High-contrast imaging of exoplanet Beta Pictoris b with Magellan AO: Simultaneous 0.9-5µm observations with VisAO and Clio

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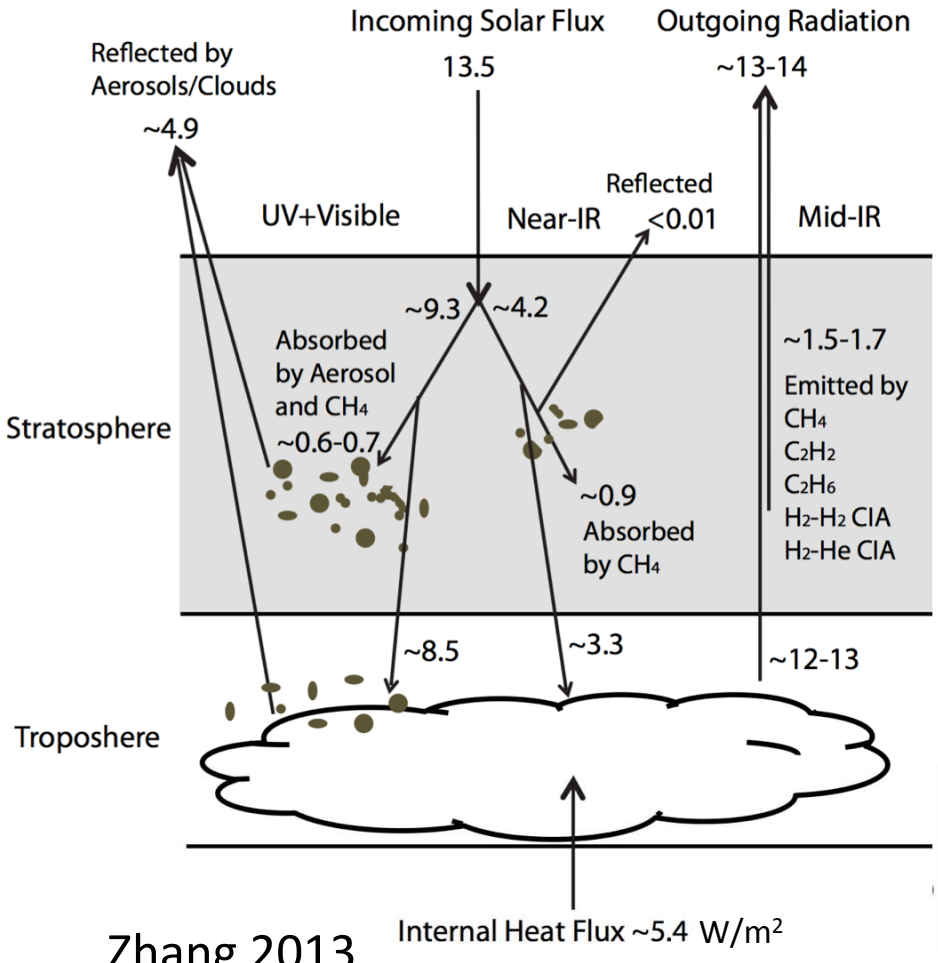
Marco Xompero, Runa Briguglio, Carmelo Arcidiacono, Fernando
Quiros-Pacheco, Javier Argomedo, Lorenzo Busoni
(Arcetri Observatory);
Alan Uomoto, Tyson Hare (Carnegie Observatories)

