Stellar and substellar companions from Gaia DR2

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Image: NASA, ESA and G. Bacon (STScI)

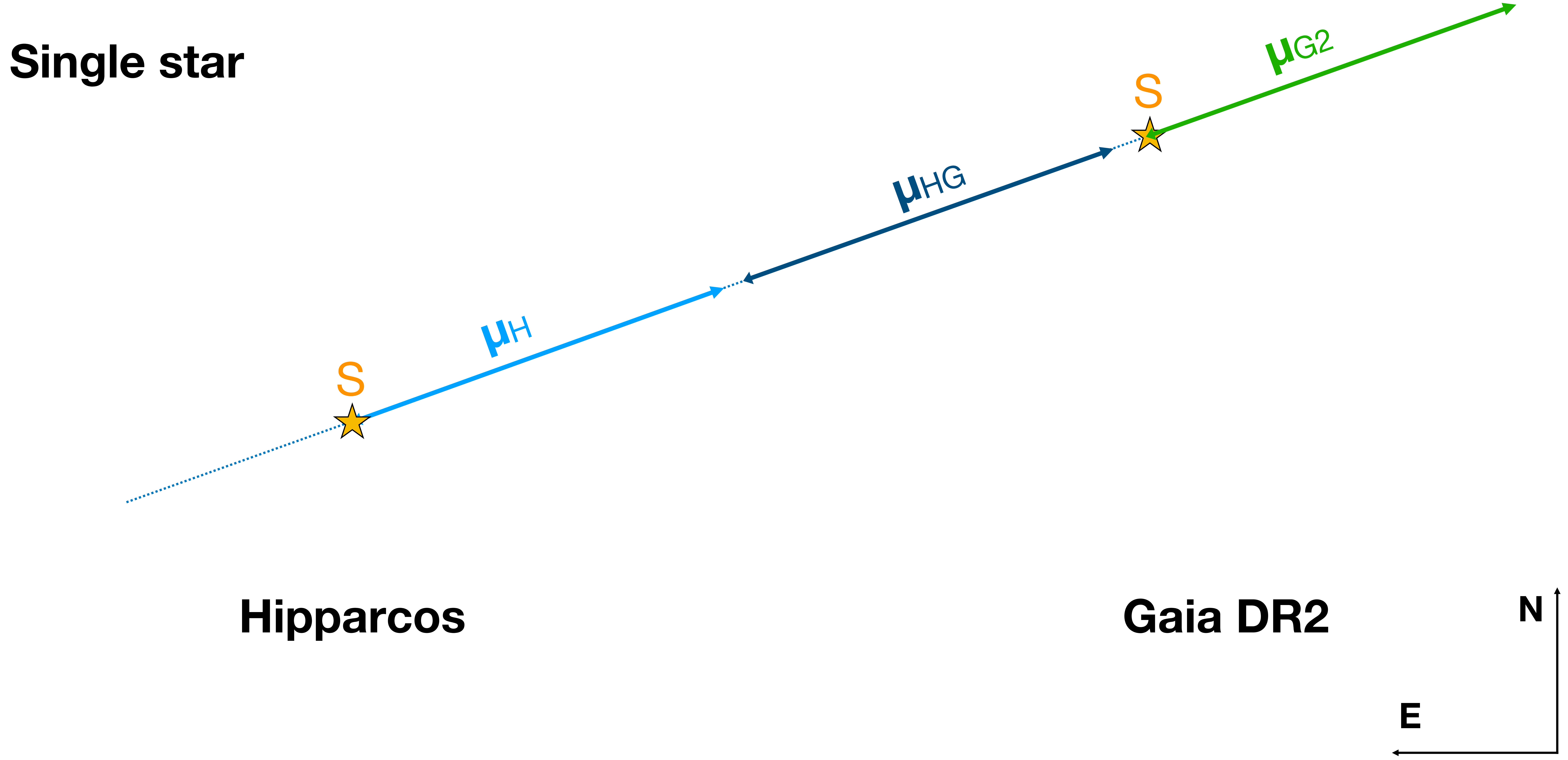
Overview

Detection of companions of nearby stars from Gaia DR2 proper motions using two methods:

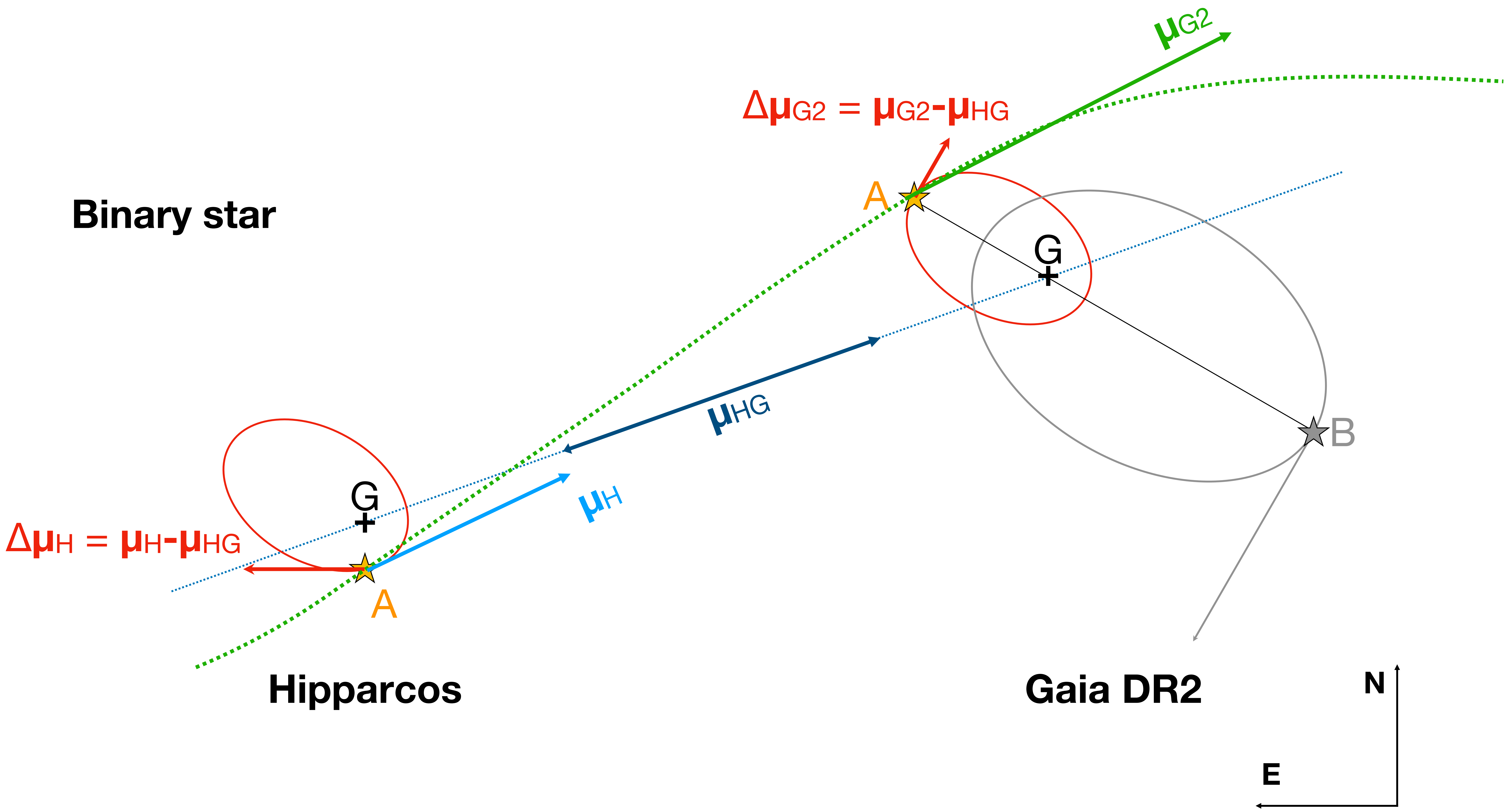
1. **Proper motion anomaly** between Hipparcos-Gaia positions and Gaia proper motions

