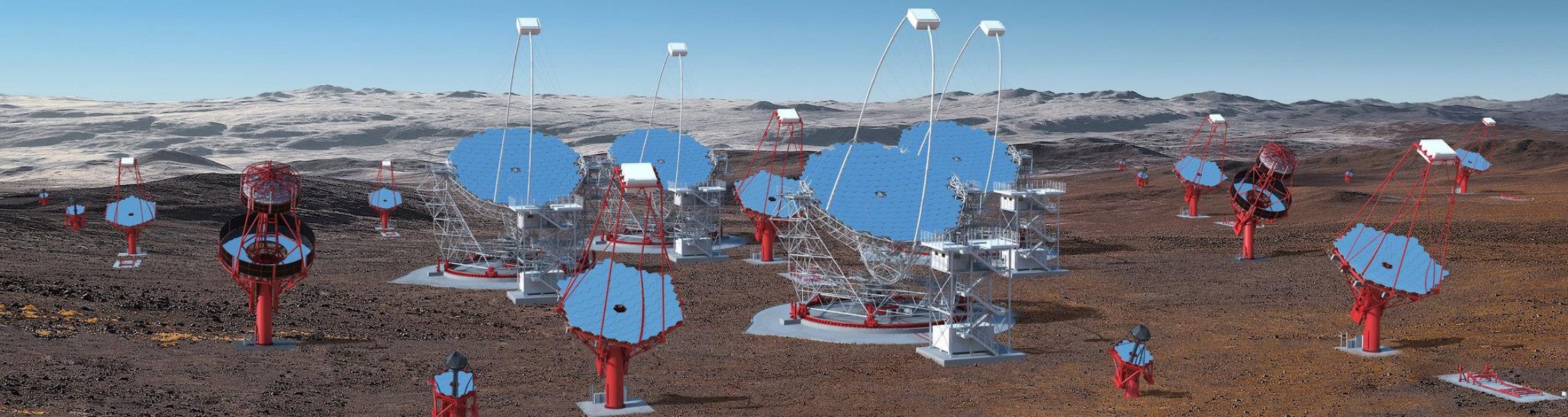
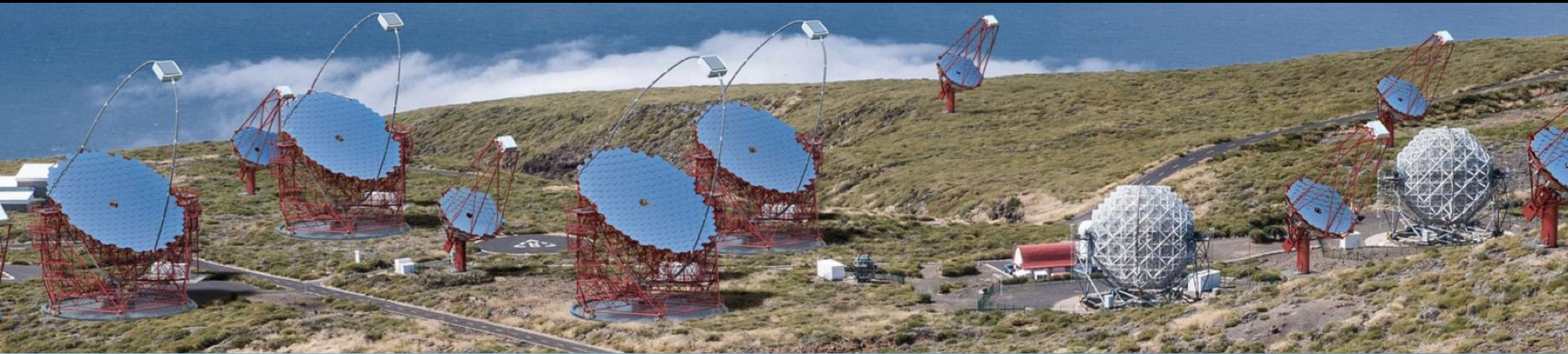


The LST Project

Masahiro Teshima

*Max Planck Institute for Physics
ICRR, The University of Tokyo*

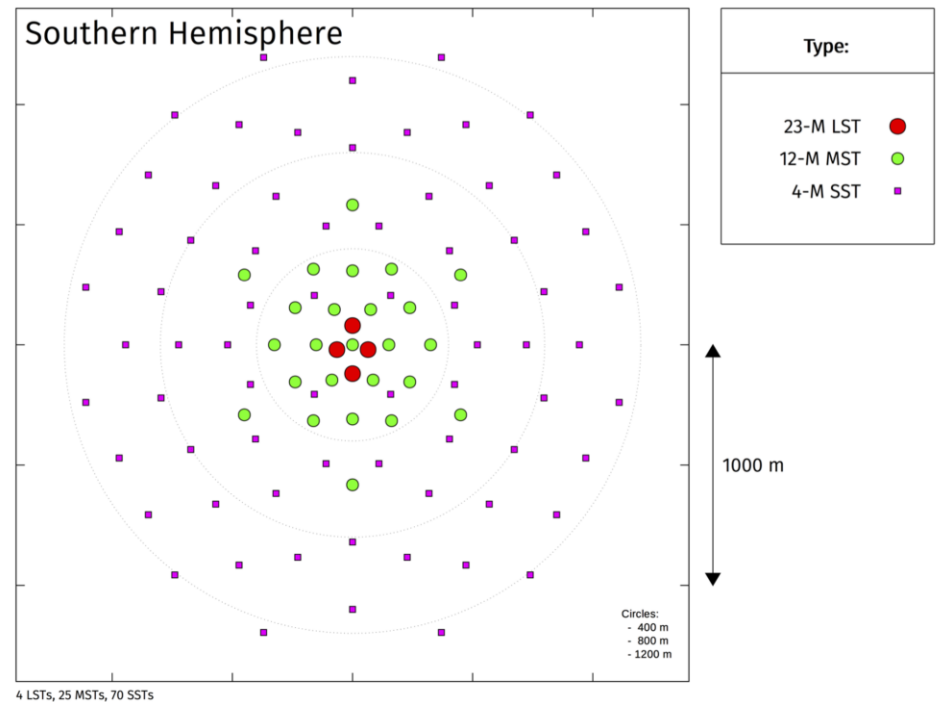
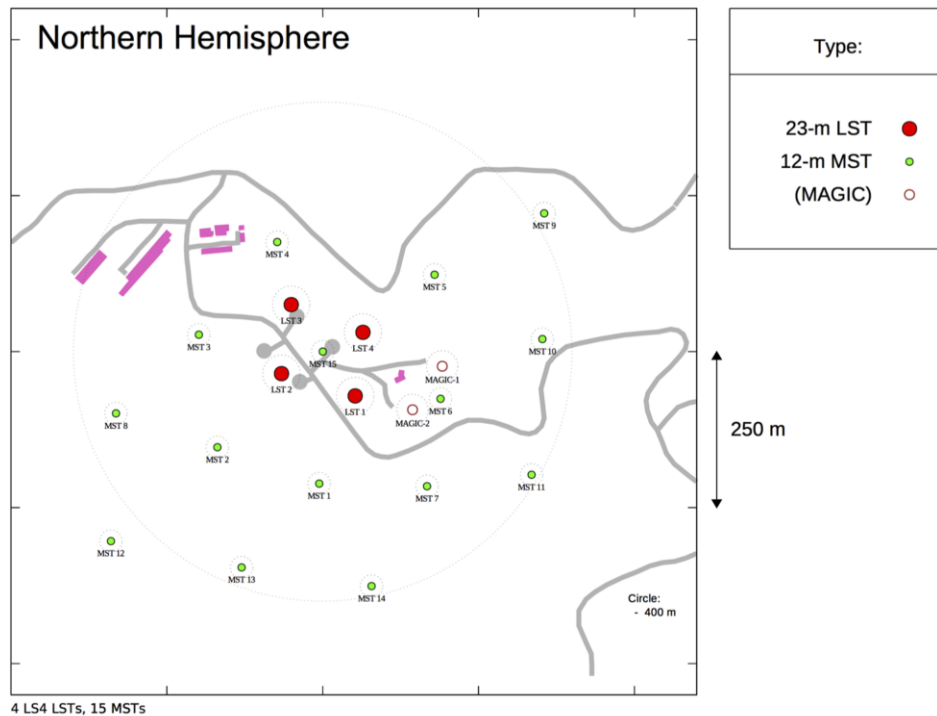
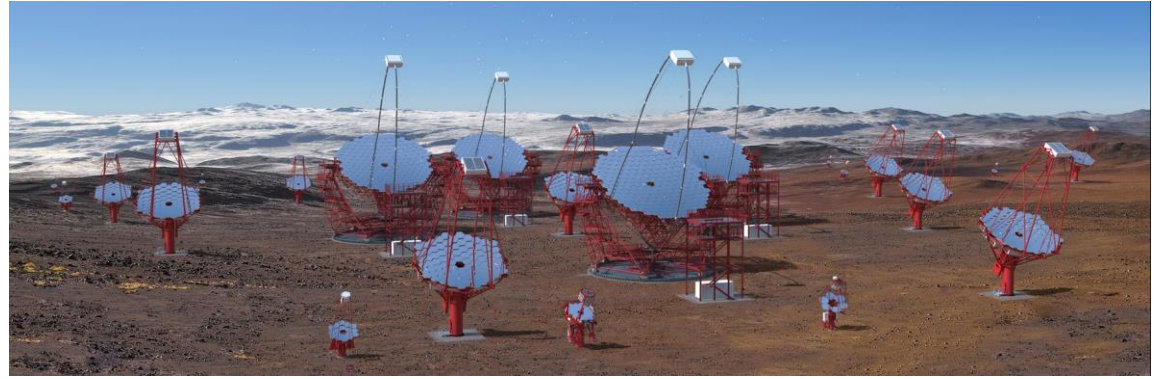


