



# The ASTRI Mini-Array

G. Tosti, P. Bruno  
for the ASTRI Project

**2<sup>nd</sup> TETIS WORKSHOP, 02-03 Feb 2023**

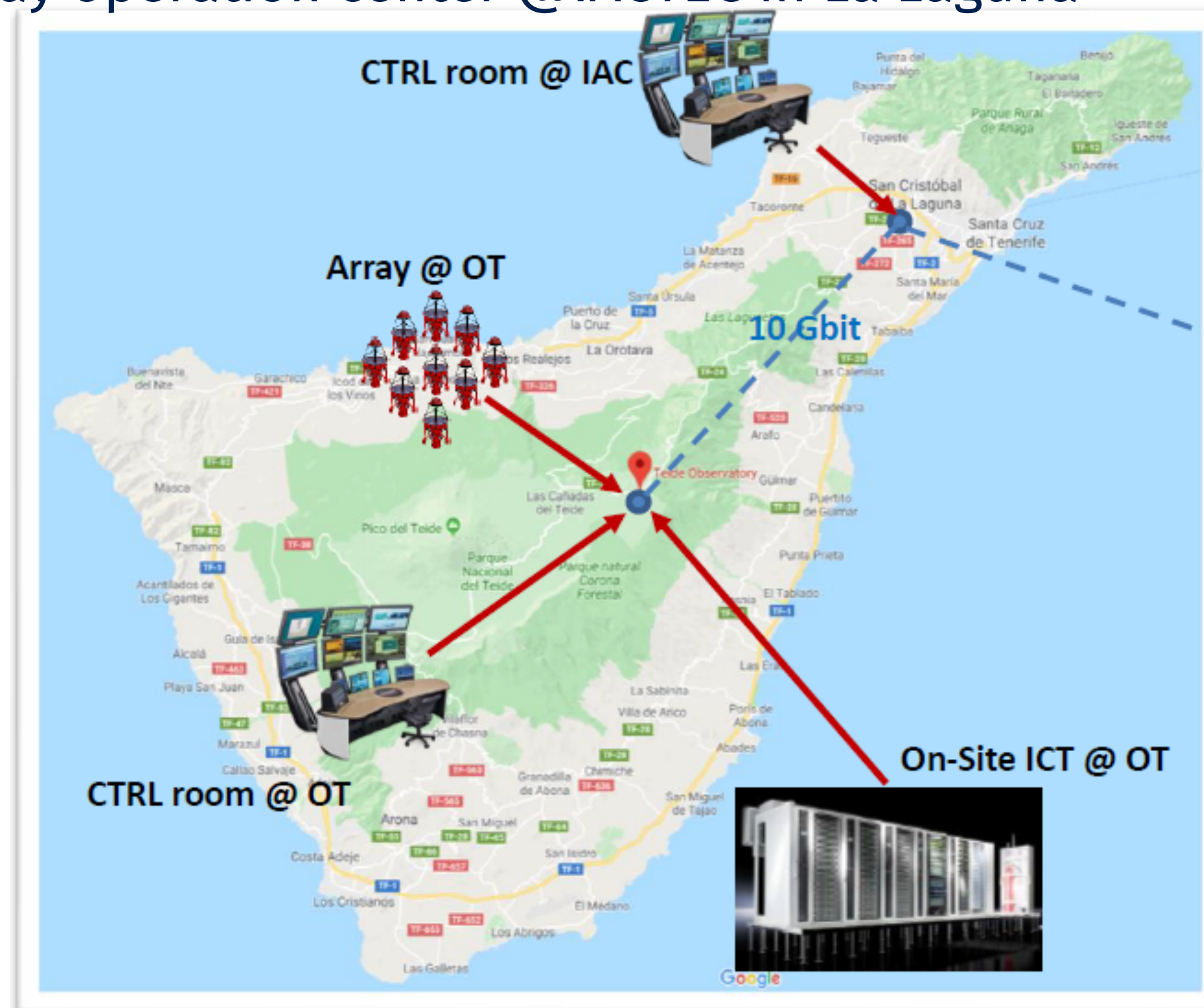




# The ASTRI Mini-Array

## The ASTRI Mini-Array in Tenerife

- Telescope Array & auxiliaries (Observatorio del Teide - OT)
- Local Control Room @ THEMIS building (OT)
- On site Data Centre @ IAC Teide Residencia (OT)
- Array operation center @IACTEC in La Laguna



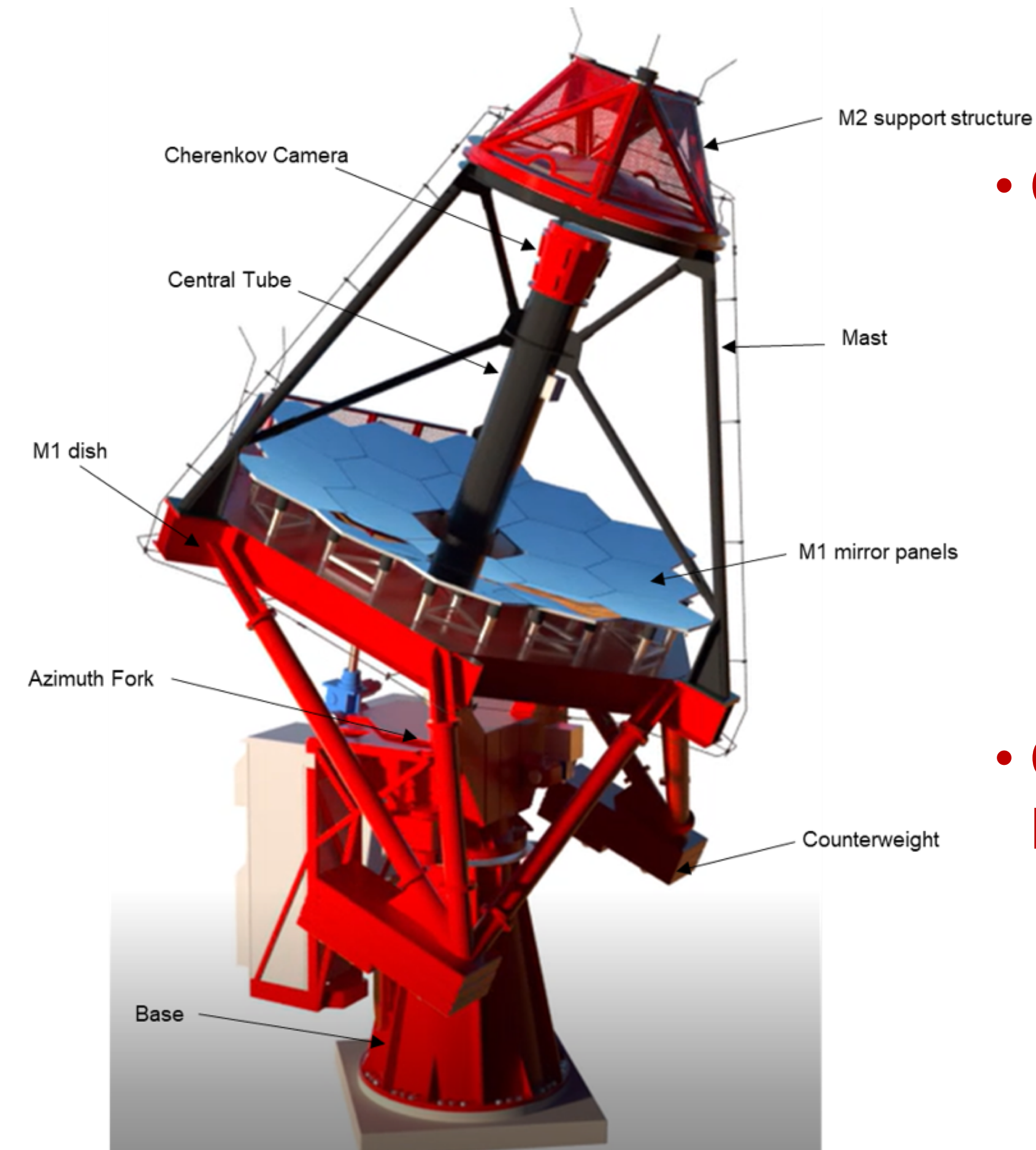
## The ASTRI Mini-Array in Italy

- Data Centre in Rome
- Remote Array operation centers





# ASTRI Mini-Array telescopes in a nutshell

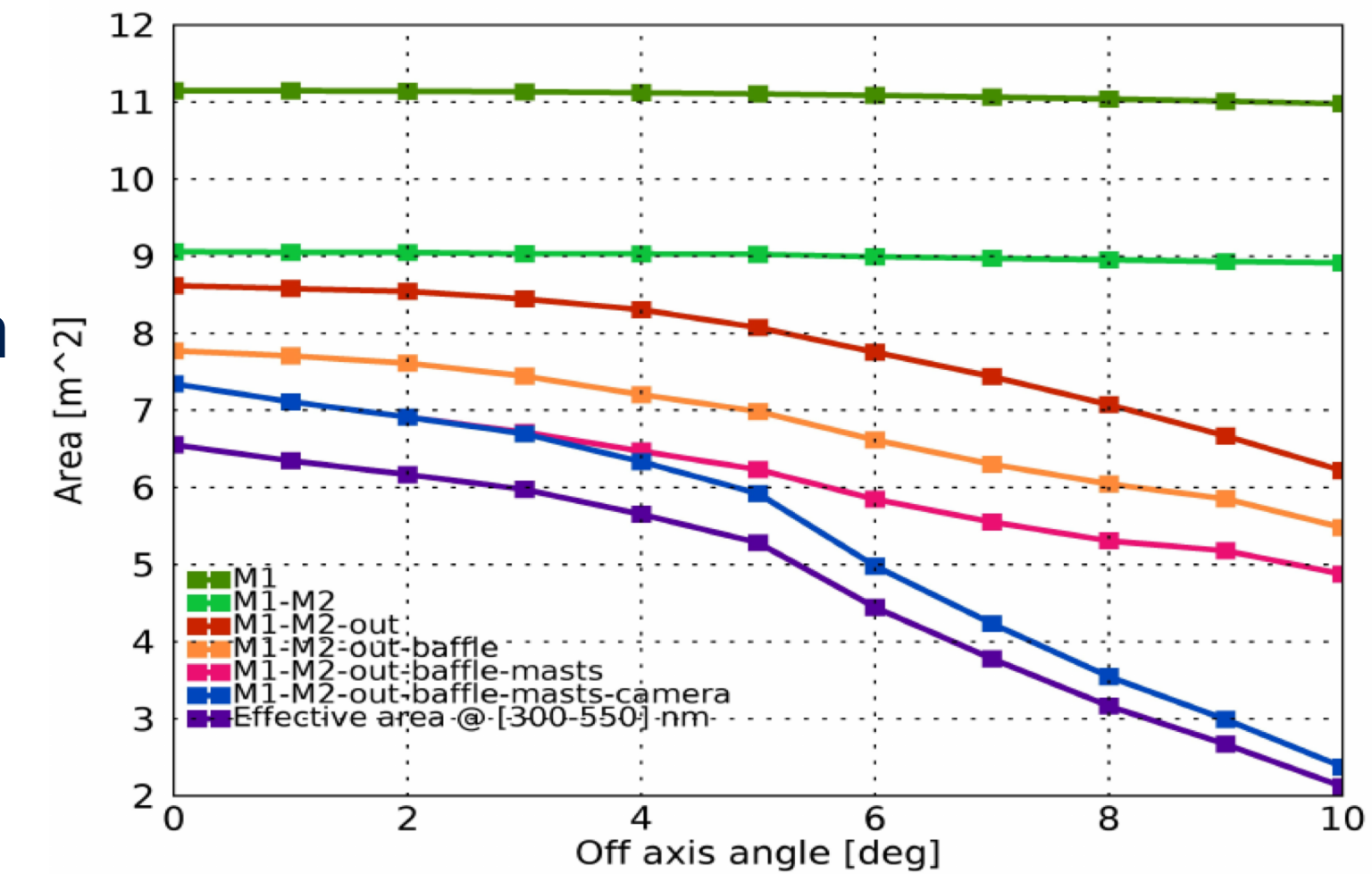


## • Opto-mechanics (EIE, MLT, Flabeg, ZAOT)

- Alt-azimuthal mount
- Modified Schwarzschild-Couder configuration
- Primary Mirror: 4.3 m (18 segments)
- Secondary Mirror: 1.8 m (monolithic)
- F-number: 0.5
- Average effective area  $> 5.0 \text{ m}^2$
- Optical PSF  $\leq 0.19 \text{ deg}$
- Post calibration pointing precision  $\leq 7 \text{ arcsec}$

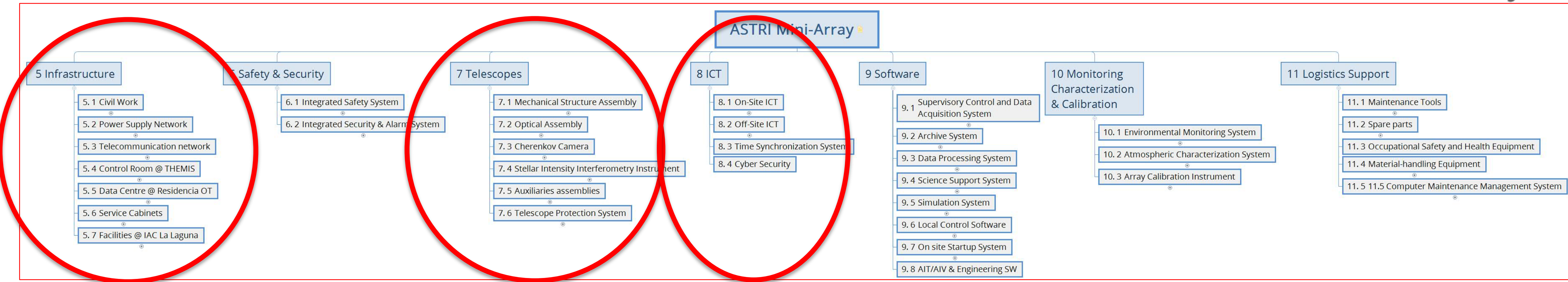
## • Cherenkov Camera (CAEN, EIE, NI, Hamamatsu, Weeroc)

- Front-end electronics based on CITIROC-1A ASIC
- SiPM sensors: 7x7 mm (series LV3 – 75  $\mu\text{m}$  pixel size)
- 2368 pixels (37 matrices of 8x8 pixels)
- Filter Window with dielectric coating
- Angular pixel size: 0.19 deg
- Field of View: 10.5 deg





# The ASTRI Mini-Array architecture: Product Tree



**Infrastructure:** composed by all those parts needed to make the observational site suitable to host the telescopes of the ASTRI Mini-Array.

**Safety & Security:** an independent system for the protection of people and site assets

**Telescopes:** include mainly the hardware used to collect and image Cherenkov light from air showers and the auxiliary assemblies needed to support this function.

**ICT:** includes all computing/storage hardware, the overall networking infrastructure (including cabling and switches) and all system services (operating system, networking services, name services, etc.) necessary on site and off site to control and monitor the array and to archive and analyse the scientific and engineering data.

