# Ground Layer AO Performance and Implementation for WFOS on TMT

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presenting for Lianqi Wang and Corinne Boyer
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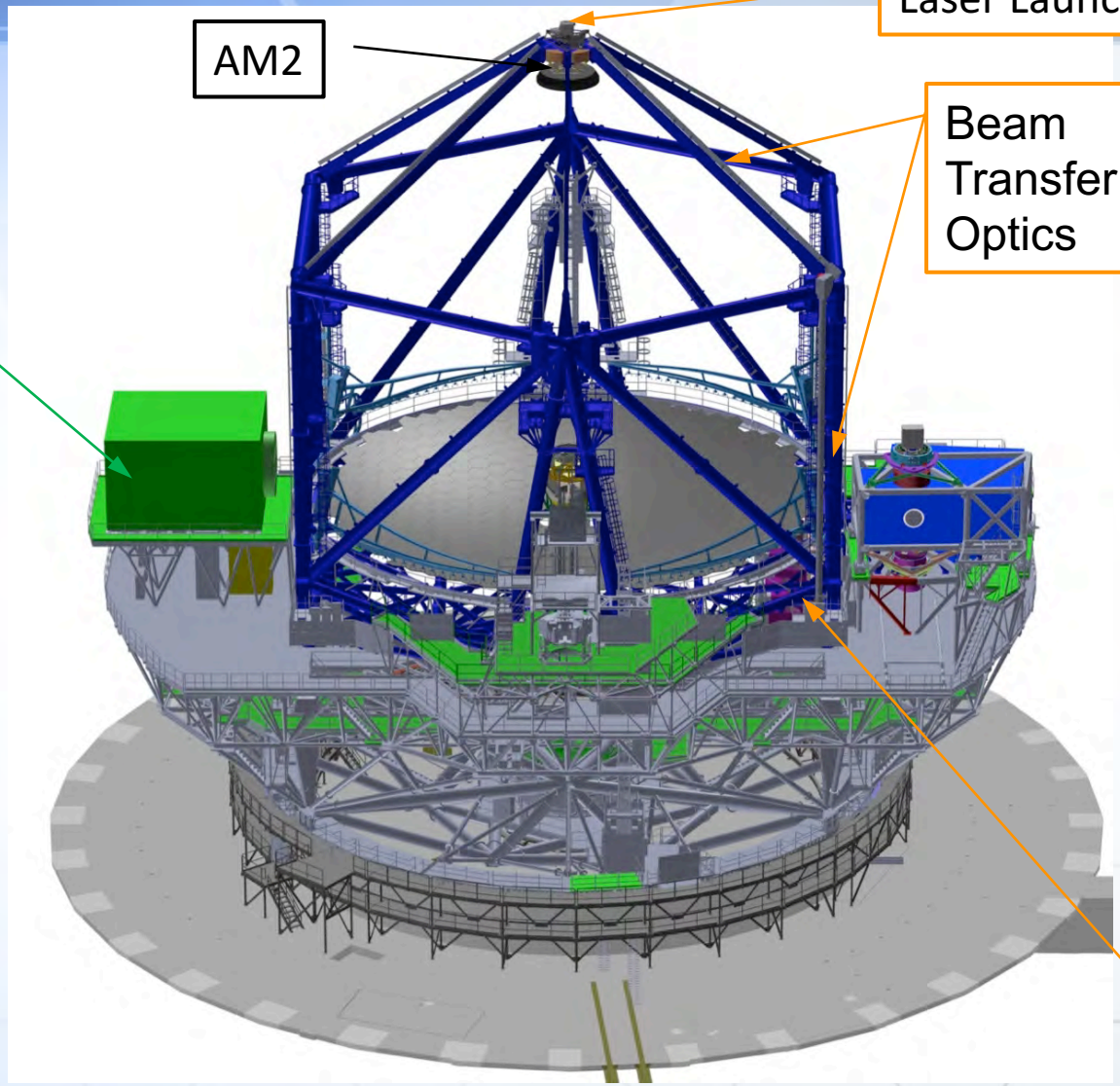
# TMT Subsystems Needed for WFOS GLAO



# Presentation Outline

- GLAO performance modeling for TMT/WFOS
  - System parameters and assumptions
  - Performance sensitivity studies
    - Adaptive secondary conjugation range
    - Field of view
    - Guide star asterism
    - Order of wavefront correction
  - Performance metrics
    - PSF peak, PSF FWHM, PSSN, and ensquared/enslitted energy
- Design concepts for GLAO components
  - LGS asterism generation
  - Adaptive secondary mirror (AM2)
  - Approach to wavefront sensing
- Summary

# System Parameters and Assumptions for GLAO Performance Modeling

- Field-of-view options (6‘x6‘ and 10‘x10‘) and wavelength range
  - Some early results for MOBIE 8‘x3‘ FoV included for comparision
- AM2 wavefront correction at z=-280m conjugate
  - Somewhat poorer correction compared to 0 m conjugation.
- Asterism of 4 LGS on a rectangular grid, with order 60x60 WFS‘s
  - LGS WFS camera design adopted from NFIRAOS
- Median and 75% turbulence profiles for MaunaKea and ORM
- Other modeling approximations and assumptions:
  - Natural, instead of laser, guide stars (negligible effect for GLAO)
  - Standard 7-layer turbulence profiles from TMT site testing campaigns
  - Order 30x30 AM2 with *square* actuator geometry

