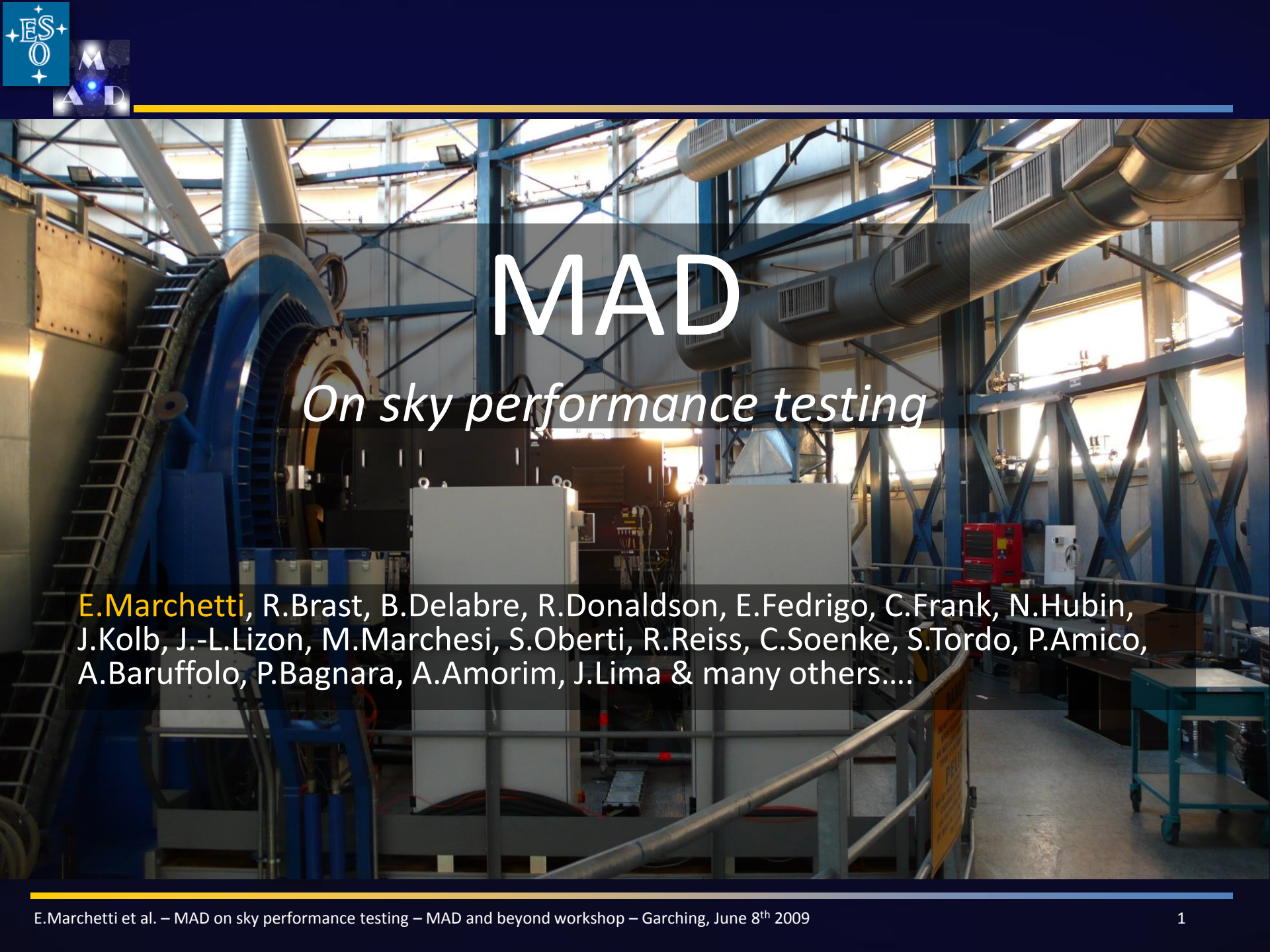


# MAD

## *On sky performance testing*

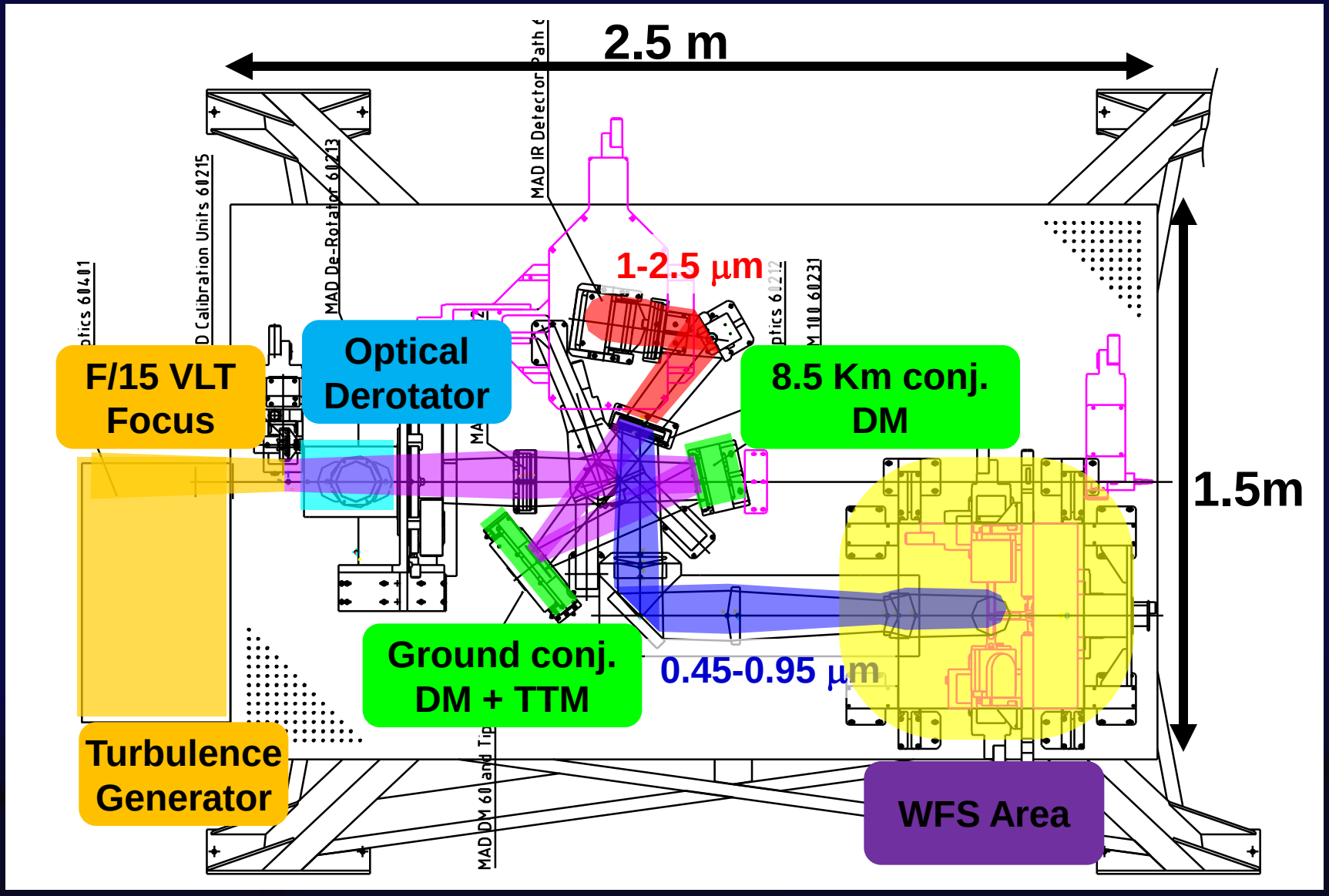
E.Marchetti, R.Brast, B.Delabre, R.Donaldson, E.Fedrigo, C.Frank, N.Hubin, J.Kolb, J.-L.Lizon, M.Marchesi, S.Oberti, R.Reiss, C.Soenke, S.Tordo, P.Amico, A.Baruffolo, P.Bagnara, A.Amorim, J.Lima & many others….

# The MAD experience

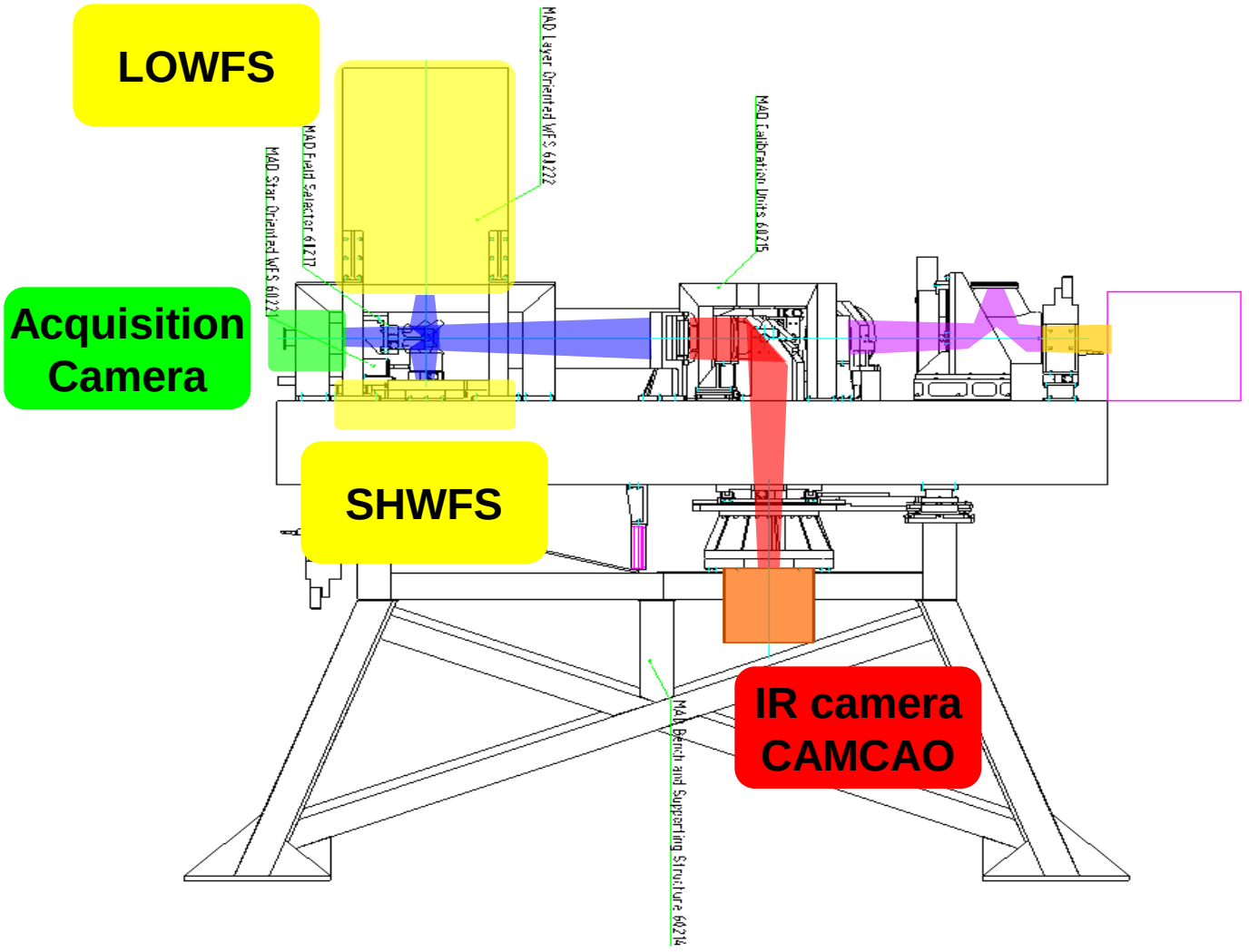
- Multi-Conjugate Adaptive Optics (MCAO) prototype demonstrator to validate of MCAO correction techniques in the framework of future VLT instrumentation and ELTs
- MAD Shack-Hartmann system: wavefront sensing on 3 Natural Guide Stars in 2 arcmin FoV (Natural Guide Stars)
- Correcting with 2 deformable mirrors (0 & 8.5 Km)
- IR camera imager CAMCAO (U.Lisboa - Portugal)
- Multi-Pyramid wavefront sensor (see R.Ragazzoni)

