“Data processing on simulated data for SHARK-NIR”

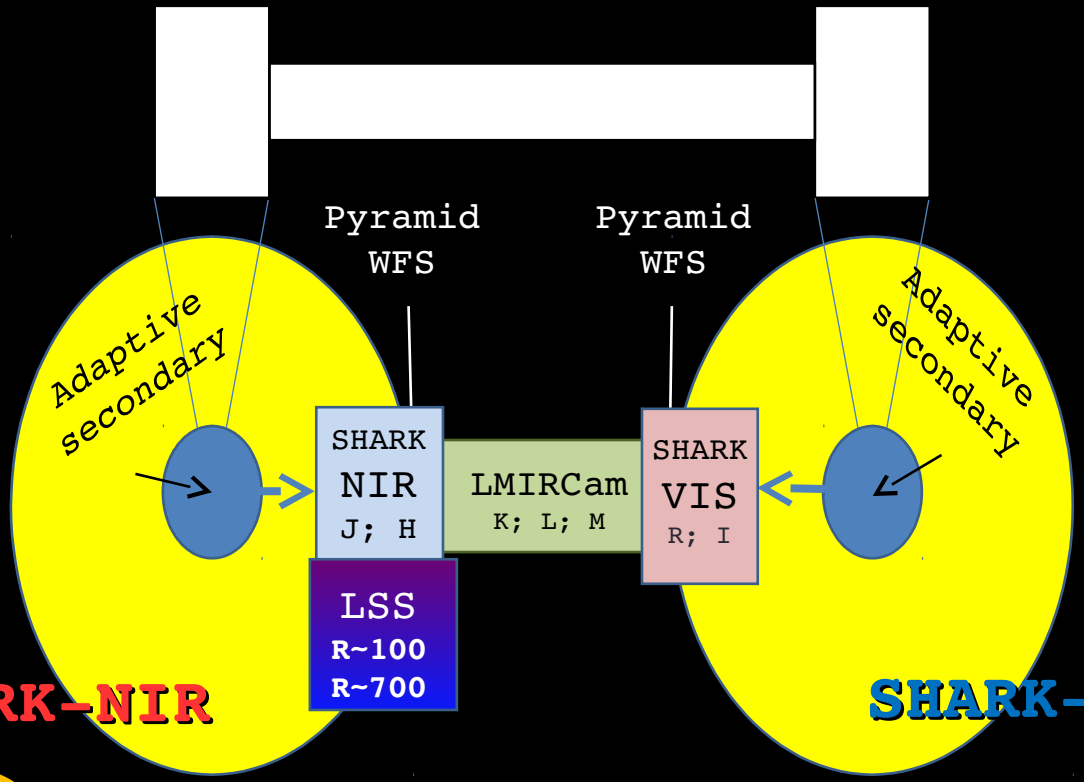
Carolo E., Vassallo D., Farinato J., Agapito G., Bergomi M., Carlotti A., De Pascale M., D'Orazi V., Greggio D., Magrin D., Marafatto L., Mesa D., Pinna E., Puglisi A., Stangalini M., Verinaud C., Viotto V., Biondi F., Chinellato S., Dima M., Esposito S., Pedichini F., Portaluri E., Ragazzoni R.

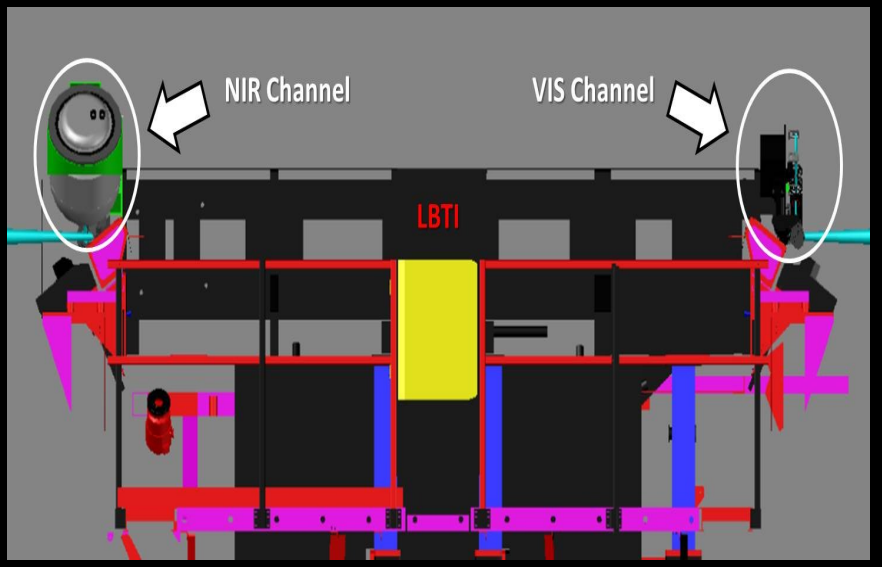
WHAT IS SHARK-NIR

Coronagraphic camera with spectroscopic capabilities

Extreme adaptive optics correction of FLAO

Synergy with other LBT instruments: SHARK-VIS, LMIRCam





SHARK NIR: Ready for construction and installation @LBT!

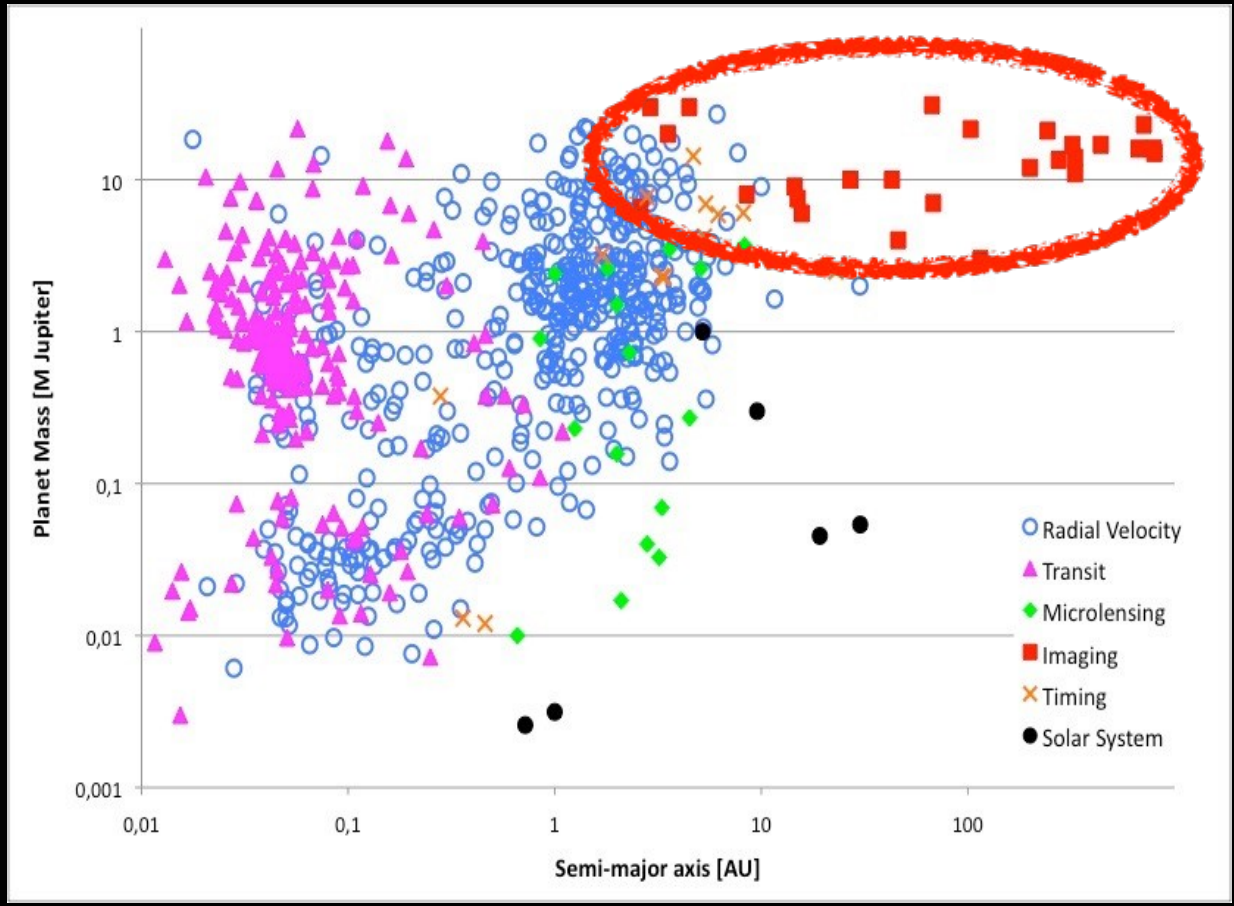
Please see also Farinato and Vassallo posters

SHARK-NIR: SCIENCE TARGETS

Main science target: direct imaging of exoplanets (detection and characterization)

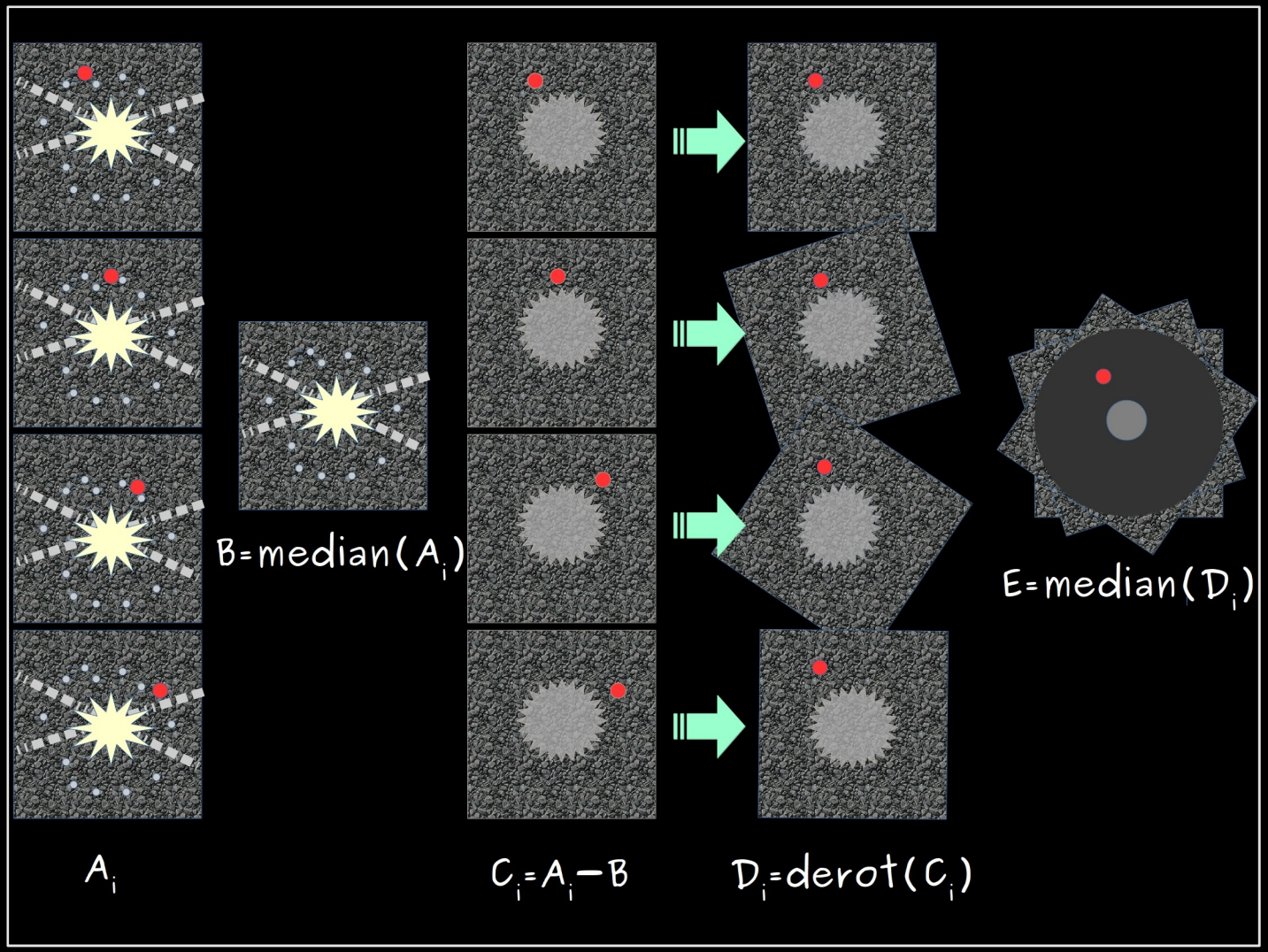
Other science:

