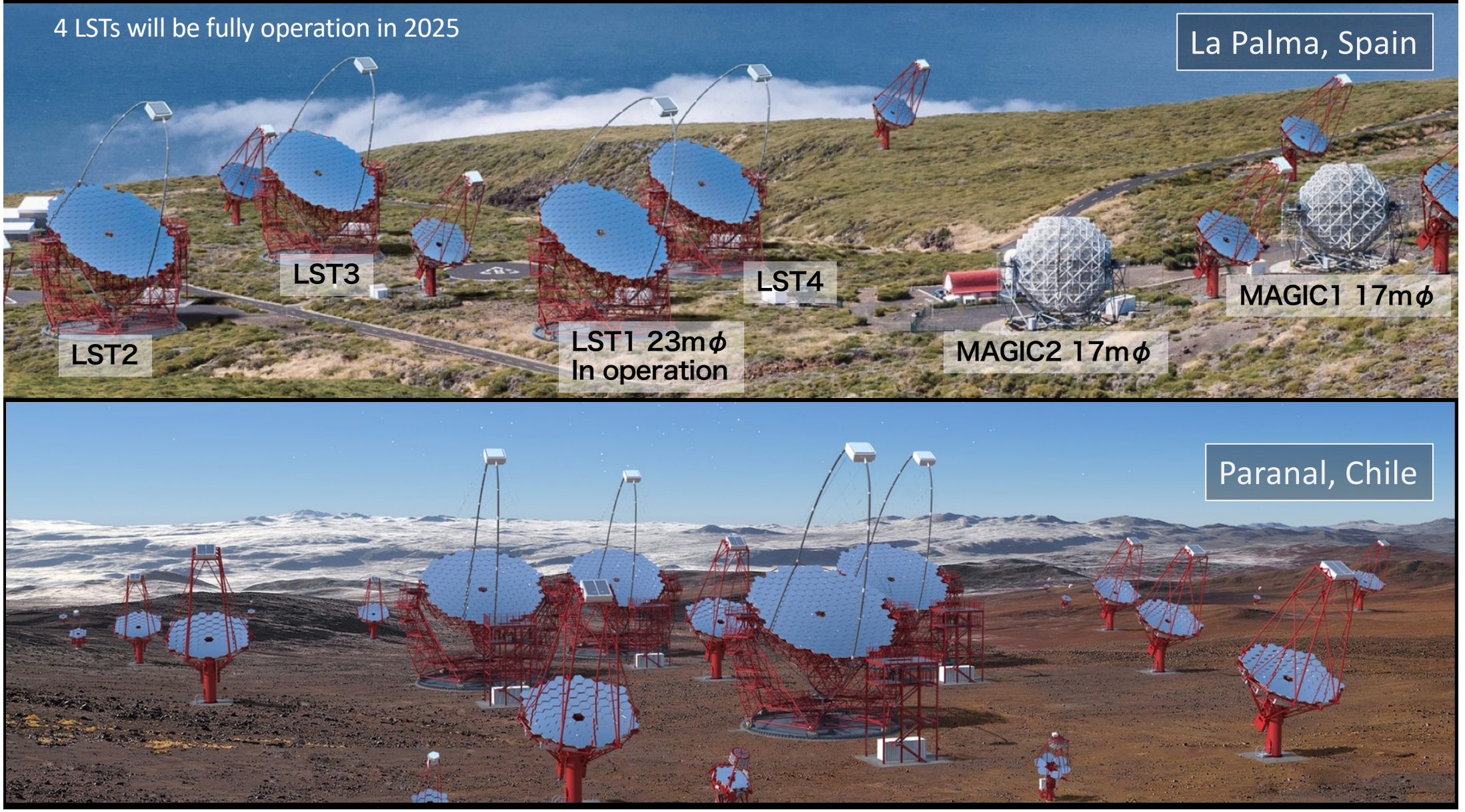
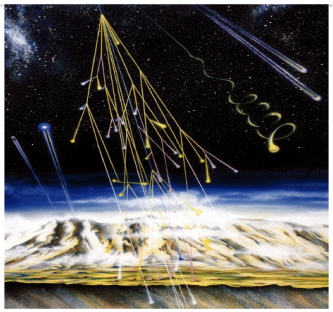
CTA - LST Project

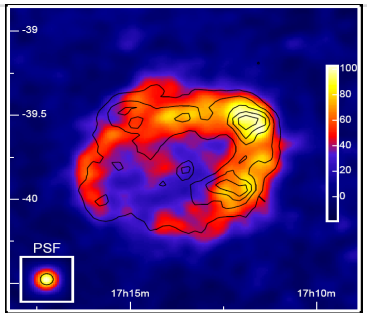
Masahiro Teshima for the LST Collaboration



Science of CTA is very wide

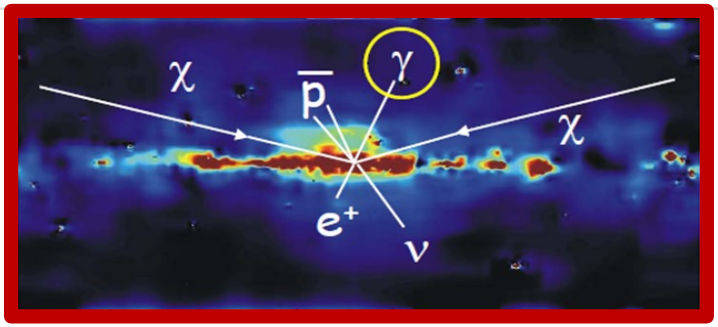
SNRs, PWNe, AGNs, GRBs, Dark Matter





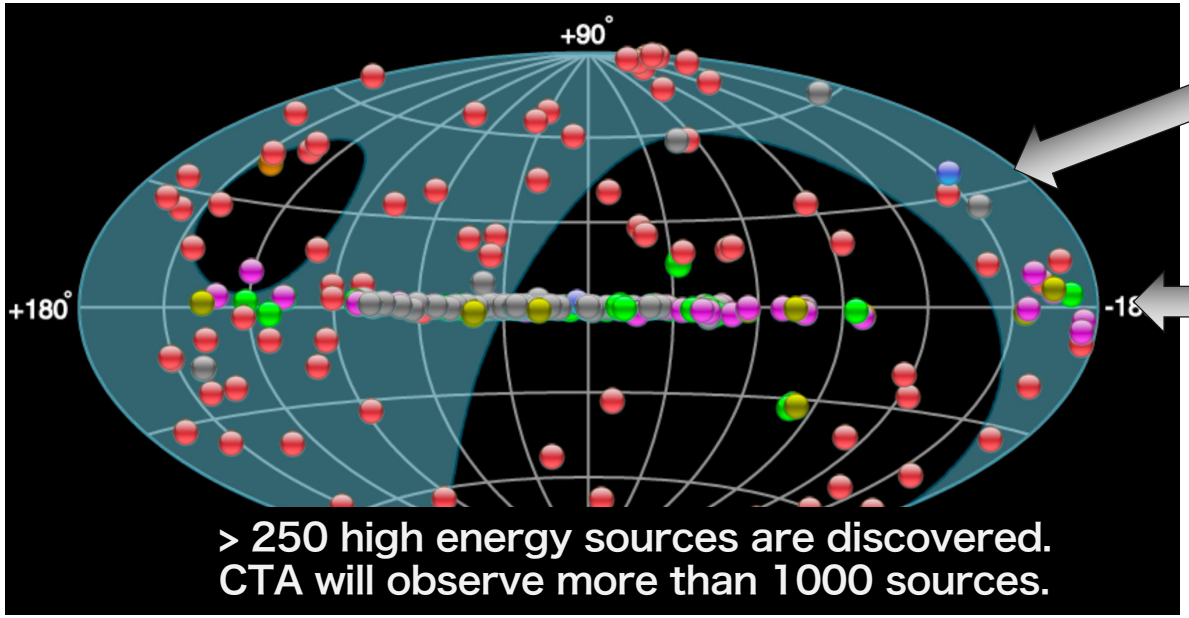
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

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

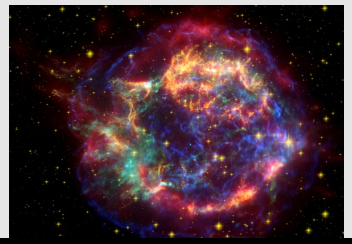


Extragalactic Sources

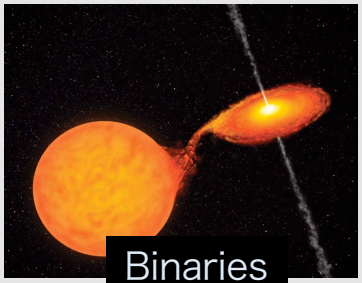
Active Galactic Nuclei

Gamma Ray Bursts

Galactic Sources



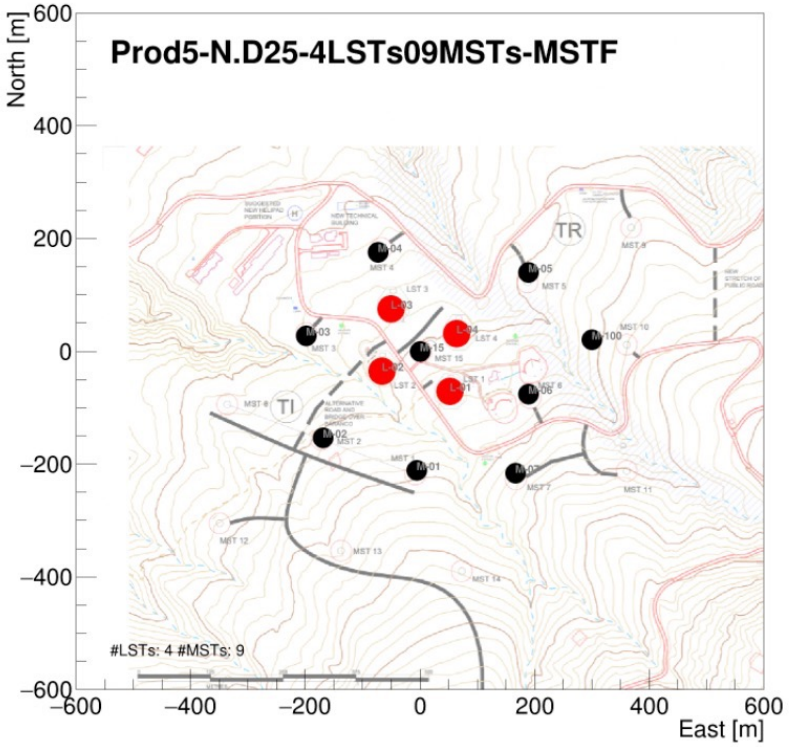
Super Nova Remnants



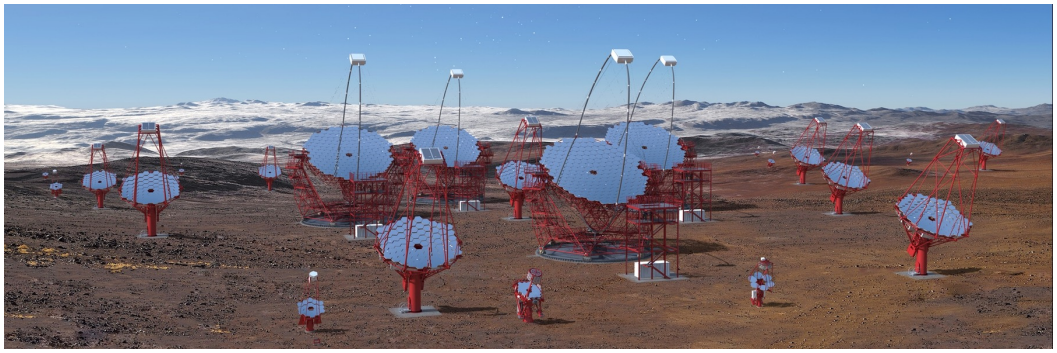
Binaries

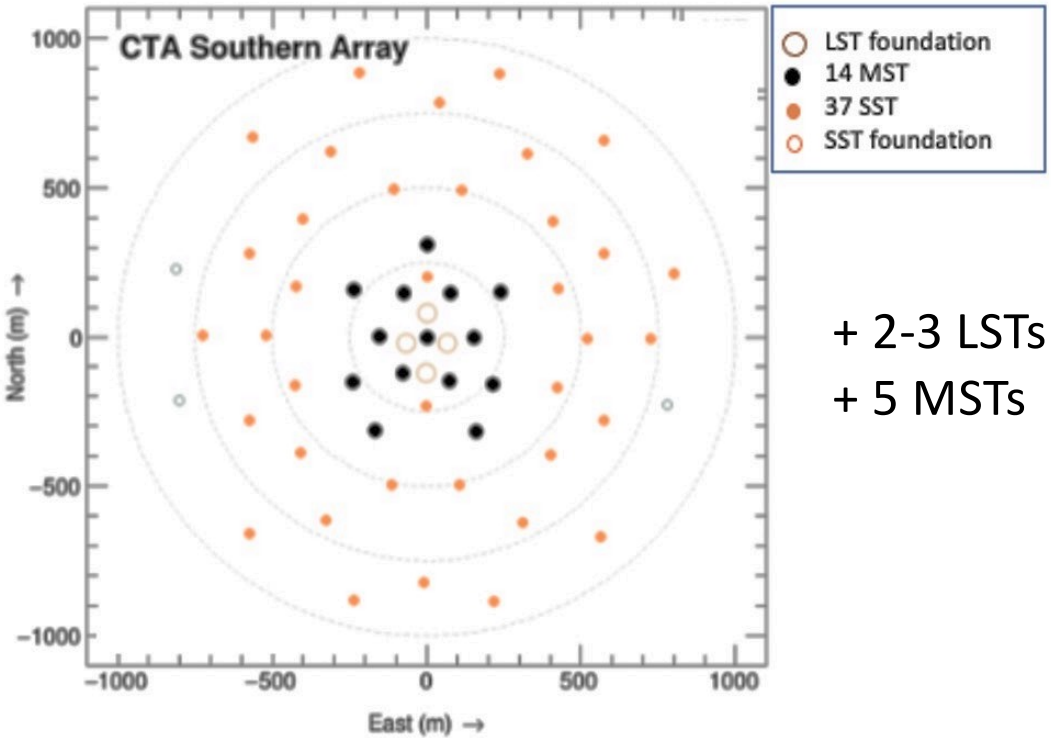
Alpha Configuration is decided with the financial constraints

