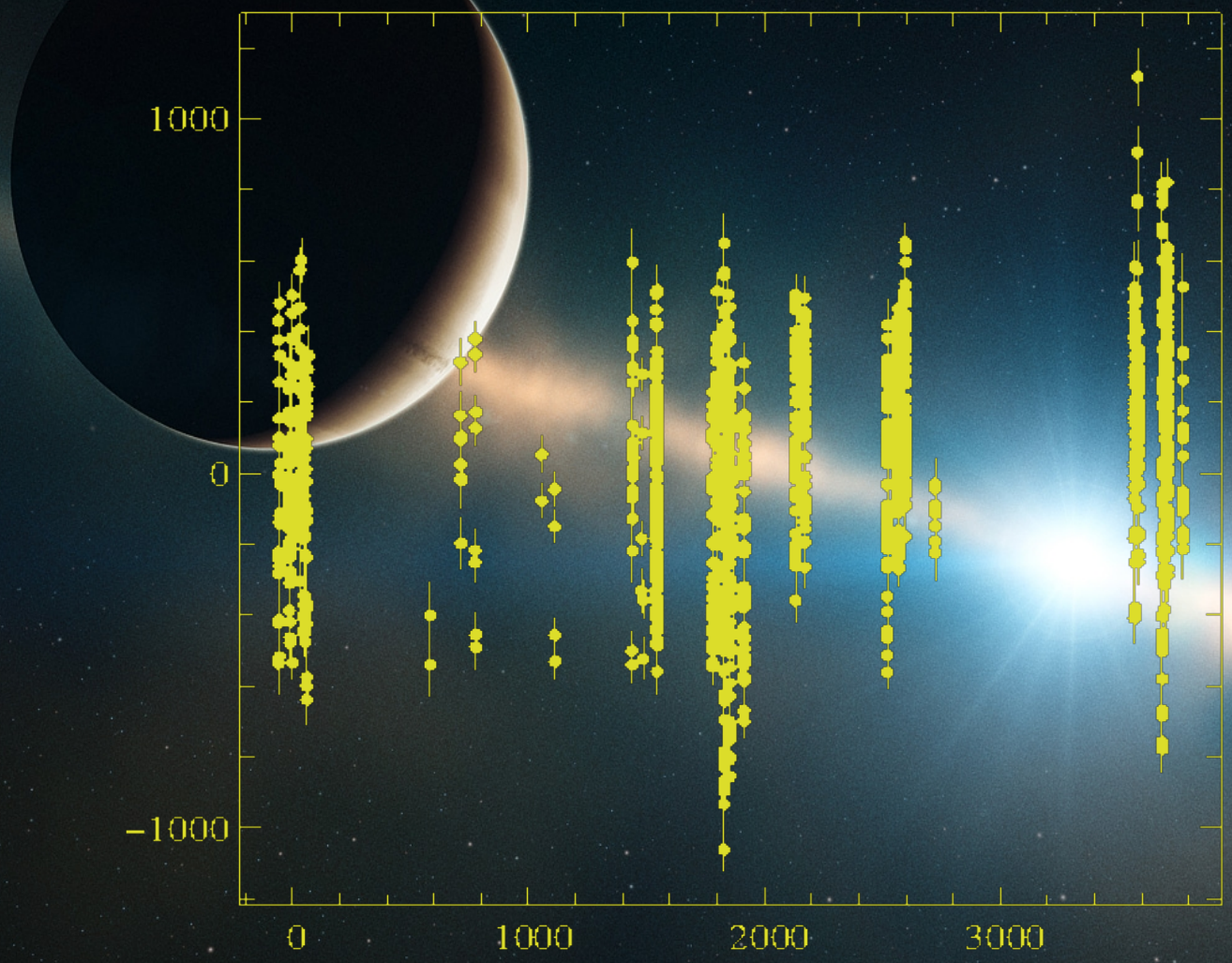
Constraining the orbital properties of β Pictoris b with Harps radial velocity data



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I. β Pic radial velocities

Precise RV computation for early-type stars

β Pictoris: A5V, vsini ~ 125 km/s, young (*Binks et al. 2014, Malo et al. 2014*)