- Brown dwarfs
- Protoplanetary disks
- Stellar jets
- AGN



Please see also Farinato and Vassallo posters

ADI: ANGULAR DIFFERENTIAL IMAGING



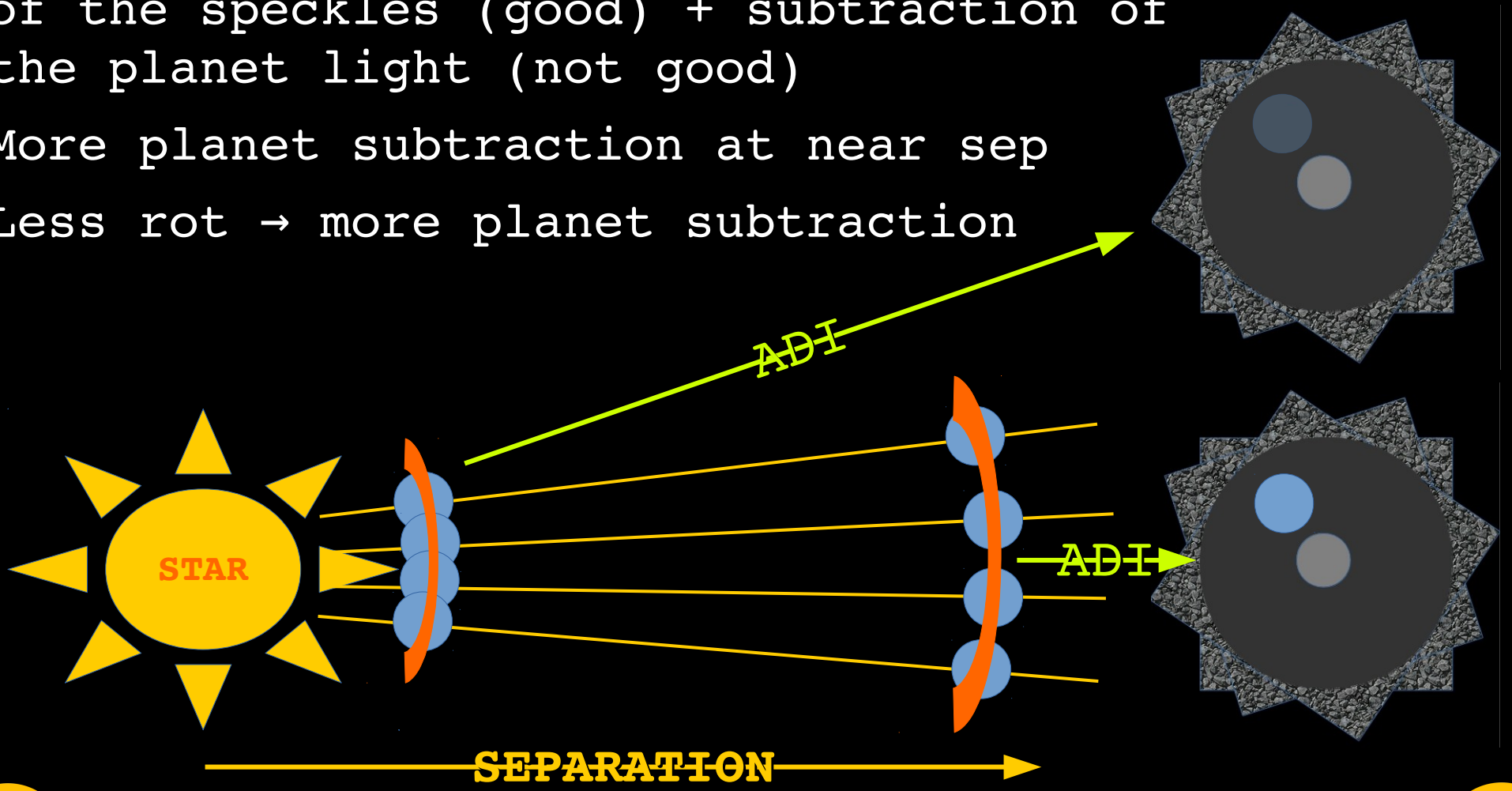
Instrument rotator turned off

Effect:
- The planet moves
- The speckle pattern is "fixed"

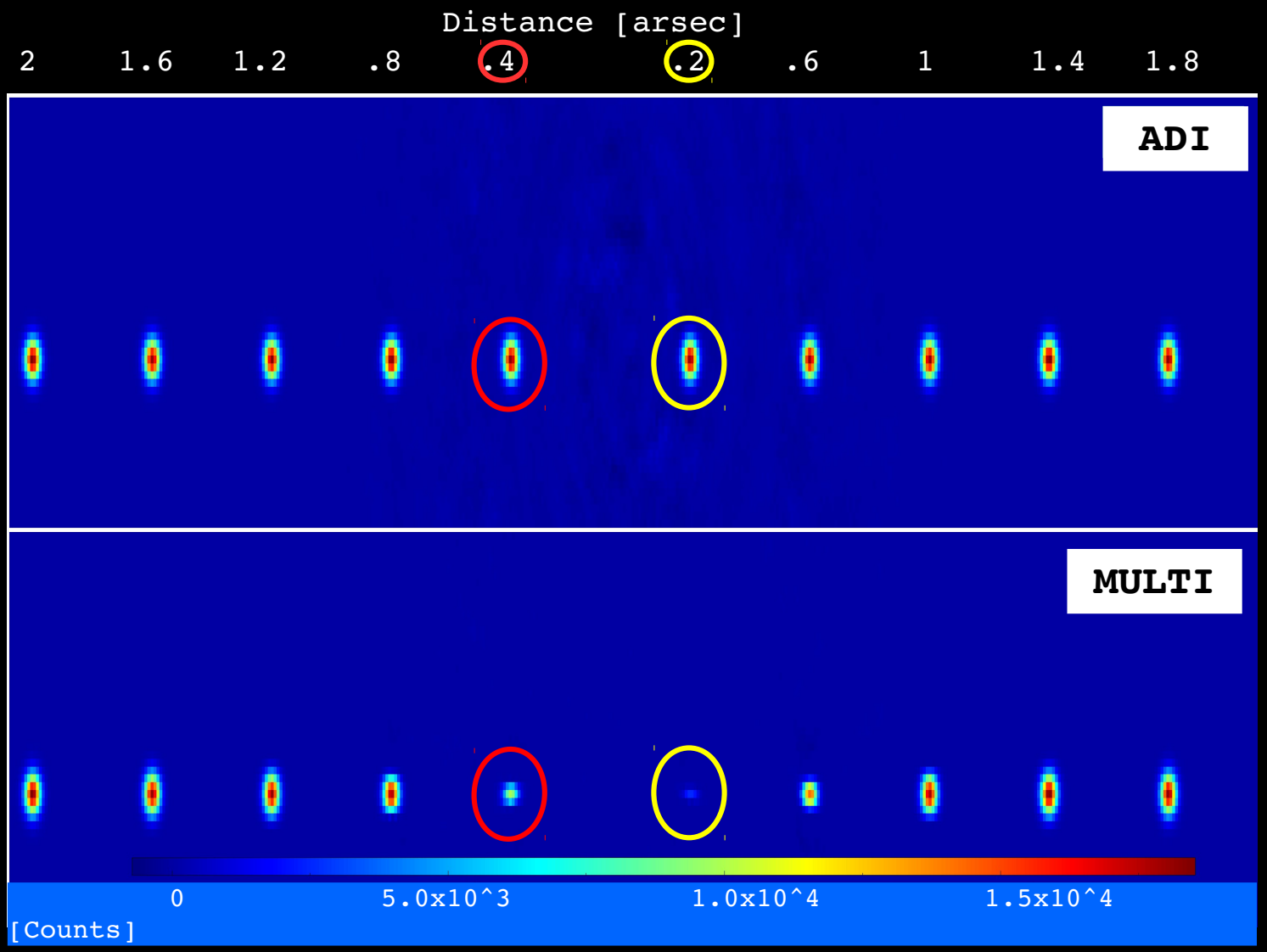
A = direct imaging data (few hundreds)
B = generate the reference PSF
C = sub to remove the quasi-static structure
D = align the FoV
E = median combined

SELF-SUBTRACTION OF THE PLANET LIGHT

- Data reduction techniques → subtraction of the speckles (good) + subtraction of the planet light (not good)
- More planet subtraction at near sep
- Less rot → more planet subtraction



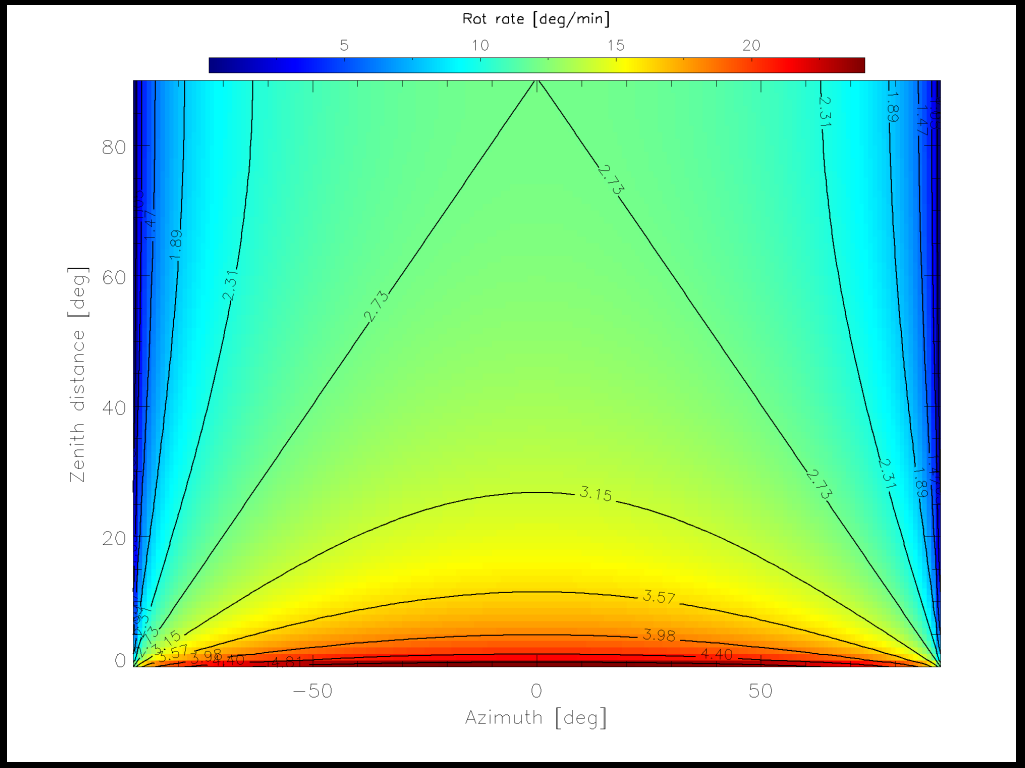
SELF-SUBTRACTION EFFECT

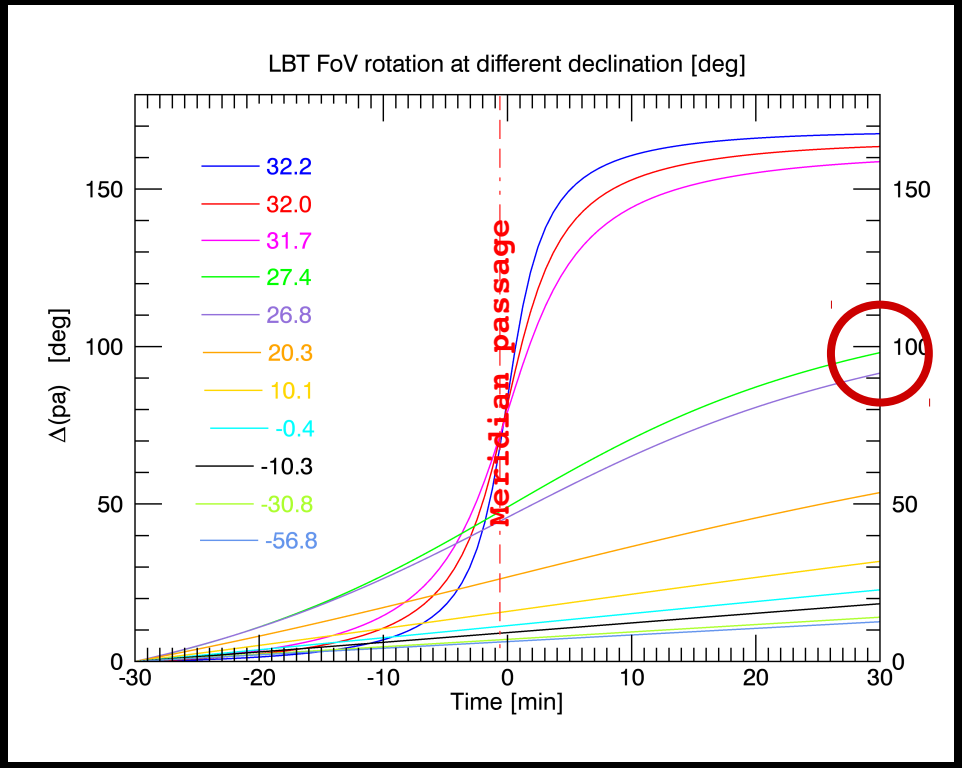


Pipeline injects fake planets at different separations from the star

More ref PSF subtractions are performed →
→ more planet signal is lost near the star

FoV ROTATION @LBT






```
lat obs [deg]:          32.7013
min max rot [deg/min]:   0.0018   24.1644
min max dec [deg]:     -56.7953   32.6955
```

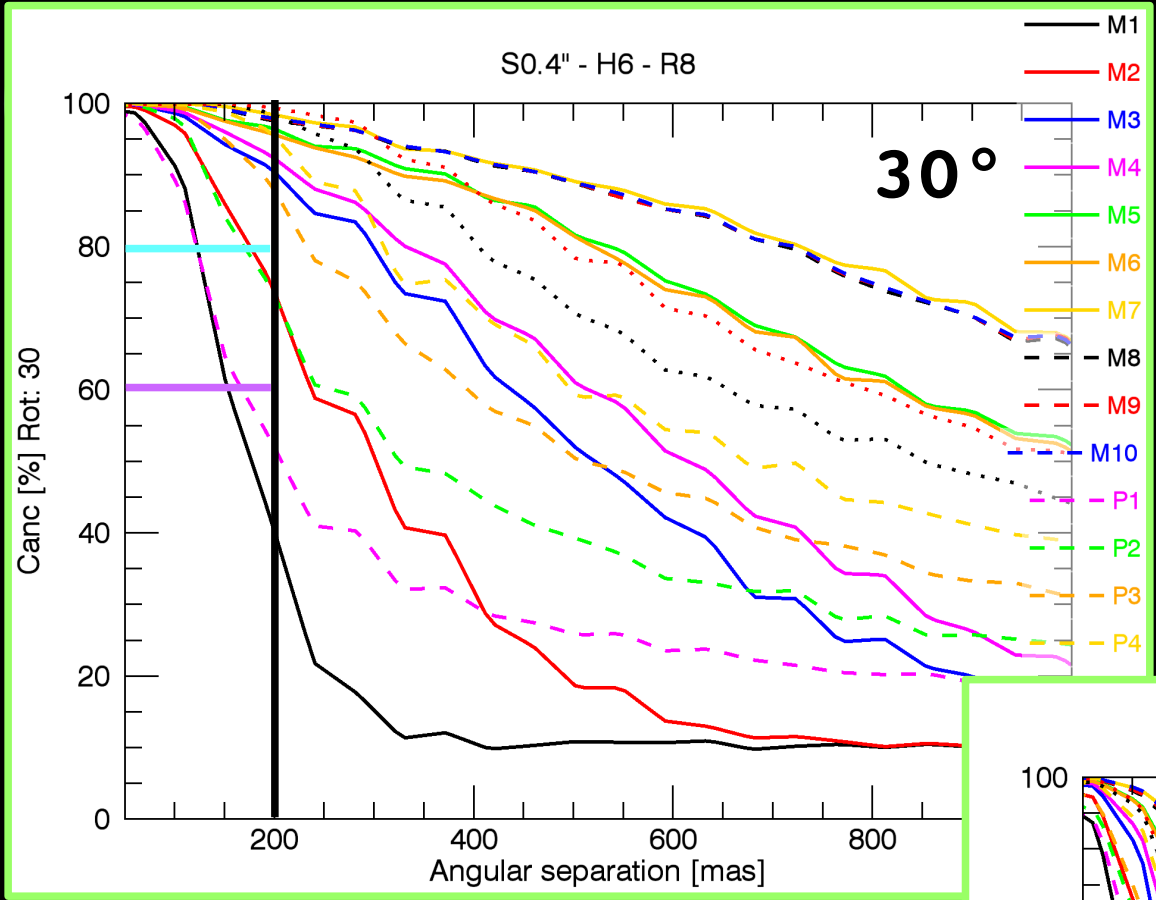
We analyse a sequence of 30 images assuming they cover an hour of obs + rotation according to LBT obj visibility