Roque de los Muchachos Observatory
La Palma, Spain



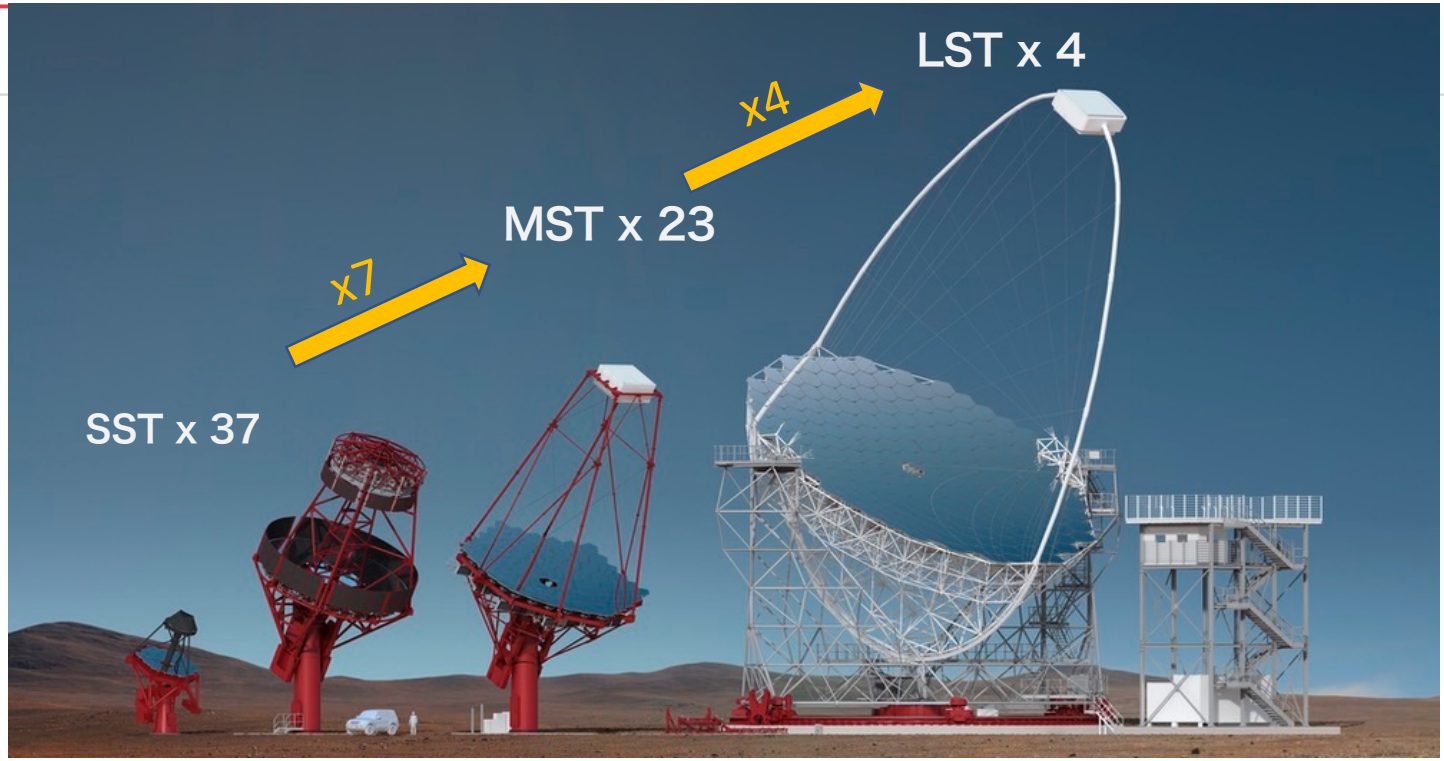
Paranal, Chile





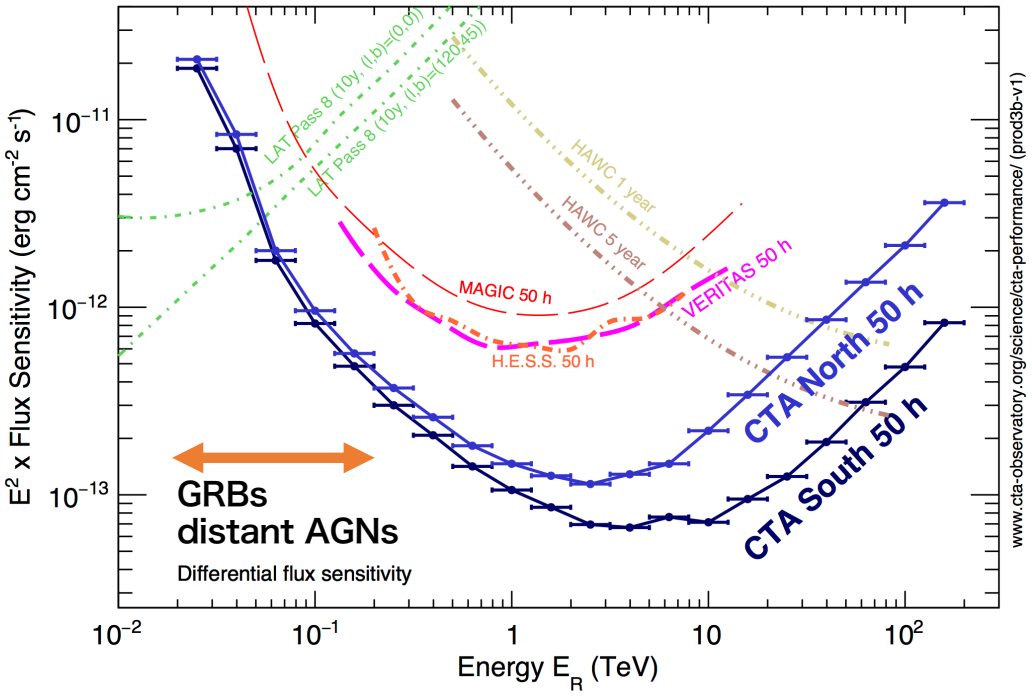
+ 2-3 LSTs
+ 5 MSTs

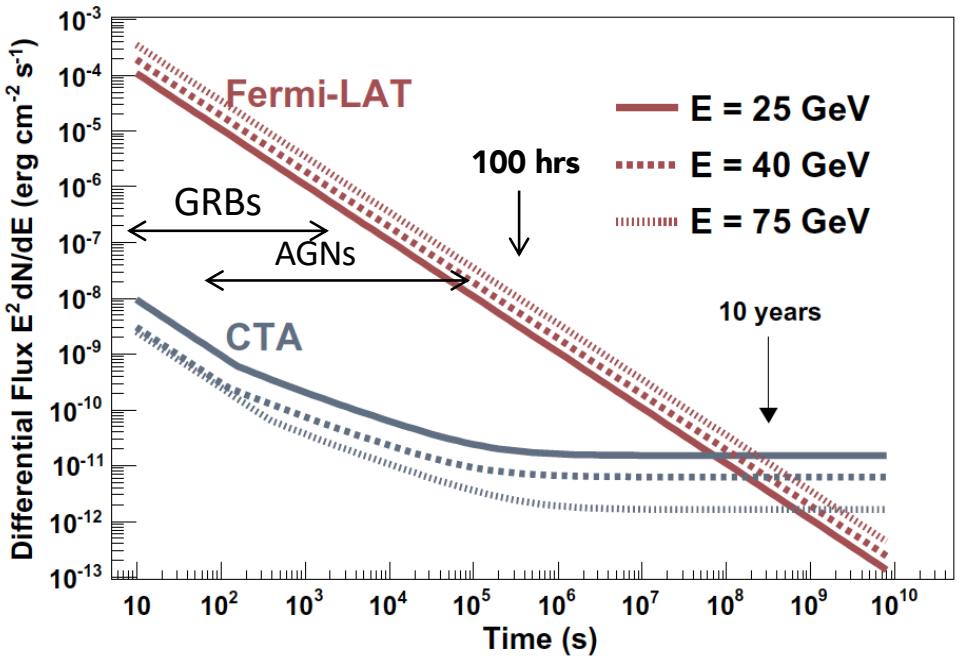
Telescope Design



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

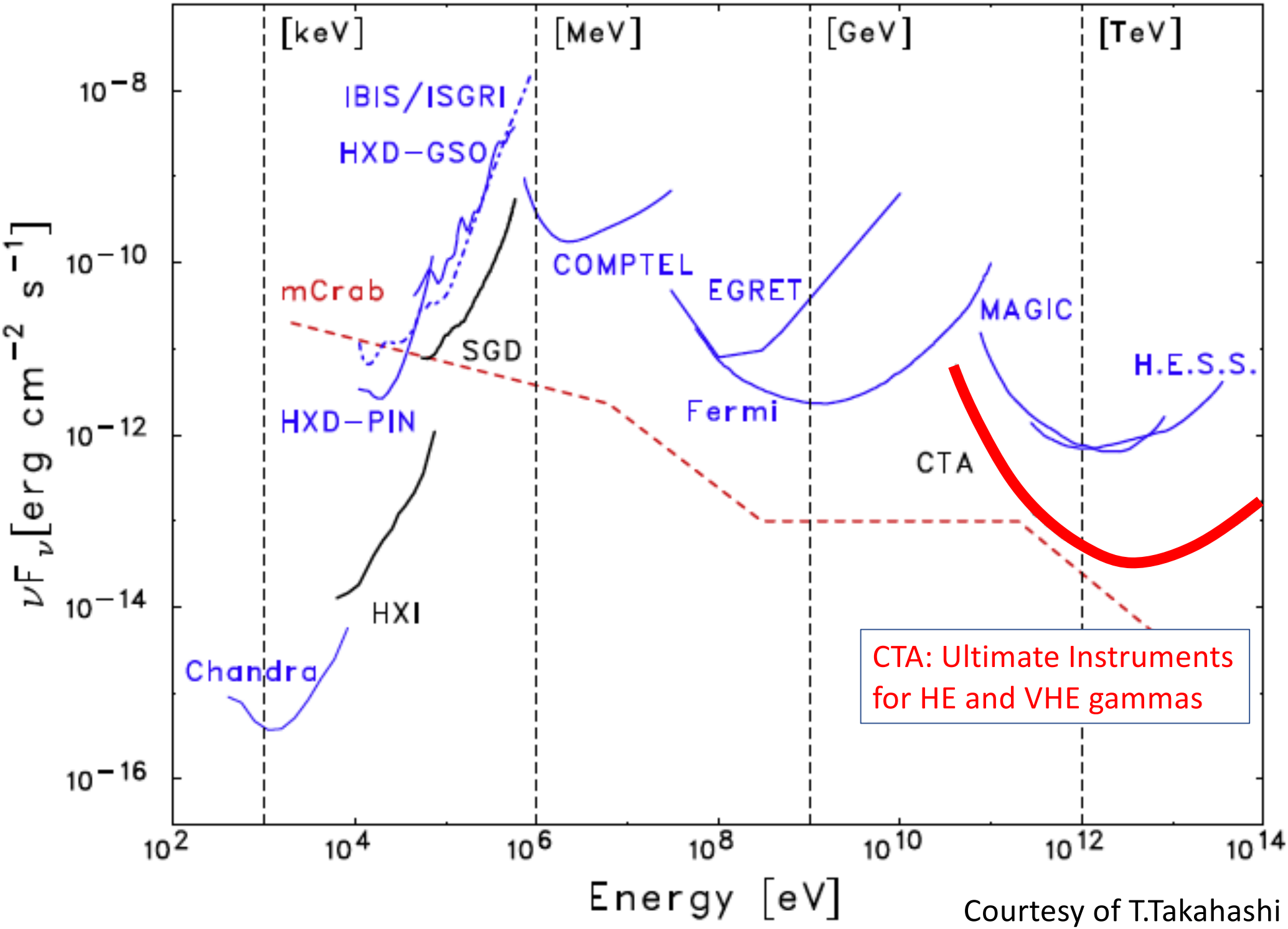
10 times better sensitivity
Wide Energy coverage 20GeV~200TeV