Two sites for all sky observatory

ORM, La Palma, Spain

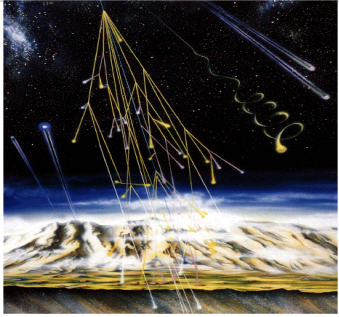


Paranal, Chile

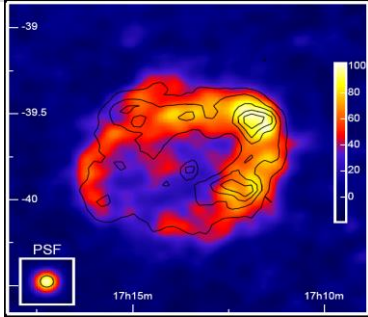


Science of CTA-LST is very wide

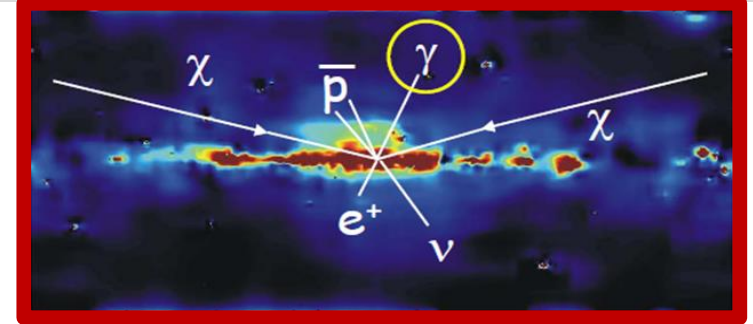
LST will cover **S.M.B.H., Dark Matter, AGNs, GRBs**



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

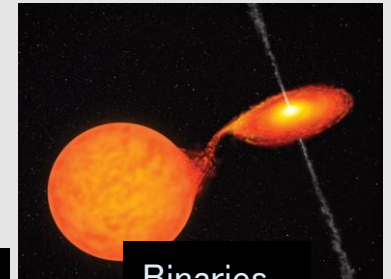


Gamma Ray Bursts

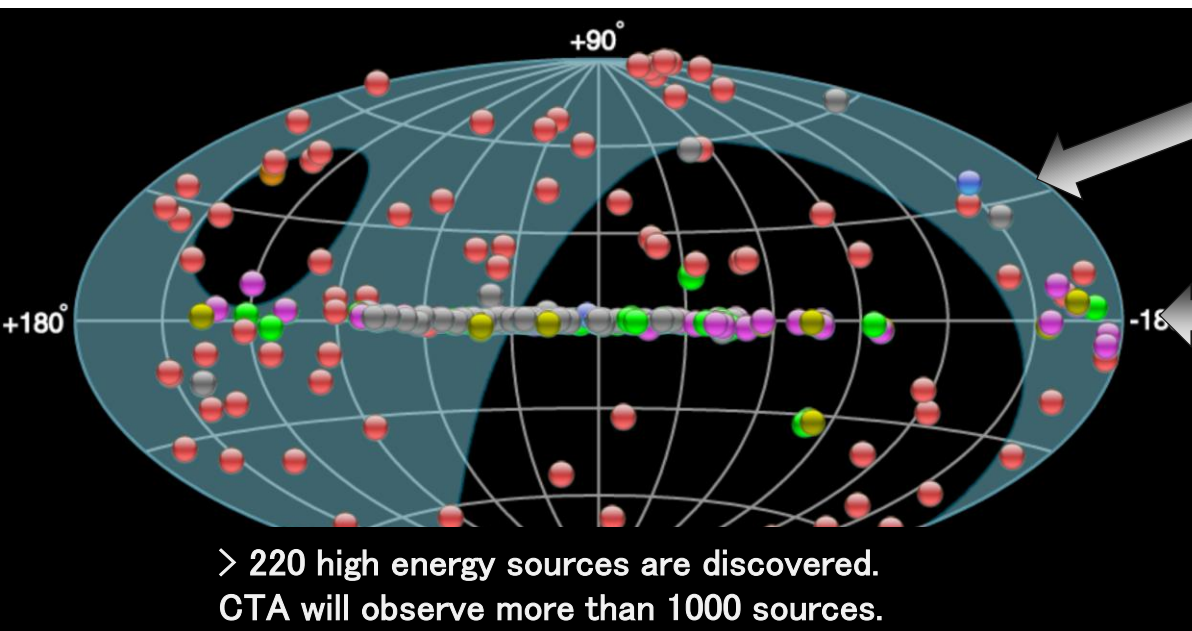
Galactic Sources



Super Nova Remnants



Binaries

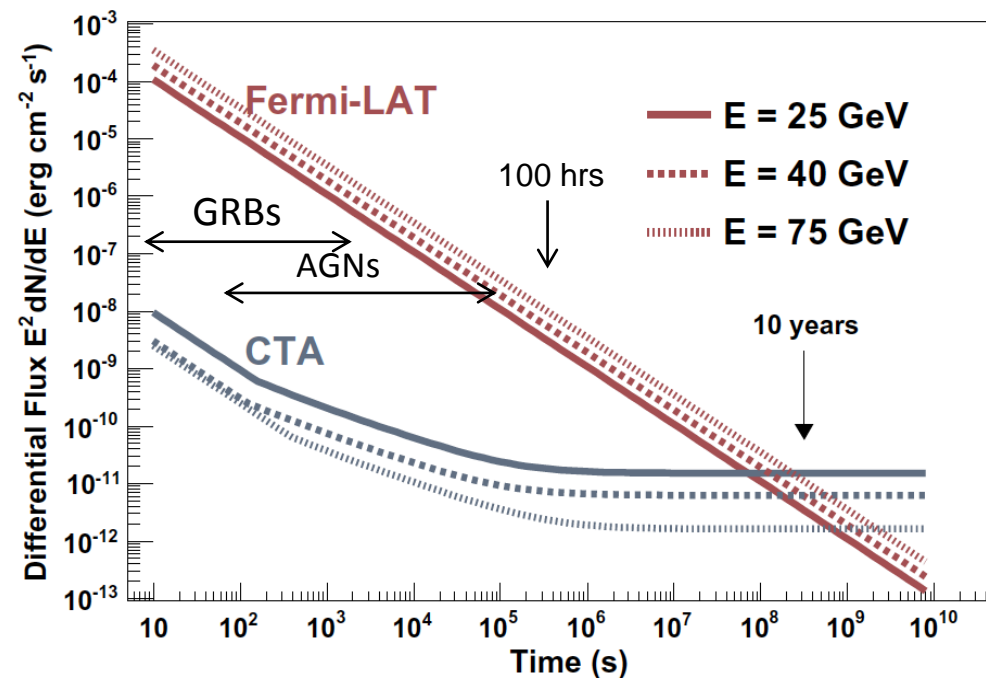
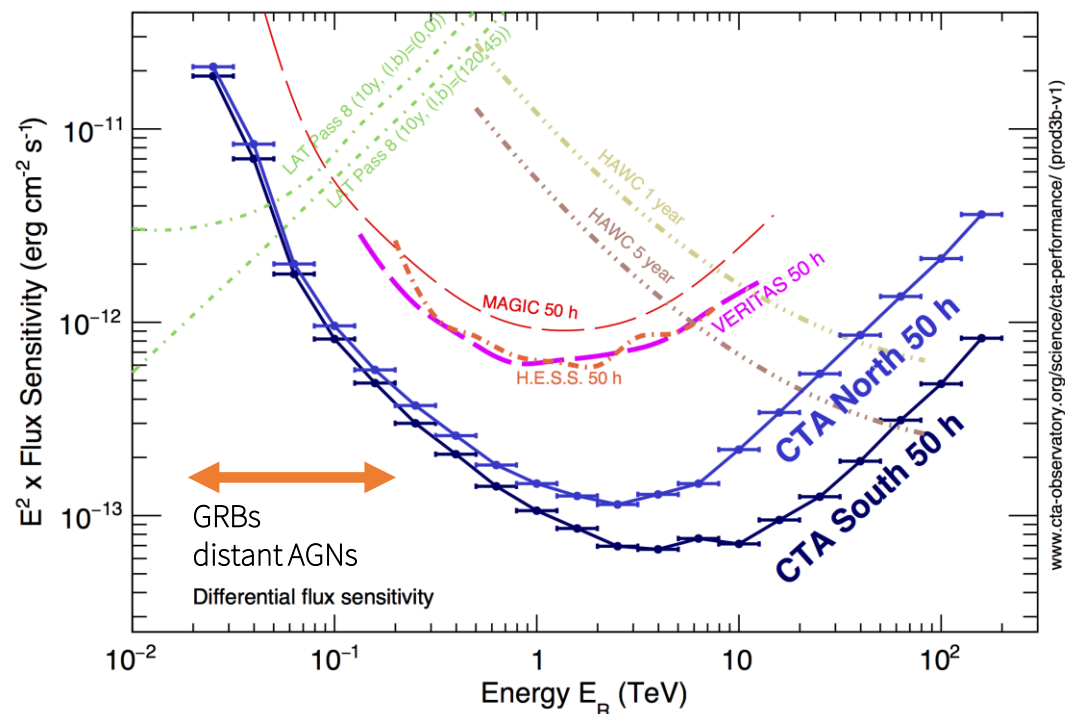


