

# ATLAS-Teide: A Modular and Cost-Effective Upgrade to the ATLAS network

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## ABSTRACT

We present the new ATLAS unit installed at Teide Observatory (TO) in Tenerife island (Spain), mid January 2025. ATLAS-Teide, the 5<sup>th</sup> ATLAS unit, was built by the IAC following a new modular design based on commercial off-the-shelf (COTS) components made by UH and IAC. ATLAS-Teide is operated by IAC and UH.

## THE ATLAS NETWORK

The Asteroid Terrestrial-impact Last Alert System (ATLAS) is an asteroid impact early warning system developed by the University of Hawaii [1] and funded by NASA. Until 2024 operated four Wright Schmidt 50cm telescopes (2 in Hawaii, 1 in Chile, and 1 in South Africa).

- Each ATLAS maps 1/4 of the sky per night, making 4 observations of each field at intervals of one hour, detecting objects of  $V=19.5$  in 30s exposures.
- The software automatically detects moving targets, discovering hundreds of new objects every night. Also provide precise astronomical and photometric measurements of thousands of asteroids making ATLAS one of the most prolific asteroid database.
- ATLAS also processes the survey data to find stationary transient events: supernovae, starbursts, and fast transients like GRB afterglows, etc. and search for electromagnetic counterparts of gravitational wave sources.

## THE NEW ATLAS MODULAR DESIGN

UH and IAC aimed a design that provide similar capabilities in terms of sensibility and sky area covered per night, easier to build and maintain, cheaper and much more flexible

- Each ATLAS module is based on COTS that consist in:
  - **Optics:** 4 x RASA11 OTAs (11" aperture f/D=2.2)
  - **Cameras:** QHY600PRO back-illuminated 9x6K 3.76 microns sCMOS
  - **Mount:** improved Planewave L-500 (the L-550) [2]
  - Ad-hoc support to mount and alignment of the 4 OTAs
- The four RASA 11 aligned to observe the same field:
  - Effective aperture combining the 4 images = 56cm
  - Field of view  $\sim 7.35 \text{ deg}^2$  (1,26 arcsec/pix)

## SOFTWARE DEVELOPMENT

- The challenges of ATLAS-Teide are robotization and data management. It has 16 cameras producing 120Mb images every  $\sim 40$ s seconds. Images have to be on-the-fly dark and flat reduced, aligned and combined before being analyzed by the ATLAS moving objects processing software (MOPS).
- ATLAS-Teide software infrastructure is organized as a distributed task system: Mount and focusers are controlled by rest api based on ASCOM Remote. Cameras are connected in pairs by USB 3.2 on two linux computers, where custom dockerized code is running and listening for messages sent by socket API. This own code allows us to control the 4 cameras simultaneously, with reading times of 2 ms and differences in trigger time of 1 ms between them.
- Once the Observing Blocks (OBs) are scheduled, the corresponding tasks are received in the RabbitMQ broker and a control worker handles all the elements for the observation. OBs are tracked in a PostgreSQL database from their scheduling to their reduction and calibration. For each camera, a set of 3x10s frames is obtained, then corrected from dark and flatfield, and finally, images from the 4 RASA telescopes are aligned and average stacked all together.
- Final images are sent on the fly to UH and processed with MOPS.
- Results are reported to MPC (Observatory Code R17).

