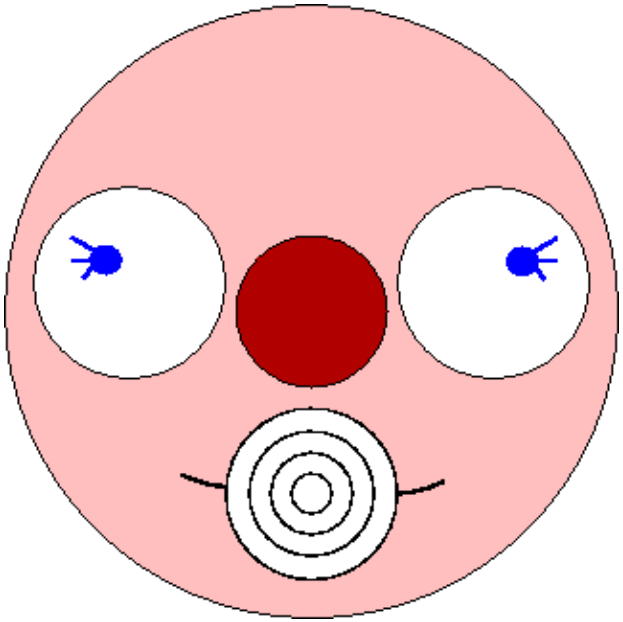
MASS-DIMM – a turbulence monitor for Adaptive Optics



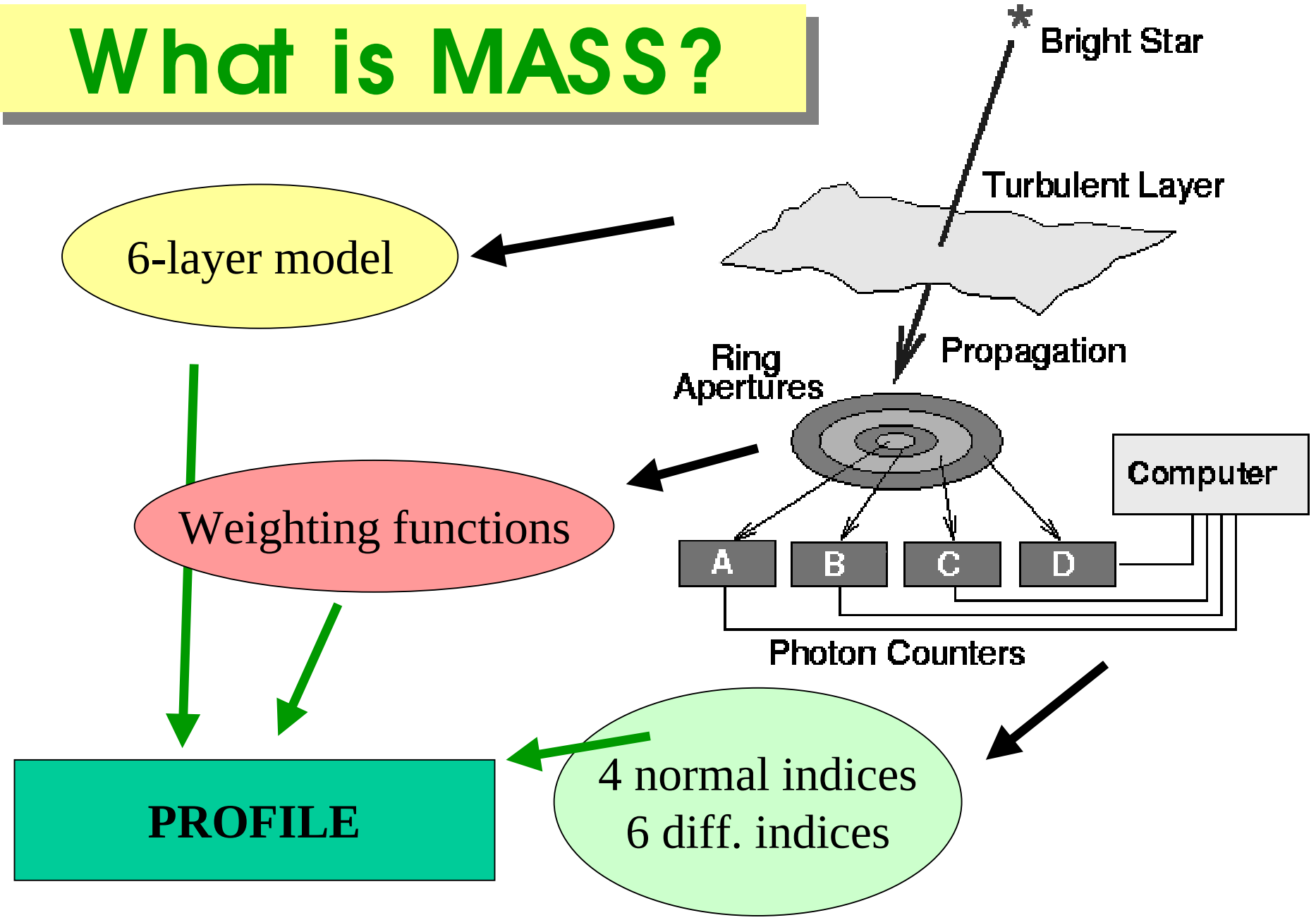
A. Tokovinin

http://www.ctio.noao.edu/~atokovin/profiler

Outline

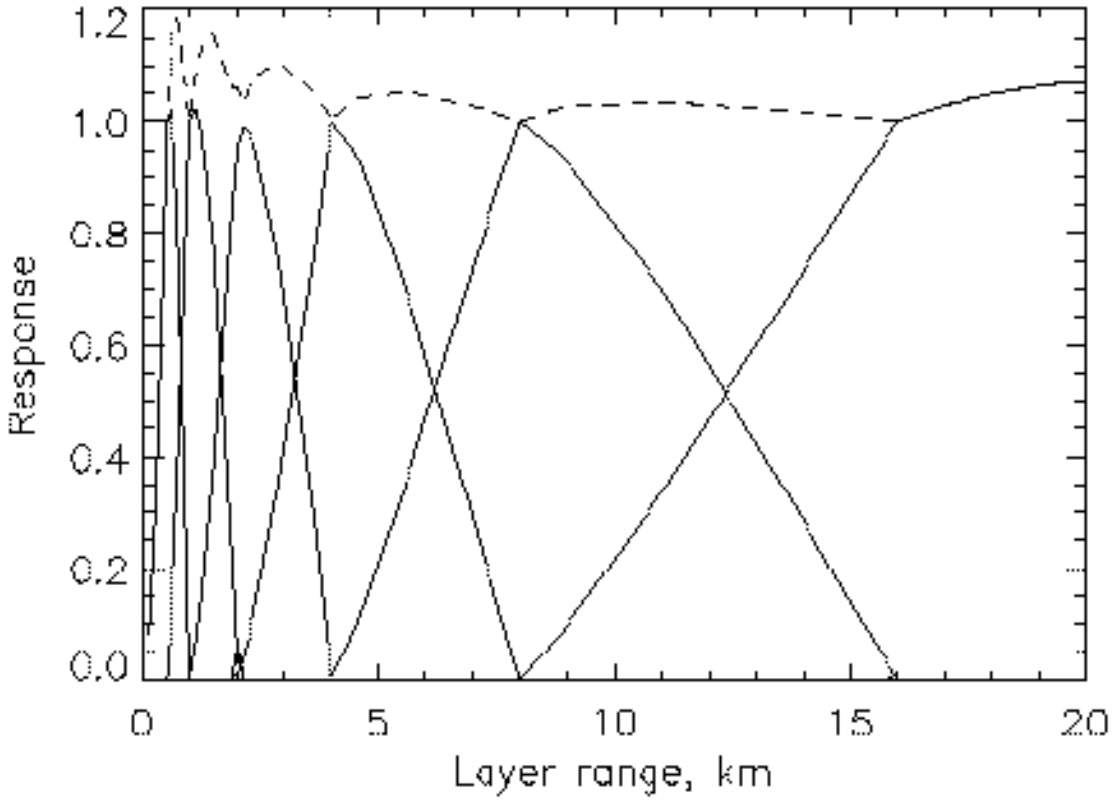
- MASS – a robust low-resolution profiler
- Ground layer: + DIMM or generalized?
- Delivered parameters
- Inter-comparisons (DIMMs, SCIDAR)
- Profile meteorology
- MASS for Ground-layer AO
- Plans

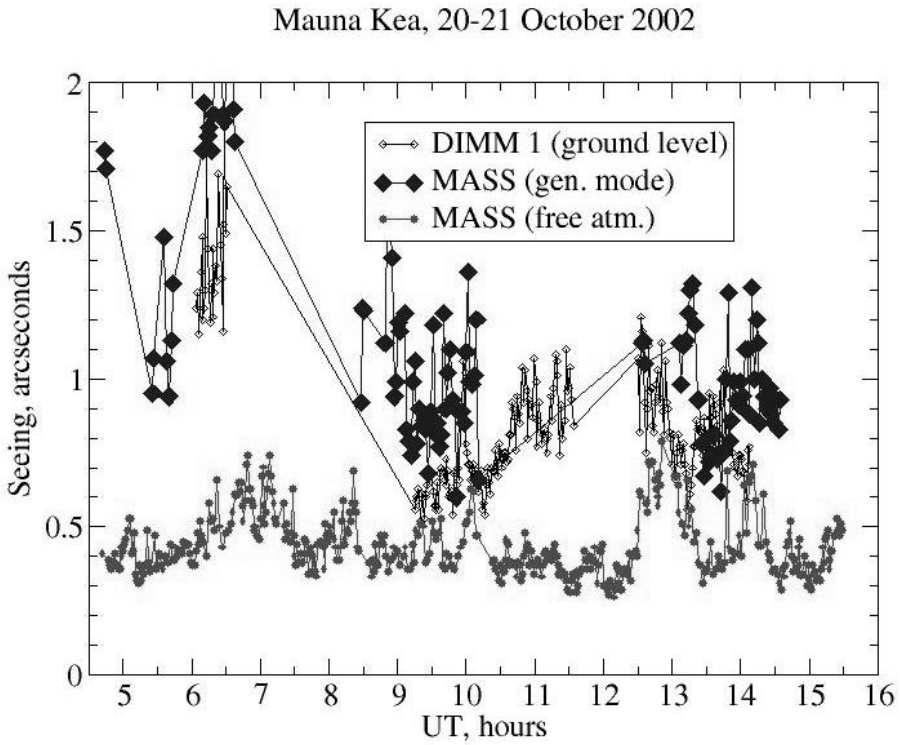
What is MASS?

