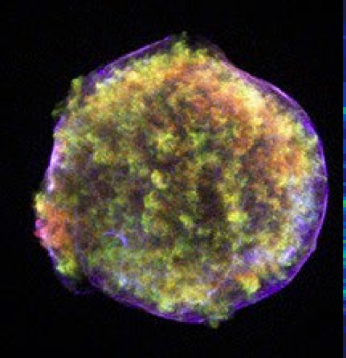
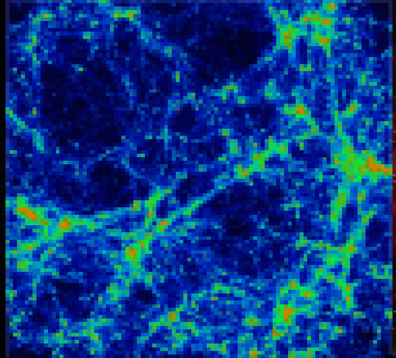
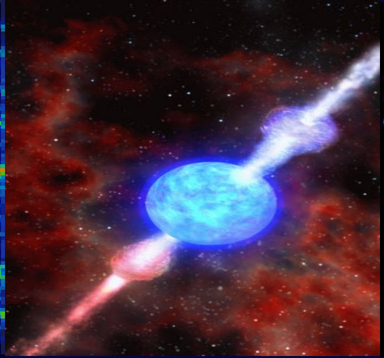
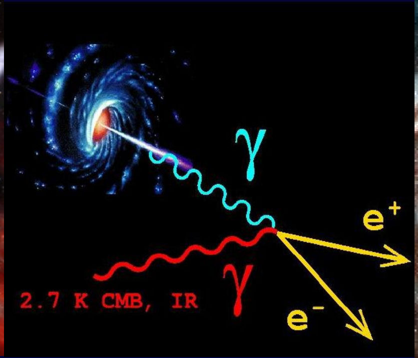





Raggi Gamma

Rene A. Ong (UCLA, INFN-Trieste)

International Cosmic Day 2023
21 novembre - Trieste

Who Am I?

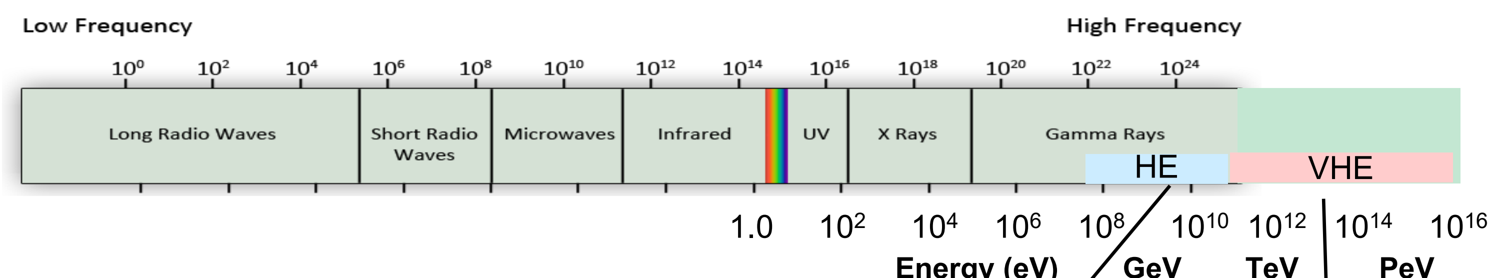
- Professor at the University of California (USA).
- Researcher in areas of cosmic rays, gamma-ray astronomy, and dark matter.
- Currently visiting INFN-Trieste and collaborating on the CTA and GAPS projects.
- I am very happy to receive any questions about research via email: rene@astro.ucla.edu

UCLA

INFN Istituto Nazionale di Fisica Nucleare
Sezione di Trieste

What is Gamma-ray Astronomy?

- **Light at high energies (very high frequency) is called a <u>gamma ray</u>.**
- **Gamma rays behave like particles, called <u>photons</u>.**
- **We cannot reflect or focus gamma rays – we can only detect them through their interaction with matter.**
- **Gamma-ray astronomy uses telescopes to study of gamma rays coming from outer space.**

