IMPACT OF BINARITY ON THE 3 MAIN ASTROPHYSICAL OBJECTIVES OF CHARA/SPICA

Group Multiplicity :

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SBRC

- Before 2024 : Remove binaries from sample used for construction of SBCR (for PLATO)
- Except for : O-type and early B-type stars : well known procedure that be able to treat binarity (not PLATO targets)

EXOPLANETS

- 1) Check for binarity
- 2) If exoplanet in binary → orbit follow-up (future)

ASTEROSEISMOLOGY

If star is an asteroseismic binary

- 1) Calibrating seismic relations
  - CHARA/SPICA orbit + (parallax OR RV) → M_A, M_B
  - CHARA/SPICA two diameters + parallax → R_A, R_B
  - Maybe a few valid targets (before PLATO)
  - Orbit follow-up with PLATO seismology

- 2) CHARA/SPICA observations can flag for multiplicity

(for binaries that have not already been detected)

GENERAL

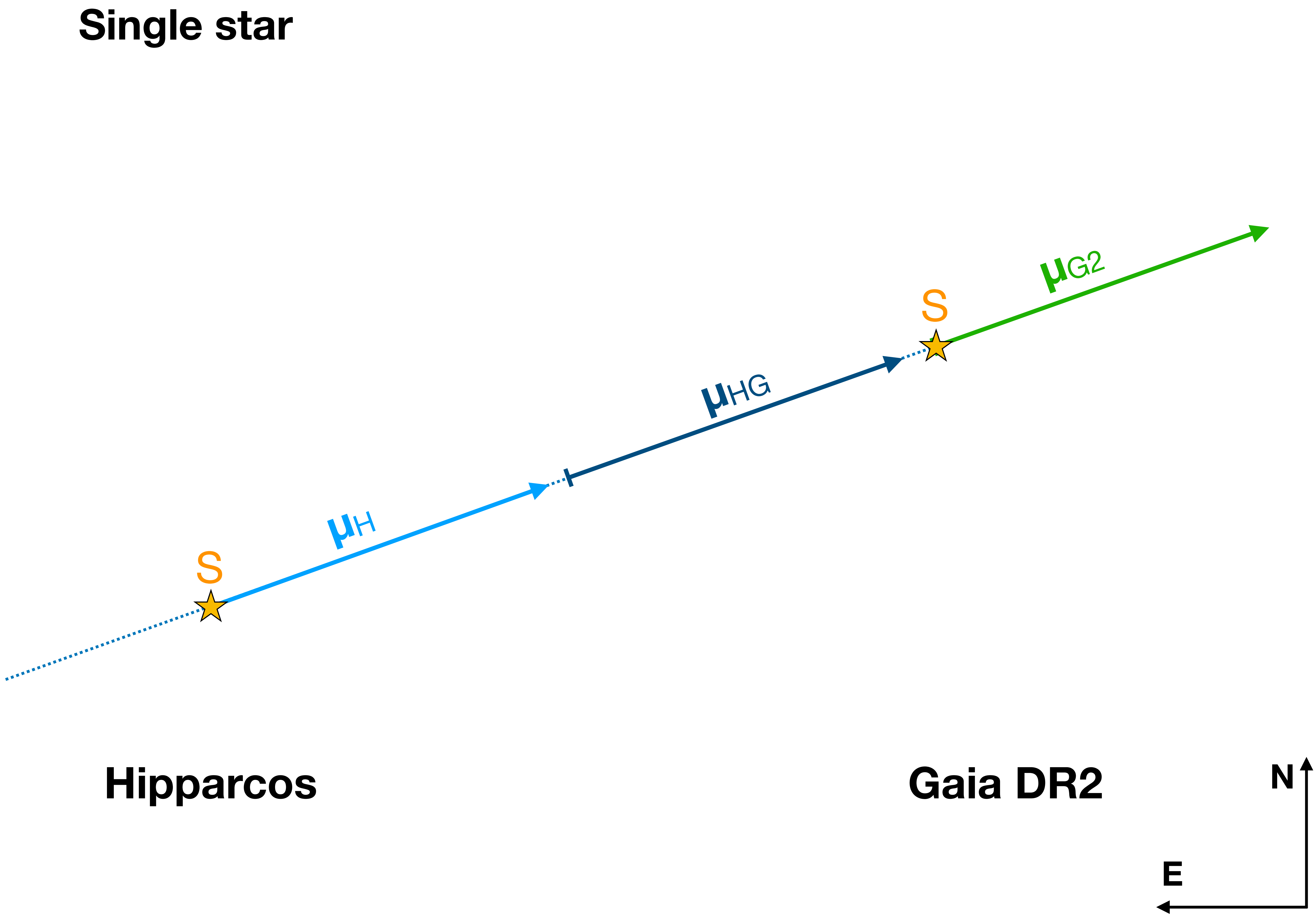
- General
  - Pierre’s catalogue (GAIA + Hipparcos) → Benchmark stars
    - M/R separated if follow orbit
      - → selection of candidates
  - Calibrators
    - Multiplicity is a problem
    - For $V < 7$ and $\theta < 0.1$ mas → about 100 stars available for CHARA/SPICA : BIII or BIV stars that should probably not be multiple
    - GAIA can help to remove some binaries from the calibrator catalogue
    - CHARA/SPICA will also clean this sample → all these stars have to be in target list

