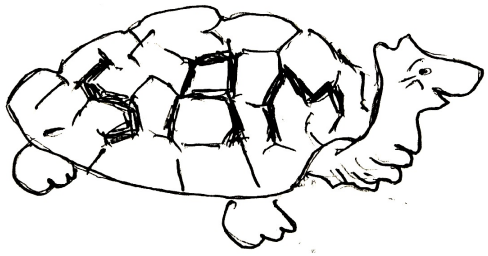
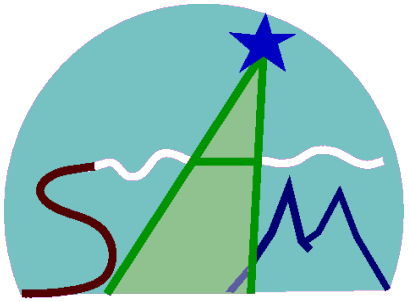
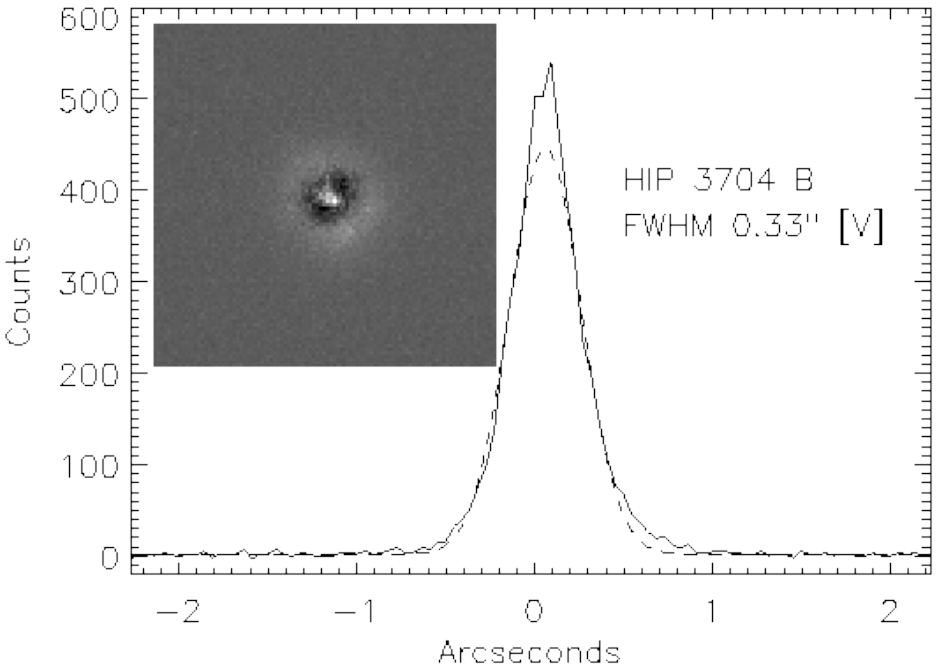
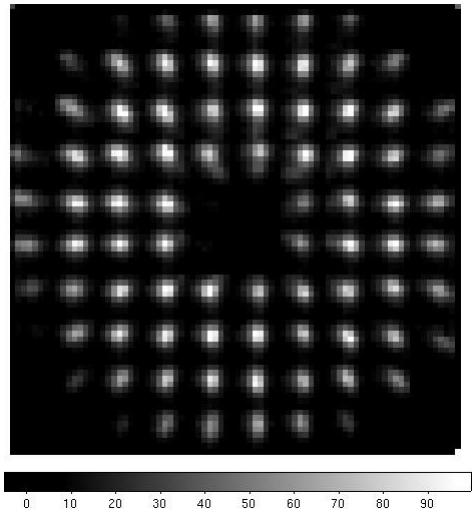




GLAO in the visible: the SAM experience

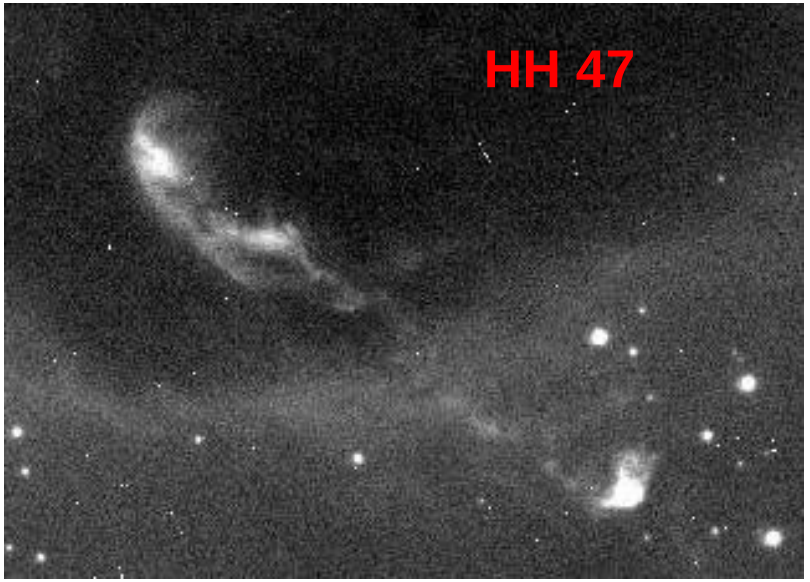


Andrei Tokovinin
NOAO/CTIO



Outline

- Status & performance
- Science with SAM
- Lessons learned
- Relevance to ELTs



10min Hα FWHM 0.33”

