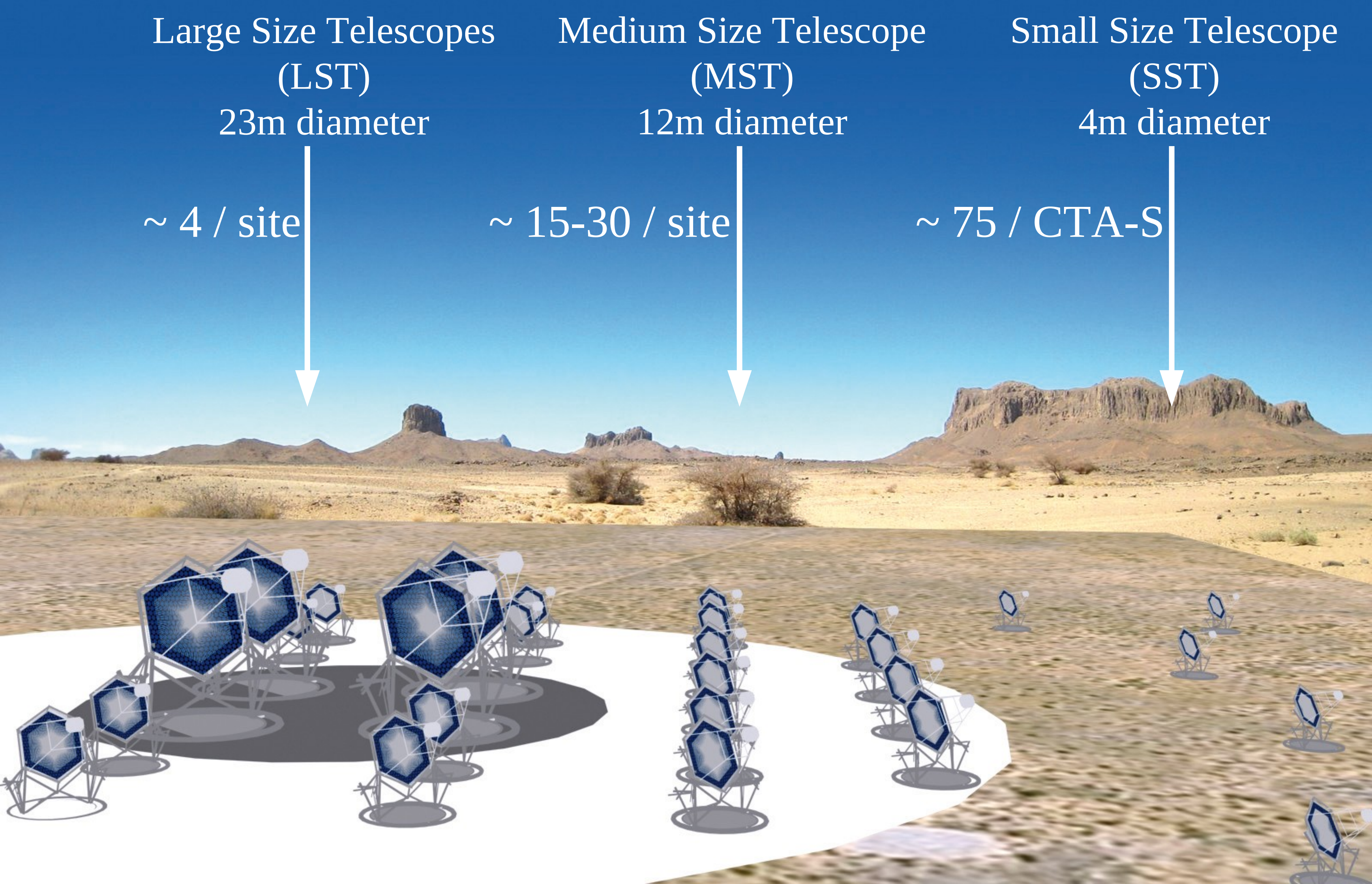
- Will cover a wide energy range (~20GeV → ~300 TeV)

- Collaboration of more than 1200 members working in 200 institutes from 29 countries

- Composed of two sites, one at each hemisphere, will provide full sky coverage

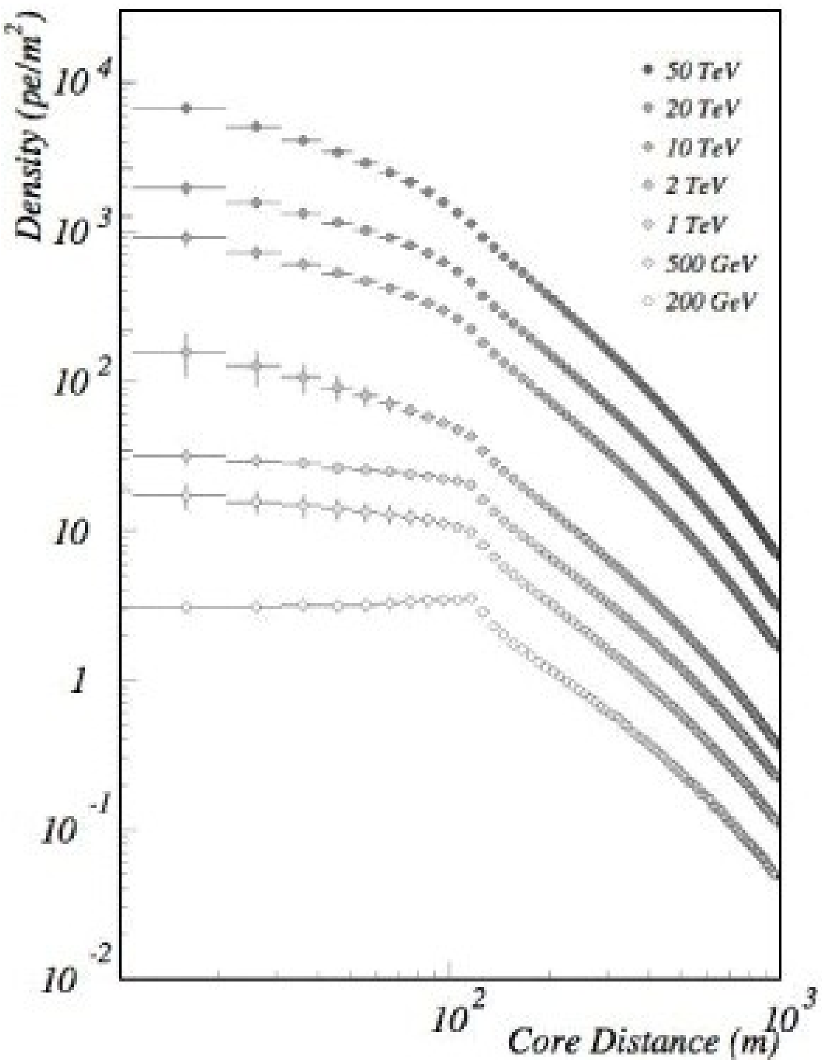
- CTA will be an observatory, with a significant amount of open time for external proposals

