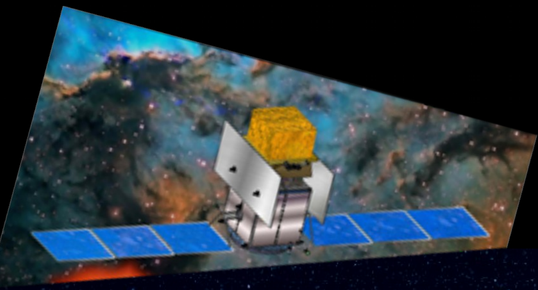
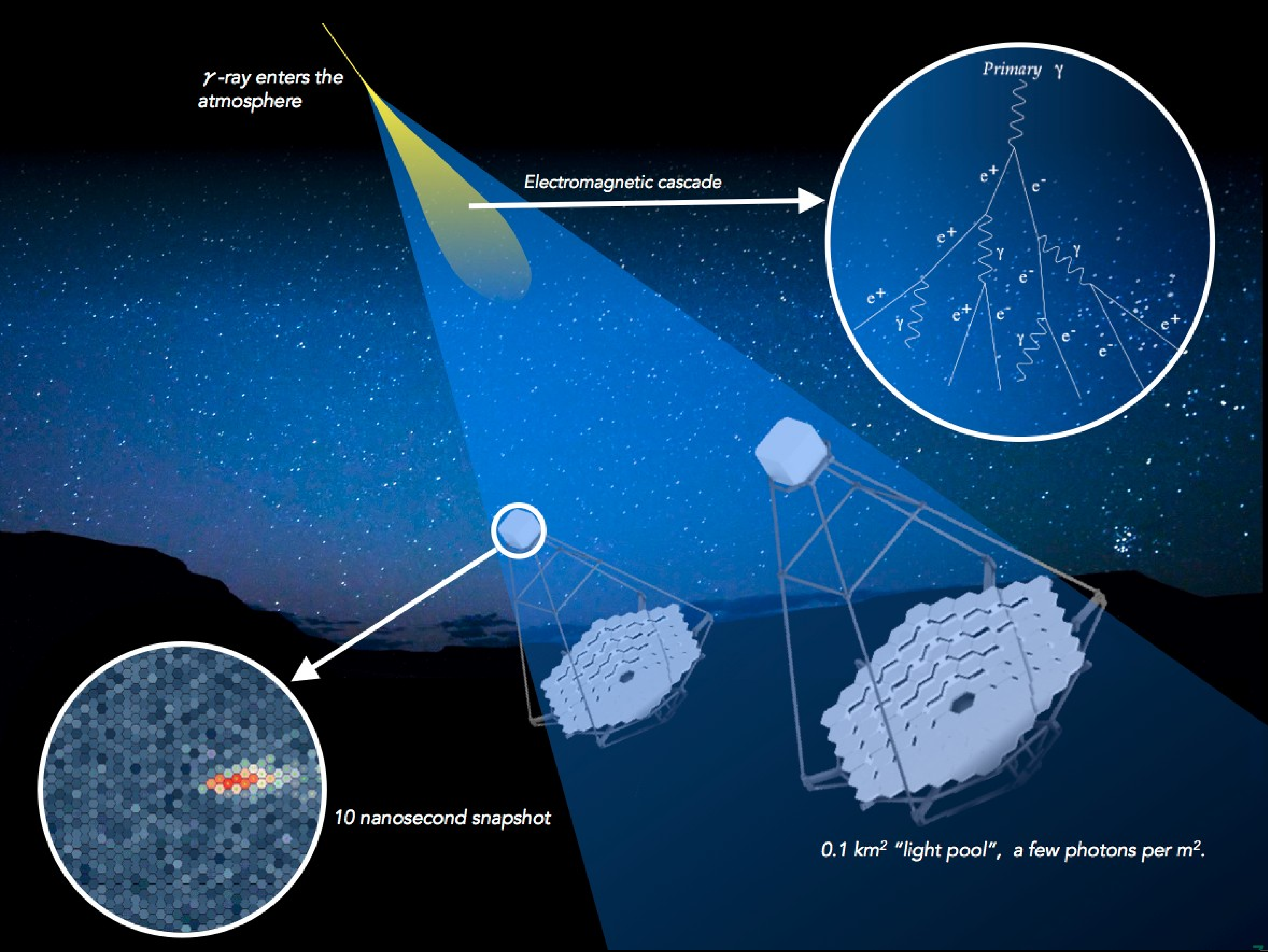


Synergies between the Cherenkov Telescope Array and eASTROGAM

Rolf Bühler for the CTA Consortium

eASTROGAM workshop

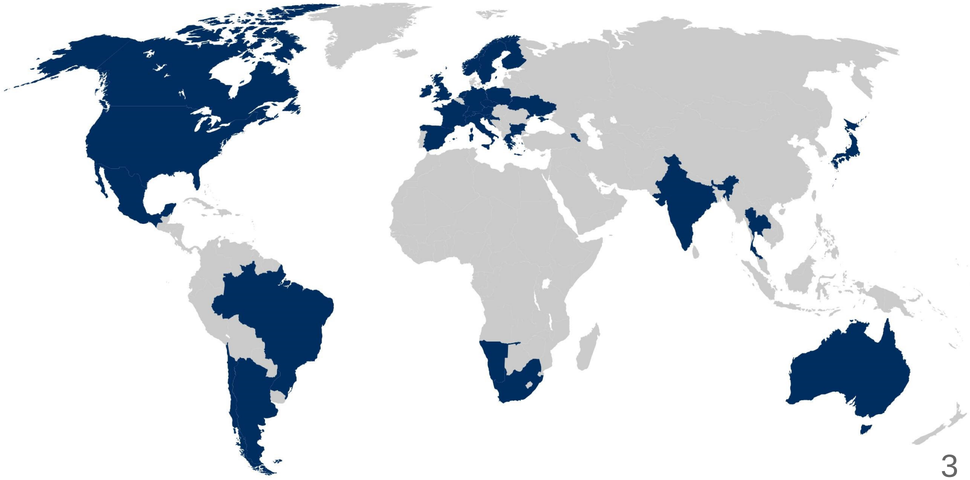
Padova 2nd March 2017



γ-ray enters the atmosphere
Electromagnetic cascade
Primary γ
e+
e-
γ
10 nanosecond snapshot
0.1 km² "light pool", a few photons per m².

The CTA Consortium includes 1,350 members from 210 institutes in 32 countries.

cherenkov telescope array



CTA Science Managment Center
Spain
La Palma
CTA Headquarters
northern hemis
southern hemis
Chile
Paranal

