# Ground-layer adaptive optics

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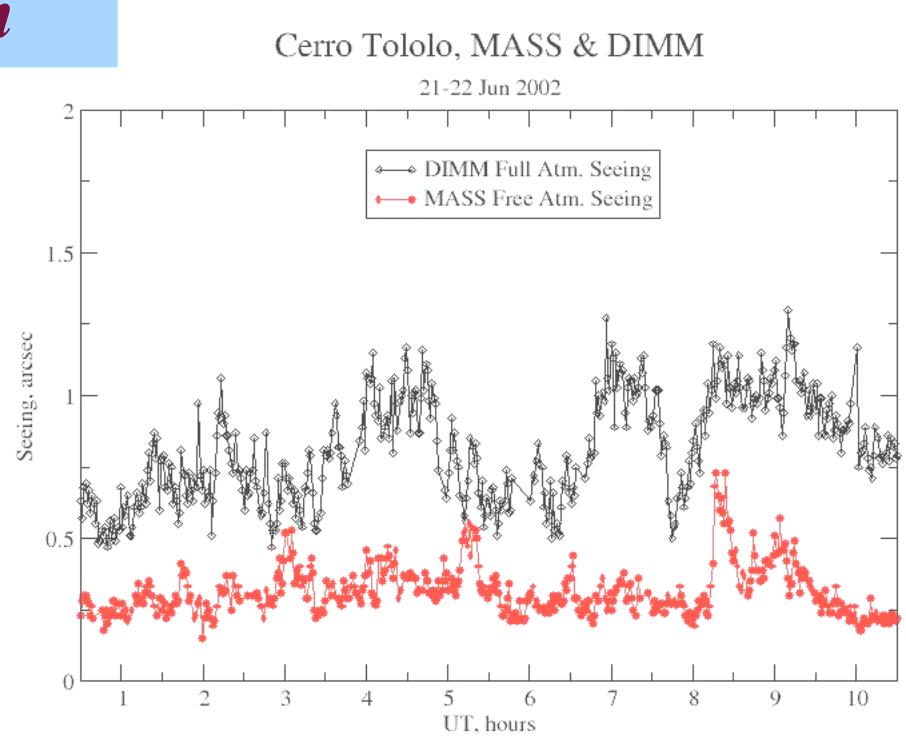
**CTIO/NOAO**



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%

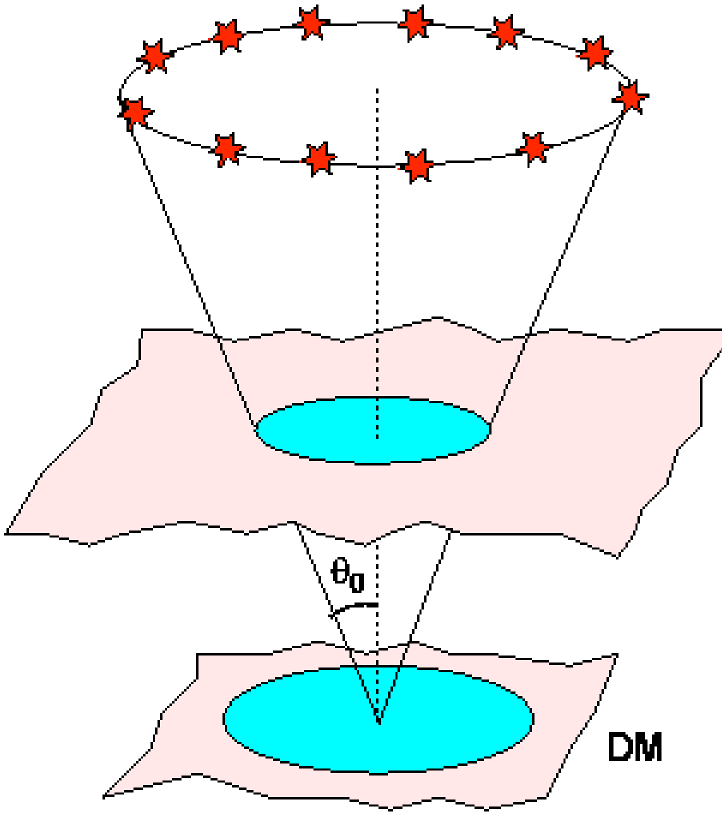
# Science with GLAO

- 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

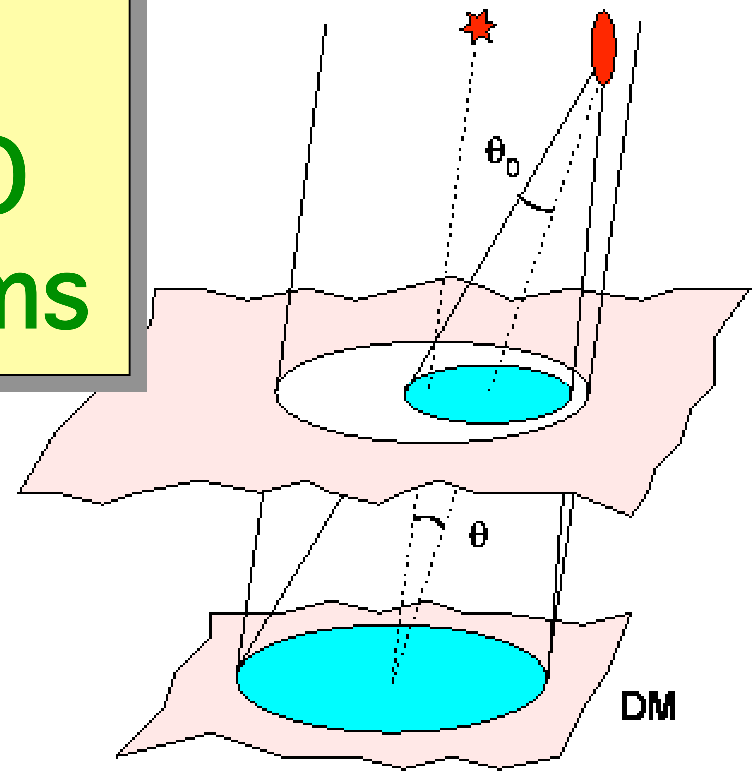



S-GLAO 5 sodium LGSs

Actuators 0.5m

_0 = 1.5’

