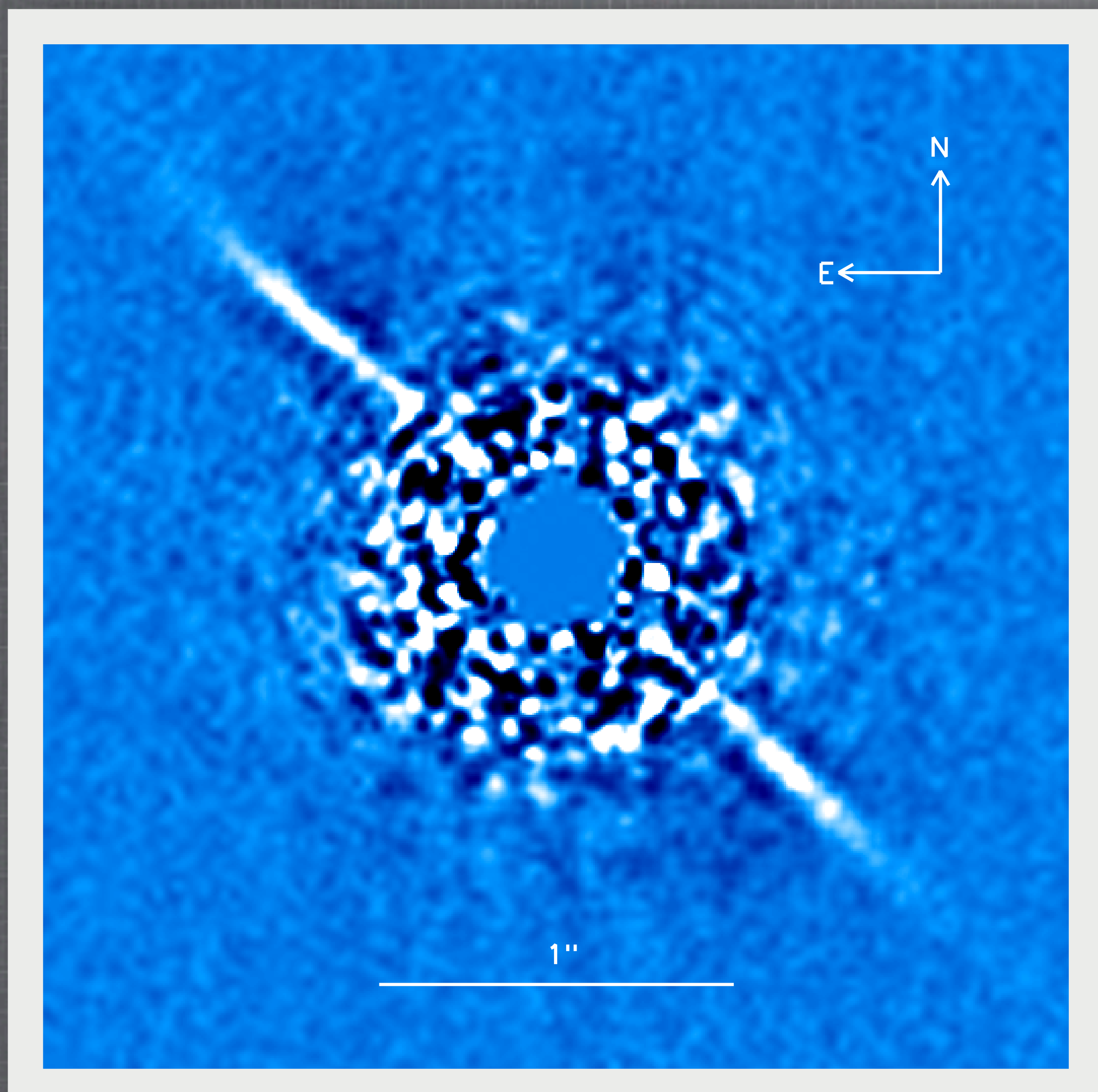
IMAGING AND STRUCTURE MODELING OF HD 32297



Anthony Boccaletti
Paris Observatory -France

Jean-Charles Augereau (IPAG - France)
Anne-Marie Lagrange (IPAG - France)
Julien Milli (IPAG - France)
Pierre Baudoz (Paris Observatory - France)
Dimitri Mawet (ESO - Chile)
David Mouillet (IPAG - France)
Jeremy Lebreton (IPAG - France)
Anne-Lise Maire (Paris Observatory - France)

THE DEBRIS DISK AROUND HD 32297

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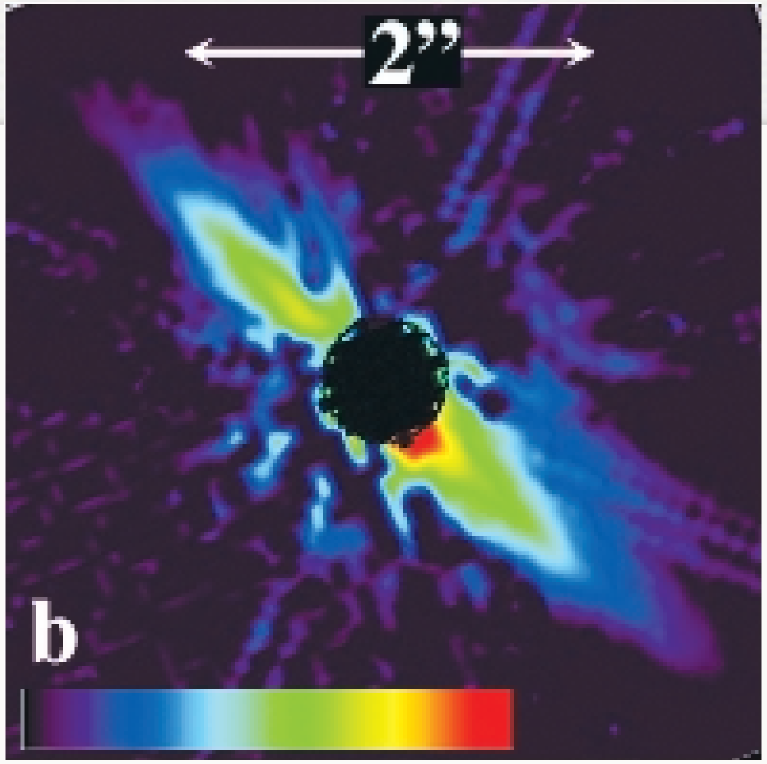
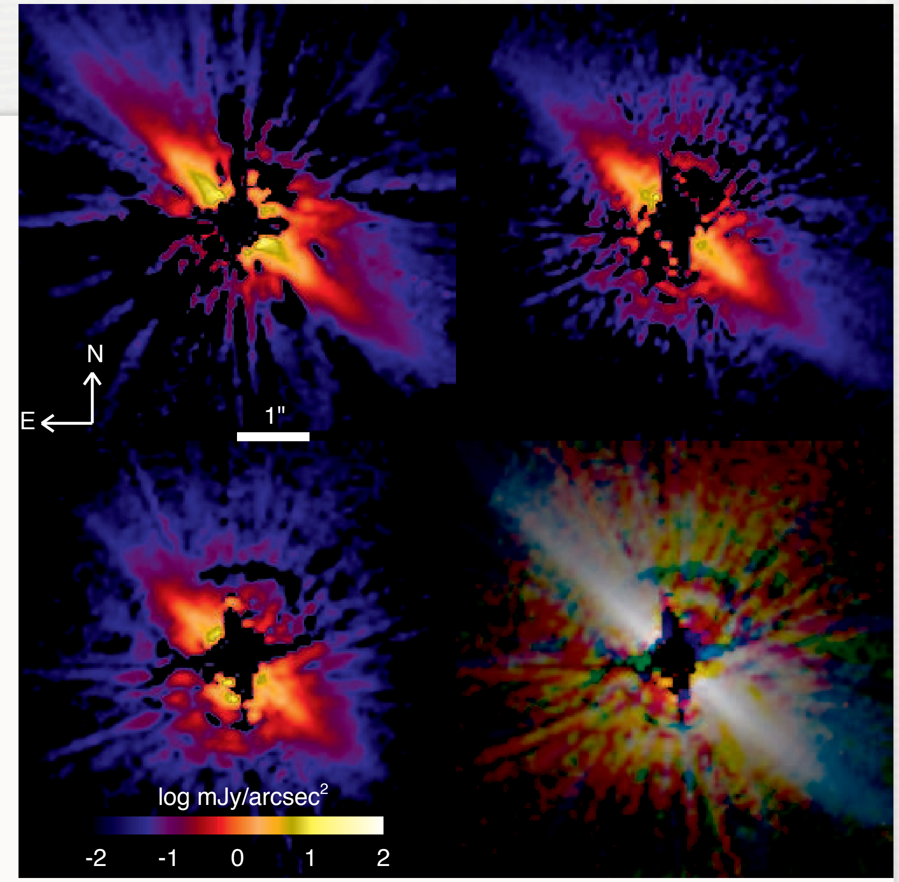


Schneider et al. 2005
- HST 1.1 μm discovery image
- inclination 77-82°
- interaction with ISM
- NE/SW brightness asymmetries



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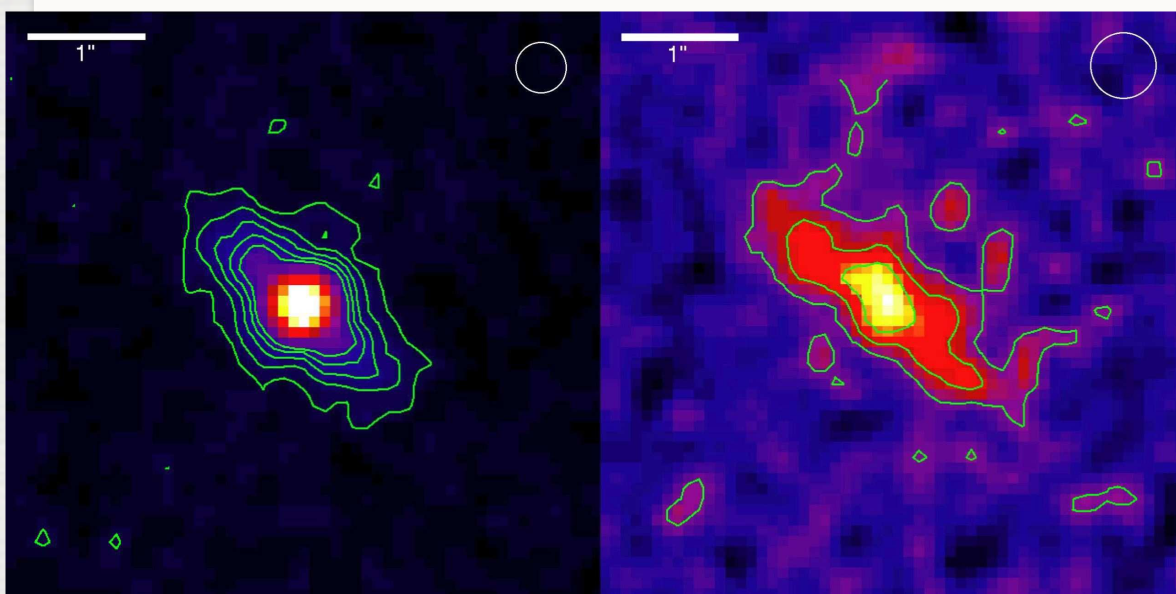
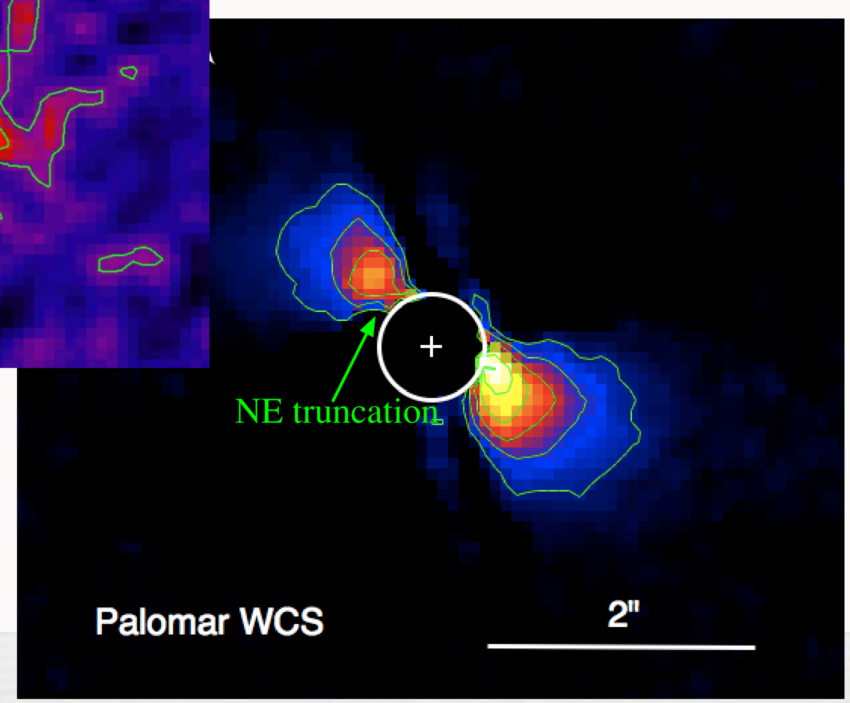