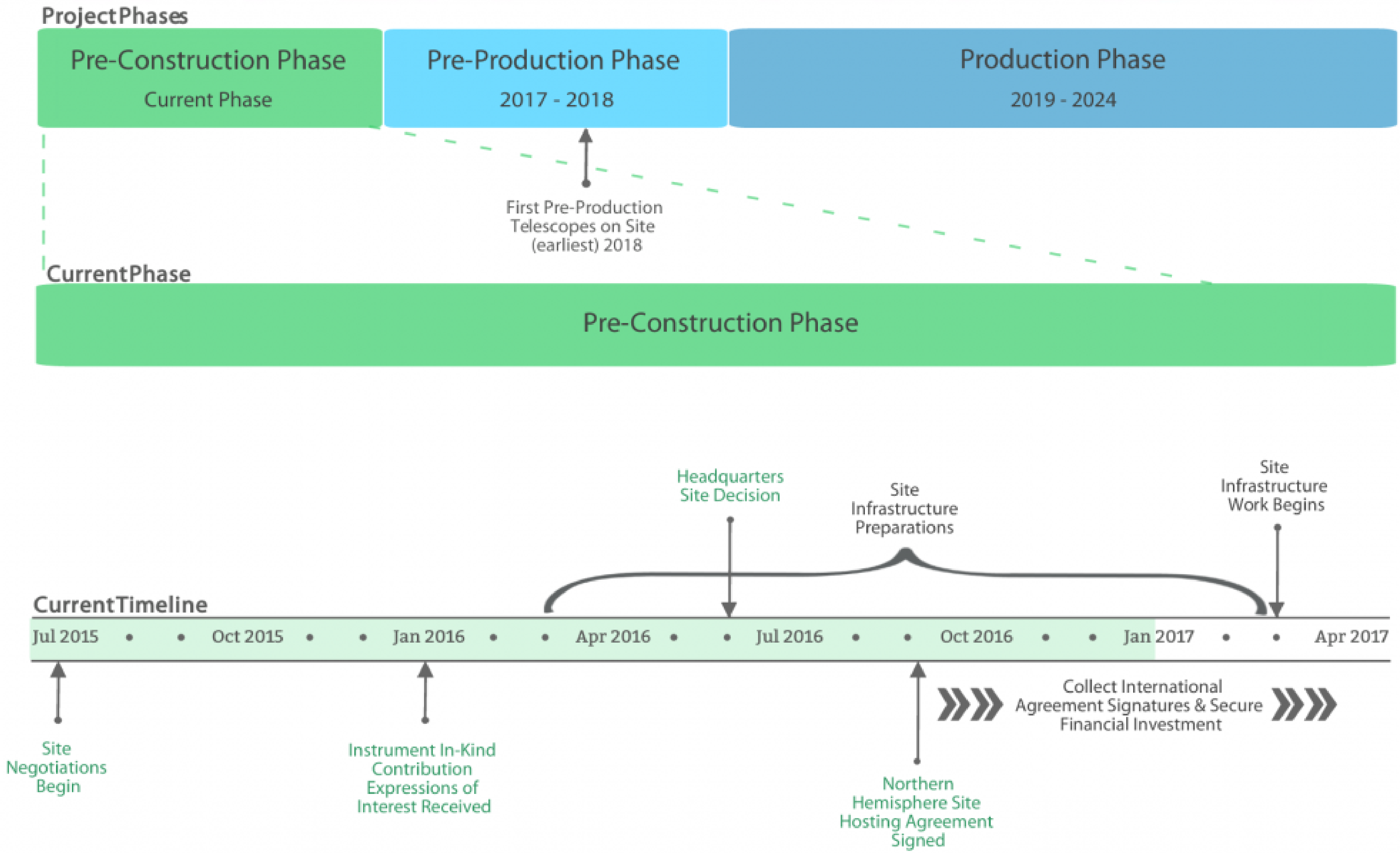

MST – Adlershof


SST 2M GCT – Meudon


SST 1M – Krakow


ASTRI SST 2M – Serra La Nave

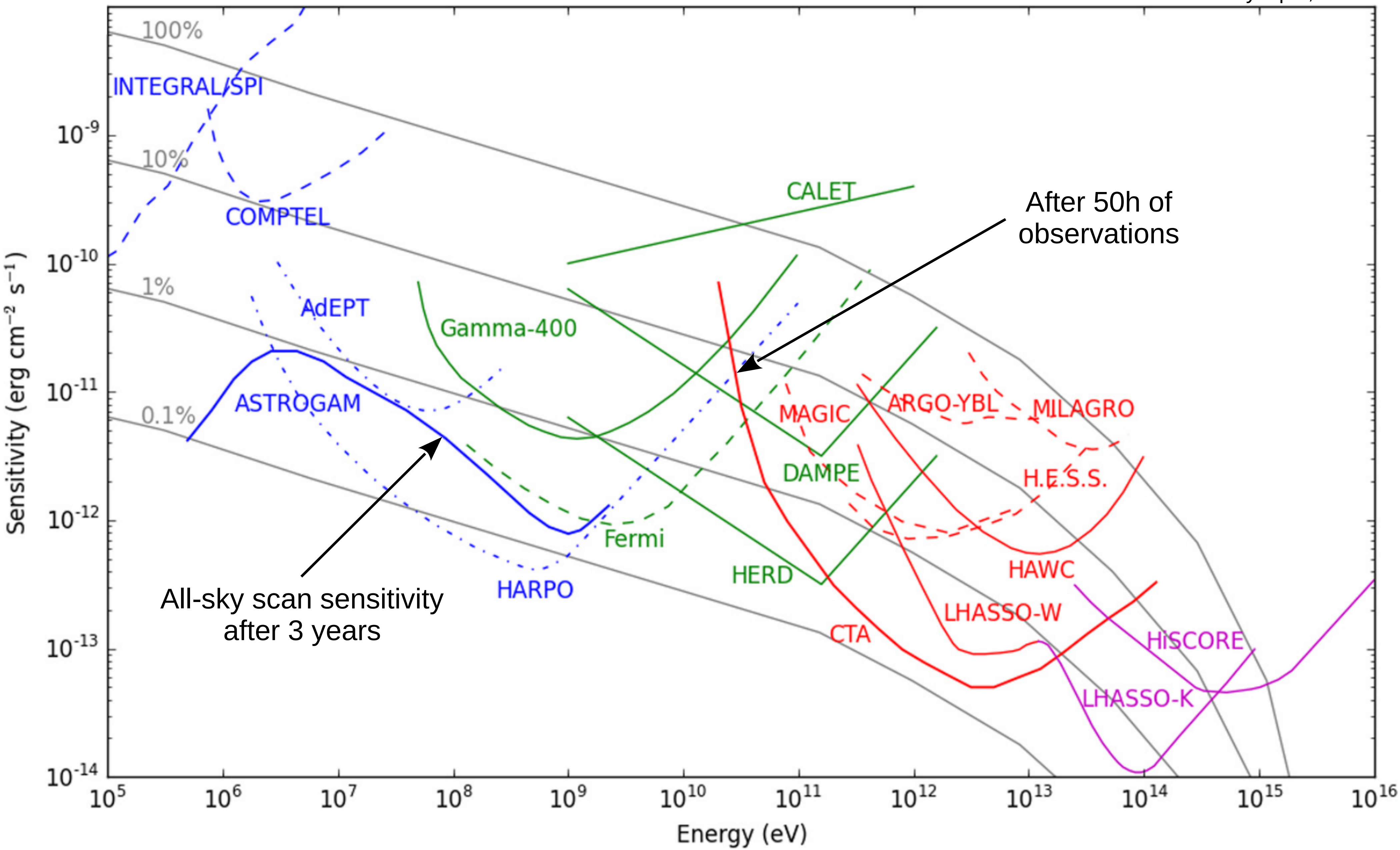

LST foundation – La Palma

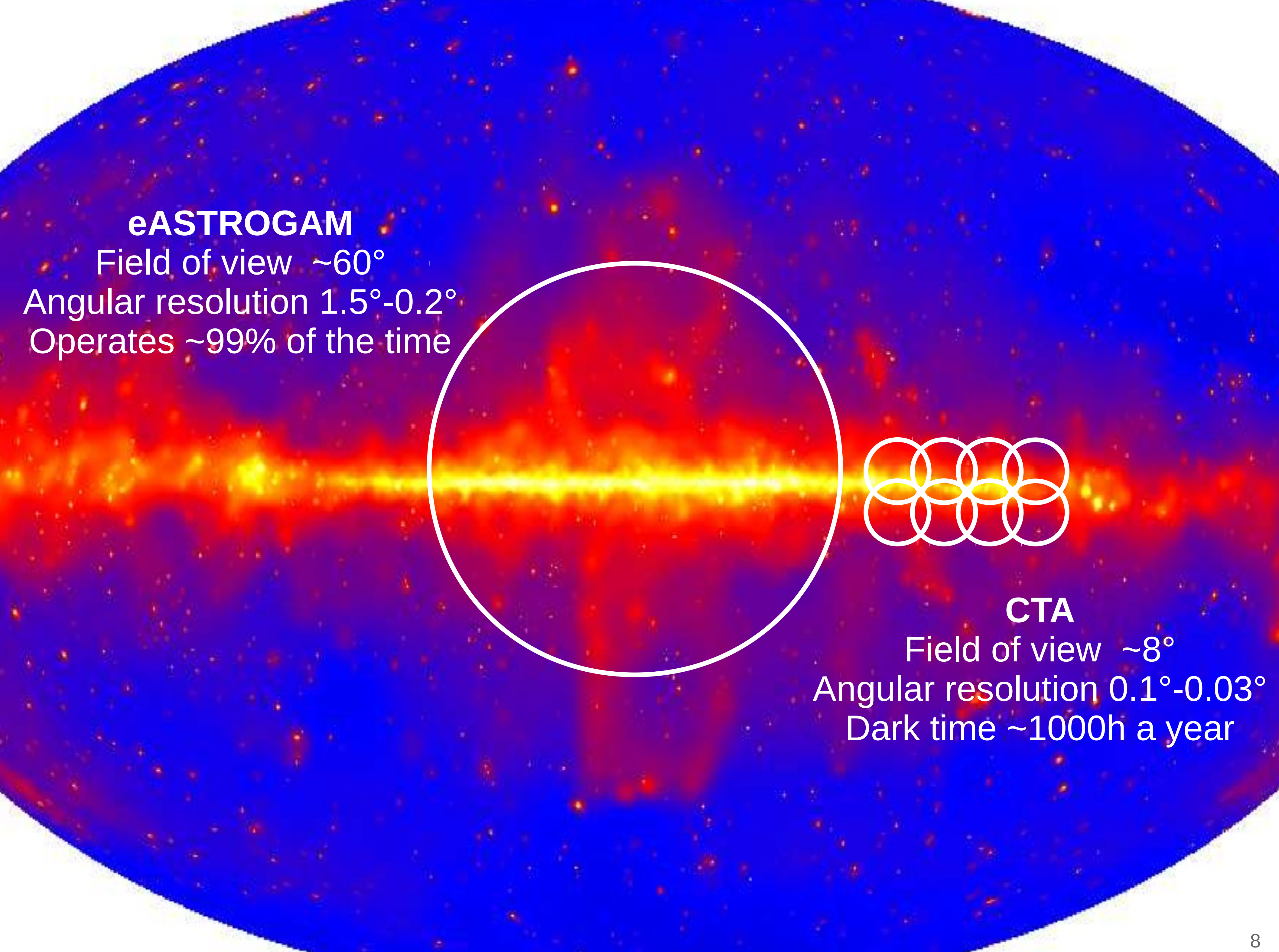


CTA is expected to reach full sensitivity in 2025 and will run as an observatory for ~30 years. It will be fully operational in coincidence to eASTROGAM.

Point source sensitivity

Knödlseder C. R. Physique, 2016




eASTROGAM
Field of view ~60°
Angular resolution 1.5°-0.2°
Operates ~99% of the time
CTA
Field of view ~8°
Angular resolution 0.1°-0.03°
Dark time ~1000h a year

Key Science Programs

Theme		Question	Dark Matter Programme	Galactic Centre Survey	Galactic Plane Survey	LMC Survey	Extra-galactic Survey	Transients	Cosmic Ray PeVatrons	Star-forming Systems	Active Galactic Nuclei	Galaxy Clusters
Understanding the Origin and Role of Relativistic Cosmic Particles	1.1	What are the sites of high-energy particle acceleration in the universe?		✔	✔✔	✔✔	✔✔	✔✔	✔	✔	✔	✔✔