- Installed at Melipal's Nasmyth platform (Feb'07)
- Three science demonstration runs (Nov'07-Jan'08-Aug'08)

# MAD overview

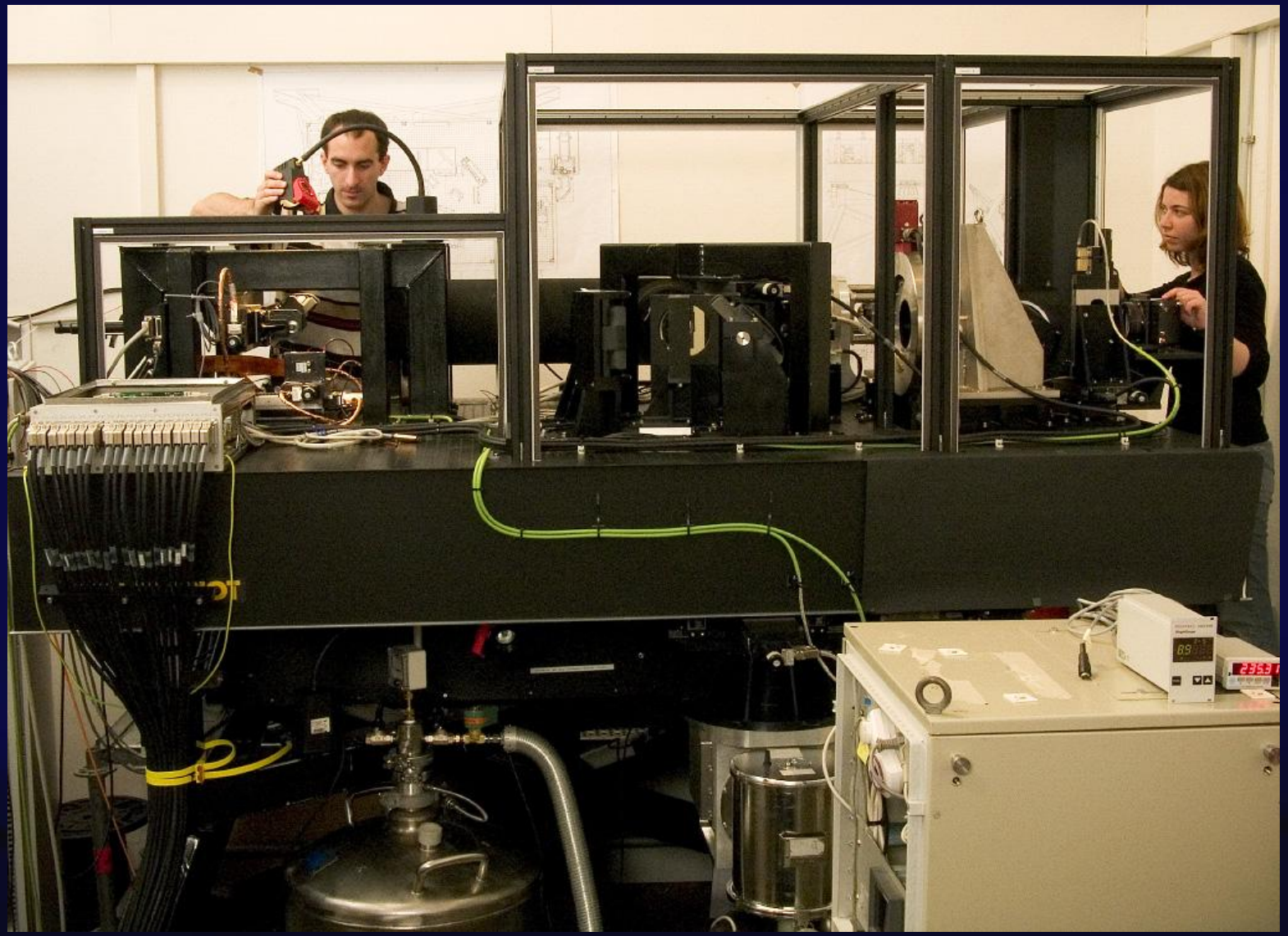


# MAD overview

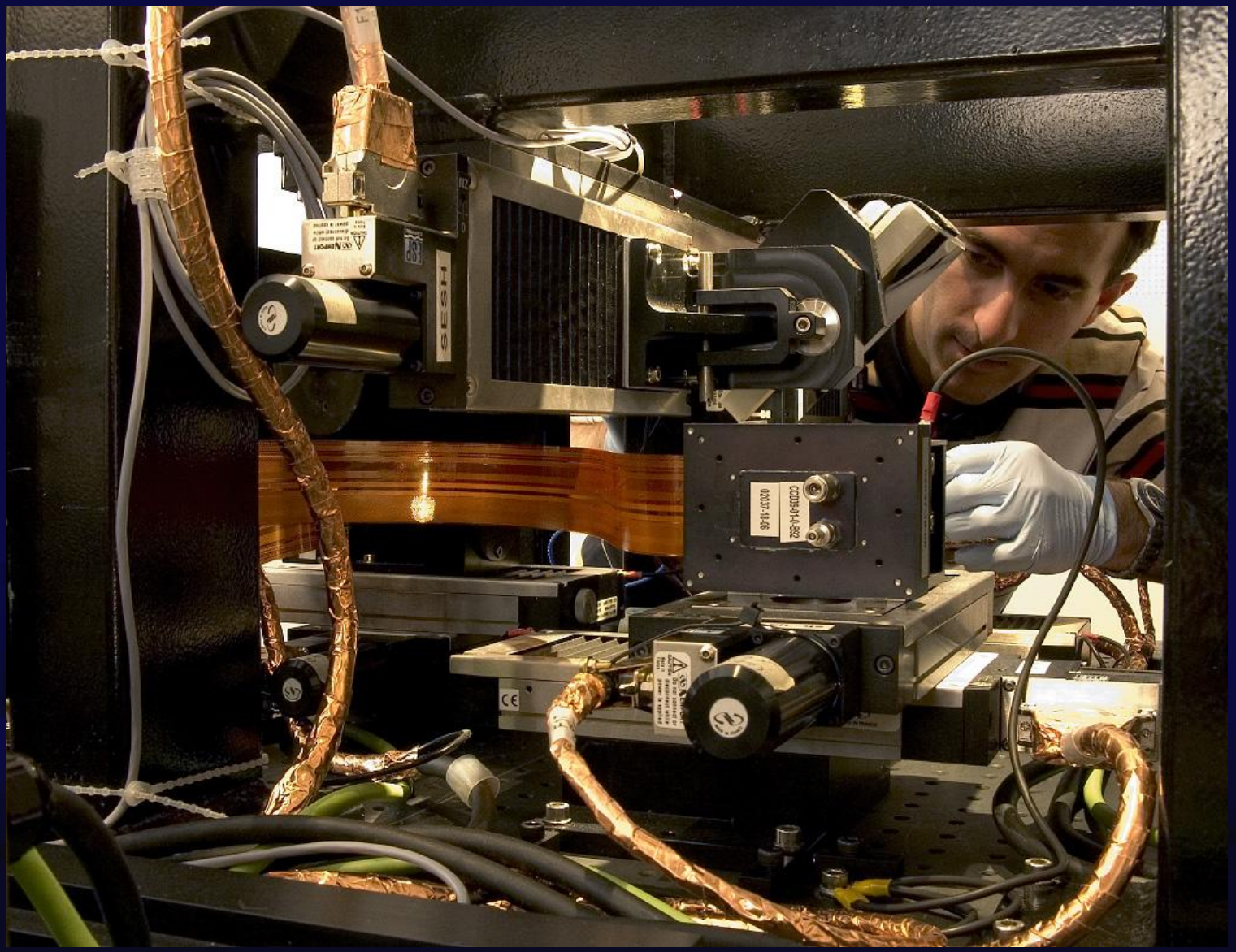


# MAD overview

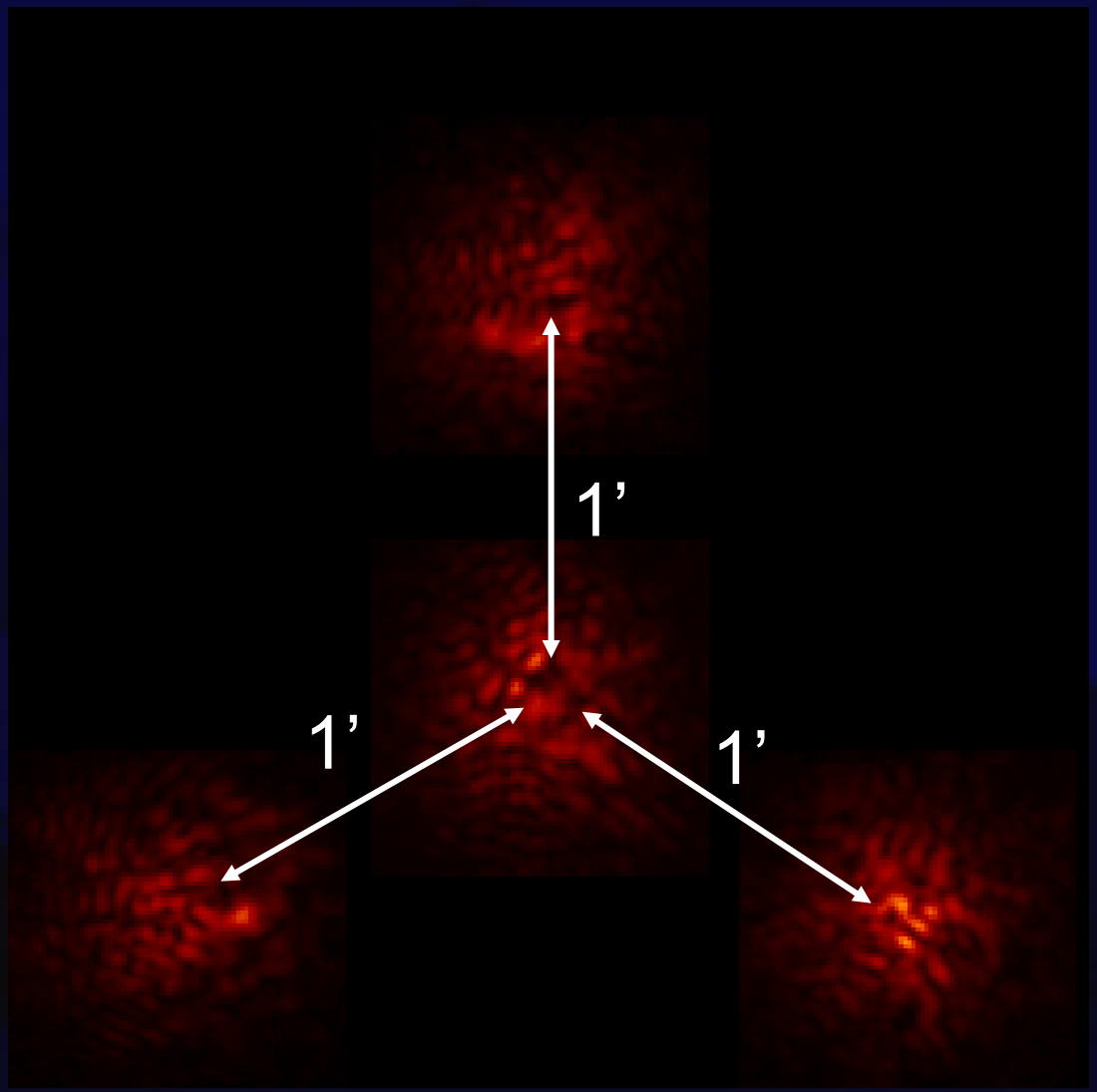
