cherenkov telescope array

Part 2
Very High Energy gamma-rays

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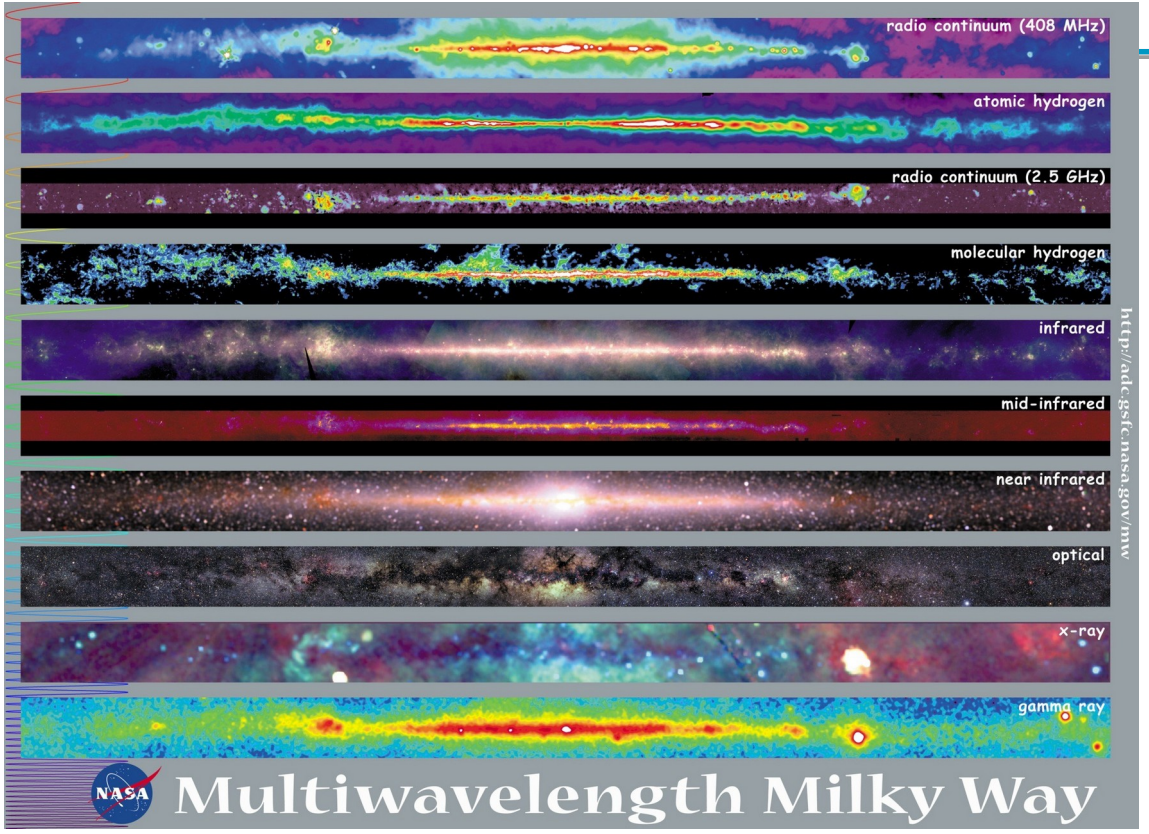
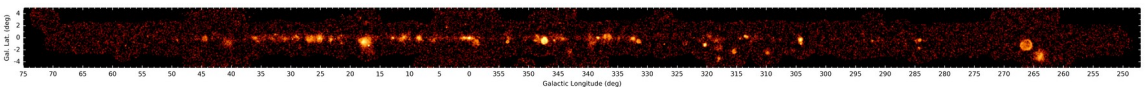
CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE
CPPM

Very High Energy gamma rays





μeV

10 μeV

meV

eV

1-3eV

keV

>keV

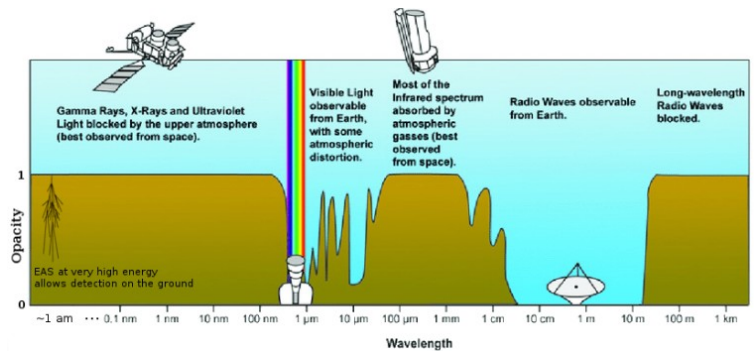
0.1-100 TeV

Energy

Very High Energy gamma rays are photons with individual energy = O(TeV)

