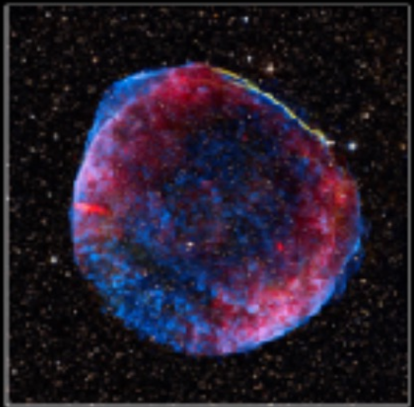
Astrofisica Nucleare e Subnucleare

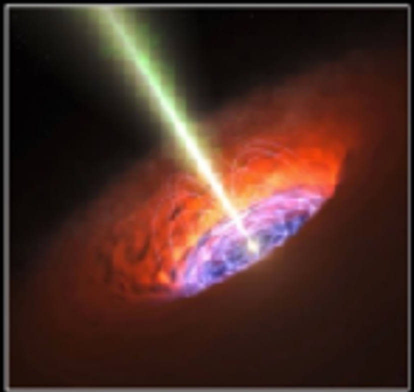
TeV Astrophysics

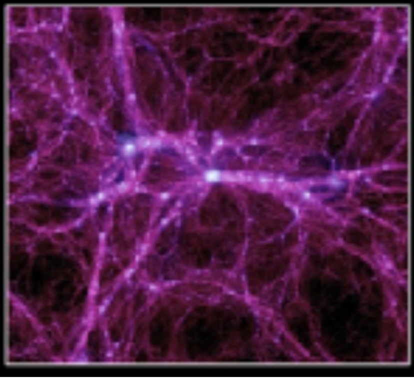
Astrofisica Nucleare e Subnucleare

Future detectors

Astrophysics with IACTs







- **COSMIC PARTICLE ACCELERATION**

What are the sites and mechanisms of particle acceleration in the cosmos?

- **EXTREME ASTROPHYSICAL ENVIRONMENTS**

The physics of neutron stars, black holes and their energetic environments, such as relativistic jets, winds and stellar explosions.

- **FUNDAMENTAL PHYSICS FRONTIERS**

Probing the nature of Dark Matter, the existence of axion-like particles, and Lorentz invariance violation cherenkov telescope array

The Science of CTA

CTA will target major science questions in high-energy astrophysics, through a large observational programme.

Sky Surveys

- Galactic and X-Gal Scan
- Dark Matter Programme
- Magellanic Clouds

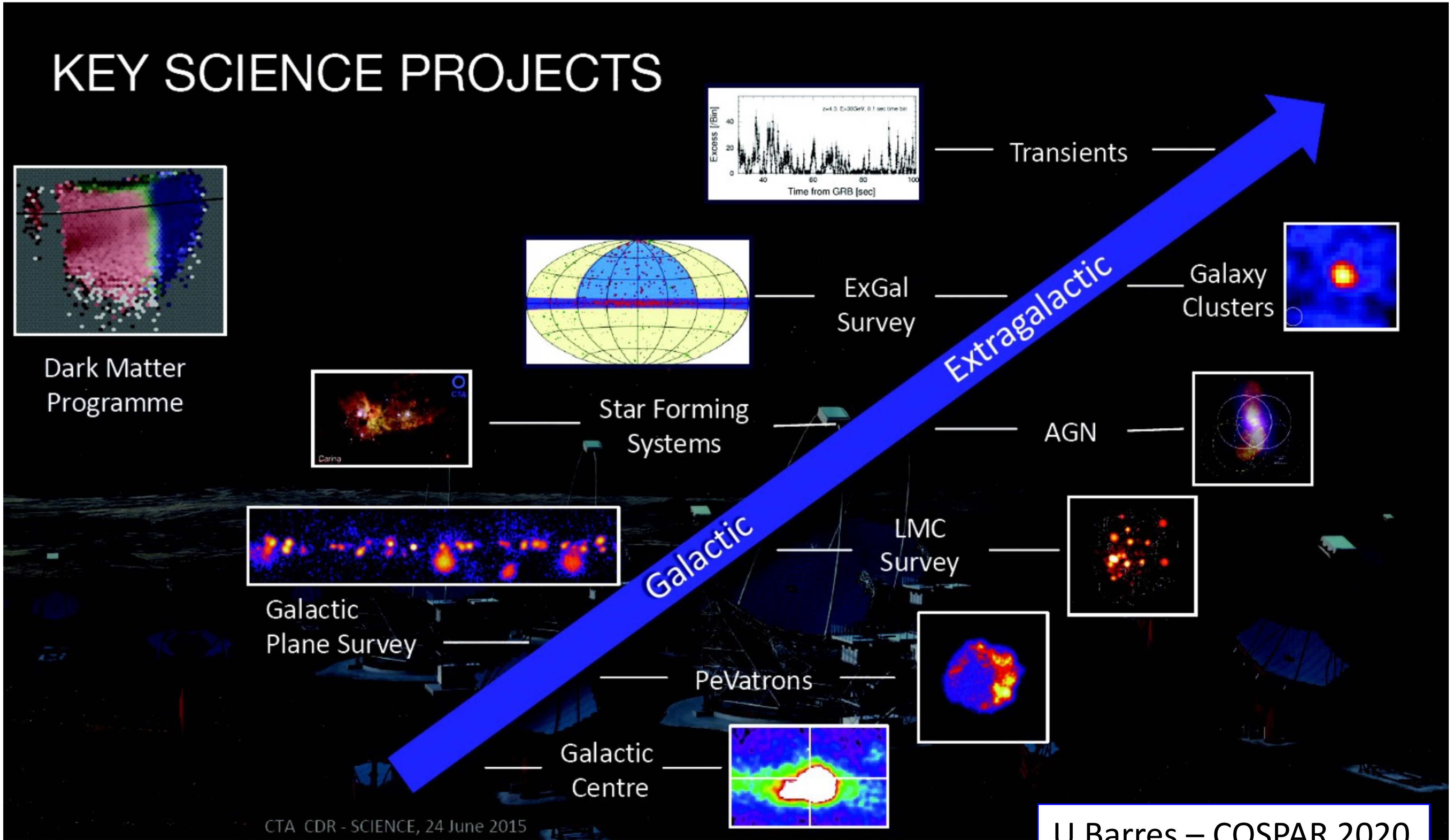
Deep Targeted Observations

- PeVatrons
- Star-forming Systems
- Radio Galaxies & Clusters

Follow-ups of Transient and Multi-messenger events

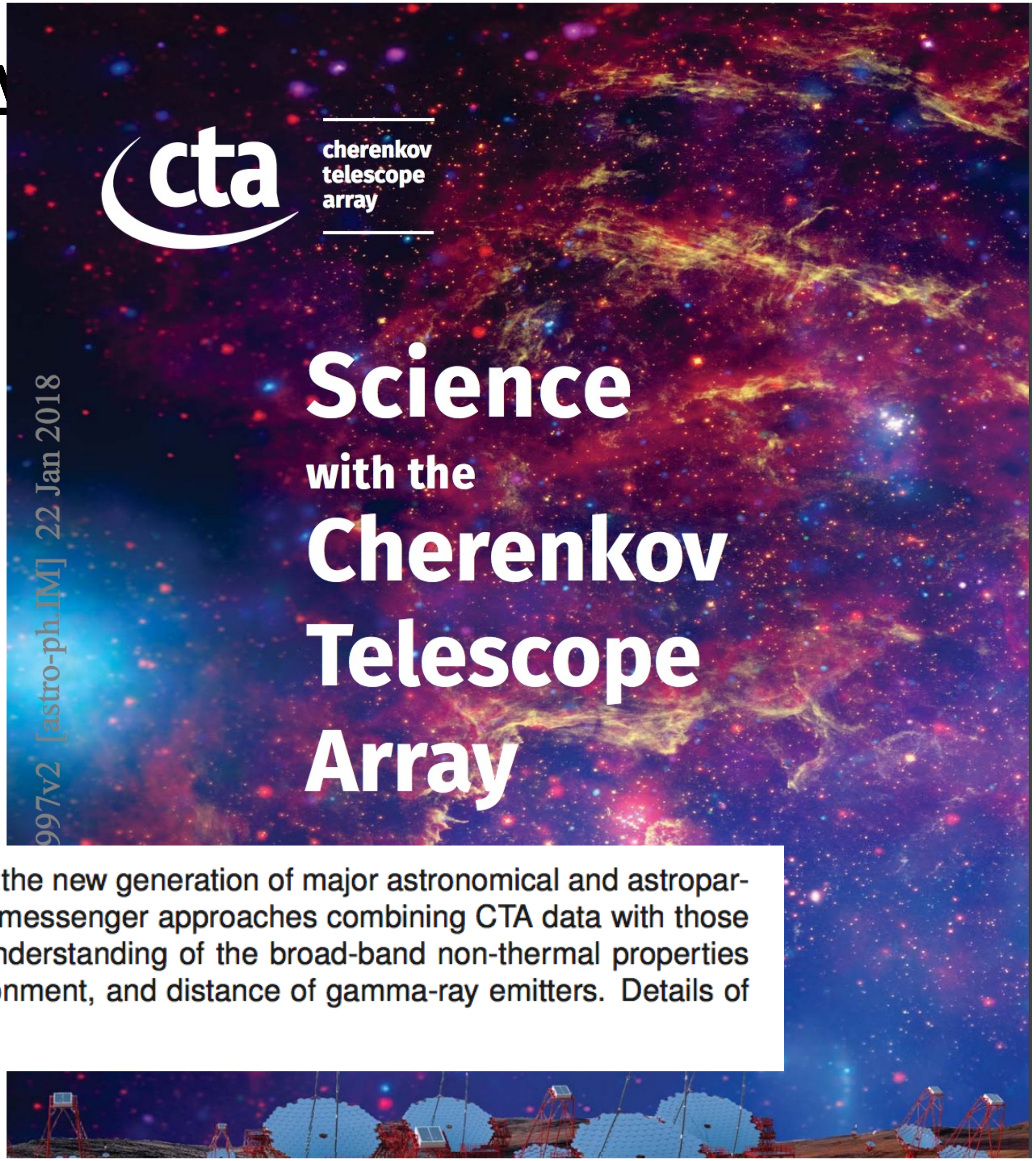
Monitoring of Variability notably of AGN