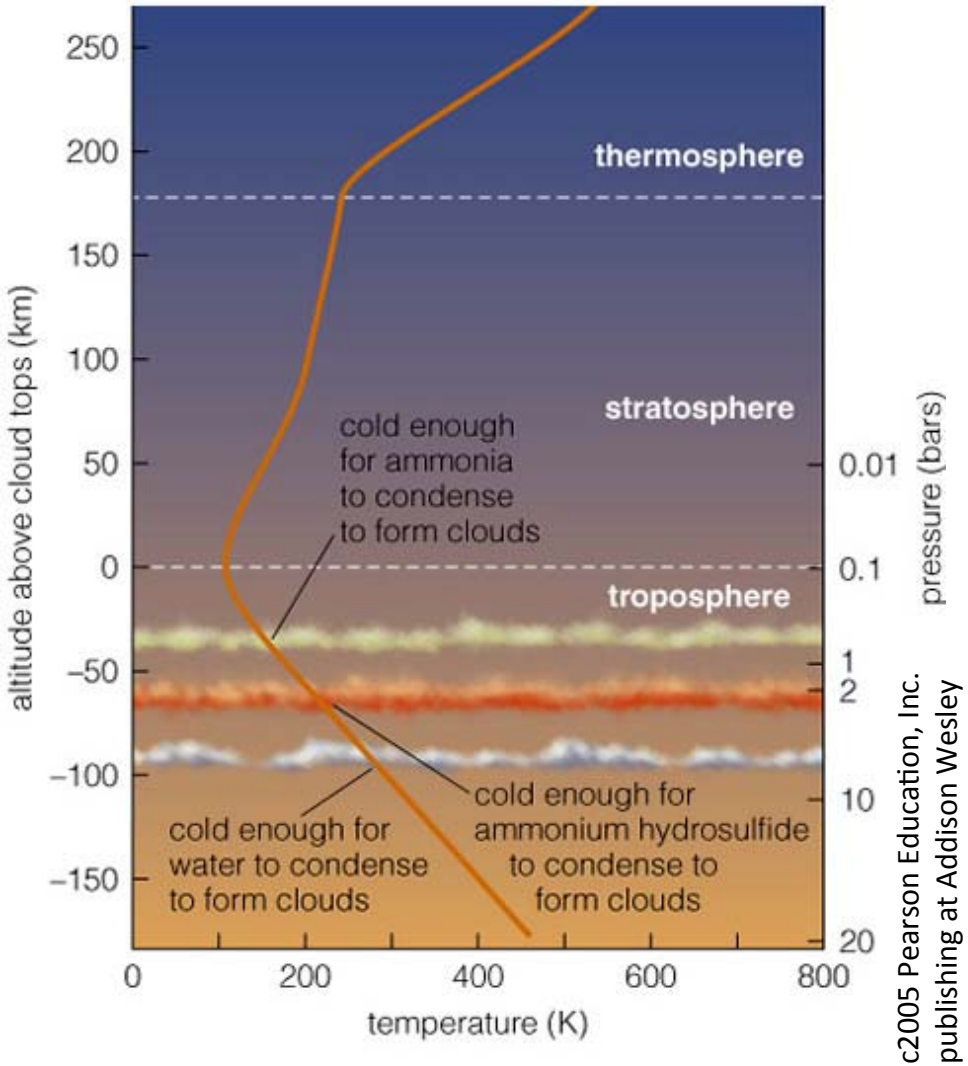
MagAO

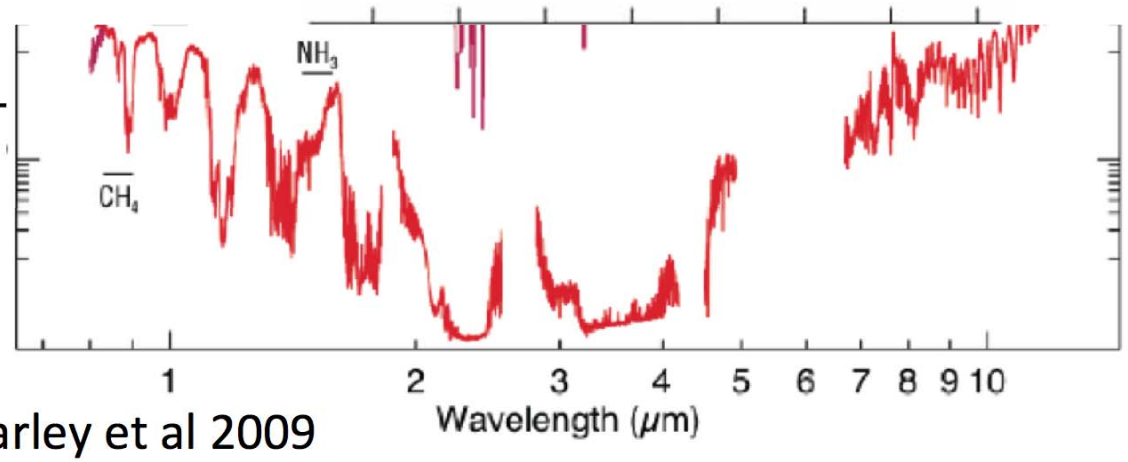
magao.as.arizona.edu

Jupiter's atmosphere



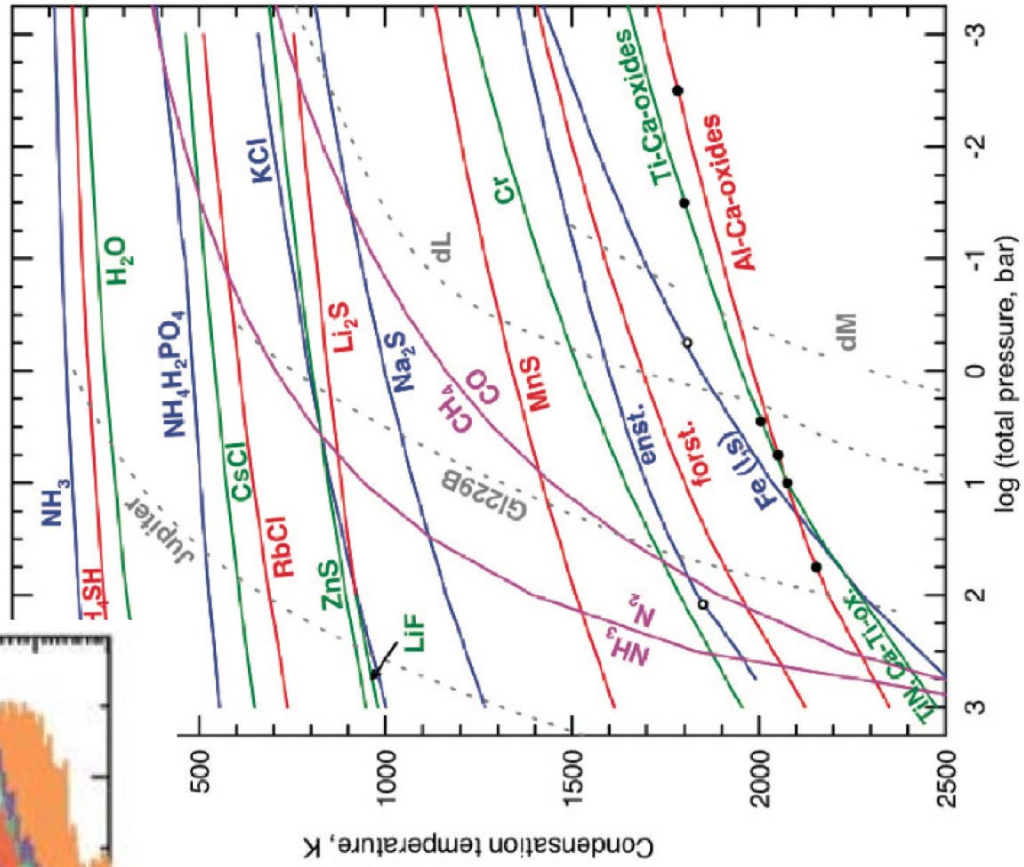
Zhang 2013



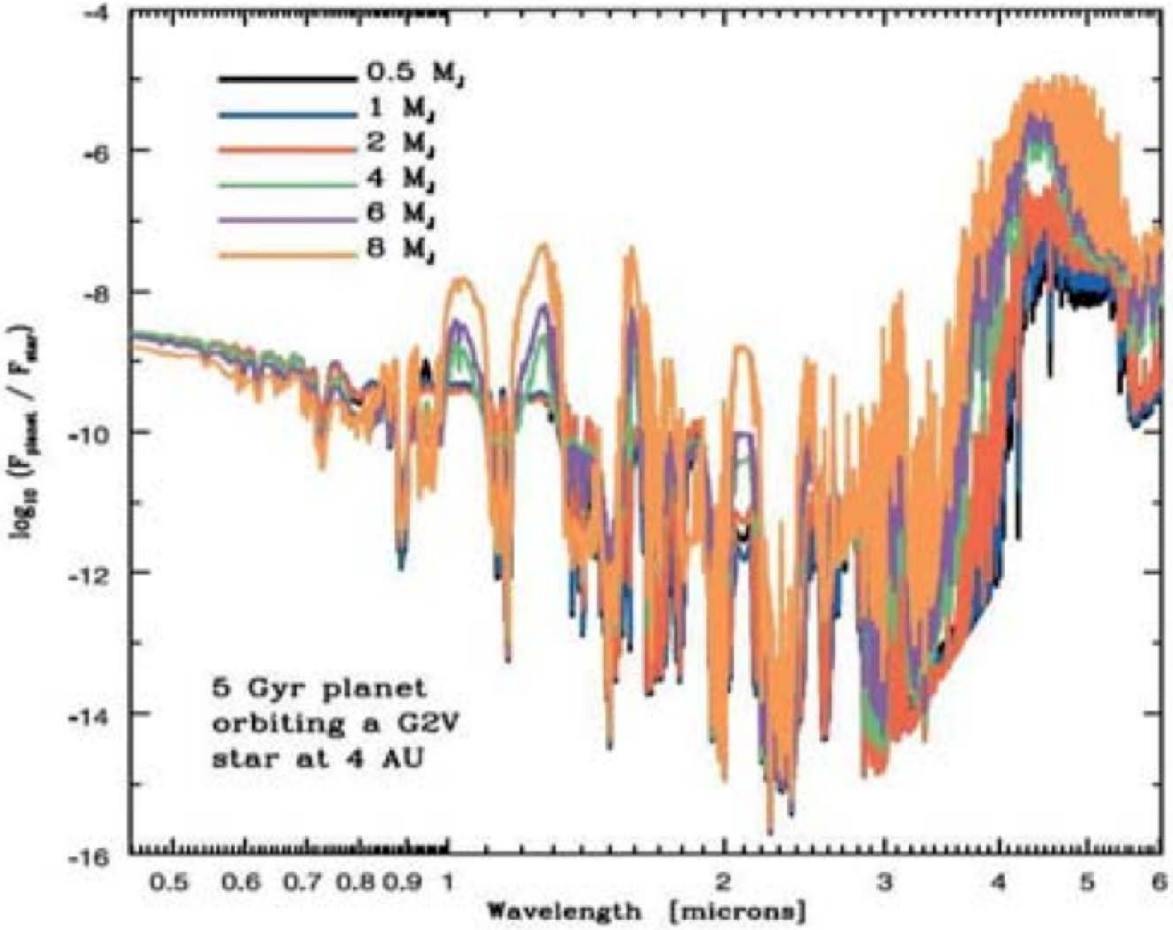


Marley et al 2009

Jupiter-like exoplanet atmospheres

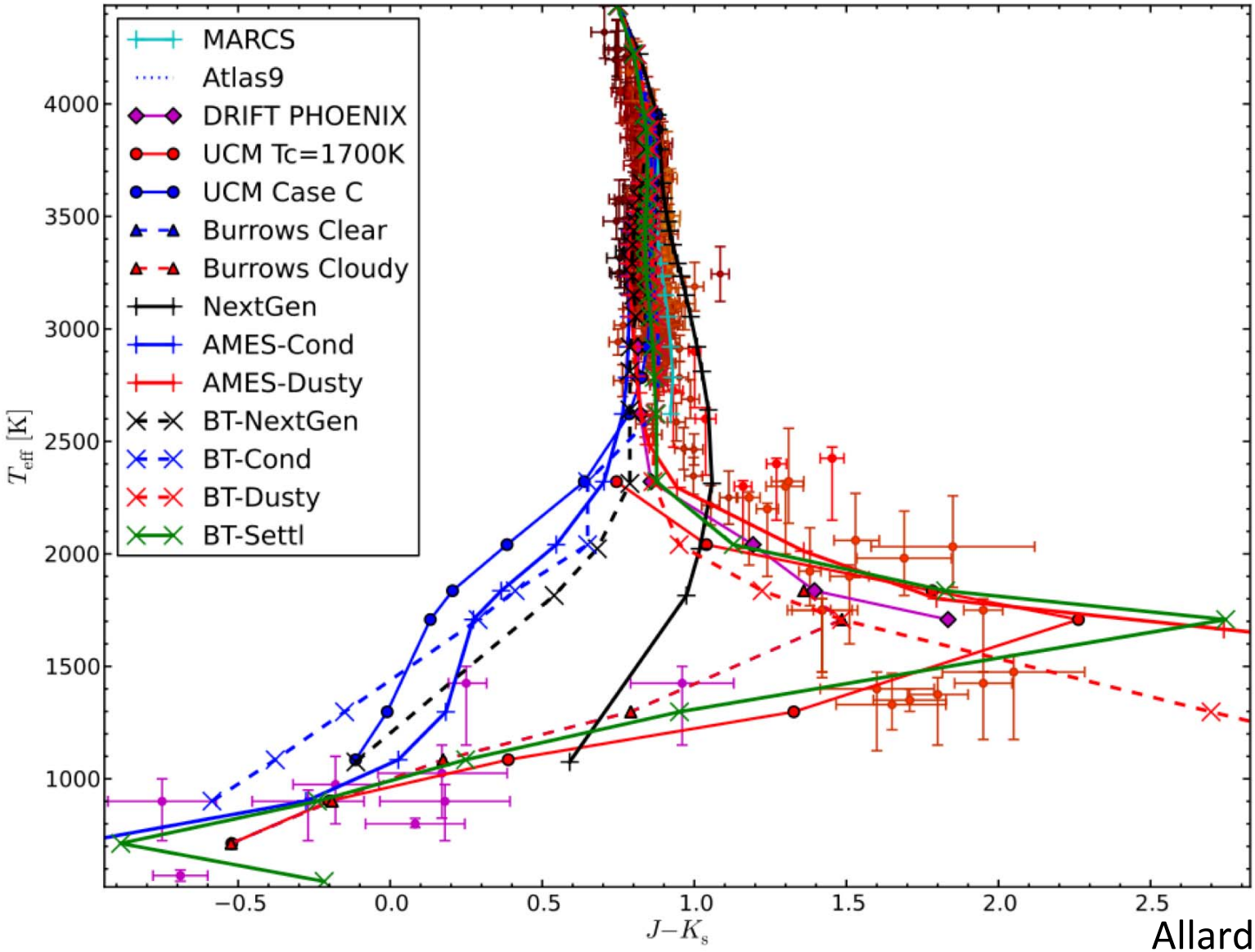


Marley et al 2009



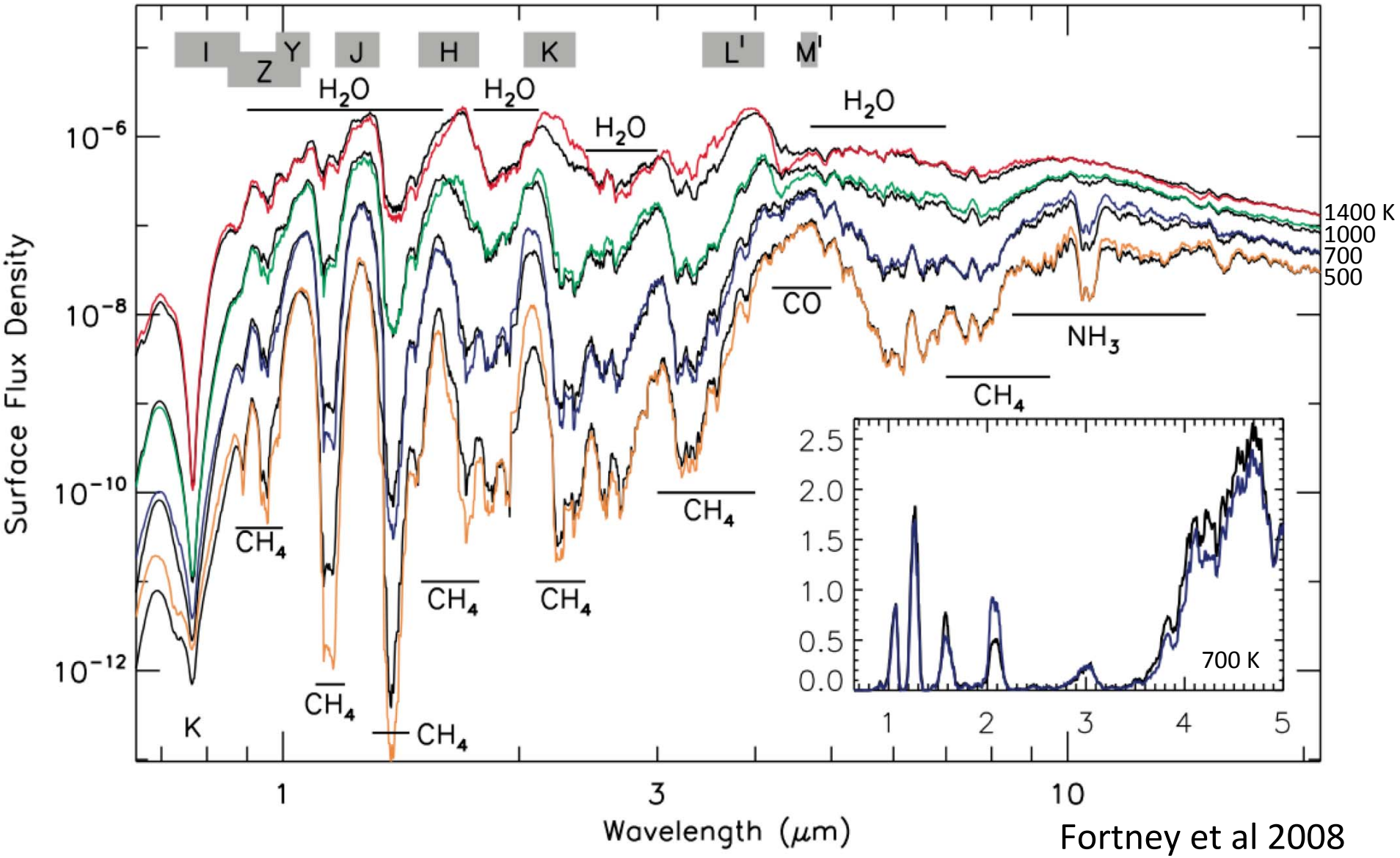
Burrows et al 2005

Models vary in opacities, abundances, clouds, metallicity, chemistry, dynamics



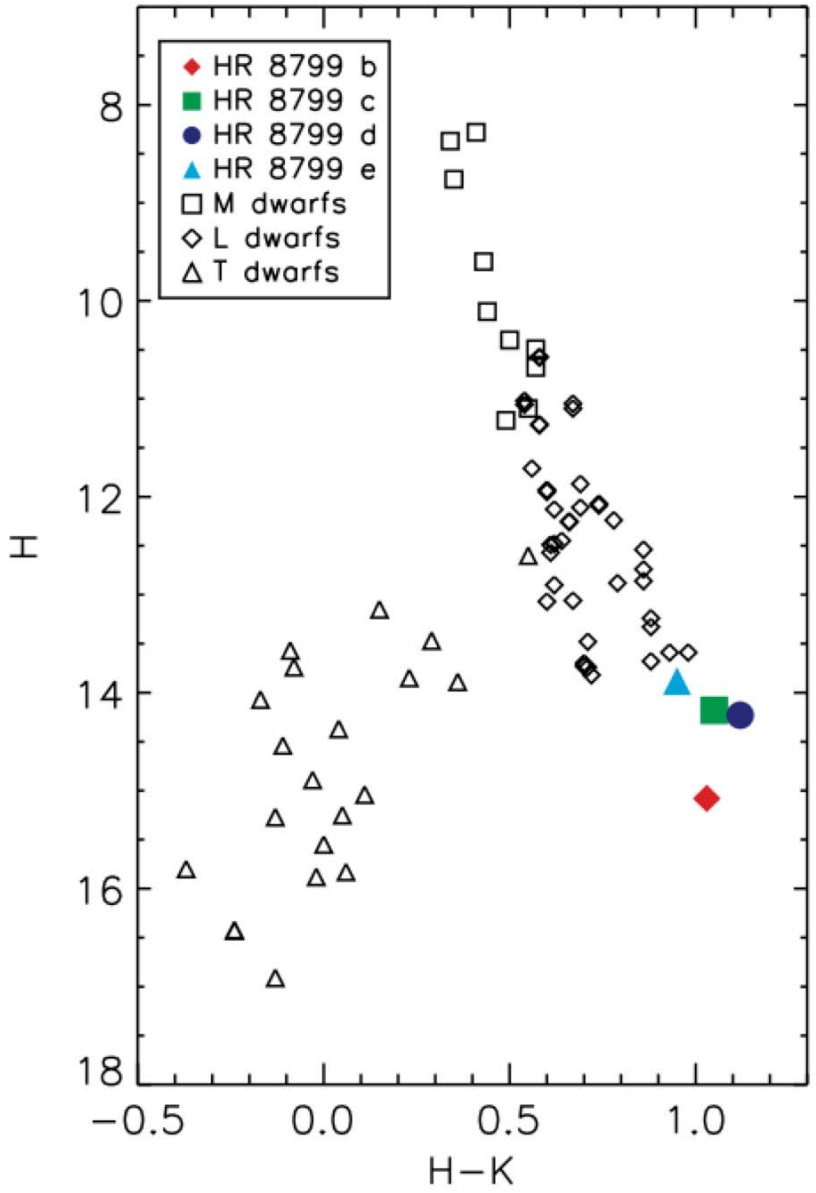
Allard et al 2013

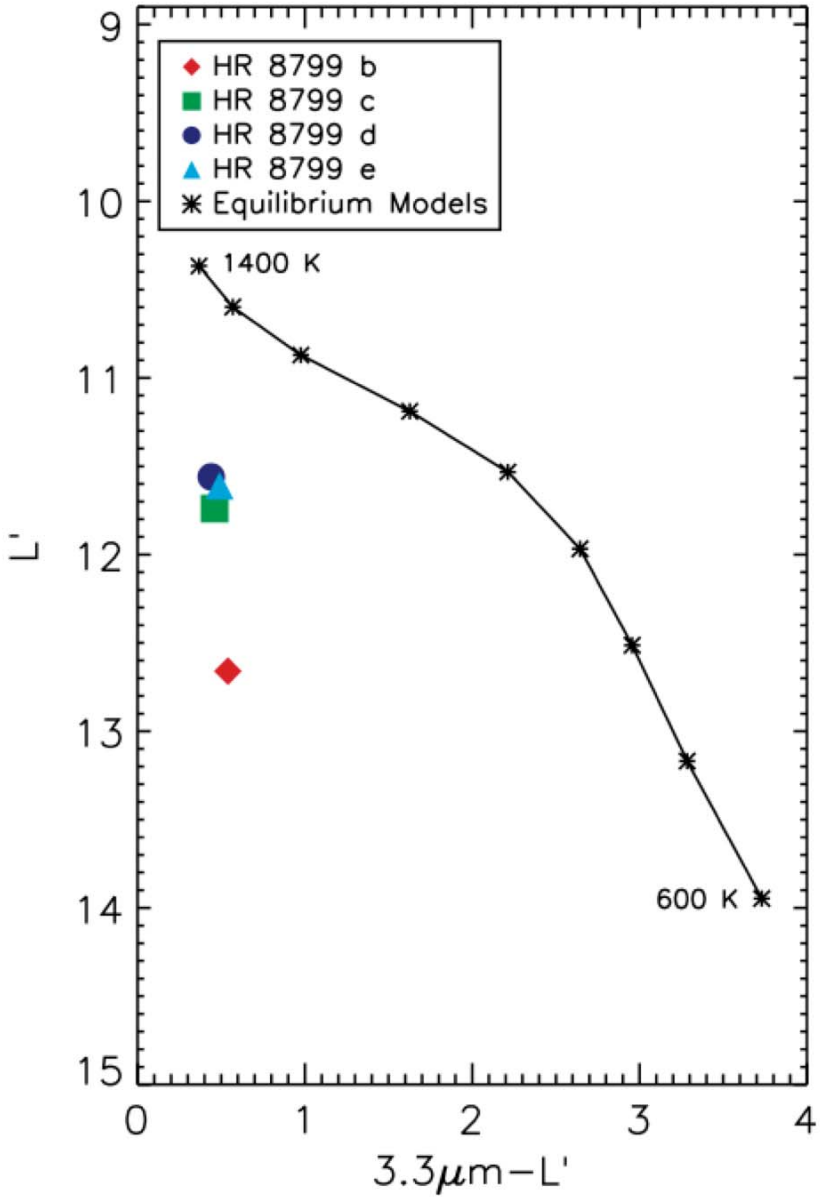
Models require more data with increased wavelength coverage



Fortney et al 2008

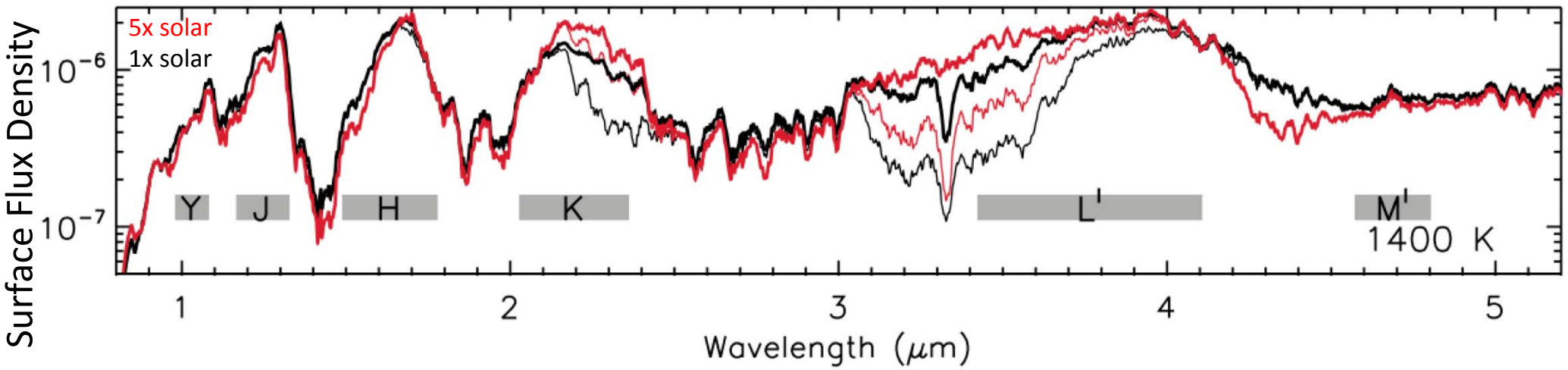
Adding thermal IR: Equilibrium chemistry models underpredict the HR 8799 planets' 3.3um fluxes



