CTAO | LST COLLABORATION

First results from LST-1

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CTAO concept

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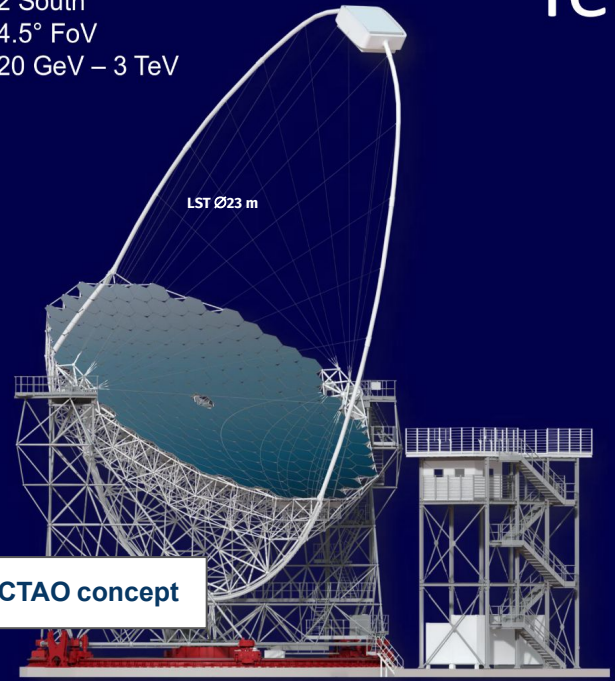
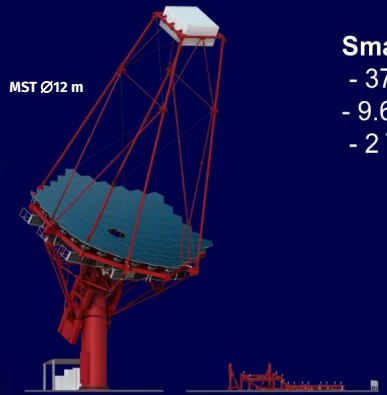
Telescopes

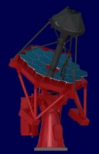
Large-Sized Telescopes:
- 4 North
- 2 South
- 4.5° FoV
- 20 GeV – 3 TeV



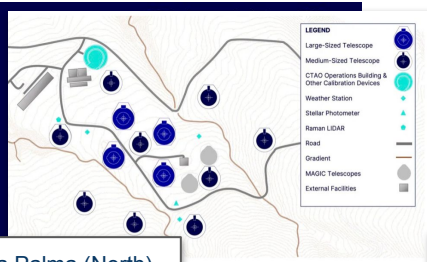
Medium-Sized Telescopes:
- 9 North
- 14 South
- 8° FoV
- 80 GeV – 50 TeV



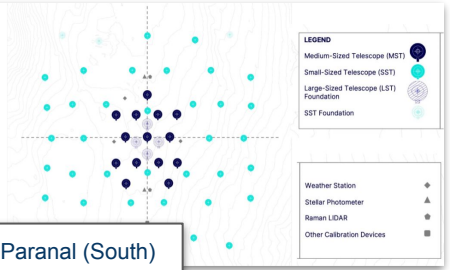
Small-Sized Telescopes:
- 37 South
- 9.6° FoV
- 2 TeV – 300 TeV



CTAO concept



La Palma (North)



Paranal (South)

- near full sky coverage
- wider energy range (~20 GeV - 300 TeV)
- higher sensitivity: ~5-10x current IACT
- better angular resolution: ~5x current IACT
- larger FoV: 2.5x current IACT

LST Collaboration

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- **>~ 300 scientists & engineers from 11 countries**
- The Collaboration is building and commissioning 4 LSTs in the north (CTAO-N) and is participating to the realization of LSTs in south side (CTAO-S)

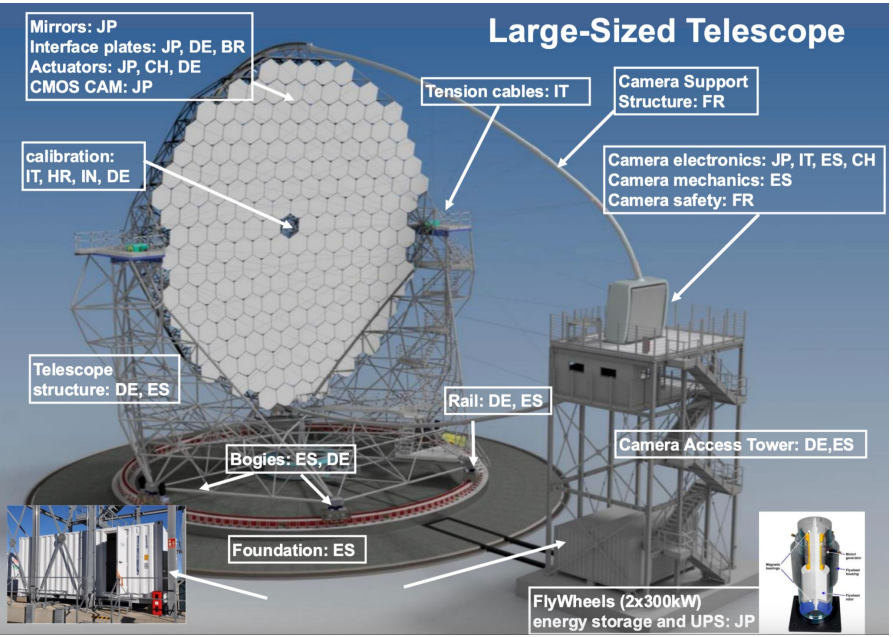
- **LST-1 is the first 23-m class telescope for the CTAO.**
- In operation since 2018 at ORM (La Palma)
- Currently performing regular observations on a wide range of astrophysical sources

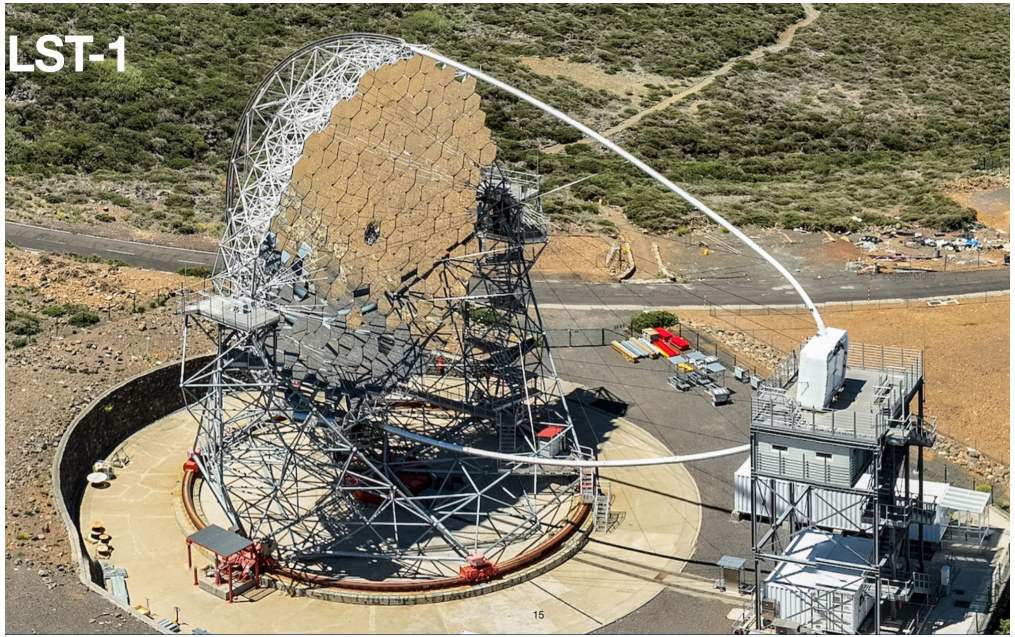
TOTAL MEMBERS	TOTAL CF	TOTAL SIGNING AUTHORS
526	329	301

Countries | Groups

COUNTRY	MEMBERS	CF	SIGNING AUTHORS	% MEMBERS	% CF	AVG MEMBERS LAST 12 MONTHS	AVG CF LAST 12 MONTHS
Brazil	22	7	7	4.18%	2.13%	20.50	7.00
Bulgaria	4	4	2	0.76%	1.22%	3.00	3.00
Croatia	10	7	8	1.90%	2.13%	8.67	7.08
Czechia	21	14	10	3.99%	4.26%	20.42	13.42
France	38	20	18	7.22%	6.08%	42.33	20.75
Germany	48	34	27	9.13%	10.33%	46.17	32.92
Italy	136	86	90	25.86%	26.14%	136.50	93.67
Japan	100	71	58	19.01%	21.58%	94.92	70.92
Poland	8	2	2	1.52%	0.61%	8.00	1.92
Spain	120	71	66	22.81%	21.58%	115.25	70.83
Switzerland	18	13	13	3.42%	3.95%	17.17	13.00

The LST-1





Large mirror area → low energy threshold (~20 GeV)

- ideal instrument for soft sources (pulsars, distant AGNs and GRBs, …)
- Low energy threshold = more photons: study variability at shorter time scales