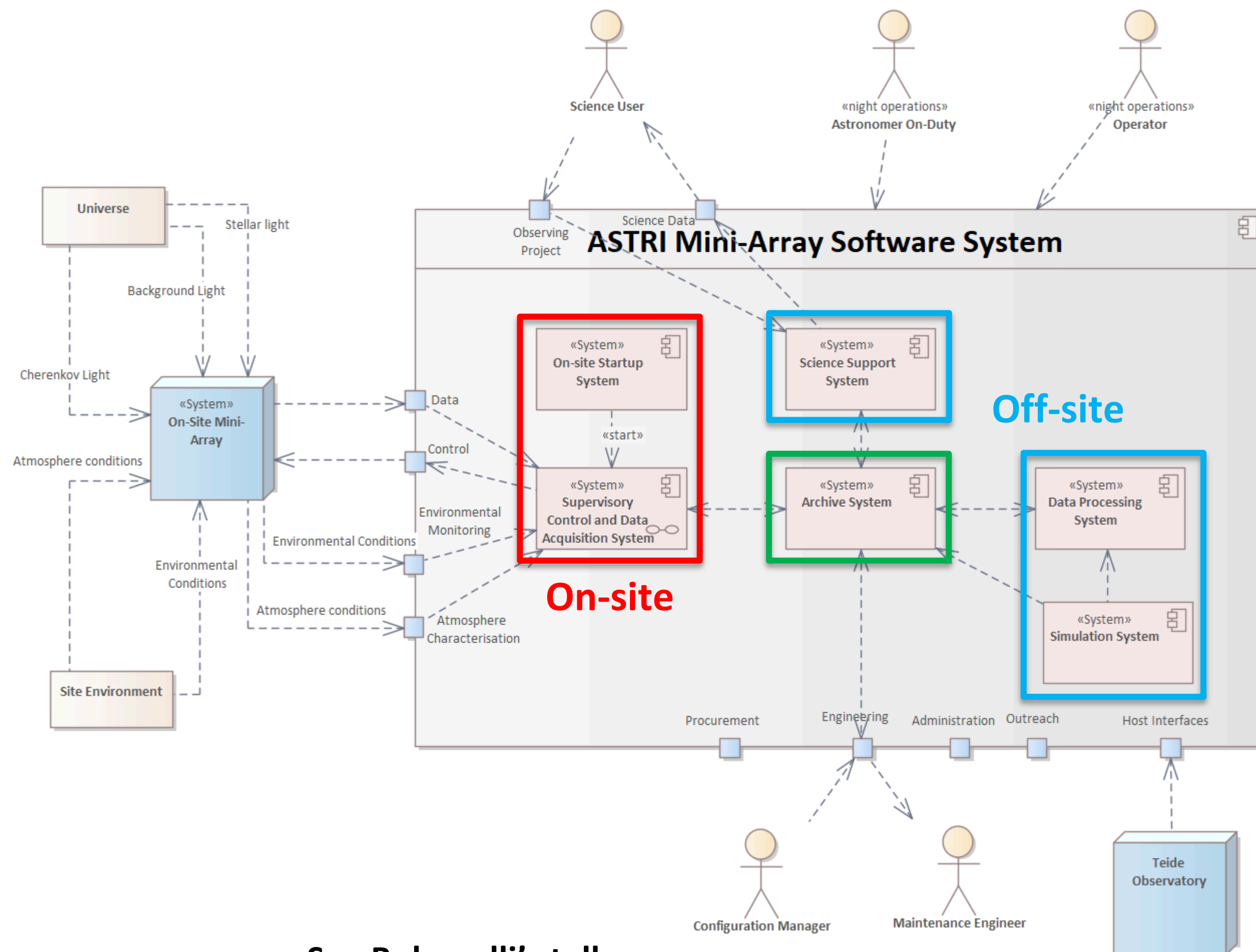
**Software:** The Mini-Array software will provide to the user a set of tools from the preparation of an observing proposal to the execution of the observations, the analysis of the acquired data online and the retrieval of all the data products from the archive.

**Monitoring, Characterization and Calibration:** the set of devices that allows the environmental monitoring the atmospheric characterization and the array calibration.

**Logistics Support:** includes all the hardware & software necessary for the preventive and corrective maintenance of the ASTRI Mini-Array.



# Software architecture: context diagram



See Bulgarelli's talk

- **Startup System.** The software to manage the sequence of the startup and shutdown of the critical on-site systems that have to be available before the start of the Mini-Array.
- **Supervisory Control And Data Acquisition (SCADA) System.** The software system devoted to control all the operations carried out at the Mini-Array site, including the startup of the Mini-Array system. SCADA is a central control system which interfaces and communicate with all equipment and dedicated software installed On-Site.
- **Archive System.** The software service that provides storage and organization for all data, data products, and metadata generated for and by the Mini-Array, and defined by the Mini-Array Data Models.
- **Data Processing System.** The software system used to calibrate and reduce the data acquired. This software is also used to check the quality of the final data products.
- **Science Support System.** The software system which provides the main point of access for the exchange of science-related data and information with the ASTRI Science Users, and which supports the whole science-related workflow, from the Observing Project submission to the access to the archived high-level Mini-Array science data products and the corresponding Science Tools to support data analysis.
- **Simulations System.** The software system that runs Monte Carlo simulations to provide simulated data for the development of reconstruction algorithms and for the characterization of real observations.



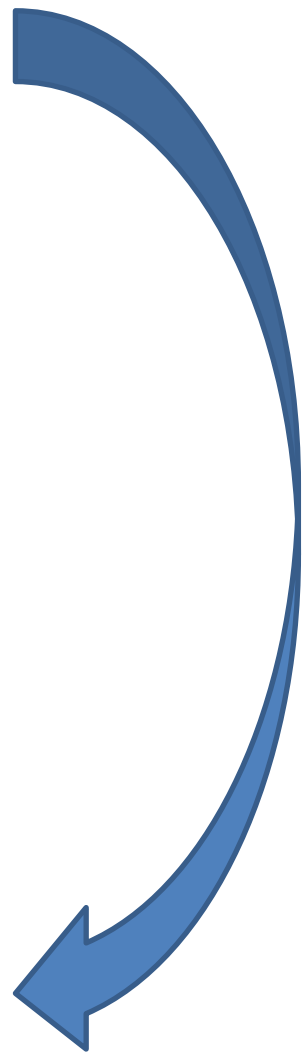
# The Teide Infrastructure

- Civil Work (including foundations for telescope and auxiliaries, roads, trenches)
- Power supply network (including transformer station, UPS and emergency power generator)
- Telecommunication network
- Control room @ Themis observatory
- Onsite Data Centre @ Teide Residencia
- Service cabinets



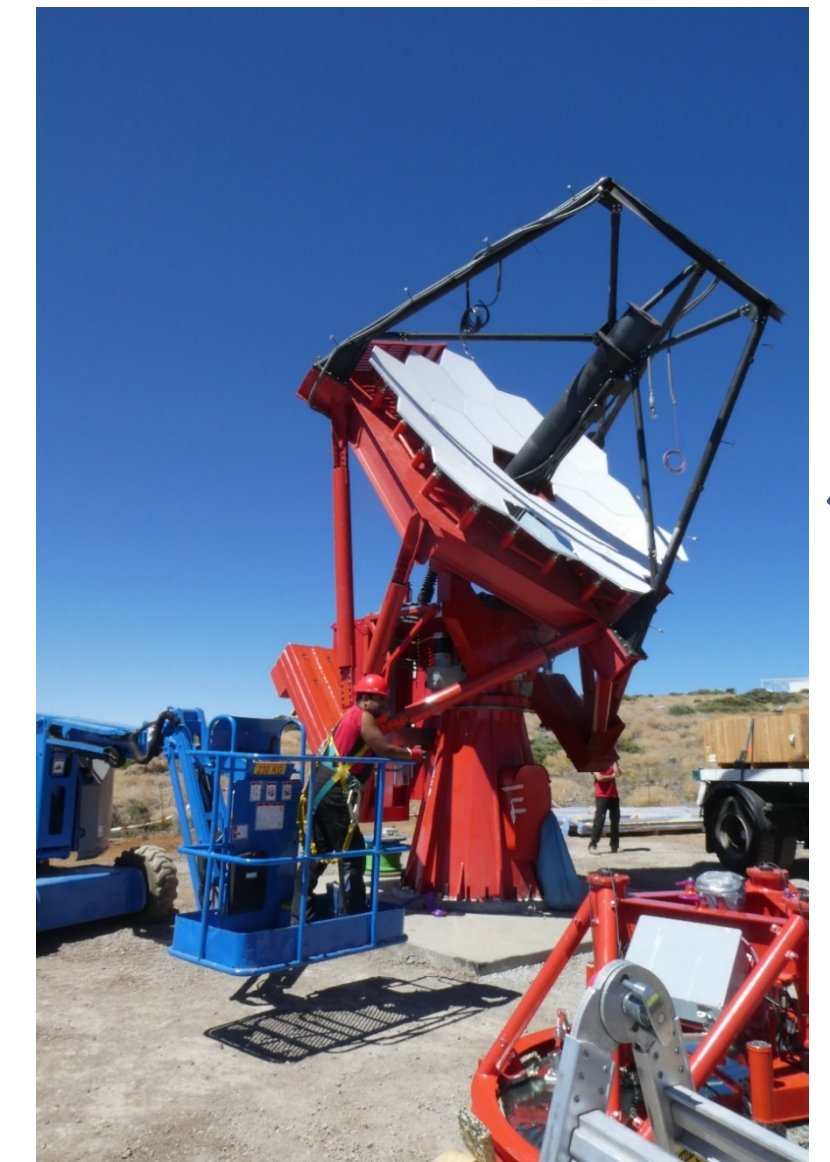


# ASTRI-1 on site integration



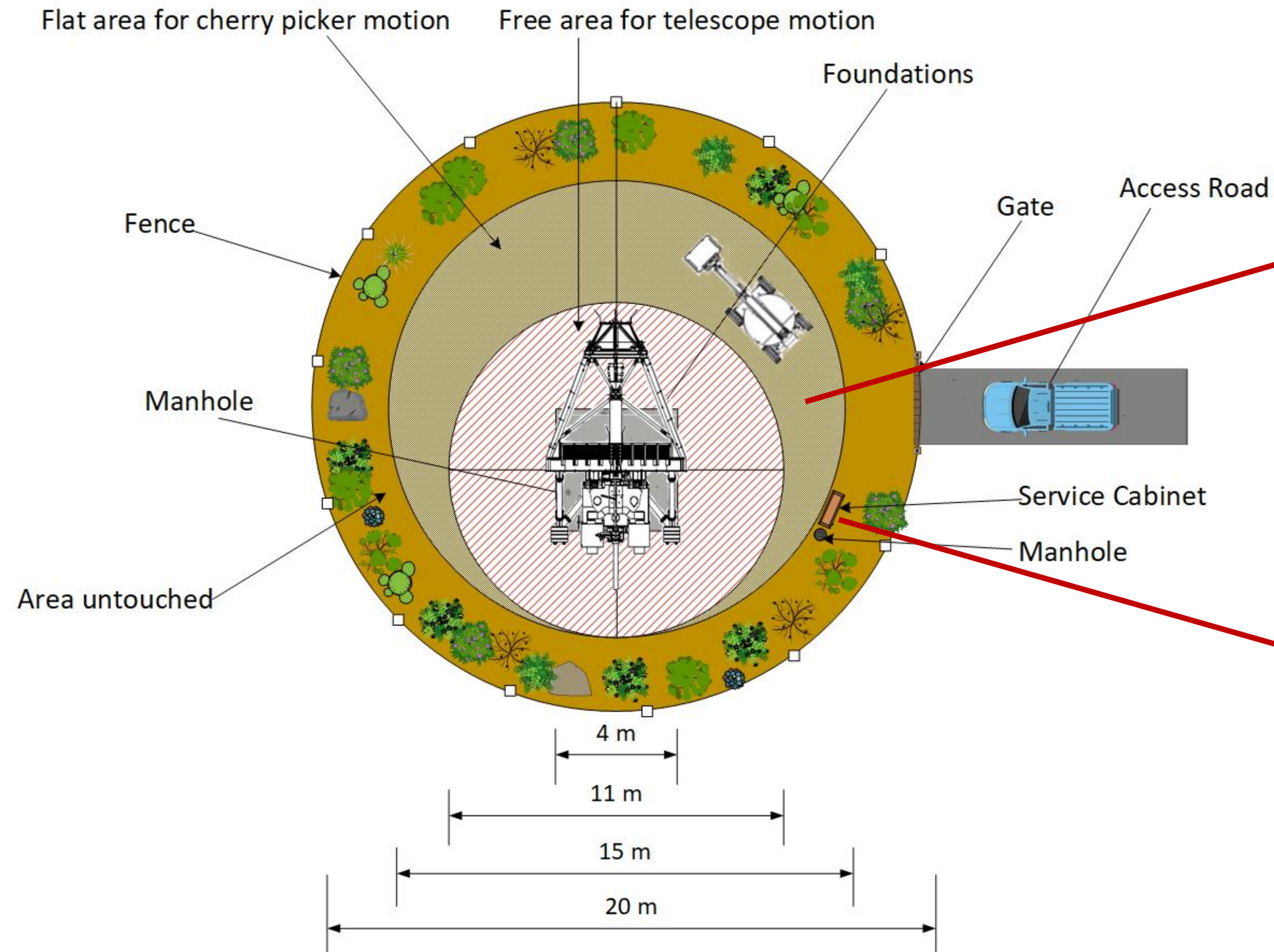
Telescope integration takes 2-3 weeks (working days) including:

- Base grouting 2-3 days
- M1 panels integration 2 days
- M2 mirror integration 2 days