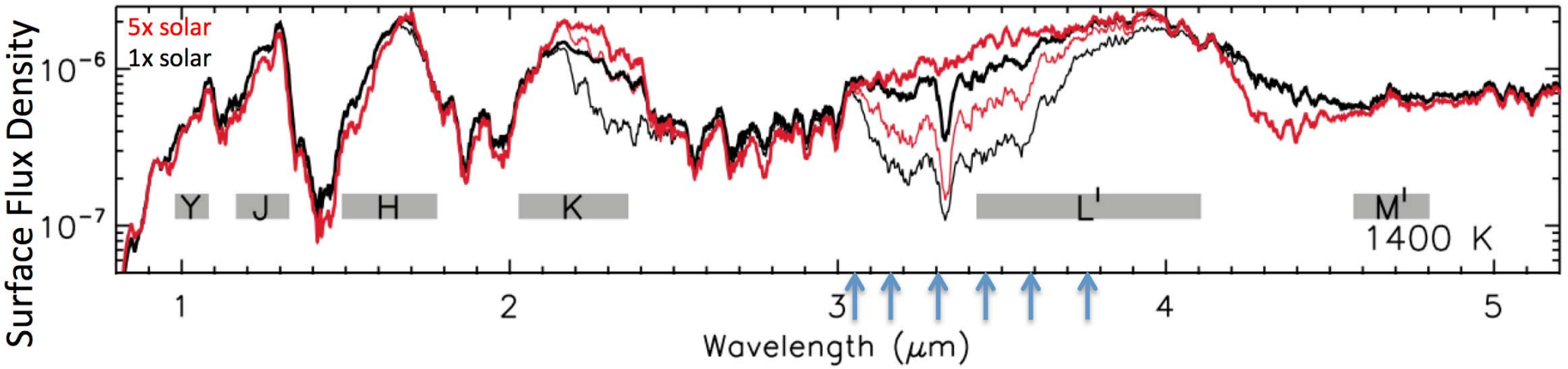


Skemer et al 2012

Thermal IR is critical for constraining cooler-effective-temperature planets



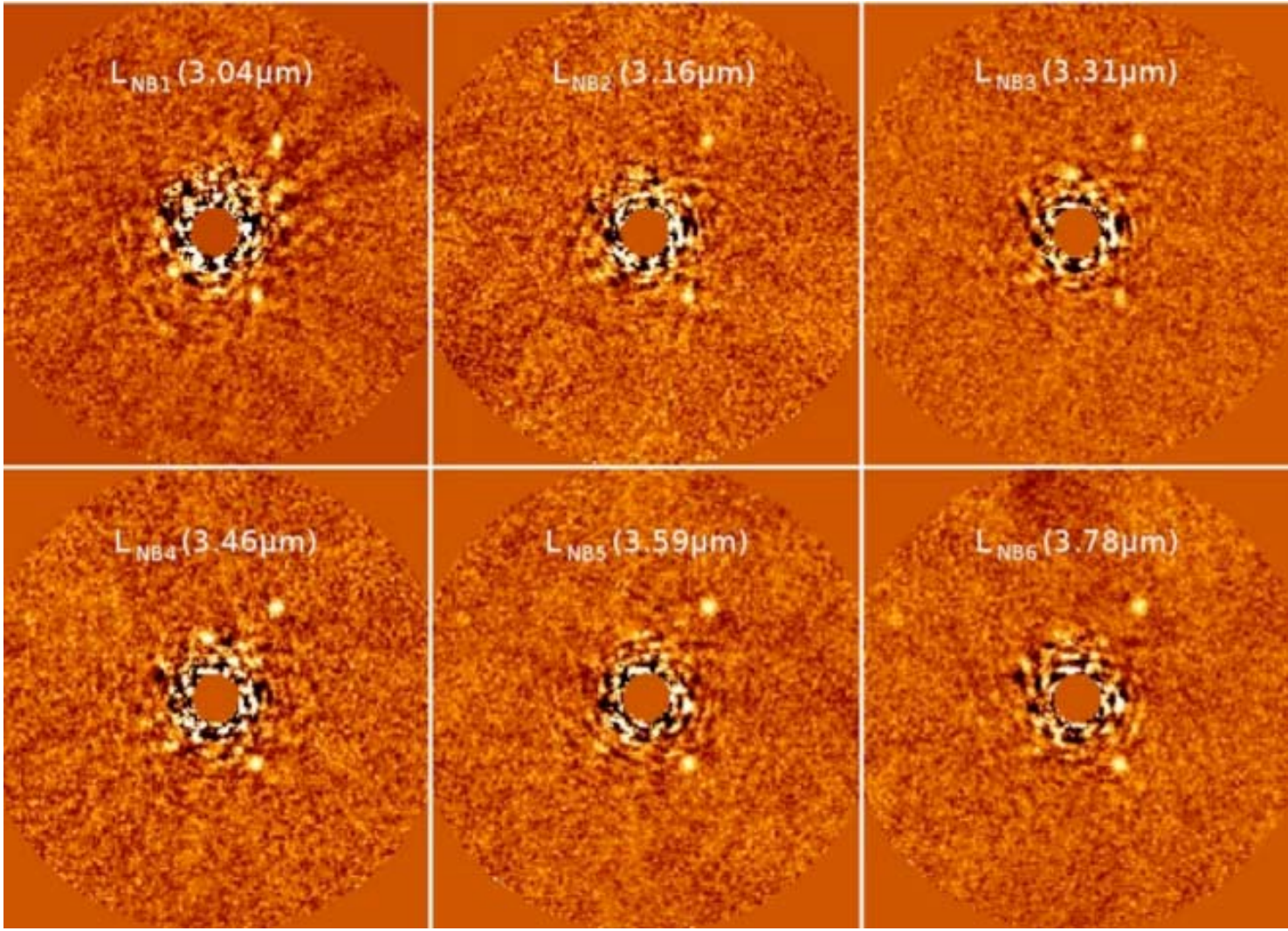
Fortney et al 2008



Andy Skemer
LBT AO

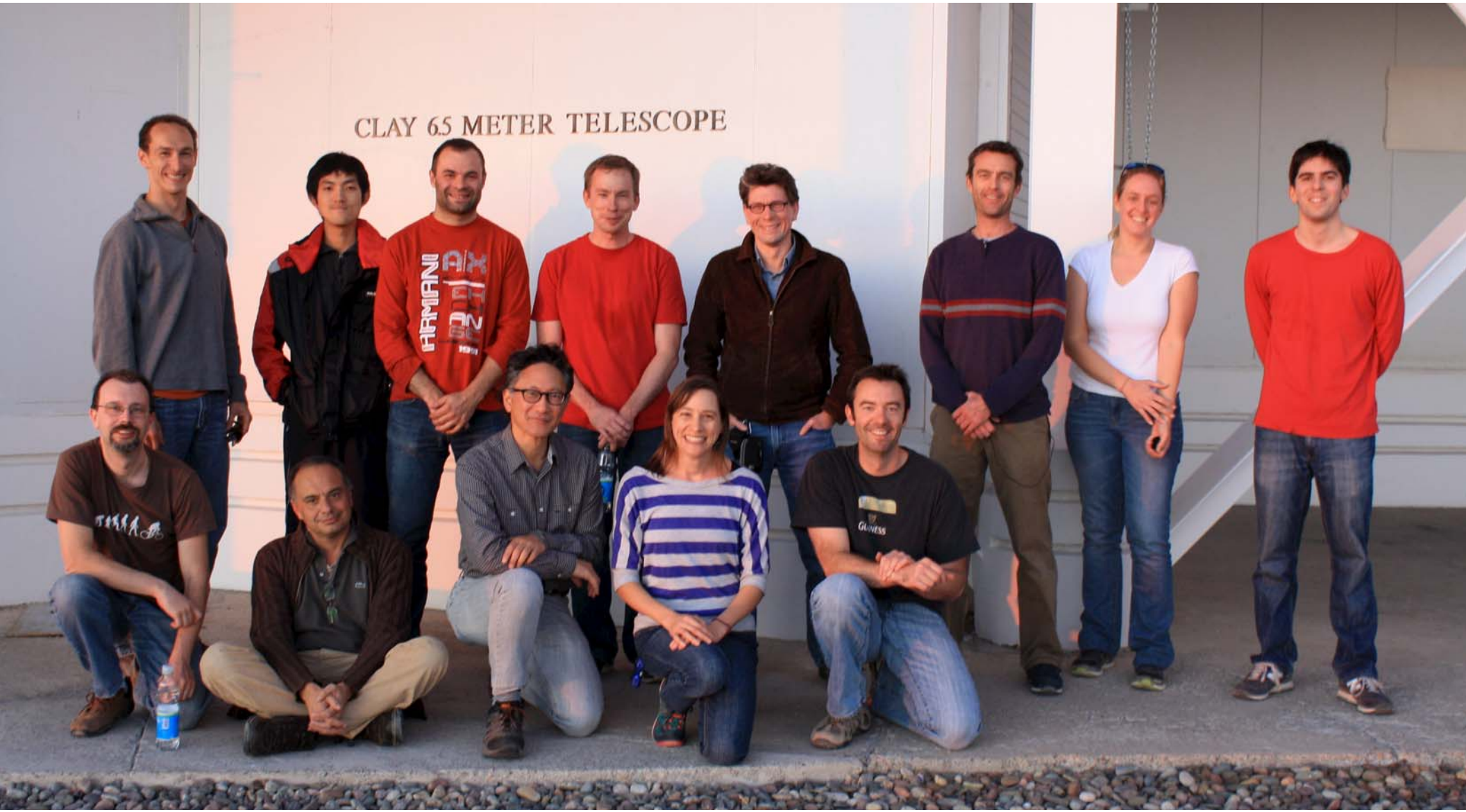
Skemer et al 2013 in prep

Poster #1.37



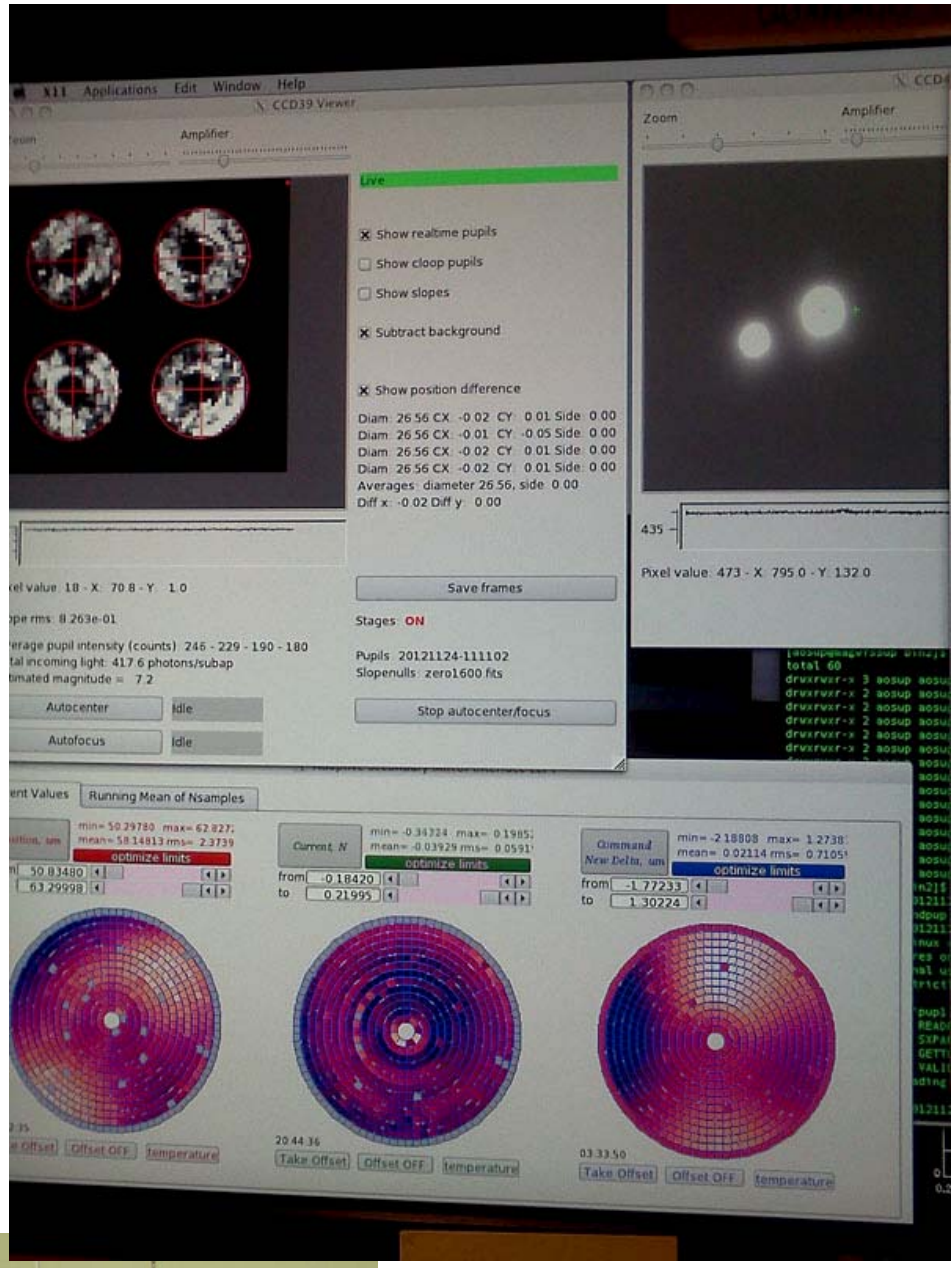
MagAO is on the 6.5-m Magellan Clay telescope at Las Companas Observatory, Chile

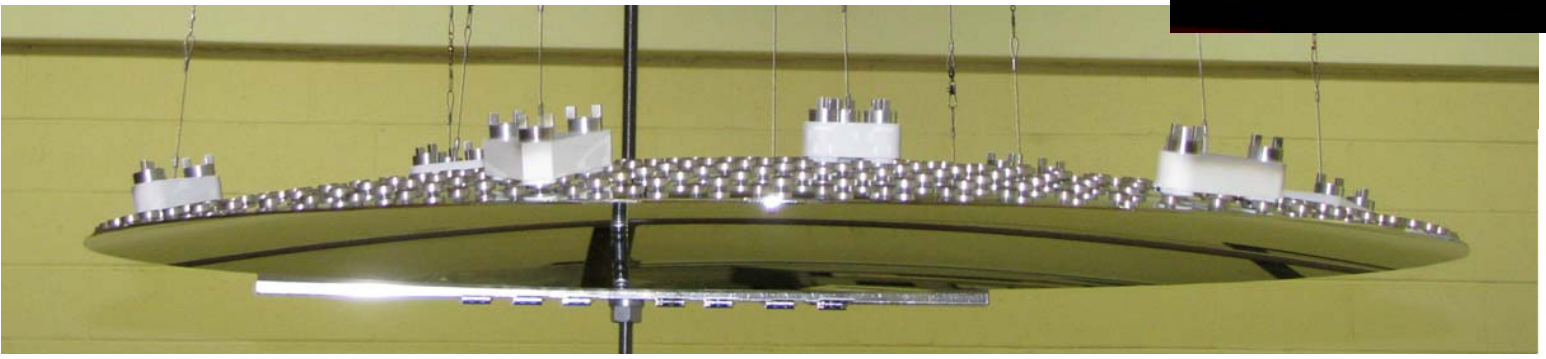
Team of astronomers from Steward Observatory (University of Arizona, Tucson), Arcetri Observatory (INAF, Florence), and Carnegie Observatories



MagAO

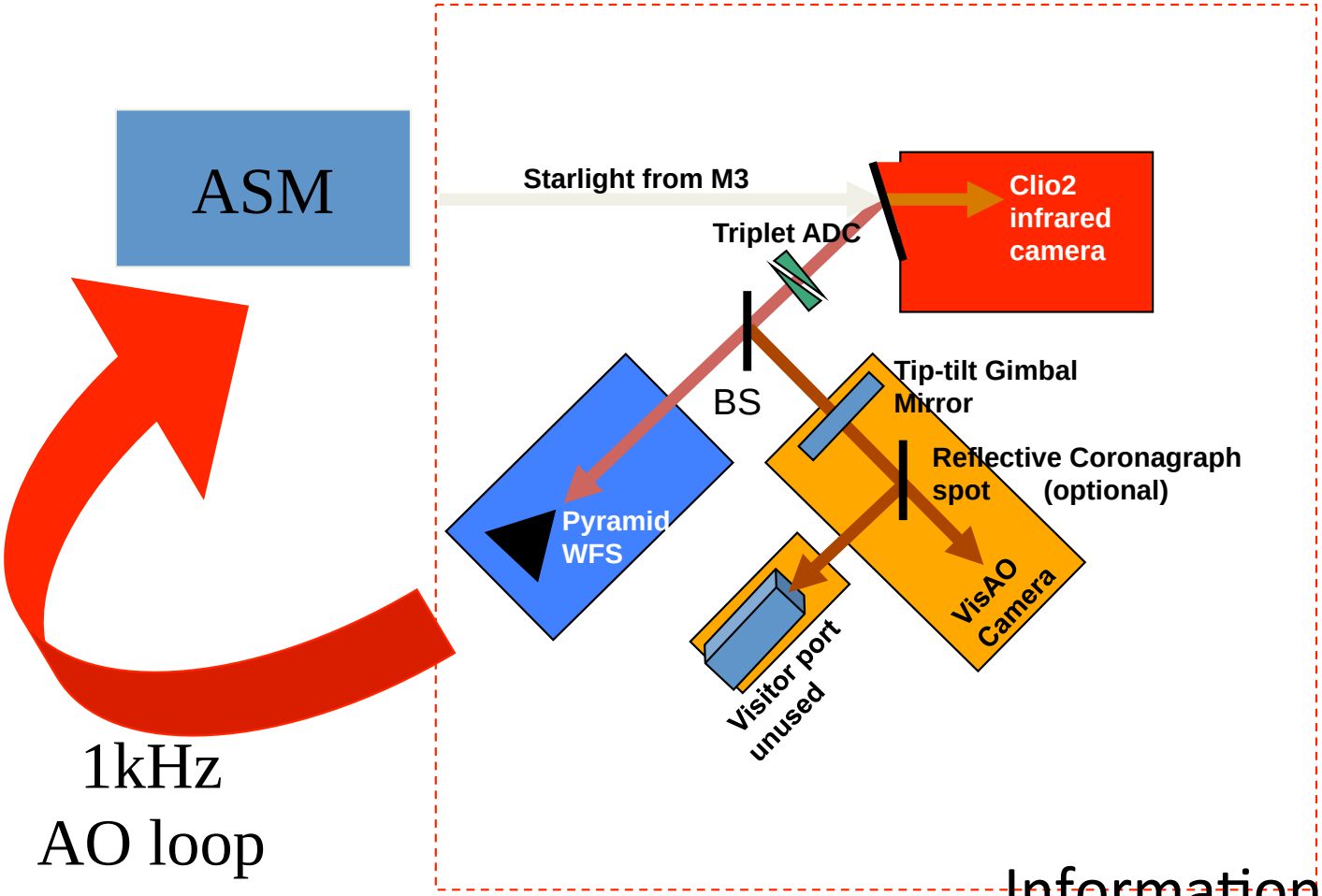
- NGS Modulating Pyramid WFS
  - 21-378 modes
  - 100-1000 Hz
  - Limiting mag:
    - *R*~14 @ <1µm
    - *R*~16.5 @ 2-5µm
- Adaptive-Secondary Mirror
  - 561 illuminated actuators
  - *d* = 23 cm
- Control
  - Modal gain: tip/tilt, low-order, high-order
  - Selectable subap. size via pix. binning