# MAD at ESO premises



# Shack-Hartmann wavefront sensors

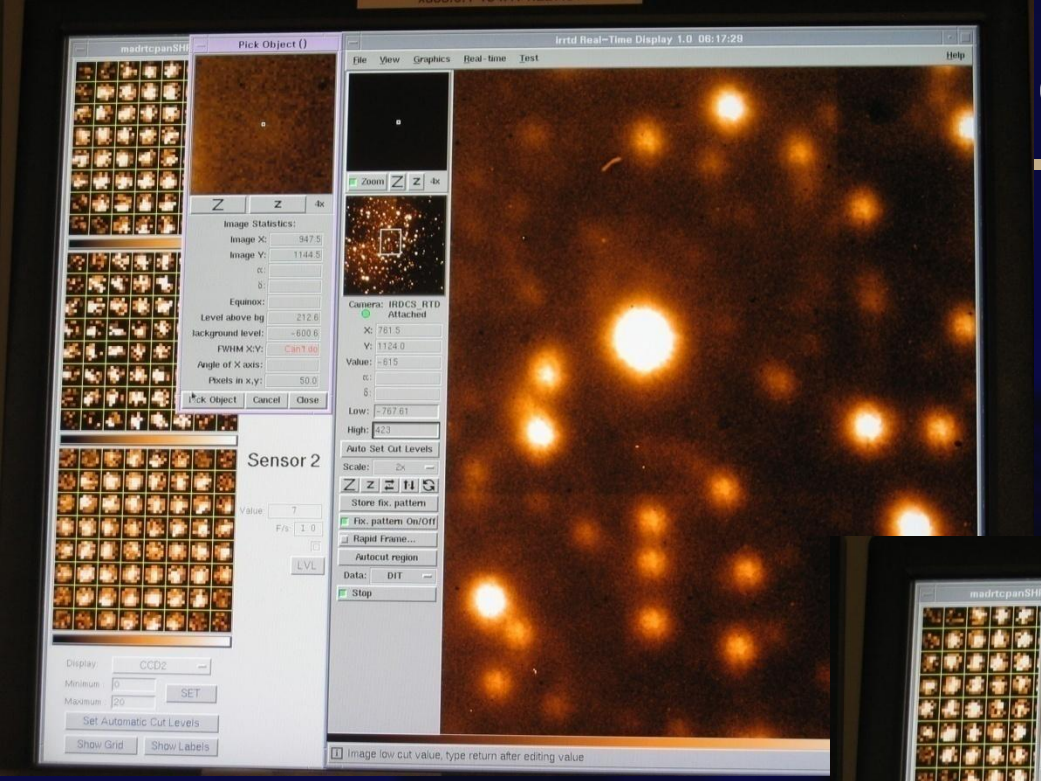


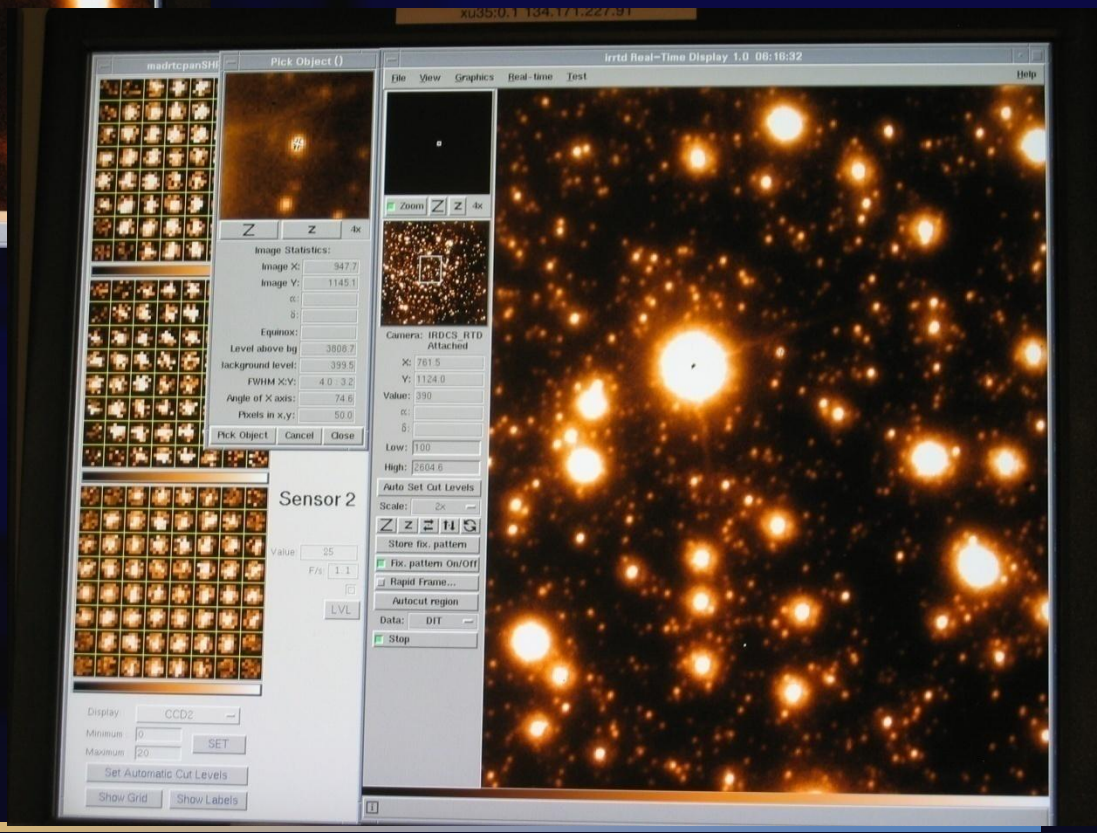
# MAD MCAO first closed loop in the lab



# MAD at Paranal

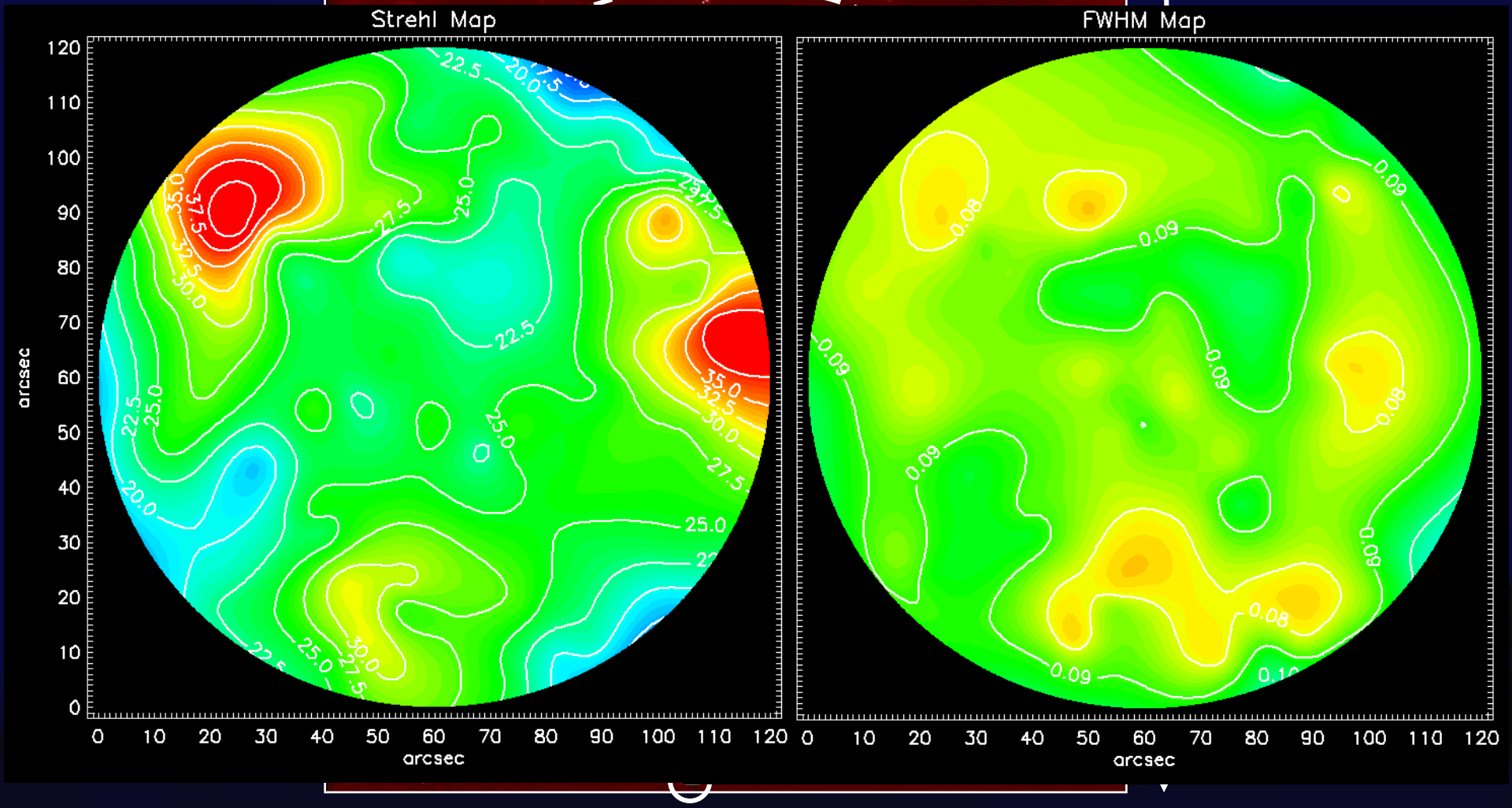
# Closing the MCAO loop…



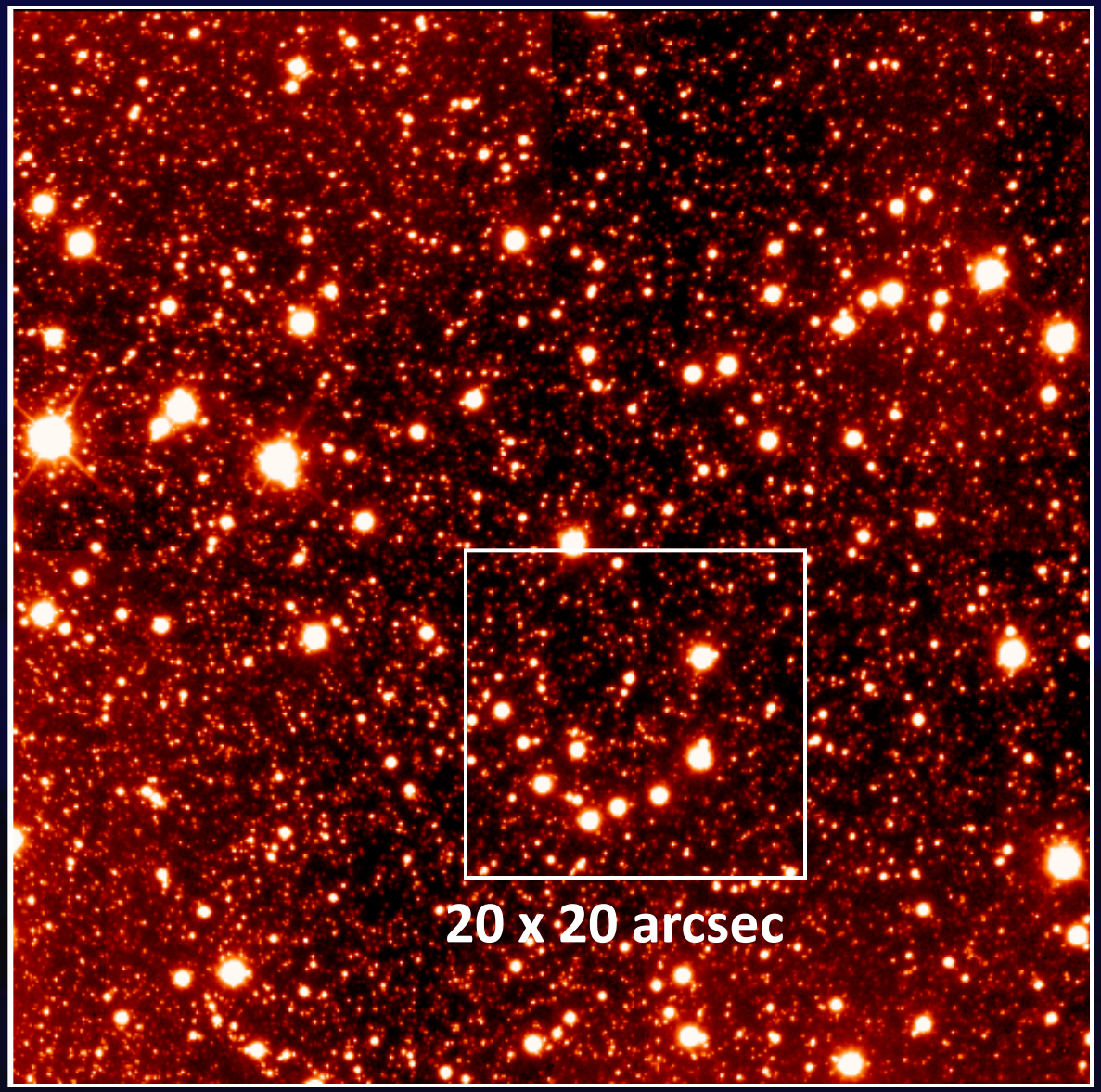
