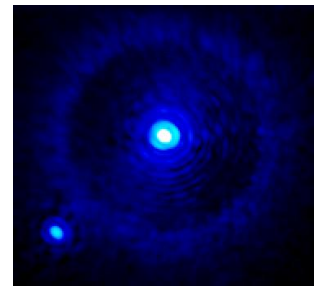
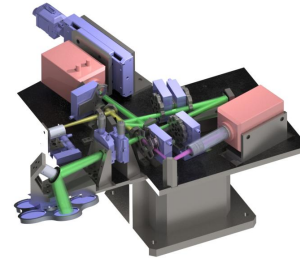




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# SHARK-VIS

*expected performances and  
simulations*

---

G. LI CAUSI, M. STANGALINI, S. ANTONIUCCI

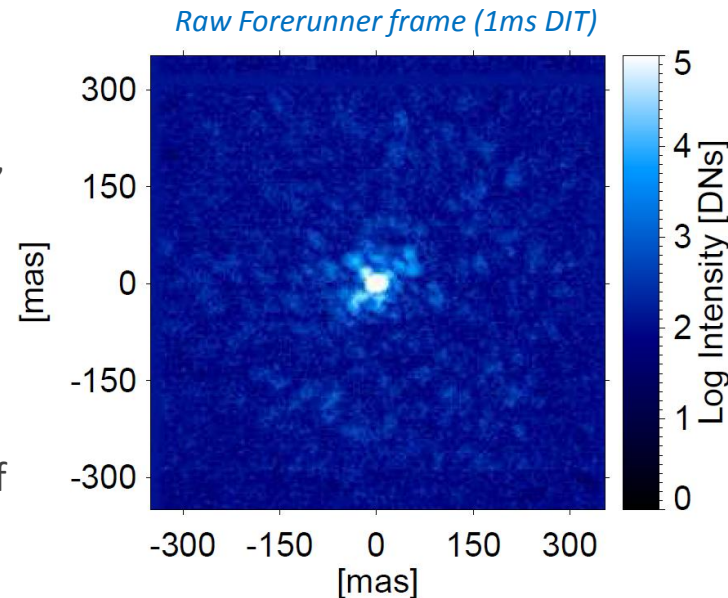
F. PEDICHINI, V. TESTA, M. MATTIOLI,

G. AGAPITO, S. ESPOSITO, E. PINNA, A. PUGLISI



# SHARK-VIS Data

- SHARK-VIS: X-AO high-resolution high-contrast LBT optical imager (400-1000 nm)
- Andor Zyla detector (low noise, high dynamic range, high frame rate)
- Frame integrations as short as 1 ms
- Huge number of frames expected ( $\sim 10^6$ , no derotator)
- Use post-processing procedures taking advantage of large frame statistics (e.g. best frame selection, then ADI)

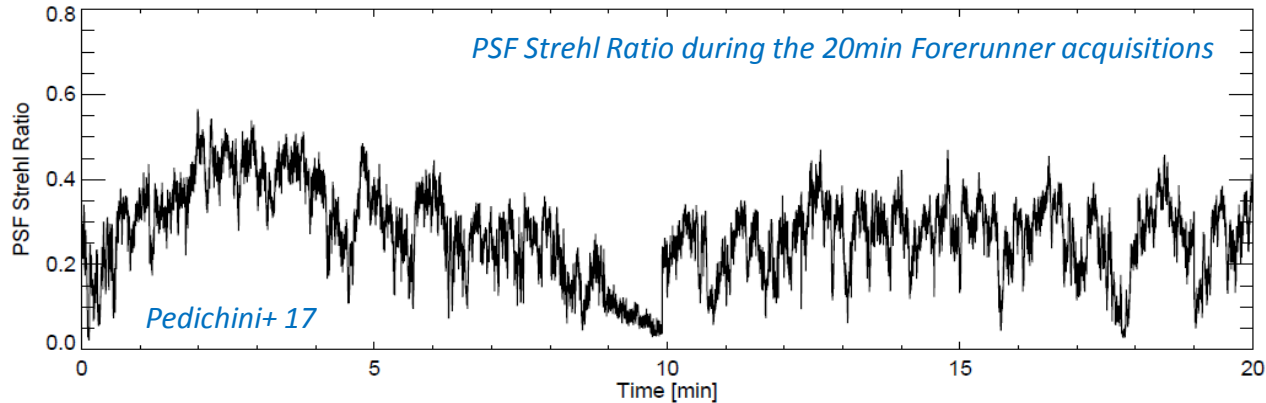


# SHARK-VIS Pathfinder: Forerunner Dataset



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- Observation of GLIESE 777 (Rmag=5.7), wide-band R.
- 1,200,000 1ms frames (20 min) with variable seeing conditions (0.8"-1.5")
- PSF estimated through median of 5000 randomly-selected frames (good representation of the entire frame "population")





# SHARK-VIS Pipeline

- Modular pipeline with two main sections:

**Data level 0: raw frames**



1

1<sup>st</sup> pipeline module (**frame calibration and registration**)

**Data level 1: calibrated and registered** (not derotated) **frames.**



2

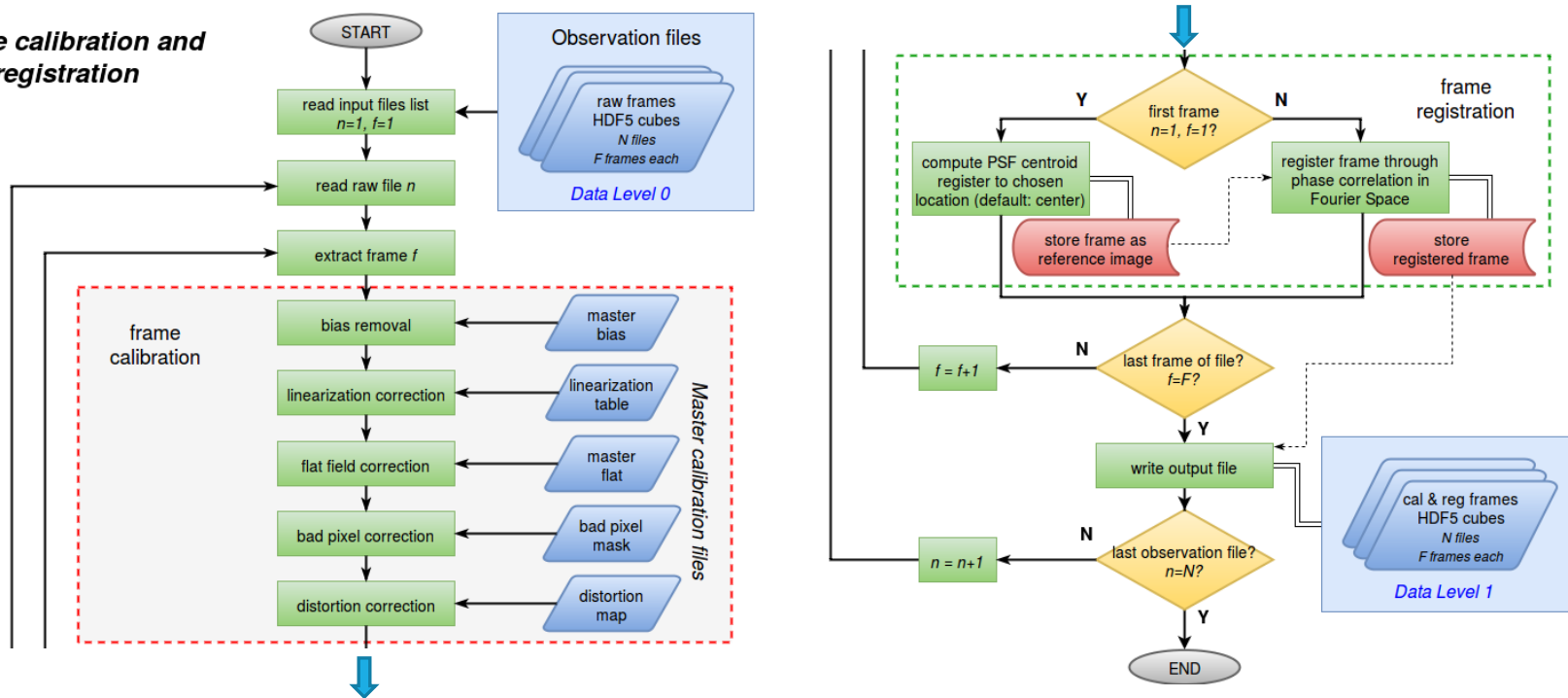
2<sup>nd</sup> pipeline module (**ADI**)

