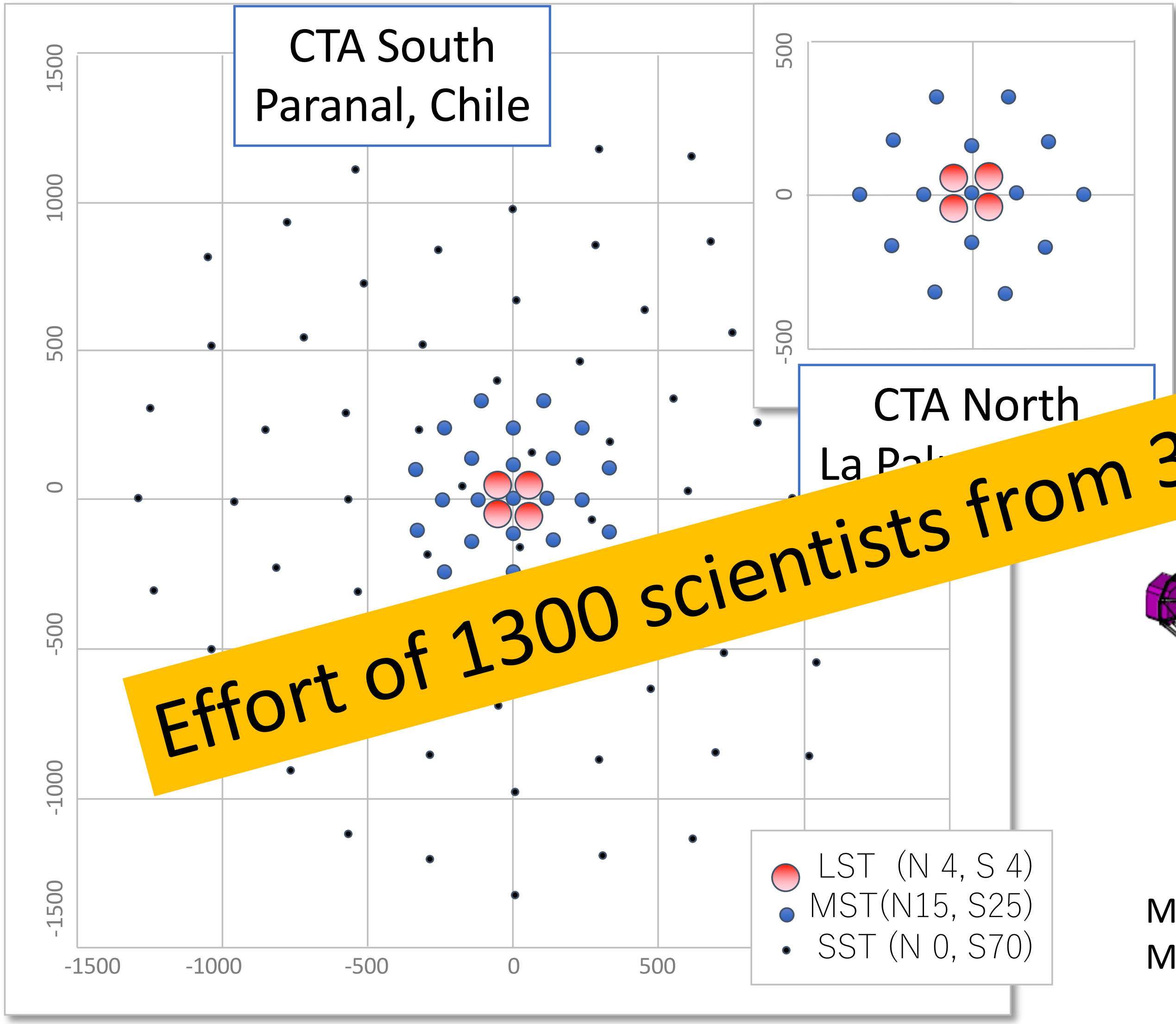
Status of the CTA-LST project

Masahiro Teshima

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

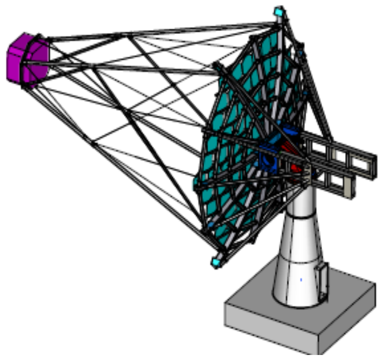
CTA Telescopes Array Configurations

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

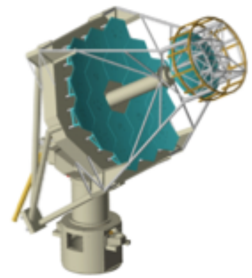


Effort of 1300 scientists from 33 countries

LST 23m (8MEuro) Low-Energy

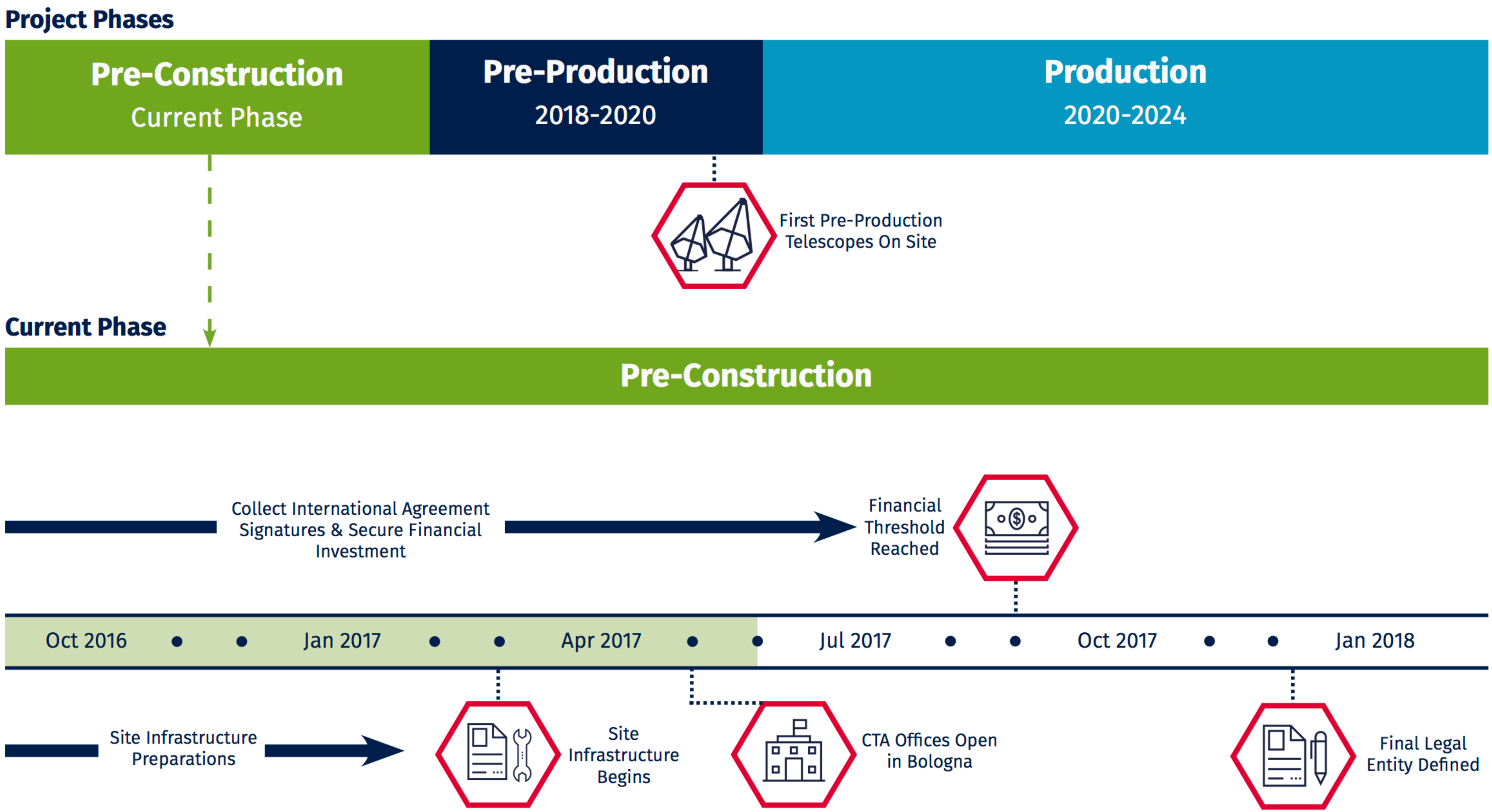


MST 12m (2.5MEuro) Mid-Energy



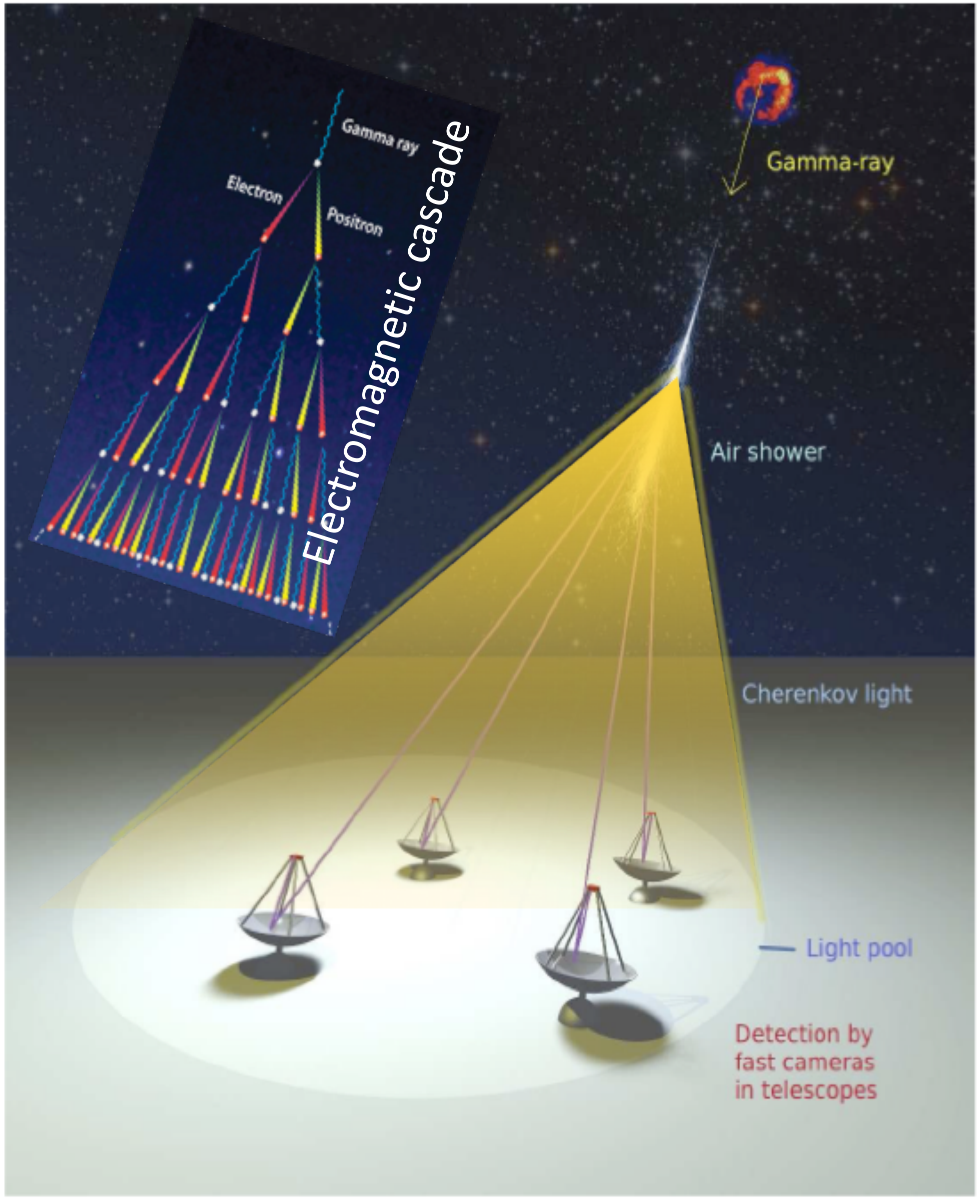
SST 4.3m(0.5MEuro) High-Energy

Timeline of CTA Project

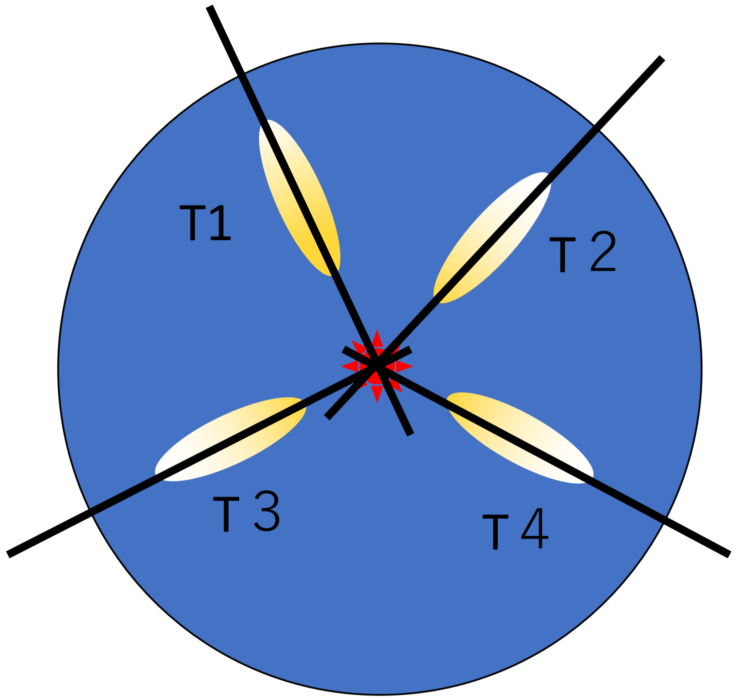


cta cherenkov telescope array

Imaging Cherenkov Telescopes



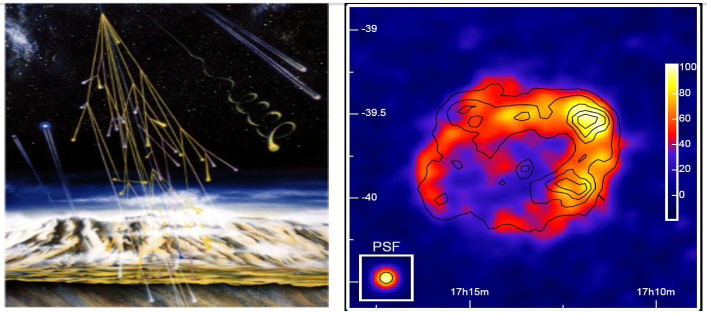
# of Photons: 50photons/m^2 at 1TeV



- Energy range 50GeV ~ 10TeV
- CR Rejection ~99.5%
- Angular Res. ~0.06 degrees
- Energy Res. ~15%
- Effective Area ~$10^5 m^2$
- Sensitivity ~0.6% Crab Flux (10^{-13} erg/cm^2s)

