Direct imaging and spectral characterisation of long period exoplanets and brown dwarfs

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esa

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Stars

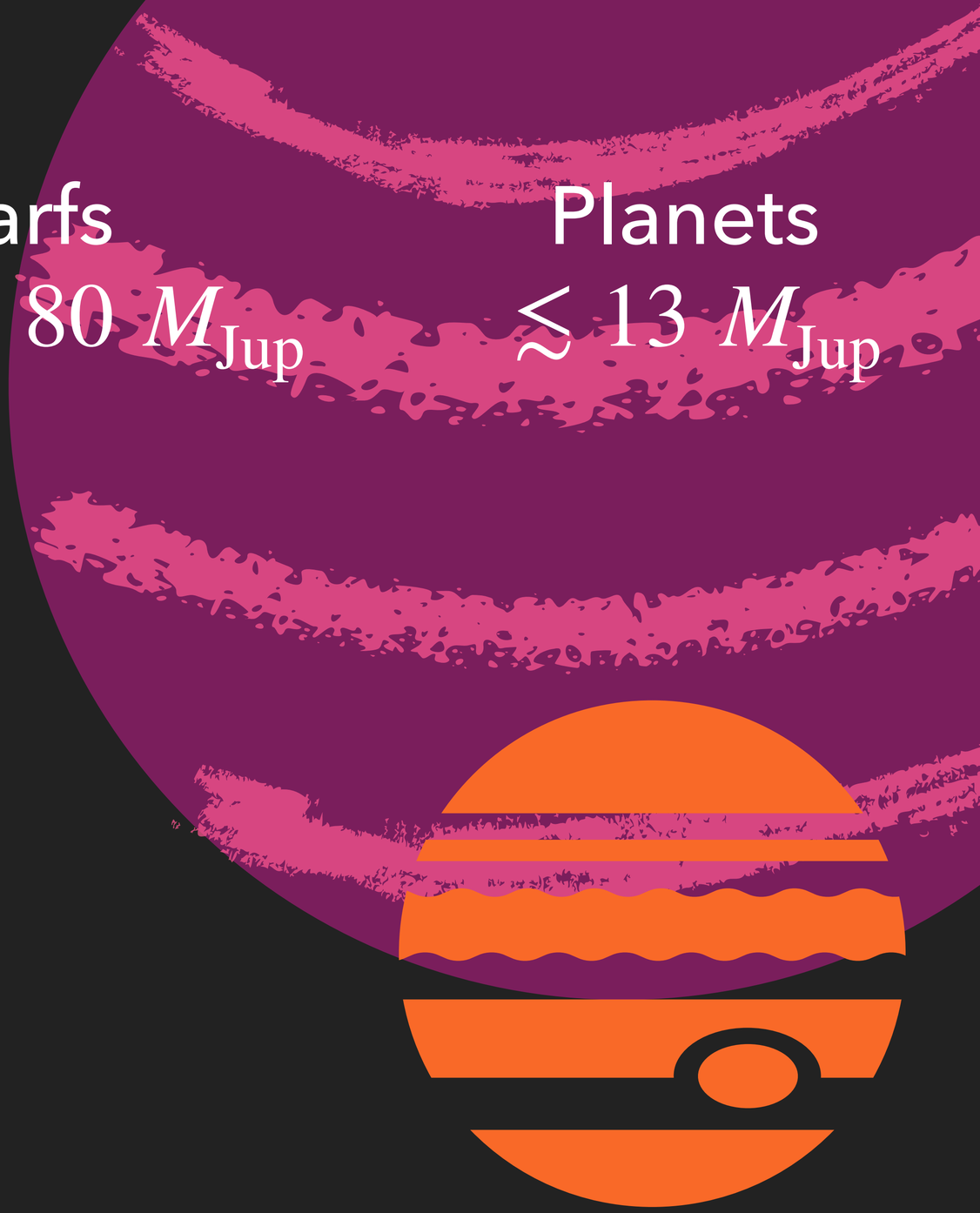
$\gtrsim 80\ M_{\rm Jup}$

Brown dwarfs

$13\ M_{\rm Jup} \lesssim M \lesssim 80\ M_{\rm Jup}$

Planets

$\lesssim 13\ M_{\rm Jup}$



What is the occurrence rate of long period planets and brown dwarfs?

How do giant planets and brown dwarfs form?

What does the mass-luminosity-age relation of brown dwarfs look like?

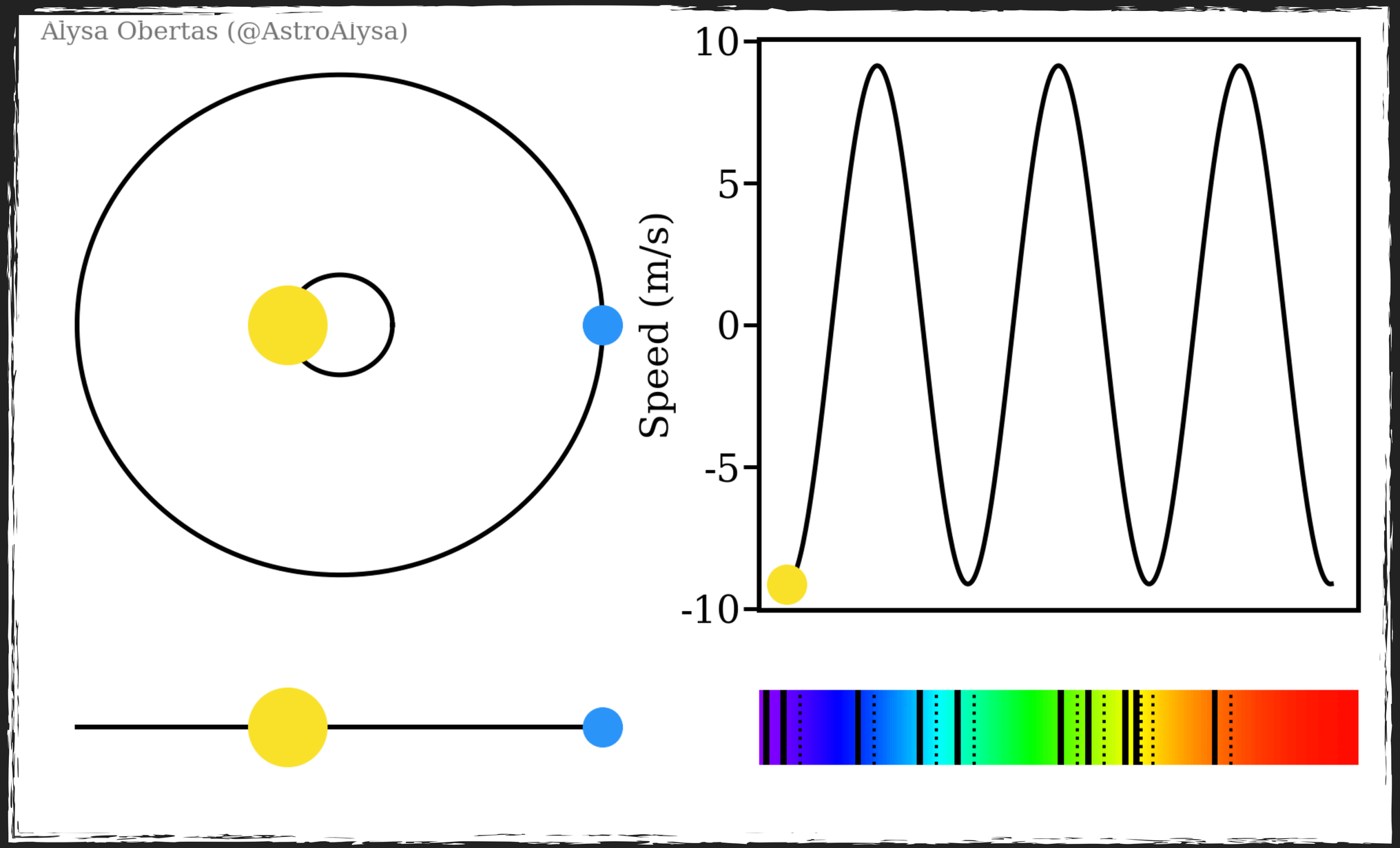
Test atmospheric models of giant gaseous planets and brown dwarfs

