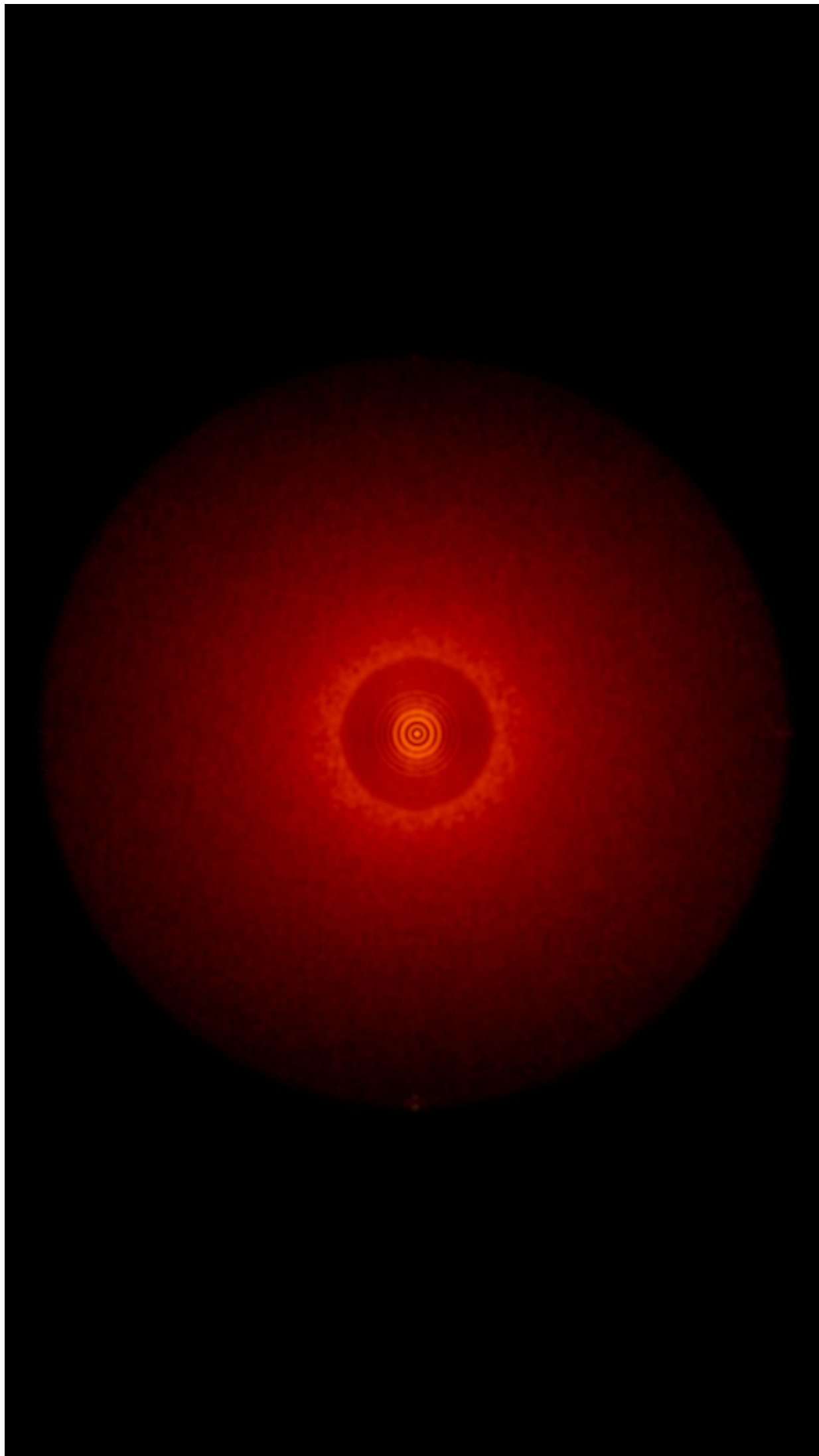


*PSF reconstruction:
the ultimate tool to
sharp your images? 3/3*

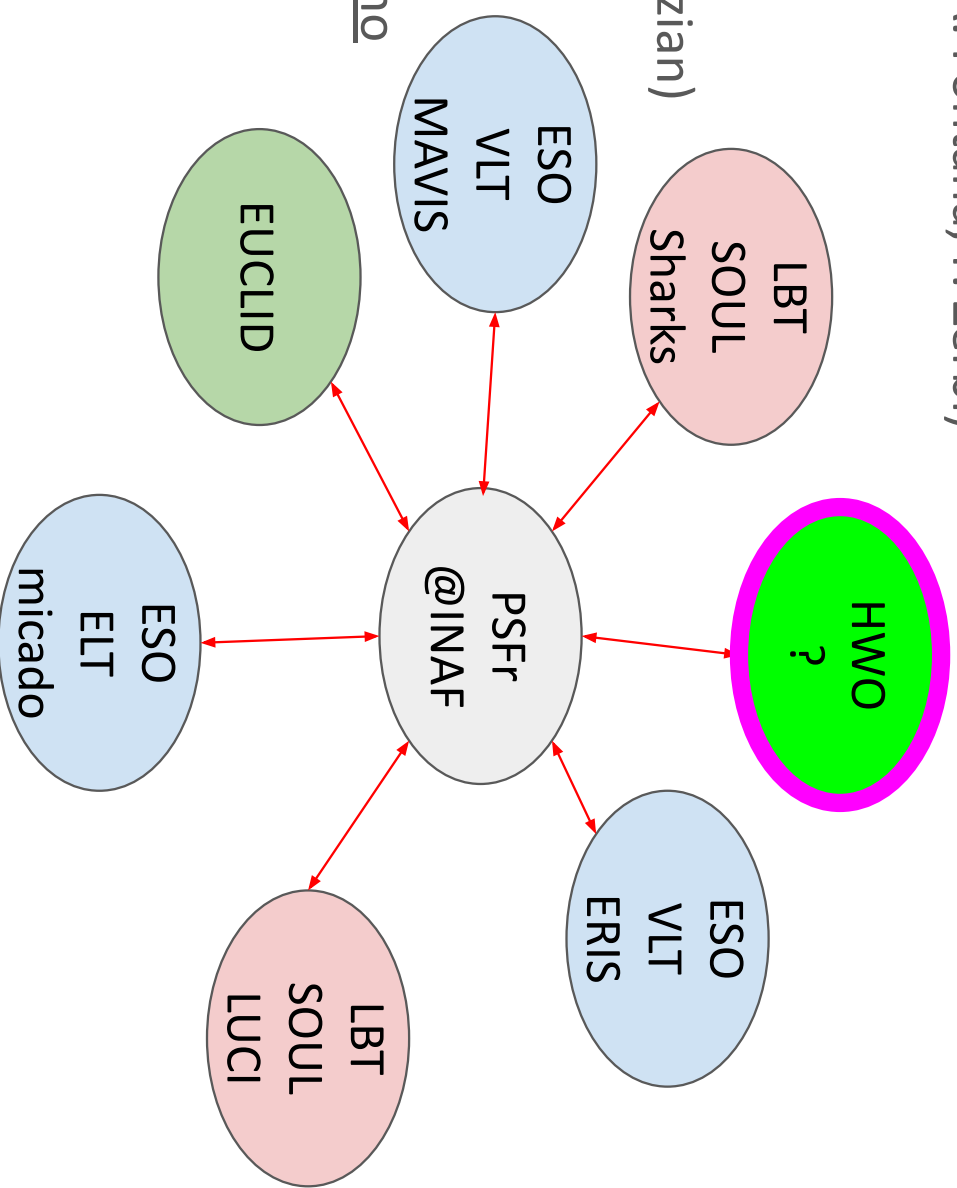


F. Pedichini on behalf of the INAF MAST&R and PSFr groups



PSFr @ INAF

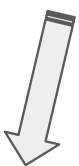
- 2019 UTG-1+DS welcome the “idea” (A. Fontana, F. Zerbi)
- 2019 MAST&R 1st coord. F. Pedichini
- 2020 AO science at Lincei Roma
- 2020 MICADO PSFr INAF team (A. Grazian)
- 2022 SPIE Montreal (M. Simioni+)
- 2021 PNRR-STILES (R. Piazzesi+)
- 2023 MAST&R 2nd coord. C. Arcidiacono
- 2024 SPIE Tokyo (A. Grazian+)
- 2025 MAST&R 3rd coord. E. Portaluri
- 2025+.....HWO?



MAST&Rs of the PSF @ INAF

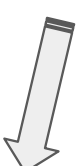
Cusano	Felice		Agapito	Guido		Castellano	Marco		Vassallo	Daniele
Massari	Davide		Marasco	Antonino		Piazzesi	Roberto		Paiano	Simona
Schreiber	Laura		Cresci	Giovanni		Merlin	Emiliano		Mesa	Dino
Dall'Ora	Massimo		Briguglio	Runa		Licausi	Gianluca		D'Orazi	Valentina
Braga	Vittorio		Pinna	Enrico		Pedichini	Fernando		Vulcani	Benedetta
Inno	Laura		Busoni	Lorenzo		Vaccari	Piero		Gullieuszik	Marco
Bono	Giuseppe		Xompero	Marco		Michele	Fabrizio		Simioni	Matteo
						Fiorentino	Giuliana		Arcidiacono	Carmelo
Paiano	Simona		Portaluri	Elisa					Grazian	Andrea
						Cantiello	Michele		Lazzarotto	Francesco

What is
PSFr ?



sci data
lorem ipsum
lorem ipsum
lorem ipsum
0123456789
0123456789
.....

data analysis



What is
PSFr ?

rec. image

What is
PSFr ?