2. **Common proper motion** and parallax pairs

Proper motion anomaly



Proper motion anomaly



- Sensitivity in mass and orbital radius ?

$$\frac{m_2}{\sqrt{r}} = \sqrt{\frac{m_1}{G}}\, v_1 = \sqrt{\frac{m_1}{G}} \left(\frac{\Delta\mu[\text{mas a}^{-1}]}{\varpi[\text{mas au}^{-1}]} \times 4740.470 \right)$$

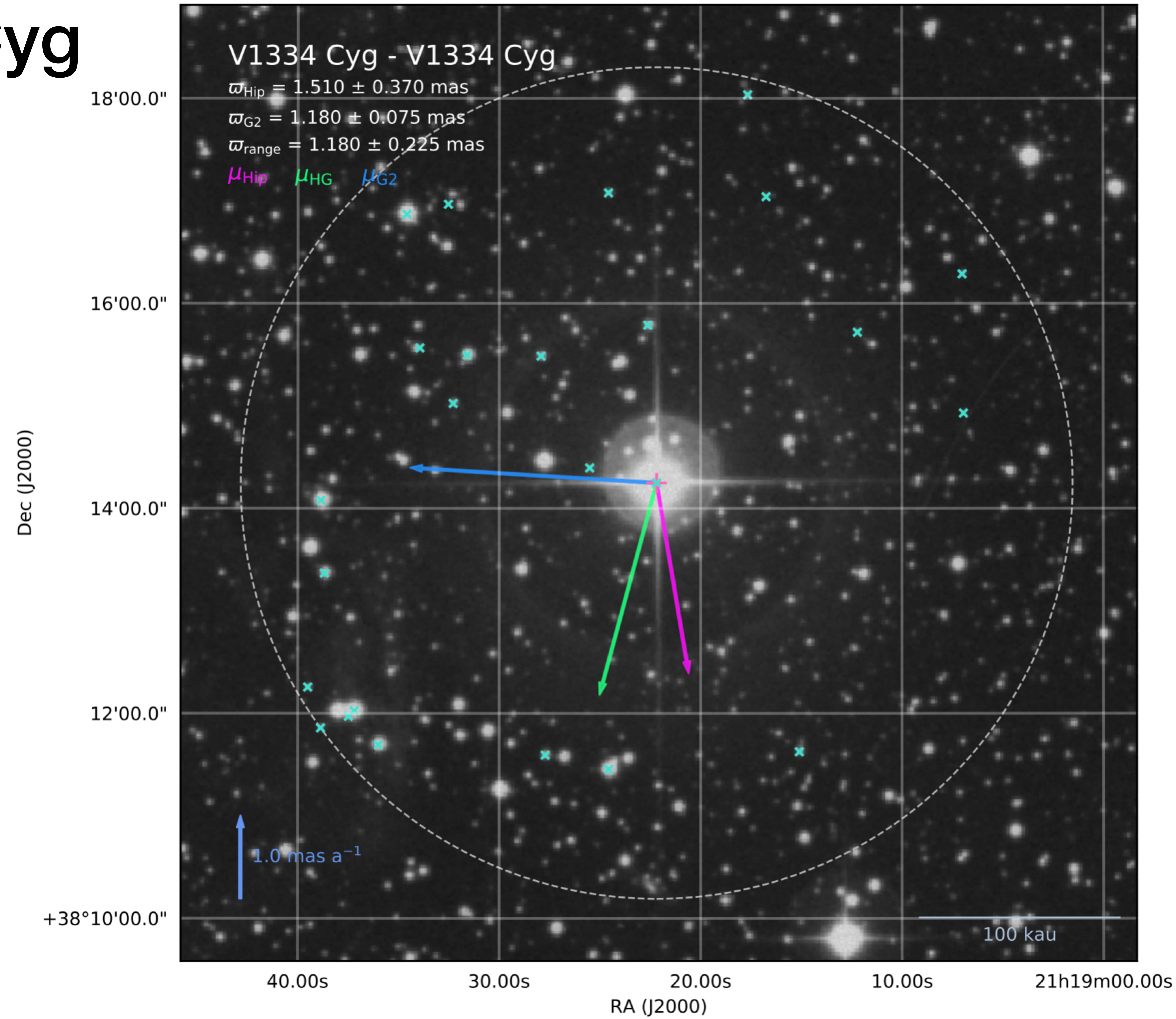
$$\sigma(\mu) \ = \ 242\,\mu\text{as a}^{-1}$$

$$\sigma\left(m_2^{\dagger}\right) = 0.040\, M_J\, \text{au}^{-1/2}\, \text{pc}^{-1}$$

