CTA, with focus on LST
TeV Gamma Ray Astronomy

Masahiro Teshima

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

GeV/TeV Gamma-Ray detectors

cherenkov telescope array

VERITAS

MAGIC-II

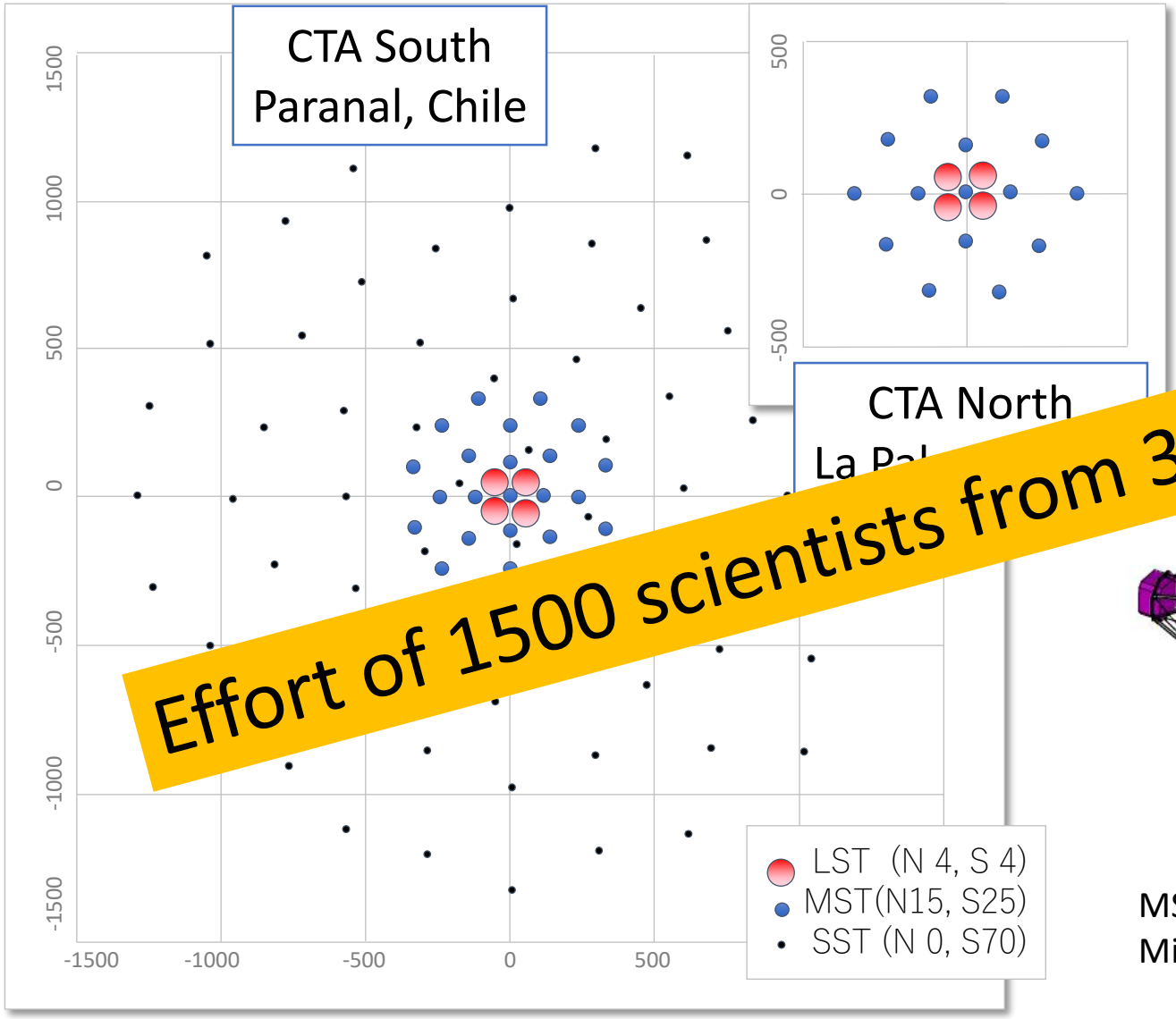
Fermi Gamma-Ray Satellite

HAWC

HESS-II

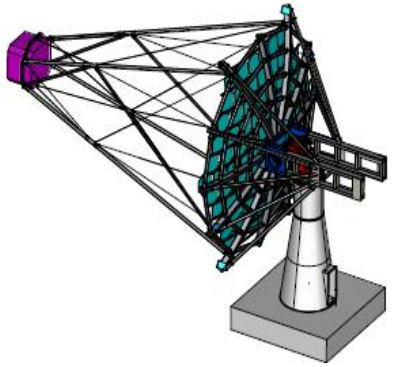
CTA Telescopes Array Configurations

CTA Observatory consists of two sites, Chile Paranal and Spain Canary Island to coverall sky.

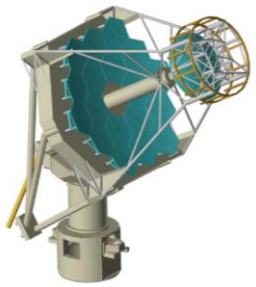


Effort of 1500 scientists from 32 countries

LST 23m (8MEuro) Low-Energy



MST 12m (2.5MEuro)
Mid-Energy

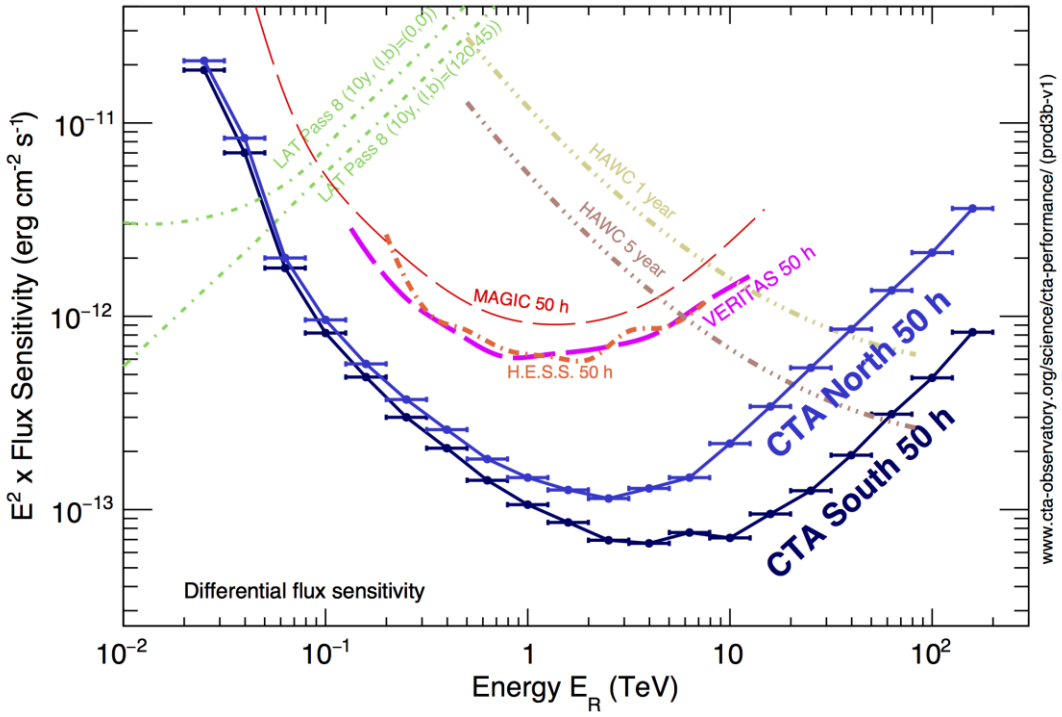


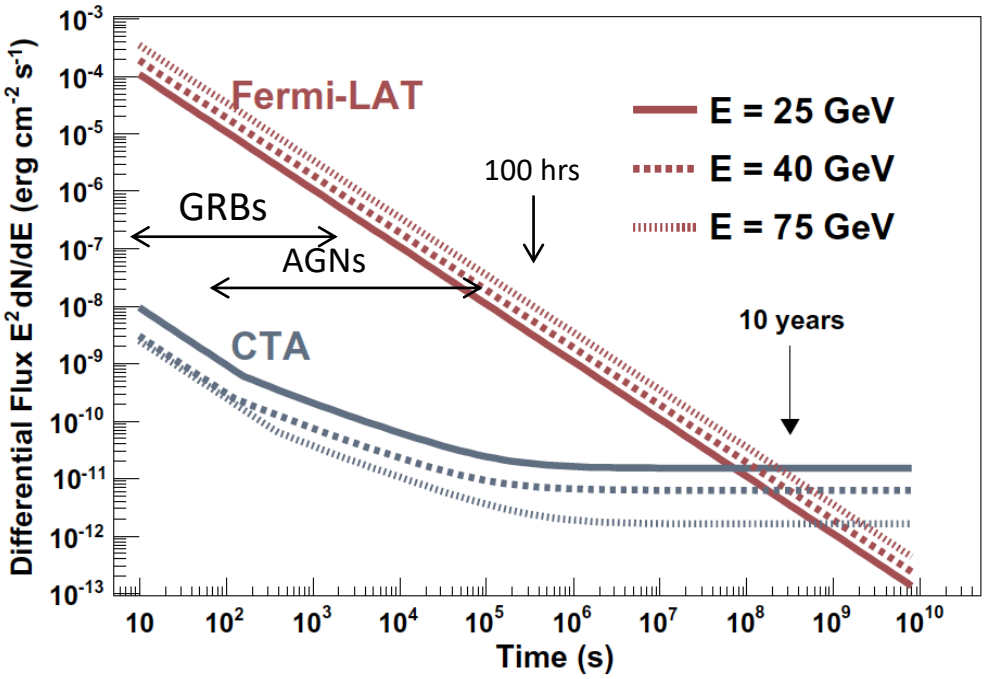
SST 4.3m(0.5MEuro)
High-Energy

CTA North and South Array

Sensitivity x10, Angular Resolution x2

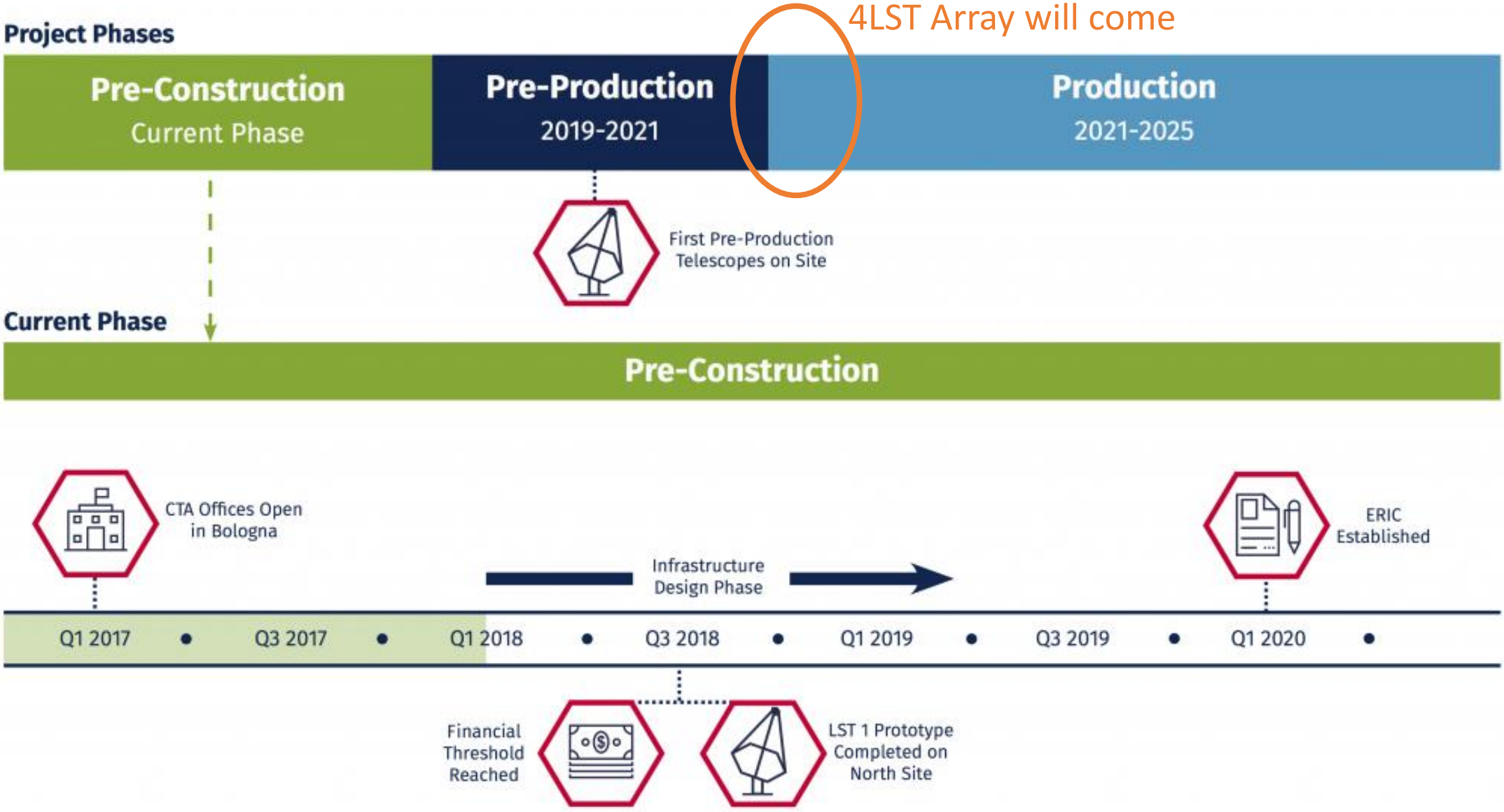
Energy Range > 20GeV



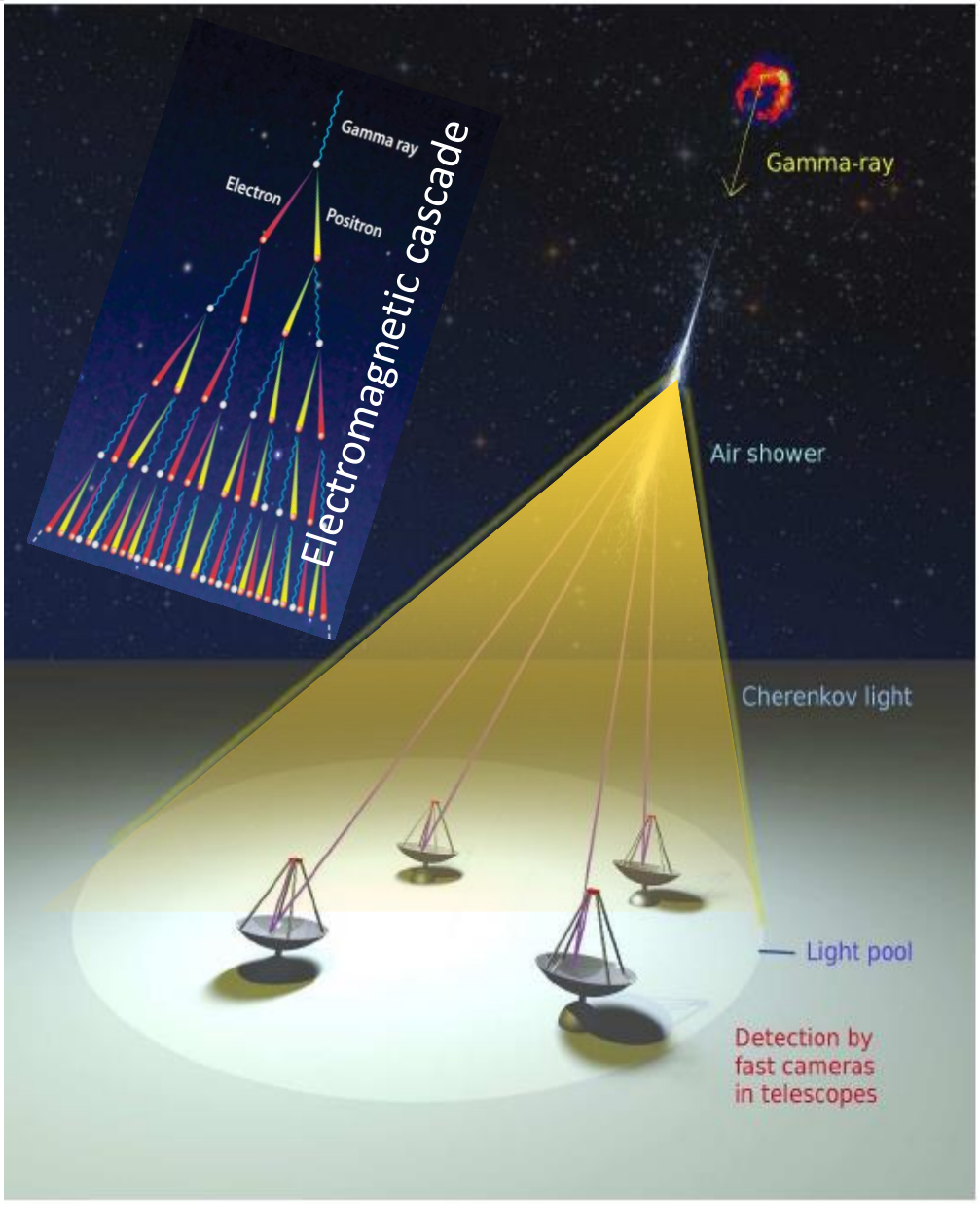


- CTA-LST array contributes to the sensitivity in low energies
- >20GeV Threshold Energy
- Distant AGNs are observable up to z=2
- X10000 sensitivity for GRBs and AGN flares than Fermi
- First firm observation of GRBs from ground