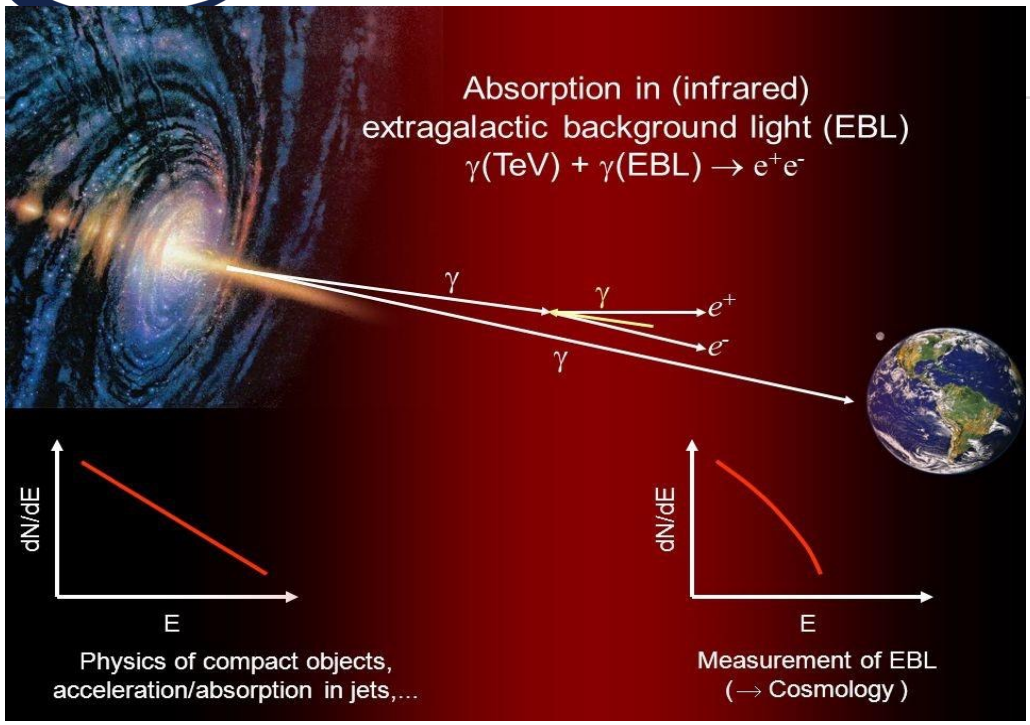
- CTA array has a 10 times better sensitivity than HESS, MAGIC, and VERITAS
- CTA covers wide energy range from 20GeV to 200TeV (4 orders of magnitude)

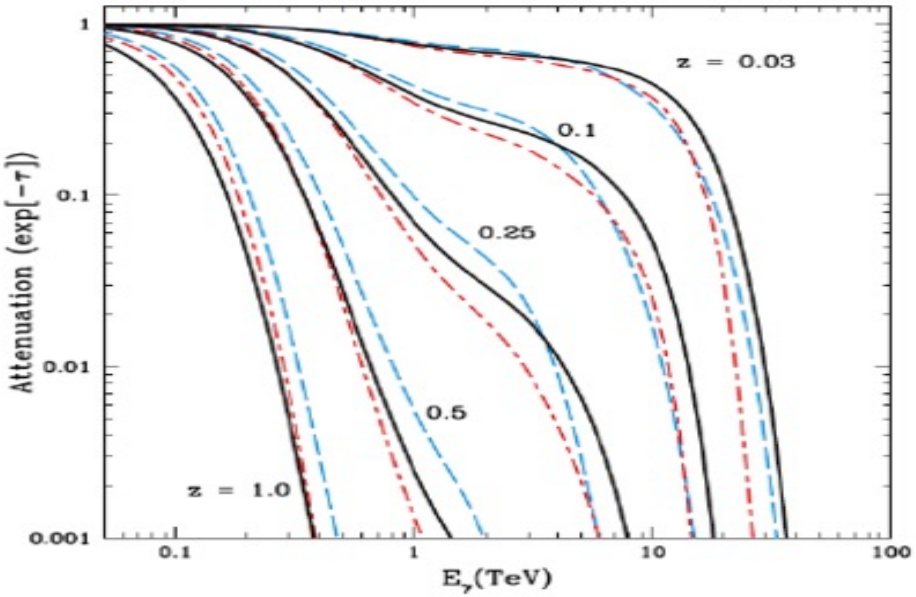
- LSTs will offer
  - Distant AGNs up to z = 2 and GRBs up to z = 4 are observable with LSTs
  - X10000 sensitivity for GRBs and AGN flares than Fermi
  - The fast rotation (20 sec) offers the observation of GRBs even in prompt phase