- The sensitivity decreases linearly as a function of the distance

Kervella et al. 2019, A&A, 623, A72

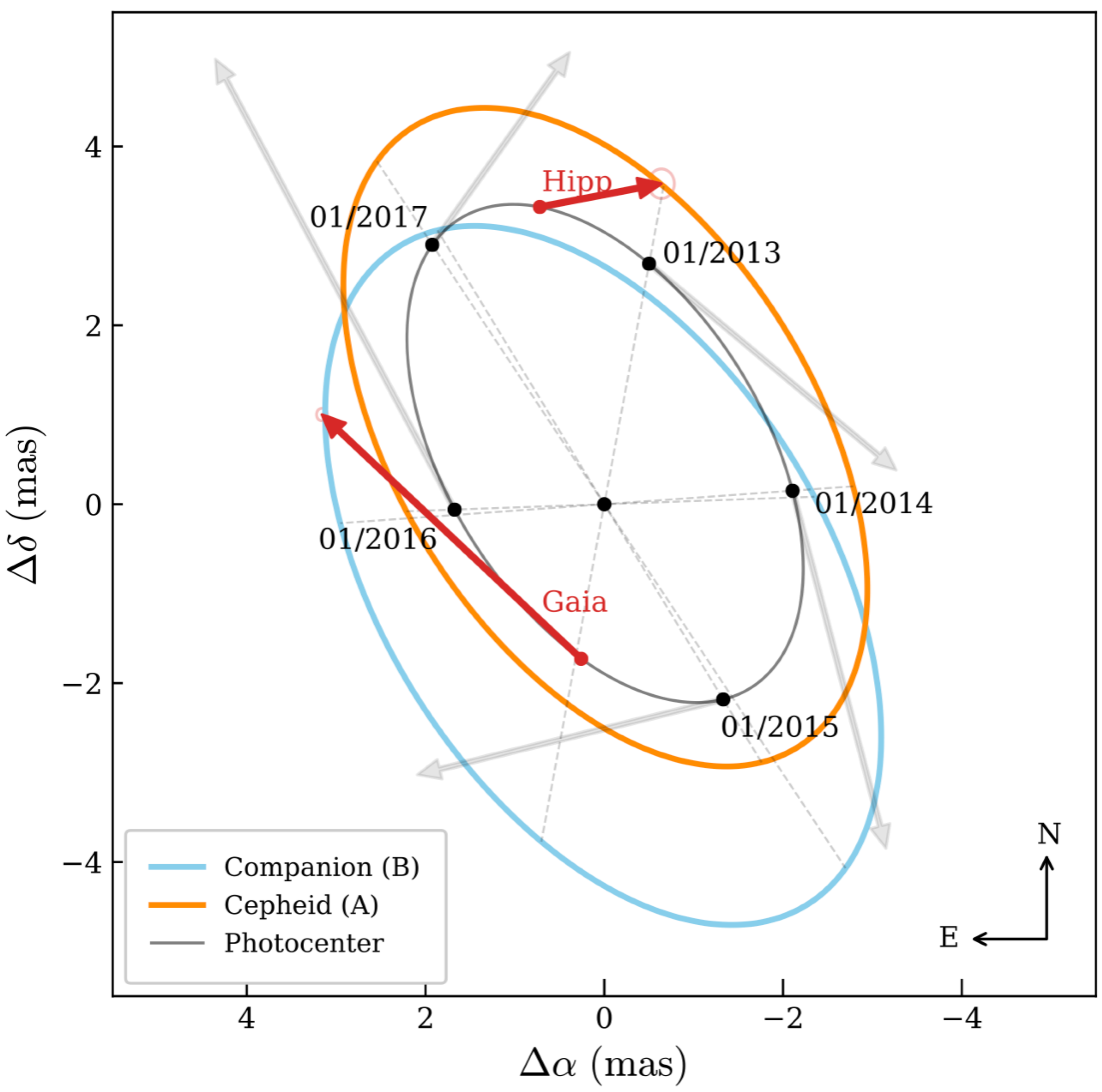
V1334 Cyg



V1334 Cyg - V1334 Cyg
ϖHip = 1.510 ± 0.370 mas
ϖG2 = 1.180 ± 0.075 mas
ϖrange = 1.180 ± 0.225 mas
μHip
μHG
μG2
1.0 mas a⁻¹
100 kau
18'00.0"
16'00.0"
14'00.0"
12'00.0"
+38°10'00.0"
Dec (J2000)
40.00s
30.00s
20.00s
10.00s
21h19m00.00s
RA (J2000)