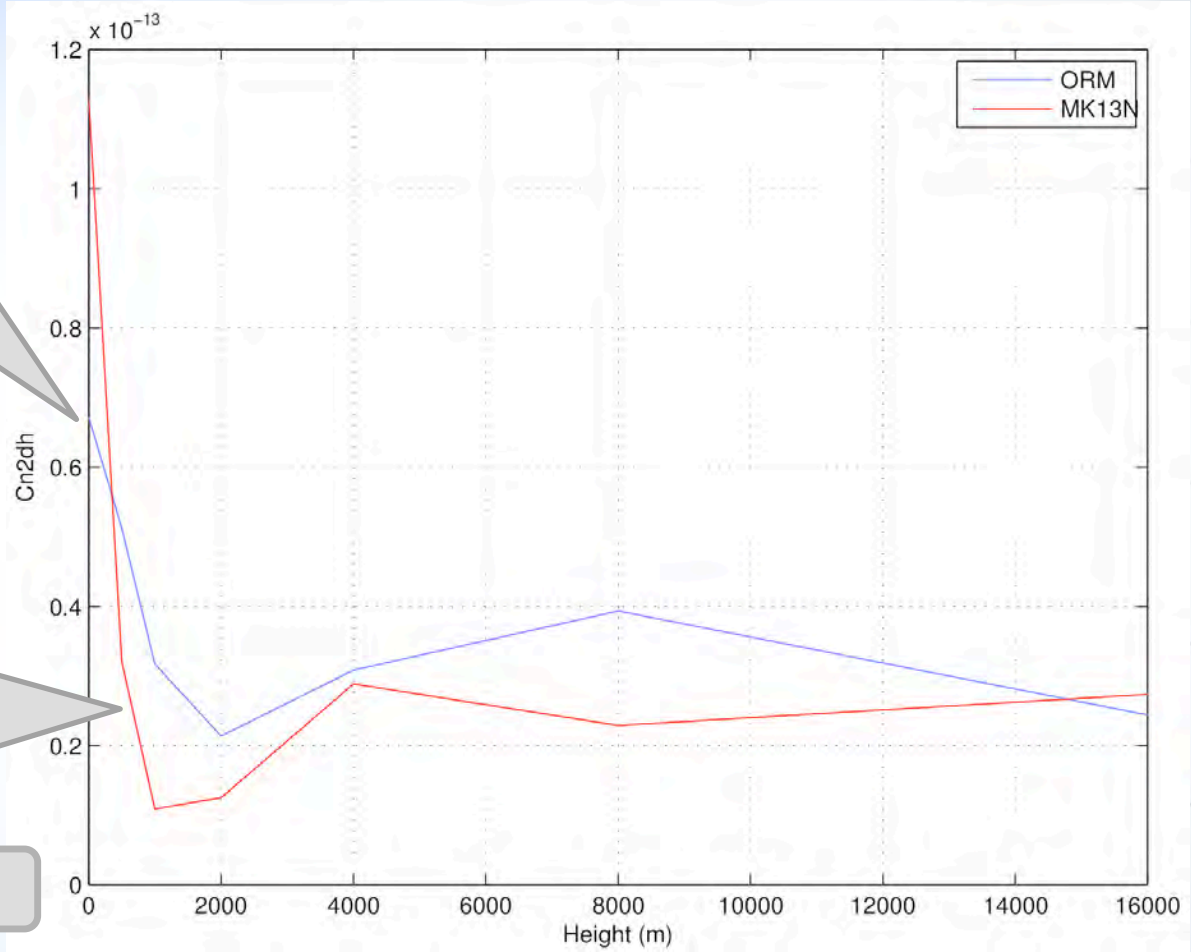
# A Word on Turbulence Profiles

Current data shows ORM having less ground layer turbulence than MK13N, but some measurements are questionable

Is ground layer sampling sufficient for GLAO modeling?

- Issue less crucial with AM2 at z=-280m

How about dome seeing??



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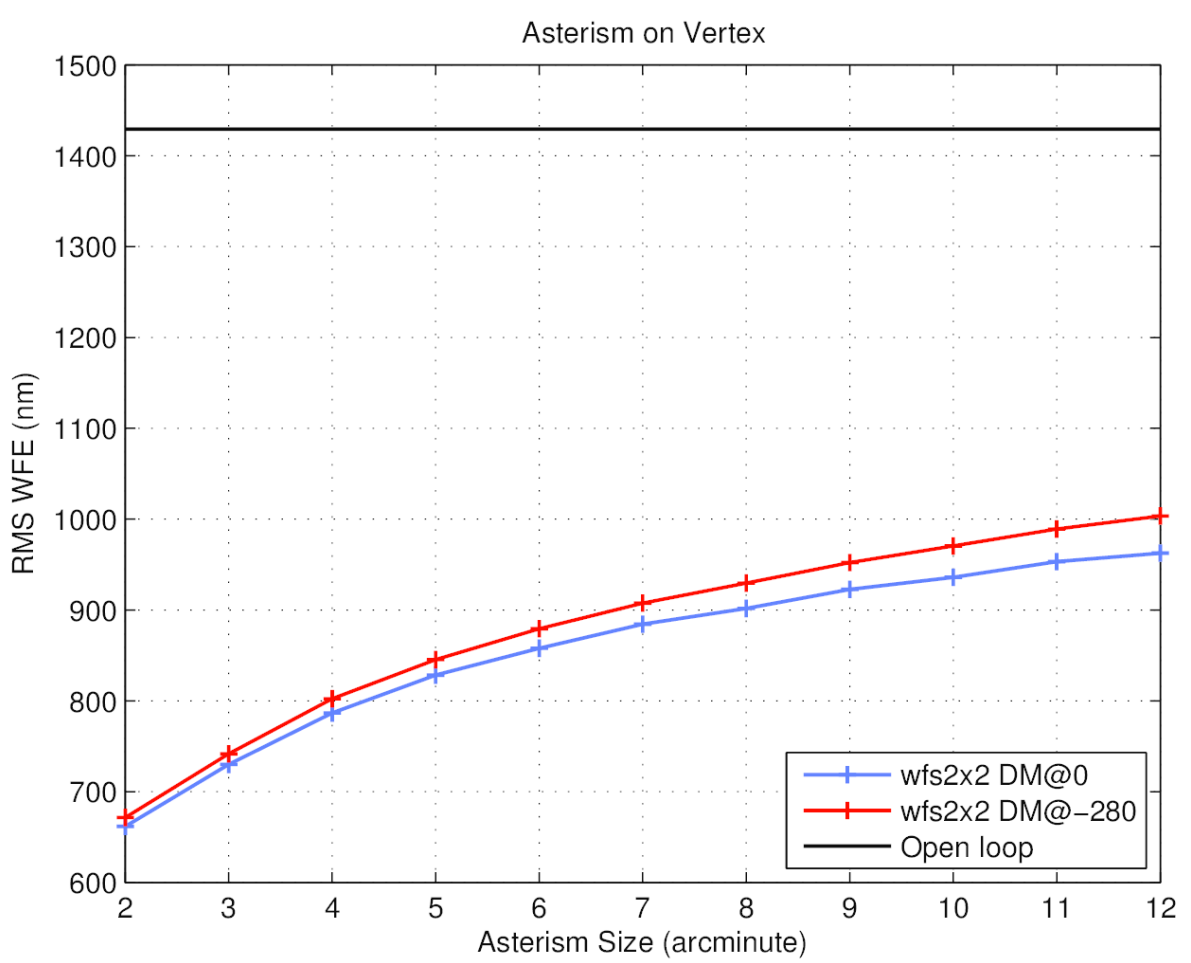
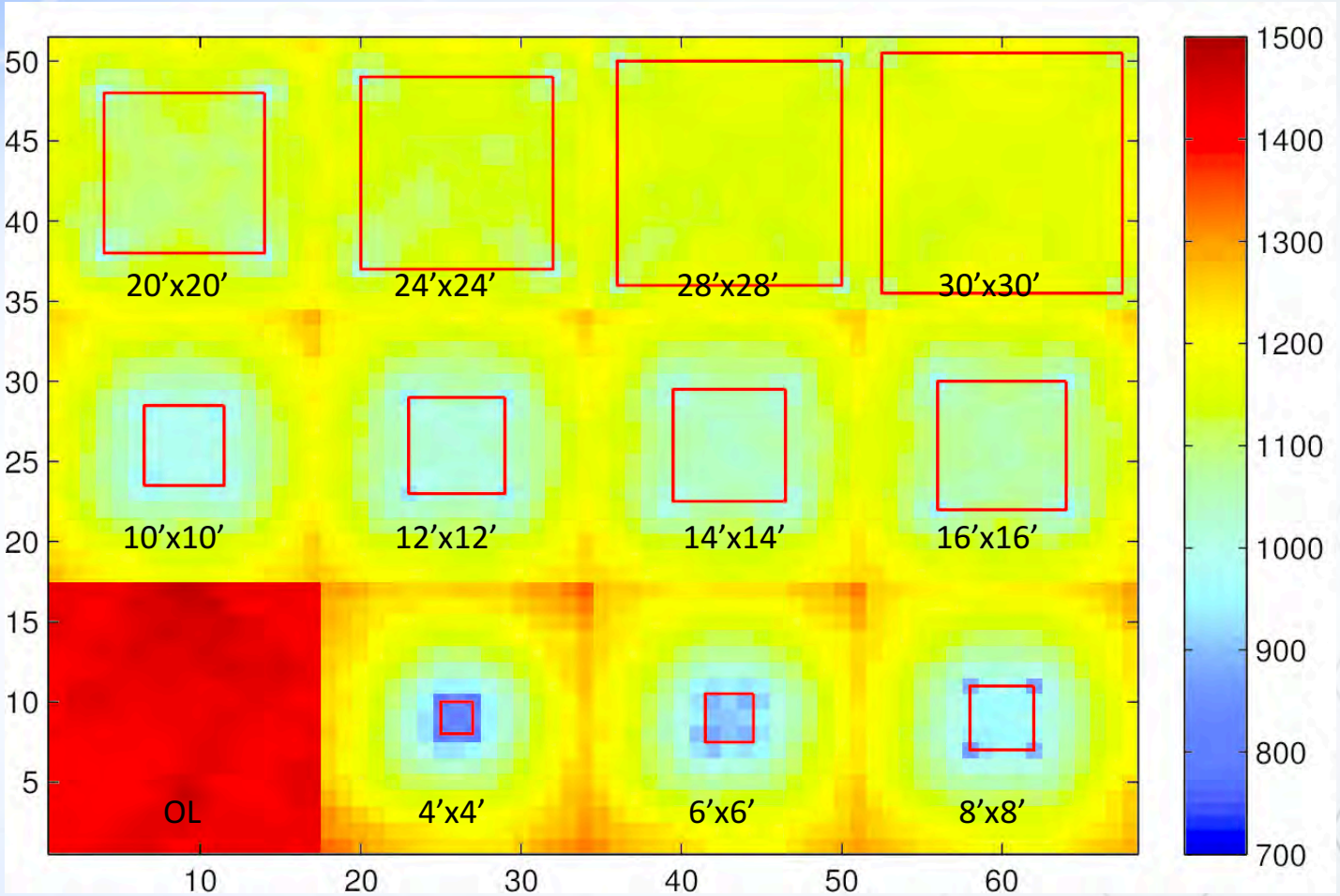
# Field-Averaged GLAO Wavefront Error vs FoV and AM2 Conjugate Range

