

First Science Results from the LST prototype for CTA

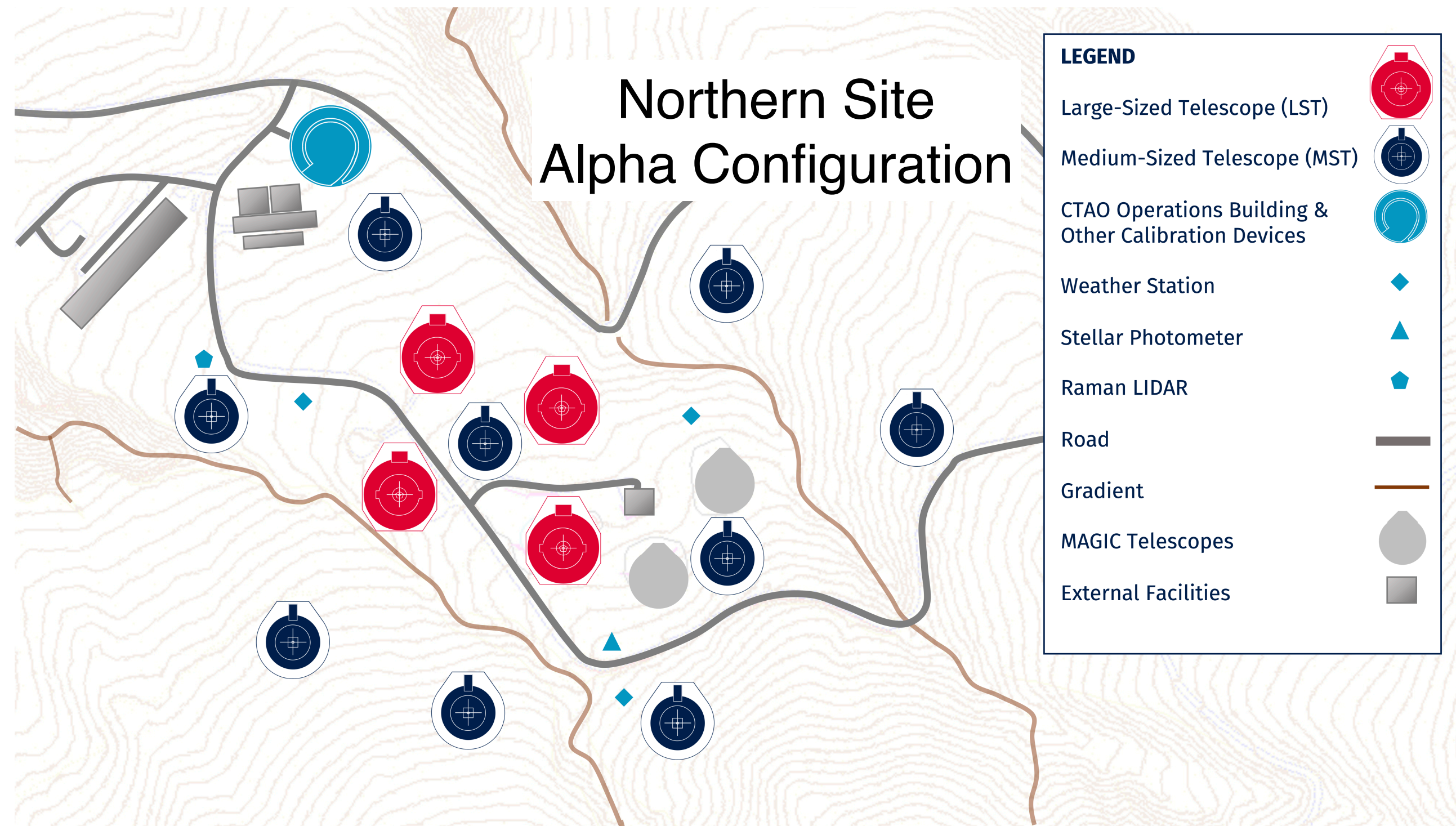
CTA LST Collaboration



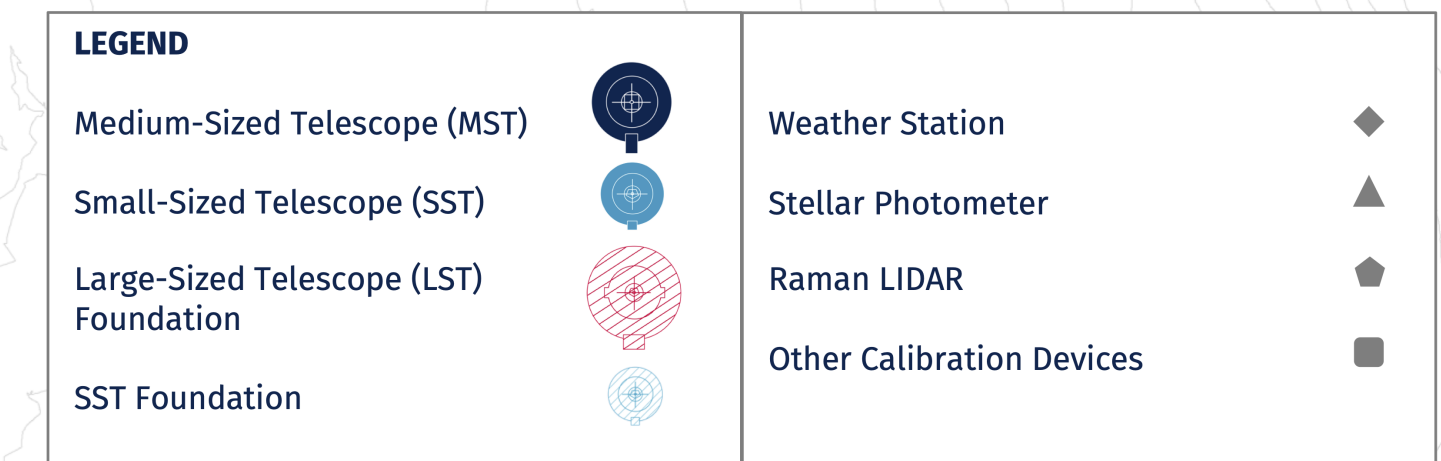
- The CTA LST Collaboration consists of 250+ scientists from 12 countries
- Learn more at : <https://www.cta-observatory.org/project/technology/lst/> and <https://www.lst1.iac.es/collaboration.html>