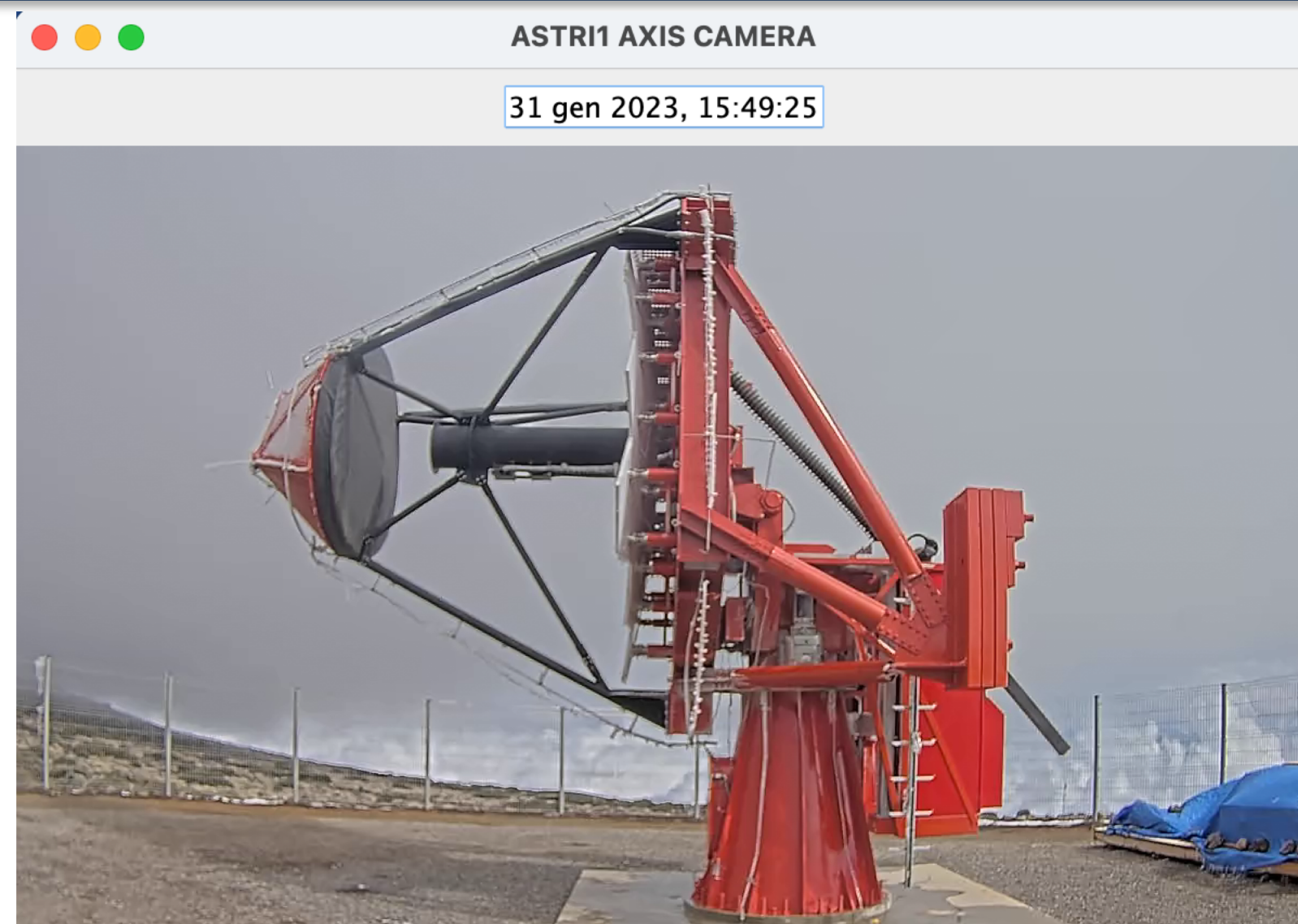
# Infrastructure: Telescope's area



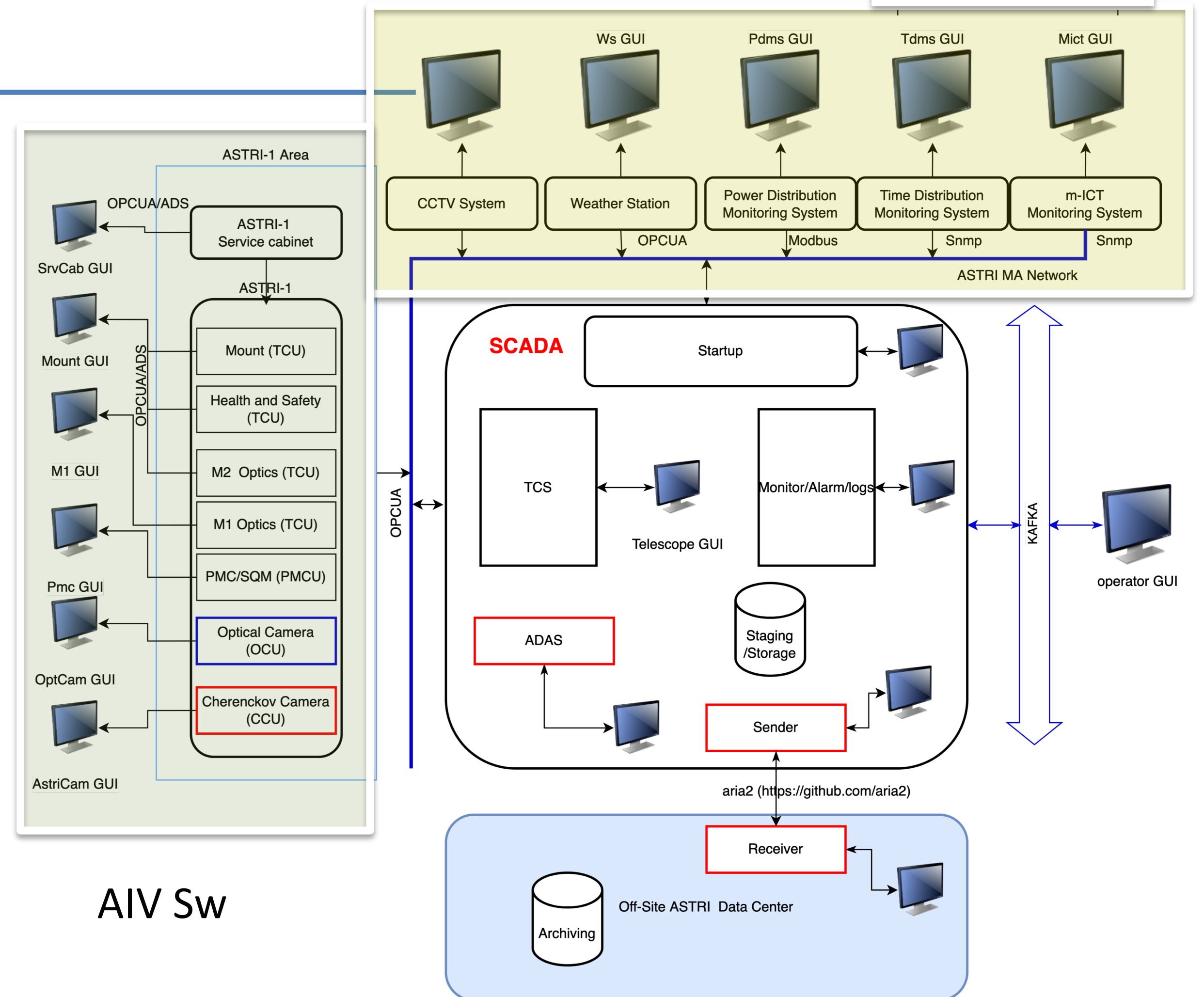
**Service cabinet**



# The MA AIV and Starter SW



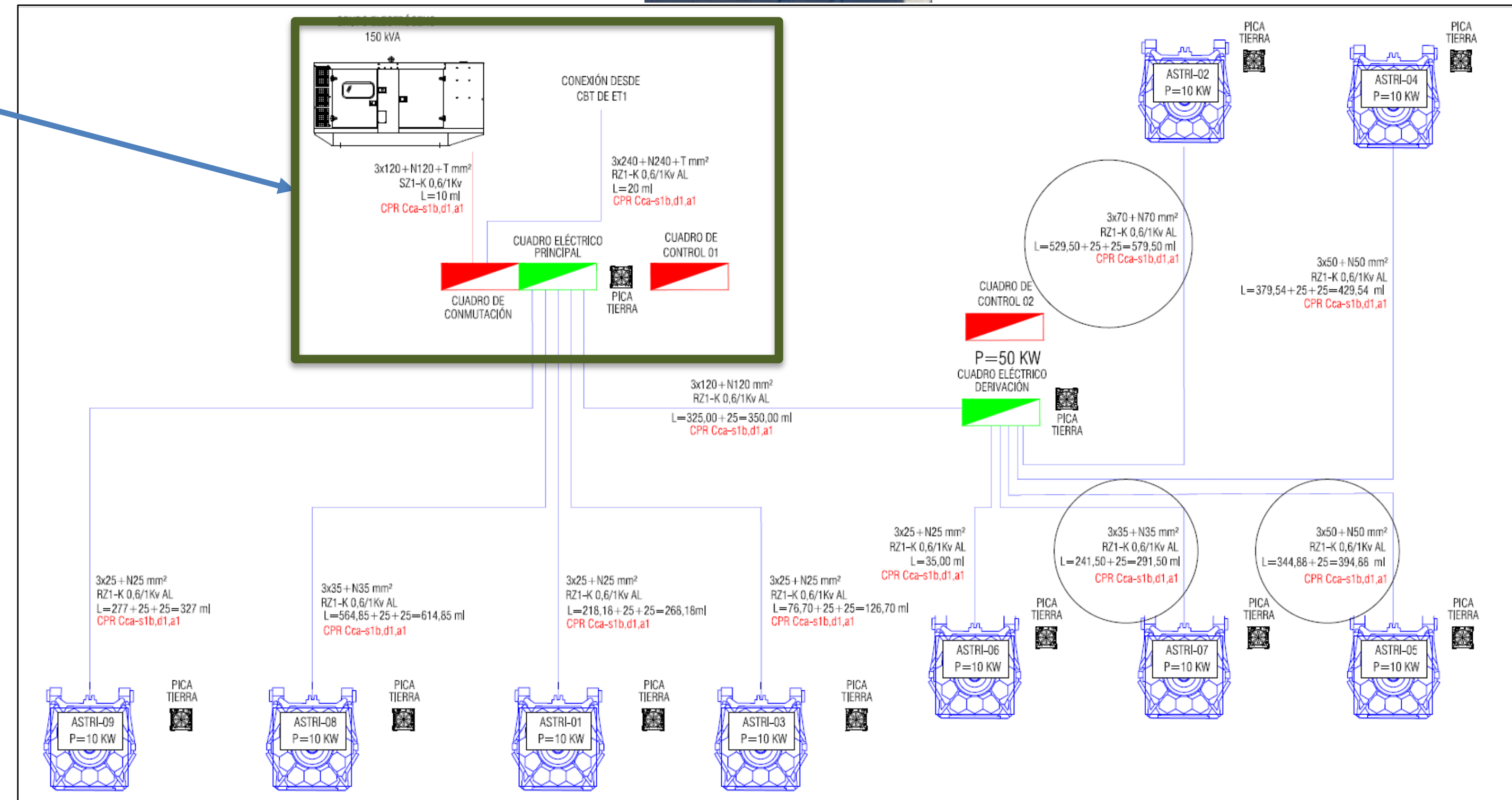
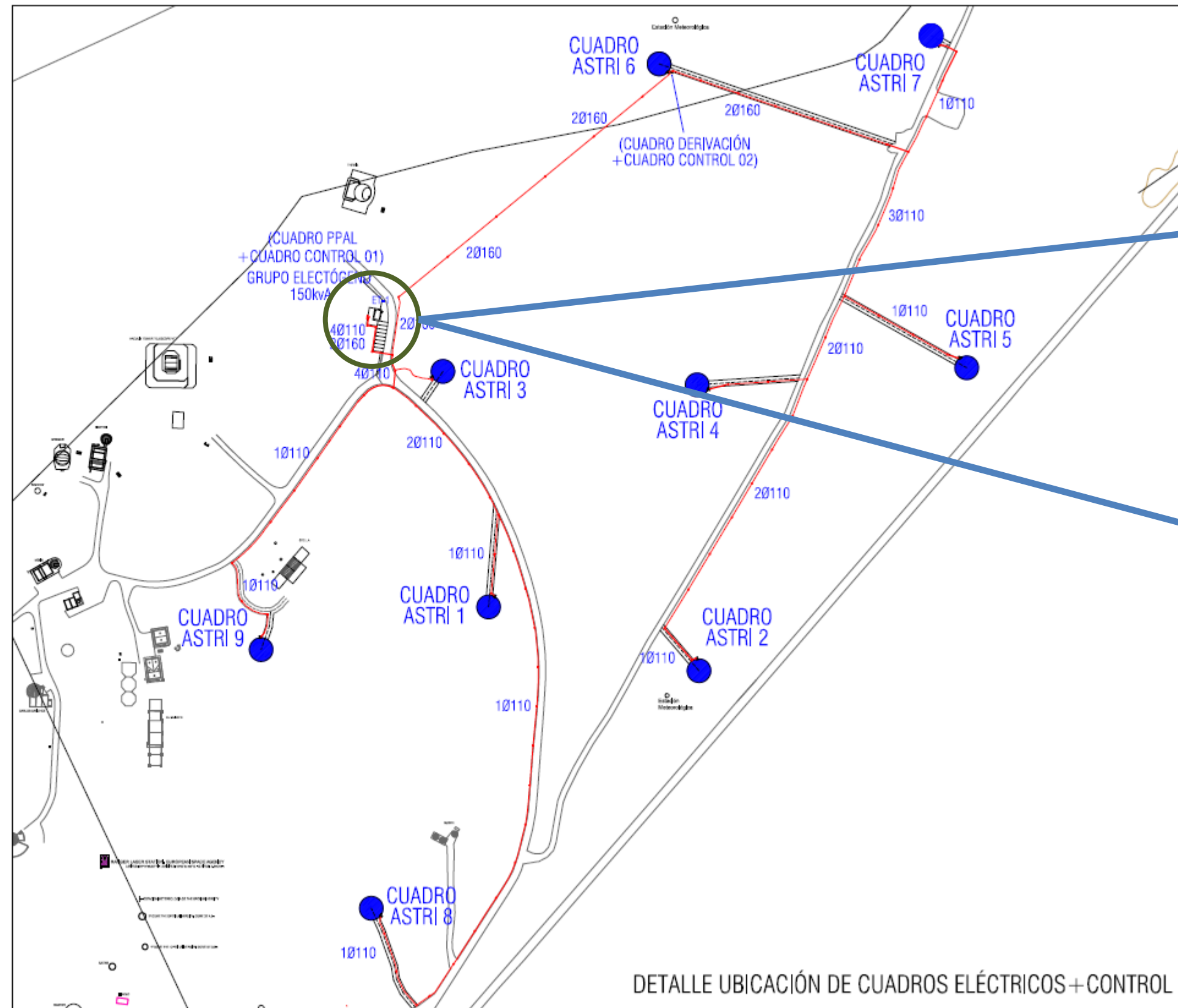
AXIS M1135 Network Camera



AIV Sw



# Infrastructure: Power network





# Power Monitoring



(1) Building Operation WebStation

Pantalla SSTT PC

**MENÚ SCADA**

**VISIÓN GENERAL**

- ANALIZADORES DE RED
- CLIMA SALA DATA CENTER
- GRUPO ELECTROGENO
- SAI
- CONTRAINCENDIOS
- GRAFICAS
- DASHBOARDS

**RESUMEN GENERAL**

Temperatura Exterior: -2.5 °C

**Cuadro principal protecciones Astris**

**Cuadro secundario protecciones Astris**

**SAI**

Alarma Activa en la SAI: 100 %  
 Batería Capacidad: 92 Ah  
 Autonomía: 0 Mn  
 20.0 °C  
 Batería OK  
 Cargada  
 Recargando  
 Funcionando con Batería

**EXTRACTOR CUADRO Ppal.**

Permiso: [I]  
 Tmp. Sala: 14.0 °C  
 PC ON: 20.0 °C  
 Diferencial Exter-Inter: 14.5 °C  
 Tiempo Min. Encendido: 5 Mn

**DATA CENTER**

Avería Centralita: [O] Alarma Extinción ON  
 Posible Incendio: [O]

**CUADRO ASTRI PRINCIPAL**

Avería Centralita: [O] Alarma Extinción ON  
 Posible Incendio: [O]

**Puertas de acceso Data Center**

Fancoil 1: T° Impulsión: 12.4 °C  
 Fancoil 2: T° Impulsión: 11.1 °C  
 Temp. Sala: 18.2 °C  
 PC Aire Sala: 20.0 °C

**MENÚ SCADA**

**VISIÓN GENERAL**

- ANALIZADORES DE RED
- CLIMA SALA DATA CENTER
- GRUPO ELECTROGENO
- SAI
- CONTRAINCENDIOS
- GRAFICAS
- DASHBOARDS
- ANALIZADORES DE RED
  - CUADRO PRINCIPAL
    - ASTRI 1
    - ASTRI 3
    - ASTRI 8
    - ASTRI 9
    - C. PRINCIPAL
  - CUADRO SECUNDARIO
    - ASTRI 2
    - ASTRI 4
    - ASTRI 5
    - ASTRI 6

**PROYECTO ASTRI CLIMA SALA DATA CENTER**

**PUNTOS DE CONSIGNAS**

PC Aire Sala: 20.0 °C  
 Dif. Arranque 2º Fancoil: 2.0 °C  
 Selección Uso Temperatura Temp. Sala

**Permiso Fancoils**

Fancoil 1: [I]  
 Fancoil 2: [O]  
 Forzado Fancoils Simultáneos: [O]

**Ventiladores**

Modo Ventilador: Automático

**Extracción y compuerta exterior**

Diferencial ON T°Ext-Int: 3.0 °C  
 Dif. Off: 0.5 °C  
 Tiempo Min. Encendido: 5 Mn

**Permiso Extractor**: [I]  
**Permiso Compuerta**: [I]

**Alarmas por Temperatura**

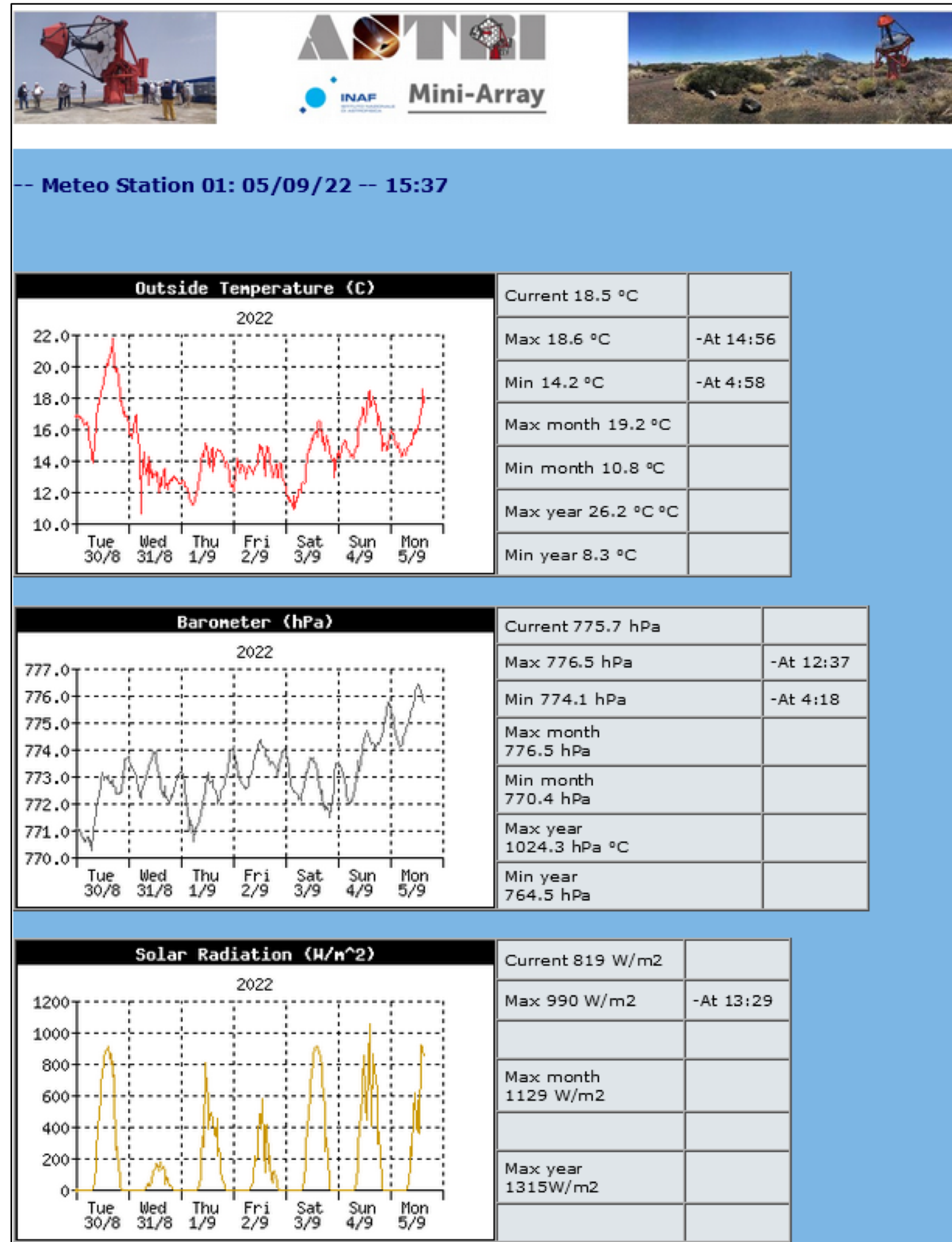
Alta Temp. en la agua: 14.0 °C, 10 Min, [O]  
 Alta Temp. en la sala: 26.0 °C, 5 Min, [I]  
 Diferencial paro alarma por Temperatura: 17.6 °C

**Diagrama de Instalación:** Muestra un sistema de climatización con unidades de impulsión (ST-1, ST-2, ST-3, ST-4), ventiladores (V2V-1, V2V-2), y un display de temperatura en la sala que muestra 18.2 °C y 39% de humedad.