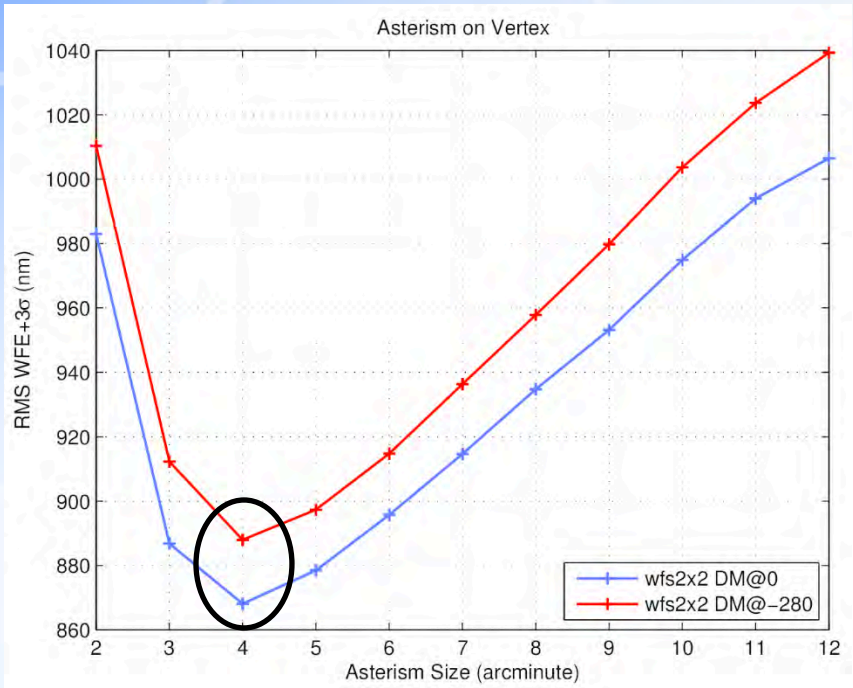
- Error increases with larger FoV
- Impact of DM conjugate is modest, but increases with larger FoV
- (RMS WFE does not include effects of WFS noise, servo lag, or AO component imperfections)