MagAO

MagAO has two co-mounted science cameras: VisAO for r', i', z', Y_s and Clio for J H K_s L' M'



VisAO:
8 mas pixels, 8x8'' FoV
Imaging, SDI

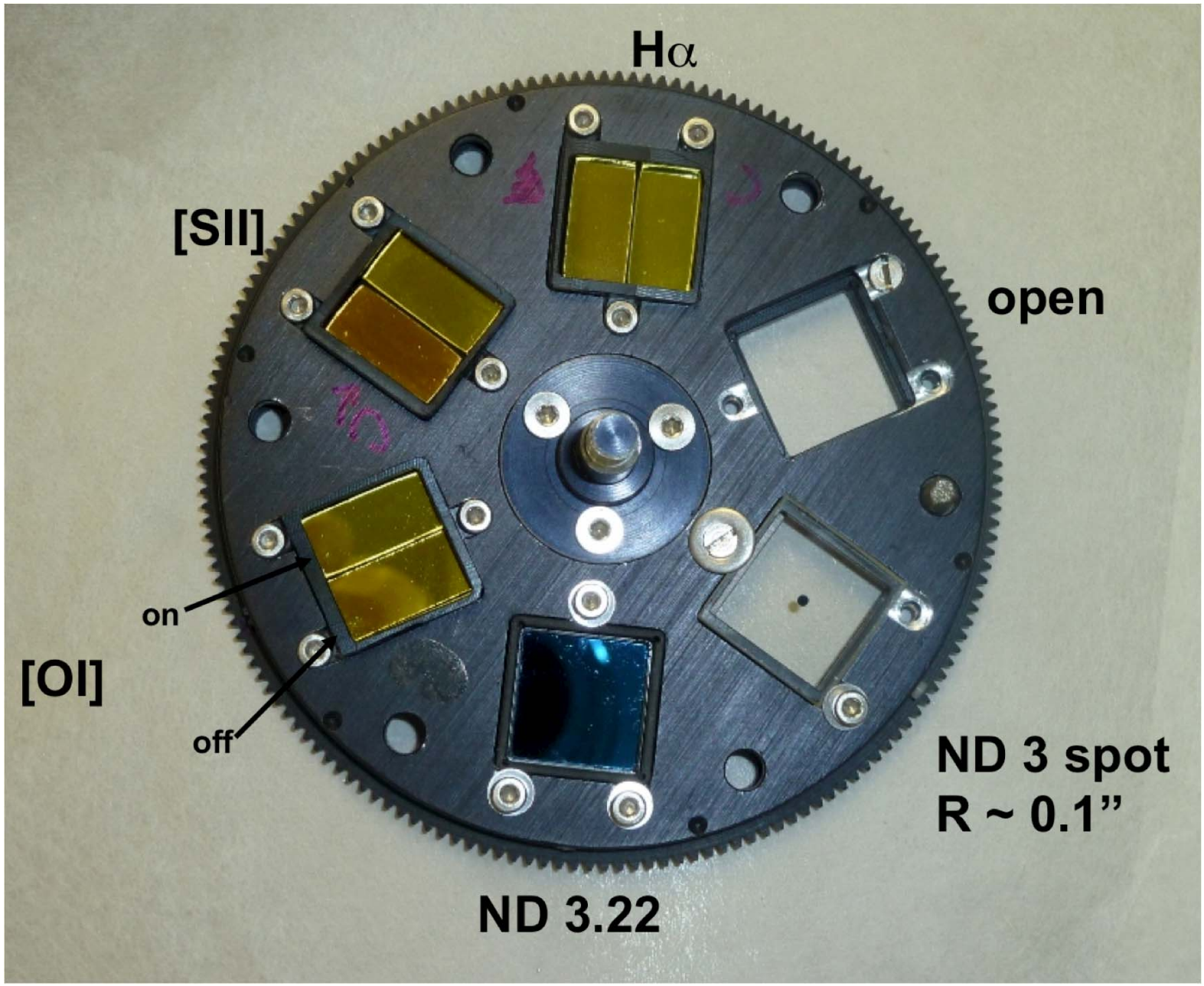
Clio:
16 mas pixels, 16x8'' FoV
27 mas pixels, 28x14'' FoV
Imaging, NRM, APP, Prism

Information for Observers:
magao.as.arizona.edu/observers

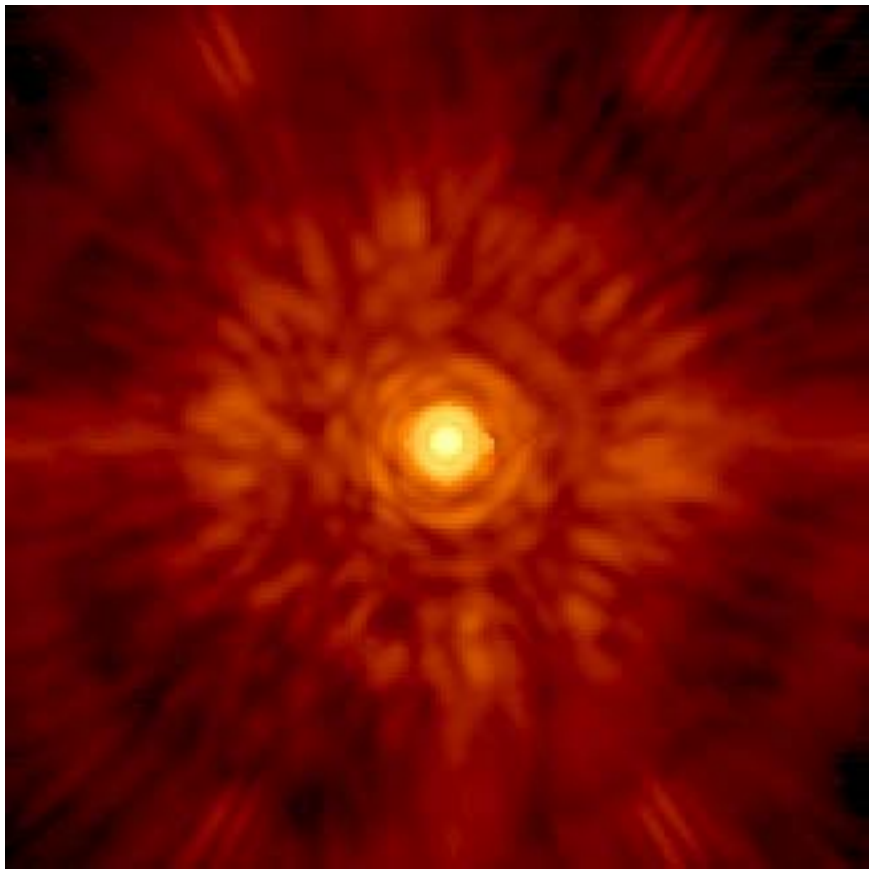
VisAO: 0.55 – 1.1 µm science

r’
i’
z’
Y_s

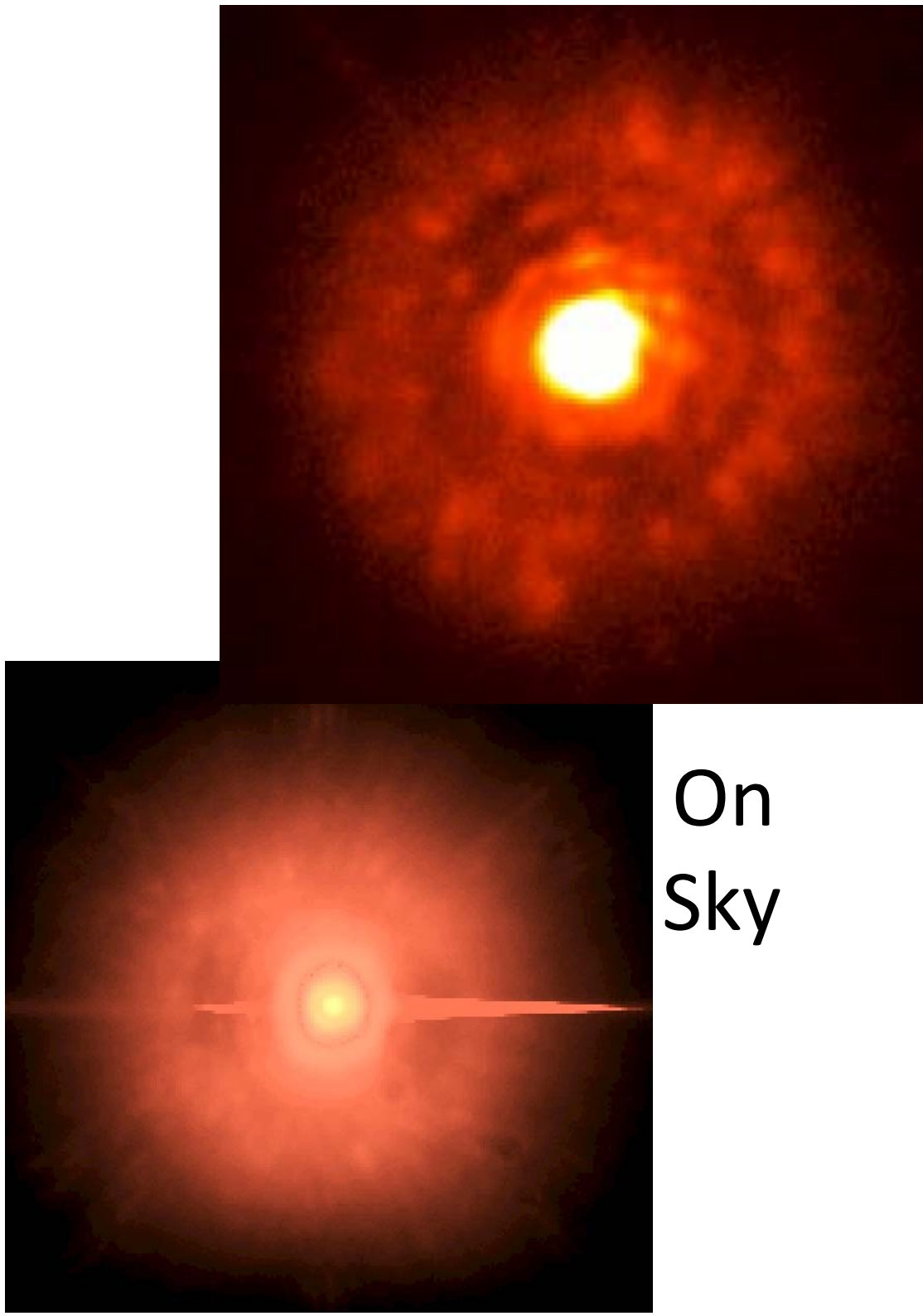
Hα
[SII]
[OI]



