MAORY (Multi conjugate Adaptive Optics RelaY) for E-ELT

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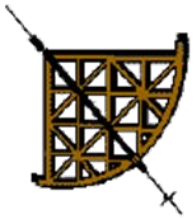
On behalf of the MAORY Consortium

MAORY Consortium



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+ Università di Bologna

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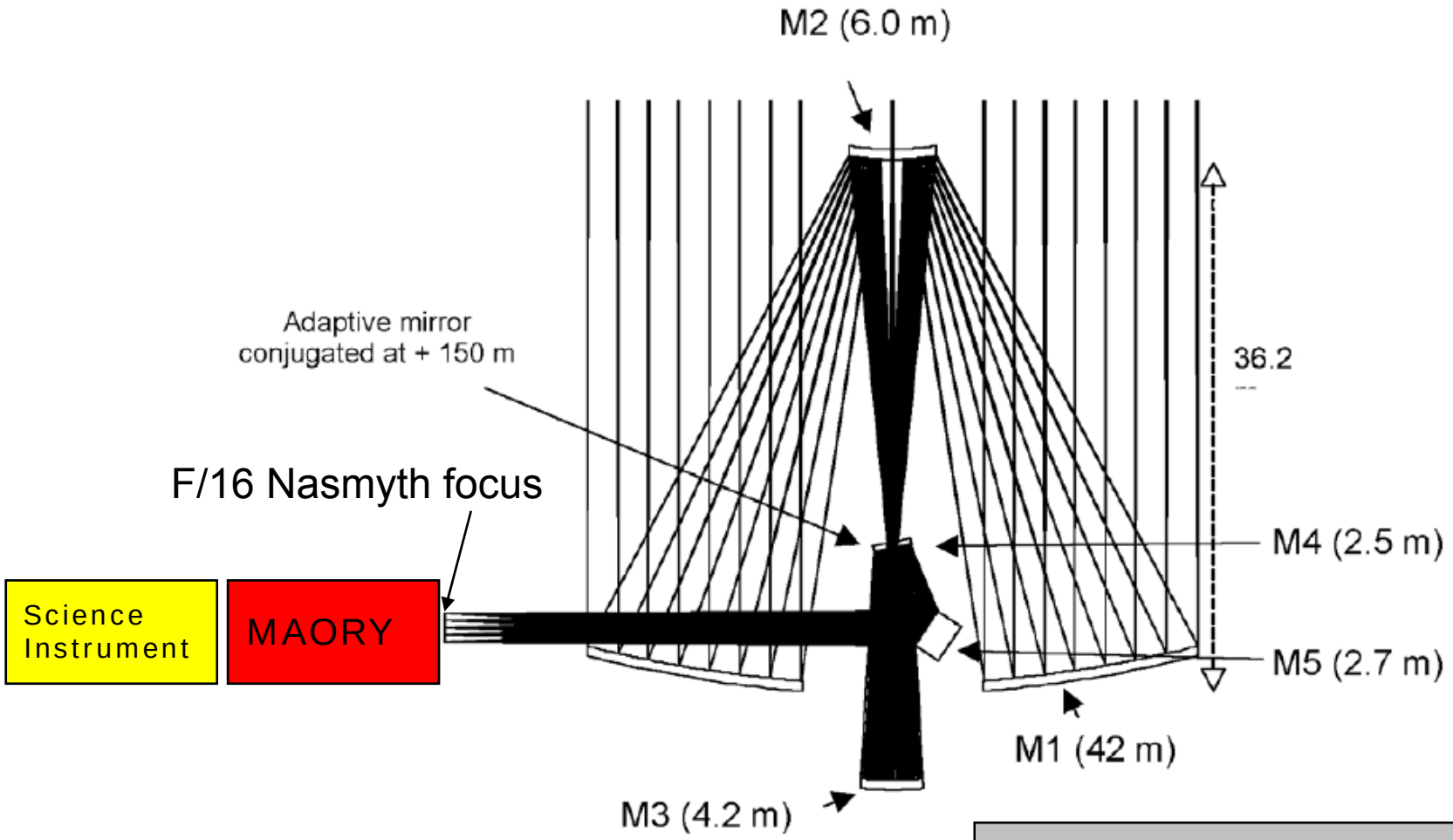
MAORY
Multi conjugate Adaptive Optics RelaY



MCAO module includes up to
2 post-focal deformable mirrors

Top level requirements

- Field of view
  - Large field of view (up to 2‘) with moderate correction (in terms of PSF quality and uniformity)
  - Medium field (20" to 1') with high correction (in terms of PSF quality and uniformity)

- Throughput (telescope excluded) and wavelength range
  - Throughput > 80% for 0.8μm < λ < 2.4μm (goal 85%)
  - Throughput > 70% for 0.6μm < λ < 2.4μm

- Low thermal background
  - < 30% than the thermal background due to the telescope @K
  - Goal < 15%

- Interfaces to instruments
  - One port allowing mechanical derotation of a light (< 4 ton) instrument
  - One port allowing easy instrument exchange (without mechanical derotation)

Top level requirements

Better performance

Better performance

FoV	λ=2.2μm	λ=1.65μm	λ=1.25μm	λ=0.8μm
2'	0.43	0.24	0.10	Best effort
1'	0.62	0.43	0.23	Best effort
20"	0.72	0.56	0.37	0.09

Expected Strehl Ratio

FoV	λ=2.2μm	λ=1.65μm	λ=1.25μm	λ=0.8μm
2'	0.13	0.13	Best effort	Best effort
1'	0.06	0.07	0.07	Best effort
20"	0.01	0.01	0.01	0.01