Independent of *D*



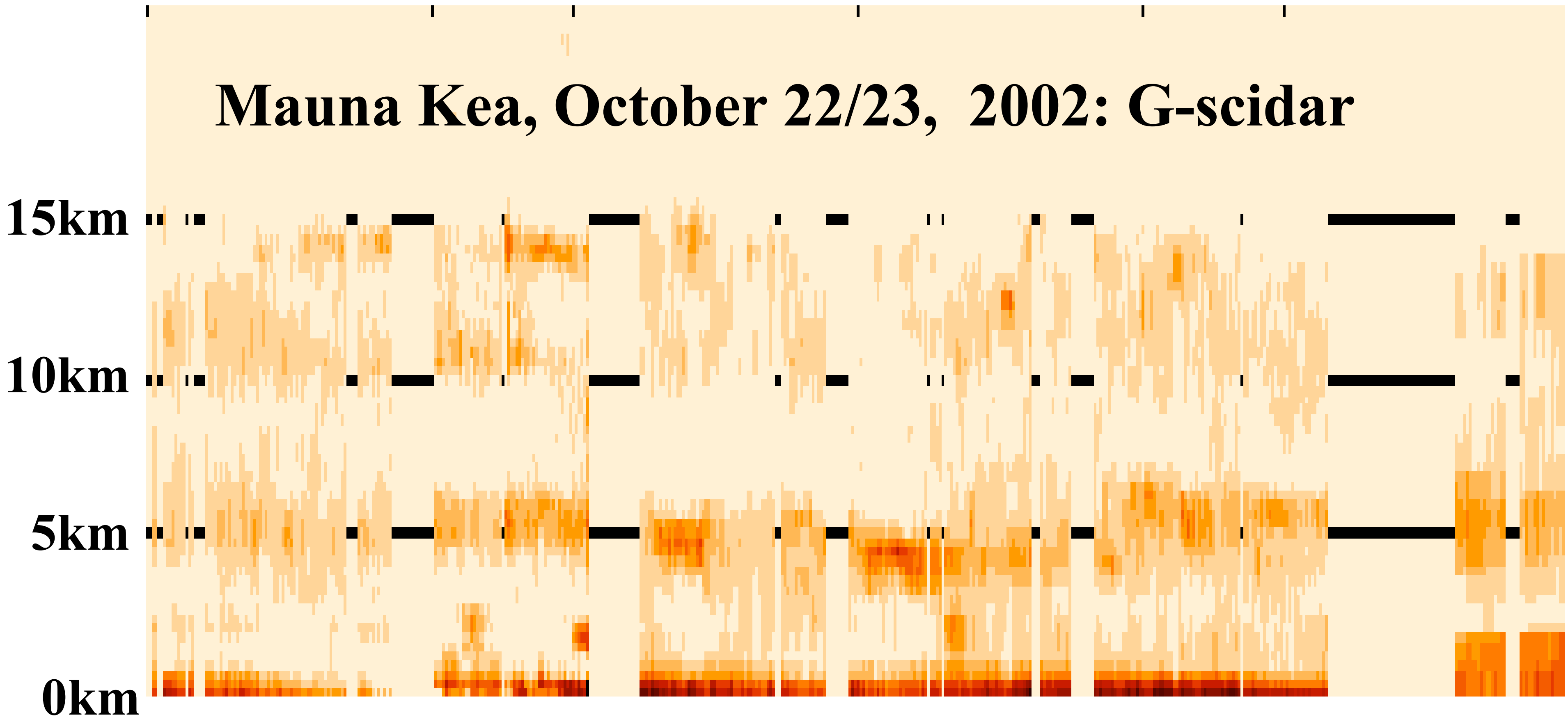

R-GLAO Rayleigh LGS

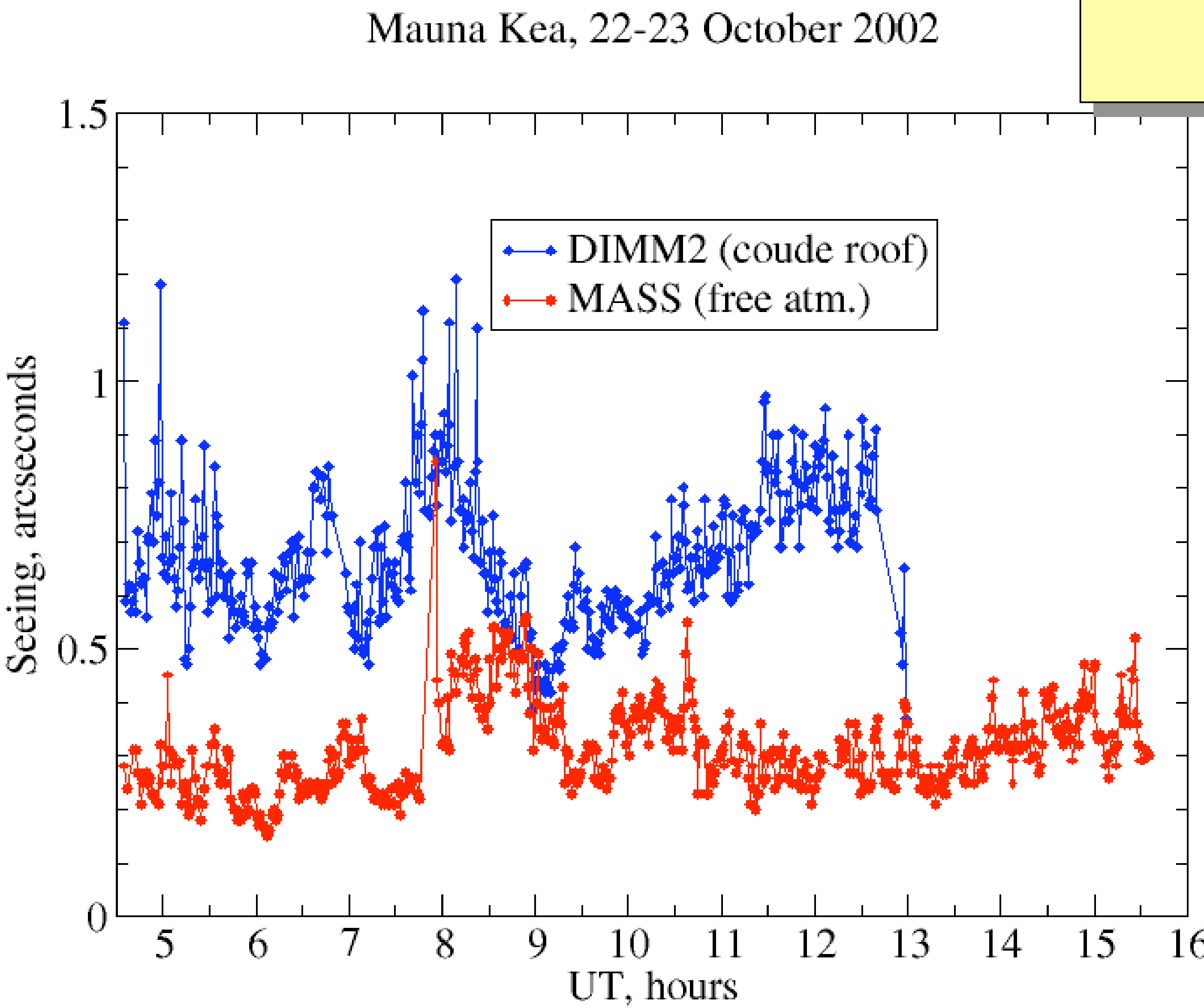
Actuators 0.5m

*D* = 8m

LGS at 10km

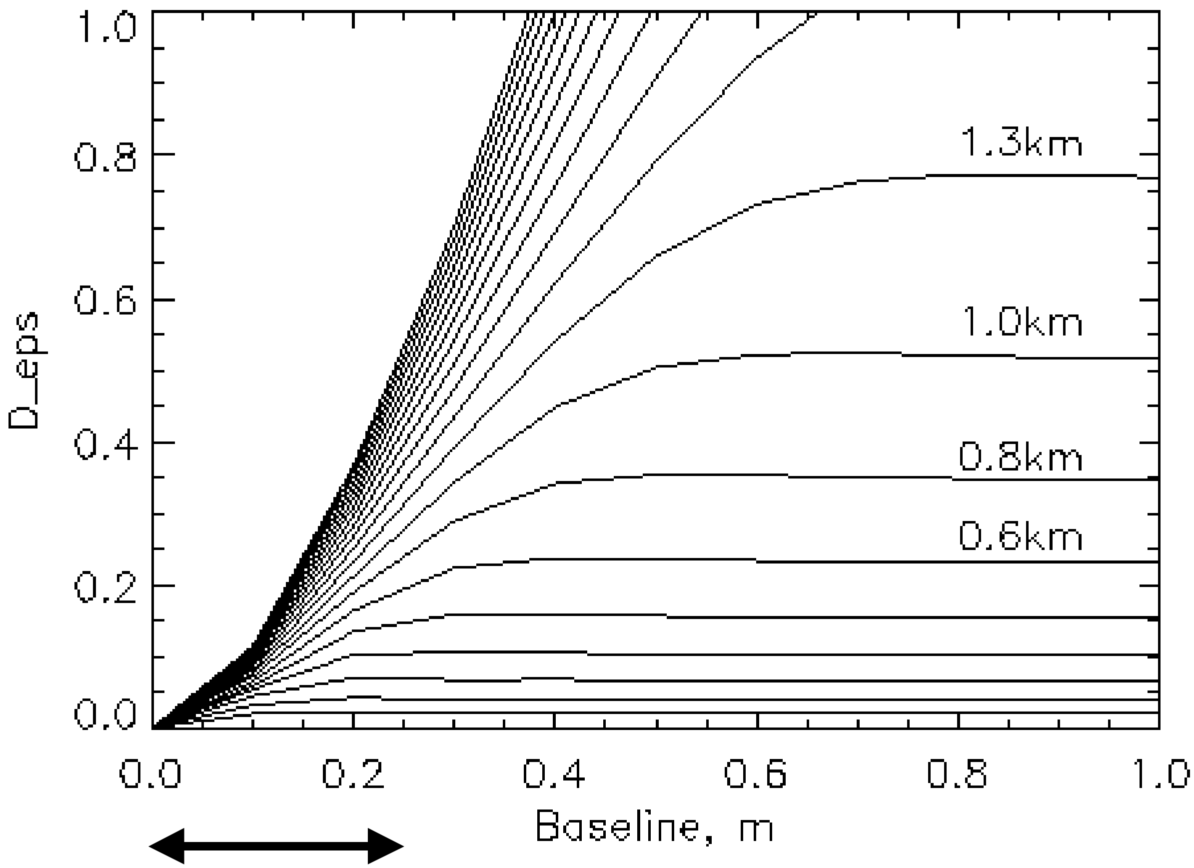
# Is there a ground layer?




Mauna Kea, 22-23 October 2002
DIMM2 (coude roof)
MASS (free atm.)
Seeing, arcseconds
UT, hours
0
0.5
1
1.5
5
6
7
8
9
10
11
12
13
14
15
16