Radial Velocities

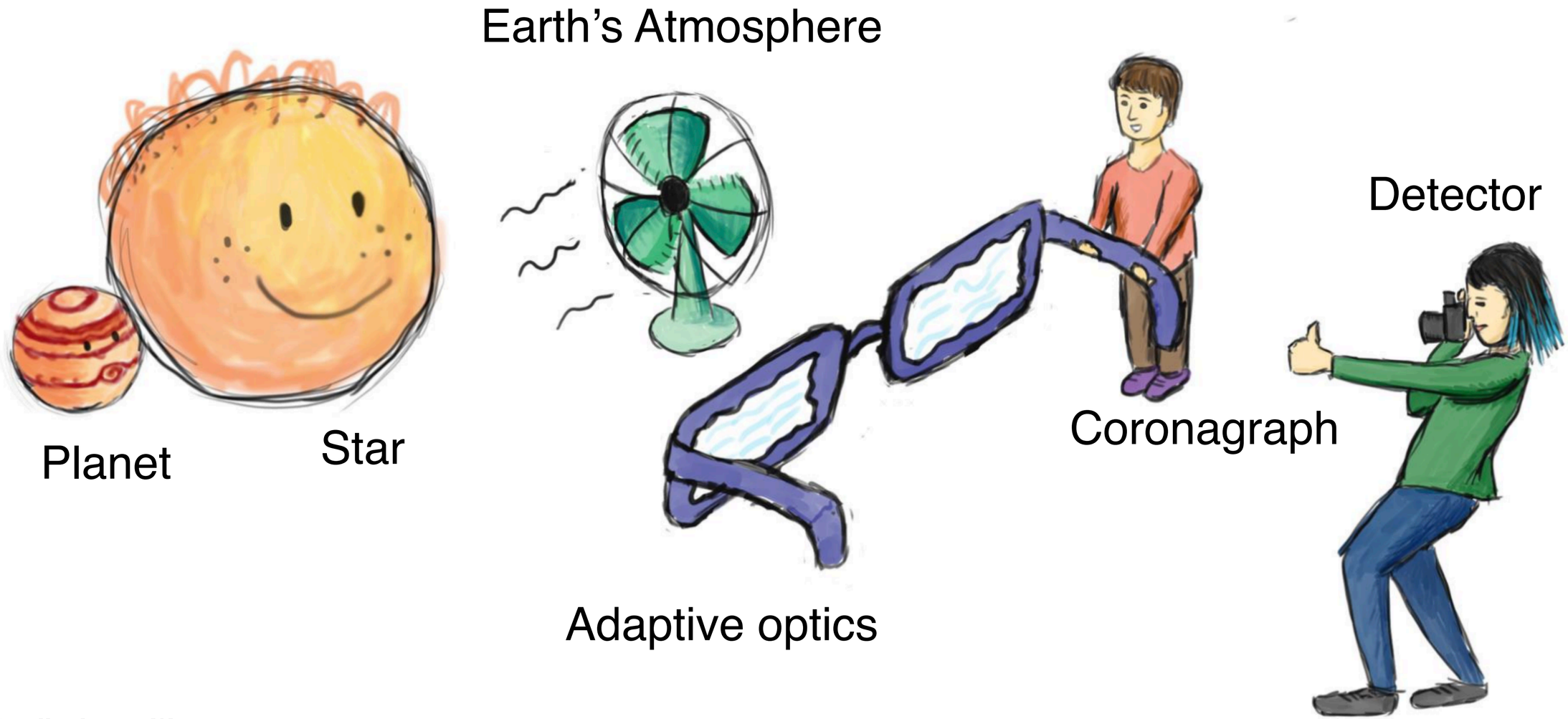
VLT/SPHERE

CORALIE Survey

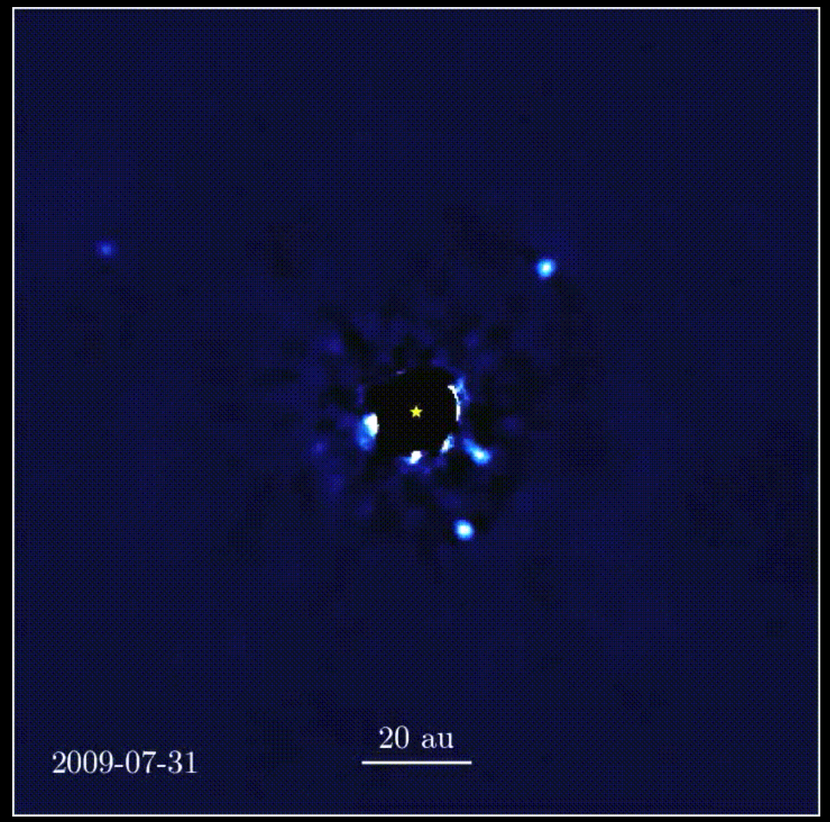
Radial velocities

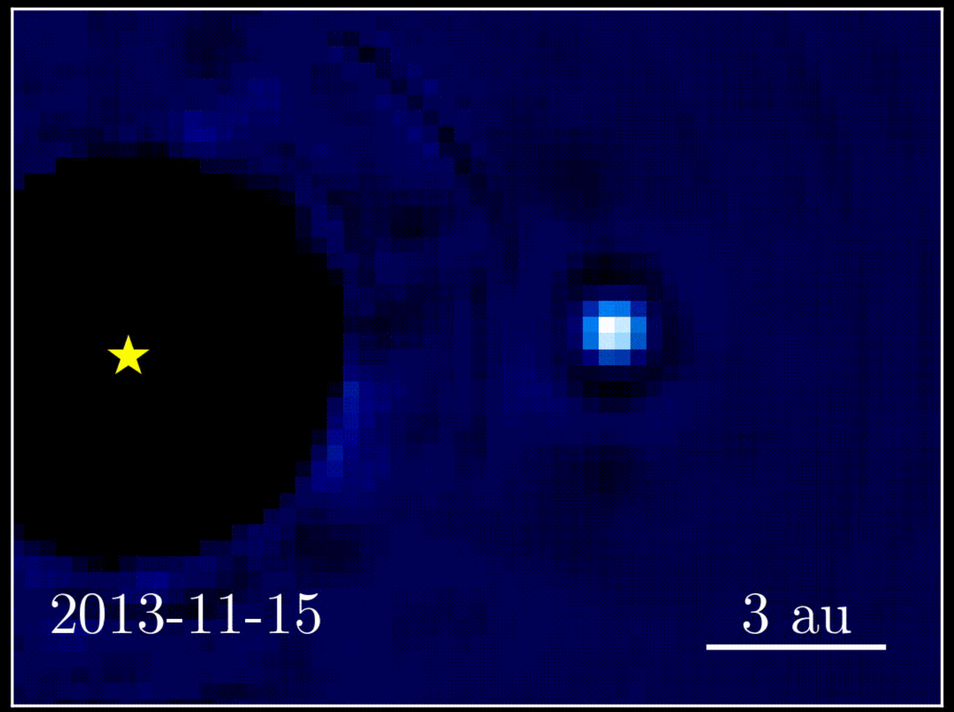


Direct imaging



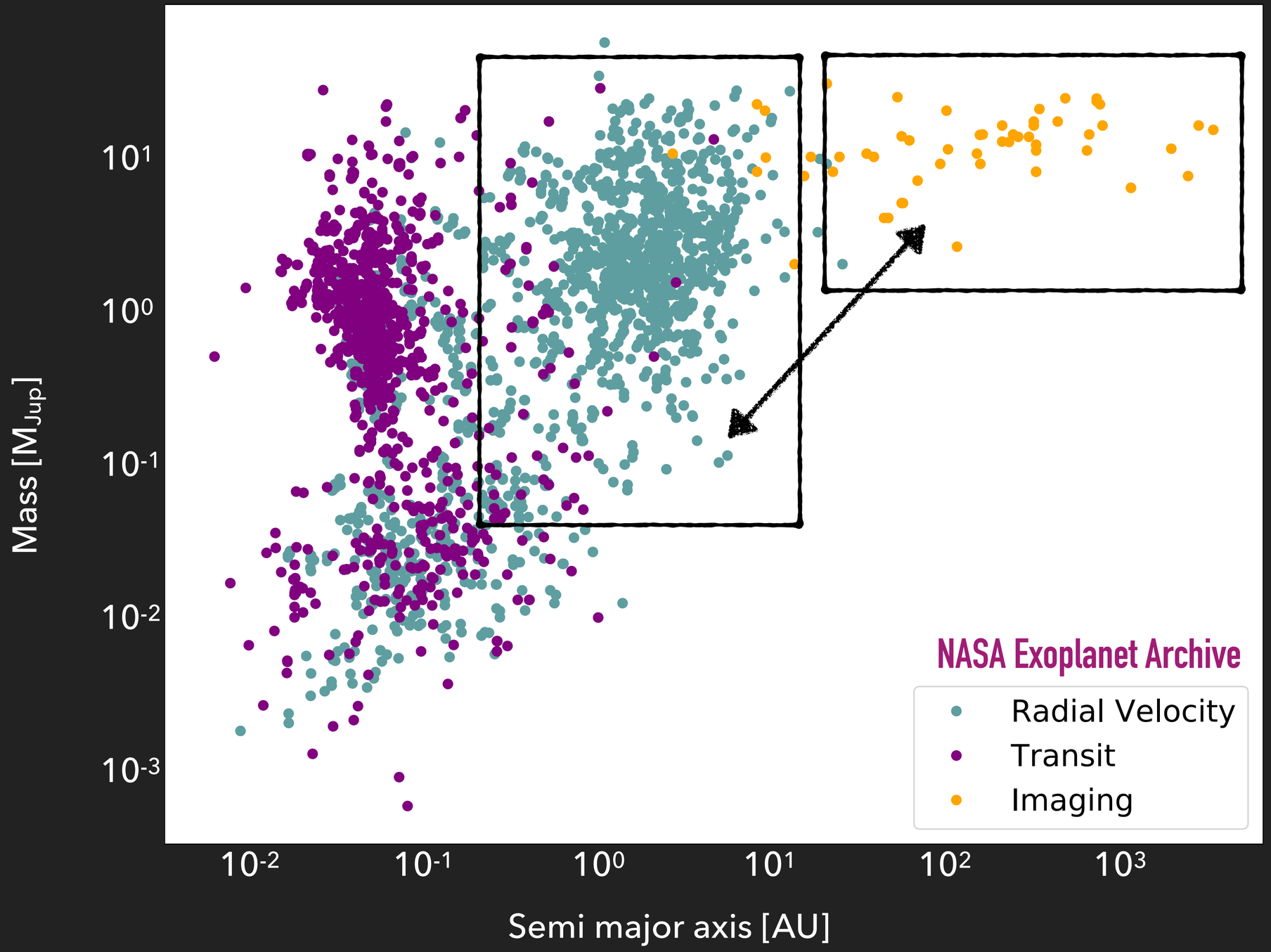
Credit: Jason Wang





Direct imaging

Credit: Jason Wang (UC Berkeley)/Christian Marois (NRC Herzberg)


NASA Exoplanet Archive
Radial Velocity
Transit
Imaging
Mass [M_{Jup}]
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Semi major axis [AU]

