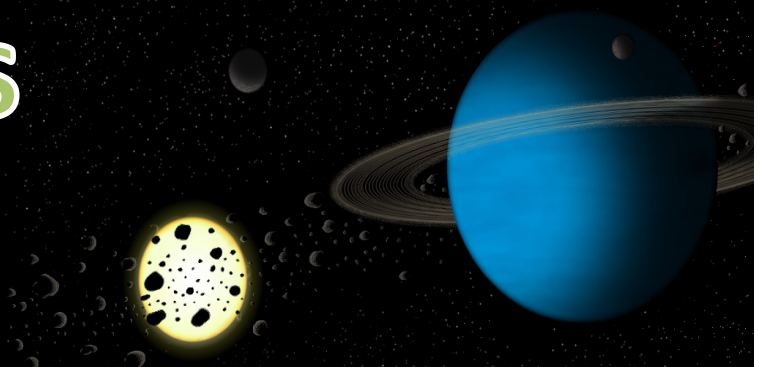
Discovering planets at Universidad de Chile



James S. Jenkins[1,2], Hugh R.A. Jones[2], Patricio Rojo[1], Mikko Tuomi[2], Matias Jones[1,3], Felipe Murgas[4], John R. Barnes[2], Yakiv Pavlenko[5], Oleksiy Ivanyuk[5], Andres Jordan[6], Avril C. Day-Jones[1,2], Maria-Teresa Ruiz[1] and David J. Pinfield[2]

1) Universidad de Chile, Chile. 2) University of Hertfordshire, UK. 3) ESO, Chile. 4) Instituto de Astrophysica de Canarias, Tenerife. 5) National Academy of Sciences, Ukraine. 6) Pontifica Universidad Catolica de Chile, Chile.

OBSERVATORIO ASTRONÓMICO NACIONAL
Organismo dependiente de la Universidad de Chile desde 1927

Cerro Calán
Observatorio Astronómico Nacional

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Fondo Nacional de Desarrollo Científico y Tecnológico
CONICYT
CHILE

Talk Format

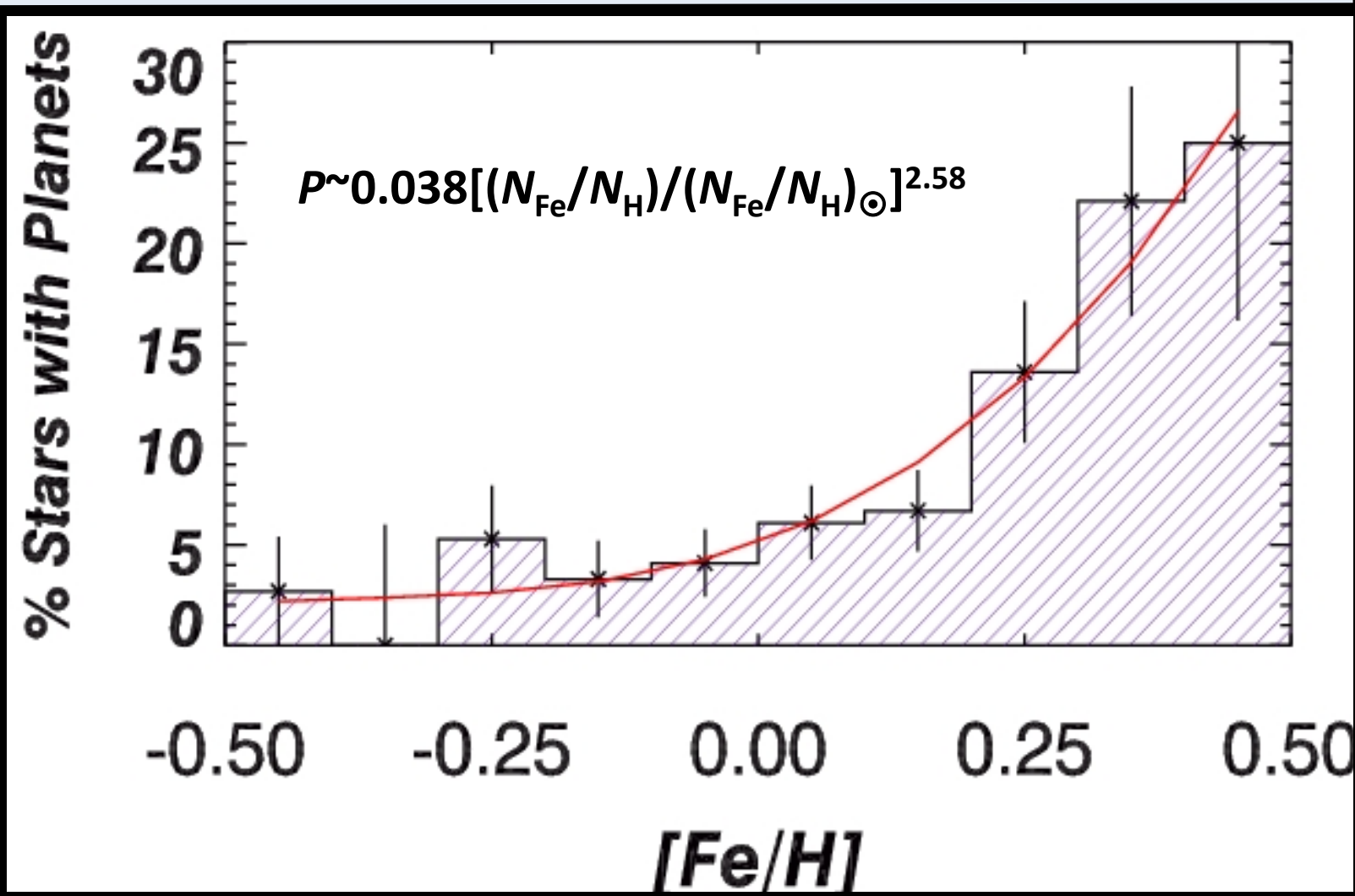
The Calan-Hertfordshire Extrasolar Planet Search

- Project Aims
- Target List Selection (Activity & Metallicity)
- Planet Detections
- Signal Analysis and Metal-Richness

Giant Star Planet Search

- Project Goals
- Target Selection
- Signal Detections, Planets, Brown Dwarfs, and Binaries
- Are the lack of short period planets due to destruction?