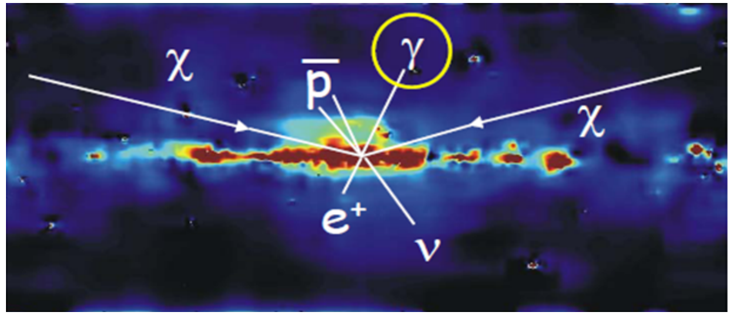
Science with CTA is very wide
Energy Frontier in Astrophysics

cta cherenkov telescope array



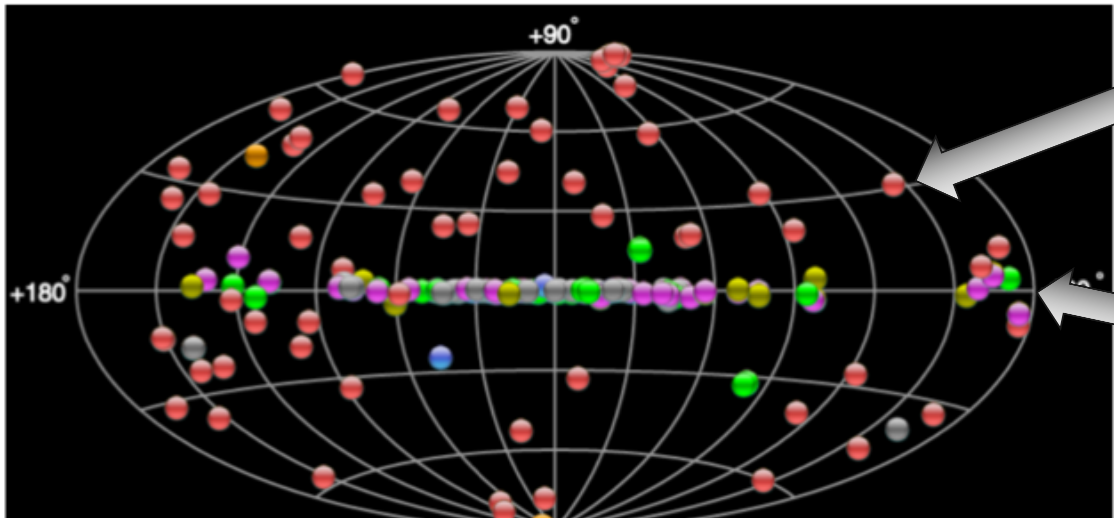
Cosmic Ray Origin

Super Massive Black Holes



Dark Matter Search (Discovery)

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



~ 200 high energy sources are discovered.
CTA will observe more than 1000 sources.

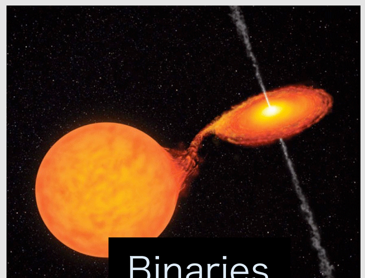
Extragalactic Sources

Active Galactic Nuclei

Gamma Ray Bursts

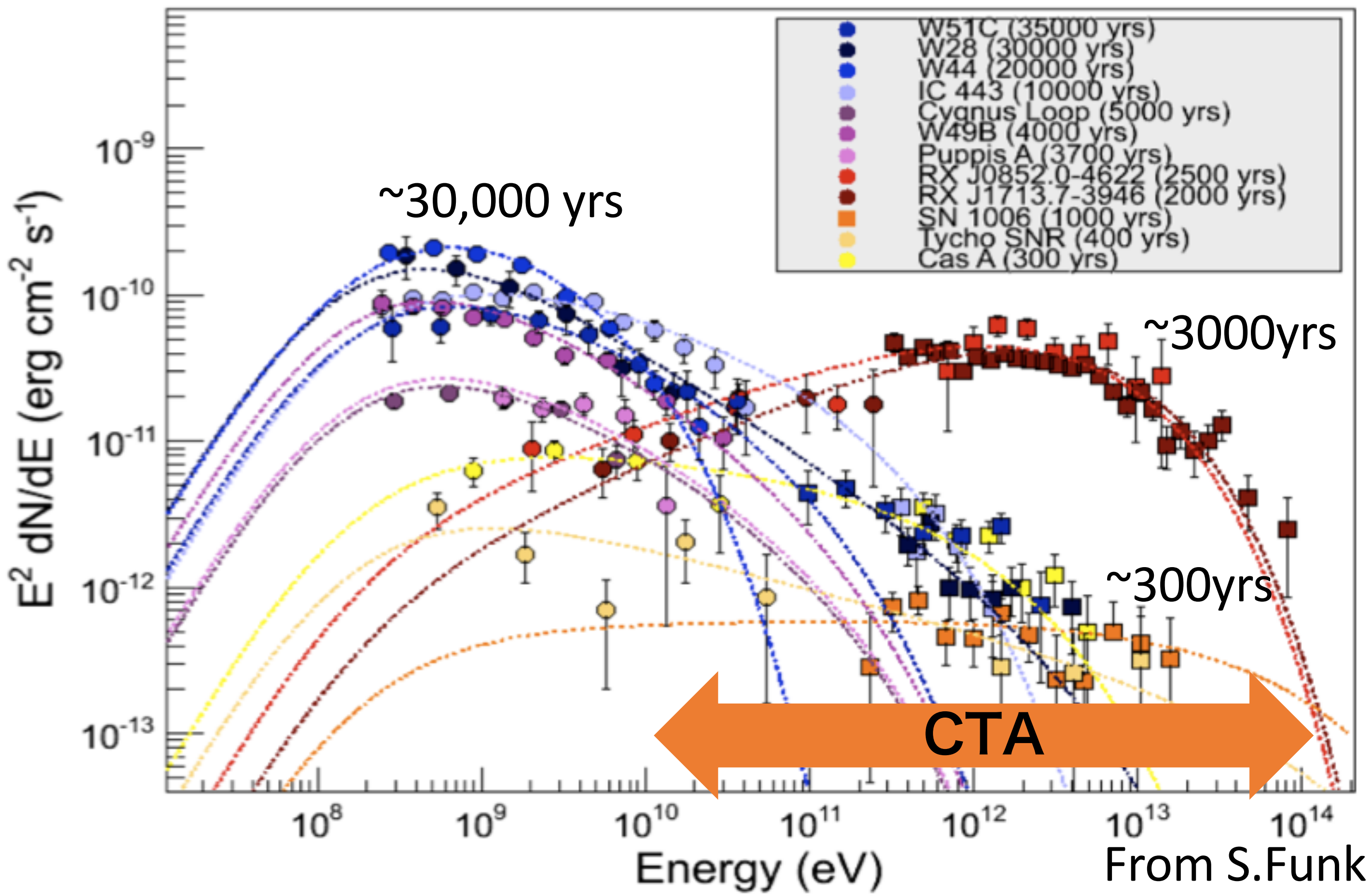
Galactic Sources

Super Nova Remnants

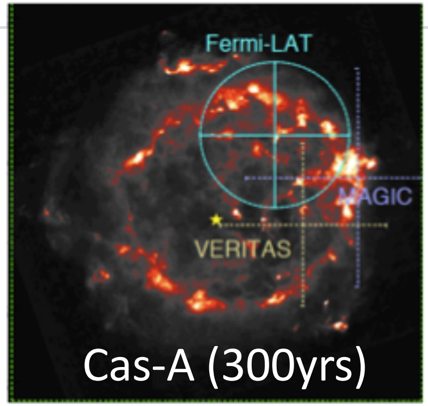


Binaries

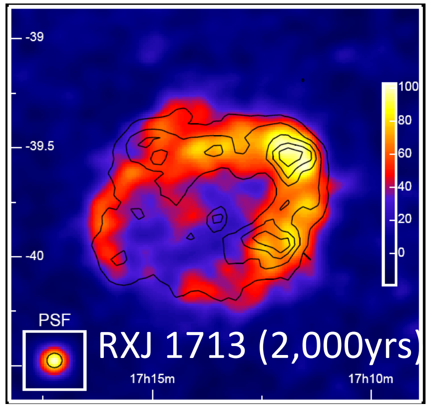
Shell Type Super Nova Remnants are identified as cosmic ray sources



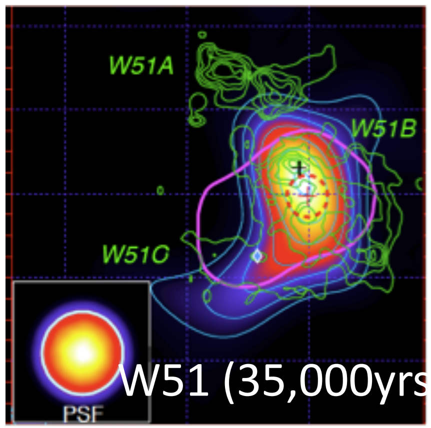
From S.Funk



Cas-A (300yrs)



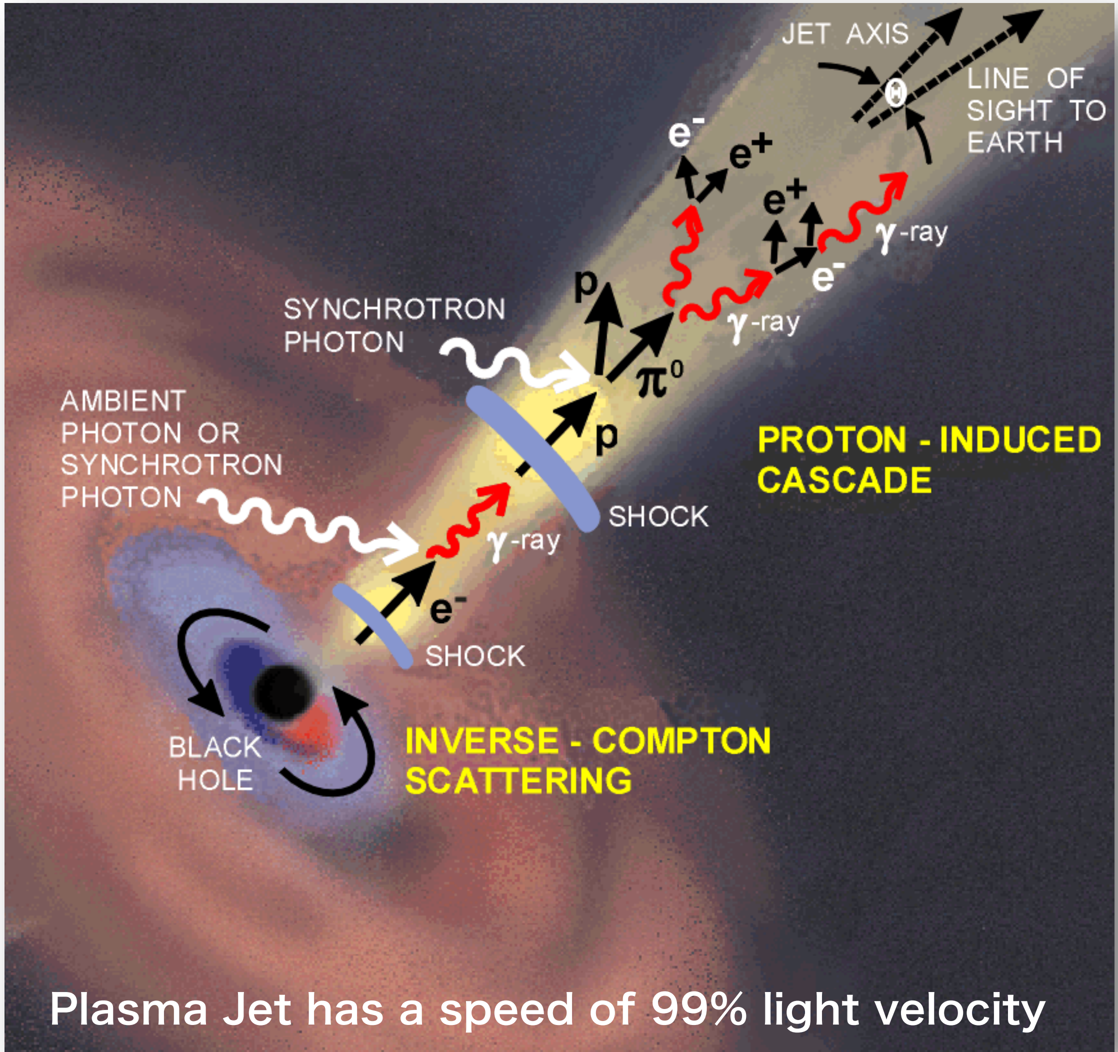
RXJ 1713 (2,000yrs)



W51 (35,000yrs

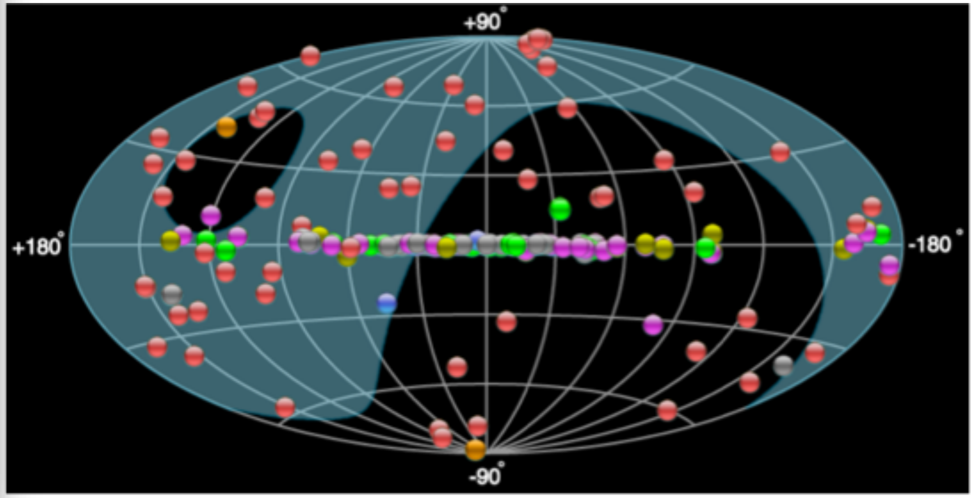
- We need 200-300 SNRs to explain the energetics of galactic cosmic rays
- What is the maximum attainable energy with SNRs

Super Massive Black Holes ~$10^8 M_\odot$
Candidates Sources for >10^{18}eV Cosmic Rays

