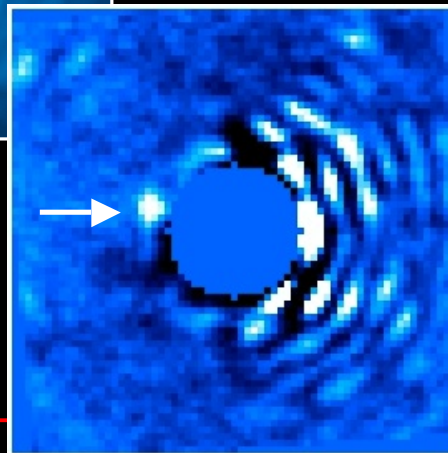
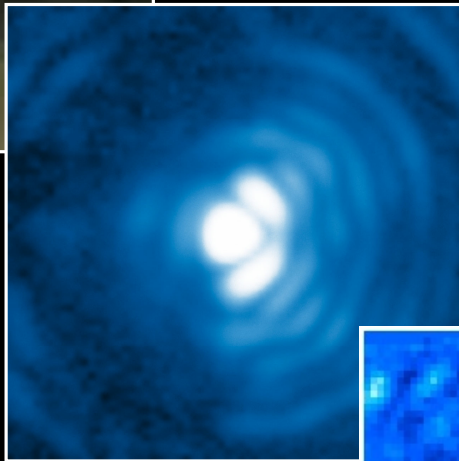


Direct imaging search for exoplanets using VLT/NACO's APP coronagraph

Exploring Strange New Worlds:
From Giant Planets to Super Earths
Flagstaff, AZ, May 1-6, 2011



Sascha P. Quanz (ETH Zurich)

APP core team:
M.R. Meyer (ETH), M.A. Kenworthy (Leiden),
J.H.V. Girard (ESO), M. Kasper (ESO)

ETH

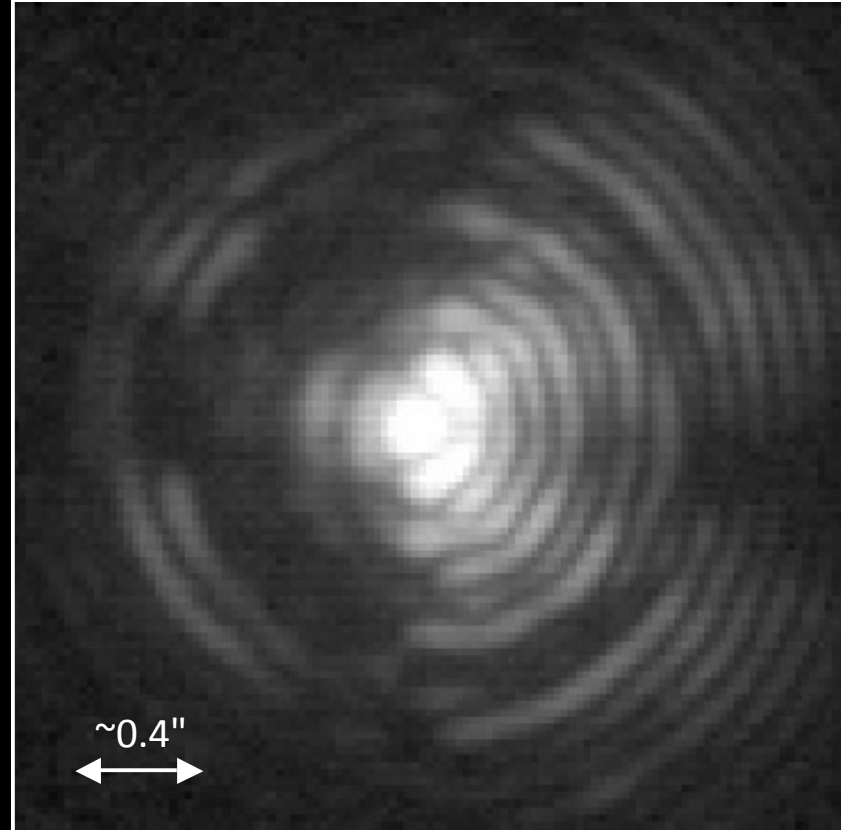
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

