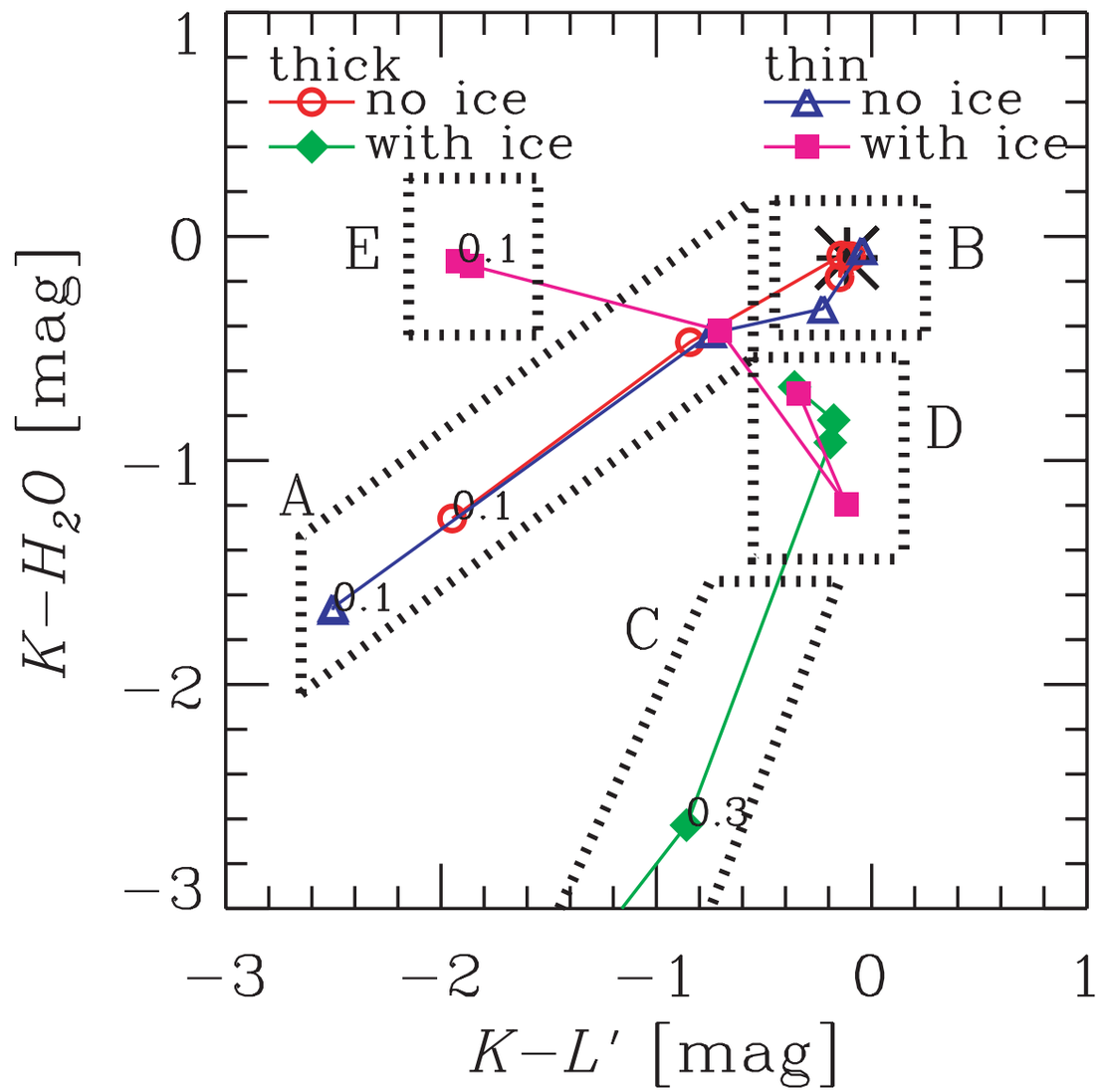
High-Contrast LBTAO & MagAO Images of Debris Disks at 2-4 μm

Timothy J. Rodigas
University of Arizona → Carnegie DTM

+ Phil Hinz, Laird Close, Alycia Weinberger, Andy Skemer, Jared Males, Vanessa Bailey, Kate Follette, Katie Morzinski, Denis Defrere, & many, many Italians from Arcetri

Why image debris disks at 2-4 μm?

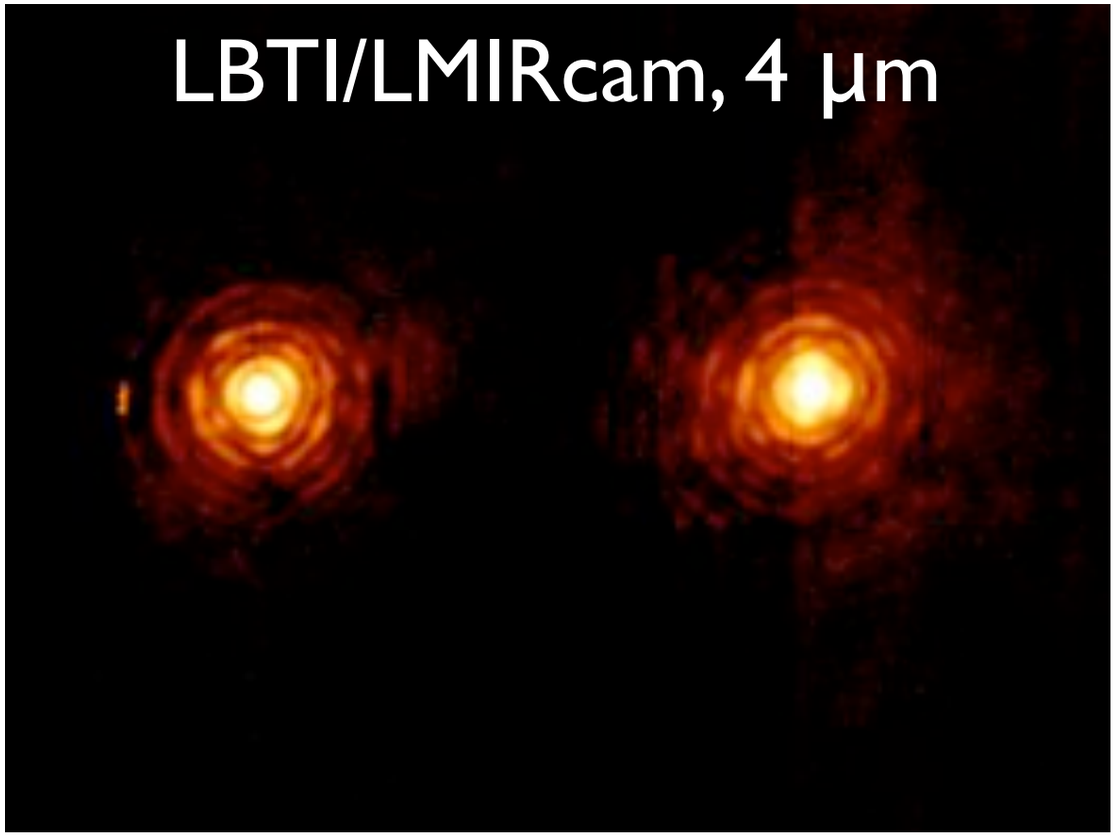
- Higher Strehl → higher contrast → clues to unseen planets
- Dust grain composition & size
  - water ice, organics, silicates (Inoue et al. 2008, Debes et al. 2009)
- 2-4 μm window also very sensitive to luminous exoplanets

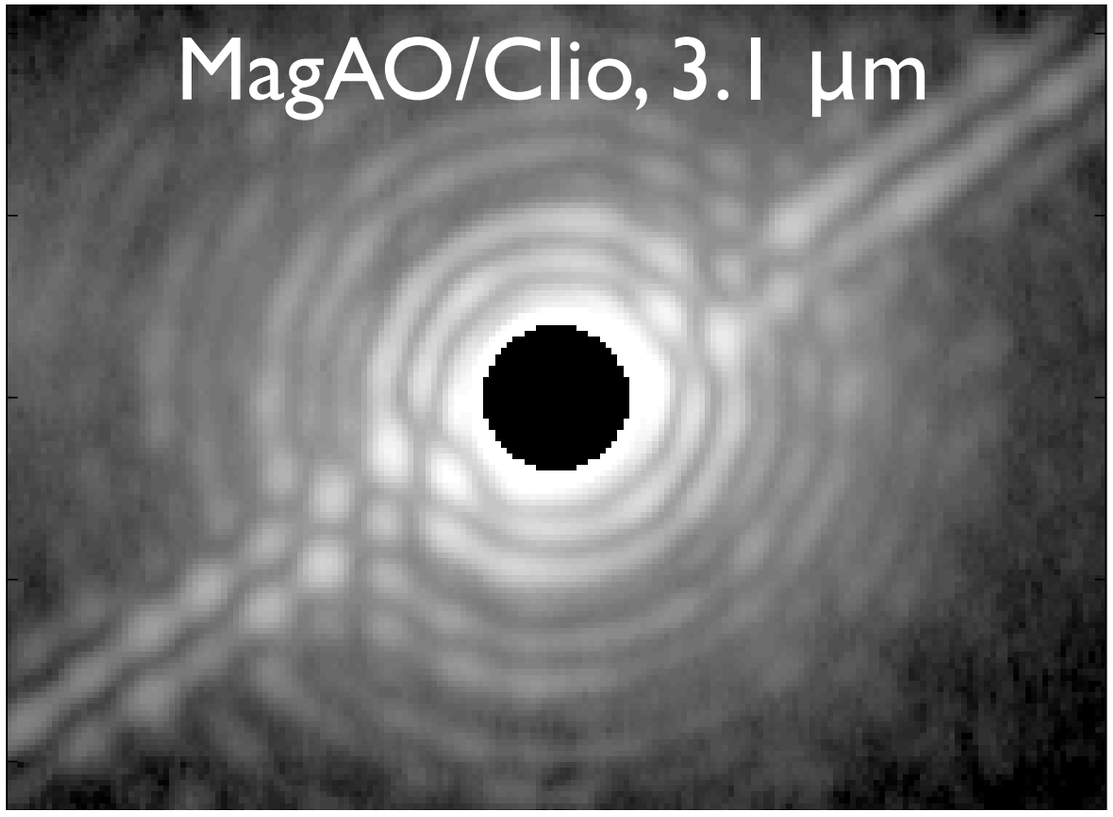


Inoue et al. 2008

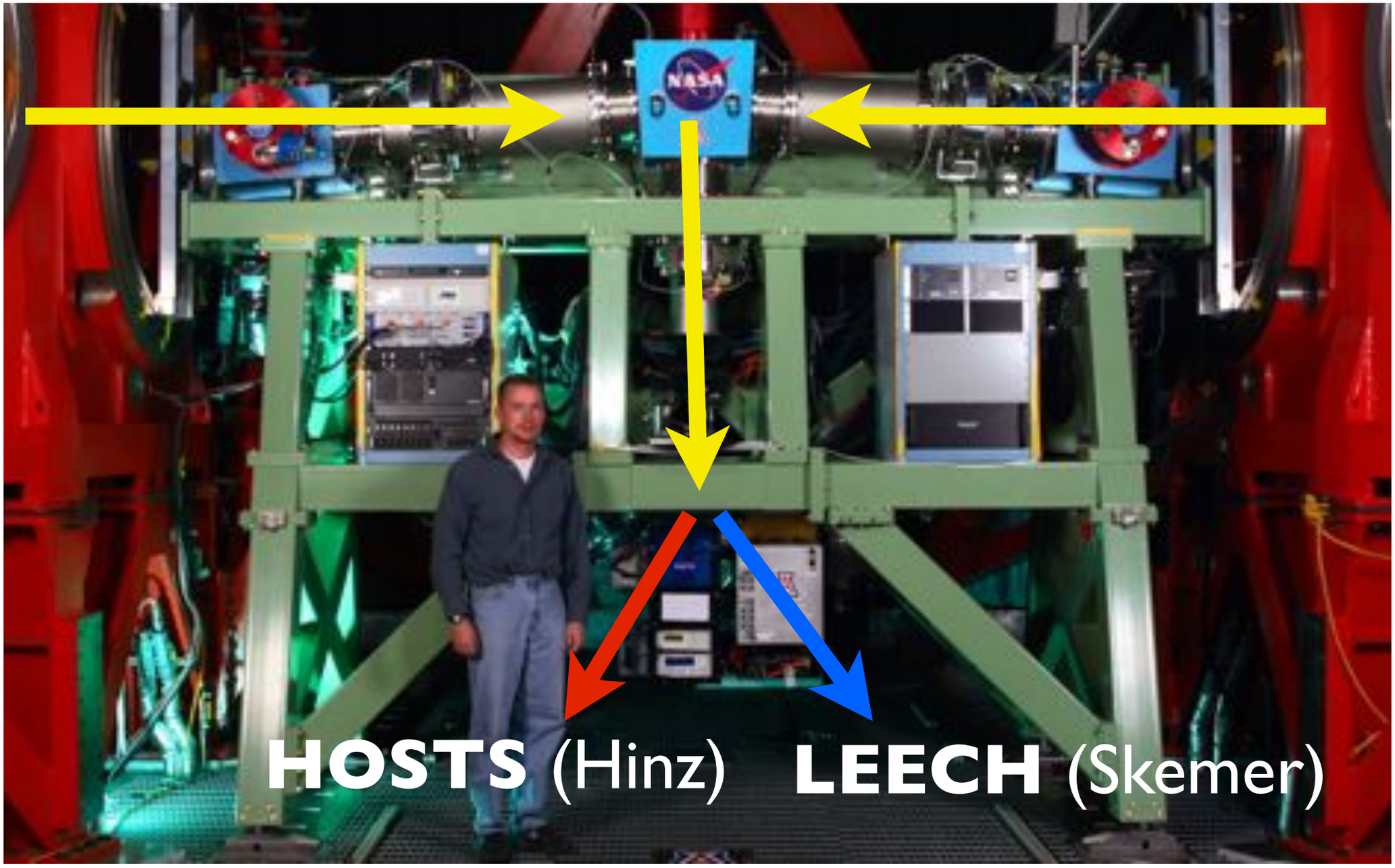
How do you image debris disks at 2-4 μm?

- Everything glows in the infrared
- Minimize number of warm surfaces → minimize noise
- Need adaptive *secondary* mirror
  - e.g., LBTI (Phil Hinz), MagAO (Laird Close)

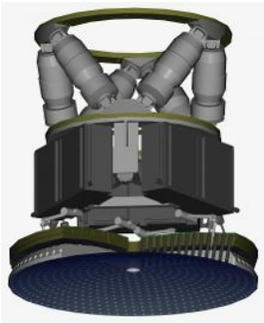




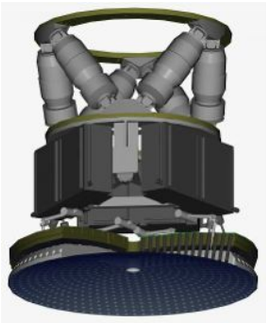
LBTI: how it works

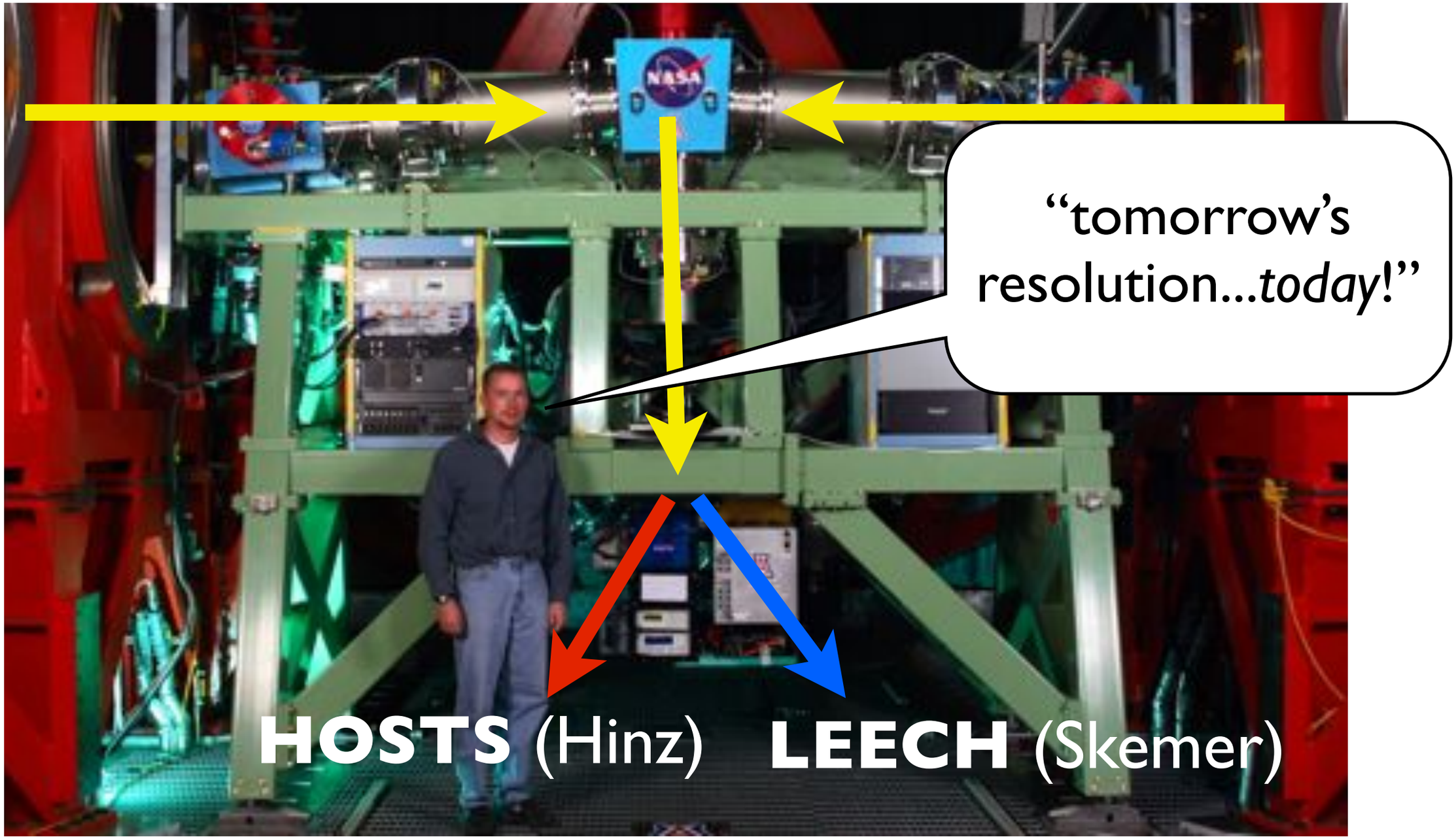


For more info: see posters by V. Bailey (1.07) & D. Defrere (6.13)