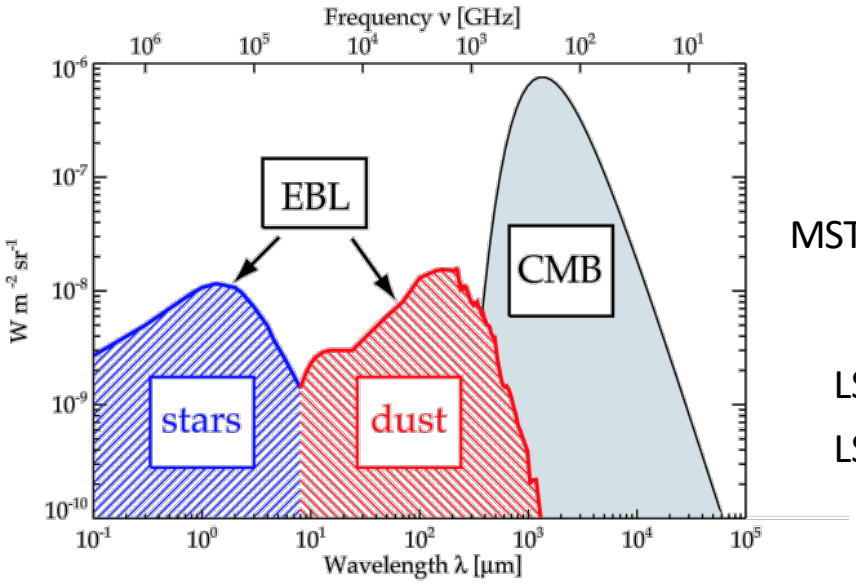


Courtesy of T.Takahashi

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



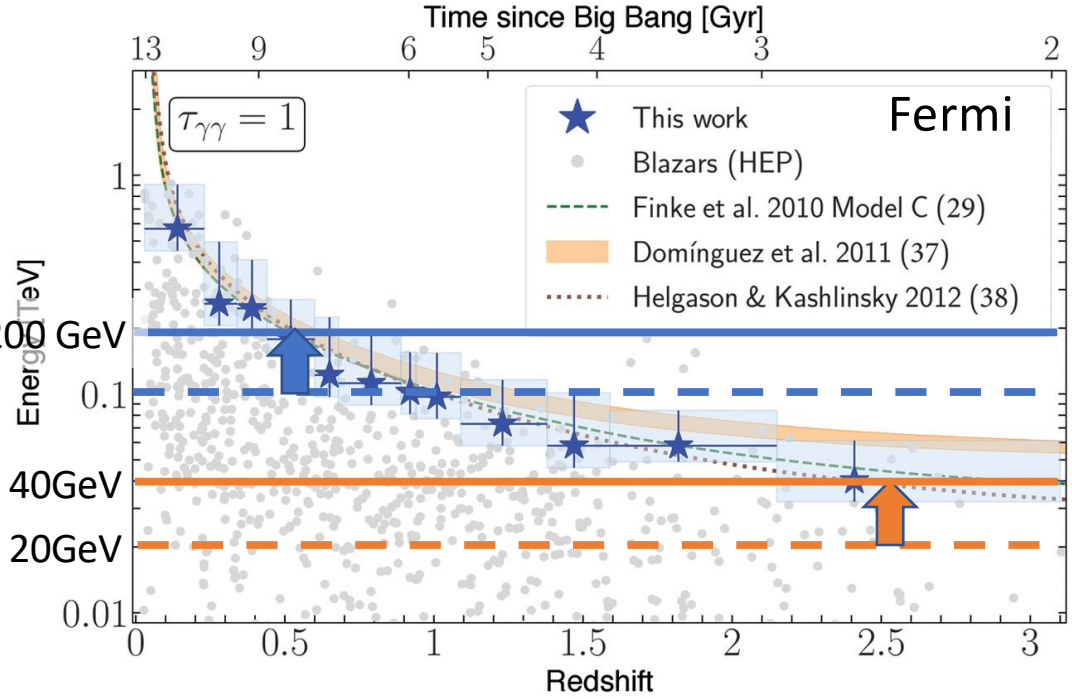




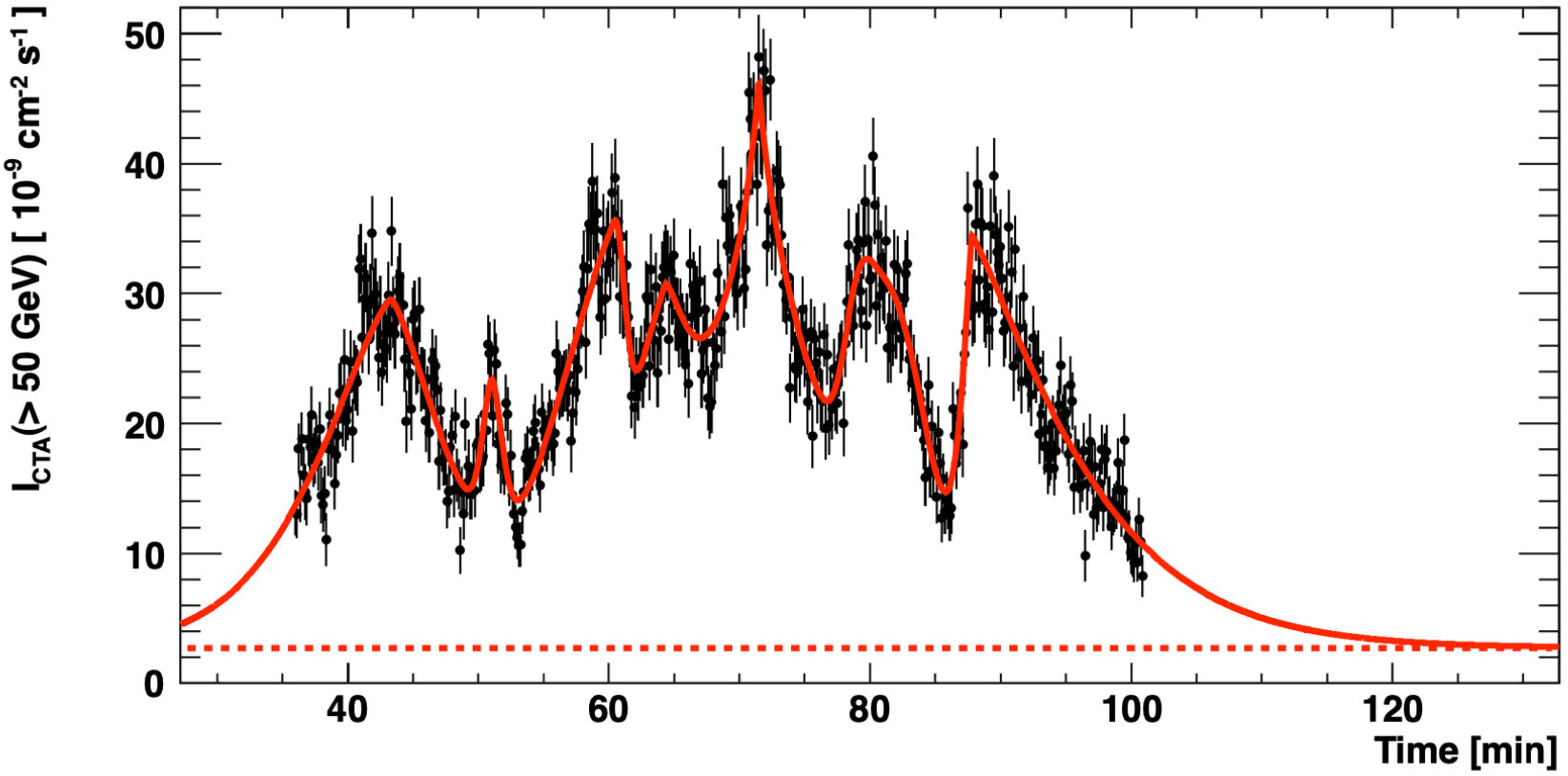
MST@45° Eth 200 GeV

LST@45° Eth 40GeV

LST@25° Eth 20GeV

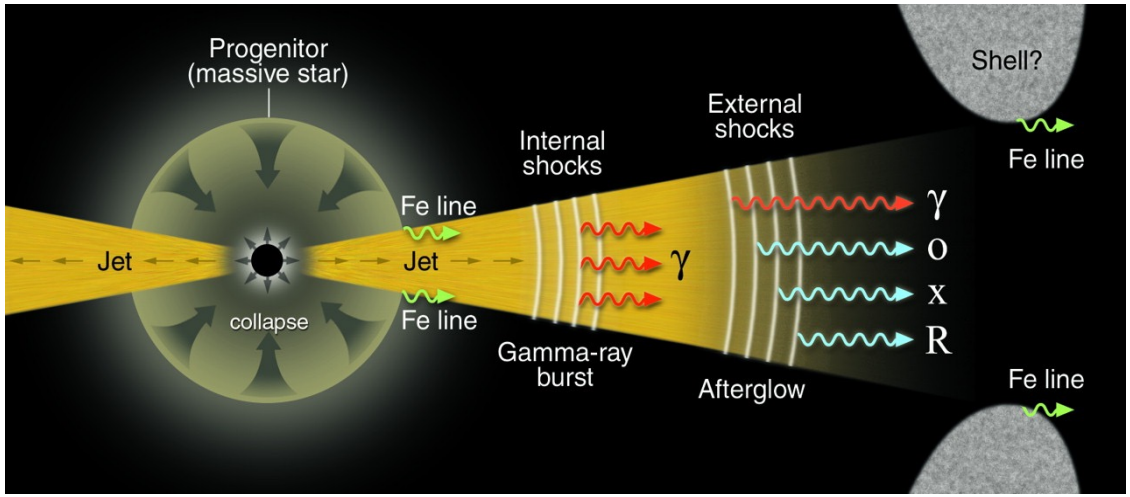


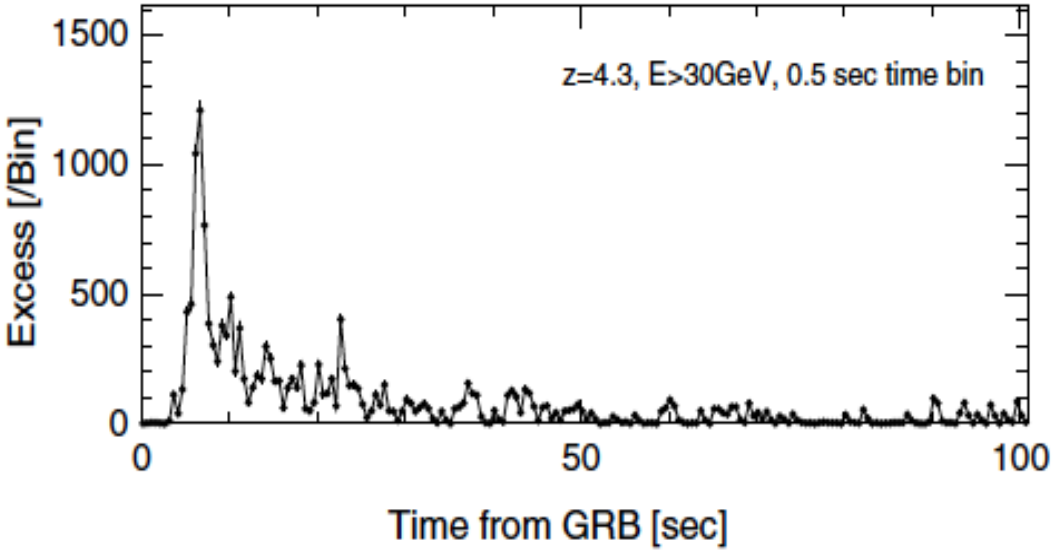
Simulated AGN Flares
Template: the 2006 flare of PKS2155-304
Low Threshold Energy ➔ High Precision Light curve

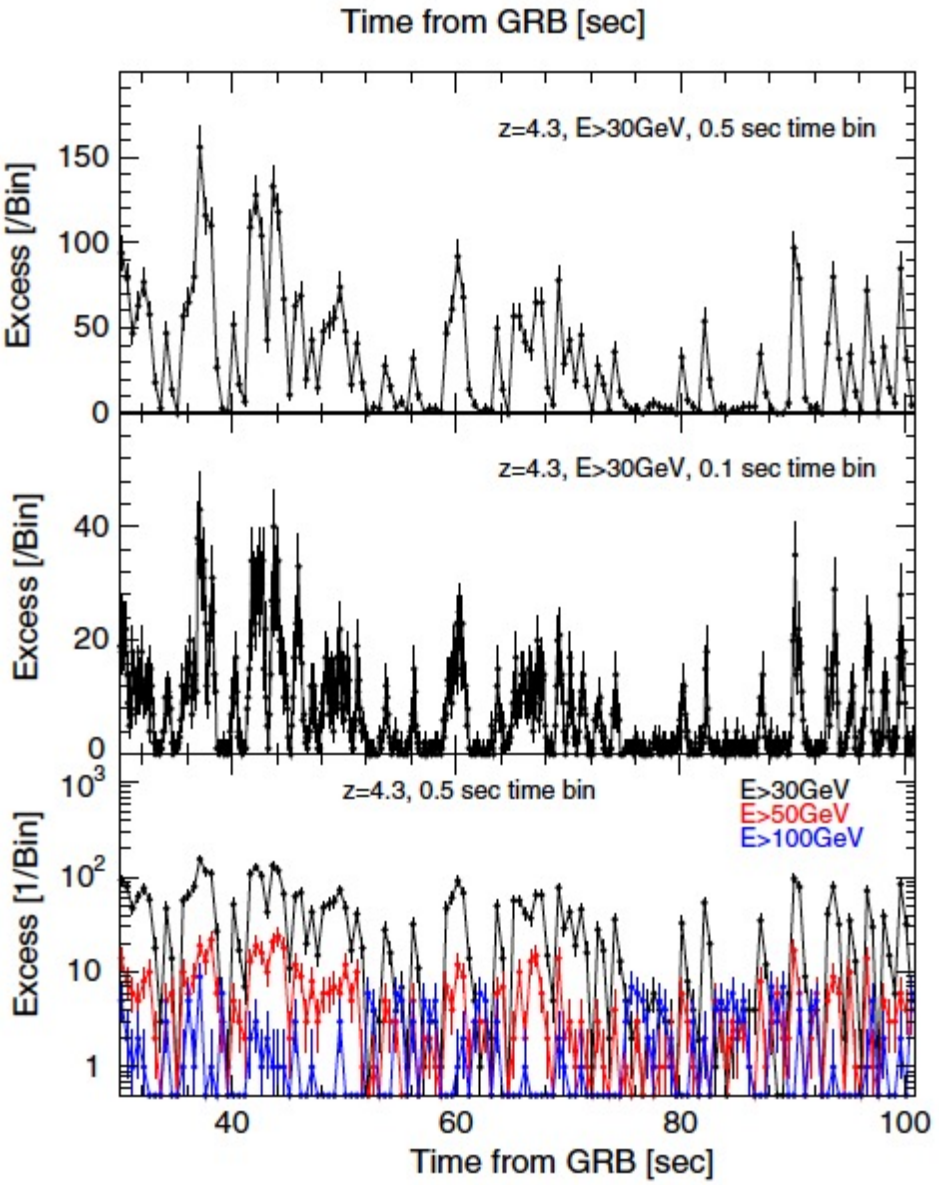


- Light curve can be examined, a few minutes scale structure ➔ a few 10s of seconds
  - Particle acceleration mechanism, Cooling process
  - Light curve vs. Energy dependence ➔ Q.G. Energy scale > Planck Mass scale

GRB: Simulated light curve
Newly Born B.H.s or N-N mergers

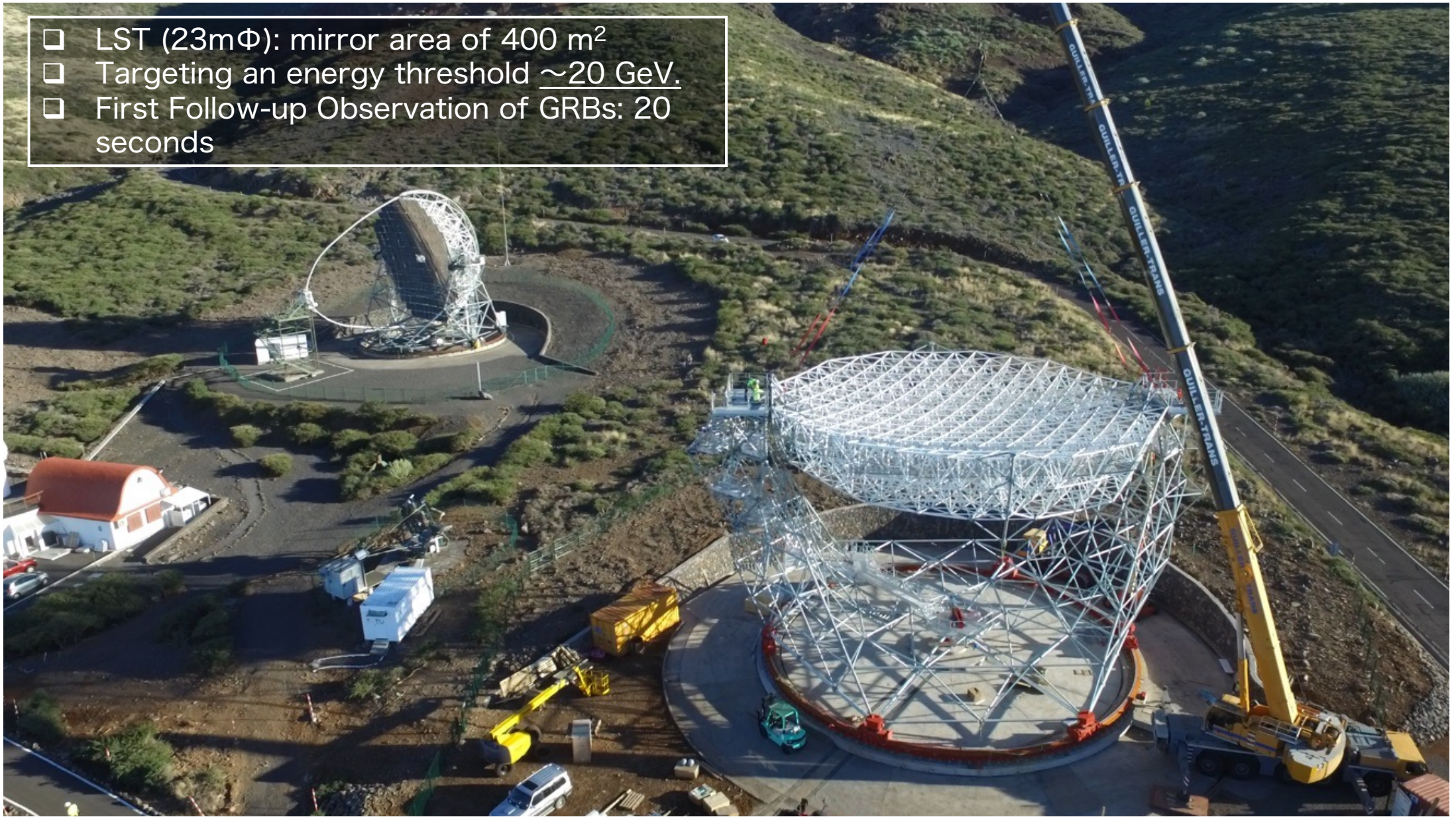






The CTA Large Size Telescope LST1

(Photo under construction in December 2017)



cherenkov telescope array

Commissioning since 2019 including Science Operation since 2020

Large Size Telescope

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

Tension cables: IT

Camera Support Structure: FR

calibration: IT, HR, IN, DE

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

Telescope structure: DE

Rail: DE

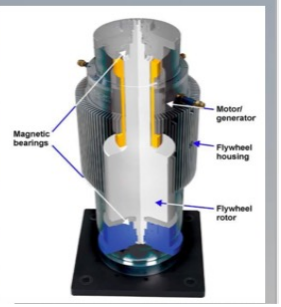
Camera Access Tower: DE, ES

Bogies: ES

Foundation: ES

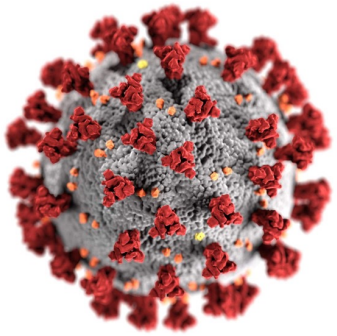
Drive and main el. cabinet: FR

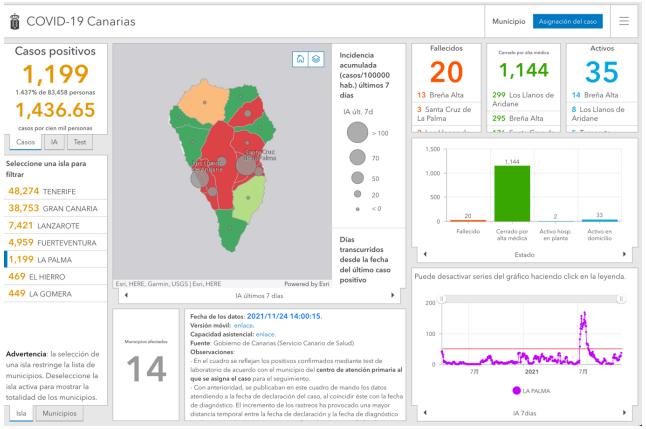
FlyWheels (2x300kW) energy storage and UPS: JP