	1.2	What are the mechanisms for cosmic particle acceleration?		✔	✔	✔		✔✔	✔✔	✔	✔✔	✔
	1.3	What role do accelerated particles play in feedback on star formation and galaxy evolution?		✔		✔				✔✔	✔	✔
Probing Extreme Environments	2.1	What physical processes are at work close to neutron stars and black holes?		✔	✔	✔			✔✔		✔✔	
	2.2	What are the characteristics of relativistic jets, winds and explosions?		✔	✔	✔	✔	✔✔	✔✔		✔✔	
	2.3	How intense are radiation fields and magnetic fields in cosmic voids, and how do these evolve over cosmic time?					✔	✔			✔✔	
Exploring Frontiers in Physics	3.1	What is the nature of Dark Matter? How is it distributed?	✔✔	✔✔		✔						✔
	3.2	Are there quantum gravitational effects on photon propagation?						✔✔	✔		✔✔	
	3.3	Do Axion-like particles exist?					✔	✔			✔✔	

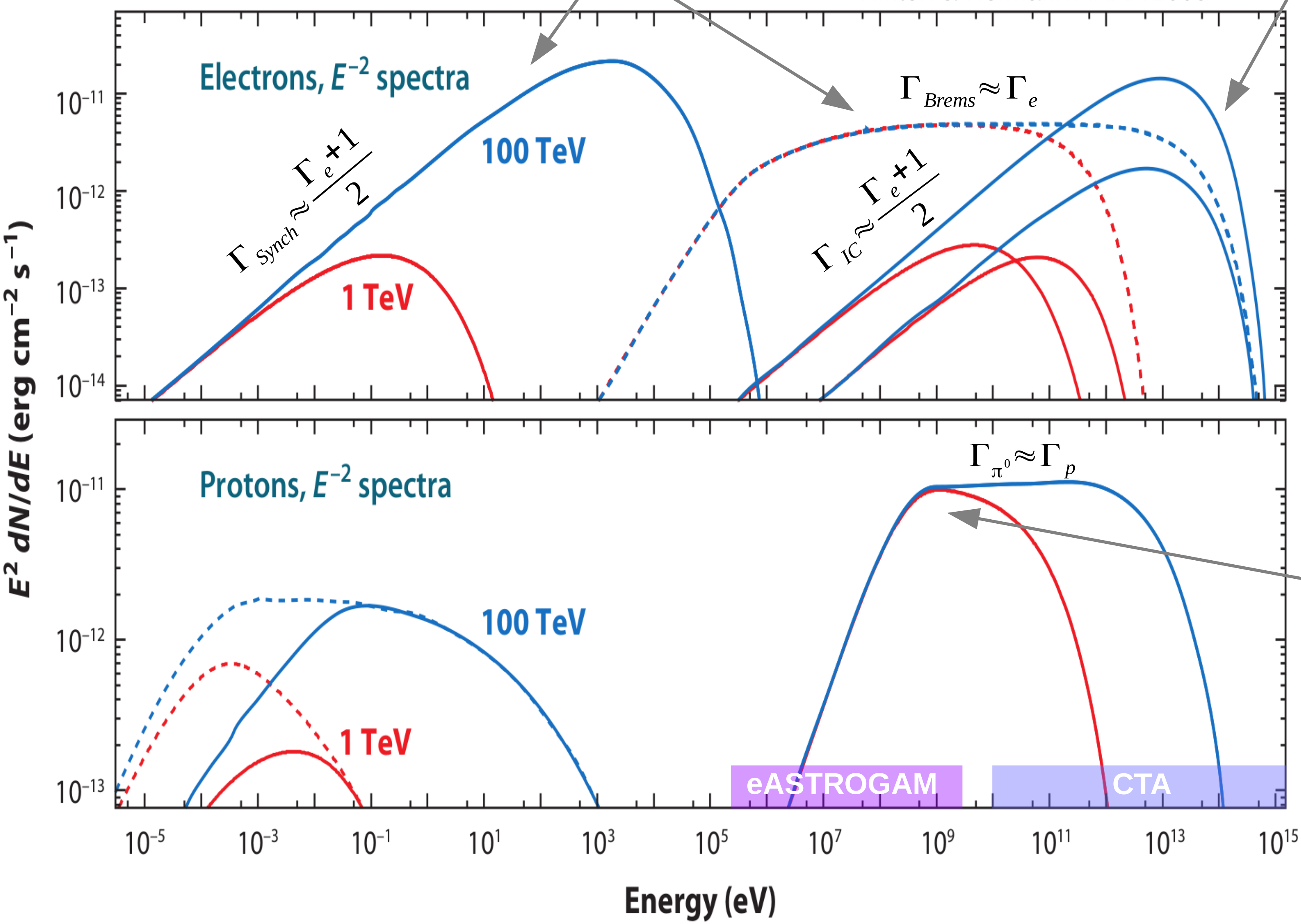
Surveys **Targets**

Emission mechanisms

Electron Bremsstrahlung typically harder. Can be disentangled with synchrotron spectrum.

