

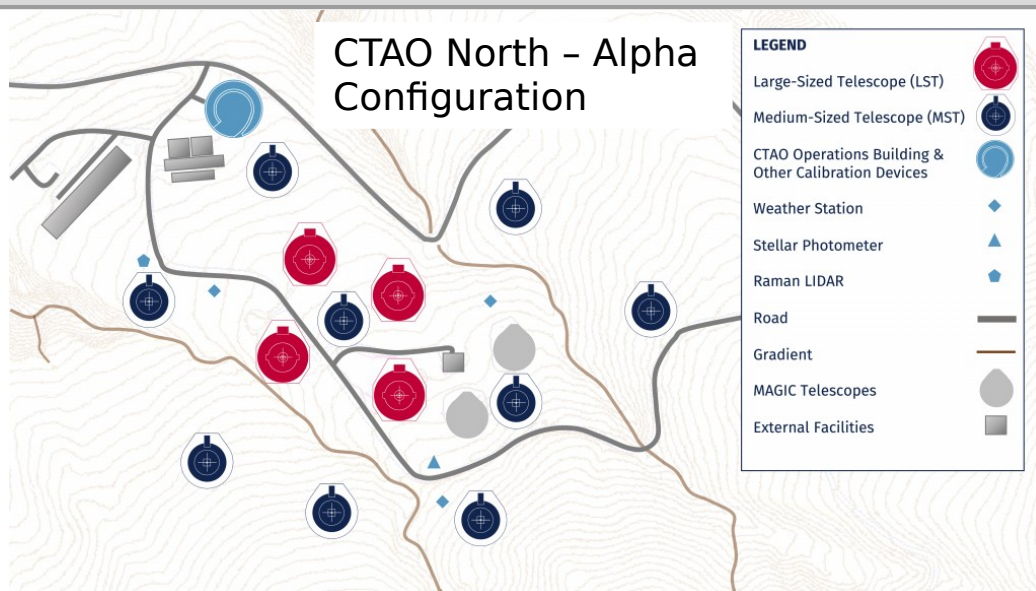
Discovery of Very High Energy emission from the distant FSRQ OP313 by the Large-Sized Telescope prototype.

And status of the LST Project

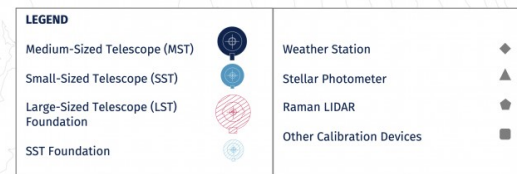


F. Di Pierro (INFN Torino), D. Morcuende, J. Otero-Santos, M. Nieves Rosillo, D. Sanchez, S. Nozaki, A. Arbet-Engels, L. Heckmann, J. Baxter, E. Visentin, R. de Menezes on behalf of the CTA-LST Project

The CTA Observatory



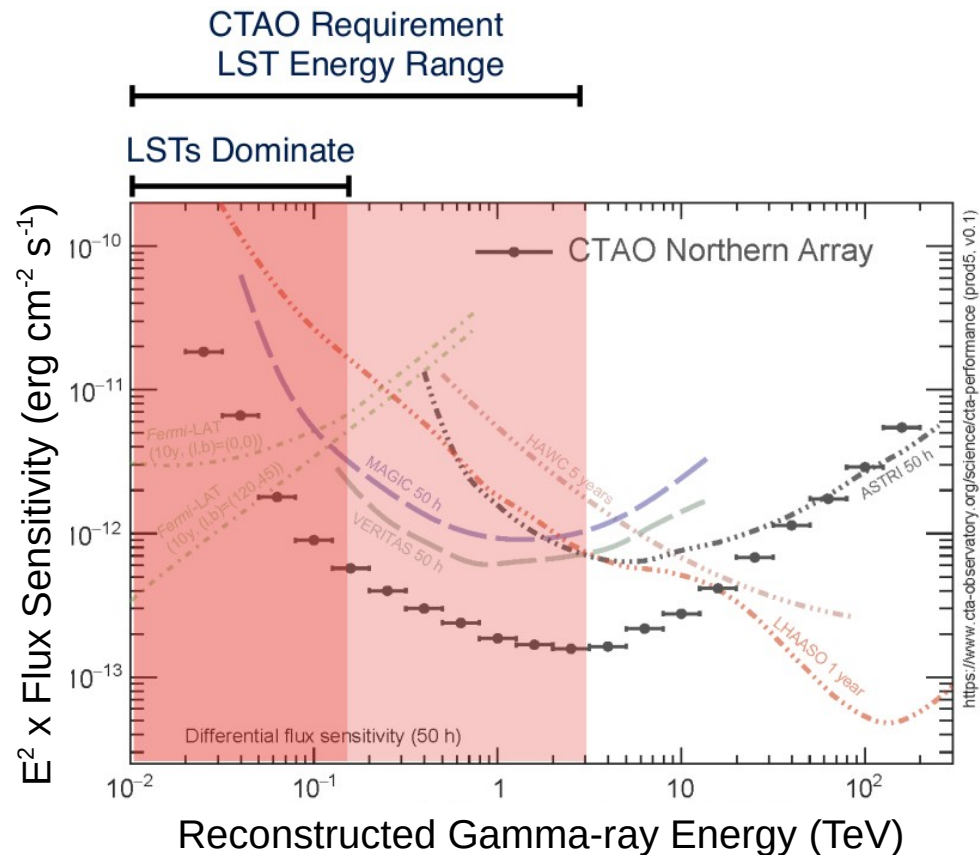
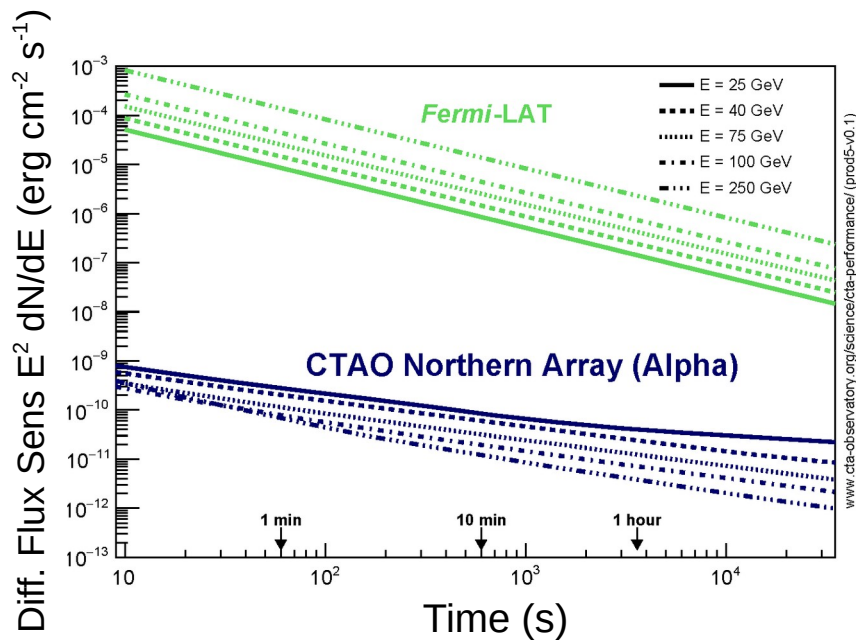
CTAO South – Alpha Configuration