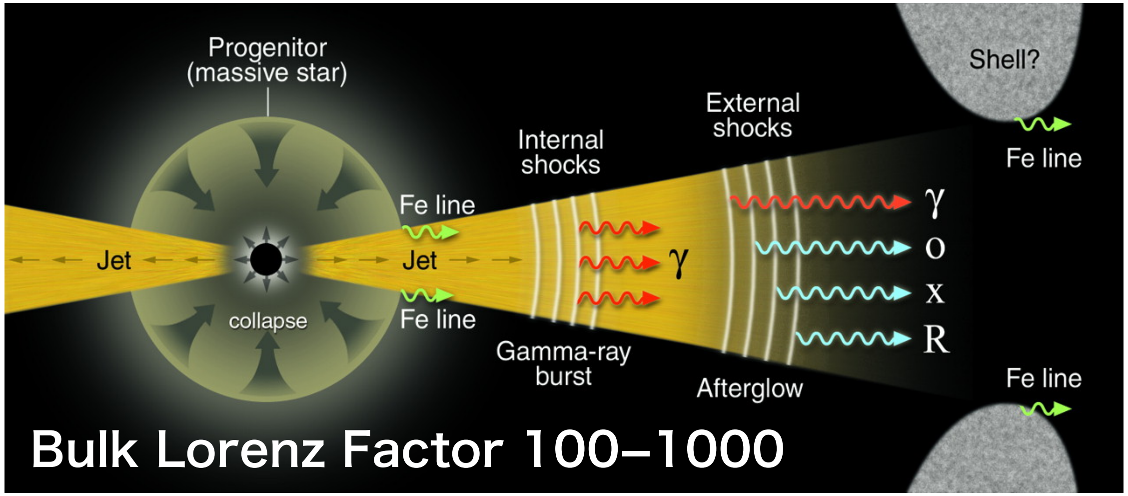


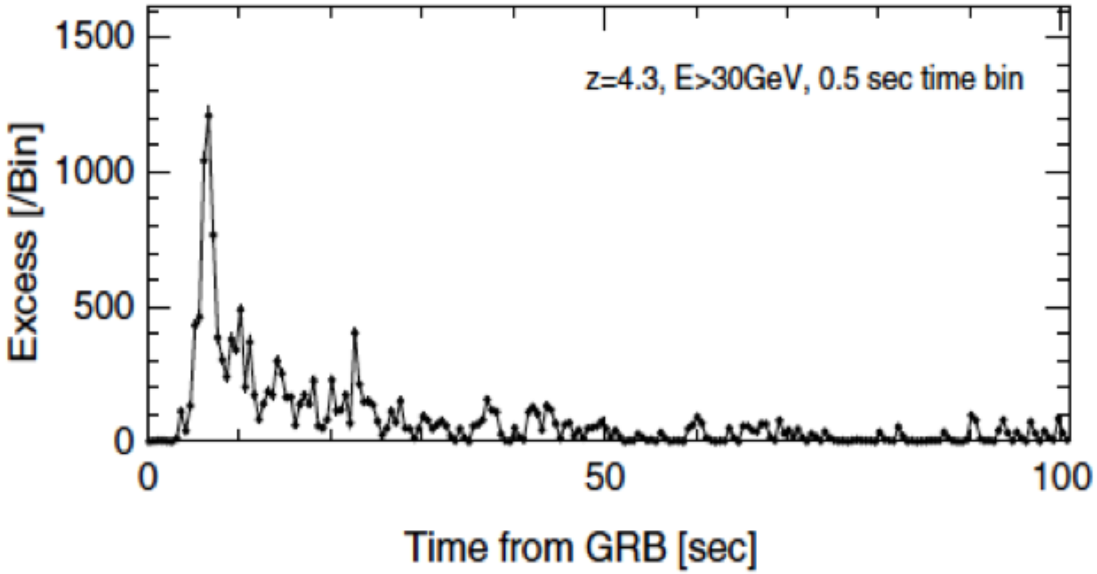
- What is the Maximum Energy?
- Can reach to 10^{20}eV?
- Energy source is accretion disk or rotation energy of Black Hole?
- Explore Black Hole sub Horizon

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

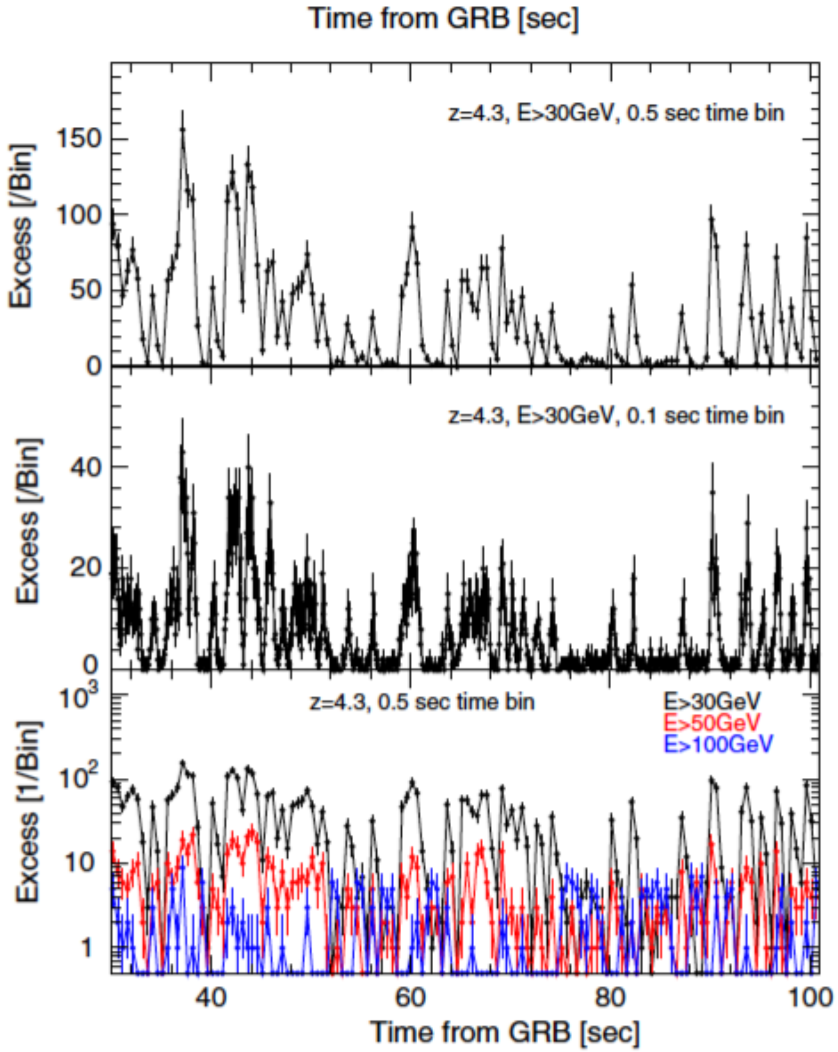


GRBs: good targets for CTA-LSTs
Study the newborn baby black holes

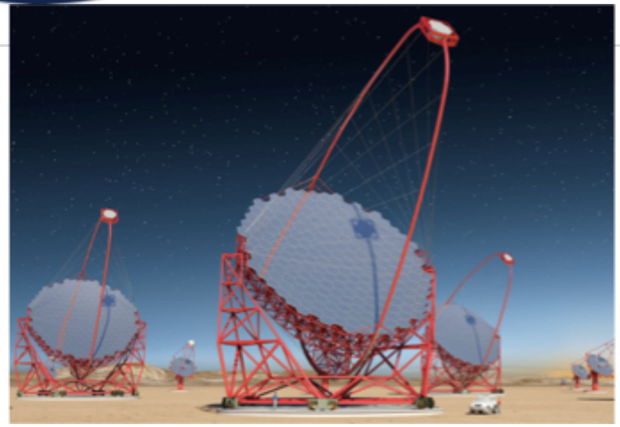


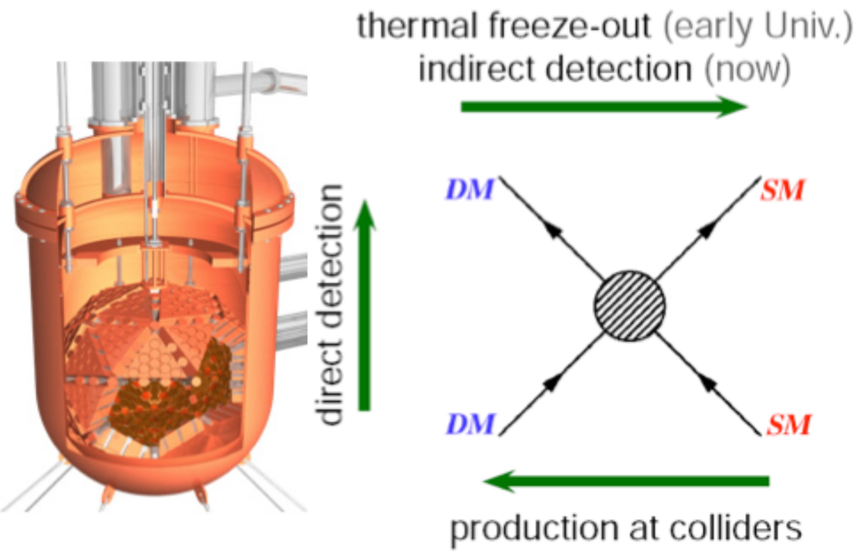


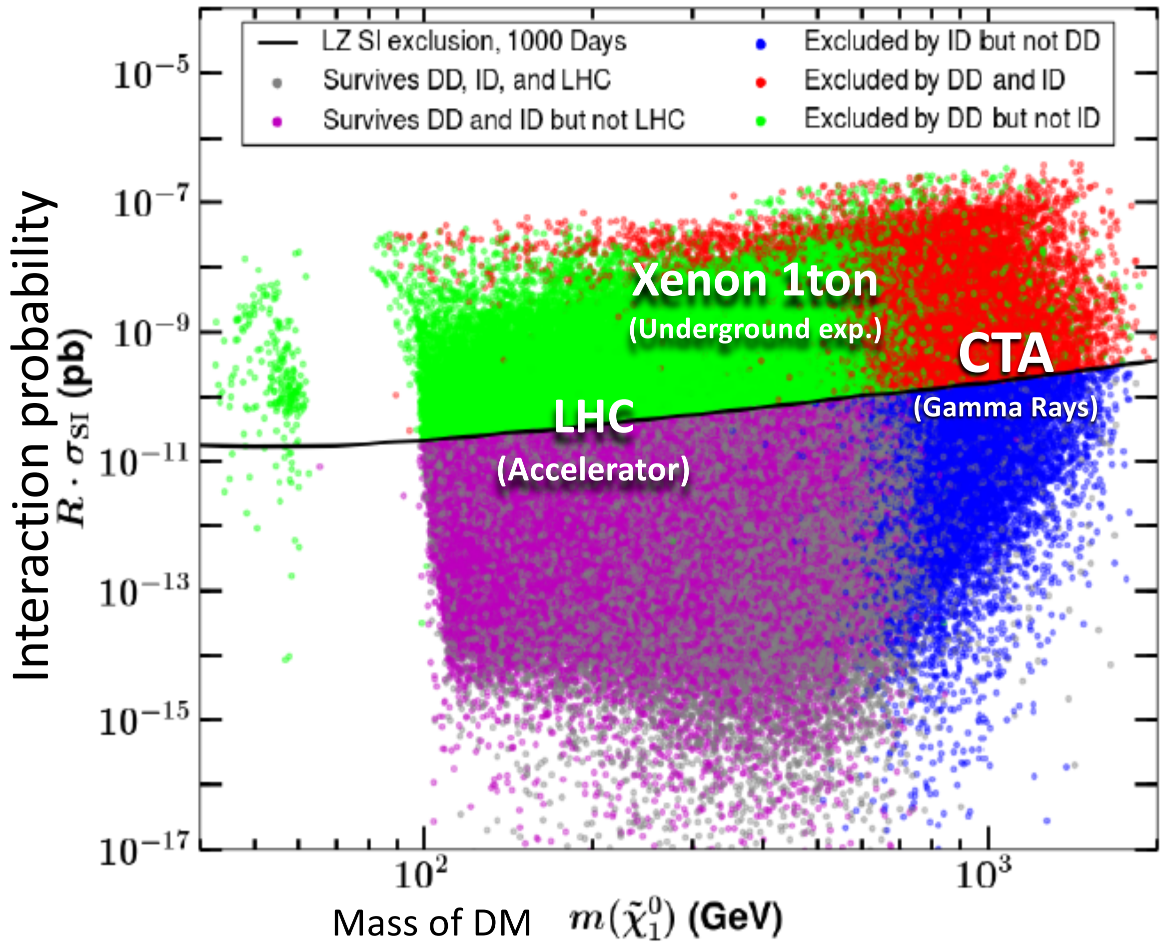
CTA Simulation
(Template GRB080916C)