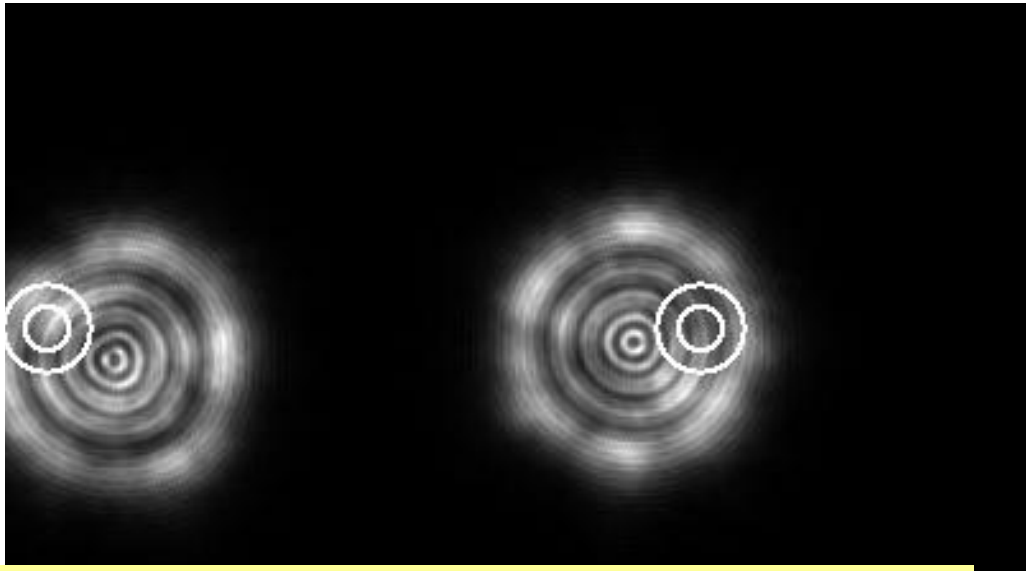

Bright Star
Turbulent Layer
6-layer model
Propagation
Ring
Apertures
Computer
Weighting functions
A
B
C
D
Photon Counters
4 normal indices
6 diff. indices
PROFILE

Restoration of profile

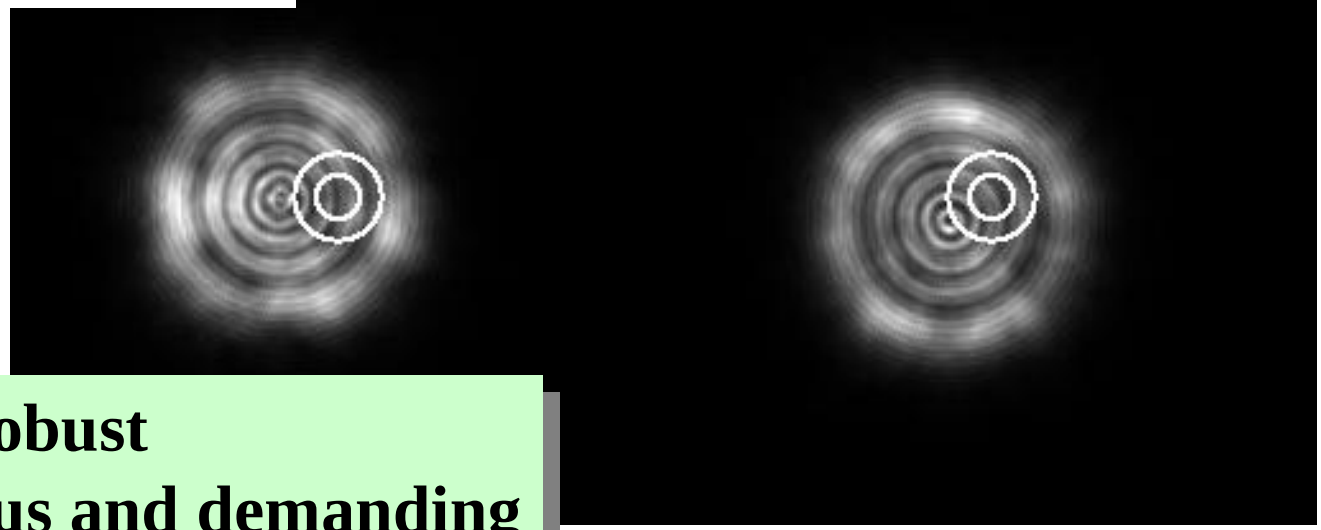
- **Response is "triangular"**
- **Good integrals ($ß_f$, $?_0$)**
- **S/N~10% (better sensitivity at low turbulence)**







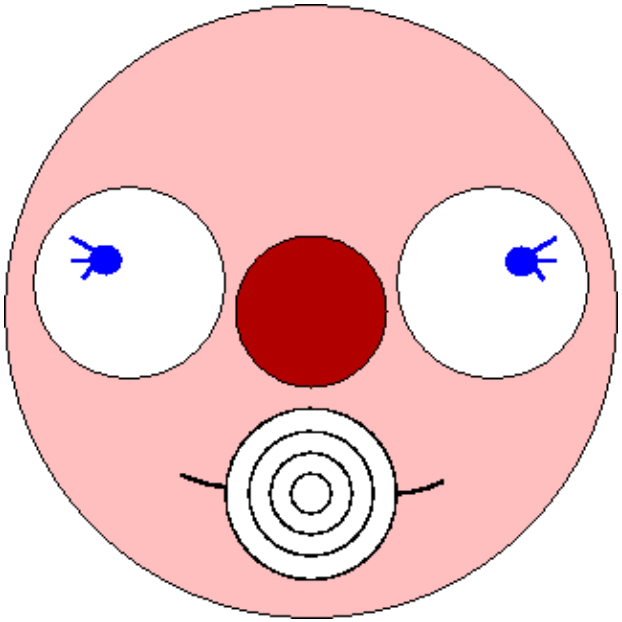
Ground layer: generalized??

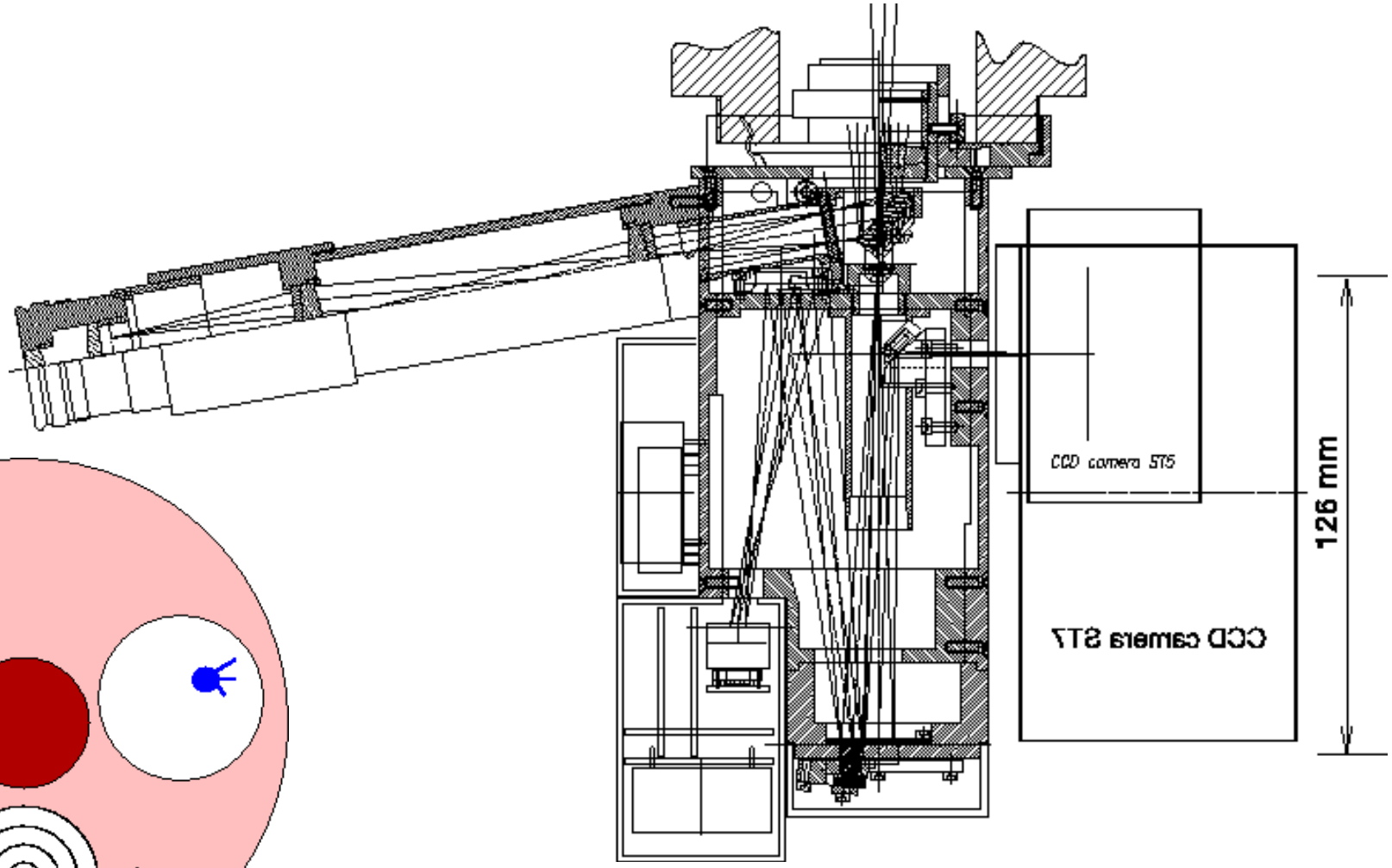


Normal: **simple and robust**

Generalized: **capricious and demanding**

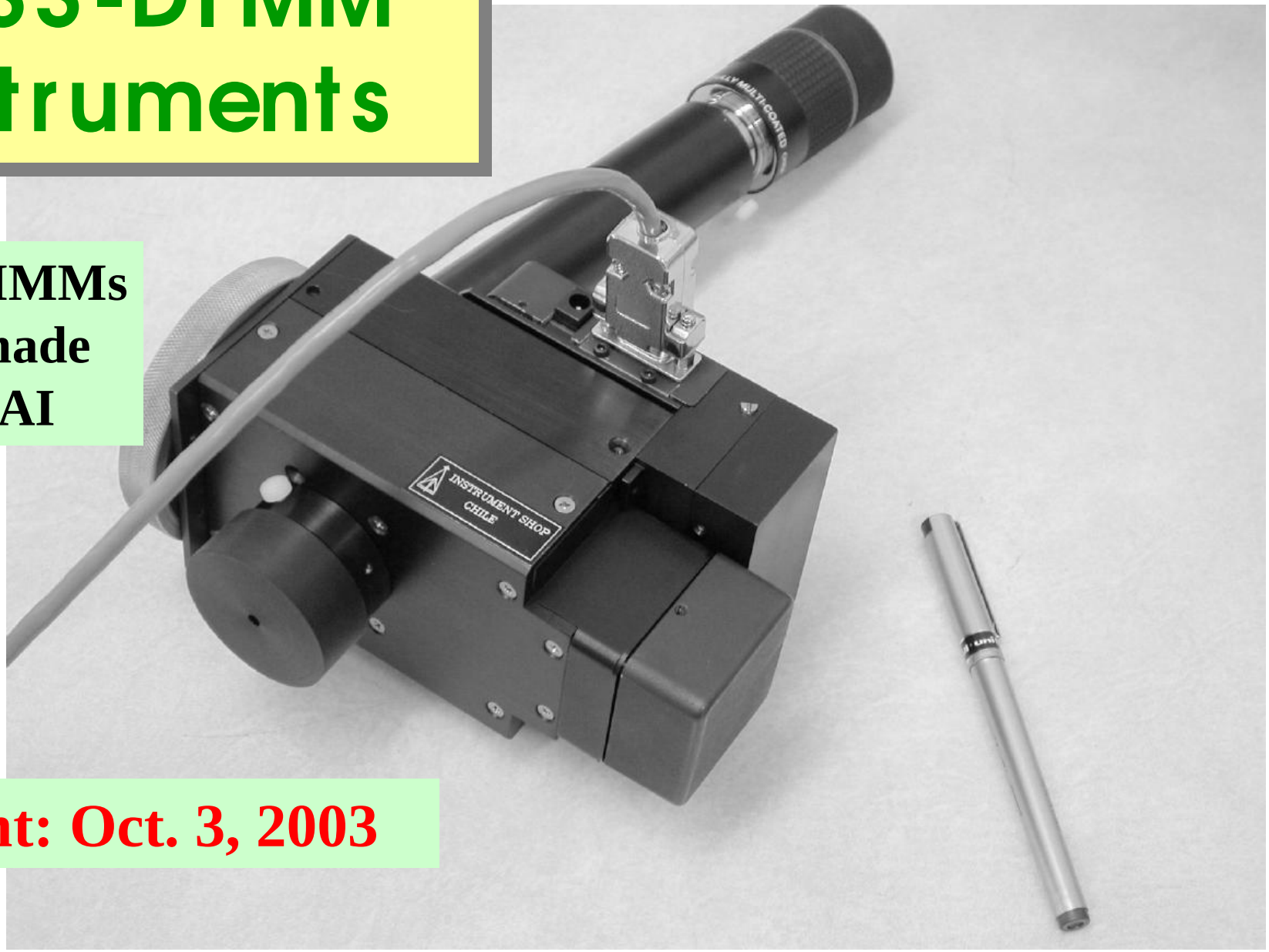
Ground layer: combine with DIMM!





