

Development of the CTA/LST telescope control system

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Cherenkov Telescope Array project



The largest Cherenkov observatory ever built

~1500 scientists and engineers

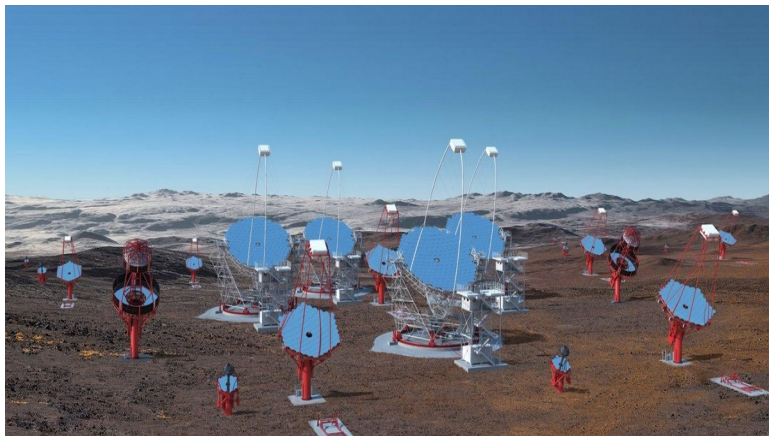
~200 institutes

31 countries



Large international effort

Southern site (Chile)



Layout: 4 large-sized telescopes
25 medium-sized telescopes
70 small-sized telescopes

Northern site (Canary Islands)



Layout: 4 large-sized telescopes
15 medium-sized telescopes

Extremely rich scientific outcome is expected

Large Sized Telescope (CTA / LST)



**Stereoscopic system of 4 IACTs,
at La Palma, Spain**

Part of CTA/North array

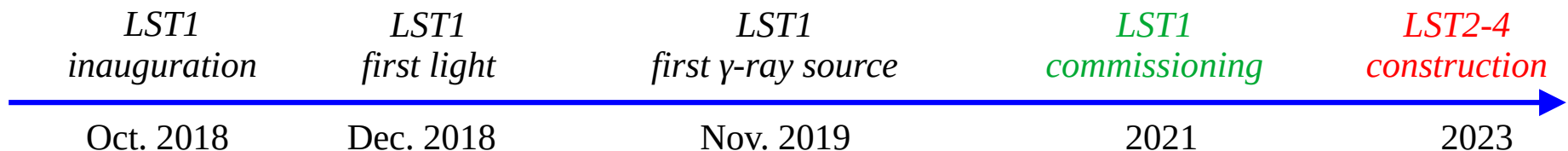
Telescopes: four D=23m

Site: La Palma (Canary Islands)

Energy range: 20 GeV – above 3 TeV

Field of view: 4.3 deg

Big contribution of Japan and ICRR group



**This project:
development of the control system for LSTs**

Development of the CTA/LST telescope control system



Who PI: Ievgen Vovk (ICRR) Budget: 380,000 + 500,000 Yen
Collaboration between ICRR and University of Geneva (Switzerland)

Where CTA-North site – La Palma, Canary Islands, Spain

What (goals for FY2020)

Work package 1 *Automatic Mirror Control*

- develop emulator environment (for testing)
- add “dynamic adjustment” functionality
- develop high-level control interface
- deploy updated version on-site

