ON-SKY GROUND-LAYER ADAPTIVE OPTICS RESULTS ON MAUNAKEA

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TMT Science Forum 2017

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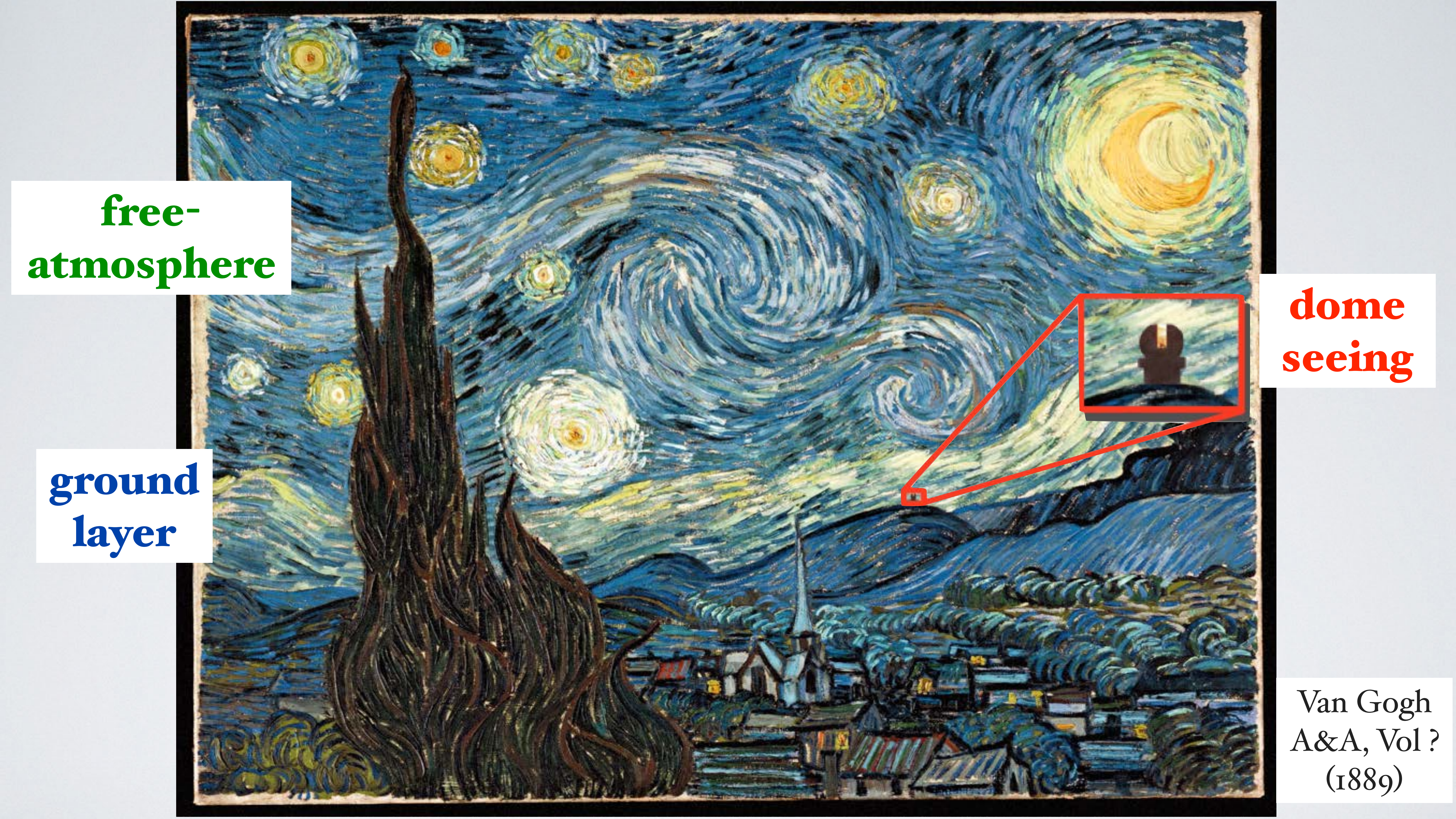
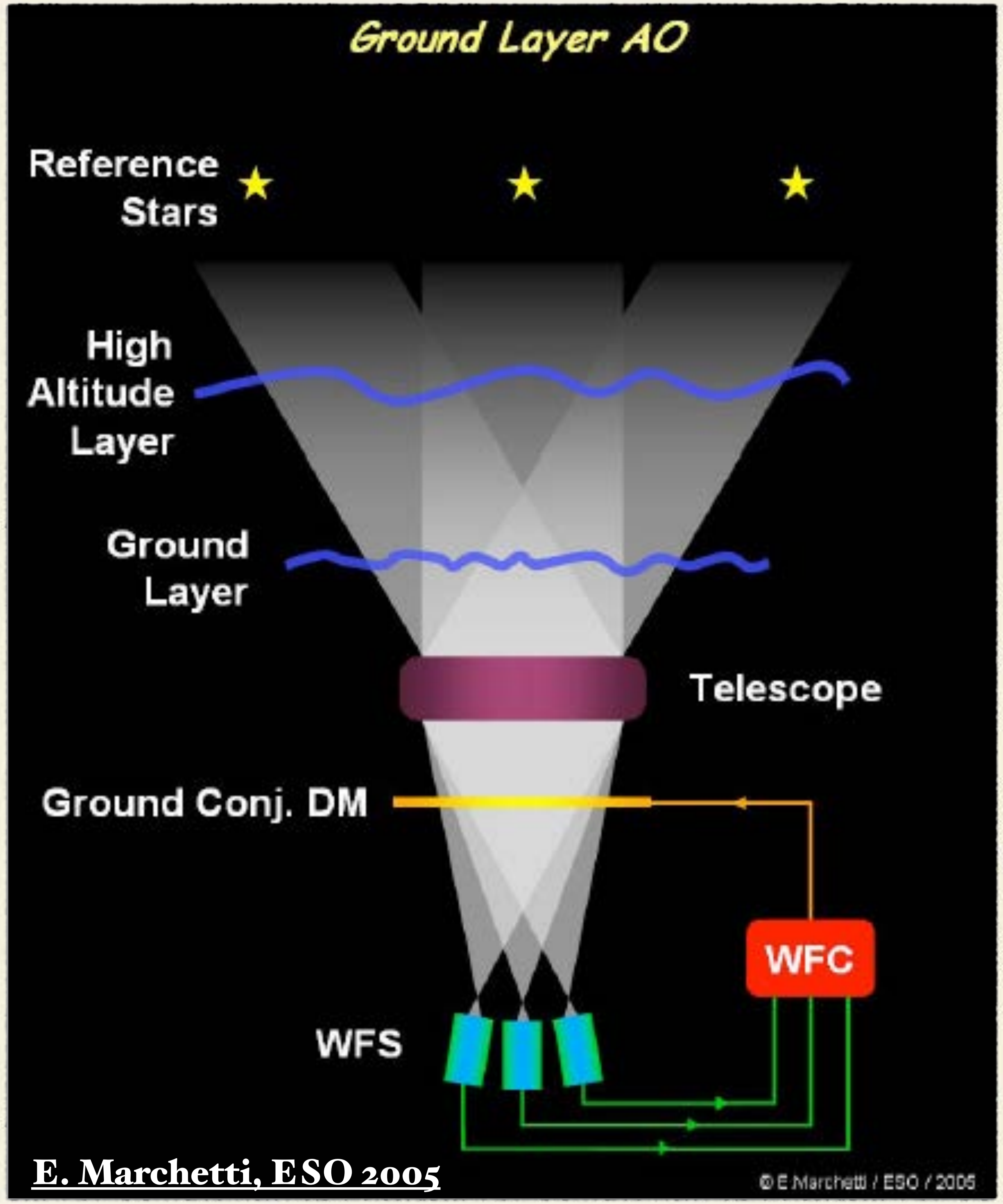

free-
atmosphere
ground
layer
dome
seeing
Van Gogh
A&A, Vol ?
(1889)

GLAO - BASIC CONCEPT

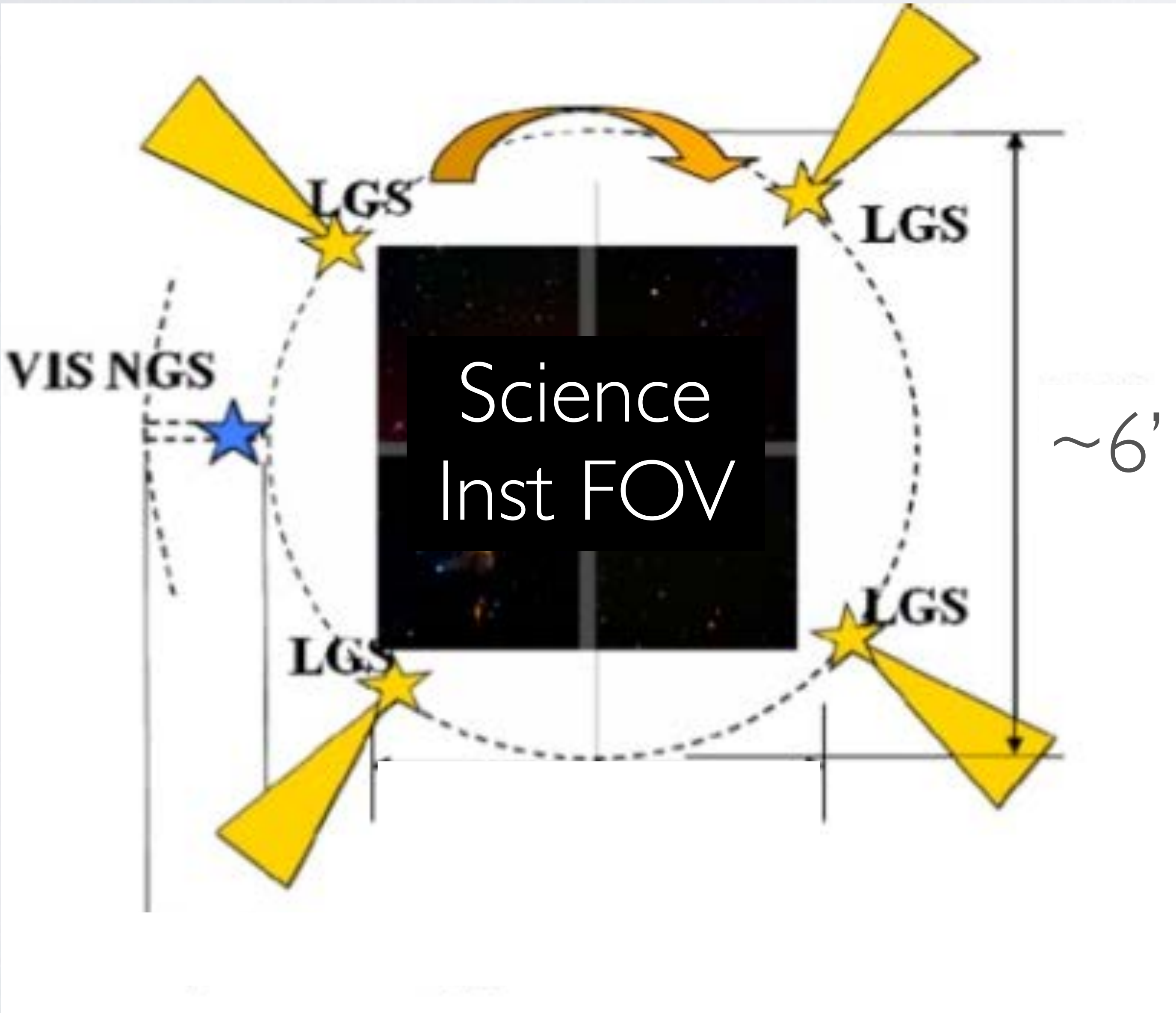
- Correct for just the “local” turbulence/aberrations including atmosphere, telescope, and enclosure
- Achieve free-atmosphere seeing over a large field of view
- GLAO is an $A\Omega/IQ^2$ instrument