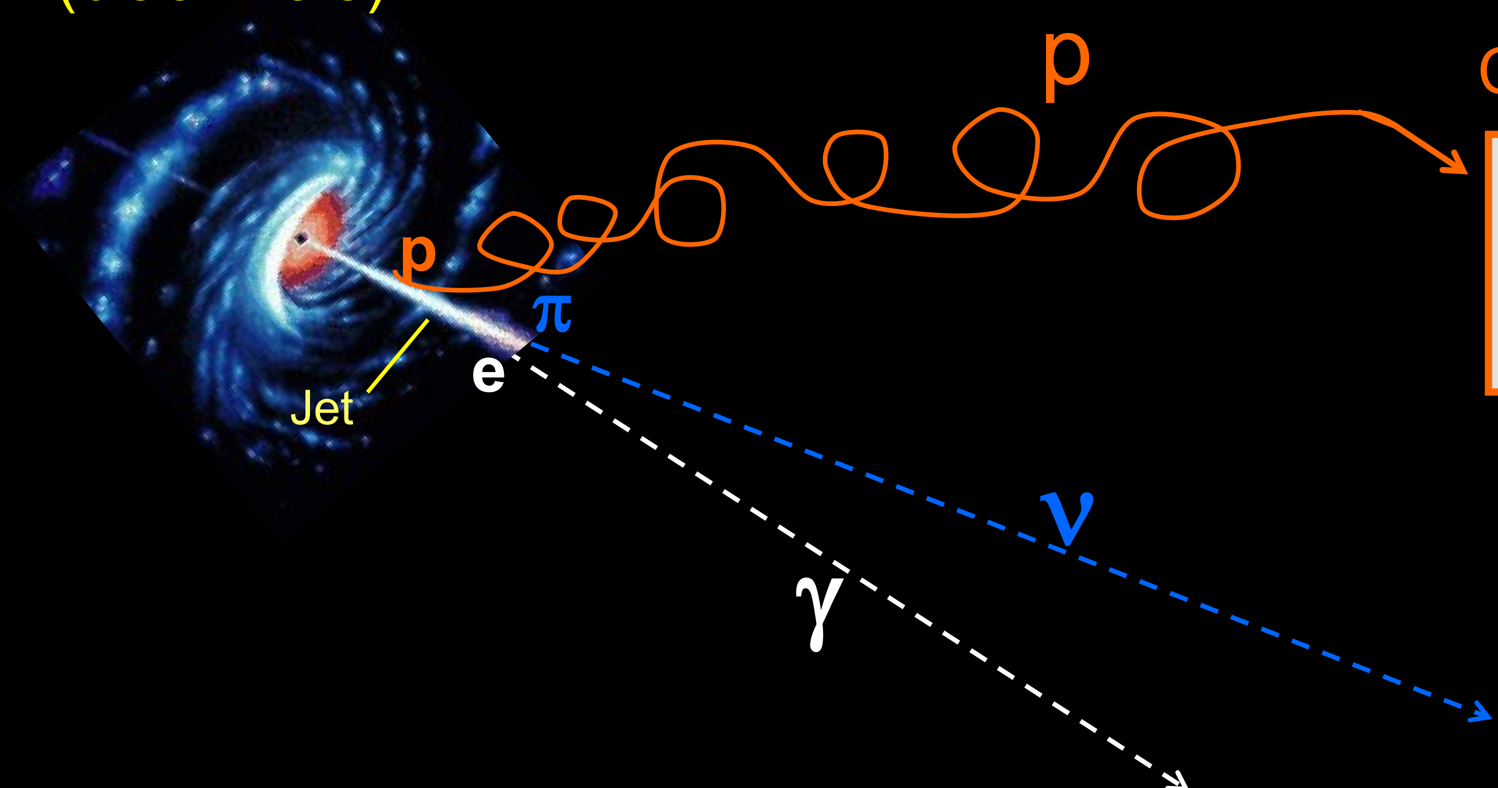


Space telescopes (Fermi-LAT)

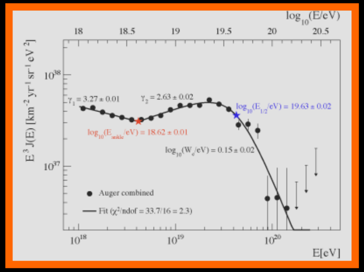
Atmospheric Cherenkov Telescopes (VERITAS)

The Science and Detection

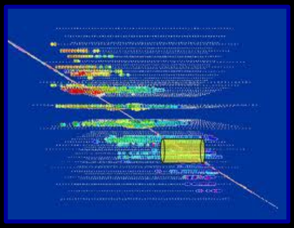
Astrophysical source
(black hole)



Cosmic Rays

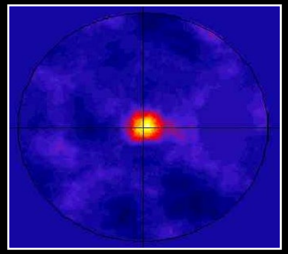


Neutrinos



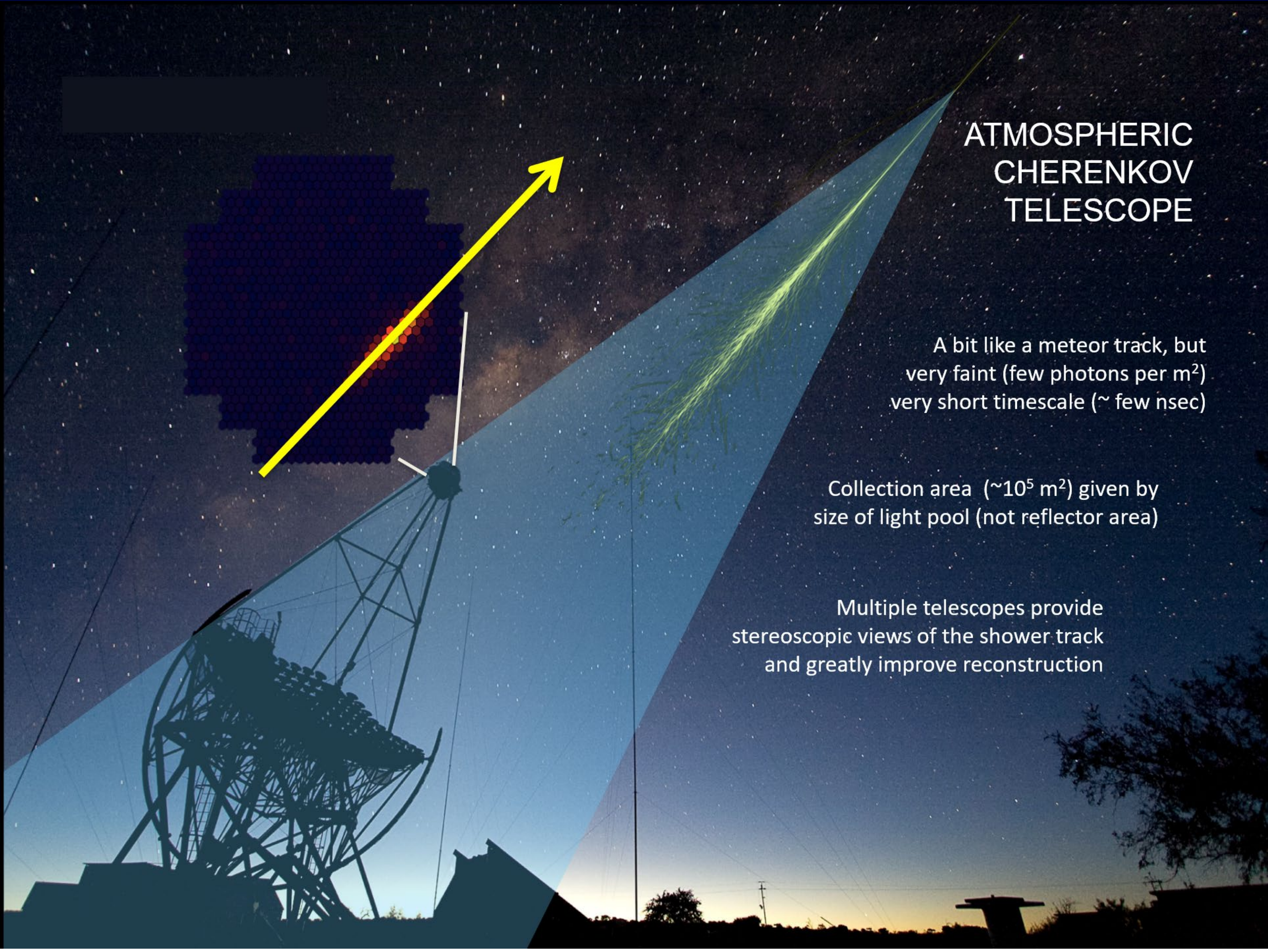
Gamma rays provide the most direct information on the HE universe