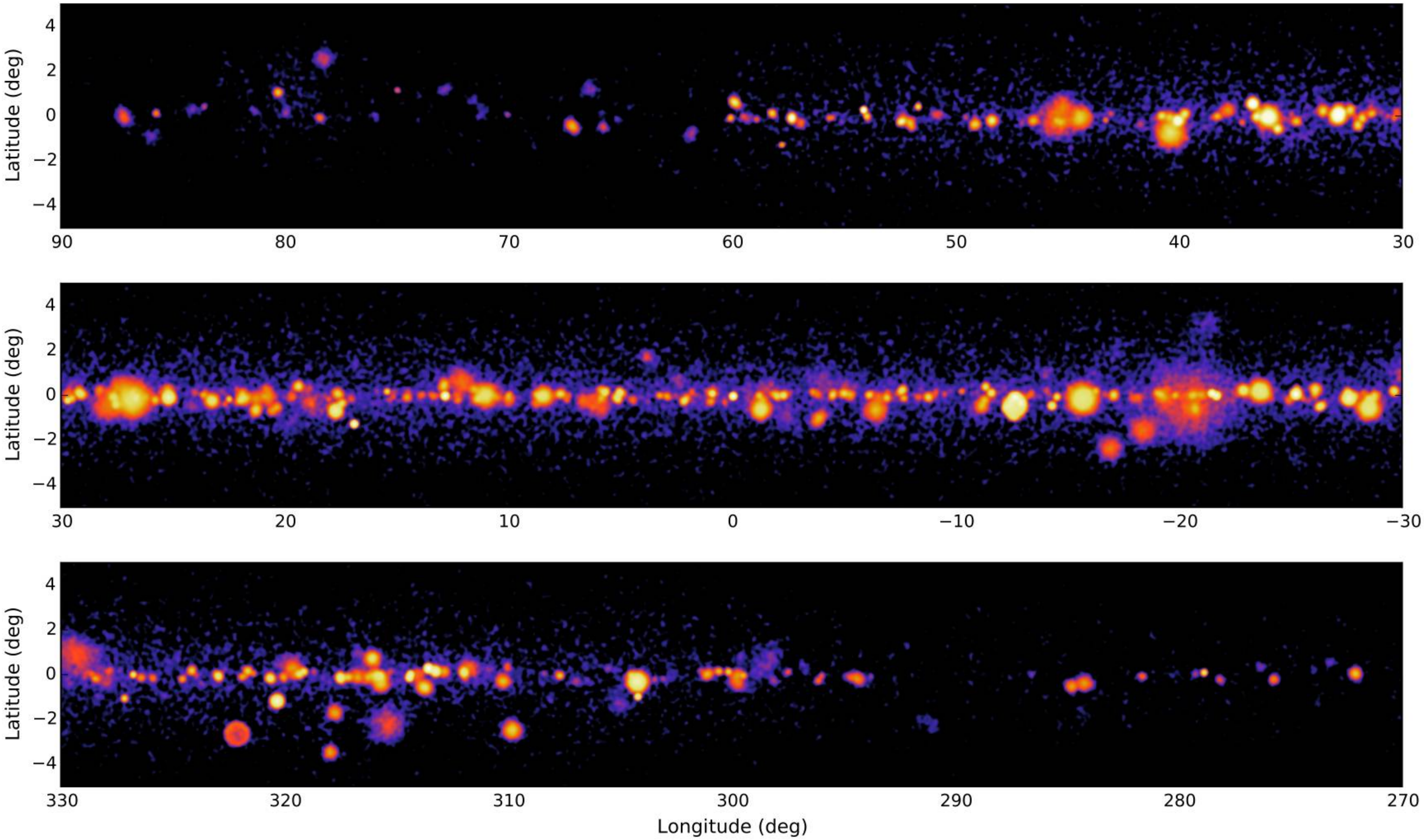
Emission >100 TeV likely hadronic as IC Klein-Nishina suppressed

Hinton & Hofmann ARAA 2009



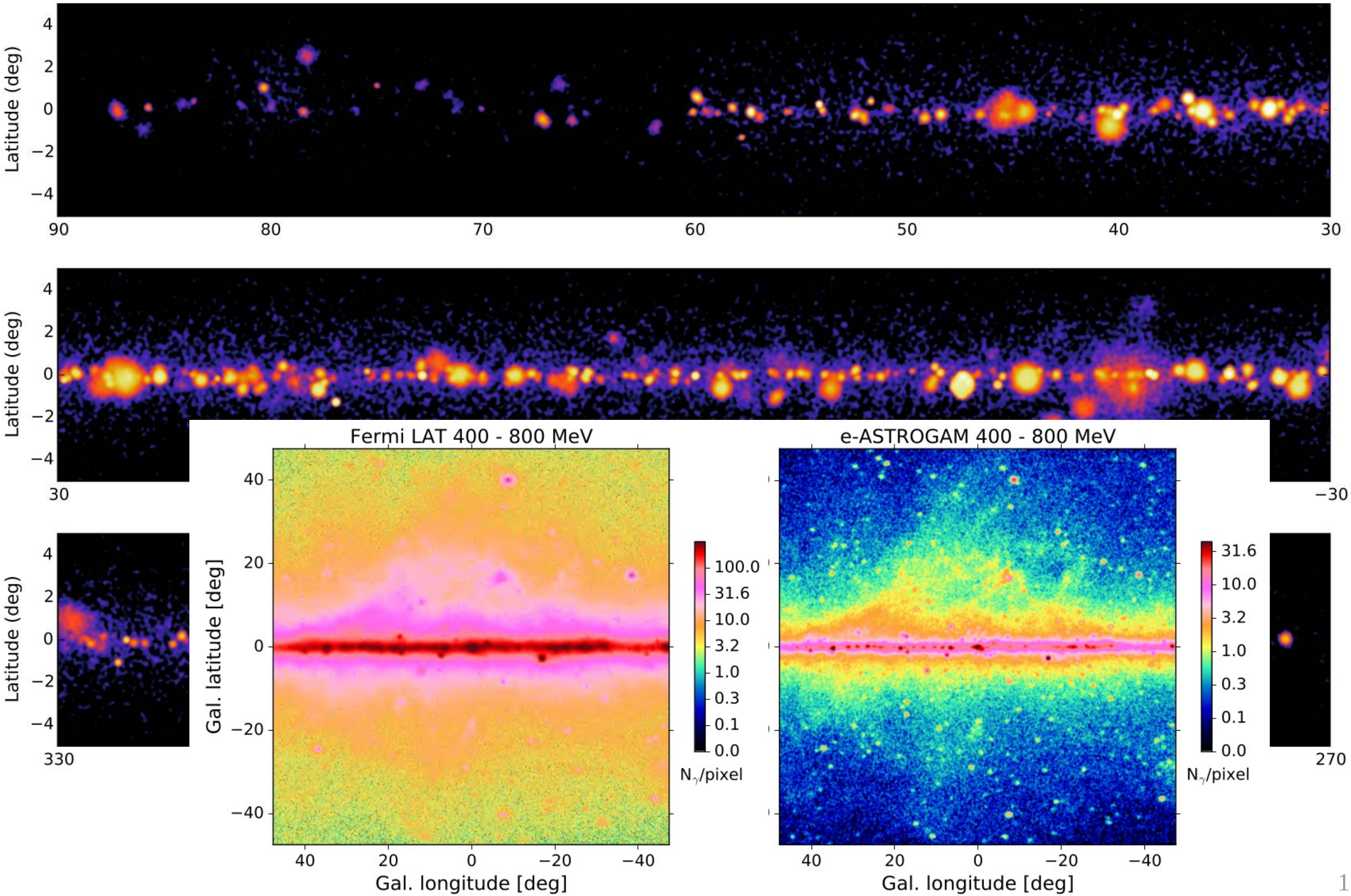
Decay leads to pion bump <100 MeV. Clear sing of hadronic origin

