

CTA Large Size Telescope Project

Masahiro Teshima for the LST Collaboration



4 LSTs will be fully operation in 2025



LST2

LST3

LST4

LST1 23m ϕ
In operation

MAGIC2 17m ϕ

MAGIC1 17m ϕ

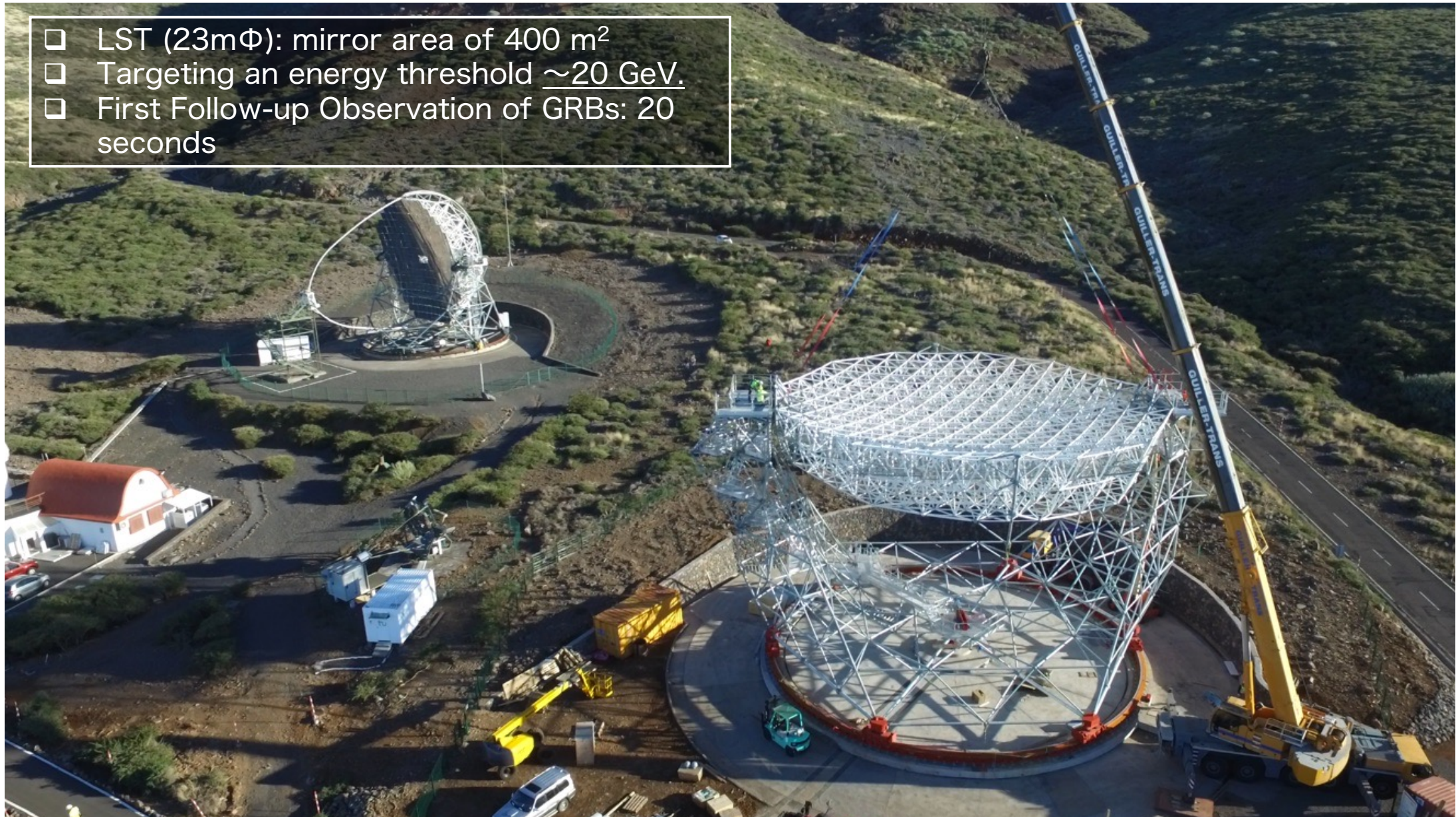


cherenkov
telescope
array

The CTA Large Size Telescope LST1

(Photo under construction in December 2017)

- ❑ LST (23m Φ): mirror area of 400 m²
- ❑ Targeting an energy threshold ~ 20 GeV.
- ❑ First Follow-up Observation of GRBs: 20 seconds





cherenkov
telescope
array

**Commissioning since 2019
including Science Operation since 2020**



The LST collaboration



A collaboration of ~300 scientists and engineers from 11 countries in charge of building the 4 LSTs in CTA-North and the 4 LSTs in CTA-South

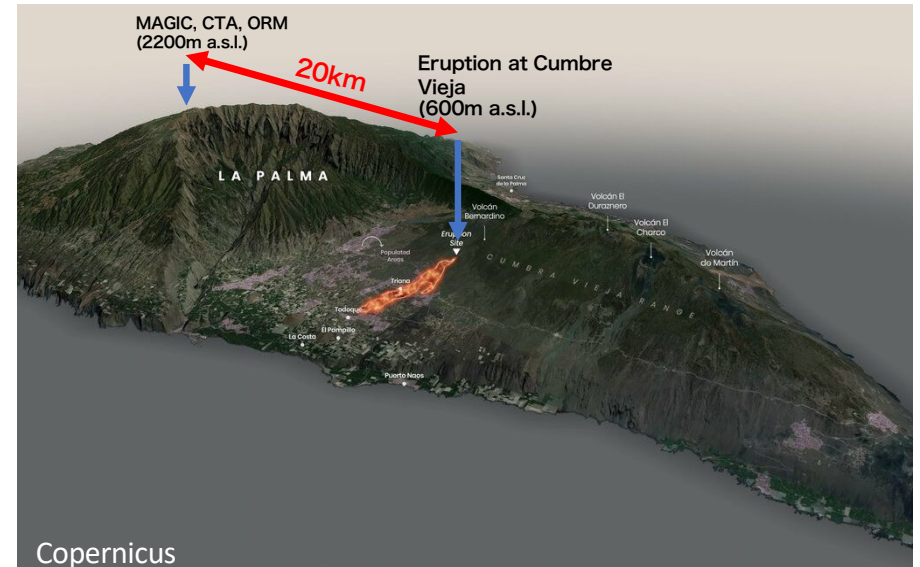
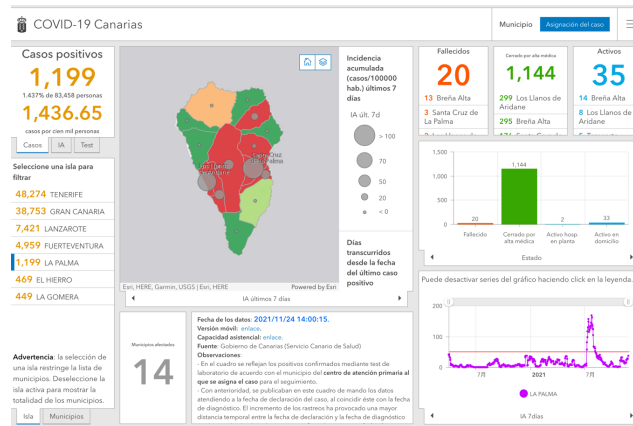
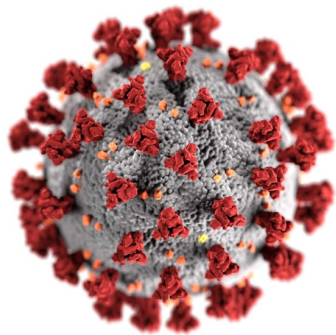


cherenkov telescope array

Last two years, we suffered from several Oh, my God!!