Cherenkov Telescope Array Observatory




**Southern Site
Alpha Configuration**



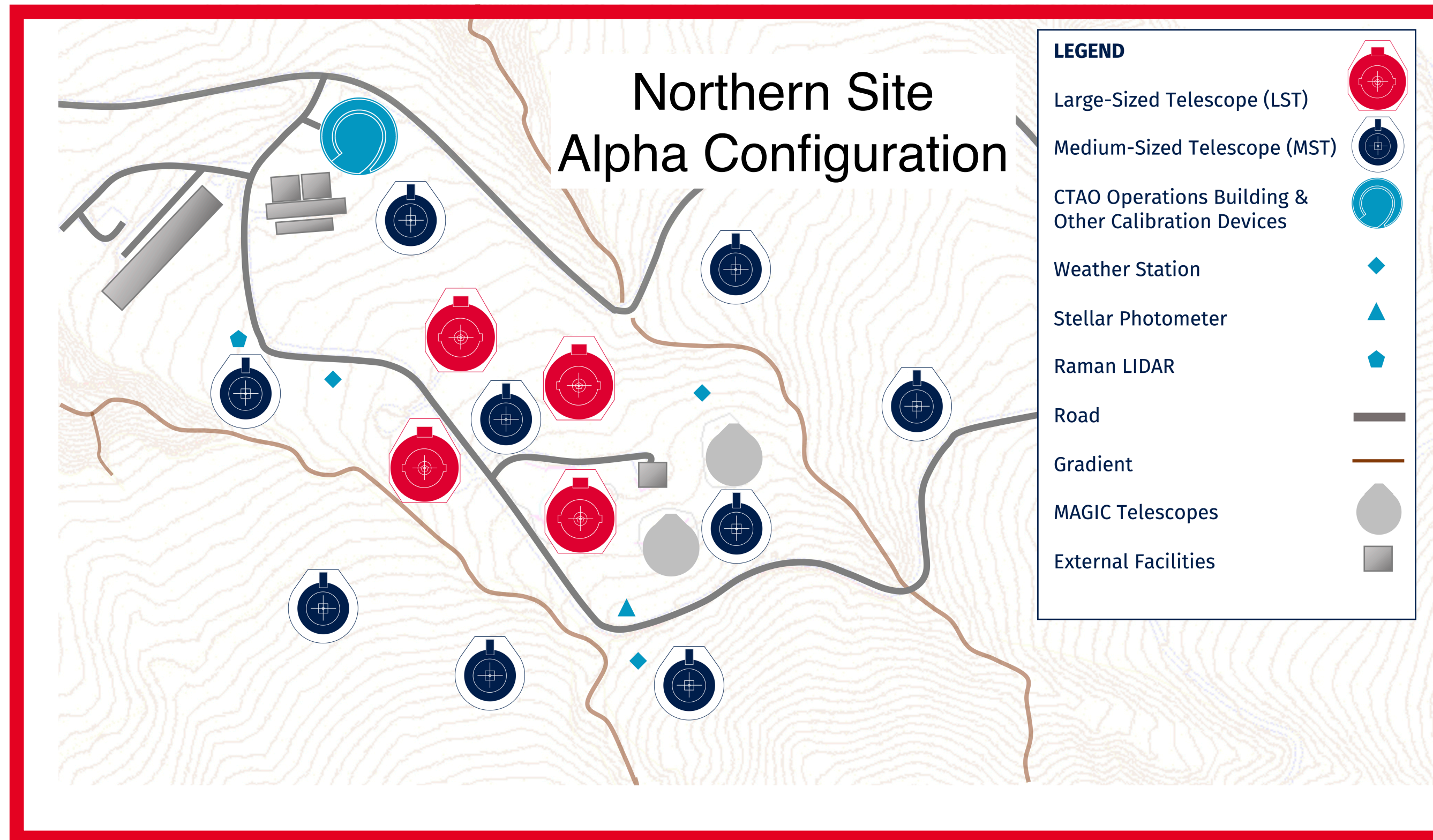
- CTA will consist of 2 arrays

- Northern array - La Palma, Spain
- Southern array - Paranal, Chile

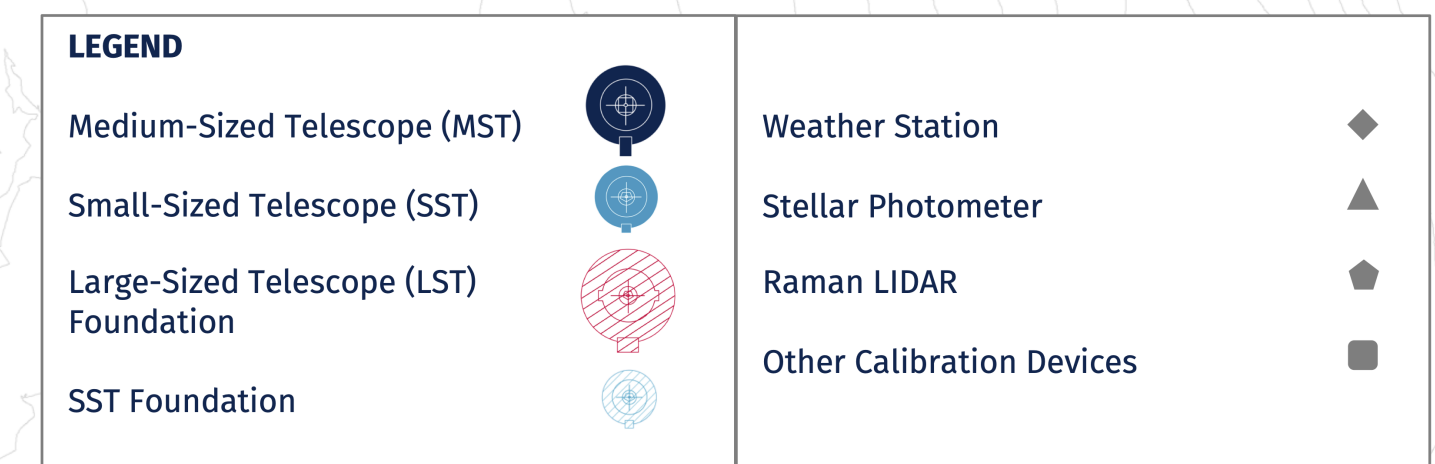
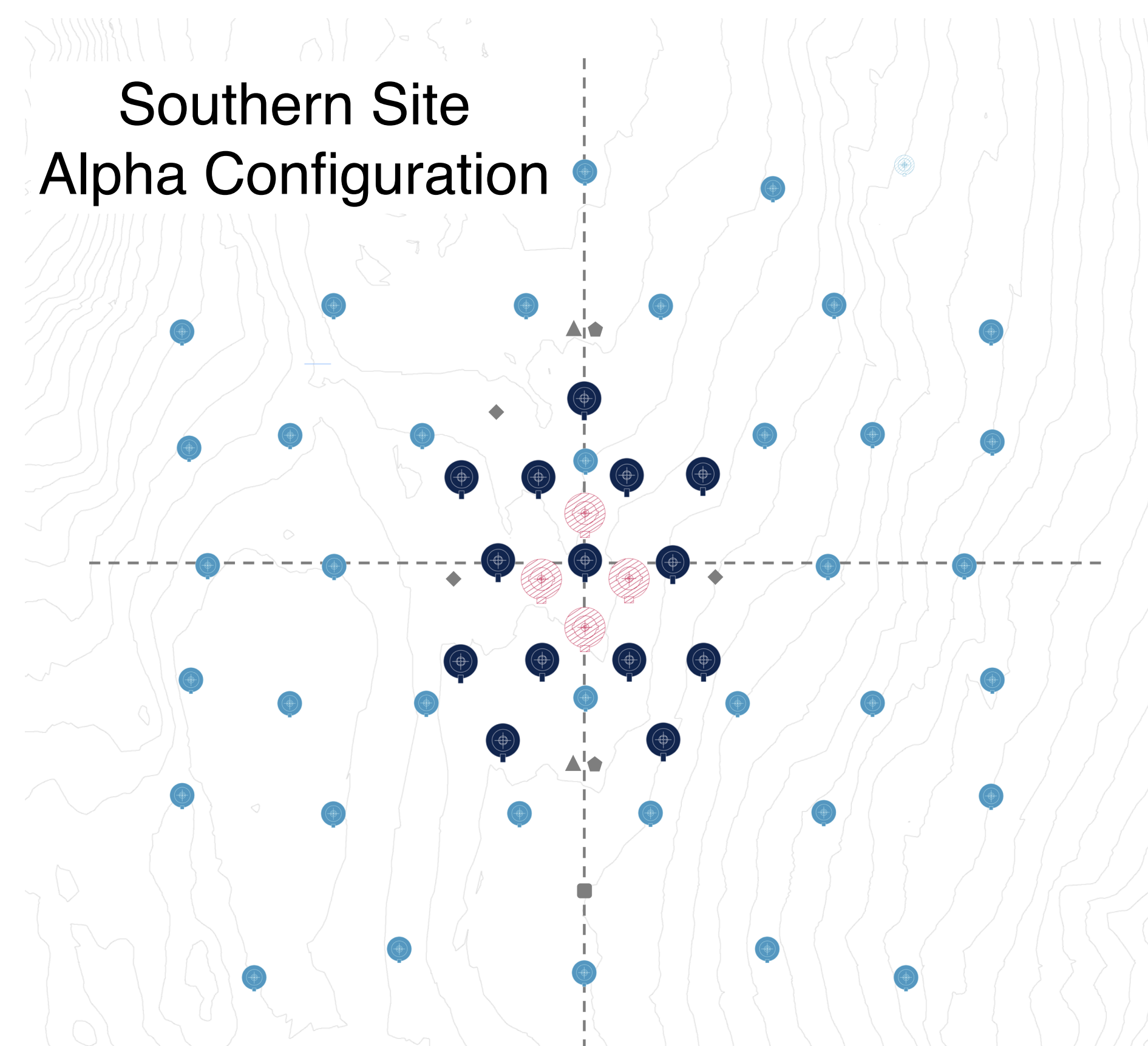
- Three Telescope Types:

- LST - Large-Sized Telescope
- MST - Medium-Sized Telescope
- SST - Small-Sized Telescope

Cherenkov Telescope Array Observatory



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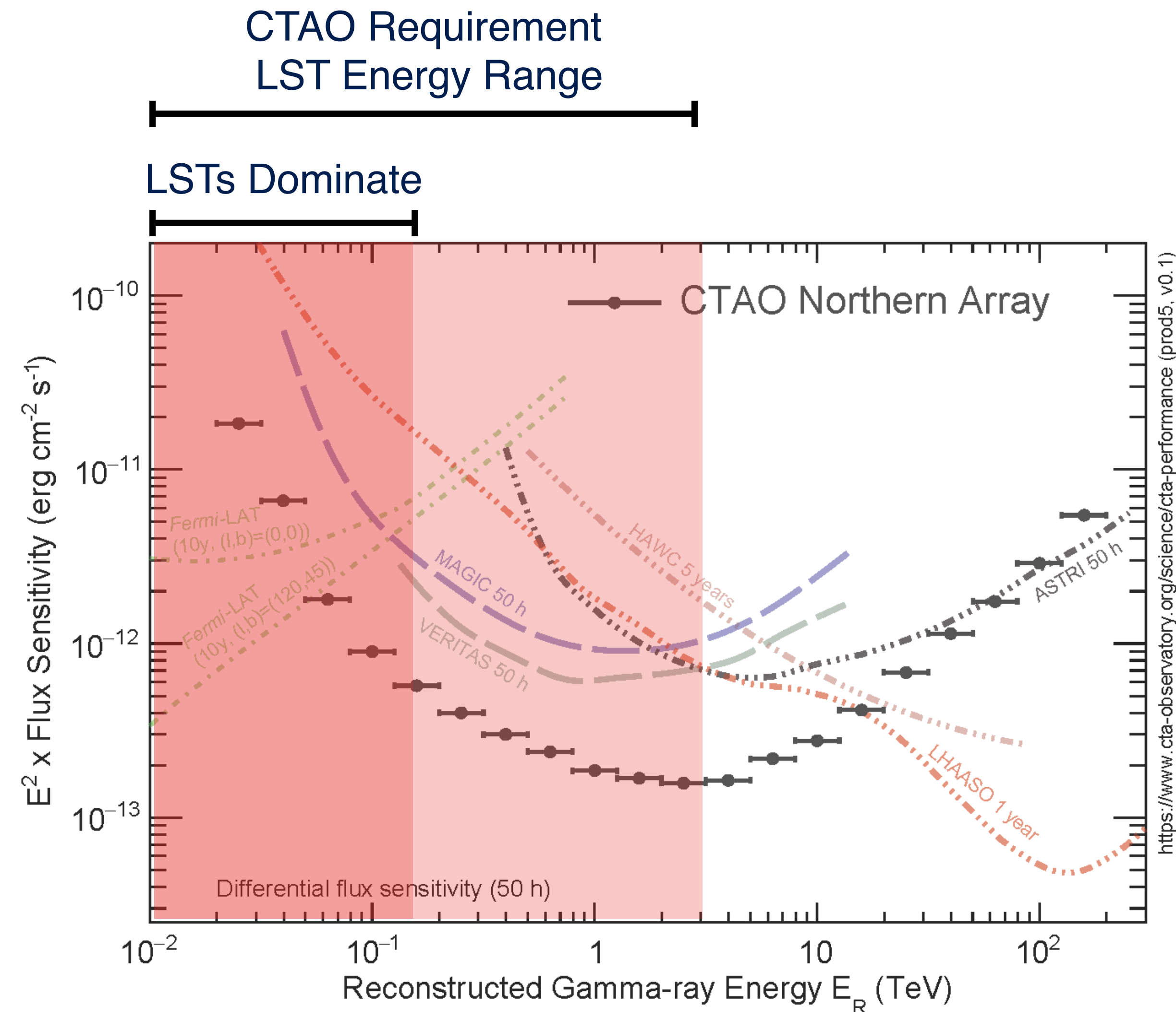
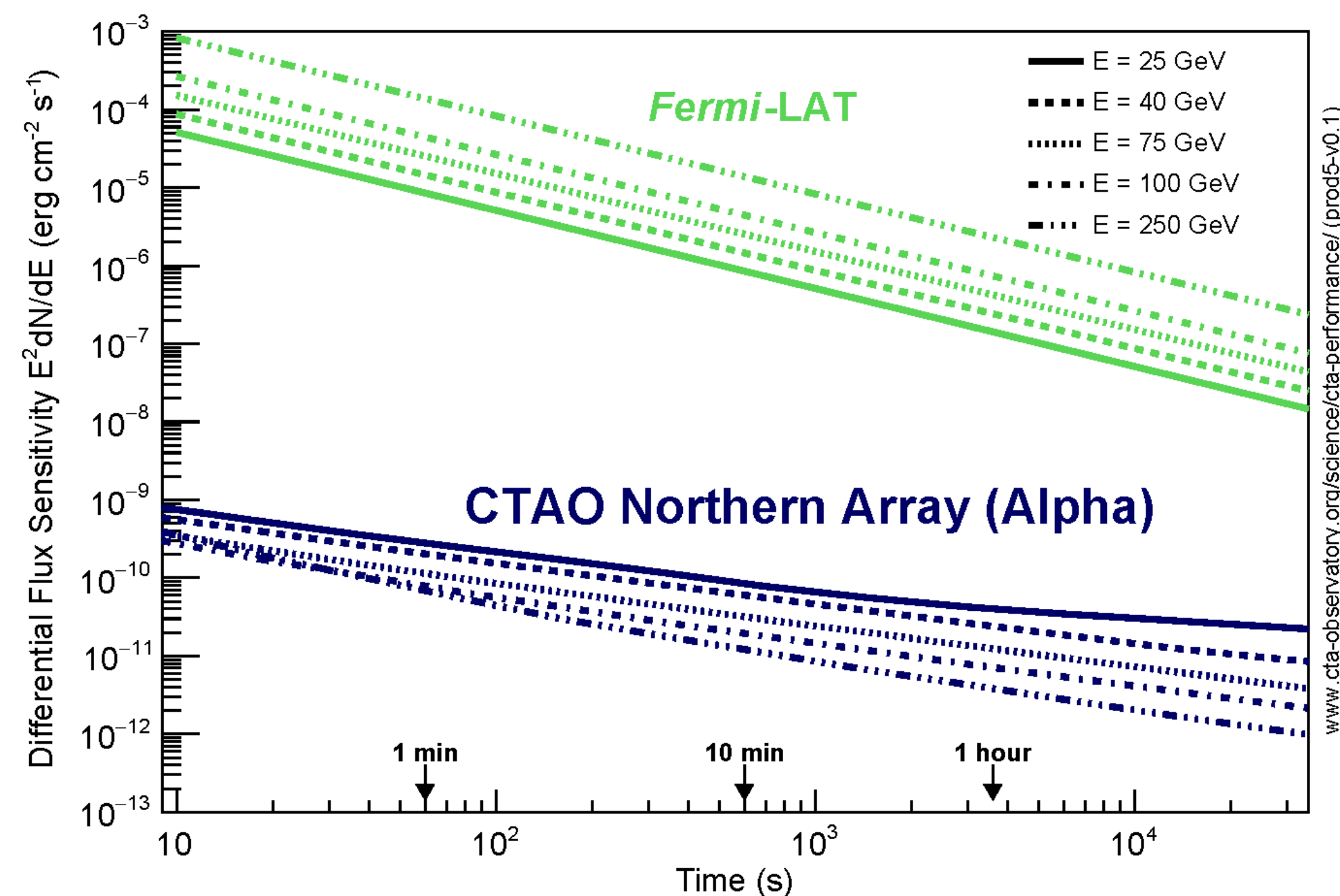
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Performance of the CTAO Northern Array

