Highlights of the LST Project

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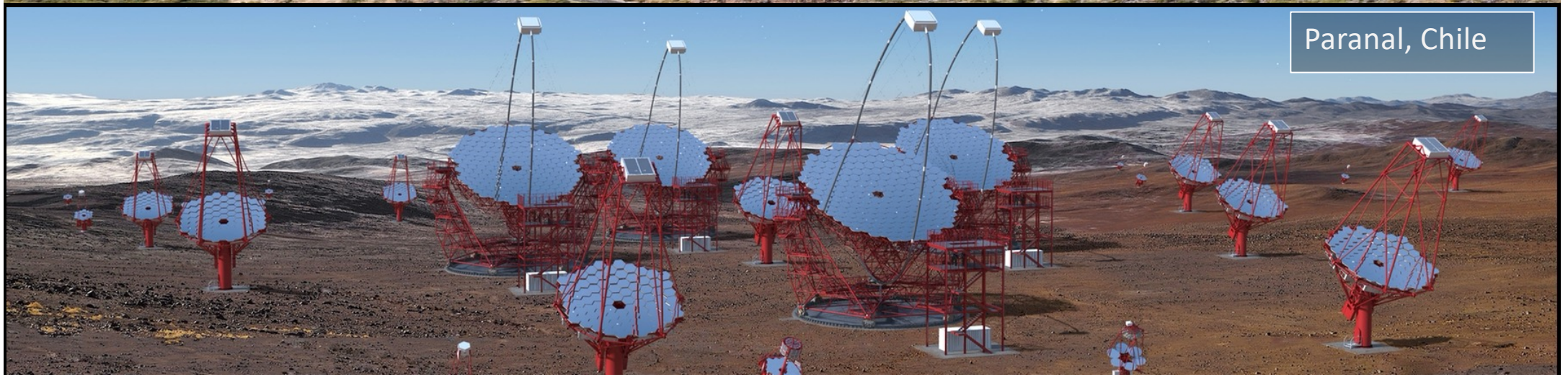
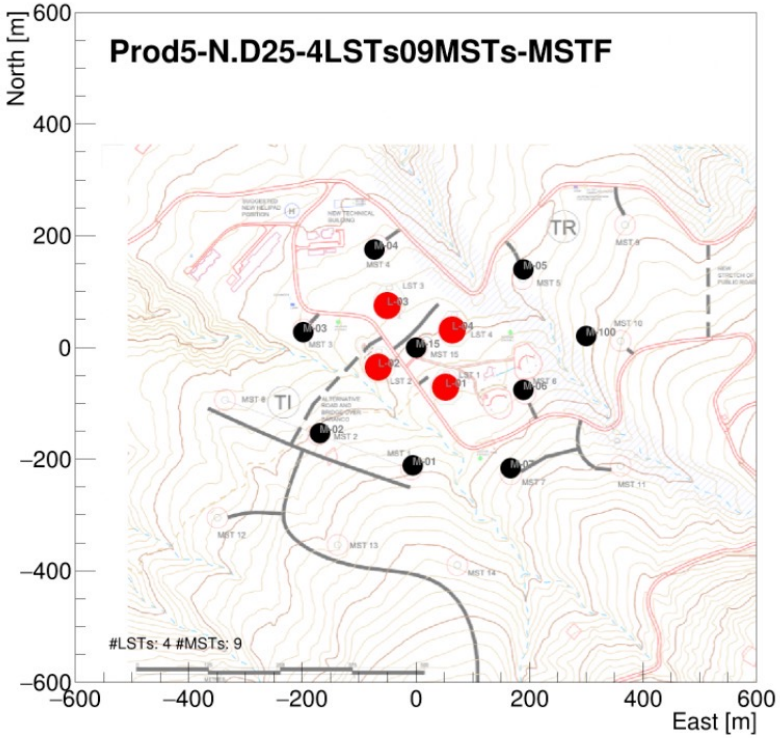
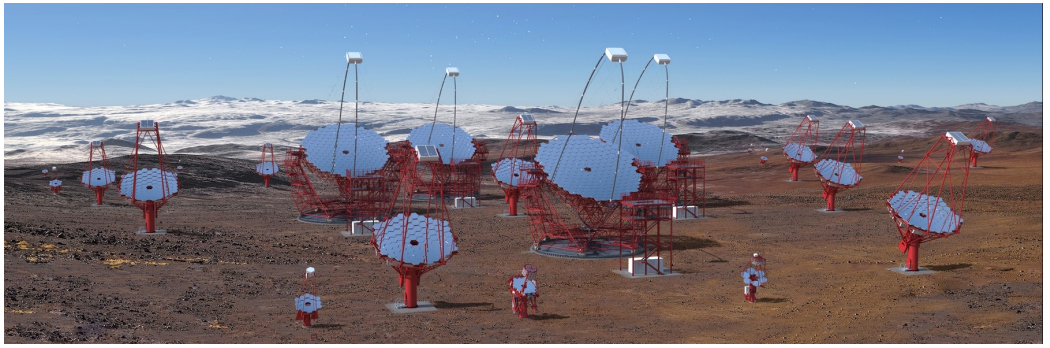


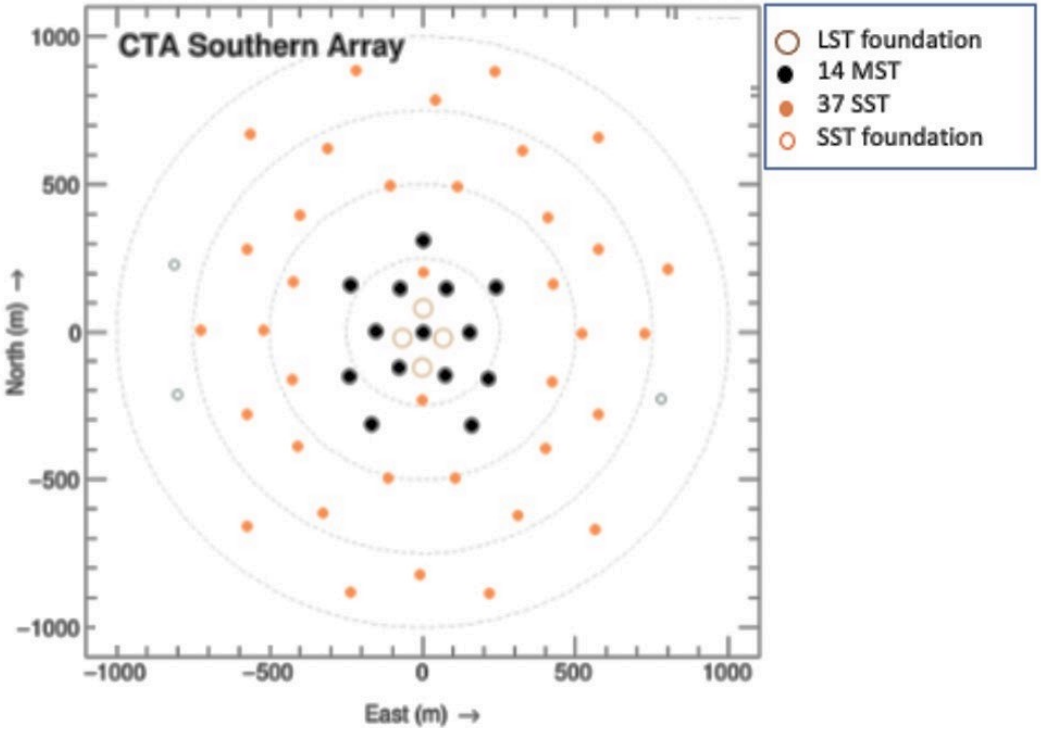
Alpha Configuration of CTA

Roque de los Muchachos Observatory
La Palma, Spain

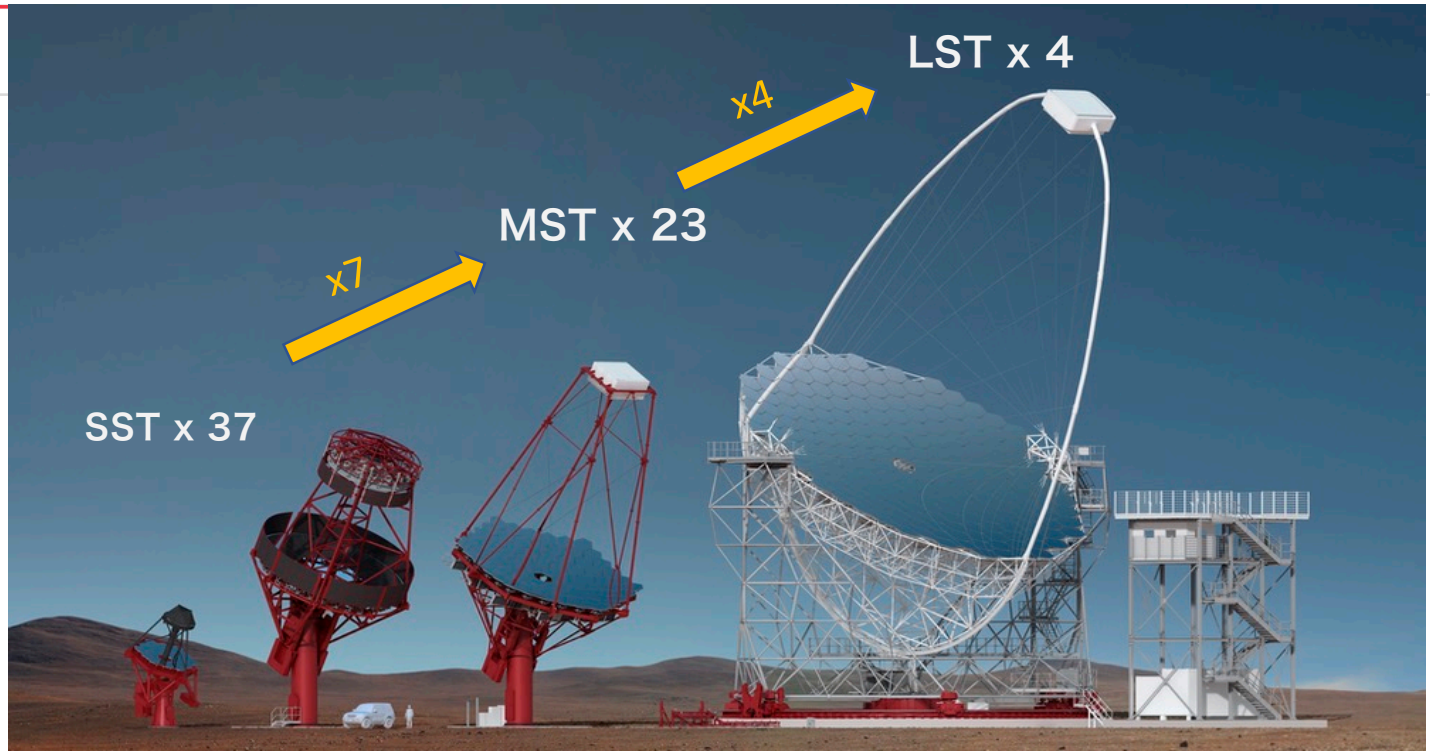


Paranal, Chile





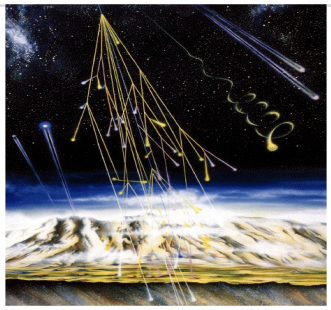
Telescope Design

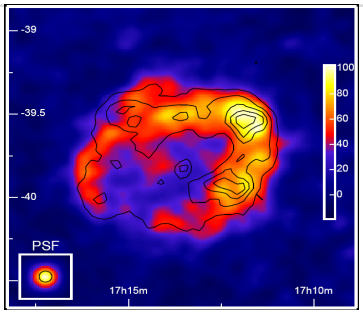


Telescope Types	SST	MST	LST
Optics	Schwarzschild-Couder	Davies-Cotton	Parabolic (Isochronous)
FoV and Camera	10.5 deg SiPM	7.5 deg PMT	4.3 deg PMT
Mirror Diameter	4.3m	11.5m	23m
Energy Range	3 TeV - 200 TeV	100GeV - 10TeV	20GeV – 2000GeV
Science Targets	Galactic Sources PeVatron (UHE CR)	Galactic Sources Nearby AGNs (z<0.5) Dark Matter	Transient Sources AGNs(z<2), GRBs(z <4) Dark Matter

Science of CTA is very wide

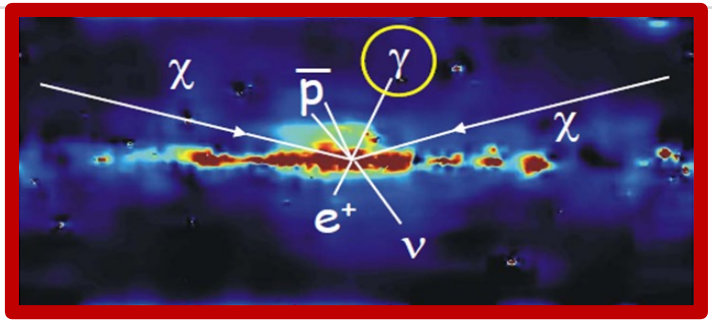
CTA-LST will cover S.M.B.H., Dark Matter, AGNs, GRBs