Volcano Eruption

Covid-19



Russian Aggression in Ukraine

Price Increase

Shortage of semiconductors and materials



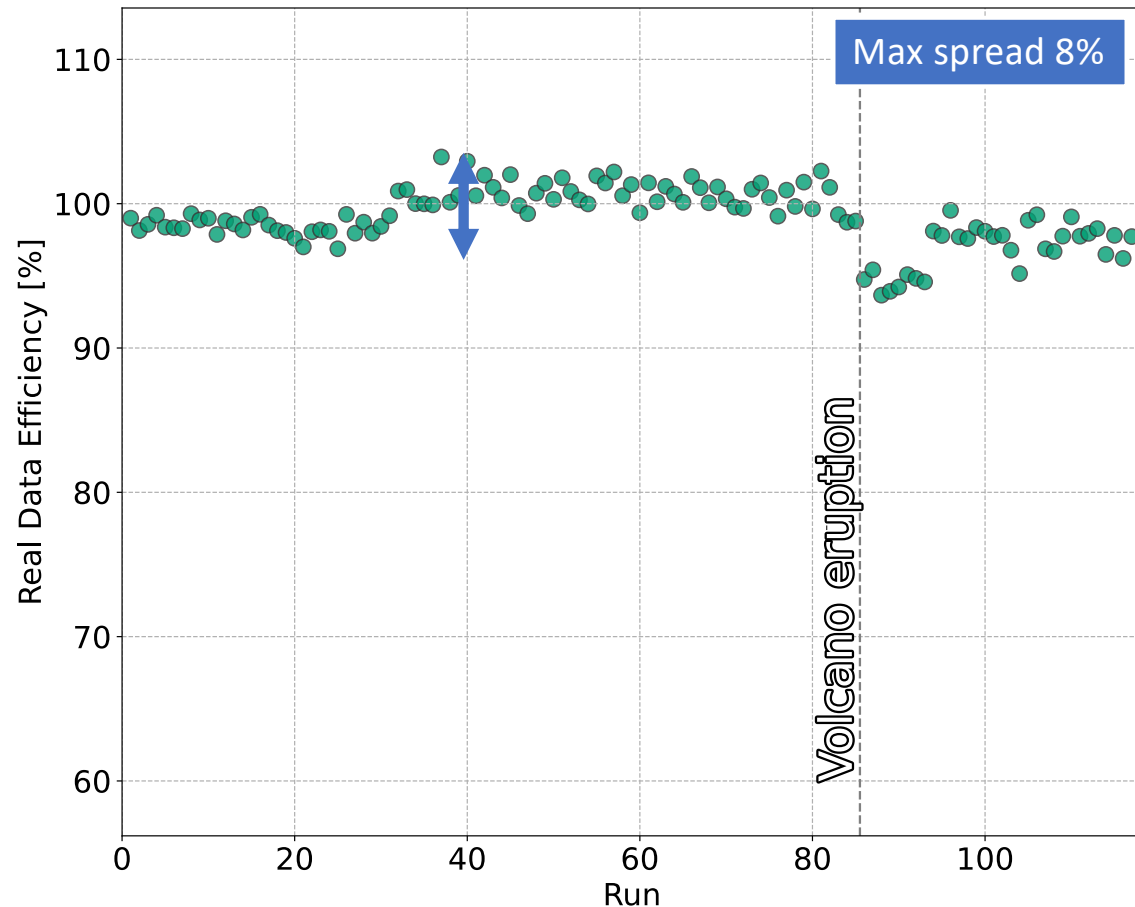
Erupciones históricas en La Palma			
#	Erupción	Año	Días erupción
1	nombre?	2021	85days ?
2	Teneguía	1971	24
3	San Juan	1949	47
4	Charco	1712	56
5	San Antonio	1667/1678	66
6	Tigalate	1646	82
7	Tehuya	1585	84
8	Tacande	1430/1440	?



