



# V1298 Tau

Extracting planetary  
signals in extreme stellar  
activity

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# V1298 Tau

Spectral Type	K1
$T_{\text{EFF}}$	$5050 \pm 100 \text{ K}$
Mass	$1.170 \pm 0.060 M_{\odot}$
Rad	$1.278 \pm 0.070 R_{\odot}$
$P_{\text{ROT}}$	$2.91 \pm 0.05 \text{ d}$ (shows diff. Rot)
$v \sin i$	$23.8 \pm 0.5 \text{ km/s}$
Age	$20 \pm 10 \text{ Myr}$

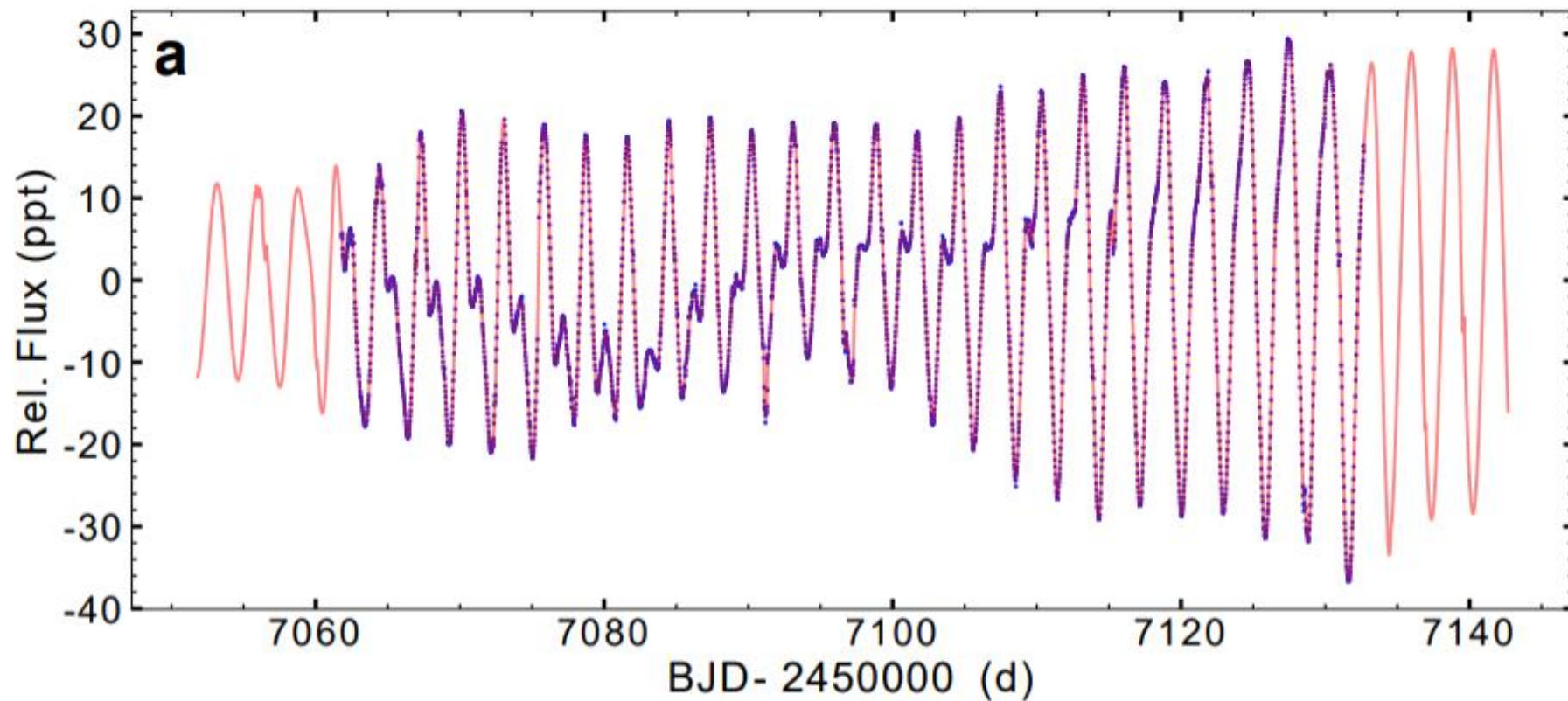


4-planet system

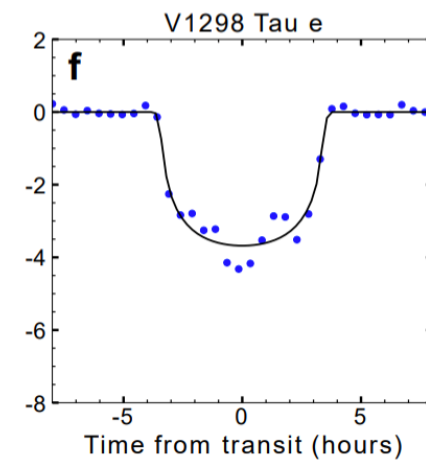
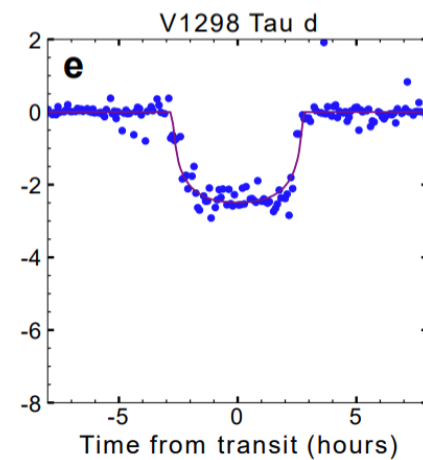
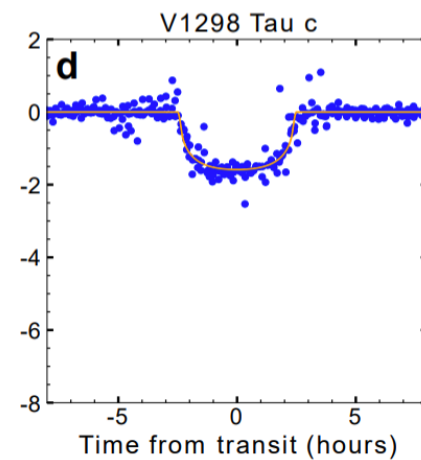
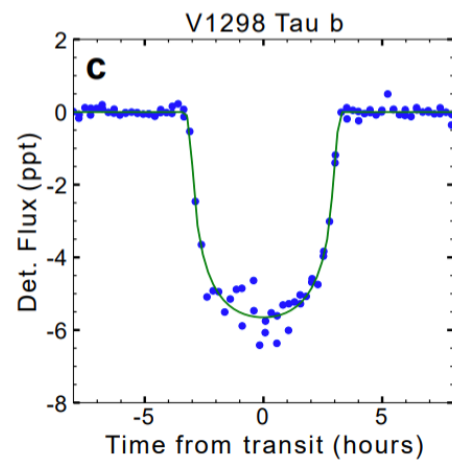
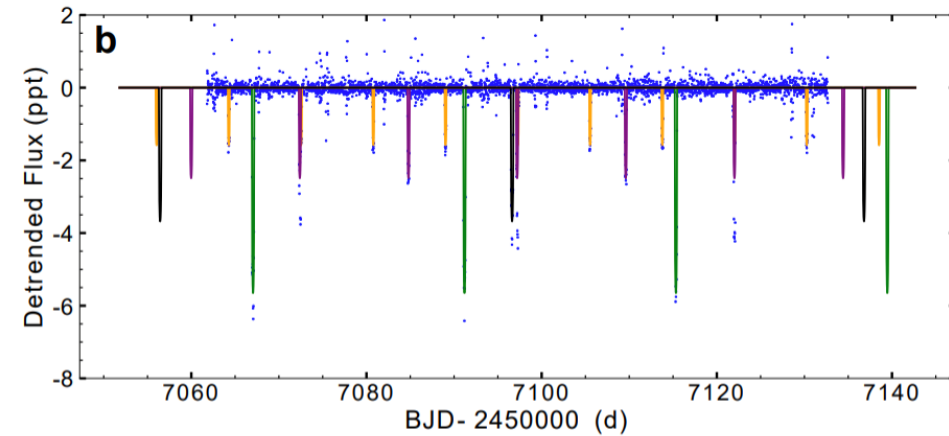
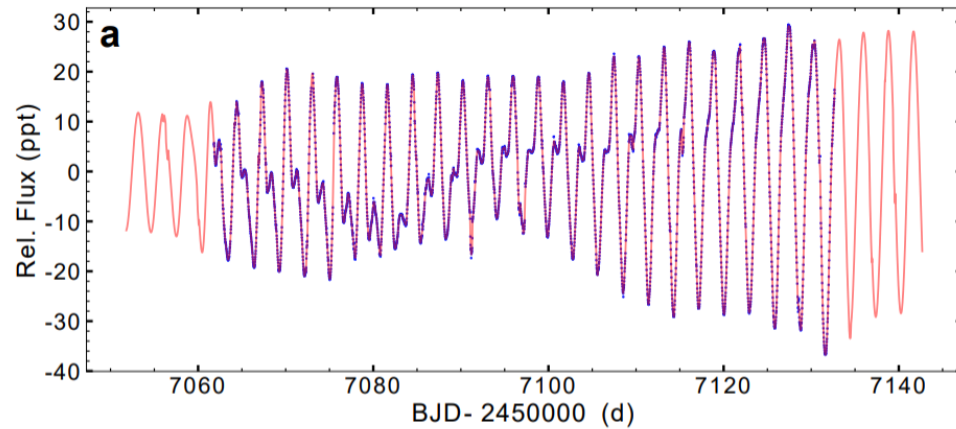
- 2 Neptune-size planets
- 2 Jupiter-size planets