Gamma rays

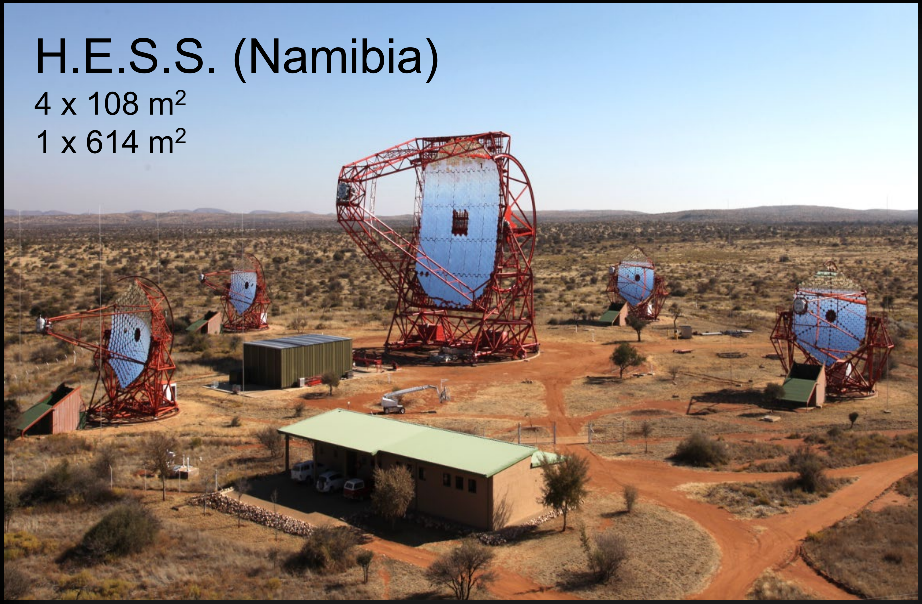


Ground-based gamma-ray Telescopes

- **Ground-based telescopes use the <u>atmosphere of the Earth</u> to detect gamma rays.**
- **A gamma ray interacts to create a shower of particles (e^-,e^+) moving at very high speeds. These particles emit light at visible wavelengths – <u>Cherenkov light</u>.**
- **The light is beamed to the ground and arrives in a few nano-seconds (ns) as a disk of diameter ~250m.**
- **On dark nights, the Cherenkov light is captured by large mirrors and measured in cameras made of <u>high-speed optical sensors</u> – photomultiplier tubes or Silicon detectors.**
- **The <u>camera images</u> are recorded as digital streams of data and analyzed by computers.**


[redacted]
ATMOSPHERIC CHERENKOV TELESCOPE
A bit like a meteor track, but
very faint (few photons per m²)
very short timescale (~ few nsec)
Collection area (~10⁵ m²) given by
size of light pool (not reflector area)
Multiple telescopes provide
stereoscopic views of the shower track
and greatly improve reconstruction

Ground-based atmospheric Cherenkov telescopes in 2023



What is CTA?

CTA = CHERENKOV TELESCOPE ARRAY

- **Future major ground-based gamma-ray observatory.**
- **Two large arrays of atmospheric Chereknov telescopes.**
- **Two sites: La Palma (Spain), Paranal (Chile).**
- **Collaboration of ~1100 scientists from 26 countries.**
- **Construction starts this year; first data in ~2030.**

