Adaptive optics corrected imaging for satellite and debris characterisation

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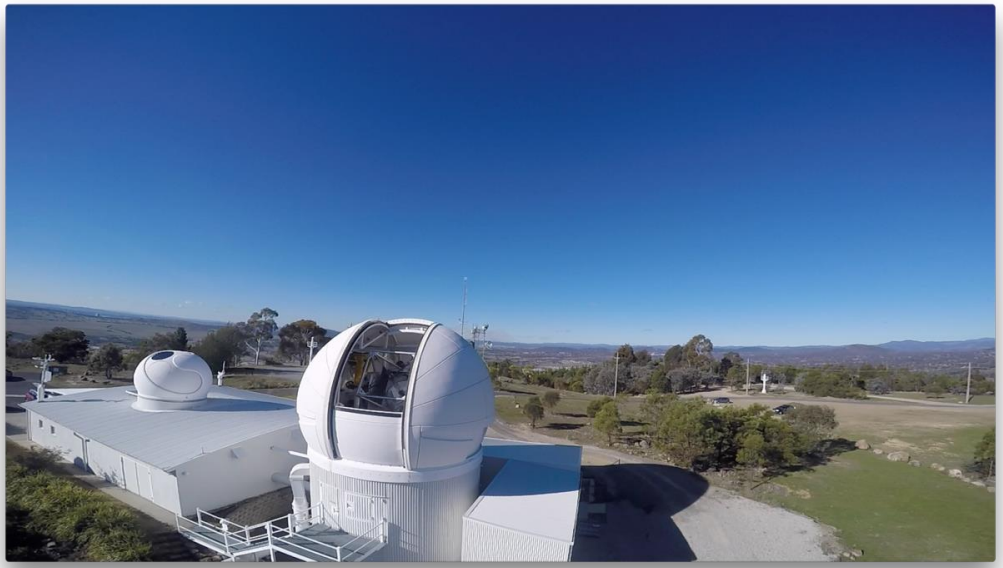
AOI: Adaptive Optics Imaging

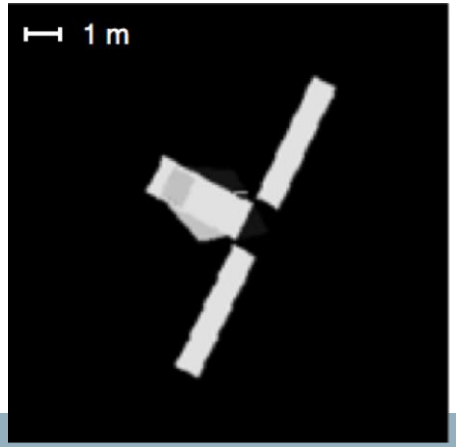
- AO system for satellite and debris imaging on 1.8 m telescope located in Canberra, Australia
- ANU contribution to SERC RP1
  - Debris characterisation and object database
  - GEO object tracking

