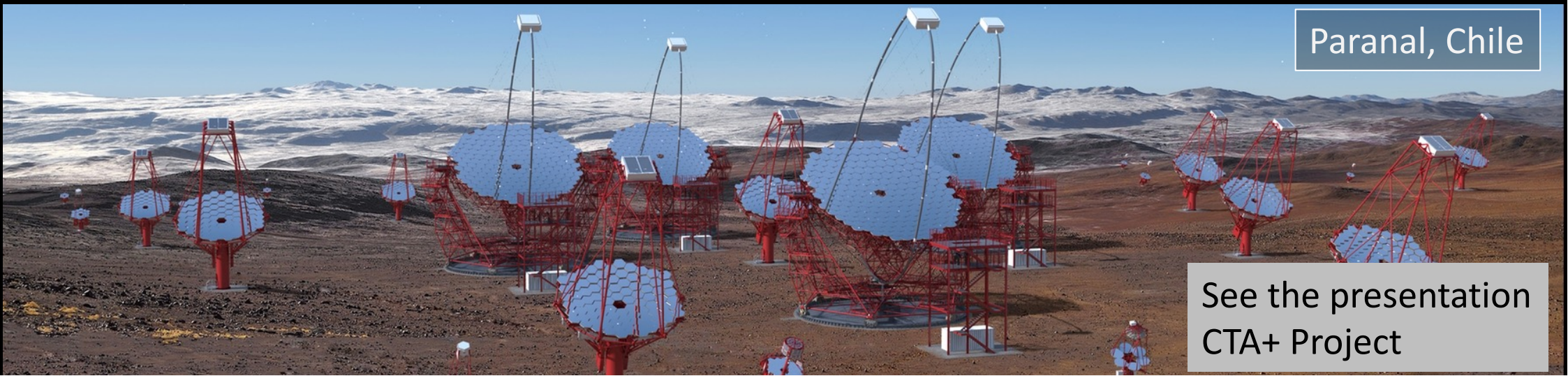
CTA-LST Project

Masahiro Teshima

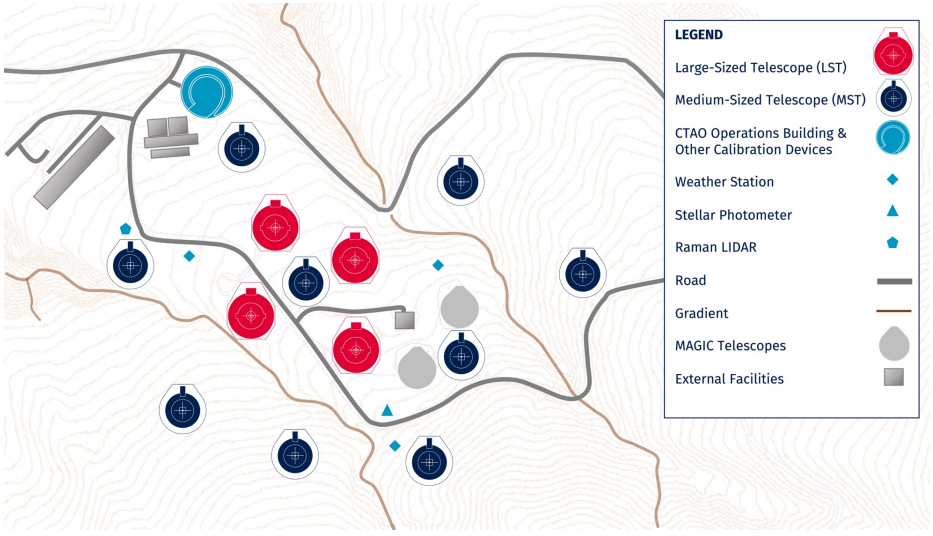
Max Planck Institute for Physics, Munich, Germany



See the presentation
CTA+ Project

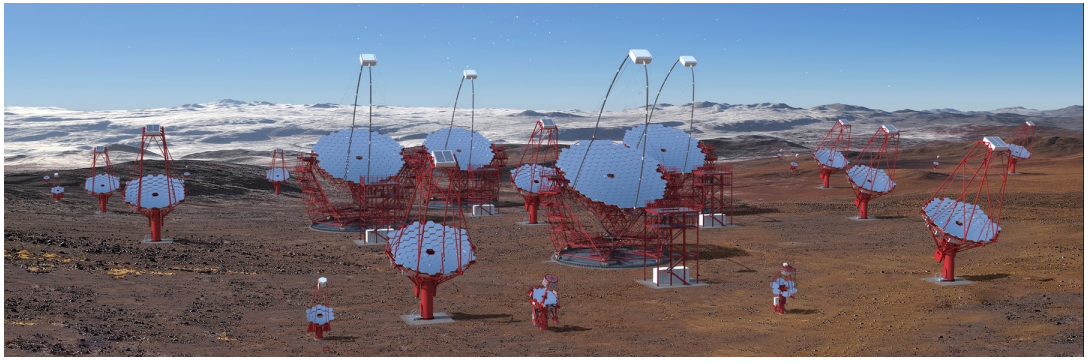
Alpha Configuration

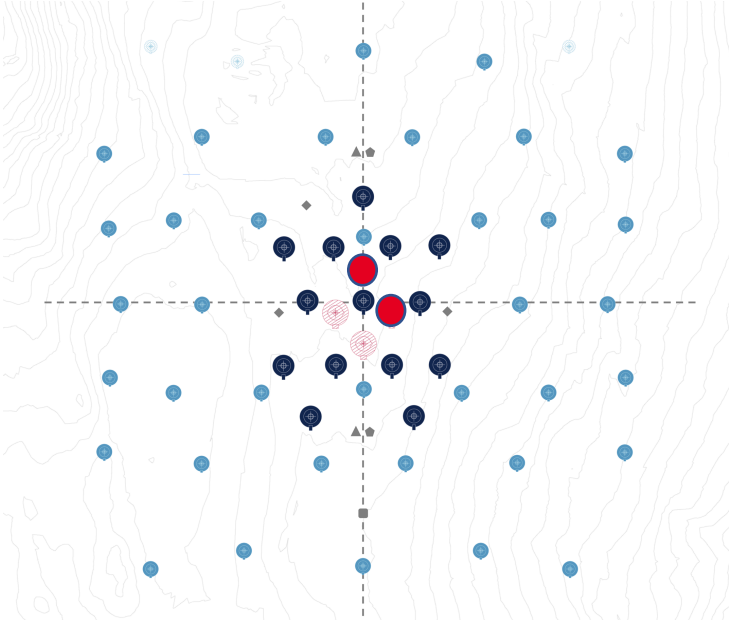
ORM, La Palma, Spain



4LSTs, 9MSTs

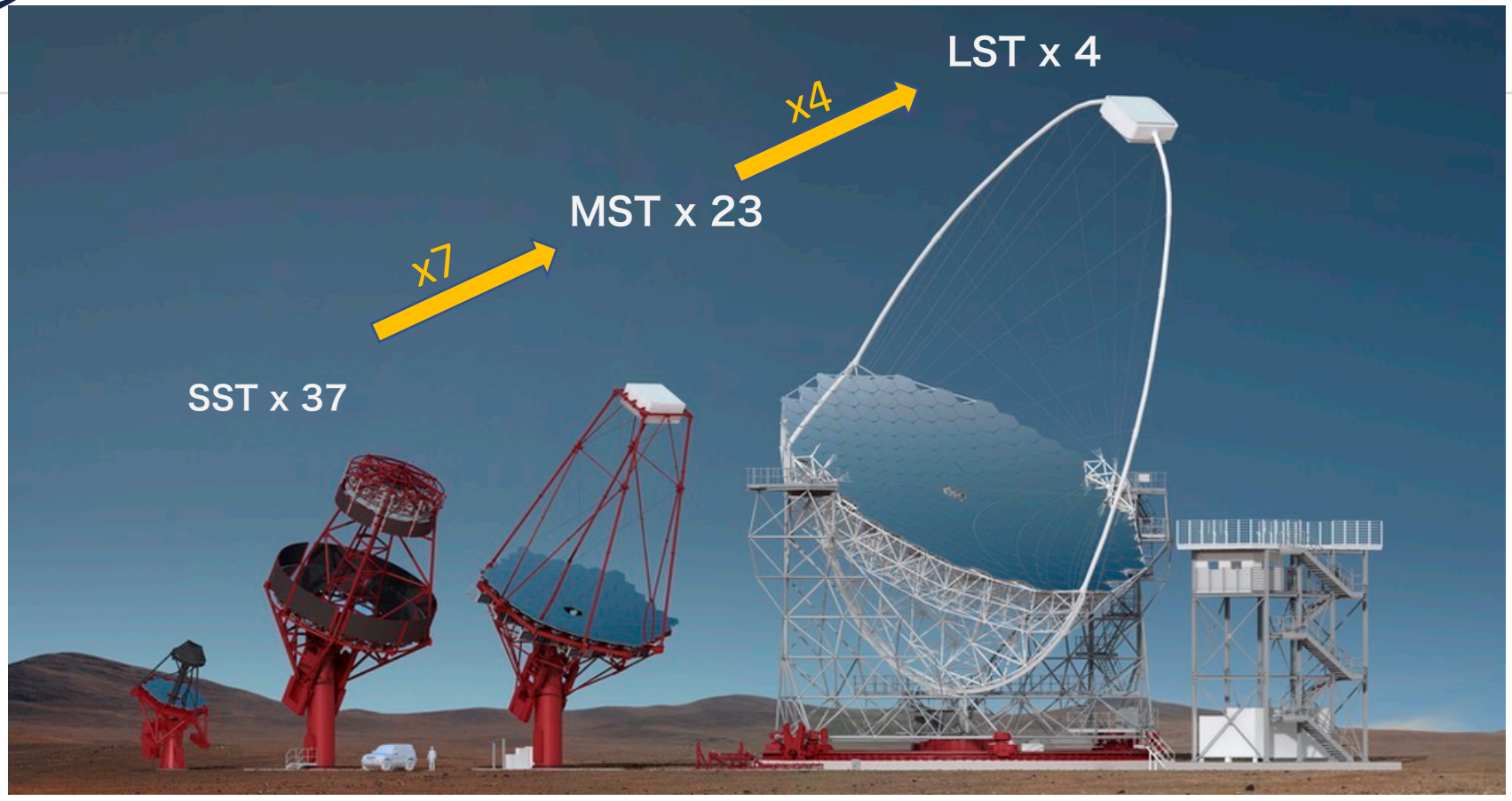
Paranal, Chile





2 LSTs, 14 MSTs, 42 SSTs ← (PNRR)

Telescope Design



Telescope Types	SST	MST	LST
Optics	Schwarzschild-Couder	Davies-Cotton	Parabolic (Isochronous)
FoV and Camera	10.5 deg SiPM	7.5 deg PMT	4.3 deg PMT
Mirror Diameter	4.3m	11.5m	23m
Energy Range	3 TeV - 200 TeV	100GeV - 10TeV	20GeV – 2000GeV
Science Targets	Galactic Sources PeVatron (UHE CR)	Galactic Sources Nearby AGNs (z<0.5) Dark Matter	Transient Sources AGNs(z<2), GRBs(z <4) Dark Matter

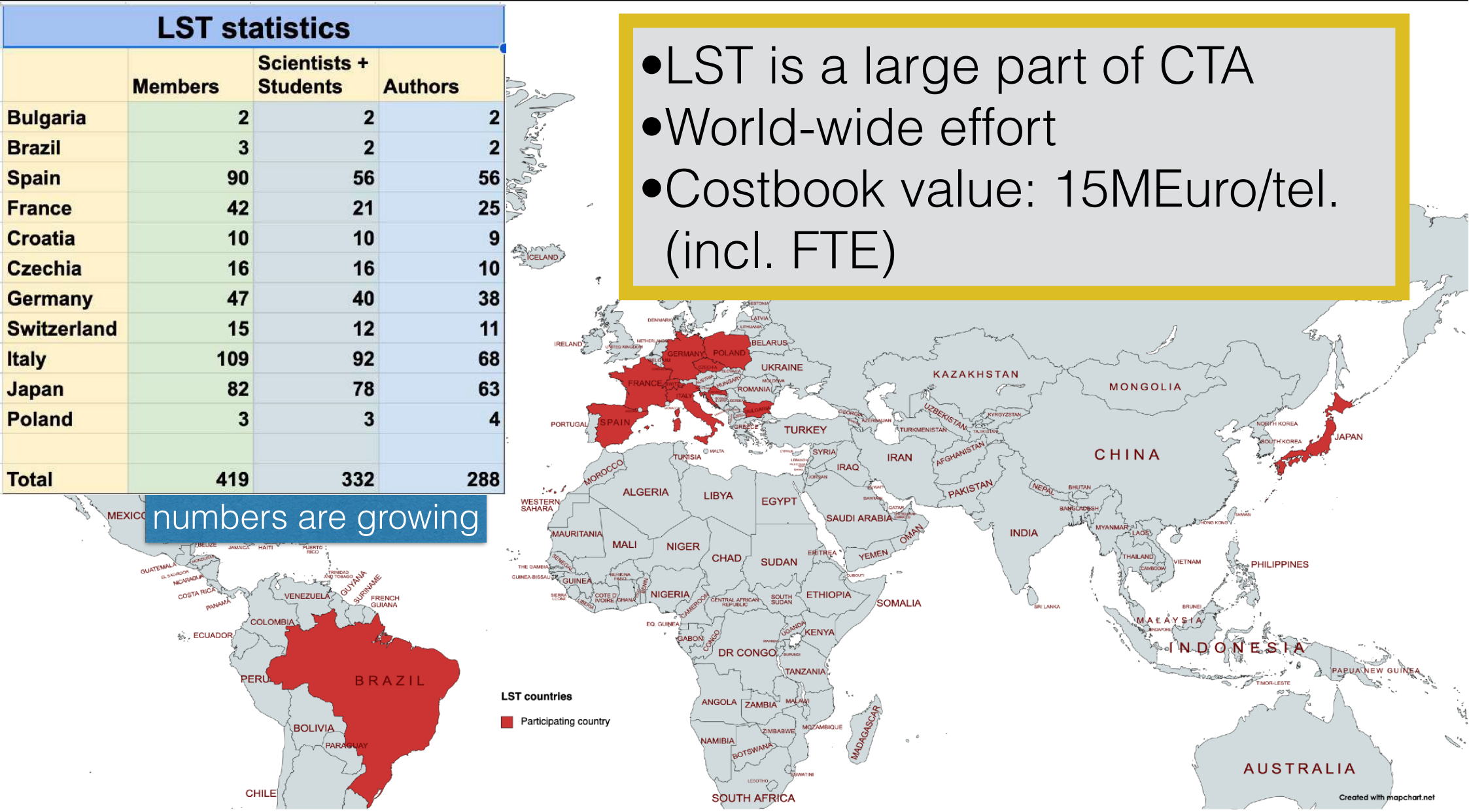
LST collaboration

cherenkov telescope array

LST statistics			
	Members	Scientists + Students	Authors
Bulgaria	2	2	2
Brazil	3	2	2
Spain	90	56	56
France	42	21	25
Croatia	10	10	9
Czechia	16	16	10
Germany	47	40	38
Switzerland	15	12	11
Italy	109	92	68
Japan	82	78	63
Poland	3	3	4
Total	419	332	288