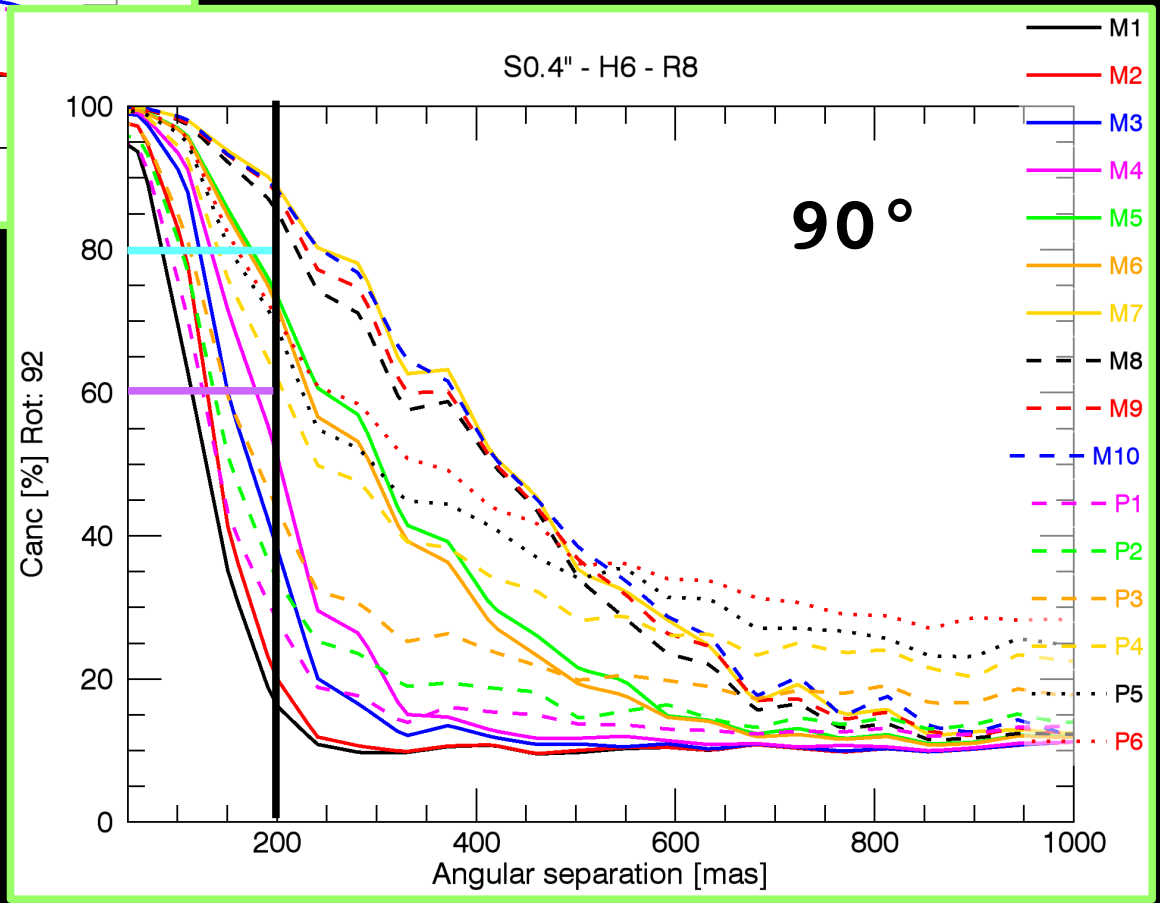
```
dec [deg]:  32.24 tot rot [deg]: 167.578
dec [deg]:  32.01 tot rot [deg]: 163.515
dec [deg]:  31.74 tot rot [deg]: 158.717
dec [deg]:  27.42 tot rot [deg]:  98.074
dec [deg]:  26.75 tot rot [deg]:  91.560
dec [deg]:  20.30 tot rot [deg]:  53.632
dec [deg]:  10.09 tot rot [deg]:  31.794
dec [deg]:  -0.39 tot rot [deg]:  22.750
dec [deg]: -10.32 tot rot [deg]:  18.326
dec [deg]: -30.76 tot rot [deg]:  14.055
dec [deg]: -56.80 tot rot [deg]:  12.612
```

Taurus - Auriga star forming region

SELF-SUBTRACTION OF THE PLANET LIGHT [%]

- for different ADI variants -





Compare the post-ADI signal to the initial one → **cancellation profile**

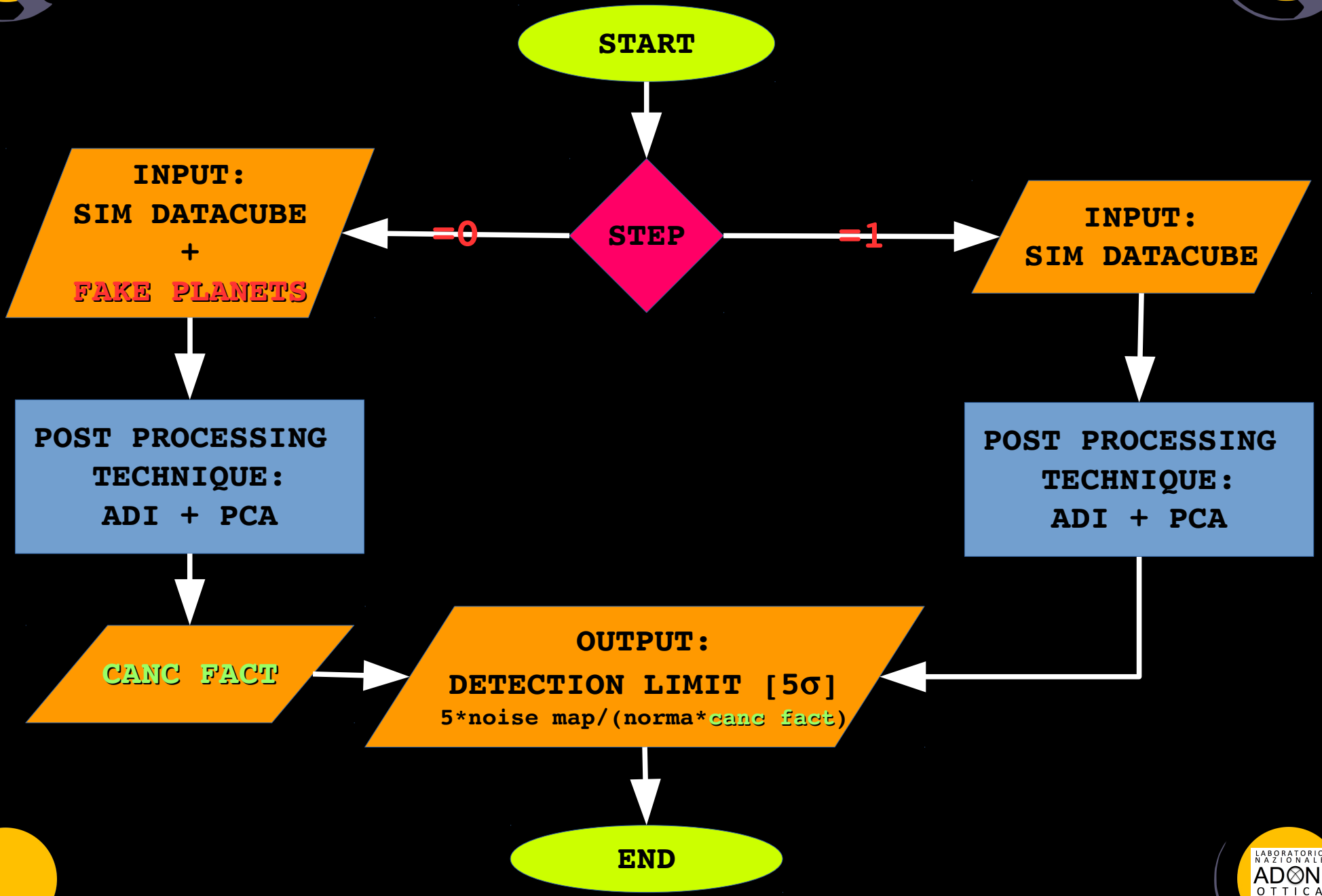
30° → 60% >200mas: M1,P1
90° → 60% >200mas: M1→M4, P1→P3

SIMULATION PARAMETERS

- **Fresnel end-to-end propagation**
- Simulation and analysis in H band = 1.6 μm
- Quasi static **speckle noise:** 30 nm rms [...]
- **Jitter:** 10 mas [...]
- **Seeing** range: 0.4" - 1.0"
- **Guide star Mag** R: 8 - 14 → Mag H: 5 - 12
  → [M type, Late type, Early type (B/A)]
- "T exp" tot: 60min
- # frames: 30
- Rot tot FoV: 90 deg

Please see also Vassallo posters

POST PROCESSING CODE



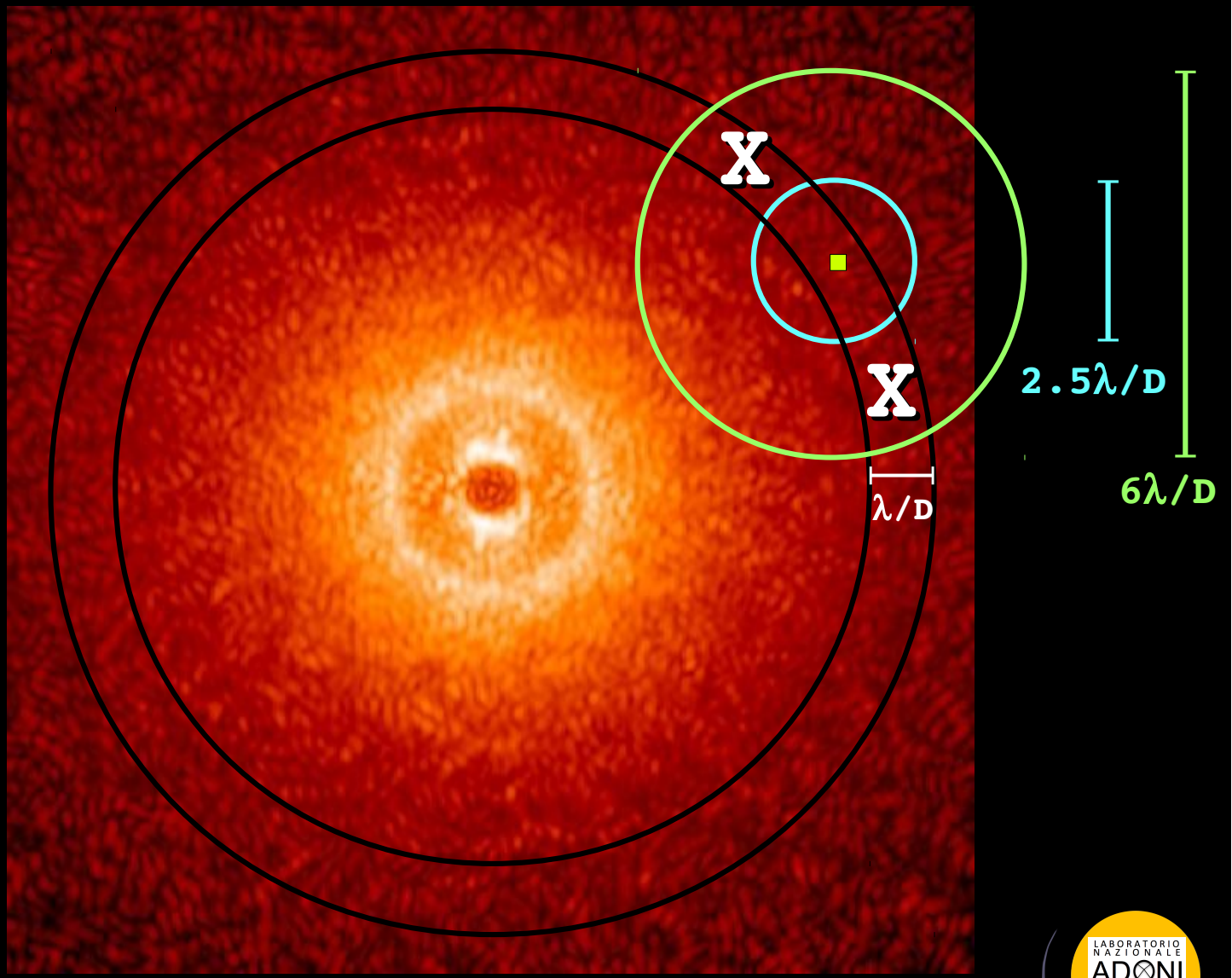
DETECTION LIMIT

For each pix:
→ STDEV XX zone[Fig]
→ bi-dim noise map
→ radial profile

DET LIM @5σ =
5*noise map/
(norma*canc fact)

OUT OF CORO. PSF
NORMALIZATION (norma)

SELF-SUBTRACTION
NORMALIZATION
(canc fact)



PERFORMANCE IN "HIGH" STREHL CONDITION OF THE DATA REDUCTION PIPELINE

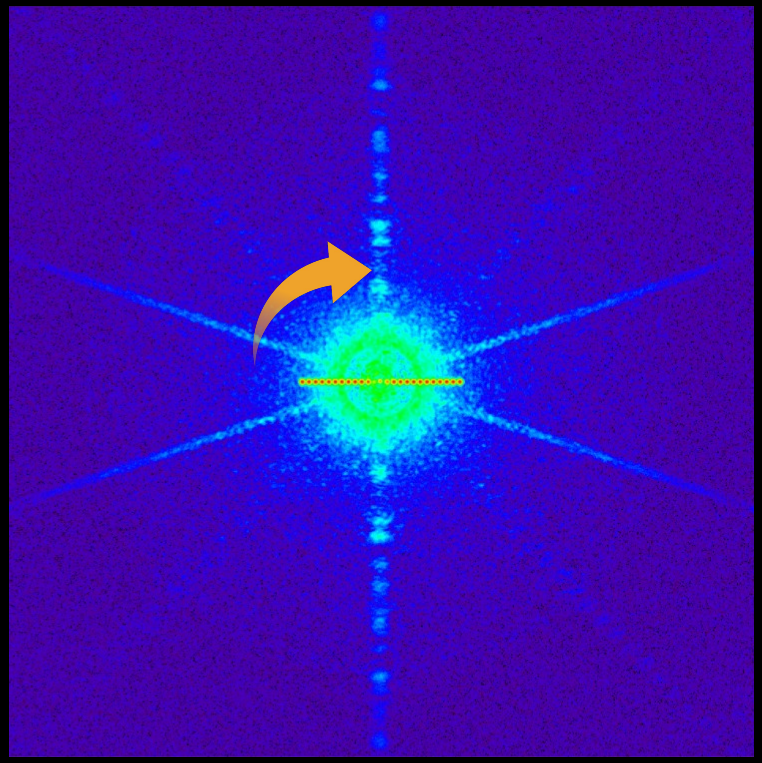
(JITTER 3nm rms [J3] and 10nm rms [J10] mag R=8)