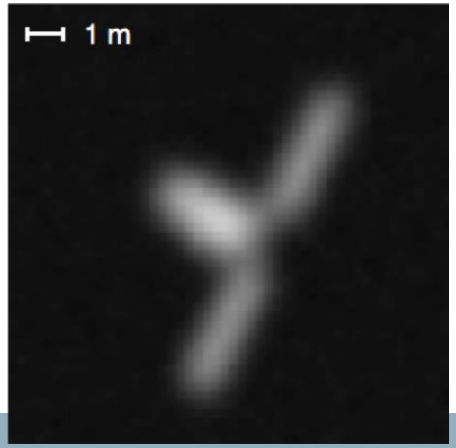


Credit: F. Bennet

Satellite and Debris Imaging in LEO

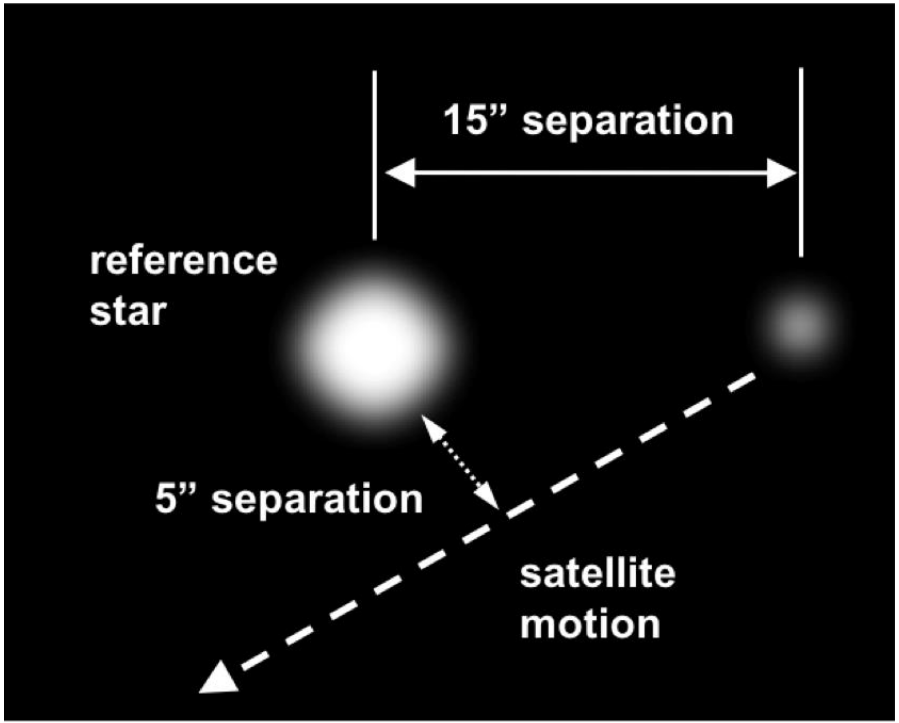
- Object Characterisation in LEO
  - Size, shape and orientation
  - AOI will achieve 50 cm resolution at 800 km range and 850 nm wavelength
- Feature recognition to improve to better understand how external forces impact orbit to improve orbit prediction





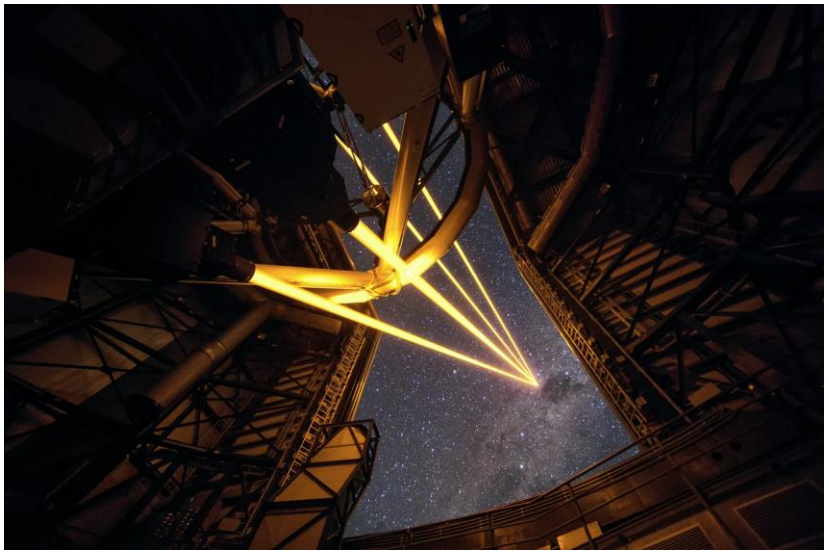
Tracking in GEO

- Positional measurements of satellites
- GAIA catalogue gives accurate astrometric reference
- Satellite tracking precision of a few metres
- Opportunity to track GEO objects with NIR lucky imager on 2.3 m telescope in October