An Apodizing Phase Plate (APP) for VLT/NACO - Increasing the contrast at small IWA in the L band

An Apodizing Phase Plate

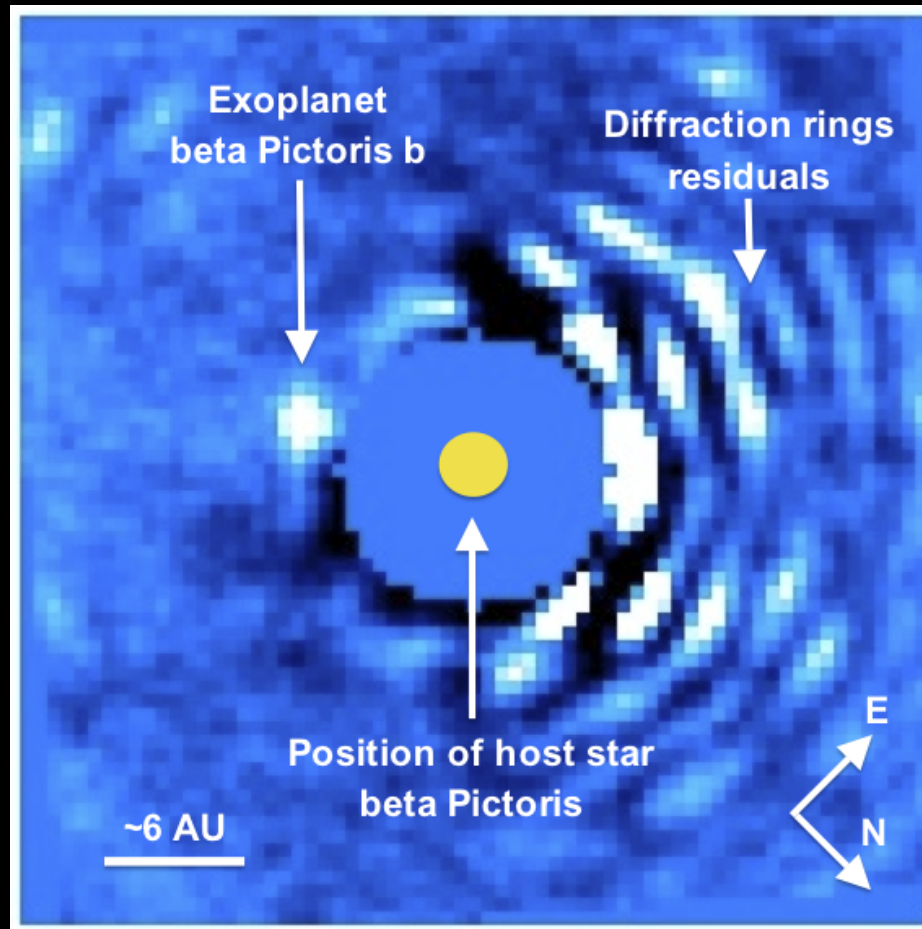


The NACO APP PSF



Codona et al. 2006, SPIE Volume 6269
Kenworthy et al. 2010, SPIE Volume 7735
Kenworthy et al. 2010, The Messenger 141
Girard et al. 2010, SPIE Volume 7736

Detection and first color information of the exoplanet beta Pictoris b with VLT/NACO APP



Results:

$r: 0.345'' \pm 0.012''$
(6.8 ± 0.2 AU)

PA: $209.13^\circ \pm 2.12^\circ$

11.20 ± 0.23 mag (NB4.05)

Teff: ~ 1700 K (from color)

Mass: $7-10 M_{\text{Jupiter}}$ (models)

