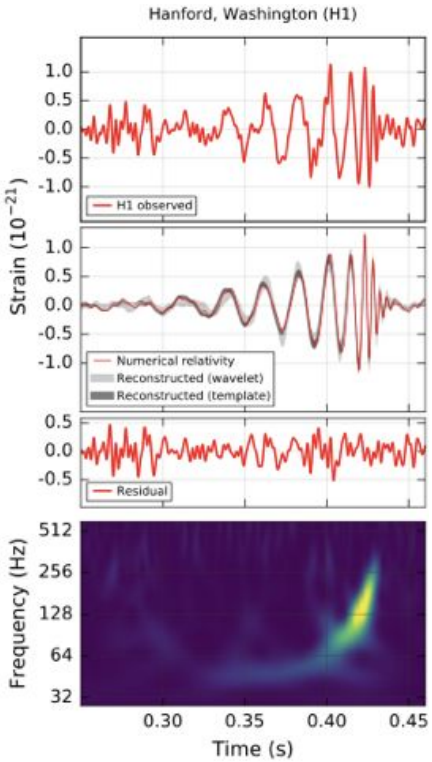
Rapporteur talk

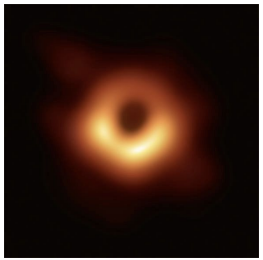
Catherine Cesarsky (AIM, CEA Saclay)
Luigi Tibaldo (IRAP, Université Toulouse III)

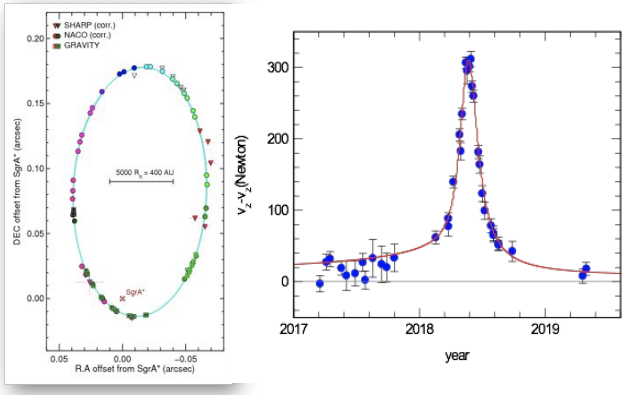
The golden era of particle/multimessenger astrophysics

Gravitational waves
(Weiss)



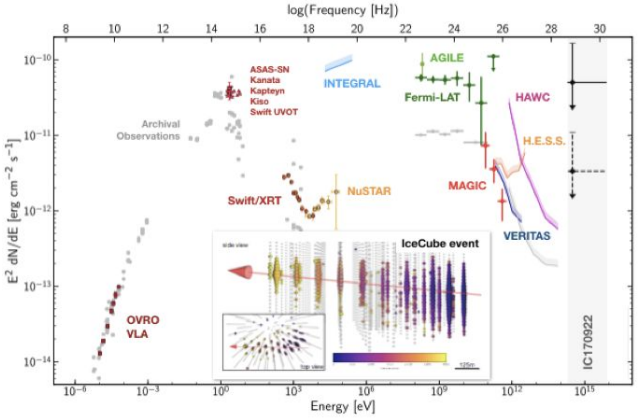
Precision black hole measurements
(Genzel, Wielgus)

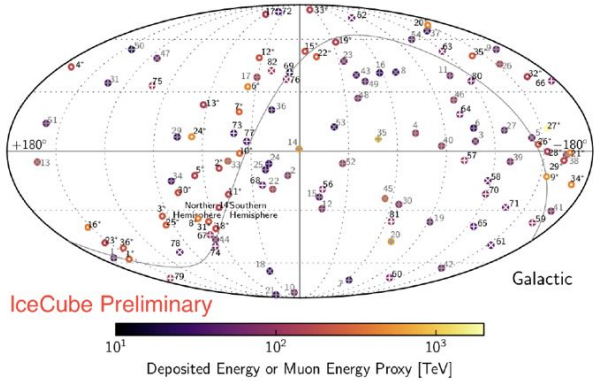




Particularly rich for black holes.
CTA is coming at the right time!

Neutrino astronomy
(Halzen)





The imaging Atmospheric Cherenkov Technique

Holder

MAGIC, H.E.S.S., VERITAS have demonstrated the **maturity of the imaging Cherenkov atmospheric technique**

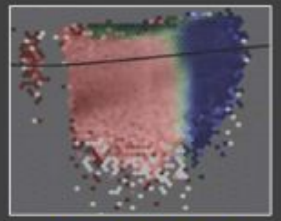
CTA: a global effort, a resource for everybody

- First ground-based gamma-ray observatory
  - first 10 years: ~40% Key Science Projects
  - rest of the time available for the community
  - public data and data reduction tools
- Improvement in sensitivity by factor of 10 with respect to current experiments
- (Beyond gamma rays: optical intensity interferometry, charged particles …)
- 31 countries, over 200 institutes, over 1400 members

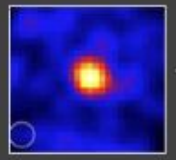
Hofmann

CTA Key Science Projects

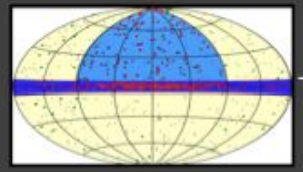
Ong



Dark Matter Programme



Galaxy Clusters

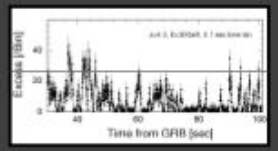


ExGal Survey

AGN

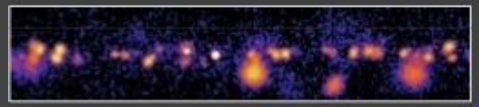
Star Forming Systems

Transients



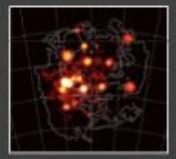
Extragalactic

Galactic

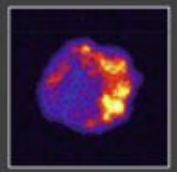


Galactic Plane Survey

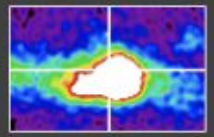
LMC Survey



PeVatrons



Galactic Centre




Heidelberg
MPIK
Zeuthen
DESY
Spain
La Palma
Bologna
INAF
northern hemisphere
southern hemisphere
Chile
Paranal
Array Sites
CTAO Offices
Science Data
Management Centre