At these energies:

- Absorbed by the atmosphere
- Particle fluxes are very low
  → Impossible to send large enough detectors in space



Very High Energy gamma rays

VHE γ-rays : 1 TeV absorbed in the atmosphere

Where does the energy go?

1 TeV = $2X10^6$ $m_{electron}$

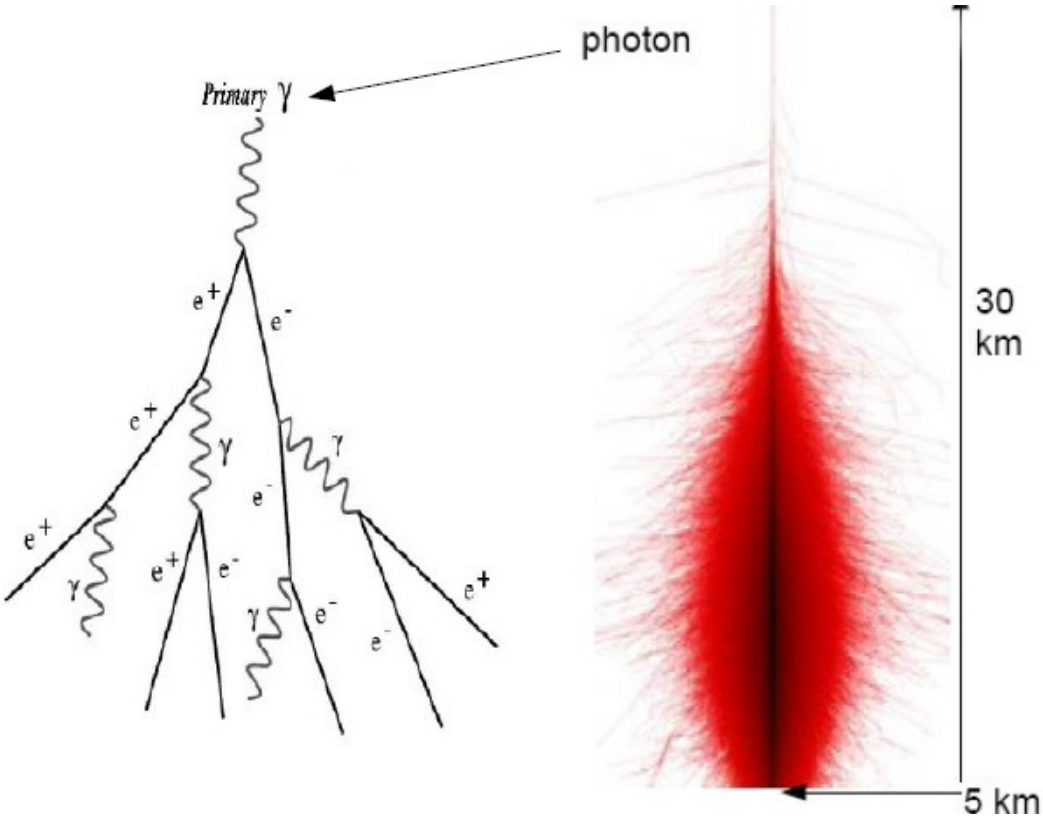
The photon initiates an Extensive Air Shower by alternating

- 1 photon → e^+e^- pair
- 1 e → 1 e + 1 photon by bremsstrahlung

e^+e^- pair created close to the start of the shower
are faster than light in the atmosphere

