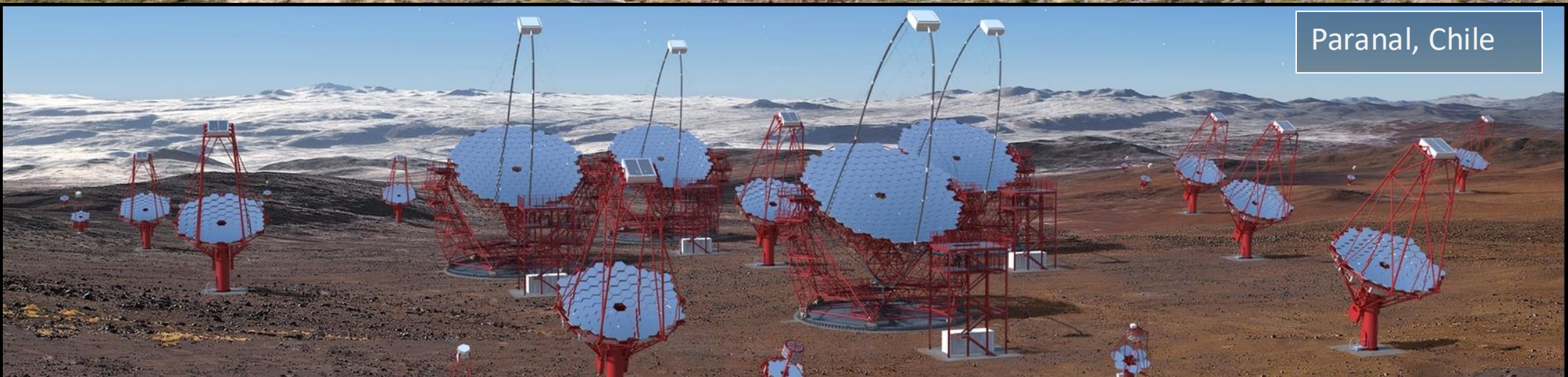
Highlights of the LST Project

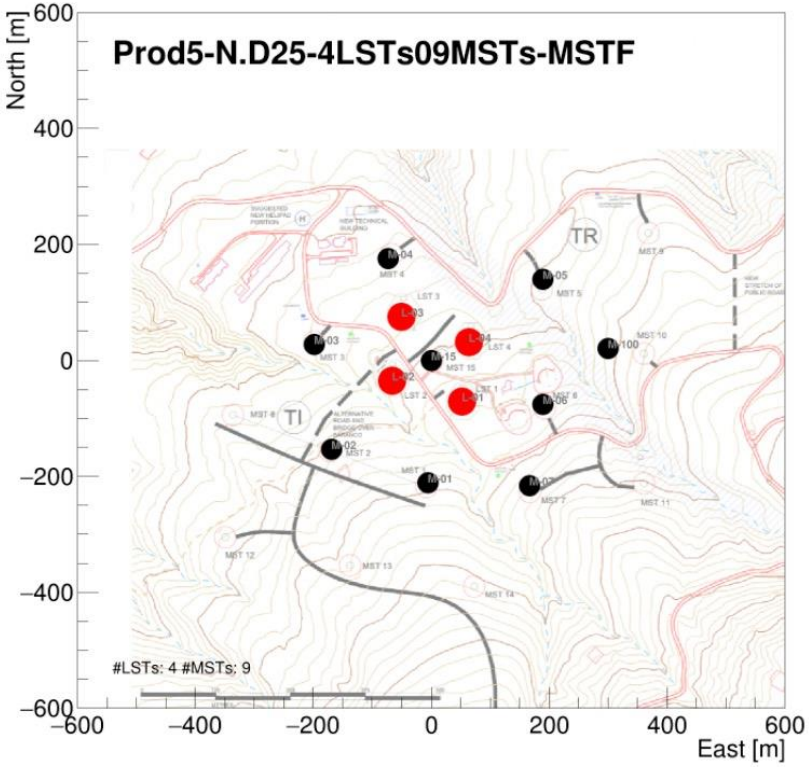
Masahiro Teshima for the LST Collaboration

Max Planck Institute for Physics, Munich, Germany
Institute for Cosmic Ray Research, The University of Tokyo, Japan

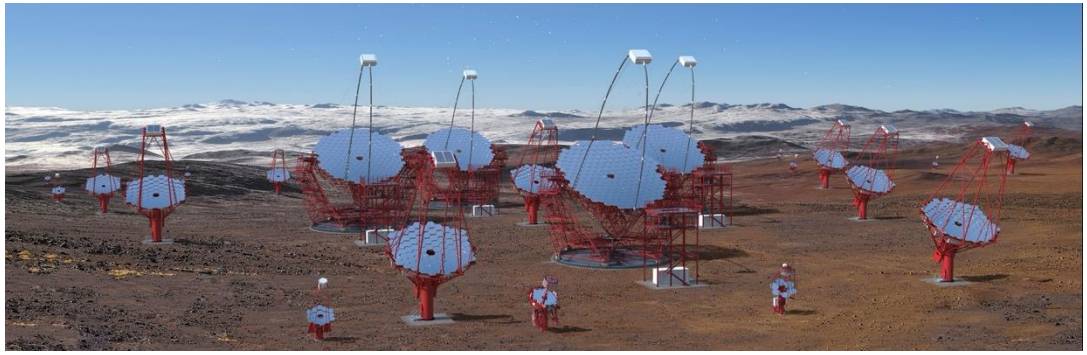


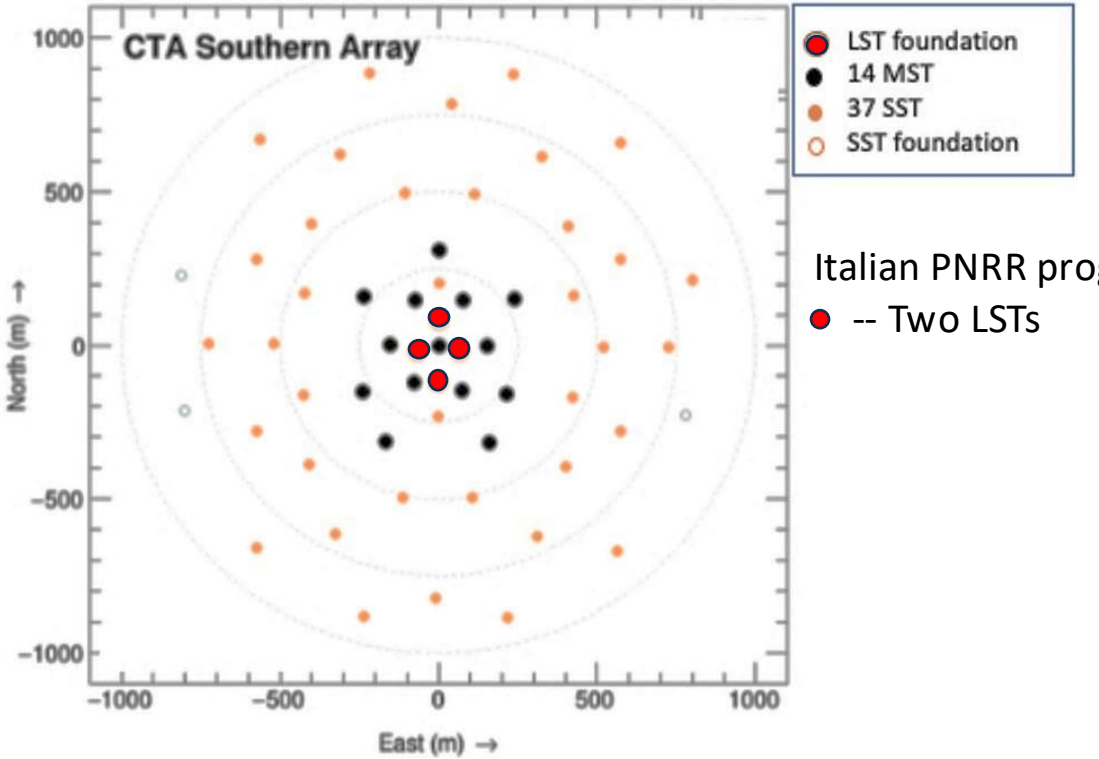
Alpha Configuration of CTA

Roque de los Muchachos Observatory
La Palma, Spain



Paranal, Chile





Italian PNRR prog.
-- Two LSTs

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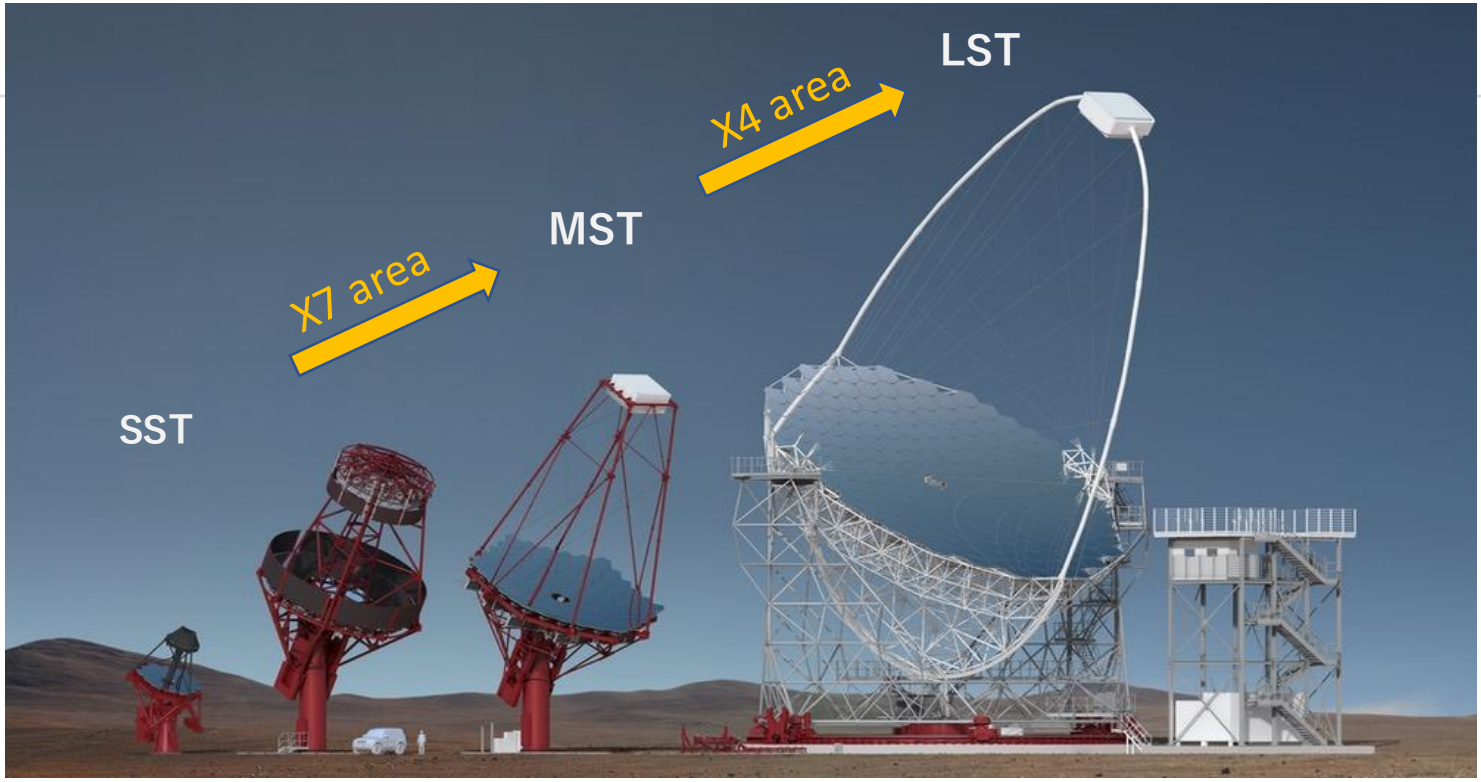
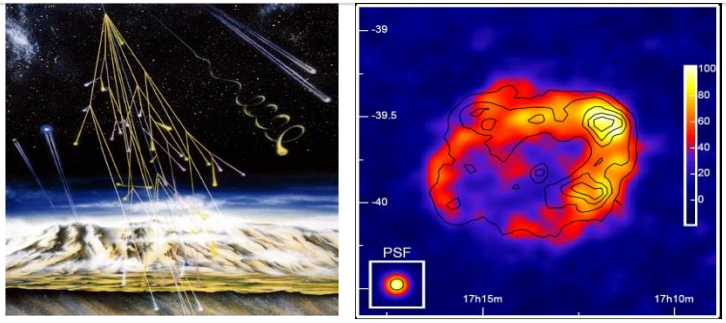
Telescope Design



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 – 2TeV
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