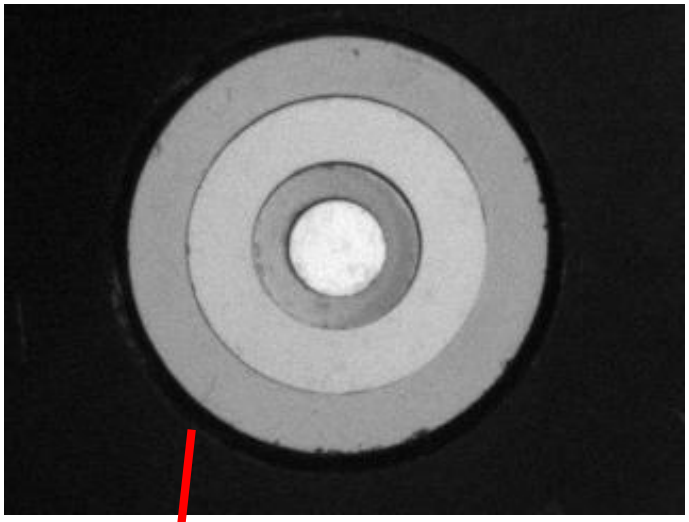
MASS-DIMM instruments

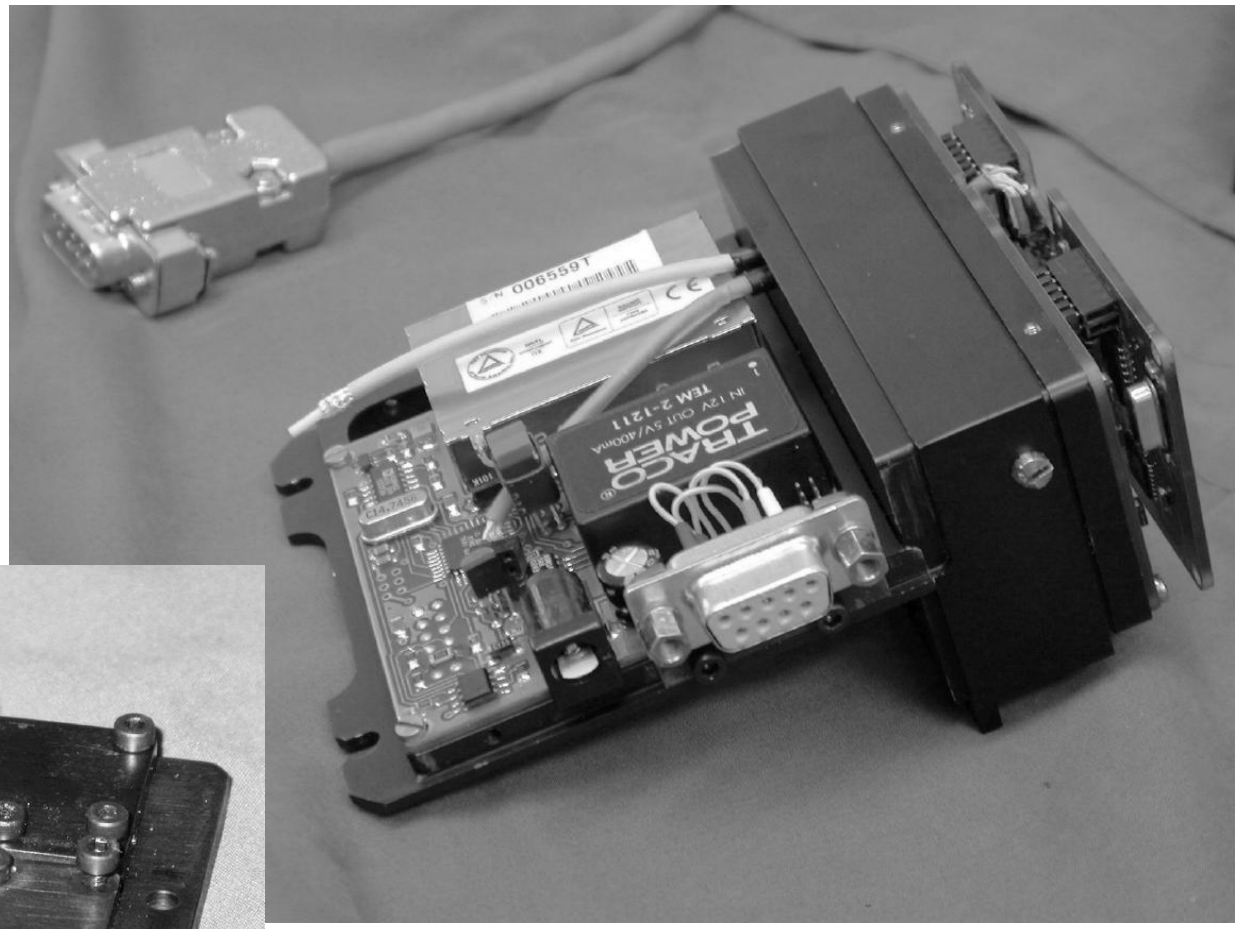
9 MASS-DIMMs are being made at CTIO+SAI

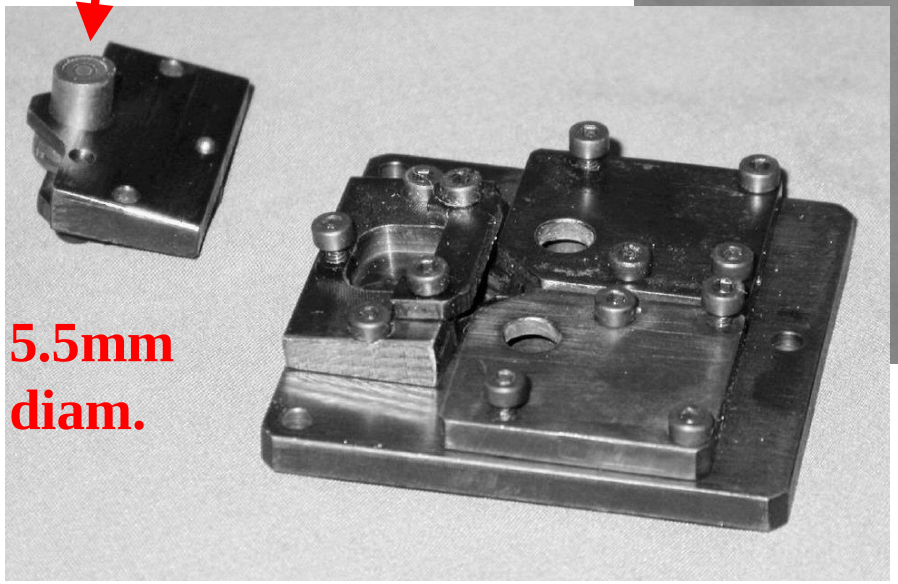


First light: Oct. 3, 2003

MASS-DIMM: details







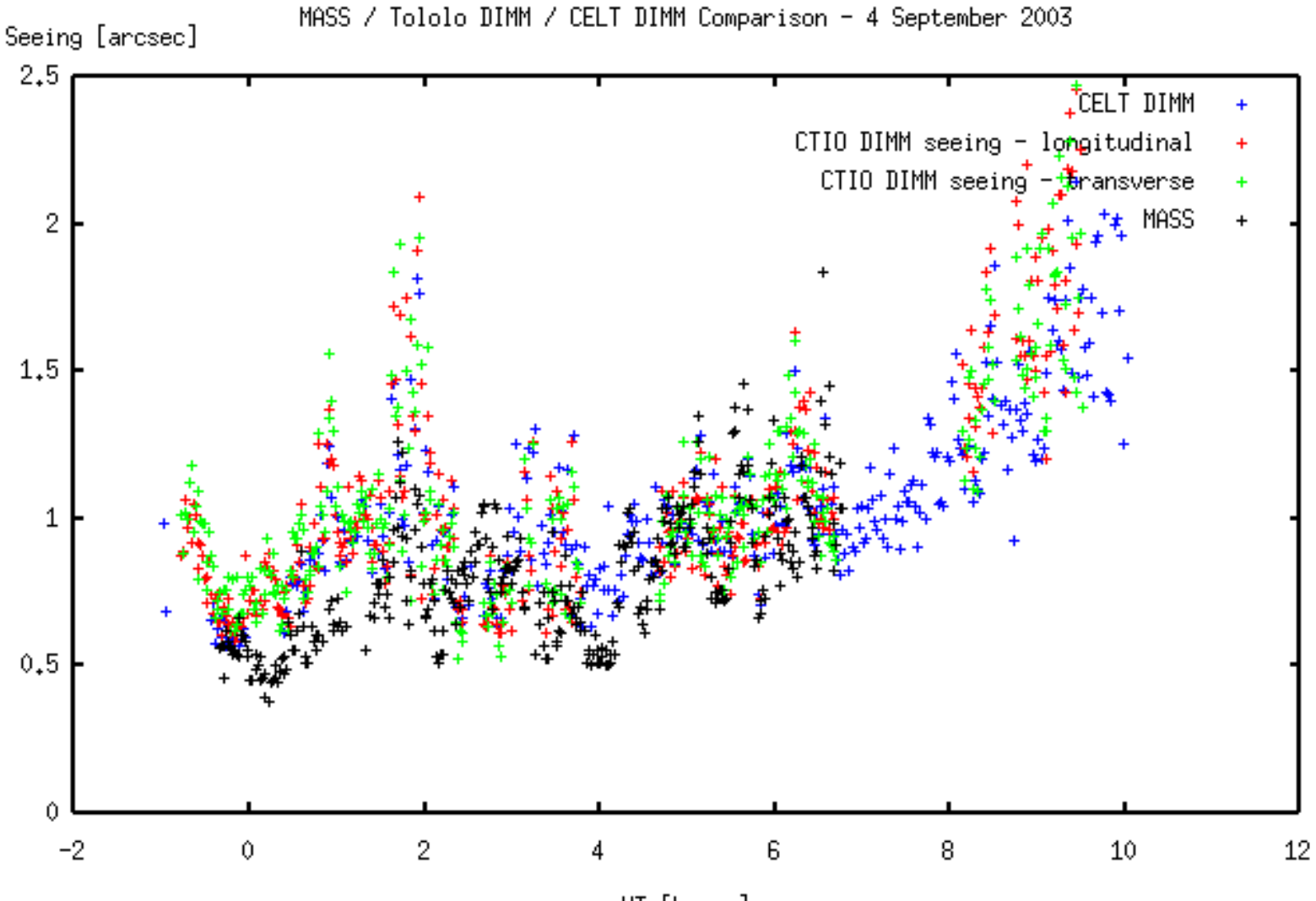
Measured parameters

- **Seeing ß (Fried parameter)**
- **Free-atmosphere seeing $ß_f$**
- **Isoplanatic angle $?_0$**
- **AO time constant t_0 (without ground layer, but…)**
- **Low-resolution profile: 6 layers at 0.5,1,2,4,8,16km**

