Wavefront Sensor Comparison Testbed

Wavefront Sensing in the VLT/ELT Era V - AO Workshop Week II

13 – 15 October 2020

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Starfire Optical Range
AFRL/RDSS

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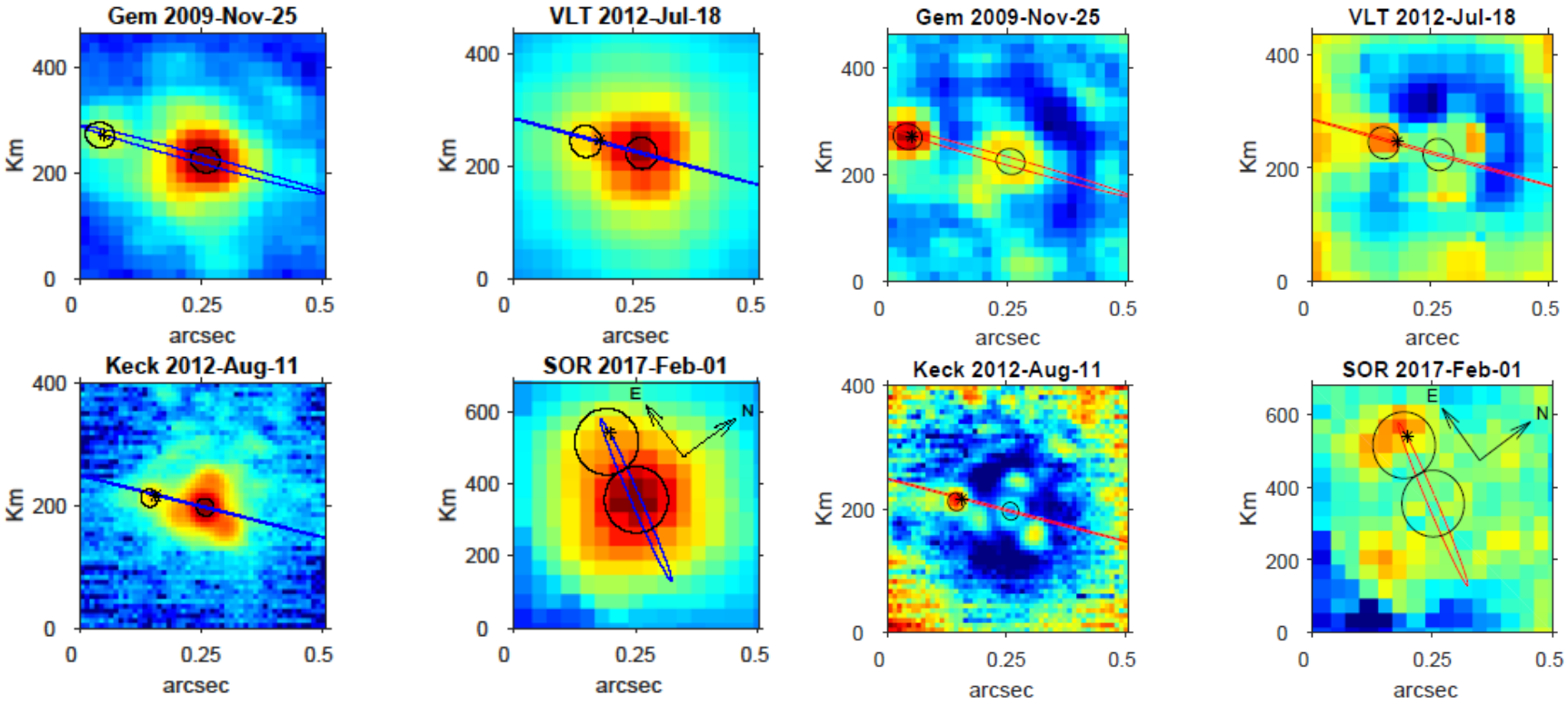
Overview

- Comparing the performance of the SHWFS, nlCWFS, PWFS4, PWFS3
- Theory
- Simulations
- Laboratory demonstration

Objective: moons around asteroids & other closely spaced objects

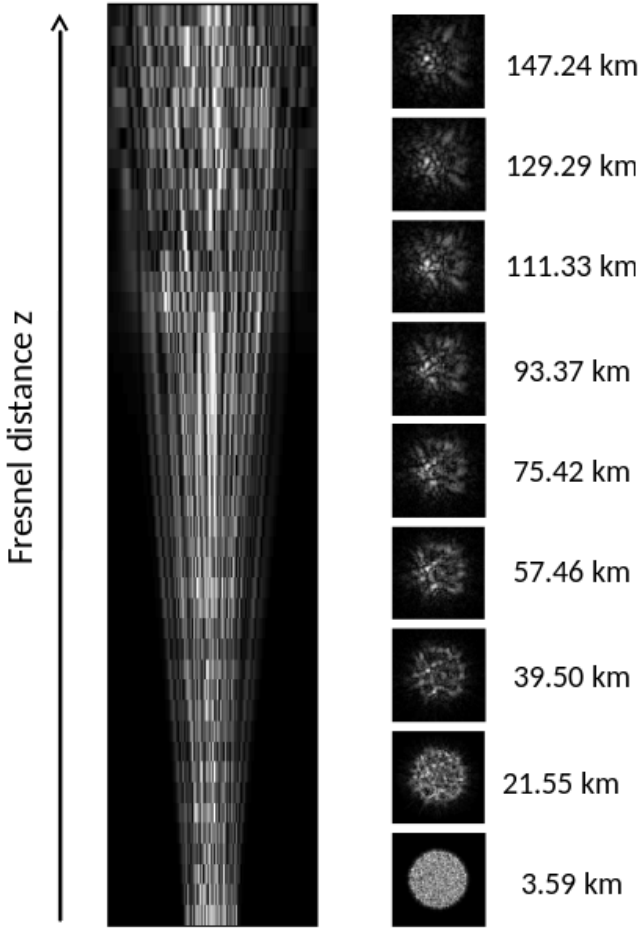


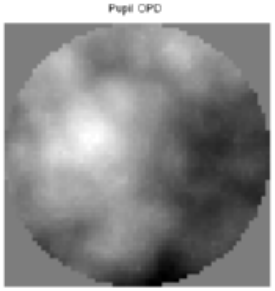
SUBMITTED TO ICARUS

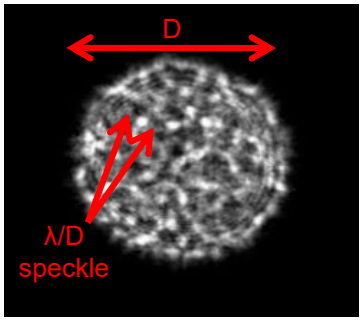
Roxanne V = 13.0 and its moon at ΔJ = 3.0; Notice the competing aberrations - LWE.
We want to obtain ΔJ ≥ 6.0 at similar separations.