VisAO PSF

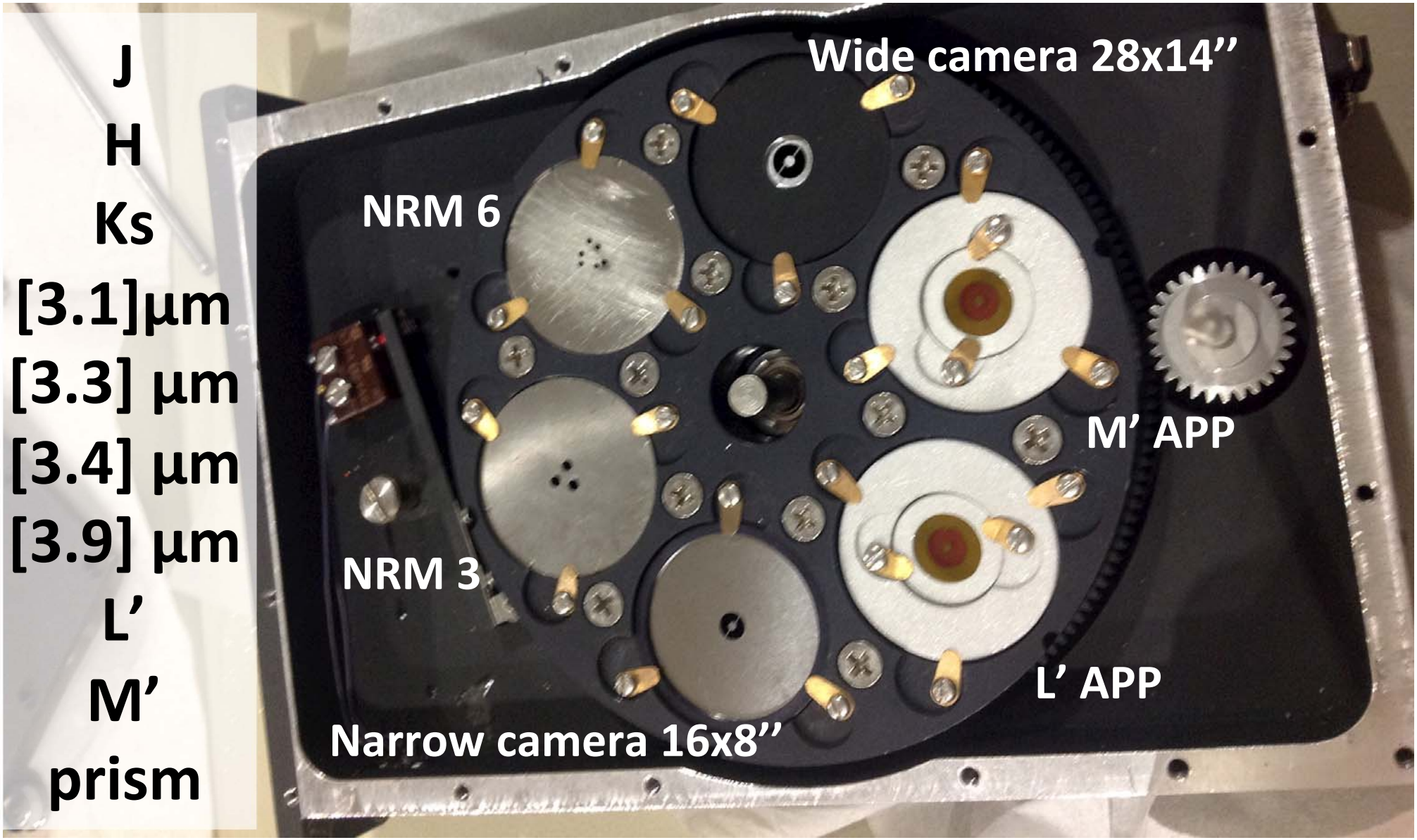


Lab

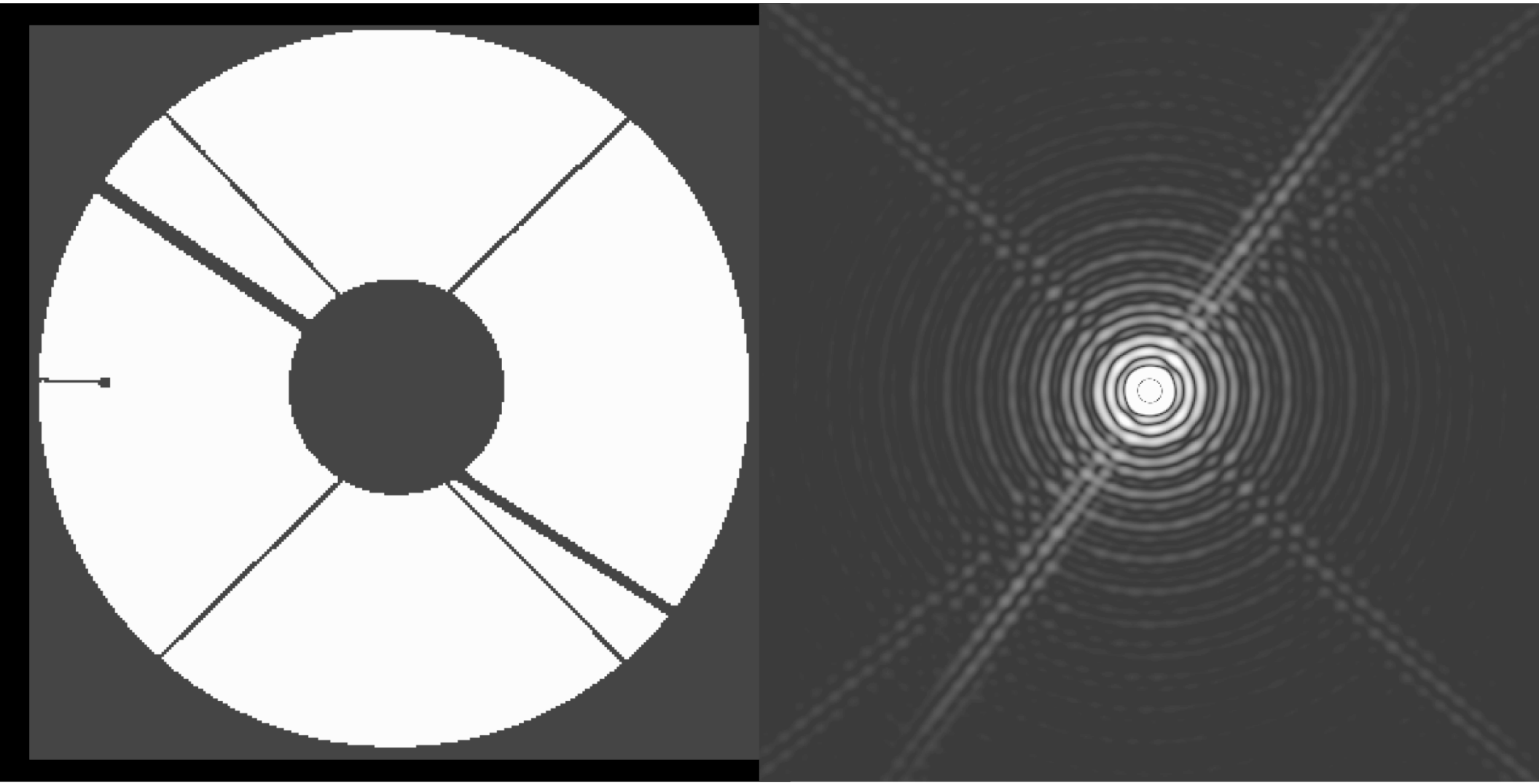


On Sky

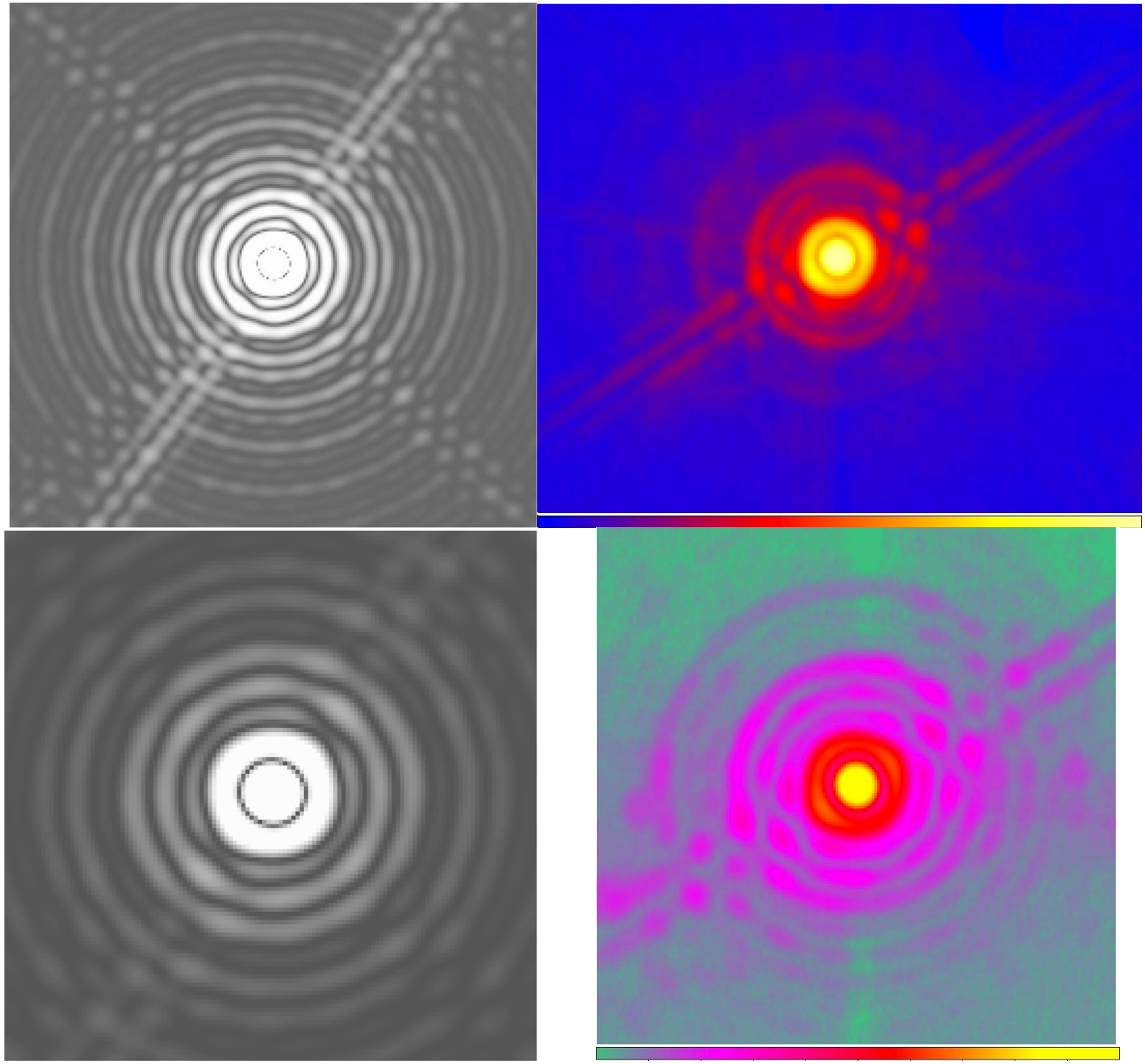
Clio: 1 – 5 µm science



Pupil and theoretical PSF



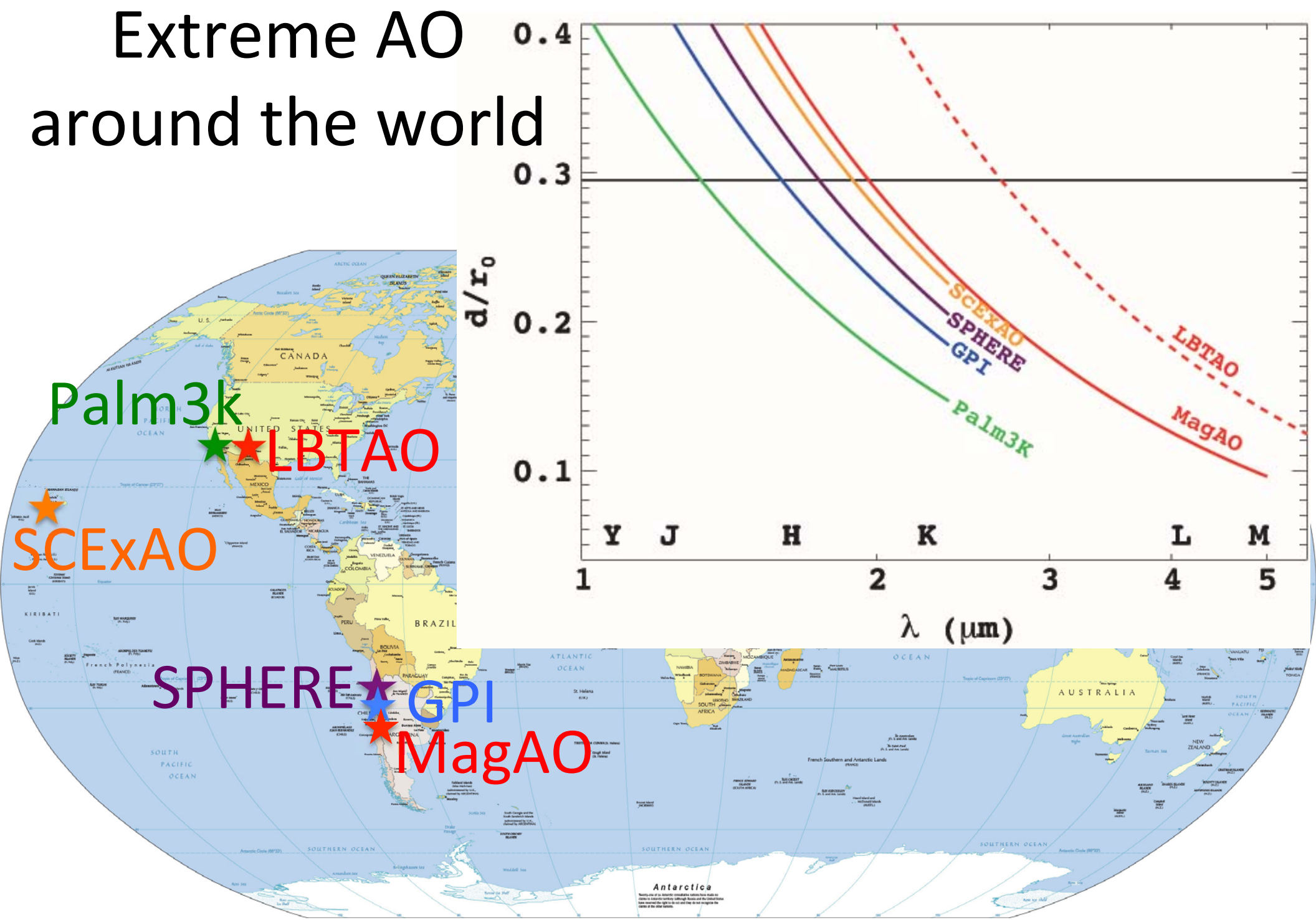
Clio
3–5
μm
PSFs



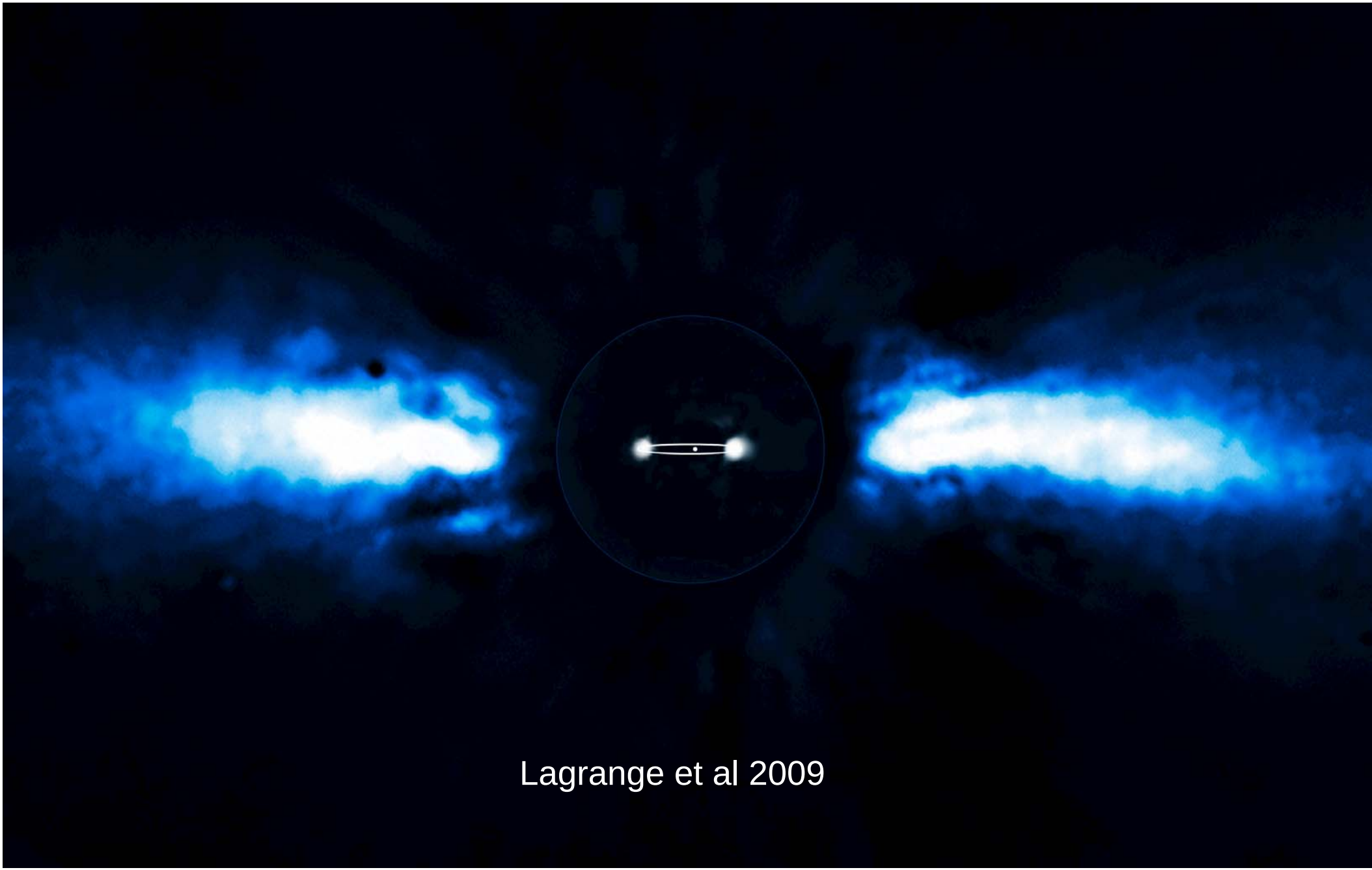
Model

Data

Extreme AO around the world

