

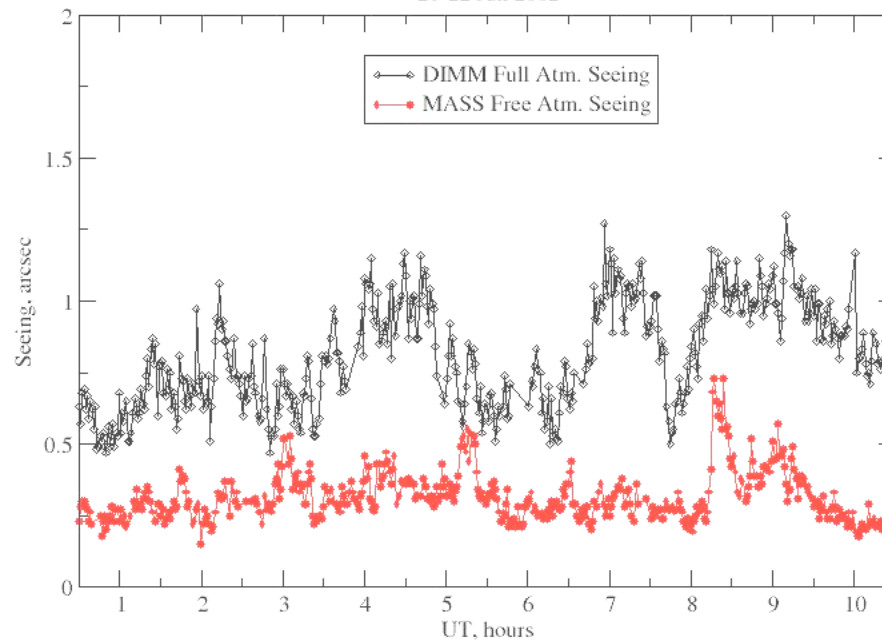
Ground-layer adaptive optics

Andrei Tokovinin

CTIO/NOAO

Cerro Tololo, MASS & DIMM

21-22 Jun 2002






Seeing-limited (>90% of ground-based astronomy!)

**Ground
Layer
Adaptive
Optics**

=

**Better
seeing
in wider
field**

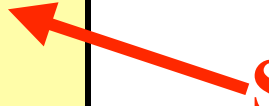
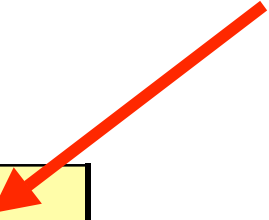
-  **Turbulence profile**
-  **Guide star(s)**
-  **Gain?**

**Diffraction limit
(full AO or
MCAO)**

GLAO gain

+ in the visible!!!

	MCAO	GLAO
Resolution (K-band)	0.05''	0.2''
Field diameter	1'	10'
Number of pixels	1.4 Mpix	9 Mpix



Sky coverage ~100%

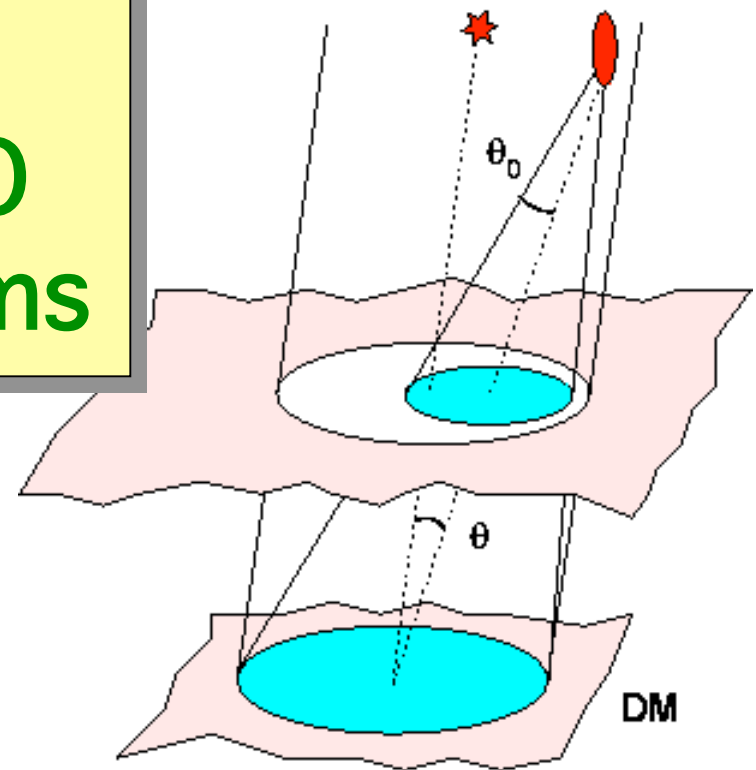
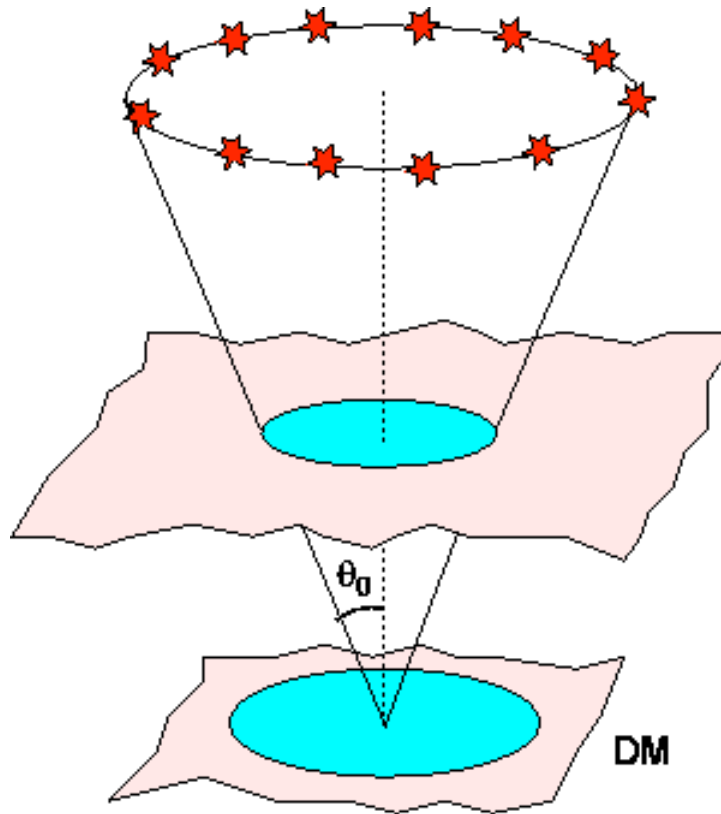
Science with GLAO

- Dynamics of galaxies, AGNs (+IFU)
- Stellar populations, clusters (confusion!)
- Supernovae, cepheids
- Weak lensing
- ISM (PNe, jets)

and more...