# MAD MCAO first light

# MAD MCAO first light



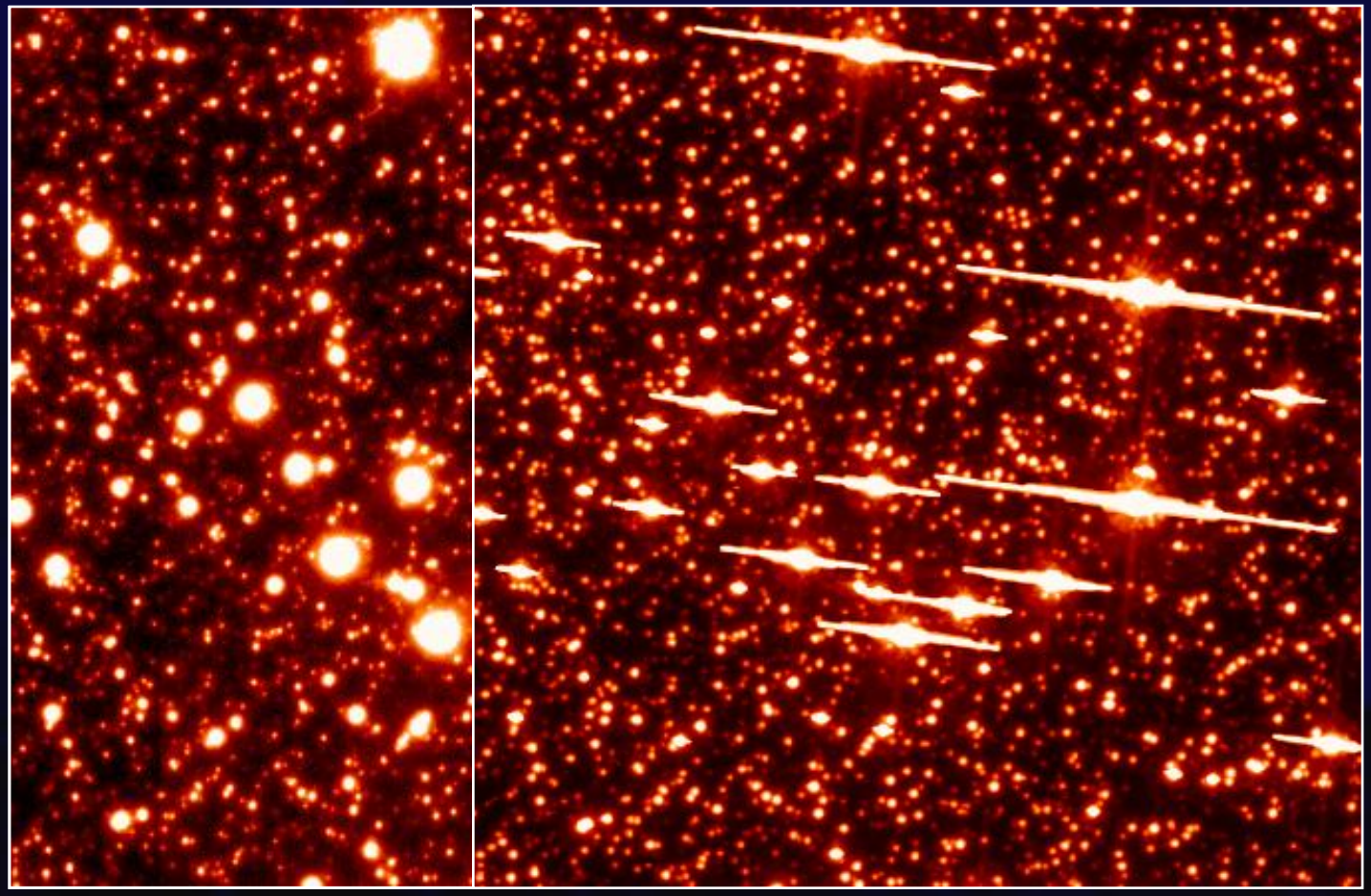
# Omega Centauri

$T_{exp}$[Ks]: 600s
FWHM: 100mas
K~20.5
DIMM: 0.69”



# Omega Centauri

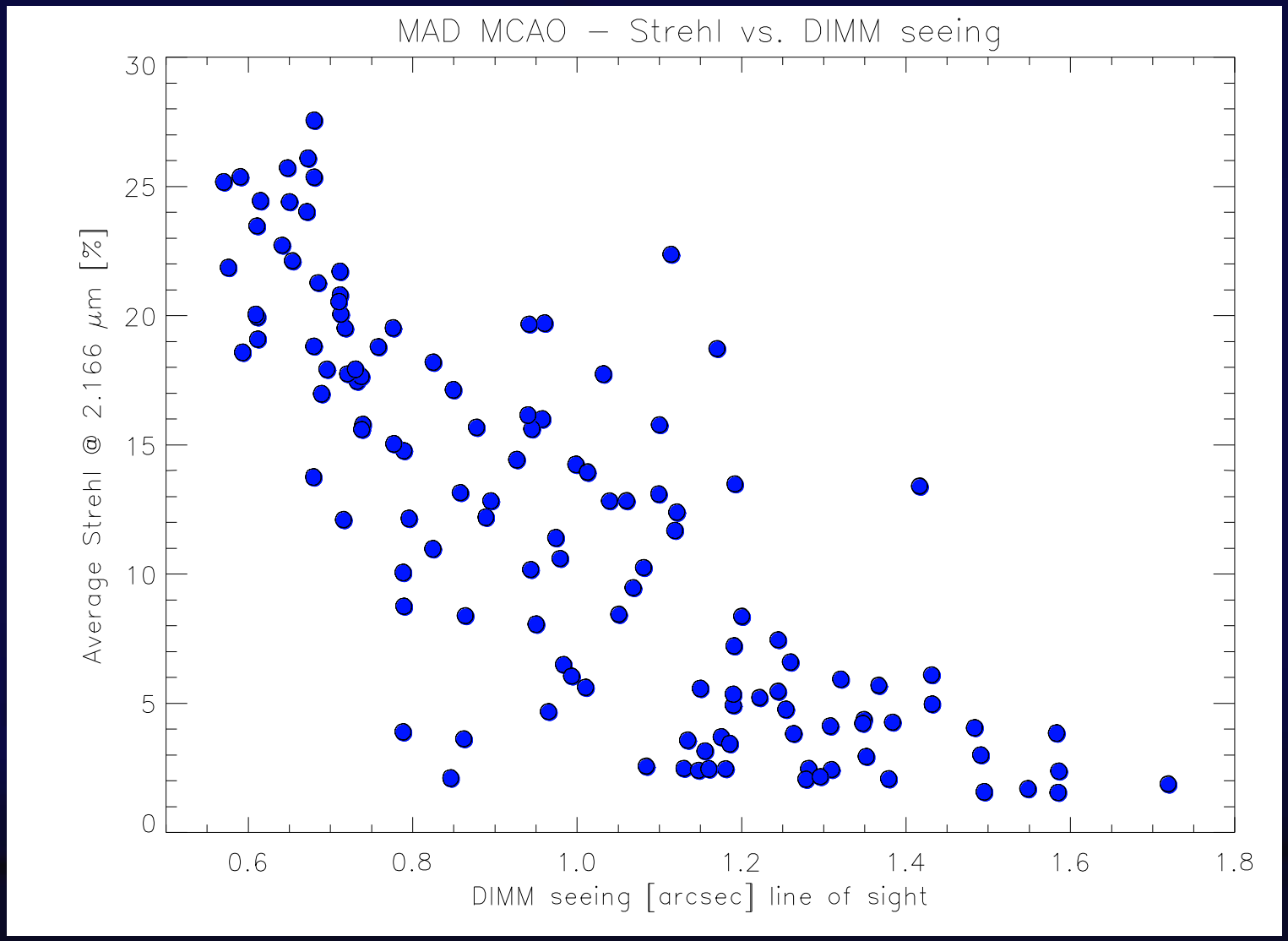
**Guide stars @ 60”** 20” x 20”