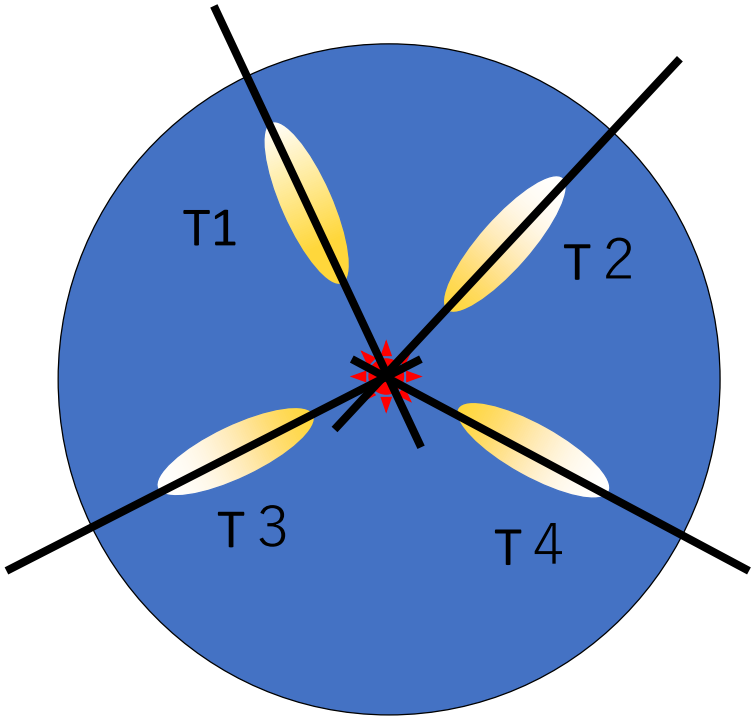
Timeline of CTA Project



Imaging Cherenkov Telescopes

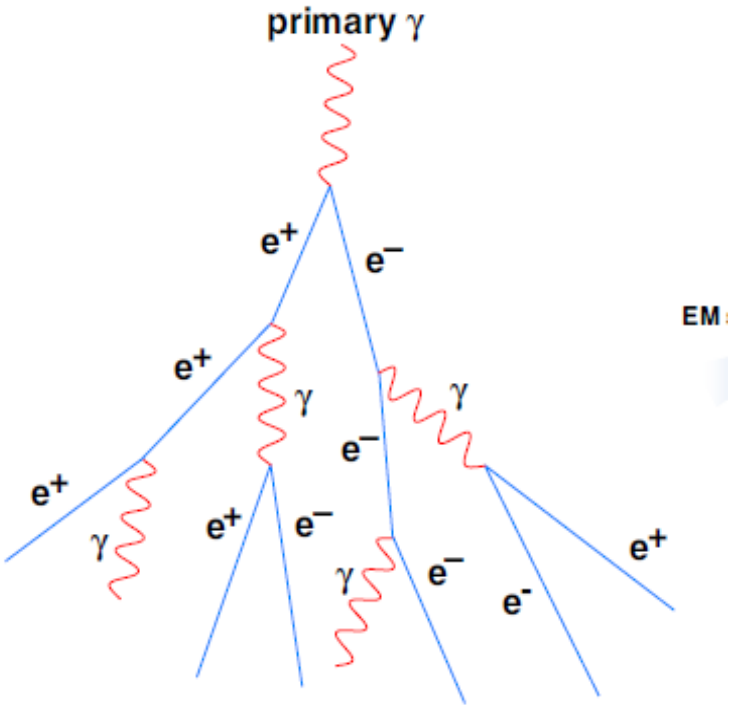


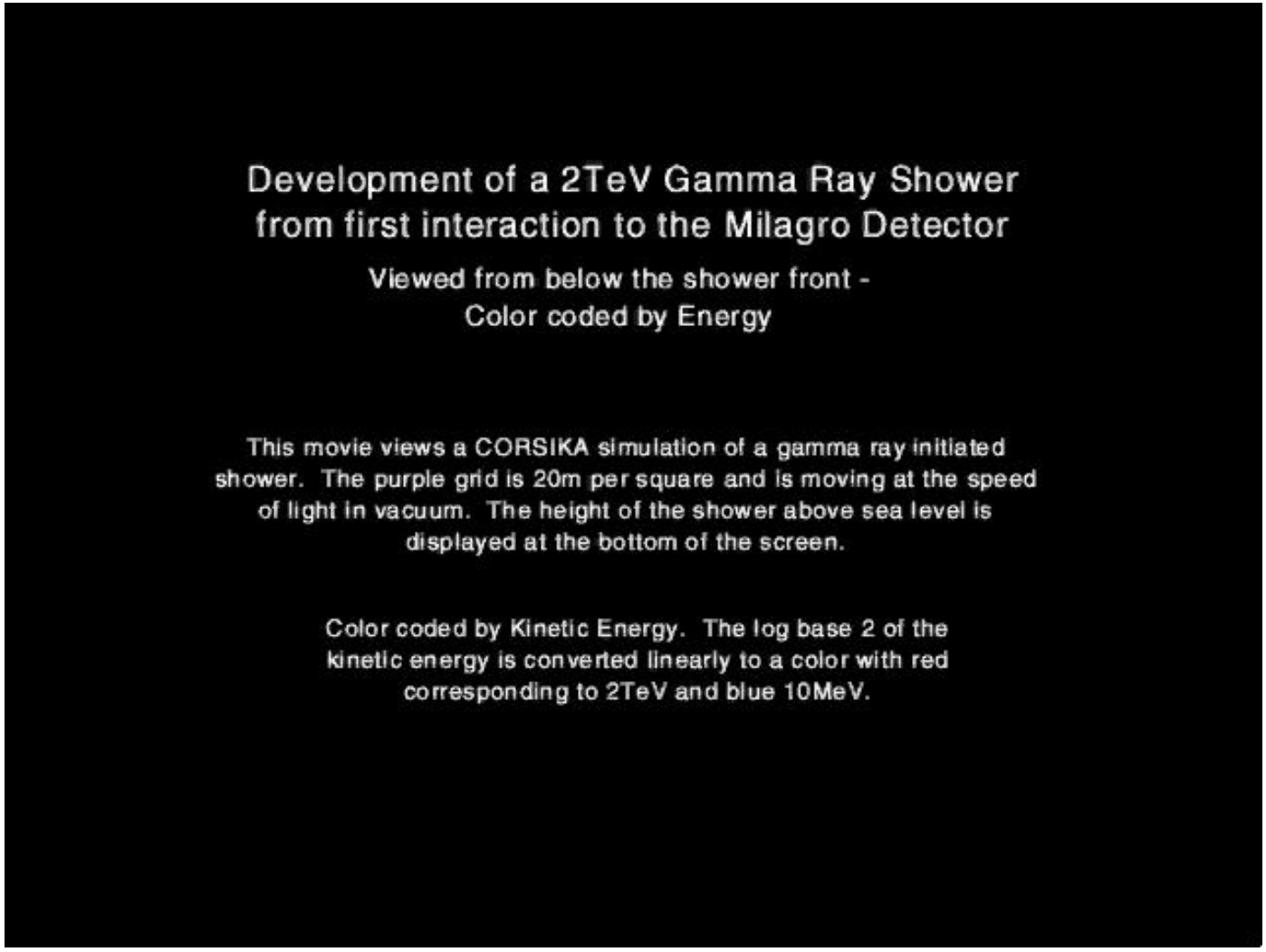
# of Photons: 50photons/m^2 at 1TeV



- Energy range 20GeV ~ 300TeV
- CR Rejection ~99.9%
- Angular Res. ~0.02 degrees
- Energy Res. ~10%
- Effective Area ~$10^6 m^2$
- Sensitivity ~0.1% Crab Flux (10^{-14} erg/cm^2s)

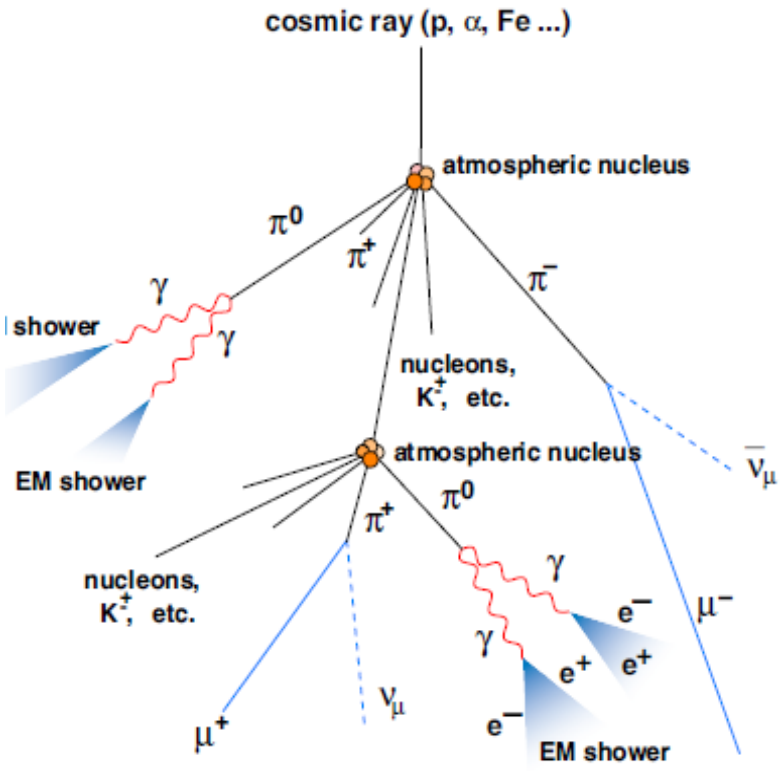
TeV ガンマ線からの空気シャワー





cherenkov telescope array

Proton からの空気シャワー



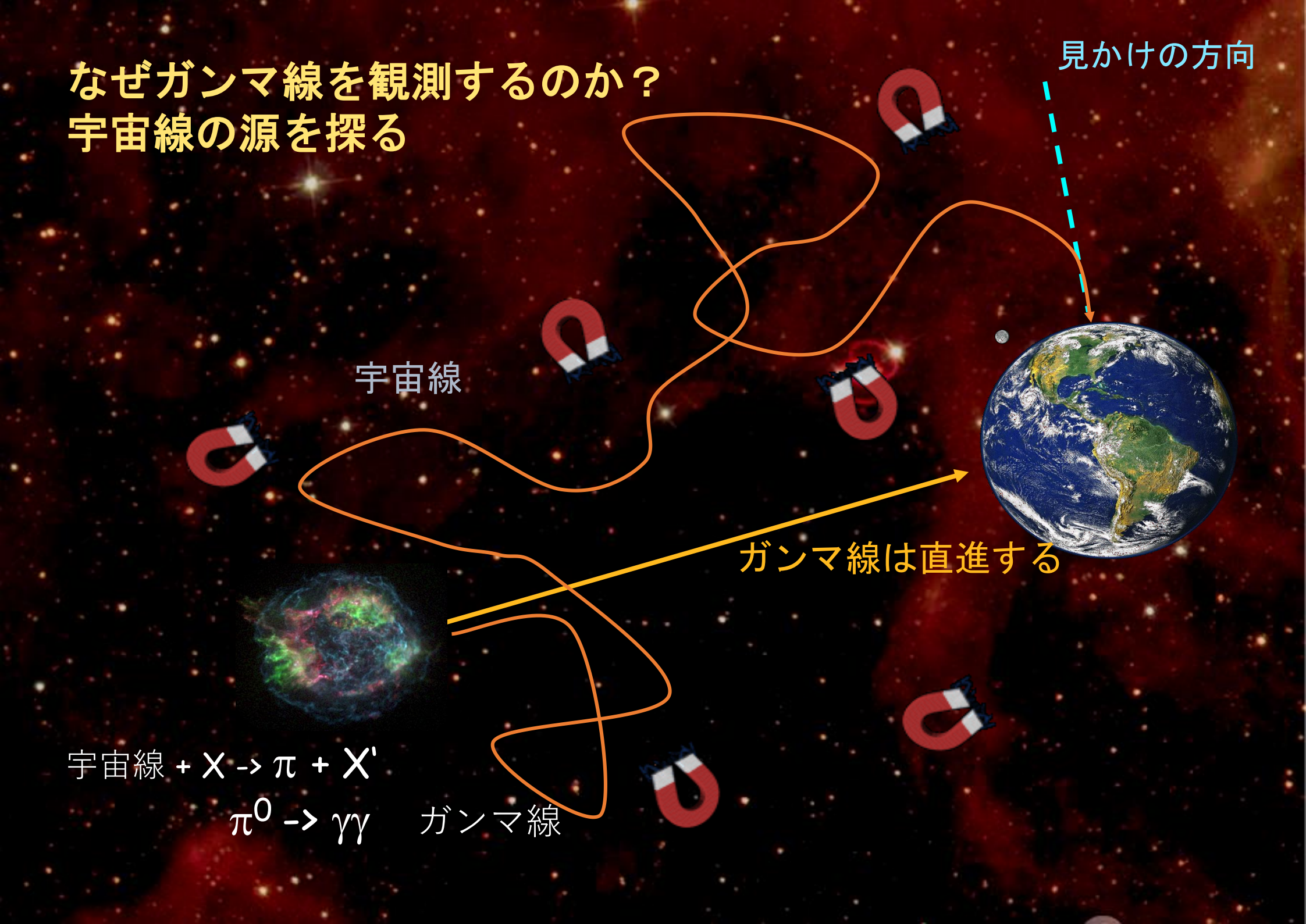
Development of a 2TeV Proton Shower
from first interaction to the Milagro Detector

Viewed from below the shower front -
Color coded by Energy

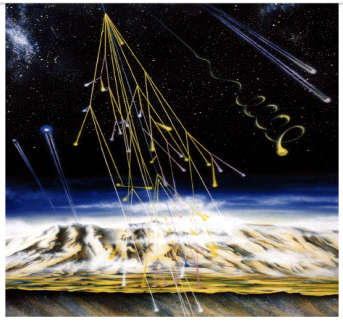
This movie views a CORSIKA simulation of a proton initiated shower. The purple grid is 20m per square and is moving at the speed of light in vacuum. The height of the shower above sea level is displayed at the bottom of the screen.

Color coded by Kinetic Energy. The log base 2 of the kinetic energy is converted linearly to a color with red corresponding to 2TeV and blue 10MeV.

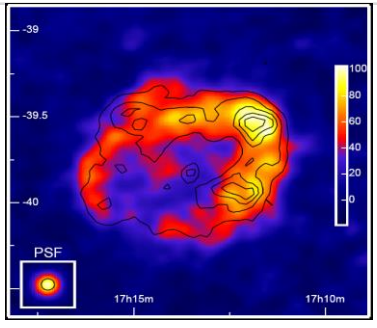
MAGICMovie


なぜガンマ線を観測するのか？
宇宙線の源を探る
見かけの方向
宇宙線
ガンマ線は直進する
宇宙線 + X -> π + X'
π0 -> γγ　ガンマ線

Science with CTA
Energy frontier of Astrophysics

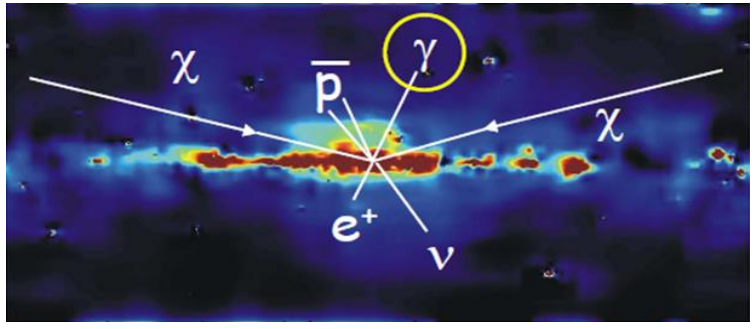


Origin of CR
UHECR



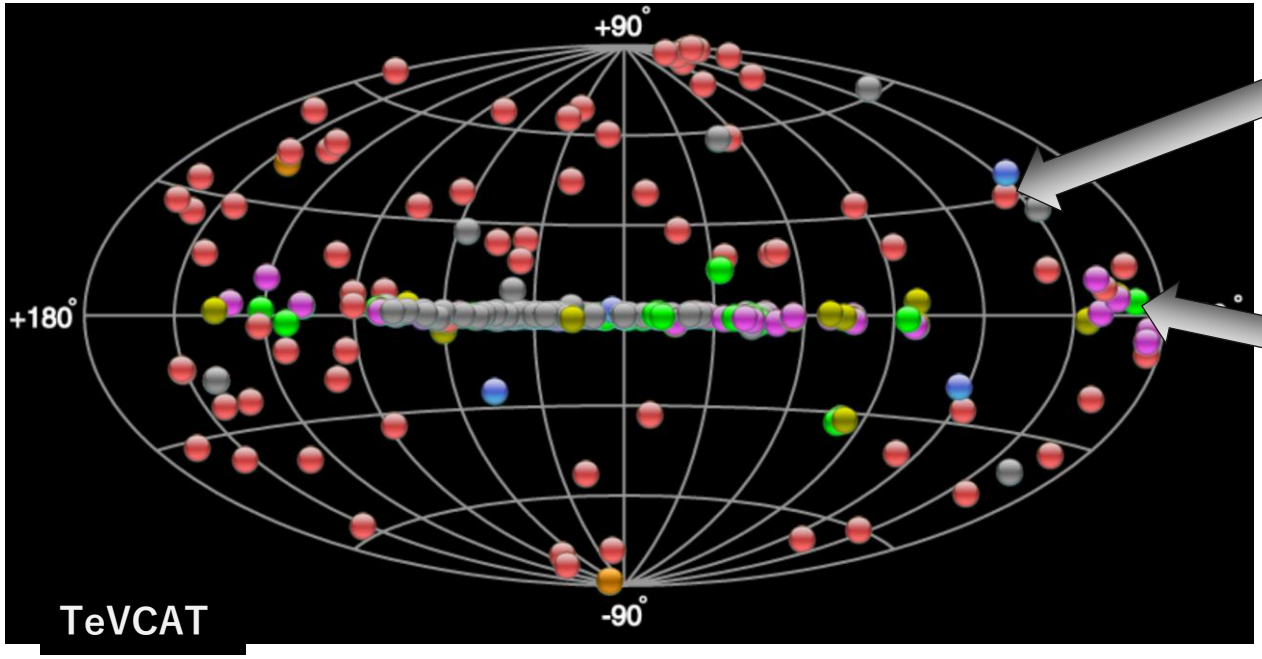
Cosmic Accelerators

Super Massive
Blackhole



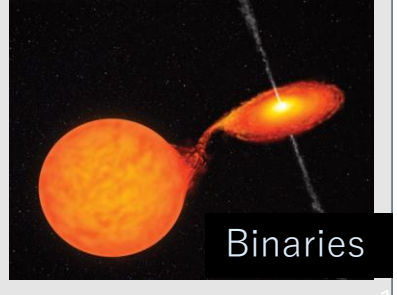
Dark Matter

- Origin of Cosmic Rays (Cosmic Accelerators)
- High Energy Phenomena around Blackholes
- Gamma Rays from Dark Matter Annihilation