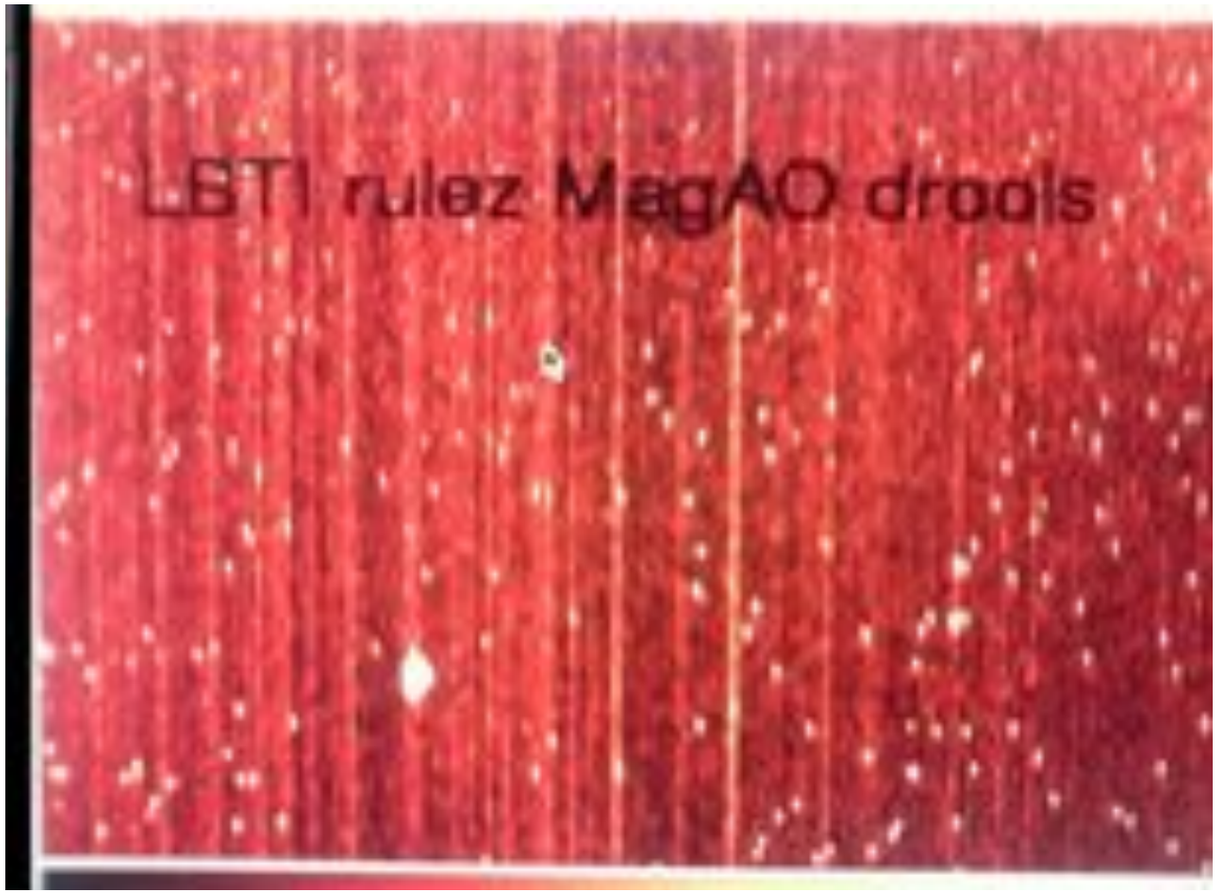
LBTI: how it works

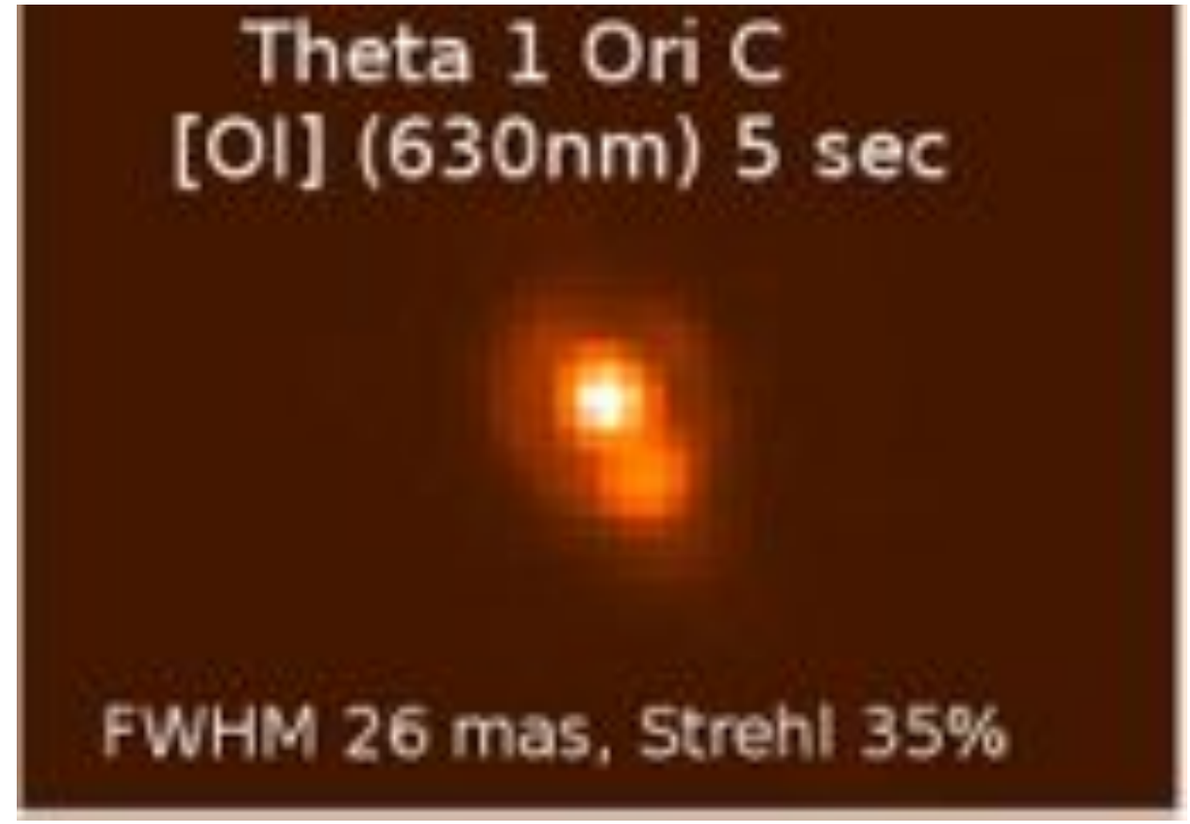




For more info: see posters by V. Bailey (1.07) & D. Defrere (6.13)

LBTI vs. MagAO



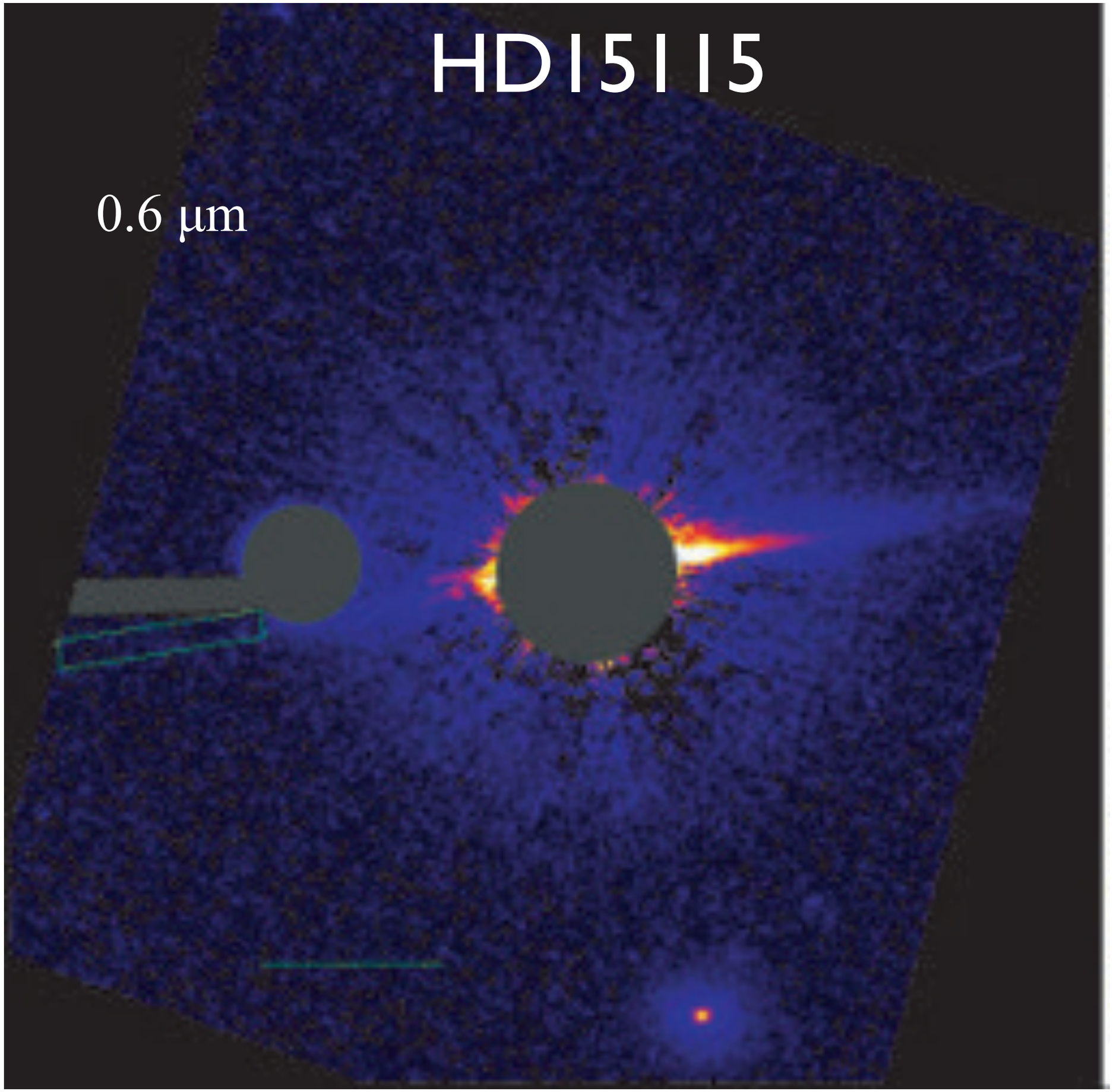


Close et al. 2013

zero.as.arizona.edu/groups/lbti/blog/

visao.as.arizona.edu

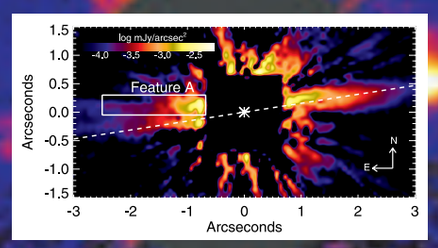
and see talk by K. Morzinski on Wednesday!



