TMT AO Performance with AM2

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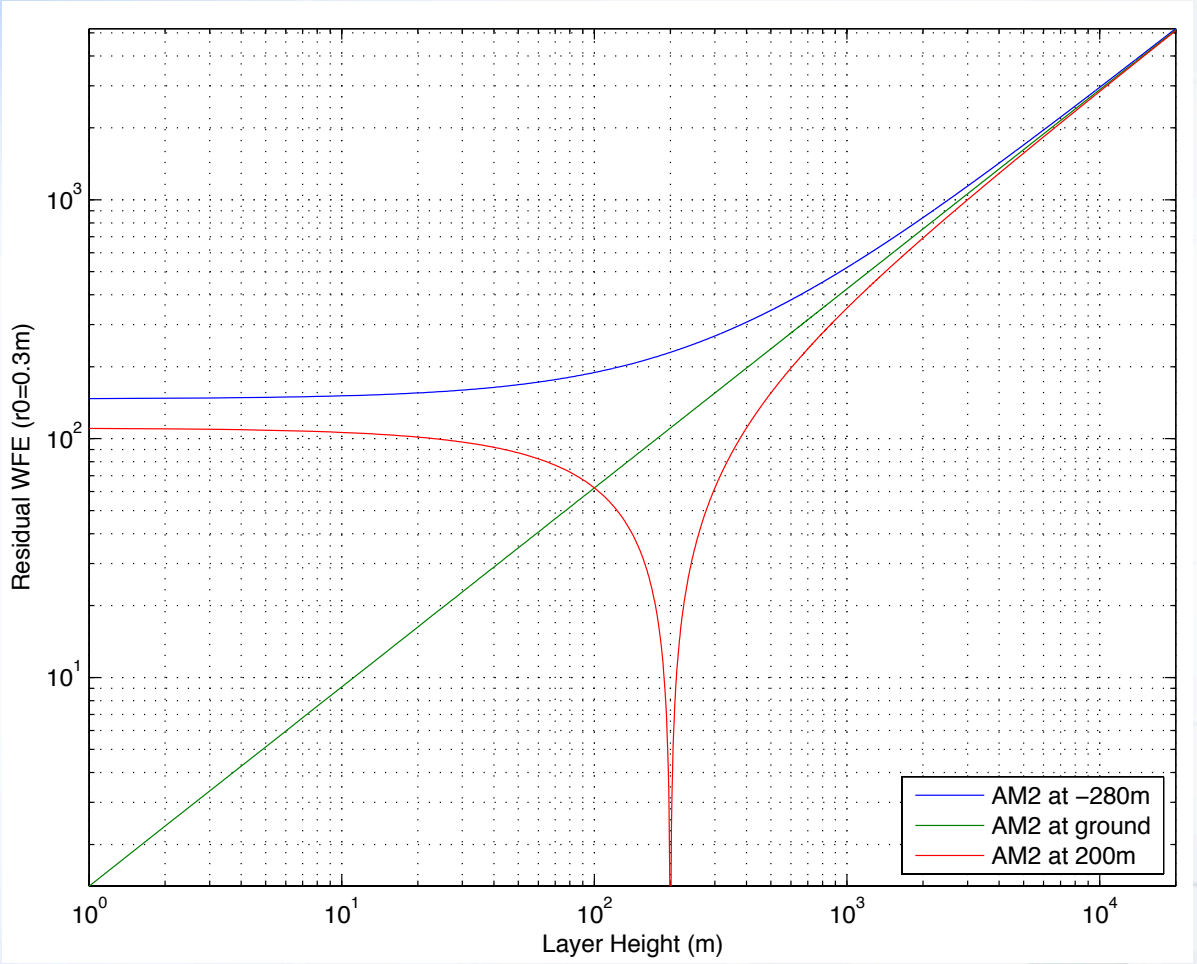
Introduction

- Motivation:
  - Define requirement for AM2 order of correction.
  - Optimize correction over wide FoV(GLAO)

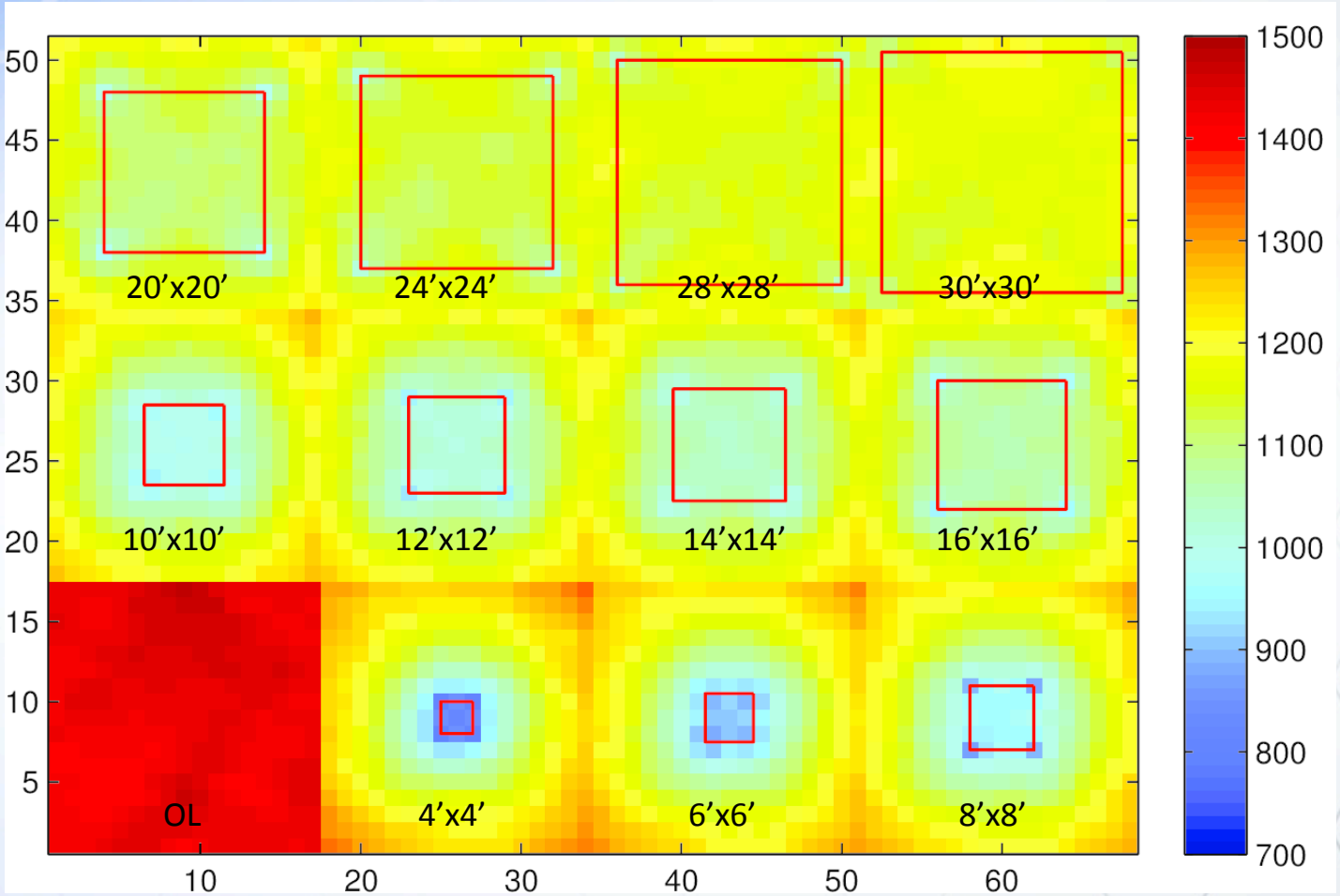
Parameters

- AM2 at -280m for TMT
  - Slightly worse correction compared to 0 m conjugation.
- Science FoV: 8'x3' (WFOS: 8.3'x3')
- Use 4 bright NGS WFS on square grid
- Turbulence
  - Height:
    - ht=[0 500 1000 2000 4000 8000 16000]m
  - MK13N 50 percentile: r0=0.186m
    - Layer weight: [0.4557 0.1295 0.0442 0.0506 0.1167 0.0926 0.1107]
  - ORM 50 percentile: r0=0.178m
    - Layer weight: [0.2524 0.1925 0.1192 0.0803 0.1160 0.1479 0.0917]
  - MK13N 75 percentile: r0=0.135m
    - Layer weight: [0.3952 0.1665 0.0703 0.0773 0.0995 0.1069 0.0843]