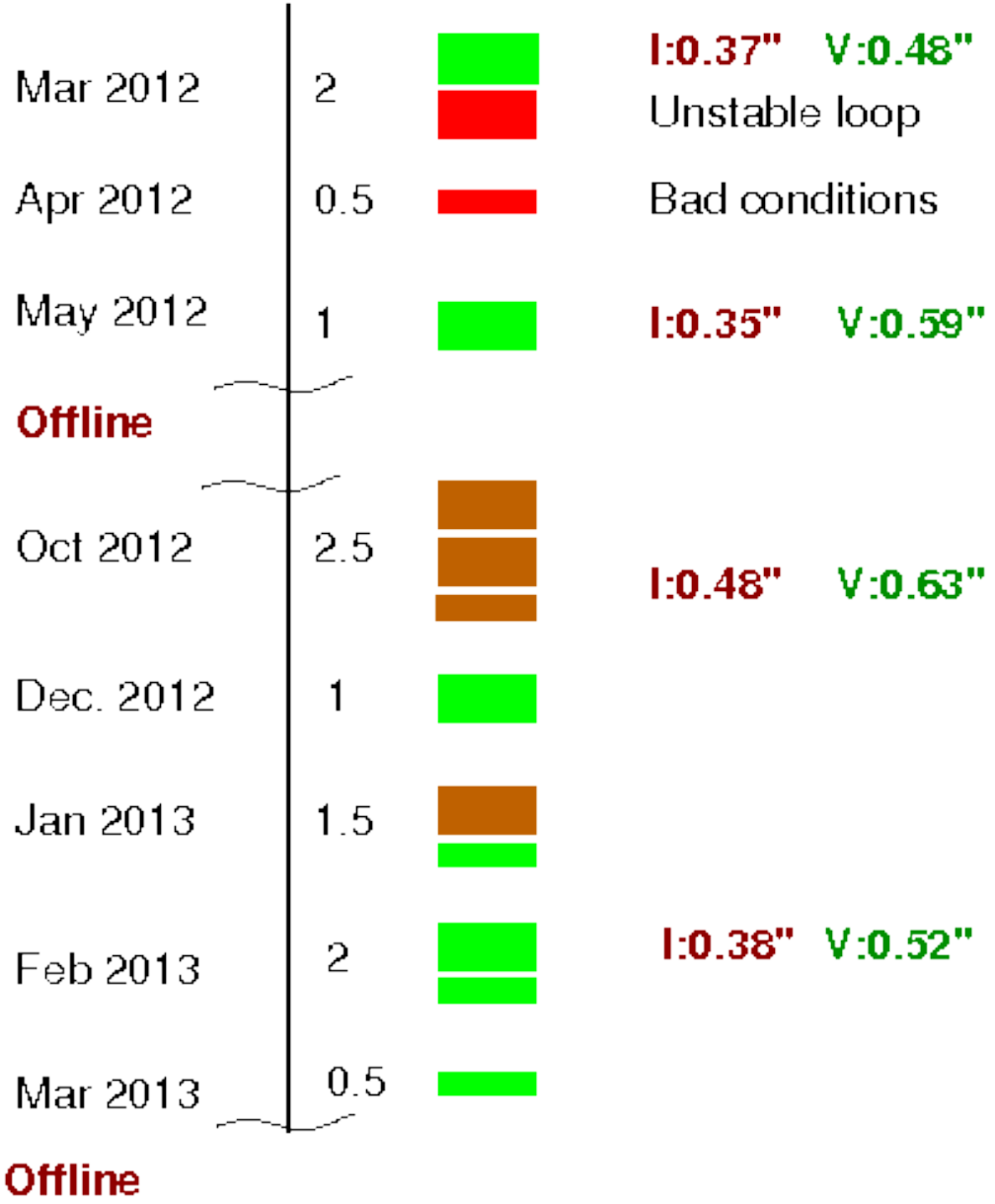
SOAR Adaptive Module is a unique facility instrument delivering improved seeing at optical wavelengths. It uses a UV Rayleigh laser to compensate ground-layer turbulence partially at the 4-m telescope.