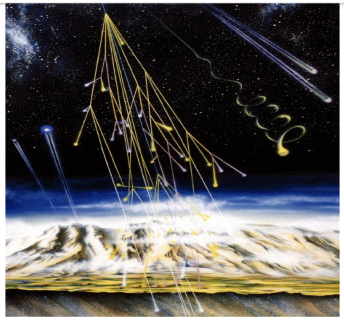
numbers are growing

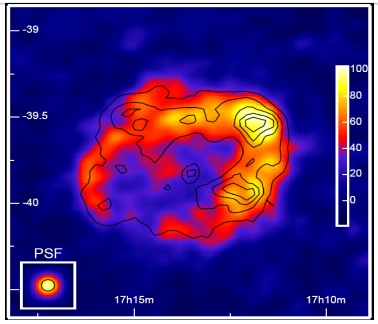
- LST is a large part of CTA
- World-wide effort
- Costbook value: 15MEuro/tel. (incl. FTE)



Science of CTA is very wide

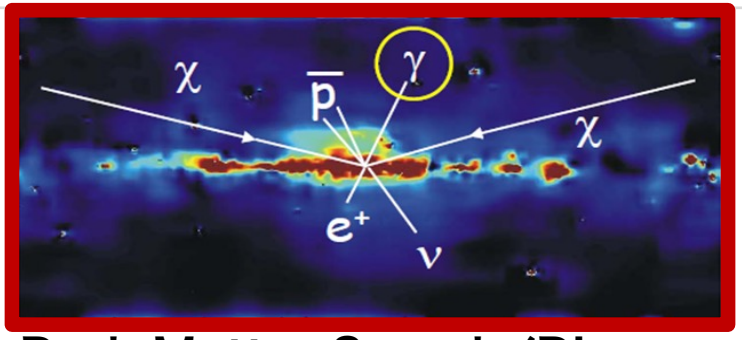
SNRs, PWNe, AGNs, GRBs, Dark Matter





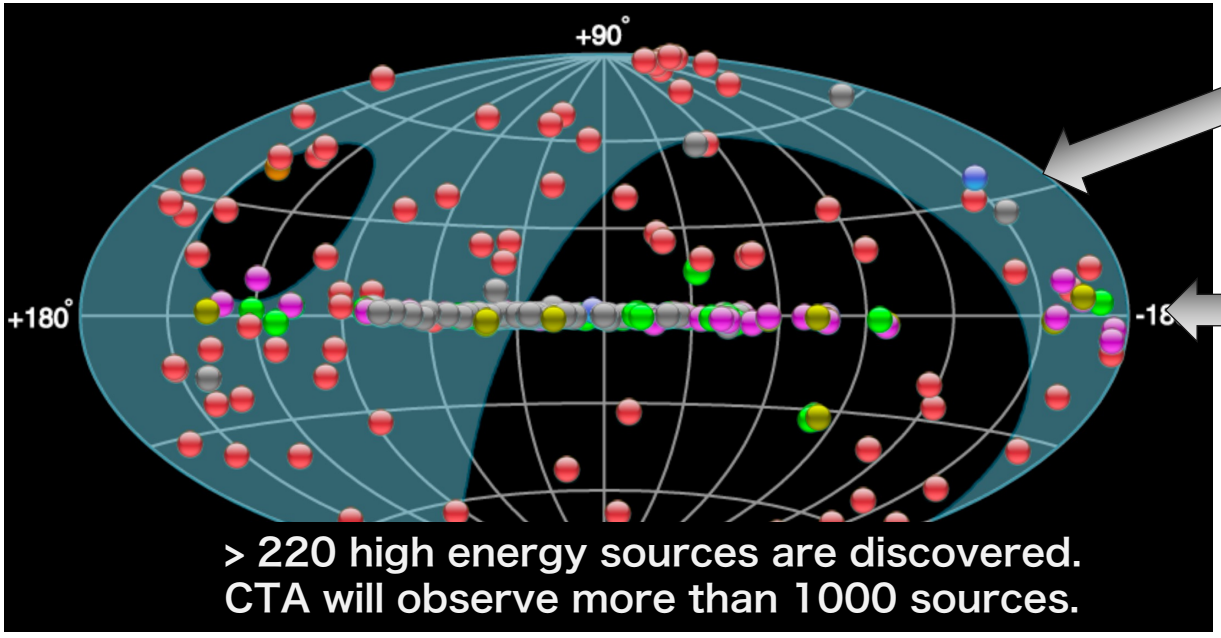
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

- Origin of Cosmic Rays (Big accelerators)
- Black Hole and S.M.B.H.
- Dark Matter Search



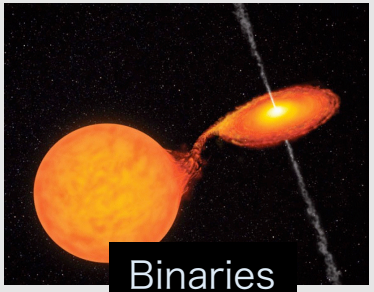
Extragalactic Sources

Active Galactic Nuclei

Gamma Ray Bursts

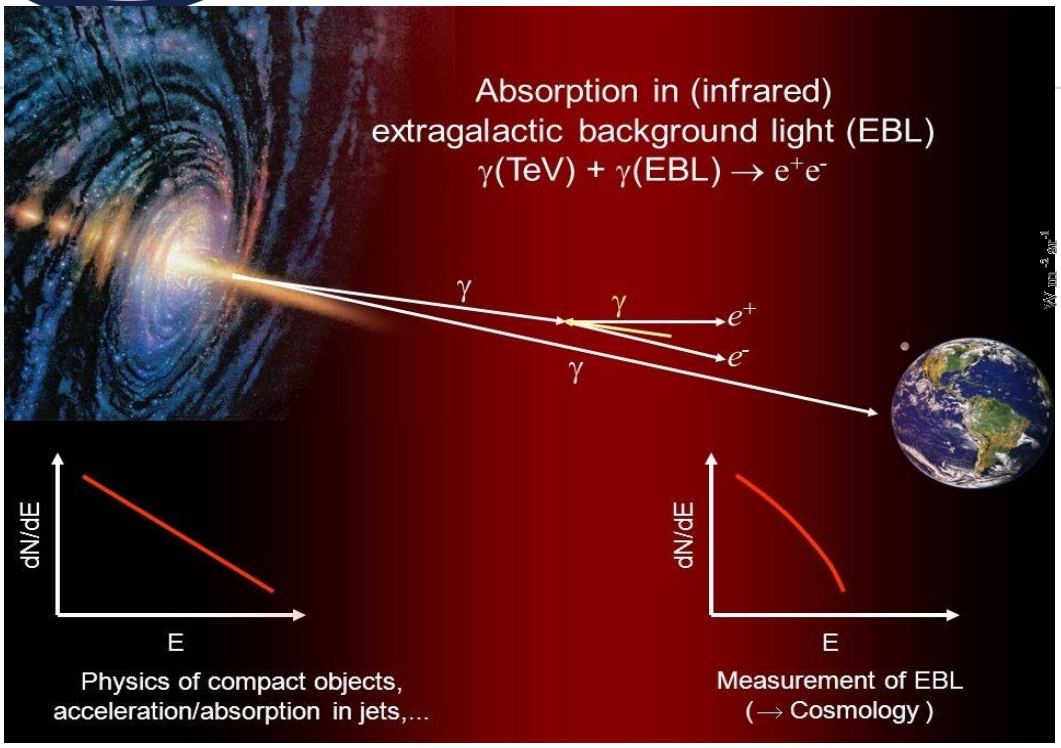
Galactic Sources

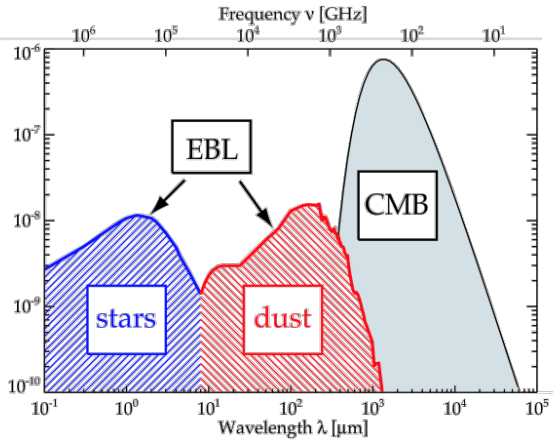
Super Nova Remnants

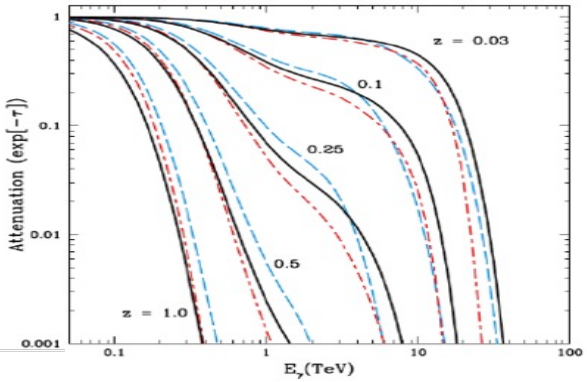


Binaries

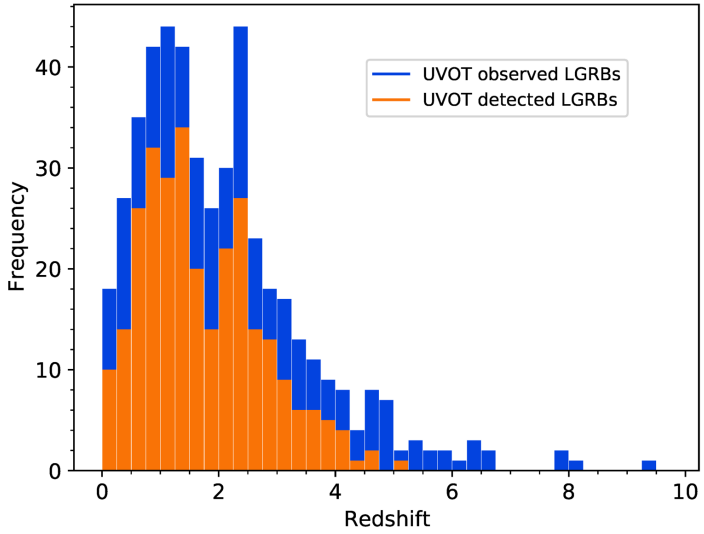
Gamma Ray Horizon
20GeV Low Threshold Energy → z~4





