BEBOP

CONFIRMING & DETECTING CIRCUMBINARY PLANETS USING RADIAL-VELOCITIES

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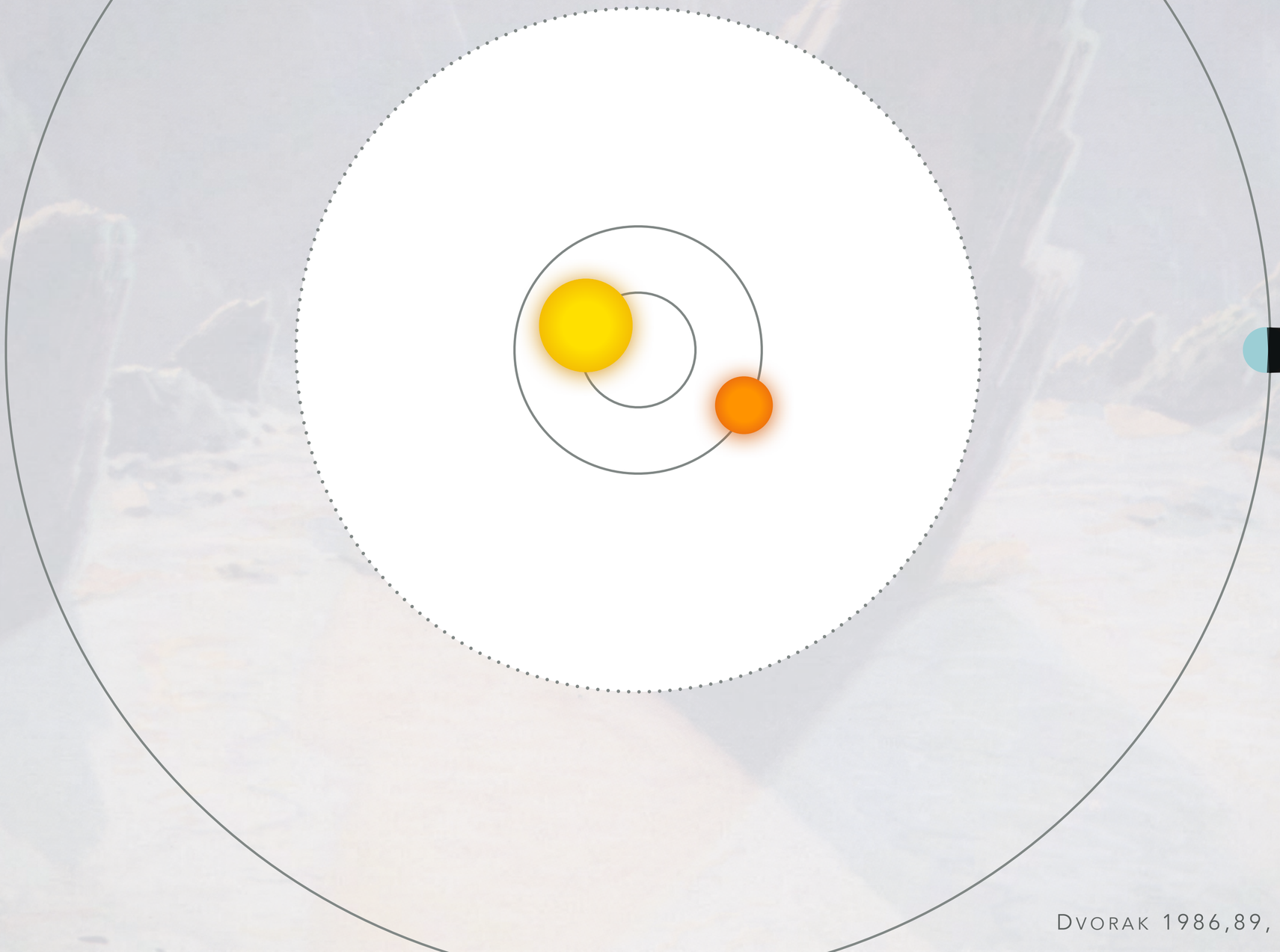
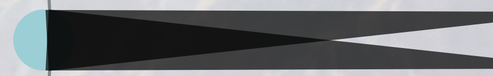
Circumbinary planets
p-type