The Milky Way

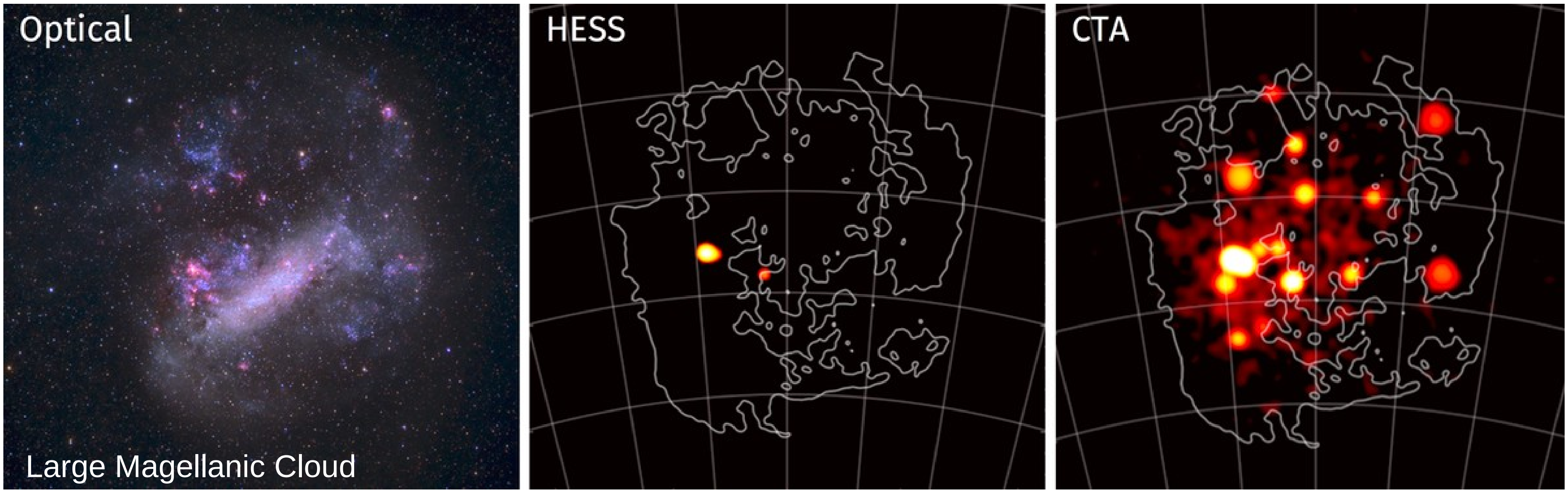


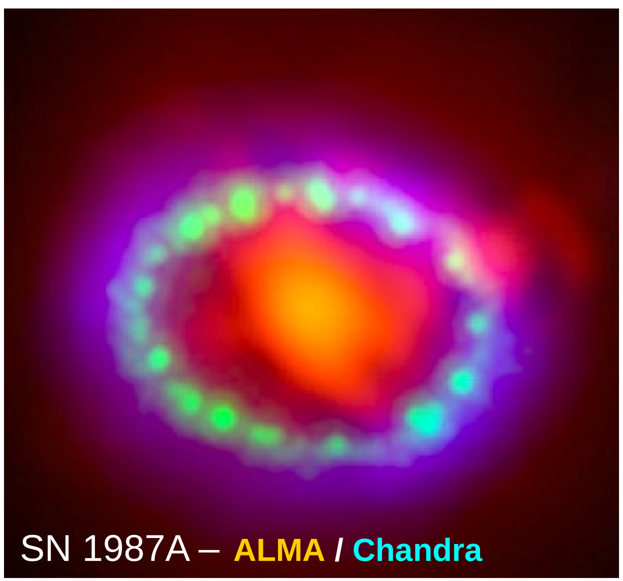
CTA will scan the galactic plane at ~0.2% Crab flux sensitivity level.

The Milky Way

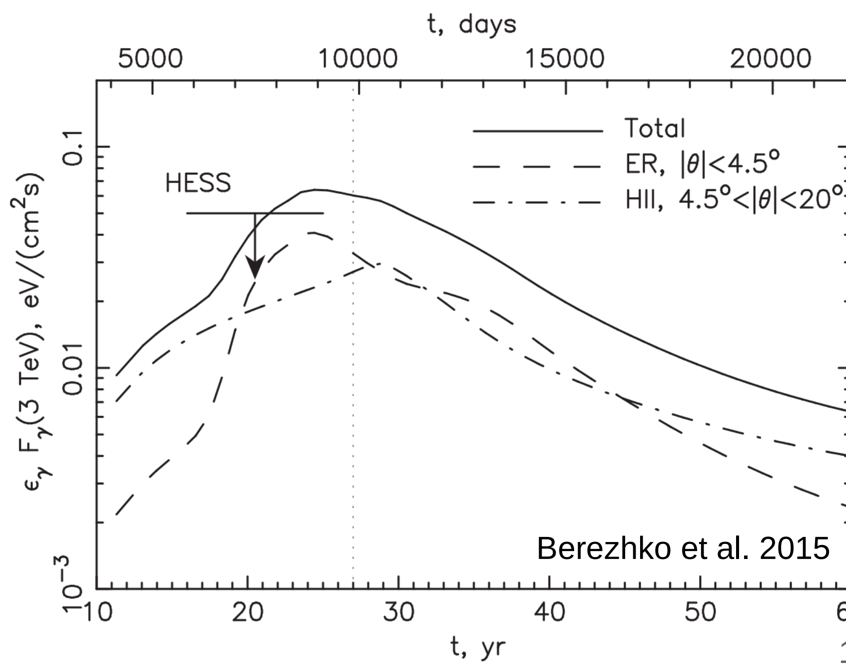


Supernova Remnants



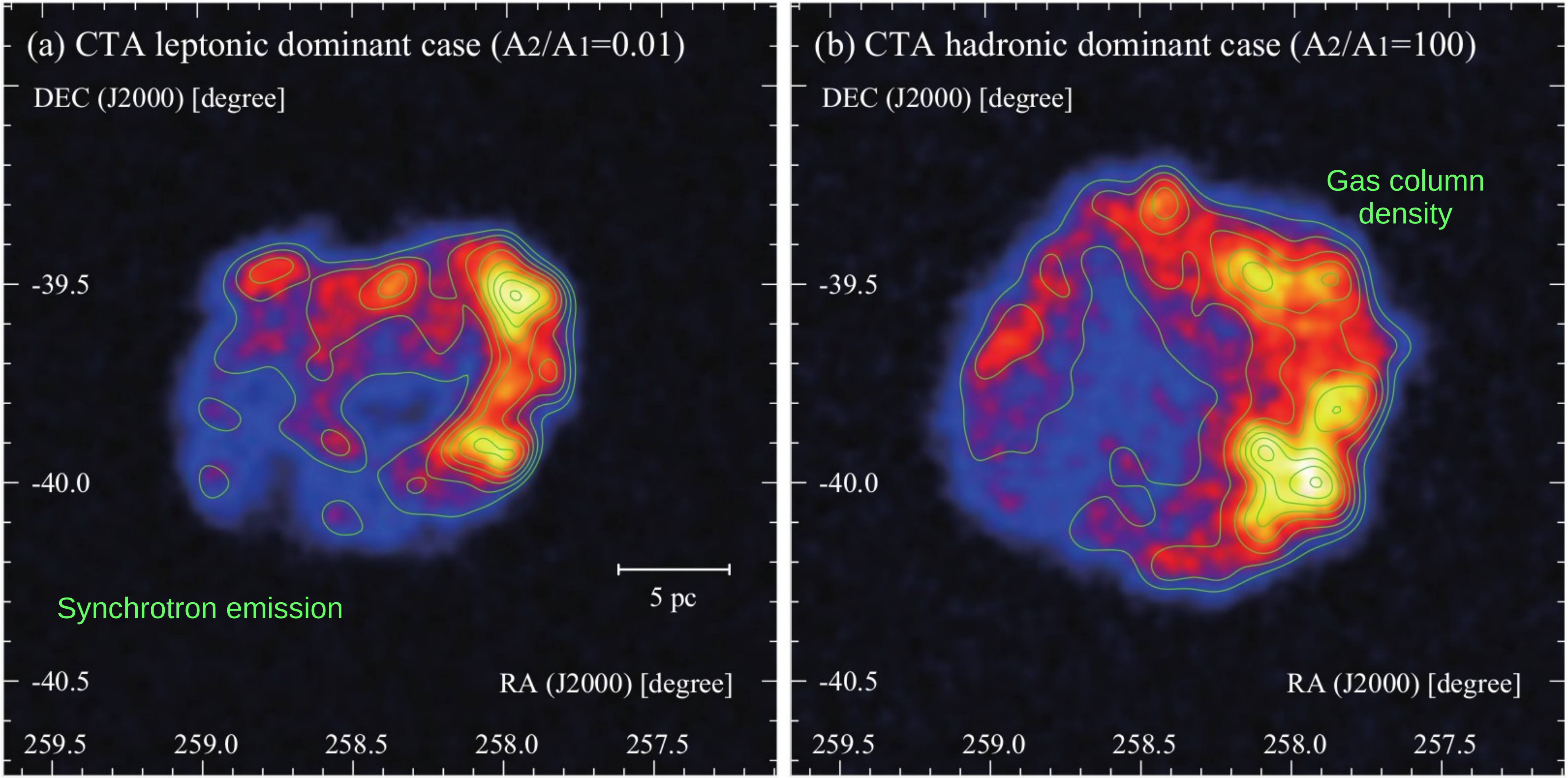


High-energy particle acceleration over time could be detected by CTA and eASTROGAM



