

Status of the Large-Sized Telescope project

Juan Cortina (CIEMAT, Madrid)
for the CTA LST project

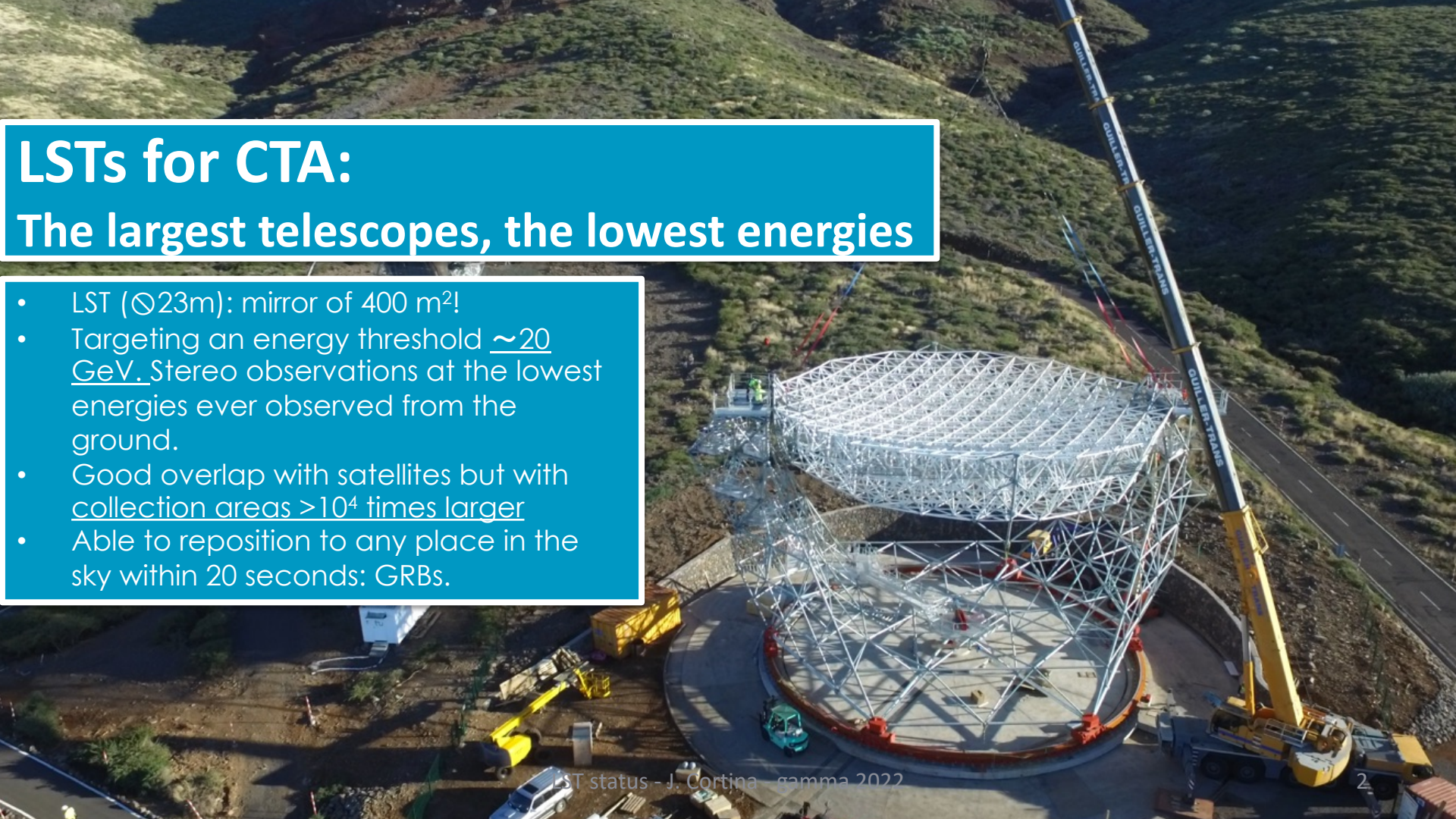


7th Heidelberg International Symposium on
High Energy Gamma-Ray Astronomy
Barcelona, July 4-8 2022

LSTs for CTA:

The largest telescopes, the lowest energies

- LST ($\varnothing 23\text{m}$): mirror of 400 m²!
- Targeting an energy threshold ~ 20 GeV. Stereo observations at the lowest energies ever observed from the ground.
- Good overlap with satellites but with collection areas $>10^4$ times larger
- Able to reposition to any place in the sky within 20 seconds: GRBs.



LST collaboration



A collaboration of ~300 scientists and engineers in charge of building the 4 LSTs in CTA-North and the 4 LSTs in CTA-South

Status of the project



- Construction ahead of CTAO ERIC constitution: funding available <2015.
- LST-1 first telescope at CTA site:
 - Telescope installed in La Palma: 2018