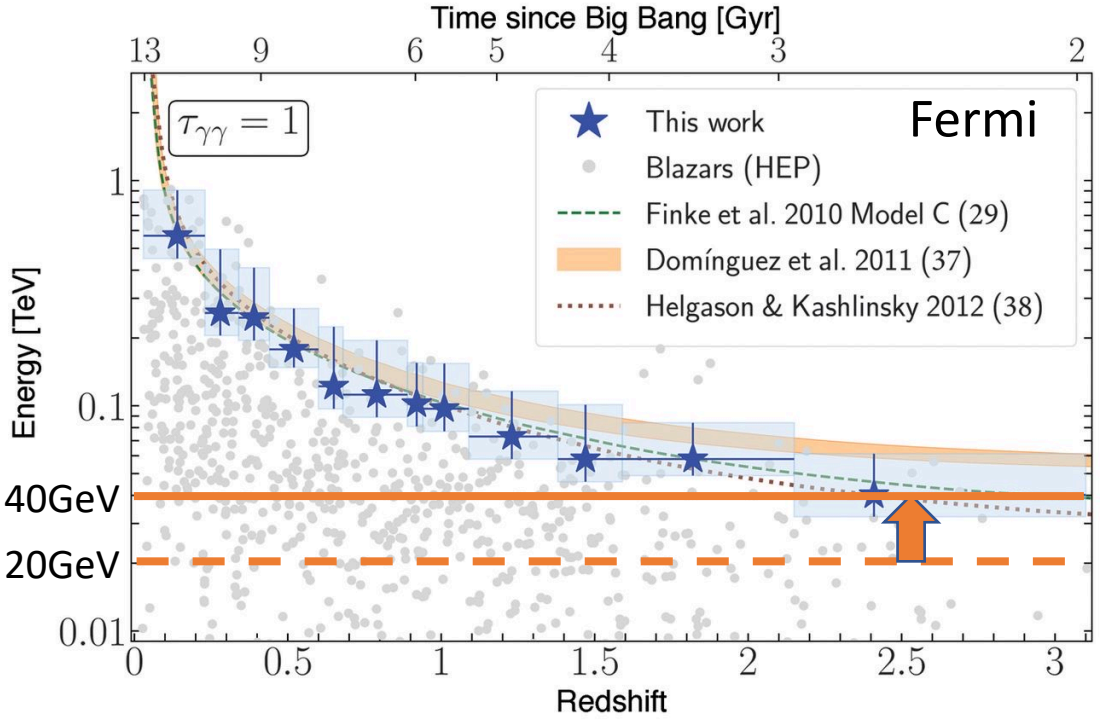


SWIFT GRBs with z observation



LST@45° Eth 40GeV

LST@25° Eth 20GeV



Large Size Telescope

Mirrors: JP
Interface plates: JP, DE, BR
Actuators: JP, CH, DE
CMOS CAM: JP

Tension cables: IT

Camera Support Structure: FR

calibration: IT, HR, DE

Camera electronics: JP, IT, ES, CH
Camera mechanics: ES
Camera safety: FR

Telescope structure: DE, ES

Rail: DE, ES

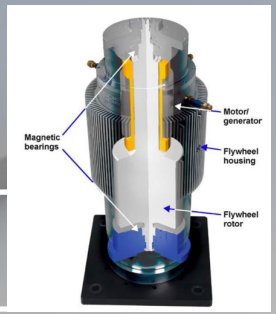
Camera Access Tower: DE,ES

Bogies: ES, DE

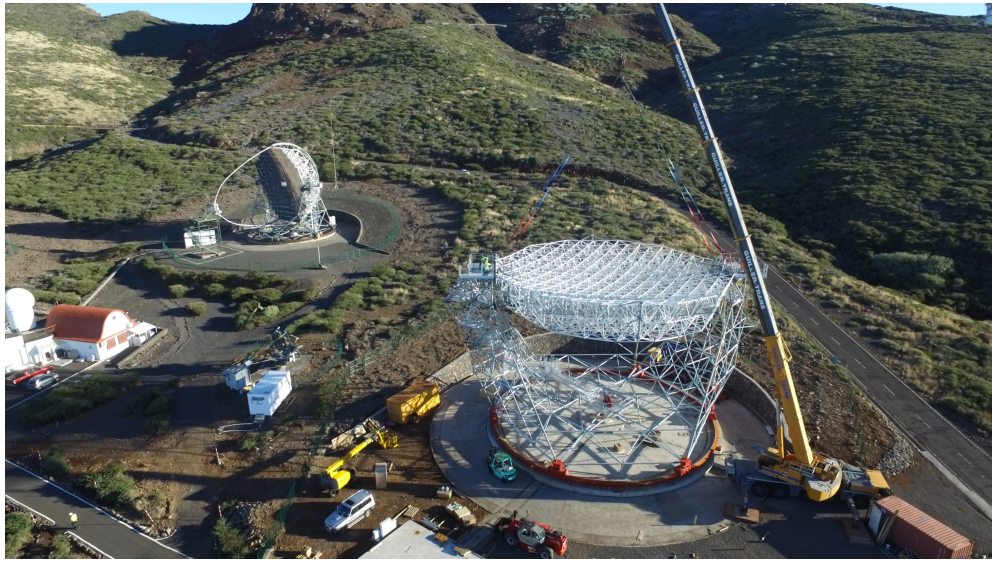
Foundation: ES

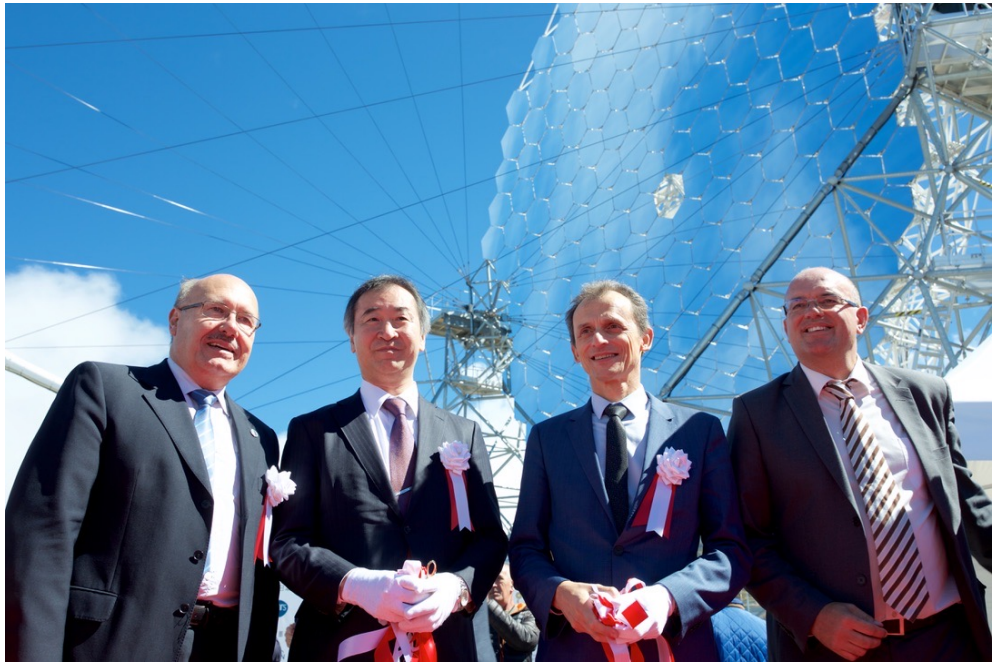
Drive and main el. cabinet: FR

FlyWheels (2x300kW) energy storage and UPS: JP



LST1 construction and Inauguration (Oct.2018)

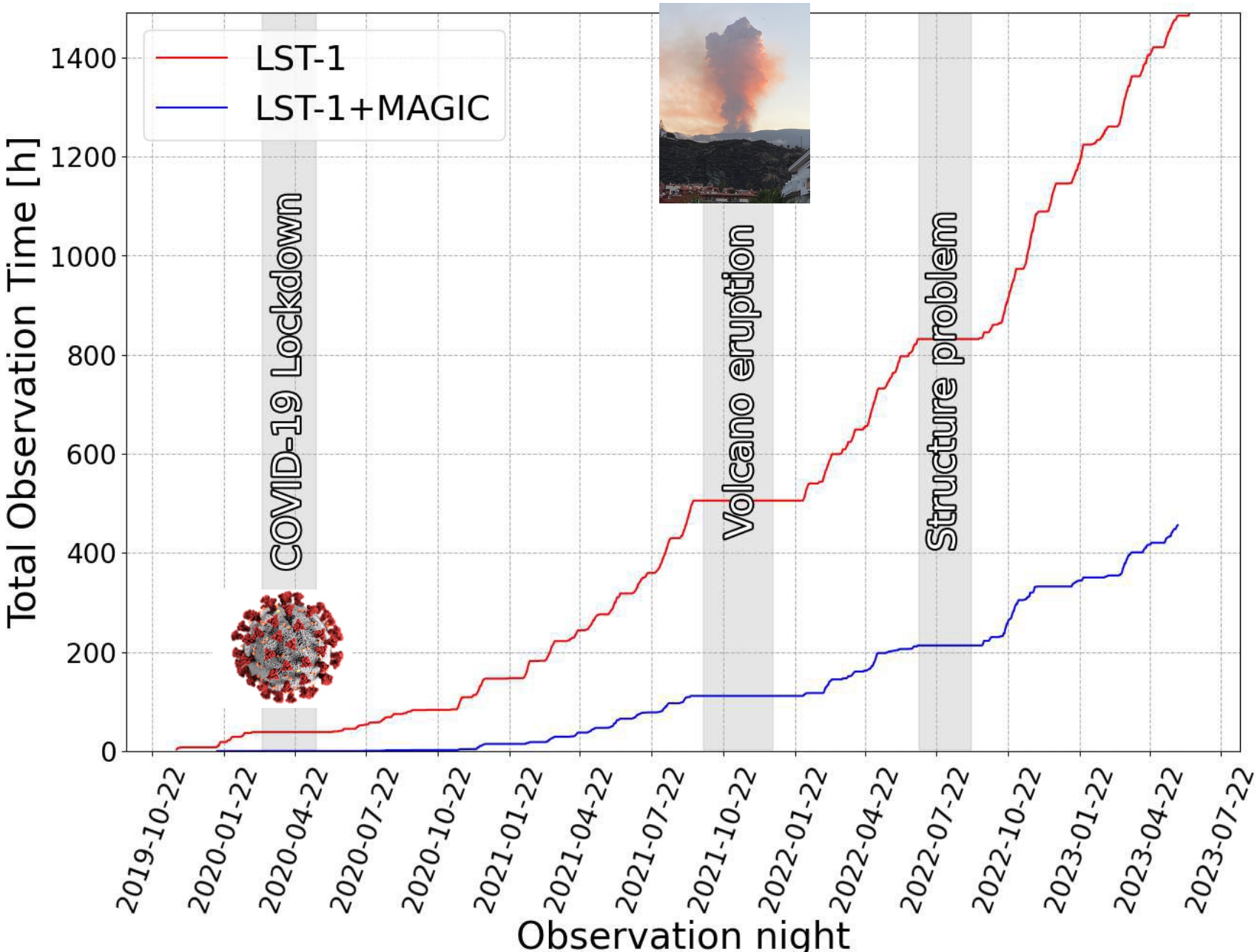




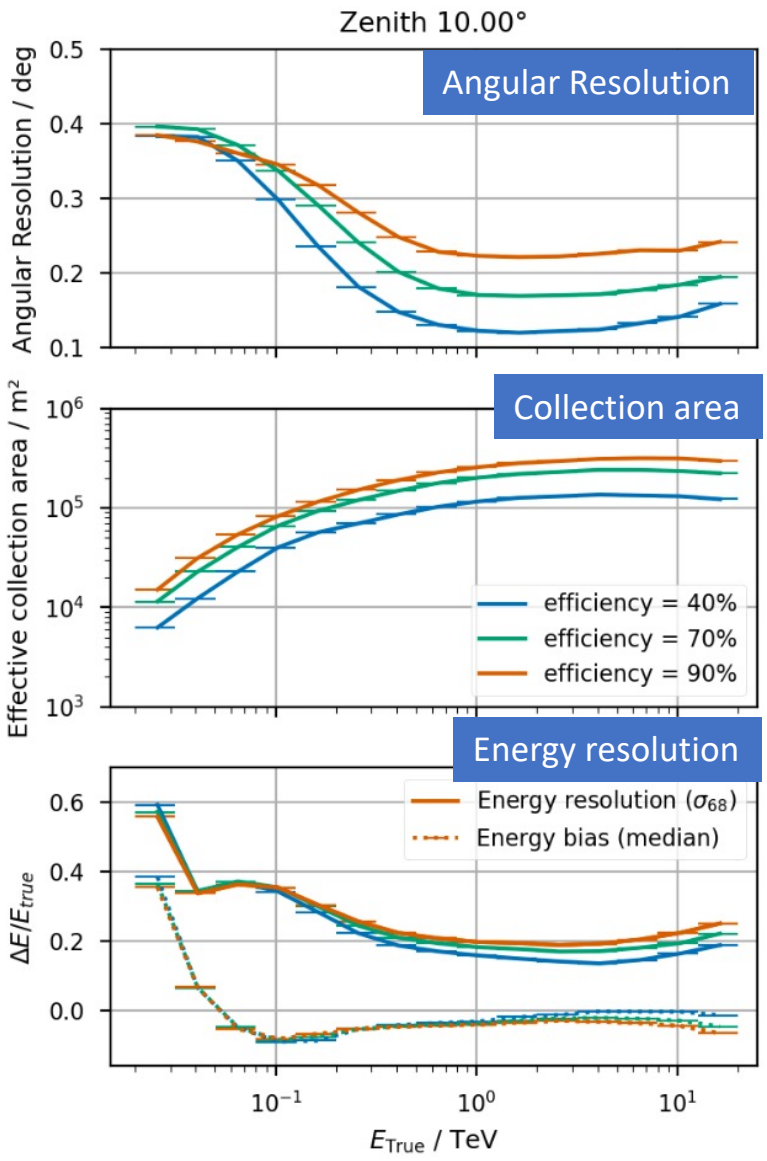
cherenkov telescope array

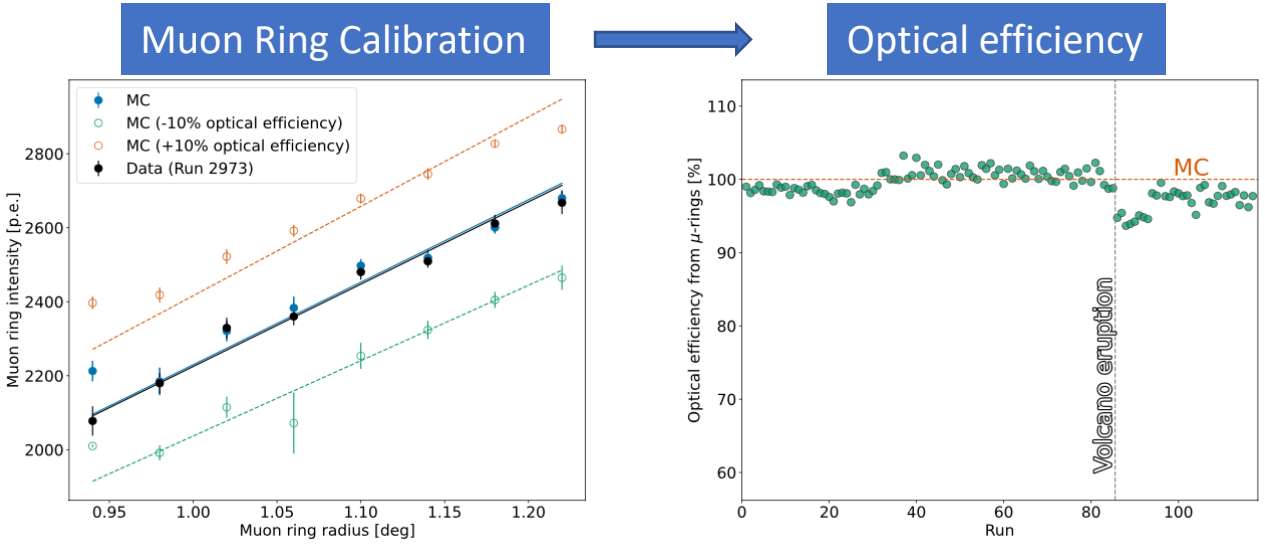
Regular Observation started in 2020 January

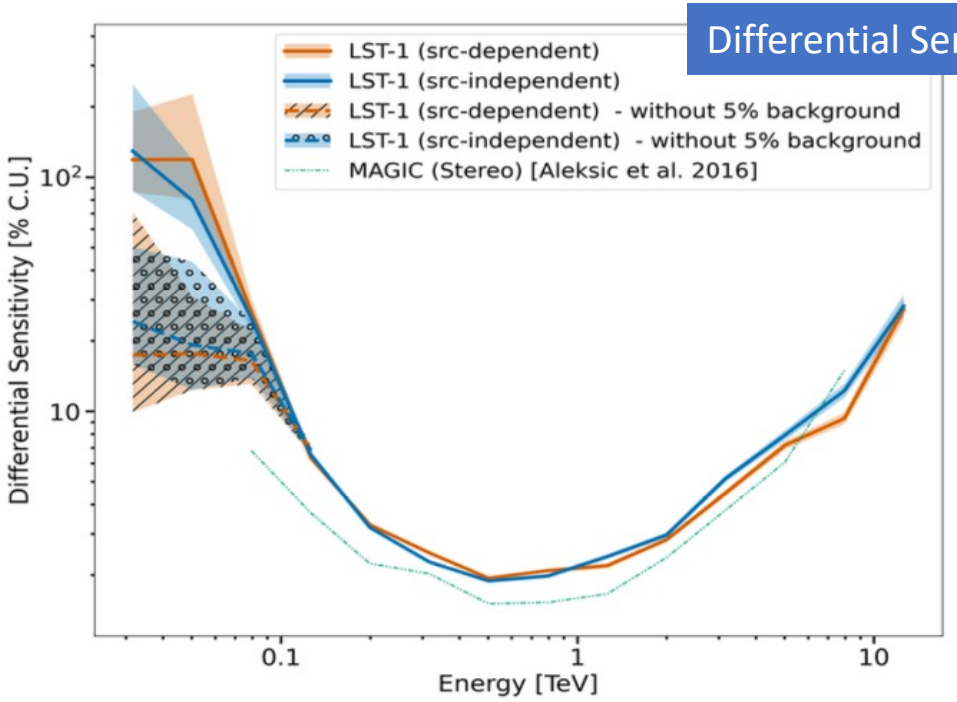
LST1 Commissioning
>1400hrs taken Jan2020-June 2023