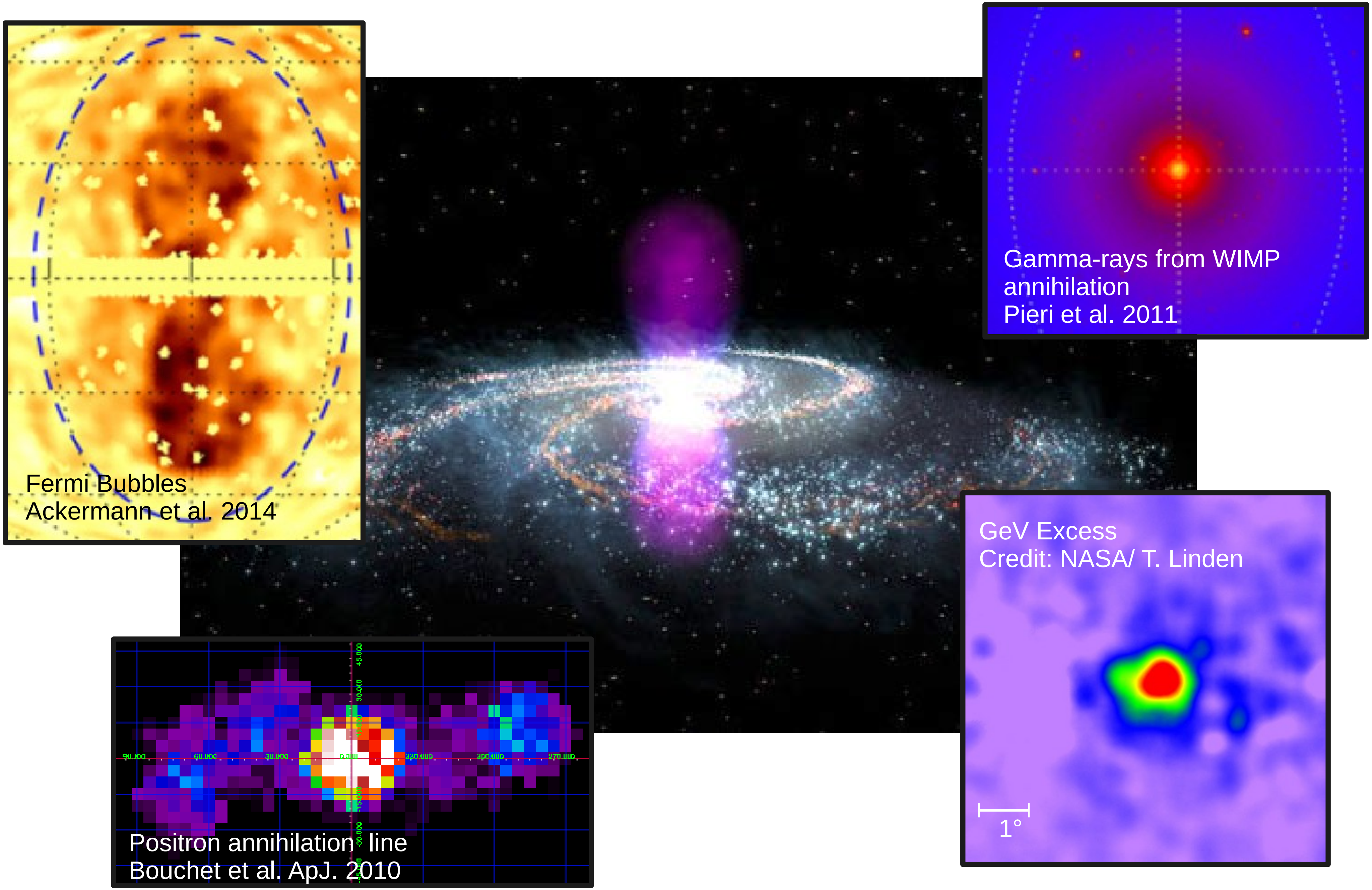
Supernova Remnants

CTA simulation for RX J1713.7-3946 from Nakamori et al. ICRC 2015

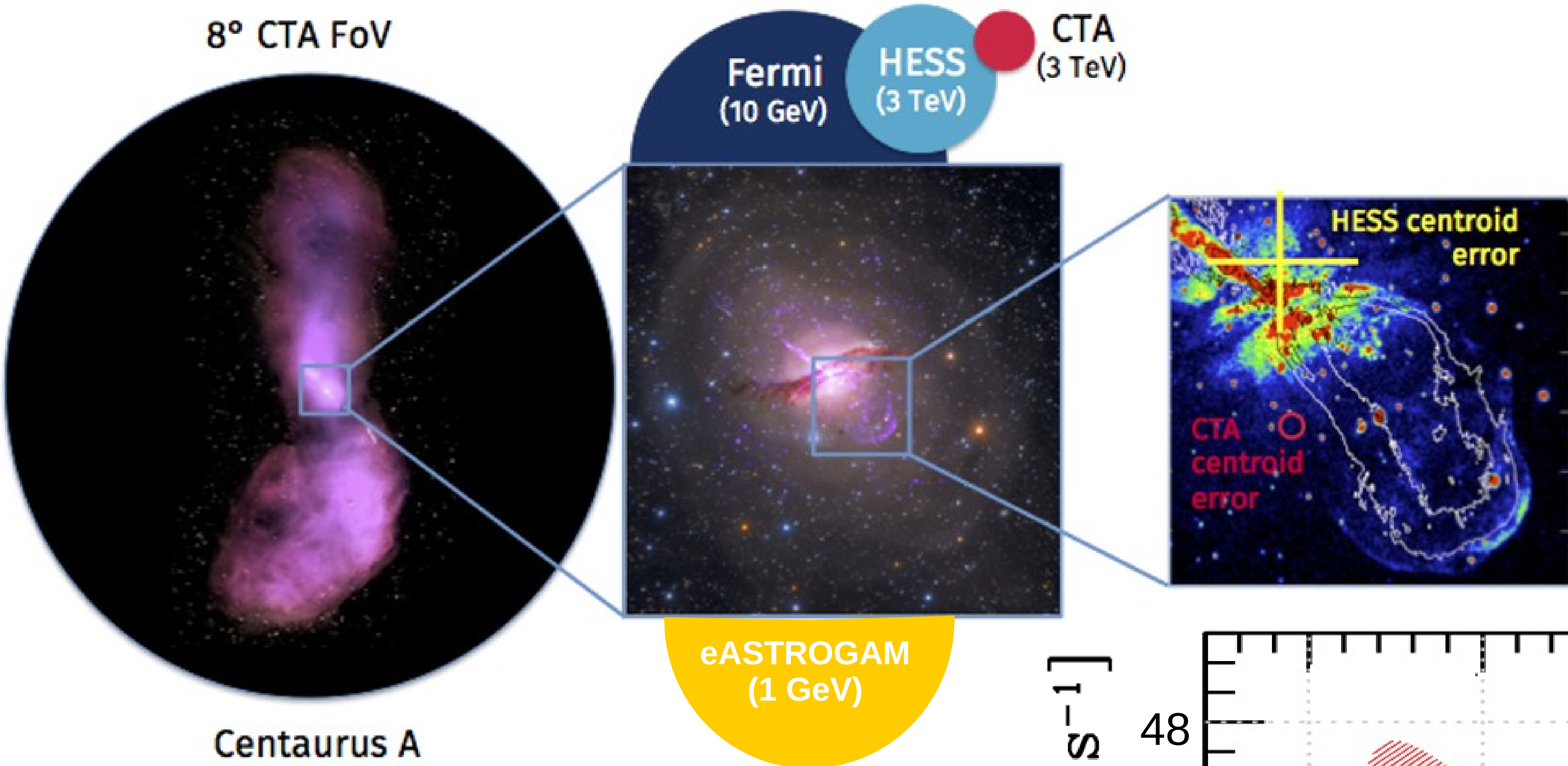


Morphology and spectra can resolve the leptonic/hadronic origin of the emission in SNRs. eASTROGAM complements this with the “pion bump”.