cherenkov
telescope
array

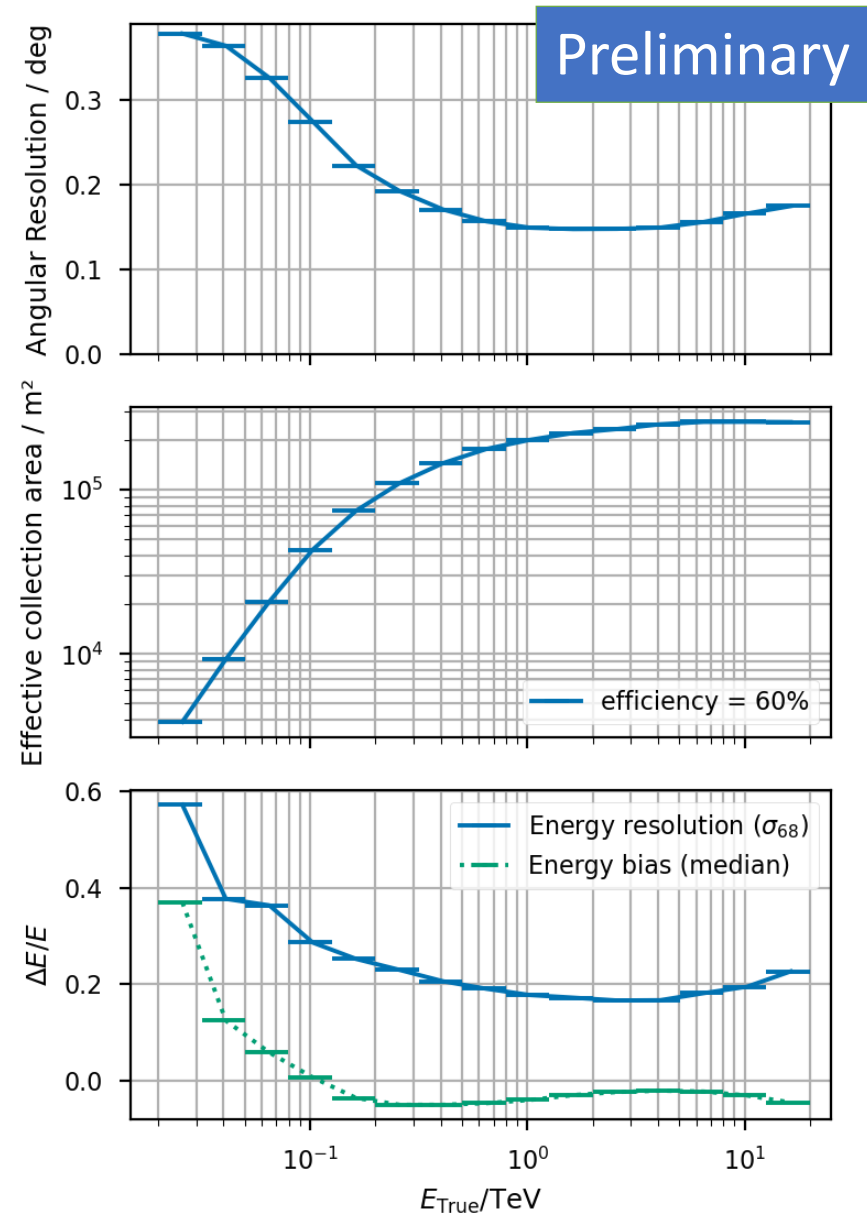
LST-1 performance: Optical Efficiency

- ❑ “Optical efficiency” takes into account mirror reflectivity, mirror focusing, and Camera optics.
- ❑ 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 the volcano: rain cleaned mirrors of volcanic ash.

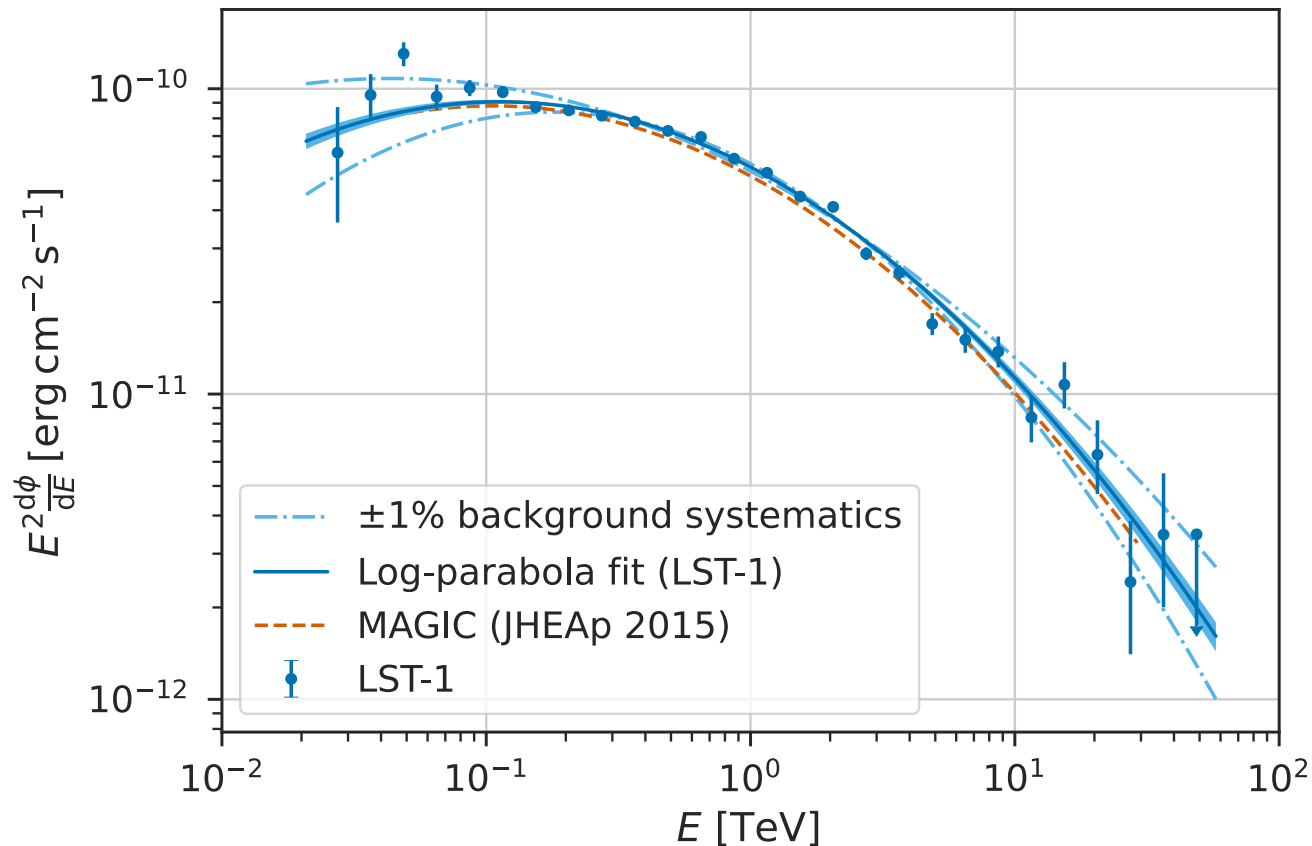


Single Telescope LST-1 performance: effective area, angular+energy resolution

- 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 energy resolution. Still they are competitive down to 100 GeV.
- Effective area $>10^3$ m² down to ~ 20 GeV.