Moerchen et al. 2007
- T-ReCs 11.7 and 18.3 μm
- inner cavity < 70 AU



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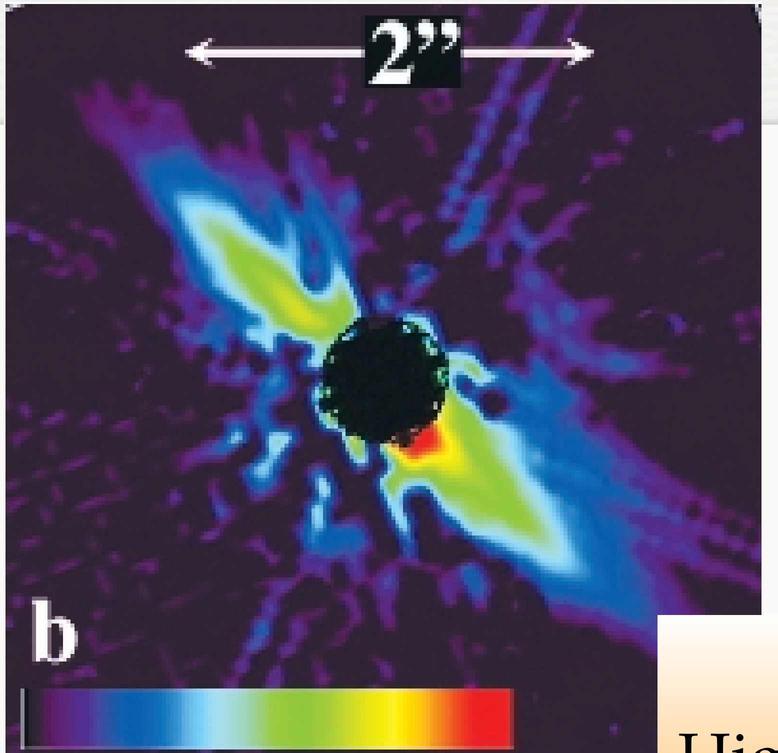
- NE/SW asymmetries

THE DEBRIS DISK AROUND HD 32297



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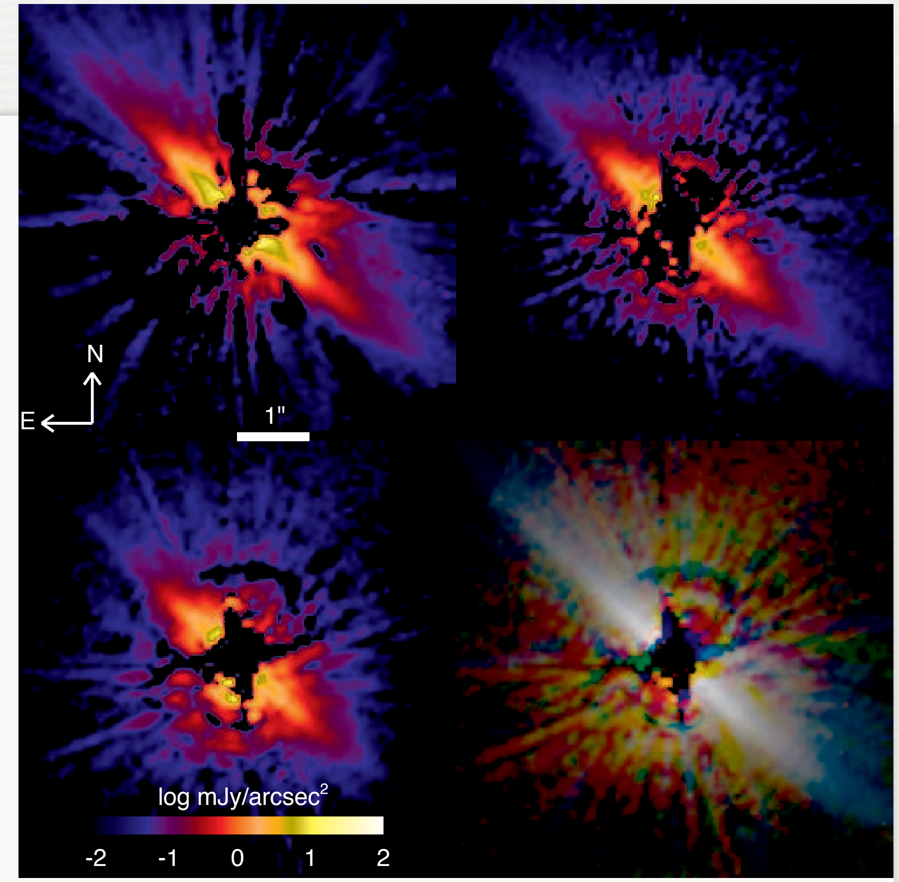
interest for :
Higher Angular Resolution
Higher Contrast



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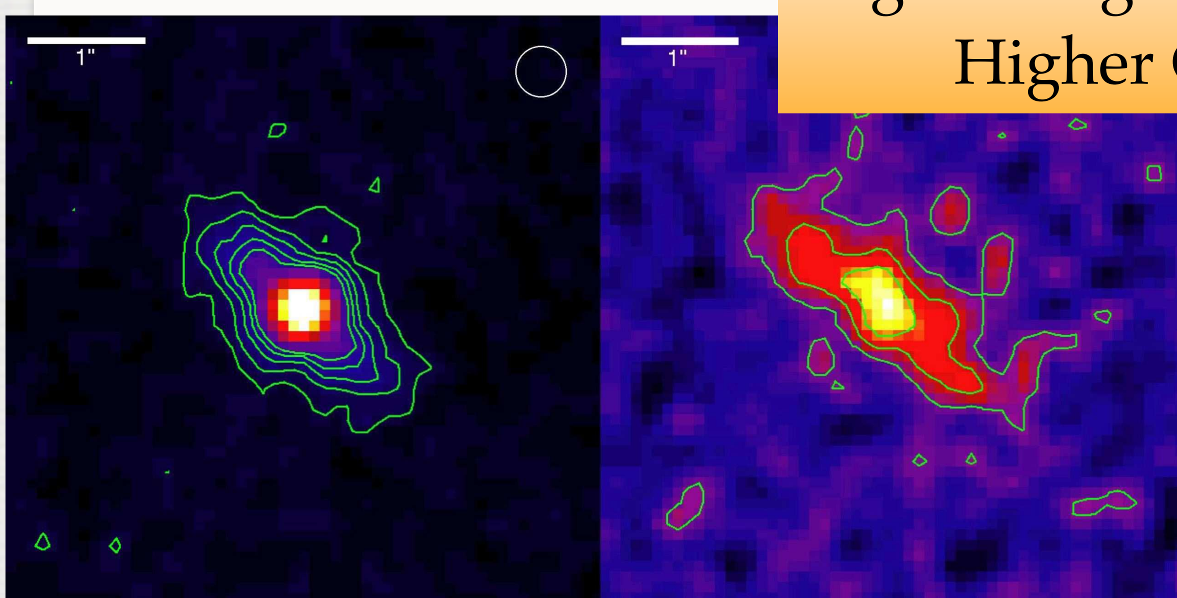

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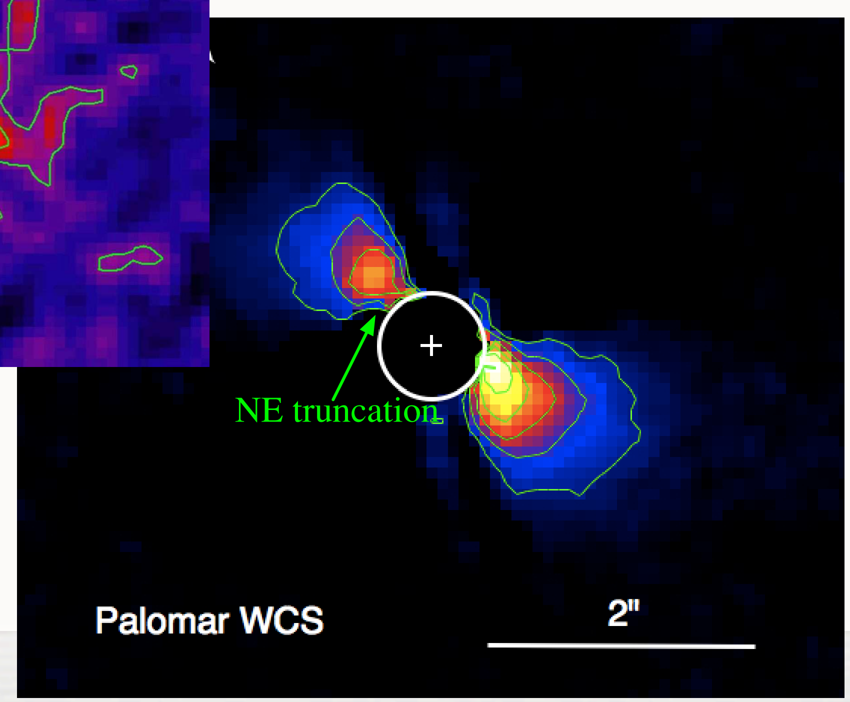

Mawet et al. 2009
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OBSERVING PROGRAM

- Program with NACO/VLT (385. 0476) to observe several known debris disks at high resolution/high contrast. Objectives were to:
  - probe the dust spatial distribution
  - study grain properties
  - search for signposts of planets
- Strategy:
  - coronagraph (4QPM) to attenuate the star
  - differential imaging to reduce the stellar pattern

ANGULAR DIFFERENTIAL IMAGING

Marois et al, 2008

Exploit the deterministic rotation of the field of view in Alt-Az telescope w.r.t the temporal evolution of stellar speckles

Several levels of ADI algorithms :

- cADI (Marois et al. 2006)
- rADI (Marois et al. 2006)
- LOCI (Lafrenière et al. 2007)