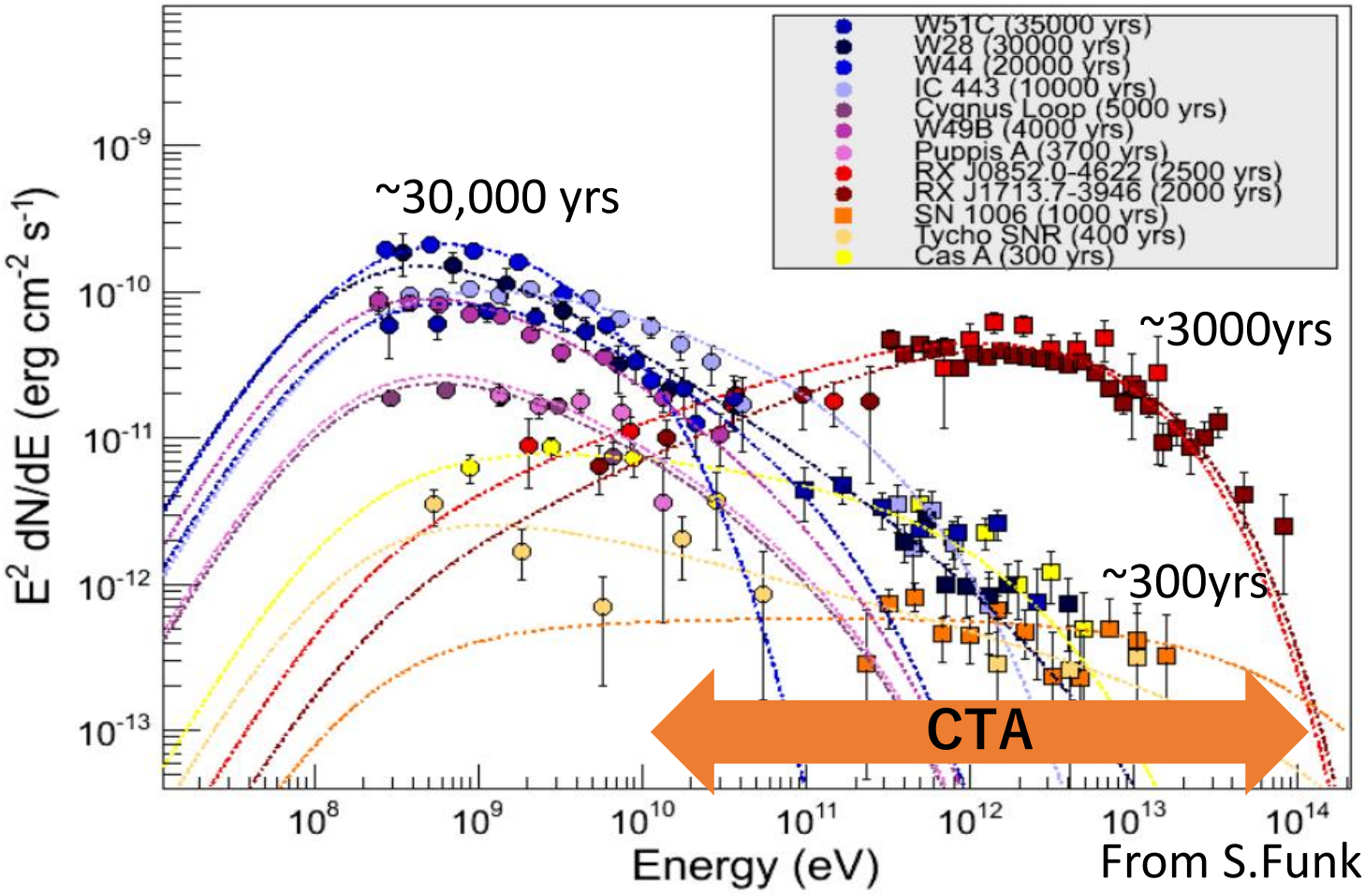


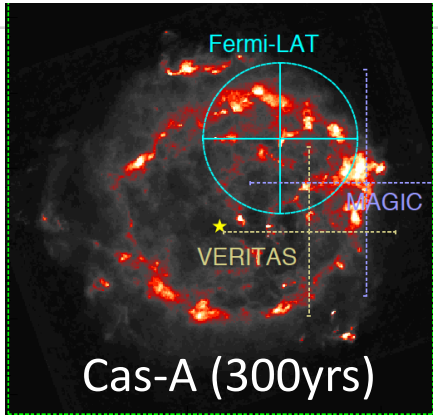
Extragalactic

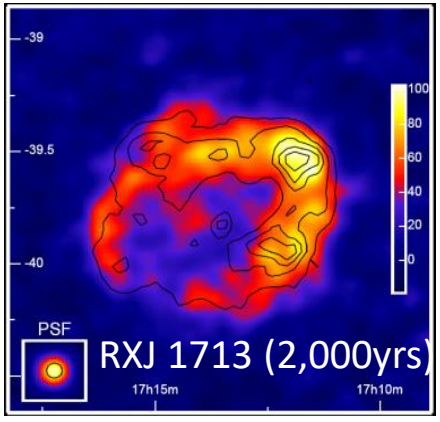
Galactic Sources

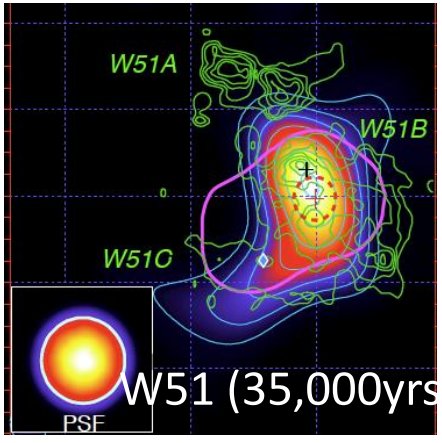


Shell Type Super Nova Remnants are identified as cosmic ray sources







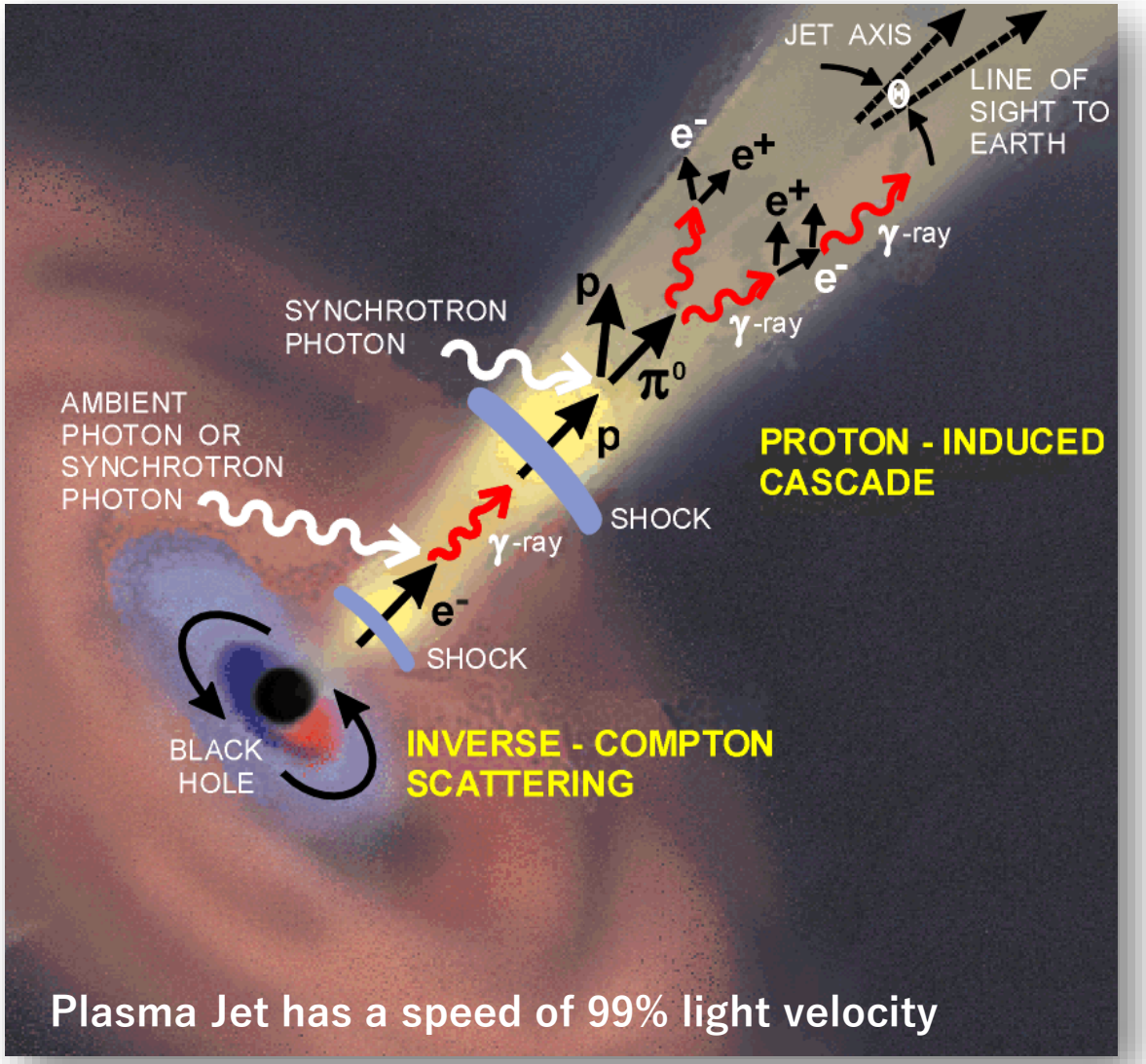


- We need 200-300 SNRs to explain the energetics of galactic cosmic rays
- What is the maximum attainable energy with SNRs

cherenkov telescope array

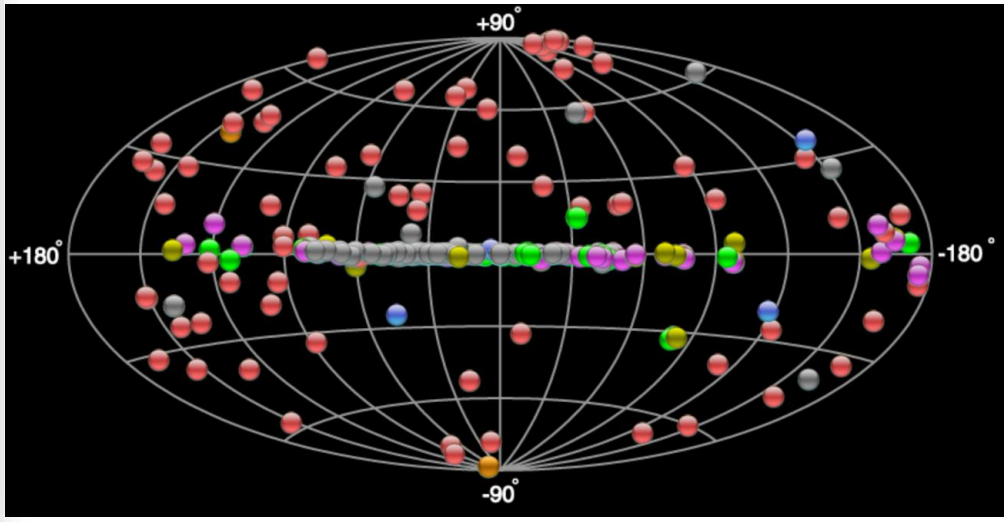
Super Massive Black Holes ～10^8 $M_\odot$

Candidates Sources for >10^{18}eV Cosmic Rays



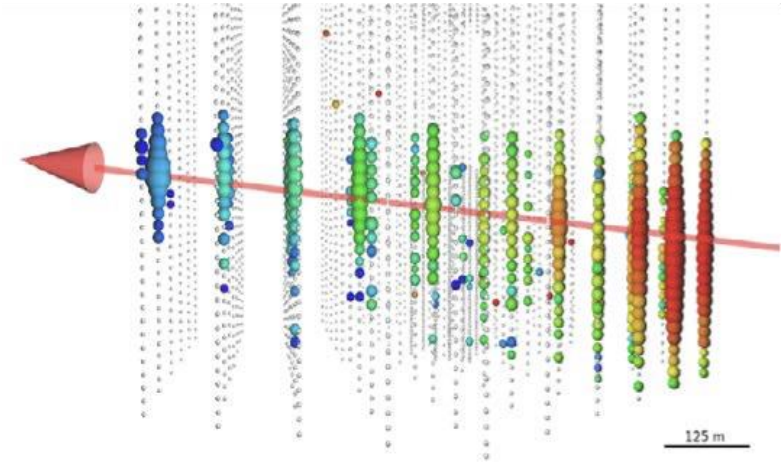
- What is the Maximum Energy?
- Can reach to 10^{20}eV?
- Energy source is accretion disk or rotation energy of Black Hole?
- Explore Black Hole sub Horizon

Red closed circles are Super Massive Black Holes observed MAGIC, HESS, and VERITAS

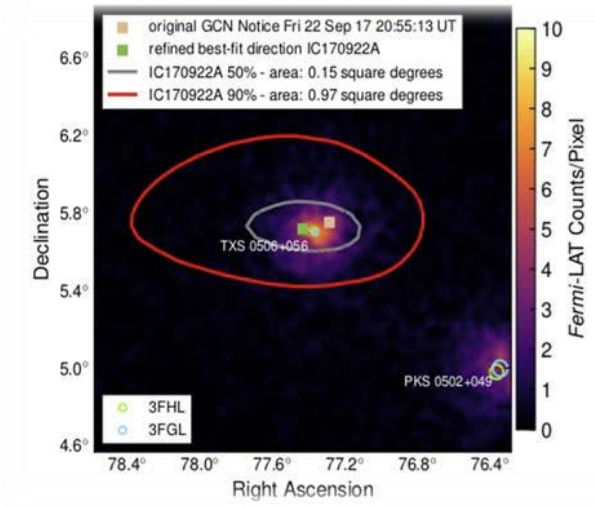


IC170922A / TXS 0506+056

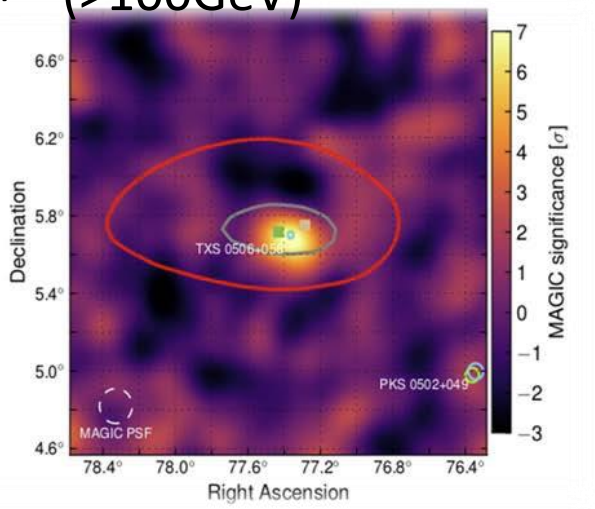
Ice Cube Observation (~300TeV)



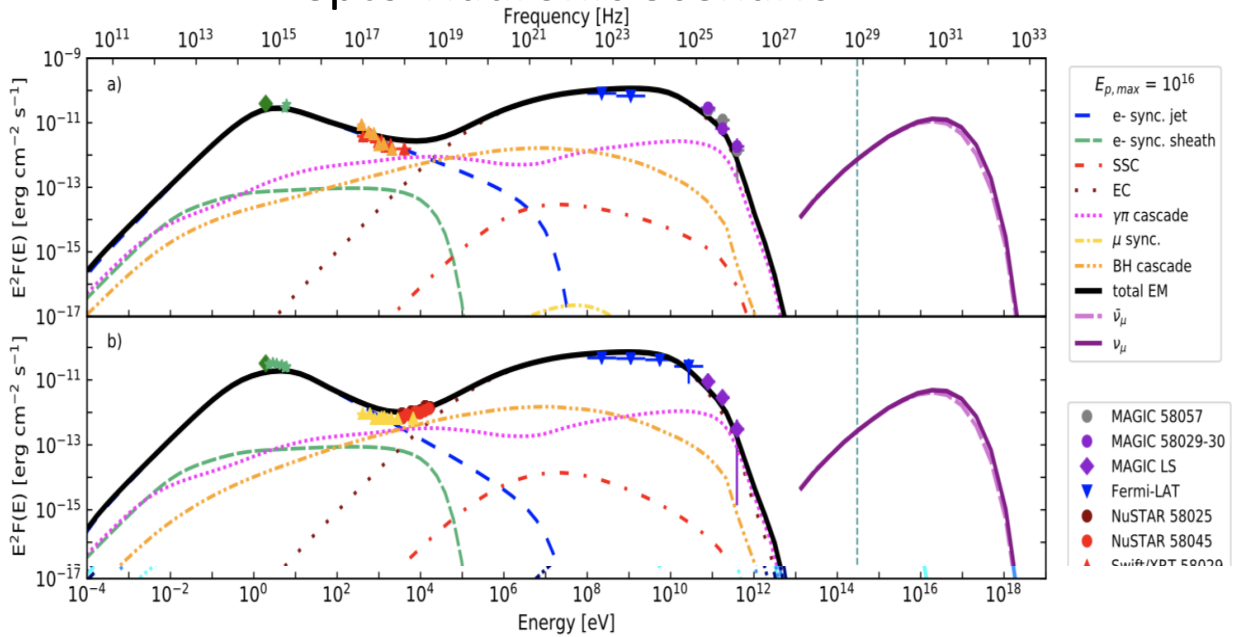
Fermi LAT Observation (GeV)



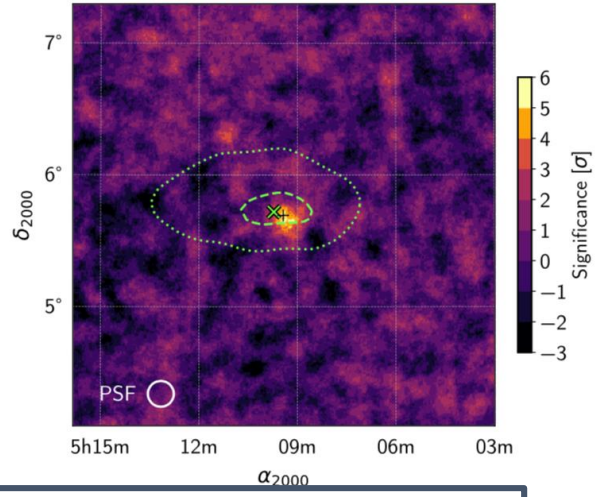
MAGIC Observation (>100GeV)



Lepto-Hadronic Scenario

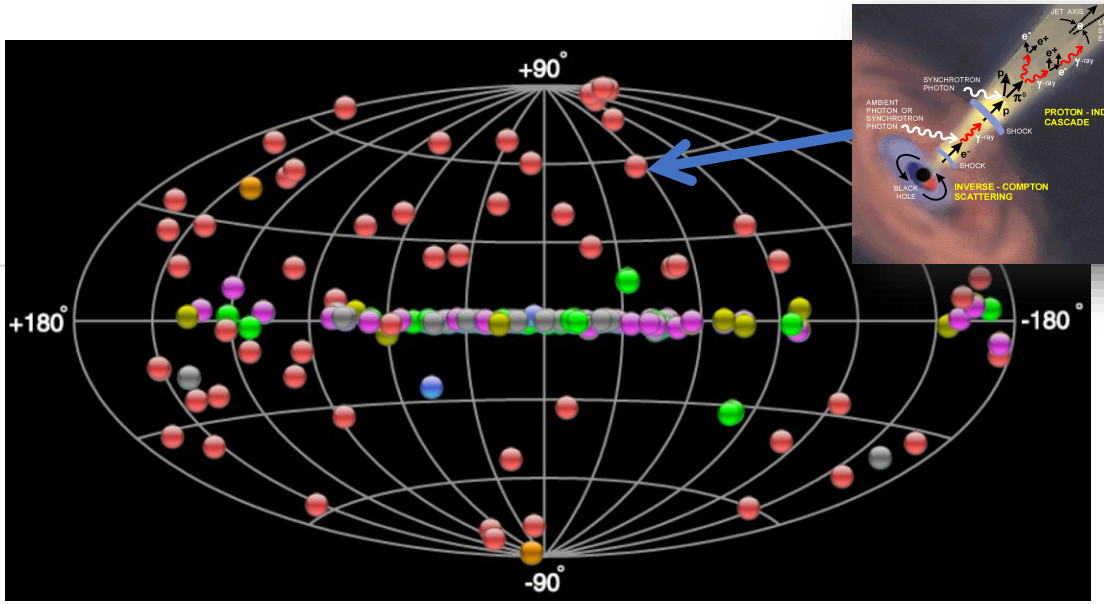


VERITAS Obs.



GTC Observation z = 0.3365
S. Paiano etl al 2018

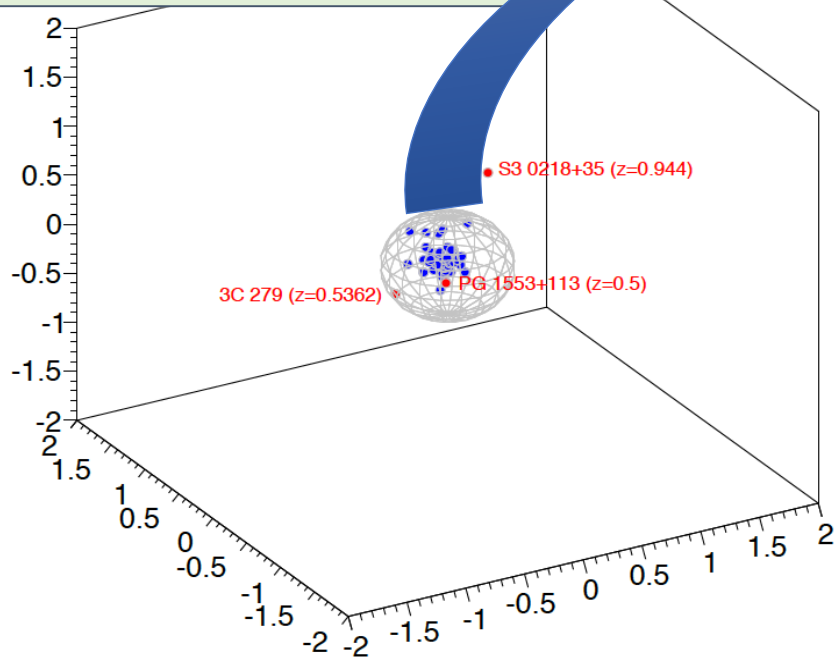
cherenkov telescope array



CTA is the ultimate survey machine

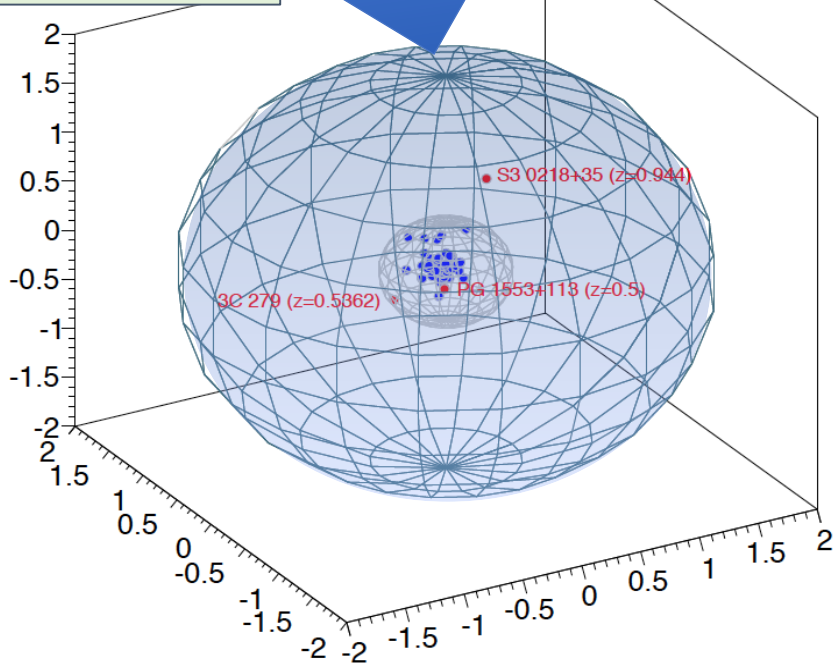
observing the early Universe up to 1.6 billion years after big bang (z<2.0)