Introduction I

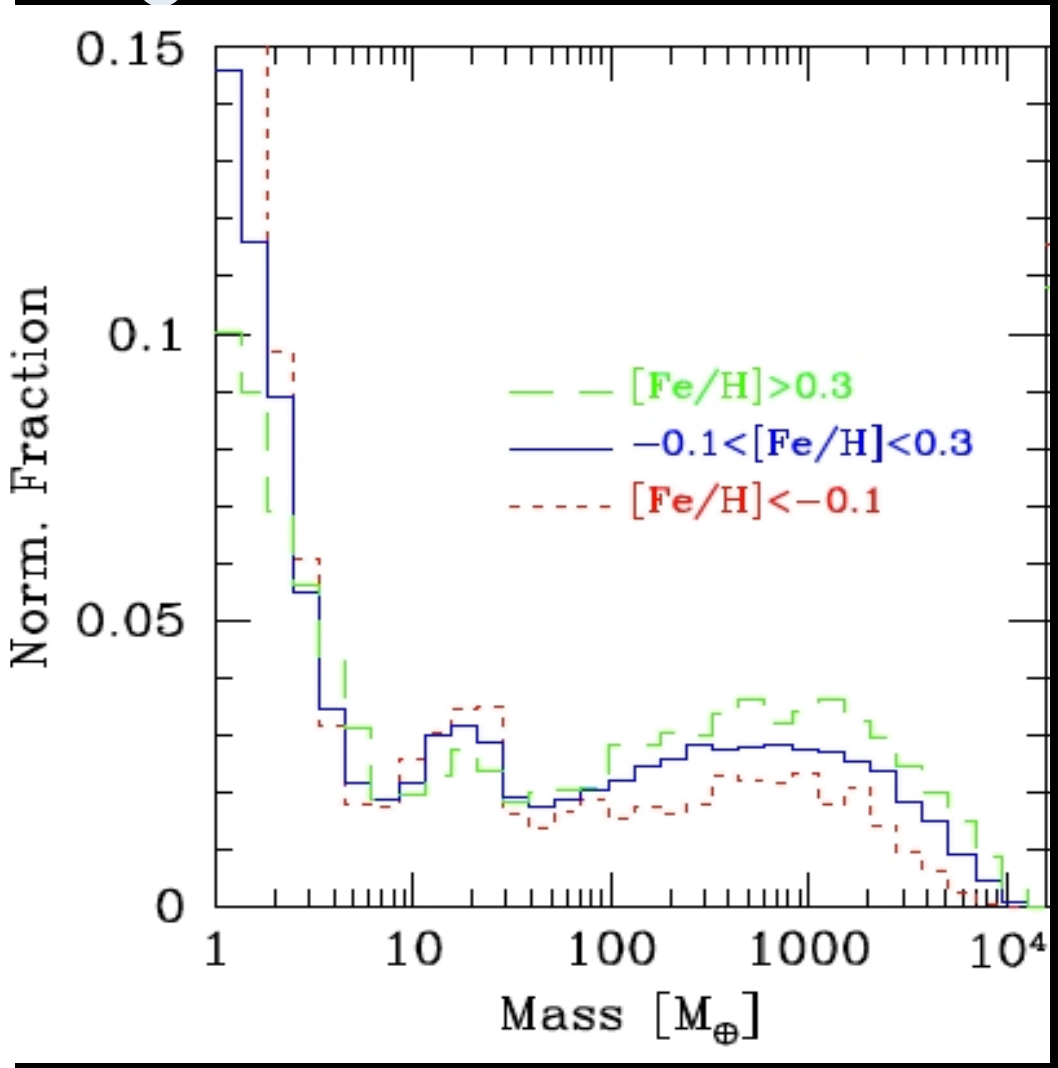


Gonzalez 1997, MNRAS, 205, 403

Fischer & Valenti 2005, ApJ, 622, 1102

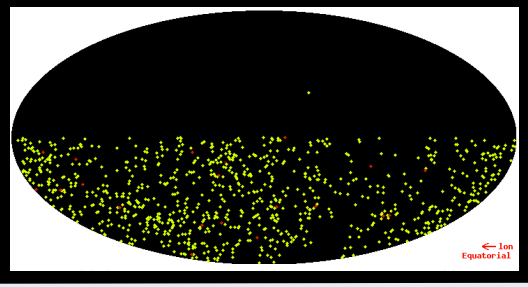
Sousa et al. 2011, A&A, 533, 141

Introduction II



- Metal-poor stars have a more peaky low-mass distribution
- Peak between 10-30M_{Earths} has a metallicity dependence
- Ratio of peaks changes with metallicity i.e. high metallicity means lower mass ratio between the low and high mass planets

Mordasini et al. 2012, A&A, 541, 97
Ida & Lin 2004, ApJ, 616, 567



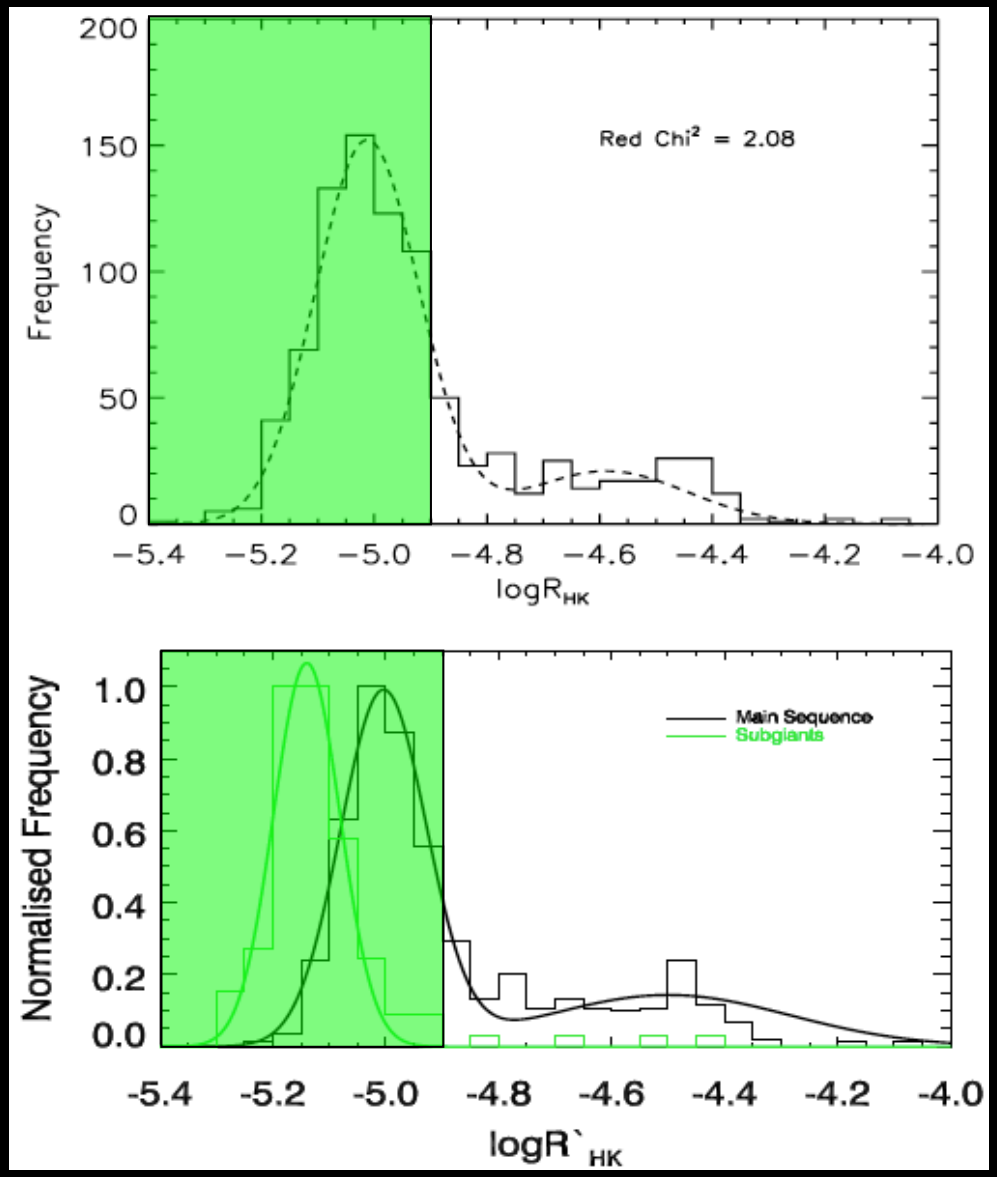
CHEPS

- Hipparcos selected stars
- Visual magnitude range between 7.5 – 9.5
- Colour range (B – V) of between 0.5 – 0.9
- Hipparcos spectral types of V-IV i.e. no Hipparcos giants
- All southern objects i.e. dec ≤ 0°
- Most have parallaxes ≥ 10”
- No double or multiple systems as of Hipparcos astrometry
- No significantly variable objects as of Hipparcos photometry
- Not on any other southern survey, like the AAPS and HARPS-GTO