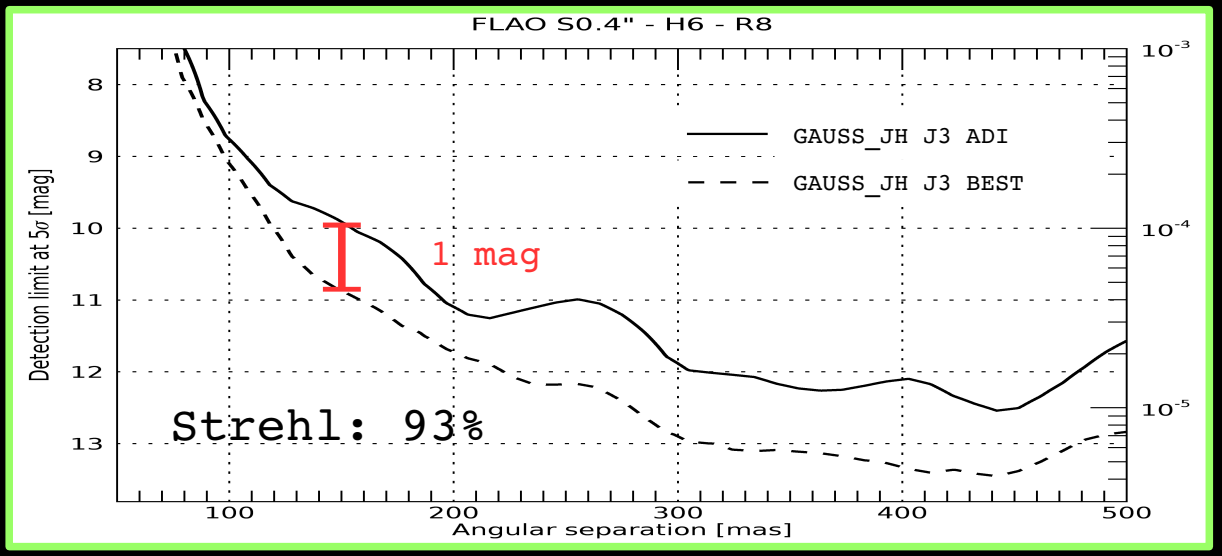
JITTER → amount in rms of the residuals after the AO correction