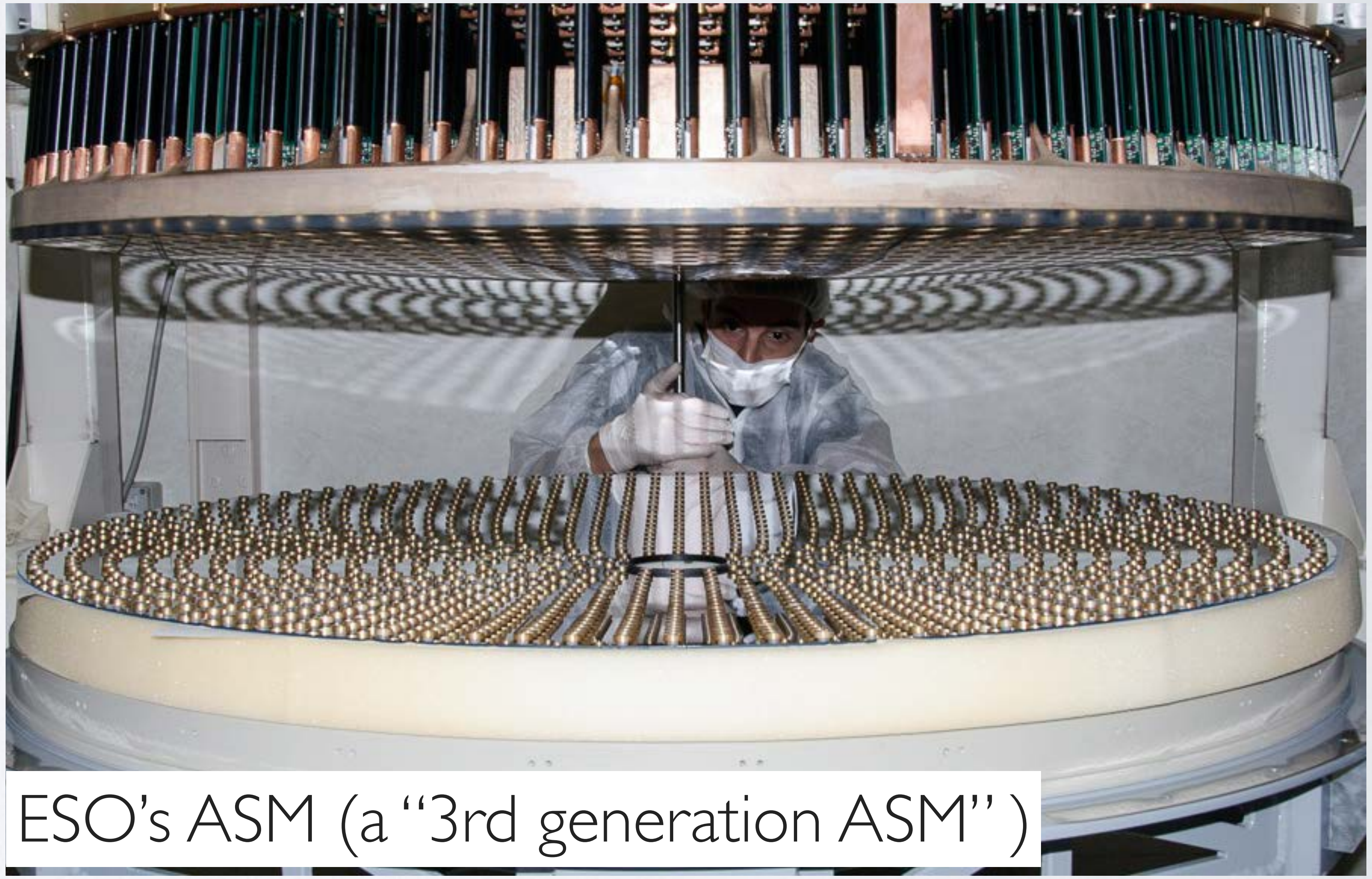
E. Marchetti, ESO 2005

A BASELINE IMPLEMENTATION

Multiple LGS (4-6) around the FOV



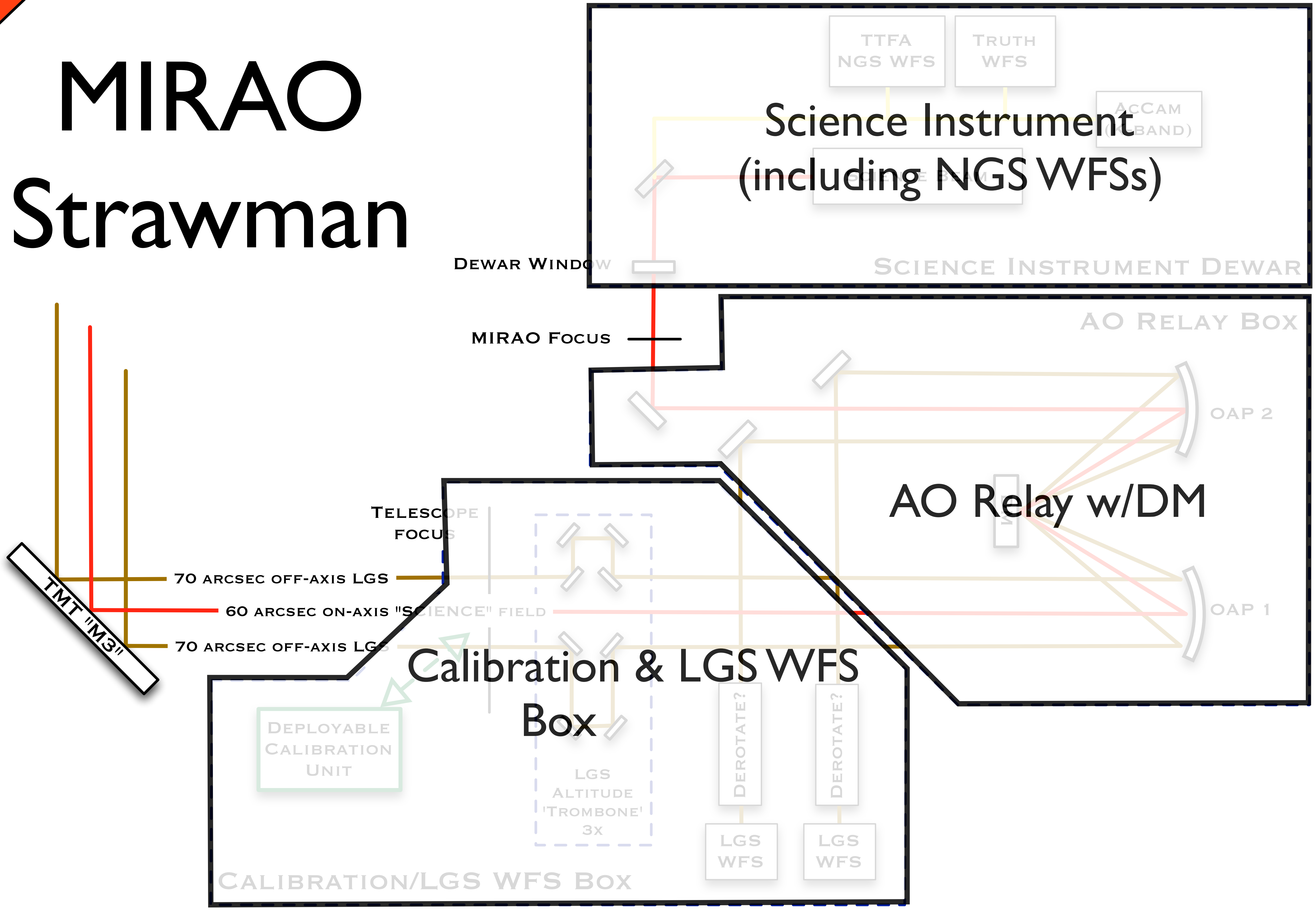
Adaptive Secondary Mirror



ESO's ASM (a "3rd generation ASM")