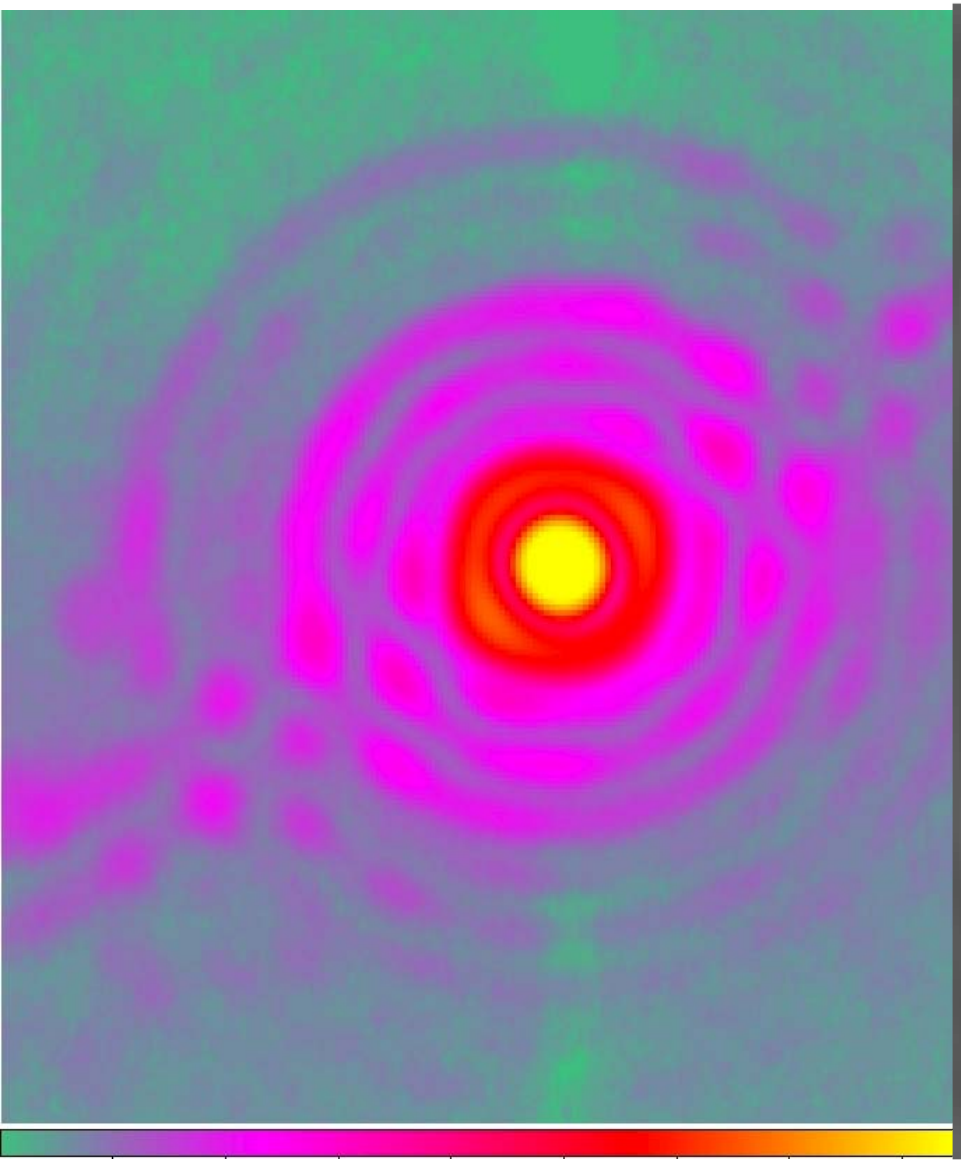


β Pictoris b

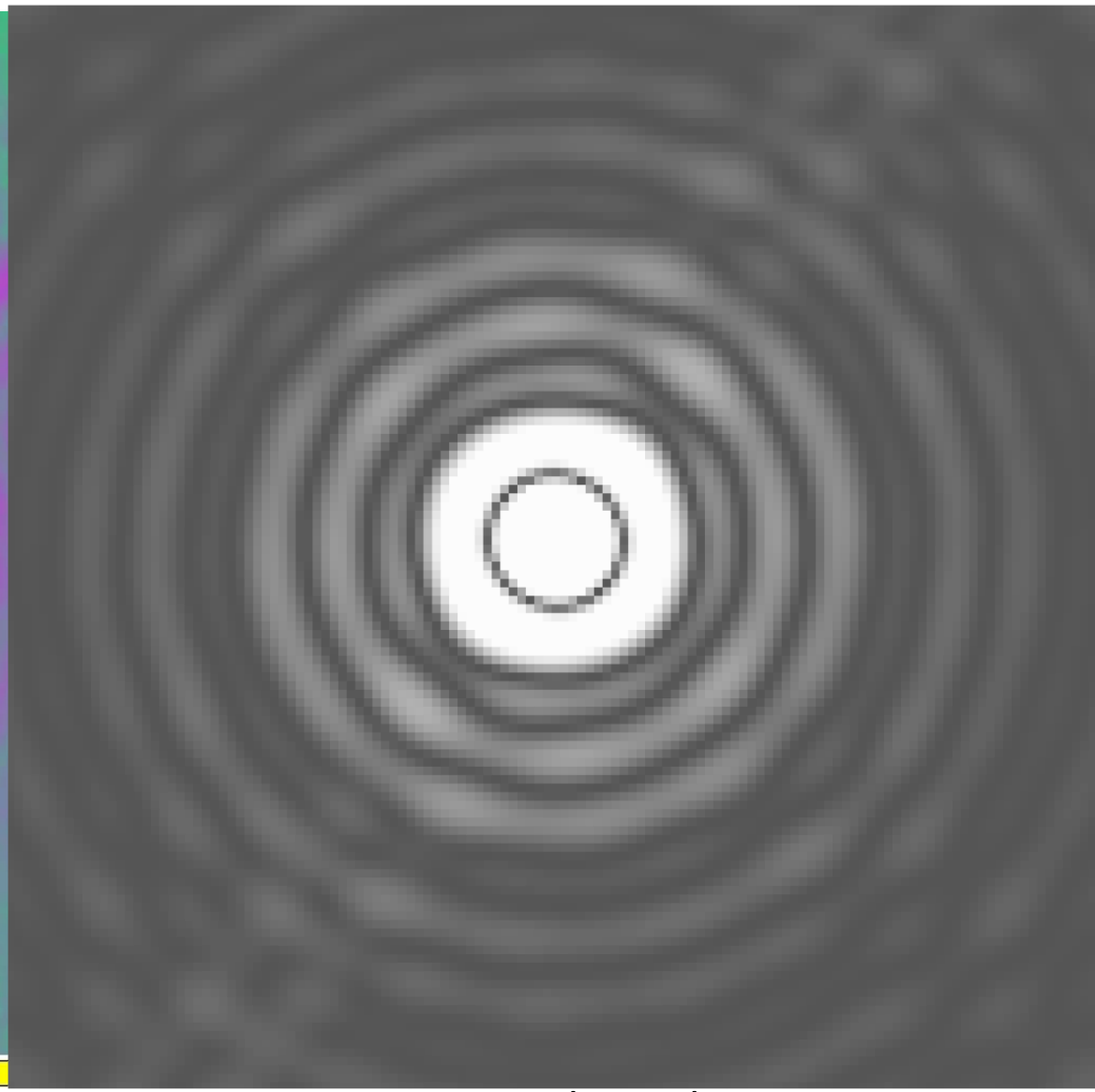


Lagrange et al 2009

Clio – βPic – M’



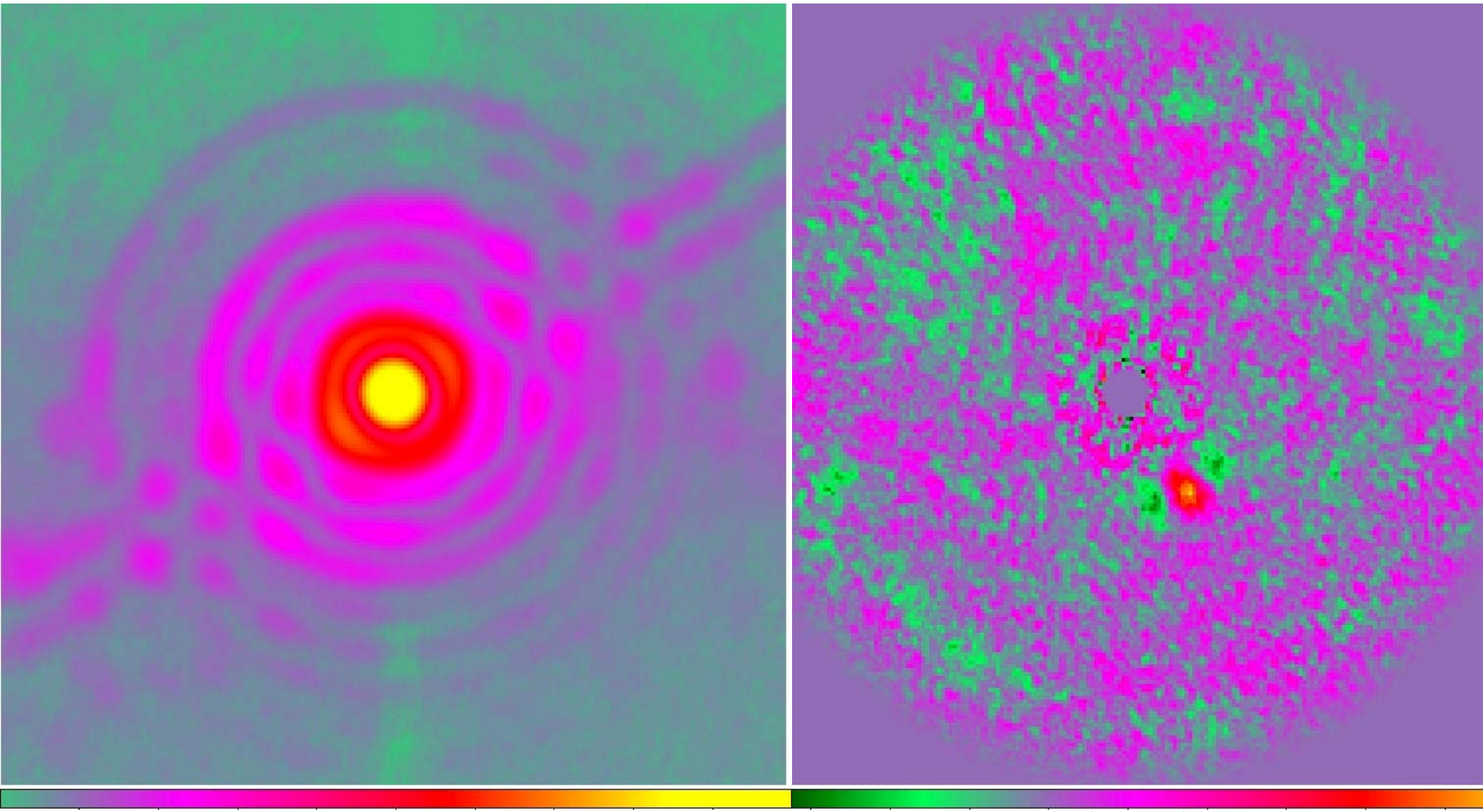
Data



Morzinski et al 2013 in prep

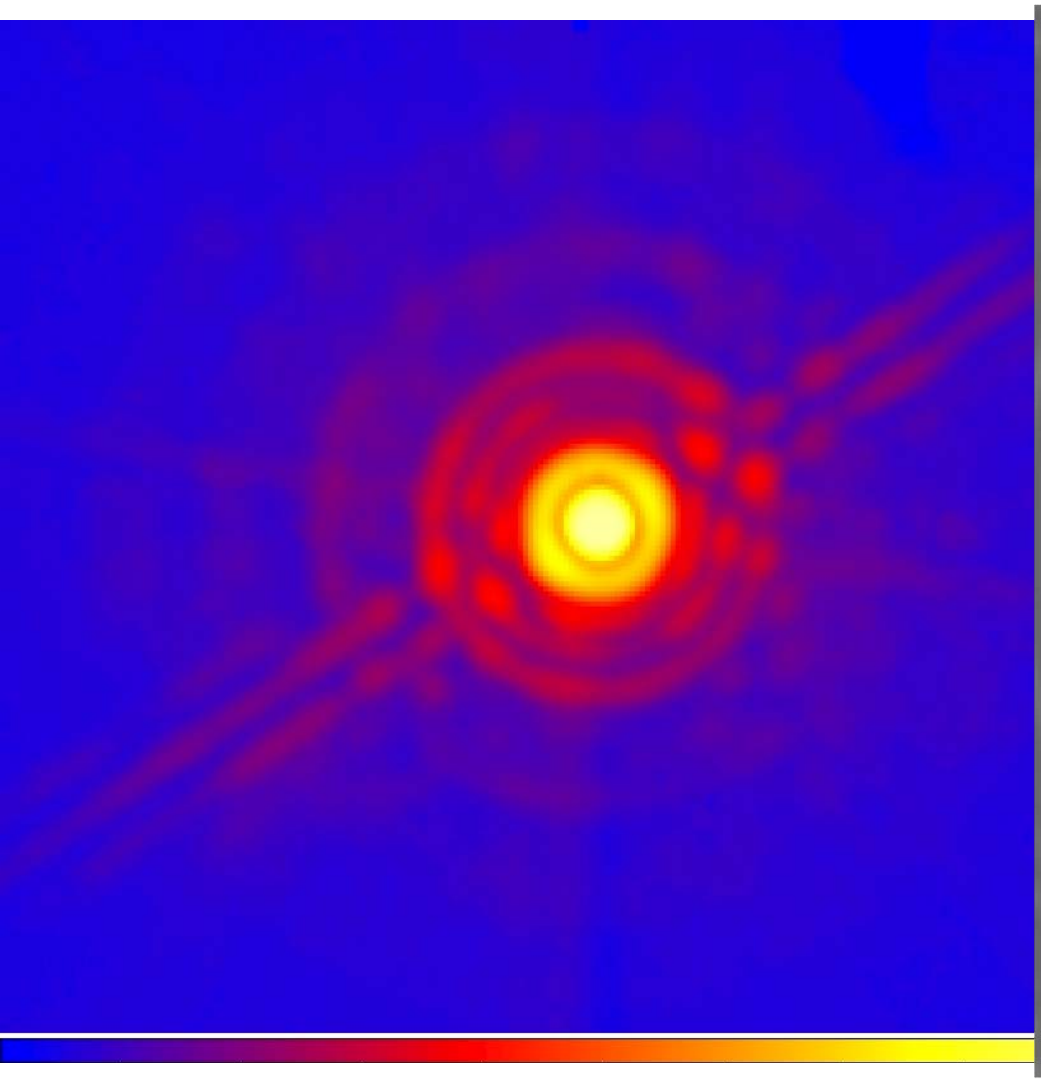
Model

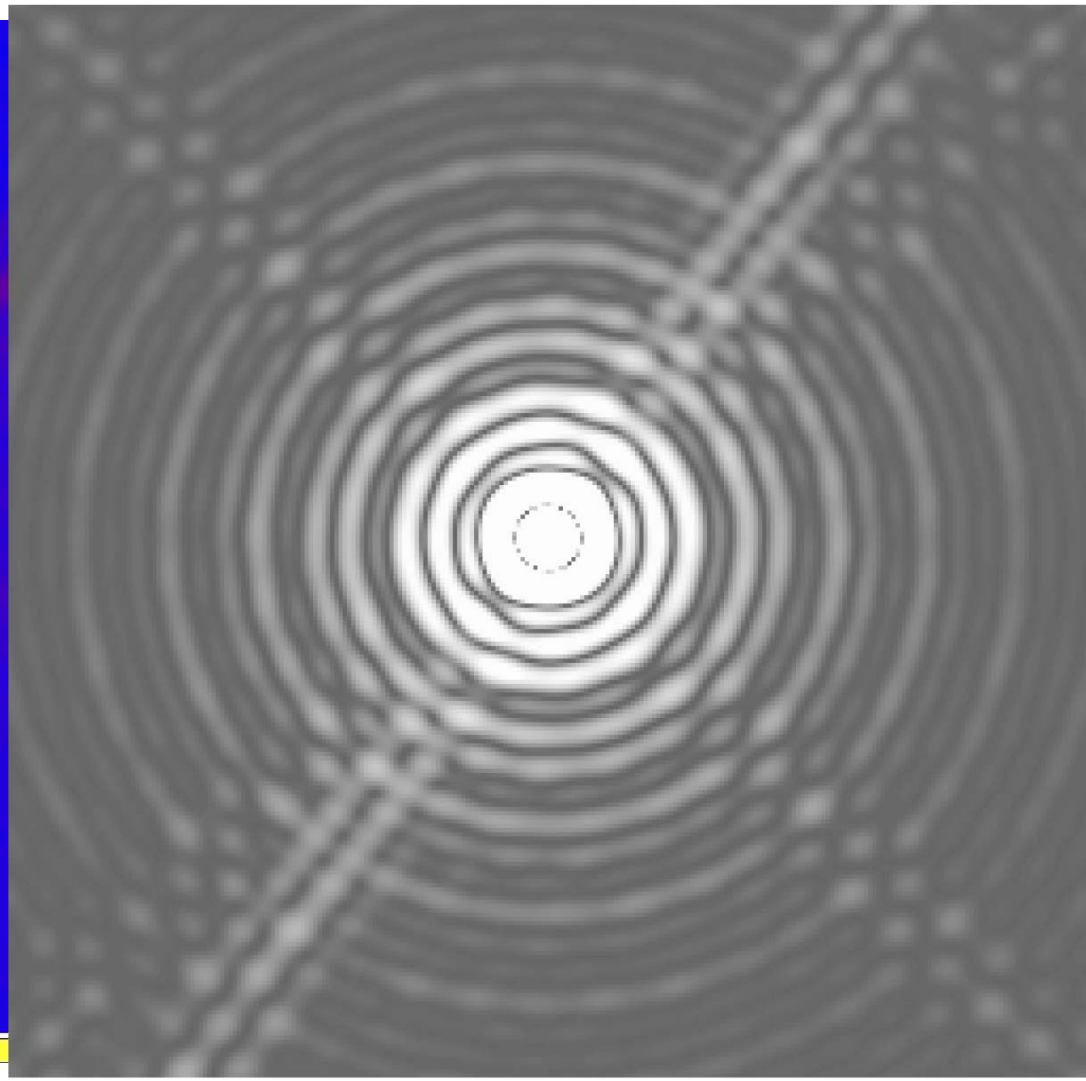
Clio – βPic – M’