FoV Averaged Anisoplanatic WFE for a Single Layer (r0=0.3m)



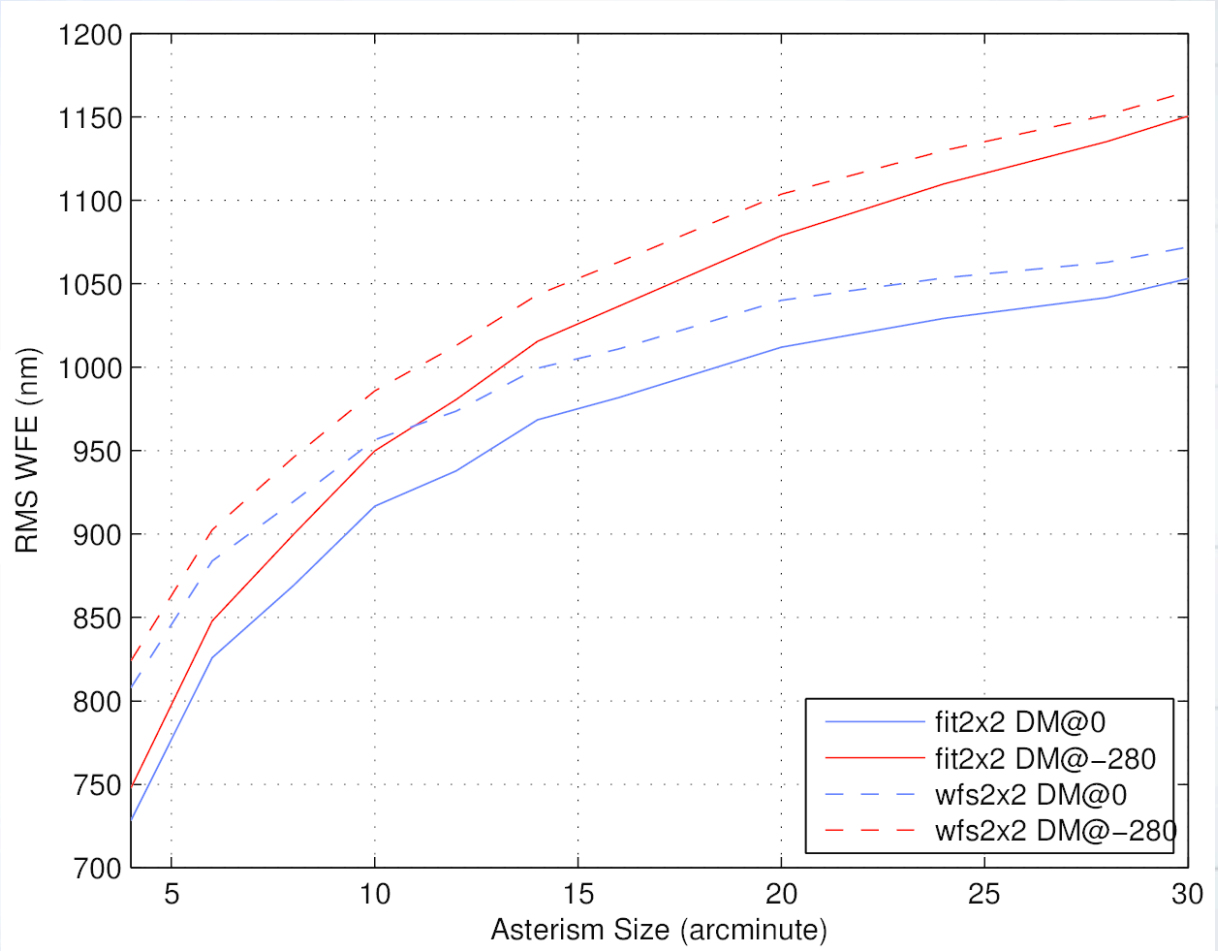
AM2 correction with Different FoV Order 30x30, AM2@-280m



Field Averaged Wavefront Error vs Correction FoV

With larger FoV:

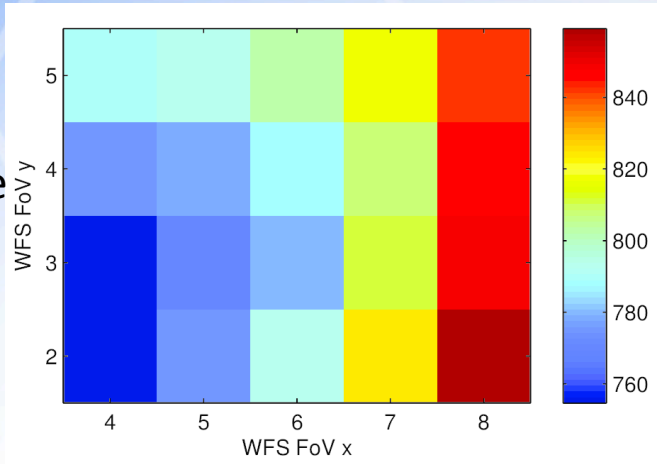
- Correction degrades
- Impact of AM2 conjugation increases

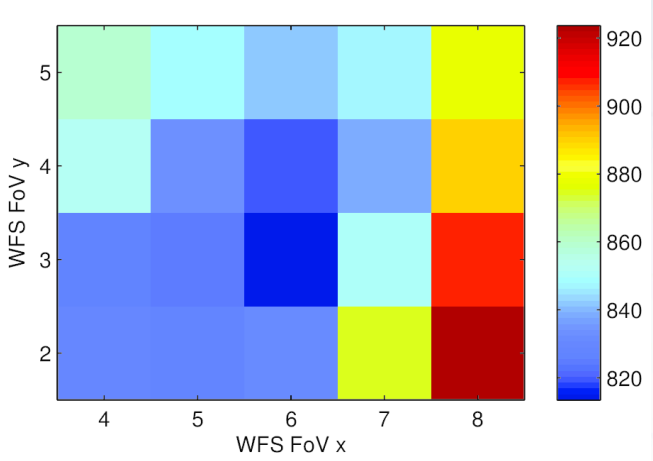


- fit2x2: Assume perfect knowledge of turbulence. Fit to DM using 2x2 directions (corner)
- wfs2x2: Actual performance with 2x2 guide star asterism.