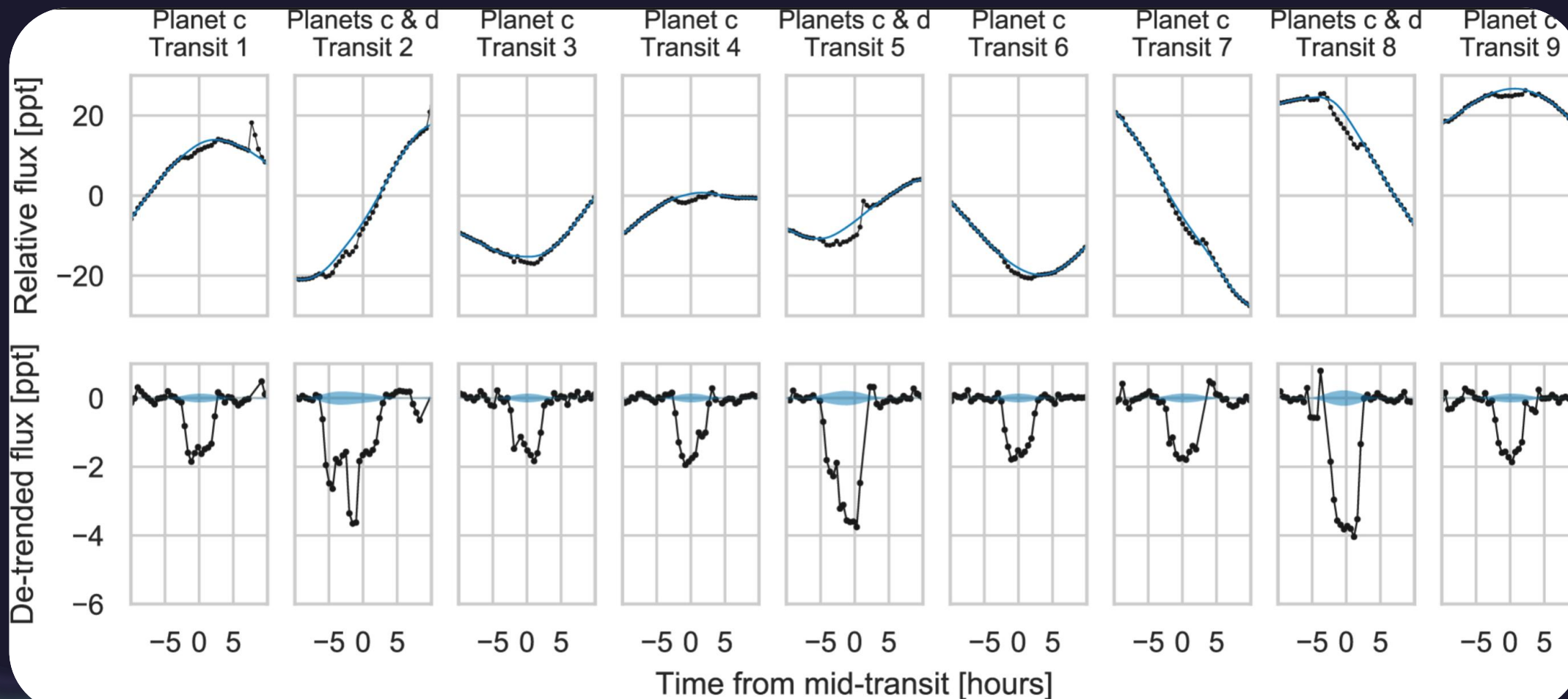
# V1298 Tau K2 data

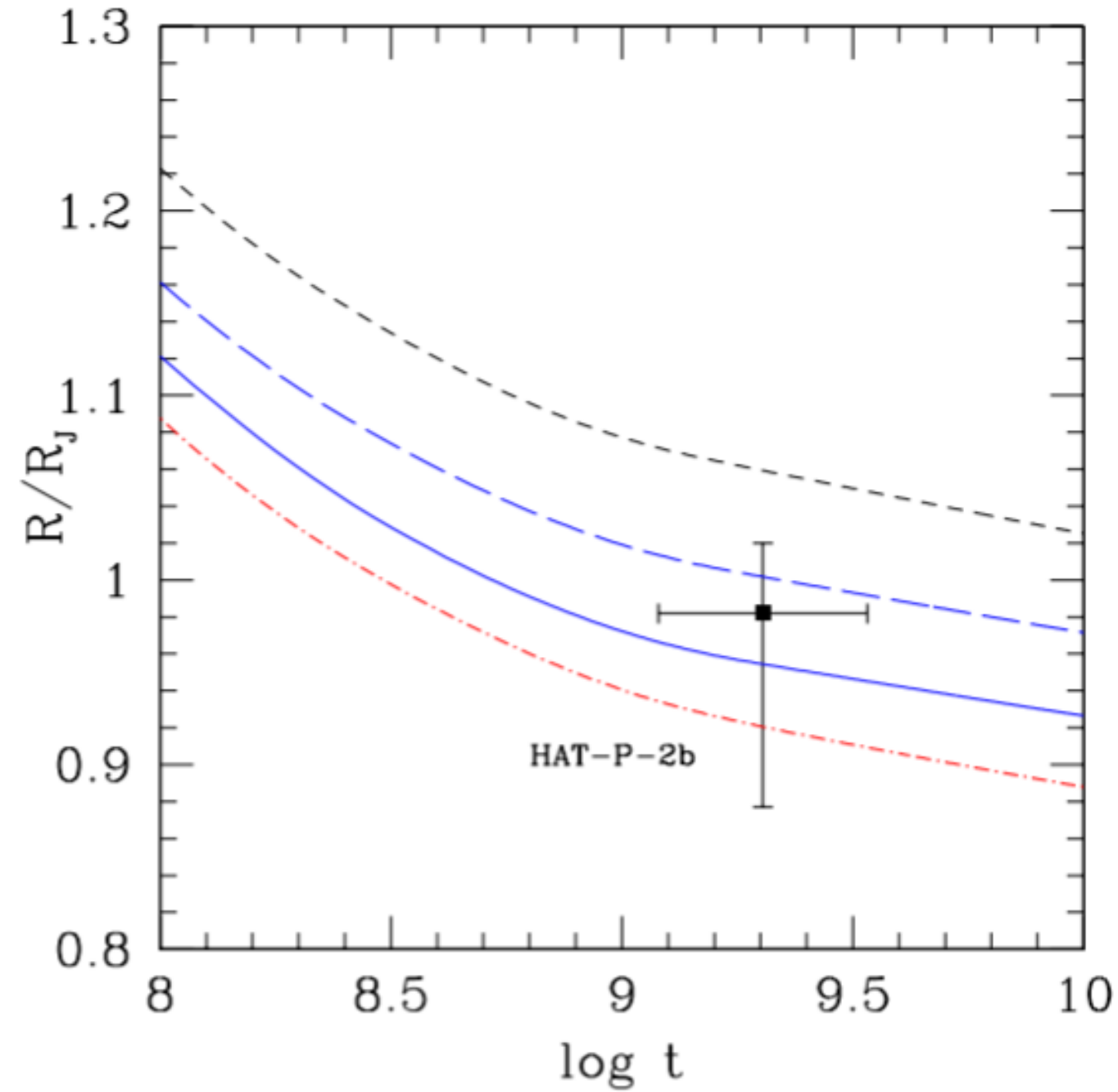


# V1298 Tau K2 data



# V1298 Tau K2 data





# Young systems

Laboratories to test models of early evolution of planets

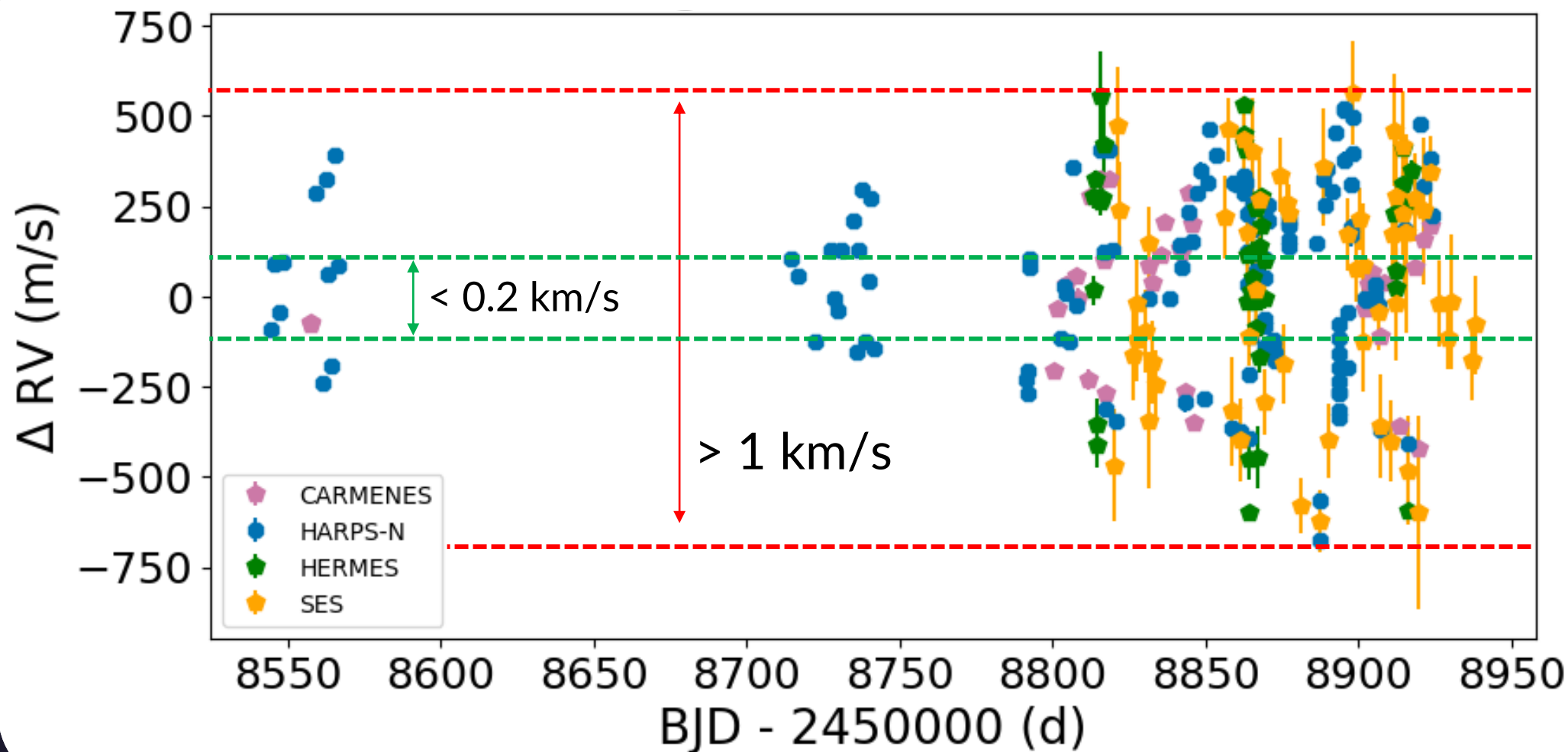