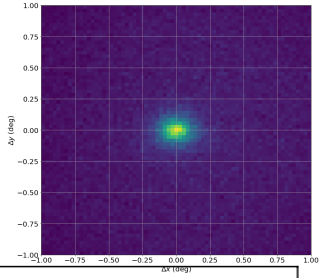
LST1 Mono Telescope Performance





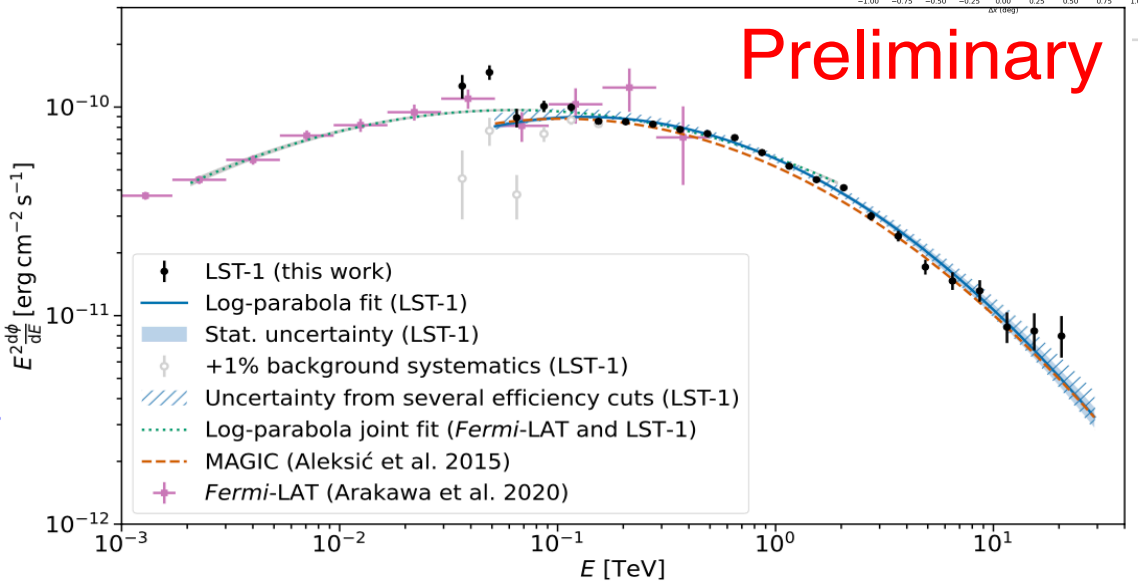


Crab Nebula and Pulsar



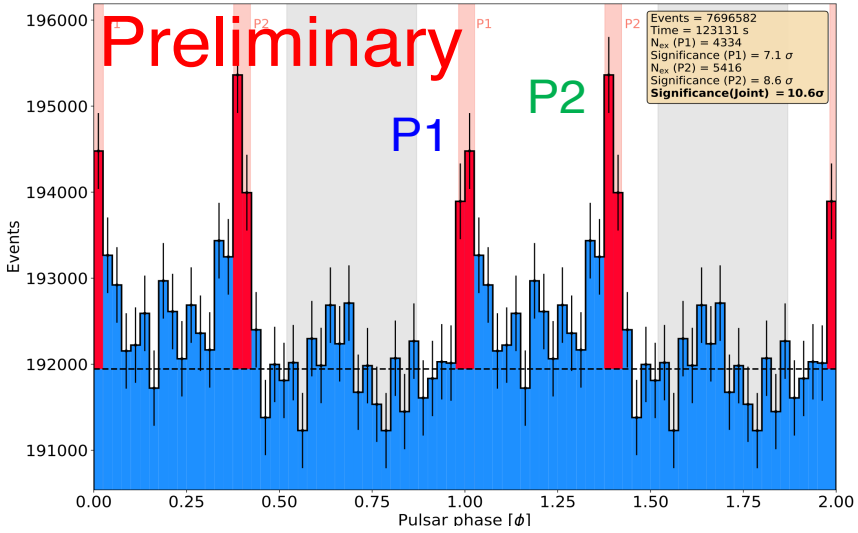
Crab Nebula spectrum

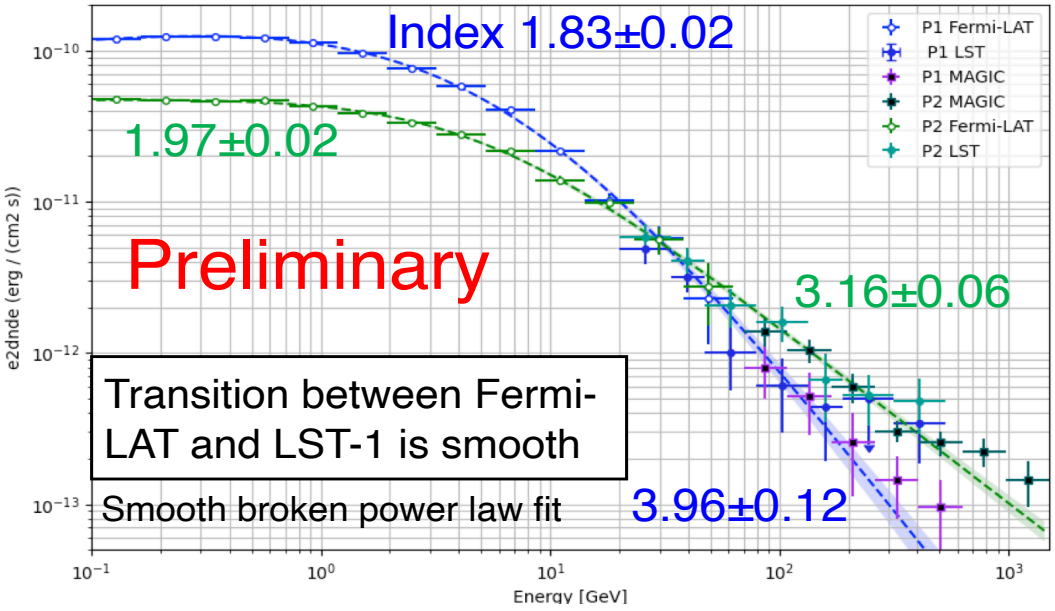
- 34.2 hours of data
- Systematic errors: gray points correspond to the effect of +1% background
- Consistent with MAGIC and Fermi-LAT



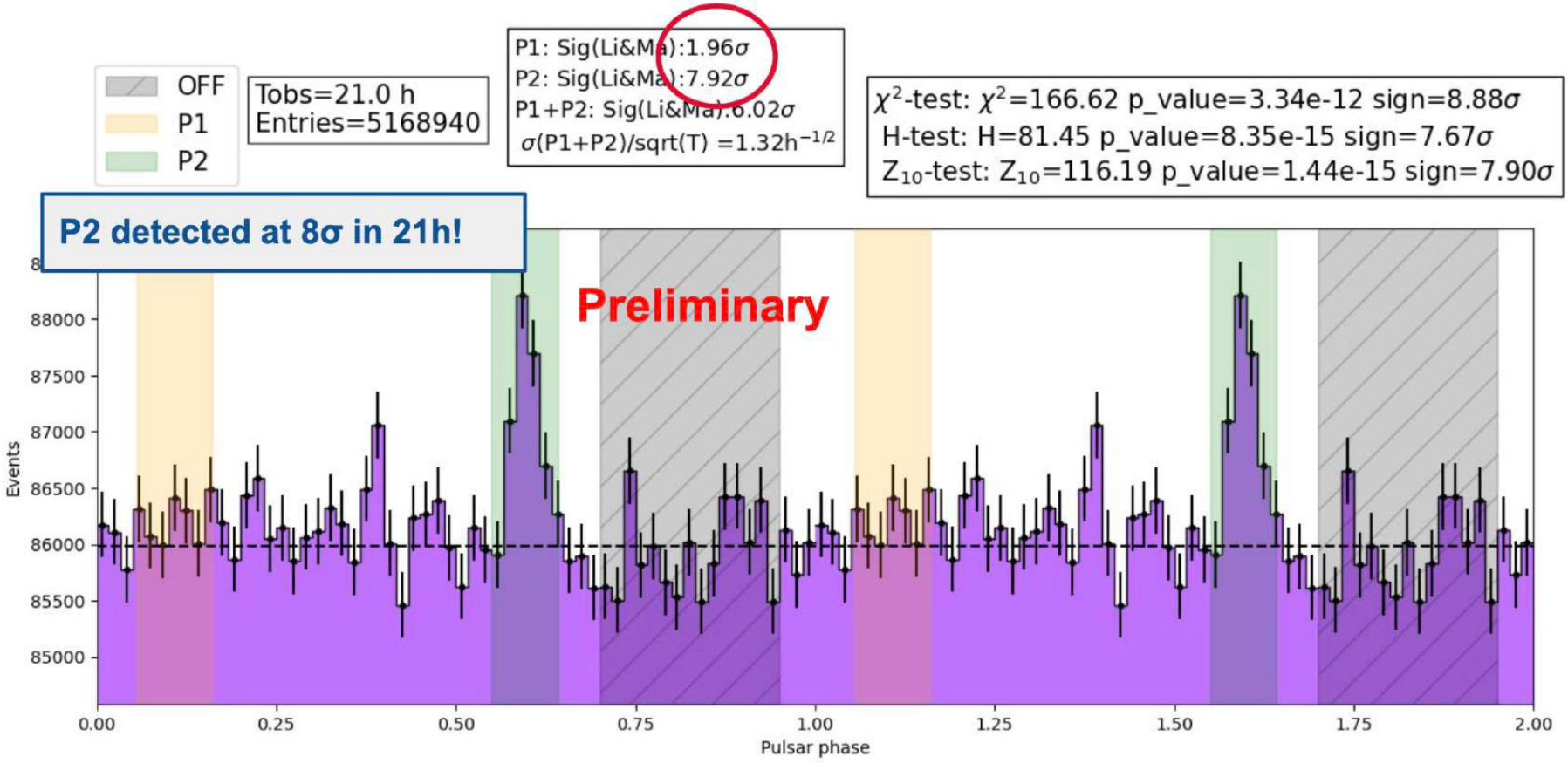
Crab pulsar

- Significant detection down to few tens of GeV
- Data from Nov 2020 - Mar 2022



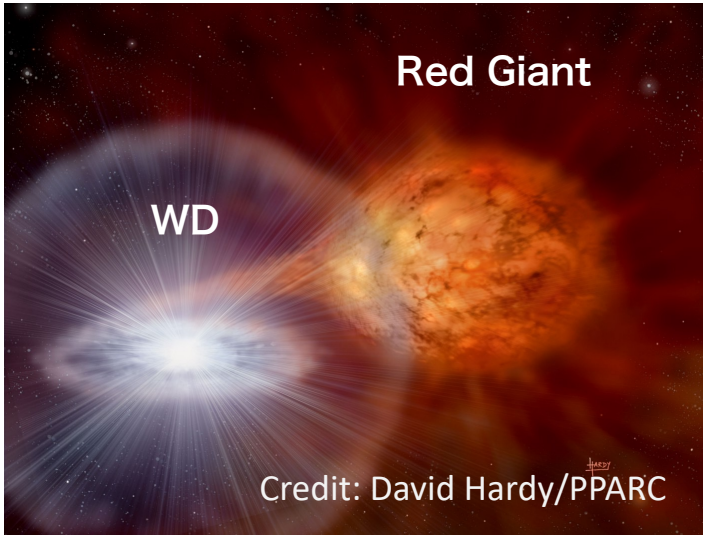


Geminga Pulsar



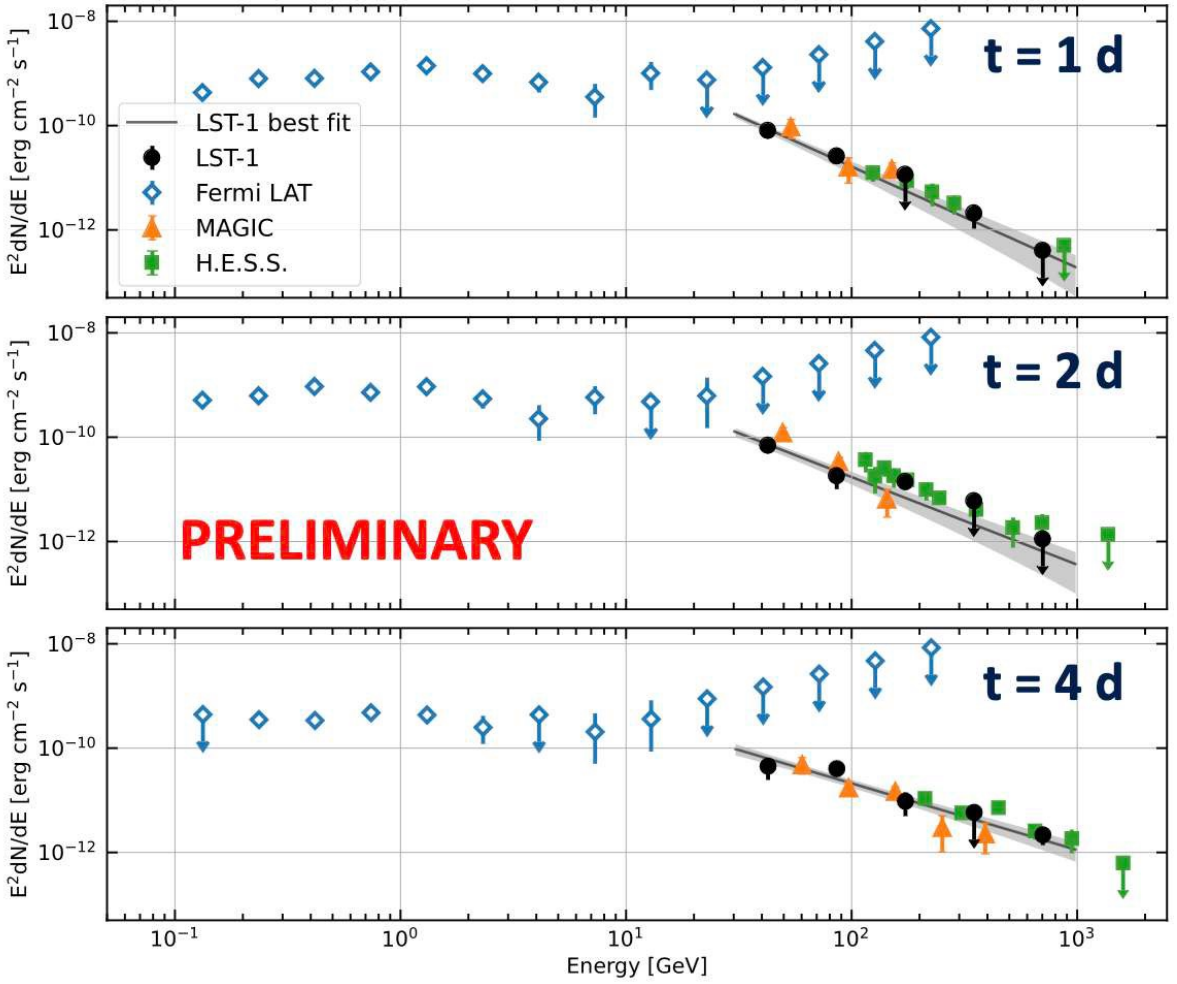
P2: 7.9σ after 21 hours. Geminga has a very soft spectrum. The LST-1 result confirms an excellent performance in the 15-30GeV regime.
This LST result can be compared with MAGIC 6.3σ after 80hrs for P2.