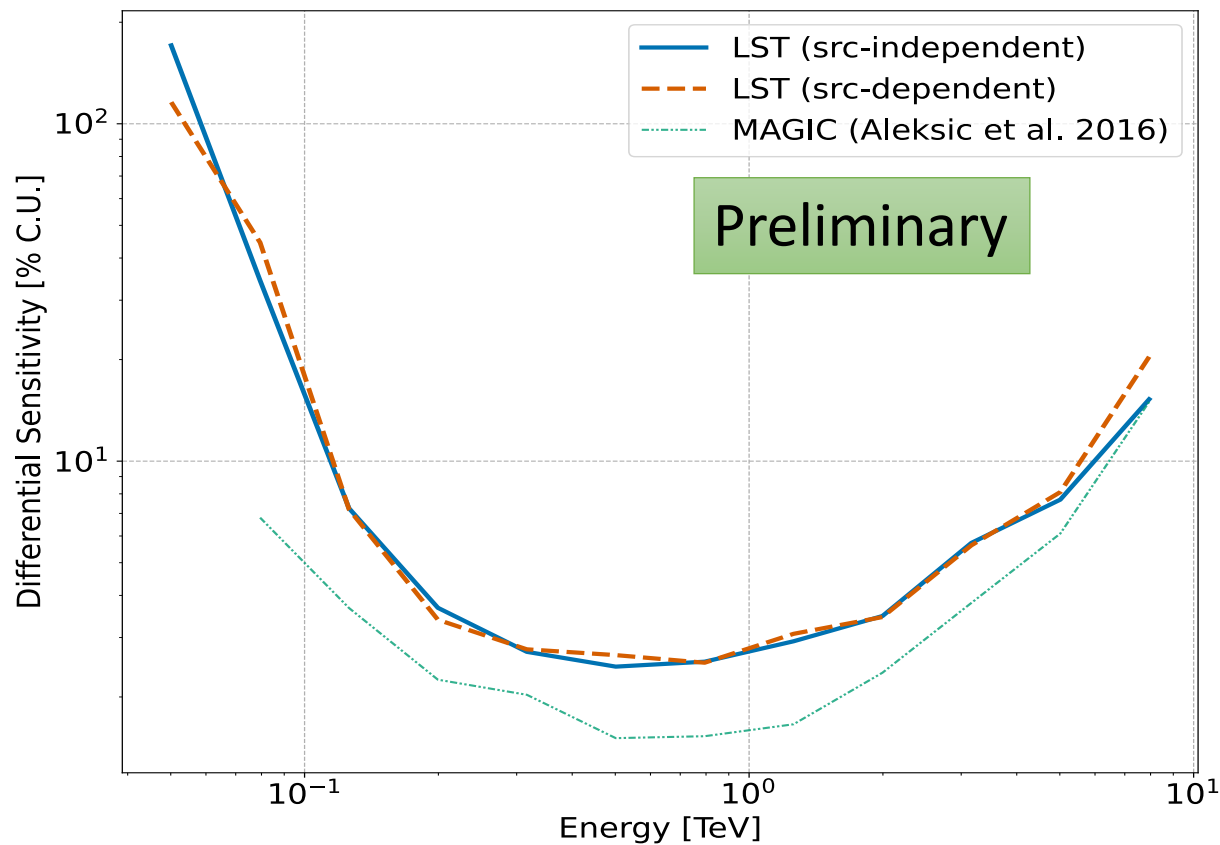


Performance: Crab Nebula spectrum



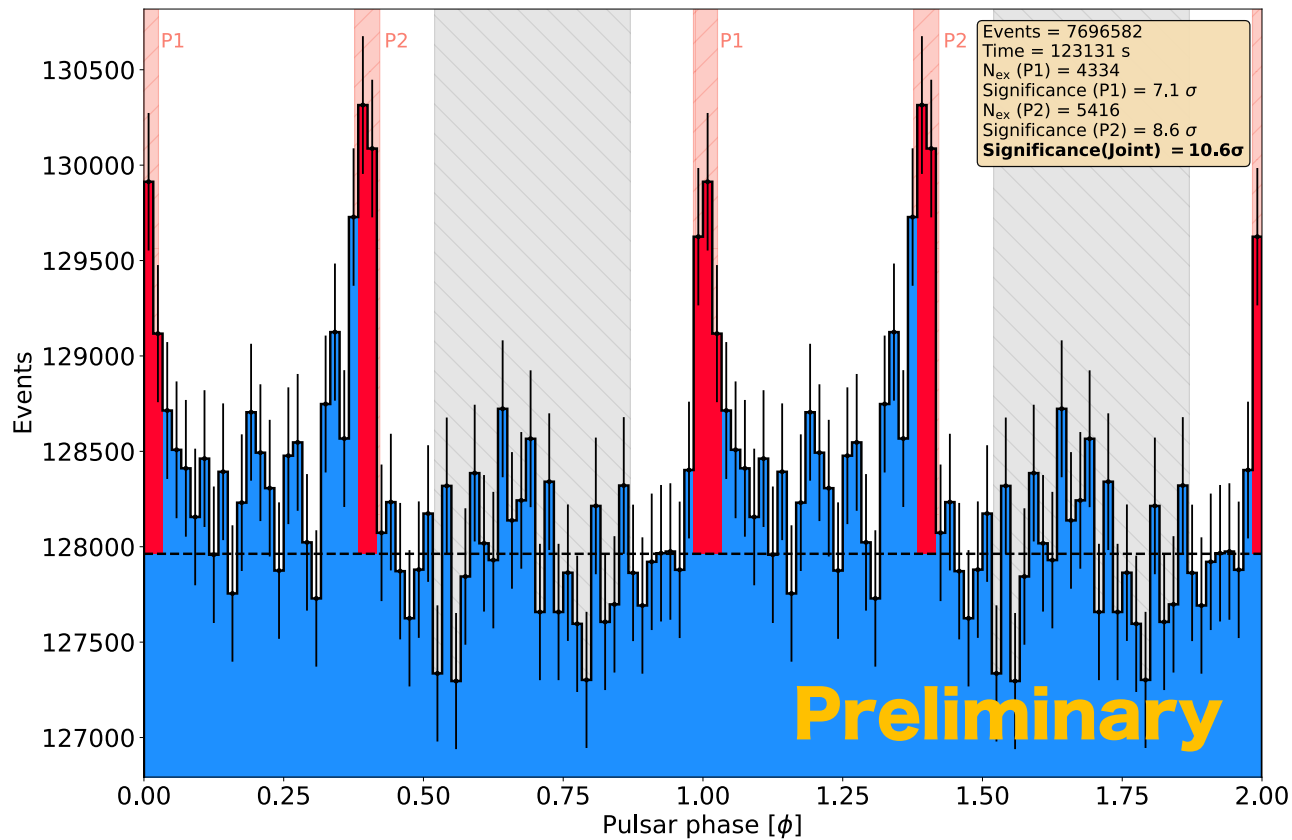
- 34 h effective time, γ -ray efficiency: 70% from gammamass cut and 70% from θ^2 cut
- Error bars are only statistical.
- Systematics: blue lines correspond to effect of $\pm 1\%$ background.
- Consistent with MAGIC and Fermi-LAT.
- Lowest data point at 25 GeV!

Single Telescope LST-1 performance: sensitivity



- ❑ Consistent sensitivity for source-dependent and source-independent analyses.
- ❑ The sensitivity is close to MAGIC stereo array.
- ❑ X10 better sensitivity is expected with 4 LST array