The LST-1

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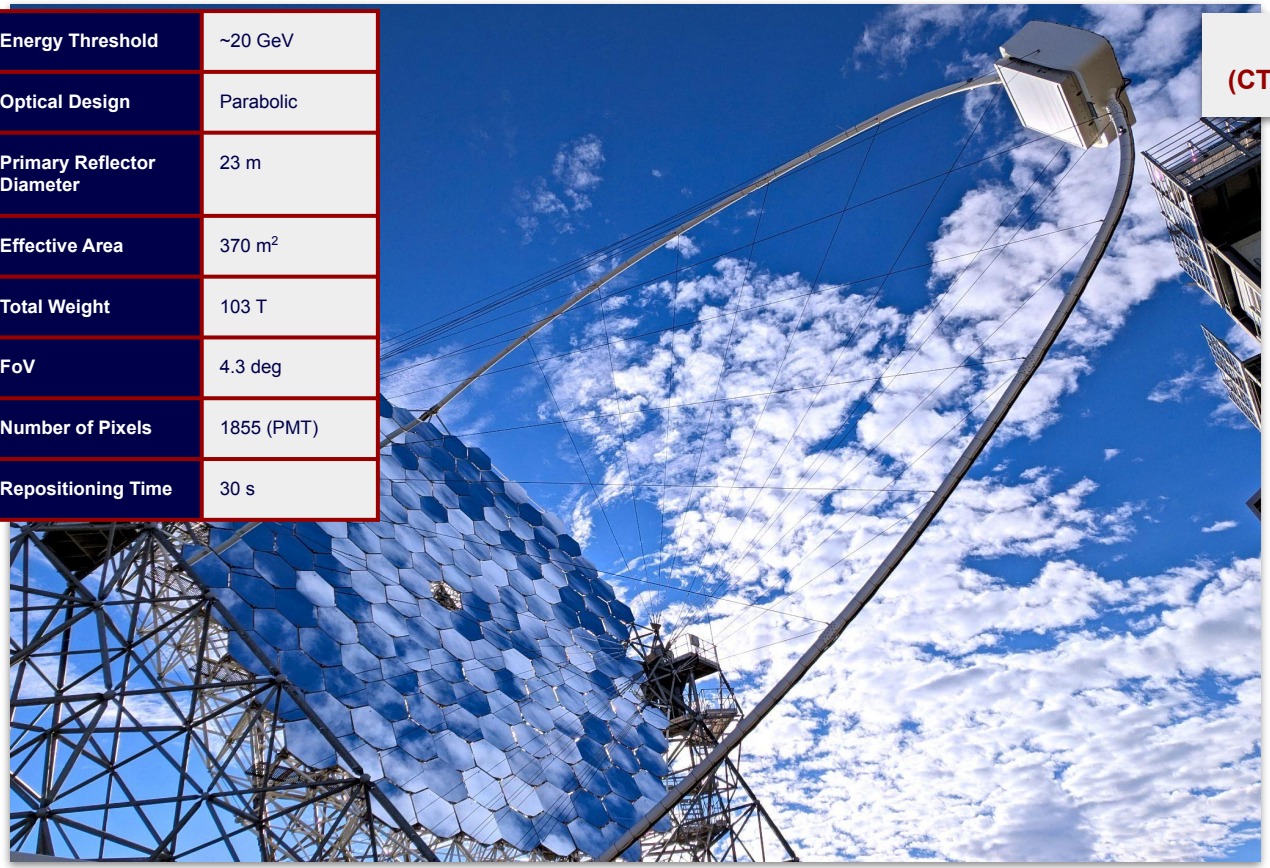
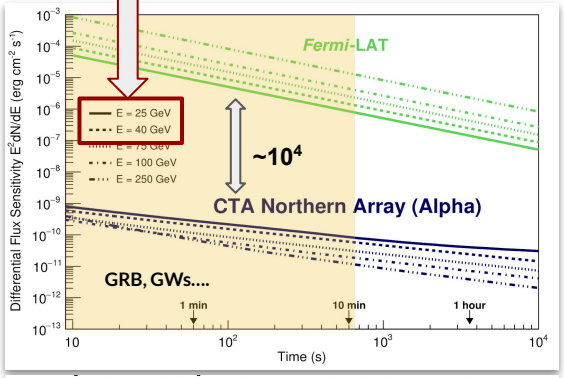
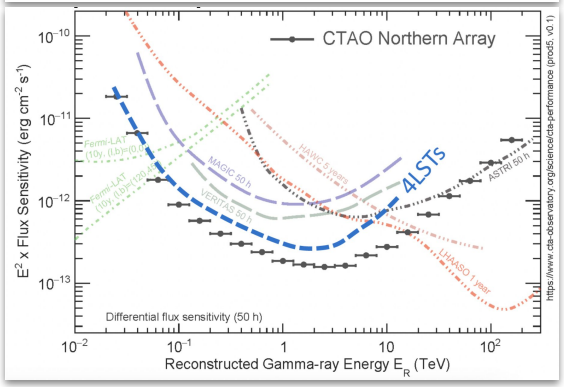
Energy Threshold	~20 GeV
Optical Design	Parabolic
Primary Reflector Diameter	23 m
Effective Area	370 m^2
Total Weight	103 T
FoV	4.3 deg
Number of Pixels	1855 (PMT)
Repositioning Time	30 s

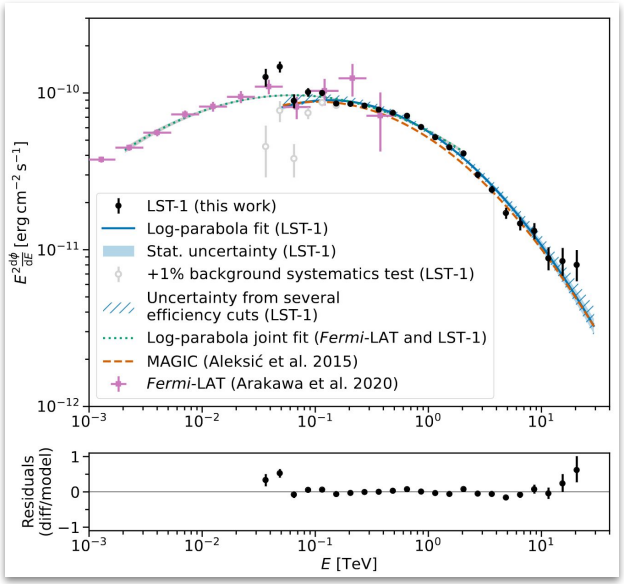


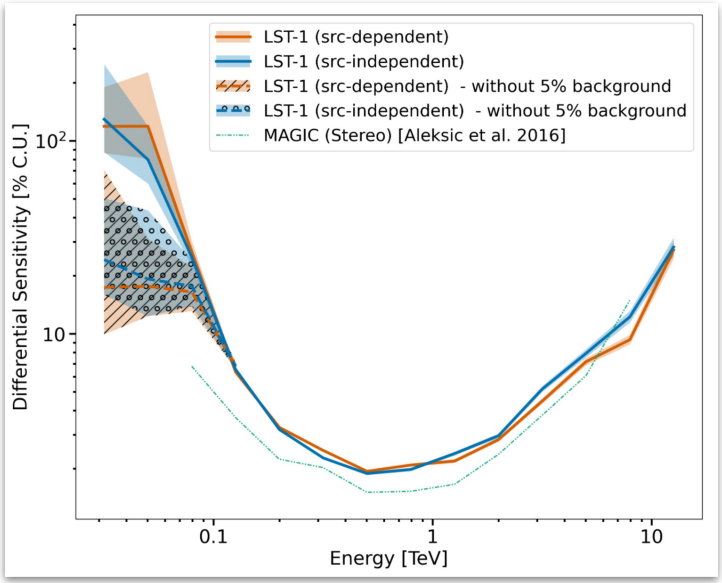
LST "sweet range"
(CTA sensitivity dominated by LSTs)





LST-1: performance





E_{th} ~ 20 GeV

Energy resolution: ΔE~15%-50%

Flux sensitivity: ~ 1.1% Crab @ > 250 GeV (5σ/50h)

Angular resolution: 0.1º-0.4º

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

- Sensitivity evaluated with real Crab Nebula data: energy range widened to lower energy compared to MAGIC (SED measured down to 30 GeV)
- MAGIC (stereo system) ~1.5 x better sensitivity then LST-1 (mono) - As expected by the difference between mono and stereo systems
- Systematics from background begin to dominate below 50 GeV → will be reduced with stereo trigger