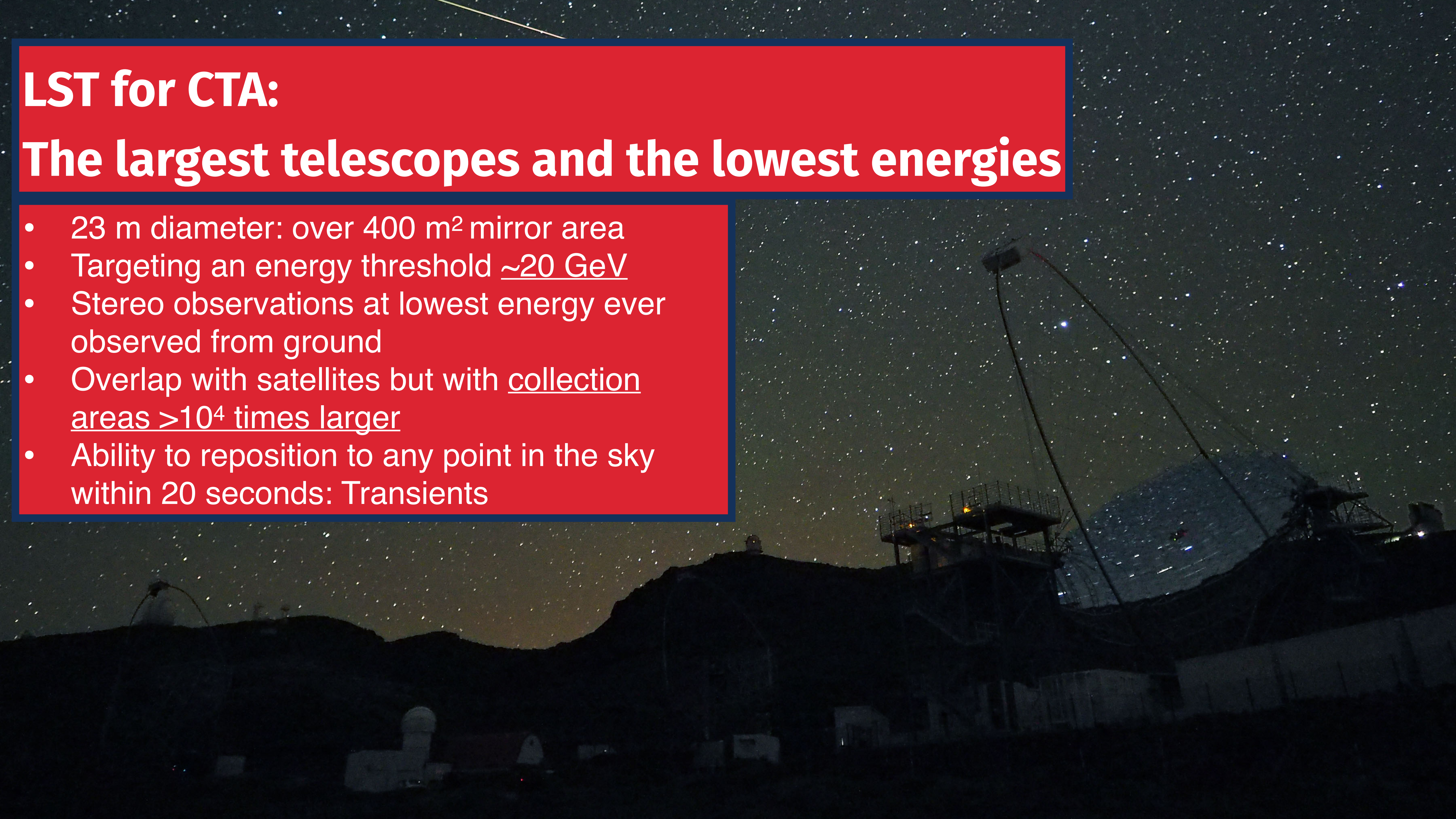
- LSTs dominate CTAO sensitivity below 150 GeV
- Ideal for fast transients and soft sources



LST for CTA:

The largest telescopes and the lowest energies

- 23 m diameter: over 400 m² mirror area
- Targeting an energy threshold ~20 GeV
- Stereo observations at lowest energy ever observed from ground
- Overlap with satellites but with collection areas >10⁴ times larger
- Ability to reposition to any point in the sky within 20 seconds: Transients



Status of the Project

- Construction ahead of CTAO ERIC formation
- LST-1 first telescope at CTA site:
 - Telescope inaugurated in 2018
 - Under commissioning: Covid-19, supply-chain crisis, volcano, inflation...
 - ~800 hours of data taken since Jan 2020
 - Data-taking efficiency 70% in dark time, not yet reaching 95% requirement, mostly due to incomplete control software
- LST-2, LST-3, and LST-4: under production
- LST-South: Partially funded



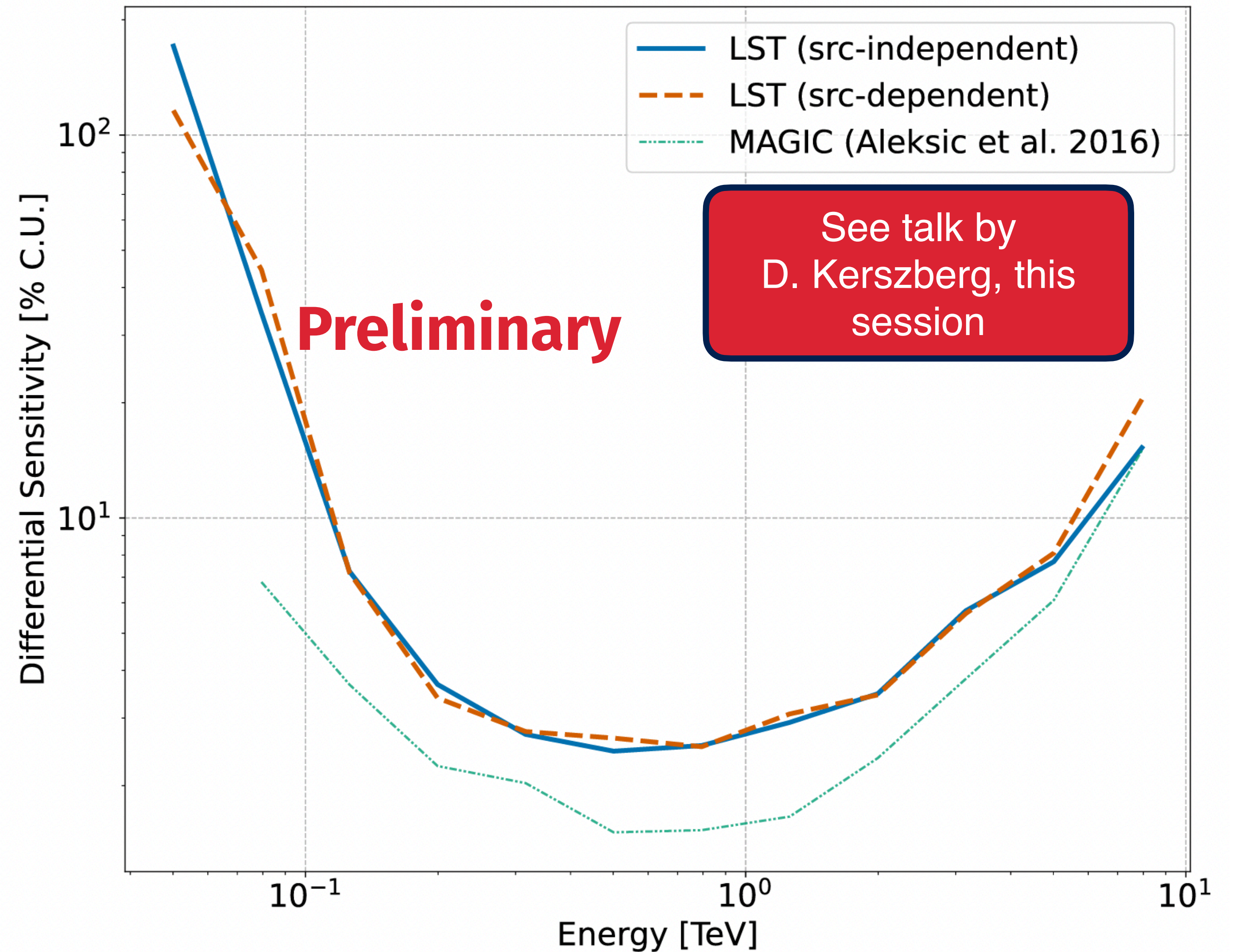
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Performance: Sensitivity

- Able to measure energy down to 50 GeV
- Roughly 1.5x less sensitive than MAGIC Stereoscopic Telescopes
- Consistent with single telescope performance vs Stereoscopic system
- Single telescope system have higher backgrounds