CTA: The Cherenkov Telescope Array



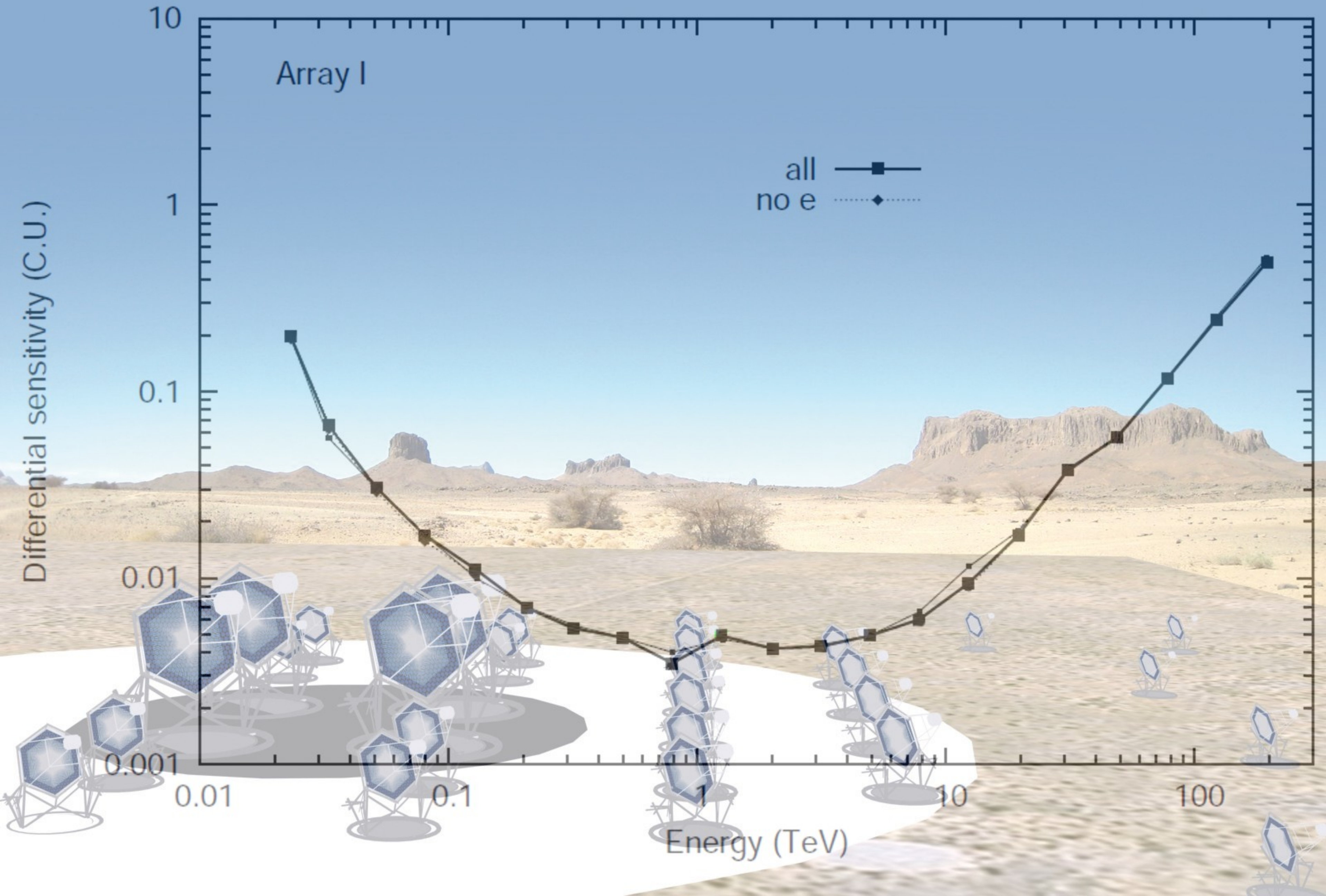
Future γ-Ray detectors

Why different telescope size?