**Data level 2: final ADI image** (PSF-subtracted and median-combined) + by-products: estimated PSF, co-added image, basic statistical info on dataset (mean jitter, RMS, Strehl ratio, ...)

- Current version of the pipeline written in IDL (v. 8.4), used for tests and for processing the Forerunner data

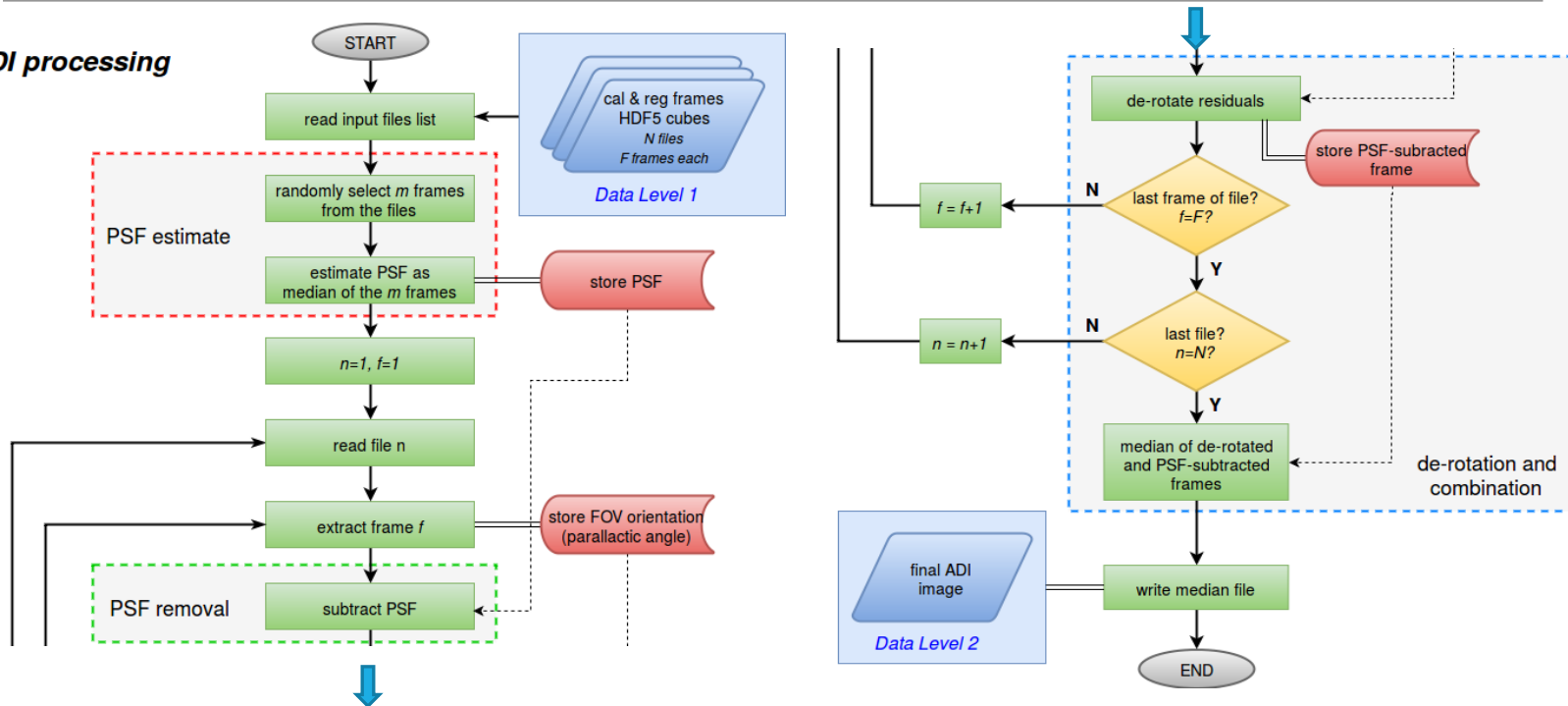
# Calib & Registration Flow

## Frame calibration and registration

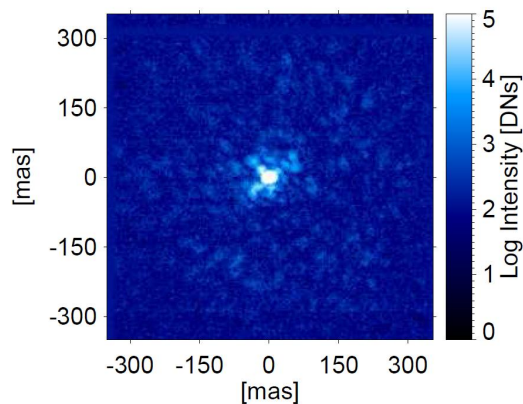


# ADI Flow

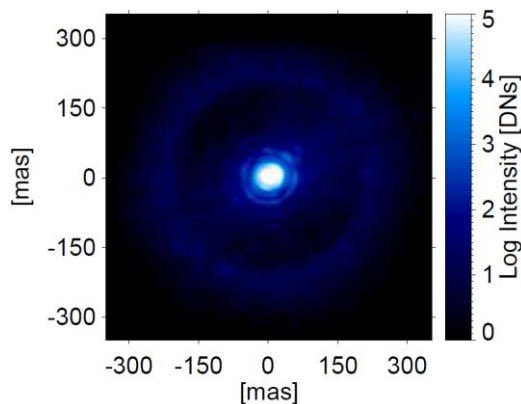
## ADI processing



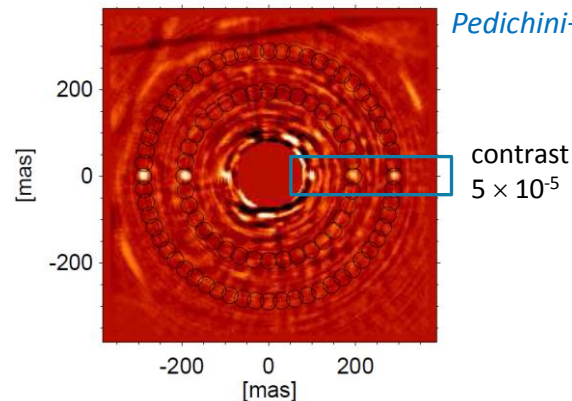
# Forerunner Dataset



*Raw 1ms-frame*



*Estimated PSF  
(median of 5000 frames)*



*ADI image with synthetic planets*

**Achieved contrast  $\sim 5 \times 10^{-5}$   
at  $\sim 100$ mas separations**

Reduction performed using current IDL pipeline

# SHARK-VIS Focal Plane Simulator (FPS)



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## SCOPE

- Simulate raw images for any:
  - SHARK-VIS configuration
  - observing conditions
  - target properties
- Measure SNR by aperture photometry
- Work as an Exposure Time Calculator

## RESULTS

- Assume perfect PSF subtraction
- Only noise-limited images
- No simulated ADI residuals (expected SNR with ADI residuals is ~10 times higher, as shown by Forerunner observations)