Optimize Asterism Size for WFOS (8'x3') Order 30x30

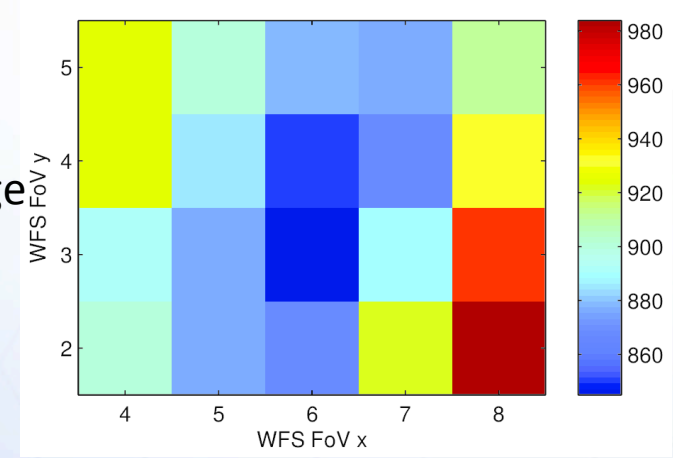
Field Average

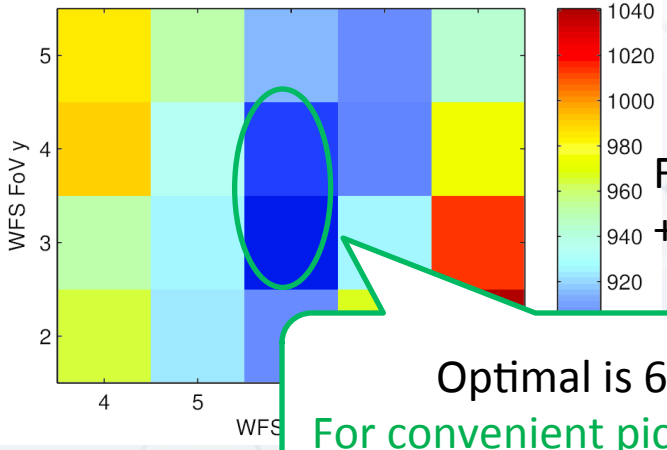




Field Average + 1 sigma

Field Average + 2 sigma





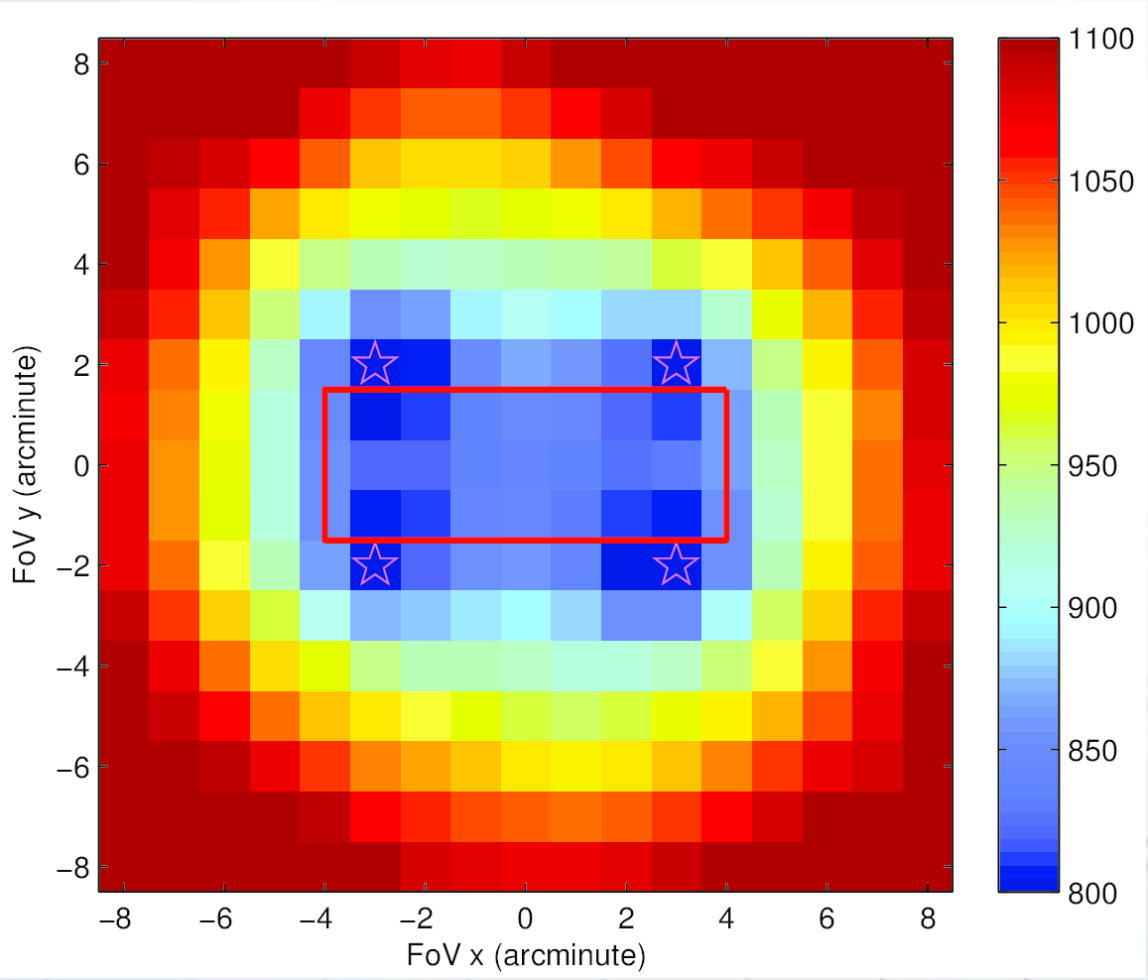
Field Average + 3 sigma

Optimal is 6'x3'

For convenient pickup: 6'x4'