A Census of particle accelerators across all cosmic scales



U.Barres – COSPAR 2020

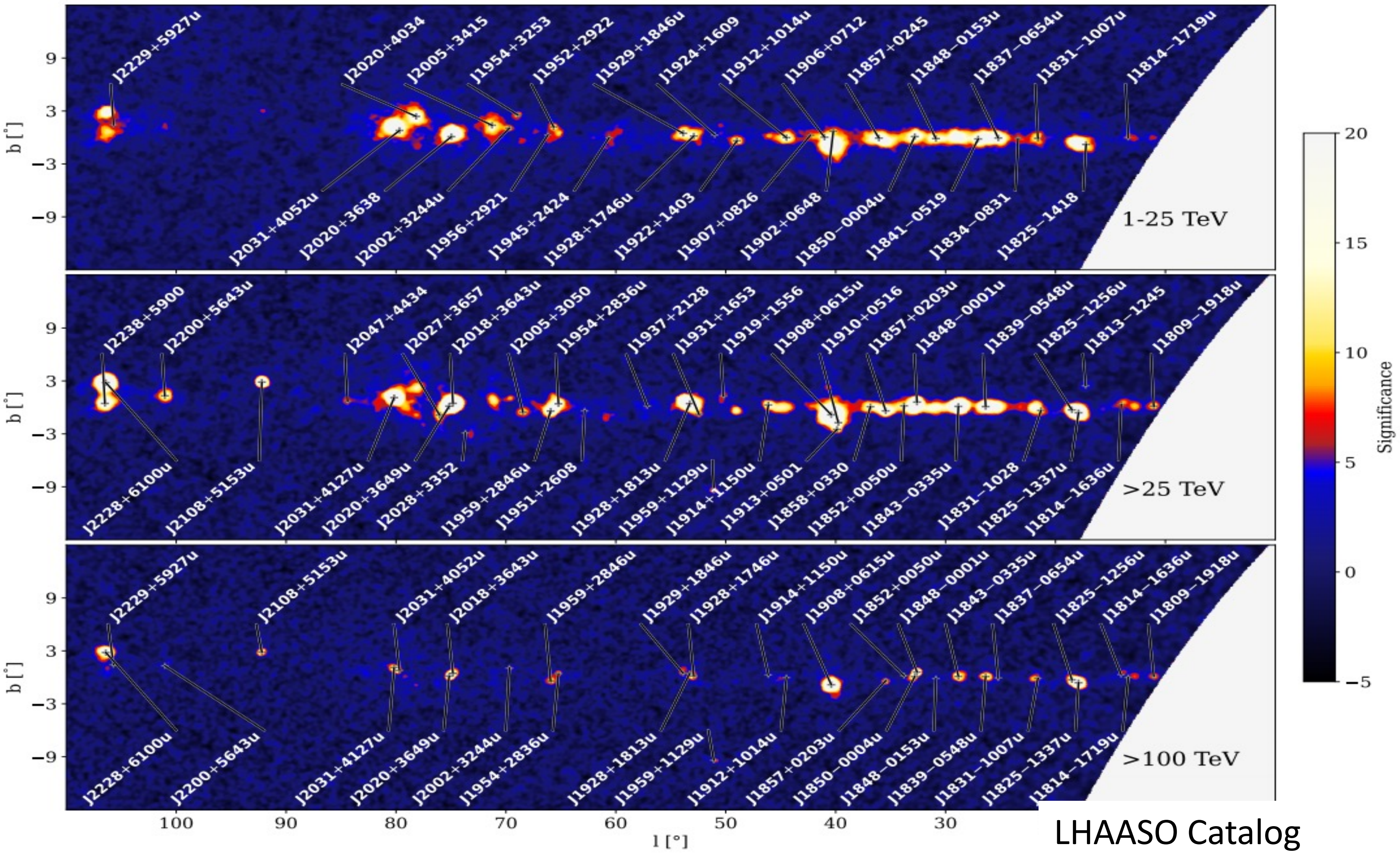
Science with CTA



CTA will have important synergies with many of the new generation of major astronomical and astroparticle observatories. Multi-wavelength and multi-messenger approaches combining CTA data with those from other instruments will lead to a deeper understanding of the broad-band non-thermal properties of target sources, elucidating the nature, environment, and distance of gamma-ray emitters. Details of synergies in each waveband are presented.

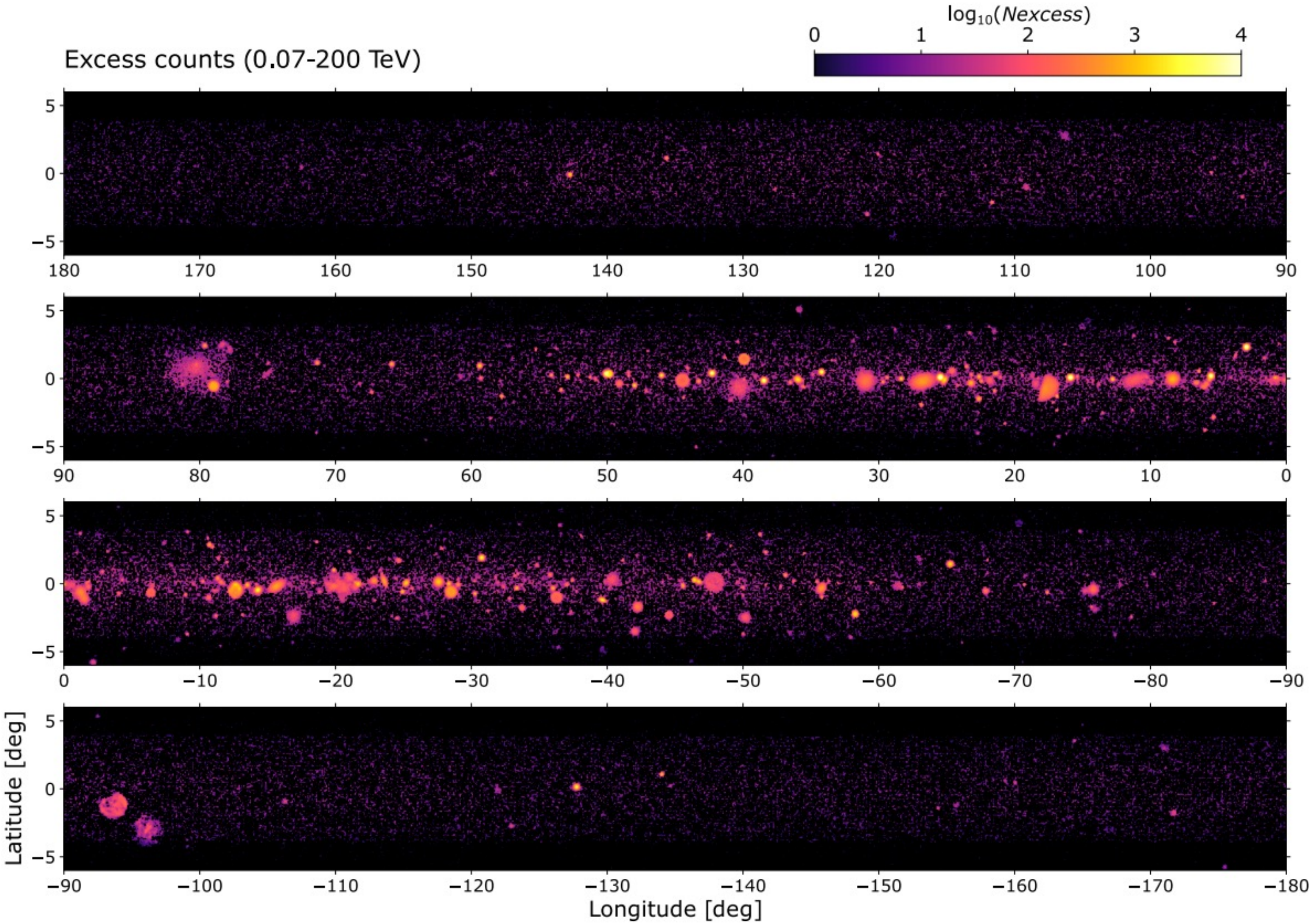
https://arxiv.org/abs/1709.07997

PeVatrons: the extreme energy frontier



LHAASO Catalog

Galactic Science with CTA



https://arxiv.org/pdf/2310.02828

The new window of VHE Gamma-ray Bursts

First time detection of a GRB at sub-TeV energies; MAGIC detects the GRB 190114C

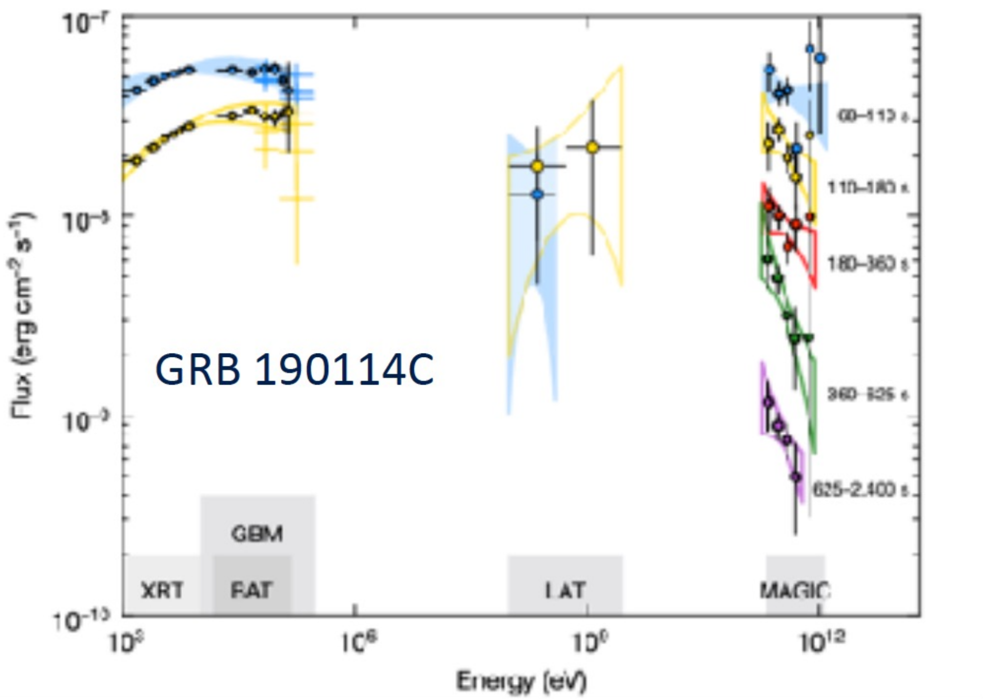
ATel #12390; ***Razmik Mirzoyan on behalf of the MAGIC Collaboration***
*on **15 Jan 2019; 01:03 UT***
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, Gamma-Ray Burst