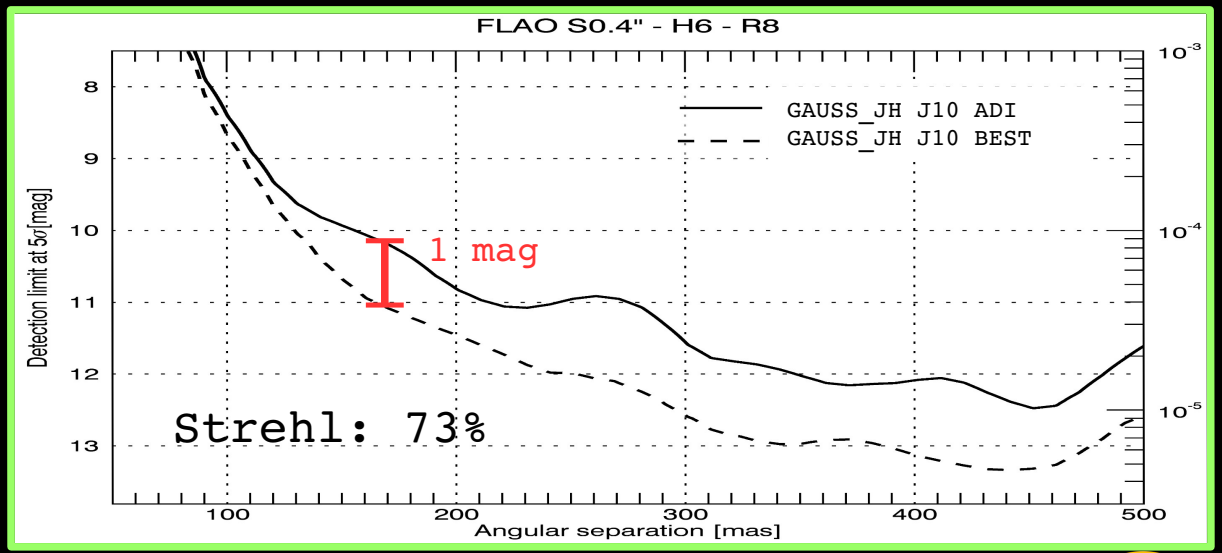
GAUSSIAN CORONAGRAPH: GAUSS

IWA: 2-2.5 λ/D

Nominal Contrast: 10^{-5}





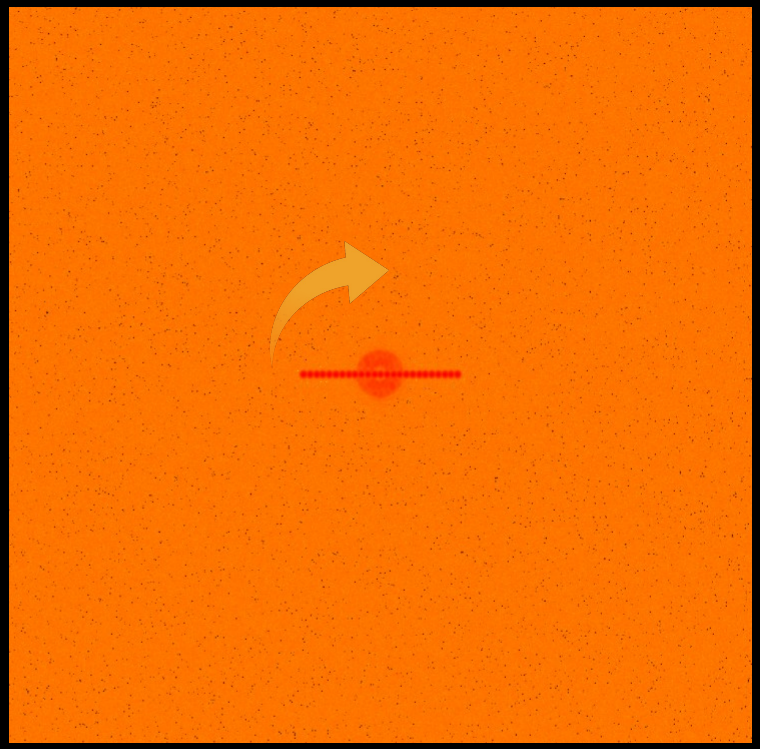


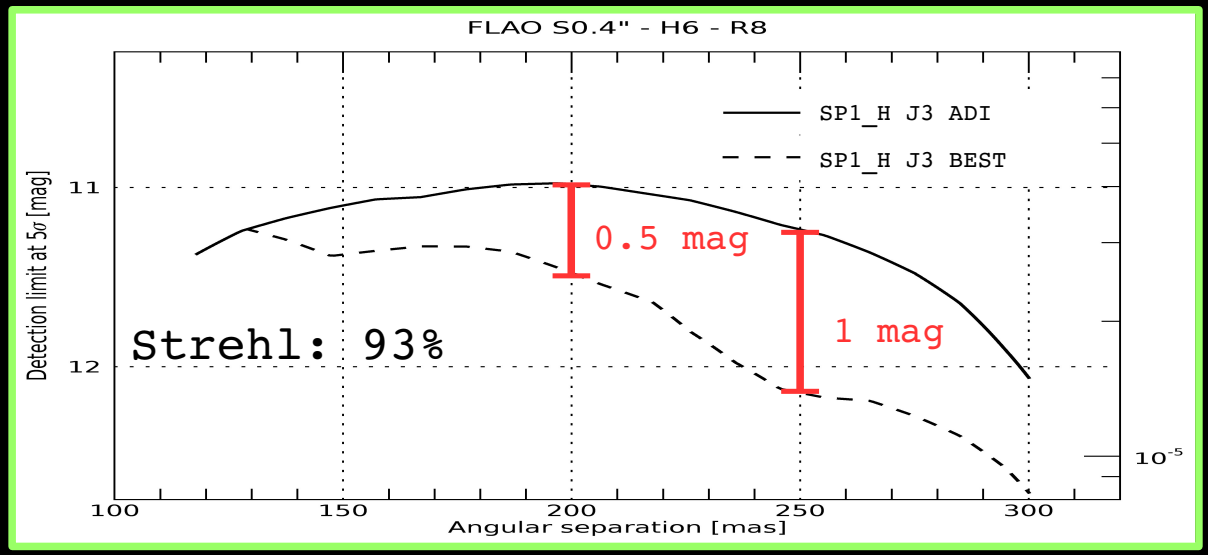
SHAPED PUPIL MASK: SP1

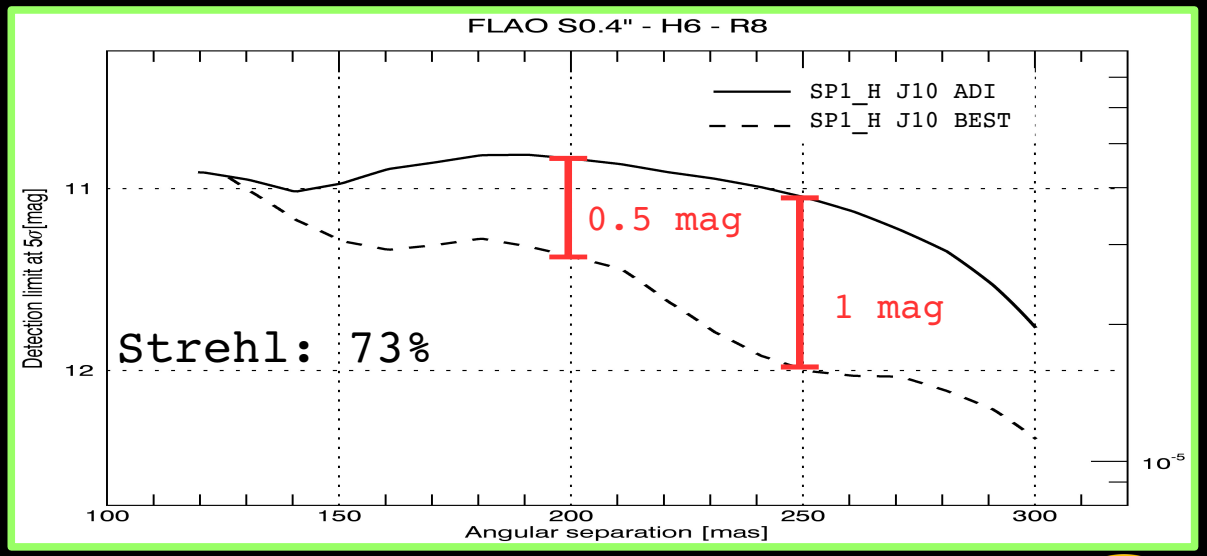
IWA: 2.6 λ/D

OWA: 8 λ/D

NOMINAL CONTRAST: 10^{-5}



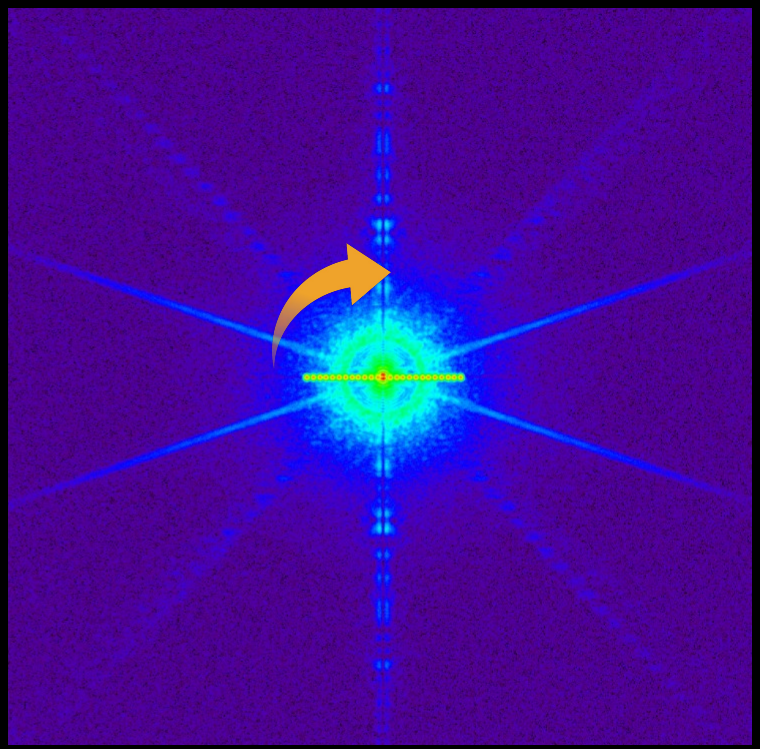


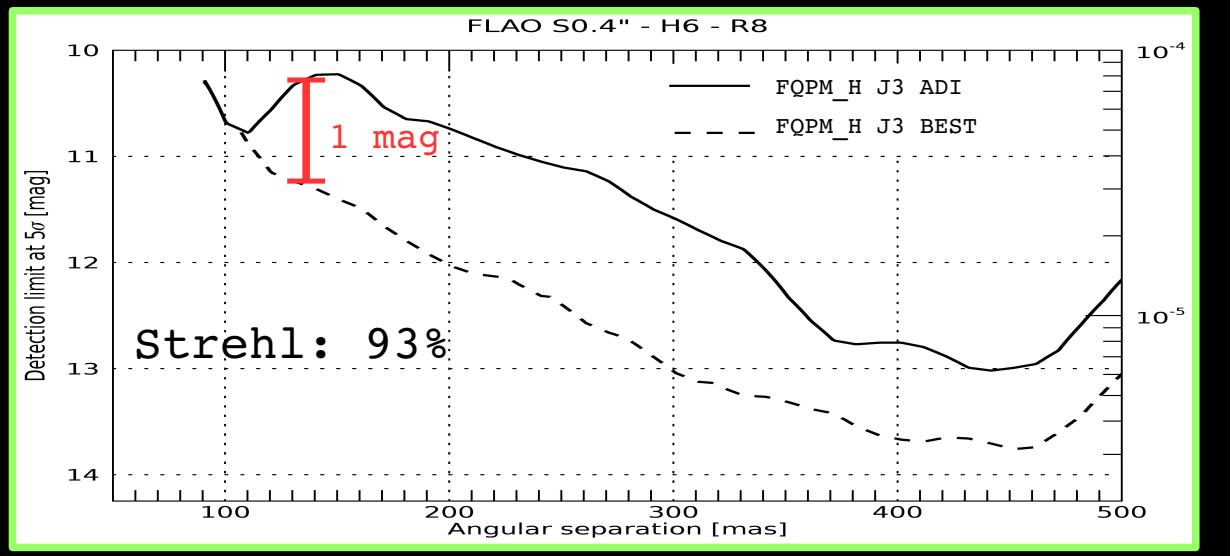


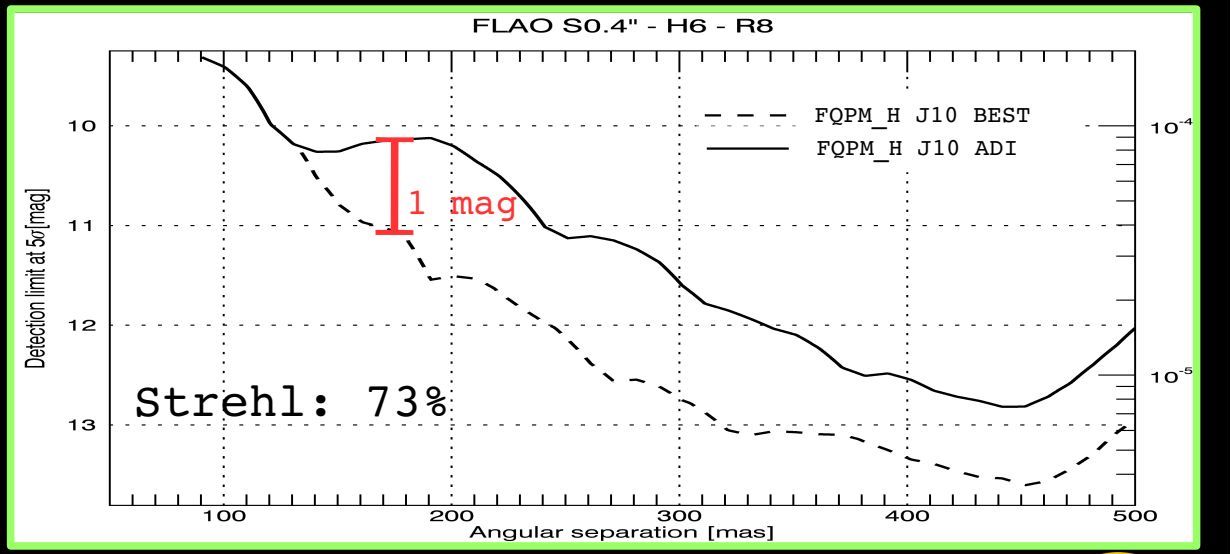
FOUR QUADRANT PHASE MASK: FQPM

IWA: 2 – 2.5 λ/D

NOMINAL CONTRAST: $5 \cdot 10^{-6}$

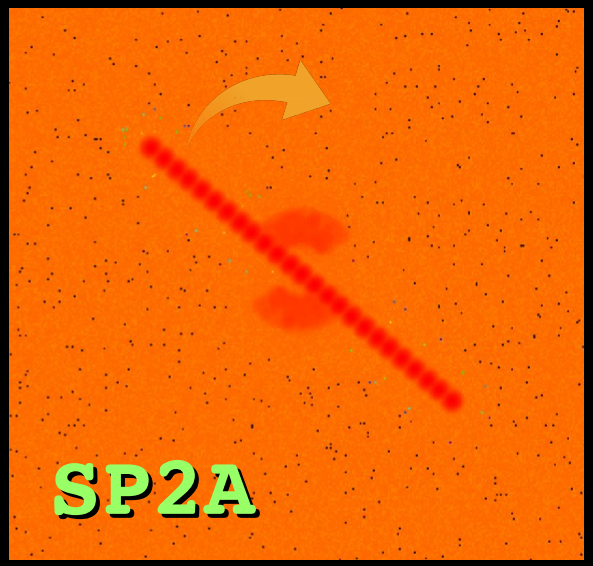


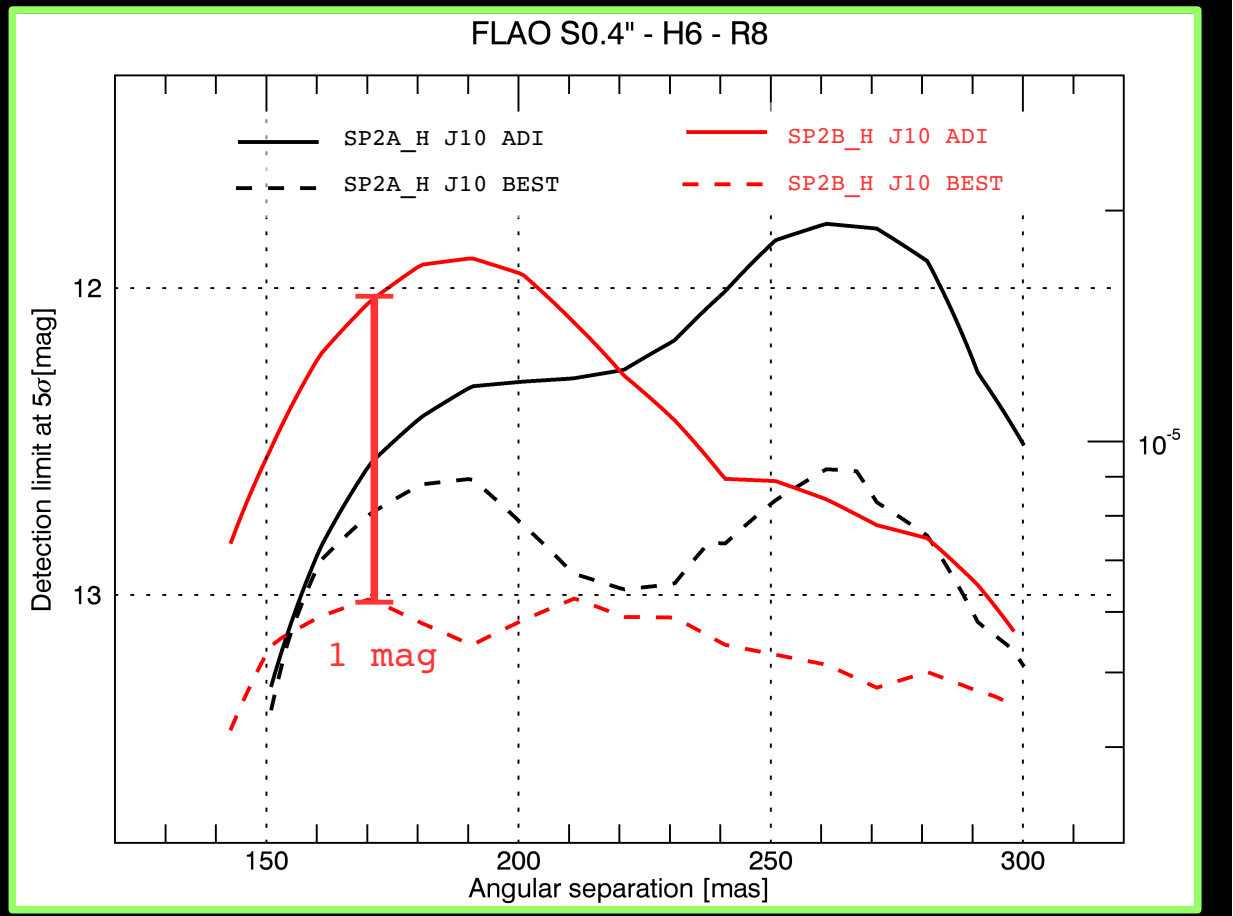