# FPS Parameters

---

## 1 - TARGET PARAMETERS

- **Planet Contrasts**
- **Planet Separations**
- **Star Magnitude**
- **Photometric Band**
- **(Star Spectrum)** *to implement*
- **(Planet Spectrum)** *to implement*
- **(Planet Polarization)** *to implement*

## 2 - INTERNAL PARAMETERS (no user input)

- **Telescope Diameter and Throughput**
- **SHARK-VIS Details and Throughput**
- **Detector Details and Efficiency**



# FPS Parameters

## 3 - SIMULATION PARAMETERS

- Total Exp Time
- Frame Exp Time
- Airmass
- Seeing FWHM
- Wavelength
- Bandwidth
- SHARK-VIS Configuration

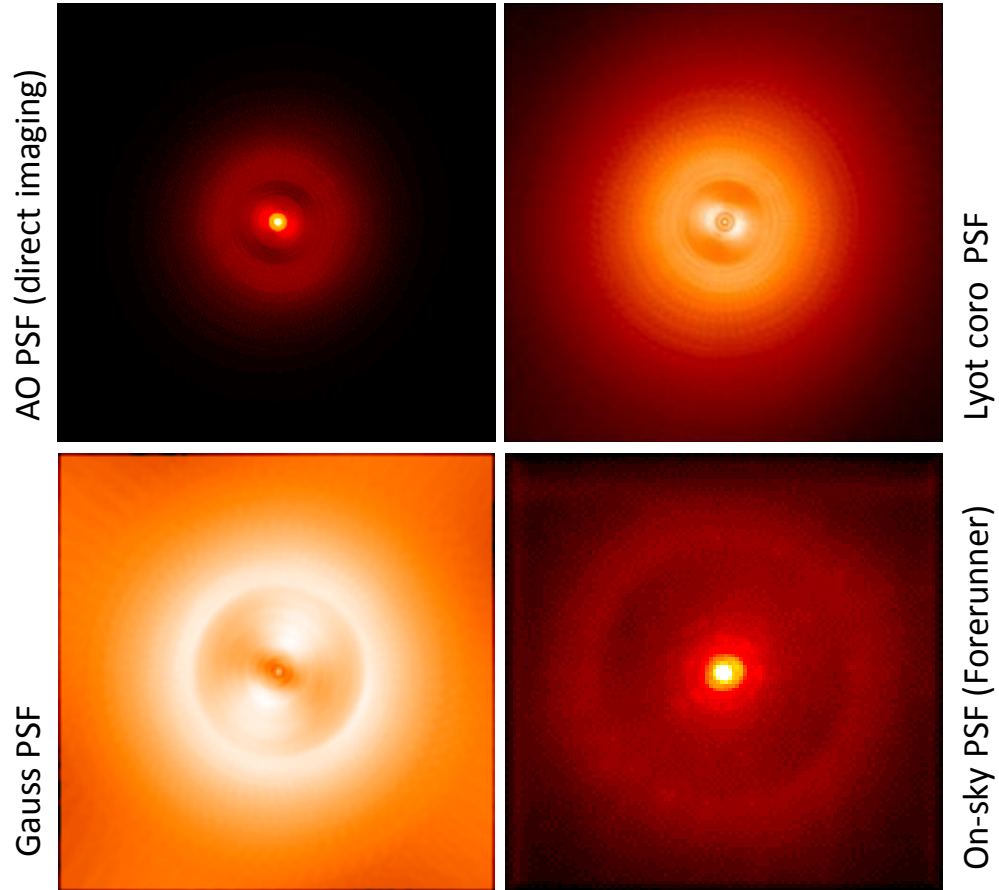
### SHARK-VIS Configuration

Input dichroic wheel	Guide dichroic wheel	Coronagr. wheel	Pupil stop wheel	Pupil filter wheel	Camera filter wheel
<b>50/50</b>	50/50	30 um	100%	WB $\lambda_1, \lambda_2, \dots$	Pupil viewer
<b>10/90</b>	10/90	60 um	95%	NB $\lambda_1, \lambda_2, \dots$	2x
<b>90/10</b>	90/10				
<b>R/G</b>	R/G	No coro	No mask	Wollaston	Split
<b>OFF</b>	None			No filter	No filter

# FPS Point Spread Functions

- Simulated externally by SSC (SHARK Simulation Code) using Phase Screens by Arcetri for a fixed grid of:
  - Seeing FWHMs
  - Wavelengths
  - Star magnitudes
- AO (no-coro) PSF
- Lyot coro PSF
- Gauss coro PSF
- Real on-sky PSF (Forerunner), useful for FPS calibration