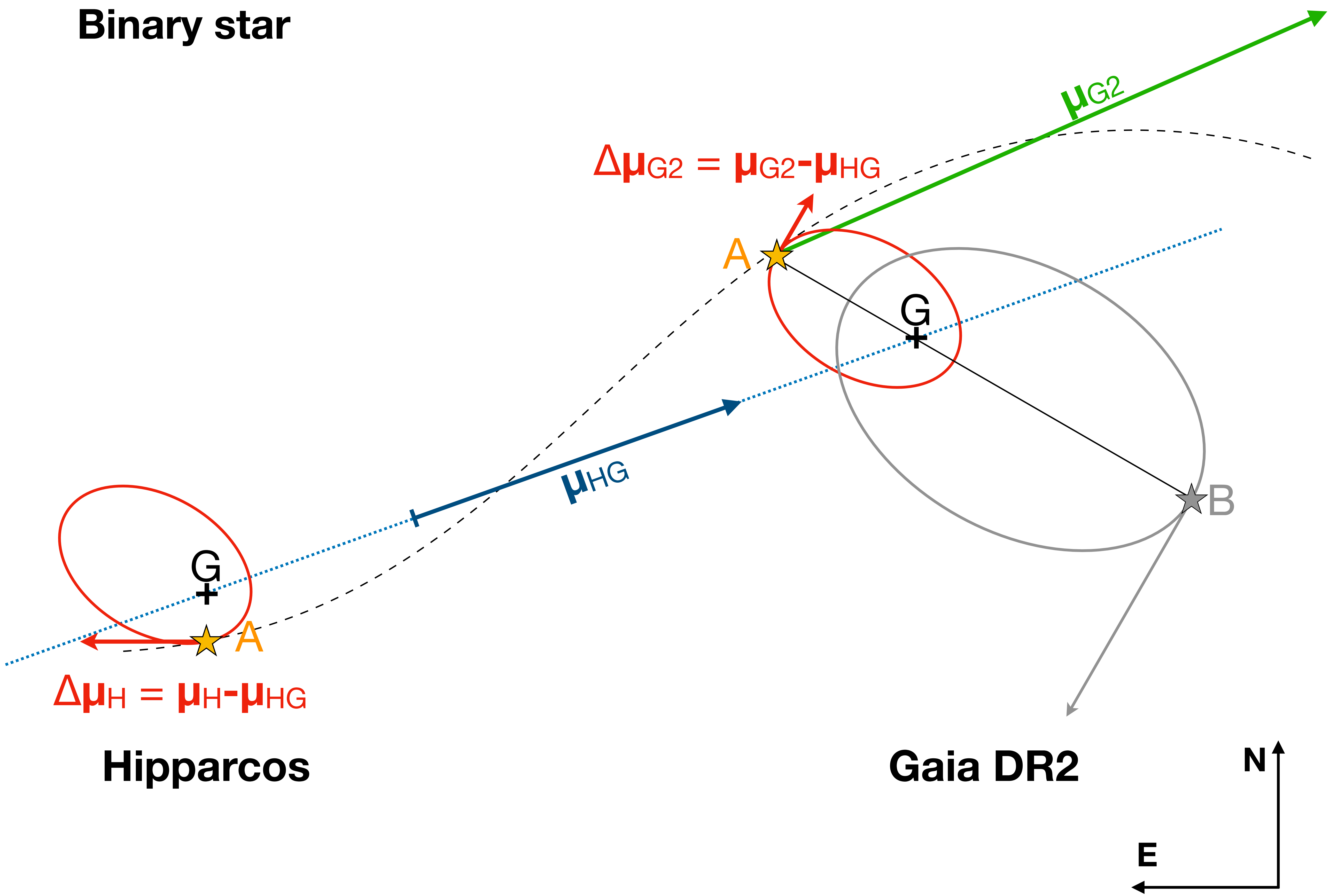
CONCLUSION

- In most cases, binarity is a plus
- Most identify cases are not specific to one of 3 scientific objectives
- Binarity : scientific case for CHARA/SPICA ?!

Hip-Gaia proper motion anomaly and binarity of Hipparcos stars

P. Kervella, F. Arenou, F. Mignard, F. Thévenin


Single star
S
μH
μHG
S
μG2
Hipparcos
Gaia DR2
N
E



Binary star
μG2
ΔμG2 = μG2-μHG
A
G
B
μHG
G
A
ΔμH = μH-μHG
Hipparcos
Gaia DR2
N
E

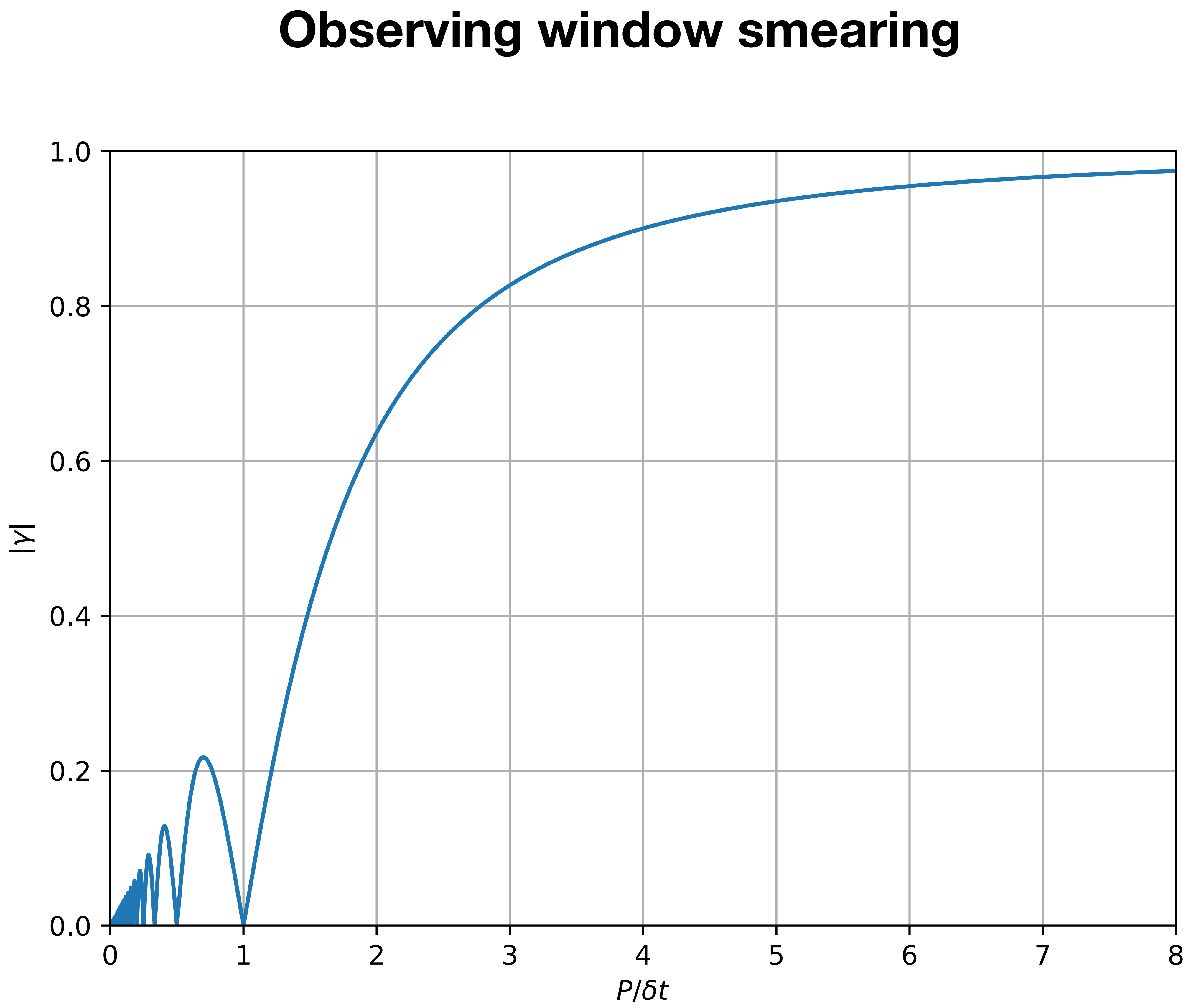
- Sensitivity in mass and orbital radius ?