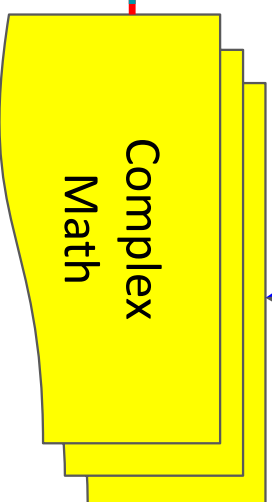
deconvolution

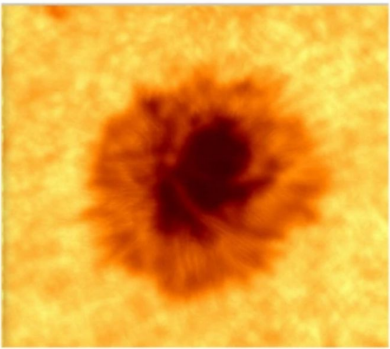
“myopic”

“blind”

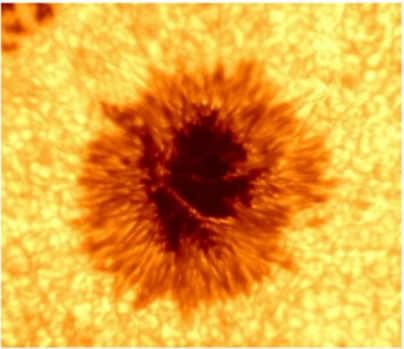
image
pixels

Complex
Math

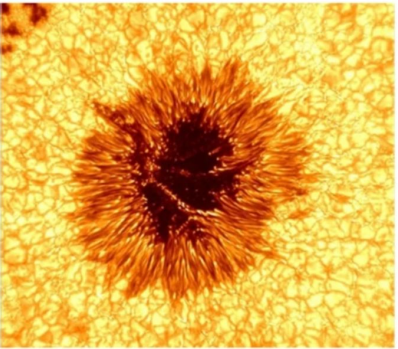




OPEN
LOOP



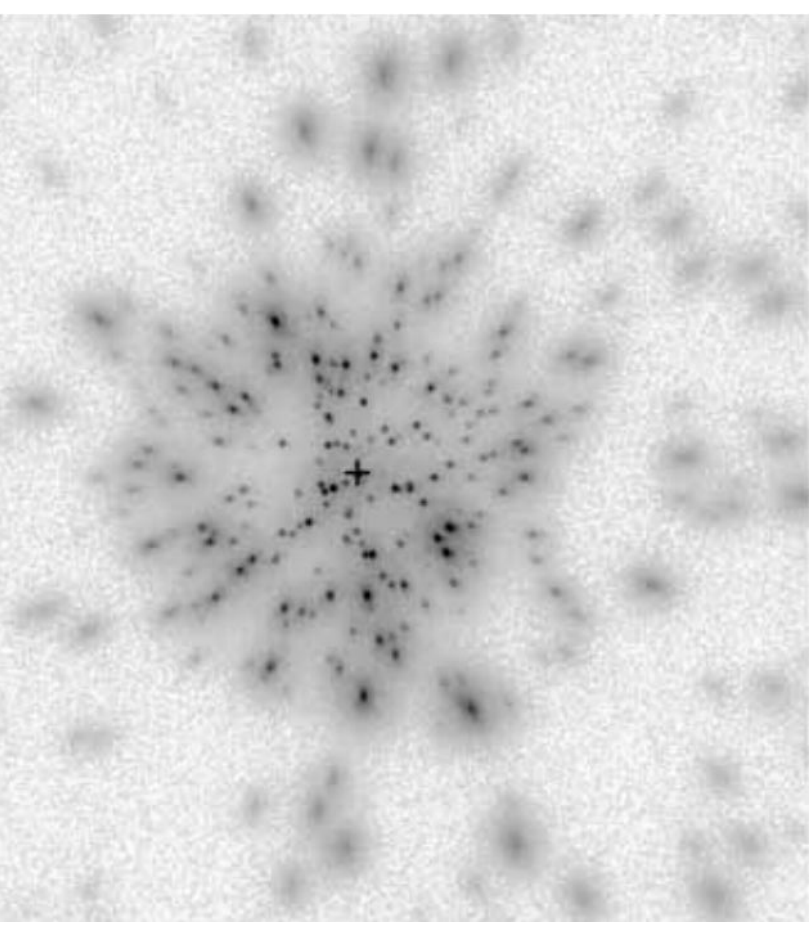
CLOSED
LOOP



MFBD

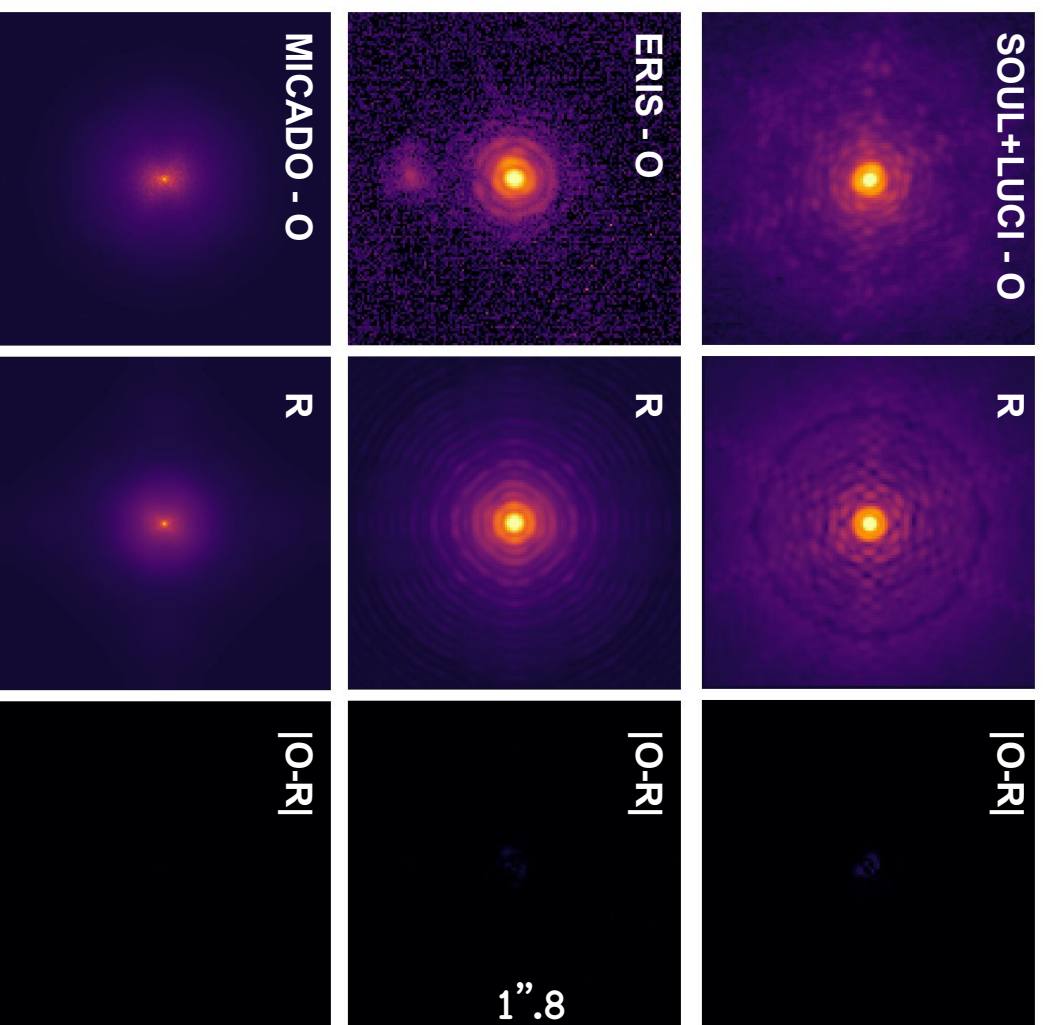


DISCRIMINATE OBJECTS
IN THIS EUCLID FIELD

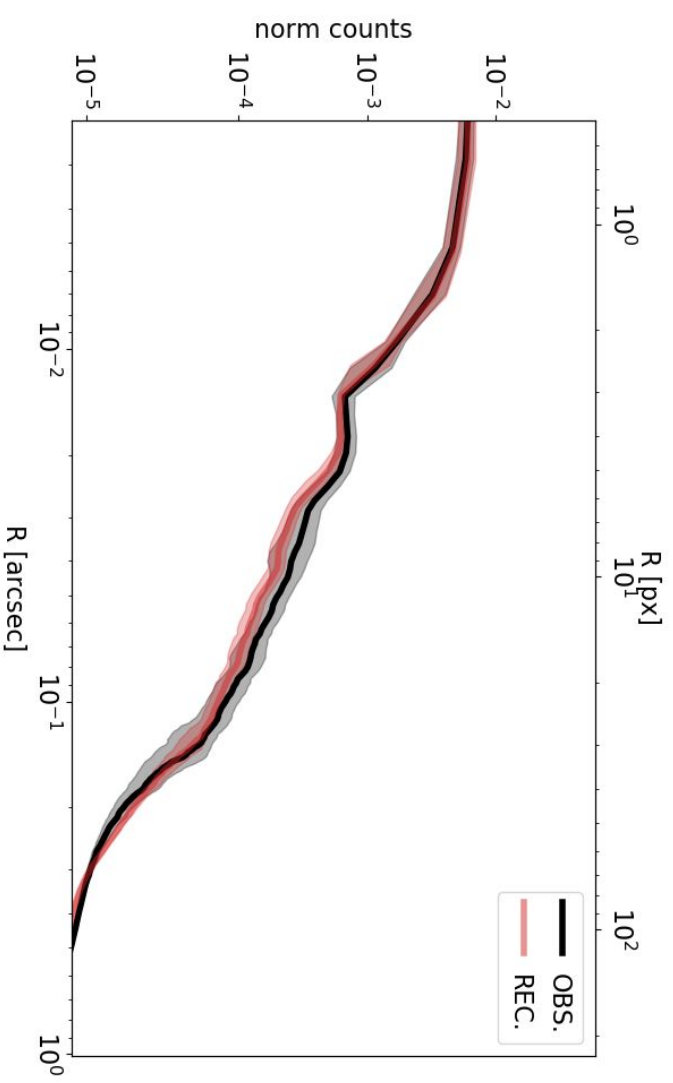


GET THE BEST PHOTOMETRY DESPITE
OF THE CONE EFFECT WHEN THE PSF
SHAPE IS POSITION DEPENDENT

INAF PSF for LUCl, ERIS, MICADO: photometry of PSF profiles