Drummond & Colleagues: The orbit of asteroid (317) Roxane's satellite Olympias from Gemini, Keck, VLT and the SOR

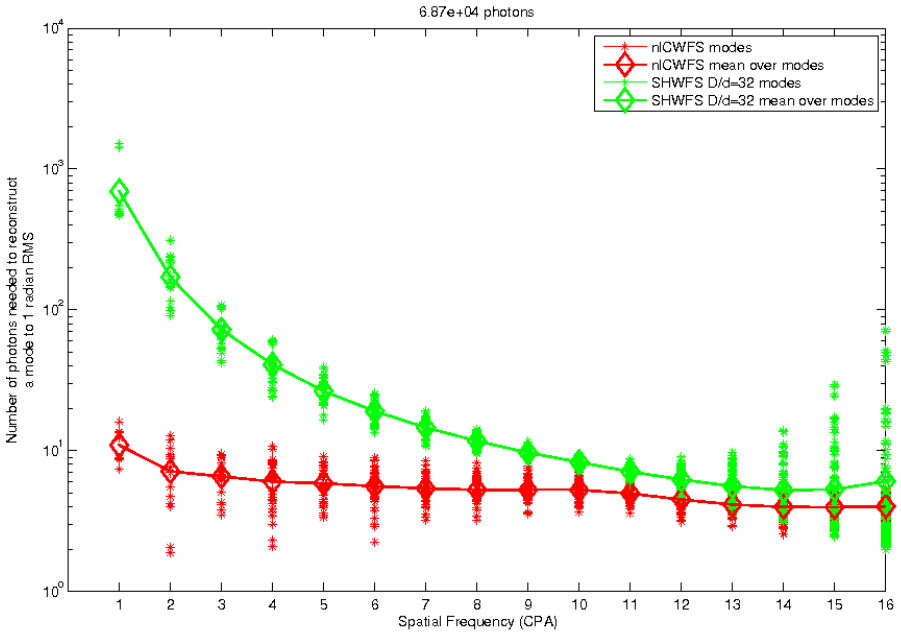
Nonlinear Curvature Wavefront Sensor







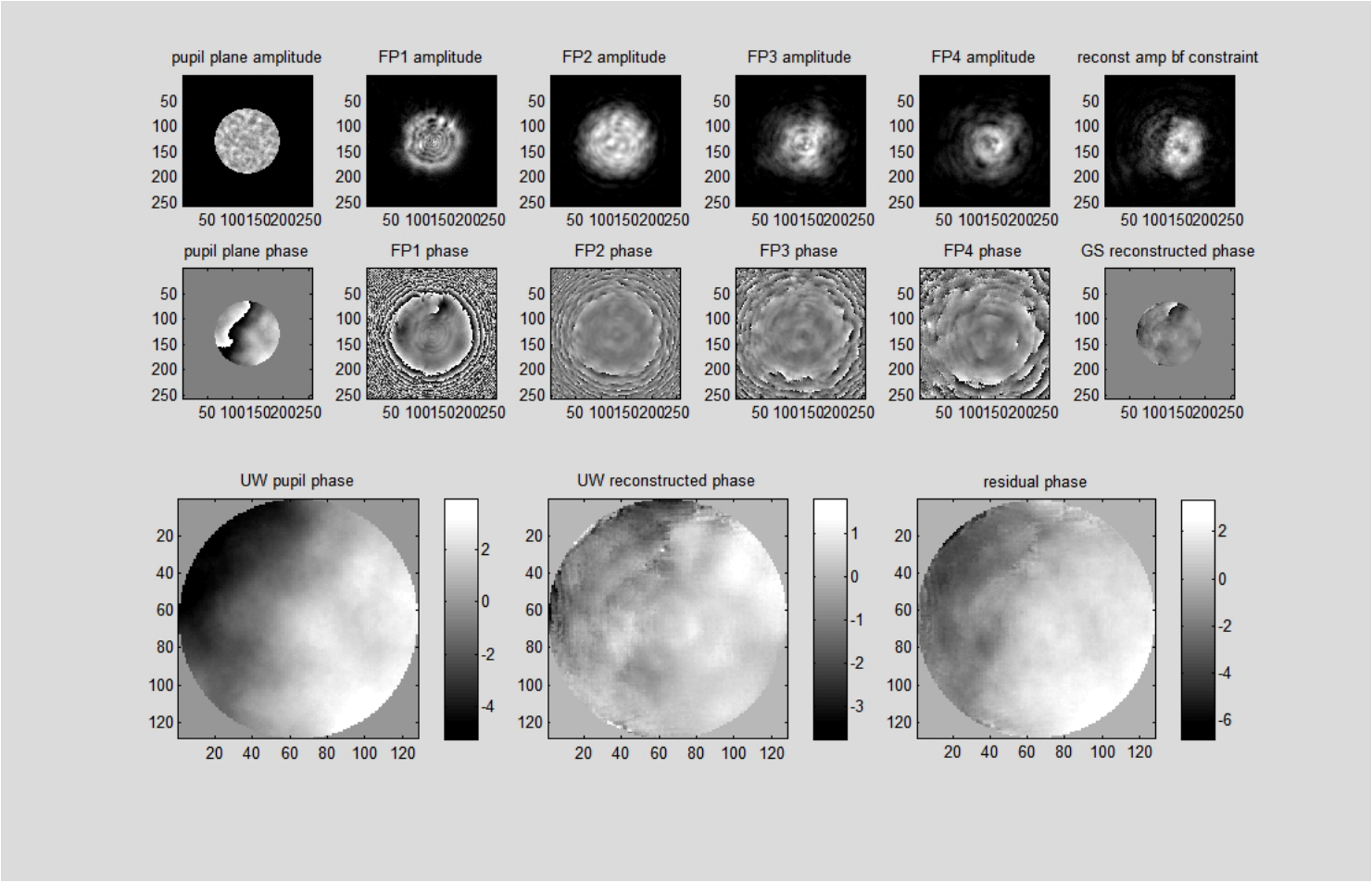
$(D/r_0)^2$ gain in Sensitivity for tip/tilt
D^4 advantage for VLTs & ELTs



At the lowest order modes the SHWFS requires ~ 100 times more photons or a $\Delta m_v = 5$ to sense the mode.

Mateen,"Development and verification of the non-linear Curvature Wavefront Sensor" Ph.D thesis, University of Arizona (2015)

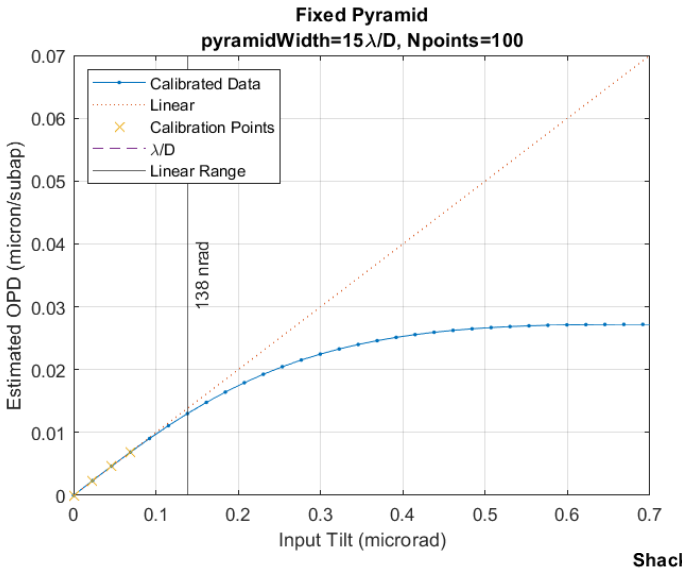
Gerchberg-Saxton based nICWFS Reconstruction