Status of SAM

- 11 nights over last year; 6 with good results
- First paper accepted

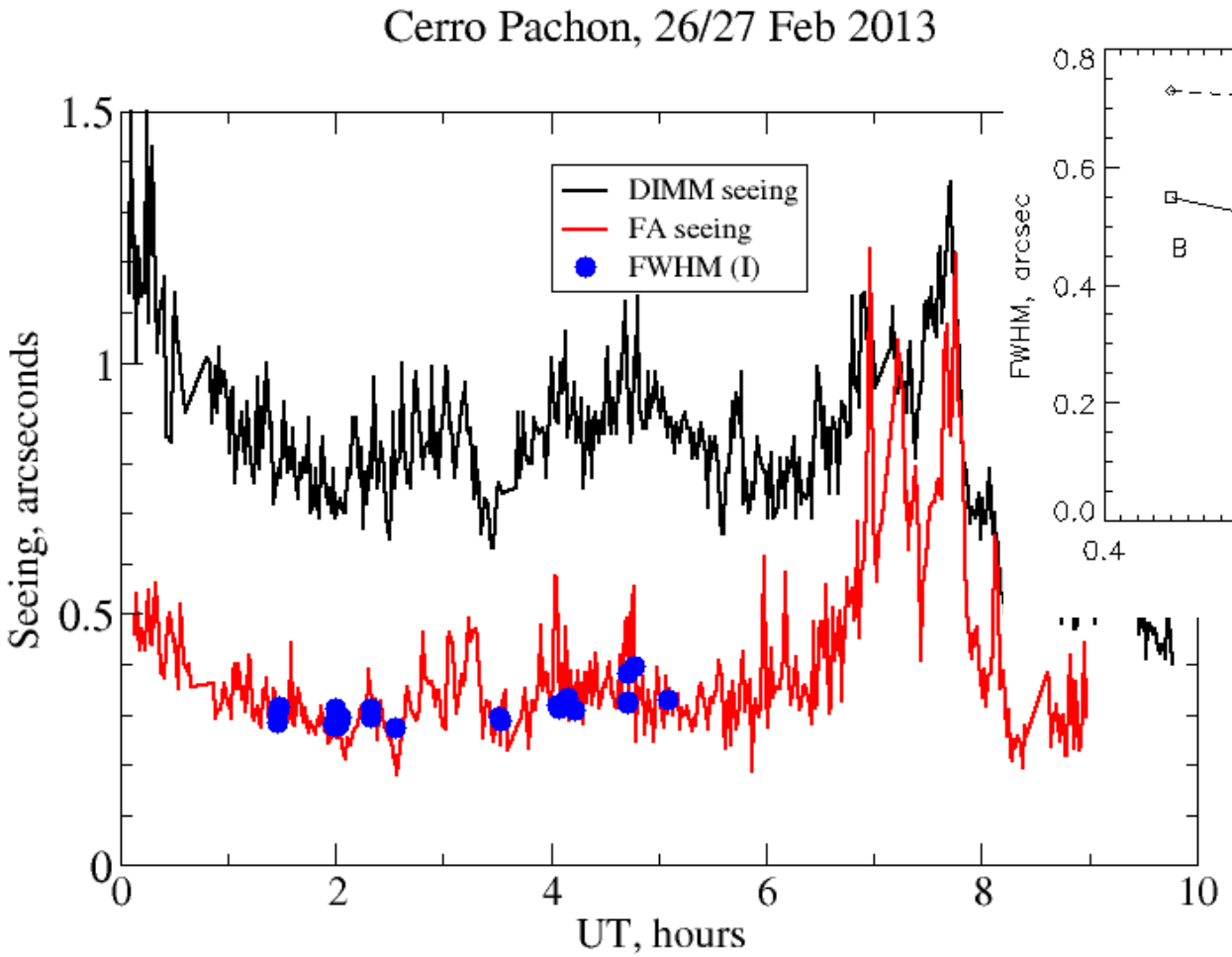
ArXiv:1304.4880

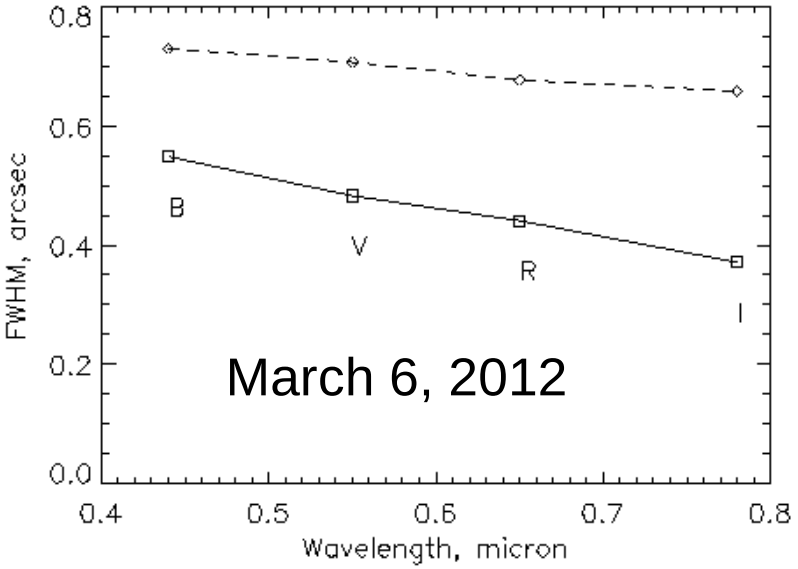
- Commissioning, science verification, operation are *mixed*



