Performance assessment of the AOC system on a 1-m telescope: stellar mode characterisation and planetary mode development

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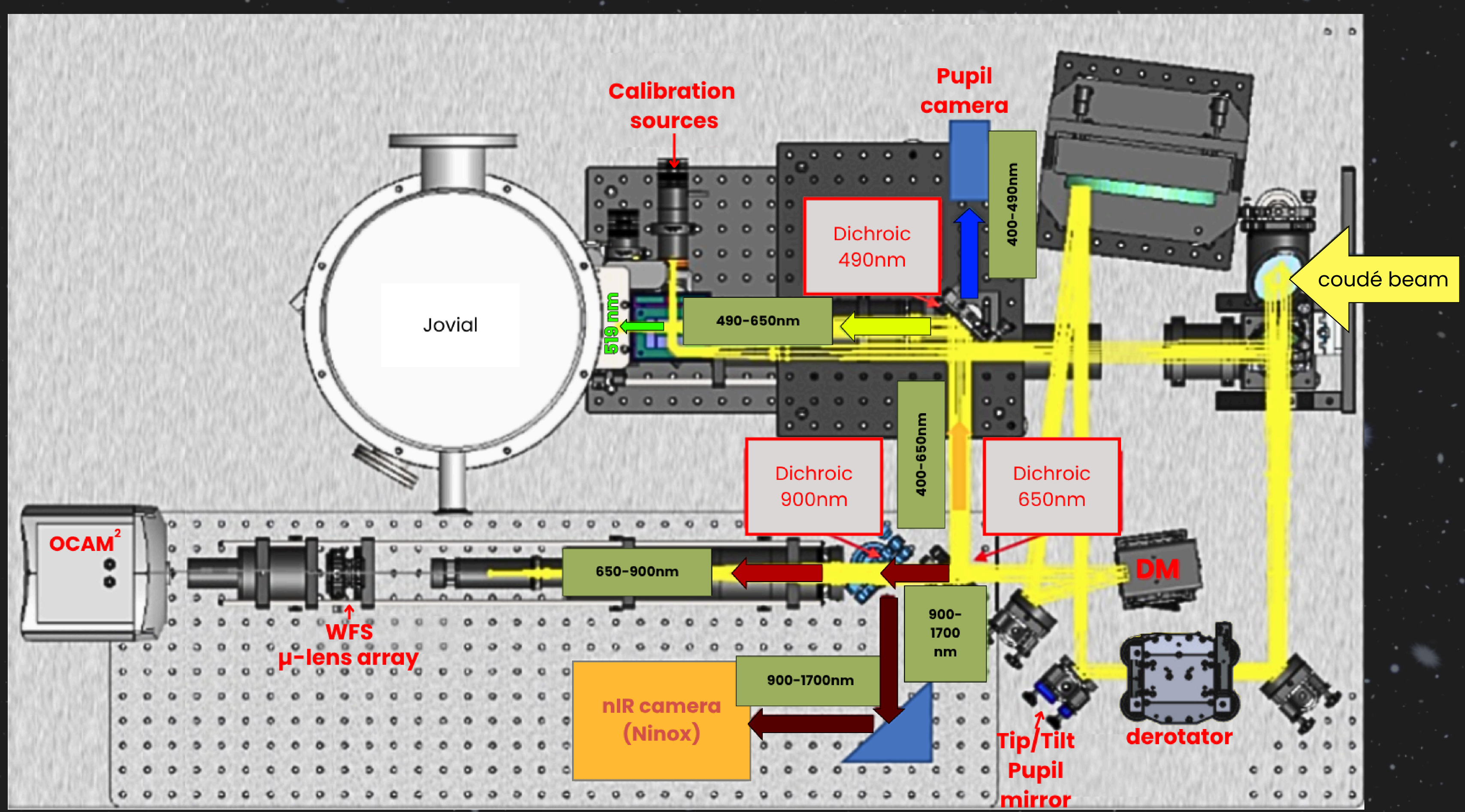
*The AOC **(Adaptive Optics at Calern)** system aims to bring AO correction to 1-m class telescopes, which typically lack such capabilities, enhancing their high-angular resolution imaging performance. It offers both stellar (8.5″ FoV) and planetary (30.5″/80.5″ FoV) modes, guiding either on point sources or extended objects (such as Jupiter or Saturn). This work focuses on the ongoing characterisation and optimisation of the system, from near-infrared to visible wavelengths. We are developing both simulation tools and diagnostic/evaluation tools, and comparing simulations, telemetry, and on-sky data, aiming at refining wavefront control and improving robustness for both stellar and planetary observations. Developments are ongoing for the latter case.*