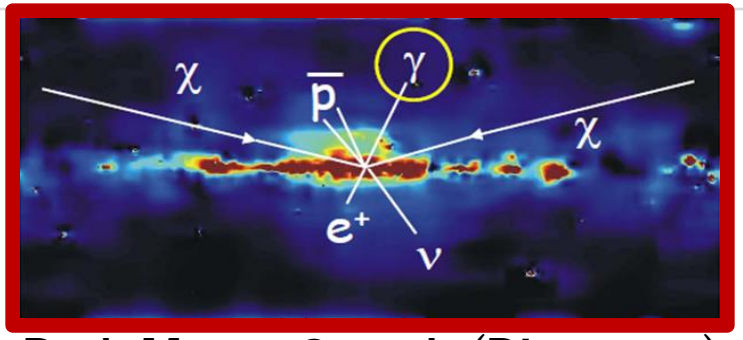
Science of CTA is very wide

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



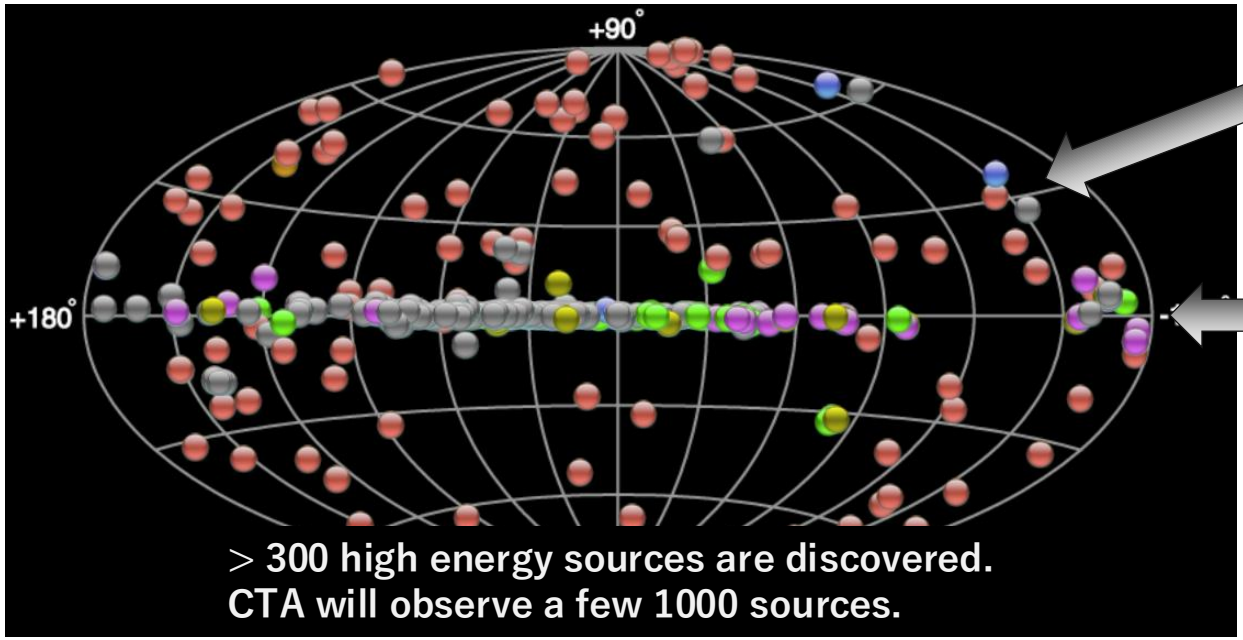
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

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

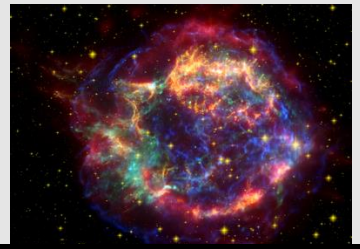


Extragalactic Sources

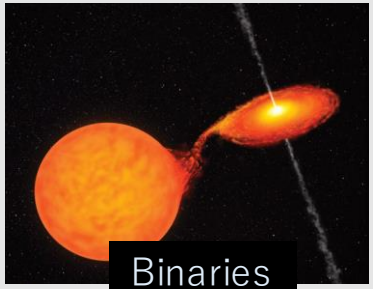
Active Galactic Nuclei

Gamma Ray Bursts

Galactic Sources



Super Nova Remnants



Binaries

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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

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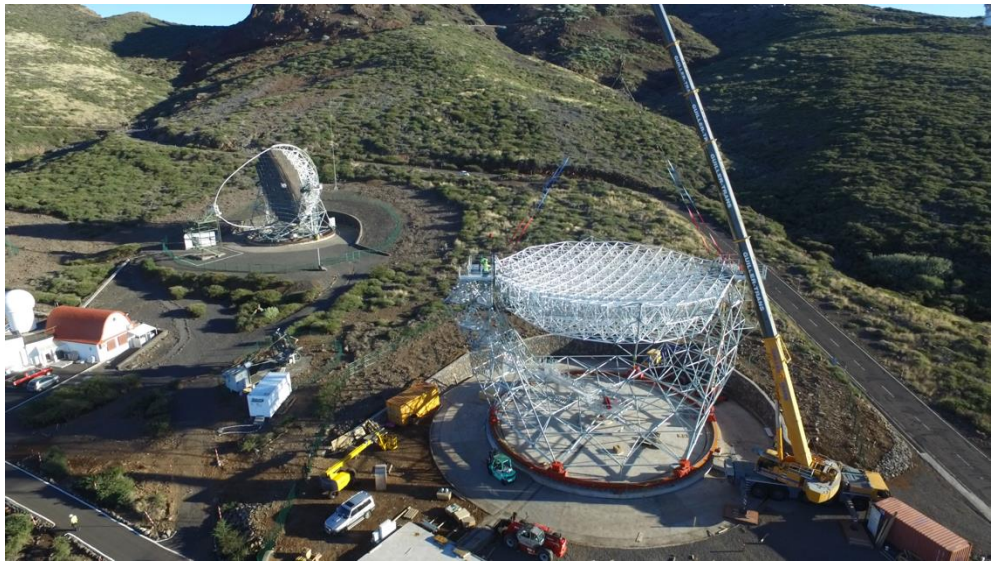
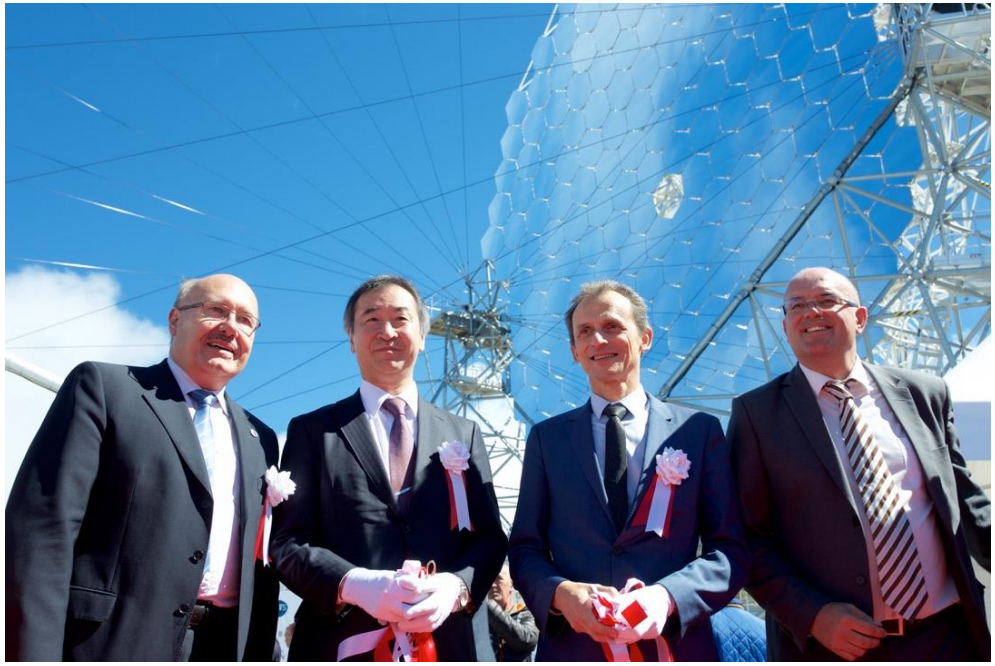
LST1 was inaugurated in Oct.2018





Large-Sized 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

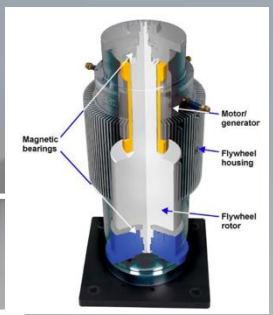
Camera Access Tower: DE,ES

Bogies: ES, DE

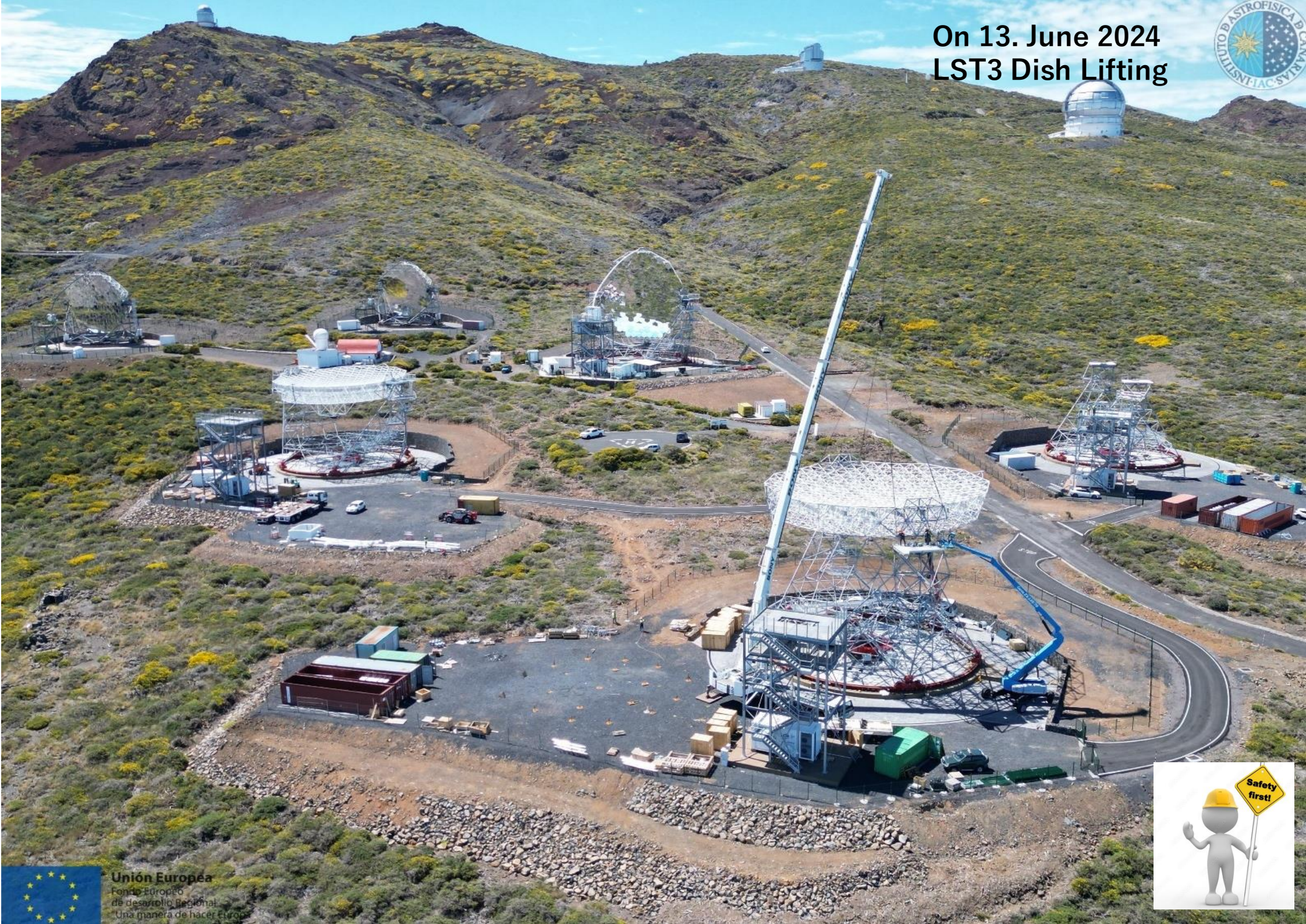
Foundation: ES

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
Safety first!


