

CTA Large Size Telescope

Masahiro Teshima for the CTA-LST sub-consortium

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



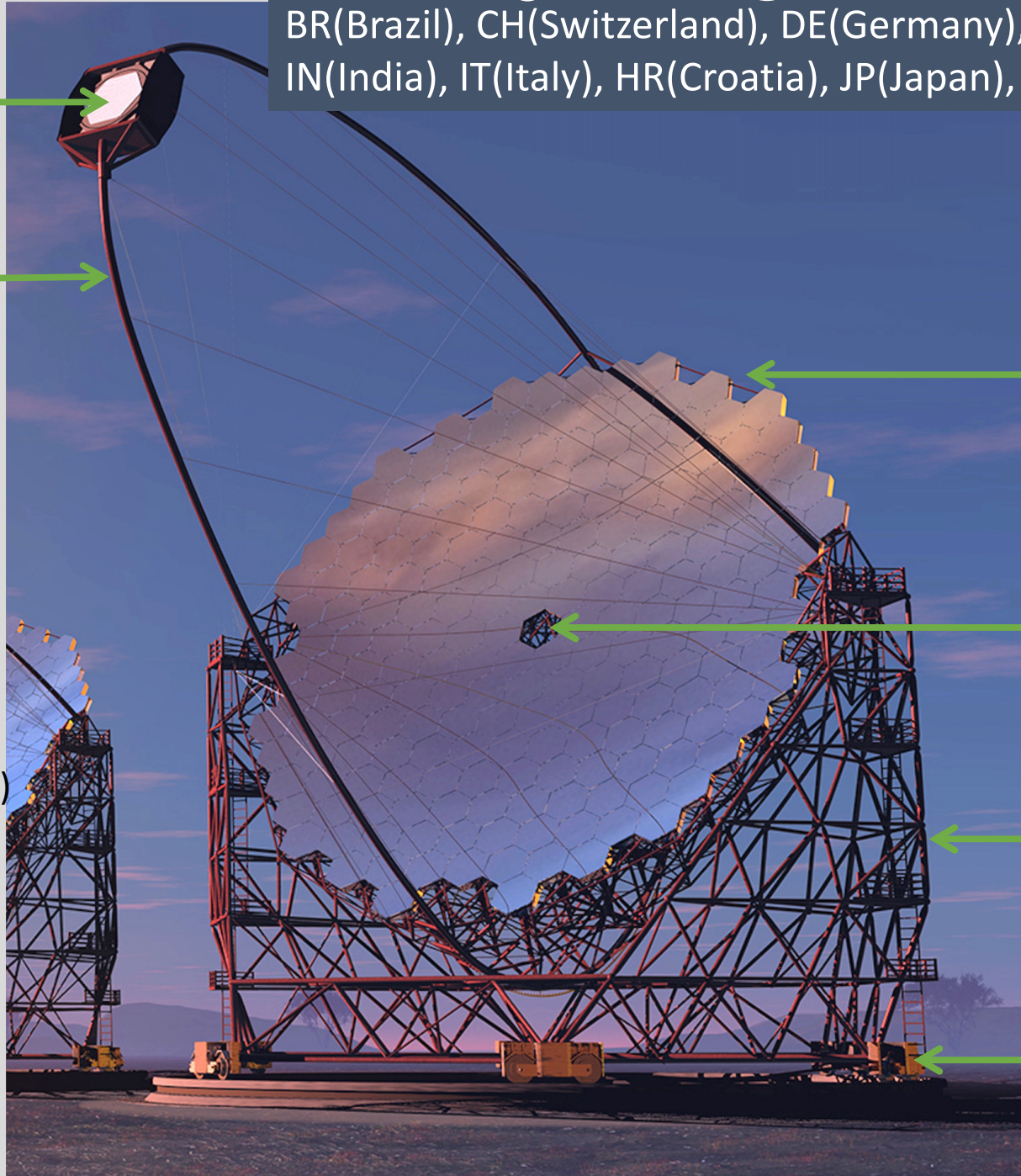
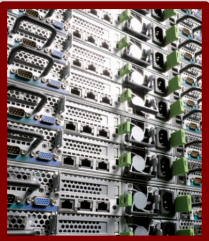
LST Project : Big International Effort

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)**

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



**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)**

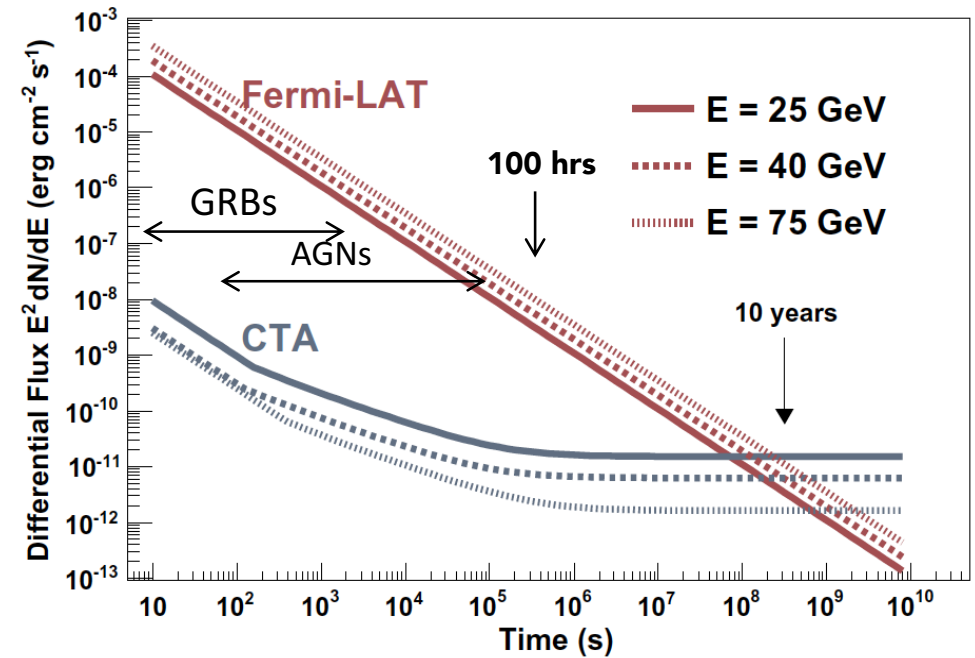
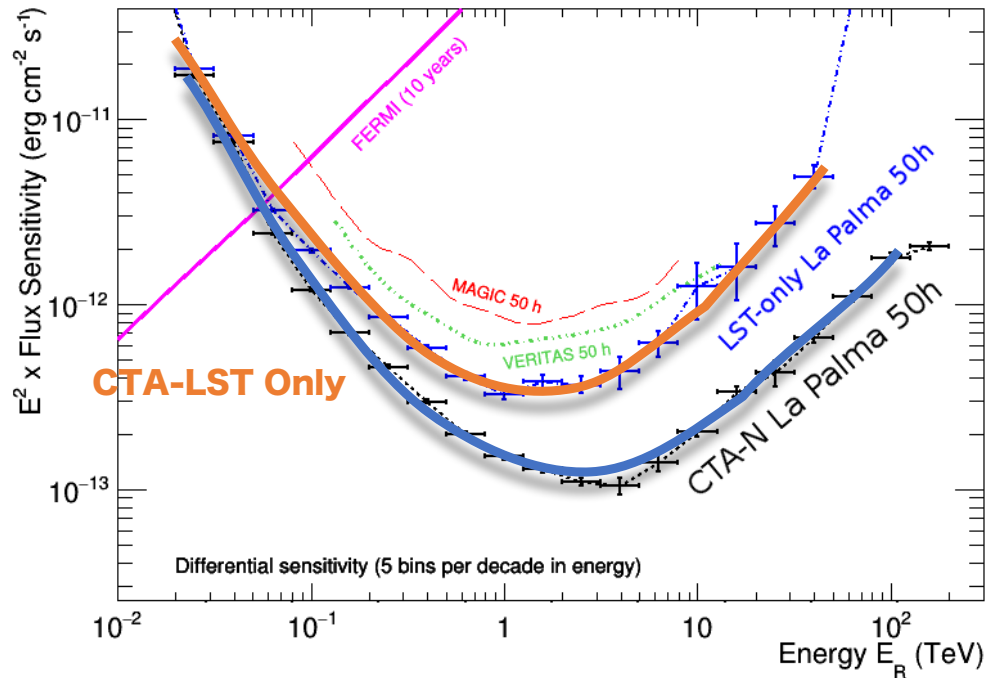


Cherenkov
telescope
array

CTAN-LST Array

Sensitivity x3, Angular Resolution x2

Energy Range > 20GeV



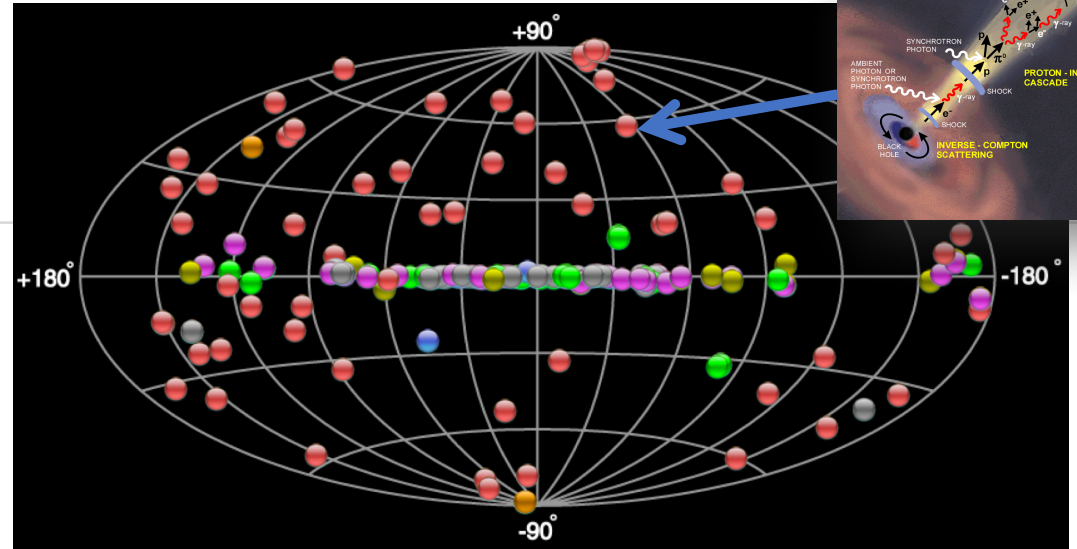
- CTA-LST array contributes to the sensitivity in low energies
- >20GeV Threshold Energy
- Distant AGNs are observable up to $z=2$
- X10000 sensitivity for GRBs and AGN flares than Fermi
- First observation of GRBs from ground