Wild

Northern array

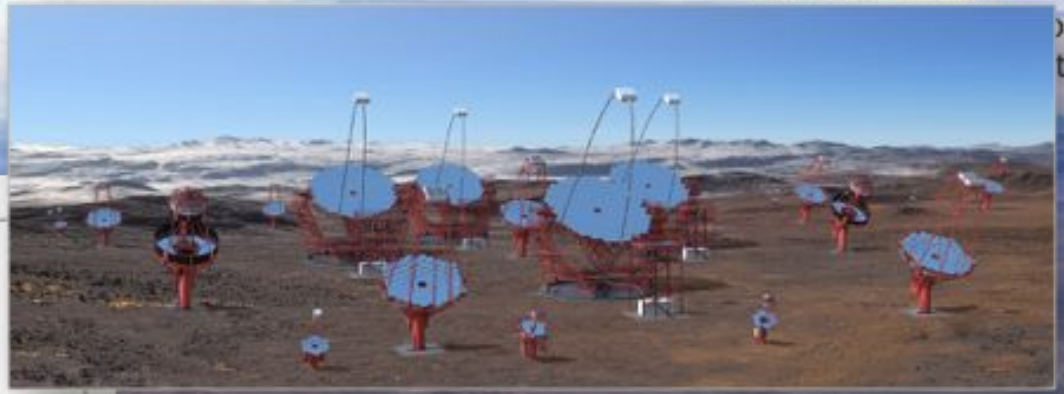
Northern array

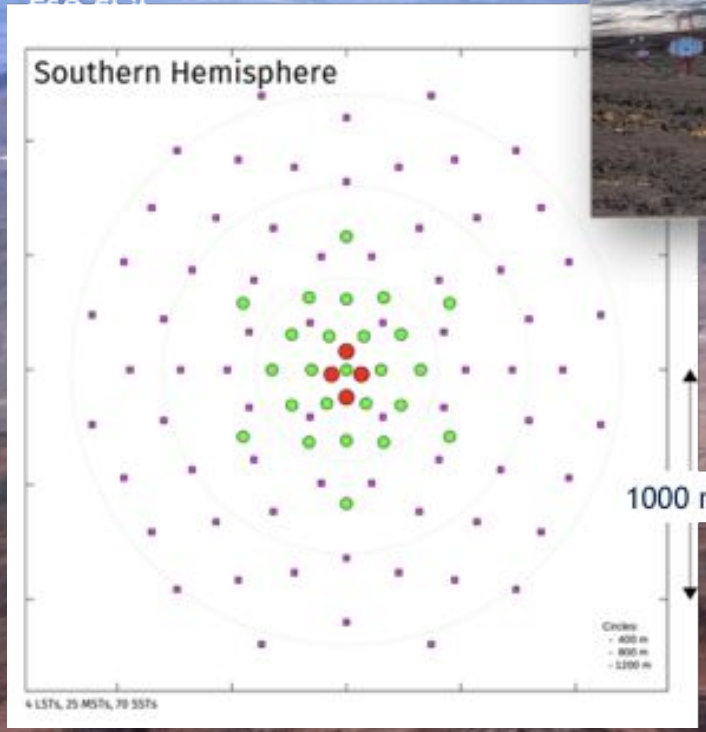
Southern array

Hofmann

Southern array

Hofmann





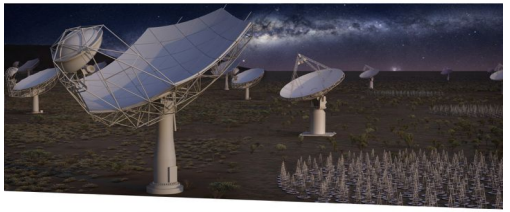
Cherenkov Telescope Array Site

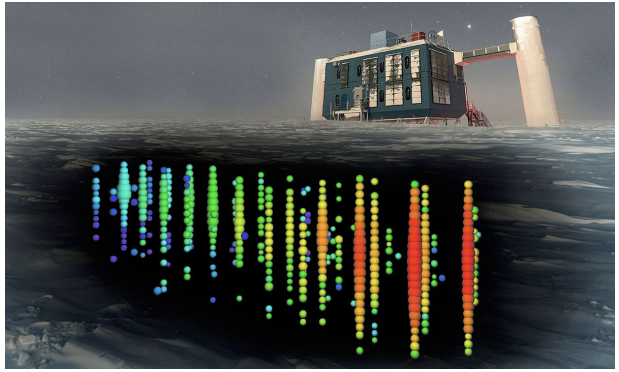
Werner Hofmann

Synergies ...

- gamma-ray satellites (Fermi!) and ground-based wide-FoV detectors (HAWC, LHAASO, SGSO?)
- radio (SKA and its precursors)
- X-rays (eROSITA and later Athena)
- High-energy neutrino and GW detectors
- Need for coordinated observations

McEnery
Hüntenmeyer
Laing
Piro
Weiss
Halzern
Spurio
Bartos

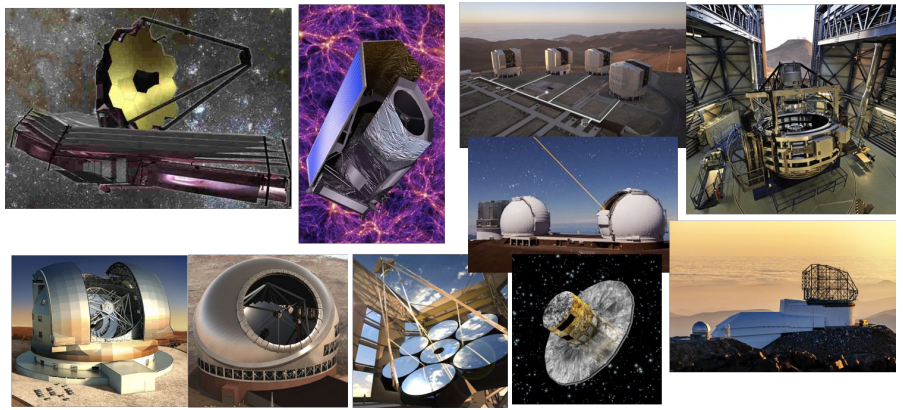




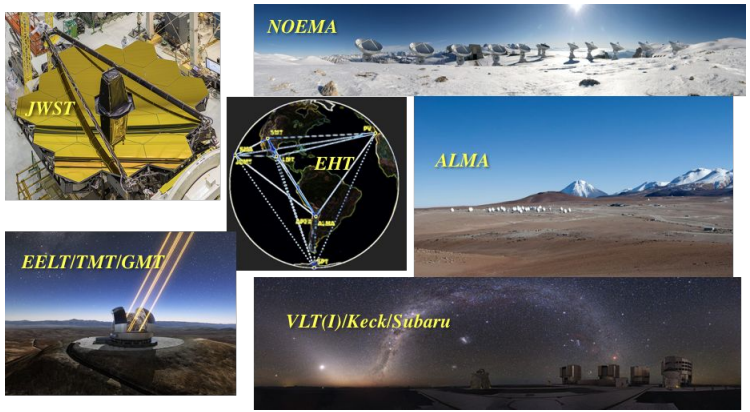
… and more synergies

- optical for source identification and distance
- optical and X-rays for gas conditions
- for details of sources VLBI, Alma
- transients/bursts: Swift, SVOM, LSST, and again Fermi, HAWC, LHAASO, LIGO/Virgo