On 13. June 2024
LST3 Dish Lifting
Safety first!
Unión Europea
Fondo Europeo
de desarrollo Regional
"Una manera de hacer Europa"

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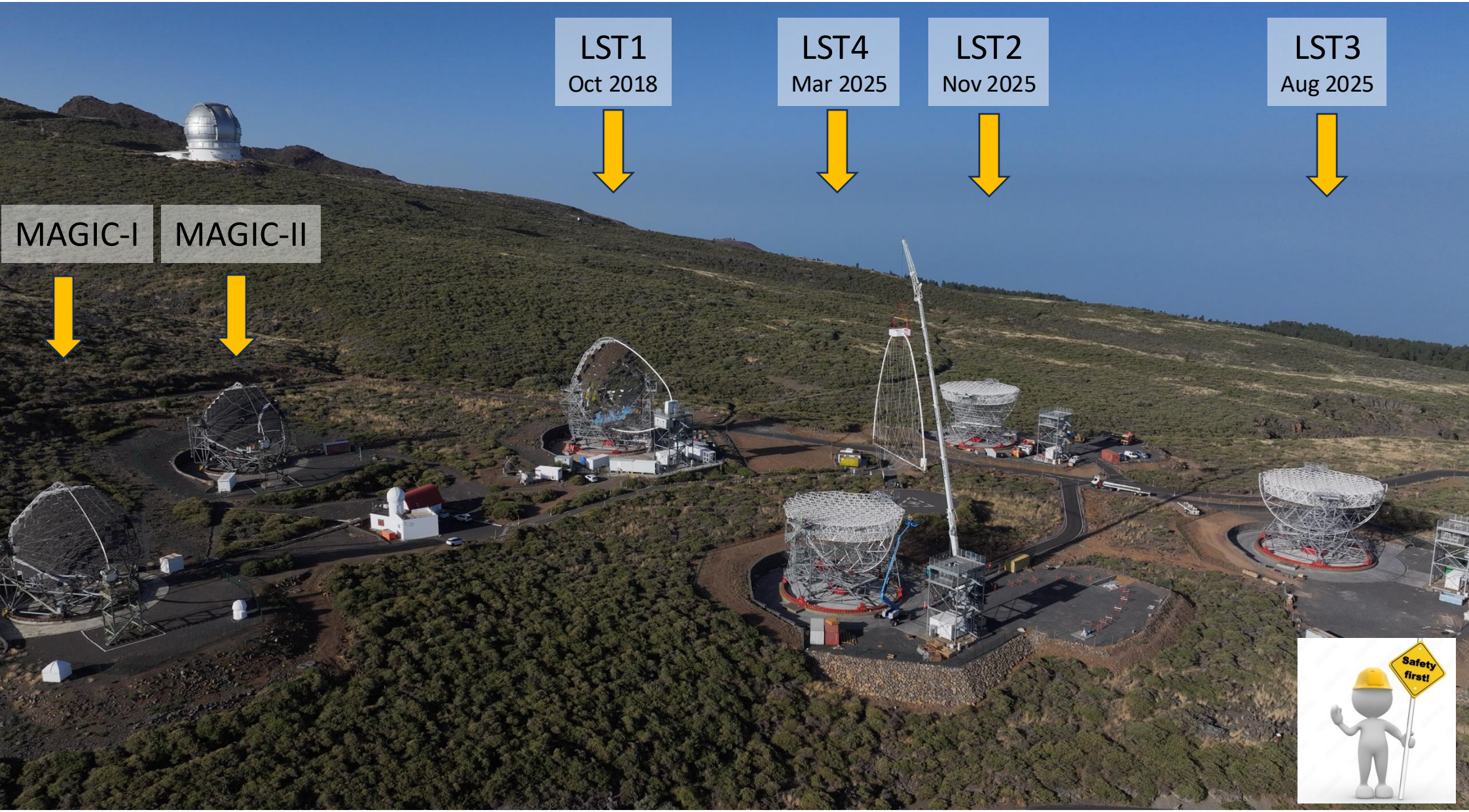
LST4 ARCH-CSS installation

on 22.Aug.2024



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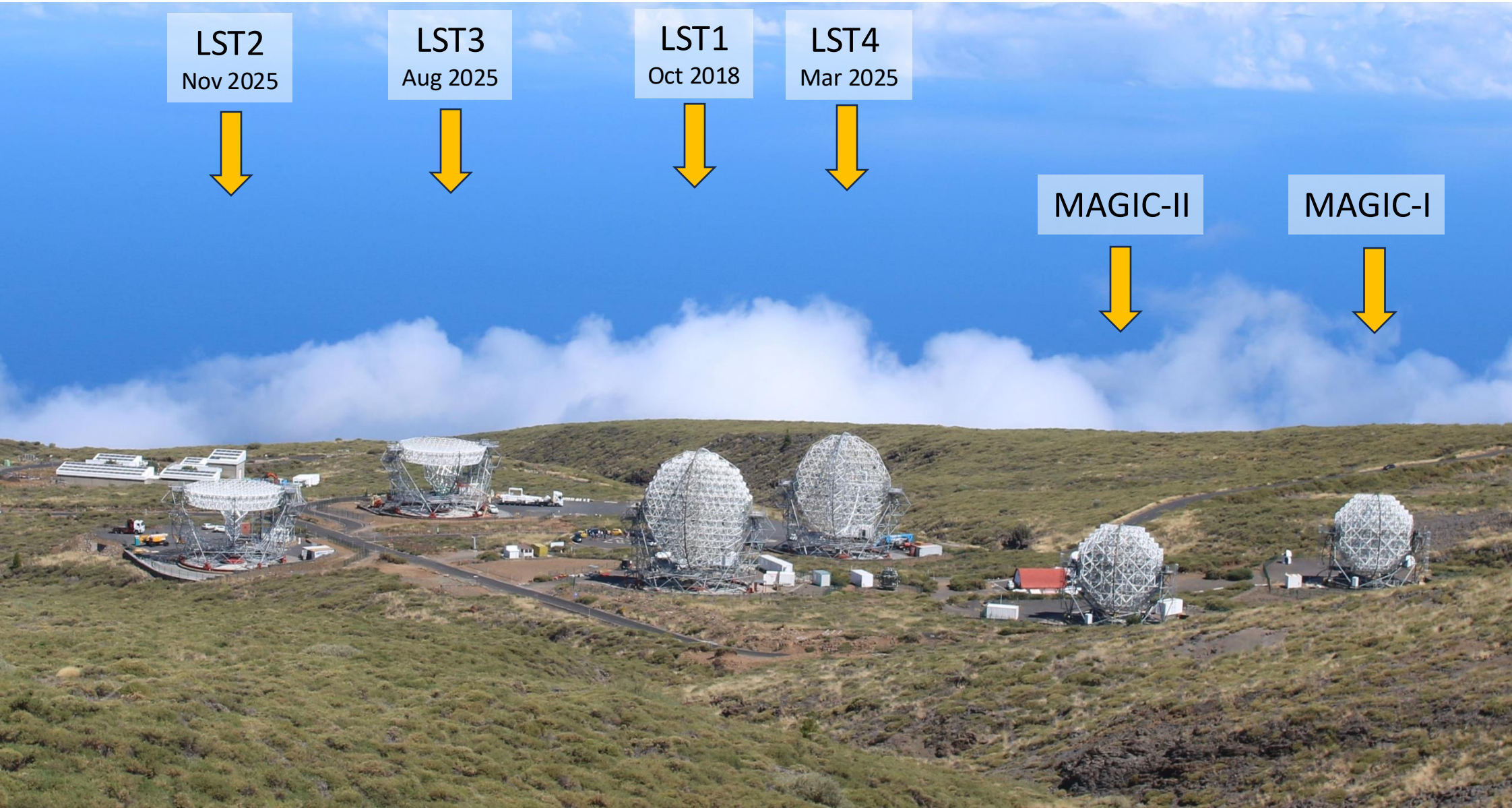
CTAO North sites
on 30.Aug.2024



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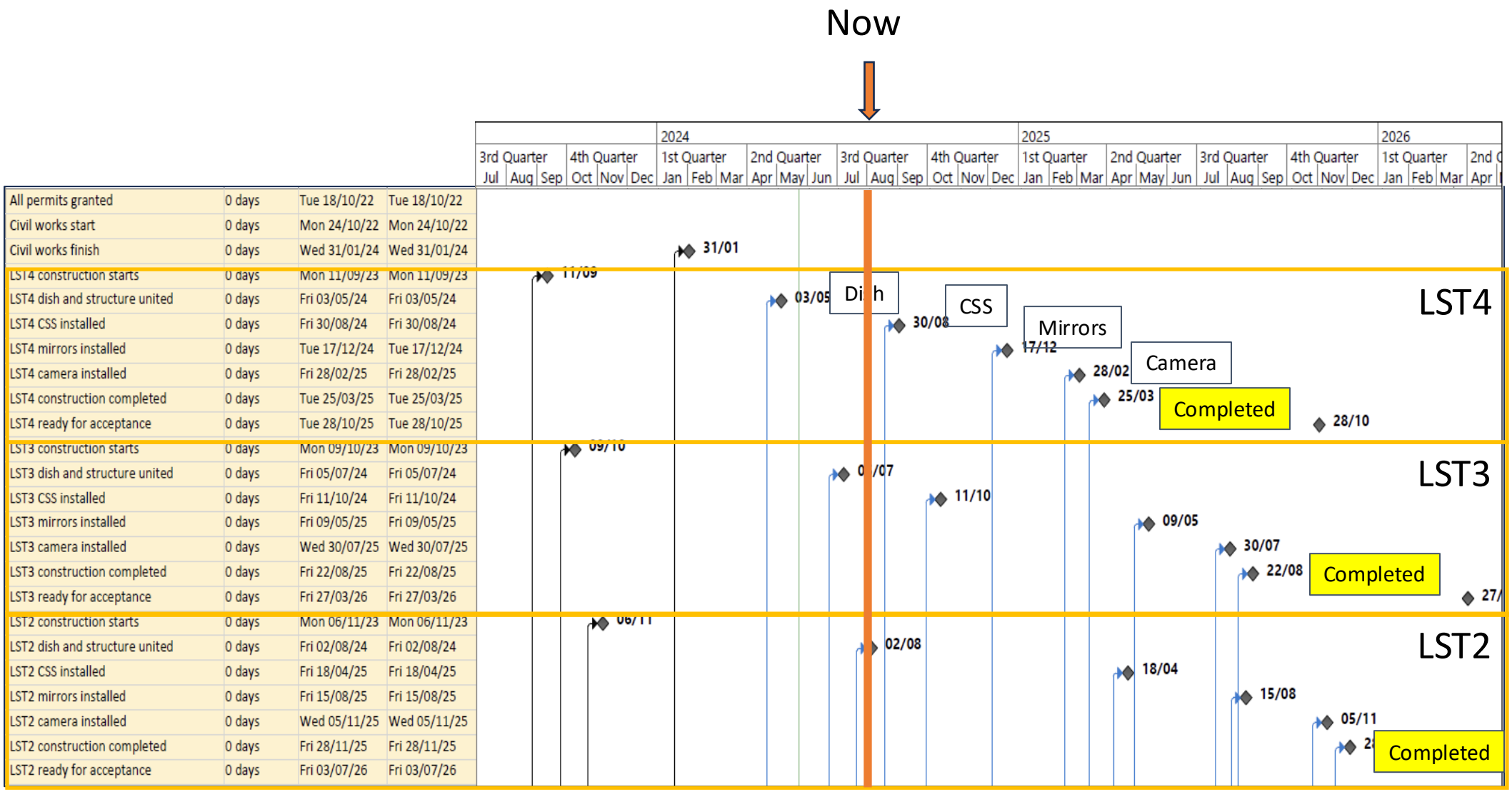
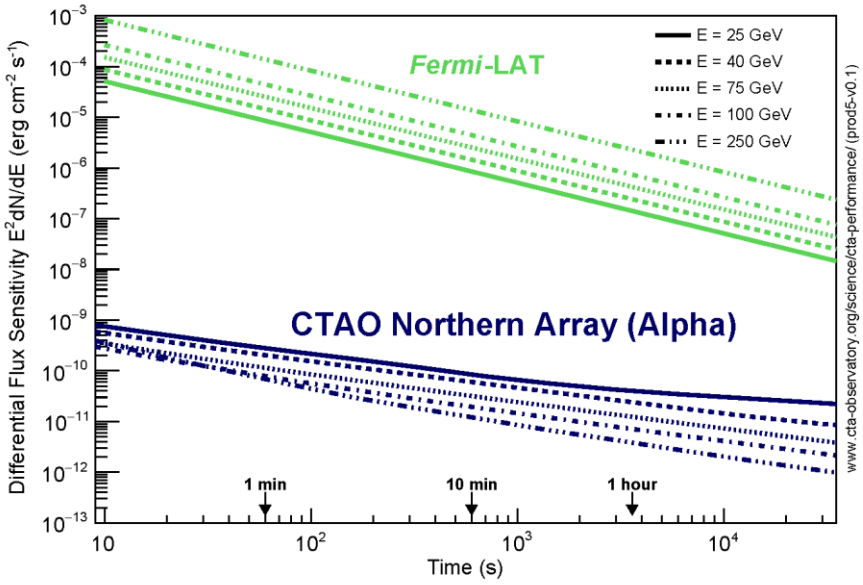
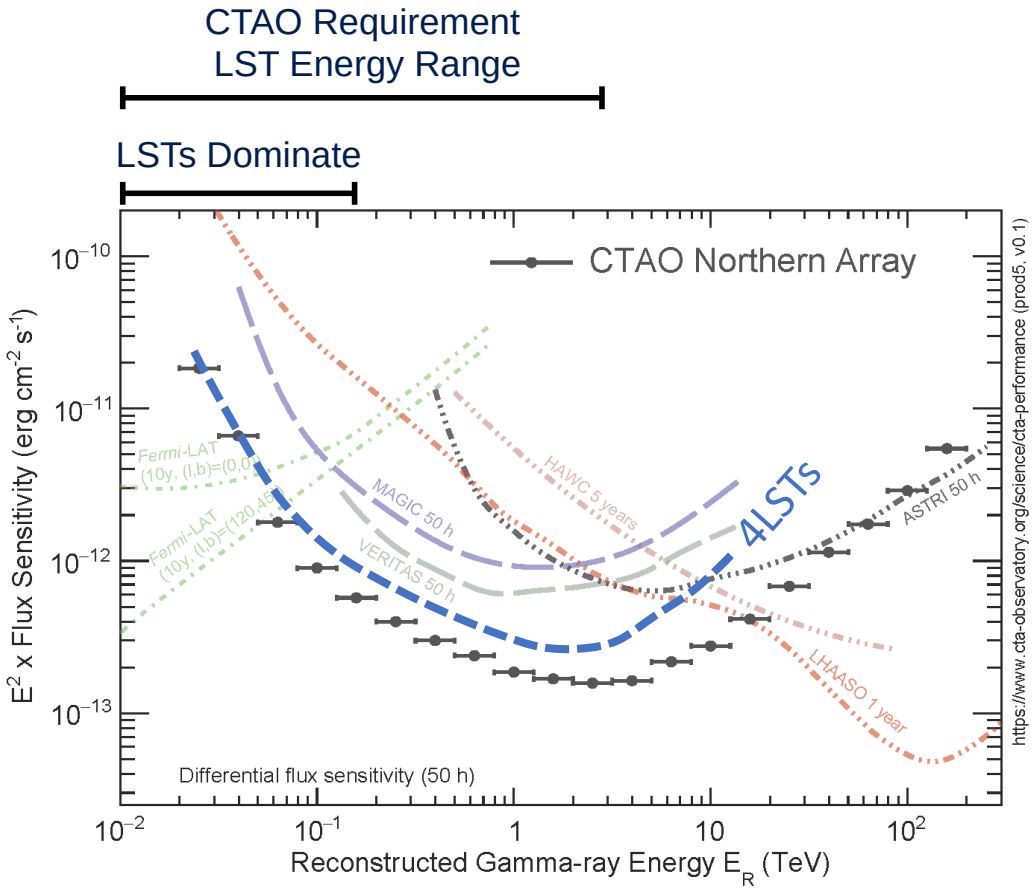
Schedule for the LST2-4 construction