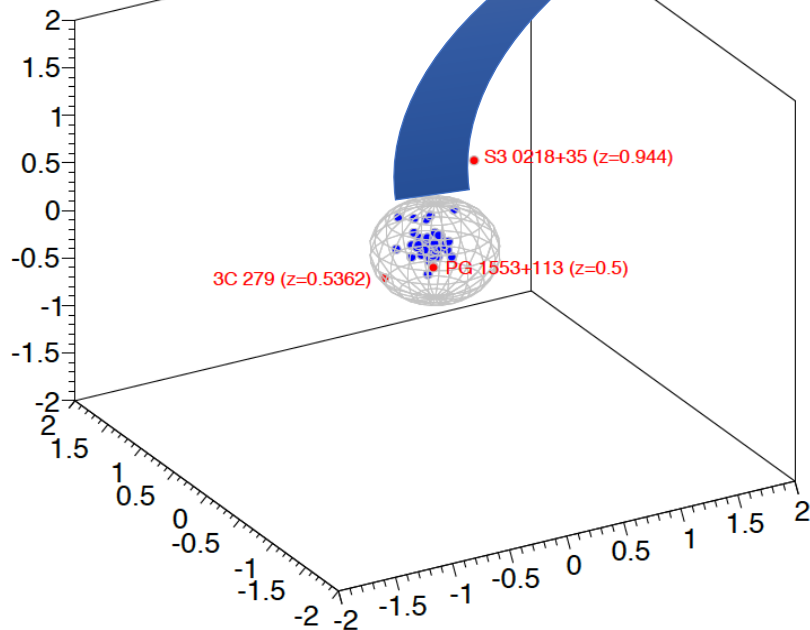
cherenkov
telescope
array

CTA is the ultimate survey machine

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

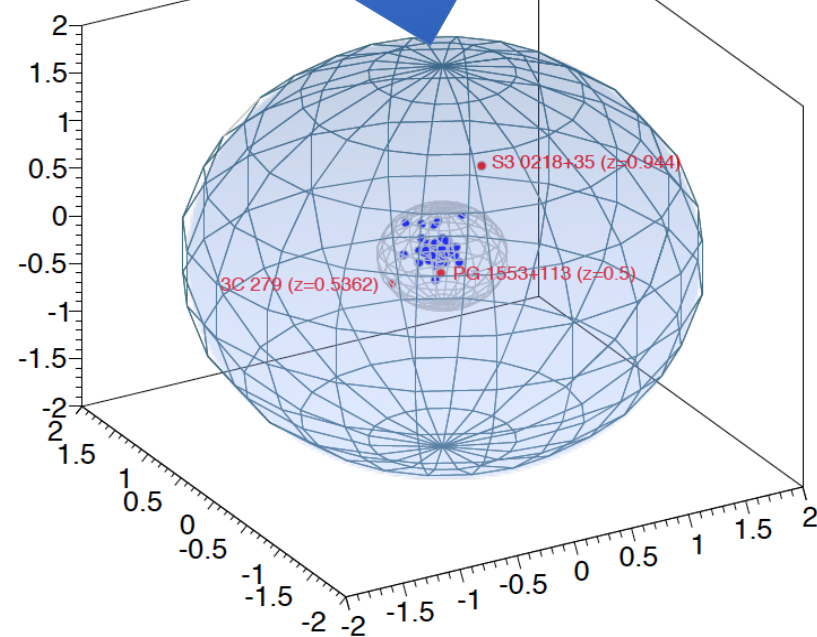


Visible Universe with VHE
Gamma rays now



Universe 9 billion years after Big Bang

CTA will expand the
visible Universe



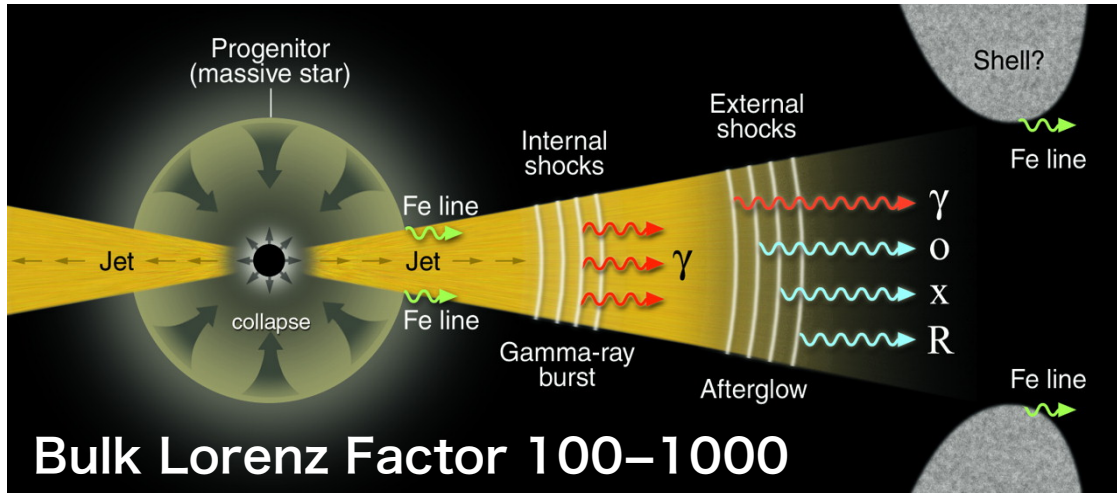
Universe 3 billion years after Big Bang



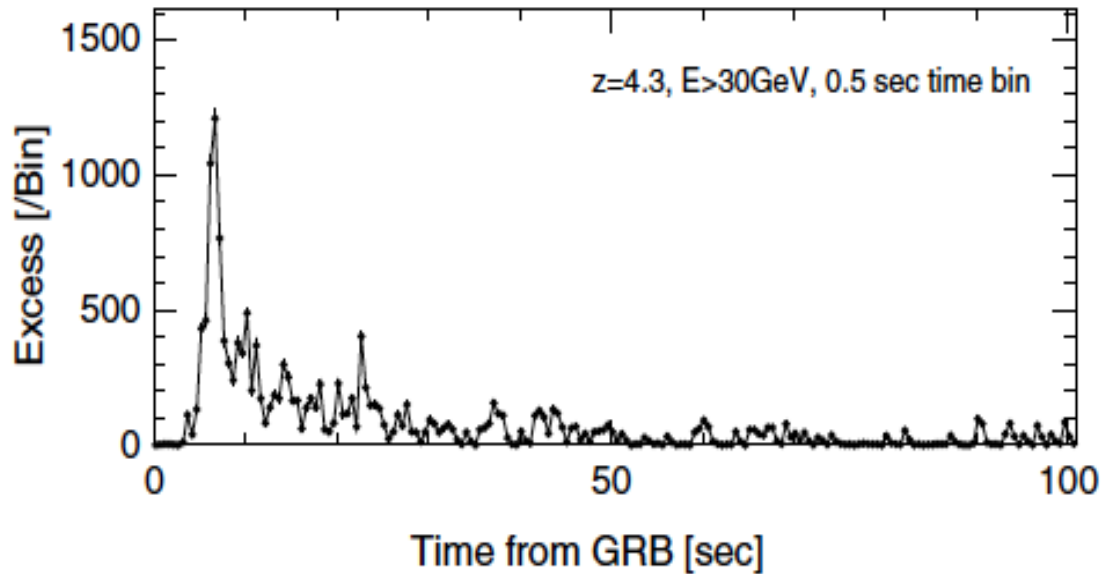
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array

GRBs: good targets for CTA-LSTs

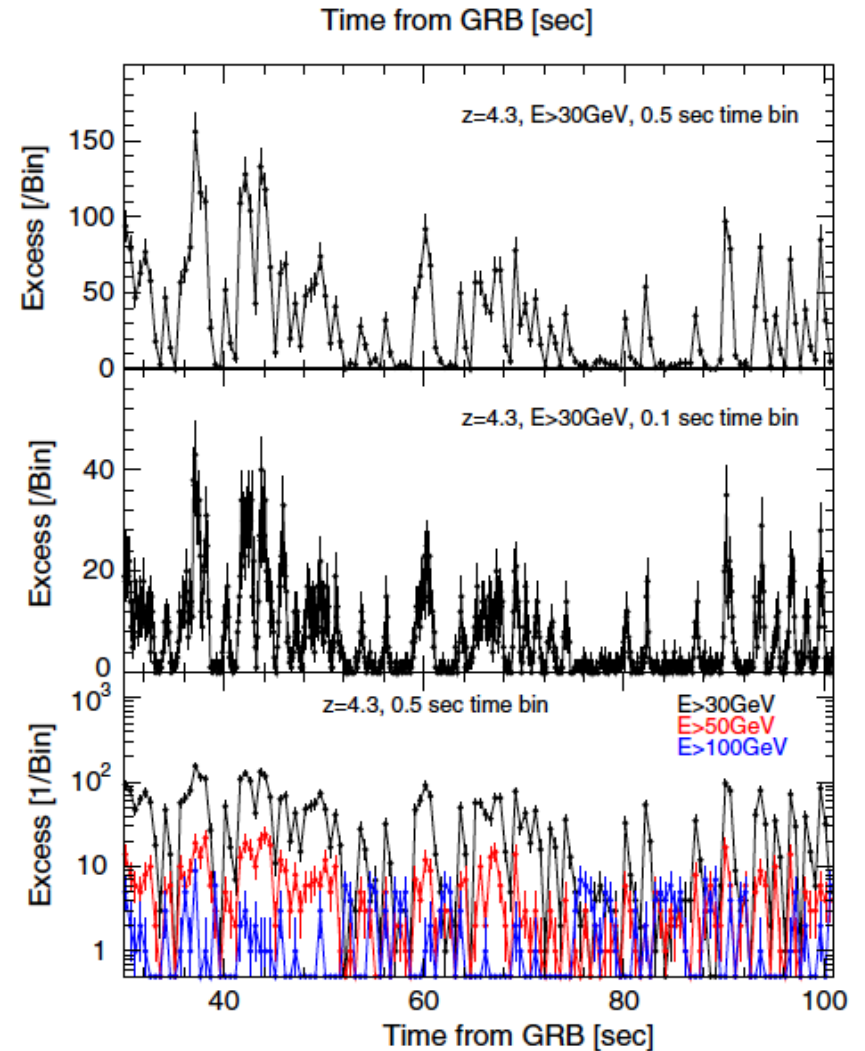
Study the newborn baby black holes



Bulk Lorentz Factor 100–1000



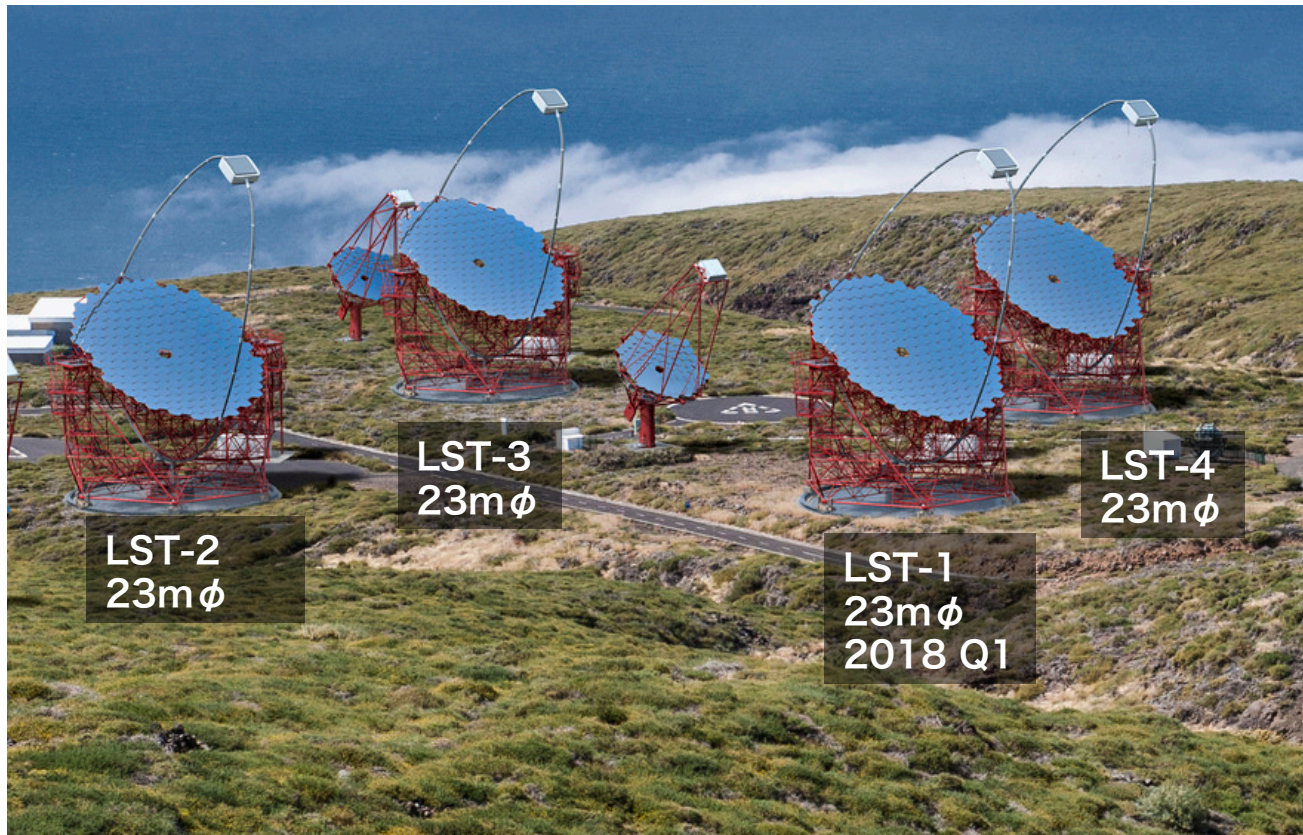
CTA Simulation (Template GRB080916C)