A commercial product by Schneider Electric was used



# Weather Station



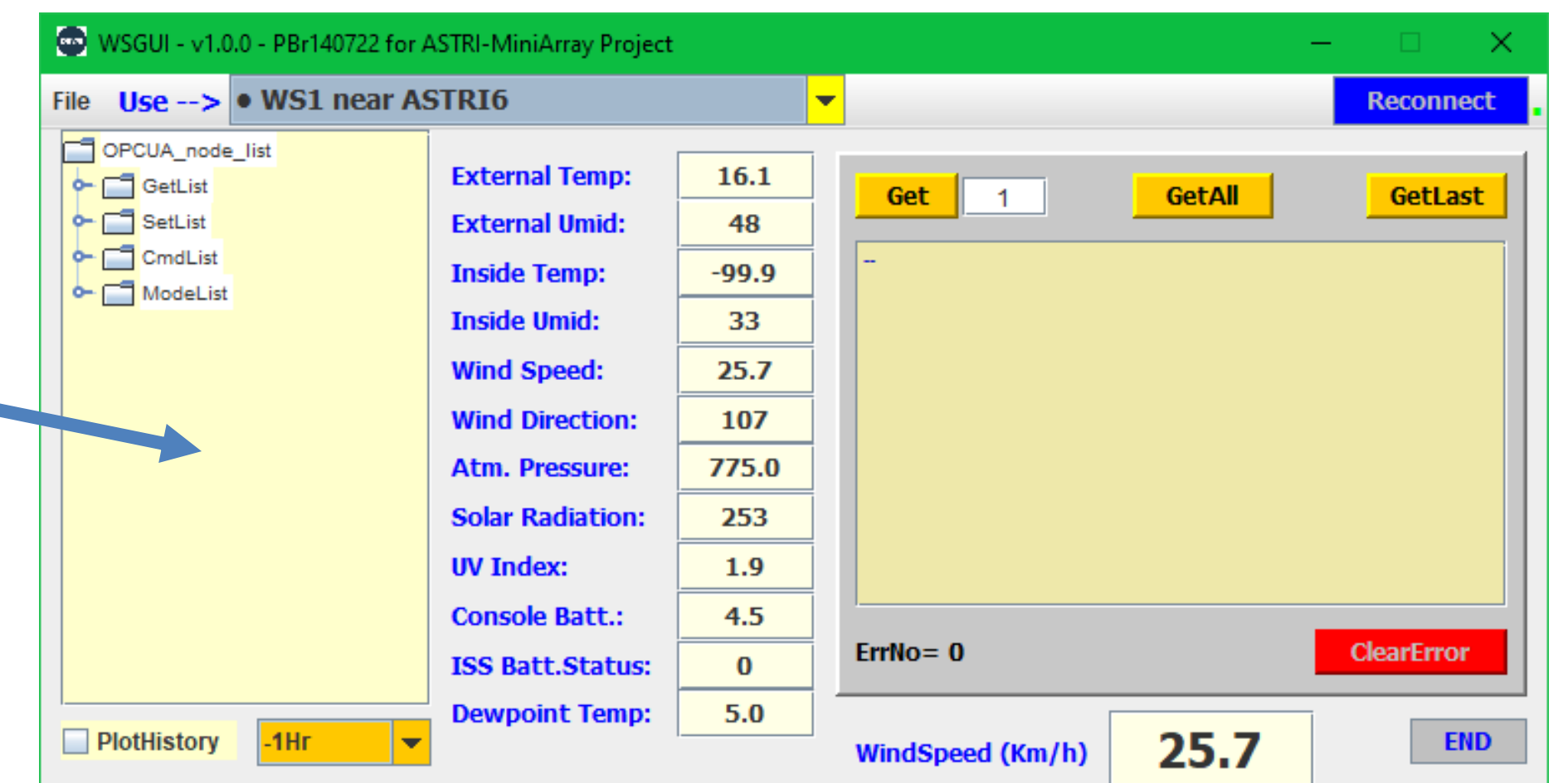
Weather Station 1 installed in July close to ASTRI-6



Weather Station 2 installed last week close to ASTRI-2

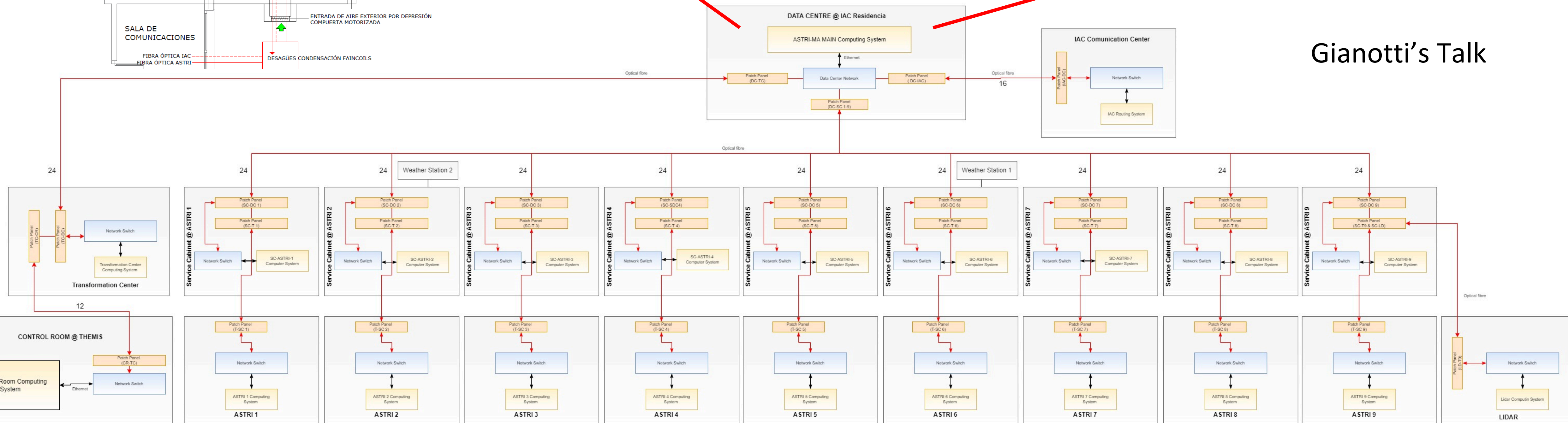
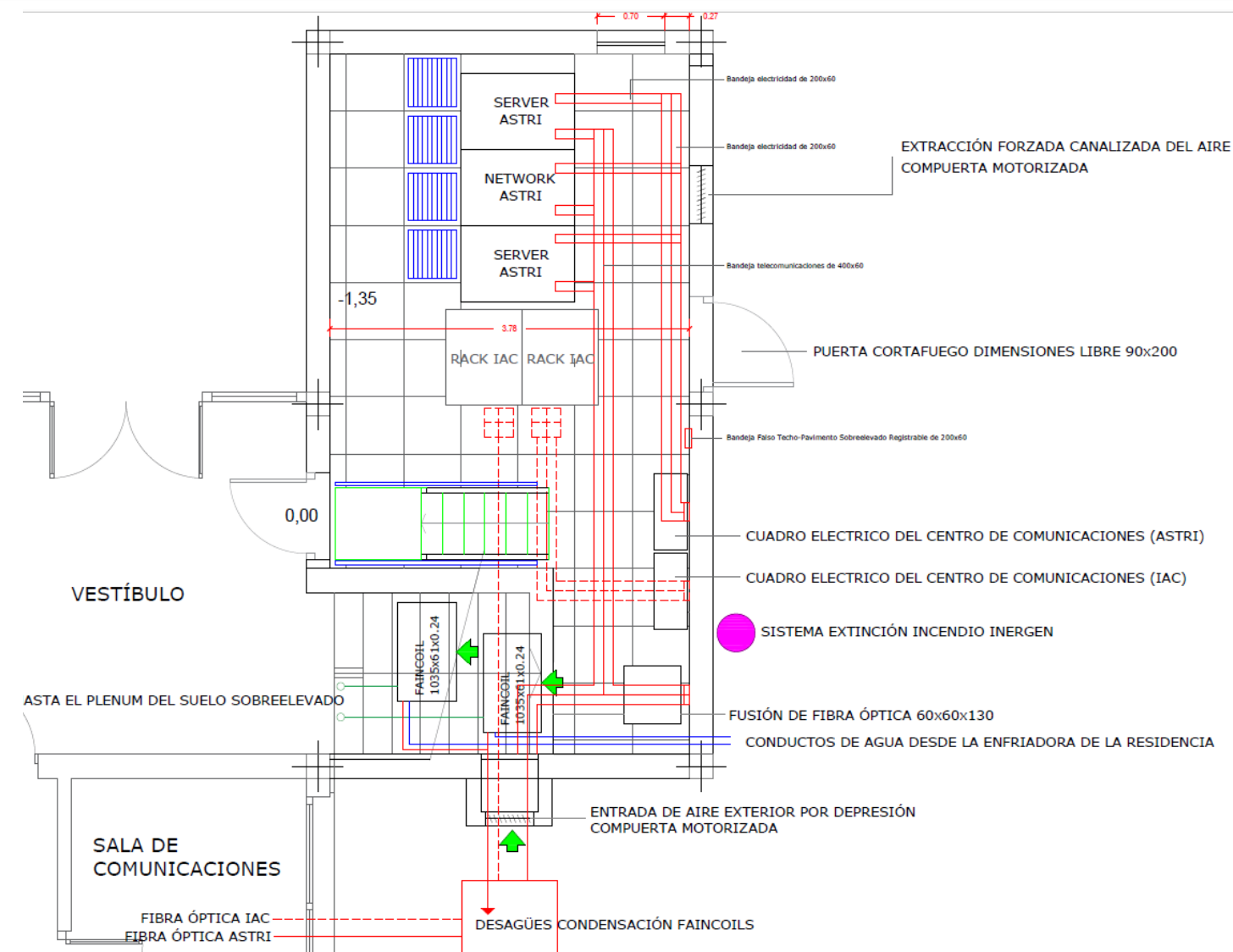
Example of WEB based GUI