The CORALIE Survey

Contains 1647 main sequence G and K dwarfs

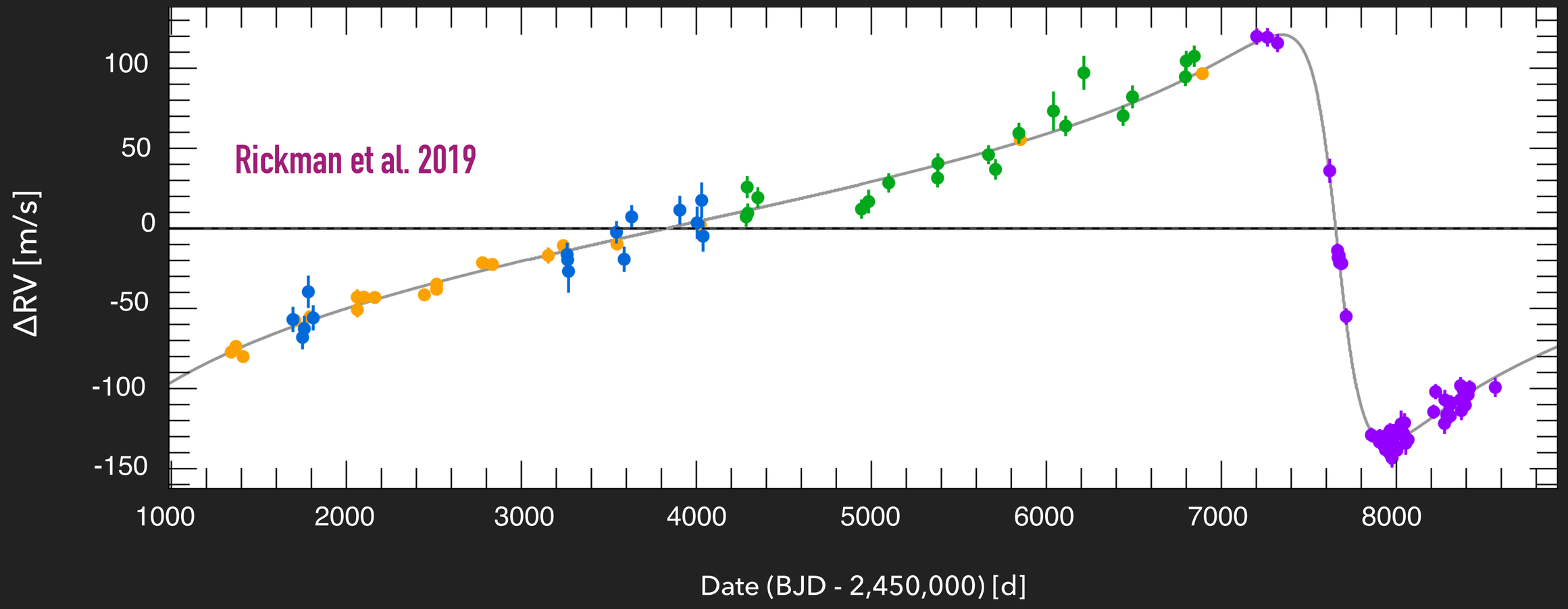
Radial velocity data from past ~20 years