Better characterise the Doppler signals of metal-rich stars

Detect the next bright transiting planet in the southern hemisphere

Chromospheric Activity

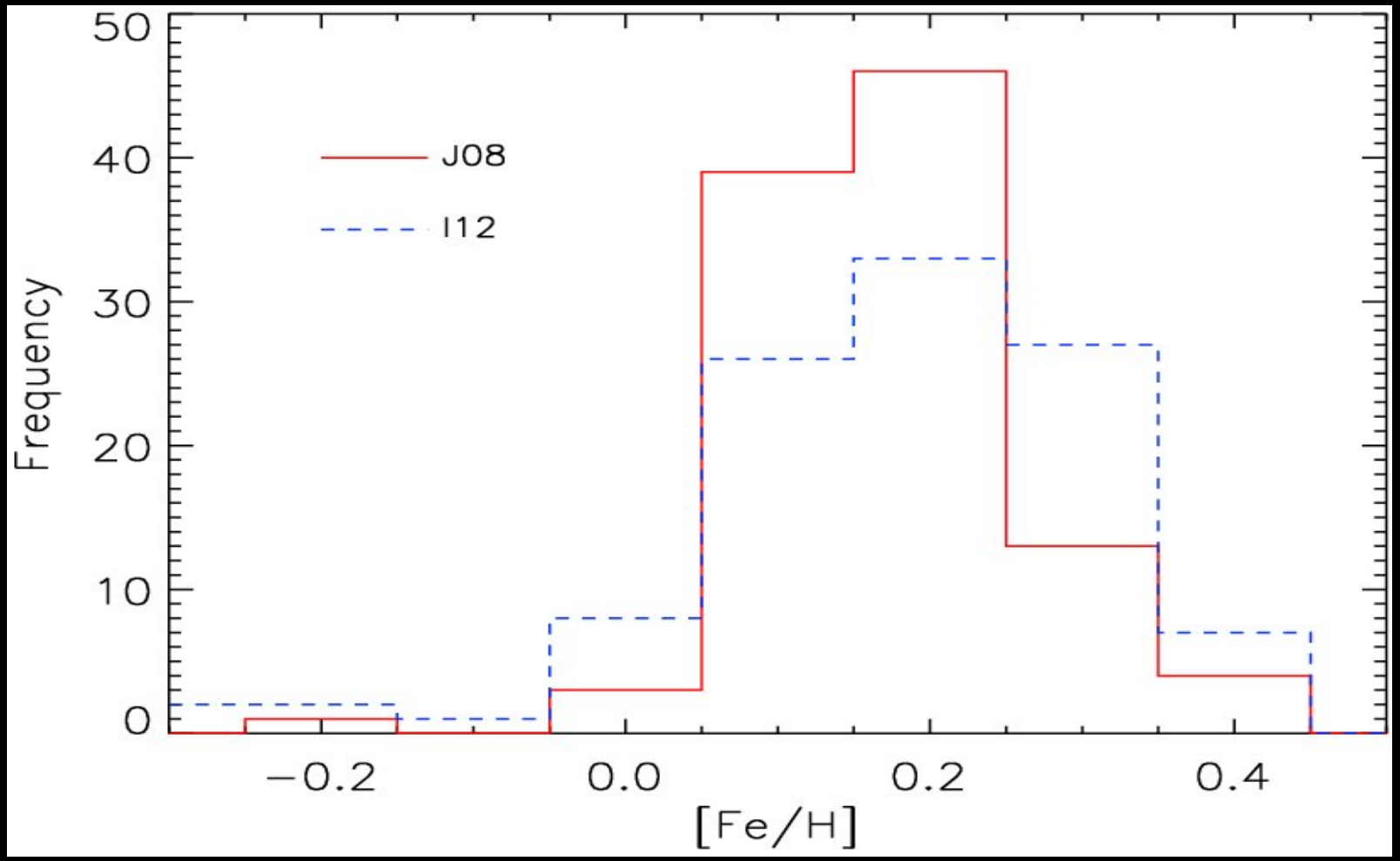


- Bimodal distribution seen
- Subgiants significantly lower $\log R'_{HK}$
- Primary selection is ≤ -4.9
- Some stars up to -4.5

Jenkins et al. 2011, A&A, 531, 8

Sample Metallicity

Pavlenko et al. (2011, MNRAS, 422, 542)

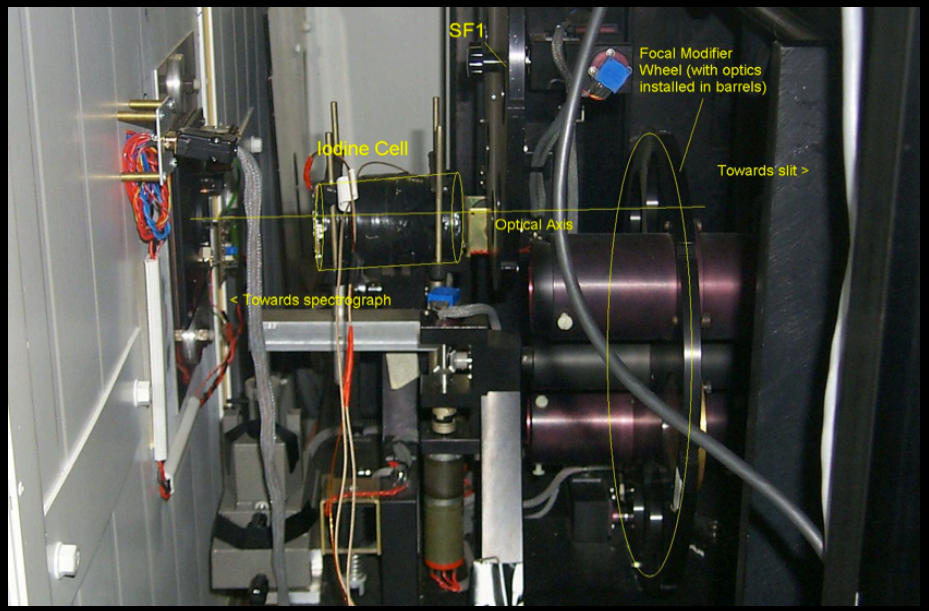


J08 = Jenkins et al. (2008, A&A, 485, 571)

I12 = Ivanyuk et al. (2012, in preparation)

See the talks by Yakiv Pavlenko and Oleksiy Ivanyuk on Thursday at 10am!!

Radial Velocities: ThAr and I2



HARPS, Coralie & FEROS

< 1m/s ThAr stability in a night

Cross-Correlation Method using binary masks

>1500 RV points from HARPS for the CHEPS sample

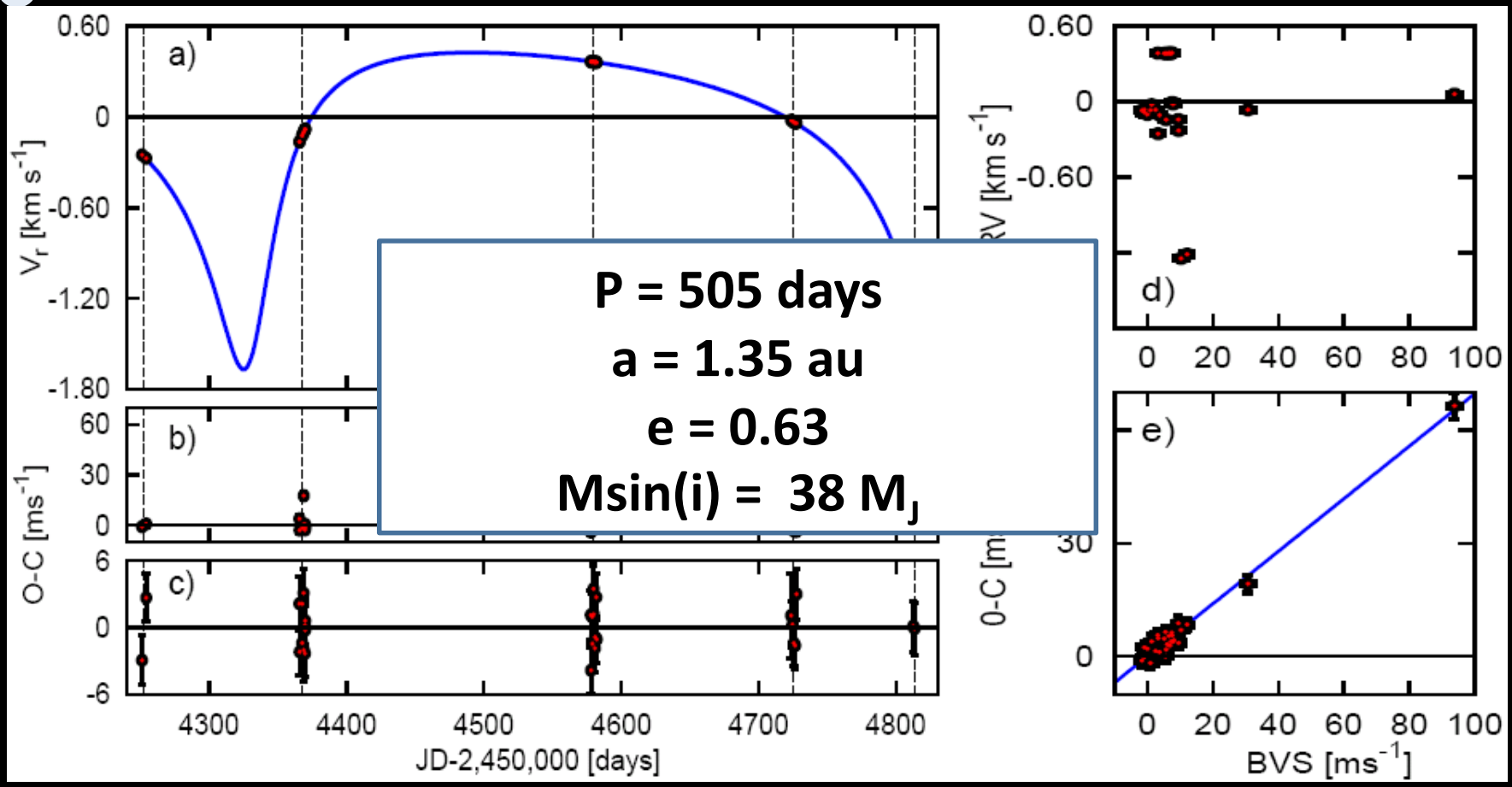
FECH & CHIRON

Forward model the stellar PSF

Use high resolution and high S/N observation of both I2 cell and star

>1200 RV points from both FECH and CHIRON spectrographs

Early Detections I



a) - Best fit Keplerian to the RVs *after* bisector velocity correction (BVS)