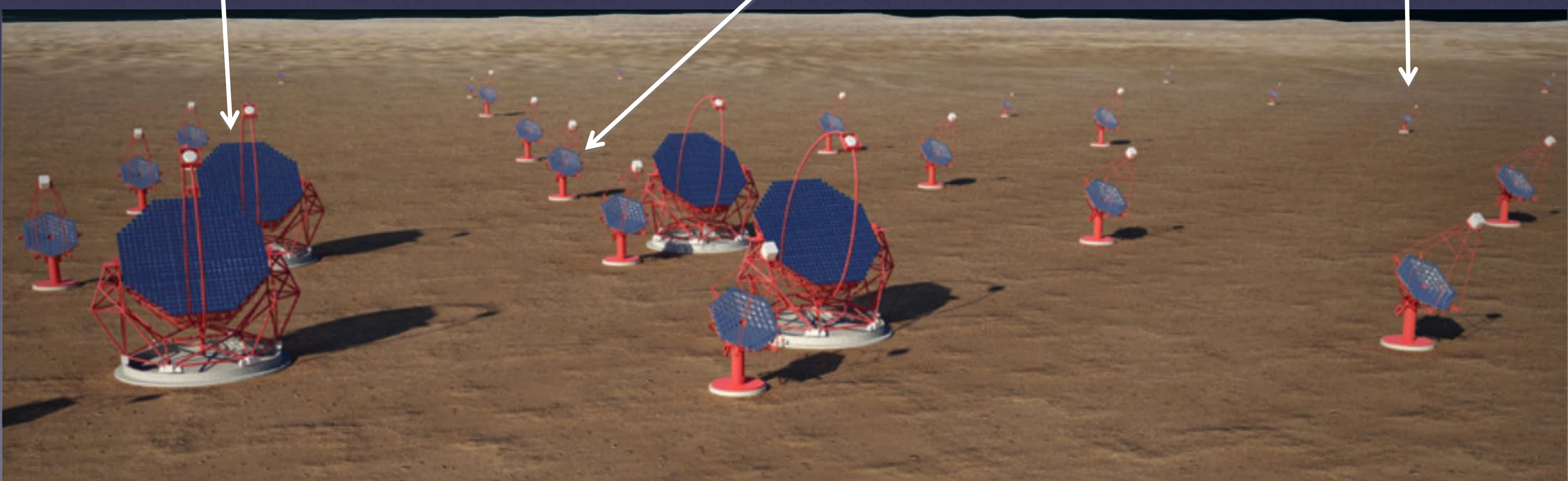
CTA-South Array

55 telescopes covering an area ~ 10 km^2

Large-Sized Telescopes
4 x 23m diameter

Medium-Size Telescopes
14 x 23m diameter

Small-Sized Telescopes
37 x 4m diameter

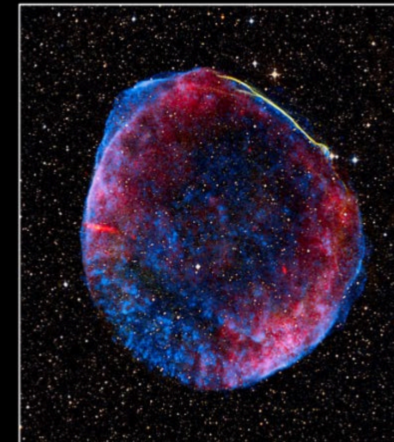


CTA SCIENCE

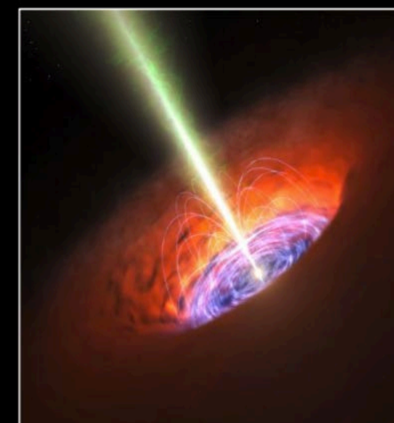
Particle acceleration in extreme astrophysical objects, such as neutron stars and black holes.

Physics frontiers such as dark matter.

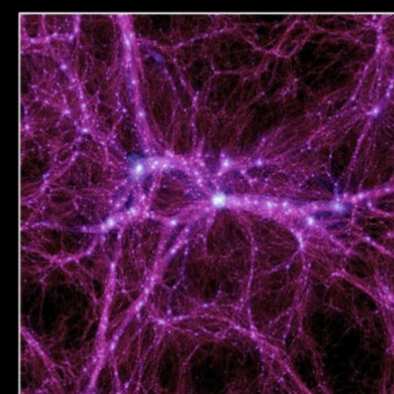
Theme 1:
Cosmic Particle Acceleration



Theme 2:
Probing Extreme Environments



Theme 3:
Physics Frontiers



First CTA Telescope

SUMMARY

cherenkov telescope array

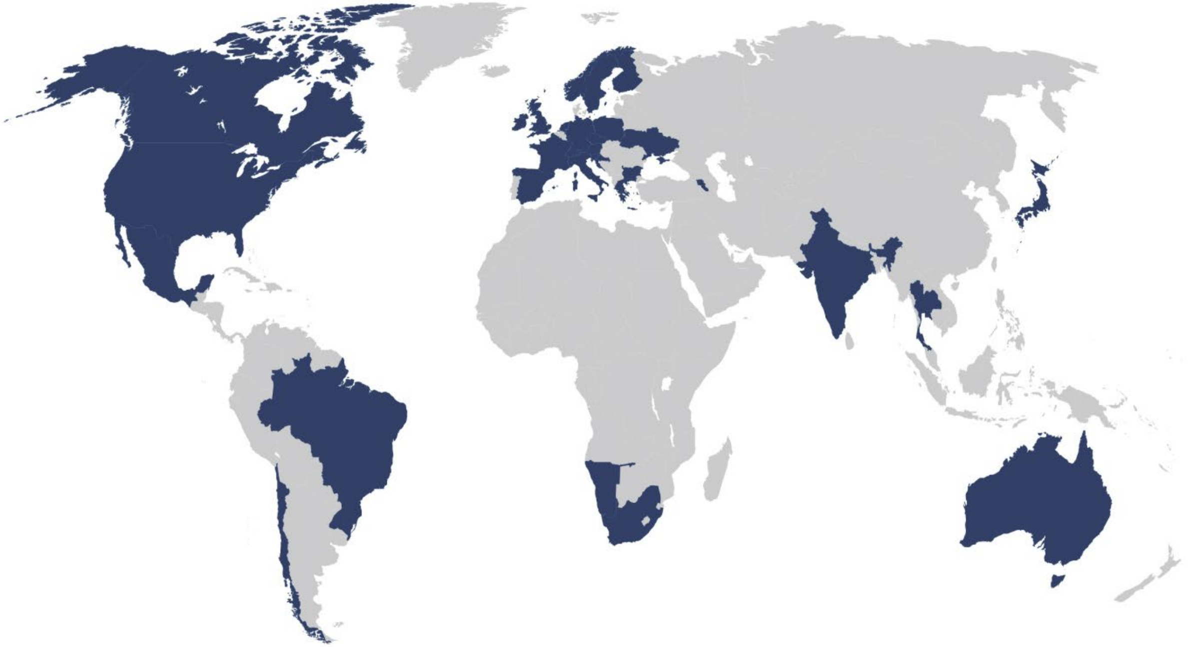
- **Gamma-ray astronomy is an exciting field of scientific research.**
- **The telescopes study black holes, neutron stars, violent collisions and dark matter.**
- **CTA is the future gamma-ray observatory, with first data in ~2030.**
- **https://www.cta-observatory.org/**

rene@astro.ucla.edu

GRAZIE !