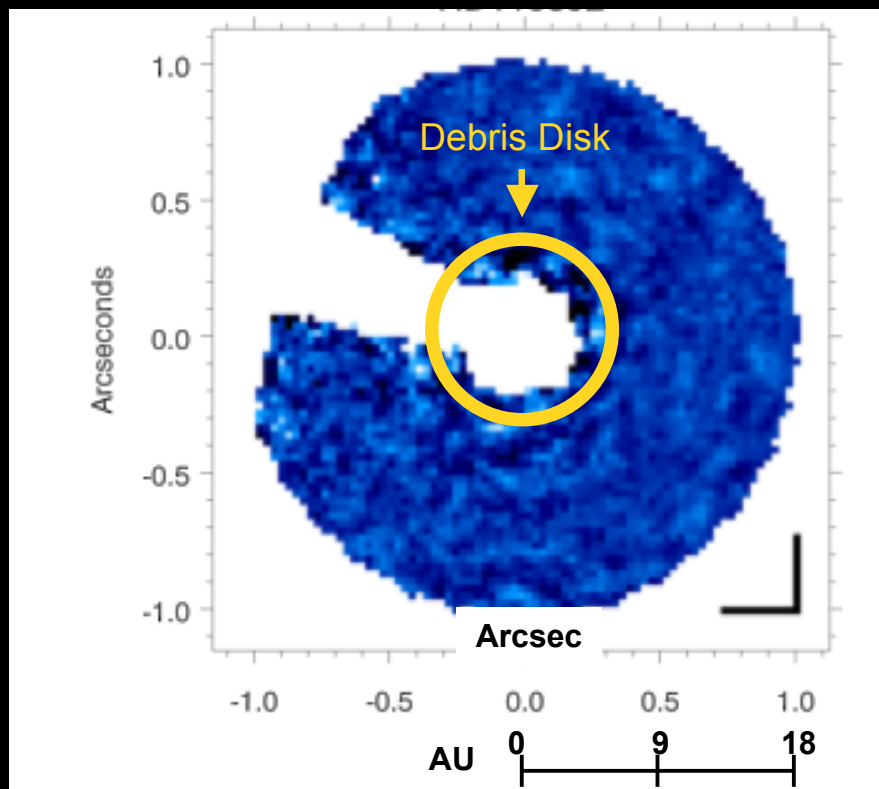
See also
Bonnefoy et al. 2011
Poster ID: Formation.01

Quanz et al. 2010, ApJL 722, 40
Lagrange et al. 2010, Science 329, 57

Probing the environment of 2 overluminous debris disks on Solar System scales - No companions detected...

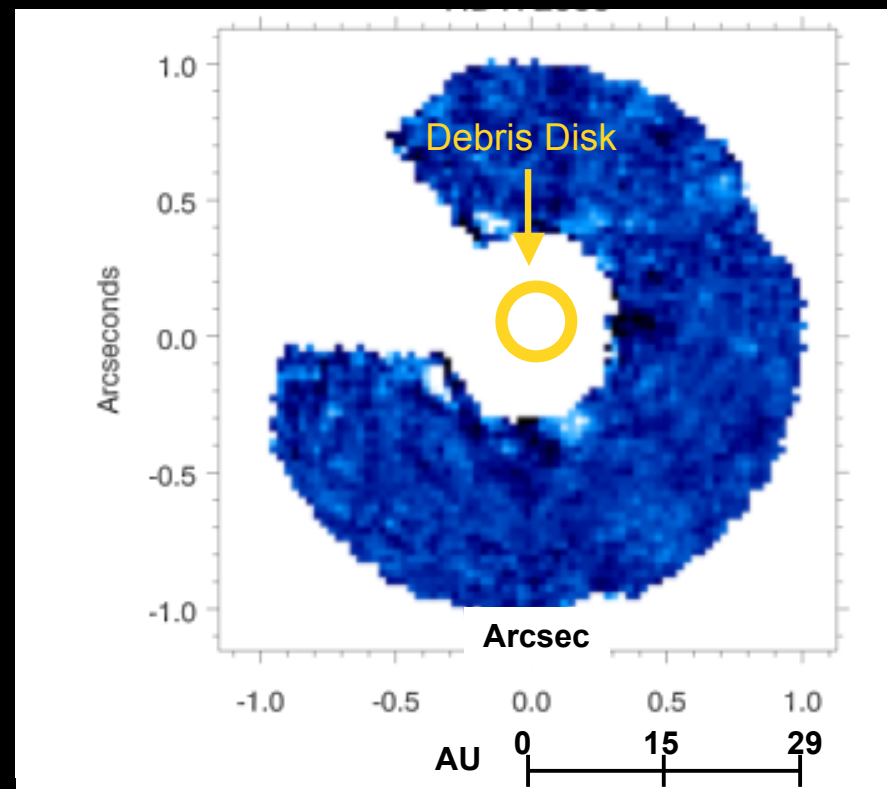
HD115892 (A2V)