50pc, solar type stars

Long term drifts hosting potential companions

Photo Credit: ESO

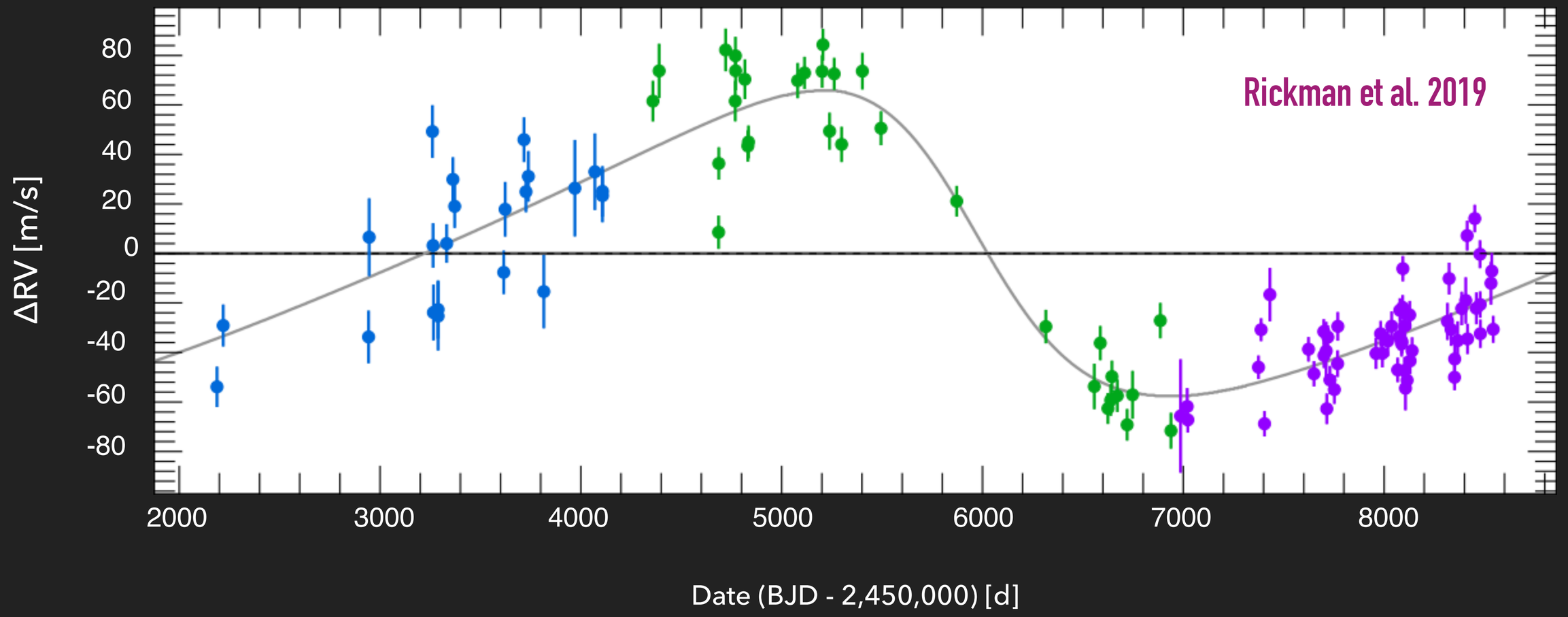
HD 181234



Minimum mass: $8.4^{+0.3}_{-0.4}\ M_{\rm Jup}$

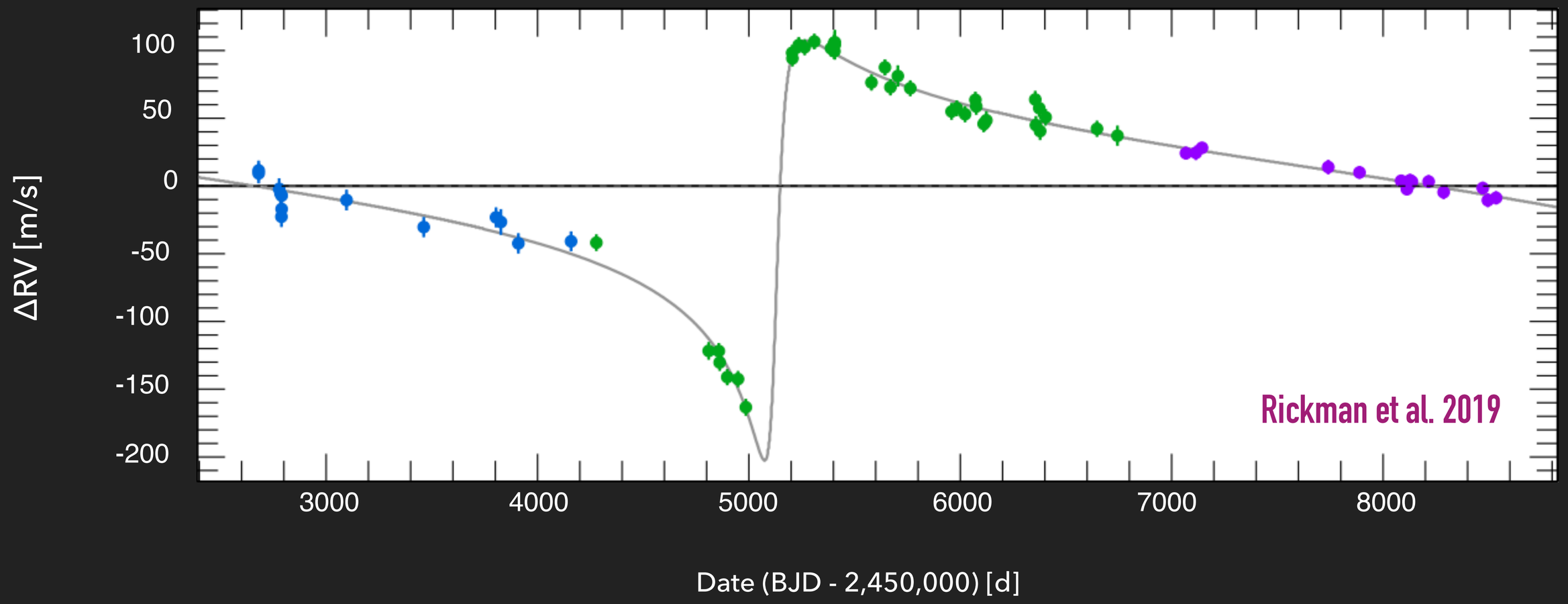
20.4 years

HD 25015



Minimum mass: $4.5 \pm 0.3\ M_{\mathrm{Jup}}$ **16.5 years**

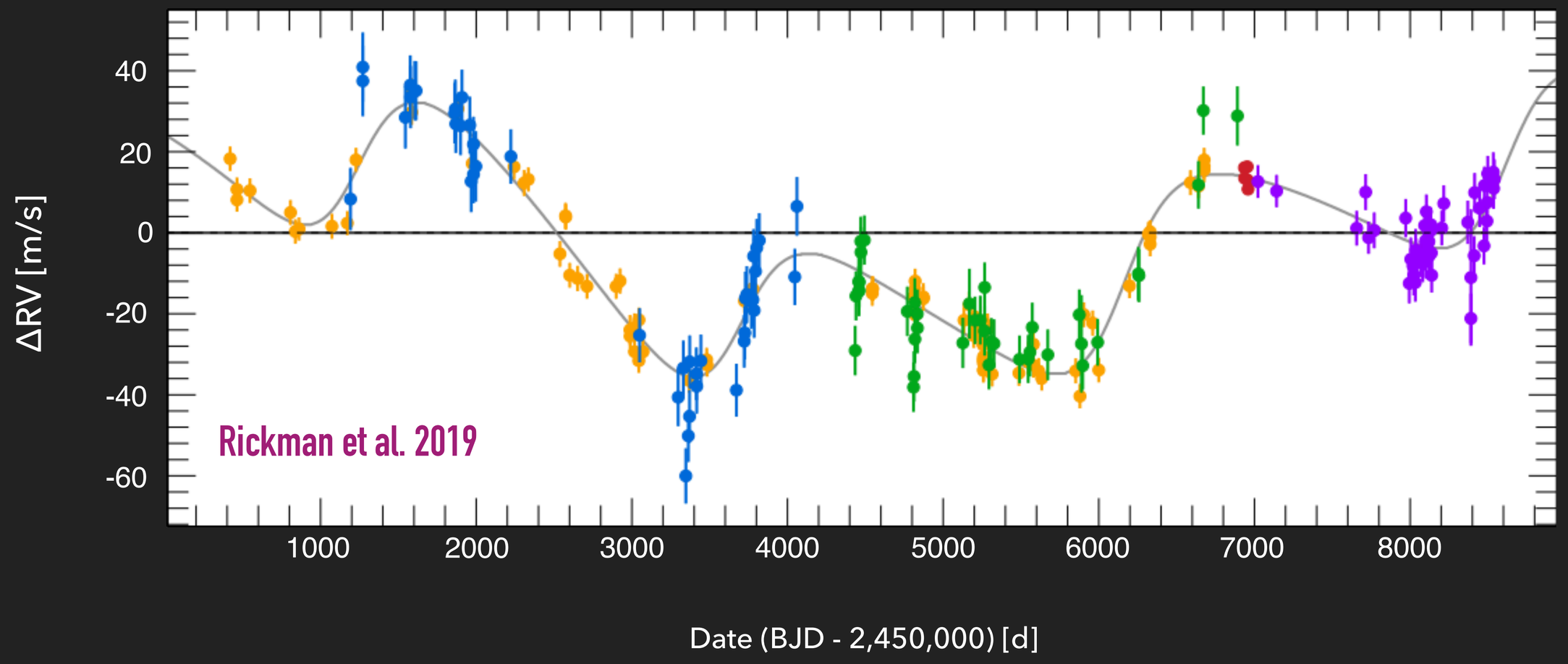
HD 98649



Minimum mass: $6.8^{+0.5}_{-0.3}\ M_{\rm Jup}$