NGS and LGS Operation

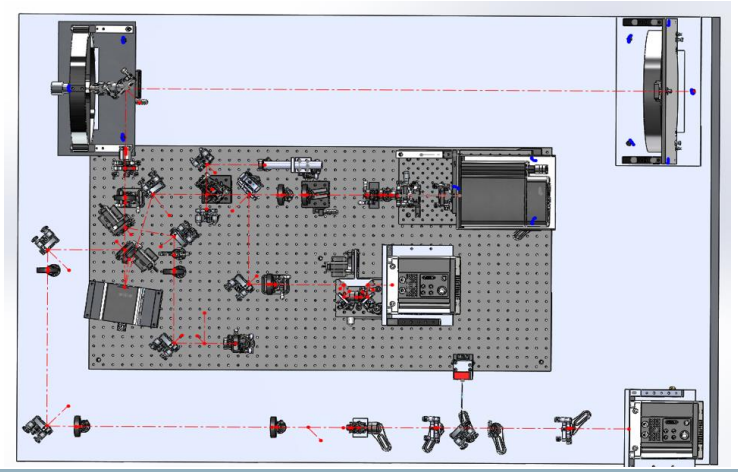
- Natural Guide Star (NGS): September 2018 – February 2019
  - The object is used as the guide star for the AO system
  - 450 – 800 nm light used for WFS, 800 – 950 nm light used for imaging
- Laser Guide Star (LGS): March 2019 onwards
  - Artificial beacon created in the sky
  - 589 nm light used for WFS, 650 – 950 nm light used for imaging



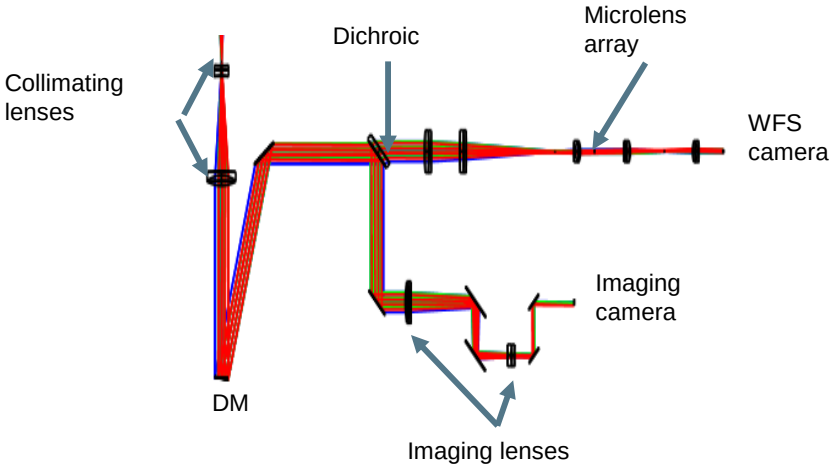
Credit: ESO

AOI Overview

- Deformable mirror – ALPAO DM277
  - 277 Actuators in 17x17 grid
- Wavefront sensor – Shack Hartmann with 16x16 subapertures
  - Up to 2 kHz frame rate with OCAM2k EMCCD camera

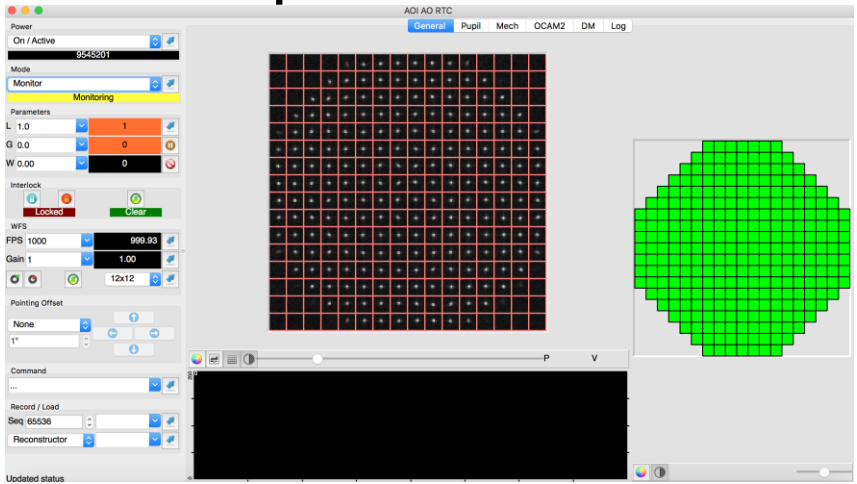


- Imaging camera – Nuvu Hnu 512 EMCCD
  - 512x512 pixels, 16 μm pixel size and 60 Hz frame rate
- Imaging field of view – 24” in high resolution imaging mode