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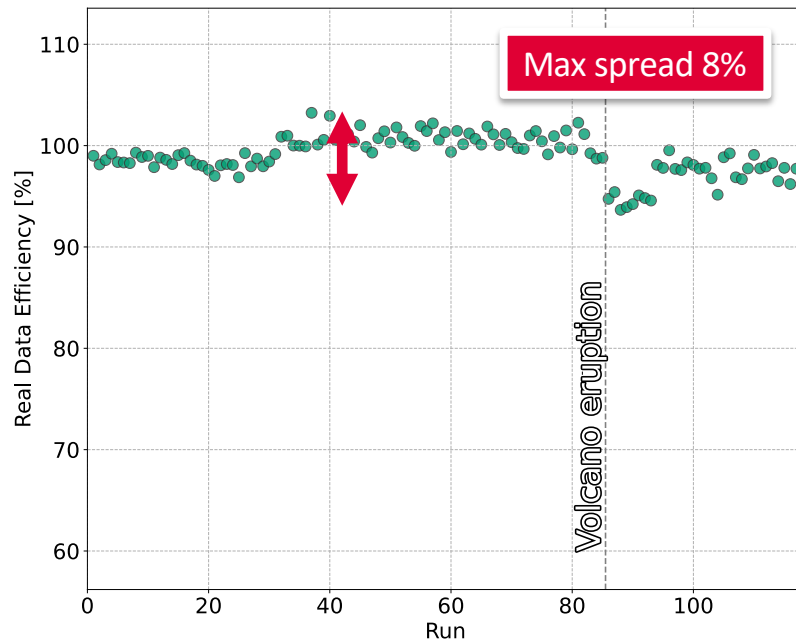


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- LST-1 first telescope at CTA site:
 - Telescope installed in La Palma: 2019
 - Under commissioning: covid-19, component crisis, volcano, inflation...
 - ~800h taken since Jan 2020
 - Data taking efficiency 70% in dark time, not reaching 95% yet mainly due to incomplete control software.
- LST-2 to LST-4: under production, starting installation in La Palma these days.
- LST-south: partly funded.



LST-1 performance: optical efficiency

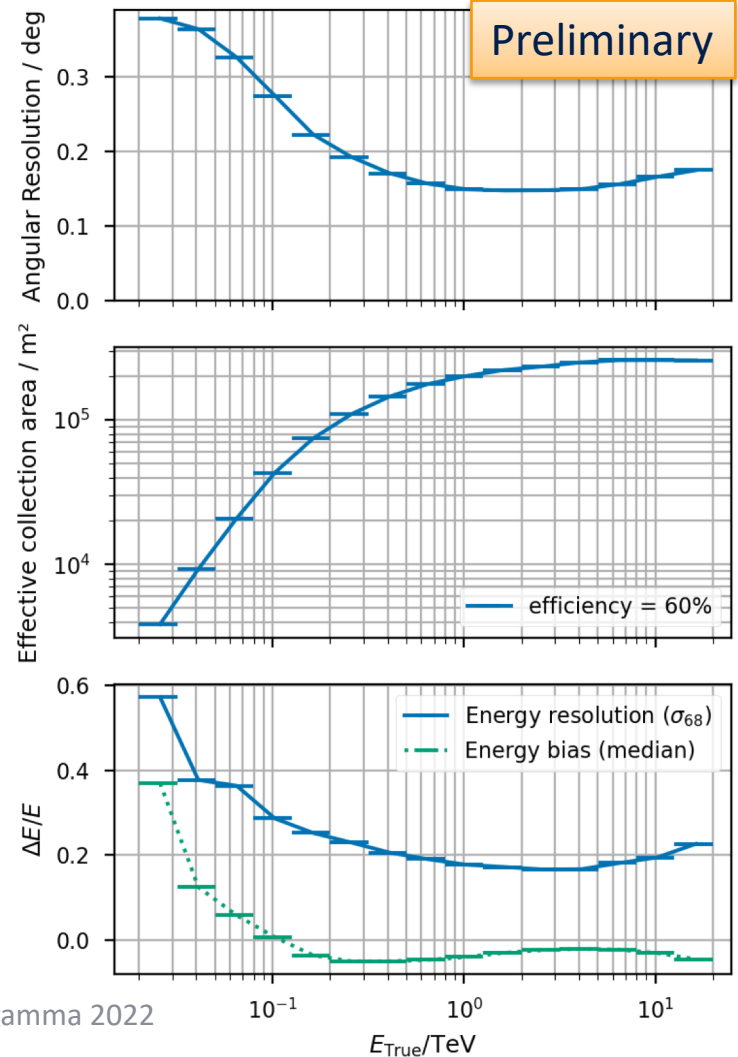
- “Optical efficiency” takes both mirror reflectivity and mirror focusing into account.
- Stable from November 2020 to March 2022: max 8% but much of the variation is due to measurement uncertainty and episodes of dust deposition.
- No long-term effect of volcano: rain cleaned mirrors of volcanic ash.



To be published
in performance
paper soon

LST-1 performance: effective area, angular+spectral resolution

- Zenith angle= 10deg, γ -ray efficiency = 60% (due to gammaness cut)
- LST-1 is a single telescope so one cannot expect a great angular or spectral resolution. Still they are competitive down to 100 GeV.
- Effective area $>10^3$ m² down to ~ 20 GeV.