$$v_1 = \sqrt{\frac{G\, m_2^2}{(m_1 + m_2)\, r}}$$

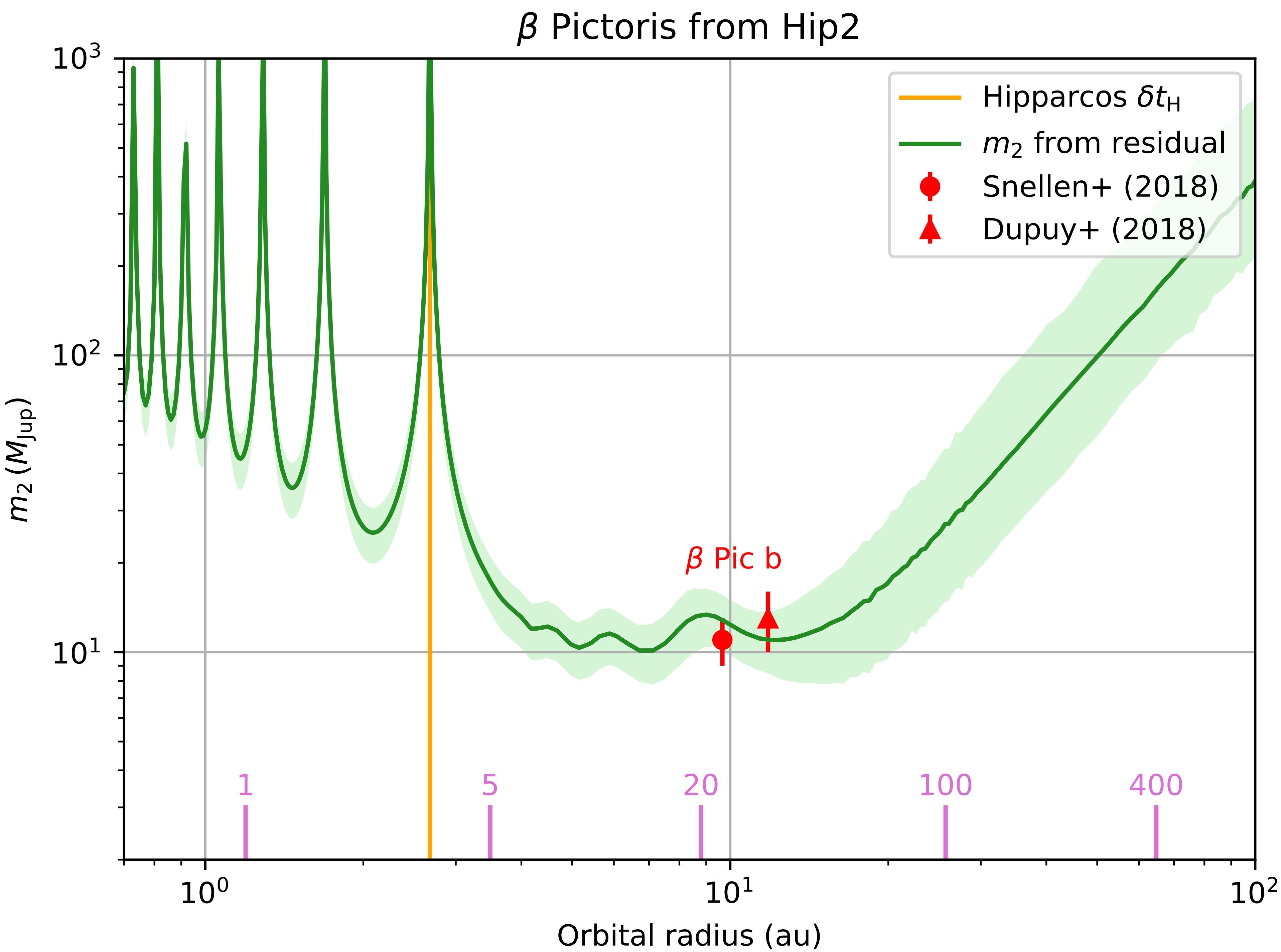
$$\frac{m_2}{\sqrt{r}} = \sqrt{\frac{m_1}{G}}\, v_1 = \sqrt{\frac{m_1}{G}} \left(\frac{\Delta\mu[\mathrm{mas\ a^{-1}}]}{\varpi[\mathrm{mas\ au^{-1}}]} \times 4740.470 \right)$$