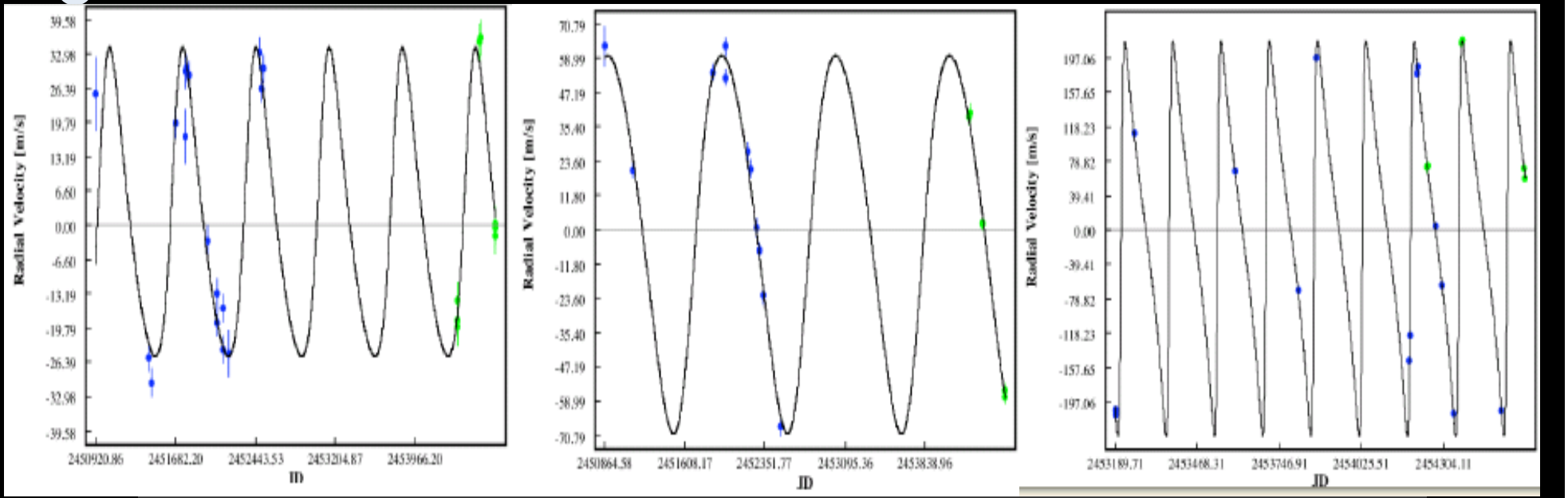
b) - Residuals to the best fit *before* BVS correction

c) - Residuals to the fit *after* BVS correction

d) - Residuals to the fit against BVS *before* correction

e) - Correlation between BVS and the measured RVs: $\alpha = 0.697 \pm 0.064$

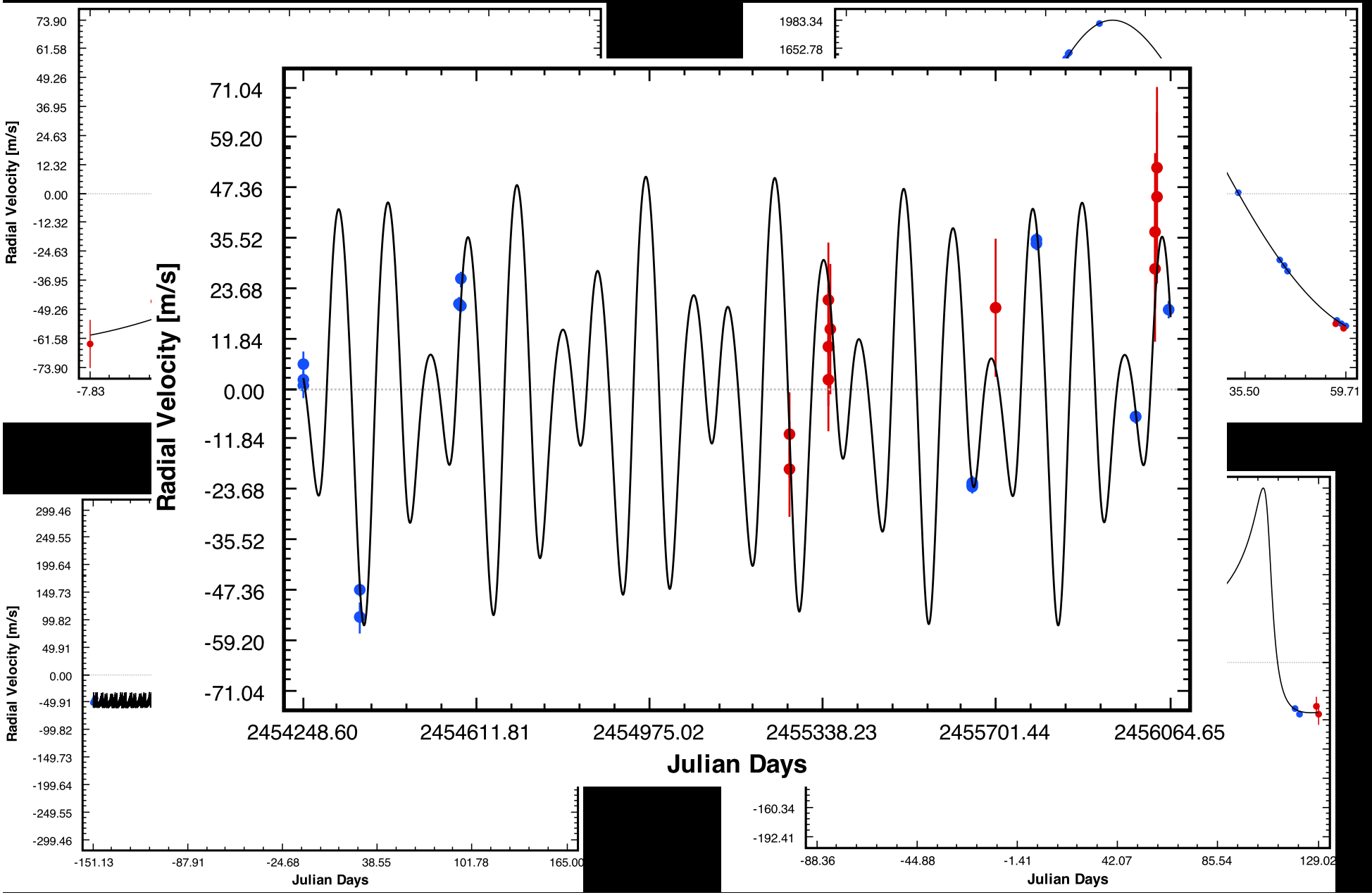
Early Detections II



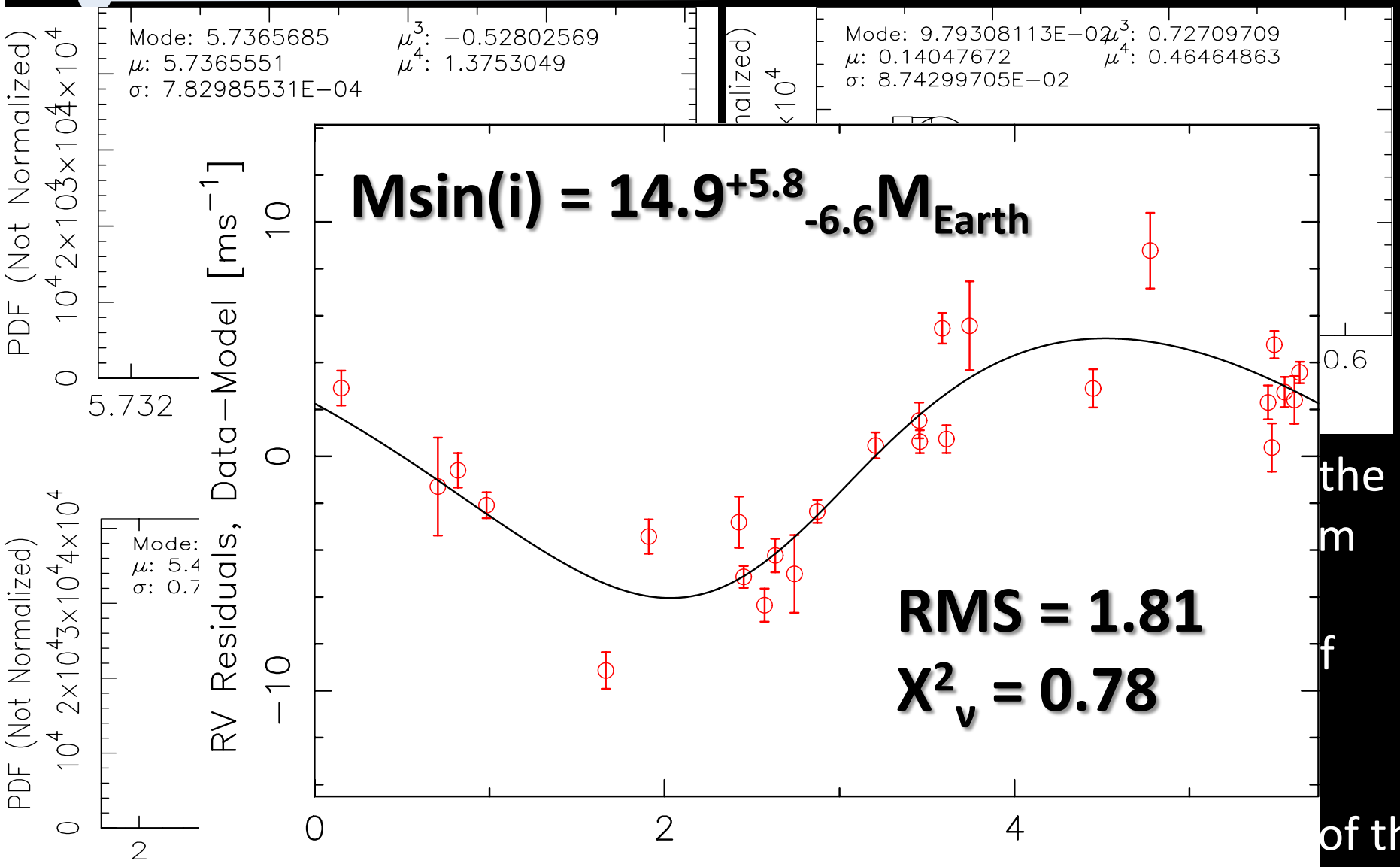
Parameter	HD191760*b*	HD48265*b*	HD143361*b*	HD154672*b*
Orbital period P (days)	505.65±0.42	700±8	1057±20	163.9±0.1
Velocity amplitude K (m/s)	1047.83±38.71	28.3±9.0	65.1±26.3	226.52±9.22
Eccentricity e	0.63±0.01	0.18±0.13	0.15±0.17	0.61±0.02
ω (°)	200.37±0.28	309±27	237±55	266±2
T_0 (JD-2,450,000)	4835.65±2.06	4486±50	3746±147	4520±1
M sin i (M_J)	38.17±1.02	1.16±0.38	3.12±1.44	5.02±0.17
Semimajor axis a (AU)	1.35	1.51	2.00	0.60
rms (m/s)	2.00	6.756	3.37	3.37
χ^2_ν	1.04	3.33	2.42	2.14
N_{Obs}	29	25*	18	22