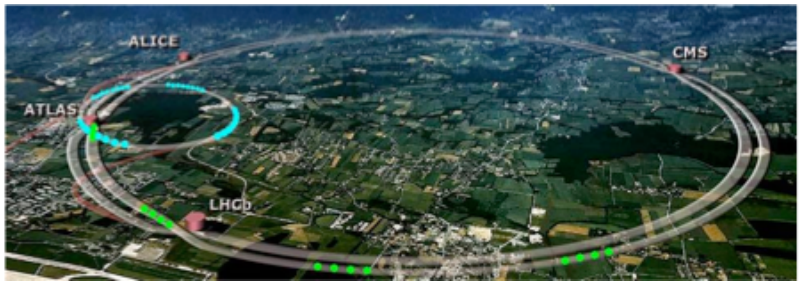


Toward the discovery of Dark Matter
Complementarity of different approaches









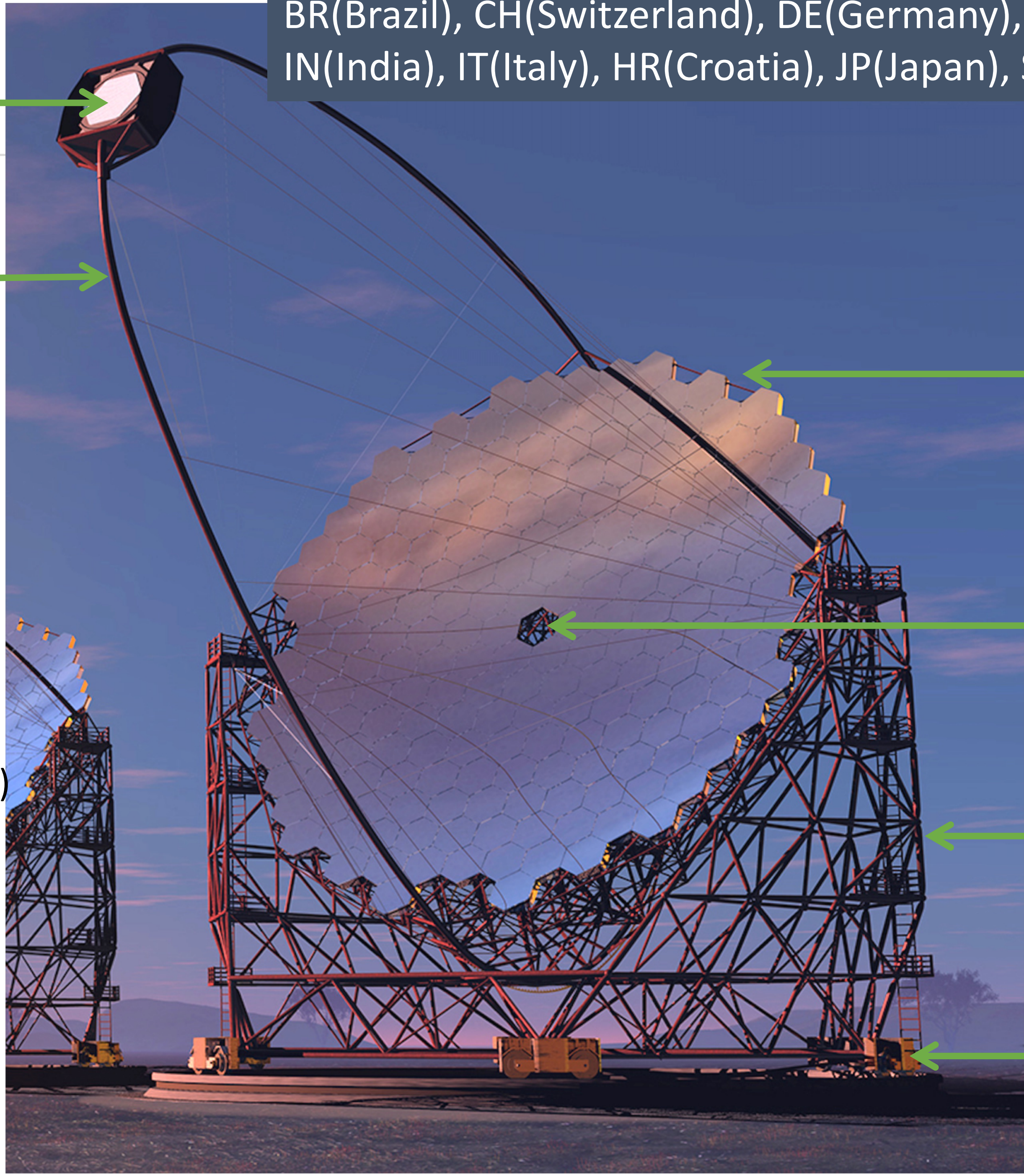
- Explore Dark Matter in the Galactic Center and Dwarf Sph. Galaxies
- CTA has the best sensitivity above 700GeV

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)
Access Tower (DE/ES)

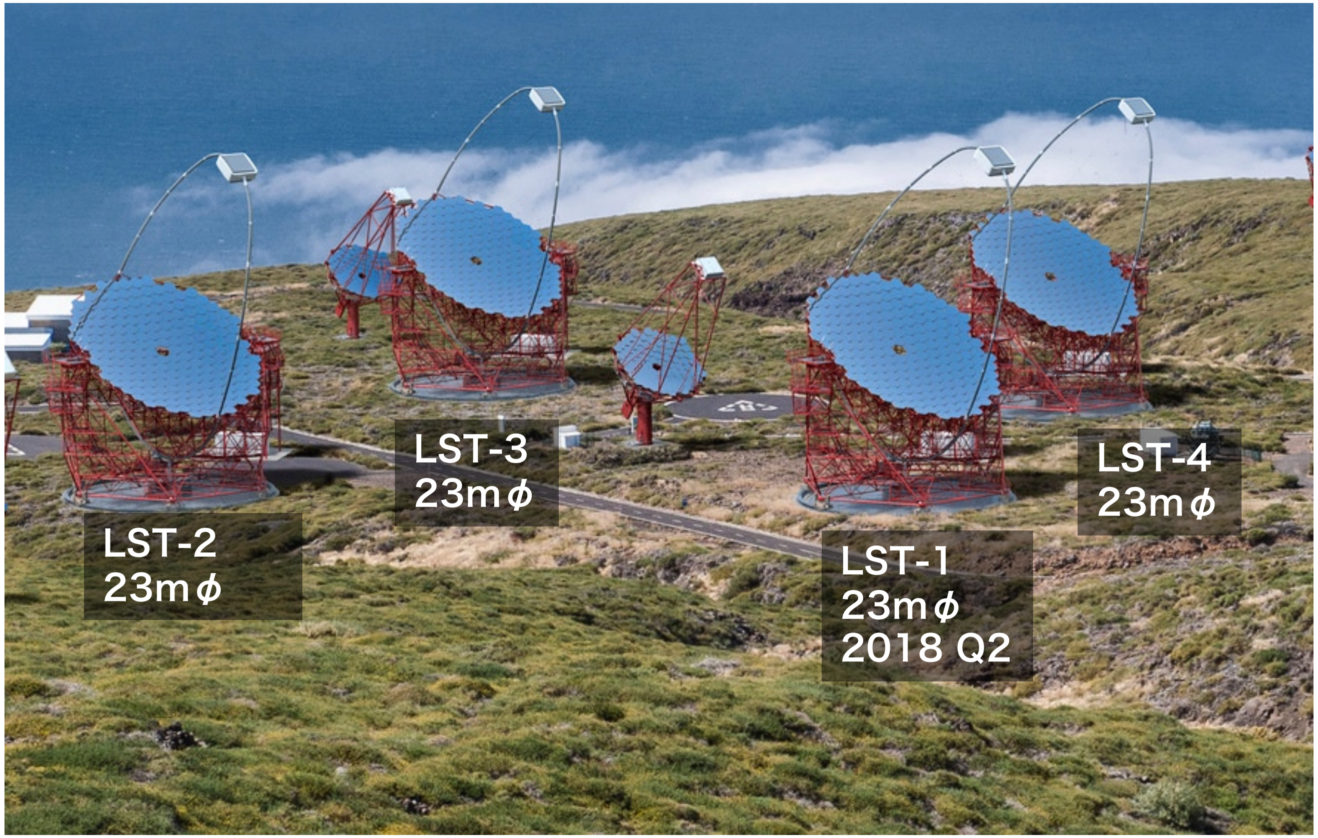
Drive (DE/FR/ES)
Bogie (DE/ES/IT)
Rail (DE/ES)
Foundation (ES)

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

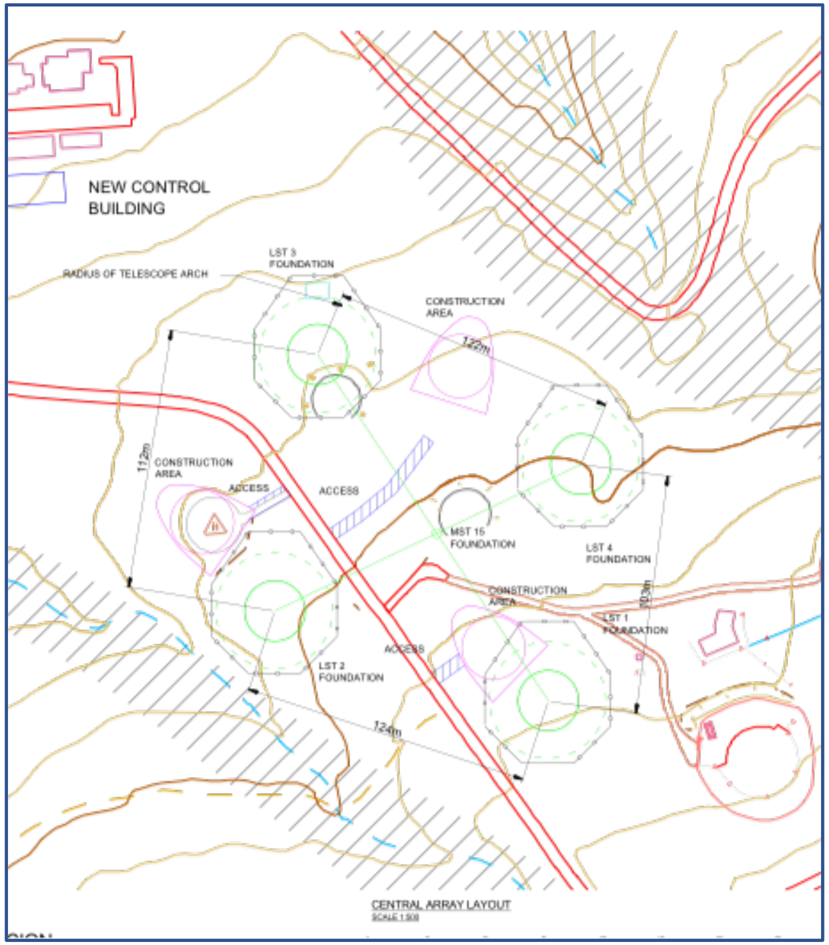
cherenkov telescope array

Plan for the four LSTs in CTA North (La Palma, Spain)

Budget for four LSTs are 100% secured!!



Artist view of the central part of CTA North

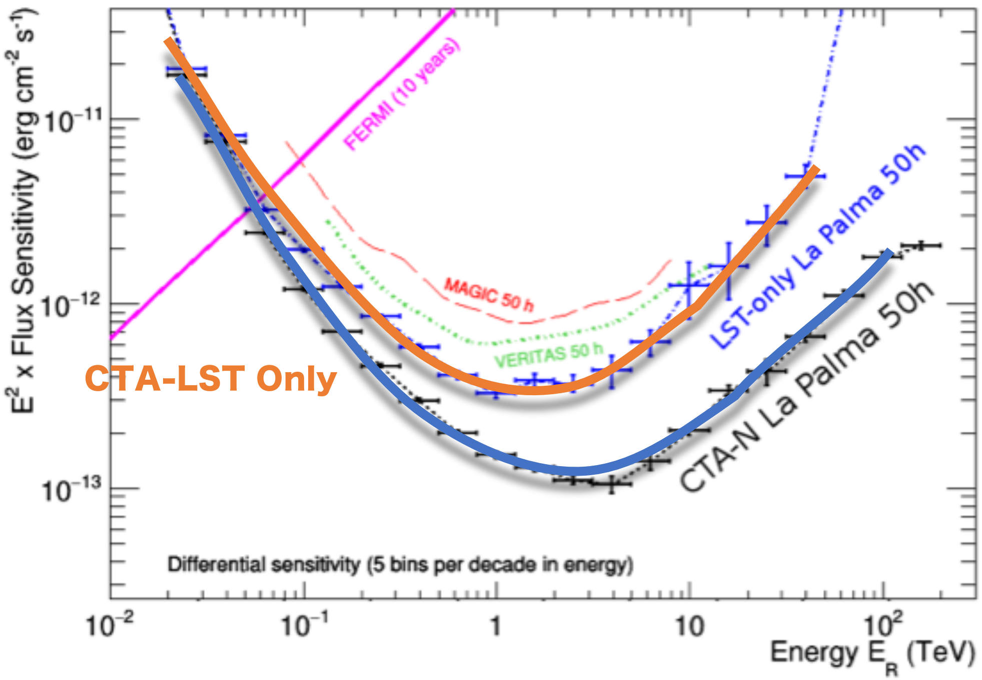


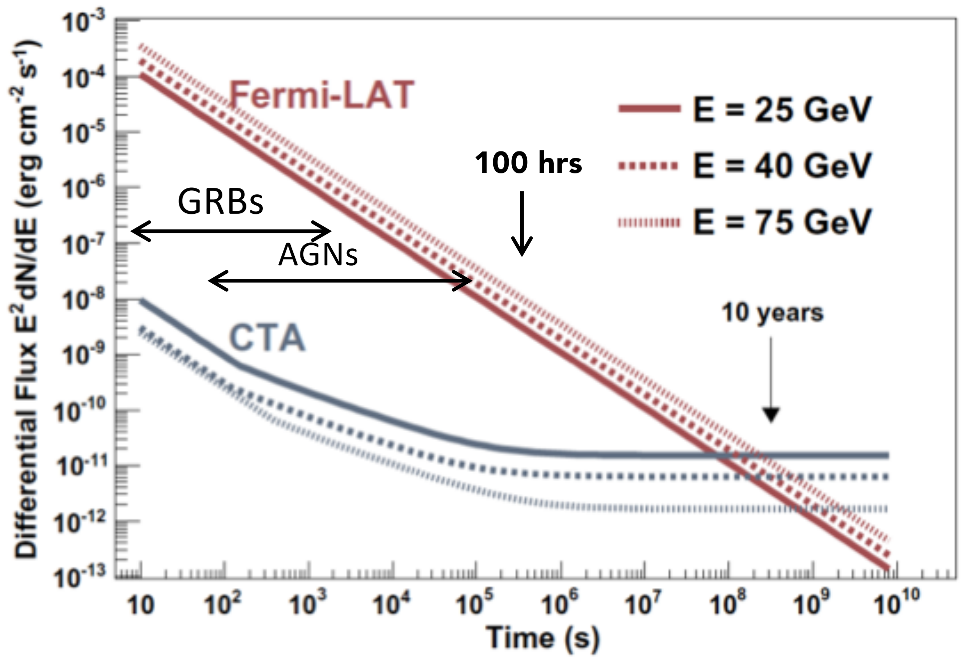
The location of four LSTs

cherenkov telescope array

CTAN-LST Array

Sensitivity x3, Angular Resolution x2
Energy Range > 20GeV



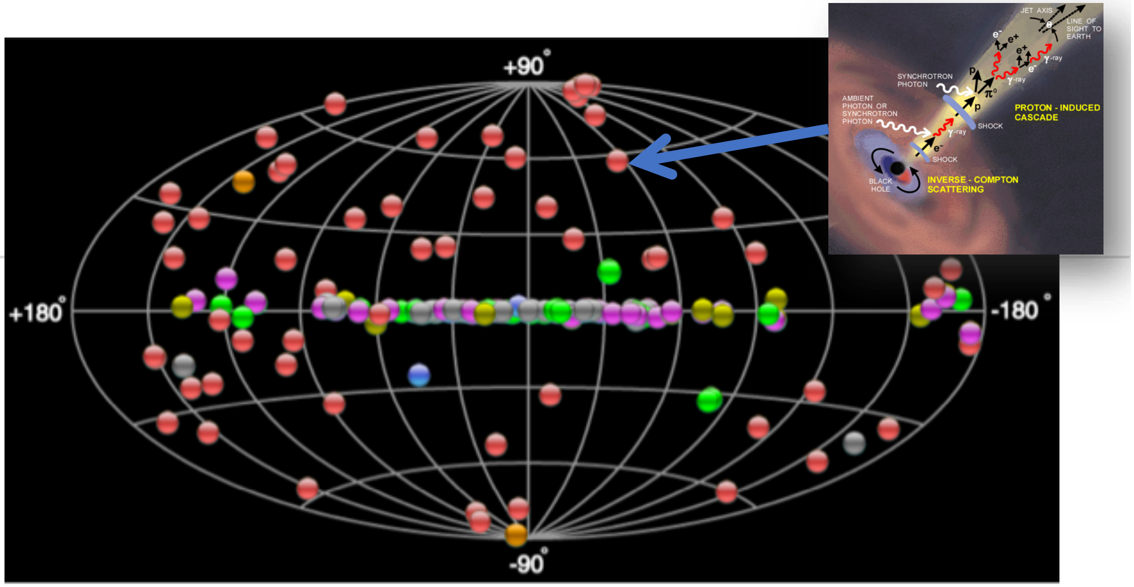


- CTA-LST array contributes to the sensitivity in low energies
- >20GeV Threshold Energy
- Distant AGNs are observable up to z=2
- X10000 sensitivity for GRBs and AGN flares than Fermi
- First observation of GRBs from ground