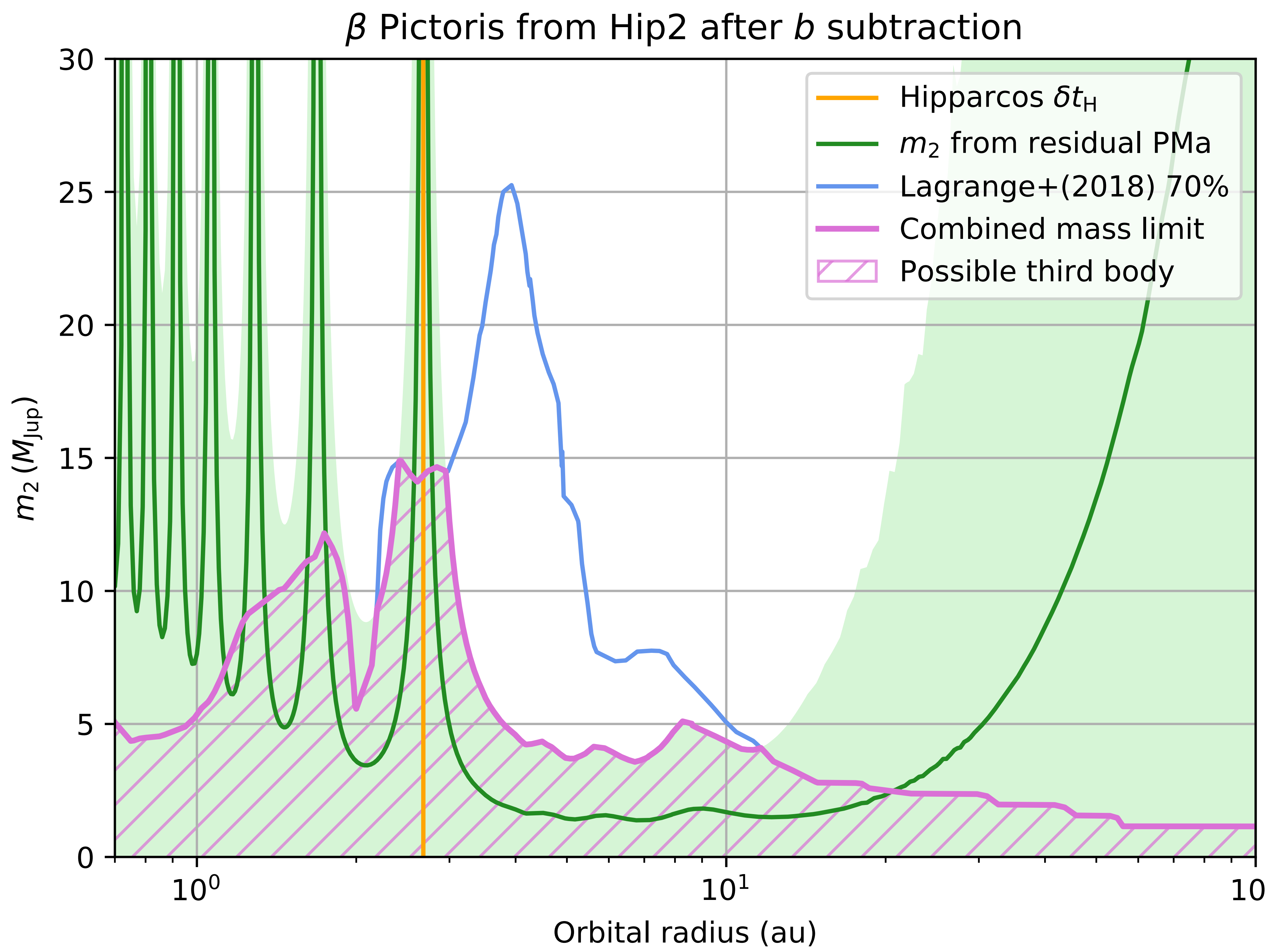
$$\sigma(\mu) = 242\, \mu\mathrm{as\ a^{-1}}$$

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

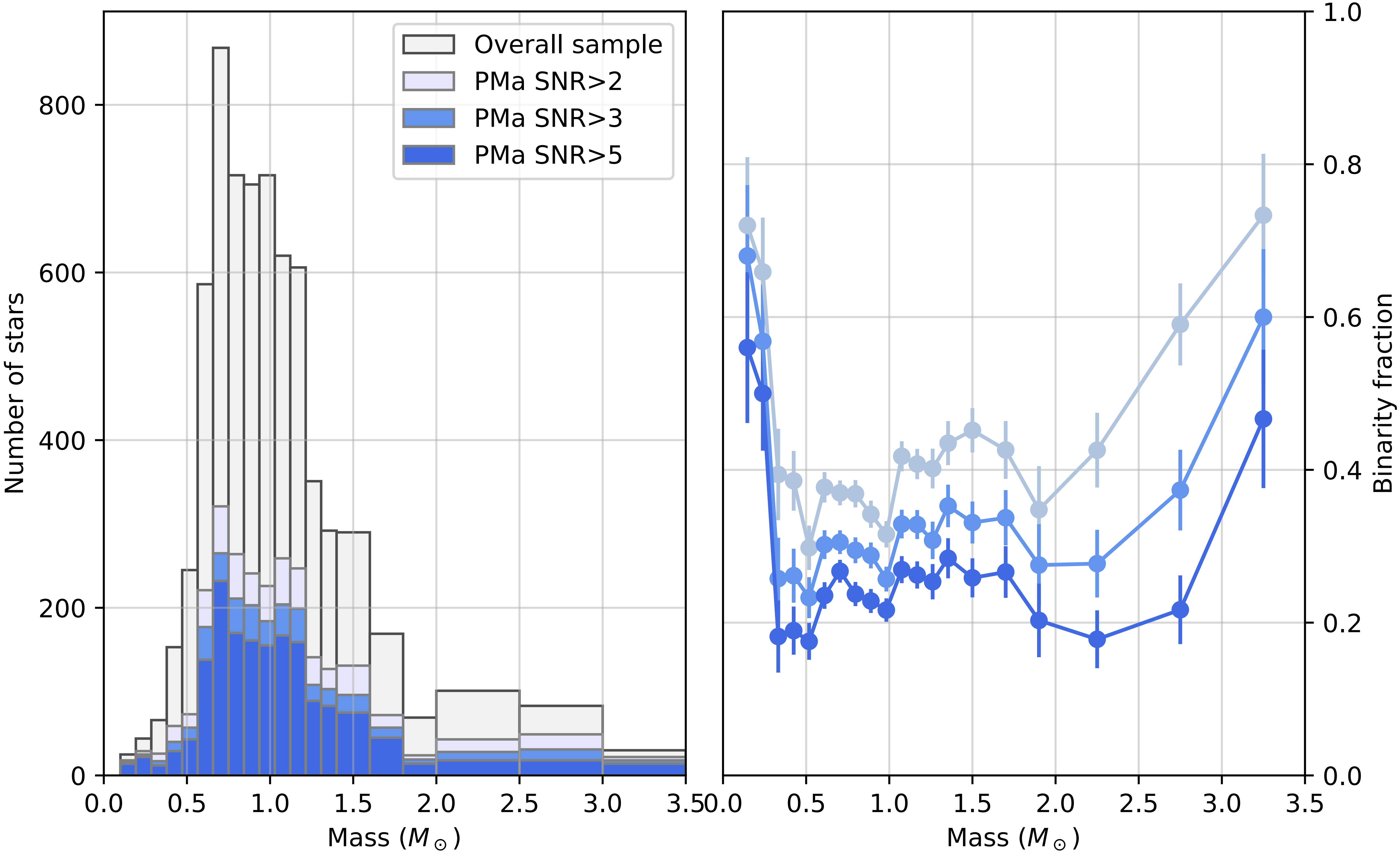

Observing window smearing
|γ|
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
P/δt

- β Pic: position and μ imprecise in Gaia DR2, but PMa of Hipparcos ok (article Snellen & Brown 2018, Nat. Ast.)