Referred to by ATel #: 12395, 12475

Tweet

The MAGIC telescopes performed a rapid follow-up observation of GRB 190114C (Gropp et al., GCN 23688; Tyurina et al., GCN 23690, de Ugarte Postigo et al., GCN 23692, Lipunov et al. GCN 23693, Selsing et al. GCN 23695). This observation was triggered by the Swift-BAT alert; we started



Three long GRBs detections announced in the past two years:

- GRB 180720B (z=0.65)
- GRB 190114C (z=0.42)
  - Afterglow detected > 300 GeV
  - Huge statistics (1000s gammas)
  - Sub-minute timescale spectra
- GRB 190829A (z=0.08)

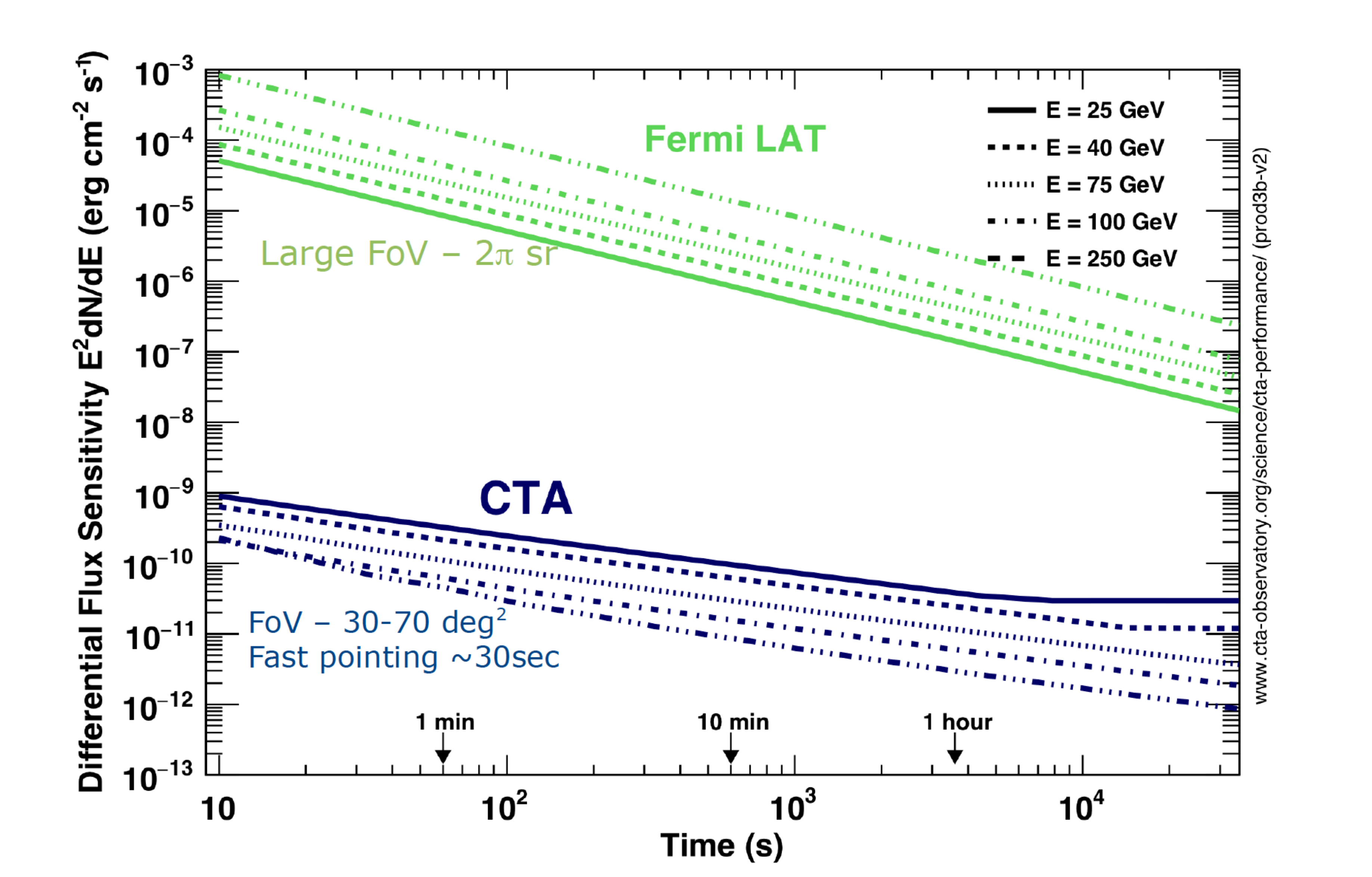
+ GRB 201216C (z = 1.1)

Strong MWL and MM synergies for spectral and variability studies

U.Barres – COSPAR 2020

Transients & Variable Sources: CTA Sensitivity vs. Time

(CTA Collab 2019)

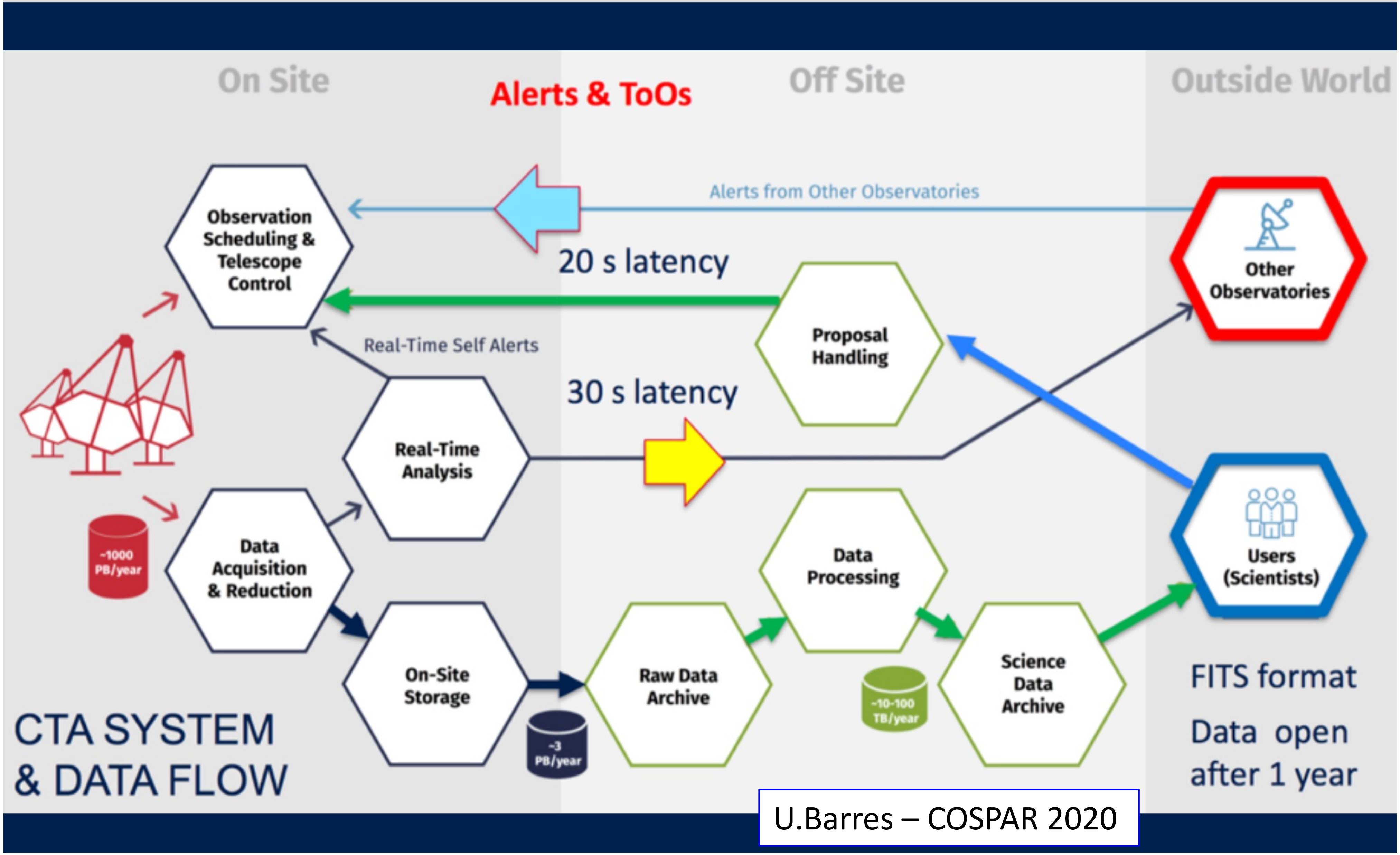


CTA >10,000 times more sensitive than Fermi-LAT in multi-GeV range

→ GRBs, AGN, giant pulses, FRBs, GW, SGR bursts...