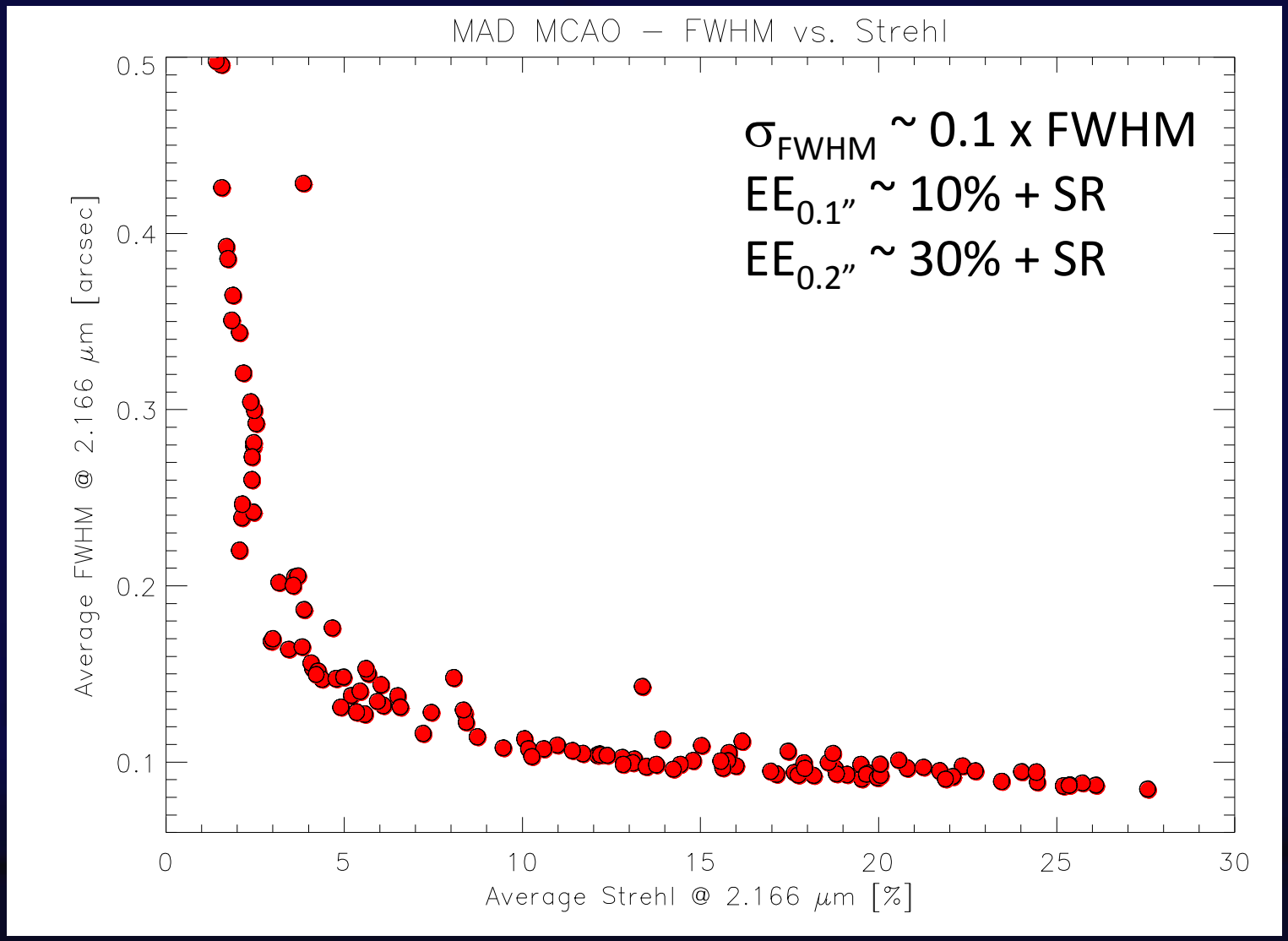
MAD [Ks] (0.028”/px) FWHM: 100mas – $T_{exp}$: 340s

MAD [Ks] (0.050”/px) FWHM: 100mas – $T_{exp}$: 340s

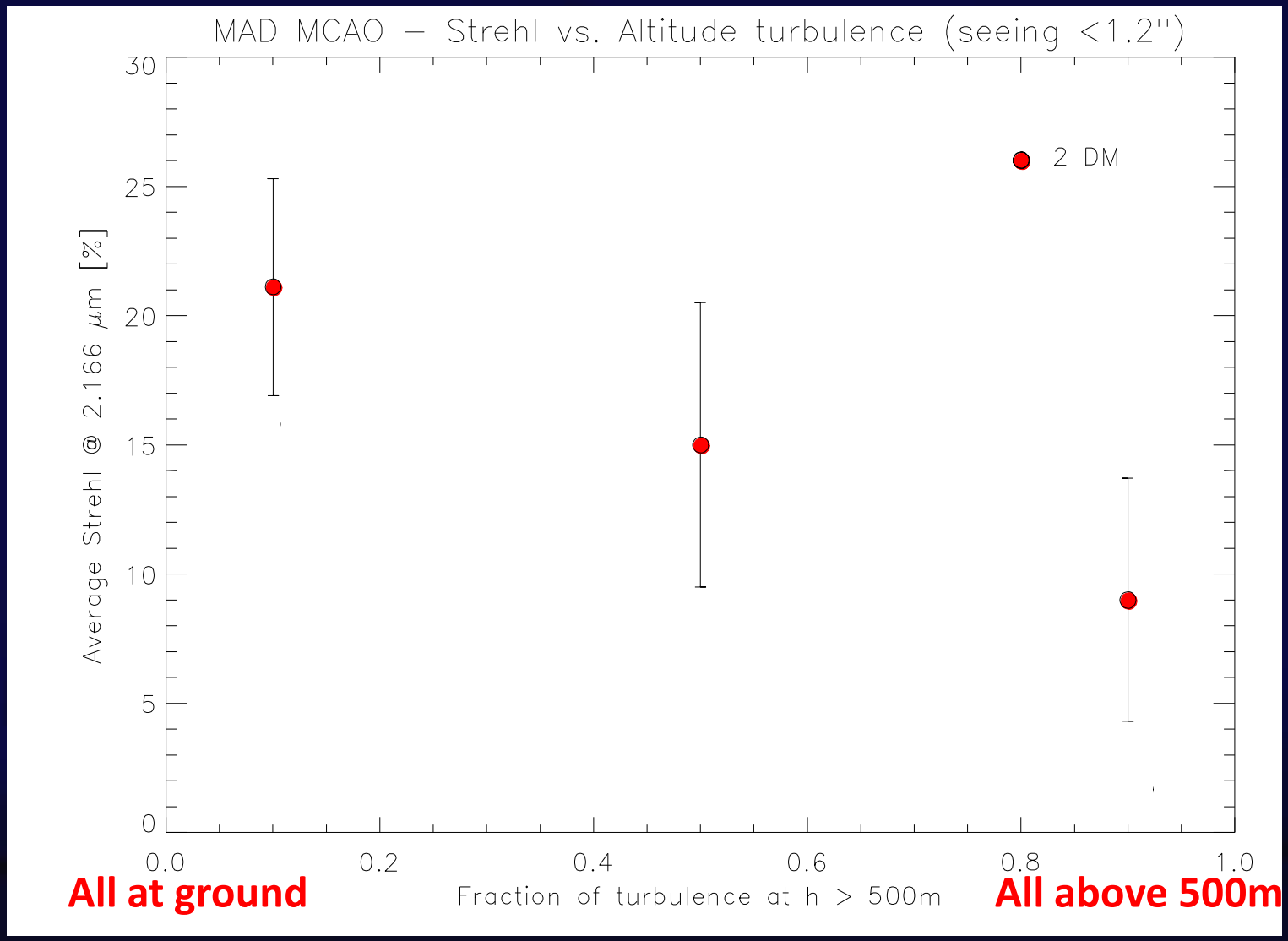
# MAD MCAO correction



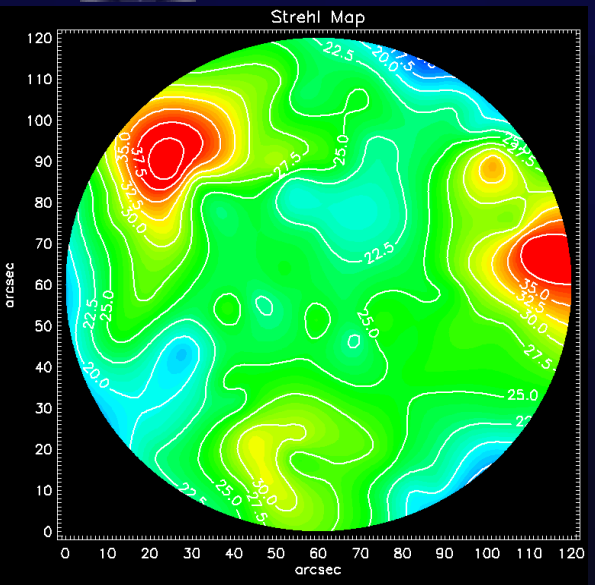
# MAD MCAO correction



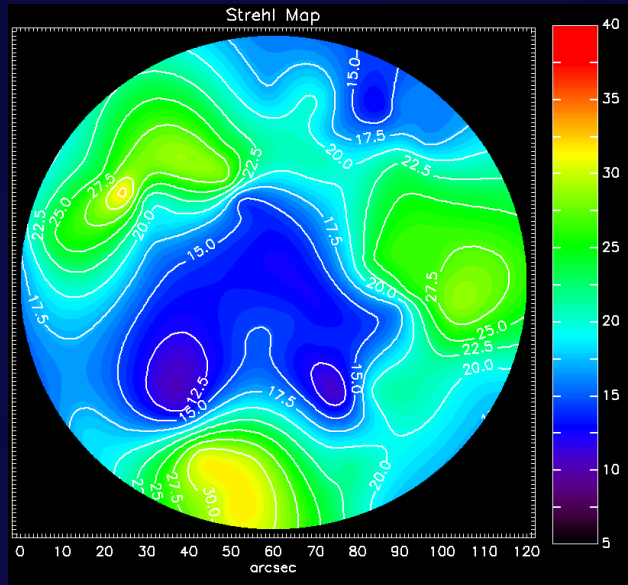
# MAD MCAO correction

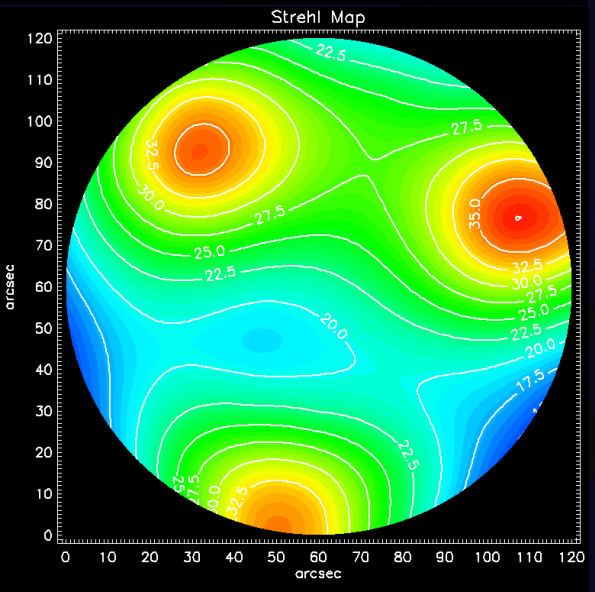


# Effects of turbulence vertical profile

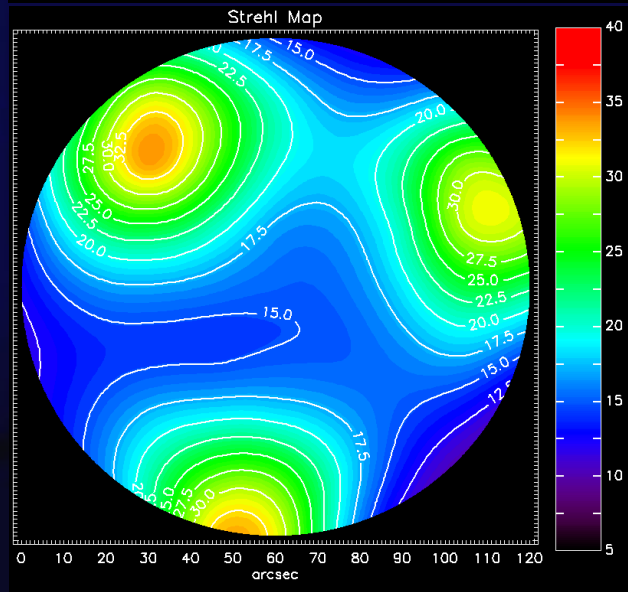



| | | |
|---|---|---|
| 0.64” | DIMM | 0.64” |
| 3.0 ms | $\tau_o$ | 3.0 ms |
| 0.40 | Alt | 0.35 |
| 74% | 0.5 < h < 9 | 55% |
| 14% | 9 < h < 13.5 | 25% |
| 12% | h > 13.5 | 20% |