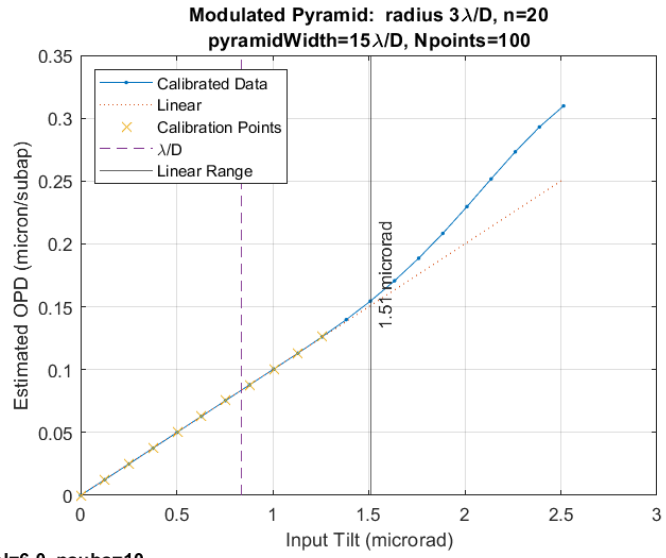


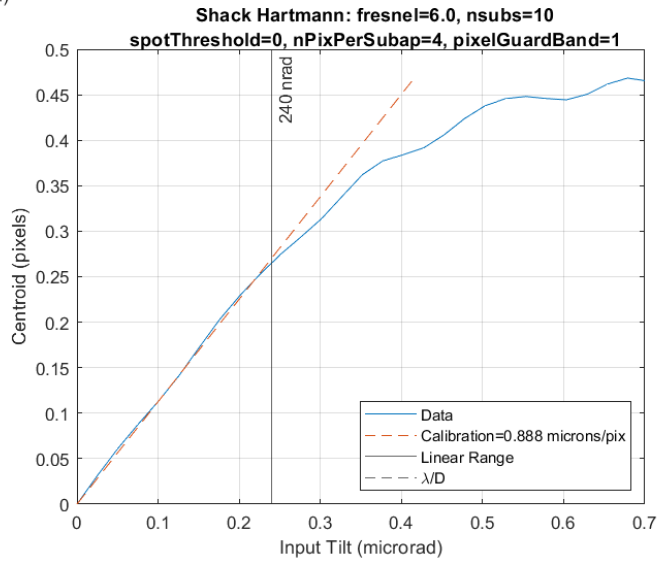
Faster reconstruction algorithm developed:

Codona et al. “A fast wavefront reconstructor for the nonlinear curvature wavefront sensor”, Proc. SPIE 10703 (2018).