BACKUP

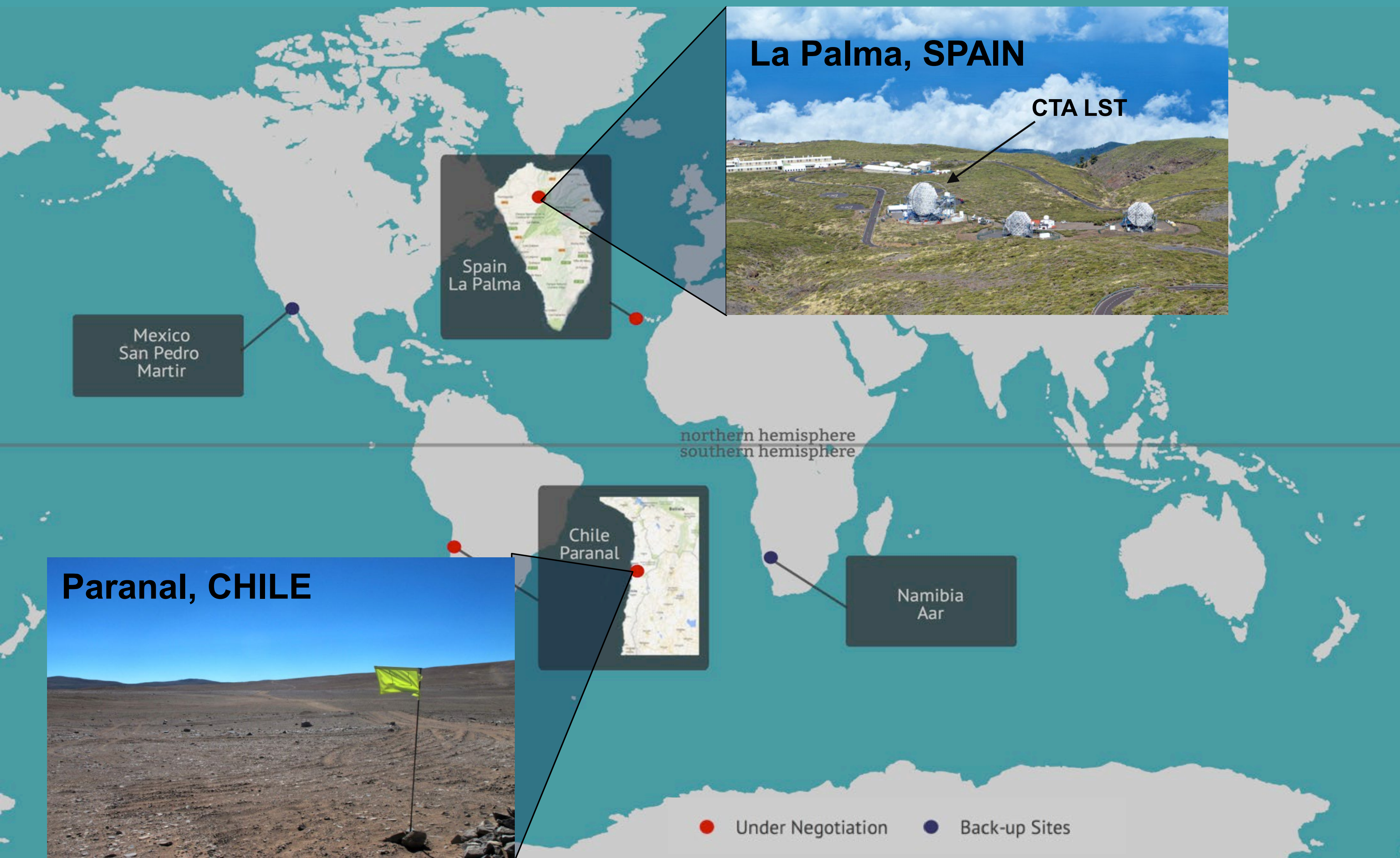
First CTA Telescope



CTA Consortium
~1100 scientists/engineers
165 institutes in 26 countries

Bologna, Oct 2019

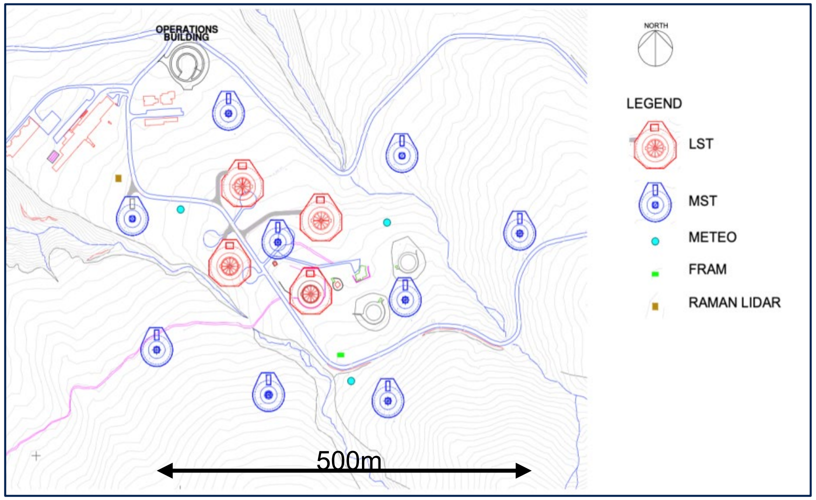
Selected Sites for CTA



CTA Initial Configuration

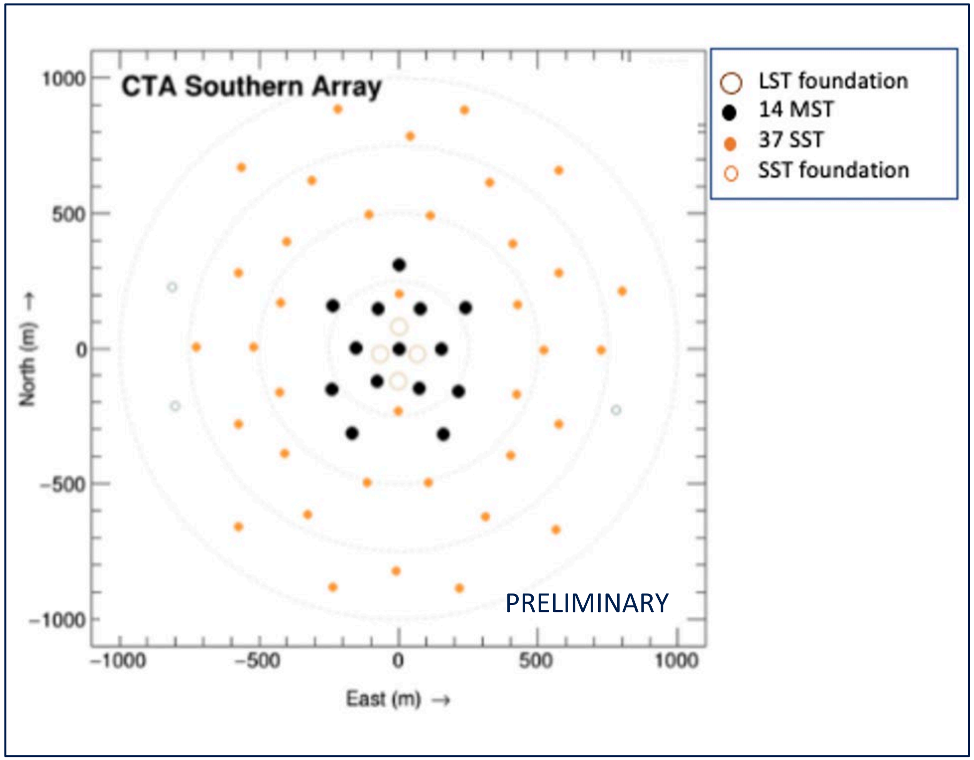
CTA Northern Array

- **4 LSTs + 9 MSTs**
- 0.25 km^2 footprint
- construction already started