G. Rowell – COSPAR 2020

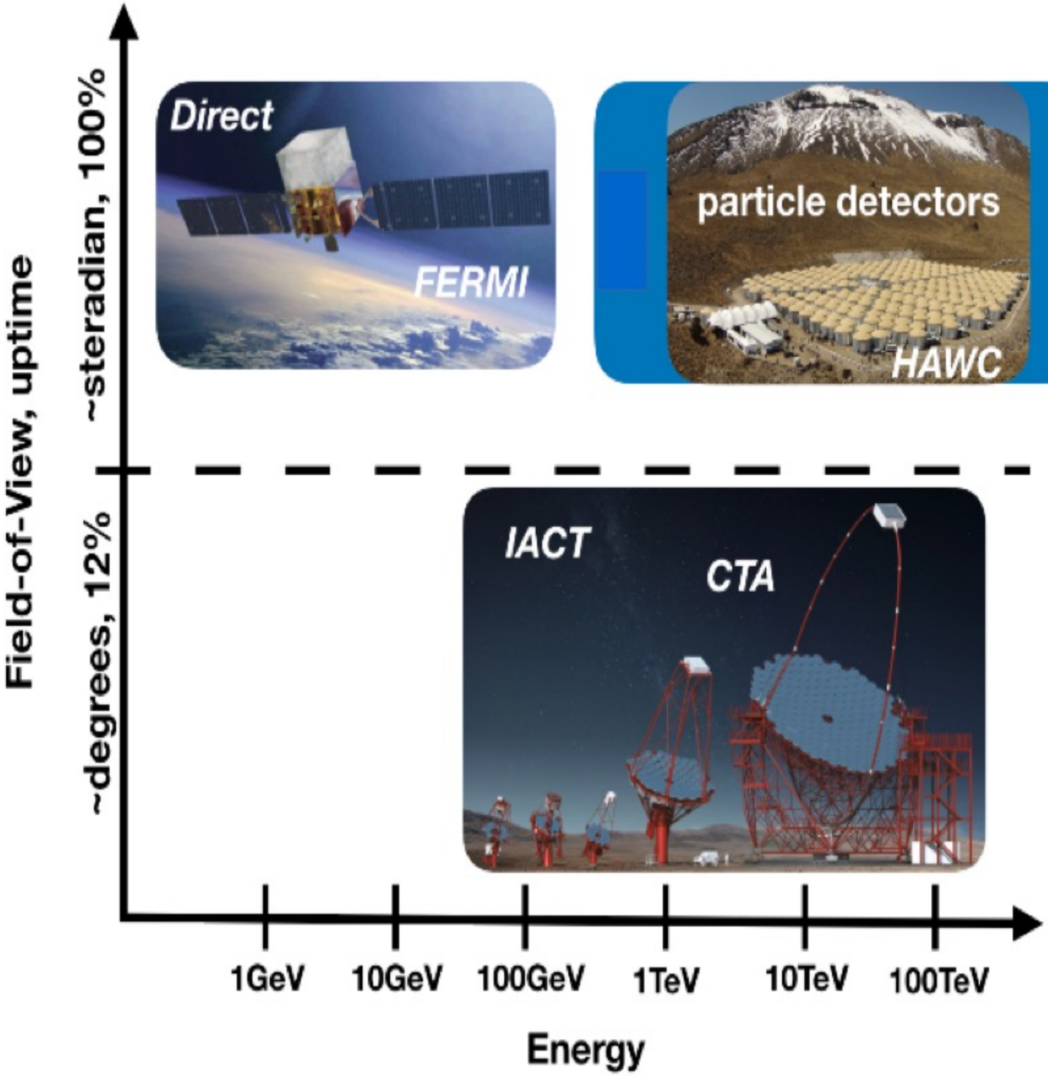
CTA Transients Science

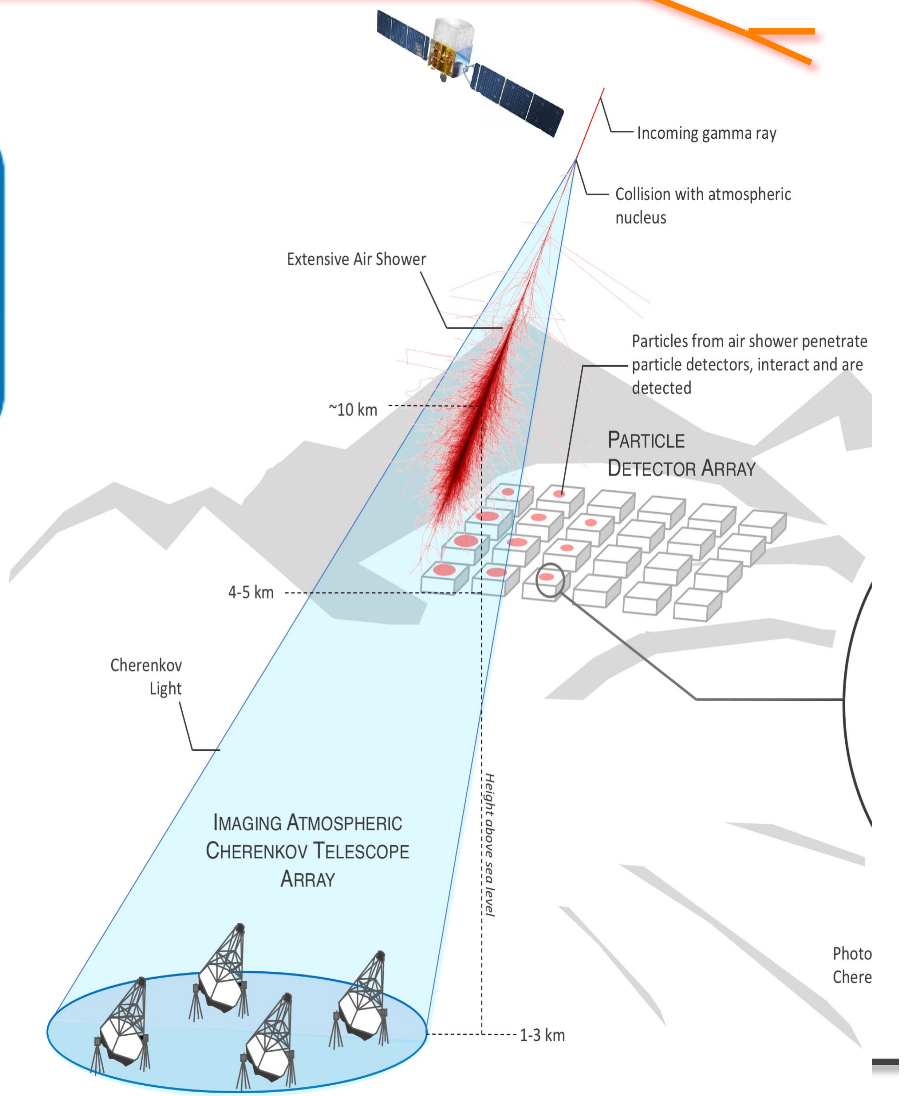


U.Barres – COSPAR 2020

SWGO
The Southern Wide-field Gamma-ray Observatory

Gamma-ray Astronomy



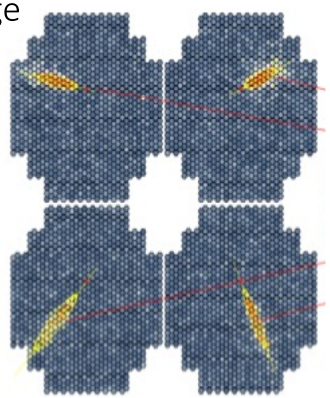


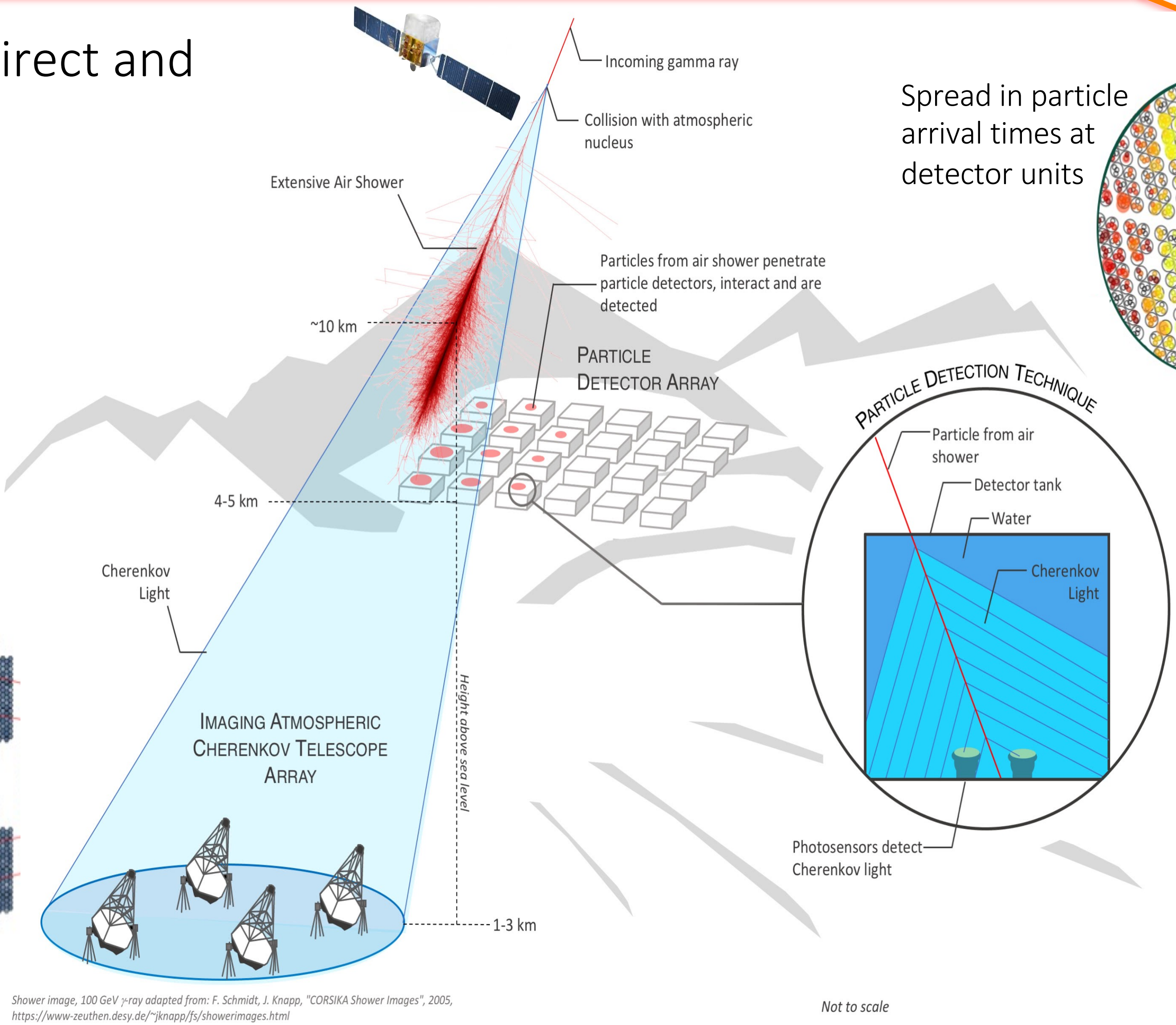
Shower image, 100 GeV γ-ray adapted from: F. Schmidt, J. Knapp, "CORSIKA Shower Images", 2005, https://www-zeuthen.desy.de/~jknapp/fs/showerimages.html