Work package 2 *Telescope Control Unit*

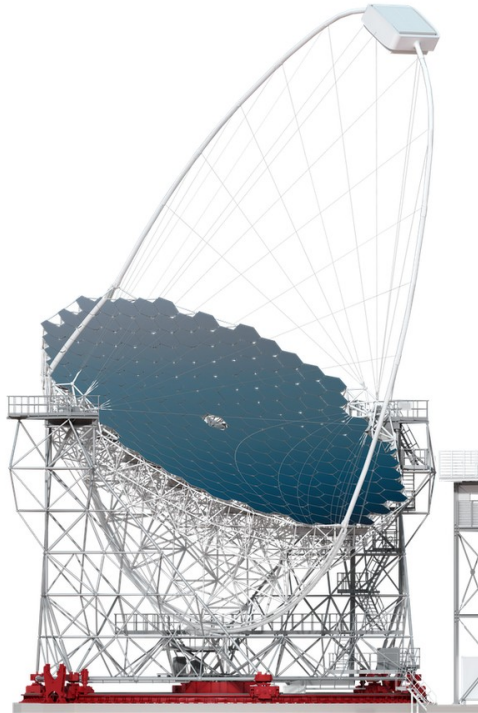
- prepare the subsystems environments for TCU structure block testing
- develop high-level control interfaces following the State Machine paradigm;
- deploy on-site

Many travels canceled due to Covid-19 – had to find a way to work remotely

WP1: CTA/LST1 mirror control



AMC - Active Mirror Control



Credit: CTA website

Goal:

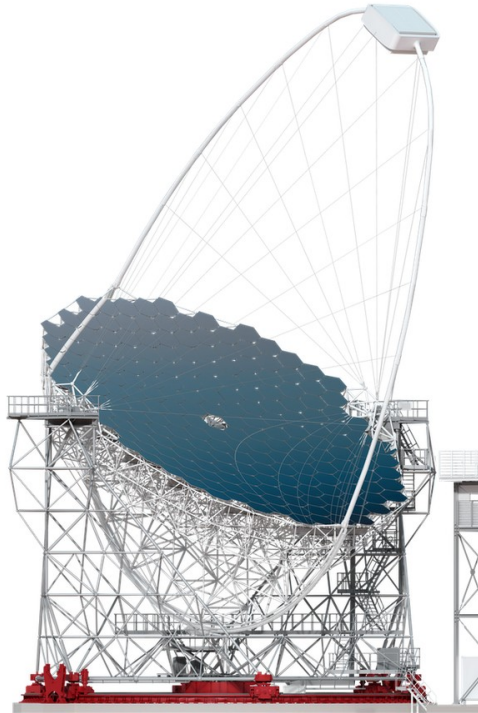
- focus EAS light onto the LST camera;
- adapt to LST structure deformations with pointing and time.

How it works:

- mirror positioning algorithms:
 - look-up tables (fixed altitudes, works);
 - **interpolation (any altitude, this project)**;
 - automatic positioning (future);
- control software:
 - 16 servers in the dish + 1 central server
 - **dedicated control GUI/CLI (this project)**
 - **telescope control integration (this project)**

WP1: CTA/LST1 mirror control

AMC development progress (this project)



Credit: CTA website

Goal:

- dynamic adjustments;
- telescope control integration

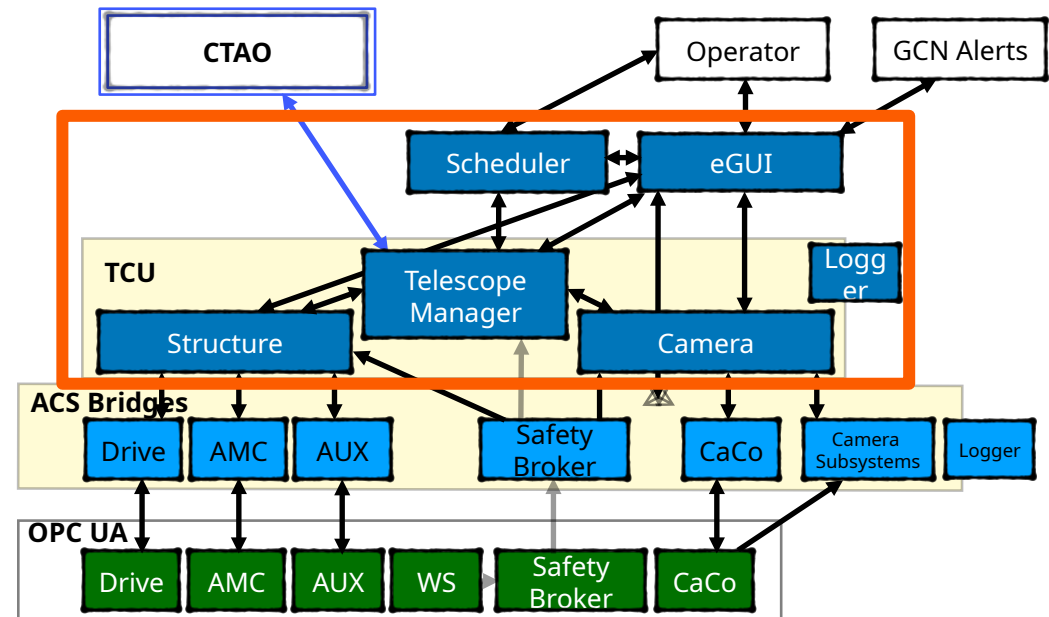
What was done:

- development pipeline established:
 - version control, testing, deployment;
 - redesign following CTA standards;
- “interpolation” mode added (under testing);
- telescope control integration:
 - AMC control interface;
 - real-time telemetry;
 - automatic daily status reports.

WP2: telescope control unit (TCU)

Telescope control unit (TCU):

- combines interfaces to all subsystems
- implements control logic and subsystem orchestration
- provides a simple telescope control interface to CTA observatory
- includes a web-based user interface



Crucial for CTA/LST1 commissioning
(remote / robotic operation – also from ICRR)

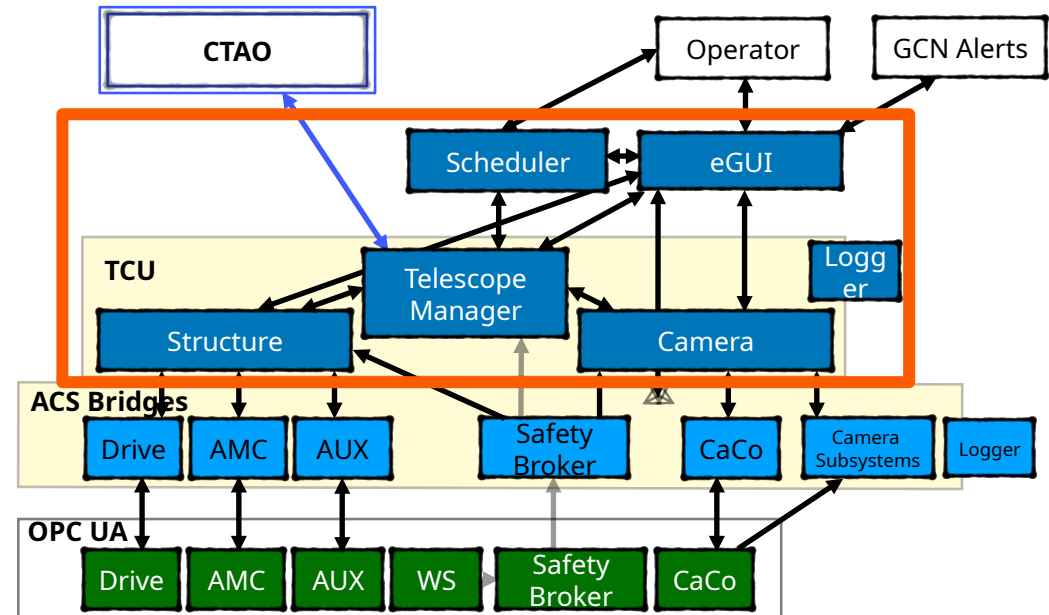
Crucial for CTA array control
(high-level management of telescopes)

TCU implementation performed within this project

WP2: telescope control unit (TCU)

What was done:

- camera / drive / AMC integrated
- high-level managers for “structure” and “camera” added
 - control logic
 - calibration operations
- commissioning database set up
 - settings
 - robotic operations log
 - subsystems telemetry
- user web-interface created
 - (multi)password-protected
 - access from anywhere
- deployment pipeline created
 - start up with a single command



**TCU runs on-site since mid-2020
(testing phase)**

Control software deployment / usage



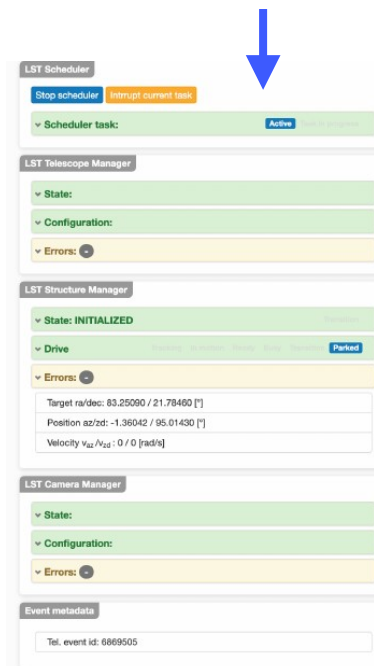
AMC:

- deployment:
 - build recipes / scripts
 - software containers
- usage:
 - daily basis
 - interpolation accuracy tests
 - telemetry data for experts

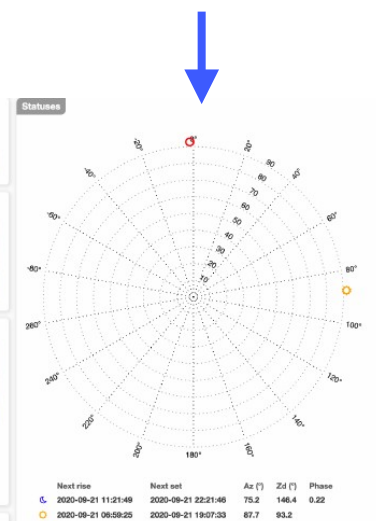
TCU:

- deployment:
 - software containers
- usage
 - in parallel to “engineering” software (for testing)
 - remote operations (Jan 2021 on)

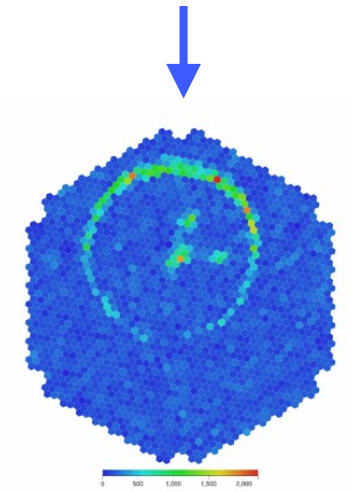
Drop-down menus with info and control



Pointing overview



Camera overview



September 2020

Time	Event	Target	Track	RA	DEC	Az	Zd	Phase
00:06 - 00:09	[unpark]							
00:47 - 00:56	[skyTarget] Mirach	(track ra = 17.43250, dec = 35.62083)				75.2	146.4	0.22
00:56 - 01:11	[skyTarget] Enif	(track ra = 326.04625, dec = 9.87500)						
01:11 - 03:03	[fixedPosition] parkout	(az = -1.36600, zd = 74.99000)						
03:03 - 03:37	[skyTarget] Crab	(track ra = 84.01030, dec = 22.24256; target: ra = 83.63000, dec = 22.01400; wobble: custom0.352, 0.2291)				87.7	93.2	

Observation schedule

Prospects for FY2021



AMC:

- automatic (real-time) positioning
- complete control interface
- improve error handling

2022

2021

TCU:

- complete subsystems integration
- error handling and safety logic
- overall telescope “manager” interface
- target-of-opportunity handling
- review for LST2-4