Kalas et al. 2007

HD15115

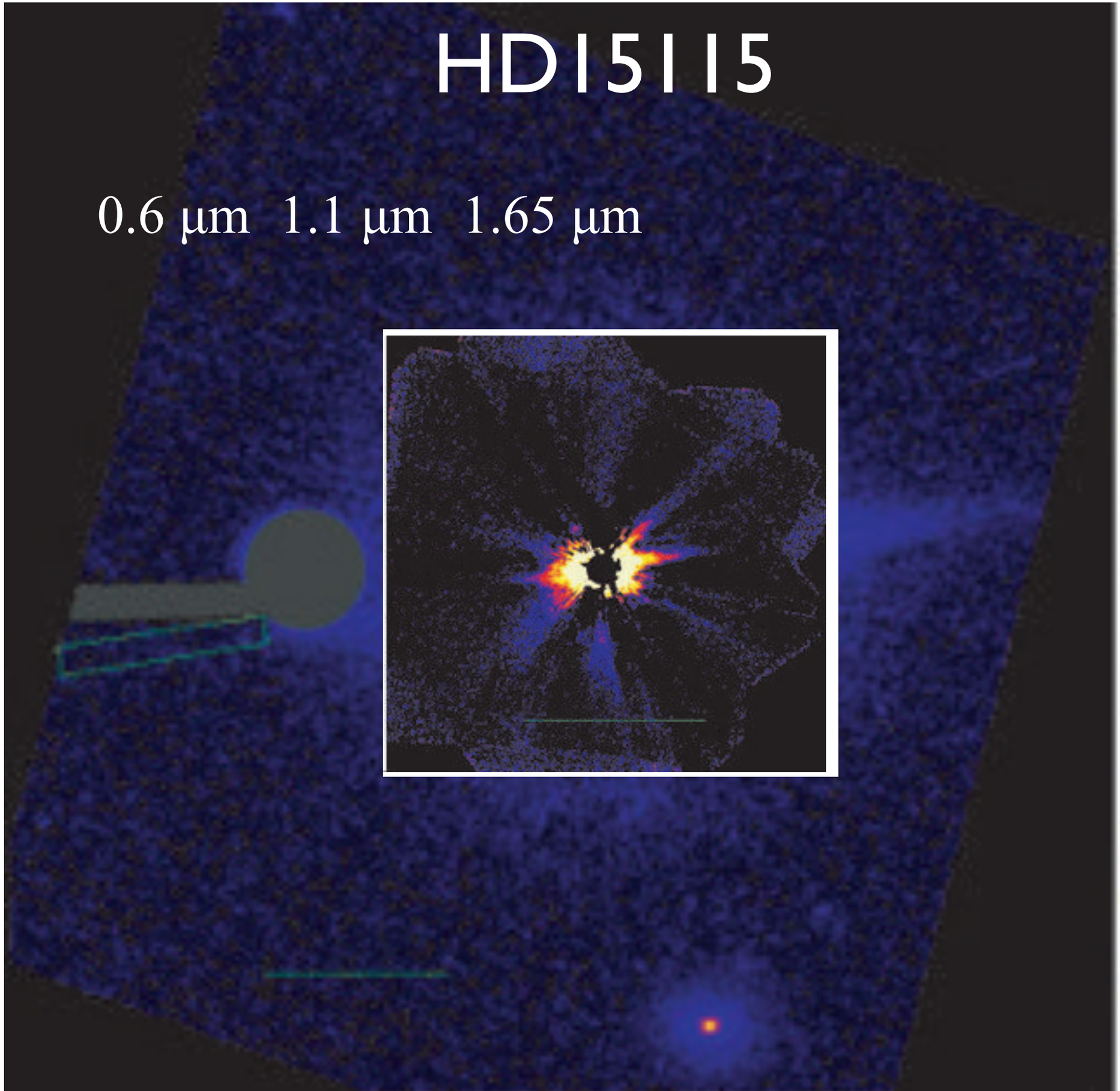
0.6 μm 1.1 μm



Kalas et al. 2007

Debes et al. 2008

HD15115

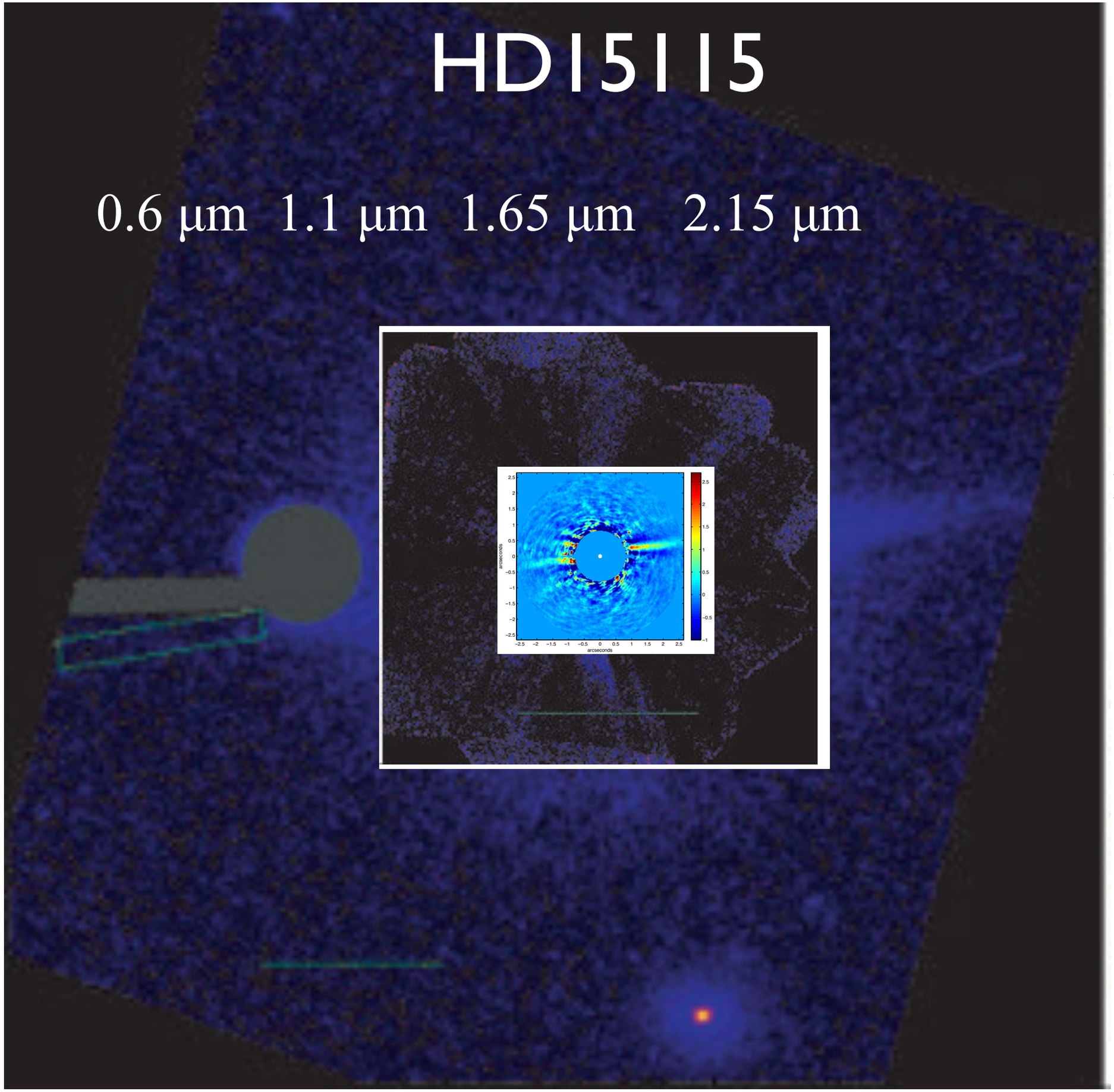


Kalas et al. 2007

Debes et al. 2008

Kalas et al. 2007

HD15115



Kalas et al. 2007

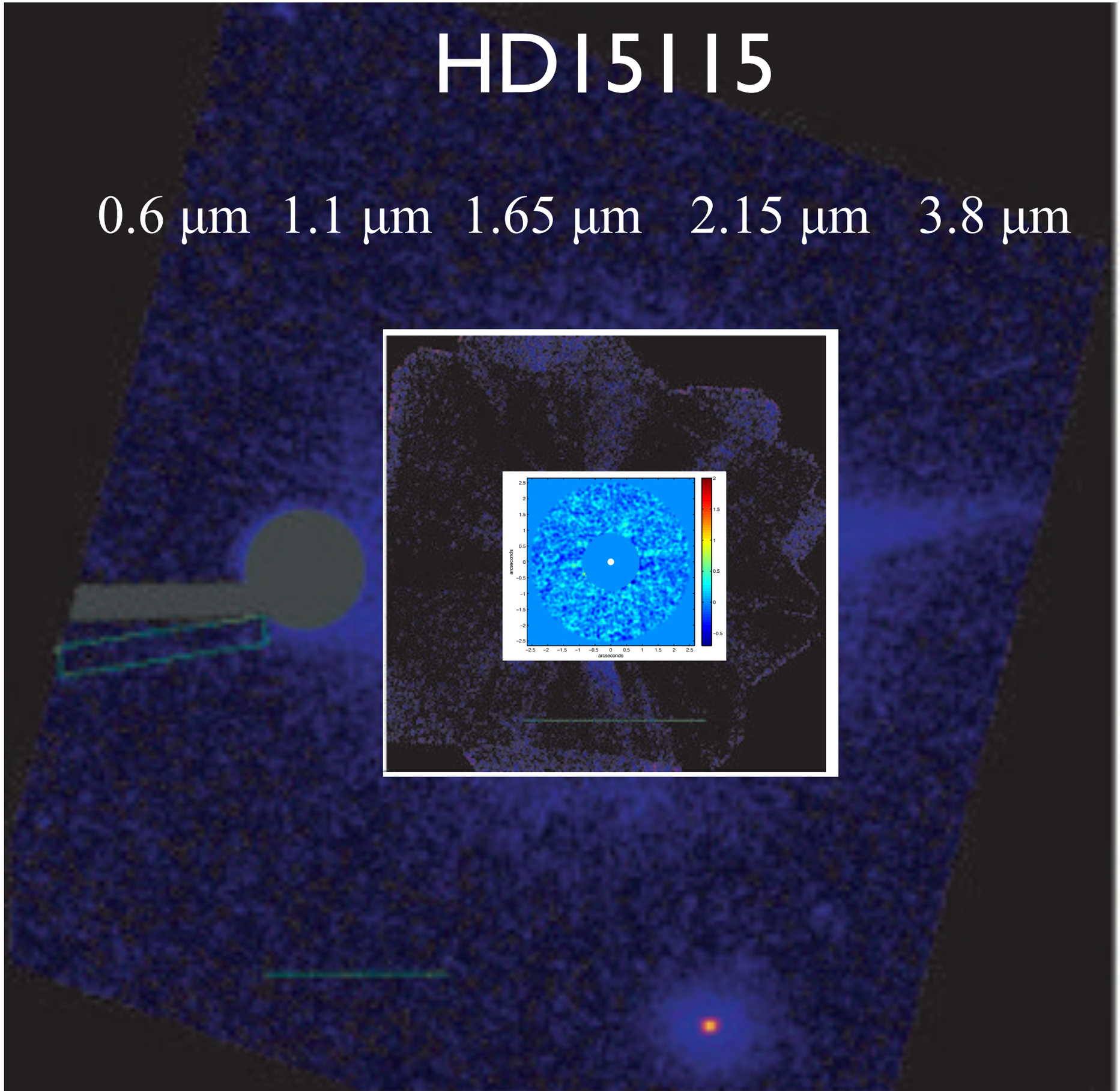
Debes et al. 2008

Kalas et al. 2007

Rodigas et al. 2012

HD15115

0.6 μm 1.1 μm 1.65 μm 2.15 μm 3.8 μm



Kalas et al. 2007

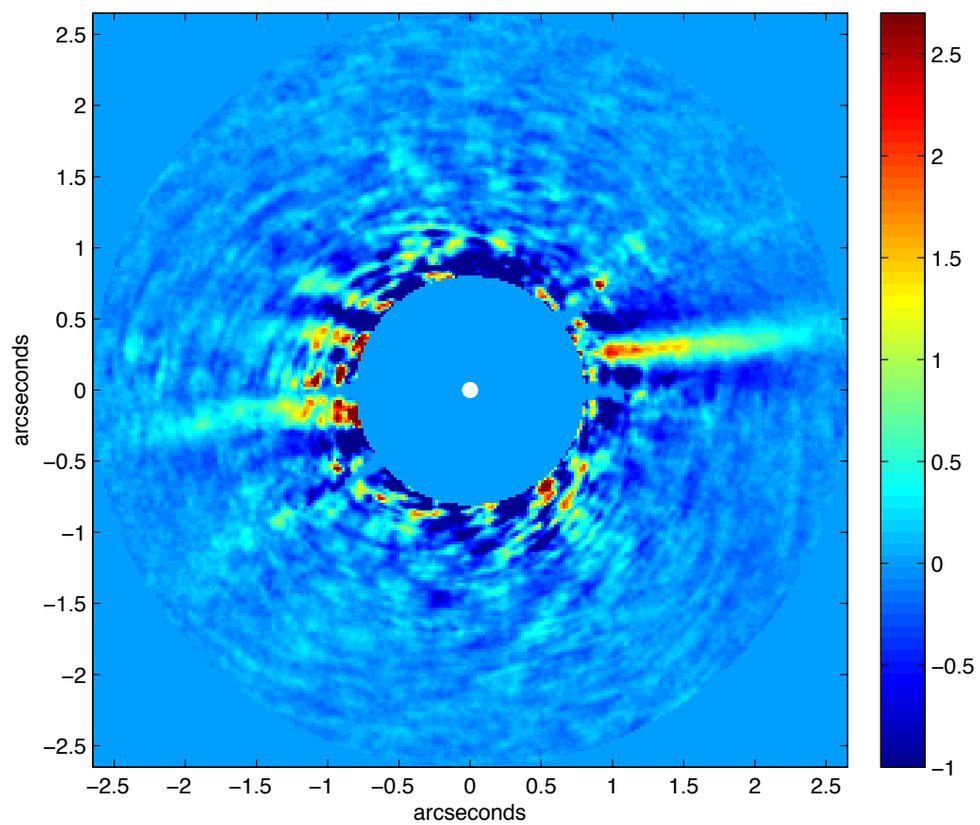
Debes et al. 2008

Kalas et al. 2007

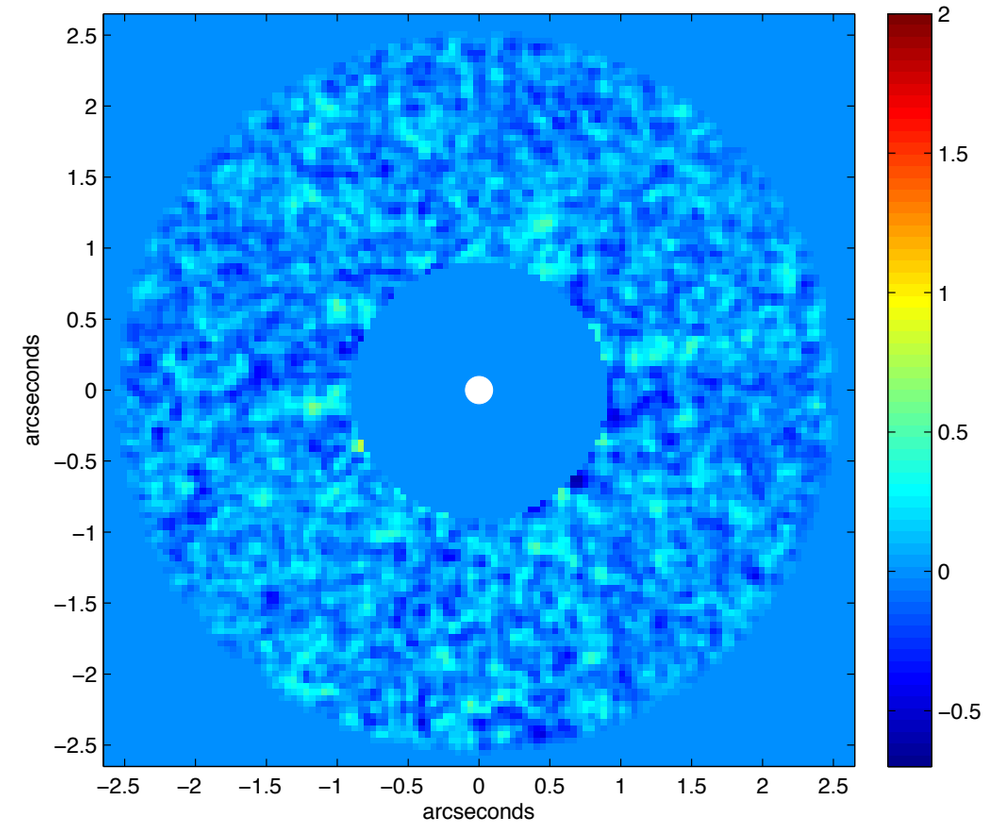
Rodigas et al. 2012

HD 15115 at 2-4 μm

2.15 μm



3.8 μm

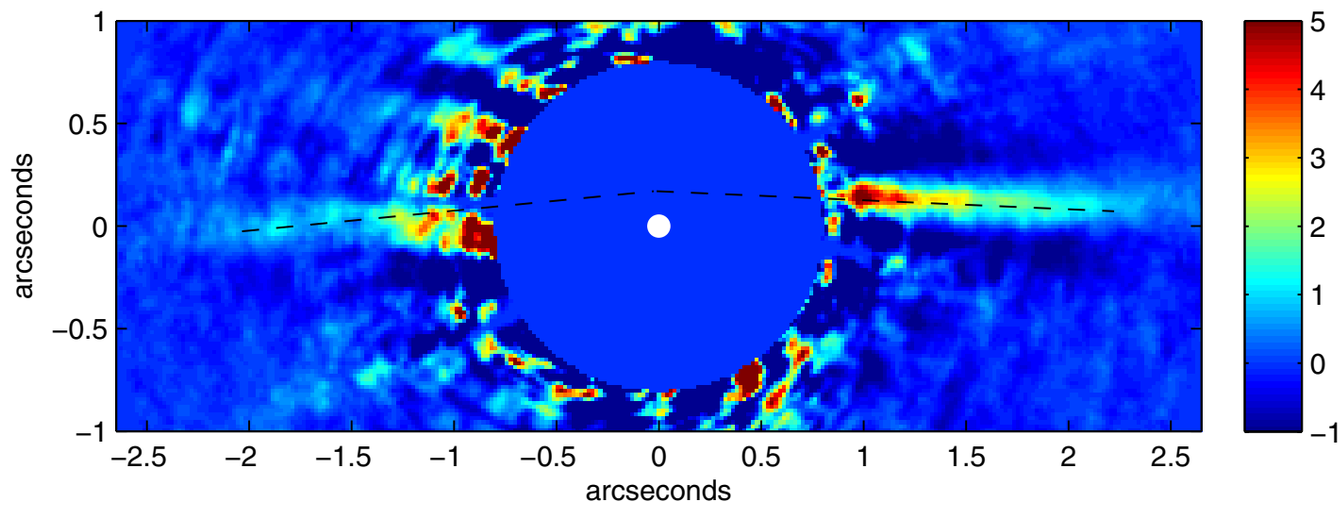


Rodigas et al. 2012

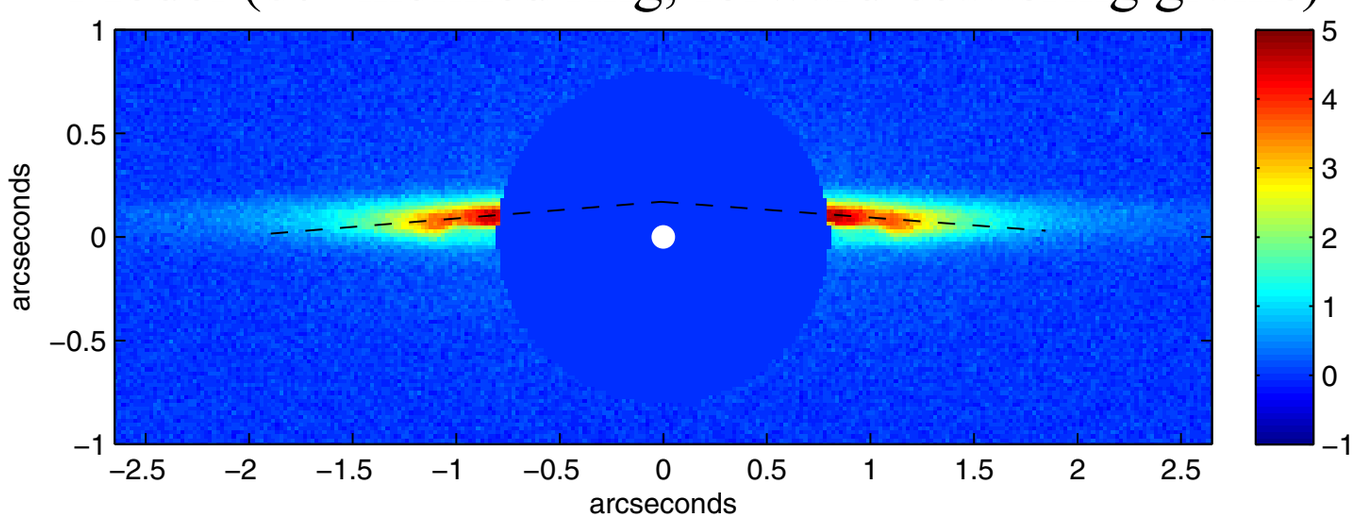
The disk is morphologically different between the visible & NIR