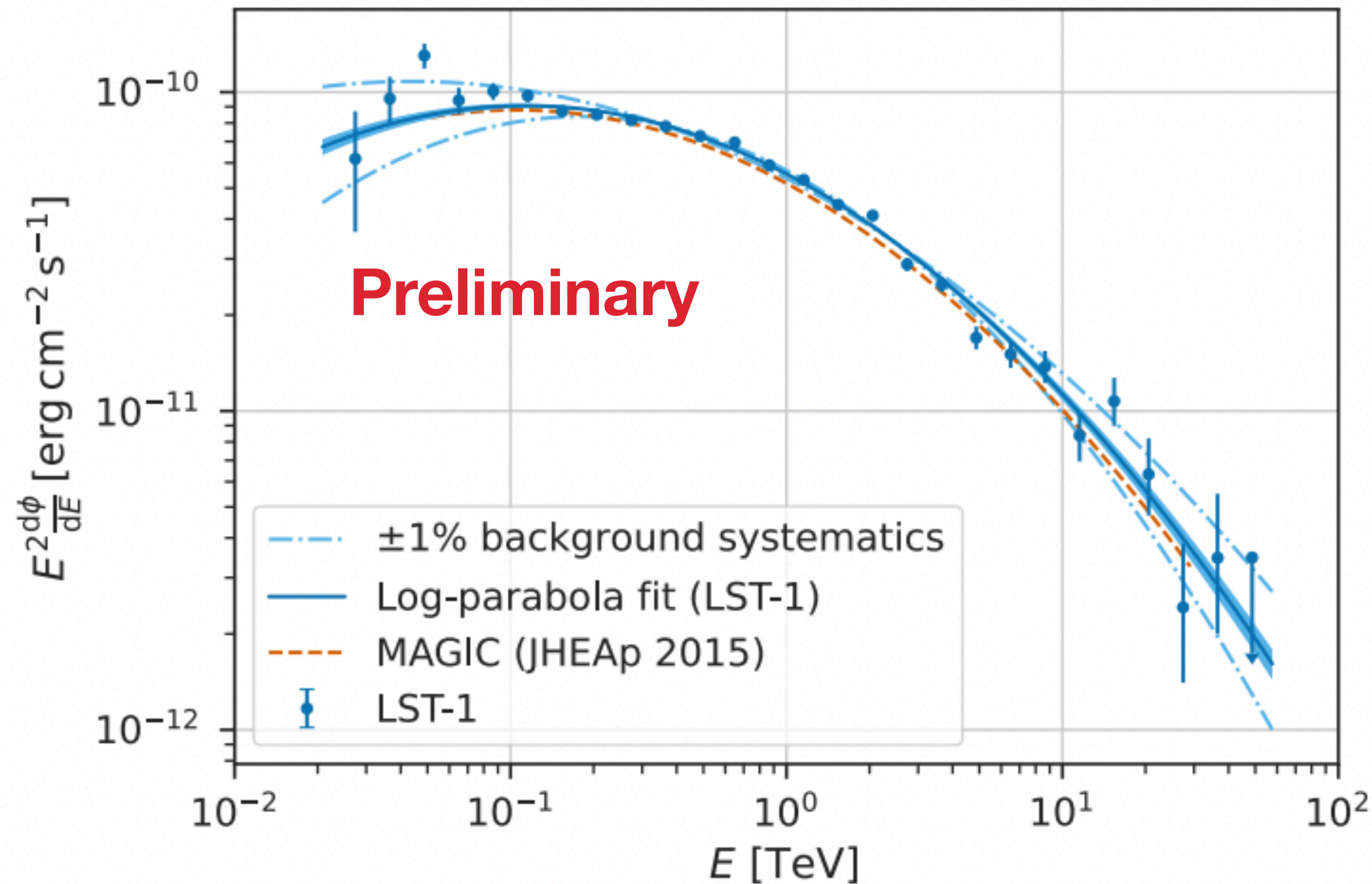


LST-1 is Ready for Science

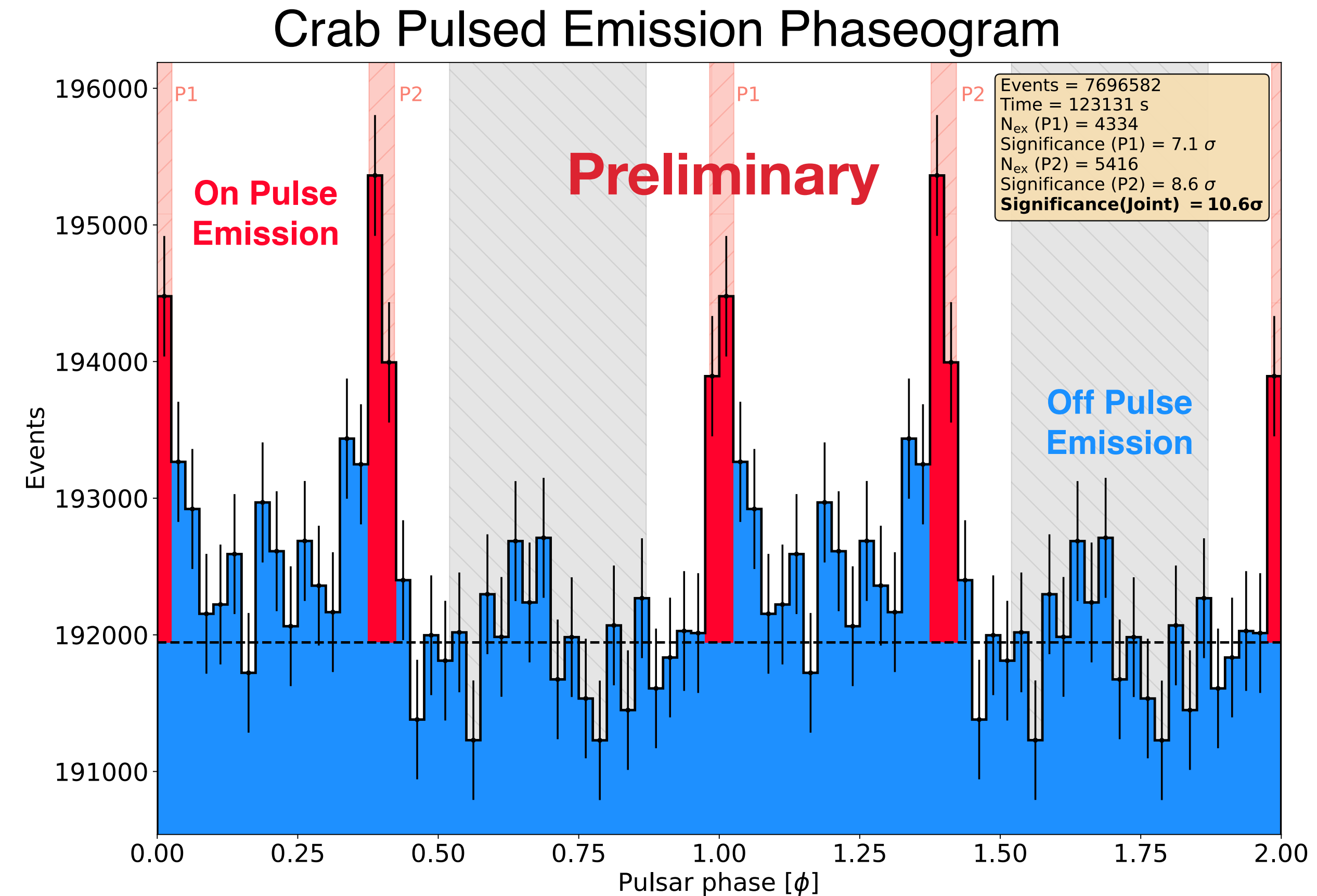
- We are about to publish the LST Performance paper
- Confident in the understanding of our telescope
- A number of publications are already in the pipeline



Crab Nebula and Pulsar



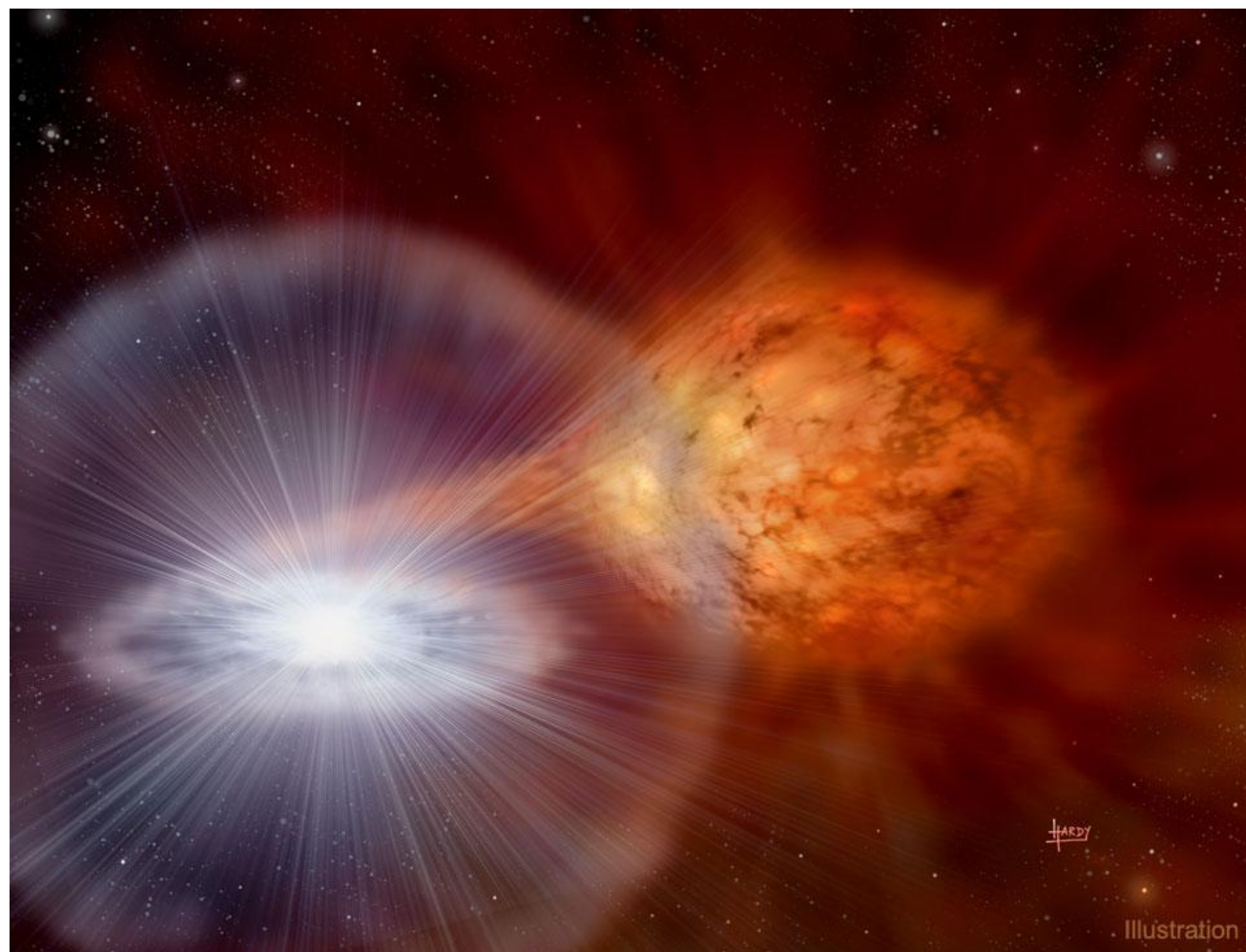
See talk by
D. Kerszberg, this
session



- Yes, we looked at the Crab Nebula and Pulsar
- 34 hours of effective time
- Data down to 25 GeV, a first for LST