GLAO benefits most “classical” astronomical programs

Two
GLAO
systems



S-GLAO 5 sodium LGSs

R-GLAO Rayleigh LGS

Actuators 0.5m

$\theta_0 = 1.5'$

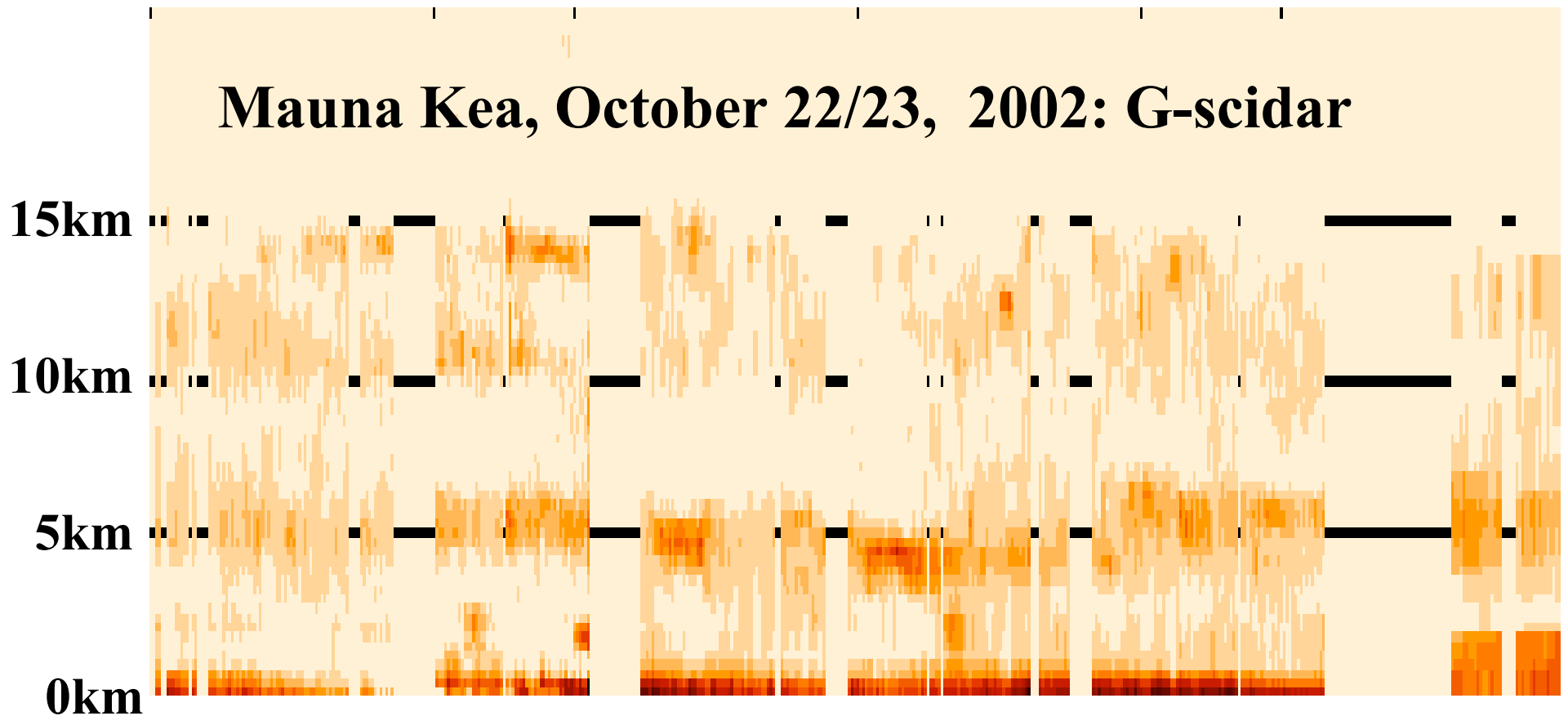
Independent of D

Actuators 0.5m

$D = 8\text{m}$

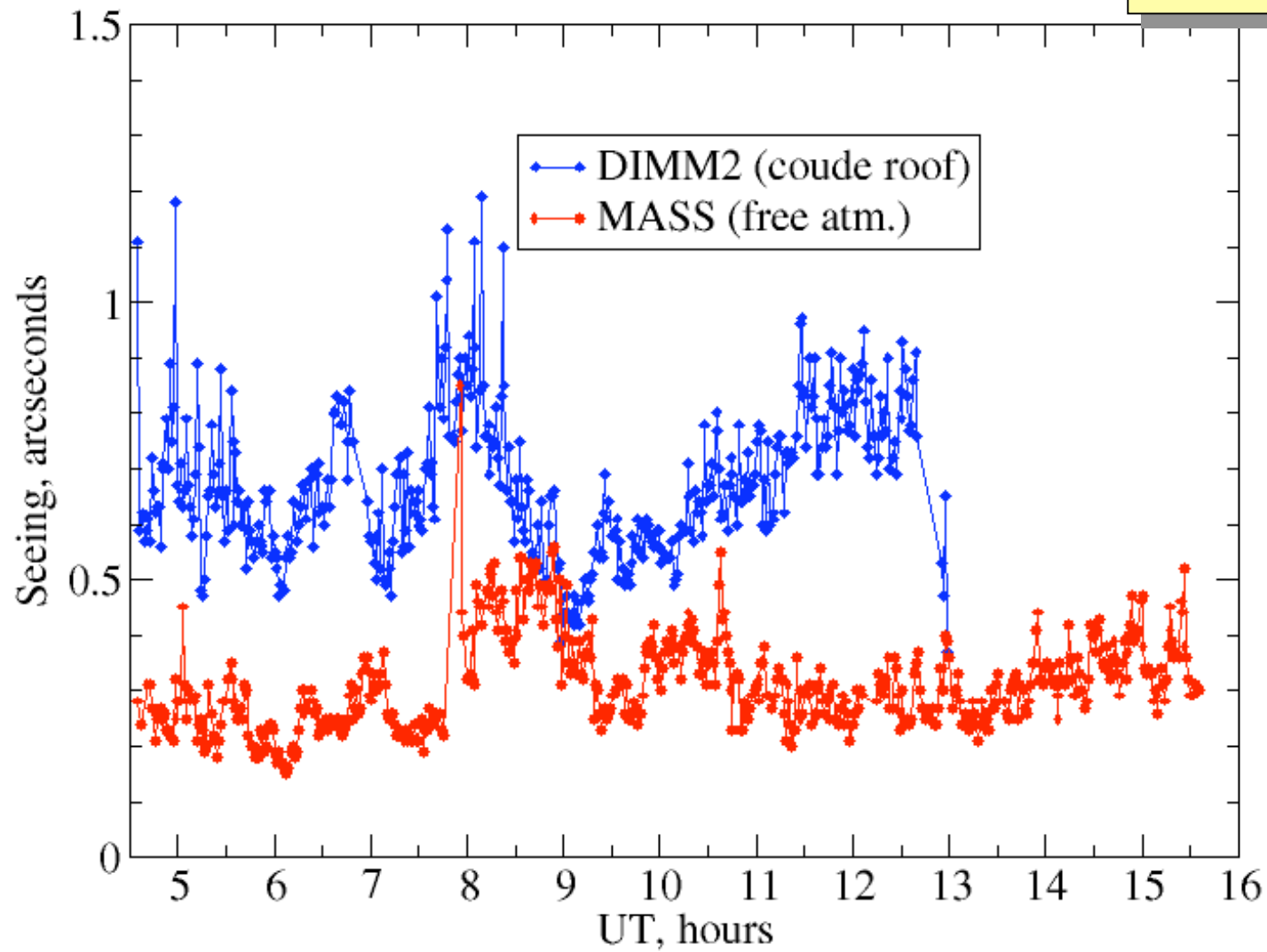
LGS at 10km

Is there a ground layer?