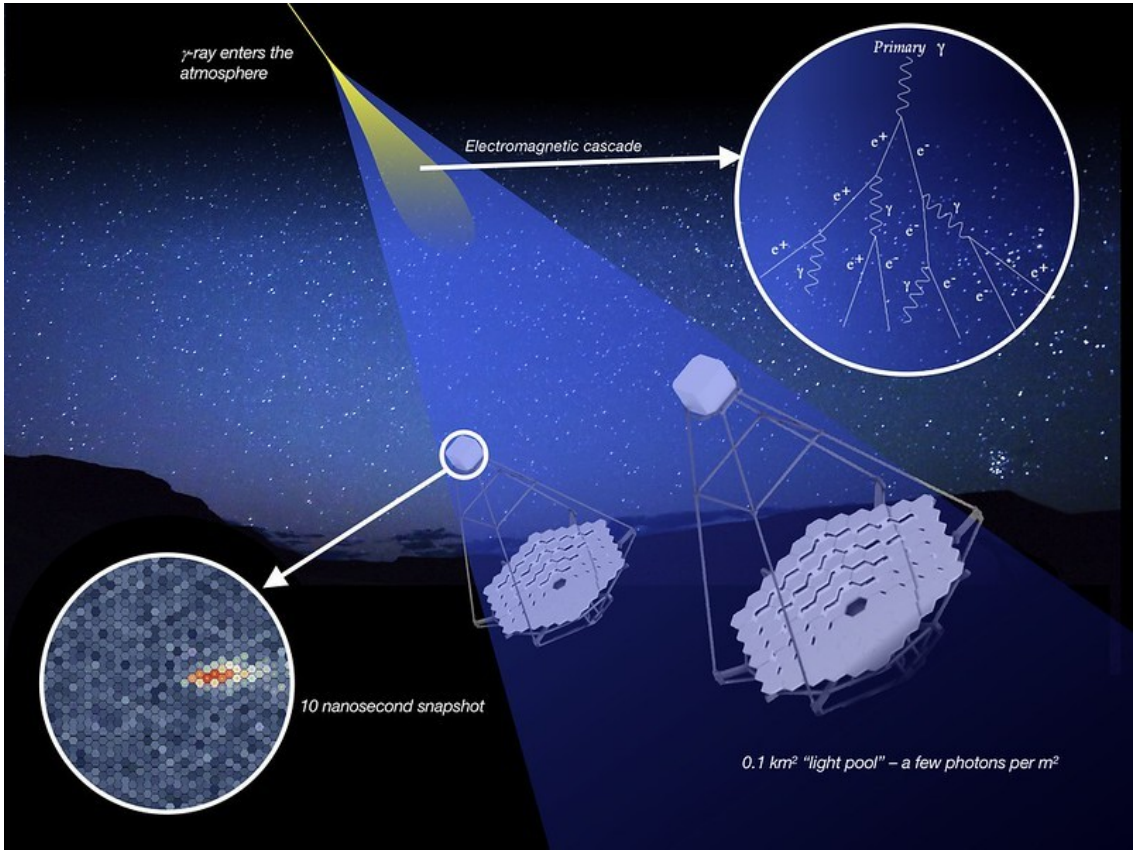
→ Cherenkov radiation

! Other energetic particles (protons,...) also initiate EAS

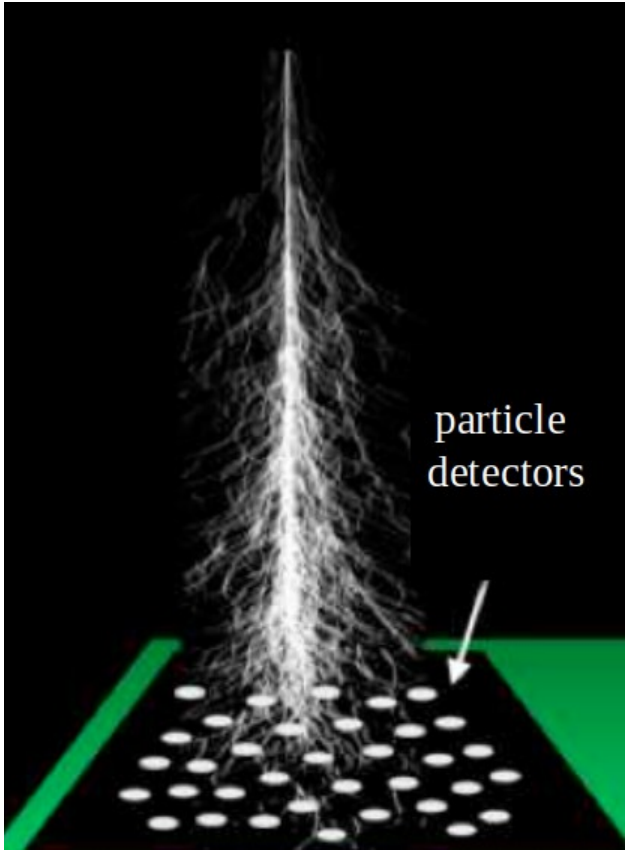


Very High Energy gamma rays indirect detection

Imaging Atmospheric Cherenkov Telescopes



Air shower arrays



The Cherenkov Telescope Array (CTA)