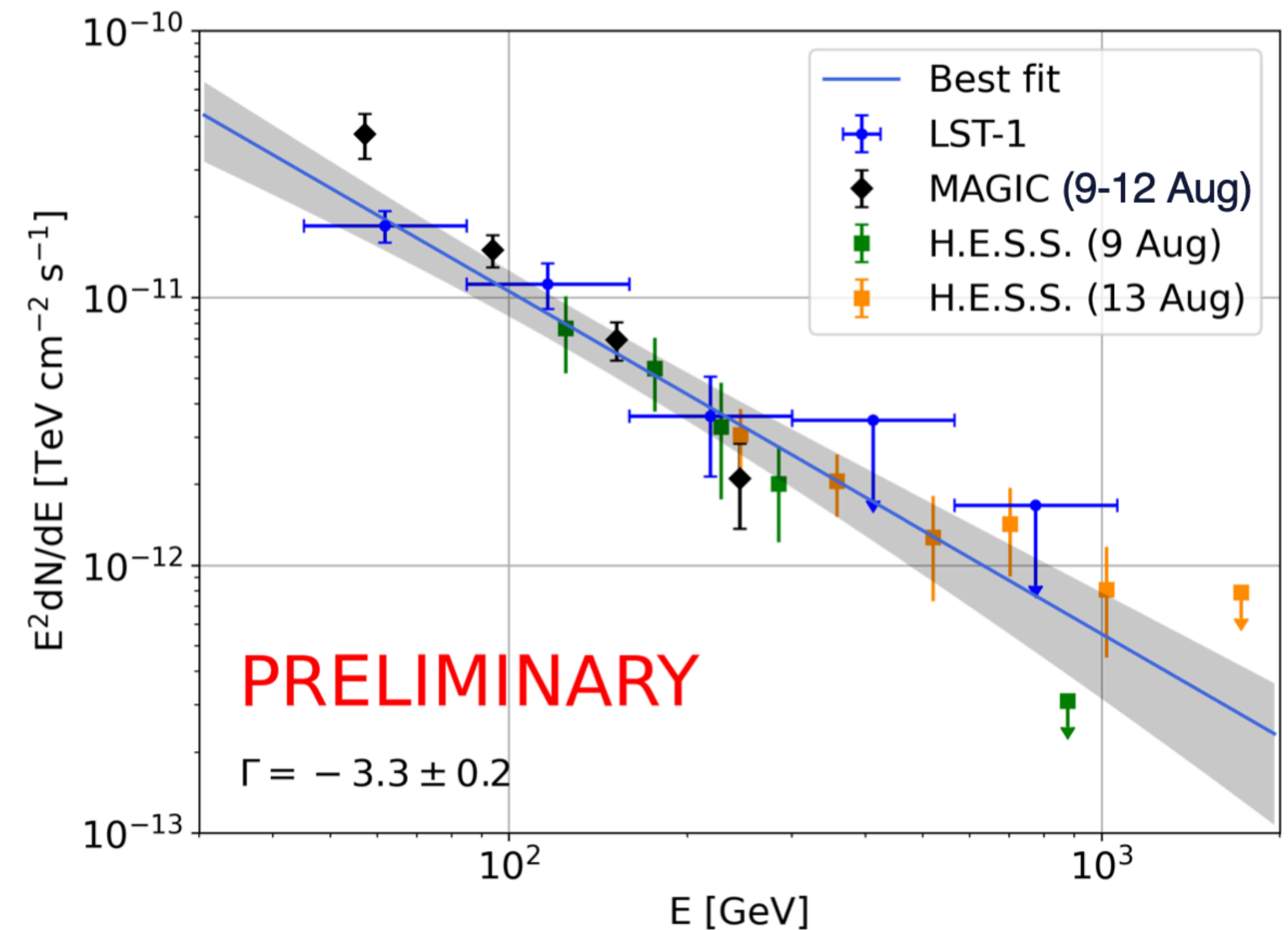
First VHE-detect Nova: RS Ophiuchi

See talk by
Y. Kobayashi
Thursday



Credit: David A. Hardy

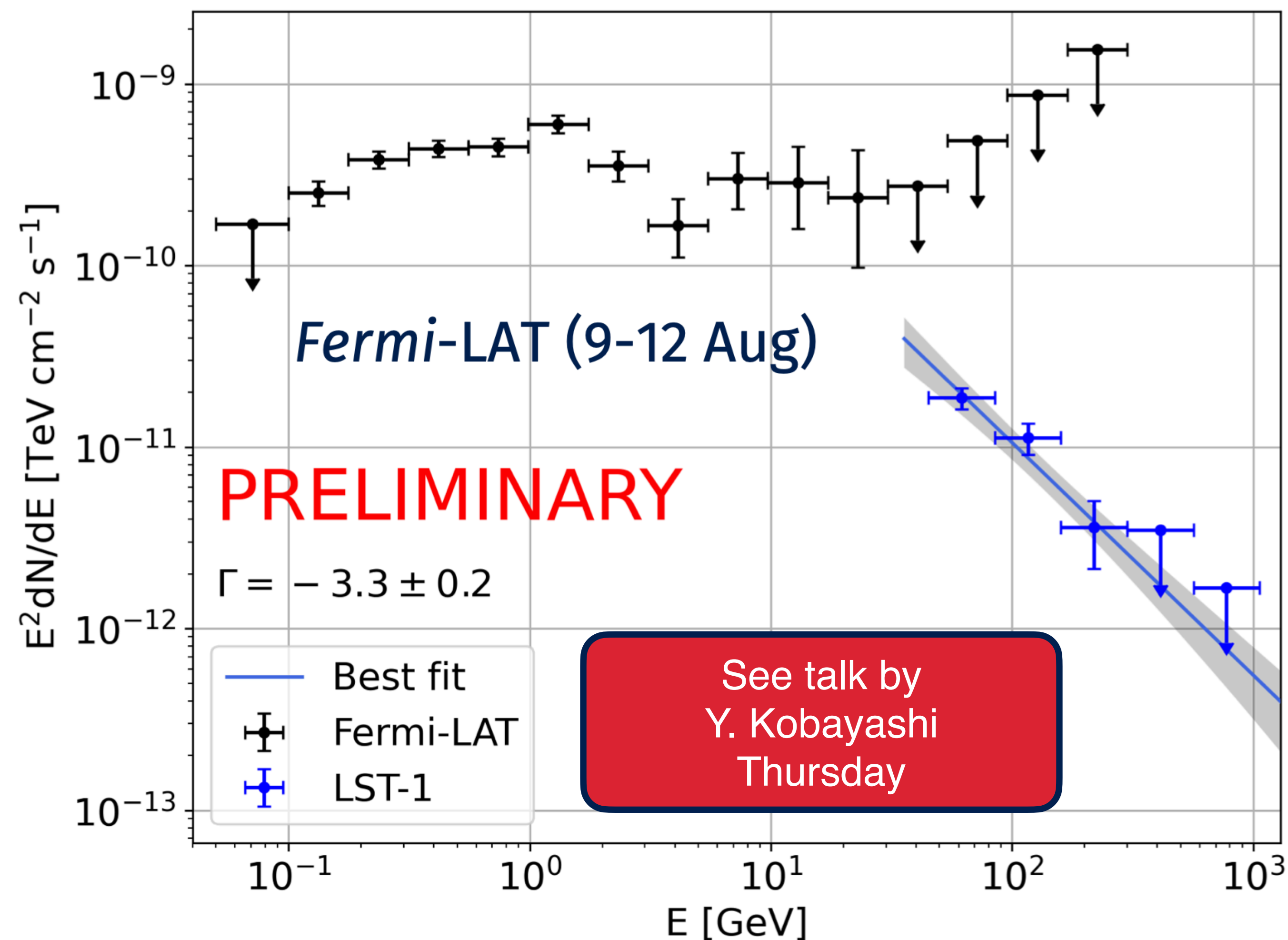
- LST-1, 4-day average
- MAGIC, 4-day joint data ([Acciari 2022](#))
- H.E.S.S. Aug 9 + 13 SEDs ([H.E.S.S. Collab 2022](#))
- Consistent SEDs



MAGIC results from Acciari et al. 2022
H.E.S.S. results from H.E.S.S. Collaboration 2022.

First VHE-detect Nova: RS Ophiuchi

- Nice connection between LST-1 and Fermi-LAT data
- Energy threshold already competitive with MAGIC (~45 GeV)
- Paper already in progress

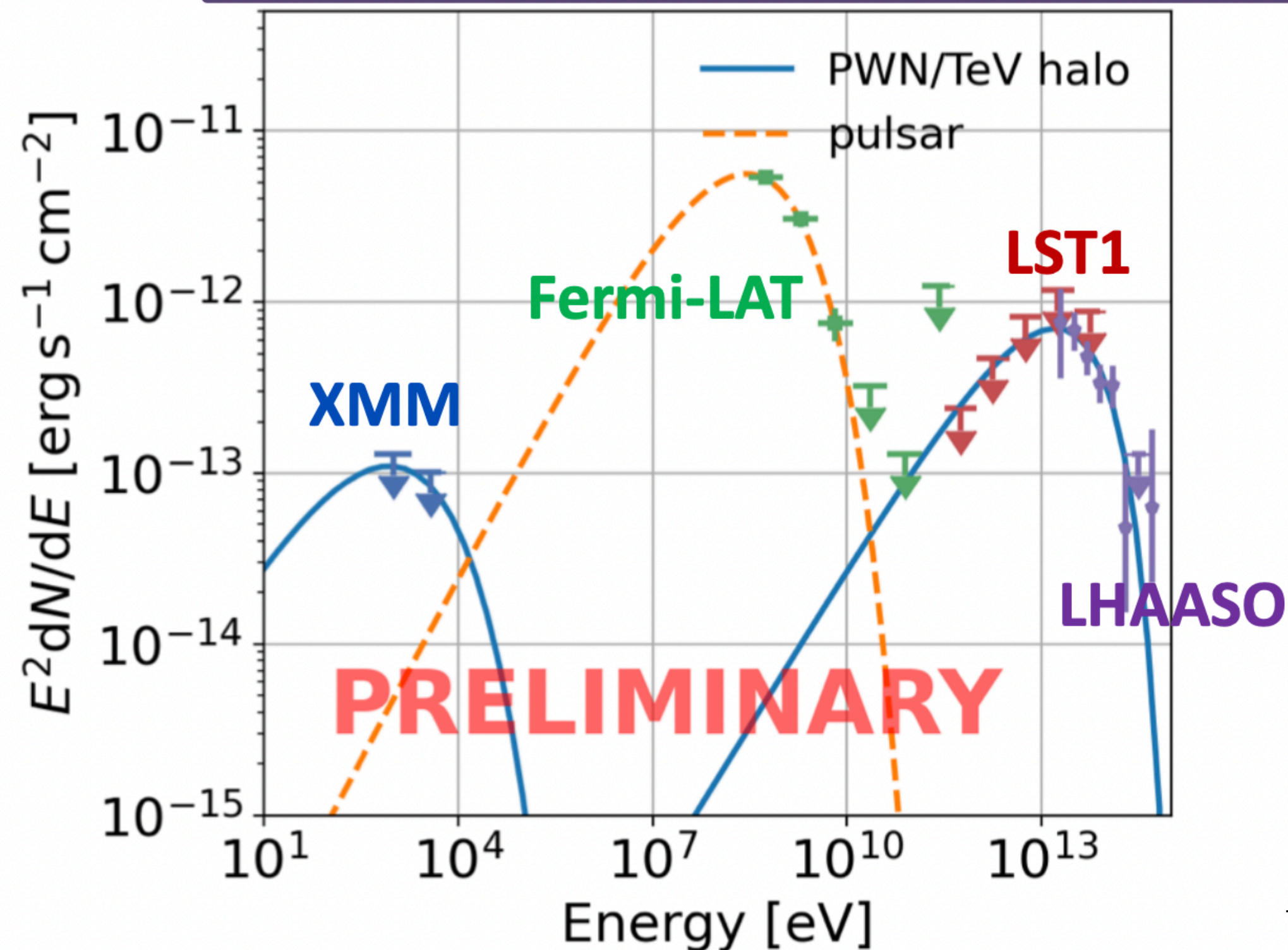


LHAASO J2108+5157

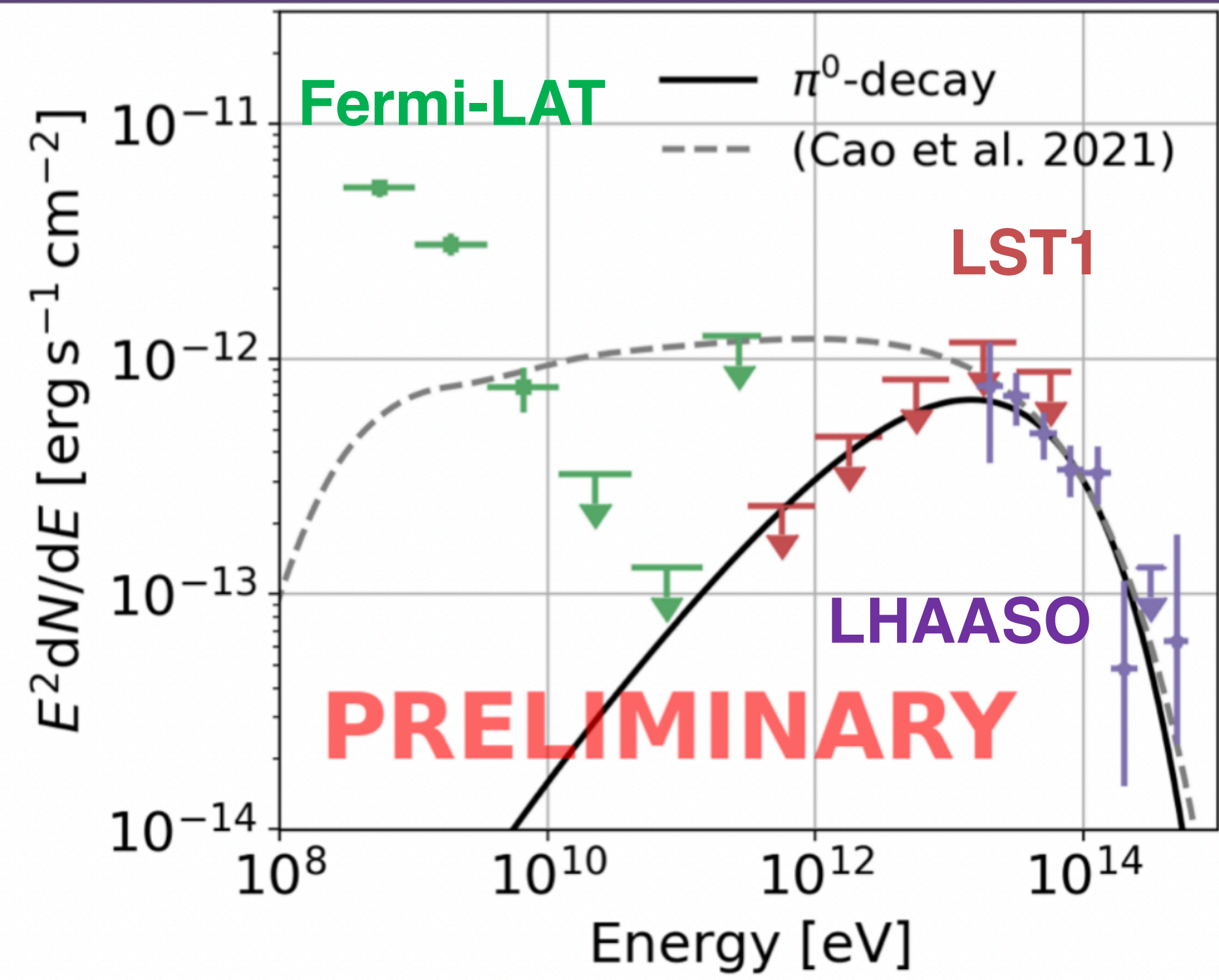
- Cao et al. 2021: PeVatron, reported to be point-like (<0.26 deg). No X-ray or VHE counterpart, possible LAT counterpart, but soft spectrum (pulsar?)
- 91 hour observation, no detection but relevant upper limits.