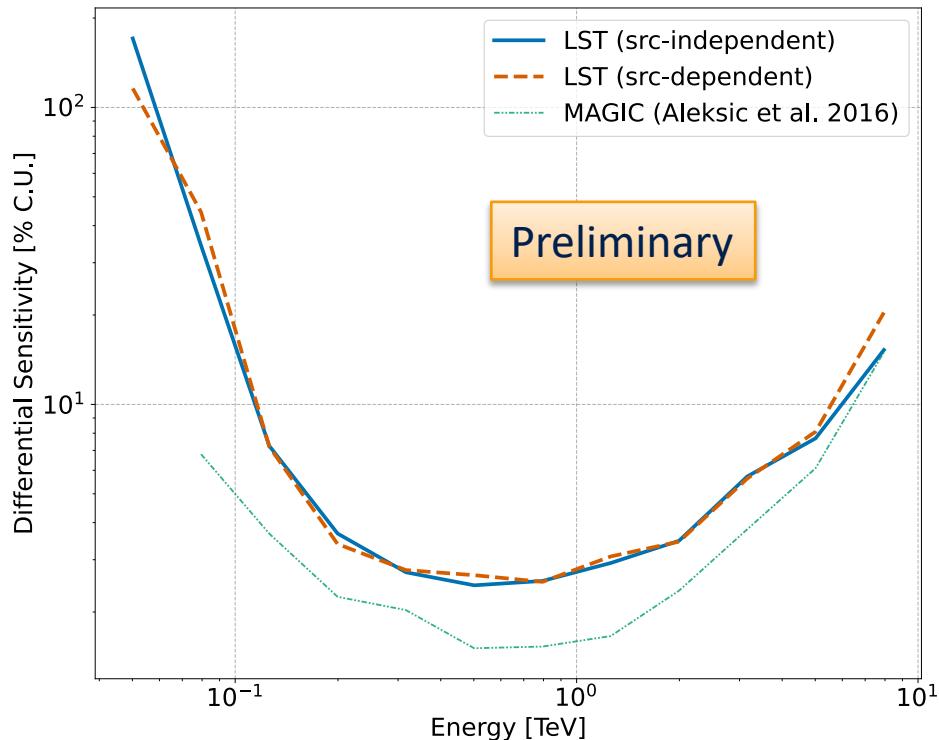


To be published in performance paper soon

LST-1 performance: sensitivity



To be published in performance paper soon

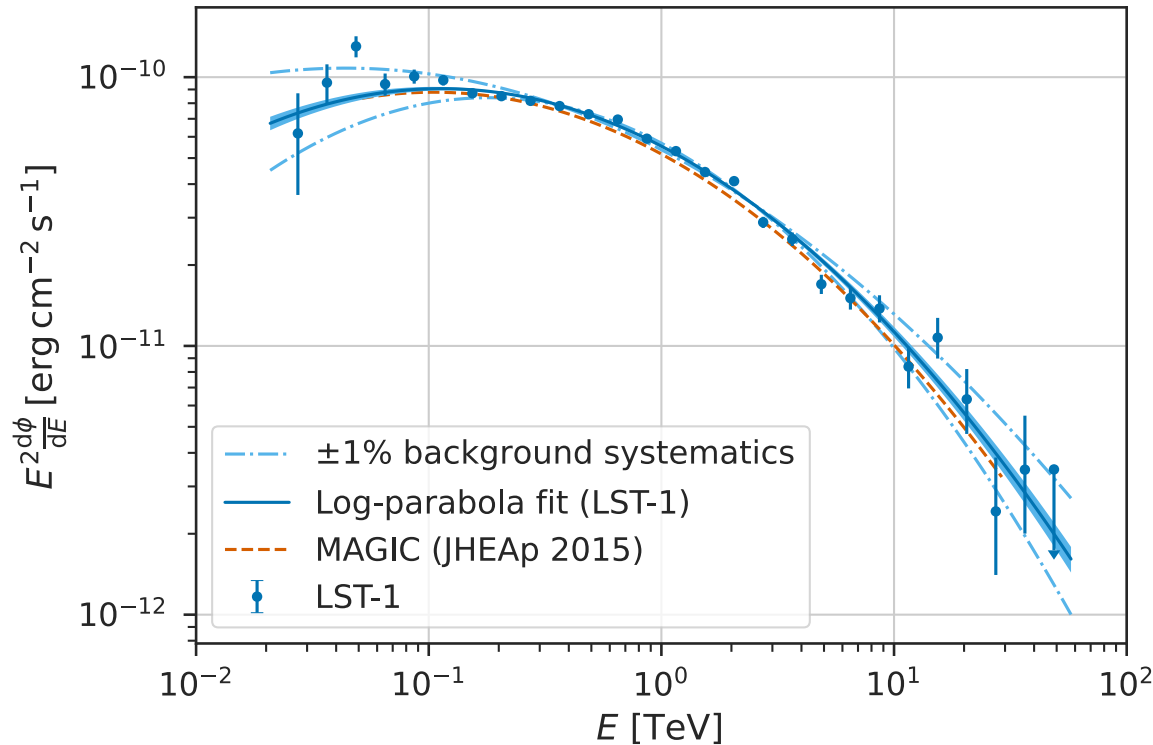


- Consistent sensitivity for source-dependent and source-independent analyses.
- Roughly 1.5x worse sensitivity than MAGIC stereo array.
- But down to ~50 GeV.

Performance: Crab Nebula spectrum



To be published in performance paper soon



- 34 h effective time, γ -ray efficiency: 70% from gammaness cut and 70% from θ^2 cut
- Error bars are only statistical.
- Systematics: blue lines correspond to effect of $\pm 1\%$ background.
- Consistent with MAGIC and Fermi-LAT.
- Lowest data point at 25 GeV!