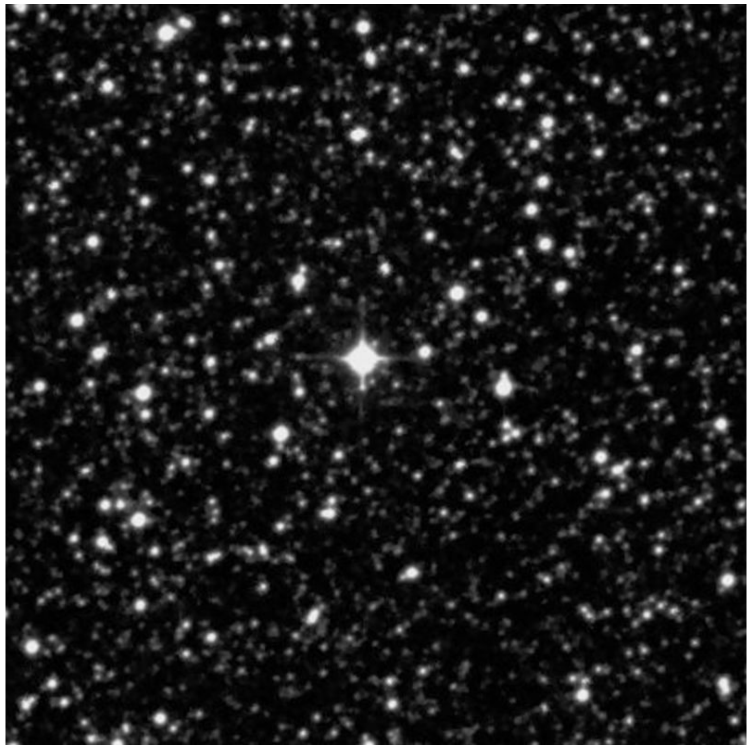


β Pictoris from Hip2 after b subtraction
Hipparcos δt_H
m_2 from residual PMa
Lagrange+(2018) 70%
Combined mass limit
Possible third body
m_2 (M_Jup)
Orbital radius (au)
0
5
10
15
20
25
30
10^0
10^1
10^2



Overall sample
PMa SNR>2
PMa SNR>3
PMa SNR>5
Number of stars
0
200
400
600
800
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Mass ($M_\odot$)
Binarity fraction
0.0
0.2
0.4
0.6
0.8
1.0

Example: Ross 154 (M3.5V)



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Parallax:
Hip2        1991.250  336.720 (2.030) mas (observed)
GDR2        2015.500  336.152 (0.072) mas (observed)

Measured PM vector in ICRS frame:
Hip2        1991.250    +637.020 ( 2.800)     -191.640 ( 1.700) mas/a
GDR2        2015.500    +639.344 ( 0.143)     -193.659 ( 0.121) mas/a

Computed (μalpha,μdelta) mean angular PM vector in ICRS frame:
GDR2-Hip2   2003.375    +639.499 ( 0.068)     -193.878 ( 0.056) mas/a

Computed diff. PM vector in ICRS frame:
Hip2-G2H2   1991.250      -2.361 ( 2.801)       +2.225 ( 1.701) mas/a = (-0.8,+1.3) sig
GDR2-G2H2   2015.500      -0.155 ( 0.159)       +0.220 ( 0.133) mas/a = (-1.0,+1.7) sig

Transverse velocity residual norm H2-G2H2   : 45.75 (46.21) m/s
Position angle of vel. residual   H2-G2H2   : 313.31 (31.69) deg
Delta H2-G2H2 PM anomaly SNR                : 0.99