Optical/IR (Steinmetz)

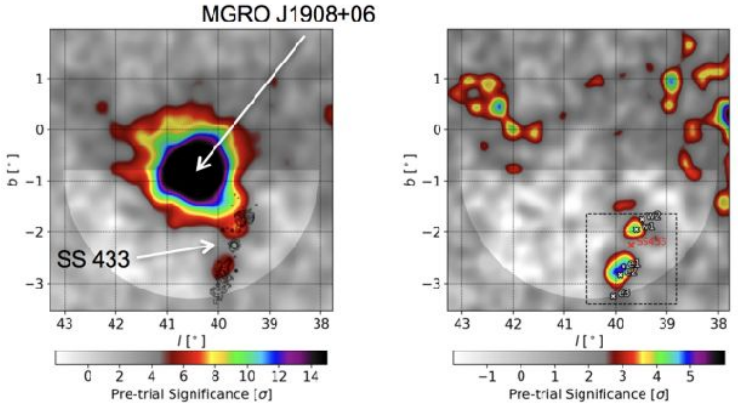


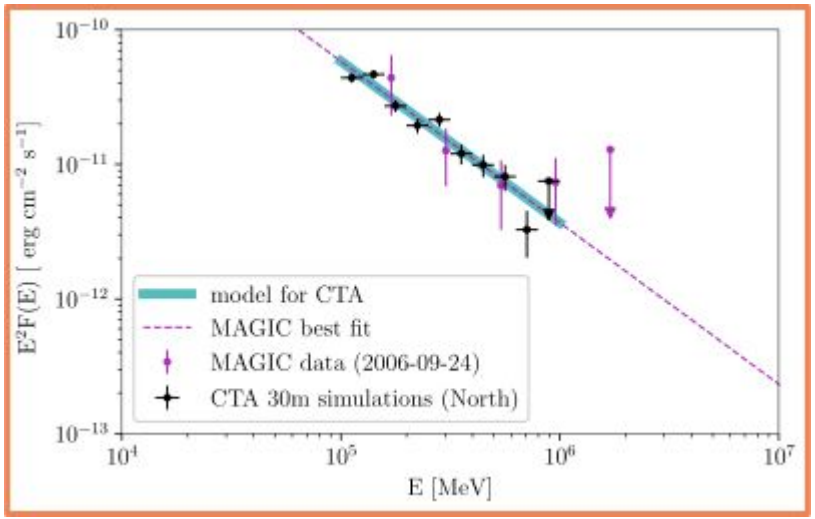
IR/mm (Genzel)



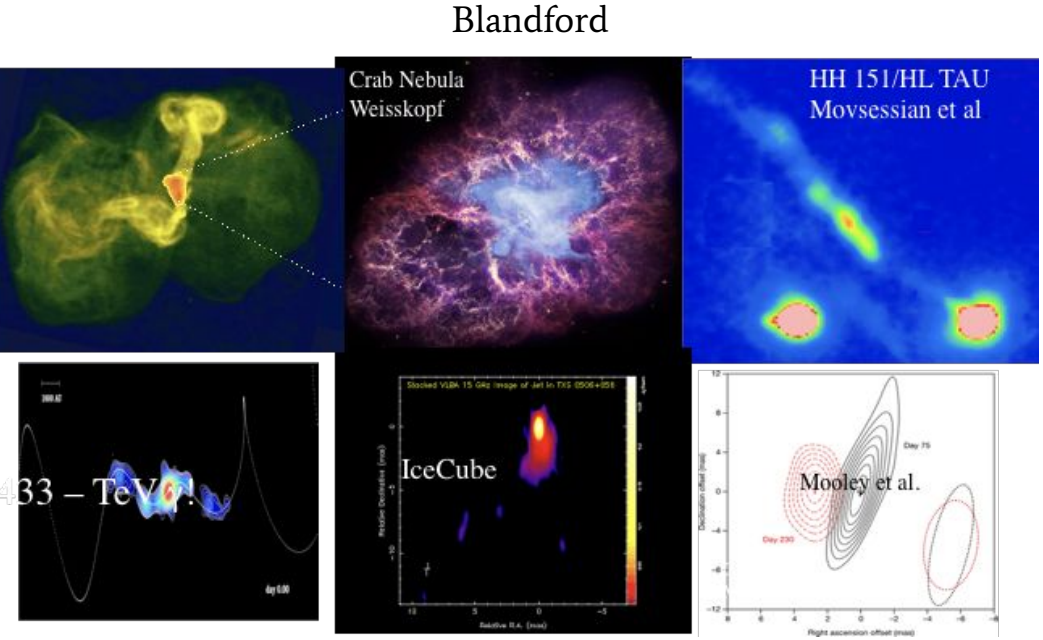
Black hole environment: Microquasars

- SS433 detected by HAWC close to PWN (Hüntenmeyer)
- Cyg X-1 like flares readily detectable by CTA (Piano)
  - long exposures required for steady emission