The disk is bowed

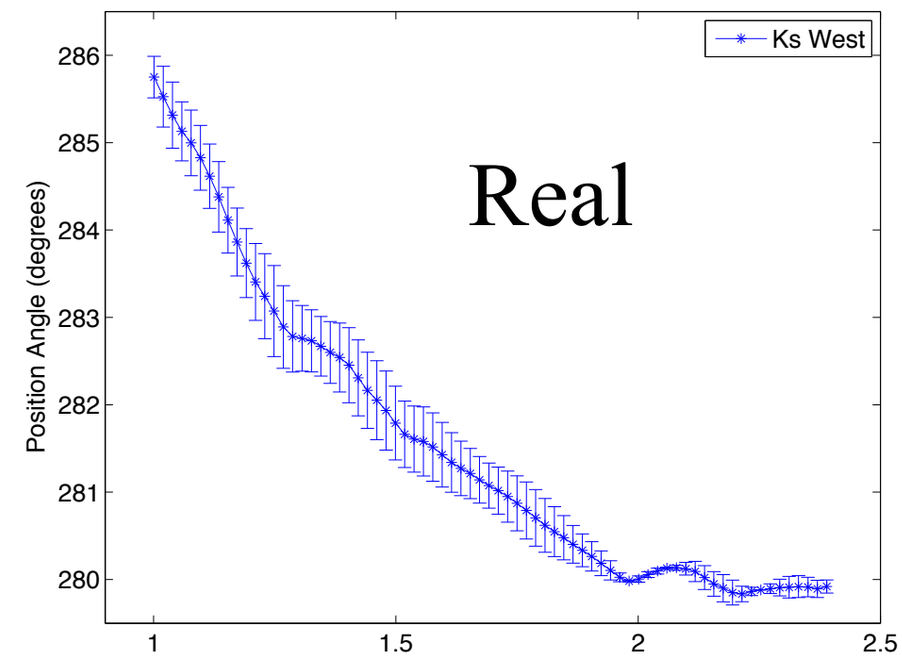
Real

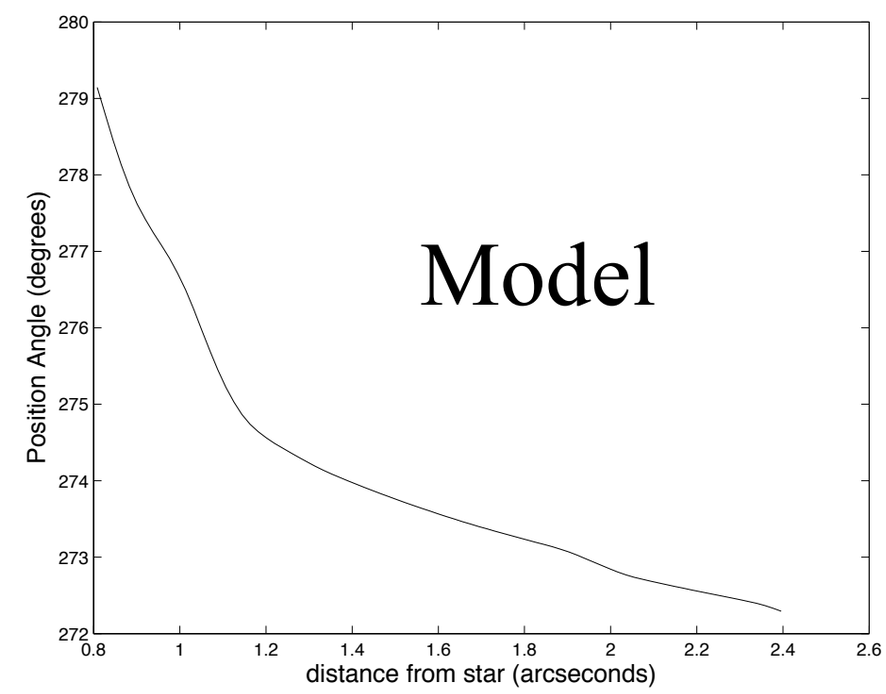


Model (87° inclined ring, forward-scattering grains)



PA vs. radius

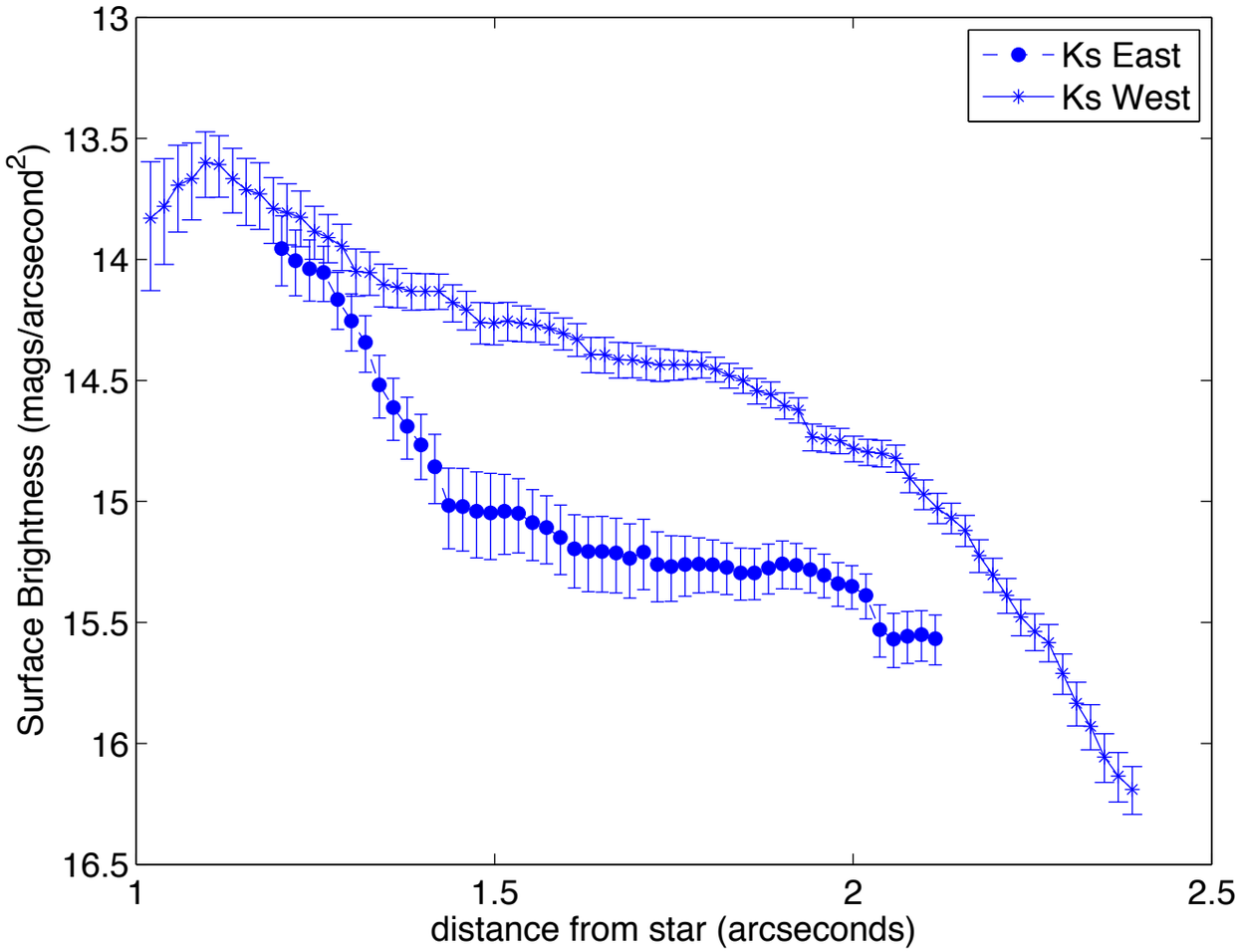


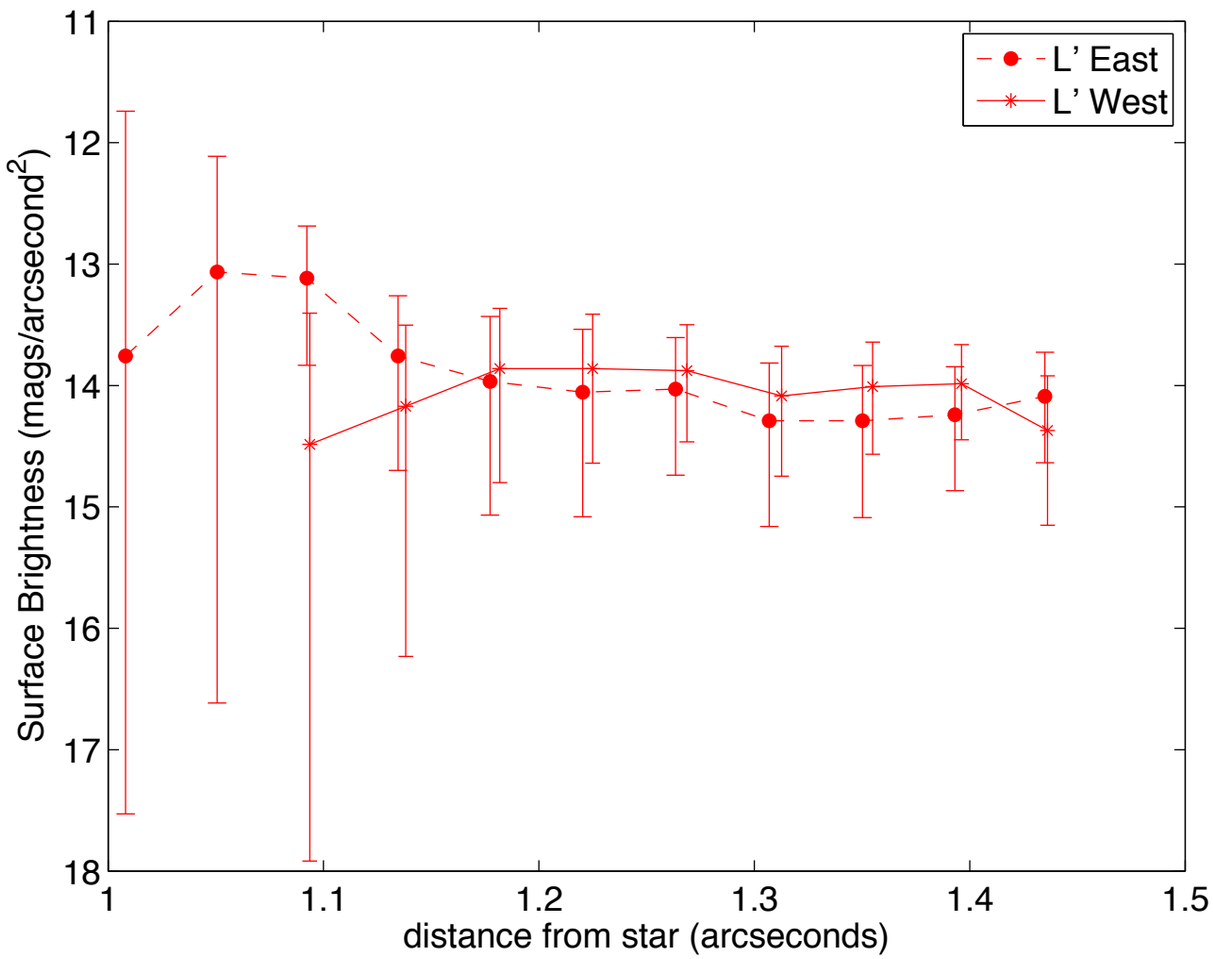


Model reproduces PA well (though not unique)

Rodigas et al. 2012

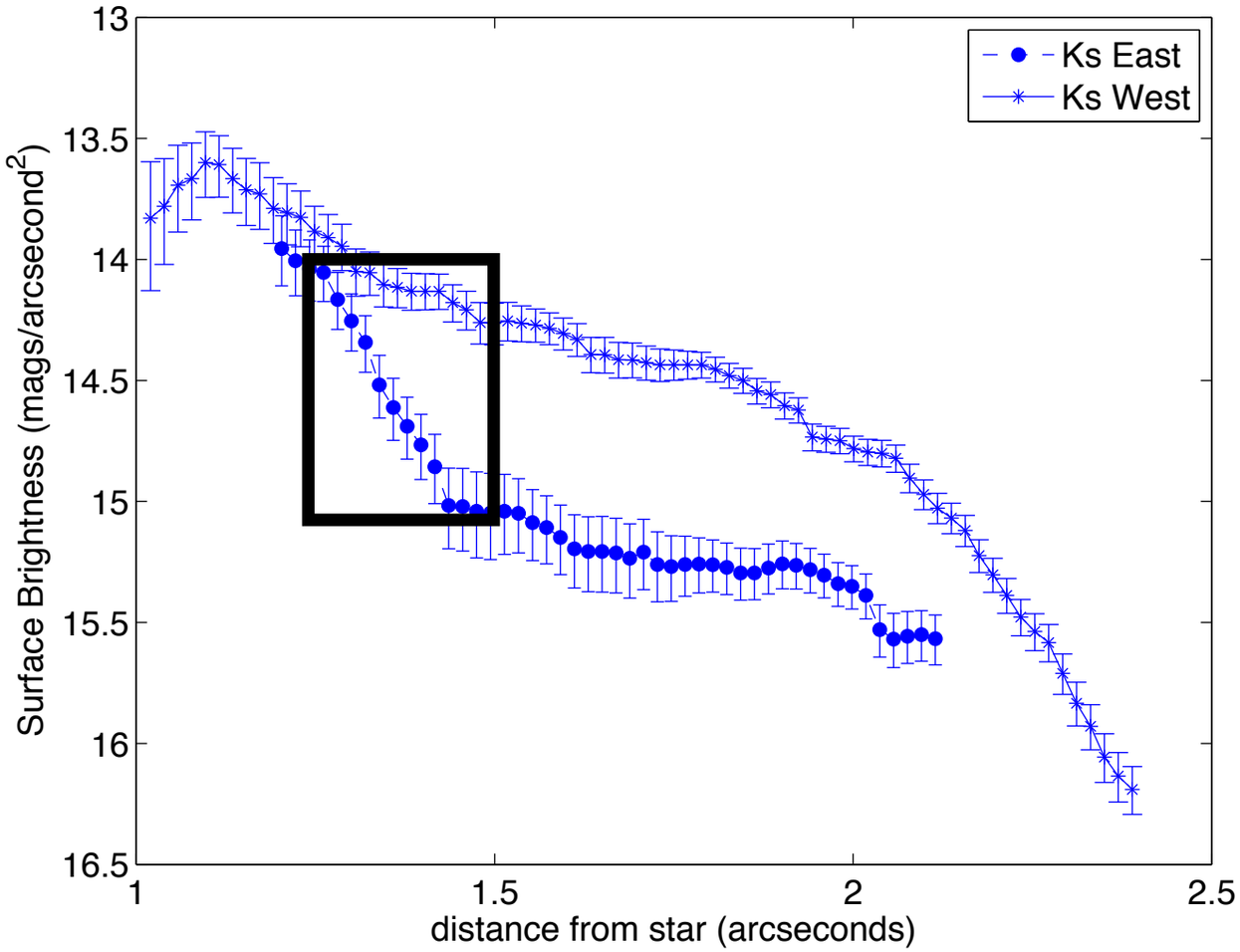
Surface brightness asymmetries & a possible gap