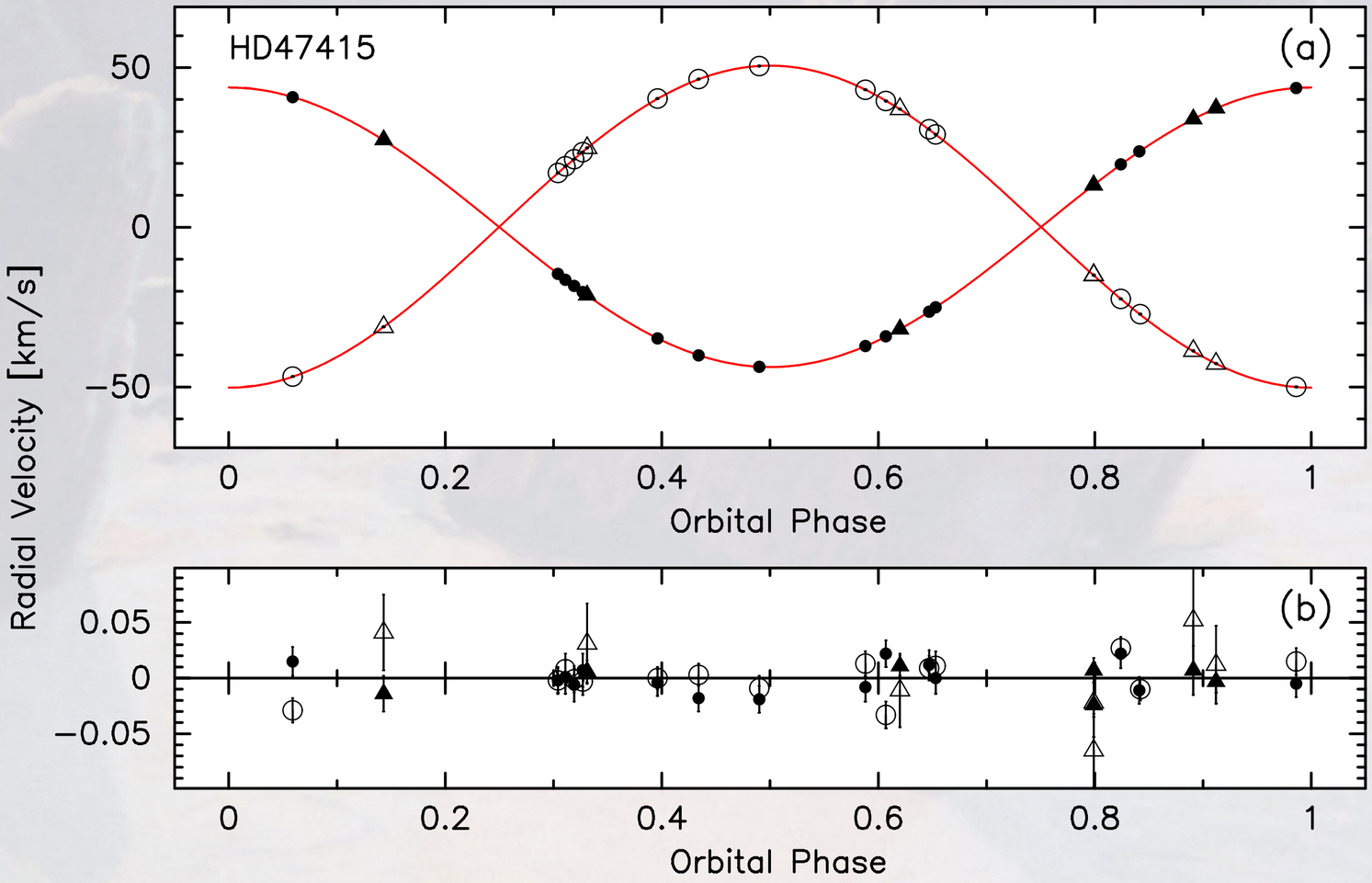




Dvorak 1986,89, Holman & Wiegert 1999

Let's search circumbinaries from the ground

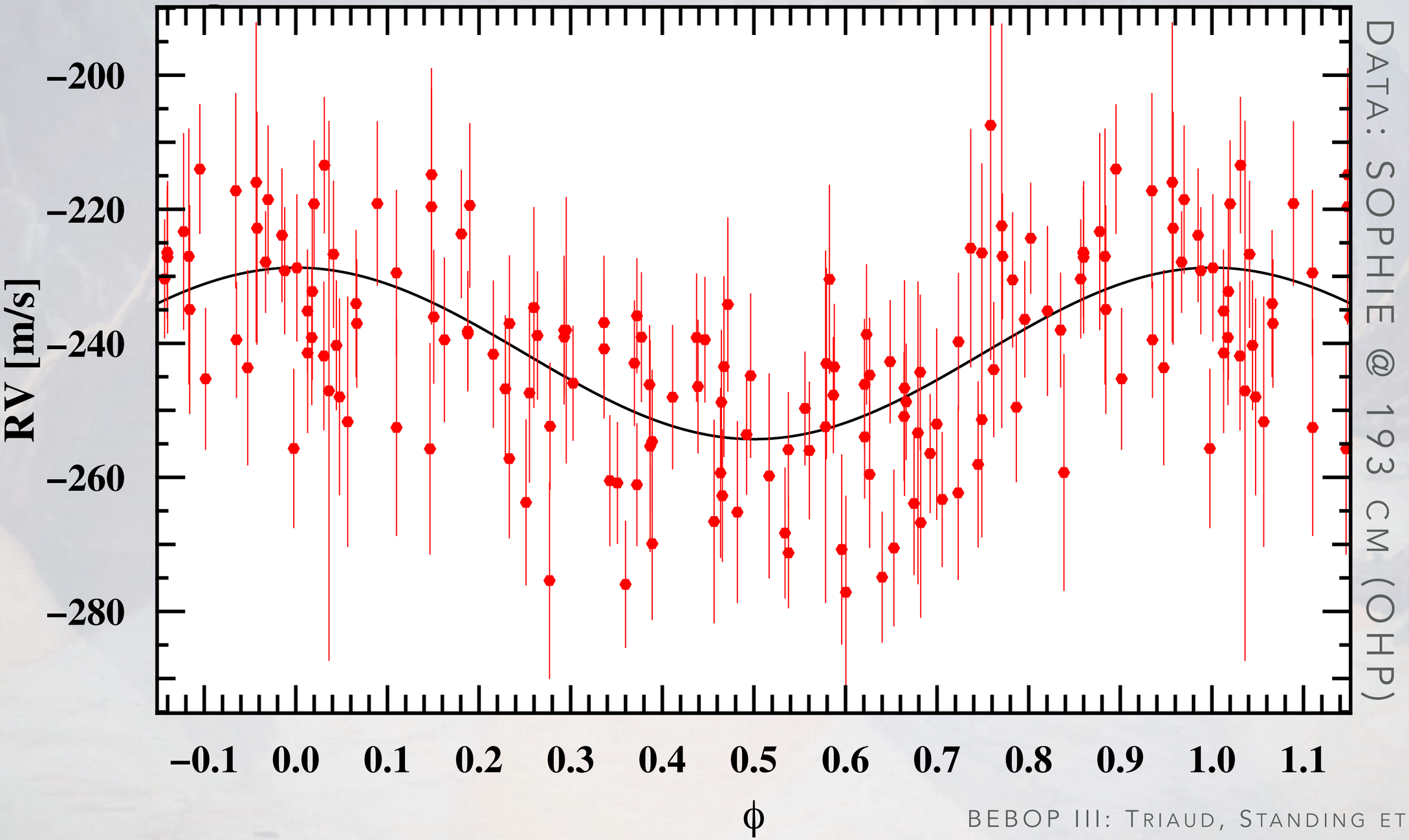
RVs are more efficient, however, problem with double-lined binaries
SB2: a noise floor of 15-20 m/s is found (Konacki+ 2009)



Problems solved by considering single-lined binaries (SB1).

Proof-of-Concept: **Kepler-16b** - Vmag = 12.5

Precision on K_P is **1.5 m/s**



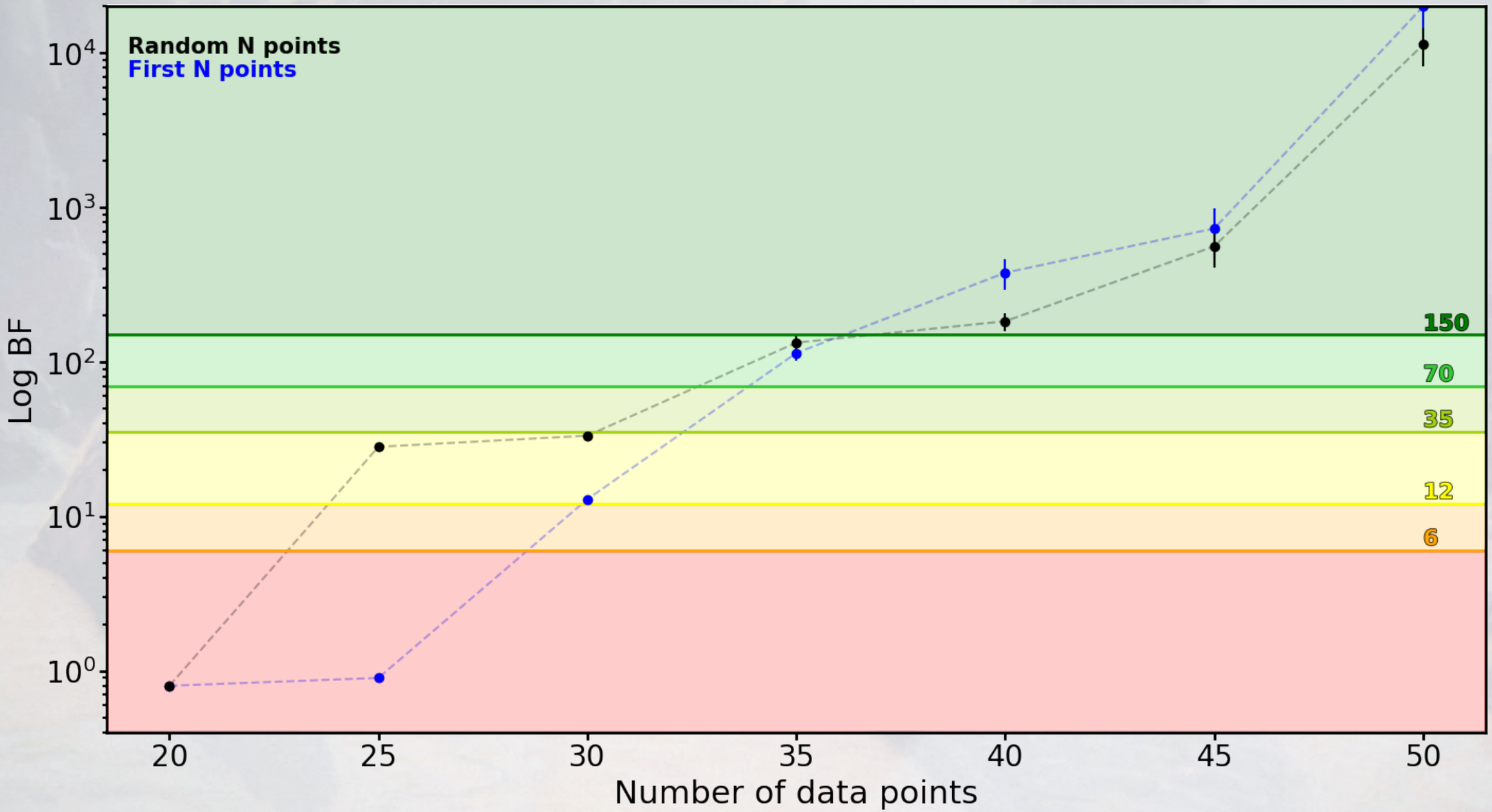
BEBOP III: Triaud, Standing et al. in prep