**Yes!**

# How low is the "ground layer"?




$\sim \square h/2$

$\sim \square/2\square$

$H_{max} \sim \square/(\square\square)$

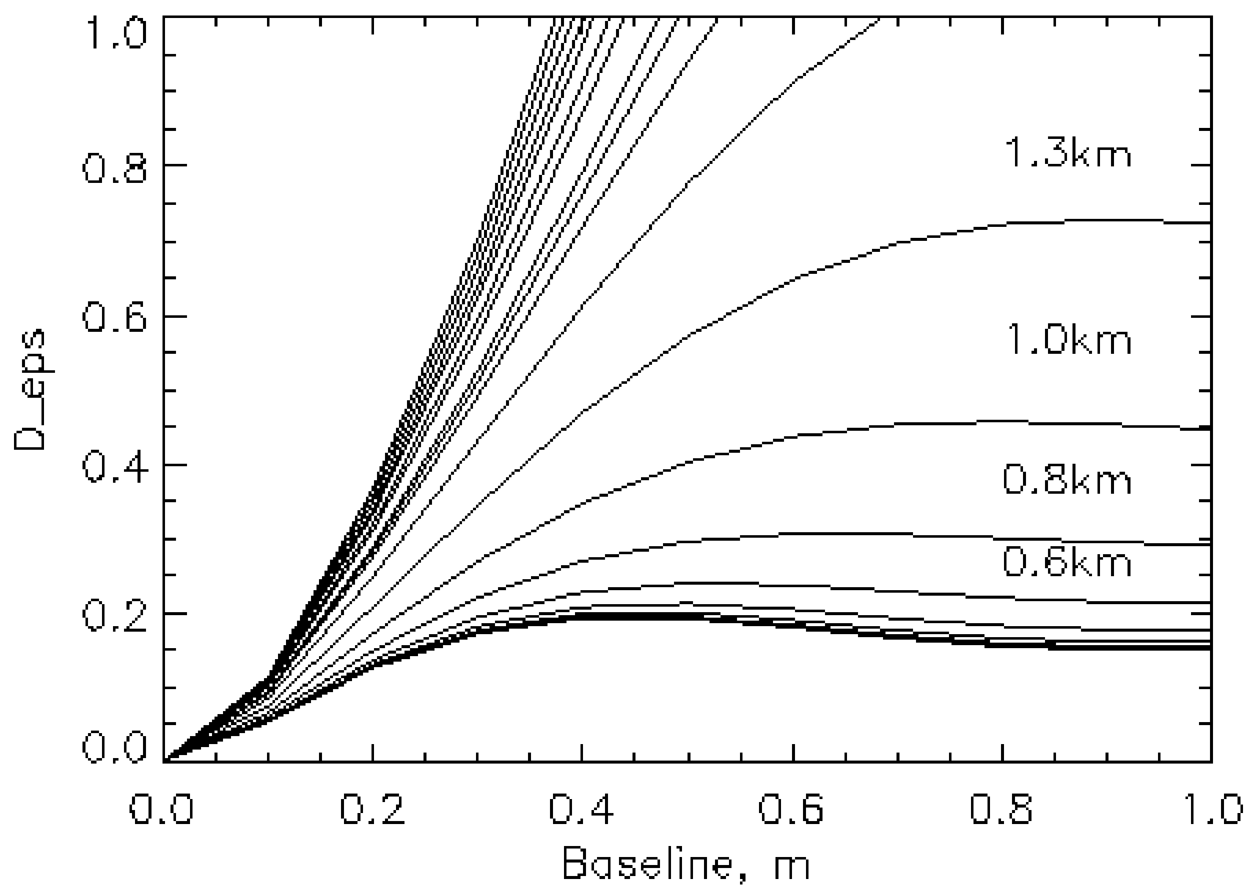
**FWHM □ = 0.2"**

**□ =0.7 □m**

**Field □ = 1.5'**

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

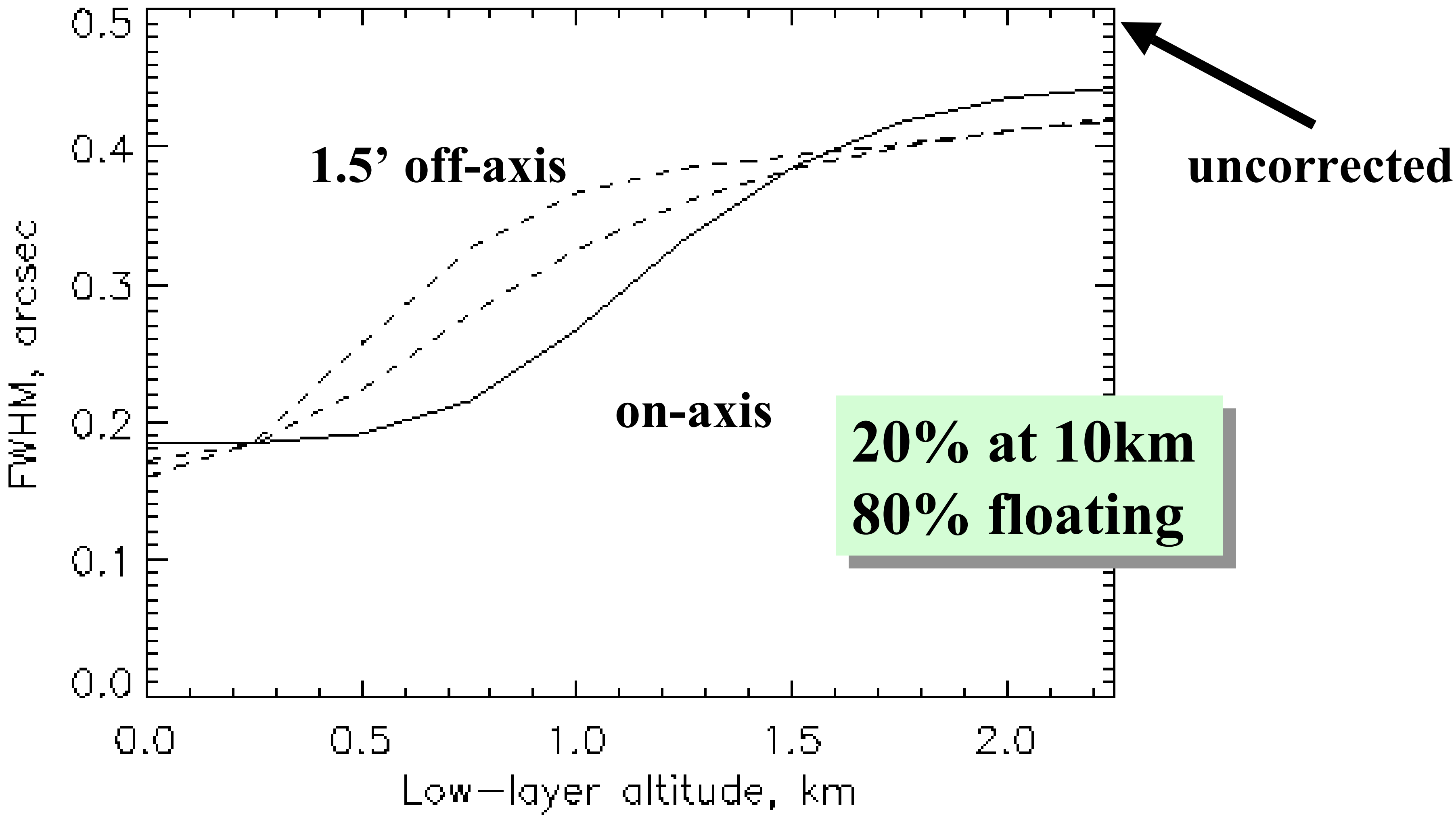