Strehl Ratio uniformity

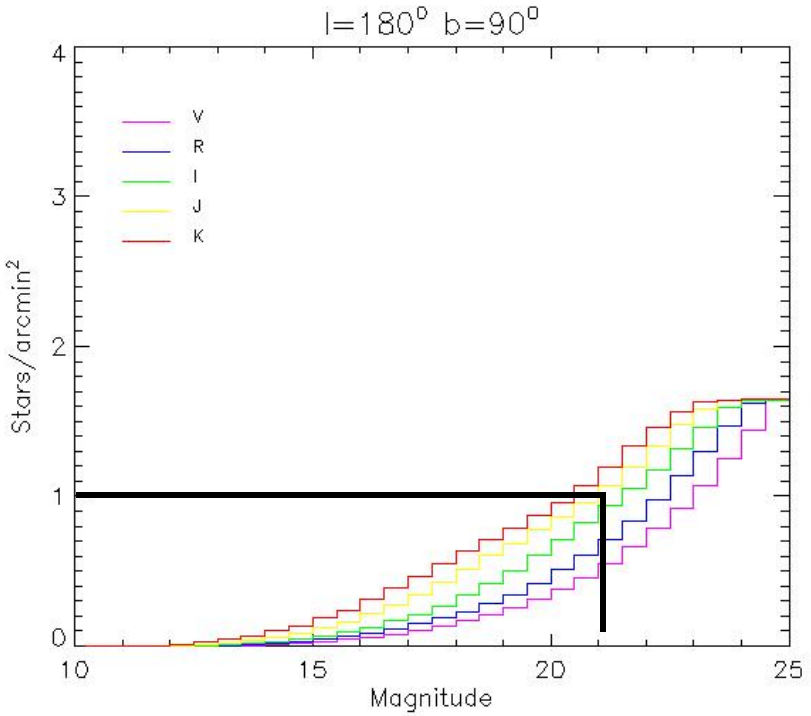
FoV	λ=2.2μm	λ=1.65μm	λ=1.25μm	λ=0.8μm
1'	0.50	0.30	0.14	N/A
20"	0.60	0.41	0.23	0.04

Strehl Ratio on 50% of the sky at the North Galactic Pole

MAORY Natural Guide Stars

- Low orders of aberration have to be measured using “natural” guide stars
  - Tip-tilt indetermination with LGS
  - LGS focus error
- NGS wavefront sensor determines sky coverage!
- Two possible locations for NGS wavefront sensor
  - Before the MCAO module → large field, low correction
  - After the MCAO module → smaller field, higher correction
- NGS wavefront sensing in NIR benefits from MCAO correction

Data from Besançon model
Very good agreement with SDSS



MAORY Science Team Workplan

- Objectives of science team
  - Check performance of MCAO module with respect to Top Level Requirements and Instruments requirements
  - Check competitiveness of MCAO module with other AO system
  - Provide interface between MCAO technical team and Instruments science teams to collect feedbacks about performance/design

- A Simulator is under development
  - Inputs: adaptive optics PSFs, object type, Instruments properties (sampling, detector noise, etc.)
  - Language: IDL
  - Object types taken from “Science Case and Requirements for the ESO ELT” and, when available, from Instruments studies (IR camera, spectrograph)
    - S5 IMF in Stellar Cluster
    - G4 Resolved Stellar Populations
    - G9 BH/AGN including the Galactic Center
    - C4 First light-the highest redshift galaxies
    - C10 Physics of high redshift galaxies

- First step: evaluation of systematic effects due to MCAO PSF on point-source photometry

FIRST SIMULATED PSF from ONERA team (J.M CONAN , C. PETIT)

- Turbulence profile with 10 layers : 0 → 16.5 Km
- Seeing 0.85 arcsec at 5000 Å
- Central obstruction 0.3 on the diameter
- ANALYTIC MODEL
- 6 Laser Guide Stars on a field of Ø 45 arcsec
- 3 Deformable Mirrors conjugate at 0 Km (M4) 5 Km and 14 Km
- 84 actuators over pupil diameter

NO COMPLETE ERROR BUDGET !!!!

CONSIDERED :