V1334 Cyg

Gallenne et al. 2018, ApJ, 623, A116

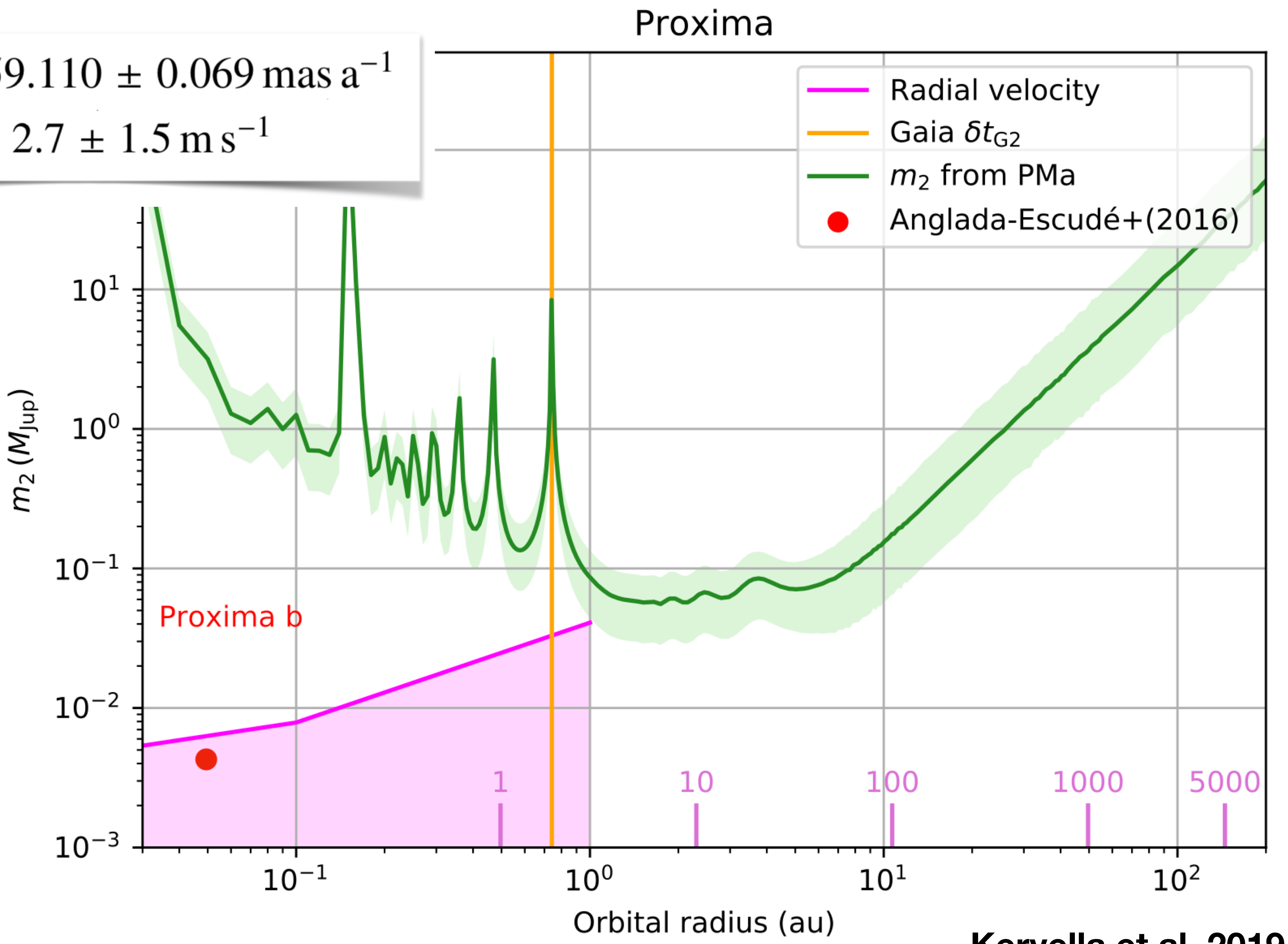


Adopted parameters	
Parallax from GDR2 ϖ	$1.180_{\pm 0.066}$ mas ($1.388_{\pm 0.015}$ mas)
Mass from P-M m_1	$4.6_{\pm 0.7}$ $M_\odot$ ($4.29_{\pm 0.13}$ $M_\odot$)
Parameters from Evans (2000)	
Orbital period P	$1937.5_{\pm 2.1}$ d ($1932.8_{\pm 1.8}$ d)
Eccentricity e	$0.197_{\pm 0.009}$ ($0.233_{\pm 0.001}$)
Arg. of periastron ω	$226.4_{\pm 2.9}$ deg ($229.8_{\pm 0.3}$ deg)
v_r amplitude K_1	$14.1_{0.1}$ km s^{-1} ($14.168_{0.014}$ km s^{-1})
v_r at Hip epoch	$+9.86 \pm 0.41$ km s^{-1}
v_r at GDR2 epoch	-9.66 ± 1.33 km s^{-1}
PMa vectors	
μ_{Hip}	$[-1.36_{\pm 0.29}, +0.26_{\pm 0.33}]$ mas a^{-1}
μ_{G2}	$[+2.90_{\pm 0.12}, +2.73_{\pm 0.14}]$ mas a^{-1}
Parameters from present analysis	
Inclination i	$118_{\pm 6}$ deg ($124.94_{\pm 0.09}$ deg)
Semimajor axis a	$6.18_{\pm 0.21}$ au ($6.16_{\pm 0.07}$ au)
Ang. semimajor axis θ	$7.3_{\pm 0.5}$ mas ($8.54_{\pm 0.04}$ mas)
Long. of asc. node Ω	$208_{\pm 6}$ deg ($213.17_{\pm 0.35}$ deg)
Mass of secondary m_2	$3.80_{\pm 0.57}$ $M_\odot$ ($4.04_{\pm 0.05}$ $M_\odot$)