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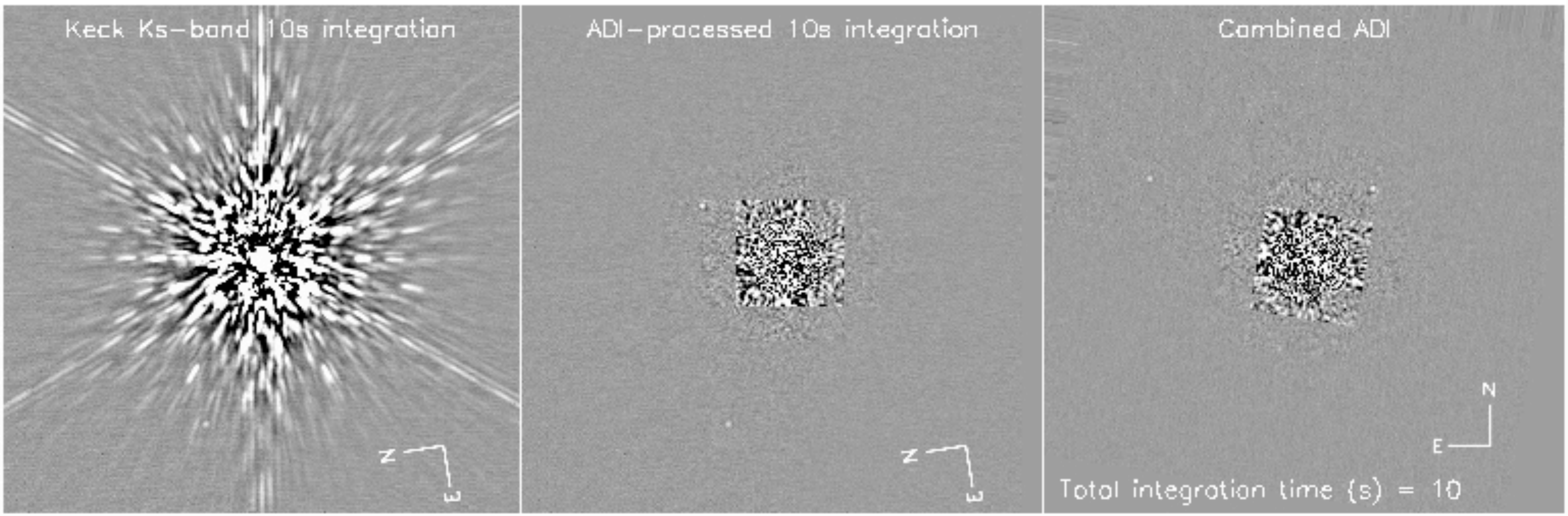

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ANGULAR DIFFERENTIAL IMAGING

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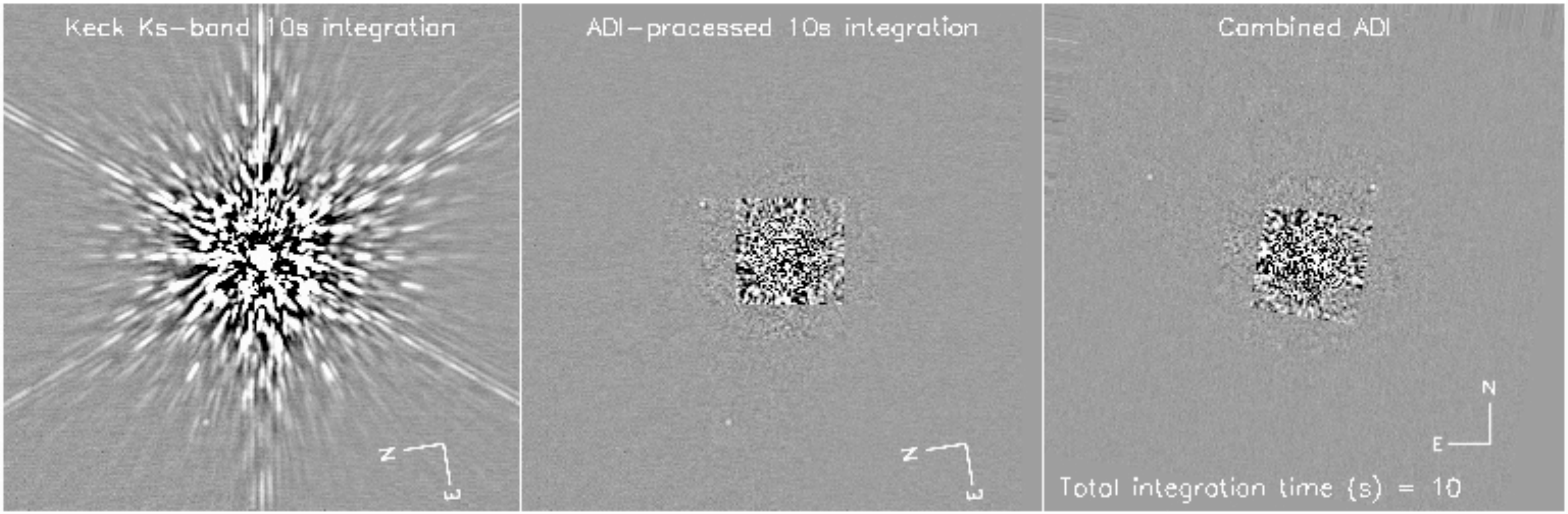

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ADI algorithms differ by the way to build a reference PSF

A TOOL FOR PLANET DETECTION ...

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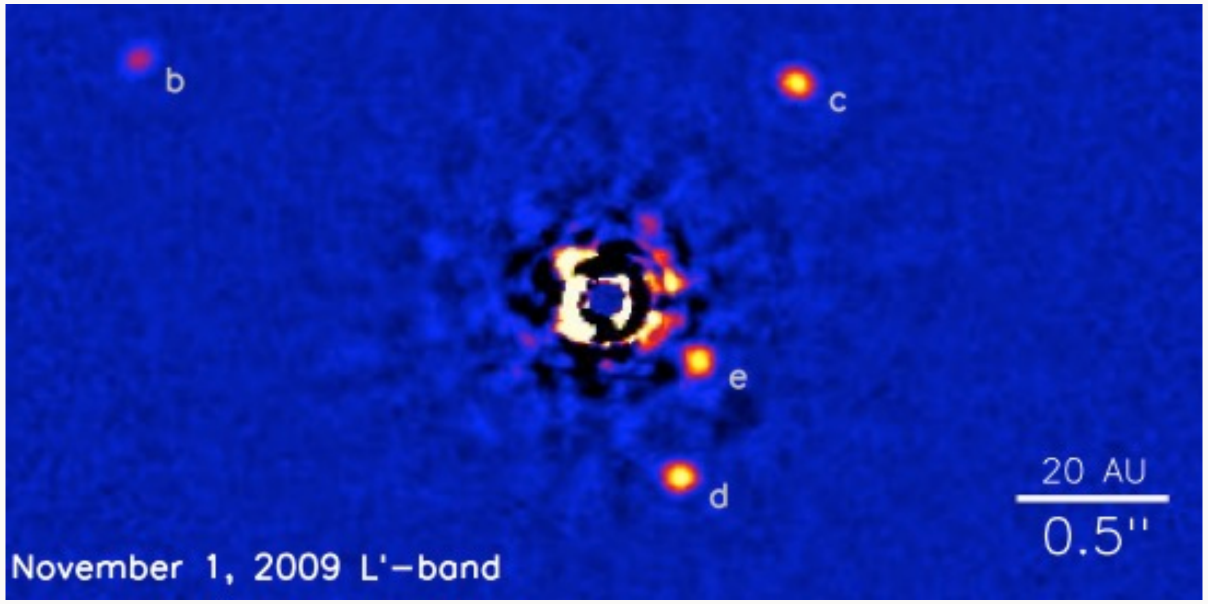
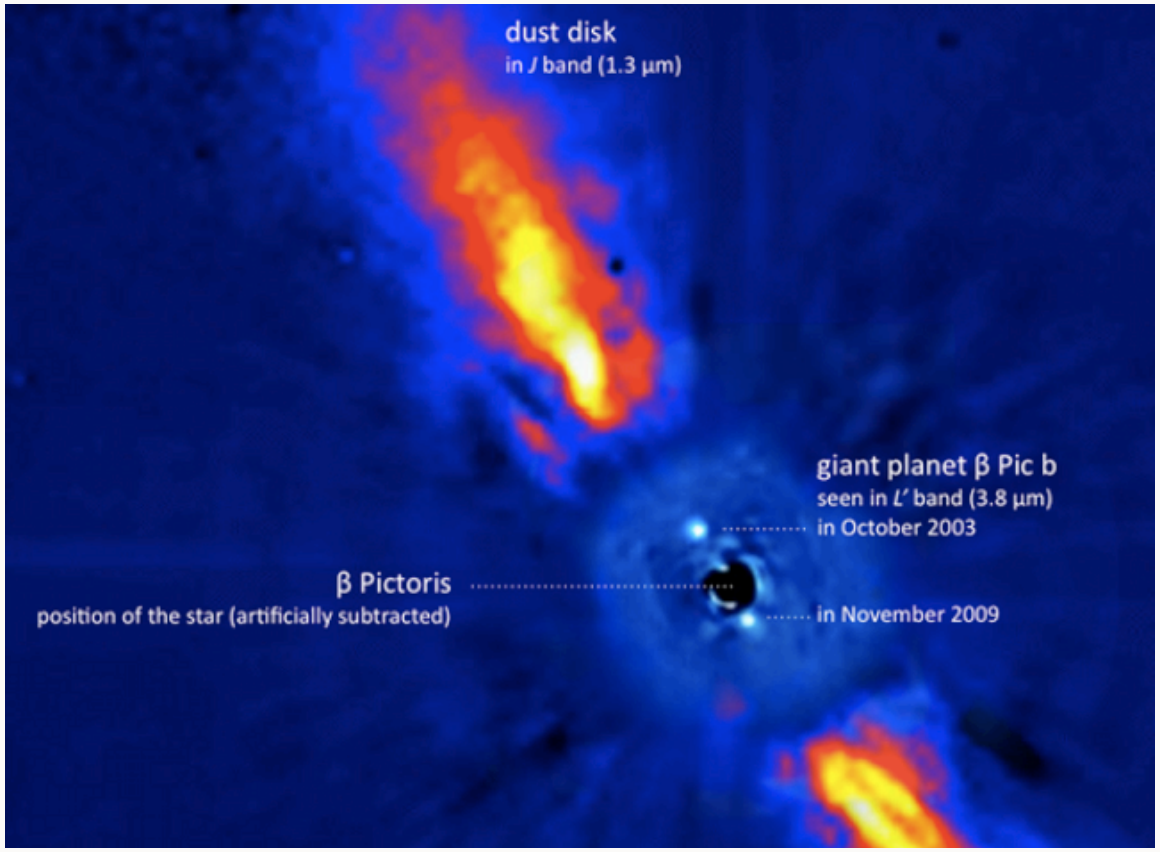
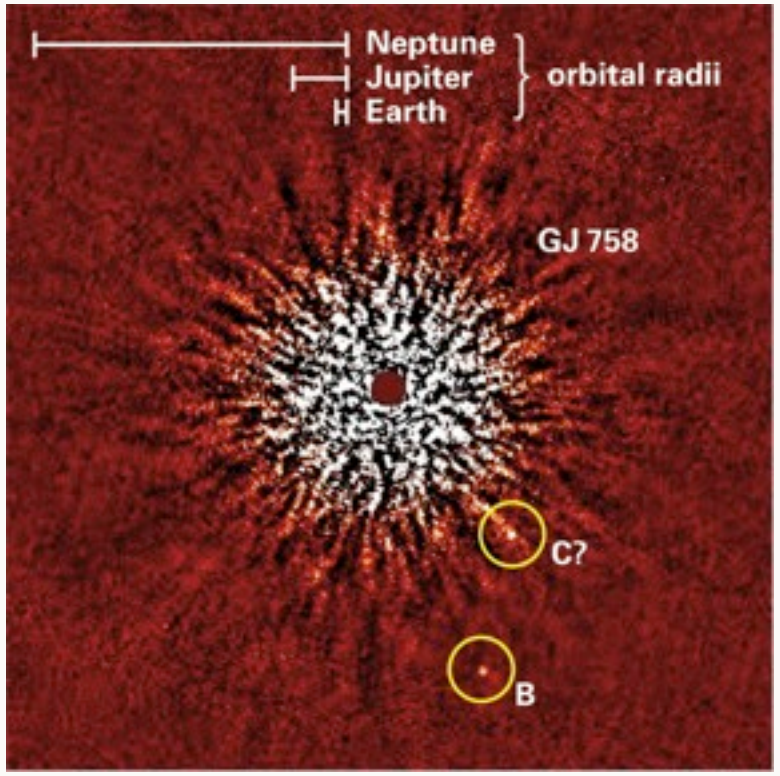
A TOOL FOR PLANET DETECTION ...