A-F stars: usually not suited for RV studies

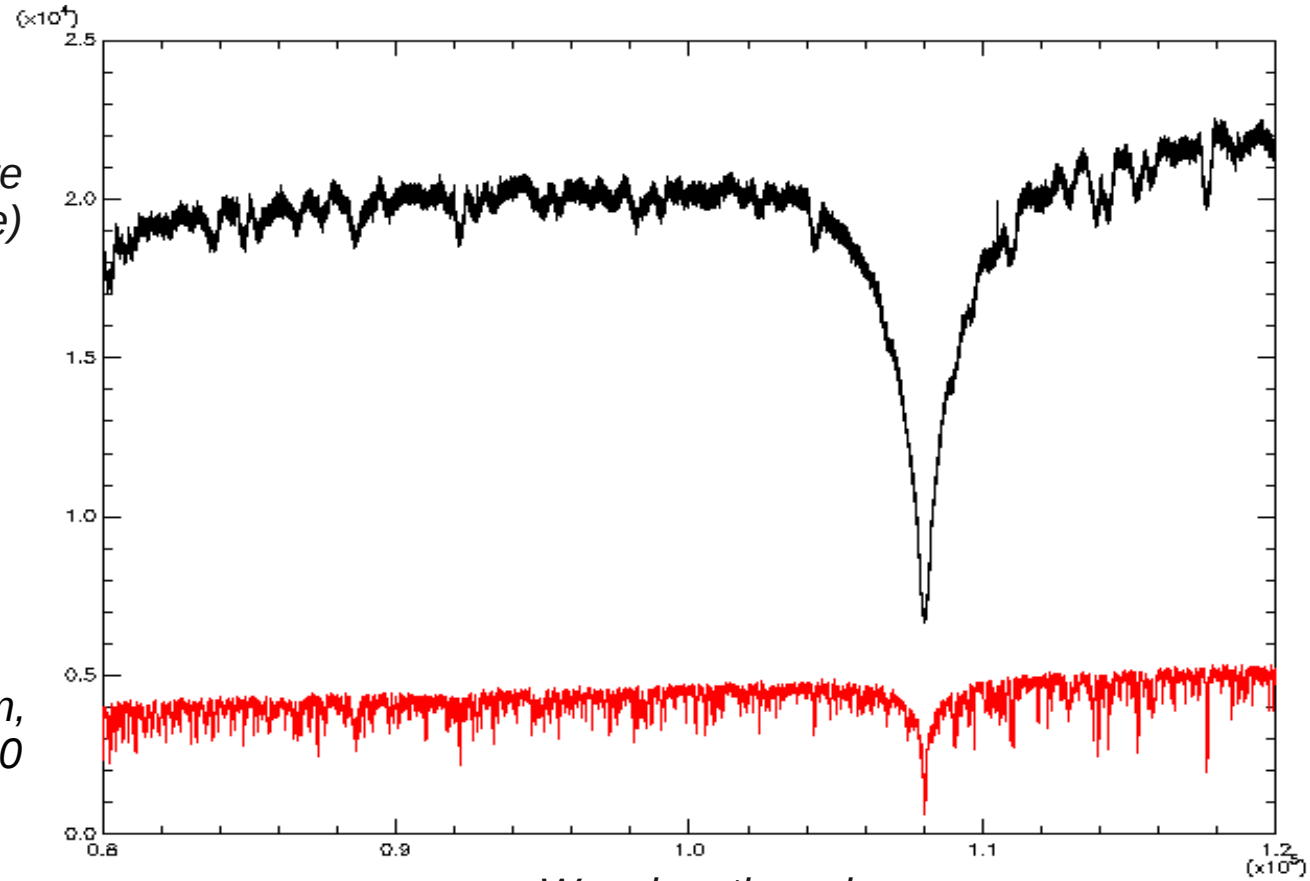
SAFIR method for A-F stars (*Galland et al. 2005*): **reference spectrum** (average of all spectra) used instead of classical binary mask for cross-correlation and estimation of the RV

Relative flux corr. from blaze (inst. response)

β Pic spectrum

G0V spectrum

[part of HARPS spectrum, spectral range 4600-5000 Angstrom]



*Wavelength scale (*0.01 Angstrom)*

I. The β Pic radial velocities

Eleven years of Harps data

1695 high S/N Harps spectra

(2003 – 2014)