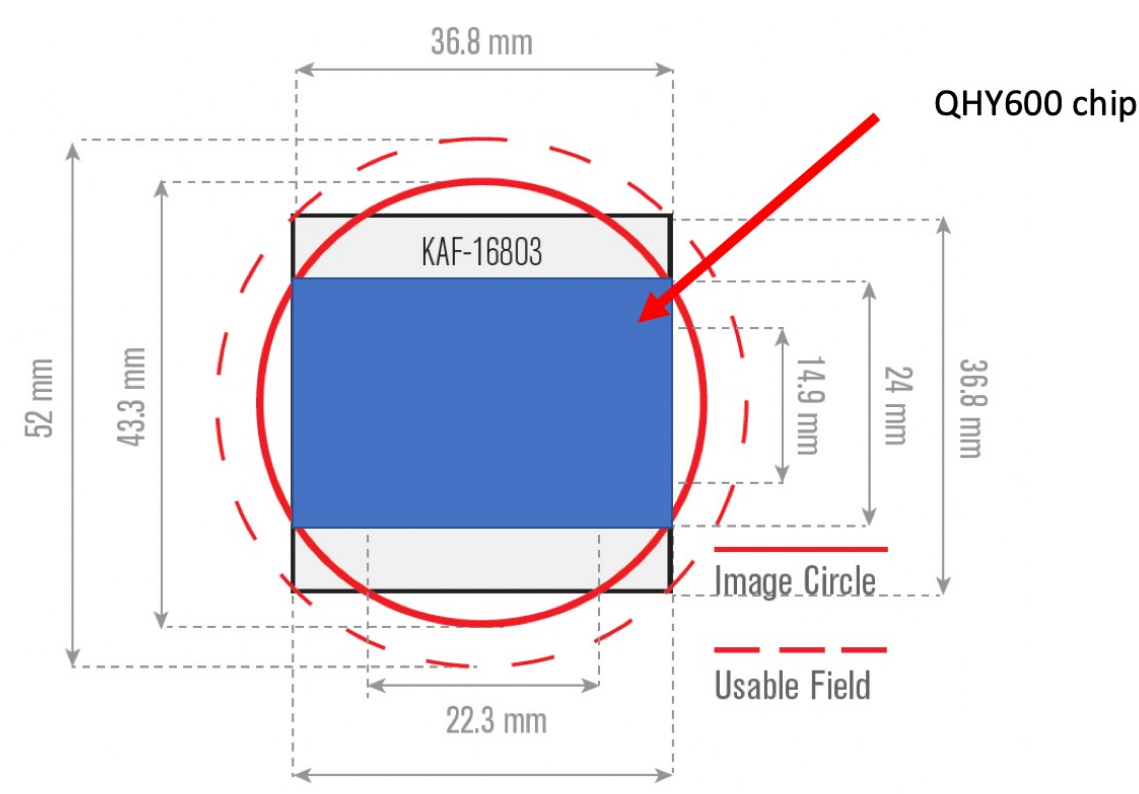


Final 30s,  $3.32 \times 2.22 \text{ deg}$  ( $7.37 \text{ deg}^2$ ) image obtained by median combine the 3x10s exposures obtained with the four telescopes after properly align them.

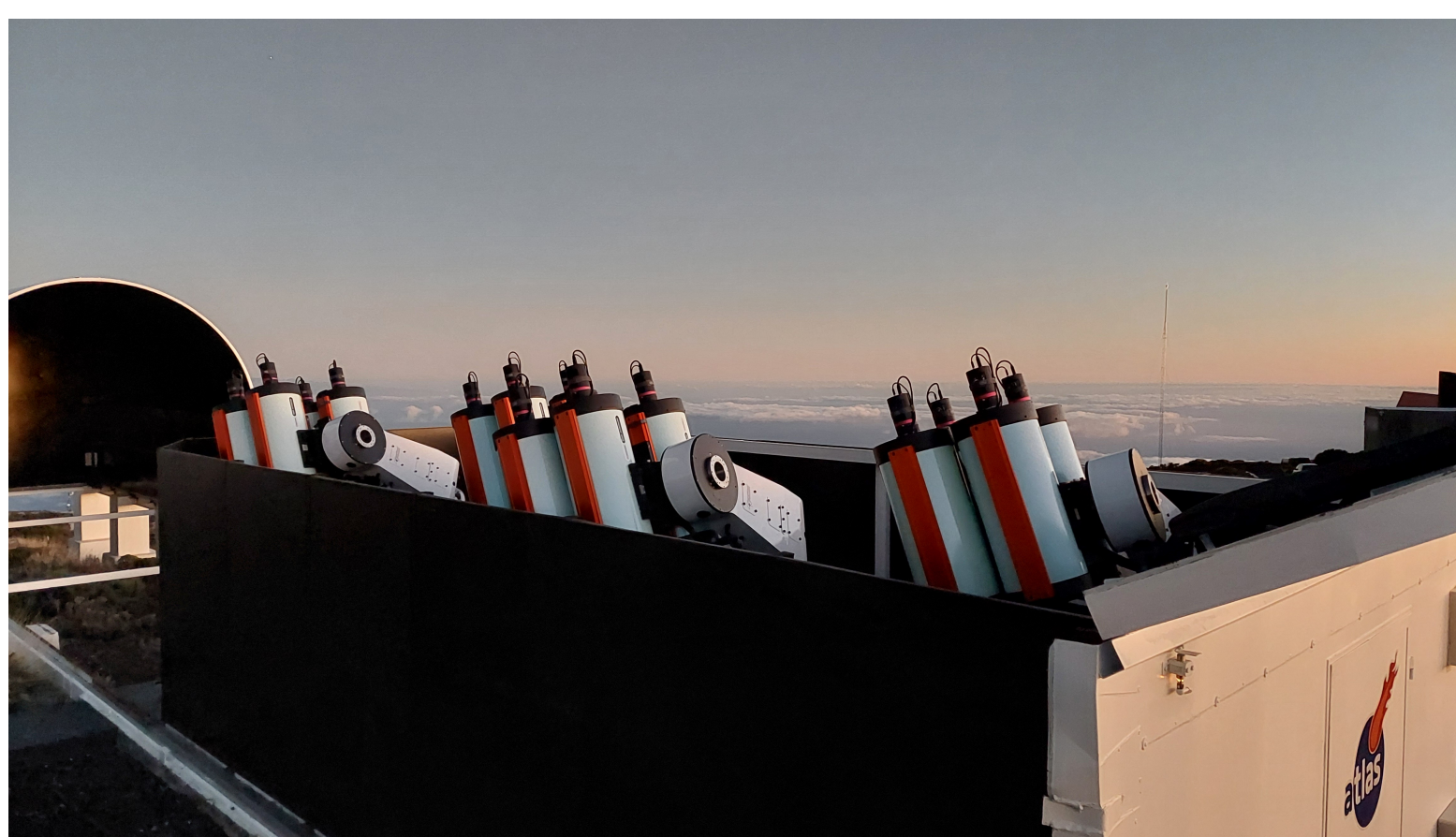
Analysis of the image quality showing the mean PSF in different regions of the image demonstrate that the final products present a reasonably good PSF all along the field.