Morzinski et al 2013 in prep

Clio – βPic – 3.3 μm



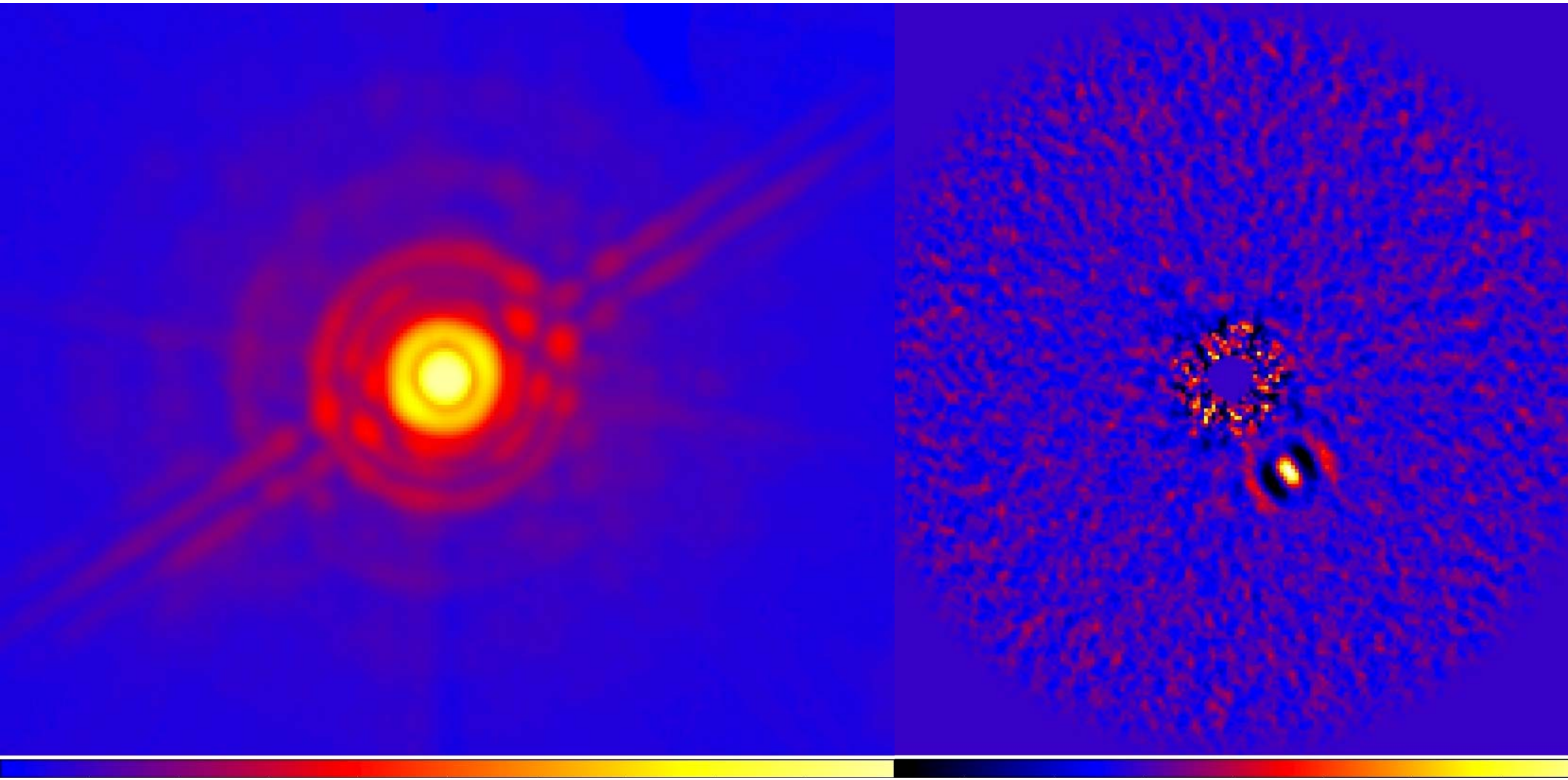


Data

Morzinski et al 2013 in prep

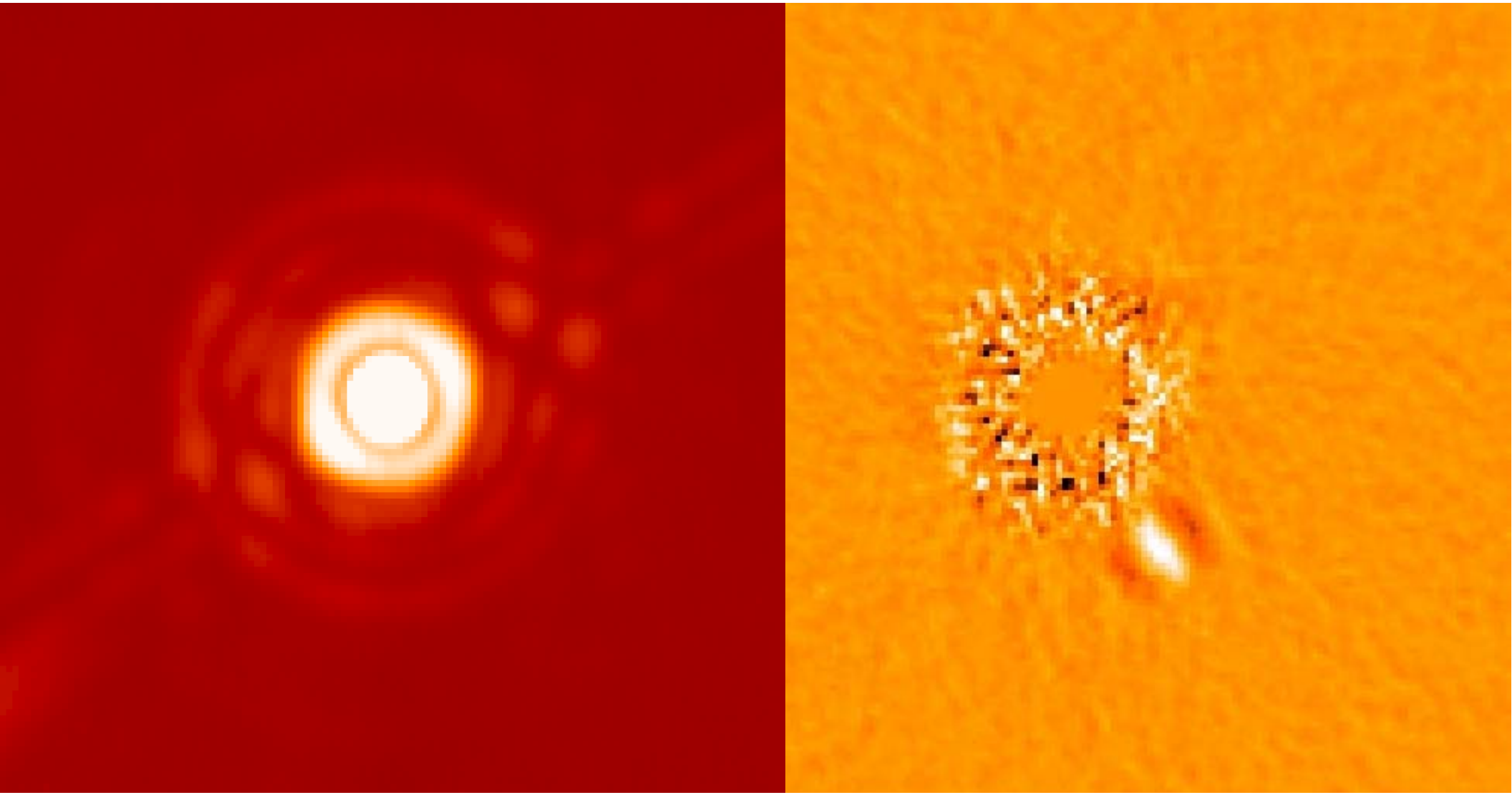
Model

Clio – βPic – 3.3 μm



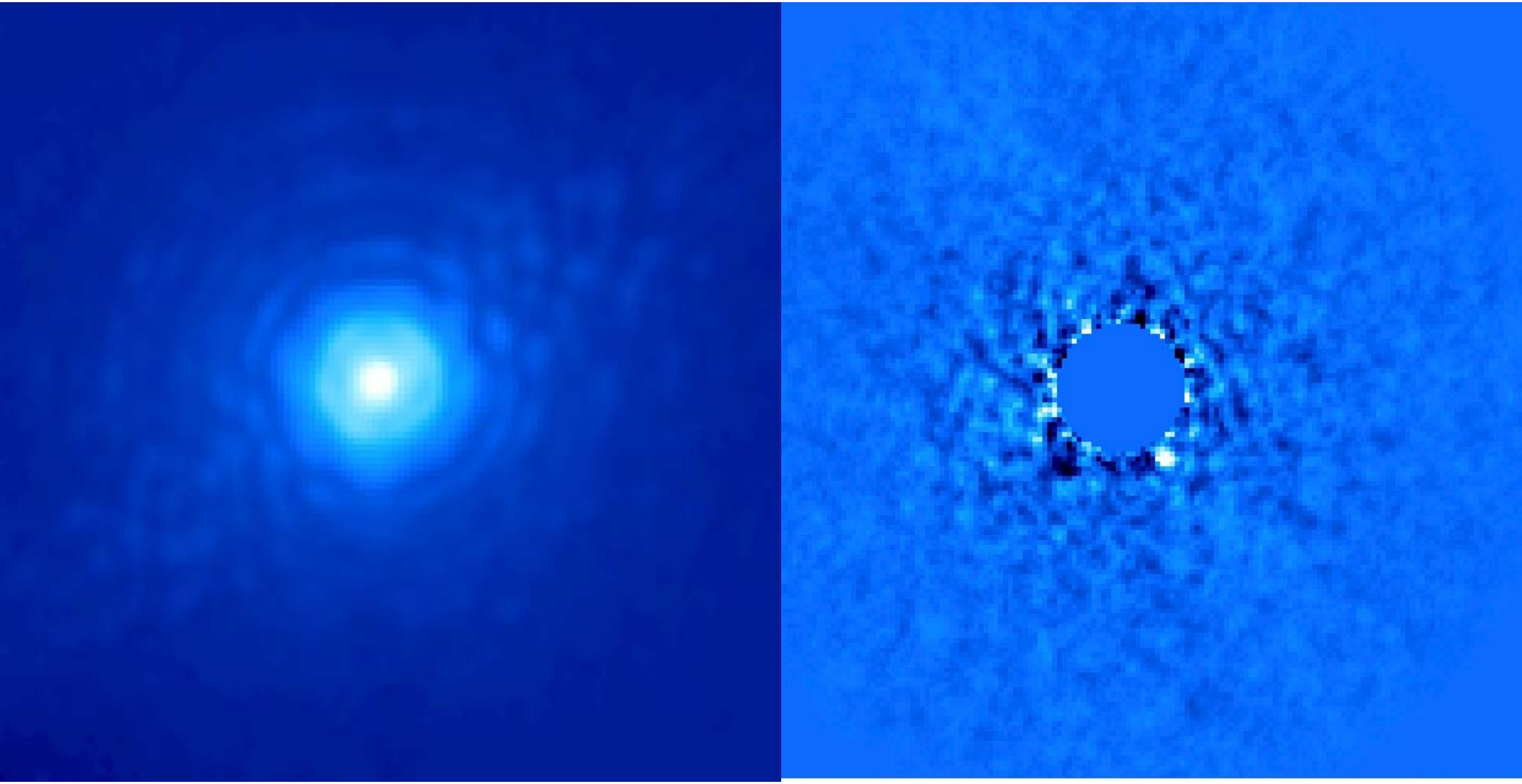
Morzinski et al 2013 in prep

Clio – βPic – L’