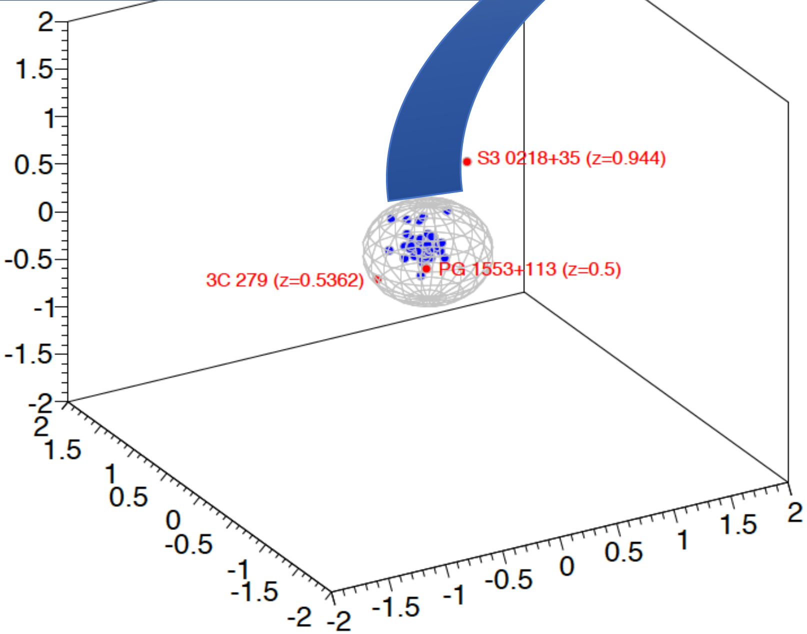
cherenkov telescope array

CTA is the ultimate survey machine

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

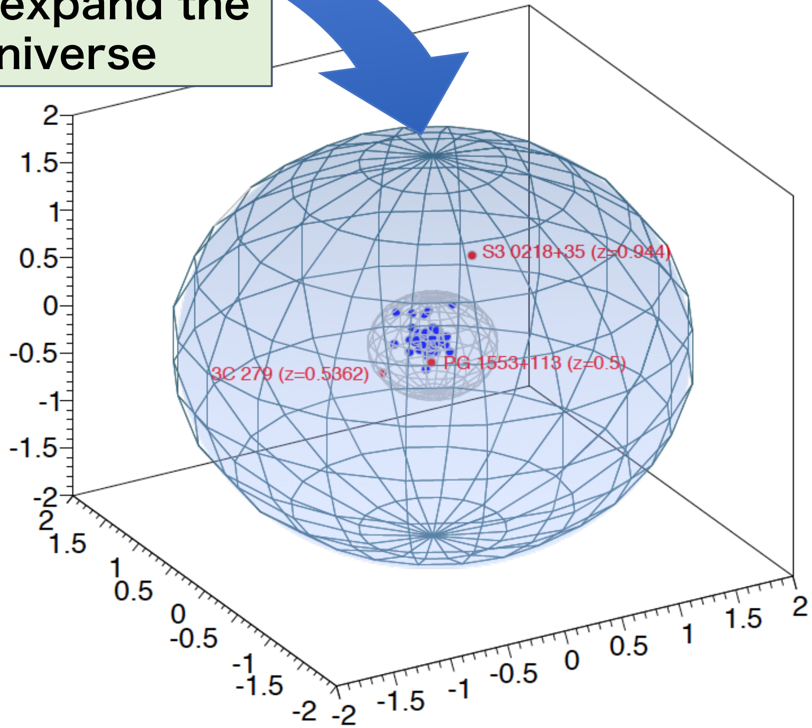


Visible Universe with VHE Gamma rays now



Universe 9 billion years after Big Bang

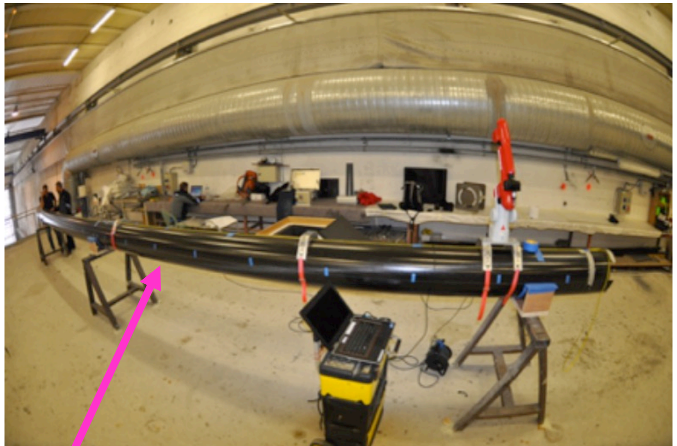
CTA will expand the visible Universe

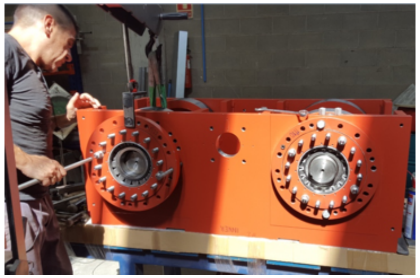


Universe 3 billion years after Big Bang

Status of LST-1 construction in March 2017

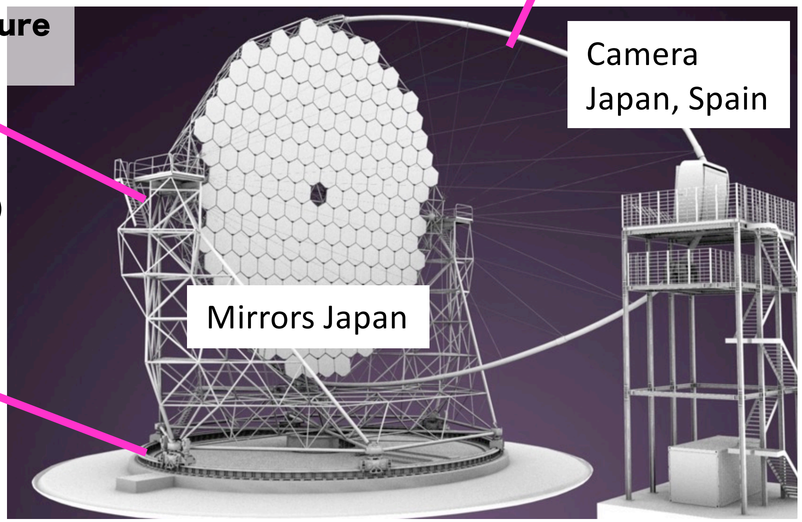
Camera Supporting Structure (France, Italy)





Telescope Structure (Germany MPP)

Bogie and Rail system (Spain, Italy, Germany)



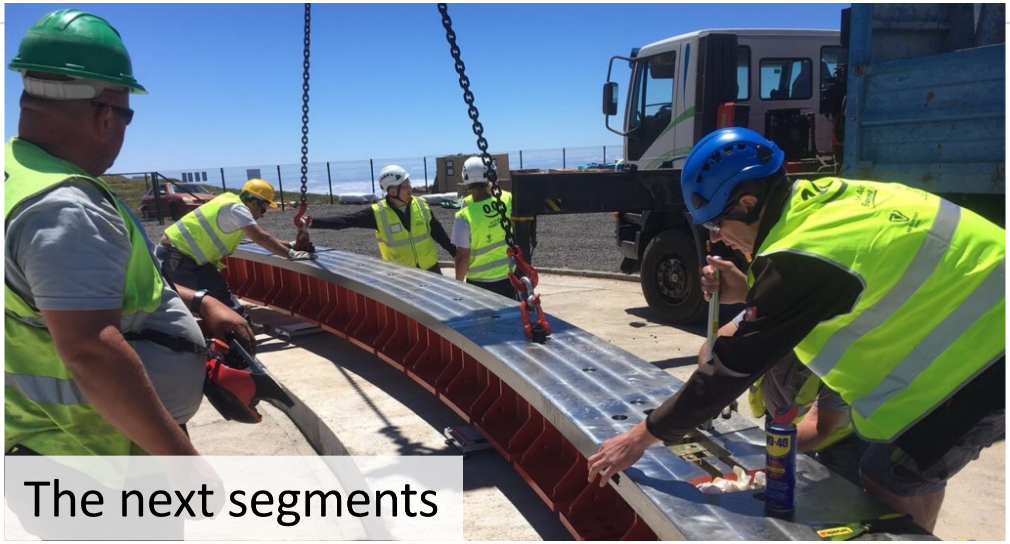
Computers and Network (Japan)

Energy Storage (Japan)

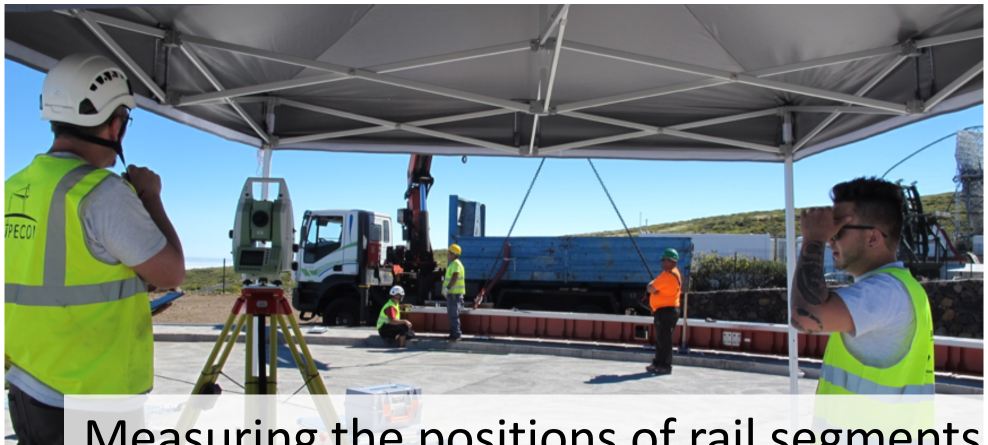
cherenkov telescope array

Installation work of the Rail System, on 4-7 July 2017

The first rail segment on the foundation



The next segments



Measuring the positions of rail segments with an accuracy of 0.25mm

The last segment closed the large circle of the rail system

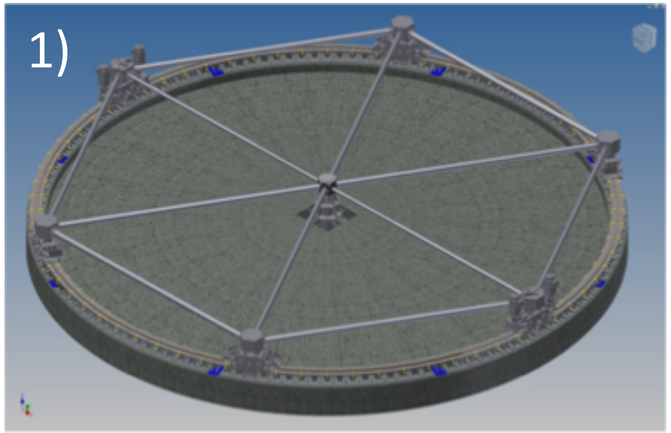
CTA-LST1 Construction La Palma, Canary Island

After the long delay of the construction permission

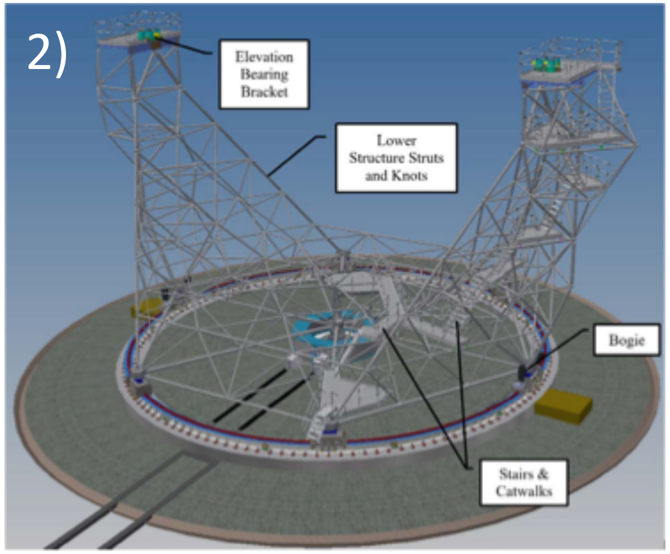
Status of LST1 construction

https://www.cta-observatory.org/project/technology/lst/

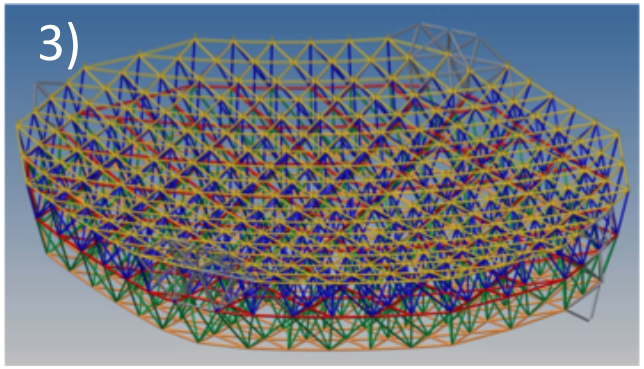
Installation Sequence after the rail system