Visible Universe with VHE Gamma rays now



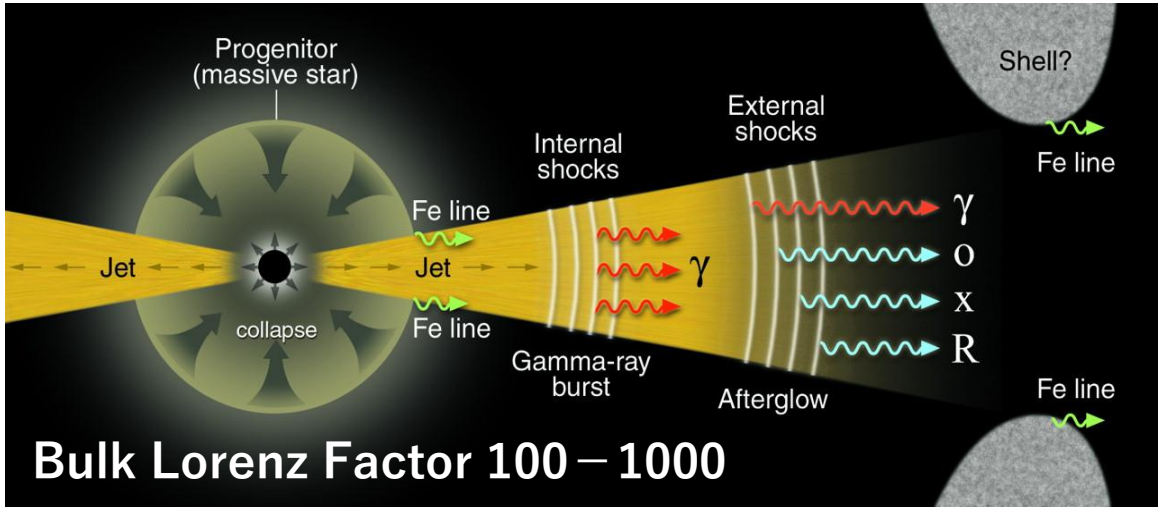
Universe 9 billion years after Big Bang

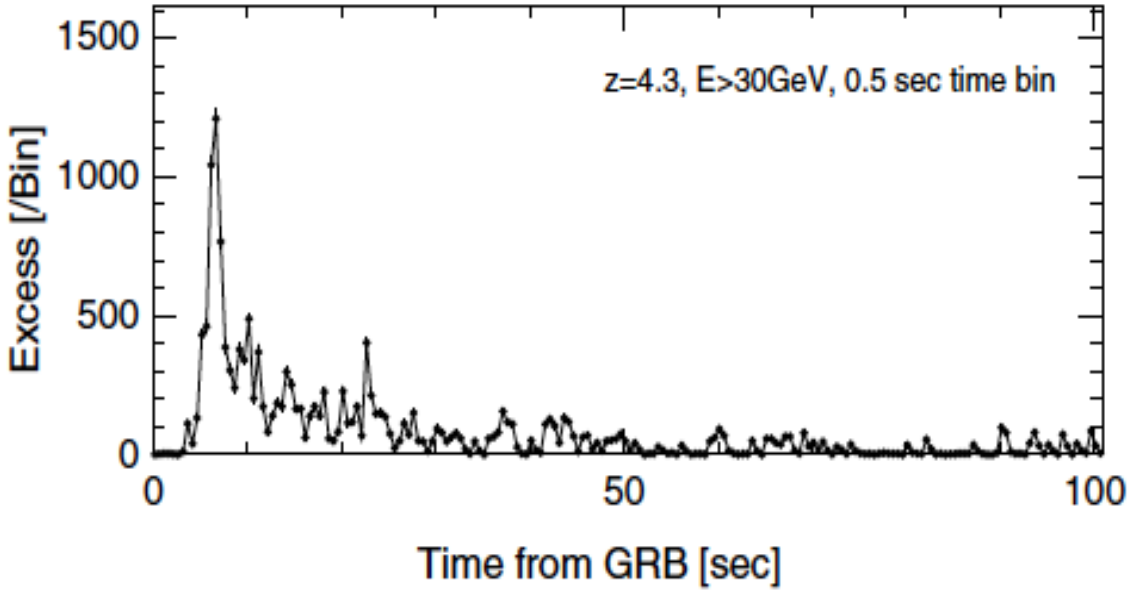
CTA will expand the visible Universe



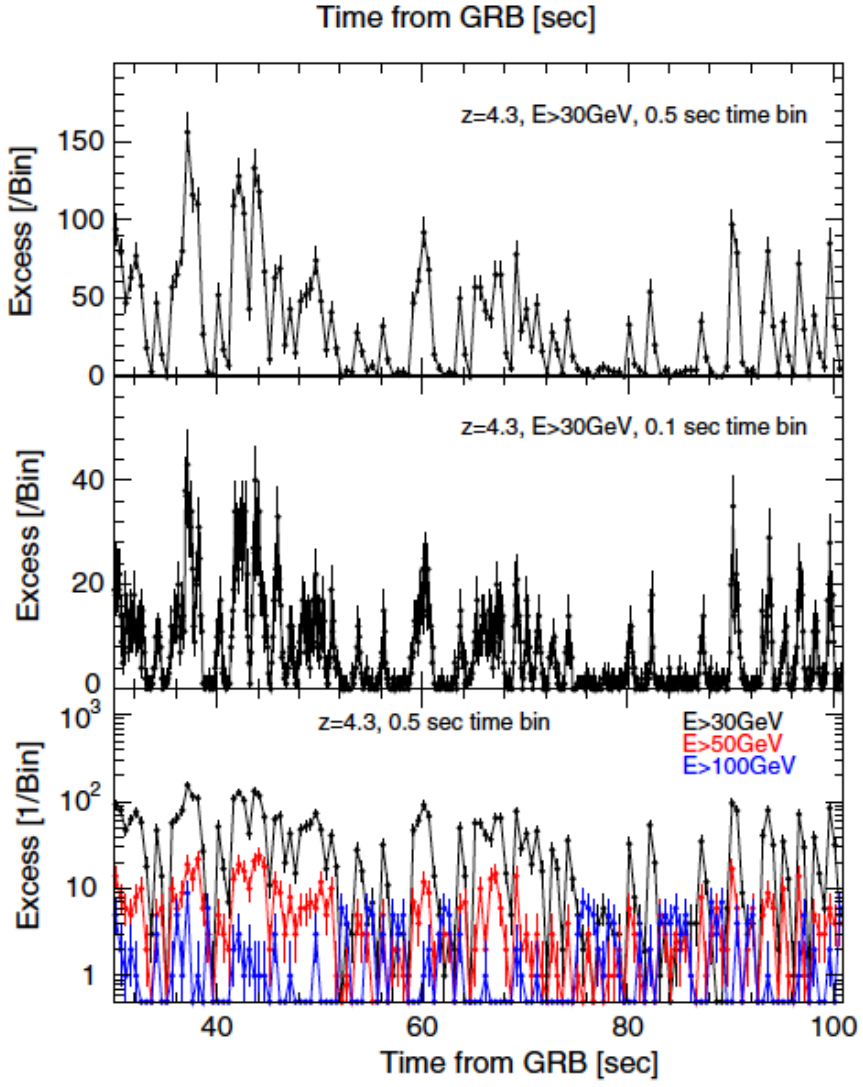
Universe 3 billion years after Big Bang

GRBs: good targets for CTA-LSTs
Study the newborn baby black holes

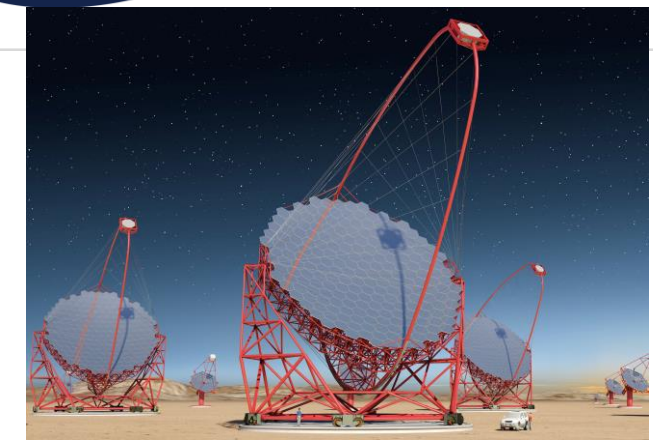




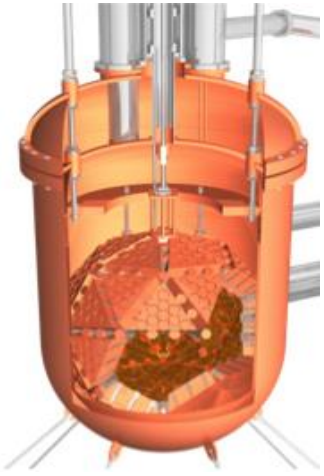
CTA Simulation
(Template GRB080916C)



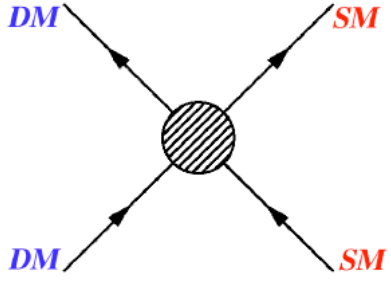
Toward the discovery of Dark Matter
Complementarity with different approaches



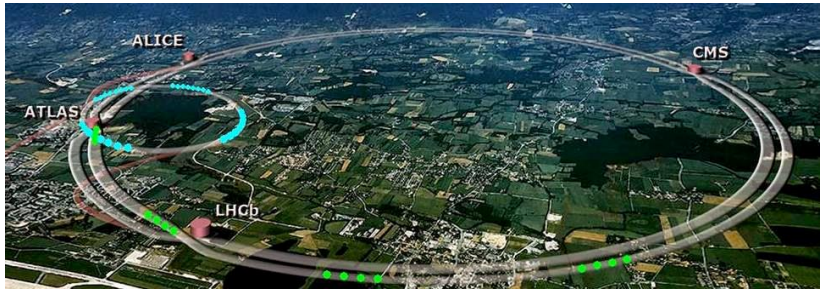
thermal freeze-out (early Univ.)
indirect detection (now)

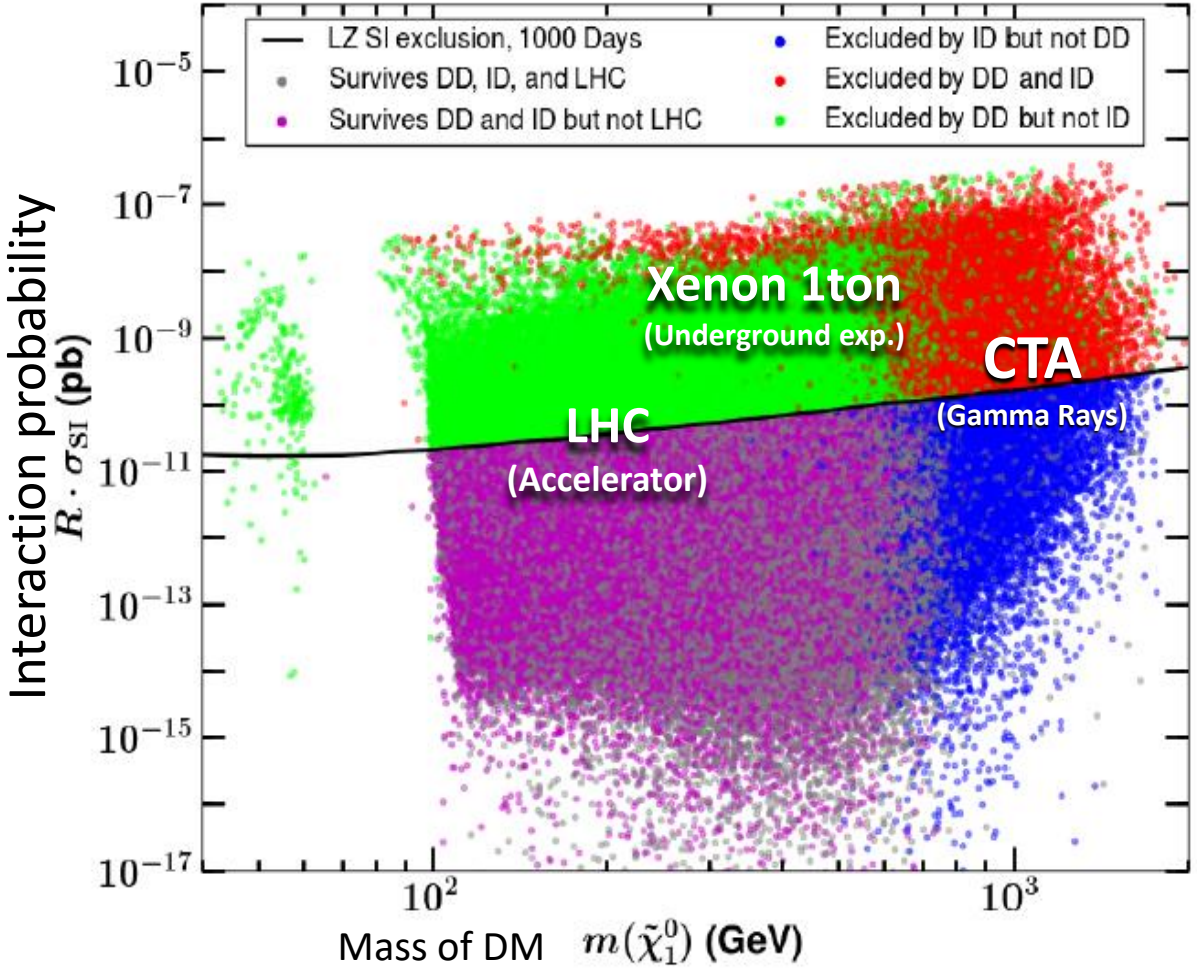


direct detection



production at colliders





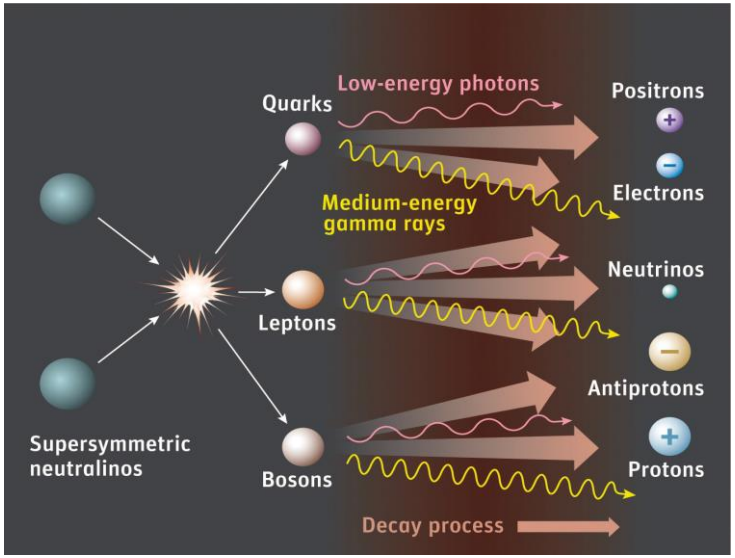
- **Explore Dark Matter in the Galactic Center and Dwarf Sph. Galaxies**
- **CTA has the best sensitivity above 700GeV**