16.5 years

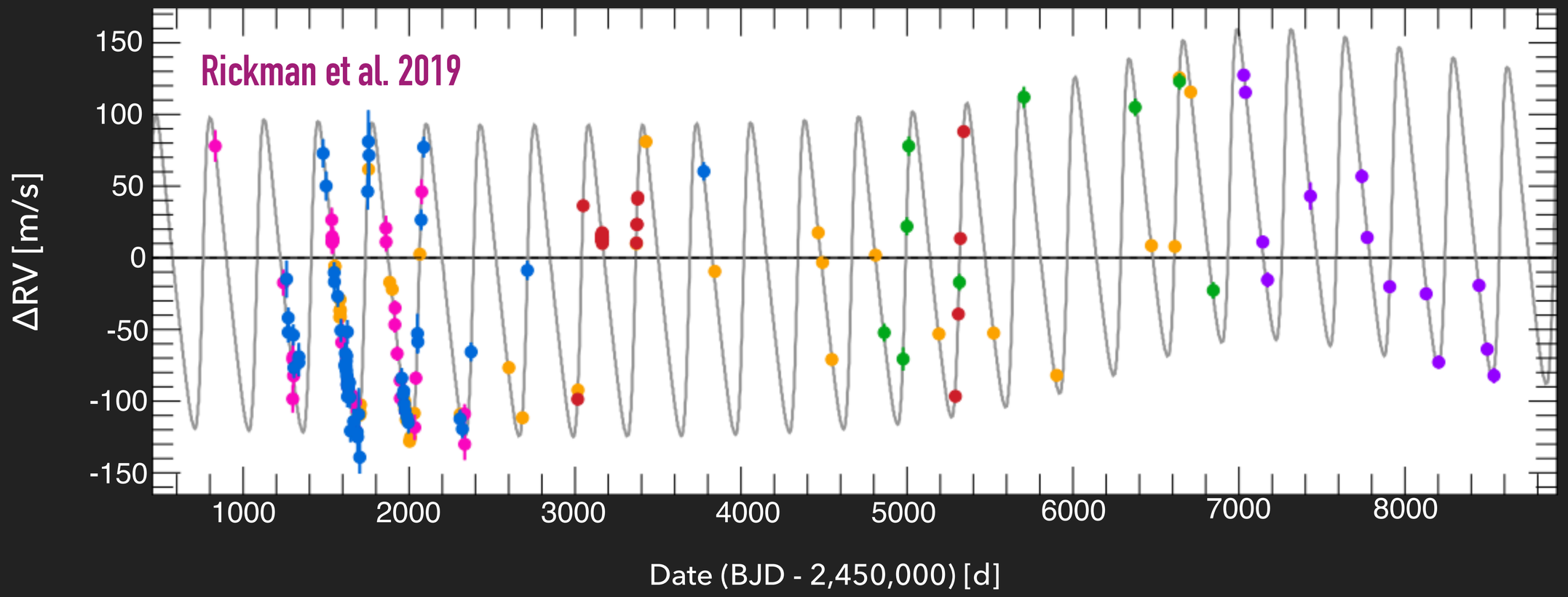
HD 50499



Minimum mass b: $1.45 \pm 0.08\ M_{\rm Jup}$ **7 years**

Minimum mass c: $2.93^{+0.7}_{-0.2}\ M_{\rm Jup}$ **24 years**

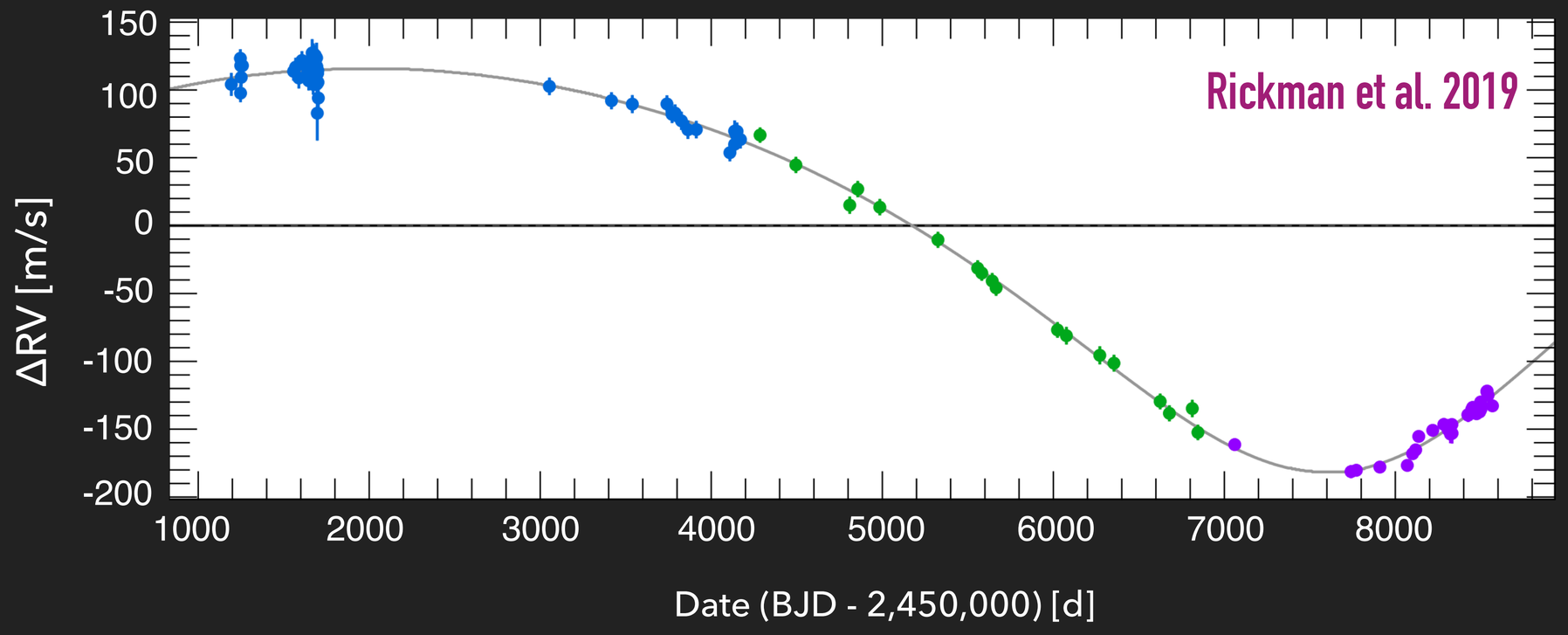
HD 92788



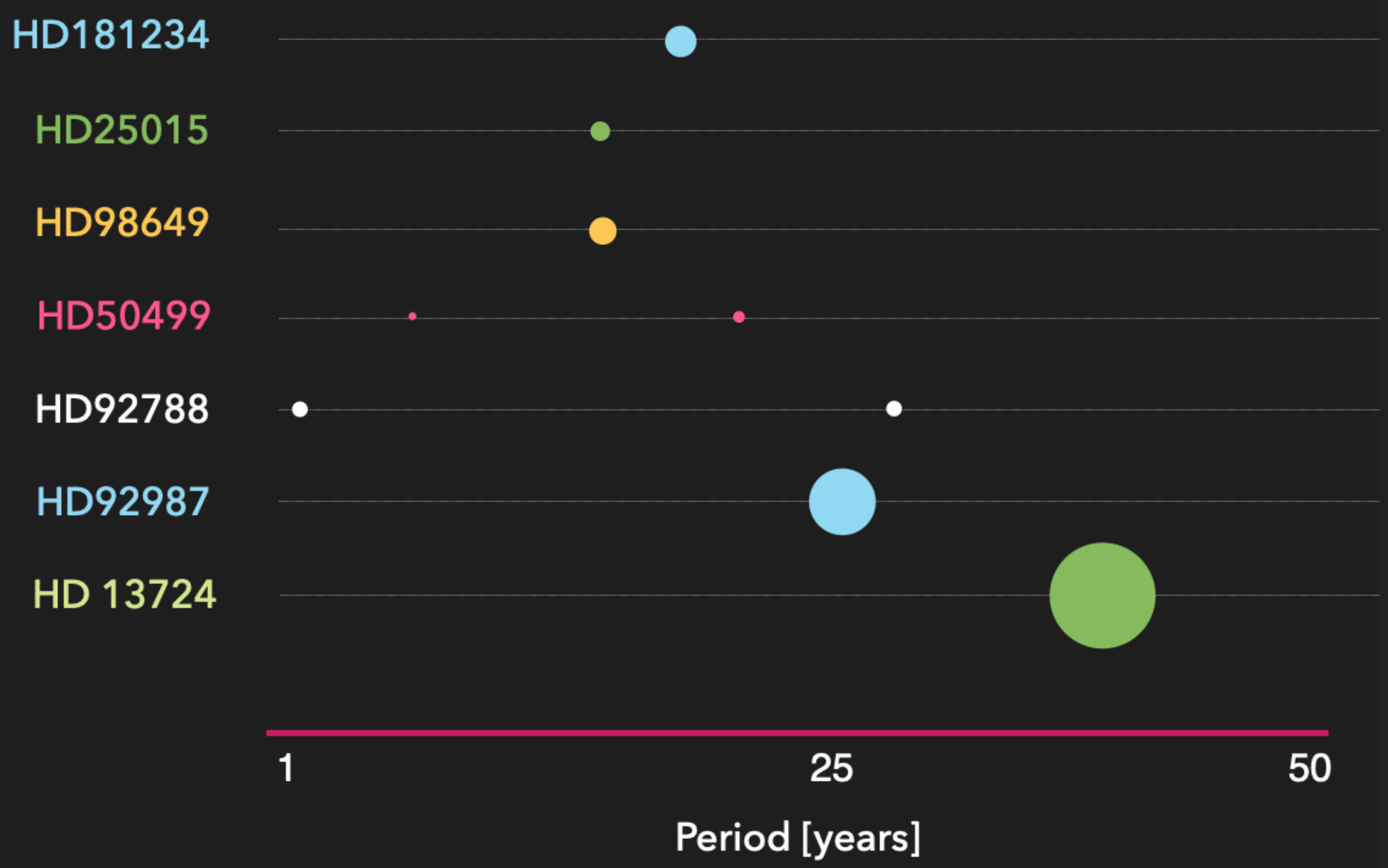
Minimum mass b: $3.8 \pm 0.2\ M_{\rm Jup}$ 0.9 years

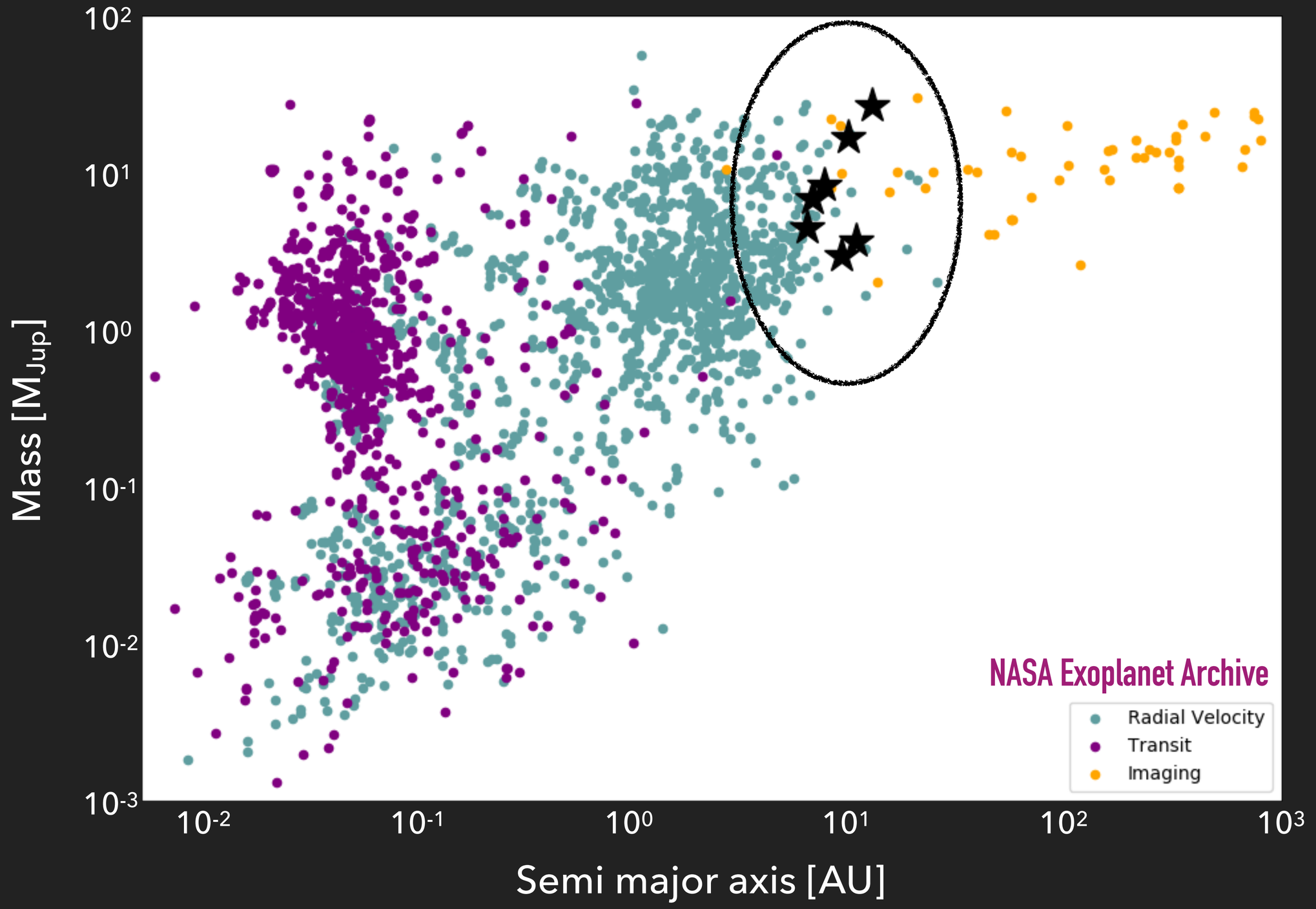
Minimum mass c: $3.7 \pm 0.3\ M_{\rm Jup}$ 32 years