See talk by
J. Juryšek
Wednesday

Leptonic scenario



Hadronic scenario



BL Lac Flare 2021: CTA's First ATEL

[[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

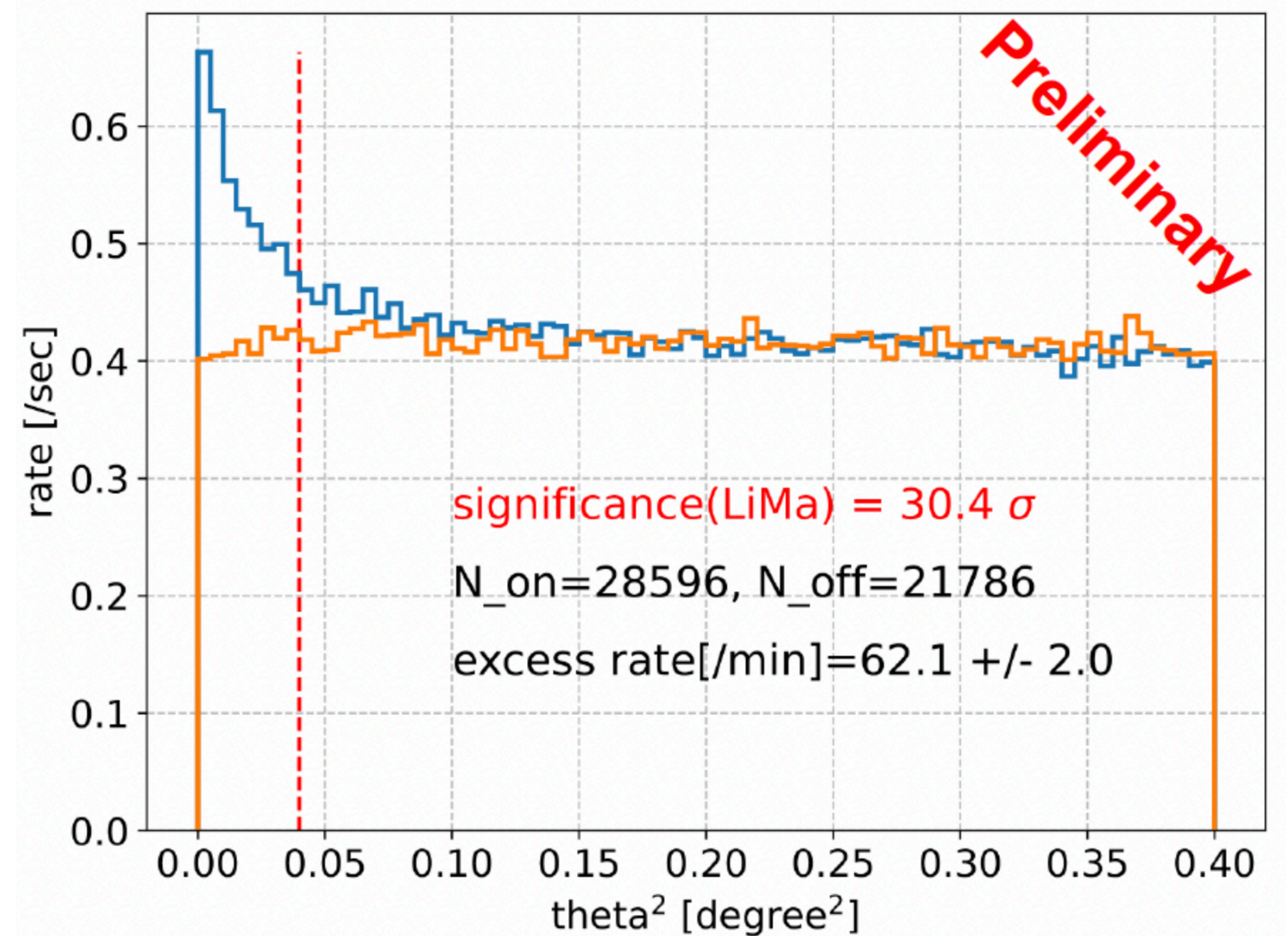
Credential Certification: *Juan Cortina (Juan.Cortina@ciemat.es)*

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

Referred to by ATel #: [14820](#), [14826](#), [14839](#)



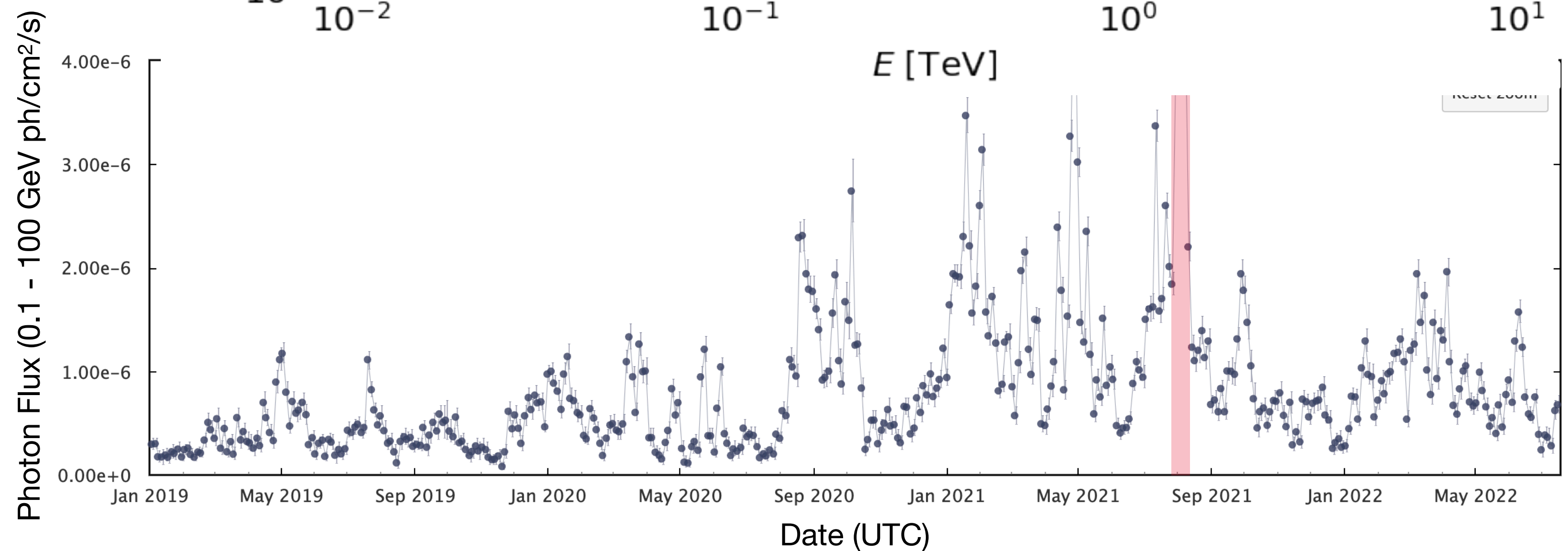
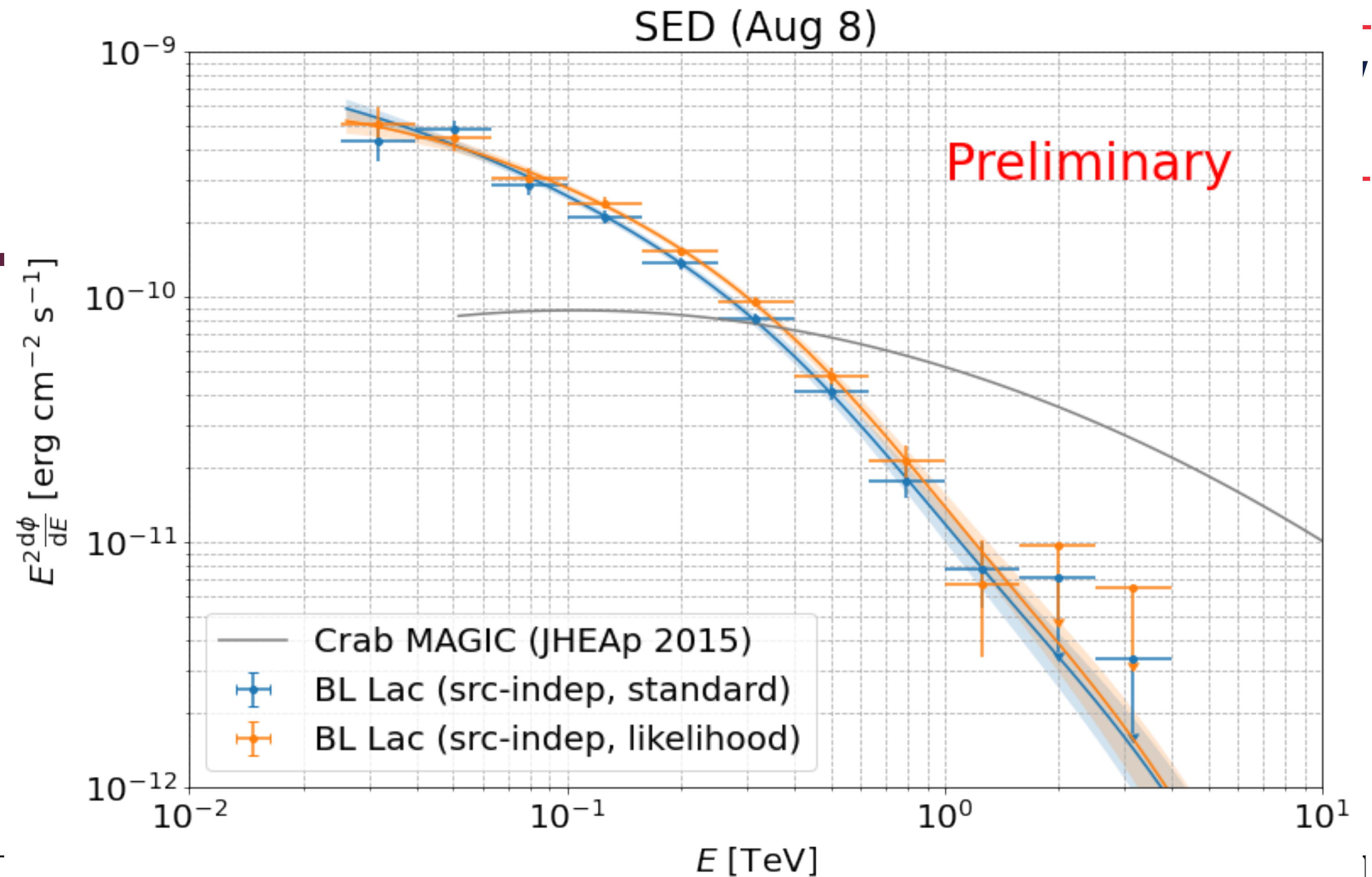
The LST-1 telescope has observed an increase in the very-high-energy (VHE; >100 GeV) gamma-ray flux from BL Lacertae (RA=22:02:43.3, DEC=+42:16:40, J2000.0). The preliminary offline analysis of the LST-1 data taken on 2021/07/11 (MJD 59406), triggered by an increase of the optical flux (see ATEL #14773 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 2018. LST-1 is a prototype of the Large-Sized Telescope for the Cherenkov Telescope



- Fast response by LST and CTAC
- ATEL was Published under 48 hours of observation with confirmation and cross-check

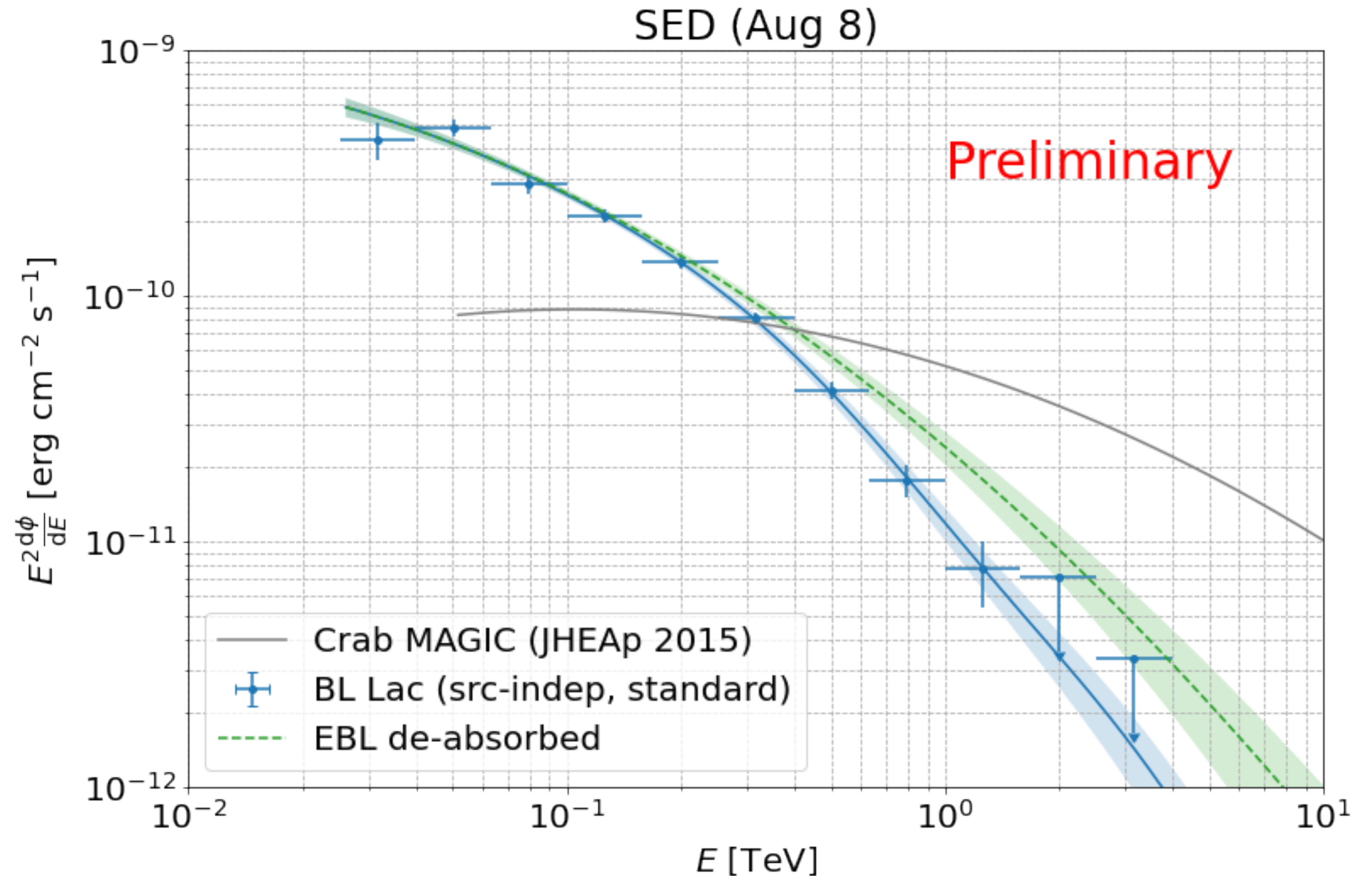
BL Lac Flare 2021

- IBL at $z=0.069$
- 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
- Two separate analyses are in good agreement