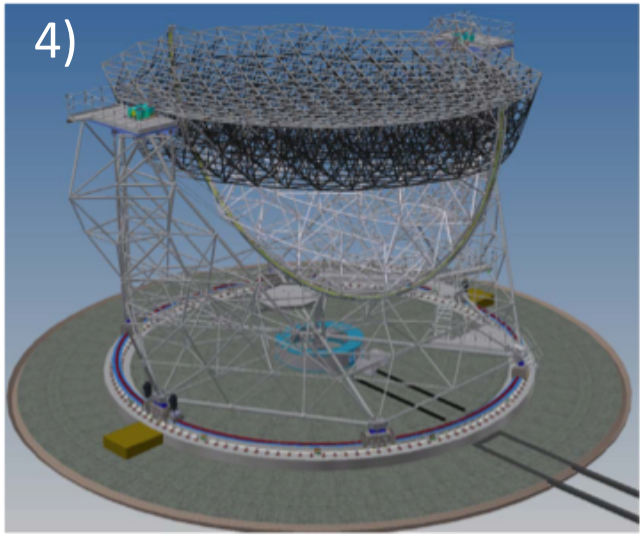
Install bogies and lower structure



Install azimuth structure

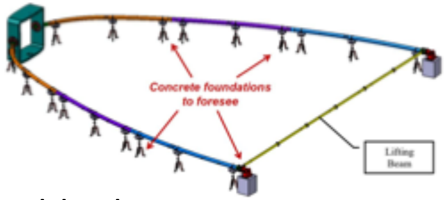


Assemble dish structure on the ground

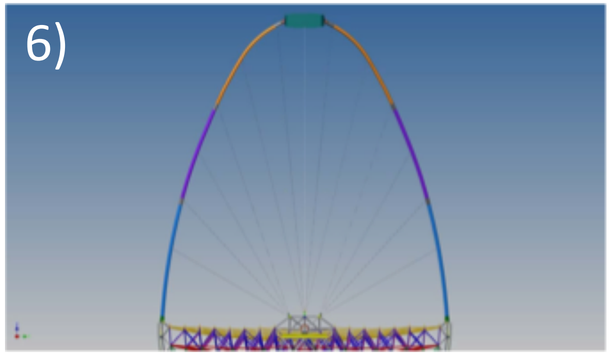


Mount dish structure and assemble elevation sub-structure/ mount mirrors

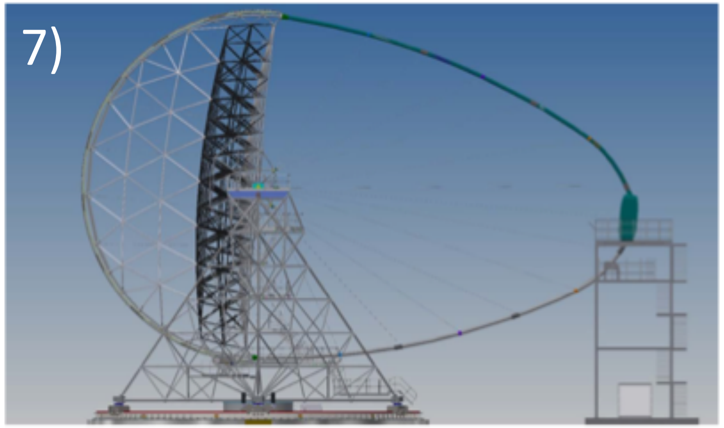
5)



Assemble the camera supporting structure



Mount the camera supporting structure



Install the camera access tower and the camera

Dish was mounted on the lower structure on 4 Dec

cherenkov telescope array

ICRR

LST Optics:
Mirror Production
High reflectivity, high durability

Developed last 6 years

- Light weight 45kg
- Tolerance $<10\mu m$
- Reflectivity $> 92\%$
- Aging ~1% /yr

Before 2016 : 100 Mirror proto.
2016 : LST1-LST2 Mirrors (400)
2017 : LST3-LST4 Mirrors (500)
produced and in production

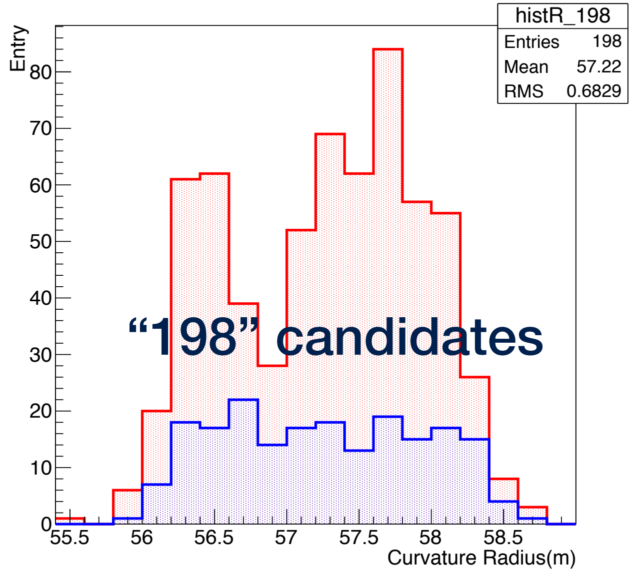
shipped

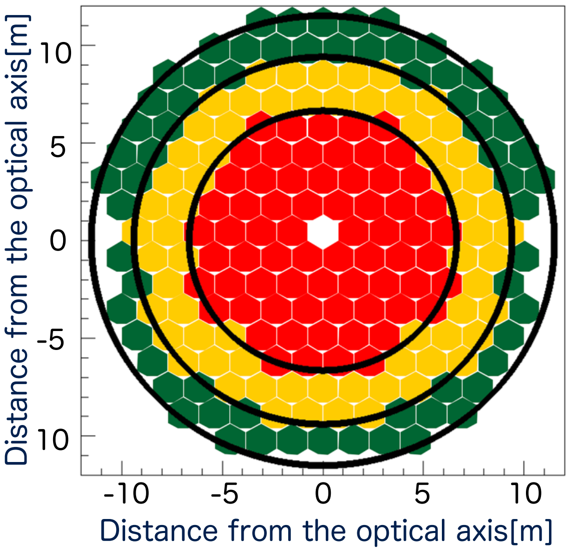
Shipping schedule

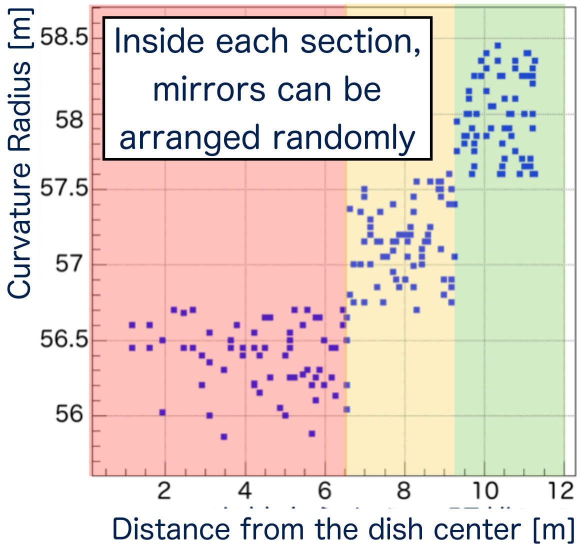
2017 Aug : LST1-2 Mirrors (400 units) @La Palma
2017 Oct: LST3 (200 units) are shipped
2017 Dec : LST4-5 Mirrors (300 units)

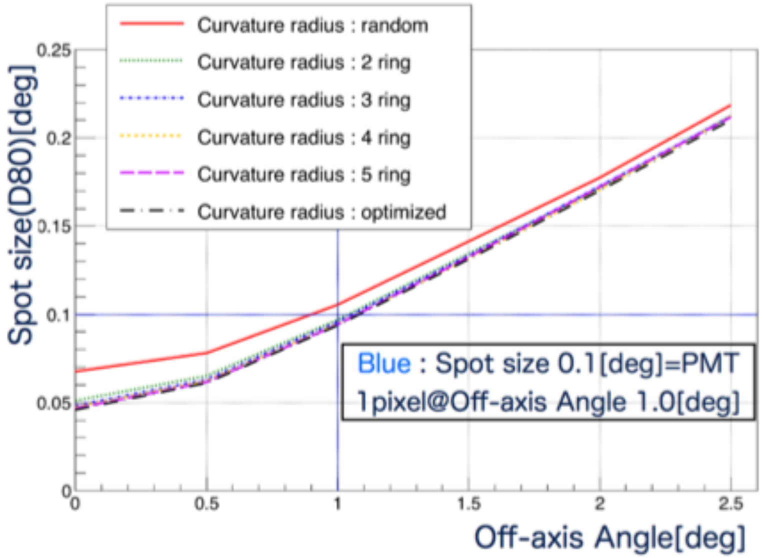
Mirrors

400 are in La Palma, 200 are shipped





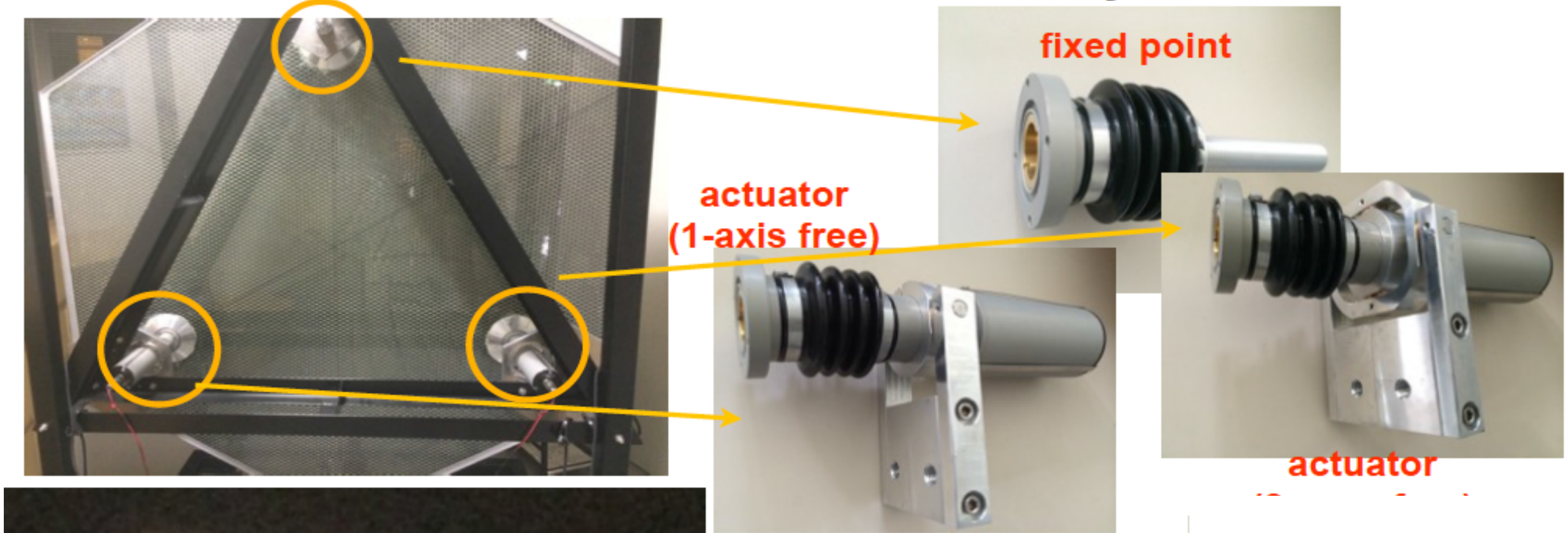




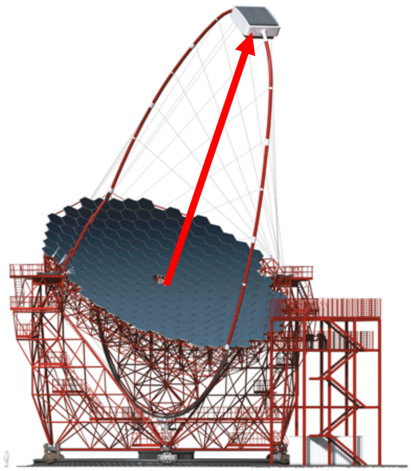
LST Optics: Actuators and CMOS Camera

ICRR, U.Zurich

Introduction : Devices of AMC system



CMOS camera (Imaging Source DMK023GM021) + IP67 hood



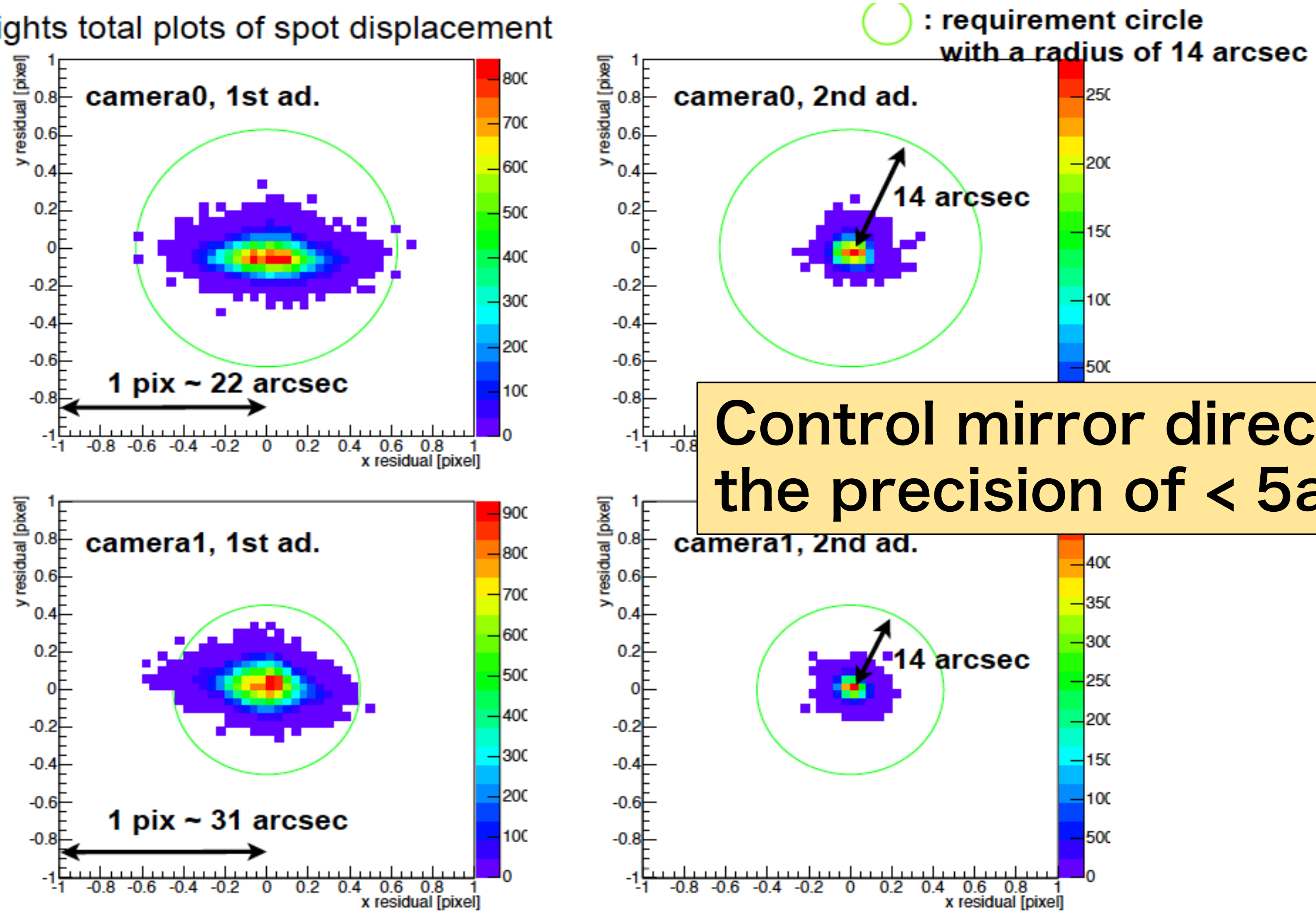
- Two Optical Axis Infrared Laser shoot the screen.
- CMOS cameras monitor the laser spots.
- Mirrors change autonomously the direction according to the given laser position

