



Adaptive Optics R&D

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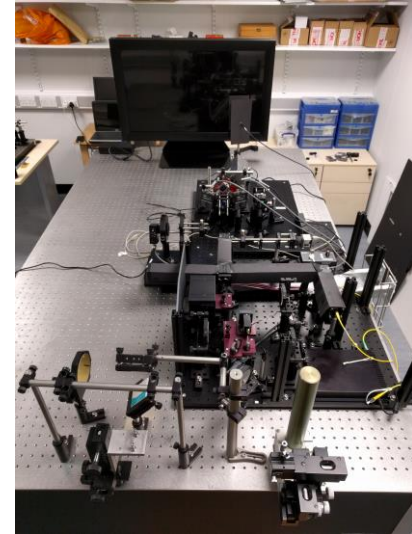
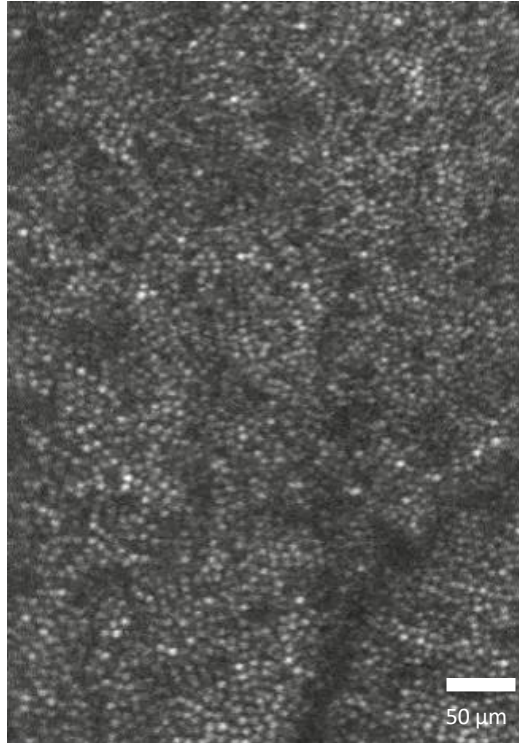
Adaptive Optics research at Durham

- The AO group within Durham comprises ~20 researchers and students
- We focus principally on developing astronomical adaptive optics for large telescopes
 - Wide-field laser guide star AO
- Also have active research programs in:
 - Turbulence profiling
 - Ophthalmic AO and vision science
 - Active optics control for space telescopes



Ophthalmic AO

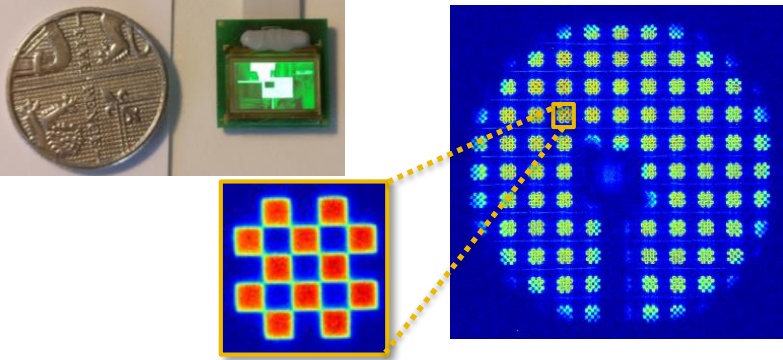
- Built a low-cost compact scanning ophthalmic AO system in collaboration with Oxford
- Designed primarily for psycho-visual experiments
- Also used for medical tests
- Continued research into
 - application of astronomical wide-field techniques to ophthalmic imaging
 - High-speed accommodation tracking
- Close collaborations with local medical institutions and Oxford University



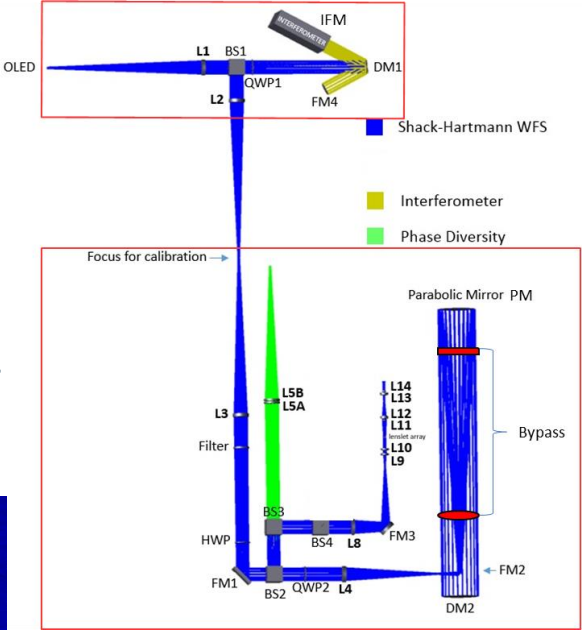
Compact scanning laser ophthalmoscope built in collaboration with the Department of Experimental Psychology (Oxford)