Jets everywhere

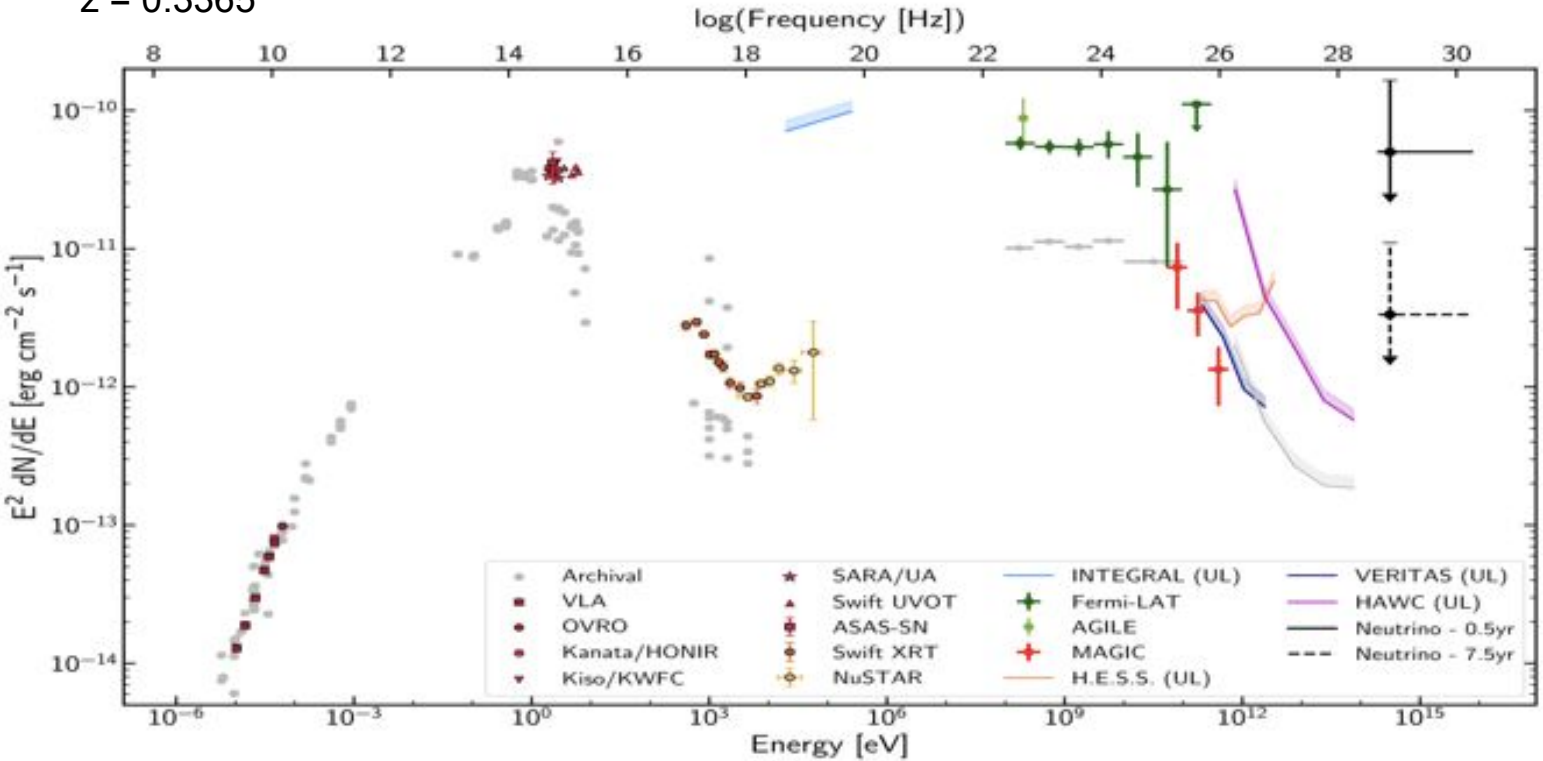


- More luminous than black hole accretion disk
- How is accretion/BH spin energy converted into jet/accelerated particles? (Blandford, Done)
- TeV flares of blazars, time scales of the order of minutes.
- Acceleration so rapid cannot be attributed to shock acceleration. Possibilities:
- strong magnetic fields in jets, energy release and particle acceleration due to relativistic magnetic reconnection
- pressure anisotropy-driven kinetic instabilities (Riquelme)