from the MAST&R working group
“MYOPIC” by using only:
WFS+AO+SITE telemetry data

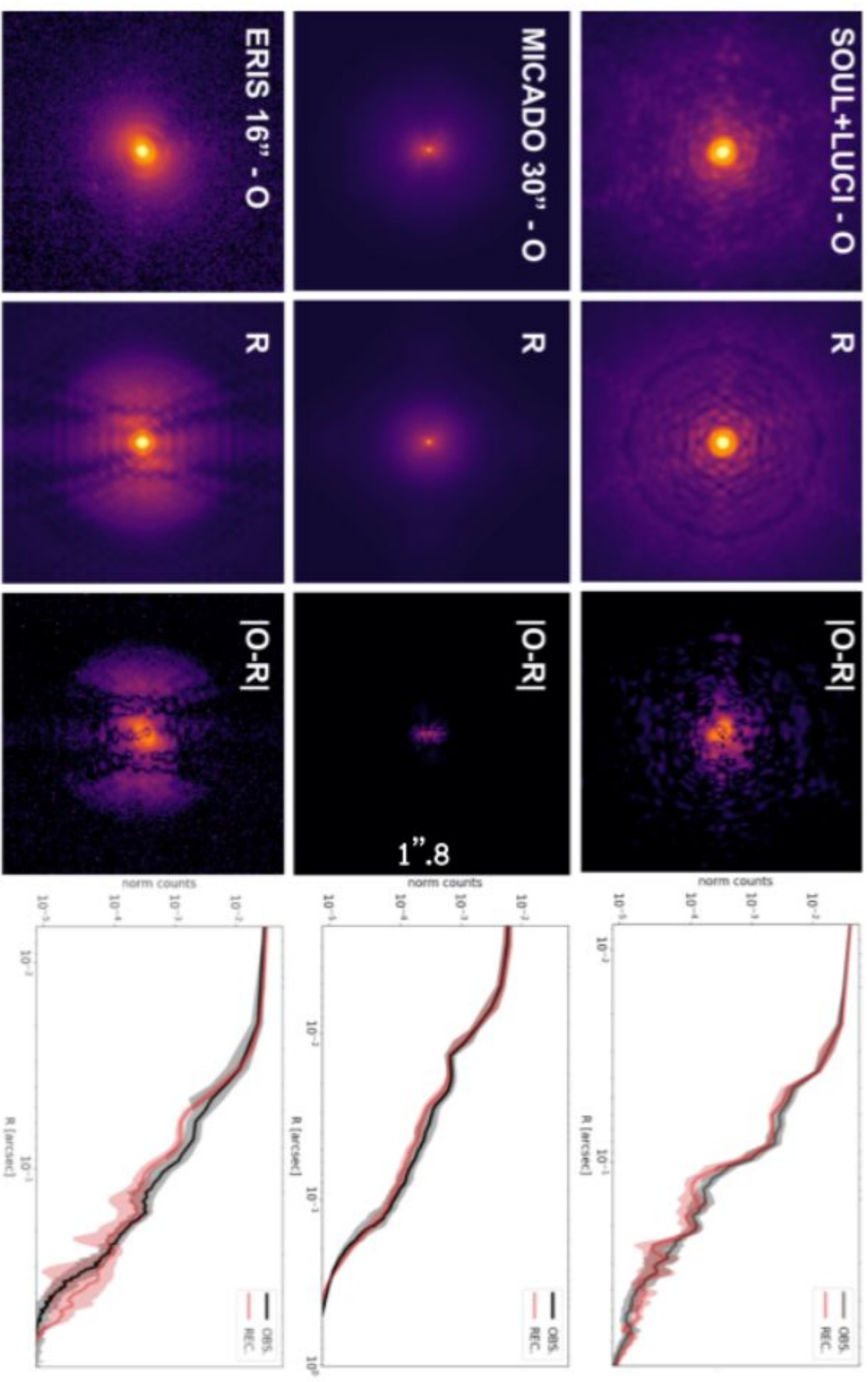


30" off-axis
 K band

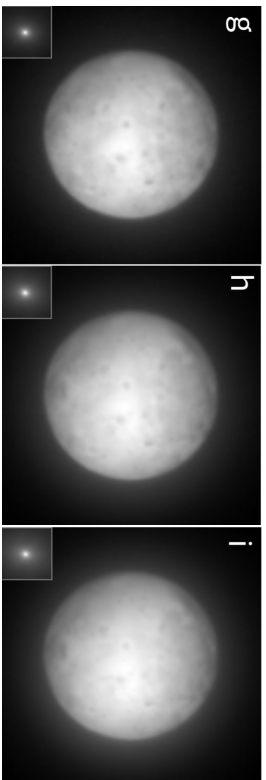
[Simioni+ SPIE 2022](#)

MAST&R working group “MYOPIC” by using only: WFS+AO+SITE telemetry data

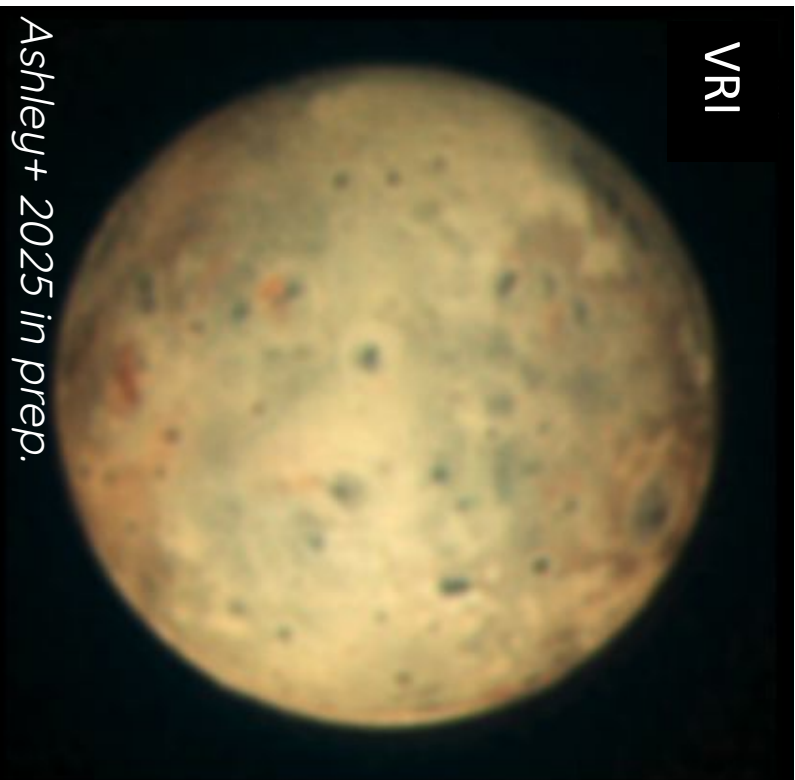
Simioni+2023



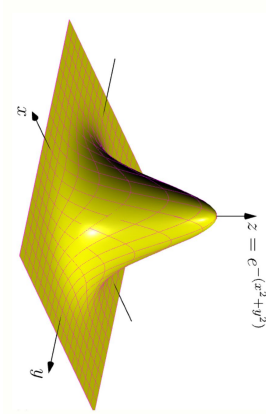
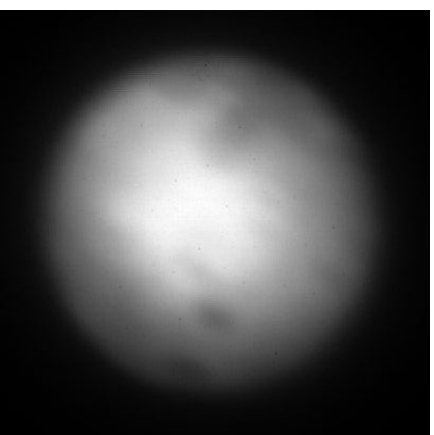
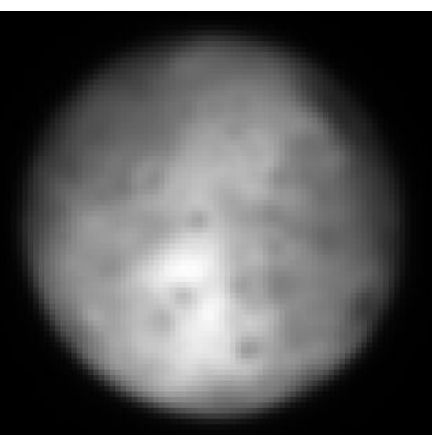
INAF PSF SHARK-VIS/NIR: image sharpening (blind and myopic)