持帰不可

cherenkov telescope array

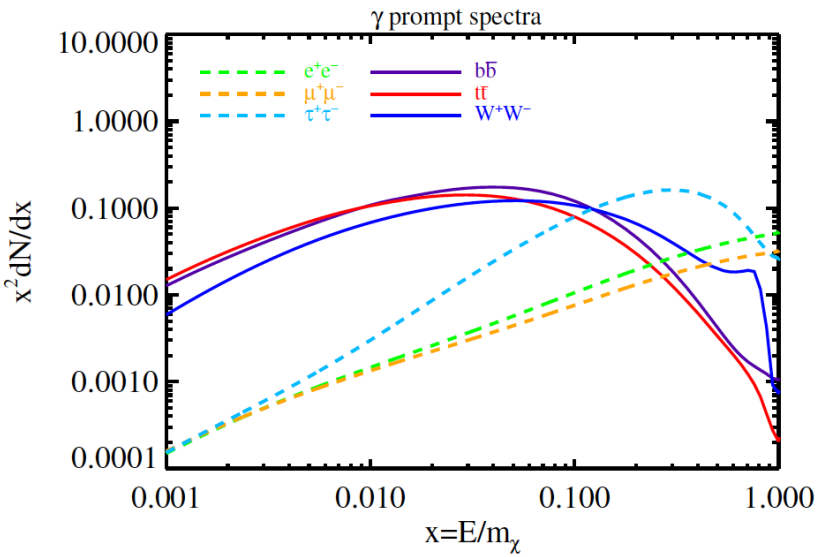
高感度での暗黒物質探索

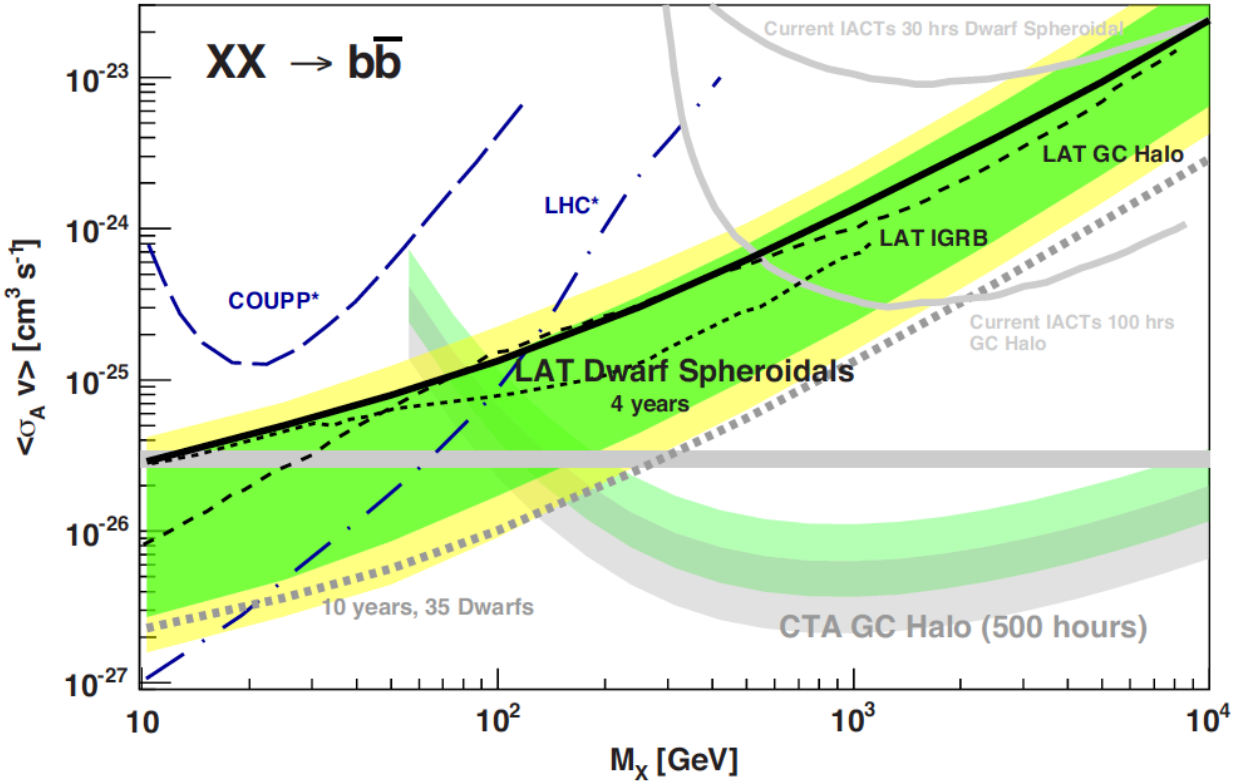
質量領域　M_χ：　200GeV - 10TeV



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

素粒子物理項　　**宇宙天体物理項**





対消滅で放出されるガンマ線は1/10 Mχにバンプを作る
20GeV – 1TeV 領域でのガンマ線観測が重要

CTA は、銀河中心、矮小楕円銀河の観測により
理論的な予測より厳しいリミットを与える

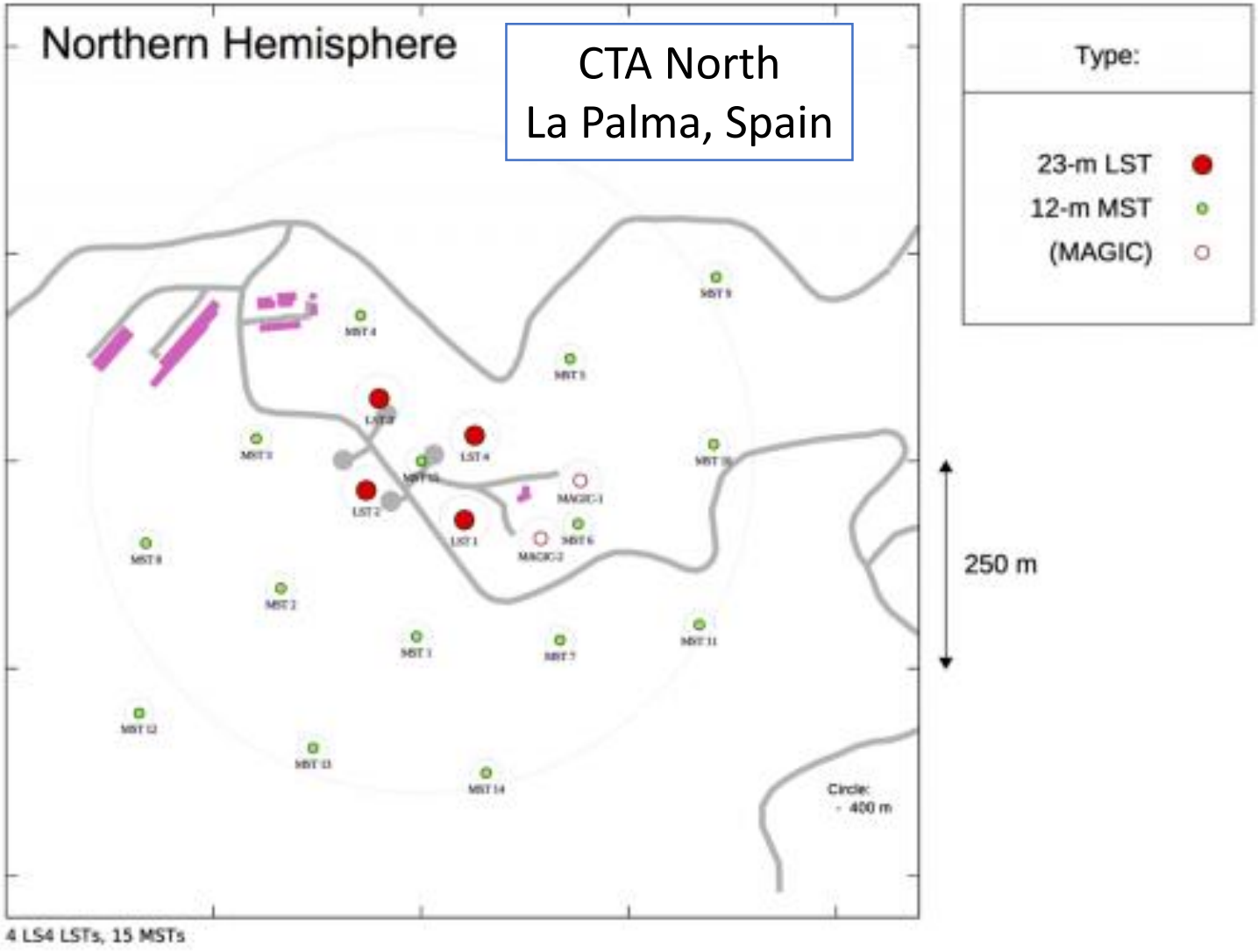
cherenkov telescope array

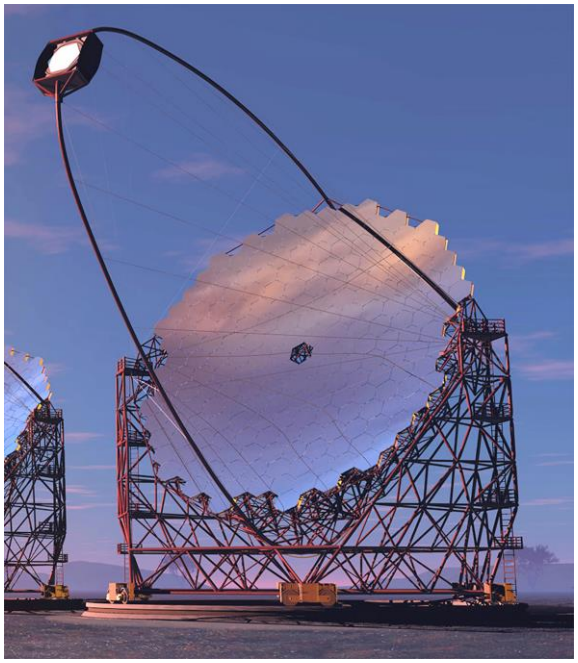
CTA North at ORM

Observatorio del Roque de los Muchachos

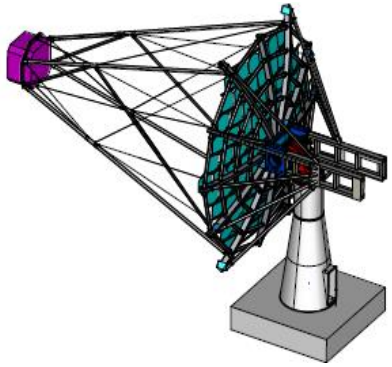
CTA North Array Configurations

CTA Observatory consists of two sites, Chile Paranal and Spain Canary Island to coverall sky.

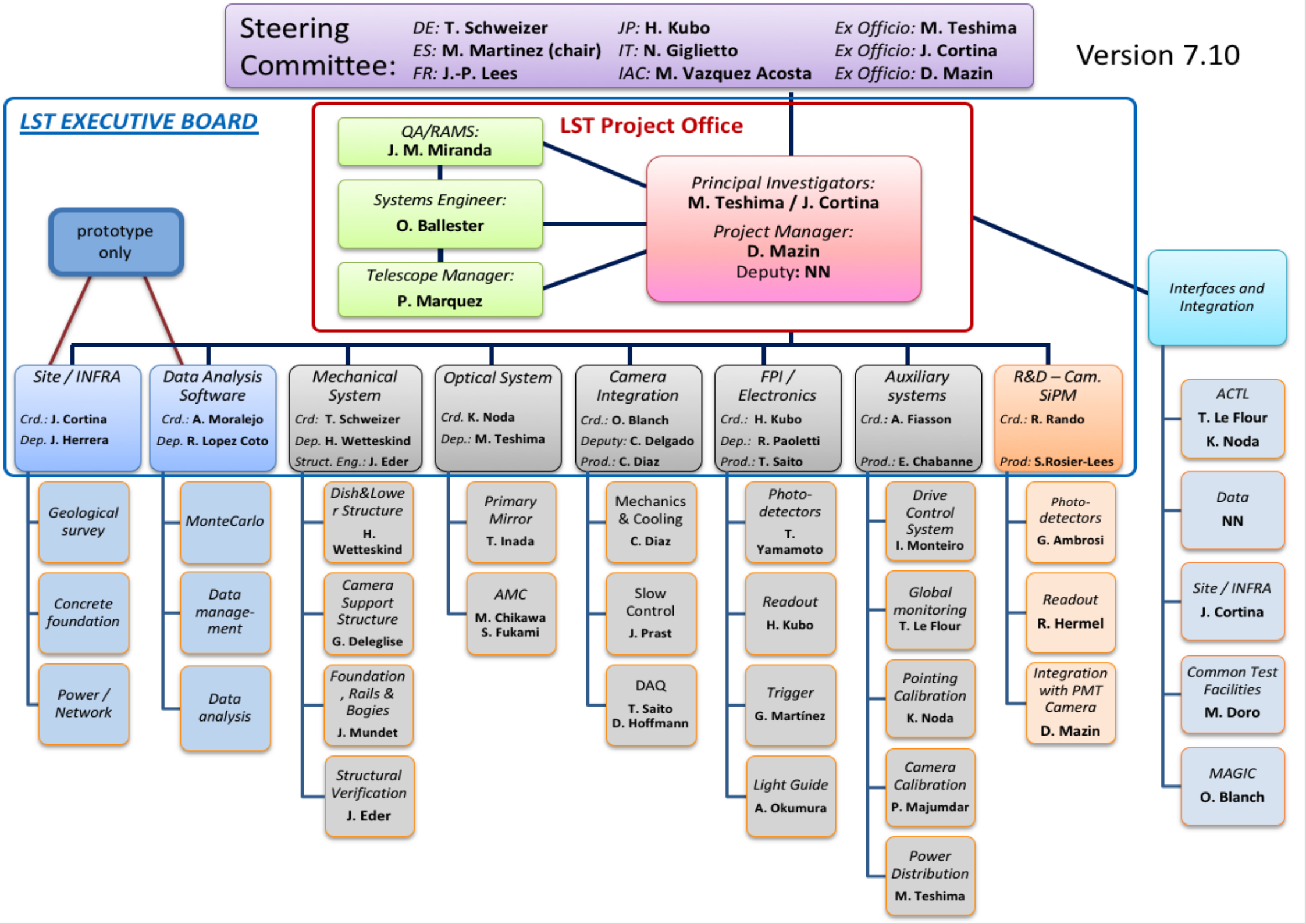




LST 23m Low-Energy



MST 12m
Mid-Energy


Steering Committee:
DE: T. Schweizer
ES: M. Martinez (chair)
FR: J.-P. Lees
JP: H. Kubo
IT: N. Giglietto
IAC: M. Vazquez Acosta
Ex Officio: M. Teshima
Ex Officio: J. Cortina
Ex Officio: D. Mazin
Version 7.10
LST EXECUTIVE BOARD
LST Project Office
QA/RAMS: J. M. Miranda
Systems Engineer: O. Ballester
Telescope Manager: P. Marquez
Principal Investigators: M. Teshima / J. Cortina
Project Manager: D. Mazin
Deputy: NN
prototype only
Interfaces and Integration
Site / INFRA
Crd.: J. Cortina
Dep. J. Herrera
Data Analysis Software
Crd.: A. Moralejo
Dep. R. Lopez Coto
Mechanical System
Crd: T. Schweizer
Dep. H. Wetteskind
Struct. Eng.: J. Eder
Optical System
Crd. K. Noda
Dep.: M. Teshima
Camera Integration
Crd.: O. Blanch
Deputy: C. Delgado
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Crd.: H. Kubo
Dep.: R. Paoletti
Prod.: T. Saito
Auxiliary systems
Crd.: A. Fiasson
Prod.: E. Chabanne
R&D – Cam. SiPM
Crd.: R. Rando
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MonteCarlo
Data manage-ment
Data analysis
Dish&Lowe r Structure
H. Wetteskind
Camera Support Structure
G. Deleglise
Foundation , Rails & Bogies
J. Mundet
Structural Verification
J. Eder
Primary Mirror
T. Inada
AMC
M. Chikawa
S. Fukami
Mechanics & Cooling
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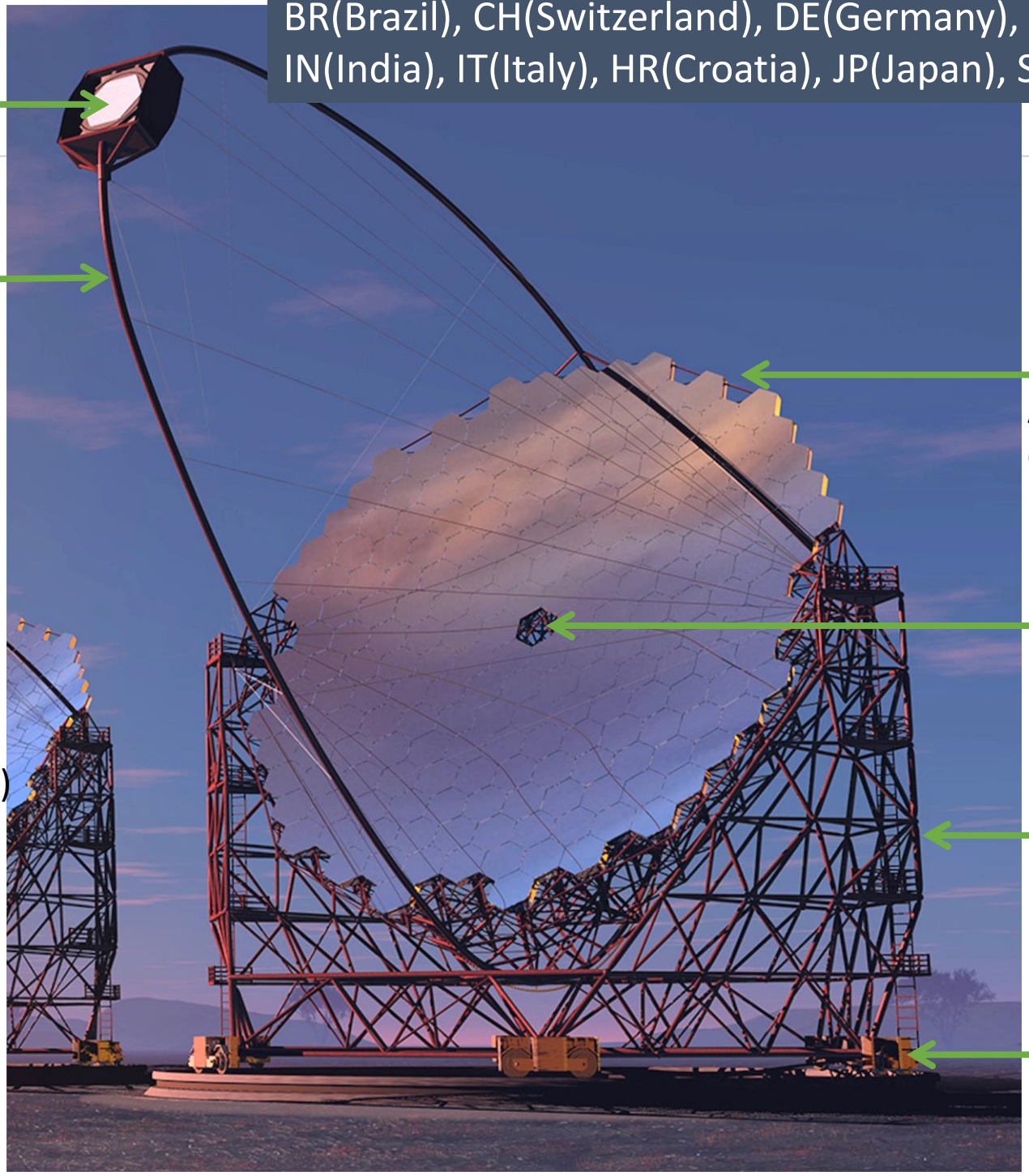
DAQ
T. Saito
D. Hoffmann
Photo-detectors
T. Yamamoto
Readout
H. Kubo
Trigger
G. Martínez
Light Guide
A. Okumura
Drive Control System
I. Monteiro
Global monitoring
T. Le Flour
Pointing Calibration
K. Noda
Camera Calibration
P. Majumdar
Power Distribution
M. Teshima
Photo-detectors
G. Ambrosi
Readout
R. Hermel
Integration with PMT Camera
D. Mazin
ACTL
T. Le Flour
K. Noda
Data
NN
Site / INFRA
J. Cortina
Common Test Facilities
M. Doro
MAGIC
O. Blanch

CTA-LST Project : Big International Effort
BR(Brazil), CH(Switzerland), DE(Germany), ES(Spain), FR(France), IN(India), IT(Italy), HR(Croatia), JP(Japan), SE(Sweden)

Focal Plane Instr.
Electronics (JP/IT/ES)
Camera body (ES)

Camera Supporting Structure (FR/IT)



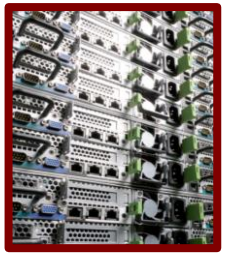
Mirror (JP)
Interface Plate(DE/BR/JP)
Actuator (JP/CH)
CMOS-Cam (JP)

Star Guider (SE)
Calibration Box (IN/IT)

Structure (DE/ES)
Access Tower (DE/ES)

Drive (ES/FR)
Bogie (ES/DE/IT)
Rail (ES/DE)
Foundation (ES)

Flywheel, UPS (JP)
Computers, network (JP)
INFRA (ES)



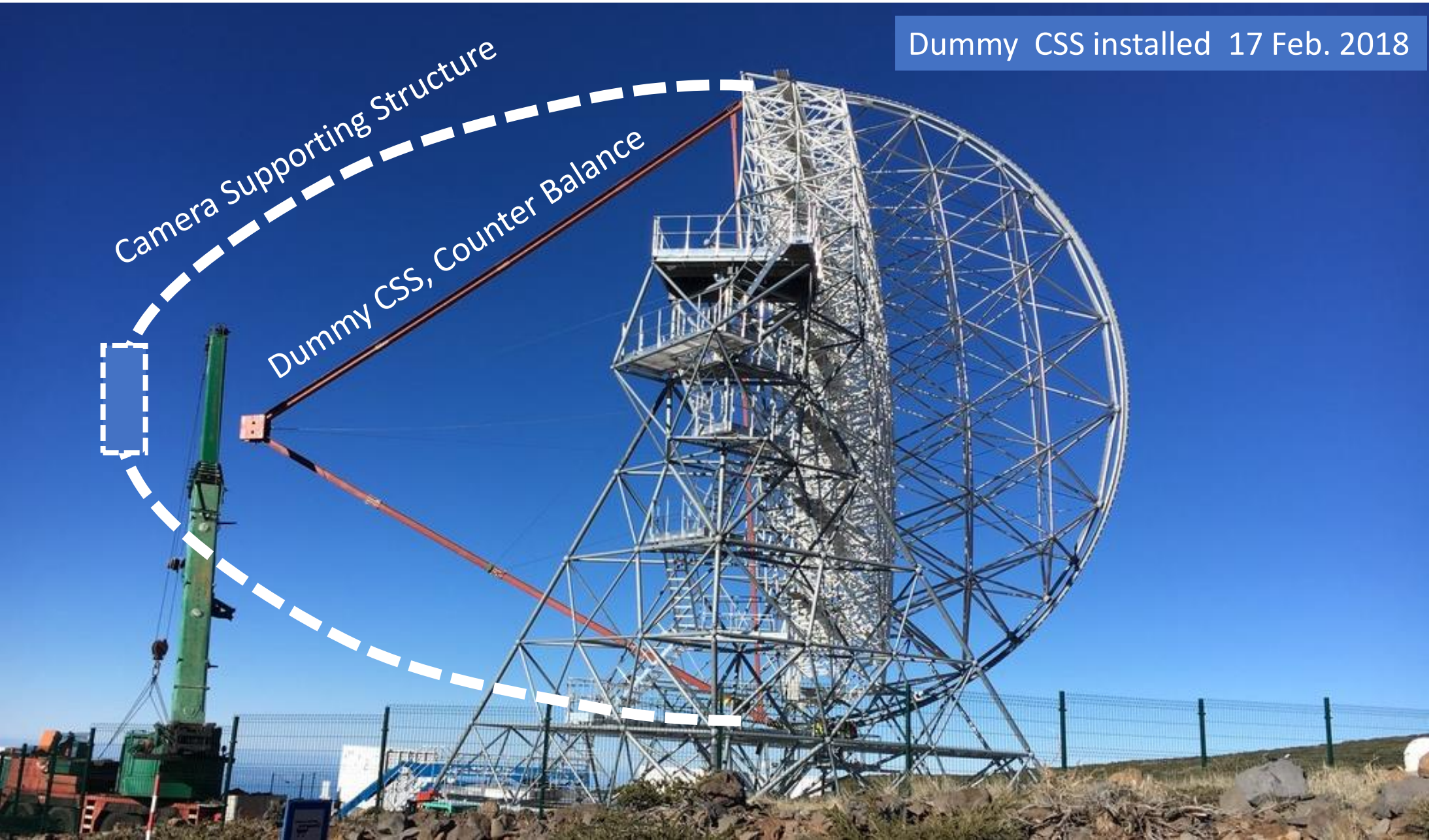
cherenkov telescope array

LST1 construction

LST1 construction

Very good test for the ice load

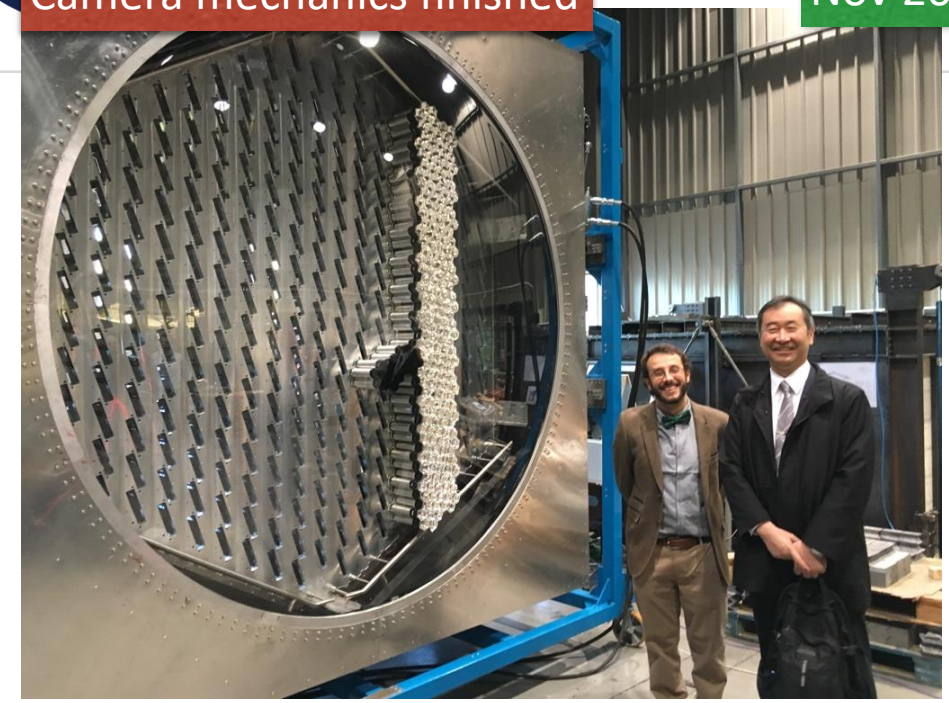
CTA LST1 Construction
Dummy CSS for balancing