Giant planets are expected to have much larger radii  
at 20 Myr

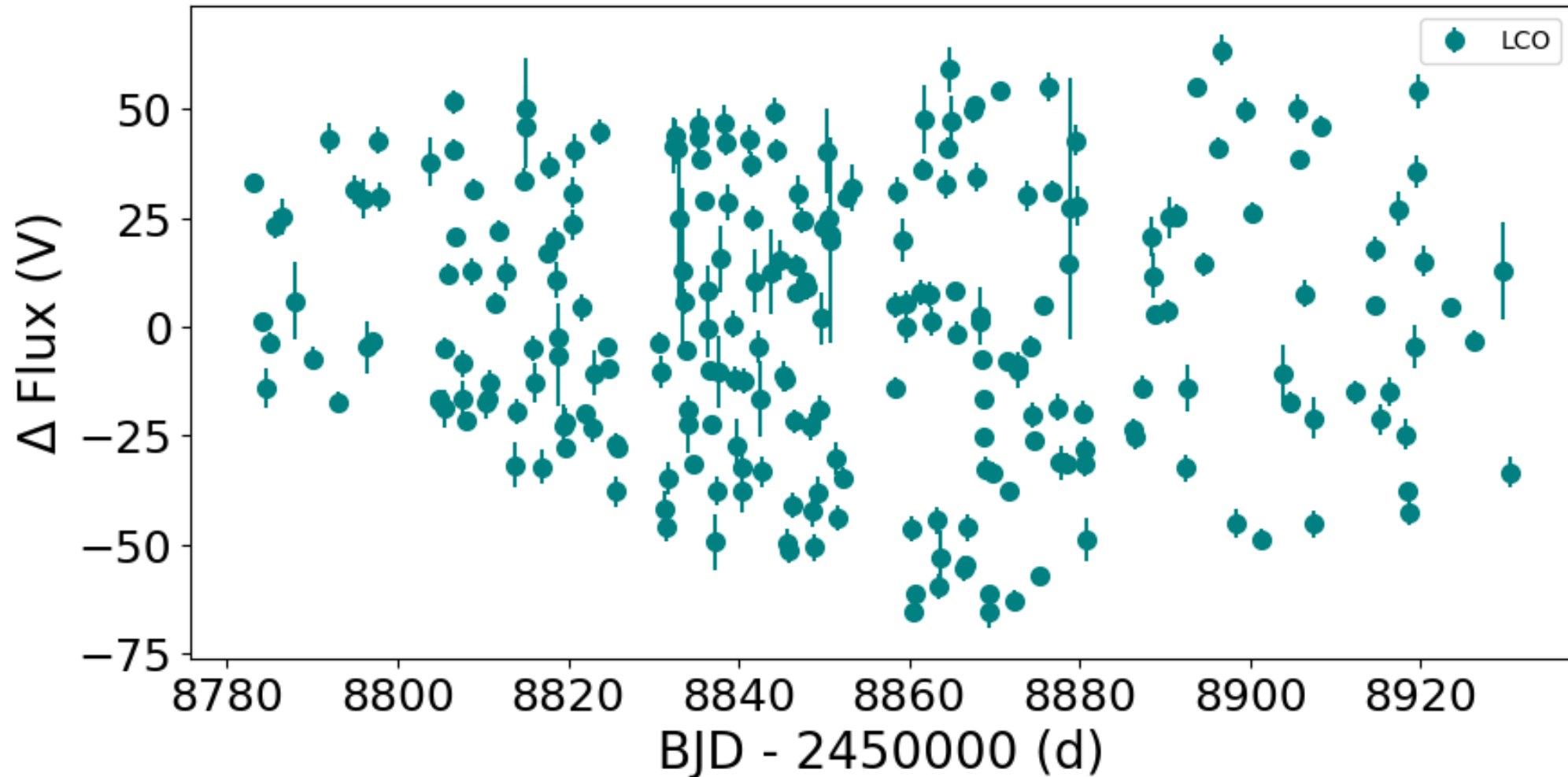


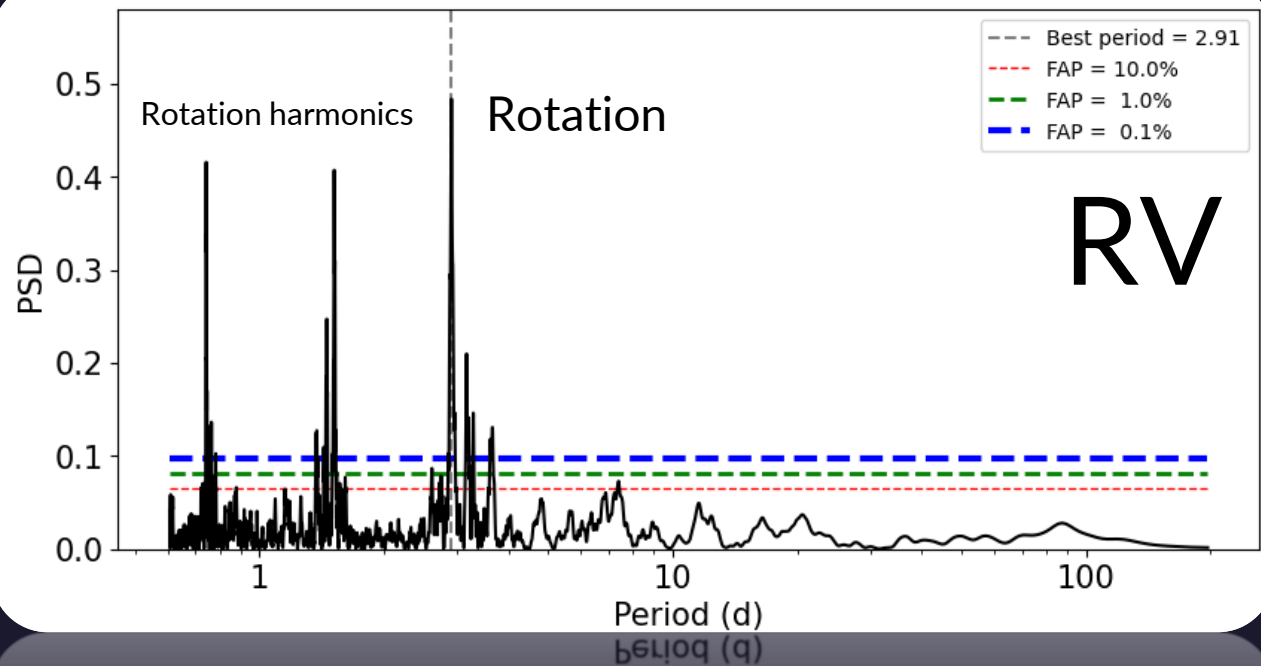
# V1298 Tau RV data

RVs measured with SERVAL and CCF, depending on the instrument (les than ideal solution)