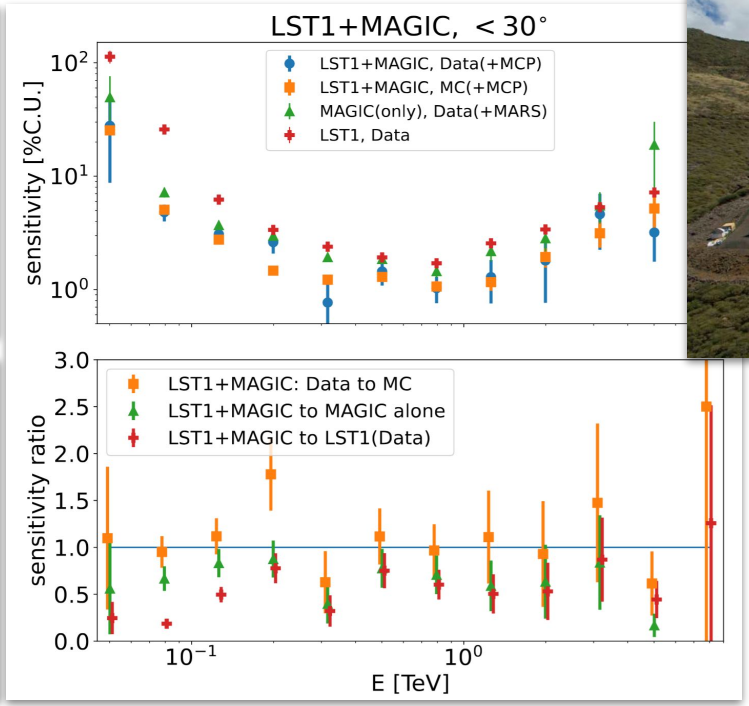
The ORM landscape

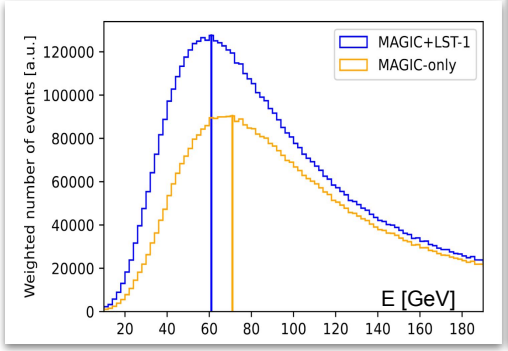
All LSTs will be completed by 2026

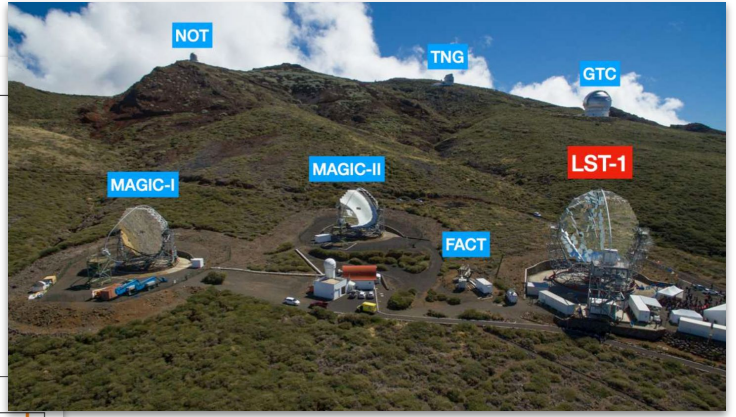
Official LST-array inauguration on October 15th 2026

LST-1+MAGIC

- Separation between MAGICs and LST-1 is ~100m. A dedicated pipeline is in place to analyze stereo MAGIC & LST data







- joint observations allow detection of 30% (40%) lower fluxes than MAGIC alone (LST-1 alone) (better background suppression)
- "Performance paper"

A&A, 680, A66 (2023)

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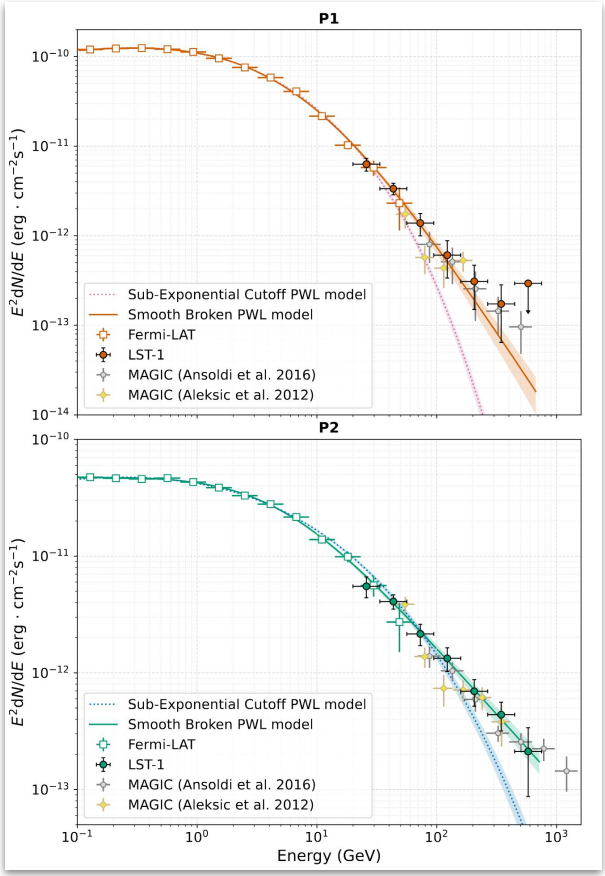
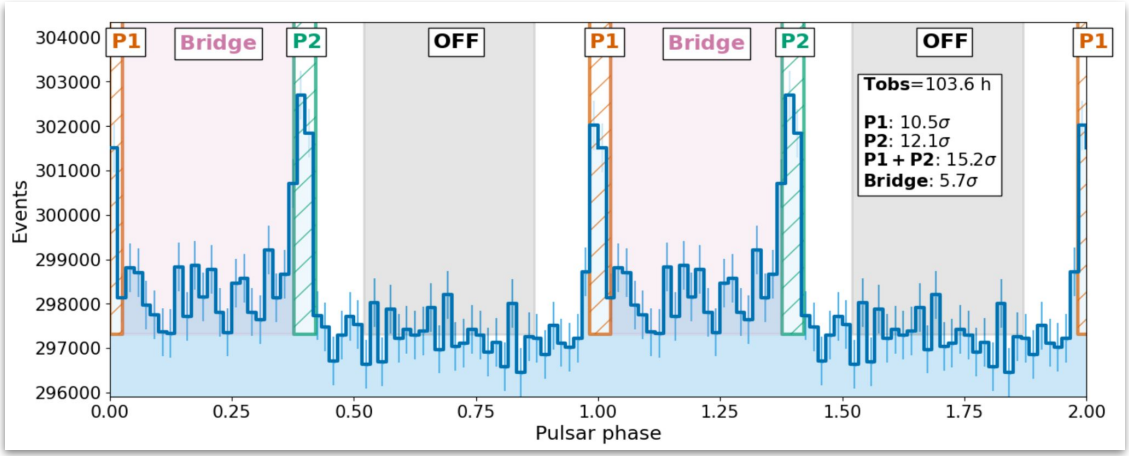
First LST-1 Results

LST-1: early science





A detailed study of the very-high-energy Crab pulsar emission with the LST-1
A&A, 690, A167 (2024)

Detection of Crab Pulsar:

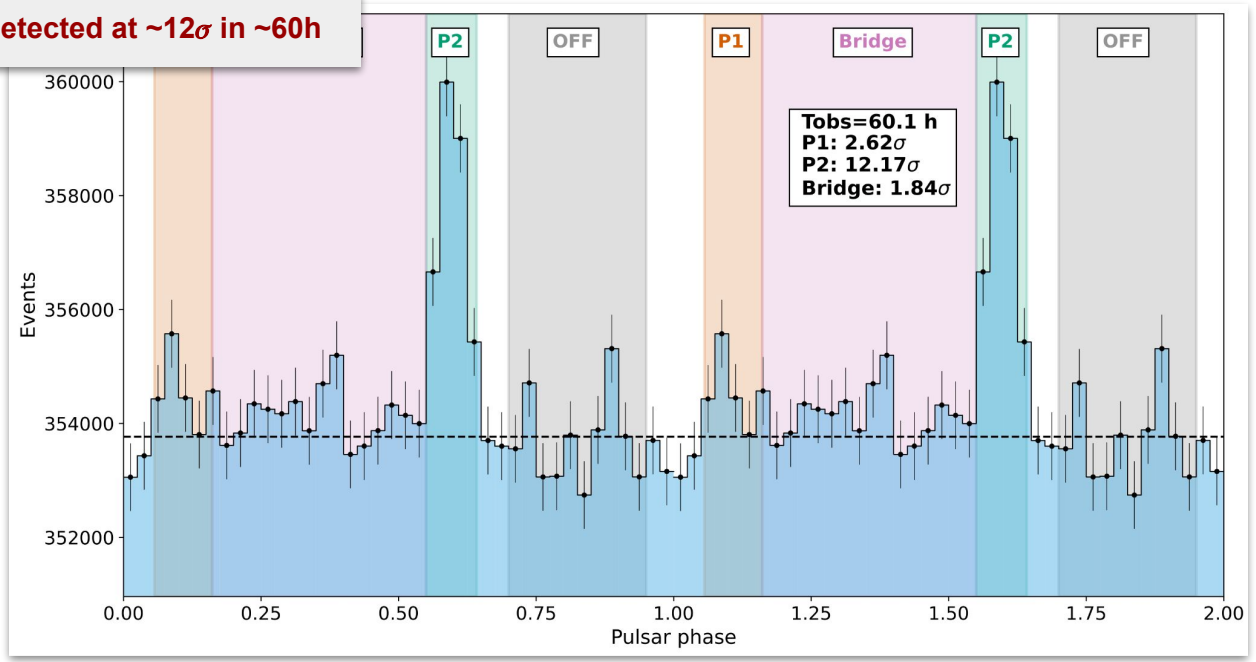
- ❏ Source physics + telescope performances (threshold, cross-calibration, energy resolution…)
- ❏ Clear detection of P1 and P2 → **Ethr down to ~20 GeV**
- ❏ Smooth transition between *Fermi*-LAT and LST-1