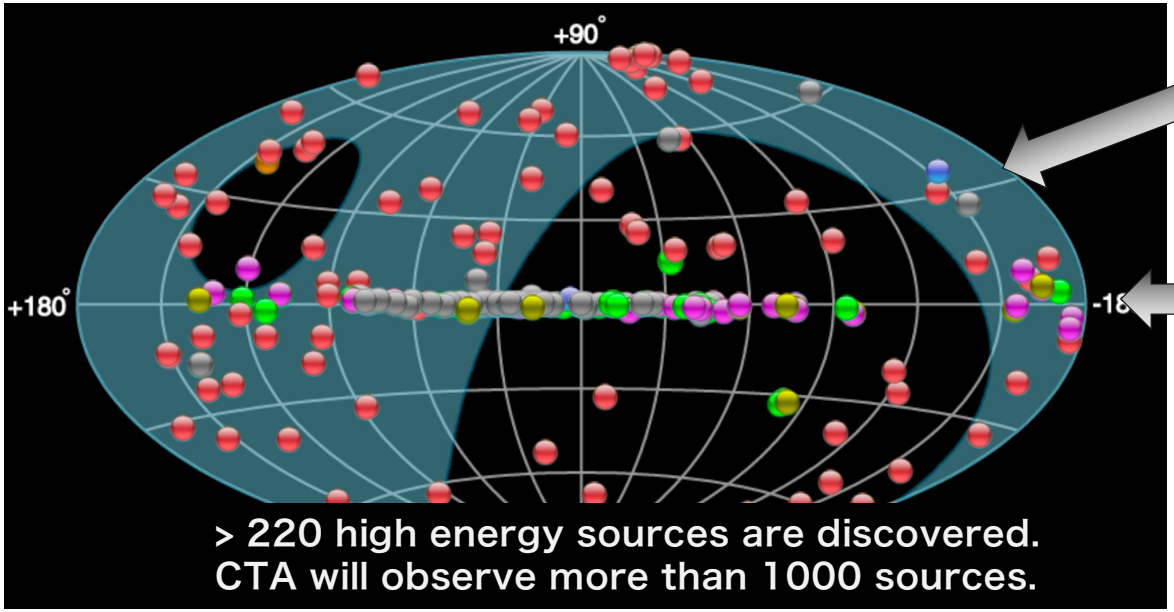
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

- Origin of Cosmic Rays (Big accelerators)
- Black Hole and S.M.B.H.
- Dark Matter Search

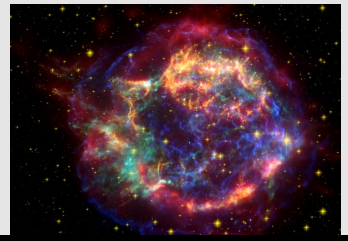


Extragalactic Sources

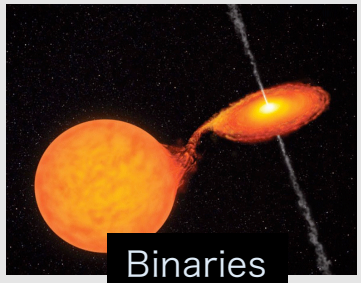
Active Galactic Nuclei

Gamma Ray Bursts

Galactic Sources



Super Nova Remnants



Binaries

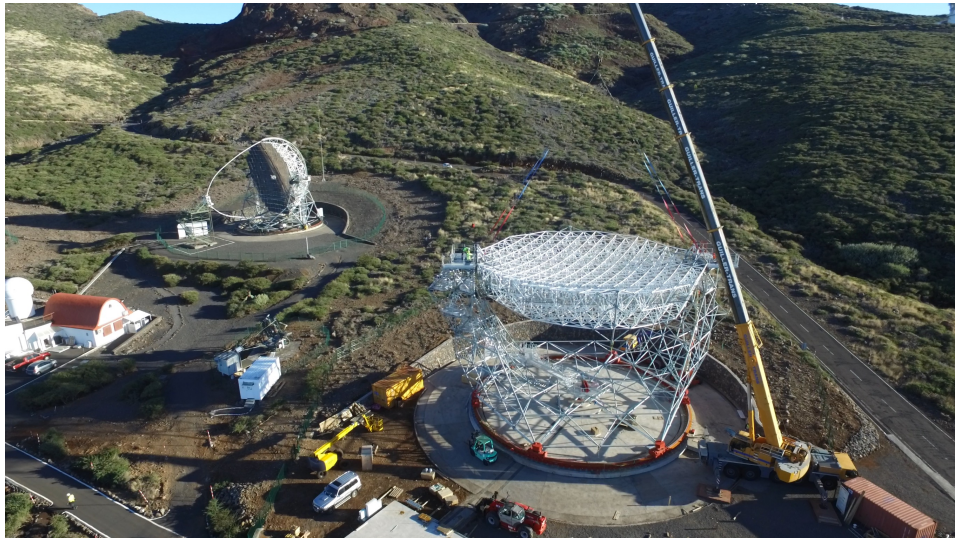
LST Collaboration

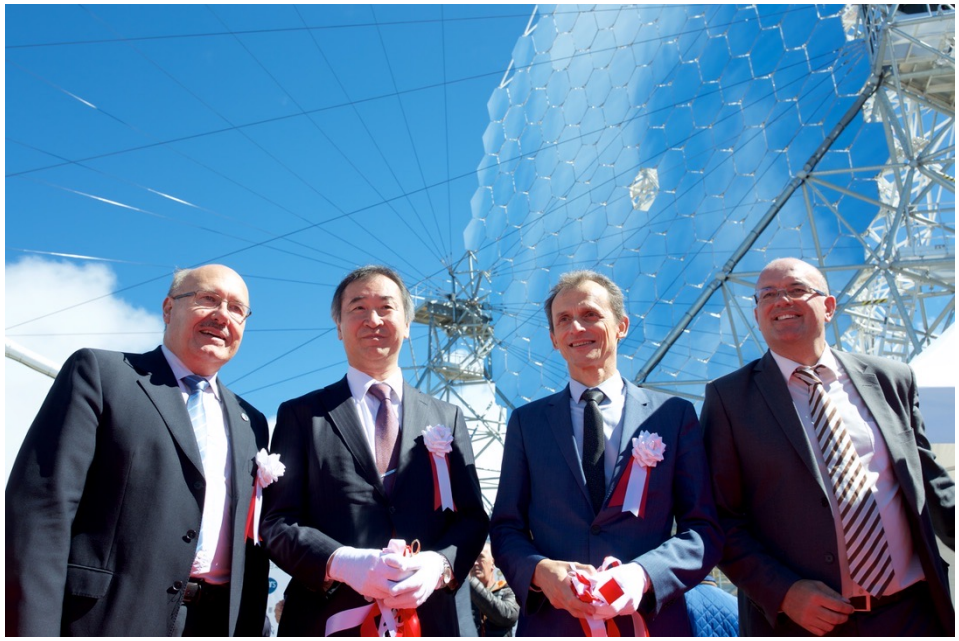
LST statistics			
	Members	Scientists + Students	Authors
Bulgaria	2	2	2
Brazil	3	2	2
Spain	92	61	56
France	42	21	21
Croatia	9	9	9
Czechia	19	19	12
Germany	49	42	39
Switzerland	22	19	16
Italy	129	103	78
Japan	87	82	65
Poland	5	5	5
Total	459	365	305

We have a good number of people

cherenkov telescope array

LST1 was inaugurated in Oct.2018





Large Size Telescope

Mirrors: JP
Interface plates: JP, DE, BR
Actuators: JP, CH, DE
CMOS CAM: JP

Tension cables: IT

Camera Support Structure: FR

calibration: IT, HR, IN, DE

Camera electronics: JP, IT, ES, CH
Camera mechanics: ES
Camera safety: FR

Telescope structure: DE, ES

Rail: DE, ES

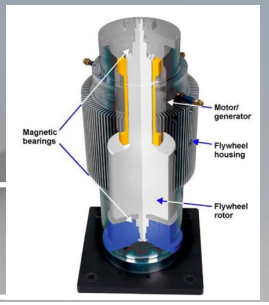
Camera Access Tower: DE,ES

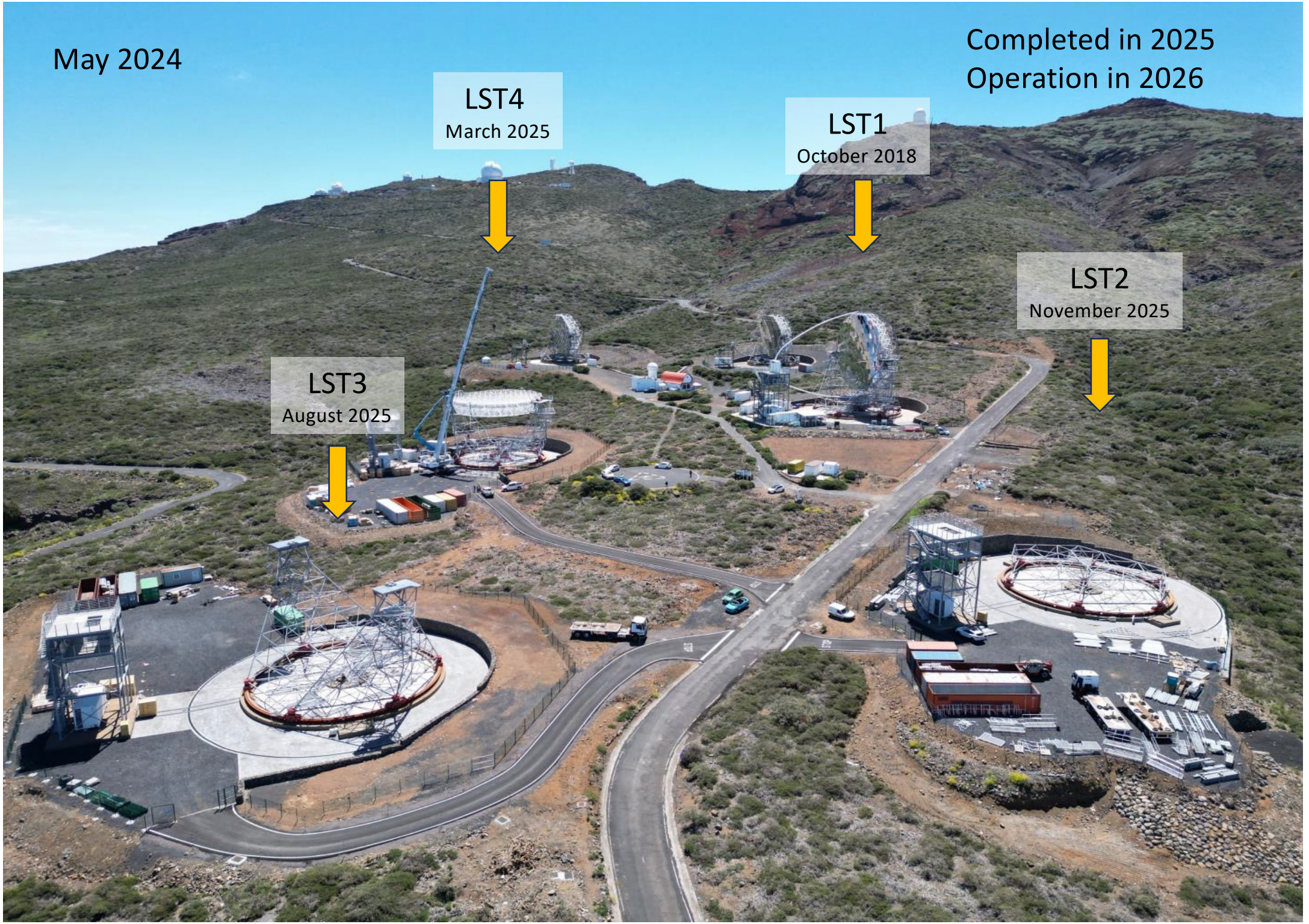
Bogies: ES, DE

Foundation: ES

Drive and main el. cabinet: FR

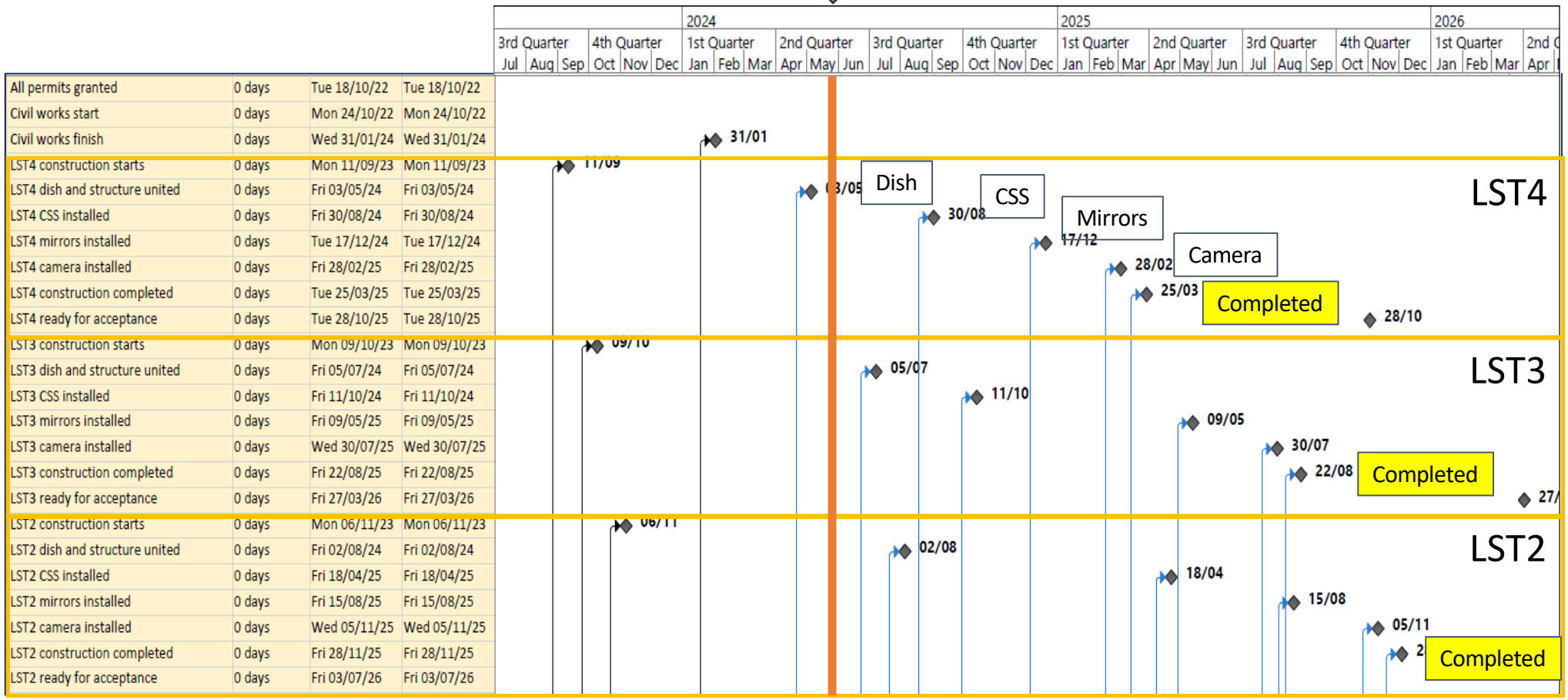
FlyWheels (2x300kW) energy storage and UPS: JP