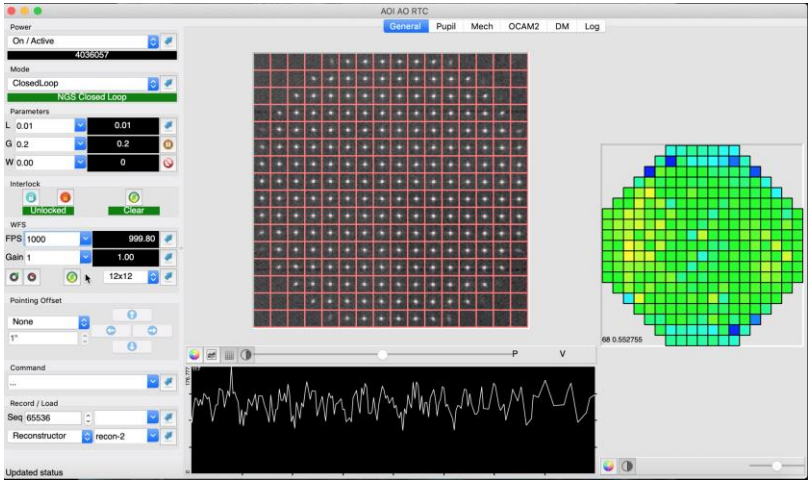


AOI Current Status

- AOI is built and installed in the telescope clean room
- AO loop closed with calibration source