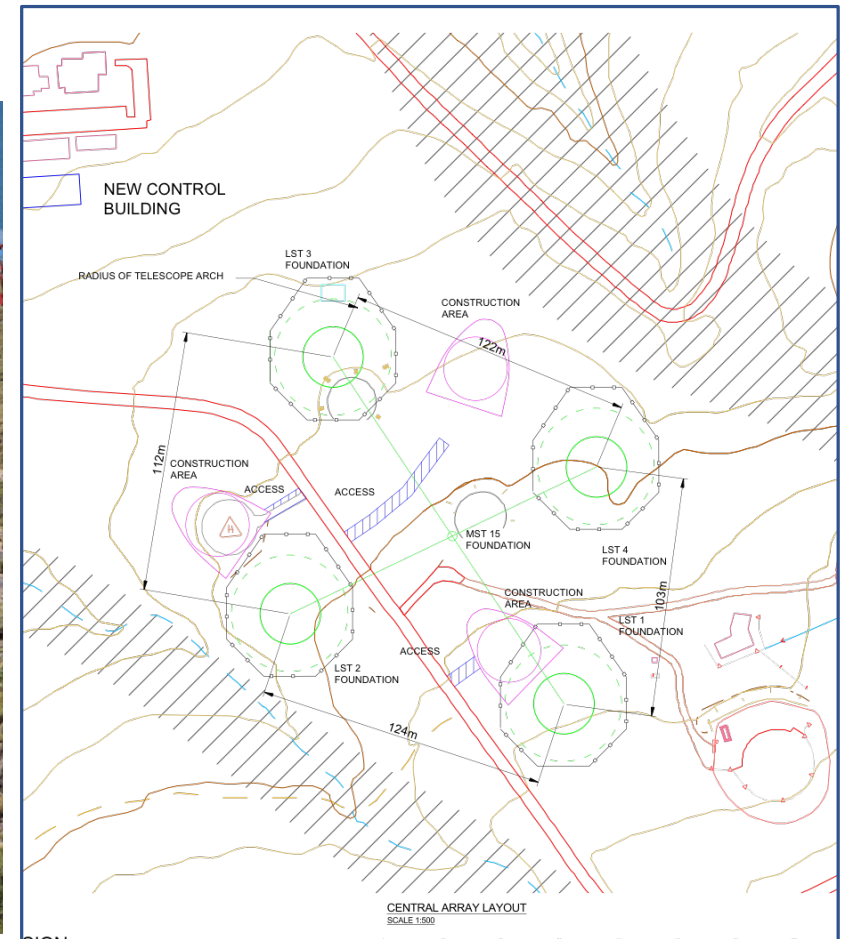


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Plan for the four LSTs in CTA North (La Palma, Spain)



Artist view of the central part of CTA North



The location of four LSTs



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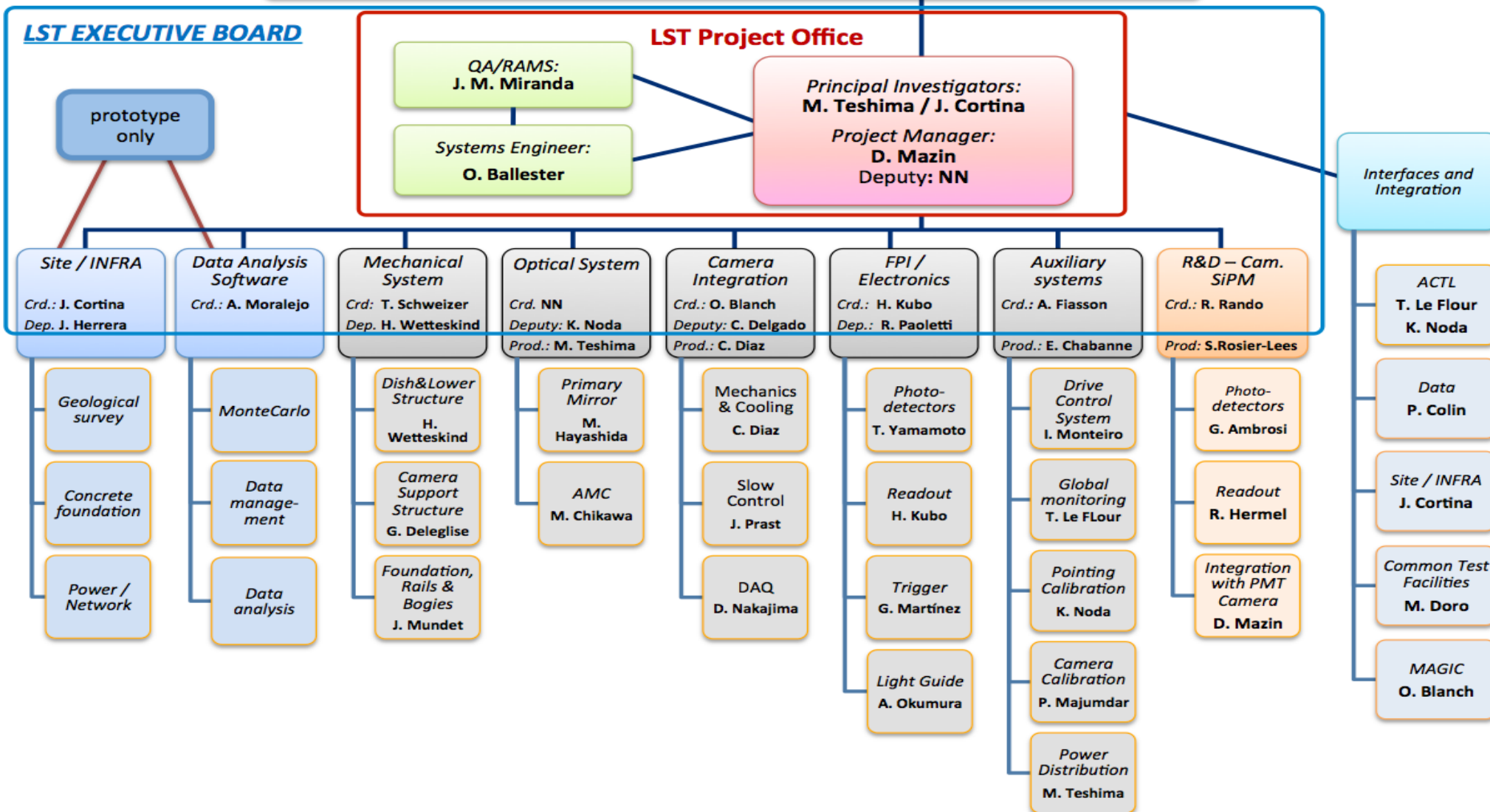
CTA-LST sub-Consortium

Version 6.94

Steering Committee:

DE: T. Schweizer
ES: M. Martinez (chair)
FR: J.-P. Lees
JP: H. Kubo
IT: N. Giglietto

Ex Officio: M. Teshima
Ex Officio: J. Cortina
Ex Officio: D. Mazin
IAC: M. Vazquez Acosta





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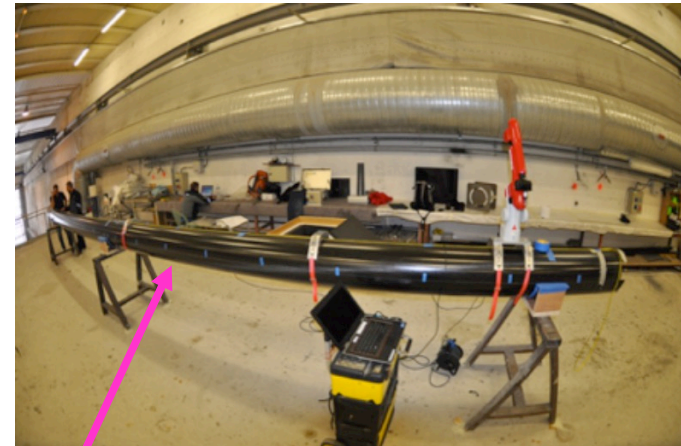
Status of LST-1 construction in March 2017



Containers for Telescope Structure components

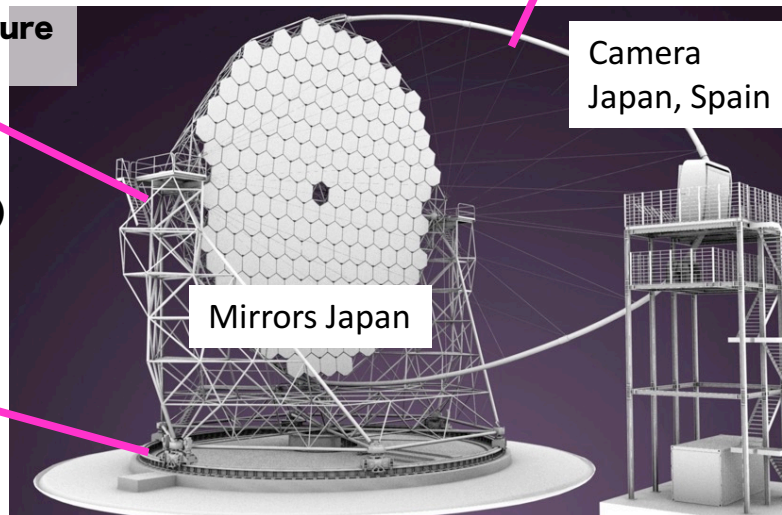
Concrete foundation for LST1

Camera Supporting Structure (France, Italy)



Telescope Structure (Germany MPP)

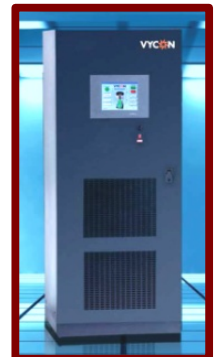
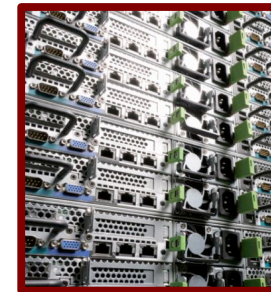
Bogie and Rail system (Spain, Italy, Germany)



Camera Japan, Spain

Mirrors Japan

Computers and Network (Japan)



Energy Storage (Japan)





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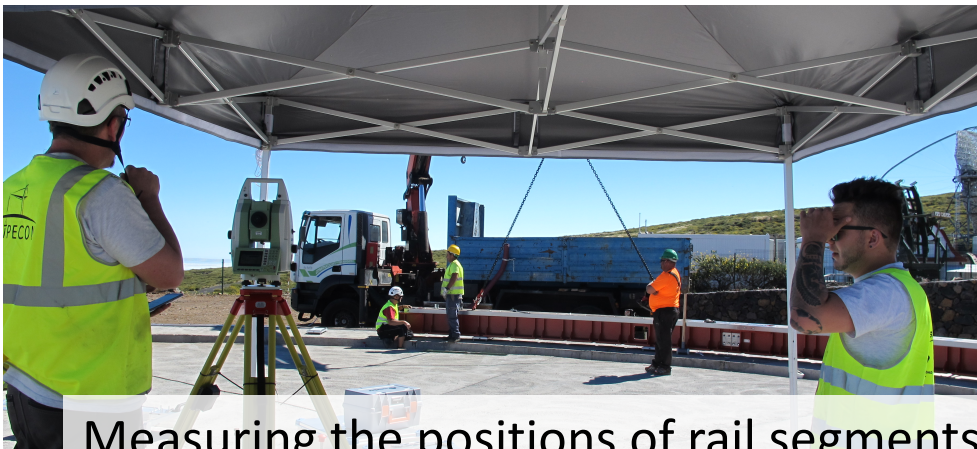
Installation work of the Rail System, on 4-7 July 2017



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



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Rail system and central pin are installed

23. July 2017

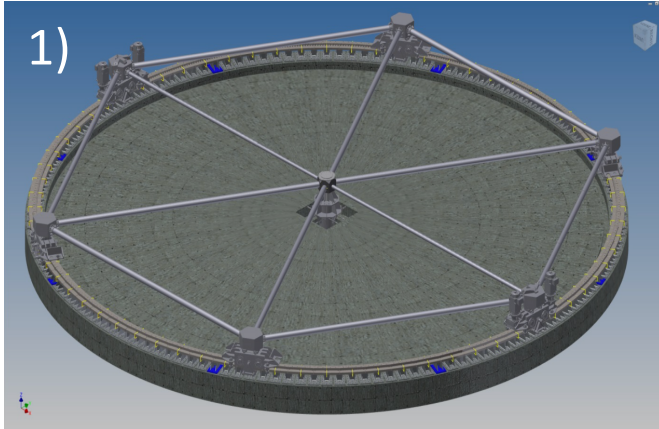
<https://www.cta-observatory.org/project/technology/lst/>