LST-1 ready for science



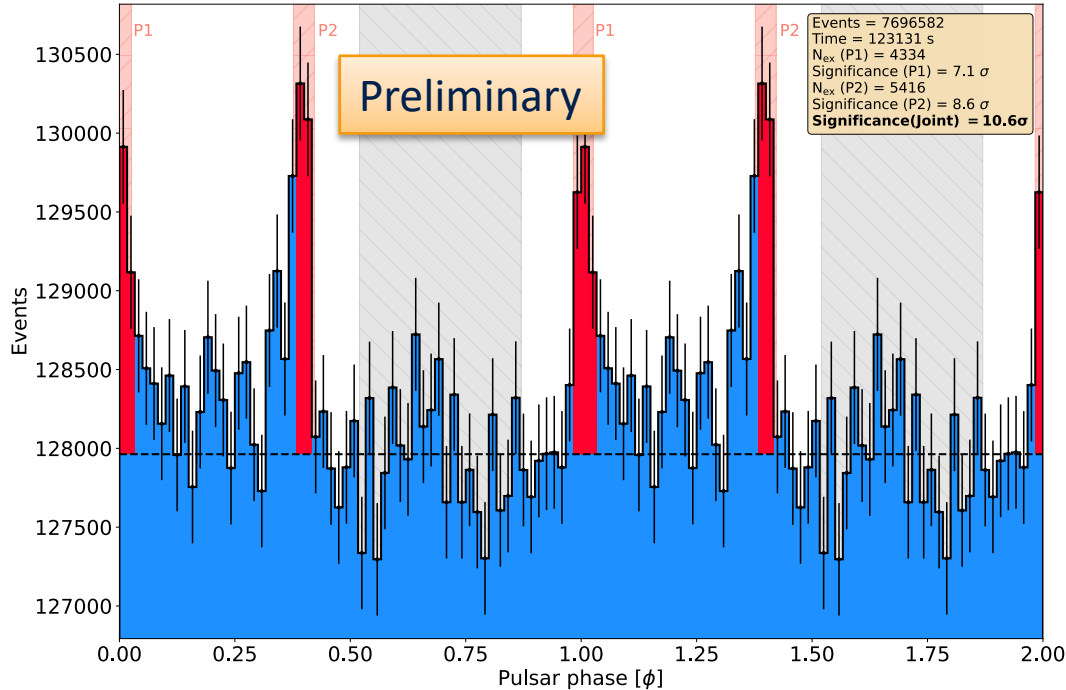
- We are about to publish a performance paper. We are confident we understand our instrument.
- We are planning for a set of papers with the data of the last year. A preview follows.



Crab pulsar phaseogram



To be published in performance paper soon



- Observation time: 34.2 hours
- Nov 2020 - March 2022
Data selection: cut in rate + no technical issues (more strict than previous analyses).
- Highly significant detection down to few tens of GeV.
- Low energies: P1/P2 tends to 1.
- Stay tuned for spectrum down to few tens of GeV...

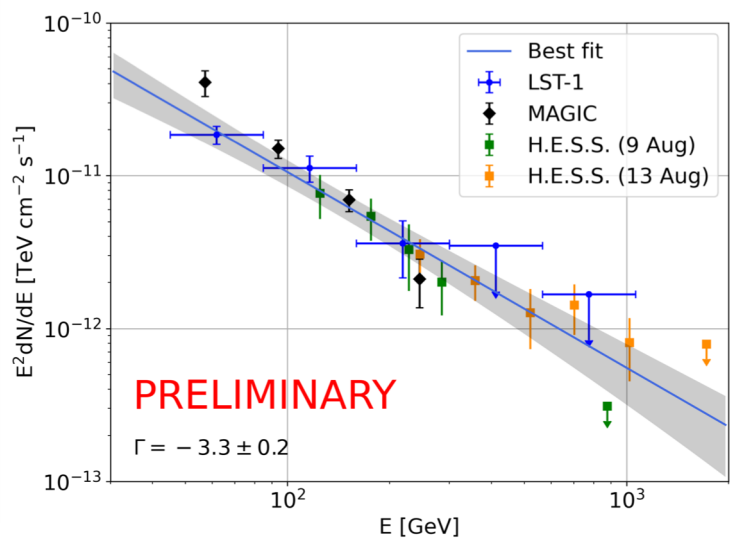
First VHE-detected nova: RS Ophiuci

A. Aguasca-Cabot, talk in this conference

Working on paper



Credit: David A.Hardy/ www.astroart.org & PPARC.



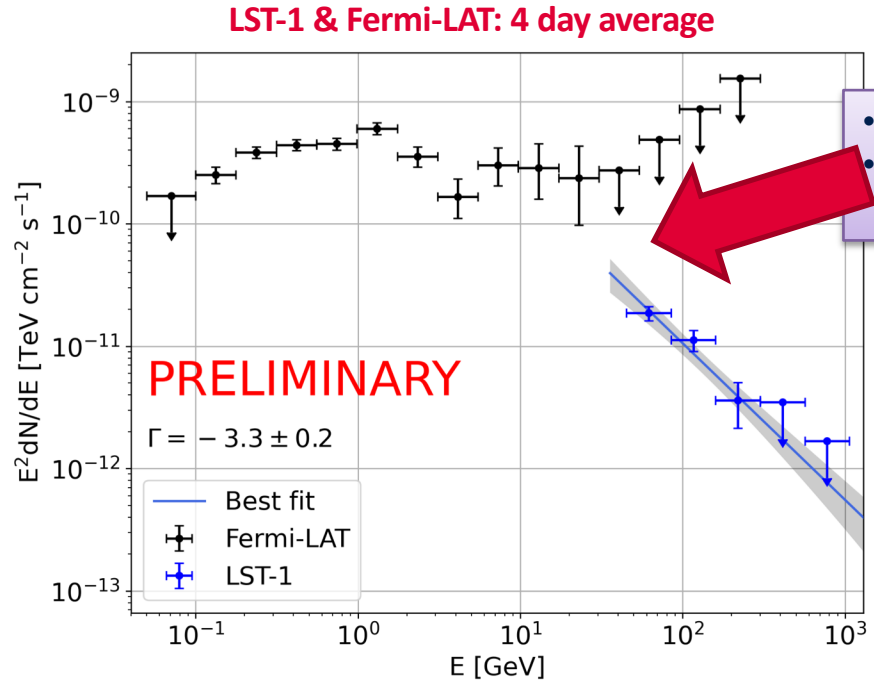
- LST-1, 4-day average
- MAGIC, 4-day joint data (Acciari 2022)
- H.E.S.S. August 9+13 SEDs (H.E.S.S. coll 2022)

