A High Strehl Instrument for the AOF

Mark Casali

outline

- Instrument evolution on the VLT
- AO on the VLTs in 2013
- High-strehl imaging

VLT Instrument evolution 2009-2013

Current

UT1			UT2			UT3			UT4		
Na	cass	Nb	Na	cass	Nb	Na	cass	Nb	Na	cass	Nb
crires	FORS	ISAAC	FLAMES	X-shooter	UVES	Visitor	VISIR	VIMOS	HAWKI	SINFONI	NACO

VLT Instrument evolution 2009-2013

2009-10

UT1			UT2			UT3			UT4		
Na	cass	Nb	Na	cass	Nb	Na	cass	Nb	Na	cass	Nb
crires	FORS	Visitor	FLAMES	X-shooter	UVES	Isaac	VISIR-2	VIMOS	HAWKI	SINFONI	NACO

- ISAAC moved to UT3 (Q3)
- VISIR upgraded

VLT Instrument evolution 2009-2013

2011-2012

UT1			UT2			UT3			UT4		
Na	cass	Nb	Na	cass	Nb	Na	cass	Nb	Na	cass	Nb
crires	FORS	KMOS	FLAMES	X-shooter	UVES	Sphere	VISIR-2	VIMOS	HAWKI	SINFONI	MUSE

- ISAAC removed / SPHERE installed on UT3
- NACO removed / MUSE installed on UT4
- Visitor focus lost / KMOS installed (Q2)

VLT Instrument evolution 2009-2013

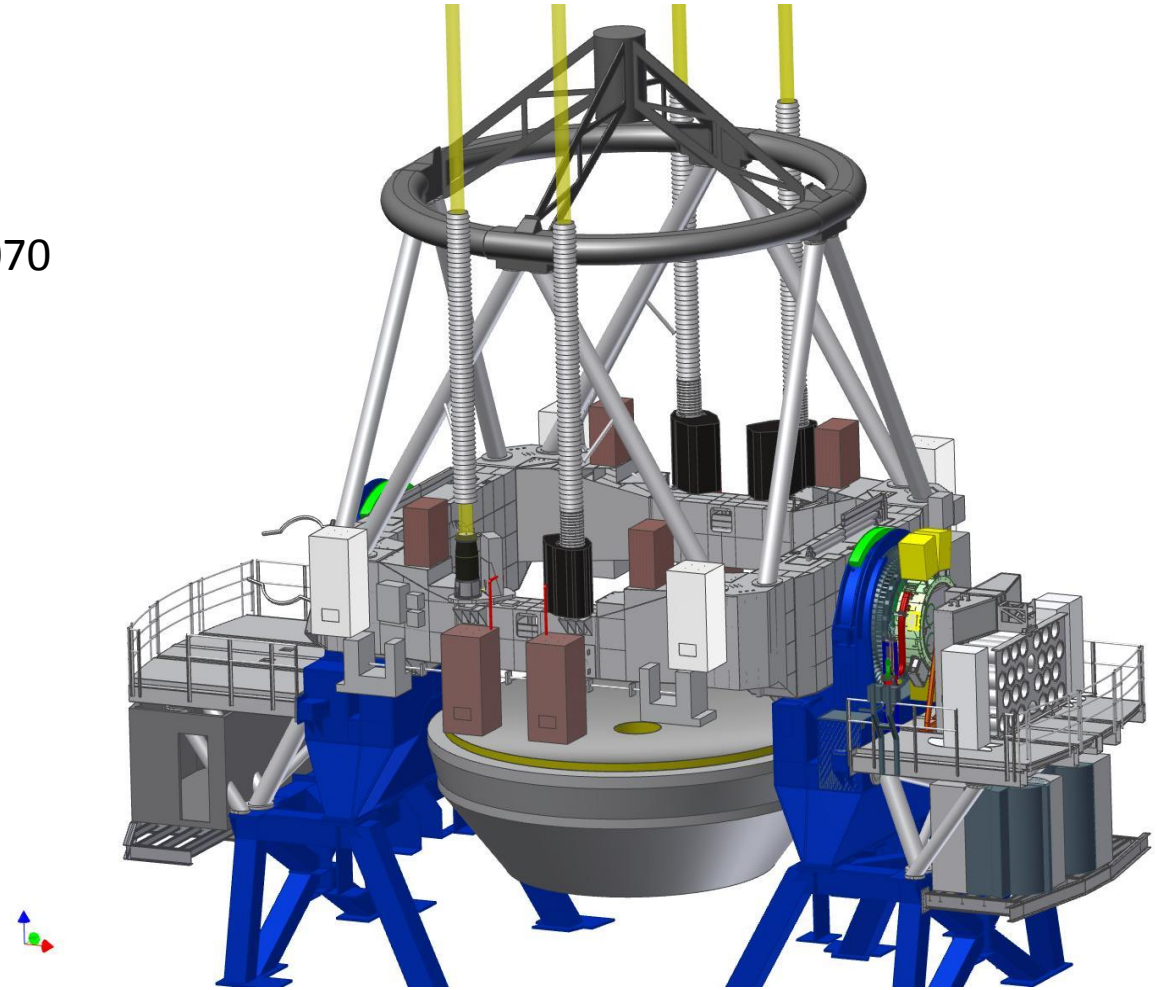
2013-14

UT1			UT2			UT3			UT4-AOF		
Na	cass	Nb	Na	cass	Nb	Na	cass	Nb	Na	cass	Nb
crires	FORS	KMOS	FLAMES	X-shooter	UVES	Sphere	VISIR-2	VIMOS	HAWKI	SINFONI	MUSE