Crab pulsar phaseogram



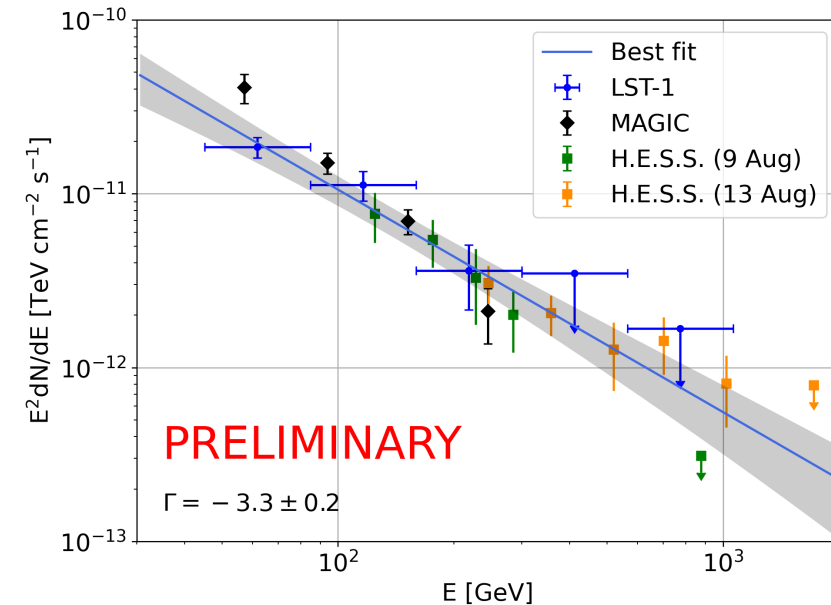
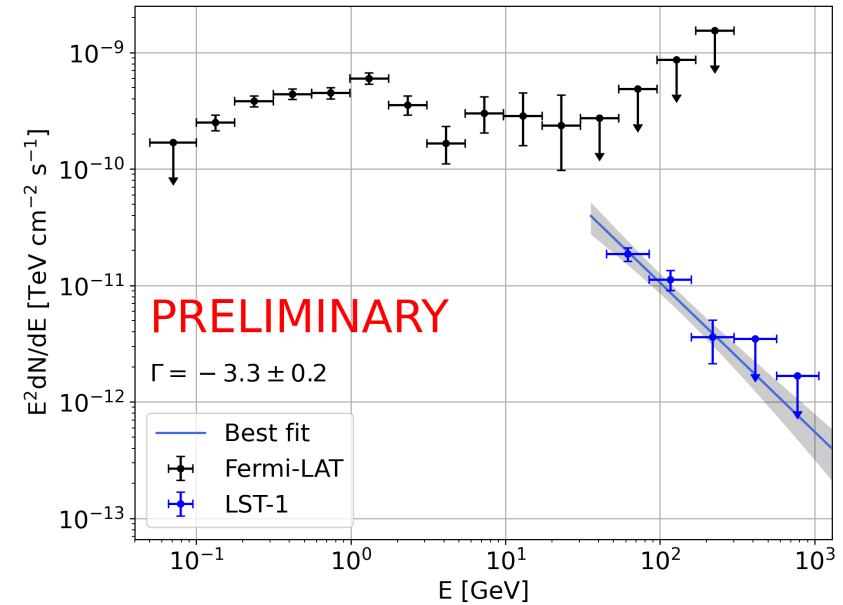
- Observation time: 34.2 hours
- Nov 2020 - March 2022
- Highly significant detection down to few tens of GeV.
- Low energies: P1/P2 tends to 1.
- Stay tuned for spectrum down to few tens of GeV...

First VHE-detected Recurrent nova: RS Ophiuci

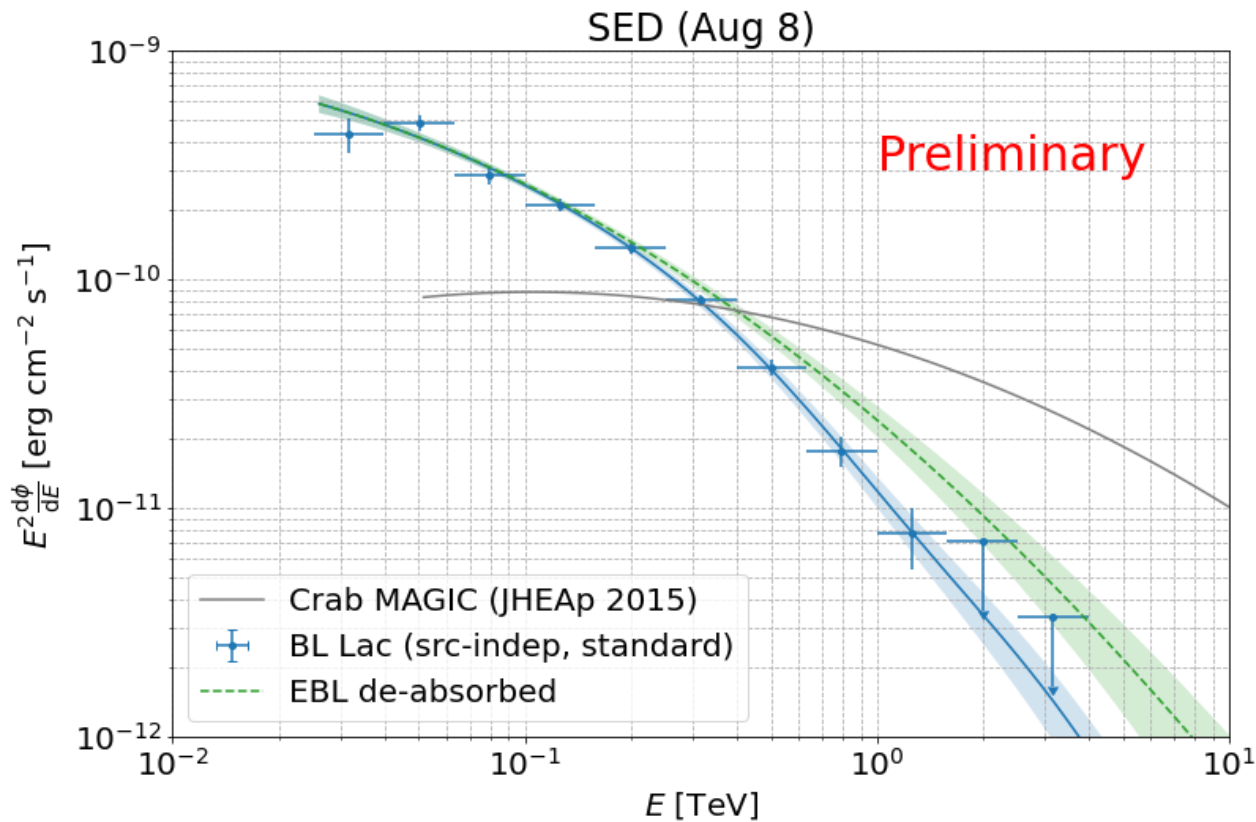
- ❑ RS Ophiuchi is a recurrent Nova.
- ❑ Explosions, 1898, 1933, 1958, 1985, 2006, **2021**
- ❑ Mag 12.5 (low state) → Mag 4.7 (~1000 times)
- ❑ Binary System with a White Dwarf and a Red Giant
- ❑ Accumulation of material on the WD, and then thermonuclear reaction makes recurrent explosions