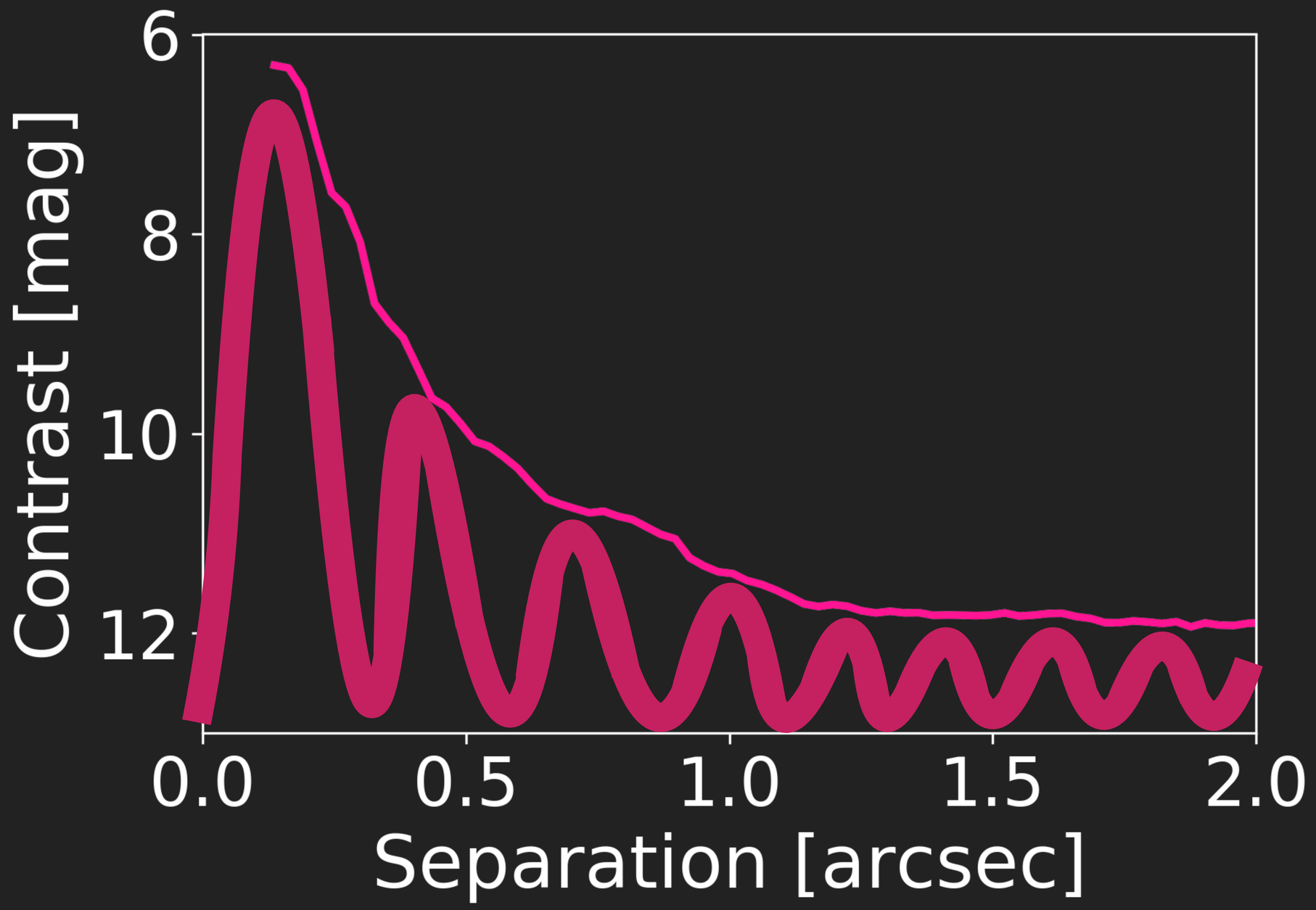
HD 92987



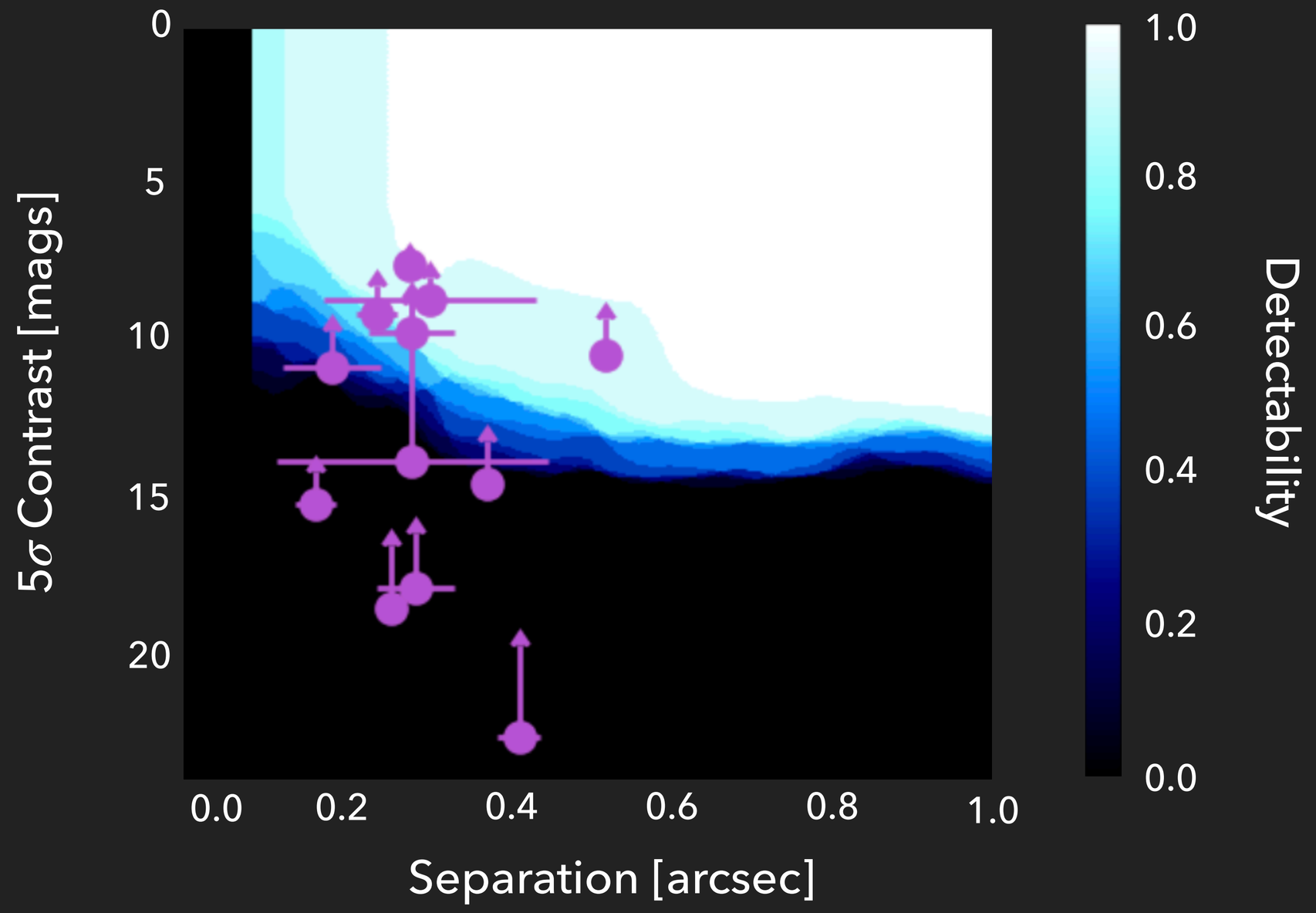
Minimum mass: $16.9 \pm 0.7\ M_{\mathrm{Jup}}$ **28 years**

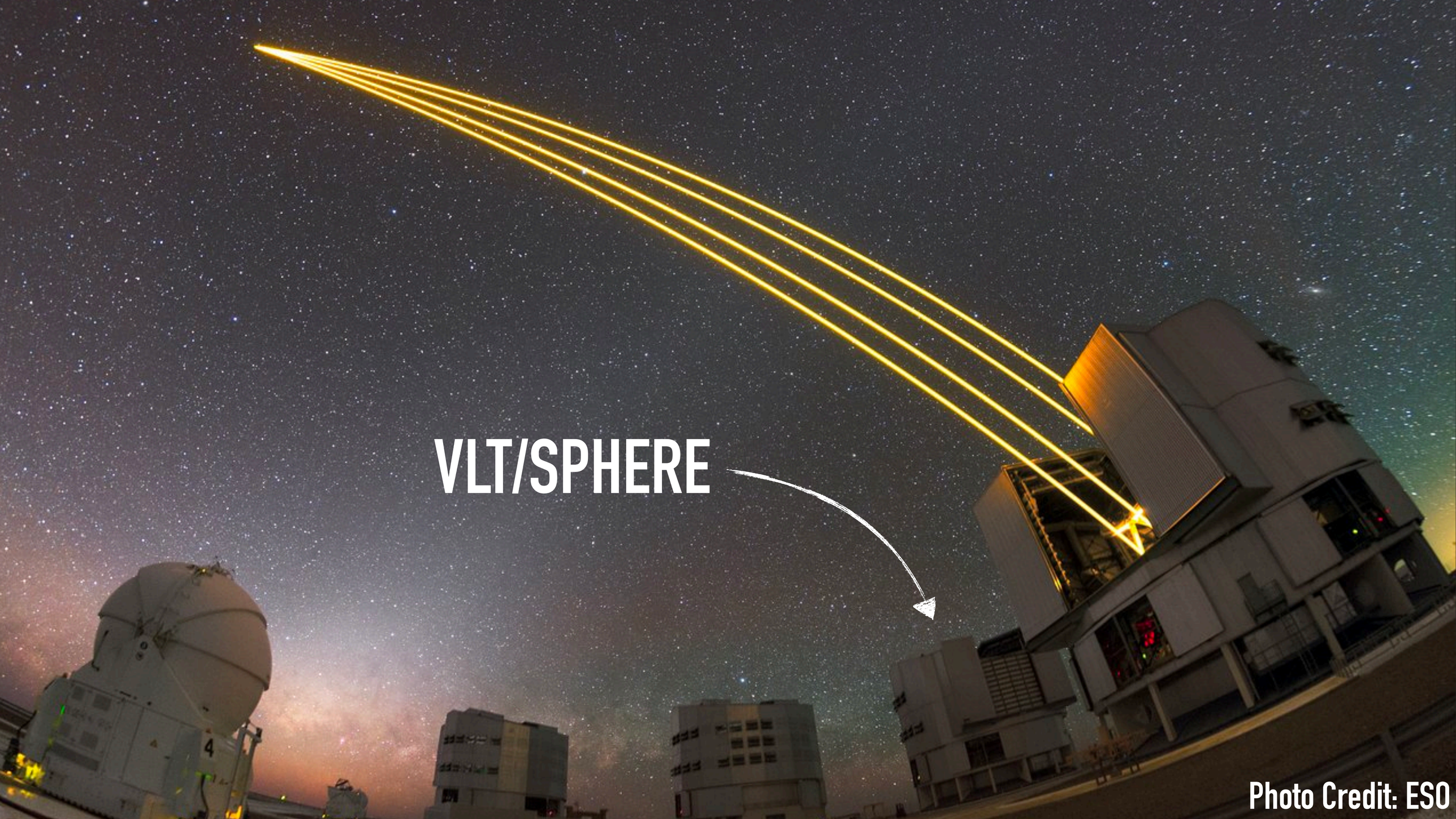

HD181234
HD25015
HD98649
HD50499
HD92788
HD92987
HD 13724
1
25
50
Period [years]


NASA Exoplanet Archive
Radial Velocity
Transit
Imaging
Mass [M_{Jup}]
Semi major axis [AU]
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}