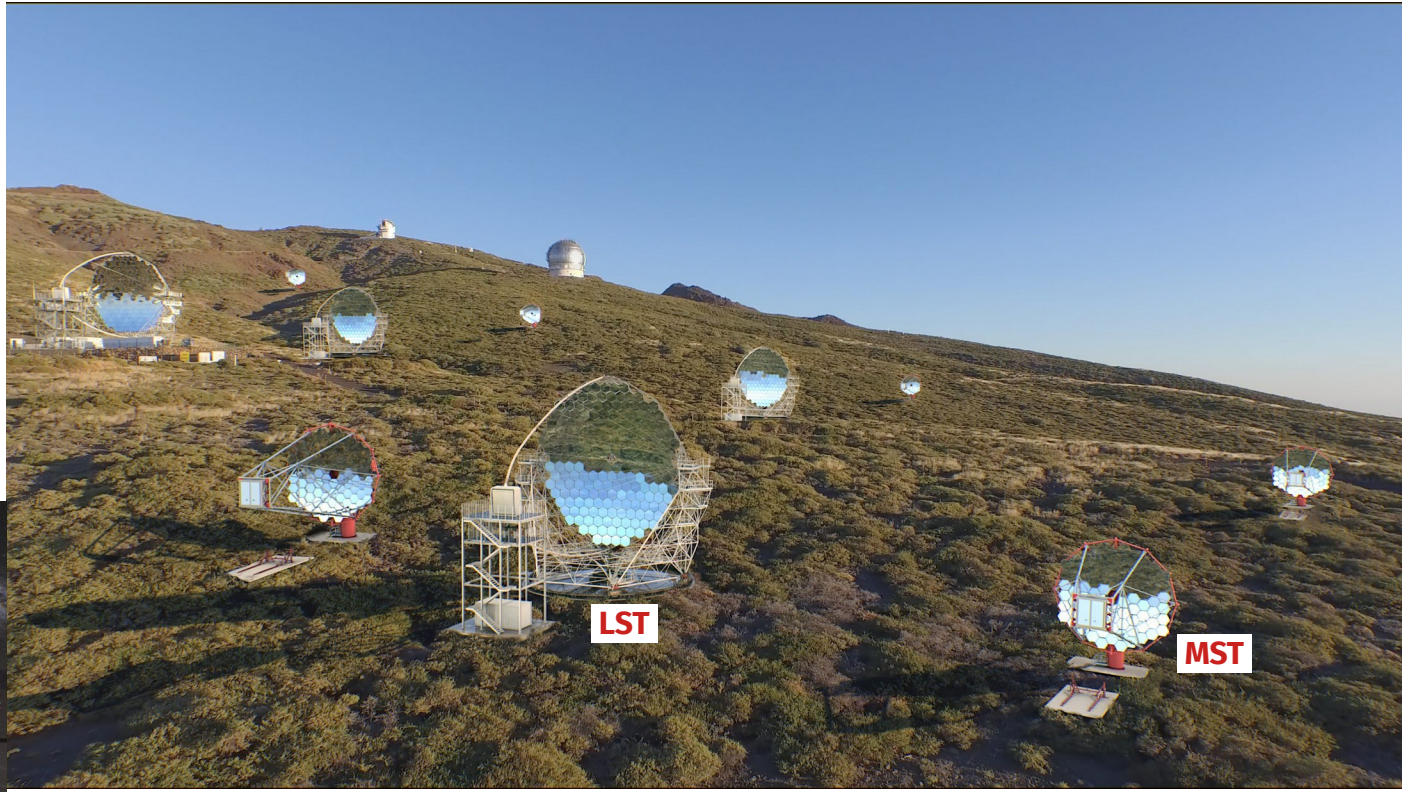
Two IACTs arrays on La Palma and in Chile