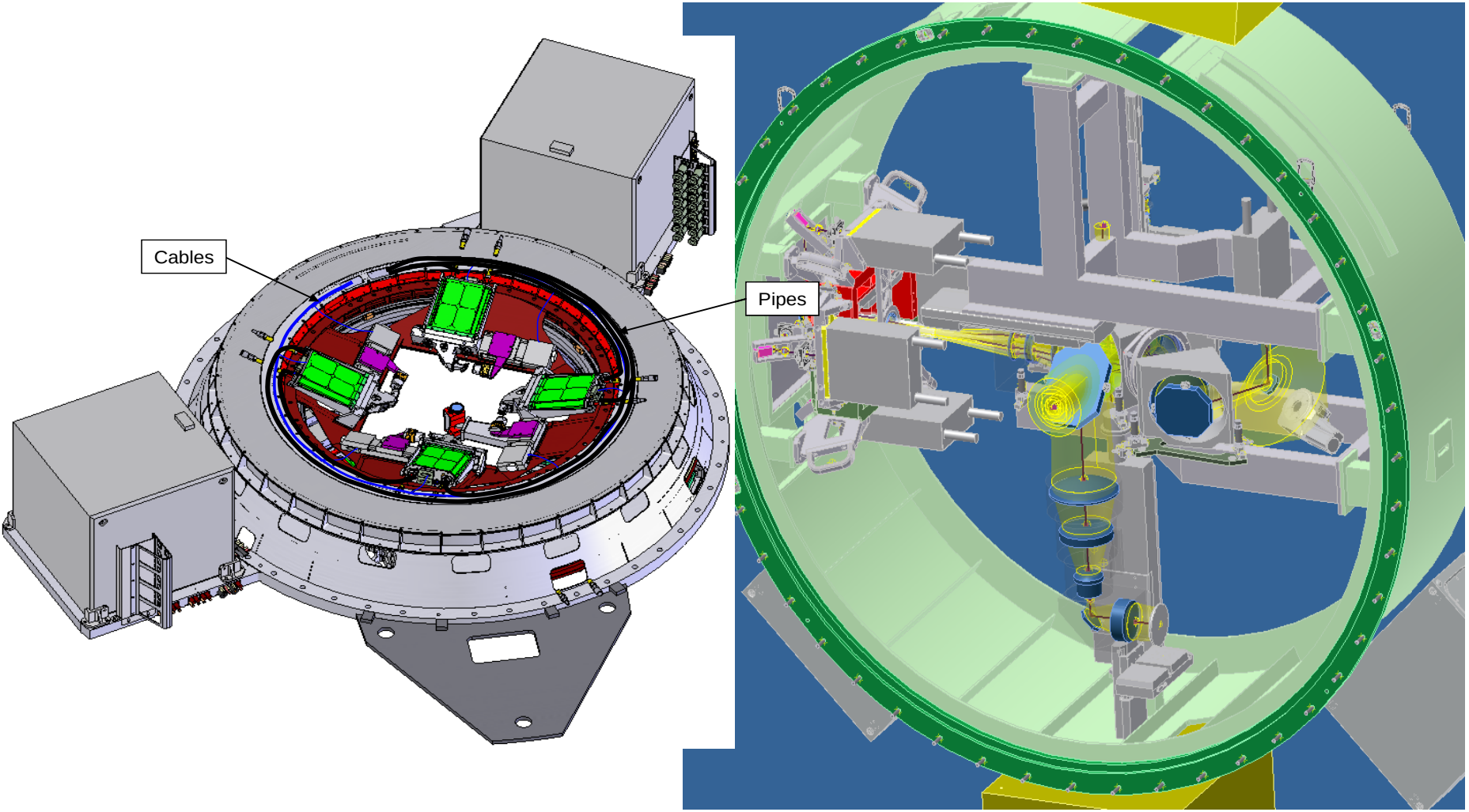
- AOF installed on UT4

The Adaptive Optics Facility

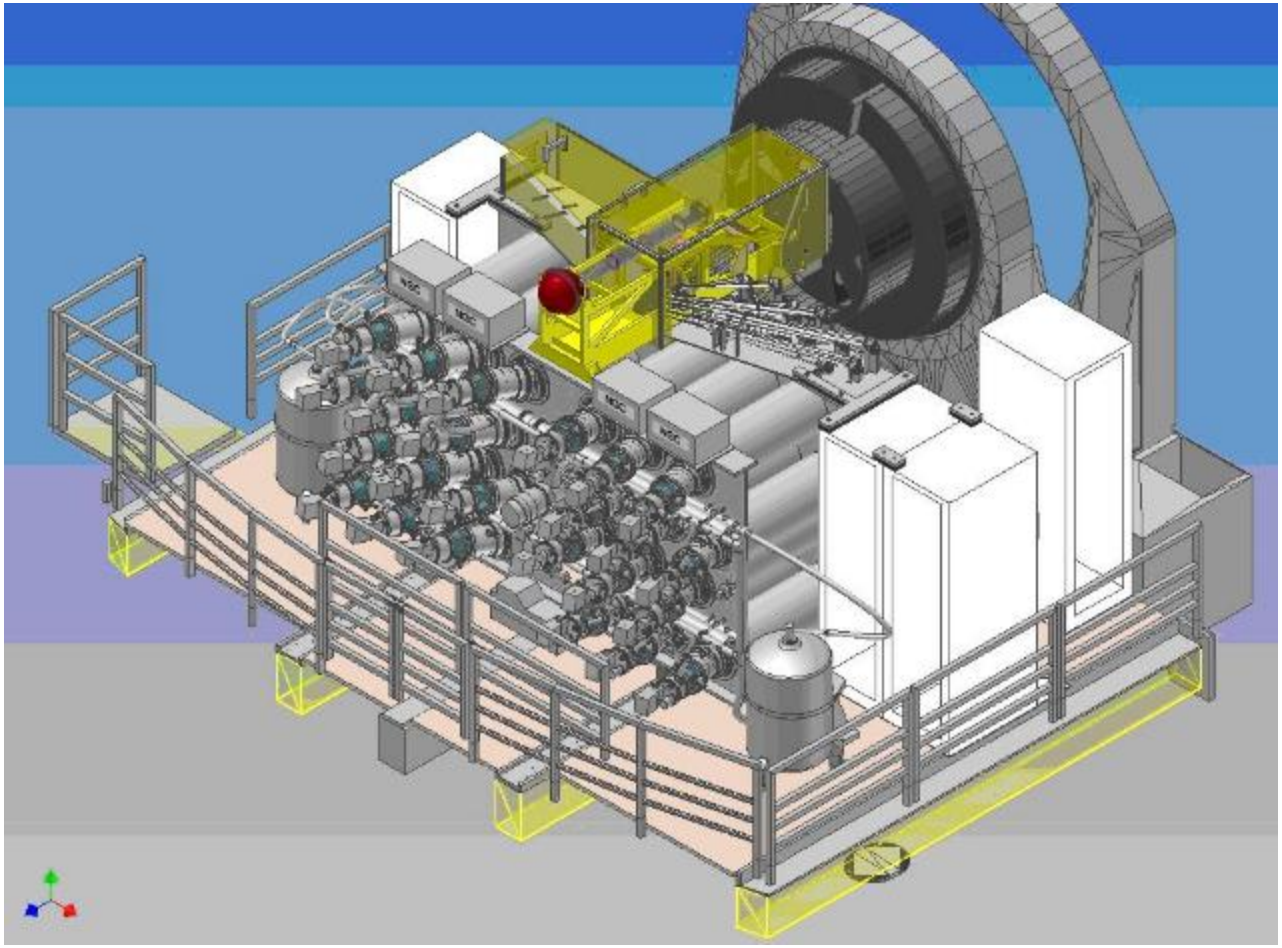
- 4 Lasers
- Deformable thin-shell secondary mirror with 1070 actuators
- WFS modules



The Adaptive Optics Facility



MUSE



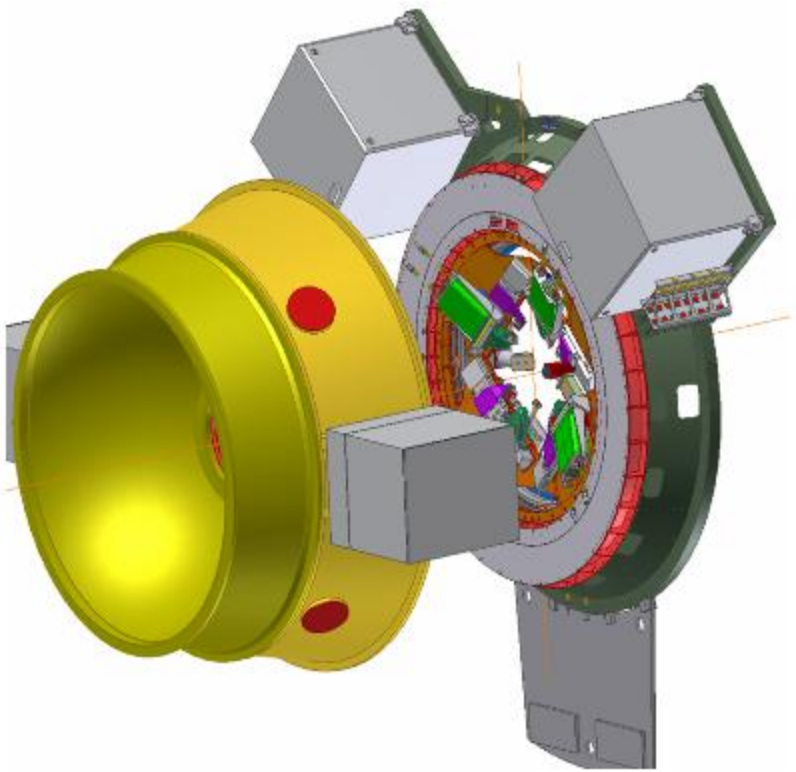
- 24 IFU spectrographs
- R=2000-4000
- 0.46 – 0.93 microns