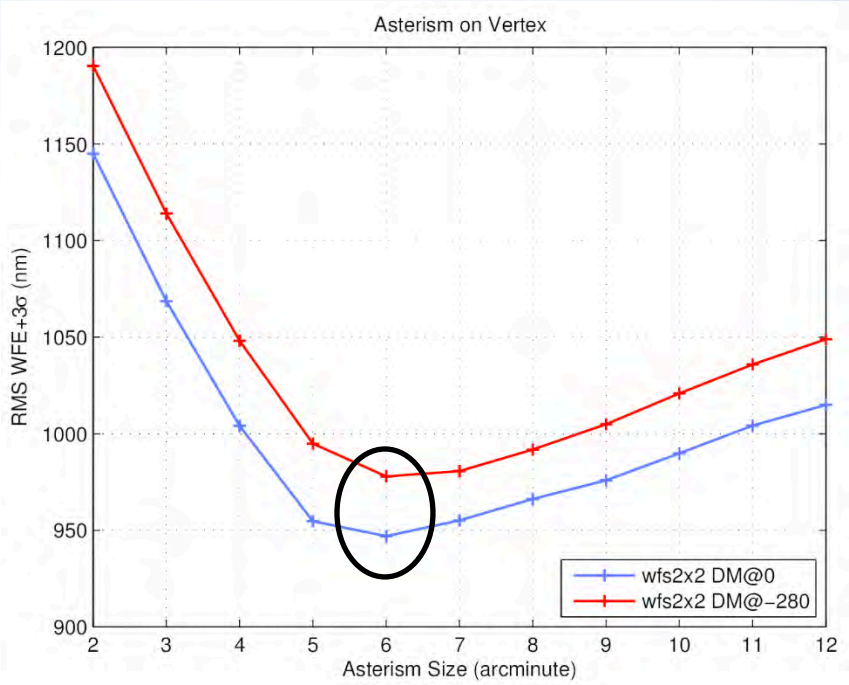


# GLAO Performance vs FoV
# AM2 at z=-280m



# Optimizing the LGS Asterism Diameter for 10’ and 6’ Diameters FoVs



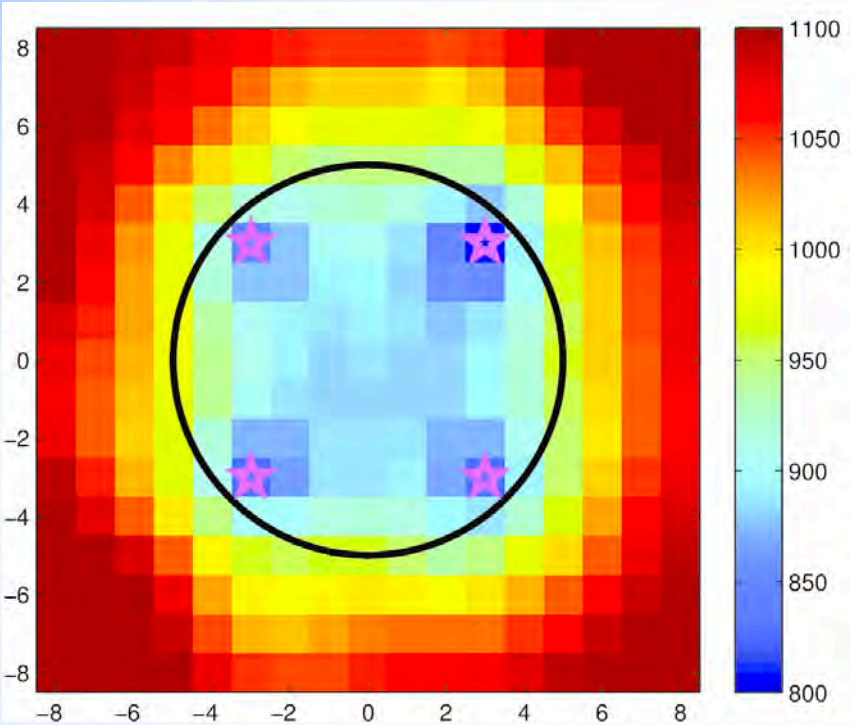




6’ diameter FoV
4’x4’ asterism is optimal

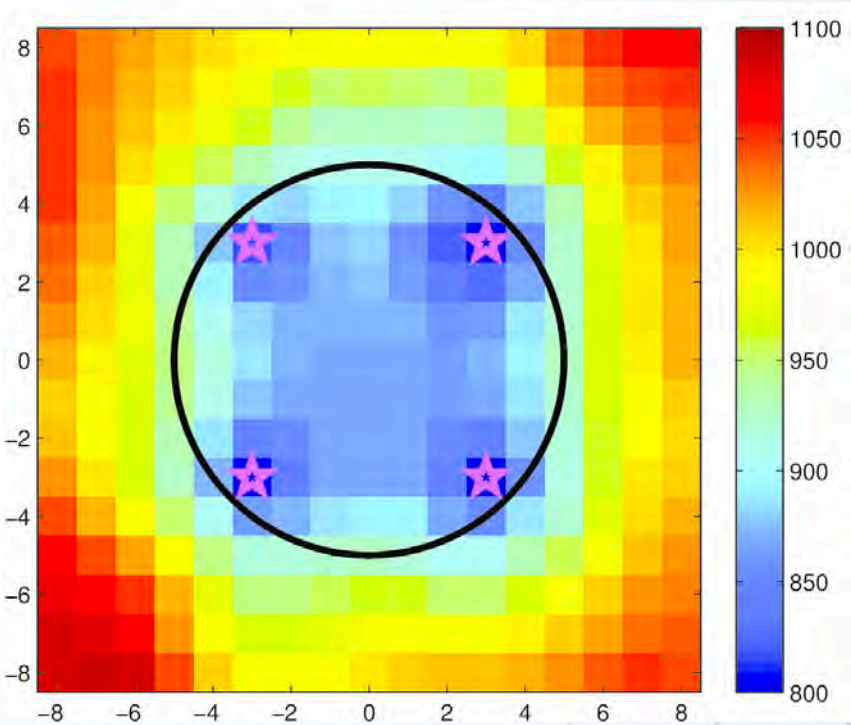
10’ diameter FoV
6’x6’ asterism is optimal

- Results for AM2 conjugates of 0m (blue) and -280m (red)
- Plotted values are [RMS Wavefront Error + 3(RMS spatial variability)]