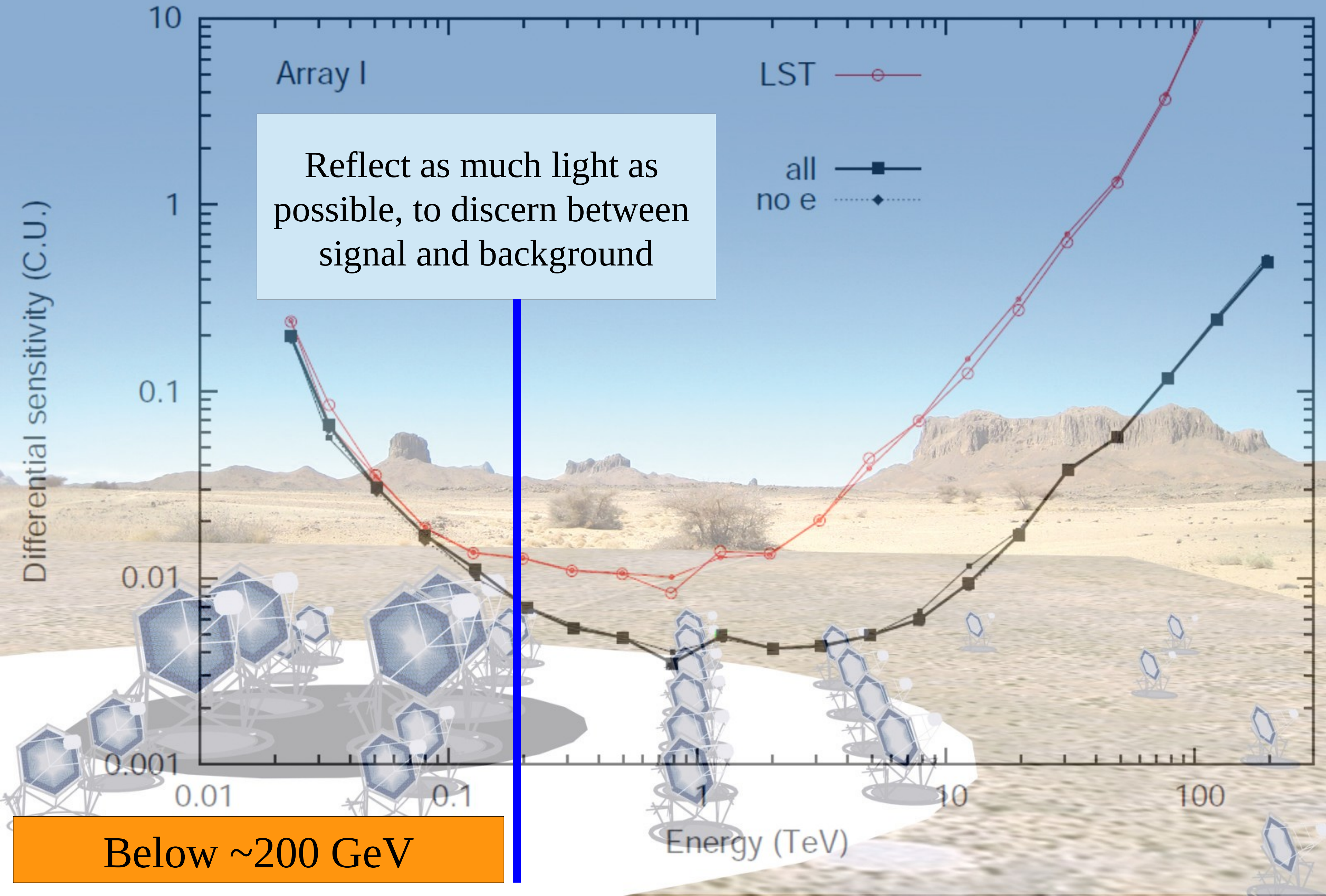


- Photon density increases with energy
- Higher energy cascades can be observed farther away, or by smaller telescopes
- As the energy increases large telescopes are not needed anymore, but events are less frequent