May 2024
Completed in 2025
Operation in 2026
LST4
March 2025
LST1
October 2018
LST2
November 2025
LST3
August 2025

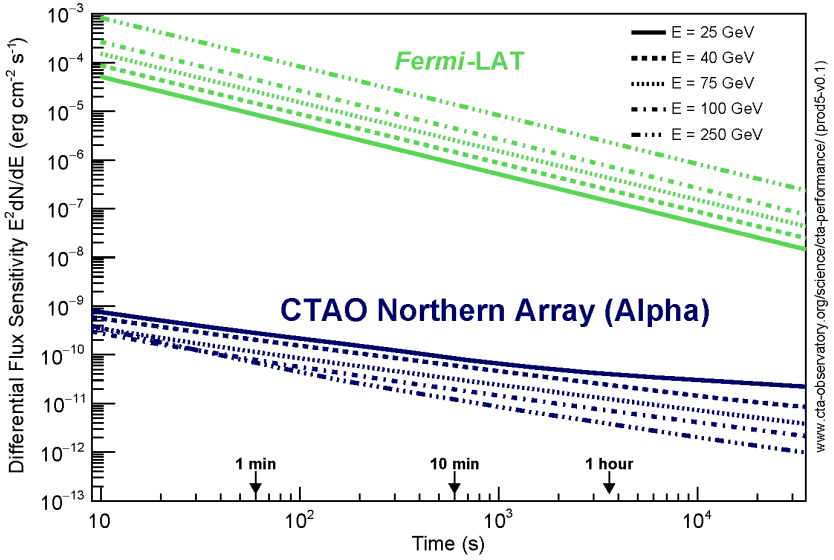
Schedule for the LST2-4 construction We will have the

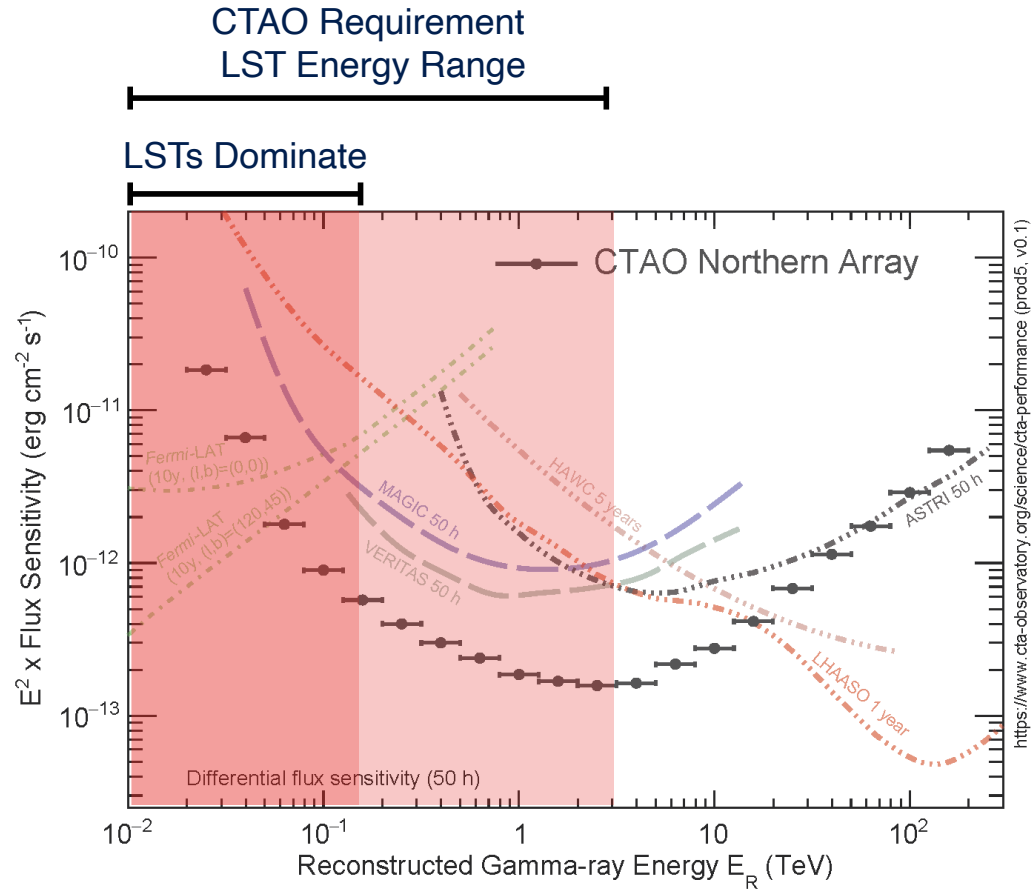
Now

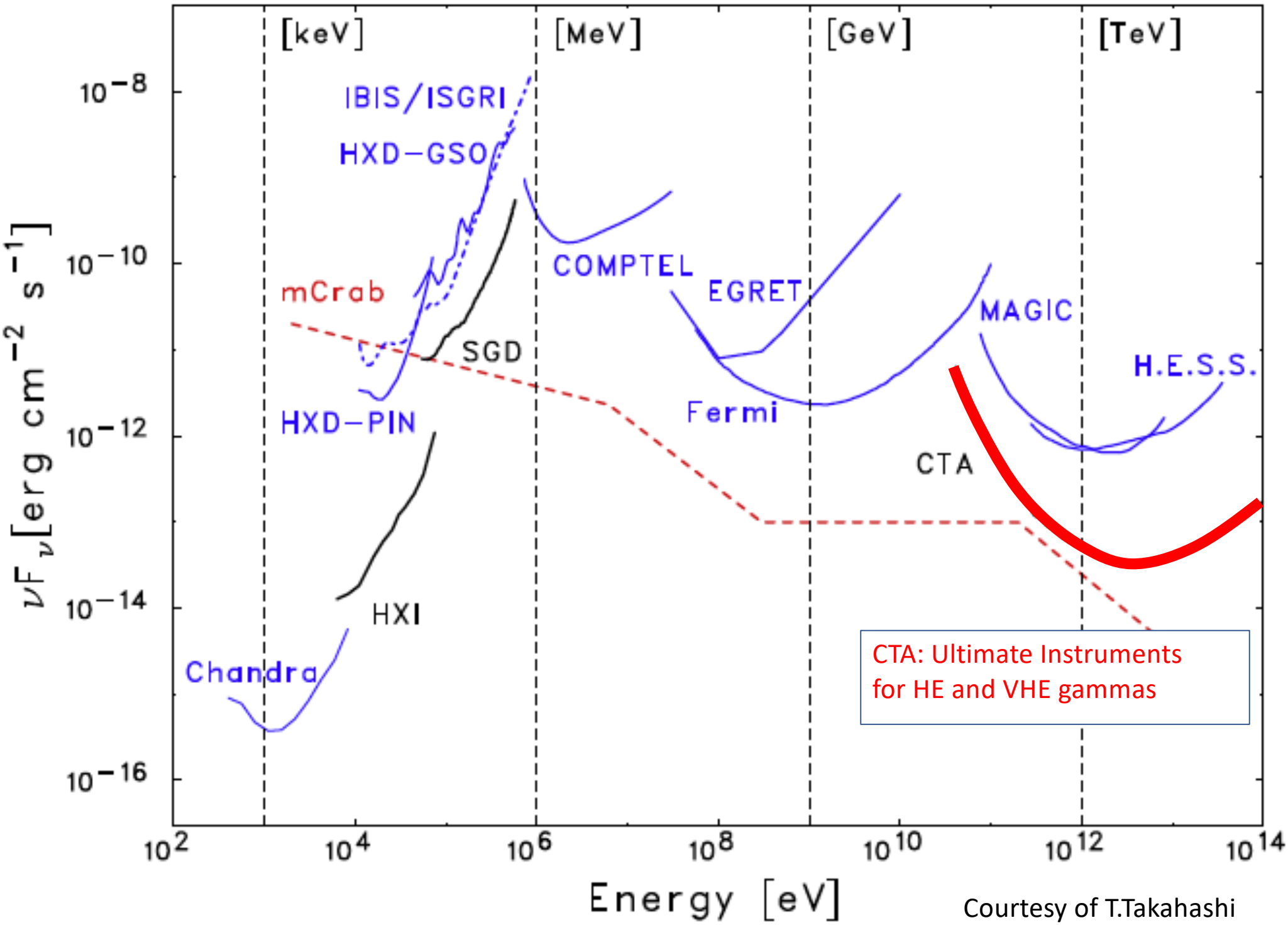


Performance of the CTAO North Array

- LSTs dominate CTAO sensitivity below 150 GeV
- Ideal for fast transients and soft sources