# GLAO Performance with 10′ FoV and 6′x6′ LGS Asterism

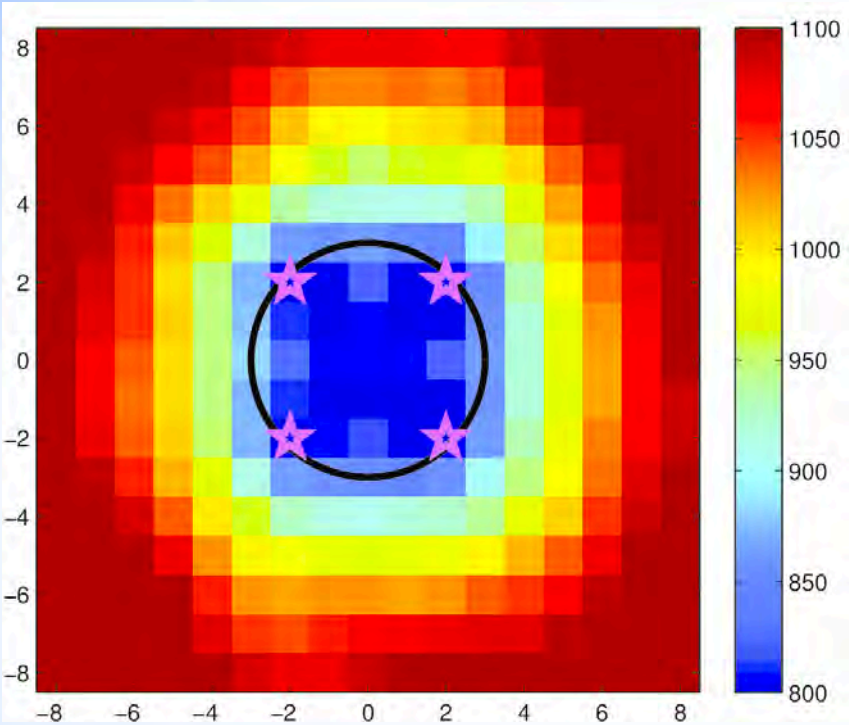



DM@-280m

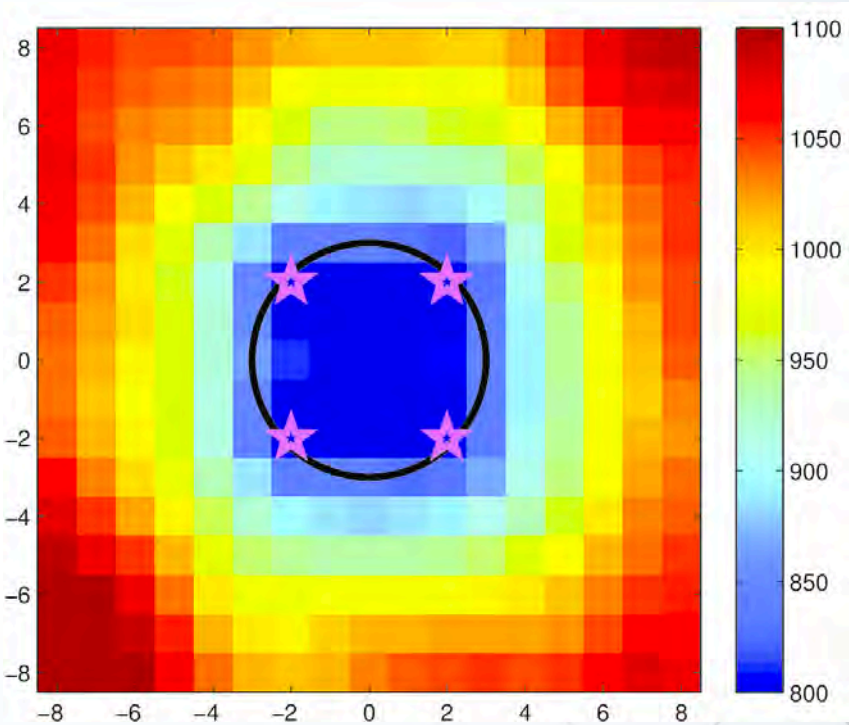



DM@0m

# GLAO Performance with 6' FoV and 4'x4' LGS Asterism



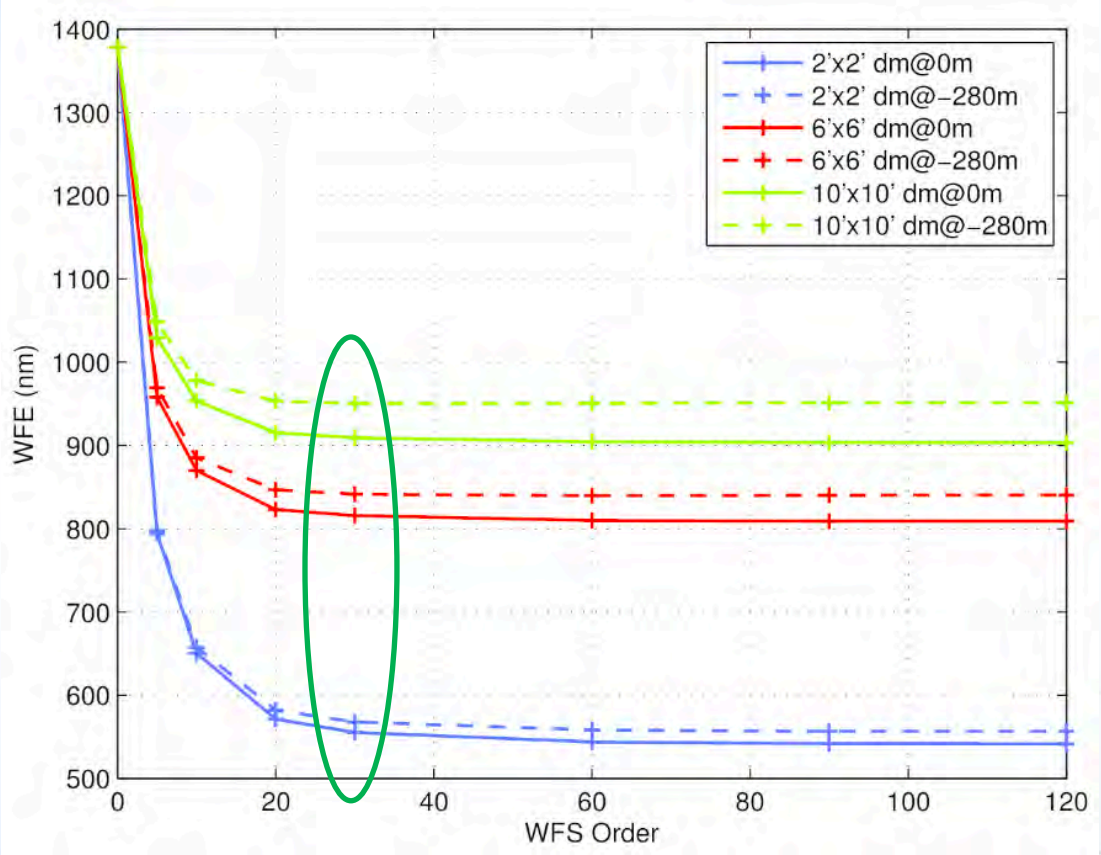

DM@-280m




DM@-0m