## PSF SIMULATIONS (by SSC simulator)



# FPS flow chart

## INPUTS:

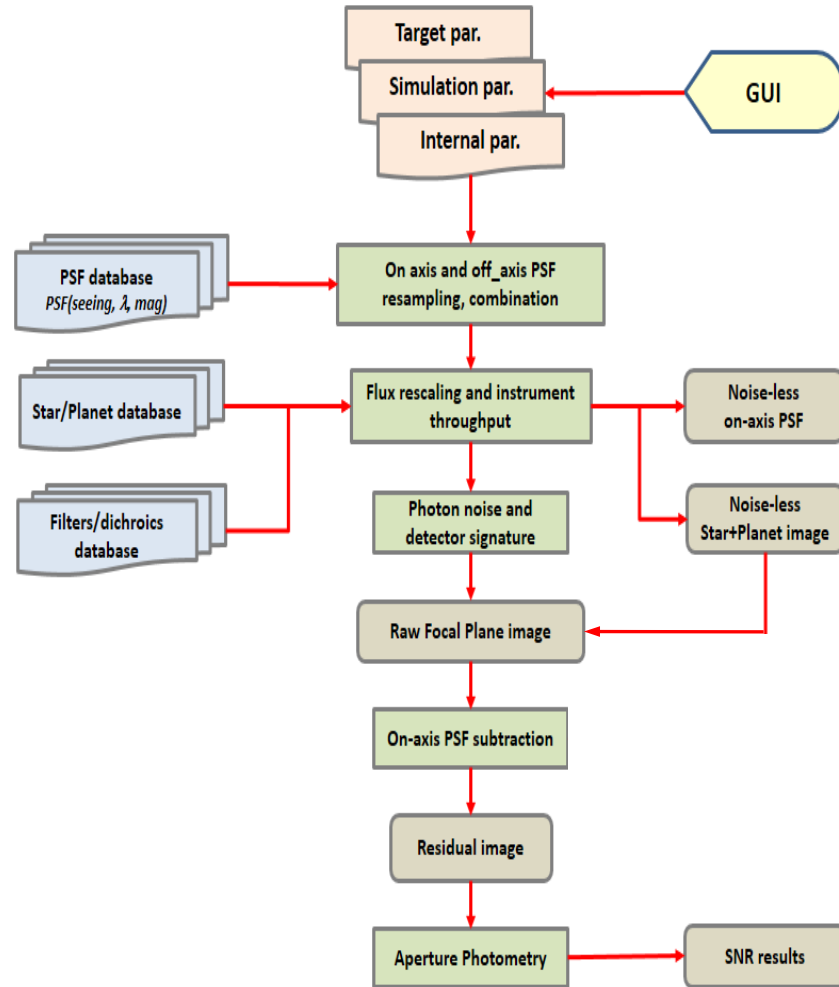
- FPS parameters (ASCII files)
- PSF database (seeing,  $\lambda$ , mag)
- Star and Planet properties
- SHARK-VIS optics efficiency

## PROCEDURE (IDL language):

- PSF resampling, PSF combination for wide band
- Target flux propagation
- Noises contribution
- Noiseless PSF subtraction
- Aperture photometry

## OUTPUT:

- Raw focal plane image
- Residual image
- Companion SNR plots



# FPS Graphical User Interface

- MENU:

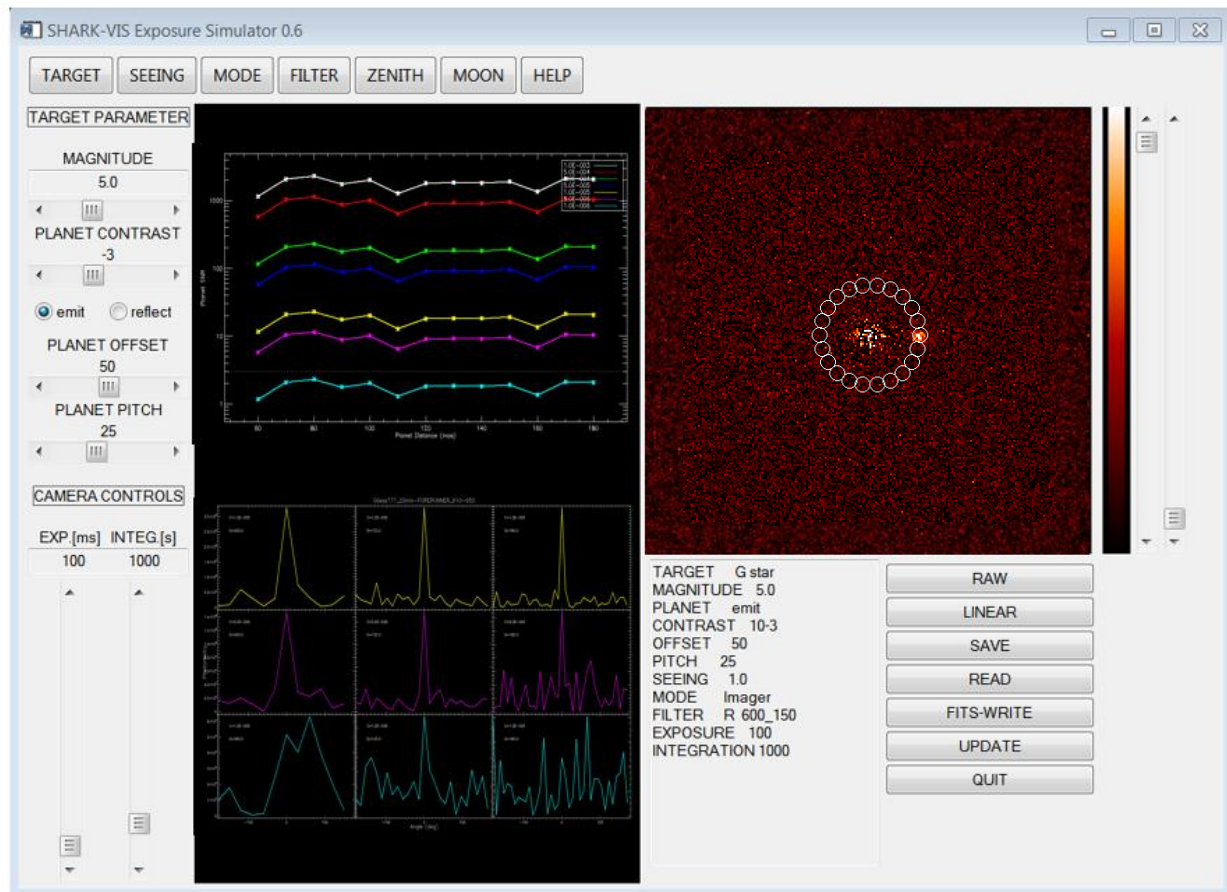
- Target
- Parameters
- Observing conditions

- PANELS:

- Residual image
- SNR results

- SLIDER / BUTTONS:

- Display
- Load/Store simulations
- Parameters variation





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# FPS Simulation Examples

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## SIMULATED OBSERVATIONS

Find contrast limit assuming different planet contrasts and separations:

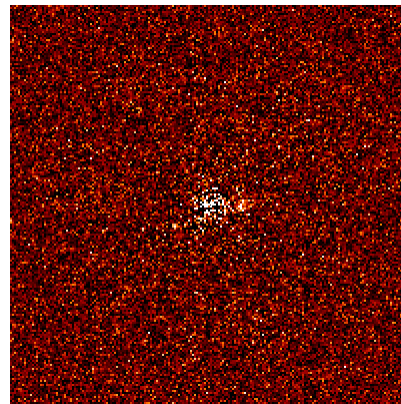
- Forerunner on Gliese 777 (→ “calibrate” the FPS)
- SHARK-VIS with Forerunner PSF on Gliese777
- SHARK-VIS with coronagraph on LAL 21185
  