Engineering GUI





# Infrastructure: Telecommunication network

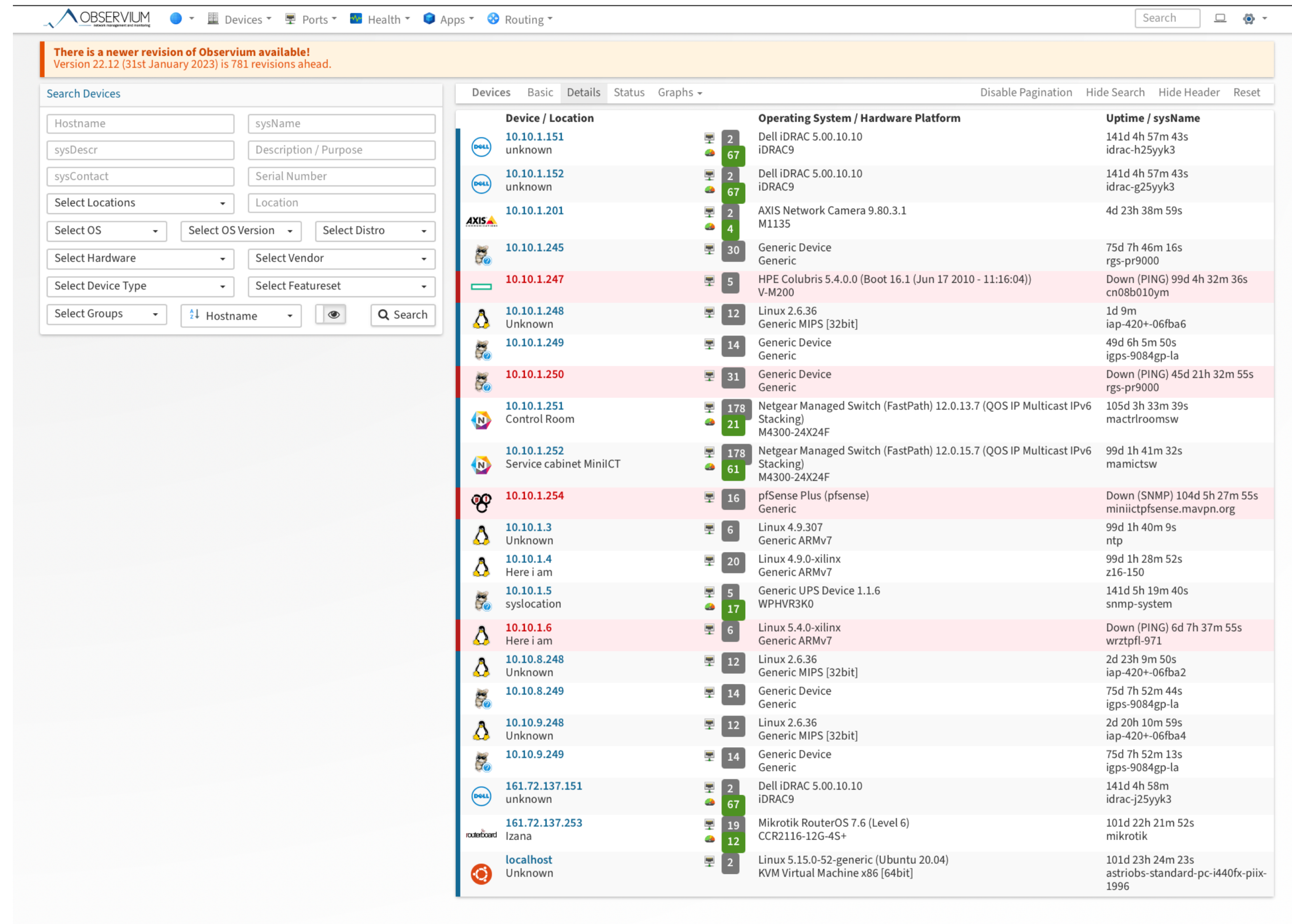


Gianotti's Talk



# ICT Monitoring

An open source software is used: Observium

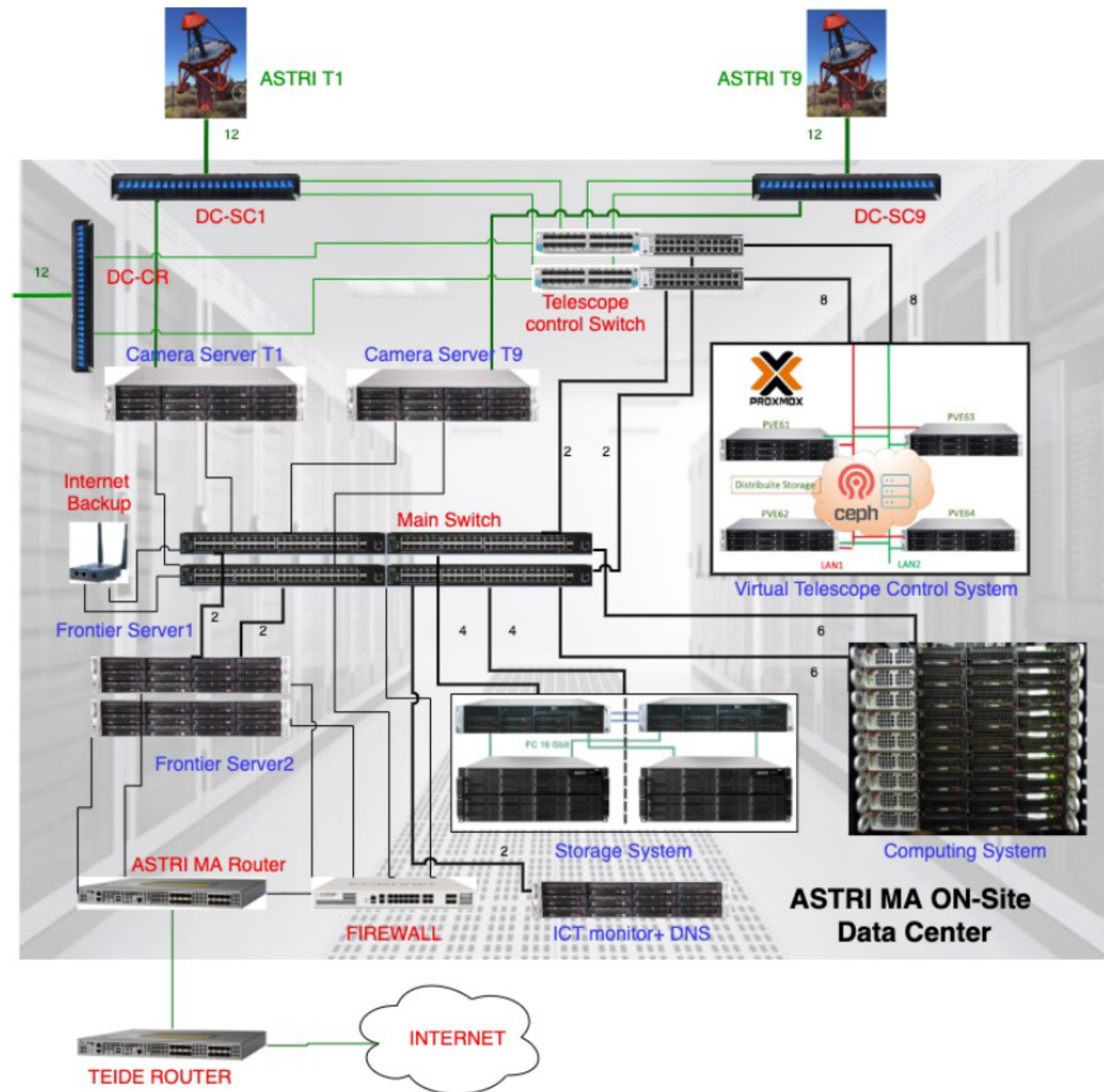


The screenshot displays the Observium web interface. At the top, there is a navigation bar with tabs for 'Devices', 'Ports', 'Health', 'Apps', and 'Routing'. A search bar is located on the right. Below the navigation bar, a notification banner states: 'There is a newer revision of Observium available! Version 22.12 (31st January 2023) is 781 revisions ahead.' The main content area is divided into a search sidebar on the left and a device list table on the right. The search sidebar includes fields for Hostname, sysName, sysDescr, Description / Purpose, sysContact, Serial Number, Location, and various filters for OS, OS Version, Distro, Hardware, Vendor, Device Type, Featureset, and Groups. The device list table has columns for 'Device / Location', 'Operating System / Hardware Platform', and 'Uptime / sysName'. The table lists various devices, including Dell iDRACs, AXIS Network Cameras, Generic Devices, HPE Colubris, Linux-based systems, Netgear Managed Switches, pfSense Plus, and Mikrotik RouterOS. Some devices are highlighted in red, indicating they are down or have issues.

Device / Location	Operating System / Hardware Platform	Uptime / sysName
10.10.1.151 unknown	Dell iDRAC 5.00.10.10 iDRAC9	141d 4h 57m 43s idrac-h25yyk3
10.10.1.152 unknown	Dell iDRAC 5.00.10.10 iDRAC9	141d 4h 57m 43s idrac-g25yyk3
10.10.1.201	AXIS Network Camera 9.80.3.1 M1135	4d 23h 38m 59s
10.10.1.245	Generic Device Generic	75d 7h 46m 16s rgs-pr9000
10.10.1.247	HPE Colubris 5.4.0.0 (Boot 16.1 (Jun 17 2010 - 11:16:04)) V-M200	Down (PING) 99d 4h 32m 36s cn08b010ym
10.10.1.248 Unknown	Linux 2.6.36 Generic MIPS [32bit]	1d 9m iap-420+-06fba6
10.10.1.249	Generic Device Generic	49d 6h 5m 50s igps-9084gp-la
10.10.1.250	Generic Device Generic	Down (PING) 45d 21h 32m 55s rgs-pr9000
10.10.1.251 Control Room	Netgear Managed Switch (FastPath) 12.0.13.7 (QOS IP Multicast IPv6 Stacking) M4300-24X24F	105d 3h 33m 39s mactrooms
10.10.1.252 Service cabinet MiniICT	Netgear Managed Switch (FastPath) 12.0.15.7 (QOS IP Multicast IPv6 Stacking) M4300-24X24F	99d 1h 41m 32s mamictsw
10.10.1.254	pfSense Plus (pfsense) Generic	Down (SNMP) 104d 5h 27m 55s miniictpfsense.mavpn.org
10.10.1.3 Unknown	Linux 4.9.307 Generic ARMv7	99d 1h 40m 9s ntp
10.10.1.4 Here i am	Linux 4.9.0-xilinx Generic ARMv7	99d 1h 28m 52s z16-150
10.10.1.5 syslocation	Generic UPS Device 1.1.6 WPHVR3K0	141d 5h 19m 40s snmp-system
10.10.1.6 Here i am	Linux 5.4.0-xilinx Generic ARMv7	Down (PING) 6d 7h 37m 55s wrztpfl-971
10.10.8.248 Unknown	Linux 2.6.36 Generic MIPS [32bit]	2d 23h 9m 50s iap-420+-06fba2
10.10.8.249	Generic Device Generic	75d 7h 52m 44s igps-9084gp-la
10.10.9.248 Unknown	Linux 2.6.36 Generic MIPS [32bit]	2d 20h 10m 59s iap-420+-06fba4
10.10.9.249	Generic Device Generic	75d 7h 52m 13s igps-9084gp-la
161.72.137.151 unknown	Dell iDRAC 5.00.10.10 iDRAC9	141d 4h 58m idrac-j25yyk3
161.72.137.253 Izana	Mikrotik RouterOS 7.6 (Level 6) CCR2116-12G-4S+	101d 22h 21m 52s mikrotik
localhost Unknown	Linux 5.15.0-52-generic (Ubuntu 20.04) KVM Virtual Machine x86 [64bit]	101d 23h 24m 23s astriobs-standard-pc-i440fx-piix-1996



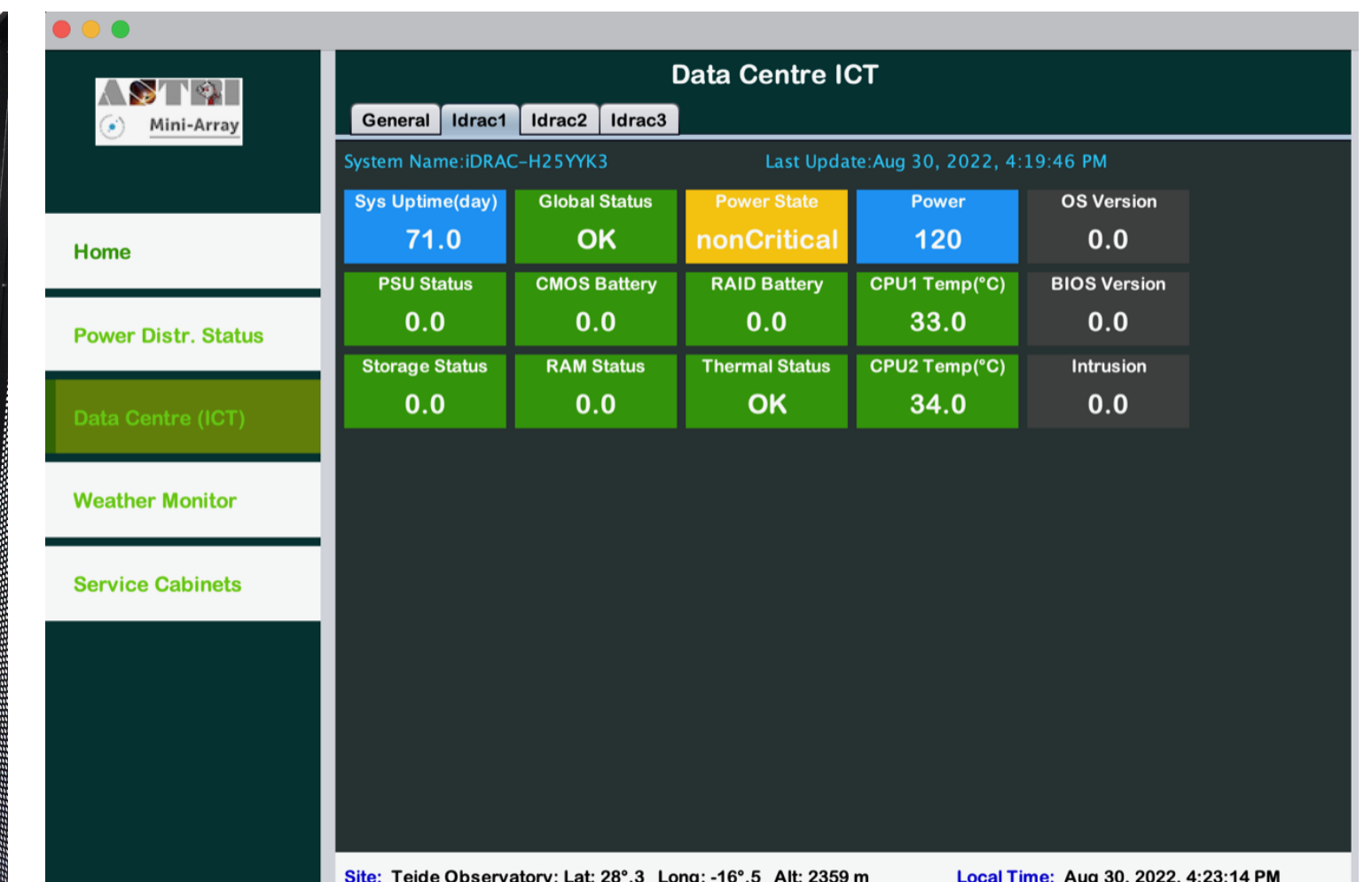
# ICT – On site Data centre



- **Virtual Telescope Control System:** the system hosting the virtual machines that will be used for the telescopes control.
- **Camera Servers:** are the physical servers, one for each telescope, for the Cherenkov camera and stellar intensity interferometry data acquisition.
- **Computing System:** is the set of physical servers dedicated to the on-line analysis of scientific data for quality check and of monitoring data for the alarm management.
- **Storage System:** is the collection point of the raw scientific data, of the monitoring and of the alarm data. It also the location from where all these data are accessible for remote transfer and for all on-site uses.
- **Network System:** is the set of devices responsible for internal and external network connections.

## m-ICT

Reduced version of the onsite ICT to run single telescopes installed in the data centre in July

Data Centre ICT				
General	Idrac1	Idrac2	Idrac3	
System Name: IDRAC-H25YYK3 Last Update: Aug 30, 2022, 4:19:46 PM				
Sys Uptime(day)	Global Status	Power State	Power	OS Version
71.0	OK	nonCritical	120	0.0
PSU Status	CMOS Battery	RAID Battery	CPU1 Temp(°C)	BIOS Version
0.0	0.0	0.0	33.0	0.0
Storage Status	RAM Status	Thermal Status	CPU2 Temp(°C)	Intrusion
0.0	0.0	OK	34.0	0.0

Site: Teide Observatory: Lat: 28°.3 Long: -16°.5 Alt: 2359 m Local Time: Aug 30, 2022, 4:23:14 PM

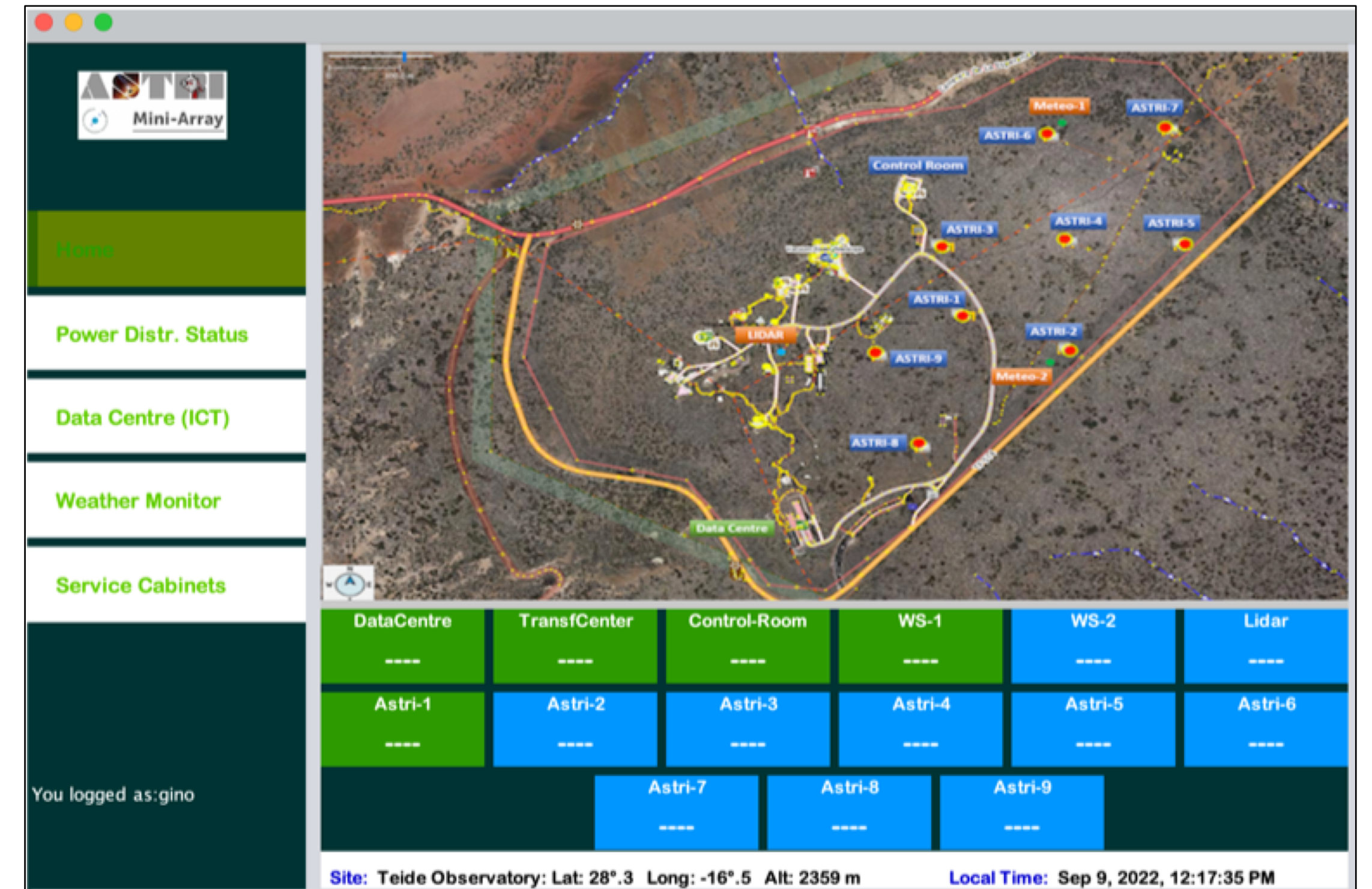
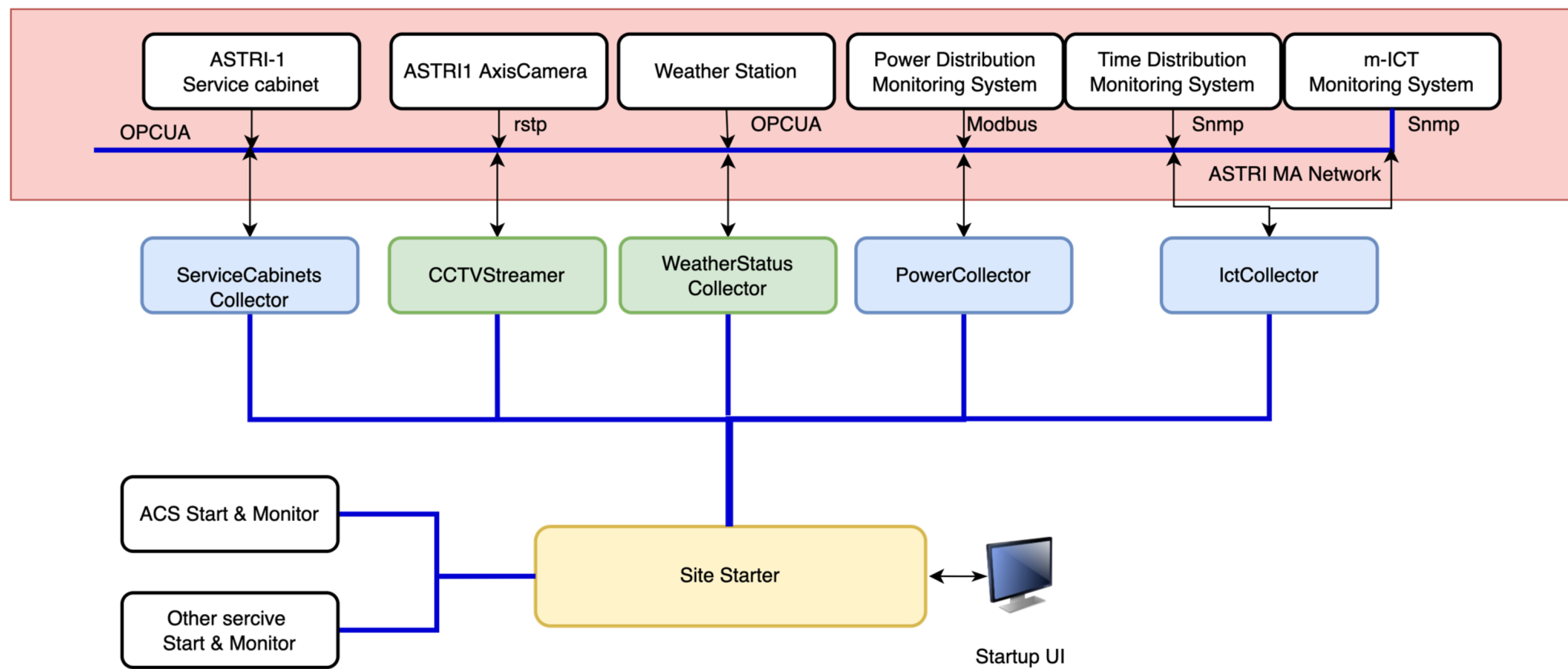
Gianotti's Talk