# GLAO Performance vs Order of Wavefront Correction

- Diminishing return for order of correction > 20x20



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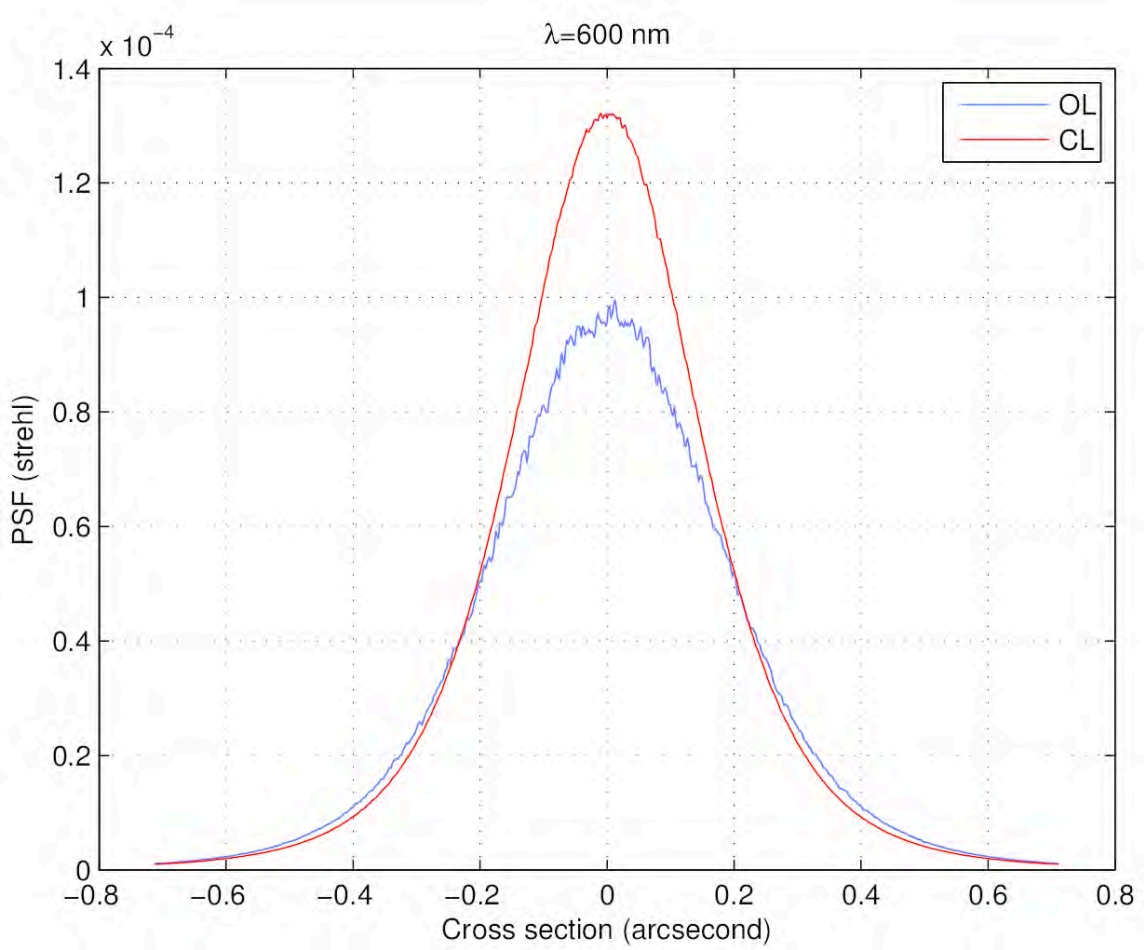
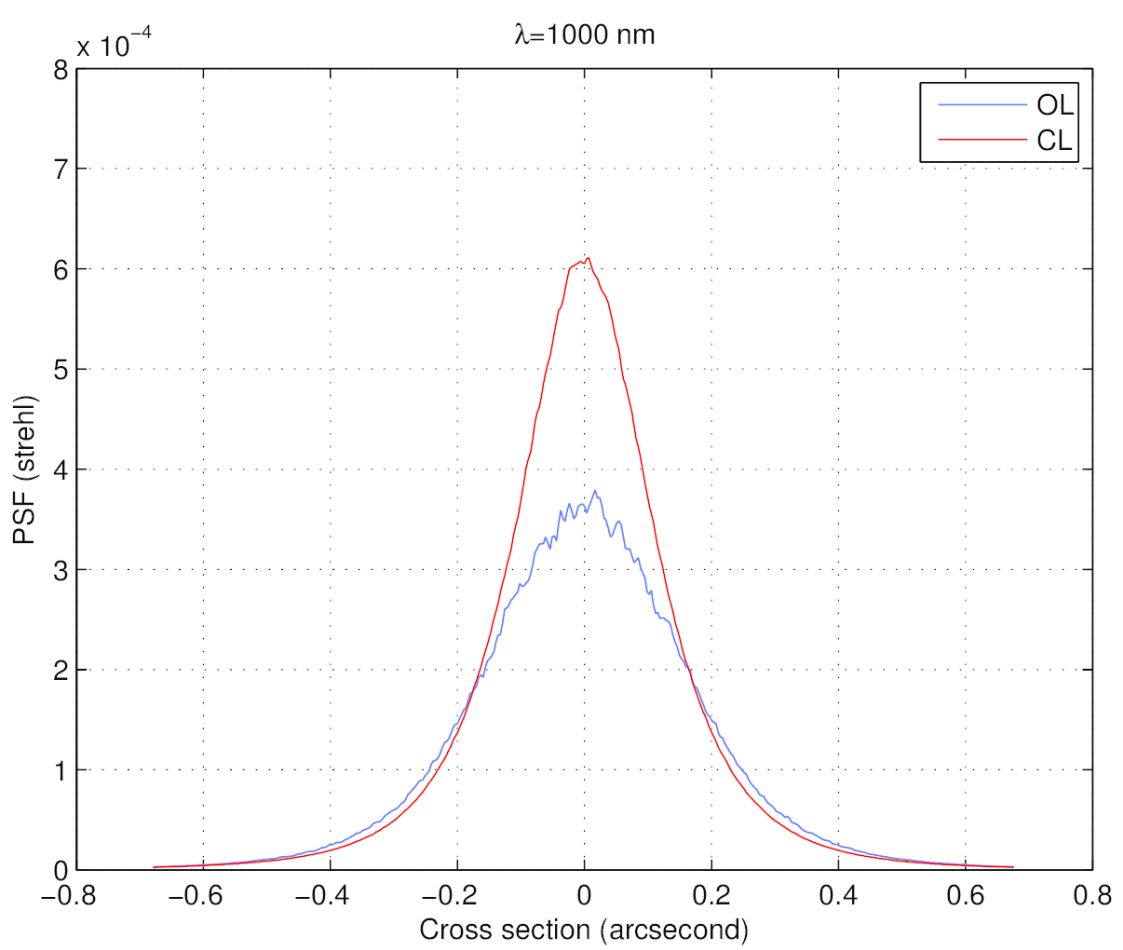
# Field-Averaged PSF Profile at 600 nm