OTHER TESTED MASKS

SHAPED PUPIL ASYM MASKS: SP2A+SP2B





IWA: 3.5 – 3.3 λ/D

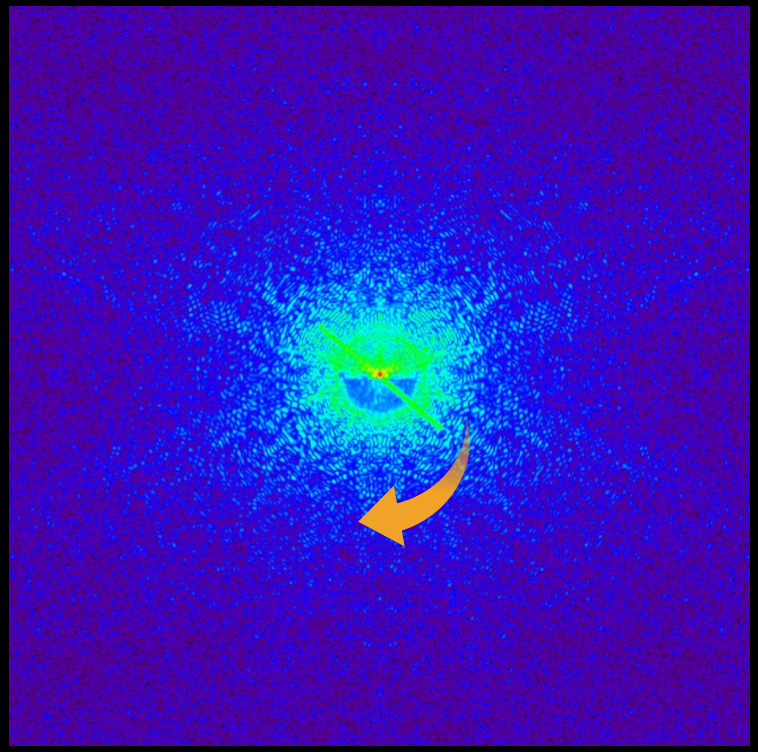
OWA: 8 λ/D

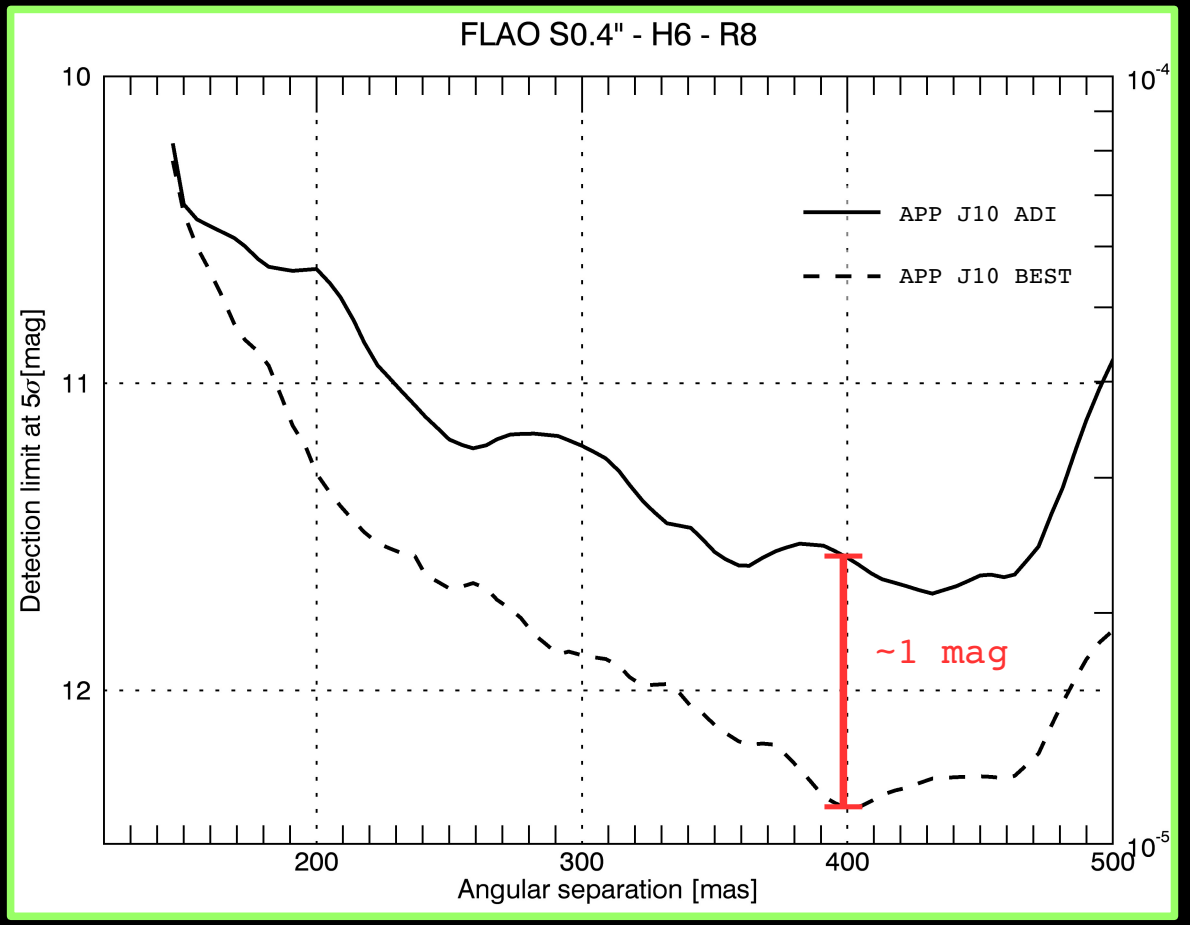
NOMINAL CONTRAST: 10^{-6}

Strehl: 73%

APODIZED PHASE PLATE MASK: APP

IWA: 2.1 λ/D
OWA: 12 λ/D
NOMINAL CONTRAST: $10^{-5.8}$
Strehl: 73%



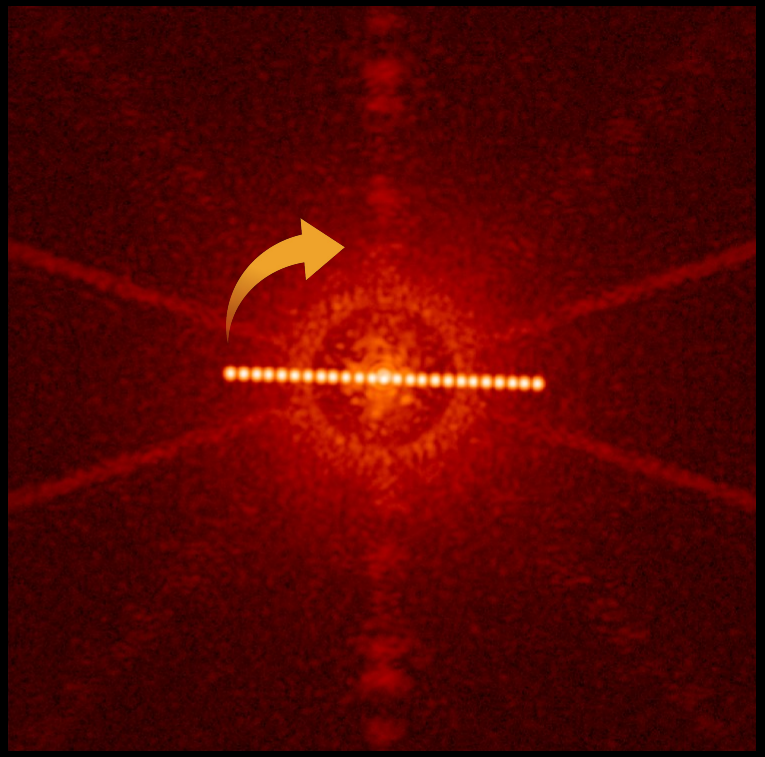


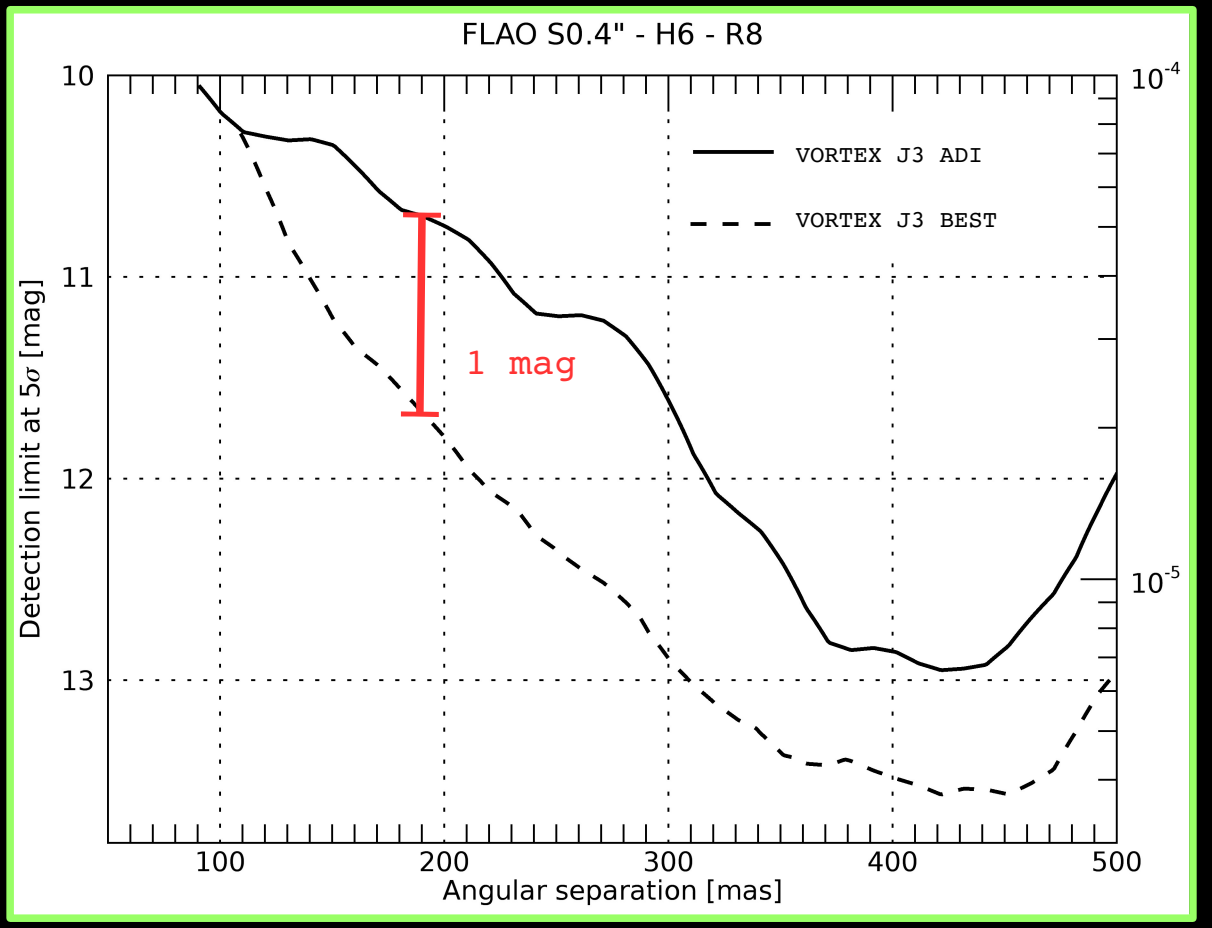
VORTEX

IWA: 1 λ/D

NOMINAL CONTRAST: $5 \cdot 10^{-6}$

Strehl: 93%





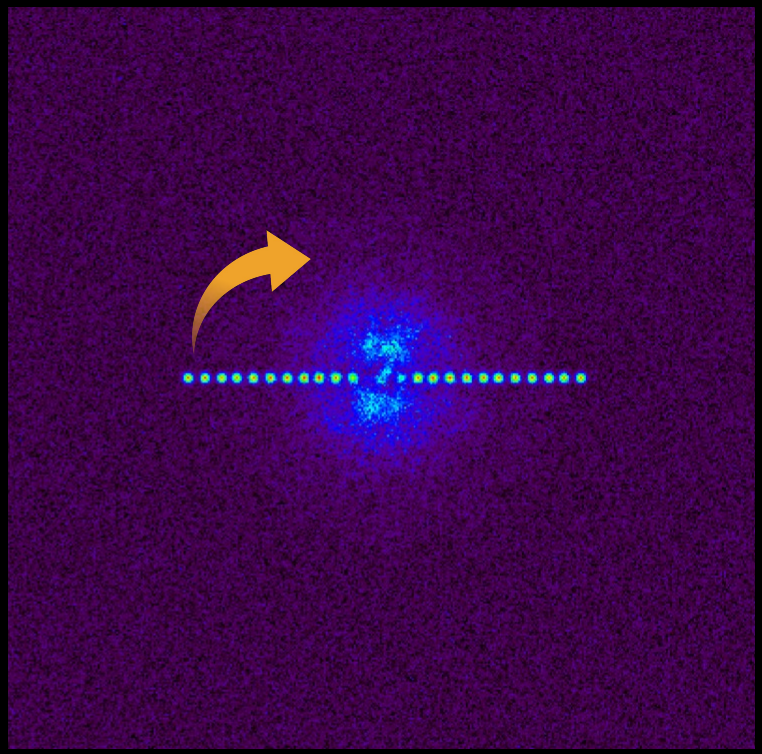
PERFORMANCE IN "LOW" STREHL CONDITION

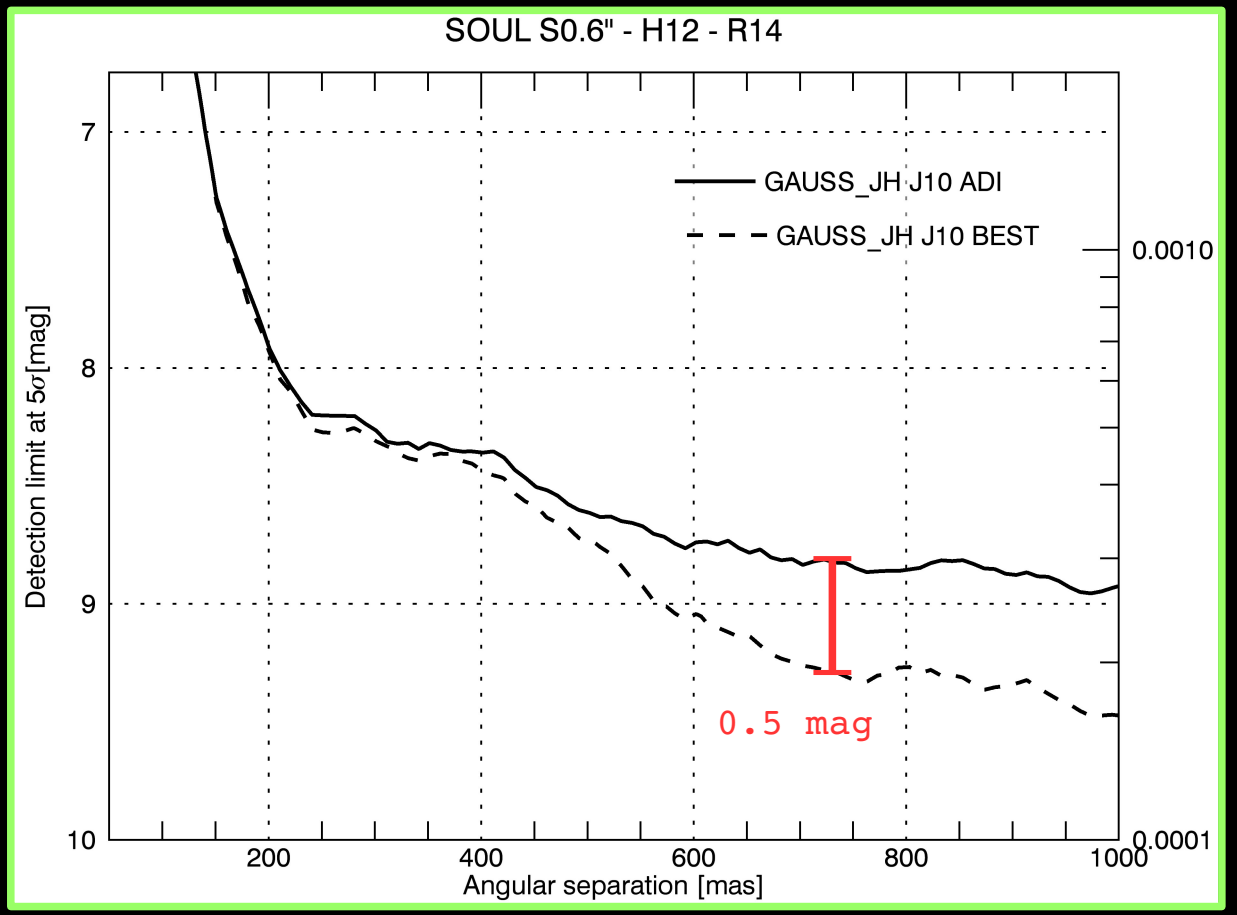
(JITTER 10nm rms [J10]
Mag R=14)