High amplitude RV variations

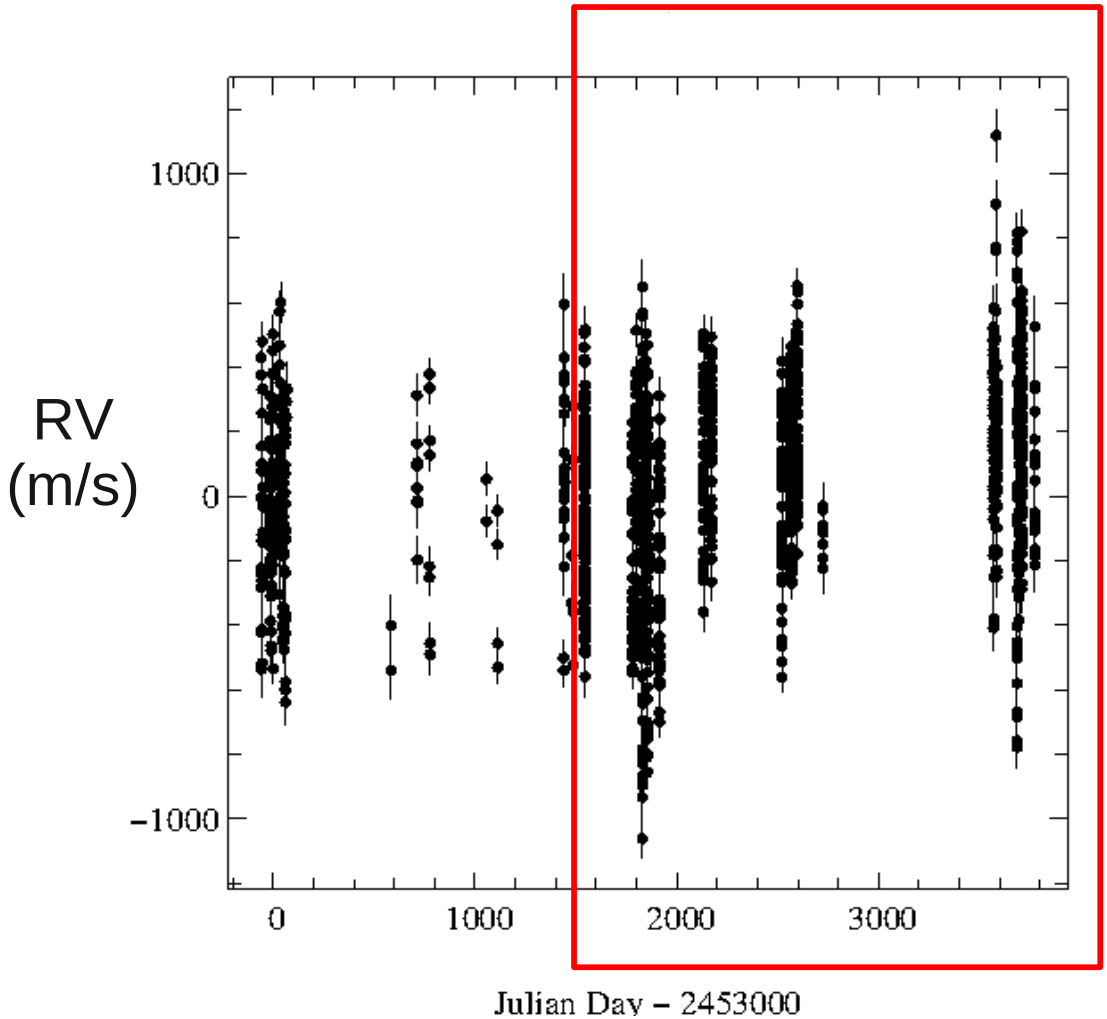
rms 294 m/s

Observing strategy:

1-2 points / night before 2008

1h30-2h / night after 2008

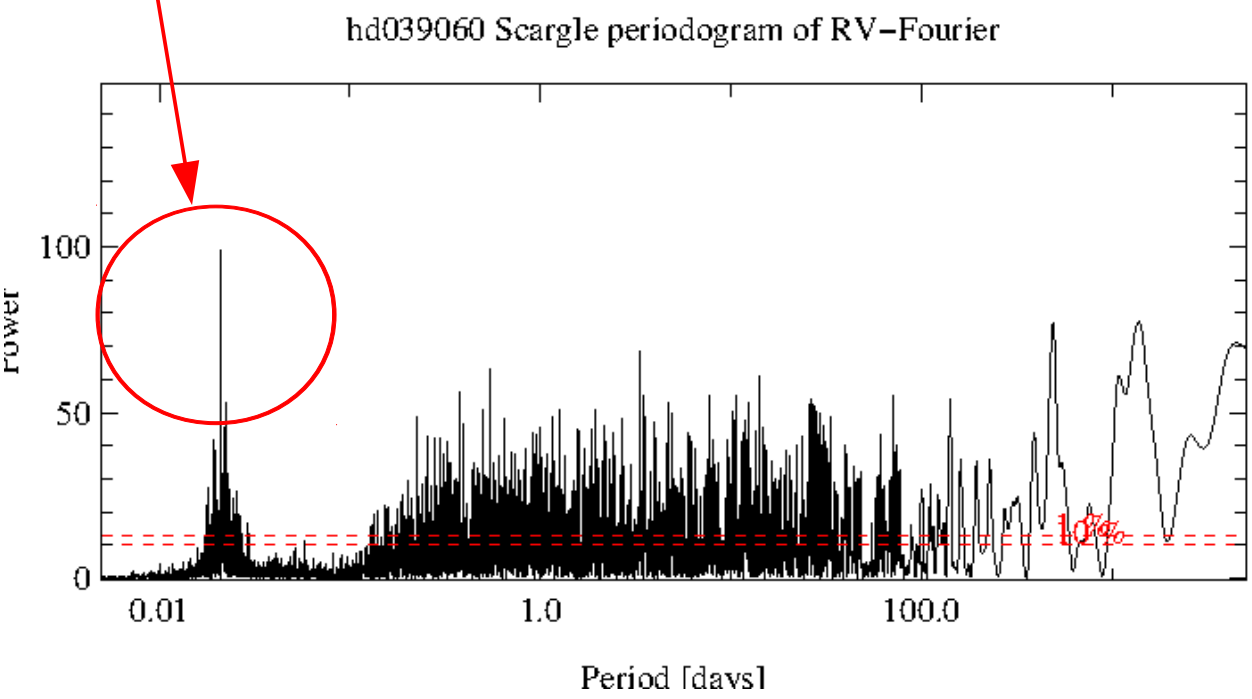
(Lagrange et al. 2012)