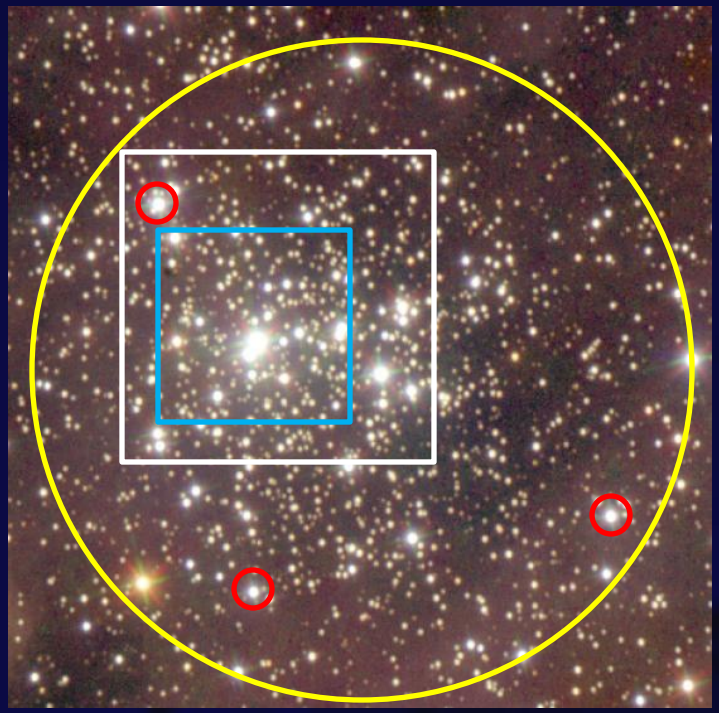



Numerical simulations
10 layers
measured $C_n^2$ profile



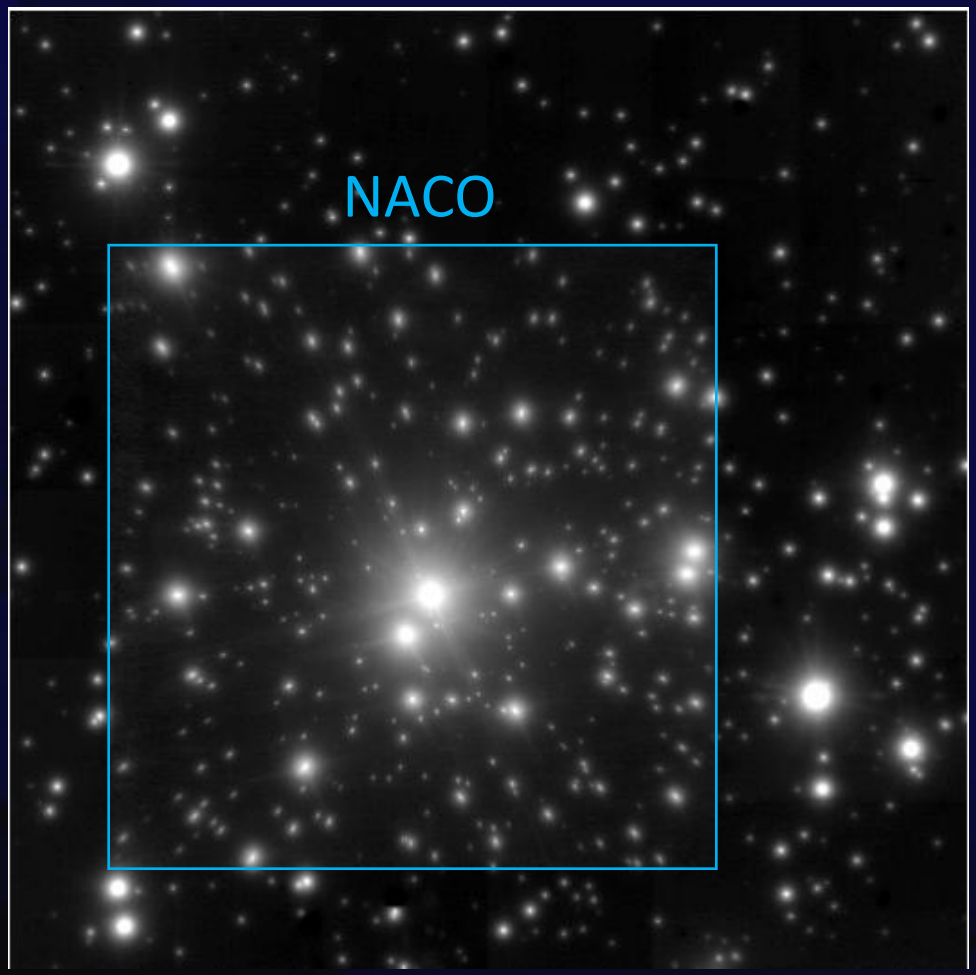
# Classical SCAO vs. MCAO: an example



MAD [H] 0.028”/px
$T_{epx}$: 1680s
DIMM: 1.20”

NACO [H] 0.054”/px
$T_{exp}$: 690s
DIMM: 0.85”