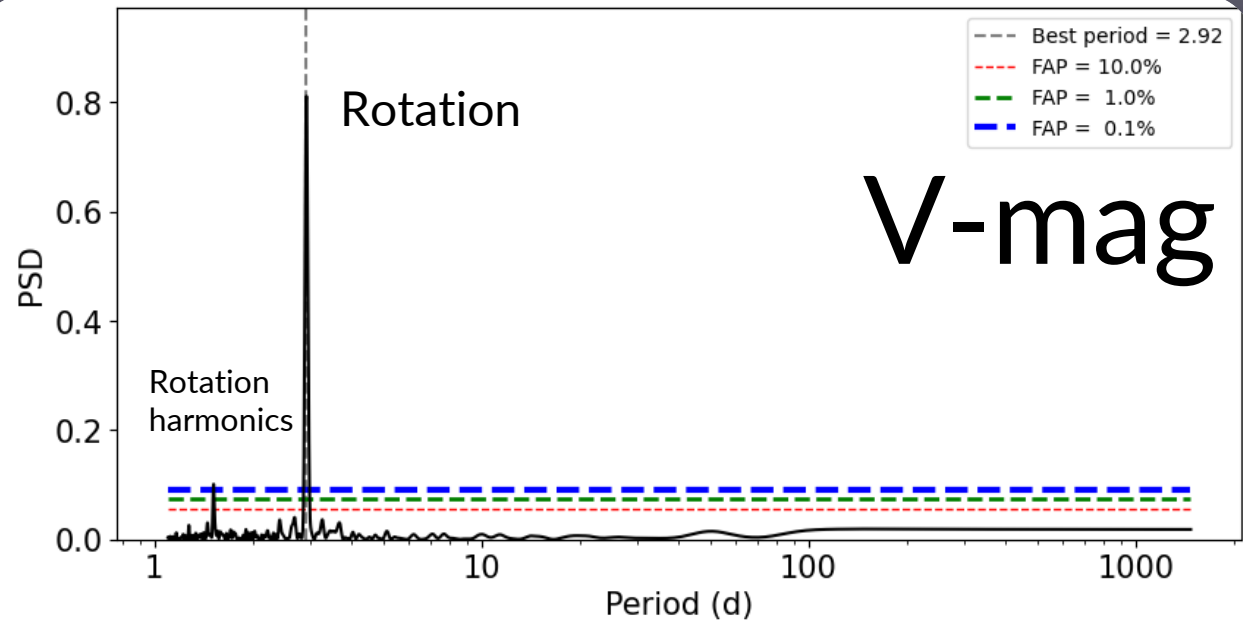


# V1298 Tau ground based photometric data





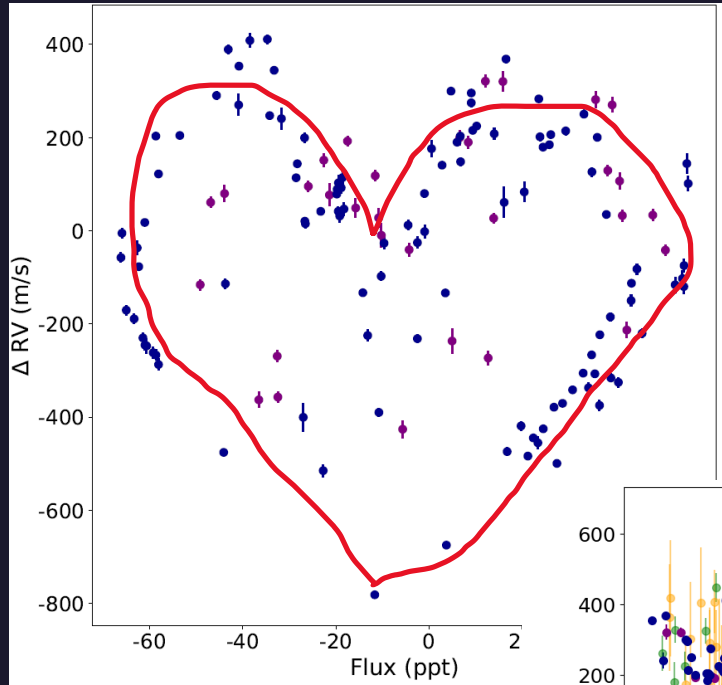
Higher  
harmonic  
complexity



Lower  
harmonic  
complexity



# $RV \sim d/dt \text{ Flux}$

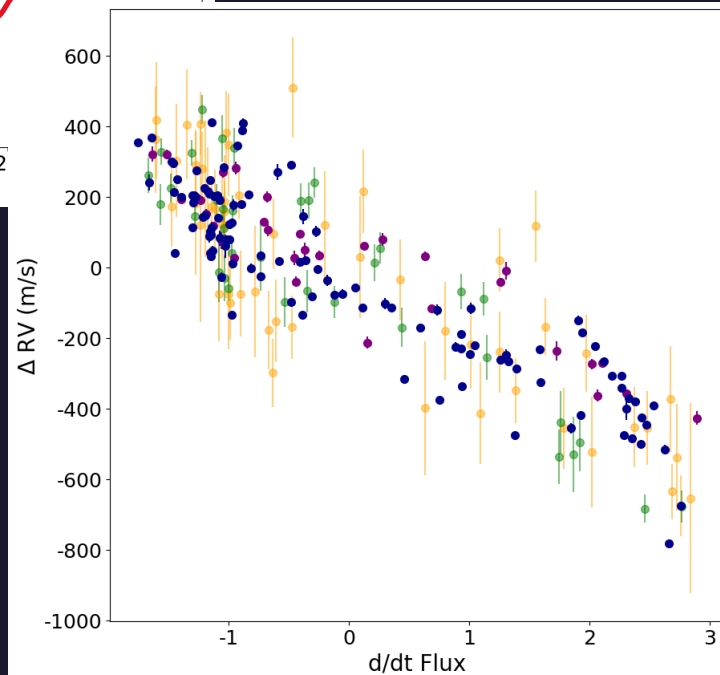


\*It doesn't actually love us :(

$d/dt$  Flux and RV correlated for  
V1298 Tau



Joint RV+ Flux fit  
Flux constraints activity parameters



# Choice of Activity model

Several activity models tested:

Quasi-Periodic GP, SHO (x1, x2, x3), Mattern 3/2, Quasi-Periodic Cosine, Combinations of Periodic GPs, Correlation with d/dt Flux, MEP, ESP...

**Winner?** (i.e highest LogZ, lowest bias?) :

$$k(\tau) = \frac{B_1}{2 + C} e^{-\tau/L_1} \left[ \cos \left( \frac{2\pi\tau}{P_{\text{rot}}} \right) + (1 + C) \right]$$

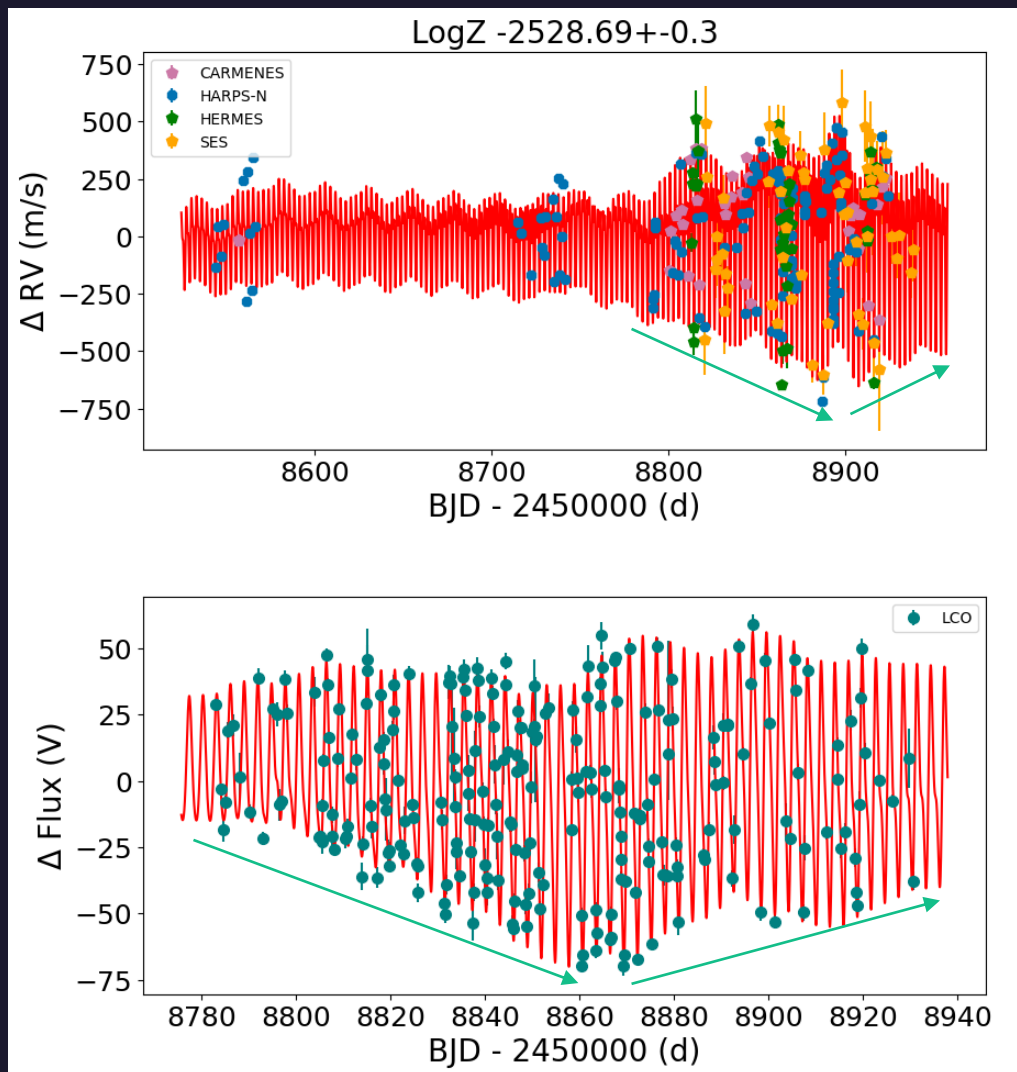
+

$$\frac{B_2}{2 + C} e^{-\tau/L_2} \left[ \cos \left( \frac{4\pi\tau}{P_{\text{rot}}} \right) + (1 + C) \right]$$

**Fit of K2 (SOx2) + RV + LCO:**

\*7 days NS run on 40-cores CPU.