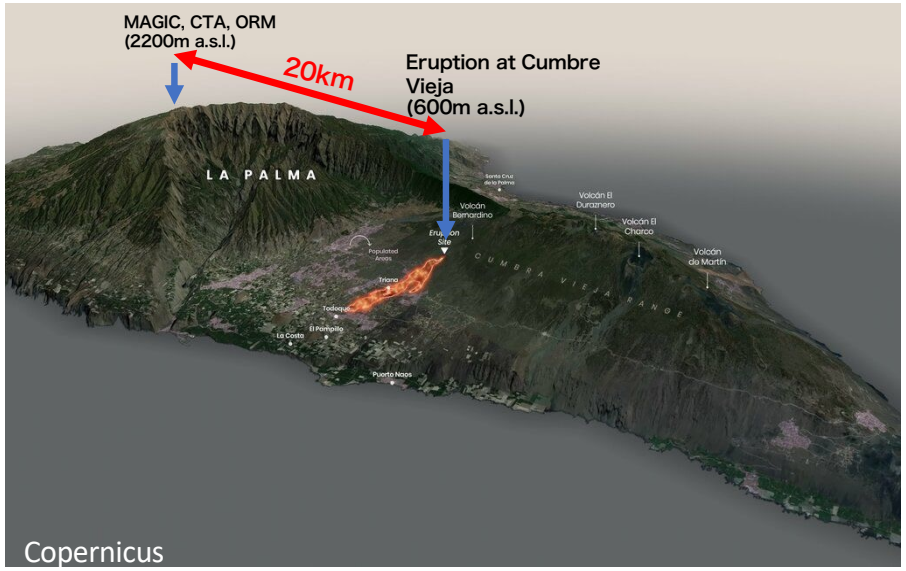
Last three years, we suffered from „„ Oh, my God!!

Covid-19





Volcano Eruption



Russian Aggression in Ukraine

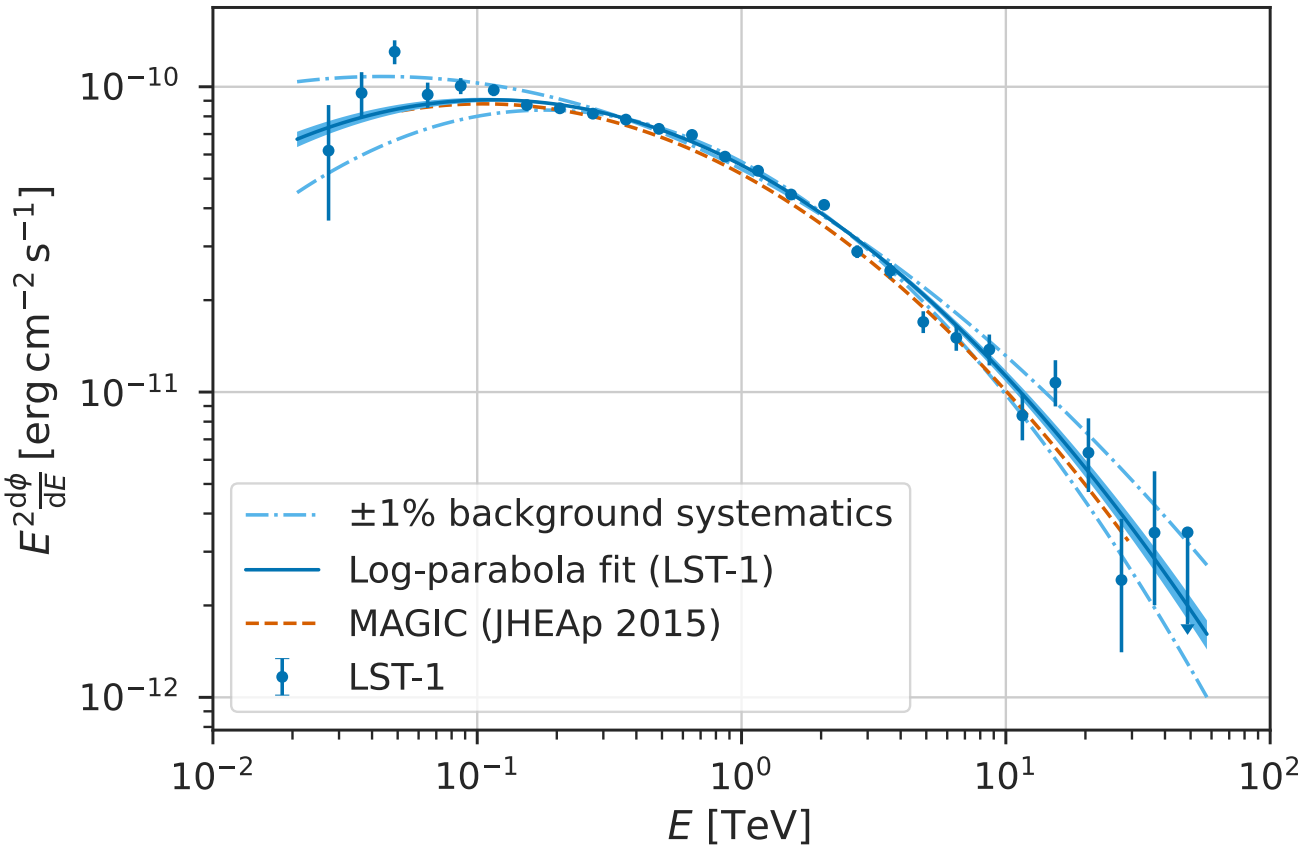
Inflation / Cost Increase

Shortage of semiconductors and materials

Erupciones históricas en La Palma

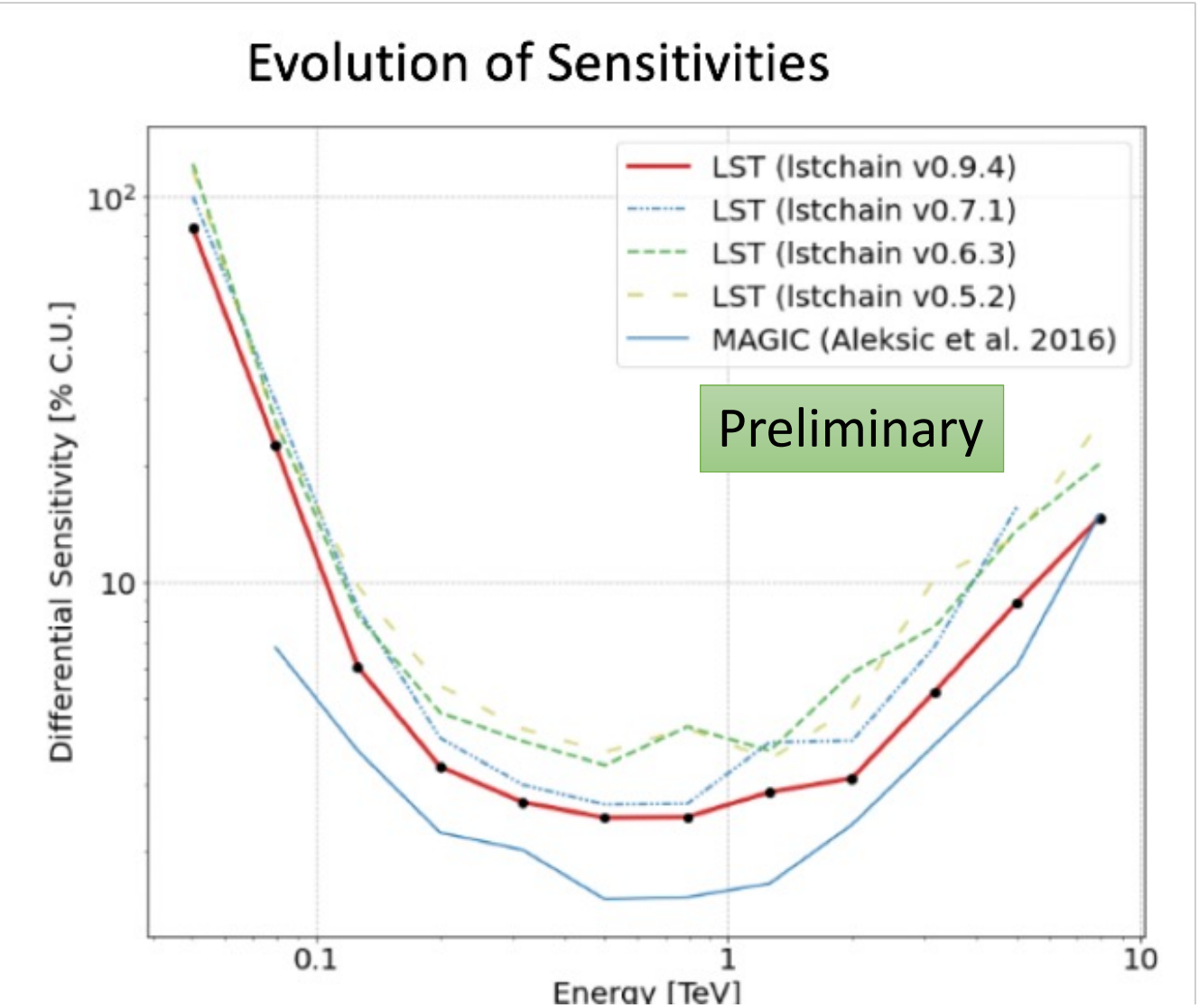
#	Erupción	Año	Días erupción
1	nombre?	2021	85days ?
2	Teneguía	1971	24
3	San Juan	1949	47
4	Charco	1712	56
5	San Antonio	1667/1678	66
6	Tigalate	1646	82
7	Tehuya	1585	84
8	Tacande	1430/1440	?

Performance: Crab Nebula spectrum



- 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 ±1% background.
- Consistent with MAGIC and Fermi-LAT.
- Lowest data point at 25 GeV!

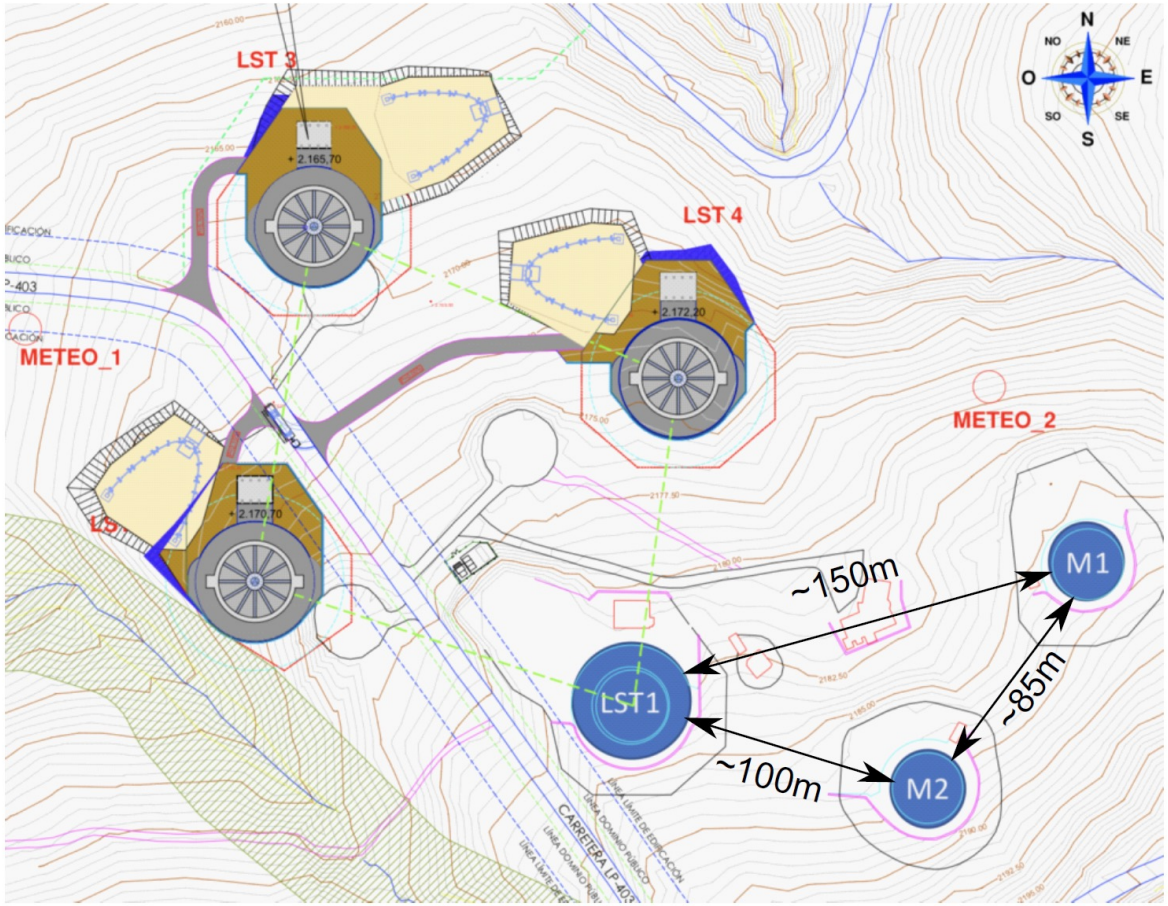
Single Telescope LST-1 performance: sensitivity