> 220 high energy sources are discovered.
CTA will observe more than 1000 sources.



ch
erenkov
telescope
array

Sensitivity x10,
Angular Resolution x2
Energy Range 20GeV~200TeV



- LST sub consortium focuses on the CTA-LST Array on La Palma
- The CTA-LST array has a good sensitivity from 20 GeV to 1000 GeV
- Distant AGNs up to $z = 2$, and GRBs up to $z = 4$ are observable
- X10000 sensitivity for GRBs and AGN flares than Fermi
- The fast rotation (20 sec) offers the observation of prompt emission of GRBs



cherenkov
telescope
array

CTA Phase I and the enhancement in CTA CB and BP

COST Book 2020		CTA Construction	CTA Enhancement
Northern Array	Number of LSTs	4	0
	Number of MSTs	5	10
Southern Array	Number of LSTs	0	4
	Number of MSTs	15	10
	Number of SSTs	50	20
Total		74	44

Business Plan 2016

Site	Telescope	Baseline Number	Threshold Scenario	Priorities Beyond Threshold
CTA-South	LST	4		4
	MST	25	15	
	SST	70	50	
CTA-North	LST	4	4	
	MST	15	5	+5

LST sub-consortium



LST statistics

	Members	Scientist + Students	Authors
Bulgaria	5	5	5
Brazil	4	3	3
Spain	75	38	47
France	34	14	14
Croatia	11	11	11
Germany	36	29	29
India	3	3	3
Italy	39	34	35
Japan	60	56	56
Poland	2	2	2
Switzerland	9	9	9
Total	278	204	214



~80 FTE per year

Mission 2:
Four LSTs at CTA-S

Steering Committee

Composed by Party representatives
Chair: M. Martinez

Ex Officio: M. Teshima
Ex Officio: J. Cortina
Ex Officio: D. Mazin

Version 8.24

LST EXECUTIVE BOARD

LST Project Office

Telescope Manager:
P. Marquez

Principal Investigators:
M. Teshima / J. Cortina
Project Manager:
D. Mazin
Deputy: M. Will

Lead Systems Engineer:
D. Della Volpe
Deputy: M. Heller

Safety and Operations coordinator:
M. Will

Outreach:
D. Green

QA/RAMS:
J. M. Miranda

Interfaces and Integration

Mechanical System

Crd: T. Schweizer
Dep. H. Wetteskind
Struct. Eng.: J. Eder

Dish&Lower Structure
H. Wetteskind

Camera Support Structure
G. Deleglise

Tension Ropes
M. Mariotti

Foundation, Rails & Bogies
J. Mundet

Structural Verification
J. Eder

Telescope Control

Crd: T. Le Flour
Dep. K. Noda

TCU
Ie. Vovk
V. Sliusar

Camera
C. Pio

AMC
S. Fukami

Drive
T. Le Flour

Power
K. Noda

Data Analysis Software

Crd: A. Moralejo
Dep. R. Lopez Coto

Raw Data Calibration
J. Sitarek

Onsite analysis
T. Saito

Monte Carlo
A. Moralejo

Offline calibration
F. Cassol

Data quality
I. Aguado

RealTime
T. Guillaume

X-calib MAGIC
NN

Optical System

Crd. K. Noda
Dep.: M. Teshima

Primary Mirror
T. Inada

AMC
M. Chikawa
S. Fukami

Camera Integration

Crd.: C. Delgado
Deputy: T. Saito
Prod.: C. Diaz

Mechanics & Cooling
C. Diaz

Embedded Camera Control
J. Prast

DAQ
T. Saito
D. Hoffmann

Clock
J.A. Barrio

LST1 camera operation
O. Blanch

FPI / Electronics

Crd.: H. Kubo
Dep.: R. Paoletti
Prod.: T. Saito

Photo-detectors
T. Yamamoto

Readout
H. Kubo

Trigger
G. Martínez

Light Guide
T. Yamamoto

Aux systems

Crd.: A. Fiasson
Prod.: E. Chabanne

Drive Control System
I. Monteiro

Global monitoring
T. Le Flour

Pointing Calibration
K. Noda

Camera Calibration
M. Iori

Power Distribution
M. Teshima

Cabling
E. Chabanne

SiPM R&D

Crd.: M. Heller
Dep.: F. Di Piero
Prod:

Simulations and Specs
NN

Photo-detectors
NN

Readout
R. Hermel

Mechanics and Cooling
NN

Integration with PMT Camera
D. Mazin

IAC
J. Herrera

OES
T. Le Flour

DPSS
A. Moralejo

Site / INFRA
P. Marquez

Onsite IT
D. Hadasch

Offsite IT
J. Delgado

MAGIC
M. Teshima

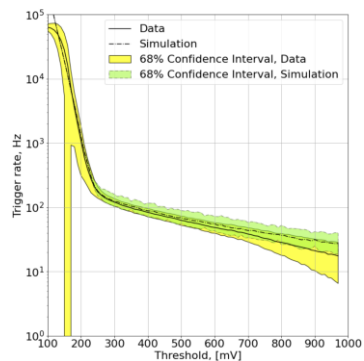


cherenkov
telescope
array

Swiss scientist's role in LST

UNIGE DPNC

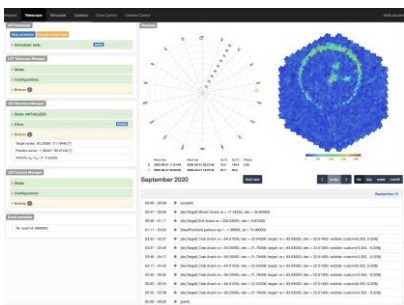
- Data analysis pipeline
- Data/Monte Carlo validation



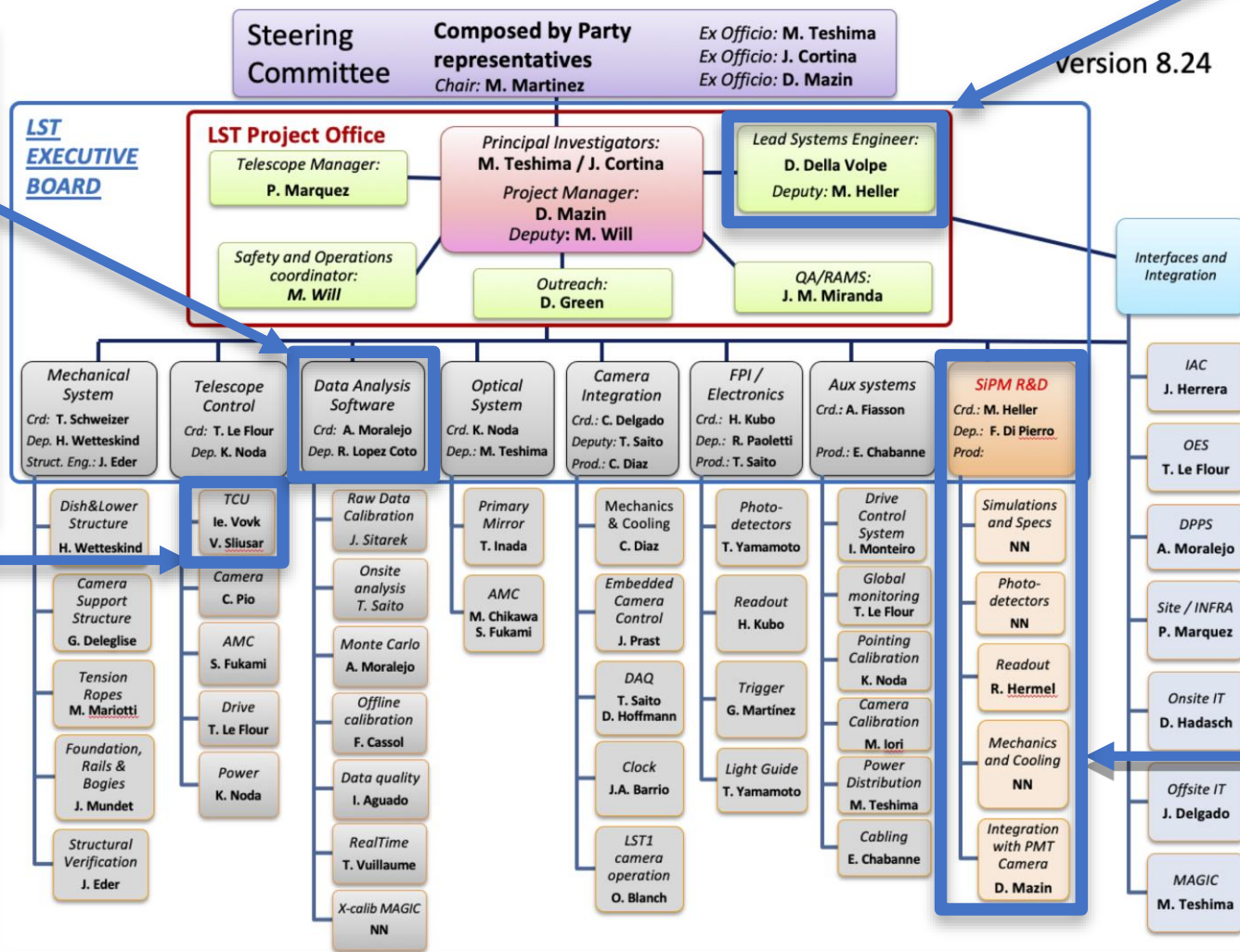
L1 trigger rate data/MC comparison

UNIGE ASTRO

- Telescope Control Unit
- Engineering GUI



LST Observation scheduler



UNIGE DPNC:

- System engineering with main focus on CDR follow-up



Declaration of CDR Pass

Following the criteria for passing the CDR given in Section 2 and the agreed work plan given in Section 3, the CTAD is pleased to confirm that the criteria are fulfilled to pass the CDR. Therefore,

CTAO declares the LST Critical Design Review as passed.