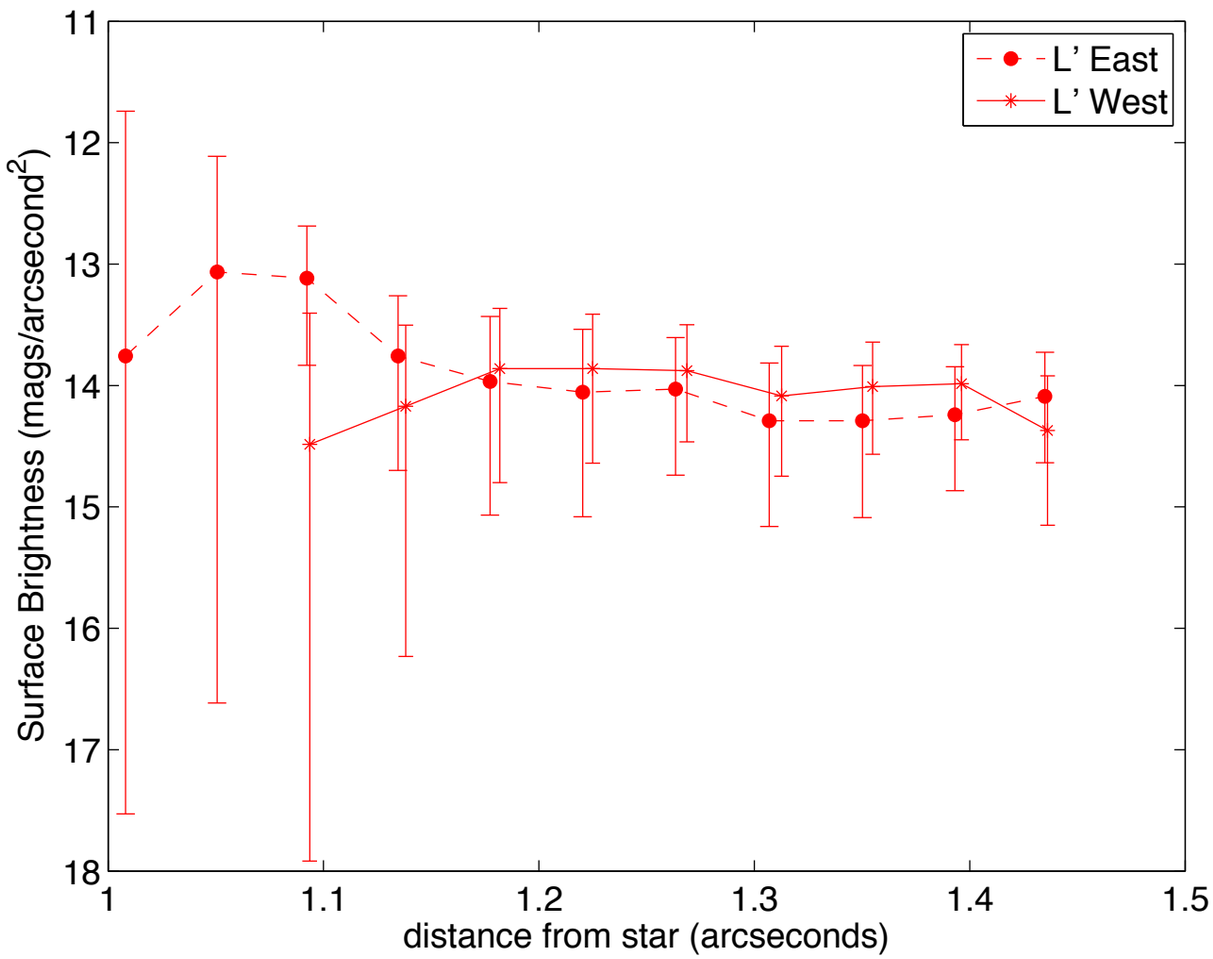




Rodigas et al. 2012

Surface brightness asymmetries & a possible gap

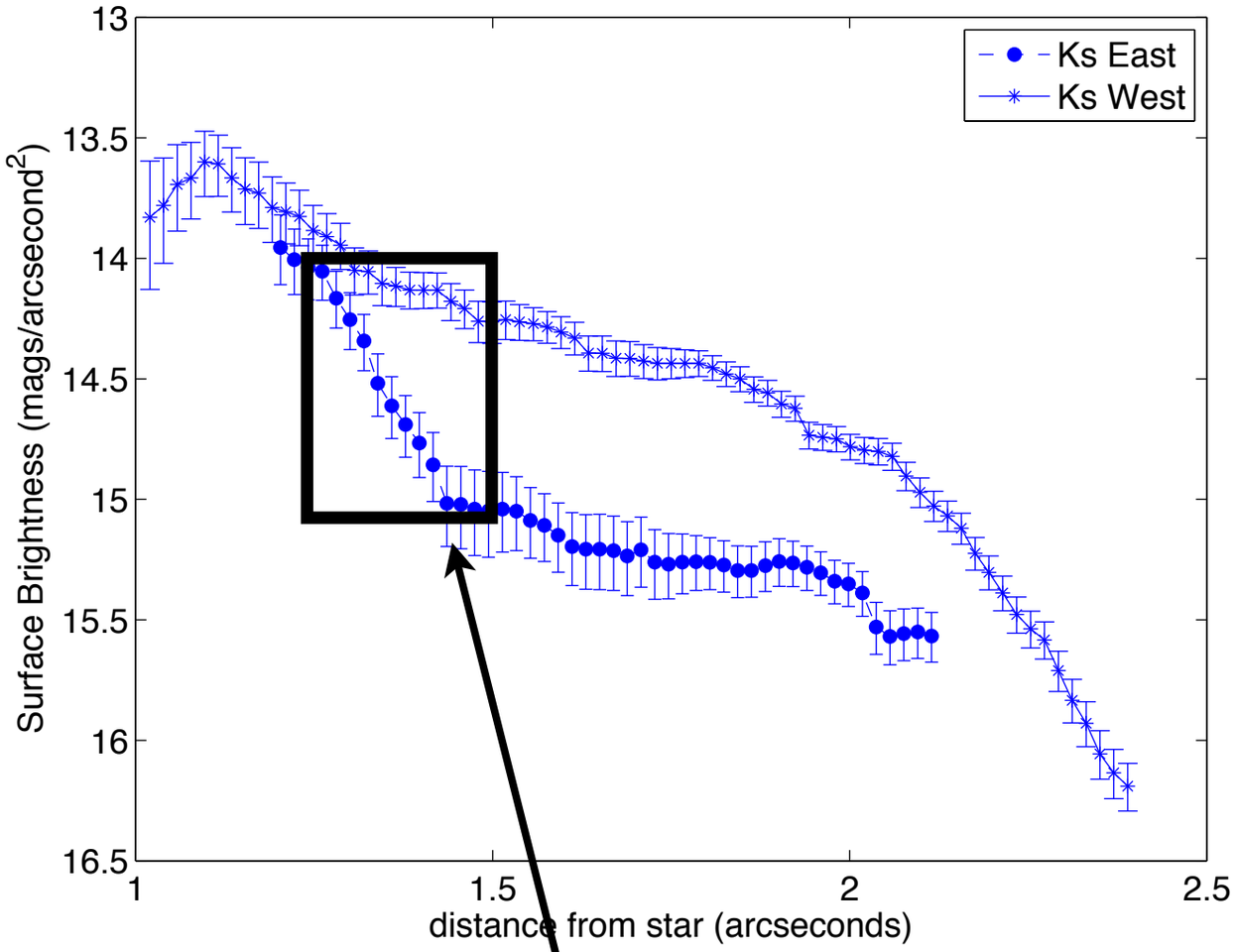




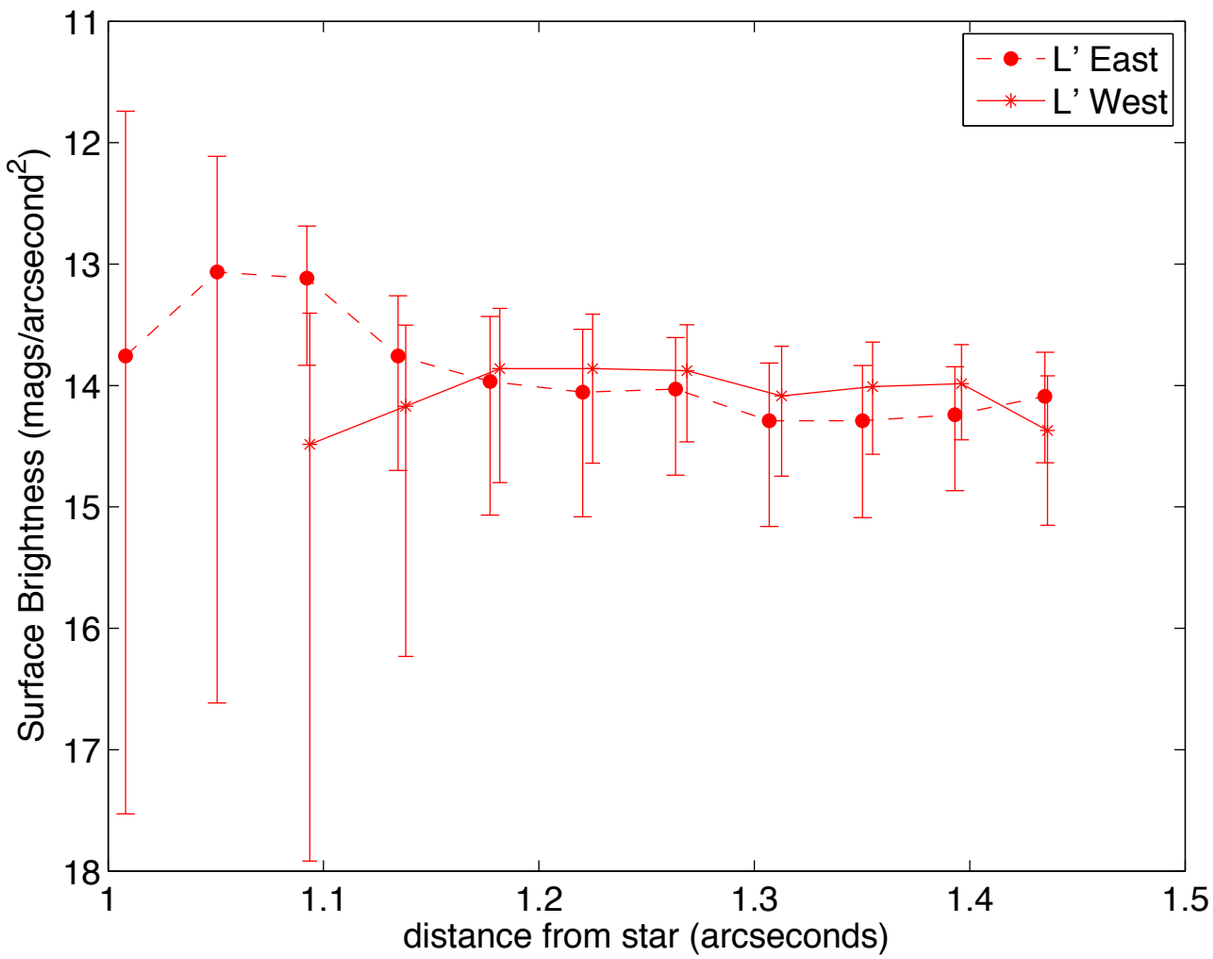
Rodigas et al. 2012

Surface brightness asymmetries & a possible gap

2.15 μm



3.8 μm

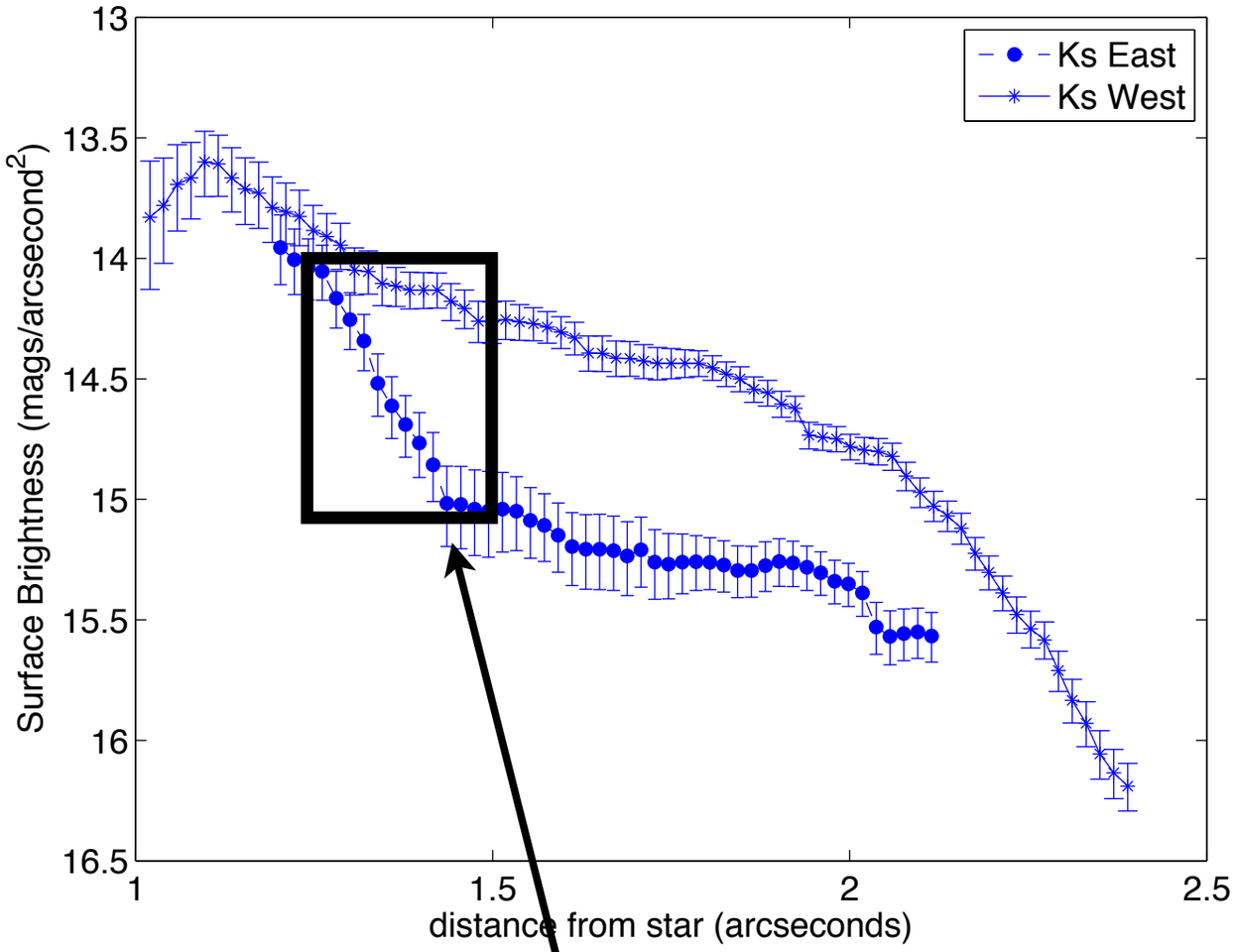


Rodigas et al. 2012

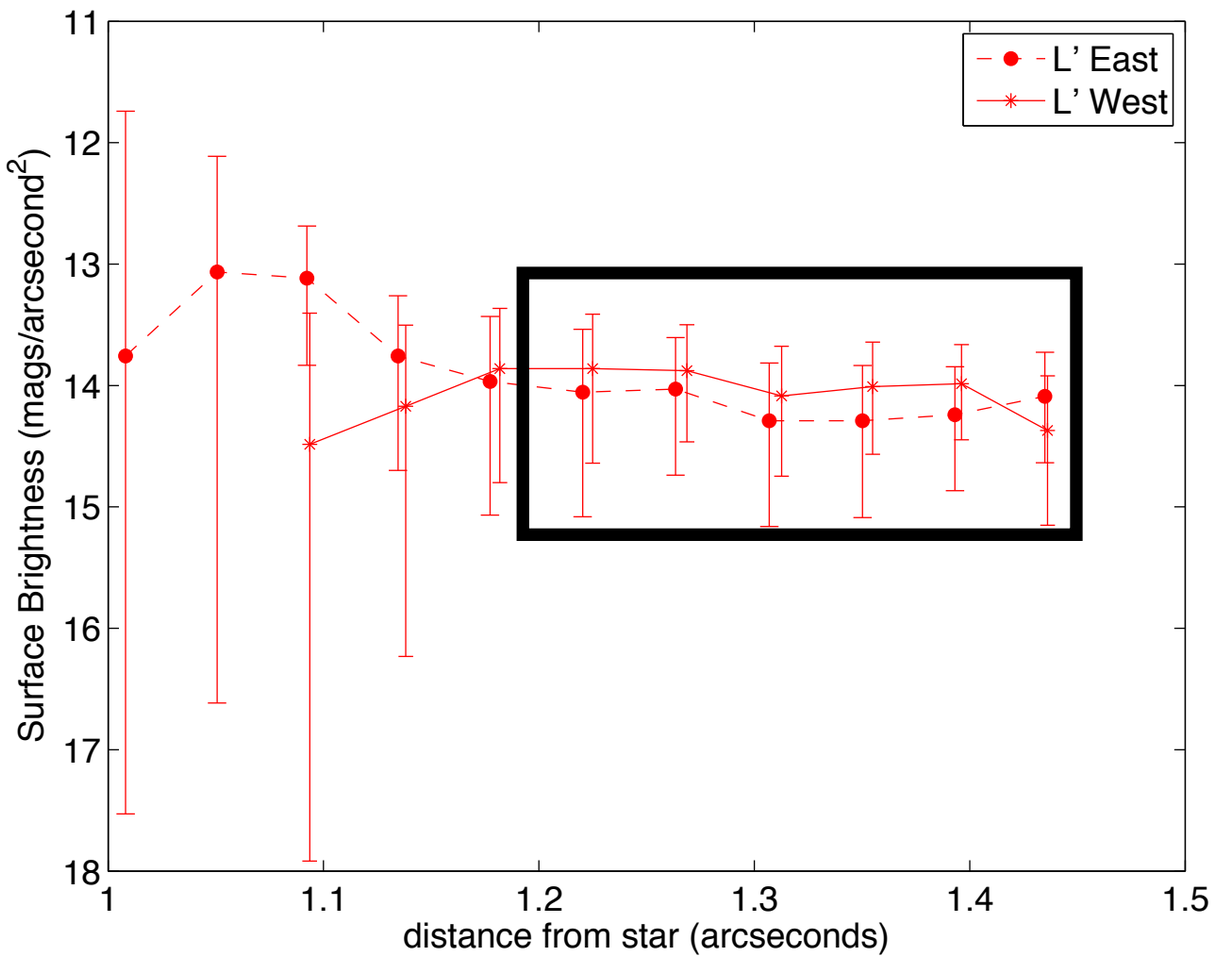
West brighter than East