Jenkins et al. 2009, MNRAS, 398, 911

Planet Candidates



HD77338 Planet I



Jenkins et al. 2012, ApJ, accepted

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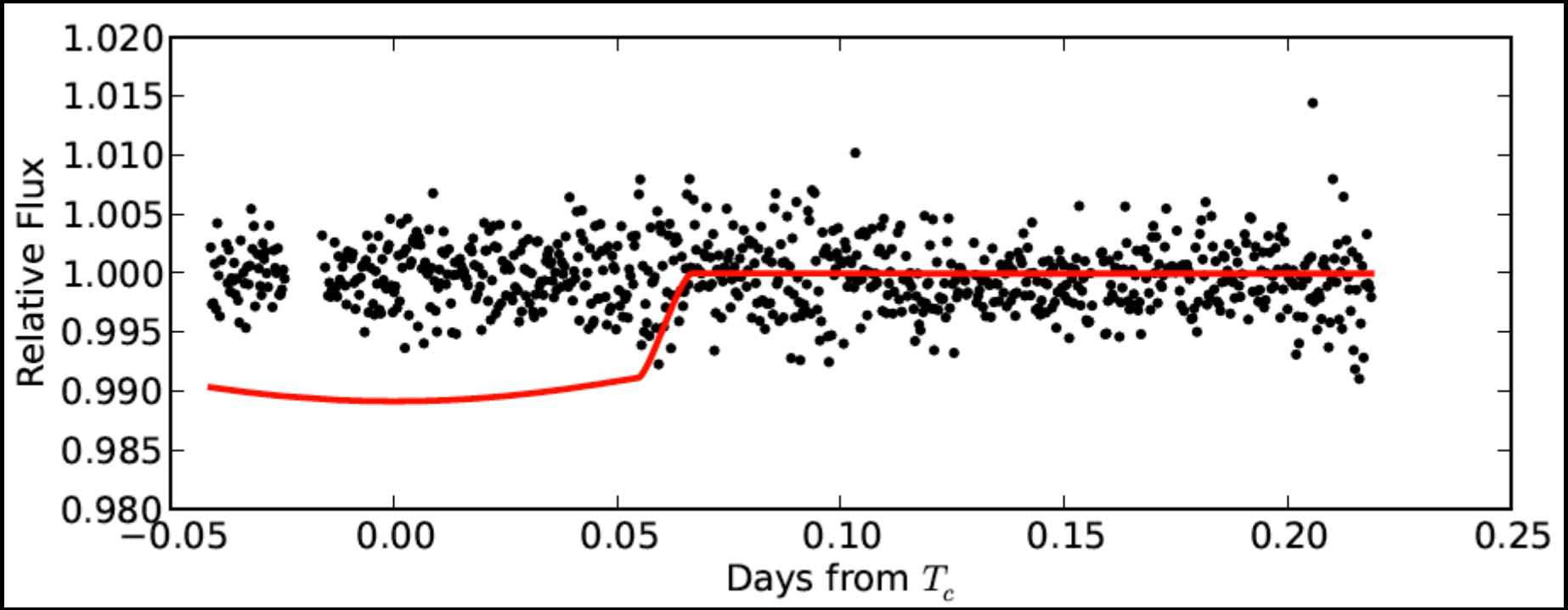
HD77338 Planet II

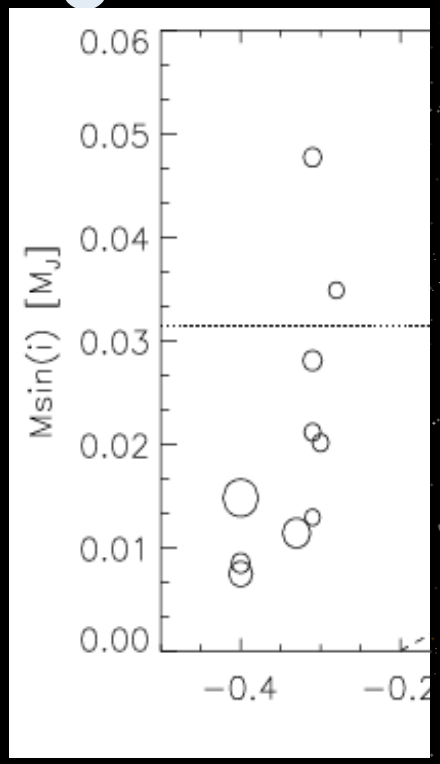


No transit detected with our preliminary results above rms of 0.002

Photometric search is still ongoing

Jenkins et al. 2012, ApJ, accepted, arxiv:1207.1012

Mass



JTP

- Kepler shallow
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- Interpretation
- Appears a defi

