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The MCAO laboratory bench
@ NRC Herzberg

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TEAM:

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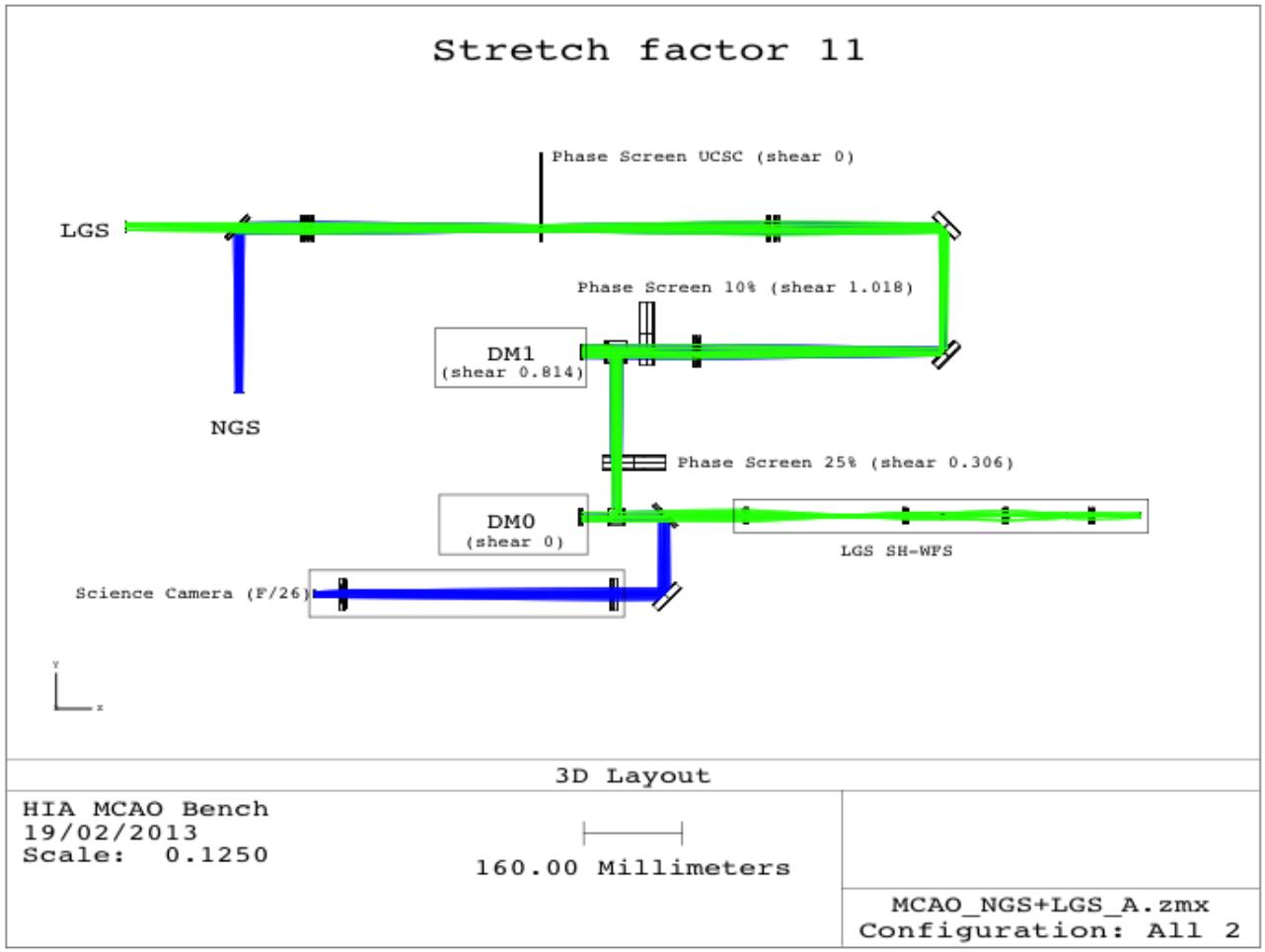
Scientific Goals