MAD

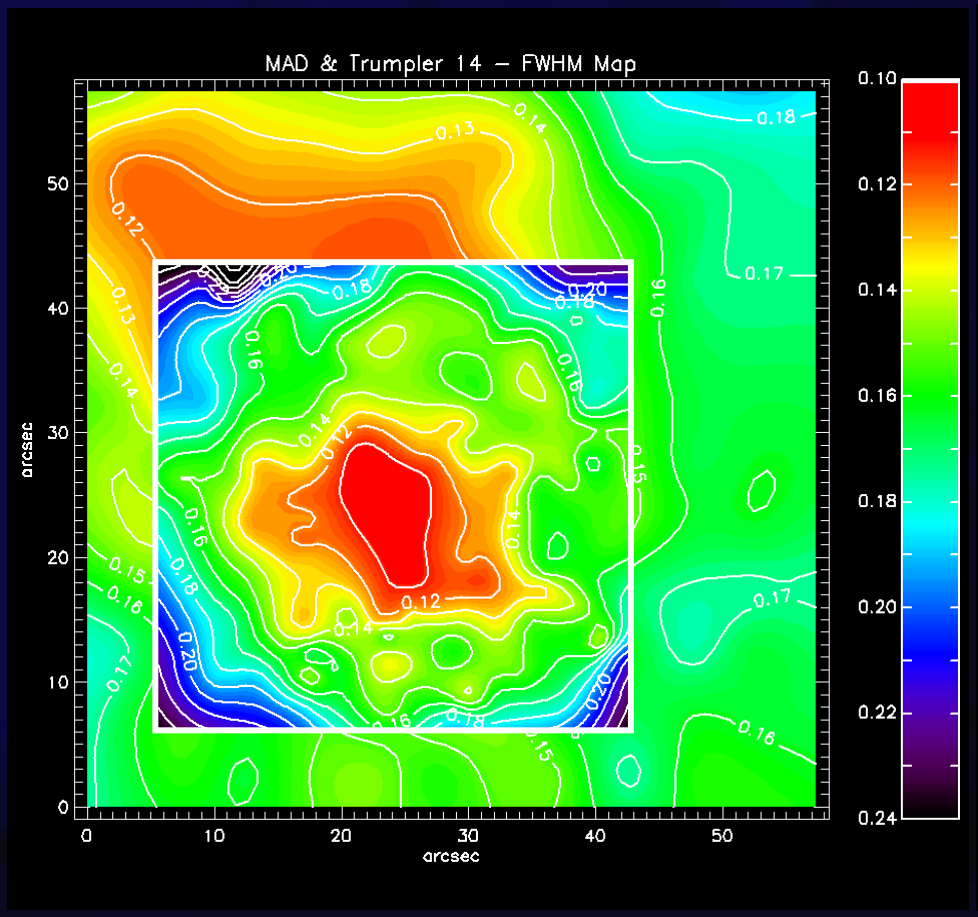



**60” x 60”**

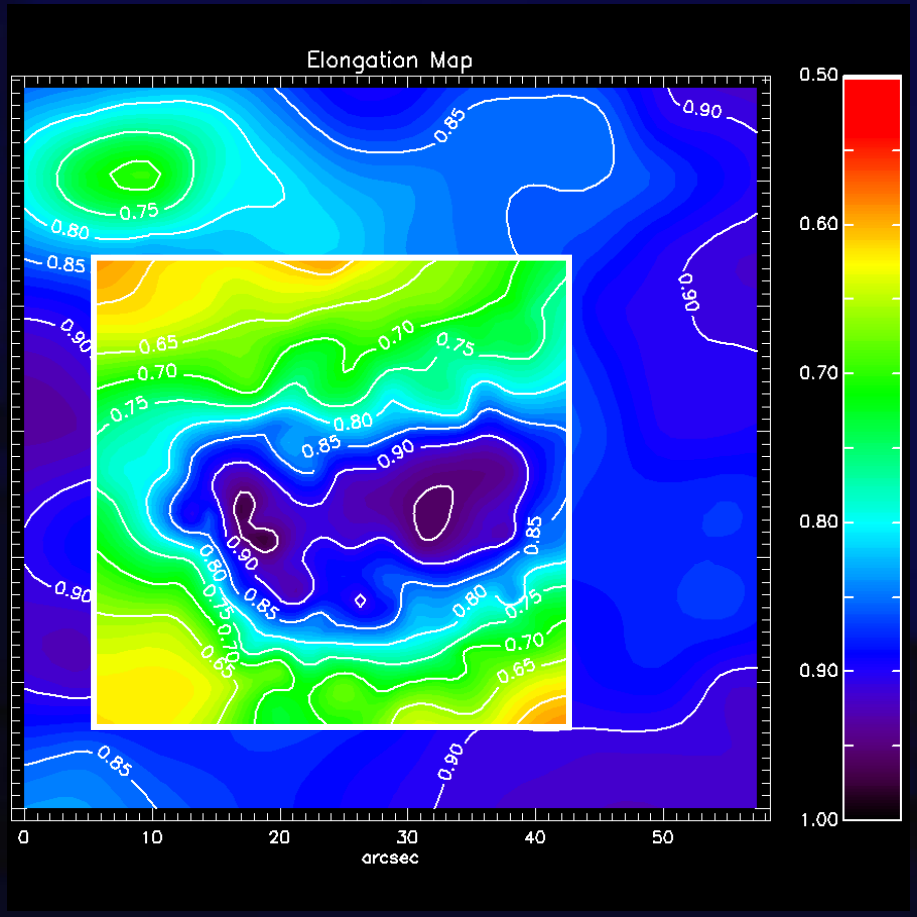
Courtesy: J.Ascenso

# Classical AO vs. MCAO correction uniformity

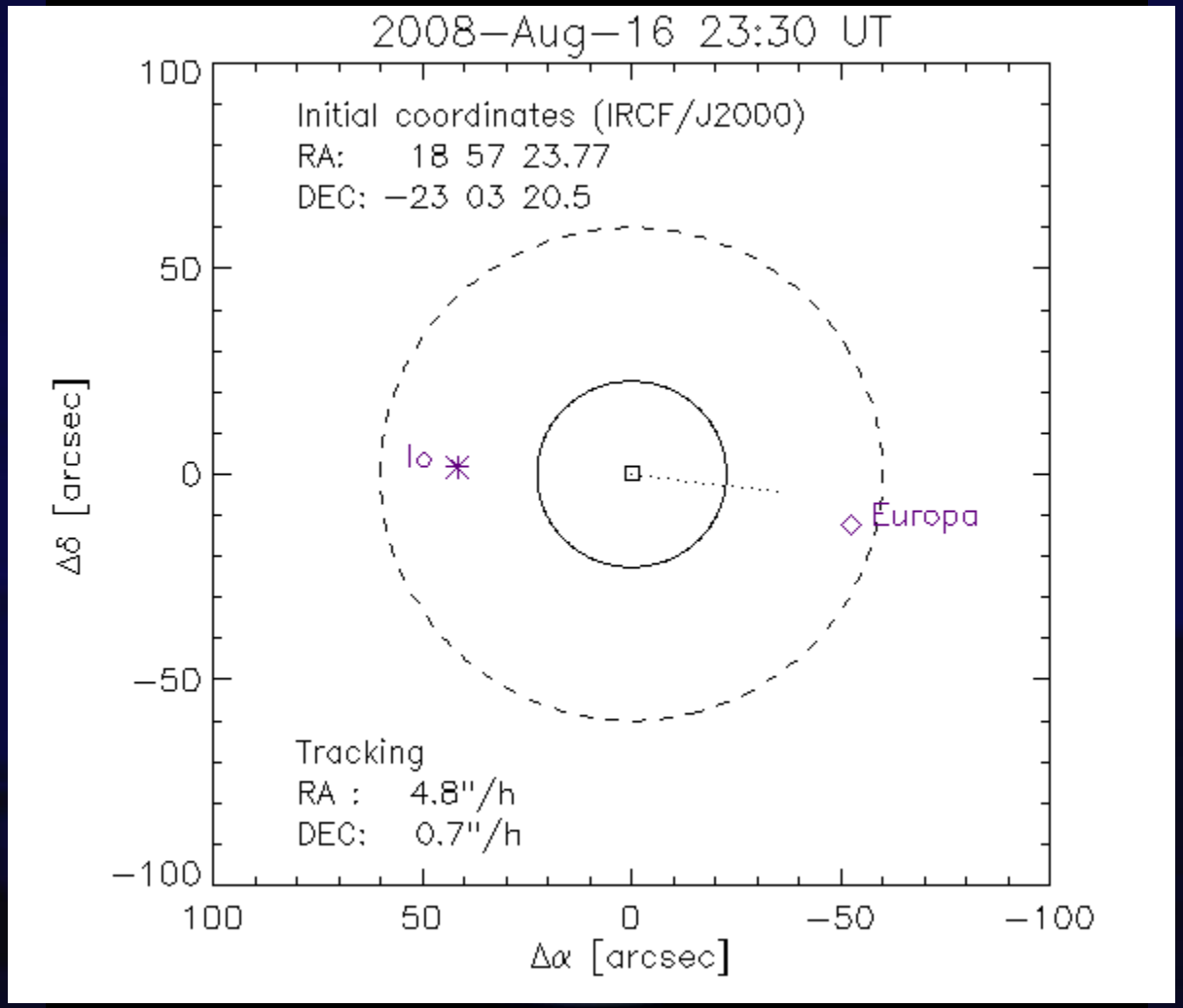
## FWHM




## Elongation

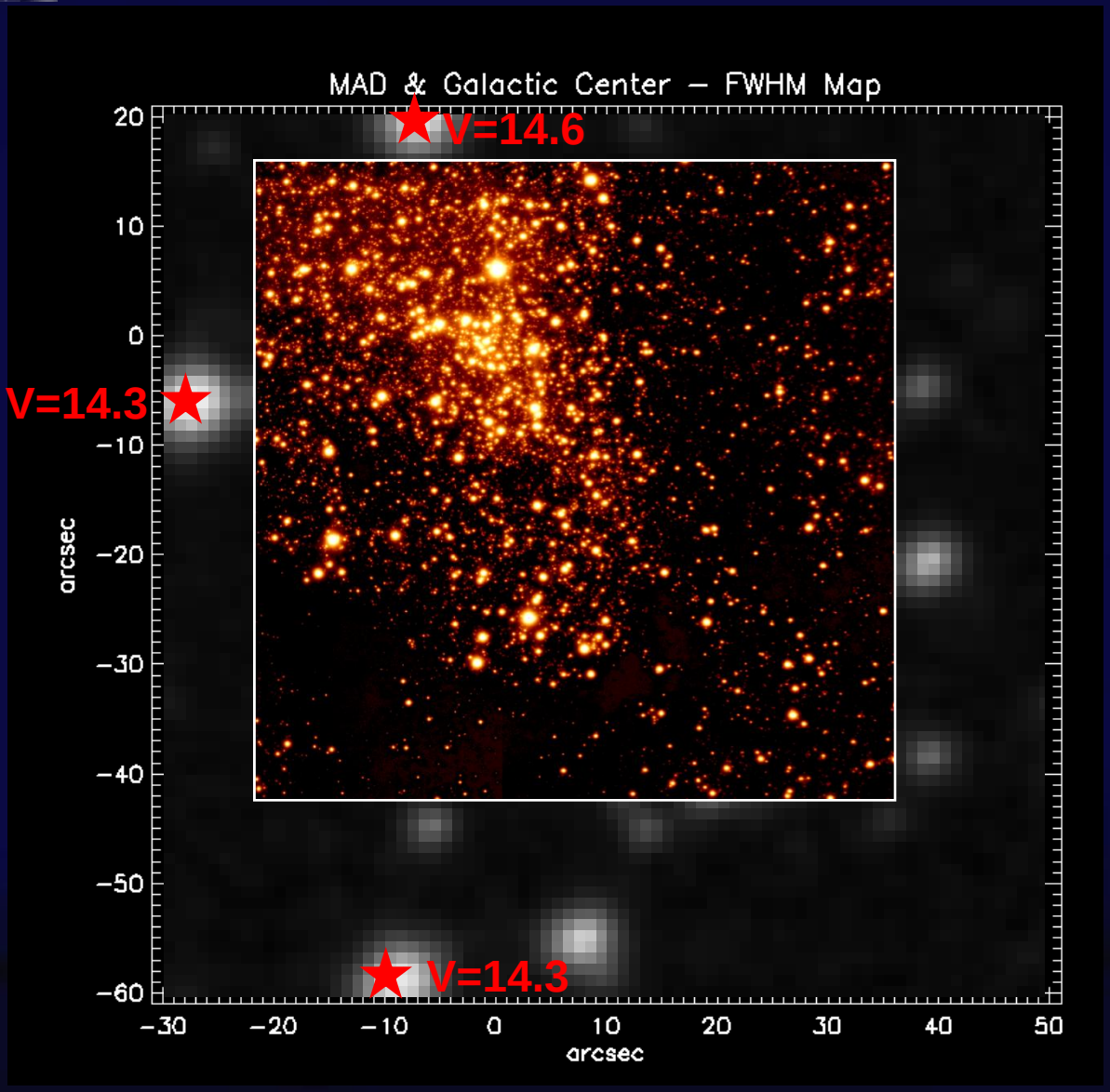


# Two guide star MCAO: Jupiter

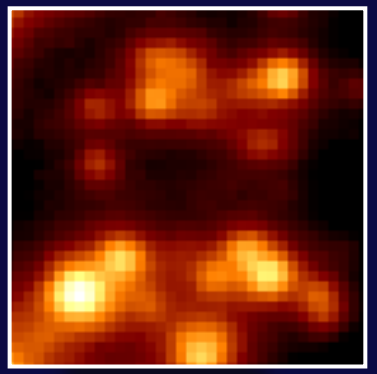



FWHM [Ks]: 90mas DIMM: 0.7” – 1.0”

# Galactic Center



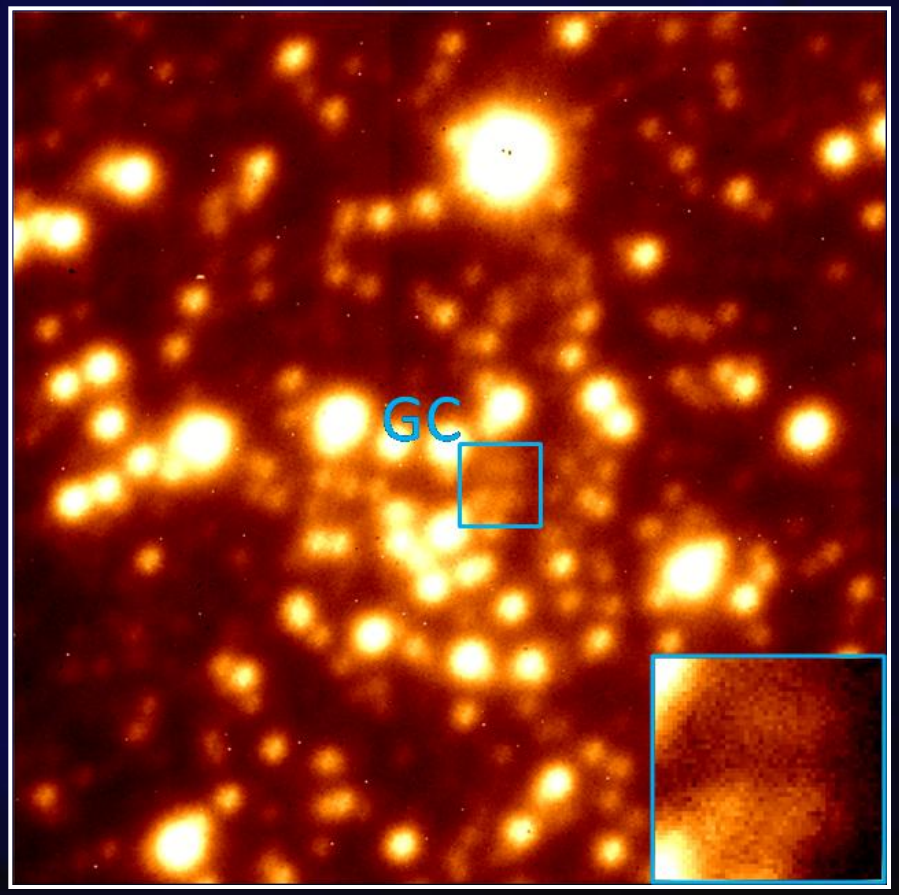

1” x 1”