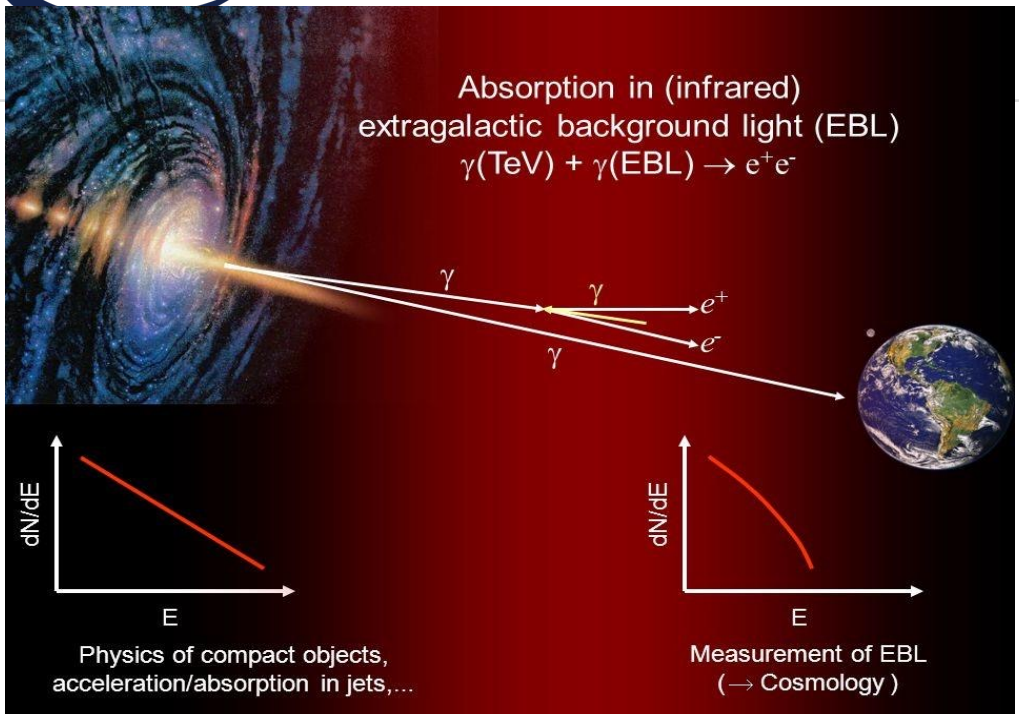


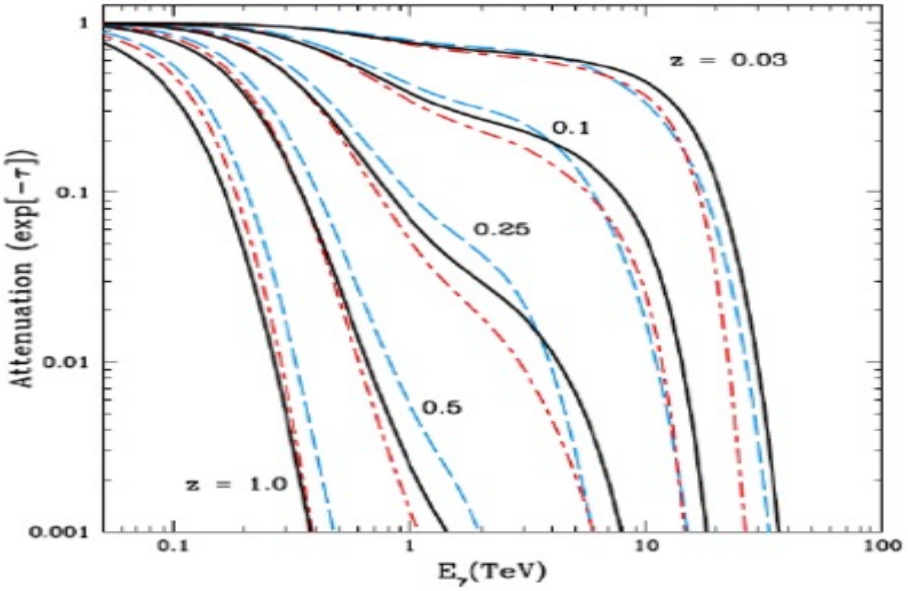


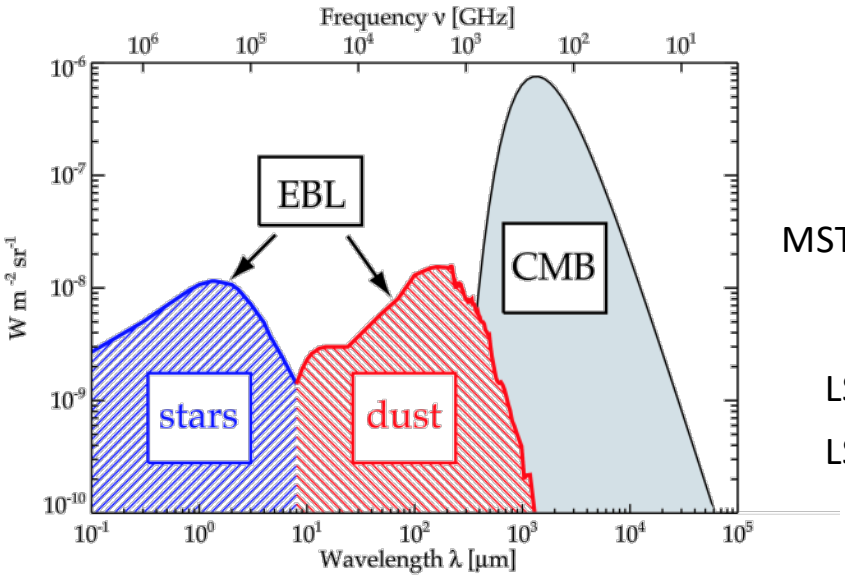


Courtesy of T.Takahashi

Gamma Ray Horizon
Access the deep Universe with LSTs



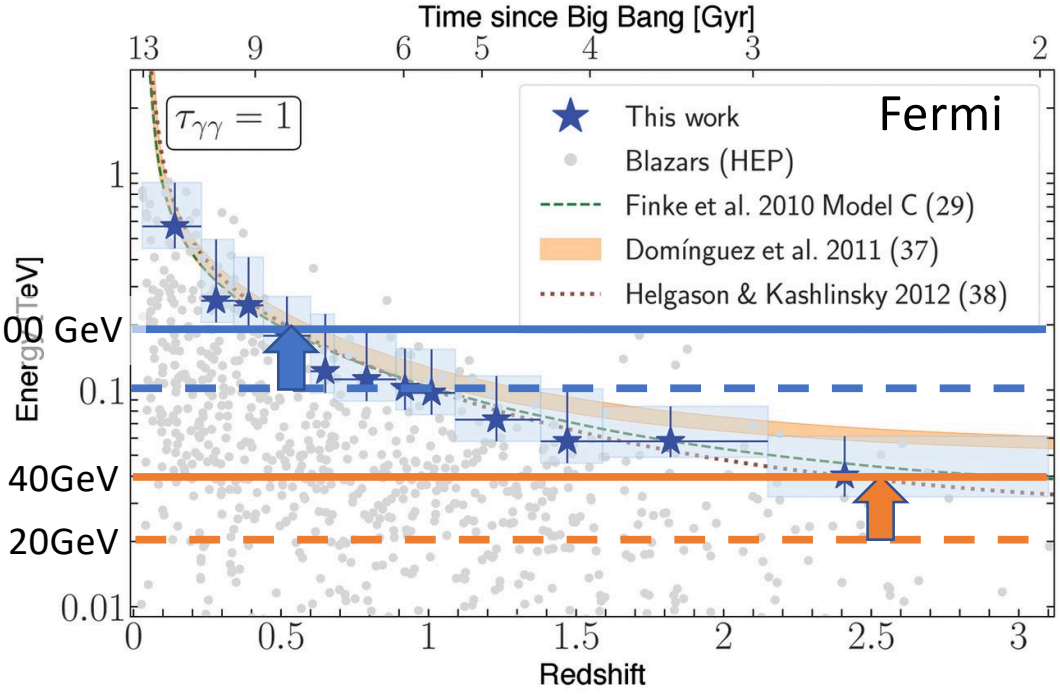




MST@45° Eth 200 GeV

LST@45° Eth 40GeV

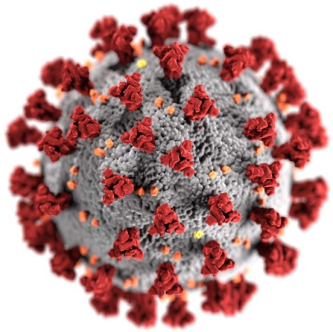
LST@25° Eth 20GeV

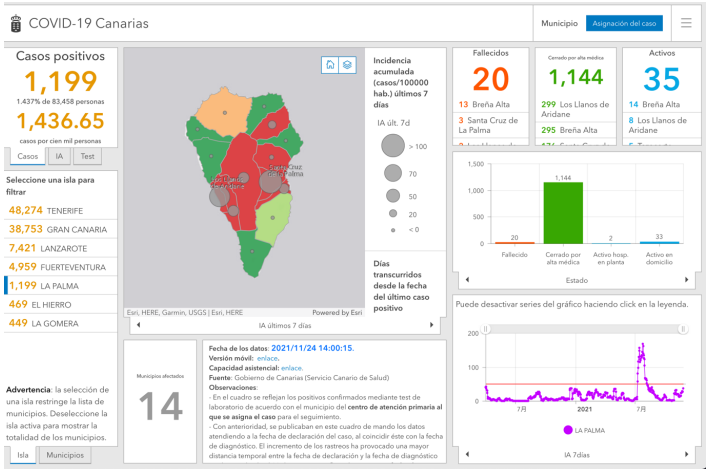


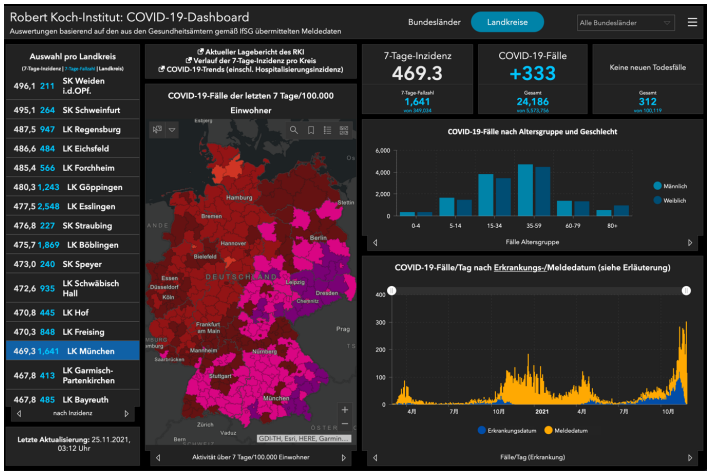
We suffered very much from Nature last years

Oh, my God!!

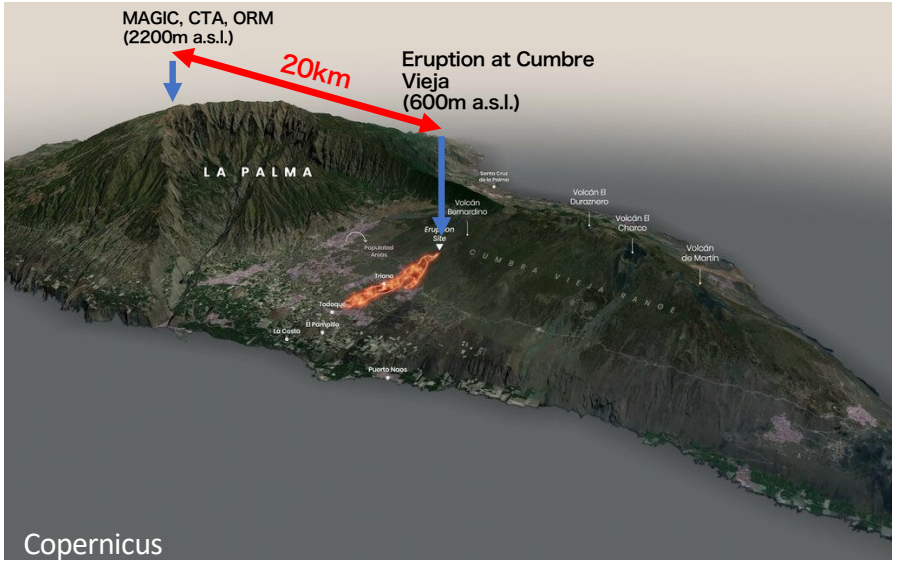
- Covid-19







- Volcano Eruption (19.Sep-14.Dec)

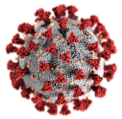


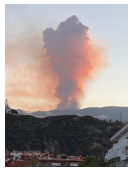
Erupciones históricas en La Palma			
#	Erupción	Año	Días erupción
1	nombre?	2021	85?
2	Teneguía	1971	24
3	San Juan	1949	47
4	Charco	1712	56
5	San Antonio	1667/1678	66
6	Tigalate	1646	82
7	Tehuya	1585	84
8	Tacande	1430/1440	?

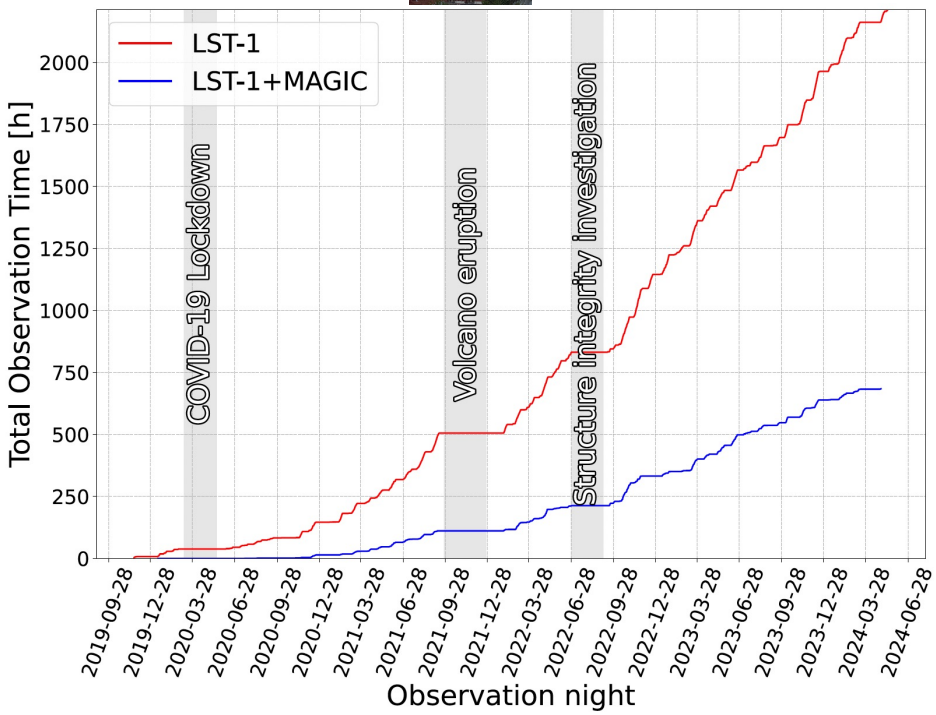
We are very sorry for the local people who evacuated from their living places and lost heir properties. Fortunately the ORM is located 20km from the volcano, so far there is no damage to MAGIC and CTA LST.

LST1 has been collecting data for more than 2000hrs

Oct 2018: LST1 Inaugurated
Jan 2020: Scientific operation started



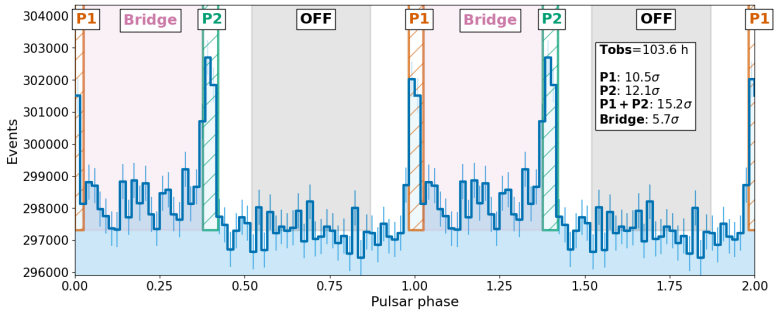




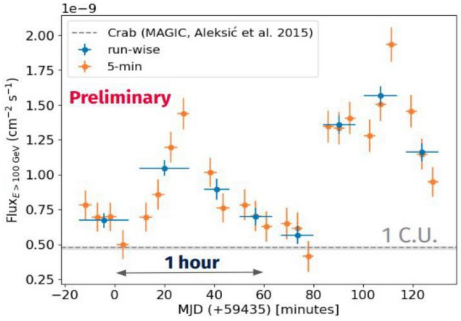
Quick follow-up observation with LST1 for GRBs and other transients.
LST can point any sky direction in 20 seconds

Many scientific results are delivered

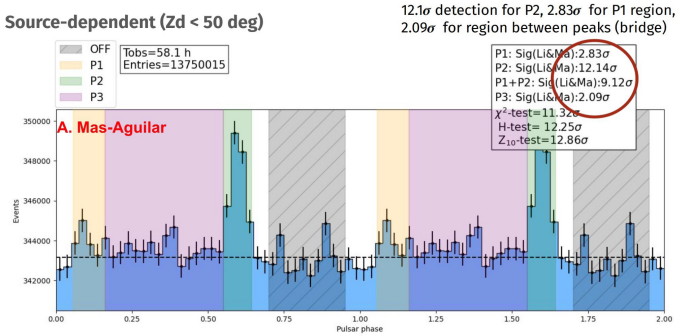
Crab pulsar above 20GeV



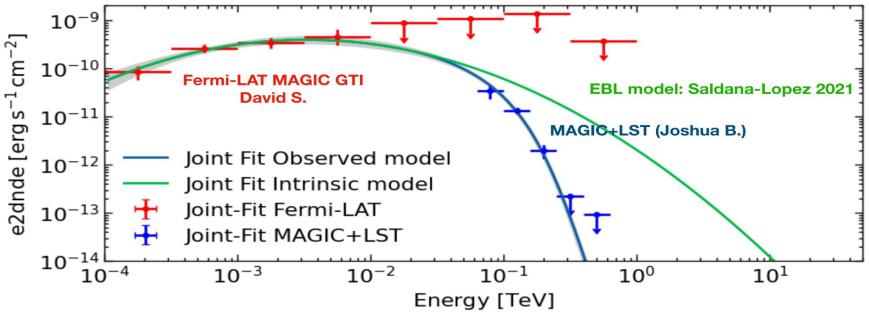
BL Lac intranight fast variability (a few min)