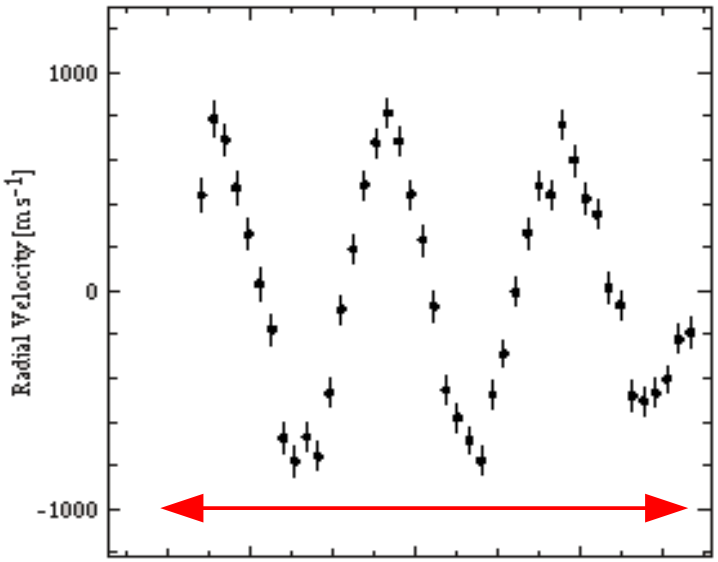


I. β Pic radial velocities

RV variability dominated by high-frequency pulsations

Main period 30.2 min





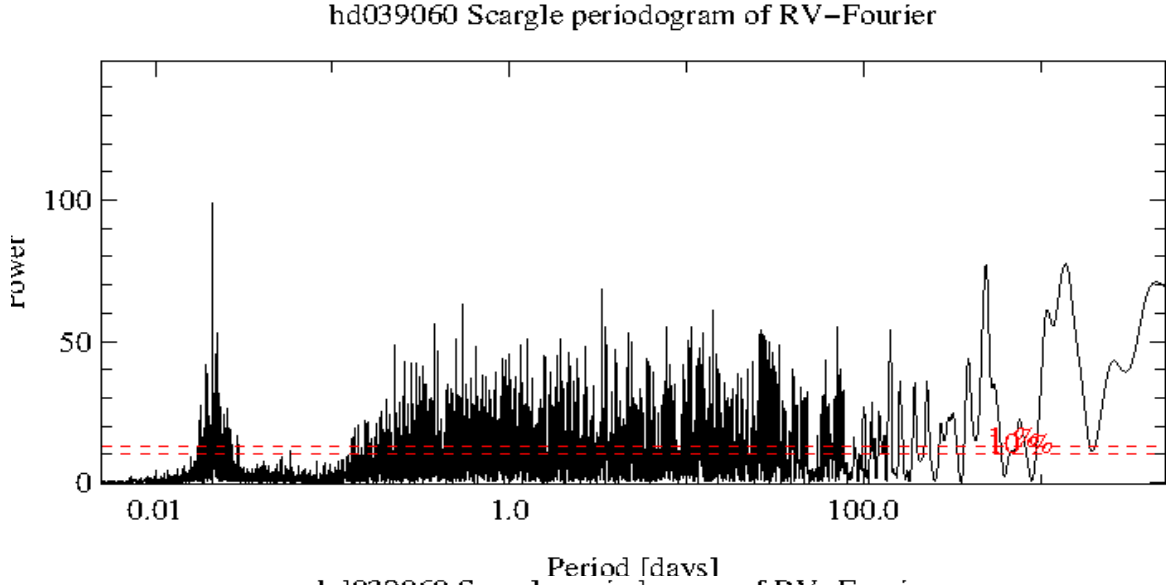
1h30
(50 consecutive exposures)