Surface brightness asymmetries & a possible gap

2.15 μm



3.8 μm

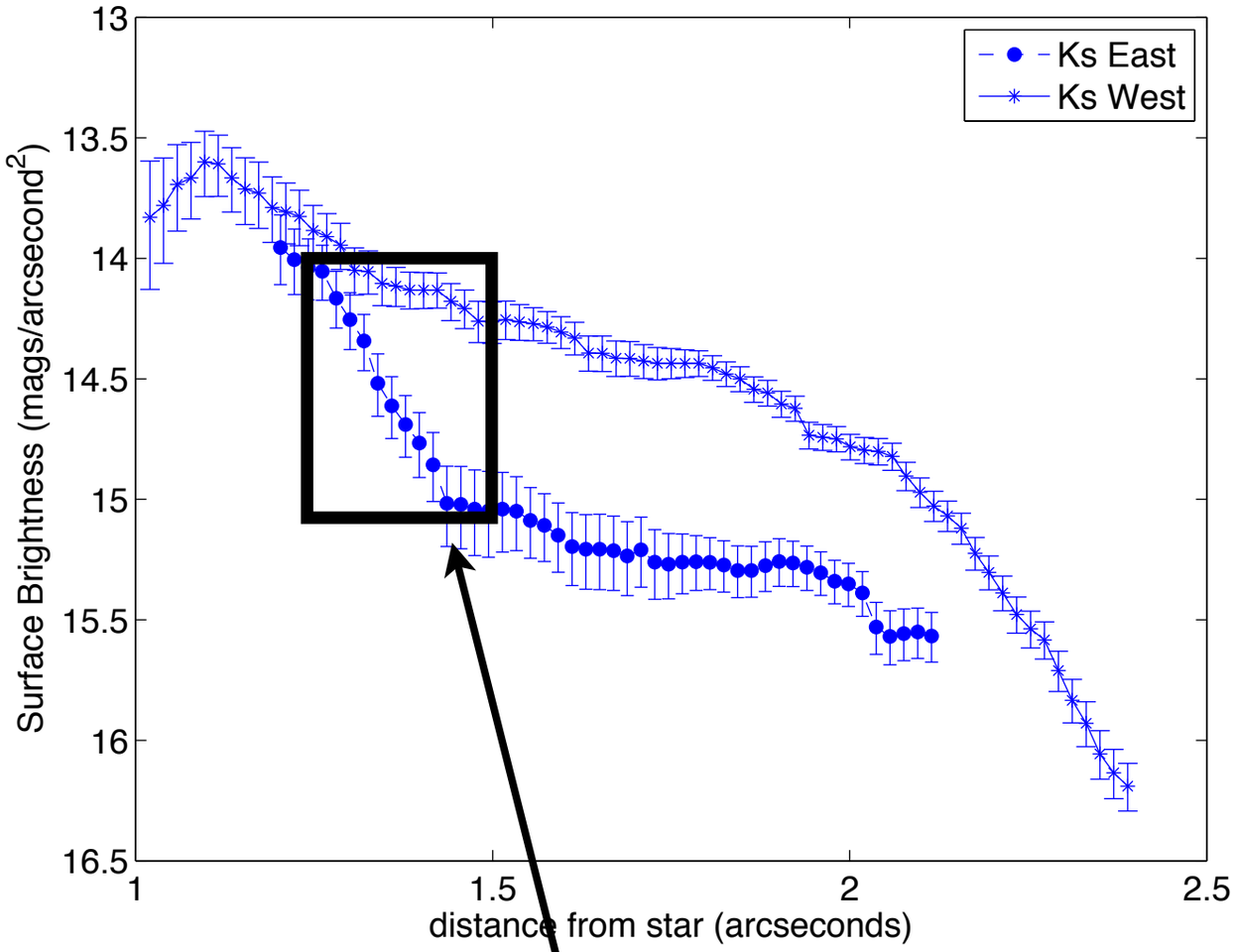


Rodigas et al. 2012

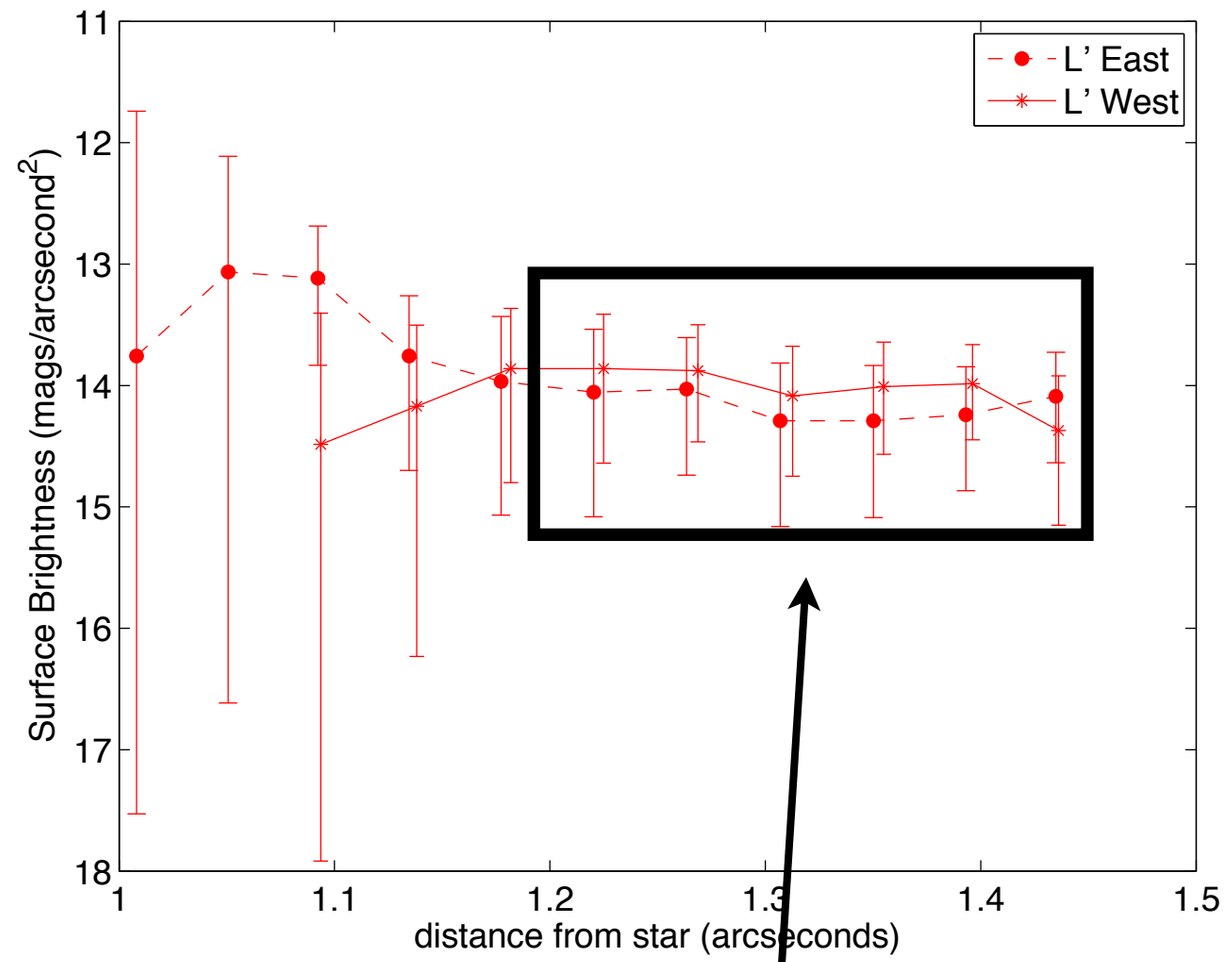
West brighter than East

Surface brightness asymmetries & a possible gap

2.15 μm



3.8 μm



Rodigas et al. 2012

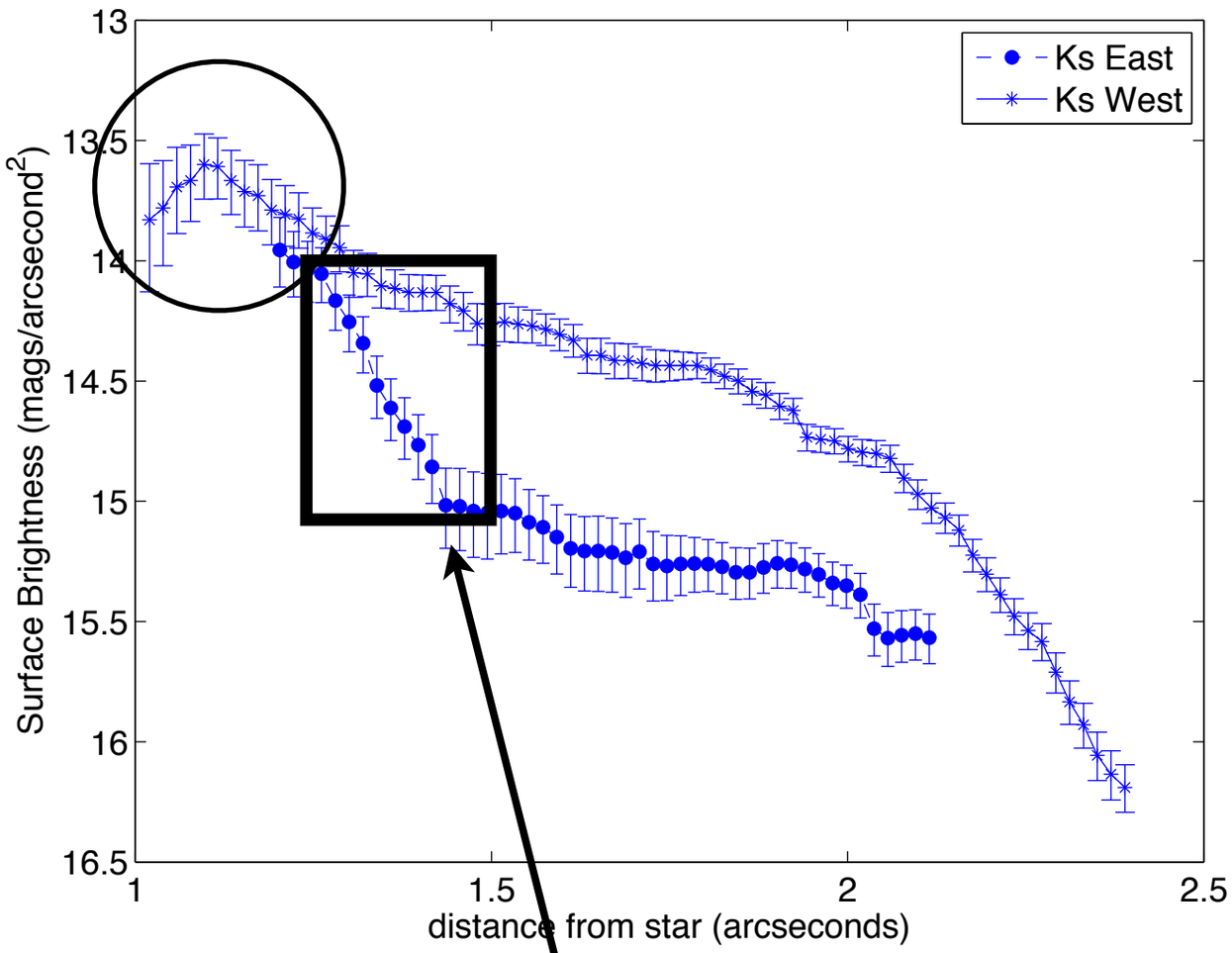
West brighter than East

~ equal

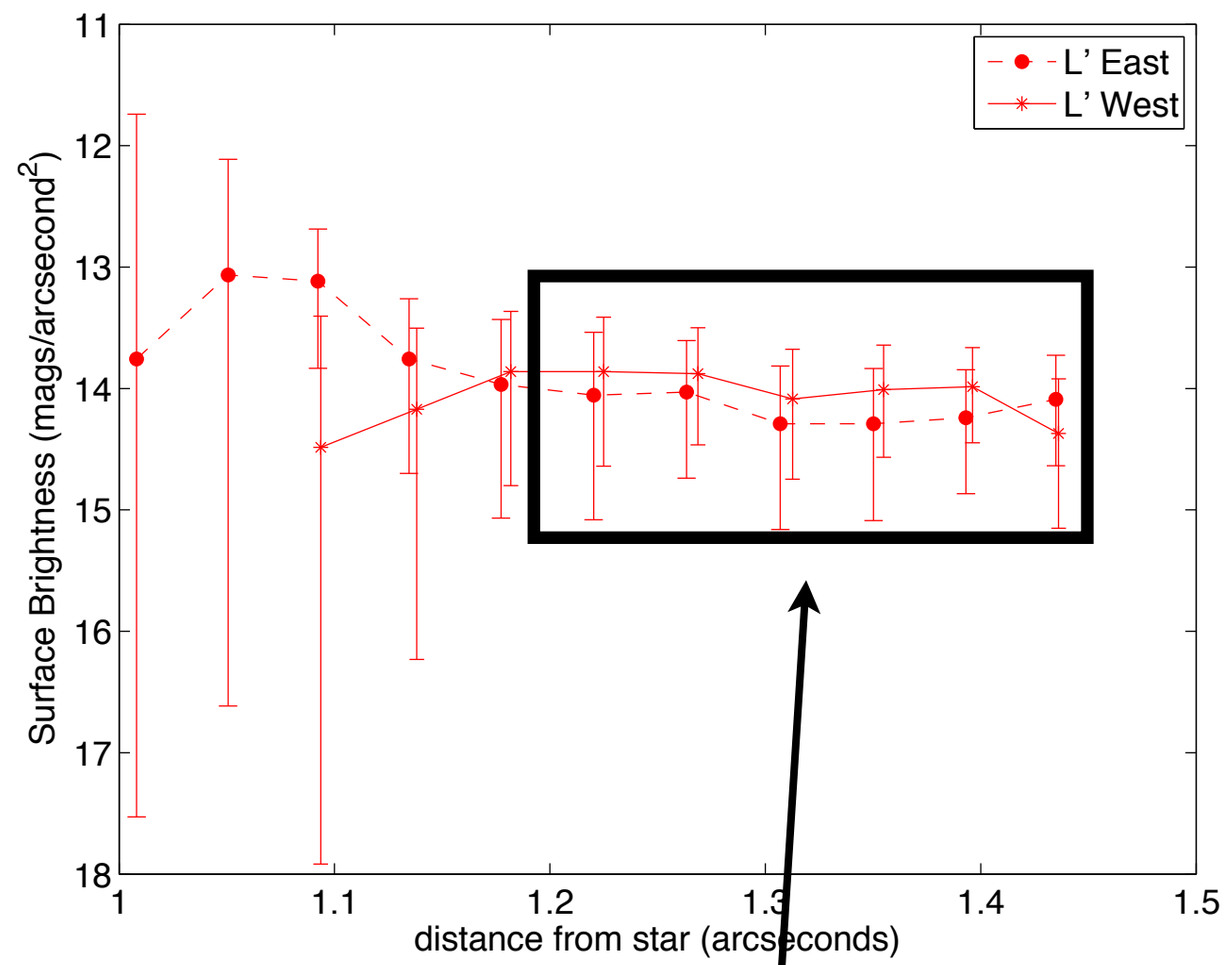
→ we are seeing different grain distributions at 2 & 4 μm