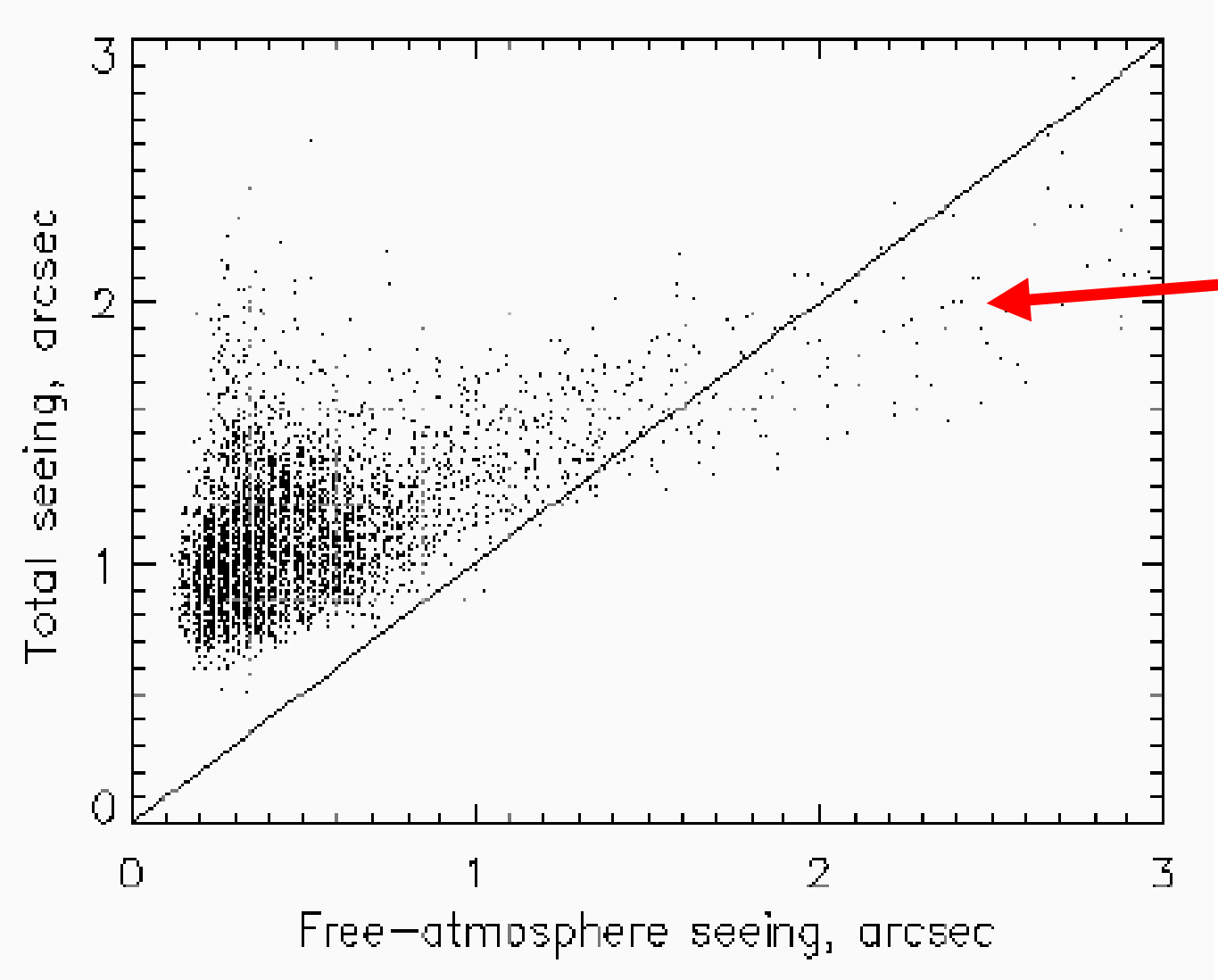
NOT MEASURED: Outer scale, detailed profile, wind

MASS database: http://mass.ctio.noao.edu

MASS vs. DIMM: Halfmann

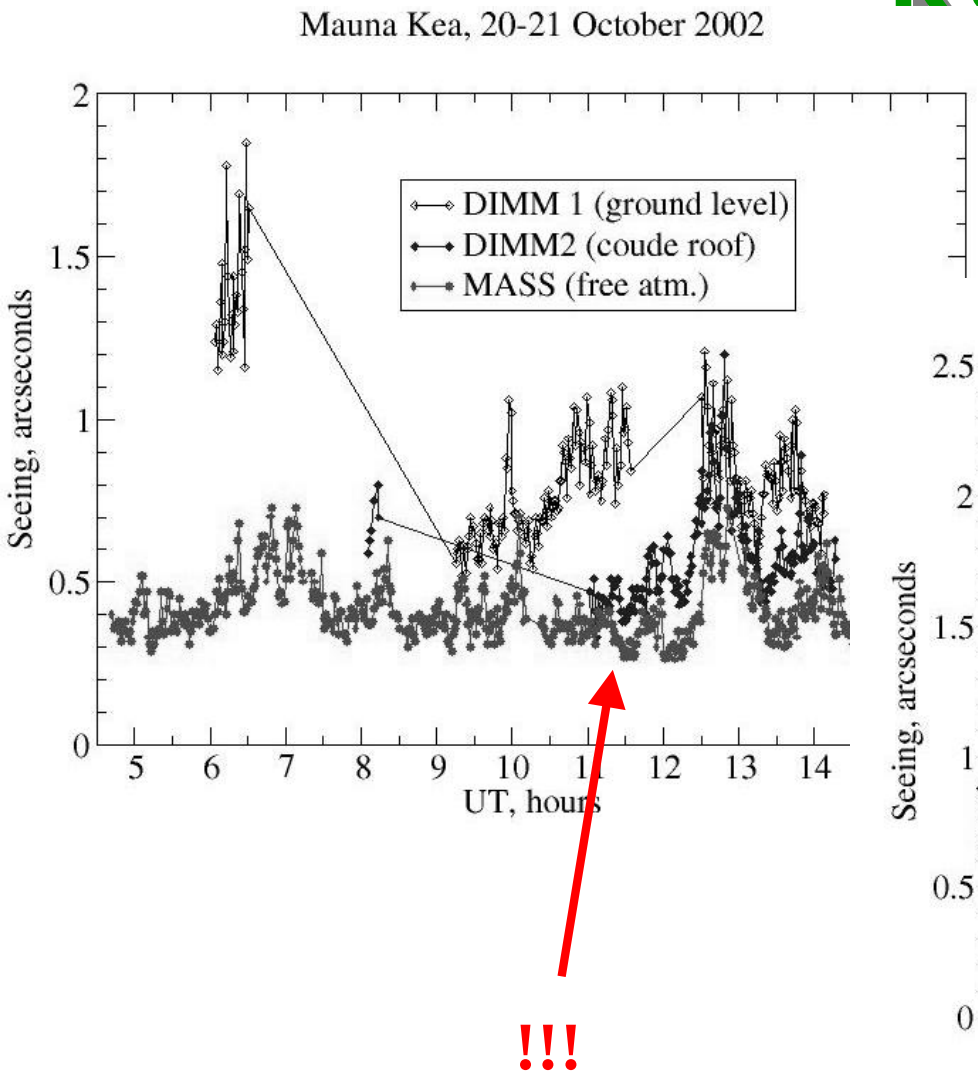


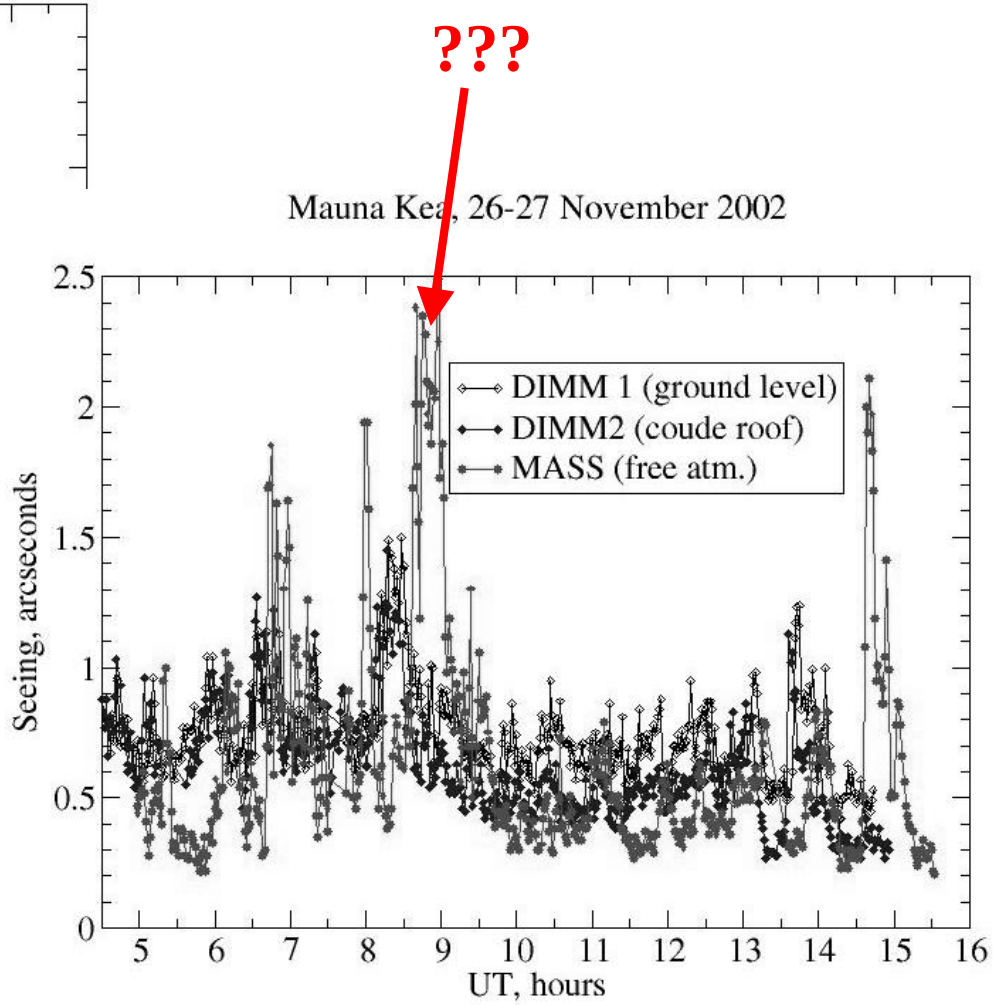
MASS vs. DIMM: Cerro Pachon



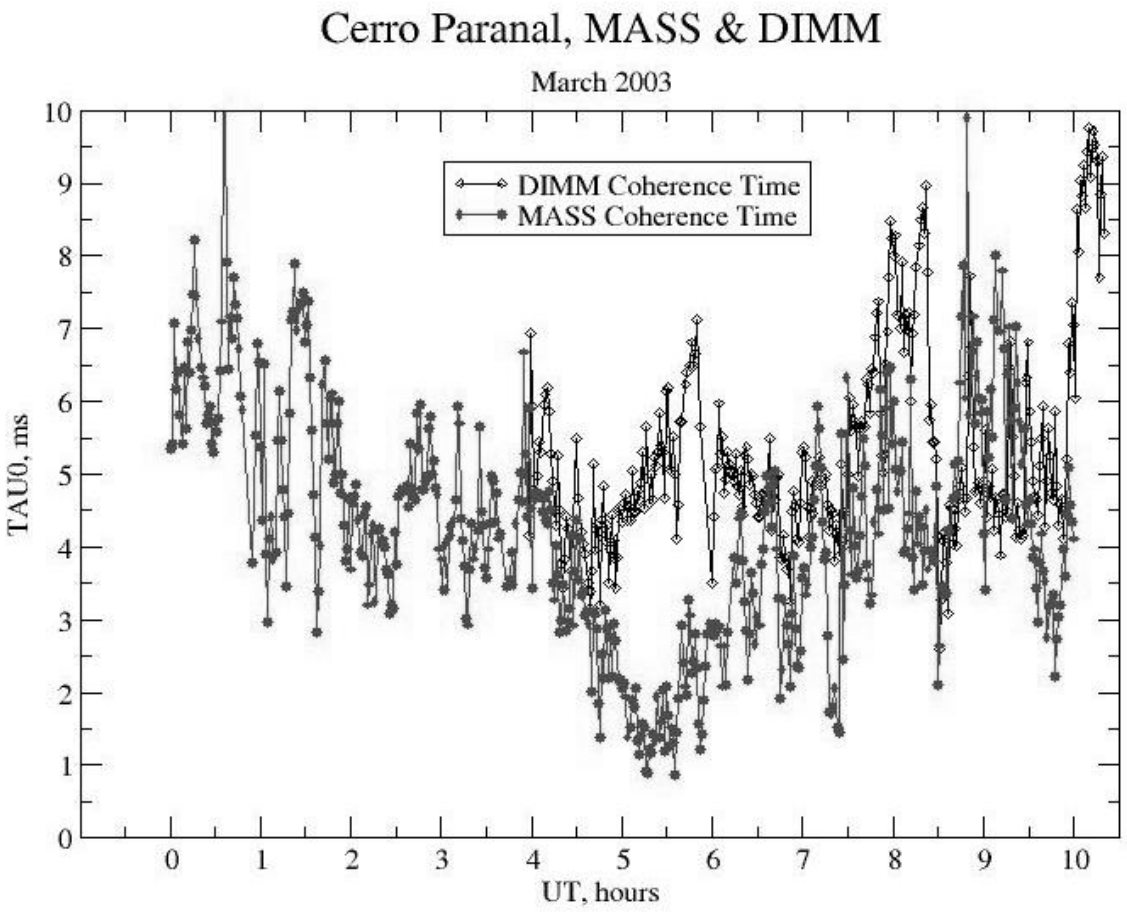
MASS "over-shoots"?