- Anchor TMT NFIRAOS simulation
  - Show that the TMT NFIRAOS simulation tool MAOS is able to correctly predict the performance of a NFIRAOS-like laboratory MCAO system
- Develop and demonstrate calibration procedure
  - Tomographic reconstruction and correction of field dependent NCPAs using phase diversity
  - Wide-field PSF reconstruction
- Demonstrate LGS tomographic AO
  - With elongated LGSs and evolving Na layer structure
  - Effect of spatial non-uniformities in Na layer
  - Test of different tomographic algorithms
- Validate long time scale optimization method
  - Matched filter update with changing Na profile and only 1 Moderate Order Truth WFS
  - Cn2 estimation with SLODAR method

Basic components

- Deformable mirrors
  - DM0 (height: 0 km) ALPAO 11x11 (DM97-15)
  - DM1 (height: 11.2 km) ALPAO 19x19 (DM277-15)
- LGS asterism: 4 stars in a square with a 30x30 SH-WFS (2448x2048 CCD, 15 fps)
- 3 NGSs (2x T/T, 1x T/T/F), measured on the science camera
- 3 turbulence screens:
  - 2 index-matching Lexitek screens
  - 1 UCSC acrylic spray screen
- Science camera: 2448x2048 CCD (Point Grey)
- RTC: 6-core machine running the bench with MATLAB for easier development of complicated algorithms (@ 1 – 15 fps)

MCAO bench current layout



MCAO bench design considerations

- Simulate 8m telescope (low order DM0: pitch 0.89 m)
- Visible imagining wavelength: λ = 690 nm
- FOV bench: 10.9 arcsec
- Goal: preserve FOV/anisoplanatism(θ) of NFIRAOS

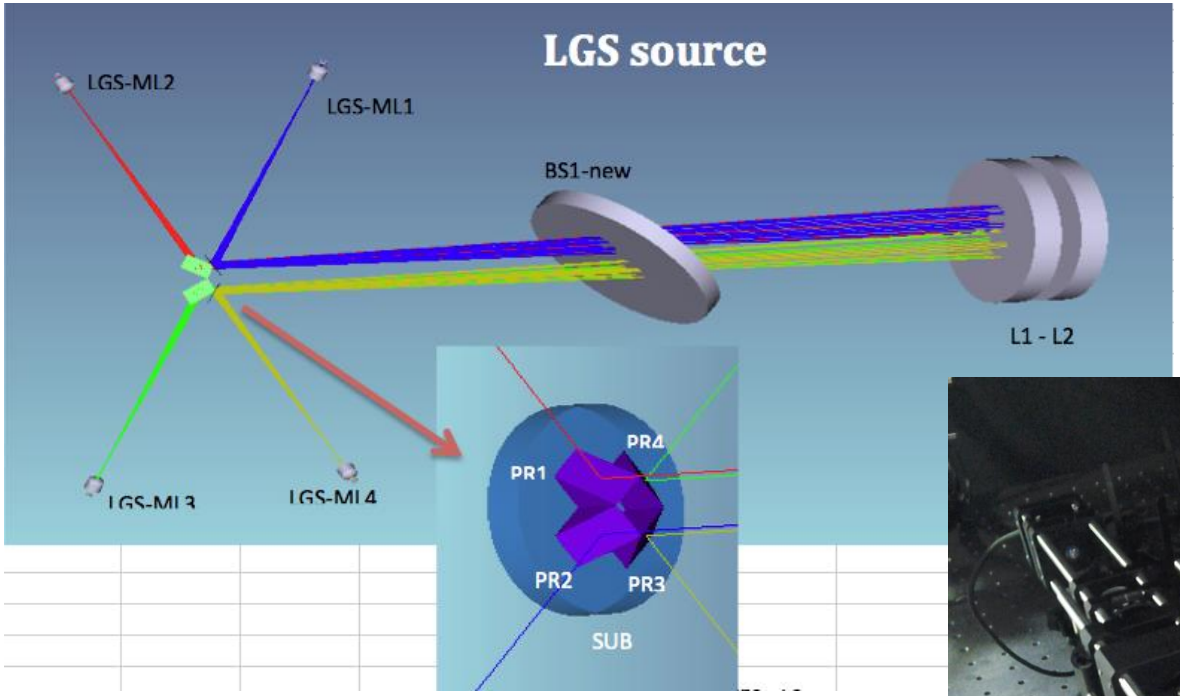
  → specific θ needed for the bench
- But: with NFIRAOS turbulence profile necessary r_0 too small for the bench (~0.07 m)
- Idea: stretch the turbulence in amplitude (with same Cn2 weights)
- Result: acceptable r_0 for the bench
- Also stretch height of DM1 to preserve tomographic error