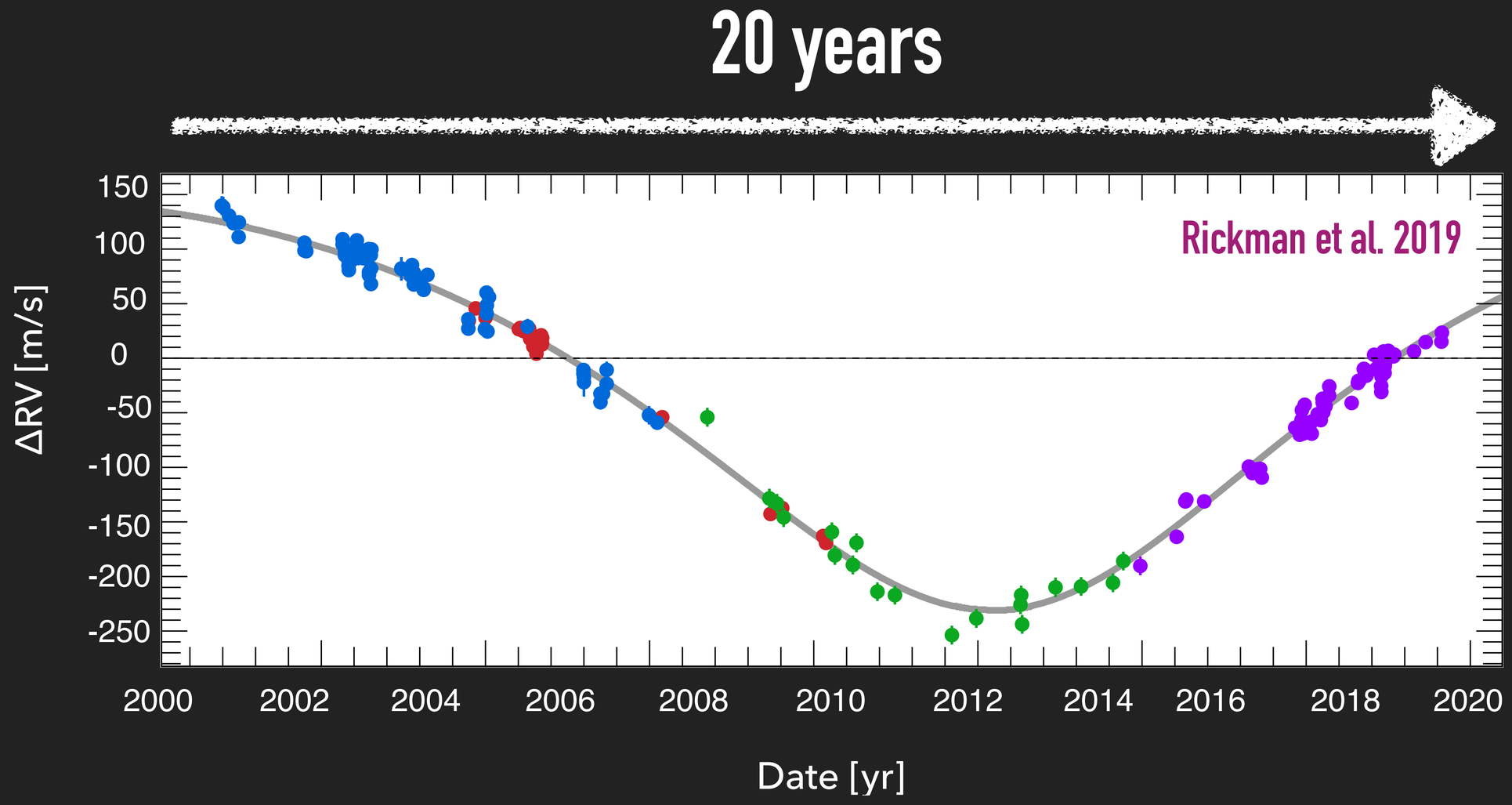
COND Isochrones (Baraffe et al. 2003)


0
5
10
15
20
5σ Contrast [mags]
0.0
0.2
0.4
0.6
0.8
1.0
Separation [arcsec]
1.0
0.8
0.6
0.4
0.2
0.0
Detectability