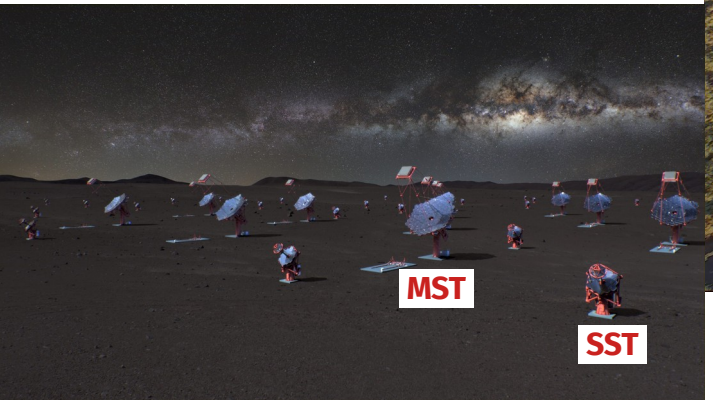
More than 50 telescopes in total

Sensitive between 20 GeV and 300 TeV
Thanks to 3 telescope models

Better than current instruments with , e.g.
10 times better sensitivity

Rendering of the northern array site, CTAO-North, located on La Palma (Spain). Credit: CTAO.





Rendering of the southern array site, CTAO-South, located in Chile. Credit: CTAO.

The Large Sized Telescope(s) on La Palma Island

CTA construction began on both sites
The first LST was installed in 2018.

Ongoing construction of 3 LSTs

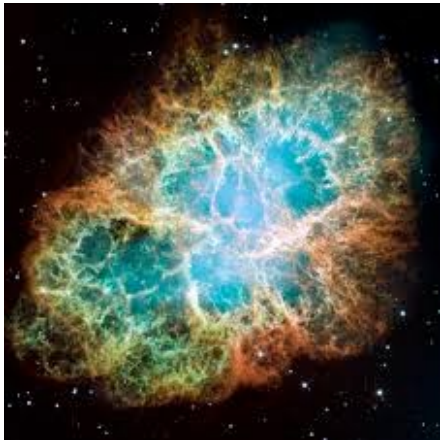
LST :

- Most sensitive CTA telescope between 20 and 150 GeV, but can observe up to O(10) TeV alone
- 23 meters mirror diameter
- 1855 pixels in the camera (Photo-multiplier tubes → sensitive to single photons)
- 103 Tonnes re-pointing in less than a minute

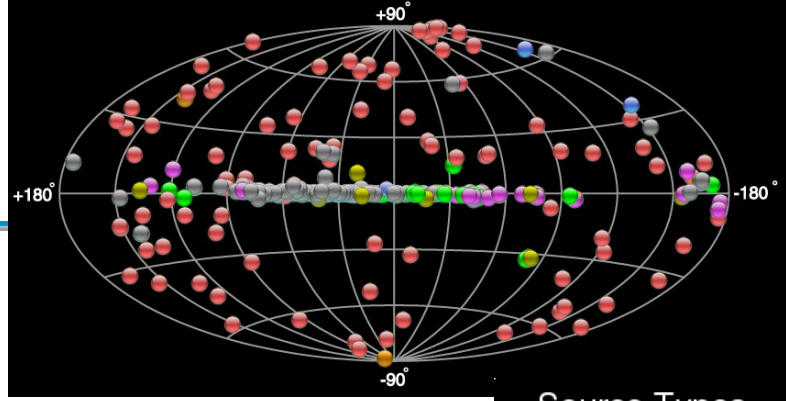
Source overview

relativistic jets from supermassive black holes
(Micro-quasar, quasar, AGN)