MASS vs. DIMM: Mauna Kea



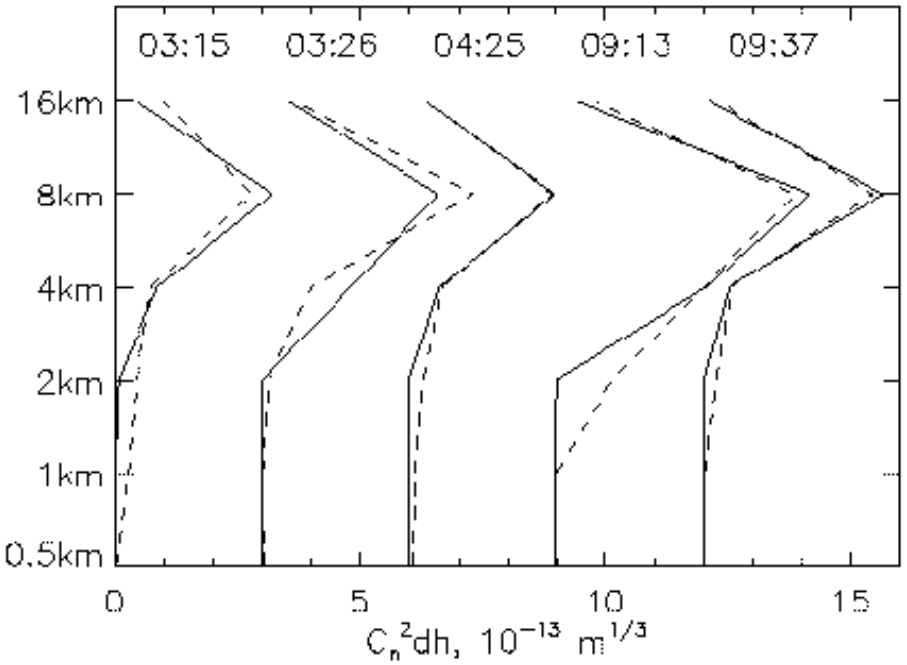


Comparing t_0 (Paranal)

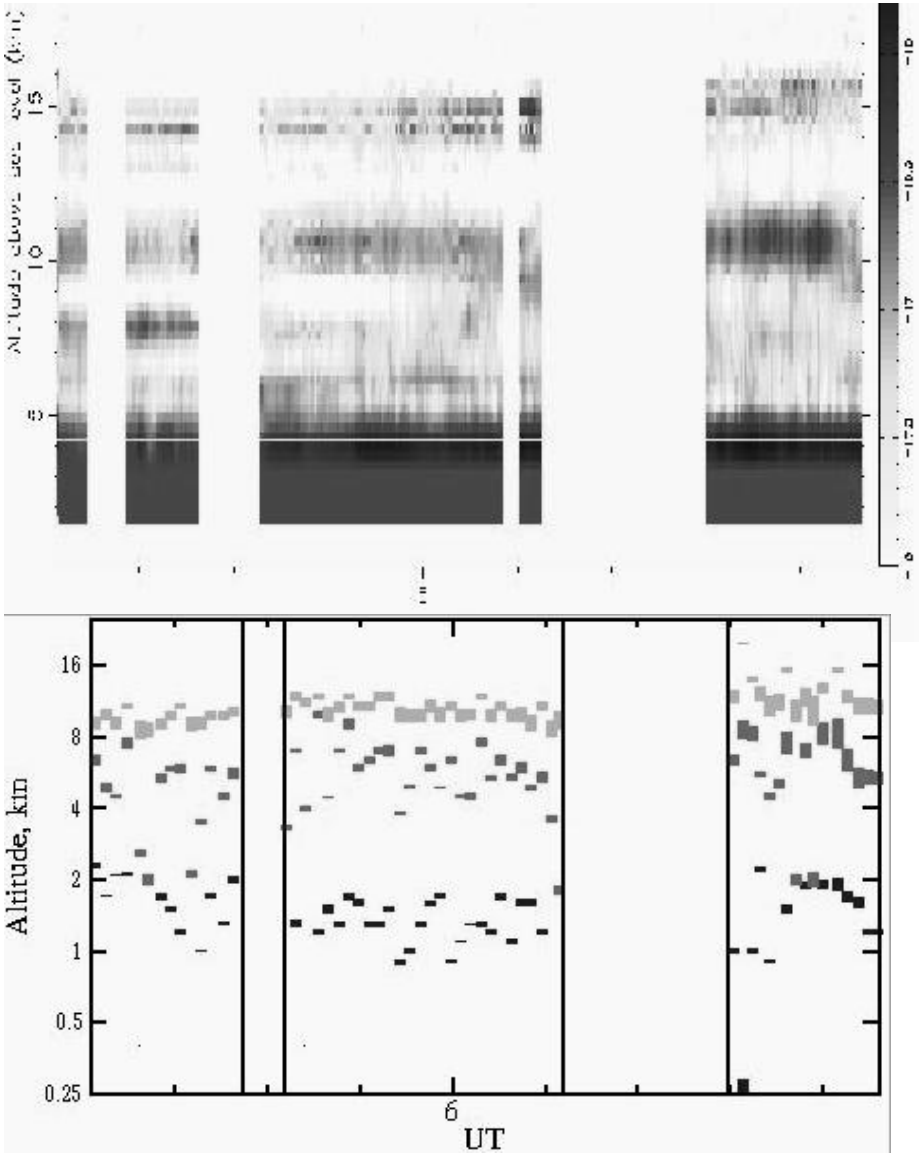


MASS vs. SCIDAR

Mauna Kea, 2002

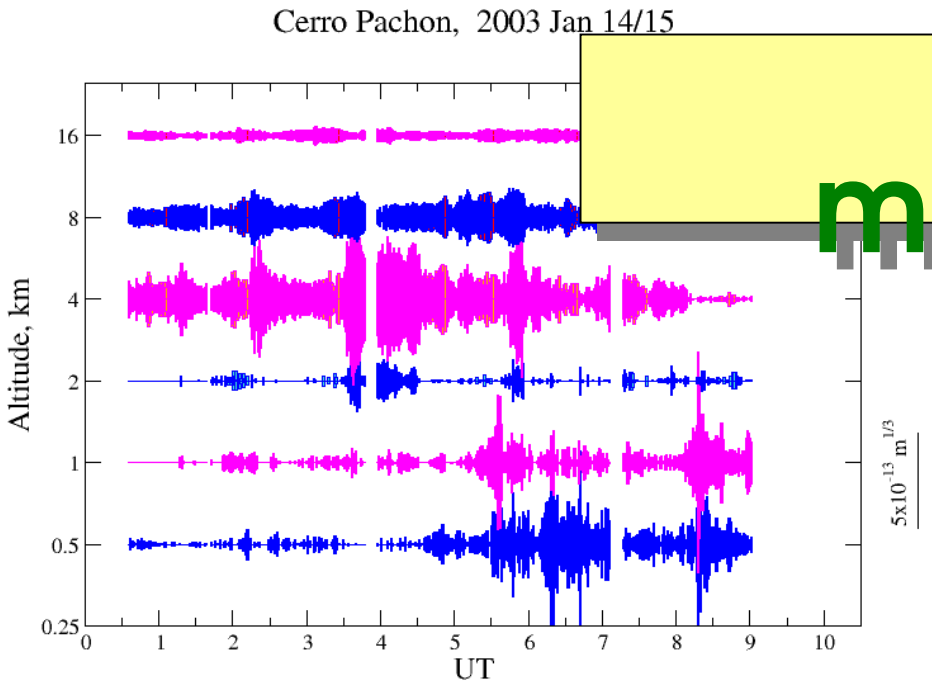


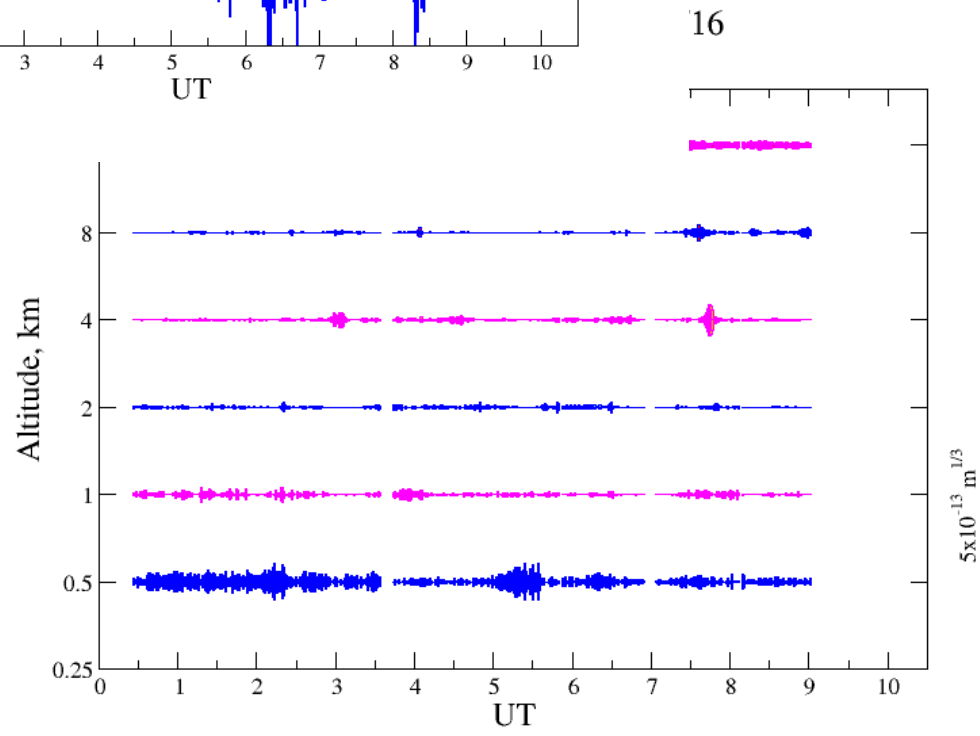
La Silla, 2002



More comparisons are needed!

Profile meteorology?