AMC precision test with the test structure at MPI

First adjustment

Second Adjustment

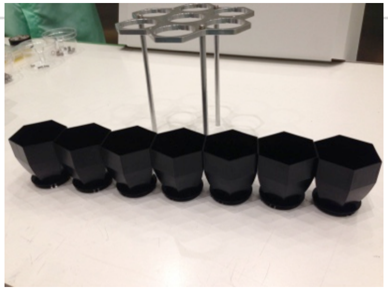
- 7 nights total plots of spot displacement



Control mirror directions with the precision of < 5arcsec

Pixel module assembly at IAC Tenerife

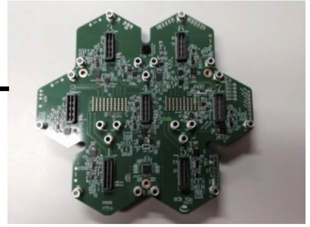
ICRR, INFN, KYOTO, IAC


7 LGs

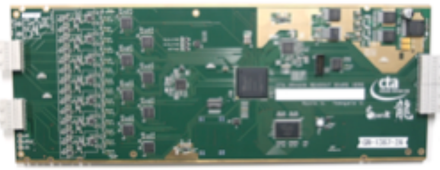
+


7 PMTs

+


SCB

+

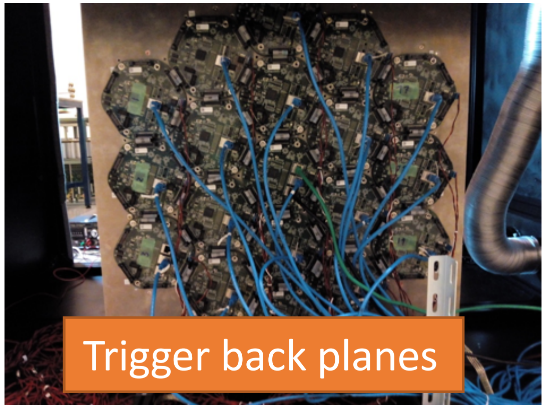

Dragon board

=


FPI module

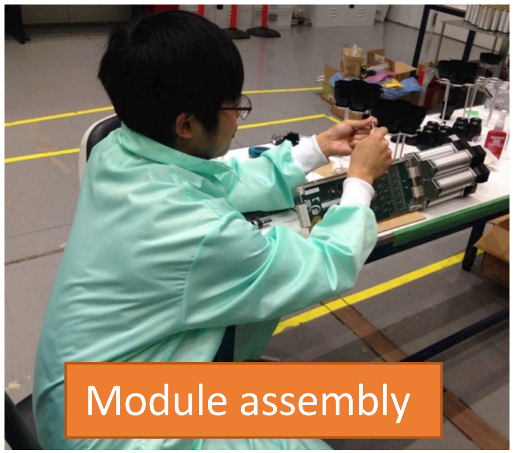

Module assembly

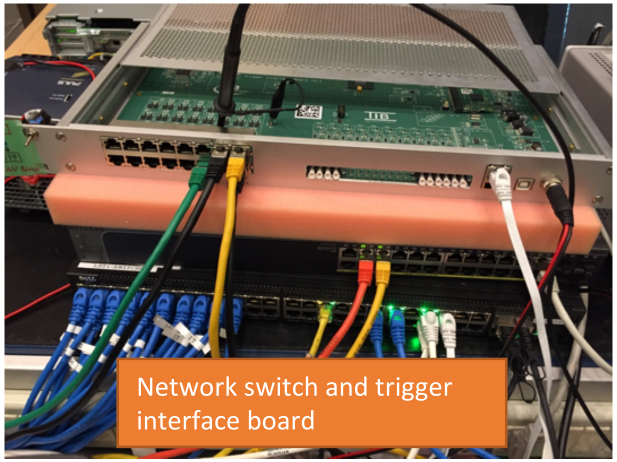

19 tested modules


Trigger back planes

265 modules/ Tel. needed.

270 modules are assembled @ IAC

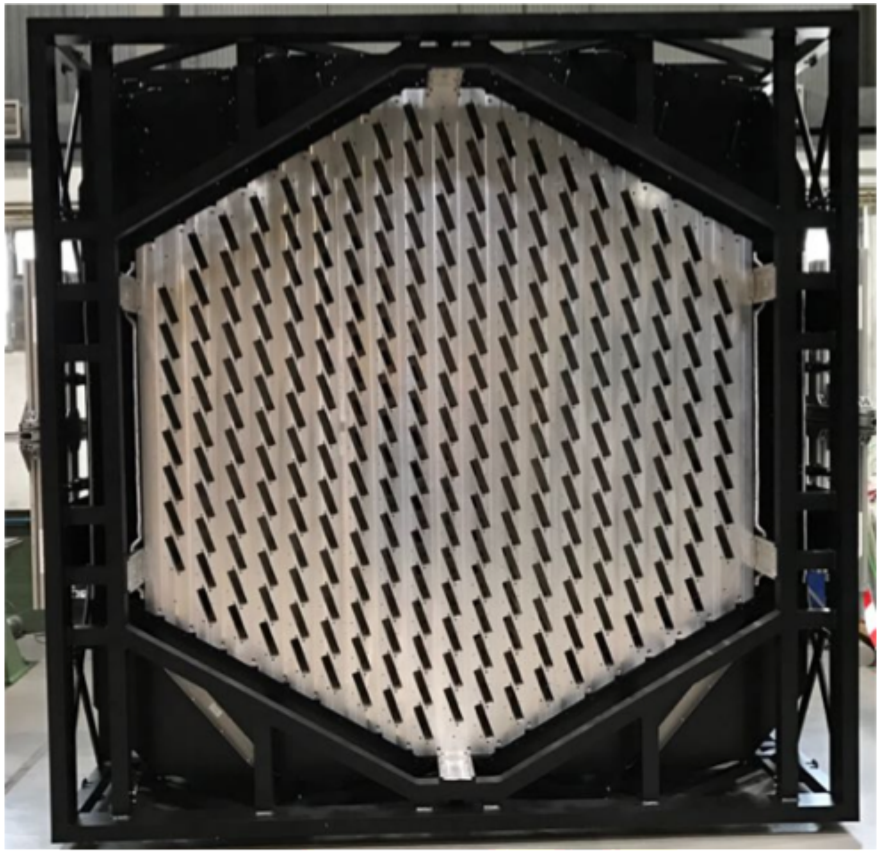

Module assembly


Network switch and trigger interface board


Camera server

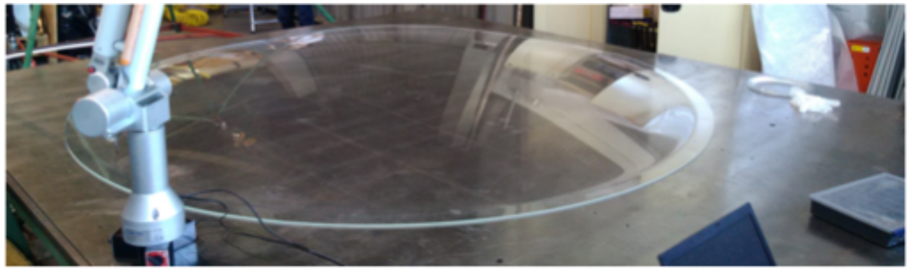
Camera Mechanics

Cluster Holder & Tubular structure



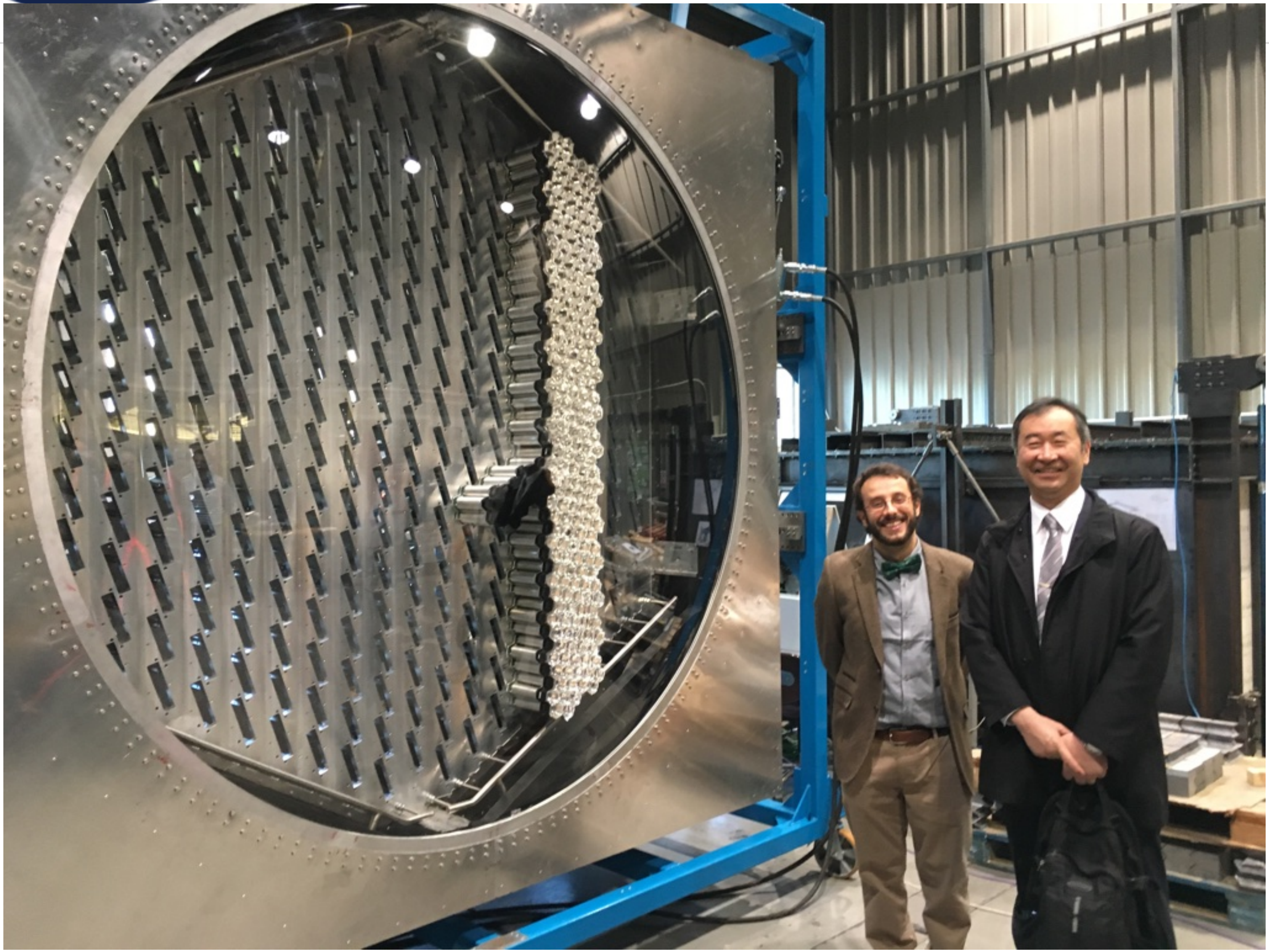
- Cluster Holder is already inside the final tubular structure
- The rear part of the camera is built
- Finishing the front part