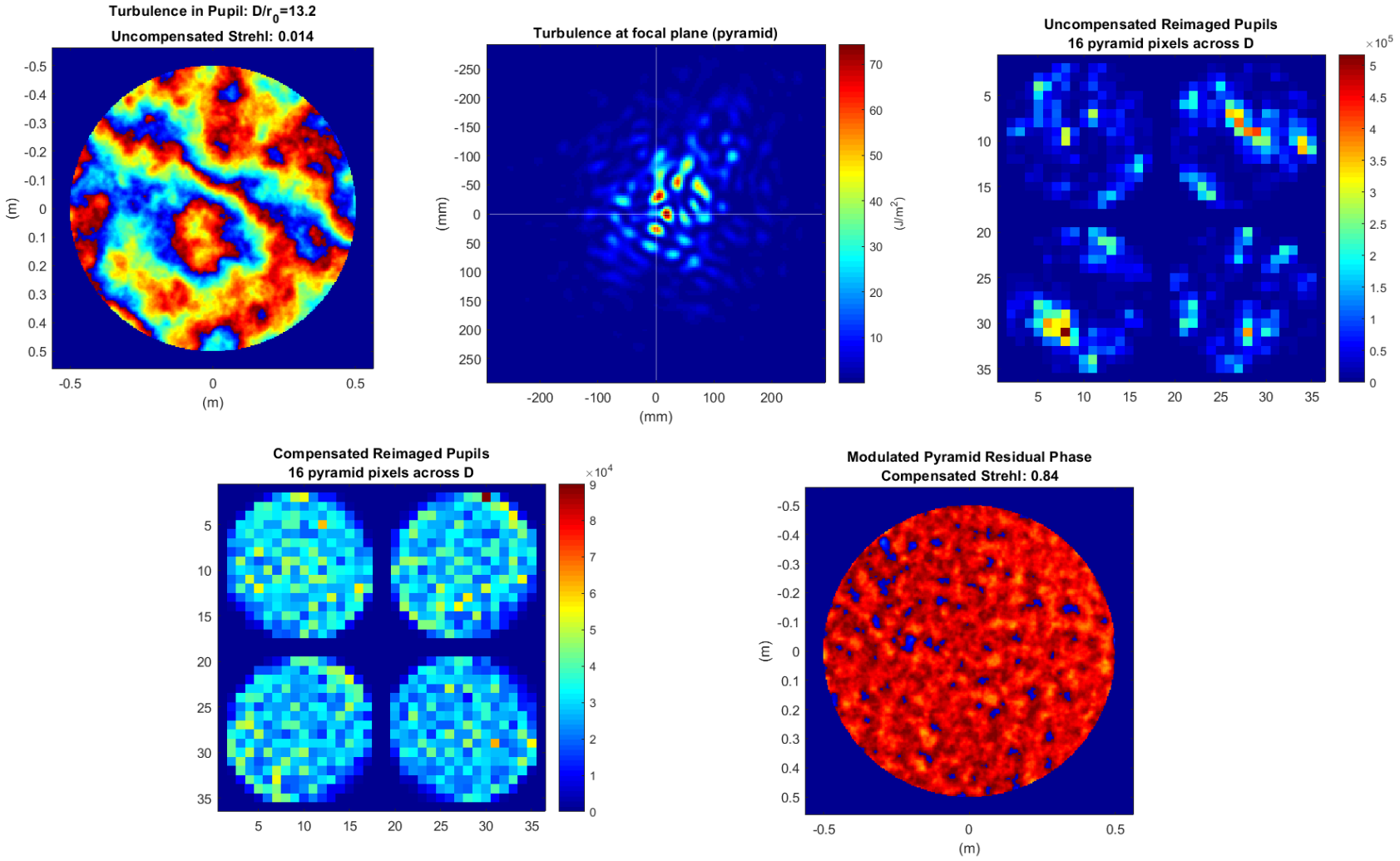
WFS Calibration Curves



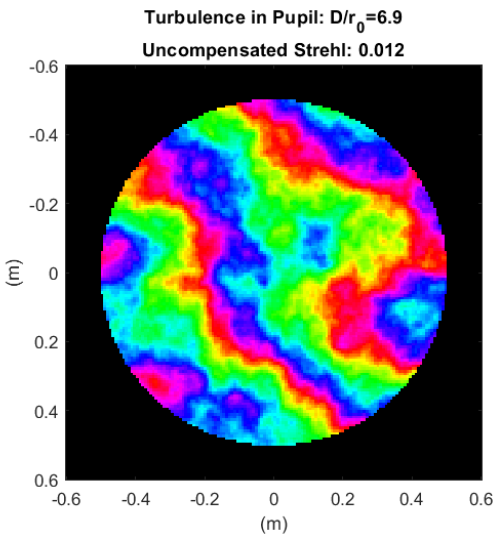


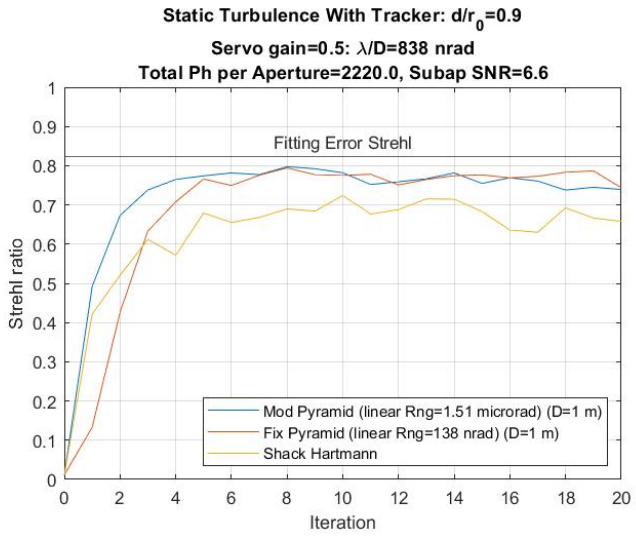


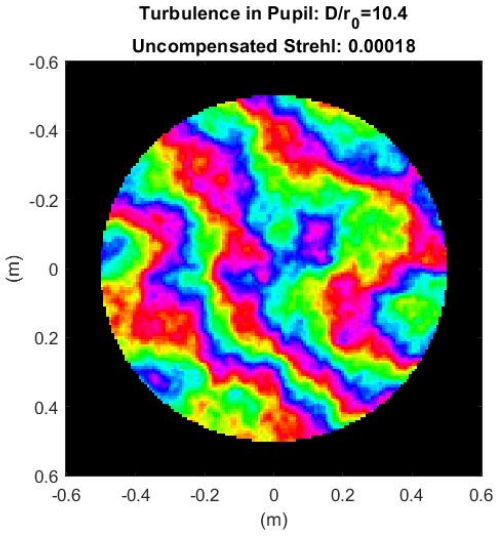
Pyramid Wavefront Sensor Simulation

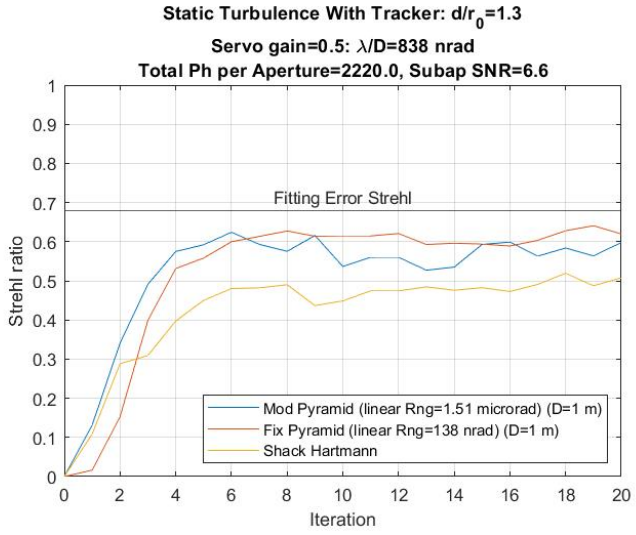


Strehl Comparison