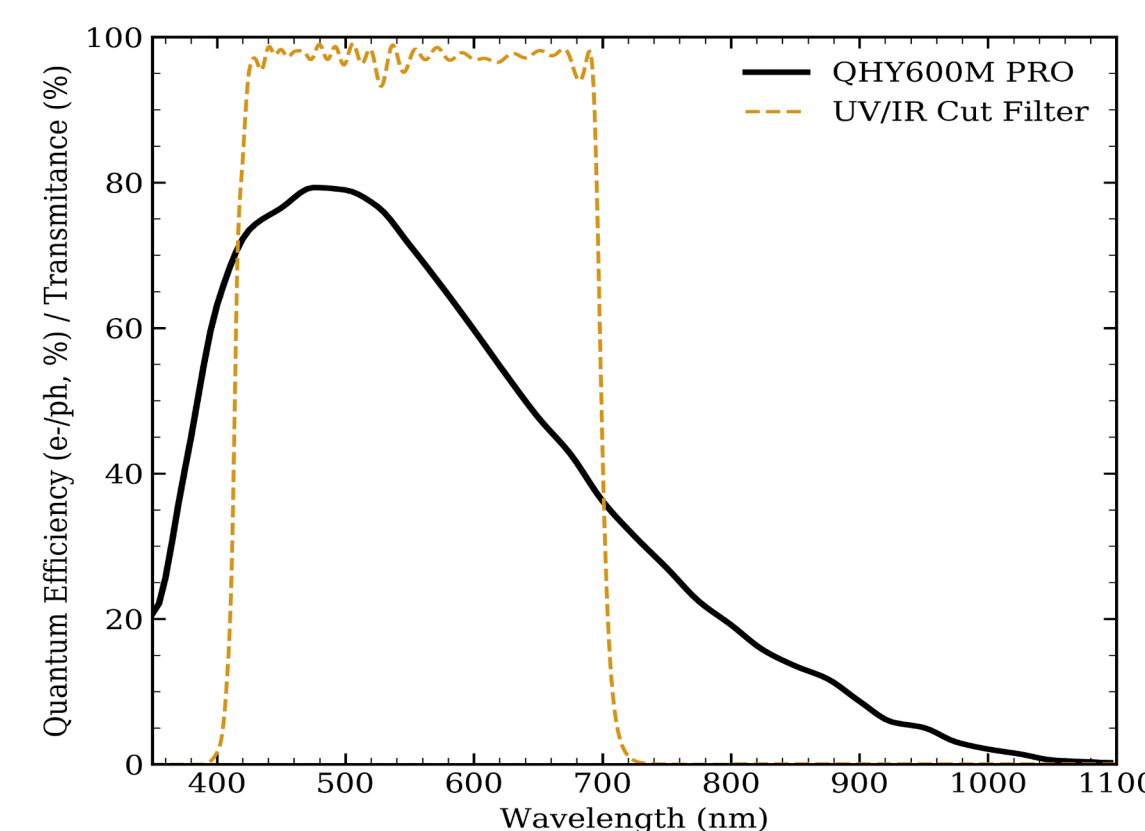
Two of the 4 ATLAS modules installed at Teide Observatory.