Age: ~350 Myr
L band: 2.7 mag
Distance: 18 pc



HD172555 (A5IV/V)

Age: ~12 Myr
L band: 4.3 mag
Distance: 29 pc

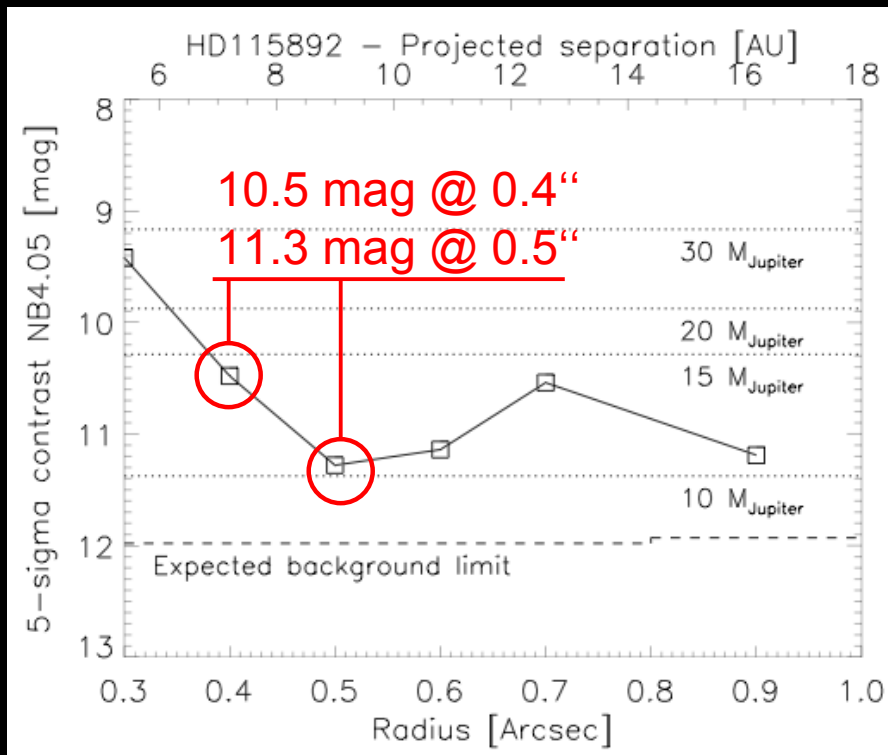


Quanz et al. 2011, to be submitted

However, the APP pushes the contrast (close) to the background limit at very small inner working angles