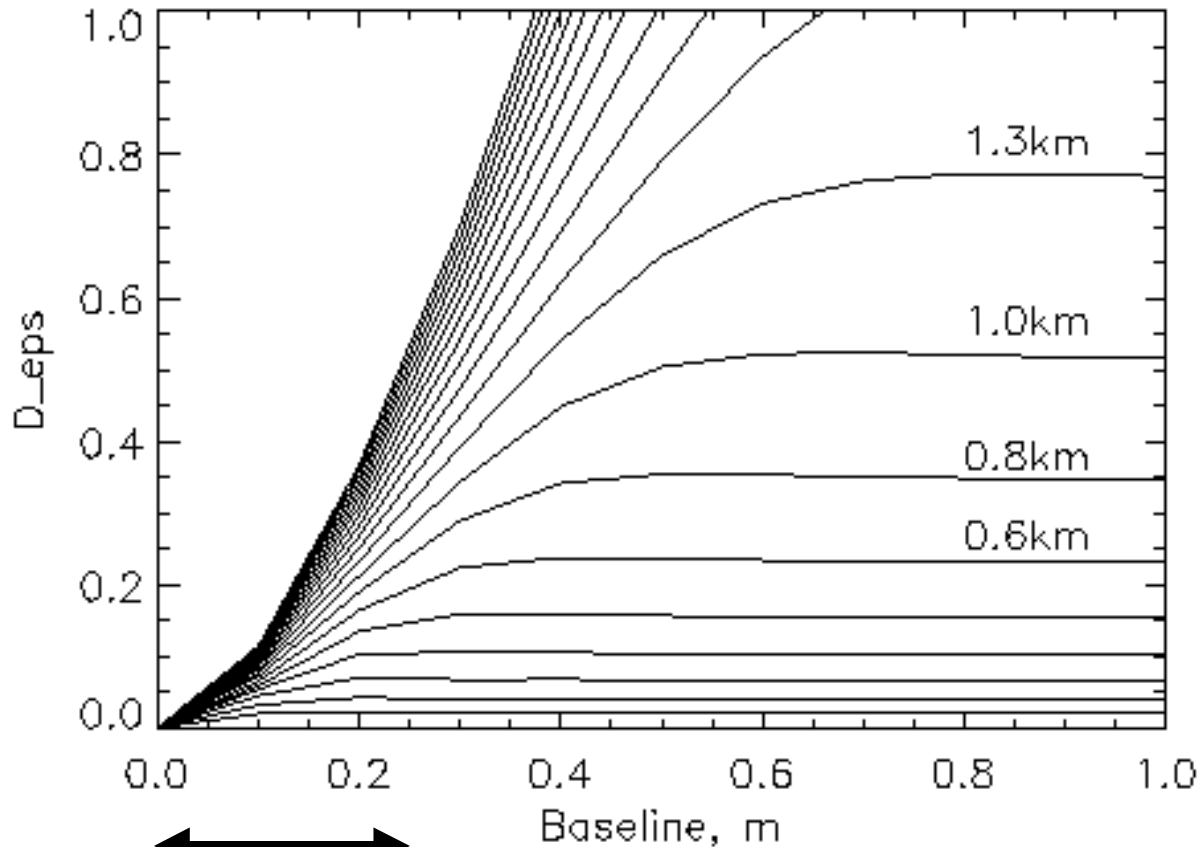


Mauna Kea, 22-23 October 2002

Yes!



How low is the “ground layer” ?