# The role of DM resolution



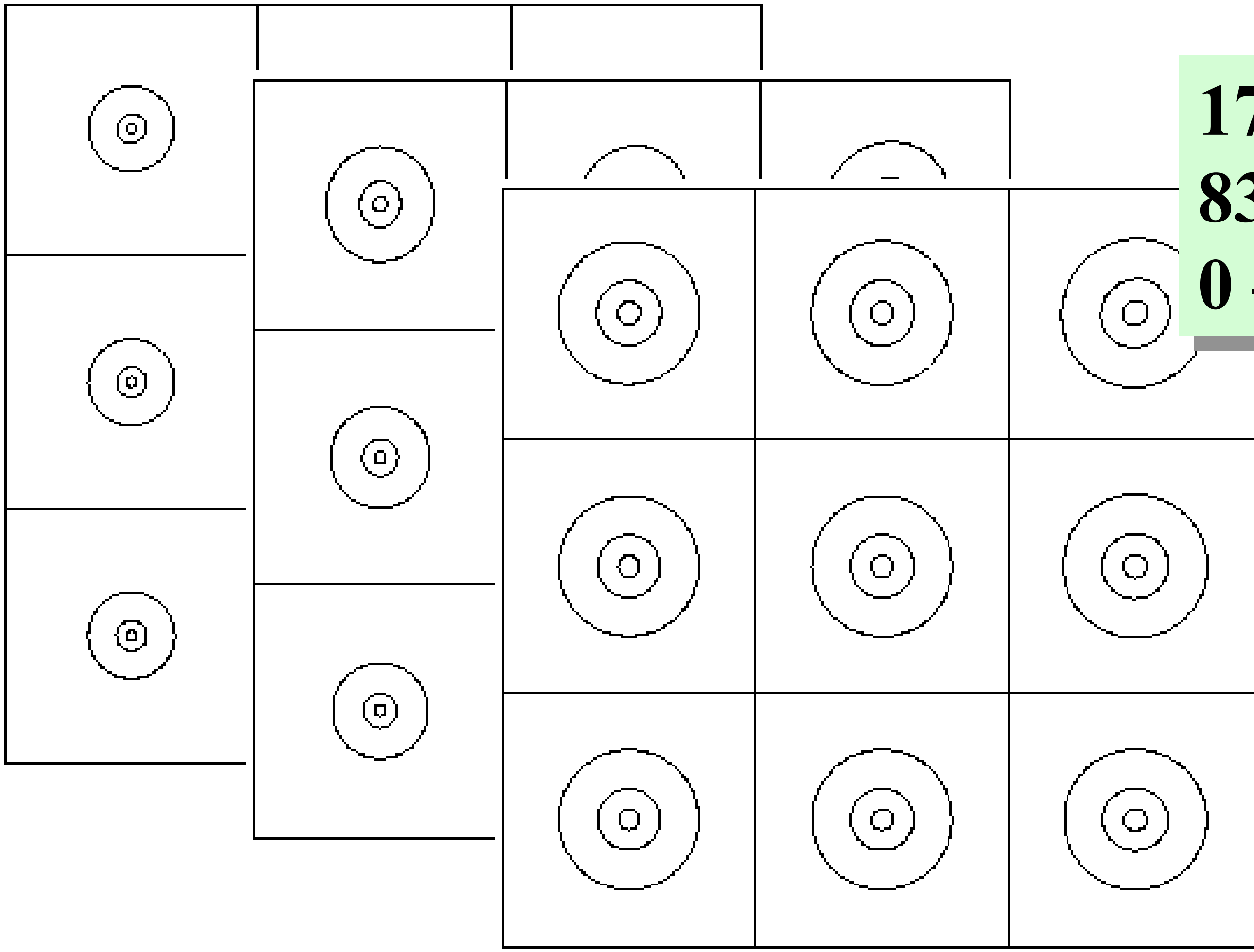

$H_{min} \sim d/(2\pi)$

# The "gray zone"

$H_{min} \ldots H_{max}$



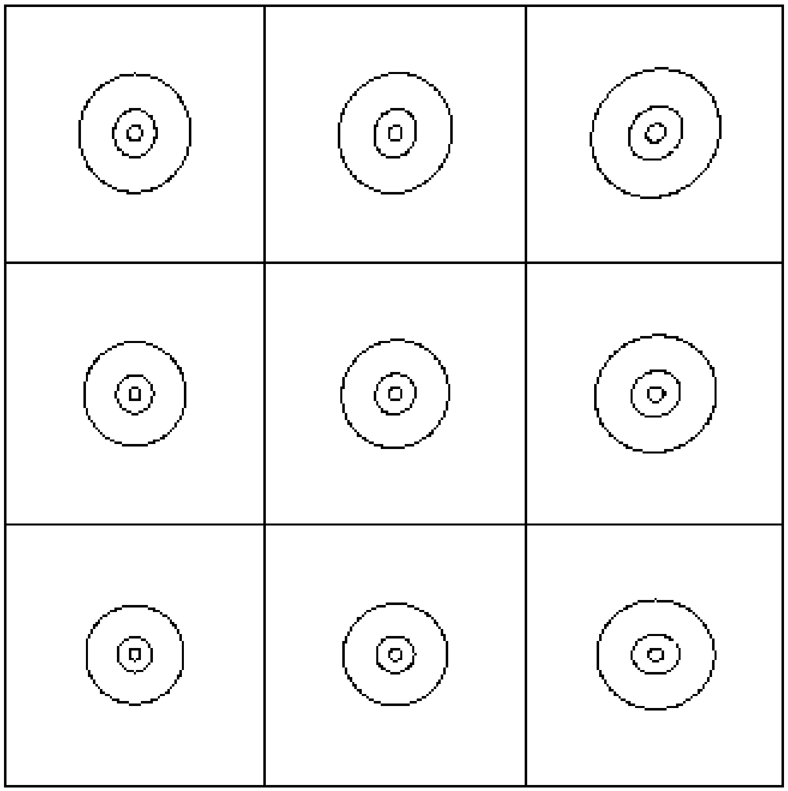
# PSFs for S-GLAO



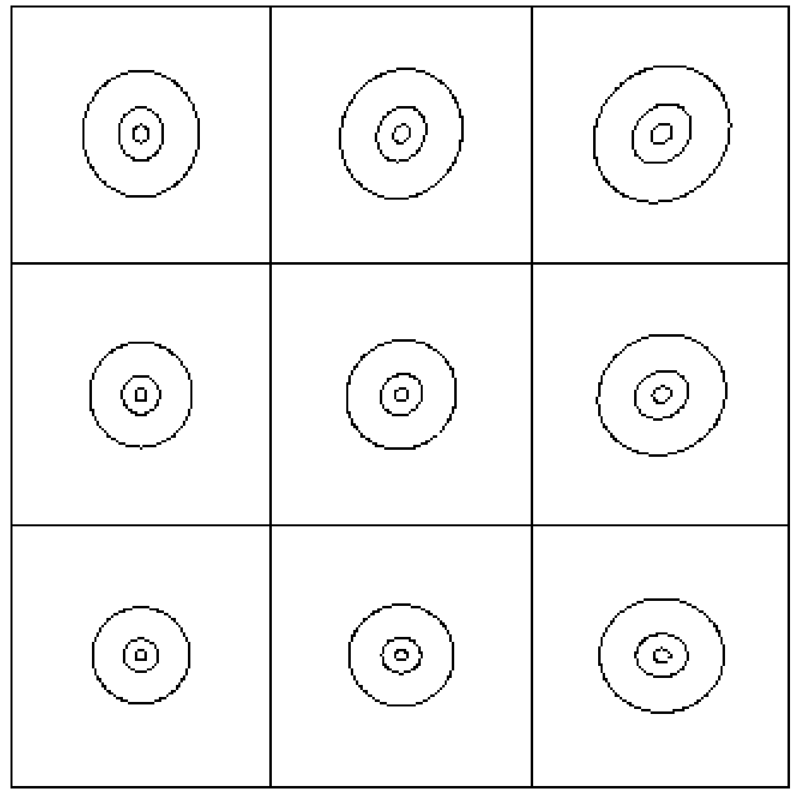
**17% at 8km**
**83% at**
**0 – 0.5 – 1 km**