Proof-of-Concept: Kepler-16b - Vmag = 12.5

Parameters & units		Yorbit	kima	Doyle+(2011)
binary parameters				
$P_{\rm bin}$	day	41.077779(54)	41.077772(51)	41.079220(78)
$T_{0,\rm bin}$	BJD	8558.9640(44)	7573.098(47)	–
$K_{1,\rm bin}$	m.s^{-1}	13 678.2(1.5)	13 678.7(1.5)	–
$e_{\rm bin}$	–	0.15989(11)	0.15994(10)	0.15944(62)
$\omega_{\rm bin}$	deg	263.661(40)	263.672(40)	263.464(27)
planet parameters				
$P_{\rm pl}$	day	228.3(1.8)	226.0(1.7)	228.776(37)
$T_{0,\rm pl}$	BJD	8532.5(4.4)	7535(92)	–
$K_{1,\rm pl}$	m.s^{-1}	12.8(1.5)	11.8(1.5)	–
$e_{\rm pl}$	–	0 (fixed)	<0.21	0.0069(15)
$\omega_{\rm pl}$	deg	–	231(65)	$318^{(+10)}_{(-22)}$
system parameters				
γ	km.s^{-1}	-33.8137(69)	-33.803(24)	-32.769(35)
$\sigma_{\rm jitter}$	m.s^{-1}	–	$0.070\ ^{+1.104}_{-0.067}$	–
derived parameters				
M_1	$M_\odot$	0.654(17)[1]	0.654(17)[1]	0.6897(35)
M_2	$M_\odot$	0.1963(31)	0.1964(31)	0.20255(66)
$m_{\rm pl}$	$M_{\rm Jup}$	0.345(41)	0.313(39)	0.333(16)
$a_{\rm bin}$	AU	0.2207(18)	0.2208(18)	0.22431(35)
$a_{\rm pl}$	AU	0.6925(67)	0.6881(58)	0.7048(11)

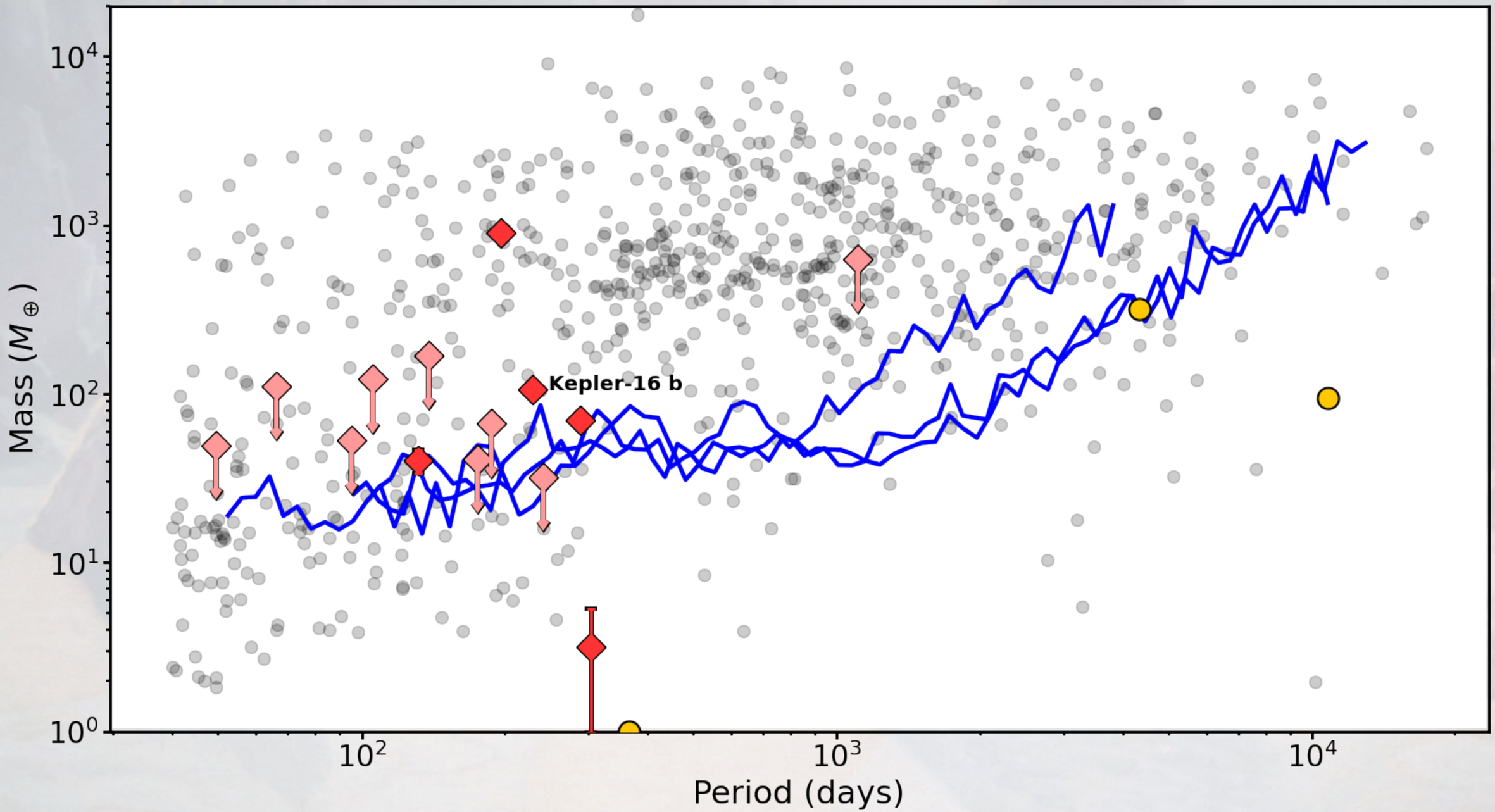
Notes: 1 - adopted from Bender et al. (2012)

Proof-of-Concept: when do we reach detection?