# V1298 Tau – Joint model



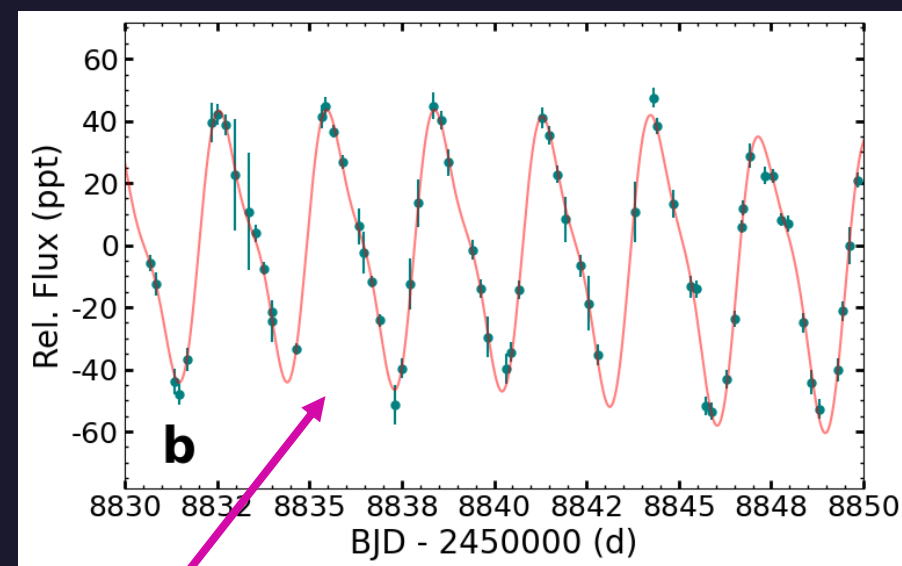
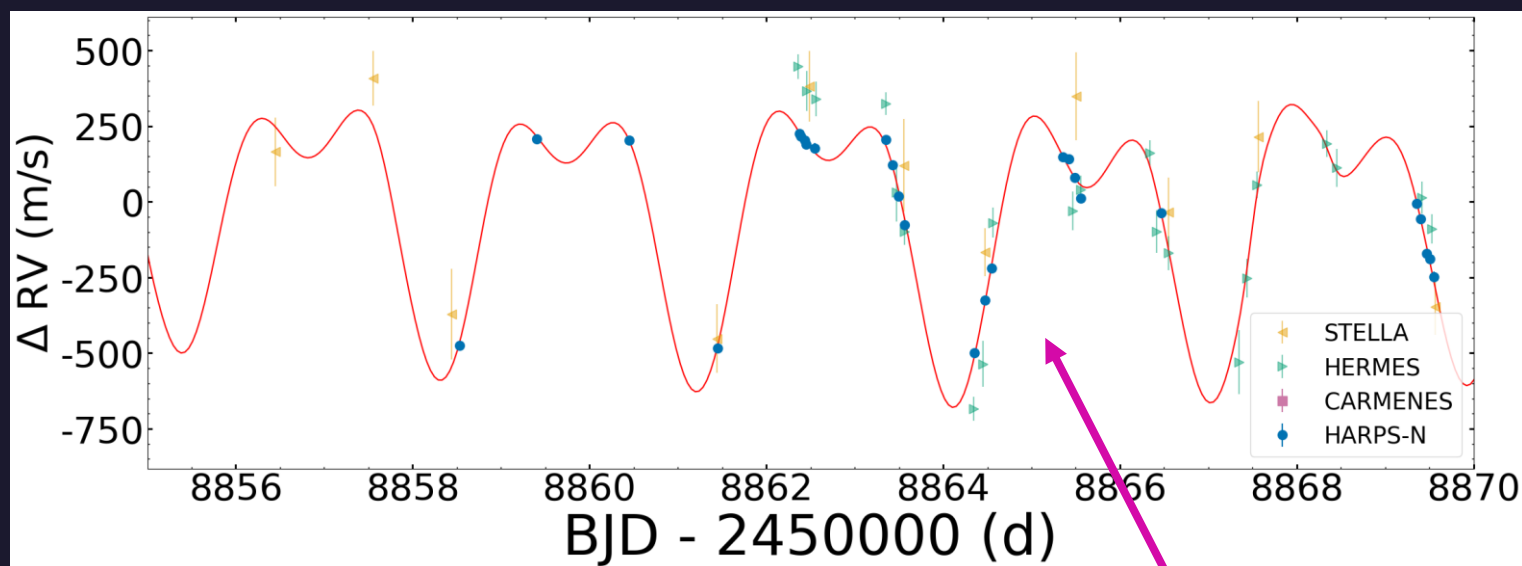
## Activity fit

RV + V-band photometry

Very similar behavior

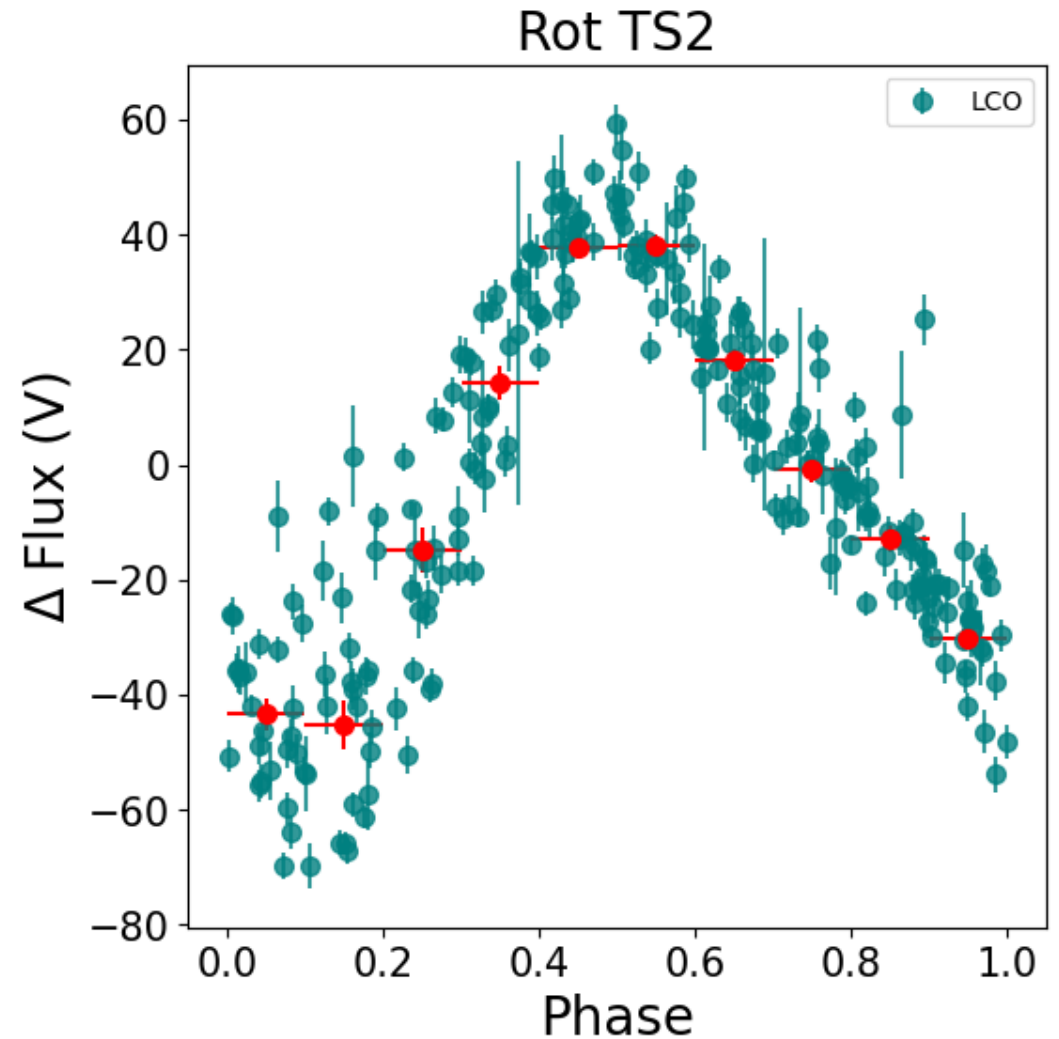
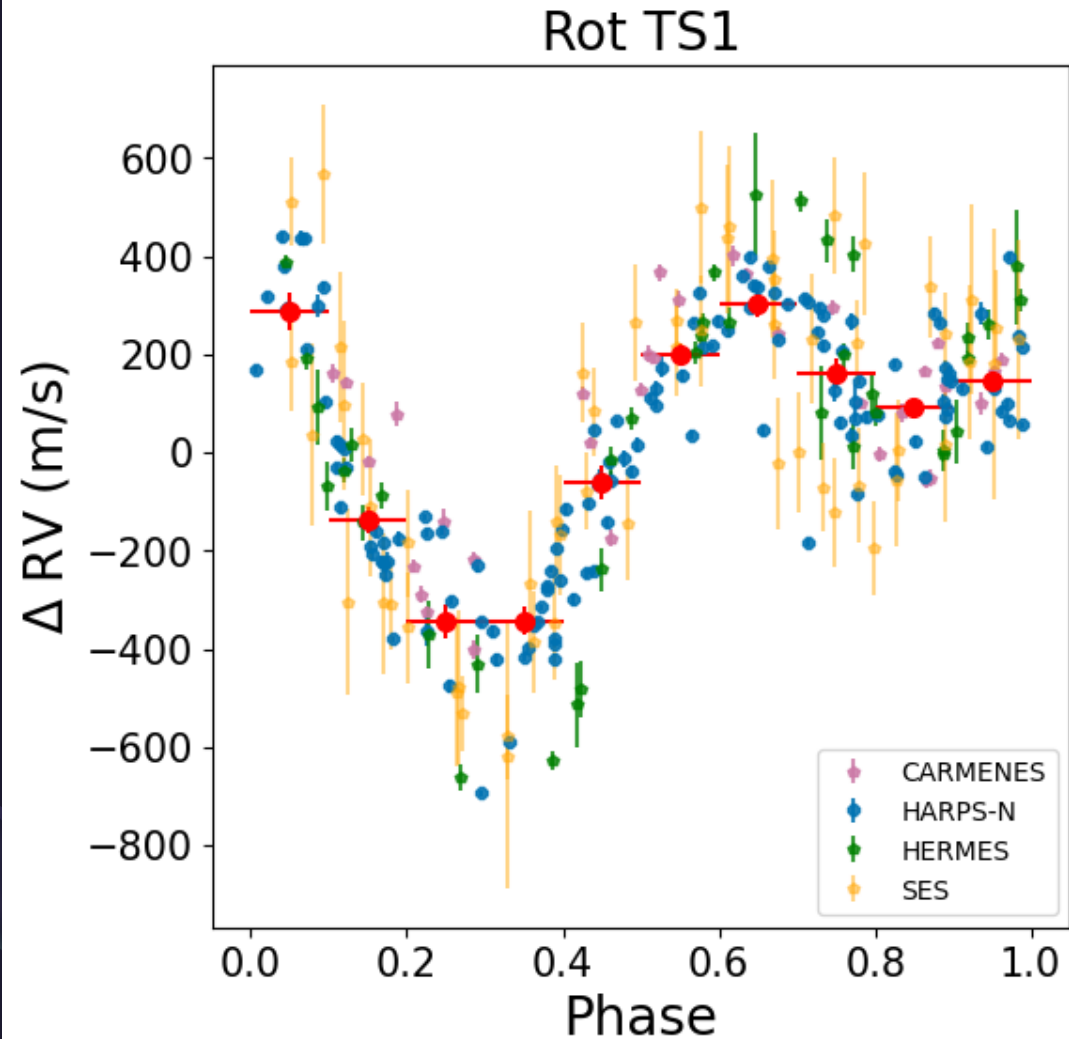