MUSE

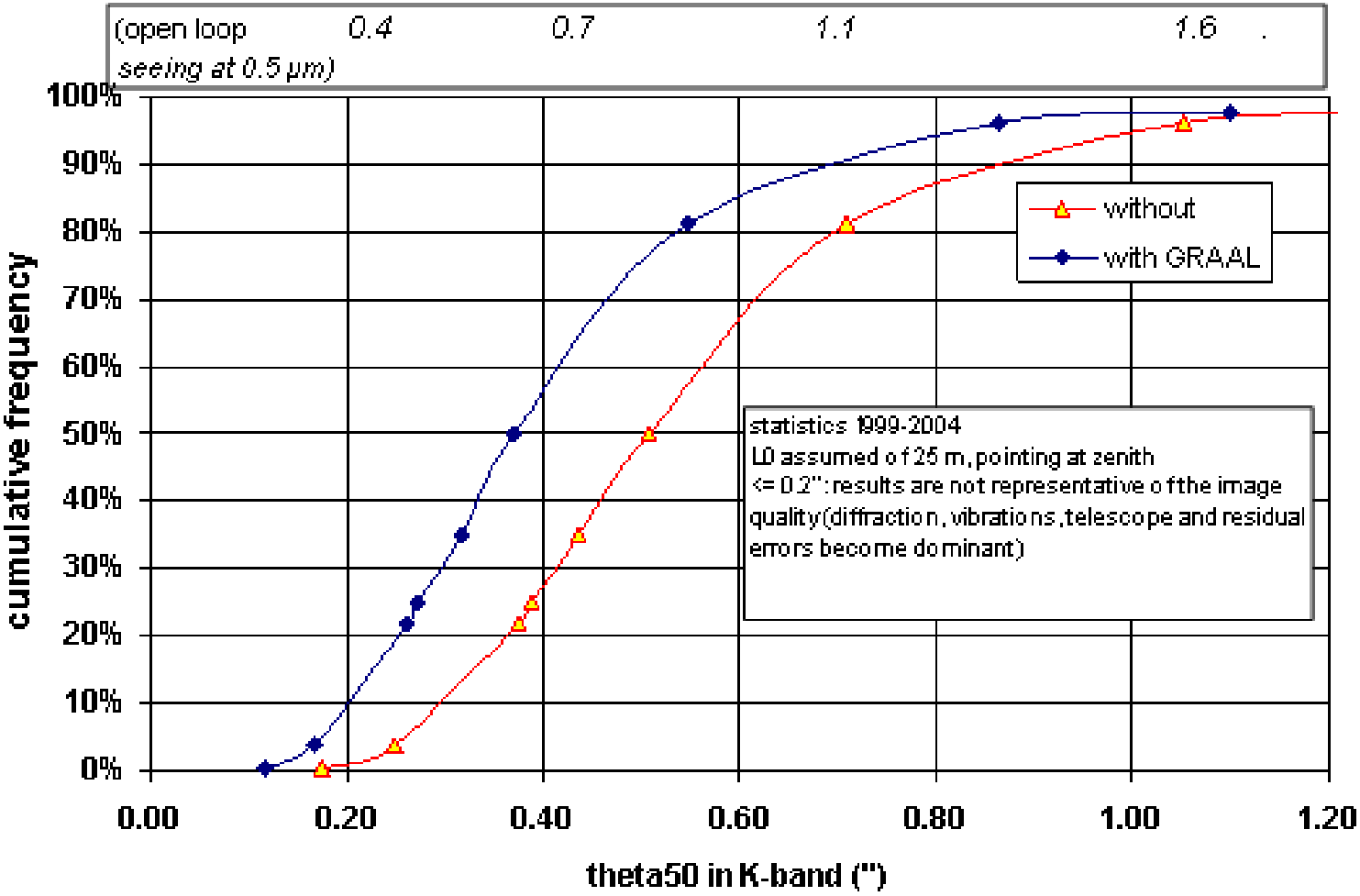
Observational Parameters	
Spectral range (simultaneous)	0.465-0.93 μm
Resolving power	2000@0.46 μm
	4000@0.93 μm
Wide Field Mode (WFM)	
Field of view	1x1 arcmin^2
Spatial sampling	0.2x0.2 arcsec^2
Spatial resolution (FWHM)	0.3-0.4 arcsec
Gain in ensquared energy within one pixel with respect to seeing	2
Condition of operation with AO	70%-ile
Sky coverage with AO	70% at Galactic Pole
Limiting magnitude in 80h	I_{AB} = 25.0 (R=3500)
	I_{AB} = 26.7 (R=180)
Limiting Flux in 80h	3.9 10^{-19}erg.s^{-1}.cm^{-2}
Narrow Field Mode (NFM)	
Field of view	7.5x7.5 arcsec^2
Spatial sampling	0.025x0.025 arcsec^2
Spatial resolution (FWHM)	0.030-0.050 arcsec
Strehl ratio	10-30%
Limiting Flux in 1h	2.3 10^{-18}erg.s^{-1}.cm^{-2}
Limiting magnitude in 1h	R_{AB} = 22.3
Limiting surface brightness in 1h	R_{AB} = 17.3 arcsec^{-2}