An aside

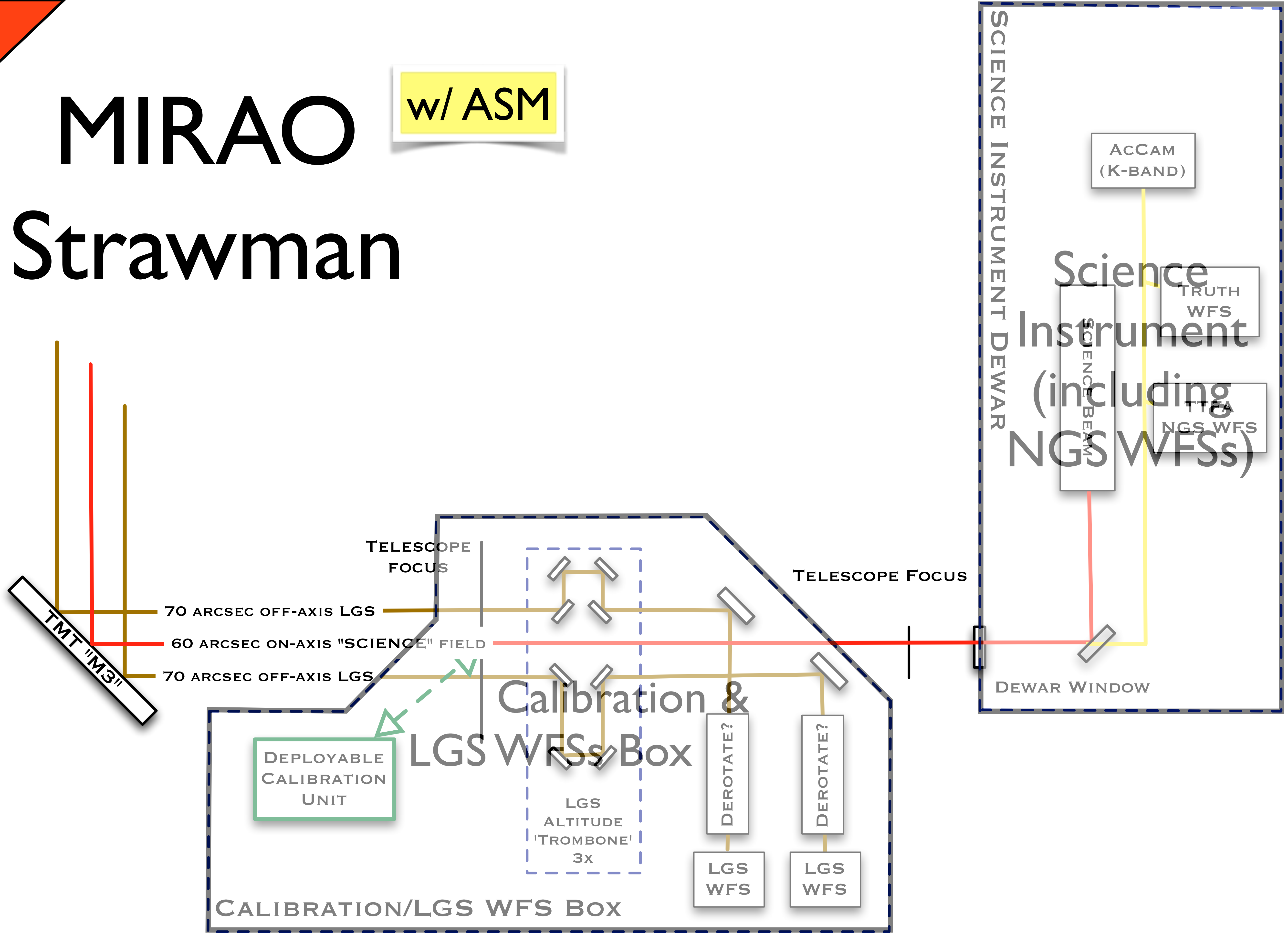
MIRAO Strawman



An aside

MIRAO Strawman

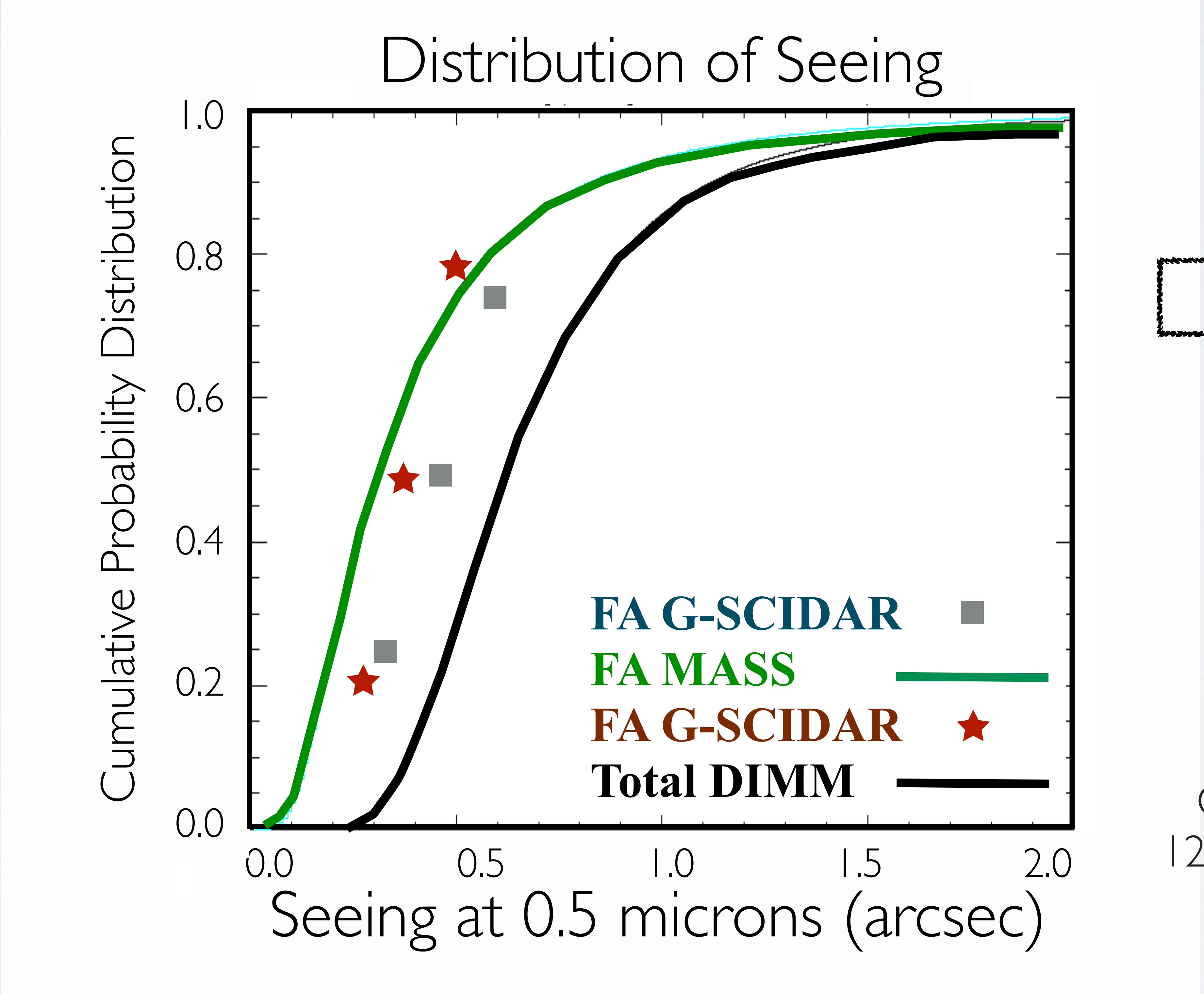
w/ ASM



QUANTIFYING THE OPTICAL TURBULENCE ABOVE MAUNAKEA

	Dome?	GL?	FA?
• SCIDAR/G-SCIDAR (1988/89, 2000s)	✓	✓	✓
• Gemini GL (2007-2008) (SLODAR & LOLAS)		✓	✓
• **TMT 13N (2008-2009) (MASS, DIMM, SODAR)**		✓	✓
• **MKAM (2009+) (MASS & DIMM)**		✓	✓
• PTP (LunarShabar (2010)		✓	
• CFHT OTP (2009-2016)	✓	✓	
• CFHT DIMM (2009?+)	✓		
• mWFS (2012)	✓	✓	✓

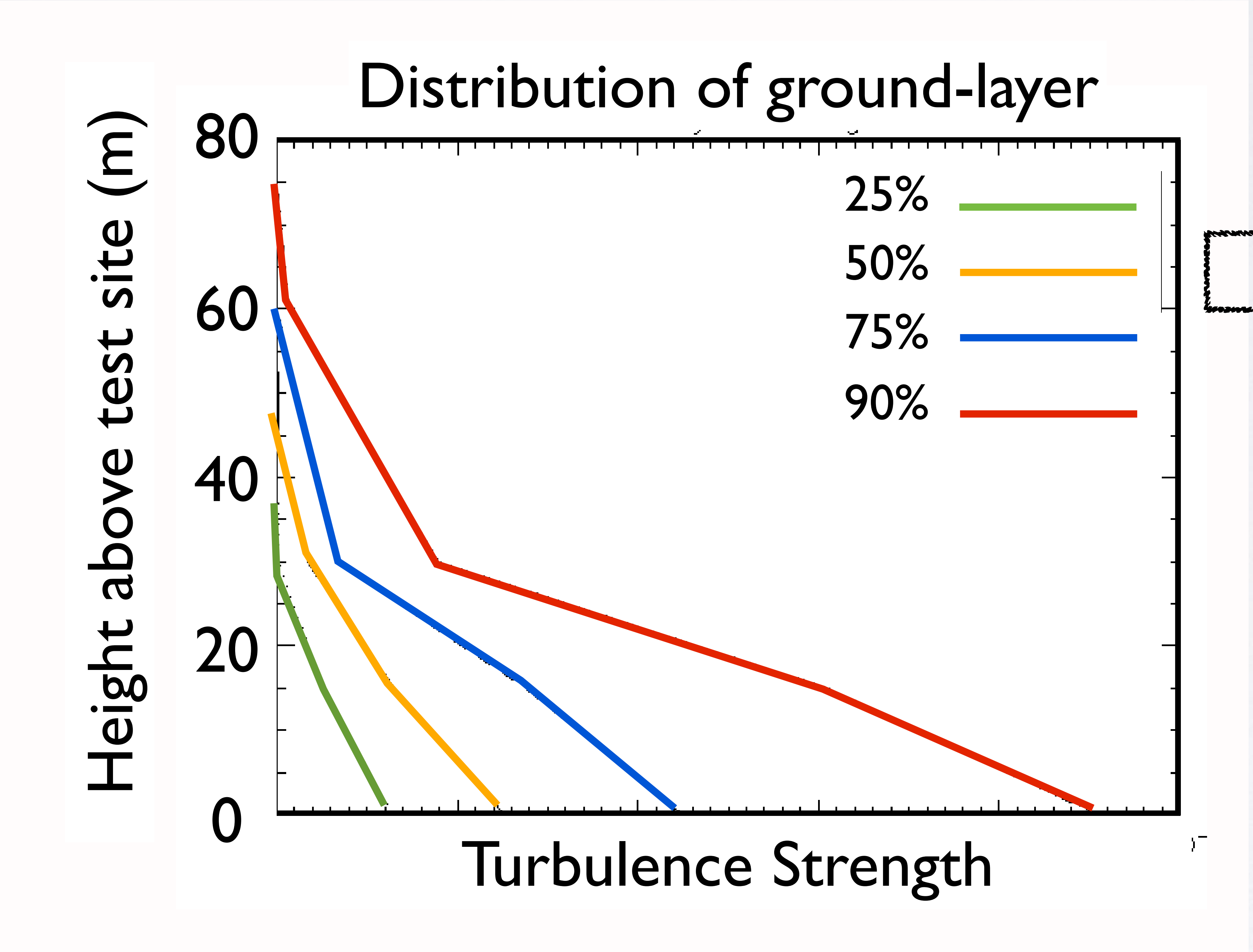
1. Free-atm is generally weak on Maunakea



The median "free-atmosphere seeing" is 0.33-0.4 arcseconds

Gemini MKGL Study (Chun et al. 2009)
12-night campaign G-SCIDAR (2002/2005)
TMT Site Testing (Schoeck et al 2009)
Summit Seeing Monitor 2009+