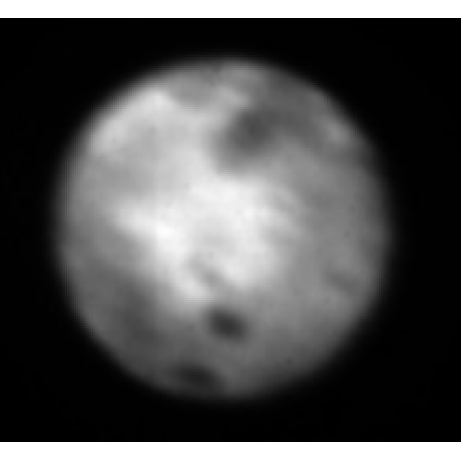
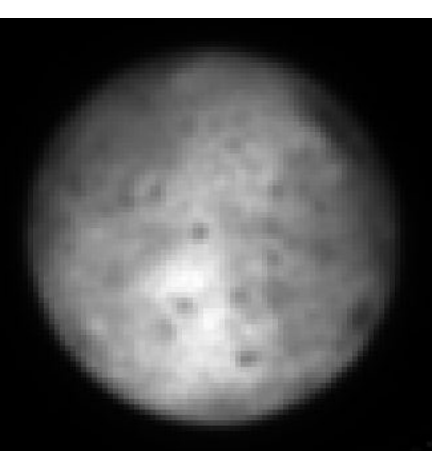
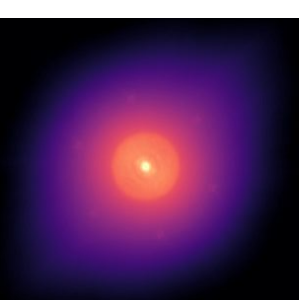
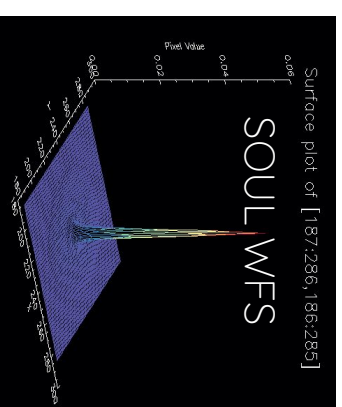
VRI



Ashley+ 2025 in prep.