BEBOP III: Triaud, Standing et al. in prep

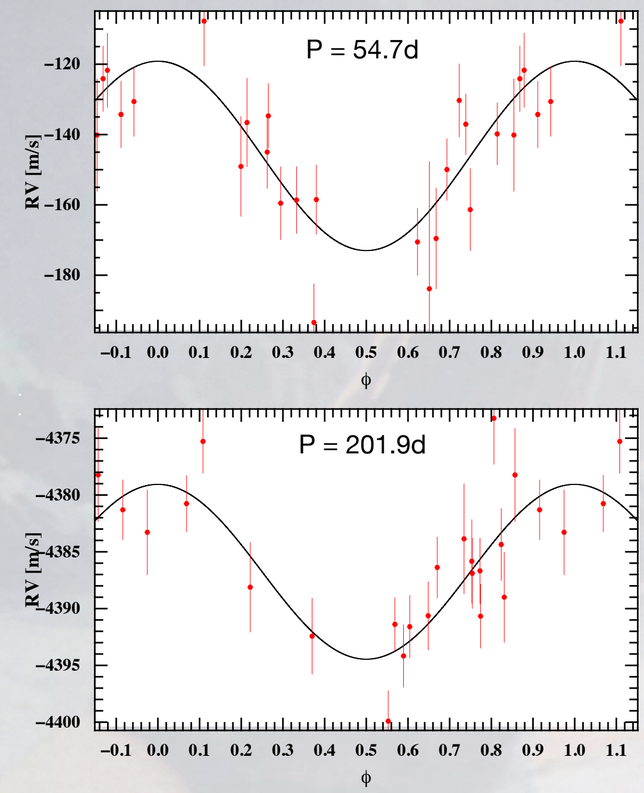
Proof-of-Concept: what precision do we have?

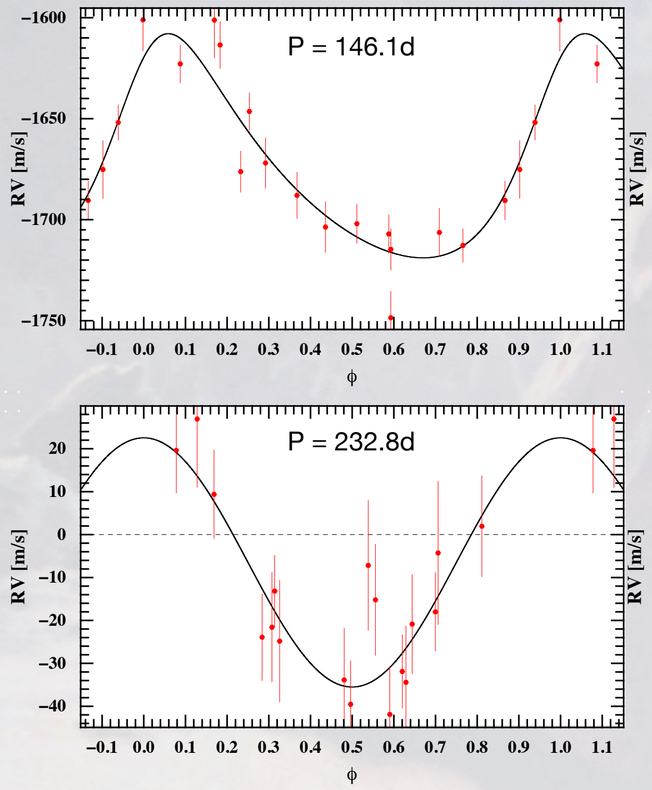


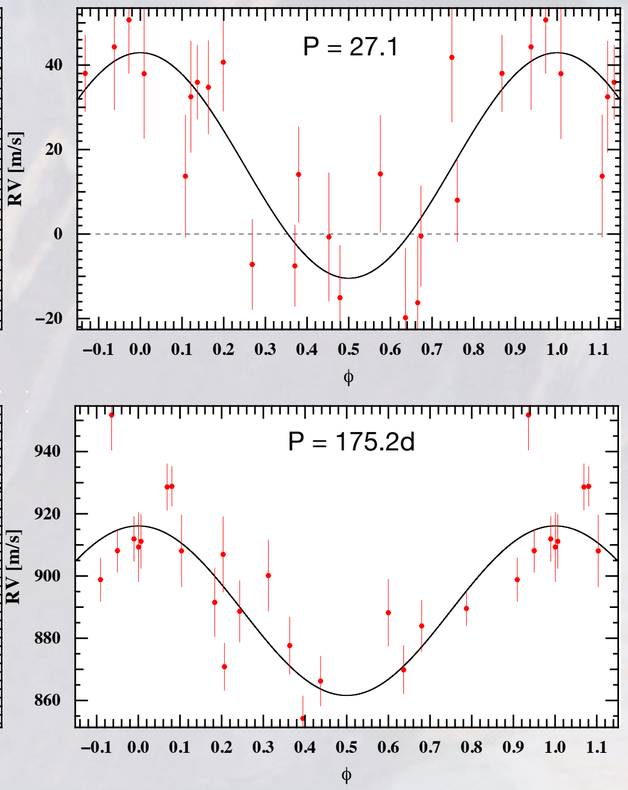
BEBOP II: Standing, Triaud et al. submitted

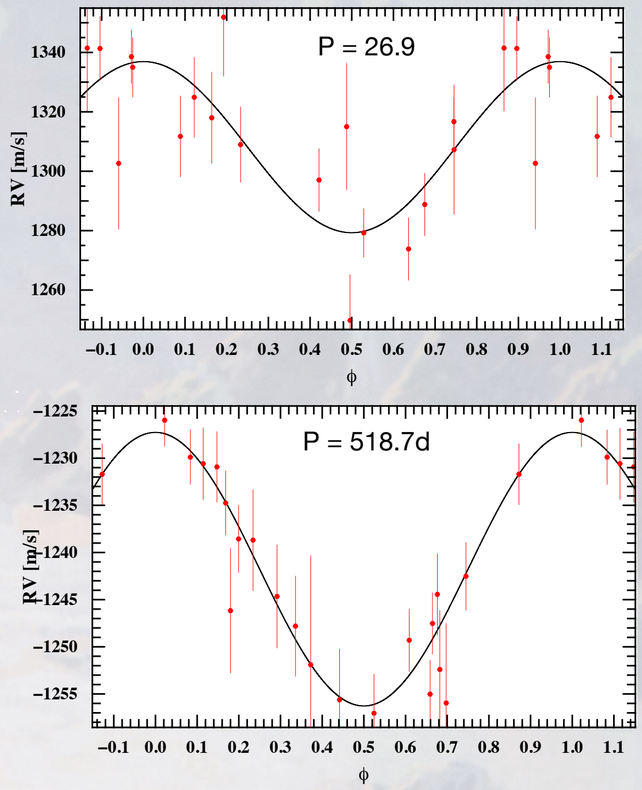
BEBOP Binaries Escorted by Orbiting Planets