1) tomography error

2) finite number of actuators

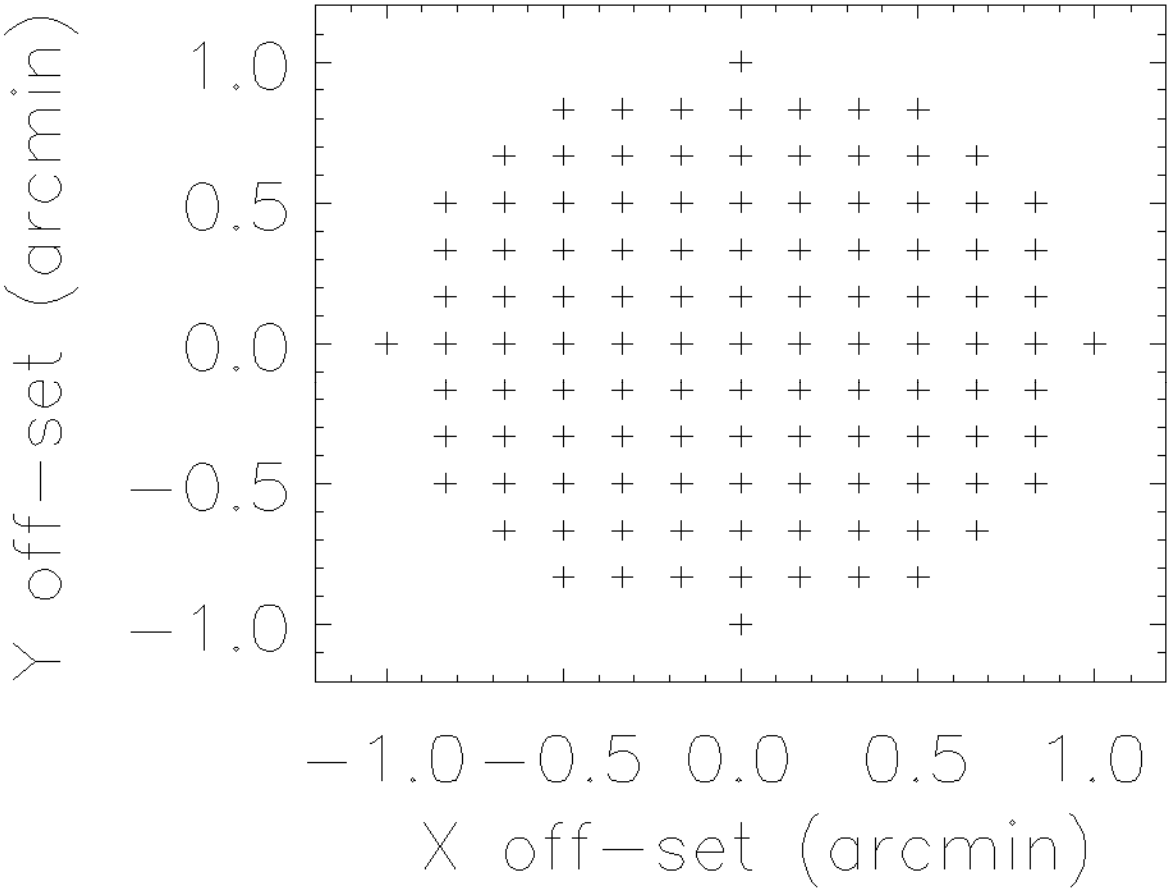
NOT CONSIDERED

Time delay

Wave Front sensor noise

Cone effect (LGS ≈ NGS)

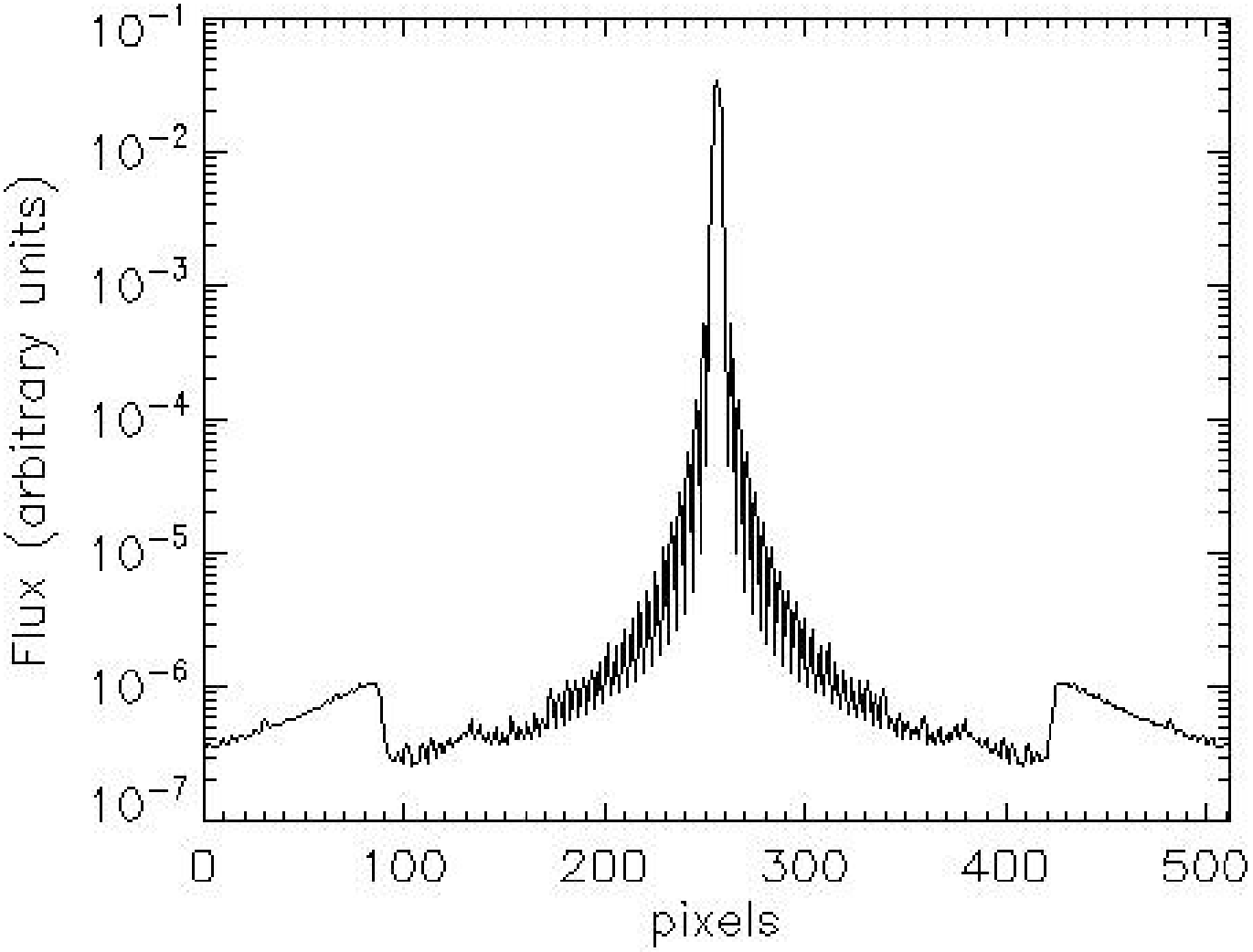
other effects …….