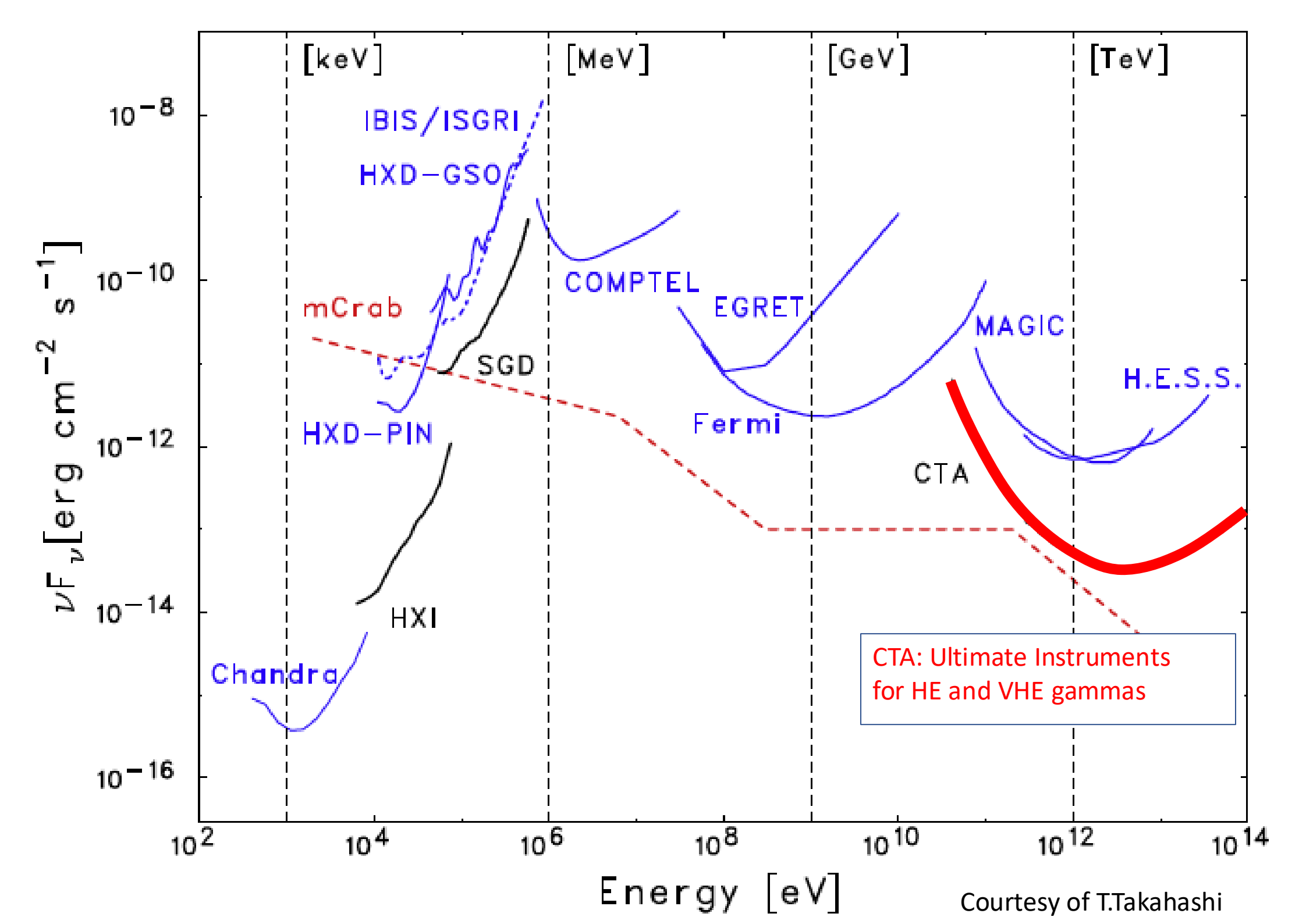


Performance of the CTAO North Array

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



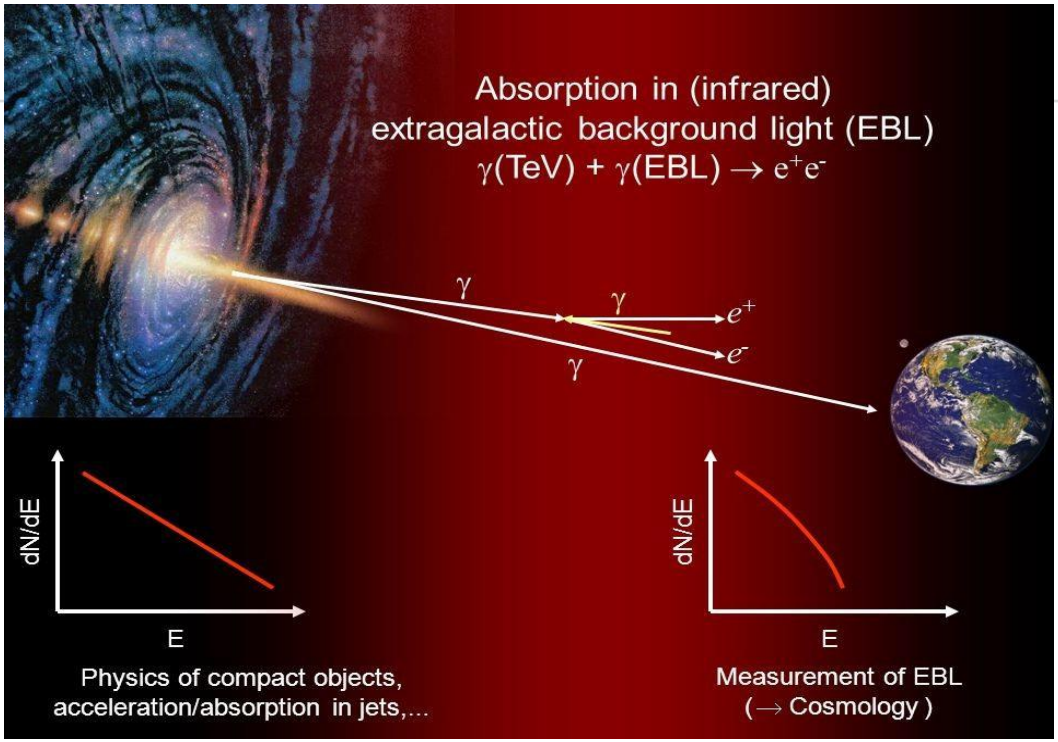


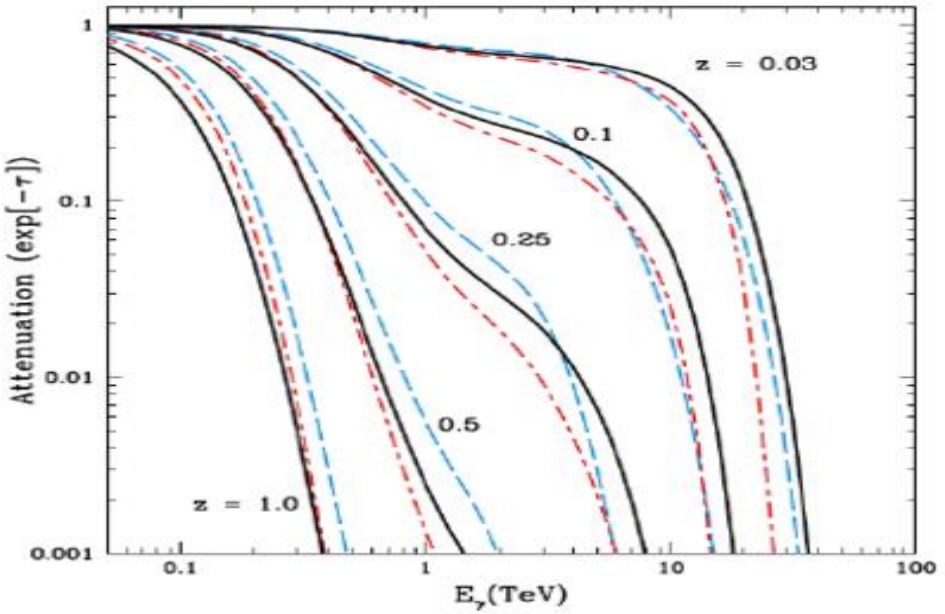


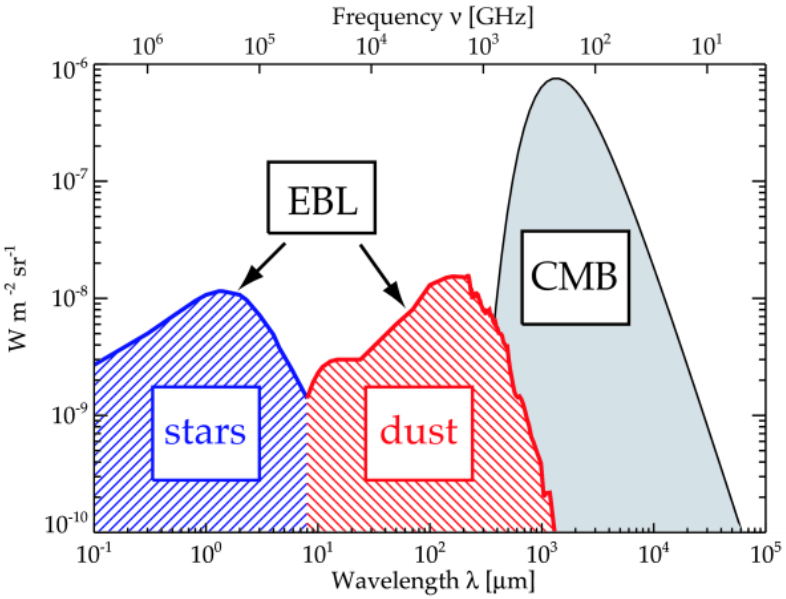
Courtesy of T.Takahashi

Gamma Ray Horizon
Access the deep Universe with LSTs

CTAO | LST COLLABORATION



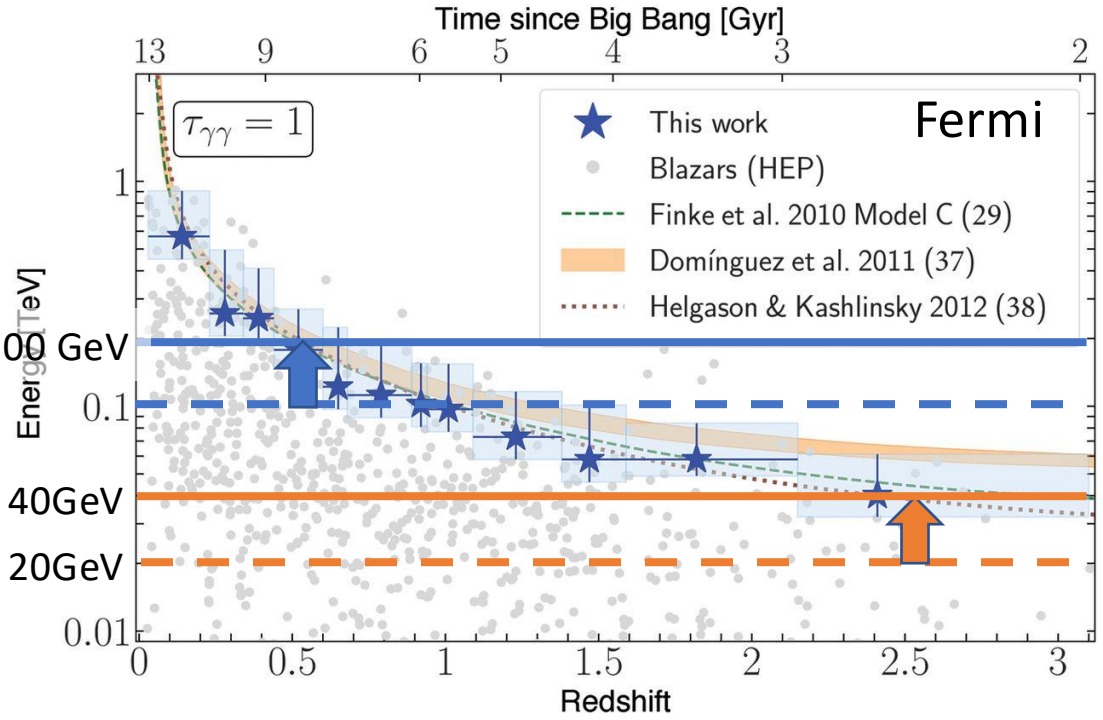




MST@45° Eth 200 GeV

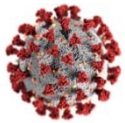
LST@45° Eth 40GeV

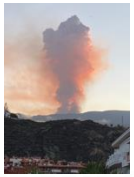
LST@25° Eth 20GeV

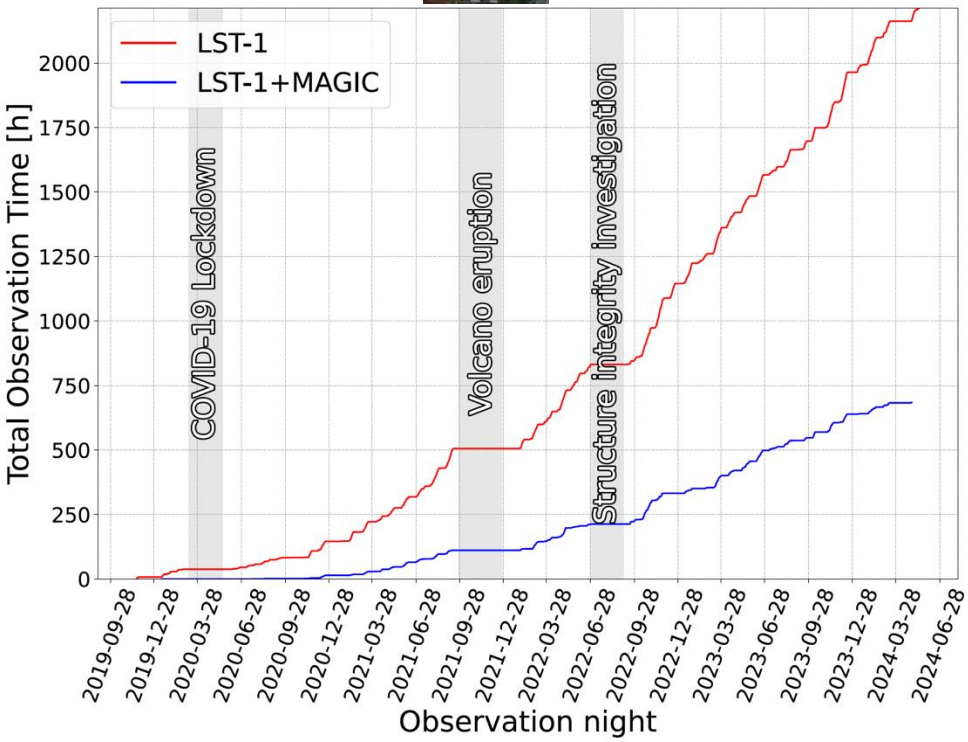


LST1 has been collecting data for more than 2000hrs

Oct 2018: LST1 Inaugurated