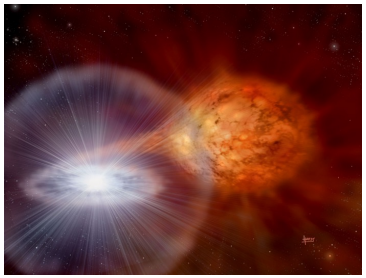
Geminga pulsar above 15GeV

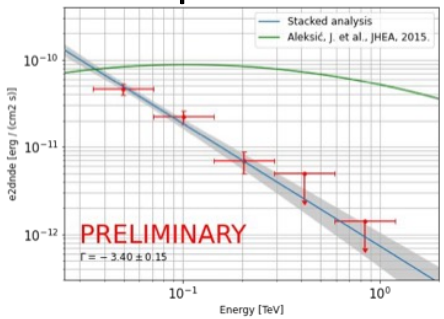


OP313: discovery of the most distant VHE AGN

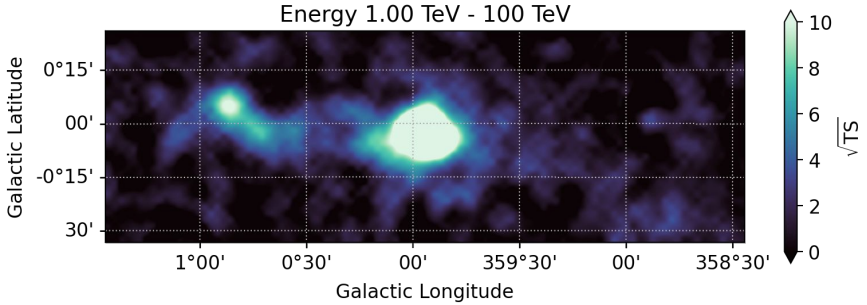


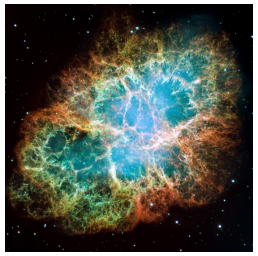
Symbiotic Nova RS Ophiuchi



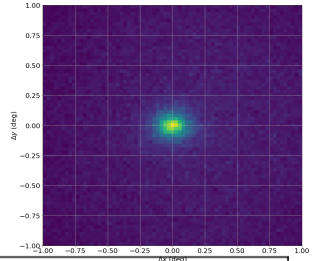


Galactic Center 39hrs (Sgr A*, diffuse, DM)



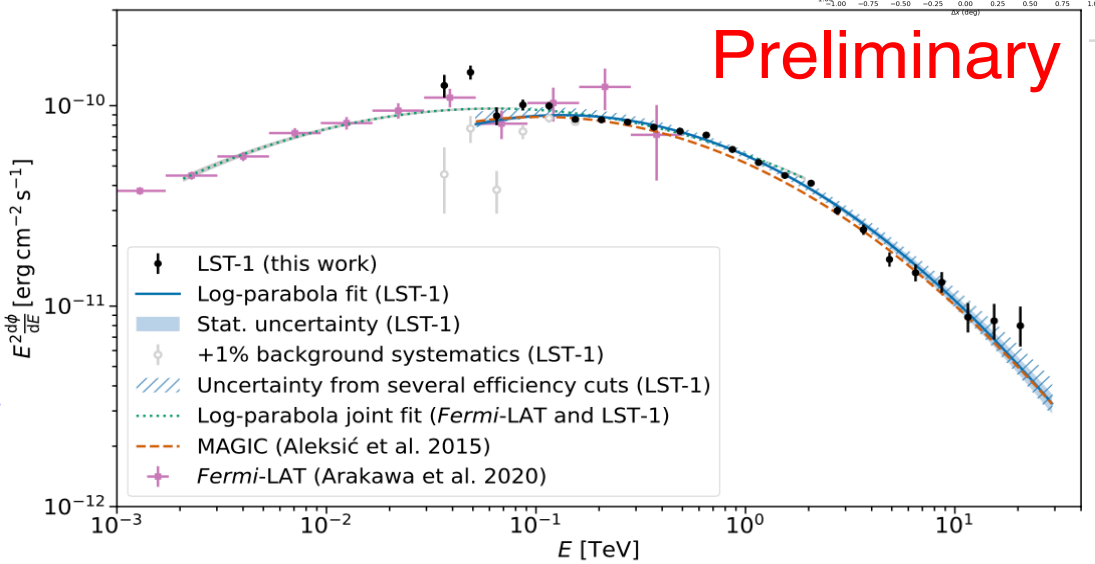


Crab Nebula and Pulsar



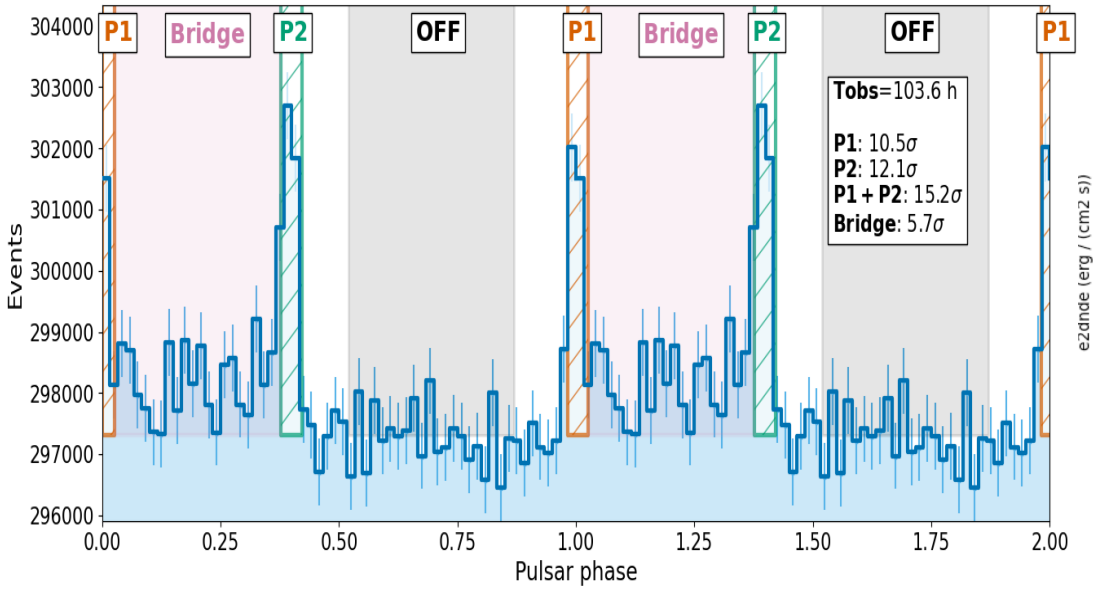
Crab Nebula spectrum

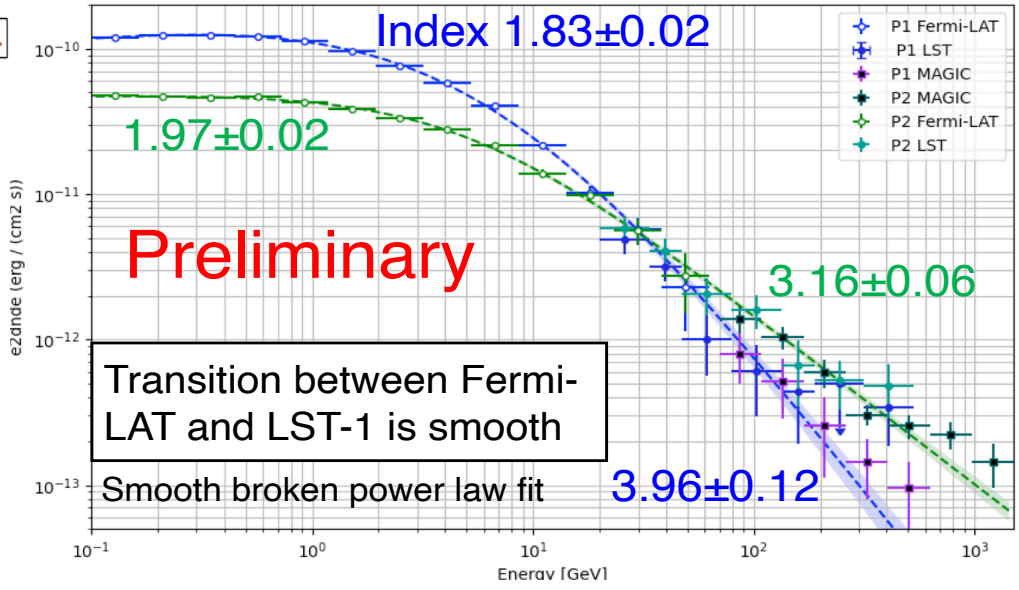
- 34.2 hours of data
- Systematic errors: gray points correspond to the effect of +1% background
- Consistent with MAGIC and Fermi-LAT



Crab pulsar

- Significant detection down to few tens of GeV

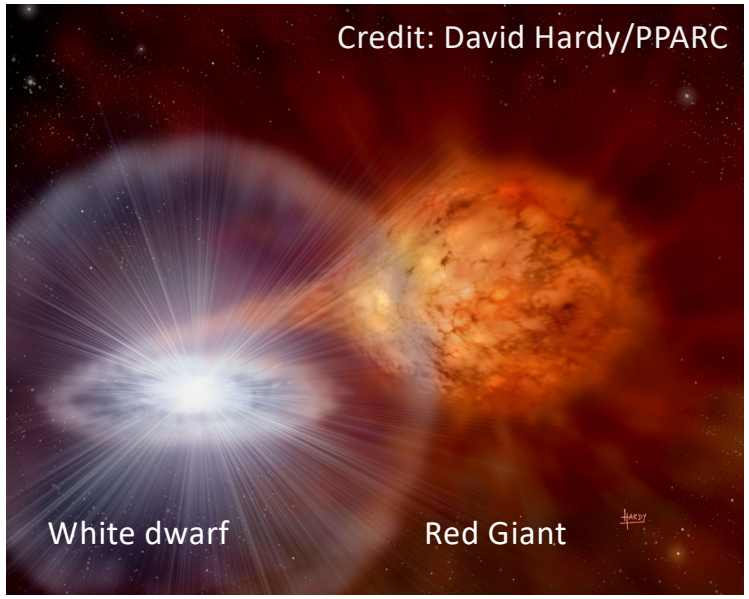


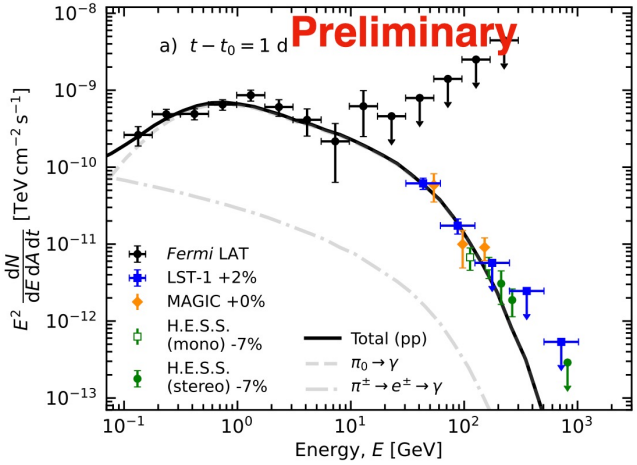


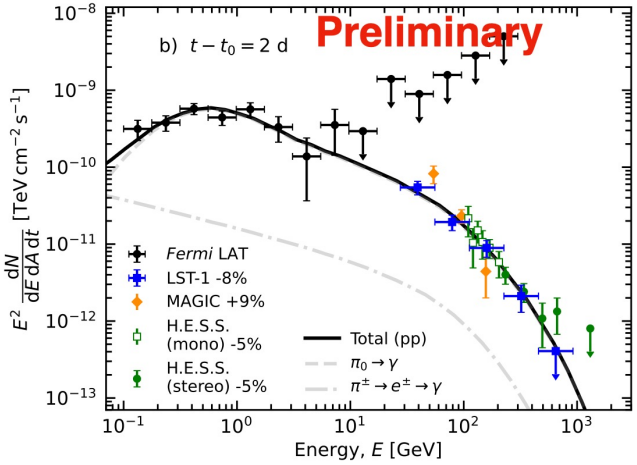
RS Ophiuchi Outburst in August 2021: Evolution of the Energy Spectrum

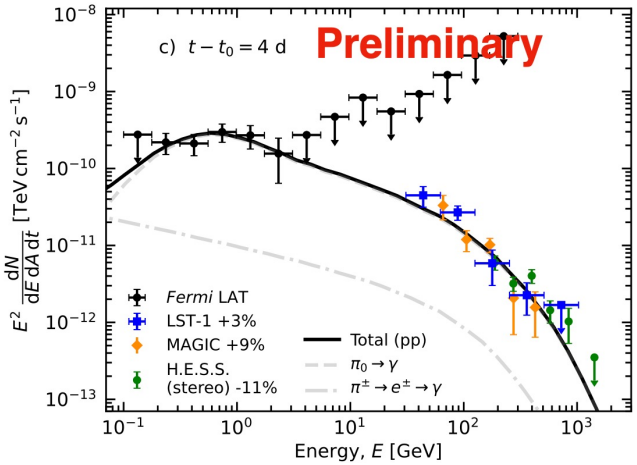
- RS Ophiuchi is a recurrent Nova.
  - Explosions, 1898, 1933, 1958, 1985, 2006, 2021
  - Mag 12.5 (low state) ➔ Mag 4.7 (~1000 times)
  - Binary System with a White Dwarf and a Red Giant
  - Accumulation of material on the WD, and then thermonuclear reaction makes recurrent explosions

- The Hadronic model is preferred.
- Cutoff energy increased with time.