- CTA will consist of 2 arrays
 - Northern, La Palma Spain
 - Southern, Paranal Chile
- Three telescope types
 - Large-Sized Telescopes (LST)
 - Medium-Sized Telescopes (MST)
 - Small-Sized Telescopes (SST)

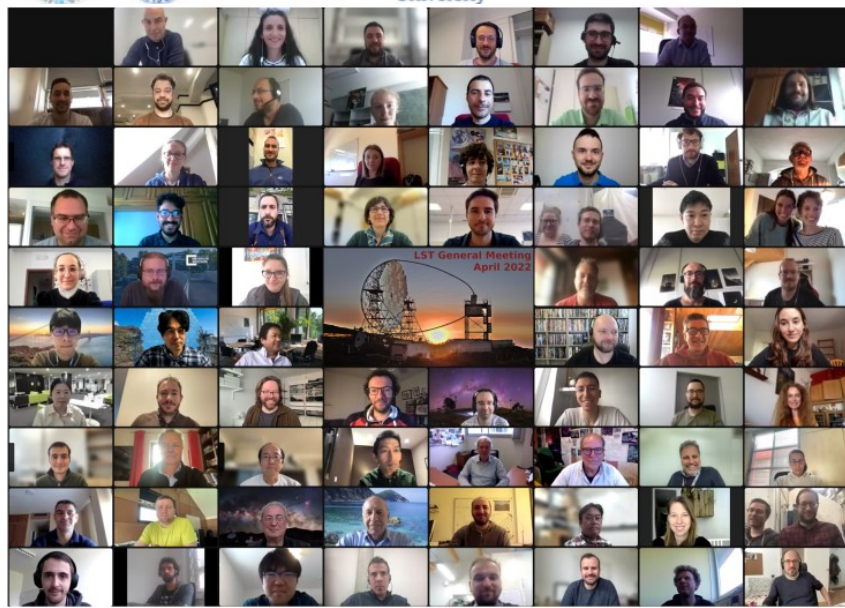
Performance of CTAO North

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



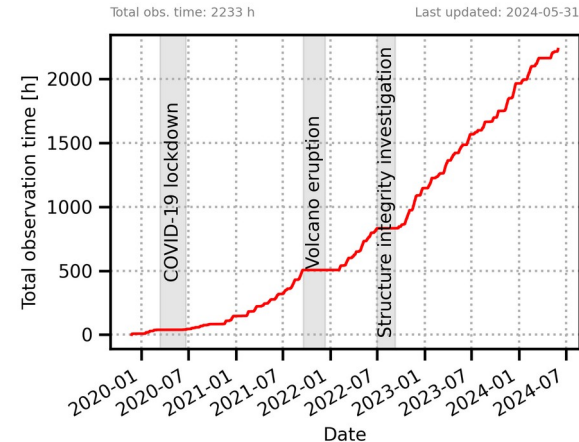
The LST Collaboration

CTAO



Status of the project

- LST-1 first telescope at CTAO-North site:
 - ~2200+ h taken since Jan 2020
 - Current data-taking efficiency >90% in dark time, almost at 95% requirement
- LST-2, LST-3, LST-4: under construction;
- LST South: partially funded through PNRR (*EU funded Italian Resilience and Recovery Plan*);



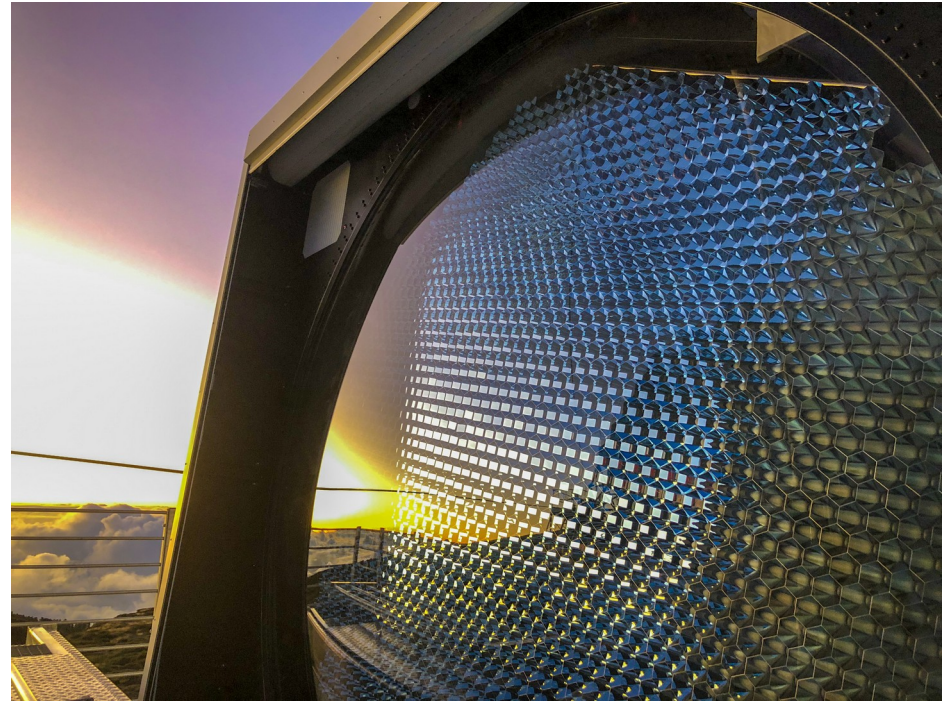
The Large-Sized Telescope

- Structure
 - Alt-Az mount on circular rail
 - Carbon fiber / steel structure
 - Total moving weight ~ 120 tons
 - Repositioning speed: 10 deg/s
 - Re-pointing any sky direction < 20 s
- Optics
 - Parabolic mirror: ~ 400 m² and \varnothing 23 m