CCD imager 4Kx4K pixel 45mas, 3'x3' BVRI +Hα

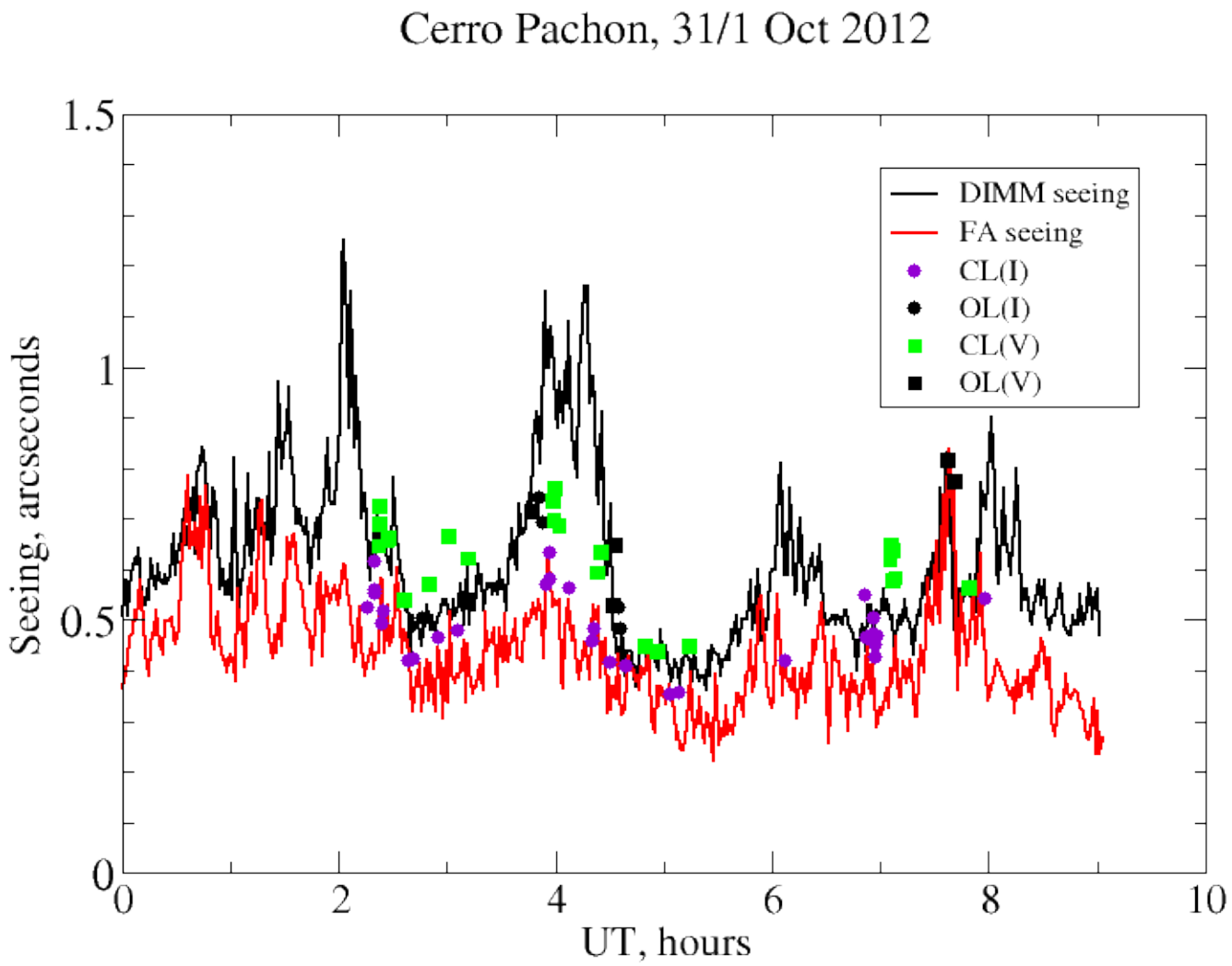
Performance: two good nights





Median FA seeing at Pachon 0.40”

Performance: a poor night (with good seeing)

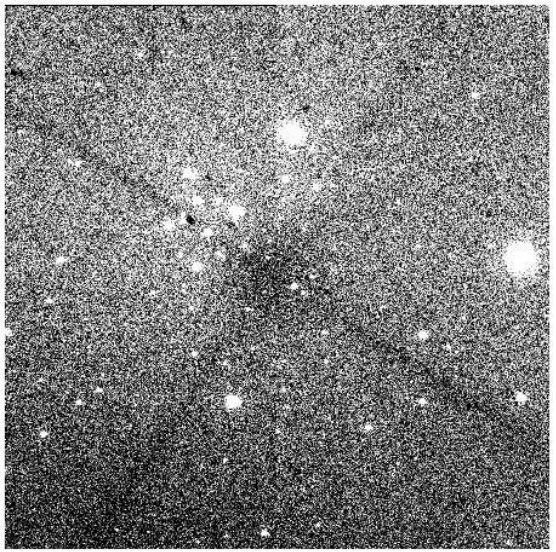


Small
gain in FWHM

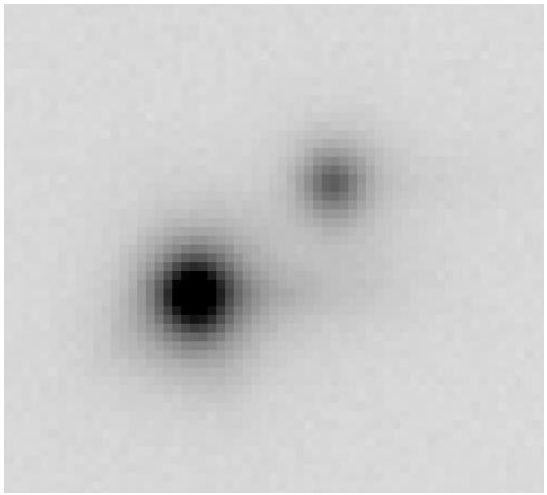
No direct correlation between SAM resolution and site seeing

Other performance metrics

- FWHM uniformity over the field (often <2%)
- PSF (Moffat profile with β~2)
- Ellipticiy (typ. <0.05)
- Overhead (record: ~10min), loop robustness
- Artifacts