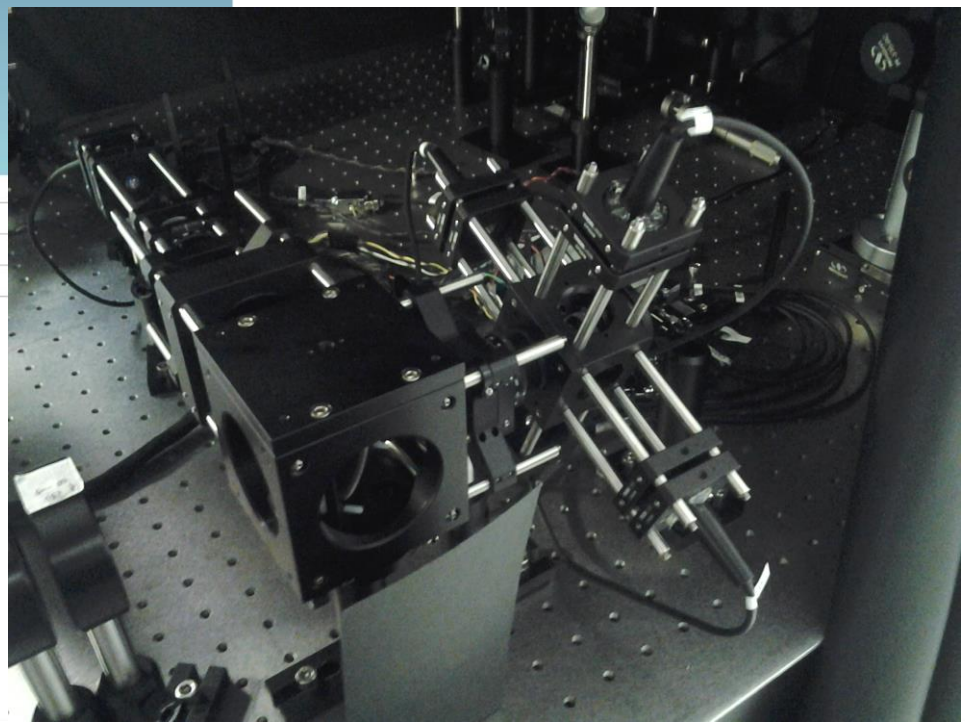
NFIRAOS / MCAO bench – scaling comparison

	NFIRAOS	Bench
FOV	120”	10.9”
Telescope diameter	30 m	8 m
Wavelength λ	1.6 um	690 nm
LGSs	6	4
LGS asterism diameter	70”	4.5”
Altitude stretch	1	11
r0 (@ λ)	0.75 m	0.751 m