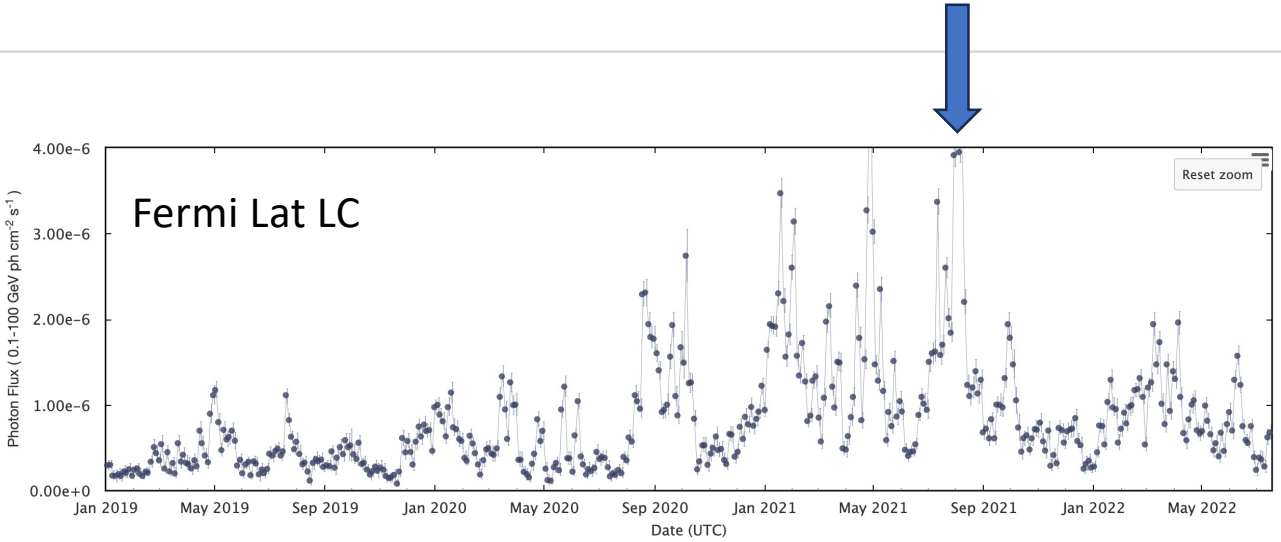
Preliminary

Parameter	Best-fit value on observation day		
	Day 1	Day 2	Day 4
Hadronic ECPL model with systematics			
Slope, Γ_p	$-2.16^{+0.19}_{-0.18}$	$-2.49^{+0.05}_{-0.04}$	$-2.42^{+0.16}_{-0.16}$
$E_{c,p}$ [TeV]	$0.21^{+0.12}_{-0.11}$	$0.9^{+0.2}_{-0.2}$	$1.1^{+0.7}_{-0.7}$
LST-1 syst. [%]	2^{+5}_{-5}	-8^{+8}_{-7}	3^{+6}_{-5}
MAGIC syst. [%]	0^{+7}_{-6}	9^{+6}_{-7}	9^{+6}_{-6}
H.E.S.S. syst. [%]	-7^{+9}_{-7}	-5^{+6}_{-5}	-11^{+4}_{-4}
$\chi^2/N_{d.o.f}$	17.8/12	20.0/19	20.0/13
χ^2_{red}	1.48	1.05	1.54
AIC	29.8	32.0	32.0

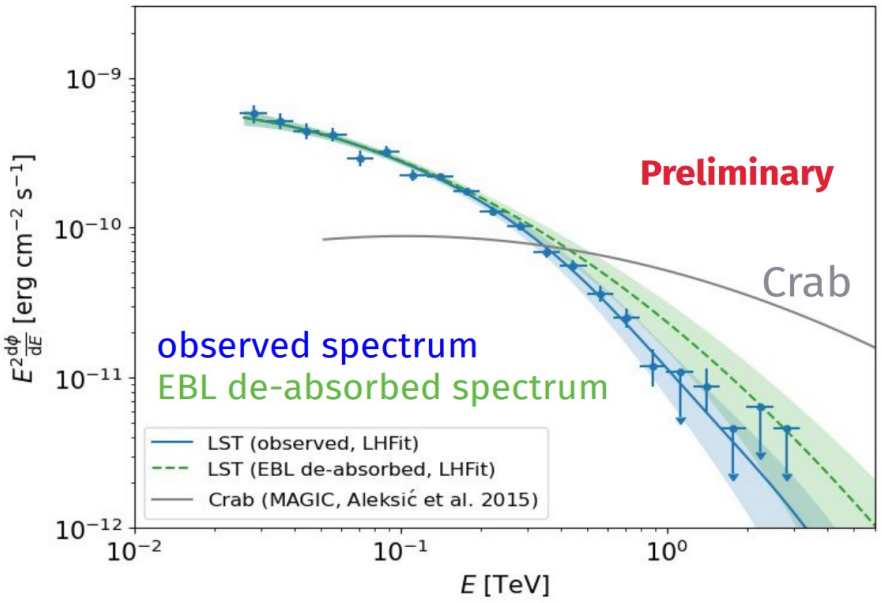
BL Lac Flare 2021

- BL Lac Flare 2021
- BL Lac: IBL, z= 0.069

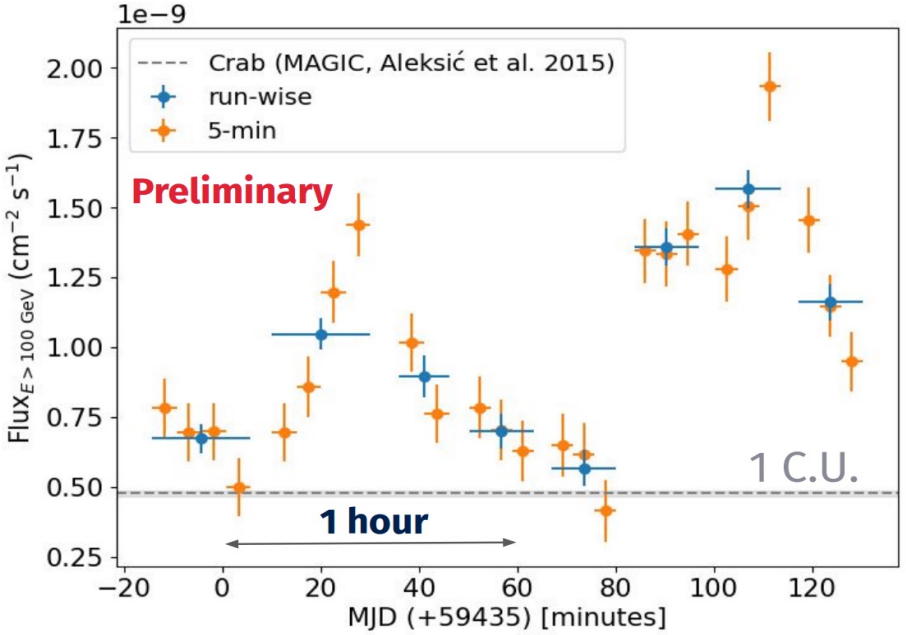
- Spectrum observed > 25GeV
- August 9, about 3-5 Crab
  Unit at 30-100 GeV
- Very fast variability (<5min)



Aug 9, 2021

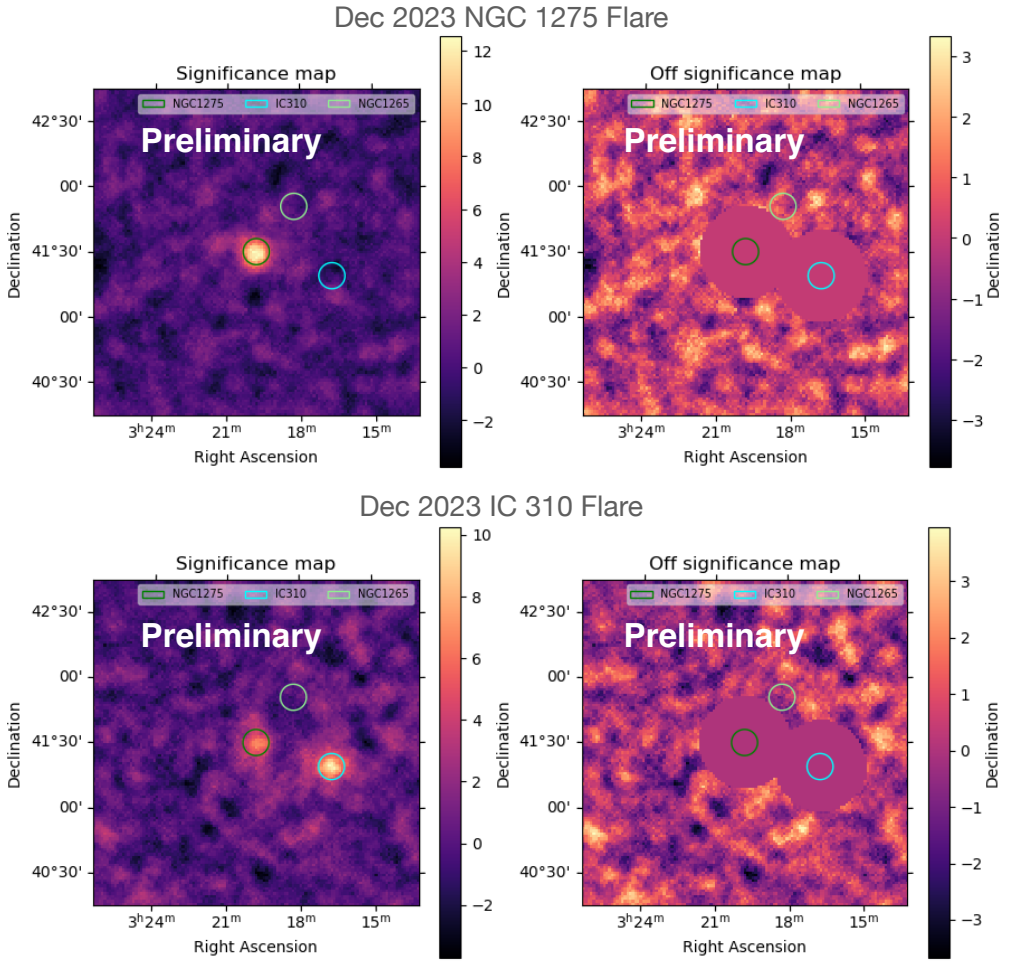


Intranight LC on 9 August, 5 min fast variability



Perseus Cluster
NGC1275 and IC310

- Cluster of radio galaxies in Perseus; ideal targets for LST: NGC 1275 and IC 310
- Timeline of Observations
  - NGC 1275 detected in Dec 2020, and then quiet afterwards
  - NGC 1275 began flaring again in December 2022 - January 2023
  - Again in December 2023, NGC 1275 and IC 310 began flaring together
  - While observing cluster, detected a single night flare of IC 310



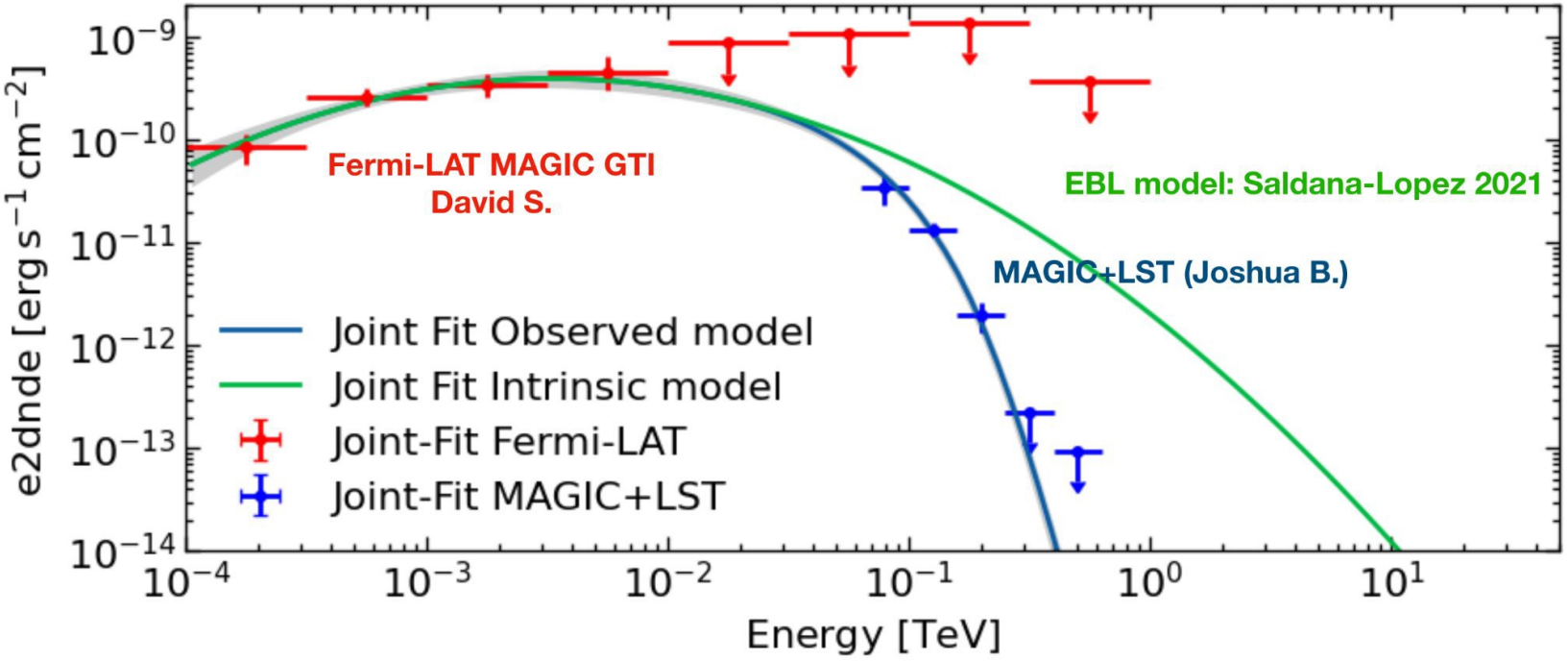
One Day

OP313 (z = 0.997)
The most distant AGN >100GeV

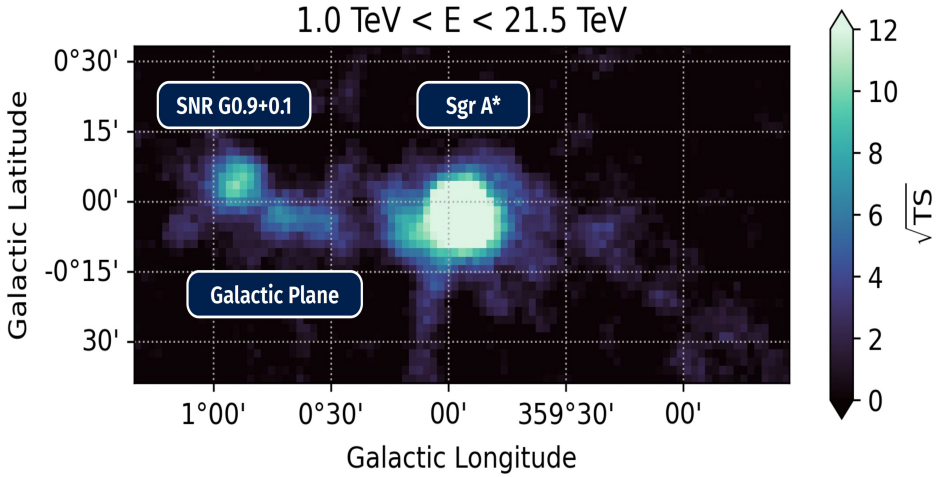
First detection of VHE gamma-ray emission from FSRQ OP 313 with LST-1