Blazars as gamma-ray and neutrino sources

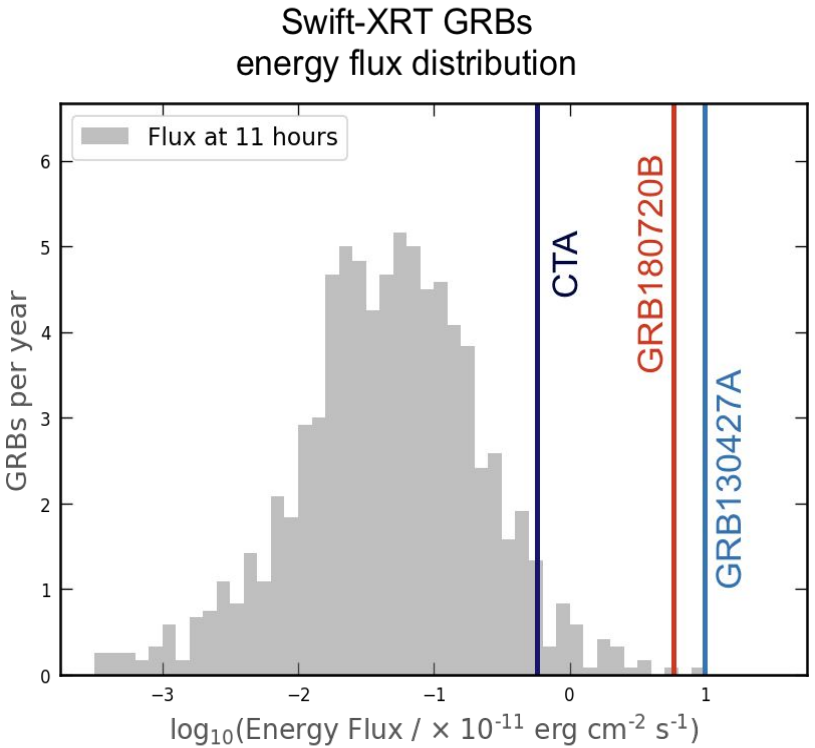
BL Lac object TXS 0506+056
z = 0.3365

Ghisellini



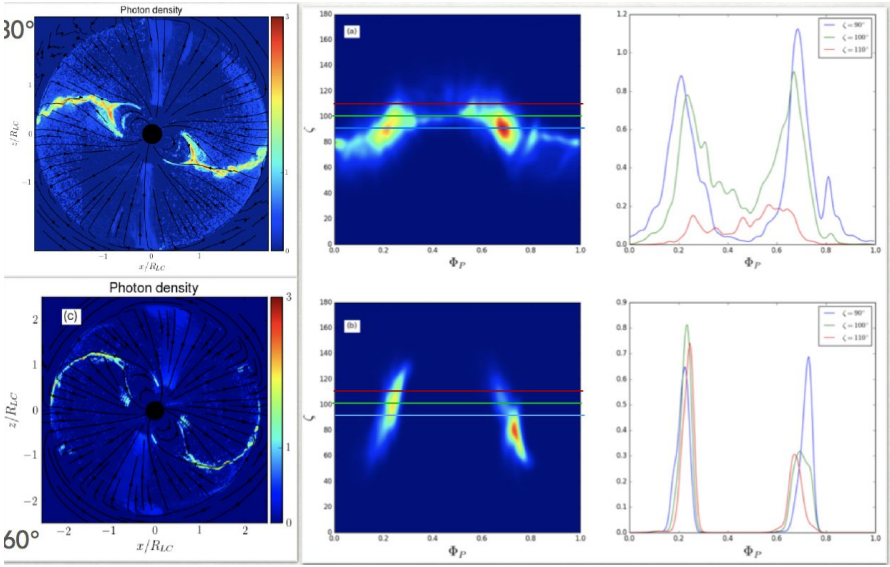
Gamma-ray bursts and supernovae

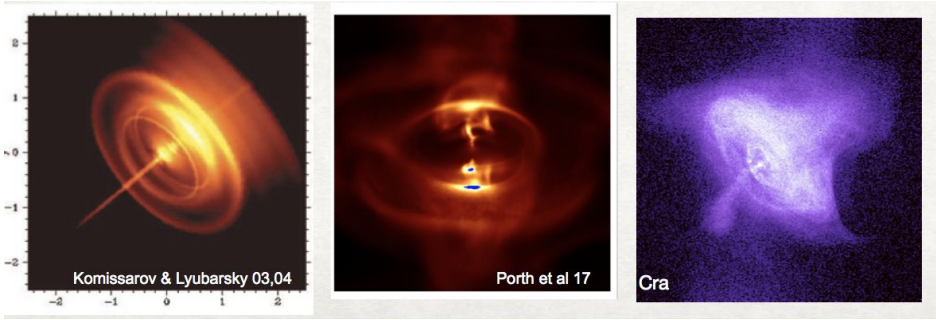
- Short GRBs identified as neutron star mergers thanks to GW, interesting to follow up with CTA (Bartos)
- Prompt emission from GRBs does finally look like synchrotron emission (Ghirlanda)
- One GRBs detected by MAGIC and one by H.E.S.S.: CTA will detect a few per year (Ruiz Velasco)
- Ideal tools for fundamental physics
- Will we be able to catch a supernova? With neutrinos too? (Kajita)



Pulsars and their wind nebulae

- Exquisite simulations (Spitkovski)
- Pulsars
  - GeV emission may be synchrotron emission from current sheet beyond light cylinder
  - end of curvature radiation paradigm?
  - TeV emission may be IC or SSC
- Winds and nebulae
  - nebular magnetisation, particle acceleration and transport poorly understood, CTA will be essential
  - need to understand details, e.g. bowshocks (Olmi)

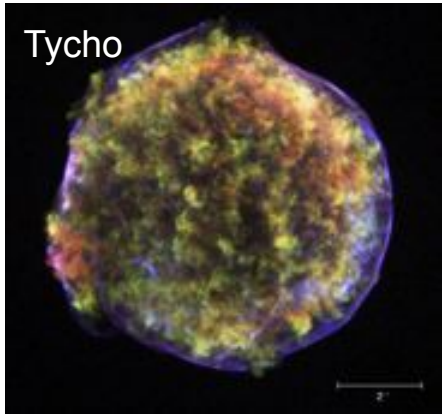




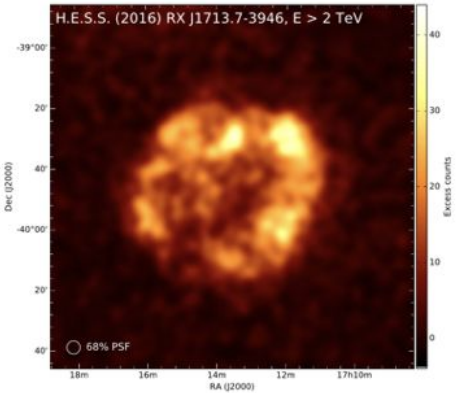
Supernova remnants: theory and observations ...

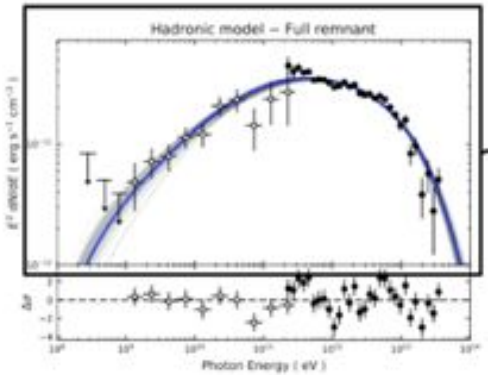
Progress with nonlinear diffusive shock acceleration:

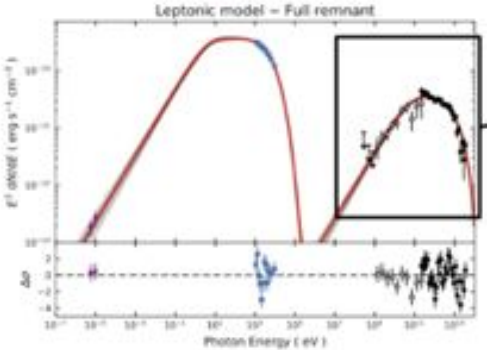
Decourchelle



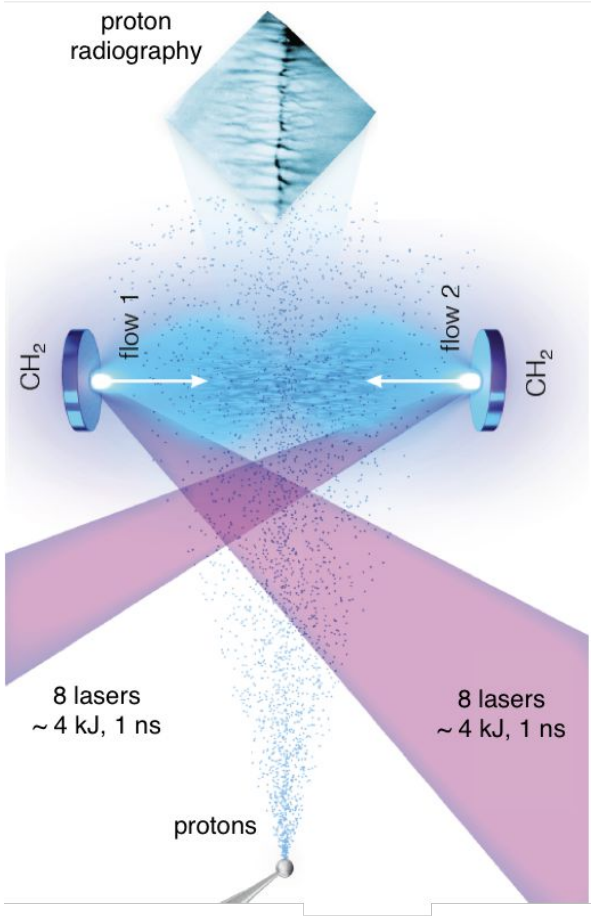
- Dynamical role of accelerated particles
- Plasma instabilities induced by accelerated particles (magnetic field amplification)
- Dynamical reaction of the amplified magnetic field