Transverse velocity residual norm G2-G2H2   : 3.79 (2.92) m/s
Position angle of vel. residual   G2-G2H2   : 324.81 (27.73) deg
Delta G2-G2H2 PM anomaly SNR                : 1.30
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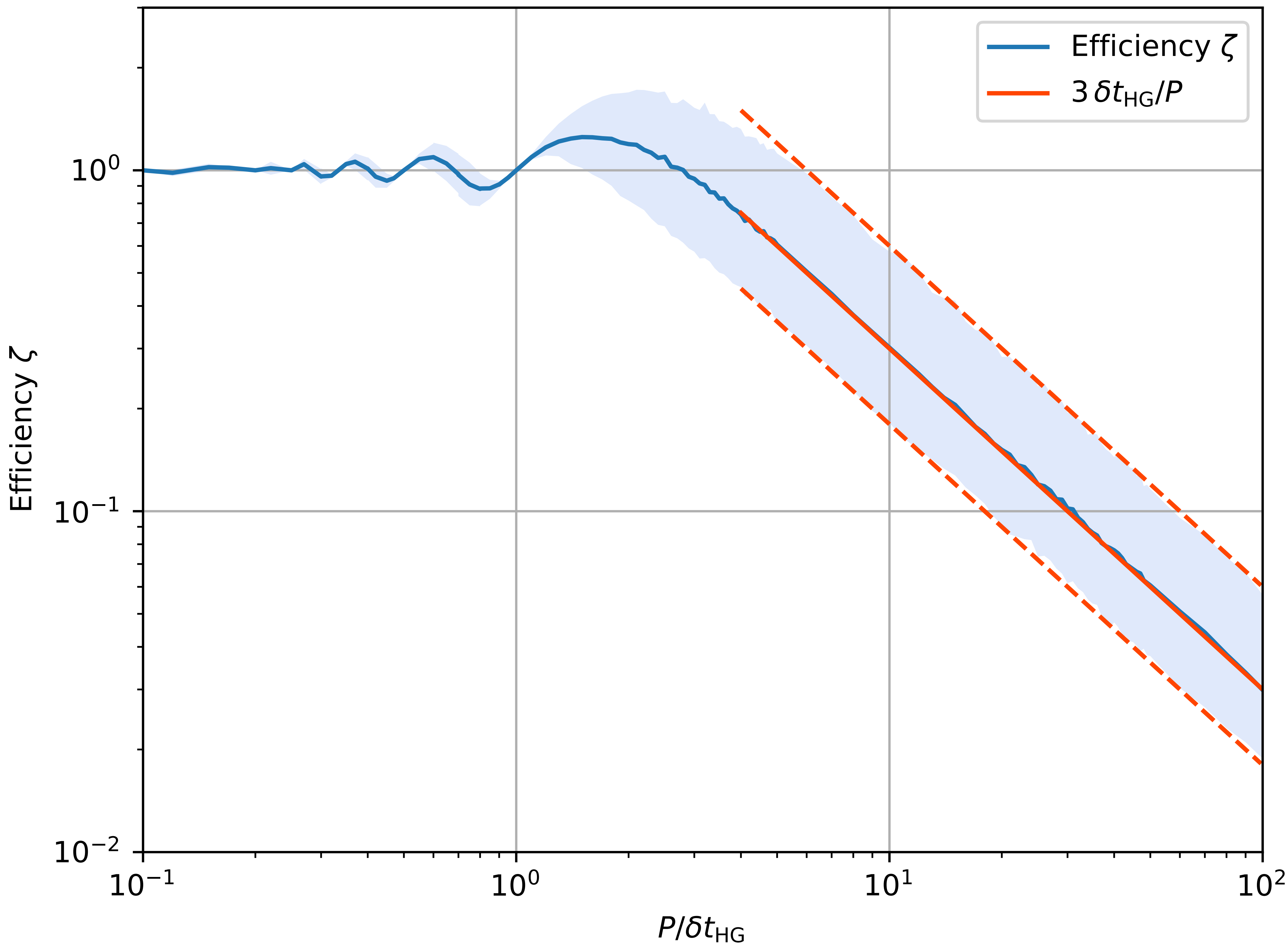
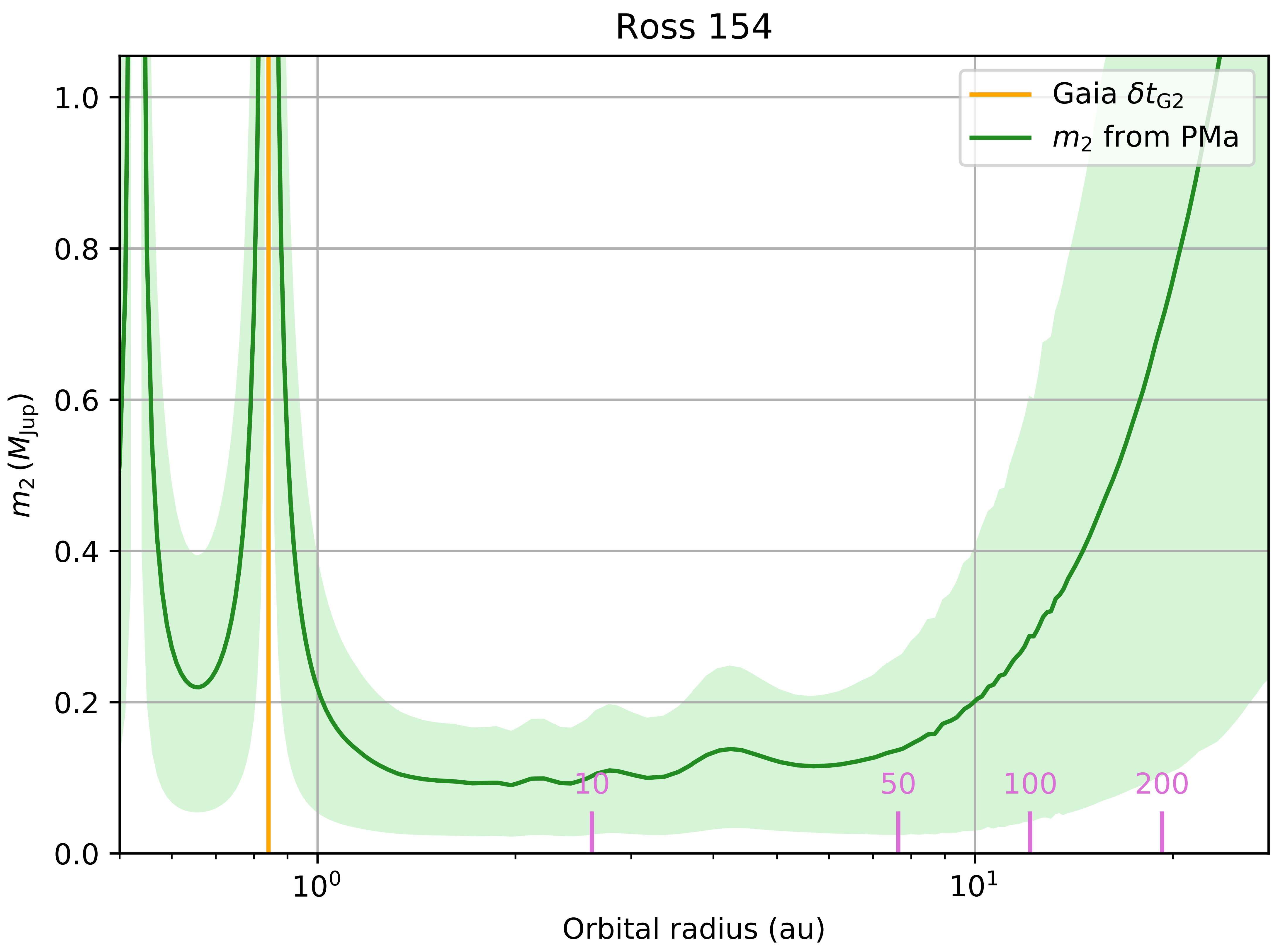
Long periods