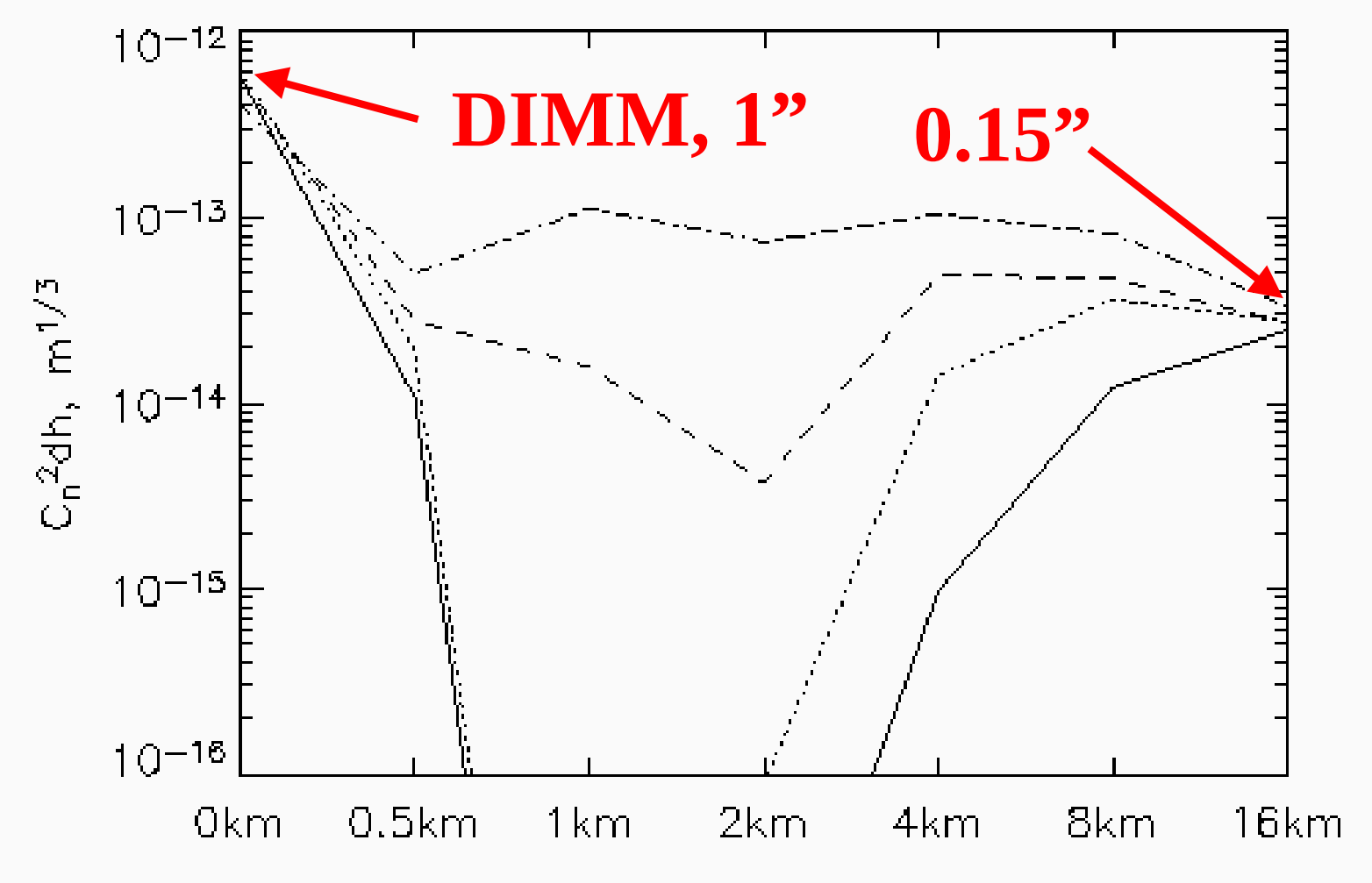




- Bursts < 1h
- Calm periods ("lucky observer")
- Jet-stream (prediction?)
- Upper layers > 0.1" always
- Fragility of good seeing

Cerro Pachon MASS profiles

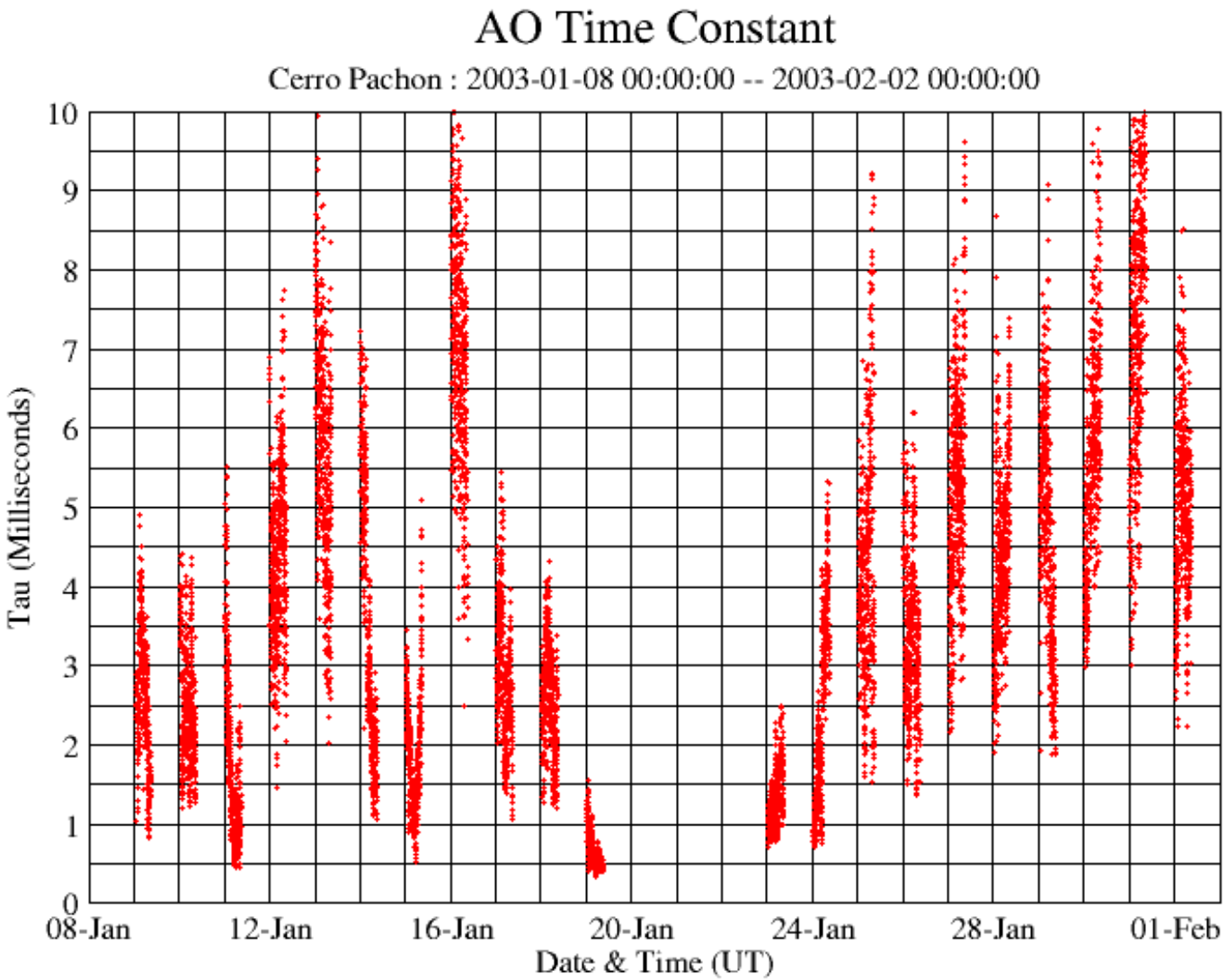
- January 8-31, 2003
- 4234 profiles



Free-atmosph. seeing

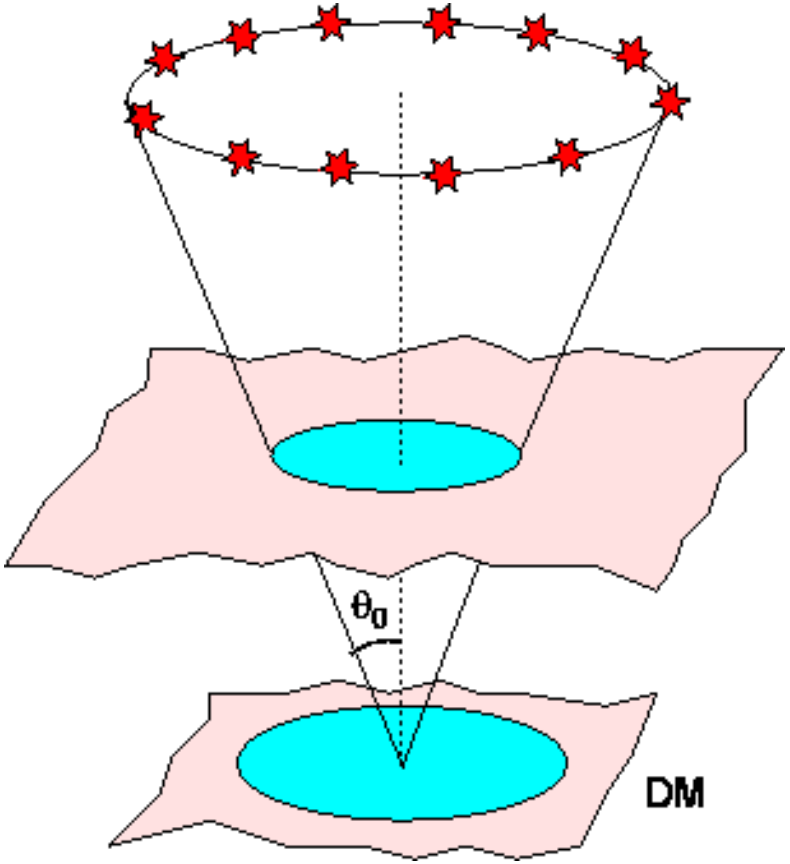
0.245”
0.356”
0.518”
0.90”

Statistics of AO time constant



Some nights are good for AO, some are not!

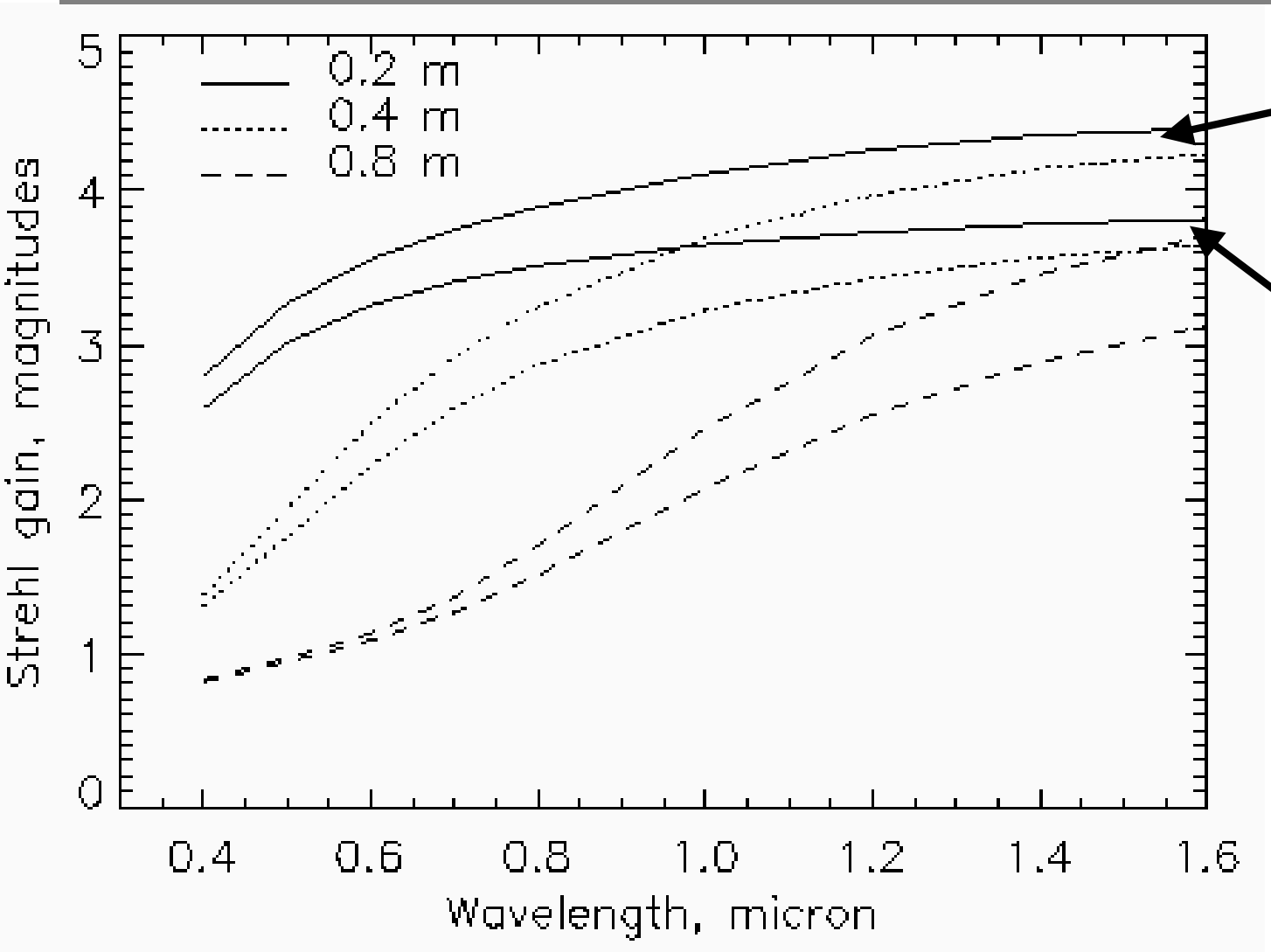
Ground-layer Adaptive Optics



3’ * 1km = 0.9m

Profile vertical resolution required for GLAO analysis depends on system parameters