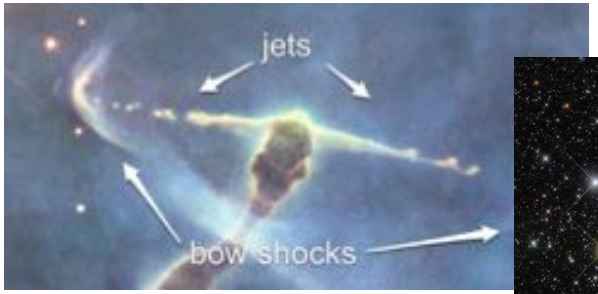
Collisionless shock acceleration in the lab and simulations



Fiuza

- Laboratory experiments with energetic lasers (Rochester, NIF)
- B amplification, development of filaments from small scale to large scale, 1% kinetic energy goes to B
- For the moment only electrons
- Consistent results between simulations and experiments

Star formation

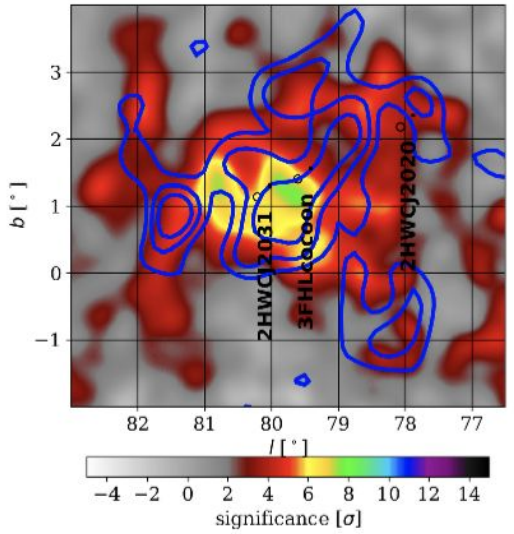


Link with non-thermal particles/high-energy emission emerging on all scales

- protostellar jets (Araudo)
- Shock between star clusters (Ellison)
- In general, extended emission from star-forming regions and galaxies

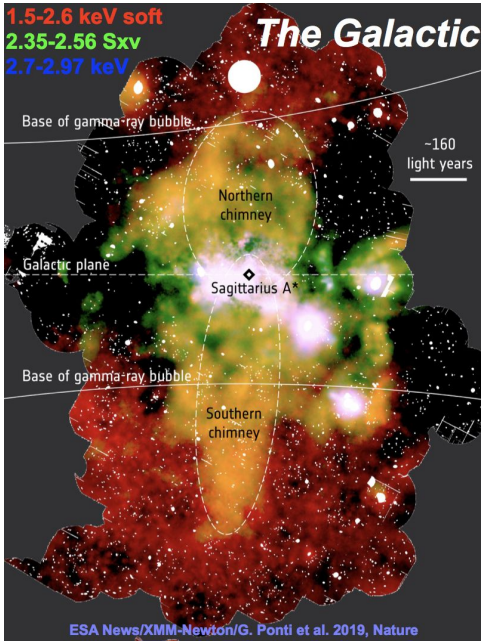
Mostly attributed to shock acceleration from stellar winds/outflow collisions.

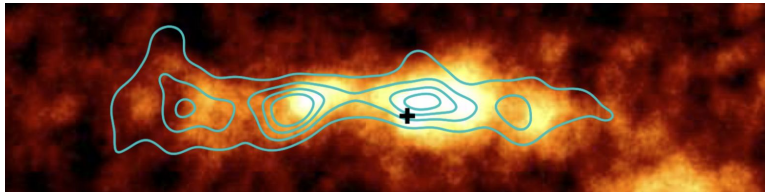
Emission from Cygnus star-forming region with HAWC (Hüntenmeyer)



High-energy emission around the Galactic center: black hole or star formation?

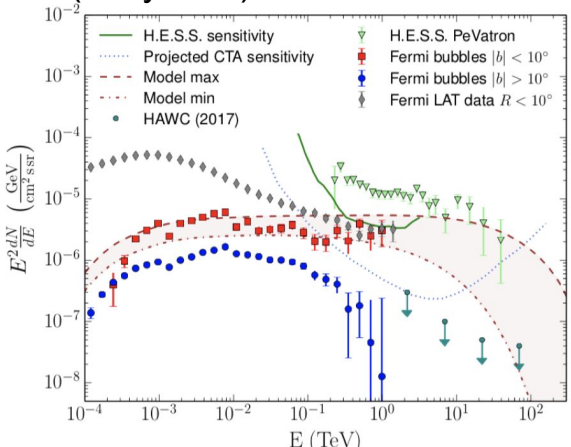
Chimneys (Ponti)



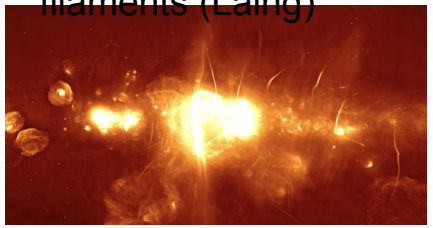


H.E.S.S.: ridge diffuse TeV emission (PeVatron)

Will CTA detect the bubbles? (Malyshev)



Meerkat: ridge radio emission + filaments (Laing)