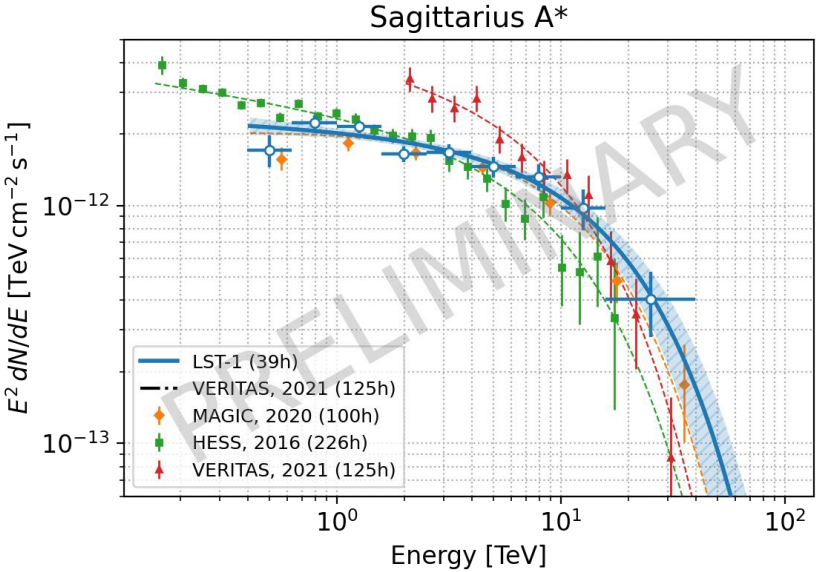
ATel #16381; *Juan Cortina (CIEMAT) for the CTAO LST collaboration*
*on **15 Dec 2023; 14:31 UT***
Credential Certification: Juan Cortina (Juan.Cortina@ciemat.es)

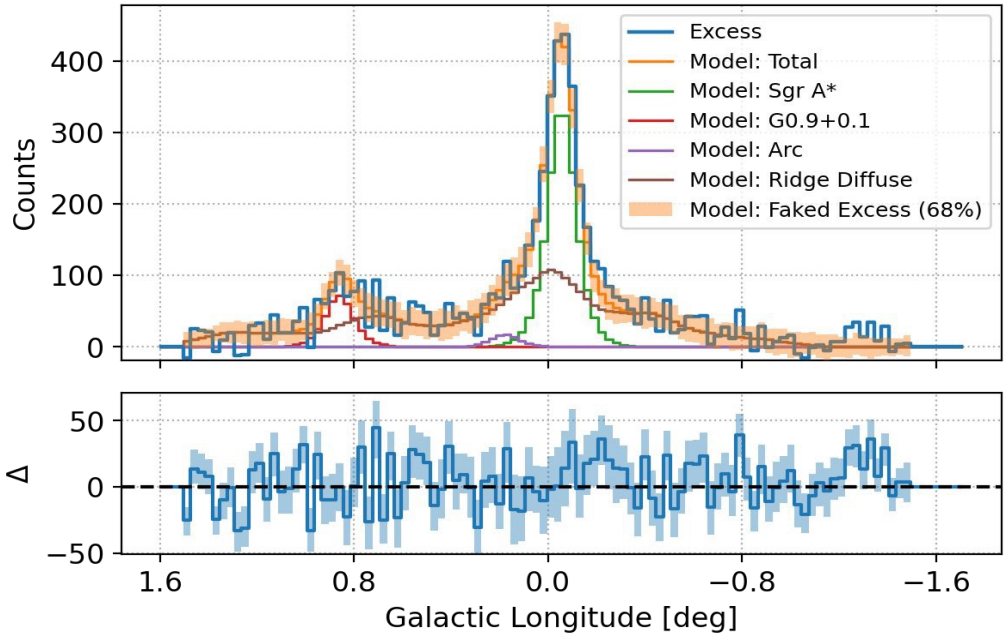
Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, AGN, Blazar, Quasar

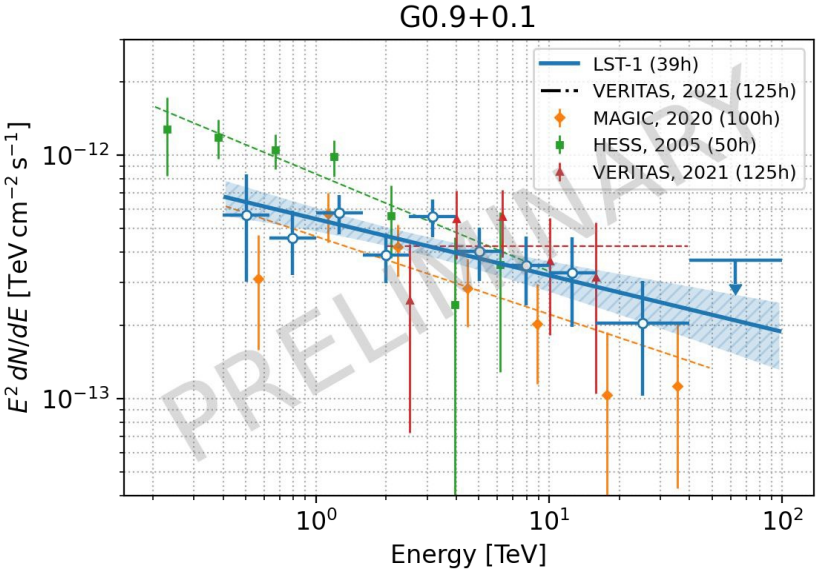


Galactic Center region Discrete Sources

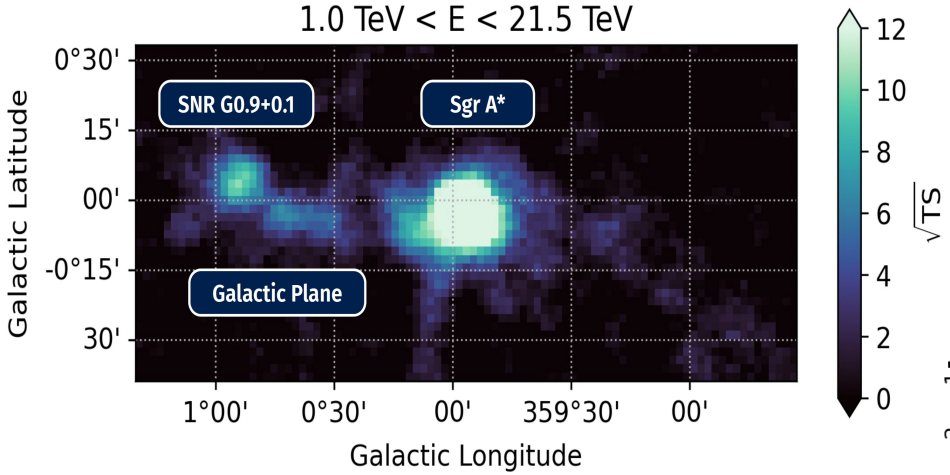


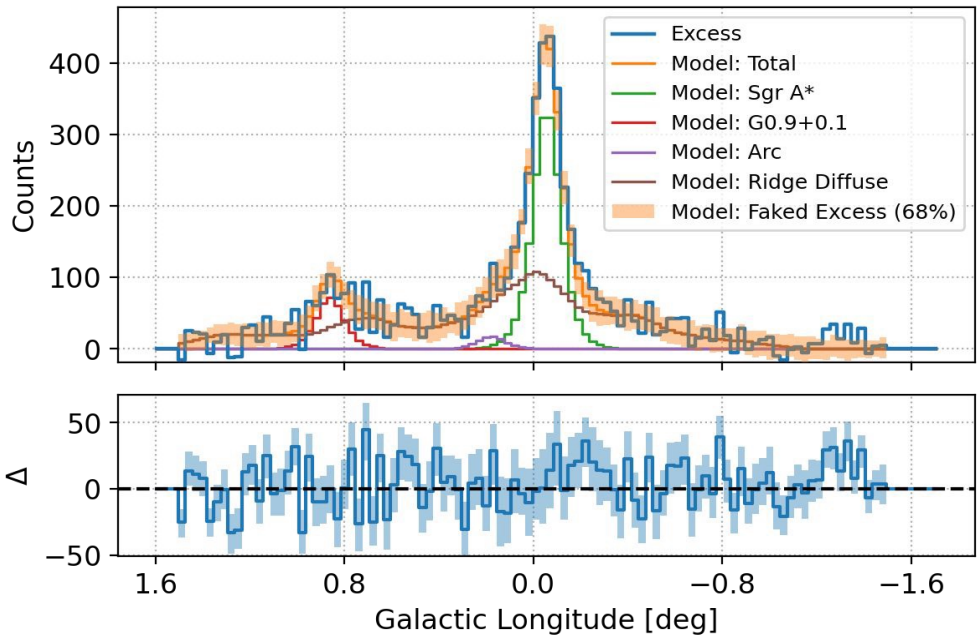


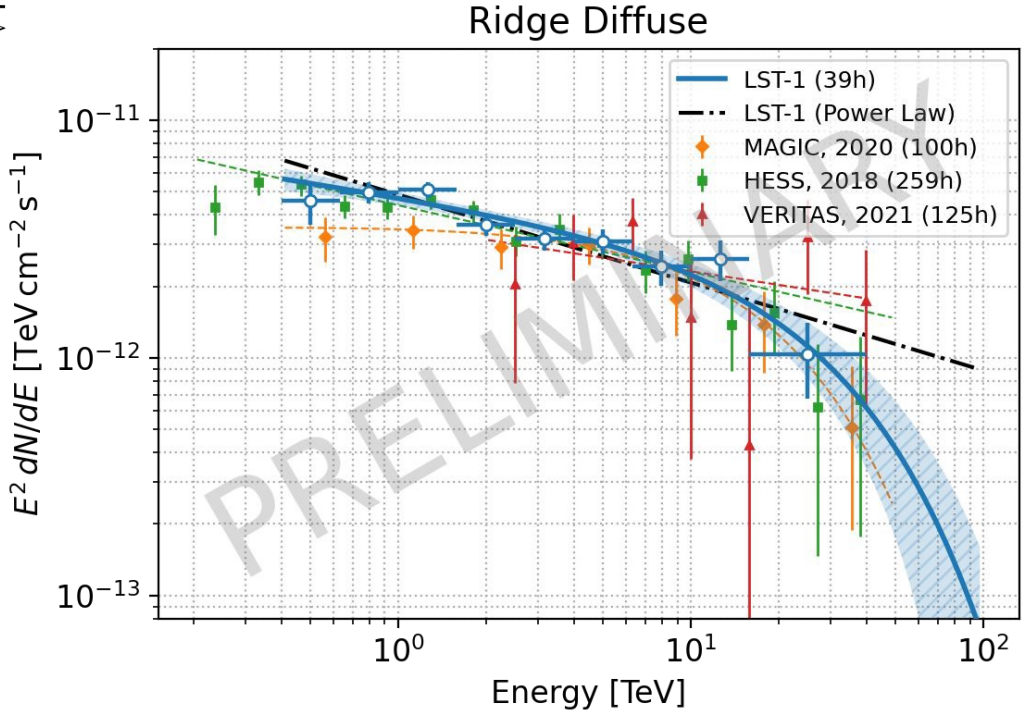




Galactic Center Region Ridge Diffuse







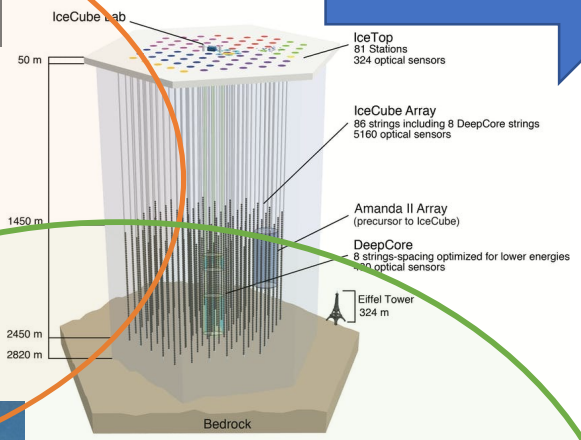
Multi-messenger and Multi-wavelength Astrophysics