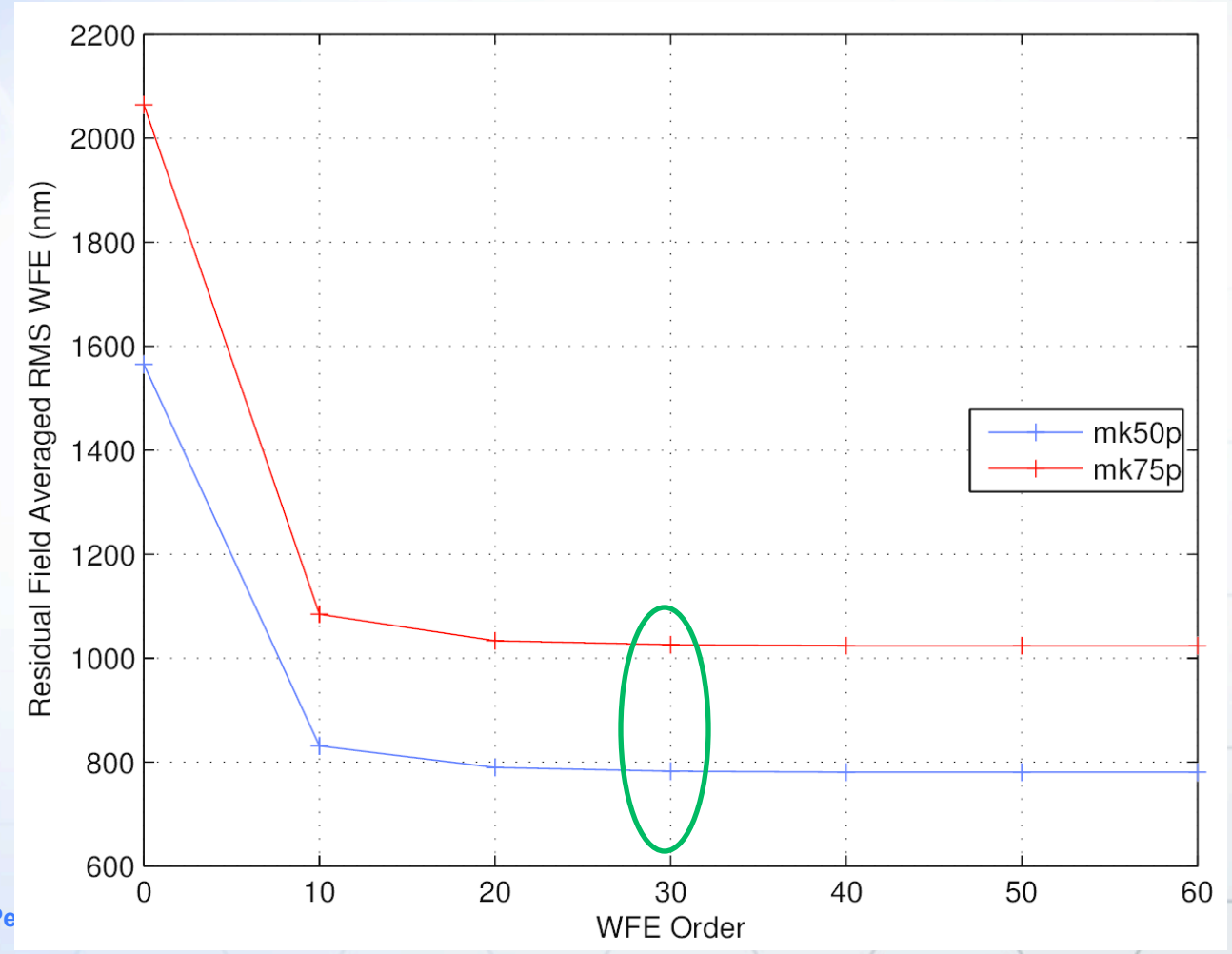
WFE Across FoV
6'x4' Asterism selected

- Even correction within

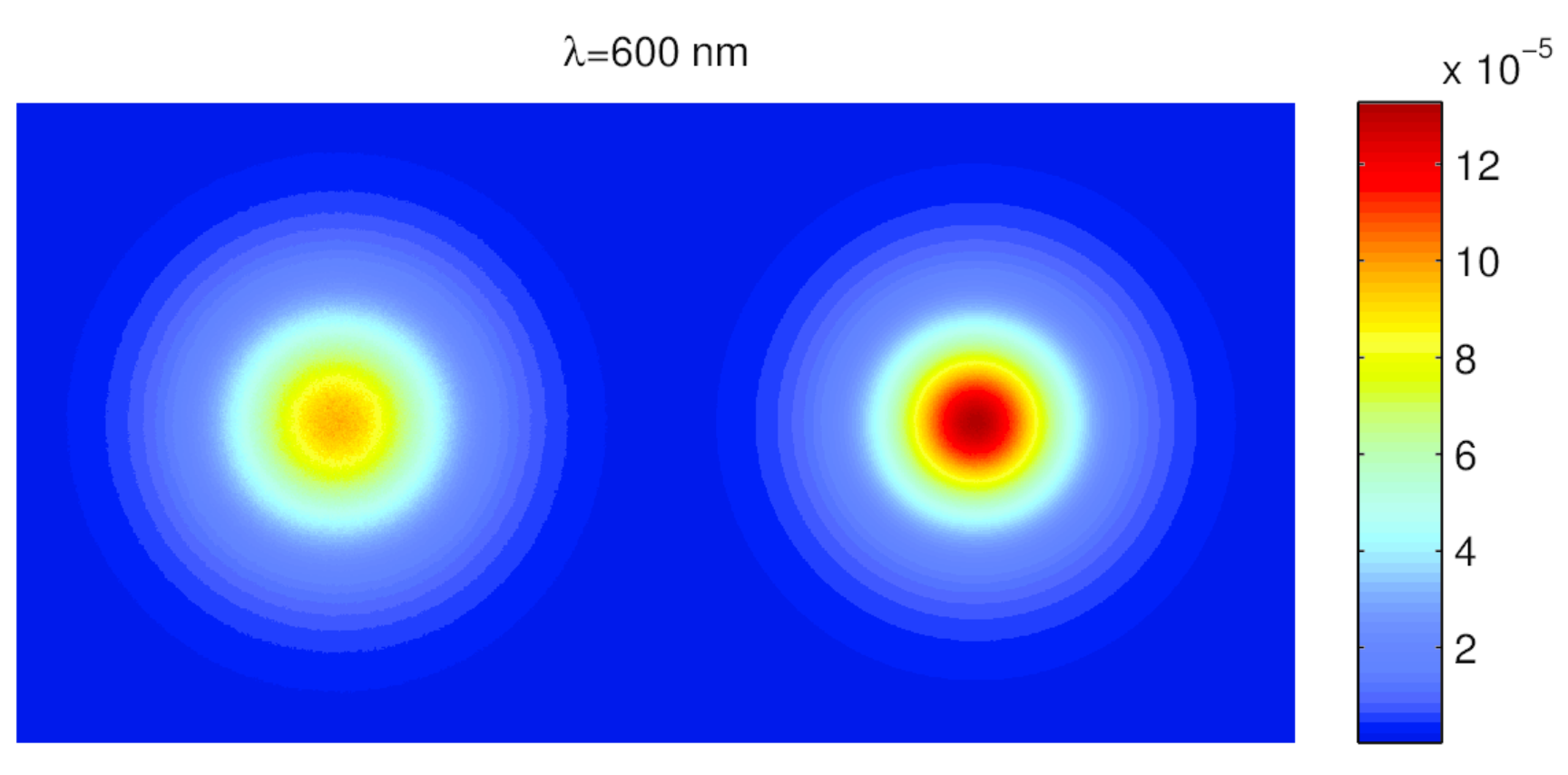


AM2 Correction Order
Order 30x30 selected

- Negligible improvement at order > 30



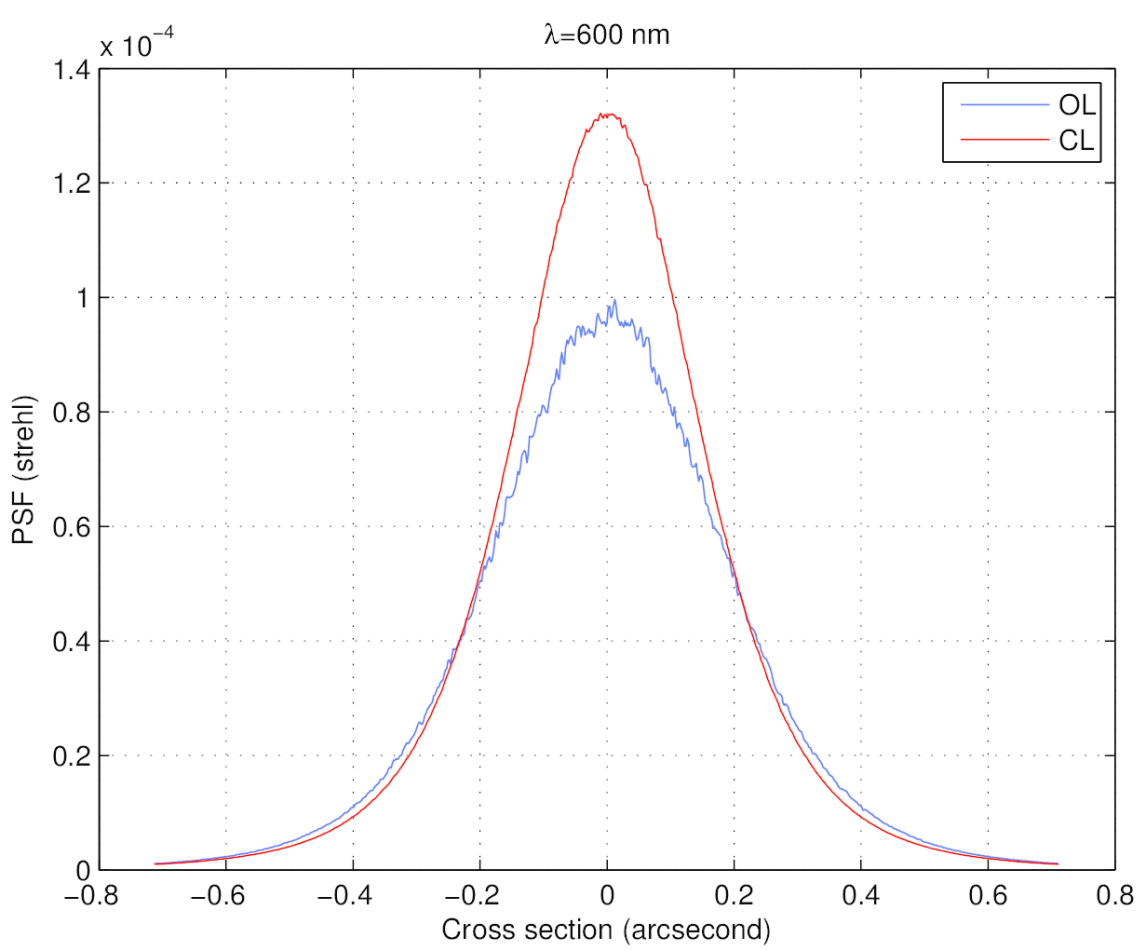
Field averaged PSF @600 nm



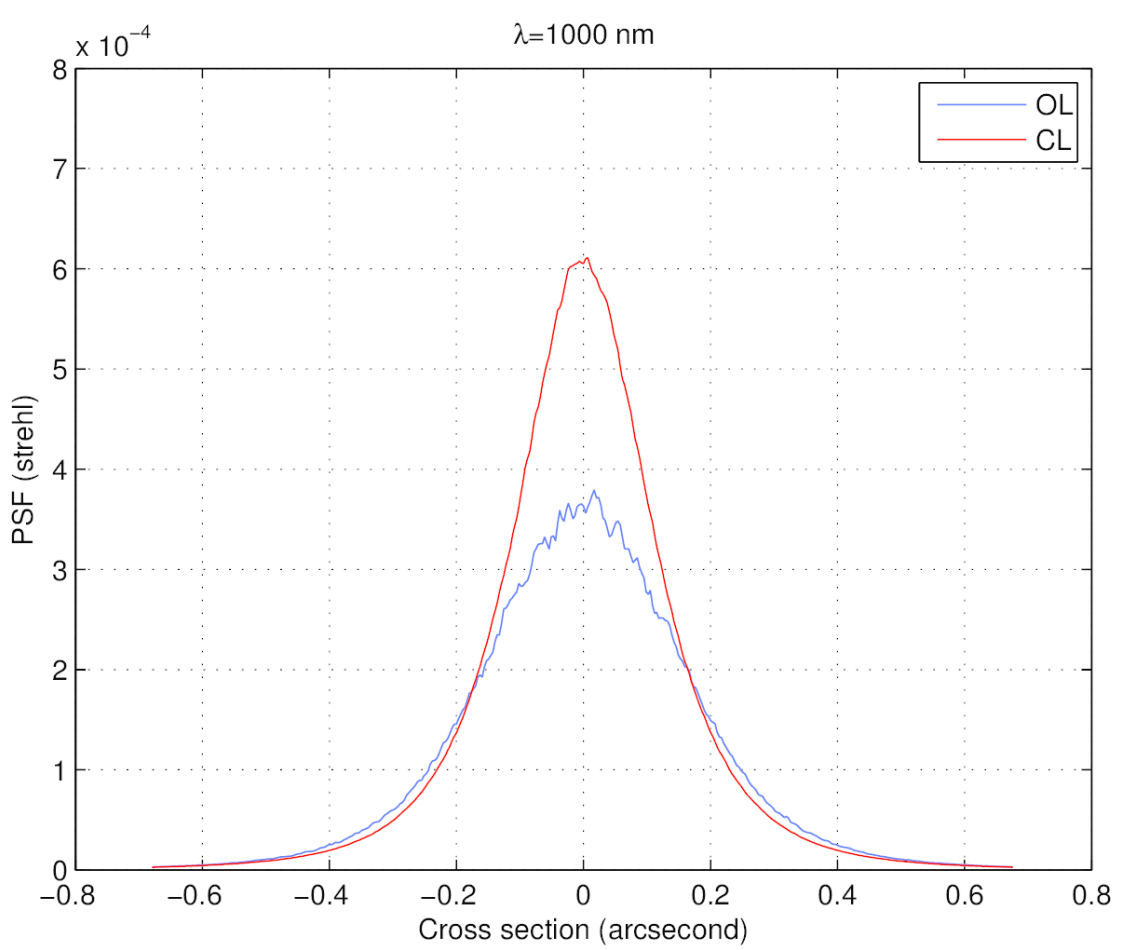
OL

CL with AM2@-280m

PSF 1-d cut @600 nm