Gamma-ray Astronomy

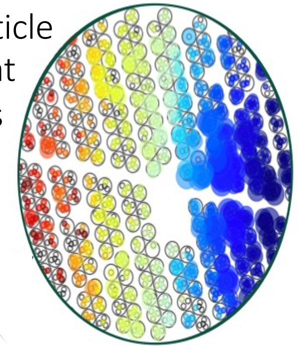
Complementary direct and indirect detection techniques

Atmospheric Cherenkov light image

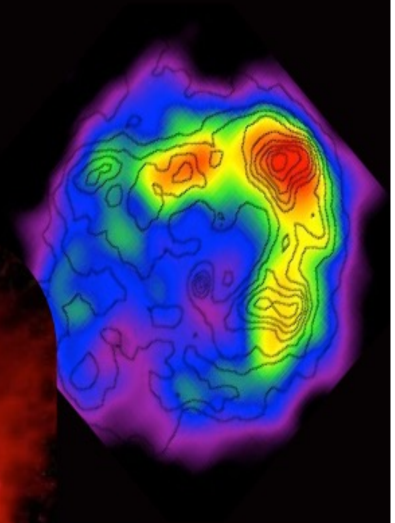


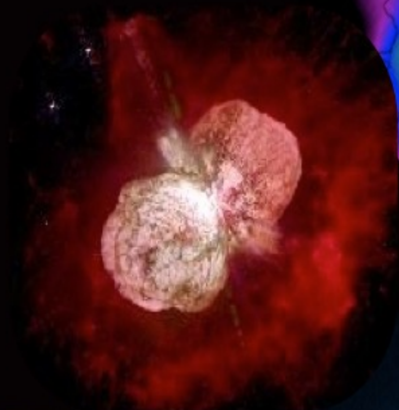


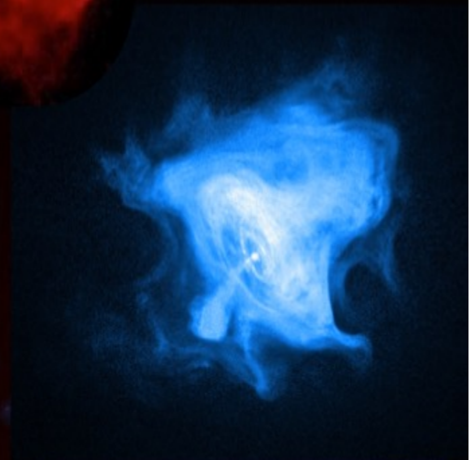
Spread in particle arrival times at detector units



- Astonishing variety of TeV* emitters
  - Within the Milky Way
    - Supernova remnants
    - Bombarded molecular clouds
    - Stellar binaries - colliding wind & X-ray
    - Massive stellar clusters
    - Pulsars and pulsar wind nebulae
    - Supermassive black hole Sgr A*
  - Extragalactic
    - Starburst galaxies
    - MW satellites
    - Radio galaxies
    - Flat-spectrum radio quasars
    - ‘BL Lac’ objects
    - Gamma-ray bursts
- Acceleration to TeV energies is common, gamma-rays are an effective probe
  - Strongly complementary to sync. measurements



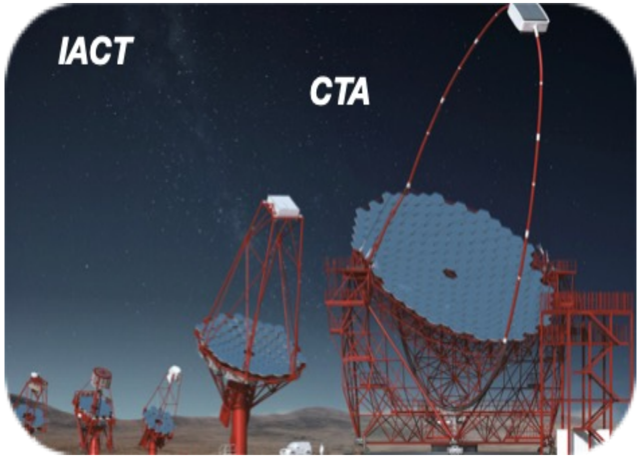


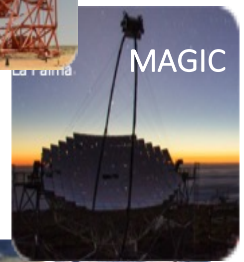


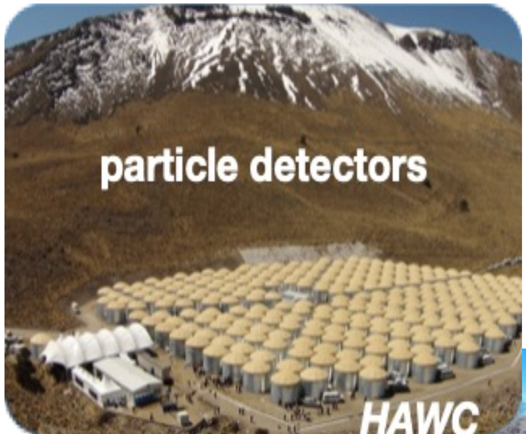
*0.05-50 TeV

Observational Panorama

- Cherenkov Atmospheric Telescopes
  - 20% duty-cycle
  - Pointing (few degrees FoV)
  - Energy threshold down to 10s GeV
  - Good energy and angular resolution

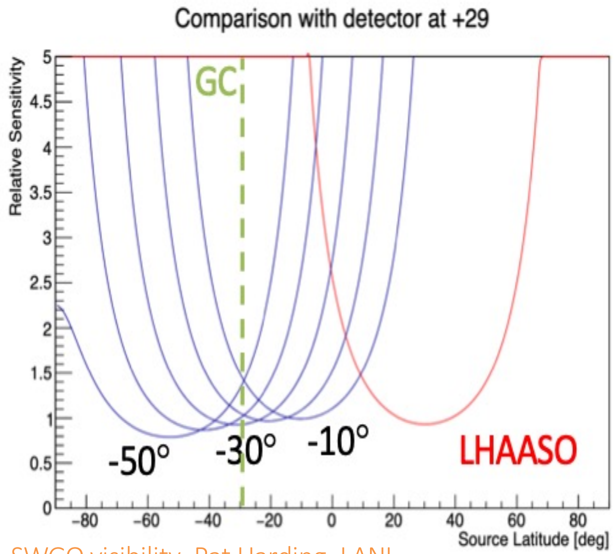






- Particle Detector Arrays
  - → 100% duty-cycle
  - → Wide-field of View (~ steradian)
  - → Energy range 100s GeV up to 100s TeV
  - → Continual view and accurate background determination