VLT/SPHERE
Photo Credit: ESO

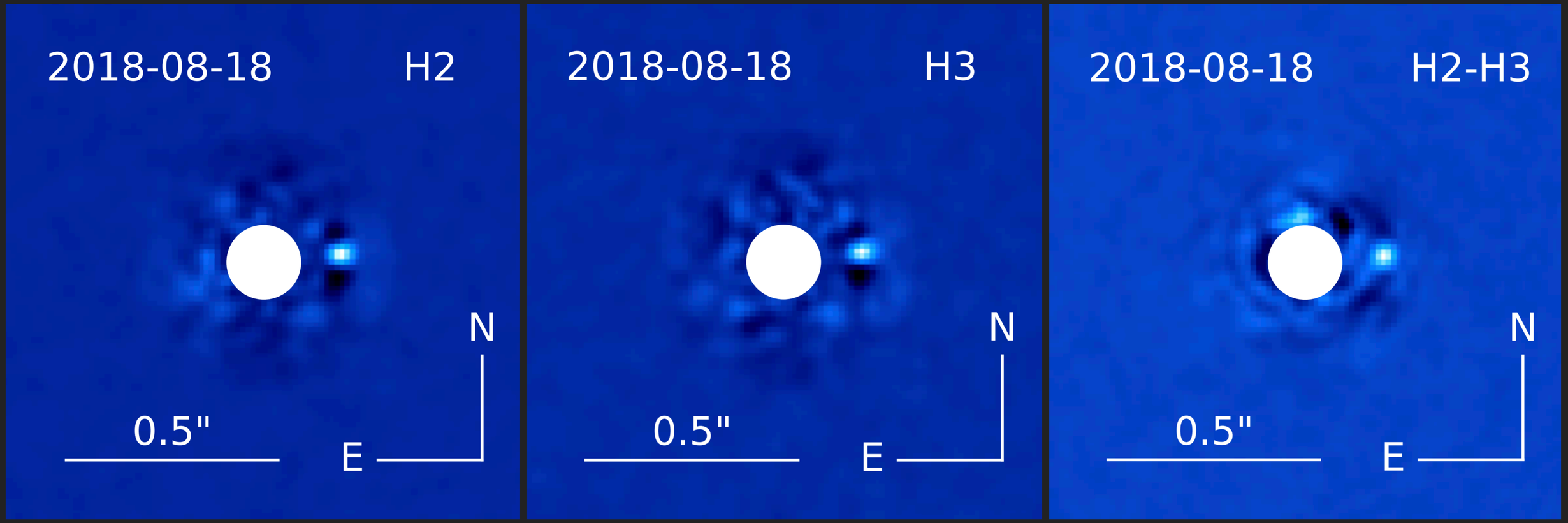
HD 13724 B

Min. mass: 27 M_{Jup}



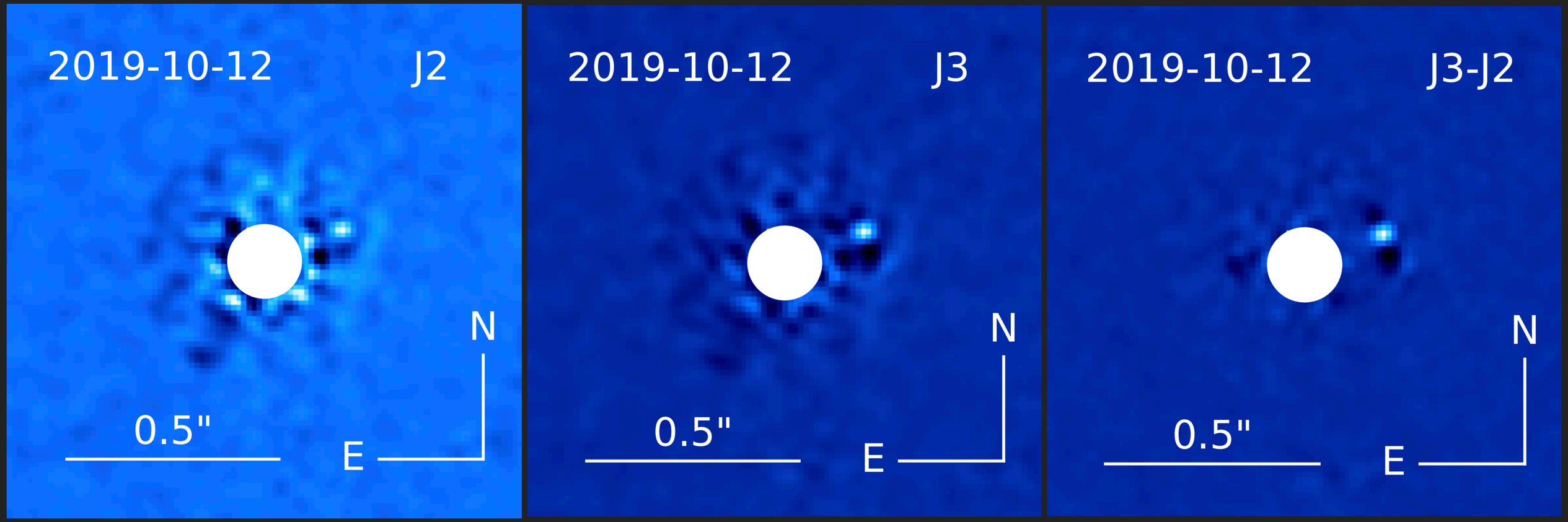
HD 13724 B

Rickman et al. 2020

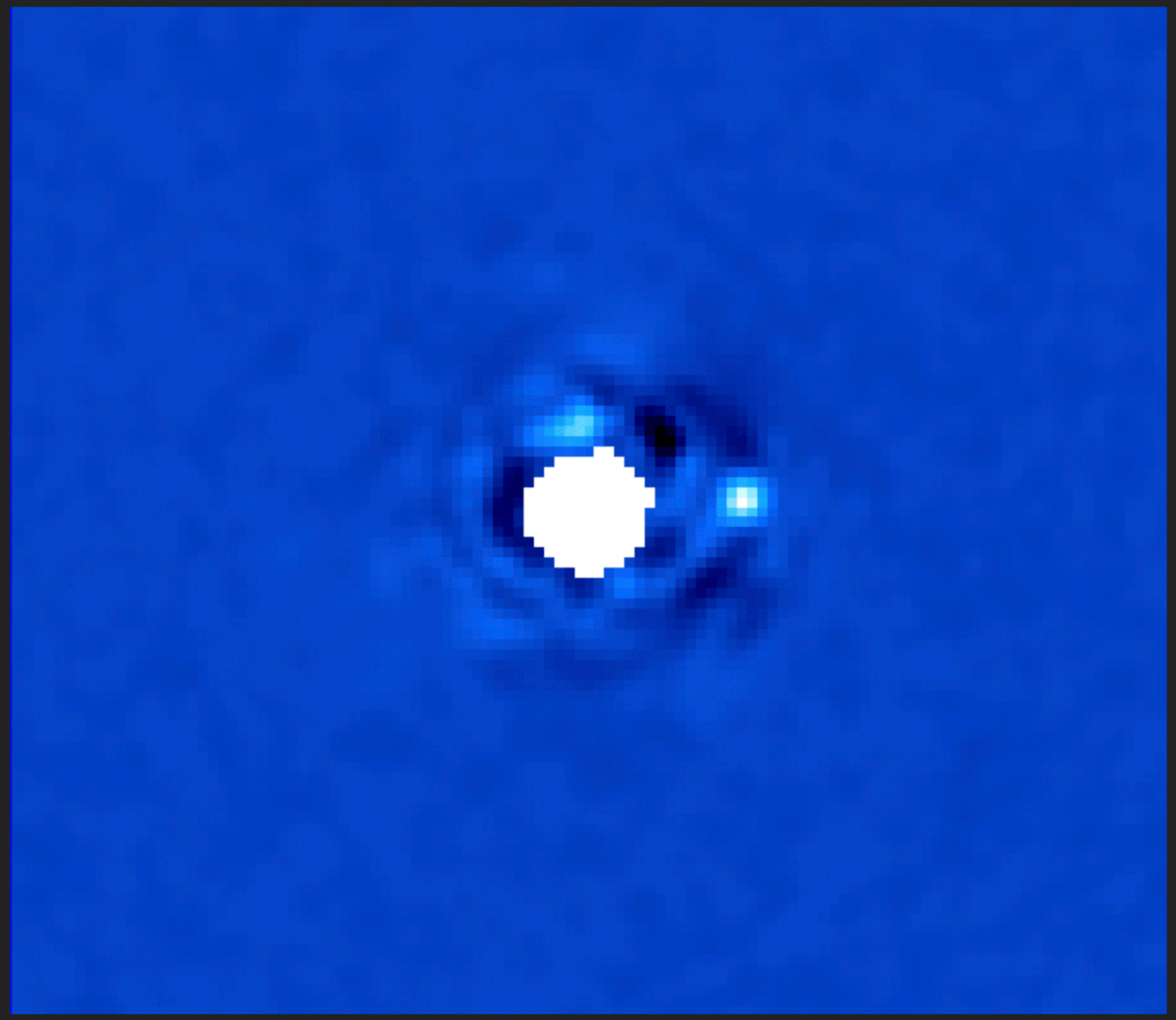


HD 13724 B

Rickman et al. 2020



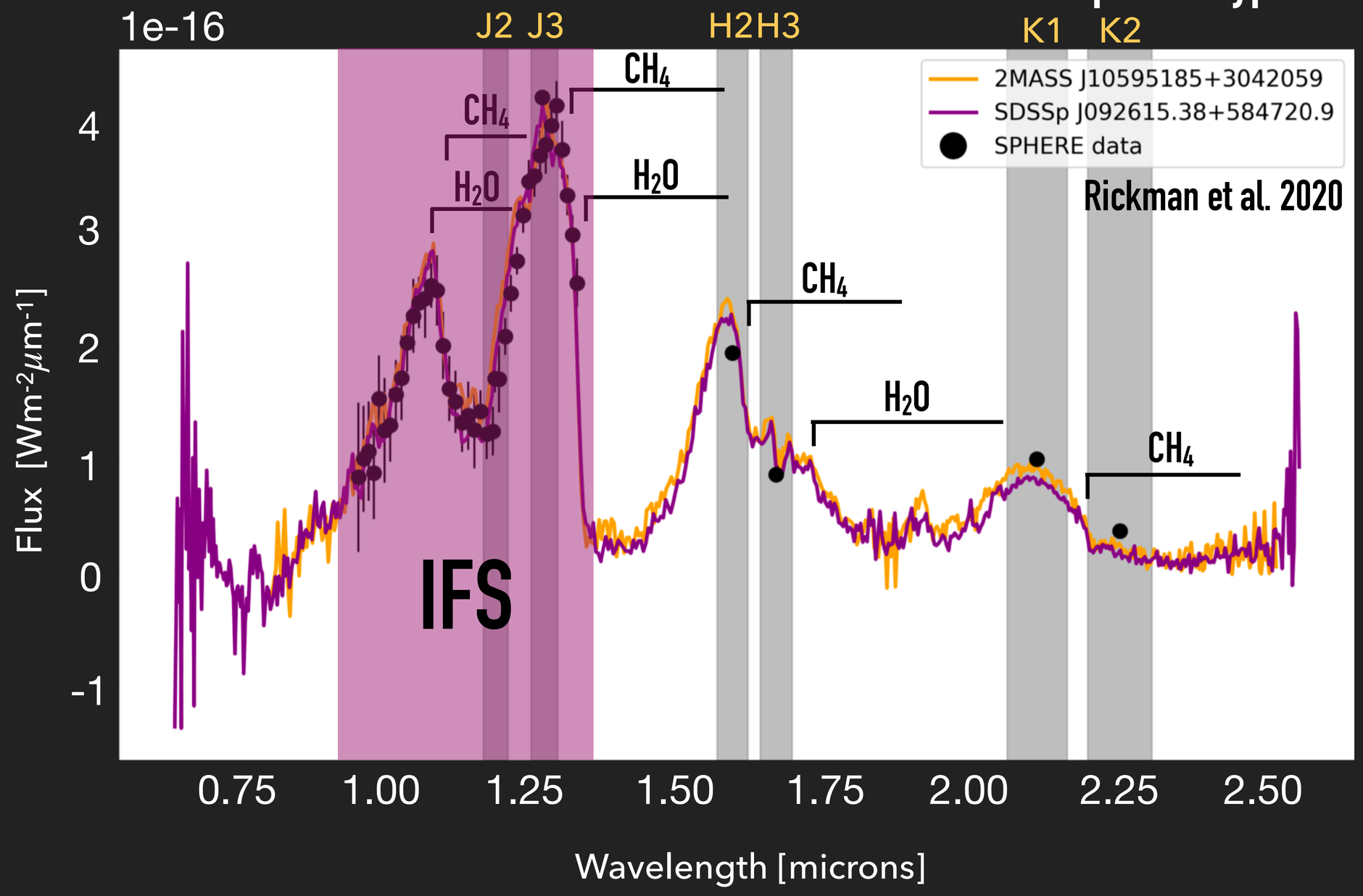
HD 13724 B



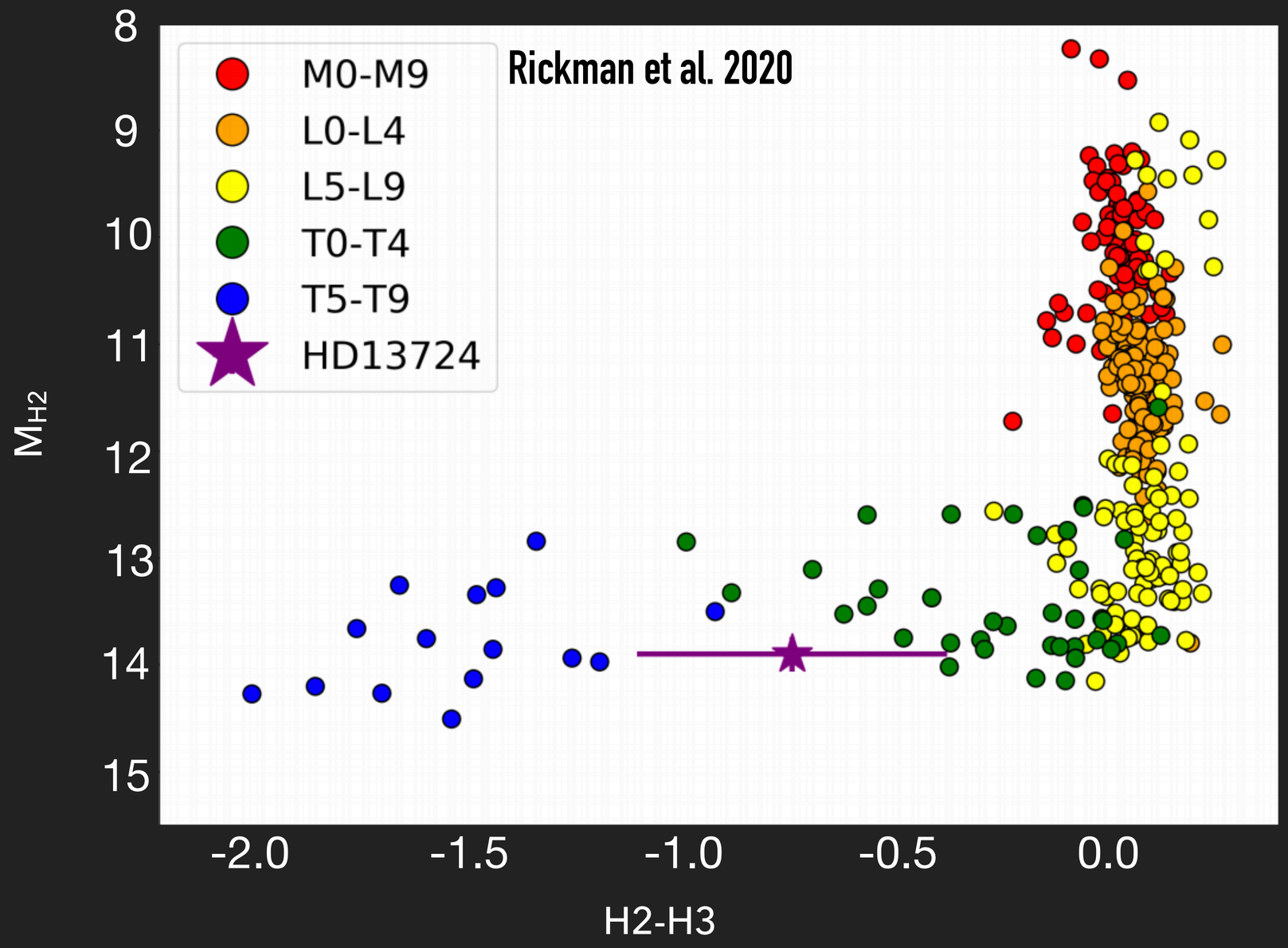
Dynamical mass: 50 M_{Jup}

HD 13724 B

Temperature: 1000 K
Spectral type: T4



HD 13724 B


Rickman et al. 2020
M0-M9
L0-L4
L5-L9
T0-T4
T5-T9
HD13724
8
9
10
11
12
13
14
15
M_{H2}
-2.0
-1.5
-1.0
-0.5
0.0
H2-H3

Conclusions

Important benchmarks to test atmospheric, formation, and evolutionary models of ultracool substellar companions, that can serve as analogues for giant gaseous planets

These detections join just a short list of brown dwarf companions with a known dynamical mass - contribute to the mass-luminosity-age relation of brown dwarfs

Future prospects

Combine astrometric data from *Gaia* and *Hipparcos*

Carry out an informed imaging survey using astrometric and radial velocity data to find such companions

Test observational signatures to decipher formation mechanisms

Dr. Emily Rickman

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