CTA Telescopes contribution



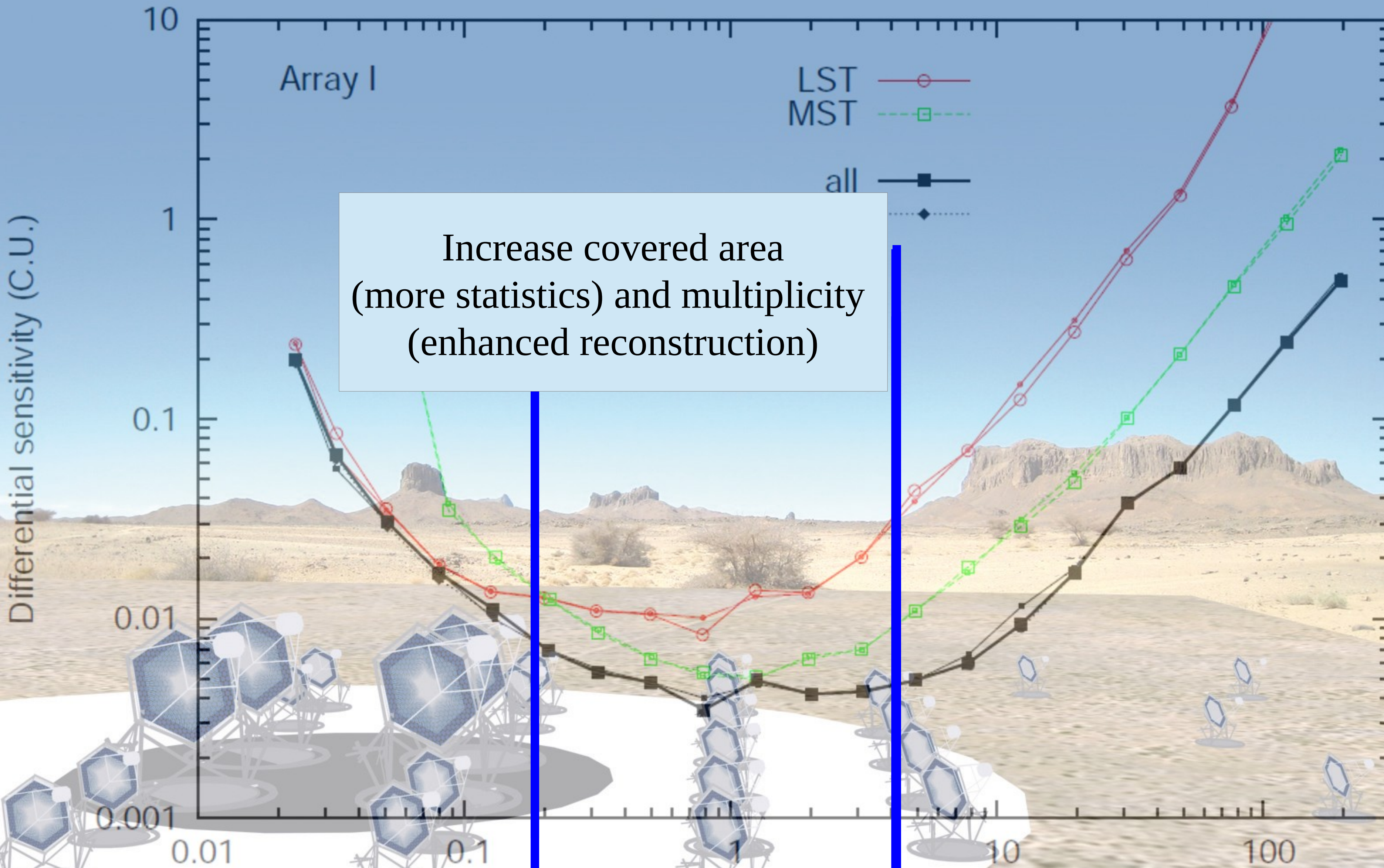
CTA Telescopes contribution



Reflect as much light as possible, to discern between signal and background

Below ~200 GeV

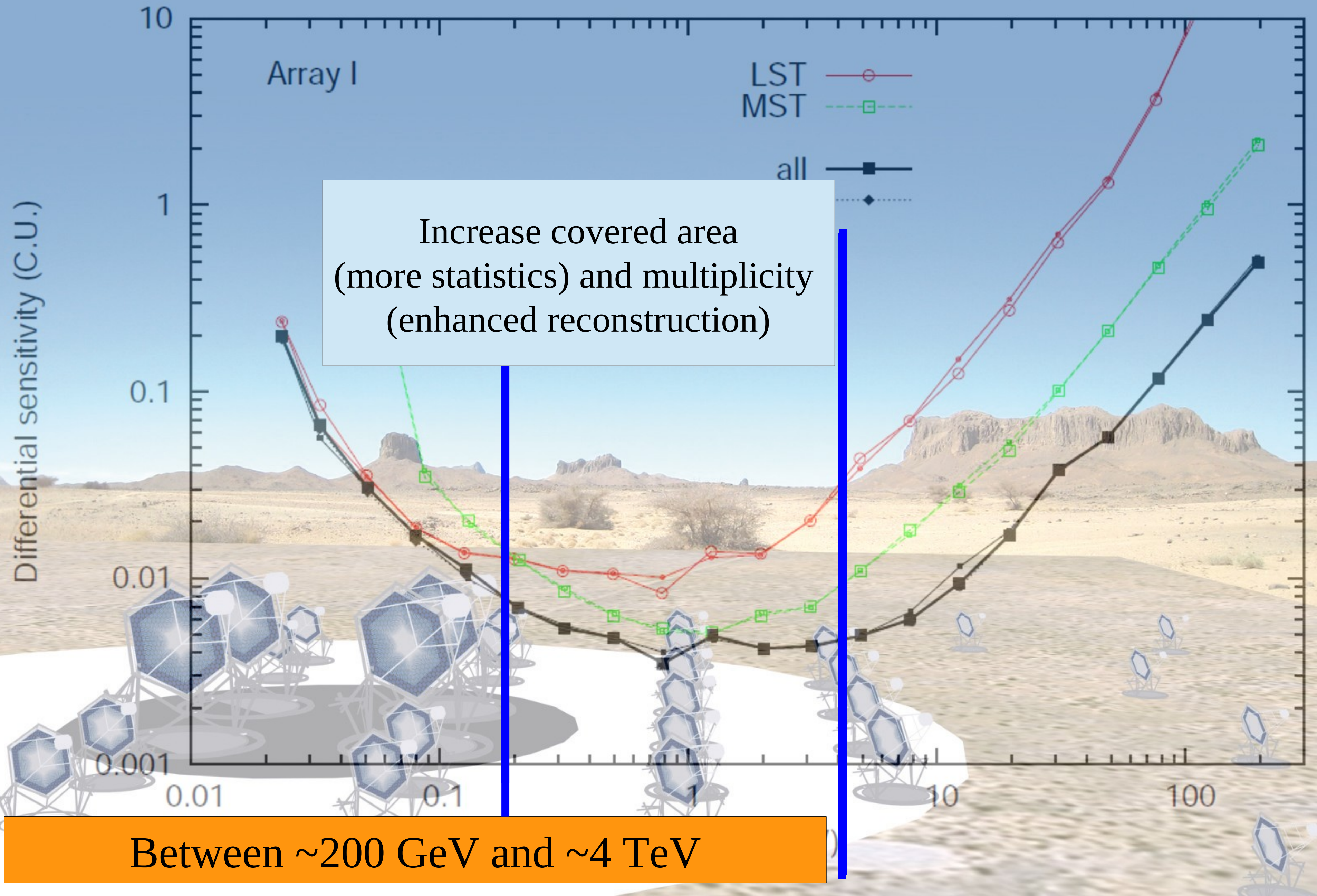
CTA Telescopes contribution



Increase covered area
(more statistics) and multiplicity
(enhanced reconstruction)