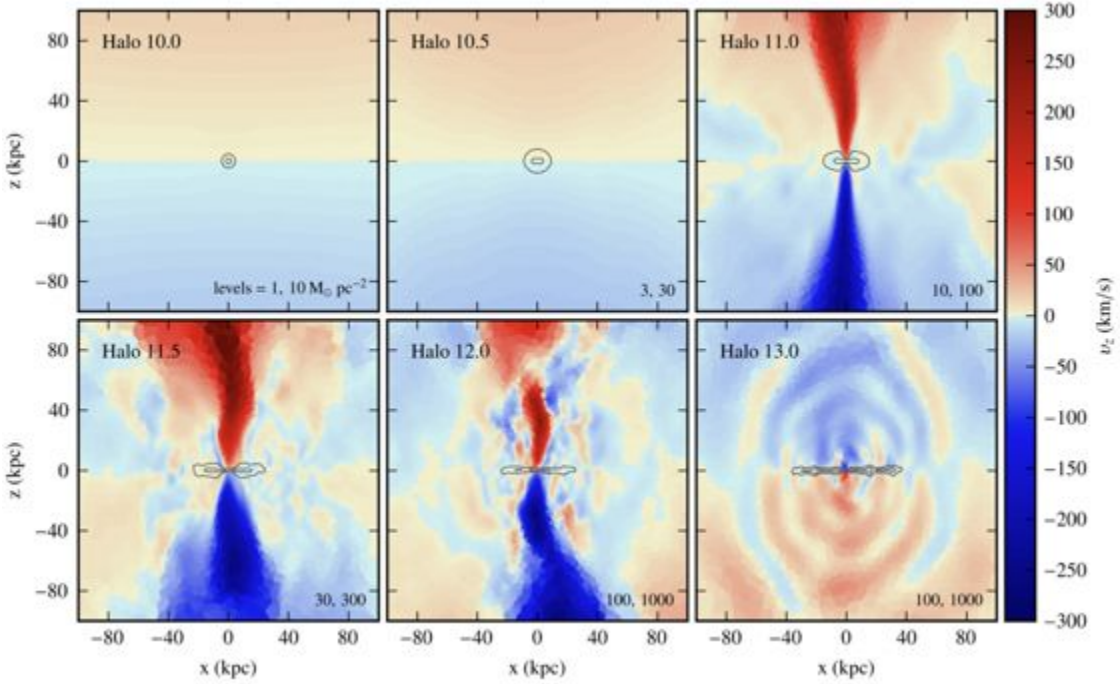


- many manifestations of high-energy phenomena around GC
- particle origin and transport to be understood
- star formation may play a bigger role than previously thought (Crocker)
- dark matter signal (if at all) not dominant

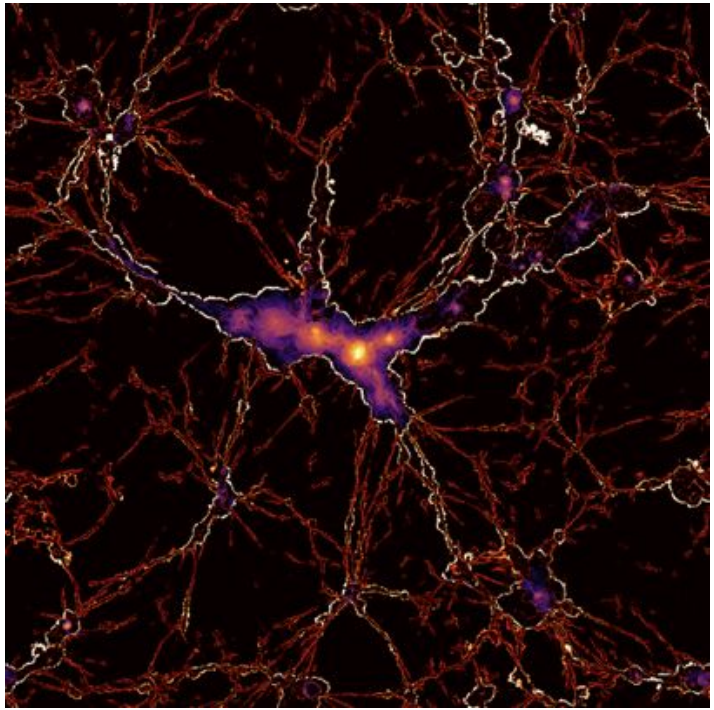
Relativistic particles on large scales

Springel

Cosmic-ray driven Galactic outflow
Strong function of halo mass

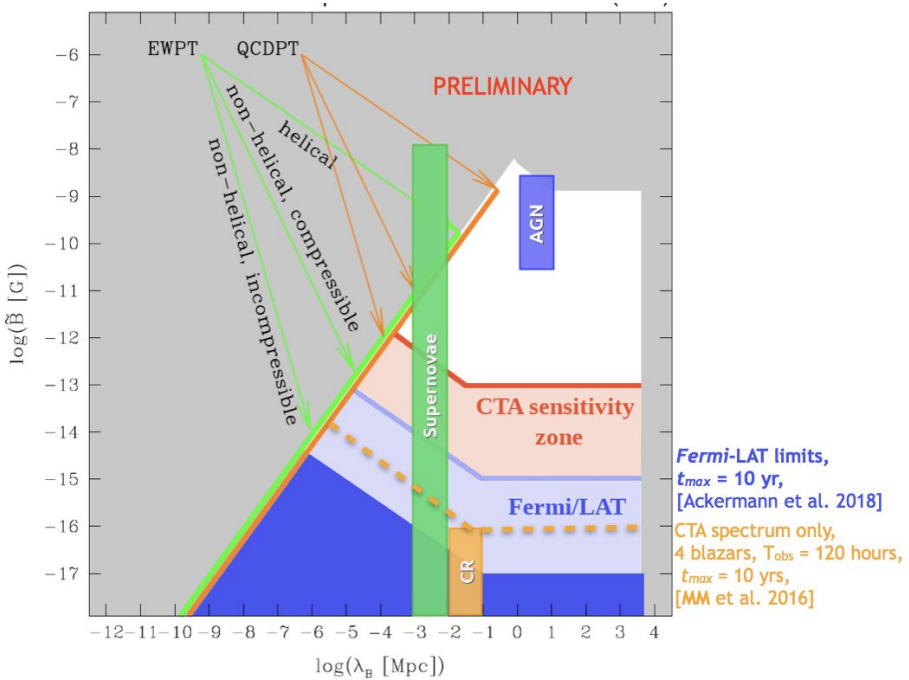


High-Mach number shocks around galaxy clusters

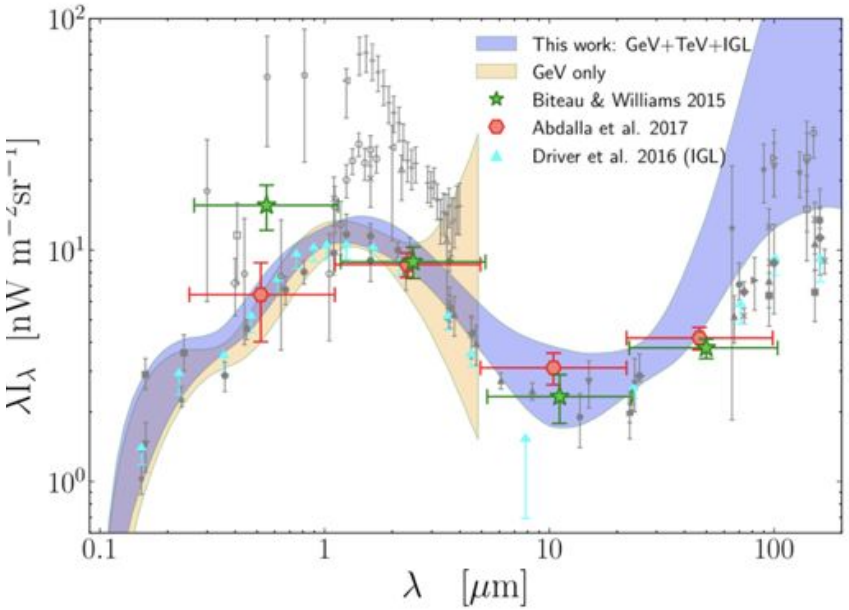


The evolution of the Universe in gamma rays

Intergalactic magnetic fields
(Alves Batista, Meyer)