Status of LST1 construction

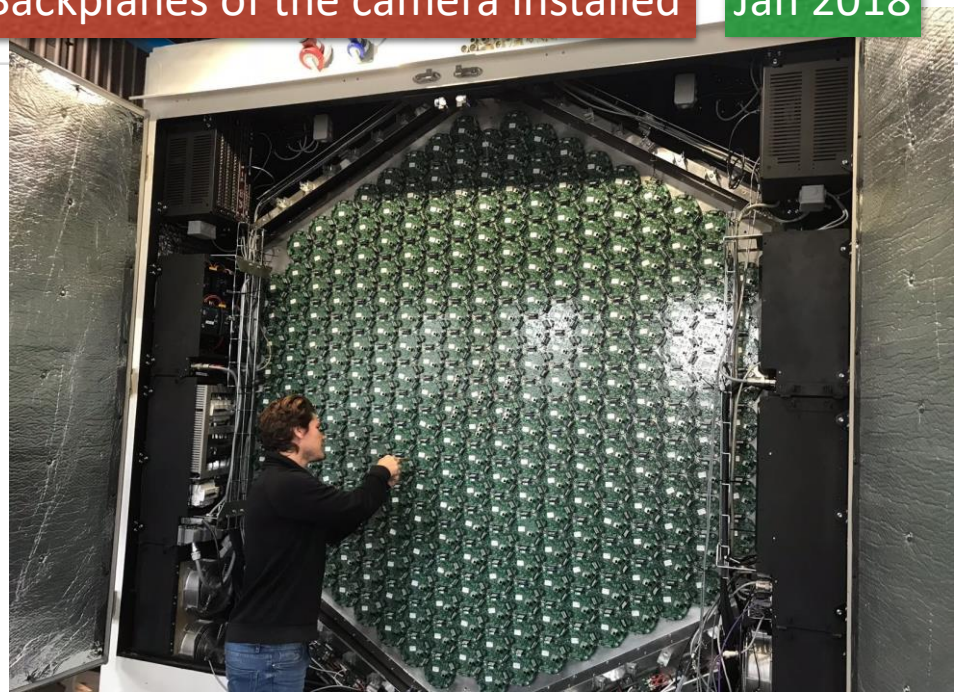
Camera mechanics finished

Nov 2017



Backplanes of the camera installed

Jan 2018



IT computer center installed, 2k Cores, 3PB

Dec 2017

Power and Network ready

Mar 2018

Diesel

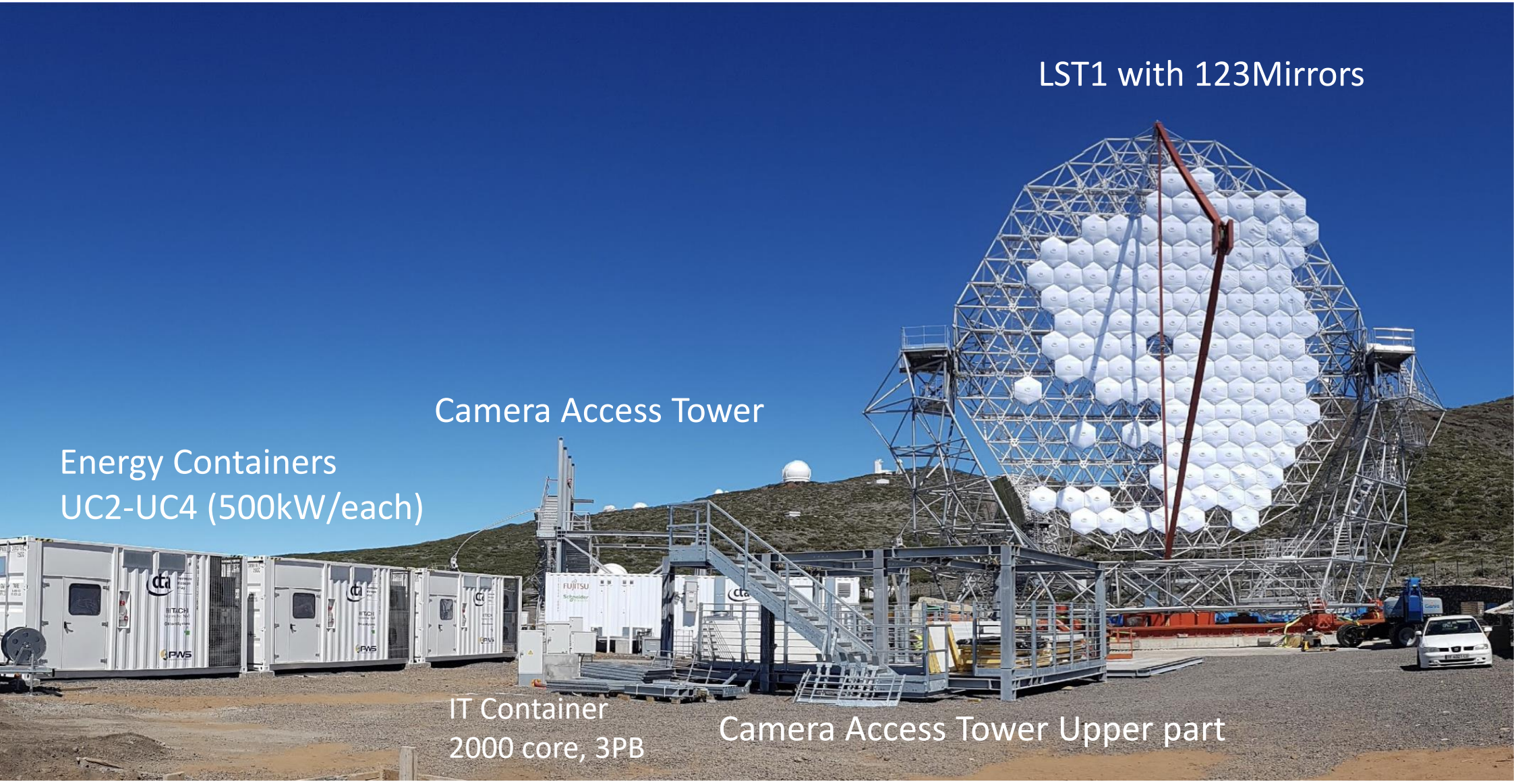
ATS, Transformer

500kW Flywheel Power Units

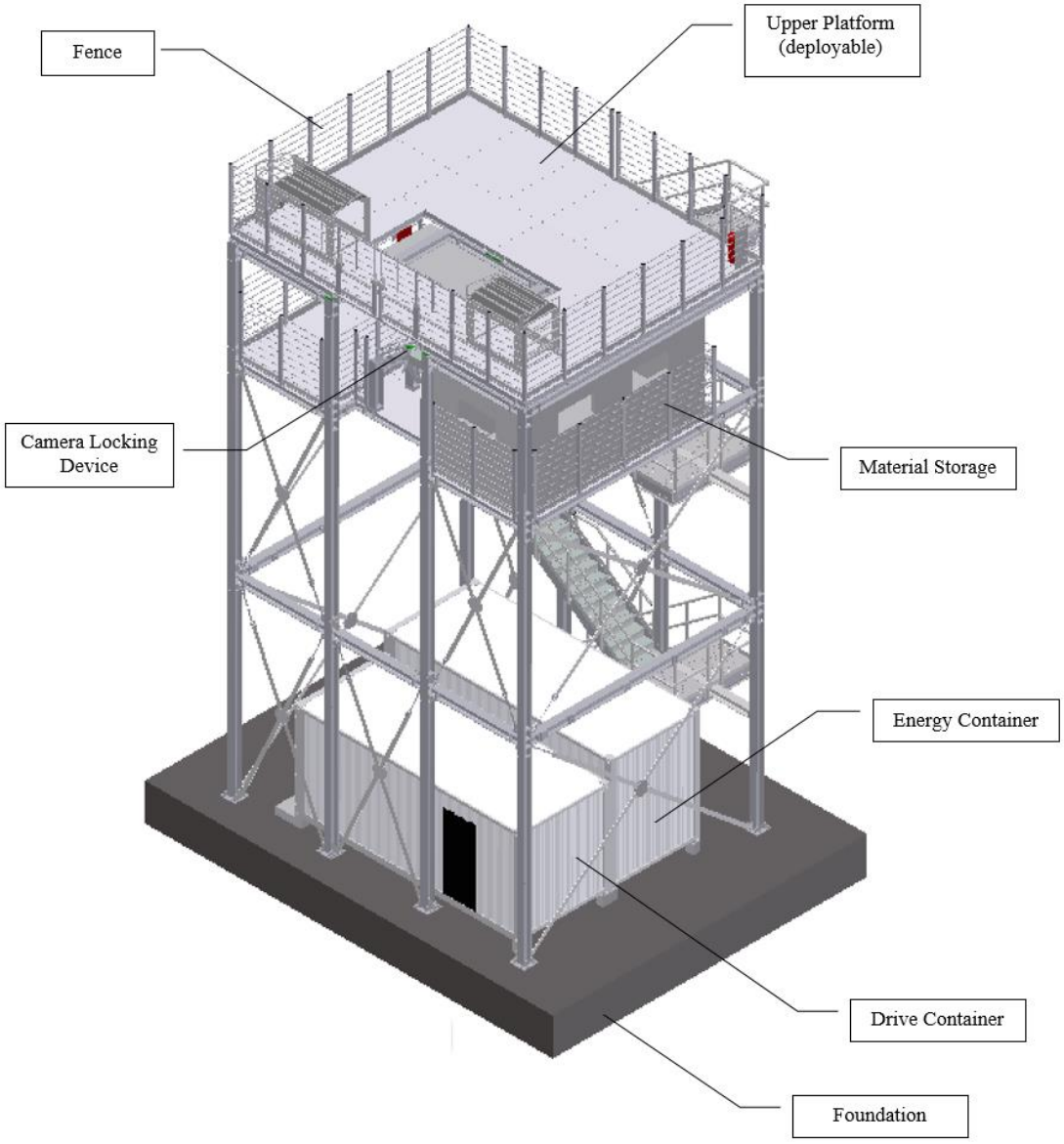
cherenkov telescope array

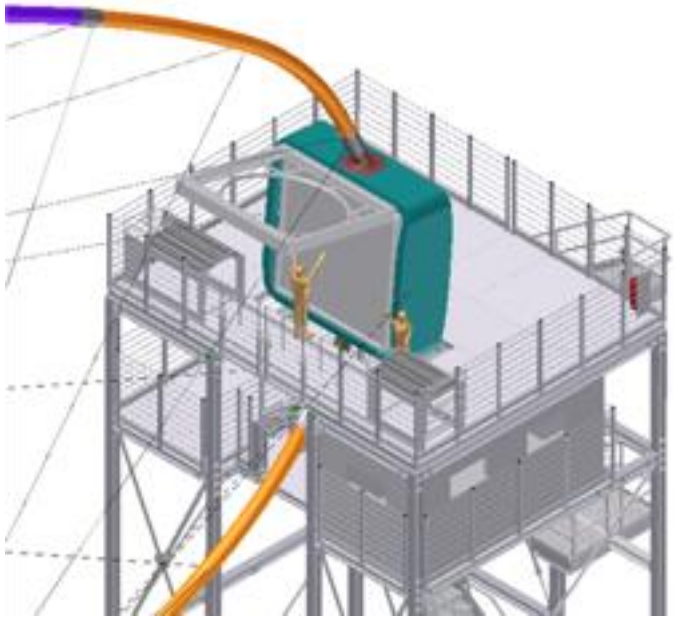
The LST-1 Site

on 11. May 2018



Camera Access Tower

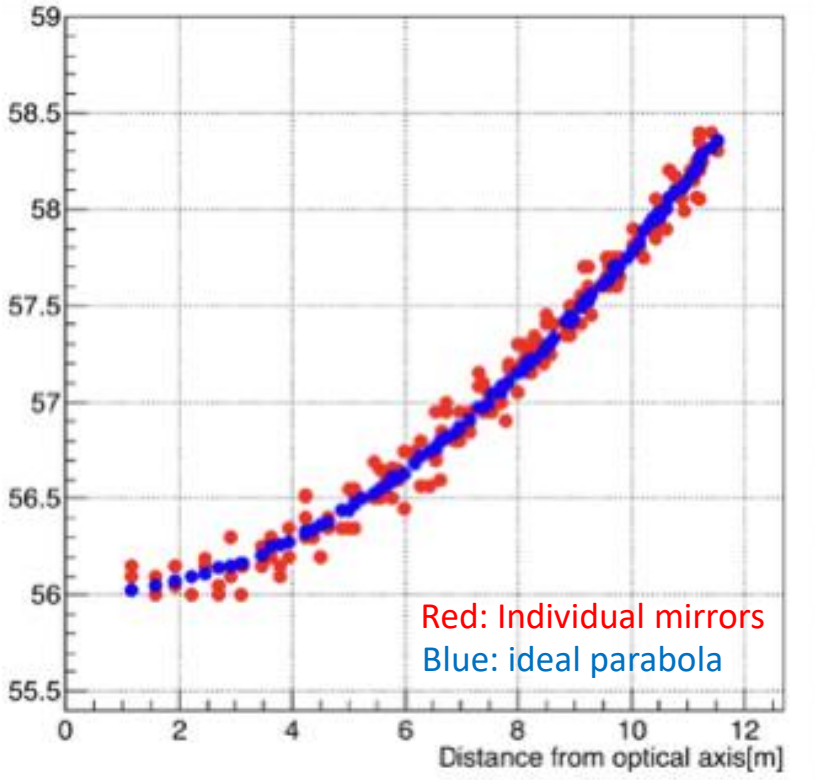




198 Mirrors for LST1

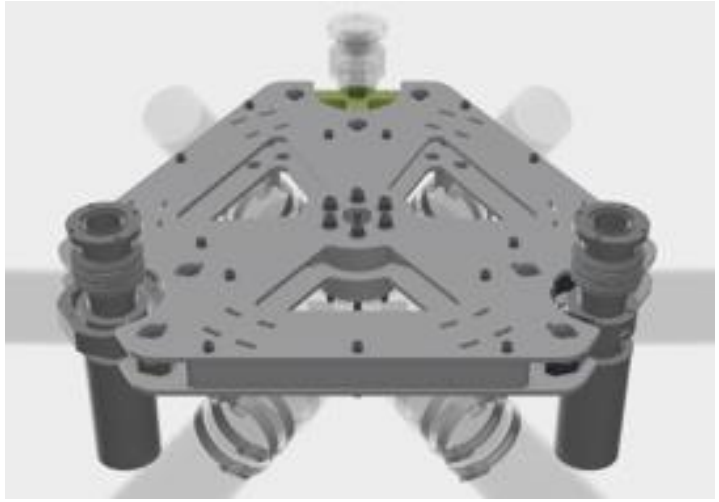
198 Mirrors are brought to the LST1 site

The Radius of Curvature of mirrors as a function of distance of the center



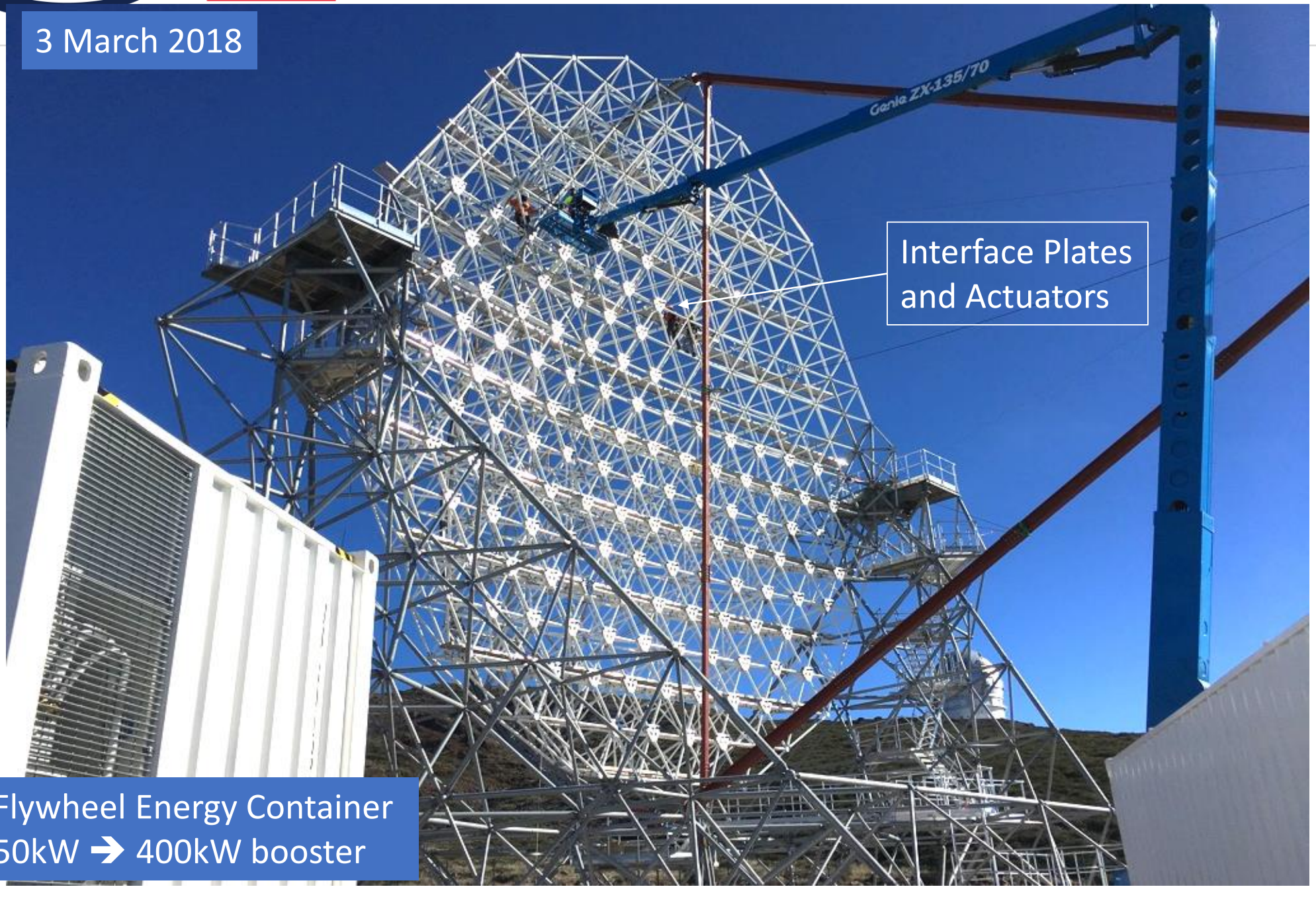
Preparation of Interface Plates and Actuators in MIRCA

Assembled Interface plates and Actuators



LST1 construction

Installing Mirror Interface Plates and actuators



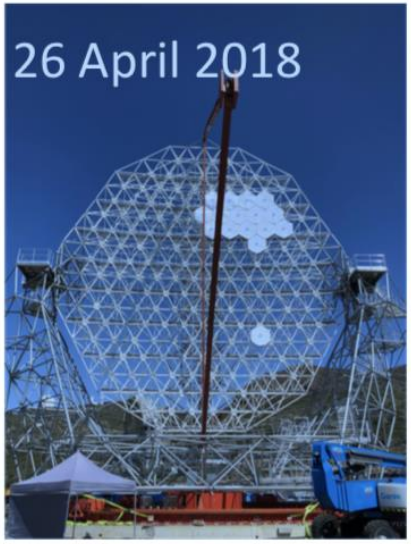
Mirror Installation

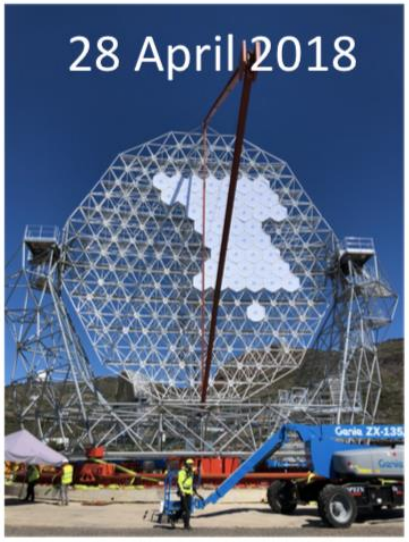
Special offer for you:
We can put your name with 5kEuro

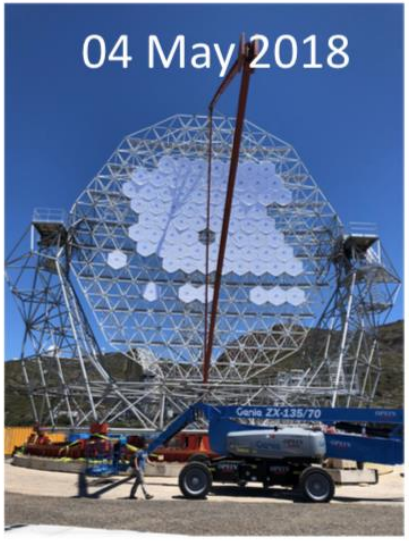
There is 'Martin' mirror as well ;)