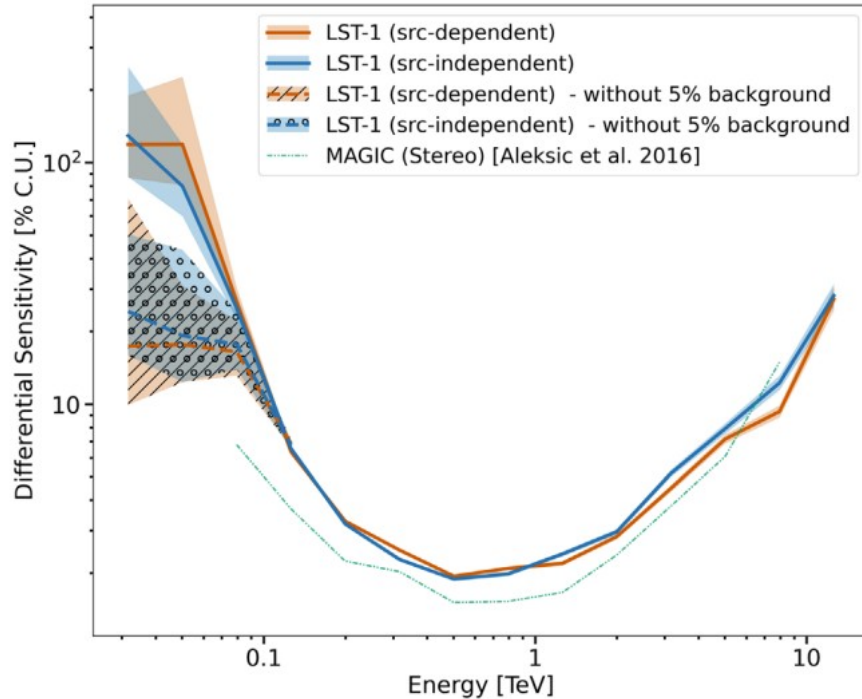


The Large-Sized Telescope

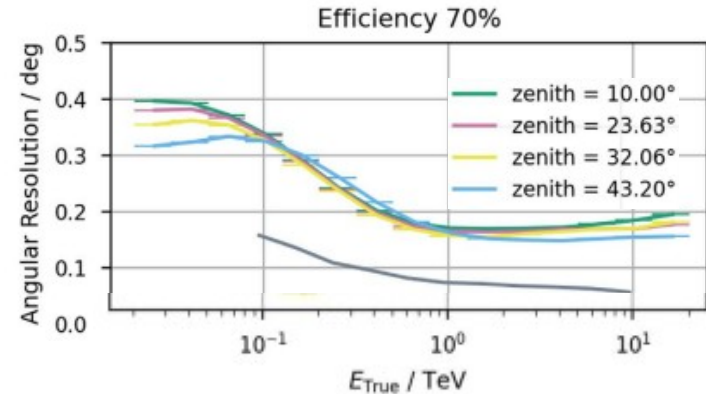
- Camera
 - Number of pixels: 1855 PMTs
 - Field of View: $\sim 4.5^\circ$
 - Pixel size: 0.1°
 - Sampling rate: 1 GHz
- Energy range > 20 GeV
- Overlap with satellites but with collection area $> 10^4$ times larger



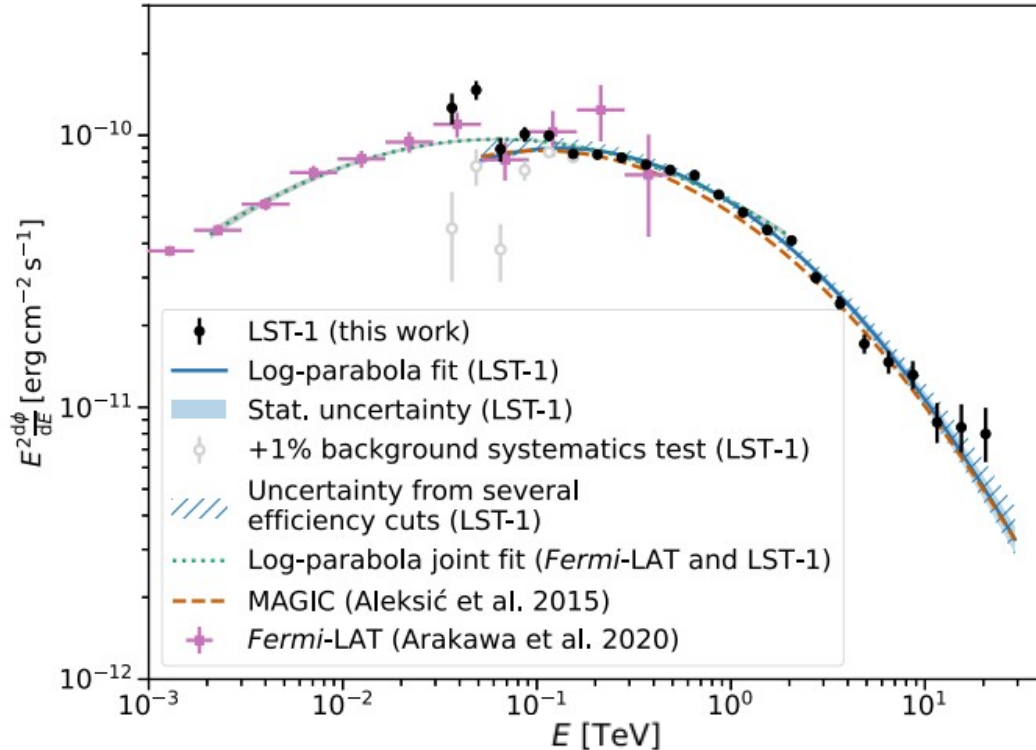
LST-1 performance



- [Performance paper: Abe H., et al., ApJ 956:80 \(2023\)](#)
 - Estimated from Crab Nebula observations
- Energy threshold, aiming at ~ 30 GeV
 - Key to be less affected by EBL and opening to a horizon up to $z \lesssim 2$
- Sensitivity at design target (mono)