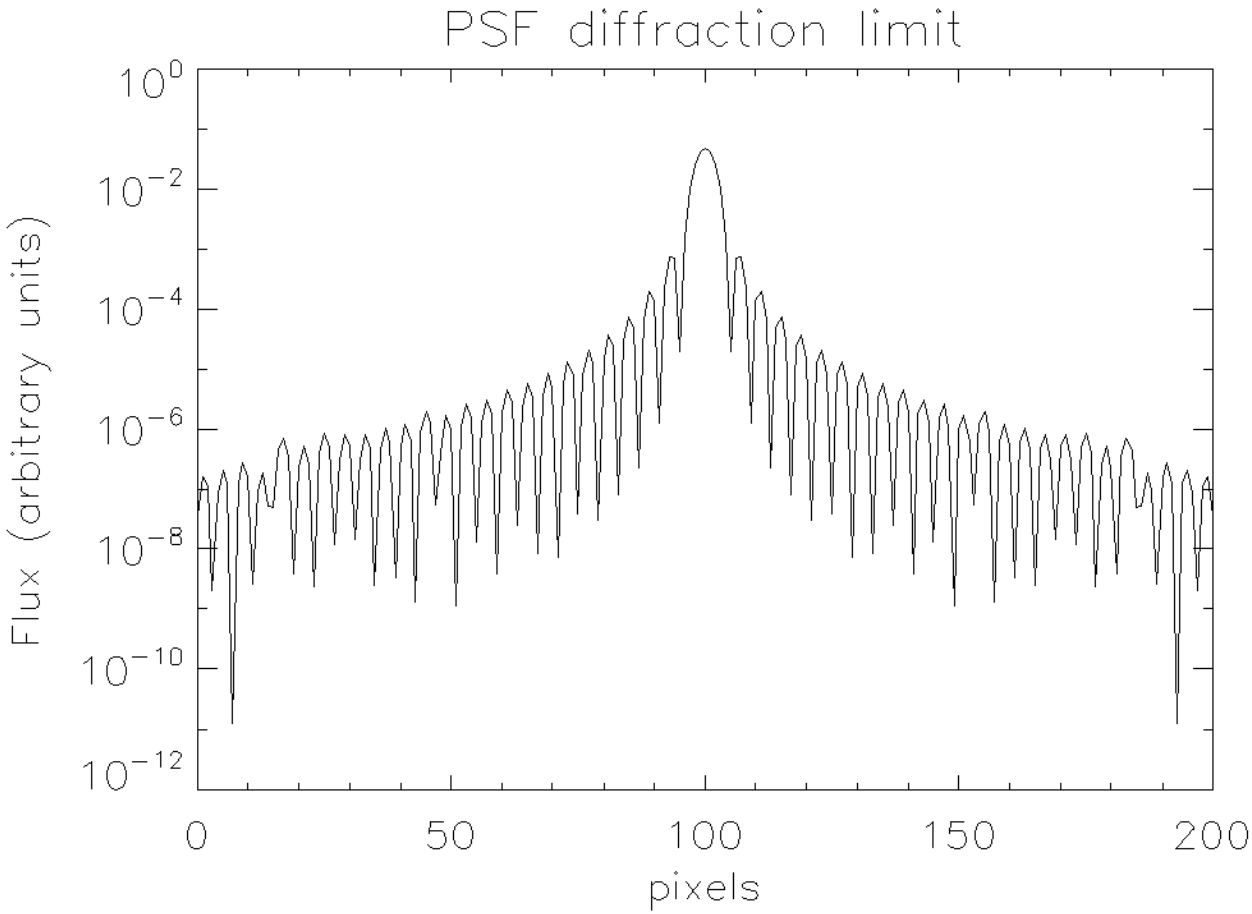


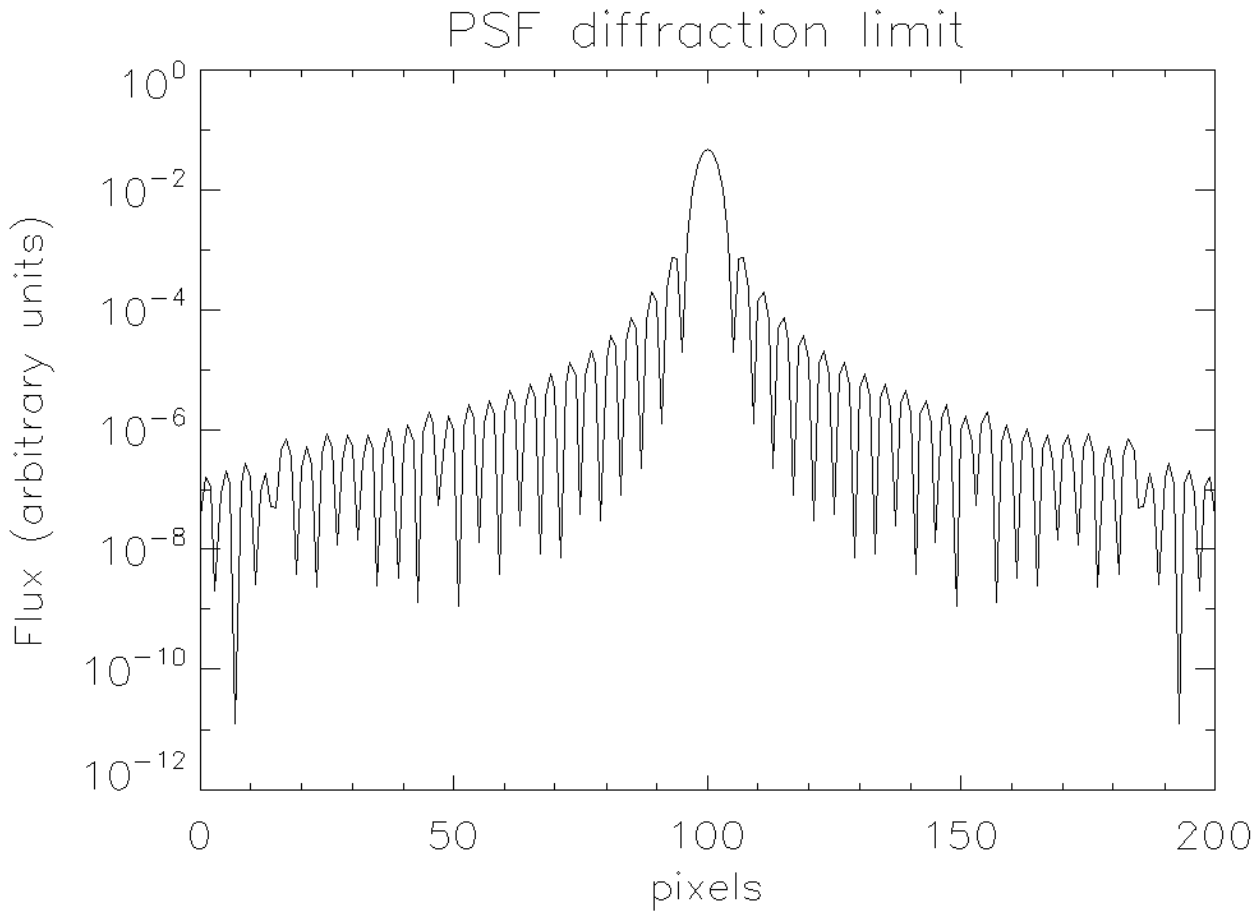