Surface brightness asymmetries & a possible gap

2.15 μm



3.8 μm



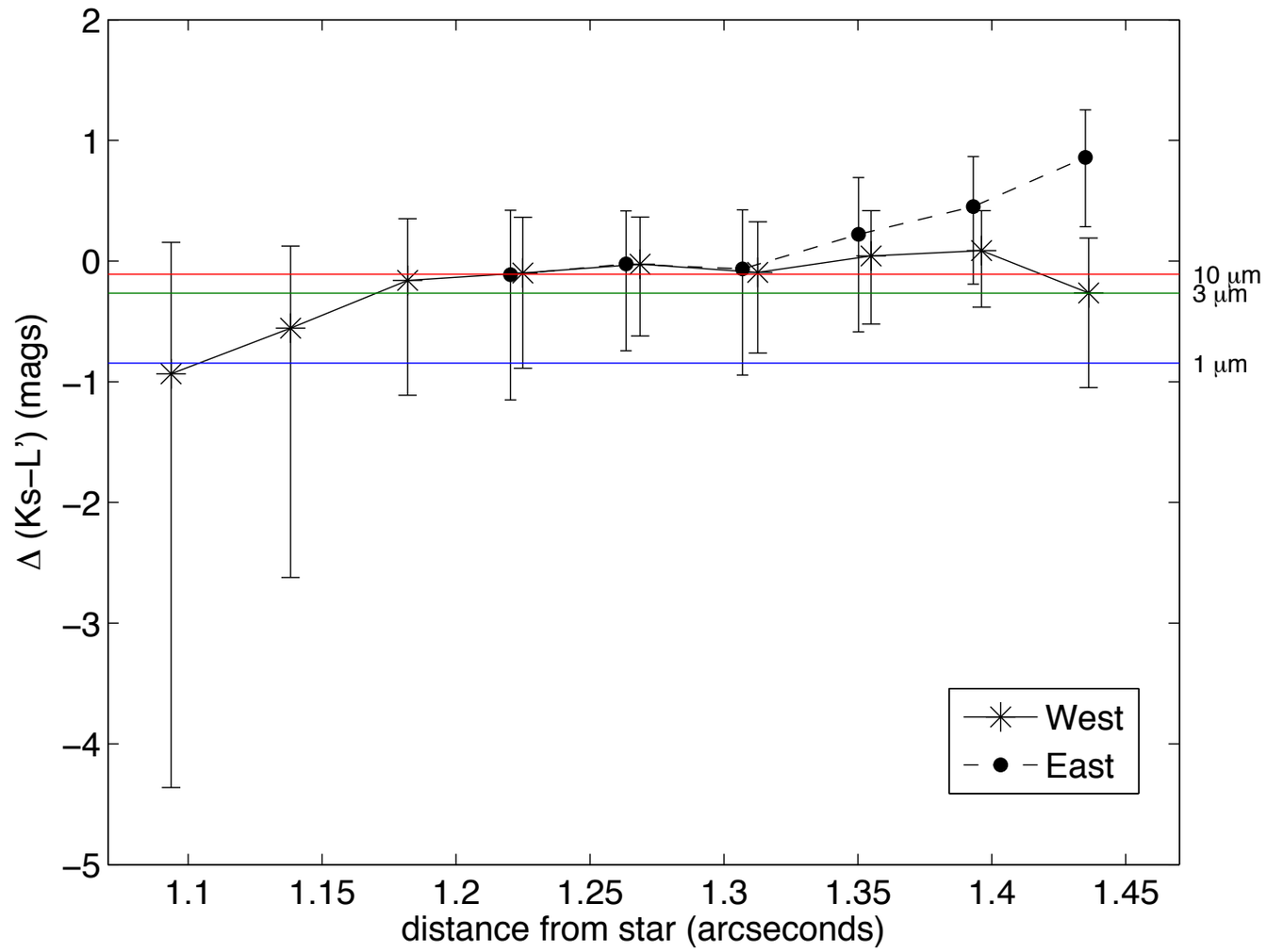
Rodigas et al. 2012

West brighter than East

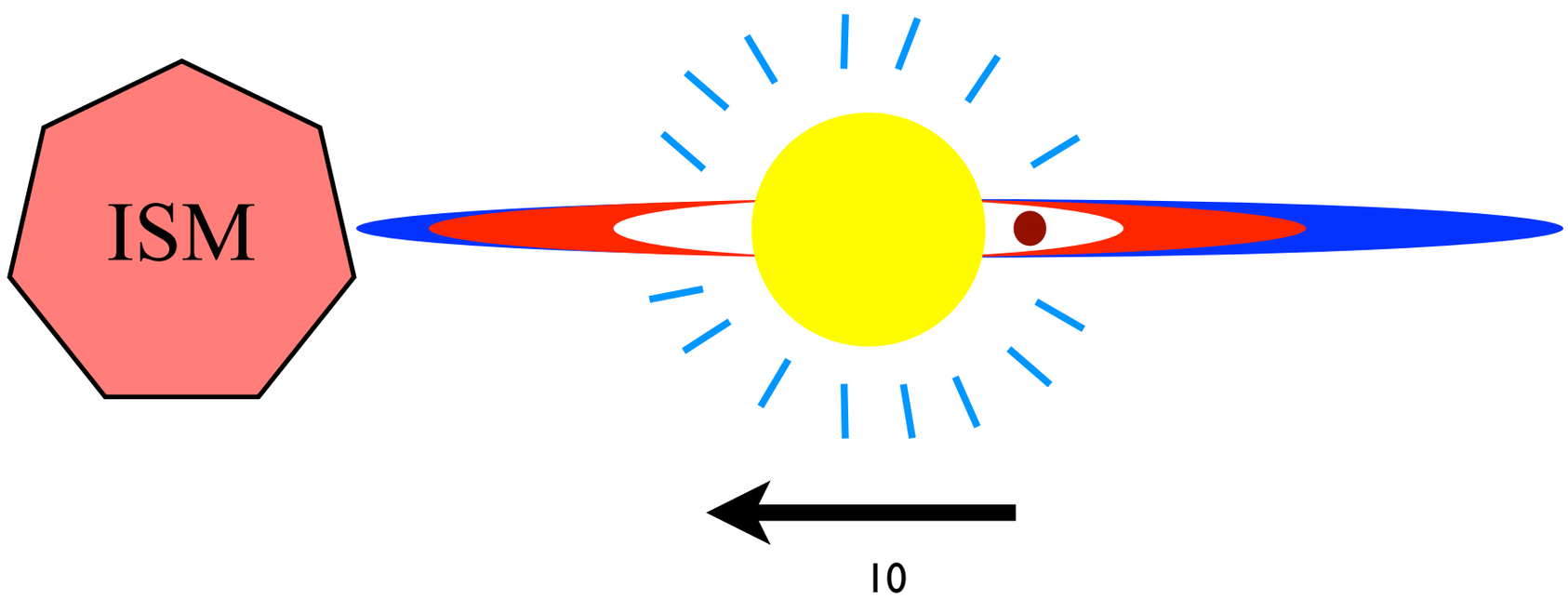
~ equal

→ we are seeing different grain distributions at 2 & 4 μm

Large, gray grains

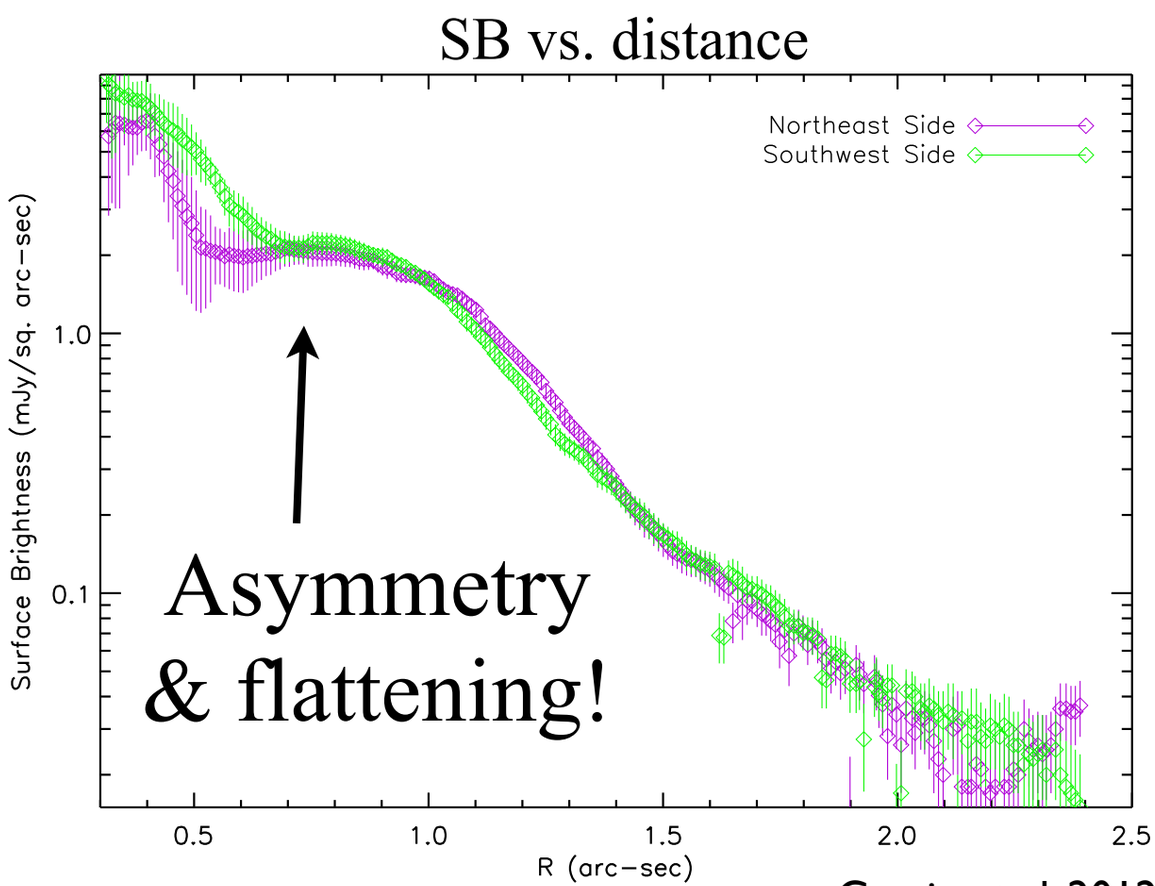


Rodigas et al. 2012



HD 32297

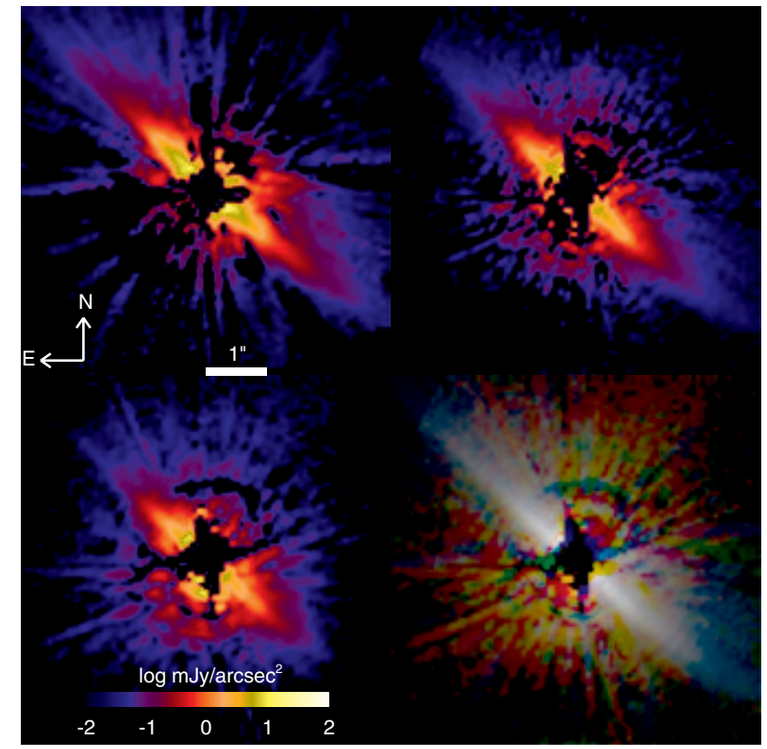
- Young, bright, & edge-on
  - → easier to detect!
- Interesting morphological features



Currie et al. 2012

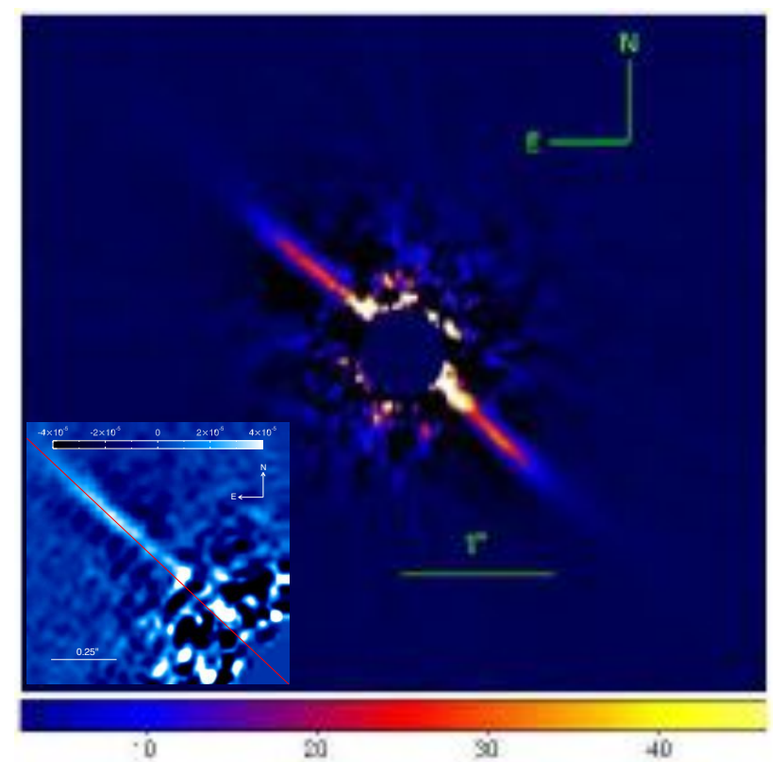
HST, JHK

Debes et al. 2009



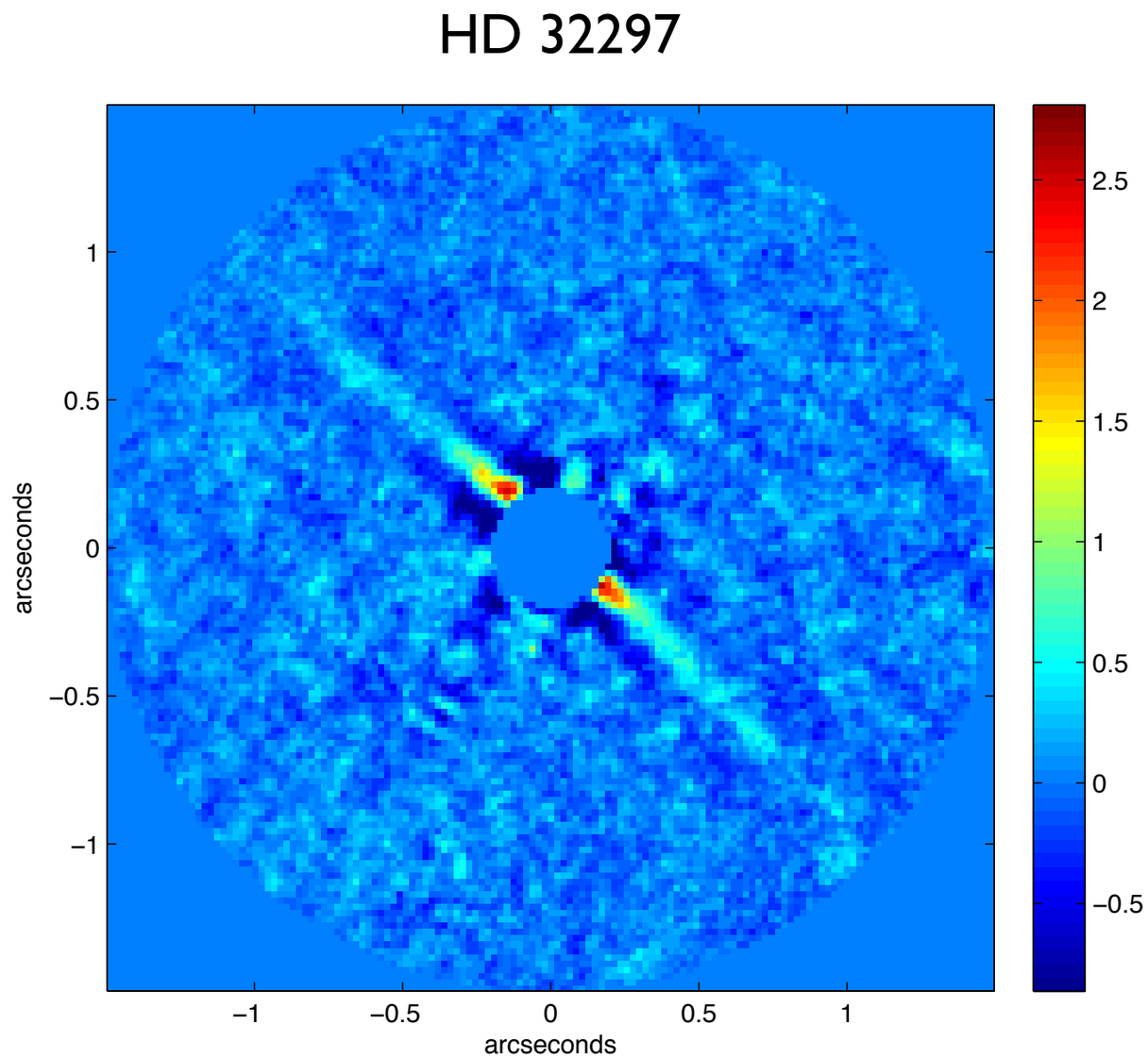
Ks

Currie et al. 2012,
Boccaletti et al. 2012



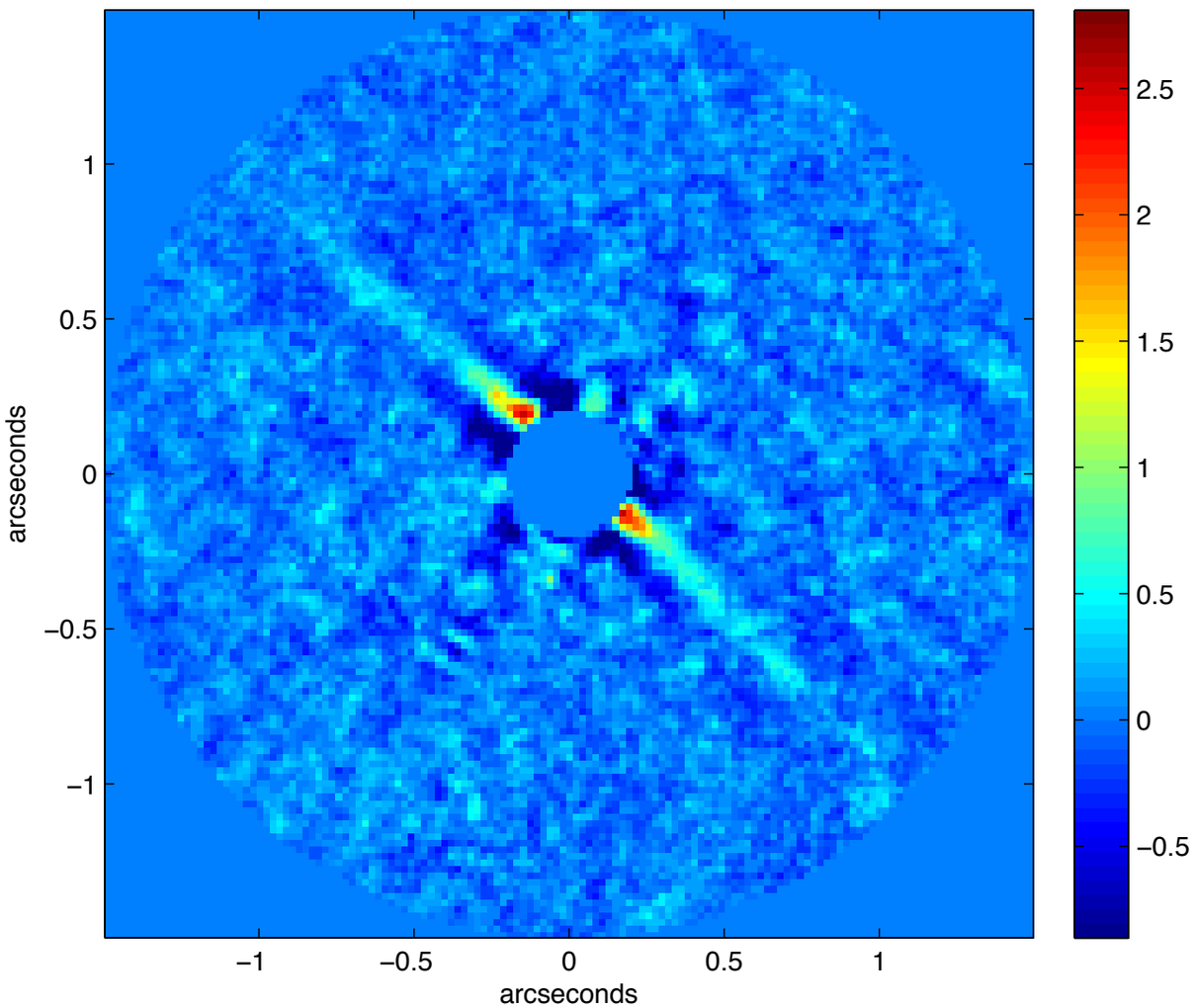
HD 32297 at L’