Geminga (PSR J0633+1746)

- **Performance at lower energies confirmed by the detection of Geminga (PSR J0633+1746)**

- Being a soft spectrum source, the detection of Geminga confirms the good performance in the 15-30 GeV band, one of the main scientific drivers of LST
- **P1 undetected** (2.6σ hint => 200h for a 5-σ signal)
- MAGIC: 6.3σ after 80 hours for P2
  (MAGIC coll., A&A 643 (2020) L14)

Detected at ~12σ in ~60h



Abe et al. (LST Coll.), A&A, 2025, 698, A283

Transients Follow-up

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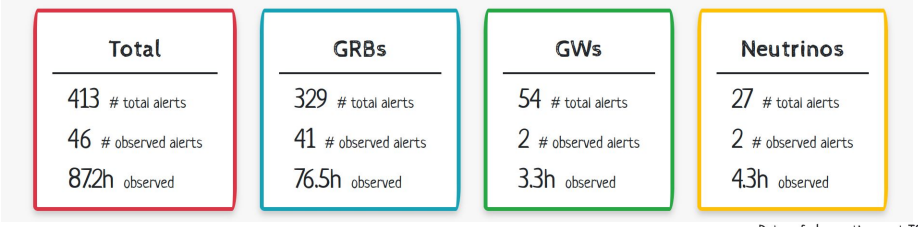
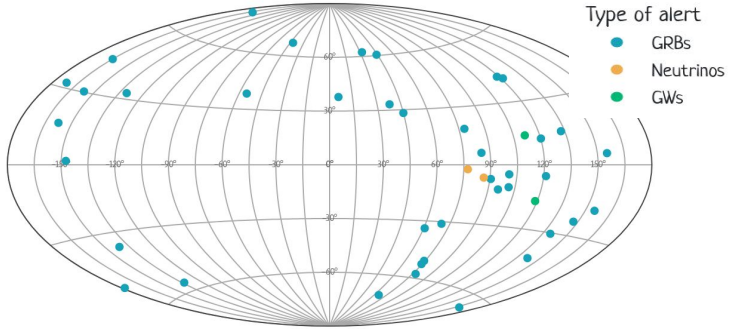
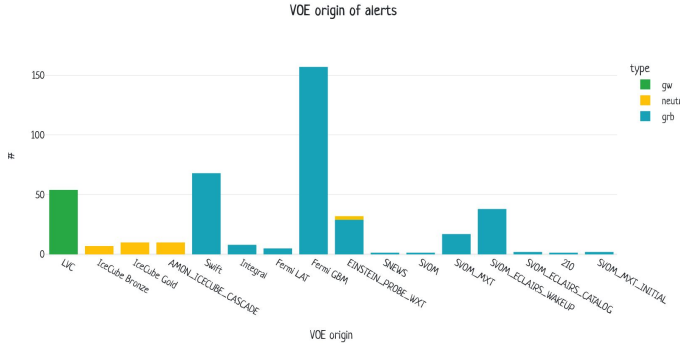
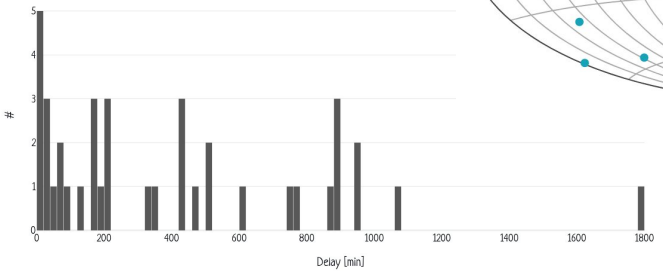
- **LST is built for transients (low energy threshold & fast repointing)**
  - First follow-up started at the end 2020/beginning of 2021
  - Routine follow-up on a wide range of transients - some of them in joint mode

  - Dedicated TH and automatic follow up procedure have been implemented
  - Large uncertainty alerts (i.e., GW) handled by tilepy (M. Seglar-Arroyo et al., ApJS 274, 1 (2024))

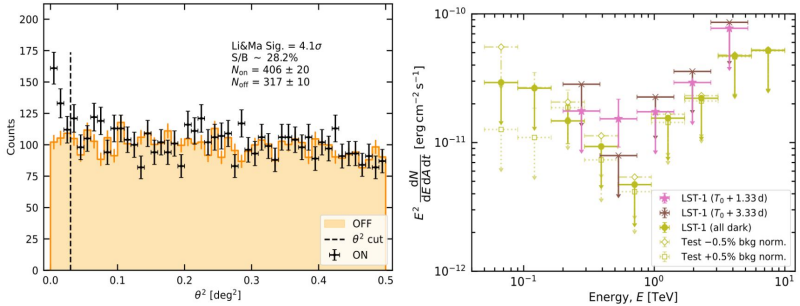


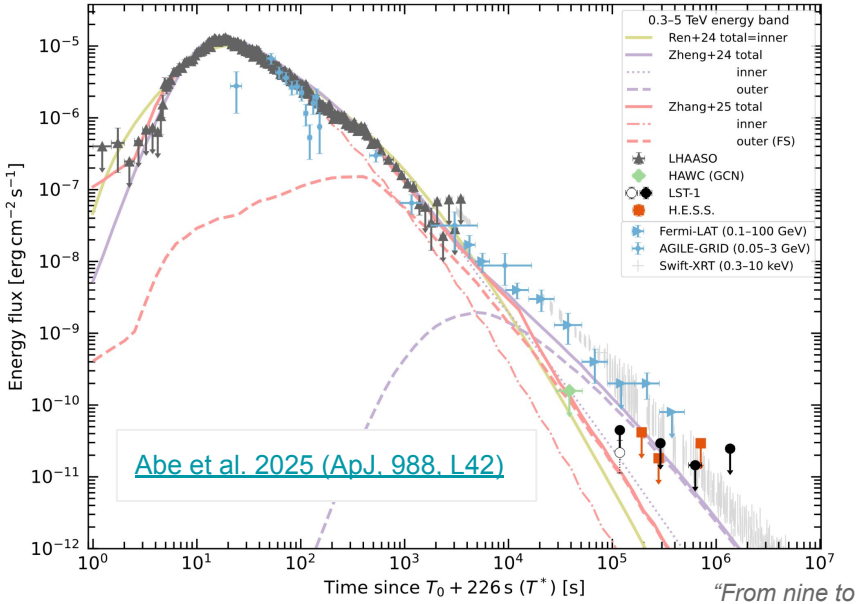






BOAT follow up by LST-1





GRB deeply entering in the TeV band with **GRB 221009**

The brightest of all time ("The BOAT") GRB

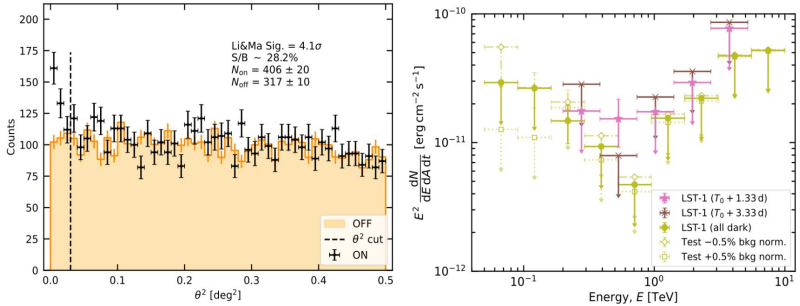
- E_{iso} ~ 2x10^{54} erg, z = 0.151
- only 1 event expected every ~10^3 yr (or even 10^4 yr)
- Peak energy flux reaching ~ 10^5 Crab Units
- detected up to **~13 TeV** with LHAASO but not with IACT

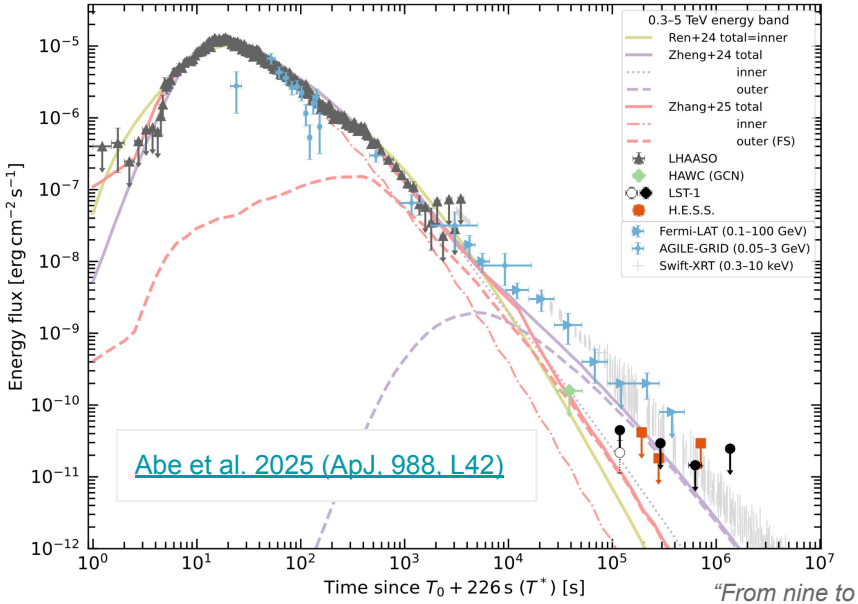
LST observation:

- 2022/10/10 ~21:34 UTC T_0 + 1.1 x 10^5 sec (~31 h, red. HV)
- First two observing nights under strong moonlight
  + Several days under dark/low moonlight afterwards

Large effort for analysis optimization of moon data

BOAT follow up by LST-1





Abe et al. 2025 (ApJ, 988, L42)

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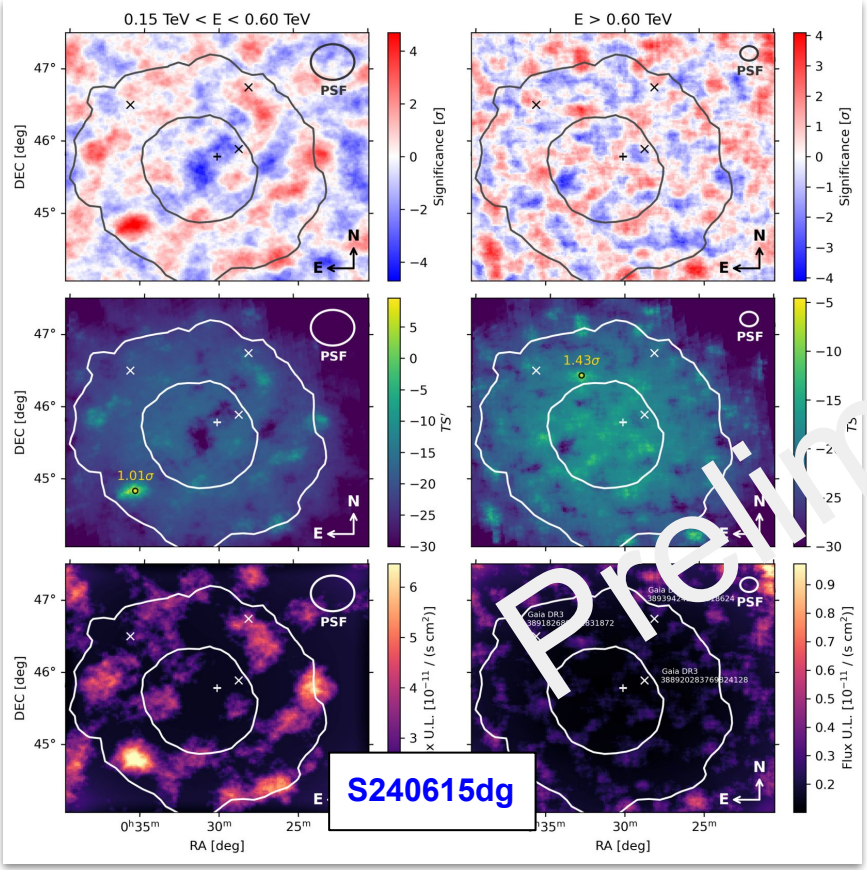
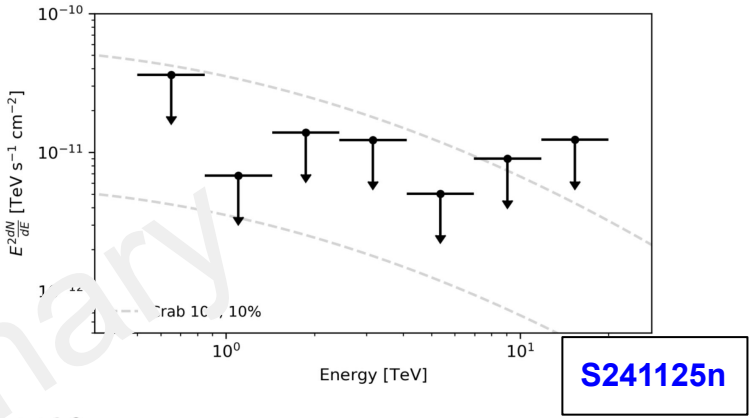
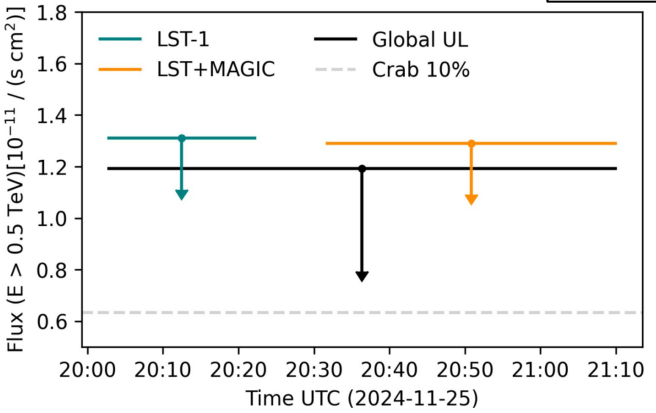
- only 1 event expected every ~10^3 yr (or even 10^4 yr)
- Peak energy flux reaching ~ 10^5 Crab Units
- detected up to **~13 TeV** with LHAASO but not with IACT

- 4.1σ hint of a signal
- Bridges the HAWC and H.E.S.S. ULs at late afterglow phase, constraining between the models of the jet structure

Gravitational waves





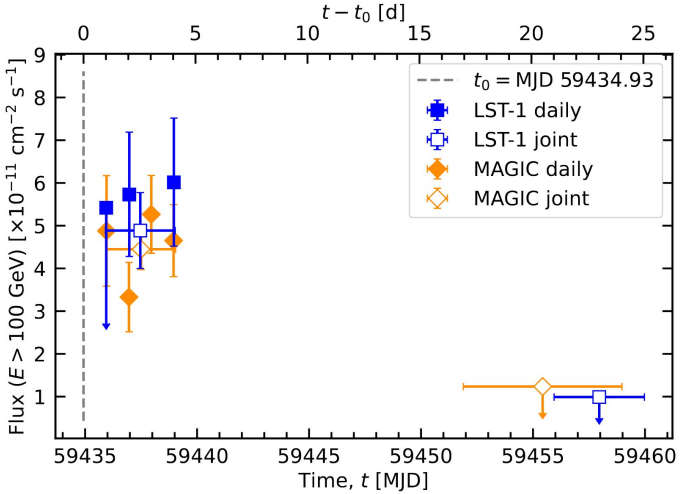


Preliminary

Accepted for publication

RS Ophiuchi Nova

Novae are thermonuclear explosions caused by accumulation of material from donor star on a surface of a white dwarf (WD)



- System **is not** disrupted after the nova event -> cycle restarts
  - Most novae detected only once:
  - Outburst once every (hundreds of) thousand years

- Some novae show repeated outbursts within few years/human lifetime: recurrent novae (RN)
  - 10 known RN in the Galaxy with repetition rate <100 y
  - For a symbiotic nova to be RN, the WD must be massive

(≥1.1 M ⊙) (if M > 1.44 M ⊙ → Sn Ia)

Observation day	Γ	ϕ_0 [10^{-10} TeV^{-1} cm^{-2} s^{-1}]
Day 1	-4.2 ± 0.3	3.3 ± 1.3
Day 2	-3.65 ± 0.13	5.9 ± 1.0
Day 4	-3.50 ± 0.15	5.9 ± 1.1
Day 1, 2 and 4	-3.73 ± 0.10	5.2 ± 0.7

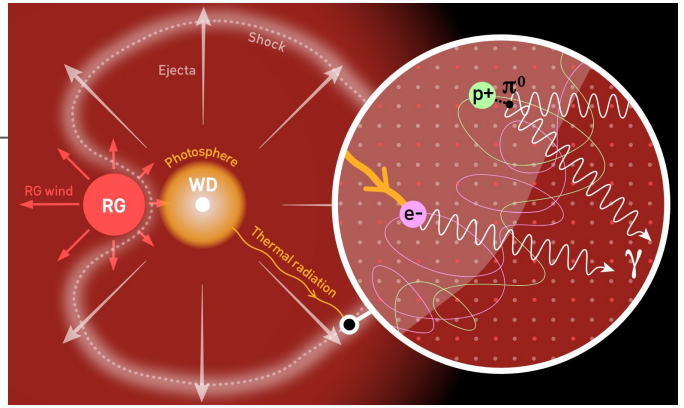
RS Oph is a recurrent symbiotic nova which displays major outbursts every 14.7 years

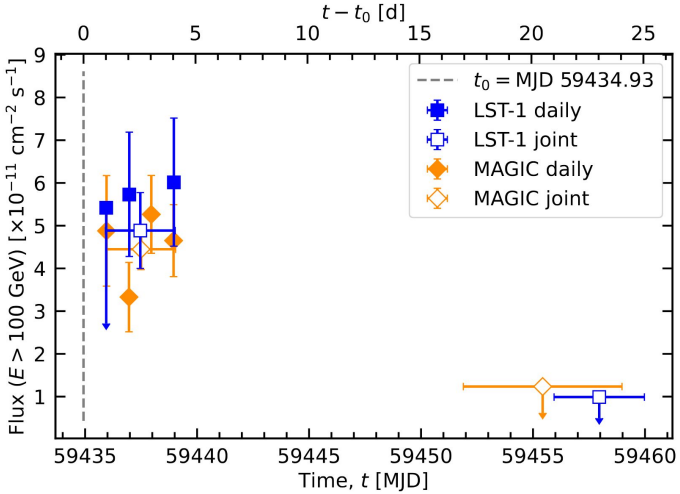
Observed and detected on August 2021 by both MAGIC and LST-1