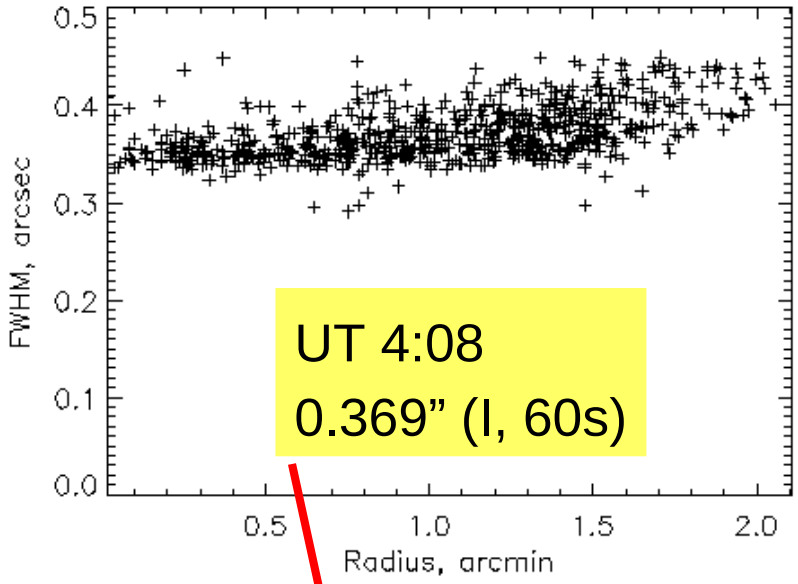


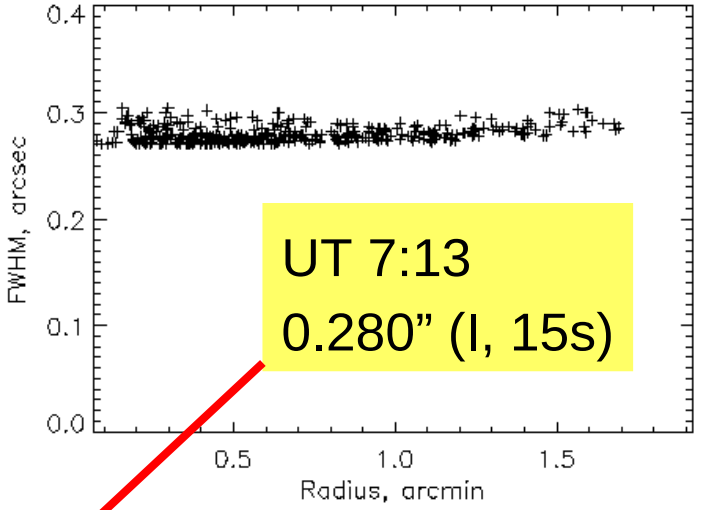
B-filter, 3 min

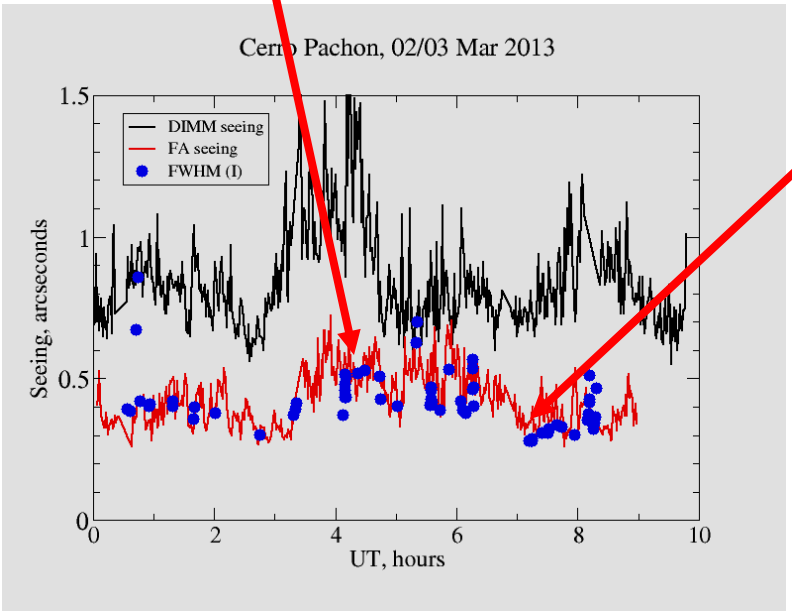


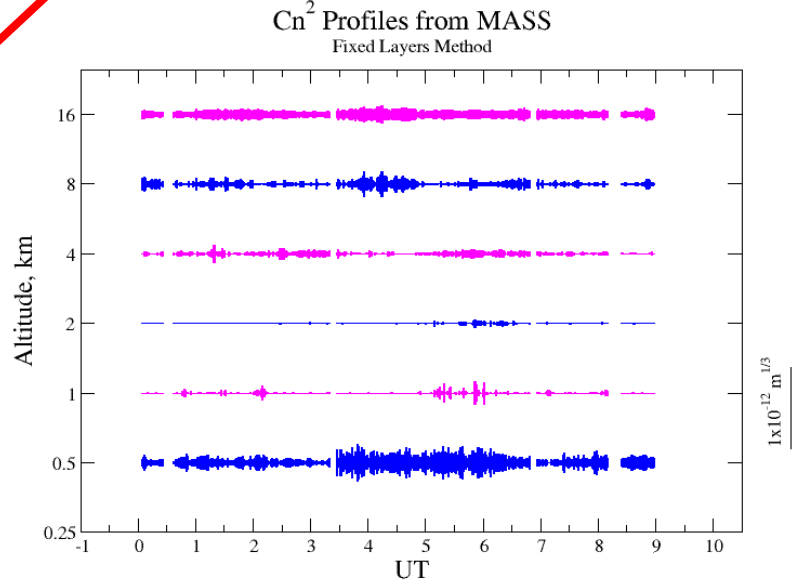
"Tail"