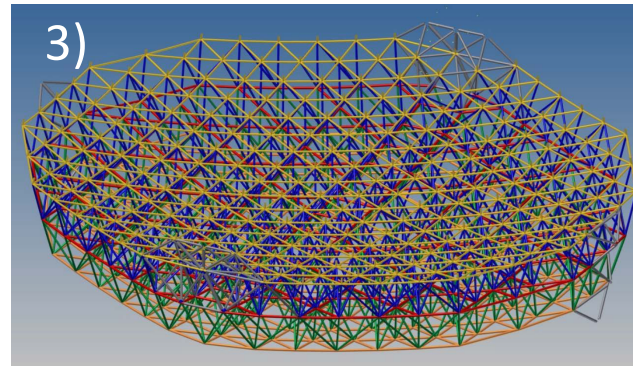


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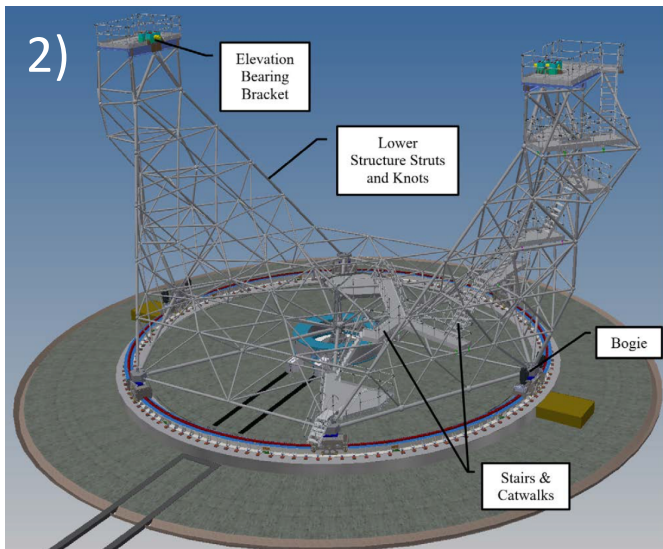
Installation Sequence after the rail system



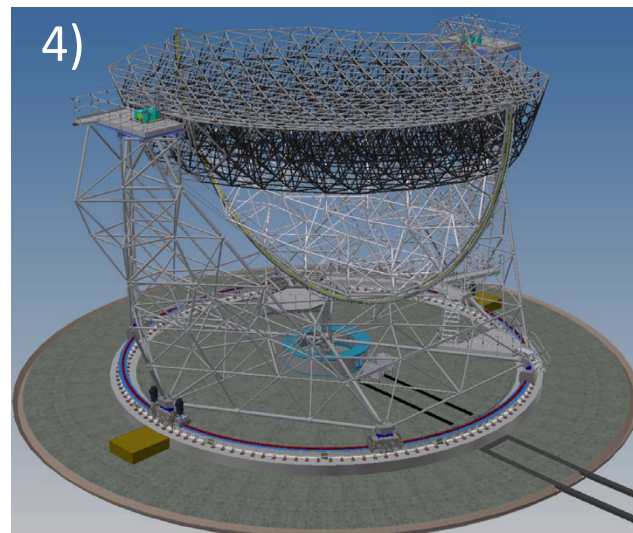
Install bogies and lower structure



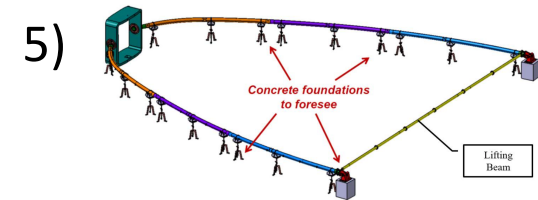
Assemble dish structure on the ground



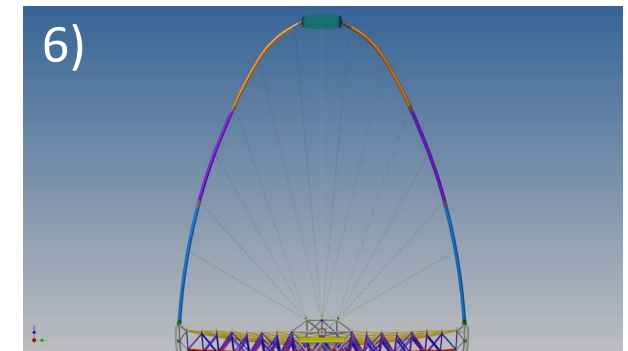
Install azimuth structure



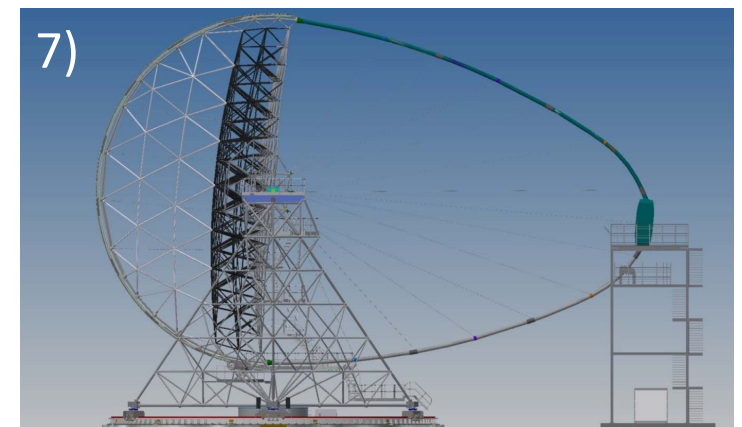
Mount dish structure and assemble elevation sub-structure/ mount mirrors



Assemble the camera supporting structure



Mount the camera supporting structure



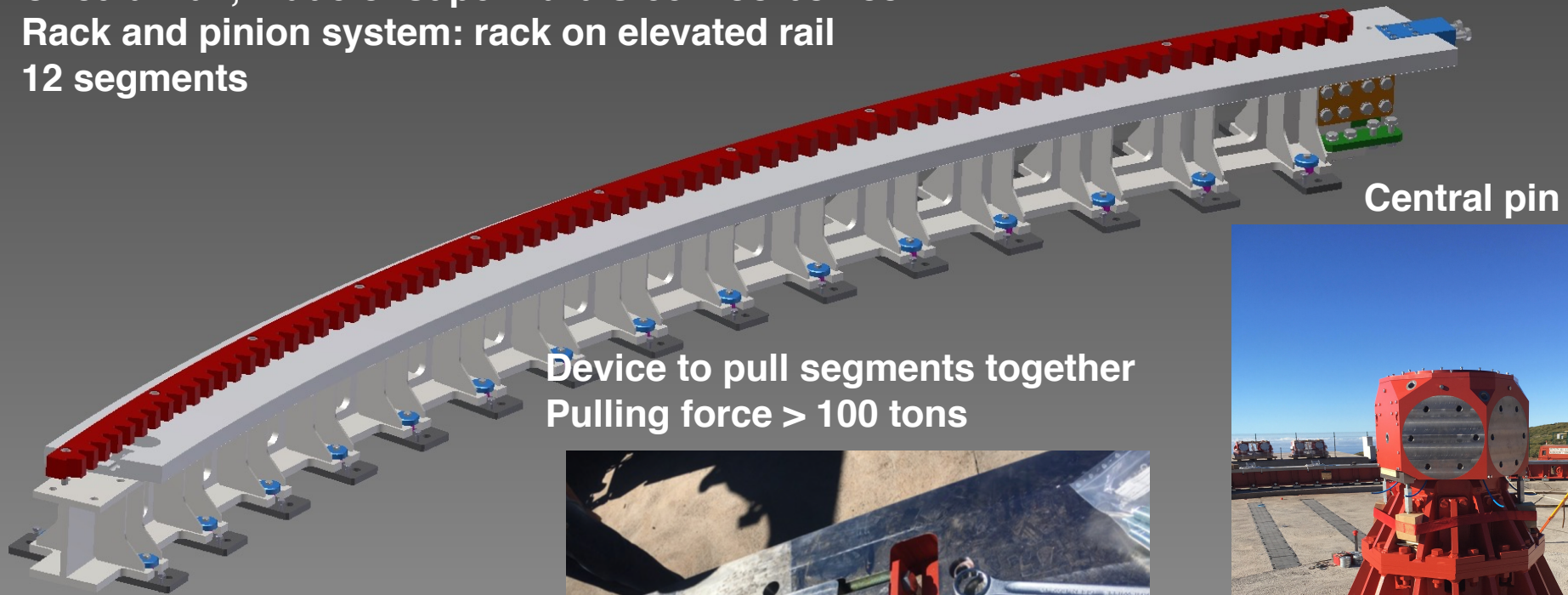
Install the camera access tower and the camera



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LST Mechanics: Rail and central pin

- Circular rail, made of super hard steel Toolbox 33
- Rack and pinion system: rack on elevated rail
- 12 segments



Device to pull segments together
Pulling force > 100 tons

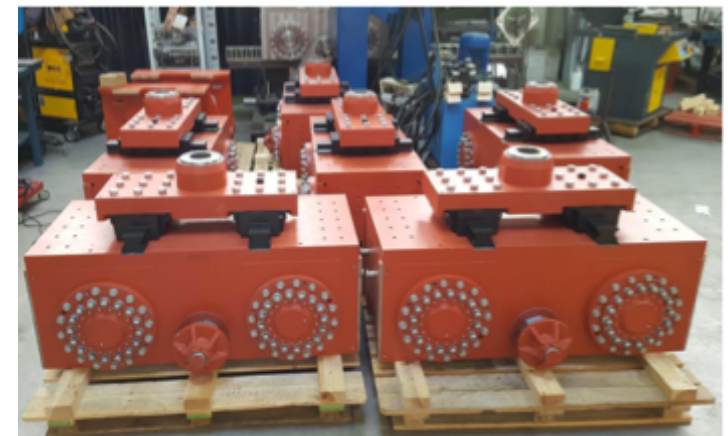
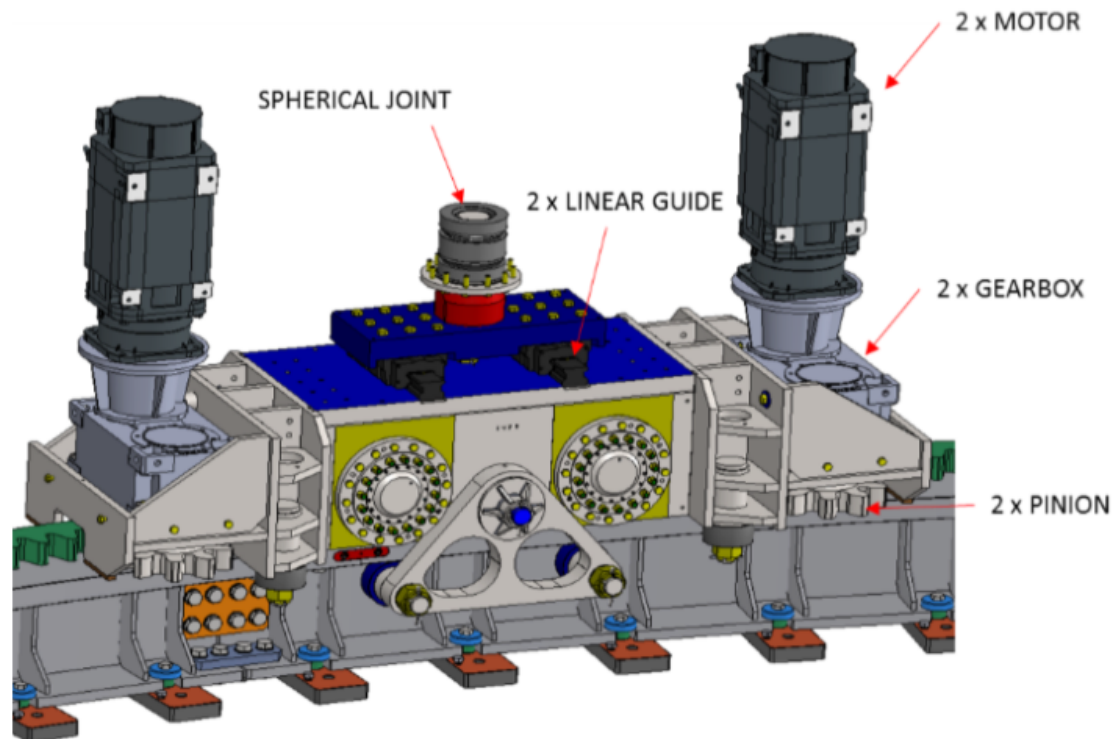