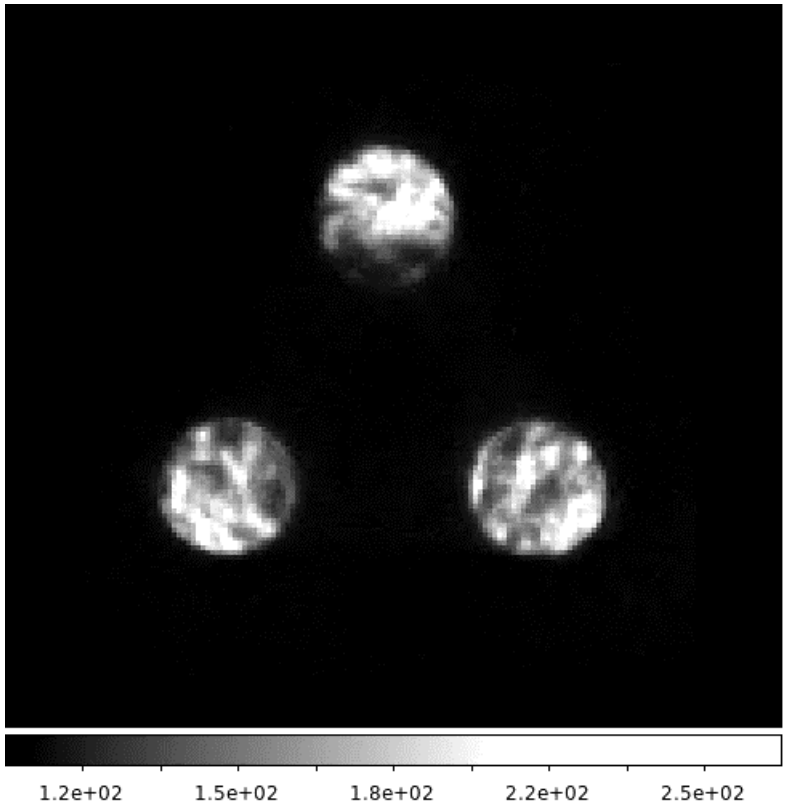


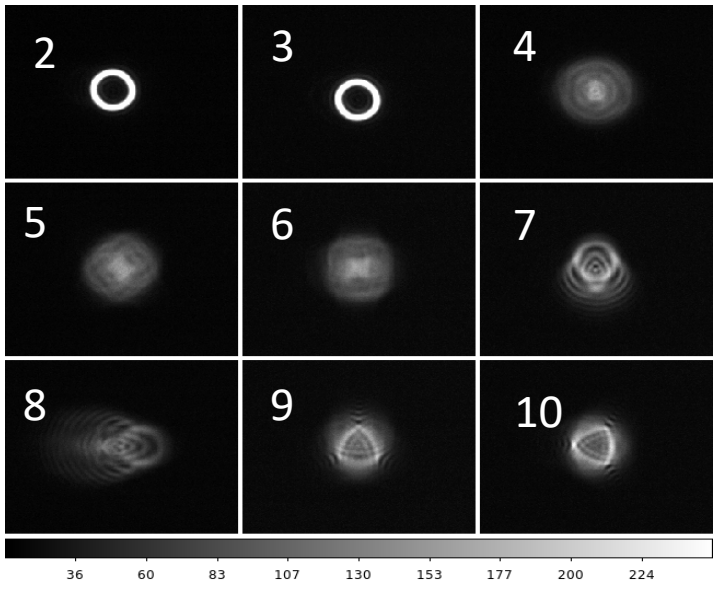


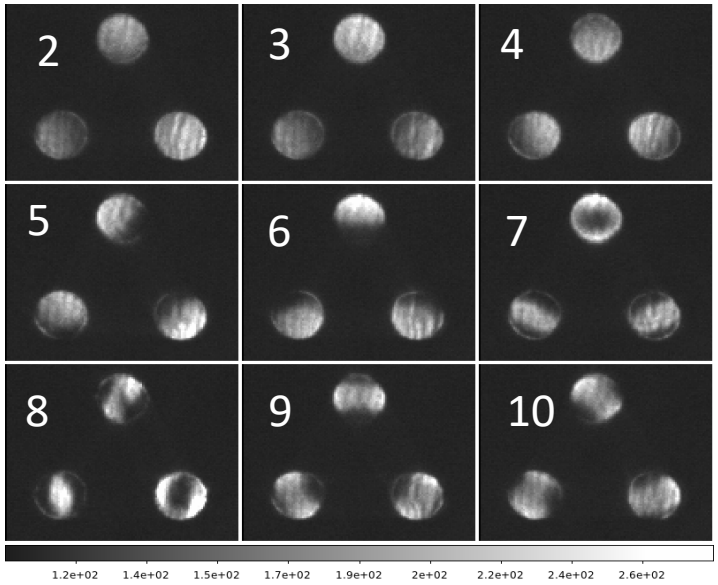




PWFS3 First Lab Results

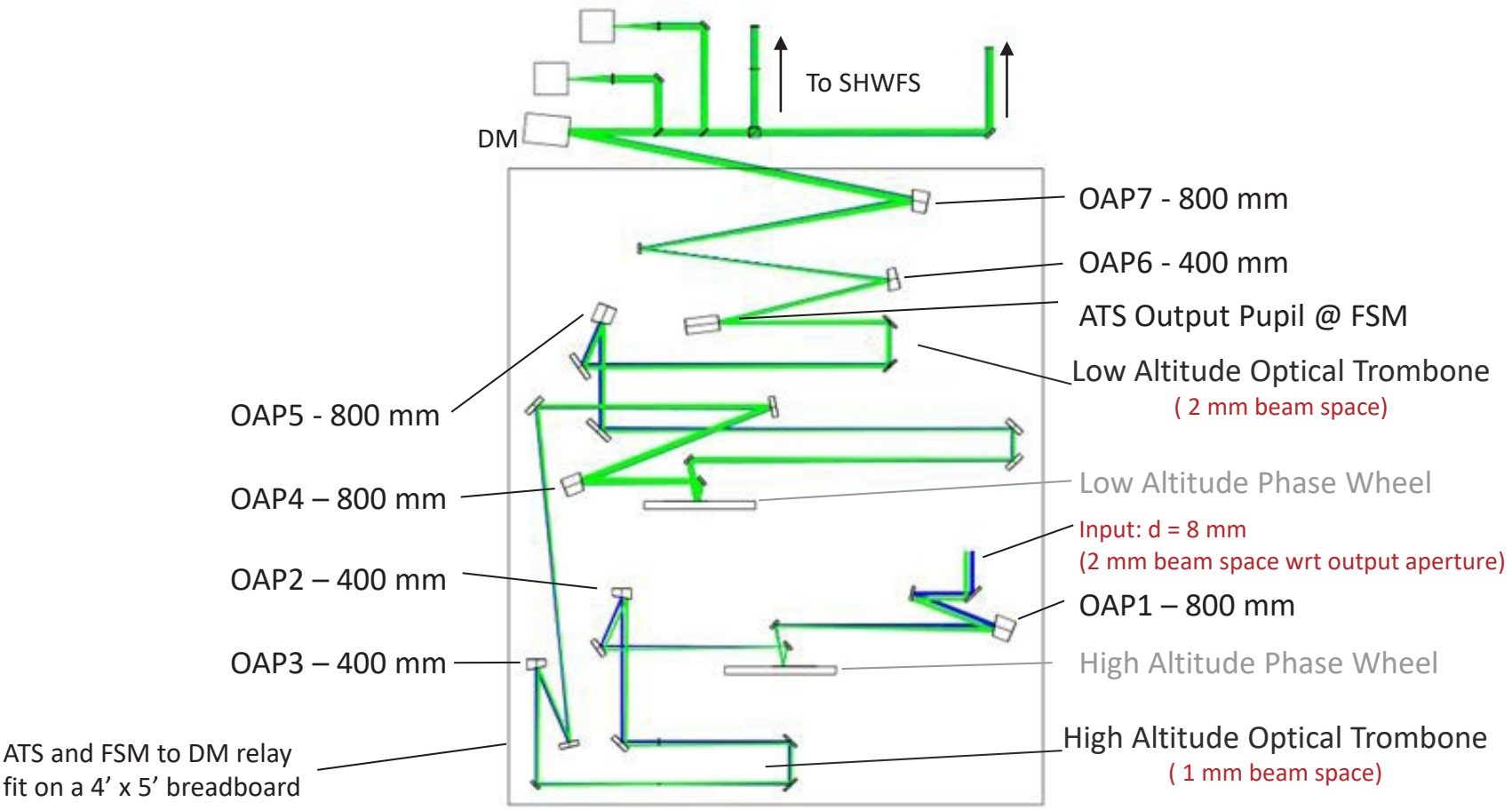






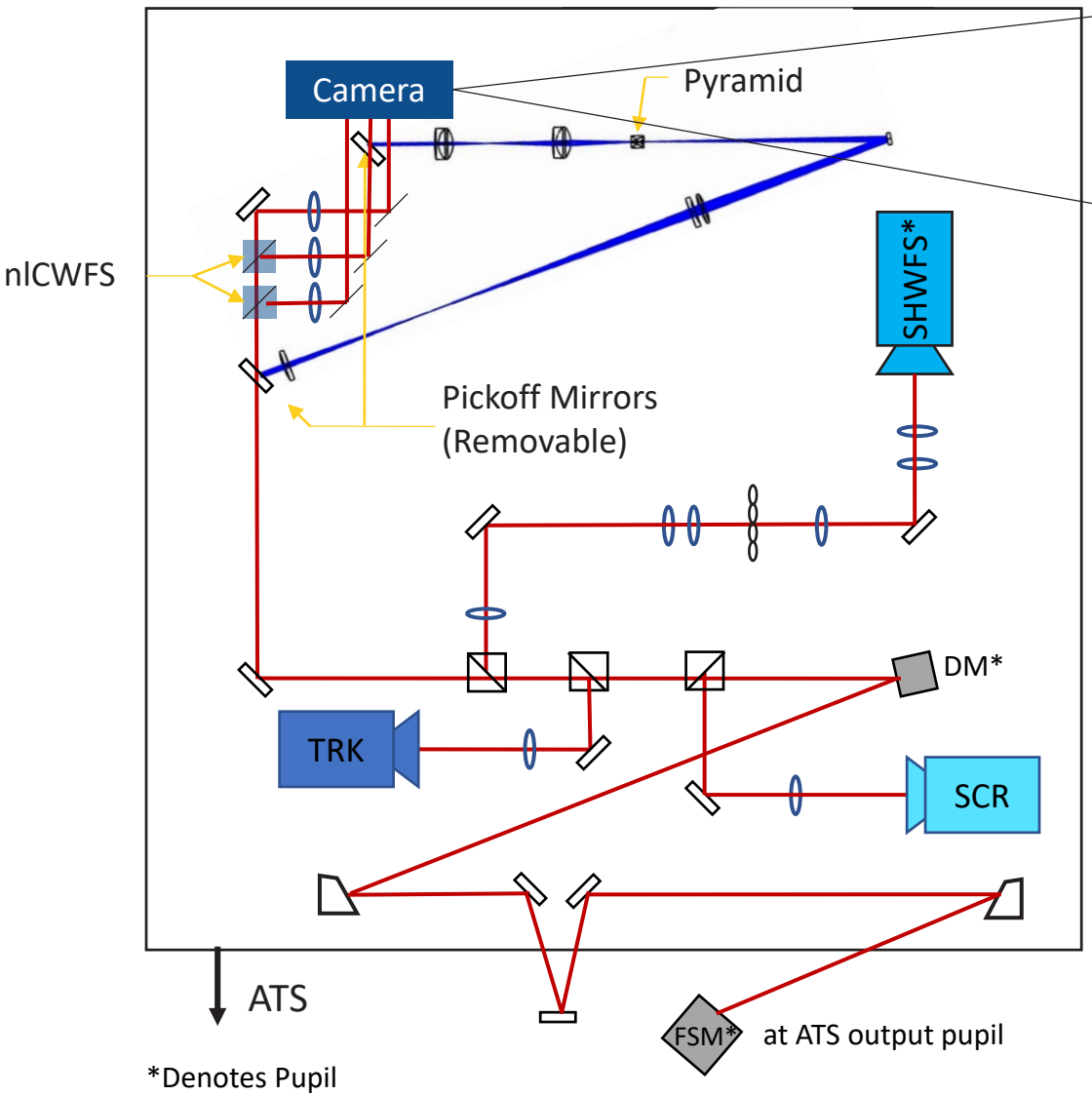
Courtesy University of Arizona & Hart Scientific Inc.