Correction uniformity over field







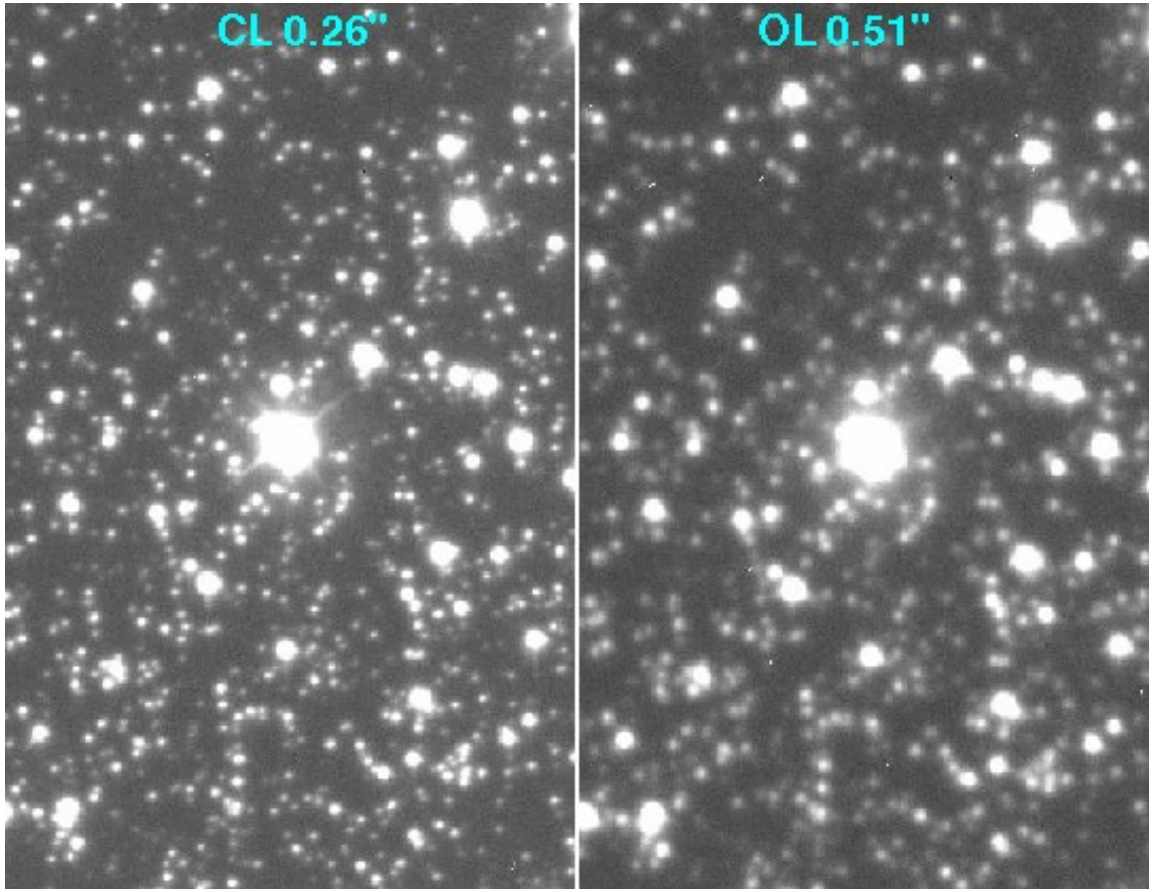


Ma

SAM science. I.

- Stellar populations in crowded fields

L.Fraga et al., AJ
ArXiv:1304.4880
globular cluster
NGC 6496



Competition with HST
Collaboration with GEMS

Non-uniform PSF is OK

SAM science II.

- Nebulae,

star formation

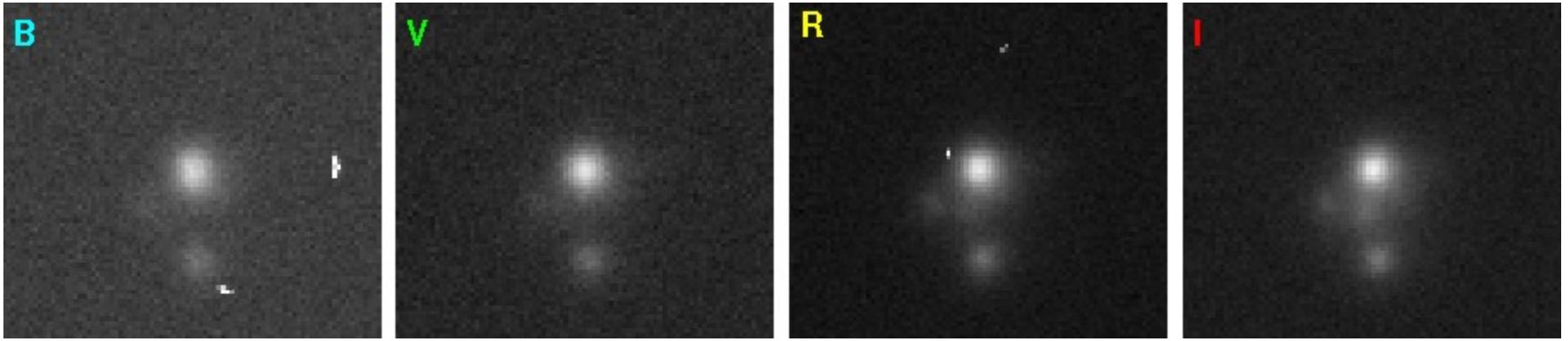
(proplyds etc)

Best ground-based image of NGC 2440

Feb. 26, 2013
Exp. 60s
(Hα,V,B)→ (rgb)
FWHM 0.35”
Fragment
(nebula 72”)

SAM science III.

- Small targets: galaxies, gravitational arcs, lensed quasars, solar-system bodies (Pluto, asteroids, comets), binary companions. LSST… Only on-axis FWHM matters!
- Future: imaging+spectroscopy (IFU and/or MOS)



Lensed quasar SDSS_0924 (0.5” in *B*, 0.4” in *I*). Jan. 2013, 5-min. exp

SAM science verification proposals

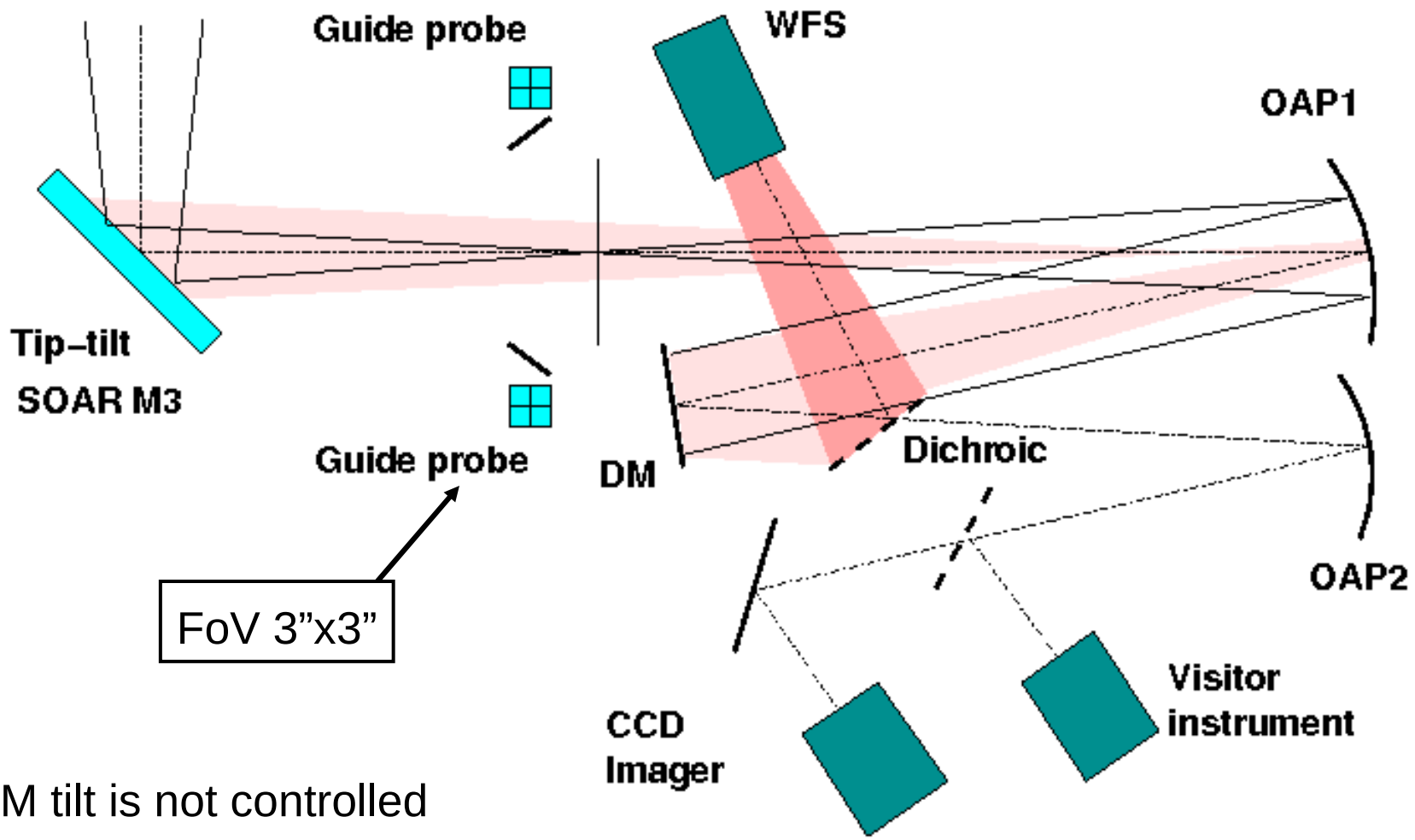
- 16 proposals for ~60h, mostly dark time
- 20h allocated (Apr. 17,18), lost to telesc. failure
- Galactic: clusters, planetary nebulae, pulsar shock, triple star
- Extragalactic: polar-ring galaxies, compact groups, gravitational lenses, “green beans”
- Solar system: Pluto, comets (non-siderial track?)