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LST Mechanics: Bogies

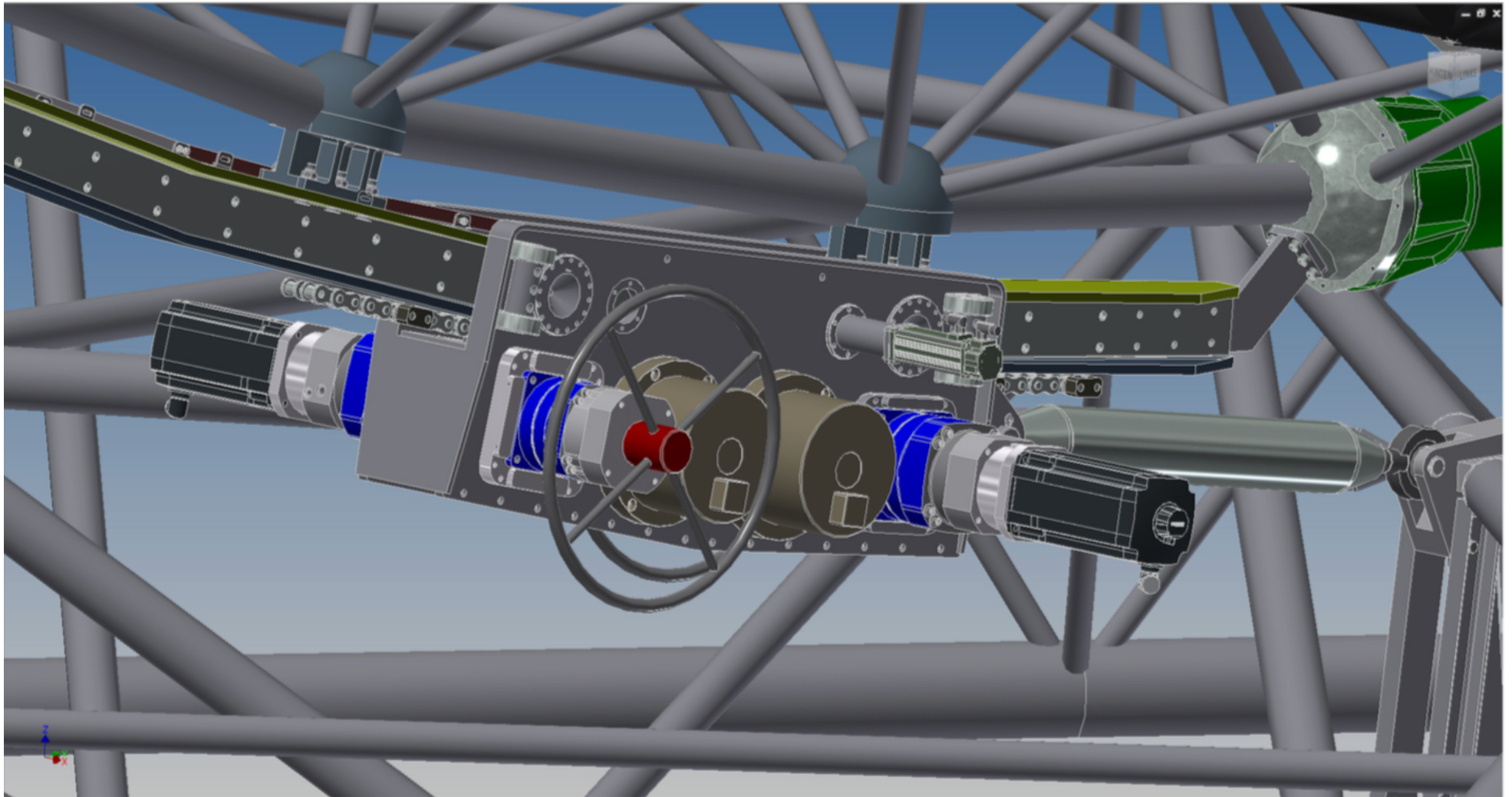
- 6 bogies, 2 of them heavy holding motors, under bearings
- All bogie nodes installed on linear guides to allow radial displacement
- Only heavy bogies are locked





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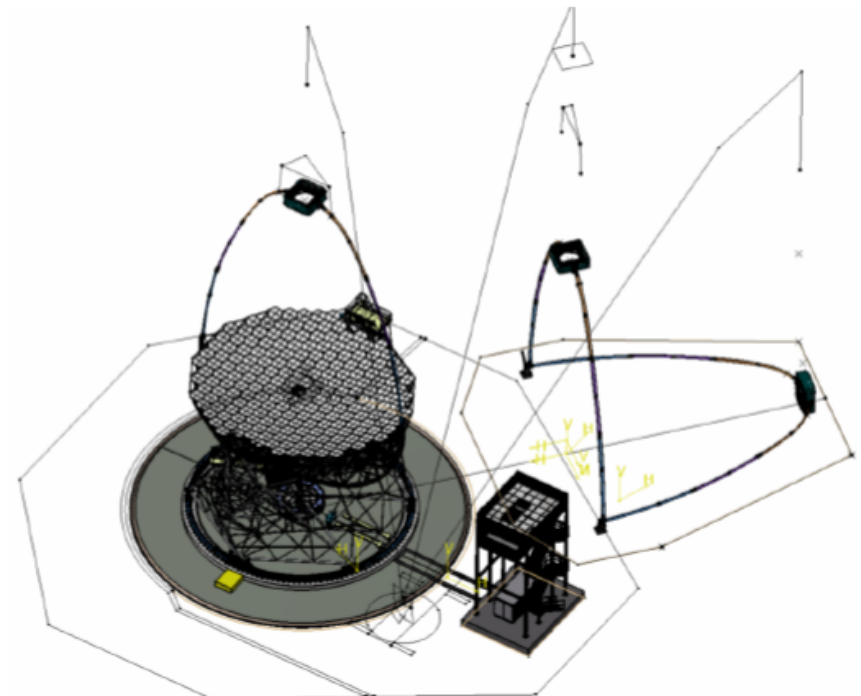
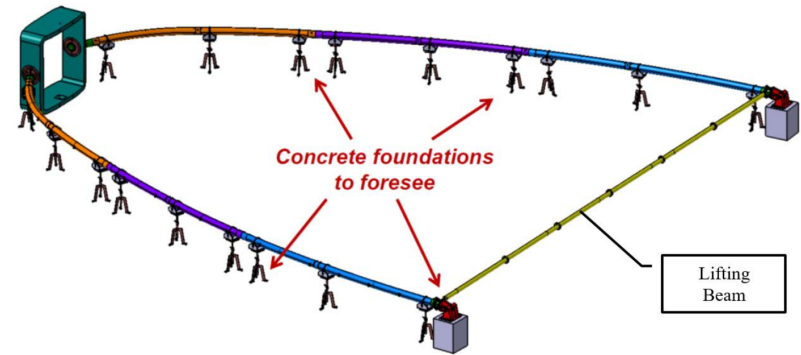
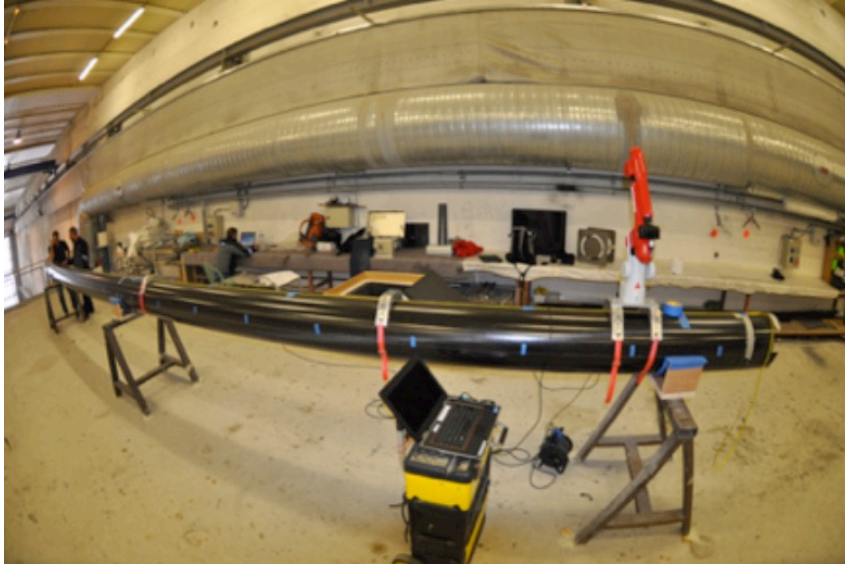
LST Mechanics: Elevation Drive Support





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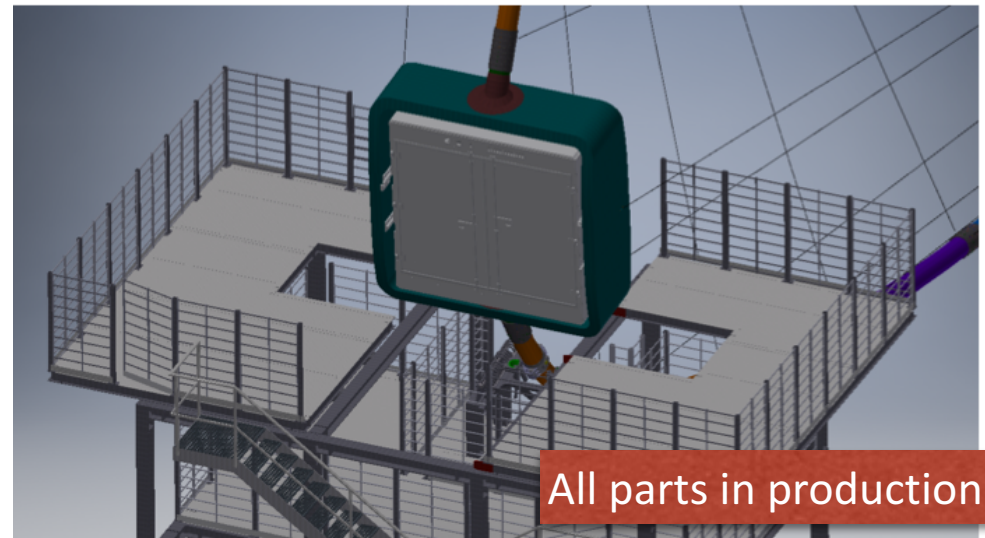
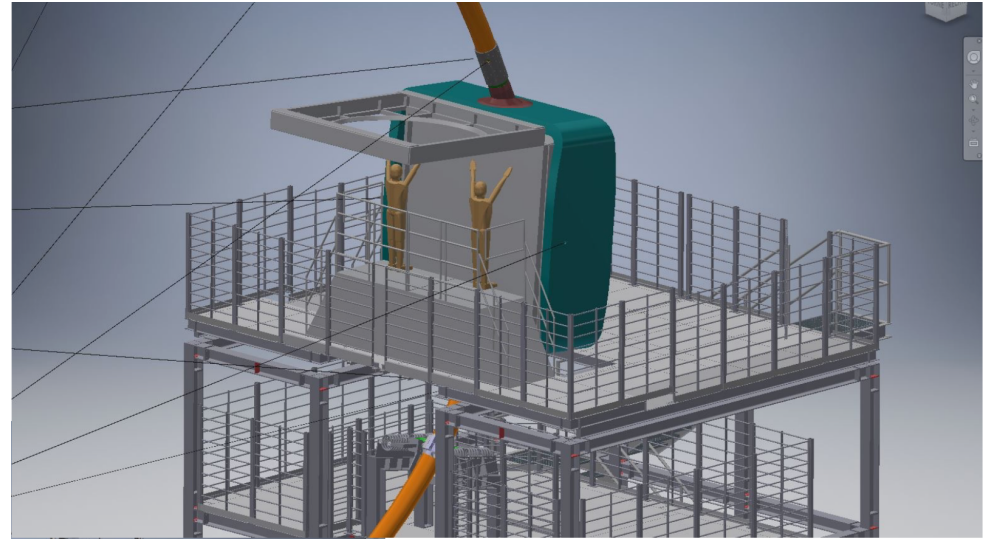
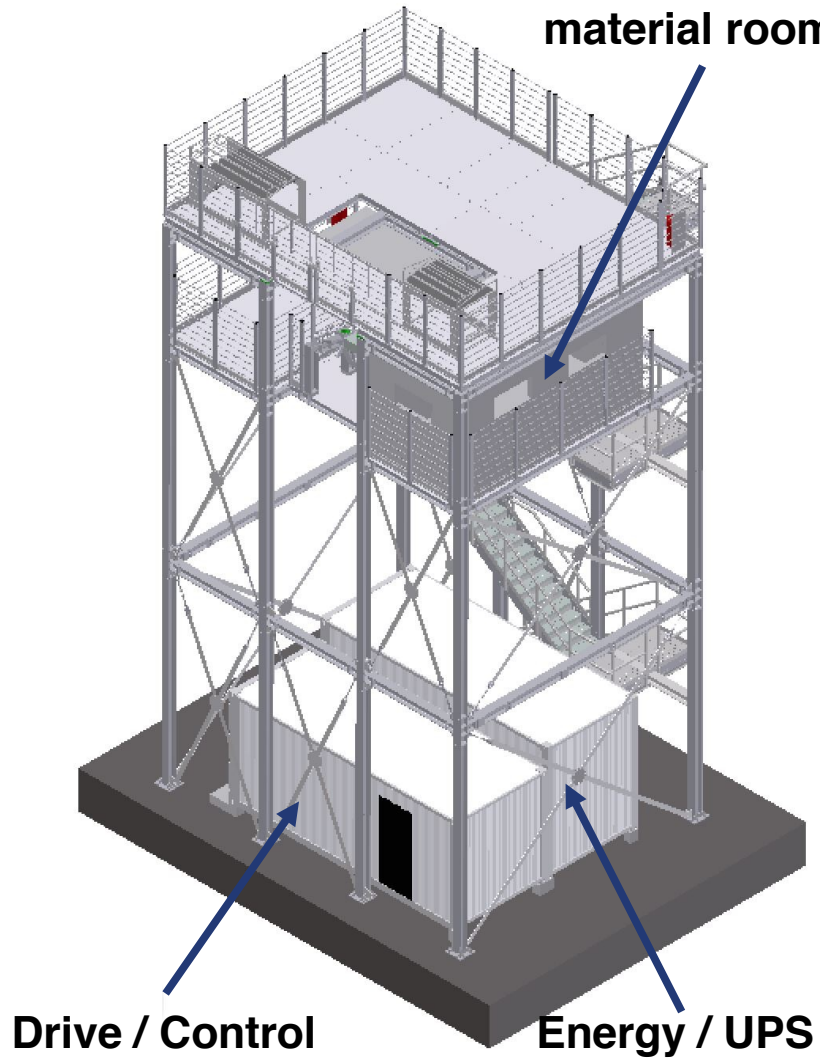
LST Mechanics: Camera Supporting Structure