Consistent spectra

First VHE-detected nova: RS Ophiuci

A. Aguasca-Cabot, talk in this conference

Working on paper



- No gap between Fermi and LST.
- Compare error bars for a few hours with LST1 and 4 days of Fermi.

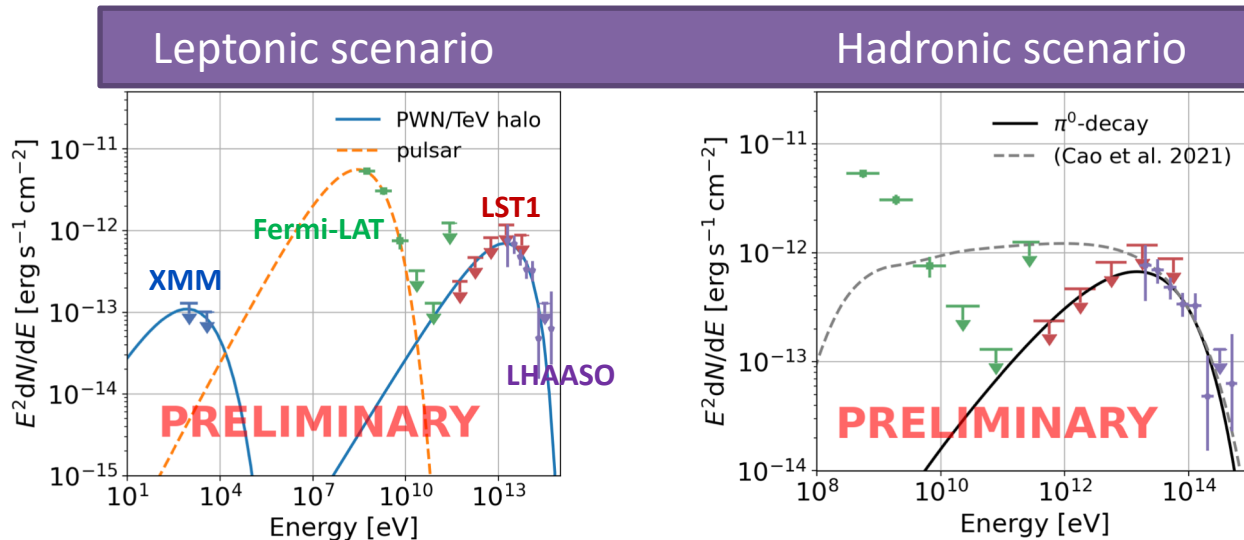
LHAASO J2108+5157



J.Juryšek, poster in this conference

Working on paper

- Cao et al. 2021: PeVatron, reported to be point-like (<0.26 deg). No X-ray or VHE counterpart, maybe LAT counterpart.
- 91 hour observation, no detection but relevant (point source) upper limits.



BL Lac flare 2021: first ATEL submitted by CTA

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

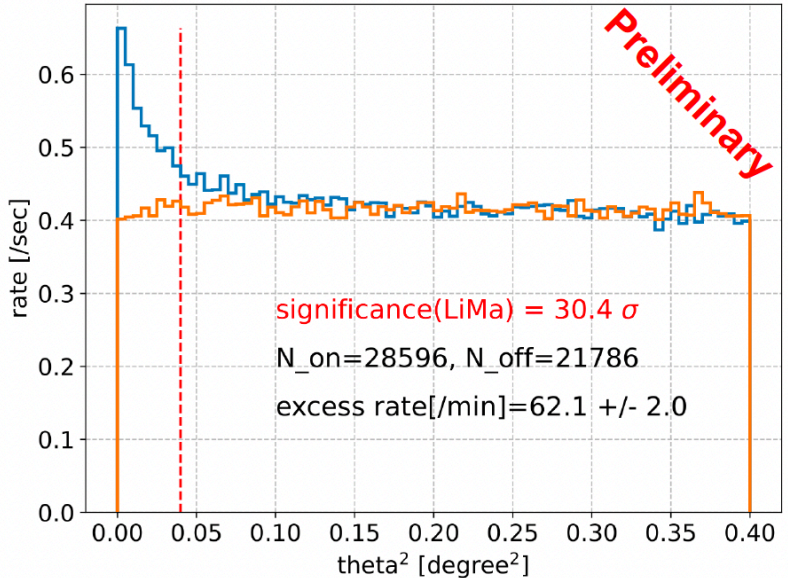
ATel #14783; *Juan Cortina for the CTA LST collaboration*
 on 13 Jul 2021; 21:03 UT
 Credential Certification: *Juan Cortina (Juan.Cortina@ciemat.es)*