HAWK-I + GLAO

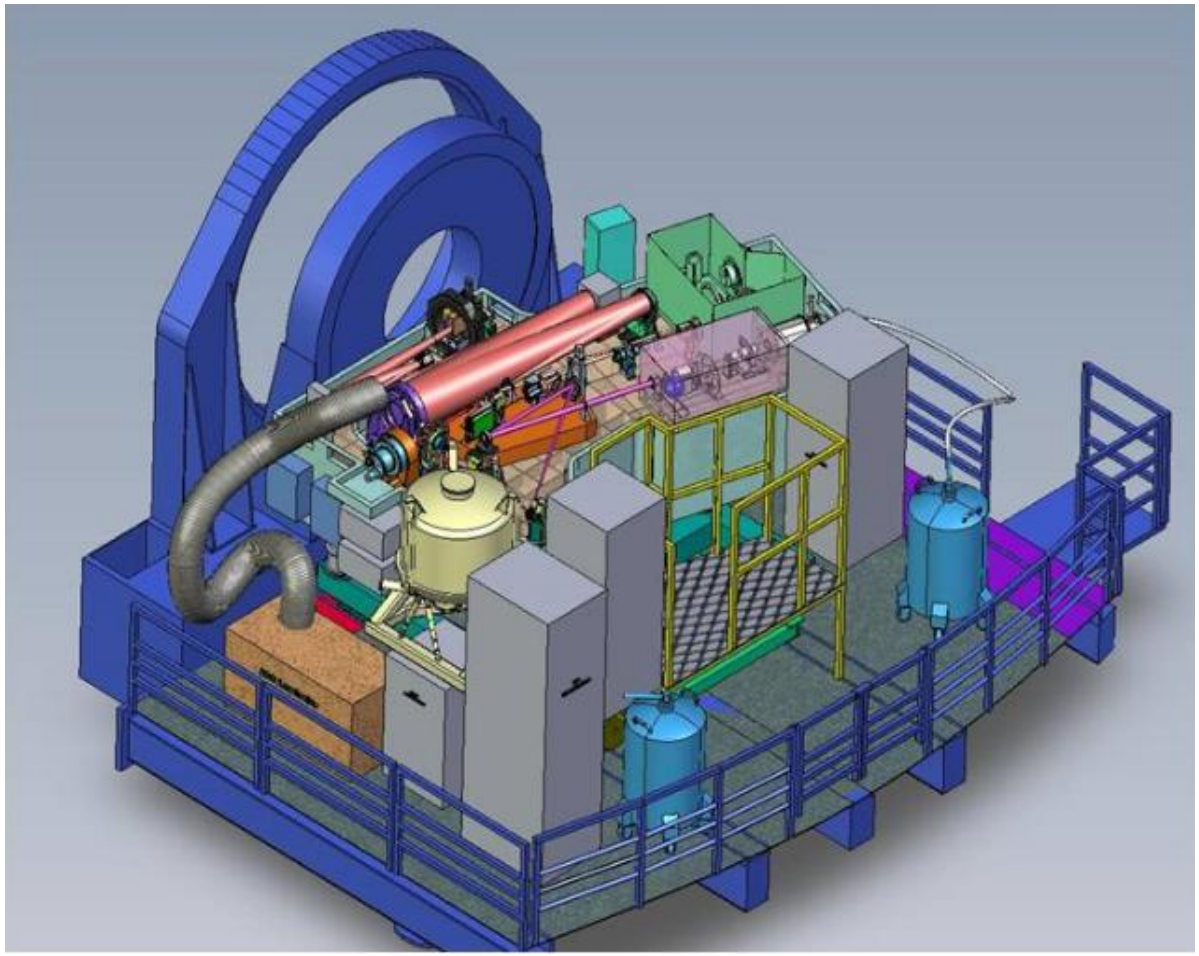
HAWK-I + GLAO



HAWK-I + GLAO


(open loop 0.4 0.7 1.1 1.6 .
seeing at 0.5 µm)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
cumulative frequency
0.00
0.20
0.40
0.60
0.80
1.00
1.20
theta50 in K-band (")
without
with GRAAL
statistics 1999-2004
L0 assumed of 25 m, pointing at zenith
<= 0.2": results are not representative of the image quality (diffraction, vibrations, telescope and residual errors become dominant)

SPHERE



1. IR dual-beam Imager and spectrograph
   - 0.95-2.3 um
   - 11” FoV
2. IR IFU spectrograph
   - 0.95-1.7 um
   - R~30
3. Visible polarimetric imager
   - 3” field
   - 600-900 nm

AO on the VLT circa 2013

- AO for MUSE and HAWK-I
- SINFONI
- SPHERE
- MACAO + CRIRES

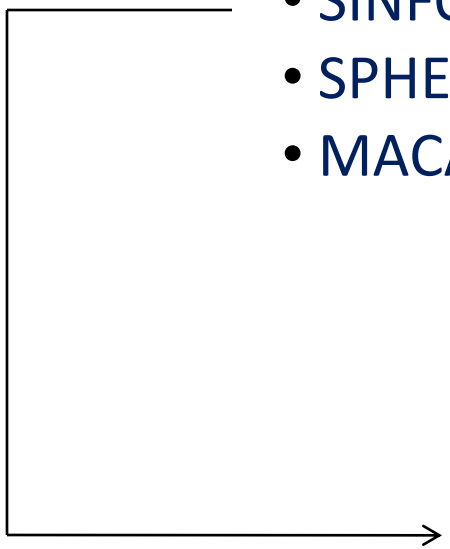
AO on the VLT circa 2013

- AO for MUSE and HAWK-I
- SINFONI
- SPHERE
- MACAO + CRIRES

- GLAO for MUSE wide field and HAWK-I
- MUSE narrowfield LTAO

AO on the VLT circa 2013

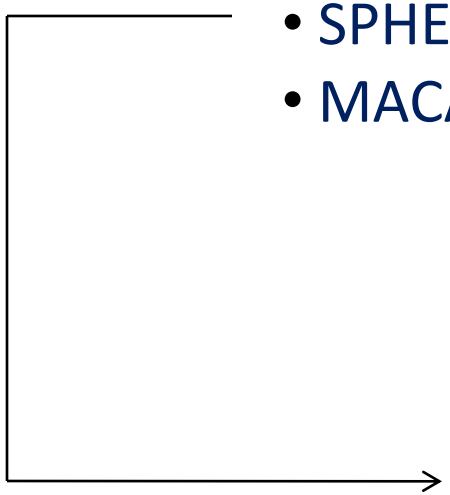
- AO for MUSE and HAWK-I
- SINFONI
- SPHERE
- MACAO + CRIRES