Jan 2020: Scientific operation started



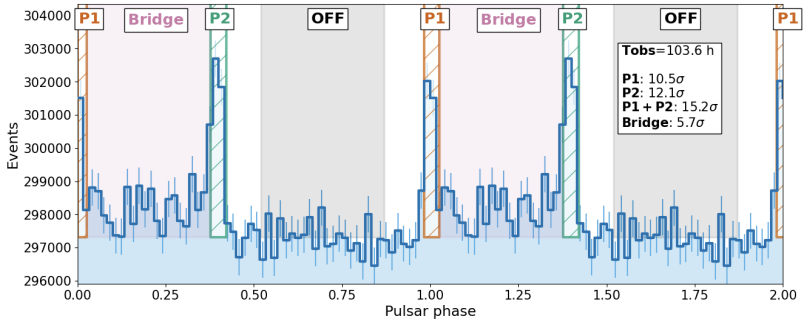




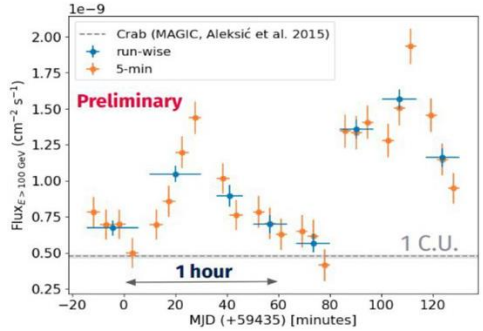
Quick follow-up observation with LST1 for GRBs and other transients.
LST can point any sky direction in 20 seconds

Many scientific results are already delivered

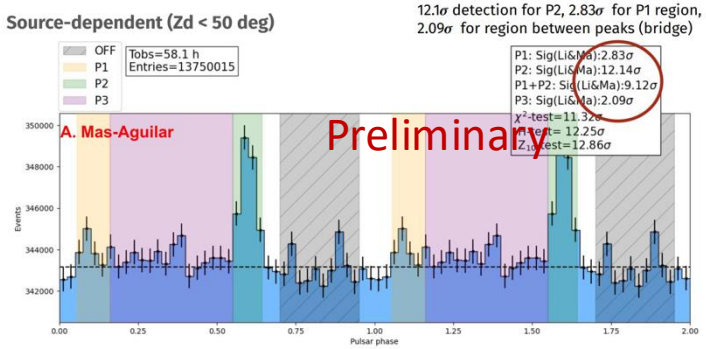
Crab pulsar above 20GeV



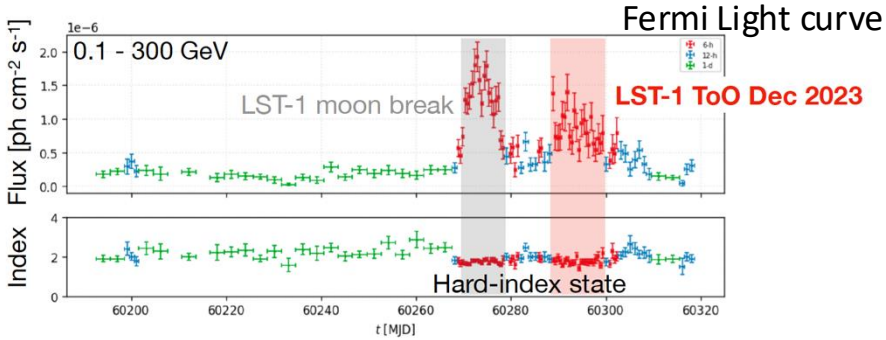
BL Lac intranight fast variability (a few min)



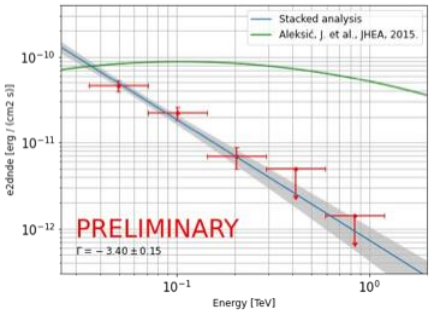
Geminga pulsar above 15GeV



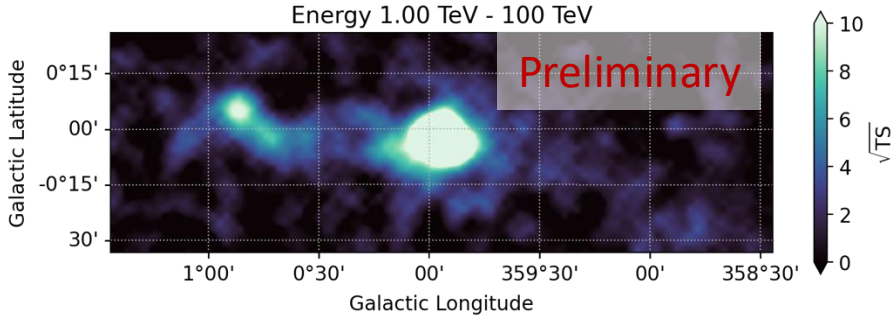
OP313: discovery of the most distant VHE AGN



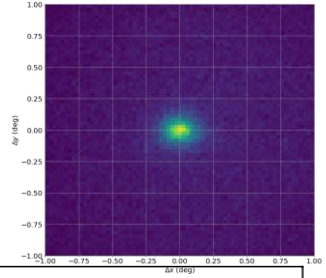
Symbiotic Nova RS Ophiuchi



Galactic Center 39hrs (Sgr A*, diffuse)