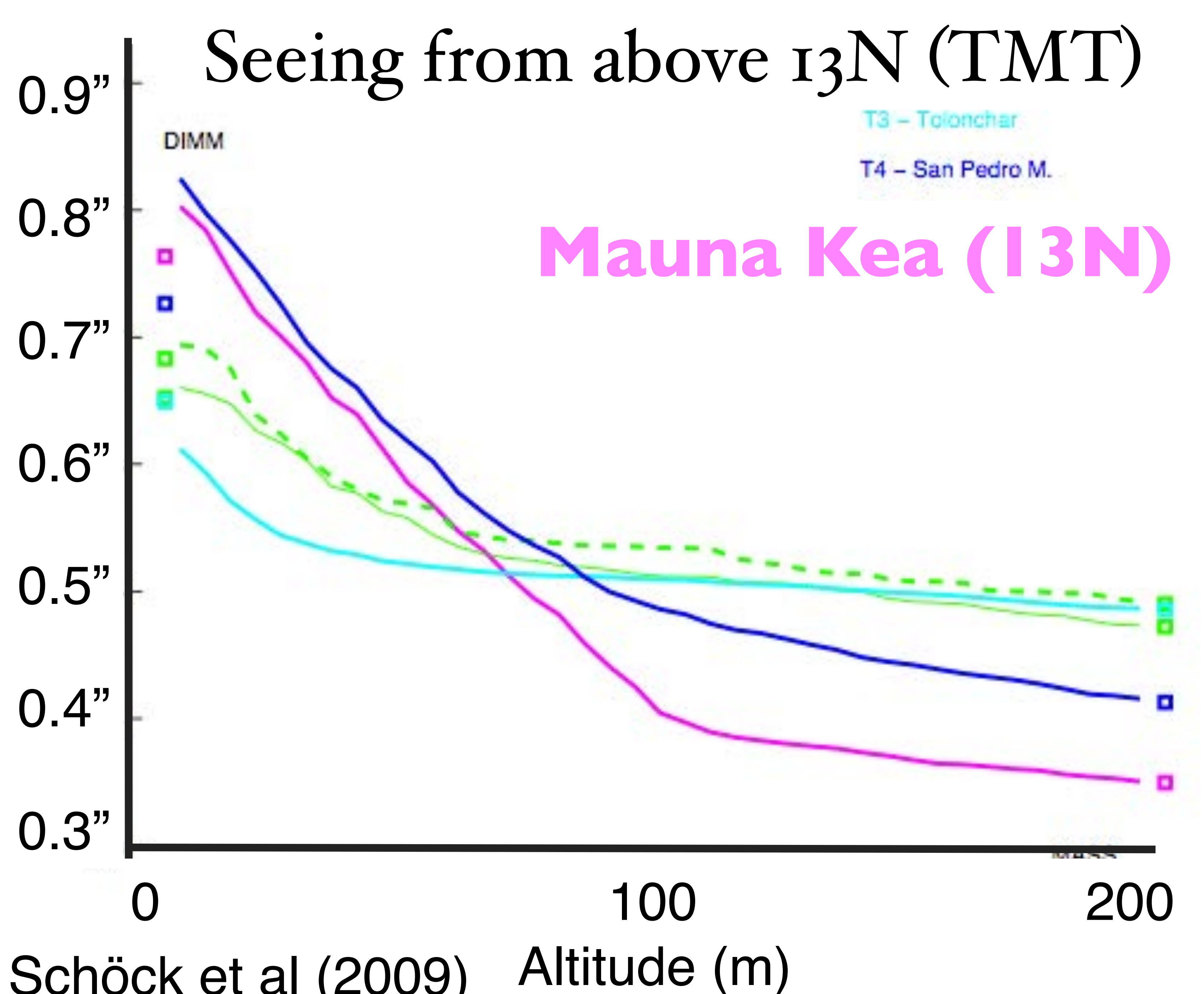
2. GROUND-LAYER IS HIGHLY CONFINED AND THERE'S LITTLE ELSE IN FIRST KILOMETER



The median "ground-layer seeing" is 0.45 arcseconds

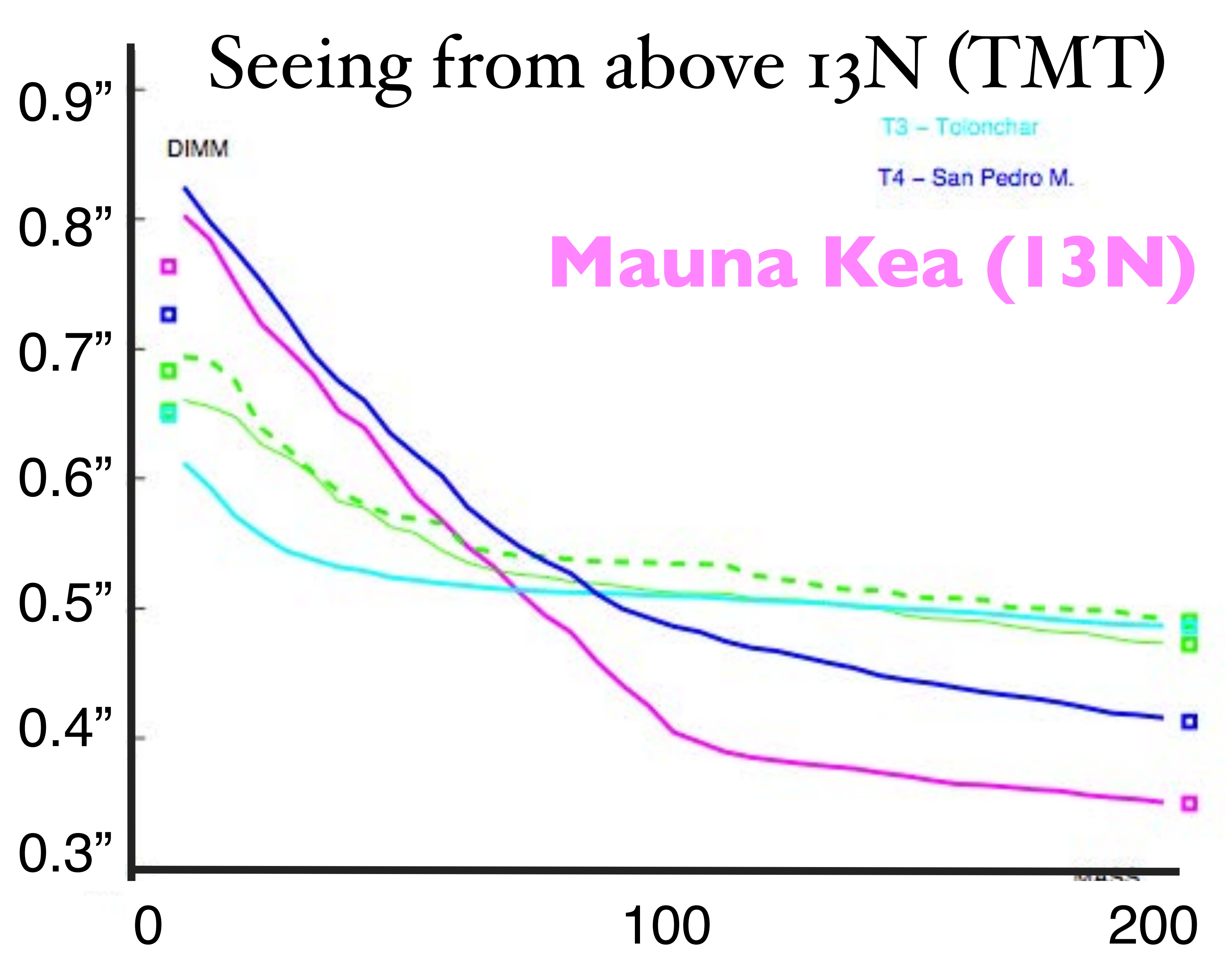
Gemini ground-layer study (Chun et al 2009)
PTP Instrument (Pfromer 2010)

GL at 13N is thicker than at summit



Schöck et al (2009)

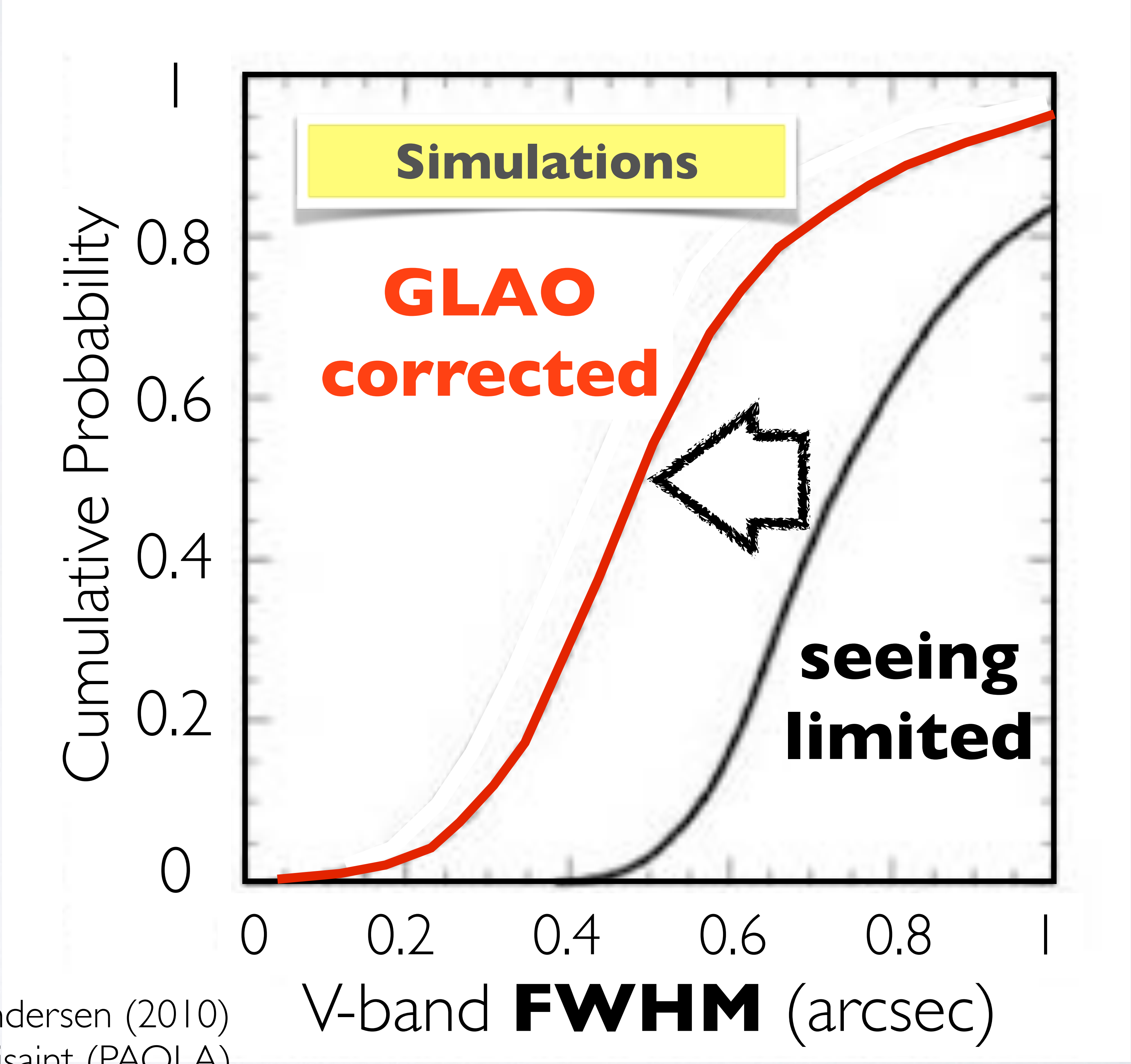
GL at 13N is thicker than at summit



Schöck et al (2009)

PERFORMANCE PREDICTIONS

- The delivered image quality depends on the conditions at the time, the level of correction, and the configuration of the AO system
- FA is main limit - residual and tomographic error
- GL thickness and/or conjugation altitude



D. Andersen (2010)
L. Jollisaint (PAOLA)

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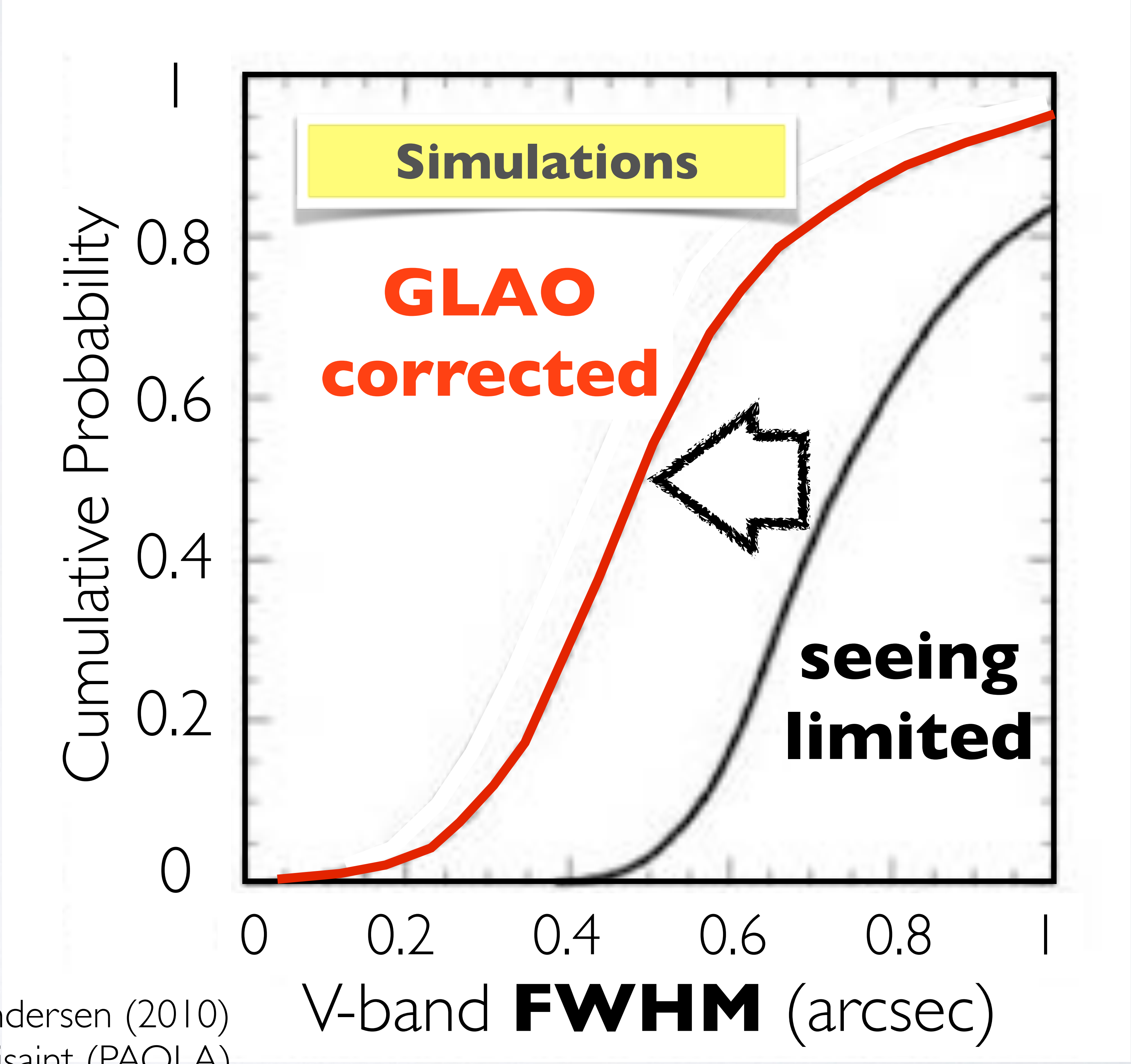
more in Brent's talk