- no longer state of the art in AO
- new laser would help

AO on the VLT circa 2013

- AO for MUSE and HAWK-I
- SINFONI
- SPHERE
- MACAO + CRIRES

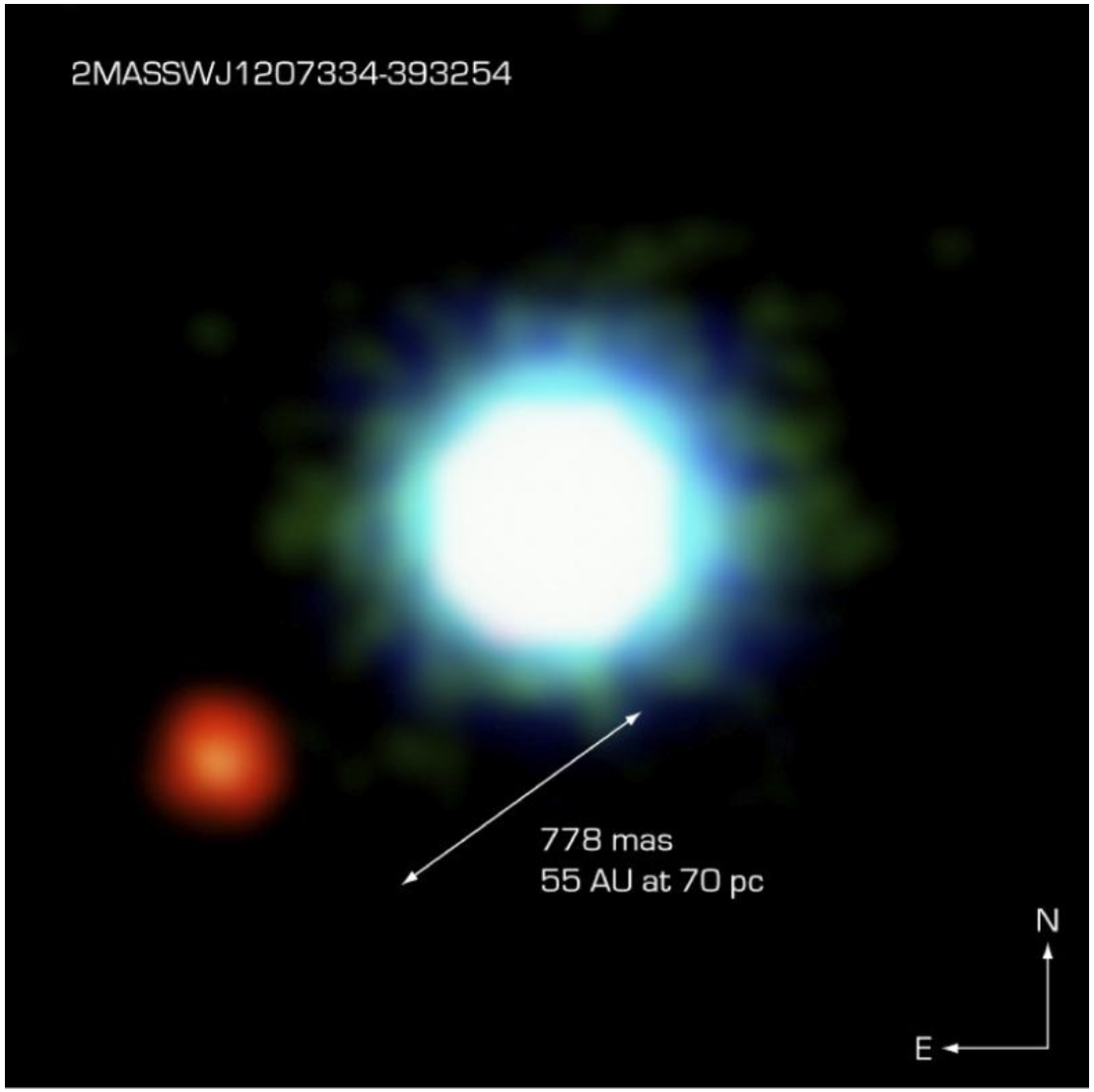


- will replace some NACO science. Planet searches.
- limited by NGS-only
- throughput not optimised
- 11” FoV diameter maximum

AO on the VLT circa 2013

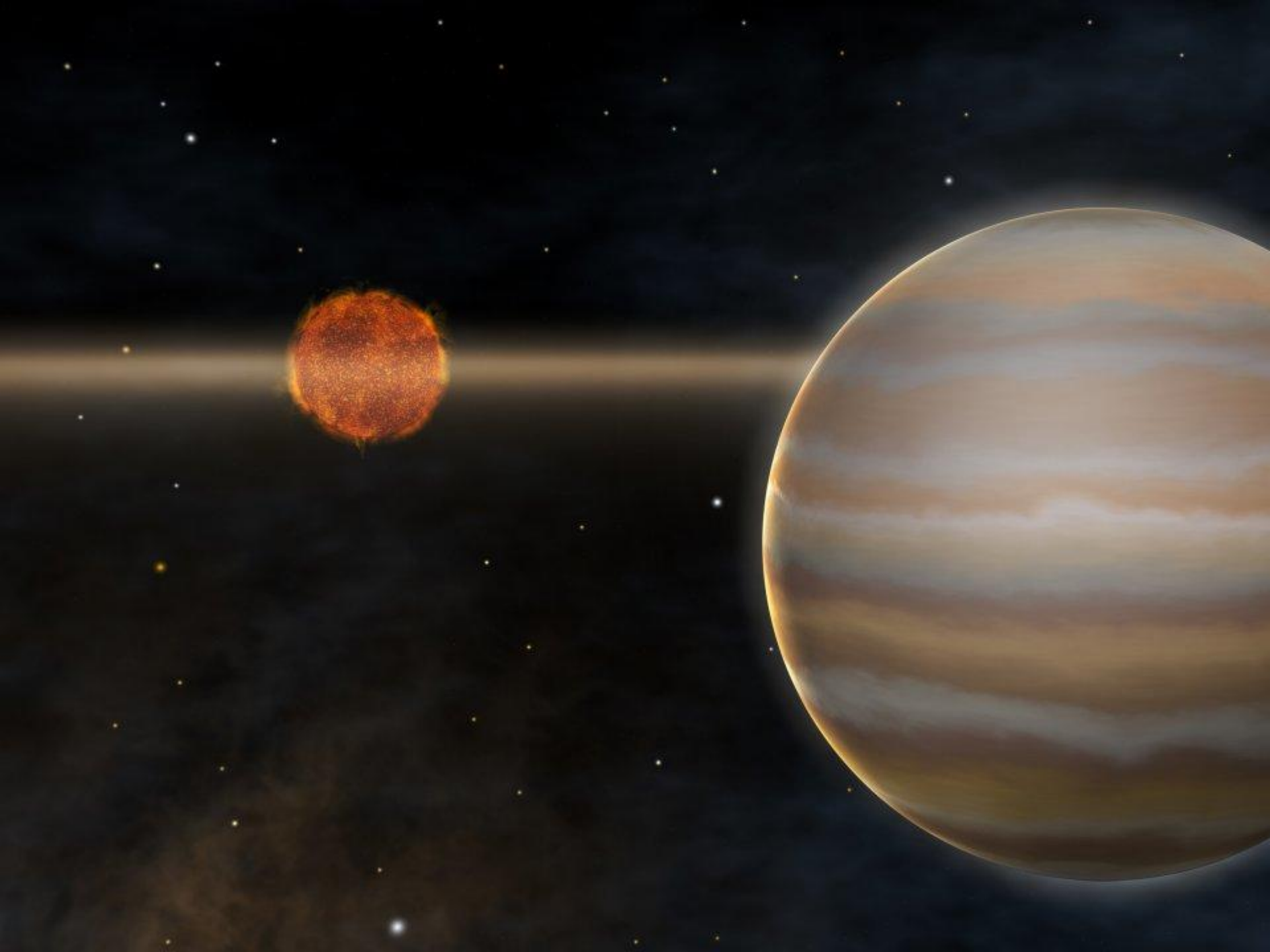
- for the moment a general-purpose high-strehl imager and IFU using the AOF are not planned