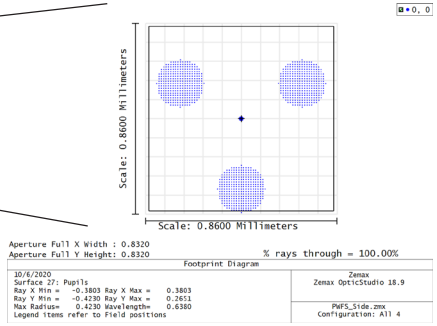
Atmospheric Turbulence Simulator Design



Phase wheel design is Guidestar Optical Systems Proprietary

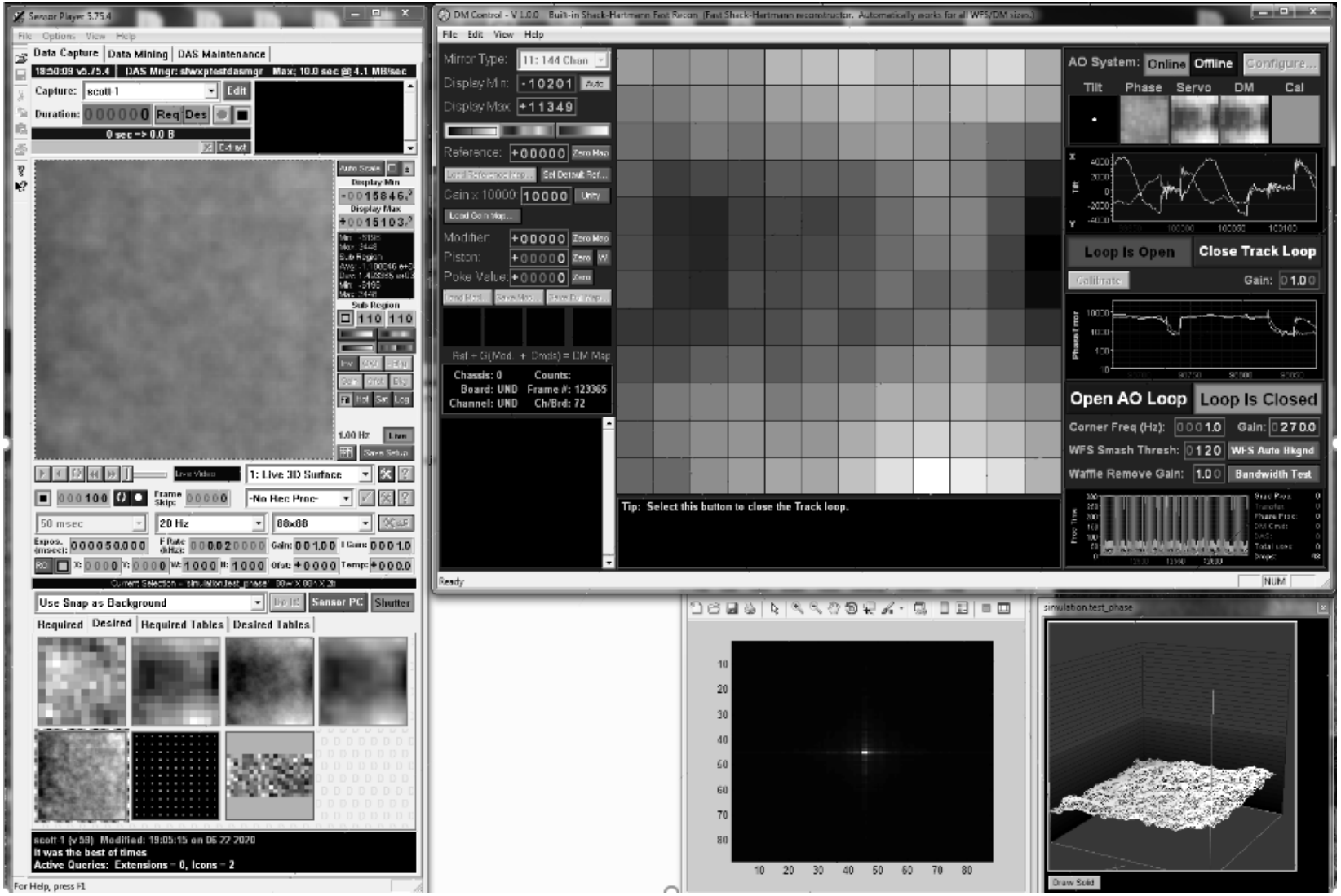
WFS Comparison Testbed at Starfire Optical Range

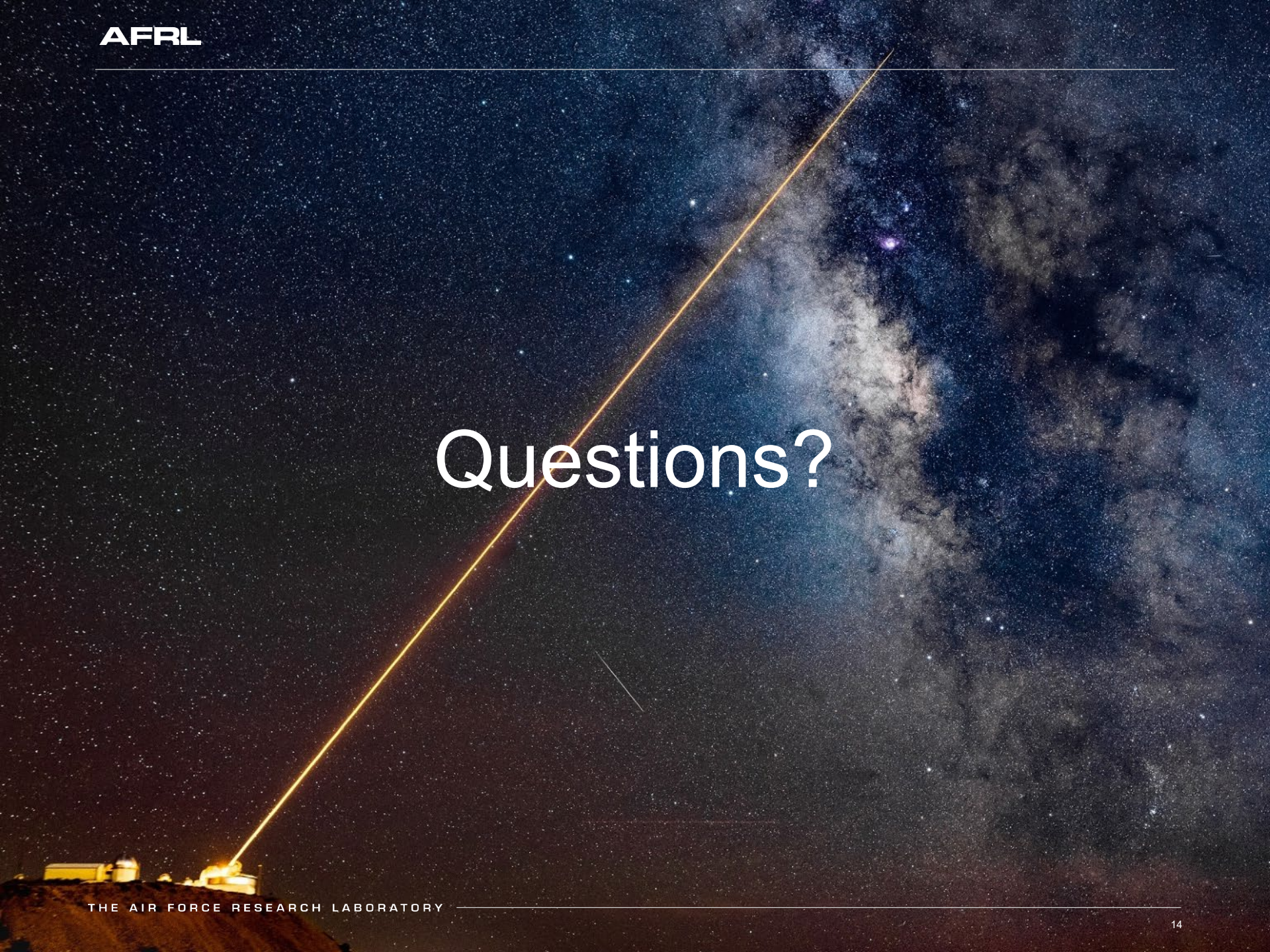




- f/45 beam at pyramid tip.
- WFS λ = 638 nm
- TRK λ = 835 nm
- SCR λ = 1550 nm

Simulated AO Control System

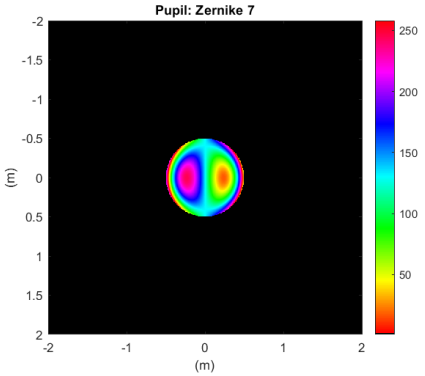


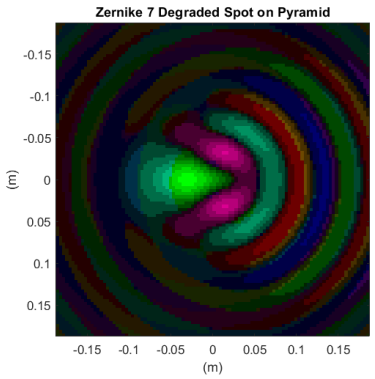


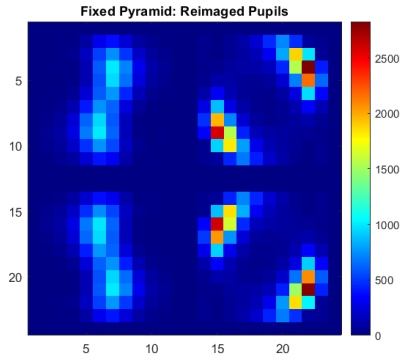
Questions?