113 PSFs

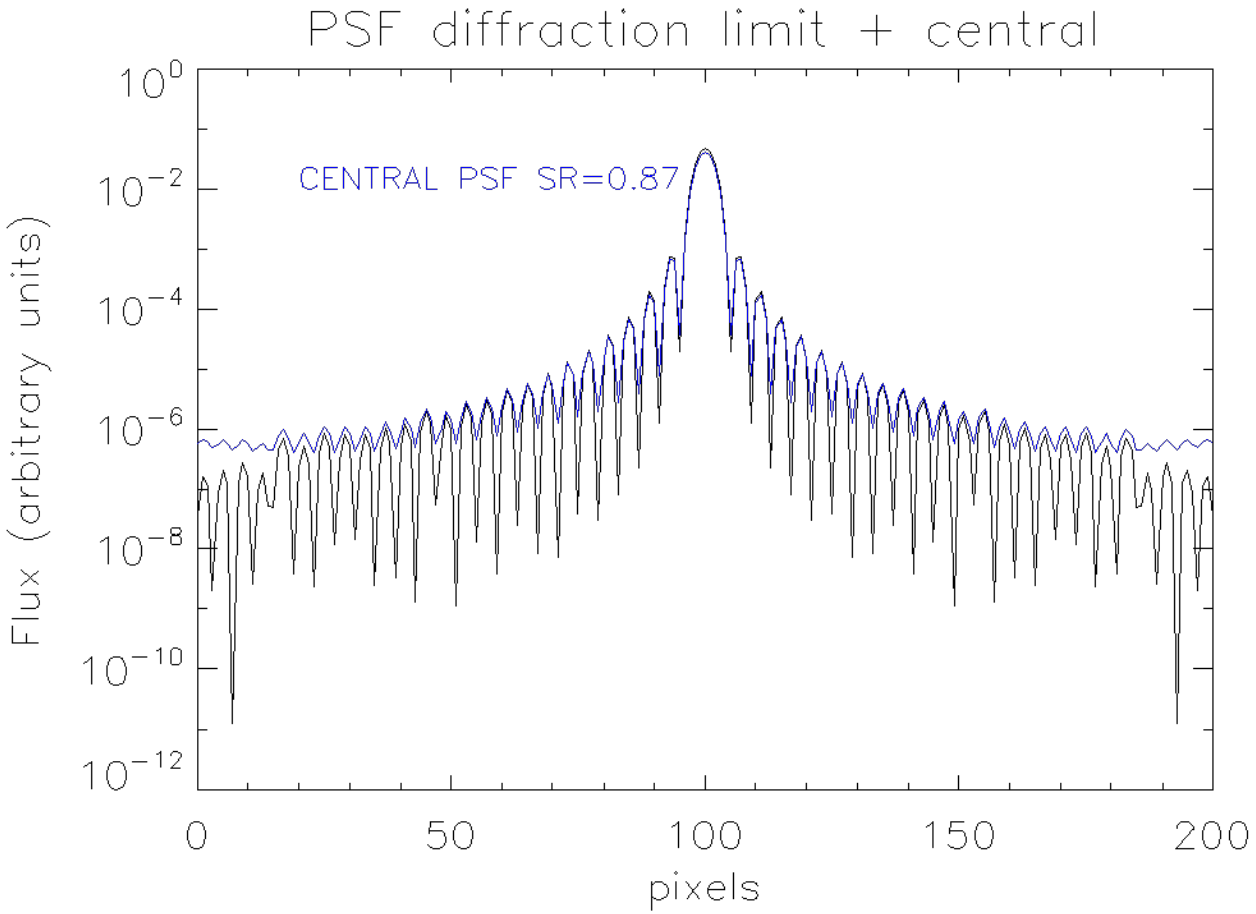
on a field of 2’

