Laboratoire d'Annecy de Physique des Particules

Variable extragalactic sources with the LST(s): Status and prospects

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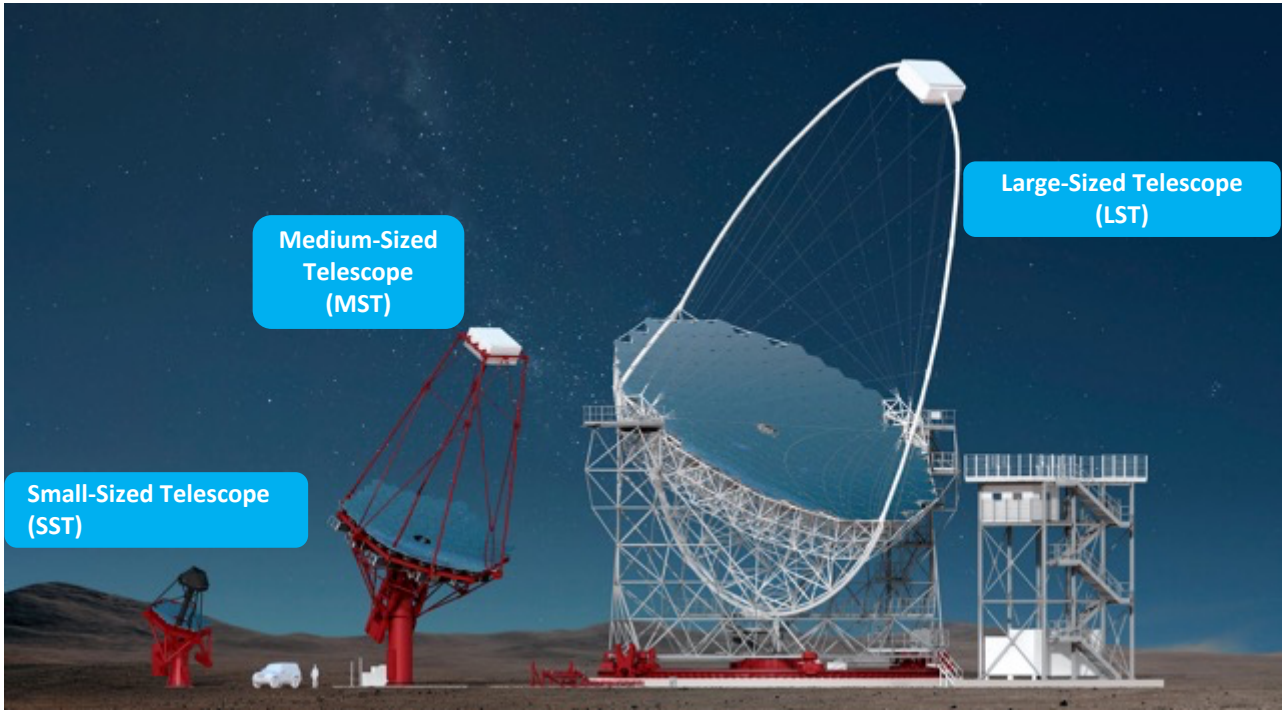
UNIVERSITÉ SAVOIE MONT BLANC