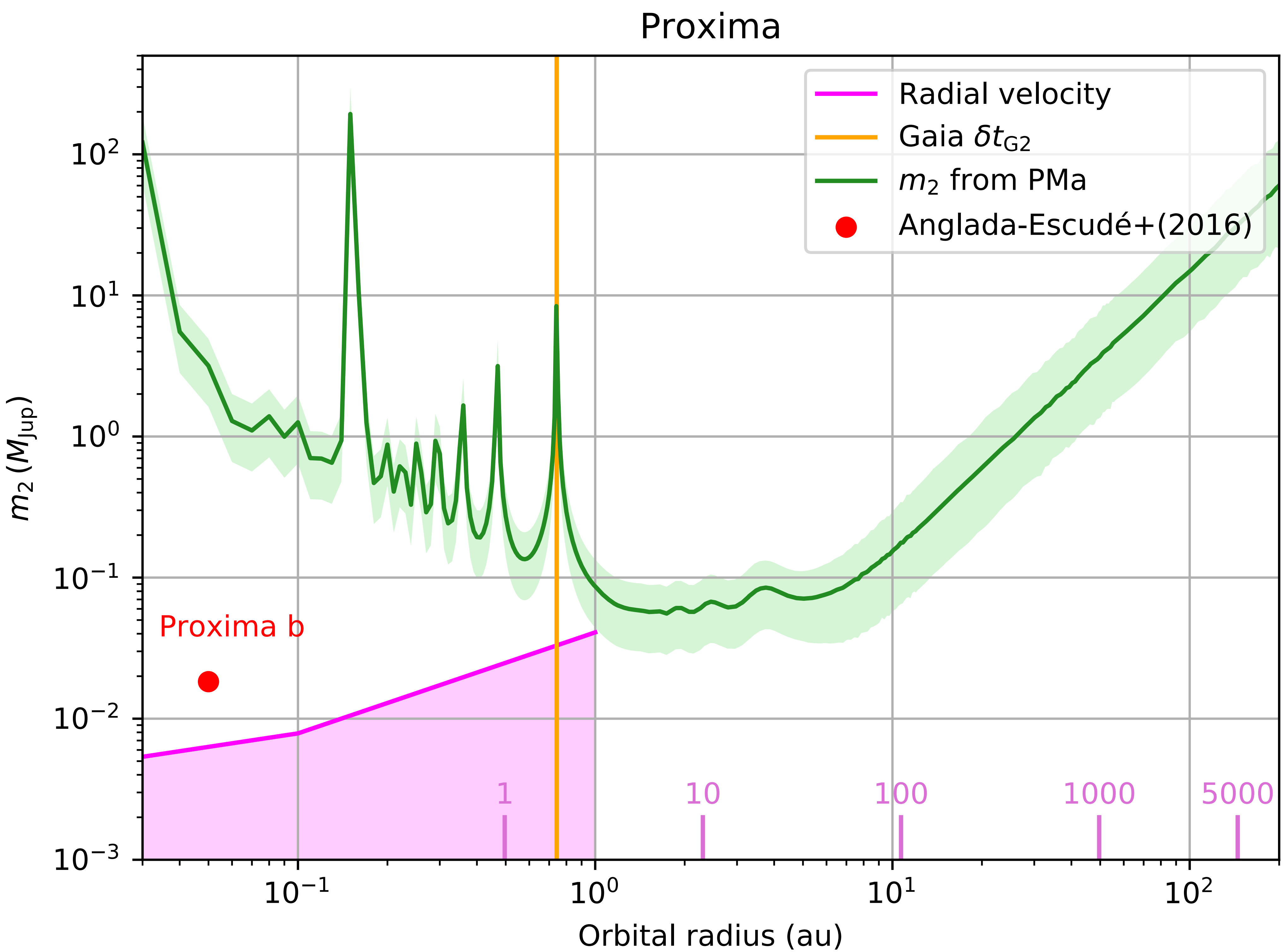


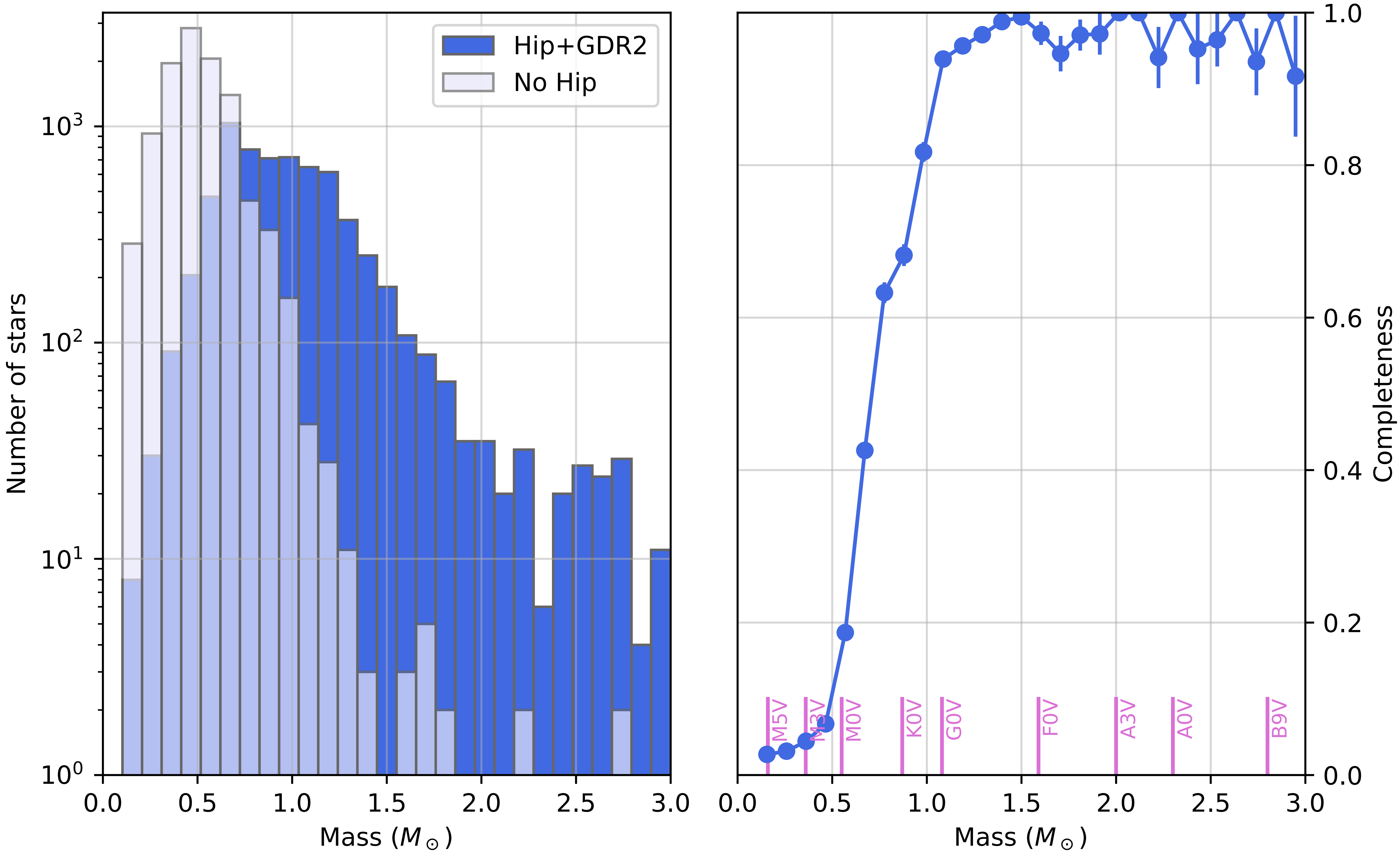


Ross 154
Gaia δt_{G2}
m_2 from PMa
1.0
0.8
0.6
0.4
0.2
0.0
m_2 (M_{Jup})
10
50
100
200
10^0
10^1
Orbital radius (au)

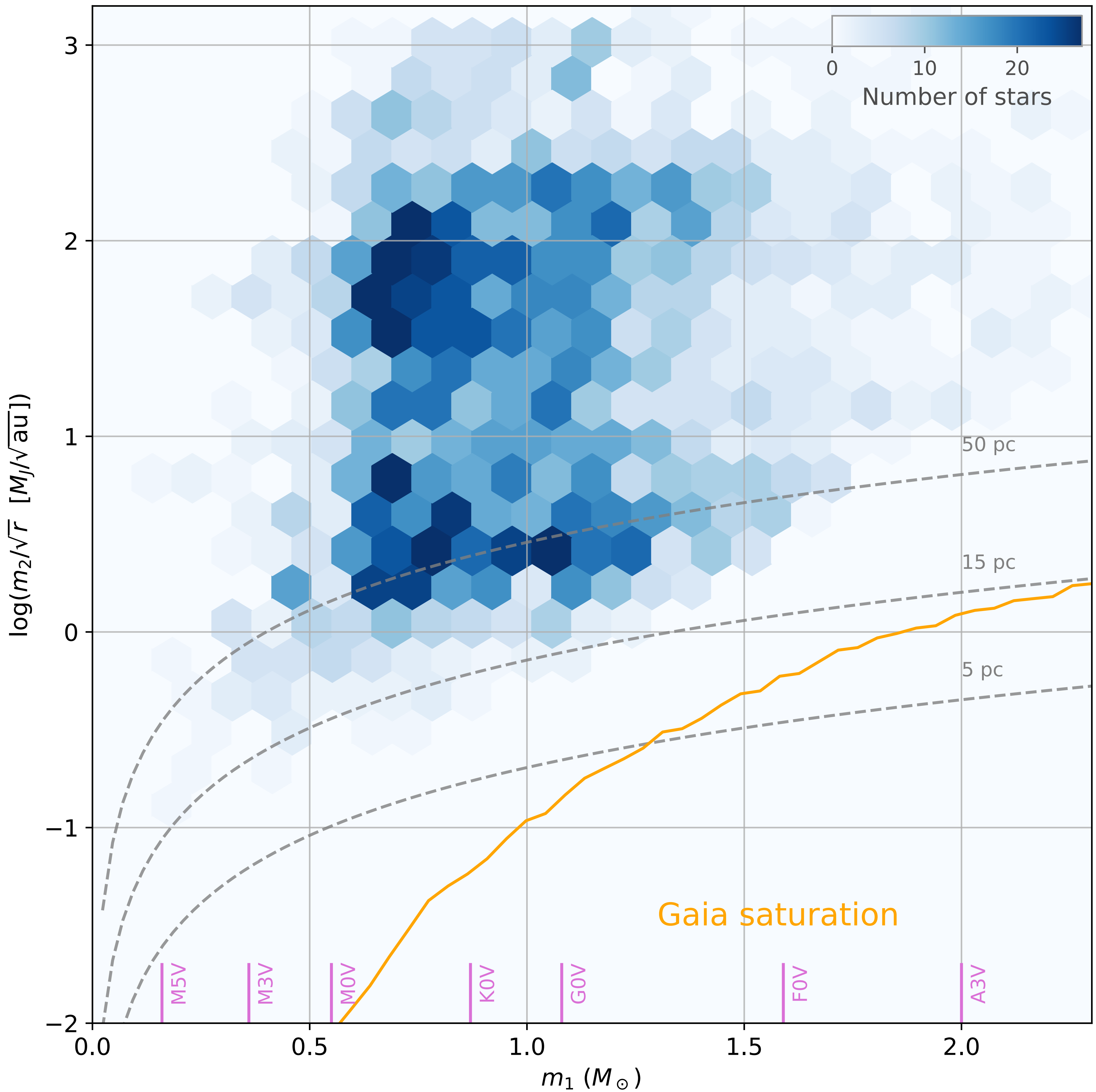
- Proxima: $\mu_{\mathrm{HG}} = 3859.110 \pm 0.069\,\mathrm{mas\,a^{-1}}$
  $\Delta v_{\mathrm{tan,G2}} = 2.7 \pm 1.5\,\mathrm{m\,s^{-1}}$

Confirmation of bind with α Cen AB





Hip+GDR2
No Hip
Number of stars
Mass ($M_\odot$)
Completeness
M5V
M3V
M0V
K0V
G0V
F0V
A3V
A0V
B9V



0
10
20
Number of stars
50 pc
15 pc
5 pc
Gaia saturation
M5V
M3V
M0V
K0V
G0V
F0V
A3V
3
2
1
0
−1
−2
0.0
0.5
1.0
1.5
2.0
$\log(m_2/\sqrt{r}\ \ [M_J/\sqrt{au}])$
$m_1\ (M_\odot)$