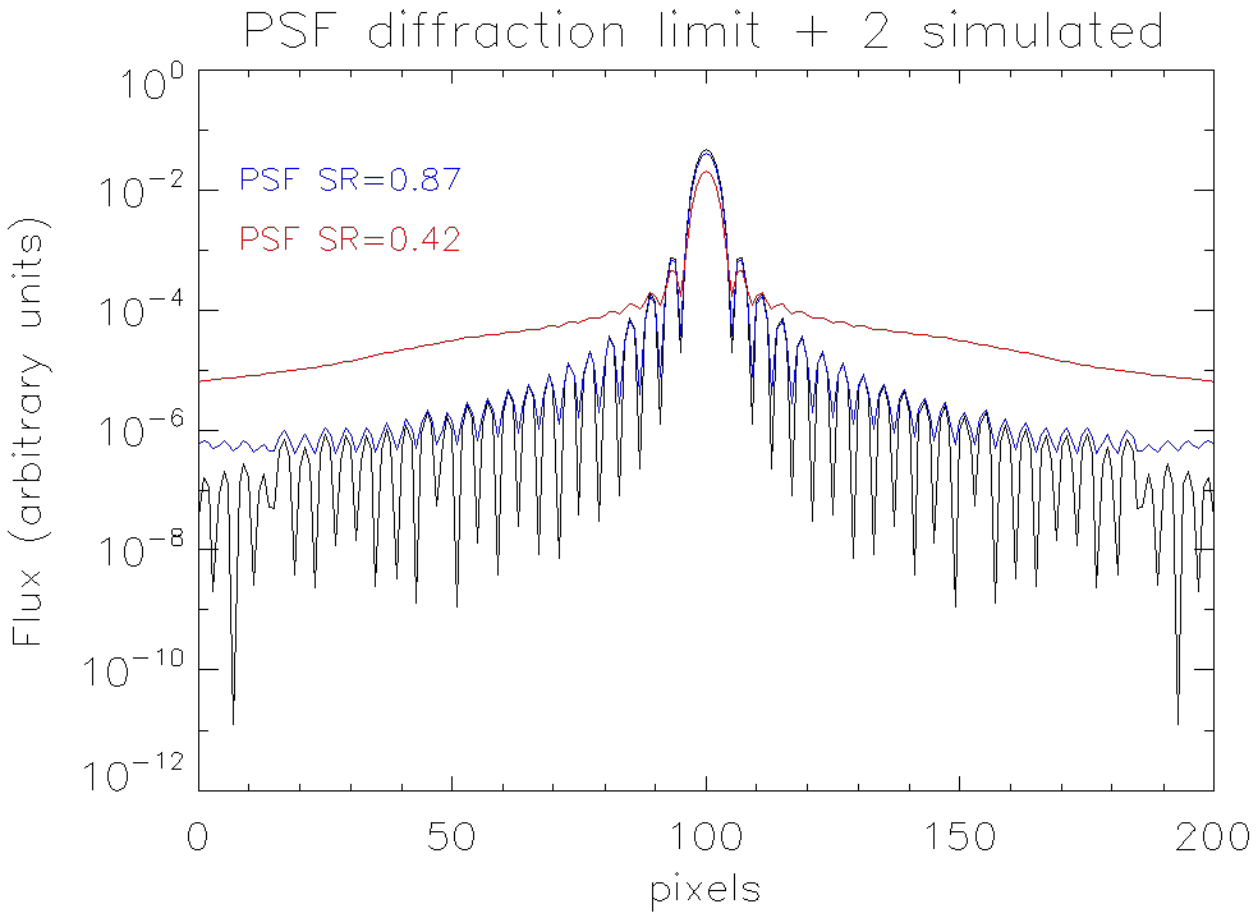
with LGS on Ø 45”


Flux (arbitrary units)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
100
200
300
400
500
pixels


PSF diffraction limit
Flux (arbitrary units)
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
50
100
150
200
pixels


PSF diffraction limit
Flux (arbitrary units)
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
50
100
150
200
pixels


PSF diffraction limit + central
CENTRAL PSF SR=0.87
Flux (arbitrary units)
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
50
100
150
200
pixels

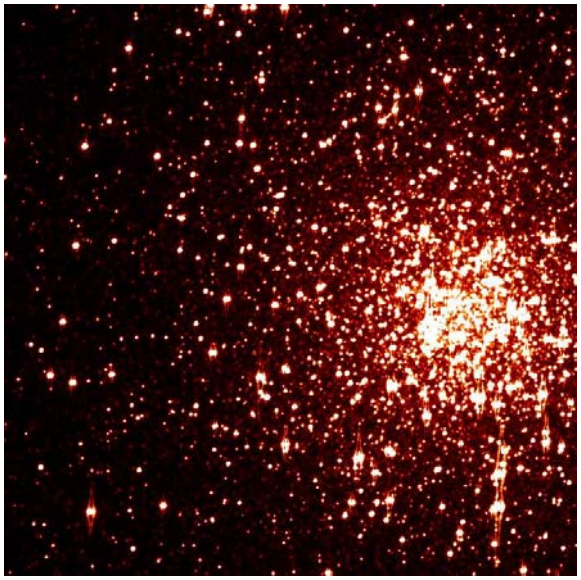

PSF diffraction limit + 2 simulated
PSF SR=0.87
PSF SR=0.42
Flux (arbitrary units)
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
50
100
150
200
pixels

