Motivation:

- Define requirement for AM2 order of correction.
- Optimize correction over wide FoV(GLAO)
- 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: $r_0=0.186m$
    - Layer weight: $[0.4557\ 0.1295\ 0.0442\ 0.0506\ 0.1167\ 0.0926\ 0.1107]$
  - ORM 50 percentile: $r_0=0.178m$
    - Layer weight: $[0.2524\ 0.1925\ 0.1192\ 0.0803\ 0.1160\ 0.1479\ 0.0917]$
  - MK13N 75 percentile: $r_0=0.135m$
    - 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)

Residual WFE (r0=0.3m)

Layer Height (m)

AM2 at ~280m
AM2 at ground
AM2 at 200m
AM2 correction with Different FoV
Order 30x30, AM2@-280m
With larger FoV:
- Correction degrades
- Impact of AM2 conjugation increases

- \textit{fit2x2}: Assume perfect knowledge of turbulence. Fit to DM using 2x2 directions (corner)
- \textit{wfs2x2}: Actual performance with 2x2 guide star asterism.
Optimize Asterism Size for WFOS (8’x3’)
Order 30x30

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

$\lambda=600\ \text{nm}$
PSF 1-d cut @600 nm
PSF 1-d cut @1000 nm

\[
\lambda = 1000 \text{ nm}
\]

Cross section (arcsecond)

PSF (strehl)
Ensquared Energy

Solid: Closed loop
Dashed: Open loop
Enslited Energy

![Graph showing enslaved energy against width (arcsecond) for different wavelengths (400 nm, 600 nm, 800 nm, 1000 nm).]
PSSN
GLAO over Seeing Limited

![Graph showing PSSN vs Wavelength (μm) for different line types: mk50p, mk75p, orm50p, orm75p.]
FWHM
6’x4’ WFS, Order 30x30

Error bar shows variation within FoV
Different Turbulence Profiles
MK vs ORM

![Graph showing different turbulence profiles MK vs ORM](image)
Current data shows ORM having less ground layer turbulence.
- 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
- 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)
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Different Correction Order (Field Average WFE + 1 Sigma)

Order 20x20: 818 nm
Order 30x30: 813 nm
Order 40x40: 813 nm
Order 60x60: 811 nm