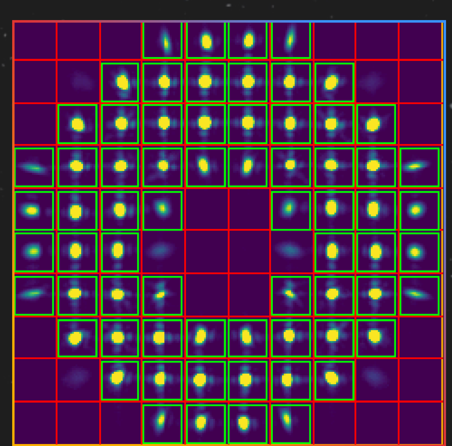
System configuration

The AOC system is a multi-purpose adaptive optics platform, correcting at **519nm** (JOVIAL [1]) and in the **near IR** (HiPIC).
Sensing is performed at **650-900nm** from **stellar or extended sources** (**3 different fields of view**).

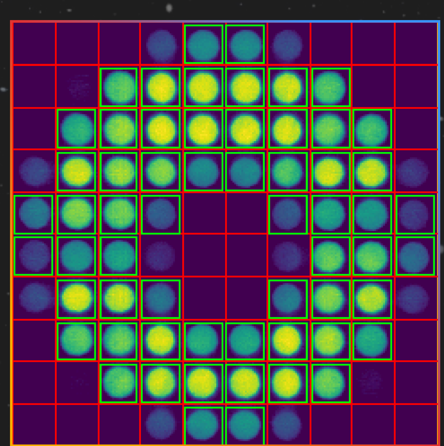


AOC bench view

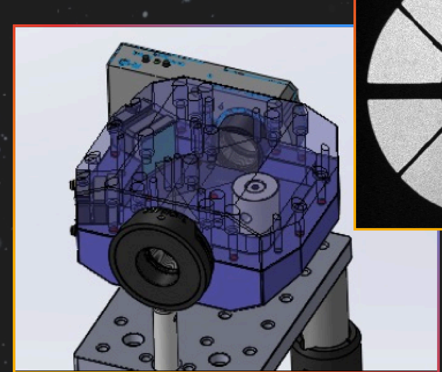
- **10x10** Shack-Hartmann wavefront sensor
- **11x11** (97 actuators) ALPAO deformable mirror, ∅ = 15mm
- 2 calibration sources: point source, extended source