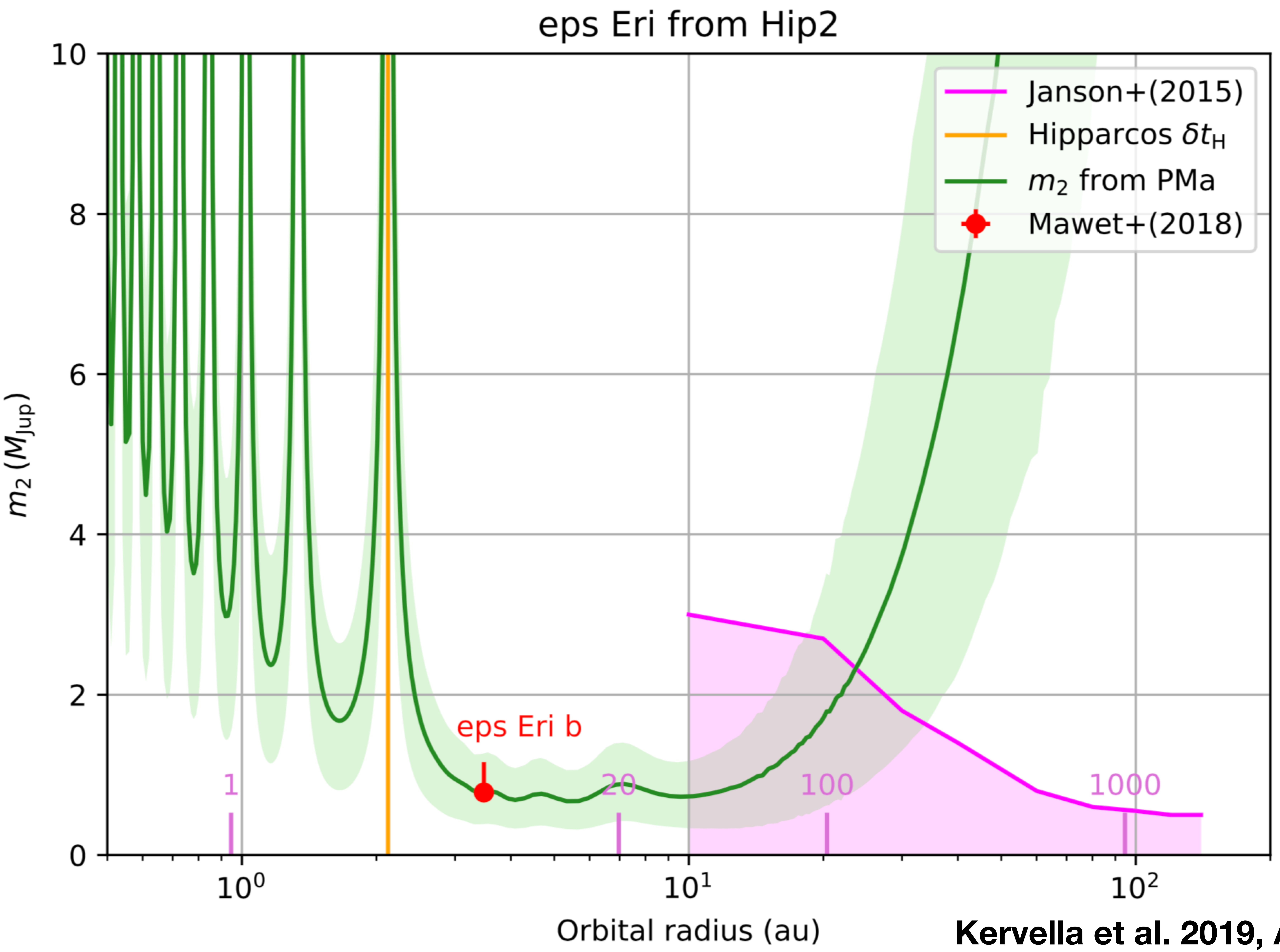
Kervella et al. 2019, A&A, 623, A116

Proxima

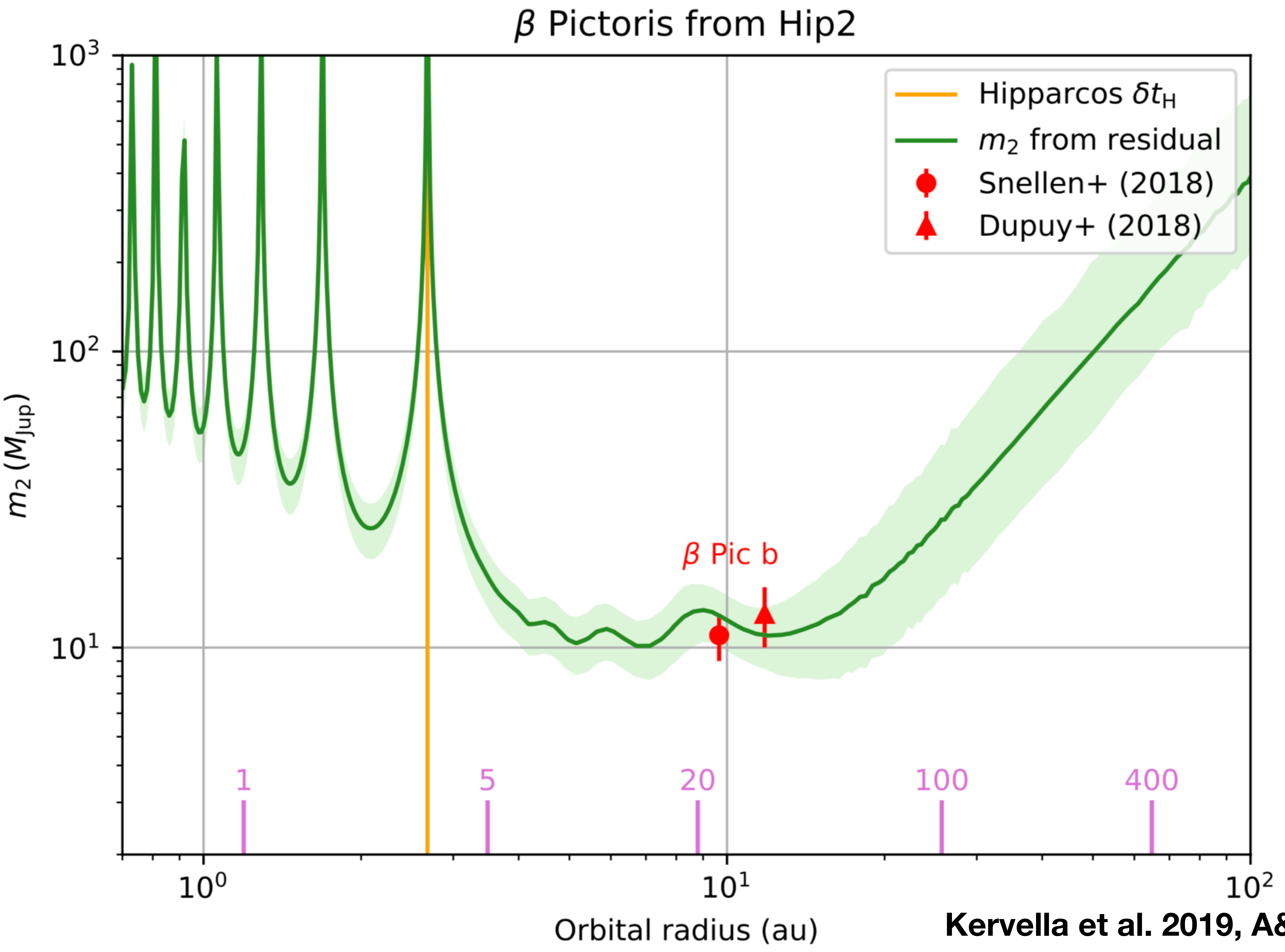
$$\mu_{\rm HG} = 3859.110 \pm 0.069\,\mathrm{mas\,a^{-1}}$$
$$\Delta v_{\rm tan,G2} = 2.7 \pm 1.5\,\mathrm{m\,s^{-1}}$$