# Joint model

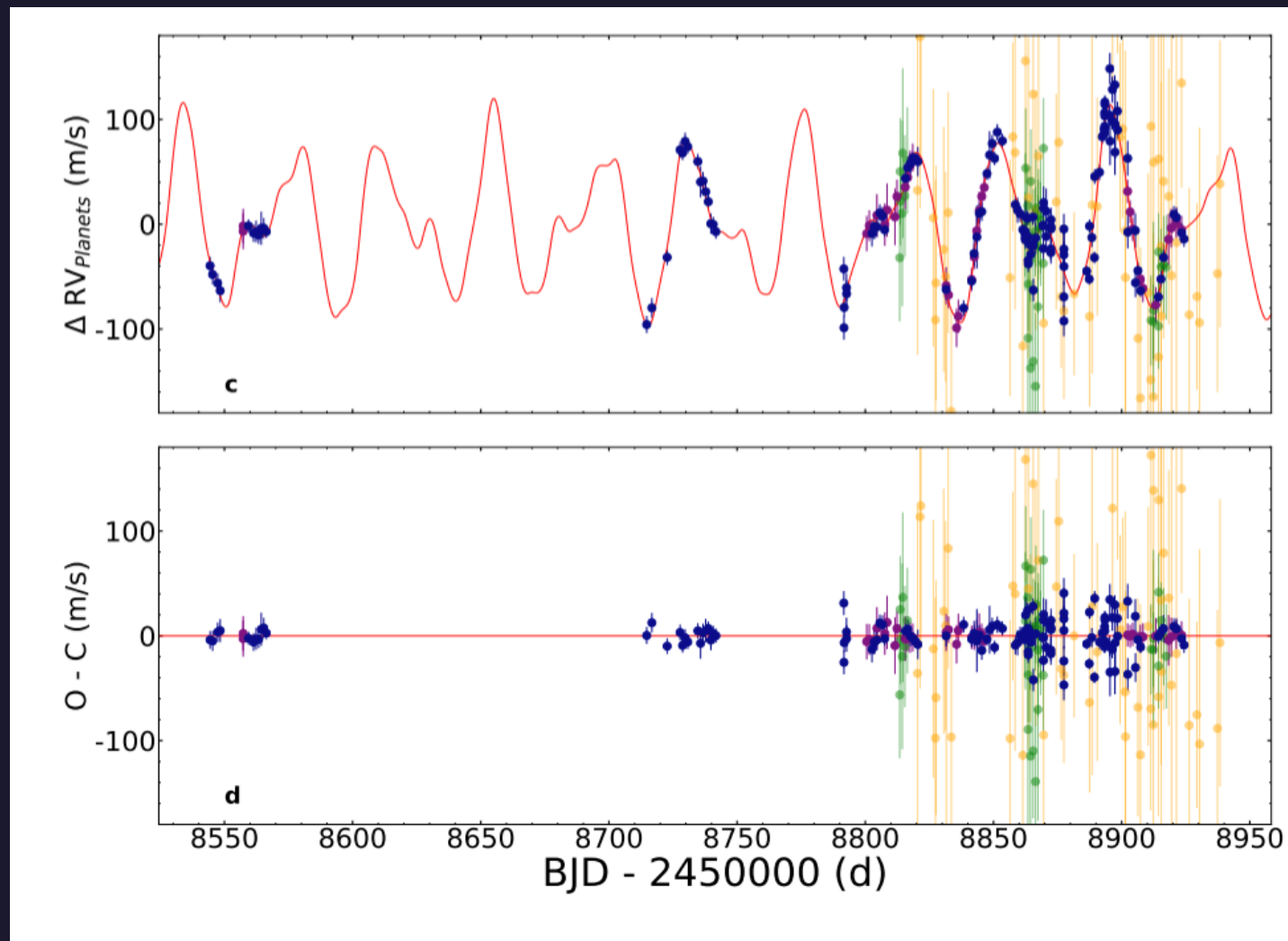


Protect your observing cadence at all costs!