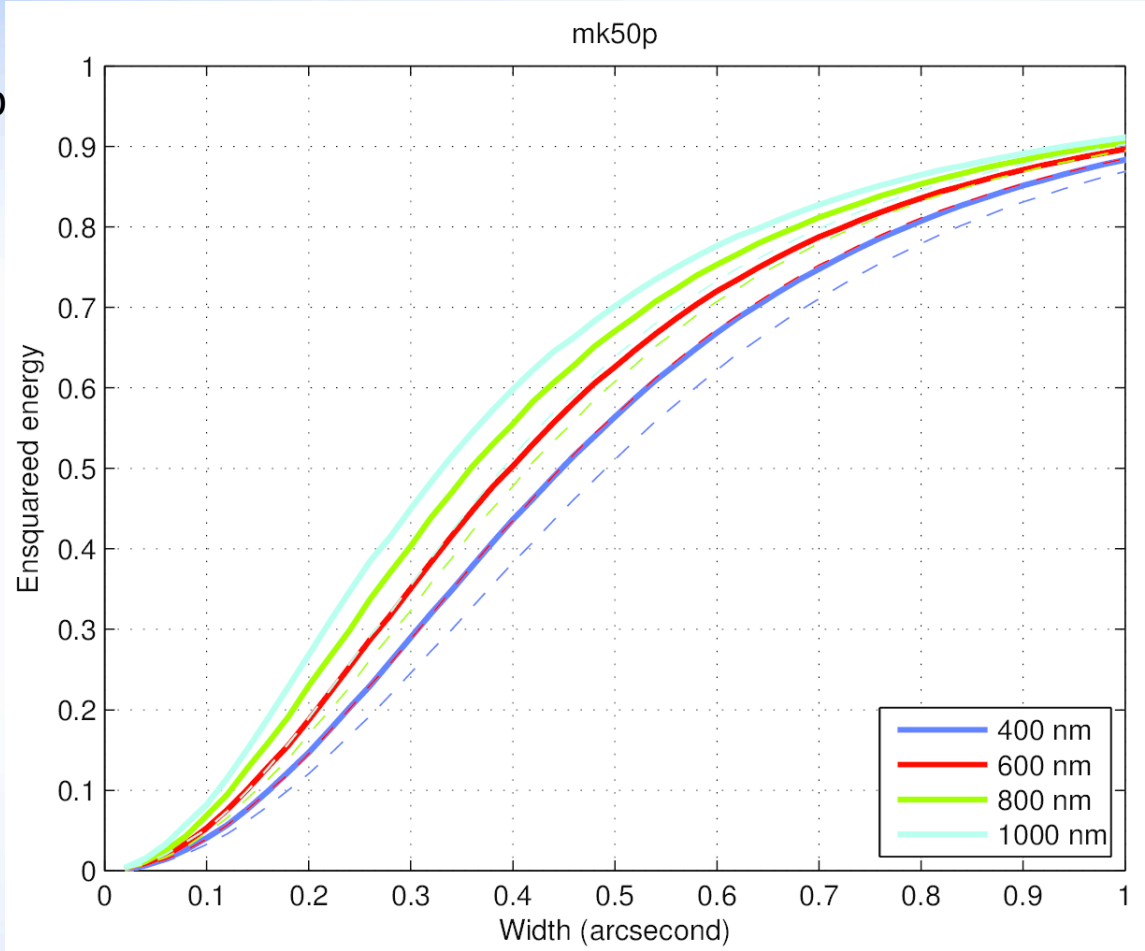


PSF 1-d cut @1000 nm

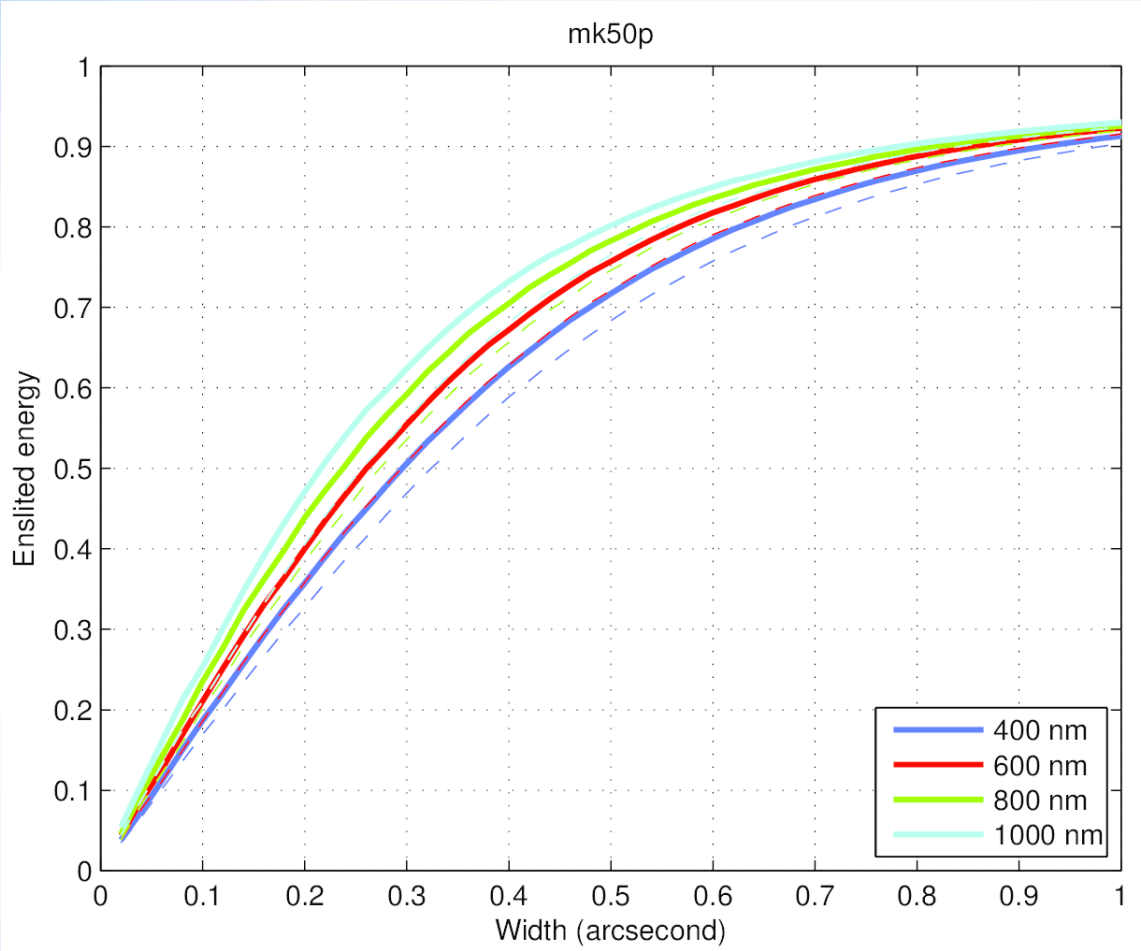


Ensquared Energy

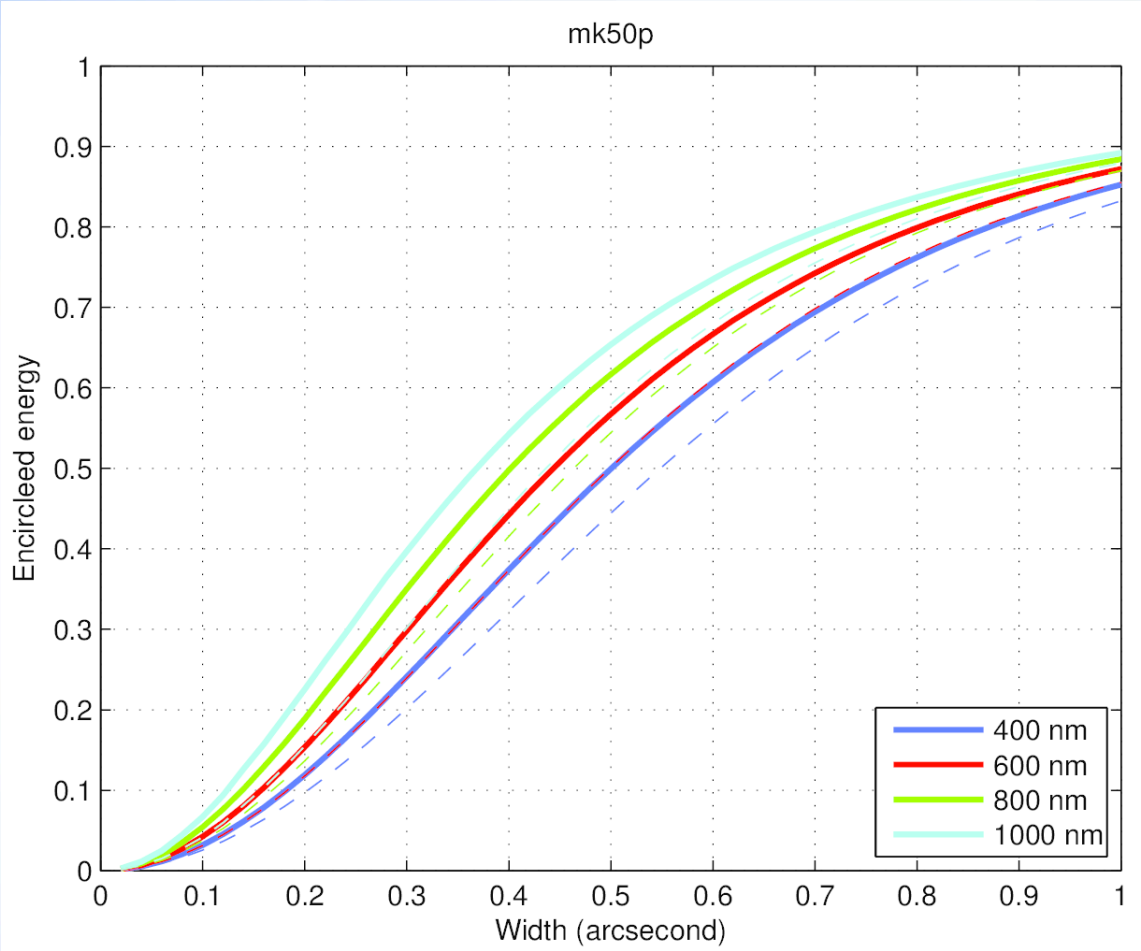
Solid: Closed loop
Dashed: Open loop



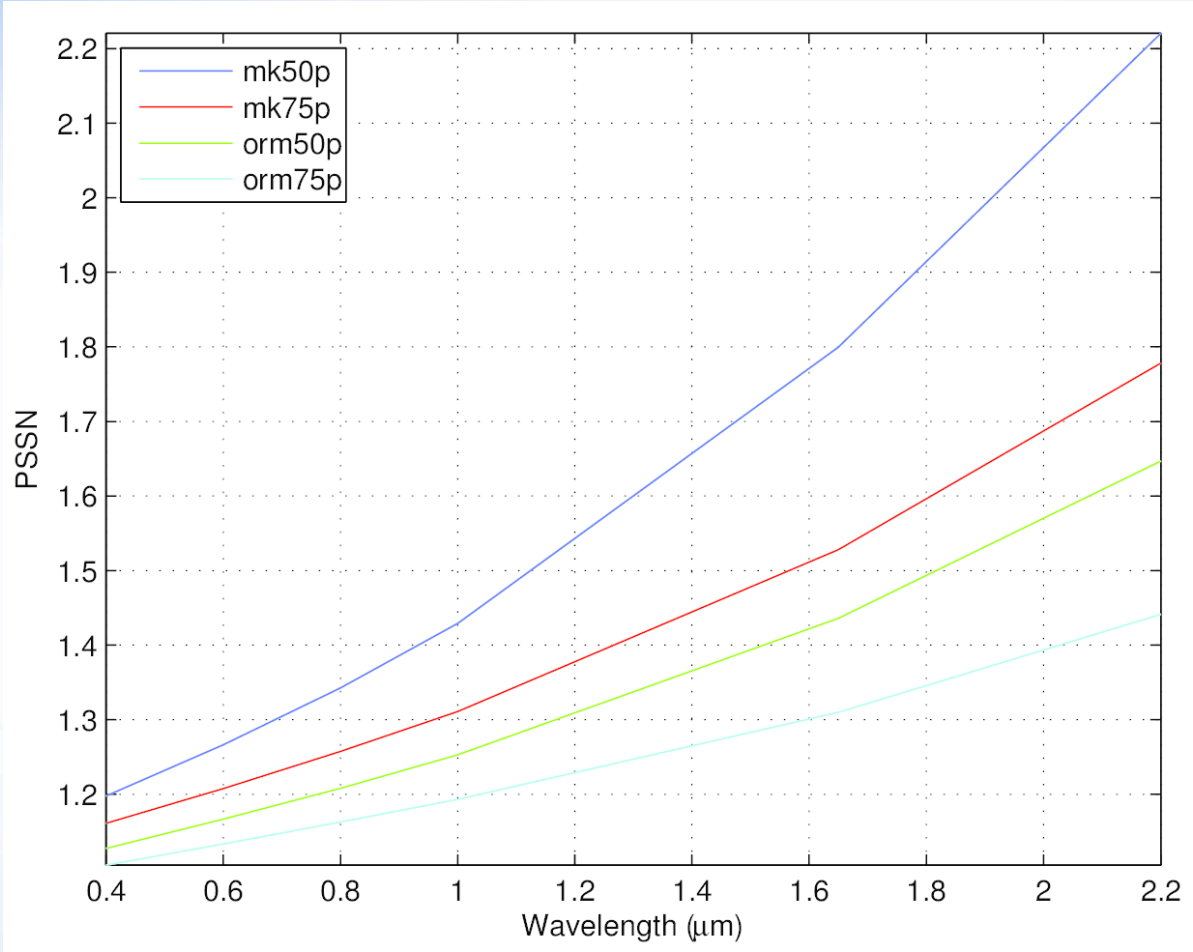
Enslited Energy



Encircled Energy

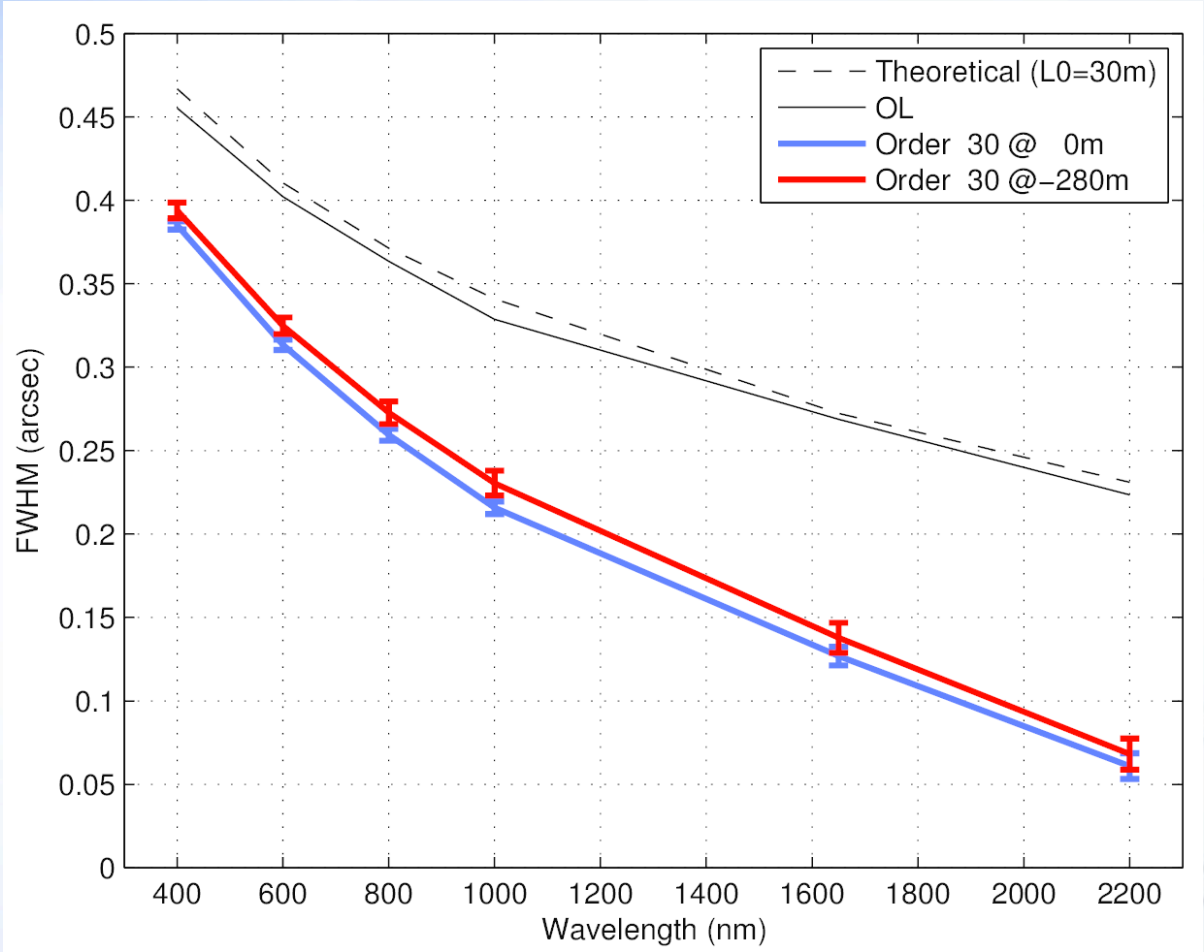


PSSN
GLAO over Seeing Limited

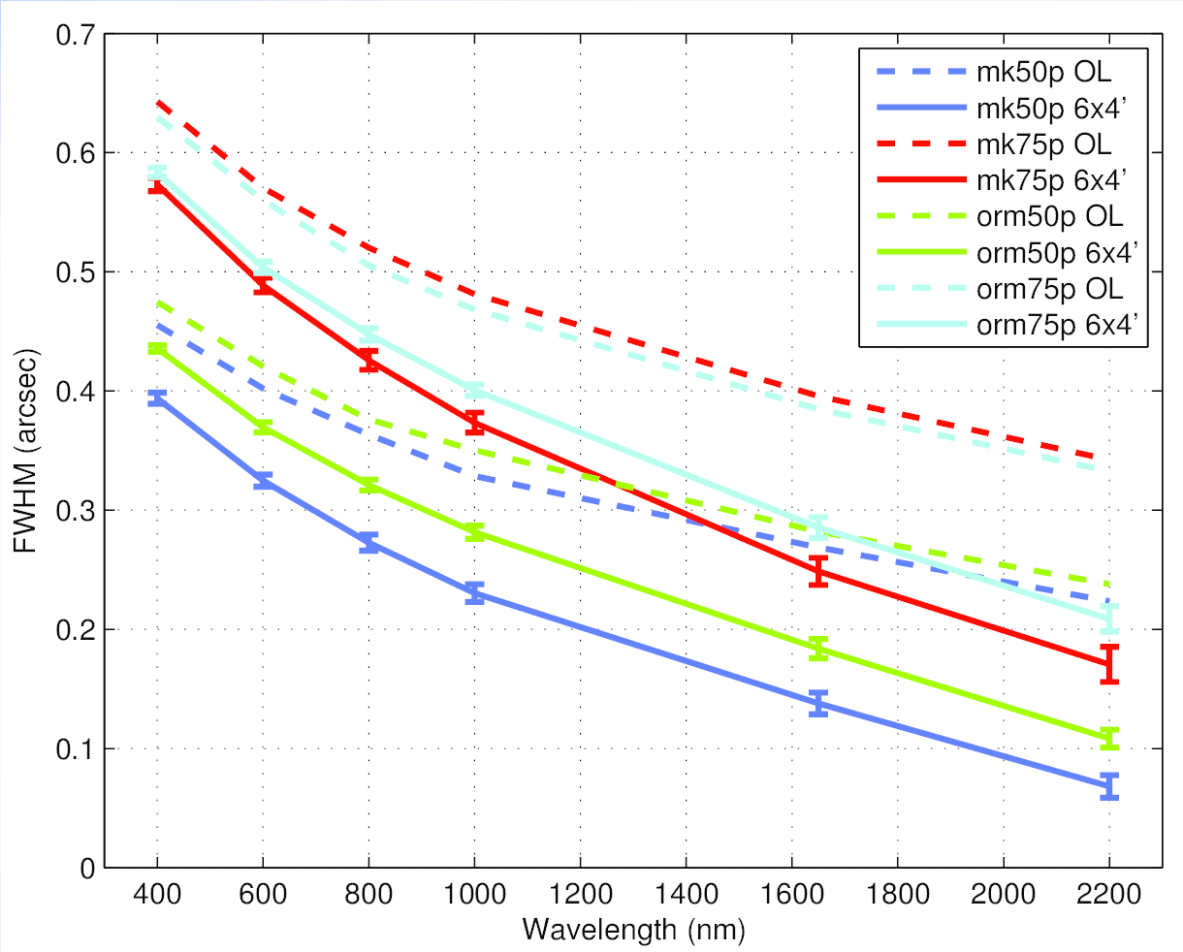


FWHM