Between ~200 GeV and ~4 TeV

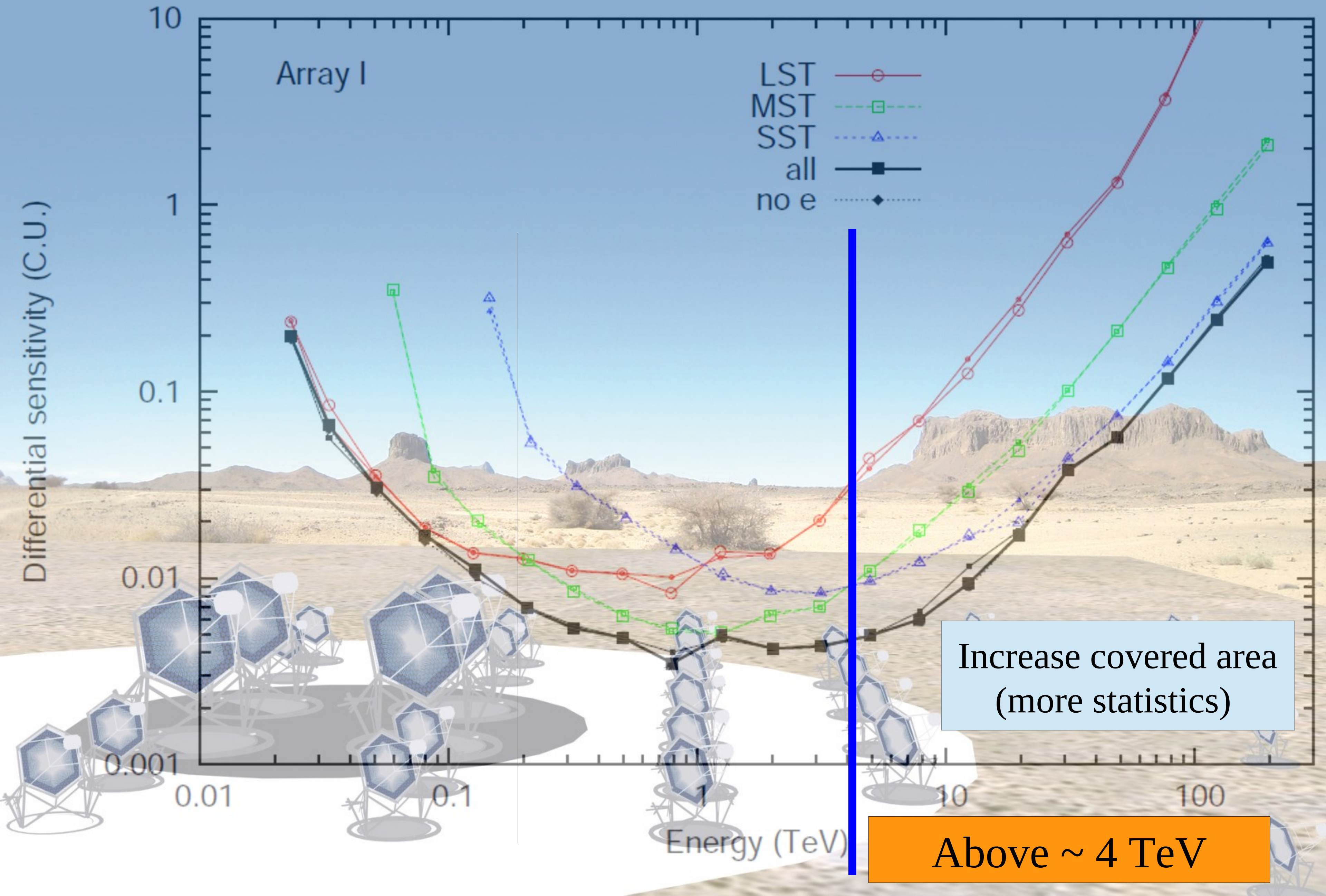
CTA Telescopes contribution



Increase covered area
(more statistics) and multiplicity
(enhanced reconstruction)

Between ~200 GeV and ~4 TeV

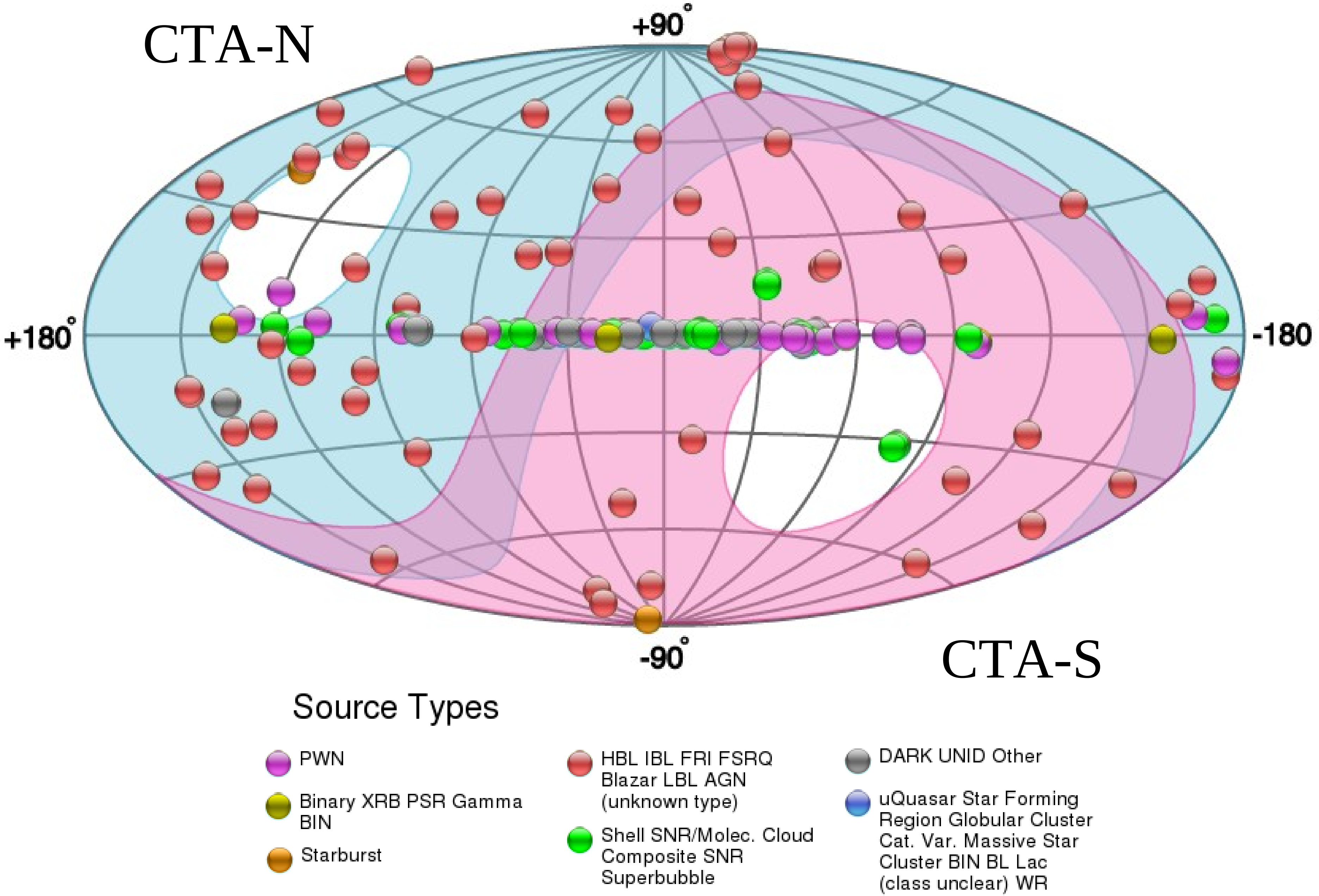
CTA Telescopes contribution



Increase covered area (more statistics)