# Phase folded rotation

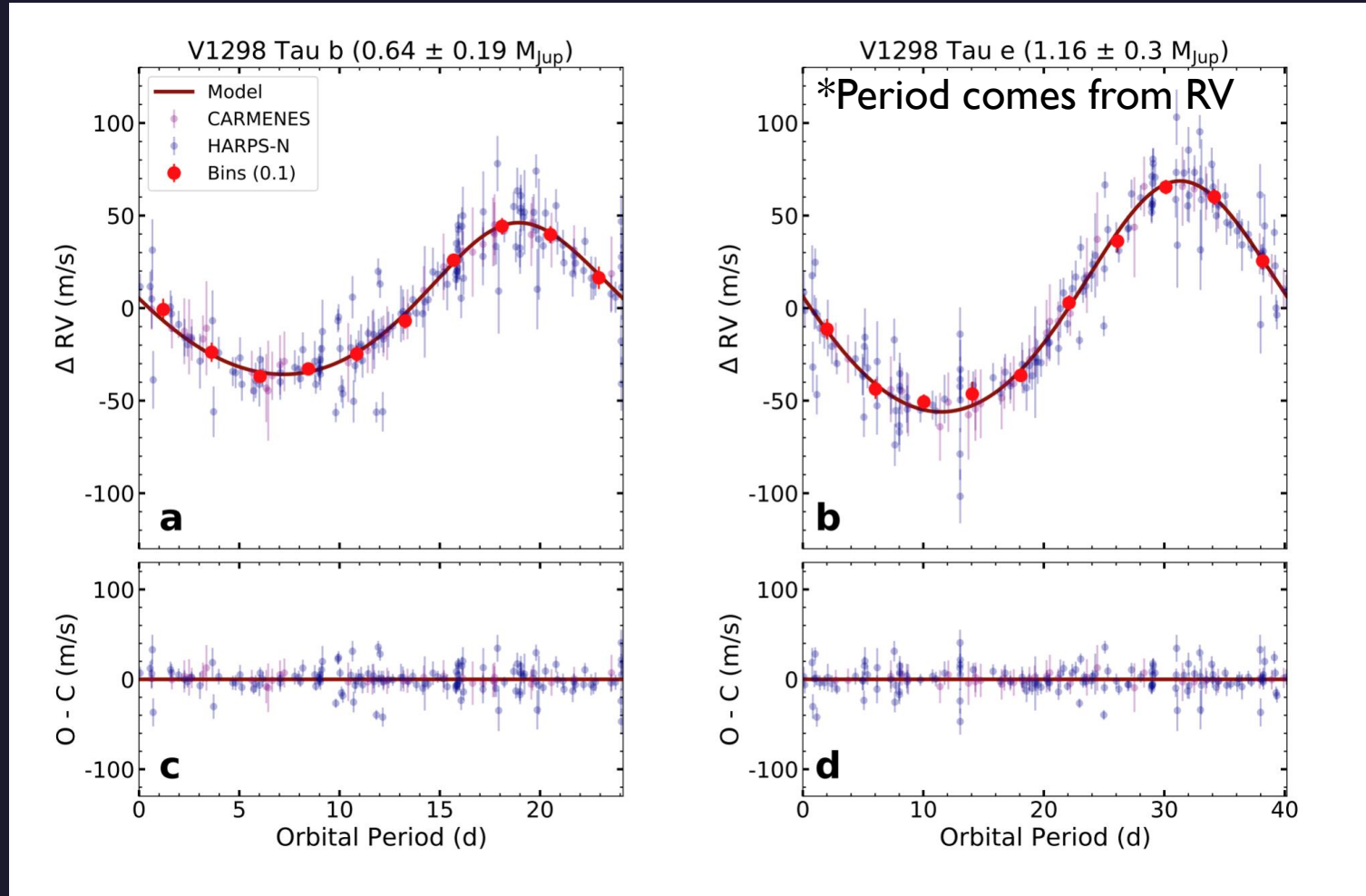


# V1298 Tau – Planetary part

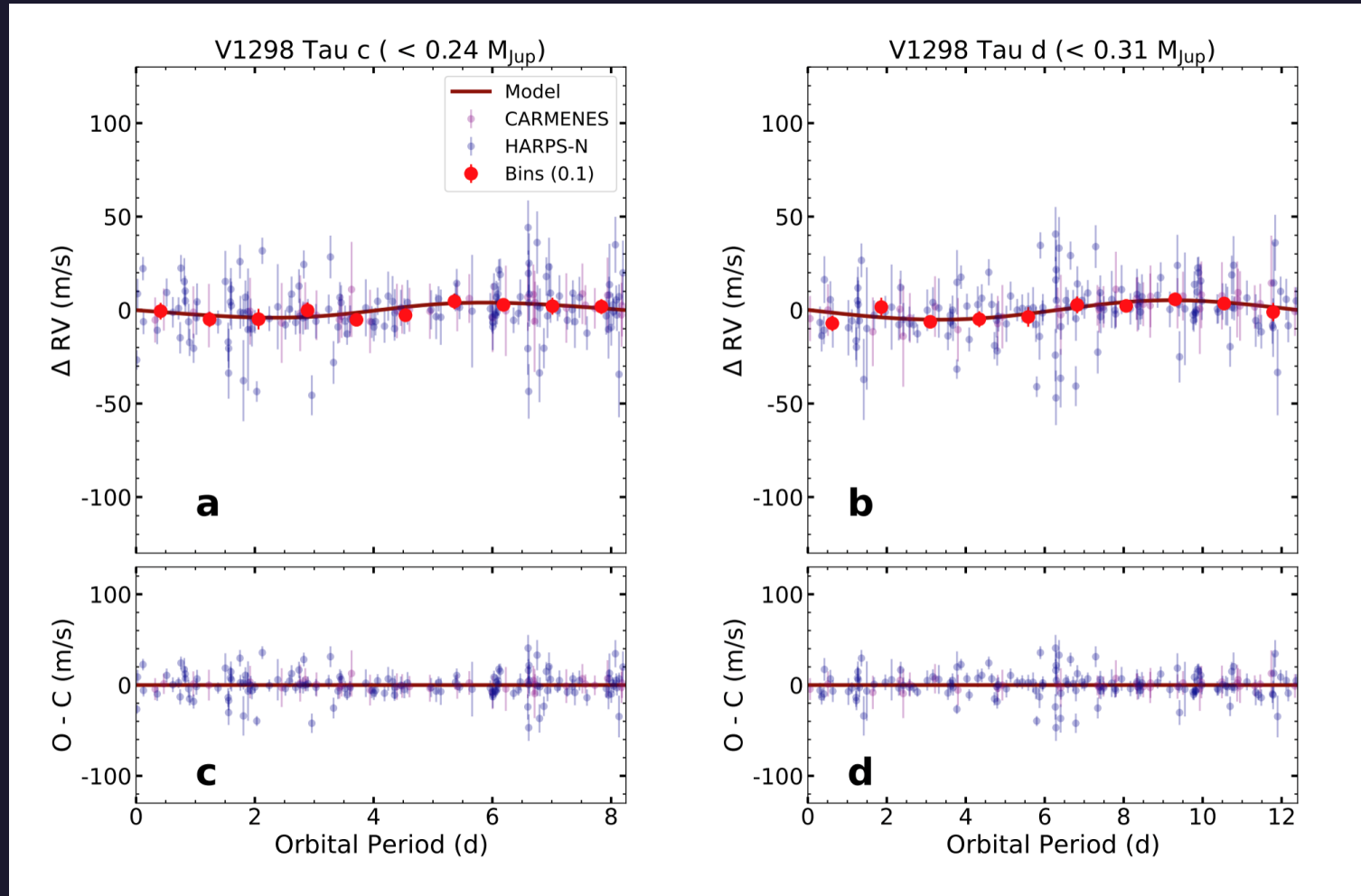




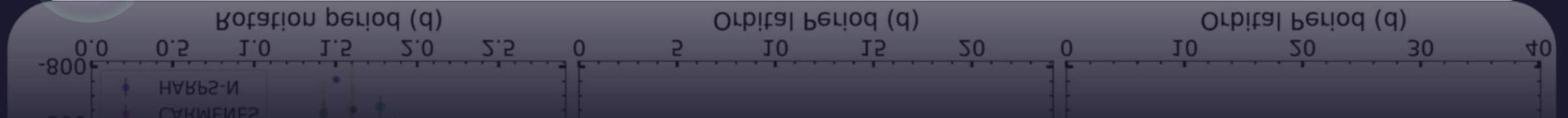
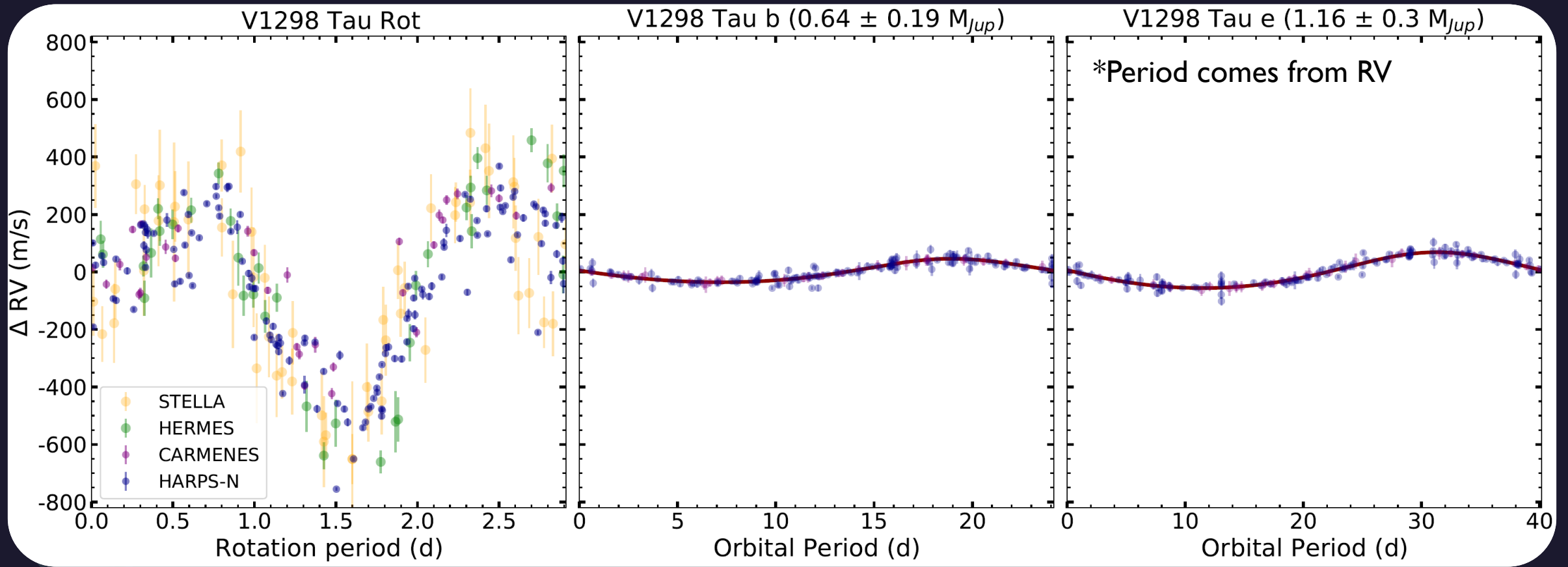
# Phase folded planets b & e



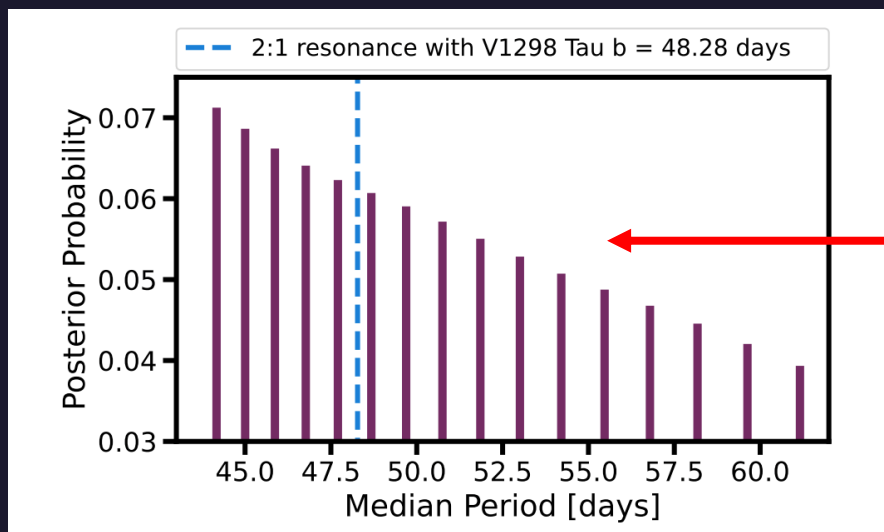
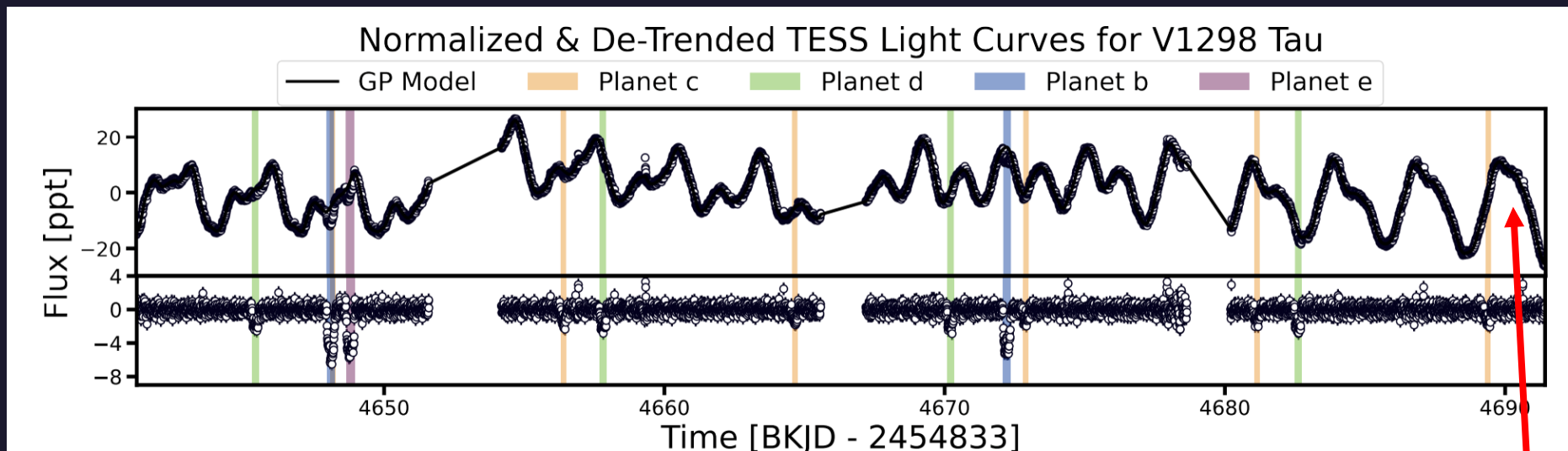
# Phase folded planets c & d