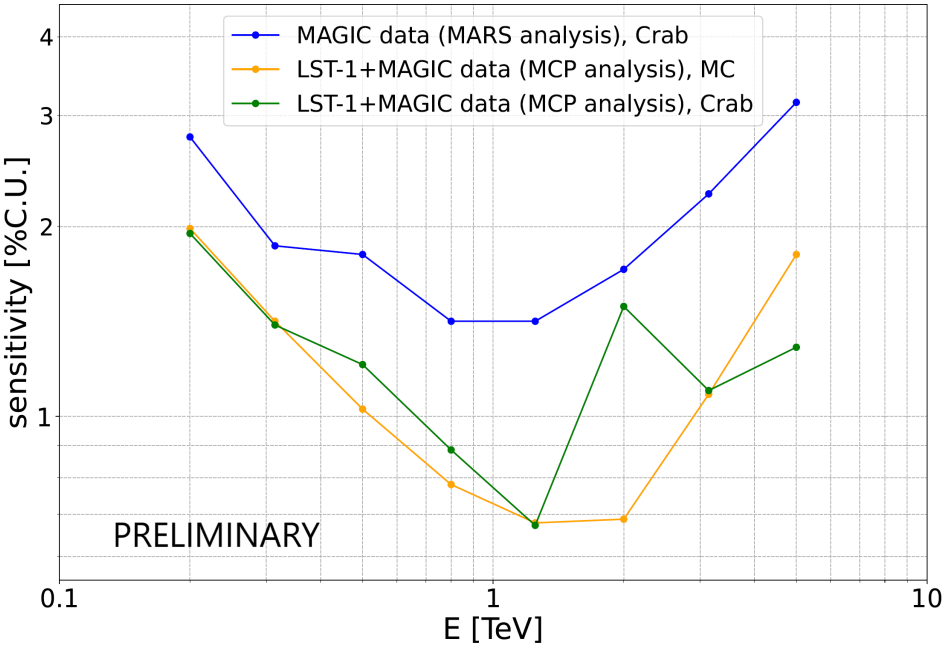


- Consistent sensitivity for source-dependent and source-independent analyses.
- The sensitivity is close to MAGIC stereo array.
- X10 better sensitivity is expected with 4 LST array

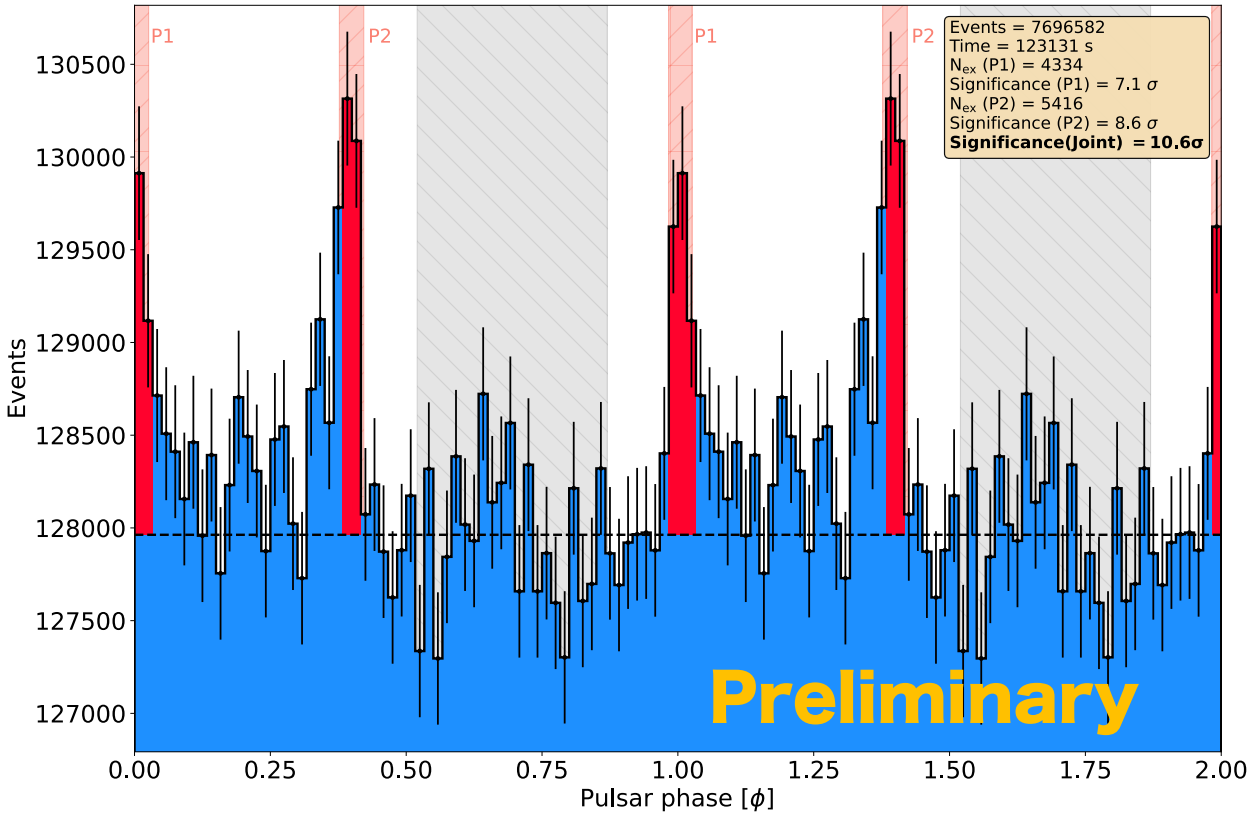
LST1 + MAGIC joint data analysis

Stereo Observations improve the sensitivity

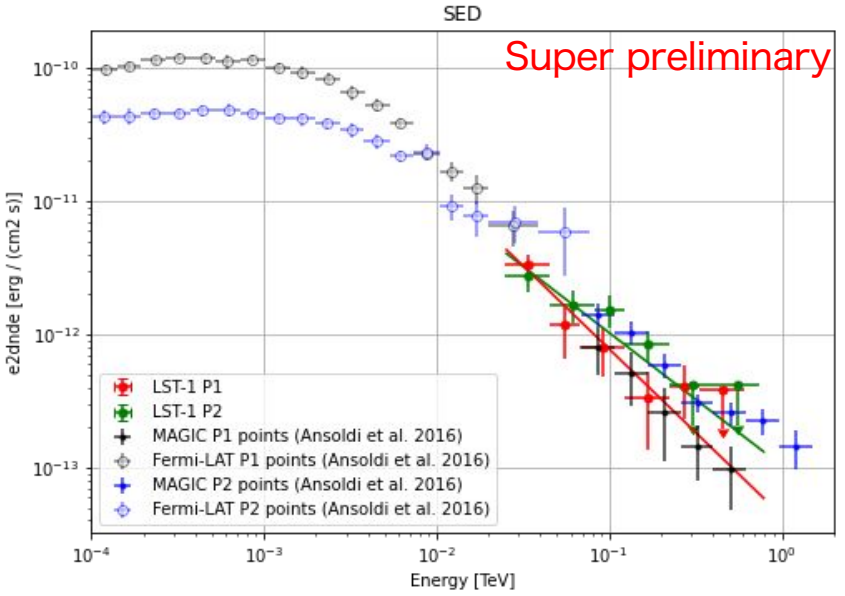




Crab pulsar phaseogram



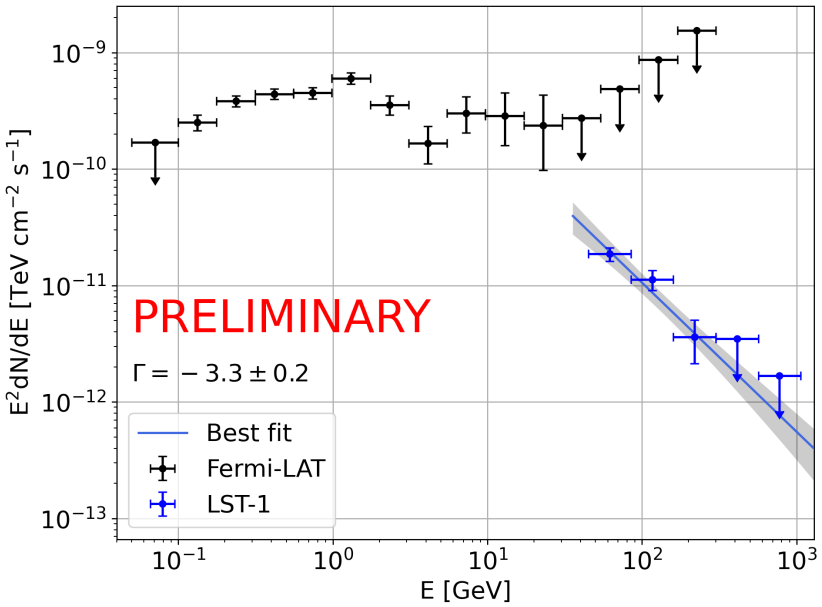
- Observation time: 34.2 hours
- Nov 2020 - March 2022
- Highly significant detection down to few tens of GeV.
- Low energies: P1/P2 tends to 1.
- Stay tuned for spectrum down to few tens of GeV…