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

Referred to by ATel #: 14820, 14826, 14839

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The LST-1 telescope has observed an increase in the very-high-energy (VHE; >100 GeV) gamma-ray flux from BL Lacertae (RA=22:02:43.3, DEC=+42:16:40, J2000.0). The preliminary offline analysis of the LST-1 data taken on 2021/07/11 (MJD 59406), triggered by an increase of the optical flux (see ATEL #14773 and references therein), has been detected with a significance of 8 sigma with a differential flux of $1.3 \pm 0.2 \cdot 10^{-9} \text{ cm}^{-2} \text{ s}^{-1} \text{ TeV}^{-1}$ (25% of the Crab Nebula) at 100 GeV. Note though that this is the result of a quick-look analysis and the data were taken under non-optimal weather conditions (atmospheric transmission at 9km of ~50-60%), hence this flux measurement is a lower bound on the true flux. The LST-1 observations were performed during commissioning which began in the summer of 2020 at the Canary island of La Palma, Spain. The LST-1 is designed to observe gamma rays in the energy range from 20 GeV to 3 TeV. LST-1 observations will continue during the next few nights, multi-wavelength observations are planned. The preliminary offline analysis has been performed by Juan Cortina (juan@ucm.es) and Ruben Lopez-Coto (rlopec@mpg.de). The LST-1 contact persons for these observations are Ruben Lopez-Coto (rlopec@mpg.de) and Juan Cortina (juan.cortina@ciemat.es).

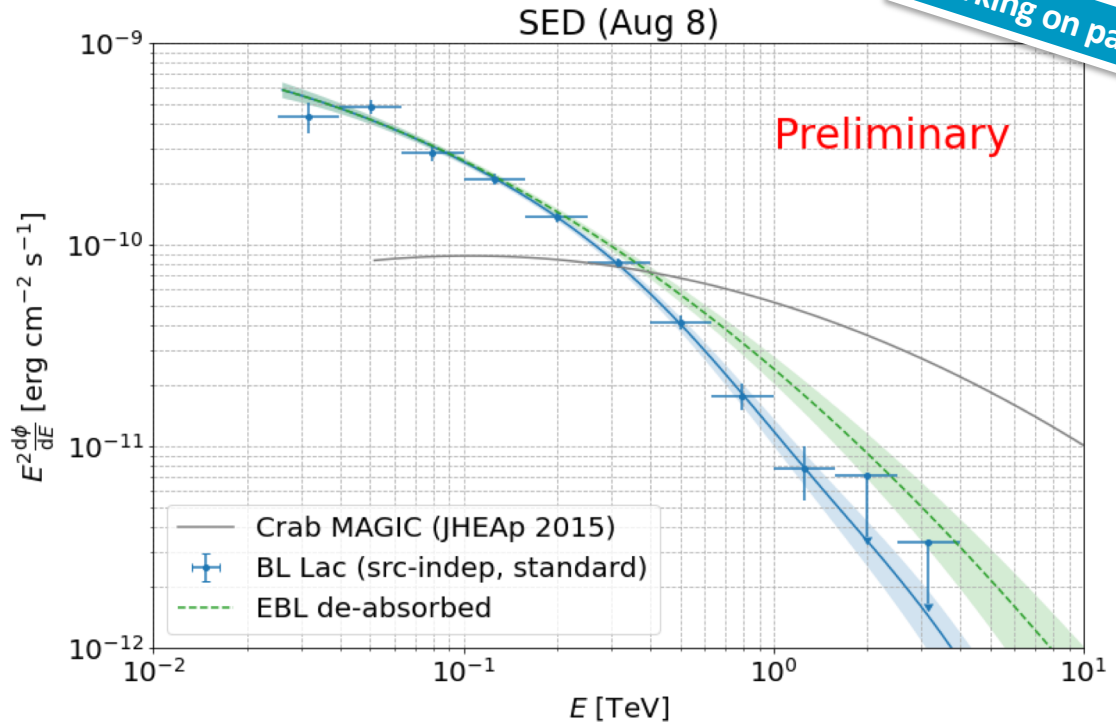


BL Lacertae flare 2021



Working on paper

- IBL at $z=0.069$
- In a high emission state since 2020
- August 8th 2021: High state >1 crab for $E < 300$ GeV.
- Soft spectrum allows to extract spectral point at 30 GeV in <2 hour observation.
- Working on intranight light curve



Transients



GRB #	Zenith angle (deg)	$T_{\text{observation}} - T_0$ (minutes)
1	40	1320
2	45	970
3	51	119
4	59	39
5	56	1072
6	61	1302
7	6	57
8	41	588
9	65	60
10	62	1138
11	49	33

We expect to have automatic & fast repositioning in 2nd half of 2022.

We are also following up: neutrino events, galactic transients, FRBs.