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

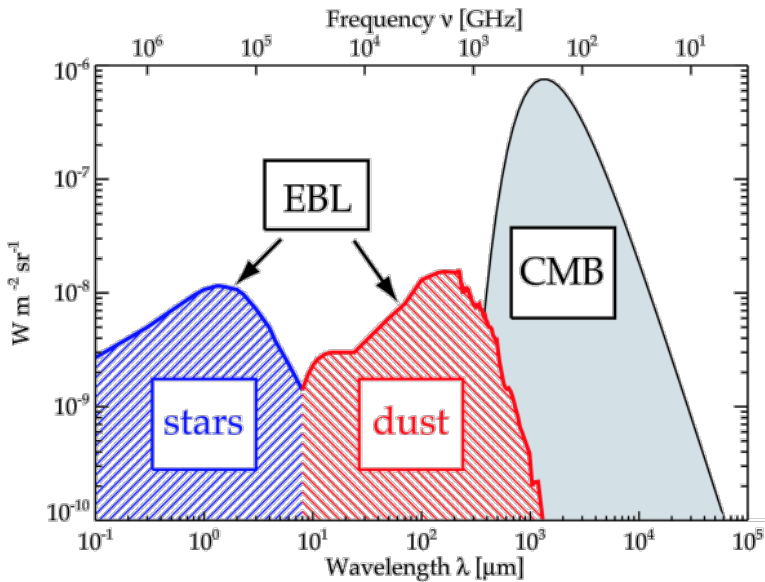
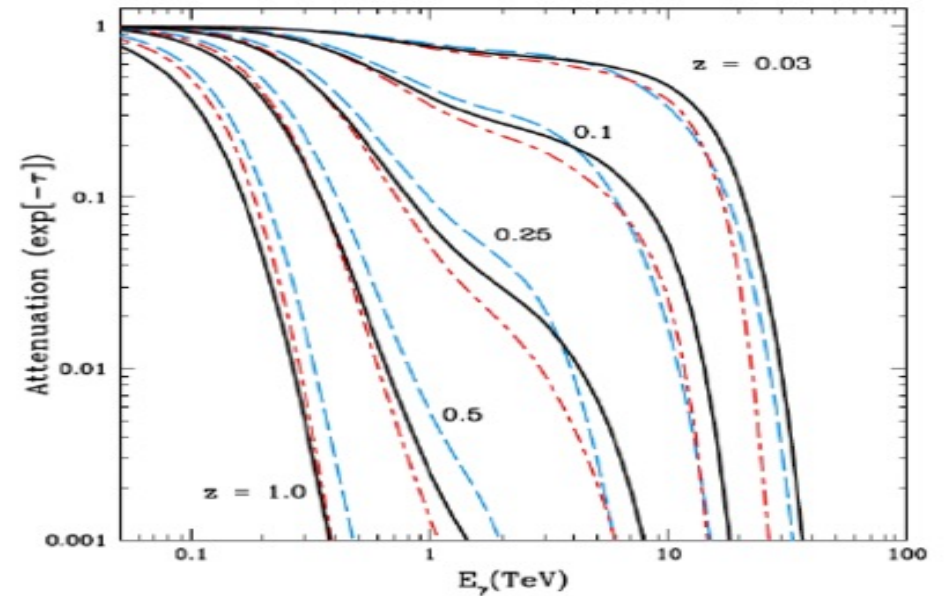
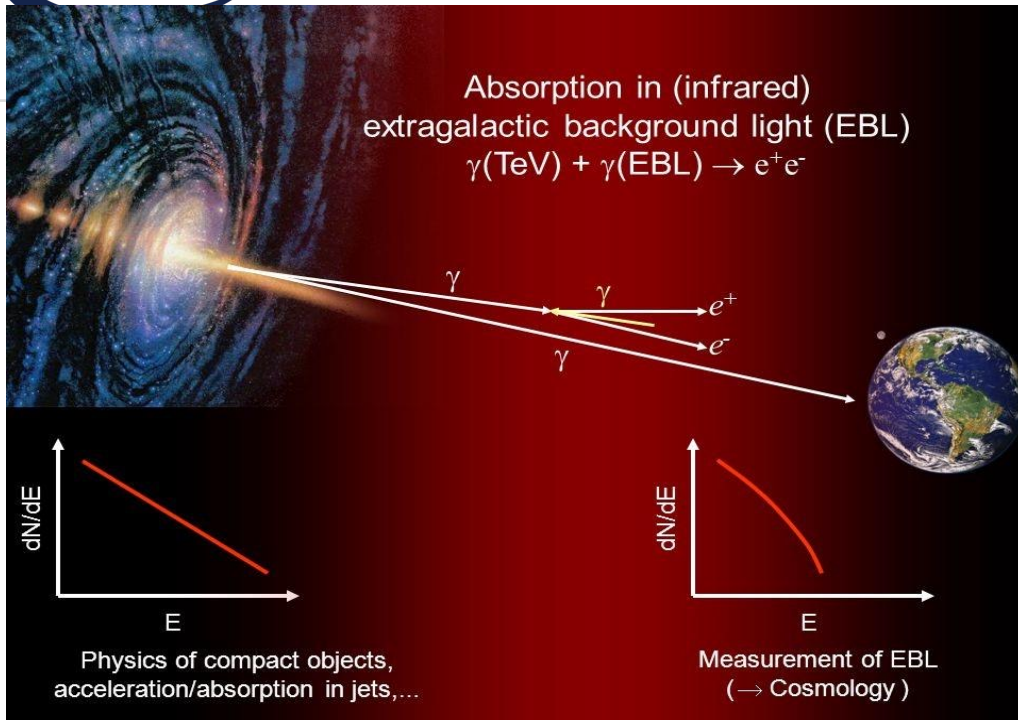


BL Lacertae flare on 8th August 2021



- ❑ 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.