Enclosure



Entrance Window

Camera Mechanics



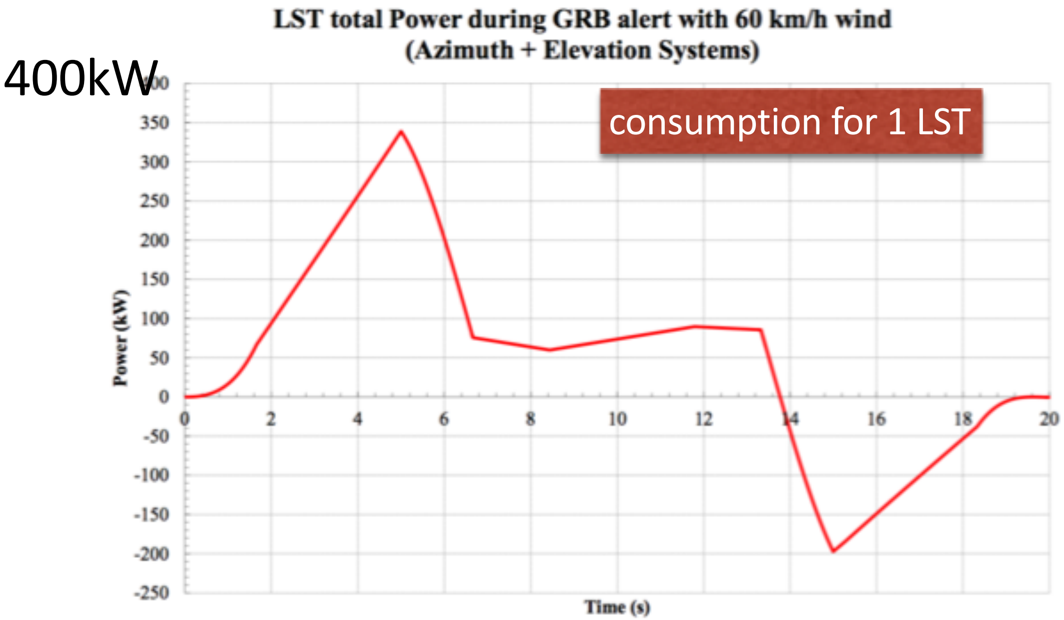
at CIEMAT
on 14th Nov

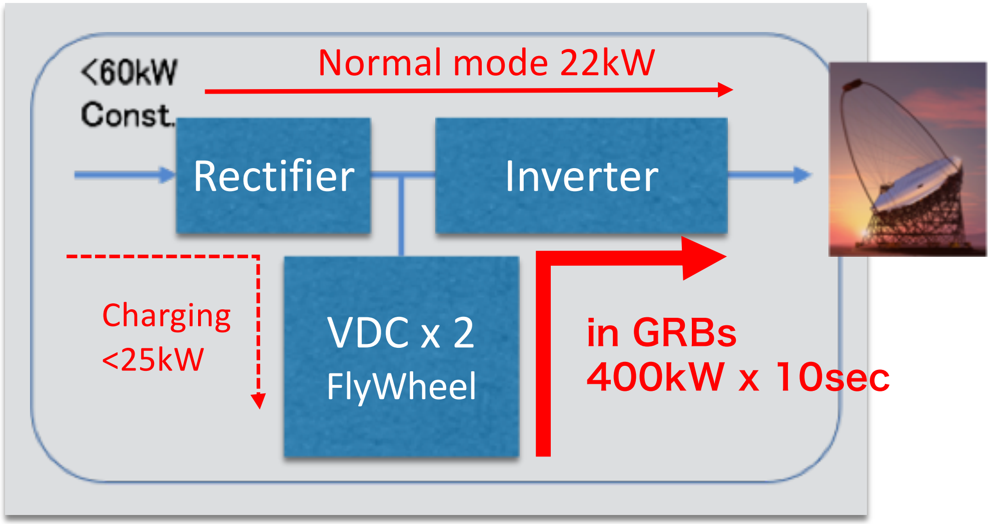
C. Delgado
T. Kajita

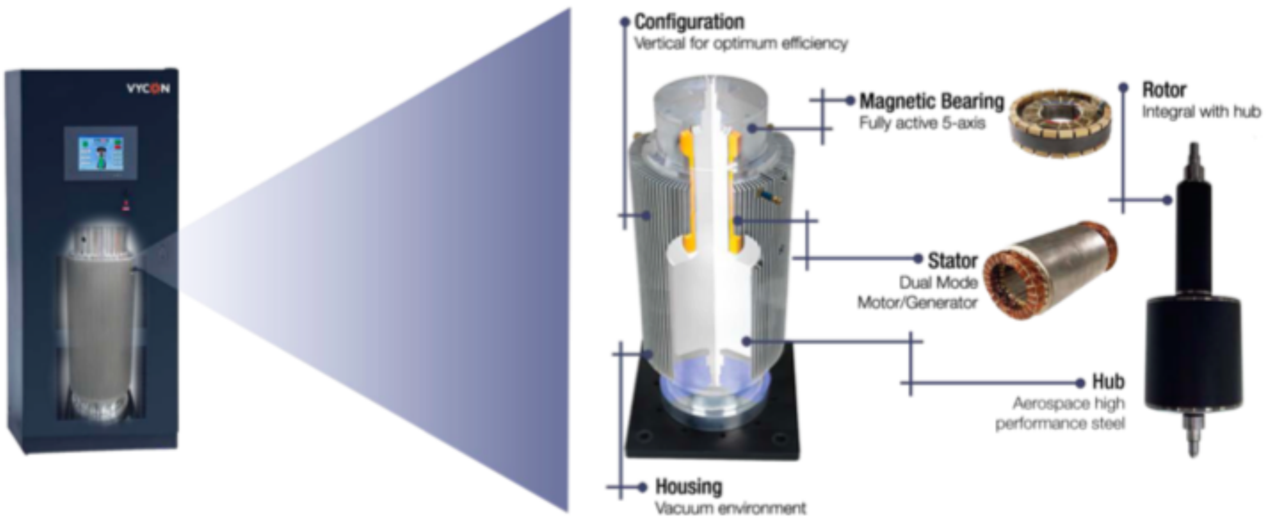
LST: Drive power supply

with the fast follow up observations

ICRR







- Extreme demand on power during the GRB fast movement
- Solution with FlyWheels
- This is also the UPS for entire telescope
- Fits nicely into a 20 feet container

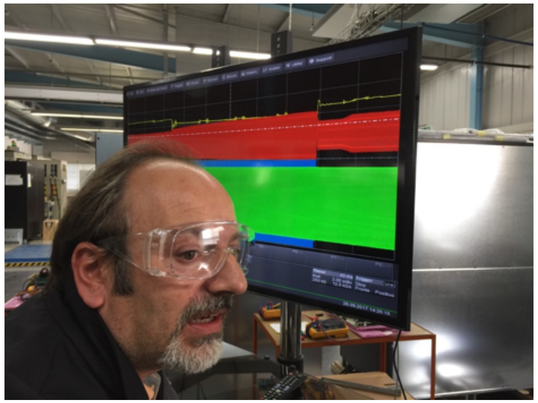
cherenkov telescope array

Test of the first LST Energy Storage System at GE in Riazzino, Switzerland on 27.Sep.17

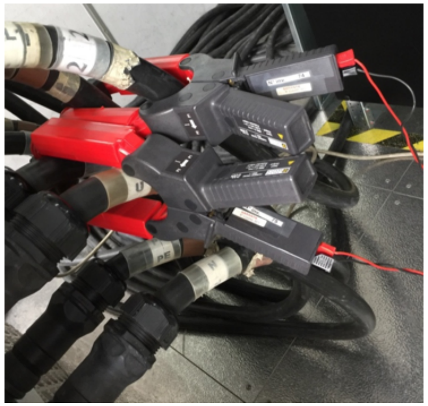
Testing 500kW x 10 seconds loads ➔ 5MJ in 10sec

ICRR

UPS System Flywheel 1 Flywheel2



Chief Engineer (Leader of technical dep.)



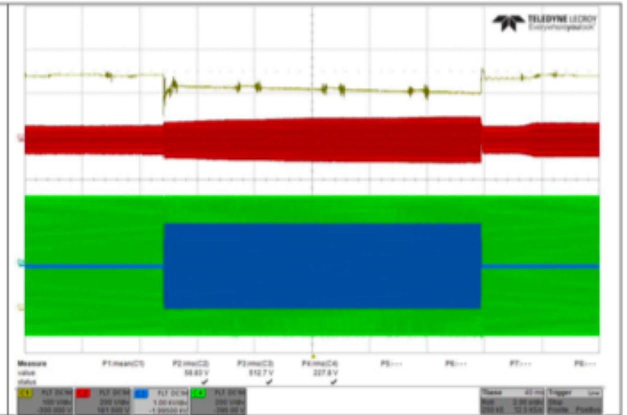
Clumps for current mes.

Input Power 400V x 66.97A x Sqrt(3) = 46kW
Output Power 400V x 688.8A x Sqrt(3) = 477 kW (22kW steady)

TEST 1
Steady state load 22KW
Rectifier limited at 46KW
Max TLE battery current 30A (flywheel is 15A per module)
Execute step load of 500KW for 10 seconds.
Measure the level of charge of the flywheels at the end of the 10 seconds.
Measure the time to fully recharge the flywheels at 100% capability.

Result:

Ch 1 UDC = 100 V/ Div
Ch 2 Iinput = 200 A/ Div
Ch 3 Iout = ~~500~~ 1000 A/ Div
Ch 4 Vout = ~~500~~ 200 V/ Div



Ch 1 UDC = 100 V/ Div
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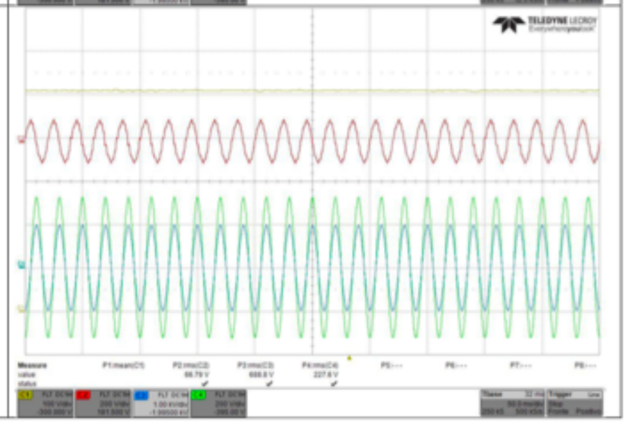
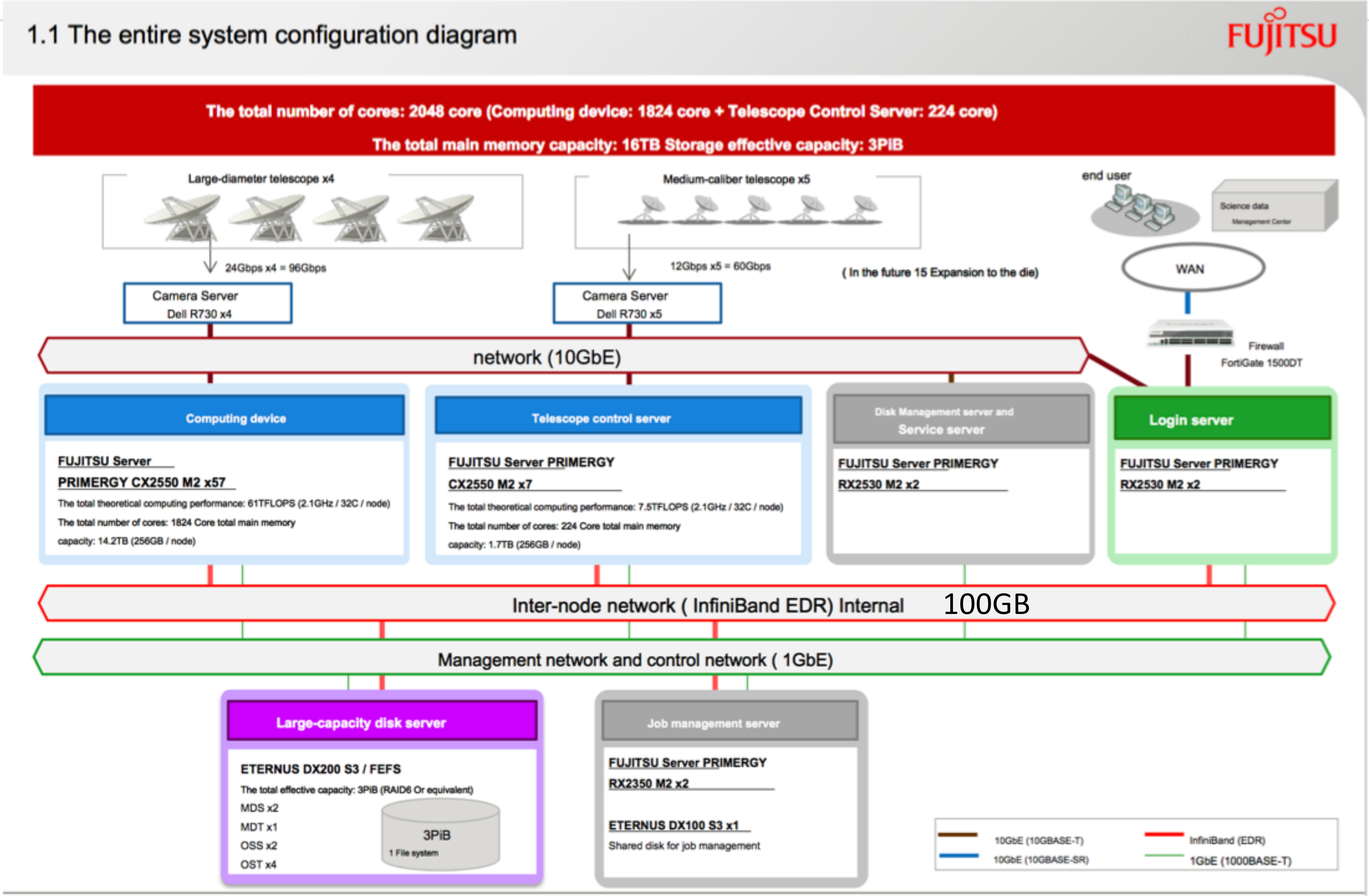
Expansion of the above picture



- Flywheels level of charge reach 40%.
- Time to fully recharge the flywheels is about 15 minutes.

CTA North Computing System
2000 cores, 3PB storage

ICRR



Everything is installed in 3 Racks

2000 cores and 3PB, 10GbE for 19 Telescope interfaces and Internal IB

ICRR

Infini-Band
Disk system

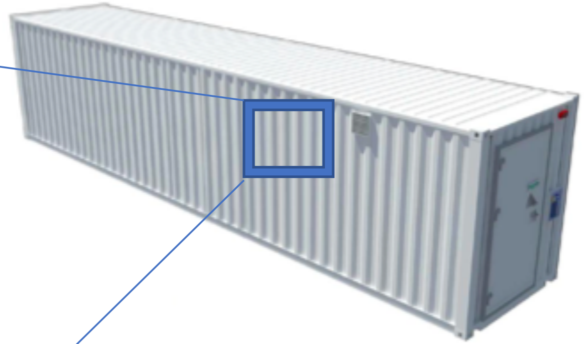
Disk system
and GbitEther

CPU Clusters
2000 cores

cherenkov telescope array

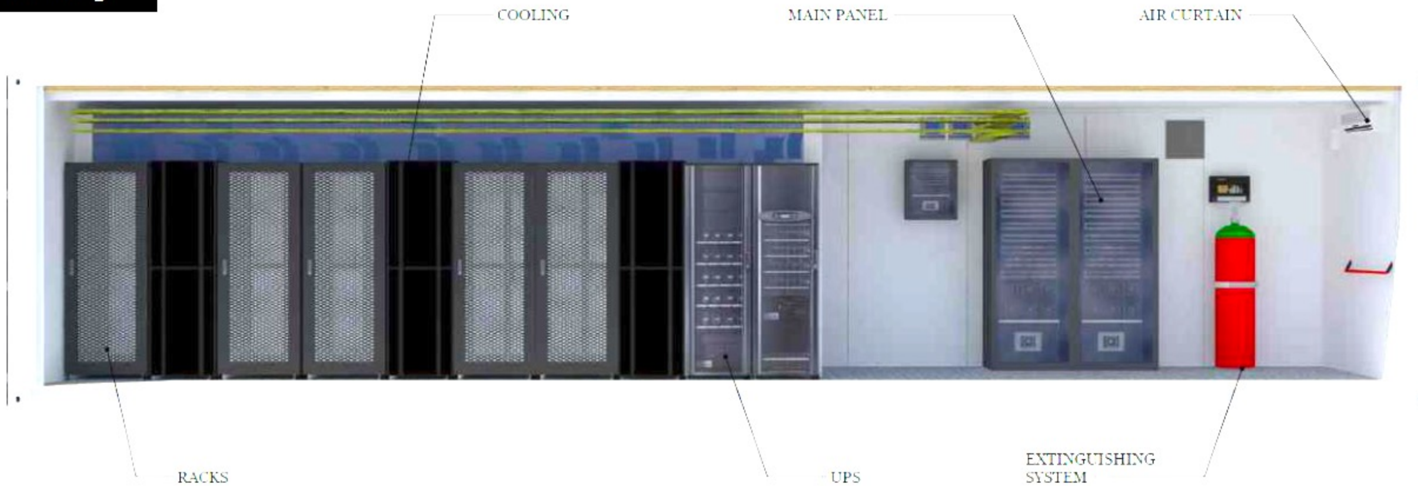
IT Container

前面 Frontal side



背面 Rear Side

前面（内部） Inside



Yes, we can do it
Construction of four LSTs

- CTA LST1 will have the first light in the early summer 2018
  - We do not see any major failure in LST1
- We shall be always positive and aggressive
  - Proceed to commissioning, engineering run, development of software, ACTL, AS
  - Cross calibration with MAGIC, Dragon 1GHzS/sec ⇔ 4GHzS/sec
  - Proof the threshold energy of 20GeV by observing Pulsars and GRBs
- Continue the the construction of LST2-4 in FY2018-FY2020