Successes of NACO

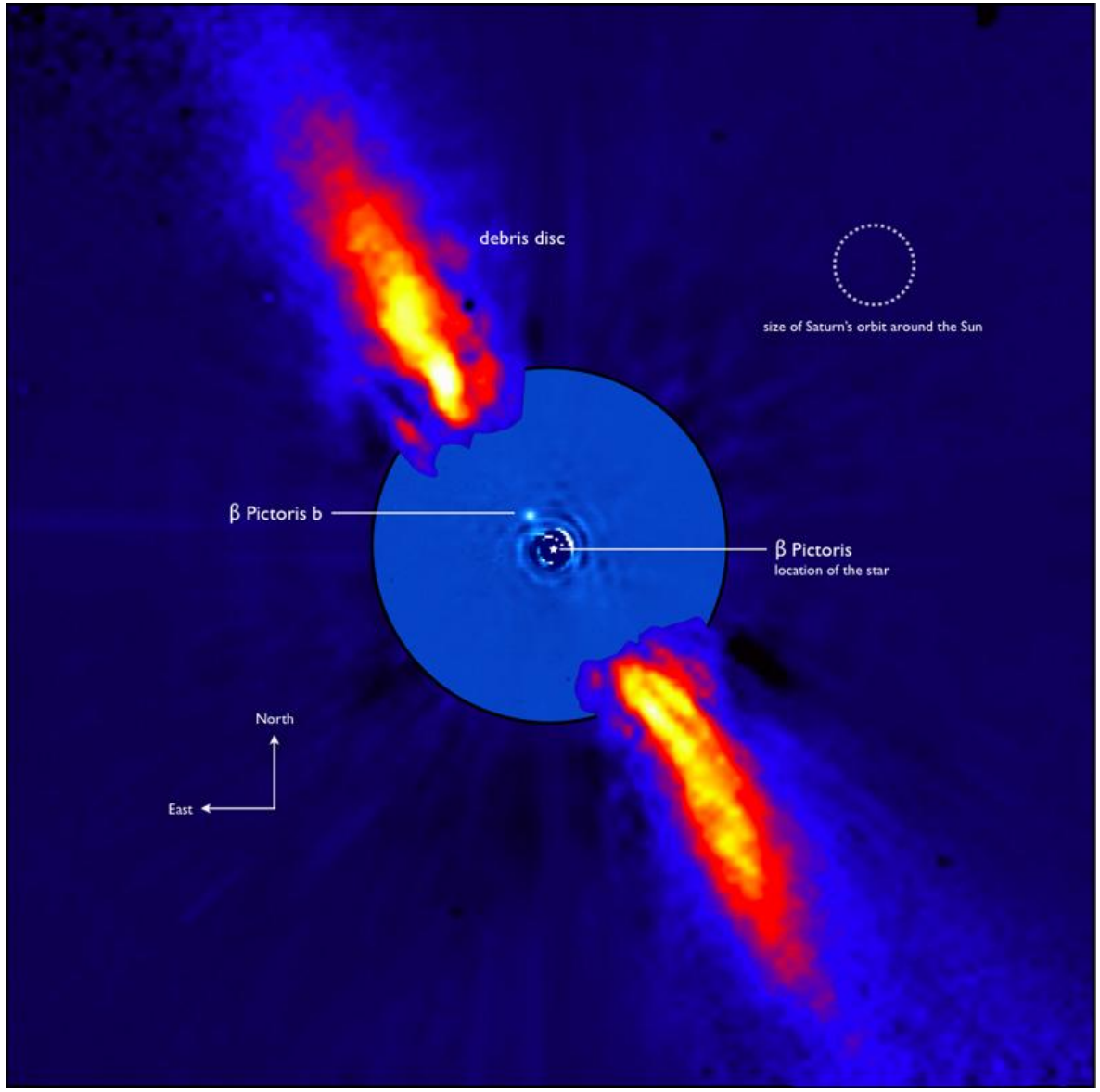


- 2M1207 planetary companion (H,K,L')
- orbital radius of 2x Neptune
- 5 x Mj
- <10 Myr

Chauvin et al 2004



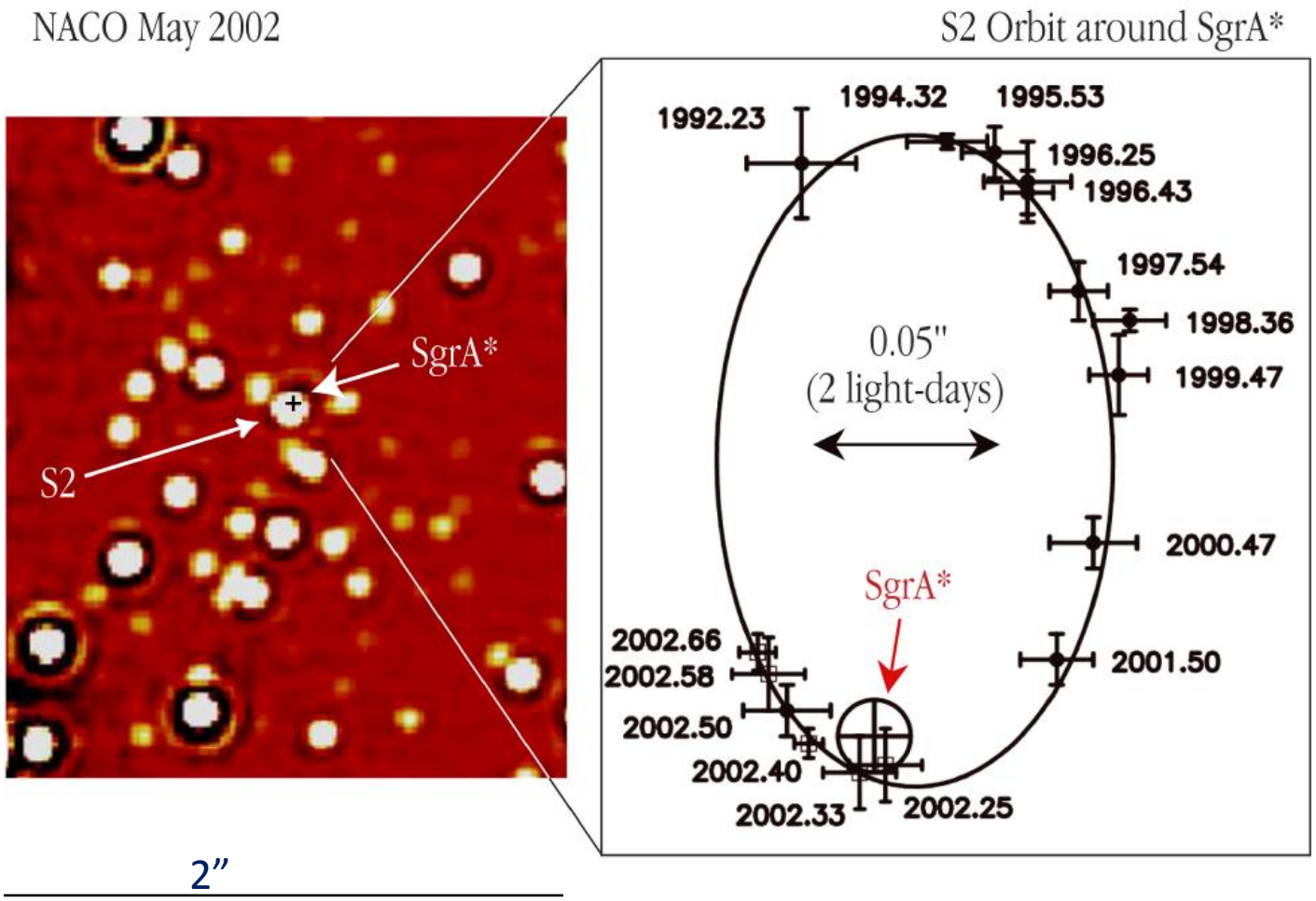
Successes of NACO



- Beta Pic planet
- 3.6 microns
- 1000 times fainter than star
- 8 Mj, 8 AU
- 12 Myr (1500 K)

Lagrange et al 2008

Successes of NACO



The Motion of a Star around the Central Black Hole in the Milky Way

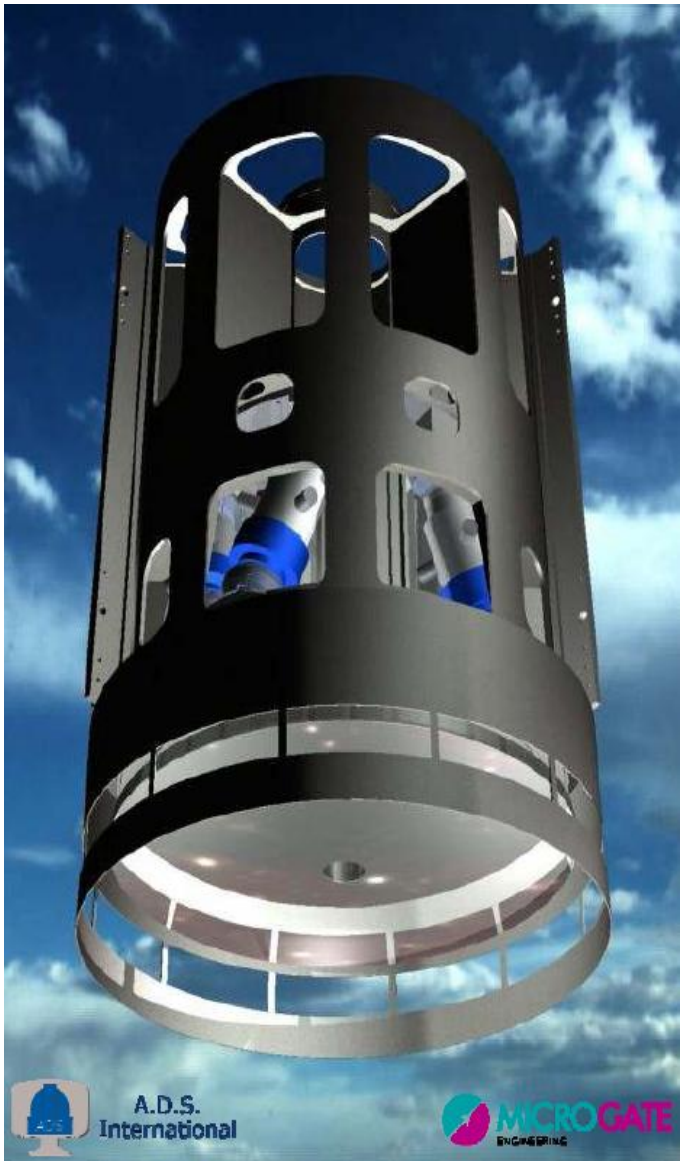
ESO PR Photo 23c/02 (9 October 2002)