Novae established as a new type of VHE emitters

RS Ophiuchi Nova

Novae are thermonuclear explosions caused by accumulation of material from donor star on a surface of a white dwarf (WD)





[LST Coll. 2025, A&A, 695A.152A](#)
MAGIC Coll. 2022, Nat Astron 6, 689

- Evidence for a spectral hardening as novae evolves and increase in cutoff energy
- Hadronic model preferred

Observation day	Γ	ϕ_0 [10^{-10} TeV^{-1} cm^{-2} s^{-1}]
Day 1	-4.2 ± 0.3	3.3 ± 1.3
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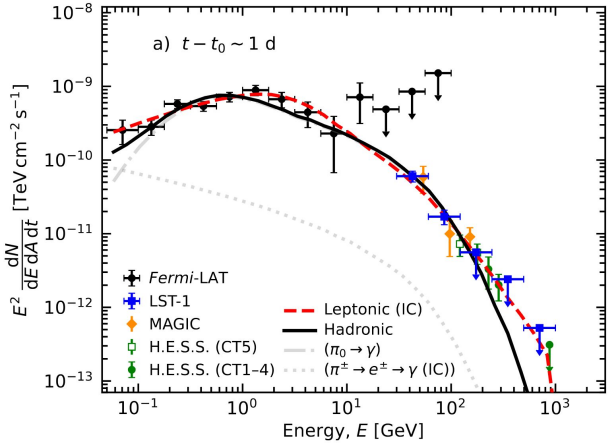
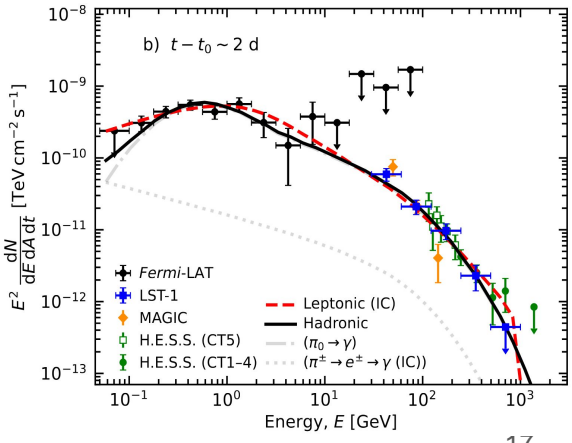
Day 1, 2 and 4	-3.73 ± 0.10	5.2 ± 0.7





CC SNe

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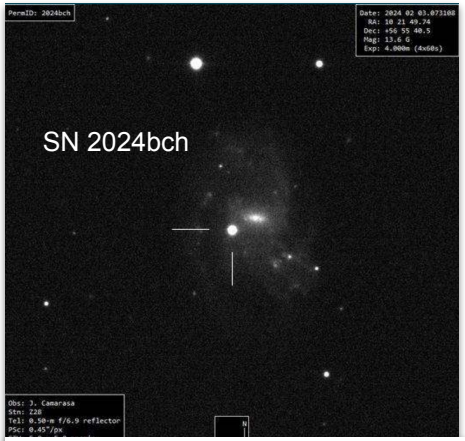
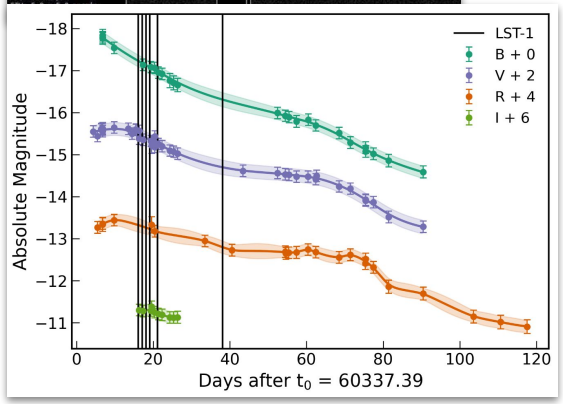
- Discovered 2023-05-19 07:45:07 UTC in M 101
- z= 0.000804 the closest CCSNe observed by MAGIC (~6.4 Mpc)
- Type II SN Likely RSG progenitor
- MAGIC and LST-1 observations started on May 20th 2023

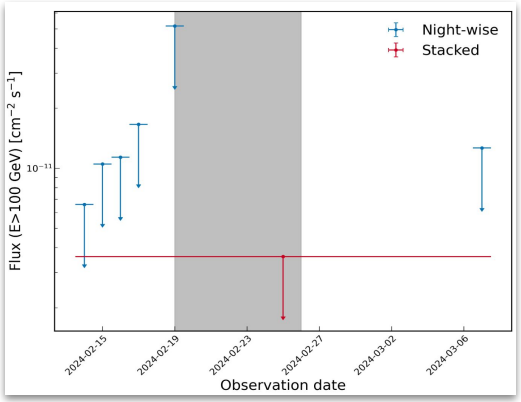
paper in preparation



CC SNe are Multimessenger and multiwavelength source …likely also at VHE

- Discovered on Jan 29, 2024
- D = 17-20 Mpc
- CCSN of type IIn-L
- 14 h of LST-1 over 6 nights.





Abe et al. A&A, 2025, 702, 125

CC SNe

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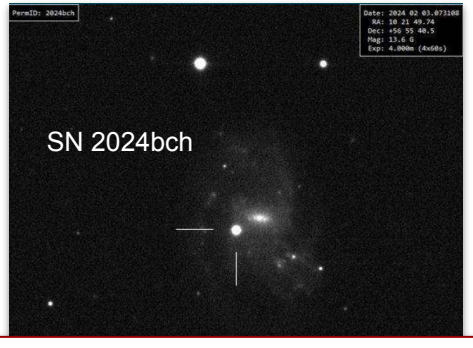

CC SNe are Multimessenger and multiwavelength source …likely also at VHE

- Discovered on Jan 29, 2024
- D = 17-20 Mpc
- CCSN of type IIn-L
- …ver 6 nights.

ULs still not constraining over theoretical models but exciting perspective for the LSTs array and CTAO

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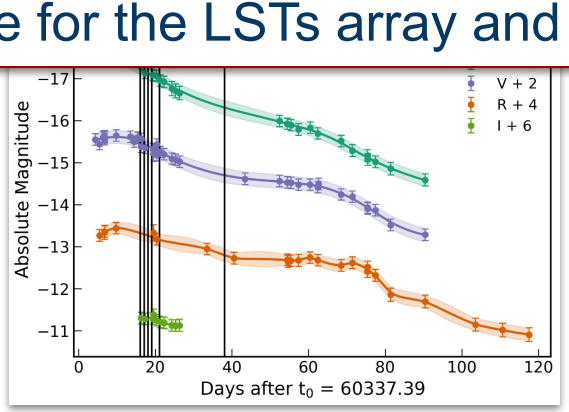
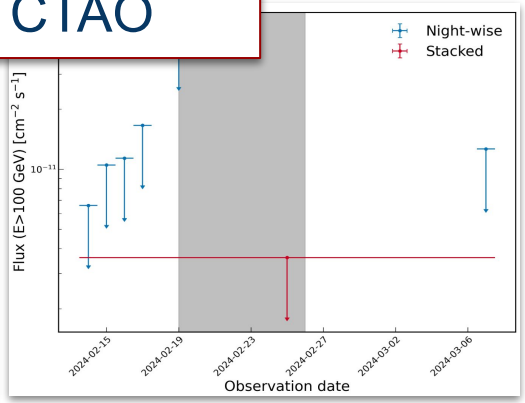
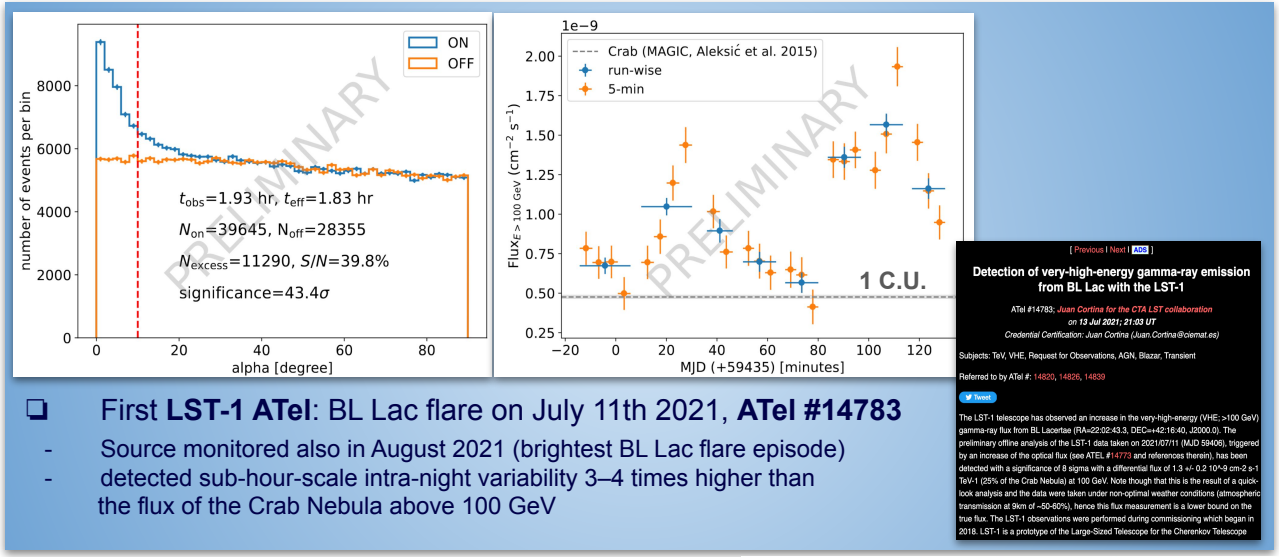
paper in preparation