Above ~ 4 TeV

CTA Sky coverage



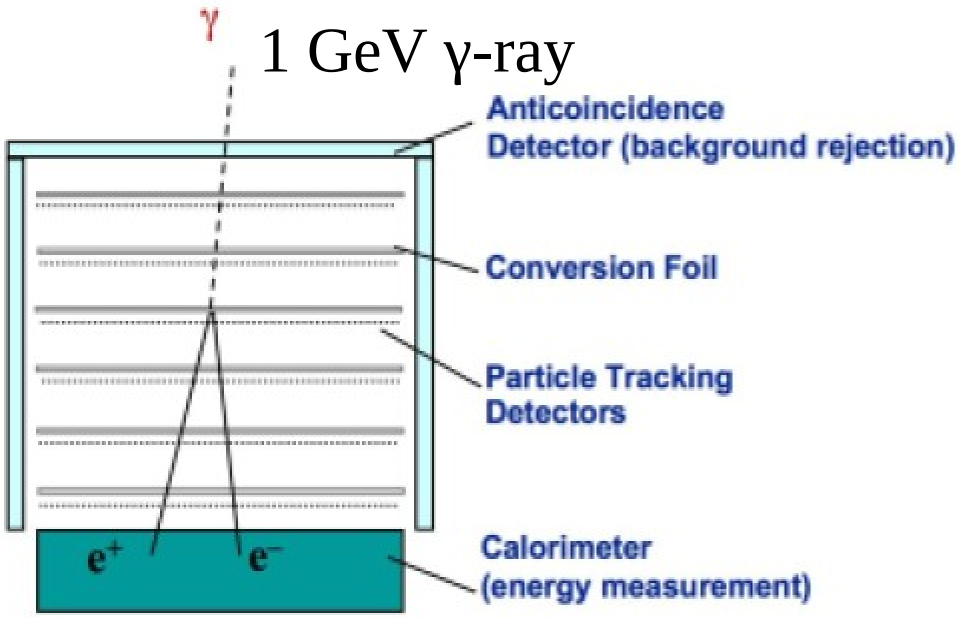
CTA Monte Carlo Simulations

Role of MC on IACTs

- The environment of IACTs is part of the instrument

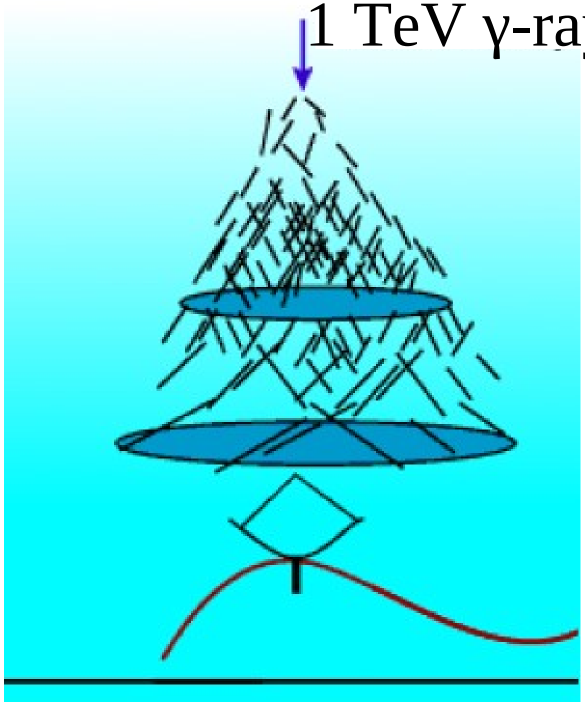
Fermi-LAT “tower”

1 GeV γ-ray



IACT

1 TeV γ-ray



Role of MC on IACTs

- The environment of IACTs is part of the instrument

- Simulations are needed to estimate Cherenkov light emitted by extended air showers and the IACT response

- Simulations are required for:

    - Direction reconstruction
    - Energy estimation
    - Discern between signal and background

CTA MC Goal

- Estimate CTA future performance, which needs to fulfill certain requirements defined by physics working groups

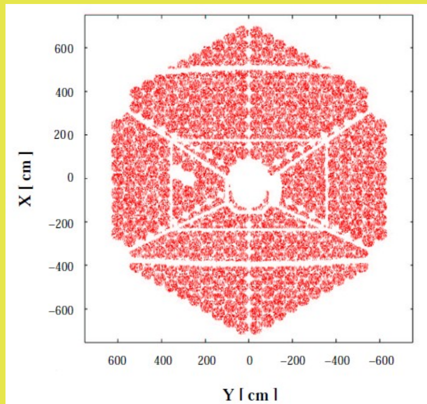
- Compare different telescope layouts and the impact of the telescopes size and distribution over final sensitivity

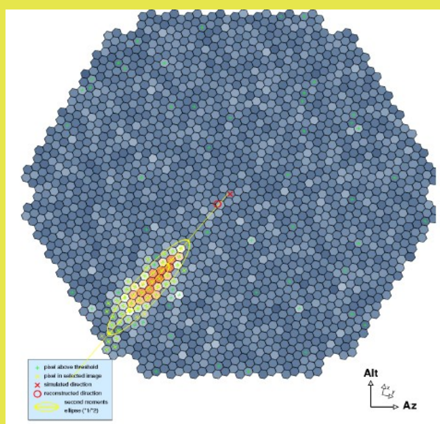
- Rate building sites location taking into account their impact on performance (mainly altitude, geomagnetic field)

