



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



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The CTA Observatory







- CTA will consist of 2 arrays
 Three telescope types
 - Northern, La Palma Spain
 - Southern, Paranal Chile
- 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





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
 - $^{\text{-}}$ Total moving weight ${\sim}120$ tons
 - Repositioning speed: 10 deg/s
 - Re-pointing any sky direction <20 s
- Optics
- $^{\text{-}}$ Parabolic mirror: ~400 m² and Ø 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 > 10⁴ 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 ≤ 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 θ² 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!





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)

CTAO

- 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)



First VHE detection of OP313



- Detected with > 5 σ (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, >GeV, TeV, VHE, Request for Observations, AGN, Blazar, Quasar

The detection of OP313





 Stacking all December 2023 data (14.6 h), significance (Li&Ma) ~ 13 σ 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

OP313: ongoing analyses





- 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!





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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



LST2-4 schedule



				2rd Quarter	Ath Quarter	2024	and Out	arter	and Quan	tor	Ath Ounts	20	25 Outerter	204	Quarter	200	uarter	Ath Quarter	2026	2nd C
				Jul Aug Sep	Oct Nov Dec	Jan Feb Mar	Apr Ma	av Jun	Jul Aug	Sep	Oct Nov	Dec Ja	Feb Ma	r Apr	May Jun	Jul		Oct Nov De	Jan Feb Ma	ar Apr
All permits granted	0 days	Tue 18/10/22	Tue 18/10/22	For Fridg Sep			1.4.								11101					
Civil works start	0 days	Mon 24/10/22	Mon 24/10/22														C		Nork	S
Civil works finish	0 days	Wed 31/01/24	Wed 31/01/24			* 31/01											-			
LST4 construction starts	0 days	Mon 11/09/23	Mon 11/09/23	(1 4)	1/09															
LST4 dish and structure united	0 days	Fri 03/05/24	Fri 03/05/24				*	03/05											ICT	
LST4 CSS installed	0 days	Fri 30/08/24	Fri 30/08/24					1.1	1	30/	/08								LJI	4
LST4 mirrors installed	0 days	Tue 17/12/24	Tue 17/12/24									17	/12							
LST4 camera installed	0 days	Fri 28/02/25	Fri 28/02/25										p 4	28/02						
LST4 construction completed	0 days	Tue 25/03/25	Tue 25/03/25										0	25.	/03					
LST4 ready for acceptance	0 days	Tue 28/10/25	Tue 28/10/25															♦ 28/10		
LST3 construction starts	0 days	Mon 09/10/23	Mon 09/10/23		09/10															
LST3 dish and structure united	0 days	Fri 05/07/24	Fri 05/07/24					1	• 05/07						•• 09/05				ICT	T 3
LST3 CSS installed	0 days	Fri 11/10/24	Fri 11/10/24							ſ	• 11/10	þ							LJI	
LST3 mirrors installed	0 days	Fri 09/05/25	Fri 09/05/25													5				
LST3 camera installed	0 days	Wed 30/07/25	Wed 30/07/25													10	30/07			
LST3 construction completed	0 days	Fri 22/08/25	Fri 22/08/25														1 22	/08		
LST3 ready for acceptance	0 days	Fri 27/03/26	Fri 27/03/26																	27/
LST2 construction starts	0 days	Mon 06/11/23	Mon 06/11/23		M 06/11															-
LST2 dish and structure united	0 days	Fri 02/08/24	Fri 02/08/24						M 0.	2/08									IST	2
LST2 CSS installed	0 days	Fri 18/04/25	Fri 18/04/25									6		18/04				LUI	~	
LST2 mirrors installed	0 days	Fri 15/08/25	Fri 15/08/25													1	• 15/	08		
LST2 camera installed	0 days	Wed 05/11/25	Wed 05/11/25														• 05/1	1		
LST2 construction completed	0 days	Fri 28/11/25	Fri 28/11/25															→ 2	28/11	
LST2 ready for acceptance	0 days	Fri 03/07/26	Fri 03/07/26																	

Then optics,..., and the other 2 telescopes in parallel

End of installation in 2025: LST4 April, LST3 August, LST2 November

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)

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- 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!

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Fermi-LAT ongoing monitoring





LST-1 Performance