$$H_{\text{max}} \sim \frac{\lambda}{\theta^2}$$

$$\text{FWHM } \theta = 0.2''$$

$$\lambda = 0.7 \mu\text{m}$$

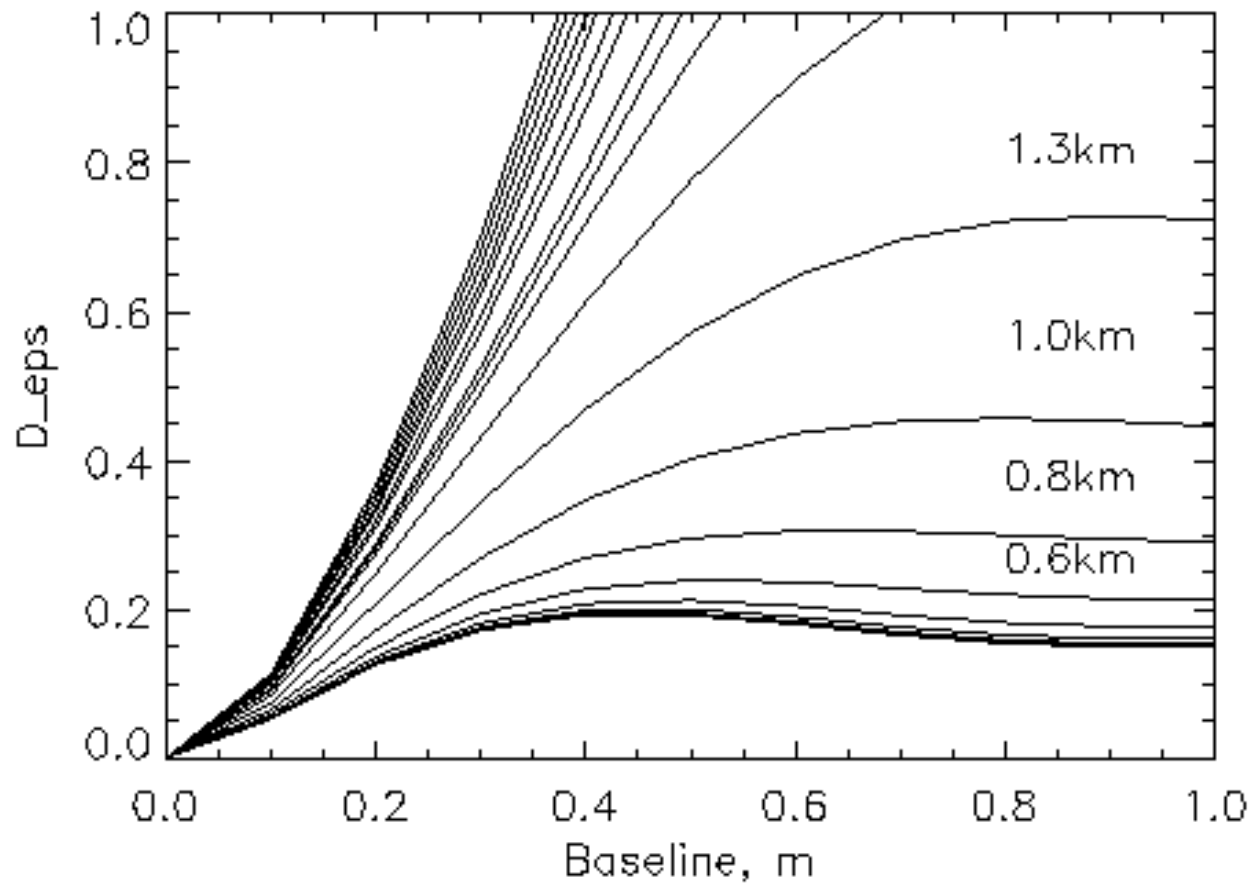
$$\text{Field } \theta = 1.5'$$

$$H_{\text{max}} \sim 1.5\text{km}$$

$$\sim \frac{\lambda}{2} h$$

$$\sim \frac{\lambda}{2} \theta$$

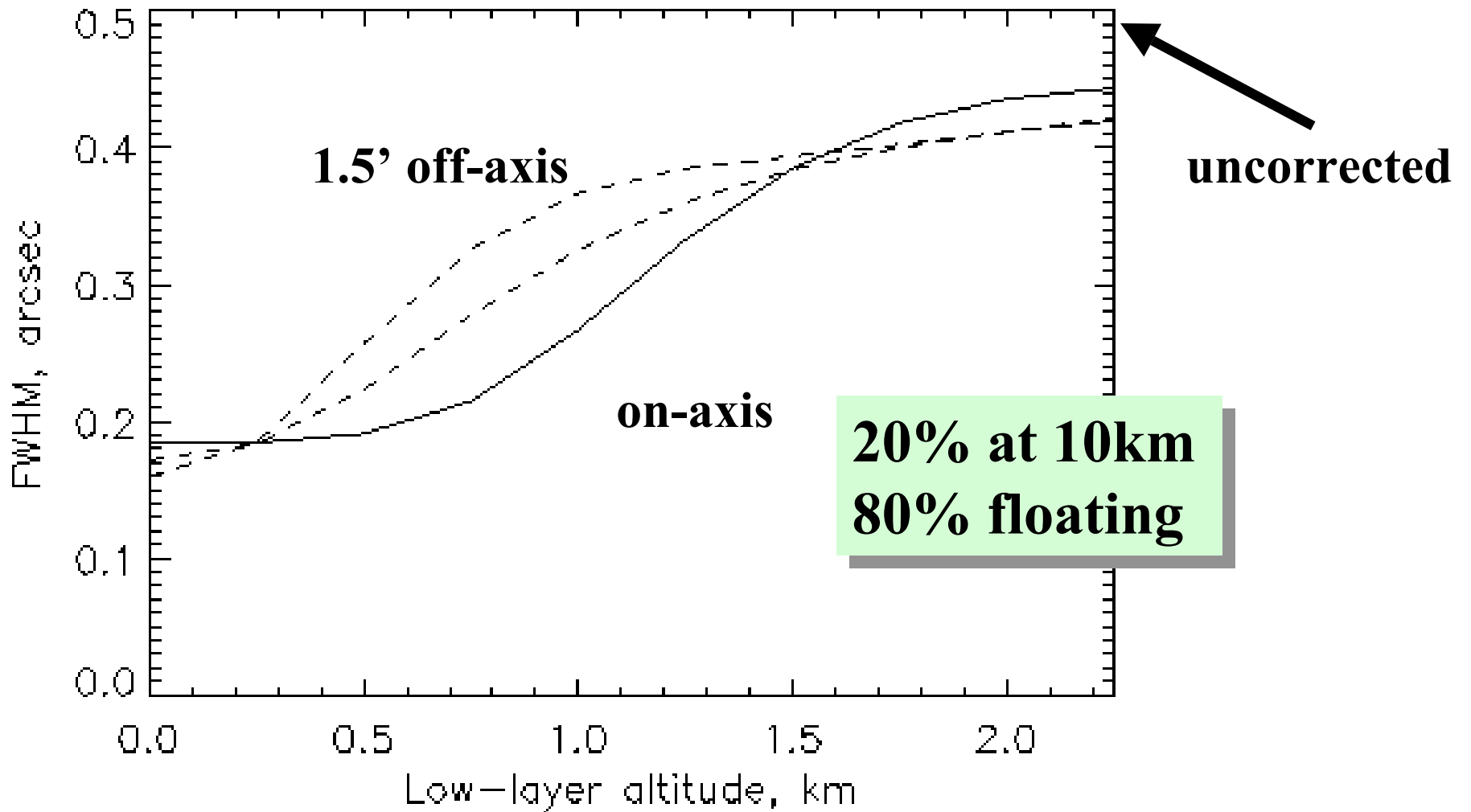
The role of DM resolution



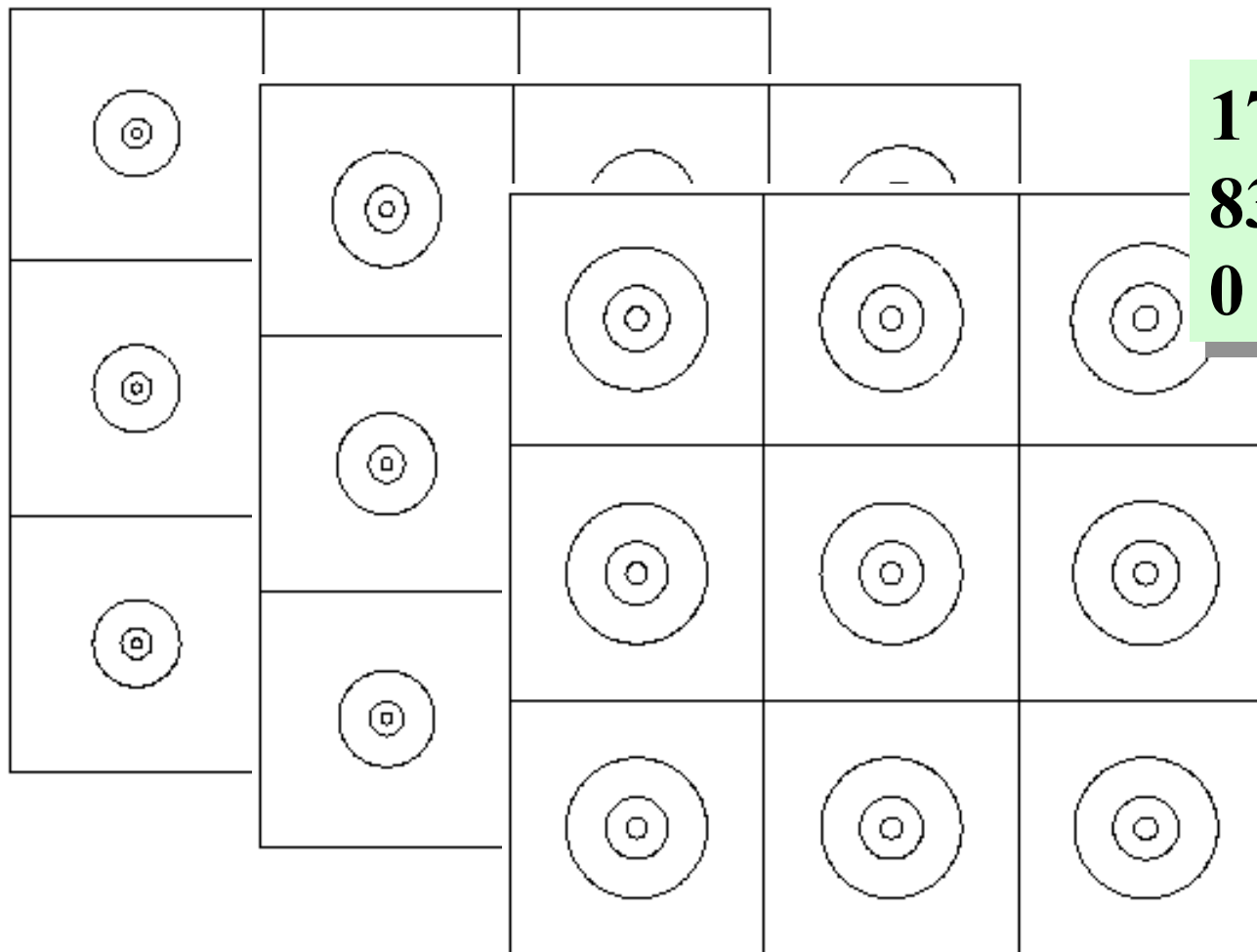
$$H_{\min} \sim d/(2\lambda)$$

The "gray zone"