JITTER → amount in rms of the residuals after the AO correction

GAUSSIAN CORONAGRAPH: GAUSS

IWA: 2-2.5 λ/D
Nominal Contrast: 10^{-5}
Strehl: 50%



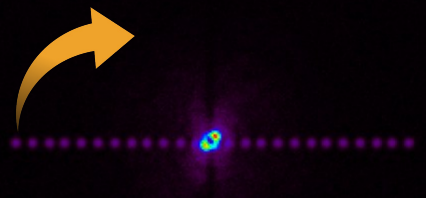


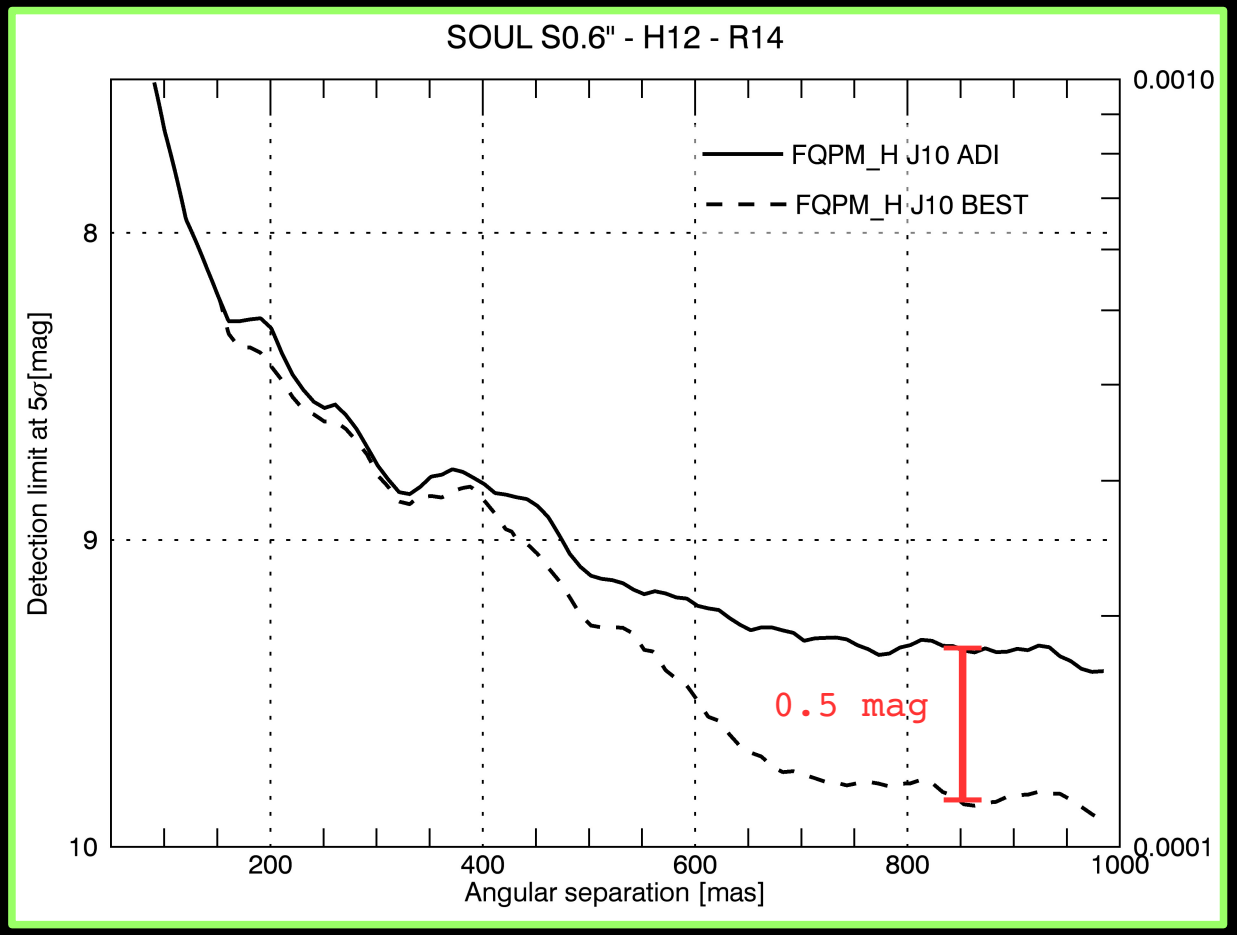
FOUR QUADRANT PHASE MASK: FQPM

IWA: 2 – 2.5 λ/D

NOMINAL CONTRAST: $5 \cdot 10^{-6}$

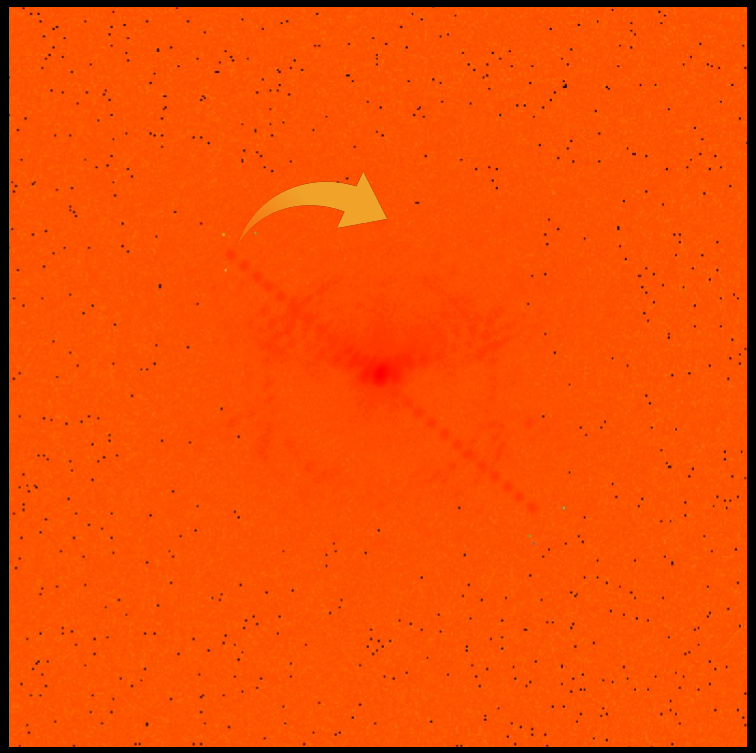
Strehl: 50%

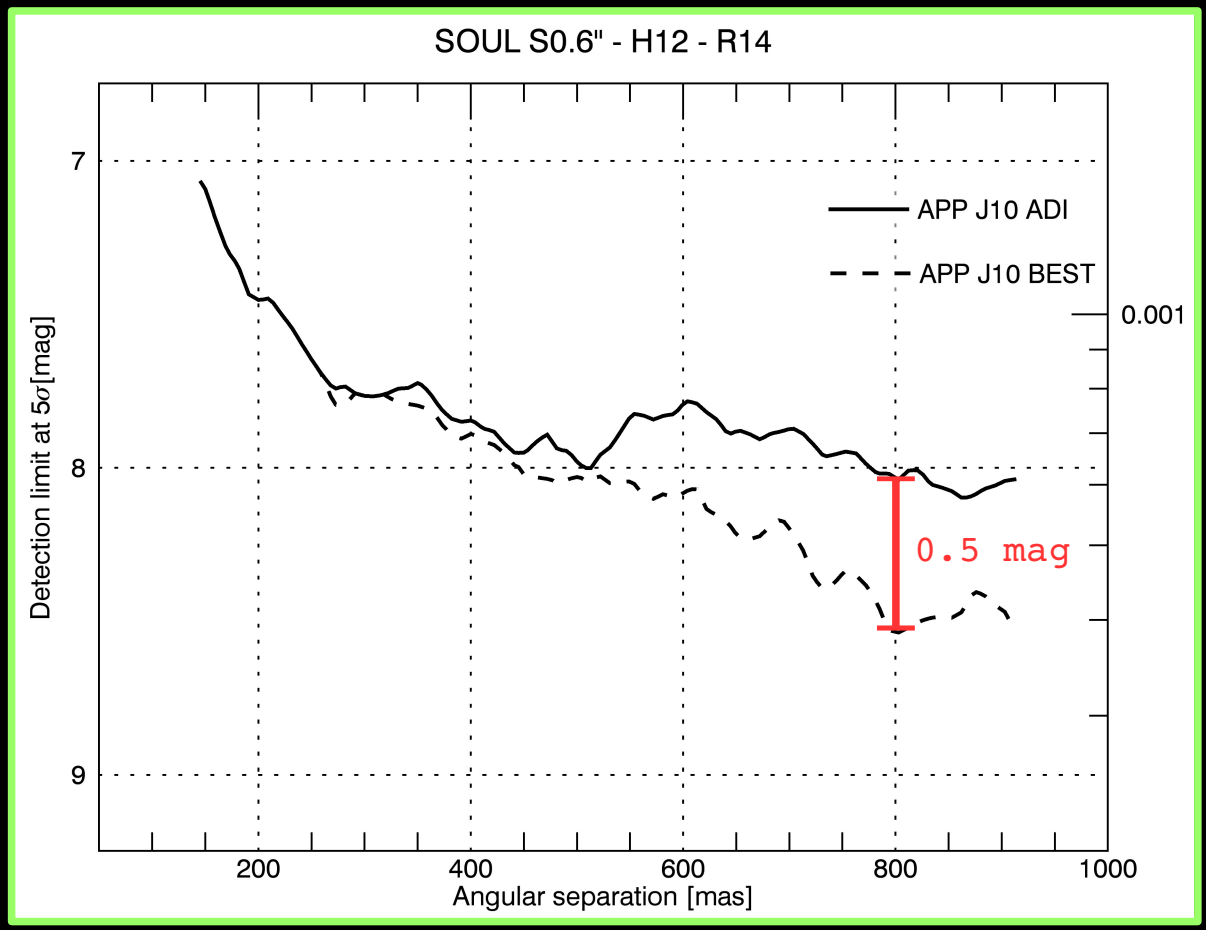




APODIZED PHASE PLATE MASK: APP

IWA: 2.1 λ/D
OWA: 12 λ/D
NOMINAL CONTRAST: $10^{-5.8}$
Strehl: 50%





CONCLUSIONS & WORK IN PROGRESS

- **We obtain realistic performance**
- **We know what is the best post processing technique at different separation and atmospheric condition**
- **We take into account the planet light subtraction (preserving the 60% @200mas)**
- New coro masks to test!(v-APP, VORTEX, SLPM ..)
- We need more simulated images / images on sky for testing the code
- Official Data Reduction Pipeline [Python]

For more details ..
POSTER ON SHARK

- [SIM] **Vassallo D.**: A virtual coronagraphic test bench for SHARK-NIR, the second-generation high contrast imager for the Large Binocular Telescope [P1020] TODAY
- [INST] **Farinato J.** **(PI)**: SHARK-NIR, the coronagraphic camera for LBT, moving toward construction [P1023] TODAY
- [VIS] **Pedichini F.** **(PI)**: SHARK-VIS the LBT high contrast imager at visible wavelengths [P2023] TOMORROW

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

WaveFront Sensing in the VLT/ELT era II

2-4 October 2017
Padova, Italy

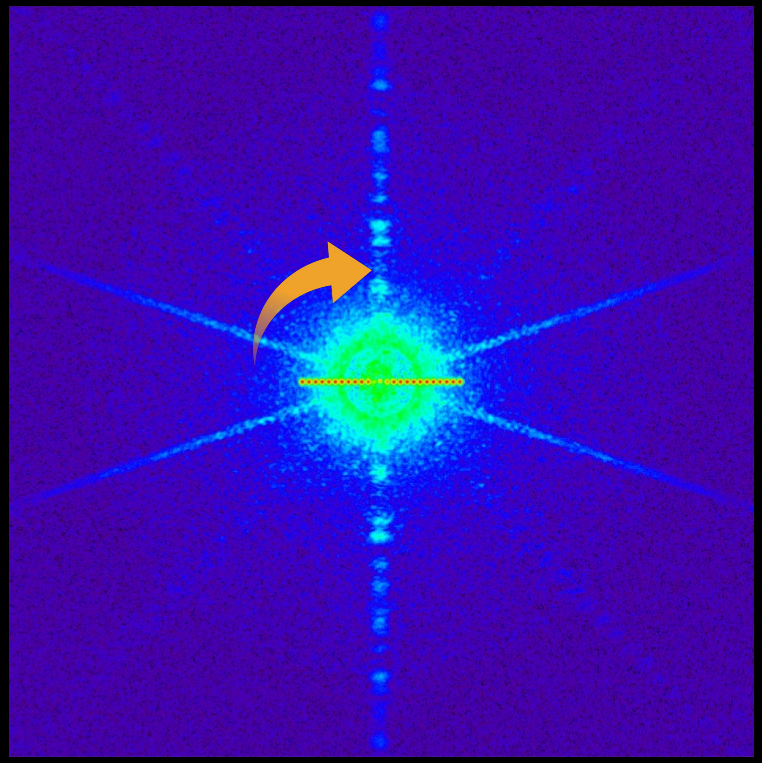
WFS in the VLT ELT era

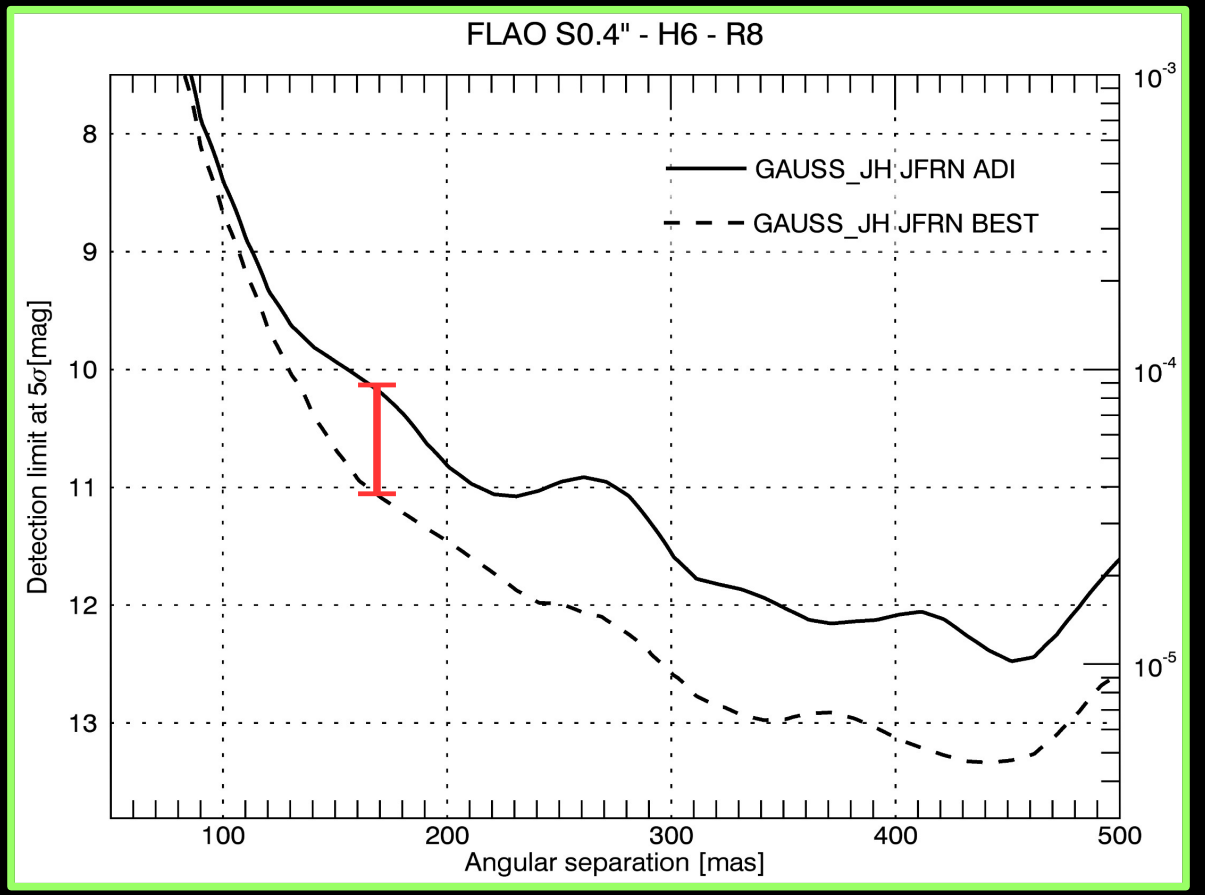
When
2-4 Oct 2017
Where
Padova (italy)
Web site:
https://www.ict.inaf.it/indico/event/521/
(or just Google the title…)


THANK YOU and ..
.. stay tuned ;)