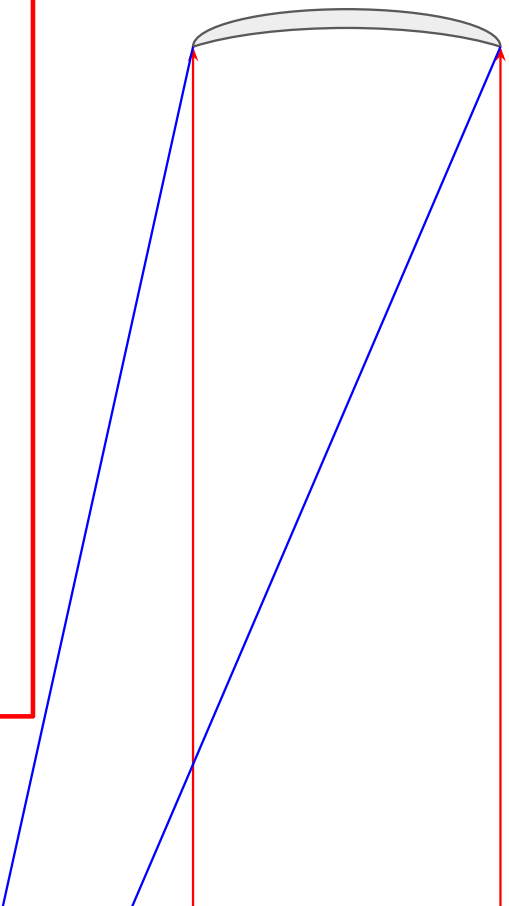


Gaussian PSF
FeII

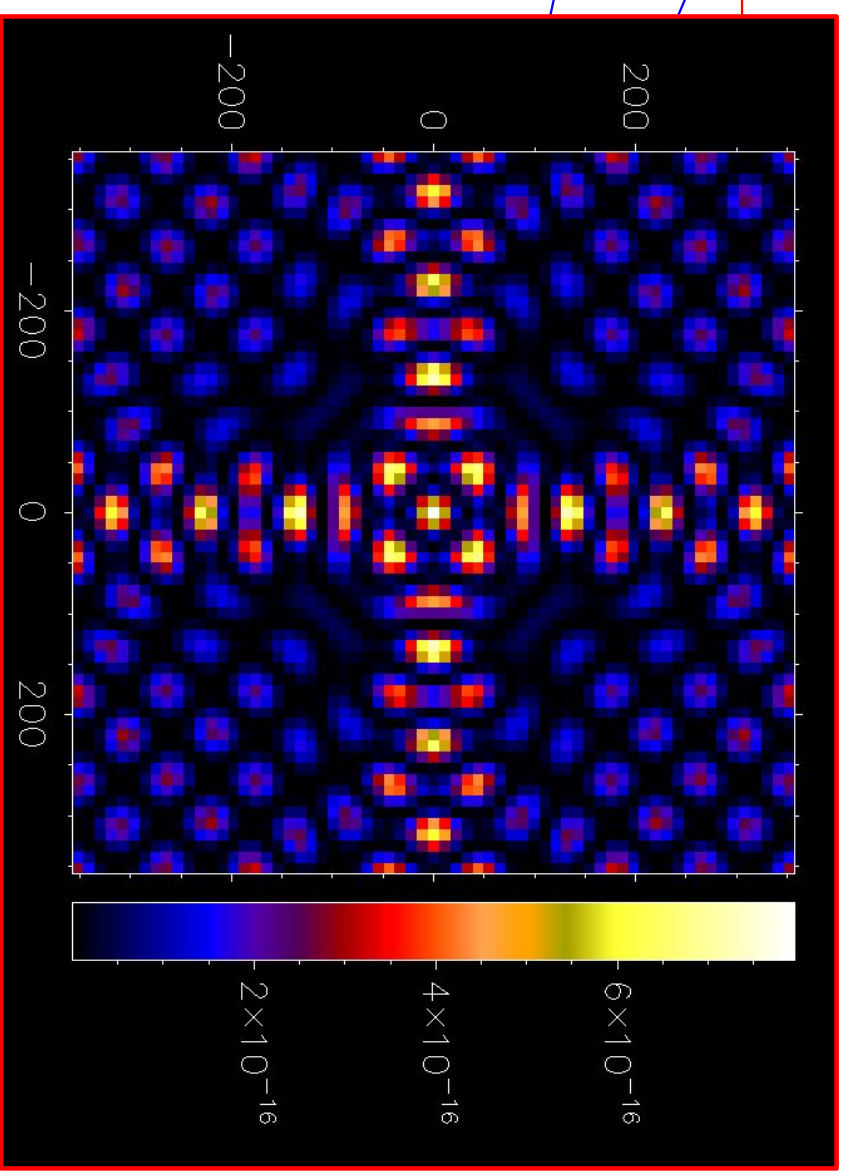


HWO 6m f#25 off axis toy model 8th order coro-mask

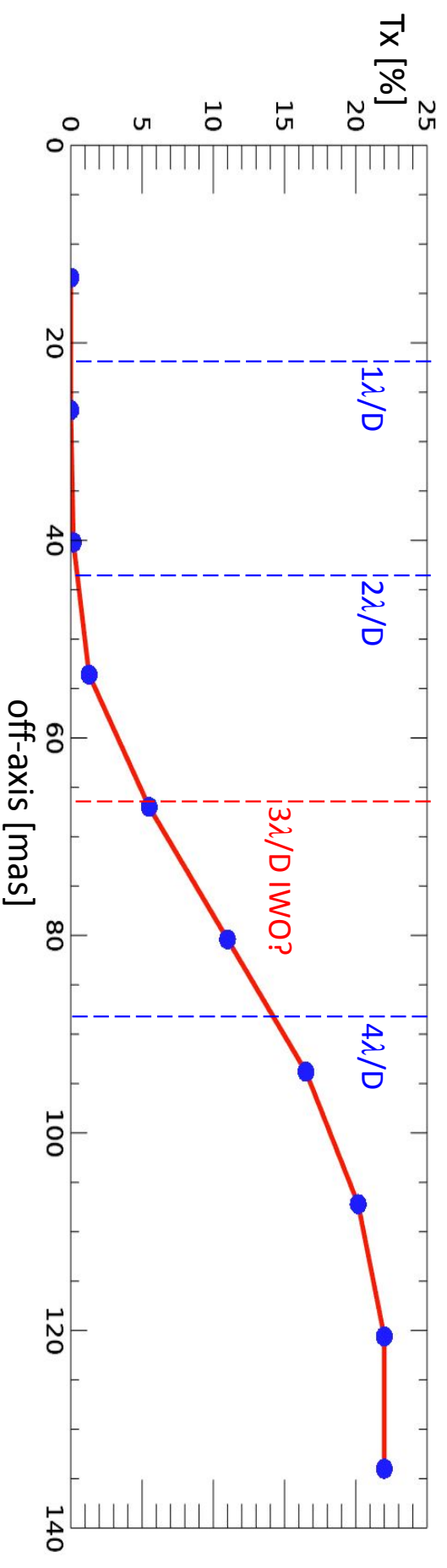
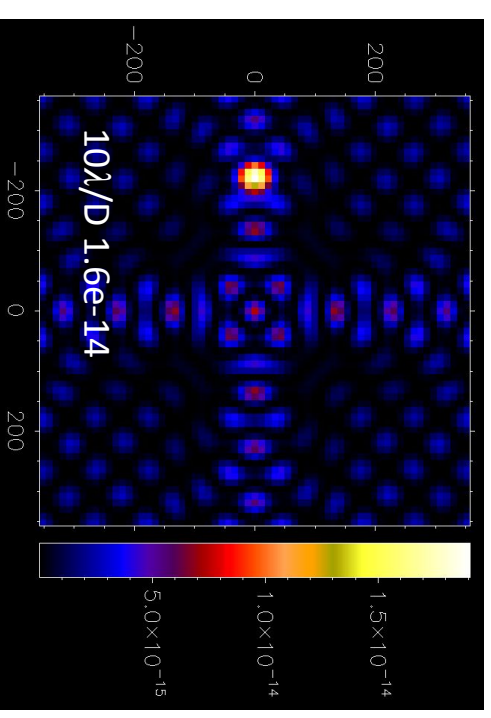
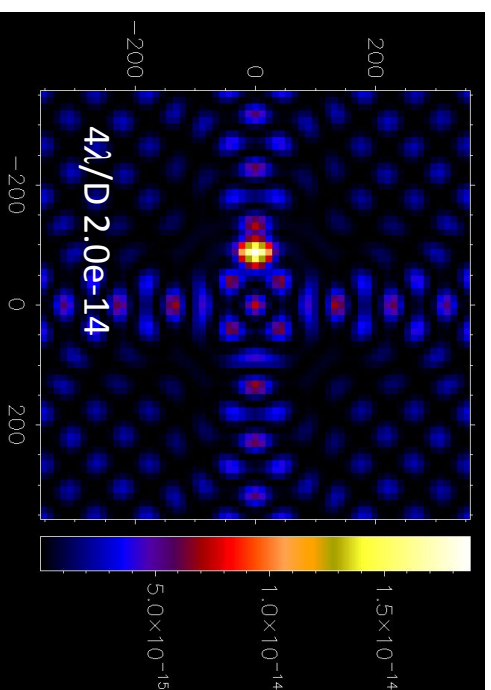
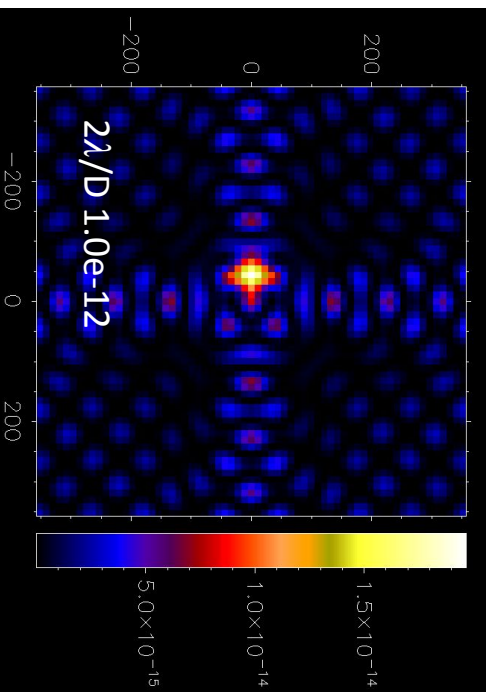
Kuchner+, ApJ, 628, 466 (2005)



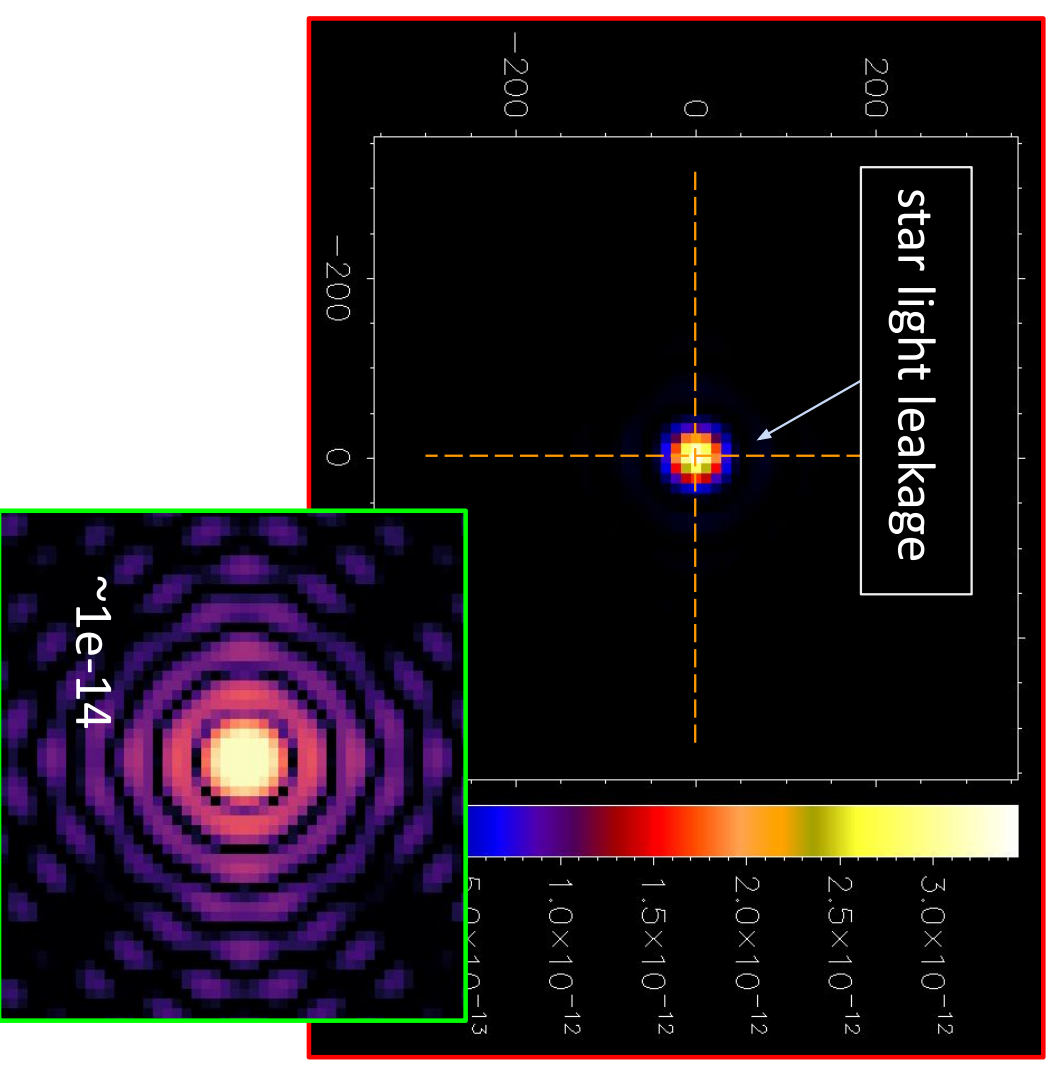
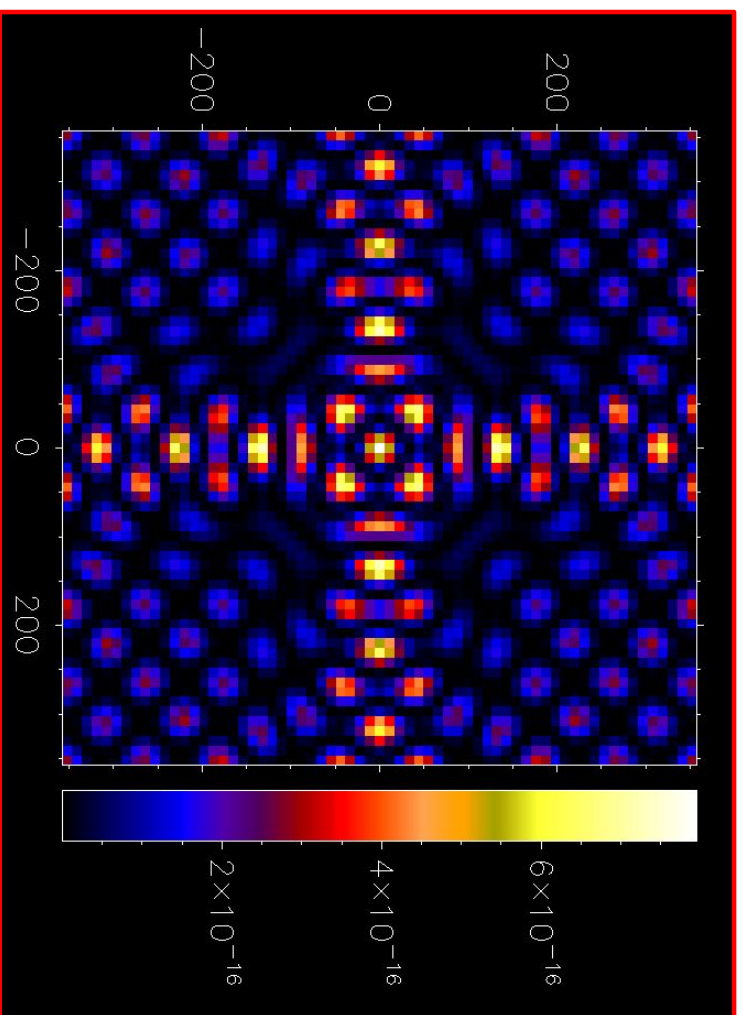
Pupil Diameter	: 6000mm
Focal Length	: 150m
Pixel size	: 8.2 μ m
Plate scale	: 11mas/pix
Throughput	: 22%
FWHM	: 44mas
Det. Contrast @ 2 λ /D	: 1.0e-12
Det. Contrast @ 4 λ /D	: 2.0e-14
Det. Contrast @ 10 λ /D	: 1.6e-14
Lambda of simulation	: 656nm