LST project

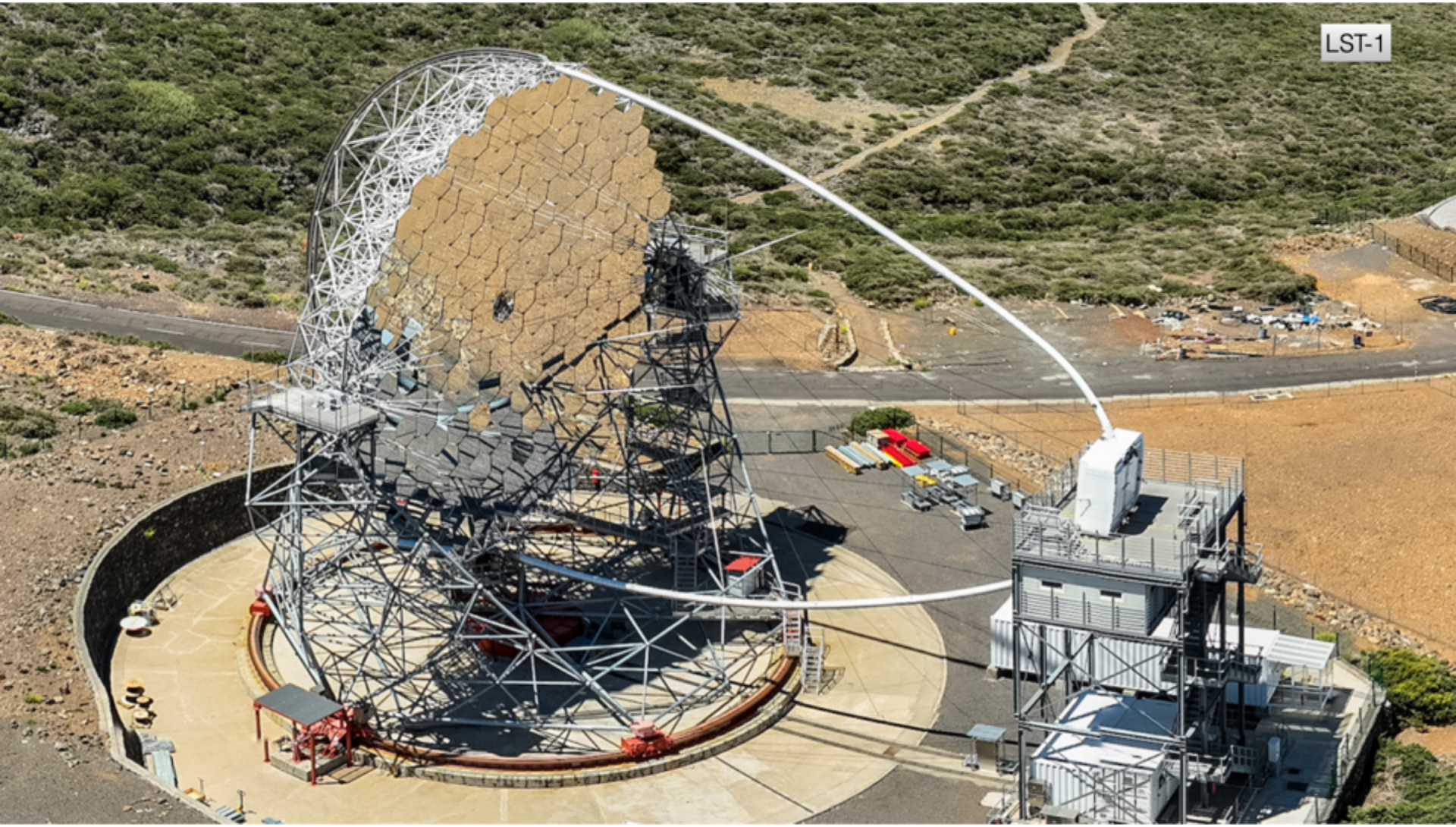
Three types of telescopes

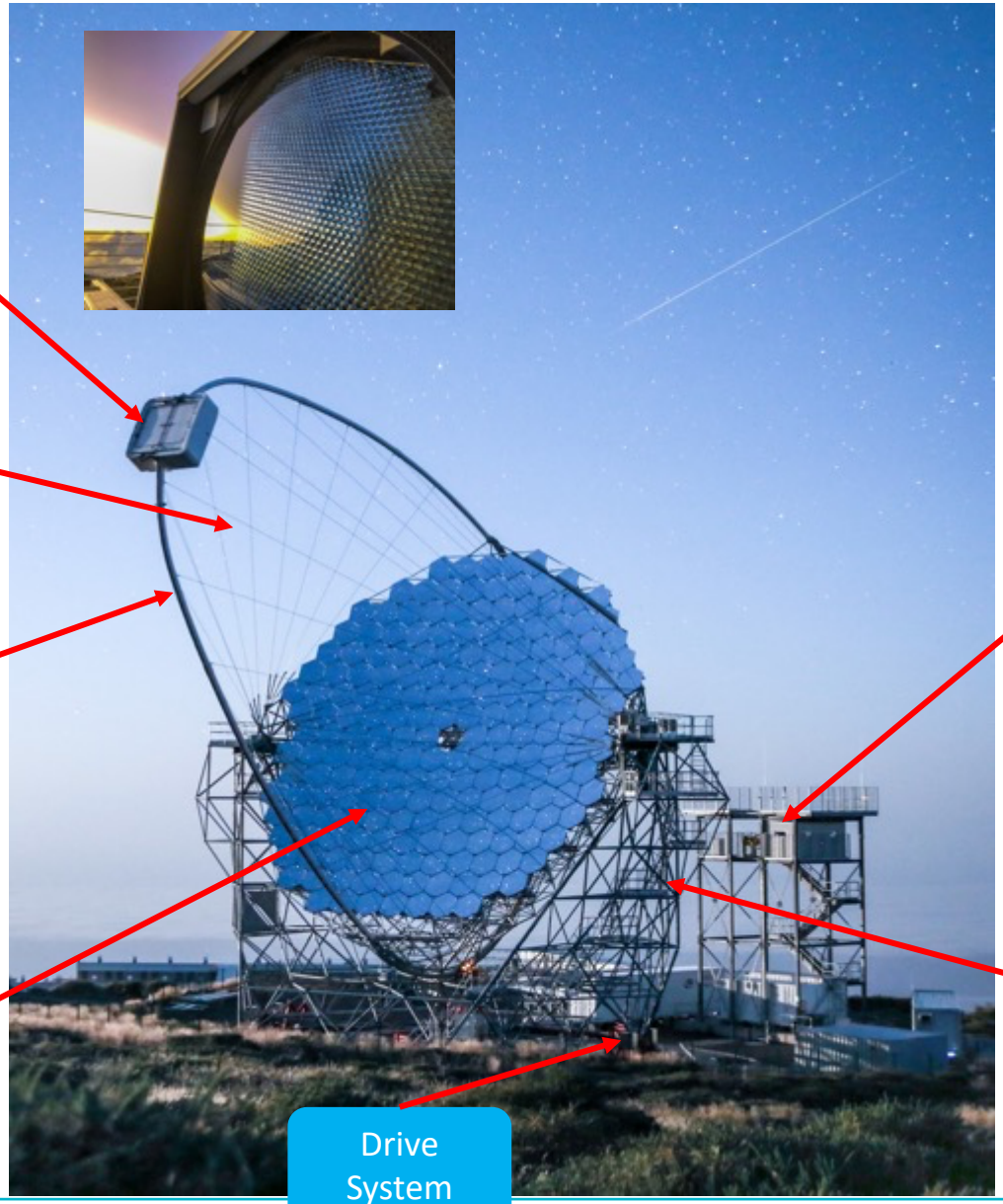


	SST	MST	LST
Effective mirror area	8m²	88 m²	*370 m²*
Energy range	1 TeV - 300 TeV	80 GeV - 50 TeV	*20 GeV - 3 TeV*
Exclusive energy range	5 TeV - 300 TeV	150 GeV - 5 TeV	*20 GeV - 150 GeV*
#Telescopes North	0	9	*4*
#Telescopes South	37 (*+5)	14	*0 (*+2)*
Photo-sensors	SiPM	PMT	*PMT*

* LST funded with Italian PNNR

The first CTAO telescope : LST-1





PMT camera

Tension ropes

Camera Support Structure

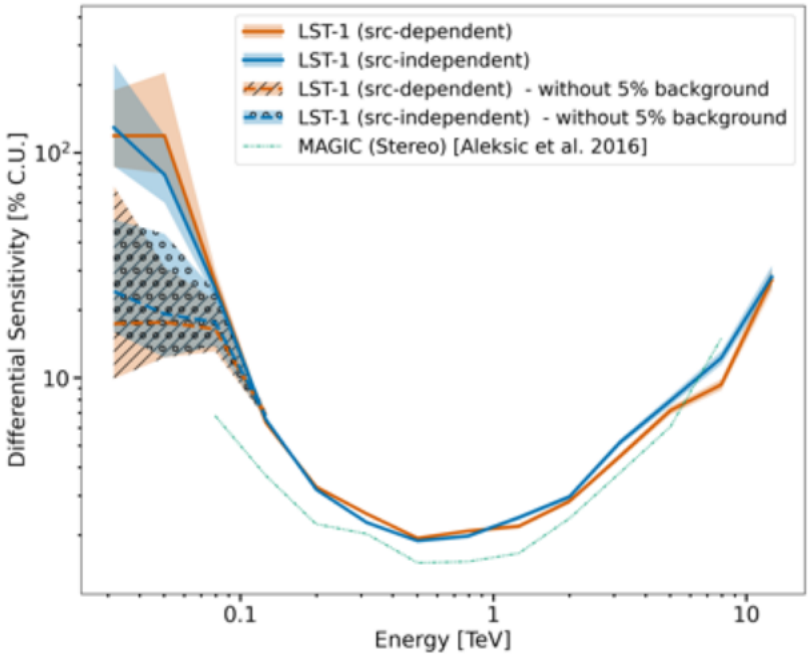
Mirrors

Drive System

Access Tower

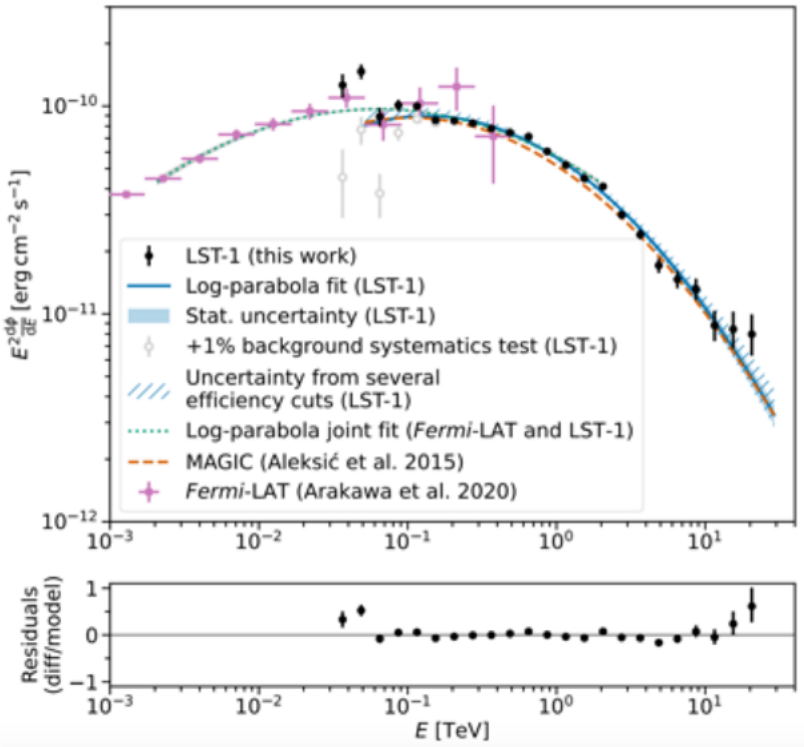
Telescope Structure

Crab Nebula is our standard candle



Roughly 1.5x less sensitive than MAGIC Stereoscopic Telescopes

Consistent with single telescope performance vs Stereoscopic system

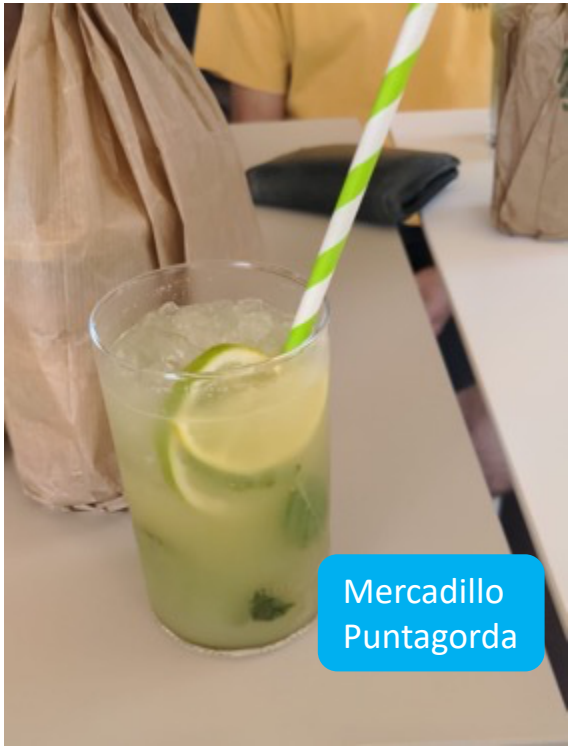


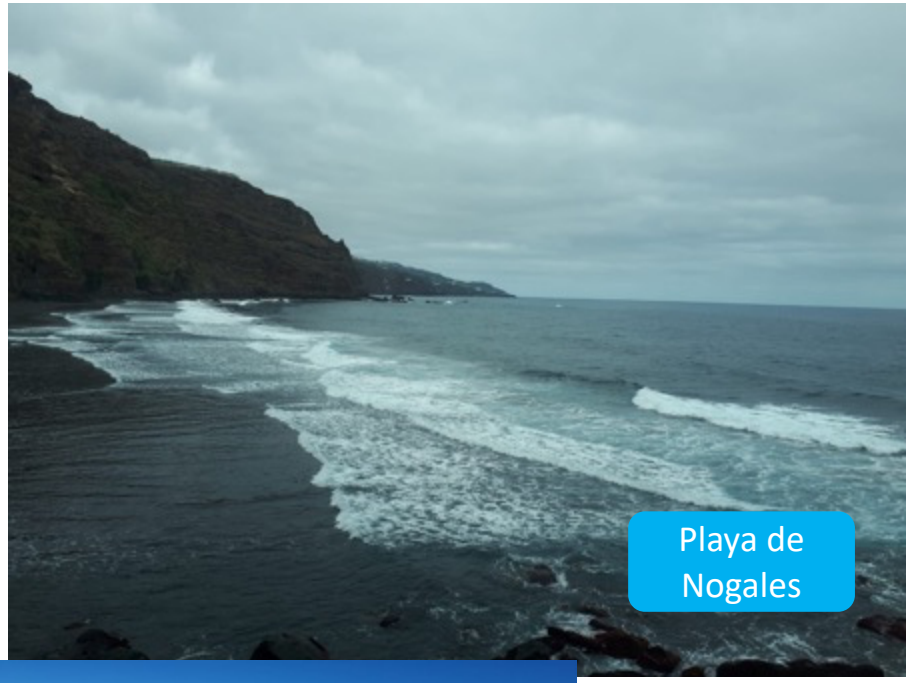
Measure Crab Nebula down to 30 GeV

Systematics from background begin to dominate below 50 GeV

Abe, H., et al,: ApJ, 956:80 (2023)