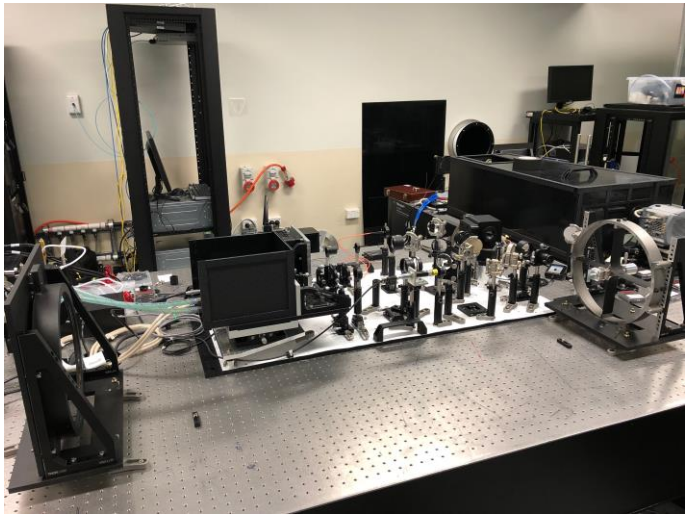
Open loop WFS spots

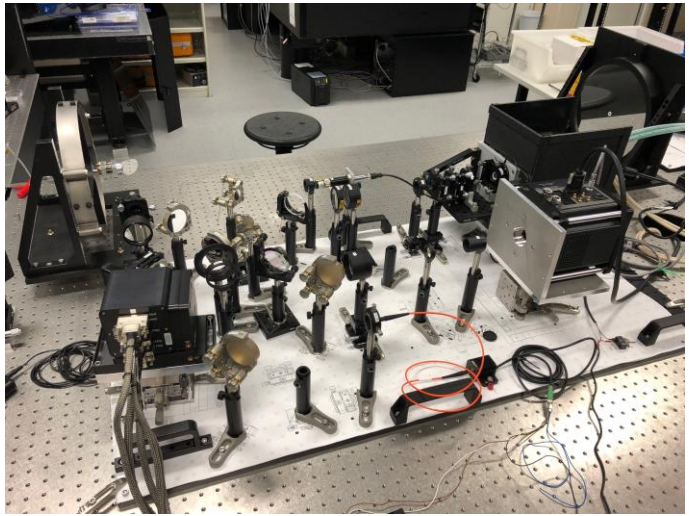


Closed loop WFS spots and DM profile

Telescope Integration

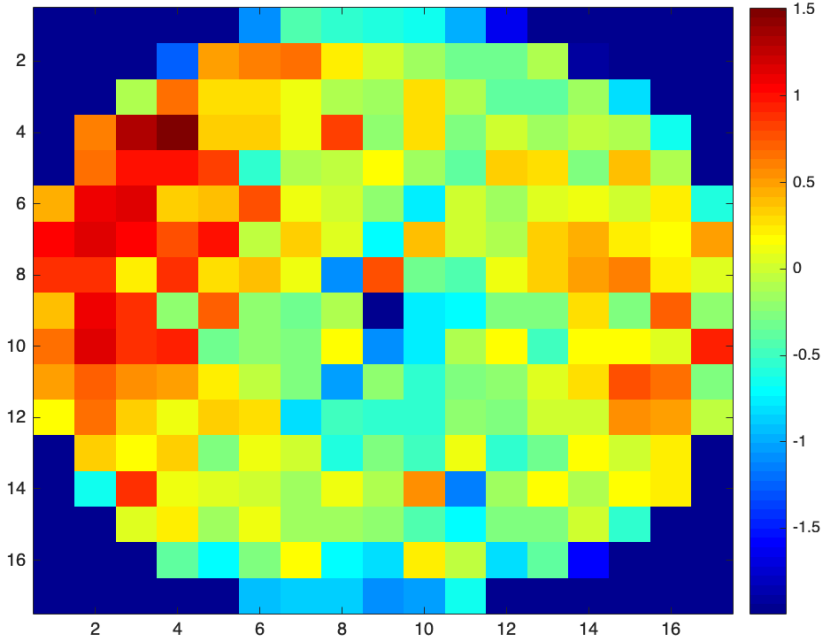
- AOI installed in 1.8 m telescope clean room
- Aligned to the Coude path
- Interface with the telescope control system has not been completed





Closed Loop Operation

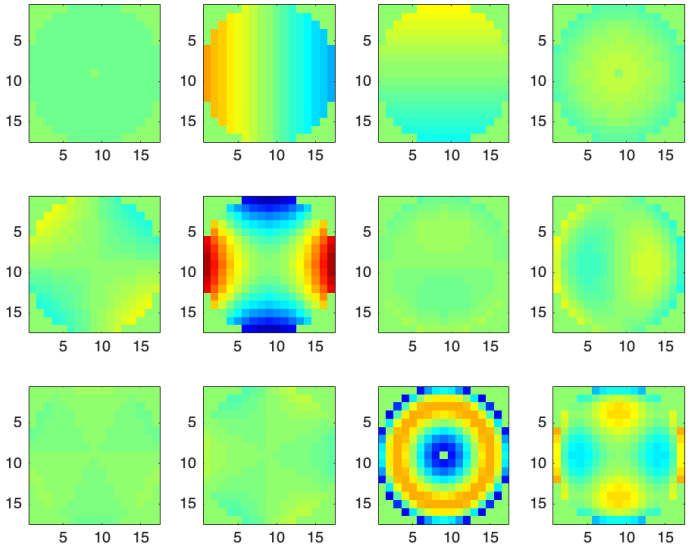
- -2 µm to +1.5 µm stroke needed to perform correction
- WFS can operate at maximum of 1.4 kHz
  - DM causing 1.4 kHz limitation
  - We are working with ALPAO so the system can operate at the designed speed of 2 kHz



DM commands for closed loop

Closed Loop DM Modes

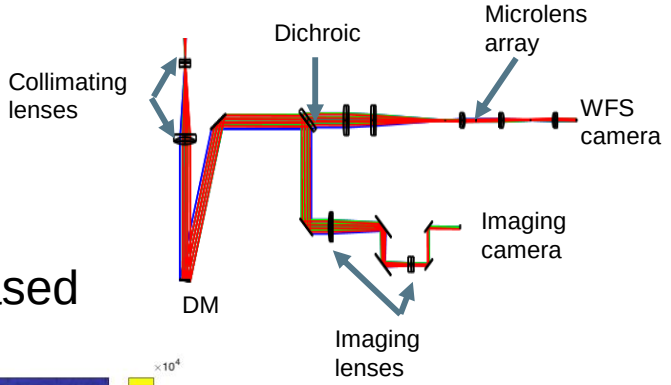
- Modes present in closed loop:
  - Tip/tilt
  - Astigmatism
  - Spherical aberration