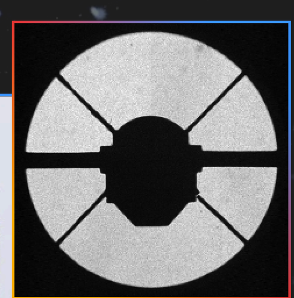
Point source



Extended source



Derotator

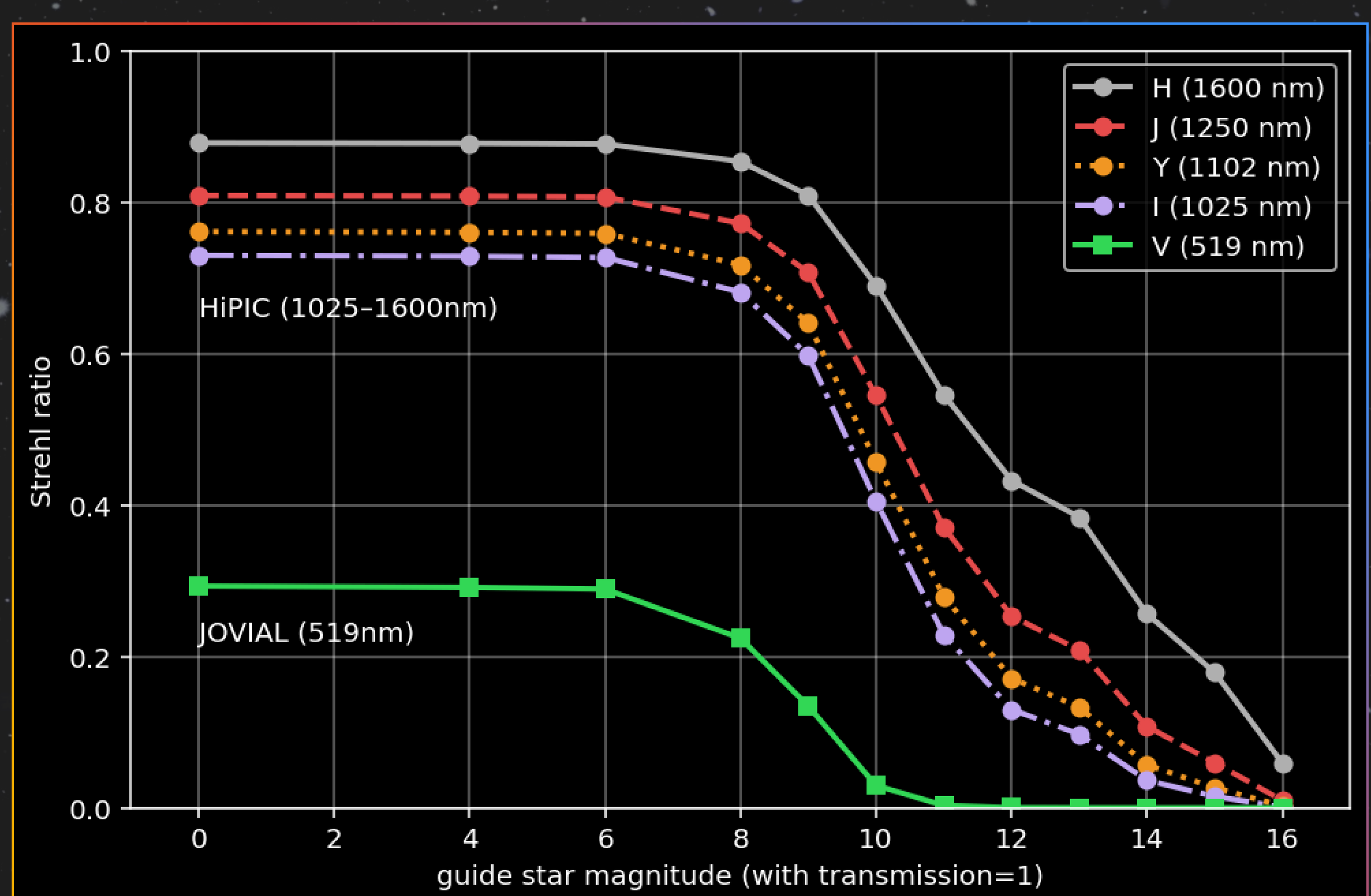


Pupil

- **3 µ-lens arrays,** with a field of view of **80.5", 31.5", and 8.5"**
- Pupil derotator and pupil tip/tilt mirror

Expected results

Simulated Strehl ratio vs magnitude for V, I, Y, J, and H filters in stellar mode (8.5"), excluding static Strehl losses.