- SHARK-VIS with no coronagraph on Proxima B

# Forerunner on Gliese 777

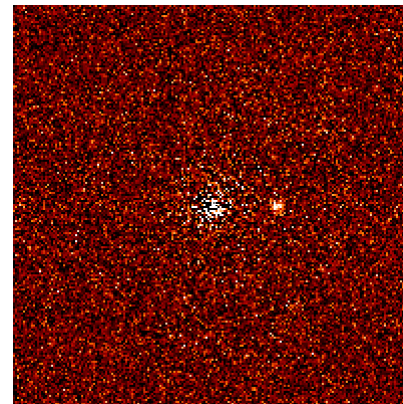
- Forerunner PSF from real data
- $R = 5.7$
- 20 min exposure, 1 ms DIT
- Dichroic 50/50
- $Q_{\text{eff}} 60\%$
- $\lambda 630 \text{ nm}, \Delta\lambda 40 \text{ nm}$

RESIDUALS FOR CONTRAST  $5 \cdot 10^{-6}$

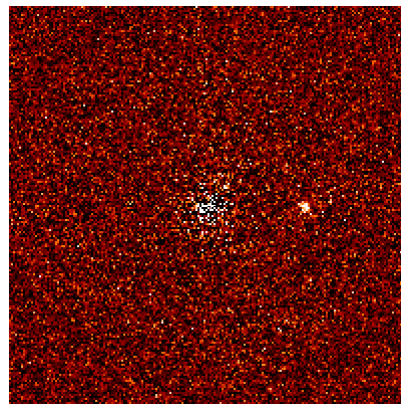
60 mas



120 mas

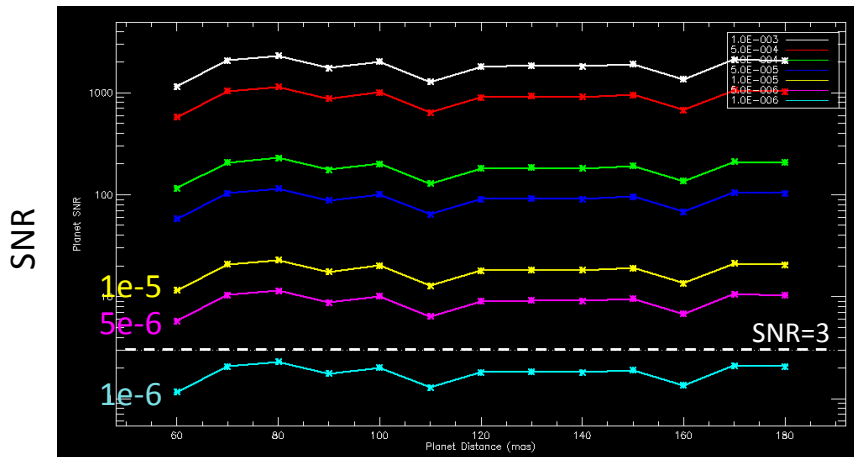


180 mas



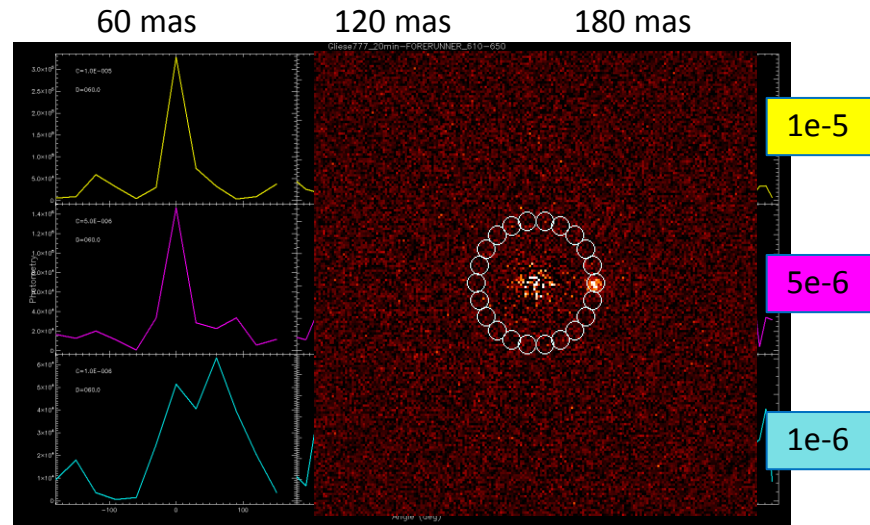
# Forerunner on Gliese 777

## SNR VS SEPARATION



Separation (mas)

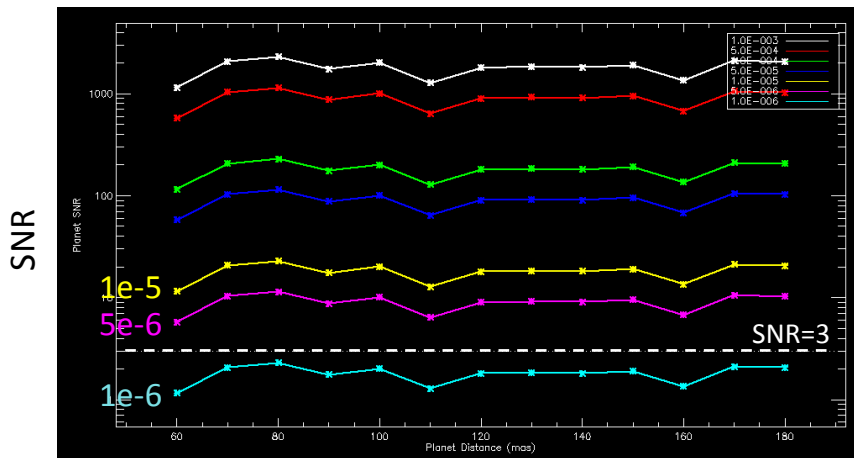
## SIGNAL VS ANGLE (FROM AP. PHOTOMETRY)





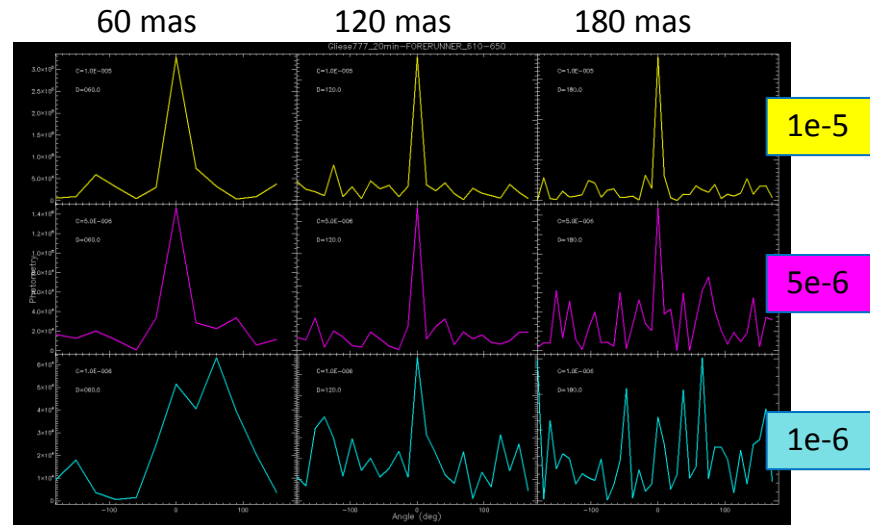
# Forerunner on Gliese 777

## SNR VS SEPARATION



Separation (mas)