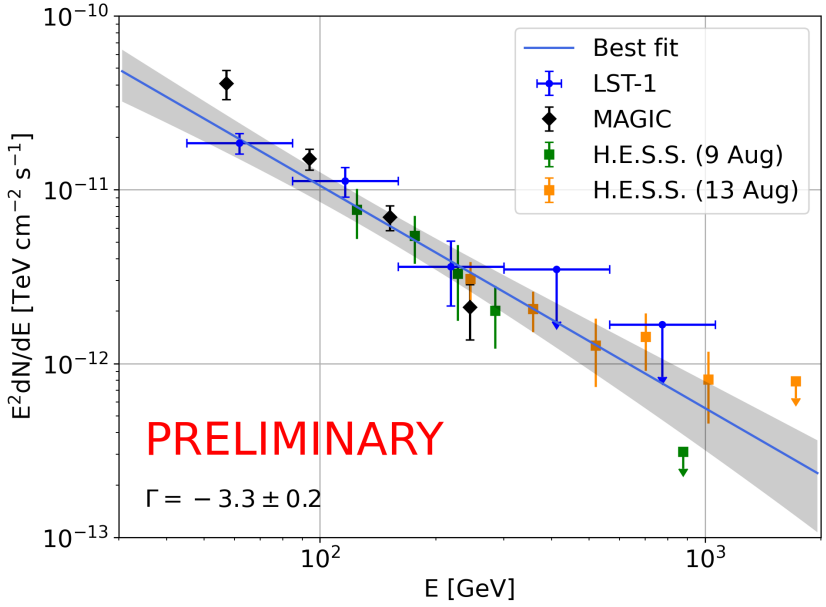


First VHE-detected Recurrent nova: RS Ophiuci

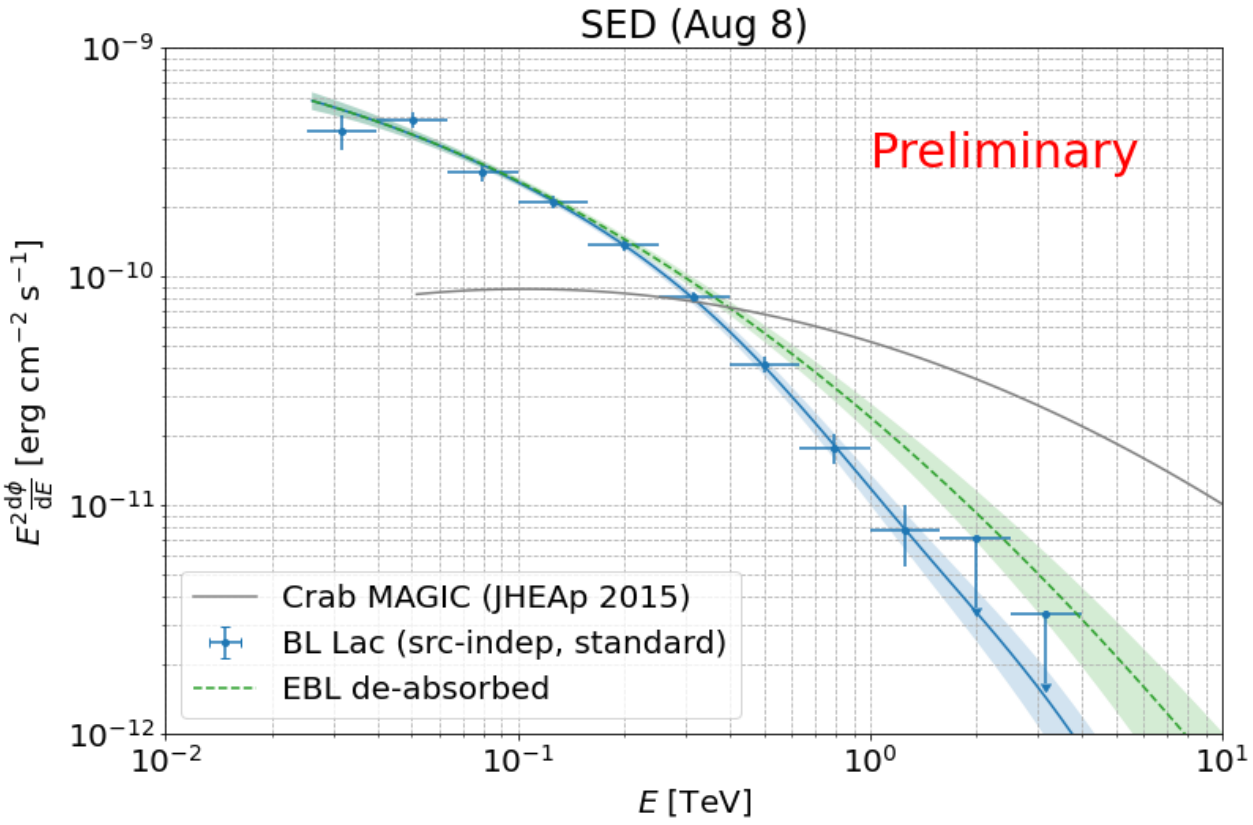
- RS Ophiuchi is a recurrent Nova.
- Explosions, 1898, 1933, 1958, 1985, 2006, 2021
- Mag 12.5 (low state) ➔ Mag 4.7 (~1000 times)
- Binary System with a White Dwarf and a Red Giant
- Accumulation of material on the WD, and then thermonuclear reaction makes recurrent explosions

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

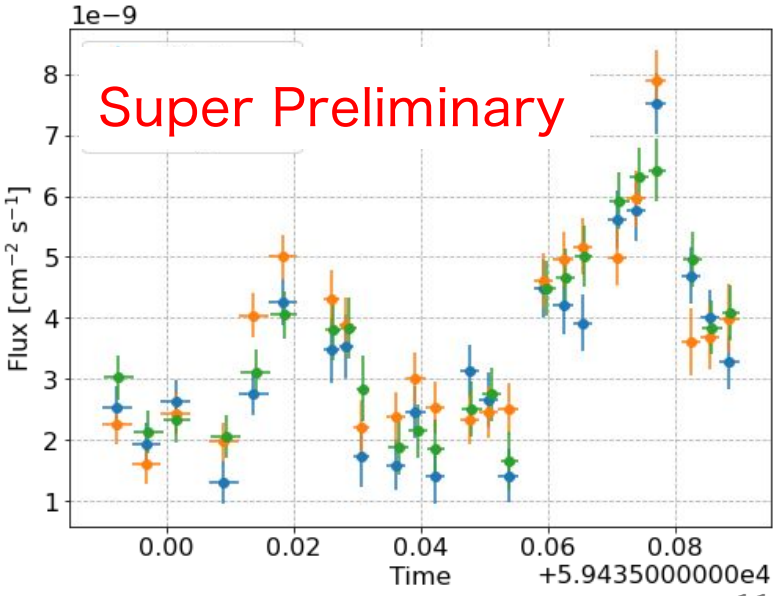




BL Lacertae flare
on 8th August 2021



- 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.



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 ???				

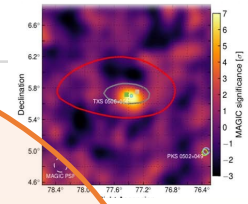
Multi-messenger and Multi-wavelength Astrophysics

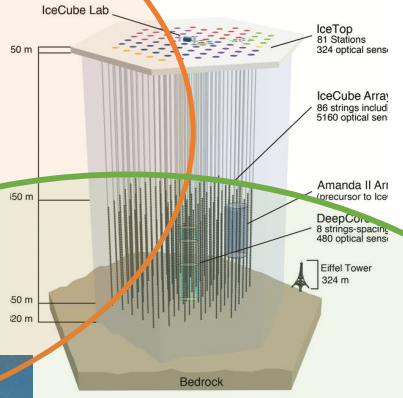
cherenkov telescope array

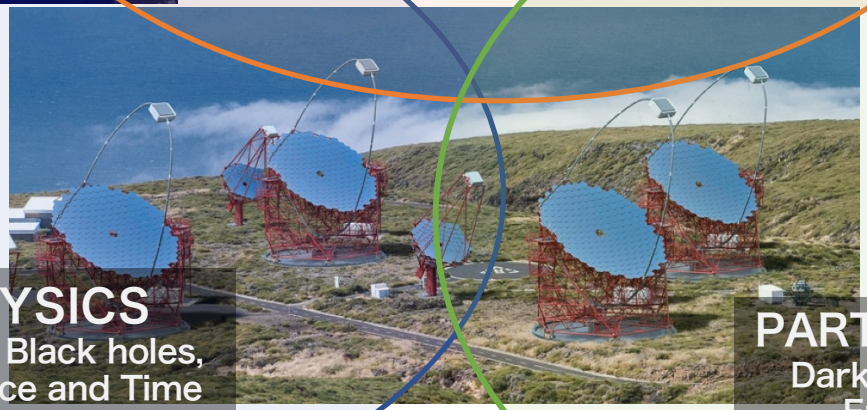
Wave AstroPhysics

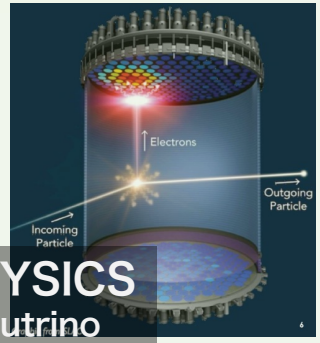
Particle Physics

ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics



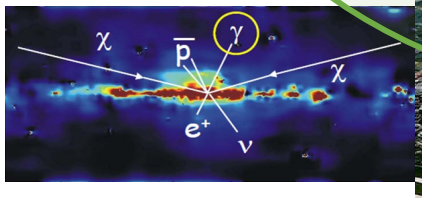






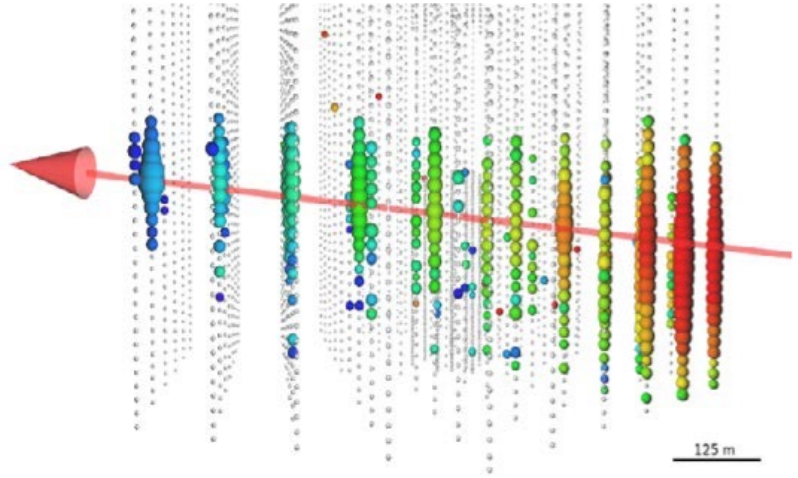
ASTRO-PHYSICS
Gamma Ray Bursts, Black holes,
Neutron Stars, Space and Time

PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier

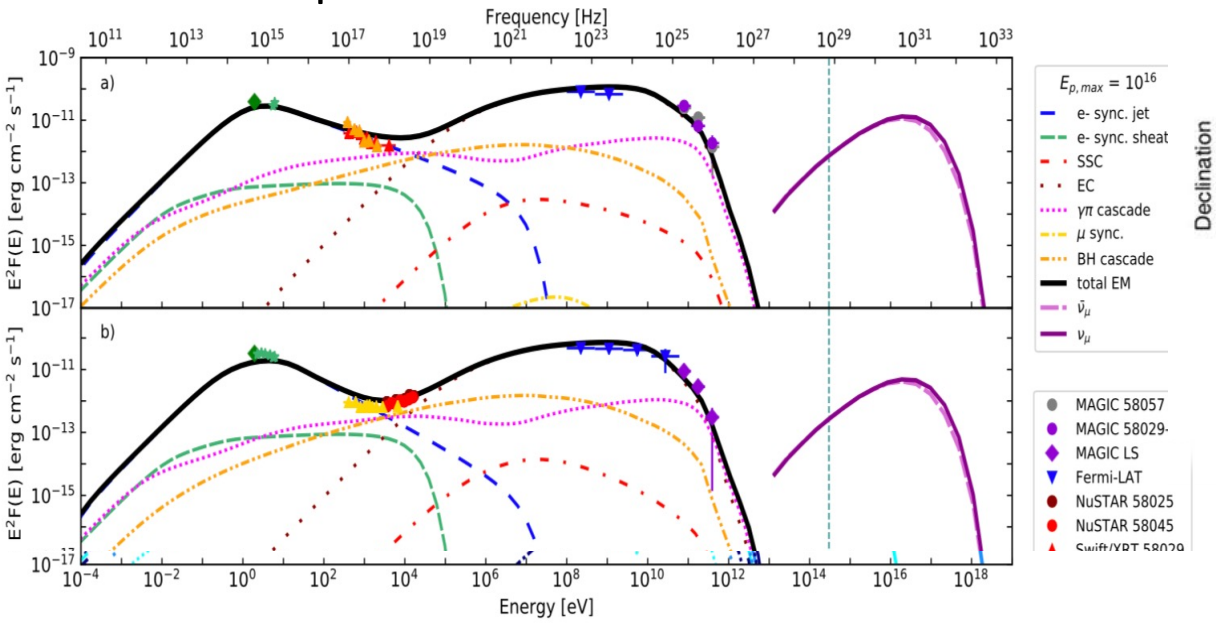


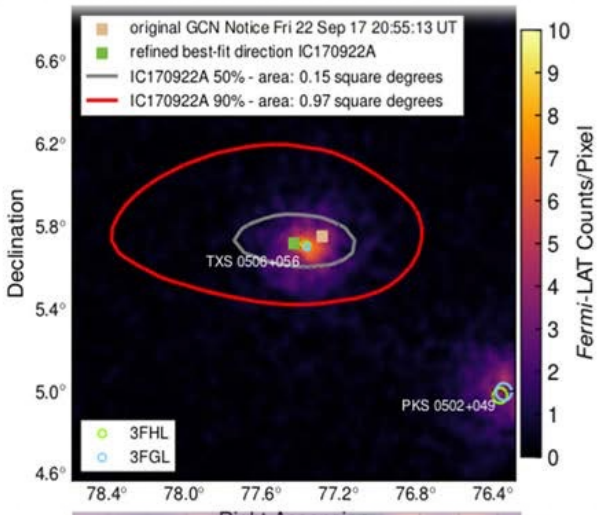
Multi Messenger Astronomy
IC170922A / TXS 0506+056

Ice Cube Observation (~300TeV)

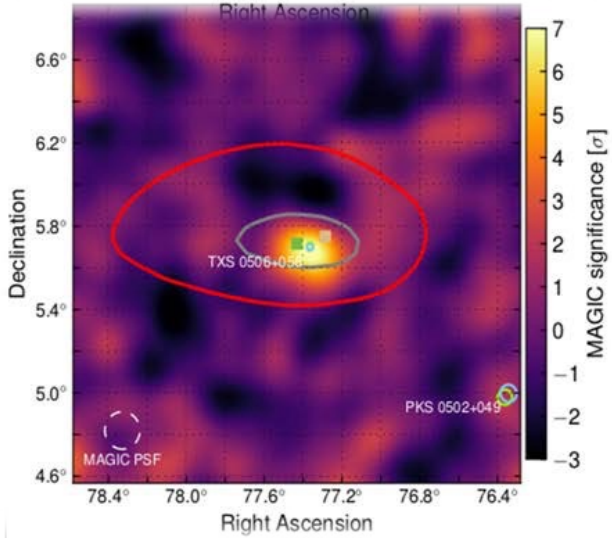


Lepto-Hadronic Scenario





Fermi LAT
(>100 MeV)