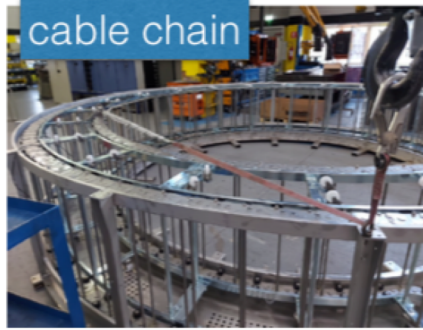
LST north: completing 4 LST subarray



Remaining three LSTs in CTA-North



assembled rail LST4



cable chain



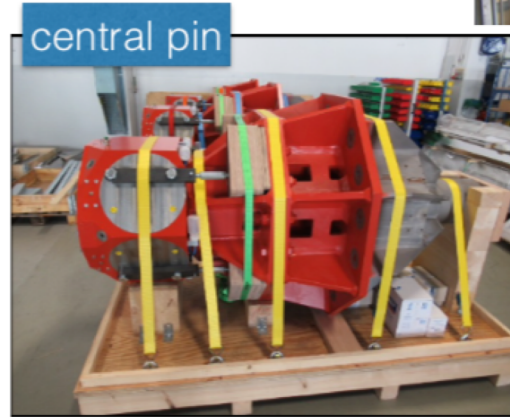
Tubes for understructure



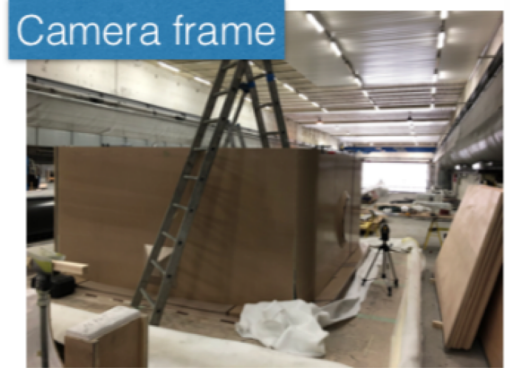
azimuth lock



backplane



central pin



Camera frame

Remaining three LSTs in CTA-North



tensioning cable parts



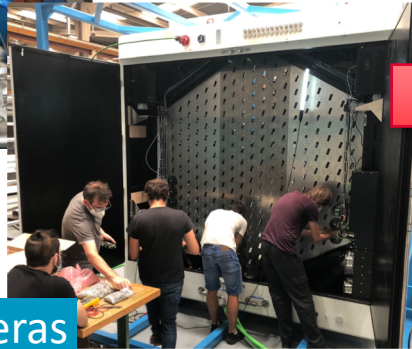
Camera of LST2 arrived on Tuesday to the Canaries for final tests



camera access tower



cameras



camera arch

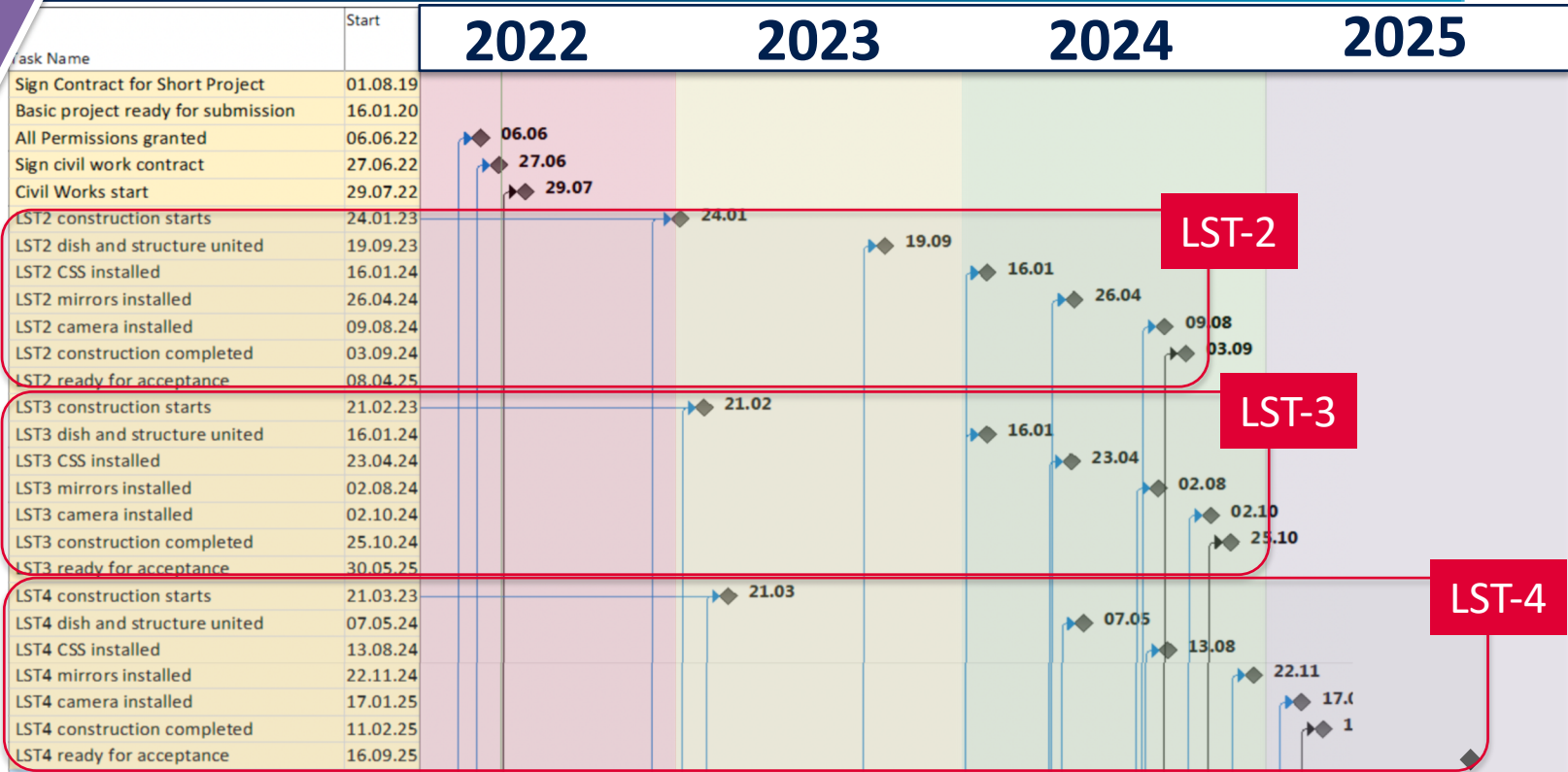


- Essentially all parts manufactured and stored, ready for installation. Most of them already in La Palma. Few parts missing (e.g. mirror actuators).
- Latest news:
 - June 24: Environmental study approved, permit for construction coming soon.
 - About to sign civil works contract.
 - July 5: First of the three new cameras already at the Canaries.