## SIGNAL VS ANGLE (FROM AP. PHOTOMETRY)

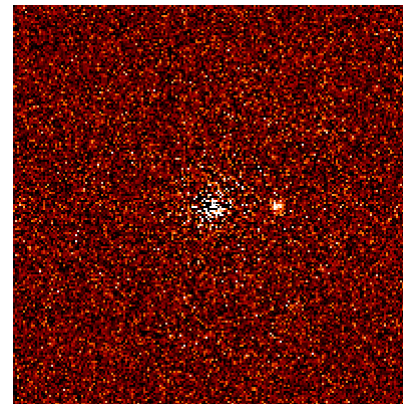
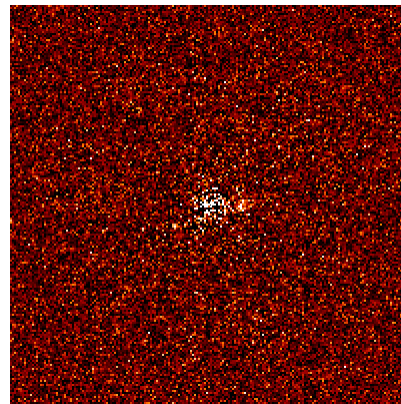


# Forerunner on Gliese 777

- Forerunner PSF from real data
- $R = 5.7$
- 20 min exposure, 1 ms DIT
- Dichroic 50/50
- $Q_{\text{eff}} 60\%$
- $\lambda 630 \text{ nm}, \Delta\lambda 40 \text{ nm}$

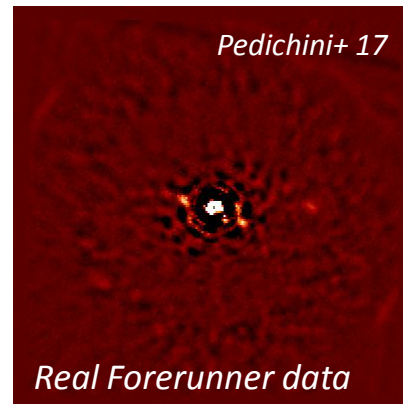
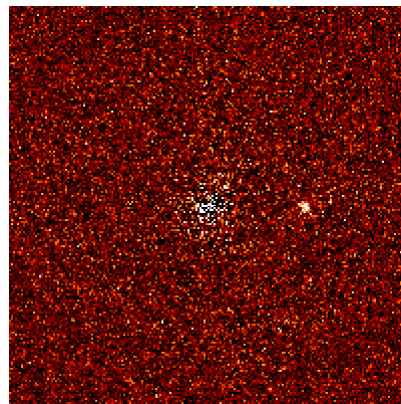
RESIDUALS FOR CONTRAST  $5 \cdot 10^{-6}$

60 mas



120 mas

180 mas

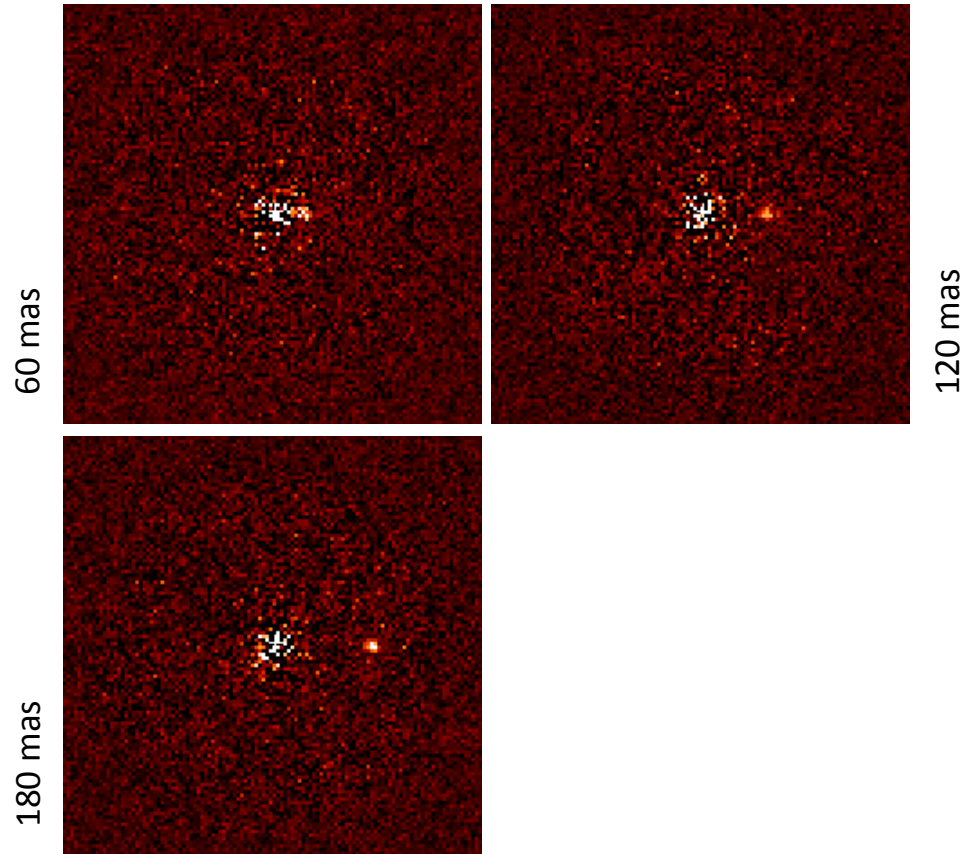


ADI for  $5 \cdot 10^{-5}$

# SHARK-VIS with Forerunner PSF on Gliese 777

- Forerunner PSF, from real data
- $R = 5.7$
- 2 hr exposure, 1 ms DIT
- Dichroic 80/20
- $Q_{\text{eff}} 80\%$
- $\lambda 630 \text{ nm}, \Delta\lambda 200 \text{ nm}$