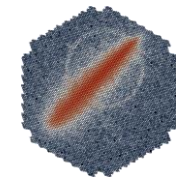
The CTAD is looking forward to the successful completion of all review related actions following the plan given in Section 3 and the acceptance of LST1 as the first CTA Observatory telescope.

The CTAD is also looking forward to the production of the LSTs 2, 3 and 4 by the LST Sub-Consortium and the acceptance and integration into the CTA-North Observatory array.



UNIGE DPNC/EPFL/ETHZ

- Project coordination
- R&D activities on sensor, front-end electronics and digital readout





cherenkov
telescope
array

CTA-LST Project

LST1 is Inaugurated on 10 October 2018

- 2017-2018 LST1 (15MEur)
- 2020-2023 LST2-4 (45MEur)
- Budget are almost secured



In Feb 2019 LST1 is awarded with 21st Cent. Technology 2019

LST-1

Large Size Telescope

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

Tension cables: IT

Camera Support
Structure: FR

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

calibration:
IT, HR, IN, DE

Telescope
structure: DE

Rail: DE

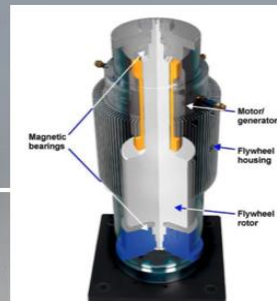
Bogies: ES

Camera Access Tower: DE, ES

Foundation: ES

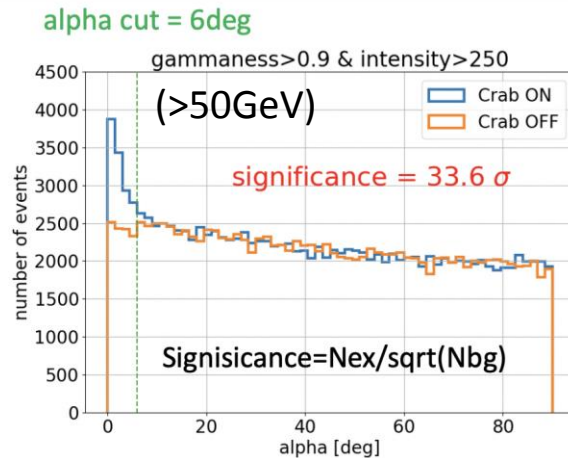
Drive and main
el. cabinet: FR

FlyWheels (2x300kW)
energy storage and UPS: JP

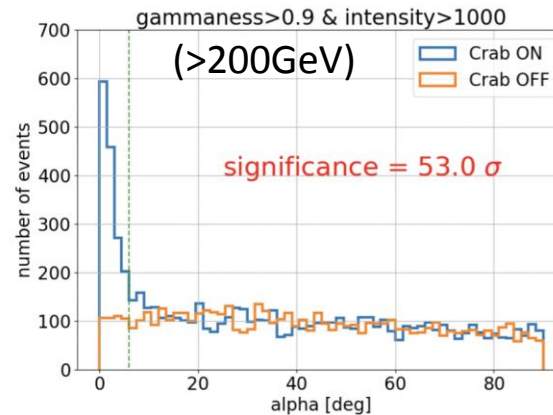


Commissioning of LST1 Crab Nebula and Pulsar

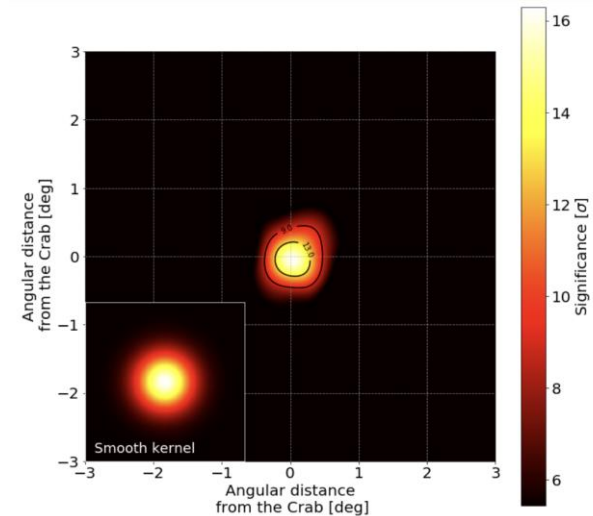
2hrs of Crab observation in Nov. 2019



Excess = 29.0/min



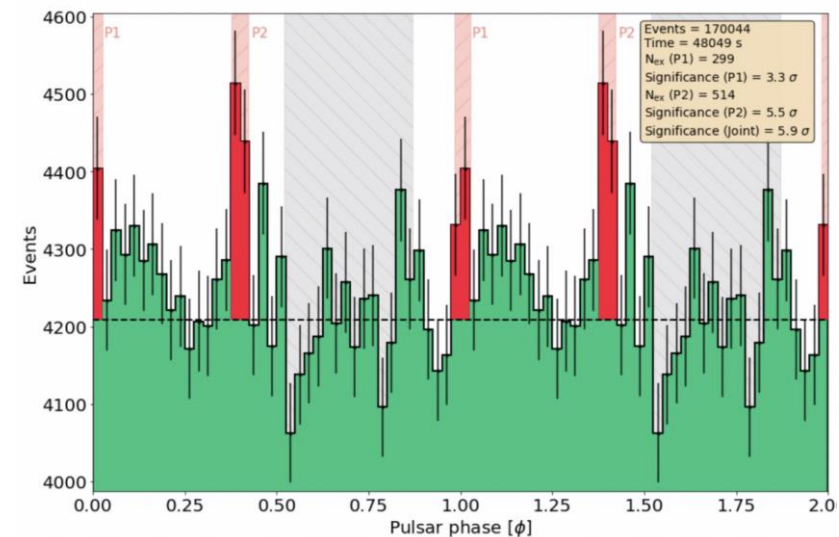
Excess = 9.6/min



16hrs of Crab Pulsar Observation,
January/February 2020

Threshold energy is estimated as 40-50GeV
Confirmed the accurate time stamp

Extragalactic Sources
Mrk421, Mrk501, 1ES1959 !!
GRB 2101XX?? and more



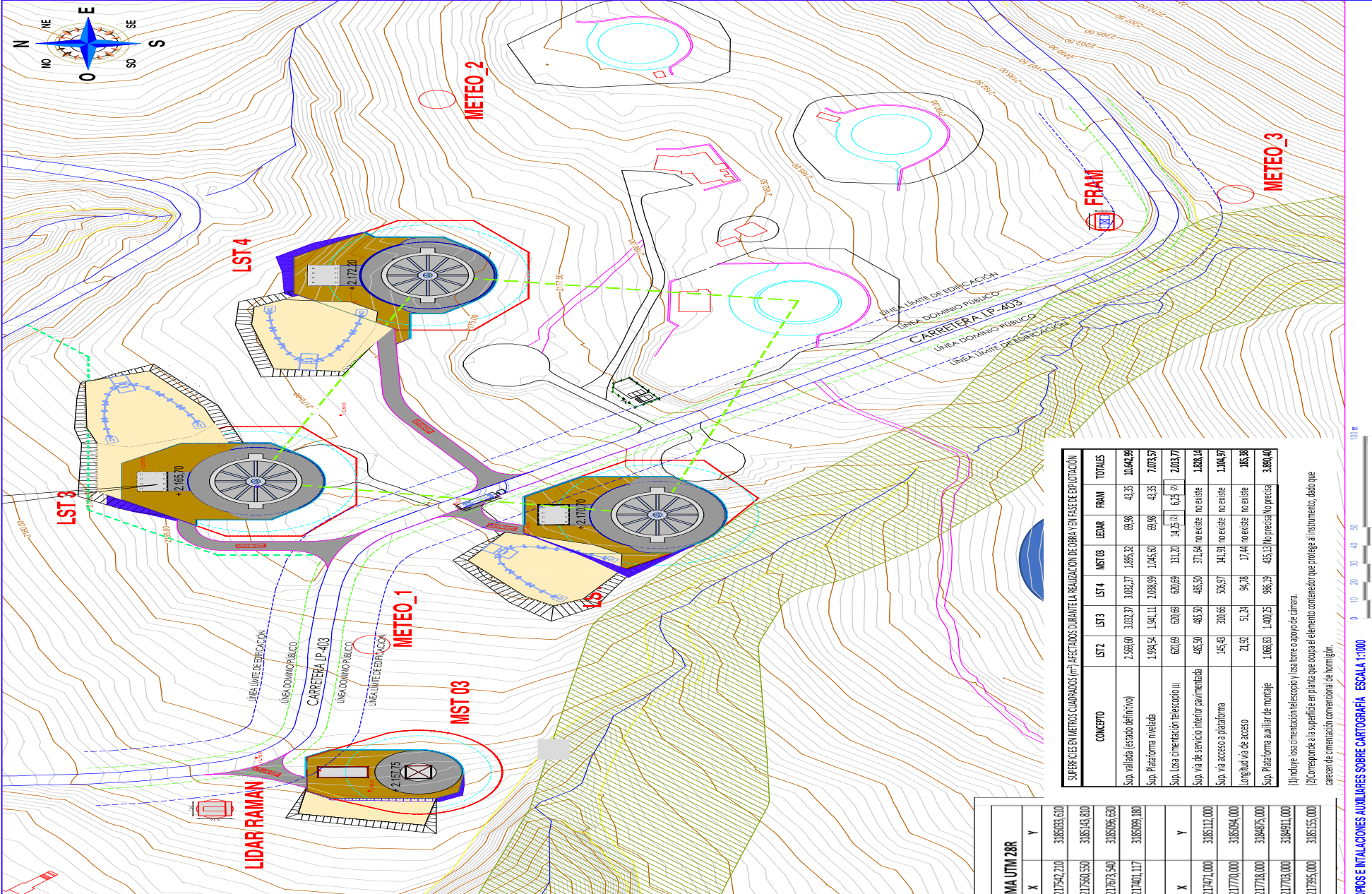
In three years, we will get an Instrument with a 10-20 times better sensitivity !!