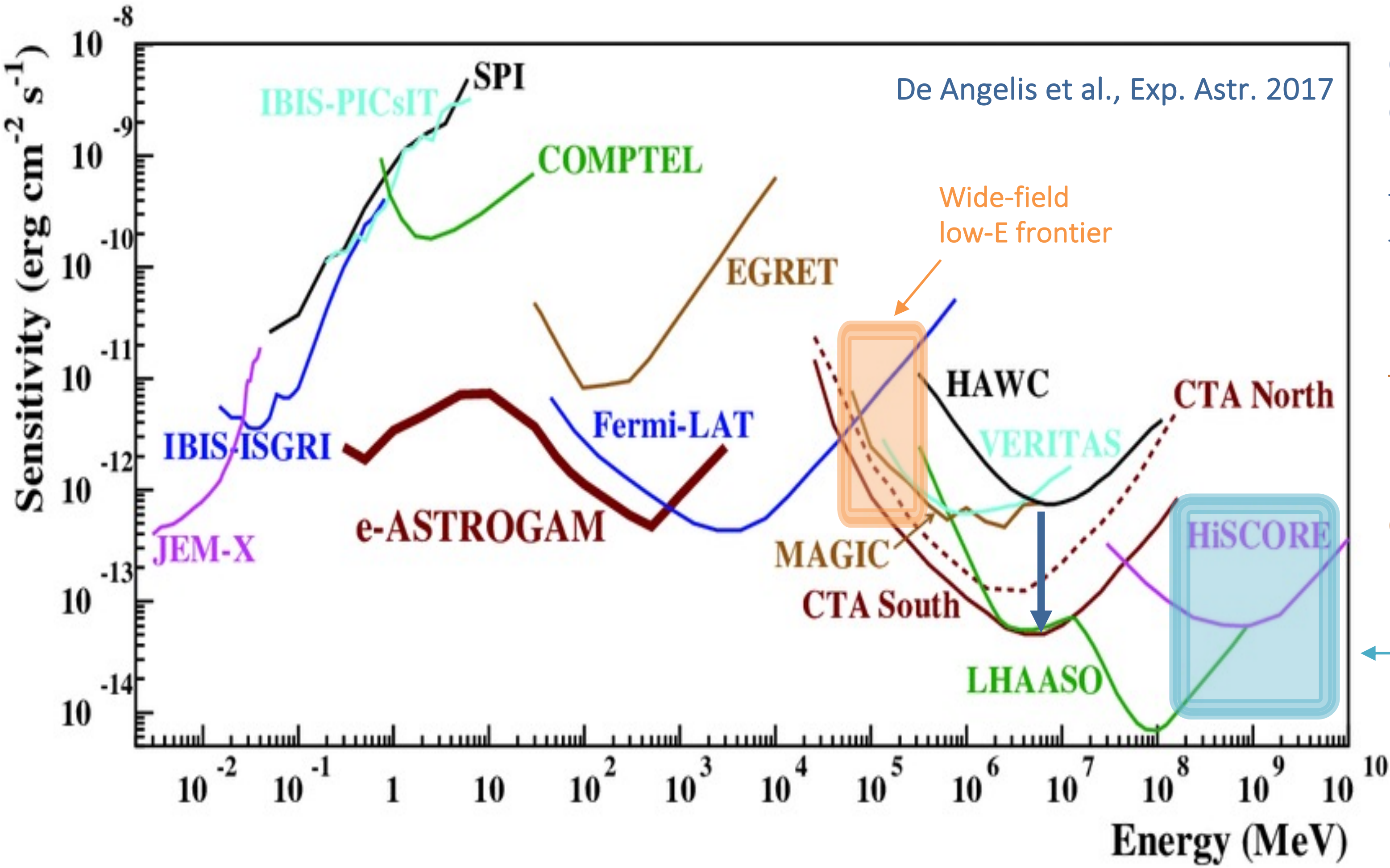
Geographic distribu



SWGO visibility, Pat Harding, LANL

Broadband panorama of high-energy Astrophysics

- Point source sensitivity for X- and gamma-ray instruments



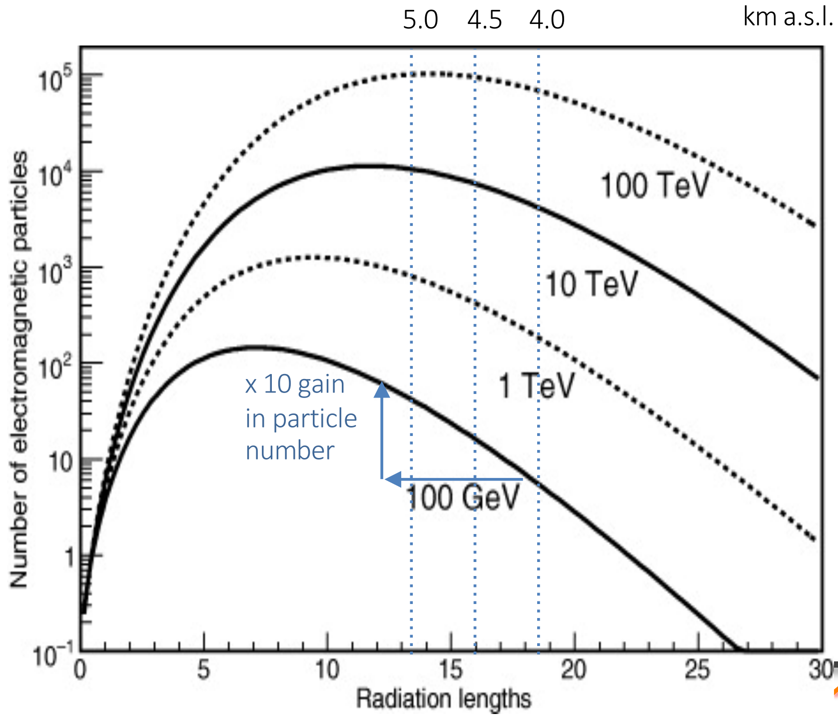
CTA and LHAASO will drive an order of magnitude increase in the TeV - PeV region in the next decade.

The 100 GeV frontier remains to be explored by wide-field gamma observatories.

High-sensitivity TeV-PeV frontier

The high-altitude frontier

The Andes provides a number of high-altitude plateaus and high-altitude lakes that constitute suitable sites for a particle array aiming to extend the low-energy frontier for Wide-Field Observatories.



Adapted from G. Sinnis, NJPh, 2009

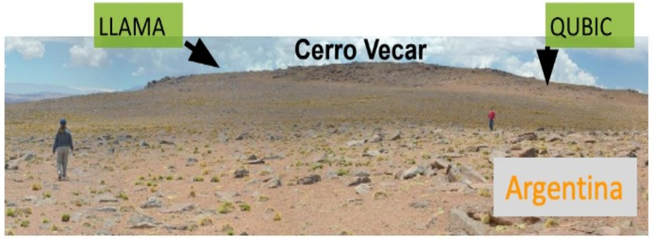
Candidate Sites

lat. 15 S

lat. 23 S

- Alto Tocomar (Argentina)
- Cerro Vecar (Argentina)
- Chacaltaya (Bolivia)
- AAP Pajonal (Chile)
- AAP Pampa La Bola (Chile)
- Lake Sibinacocha (Peru)
- Imata (Peru)
- Sumbay (Peru)
- Peru National Observatory
- Yanque (Peru)

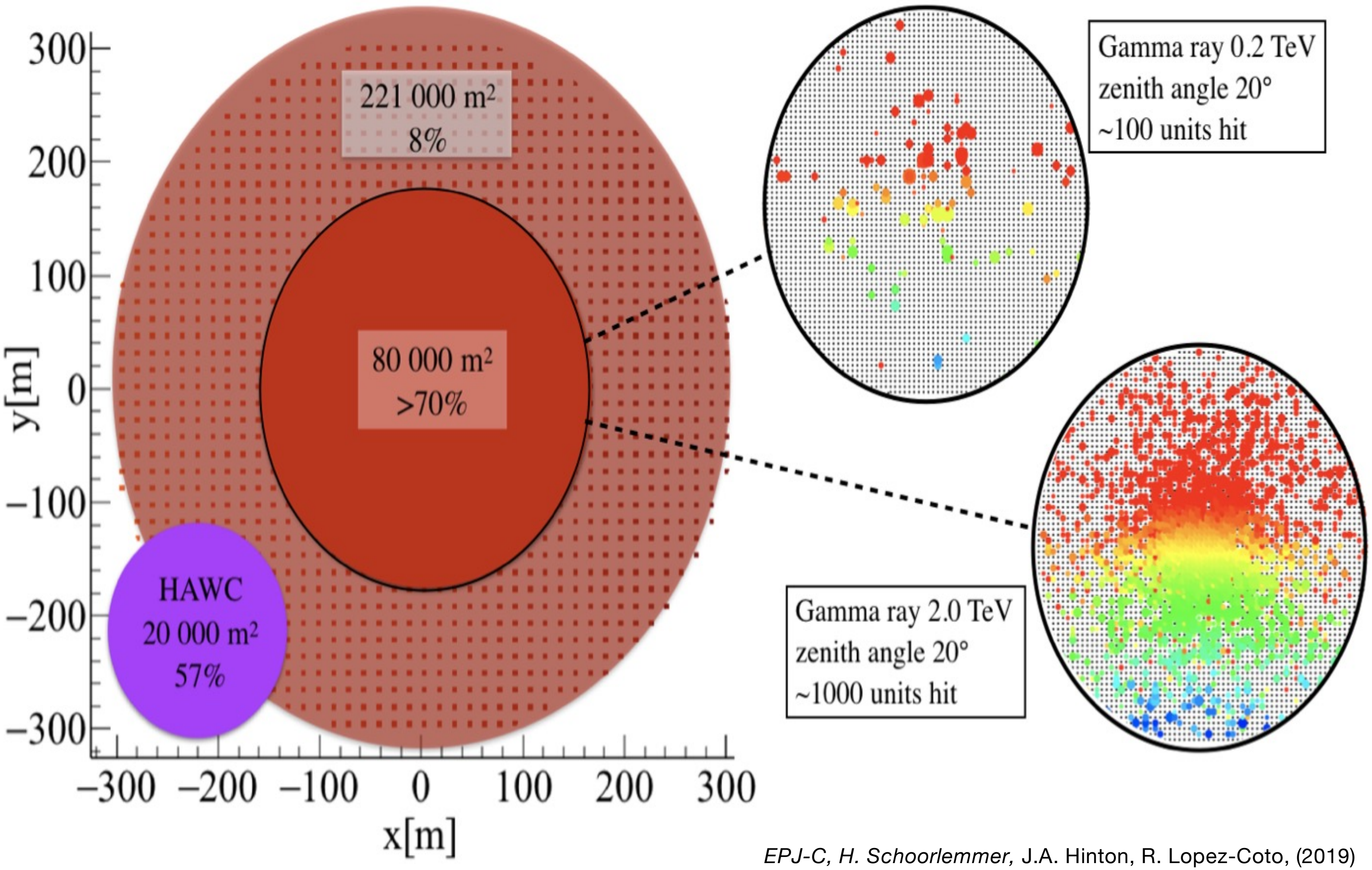
The complete list of potential sites is still under investigation, aiming at an evaluation for site choice by 2021.