Abe et al. A&A, 2025, 702, 125

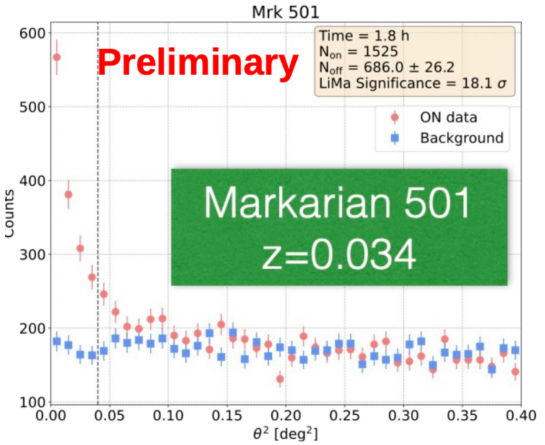
(old) extragalactic friends

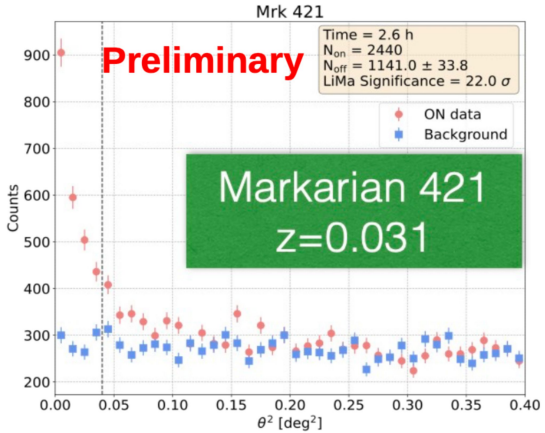


- First **LST-1 ATel**: BL Lac flare on July 11th 2021, **ATel #14783**
  - Source monitored also in August 2021 (brightest BL Lac flare episode)
  - detected sub-hour-scale intra-night variability 3–4 times higher than the flux of the Crab Nebula above 100 GeV

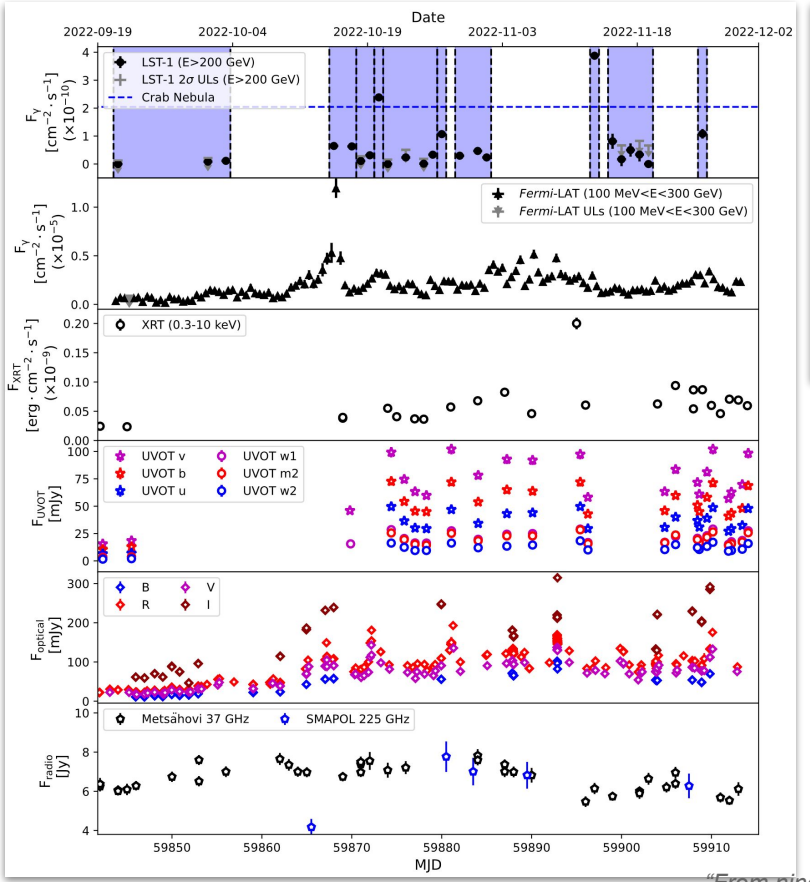
- Detection and monitoring of several known AGNs up to z~0.5
  (Mrk 421, Mrk 501, 1ES 1959+650, 1ES 0647+250, PG 1553+113…)

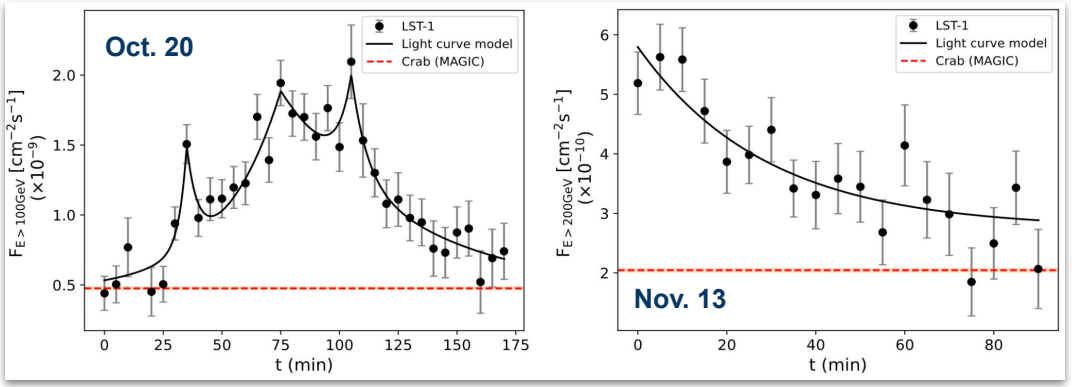
	Mrk421	Mrk 501	1ES1959+650	1ES0647+250	PG 1553+113
AGN type	HBL	EHBL	HBL	HBL	HBL
Redshift	0.031	0.034	0.048	0.45±0.05	0.433
Obs. date	2020/12/12 -2022/05/23	2020/07/10 -2022/06/29	2020/07/11 -2022/05/05	2020/12/16 -2020/12/21	2021/04/08 -2022/05/23
Obs. time BF/AF cut (h)	68.5/31.9	67.2/39.7	21.3/11.8	8.8/8.2	12.2/9.9
Significance	31 σ	21 σ	12 σ	7 σ	16 σ
Condition	Dark (No Moon) + Clear Sky				





BL Lac flare





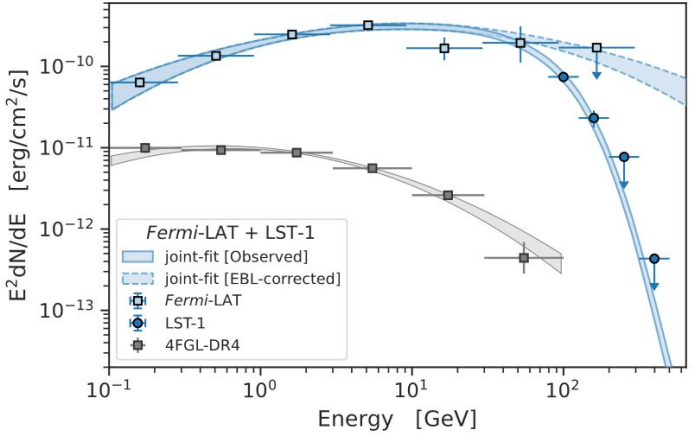
- **Brightest VHE emission** ever detected from this source (up to 4 CU)
- Clear intra-night variability detected on October 20 and November 13, 2022 (flux-doubling variations as fast as ~8 minutes)
- Particle acceleration: shock + magnetic rec.