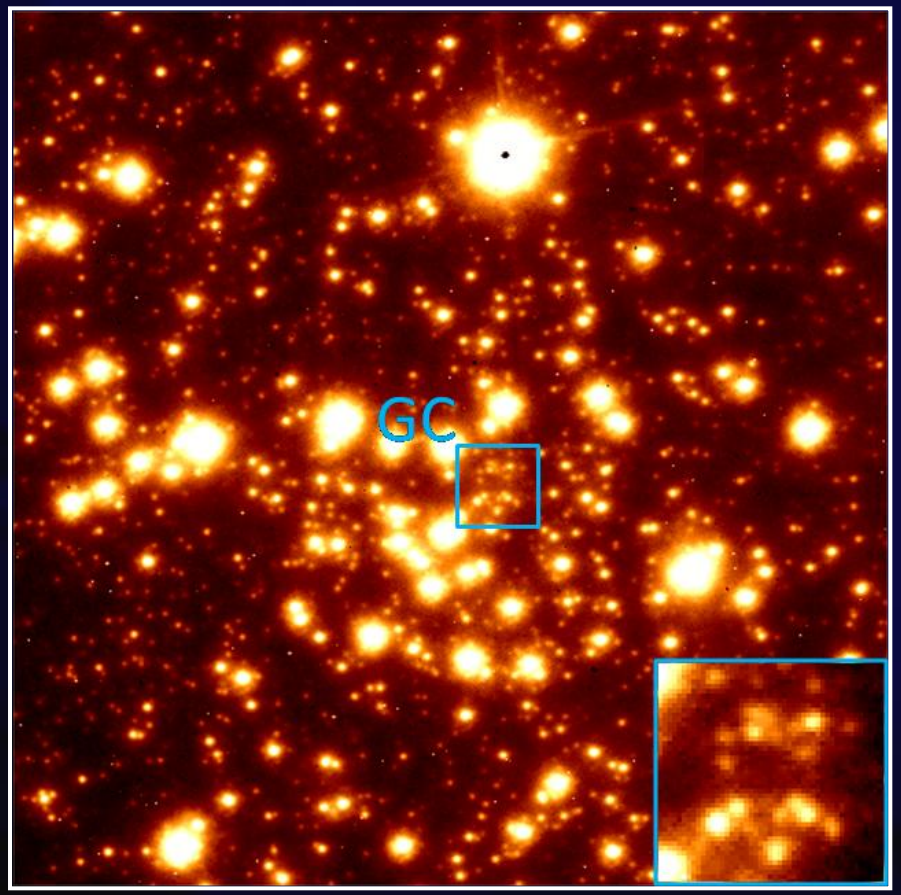
$T_{exp}$[Ks]: 50s
DIMM: 0.6”

# Galactic Center

$T_{exp}$[Ks]: 10s, FoV: 15” x 15”, DIMM: 0.6”



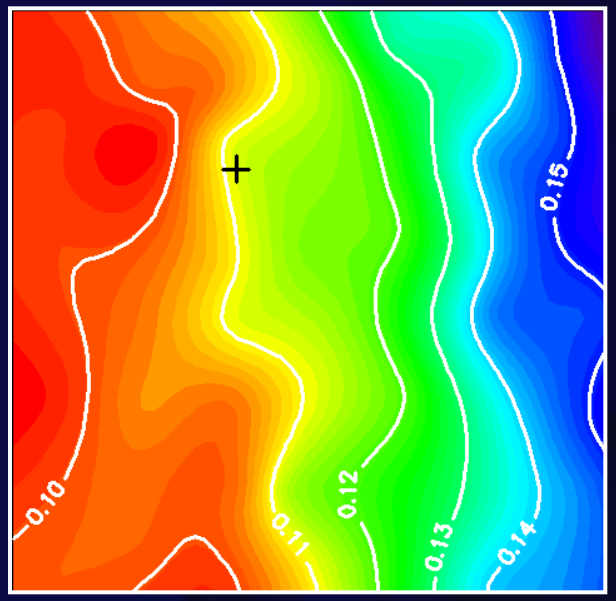

Open Loop



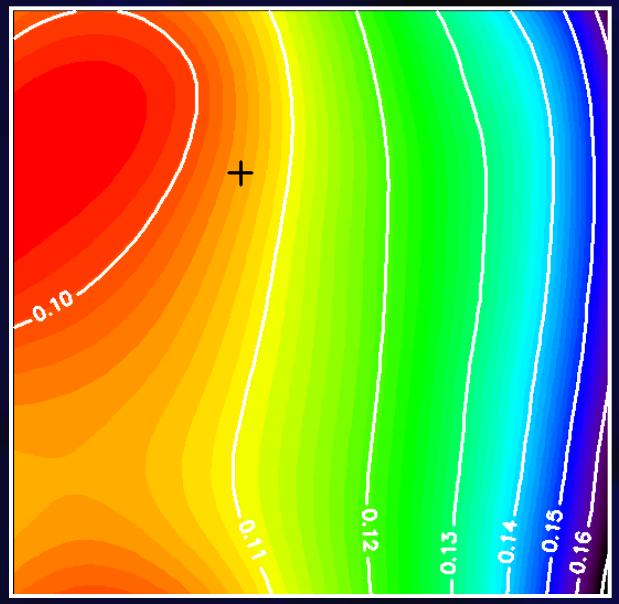

Closed Loop

# Galactic Center

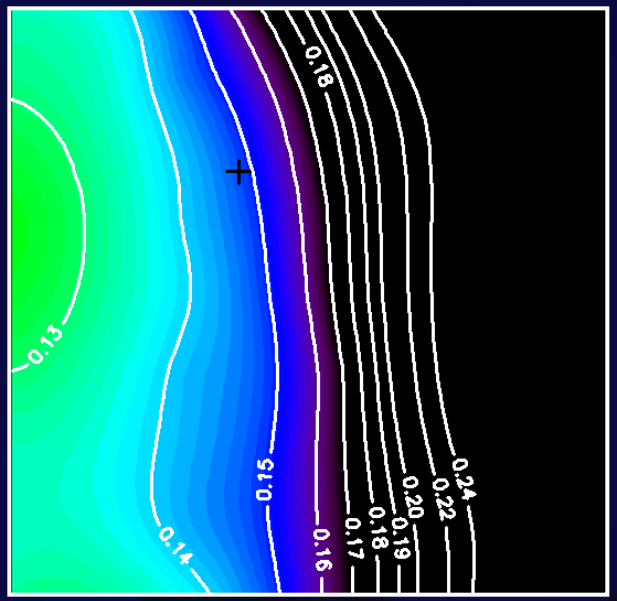
Observed




Simulated

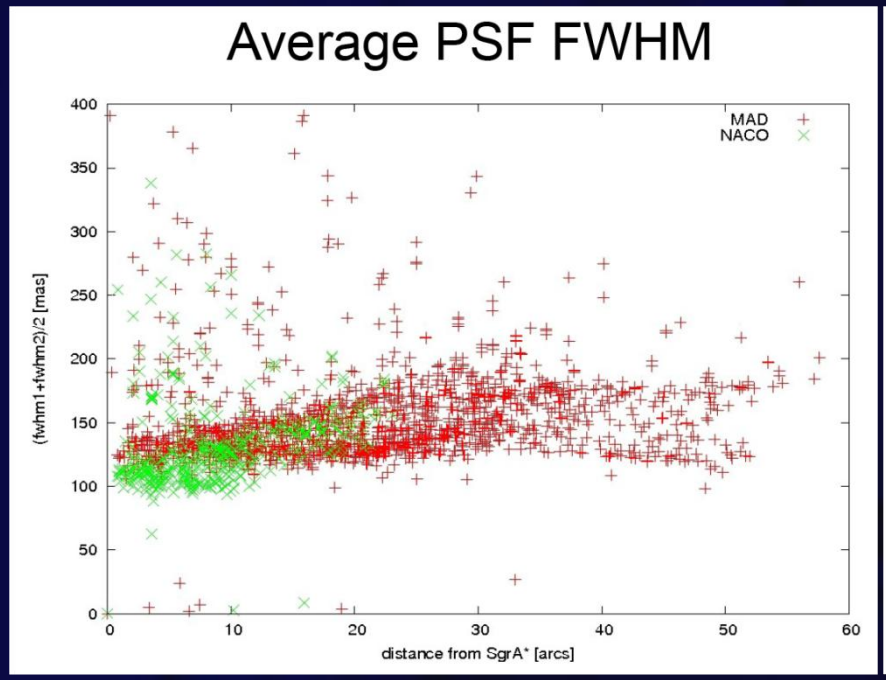


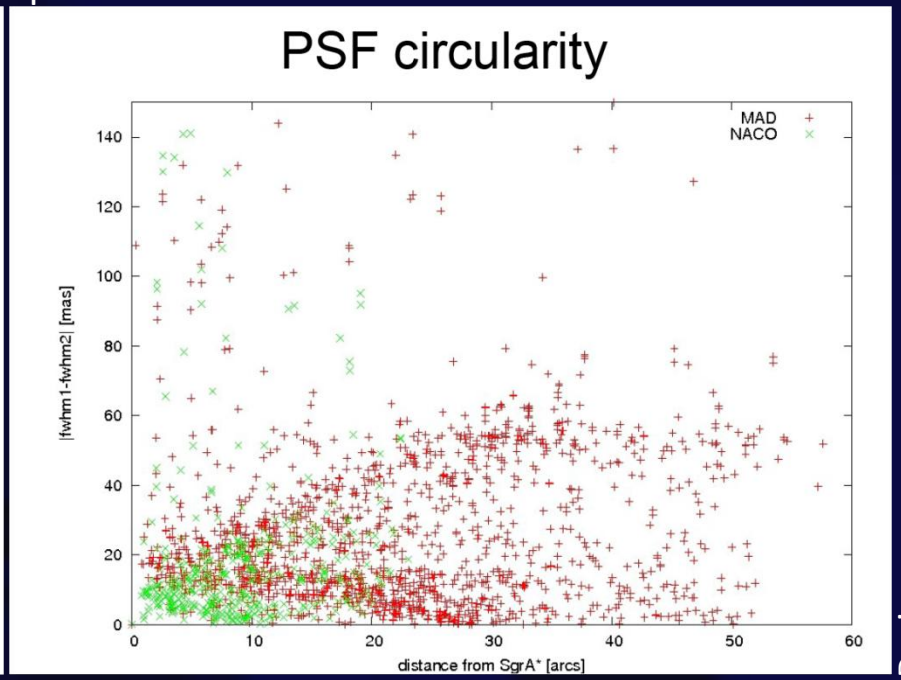

Simulated $m_V$+1



# Galactic Center: a comparison

MAD (1') vs. NACO (30") $T_{exp}$:[Ks] 100s, DIMM: ~0.6"




**Photometric accuracy (13>Ks>11):**

MAD ~0.03mag NACO ~0.02mag

**Distortion**

"… just linear transformation, rotation and shift"

| mag bin | completeness (%) | | |
|---|---|---|---|
| | NACO | MAD-K | MAD-H |
| 13 | 94 | 96 | 99 |
| 14 | 88 | 92 | 97 |
| 15 | 74 | 81 | 93 |
| 16 | 53 | 64 | 85 |
| 17 | 28 | 42 | 68 |
| 18 | 9 | 19 | 42 |

Courtesy: L.Mascetti & R.Davies

# MAD greetings from Atacama

STC-437 (Nov'07)

*"The STC continues to be impressed with the performance of MAD, and applauds ESO and the MAD team for this remarkable demonstrator. The committee has noticed that an instrument able to further exploit multi-conjugate AO on a short timescale would be highly welcomed. We encourage ESO to investigate ways to continue to make MAD available to the community for additional observing runs to exhaust the potential observing opportunities available with this NGS system."*