cherenkov
telescope
array

CTA North Phase I Installation Plan

LST1-4 location



PROYECTO BÁSICO

LOS TELESCOPIOS LST2, LST3, LST4 Y MST03 E INSTRUMENTACIÓN AUXILIAR DEL CHERENKOV TELESCOPE ARRAY

GOBIERNO DE CANTARÍAS

GOBIERNO DE CANTARÍAS

GOBIERNO DE CANTARÍAS

PLANO

PLANTA EMPALMADO DE TELESCOPIOS E INSTALACIONES AUXILIARES SOBRE CARTOGRAFÍA

5

FECHA:

NOVIEMBRE 2019

ESCALA:

1/1000

PLANO Nº:

5

AUTORES DEL PROYECTO:

UTE LST

PLANO

PLANTA EMPALMADO DE TELESCOPIOS E INSTALACIONES AUXILIARES SOBRE CARTOGRAFÍA

LST Timeline

- 2021-2023
 - Deployment of 3 more LSTs, and 5 MSTs in CTA North
 - Study the Advanced Design and Prototyping, and create budgets for LST South
- 2024-
 - Operation of CTA North will start
 - Construction of LST South (by Switzerland, Japan, Italy-INAF, Germany-MPP,,)

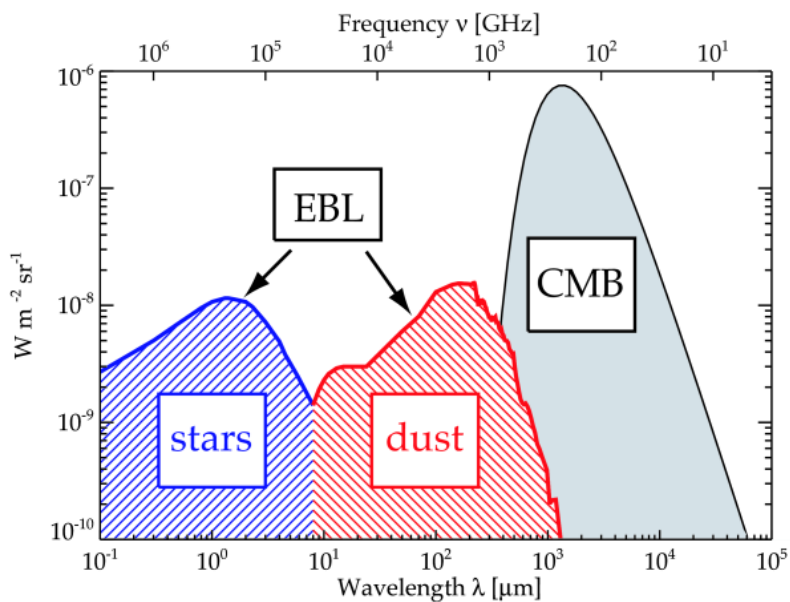
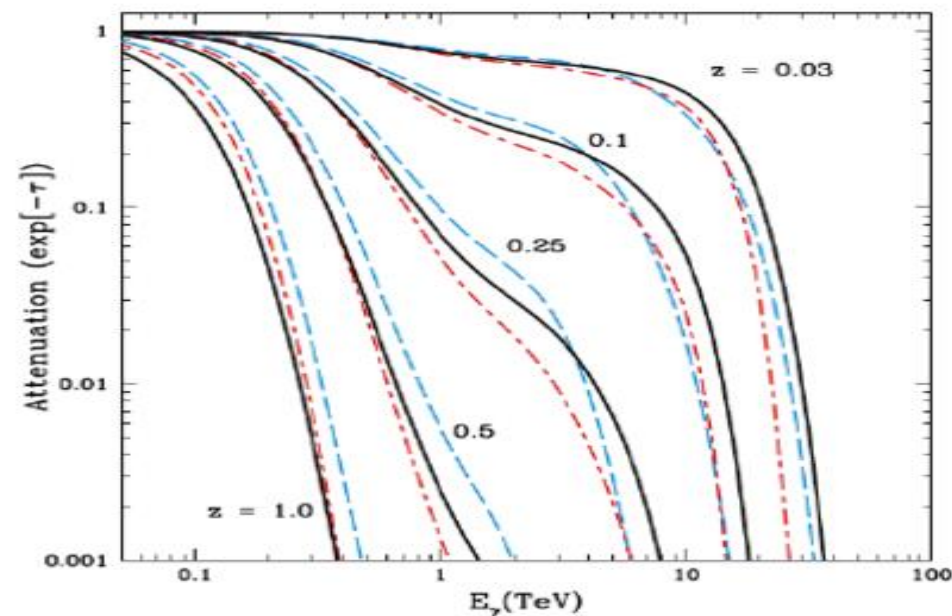
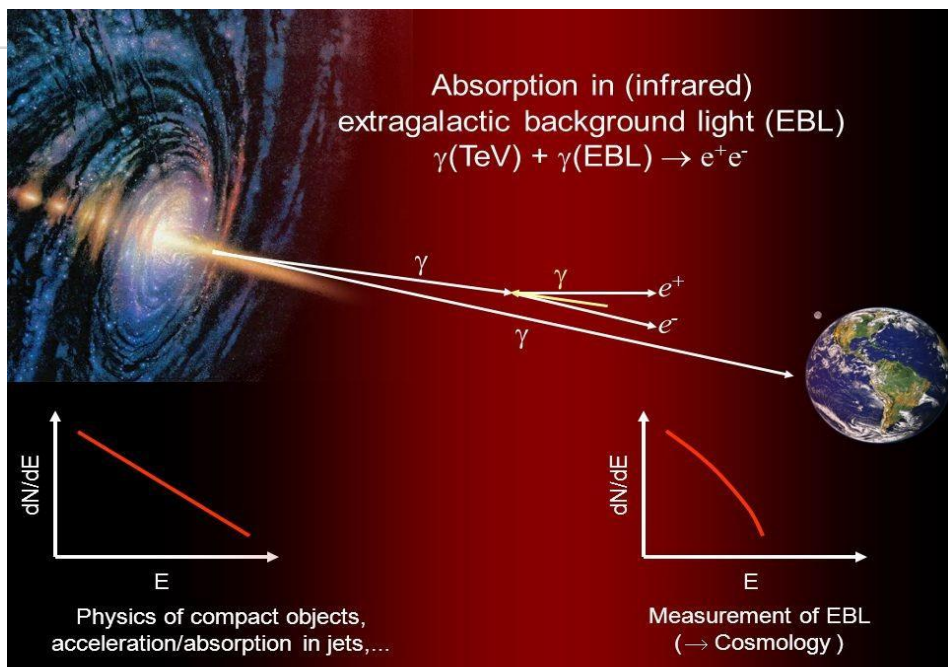
	2020	2021	2022	2023	2024	2025	2026	2027	2028
LST North	Comissioning and Operation of LST1				CTA North starts the operation with 4 LSTs and 5 MSTs				
	CDR	Deployment of LST2-4							
MST North	Design and Finance		Construction of 5MSTs						
	2020	2021	2022	2023	2024	2025	2026	2027	2028
LST South		Advanced Design and Proto / Finance / CDR			Construction of 4LSTs			Operation	
	2020	2021	2022	2023	2024	2025	2026	2027	2028
Organization	CTAO gGmbH								
			CTAO ERIC (European Research Infrastructure Consortium)						
	2020	2021	2022	2023	2024	2025	2026	2027	2028
CTA South	Design and Finance		INFRA		Construction and Deplyment of 15 MSTs		Operation of 15 MSTs		
					Construction and Deployment of 50 SSTs		Operation of 50 SSTs		