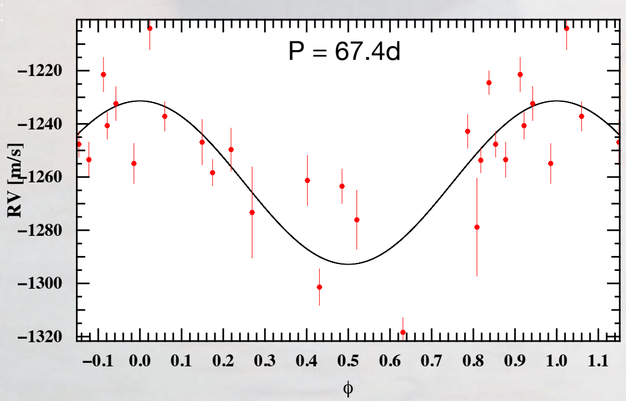
13 closed-orbit candidates + 3 open-orbit candidates

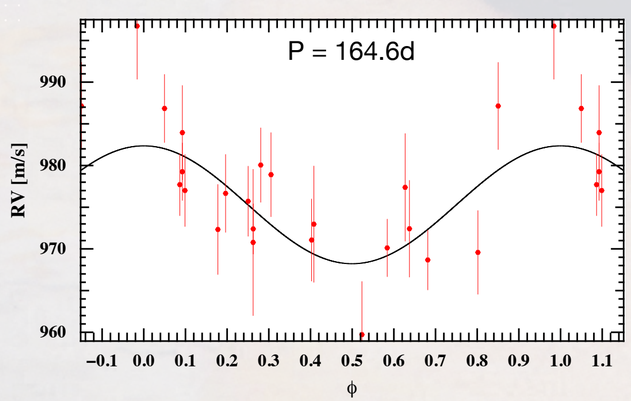


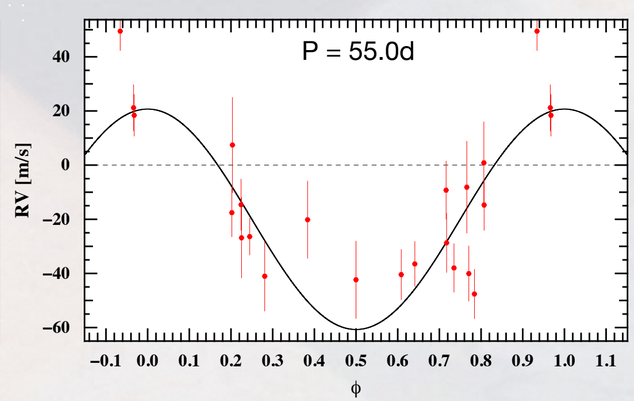


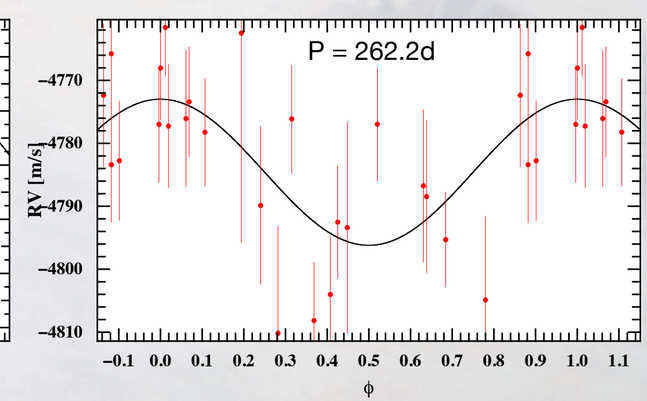






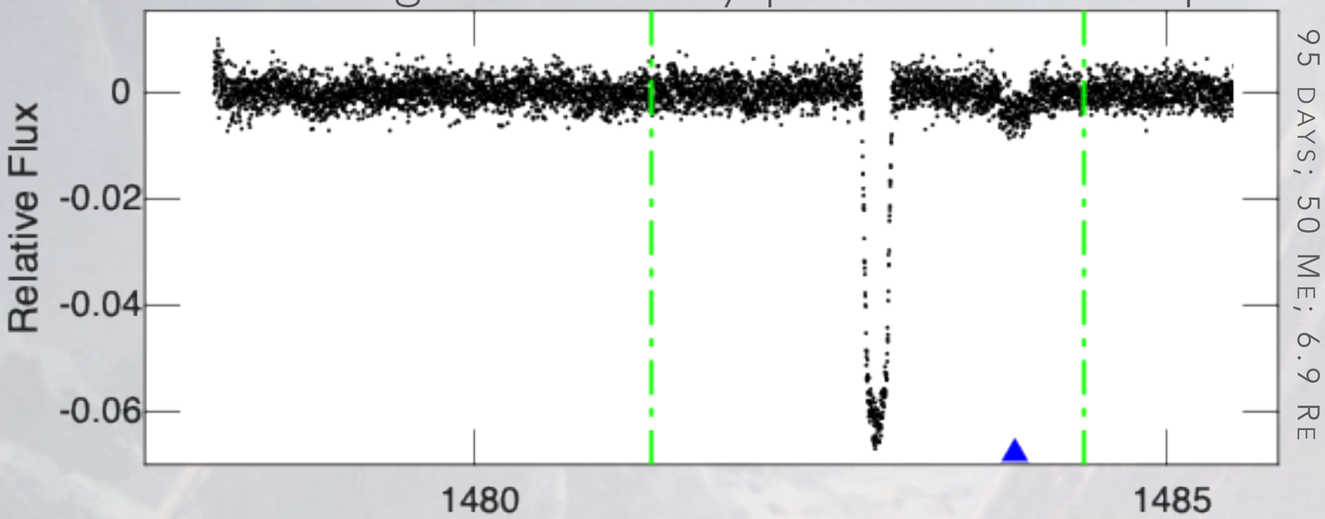