FOV/θ0 and FOV/θ2 are preserved on the bench

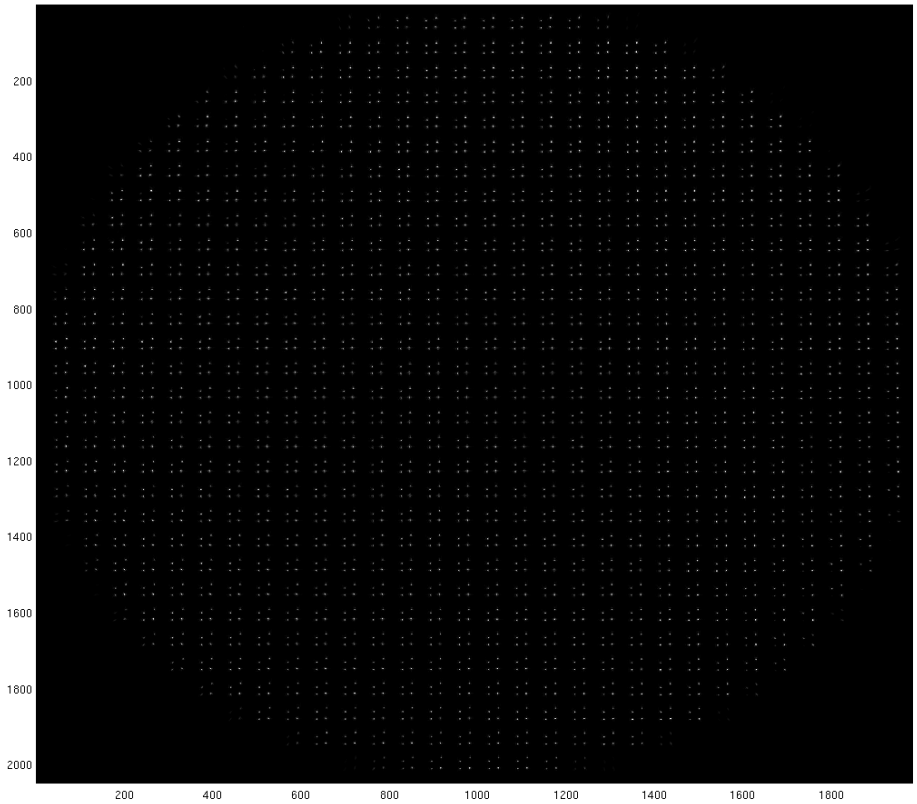
LGS source simulator

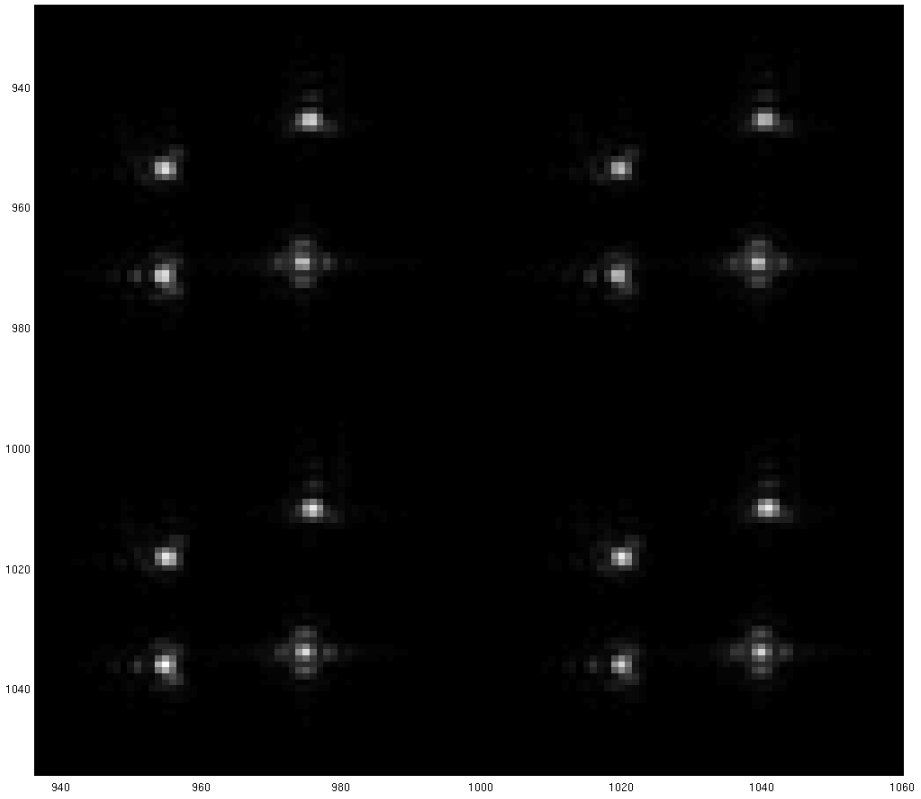




- 4 LEDs @ 690 nm in non-lasing mode
- 4096 intensity levels
- Step response to within 5% in 0.1 ms
- Asterism produced via prisms