The SWGO Concept

Detector array

Large array for low-energy events
Compact core with large instrumented area



EPJ-C, H. Schoorlemmer, J.A. Hinton, R. Lopez-Coto, (2019)

- 'Strawman' - reference detector layout

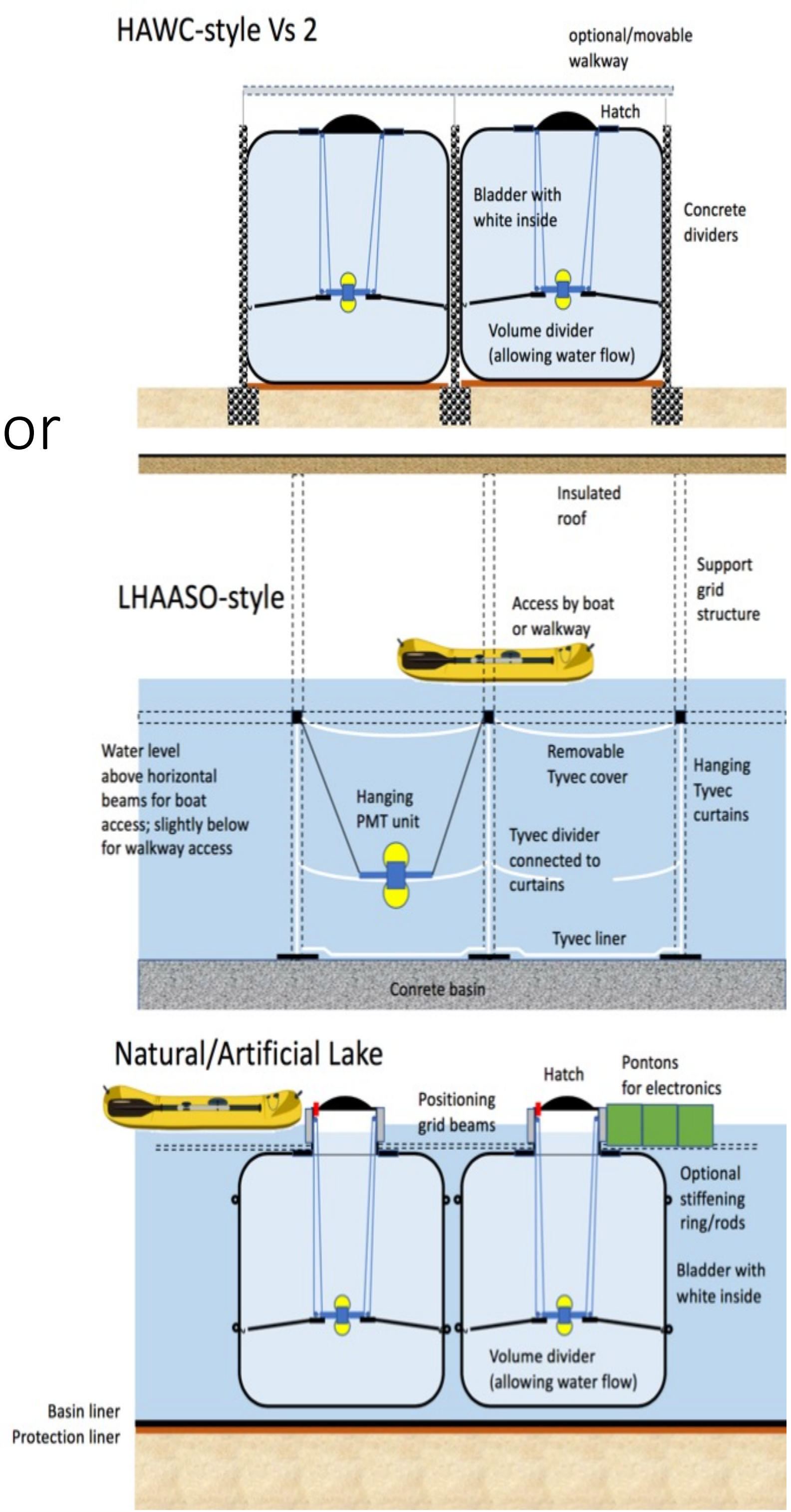
SWGO
The Southern Wide-field Gamma-ray Observatory

The SWGO Concept

Multiple detector options to be investigated

Detector units

- Core unit is a water-Cherenkov Detector
  - Options being investigated based on tanks (HAWC-like), ponds (Milagro-like) and lake-base (test pool under construction at MPIK-Heidelberg)
- Simulations currently ongoing to constrain all aspects of the detectors
- Design strongly dependent on site choice
  - Water access, construction costs, infrastructure feasibility, compatibility with scientific driven main design goals…

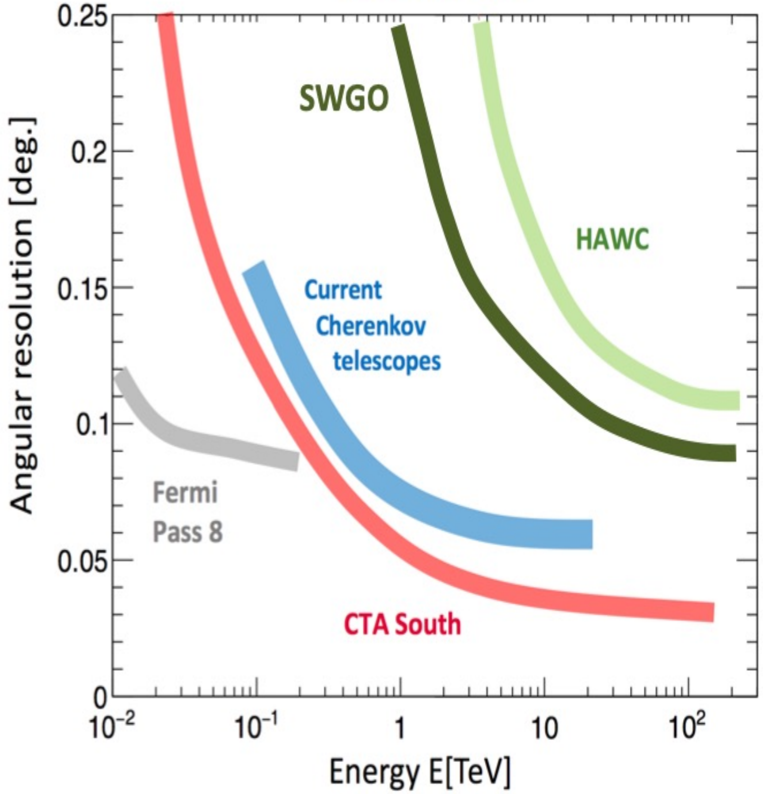


Performance goals

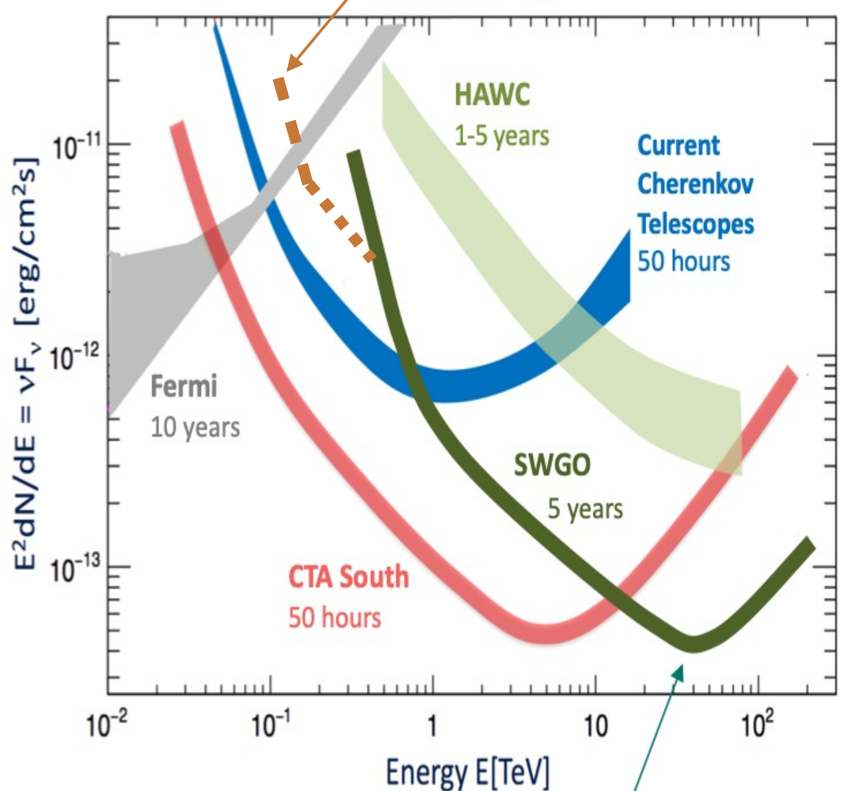
SWGO
The Southern Wide-field Gamma-ray Observatory