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LST Mechanics: Camera Access Tower





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LST Optics: Mirror Production

High reflectivity, high durability

Developed last 6 years

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

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



Shipping after quality check

FY 2016 : LST1 Mirrors (200 units)

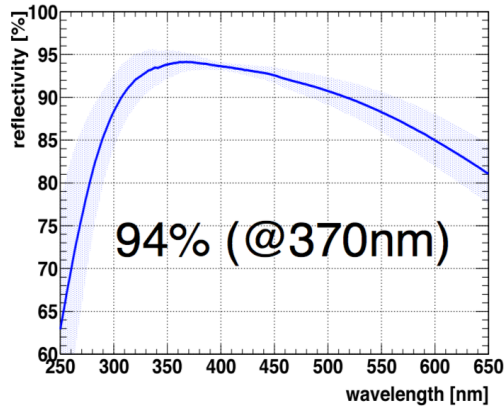
FY 2017 : LST2-4 Mirrors (600 units)



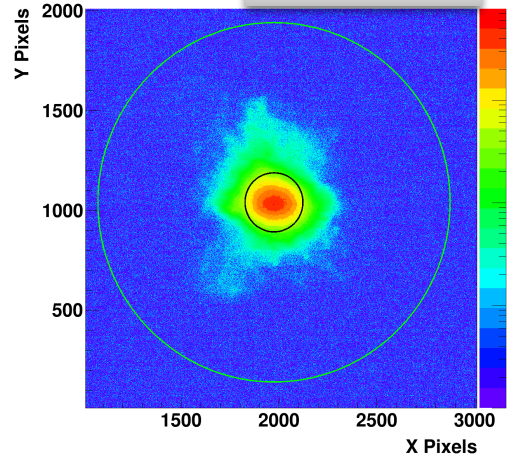
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LST Optics: Mirrors

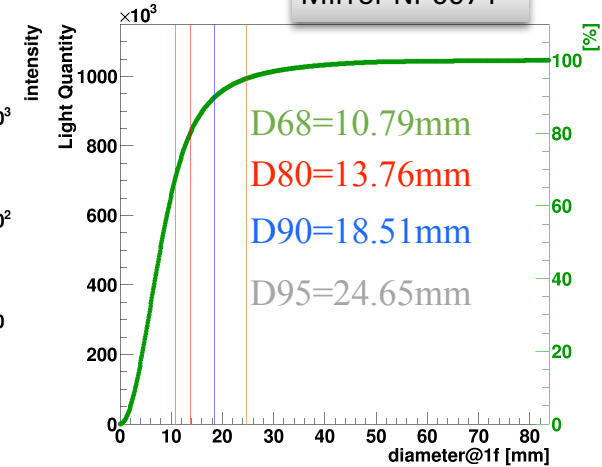
Mirror coating: Sputtering
(Cr+Al+SiO₂+HfO₂+SiO₂)



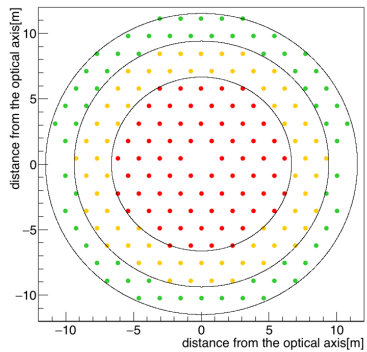
Mirror Nr 0074



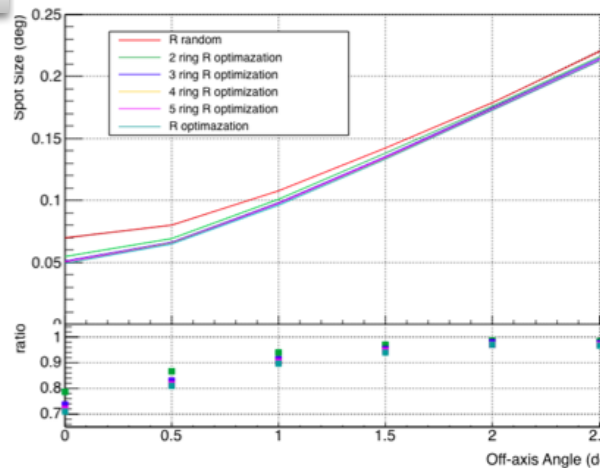
Mirror Nr 0074



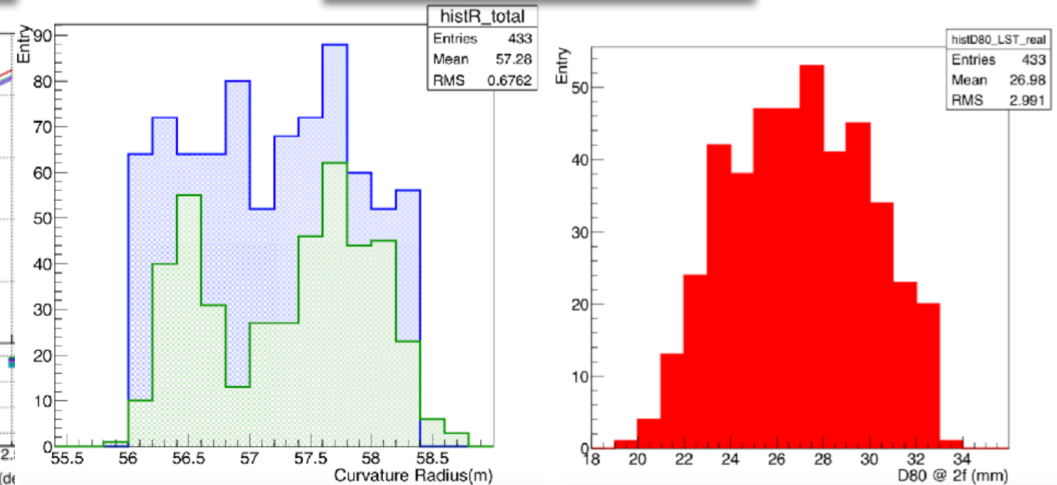
3-section arrangement



Differences in off-axis PSF

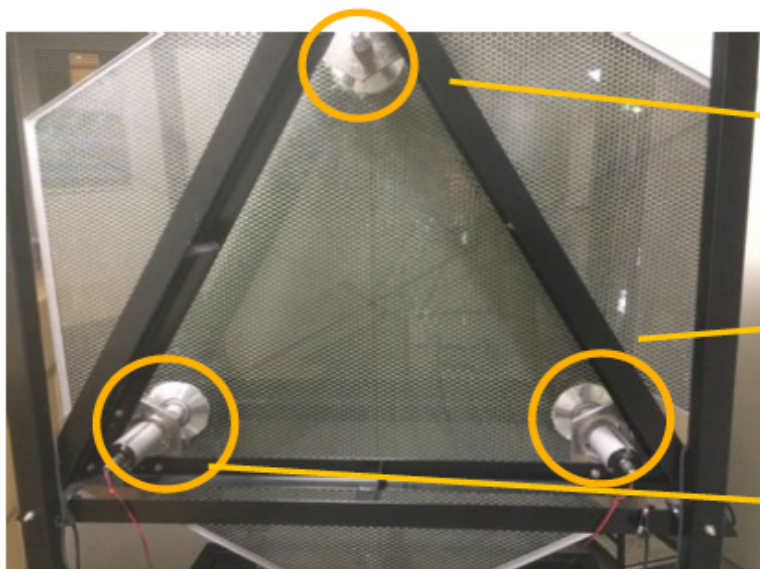


Measured mirrors so far

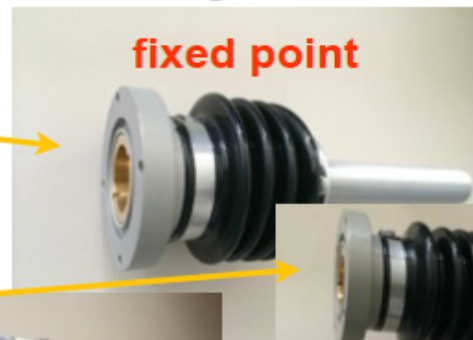


LST Optics: Actuators and CMOS Camera

Introduction : Devices of AMC system



actuator
(1-axis free)



fixed point

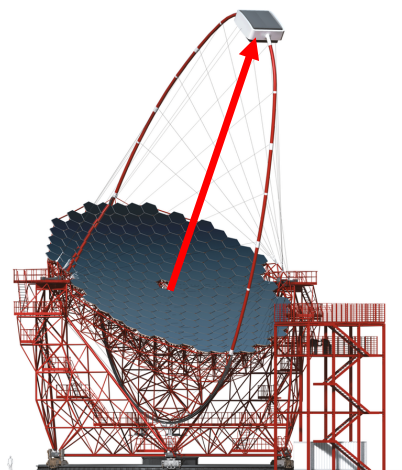


actuator

Zurich
Actuators



CMOS camera (Imaging Source
DMK023GM021) + IP67 hood

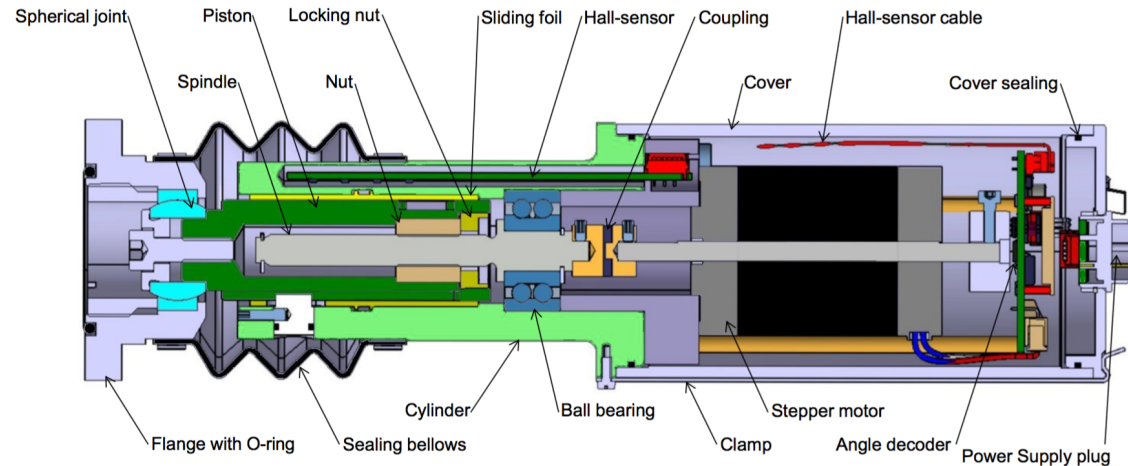


- Two Optical Axis Infrared Laser shoot the screen.
- CMOS cameras monitor the laser spots.
- Mirrors change autonomously the direction according to the given laser position