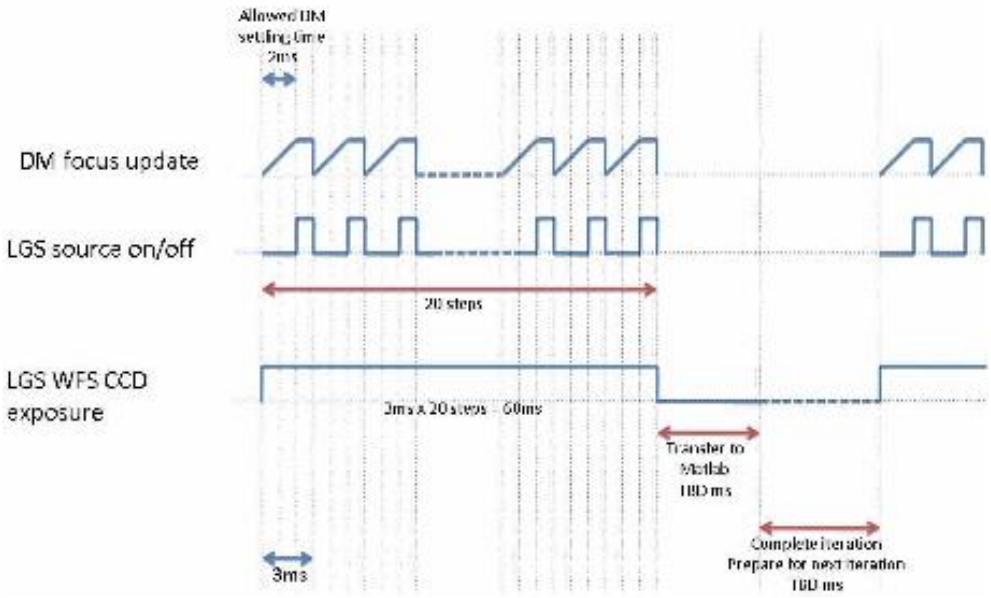
LGS Shack-Hartmann WFS (30x30)

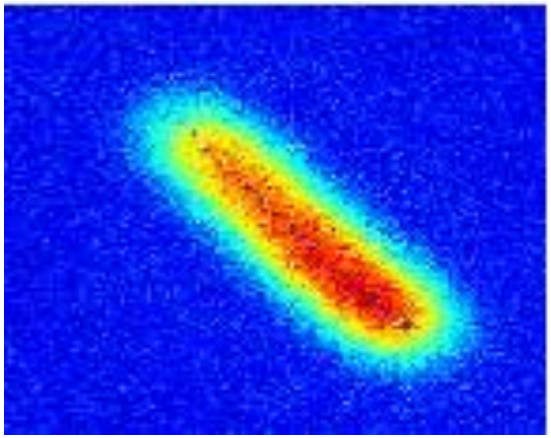




- All 4 30x30 LGS SH-WFS imaged on a single CCD
- Distance between spots ~20 pixel
- Centroid via matched filter

Elongated Spot creation





Measured elongated spot

- Elongated spot created in a single exposure with stepping:
  - Set DM0 focus to a specific height (2ms settle time)
  - Turn LGS source on (1ms) with intensity according to the sodium profile
  - Choose next focus and repeat
- Use 20 focus steps for a good sampling of the sodium profile

Current Status

- Alignment almost finished (science camera and phase screens missing)
- Both DMs can be removed and replaced by a flat if needed for calibration
- SCAO loop closed with the ground DM and one LGS and one stationary phase screen
  - With standard poke matrix reconstruction
  - With CuReD
- Electronics system for spot elongation simulation developed and ready to test on LGS WFS

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Thank you

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