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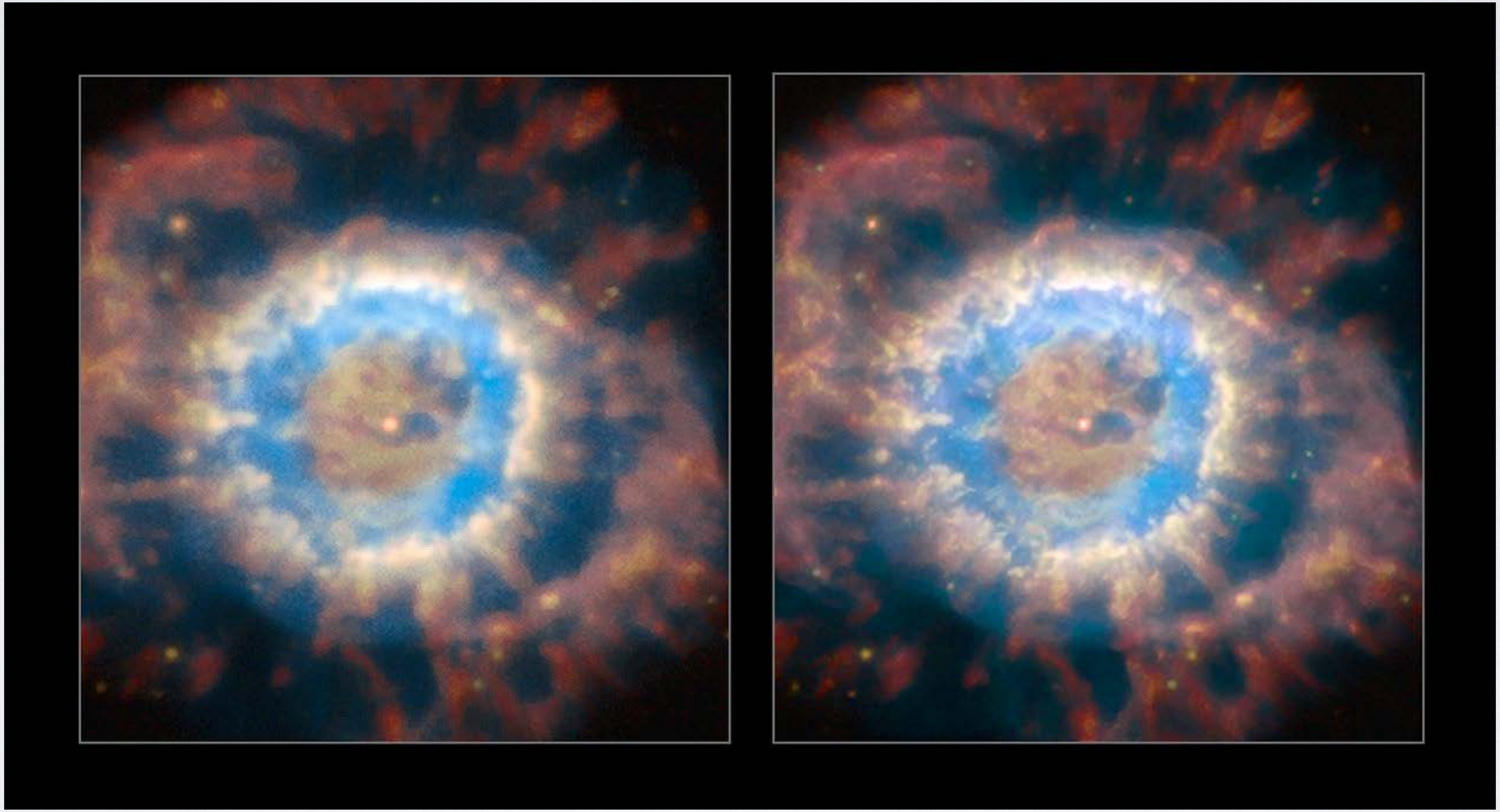
GLAO on-sky

VLT: MUSE+GALACSI

(~1'x1', visible)

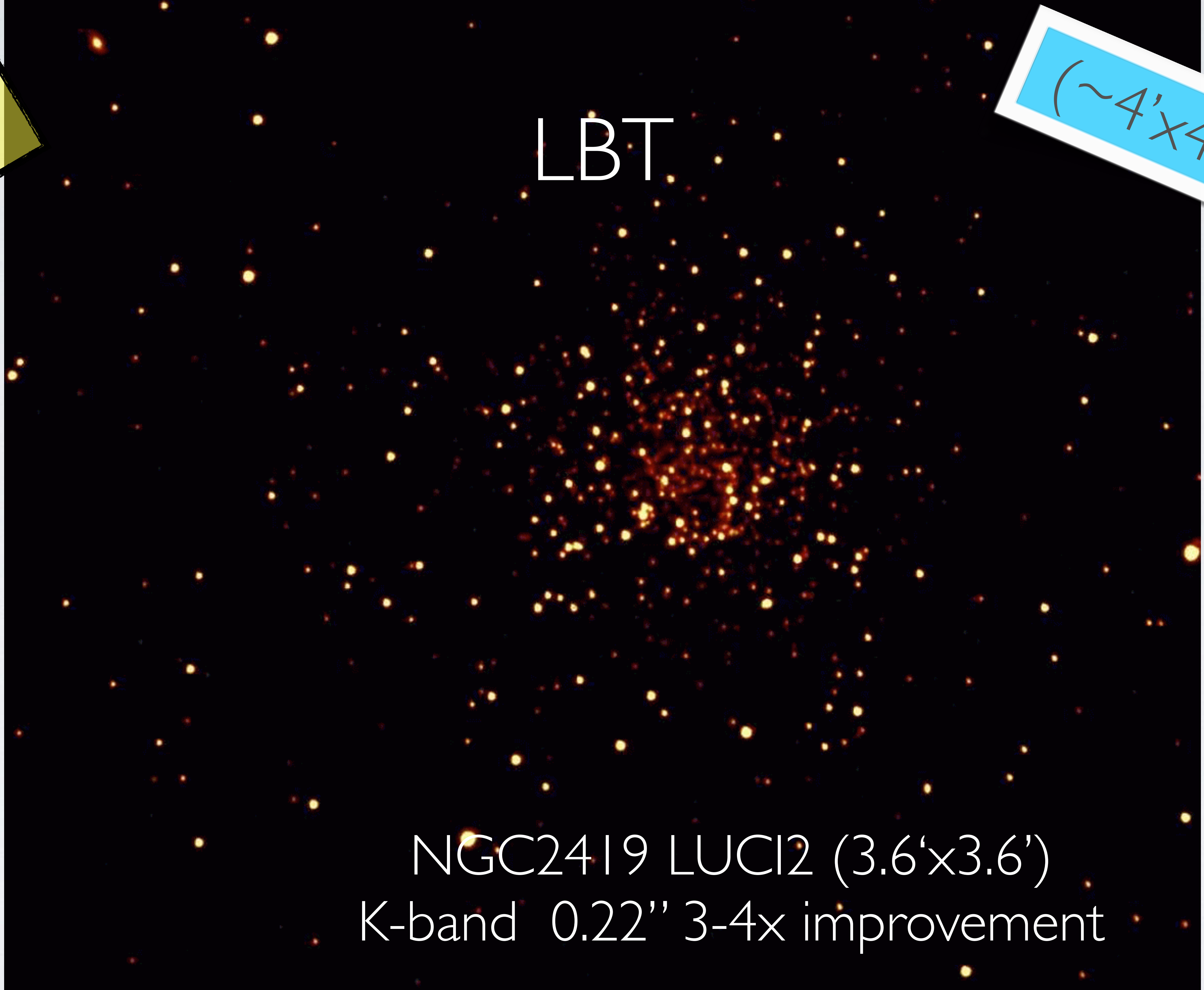


500-650nm

https://www.eso.org/public/news/eso1724/

GLAO on-sky

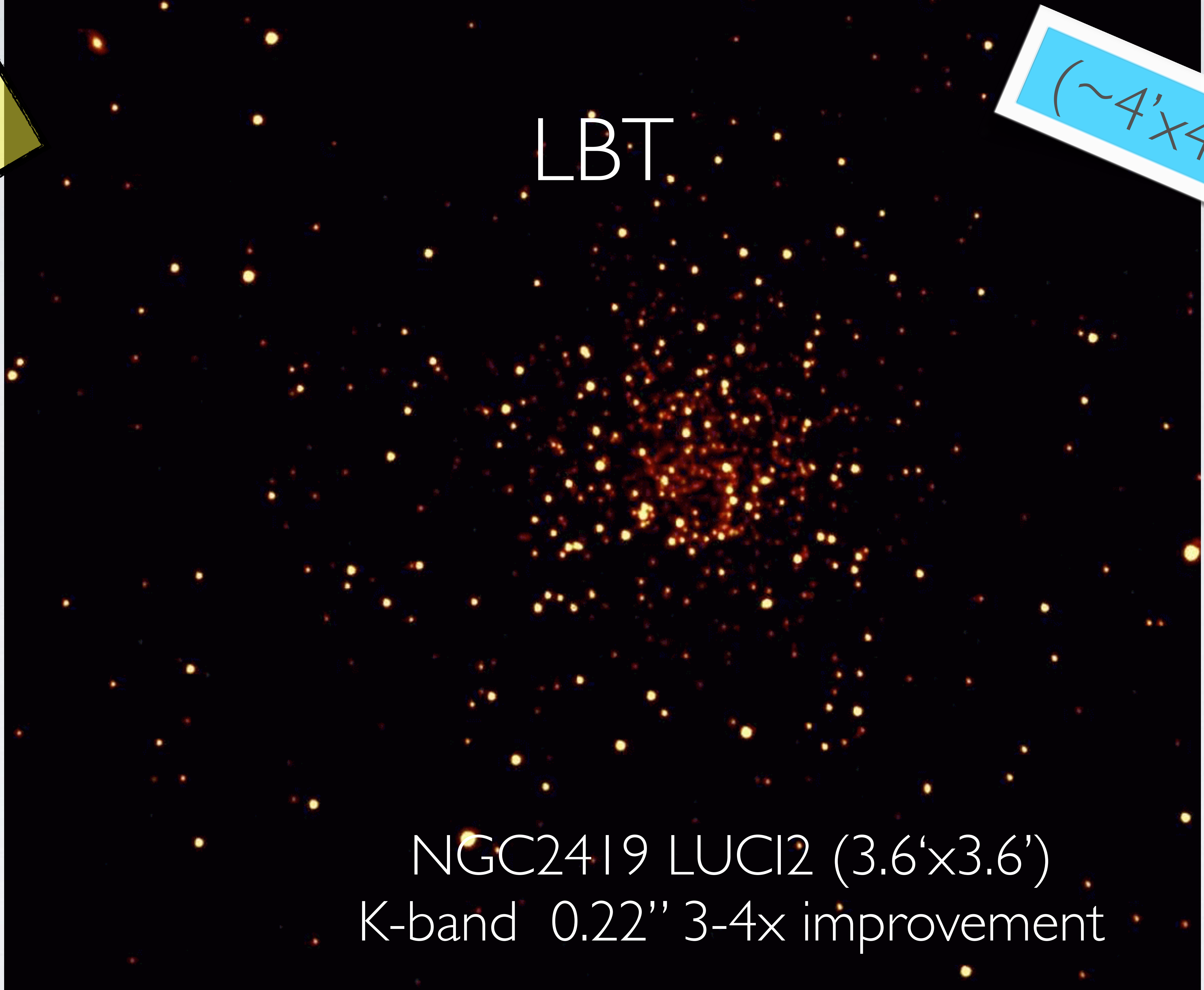
(~4'x4', NIR)