Marois et al, 2010



Lagrange et al, 2010



Thalmann et al, 2009

... BUT ALSO EXTENDED OBJECTS

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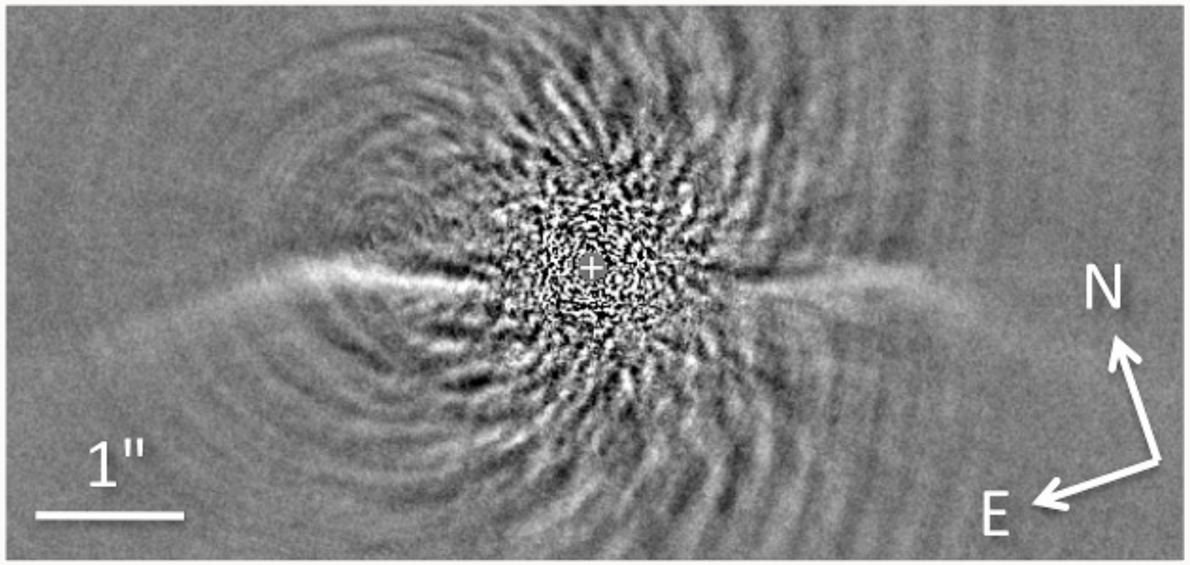
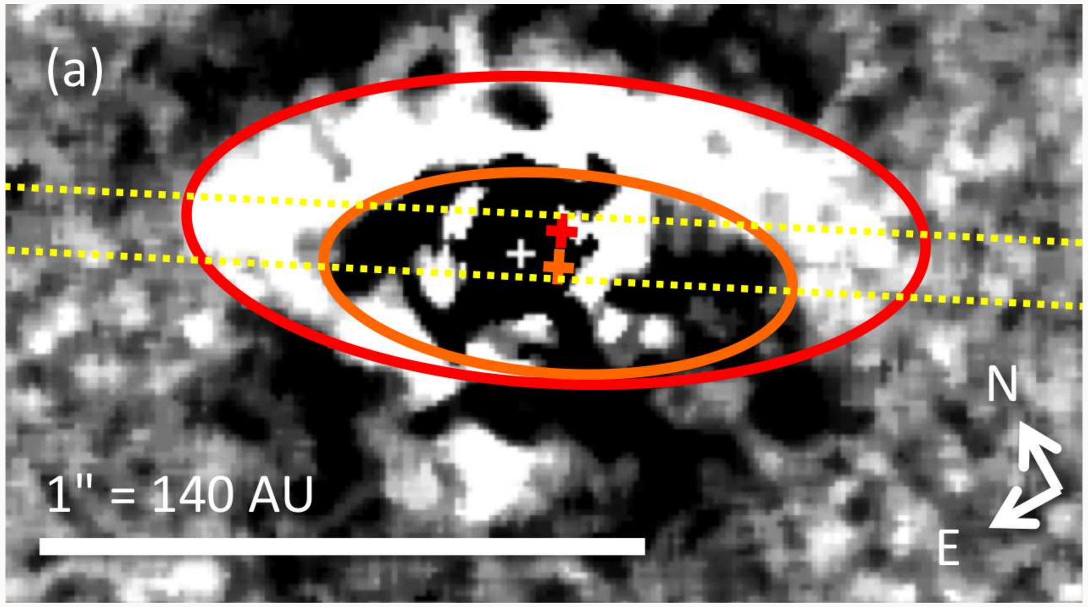


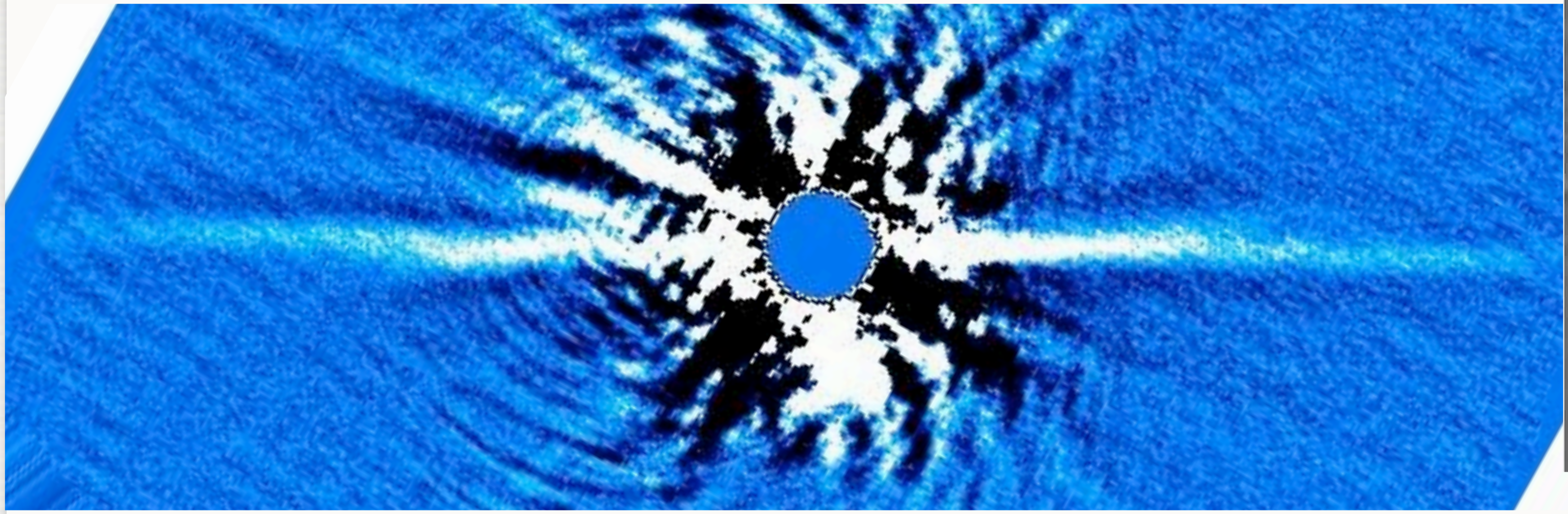
HD 61005 - Buenzli et al, 2010

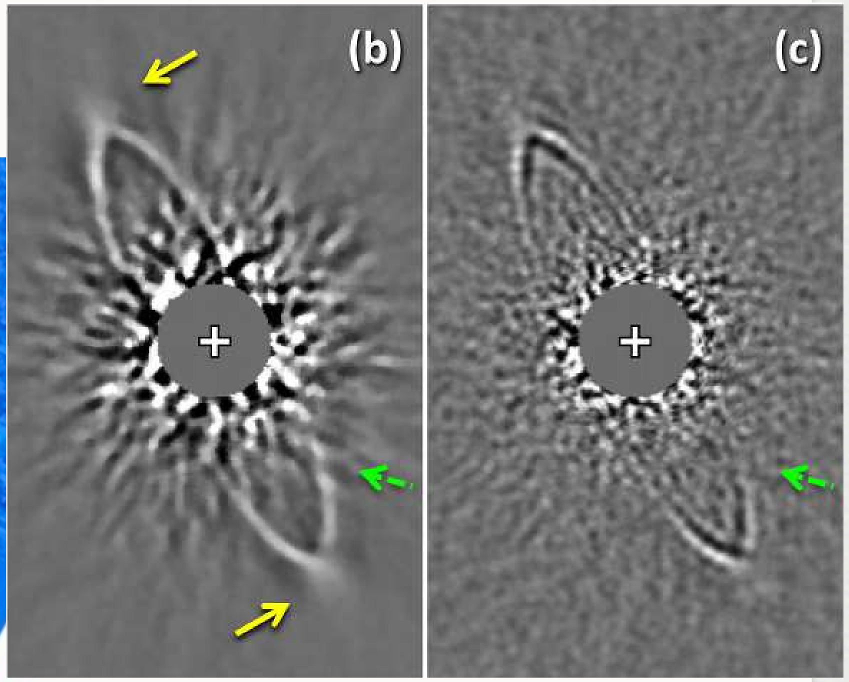
LkCa 15 - Thalmann et al, 2010



β Pic - Lagrange et al, 2012

see talk by A.M Lagrange on tuesday





HR 4796 - Thalmann et al, 2011

POTENTIAL BIASES

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starting with a simple (unrealistic !!!) disk shape

ADI can produce ...

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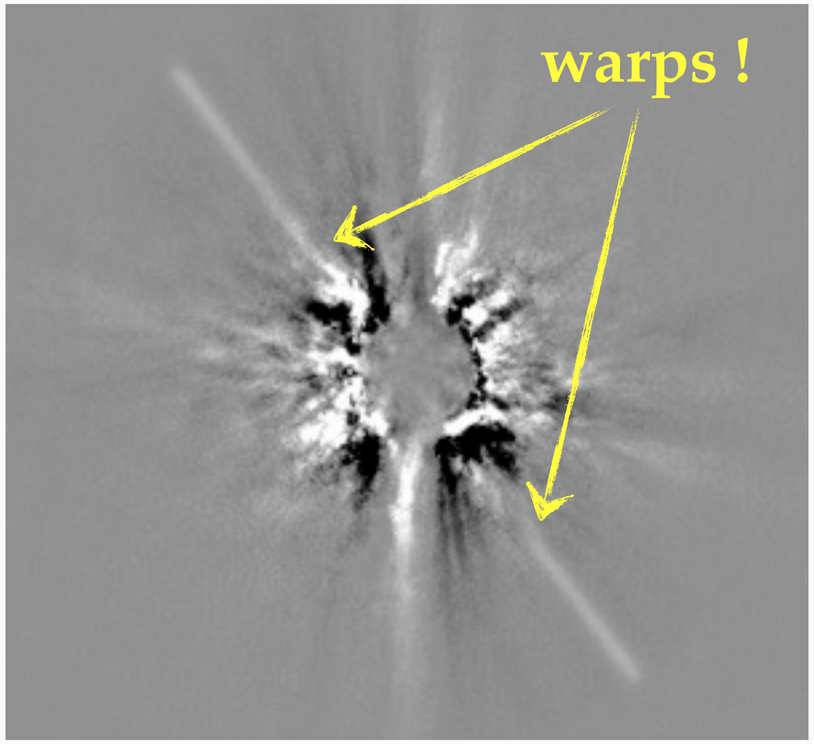