Beautiful landscape and more…



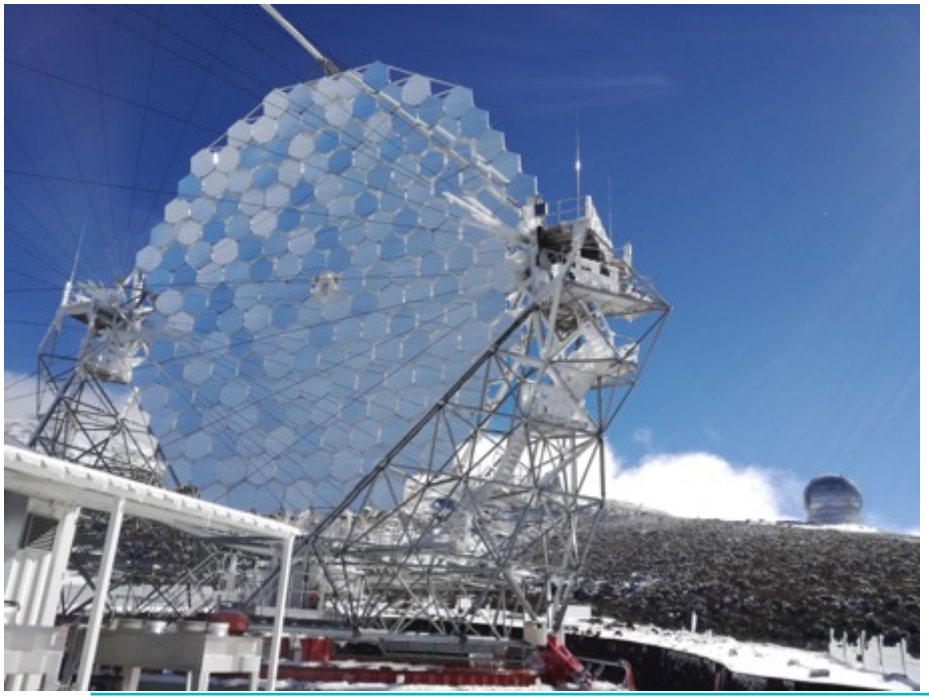


But

19/09/21 Volcano Cubre Viela

Stop operation for ~ 6 month

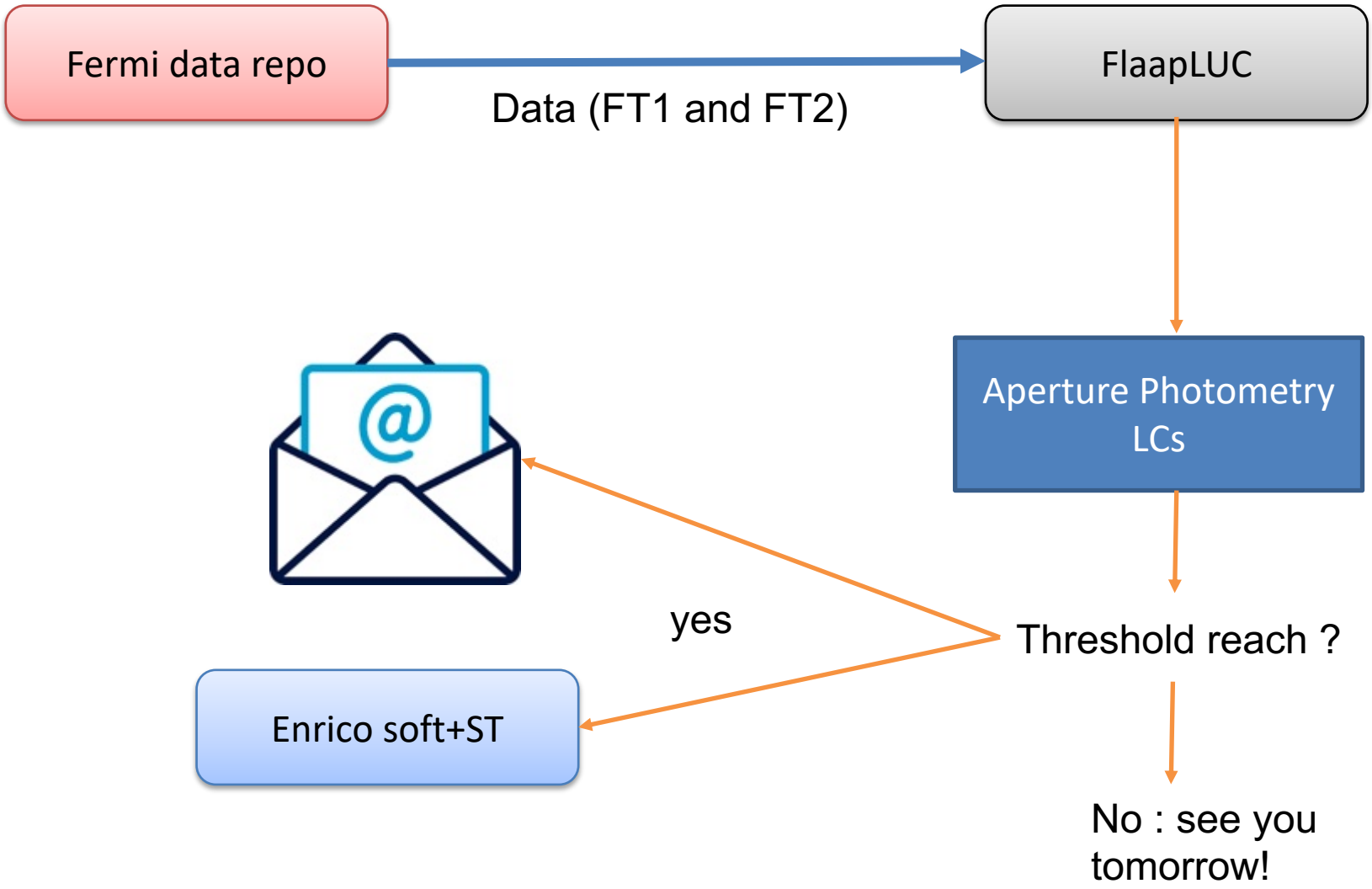
Storm during LST-1 construction



Central pin

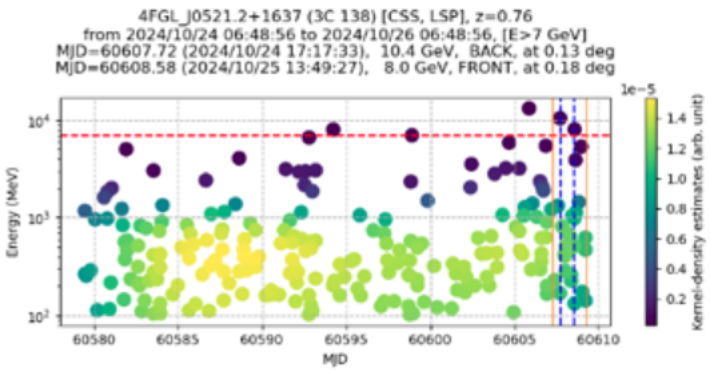
LST-1 ToO program

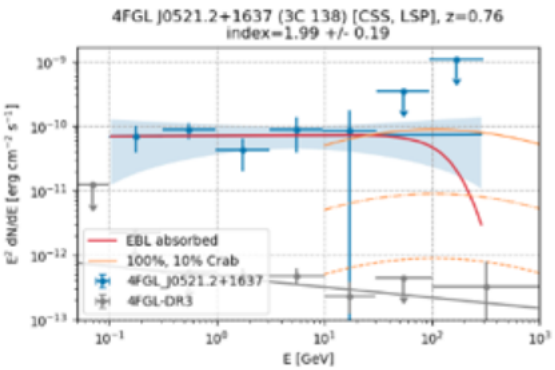
FLaapLUC: a pipeline for the generation of prompt alerts on transient Fermi-LAT γ-ray sources https://arxiv.org/abs/1709.04065

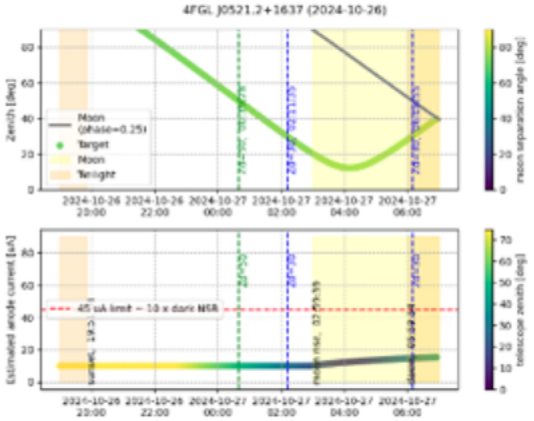


Analysis is made every 2 hours using weekly data

- Search for >2 HE photons (>7 GeV) within 2 days from all 4LAC sources
- then perform quick Fermi analysis
- Blind search (>10 GeV, |b|>10)