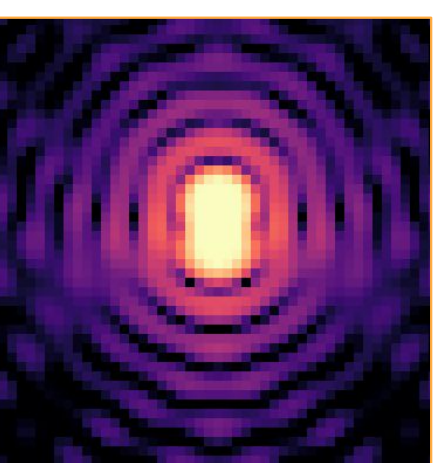
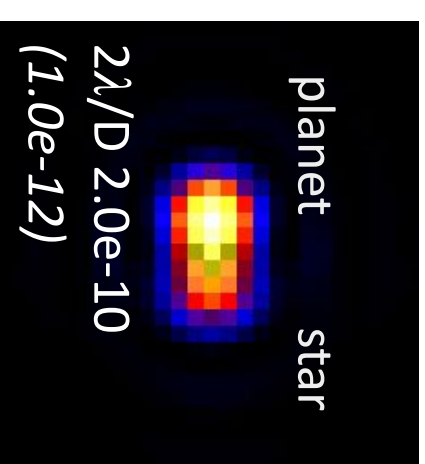
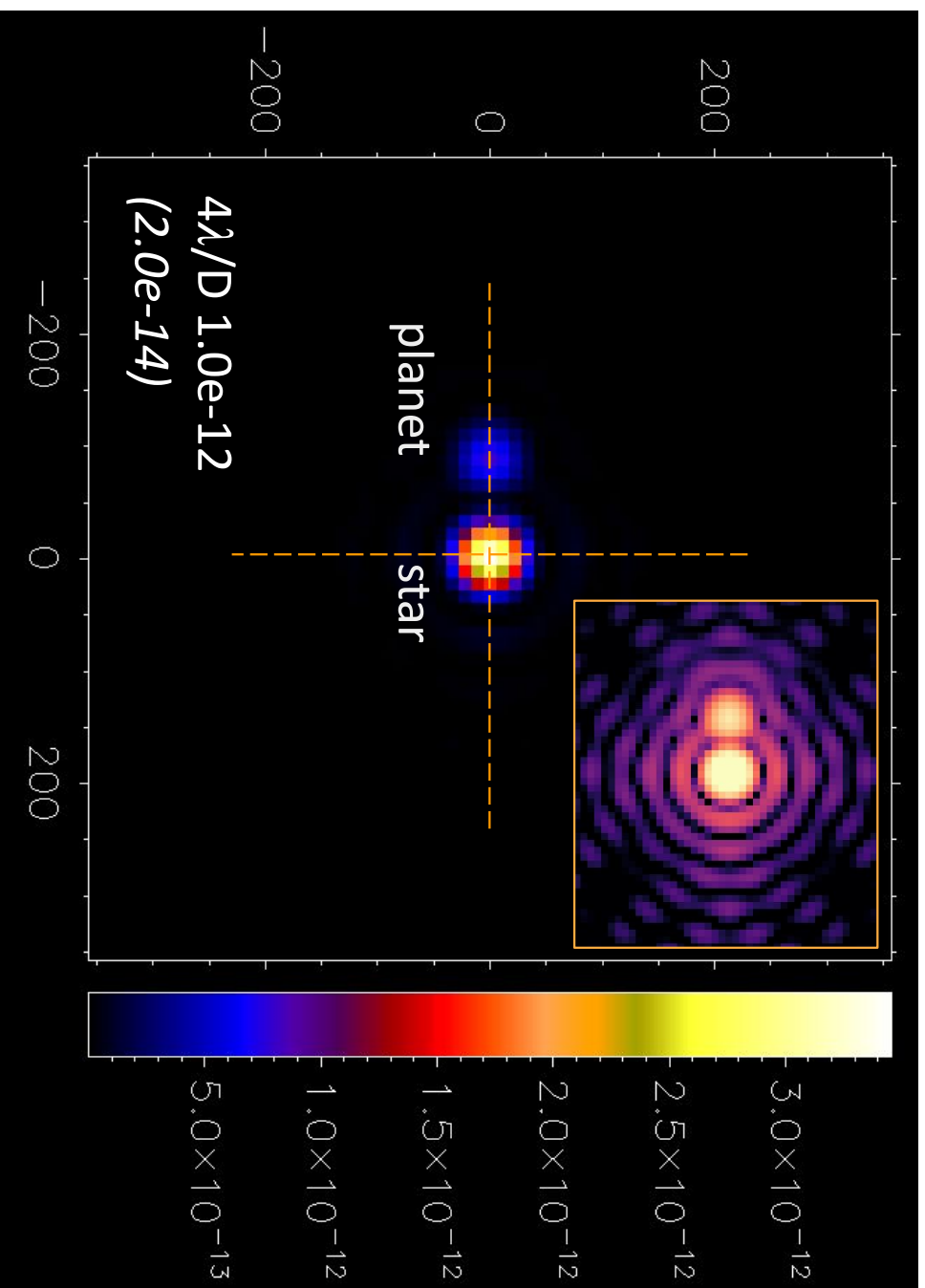
performance....($\lambda/D = 22\text{mas}$)