CTA Southern Array

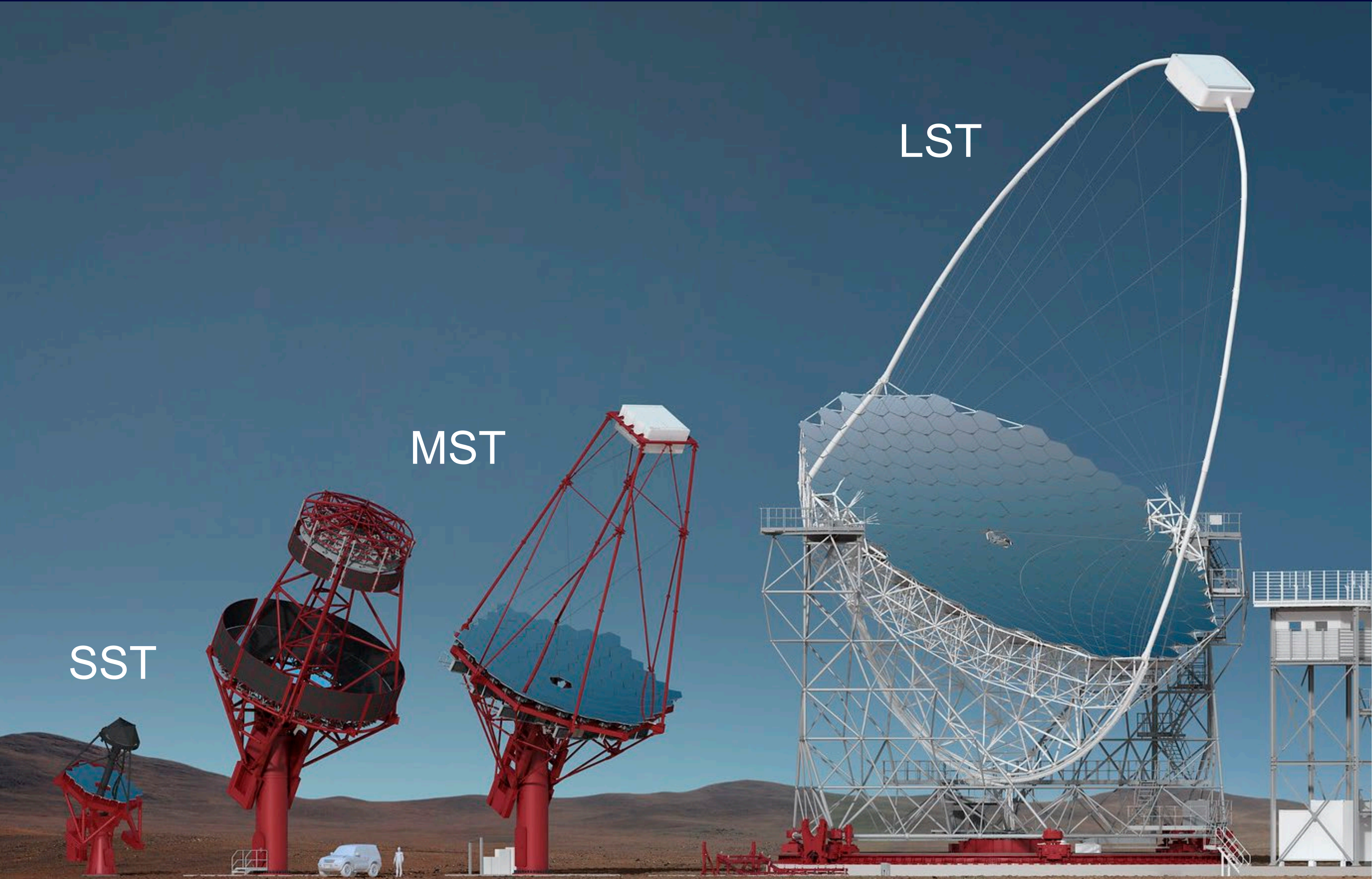
- **14 MSTs + 37 SSTs**
- 3 km^2 footprint
- construction start in 2022



ESO/PARANAL

- Atacama Desert, Chile
- Below Cerro Paranal
- Existing observatory, under management by European Southern Observatory (ESO)
- Near a set of existing (VLT) and future (ELT) telescopes
- Site agreement still being worked on (Chile, ESO, CTA)