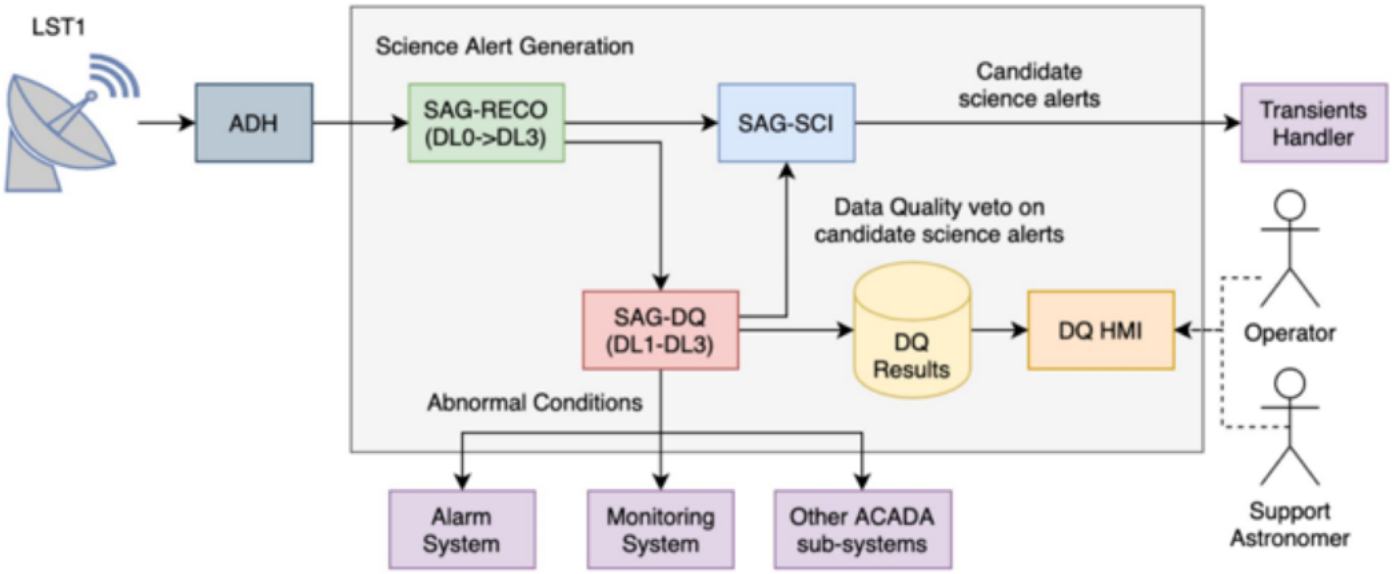


Send a ToO to observe an alert

And then?

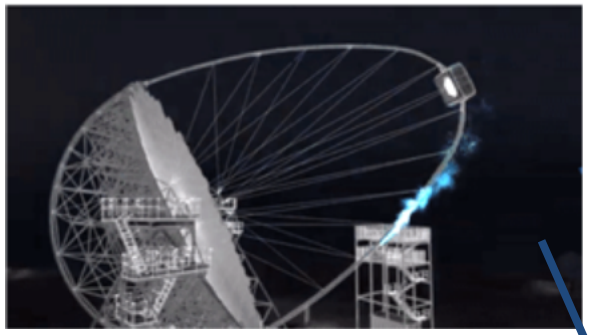
How to react to a Flare during the night or the day after?

(1) Handling telescope trigger rates of tens of kHz;
(2) Being capable of issuing candidate science alerts with a maximum **latency of 20s** after the data becomes available.

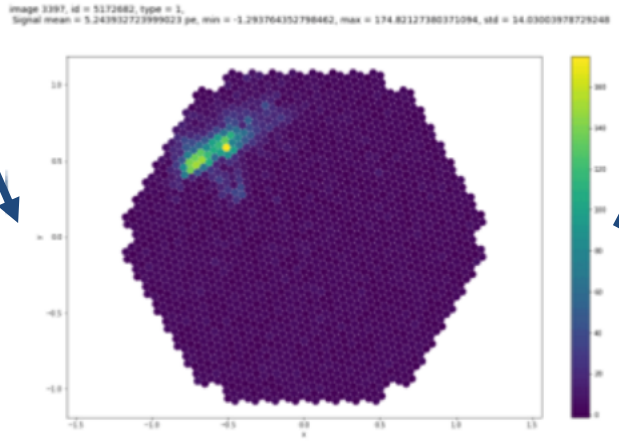


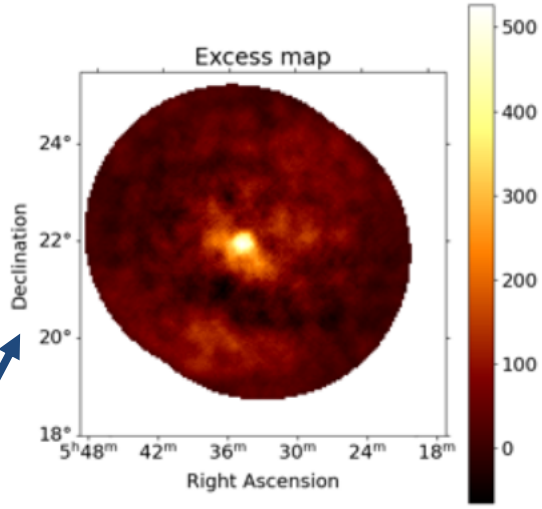
LST-1 RTA is a SAGE-Reco prototype

- Aim is to provide real time feedback on the telescope observation (for transient and variable source observations)
  - DL0/R1/**R0** (1855 pixels raw data) -> DL3 (gamma-like, energy, direction)
  - Current performances with the LST



input stream **~3 GB/s**
output data **~20 kB/s**
current speed **~0.75 GB/s/CPU**
DL3 available in **~50 secs**

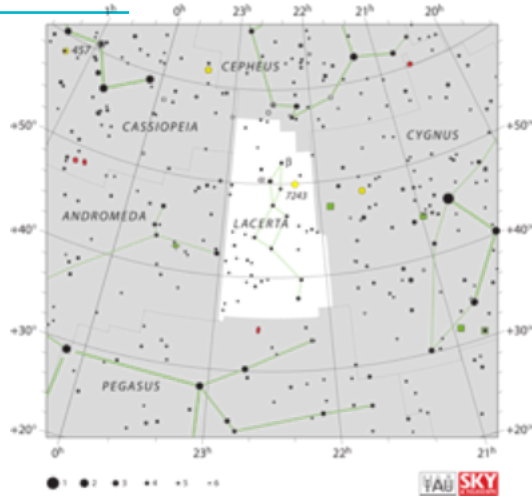


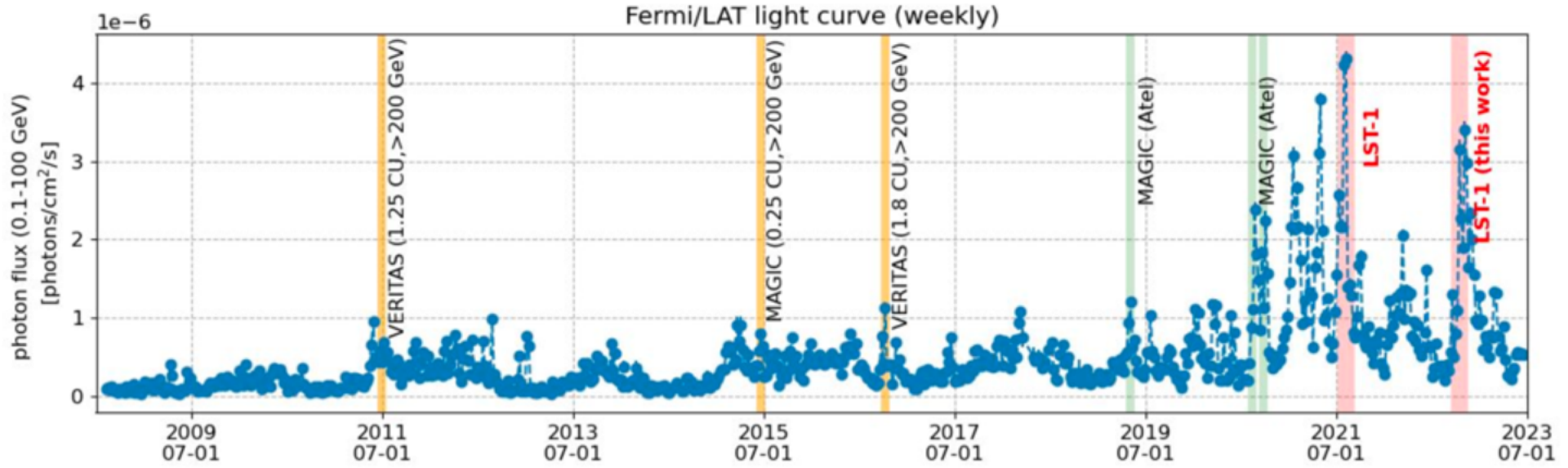


LST-1 ToO Results

BL Lac: IBL, z= 0.069

Variable in the HE range





➔ Two major flares in 2021 and 2022, brightest emission ever observed from BL Lac in VHE.