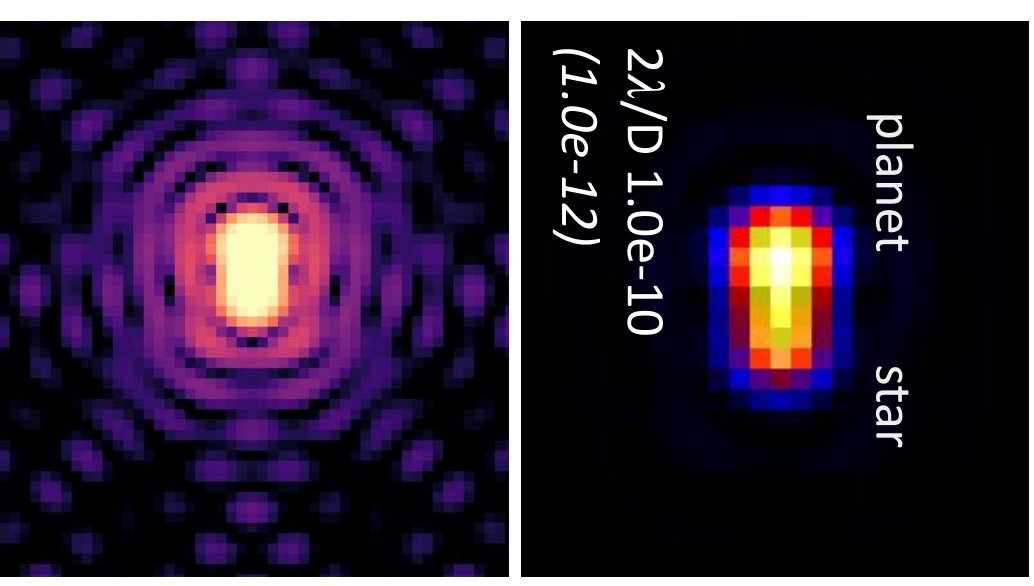
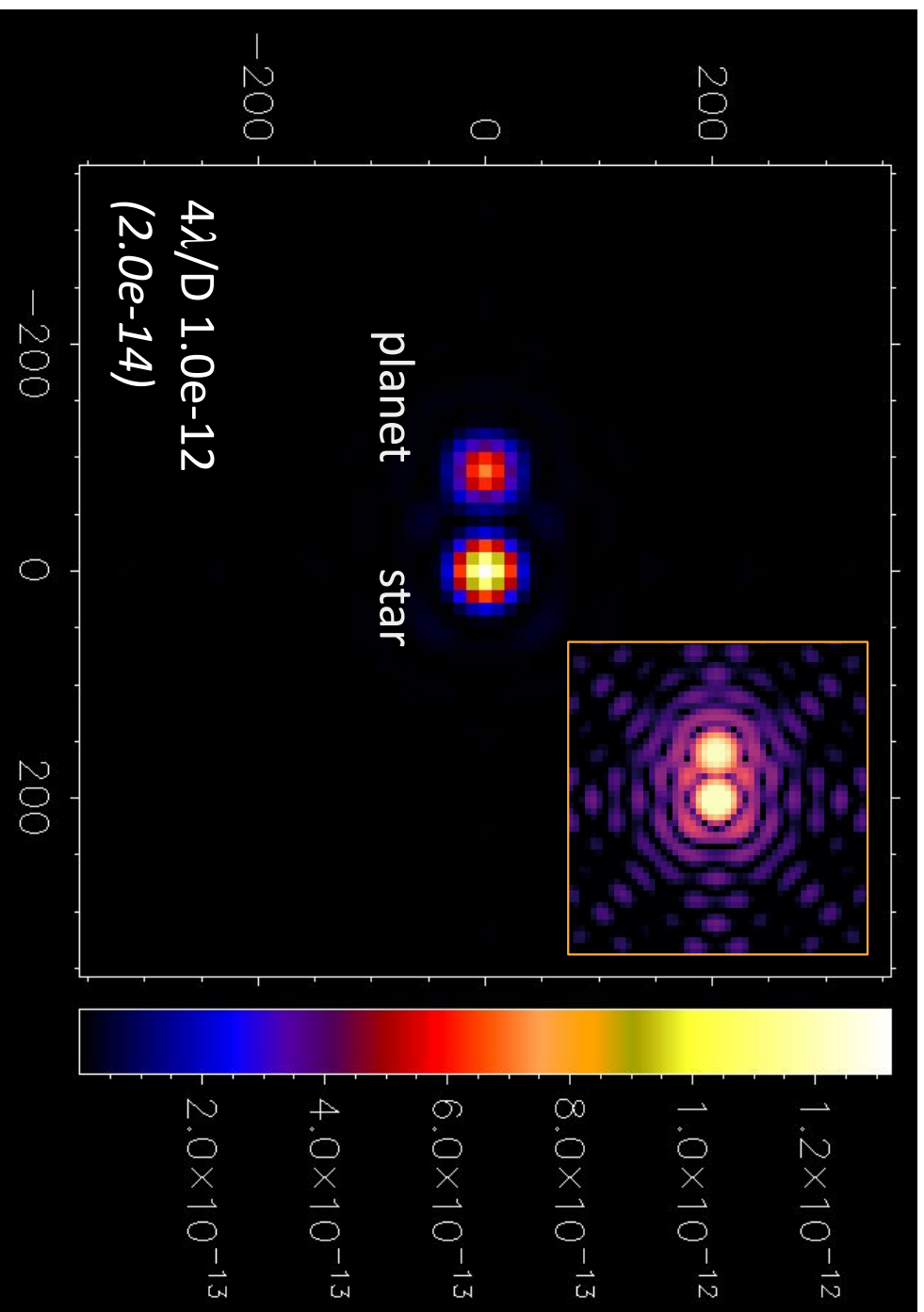
pointing error 2.5 mas $\rightarrow$ Bkg orders of magnitude higher !



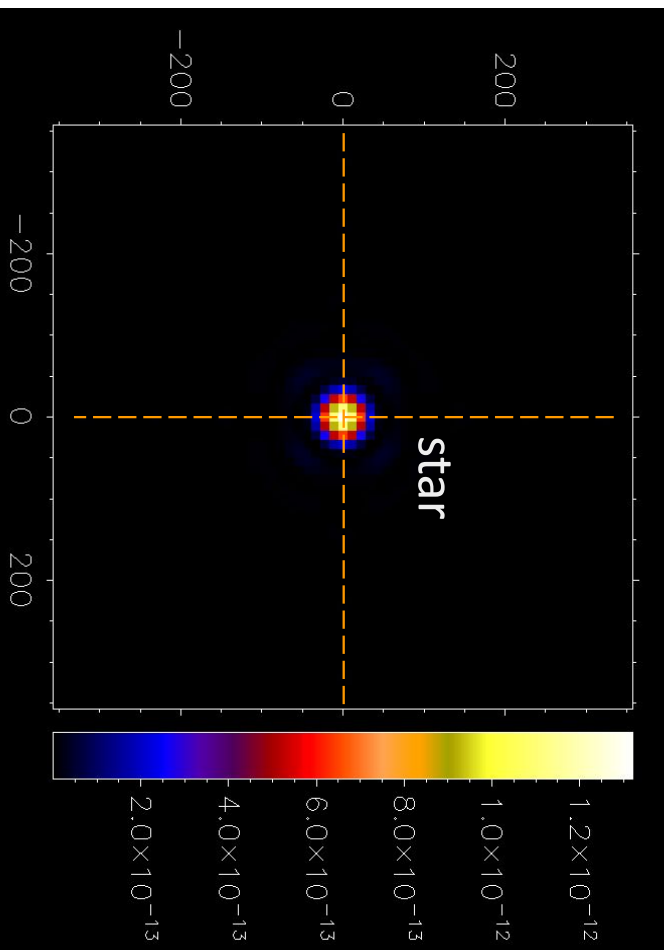
pointing error 2.5 mas $\rightarrow$ Det contrast ~ 2 order of magnitude lower



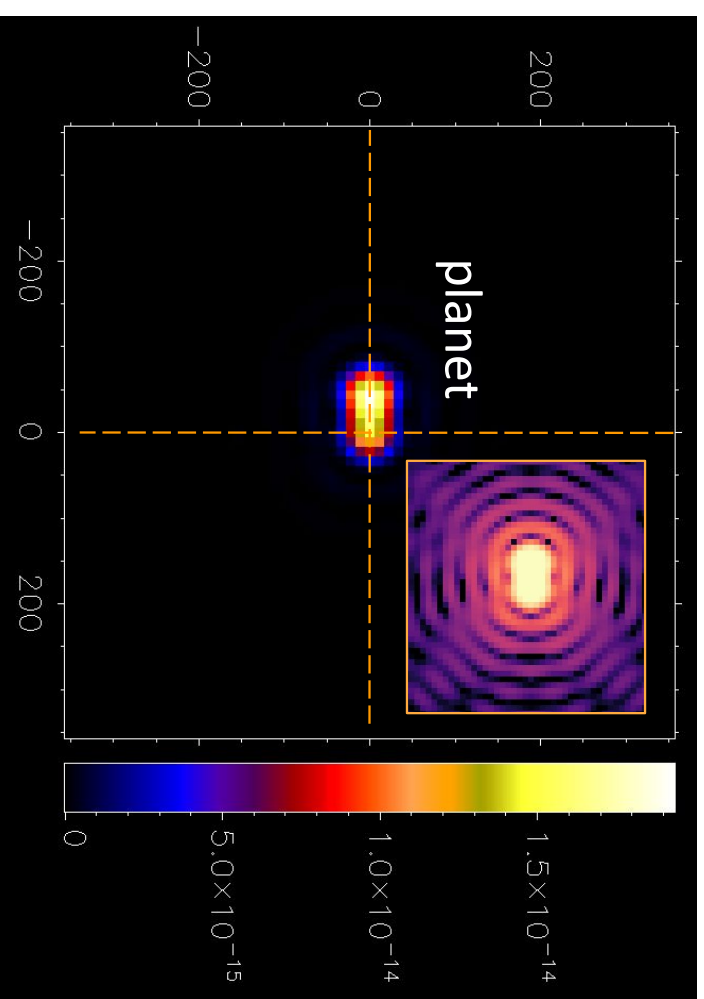
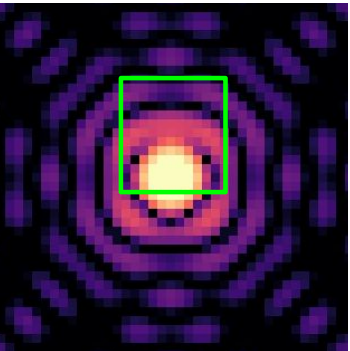
Z6 1nm RMS (0° Astigmatism) $\rightarrow$ Det. contrast lower



Recovering by WFS sensing & Fourier model of the optical train



→ -Z6 from model



2λ/D 1.0e-12 planet but...