Genzel et al 2002

A new high-strehl instrument for the AOF

Power of the DSM in a narrowfield

- Large number of actuators (1070 c.f. 185 in NAOS)
- M2. fewer mirrors and better overall emissivity

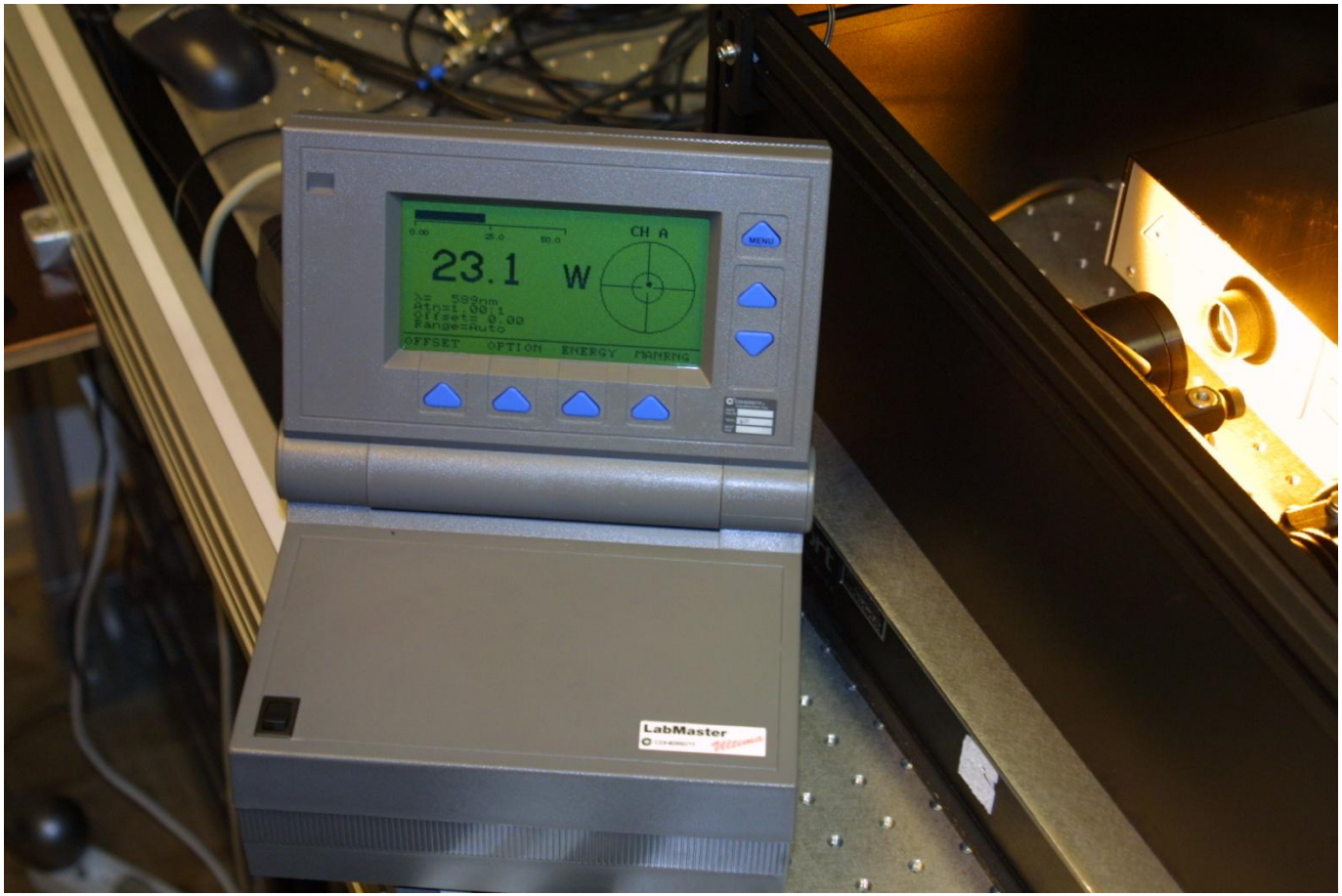


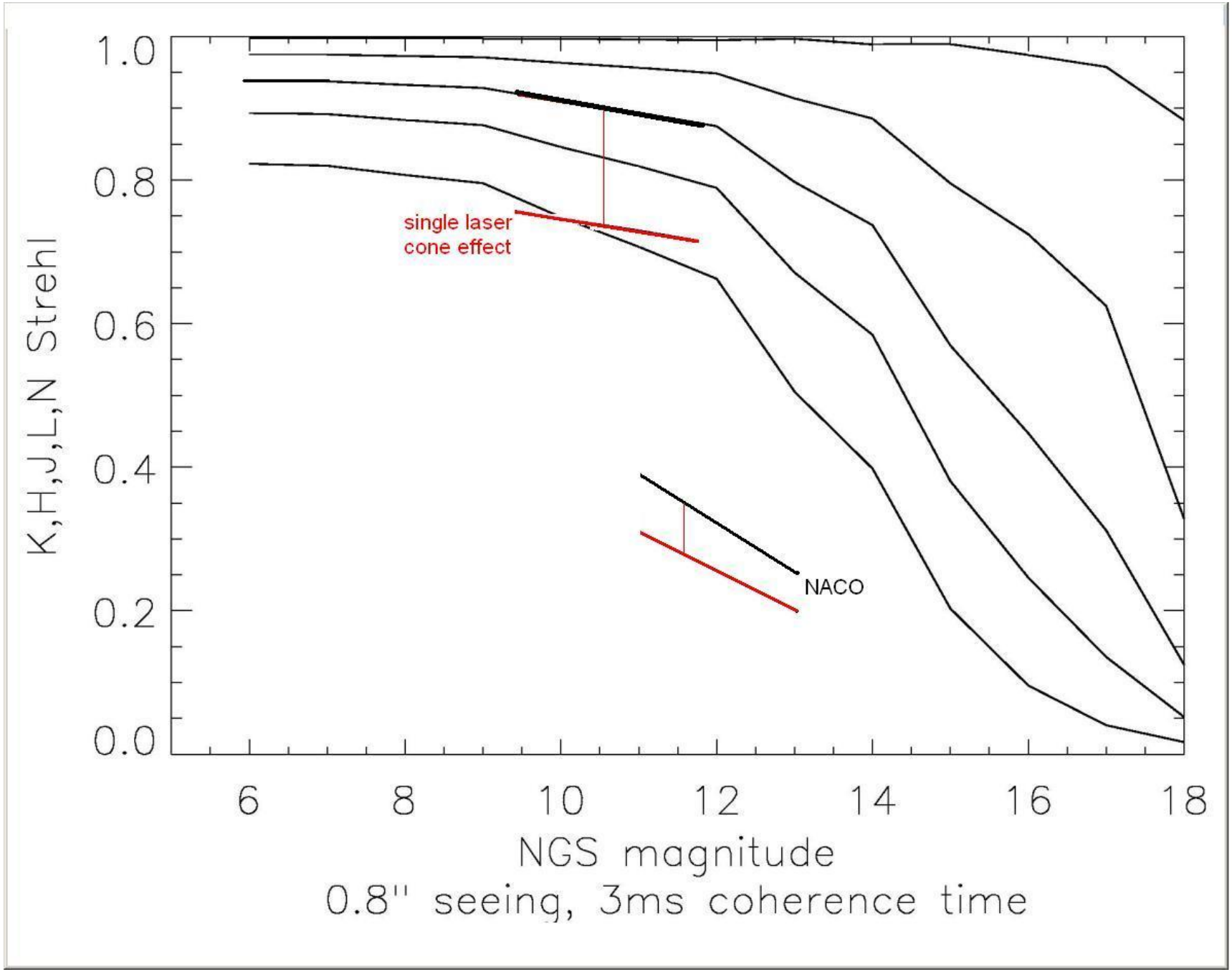
Better lasers

- Fibre-Raman approach very successful within ESO.

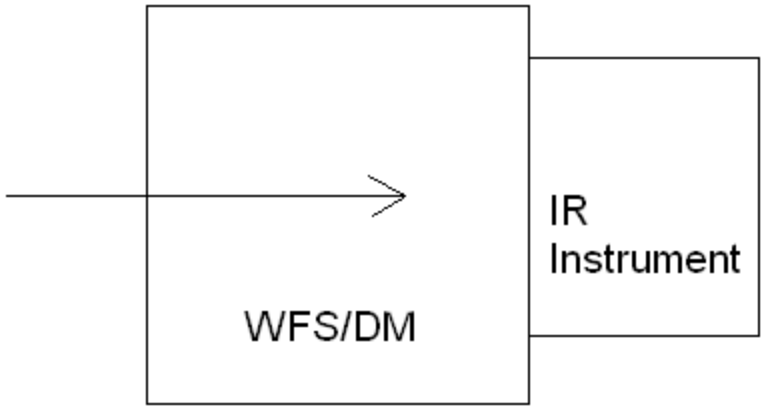
- >23W (c.f. 5 W Parsec) +back-pumping gives a >5 brighter LGS

- two contracts with industry for preliminary design/ manufacture




1.0
0.8
0.6
0.4
0.2
0.0
K,H,J,L,N Strehl
single laser
cone effect
NACO
6
8
10
12
14
16
18
NGS magnitude
0.8'' seeing, 3ms coherence time

Options



NAOS + CONICA = NACO
MACAO + SPIFFI = SINFONI
MACAO + cryo-spectrograph = CRIRES
GALACSI + MUSE
GRAAL + HAWKI

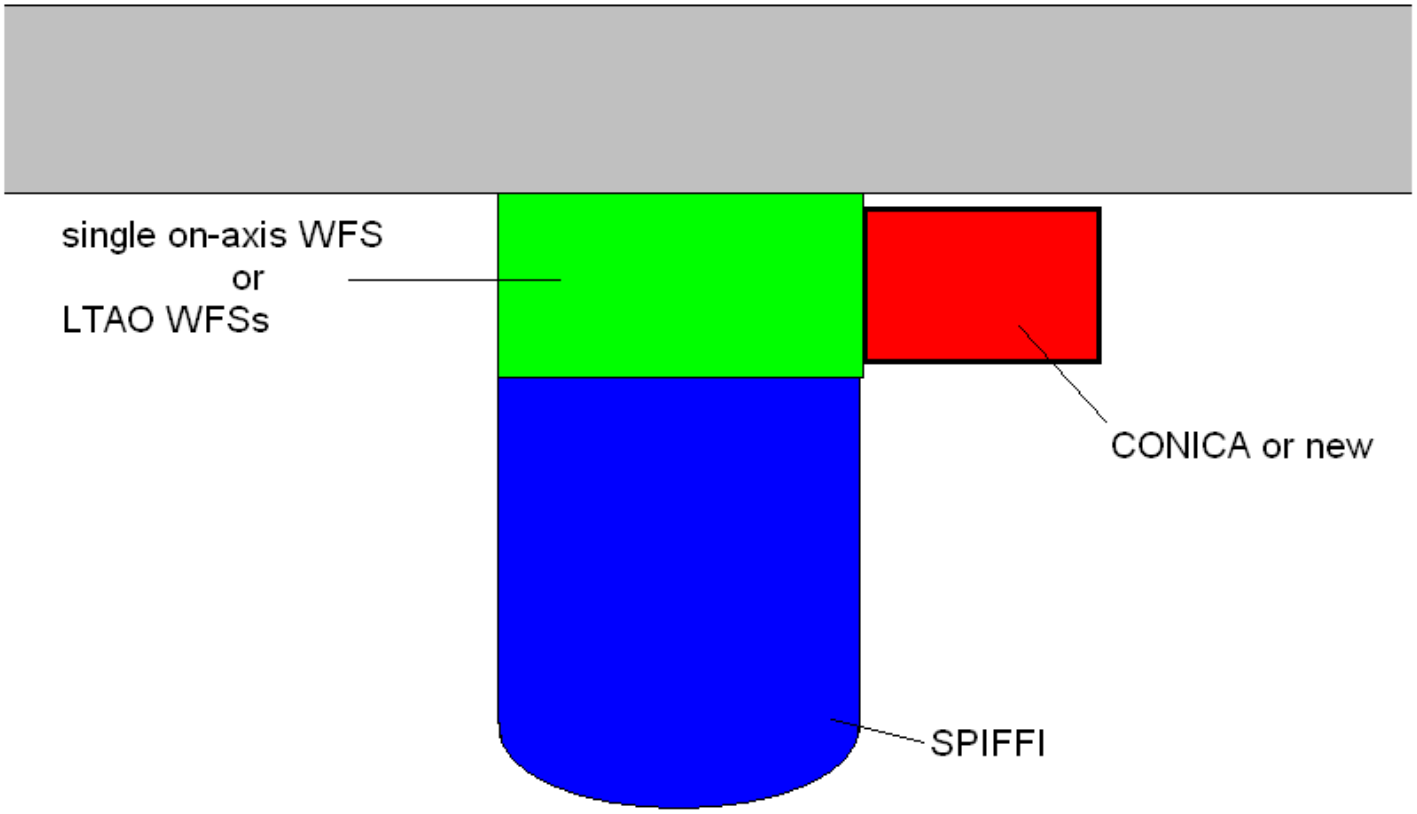
Options

- Keep SINFONI with new laser
  - Does not use new DSM
  - No direct imaging
- Keep SPIFFI, new WFSs, use new DSM
  - Remains at current port
  - No direct imaging

Options

- Re-use of SPIFFI and/or CONICA
  - NaCo already suffers from flexure problems : changing gravity will make it worse. Best might be new high-performance imager concentrating on most used modes.
  - GALACSI-type LTAO front-end or just single WFS for laser or NGS (depending on cone-effect, cost)

A simple option



MCAO option

- Revive CASIS
  - Not so successful at STC last time
  - Covers imaging but what about IFU spectroscopy
  - Mass problems
- MCAO instrument at Nasmyth port
  - Narrowfield instrument at Cass
  - Replace HAWK-I

Study in progress…


NR. 24 4. 6. 2009 Deutschland € 3,20 Österreich € 3,50 / Schweiz CHF 6.–
4190804103208 24
stern
Italien
Macht & Amore

D