Recurrent Symbiotic Nova RS Ophiuchi Outburst on 8 August 2021
by Y.Kobayashi et al., ICRC2023



- First detection of Nova with IACTs (HESS, MAGIC, and LST1)
- 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
- Thermonuclear reaction

- LST Observation is consistent with HESS, MAGIC results
- Observation indicates hadronic origin

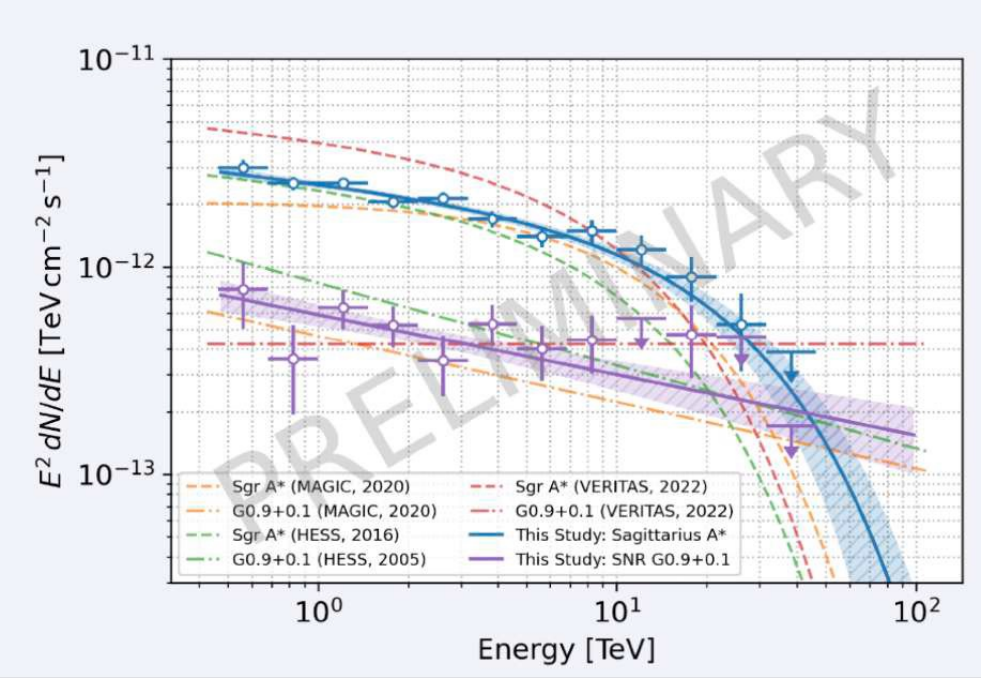


Galactic Center

Large zenith Angle Observation

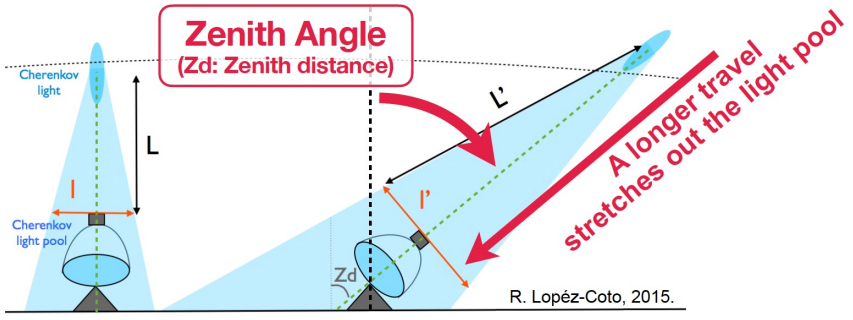
S.Abe et al, ICRC2023

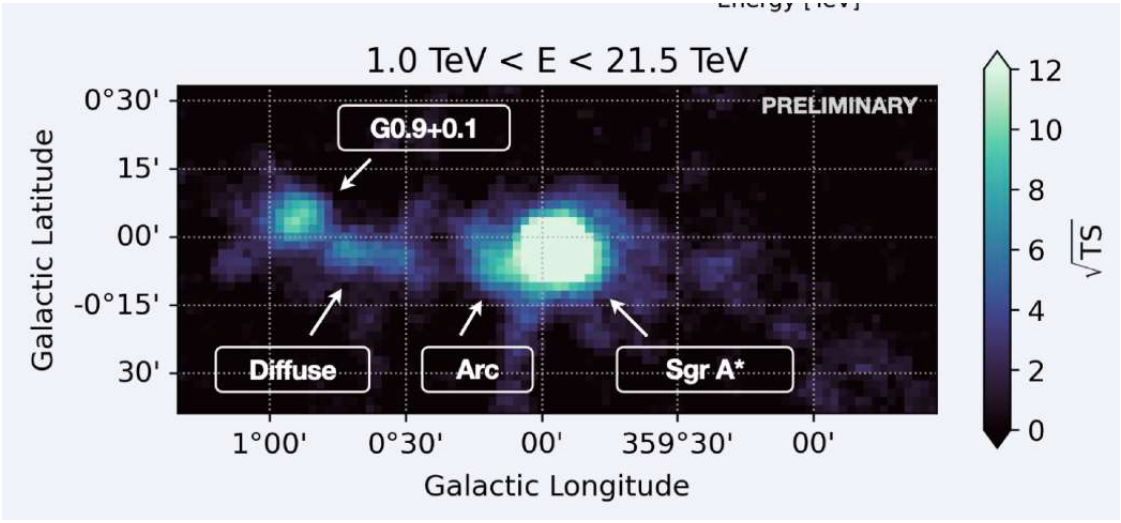
- High-quality data of 39 hrs of G.C..
- LST1 demonstrated the effectiveness of the Large–Zenith-Angle observation.



Large-Zenith-Angle Observation

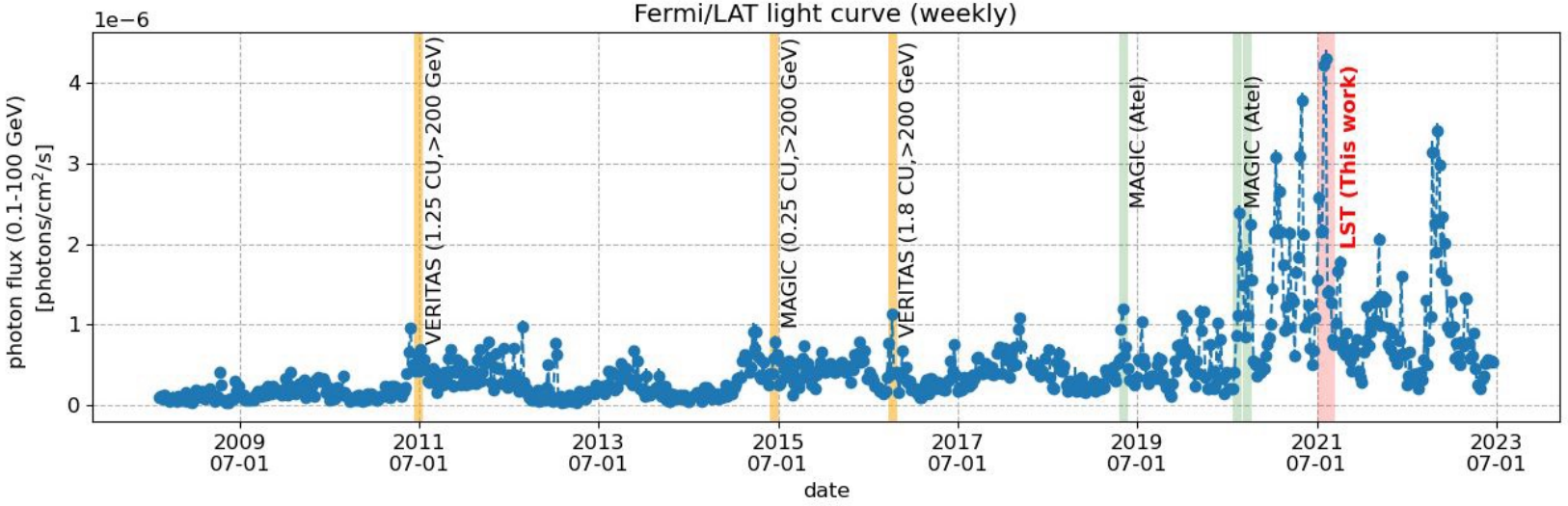
- The Cherenkov light pool is geometrically expanded.
- **A one-order-of-magnitude larger collection area** is feasible at TeV energies.