LST-1: Crab Nebula SED



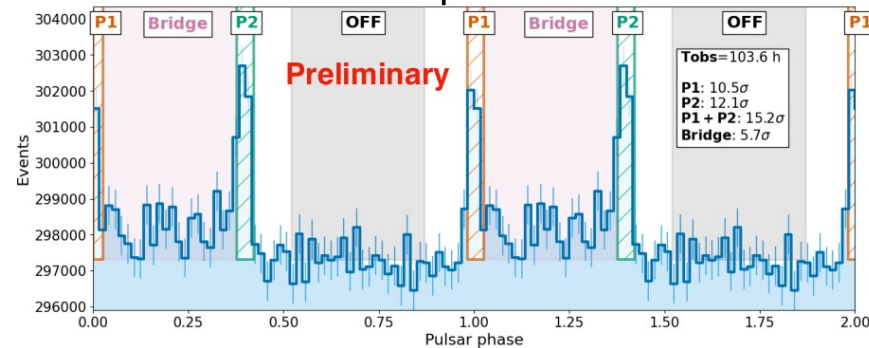
- E dependent analysis cuts, 70% γ -ray efficiency: either for gammaness cut and for θ^2 cut.
- Error bars are only statistical
- Large systematics at low E due to background normalization estimation
- Consistent with MAGIC and nicely connecting to *Fermi*-LAT SEDs
- Lowest data point at 30 GeV

First scientific results of LST-1

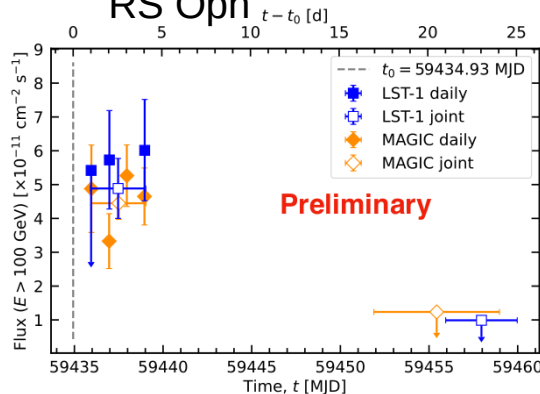
LST-1 is still in commissioning, but already:

- Crab Nebula and Pulsar
- RS Ophiuchi
- LHAASO J2108+515 (Abe, S., et al., A&A, 673, A75 (2023))
- BL Lac flare 2021
- Perseus Cluster, Mrk421, Mrk 501, 1ES1959+650, PG1553+113, etc.
- **Discovery of OP 313!**