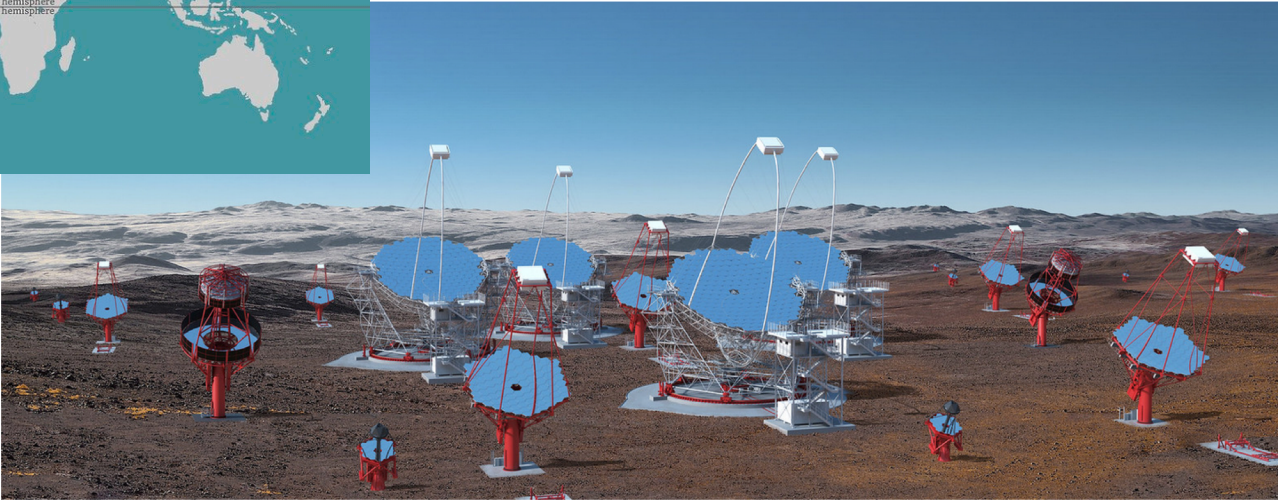
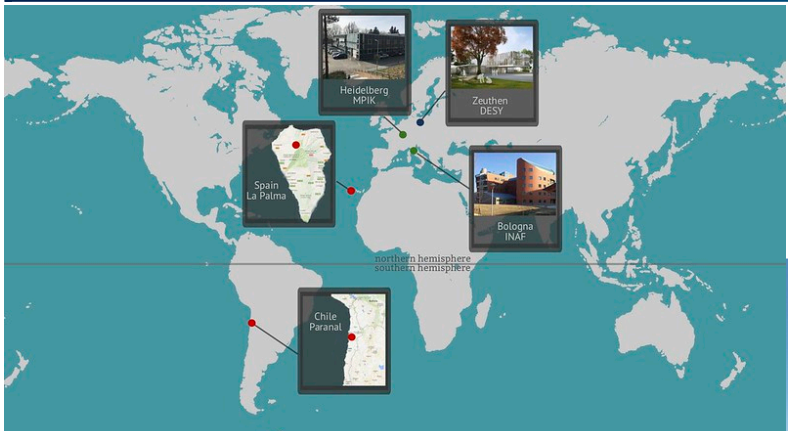


LST north: schedule

+FEW WEEKS DELAY DUE TO CONSTRUCTION PERMIT



LST south



LST south: funding secured for 2 LSTs



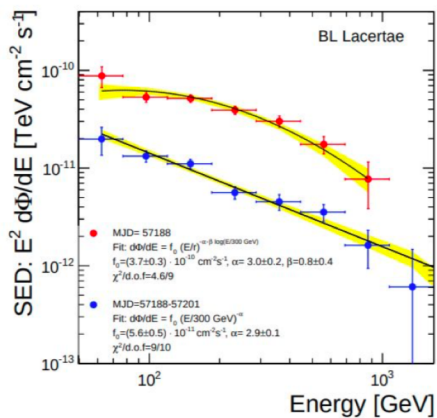
- Bring low threshold to CTA-South:
 - Transients, AGN flares, GRBs
 - DM searches
- No LSTs included in α -configuration but our Italian colleagues (INAF+INFN) have secured extra money for 2 LSTs. Manufacturing of telescopes must happen before the end of 2025!
- Still targeting all 4 telescopes! SiPM cameras?

- The fully-functional prototype telescope LST-1 was installed at CTA-North in La Palma in 2018.
 - So far as tested: performance of the telescope follows requirements.
 - Already taking scientific data: first papers coming soon.
- Remaining LSTs in CTA-North:
 - Manufacturing of parts almost finished.
 - Civil works starting in weeks, telescope erection will follow, should be complete by 2024.
- Funding secured for 2 LSTs in CTA-South:
 - Manufacturing of parts must finish before end of 2025.



- Highly variable IBL objects located at $z=0.069$
- BLLac is in a high emission state since 2020

e.g. 2015 June



MAGIC collaboration et al. (2019)