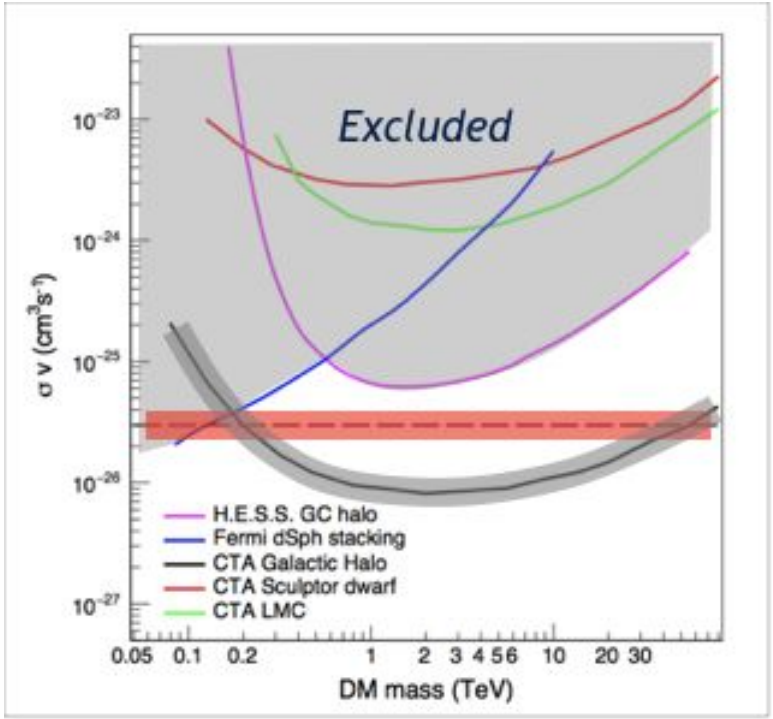
Extragalactic background light
→ constraints on local H0
(Ajello)



The hunt for new Physics

Hofmann
Ellis
Meyer

- CTA will constrain WIMP dark-matter candidates at the thermal relic cross-section level
- Will also enable us to look for axion-like particles
- And violation of Lorentz invariance.
- This alone is worth building CTA, but in many cases can be done “for free” while looking at other objects, e.g., Galactic center (Sarkar)



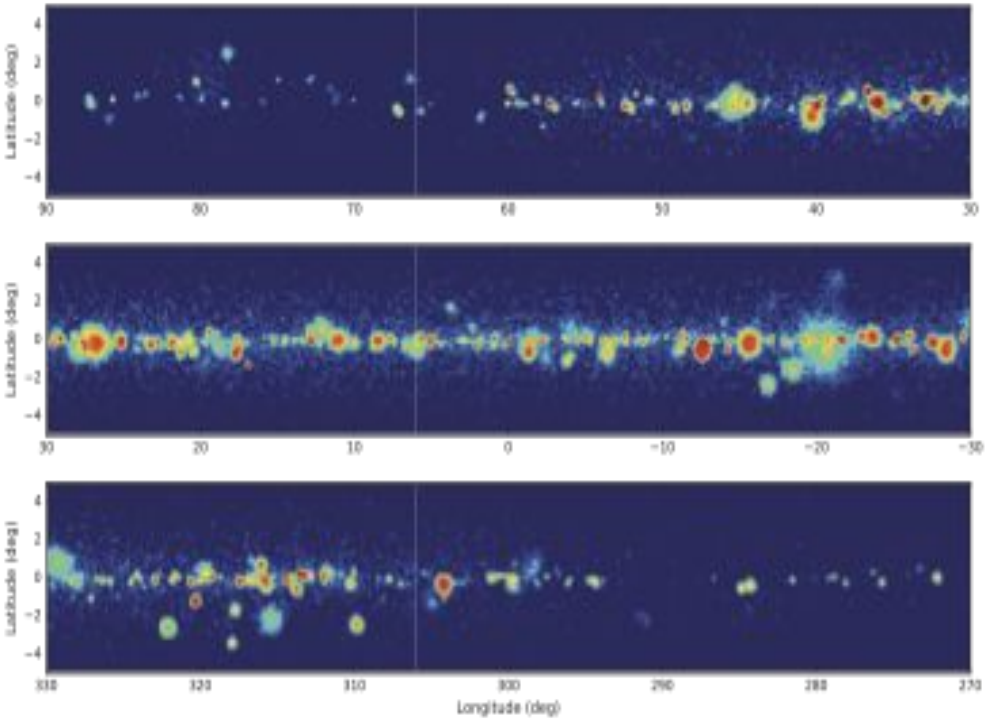
CTA “Unscripted” Discoveries

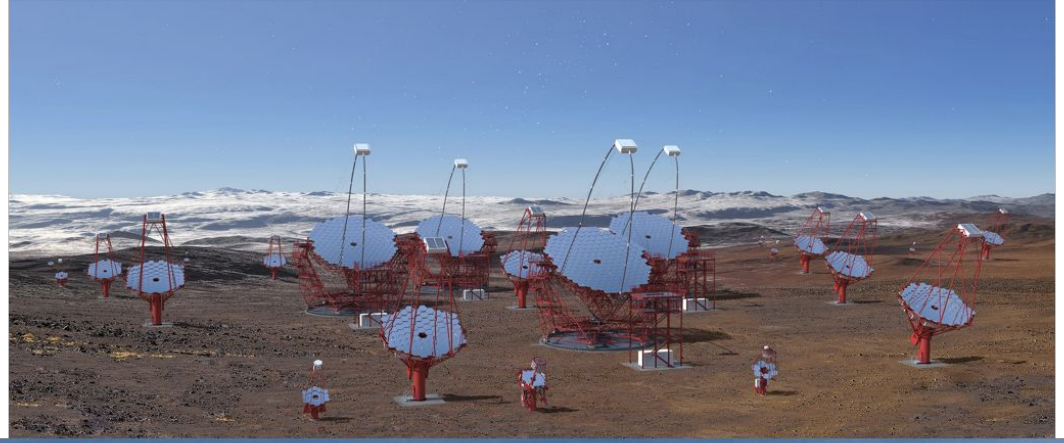
The most exciting things are those we do not expect … like it happened with pulsars!

Roger Blandford’s list:

- Double degenerate Type Ia
- New TeV transients (cf FRBs)
- Flares from Crab-like PWN
- Sun, nearby stars
- ???

Simulation of Galactic plane seen by CTA





Great expectations for CTA.
Go ahead and build it!