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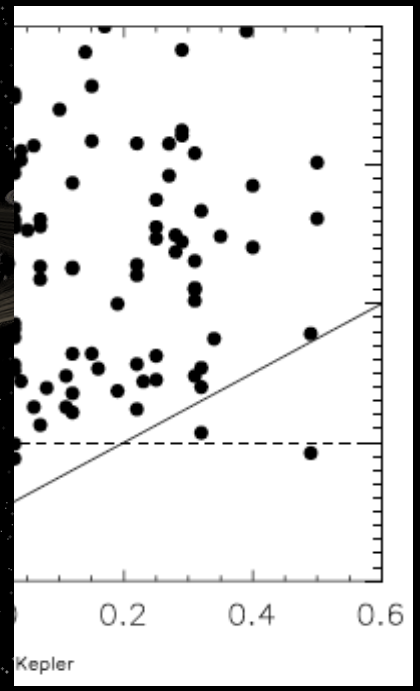
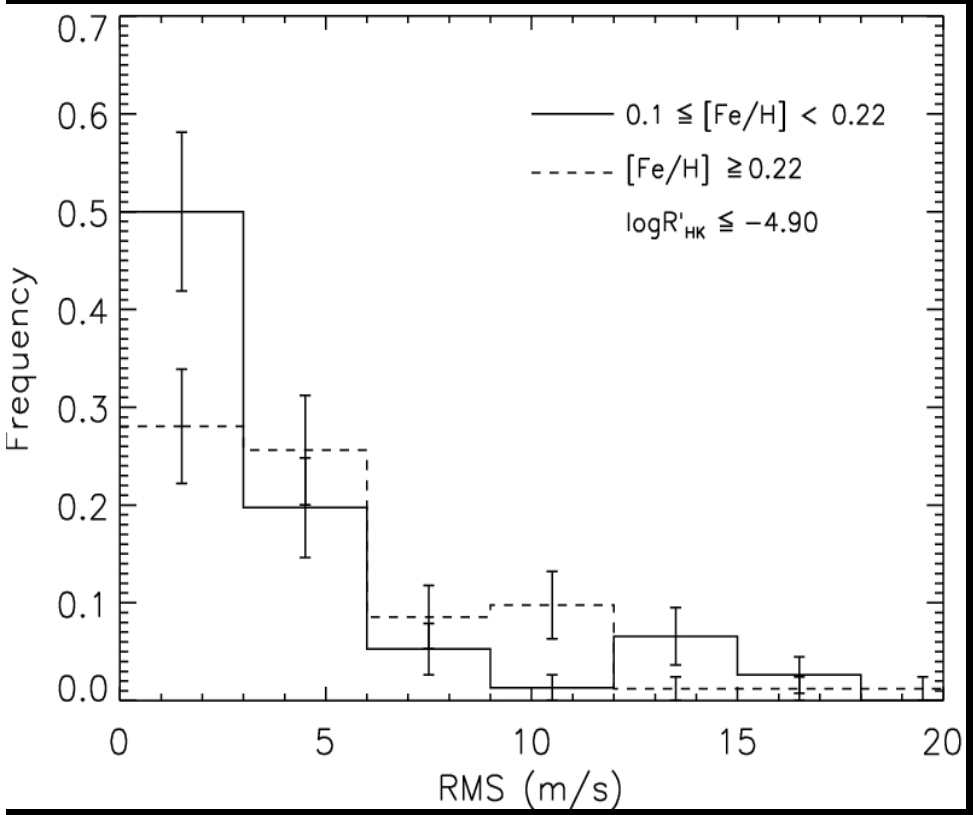
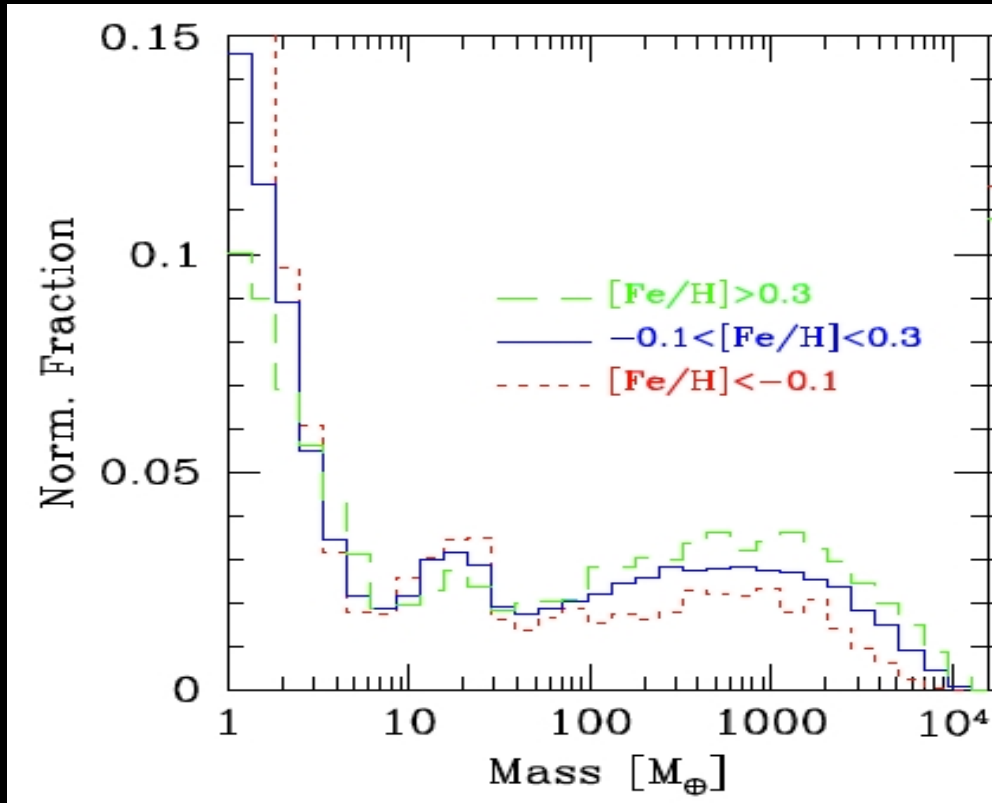


Jenkins et al. 2012, ApJ, accepted, arxiv:1207.1012

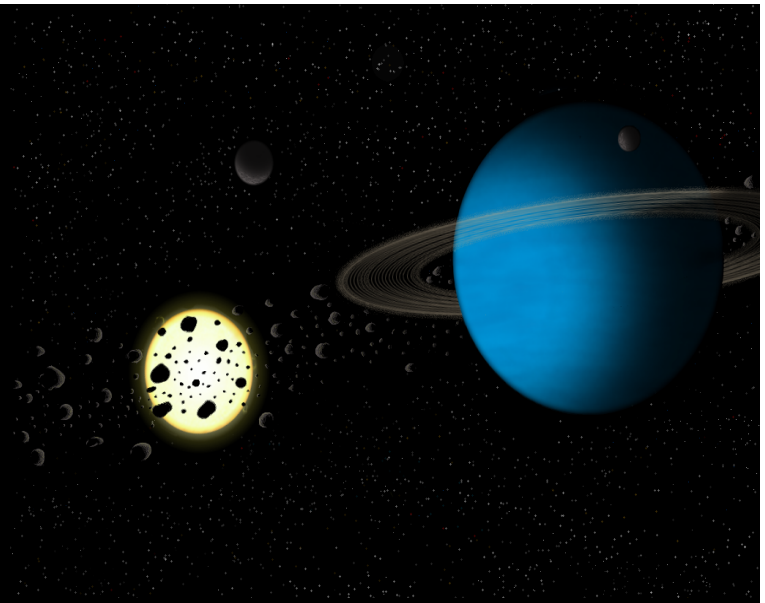
Metallicity Signal Distribution





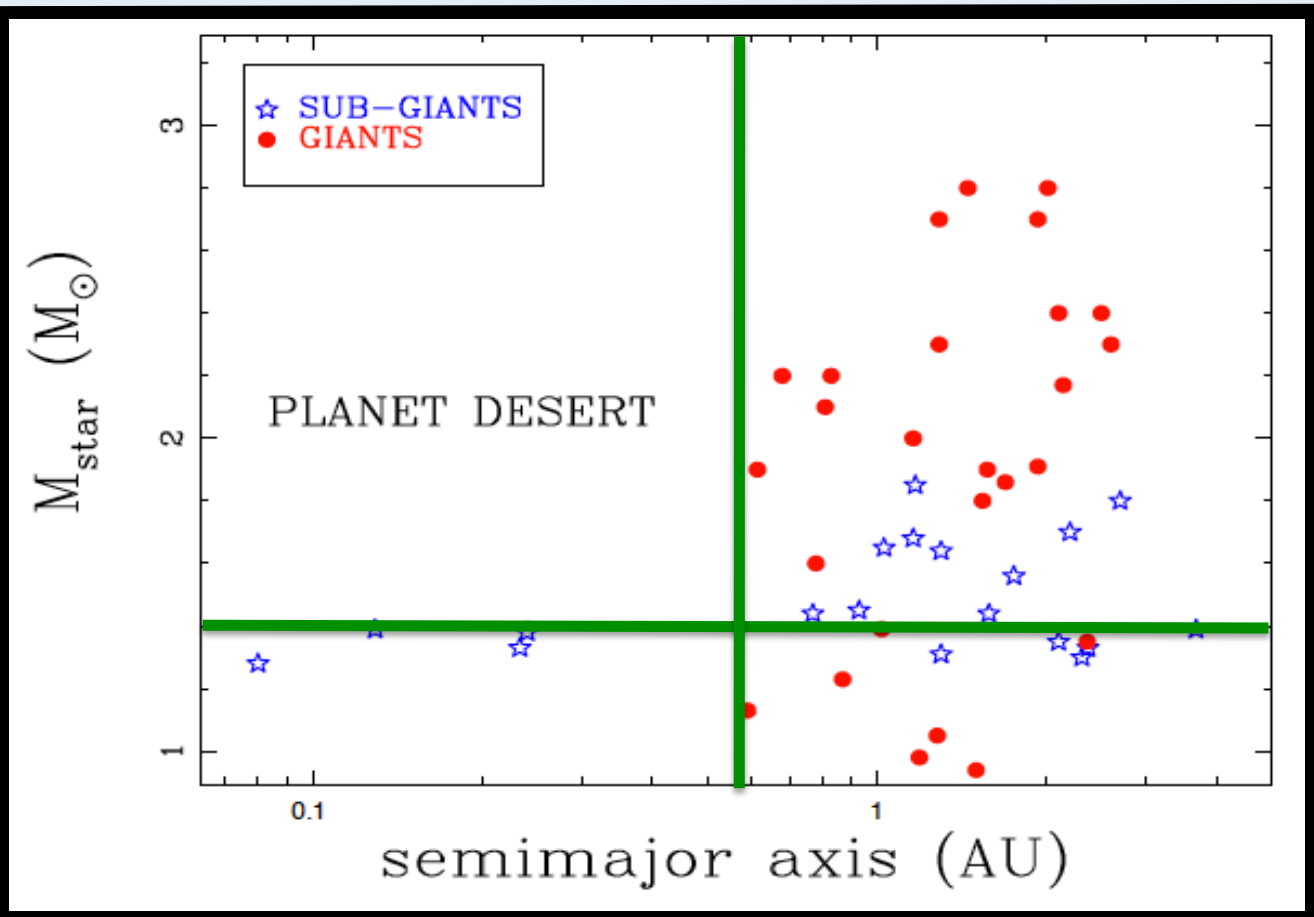
THE HIGHEST METALLICITY BIN IN THE MODELS AGREES WITH THE FRACTION WE FIND DIRECTLY FROM THE SUPER METAL-RICH STELLAR DATA!!
30-50% of the sample shows variations above the modeled noise level

Jenkins et al. 2013, MNRAS, in prep



Giant Stars

Why Giant Stars?