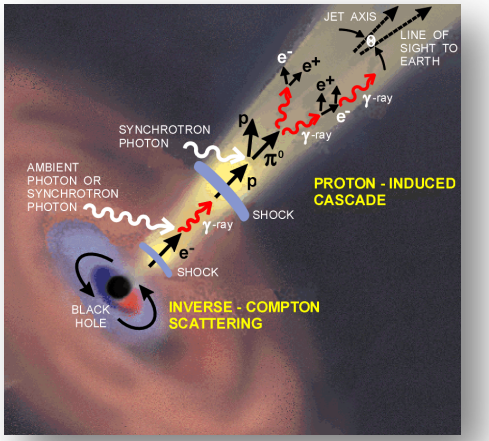


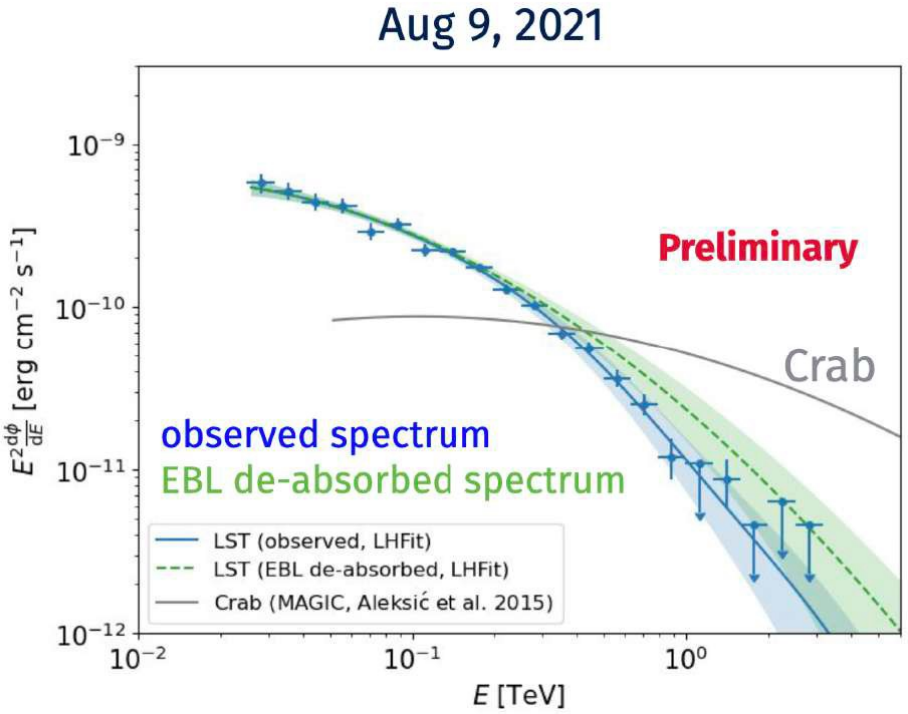


BL Lac Big Flare on 9 August

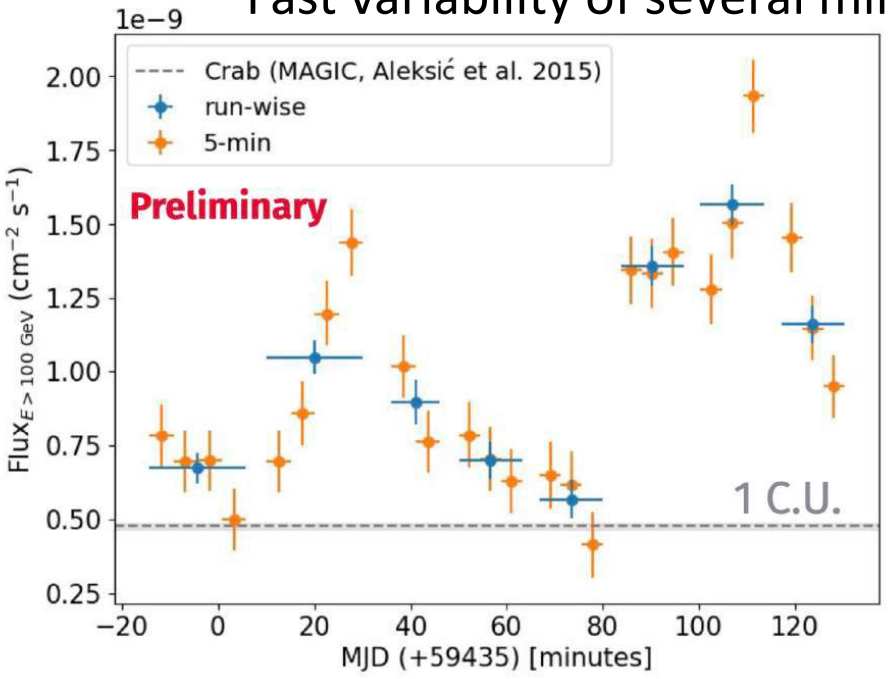
S.Nozaki et al., ICRC2023





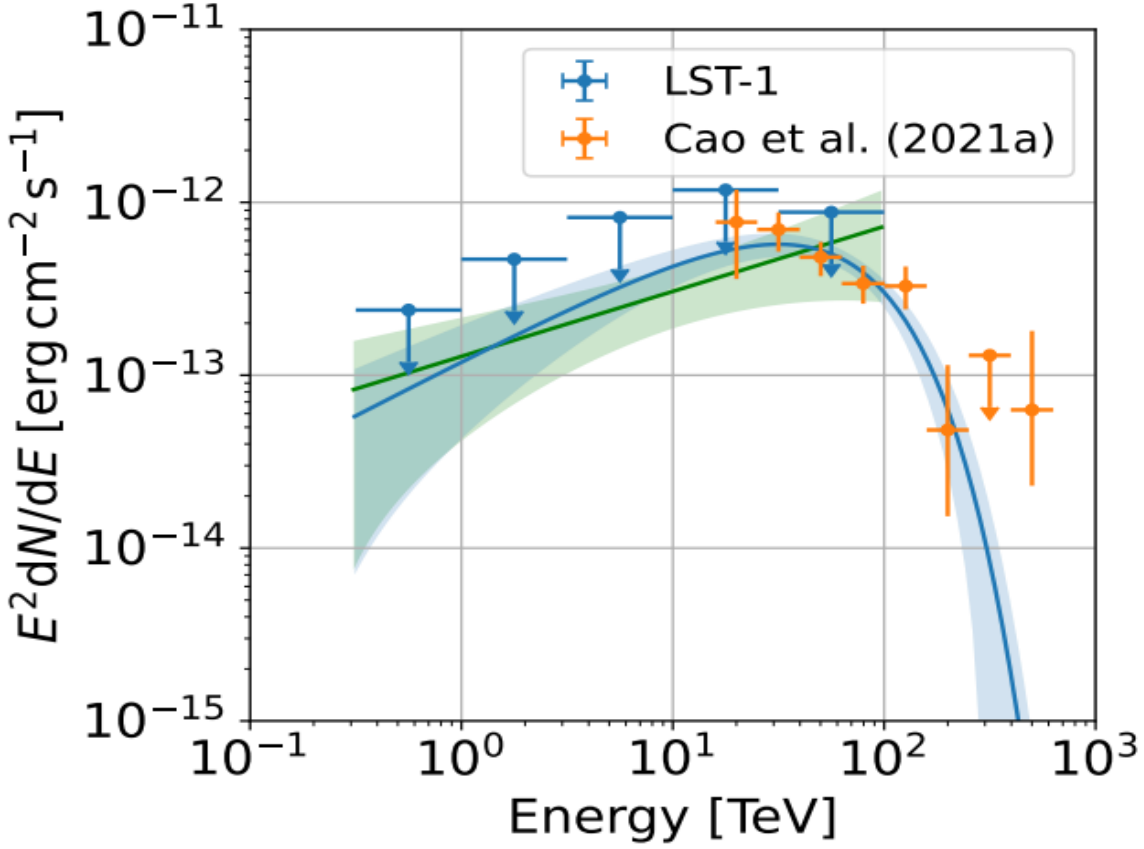


Fast variability of several minutes

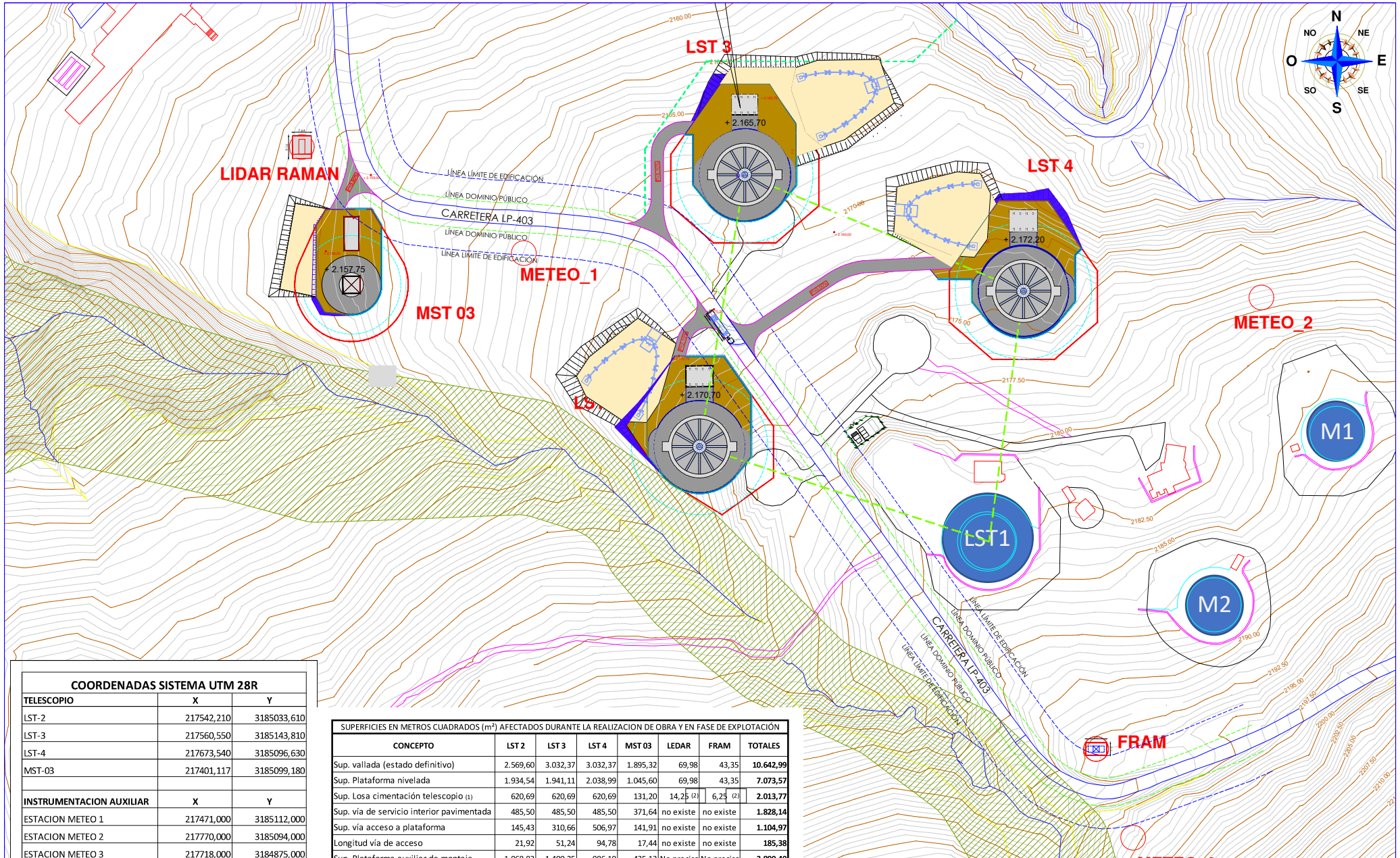


LHAASO J2108+5157
The first paper from LST Consortium

- An unidentified source in the LHAASO Observation.
- Possible PeVatron, but the origin is not clear.
- The multi-wave observation with LST favors the leptonic inverse Compton Bump extending beyond 100TeV.
- But there is a possibility that escaping protons from middle-aged SNR collide with molecular clouds.



LST2-4, MST3 location



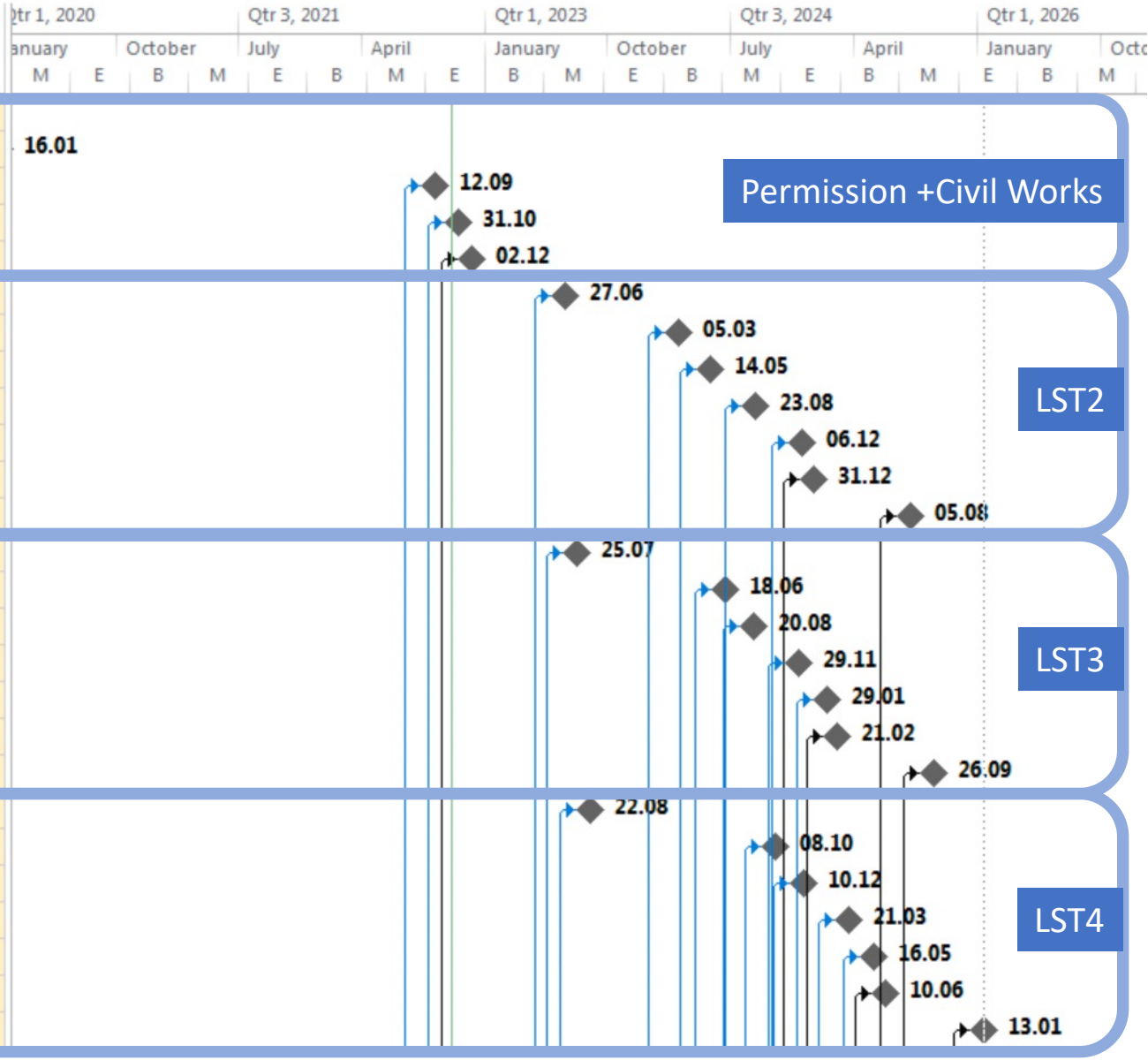
COORDENADAS SISTEMA UTM 28R		
TELESCOPIO	**X**	**Y**
LST-2	217542,210	3185033,610
LST-3	217560,550	3185143,810
LST-4	217673,540	3185096,630
MST-03	217401,117	3185099,180
INSTRUMENTACION AUXILIAR	**X**	**Y**
ESTACION METEO 1	217471,000	3185112,000
ESTACION METEO 2	217770,000	3185094,000
ESTACION METEO 3	217718,000	3184875,000

SUPERFICIES EN METROS CUADRADOS (m^2) AFECTADOS DURANTE LA REALIZACION DE OBRA Y EN FASE DE EXPLOTACIÓN

CONCEPTO	LST 2	LST 3	LST 4	MST 03	LEDAR	FRAM	TOTALES
Sup. vallada (estado definitivo)	2.569,60	3.032,37	3.032,37	1.895,32	69,98	43,35	**10.642,99**
Sup. Plataforma nivelada	1.934,54	1.941,11	2.038,99	1.045,60	69,98	43,35	**7.073,57**
Sup. Losa cimentación telescopio (1)	620,69	620,69	620,69	131,20	14,25 (2)	6,25 (2)	**2.013,77**
Sup. vía de servicio interior pavimentada	485,50	485,50	485,50	371,64	no existe	no existe	**1.828,14**
Sup. vía acceso a plataforma	145,43	310,66	506,97	141,91	no existe	no existe	**1.104,97**
Longitud vía de acceso	21,92	51,24	94,78	17,44	no existe	no existe	**185,38**
Sup. Plataforma auxiliar de montaje	1.068,82	1.409,25	986,19	425,13	No precisa	No precisa	**3.889,40**

LST2-4 Schedule: updated

	Task Name	Durat	Start	Finish
1	Sign Contract for Short Project	0 days	01.08.19	01.08.19
2	Basic project ready for submission	0 days	16.01.20	16.01.20
3	All Permissions granted	0 days	12.09.22	12.09.22
4	Sign civil work contract	0 days	31.10.22	31.10.22
5	Civil Works start	0 days	02.12.22	02.12.22
6	LST2 construction starts	0 days	27.06.23	27.06.23
7	LST2 dish and structure united	0 days	05.03.24	05.03.24
8	LST2 CSS installed	0 days	14.05.24	14.05.24
9	LST2 mirrors installed	0 days	23.08.24	23.08.24
10	LST2 camera installed	0 days	06.12.24	06.12.24
11	LST2 construction completed	0 days	31.12.24	31.12.24
12	LST2 ready for acceptance	0 days	05.08.25	05.08.25
13	LST3 construction starts	0 days	25.07.23	25.07.23
14	LST3 dish and structure united	0 days	18.06.24	18.06.24
15	LST3 CSS installed	0 days	20.08.24	20.08.24
16	LST3 mirrors installed	0 days	29.11.24	29.11.24
17	LST3 camera installed	0 days	29.01.25	29.01.25
18	LST3 construction completed	0 days	21.02.25	21.02.25
19	LST3 ready for acceptance	0 days	26.09.25	26.09.25
20	LST4 construction starts	0 days	22.08.23	22.08.23
21	LST4 dish and structure united	0 days	08.10.24	08.10.24
22	LST4 CSS installed	0 days	10.12.24	10.12.24
23	LST4 mirrors installed	0 days	21.03.25	21.03.25
24	LST4 camera installed	0 days	16.05.25	16.05.25
25	LST4 construction completed	0 days	10.06.25	10.06.25
26	LST4 ready for acceptance	0 days	13.01.26	13.01.26



cherenkov telescope array

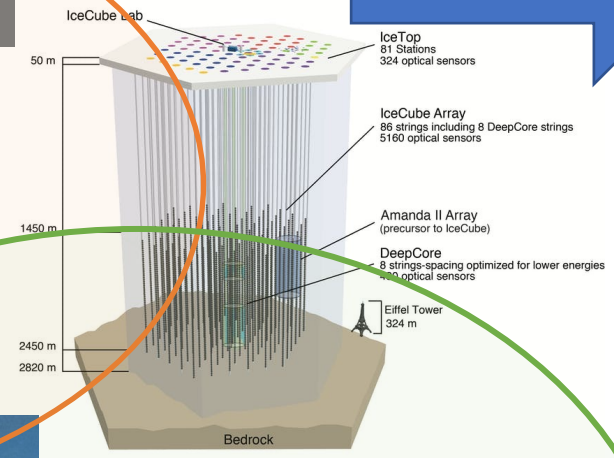
Multi-messenger and Multi-wavelength Astrophysics

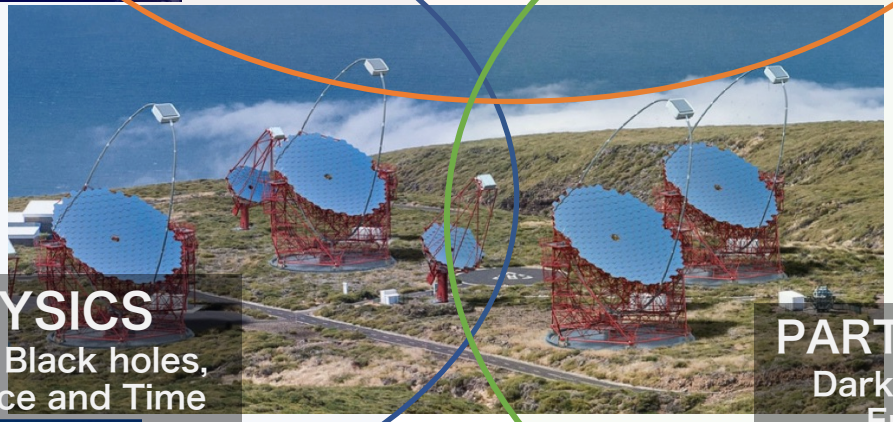
cherenkov telescope array

Wave AstroPhysics

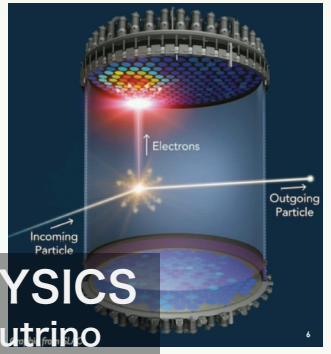
Particle Physics

ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics





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

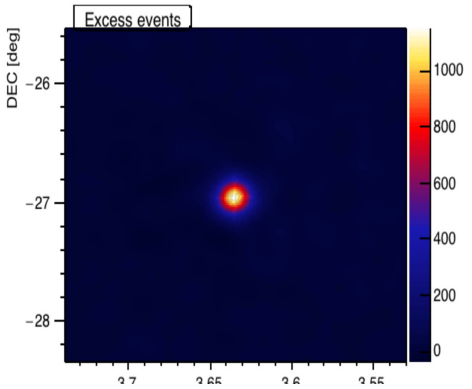


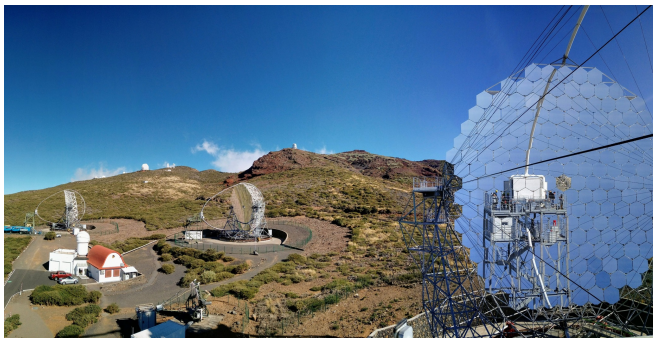
PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier

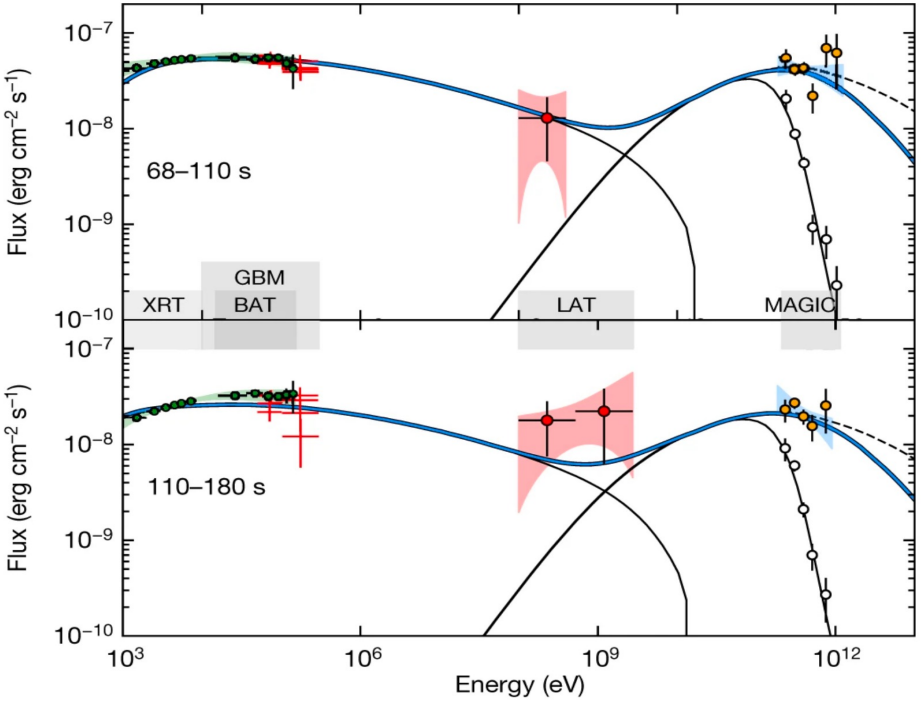
MAGIC Highlight, Gamma Ray Burst GRB190114C (z=0.42)

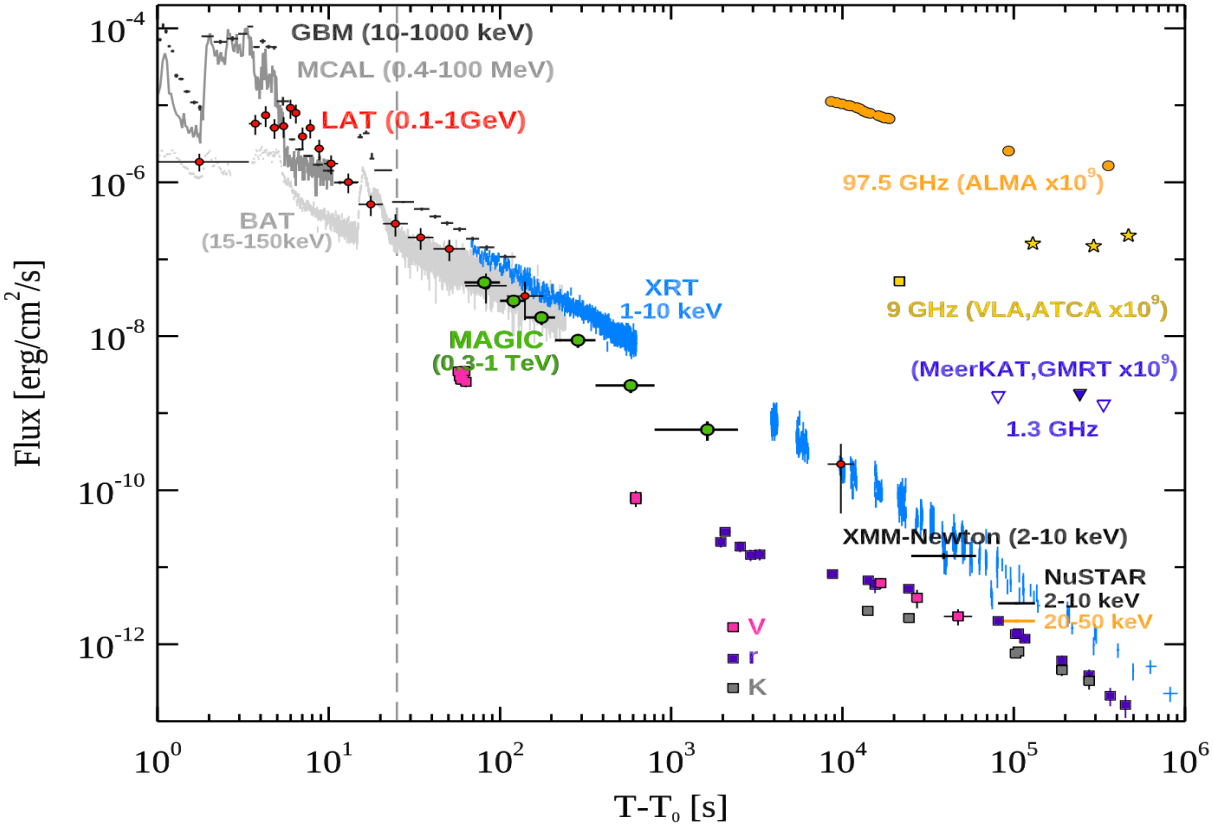
Historical achievement

- ❑ First Detection of the GRB from ground.
- ❑ ~100 Crab flux in the first minutes.
- ❑ TeV bump has a similar energetics with KeV-GeV bump



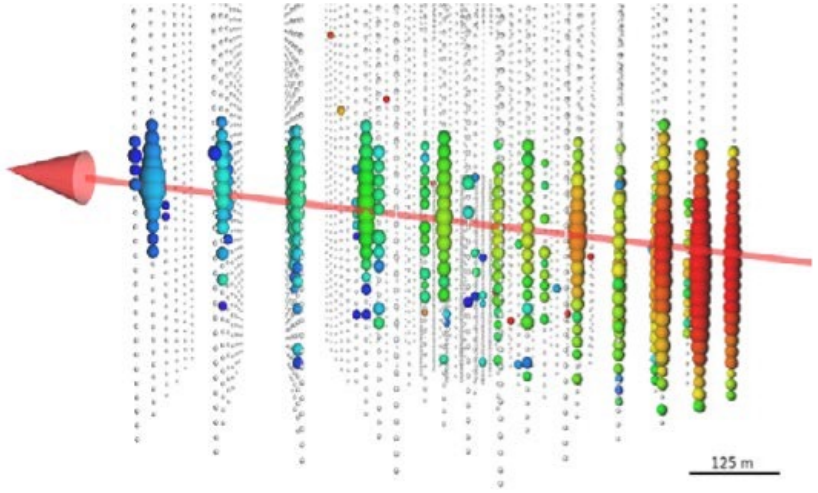




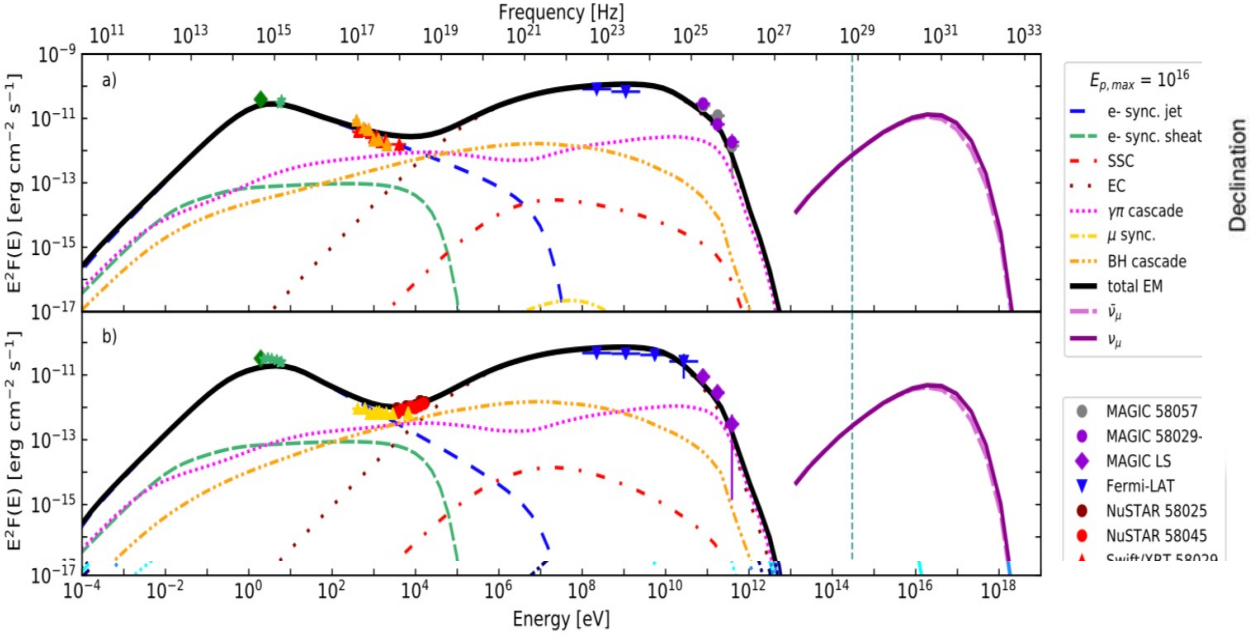


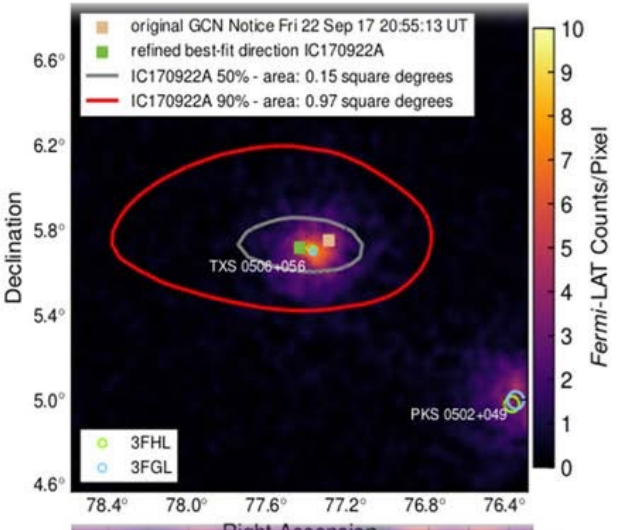
Multi Messenger Astronomy IC170922A / TXS 0506+056

Ice Cube Observation (~300TeV)

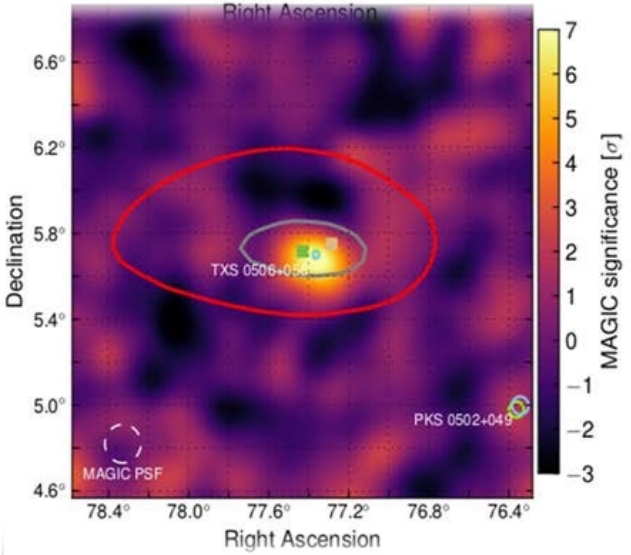


Lepto-Hadronic Scenario





Fermi LAT (>100 MeV)



MAGIC (>100GeV)

GTC Observation z = 0.3365
S. Paiano et. al 2018

Merger of giant black holes predicted

Science 1 Feb 2022, Astro-ph 2201.11633 (N.Jiang et al)

Tick ··· tick ··· boom?

SDSS J1430+2303
z = 0.081

Close supermassive black hole binaries with the separation below parsec??