**Contours:**
**0.1-0.5-0.9**

# Compare S-GLAO with R-GLAO



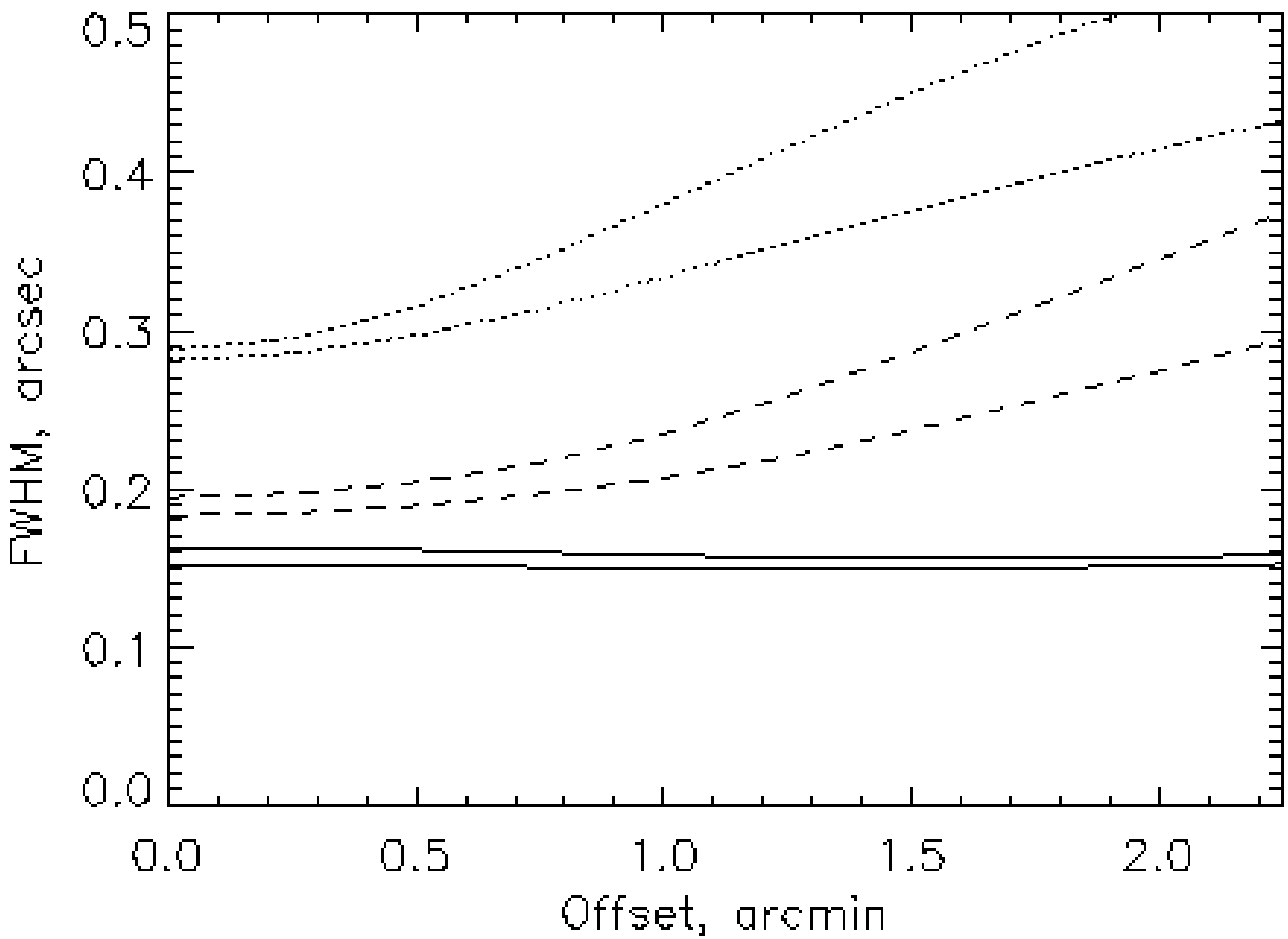
**S-GLAO**



**R-GLAO**

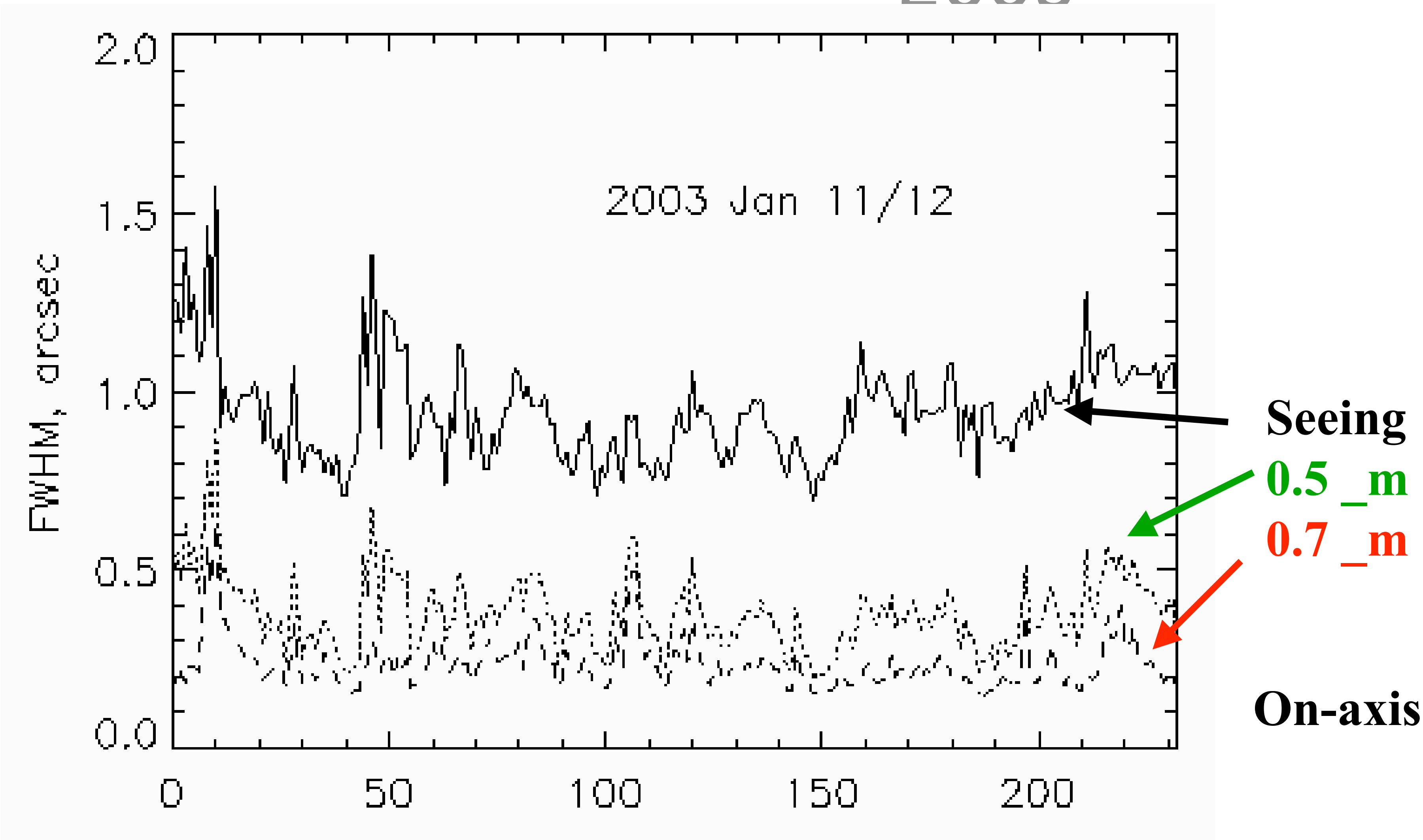
**17% at 8km, 83% at 0.5km**

# Further comparison

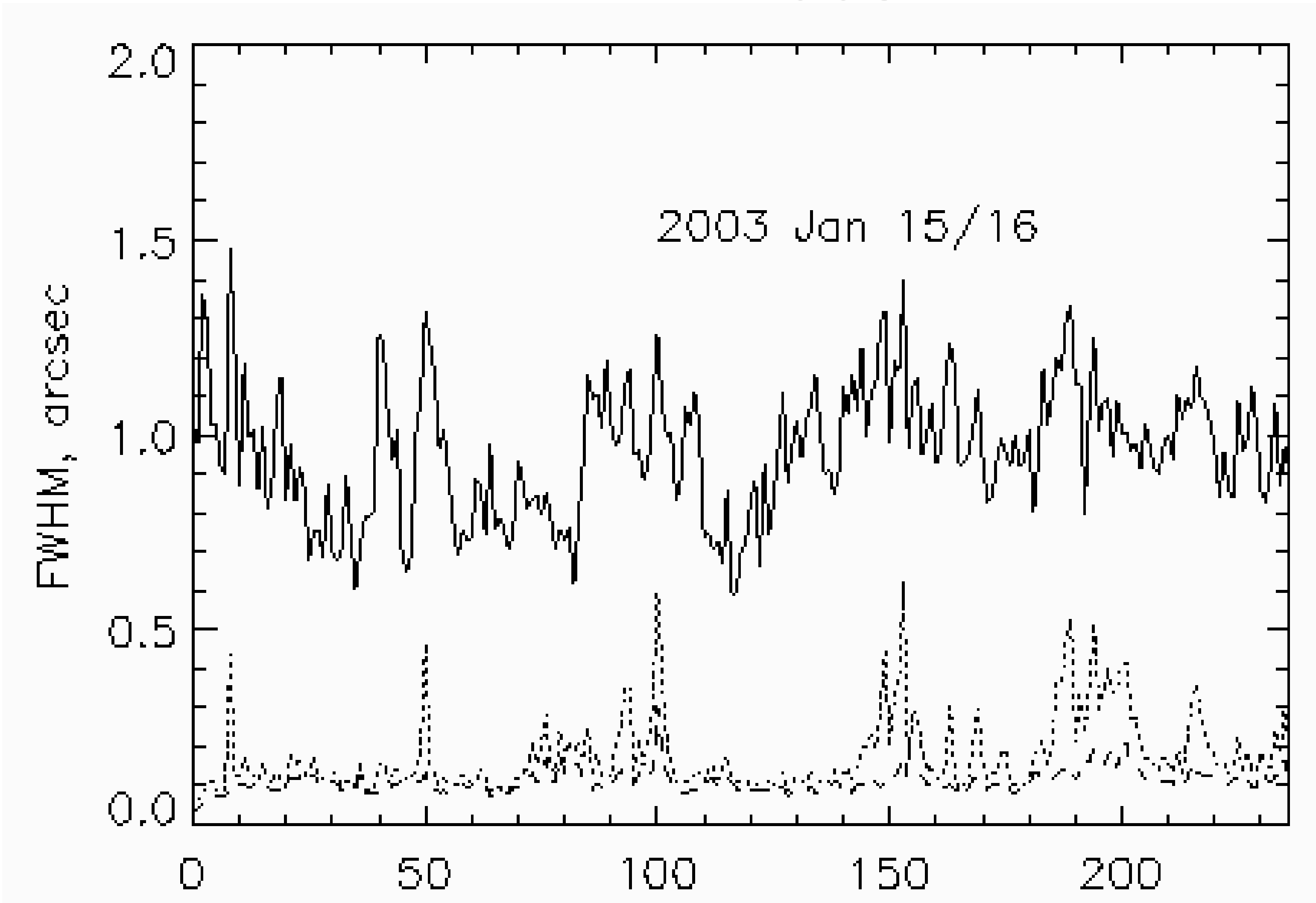


**R-GLAO, *D*=4m**

# Typical night: Jan 11/12, 2003

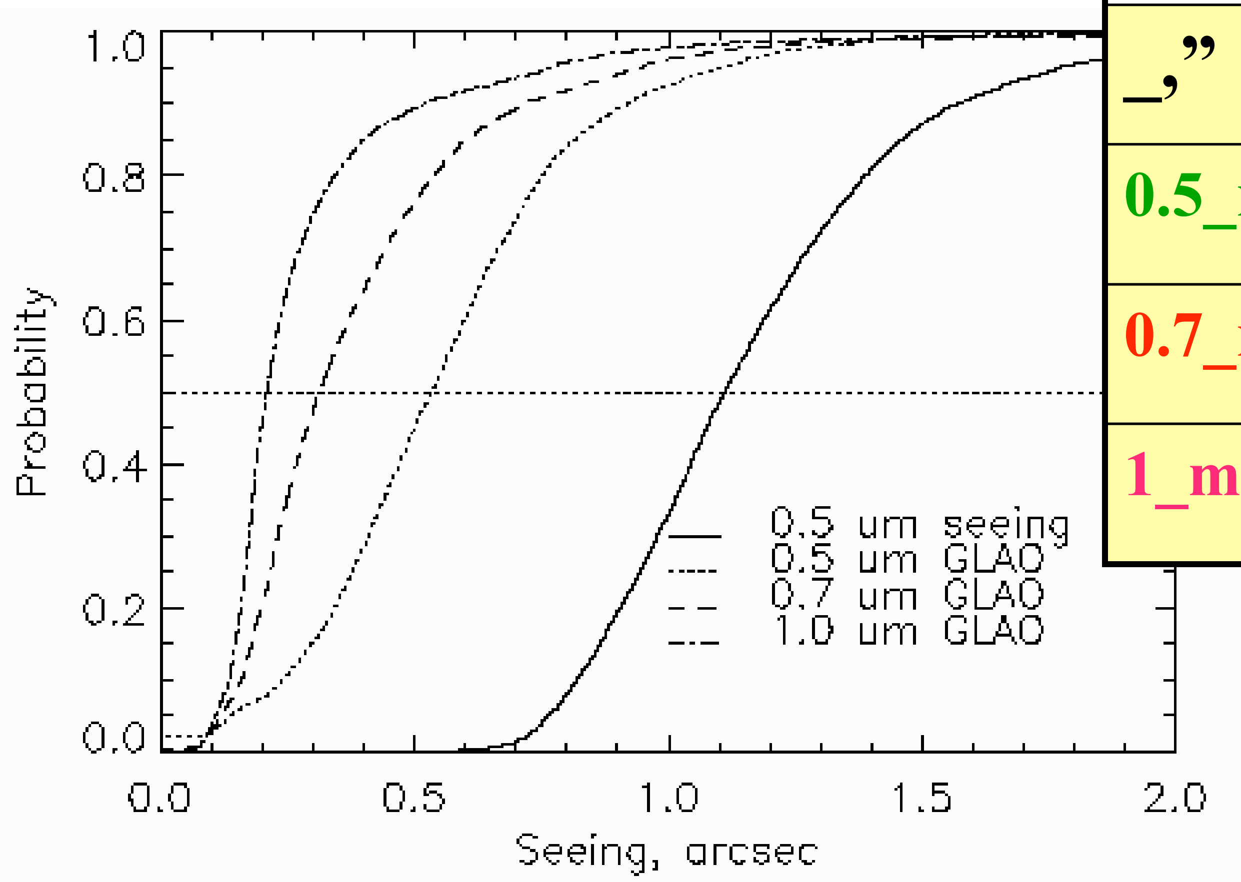