CTA Telescope Types



23 m diameter / f = 28m
390 m^2 dish area
1.5 m mirror facets

4.5^o field of view
0.1^o pixels
Camera Ø over 2 m

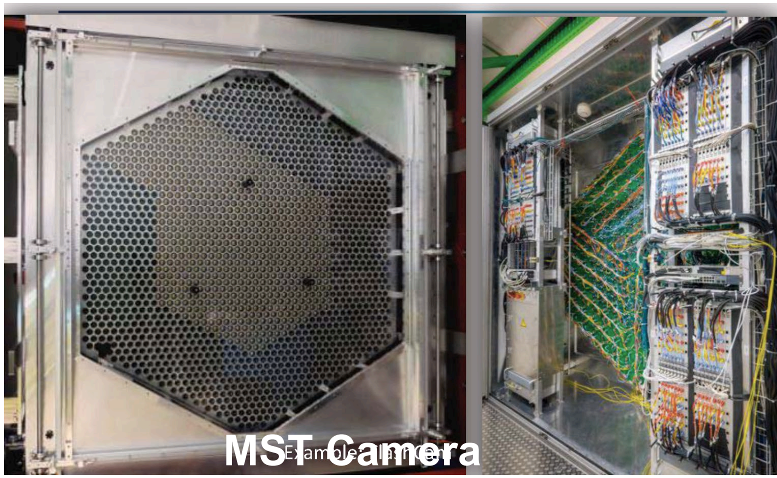
Carbon-fiber structure for 20 s positioning

Active mirror control

4 LSTs on North site
(4 LSTs on South site)

First LST taking data
(La Palma)

Medium Telescope (MST)



Prototype at DESY (Berlin)

12m diameter reflector
$100m^2$ mirror dish area
16 m focal length
1.2 m mirror facets

8^o field of view
~2000 x 0.18^o pixels

15 MSTs on North site
25 MSTs on South site

Small Sized Telescopes (SSTs)

- 3 different prototype designs
- 2 designs use two-mirror approaches (Schwarzschild-Couder design)
- All use Si-PMT photosensors
- 7-9 m^2 mirror area, FOV of 9^o
- Now merged into a single (SC) design

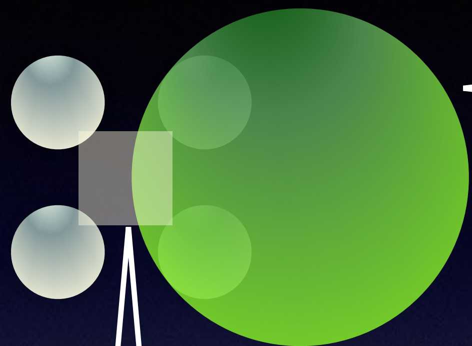
SST-1M
Krakow, Poland

SST-2M ASTRI
Mt. Etna, Italy

SST-2M GCT
Meudon, France

CTA → SHOWER CONTAINMENT

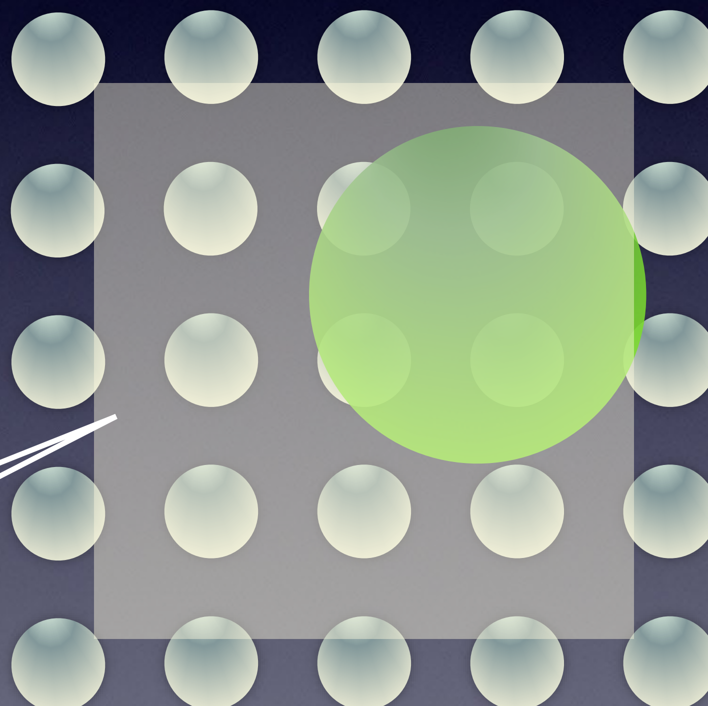
Current Instruments



Light pool radius
R ≈ 100-150m
≈ typical telescope Spacing

Sweet spot for best triggering & reconstruction…
most showers miss it!

CTA



- ✓ *Large detection Area*
- ✓ *More Images per shower*
- ✓ *Lower trigger threshold*