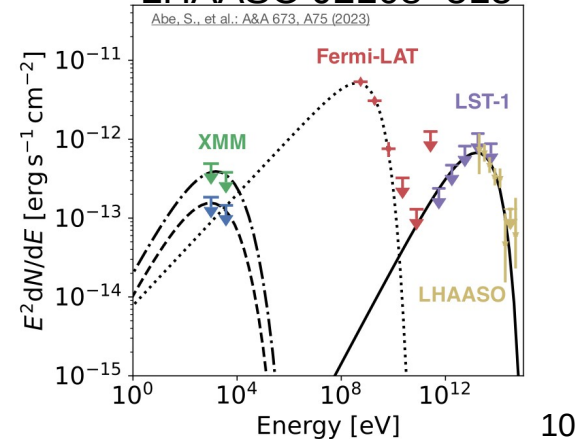
Crab pulsar



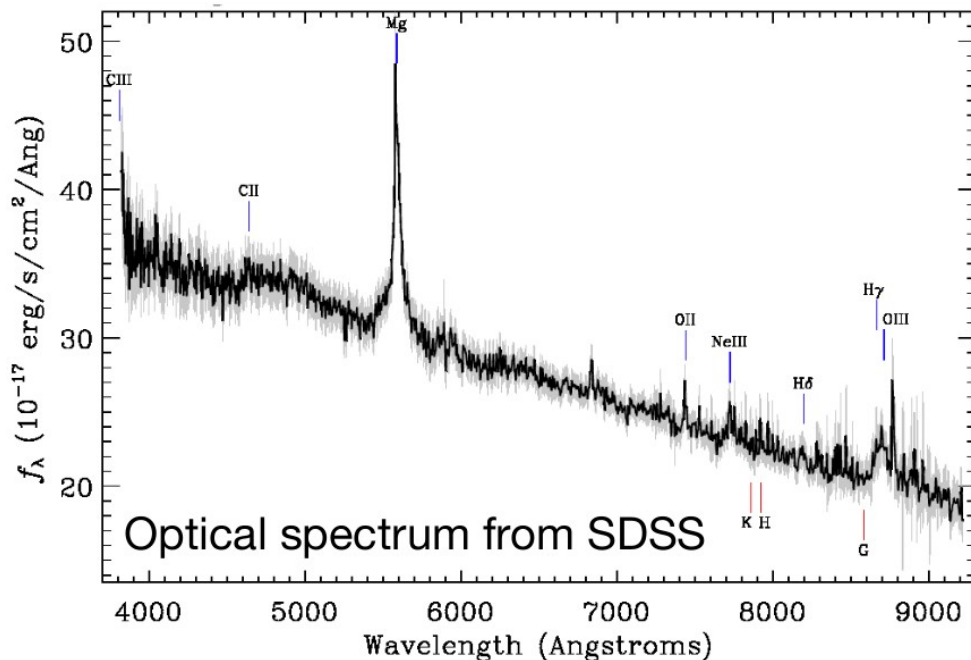
RS Oph



LHAASO J2108+515



The distant FSRQ OP313



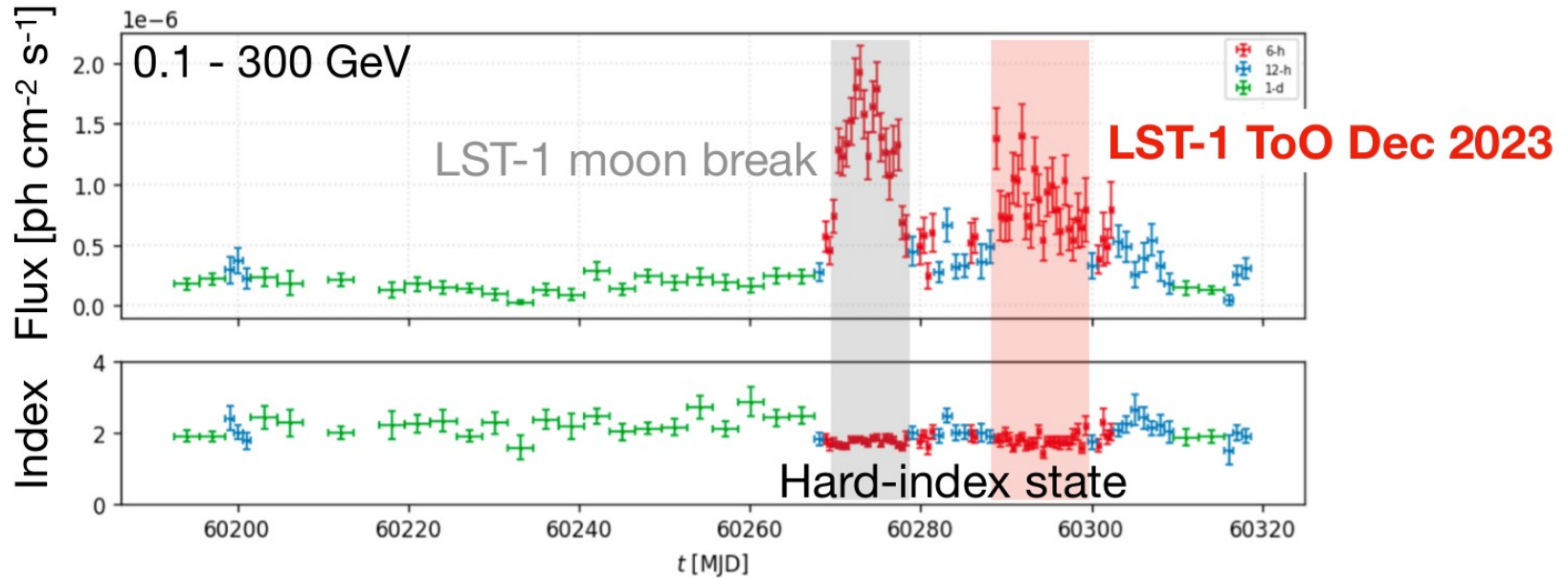
■ Flat-Spectrum Radio Quasar (FSRQ)

- among the most powerful sources in the Universe
- emitting in all bands of the electromagnetic spectrum
- strong flux variability
- Few detected at VHE so far (9)
- Possible internal absorption

■ OP 313

- Was never detected at VHE before
- $Z = 0.9973$, strong attenuation at $E > 100$ GeV due to EBL

Fermi-LAT monitoring



- Flaring episodes since November 2023 (LST-1 was in moon break)
- LST-1 ToO observations started on December 9th, 2023

LST-1 observations (Dec 2023)

- ToO triggered by the high flux state in Fermi-LAT
- From 9th to 18th December 2023
- Total effective time 14.6 h
- Zenith angles > 30deg
- Energy threshold ≈ 40 GeV (from MC weighted with an OP313-like spectrum, 30-50 deg zenith angle)



- Detected with $> 5 \sigma$ (Li&Ma) after stacking data up to Dec 14th, 2023 (about 6 hours of data)
- ATel issued by LST-1 (#16381): 10th FSRQ detected in VHE gamma rays, furthest blazar at VHE, 2nd furthest VHE gamma ray source!

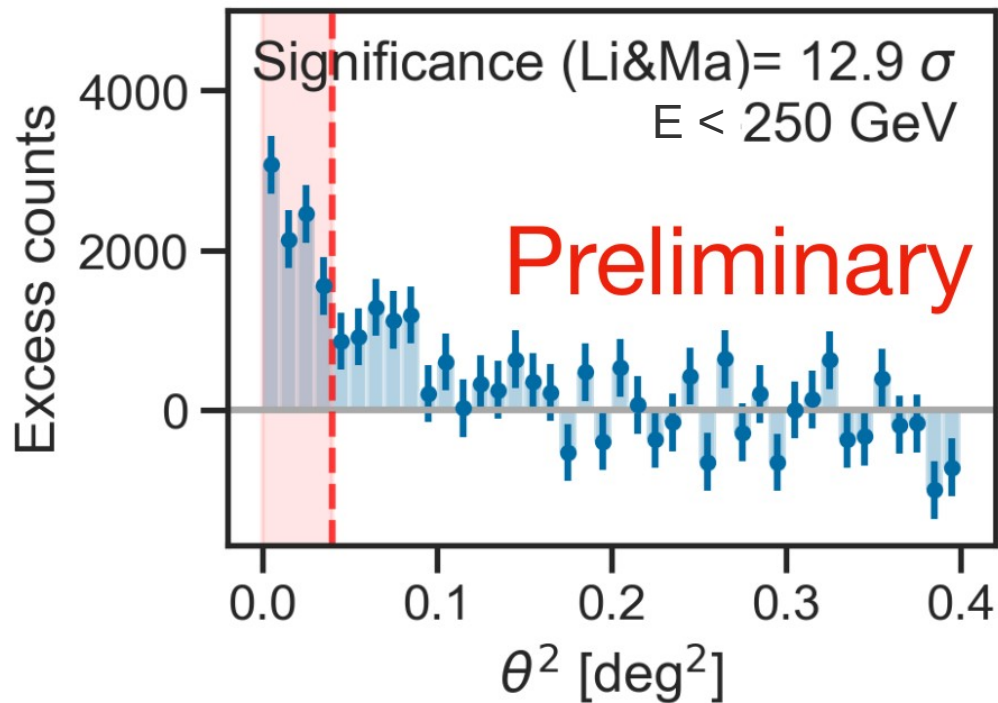
First detection of VHE gamma-ray emission from FSRQ OP 313 with LST-1

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)