ch
erenkov
telescope
array

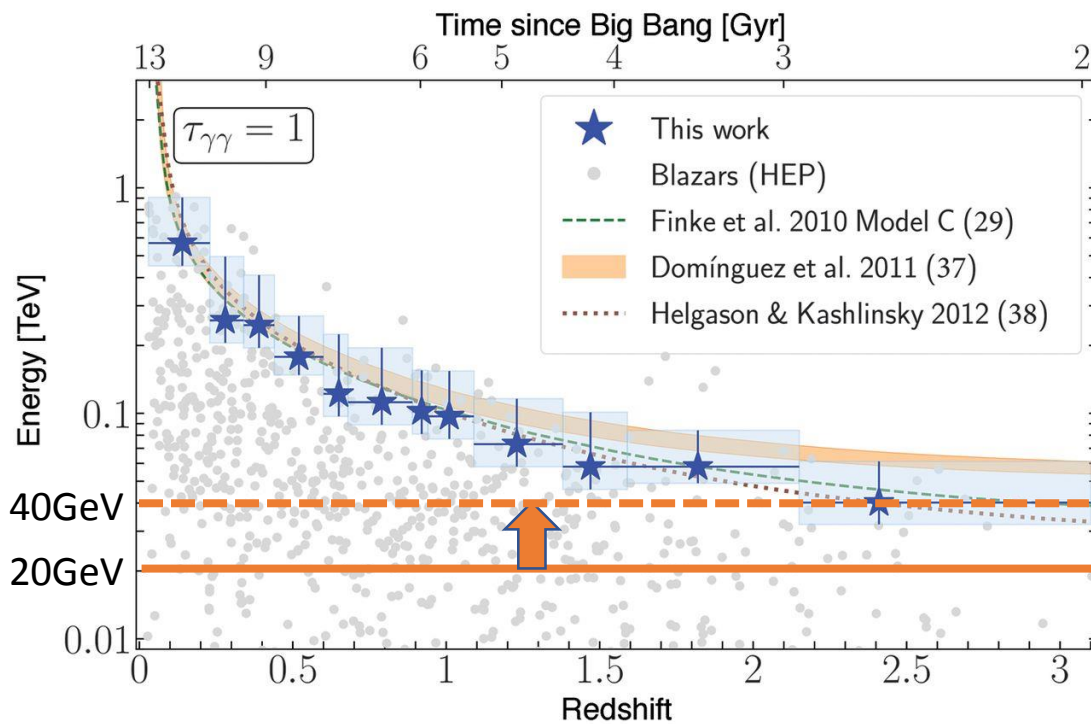
Expand Gamma Ray Horizon with LSTs

$Z_{\max} = 1.0 \rightarrow Z_{\max} = 3.0$



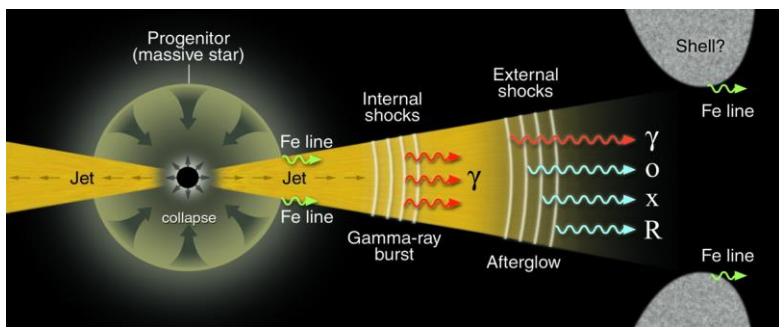
LST@45° Eth 40GeV

LST@25° Eth 20GeV

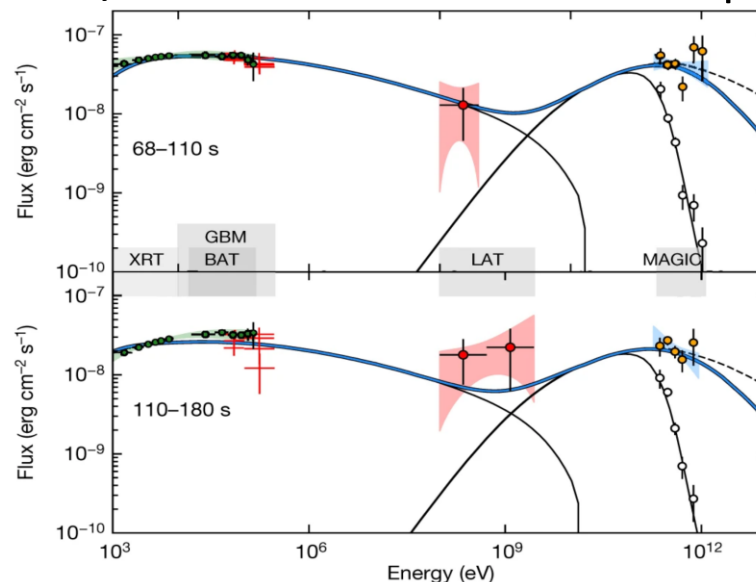


TeV-GRB 190114C observation with MAGIC

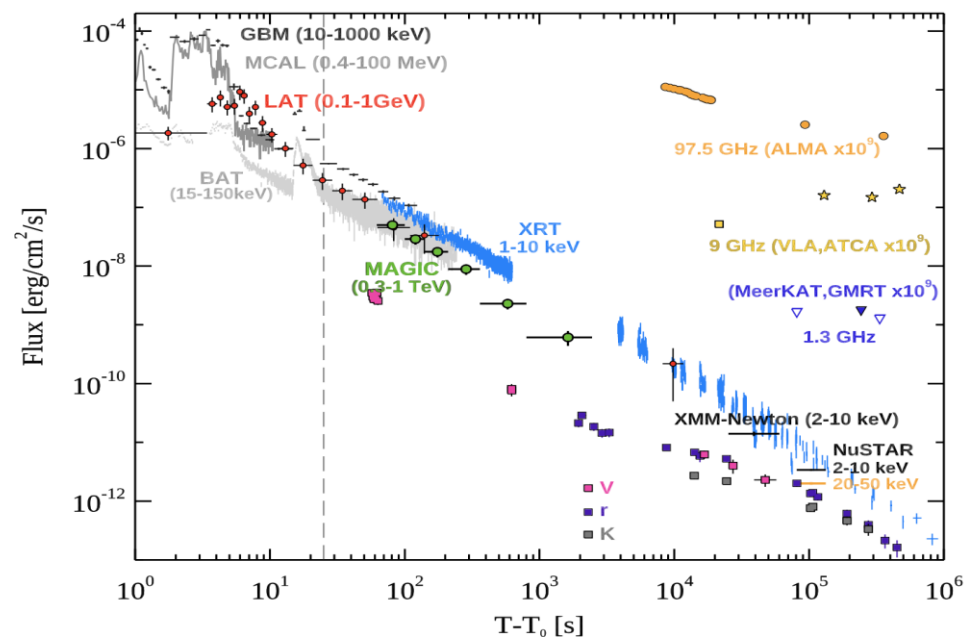
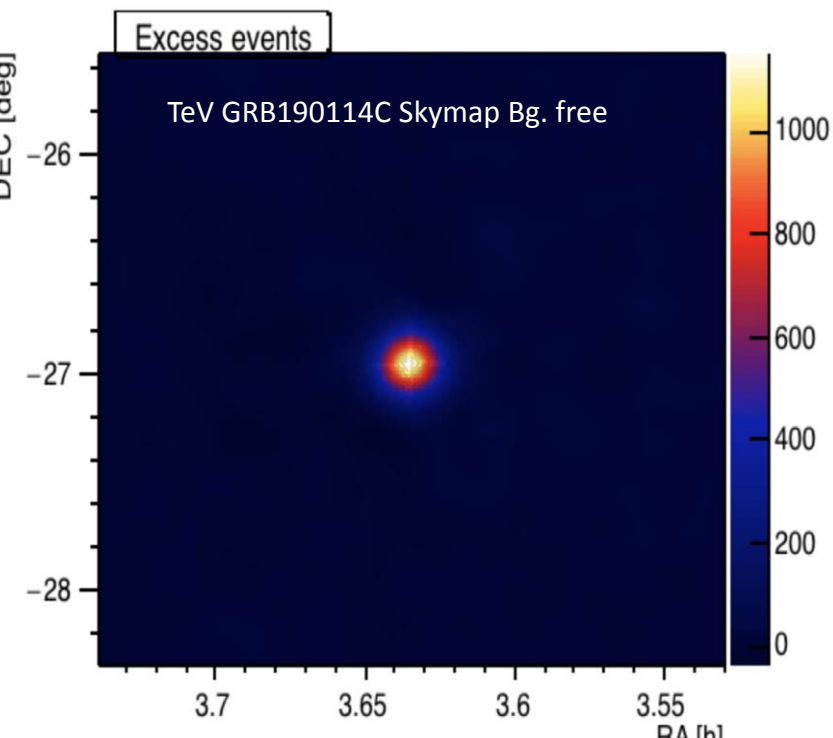
Two Nature Papers 21. Nov. 2019



Synchrotron Inverse Compton



- Energy spectrum is extending to TeV energies
- Significant energy released in TeV domain
- Afterglow curve is parallel to X-Ray afterglow
- LST will detect 10 times more events than MAGIC and HESS