6'x4' WFS, Order 30x30

Error bar shows variation within FoV

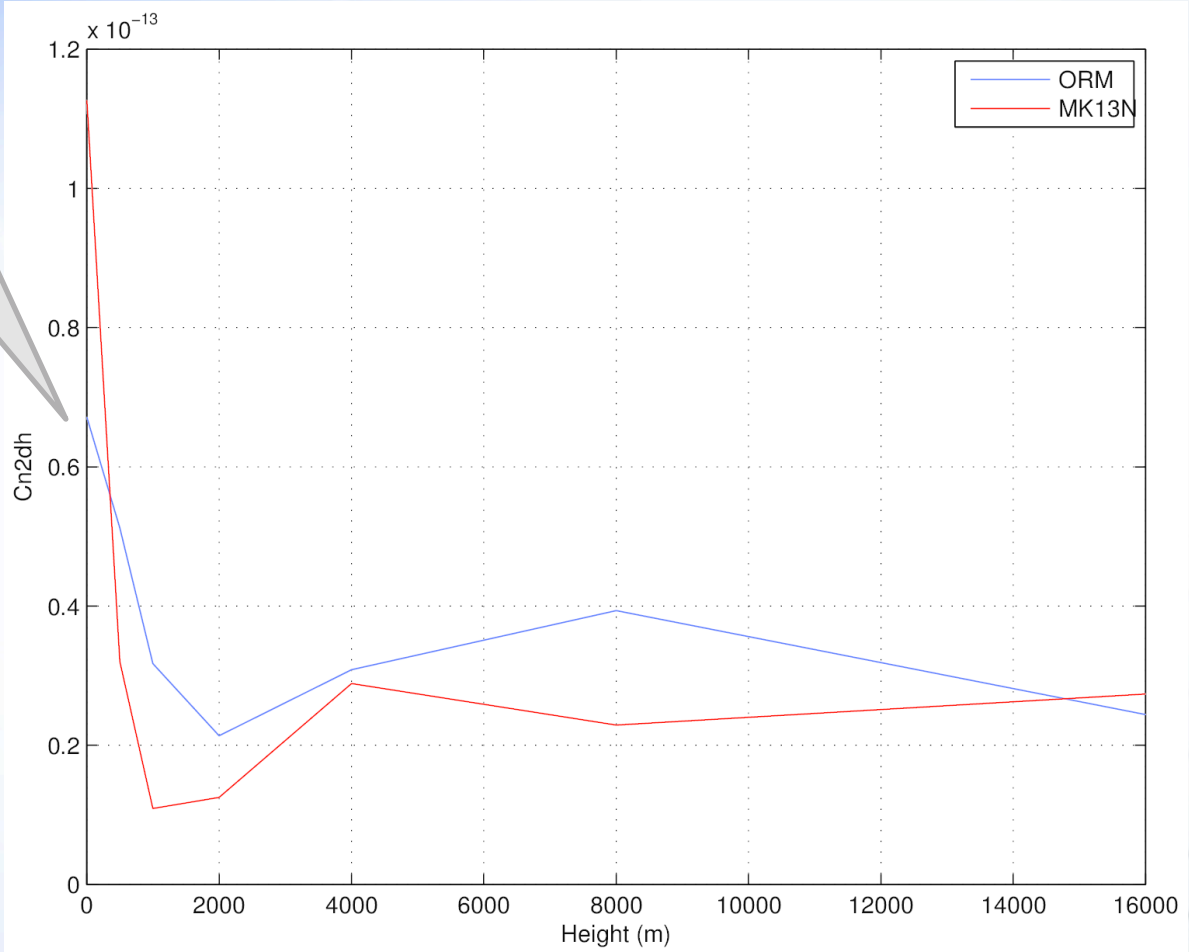


Different Turbulence Profiles MK vs ORM



Cn2 Profile
MK13N vs ORM

Current data shows ORM having less ground layer turbulence

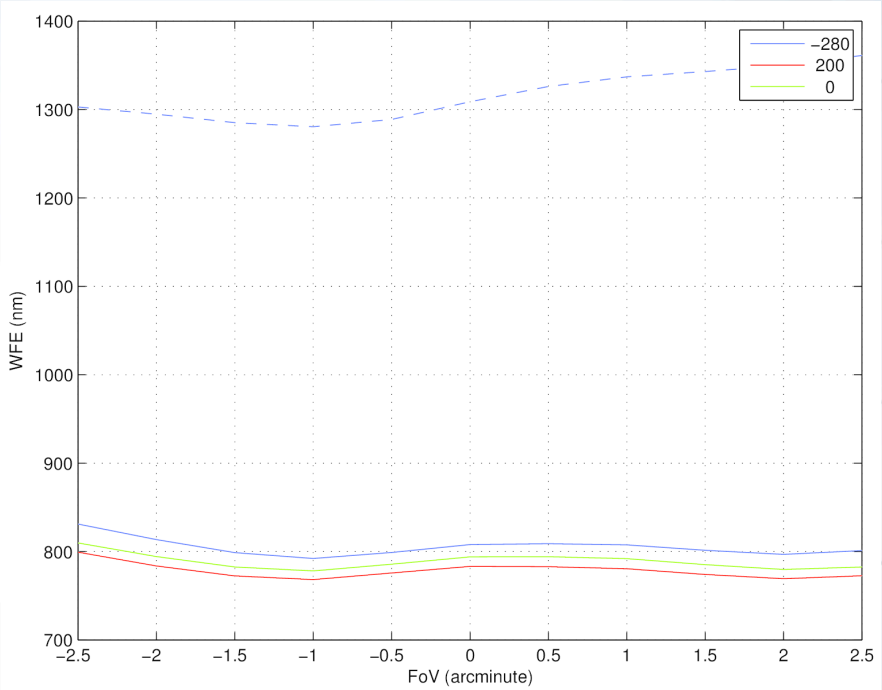


MIRAO

- 30” Imaging FoV. 60” Chop Field [2011 by M. Chun]
- WFE: <750nm or 350 nm (goal)
- Uses Single DM
- WFE is dominated by anisoplanatism
  - 350 nm fundamental error over 30”x30” FoV.
    - 115 nm DM fitting error with order 30x30 correction
  - 410 nm over 60”x60” FoV.
  - AM2 conjugation makes negligible difference

MOAO

- 5’ FoV.
- AM2 as “Woofer”
  - Reduces RMS WFE from 1400 nm to 800 nm.
  - MEMS DM stroke req. reduced by 45%.
- AM2 conjugation makes almost negligible difference



Conclusion

- Wide FoV instruments benefit from low order (mode) AM2 (~30x30)
  - Limited by anisoplanatism
  - GLAO: 10% (400nm) to 30% (1000nm) reduction in FWHM
  - MOAO
- Sufficient for MIRAO
- Small FoV instruments would benefit from higher order AM2
  - Woofer for NFIRAOS+
  - LTAO (HROS)

Acknowledgments

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Different Correction Order (Field Average WFE + 1 Sigma)