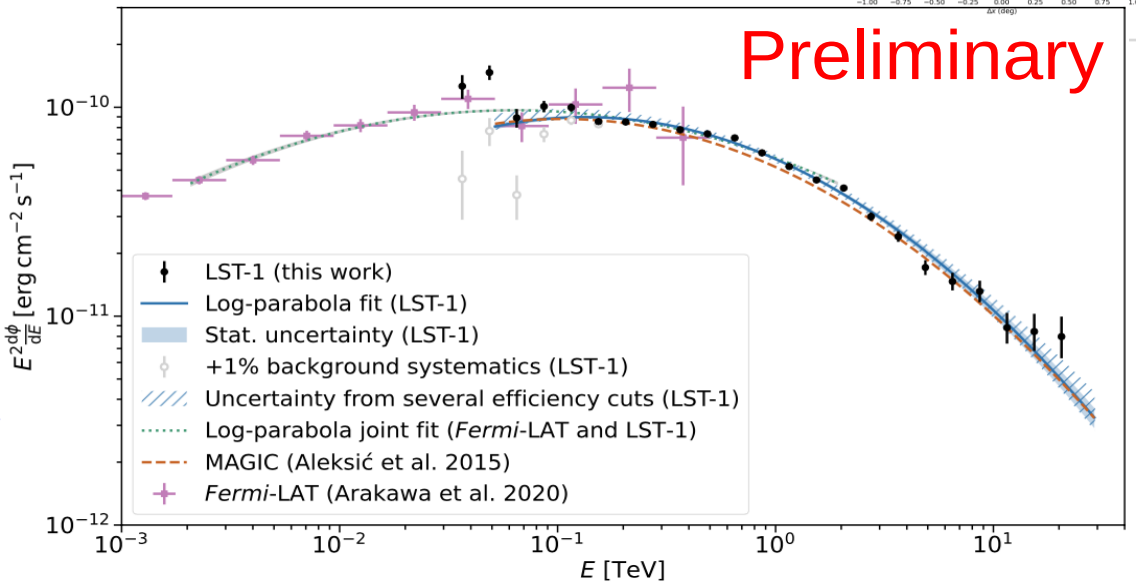


Crab Nebula and Pulsar



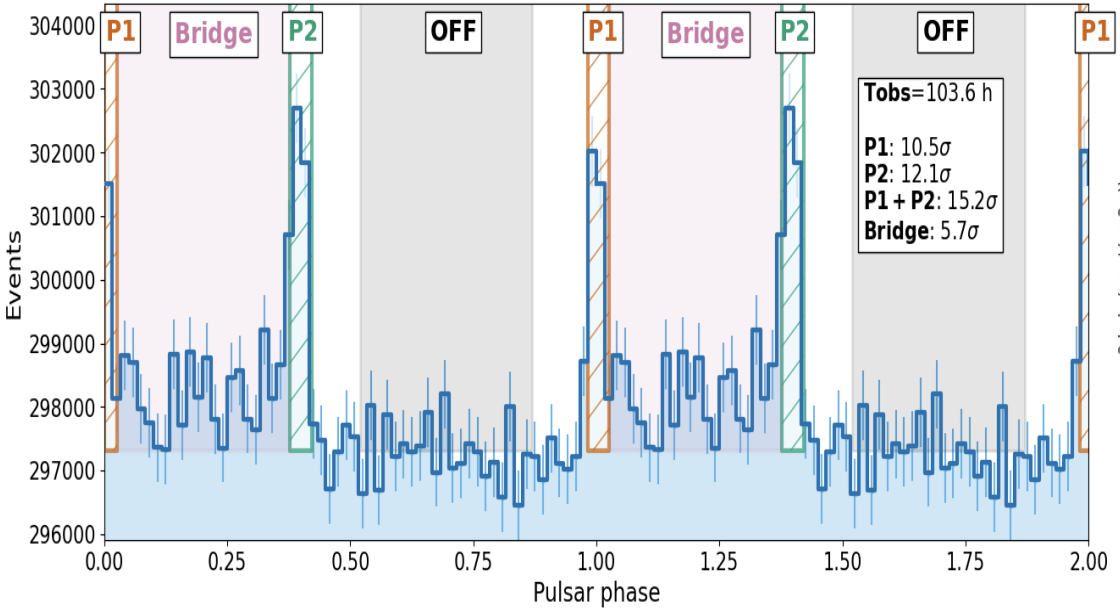
Crab Nebula spectrum

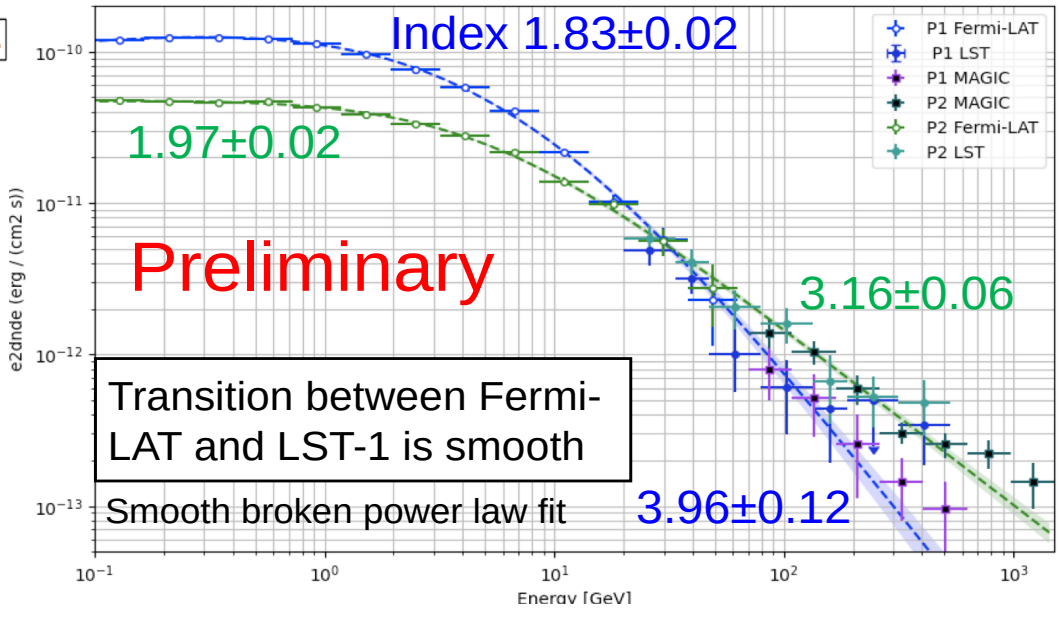
- 34.2 hours of data
- Systematic errors: gray points correspond to the effect of +1% background
- Consistent with MAGIC and Fermi-LAT



Crab pulsar

- Significant detection down to few tens of GeV

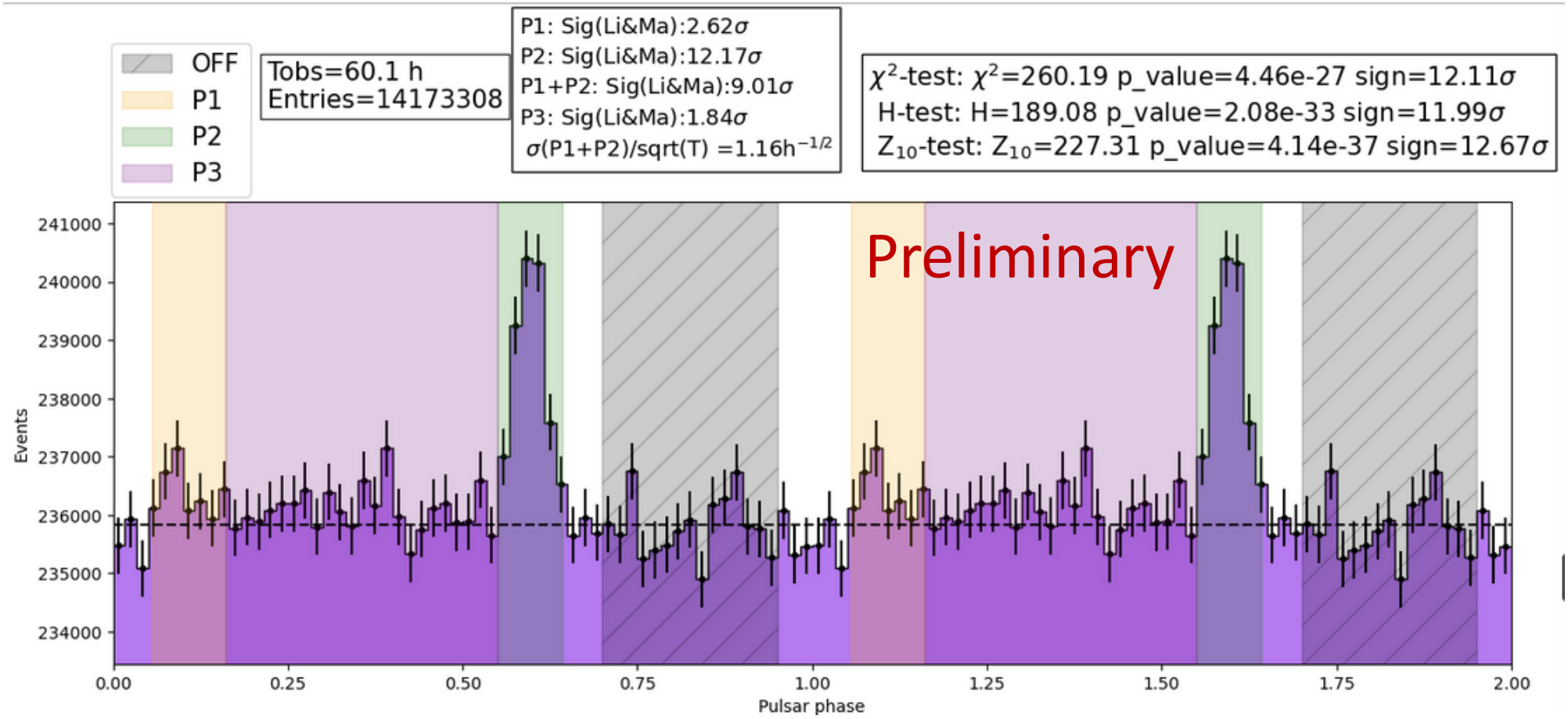




Phase diagram from Geminga Pulsar with LST-1

12 sigma signal is observed with 60hrs observation
The energy threshold is estimated to be 15-20GeV

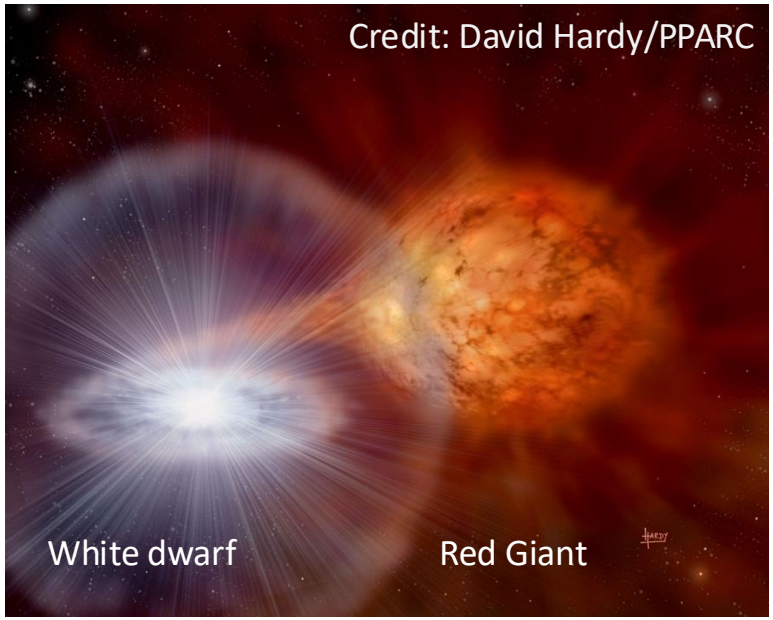
See the presentation by Dr. Paul K.H. Yeung.

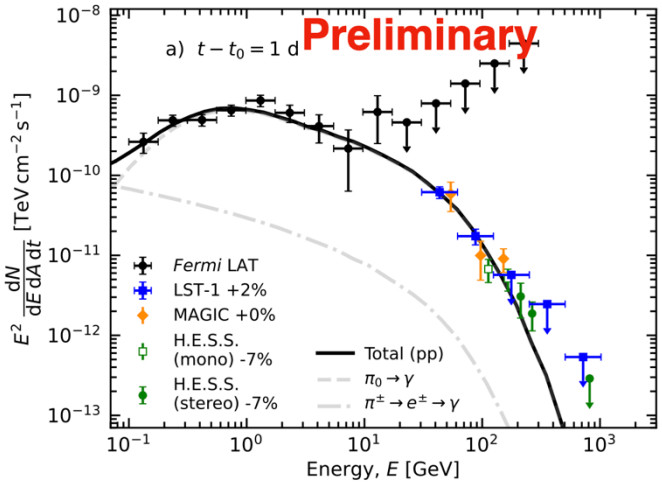


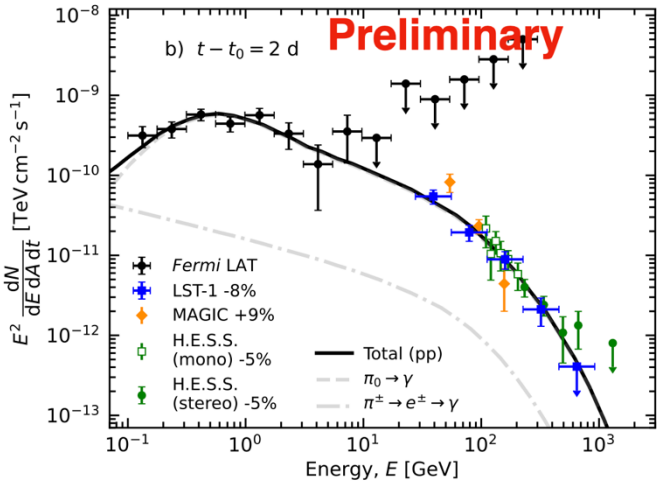
RS Ophiuchi Outburst in August 2021: Evolution of the Energy Spectrum

- 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 make recurrent explosions