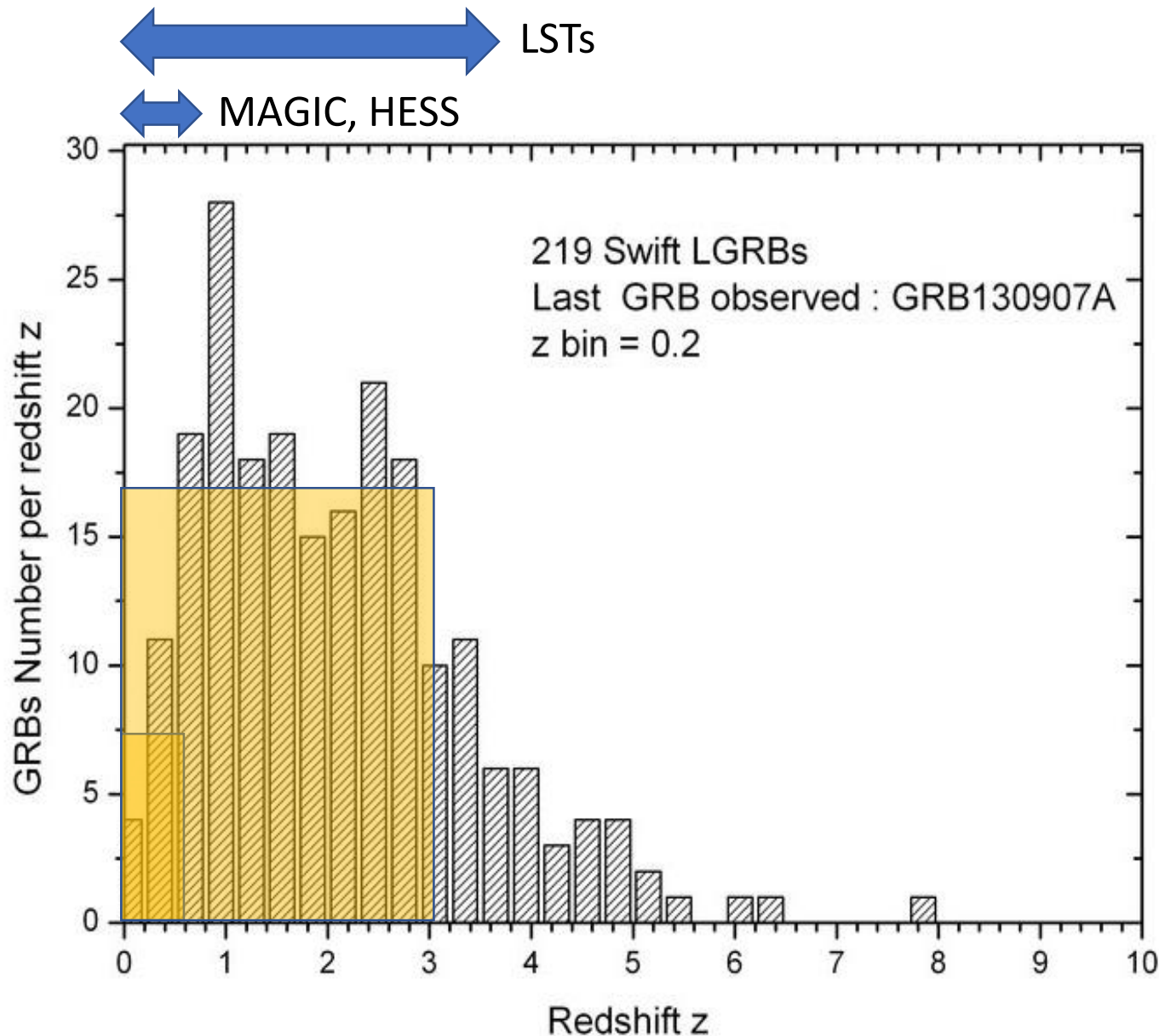




cherenkov
telescope
array

Redshift Distribution from SWIFT GRBs

W. J. Azzam et al. 2014



15 GRBs in $z < 0.5$

112 GRBs in $z < 2.0$

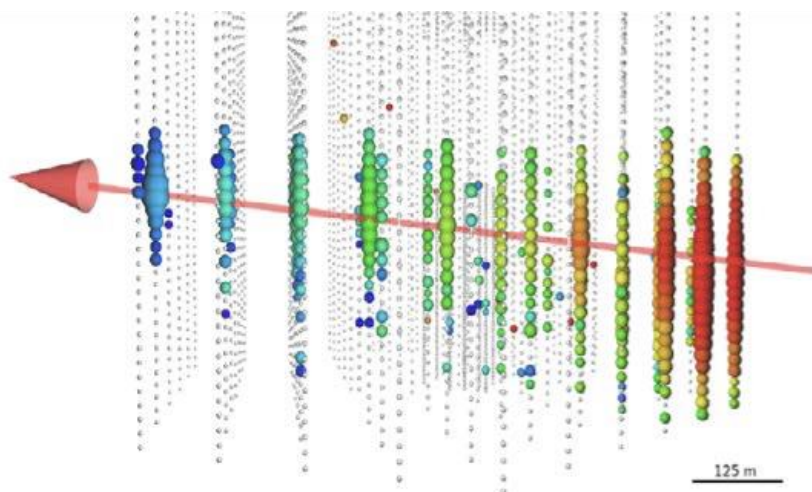
164 GRBs in $z < 3.0$

LST will increase
the detection probability $\times 10$

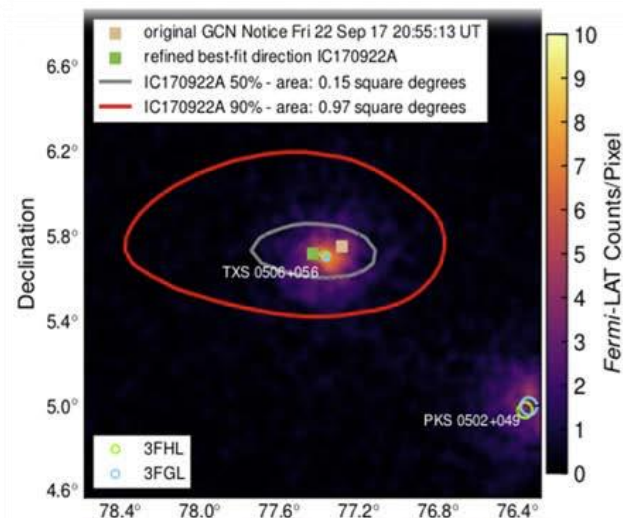
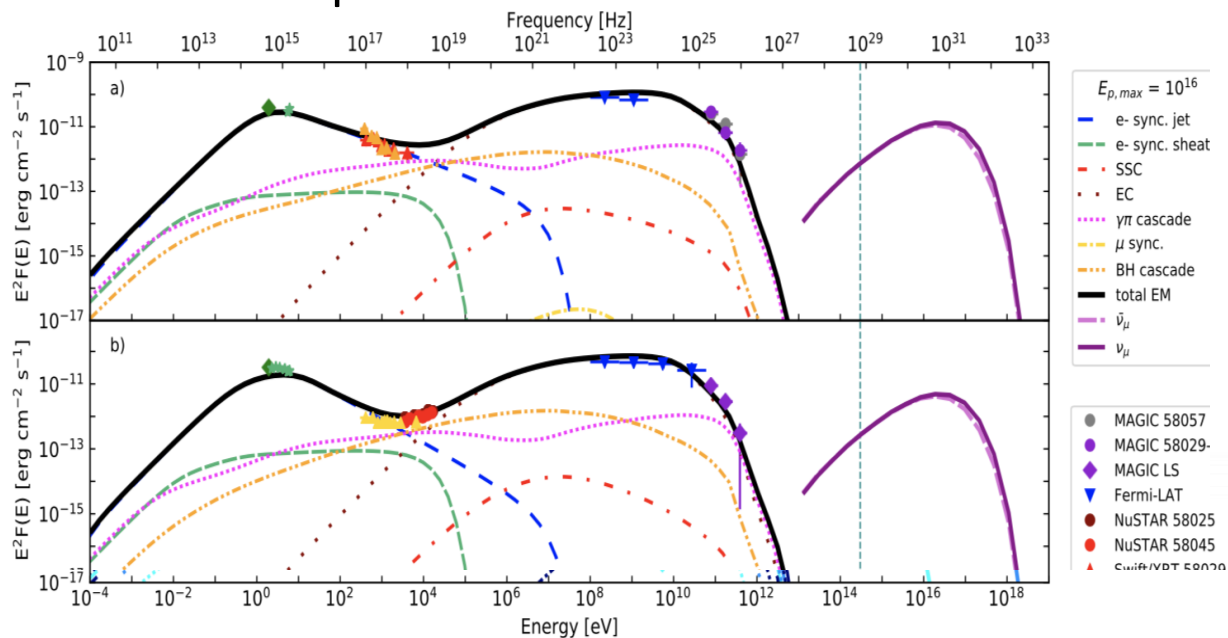
IC170922A / TXS 0506+056

PeV Neutrinos may come from distant UHECR sources
The source density relates with the Star formation rate

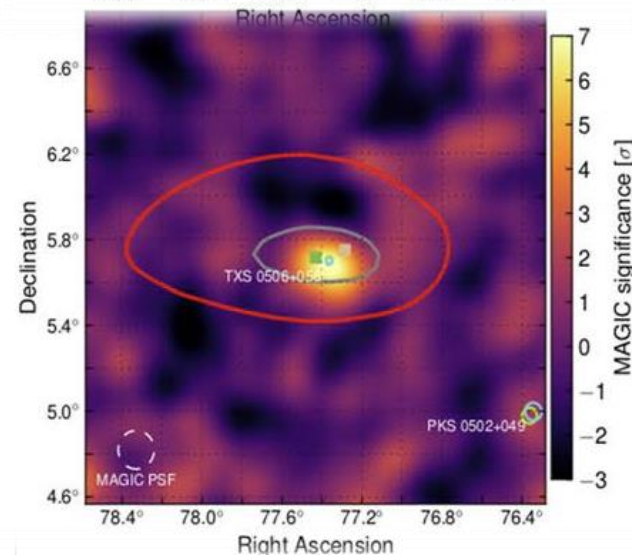
Ice Cube Observation ($\sim 300\text{TeV}$)



