GLAO in the visible: the SAM experience

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HIP 3704 B
FWHM 0.33'' [V]

May 2013, AO4ELT3
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

<table>
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<tr>
<th>Month</th>
<th>Nights</th>
<th>Status</th>
<th>Measurement</th>
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May 2013, AO4ELT3
Performance: two good nights

Cerro Pachon, 26/27 Feb 2013

Median FA seeing at Pachon 0.40"

March 6, 2012

Seeing, arcseconds

UT, hours

FWHM, arcsec

DIMM seeing
FA seeing
FWHM (I)
Performance: a poor night (with good seeing)

Cerro Pachon, 31/1 Oct 2012

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 $\beta \sim 2$)
- Ellipticity (typ. <0.05)
- Overhead (record: ~10min), loop robustness

Artifacts

“Tail”

B-filter, 3 min
Correction uniformity over field

UT 4:08
0.369” (I, 60s)

UT 7:13
0.280” (I, 15s)
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)

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

Best ground-based image of NGC 2440
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 $r_0$ 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

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