$H_{\min} \dots H_{\max}$



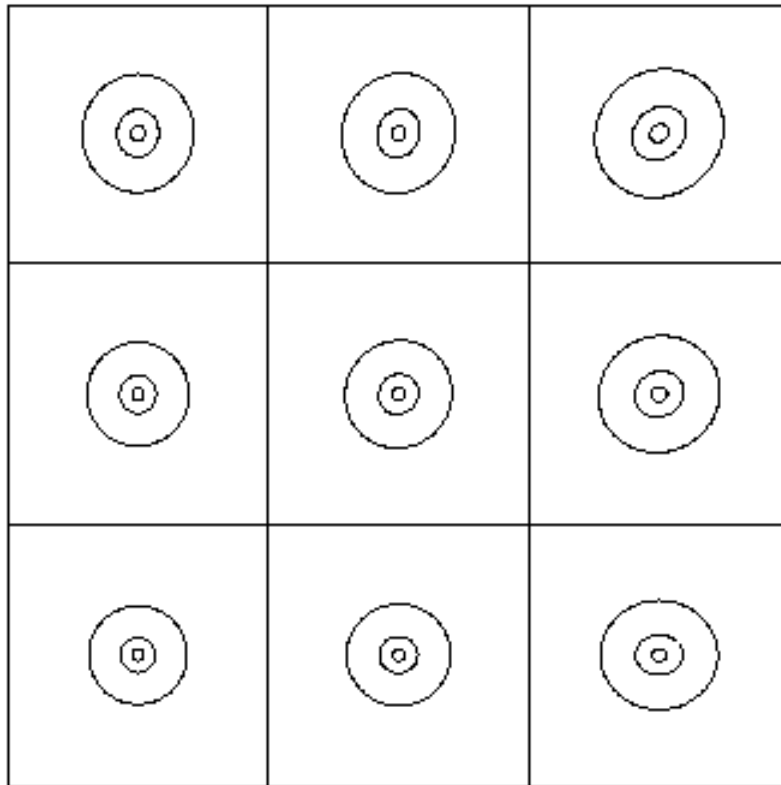
PSFs for S-GLAO



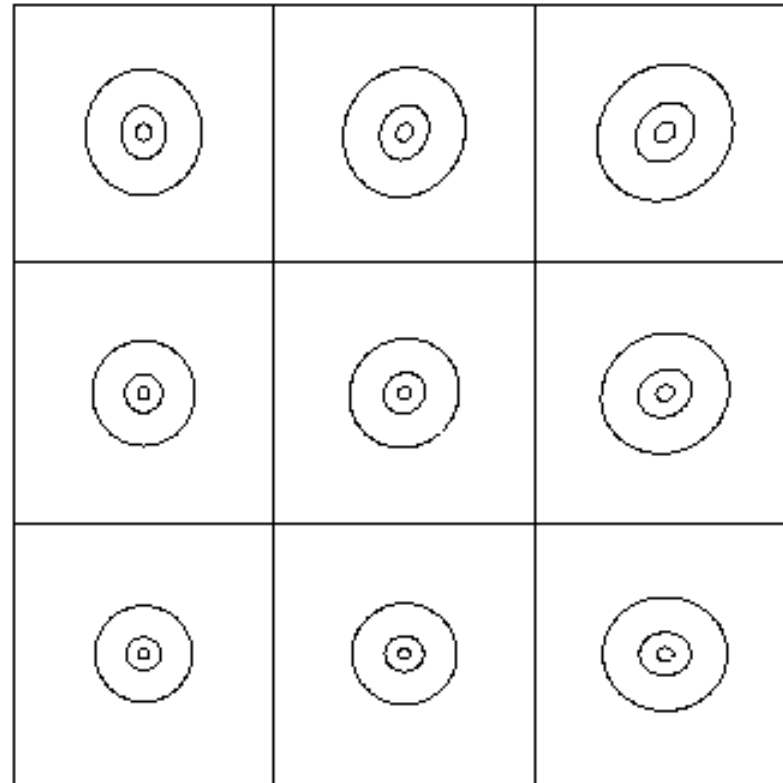
17% at 8km
83% at
0 – 0.5 – 1 km

Contours:
0.1-0.5-0.9

Compare S-GLAO with R-GLAO



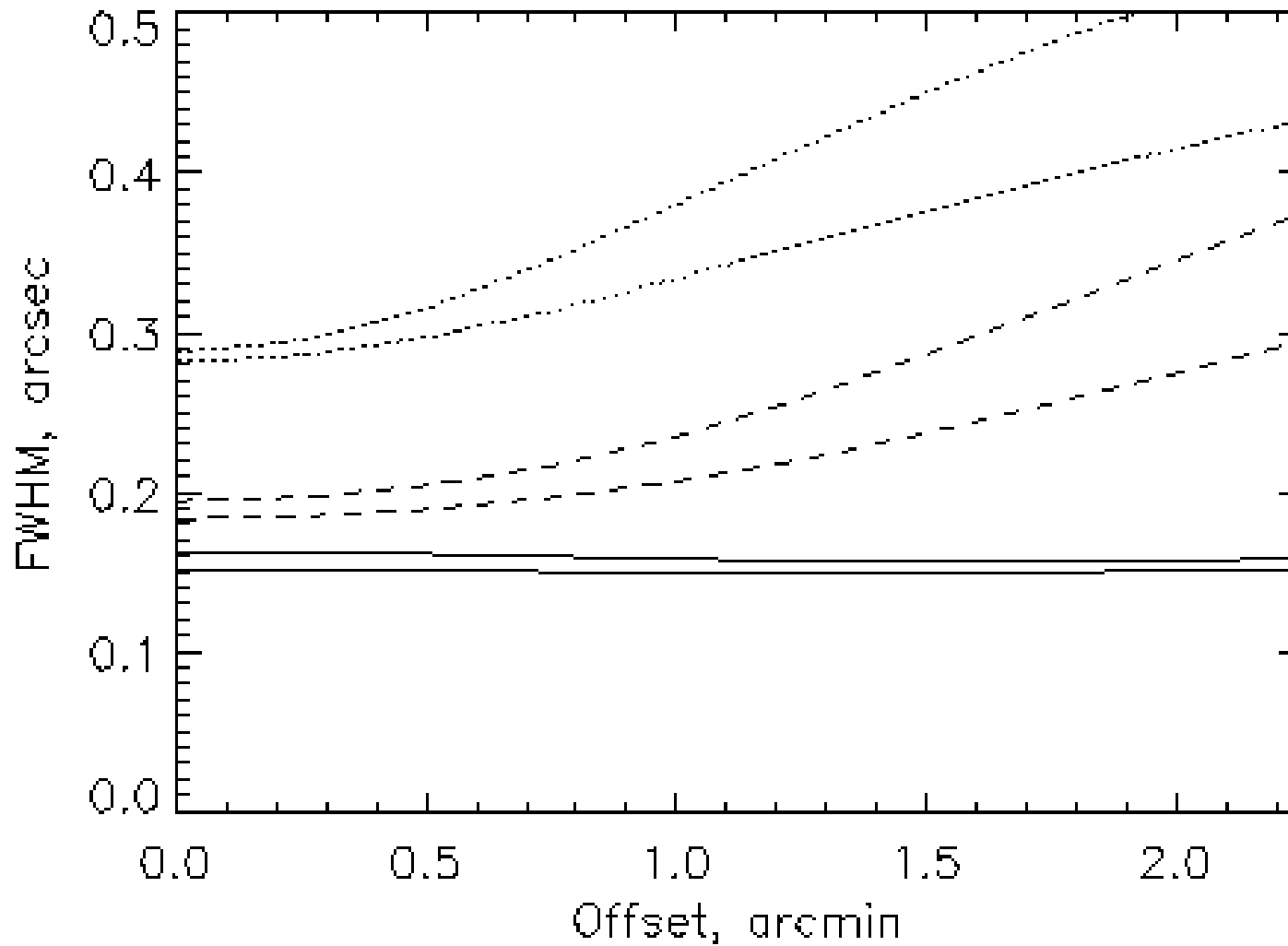