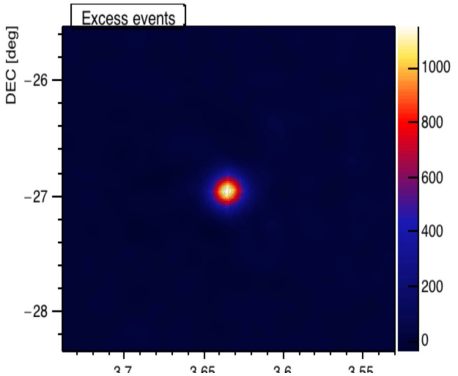
MAGIC
(>100GeV)

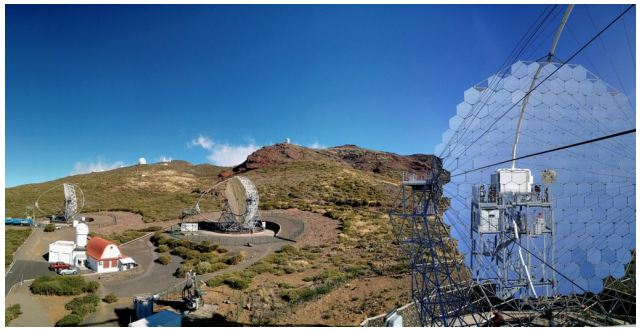
GTC Observation z = 0.3365
S. Paiano et. al 2018

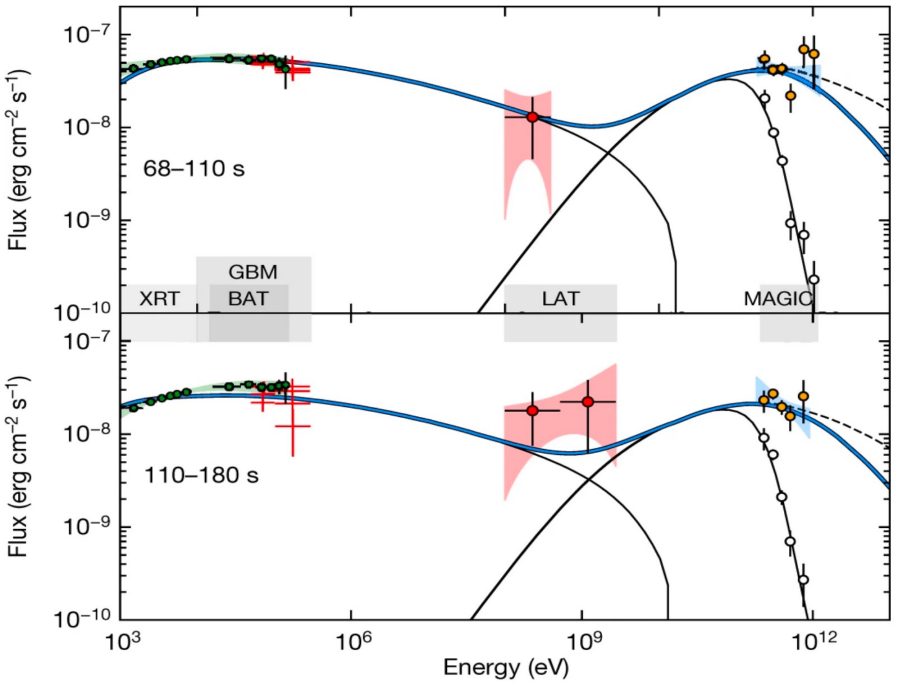
MAGIC Highlight, Gamma Ray Burst GRB190114C (z=0.42)

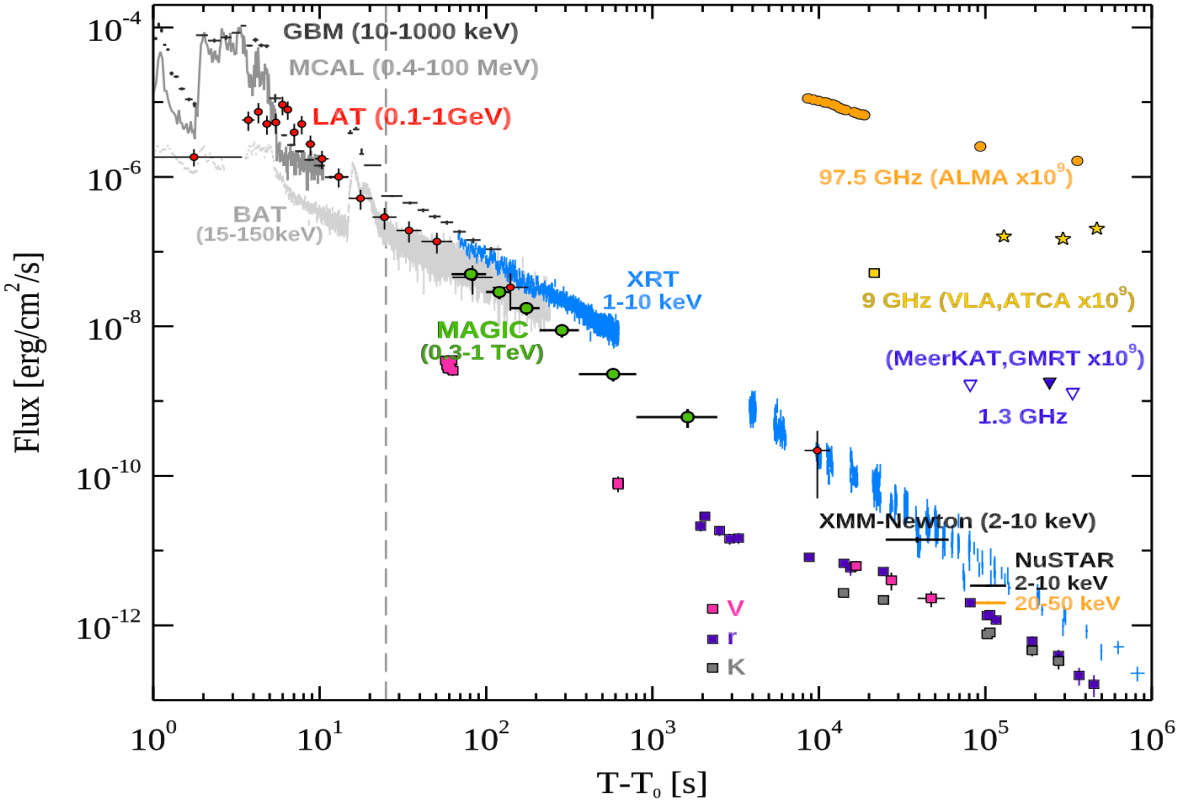
Historical achievement

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



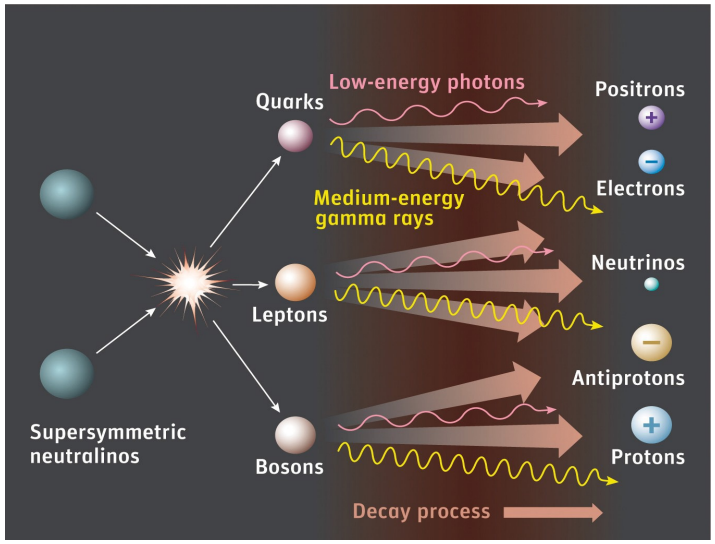






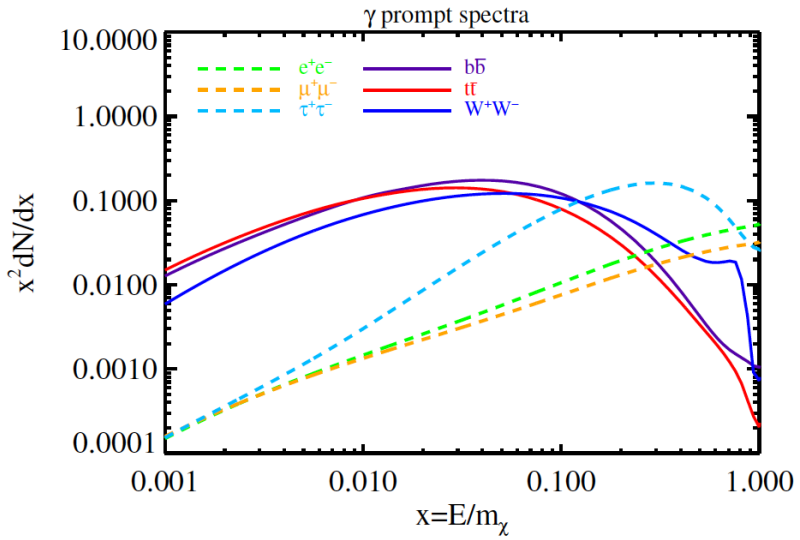
Dark Matter Search

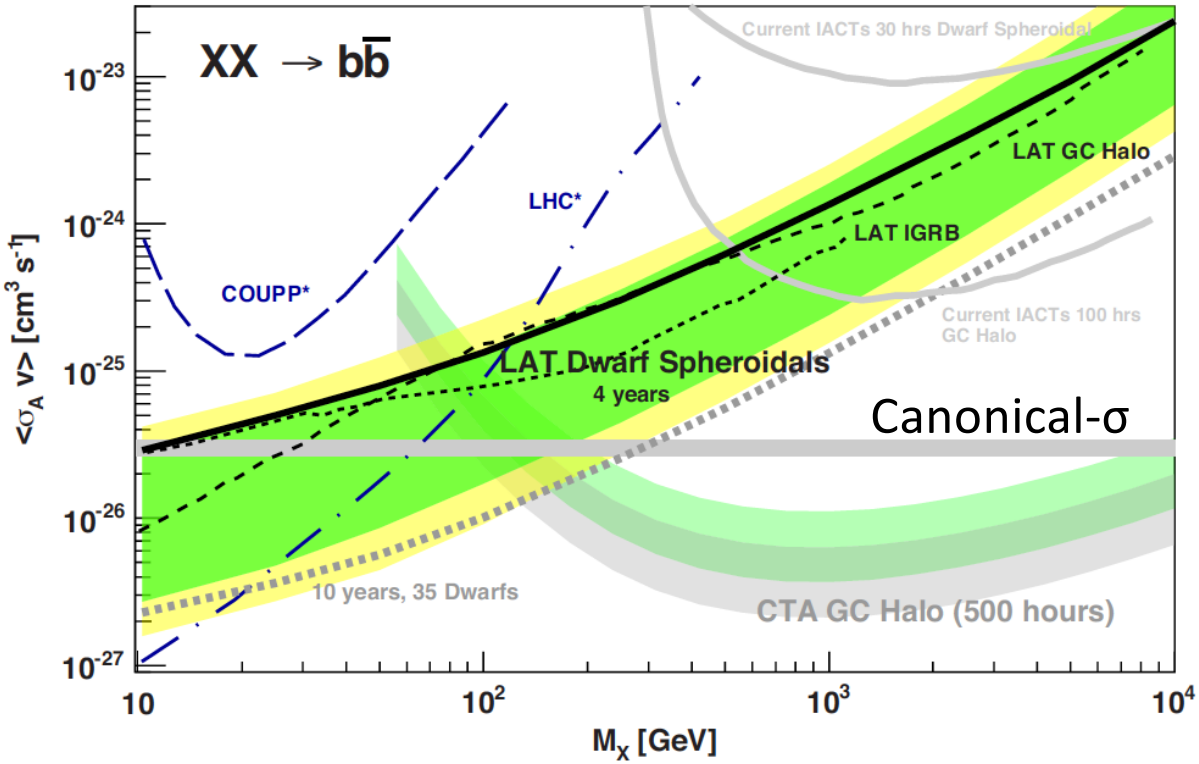
Sensitive M_χ: 200GeV - 10TeV



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

Particle Physics **Astrophysics**





Gamma rays from Annihilation produce the bump around 1/10 -1/20 Mχ ➔ 20GeV-1TeV domain

CTA gives the stringent upper limit. Stefan Funk 2015

Summary

- CTA is a big and ambitious project and plays an important role in the MM and MWL astronomy in the next decades
- CTA South construction will start in 2023
- CTA North construction, LST2-4 and MST1 will start in summer 2022 and completed in 2024
- LST5-8 construction in South is on Discussion to enhance the performance of CTA Observatory. INAF successfully got a funding for LST5-6.

- LST1 commissioning ➔
  - We confirmed LST1 satisfies the design performance
  - GRBs with the redshift up to z = 4 can be seen with LST
- ~10 sources are detected with LST1. Crab Pulsar, BL Lac flare, G.C., RS Oph are very interesting


Thank you
Landscape in 2025