# Excellent night at Cerro Pachon: Jan 15/16 2003




**Seeing**
**0.5 _m**
**0.7 _m**

# Statistics: FWHM

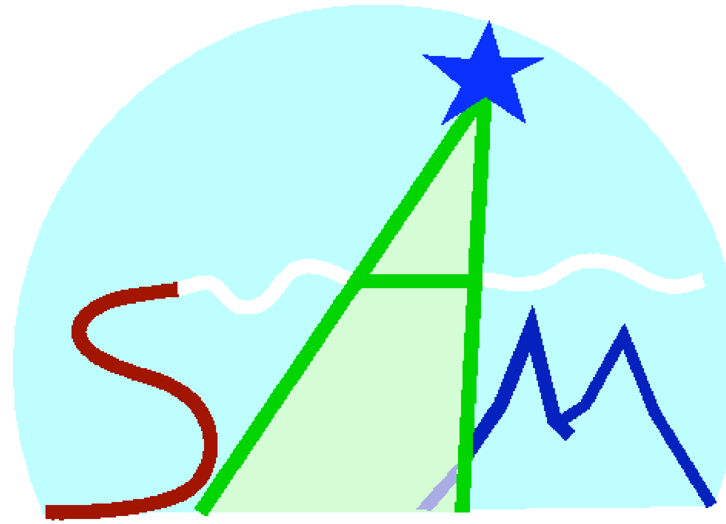



| | 25% | 50% | 75% |
|---|---|---|---|
| _,” | **0.94** | **1.11** | **1.33** |
| **0.5_m** | **0.38** | **0.53** | **0.71** |
| **0.7_m** | **0.22** | **0.31** | **0.49** |
| **1_m** | **0.17** | **0.22** | **0.30** |