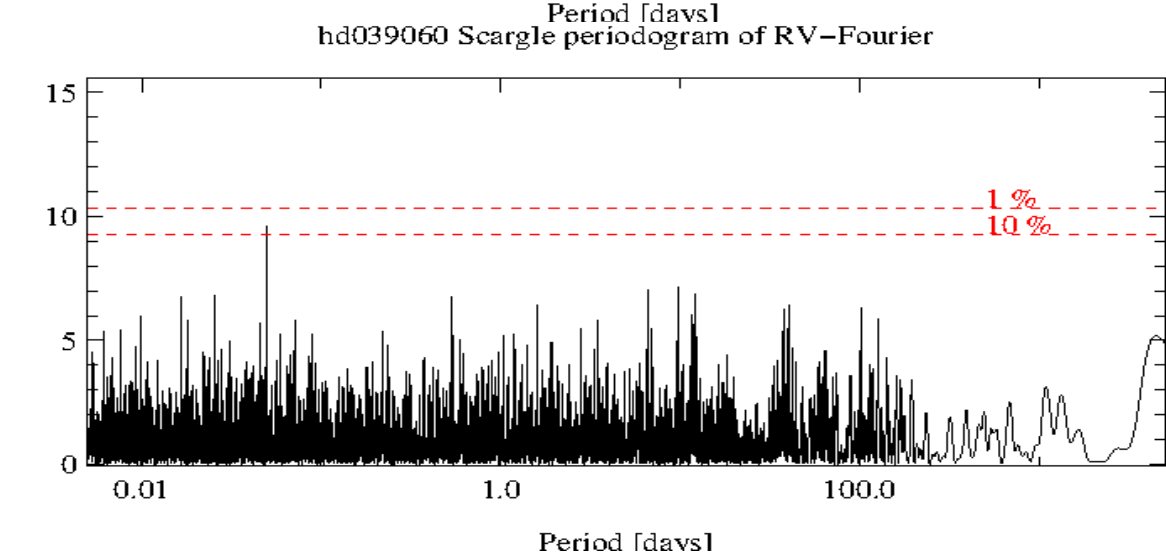
Coherent with photometric pulsation pattern (*Koen et al. 2003*)

I. β Pic radial velocities

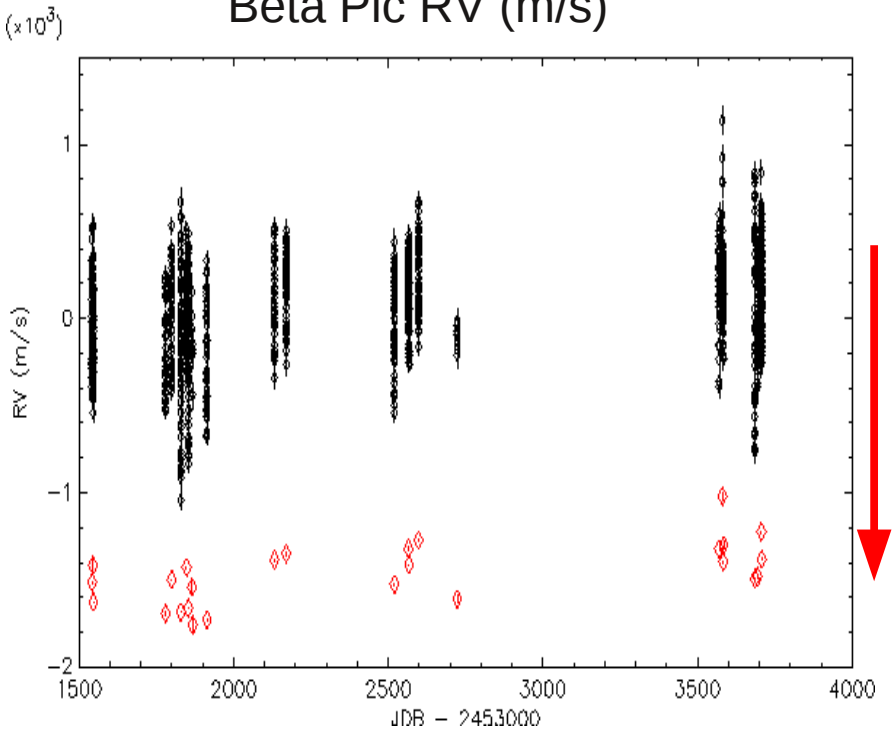
2008-2014 obs. strategy (~1h30 per night): **averaging pulsations**