Low-energy enhancement

Resolution



Sensitivity

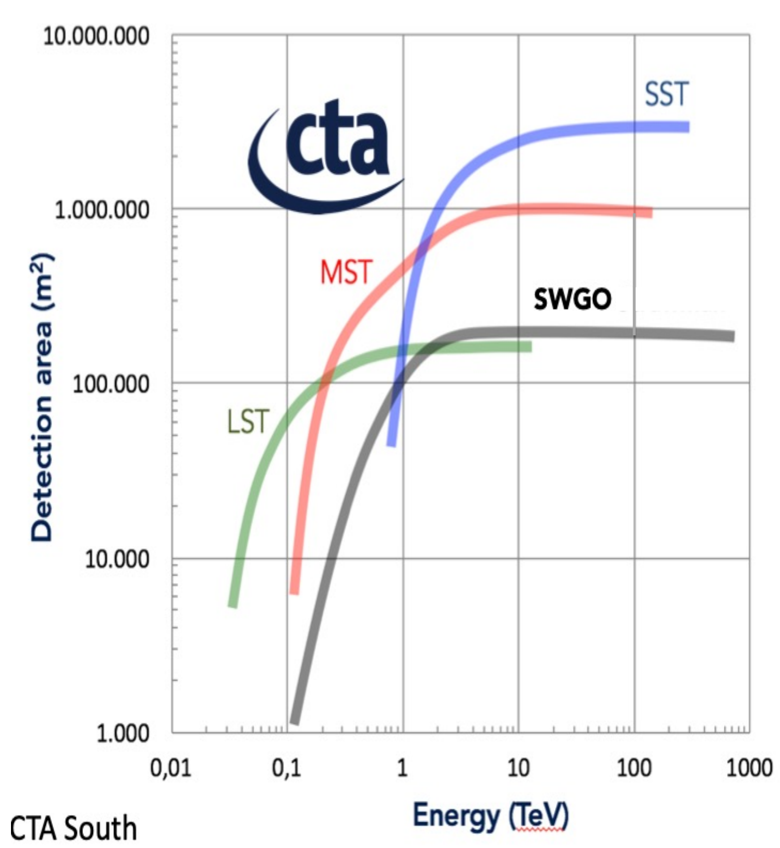


www.cta-observatory.org

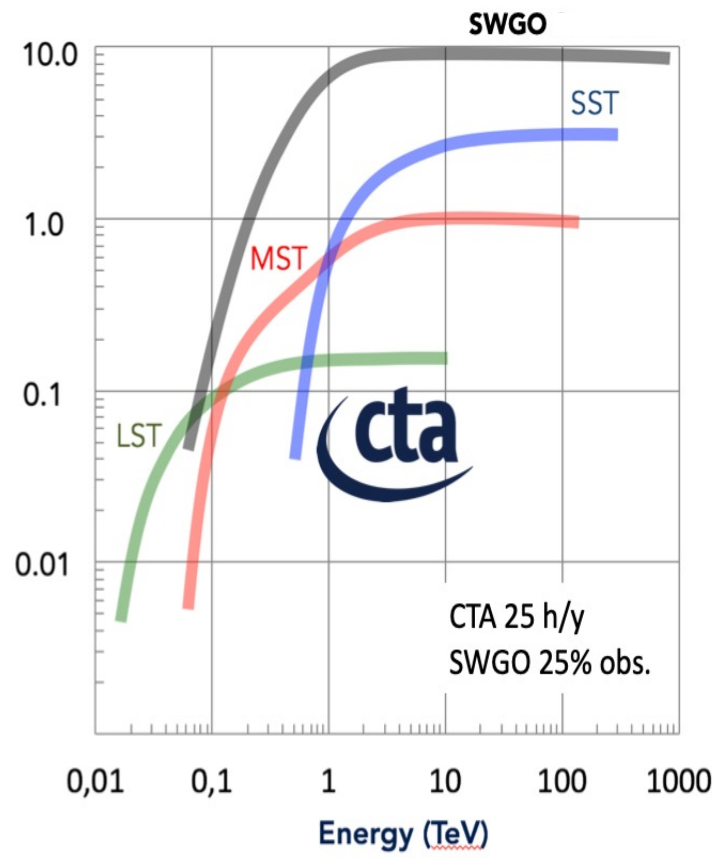
www.swgo.org

Background free above about 30 TeV for point-like sources, even after 5 years

Performance goals



Detection Area



Annual Exposure

Potentially more sensitive than CTA over several years integration time provided good background suppression is achieved.

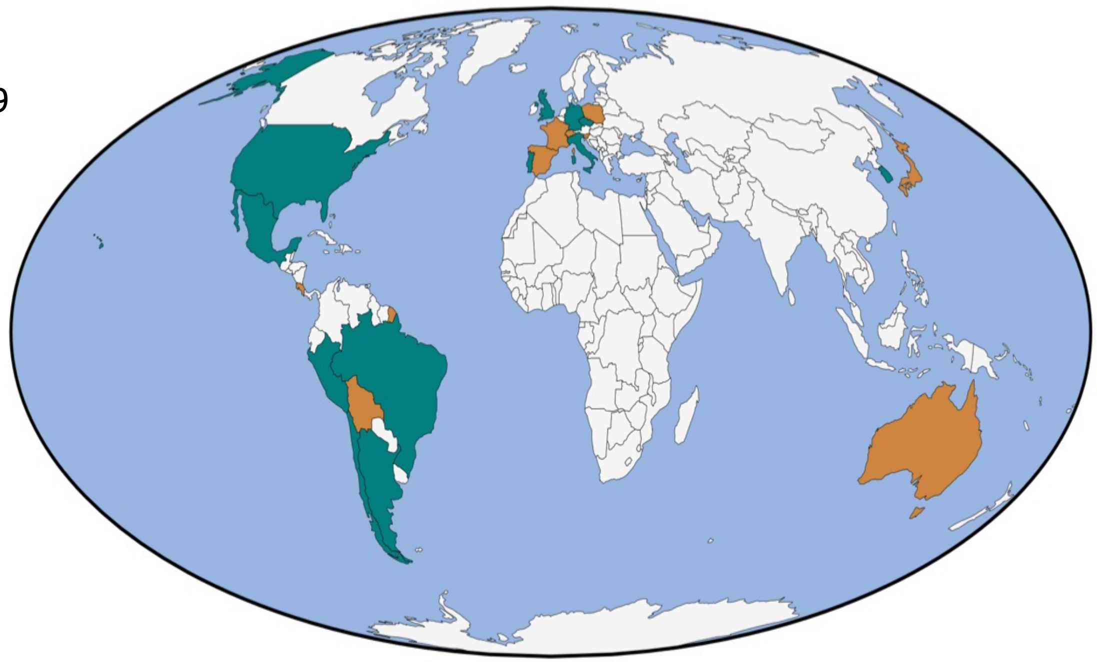
The Collaboration

The Southern Wide-field Gamma-ray Observatory

- Southern Wide-Field Gamma-ray Observatory
  - + higher altitude (4400+ m asl) and larger area
  - + more efficient detector units + muon tagging capability
  - → improved sensitivity and lower E threshold

Established in July 2019
3 year R&D Programme

www.swgo.org



Institutes

Argentina*, Brazil, Chile, Czech Republic, Germany*, Italy, Mexico, Peru, Portugal, South Korea, United Kingdom, United States*

Member institutes signed the SoI.

Supporting scientists

Australia, Bolivia, Costa Rica, France, Japan, Poland, Slovenia, Spain, Switzerland

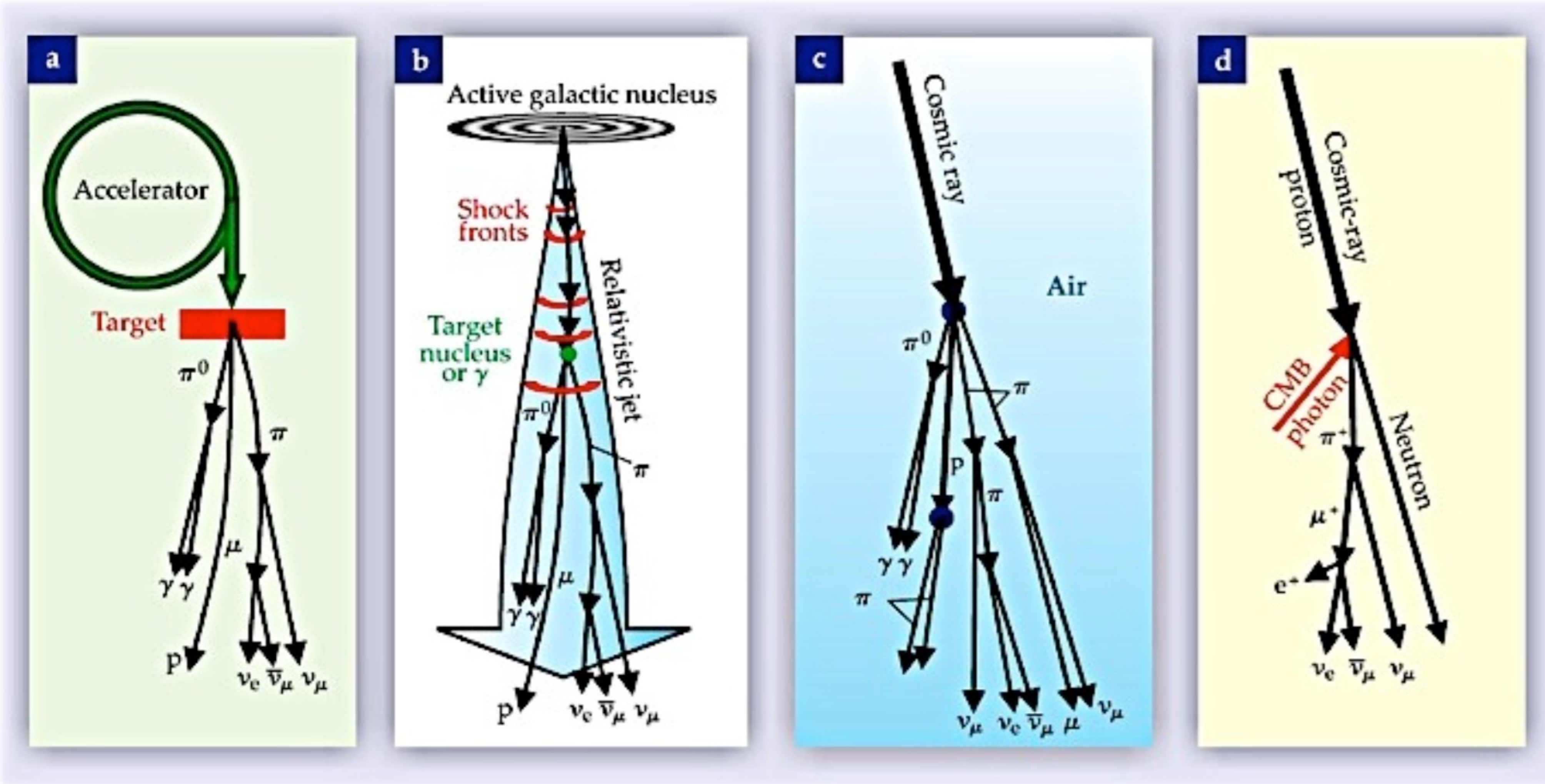
**also supporting scientists*

Any interested individual can become supporting scientist.

Astrofisica Nucleare e Subnucleare

Astrophysical Neutrinos

Summary of neutrino production modes



From Physics Today

Astrophysical Neutrinos