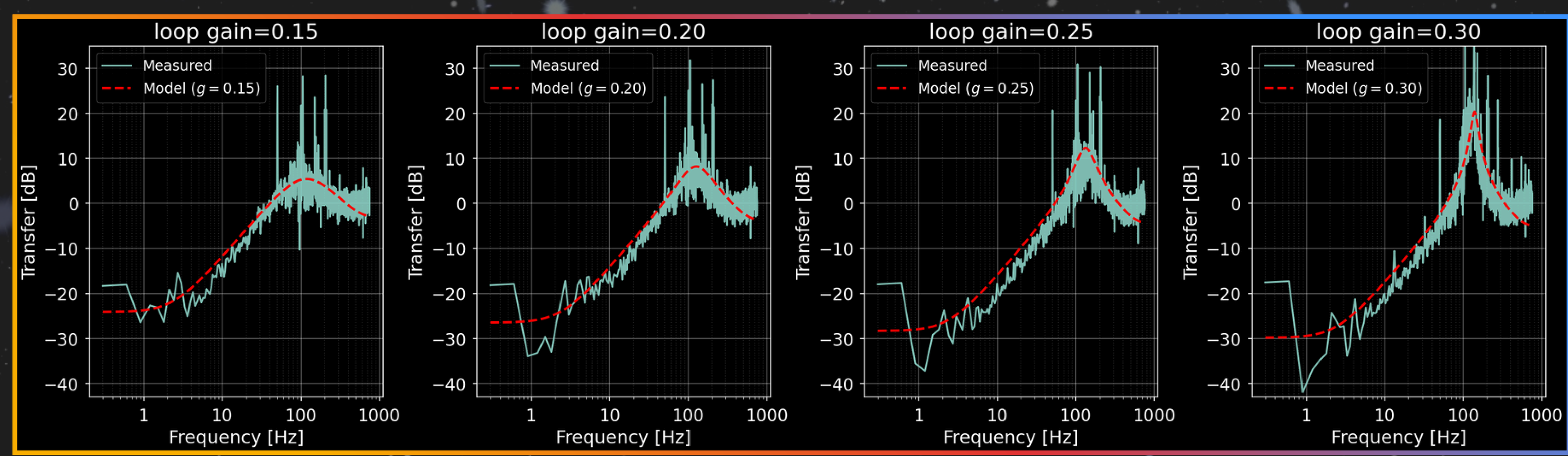
Strehl ratio as a function of magnitude (CAOS end-to-end simulations)

4-layers turbulent atmosphere	Wavefront sensing	Wavefront correction
r_0 @500nm = 7 cm	10x10 SH (68 sub-apertures)	ALPAO DM-97
[3.5, 4.5, 9.4, 22.1] m/s	650-900nm	Measured influence functions
[69, 10, 4, 17] $\%C_n^2$	OCAM² @ 1.5kHz	85 SVD modes
$\mathcal{L}_0 = 30m$	Photon noise only	Closed loop gain = 0.25

Parameters table for the simulation

Experimental transfer function analysis

- Closed-loop transfer function shows a **3-frame delay (2ms).**
- This delay increases overshoot and limits stability, forcing lower gain.
- Transfer function measured with photon noise (flat spectrum).
- Vibrations at transfer function overshoot, need to be identified and eliminated at the source.

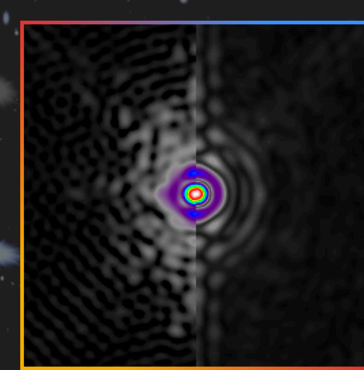


Transfer function from closed-loop measurements + fit

→ Improvement paths: reduce latency (computation, DM, data transfer) to **target 2 frames**, and explore improved PID control.

Measured static PSF in H-band

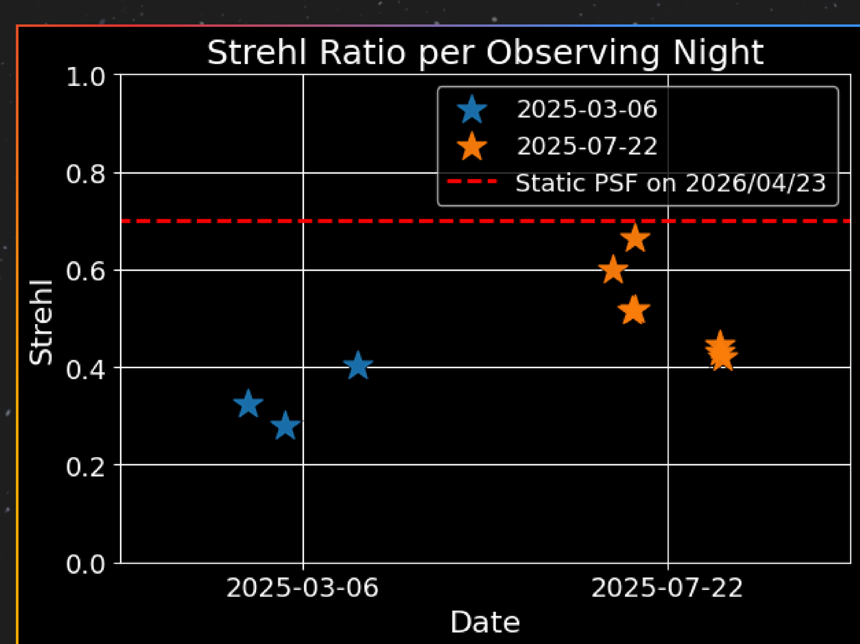
Strehl ratio: 70% in H-band.
- Optimised "by hand", can be improved, developing procedure for automated optimisation.
- Static aberrations modeled thank to Gerchberg Saxton algorithm.