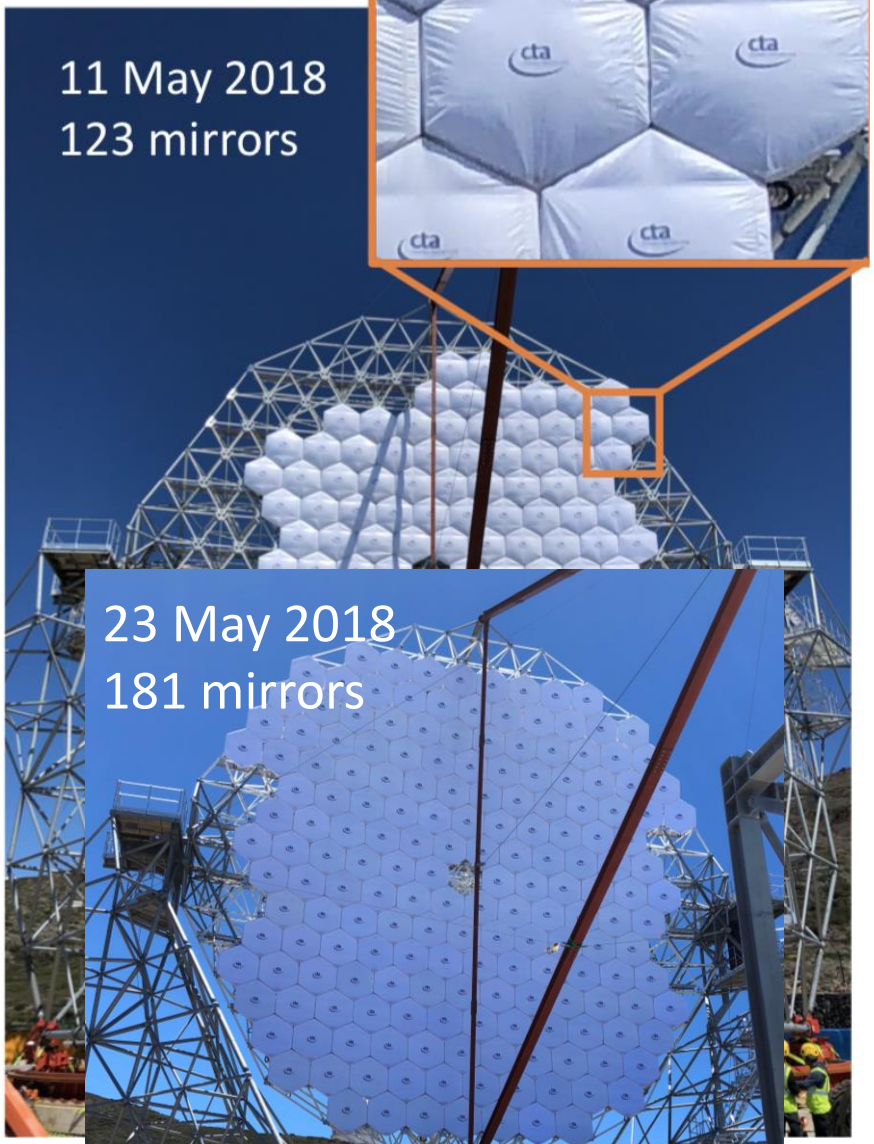
cherenkov telescope array

Mirror installation is on-going









Camera Supporting Structure by LAPP/IN2P3

Camera support structure :

- production : finished
- Trial mounting : done in February
- Shipment : in progress
- Expected arrival date on site : 21 May

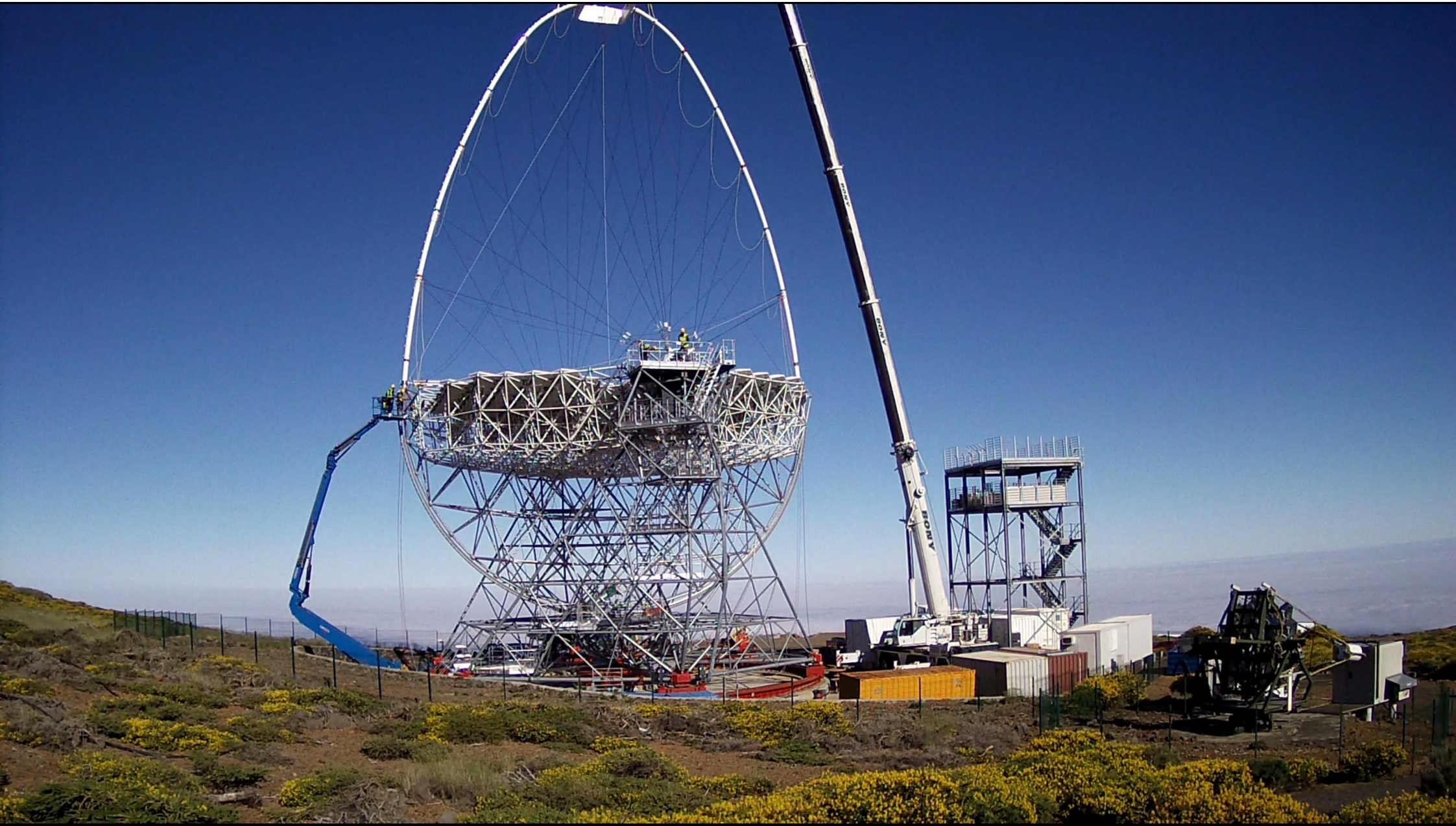
cherenkov telescope array

Camera Supporting Structure on the trailer

cherenkov telescope array

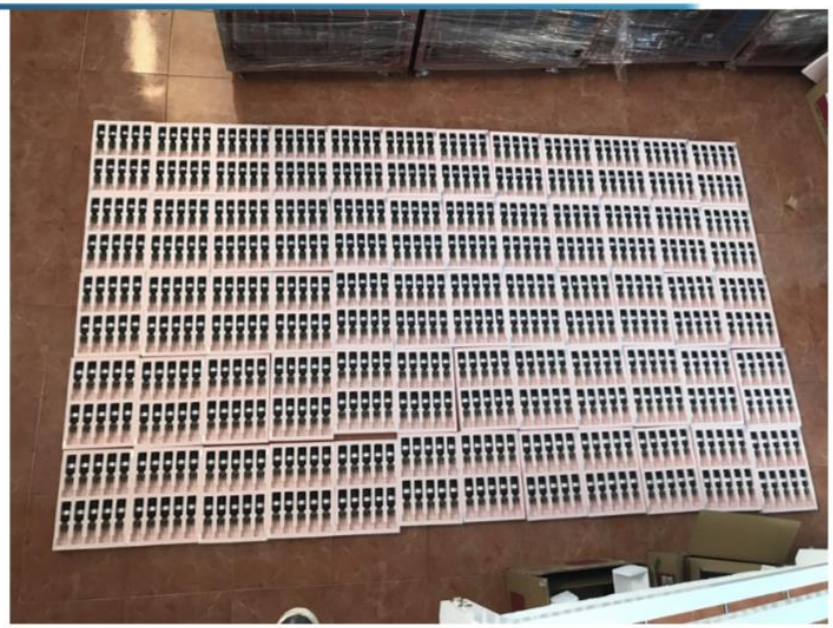
LST1 Status 2018.06.22

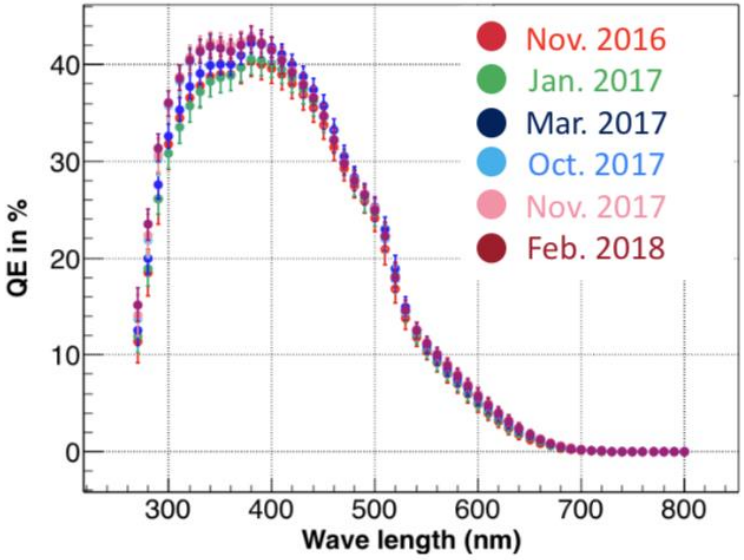
Camera Support Structure Arch

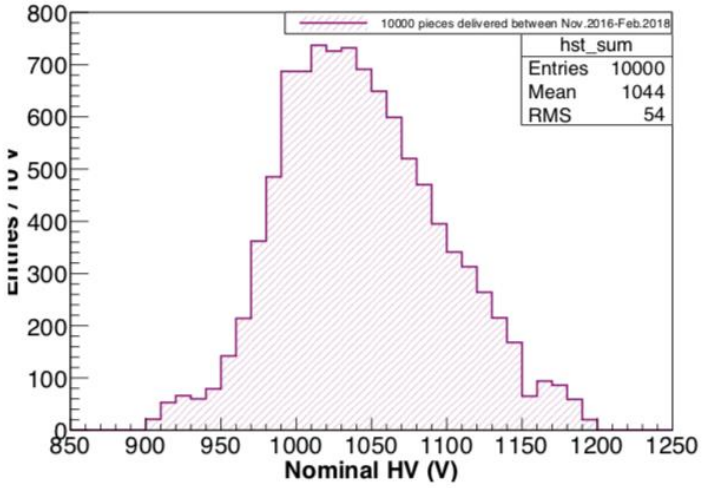


Modules for LST2-4+: PMTs

- 7-dynote 10000 PMTs delivered.
  - LST1 PMTs are with 8 dynodes.
- **QE peaked at 370 nm and >40%**
  - Slightly better than LST1
- HV at Gain 40k ranges 900 – 1200 V.
  - This diversity will be compensated by the attenuation in preamp.







Modules for LST2-4: Dragon boards

- 1100 Dragon boards delivered
- Difference w.r.t. 1st LSTs are
  - Sine wave injection circuit
  - Temperature and Humidity sensor
  - Voltage monitor
  - Other minor things
- 750 boards have a bad regulator. They are being replaced now.
- ~0.1% of DRS4 chips have also problems. They are being replaced.
- Big capacitor will be protected with an additional plastic piece

Camera Overview

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Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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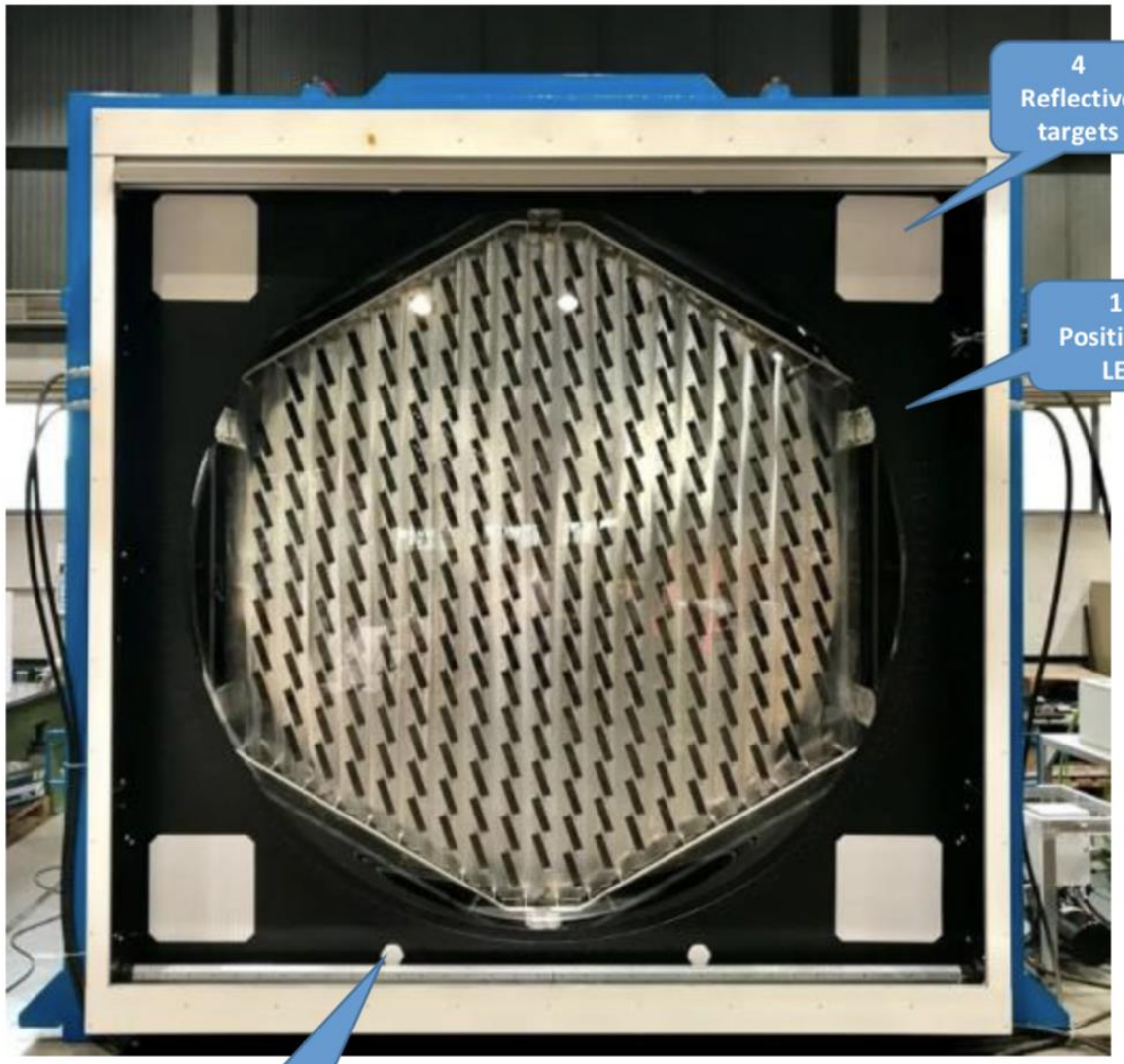
Front Part



Camera dimensions:
2895x2895x1500 mm
Weight:
2077 kg

Camera Overview

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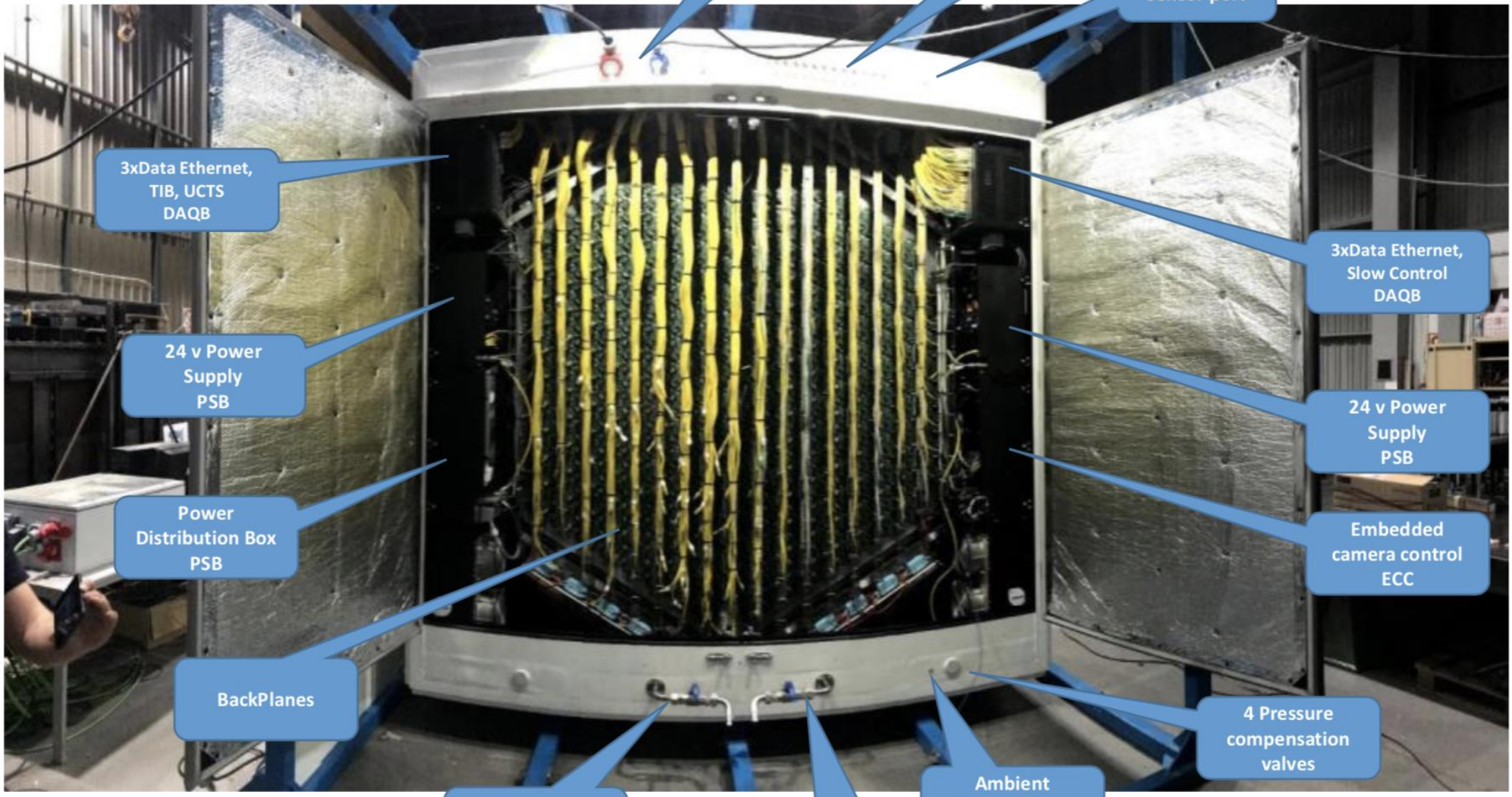
Back Part