CTA MC chain

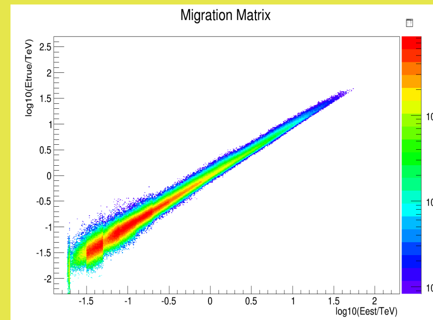
Shower simulation

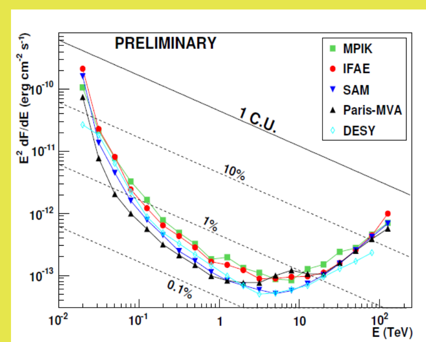
Telescope simulation



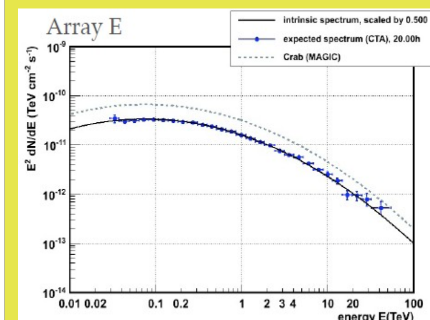


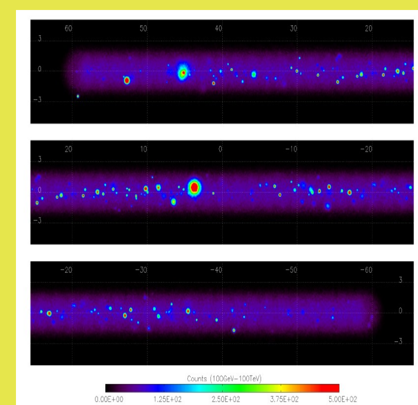
Performance analysis





Physics cases

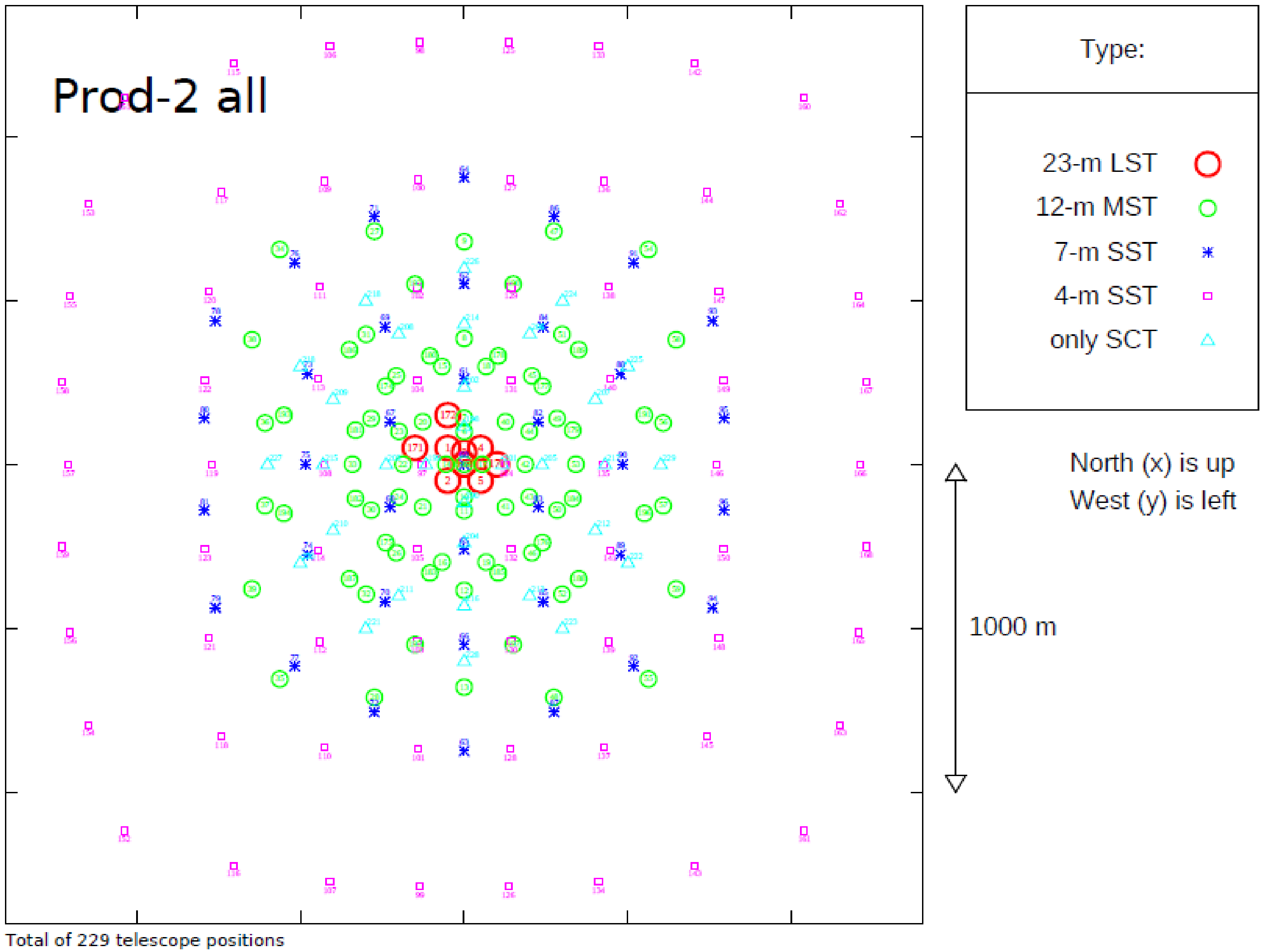




CTA MC chain

Shower Simulation (CORSIKA)