POTENTIAL BIASES

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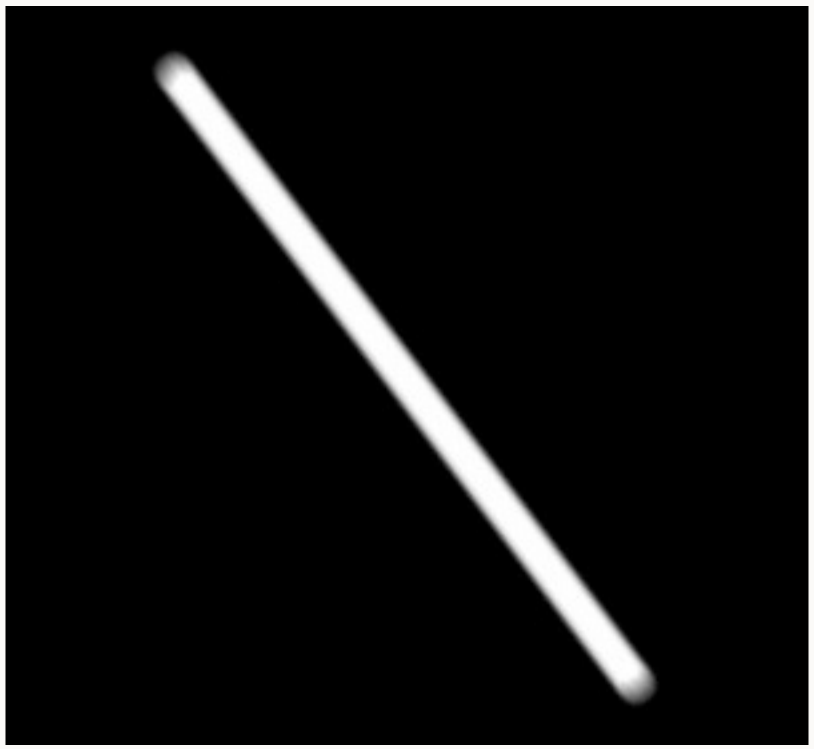

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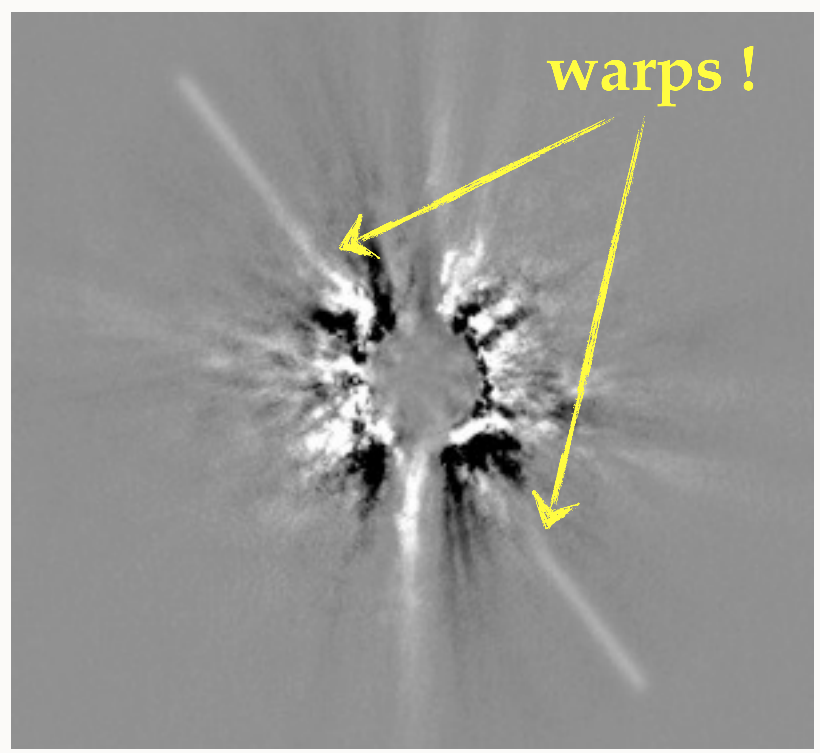

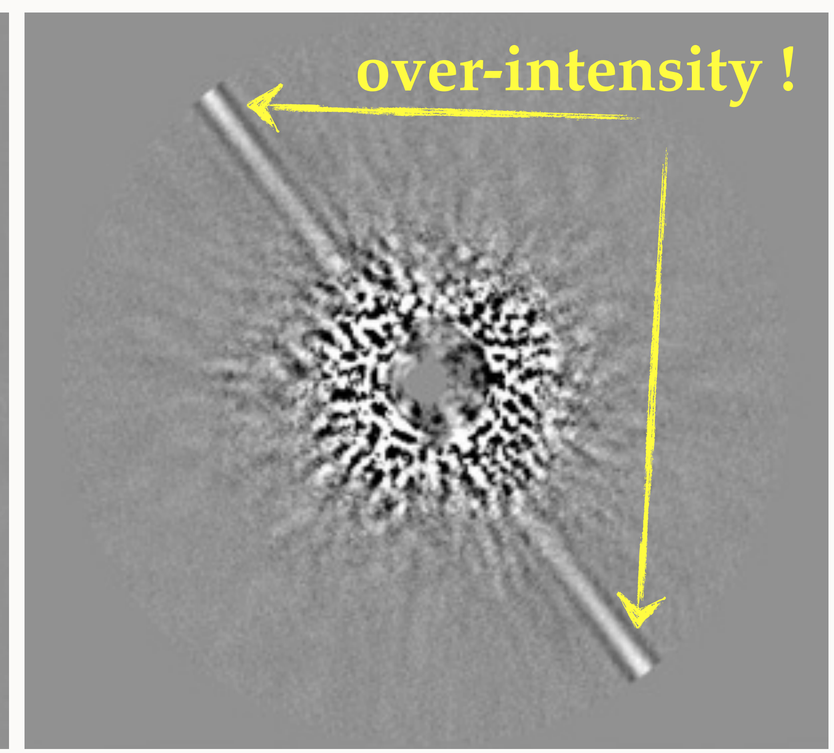

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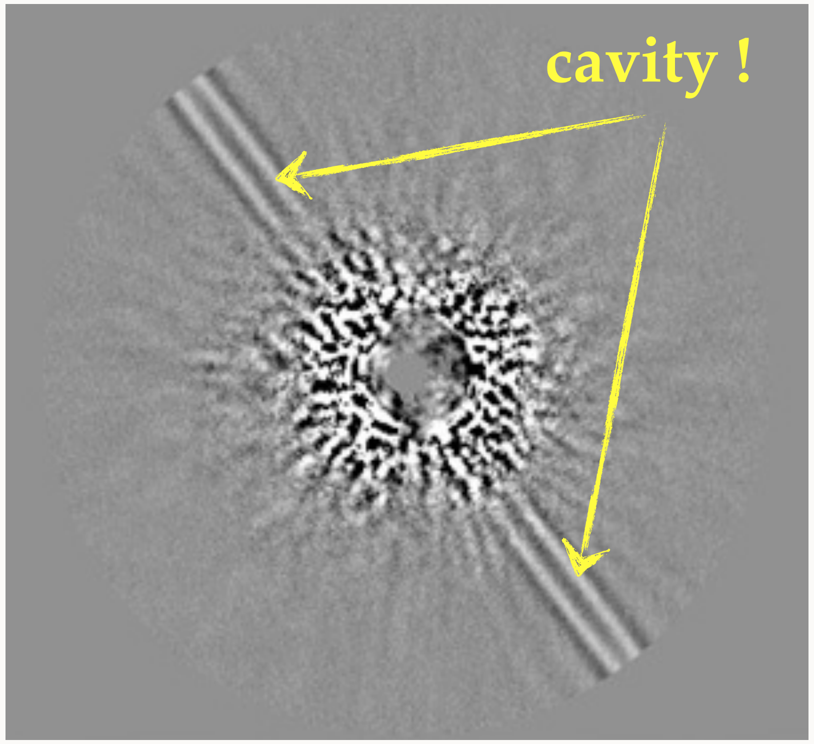
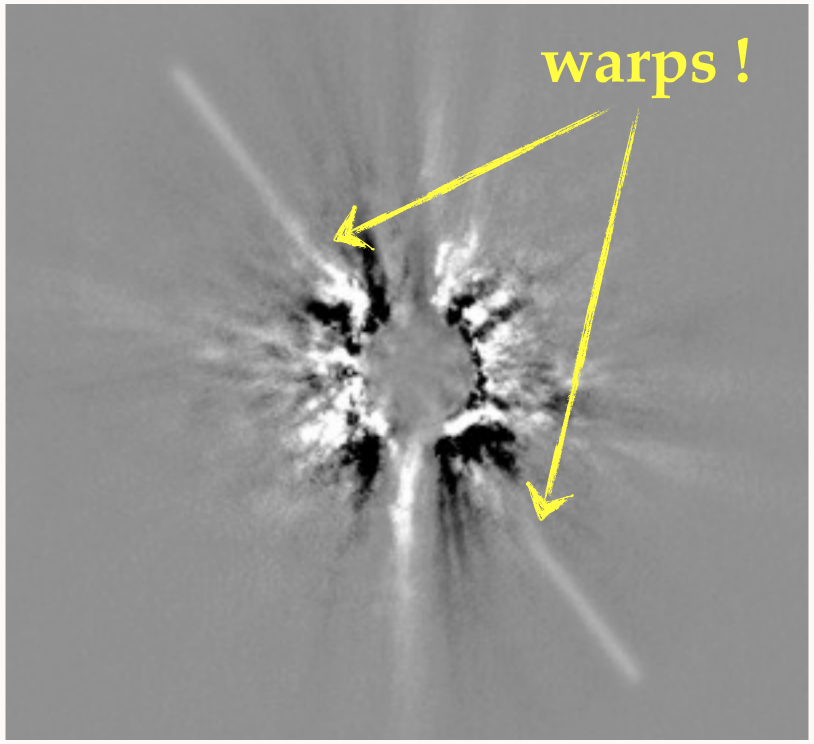
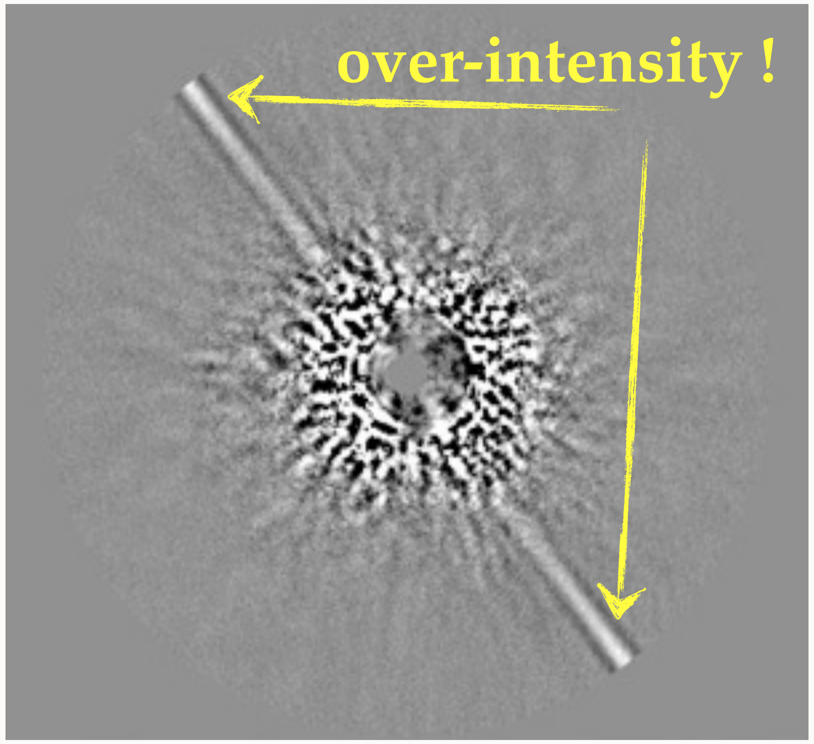


Self subtraction of the disk
=> impacts in terms of morphology and photometry
=> need a method to account for the biases