# Phase folded rotation vs planets



# What about planet e? \*Careful with periods coming only from RV

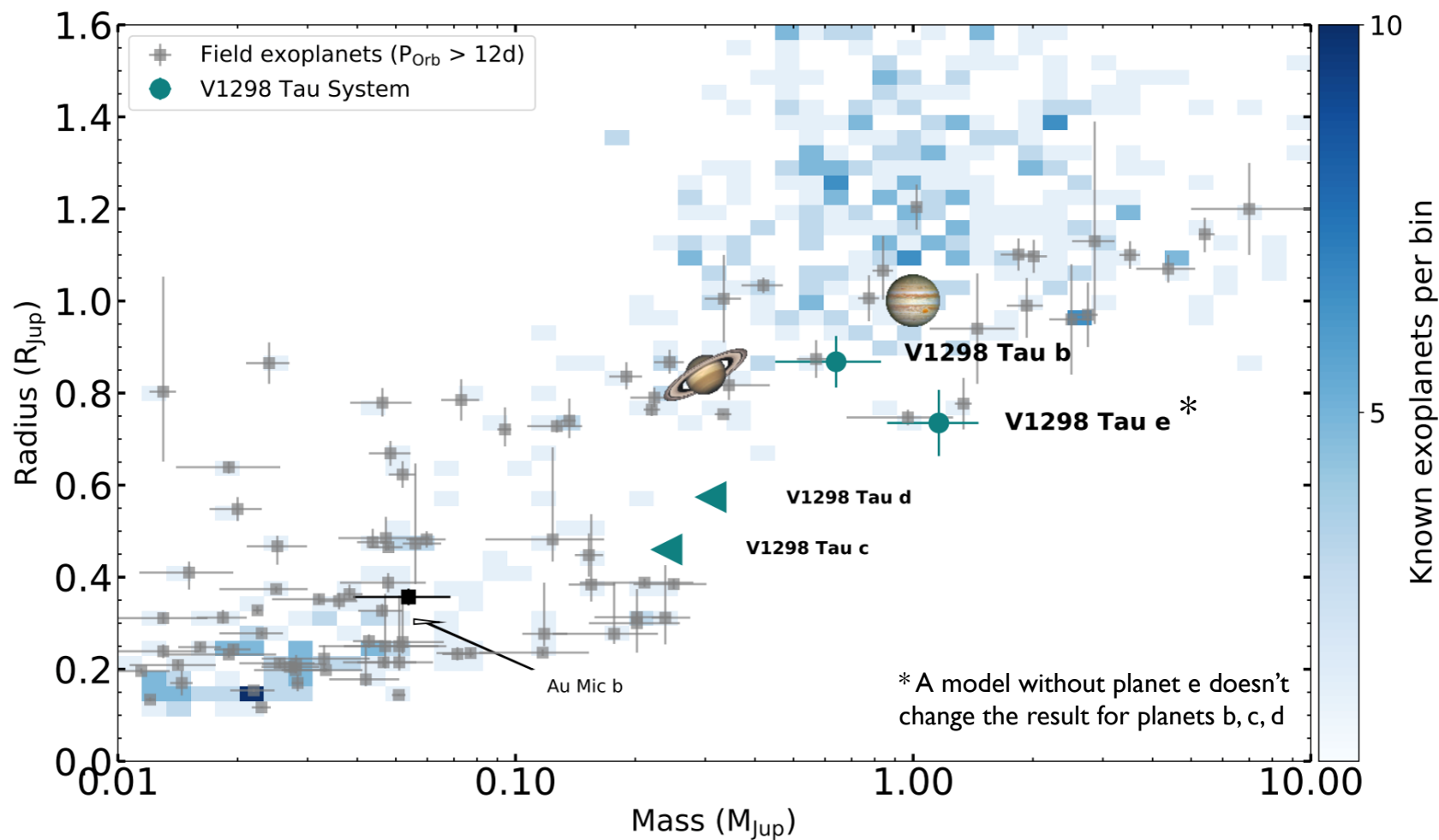


It is still **expected** to have a similar period to the one we measured

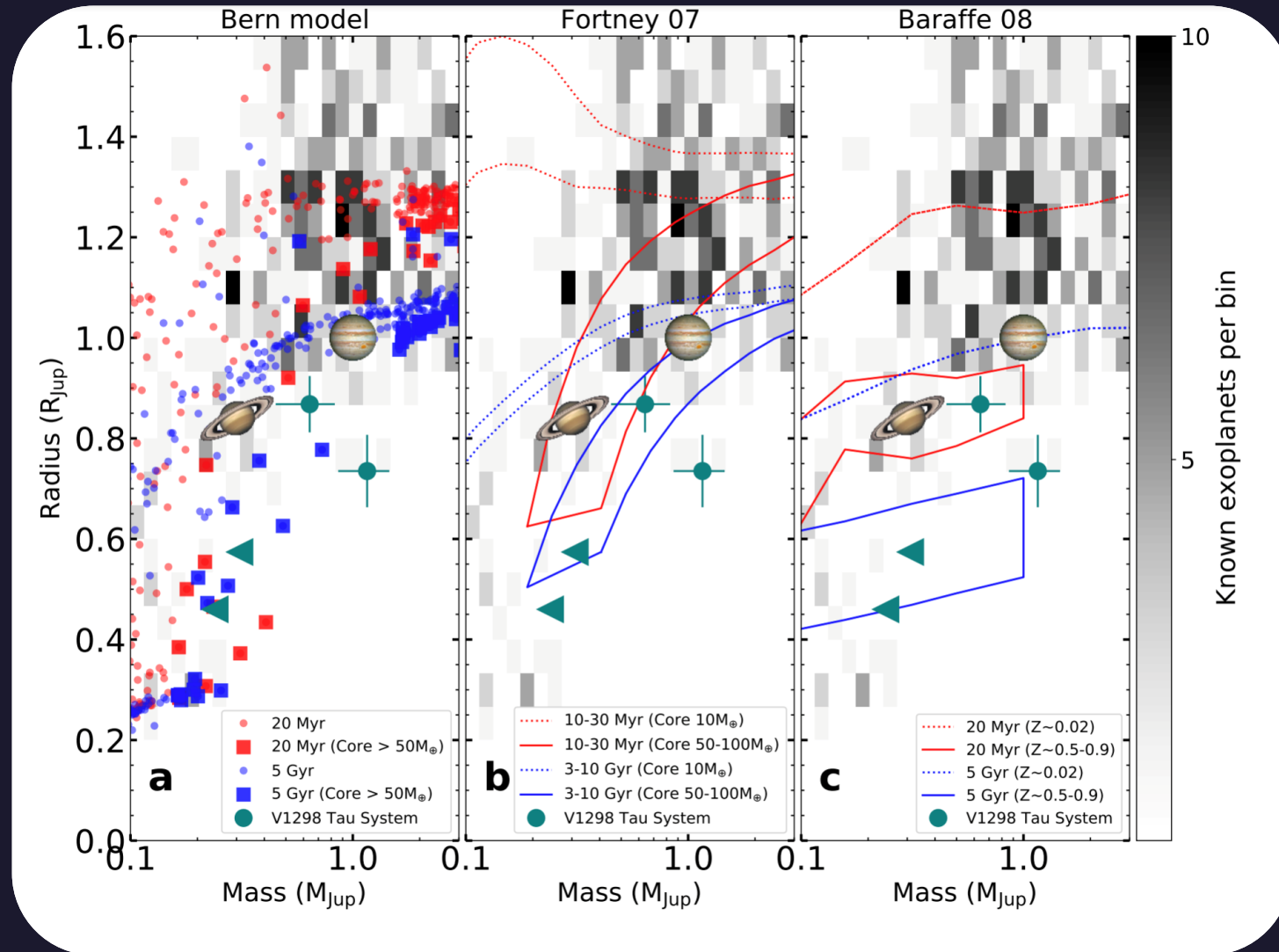
Planet e was expected to transit here (didn't seem to transit)



# V1298 Tau planets seem “old”



# V1298 Tau planets seem “old”



# Summary

**Measurement of the mass of V1298 Tau b at 0.6 Jupiter mass**

**Planet seems to have already contracted**

**Possible measurement of the mass of V1298 Tau e at 1.2 Jupiter mass**

**Planet seems to have already contracted**

*\*Uncertainty on the real origin of the RV signal!*





# Summary 2

**Young stars are a mess, don't study them**

*\*But we have to study them :(*

Activity  
Happyness

*If you decide to study young stars...*

**Don't ever underestimate the importance of your sampling**

*\*Good sampling is good for your mental health*

**Get quasi-simultaneous photometry**

*\*with the highest cadence possible*

**Don't get fooled by the vsini limit**

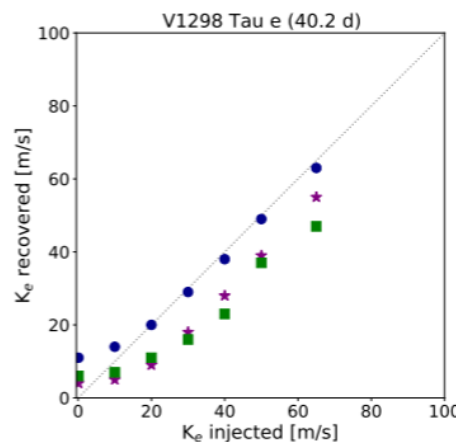
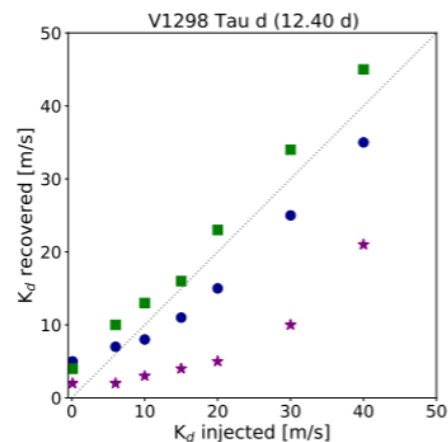
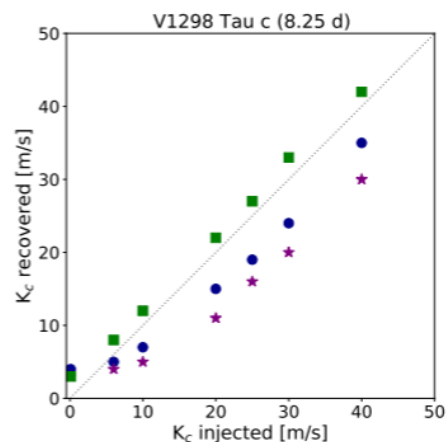
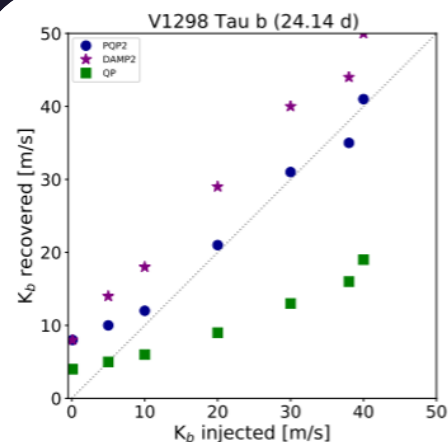
*\*You don't want to worry about the instrument.  
Stellar activity is bad enough.*

**Mixing different spectrographs is a mess**





# Small injection experiment



PQP2: Lower amplitude at short periods

QP: Lower amplitude at long periods

SHOx2: Lower amplitude at short period, higher at long period

Not all GP Kernels behave  
the same



How and when do planetary parameters change (significantly) when we change Kernel?