S-GLAO



R-GLAO

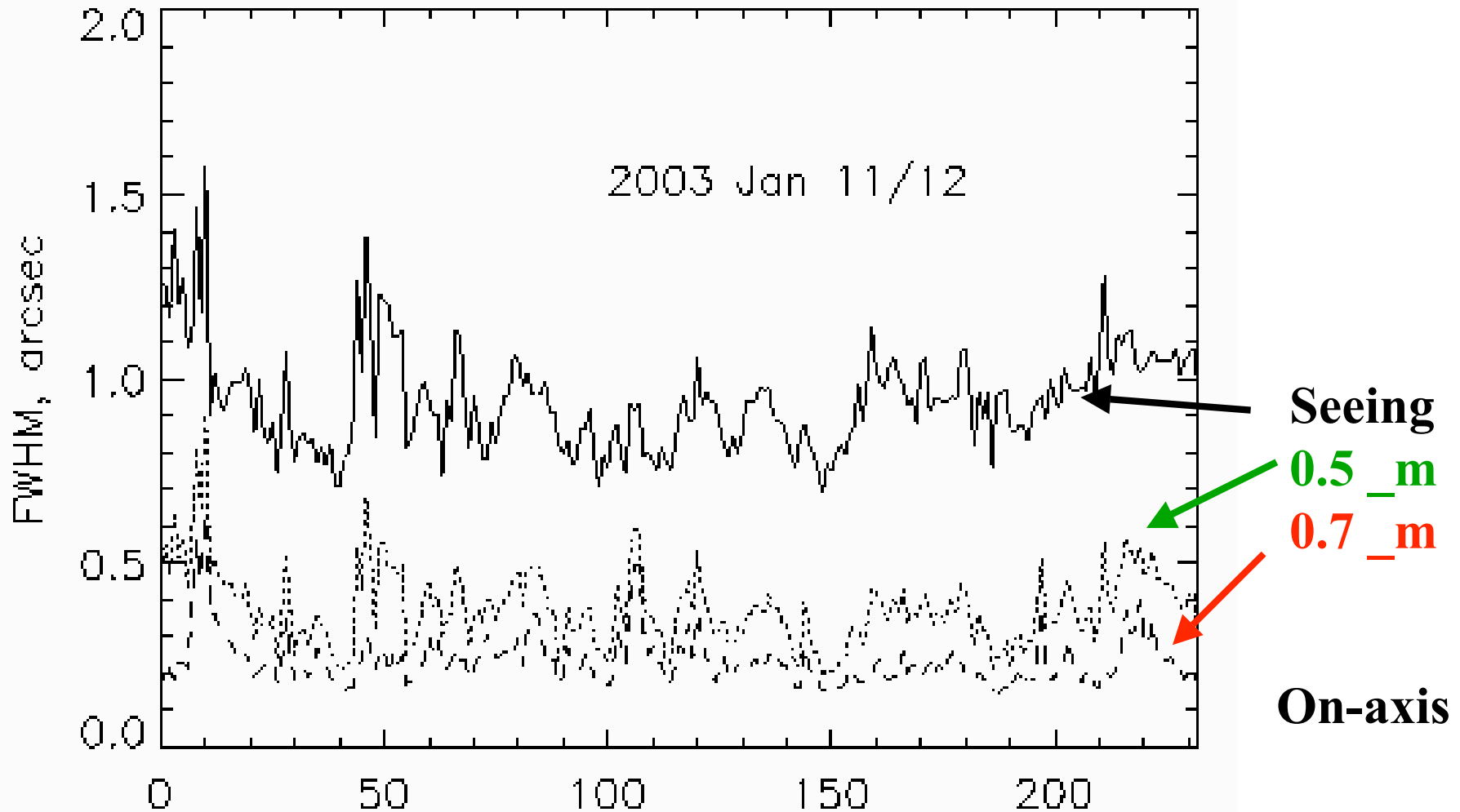
17% at 8km, 83% at 0.5km

Further comparison

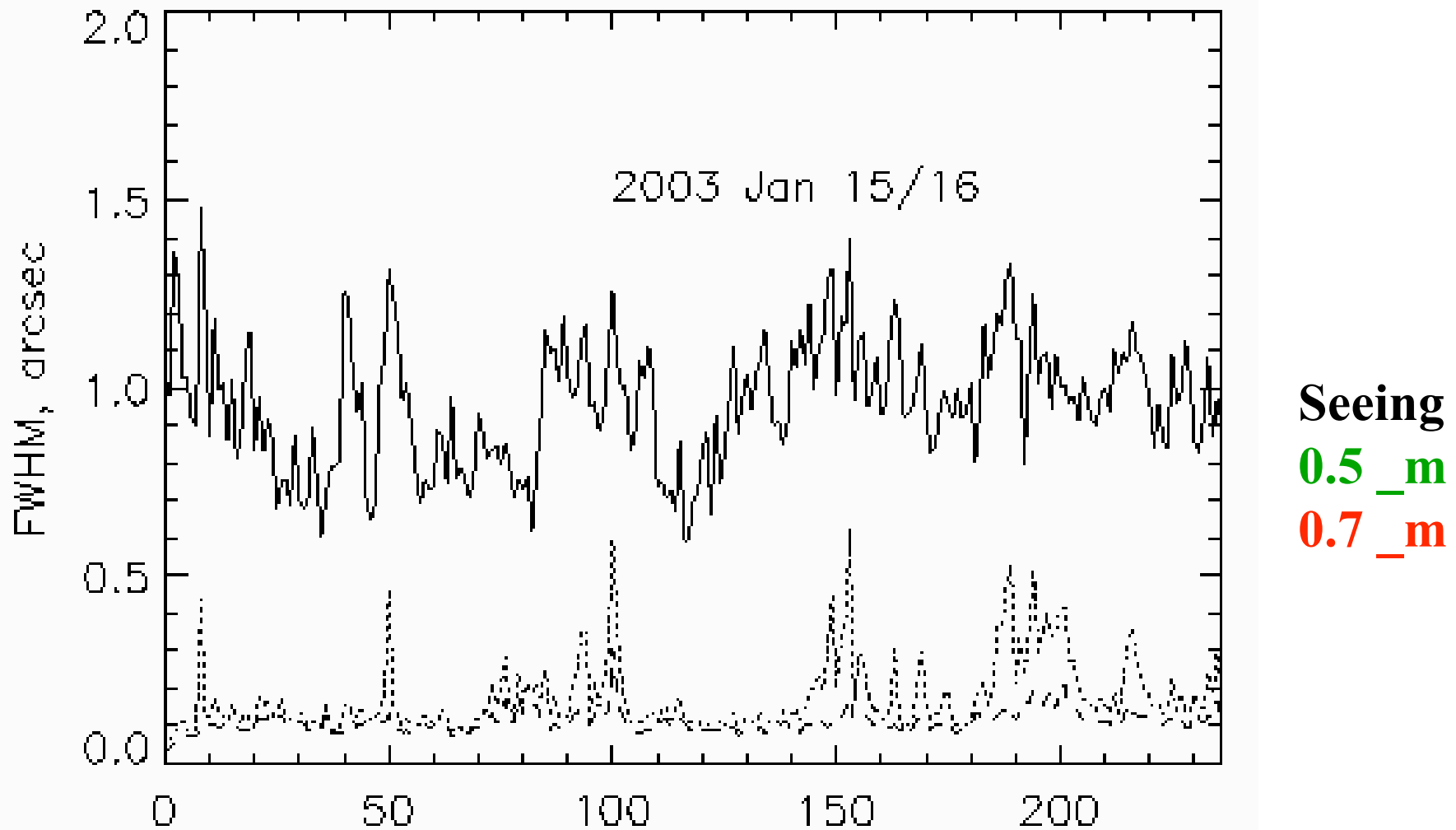


R-GLAO, $D=4\text{m}$

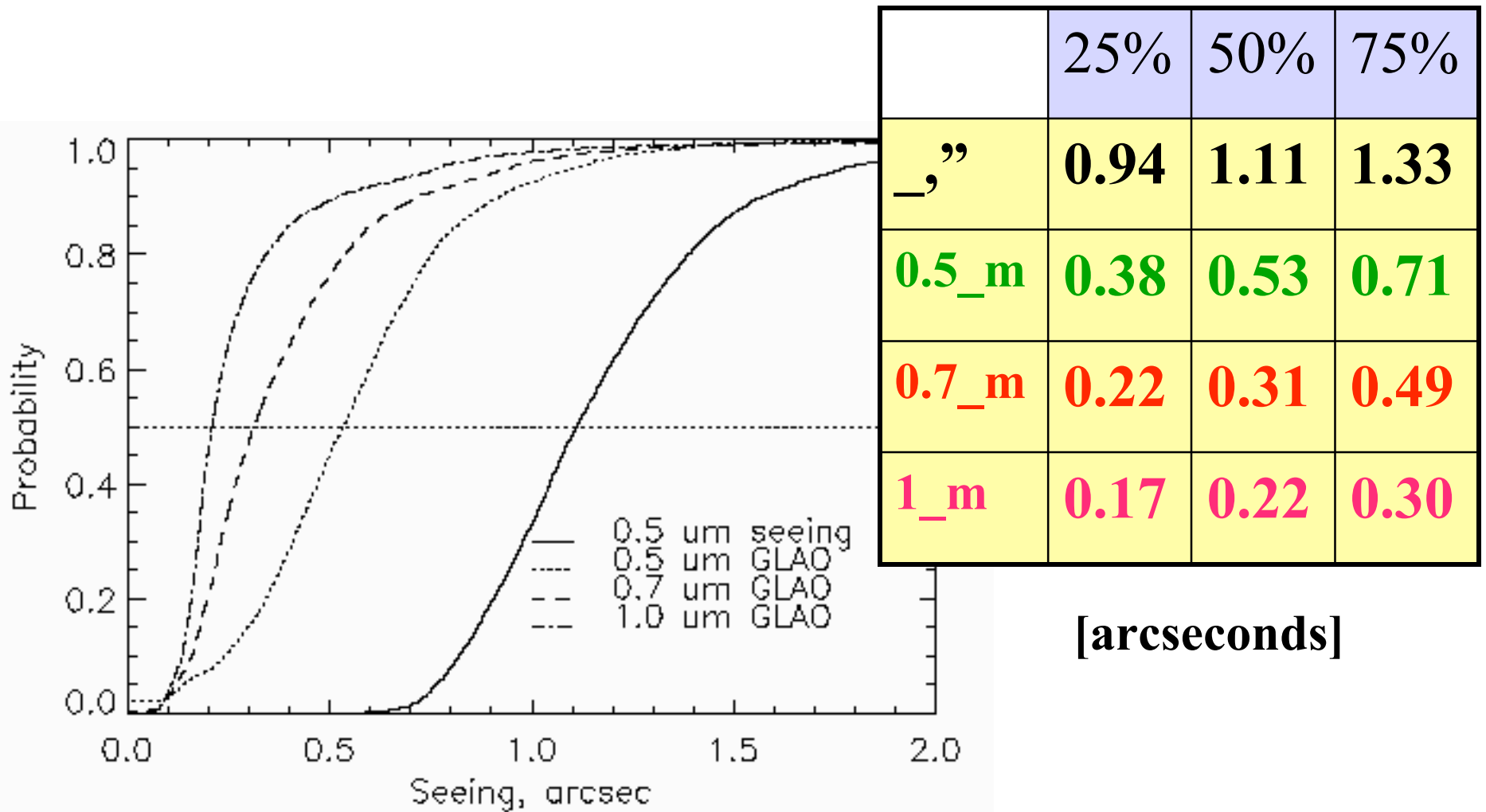
Typical night: Jan 11/12,
2003