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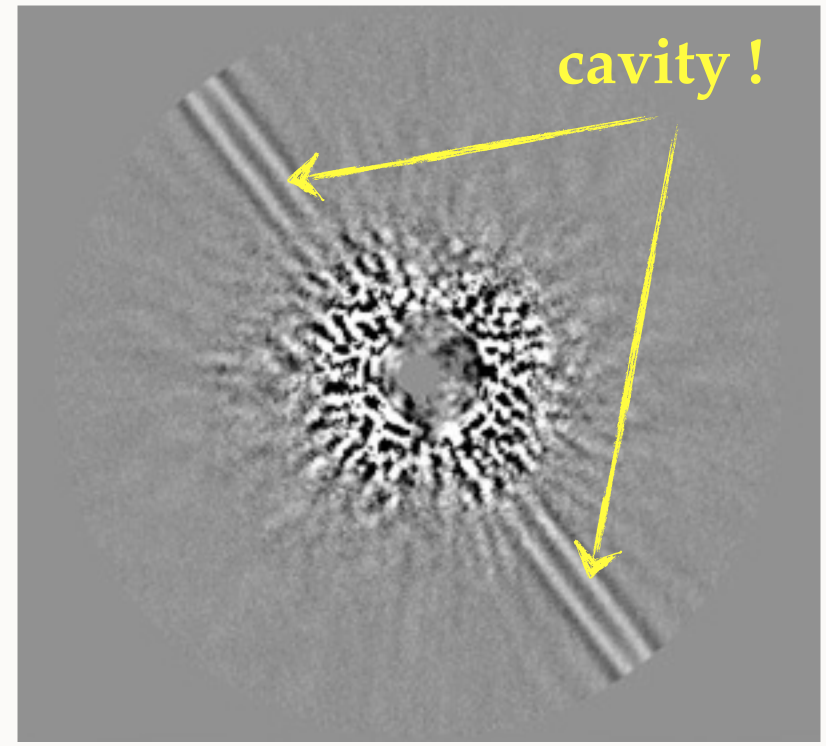

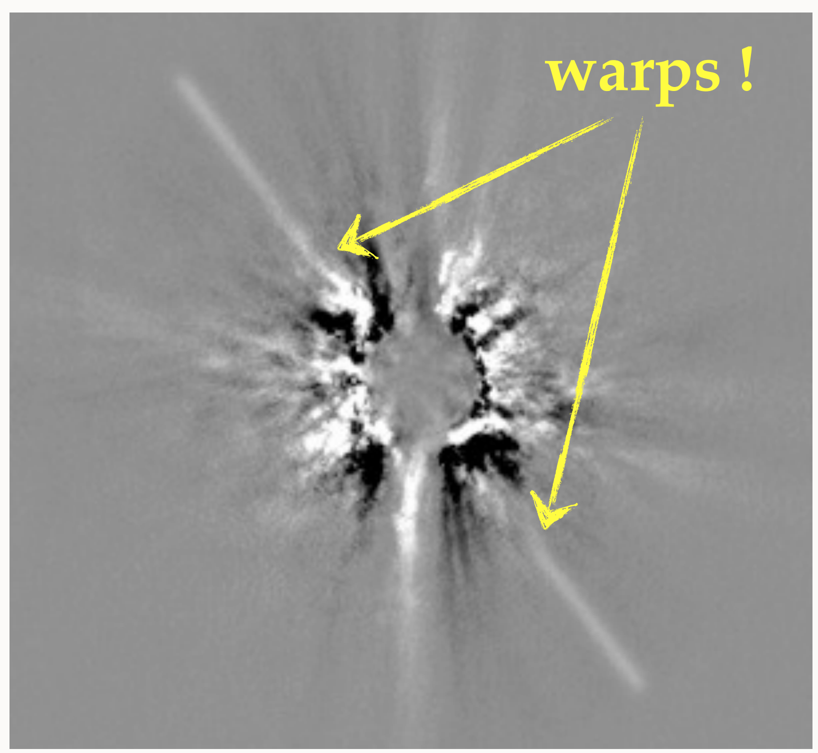

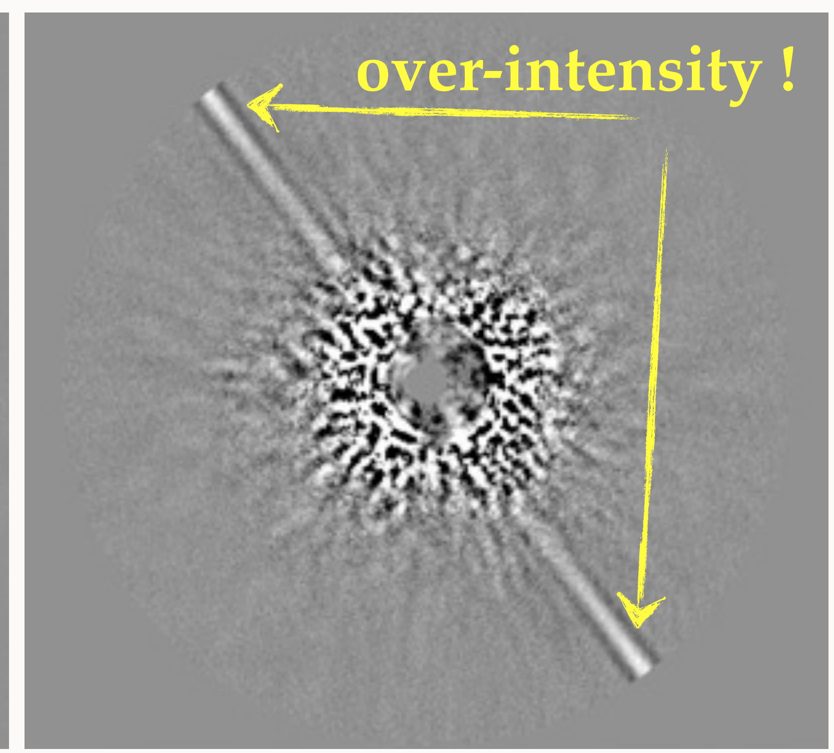

Self subtraction of the disk
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see the talk by:
Julien Milli
on thursday for a detailed analysis

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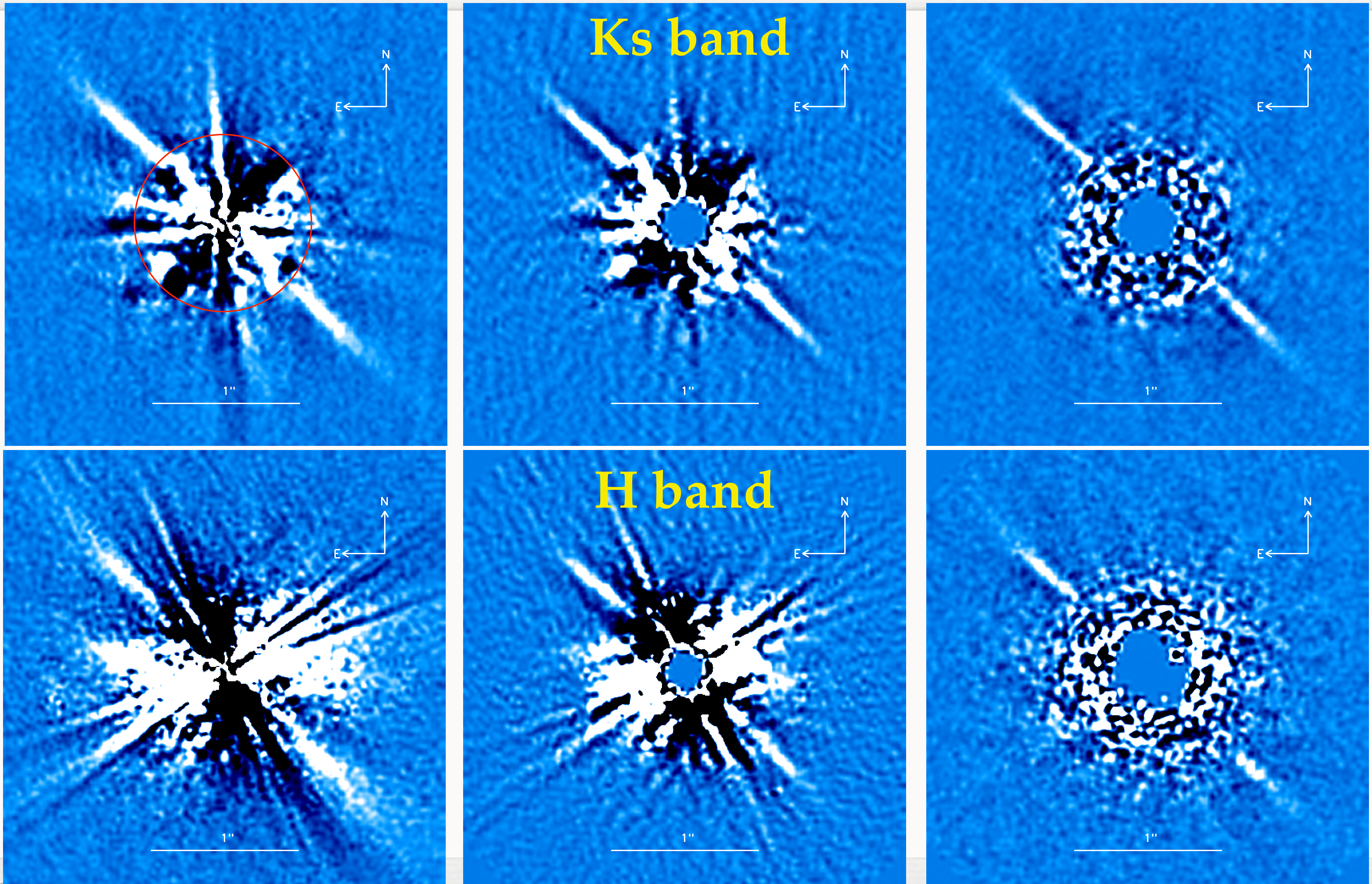
IMAGES OF HD 32297 WITH NACO/VLT

cADI | rADI | LOCI



DEVIATION TO THE MIDPLANE

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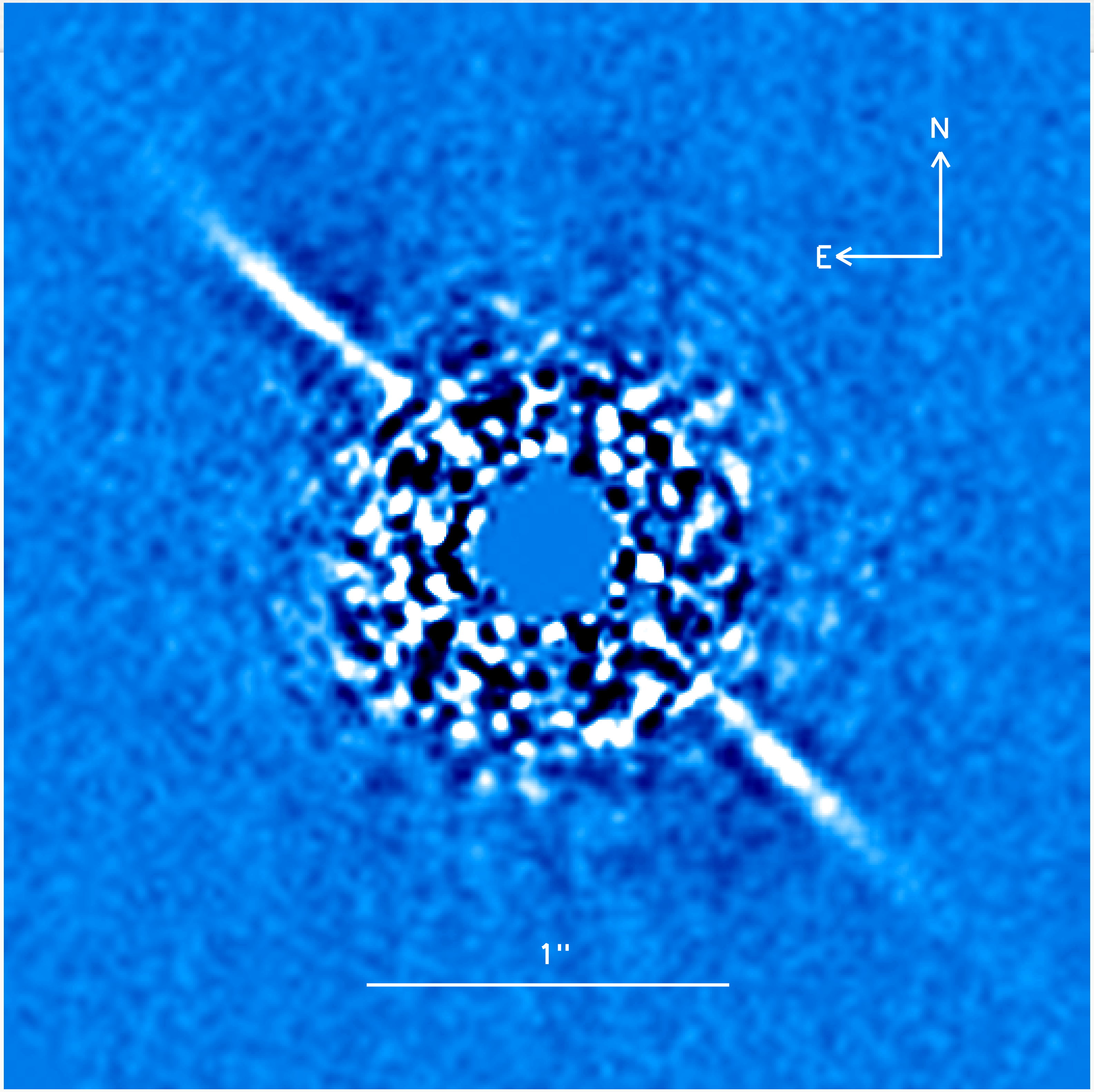