Active optics for space telescopes

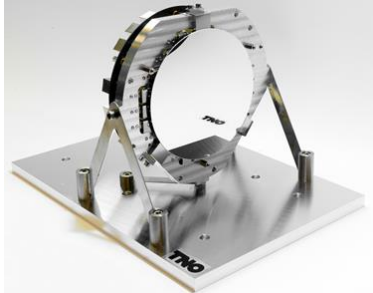
- Just completed an ESA-funded study demonstrating wavefront control in large future space telescope/earth observation satellites
- Tested a new space-qualified DM built by TNO (Netherlands)
- We concentrated on the wide-field WFSing (Shack-Hartmann and Phase Diversity) and control system



Micro-OLED for wide-field target emulation



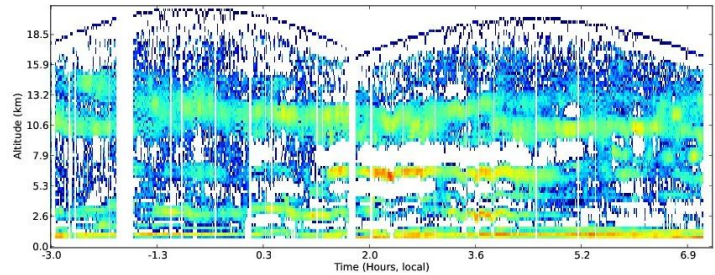
Experimental setup for system tests



TNO deformable mirror under test

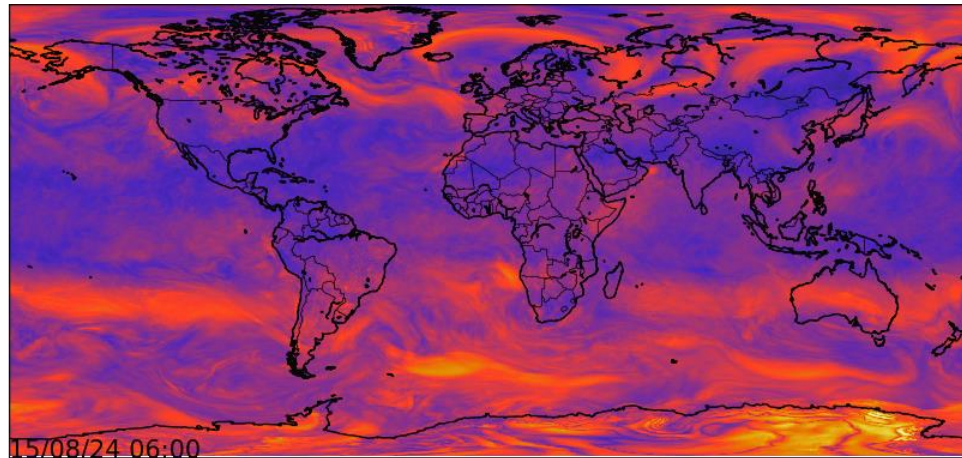
Turbulence Profiling

- We operate turbulence profilers primarily in Paranal and La Palma (+ Korea and Thailand)
- Have regular observing runs to La Palma for instrument development
- Worked with several groups to test new instruments against ours
- Large databases of high vertical resolution profile data are available
- Being used to design ELT AO instrumentation
- Also used as input to turbulence forecast models



High vertical resolution measurement of the optical turbulence strength vs. altitude over a night in La Palma (Osborn *et al*, Jphys 545, 2015)

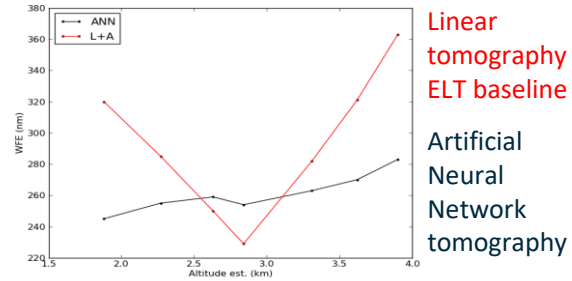
Free-atmosphere seeing in 2015 from GCM data