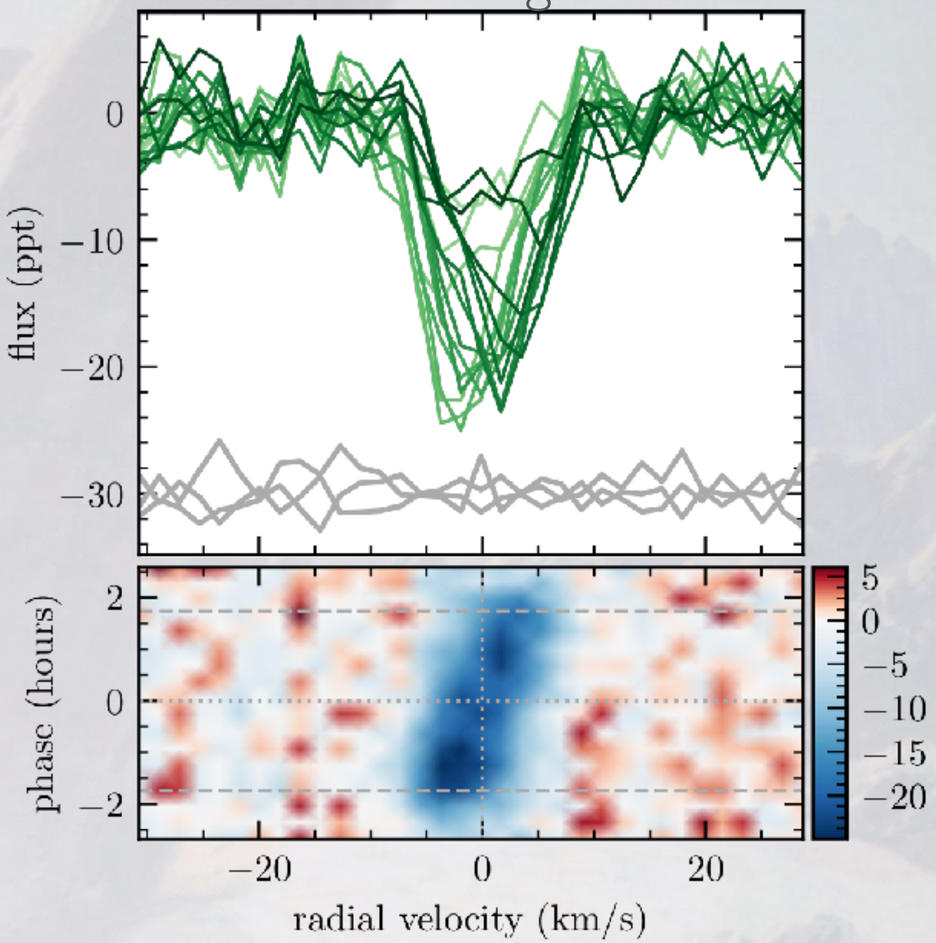


BEBOP Binaries Escorted by Orbiting Planets

a transiting circumbinary planet in our sample



Rossiter-McLaughlin effect

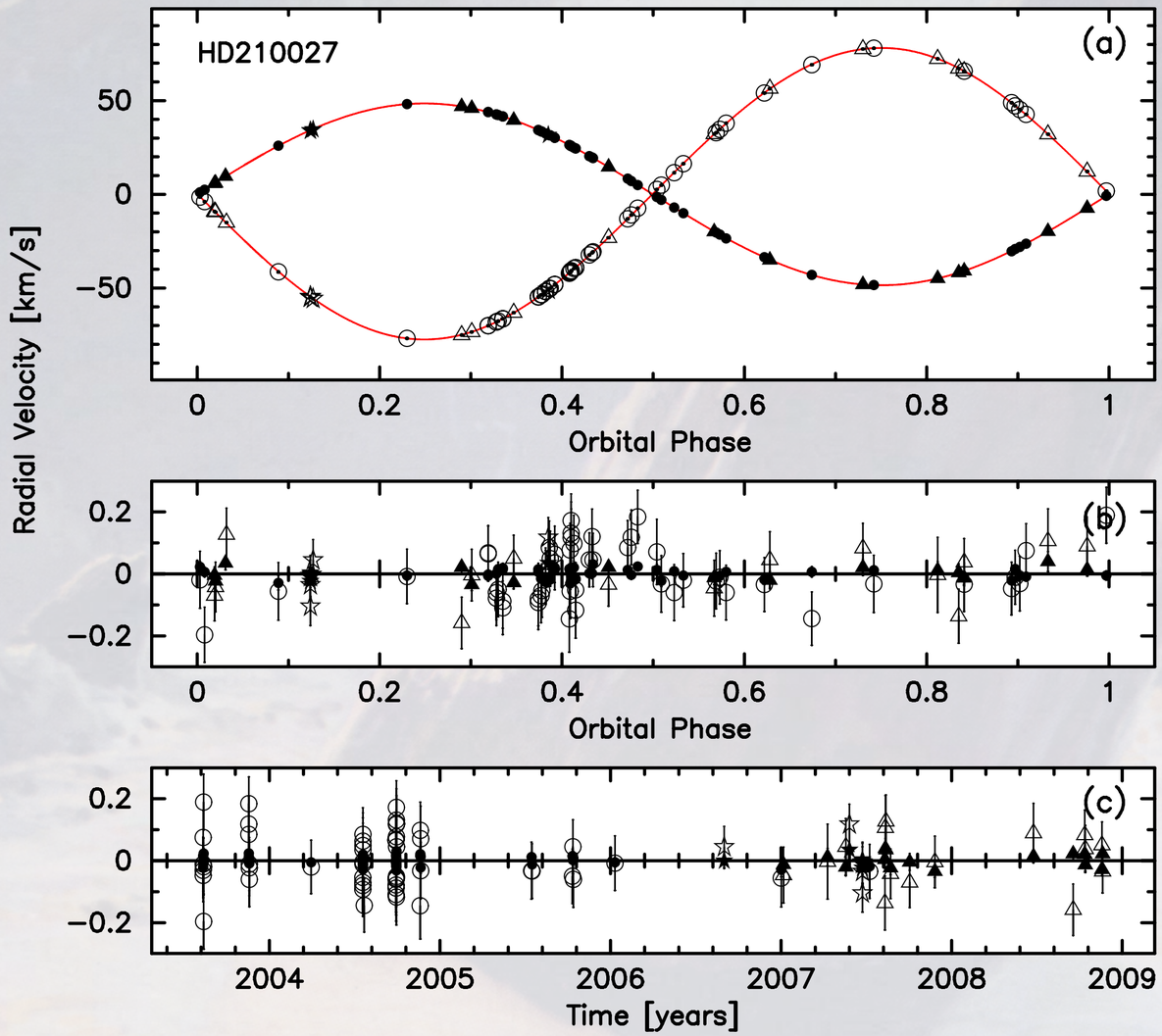


EBLM J0608-59 (aka TOI-1338)