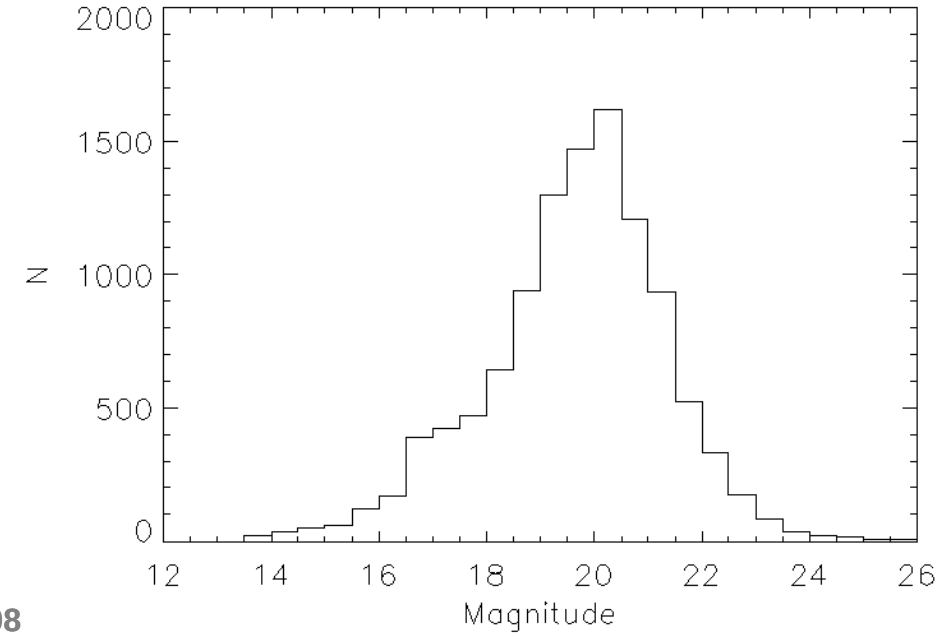
FIRST PRELIMINARY APPLICATION

Simulation of M54

FROM ACS IMAGES

CATALOG of 11050 stars





We simulated an ELT image of M54 assuming :

Array 6144 x 6144 pixels (3x3 detectors of 2048 x 2048)

pixel size 5.4 mas

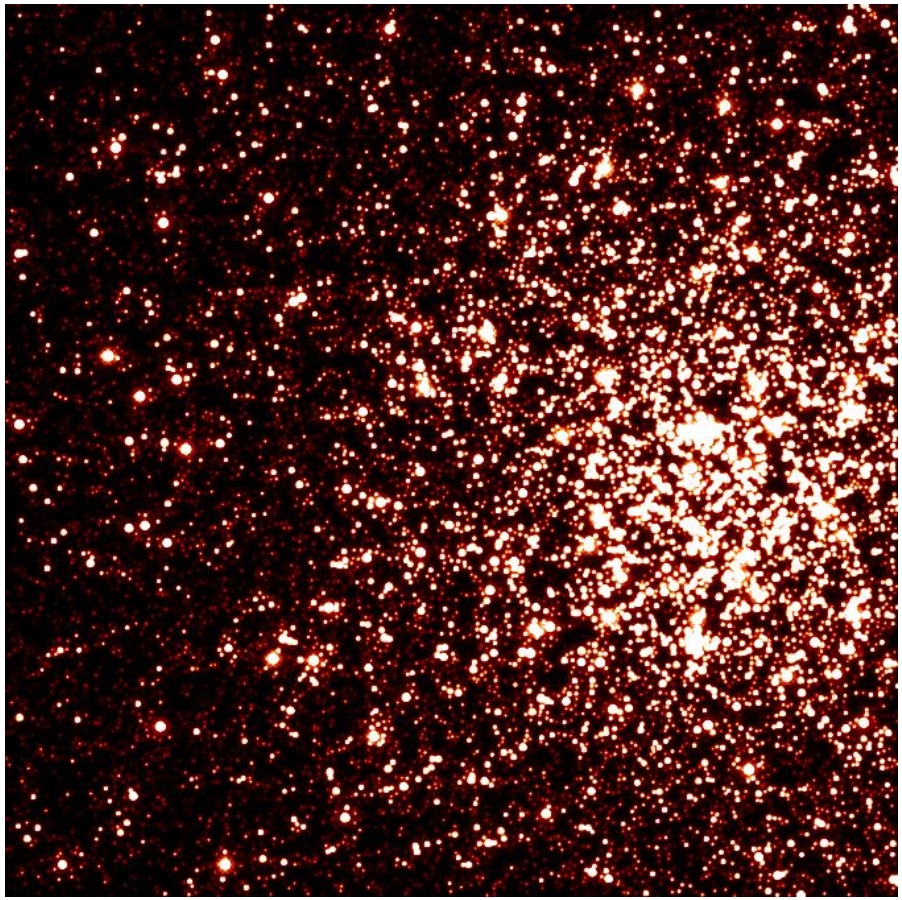
FOV 33 x 33 arcsec

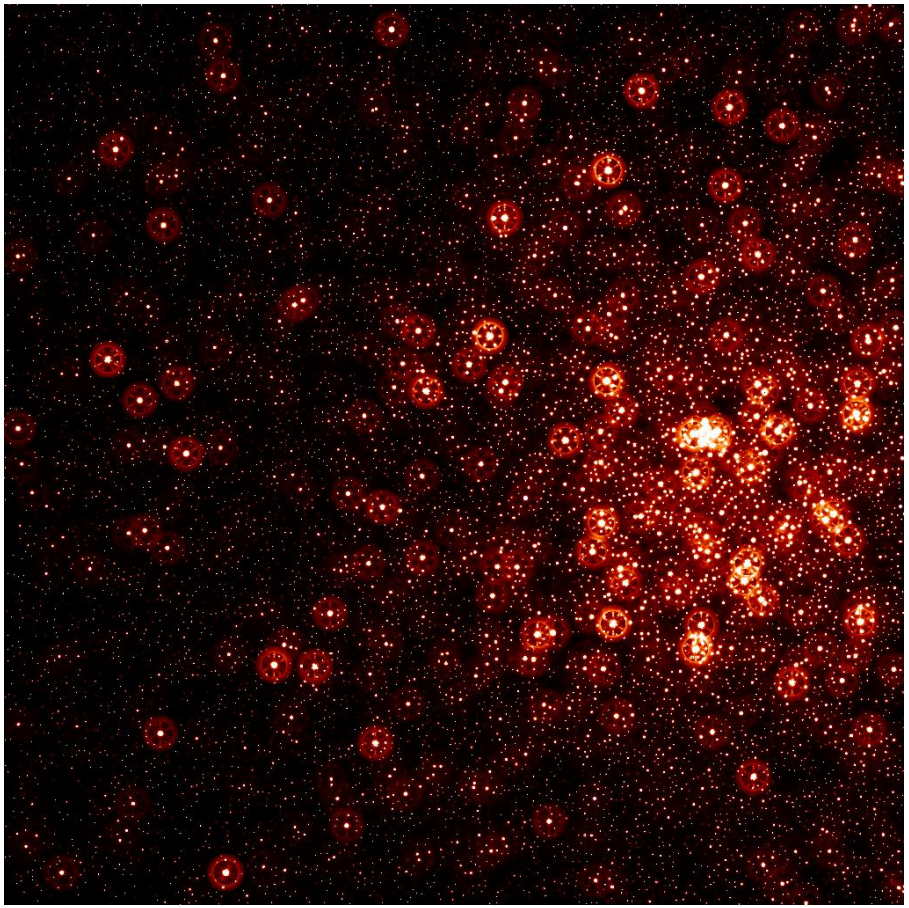
NO background added !!!