First ATel by LST/CTAO

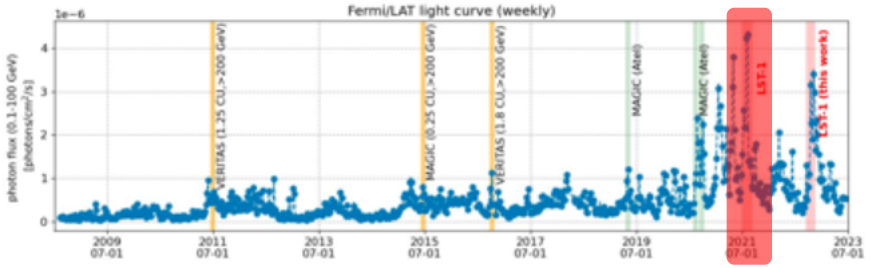
[Previous | Next | ADS]

Detection of very-high-energy gamma-ray emission from BL Lac with the LST-1

ATel #14783; *Juan Cortina for the CTA LST collaboration*
on 13 Jul 2021; 21:03 UT
Credential Certification: Juan Cortina (Juan.Cortina@ciemat.es)

Subjects: TeV, VHE, Request for Observations, AGN, Blazar, Transient

Referred to by ATel #: 14820, 14826, 14839

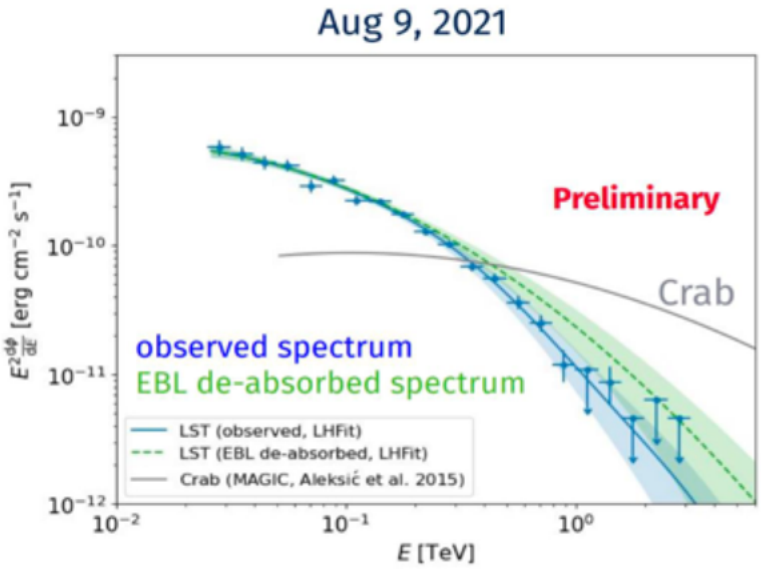


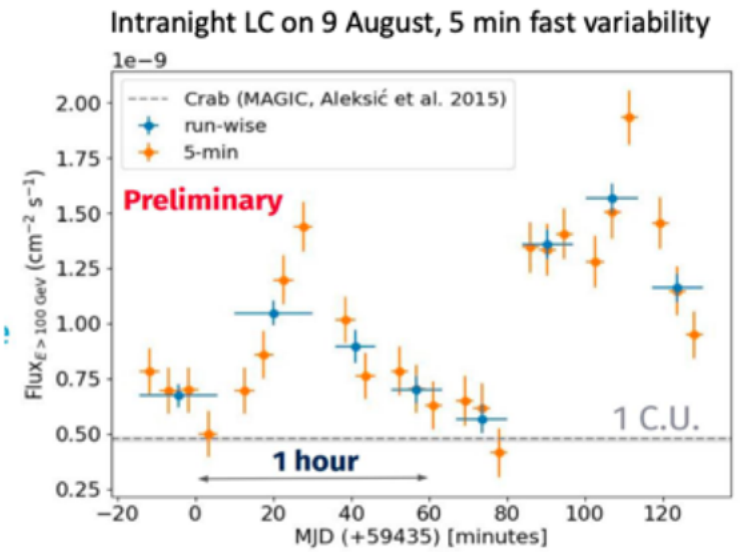
- Spectrum observed > 25GeV
- August 9, about 3-5 Crab

Unit at 30-100 GeV

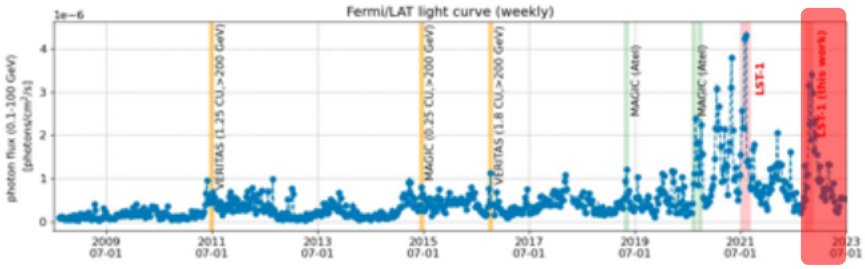
- Very fast variability (<5min)

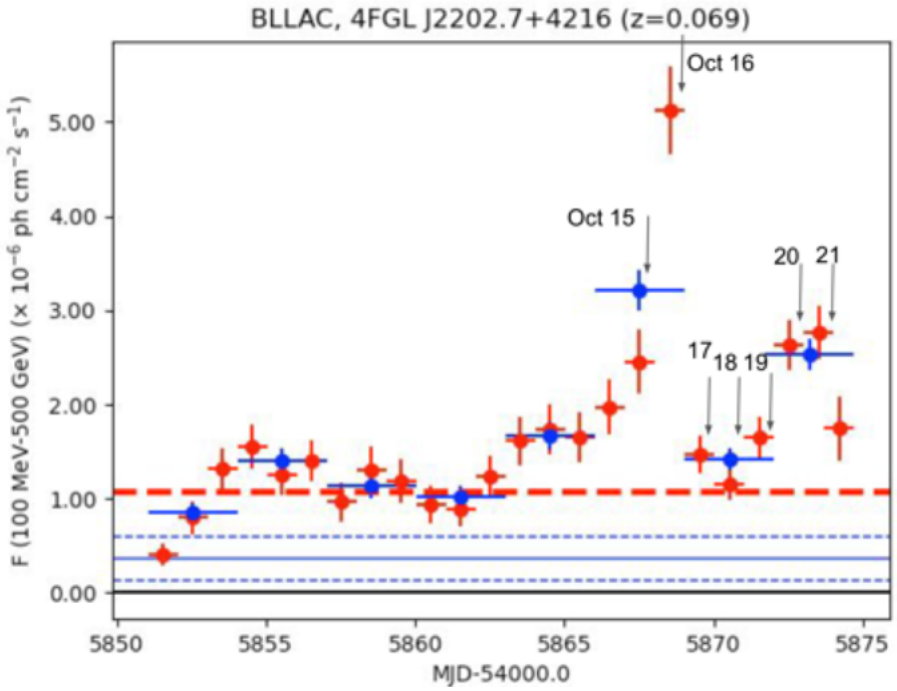
2021 flare (adapted from S. Nozaki's presentation at ICRC2023)