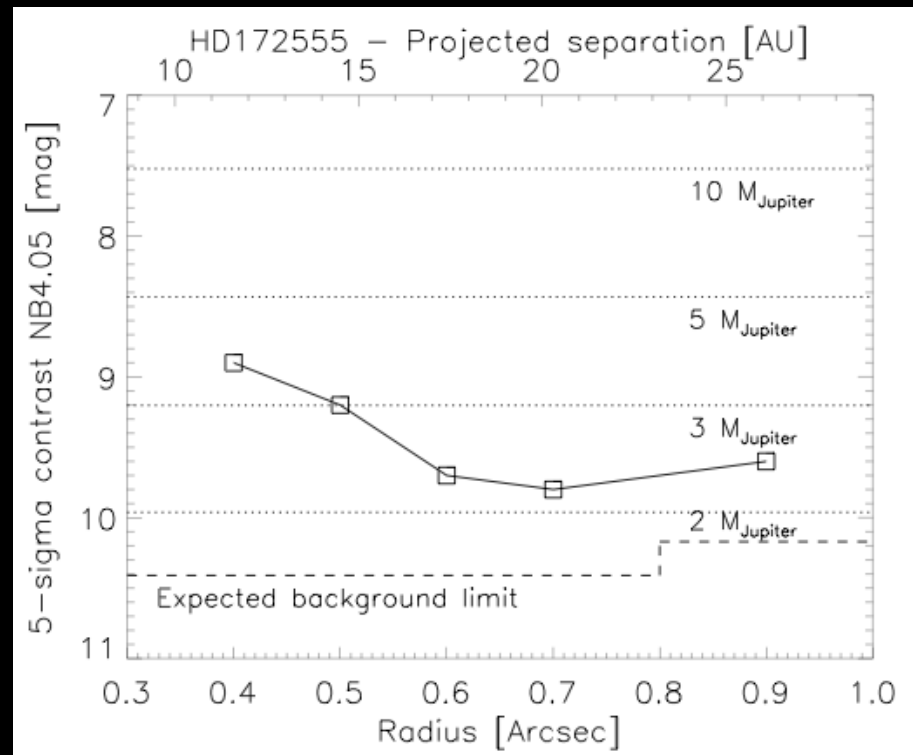
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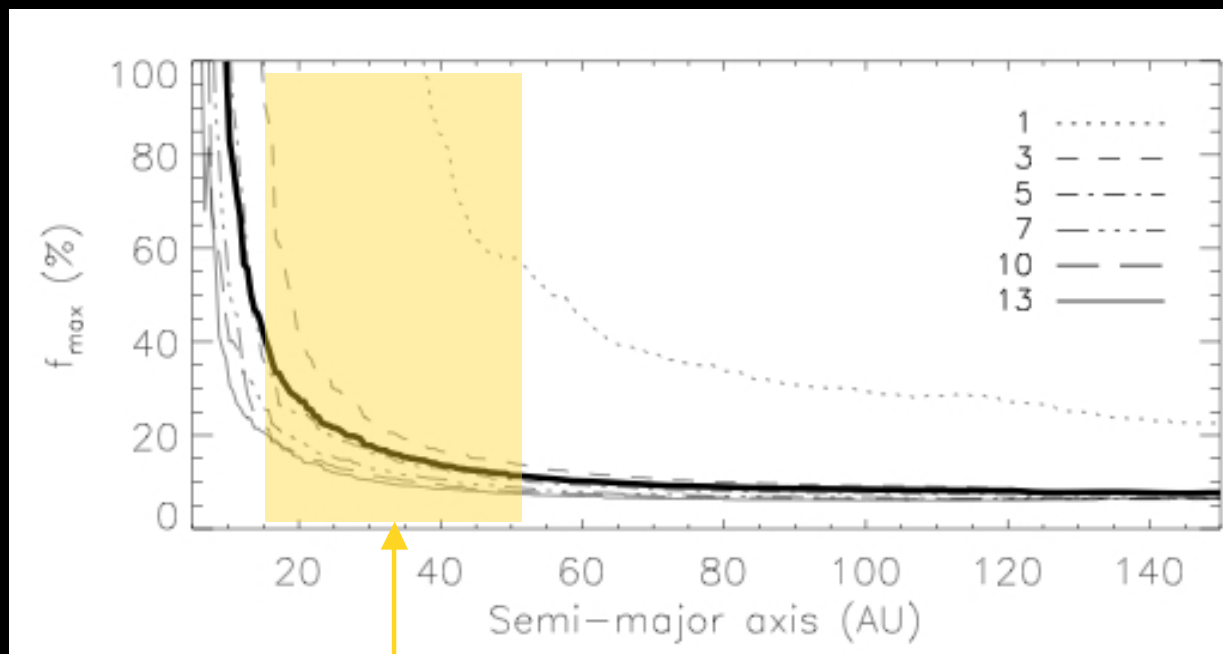


Quanz et al. 2011, to be submitted

These innermost regions are largely unconstrained by current exoplanet surveys

Upper limit of stars hosting a planet

65 young, nearby solar type stars (NIR imaging)