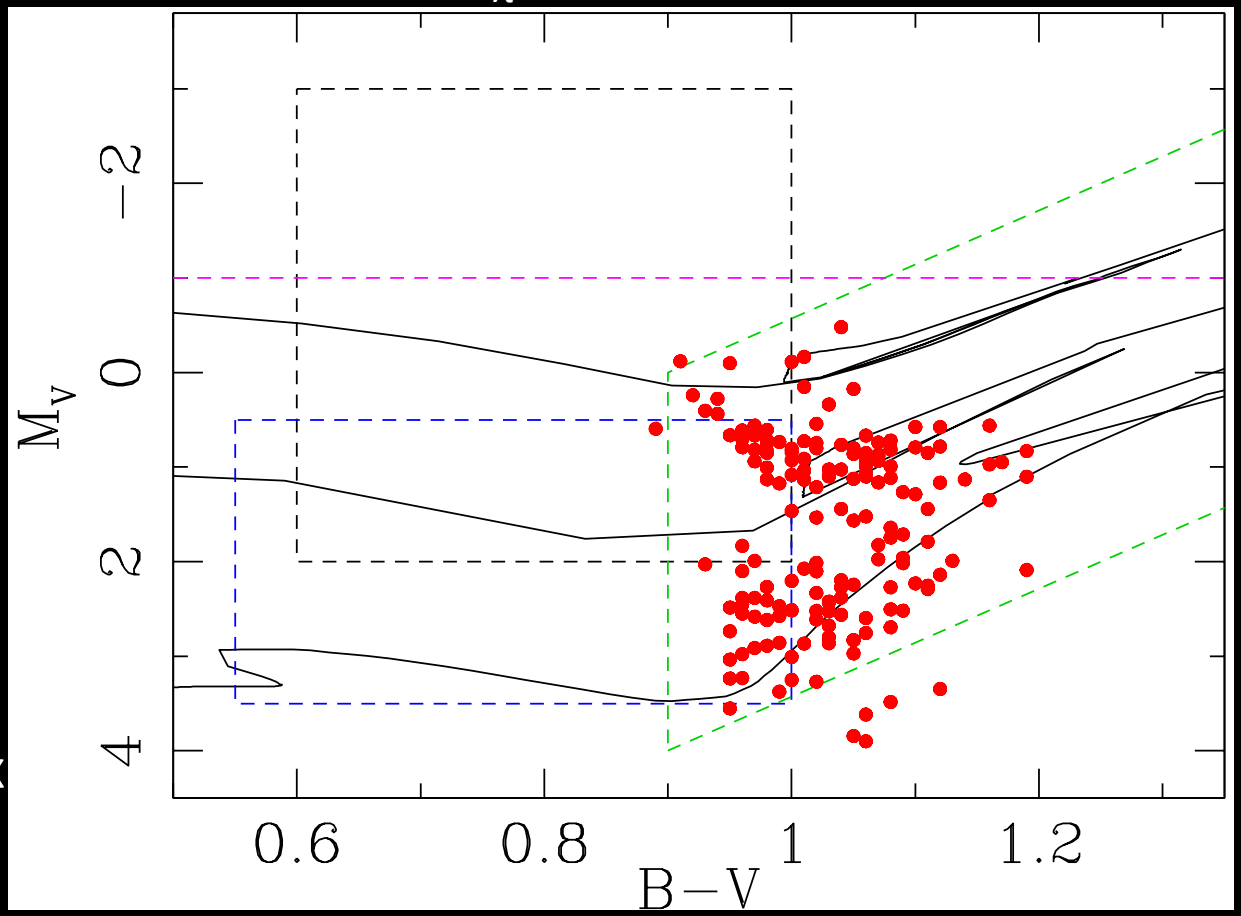
Planet desert at semimajor axes less than 0.6AU

Tidal destruction as the star evolves up the RGB (e.g. Siess & Livio 1999, MNRAS, 308, 1133)?

Different distribution of planets around giant stars, lower planet formation efficiency (Burkert & Ida 2007, ApJ, 660, 845)?

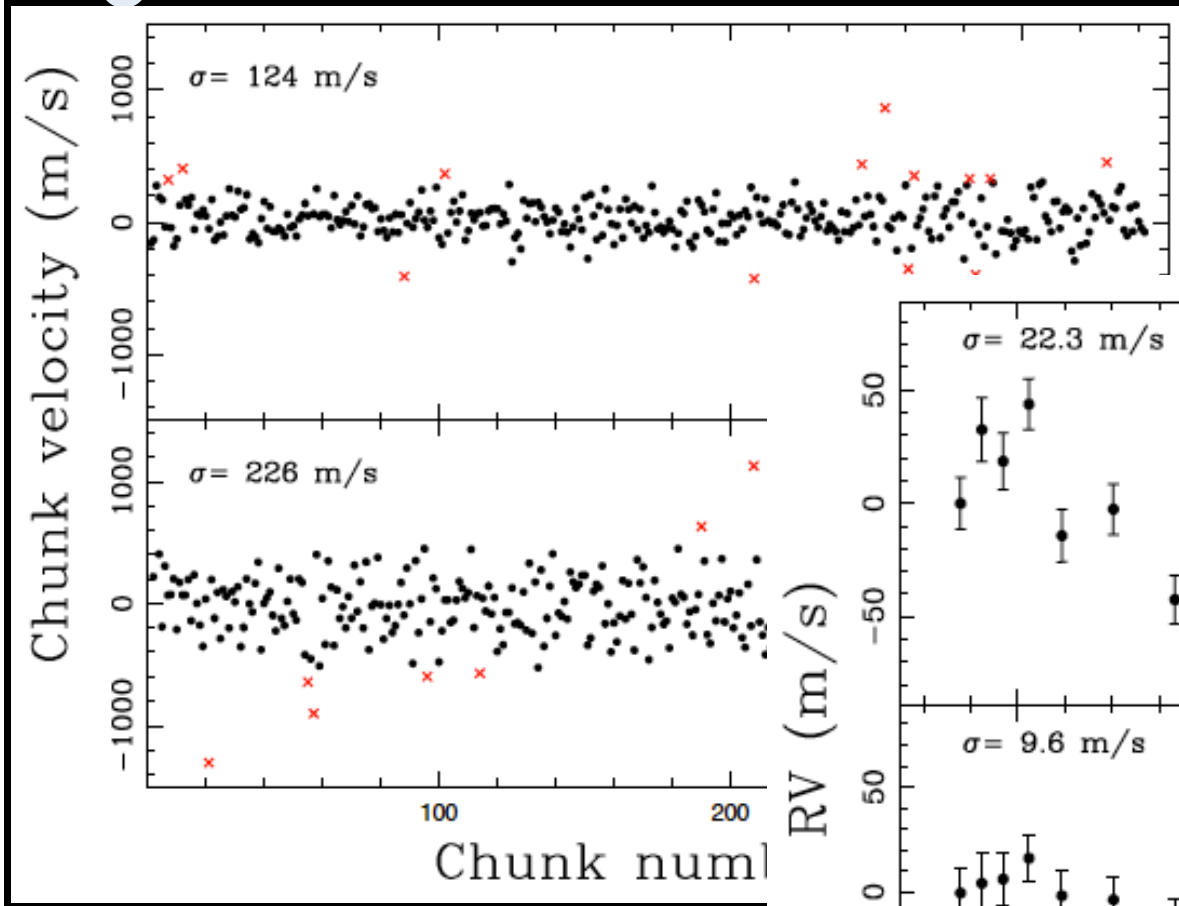
Giant Stars Sample

- Hp variability ≤ 0.015 mags
- B-V 0.8 - 1.2, M_V -0.5 – 0.4, V ≤ 8 mags, and $\sigma_\pi \leq 15\%$
- 44 HB stars and 122 RGB stars
- Not currently on other planet search program
- Masses 1.0 - 3.5 $M_\odot$
- [Fe/H] -0.5 - +0.5 dex, 50% between 0.0-0.2 dex
- No CaII HK core emission