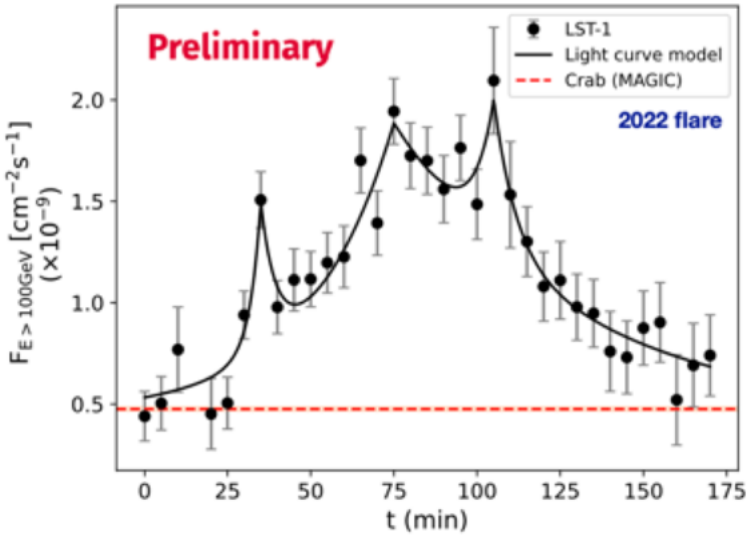




The first ToO triggered with FlaapLuC was on BL Lac





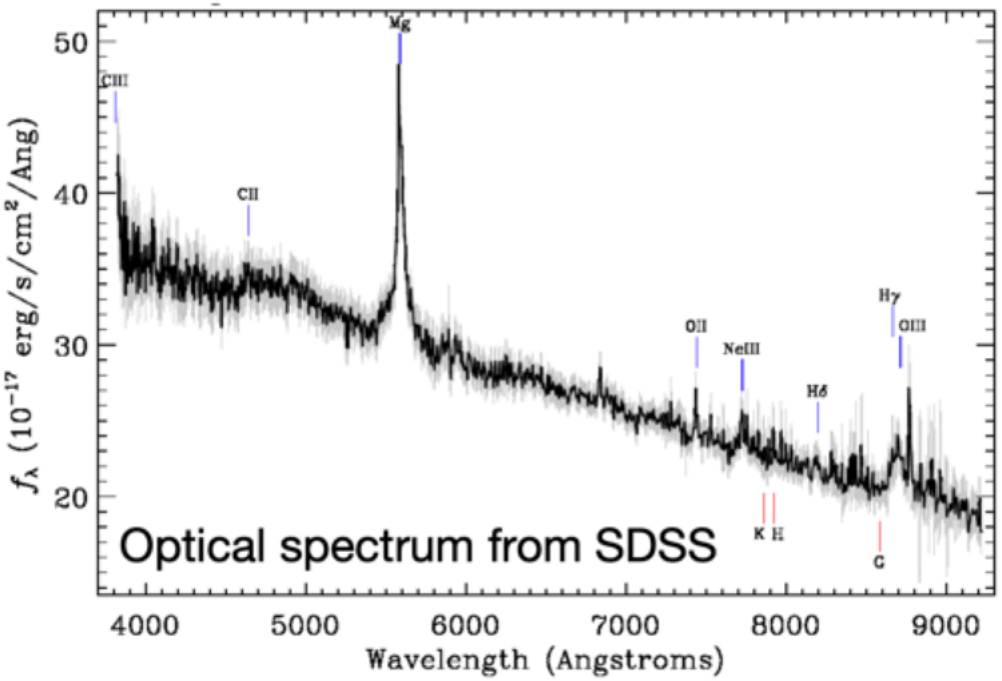


CTAO-LST project (in prep.)

Similar flux as in 2021, intra-night variability

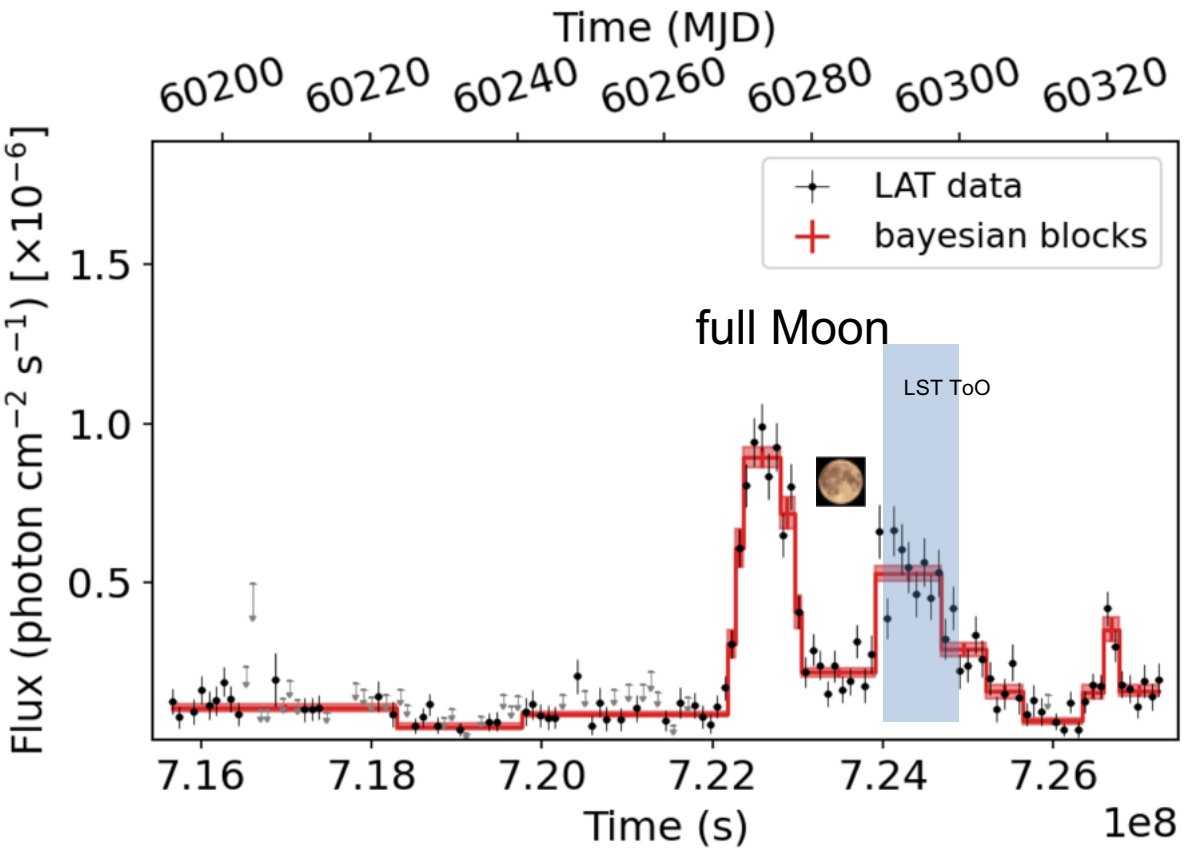
Quasar OP 313

- **Flat-spectrum radio quasar** (FSRQ)
- **Not detected at VHE** before
- Only 9 VHE FSRQs were known
- **z = 0.9973** (Schneider et al., 2010)
- **Strong attenuation at VHE** (>100 GeV) due to **EBL**
- Possible **internal absorption of its gamma-ray emission**



FlaapLuC aperture photometry Lightcurve of OP 313

Source was active before BUT during Moon break



- ATel
- Large press coverage
- Several presentations at different conferences

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

Post

The Large-Sized Telescope (LST-1) on La Palma has been monitoring the very distant Flat Spectrum Radio Quasar (FSRQ) OP 313 (z=0.997, Schneider et al. 2010, AJ, 139, 2360) since November 2023. Following the announcement of enhanced gamma-ray emission by Fermi-LAT (ATel #16356) and several optical facilities (ATel #16360) in early December, the Fermi-LAT emission of OP 313 has been closely monitored using the FlaspLUC pipeline (Astronomy and Computing, Volume 22, p. 9-15, 2018). This monitoring revealed the detection of renewed activity in the high-energy (HE, E>100 MeV) band and so, Target of Opportunity observations with LST-1 were triggered on December 10th 2023. OP 313 was detected by LST-1 with a preliminary offline analysis using data from 2023/12/11 to 2023/12/14. It was detected with a significance greater than 5 sigma and an integrated flux, above 100 GeV, at 15% flux of the Crab Nebula. LST-1 observations on OP 313 will continue during the next few nights and therefore multi-wavelength observations are highly encouraged. LST-1 is a prototype of the Large-Sized Telescope for the Cherenkov Telescope Array Observatory, and is located on the Canary island of La Palma, Spain. The telescope design is optimized for observation of gamma rays in the range from 20 GeV to 3 TeV. The preliminary offline analysis has been performed by Daniel Morcuende
rge Otero-Santos (joteros@iaa.es) and Seiya Nozaki
he LST-1 contact persons for these observations are Masahiro
.mpg.de) and Juan Cortina (juan.cortina@ciemat.es).

Announcement
2023-December-26

LST-1 Discovers the Most Distant AGN at Very High Energies

La Palma, Spain – On 15 December, the Large-Sized Telescope (LST) Collaboration announced through an Astronomer's Telegram (ATel) the detection of the source OP 313 at very high energies with the LST-1. Although OP 313 was known at lower energies, it had never been detected above 100 GeV, making this the LST-1's first scientific discovery. With these results, OP 313 becomes the most distant Active Galactic Nuclei (AGN) ever detected by a Cherenkov telescope, further showcasing the LST prototype's exceptional performance while it is being commissioned on the CTAO-North site on the island of La Palma, Spain.

>> Lee y Descarga la Nota de Prensa en Español.

>> Read and Download the Press Release in English.

OP 313 is what is known as a Flat Spectrum Radio Quasar or FSRQ, a type of AGN. These are very luminous objects found in the centres of some galaxies, where a supermassive black hole devours material from its surroundings, creating powerful accretion disks and jets of light and relativistic particles.