More images → Better reconstruction

→ Multiple views of shower

- Better measurement of air shower and hence primary gamma ray

  ✓Improved angular resolution

  ✓Improved background rejection

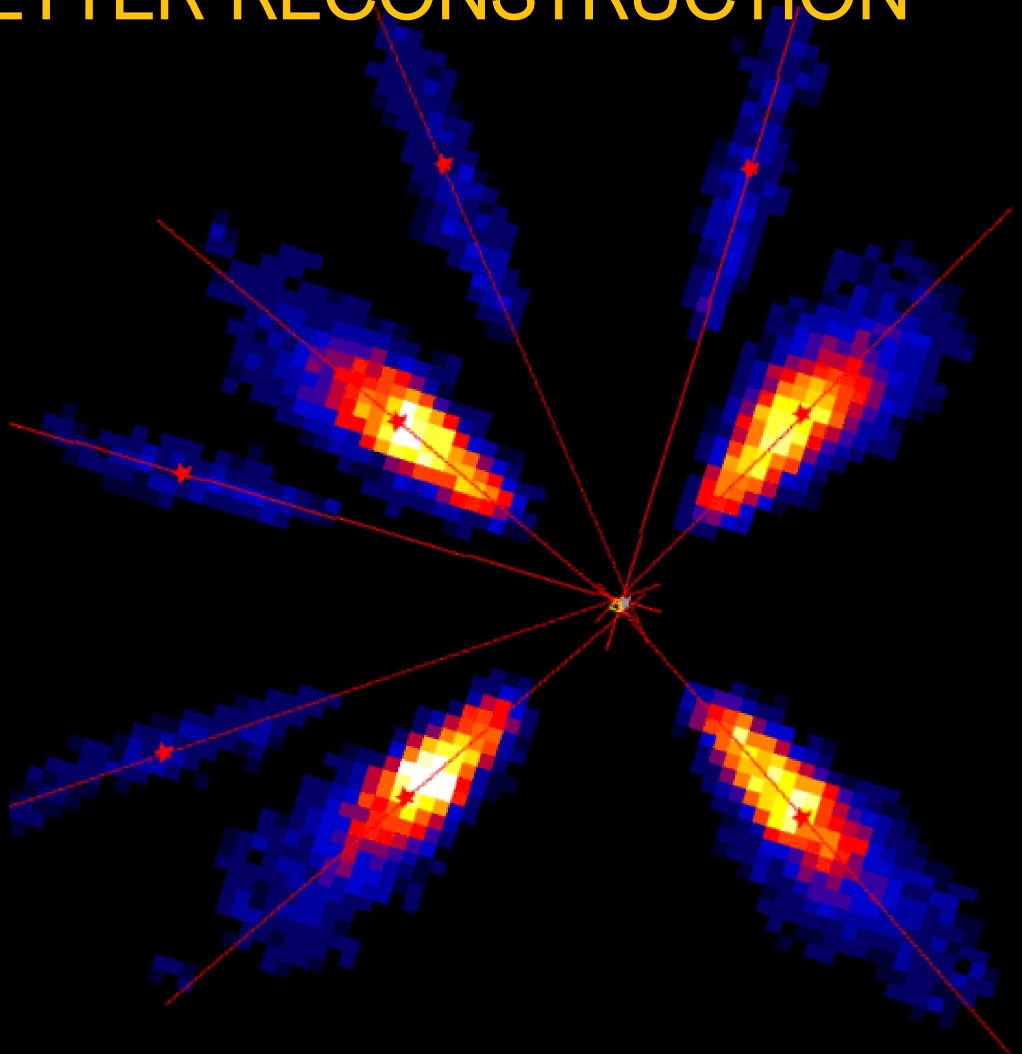
  ✓ Better spectra, images

- Collect more photons

  ✓ Larger light collecting area

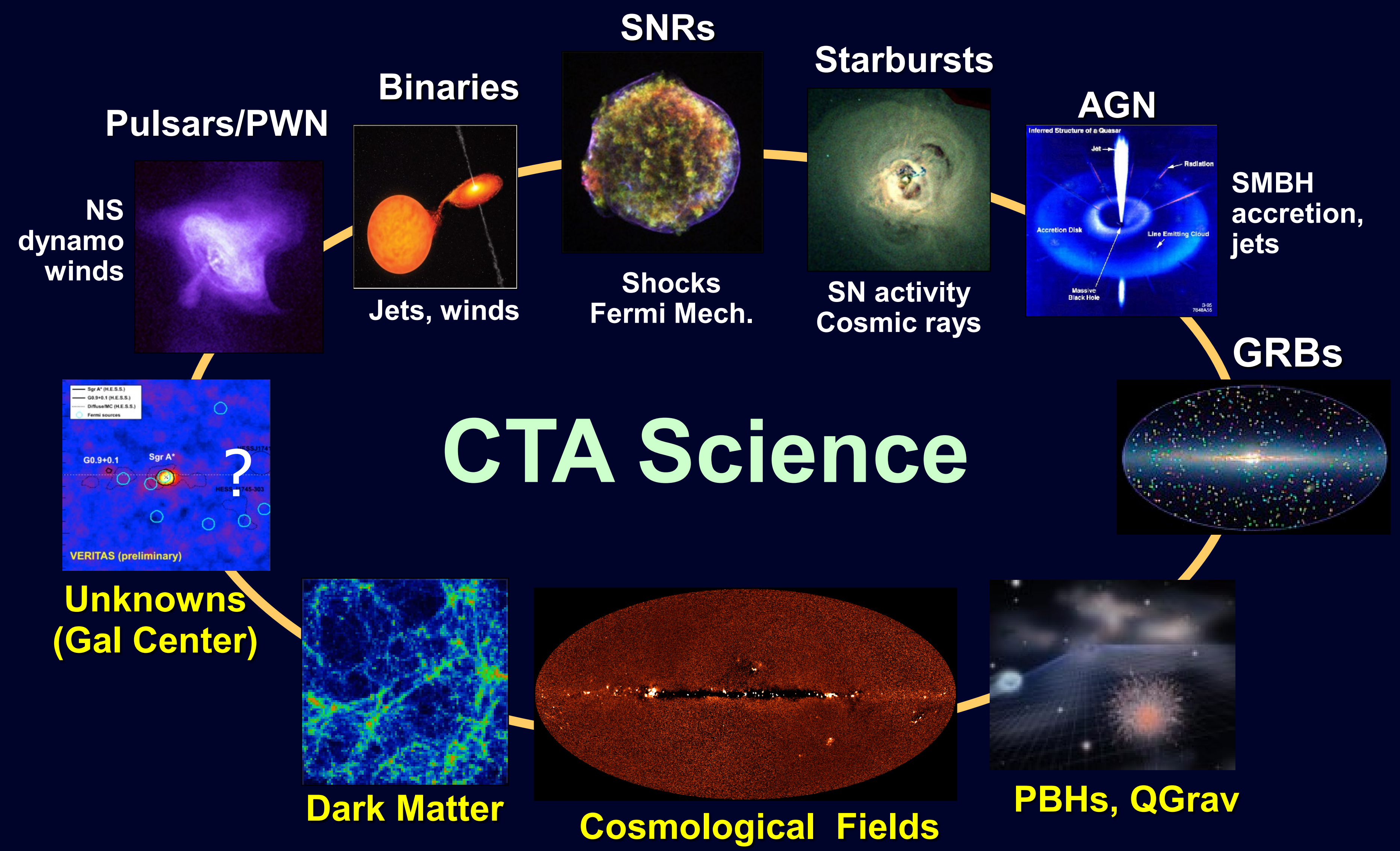
  → detect fainter sources

→ More telescopes!



Simulation:
Superimposed images from 8 cameras

Exploring the non-thermal Universe “ASTRO”



Probing New Physics at GeV/TeV scale “PARTICLE”