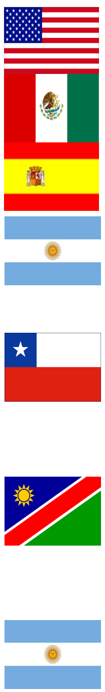
Telescopes response (`sim_telarray`)



γ-rays, hadrons and electrons are simulated over an area of 20 Km^2

CTA MC

Sites simulated



Site	Location		Altitude	B_h	B_z
	lon.	lat.			
	[deg]	[deg]	[m]	[μT]	μT
US	-115.5	31	1655	23.5	42.9
SPM	-115.5	31	2434	25.2	38.3
Tenerife	-16.5	28.3	2290	30.8	23.2
SAC	-66.2	-24	3600	20.9	-8.9
Armazones	-70.2	-24.4	2500	21.4	-8.9
Armazones++	-70.2	-24.6	2000	21.4	-8.9
Aar	16.5	-26.7	1640	10.9	-24.9
Aar500	16.5	-26.7	500	10.9	-24.9
Leoncito	-63.3	-31.8	2662	19.9	-12.6
Leoncito++	-63.3	-31.8	1650	19.9	-12.6

CTA MC

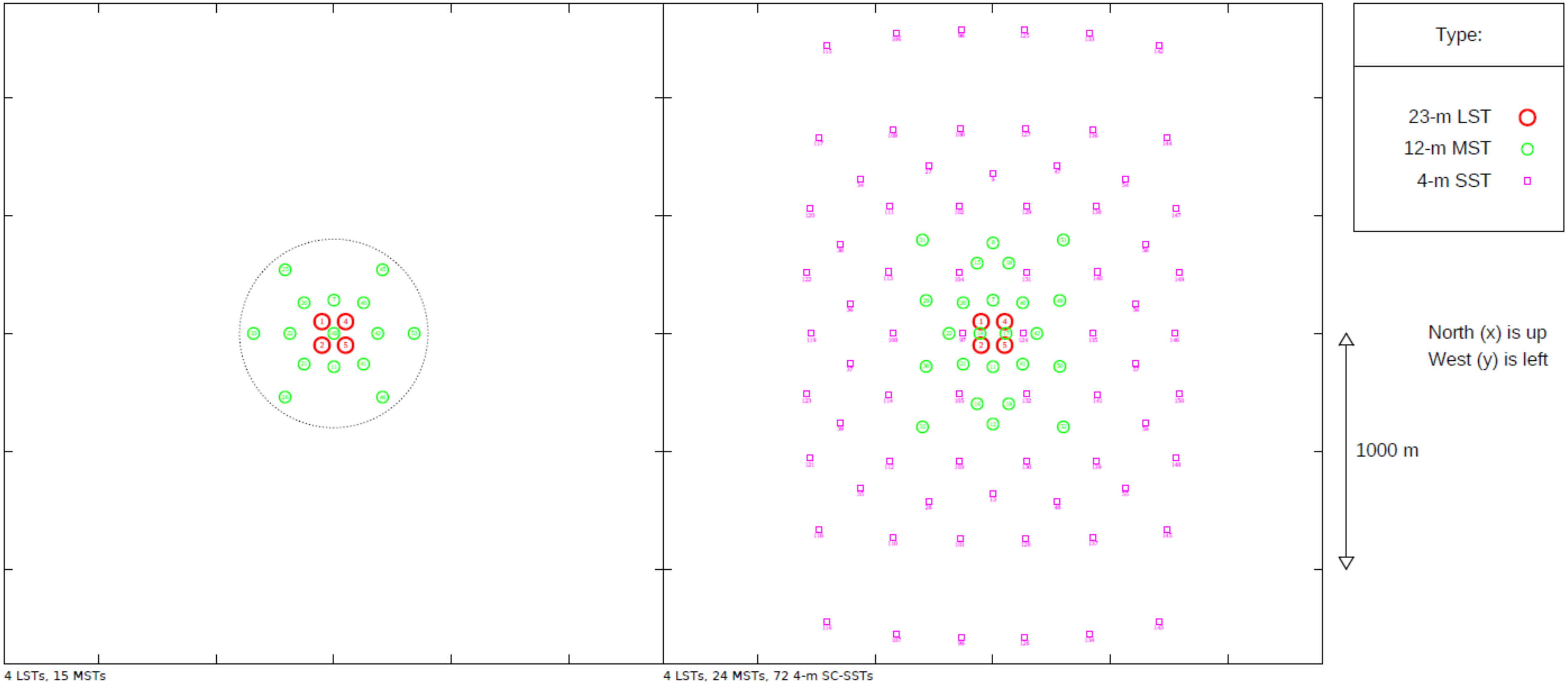
Sites simulated

Site	Location		Altitude	B_h	B_z
	lon.	lat.			
	[deg]	[deg]	[m]	[μT]	μT
~~US~~	~~-115.5~~	~~31~~	~~1655~~	~~23.5~~	~~42.9~~
SPM	-115.5	31	2434	25.2	38.3
Tenerife	-16.5	28.3	2290	30.8	23.2
~~SAC~~	~~-66.2~~	~~-24~~	~~3600~~	~~20.9~~	~~-8.9~~
Armazones	-70.2	-24.4	2500	21.4	-8.9
Armazones++	-70.2	-24.6	2000	21.4	-8.9
Aar	16.5	-26.7	1640	10.9	-24.9
Aar500	16.5	-26.7	500	10.9	-24.9
~~Leoncito~~	~~-63.3~~	~~-31.8~~	~~2662~~	~~19.9~~	~~-12.6~~
~~Leoncito++~~	~~-63.3~~	~~-31.8~~	~~1650~~	~~19.9~~	~~-12.6~~

CTA MC chain

- Telescopes are selected from the simulated super-layout and candidate arrays are defined. Then performance is estimated.

CTA-N "2N" CTA-S "2Q"



Thank you!


BACKUP