Static PSF (H-band)

On-sky results

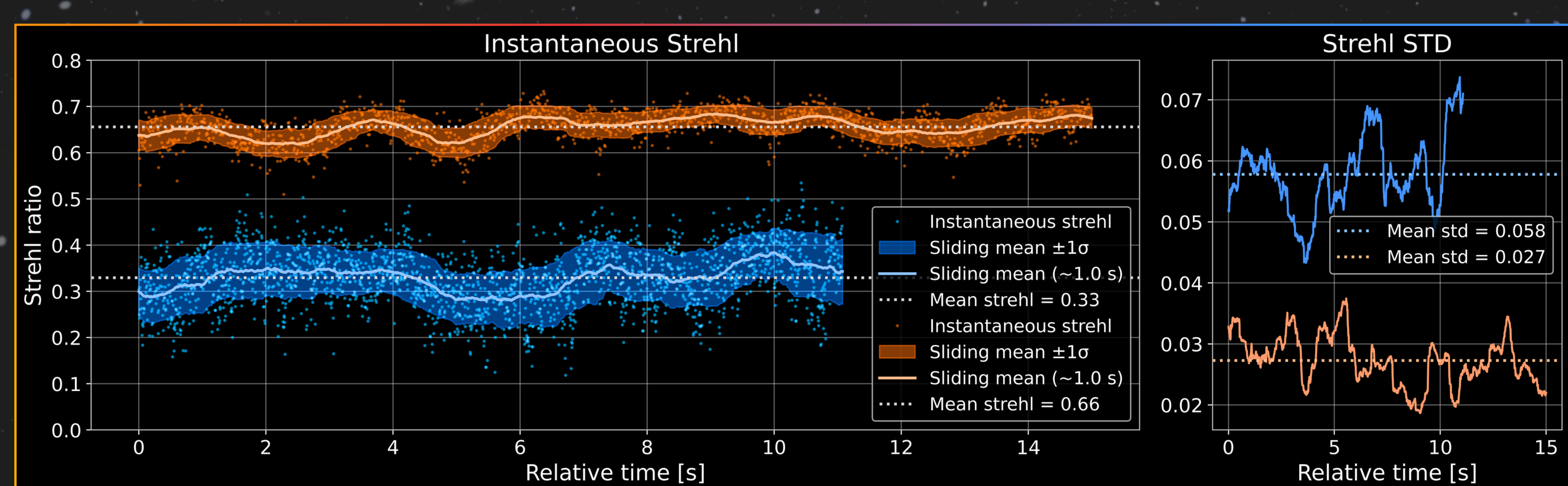
Comparison of system performance between March 2025 and July 2025, based on Strehl ratio analysis.



Strehl ratio evolution March / July 2025

AO OFF/ON

Improved correction in July (using zonal control and filtering 25 modes at inversion) compared to March (using 14 Zernike modes), thanks also to continuous improvements and slightly better turbulence conditions.



Instantaneous Strehl ratio evolution for March and July 2025 observations.

System performance improved between March and July, with more stable Strehl ratios and reduced fluctuations. Future work will include comparison with on-site seeing monitoring (Anatolia [2]).

References

[1] F.X. Schmider et al., 'Doppler imaging measurements in the visible with adaptive optics: improving and estimating the PSF for planetary atmosphere wind measurements', in 'Ground-based and Airborne Instrumentation for Astronomy XI', SPIE Astronomical Telescopes + Instrumentation, July 2026, Copenhagen, Poster 14149-175

[2] Ch. Giordano et al., 'ANAtOLIA: from first light to multi-site atmospheric characterization', in 'Adaptive Optics Systems X', SPIE Astronomical Telescopes + Instrumentation, July 2026, Copenhagen, Poster 14150-248