RESIDUAL FOR CONTRAST  $5 \cdot 10^{-7}$

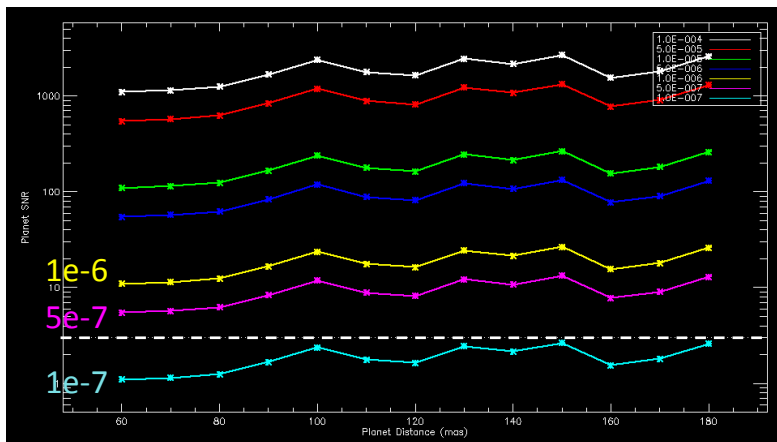


# SHARK-VIS with Forerunner PSF on Gliese 777

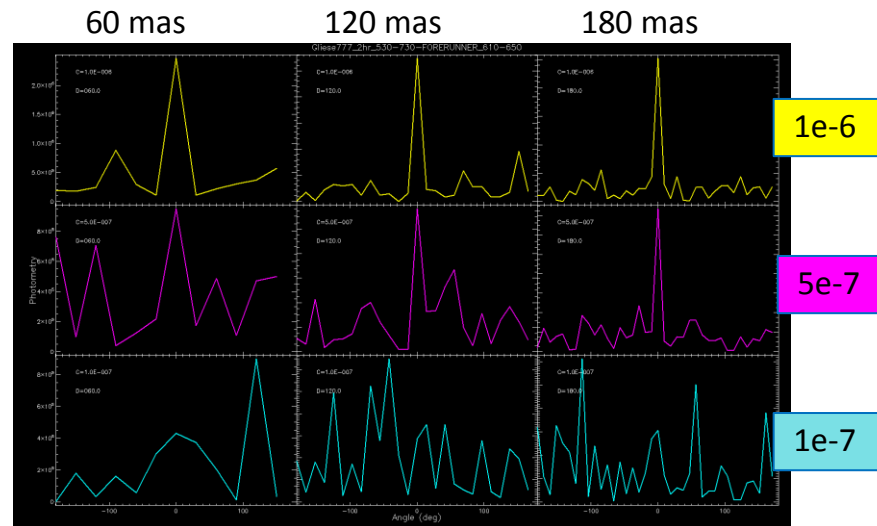


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## SNR VS SEPARATION



## SIGNAL VS ANGLE



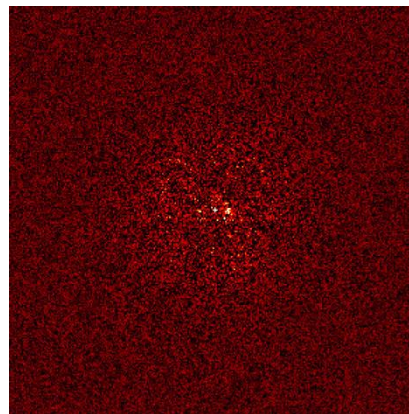
# SHARK-VIS Lyot coro on LAL 21185

- Occulter 30,60 $\mu$ m, Seeing 0.7''
- R = 7.5
- 3 hr exposure, 3 ms DIT
- Dichroic 80/20
- Qeff 80%
- $\lambda$  600 to 900 nm

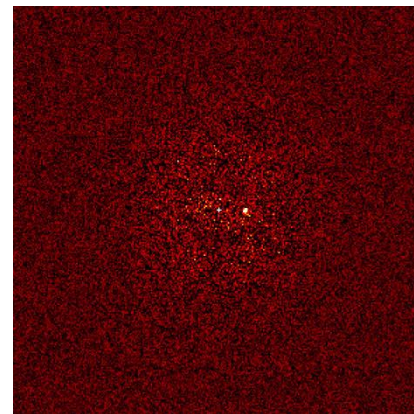
RESIDUAL FOR CONTRAST  $5 \cdot 10^{-7}$

**30 $\mu$ m  
mask  
(50 mas)**

60 mas

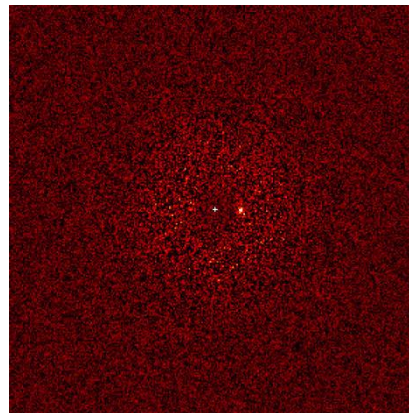


120 mas

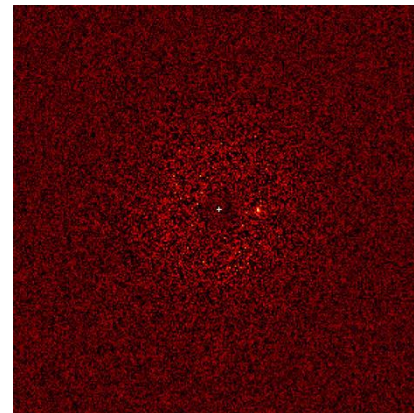


**60 $\mu$ m  
mask  
(100 mas)**

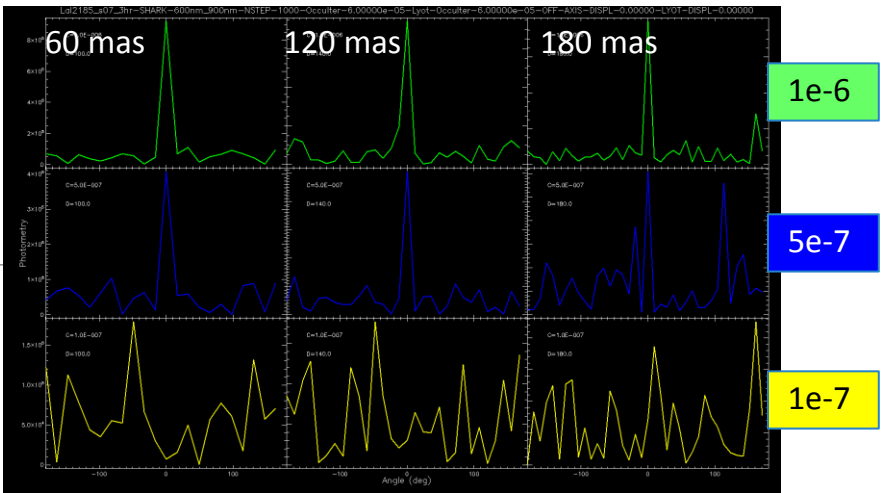
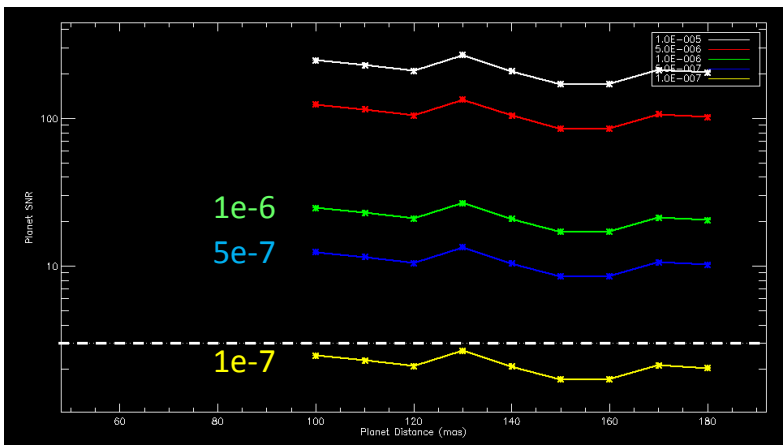
120 mas