Lepto-Hadronic Scenario



Fermi LAT
(>100 MeV)

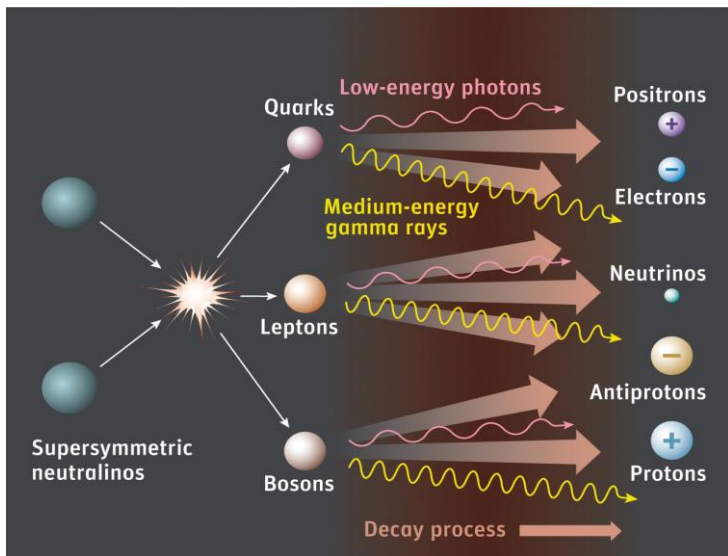


MAGIC
($>100\text{GeV}$)

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

Dark Matter Search

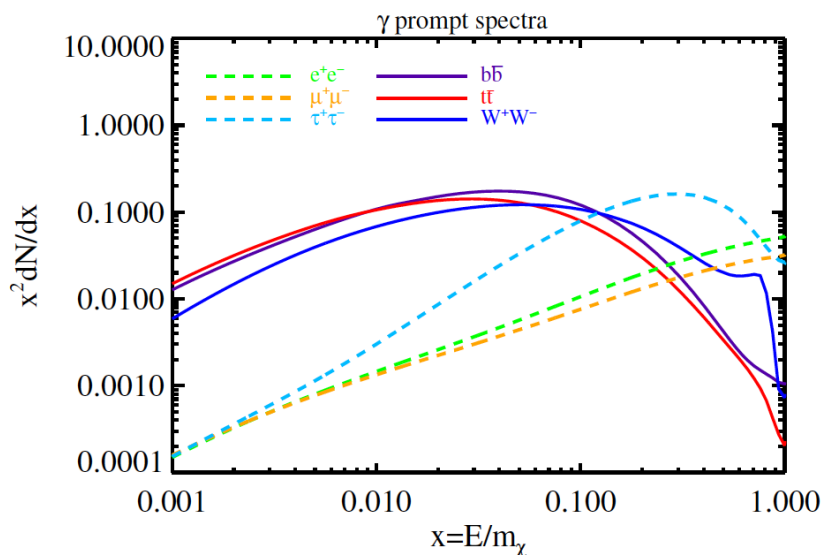
Sensitive M_χ : 200GeV – 10TeV



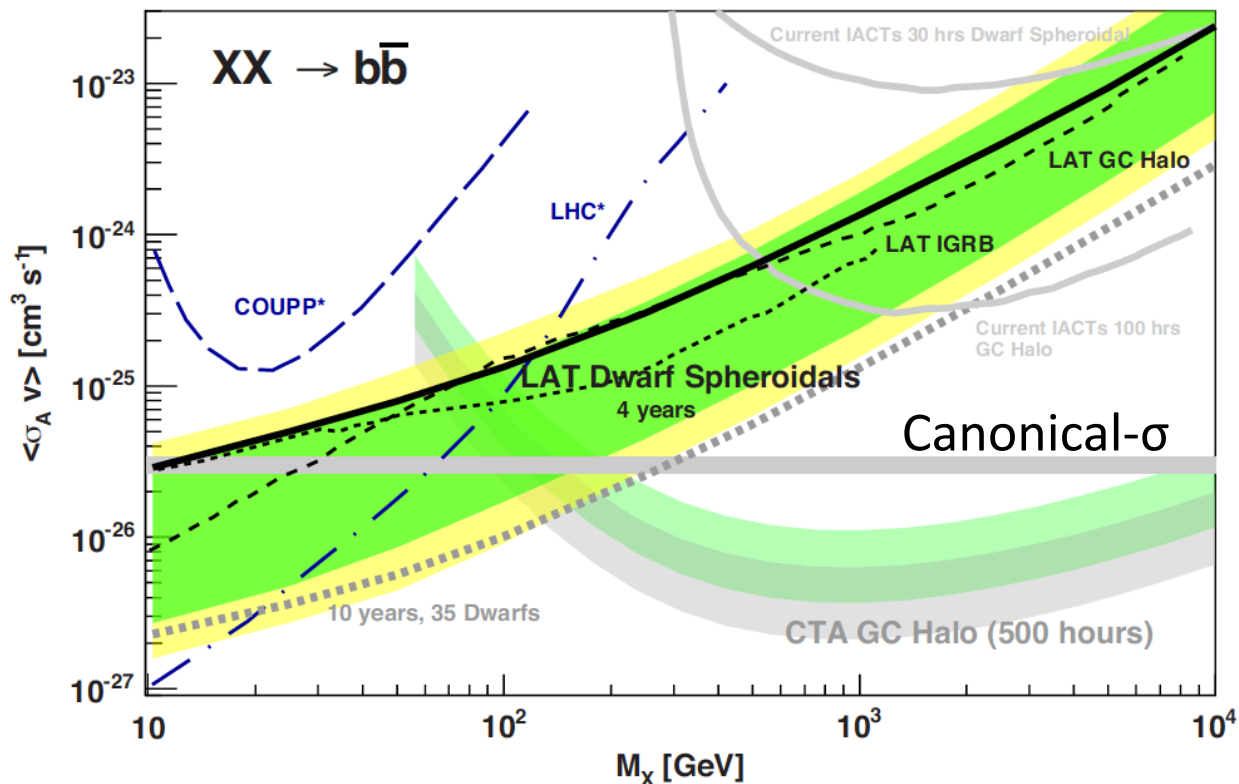
$$\frac{d\Phi_\gamma}{dE_\gamma} = \frac{1}{4\pi} \underbrace{\frac{\langle \sigma_{\text{ann}} v \rangle}{2m_{\text{WIMP}}^2} \sum_f \frac{dN_\gamma^f}{dE_\gamma} B_f}_{\text{'Particle Physics'}} \times \underbrace{\int_{\Delta\Omega} d\Omega' \int_{\text{los}} \rho^2 dl(r, \theta')}_{\text{'Astrophysics'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

Particle Physics

Astrophysics



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



CTA gives the stringent upper limit.
Stefan Funk 2015



Cherenkov
telescope
array

Multi-messenger and Multi-wavelength Astrophysics

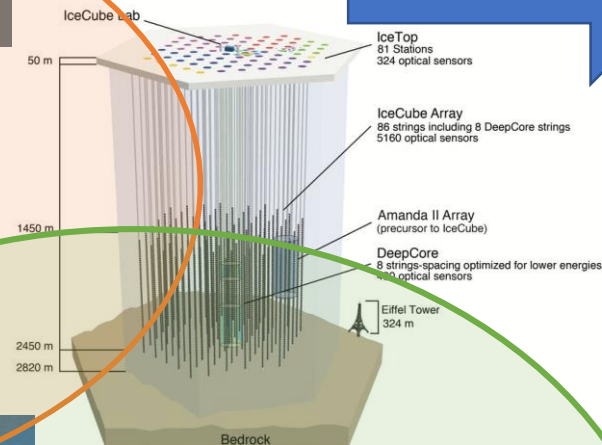
Wave
Astrophysics



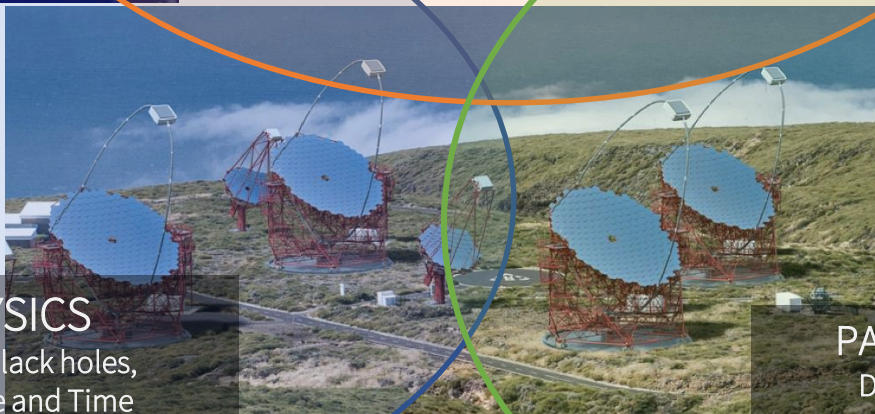
ASTRO-PARTICLE PHYSICS
Cosmic Ray Physics
High Energy Astrophysics



Particle Physics



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



PARTICLE PHYSICS
Dark Matter, Neutrino
Energy Frontier