Accueil » Techno » Recherche

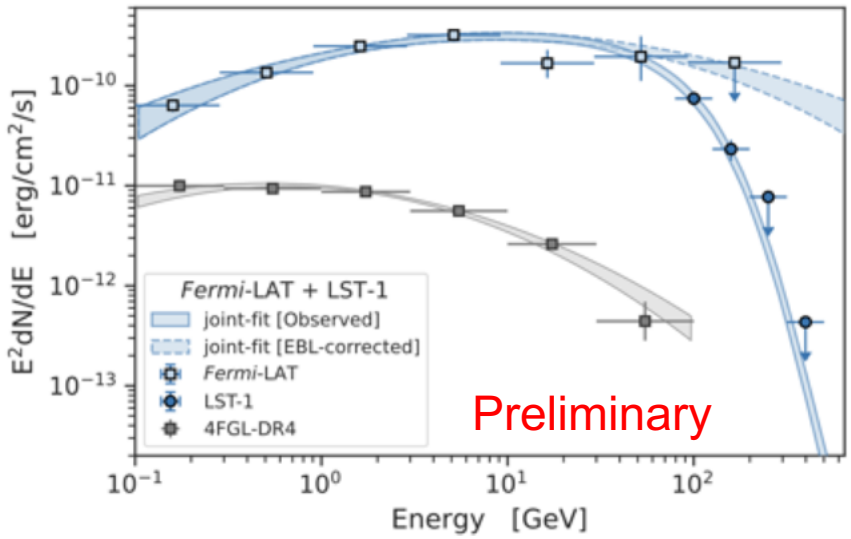
Le LST-1 détecte un quasar à plus de 100 Gigaélectronvolts

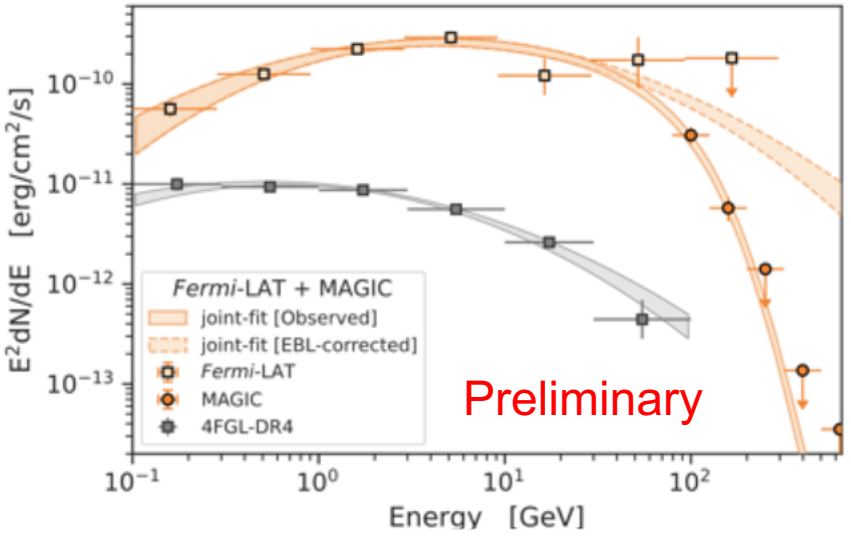
il y a 3 semaines Recherche, Techno

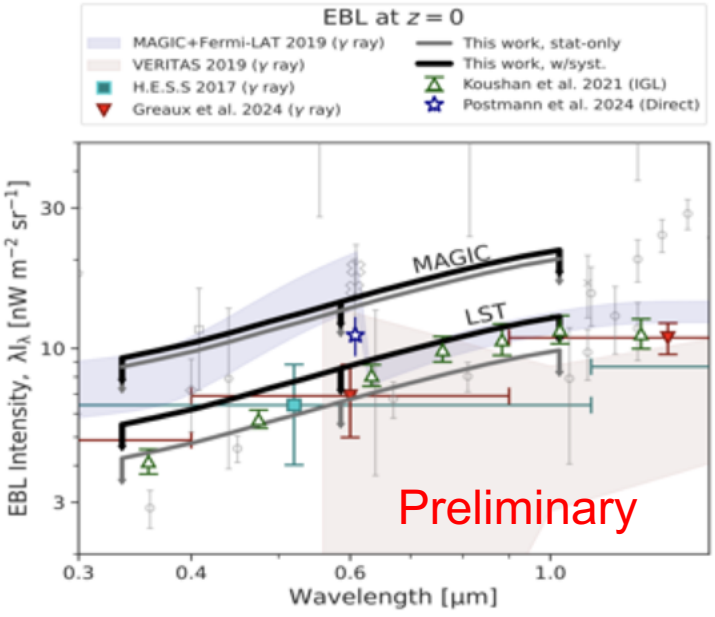
Le 15 décembre, une découverte majeure a été annoncée par la collaboration du Large-Sized Telescope (LST). L'objet OP 313 (quasar) a été détecté à des énergies très élevées, une première pour le LST-1. Cette détection marque une étape importante dans l'étude des noyaux galactiques actifs (AGN) et des quasars à spectre plat (FSRQ).

La collaboration LST a annoncé la détection de la source OP 313 à des énergies très élevées avec le LST-1. Bien que l'OP 313 soit connu à des énergies plus faibles, il n'avait jamais été détecté au-dessus de 100 GeV. Cette détection fait de l'OP 313 l'AGN le plus éloigné jamais détecté par un télescope Cherenkov, démontrant ainsi les performances exceptionnelles du prototype LST pendant sa mise en service sur le site CTAO-Nord sur l'île de La Palma, en Espagne.

OP 313 est ce que l'on appelle un quasar à spectre plat ou FSRQ, un type d'AGN. Ce sont







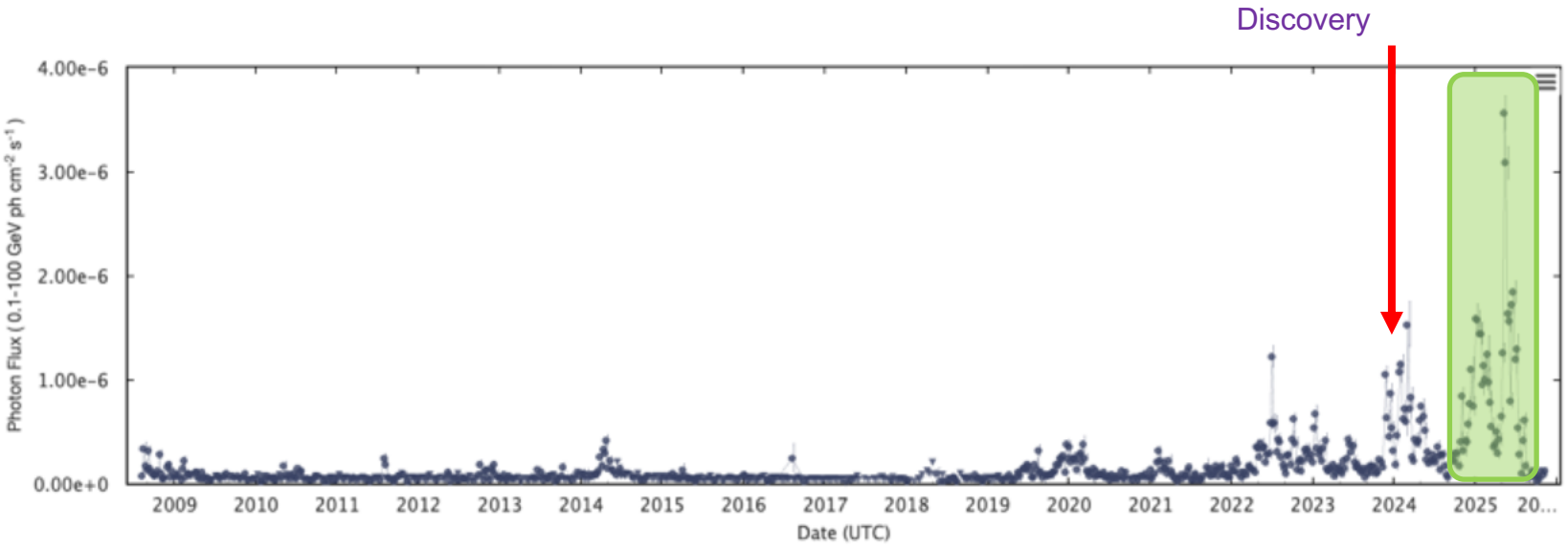
Joint LST + *Fermi*-LAT and MAGIC + *Fermi*-LAT

-> thanks to Gammapy and use work from Nievas Rosillo, M et al. 2025

Upper limits on EBL (Saldana-Lopez +21)

This is not the end.