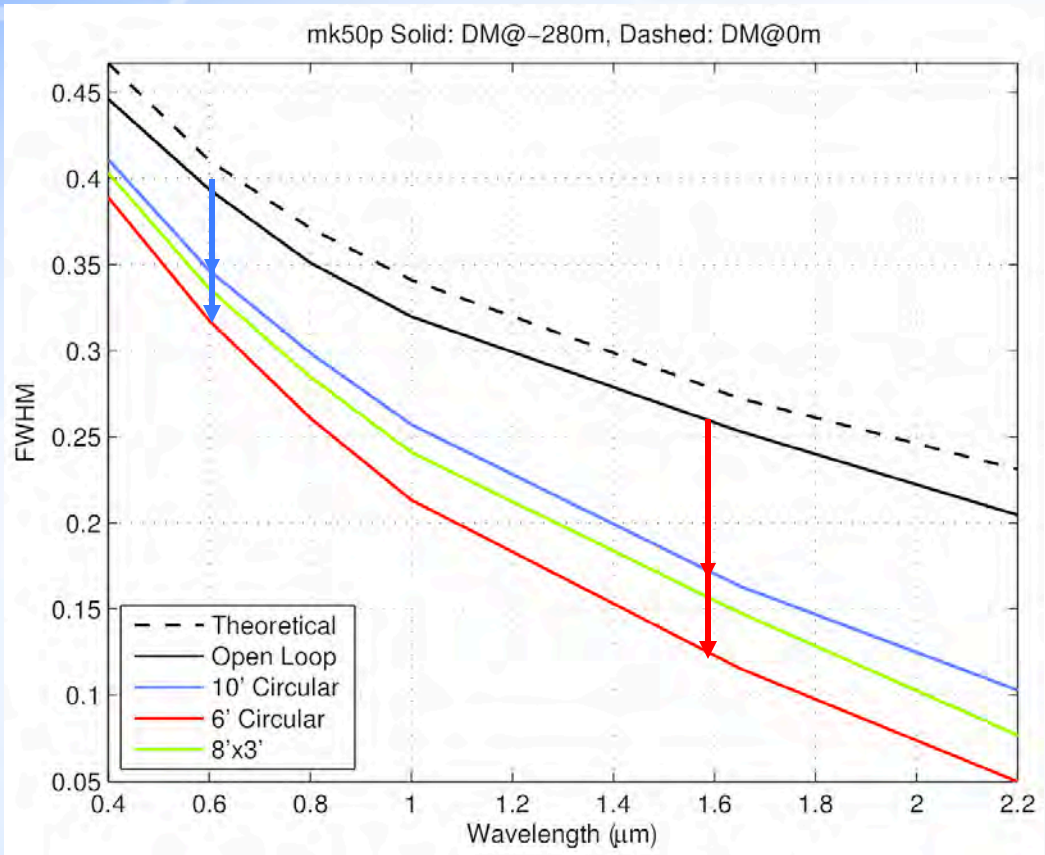

~30% increase in peak with GLAO

# Field-Averaged PSF Profile at 1000 nm



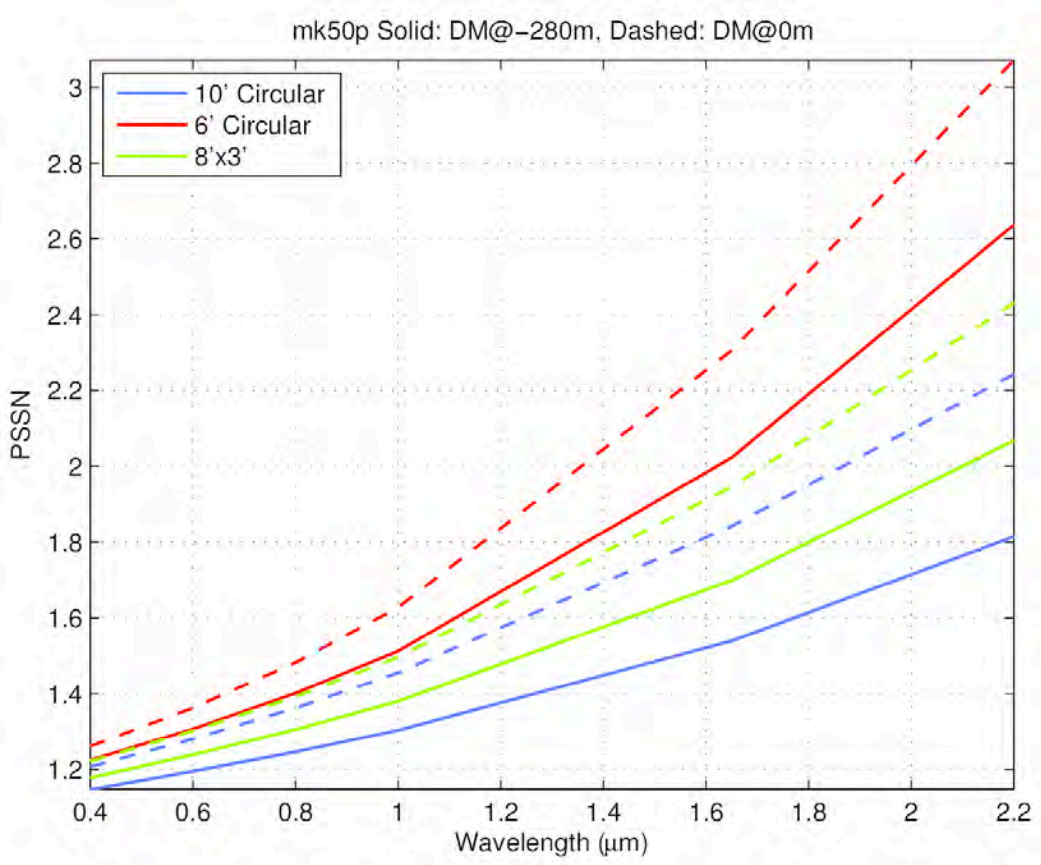

~70% increase in peak with GLAO

# FoV-Averaged PSF FWHM vs Wavelength and FoV Size



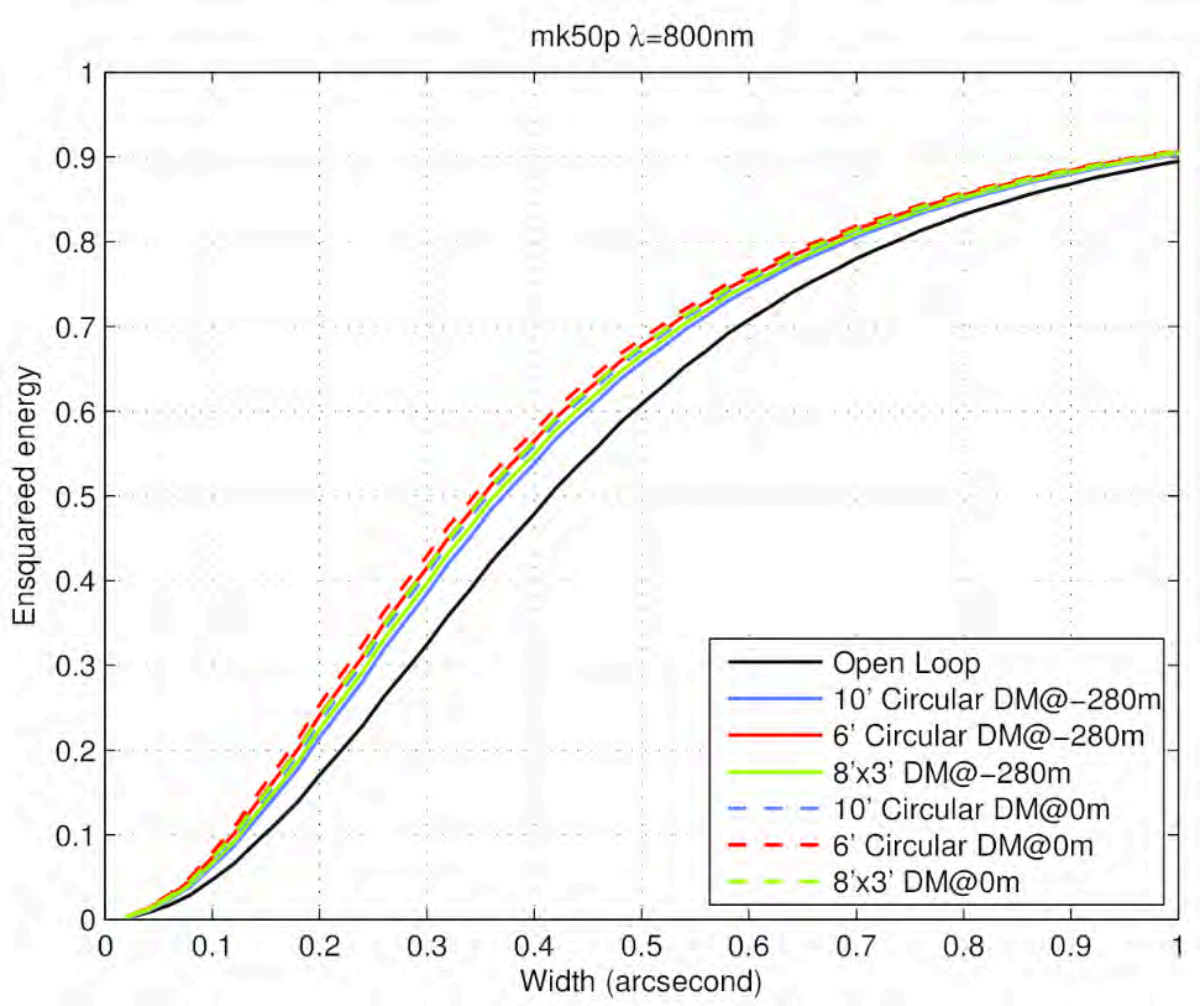

- As expected, GLAO performance improves with smaller FoV, and with longer wavelength

# GLAO Improvement to Point Source Sensitivity (PSSN)

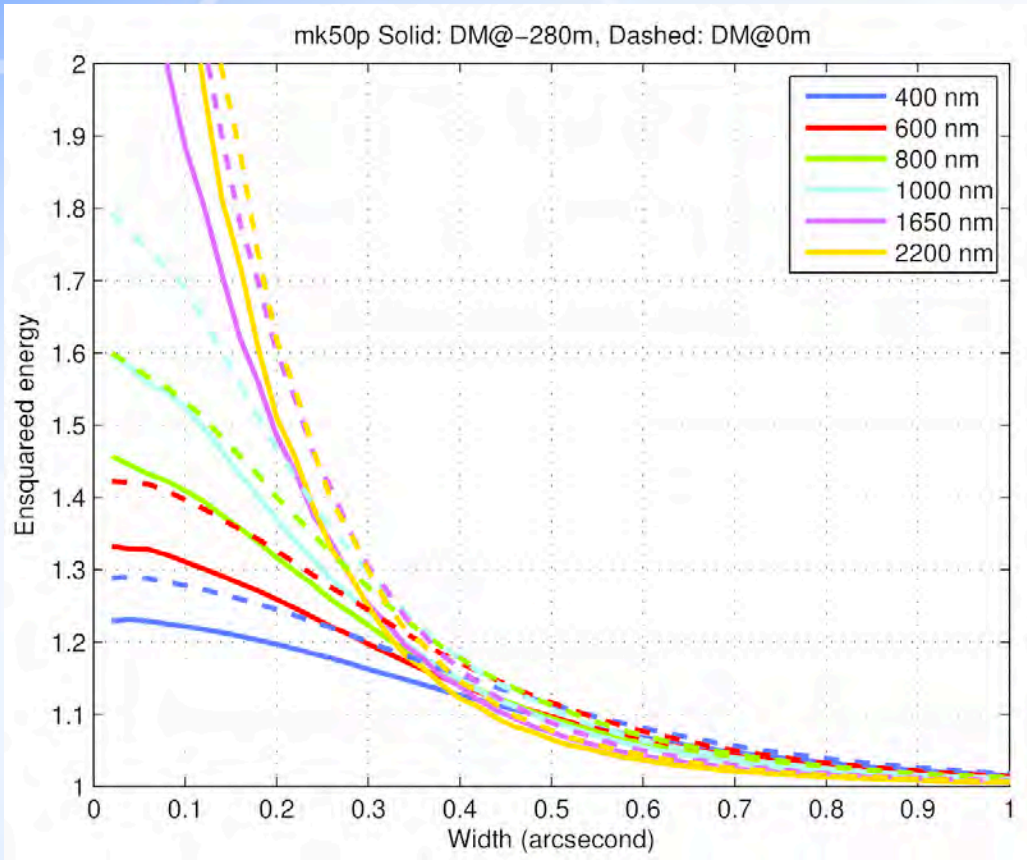



- Equivalent to the reduction in exposure time needed to detect a background-limited point source
- Exposure time is reduced by factor of 1.2-1.4 in visible, and larger factors in the near IR