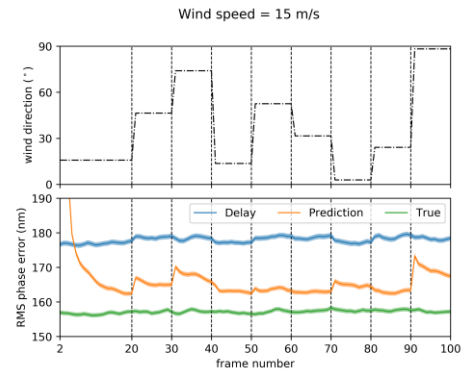
Tomographic AO for the ELT

- Involved in two ELT AO instruments
 - HARMONI**: First-light AO integral-field unit spectrograph
 - MOSAIC**: Wide-field AO multi-object spectrograph
- HARMONI** roles in Durham
 - Developing the real-time control system
 - Natural guide star wavefront sensing systems
- From the AO perspective, **HARMONI** design and analysis is ~90% complete
- MOSAIC** is currently being re-baselined to improve survey efficiency
 - There is potential scope to be involved in the AO (+ instrument) design
- Big open AO questions mostly relate to:
 - Properties of the atmosphere on 40m+ scales
 - Computationally efficient wide-field AO control and performance optimisation behind the ELT

Neural network AO control



Laboratory tests of sensitivity of tomographic control to changes in turbulence profile

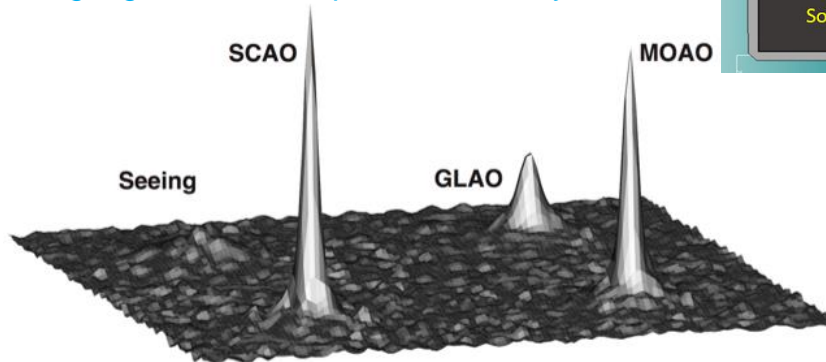
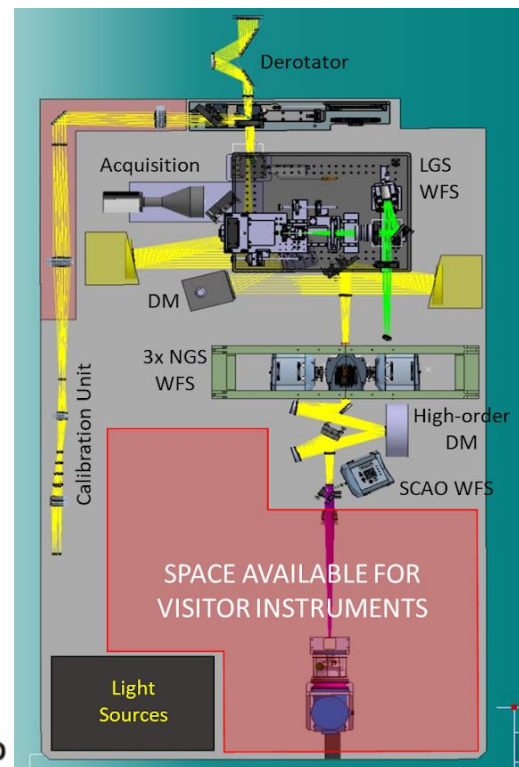