INNER PLANET IS < 17 ME & WE IDENTIFY A 220D PLANET CANDIDATE

KOSTOV ET AL. 2020, KUNOVAC HODZIC ET AL. 2020; BEBOP IV: STANDING, TRIAUD IN PREP

HEADWAY TOWARDS SOLVING THE SB2 PROBLEM

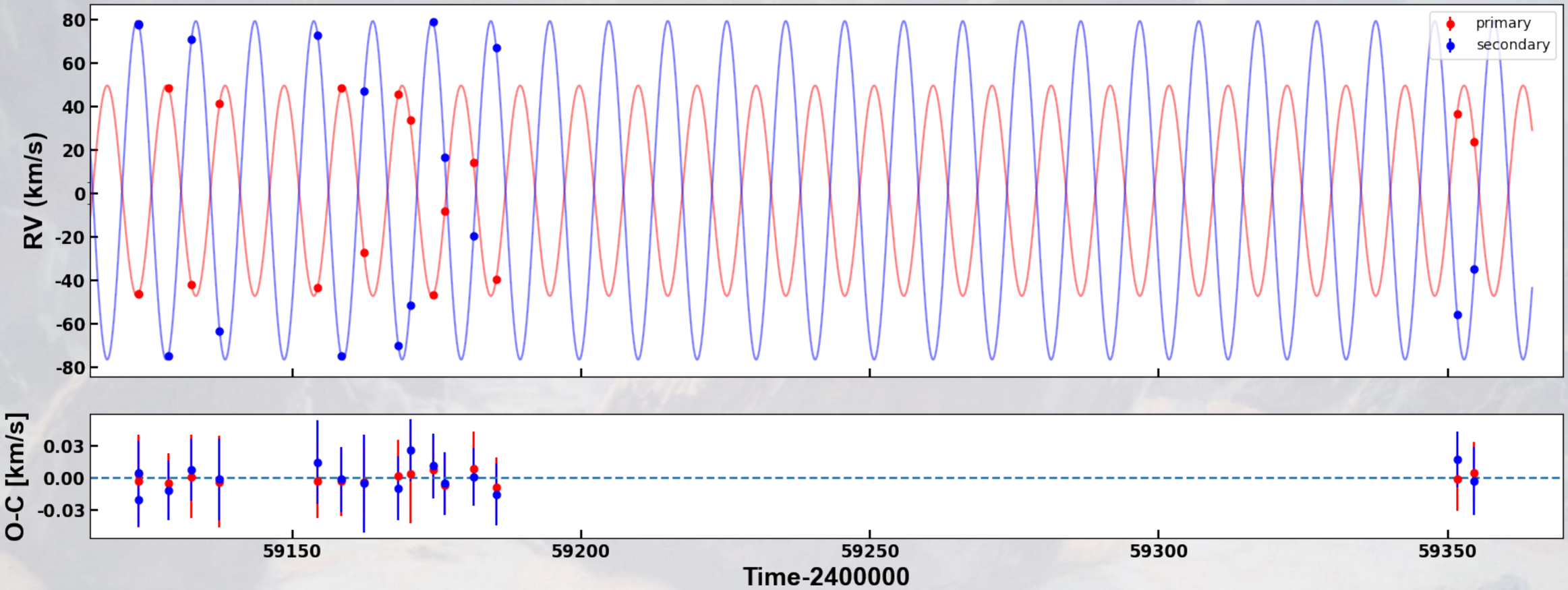


Konacki 16.5 m/s RMS on A
89 m/s RMS on B
Using HIRES@Keck

KONACKI ET AL. (2009)