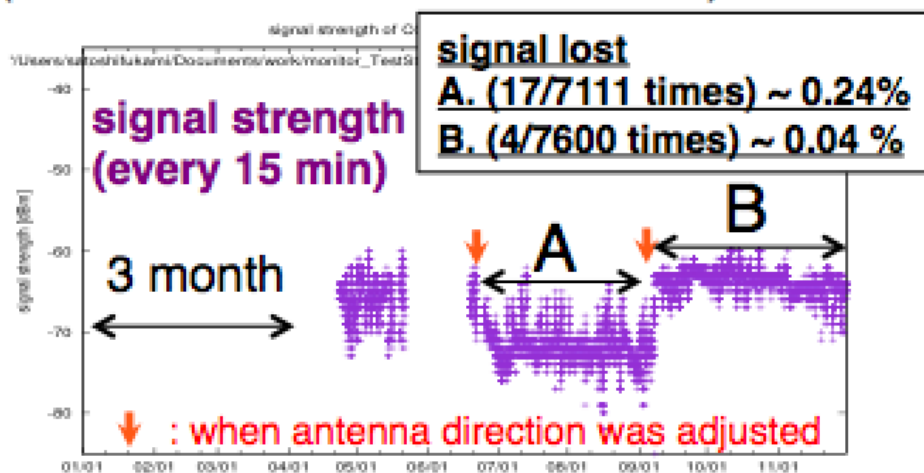
cherenkov
telescope
array

LST Optics: Active Mirror Control

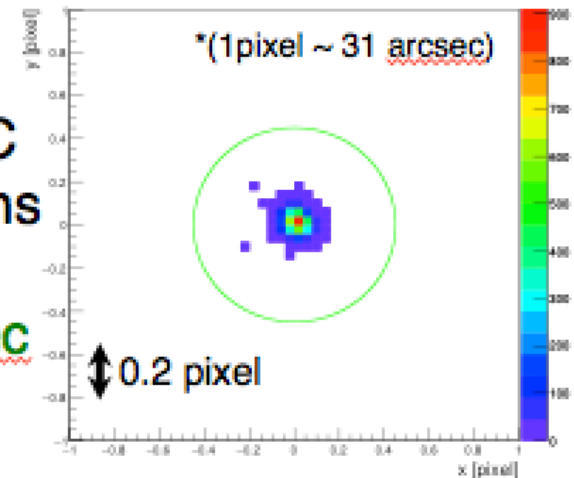


wireless communication
(actuator A: the most distant one)

~5000 AMC trials (one whole night)



residual
after AMC
corrections
Green:
(14 arcsec
in radius)



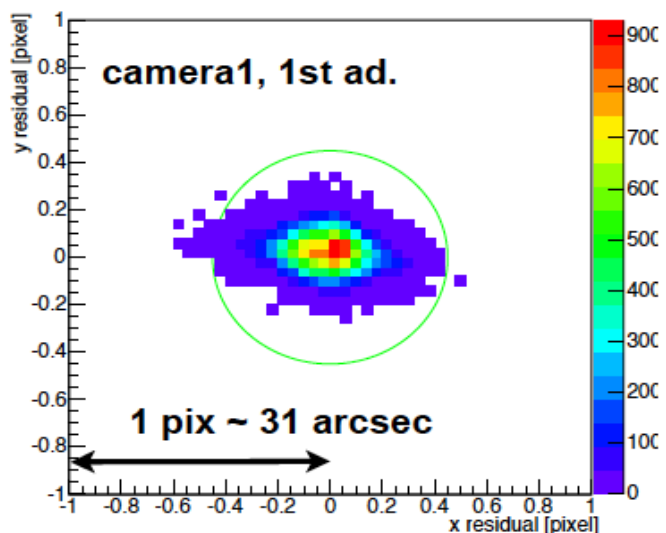
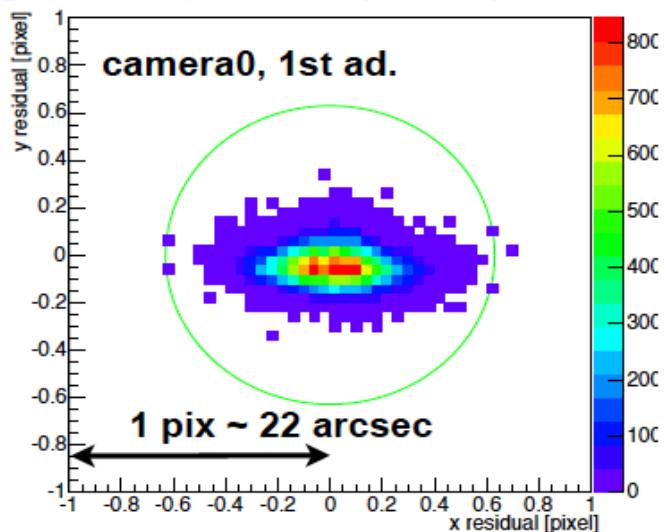


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AMC precision test with the test structure at MPI

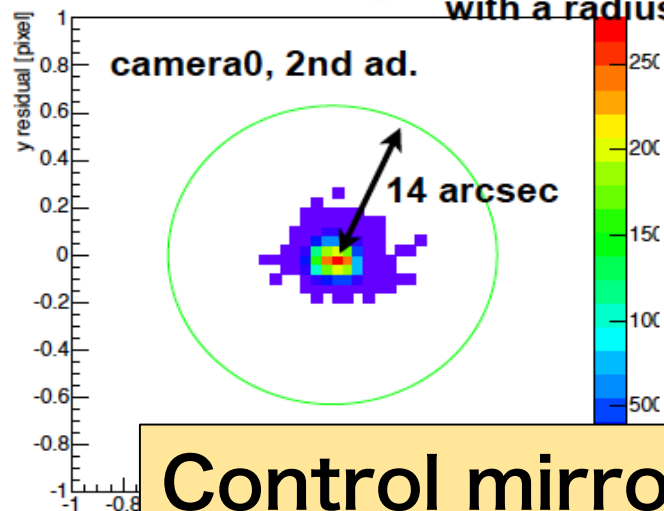
First adjustment

- 7 nights total plots of spot displacement

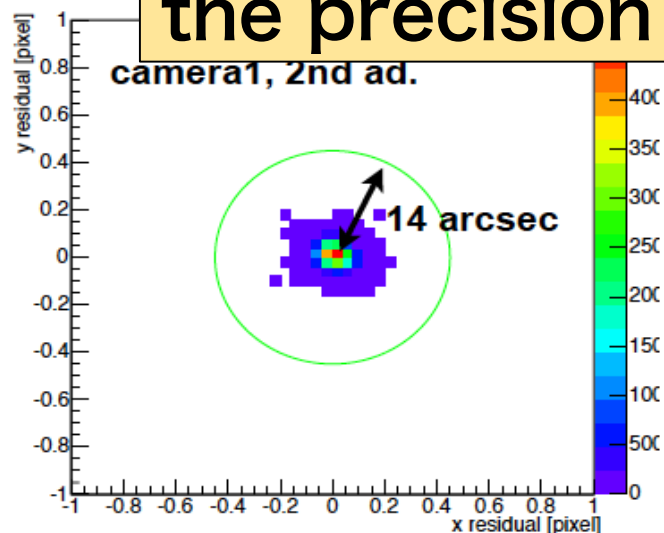


Second Adjustment

○ : requirement circle
with a radius of 14 arcsec

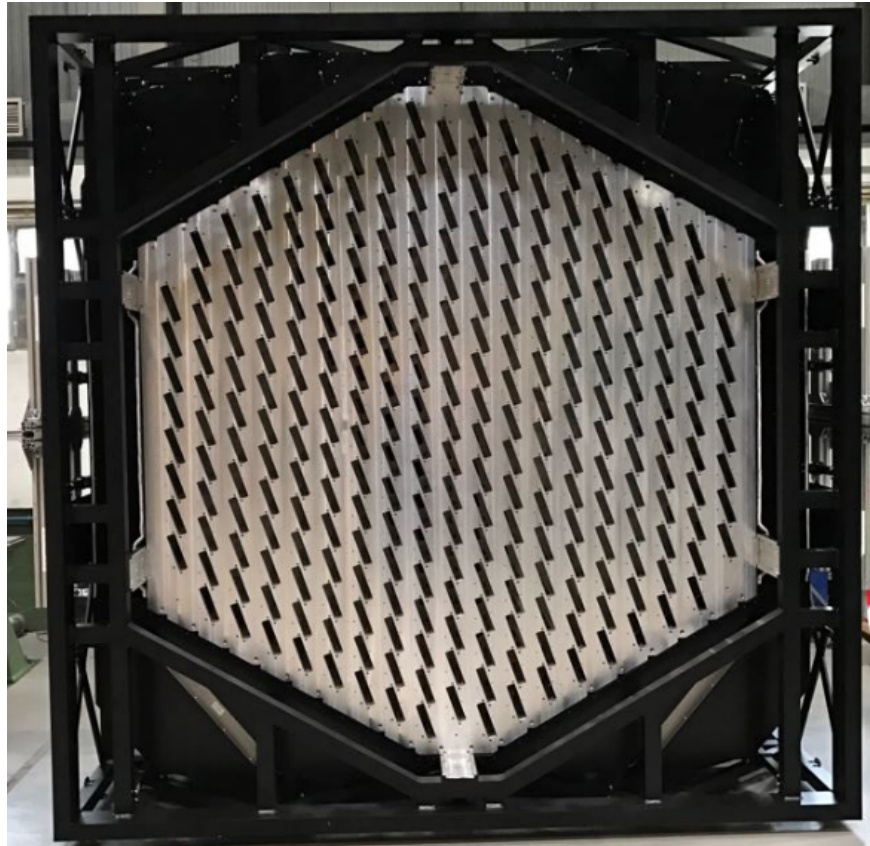


Control mirror directions with the precision of < 5arcsec



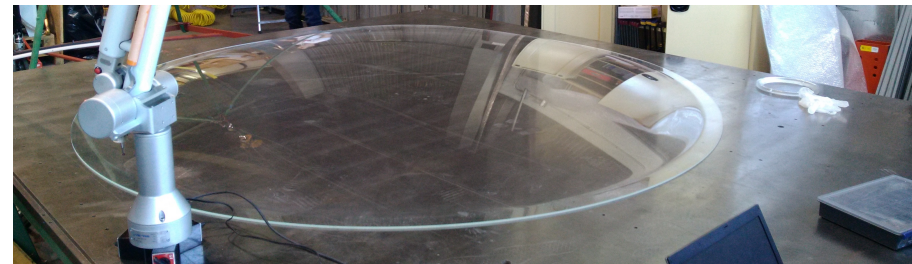
Camera Mechanics

Cluster Holder & Tubular structure



Enclosure

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



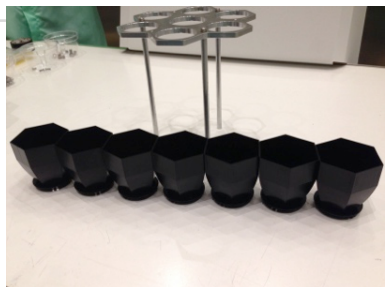
Entrance Window



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Pixel module assembly at IAC Tenerife