GLAO
on-sky

(~4'x4', NIR)

LBT

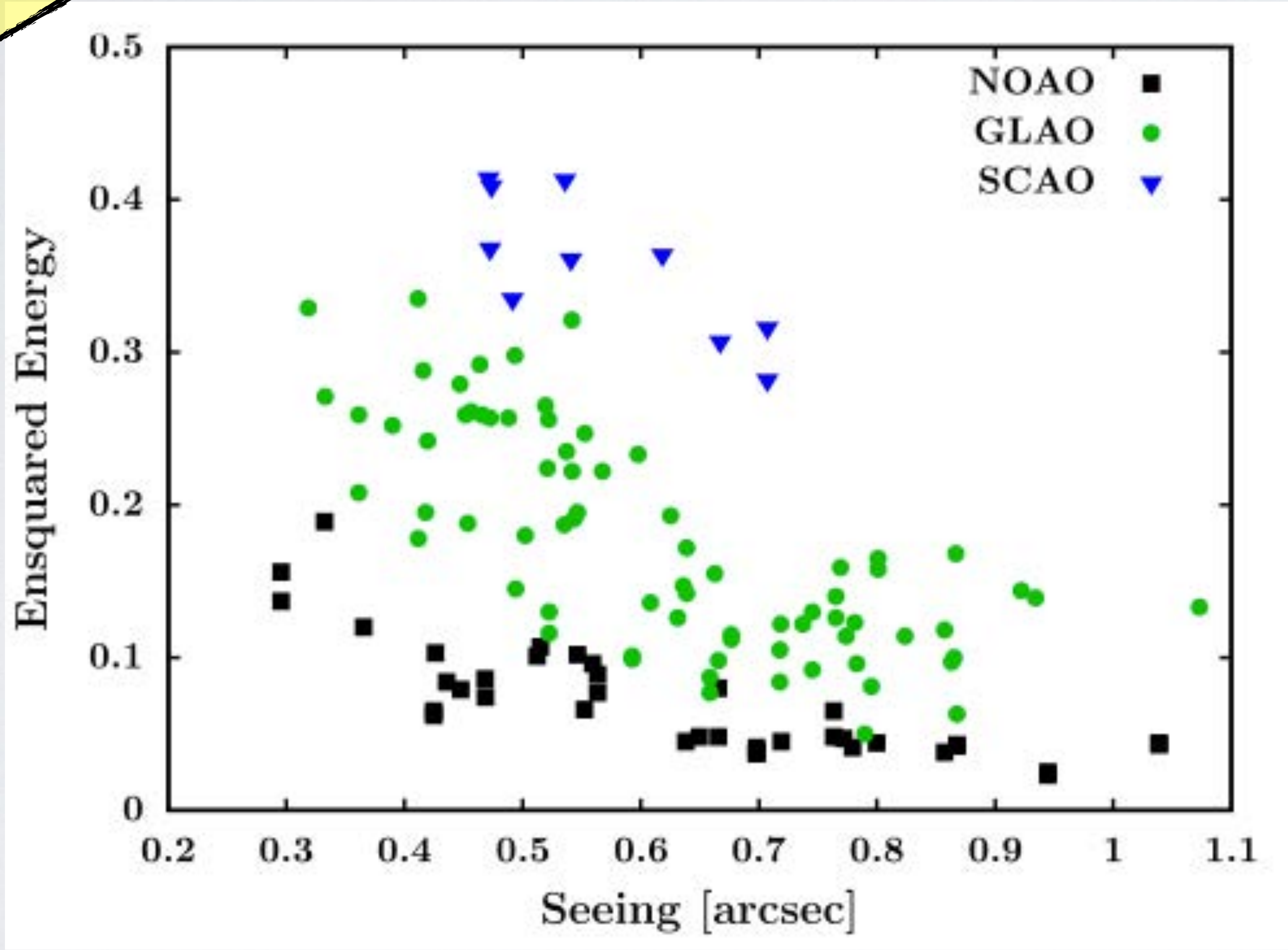


NGC2419 LUCI2 (3.6'x3.6')
K-band 0.22'' 3-4x improvement

GLAO on-sky

MAUNAKEA-SUBARU/RAVEN

(~Ø3', NIR)



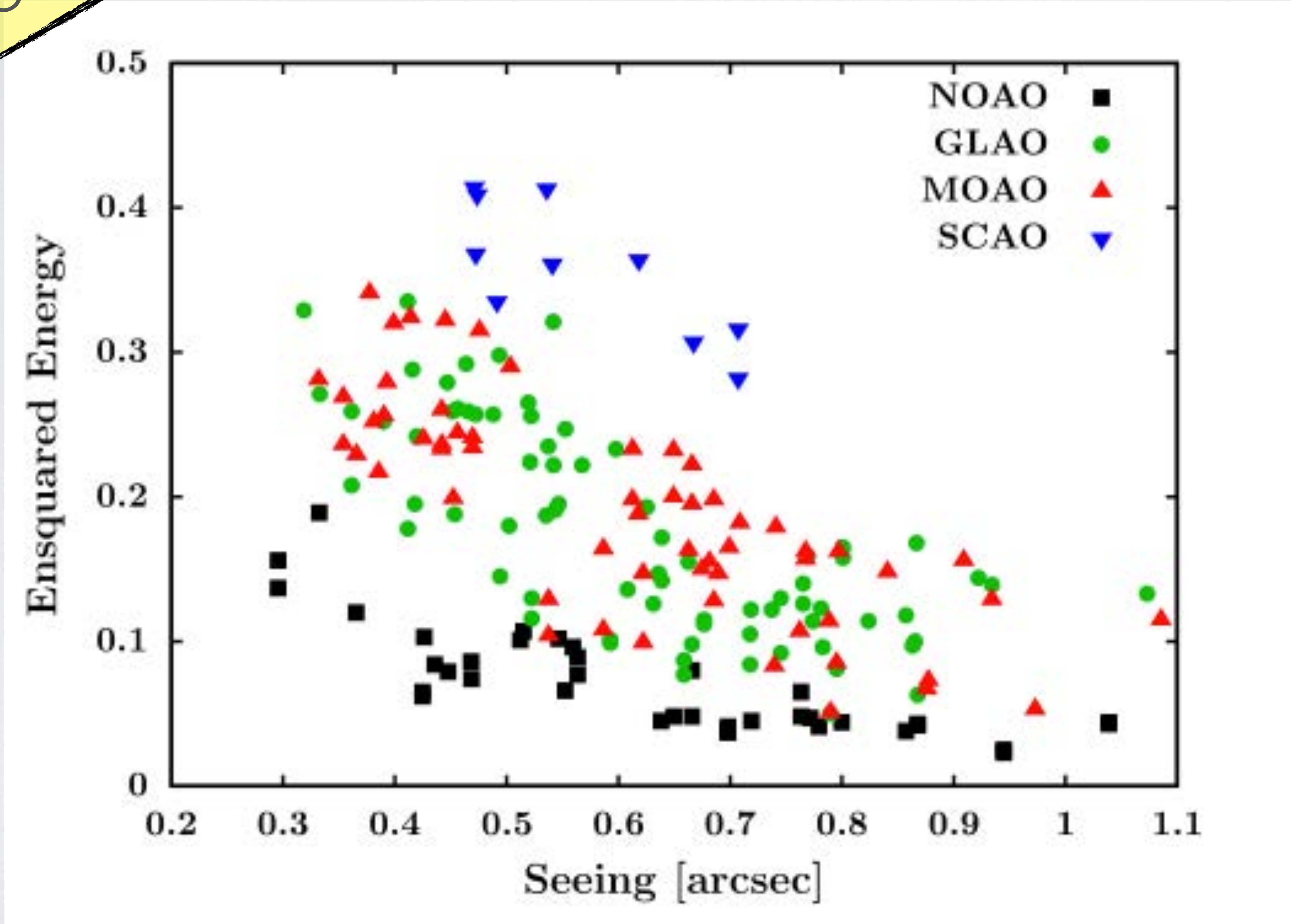
H-band
3' field of view
EE in 140mas box

Ono et al. 2016 (RAVEN)

GLAO on-sky

(~Ø3', NIR)

MAUNAKEA-SUBARU/RAVEN



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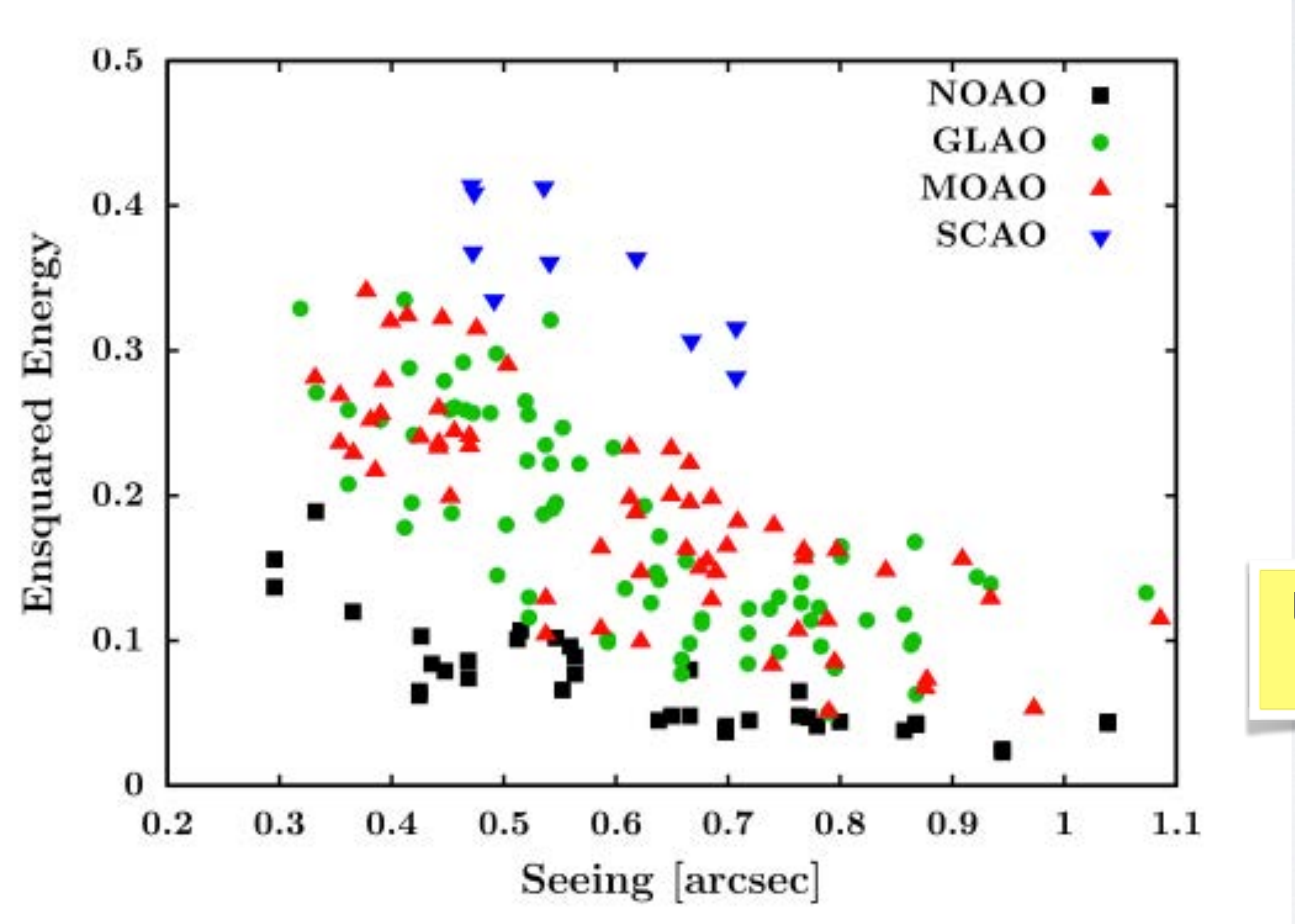