# Startup Software

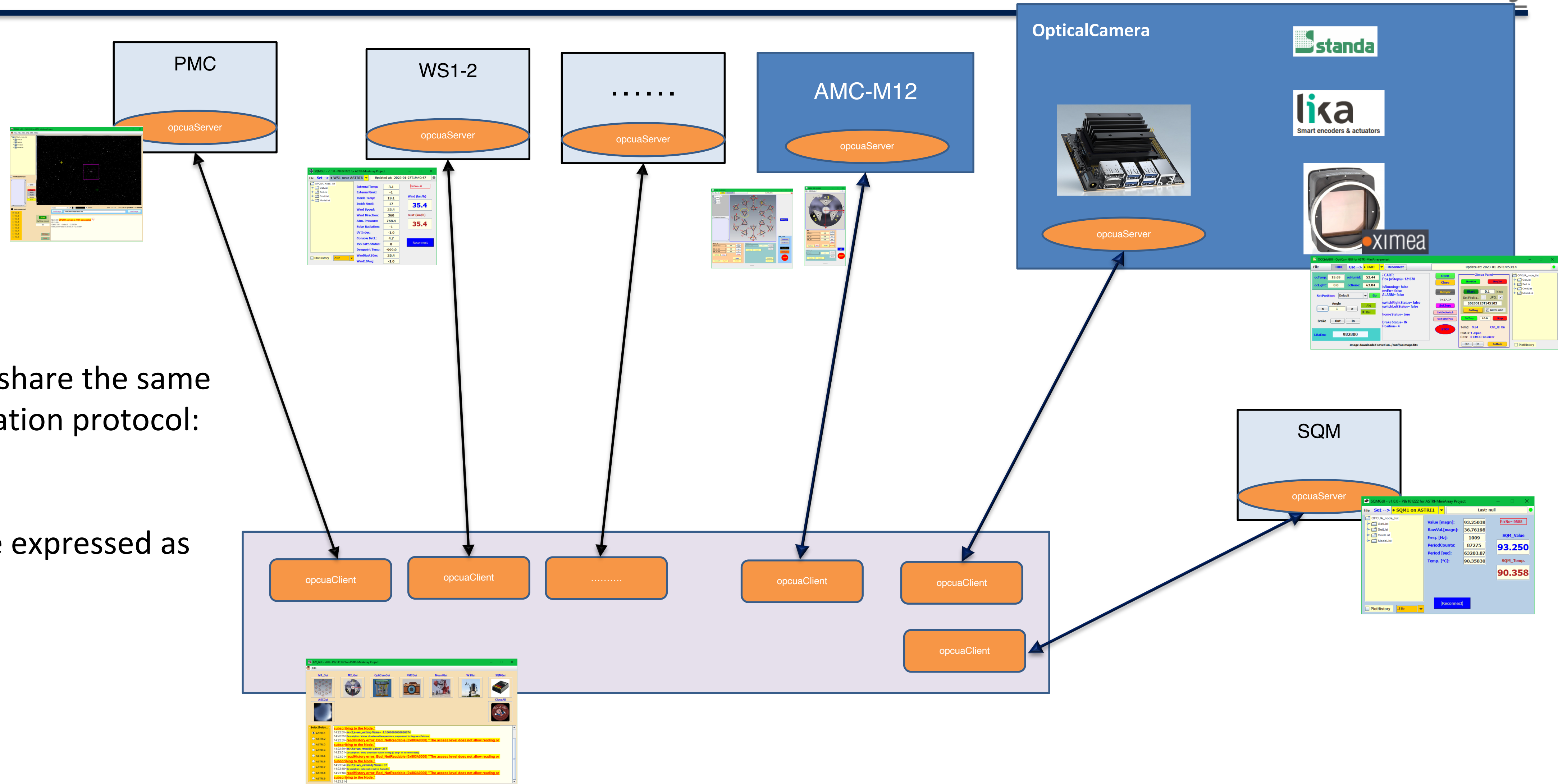
Software development mainly by  
**INAF**

## Startup system





# The Telescope AIV SW for Auxiliary devices

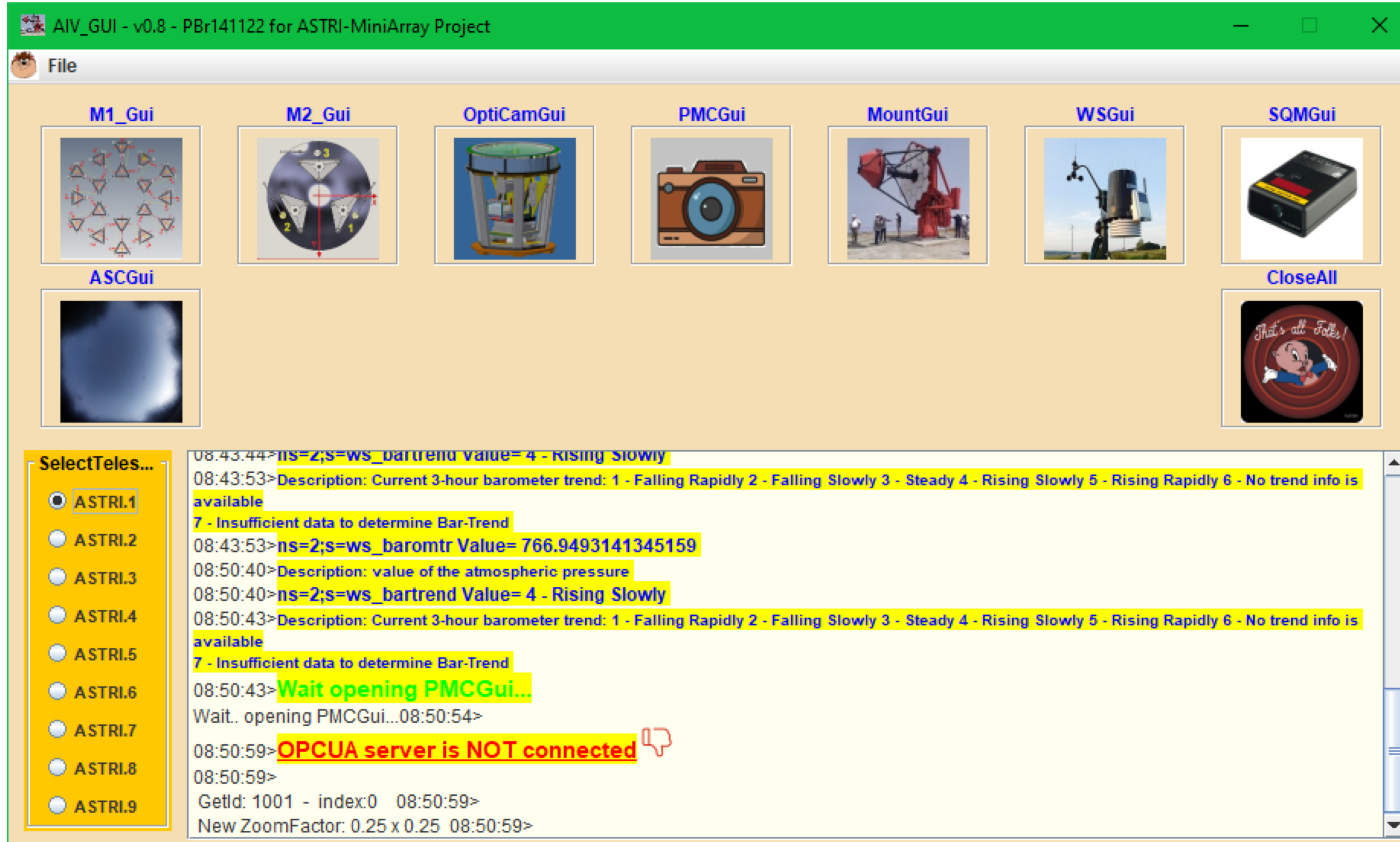


All devices share the same Communication protocol: OPC-UA

The ICD are expressed as Excel files.



# AIV SW for Mirrors Alignment and T-Point

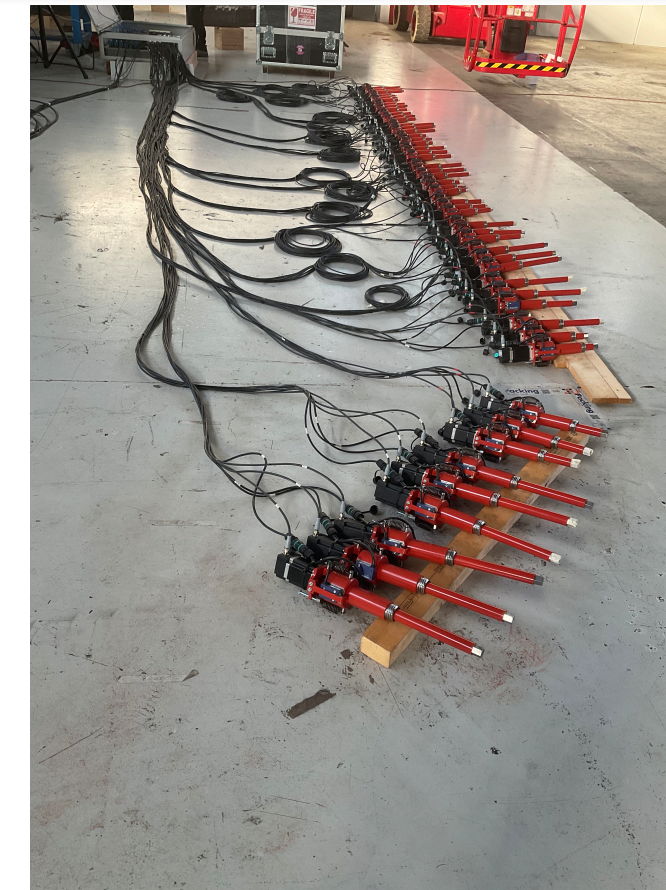
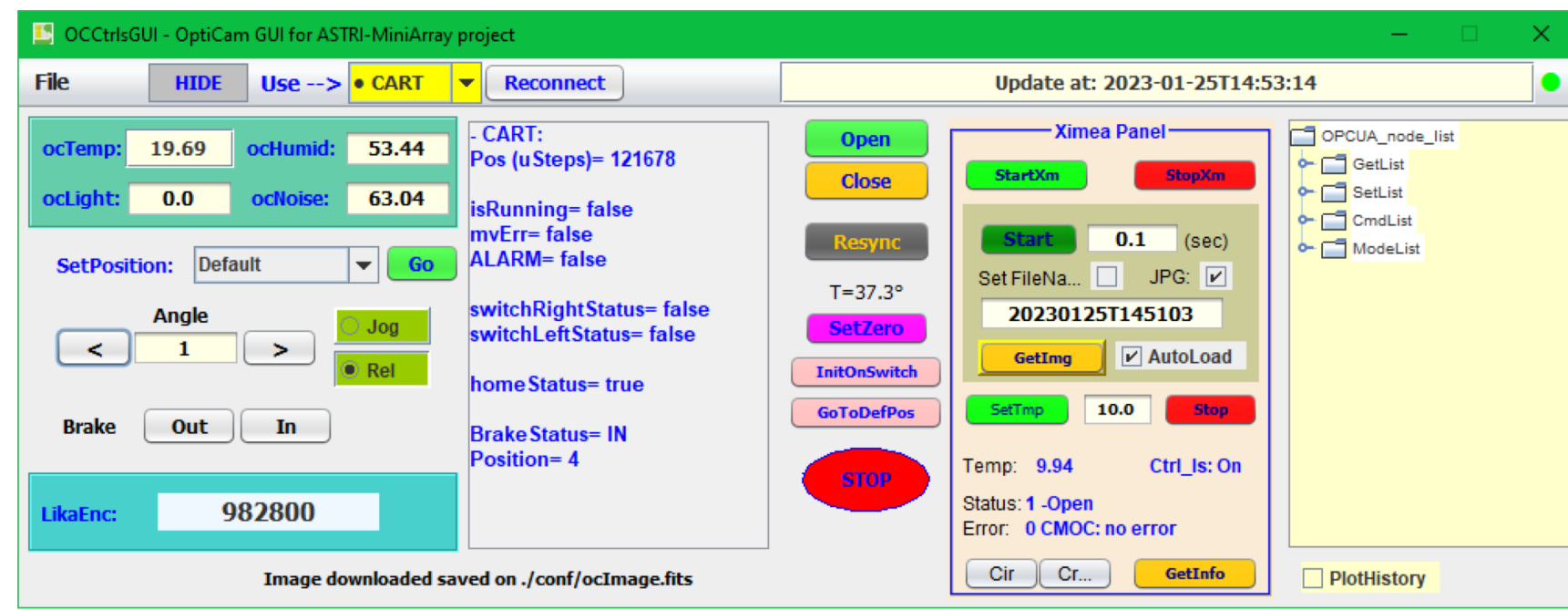


The screenshot shows the AIV GUI software interface. The title bar reads "AIV\_GUI - v0.8 - PBr141122 for ASTRI-MiniArray Project". The main window contains a "File" menu and a grid of icons for various GUIs: M1\_Gui, M2\_Gui, OptiCamGui, PMCGui, MountGui, WSGui, SQMGui, ASCGui, and CloseAll. The bottom panel displays a log window with the following text:

```
08:43:44>ns=2;s=ws_bartrend value= 4 - Rising Slowly
08:43:53>Description: Current 3-hour barometer trend: 1 - Falling Rapidly 2 - Falling Slowly 3 - Steady 4 - Rising Slowly 5 - Rising Rapidly 6 - No trend info is available
7 - Insufficient data to determine Bar-Trend
08:43:53>ns=2;s=ws_baromtr Value= 766.9493141345159
08:50:40>Description: value of the atmospheric pressure
08:50:40>ns=2;s=ws_bartrend Value= 4 - Rising Slowly
08:50:43>Description: Current 3-hour barometer trend: 1 - Falling Rapidly 2 - Falling Slowly 3 - Steady 4 - Rising Slowly 5 - Rising Rapidly 6 - No trend info is available
7 - Insufficient data to determine Bar-Trend
08:50:43>Wait opening PMCGui...
Wait.. opening PMCGui...08:50:54>
08:50:59>OPCUA server is NOT connected
08:50:59>
GetId: 1001 - index:0 08:50:59>
New ZoomFactor: 0.25 x 0.25 08:50:59>
```