Excellent night at Cerro Pachon: Jan 15/16 2003

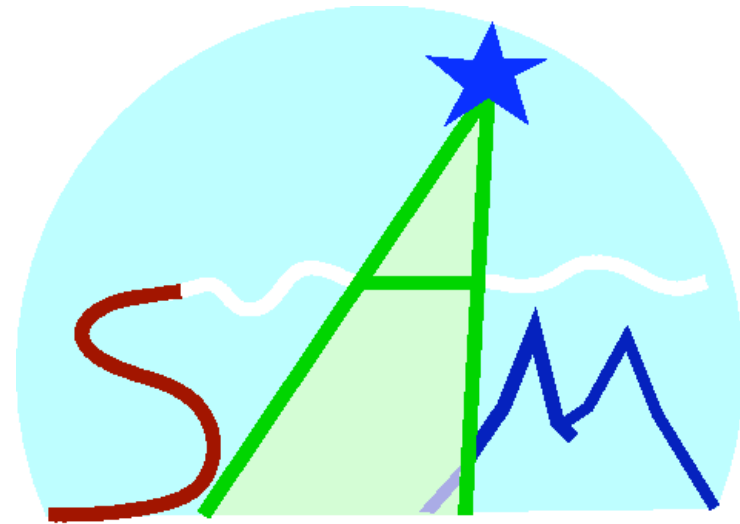


Statistics: FWHM



SAM = SOAR Adaptive Module

- Rayleigh LGS
355 nm, 8 W, 10km
- S-H WFS, 9x9
- Bimorph DM BIM-60
- CCD imager
3' x3'
- Visitor instrument
- Collimated space