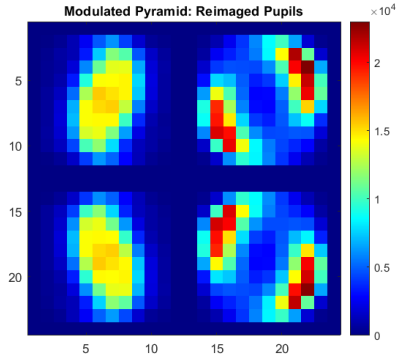
Backup Slides

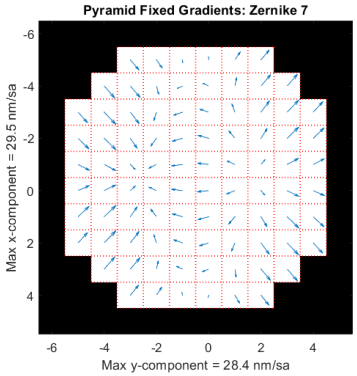
Zernike Test

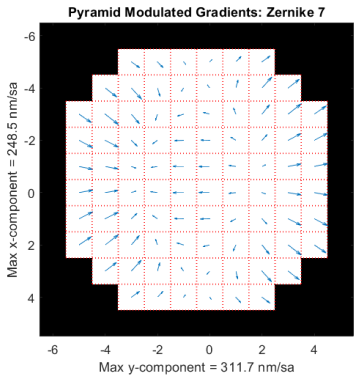


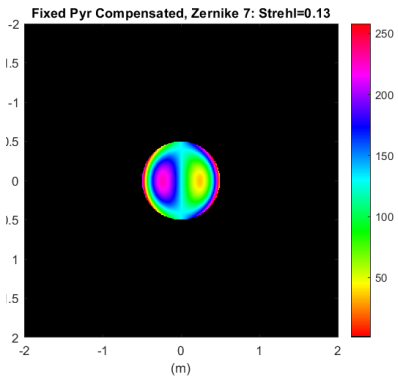


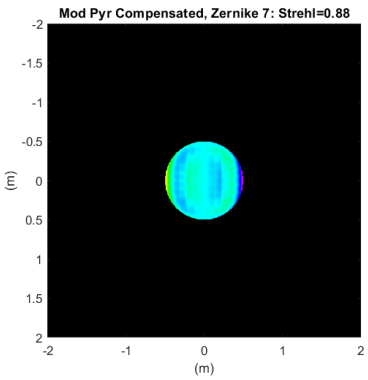


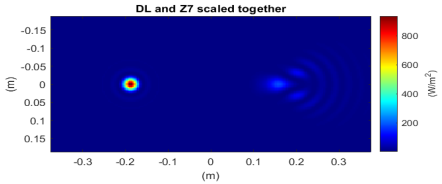




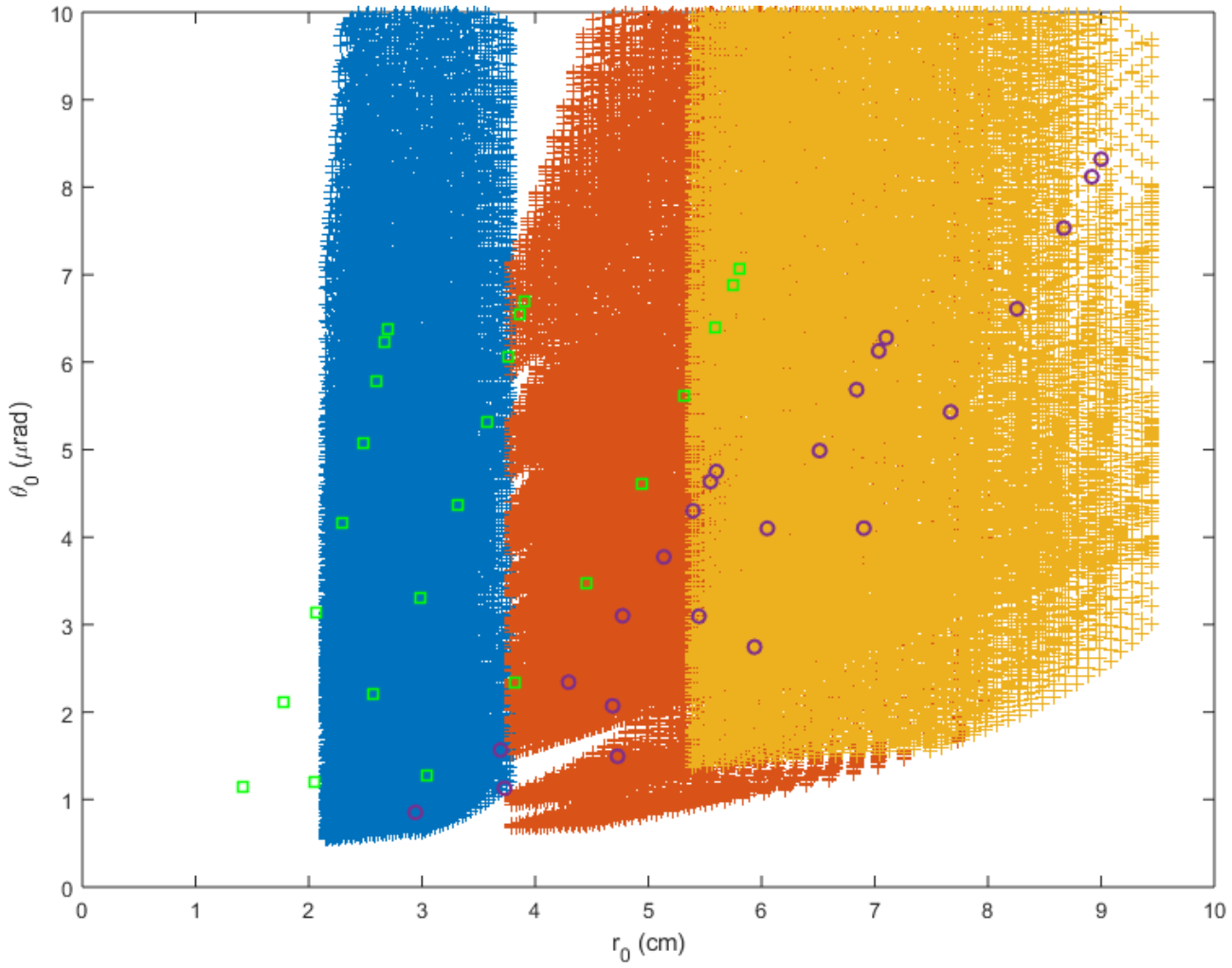




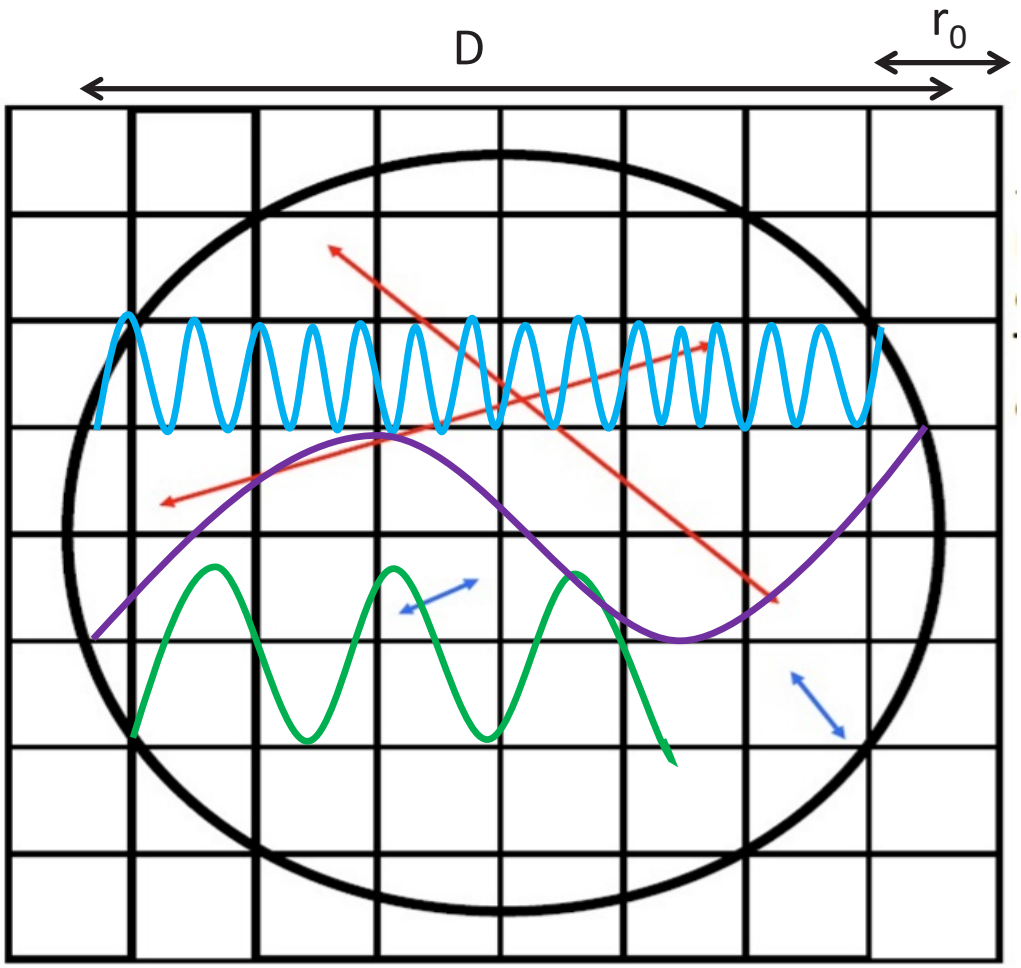