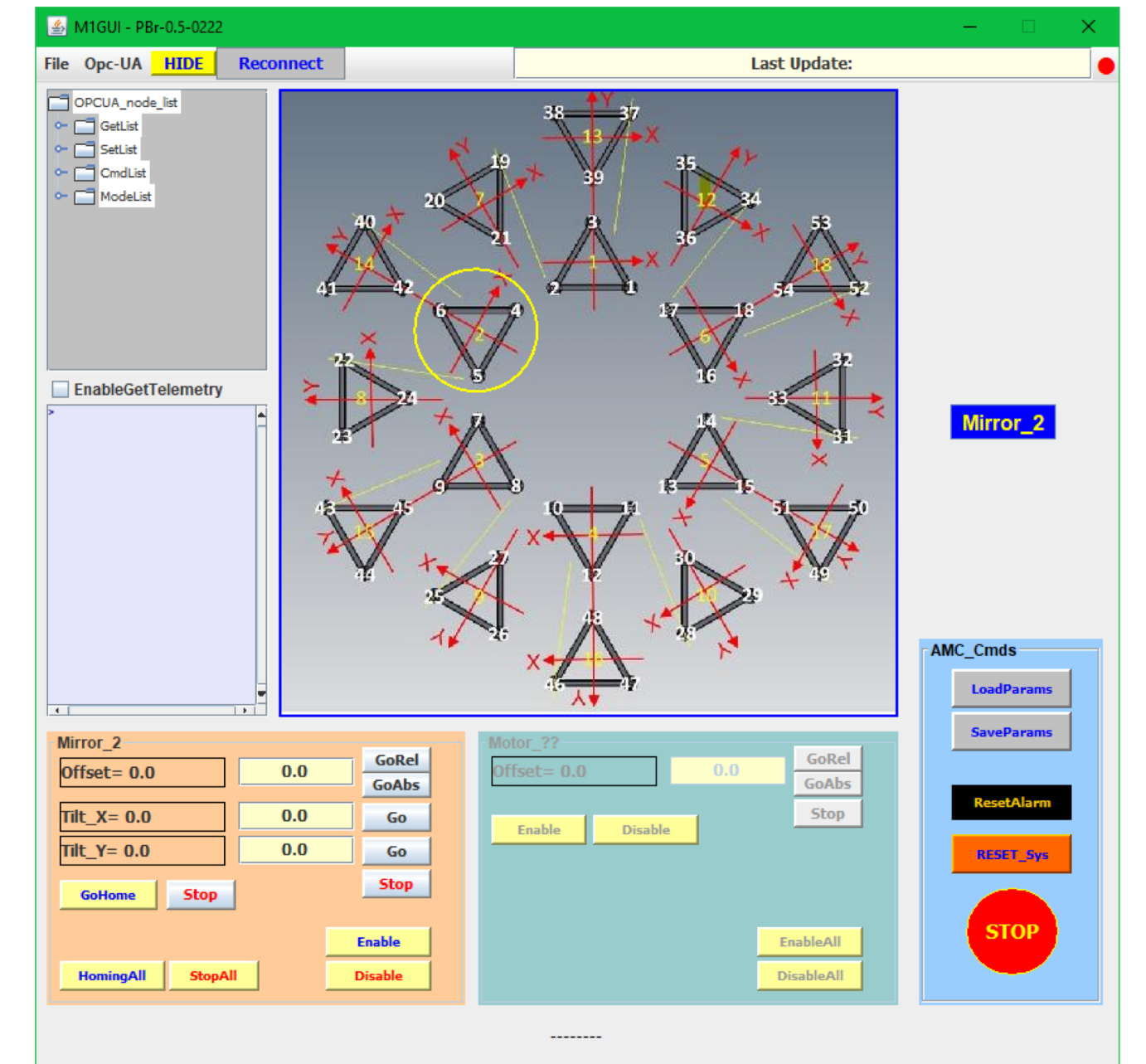
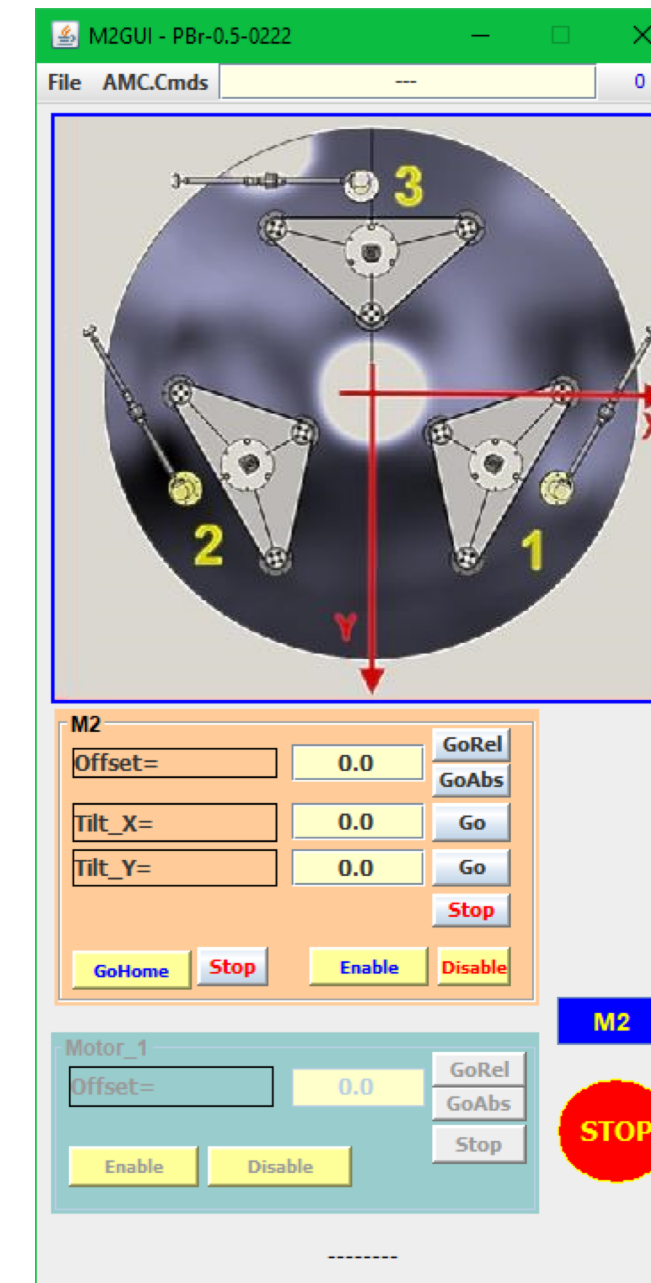
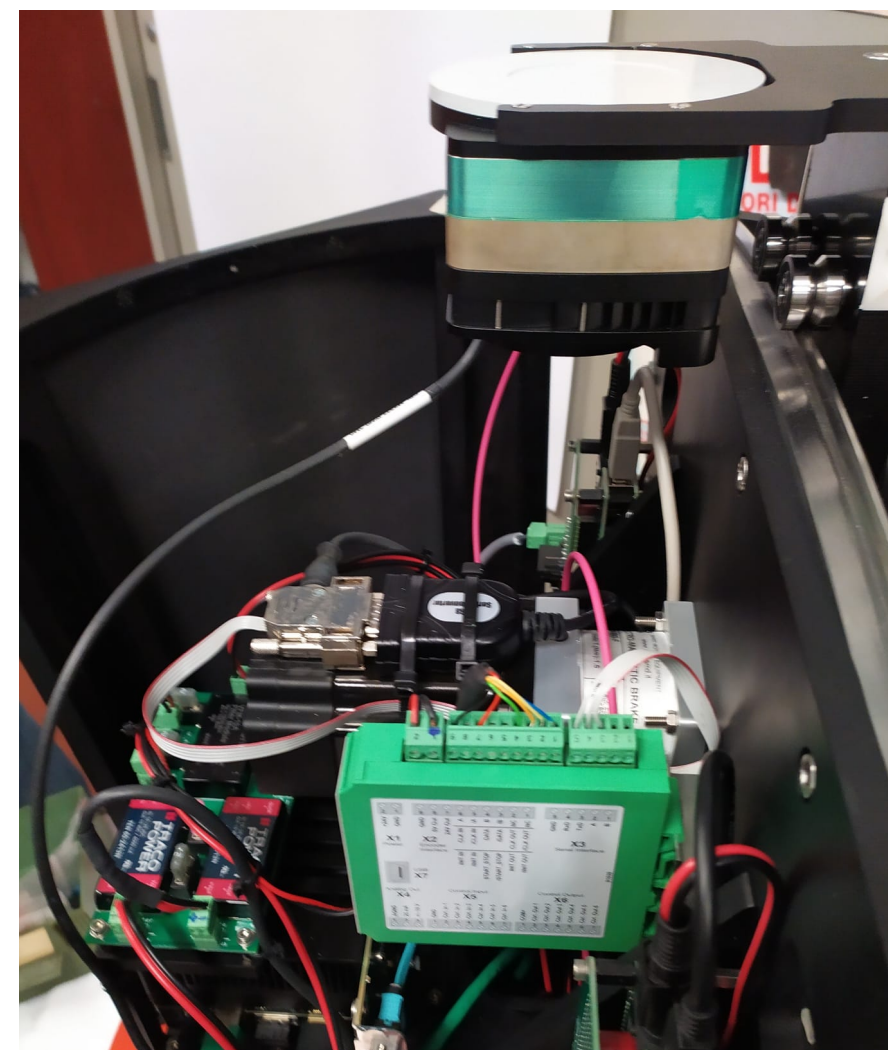
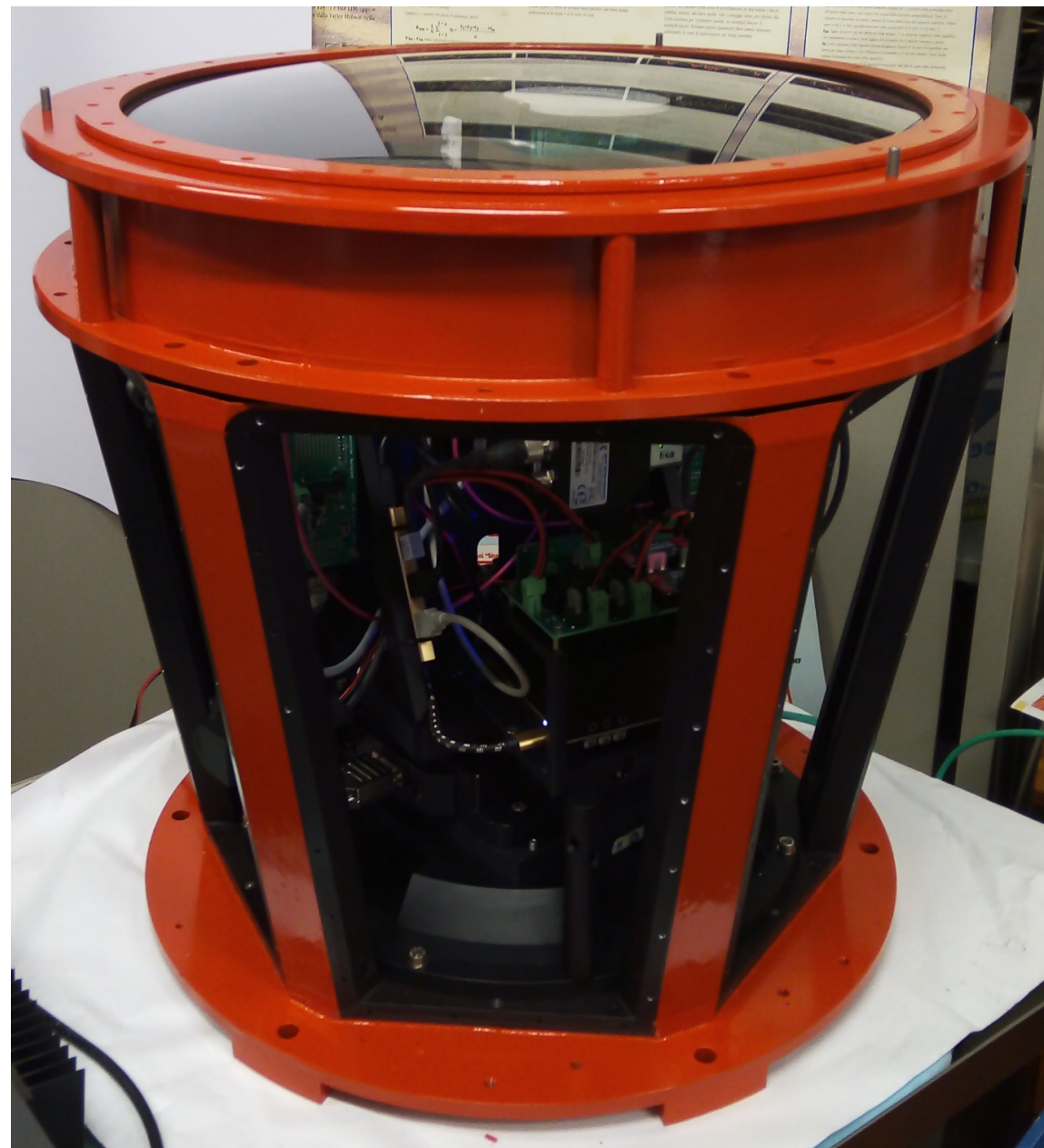
# Some specific panels



M1 (54 actuators, 3 for each of the 18 M1 mirror segments)

M2 (3 actuators)

Optical Camera (IASF-MI, OAPD, OACT, OA Brera)  
 CCD camera (Ximea sCMOS, 37.7 Mpx) placed on the telescope focal plane to align the panels of M1.



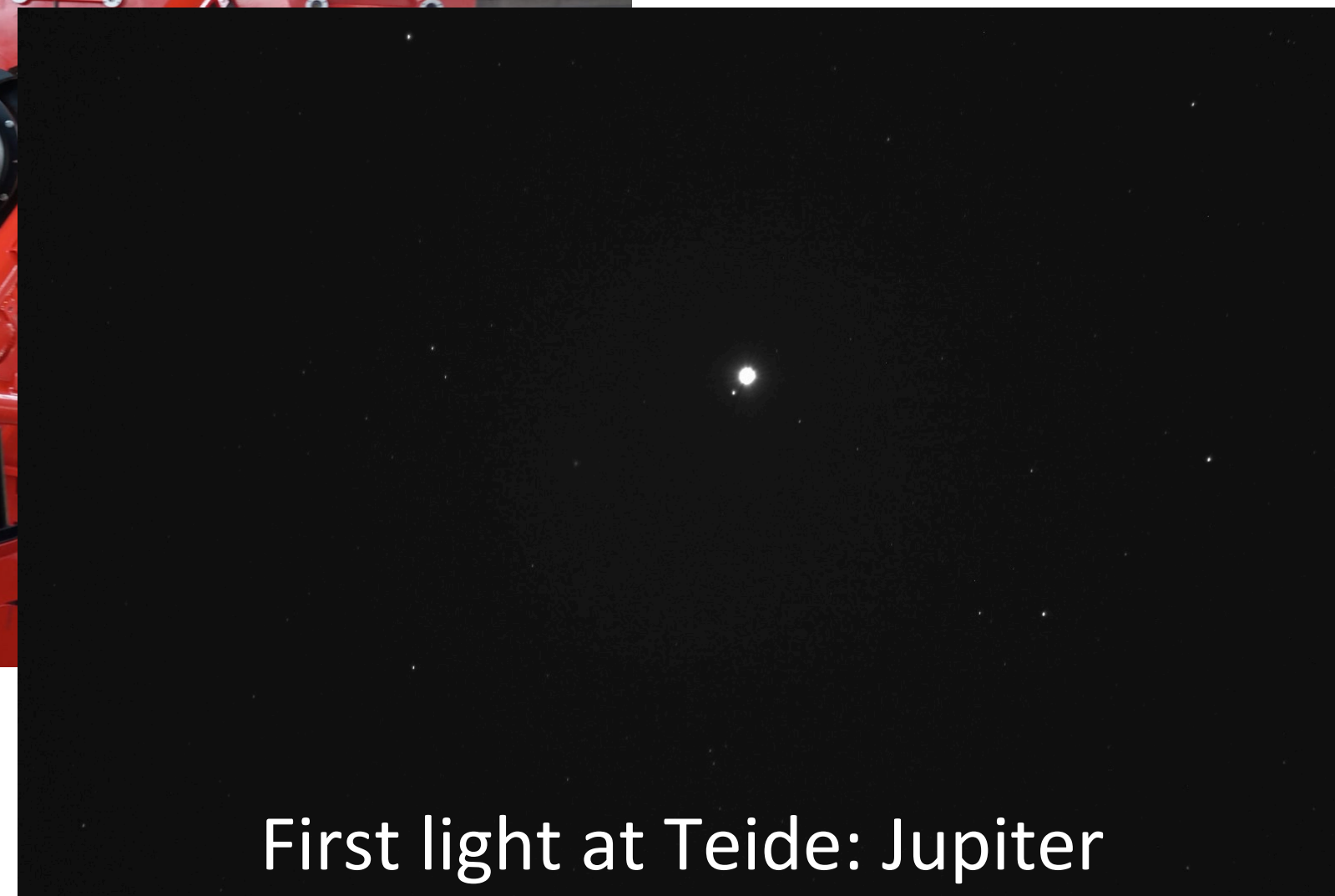
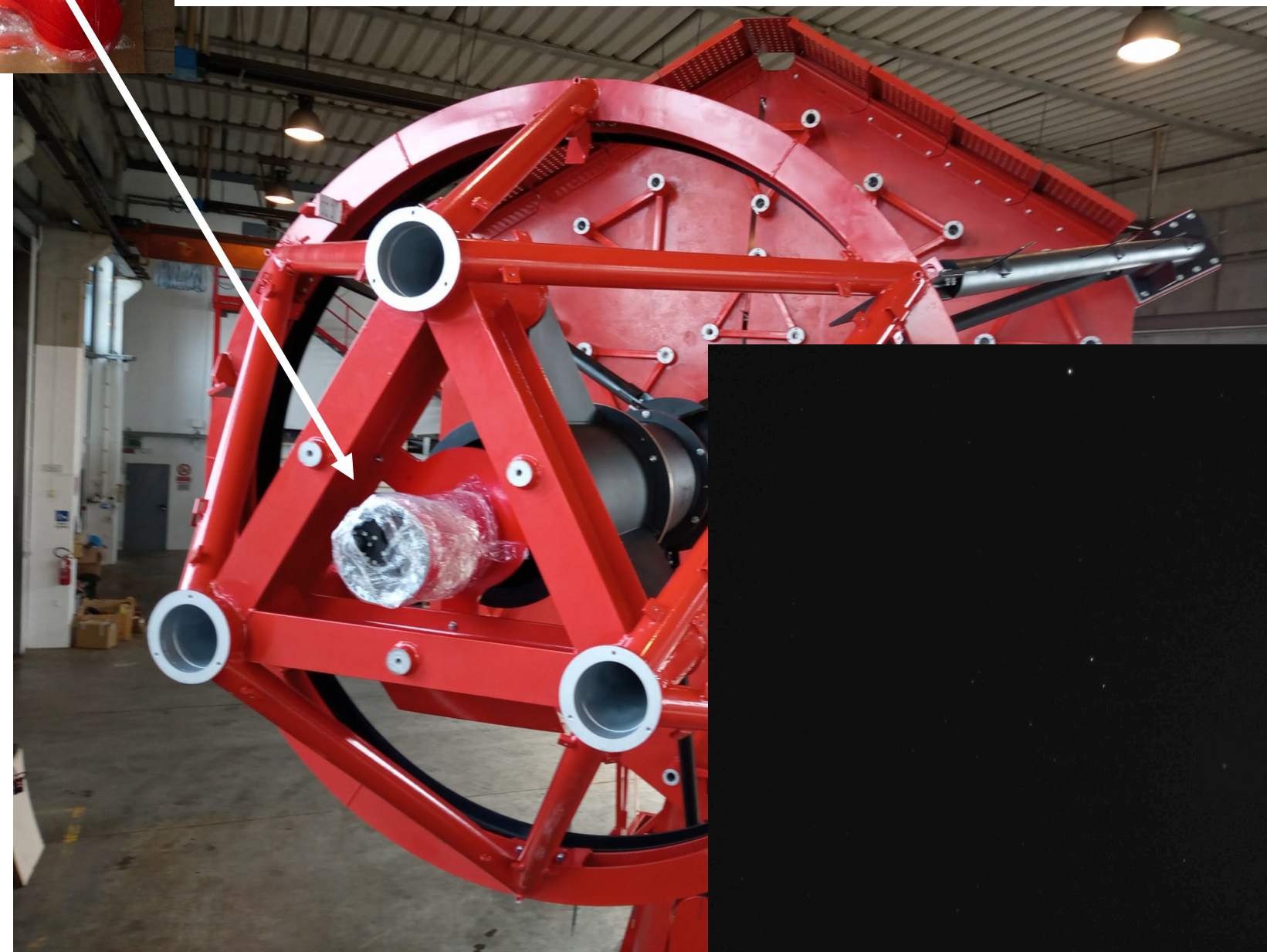