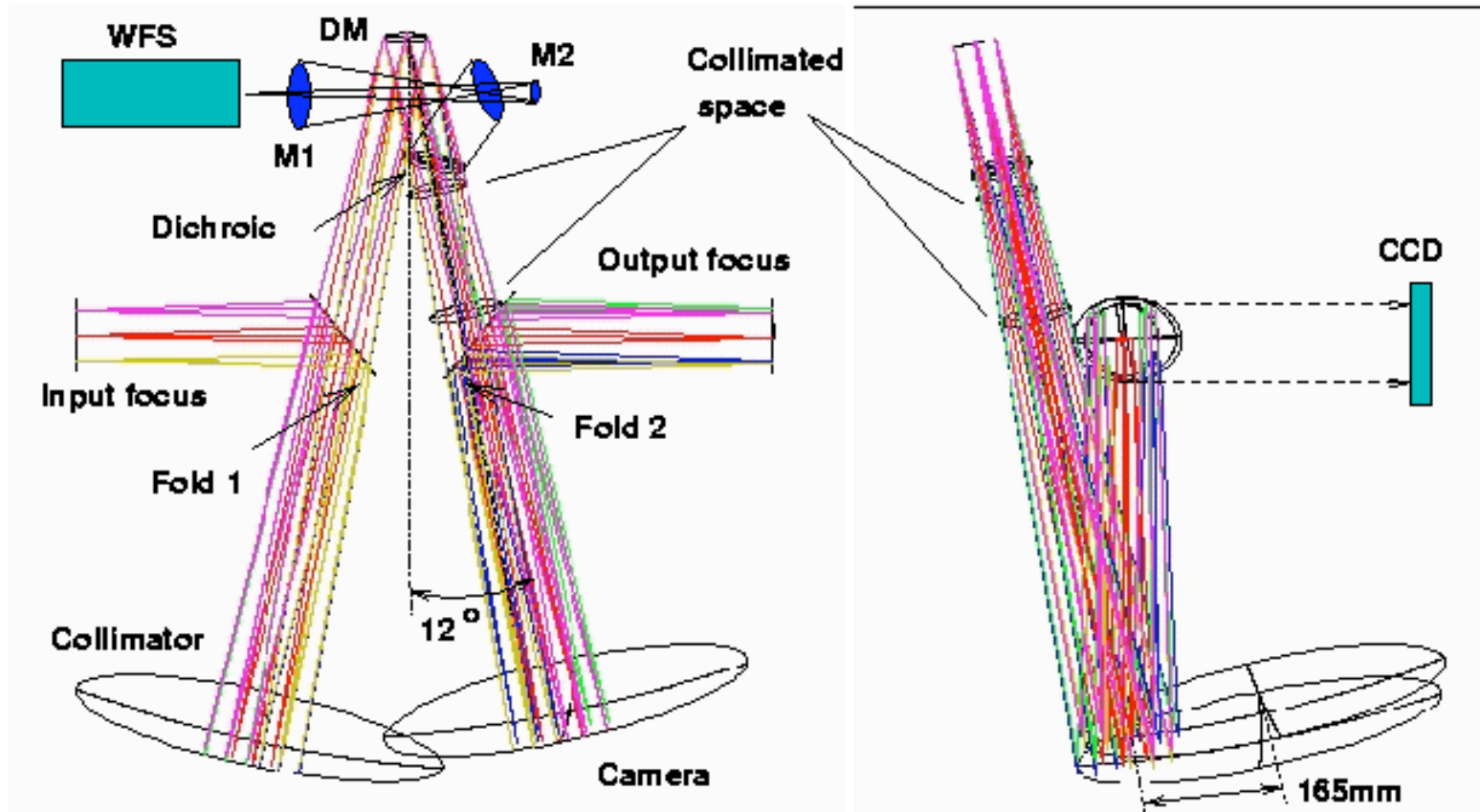
PDR: 2004

First light: 2006

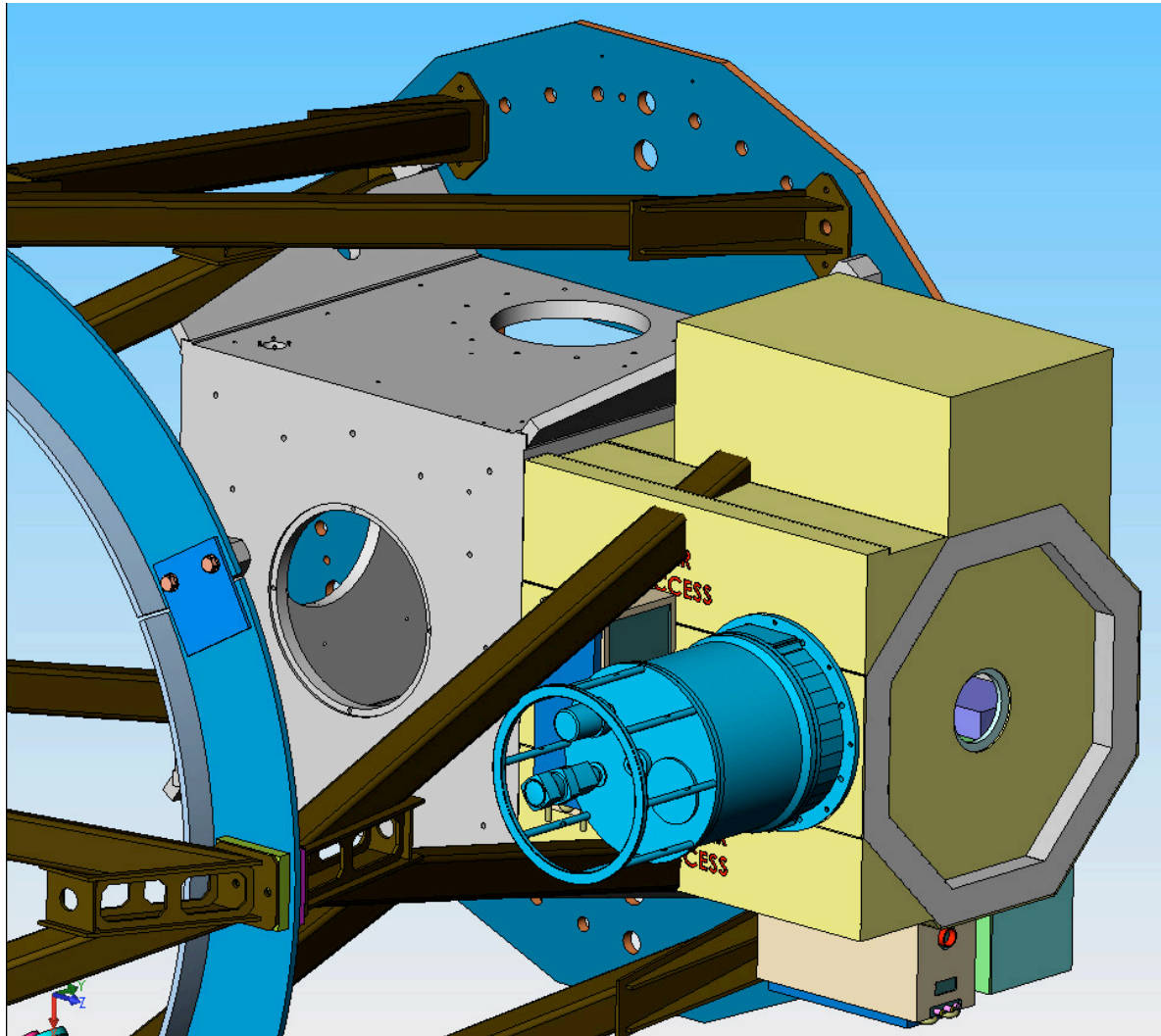
LGS: 2007

Optical design: OAP

- All-reflective
- Excellent quality
- Collimated space



SAM as adaptor



Conclusions

- GLAO is complementary to AO, MCAO
- Opens “visible” window, all-sky
- Rayleigh LGS is quite good
- SAM _ first implementation, test-bench
- Need data on turbulence in the first km!