RASA11 focal plane [3]. The solid red circle corresponds to that of the optimal 43.3 mm diameter image. The chip used is circumscribed within it



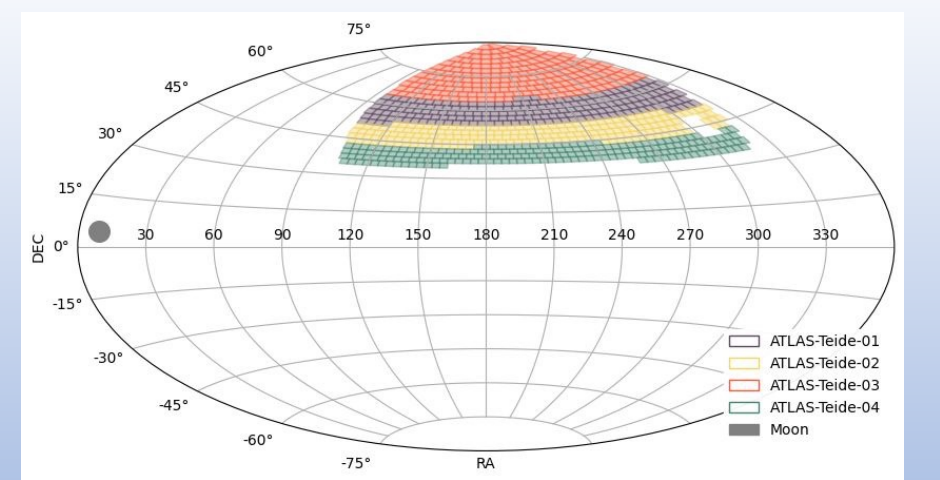
ATLAS-Teide telescopes ready to start observations at Teide Observatory inside its roll-off dome