Artificial neural network wavefront prediction under variable wind direction

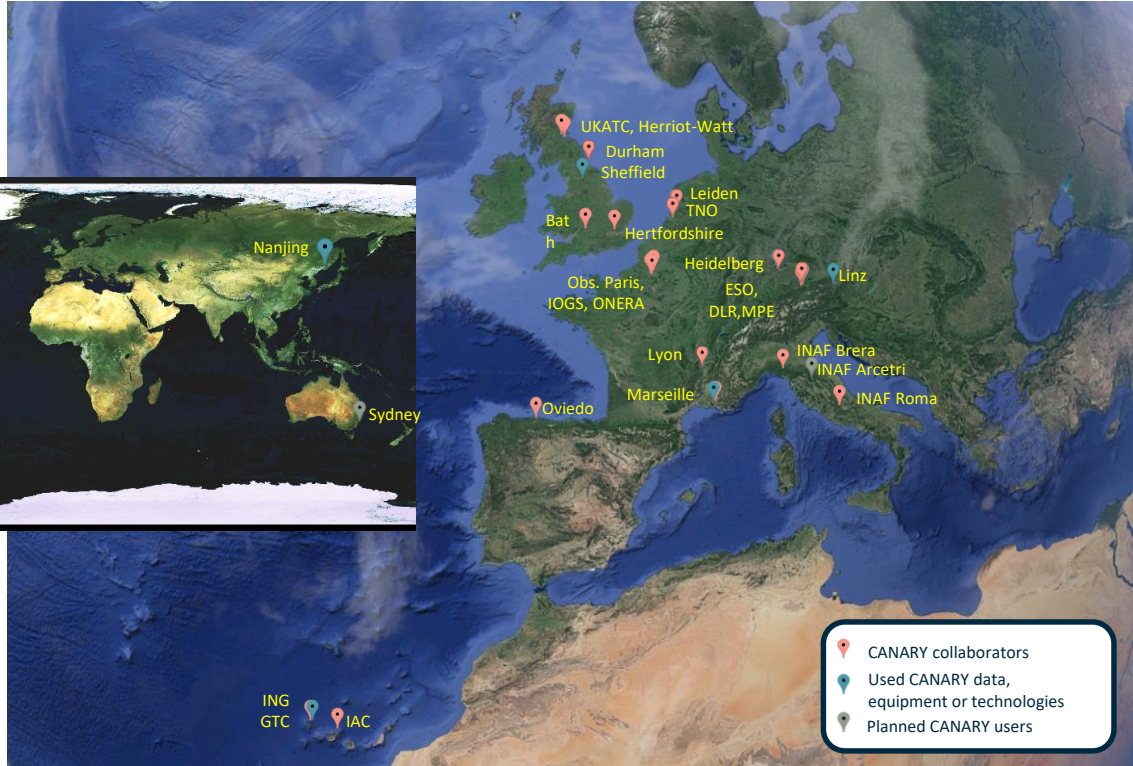
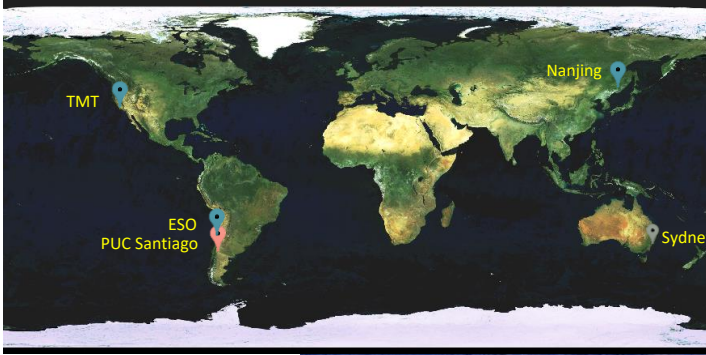
H2020 OPTICON – On-sky instrumentation test program

- We developed the CANARY instrument to demonstrate wide-field multi-guide star AO works
 - Also hosted visitor instrumentation/experiments along the way
- OPTICON provided funds for on-sky access to CANARY up until end of 2020
- Provides an AO corrected focus and has a large space available for visitor instrumentation
- One call to date – next call due soon, but dependent on William Herschel Telescope access at the end of 202
- About 7 on-sky nights on WHT and INT time remaining

<https://sites.google.com/view/opticon-ao/canary-tests>



CANARY users worldwide



Conclusion

- Durham have a broad AO research program led by astronomical AO R&D
- Key areas for potential collaborations:
 - MOSAIC AO system development
 - On-sky instrumentation testing using CANARY
 - Adapting some of the wide-field techniques developed for astronomy to other fields (although not all are directly transferrable)
- Did not have time to cover:
 - Laser guide star development
 - AO for the European Solar Telescope (currently EU-funded)
 - Novel WFS type for XAO
 - Astrophotonic wavefront sensing
- Much of the work is led by Durham's (small) army of instrument scientists who either Ray or myself can put you in contact with



CANARY open-loop AO science demo