Abe et al. A&A, 710, A41 (2026)

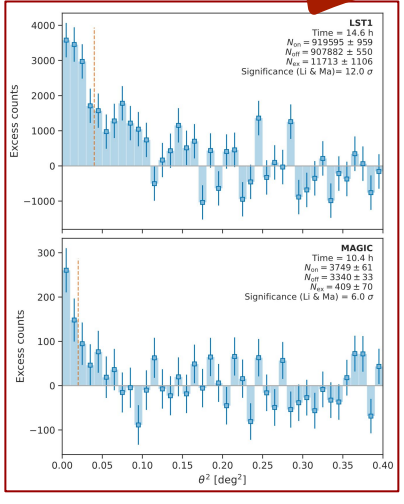
Detection of OP 313

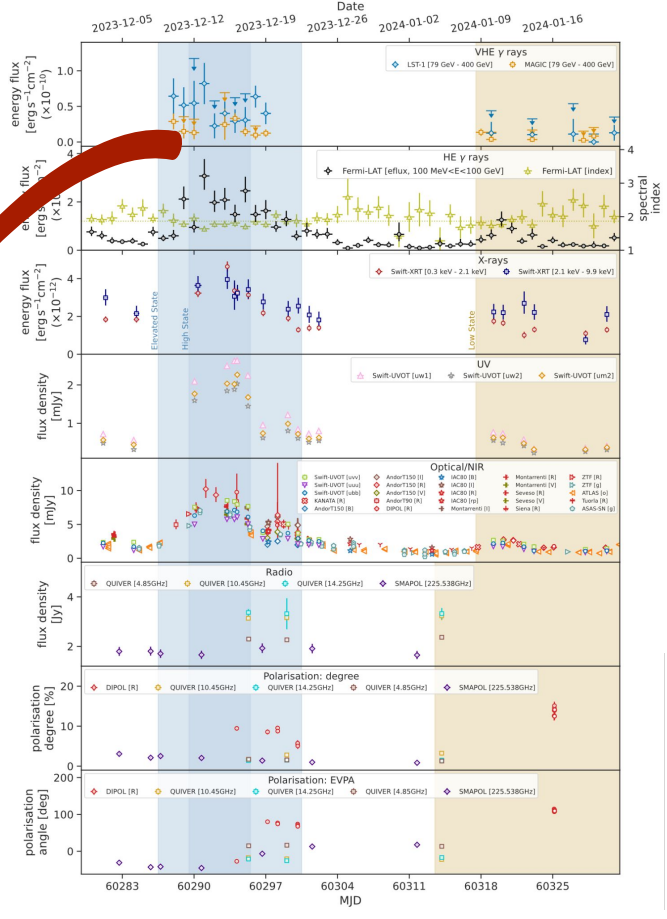
Most distant AGN detected by an IACT, **z = 0.997**

- VHE observations with MAGIC and LST-1 triggered by *Fermi*-LAT in November 2023.
- Only ten FSRQ ever detected in VHE
- Average VHE flux of ~0.28 C.U. during December flare (~15 h)
- Extensive MWL campaign (radio, IR, optical, UV, γ-ray)



Paper accepted for publication
(https://arxiv.org/pdf/2605.26681)





"From nine to forty", Sesto - 2026/07/20

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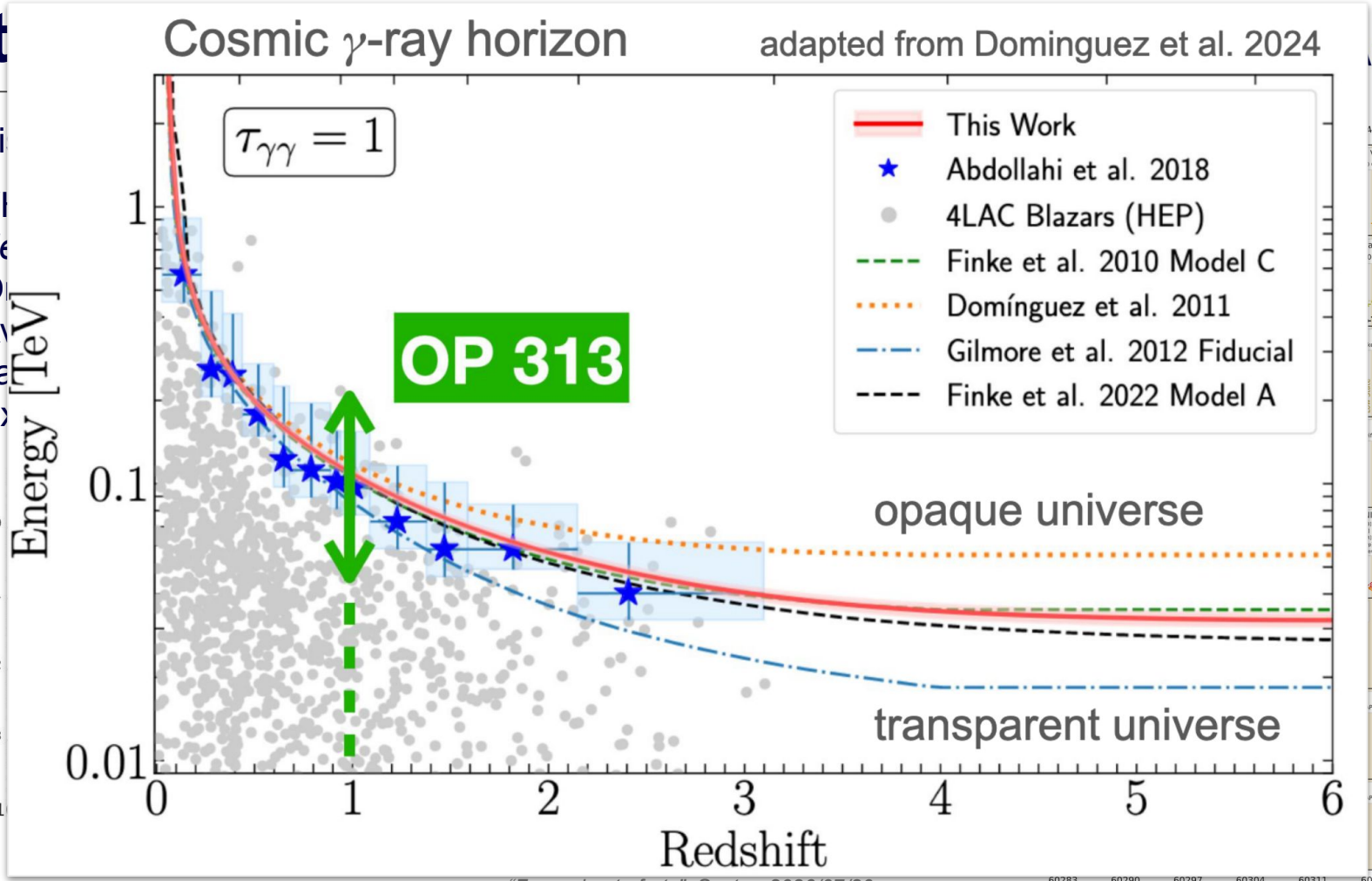
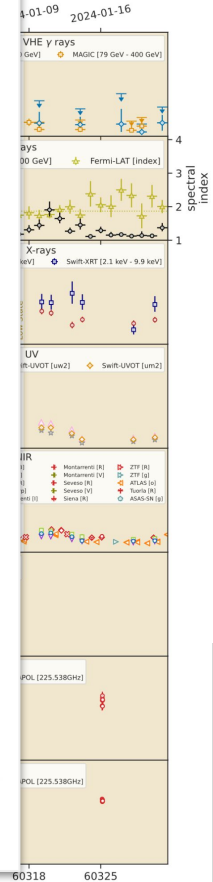
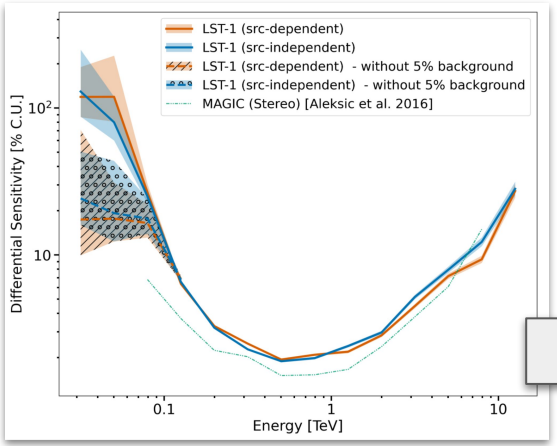




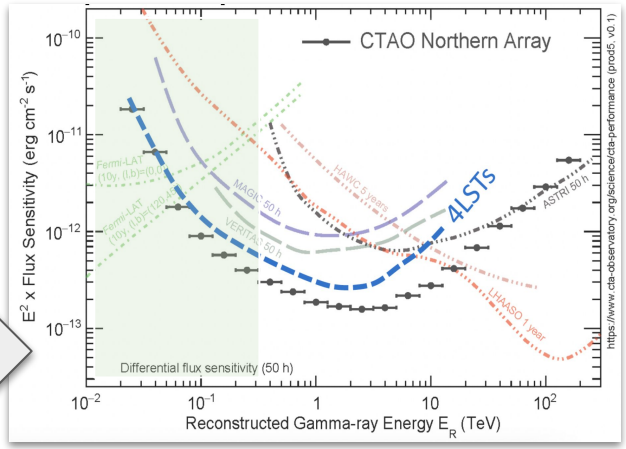
Toward the LSTs array

LST2-4: Structures completed, cameras installed. Very soon commissioning will start

Toward the LSTs array



Timescale
~12 months



In 12 months we will approach the sensitivity of the full CTAO-N array below few hundreds of GeV (10x better than current IACTs)

Conclusions

- The first Large-Sized Telescope (LST-1) of CTAO was inaugurated at the CTAO Northern Array site in La Palma in 2018. Telescope is now ending the commissioning phase.
- LST-1 Science program has been established and is growing rapidly. **Cycle IV of observations has recently started in a joint-mode with MAGIC**.
- Observations and results are coming and they cover a wide range of scientific targets (Galactic sources, transients, TeV Blazars, FSRQs…)....and that's not all! Many other results not mentioned here such as fundamental physics study, dark matter, LIV, interferometry….
- Bright future ahead: LSTs are going stereo soon….
- ….and are going south too!

Thanks for the attention!