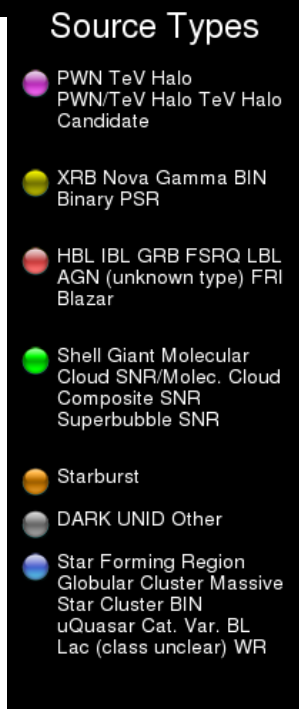
Neutrinos



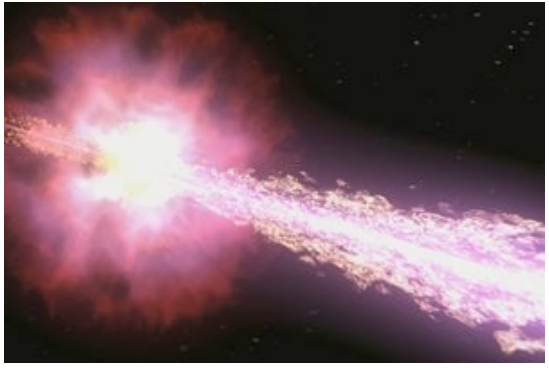
shock waves produced by a (***SuperNova***)
Galactic cosmic-rays



Dark Matter?



Gamma Ray Bursts

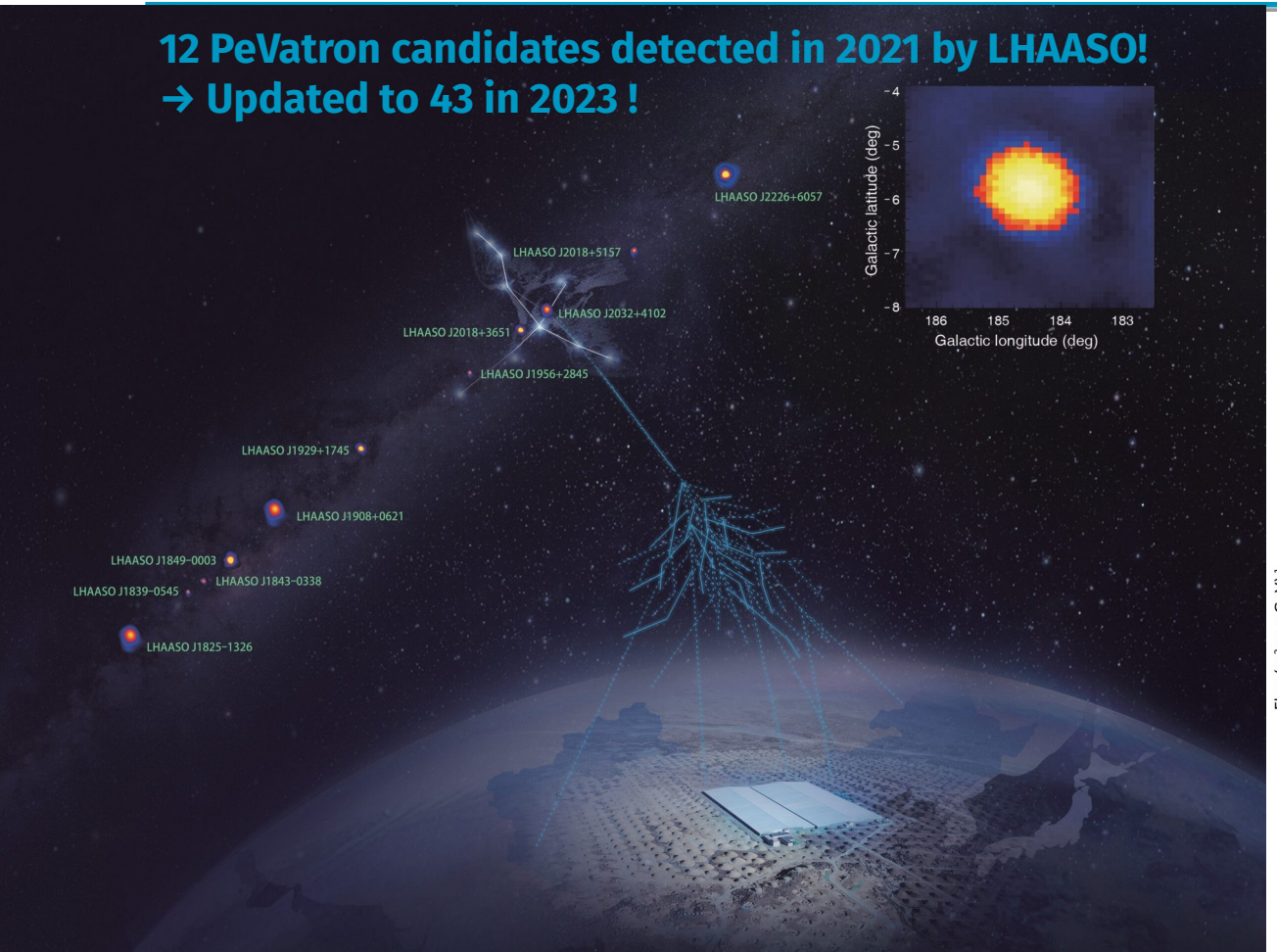


Neutrinos, GW

Sources of VHE γ-rays are extreme objects:

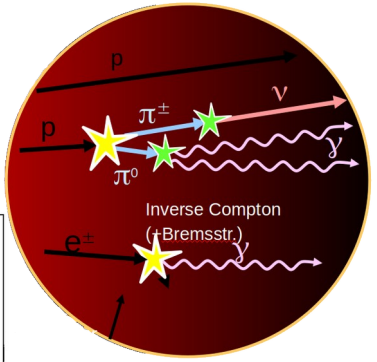
- In the galaxy : Supernovae remnant, micro-quasar, pulsars, Pulsar Wind Nebulae, …
- In the universe : Active Galactic Nuclei, Gamma Ray Bursts, …

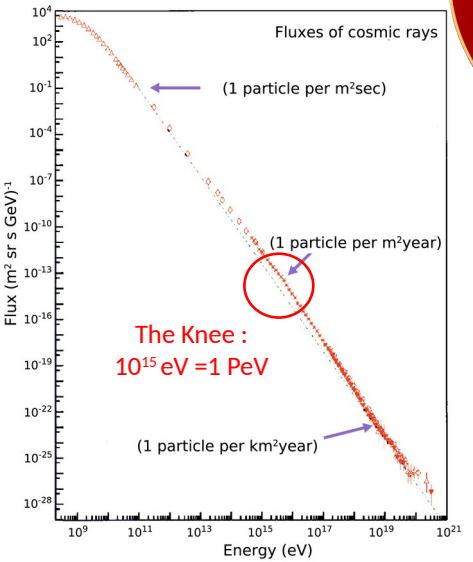
PeVatron search



PeVatrons are the sources of the most energetic galactic Cosmic-rays

PeV hadrons → 100+ TeV photons, and neutrinos





Work at CPPM

Analysis of LST-1 data, with possibility of combining with IACTs of the MAGIC experiments

Search for PeVatron : observation of the Boomerang SNR

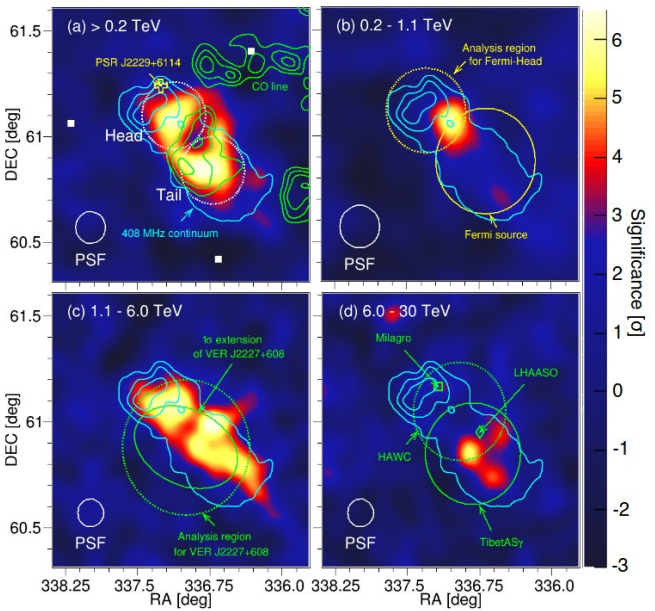
→ Work on analysis pipeline for observations at low pointing altitude (event reconstruction, background maps, ...)

→ Optimisation at highest energies : confirm potential as PeVatron, morphological studies

→ relation between emissions and SNR, PWN, molecular clouds?

Possible new studies on other sources (e.g. from the LHASSO catalogue)

Possibility of internship on different activities on observation data or on future observations. Contact emery@cppm.in2p3.fr / costant@cppm.in2p3.fr



Boomerang SNR region observed by MAGIC (2021)