GLAO: Strehl gain vs. actuator pitch

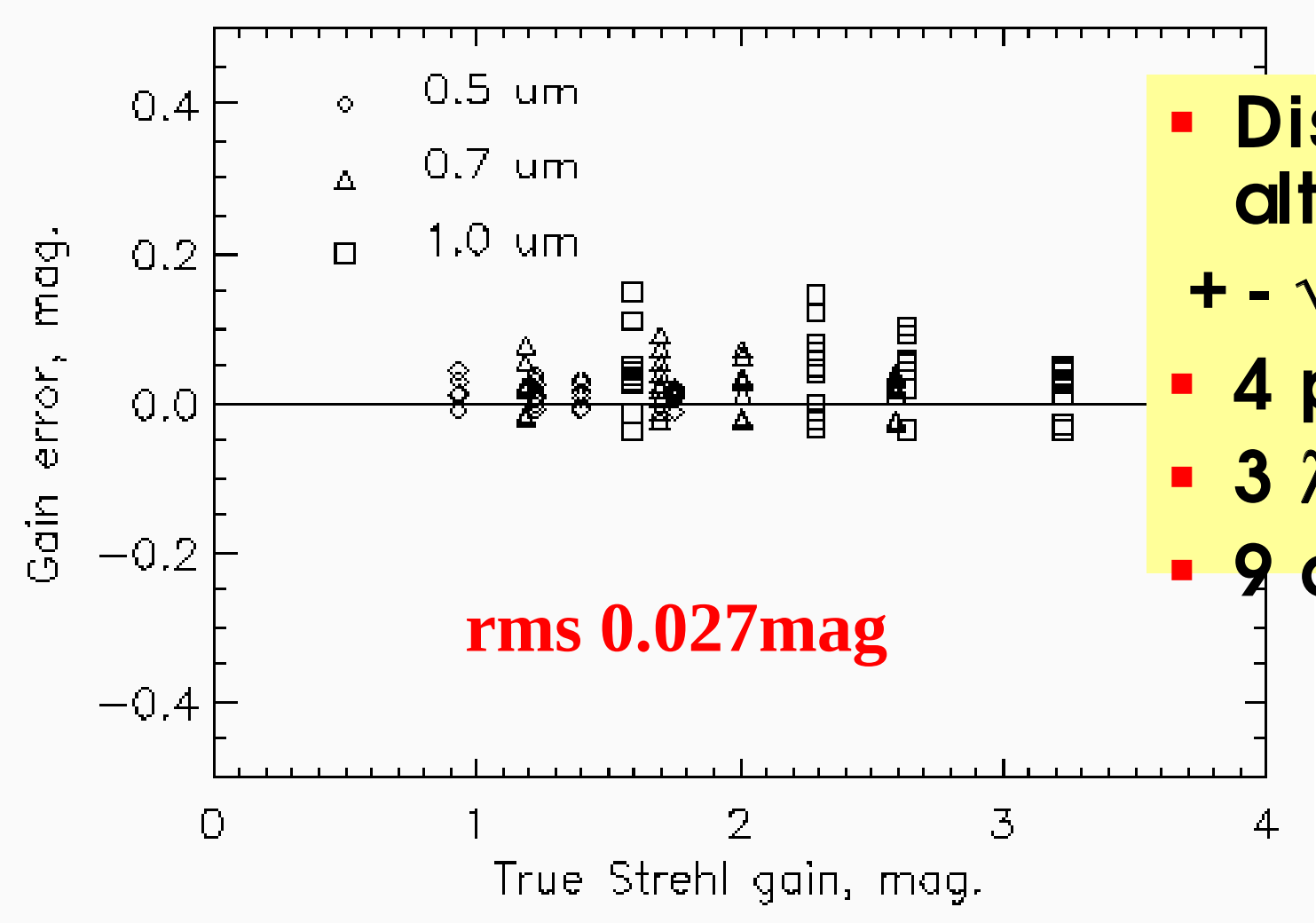


Optimized GLAO

Rayleigh LGS

Good nights at Pachon

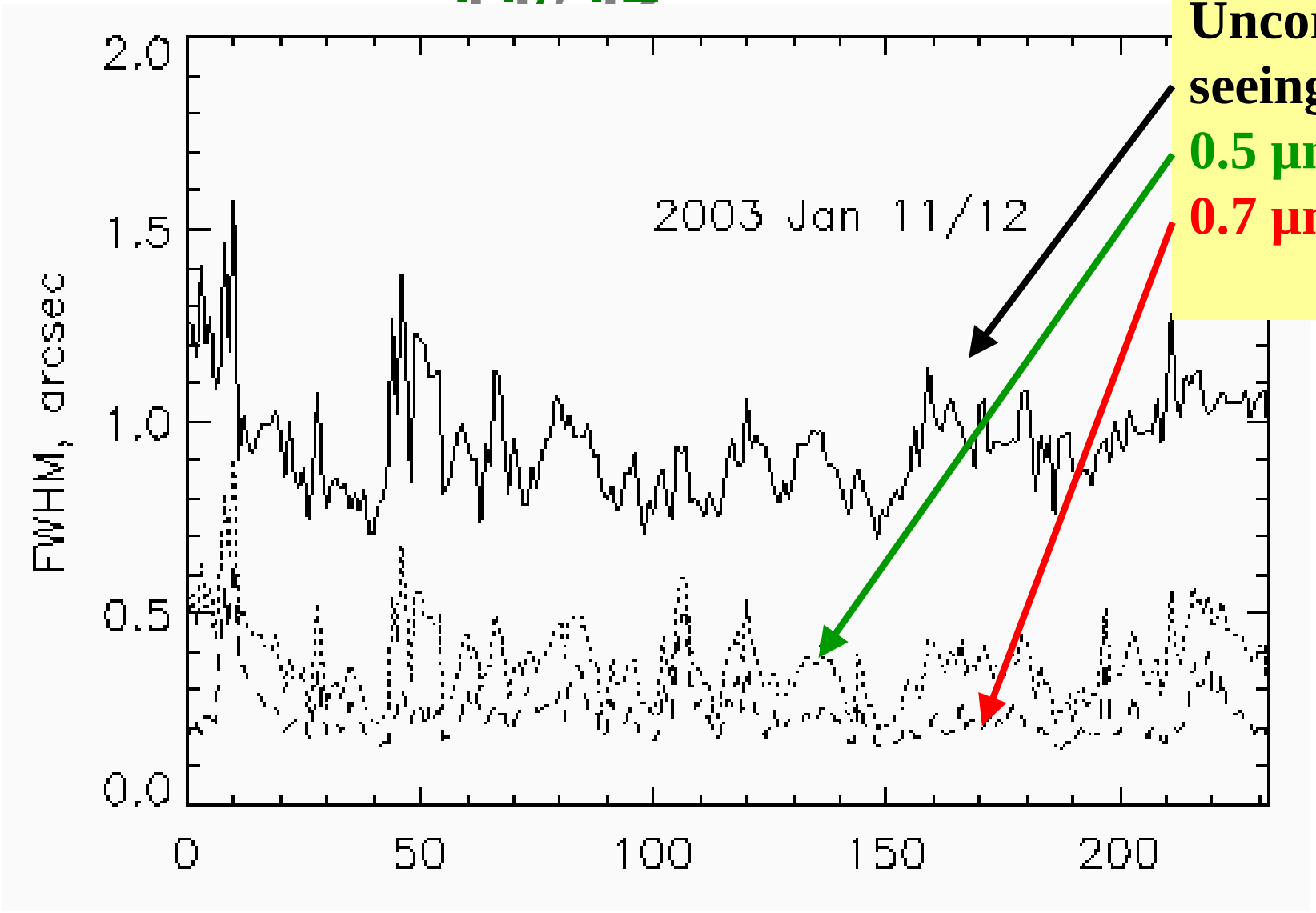
Is the MASS resolution sufficient?