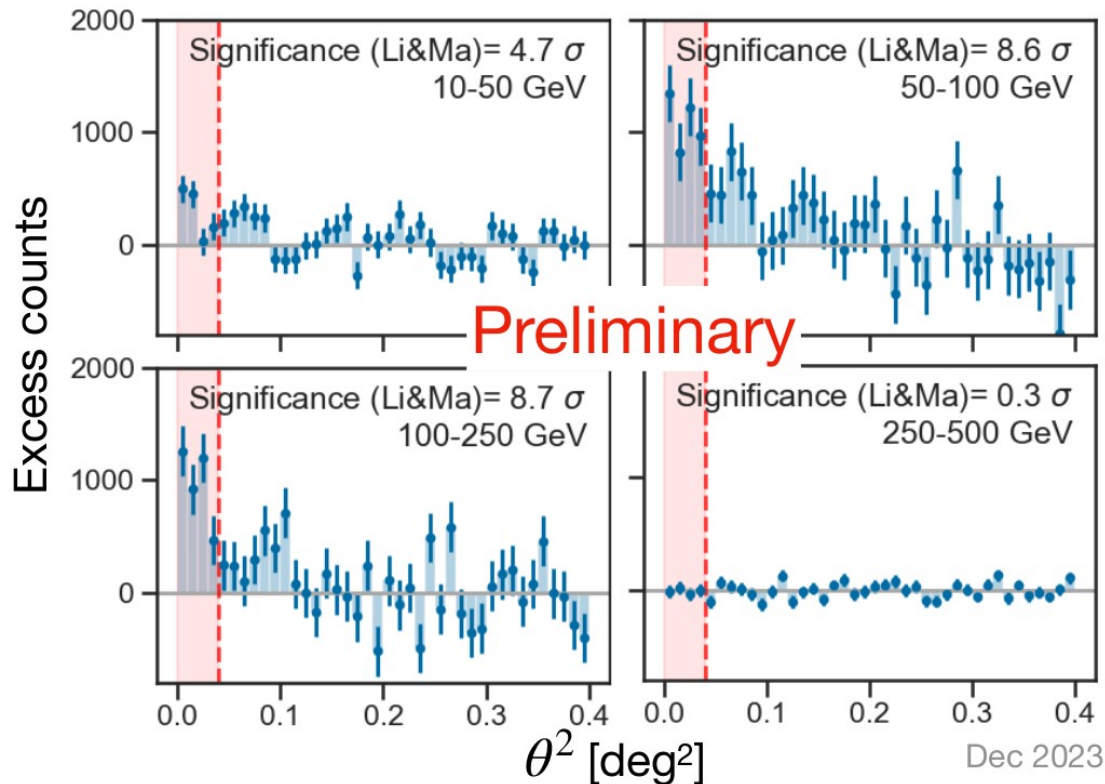
Subjects: Gamma Ray, $> \text{GeV}$, TeV, VHE, Request for Observations, AGN, Blazar,
Quasar

The detection of OP313

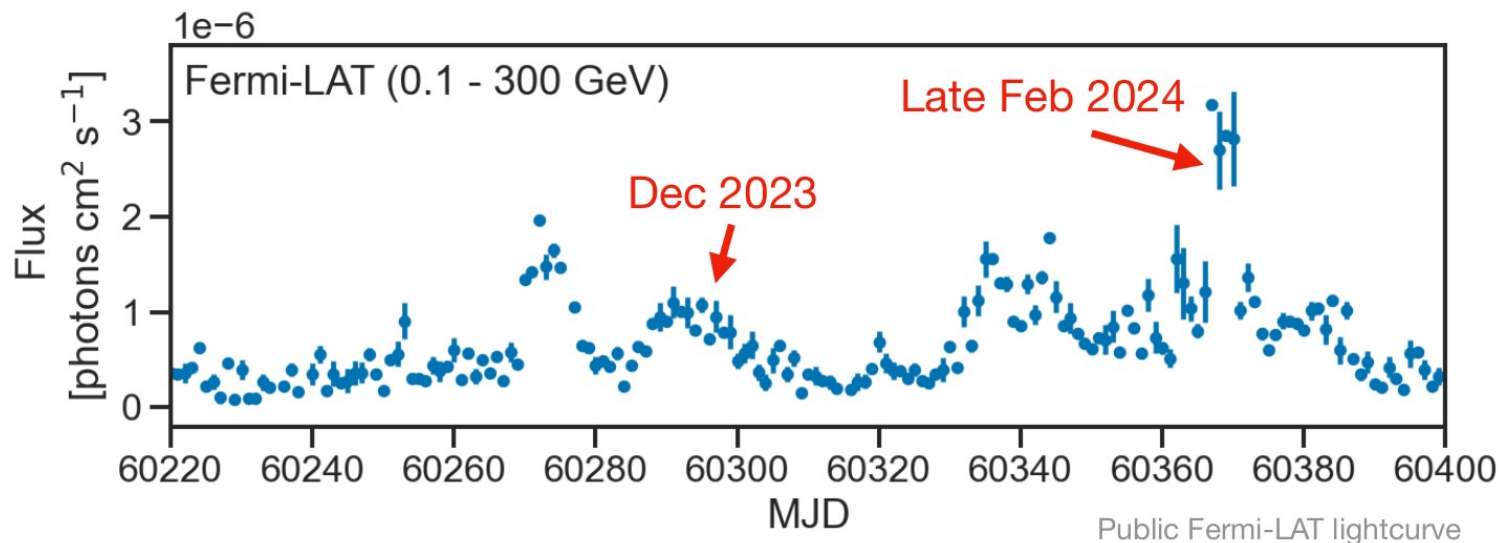


- Stacking all December 2023 data (14.6 h), significance (Li&Ma) $\approx 13 \sigma$ below 250 GeV