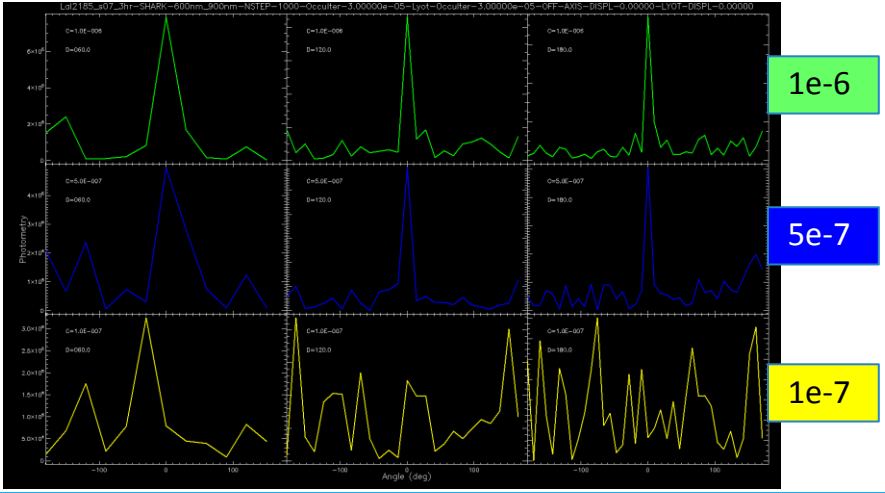
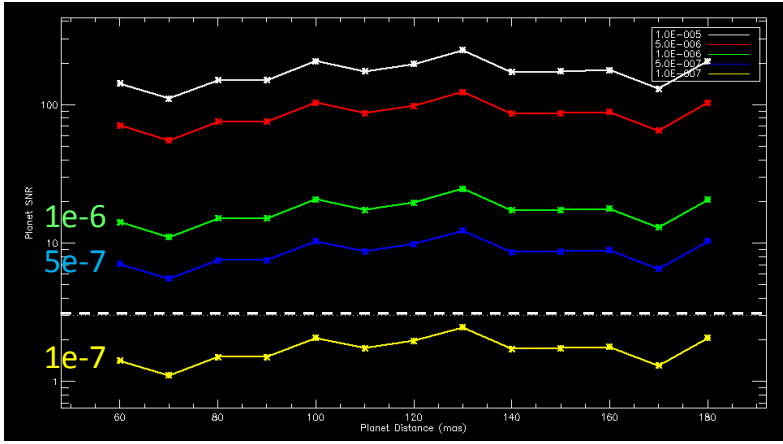
180 mas



60 $\mu$ m mask



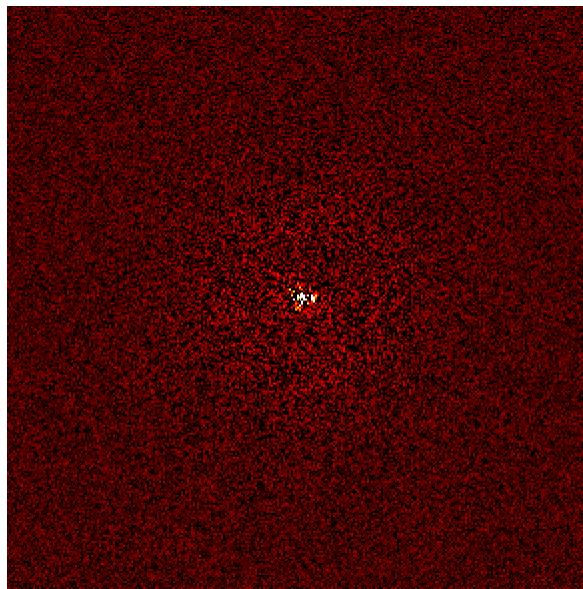
30 $\mu$ m mask



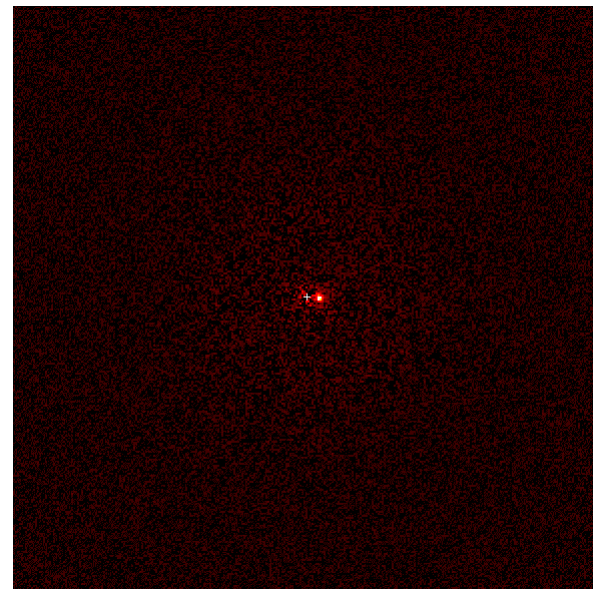
RESIDUAL FOR CONTRAST  $10^{-6}$  and  $5 \cdot 10^{-6}$

# SHARK-VIS no-coro on Proxima B

- Seeing  $0.7''$
- $R = 9.45$
- 3 hr exposure, 3 ms DIT
- Separations 38.83 mas
- Dichroic 80/20
- $Q_{\text{eff}} 80\%$
- $\lambda$  600 to 900 nm



$10^{-6}$

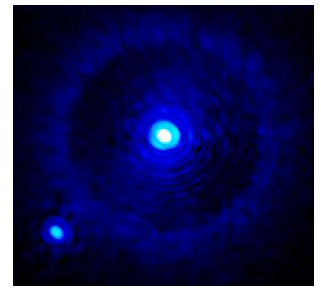
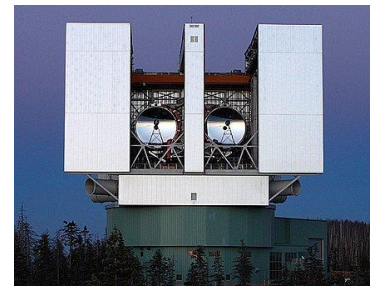


$5 \cdot 10^{-6}$



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# Grazie