- Distort altitudes
  + - √2 random
- 4 profiles
- 3 λs
- 9 distortions

Coarse layer localization with MASS is OK for GLAO

Typical night: Jan 11/12

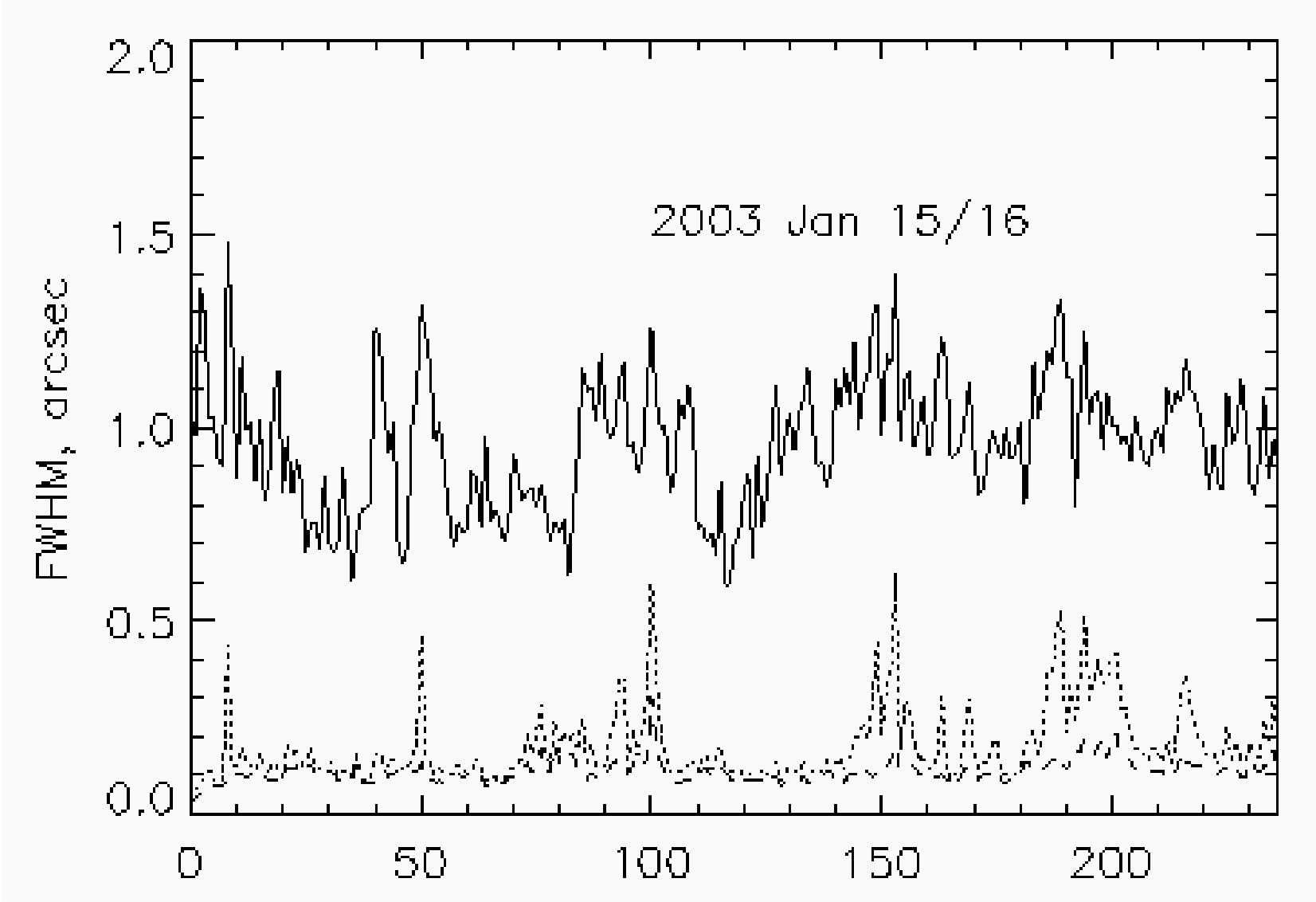


Uncorrected seeing

0.5 µm GLAO

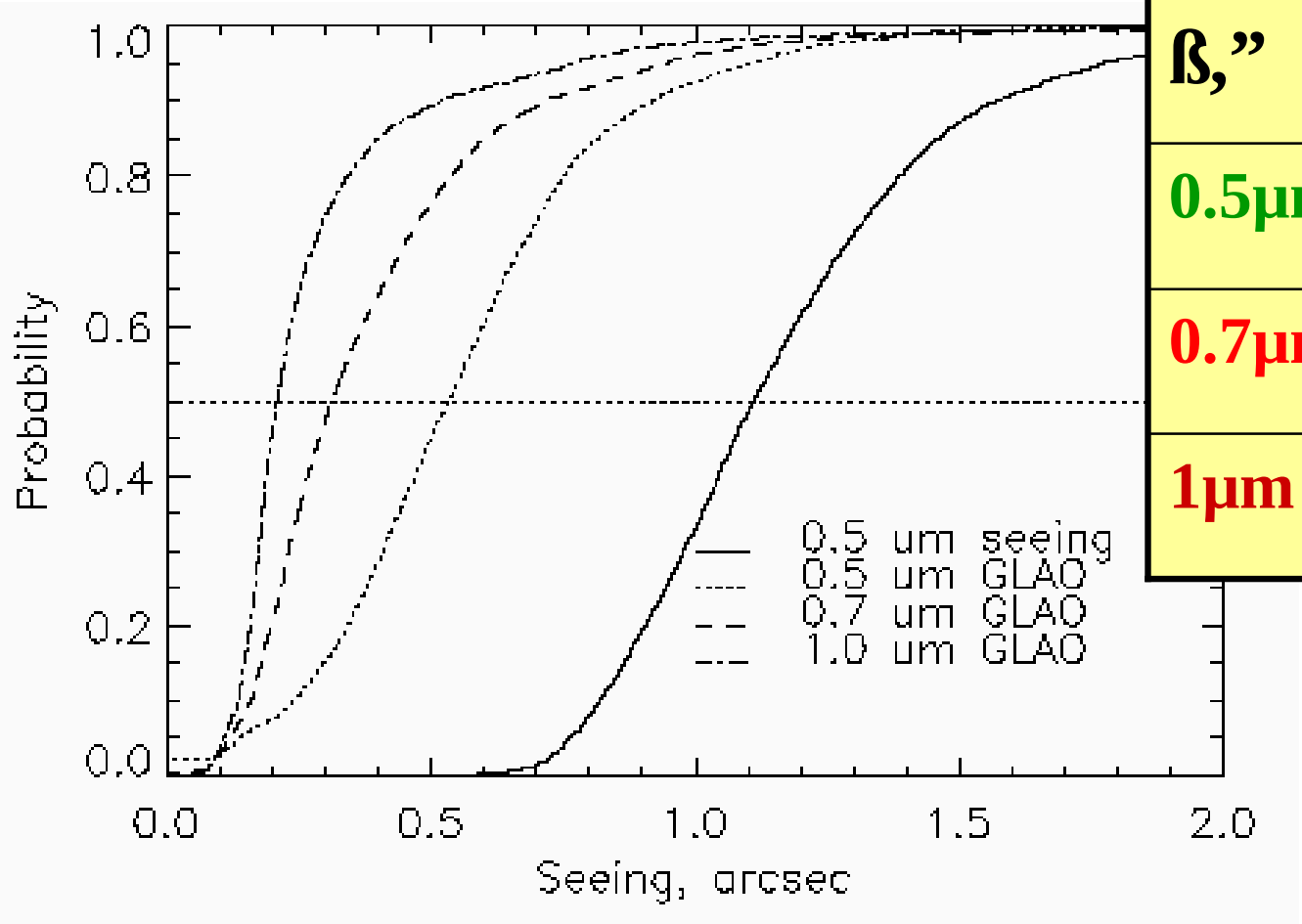
0.7 µm GLAO

Excellent night: Jan 15/16



Seeing
0.5 µm
0.7 µm

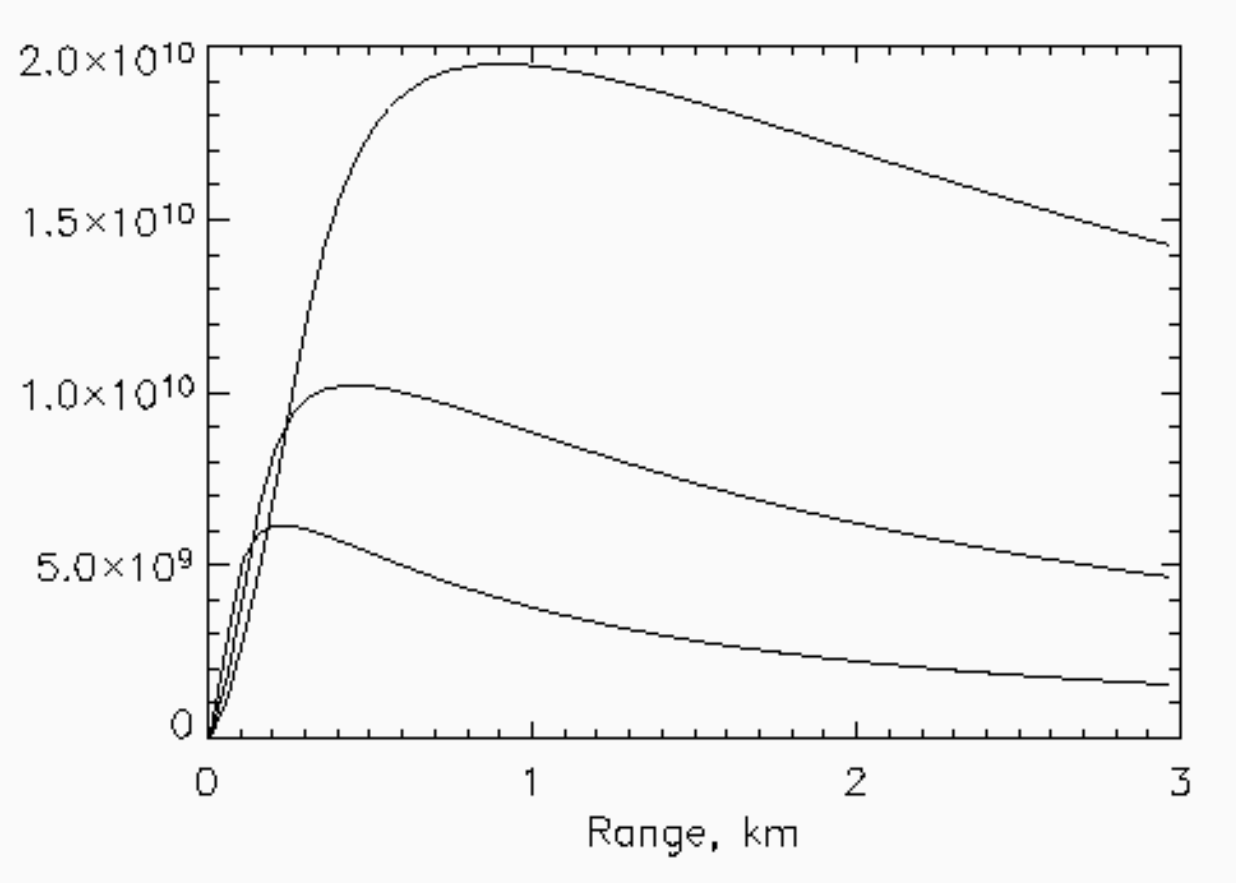
Statistics: FWHM



	25%	50%	75%
ß,"	**0.94**	**1.11**	**1.33**
0.5µm	**0.38**	**0.53**	**0.71**
0.7µm	**0.22**	**0.31**	**0.49**
1µm	**0.17**	**0.22**	**0.30**

[arcseconds]

The first kilometer: mini-MASS?



- **Star V_{mag}=1**

30 phot/ms

- **Layer 0.3" at alt. 200m:**

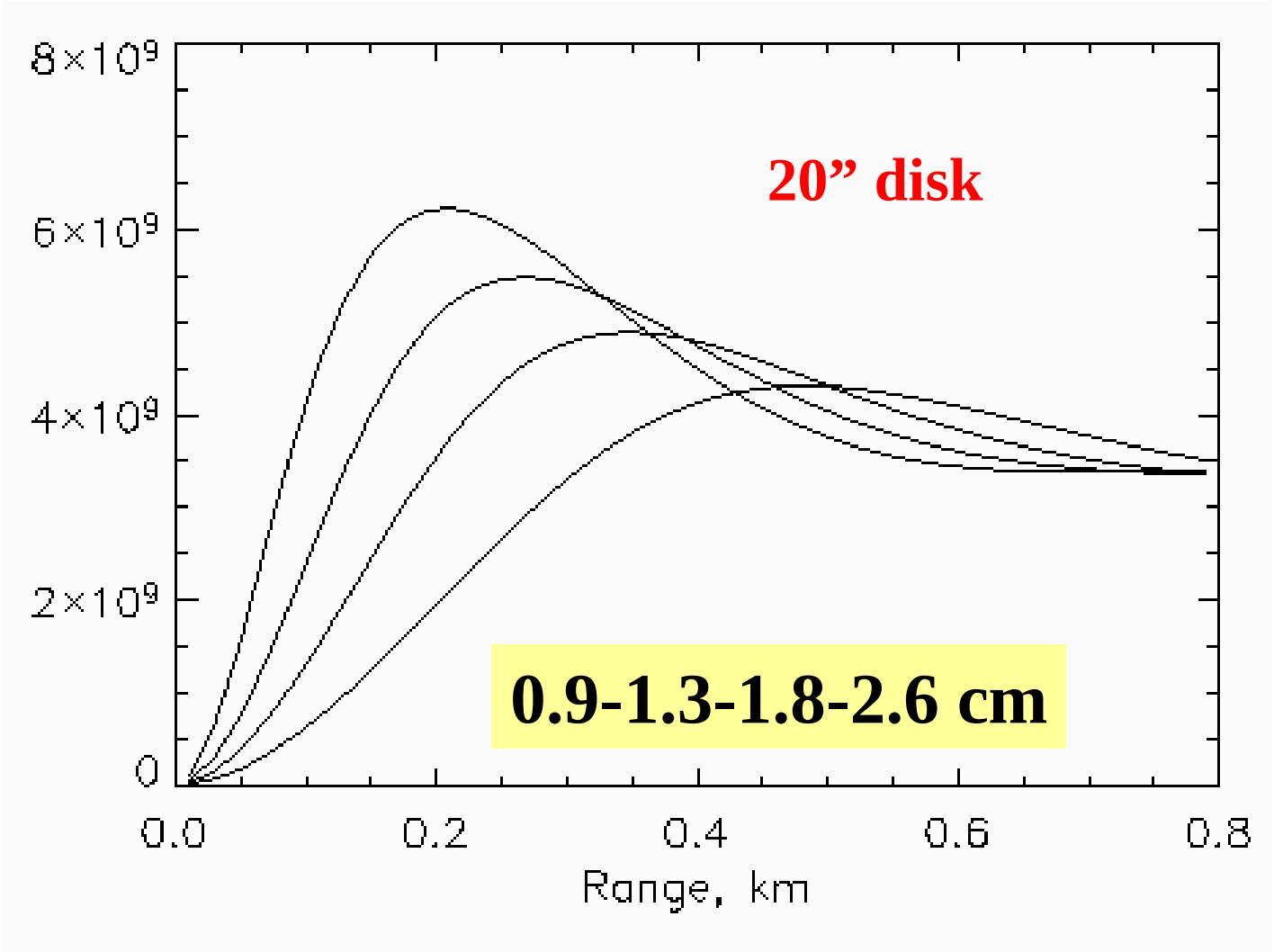
0.0005 index

- **S/N=10**

in 10 min.

0.9-1.3-1.8-2.6 cm

Planet scintillation? Yes!



Scintillation of MARS:

Oct. 8-9, 2003

Index ~0.0001

Rel. precision 3-4% in 1 min

Plans

- **Use MASS-DIMMs in the TMT site testing program, as site monitors, at Dome C**
- **Compare to SCIDAR, SODAR**
- **Build and use profile database**
- **Planet scintillation…**

Bye!