# Ensquared Energy at 800 nm vs Pixel Width and FoV



# Ensquared Energy Improvement Ratios for a 10' Diameter FoV




Best improvement ratios obtained with pixel width < 0.5", regardless of wavelength

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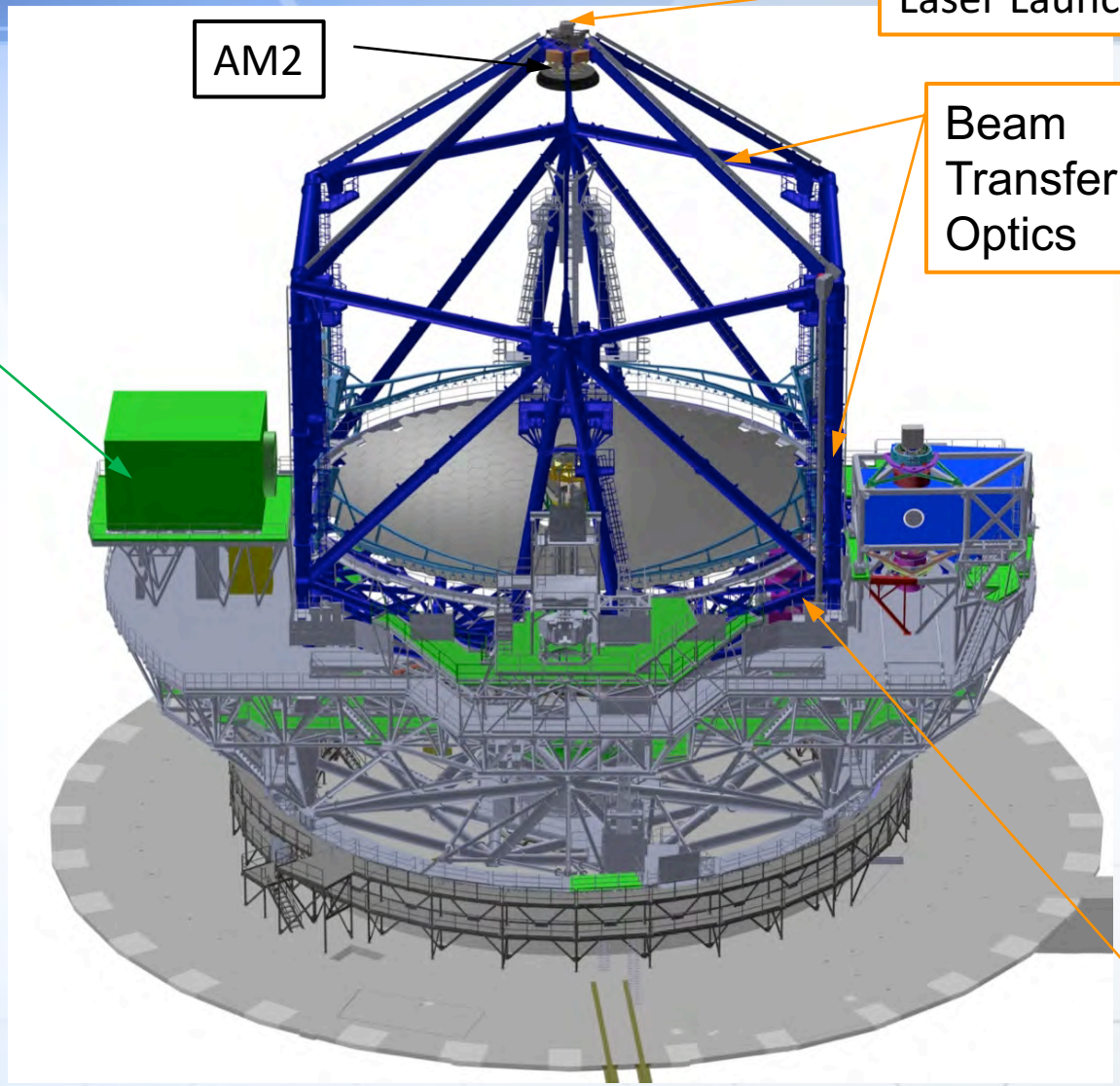
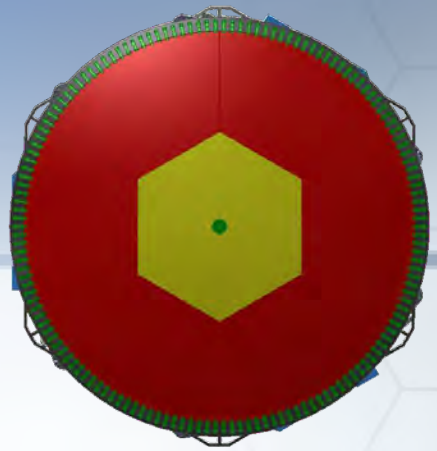
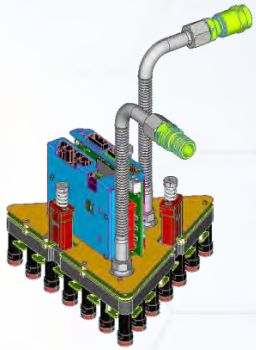


# AM2 Conceptual Design Study



- Initial concept for AM2 has been formulated by ADOPTICA:
  - Total of 3756 actuators with 50 mm spacing
  - 2.7 mm thick Zerodur shell in 7 segments
  - Actuators configured in “bricks” for electronics and cooling
  - Double SiC reference body for supporting the shell and bricks
  - Kinematic support structure with 3 bipods



- Conceptual design study (Oct 2017 – April 2018)
- TMT will also perform AM2 phasing study with APS

# Summary

- WFOS performance benefits from GLAO
  - 10% (400nm) to 33% (1000nm) improvement in PSF FWHM
    - Best improvements achieved with 4’ or 6’ diameter FoV
  - Corresponding improvements in PSSN (observing efficiency)
  - Penalty of AM2 conjugation to -280m not a showstopper
- Components and design concepts under development
  - Order ~30 x 30 wavefront correction with 4 laser guide stars
  - Guide star lasers and LGS WFS cameras taken from NFIRAOS
  - TMT Laser guide star facility delivers the GLAO asterism
  - WFOS must provide space for LGS pickoffs and WFS cameras
  - Conceptual Design Study for AM2 now underway

# Acknowledgments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