PSF in K band

HST-ACS

ELT



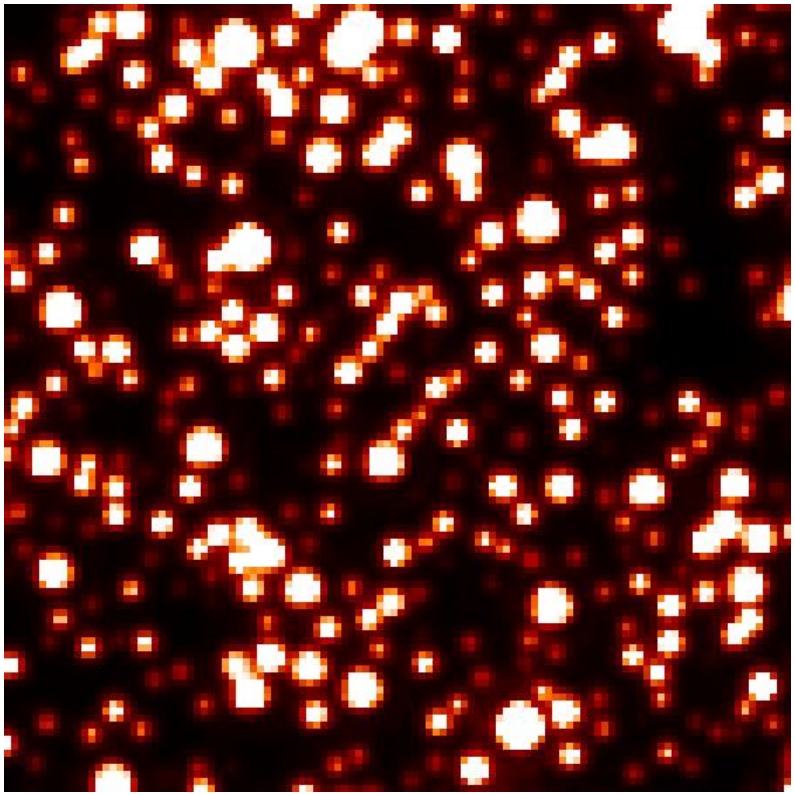


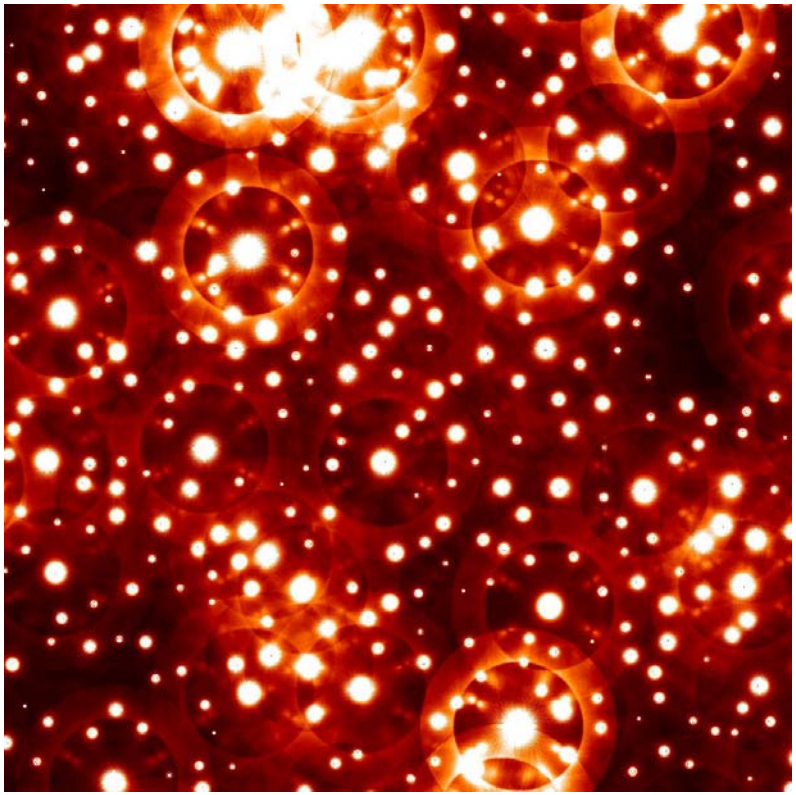
33 arcsec

33 arcsec

HST-ACS

ELT





5.5 arcsec

5.5 arcsec

NEXT STEPS

- PSF VARIATION IN THE FIELD
  - modelling with few simple components (wide plus narrow)????
- PHOTOMETRIC PRECISION
  - errors due to AO (limited strehl and PSF variation)
  - PSF fitting and aperture photometry
- ASTROMETRIC PRECISION
  - systematic effects due to PSF shape and PSF variation
  - possible effect due to LGS rotation with respect to the sky (unlikely but we will investigate….)