**[arcseconds]**

# SAM = SOAR Adaptive Module

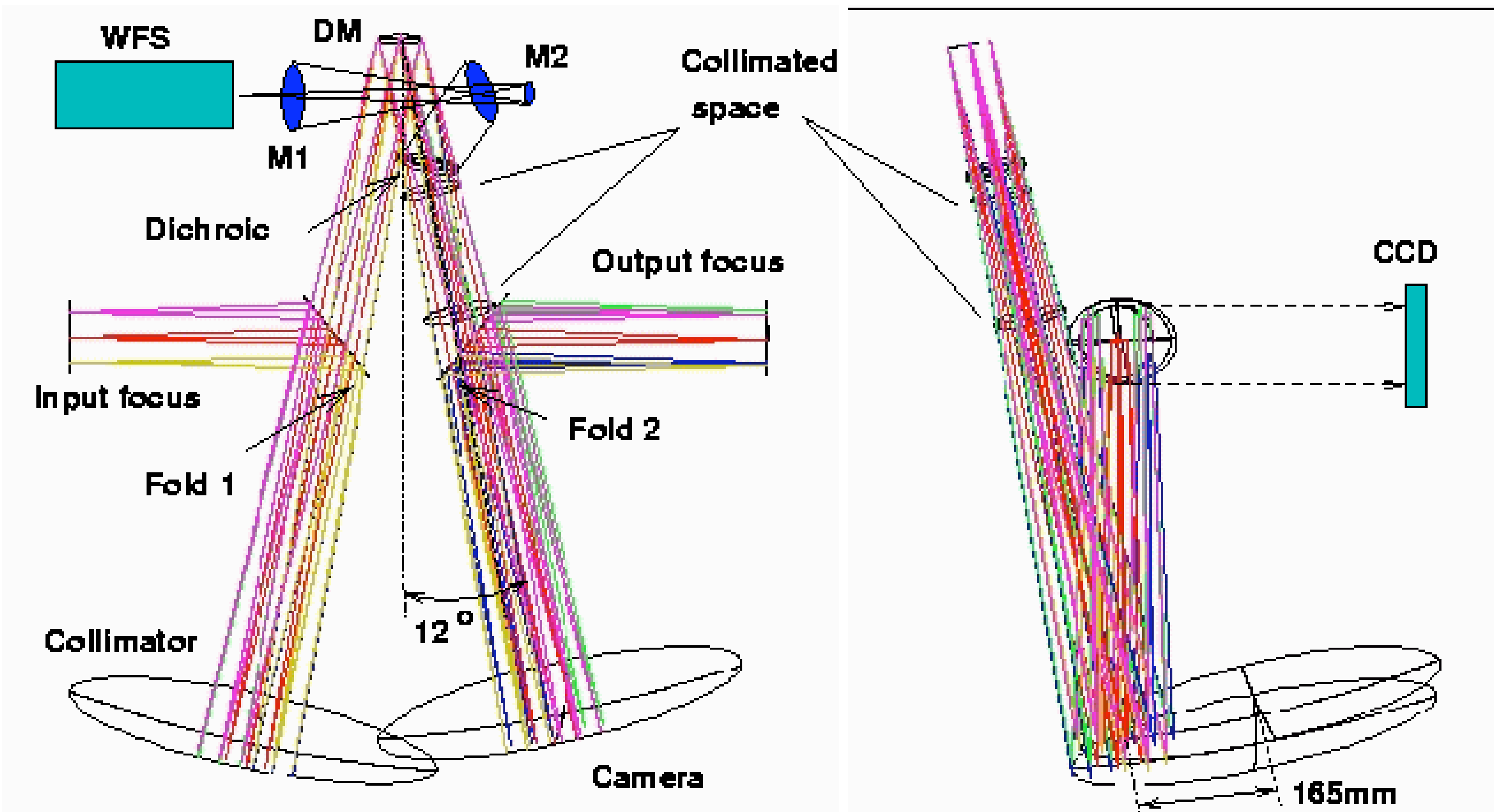
- Rayleigh LGS
  355 nm, 8 W, 10km
- S-H WFS, 9x9
- Bimorph DM BIM-60
- CCD imager 3’ x3’
- Visitor instrument
- Collimated space



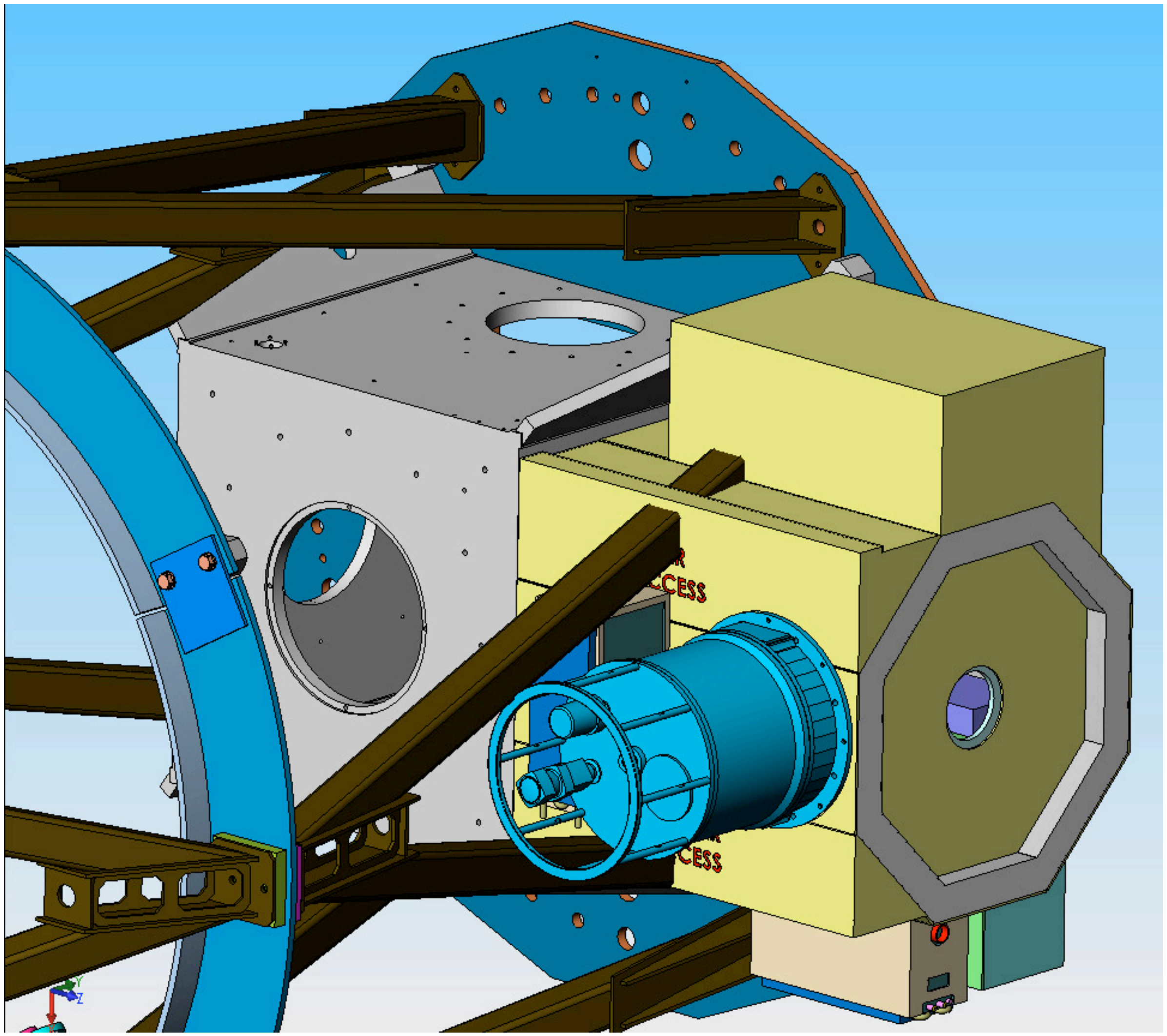
**PDR: 2004**
**First light: 2006**
**LGS: 2007**

# 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!