APP discovery space for $d=50$ pc

+

L-band advantage in mass sensitivity

Assumed planet distribution

$$dN/dM_p \sim M_p^\alpha$$

$$dN/dP \sim P^\beta$$

$$M_p \sim M_*^\gamma$$

$$\alpha = -0.74$$

$$\beta = -1.31$$

$$\gamma = 1.25$$

Chauvin et al. (2010)

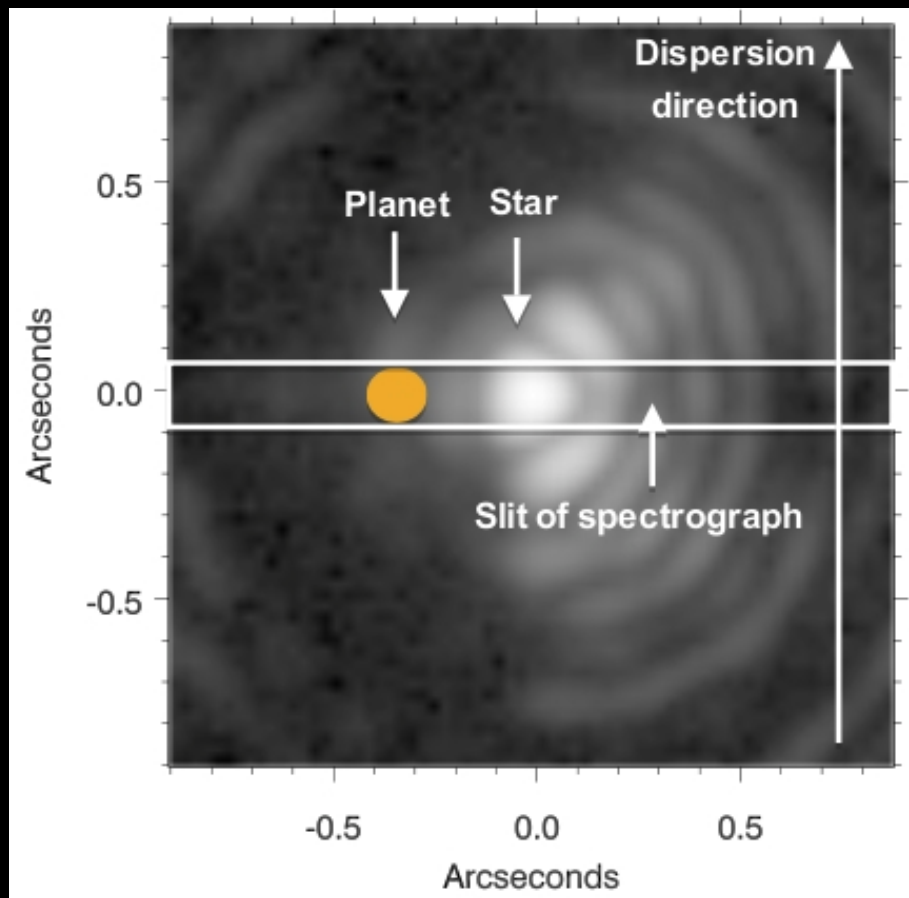
See also, e.g., Lafreniere et al. (2007)