Atmospheric Turbulence Simulator Range

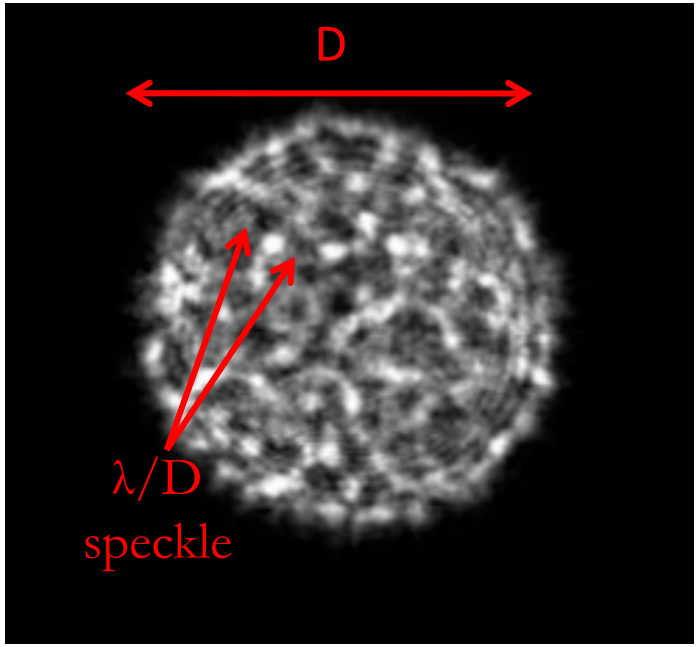


Extracting information from speckles



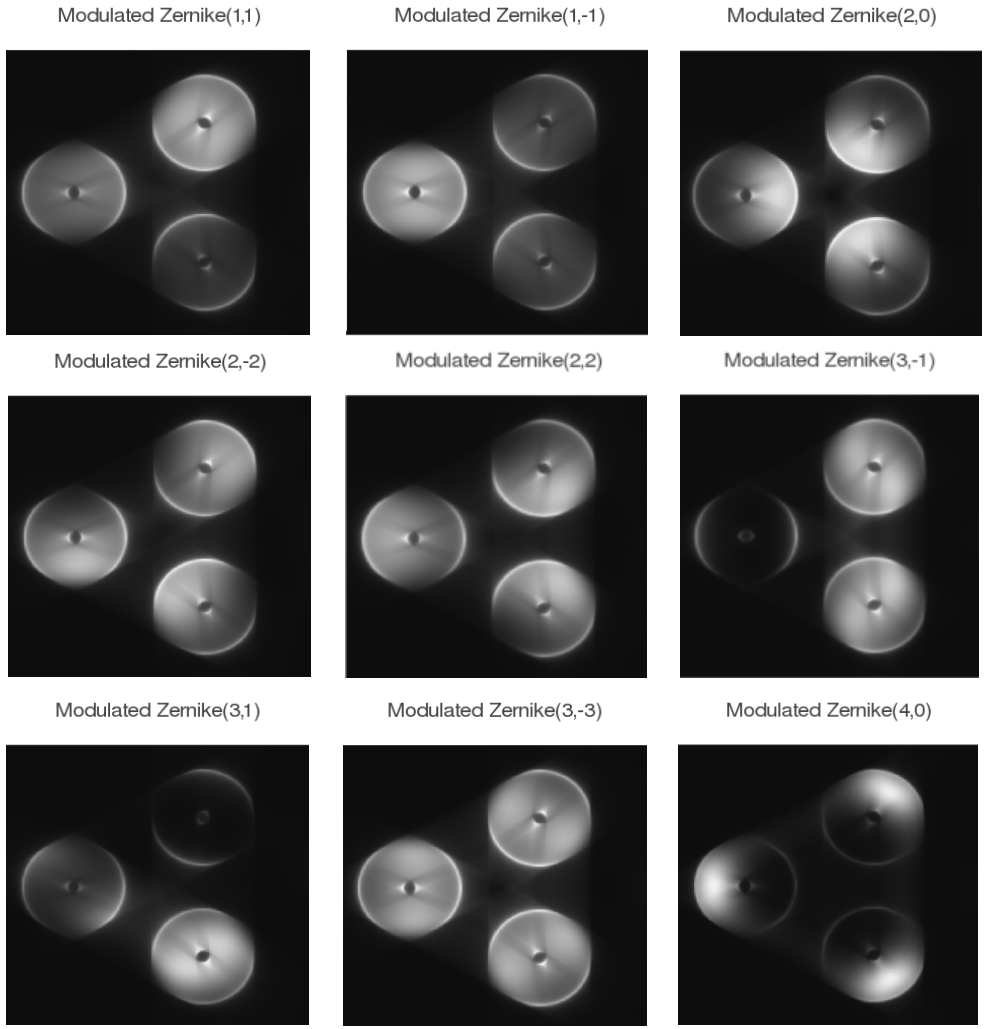
SH subapertures: Seeing limited (λ/r_0)

$(D/r_0)^2$ gain in Sensitivity for tip/tilt



D^4 advantage for VLTs & ELTs

PWFS3 Simulations



Courtesy of Hart Scientific & University of Arizona