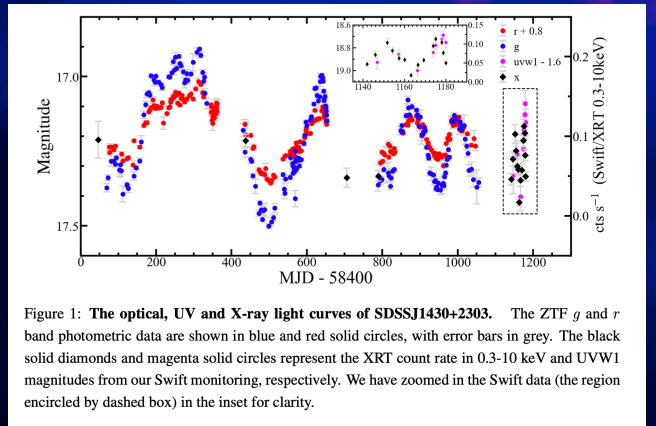
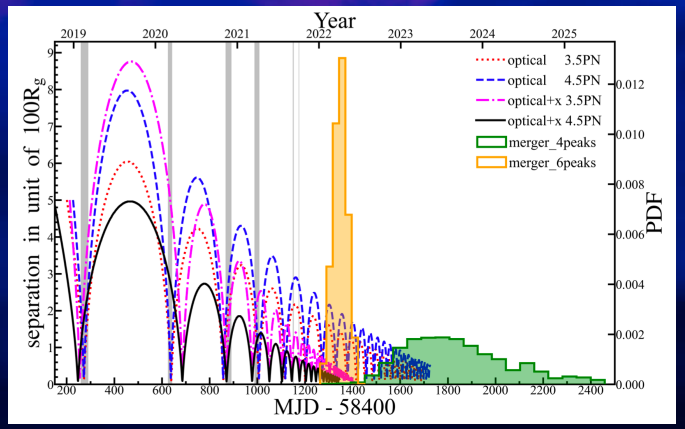
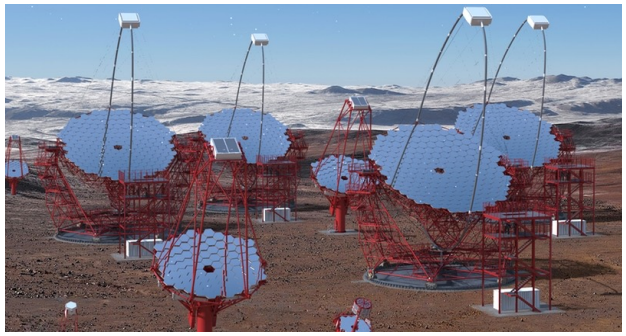


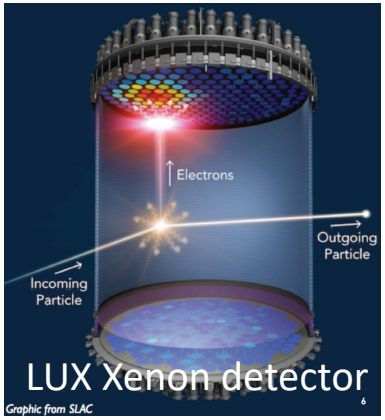
Figure 1: **The optical, UV and X-ray light curves of SDSSJ1430+2303.** The ZTF g and r band photometric data are shown in blue and red solid circles, with error bars in grey. The black solid diamonds and magenta solid circles represent the XRT count rate in 0.3-10 keV and UVW1 magnitudes from our Swift monitoring, respectively. We have zoomed in the Swift data (the region encircled by dashed box) in the inset for clarity.



Credit: NASA

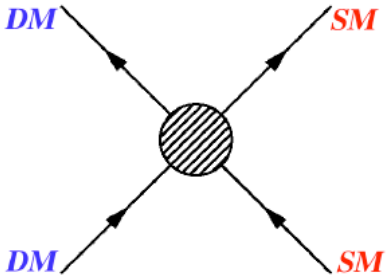
Complementarity of different approaches Direct, Indirect, and Collider Experiment



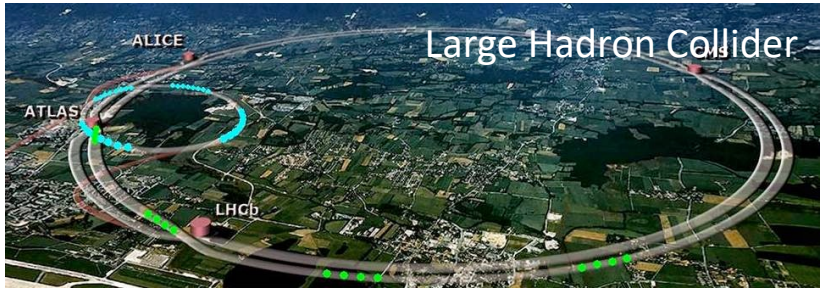


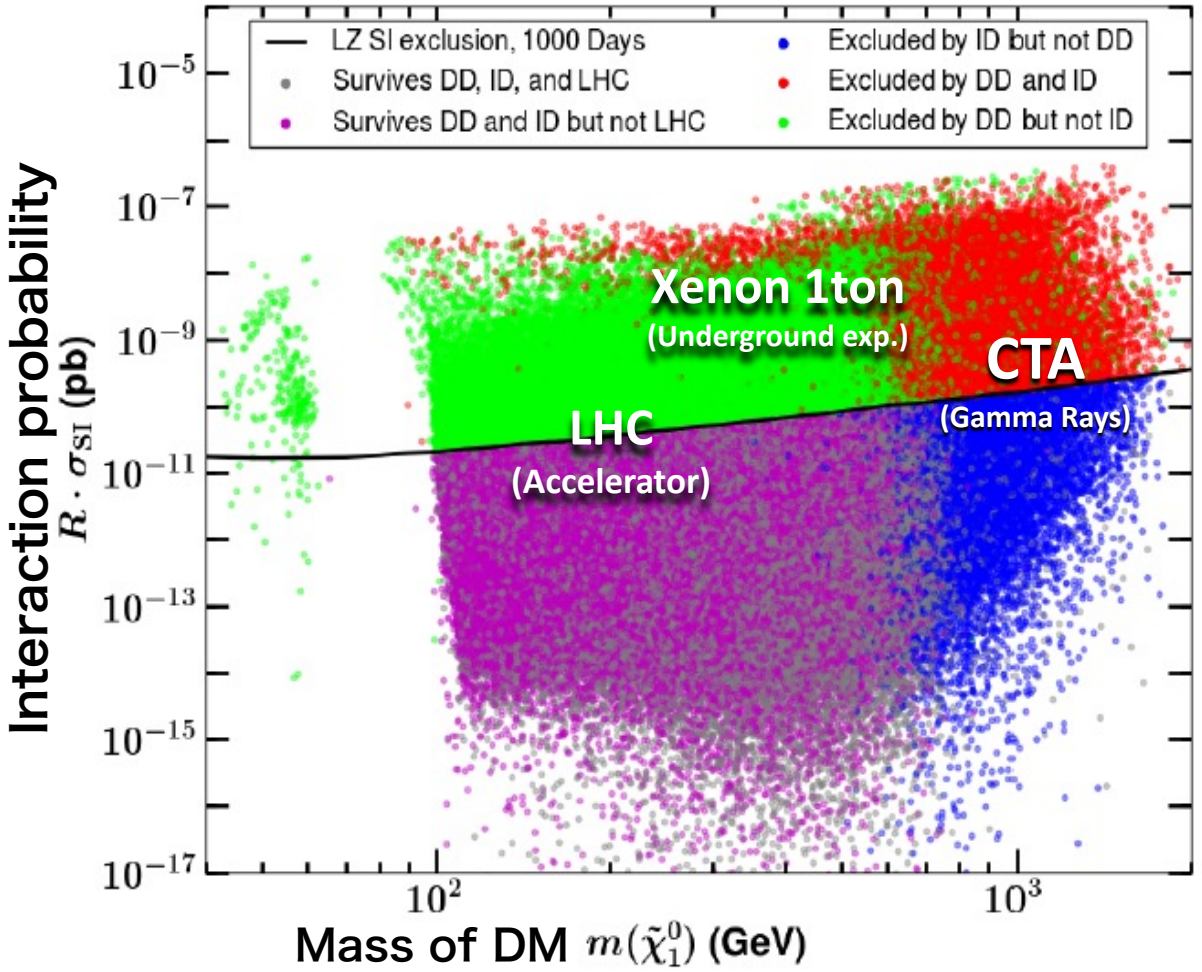
thermal freeze-out (early Univ.)
indirect detection (now)

direct detection

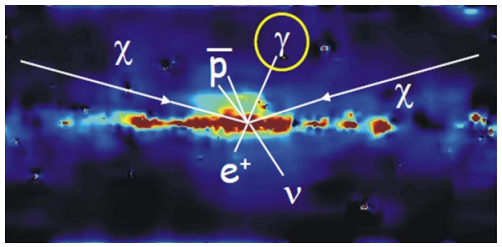


production at colliders





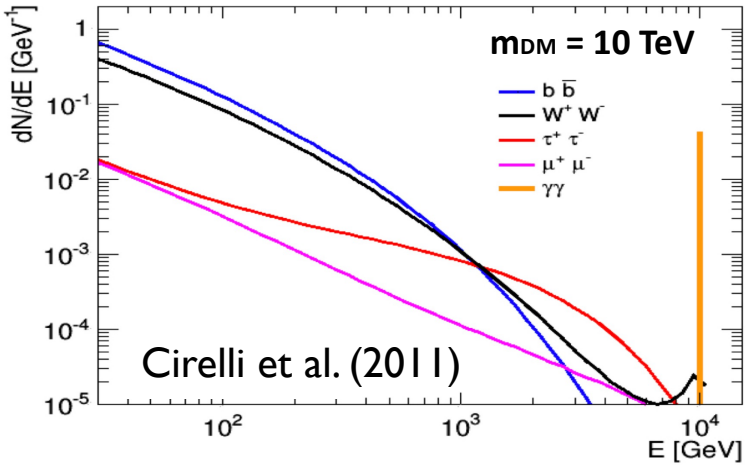
- Explore Dark Matter in the Galactic Center and Dwarf Sph. Galaxies
- CTA has the best sensitivity above 700GeV



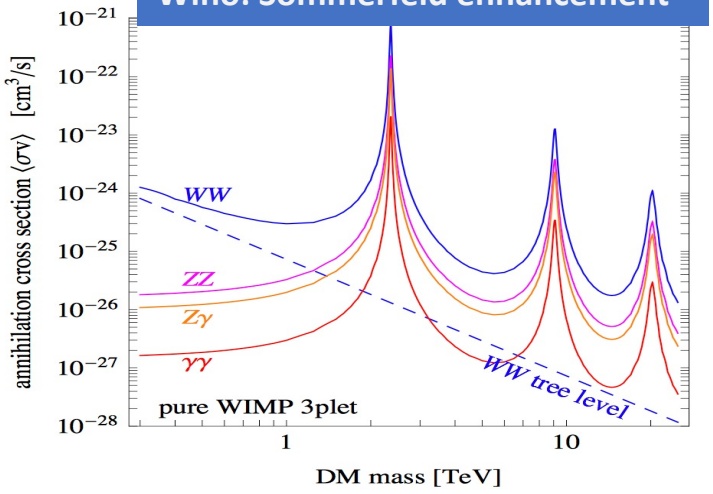
MAGIC Observation

Search for the Gamma-Ray Line Spectrum from DM annihilation (T. Inada, PRL, 2023)

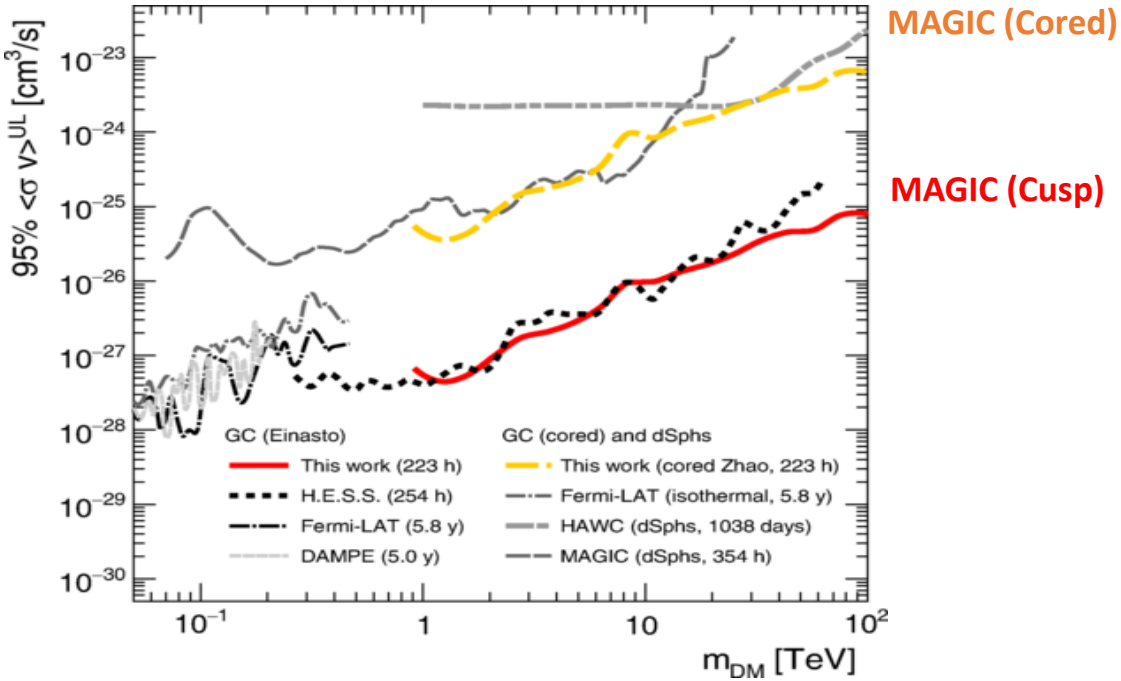
En. spectrum of Final State particles



Wino: Sommerfeld enhancement



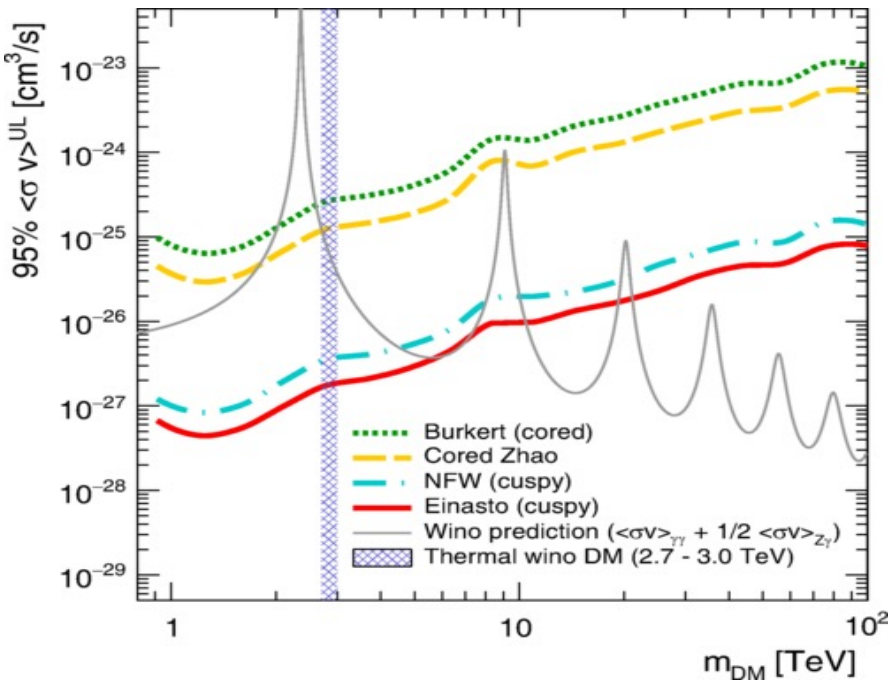
MAGIC Upper limit for Line gamma



MAGIC (Cored)

MAGIC (Cusp)

MAGIC Upper limit for Wino annihilation



Summary

- LST1 achieves the designed performance.
- LST2-4 are under construction and will be completed in 2026
- LSTs will play an essential role in the following decades in multi-messenger astronomy.

ORM in September 2023

Credit: Dominik

cherenkov telescope array

Boys and Girls, be Ambitious!

Dr. W.S. Clark

A bright future is waiting for you!

Credit: Dominik Elsaesser
Modified: Masahiro