# Some specific panels

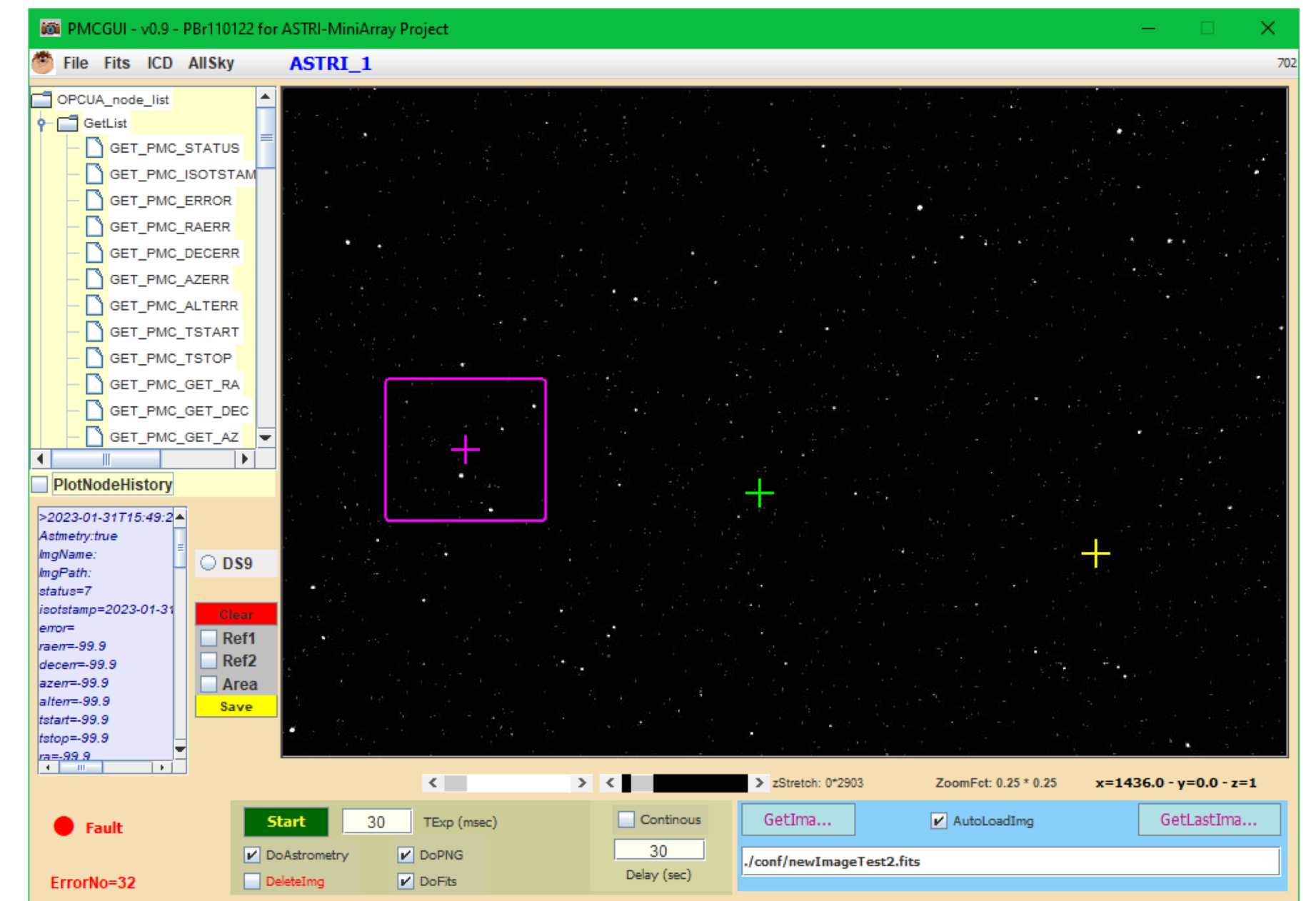
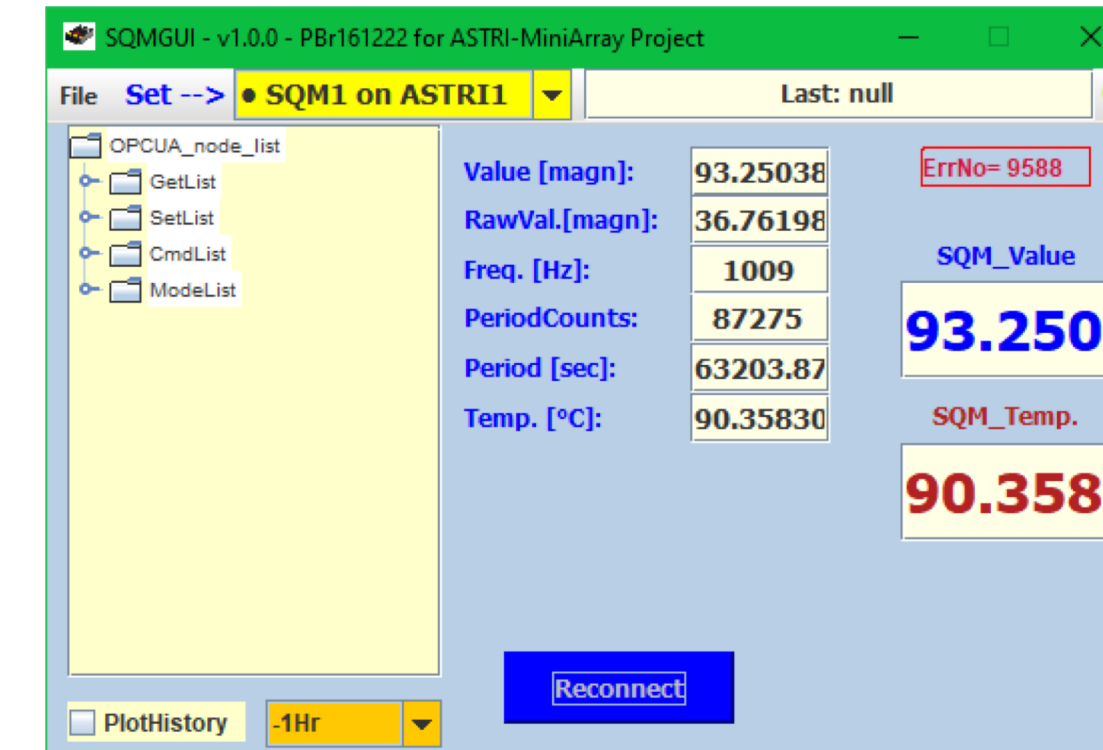


## Pointing Monitoring Cameras (Uni-PG)

CCD camera placed on the M2 support structure used to monitor pointing and tracking performances of the telescope

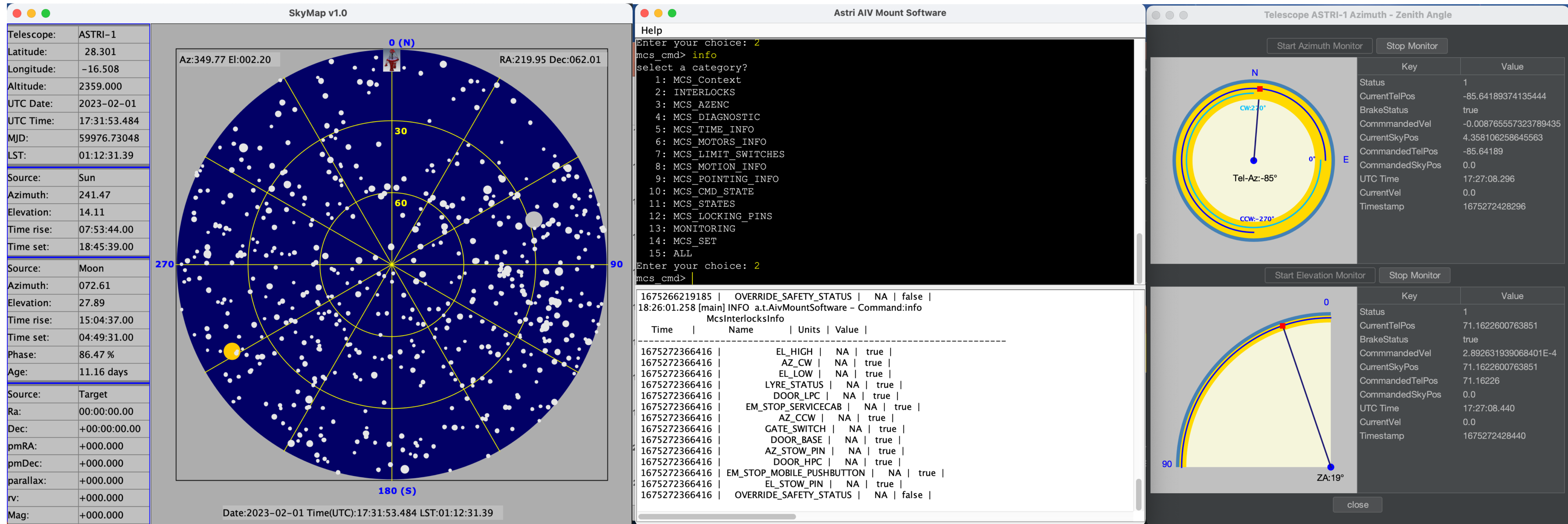


First light at Teide: Jupiter





# Mount Control System AIV SW



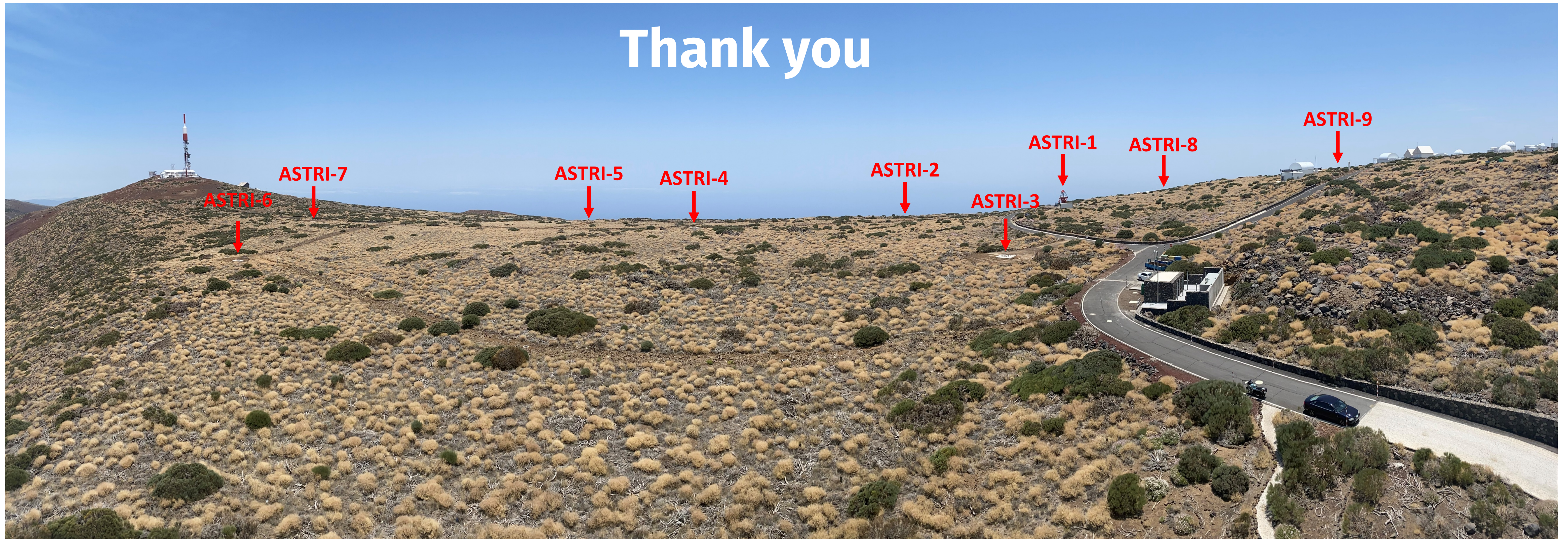
The screenshot displays three main panels of the Mount AIV Software interface:

- SkyMap v1.0:** A circular star map showing the current field of view. The map includes a grid of azimuth and elevation angles. The current telescope position is indicated as Az:349.77 El:002.20. The map also shows the current target (Sun) and its position relative to the field of view.
- Astri AIV Mount Software:** A terminal window showing the software's command-line interface. The user has entered 'info' to view system information. The terminal displays a list of categories and their current status, including MCS\_Context, INTERLOCKS, MCS\_AZENC, MCS\_DIAGNOSTIC, MCS\_TIME\_INFO, MCS\_MOTORS\_INFO, MCS\_LIMIT\_SWITCHES, MCS\_MOTION\_INFO, MCS\_POINTING\_INFO, MCS\_CMD\_STATE, MCS\_STATES, MCS\_LOCKING\_PINS, MONITORING, MCS\_SET, and ALL.
- Telescope AZTRI-1 Azimuth - Zenith Angle:** Two circular monitors showing the current azimuth and zenith angle of the telescope. The top monitor shows the current azimuth (Tel-Az:-85°) and the bottom monitor shows the current zenith angle (ZA:19°). Both monitors include 'Start' and 'Stop' buttons for monitoring.

Some Panels of the Mount AIV Software



Thank you



View from Themis Telescope