1-night average





Beta Pic RV (m/s)



1-night average

II. Constraints on β Pic b orbital properties

Context (2003-2011): planet between two quadratures

Approach: estimation of observed RV slope

simulation of RV slopes for ≠ masses, sma

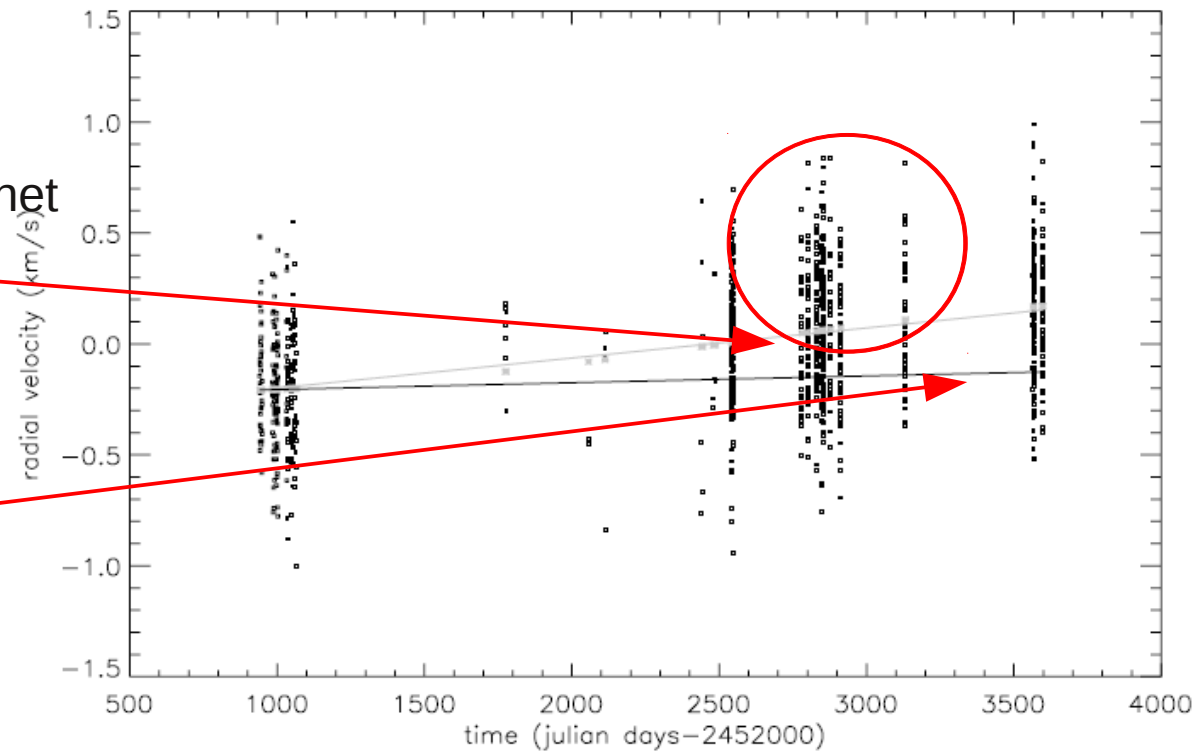
Upper mass limit

(Lagrange et al. 2012)

Separation (AU)	AU	8	10	12
Upper mass limit	Mjup	10	15.5	25

Grey curve + black dots
sim. slope for 30 Mjup planet at 9 AU + noise

Black curve
Measured slope



II. Constraints on β pic b orbital properties

2013-2014: planet not in quadrature anymore

GPI+NaCo astrometric data: constrain on sma (*MCMC model*)