Forming future SAM user base

SAM operation

- Laser propagation restrictions (LCH): manageable
- Laser system: “set-and-forget”. LGS loop is very stable (work with 2x2 binning, 440Hz). UV laser 7.5W power.
- The LGS spots are affected by **local seeing** (1.5” to 2”).
- Guide-star acquisition depends on precise pointing (needs acquisition images)

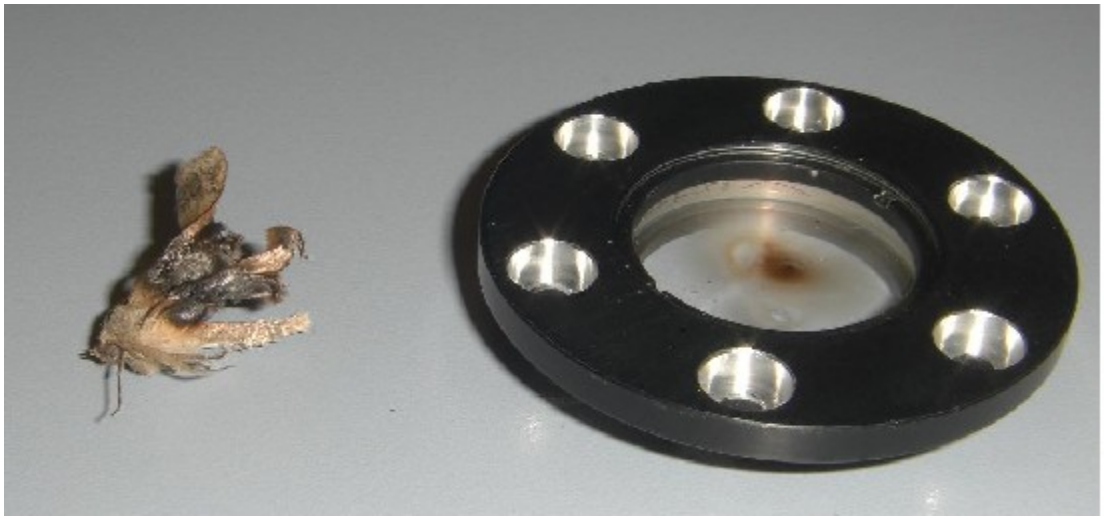
SAM at a glance

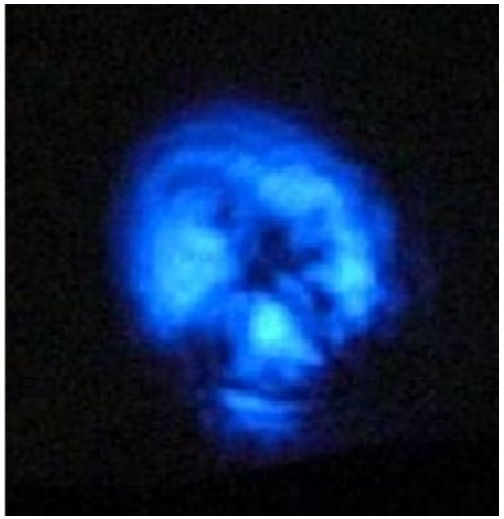


DM tilt is not controlled and it works!

What works well in SAM

- Laser, LLT, laser beam control. Enough power!
- WFS with Pockels cell
- Tip-tilt guiders with APD (over-light protection)

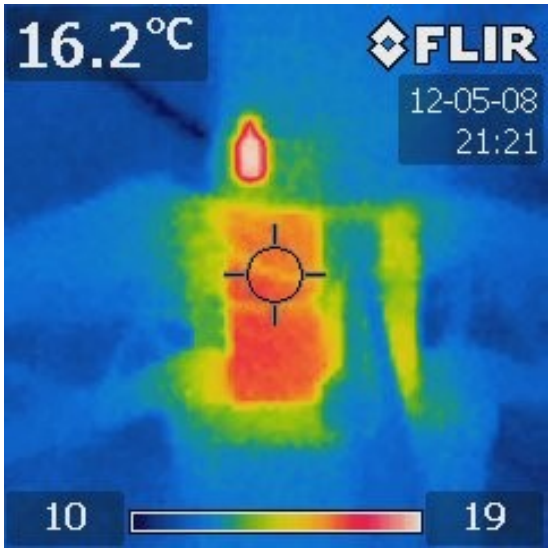




To be improved (next time)

- CCD-39+Leach controller → EMCCD
- Need an acquisition camera!
- Need “truth WFS” and/or NGS mode
- Higher-order DM (work in the blue!)