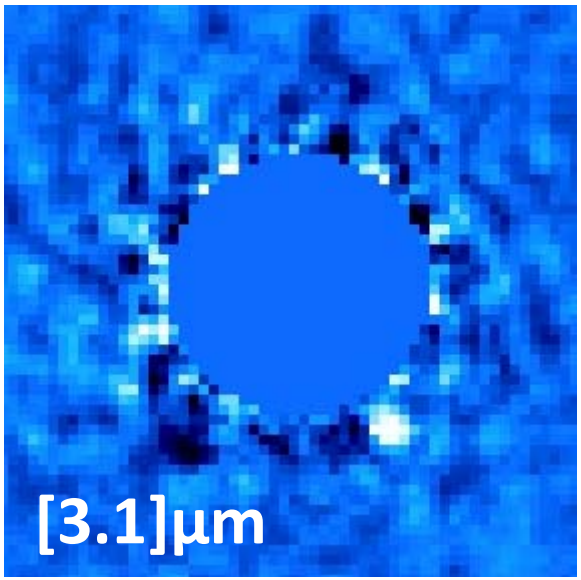
Morzinski et al 2013 in prep

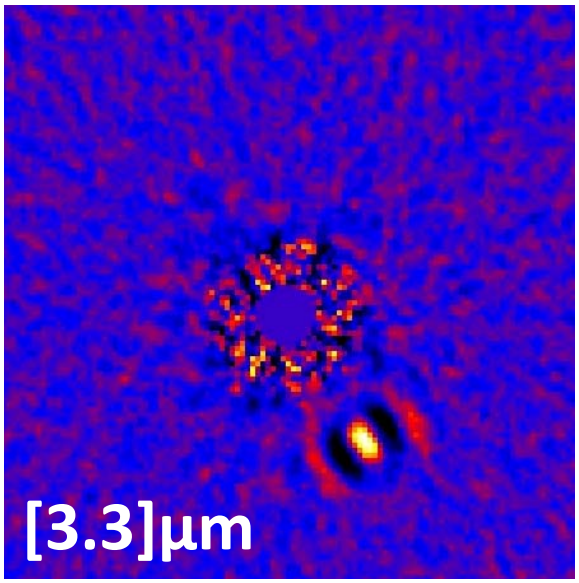
Clio – βPic – 3.1 μm

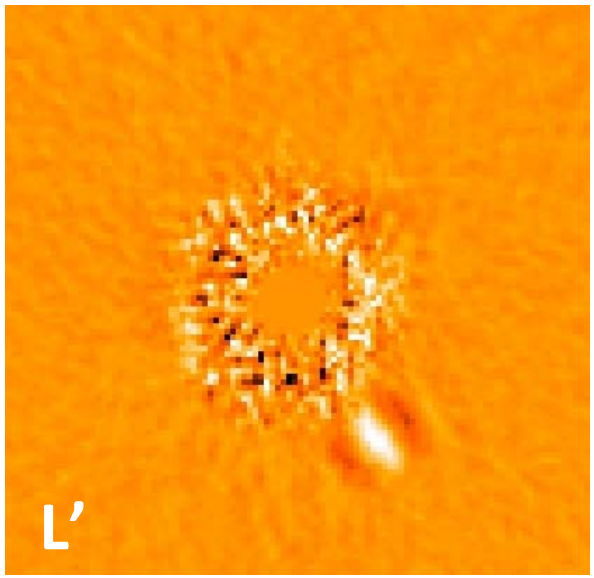


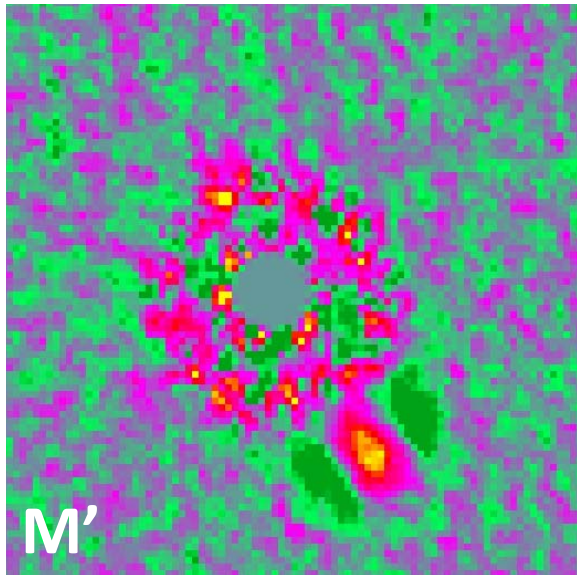
Morzinski et al 2013 in prep

β Pic b imaged simultaneously on a CCD & HgCdTe, from 0.98–5 µm

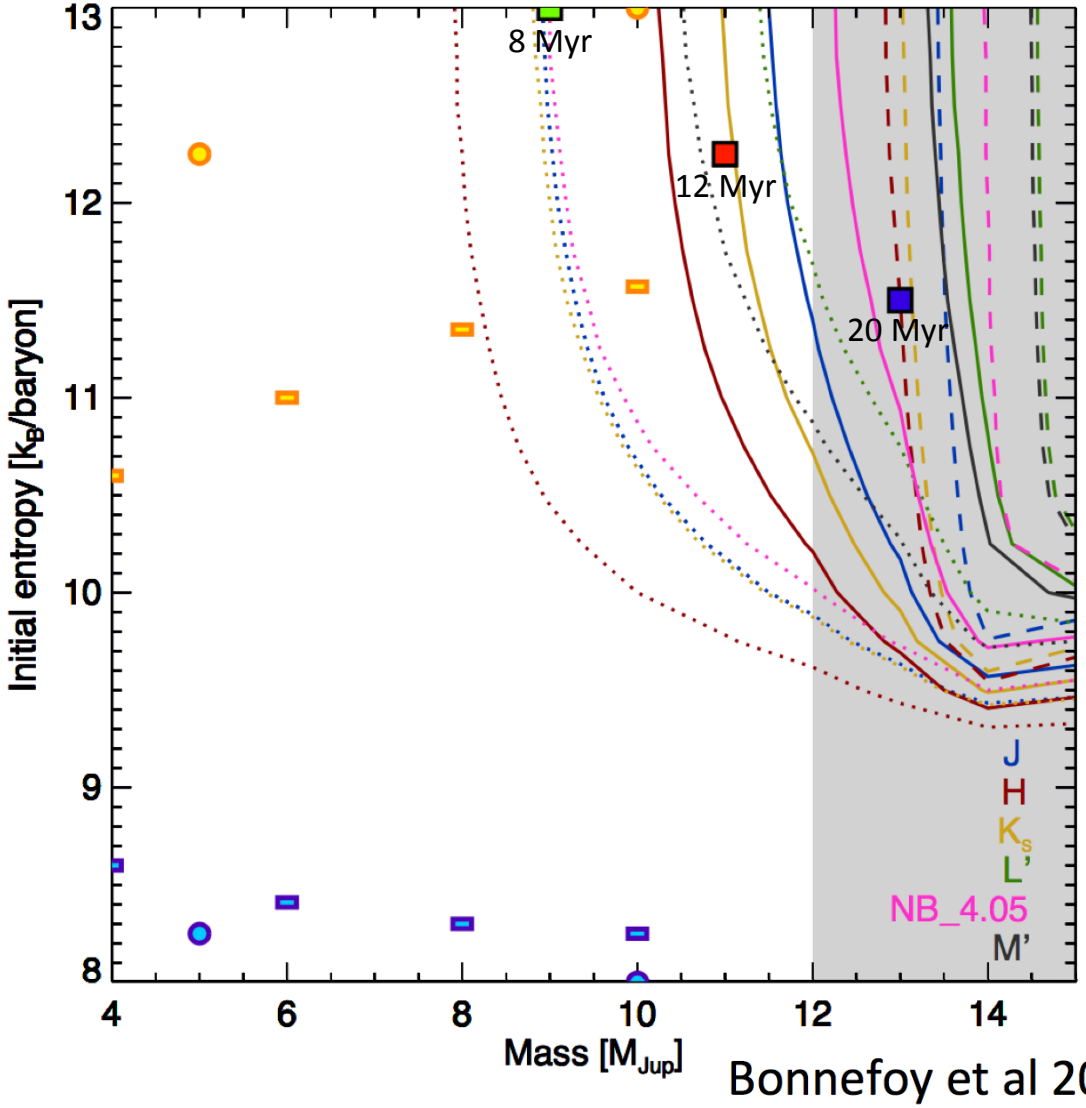




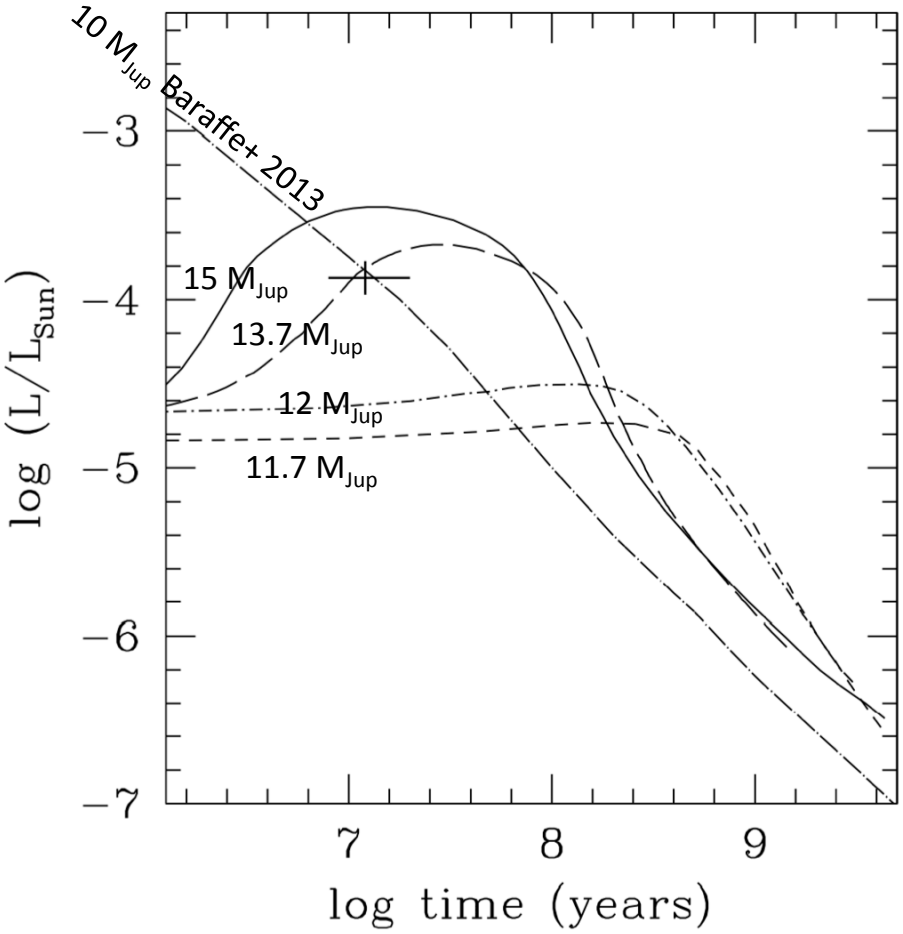




Estimated mass of Beta Pic b ranges from 9–13.7 M_{Jup} depending on formation mechanism assumed

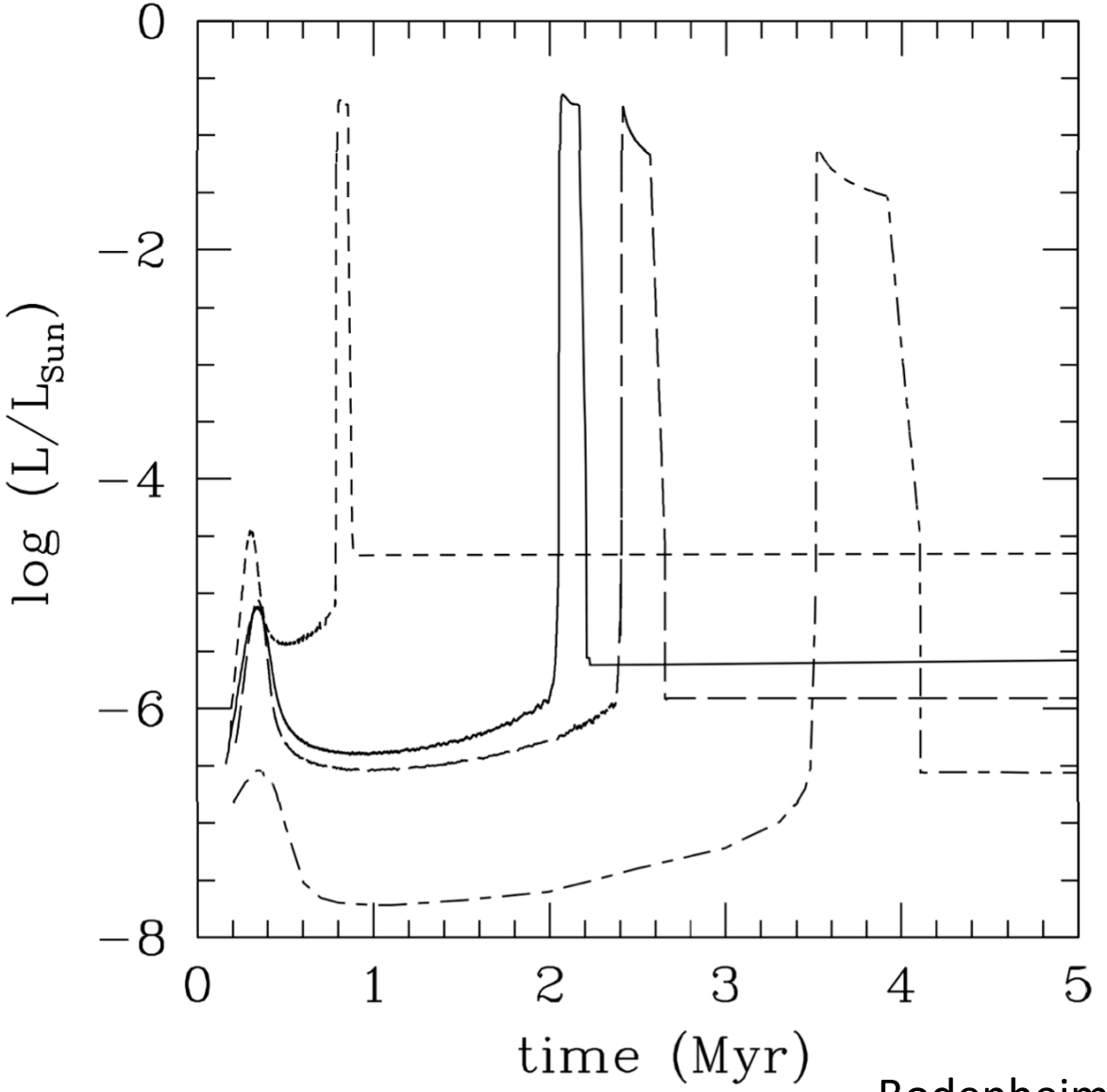


Bonnefoy et al 2013



Bodenheimer et al 2013

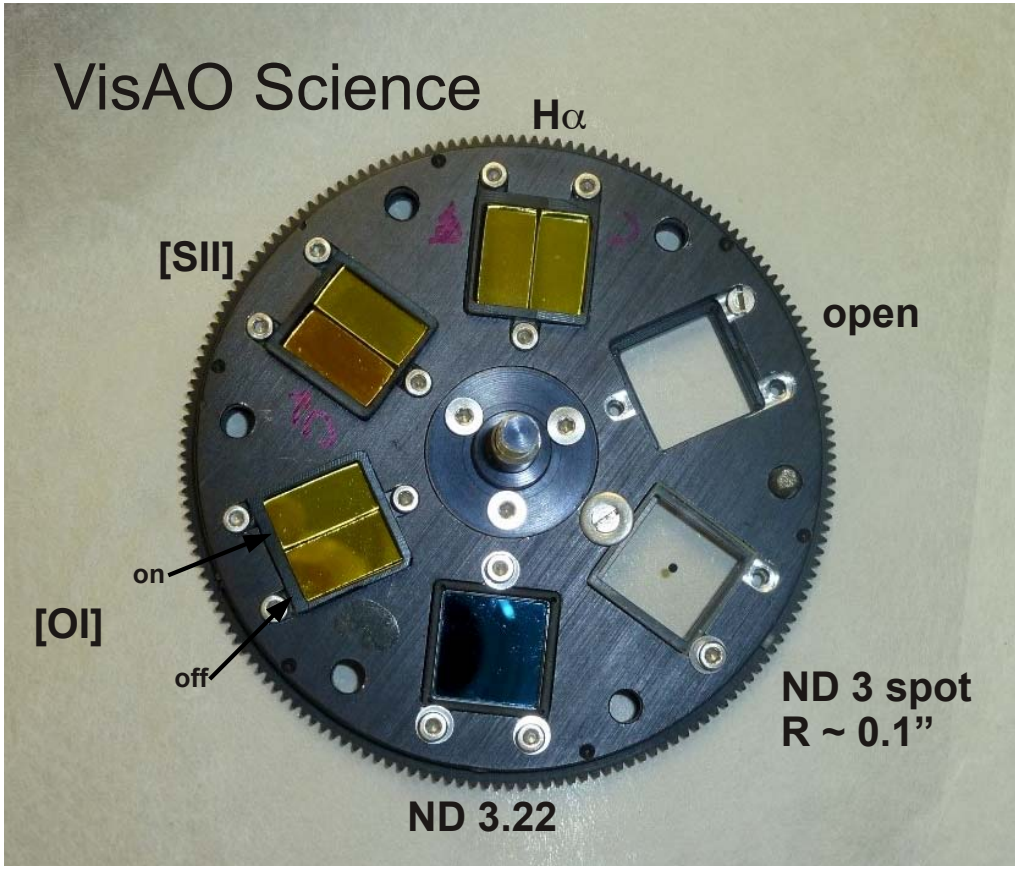
Luminosity peaks during maximum accretion of solids onto core

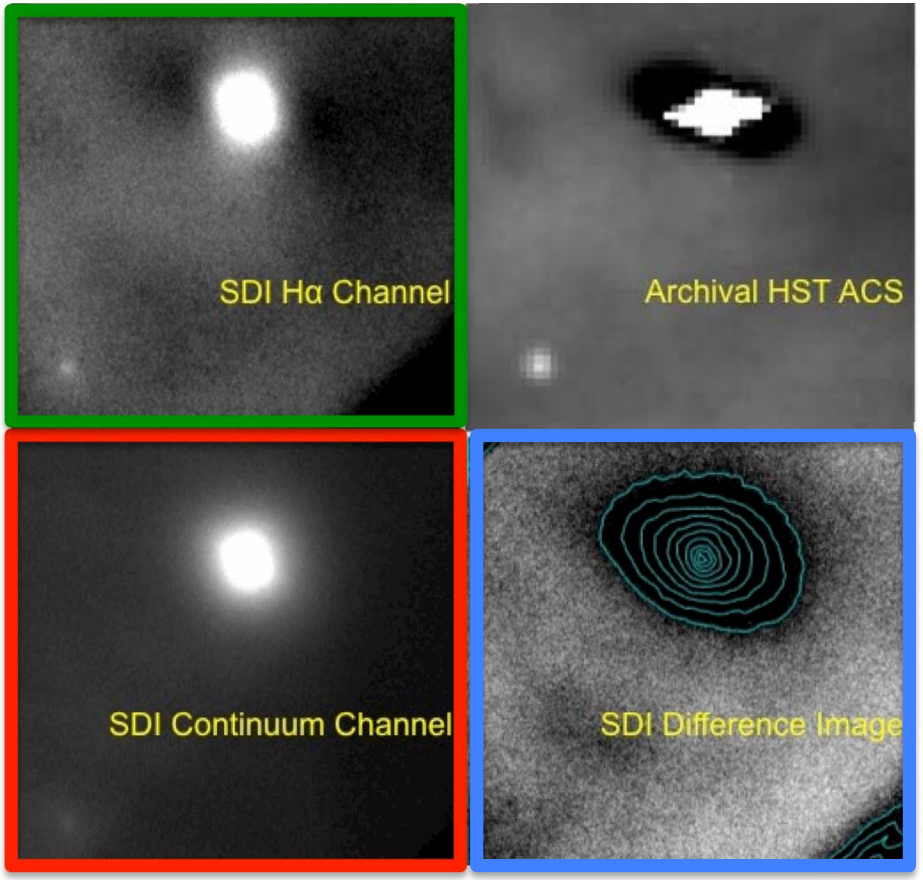


Bodenheimer et al 2013

VisAO SDI Mode – Disk imaged in Hα silhouette

Poster #3.14
Kate Follette



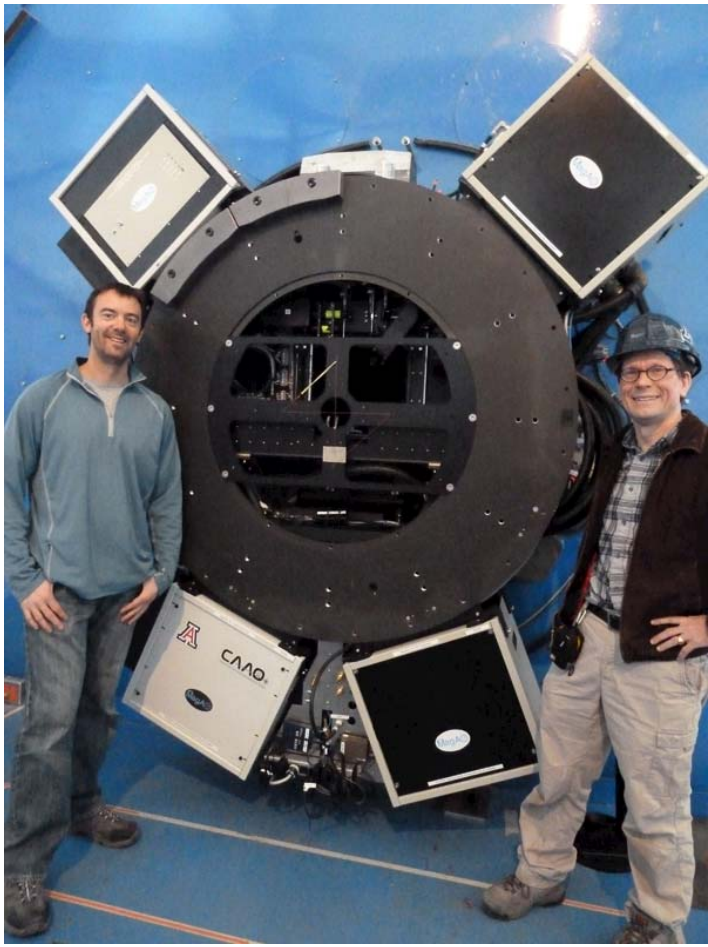


Kate Follette, Laird Close, Jared Males
& the MagAO team

A – B = C

Summary

- Detailed characterization of exoplanets
  - Models are crucial to interpreting data
  - More data is needed to constrain degeneracies
    - Within models
    - Between models
- MagAO: Unique 0.55–5µm capabilities to characterize exoplanets
  - Diffraction-limited deep imaging in O/IR
  - High-contrast imaging via SDI, ADI, APP
  - 20 mas resolution at Hα
  - Thermally optimized for 3–5µm
  - Simultaneous visible and IR imaging
- Beta Pic b
  - Mass, age, atmosphere composition, clouds



MagAO is commissioned and will be available in 2014A

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