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

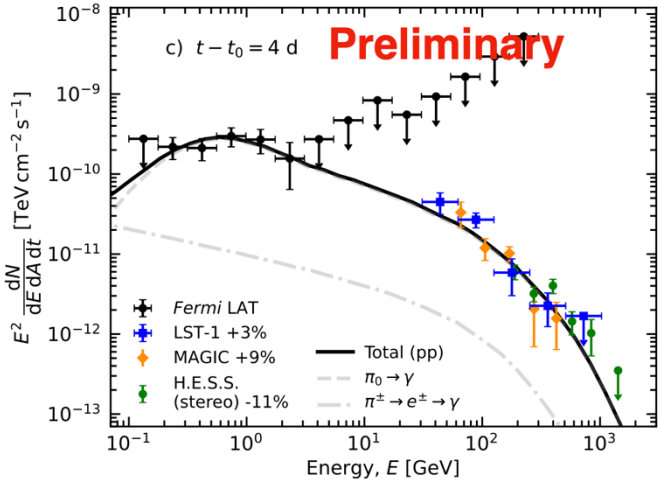






Preliminary

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



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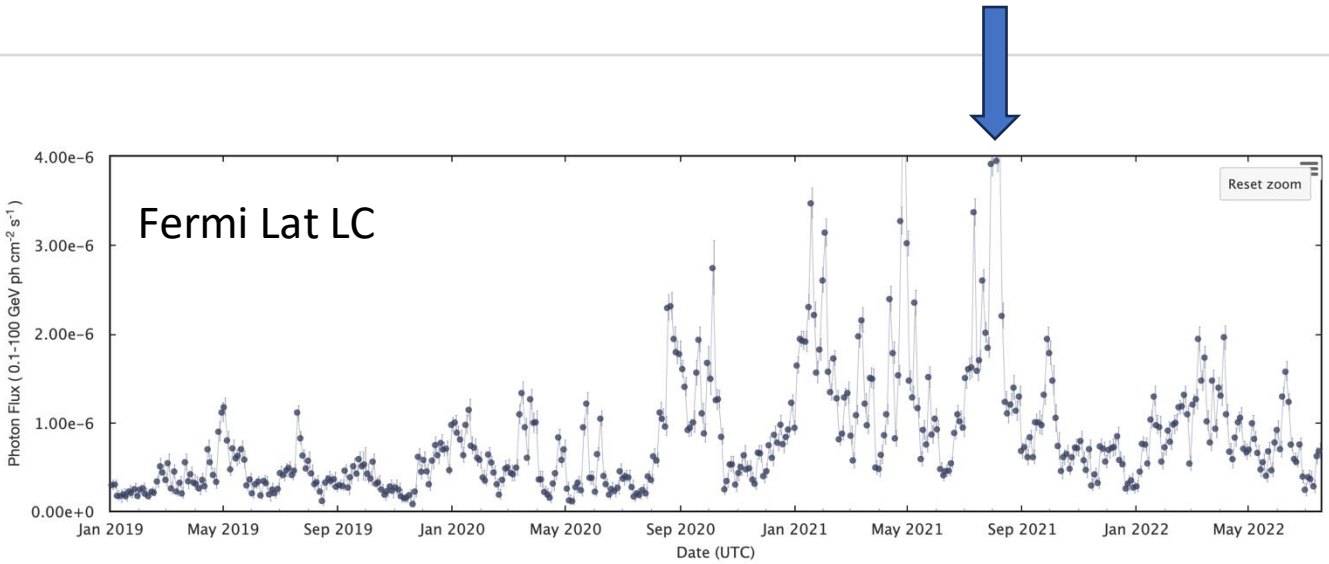
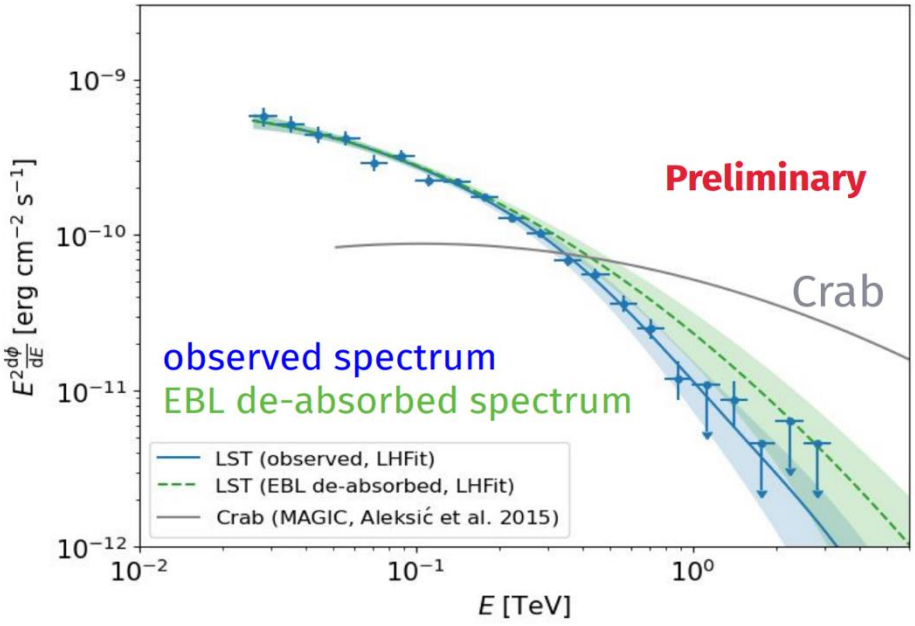
BL Lac Flare 2021

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

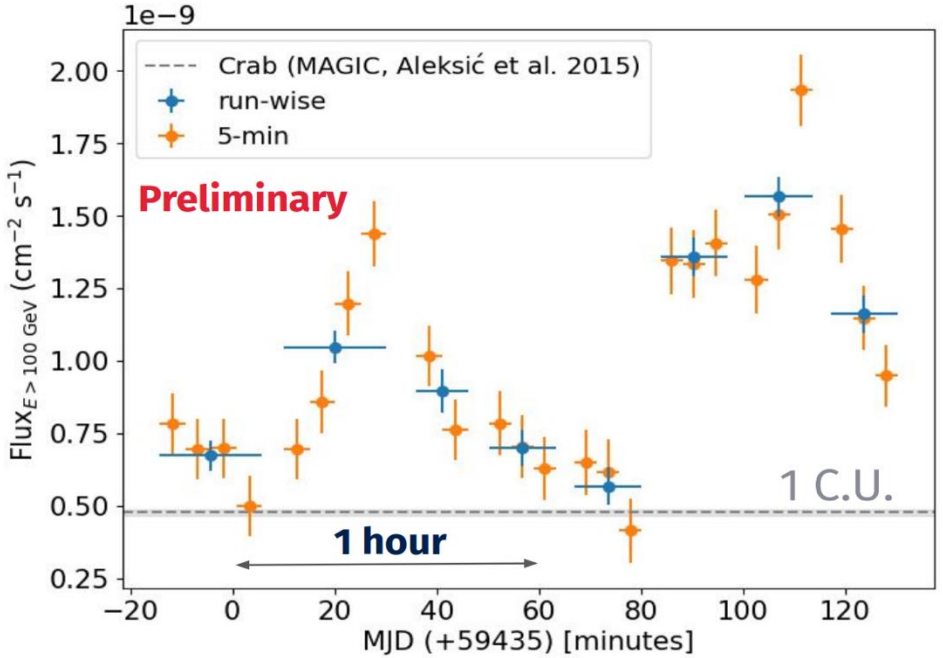
- Spectrum observed > 25GeV
- August 9, about 3-5 Crab Unit at 30-100 GeV
- Very fast variability (<5min)



Aug 9, 2021

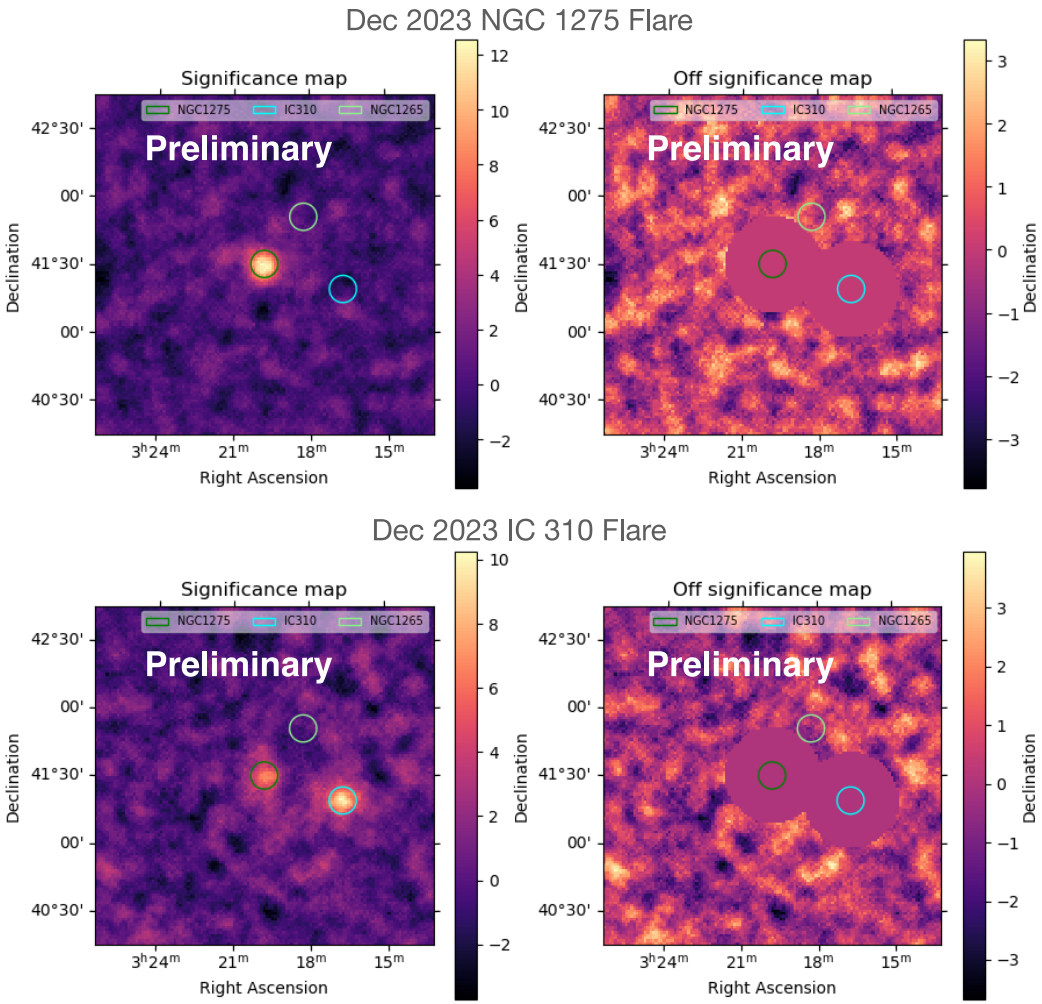


Intranight LC on 9 August, 5 min fast variability



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



Discovery of OP313 (z = 0.997) with LST-1

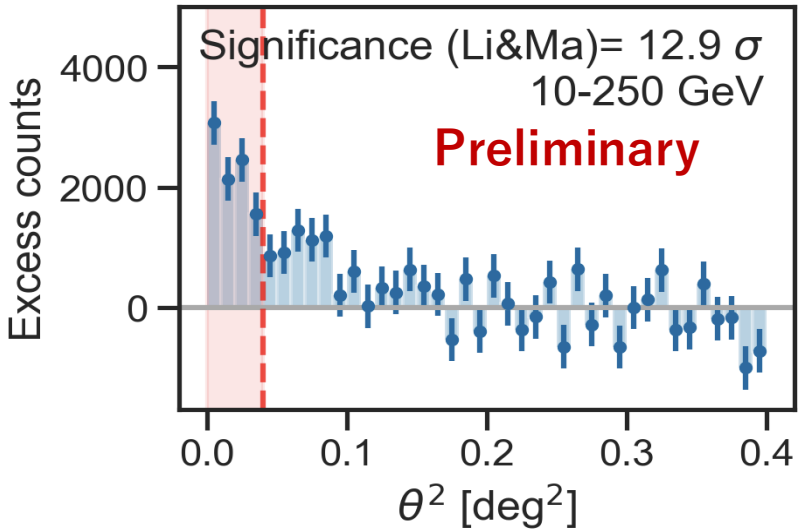
First detection of VHE gamma-ray emission from FSRQ OP 313 with LST-1

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)