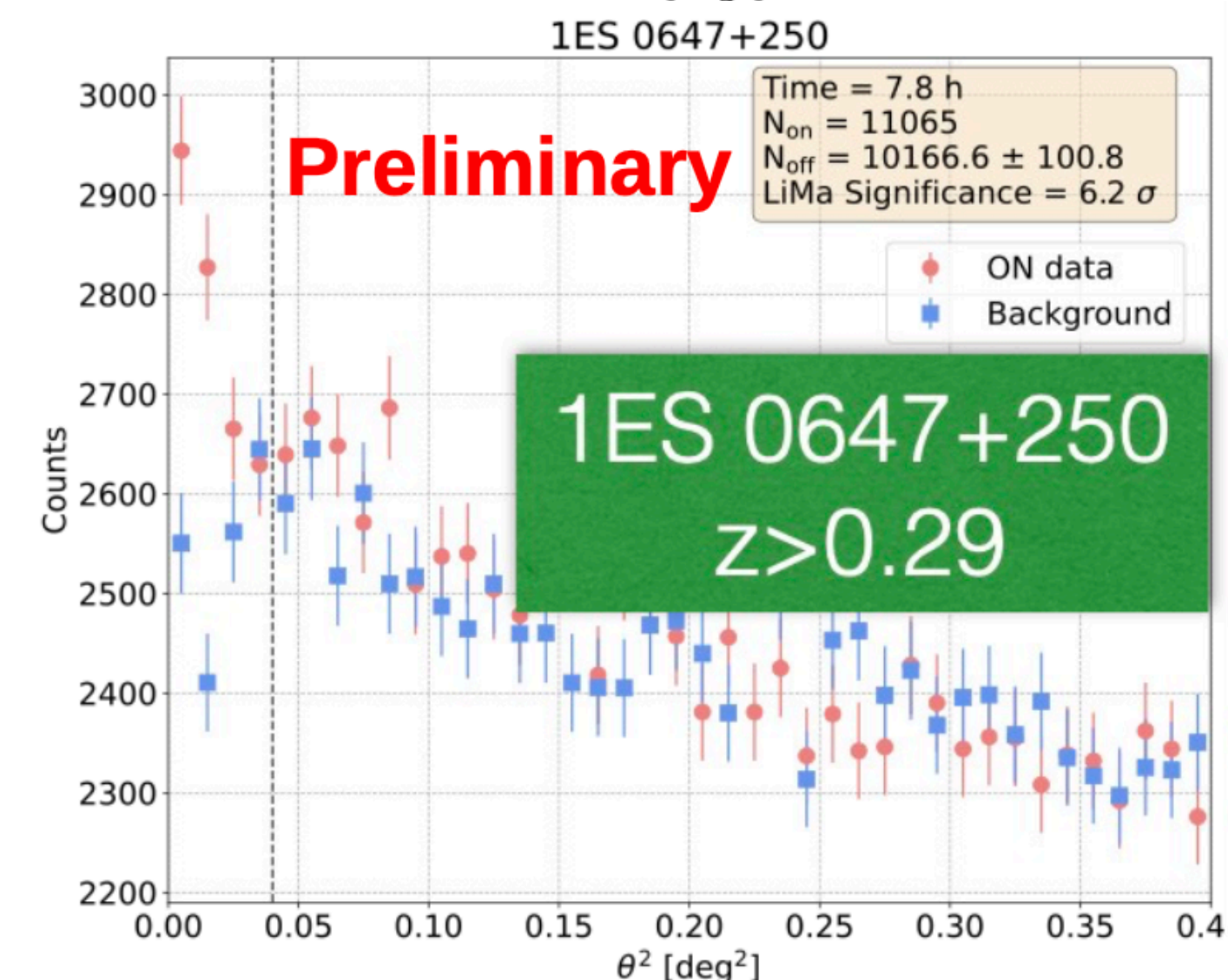
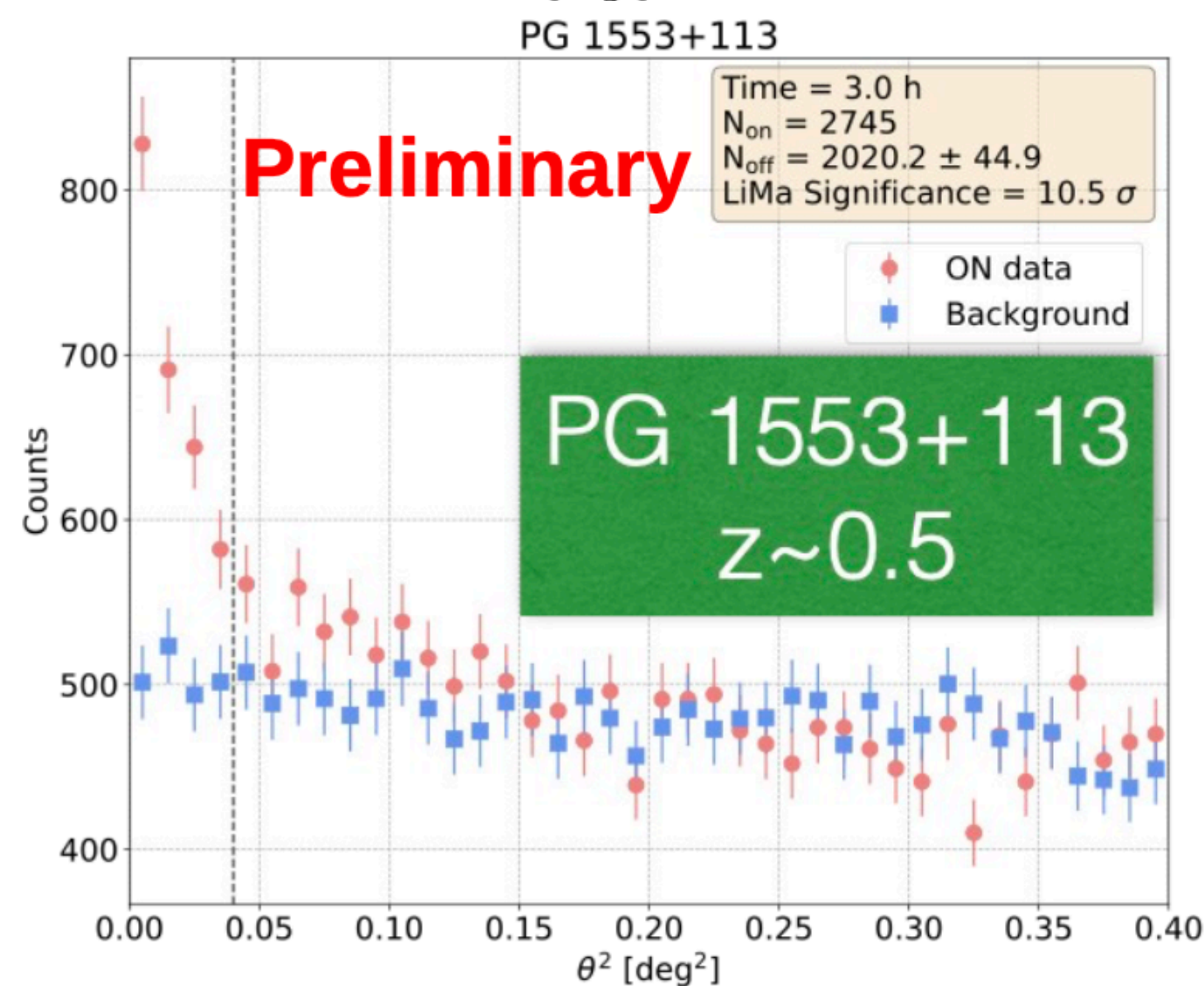
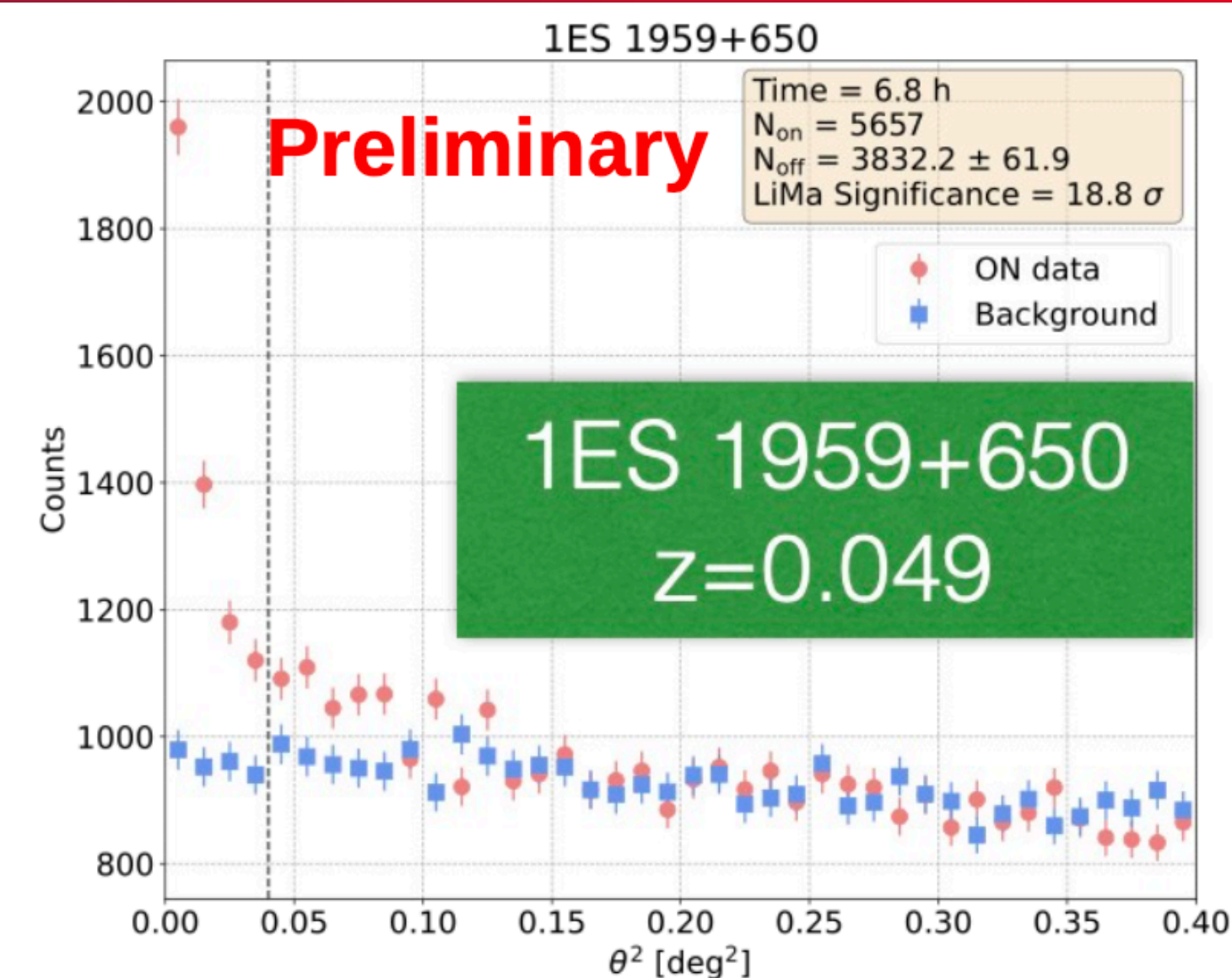
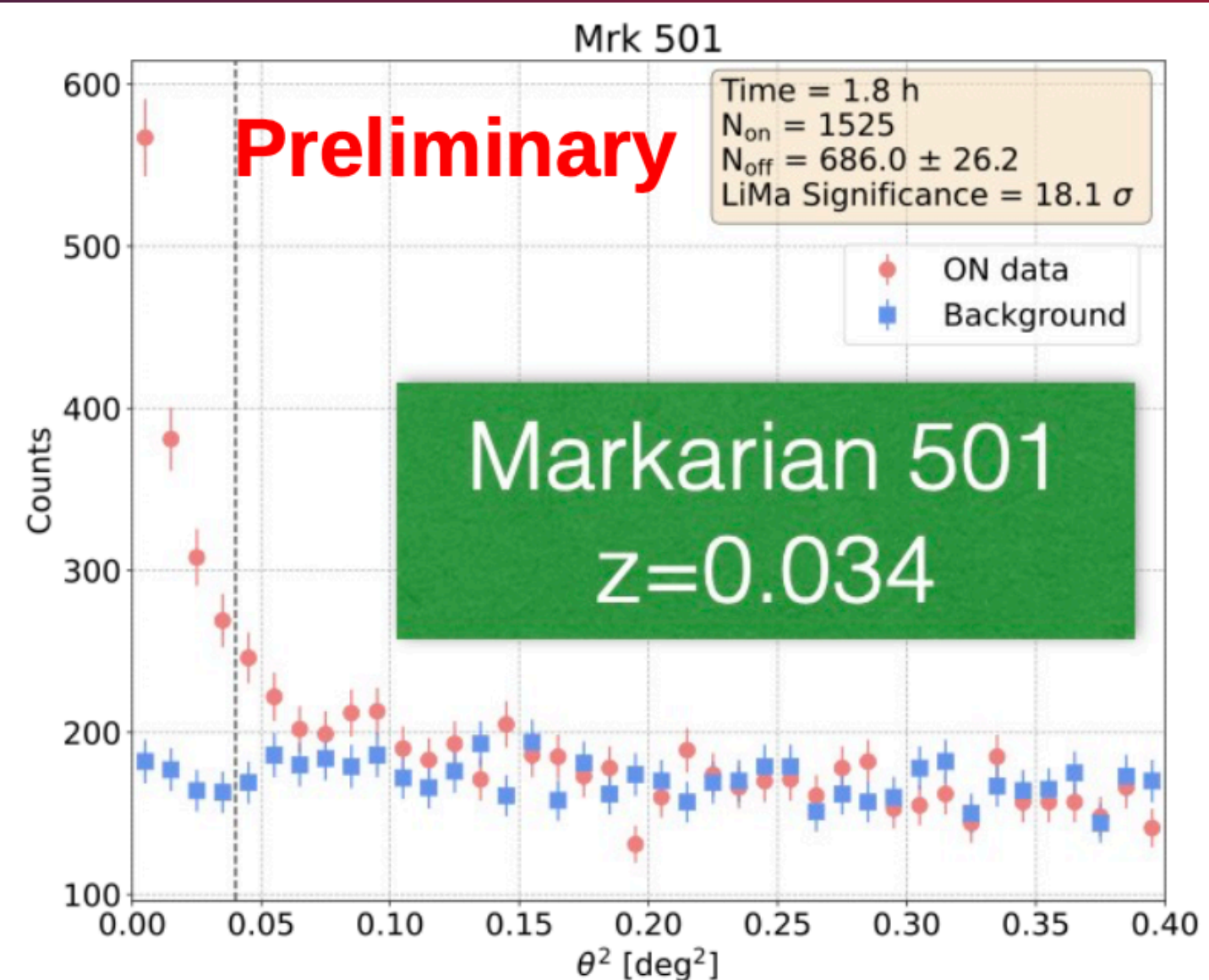
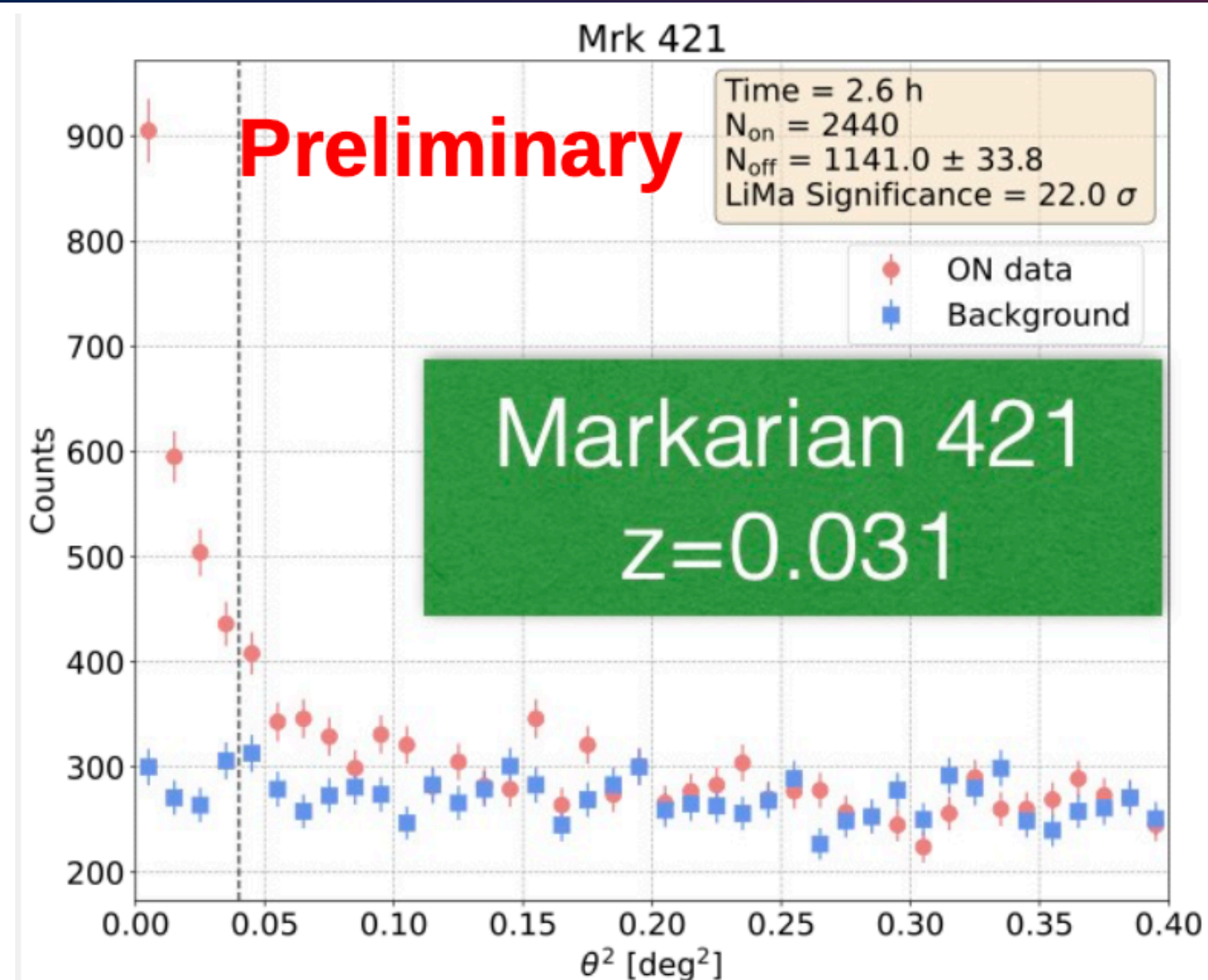