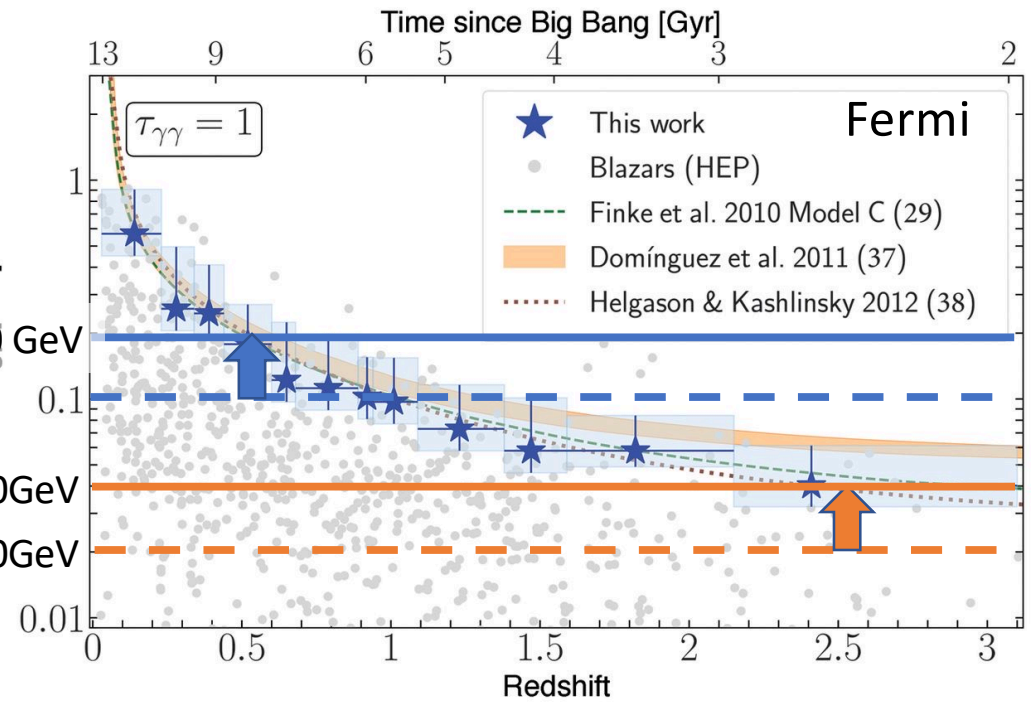
Gamma Ray Horizon



MST@45° Eth 200 GeV

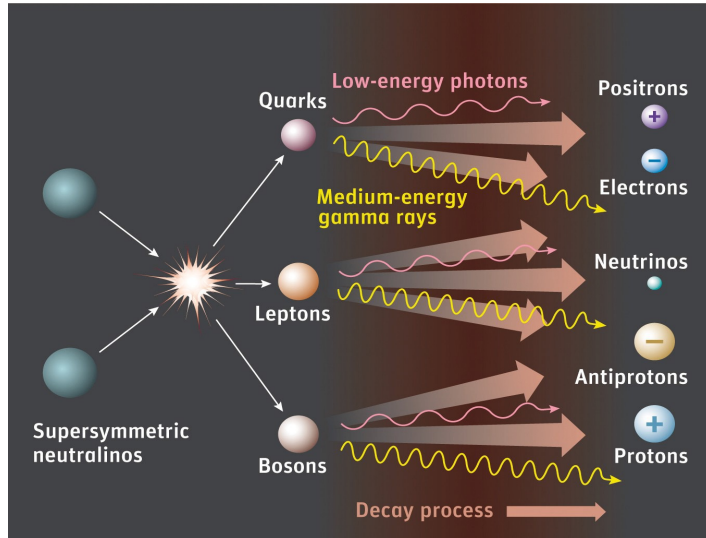
LST@45° Eth 40 GeV

LST@25° Eth 20 GeV



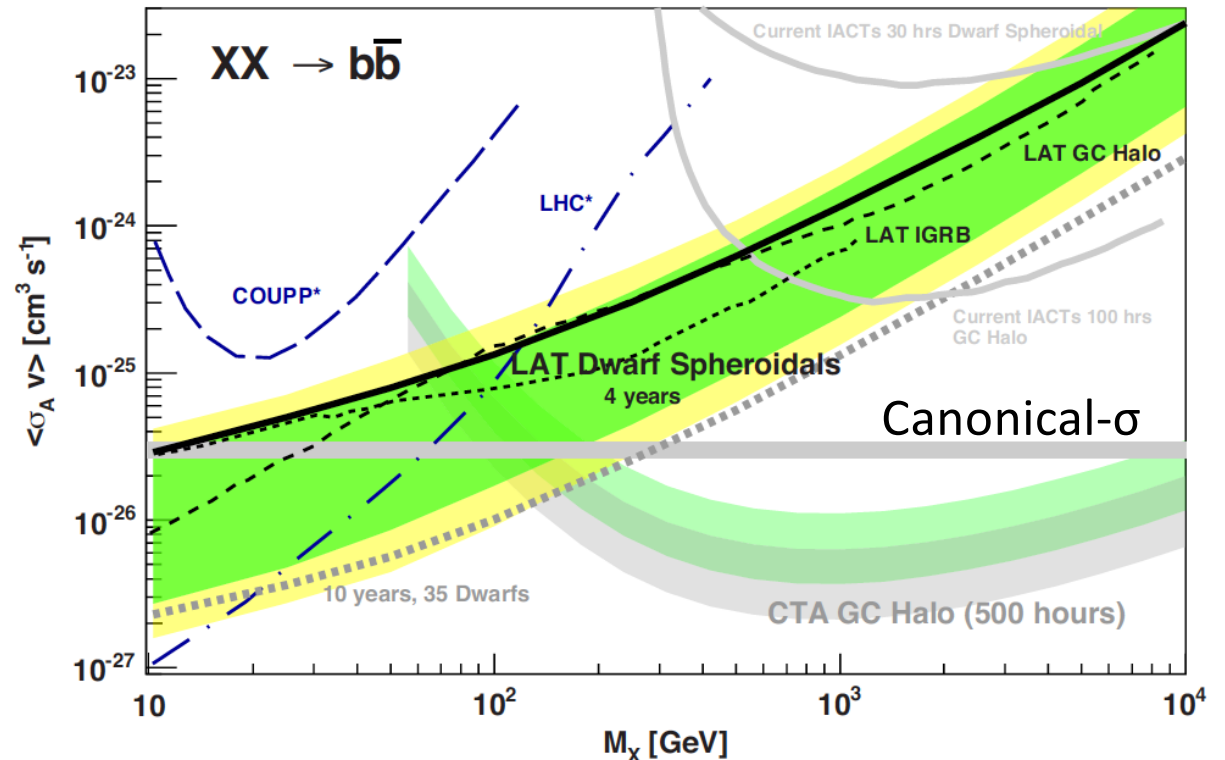
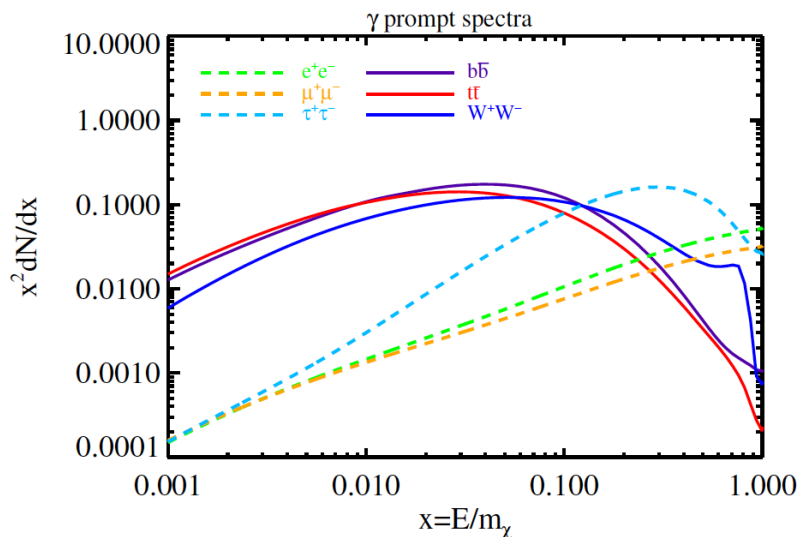
Dark Matter Search

Sensitive M_χ : 200GeV - 10TeV



$$\frac{d\Phi_\gamma}{dE_\gamma} = \frac{1}{4\pi} \underbrace{\frac{\langle \sigma_{\text{ann}} v \rangle}{2m_{\text{WIMP}}^2}}_{\text{'Particle Physics'}} \sum_f \frac{dN_\gamma^f}{dE_\gamma} B_f \times \underbrace{\int_{\Delta\Omega} d\Omega' \int_{\text{los}} \rho^2 dl(r, \theta')}_{\text{'Astrophysics' or } J(E)}$$

Particle Physics Astrophysics



Gamma rays from Annihilation produce the bump around $1/10 - 1/20 M_\chi \rightarrow 20\text{GeV}-1\text{TeV}$ gamma