First 12 Zernike modes of closed loop DM figure

NCPA Correction

- Non common path aberration correction applied for imaging arm
- Image of calibration source fibre at imaging camera
- Relative intensity of image peak to background increased by factor of 5



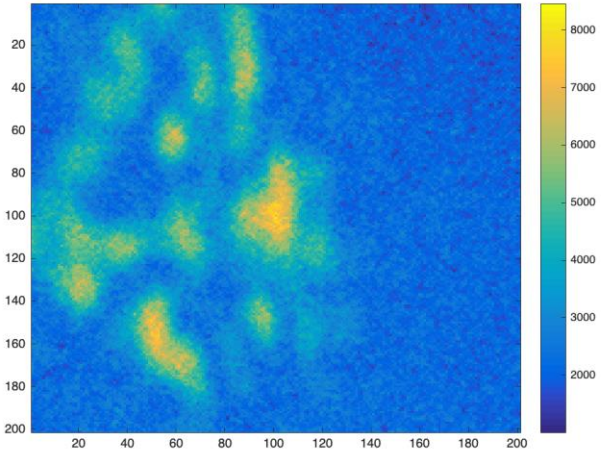


Image before NCPA

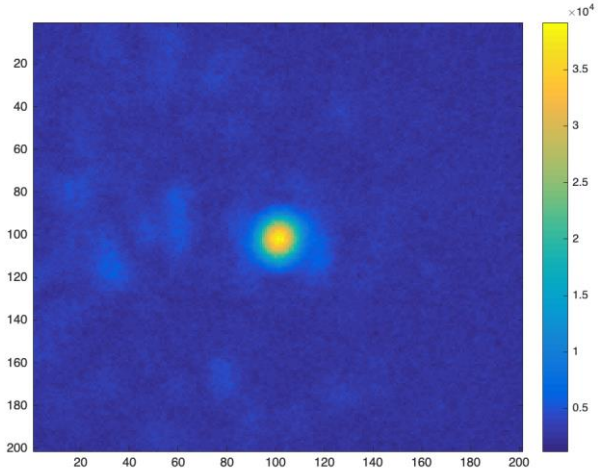
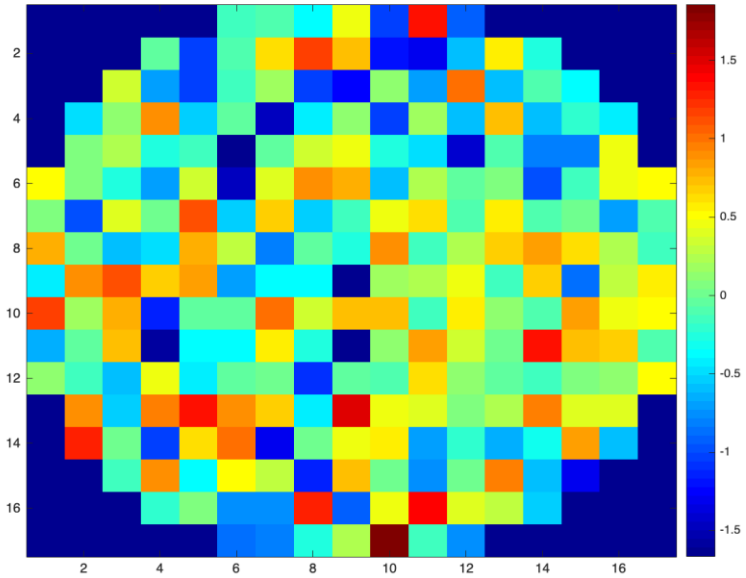