The source was very active and we called it “Never ending ToO”



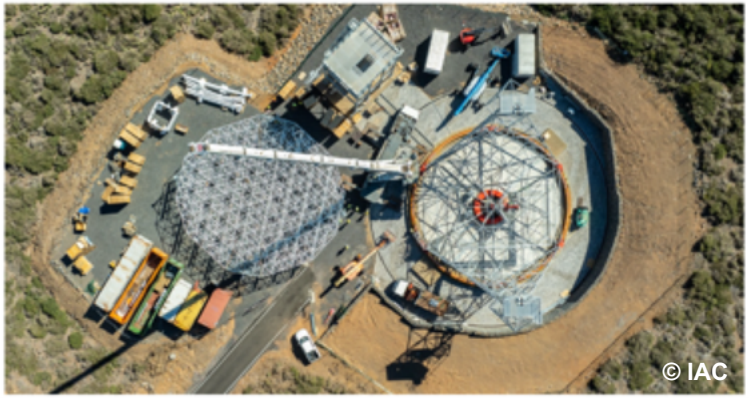
An Array of LSTs


Jun 2016

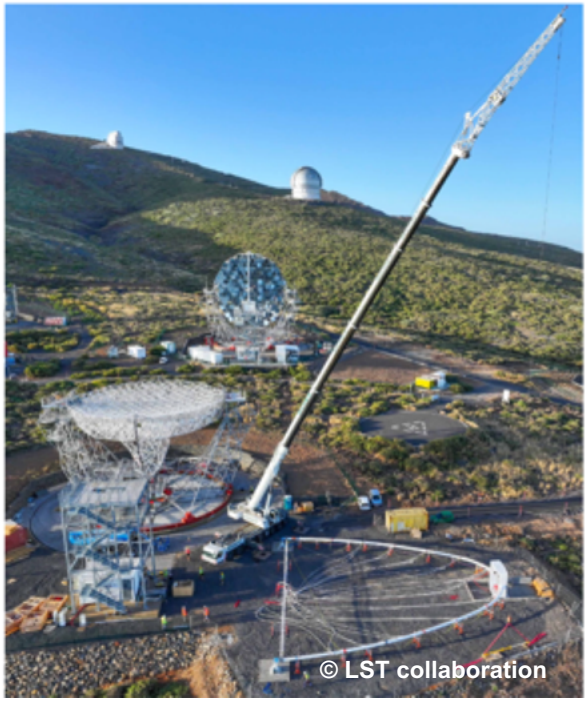

Oct 2018

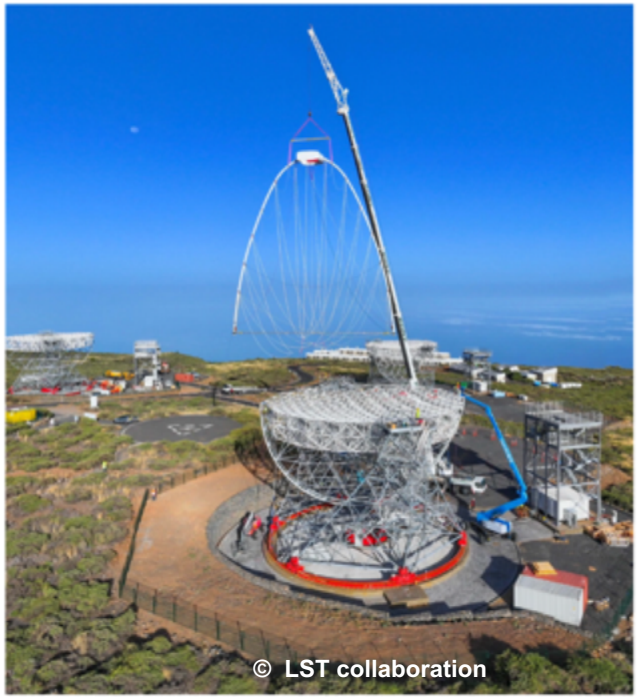

Aug 2024

How to build a LST?



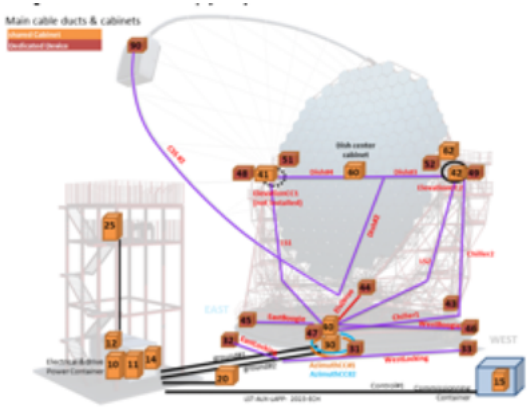
Dish of LST 4 lifted 03 May 2024
LST 3 : 13 June 2024
LST2 : 12 August 2024

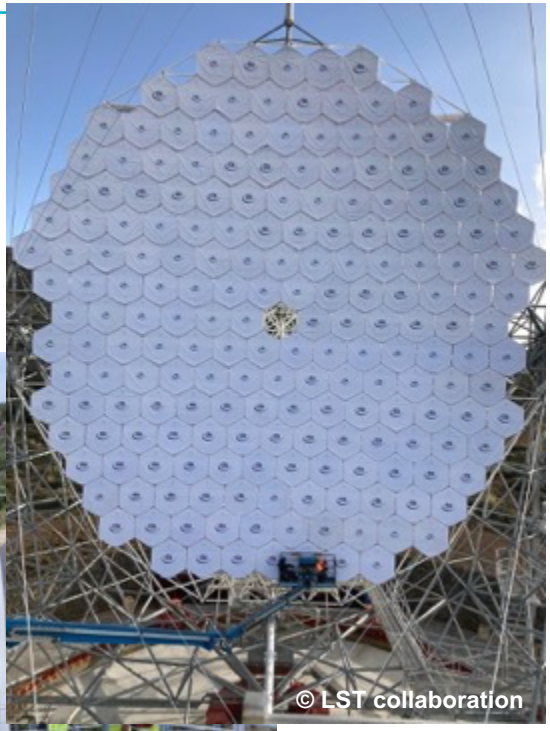




~ Half a day to lift it and release the crane

LST 4 and LST 3 CSS installed in 2024
LST 2 CSS in 2025





- Cabling
- Mirror facets installation
- Drive tests
- Camera installation
- Auxilliary devices

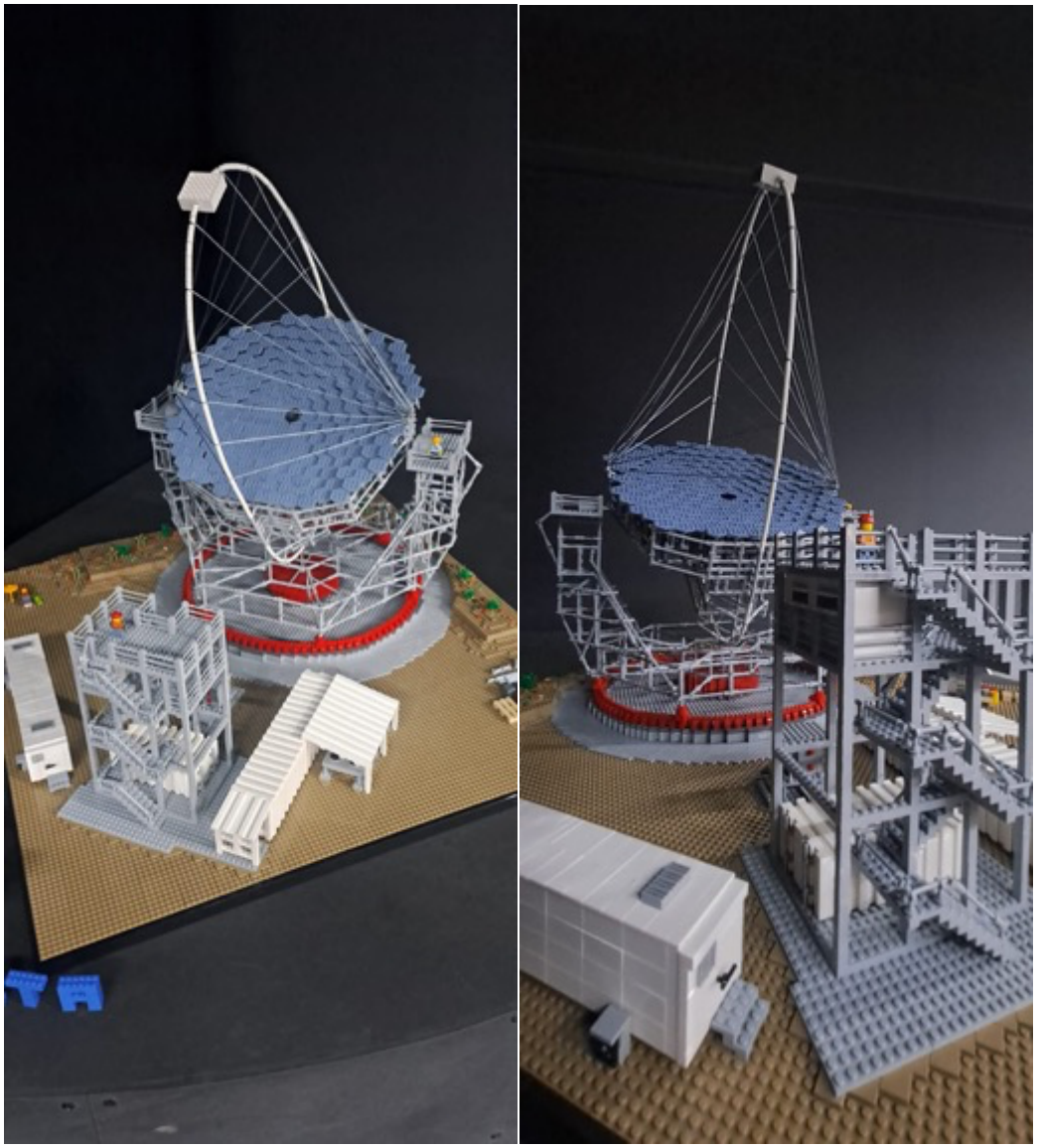
4 structures Ready :

- Arch have been installed
- Drive test LST4 finished
- Camera LST4 installed

Concepteur : Eric Pilhan

https://ericpilhan.fr/

Financement :
ENIGMASS+LAPP




Thanks you for your attention
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