H-band
3' field of view
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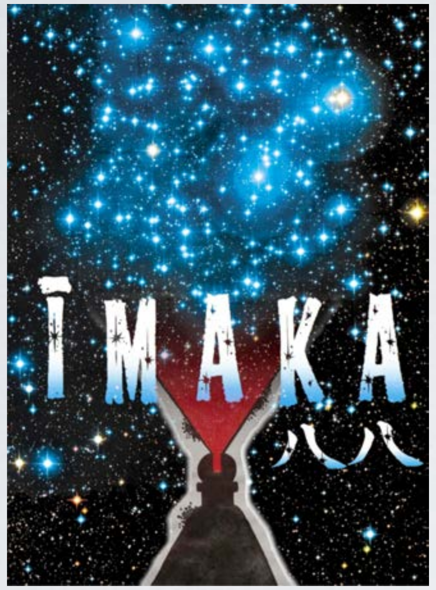
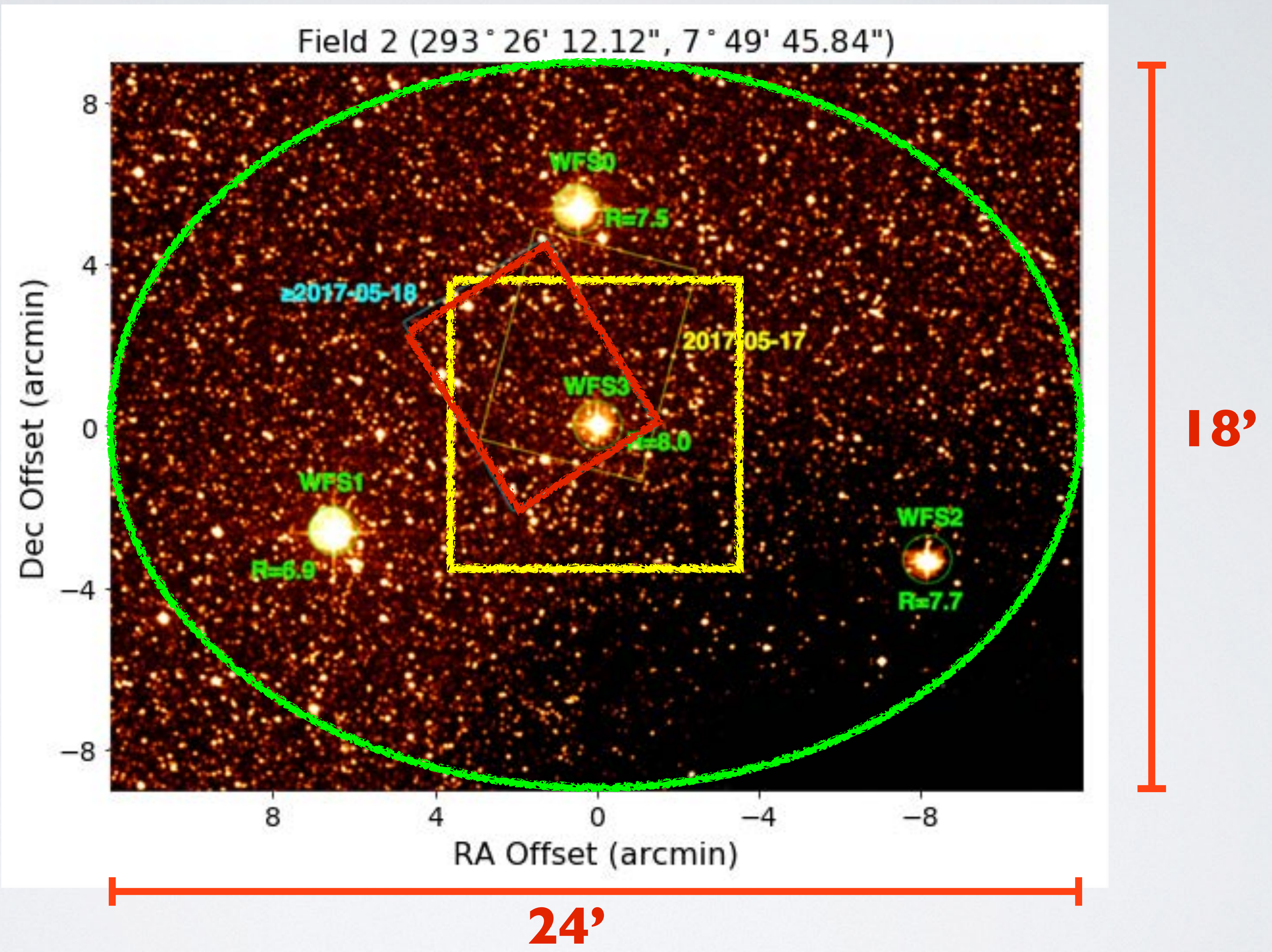
ULTIMATE-Subaru
(more in Minowa-san's talk)

Ono et al. 2016 (RAVEN)



SCAO in Dec 2016
GLAO in Jan, Feb, May 2017

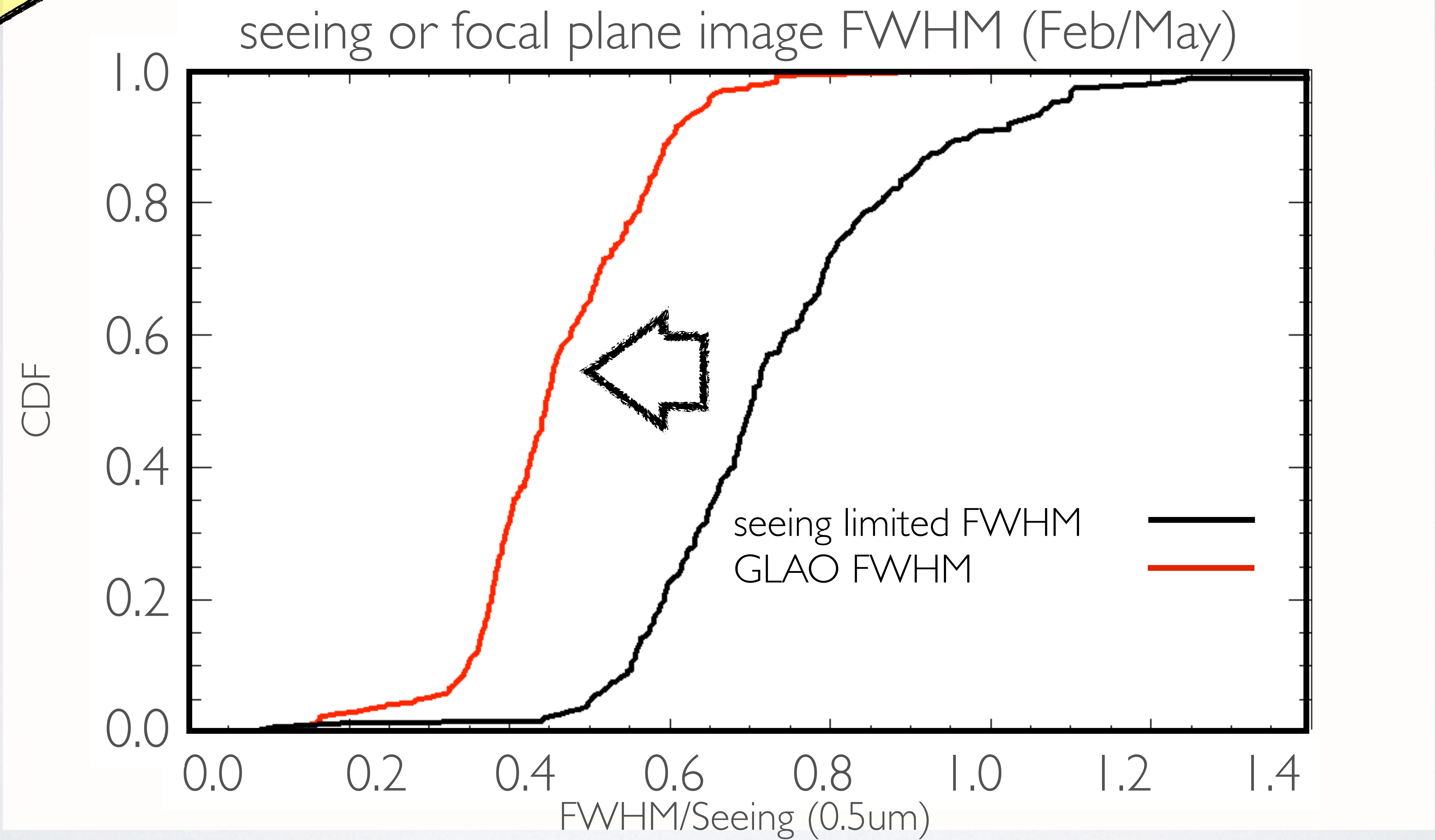


Field 2 (293 ° 26' 12.12", 7 ° 49' 45.84")
Dec Offset (arcmin)
RA Offset (arcmin)
8
4
0
−4
−8
WFS0
R=7.5
WFS1
R=6.9
WFS2
R=7.7
WFS3
R=8.0
≥2017-05-18
2017-05-17
18’
24’

GLAO on-sky

(~Ø16', visible)