ICRR, INFN, KYOTO, IAC



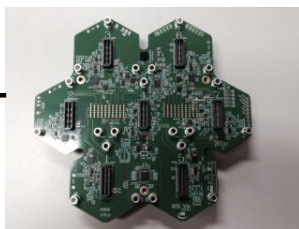
7 LGs

+



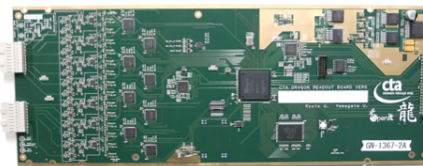
7 PMTs

+



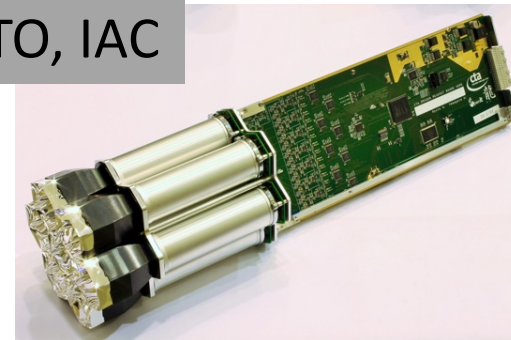
SCB

+



Dragon board

=



FPI module



Module assembly



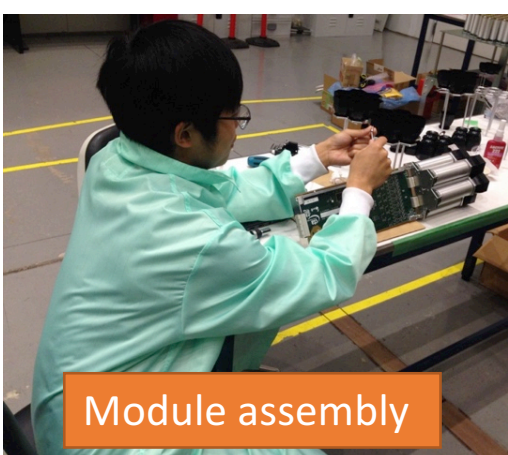
19 tested modules



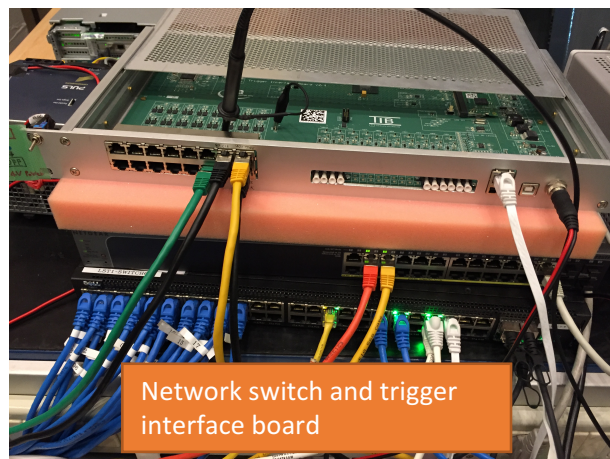
Trigger back planes

265 modules/ Tel.
needed.

270 modules are
assembled @ IAC



Module assembly



Network switch and trigger
interface board



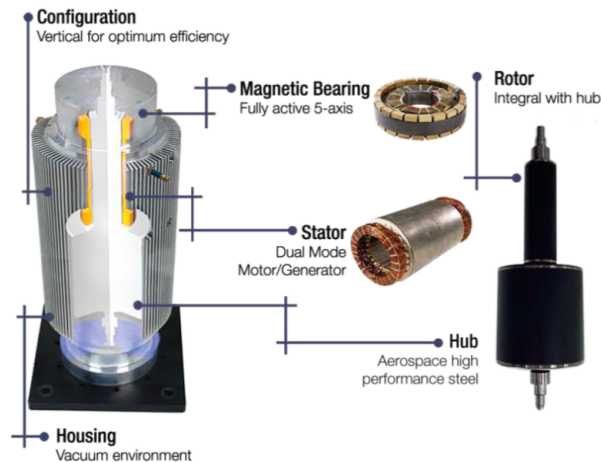
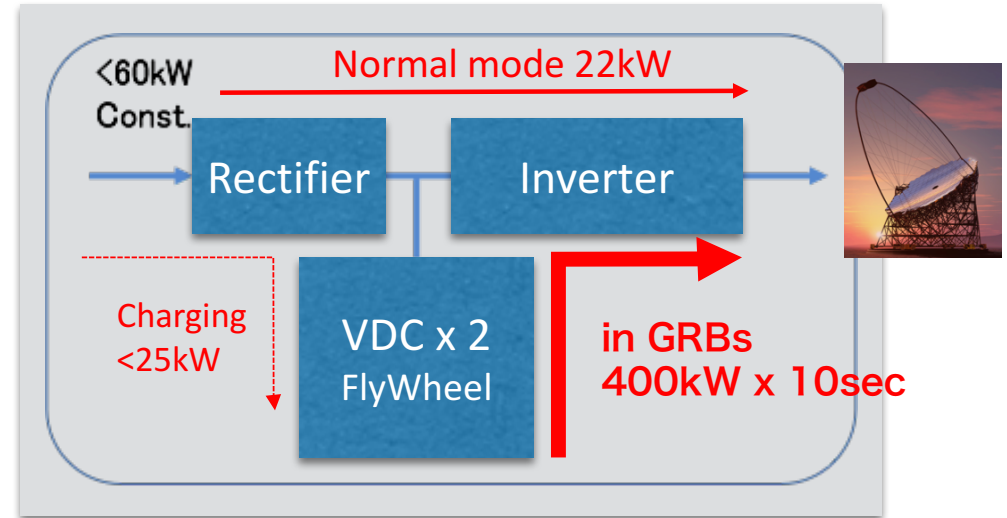
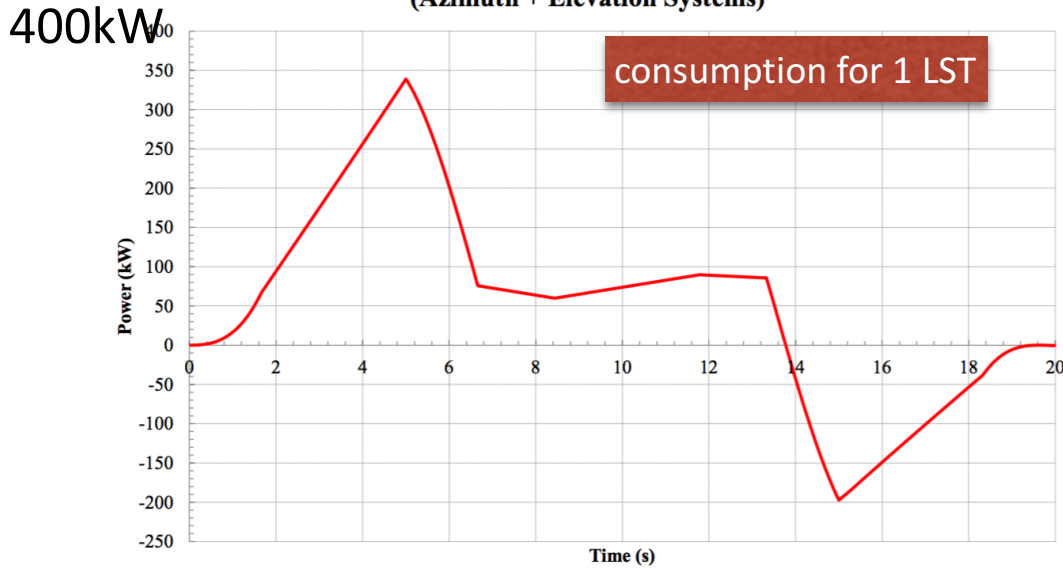
Camera server



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LST: Drive power supply with the support by PO

LST total Power during GRB alert with 60 km/h wind
(Azimuth + Elevation Systems)



- 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

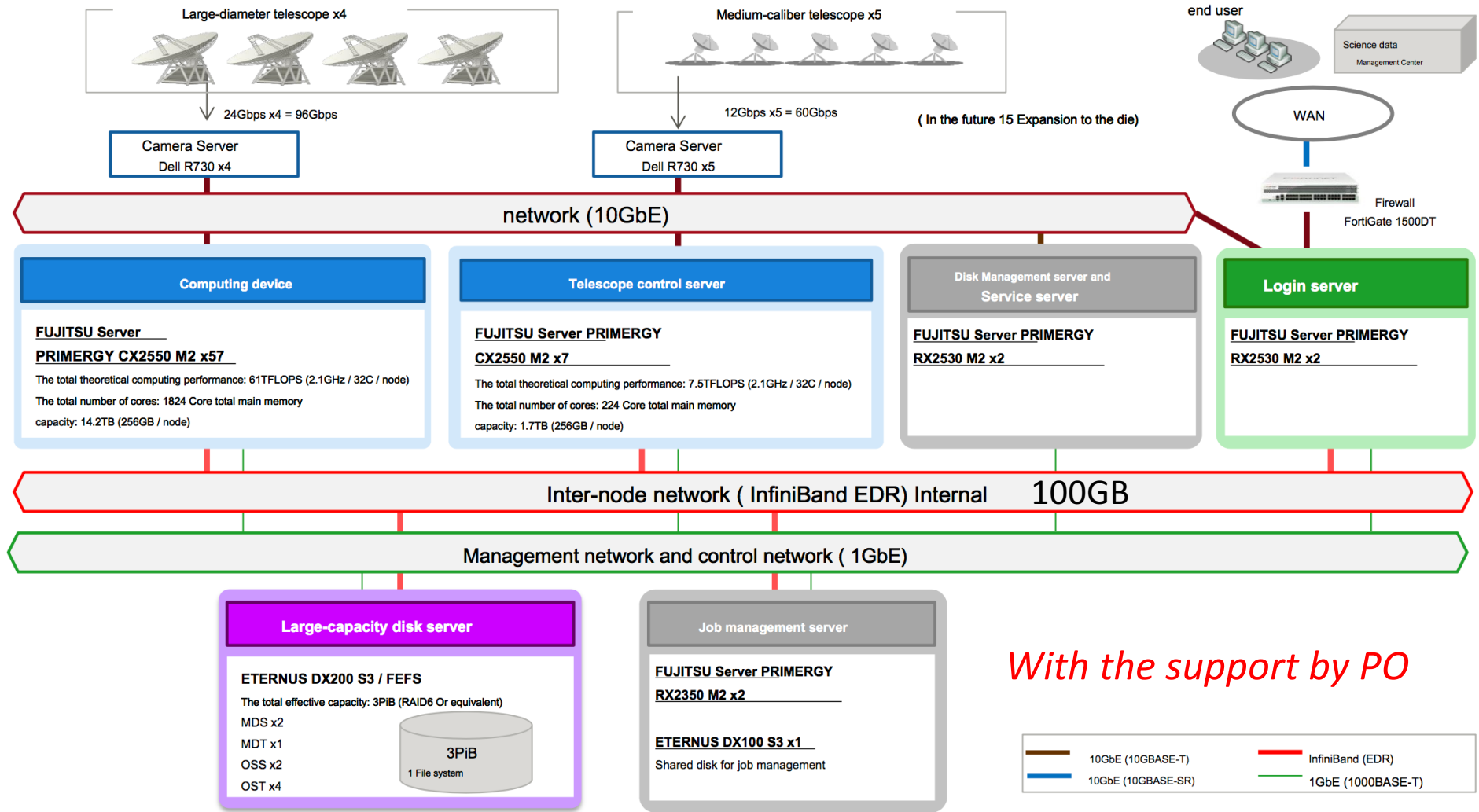
CTA North Computing System 2000 cores, 3PB storage

1.1 The entire system configuration diagram



The total number of cores: 2048 core (Computing device: 1824 core + Telescope Control Server: 224 core)

The total main memory capacity: 16TB Storage effective capacity: 3PiB





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telescope
array

We are building CTA-LSTs in North

- CTA LST-1 will have the first light in the early summer 2018
- LST2-4 will be constructed in FY2018-FY2020.
- We start the engineering run with LST1 in 2018 and the early operation with the array of LST1-4 in 2020 in La Palma, Spain
- The construction of LST5-8 is planned in 2021-2024 at Paranal, Chile