BL Lac Flare 2021

- ~ 5x brighter than Crab at 30 GeV
- De-absorbed EBL spectra still shows curvature
- Intra-night variability being examined
- Explore LST capability for short-time scale variability and Lorentz invariance studies

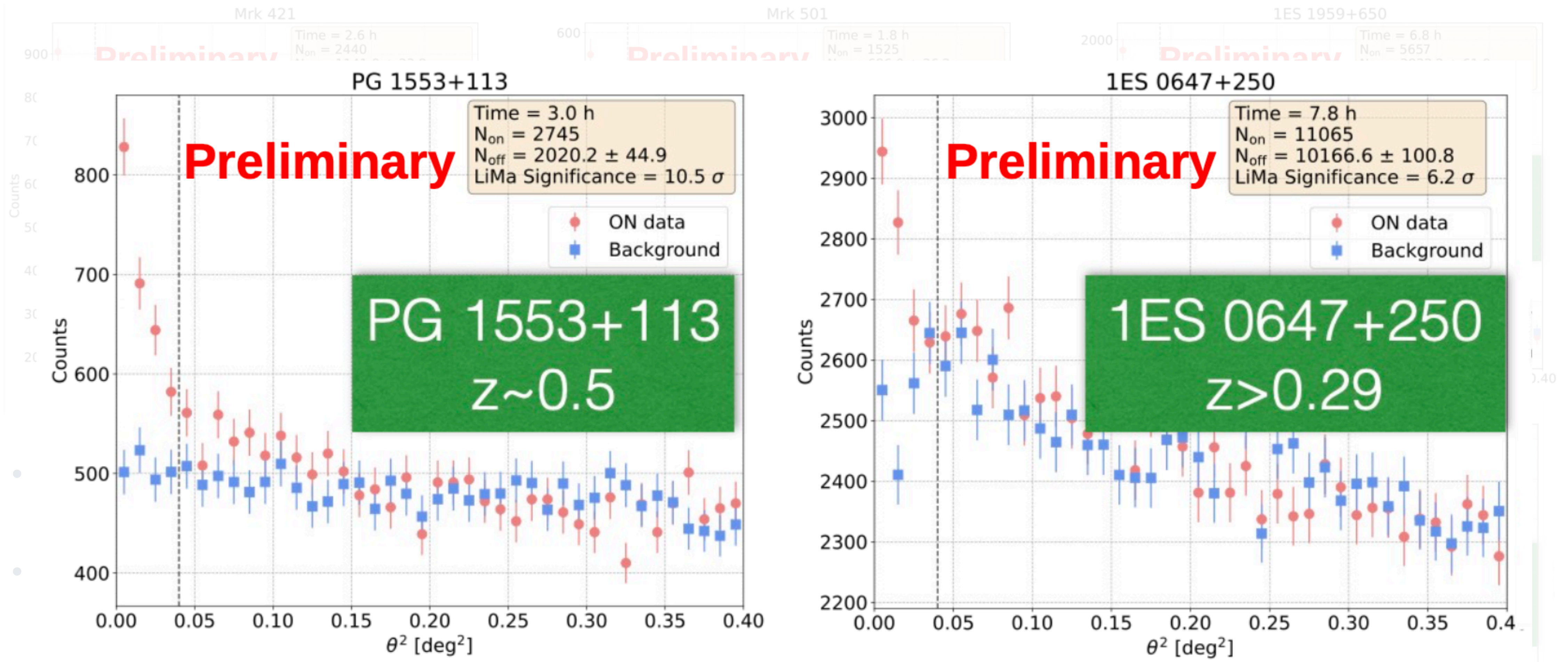


TeV Blazars

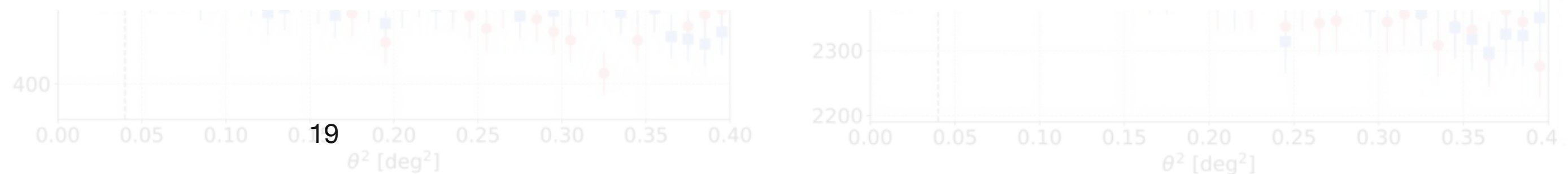


- Observed several and detected ($>5\sigma$) other TeV Blazars while flaring
- All known TeV blazars, but up to a $z \sim 0.5$
- This collection is going into a paper along with Fermi-LAT analysis

TeV Blazars



along with Fermi-LAT analysis



Transients

- Following GRBs with triggers from Swift, GBM, and LAT
 - No detection
- Also following Neutrino triggers, Galactic transients, and FRBs
- Automatic repositioning expected in second half of 2022

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	59	33

Conclusions

- The prototype telescope LST-1 was inaugurated at CTA Northern Array in La Palma in 2018.
 - So far as tested: performance of the telescope expected follows CTAO requirements.
 - Already taking scientific data: first papers coming soon.
- Performance and data analysis well understood
 - Promising observations and results ranging from Galactic: Crab(s), RS Oph, LHAASO J2108, to Extragalactic: BL Lac, other TeV Blazars