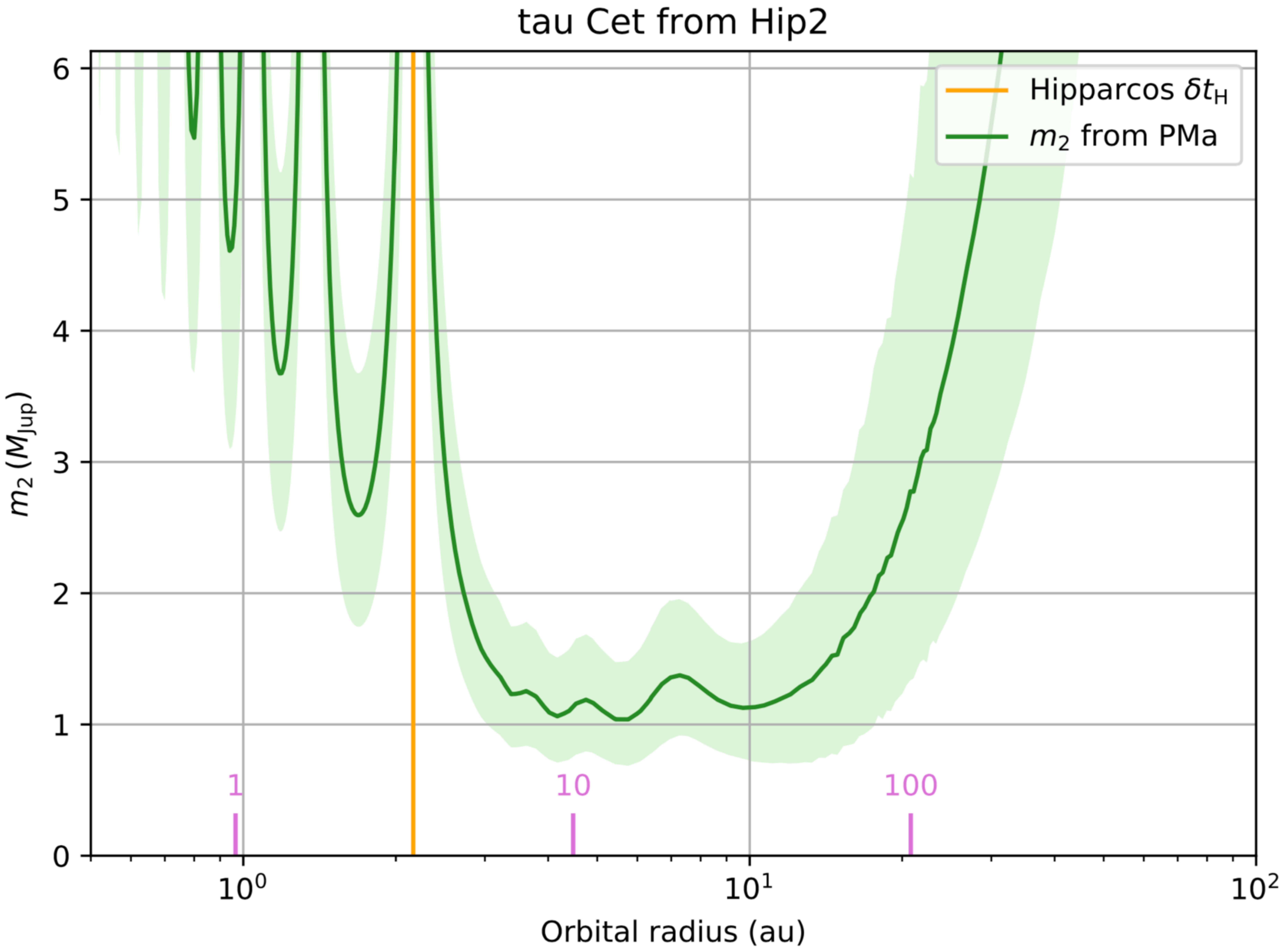
Kervella et al. 2019, A&A, 623, A72



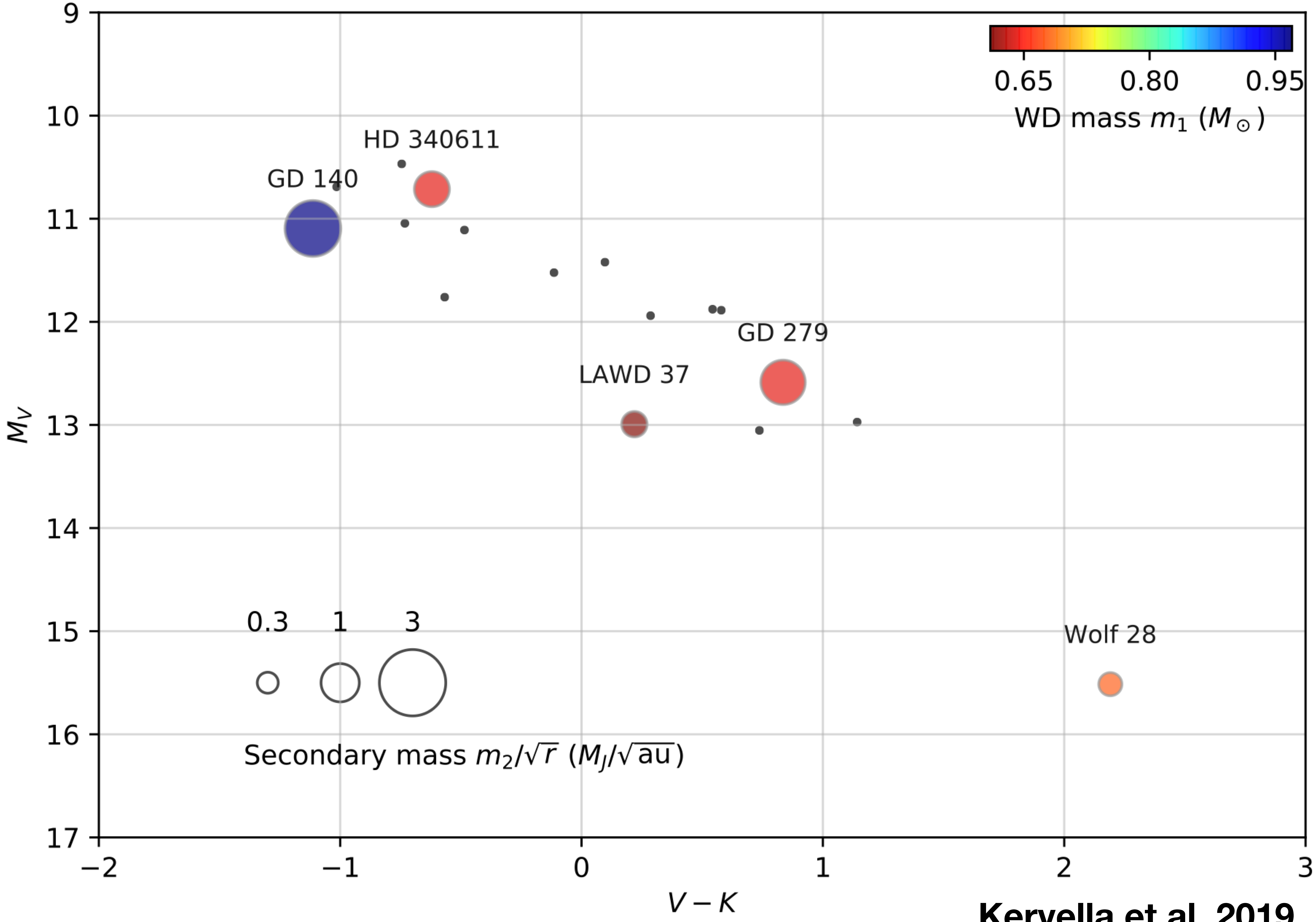
Kervella et al. 2019, A&A, 623, A72



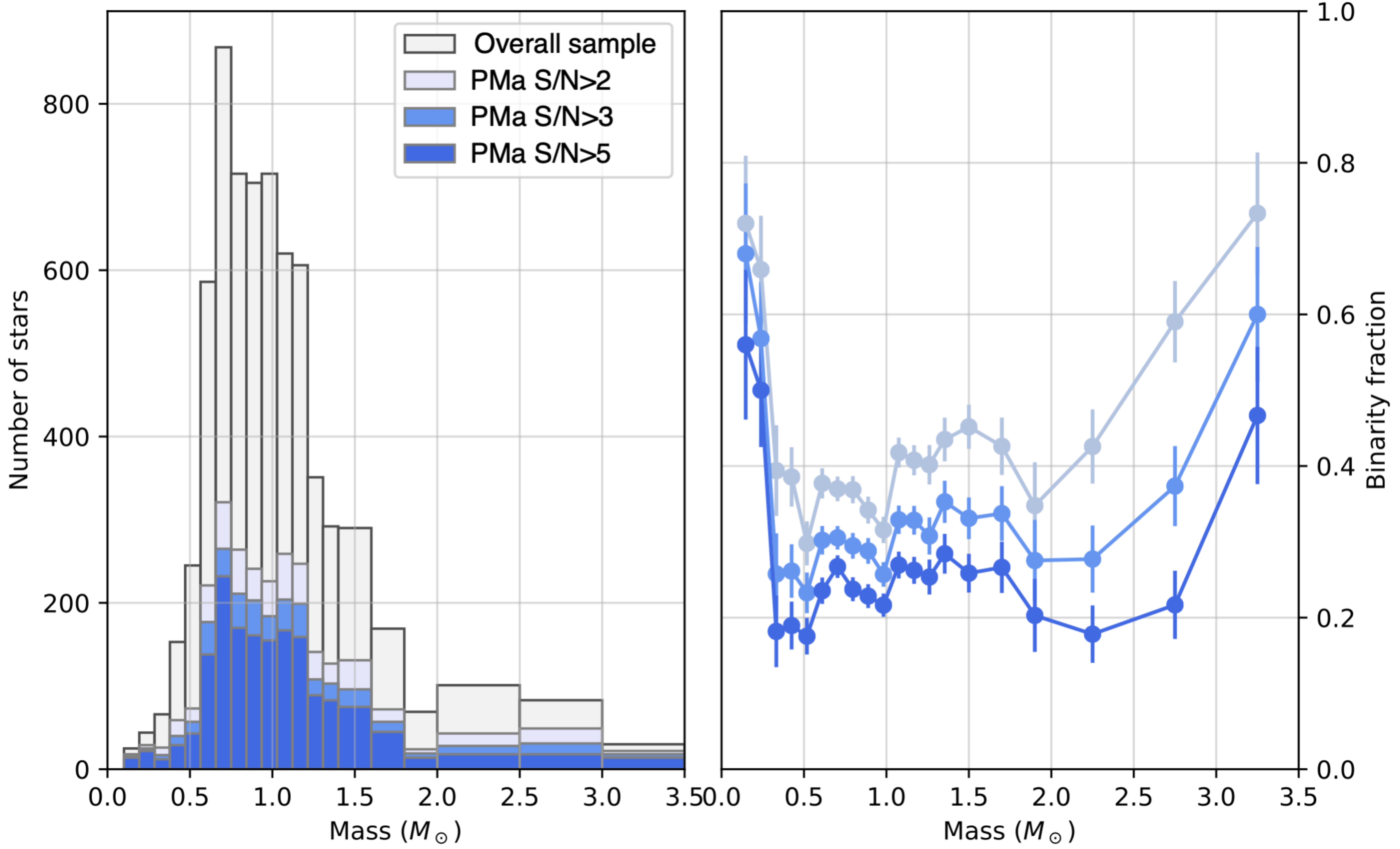
Kervella et al. 2019, A&A, 623, A72


tau Cet from Hip2
Hipparcos $\delta t_{\rm H}$
m_2 from PMa
$m_2\,(M_{\rm Jup})$
Orbital radius (au)
0
1
2
3
4
5
6
10^0
10^1
10^2
1
10
100