GAUSSIAN CORONAGRAPH: GAUSS

IWA: 2-2.5 λ/D
Nominal Contrast: 10^{-5}
Strehl: 73%





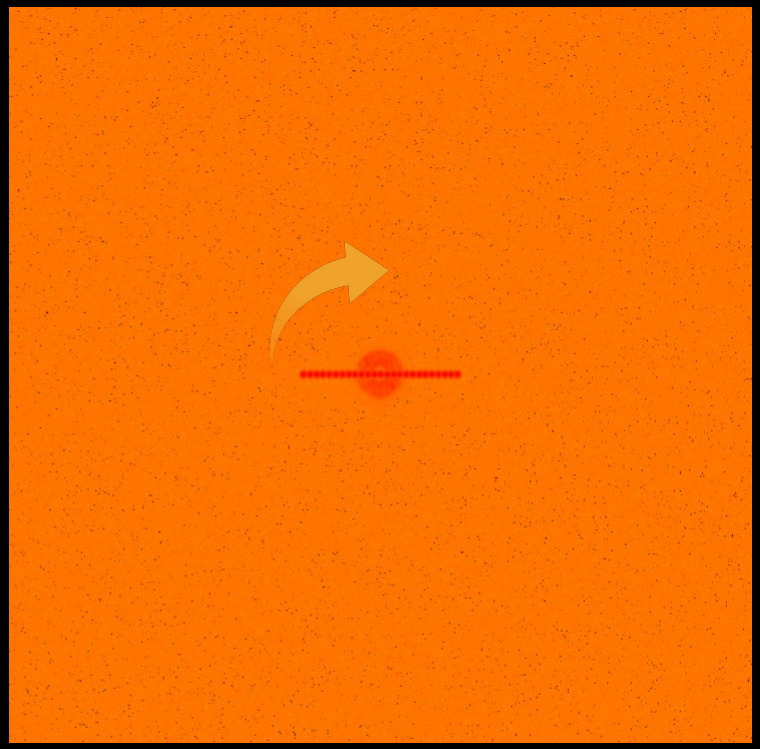
SHAPED PUPIL MASK: SP1

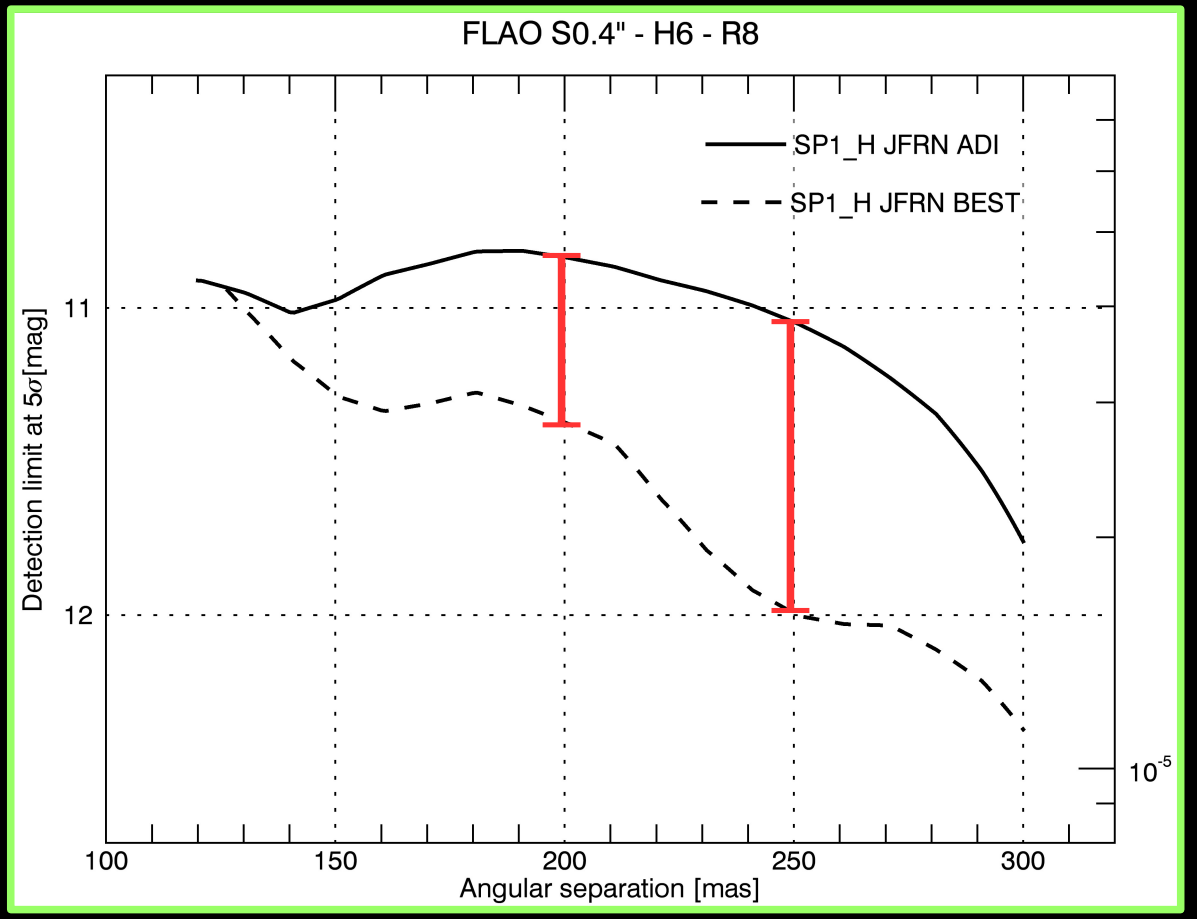
IWA: 2.6 λ/D

OWA: 8 λ/D

NOMINAL CONTRAST: 10^{-5}

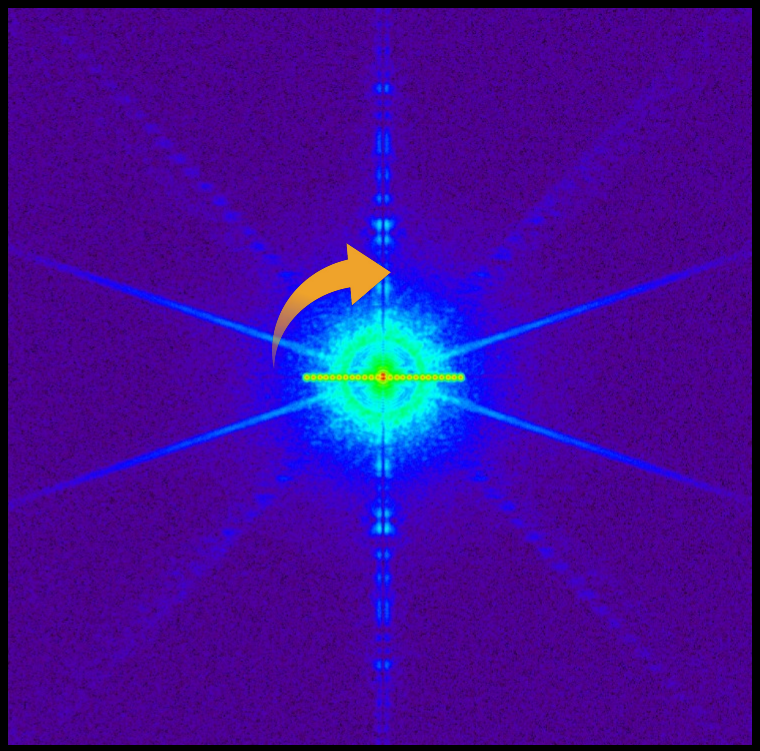
Strehl: 73%

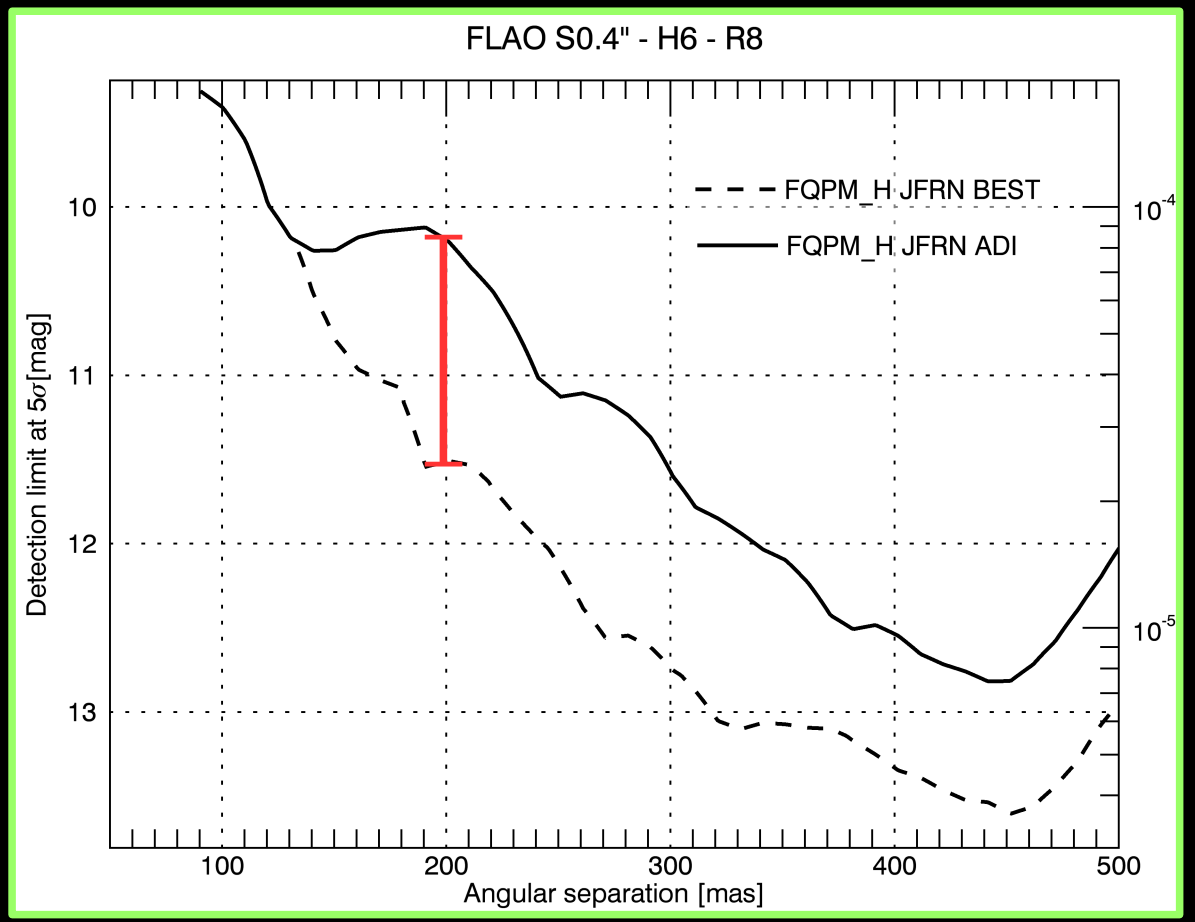




FOUR QUADRANT PHASE MASK: FQPM

IWA: 2 – 2.5 λ/D
NOMINAL CONTRAST: $5 \cdot 10^{-6}$
Strehl: 73%





SHAPED PUPIL MASK: SP1

IWA: 2.6 λ/D

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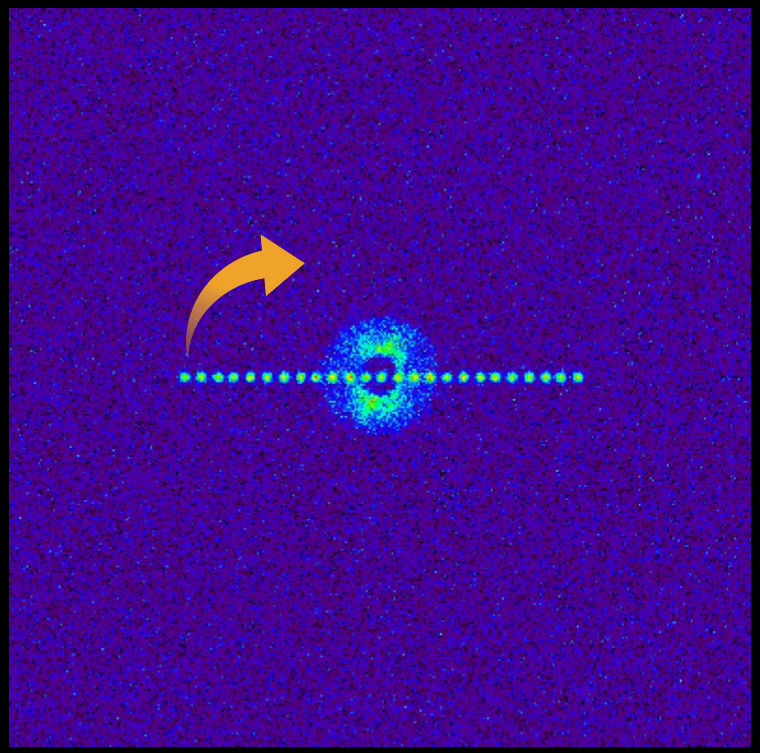
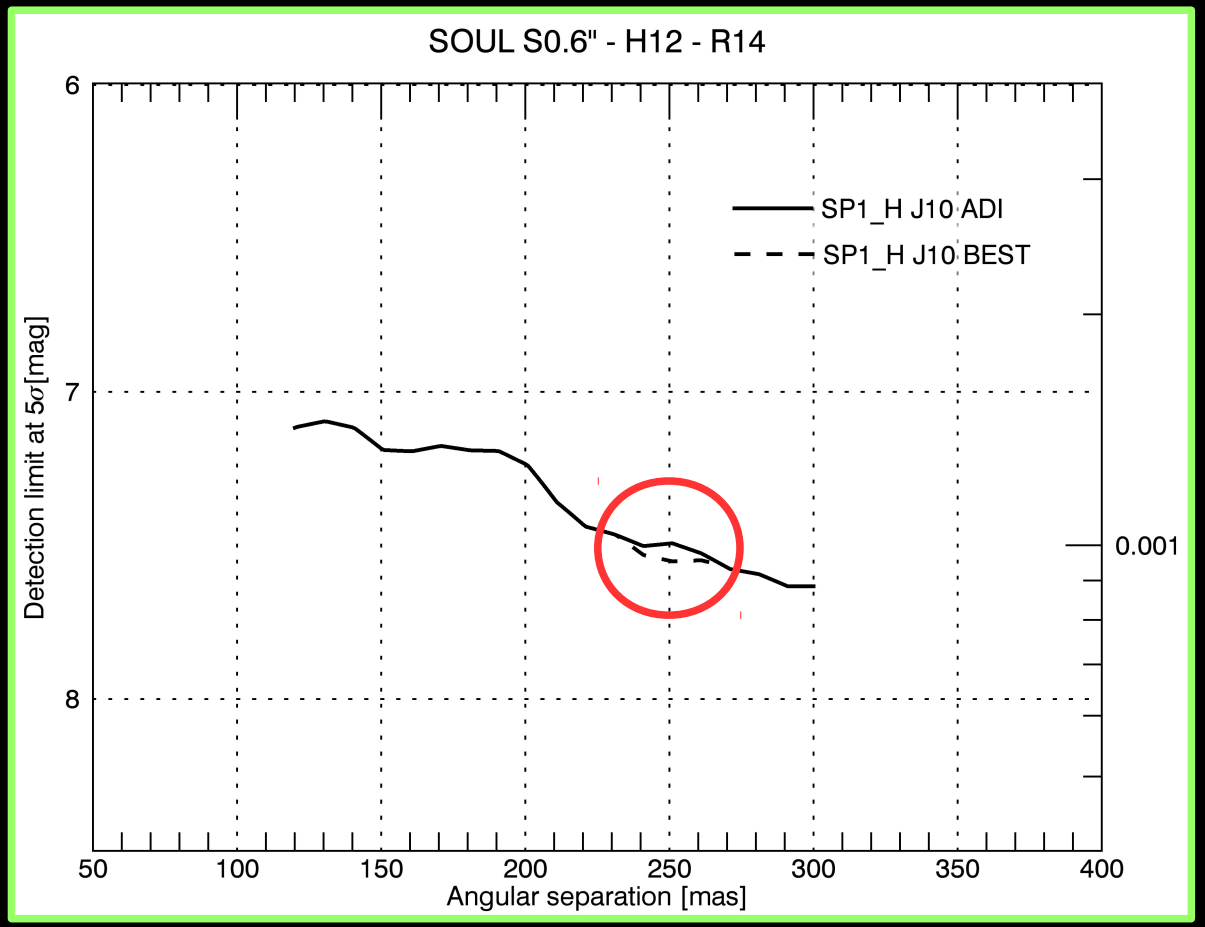
NOMINAL CONTRAST: 10^{-5}

Strehl: 50%





SPN11

SPN17 → 19

SPN18 → 20