The detection of OP313



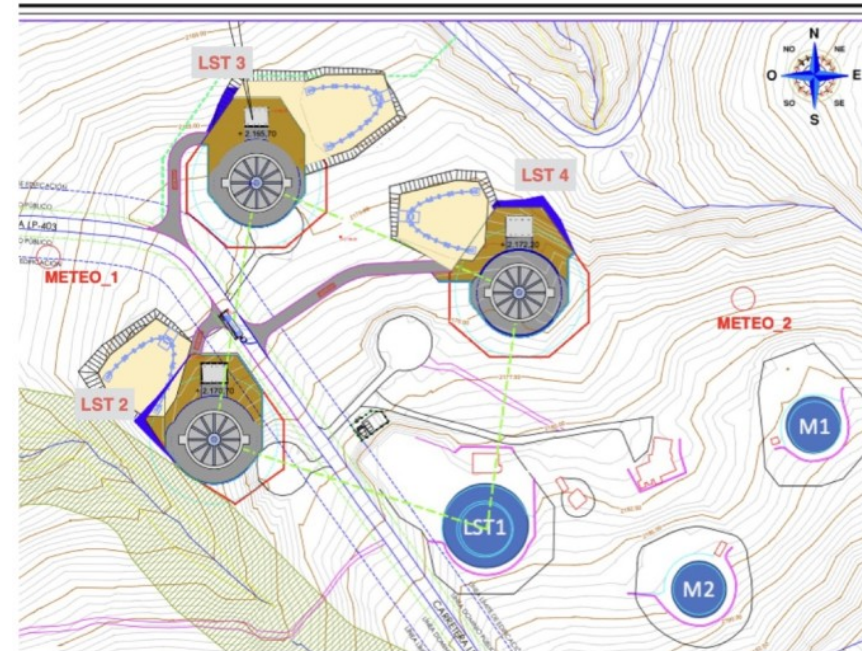
- VHE gamma-ray excess detected below ~ 250 GeV
- No detection at higher energies
- Average VHE flux (>100 GeV) ~ 0.28 C.U. in December 2023



- The source has been very active also after December!
- SED modeling ongoing: combined Fermi-LAT, LST-1, MAGIC
- Multiwavelength campaign
- EBL constraints

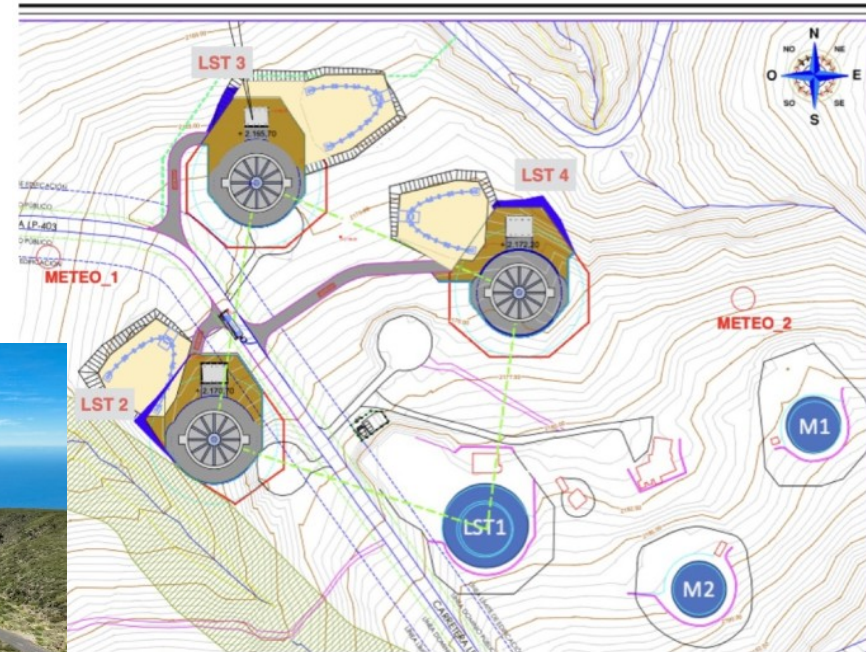
Status of LST North

- All components have been manufactured and stored, ready for installation
- Construction is progressing fast!



Status of LST North

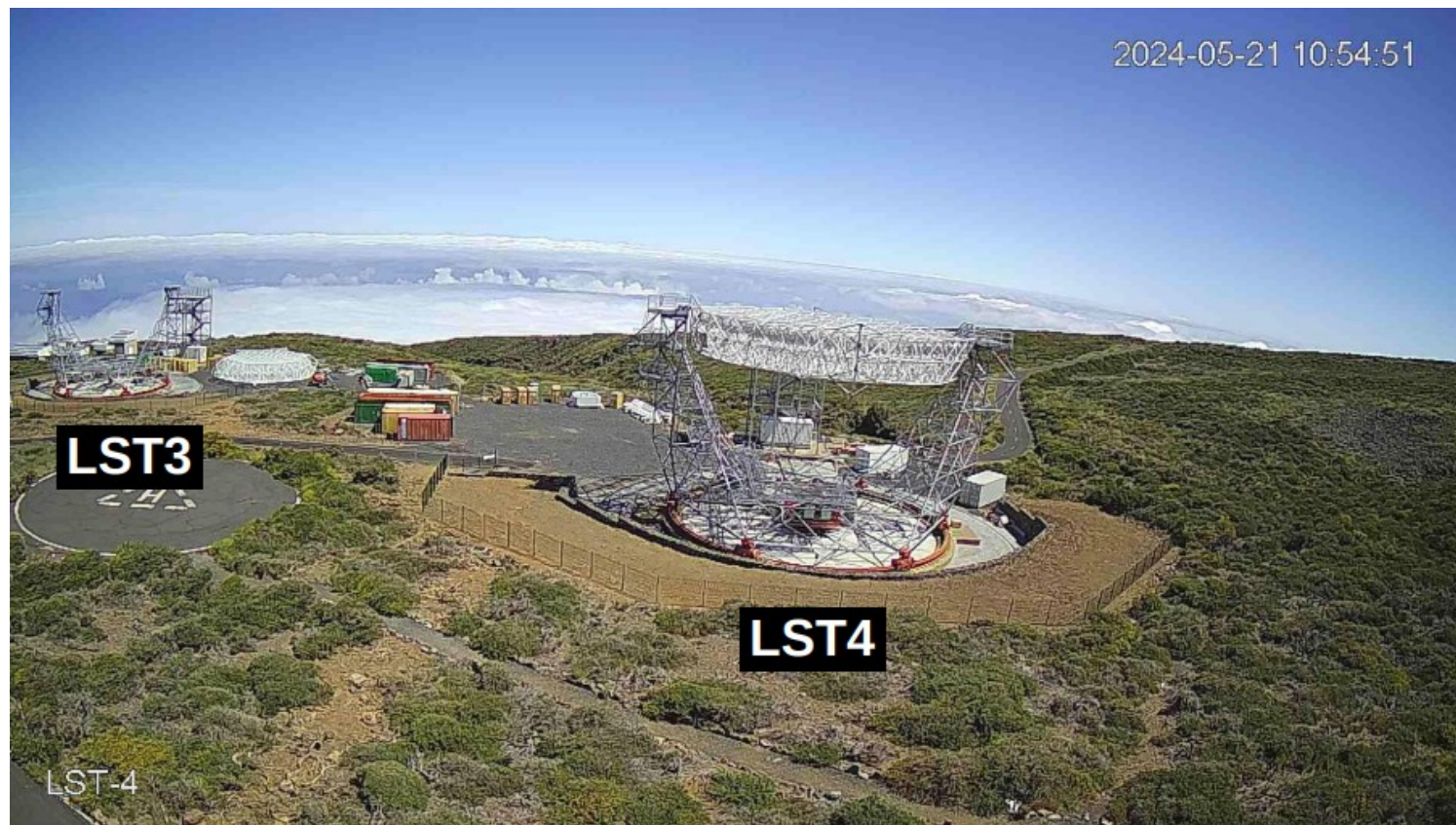
- All components have been manufactured and stored, ready for installation
- Construction is progressing fast!