Headway towards solving the SB2 problem

HD 210027

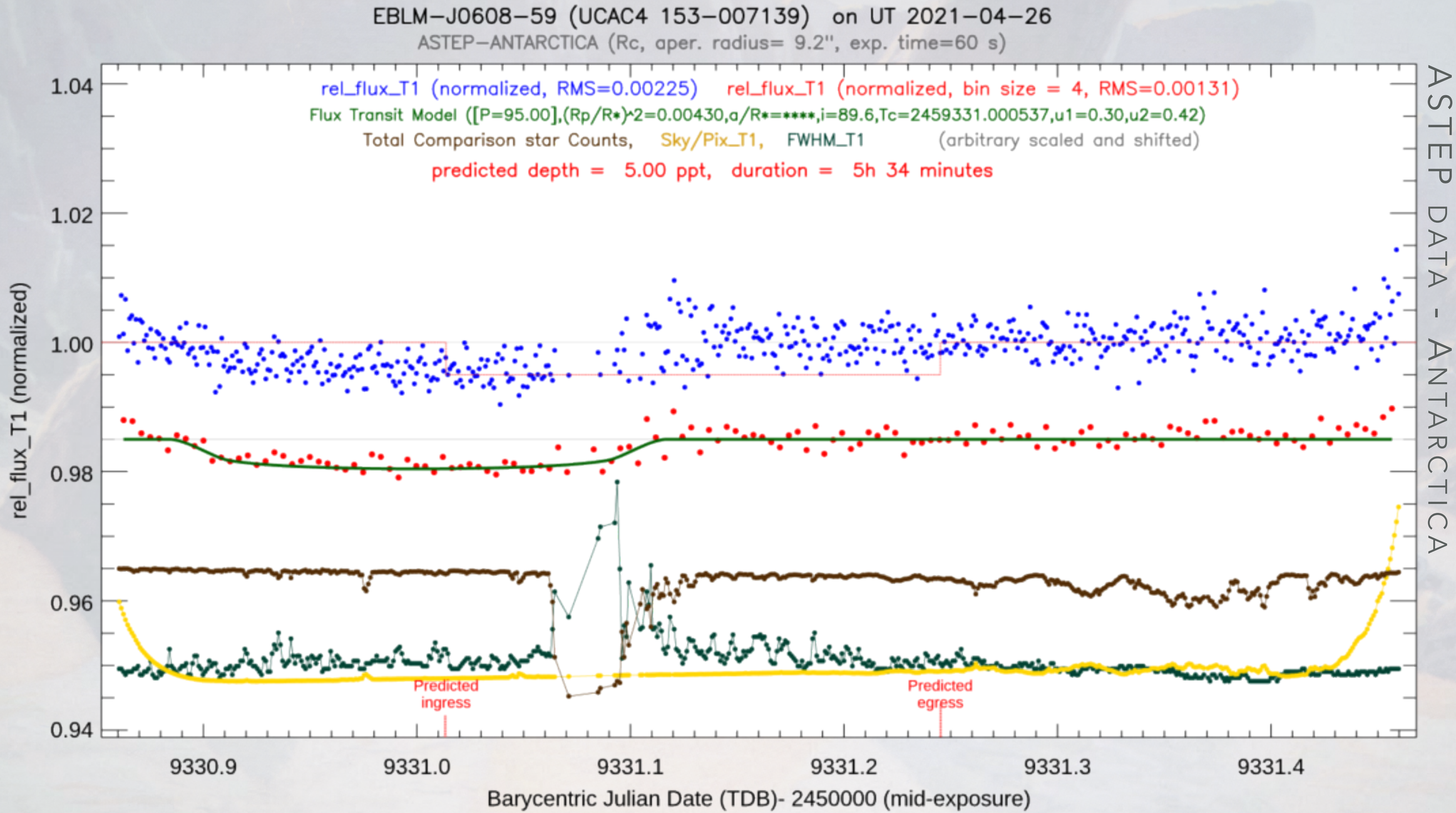


Konacki 16.5 m/s RMS on A
89 m/s RMS on B
Using HIRES@Keck

Lalitha 7 m/s RMS on A
12.5 m/s RMS on B
Using SOPHIE@193cm

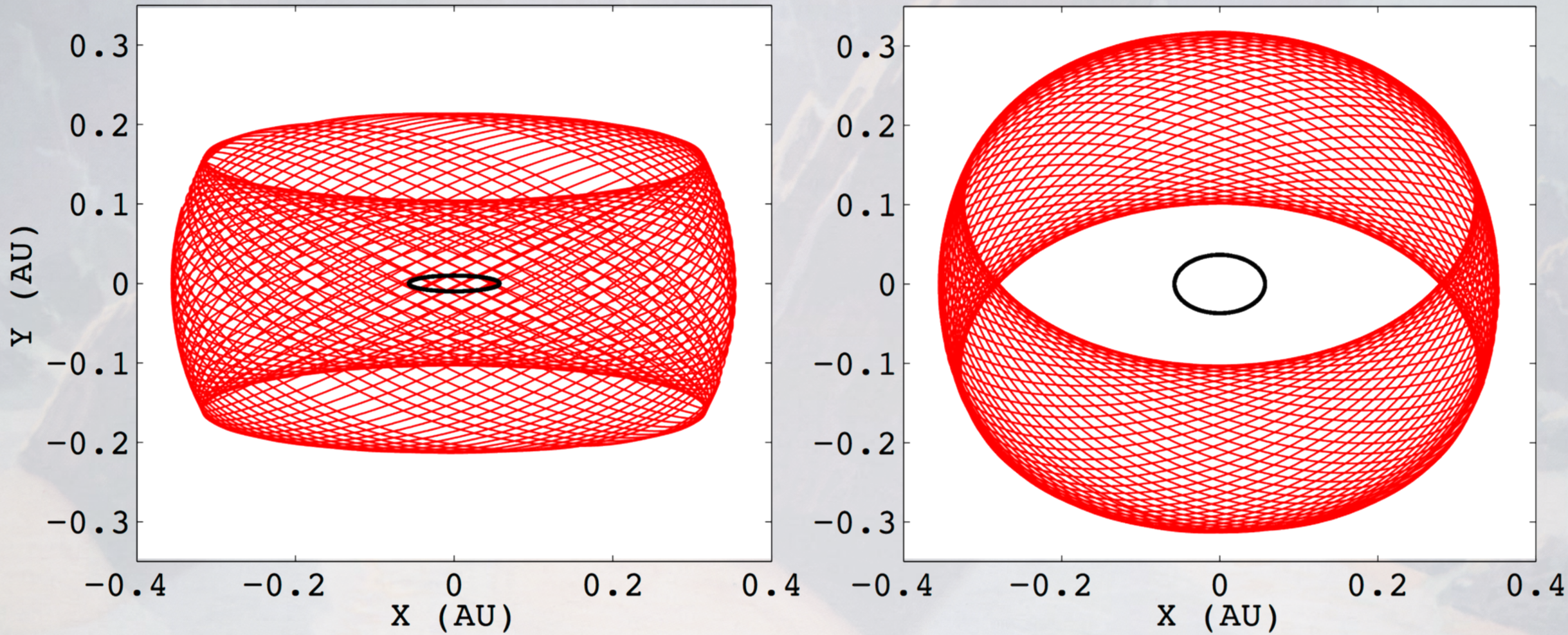
BEBOP V: Lalitha, Triaud et al. in prep

First detection of a circumbinary transit from the ground



CIRCUMBINARY PLANETS WITH PLATO

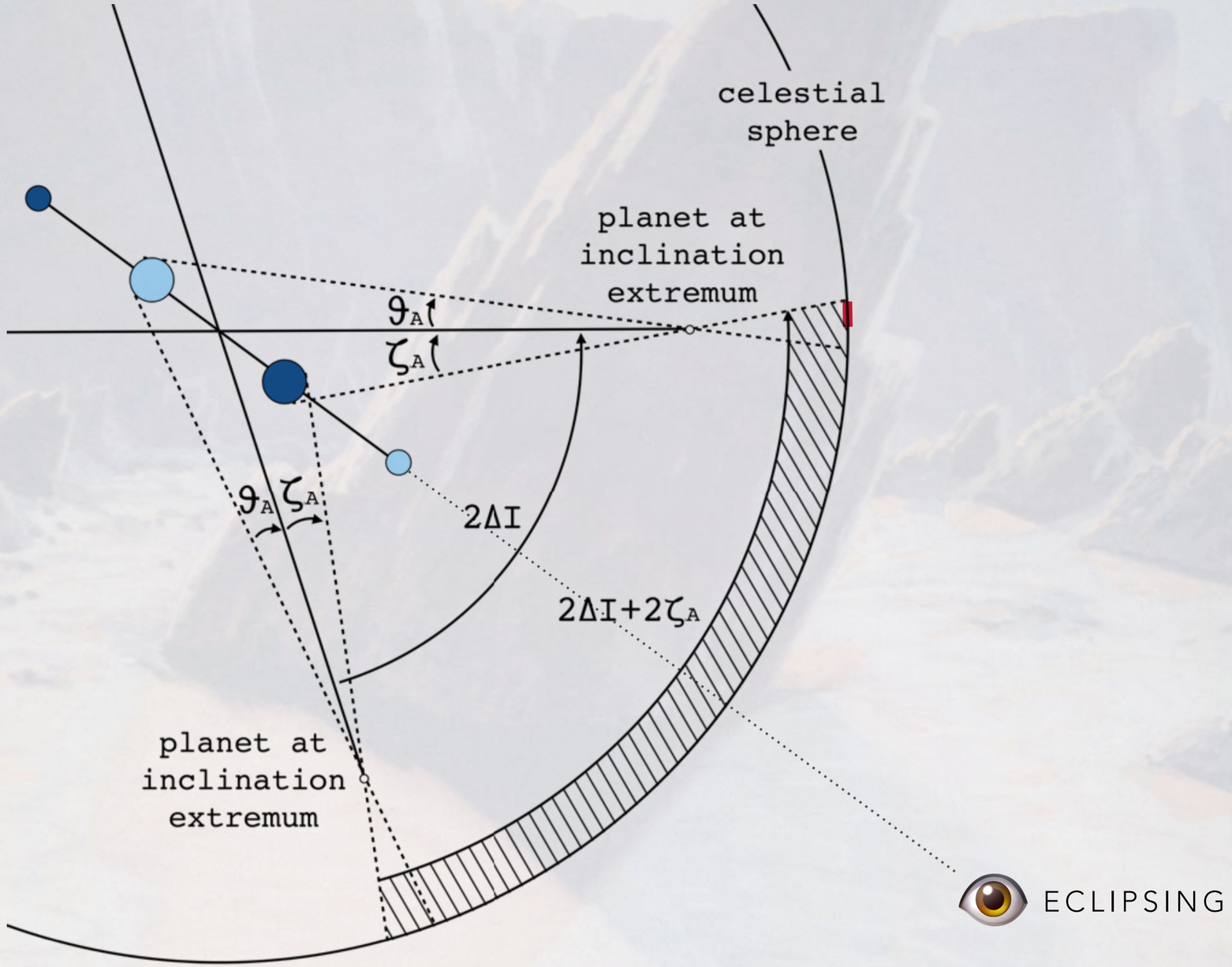
Effect of orbital inclination: transitability



Schneider et a. 1994; Martin & Triaud 2014

PROBABILITY OF TRANSIT REACHES 100%

FOR ΔI > 0.6°
IN ECLIPSING BINARY SYSTEMS;
IF YOU WAIT LONG ENOUGH



P ~ SIN ΔI FOR NON ECLIPSING BINARIES

MARTIN & TRIAUD 2015

RECOMMENDATION FOR PLATO

Re-observe the *Kepler* field should find as many new circumbinary planets as *Kepler* did.

Observe long stares better eclipse timing variations, more transits (long orbital periods)

Observe long timespans more time for orbital precession

RECOMMENDATIONS

main mission: 2x 2-yr long stares (e.g. north *(inc Kepler's)* & south)
extended mission: 2x 2yr long stares (go back to the same 2 fields)

students

Matthew Standing
Vedad Kunovac-Hodžić
Georgina Dransfield

postdocs

Lalitha Sairam
Daniel Sebastian

collaborators

David Martin - U. Chicago
Alexandre Santerne - Marseille
Richard Nelson - Queen Mary
Pierre Maxted - Keele U.

Don Pollacco, Coel Hellier, Magali Deleuil, Andrew Collier Cameron, Stéphane Udry, Rosemary Mardling, Alexandre Correia, Michaël Gillon, Tristan Guillot, James McCormac, Sam Gill, Isabelle Boisse, João Faria

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