White dwarfs

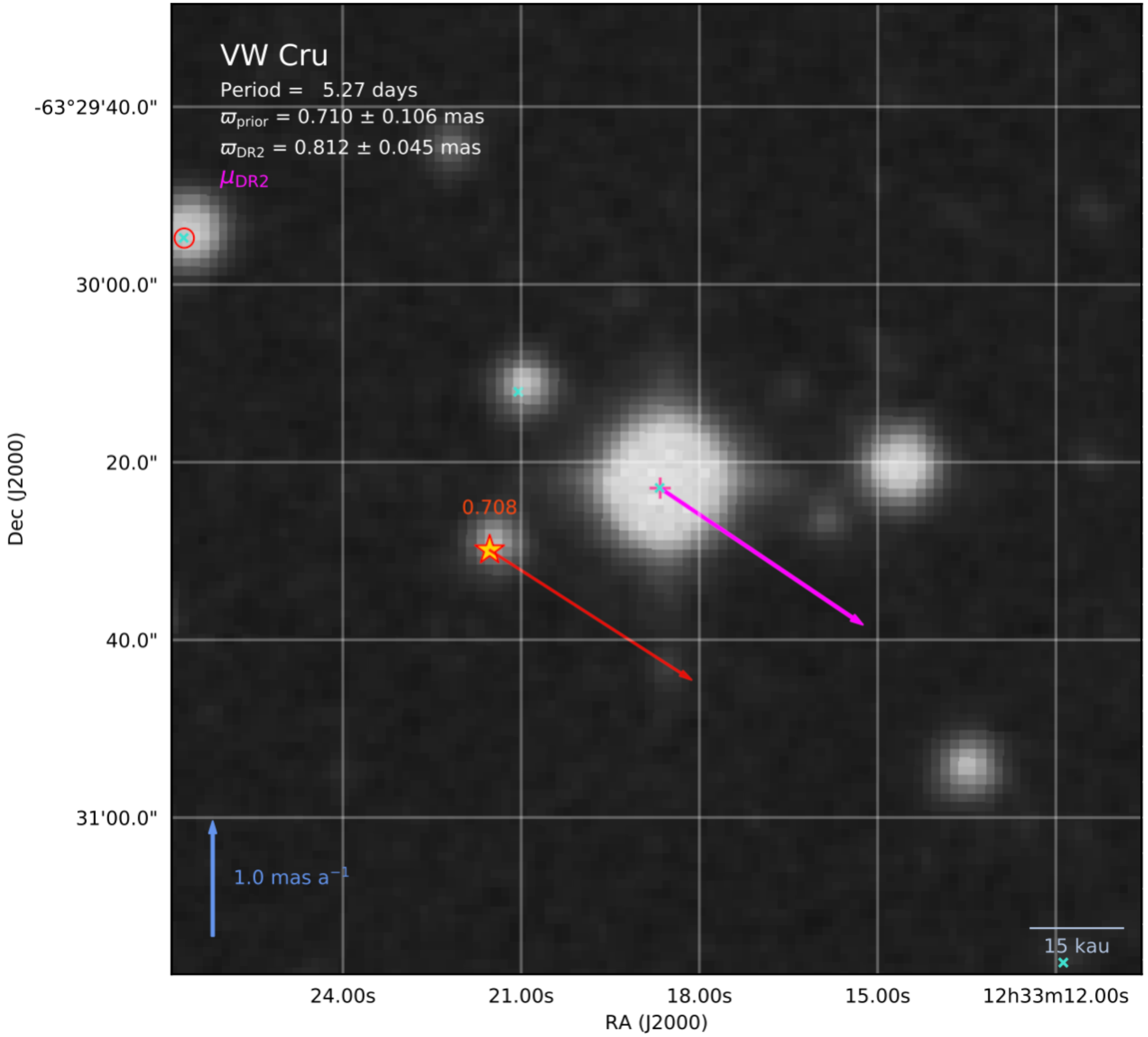


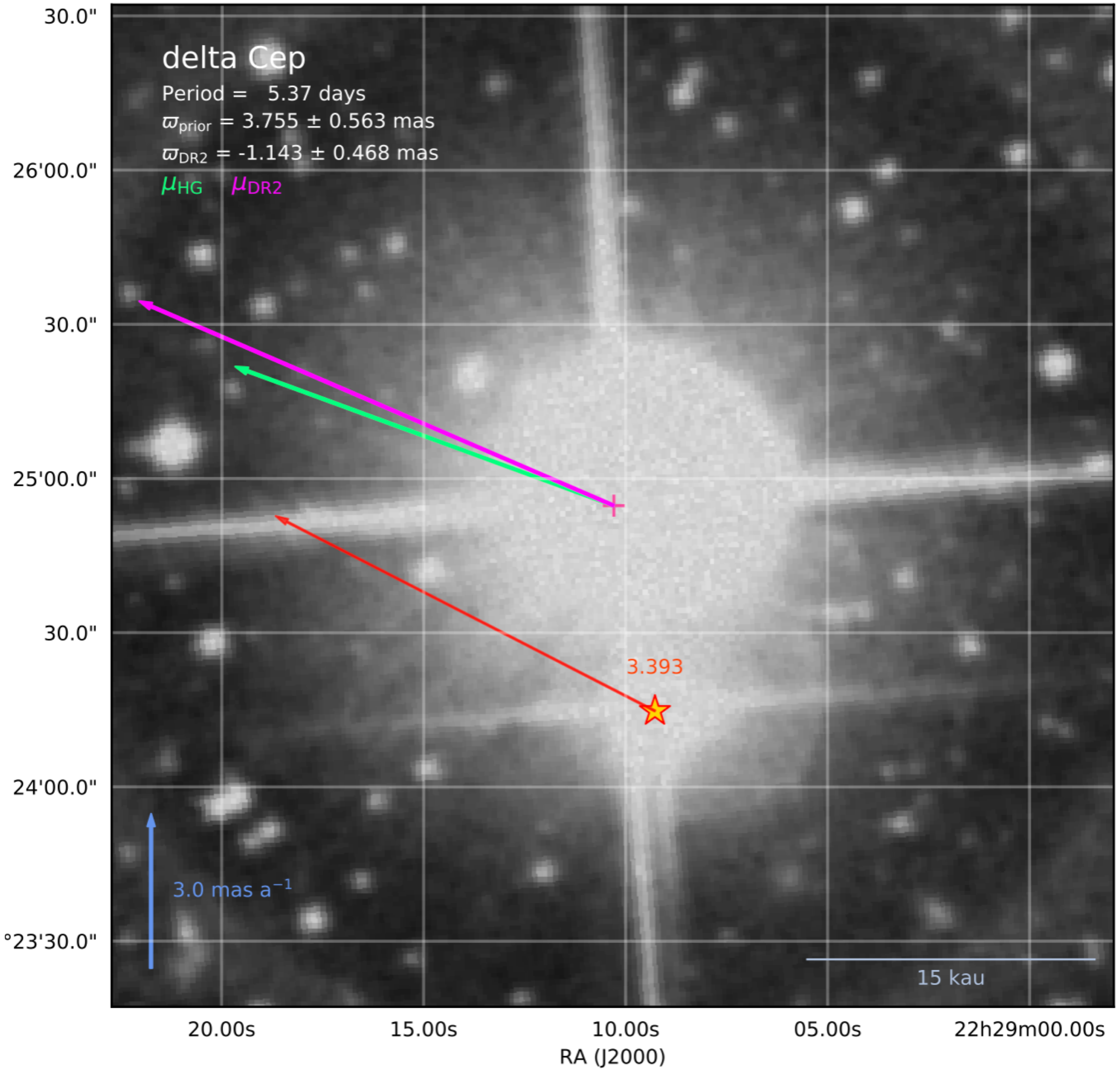
Kervella et al. 2019, A&A, 623, A72



Kervella et al. 2019, A&A, 623, A72

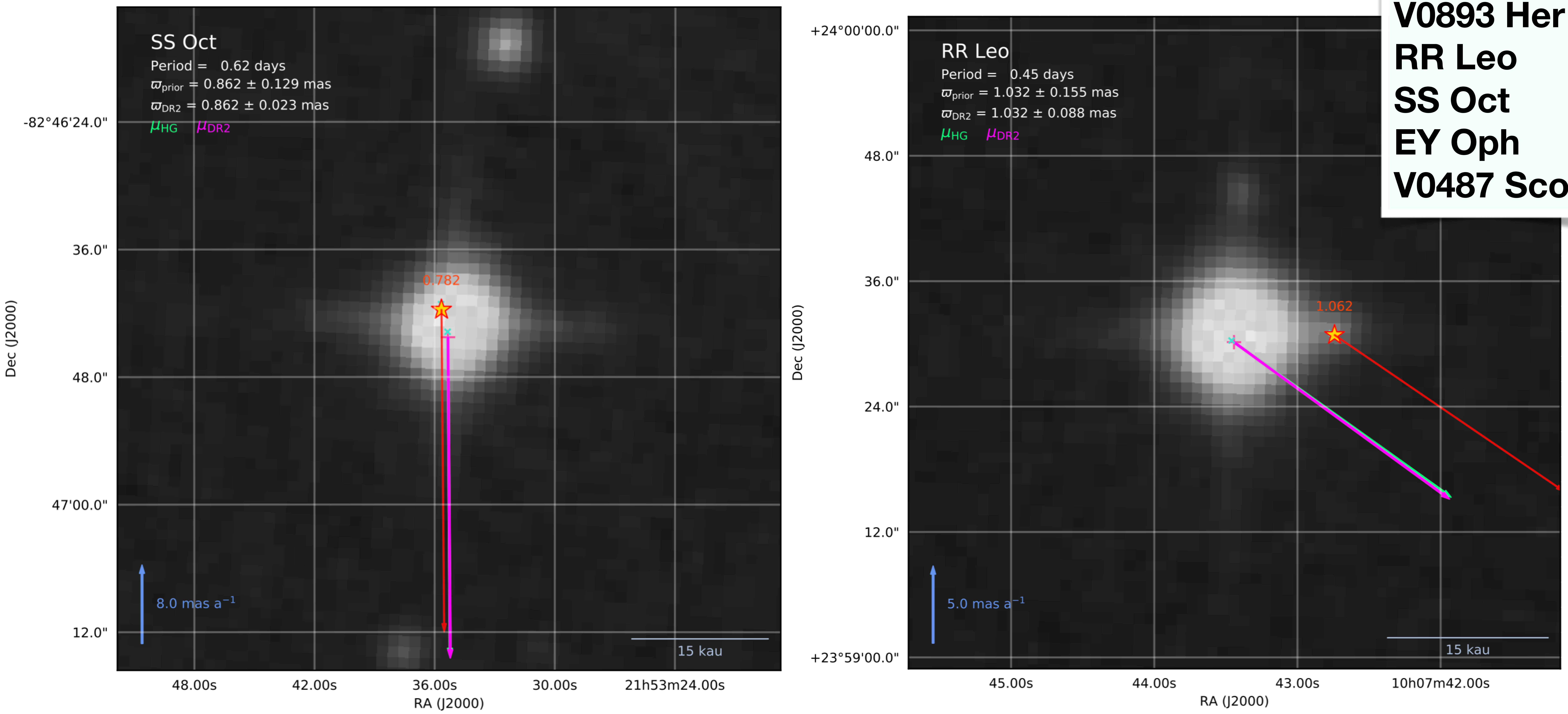
Common proper motion companions of Cepheids





Kervella et al. 2019, A&A, 623, A117

RR Lyrae companions



OV And
CS Del
V0893 Her
RR Leo
SS Oct
EY Oph
V0487 Sco

Kervella et al. 2019, A&A, 623, A117

Conclusion

- 30% of the 6500 stars within 50 pc (27% of the 117 000 Hipparcos stars) present a PMa at $> 3\ \sigma$ level
- Many low mass companion signatures, including on white dwarfs
- Accuracy of Gaia DR2 tangential velocity anomaly **Δv_{tan}~1 m/s/pc**
- >80% of Cepheids are in binary or multiple systems, as well as ~20% of RR Lyrae stars