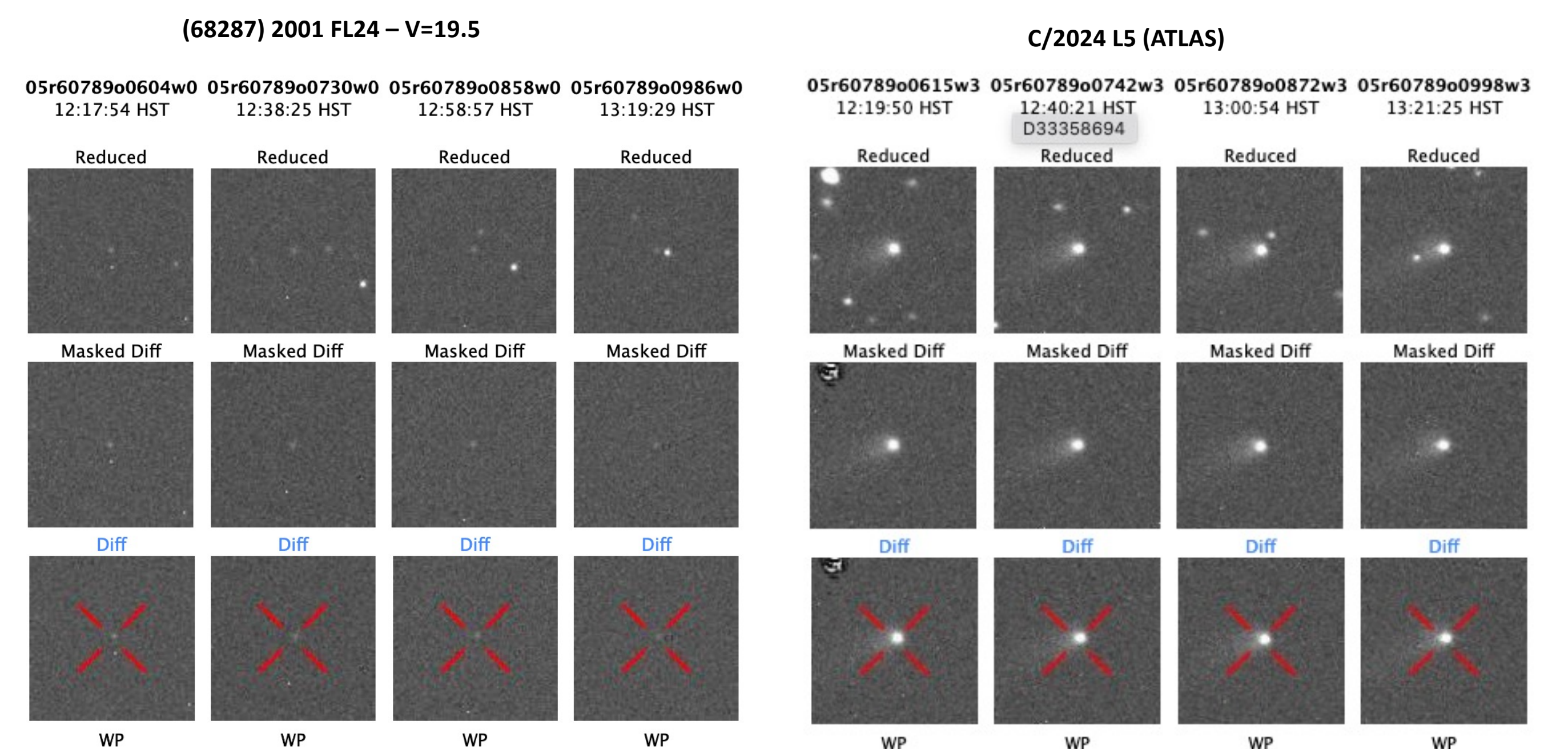
QHY600PRO [4,5] sensitivity curve measured in the IAC detector laboratory LISA. Overplotted is the transmittance of the Baader L-filter, the UV/IR cut filter we use in ATLAS-Teide. Negligible dark current at  $-10^\circ\text{C}$ ,  $\text{rdn} = 1.5e^-/\text{pix}$ , read-out time = 15ms

## FIRST RESULTS

- ATLAS-Teide commissioning started mid January 2025.
- We show that fulfill all ATLAS requirements
- Several full-night observations were successfully done.
- Several thousand asteroids are detected in dark nights, including 10-20 NEAs p/night
- Limiting magnitude:  $V \sim 20.2$



Sky coverage during one observing night



A NEA and a comet detected by ATLAS-Teide. Notice that the NEA is  $V=19.5$

## ATLAS-Teide: the 5<sup>th</sup> ATLAS unit

- It is the 5<sup>th</sup> ATLAS unit. IAC and UH signed an Operation and Science exploitation agreement of ATLAS-Teide in 2023.
- ATLAS-Teide is an IAC instrument included in the present "Strategic plan of the Canarian Observatories" EQC2021-007122-P project (P.I. Licandro, 890.000 €) and ICT2022-007828 (200.000 €), Funded by the European Union - NextGenerationEU.
- ATLAS-Teide consist in 4 ATLAS modules (16 RASA11 telescopes) installed in a  $7 \times 3.5 \text{ m}$  roll-off dome. With 4 ATLAS modules we cover the same field of view of the actual ATLAS telescopes, with similar sensitivity allowing to cover  $\frac{1}{4}$  of the night sky 4 times / night.
- Installed mid January 2025 it is actually starting regular operations.

## CONCLUSIONS

- ATLAS-Teide is successfully operating at Teide Observatory.
- Capable of detecting  $V=20$  NEAs
- ATLAS-Teide fulfils all the ATLAS requirements with only one limitation respect to the previous ATLAS: no robotic filter changer.
- ATLAS-Teide advantages: (1) cheaper, each module cost  $\sim 1/10$  of the actual ATLAS units; (2) an observatory can have the number of modules that can fund, so ATLAS network can easily grow; (3) easier to build, install, maintain and upgrade; (4) CMOS cameras allows to do very short exposures without a noticeable dead time allowing different strategies to detect very fast moving targets; (5) the four modules of ATLAS-Teide can be used in different ways, e.g. each one pointing to a different field to cover a larger possible sky area or to observe all the same field, then having a system with 1.1m equivalent aperture (an detect up to  $V=21.2$  objects in 30s exposure times).

## REFERENCES

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