HD 32297 at L'


HD 32297
arcseconds
arcseconds
1
0.5
0
−0.5
−1
−1
−0.5
0
0.5
1
2.5
2
1.5
1
0.5
0
−0.5

HD 32297 at L'

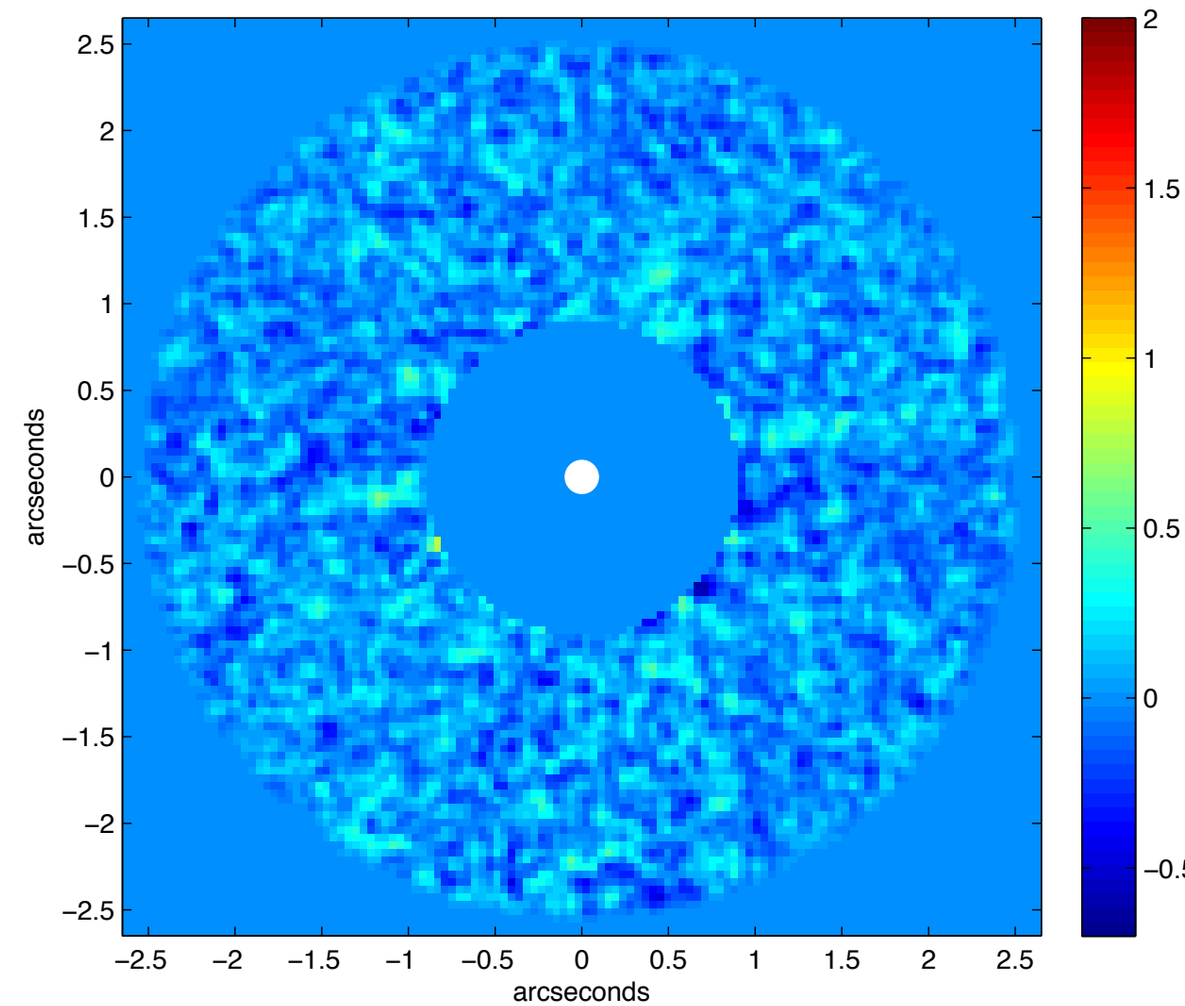
HD 32297



3 hour integration
80° rotation
new detector
400 modes AO

>>

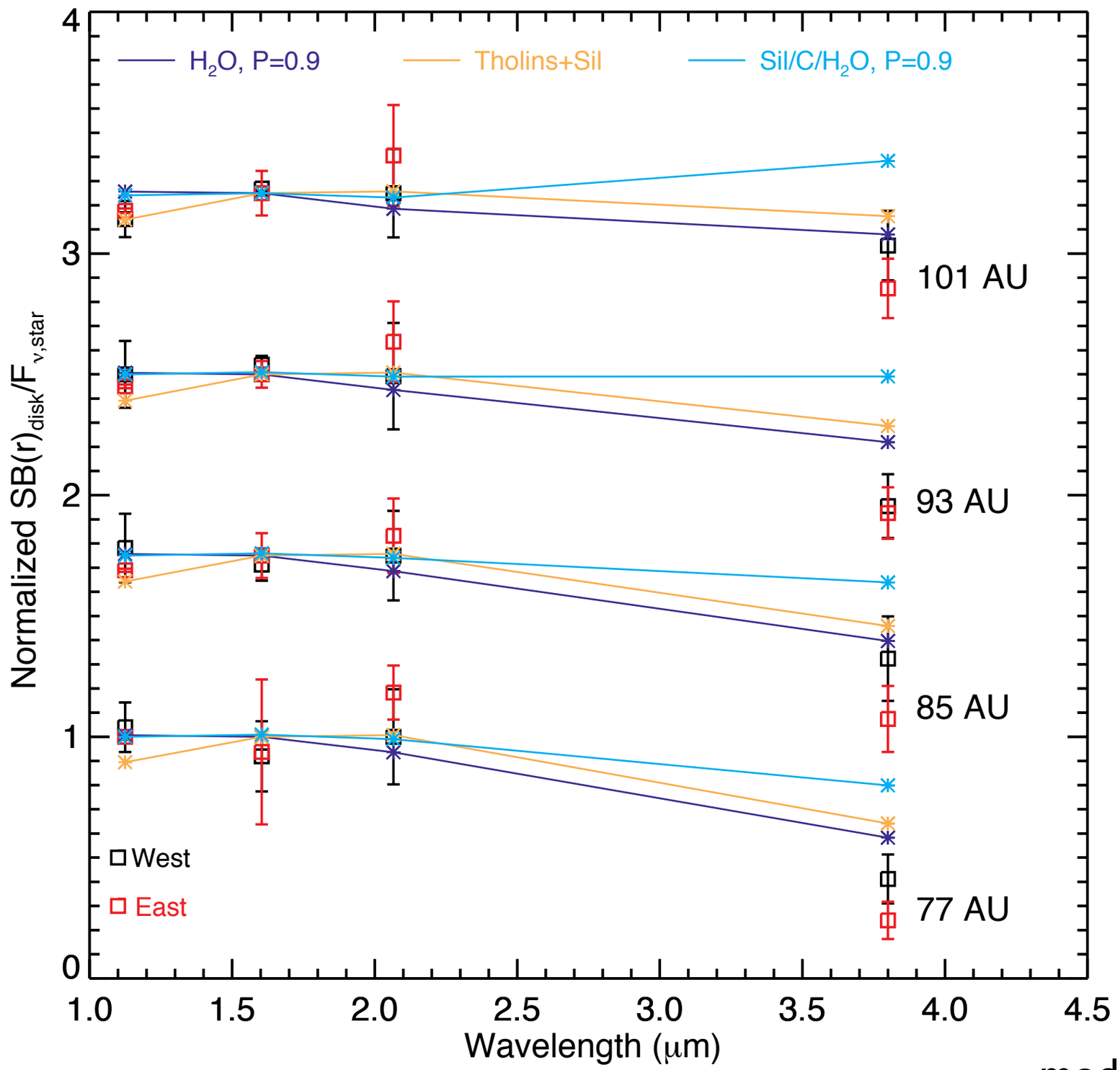
HD 15115



40 min integration
40° rotation
old detector
200 modes AO

Rodigas et al. 2013, in prep.

Preliminary dust modeling

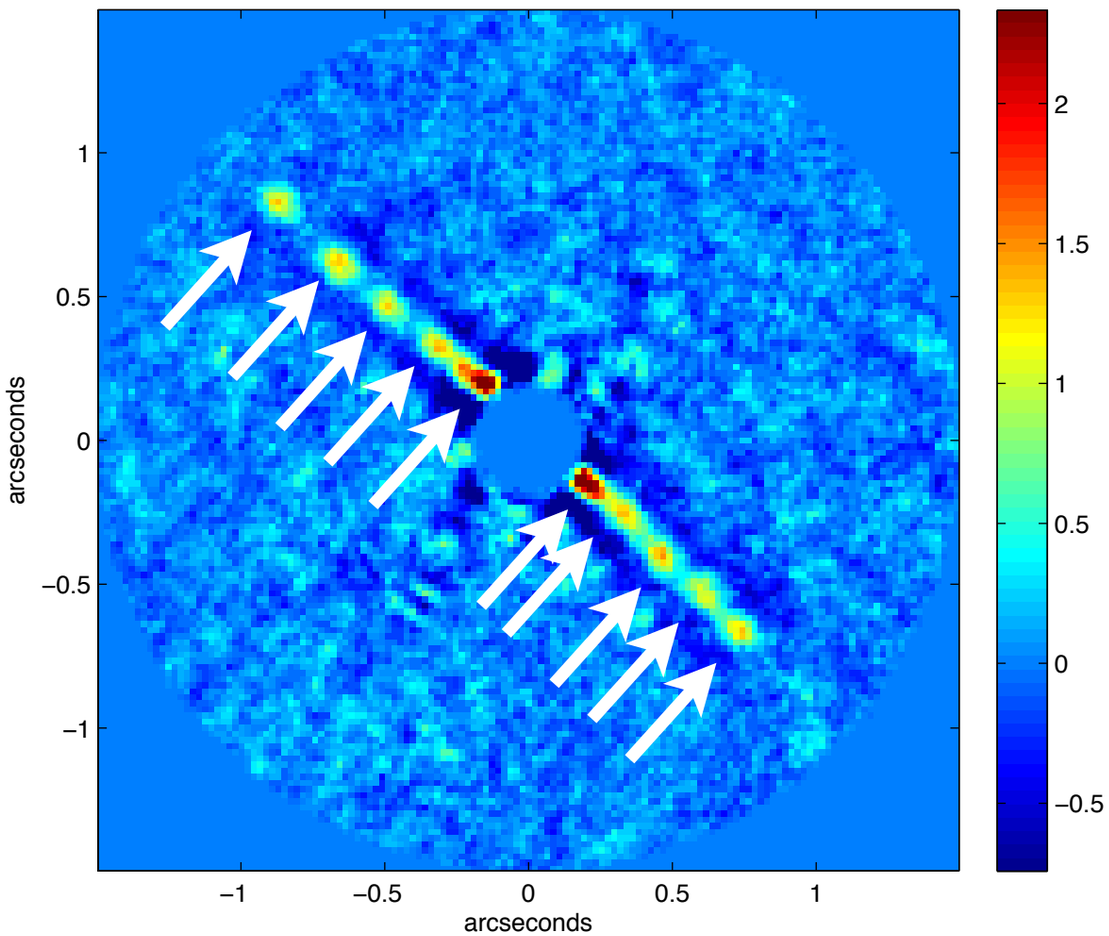


models from John Debes

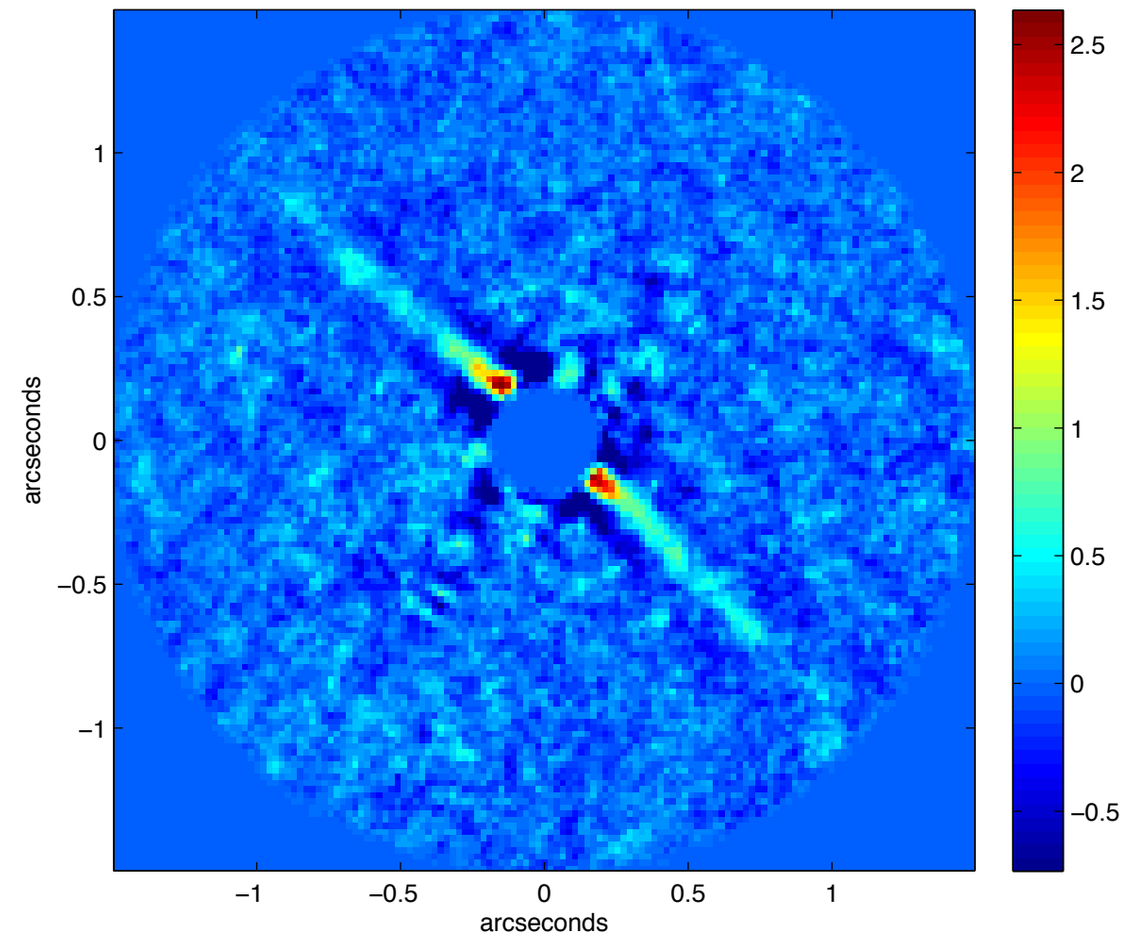
Rodigas et al. 2013, in prep.

Limits on planets

~3 MJ planets would have been recovered at >5σ confidence...outside of 0.45" (50 AU)



~1 MJ planets not detected



Summary

- HD 15115 (imaged at 2.15 & 3.8 μm)
  - bowed
  - might have gap
  - large grains
  - dynamically interacting with ISM
- HD 32297 (imaged at 3.8 μm)
  - Preliminary models: pure water ice or tholins/silicates preferred (so far)