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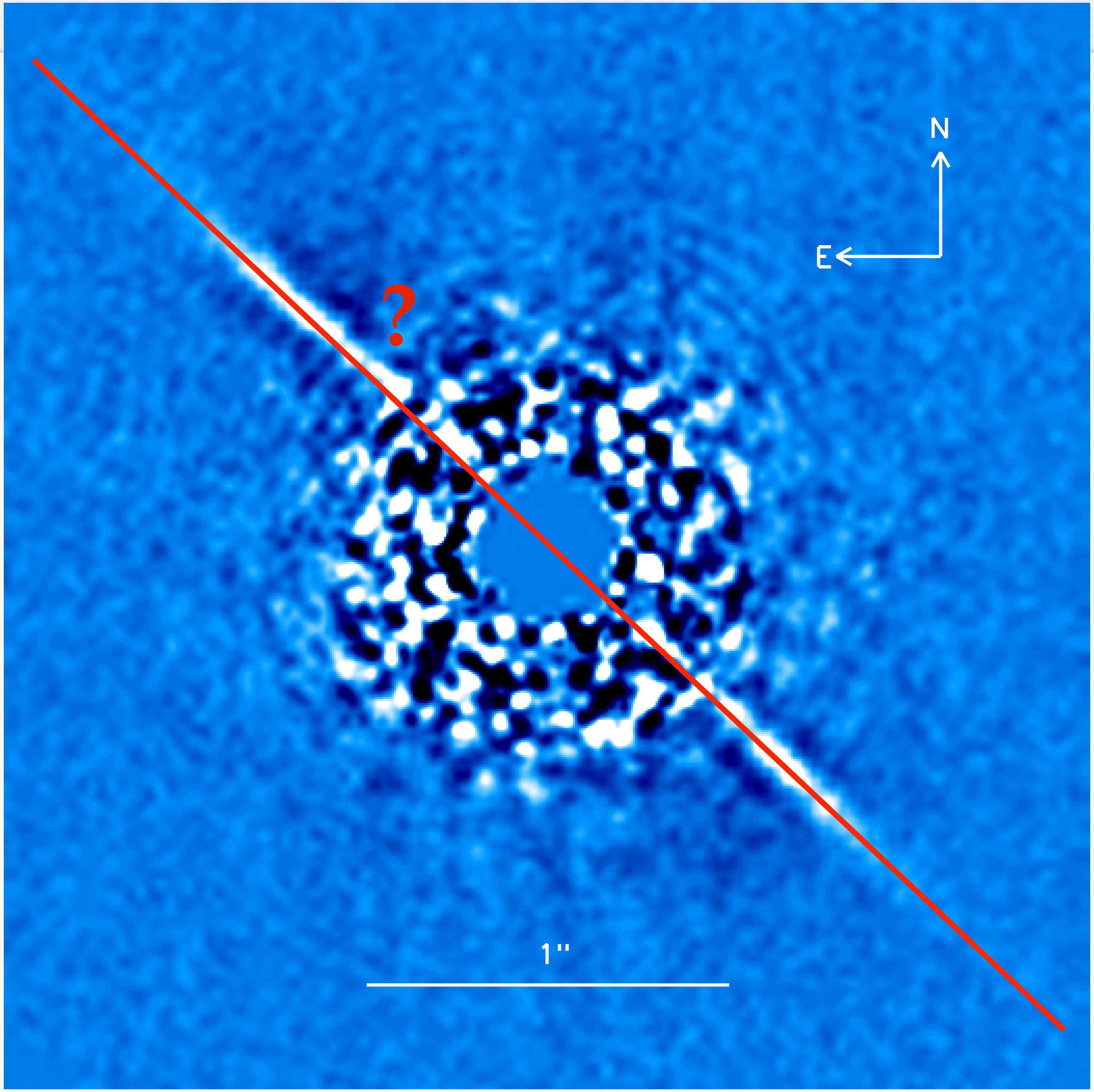


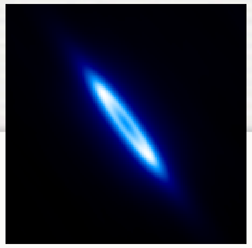
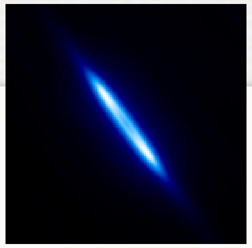
Bias or Real ?

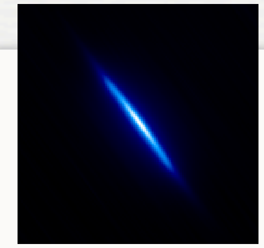
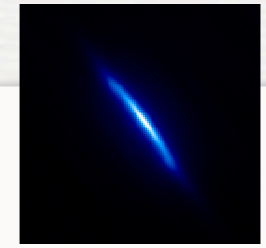
Warp ?

MODELING DEBRIS DISKS

- Model **GRaTer** of debris disks described in Augereau et al.
- assume that the disk has a inner cavity
- fake disks injected in the data cube (90° from the true disk)
- we generated models with 5 parameters
  - inclination (i): 82, 85, 88, 89.5°
  - peak intensity position of the disk (r_0): 80, 90, 100, 110 AU
  - power law index of the outer surface density(α_{out}): -4, -5, -6
  - power law index of the inner surface density (α_{in}): 2, 5, 10
  - anisotropic scattering factor (g): 0, 0.25, 0.50, 0.75
- 3456 prescriptions (5 parameters, 2 filters, 3 algorithms)

MODELING DEBRIS DISKS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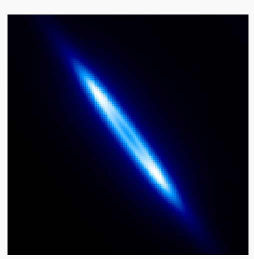
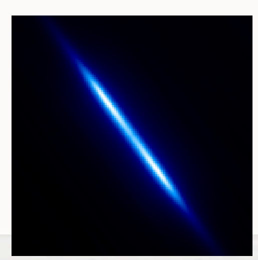
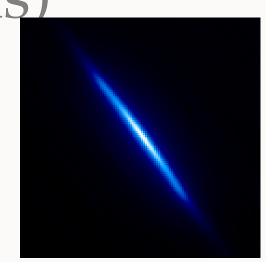


DEVIATION TO THE MIDPLANE

The spine is measured by fitting the vertical profile of the disk vs. radius and compared to fake disk

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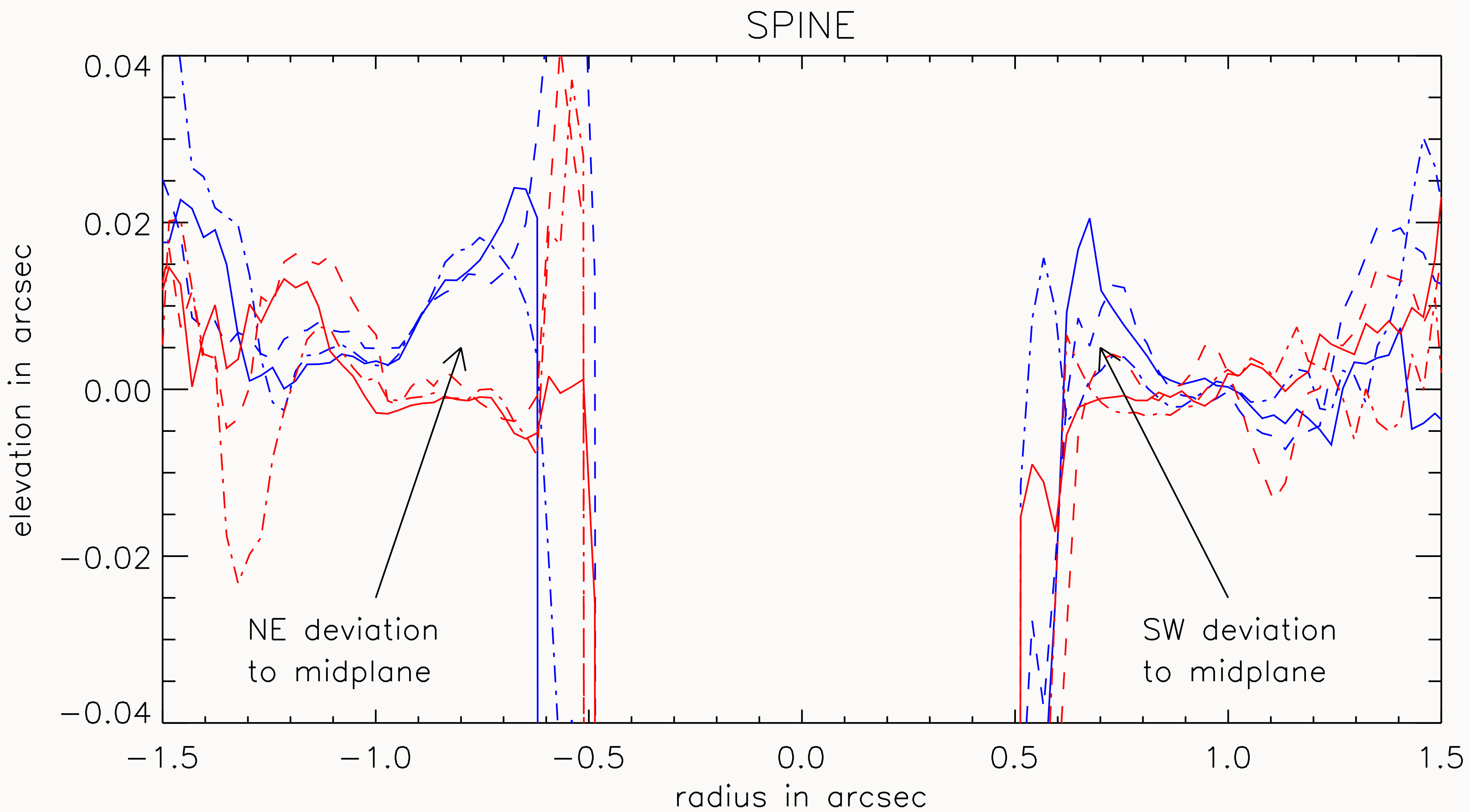