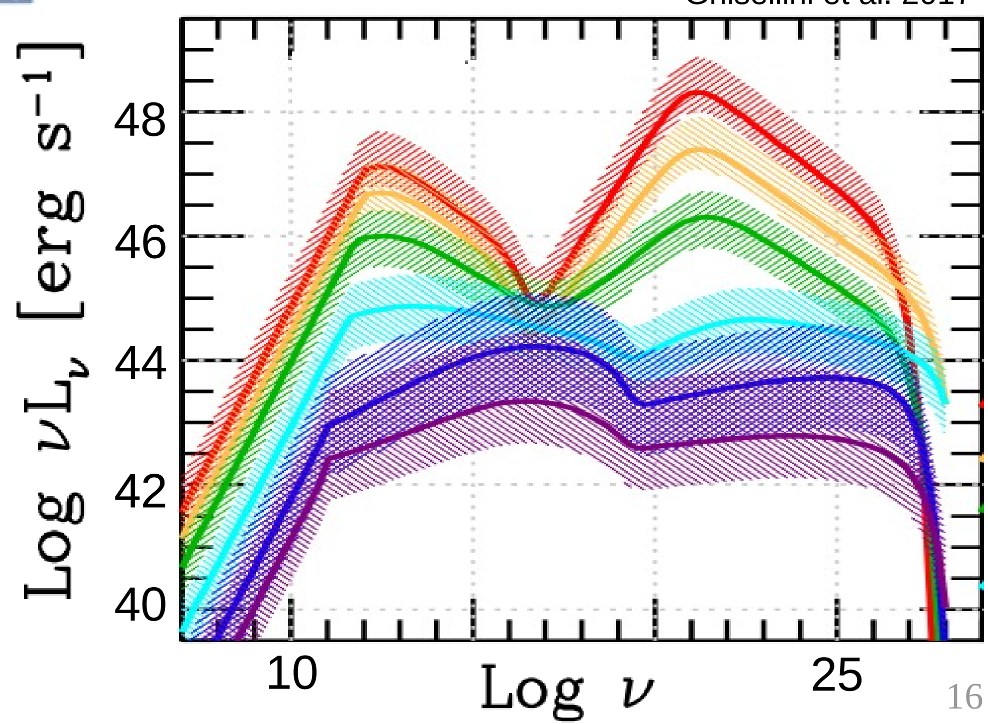
Galactic Center



Radio Galaxies and Blazars

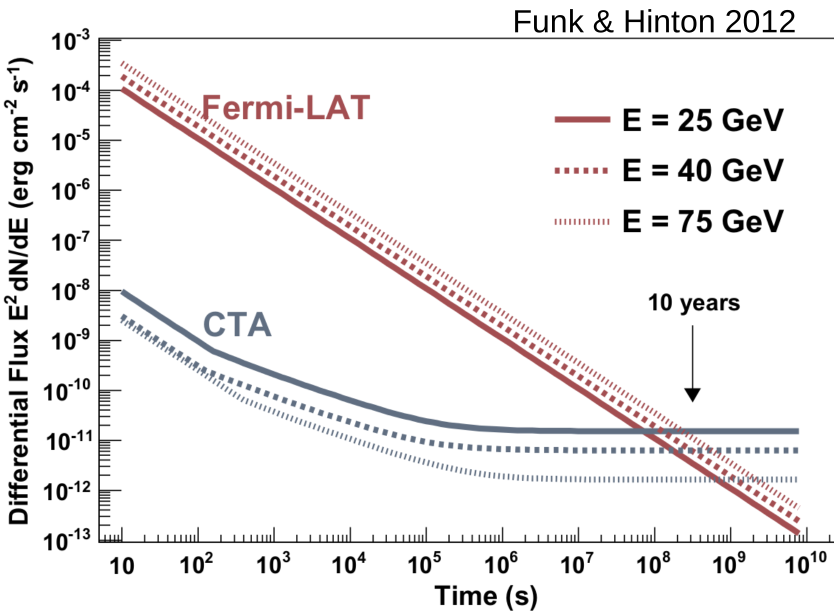


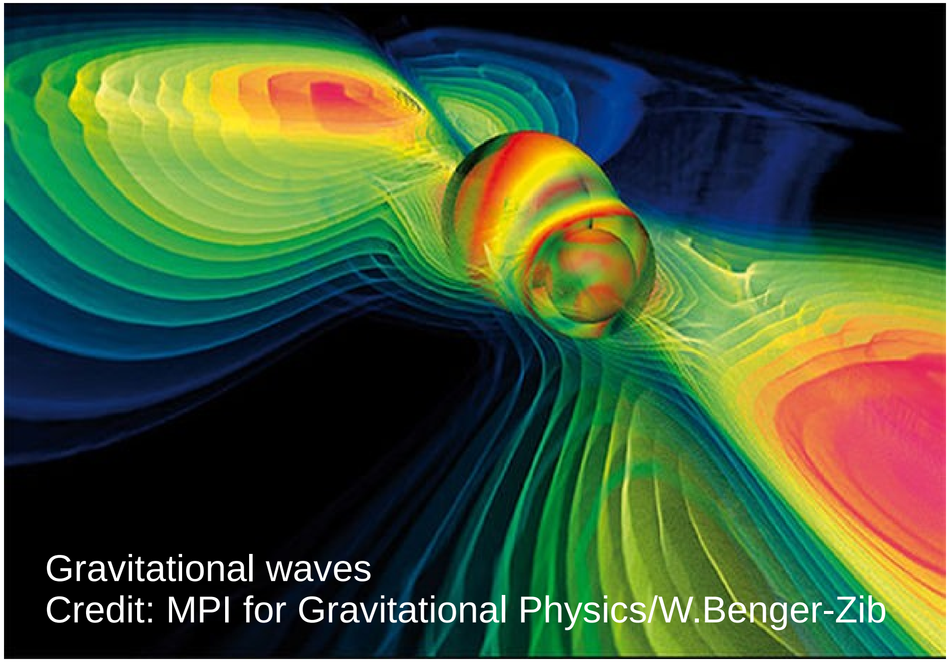
Ghisellini et al. 2017



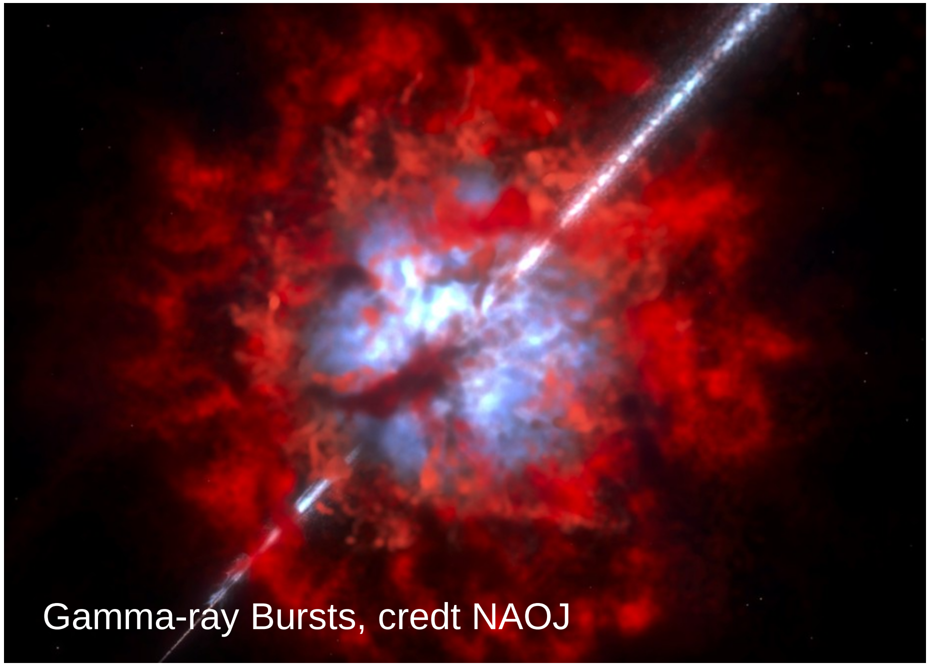
Morphological resolve radio galaxies and population studies, e.g. blazar sequence?