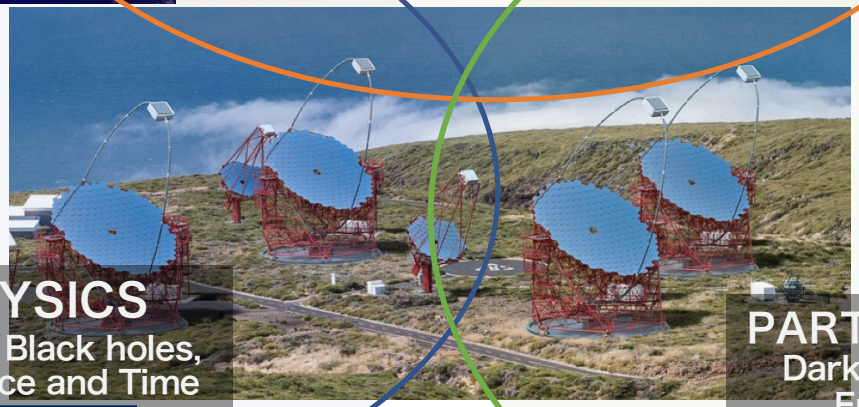
cherenkov telescope array

Wave AstroPhysics

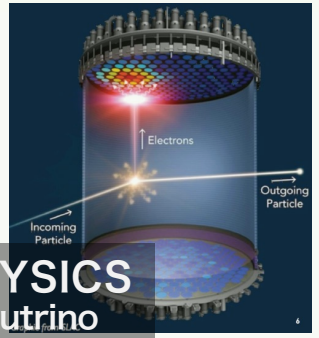
Particle Physics

ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics





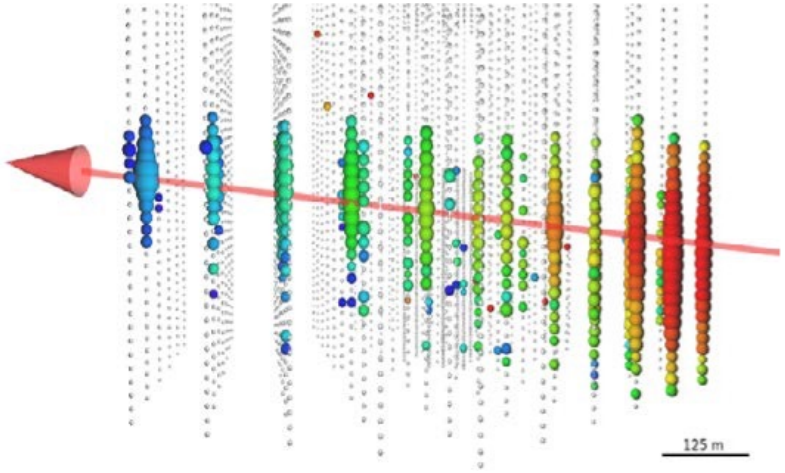
ASTRO-PHYSICS
Gamma Ray Bursts, Black holes,
Neutron Stars, Space and Time



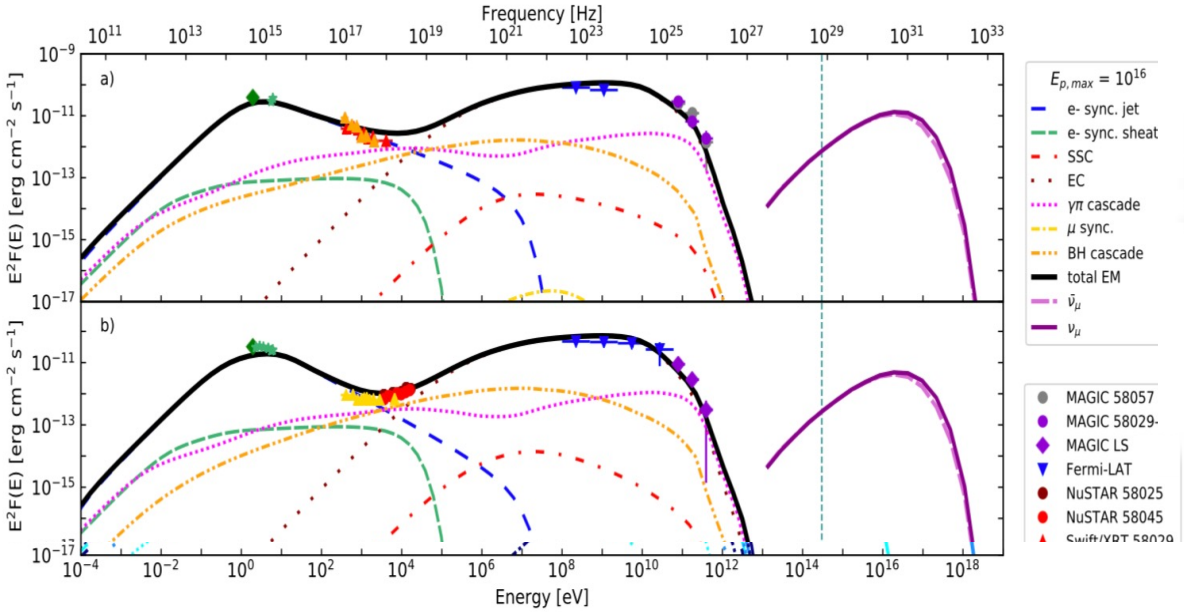
PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier

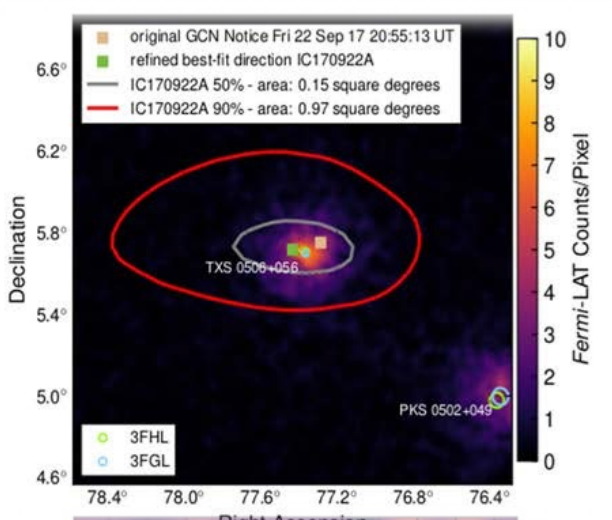
Multi Messenger Astronomy IC170922A / TXS 0506+056 MAGIC Observation

Ice Cube Observation (~300TeV)

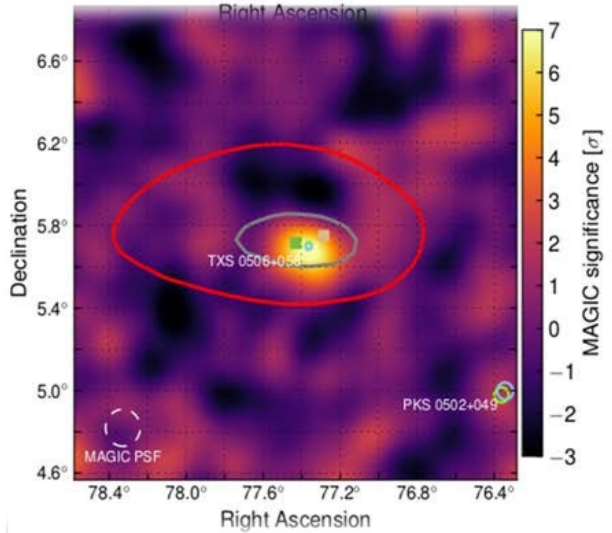


Lepto-Hadronic Scenario





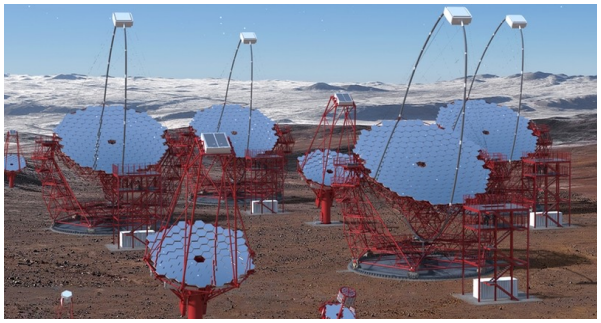
Fermi LAT
(>100 MeV)

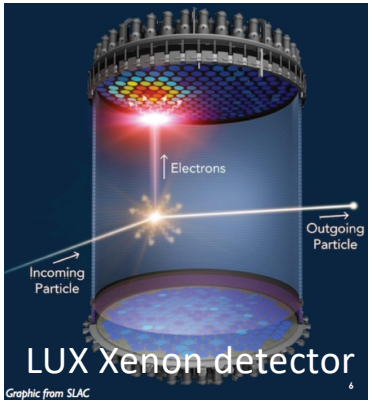


MAGIC
(>100GeV)

GTC Observation z = 0.3365
S. Paiano et. al 2018

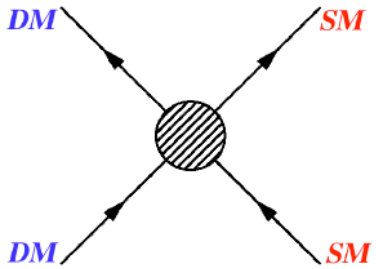
Complementarity of different approaches Direct, Indirect, and Collider Experiment



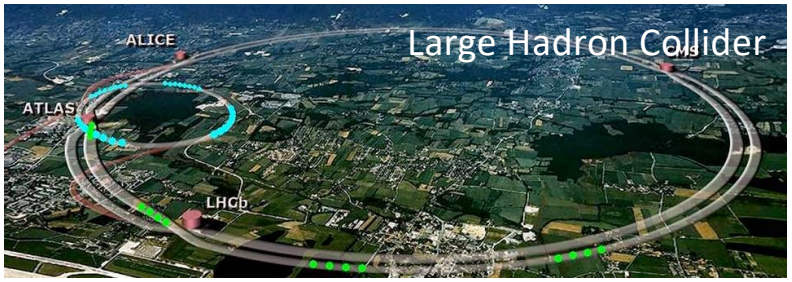


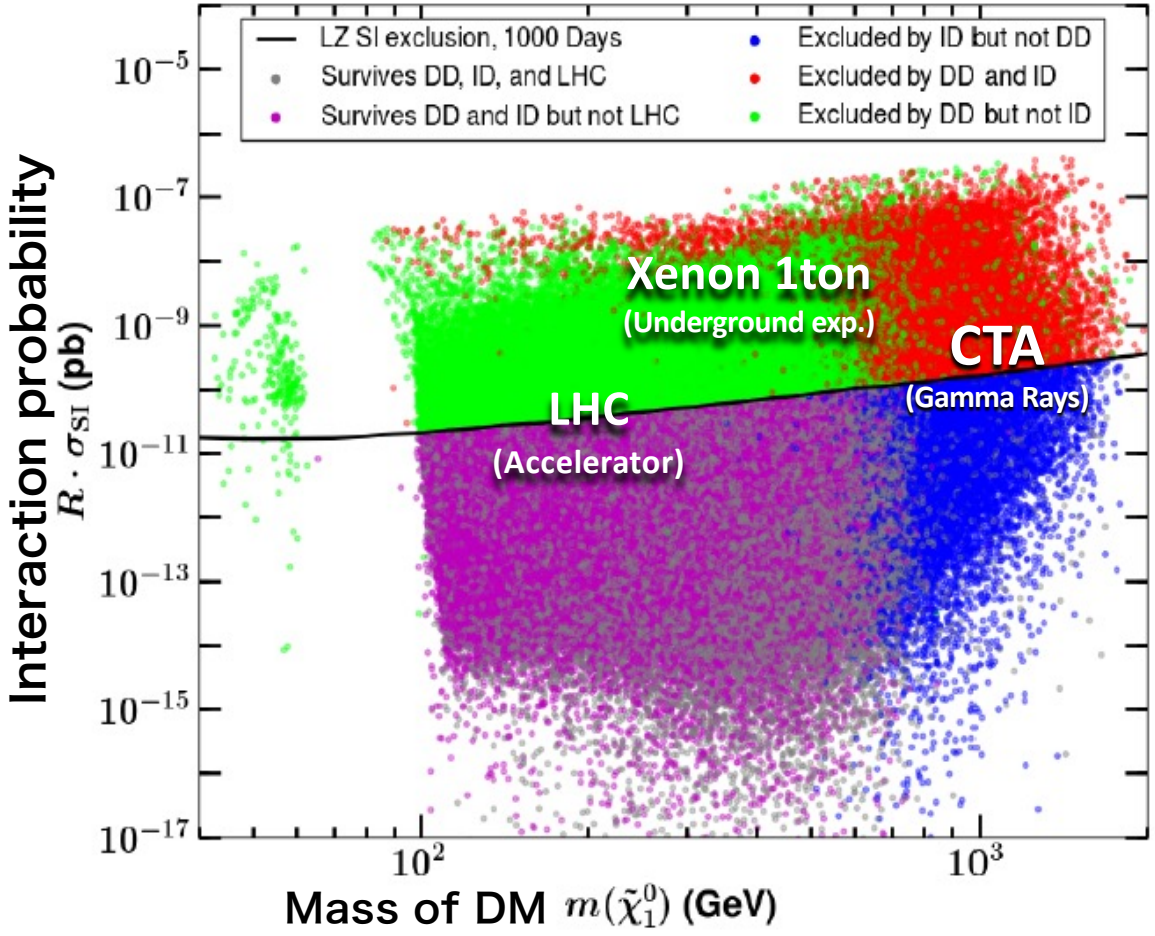
direct detection

thermal freeze-out (early Univ.)
indirect detection (now)



production at colliders





- Explore Dark Matter in the Galactic Center and Dwarf Sph. Galaxies
- CTA has the best sensitivity above 700GeV

Summary

- The prototype telescope LST1 fulfills the requirement and the design performance with a fast follow-up capability of 20 seconds.
- LST2, LST3, and LST4 will be completed by the end of 2025, and commissioning will start.

- The LST Array will achieve one order of magnitude higher sensitivity than currently running telescopes.
- The LST Array contributes to the multi-messenger and time-domain astronomy.