LST-3 and LST-4: Nov 2023



LST-3 and LST-4: May 2024



LST-2: Nov 2023 and May 2024



LST2-4 ongoing works



- LST-4 dish installation: May 2024
- LST-4 Arch and Camera Support Structure: summer 2024
- Then optics,..., and the other 2 telescopes in parallel
- **End of installation in 2025: LST4 April, LST3 August, LST2 November**

- LST-1 is working well
- Several scientific results already during the commissioning
- Discovery of the distant FSRQ OP313!
 - 10th FSRQ detected at VHE
 - The furthest VHE blazar ($z = 0.997$)

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

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on 15 Dec 2023; 14:31 UT

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

Conclusions

- LST-1 is working well
- Several scientific results already during the commissioning
- Discovery of the distant FSRQ OP313!
 - 10th FSRQ detected at VHE
 - The furthest VHE blazar ($z = 0.997$)
- LST 2-4 construction proceeds very quickly

Thanks for your attention!

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

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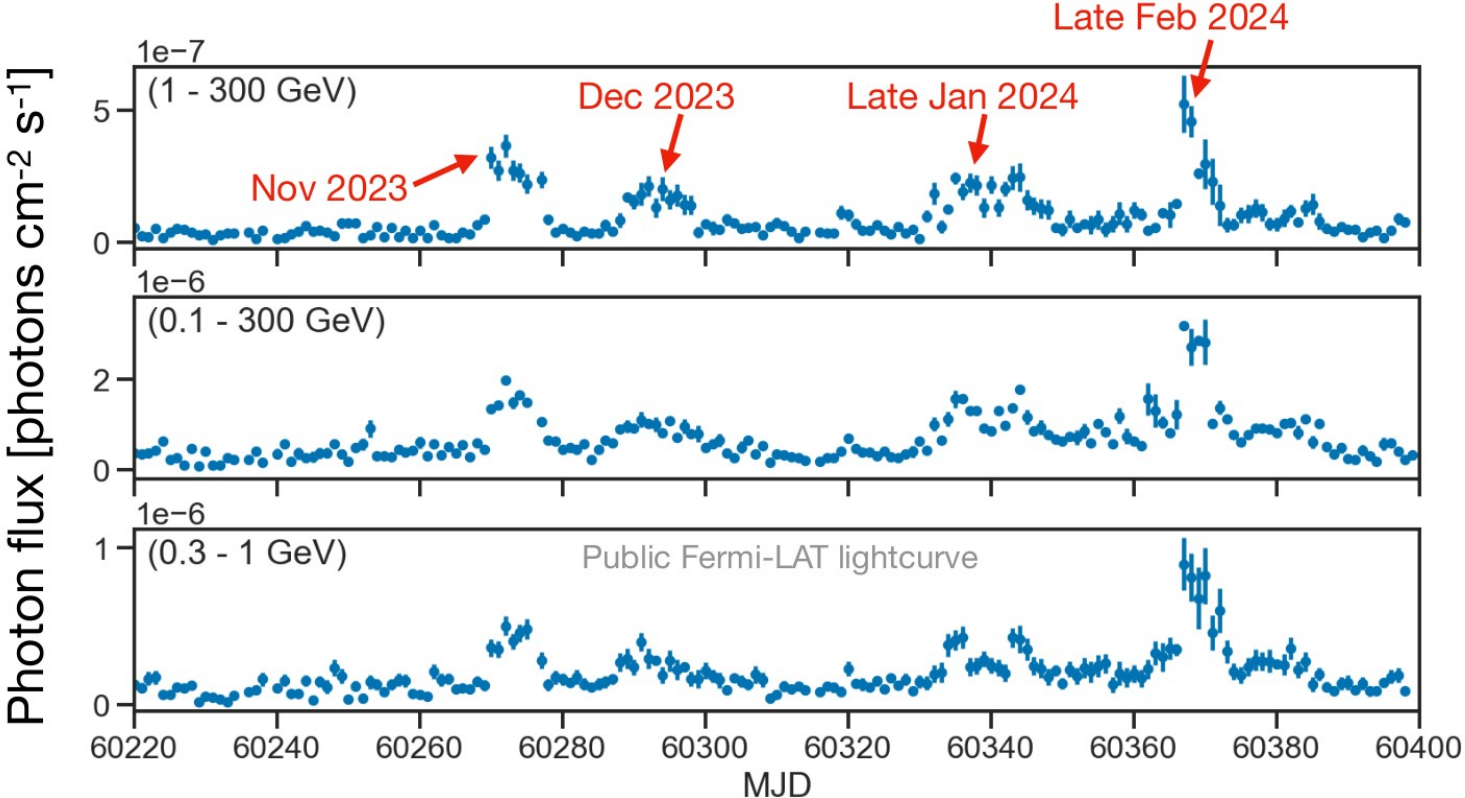
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Some time pretty soon...

BACKUP

Fermi-LAT ongoing monitoring



LST-1 Performance