Transients and Multi-messenger

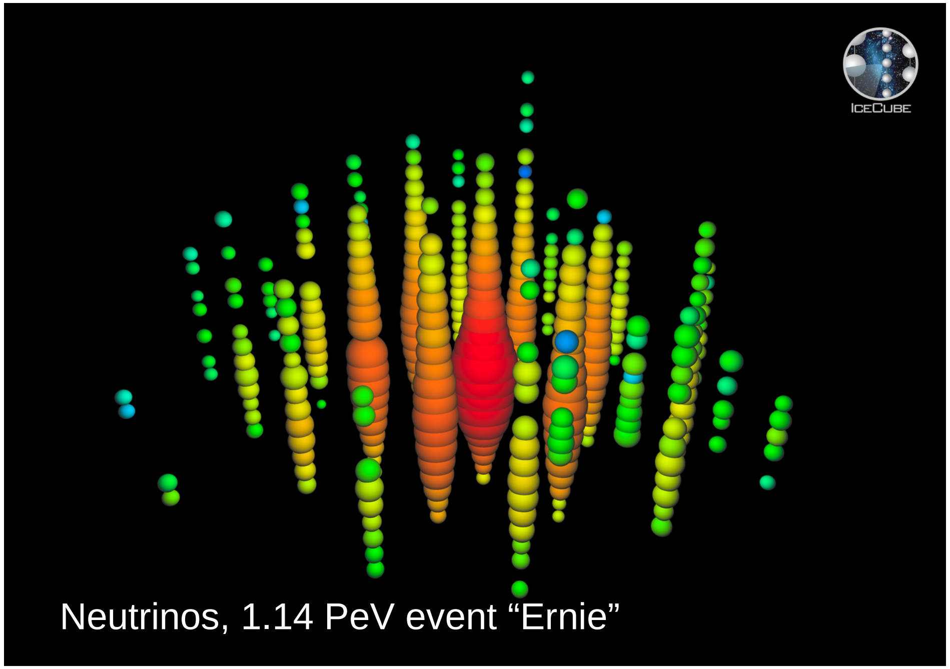




Gravitational waves
Credit: MPI for Gravitational Physics/W.Benger-Zib



Gamma-ray Bursts, credt NAOJ



Neutrinos, 1.14 PeV event “Ernie”

Summary

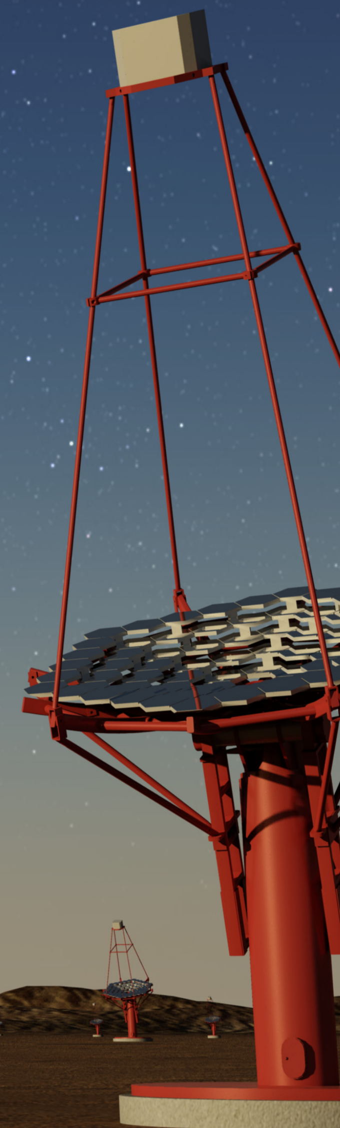
CTA and eASTROGAM could be the two major gamma-ray instruments in the 2020s and 2030s:

Together they constrain the non-thermal particle population over ~8 decades in energy.

Many interrelated science topics, only some examples were given:

Milky way, Supernova Remnants, Galactic Center, radio galaxies, transients and multi-messenger.

Also technical synergies as common high level analysis tools `(ctools)`

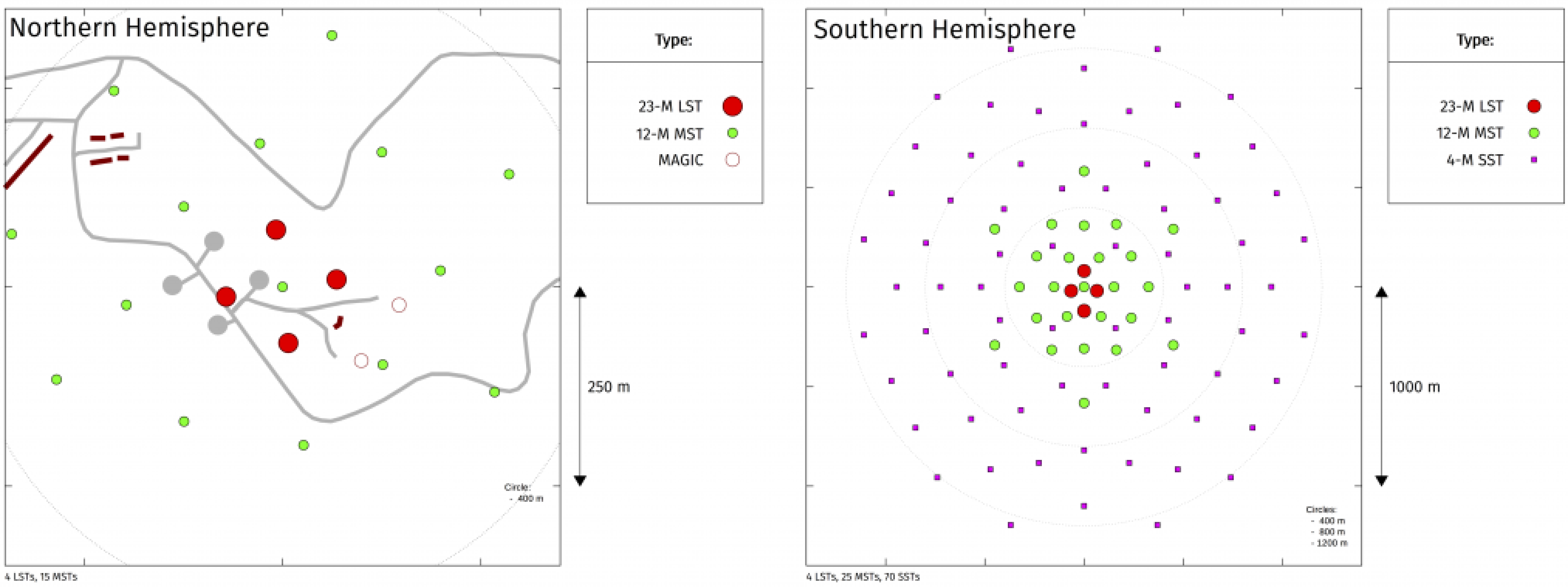


Backup slides

CTA telescope specifications

Telescope	Large	Medium		Small		
	LST	MST	SCT	SST-1M	ASTRI SST-2M	GCT SST-2M
Number North array	4	15	TBD	0		
Number South array	4	25	TBD	70		
Optics						
Optics layout	Parabolic mirror	Davies-Cotton	**Schwarzschild-Couder**	Davies-Cotton	**Schwarzschild-Couder**	**Schwarzschild-Couder**
Primary mirror diameter (m)	23	13.8	9.7	4	4.3	4
Secondary mirror diameter (m)	–	–	5.4	–	1.8	2
Eff. mirror area after shadowing (m^2)	368	88	40	7.4	6	6
Focal length (m)	28	16	5.6	5.6	2.15	2.28
Focal plane instrumentation						
Photo sensor	**PMT**	**PMT**	**silicon**	**silicon**	**silicon**	**silicon**
Pixel size (degr.), shape	0.10, hex.	0.18, hex.	0.07, square	0.24, hex.	0.17, square	0.15-0.2, square
Field of view (degr.)	4.5	7.7/8.0	8.0	9.1	9.6	8.5 - 9.2
Number of pixels	1855	1764/1855	11328	1296	1984	2048
Signal sampling rate	GHz	250 MHz / GHz	GHz	250 MHz	S&H	GHz
Structure						
Mount	alz-az, on circular rail	alt-az positioner	alt-az positioner	alt-az positioner	alt-az positioner	alt-az positioner
Structural material	CFRP / steel	steel	steel	steel	steel	steel
Weight (full telescope, tons)	100	85	~85	9	15	8
Max. time for repositioning (s)	20	90	90	60	80	60

Site Layout



40 Medium-Size Telescopes distributed over both array sites. Furthermore, eight Large-Size Telescopes and 70 Small-Size Telescopes


11 2013
Preliminary Design Review
07 2014
Sites Candidates Selected for Negotiation
late 2014
Interim legal Entity Established (CTAO gGmbH)
06 2015
Critical Design Review
2015
EU H2020 Funding for Site Preparations
2015
Consortium Grows to more th
1,500 Members from 32 Count
06 2016
HQ and Data Management Centre Site Decisions
2016
Site Hosting Agreements Finalize
11 2016
Interim Memorandum of Understanding for Construction
03 2017
Detailed Geotechnical Site Analys
late 2017
First Pre-Production Readiness Review
early 2018
First Pre-Production Telescopes c
2021
Beginning of Observatory Operations
2024
Construction Project Completion