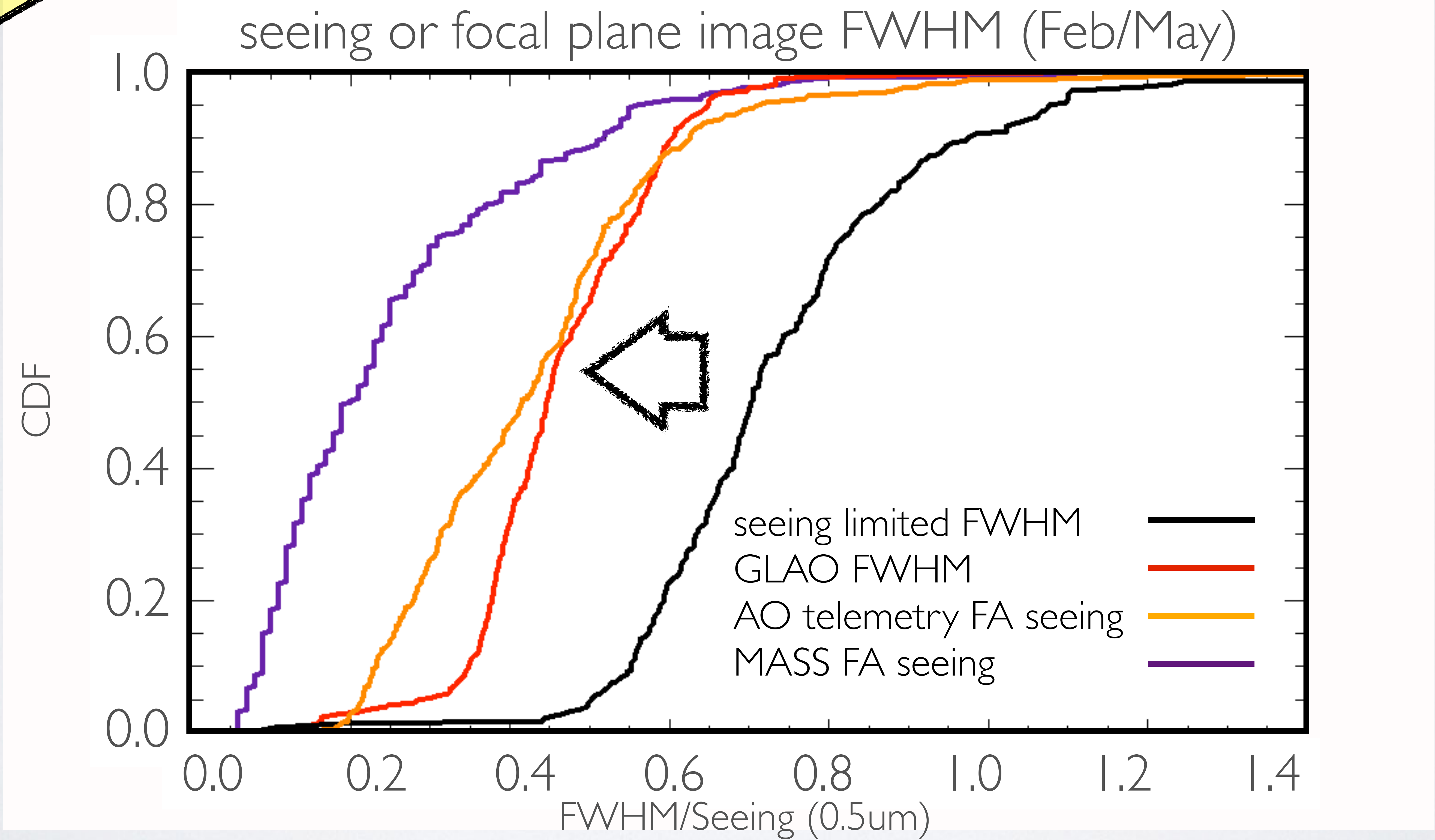
MAUNA KEA -UH88"/`IMAKA



MAUNA KEA -UH88"/`IMAKA

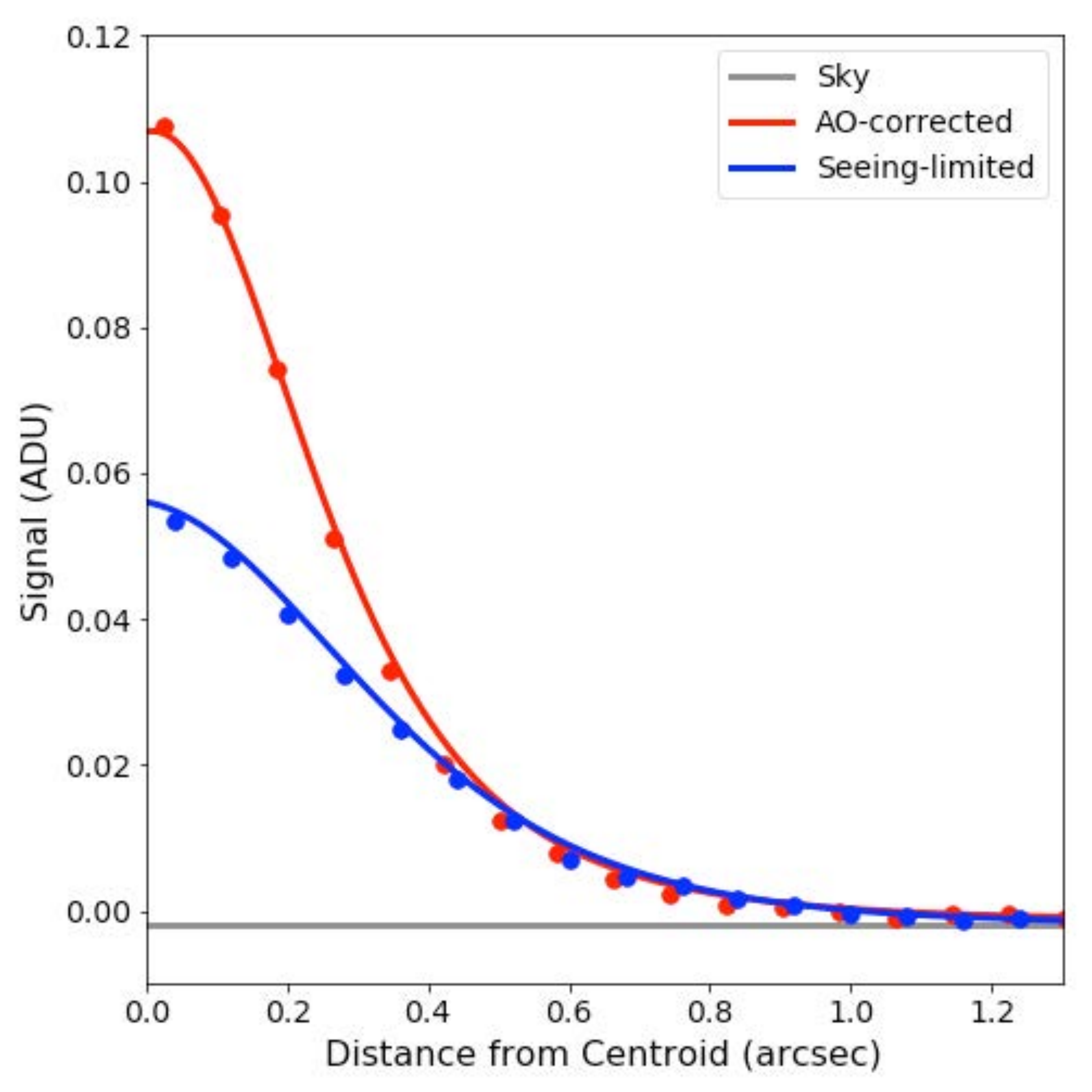
GLAO on-sky

(~Ø16', visible)



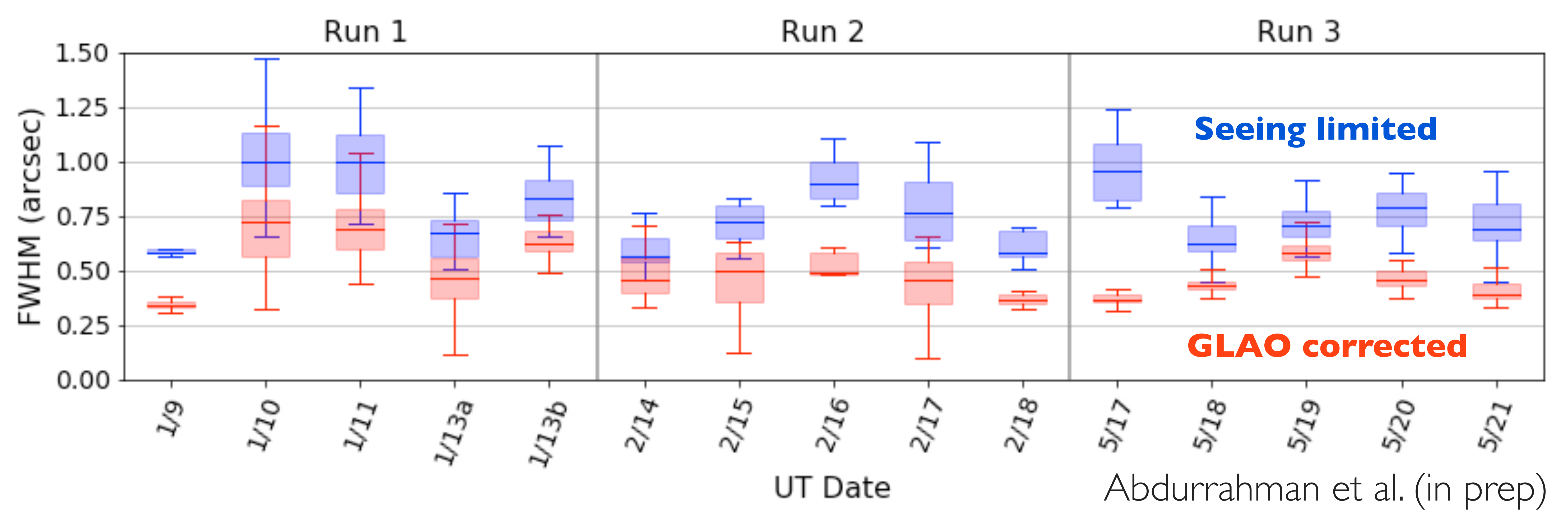
PSF VARIATIONS

- **PSF Shape**
  - Well fit with a 2-d Moffat profile
  - Moffat parameters vary in time (true of our seeing limited images too)
- **Variations across the field** look to be small but may have slow changes across the field.
  - RMS variation < 0.05'' across 4' FOV
- **Variation with wavelength** has not been explored in detail yet. Simulations suggest we do not have enough actuators for bluer wavelengths but we'll explore into the NIR



Abdurrahman et al. (in prep)

PSF VARIATIONS



- **Variation in time**
  - Looks to be times when the GLAO PSF (or maybe FA) is more stable in time that seeing-limited images

GLAO UNCERTAINTIES

CONDITIONS AT THE SITE (TRUE FOR 13N AND ORM)

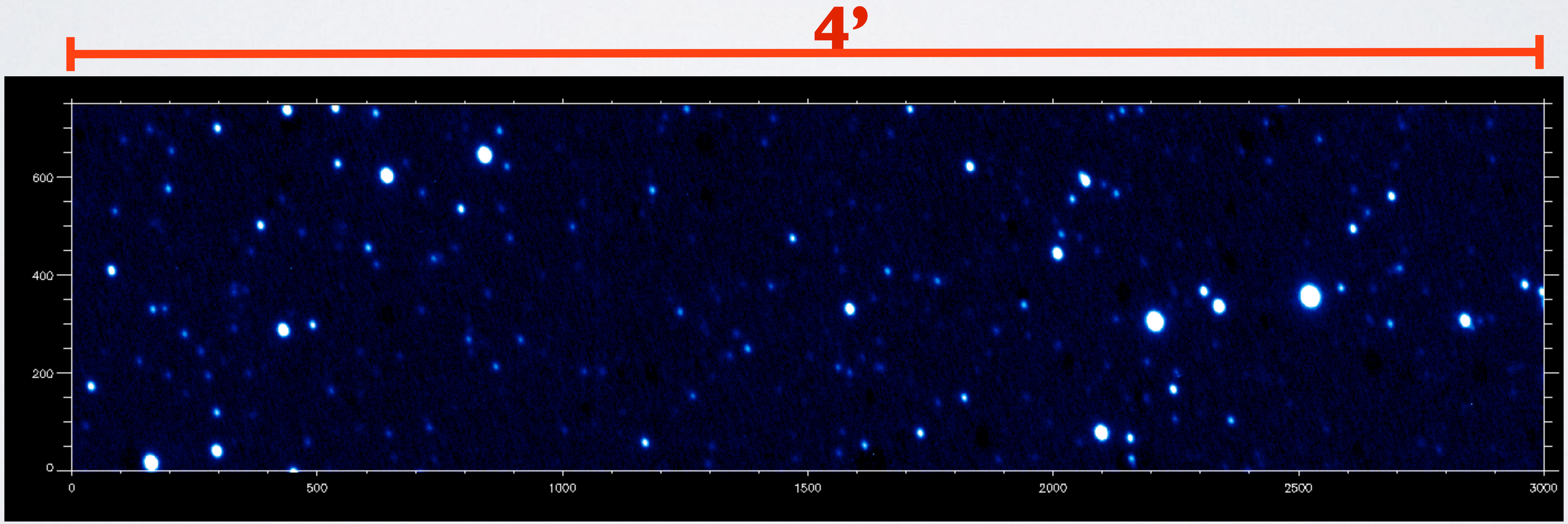
- MASS seeing? What is the absolute FA seeing value? (MK and ORM). Long-term statistics
- How thick is the GL? (ORM)
- What, in detail, will the local/dome seeing be?

GLAO IMPLEMENTATION

- Adaptive secondary conjugate to below the ground - how big an effect?
- Shape of the GLAO PSF?
  - Order of correction, seeing, dome seeing, and instrument

SUMMARY

- GLAO is working over very wide fields of view and shows promising results on Maunakea
- Working to tie realized gains for astronomy to other measurements and performance predictions.
- Caution - indications that the some of the assumptions are wrong or incomplete.



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