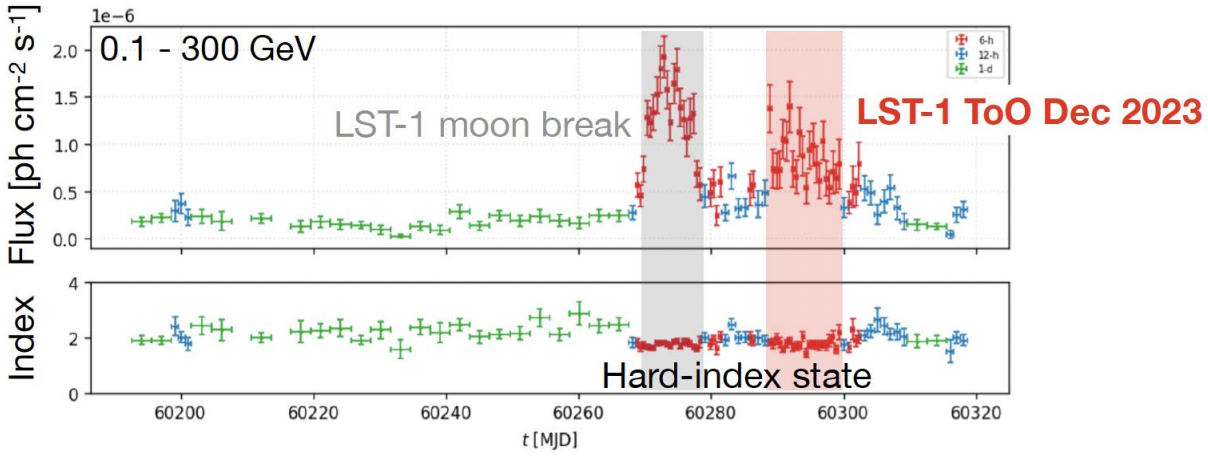
Subjects: Gamma Ray, >GeV, TeV, VHE, Request for Observations, AGN, Blazar, Quasar

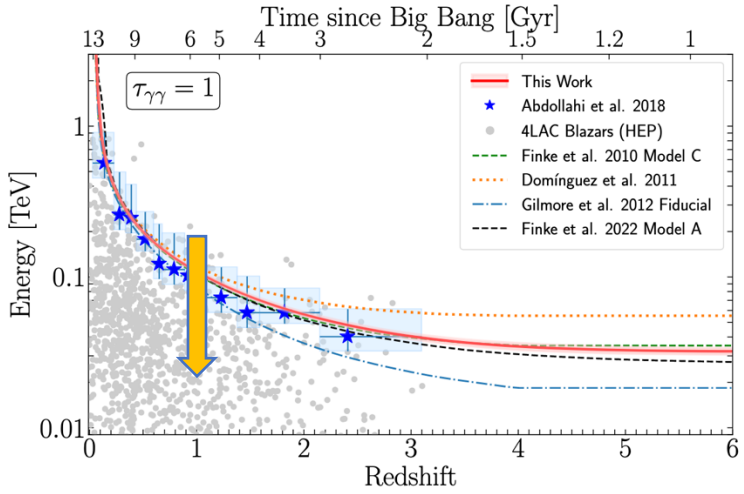
See the presentation by Joshua Baxter

Stacking all December data 2023 data (14.6hrs)
13 sigma excess below 250GeV, No detection above 250GeV
Publication with detailed analysis is expected soon.



Fermi Light Curve of OP313





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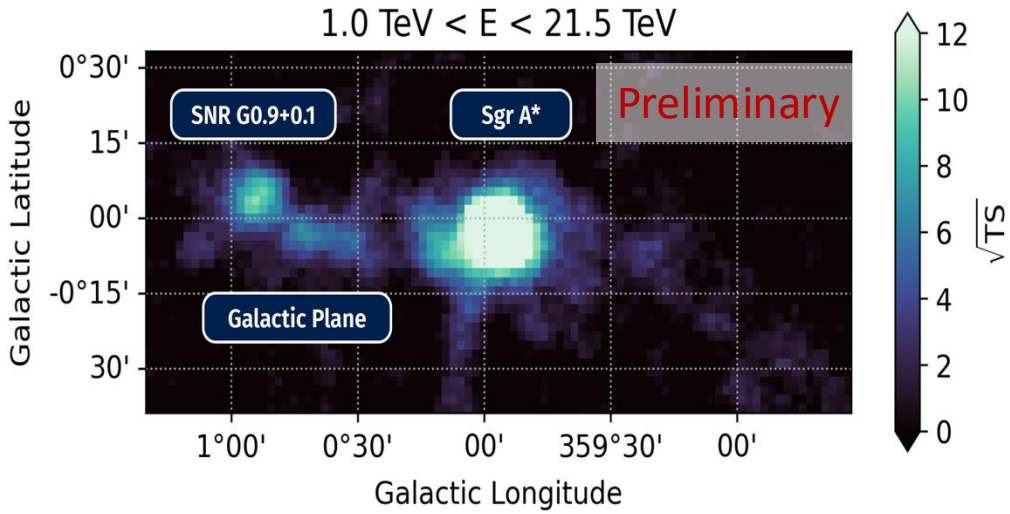
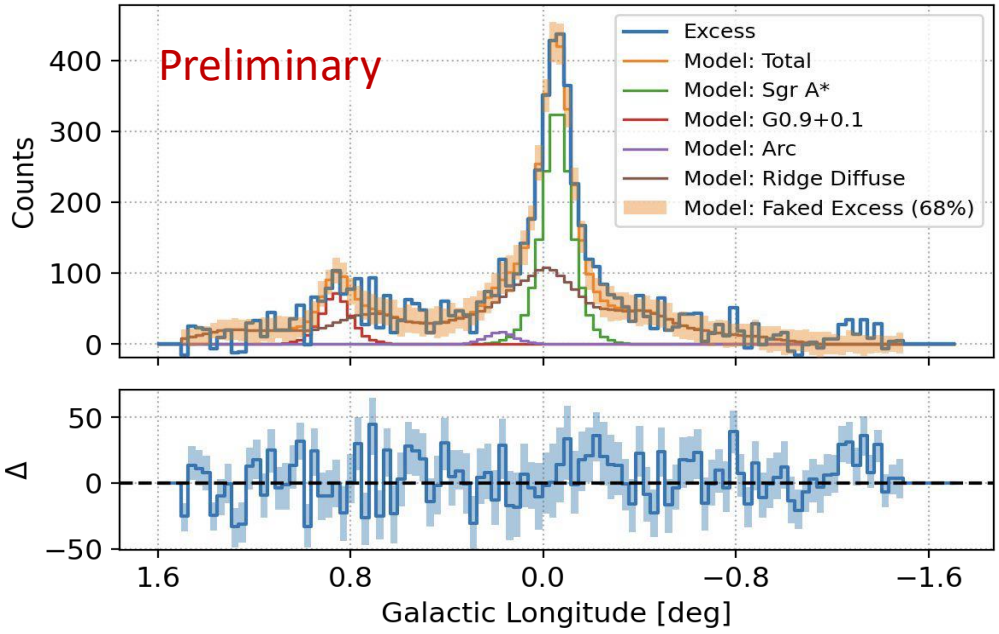
Galactic Center region

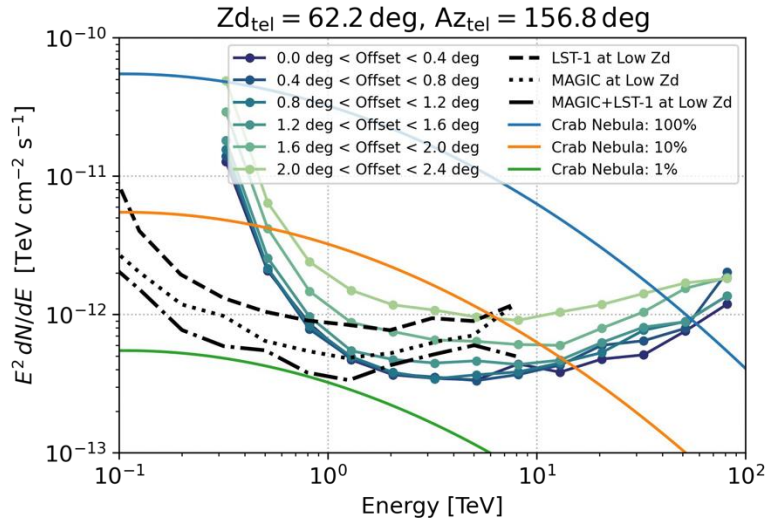
– S. Abe et al. are working on this subject



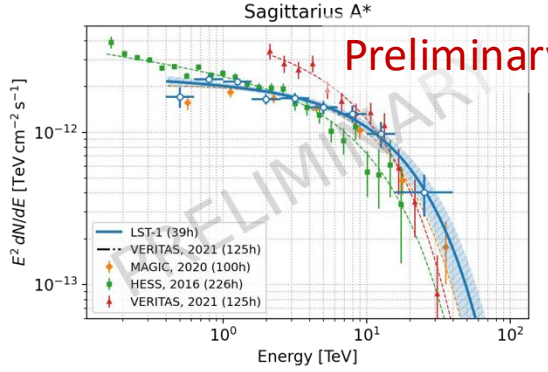


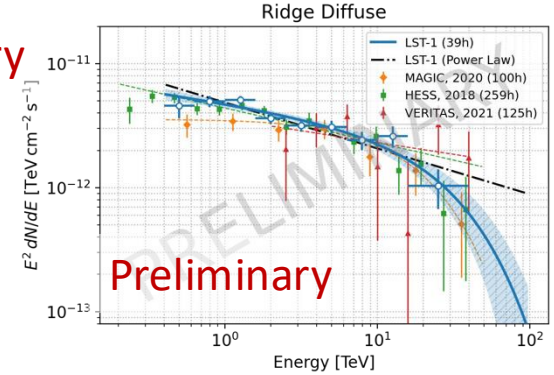
The galactic center is observed for 39hrs with the Large Zenith Angle Technique (ZD 58-68 deg).

Pros: Getting several times larger collection area
Cons: Higher Threshold Energy (> 300GeV)



Some trials to derive spectra from individuals





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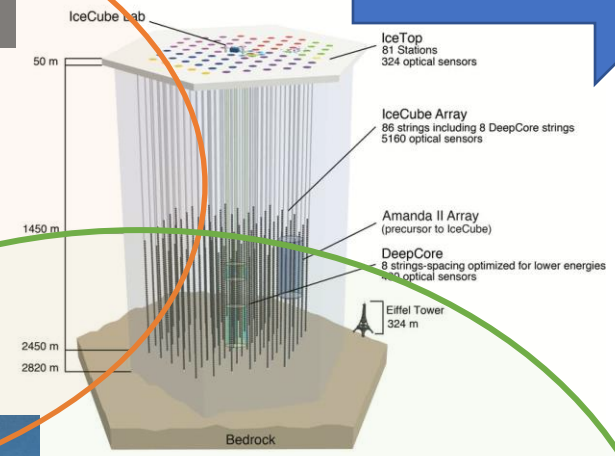
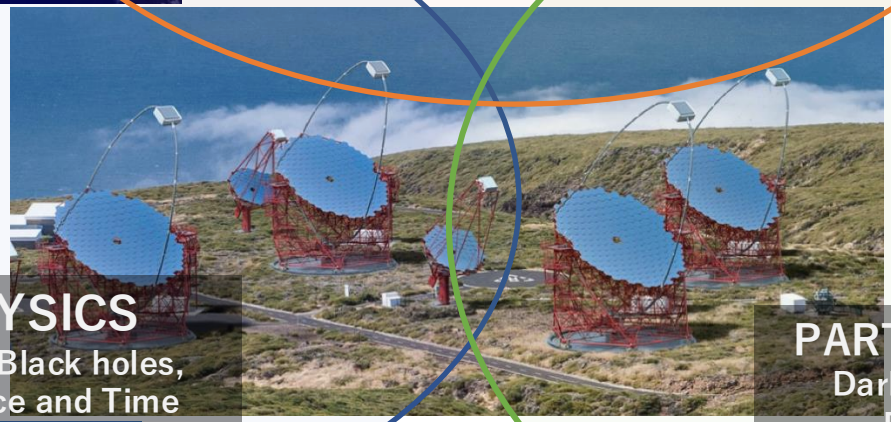
Multi-messenger and Multi-wavelength Astrophysics

Wave AstroPhysics

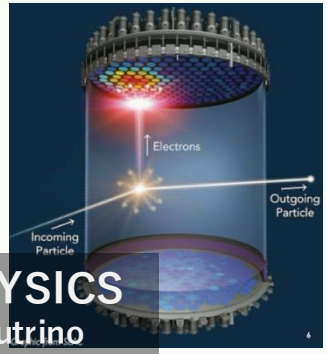
Particle Physics

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

CTAO | LST COLLABORATION

Summary

- The first Large-Sized Telescope LST1 fulfills the requirement and the design performance, including a fast follow-up capability of 20 sec.
- LST2, LST3, and LST4 will be completed by the end of 2025, and then commissioning with four LSTs will start.
- The LST Array will achieve one order of magnitude higher sensitivity than currently running telescopes below 100 GeV and several times around 1TeV.
- The LST Array contributes to the multi-messenger and time-domain astronomy.

CTAO | LST COLLABORATION

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Stay Tuned!


cta
cherenkov
telescope
array