High contrast spectroscopy in the L-band with the APP

APP spectroscopy mode

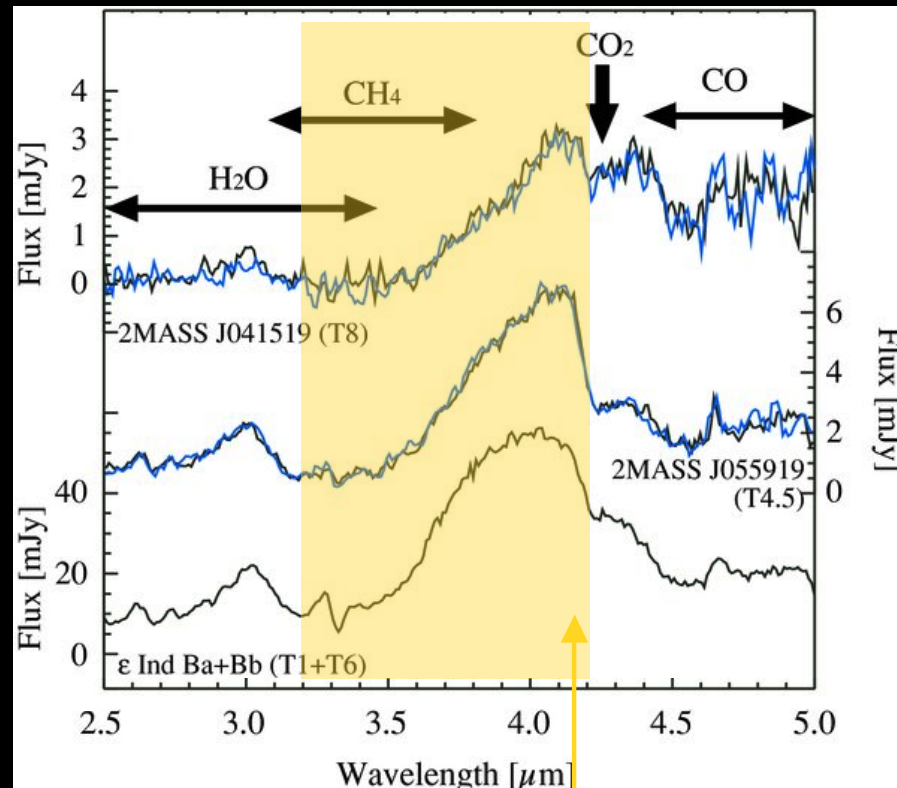
$\Delta\lambda$: $\sim 3.0 - 4.2 \mu\text{m}$

$R \sim 1000$

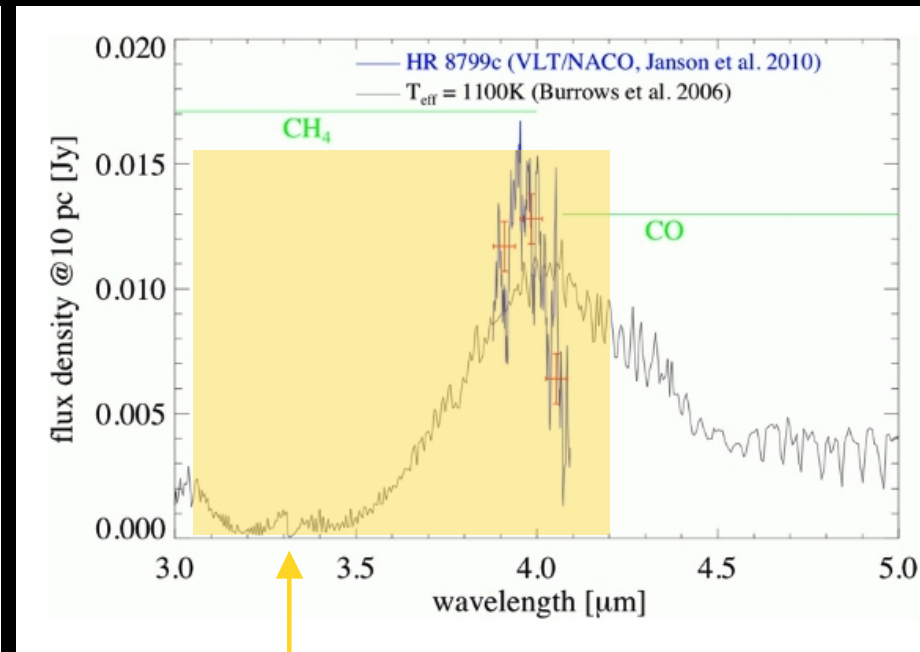


L-band is an interesting regime to study the C-chemistry in atmospheres of cool objects

Cool Brown Dwarfs observed w/ AKARI
(Yamamura et al. 2010, ApJ 722, 682)



HR8799 c
(Janson et al. 2010, ApJ 710, L35)