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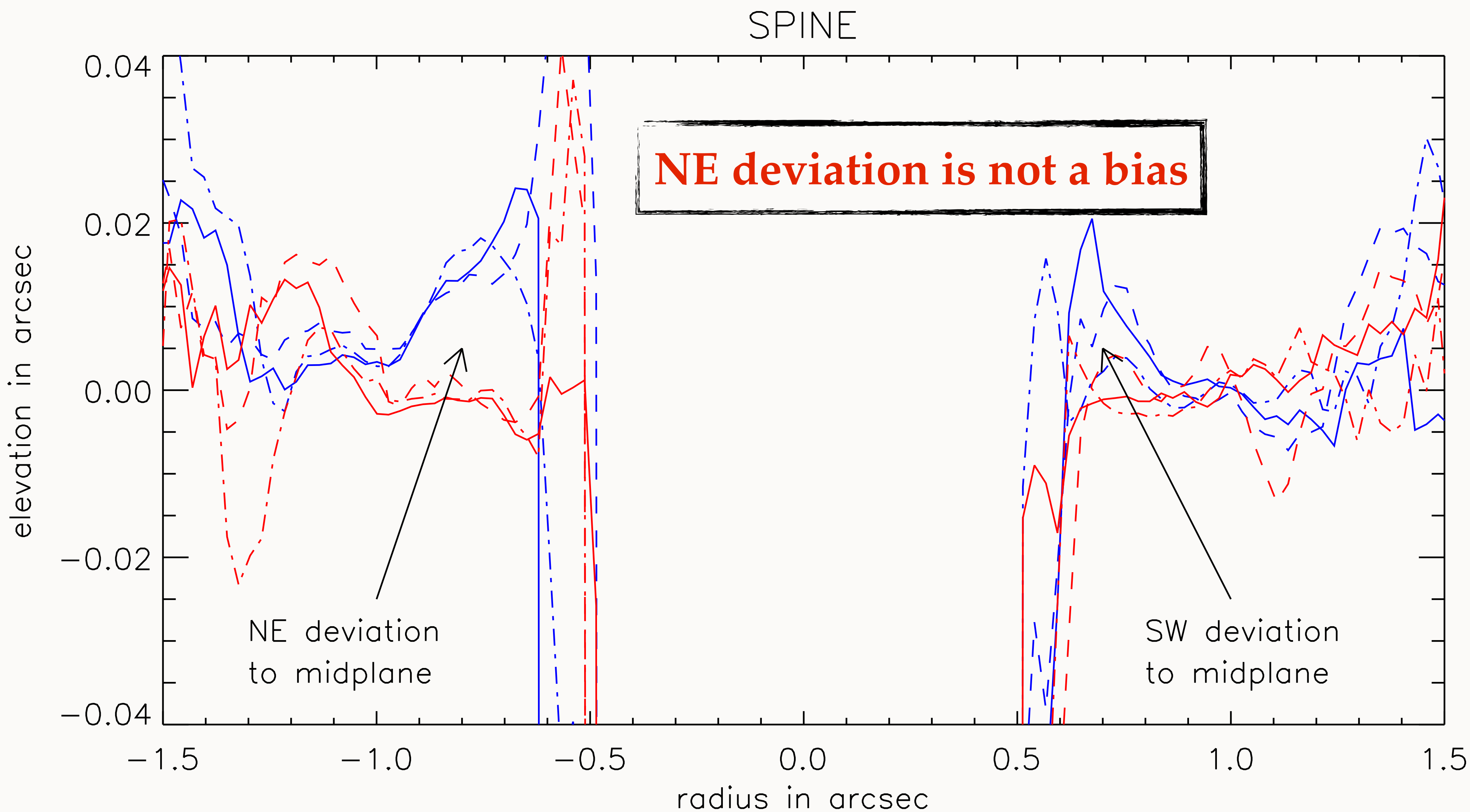

MINIMIZATIONS RESULTS

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filter	i (°)	α_{out}	α_{in}	r_0 (AU)	g
H	88 (0.50)	-6 (0.40)	10 (0.50)	110 (0.57)	0.5 (0.50)
Ks	88 (0.90)	-5 (0.57)	5 (0.37)	110 (0.97)	0.5 (0.53)

Global (pixel-to-pixel) :
- good minimization but no NE/SW information

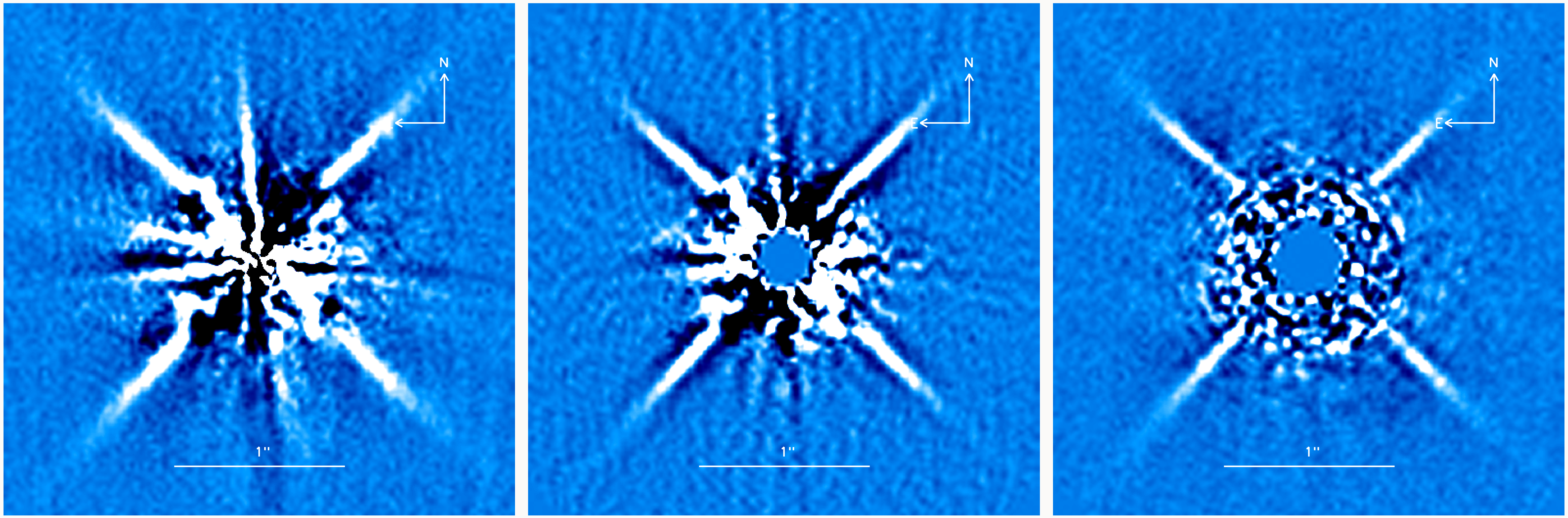
filter	area	α_{out}	α_{in}	r_0 (AU)	g
H	NE in	-	10 (0.47)	110 (0.67)	0.25 (0.50)
	SW in	-	10 (0.63)	110 (0.63)	0.25 (0.47)
	NE out	-4 (0.47)	-	110 (0.60)	0.75 (0.60)
	SW out	-4 (0.53)	-	100 (0.50)	0.00 (0.33)
Ks	NE in	-	5 (0.43)	100 (0.37)	0.50 (0.30)
	SW in	-	2 (0.47)	90 (0.47)	0.50 (0.53)
	NE out	-6 (0.70)	-	110 (0.30)	0.75 (0.70)
	SW out	-5 (0.40)	-	100 (0.40)	0.00 (0.33)

Surface brightness (indices):
- g, α_{in} not well constrained
- confirm value of r0

filter	area	α_{out}	α_{in}	r_0 (AU)	g
H	NE	- 4, -5, -6 (0,33)	10 (0,53)	110 (0,67)	0.5 (0,50)
	SW	- 6 (0,73)	5 (0,37)	80 (0,43)	0.75 (0,70)
Ks	NE	- 4, -5, -6 (0,33)	5 (0,40)	110 (0,30)	0.25 (0,47)
	SW	- 4 (0,57)	2 (0,53)	90 (0,37)	0.25 (0,67)

Spine :
- not relevant for α_{in} and α_{out}
- asymmetry for r_0

BEST MODELS



$i = 88°$: more inclined than Schneider et al. 2005, role of ISM interaction in HST images

$r_0 = 110$ AU : compatible with Debes et al. 2009 and possibly asymmetrical

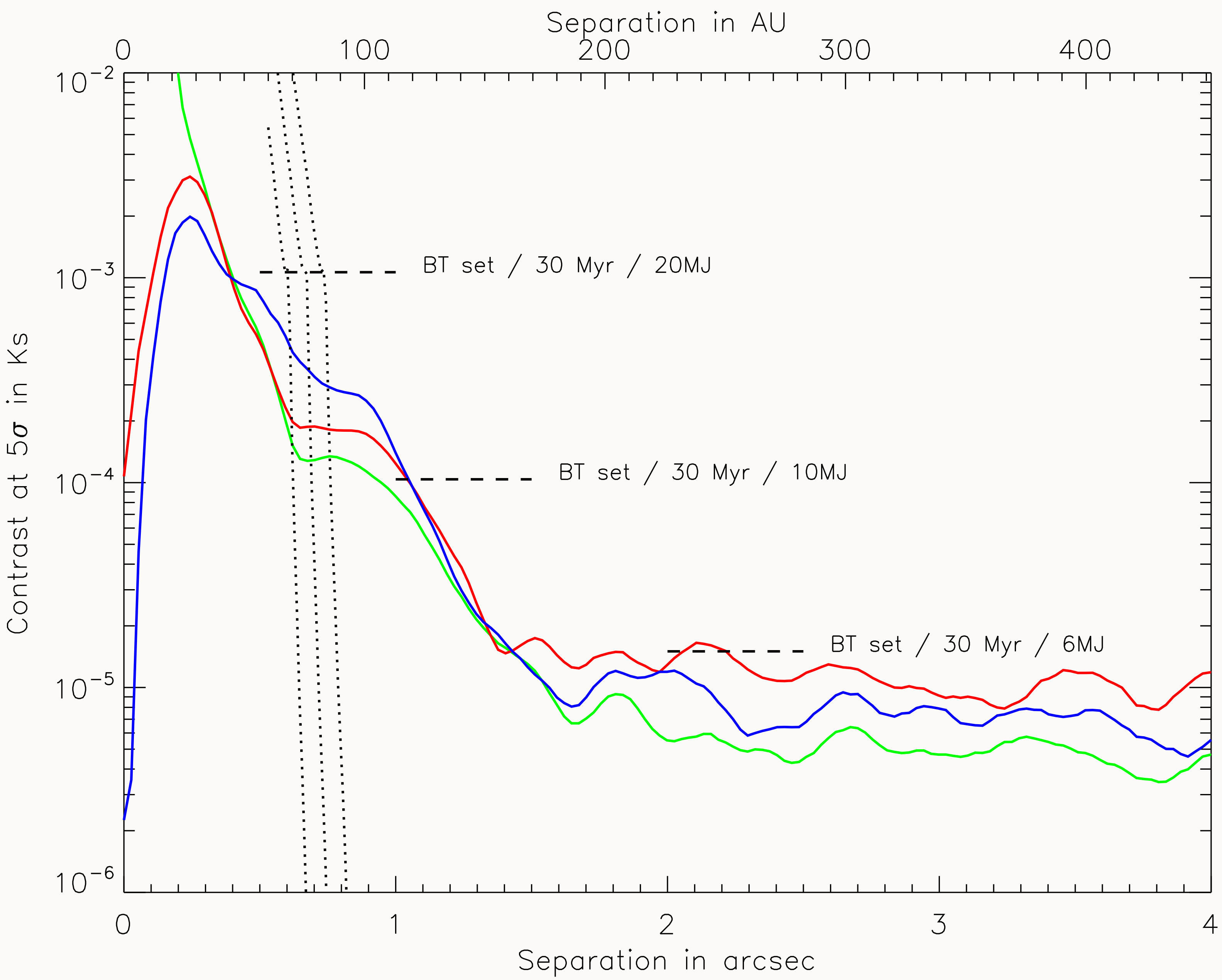
$\alpha_{out} = -5$: compatible with grains blow out by radiation pressure

$\alpha_{in} = 2$: not well constrained but compatible with small dust depletion as in Moerchen et al. 2007

$g = 0.5$: deviation to the midplane is a sign of anisotropy

LIMITS OF DETECTION

Assumptions: Age = 30 Myr, r_0 = 110 AU



Exclude a very massive planet / BD within the cavity

Dynamical constraints + limits of detection : if a planet is responsible for the cavity it is located at 65-85 AU and its mass is < 12 $M_{Jupiter}$

SUMMARY

- demonstrate the capability of NACO + Corono + ADI to recover the spatial distribution of dust in debris disks.
- Images complement the results of HST and mid IR data.
- ADI is powerful for detection but produces biases.
- using modeling and fake disks is one performant solution to un-bias ADI and retrieve the actual morphology of the disk.
- Results are promising for further observations of debris disks with NACO and in the context of SPHERE.