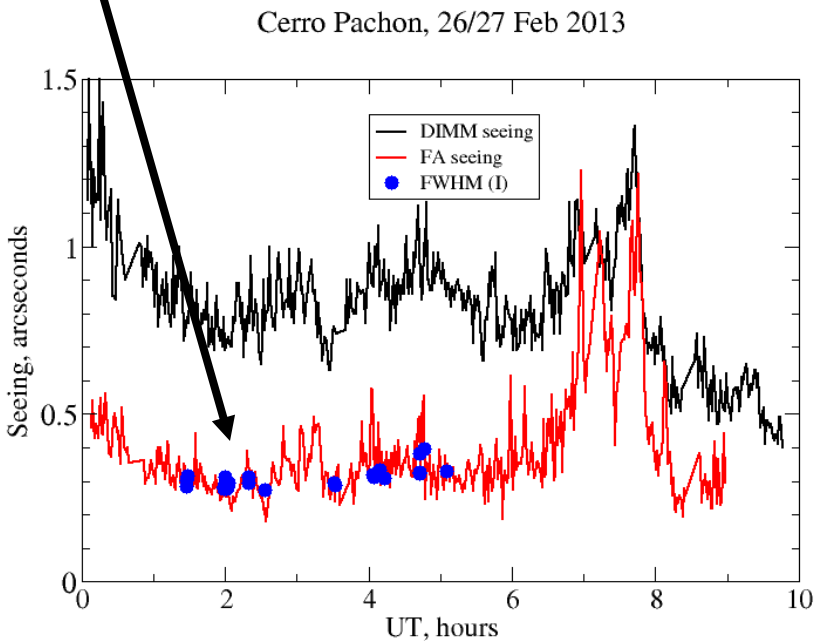
  (only 40 modes are now corrected)
- Pyramid WFS?
- Better thermal control!
- Better motion control
- Software (4 modules, 3 authors)



Performance in the blue: a weak GL?

- Feb. 26 2013, UT 2:10: FWHM=0.35” in band B (??), 0.28” in I

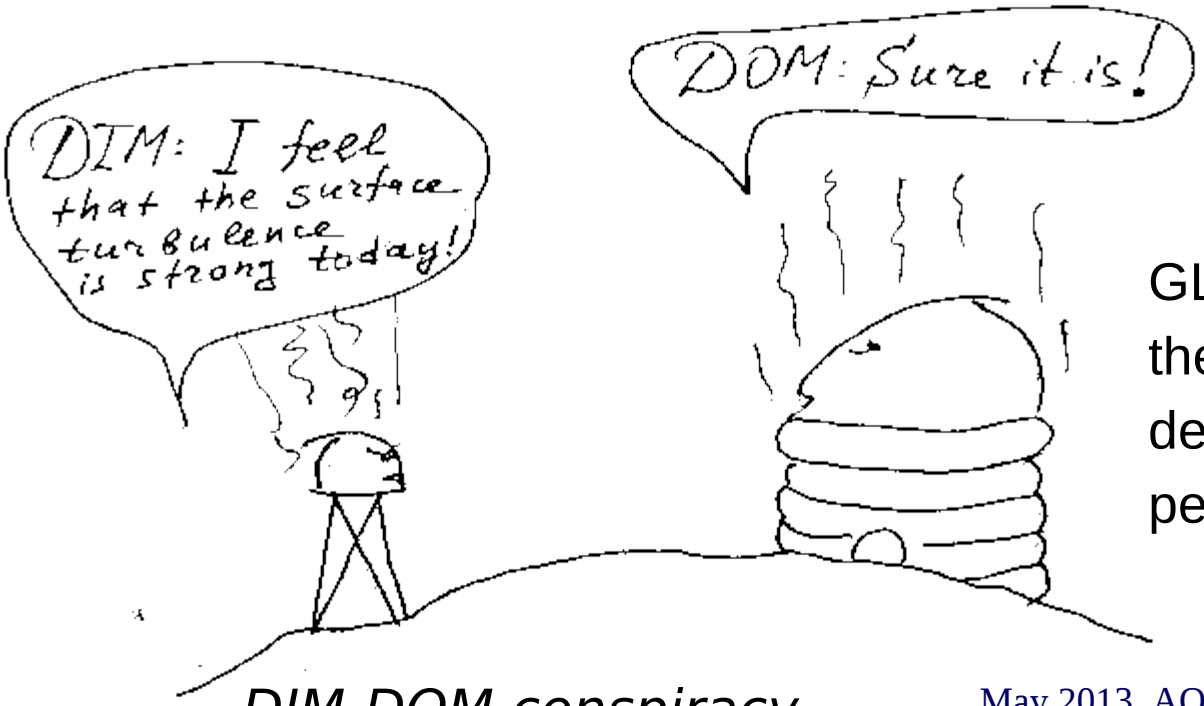
SAM measured r0 from 0.25 to 0.35m



- The GL turbulence was **weak**
- SAM compensated mostly static aberrations & dome
- DIMM measured **wrong**

GLAO 4 ELTs

- Strong science case for improved seeing **in the visible**
- Adaptive secondaries make it easier, just need lasers
- Need to compensate vibrations and dome seeing



DIM-DOM conspiracy

GLAO will neutralize the internal seeing, delivering **site-limited** performance to ELTs

END