1nm RMS Z6 error

Ok if: WFS error ~2-3pm/mode

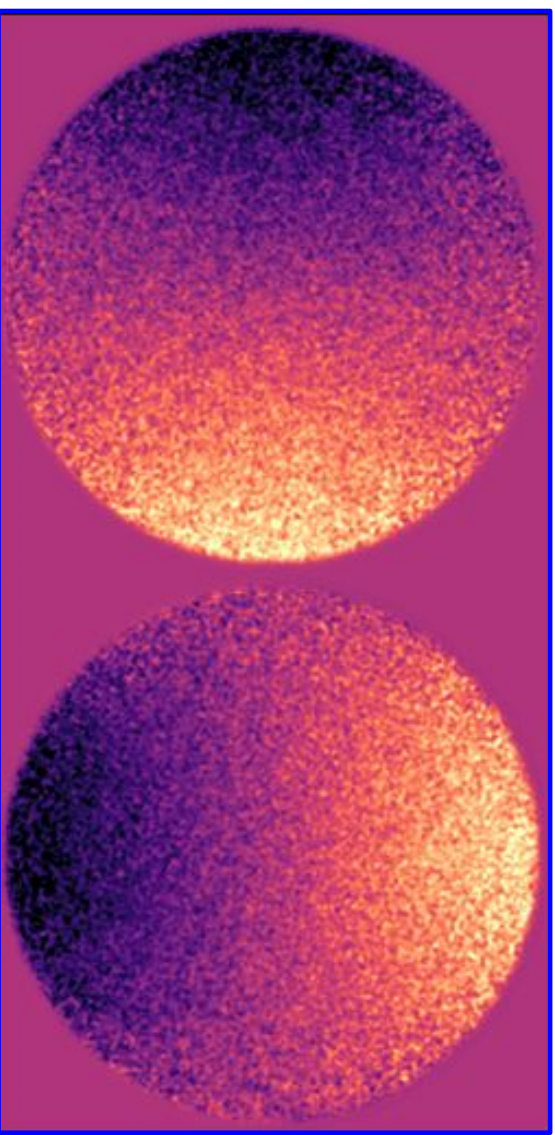
PYRAMID as the HWO-WFSensor with two jobs:

1. keep the system on-shape (pointing, WFE, dark-hole etc...)
2. record the WF metrology at pm/mode level for post-processing

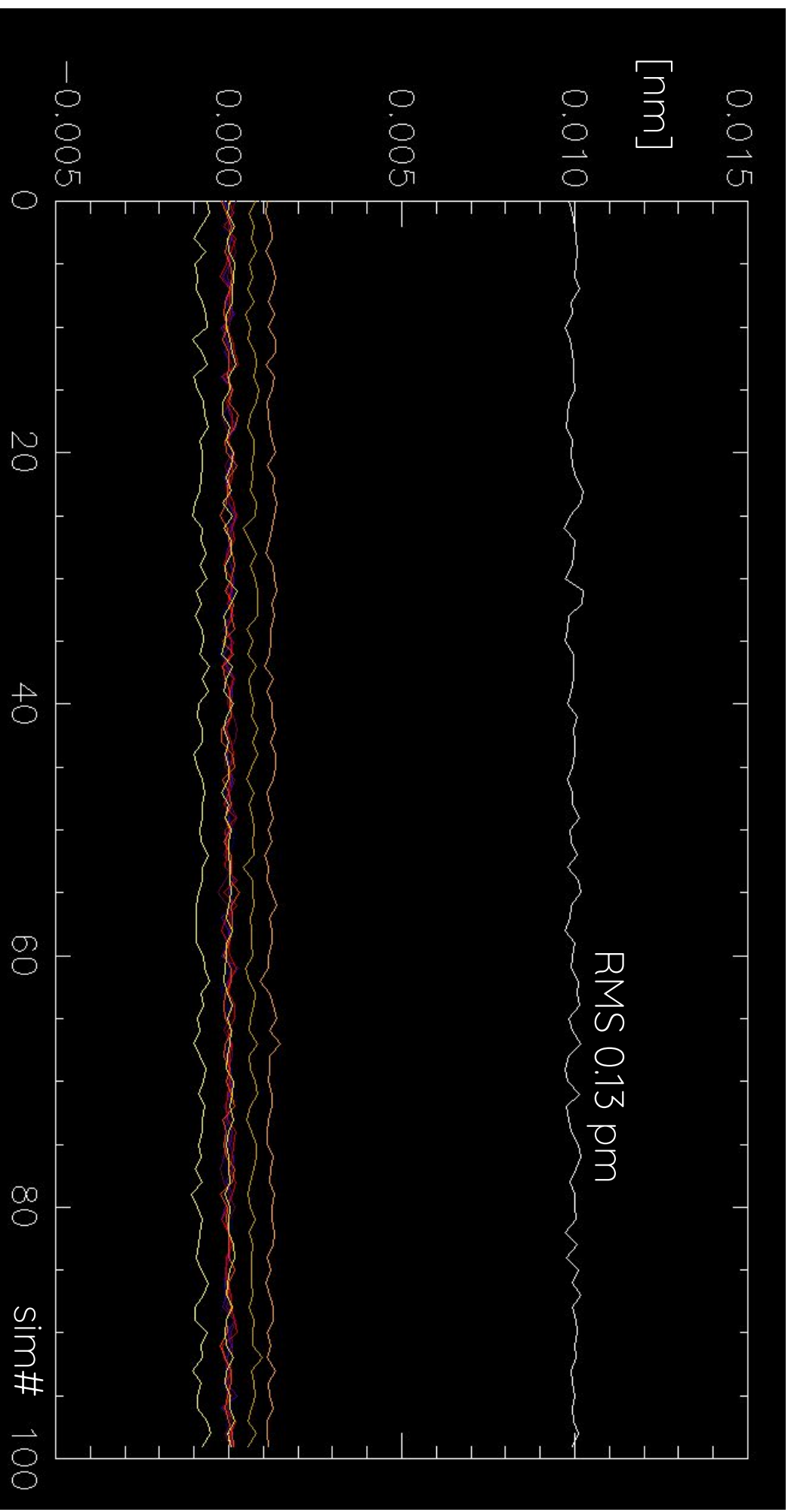
- Plenty of photons (magR < 7 targets)
- No turbulence (no modulation)
- Long integration time (< 1Hz)
- Very High Strehl operation regime
- Quite & thermal stable environment

- Very High precision machining
- Robust calibration to survive launch stress (R&D)
- Need for SOAPP: SPACE QUALIFIED AO computer (ASI R&D grant requested)

Raw slopes Pyramid sim. 5700+ subap (3x3)
HWO 6m-R5 60s exp Z6=50pm

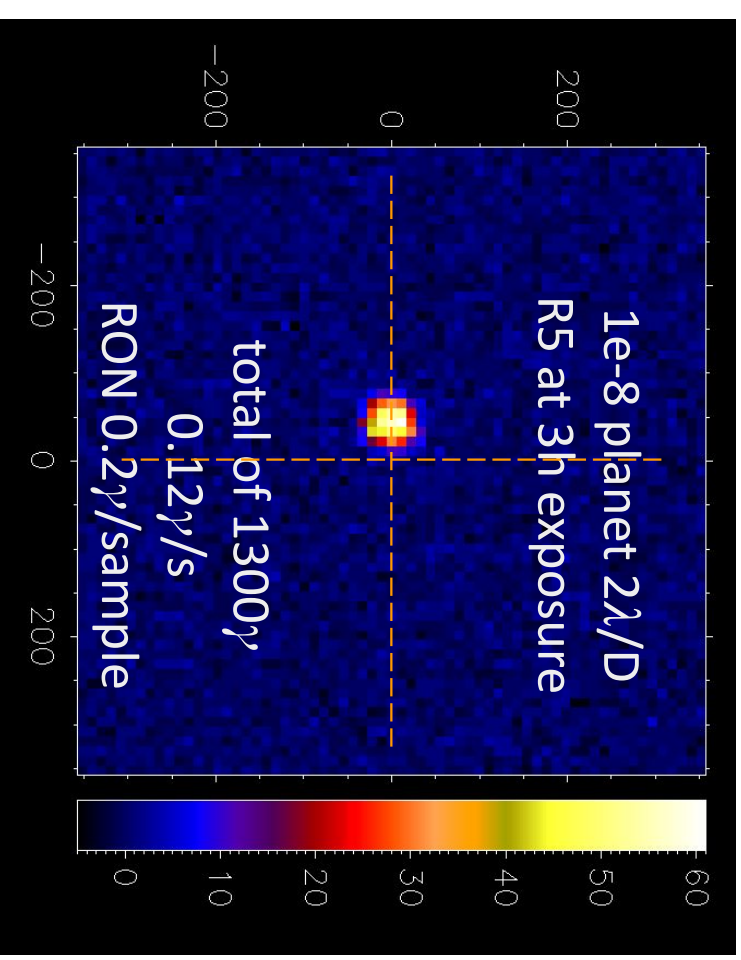


WFS: 100 Montecarlo from Z4 to Z15 (only Z6 is 10pm)



SUMMARY:

- AO technologies and PSFr are synergic
- INAF has AO post-processing expertise
- INAF has deep experience in WFS
- INAF can transfer these heritage to HWO
- Preliminary results are encouraging
- HWO-Washington: poster on this topic with more deep results is in progress





INAF
ISTITUTO NAZIONALE
DI ASTROFISICA



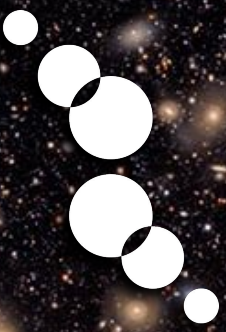
LABORATORIO
NAZIONALE
ADONI
OTTICA
ADATTIVA



THE UNIVERSITY
OF ARIZONA



Georgia State
University



LARGE
BINOCULAR
TELESCOPE
OBSERVATORY

GRAZIE !