Image after NCPA

DM Commands for NCPA Correction

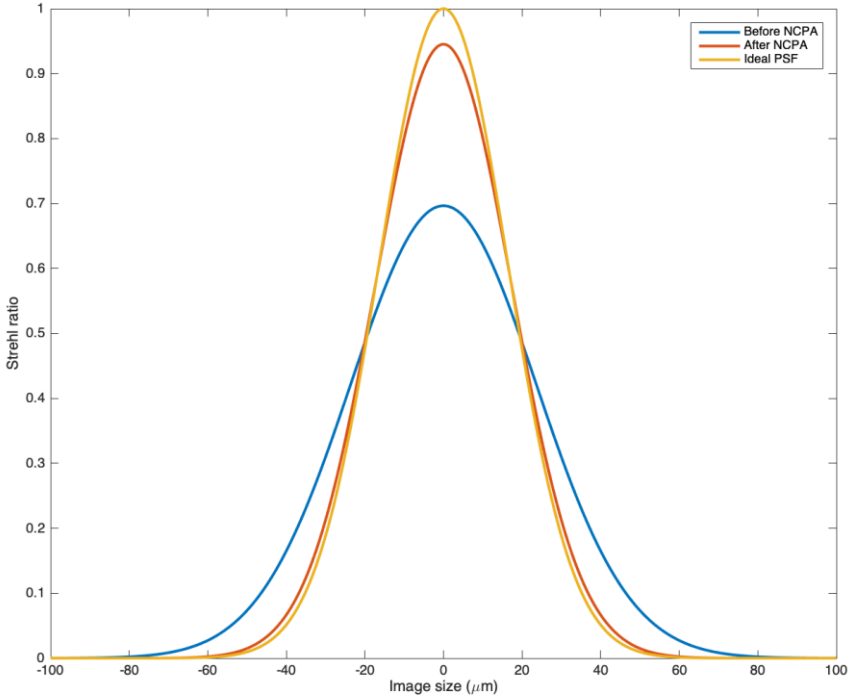
- ±1.5 μm stroke used for NCPA correction
- NCPA correction may be reduced by improving alignment and removing background light



DM commands for NCPA correction

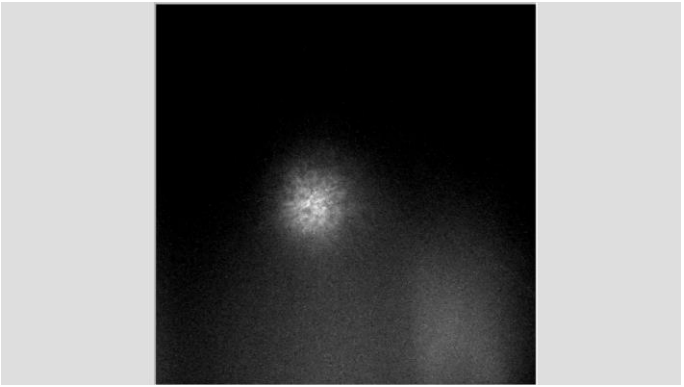
Strehl Ratio Improvement

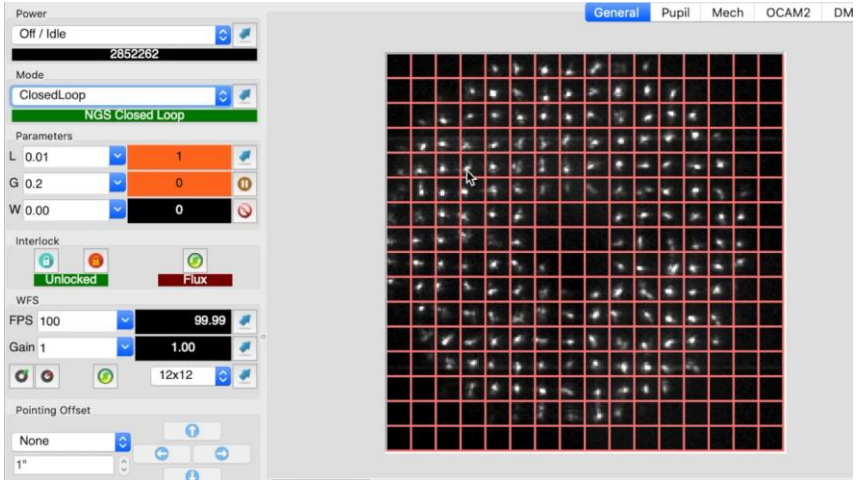
- Ideal spot FWHM of 42 μm
- Strehl ratio is increased from 70% to 93% after NCPA correction



On-sky Operation

- First light of AOI observing bright stars
- Difficult to centre star on WFS as telescope was being operated remotely and poor seeing conditions
- Not able to close loop





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