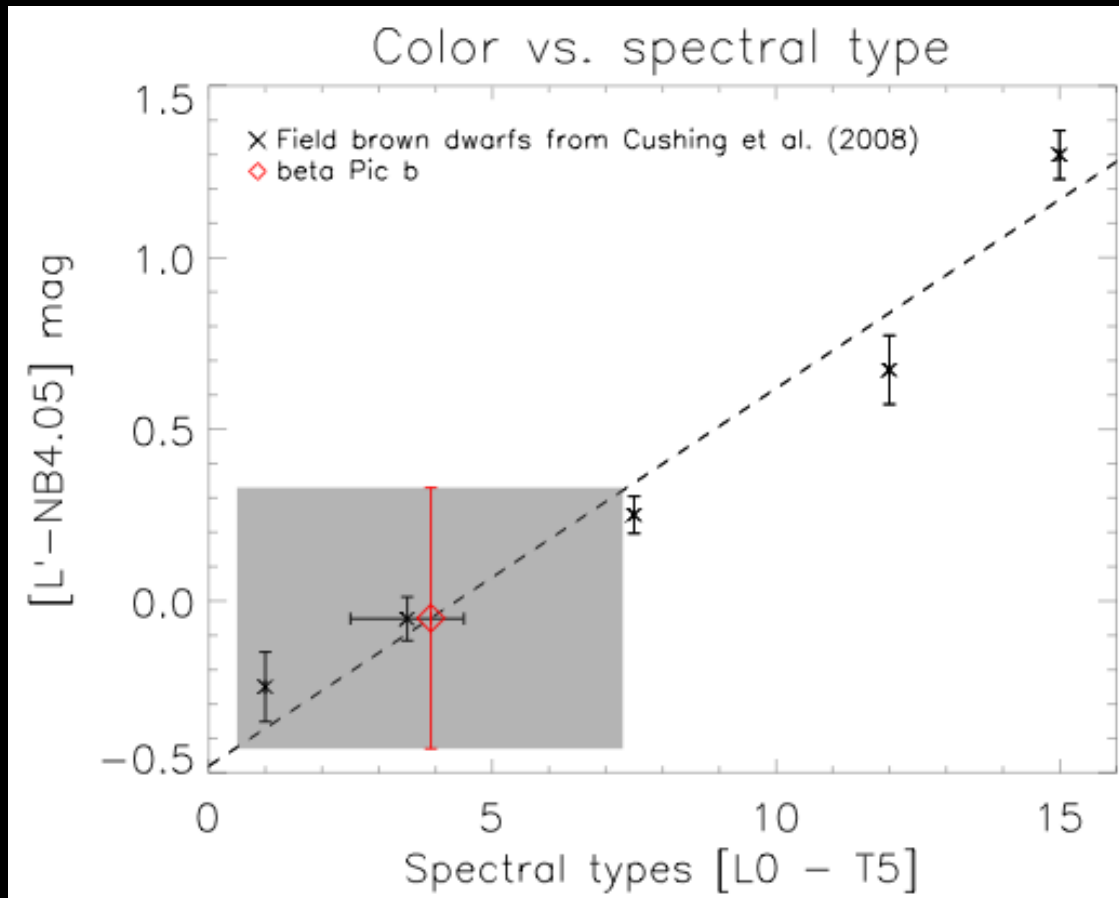
Spectral coverage with NACO/APP

Take home messages

- L band imaging provides high Strehl ratio and more favorable planet-star contrast compared to NIR
- NACO APP direct imaging allows us to search for exoplanets at very small inner working angles ($\sim 0.25''$ to $1''$) close to λ/D in the background limit
- NACO APP spectroscopy opens up new perspectives to study atmospheric properties of exoplanets in the L band

BACKUP

A first “color” estimate for beta Pictoris b



Results:

Spectral type:

~L0-L7

Effective temperature:

- 1500 - 2100 K
(from BD comparison)
- ~1500 K
(from DUSTY models)

See also
Bonnetfoy et al. 2011
Poster ID: Formation.01

Quanz et al. 2010, ApJL 722, 40