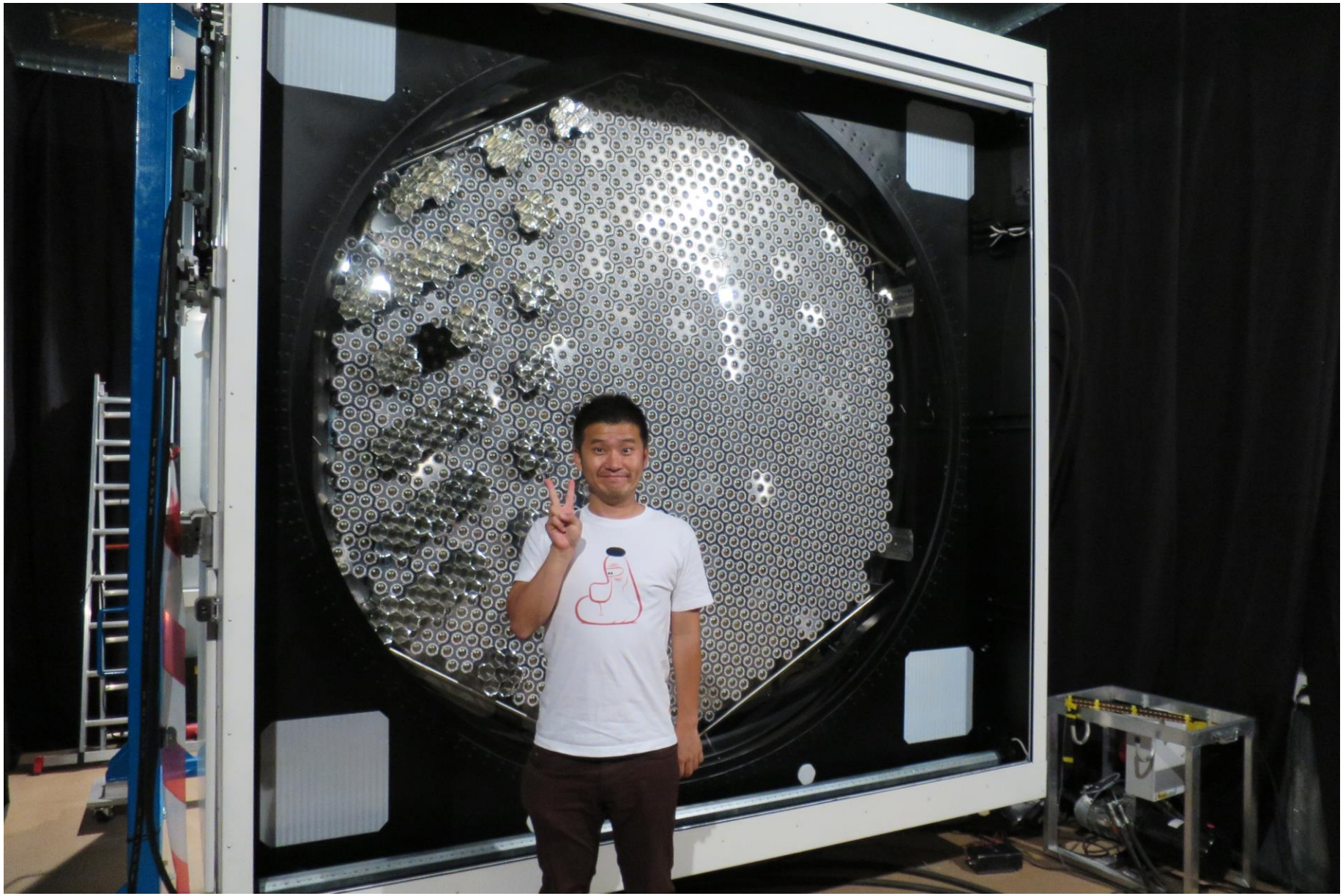
Camera Transport “CIEMAT”

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

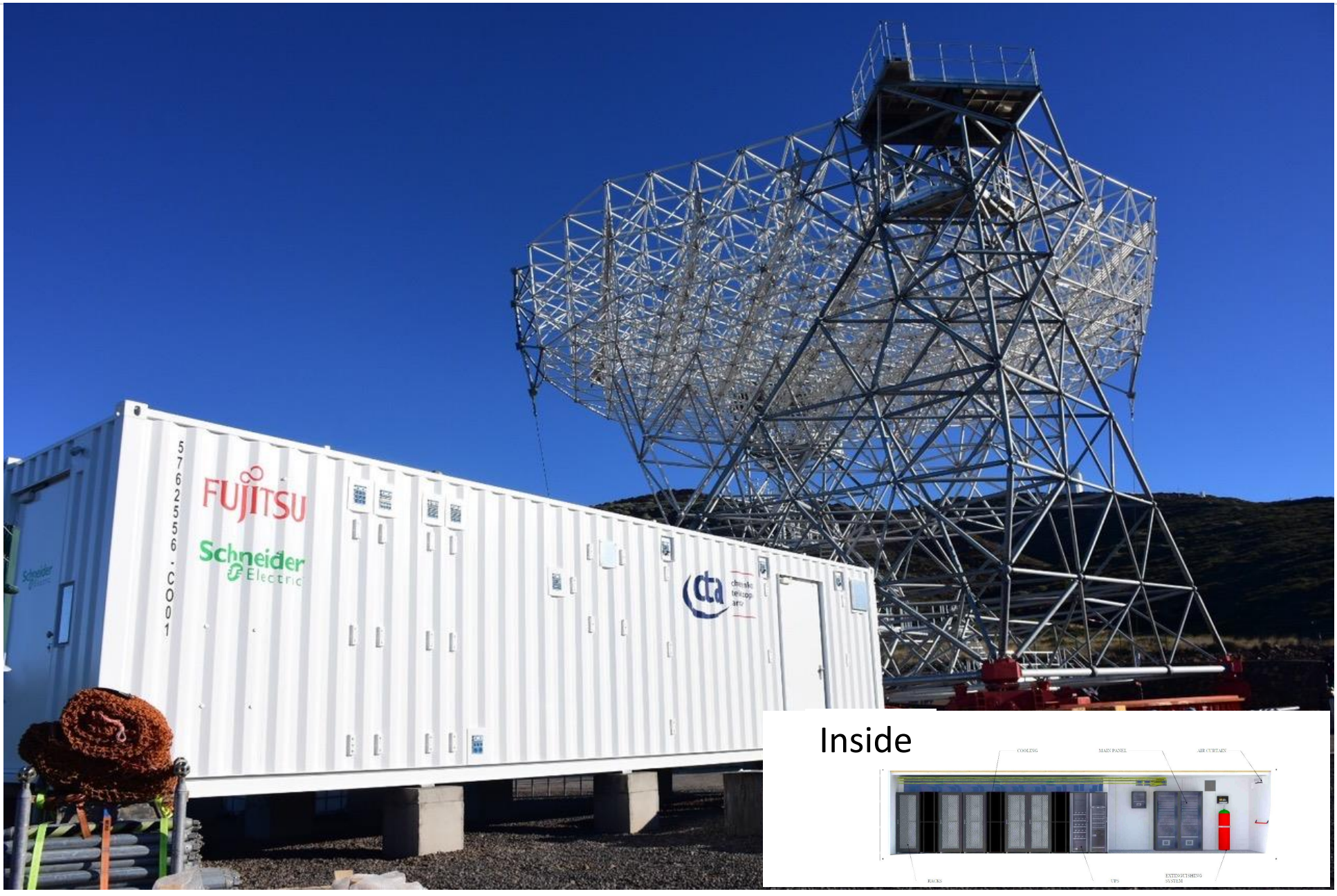
GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

26th April

Integration and final test on-going at IFAE



CTA North IT System
2000 cores, 3PBytes

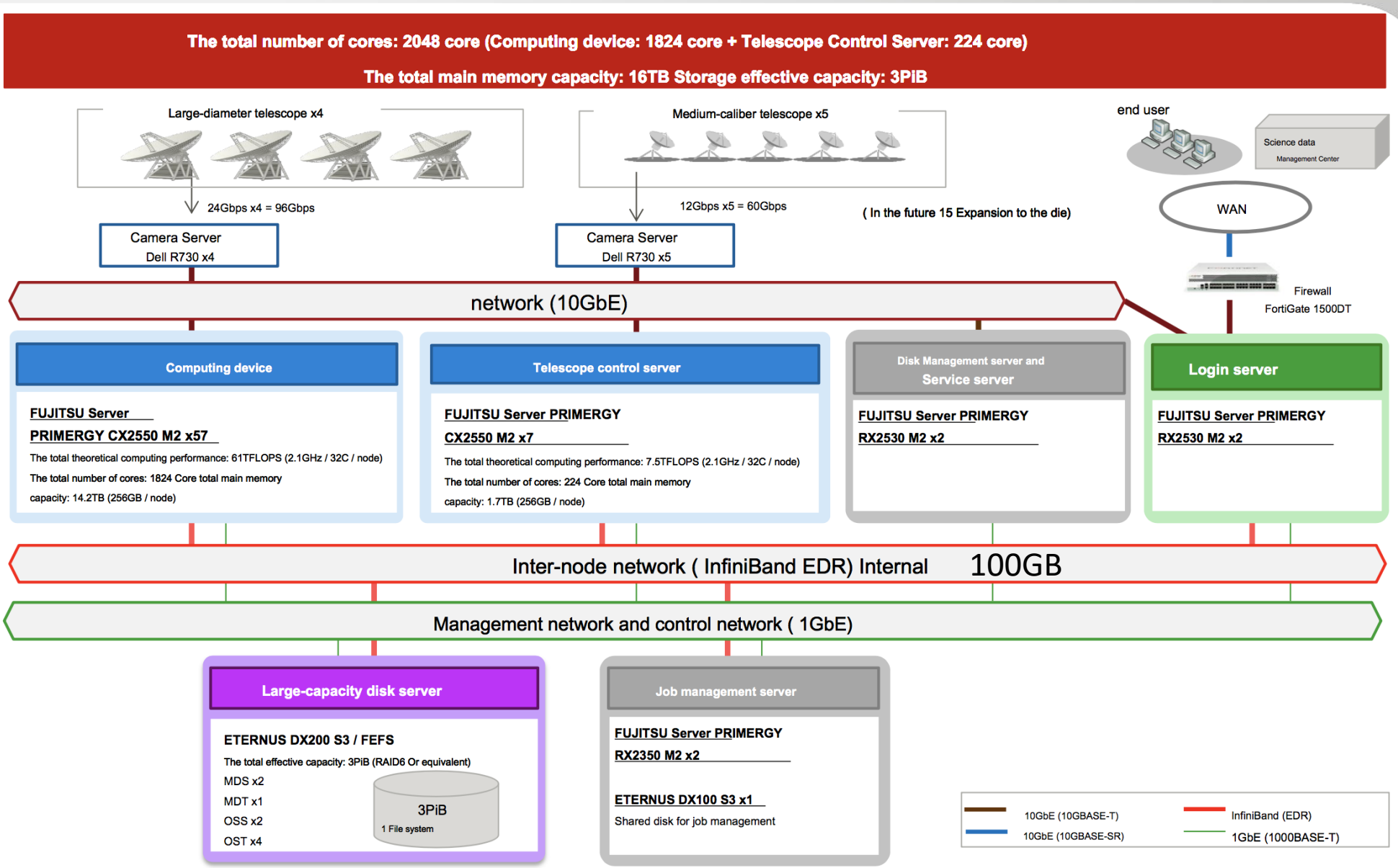


CTA North Computing System
2000 cores, 3PB storage

ICRR

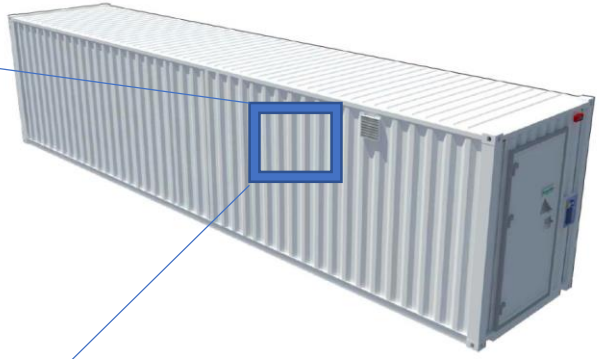
1.1 The entire system configuration diagram

FUJITSU



IT Container

前面 Frontal side

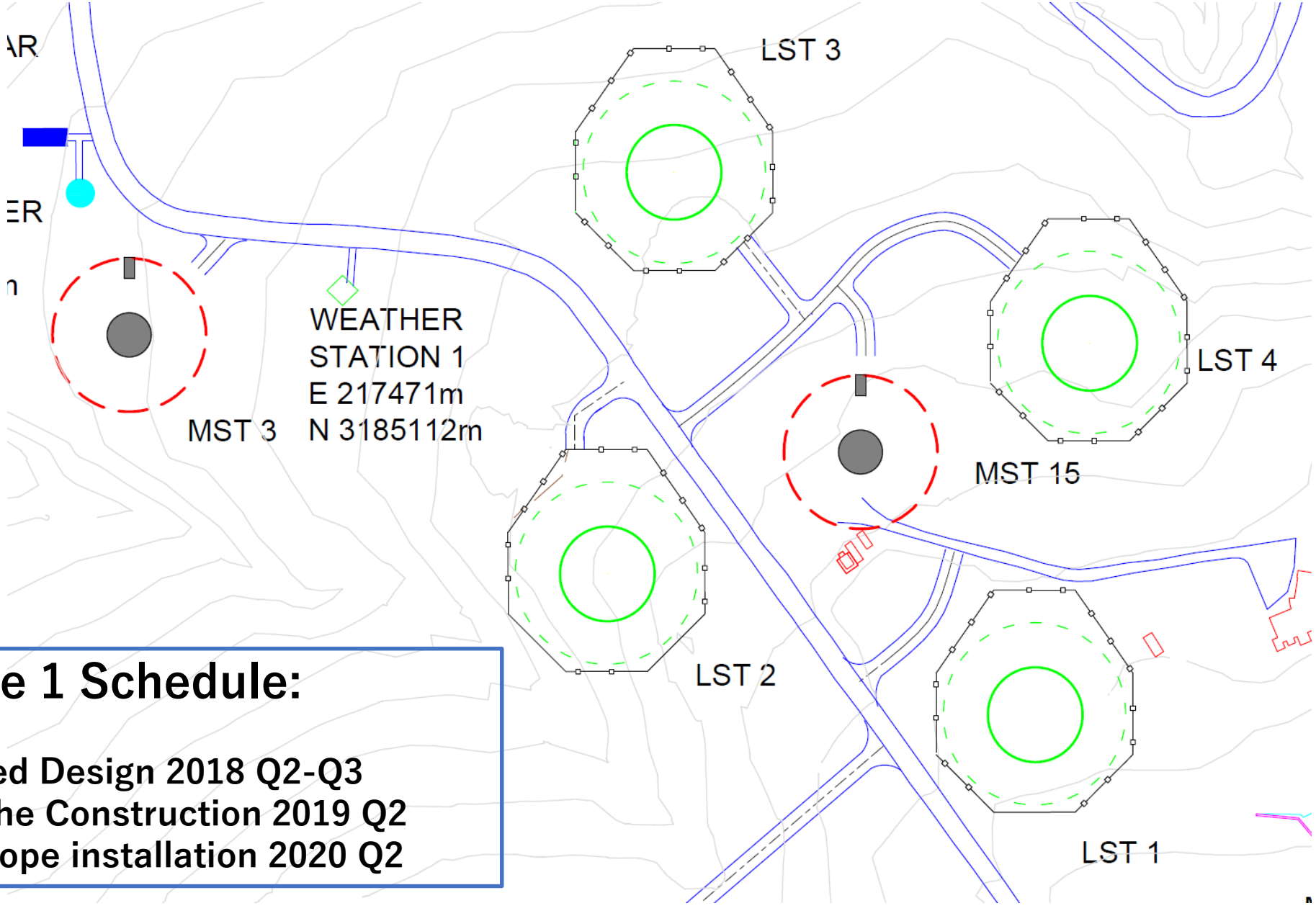


背面 Rear Side

前面（内部） Inside

28 June 2018

CTA-N INFRA in Phase 1



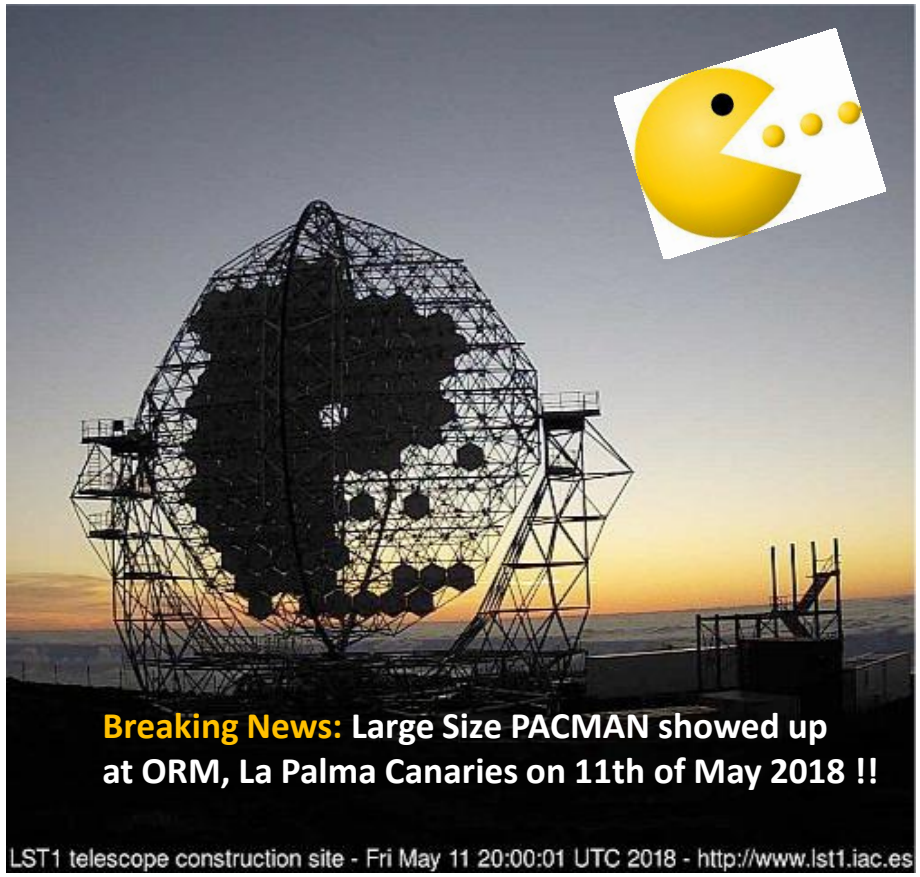
Phase 1 Schedule:

Detailed Design 2018 Q2-Q3
Start the Construction 2019 Q2
Telescope installation 2020 Q2

Summary

- The construction of LST1 is going very smooth
- So far we did not see any major problem in the LST1 construction and also LST components
- We expect the first light in Sep 2018
- LST2-4 will come in 2018-2021

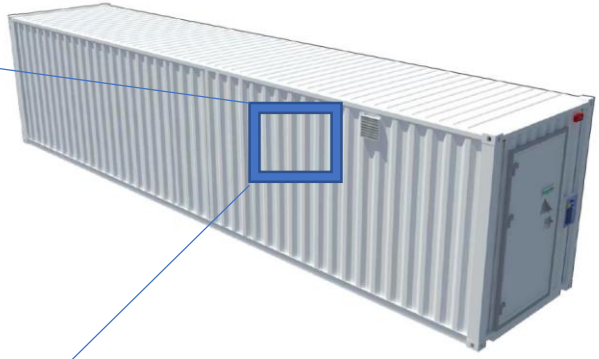
- October 10, 2018, Inauguration of LST1 is scheduled




cta
cherenkov
telescope
array

IT Container

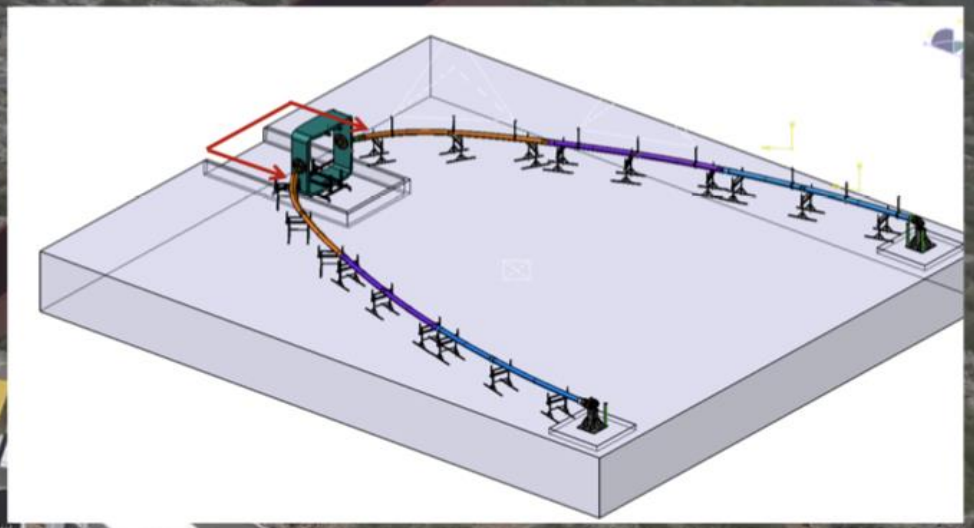
前面 Frontal side



背面 Rear Side

前面（内部） Inside

Mounting of Camera support structure (CSS) Mid June 2018



- CSS
- Dummy

- 1) Finishing the accesstower, freeing space
- 2) unmounting of Counter weight
- 3) Installation of CSS