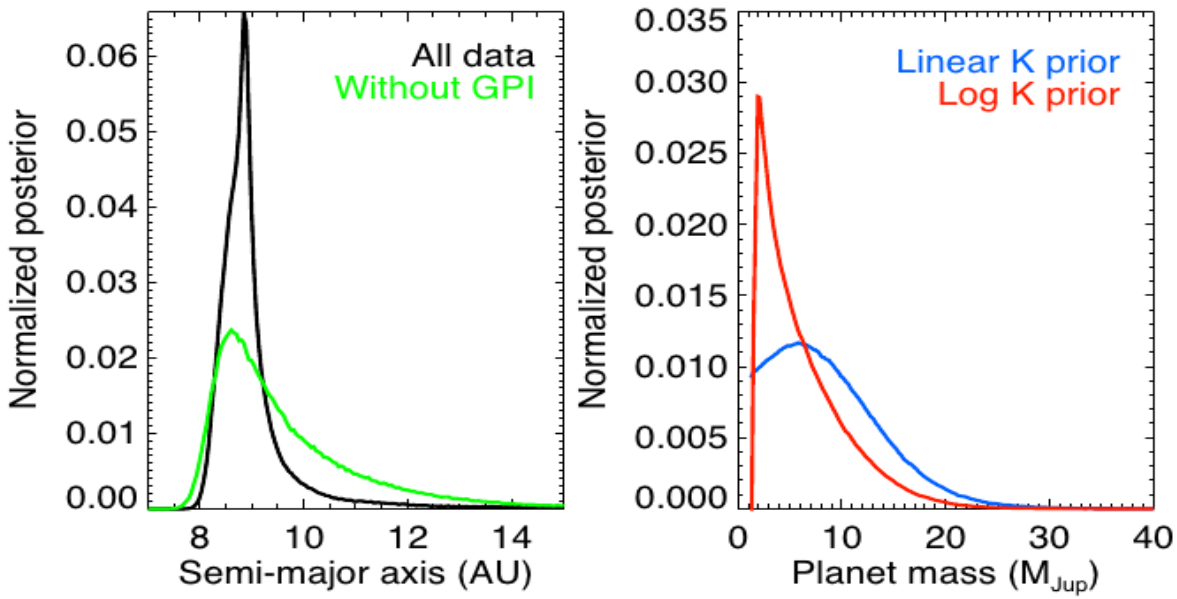
2003-2014 RV data: constrain on dynamical mass (*enhanced model combining astrometric + RV data*)

(Bonnefoy et al. 2014)

Results:

most probable sma
8.9 ± 0.5 AU

most probable mass
range [7-12] Mjup
P=96% for m<20 Mjup

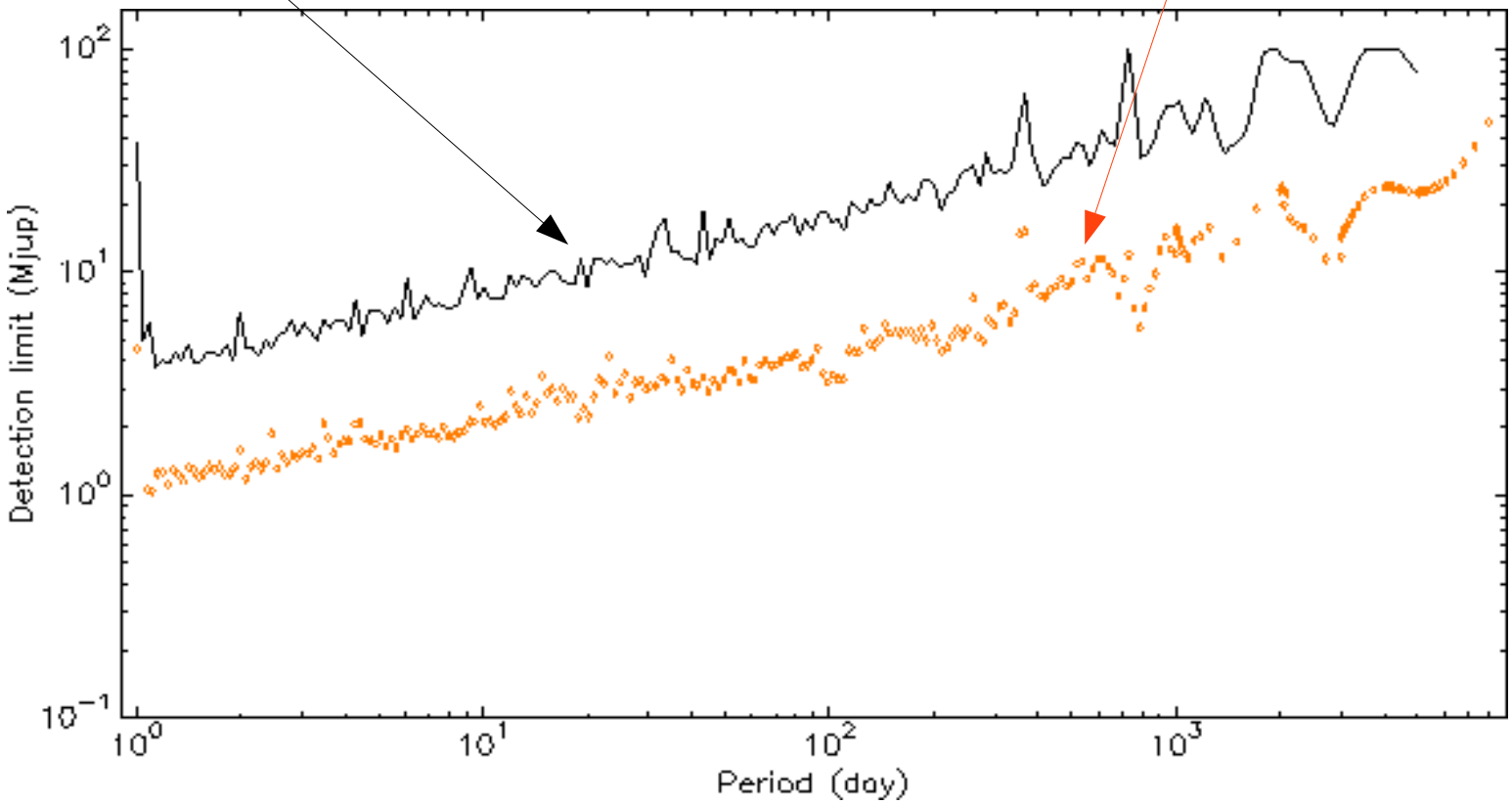


III. Exploration of GP population around β Pic

RV detection limits

Bootstrap method

Local Power Amplitude (LPA) method (*Meunier et al. 2012*) – 99% detection limits



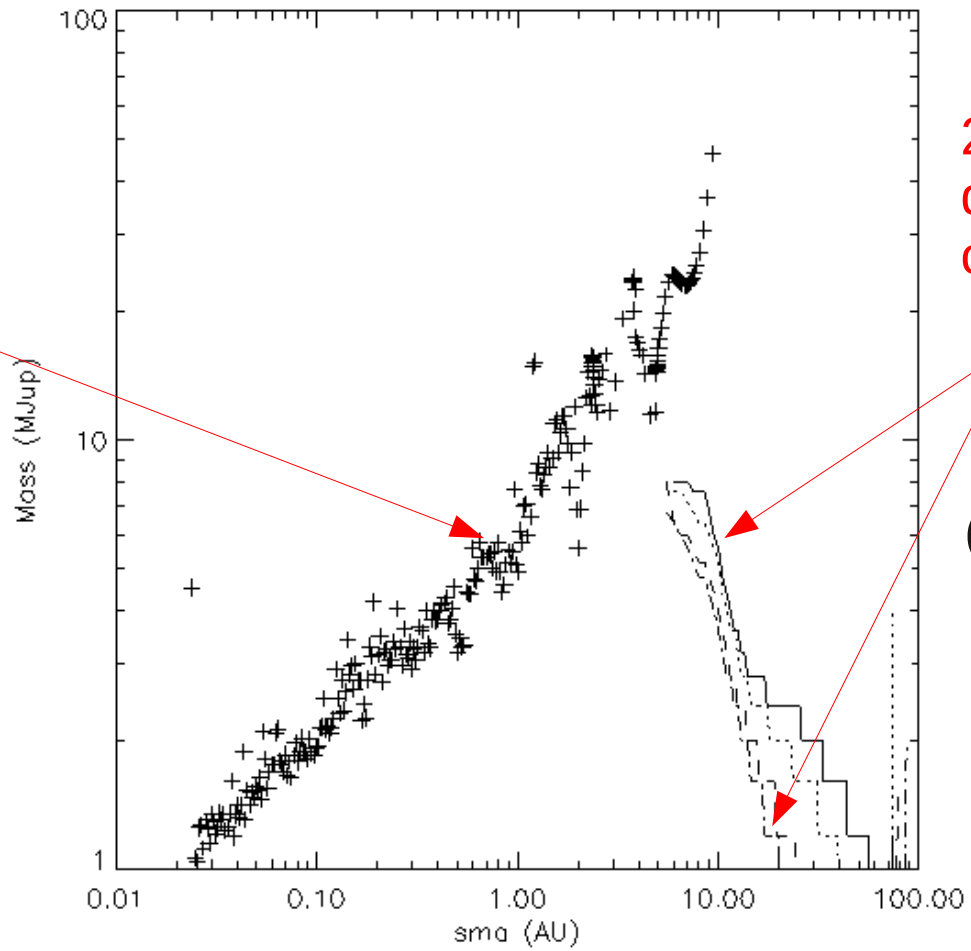
Results: no Hot massive Jupiters (m<2-3 Mjup at P<100 days)
m<10 Mjup at P<1000 days

III. Exploration of GP population around β Pic

Combination of RV and DI detection limits: "bridging the gap"

(Lagrange et al., in prep.)

2003-2014 RV data
LPA detection limits
99% prob.



2003-2013 DI data
detection limits
computed with **MESS2**
95% to 50% prob.

(*see poster by J.Lannier*)

Assumptions: no eccentricity, system seen ~ edge-on

Further work

RV data: increasing the time baseline

(*ongoing Harps LP / Young Nearby Stars*)

Coupling with Sphere

Further constraints on GP population