CTA gives the stringent upper limit. Stefan Funk 2015

CTA and LST Timeline

- ❑ 2016 - 2018 LST1 in construction
- ❑ 2019 - LST1 in commissioning phase
- ❑ 2022 - 2024 LST2-4 will be constructed
- ❑ 2025 - LST1-4 in commissioning
- ❑ 2026 - 2027 The final Acceptance of LST1-LST4 and IKC process
- ❑ 2023 - 2027 LST5-8 construction

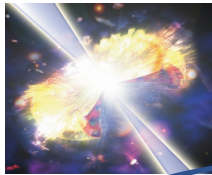
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Organization	CTAO gGmbH (Heidelberg)										
				CTAO ERIC (European Research Infrastructure Consortium)							
Alpha Config	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
LST North	Comissioning and Operation of LST1					Operation as 4 LST Array				Observatory Operation	
	CDR		Deployment of LST2-4								
MST North	Design and Finance		INFRA	Construction of 9MSTs							
CTA South	Array config, Finance and CDR		INFRA		Construction and Deplyment of 14 MSTs						
					Construction and Deployment of 37 SSTs						
Extension	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
LST South		Finance / CDR		Construction of 4 LSTs ???			Operation ???				



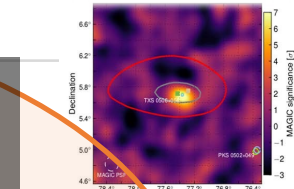
Cherenkov
telescope
array

Multi-messenger and Multi-wavelength Astrophysics

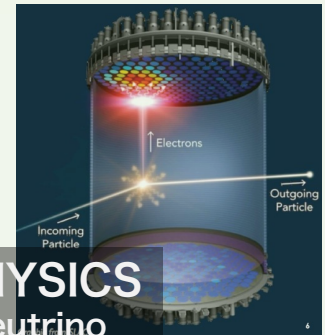
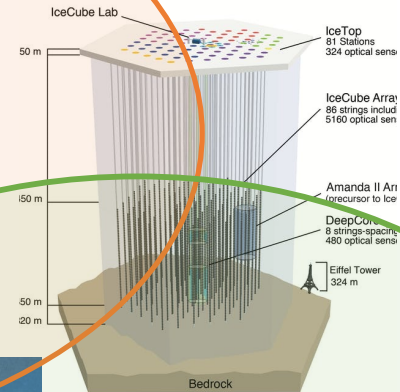
Wave
AstroPhysics



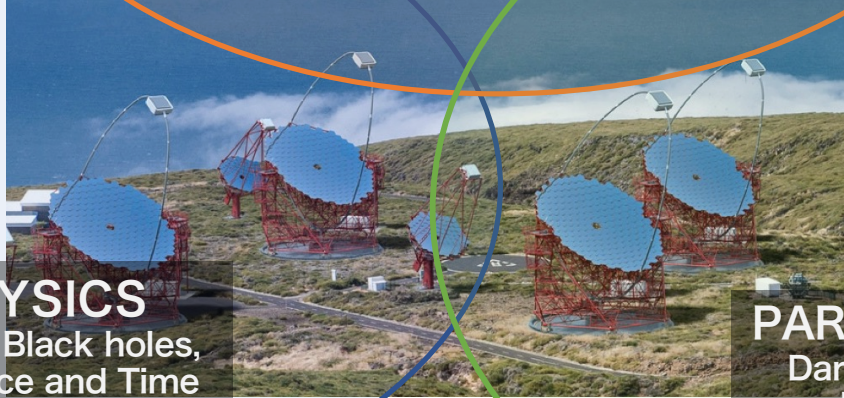
ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics



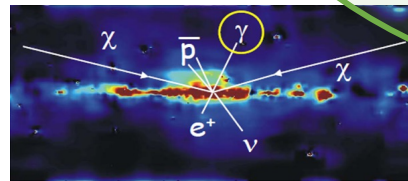
Particle Physics



ASTRO-PHYSICS
Gamma Ray Bursts, Black holes,
Neutron Stars, Space and Time



PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier





cherenkov
telescope
array

LST2-4 construction



assembled rail LST4



cable chain



Tubes for understructure

azimuth lock



backplane



central pin



Camera frame

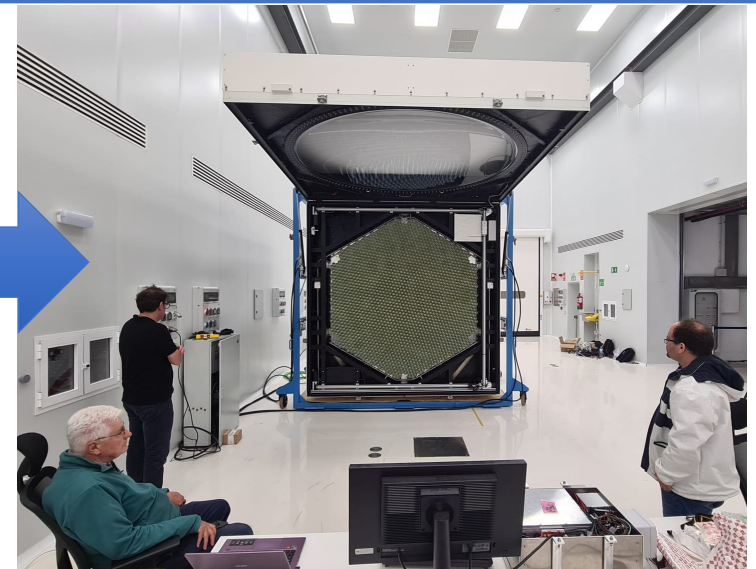


LST2-4 Construction

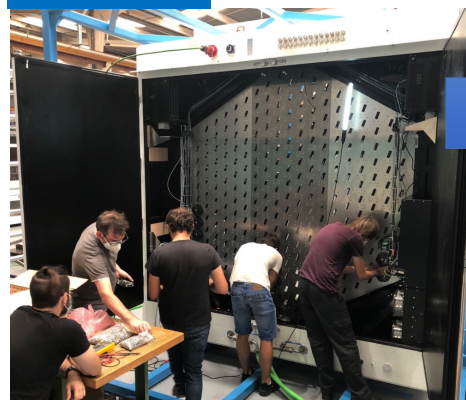
tensioning cable parts



Camera of LST2 at the Canaries for final tests



cameras



camera access tower



camera arch



Summary

- There have always been some problems in the society and world, Pandemic, Volcano eruptions, Price increases, and Shortage of materials.
 - Nevertheless, I appreciate our young colleagues' continuous development of Software and Hardware.
 - We should also continue to work to achieve our goal of a high-performance all-sky observatory with LSTs. PNRR program will make it a reality.
 - LSTs are telescopes for observations of GRBs, transient sources, multi-messenger astronomy, Gravitational-wave sources, High-Energy neutrino sources, and Search for Dark Matters.
 - Surely the CTA consortium should start to work to establish a scientific network with observatories' working in other wavelengths and messengers.
-
- **Great Scientific results are waiting for you!!**

Thank you
Landscape in 2025