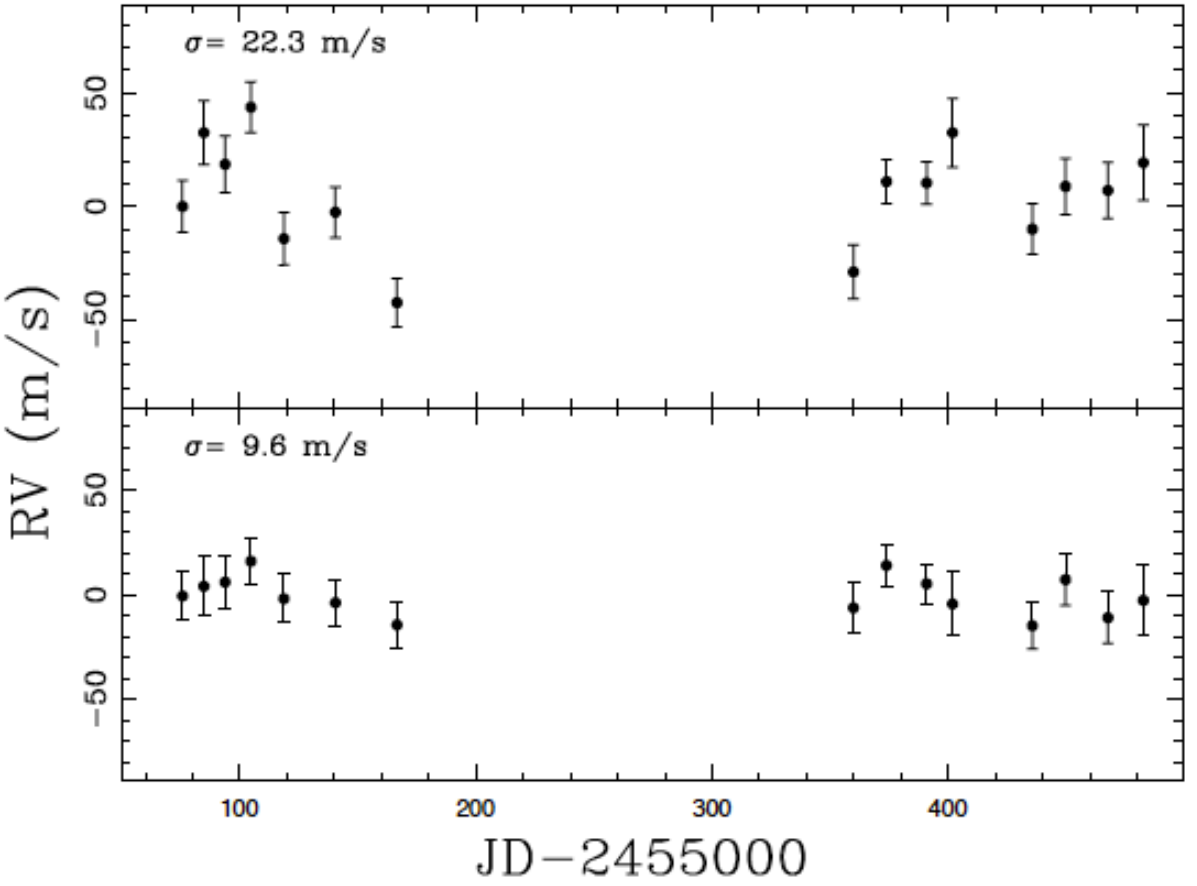


Jones et al. 2011, A&A, 536, 71

Iodine Cell: FECH & CHIRON



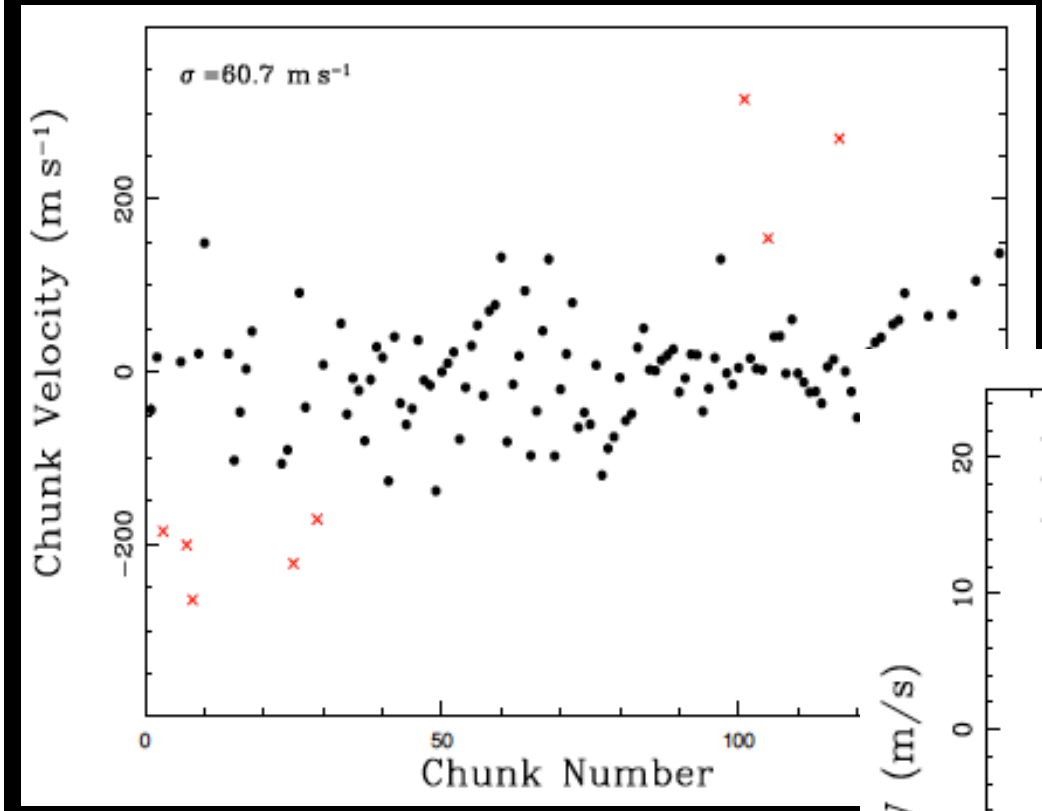
5Å regions used for PSF model
Chunks > 2.5σ rejected



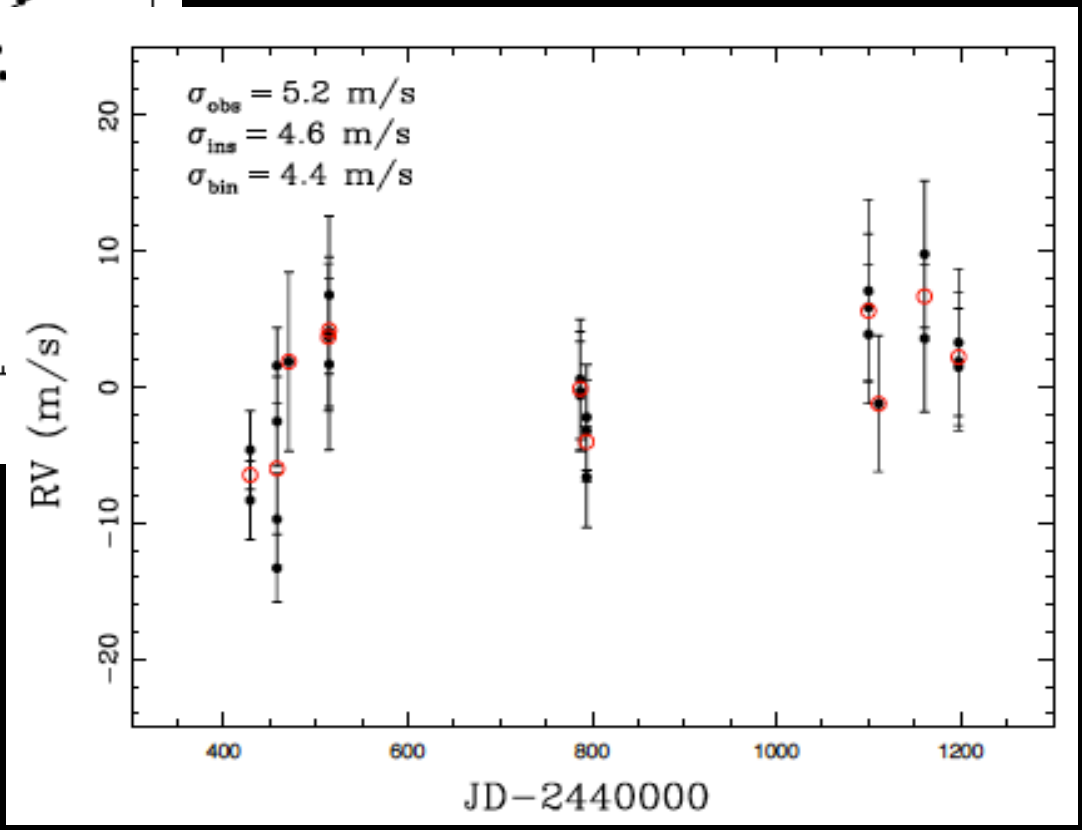
2.3x RV IMPROVEMENT!!

Jones, Jenkins, Rojo, Melo 2012b, A&A, in prep

ThAr: FEROS



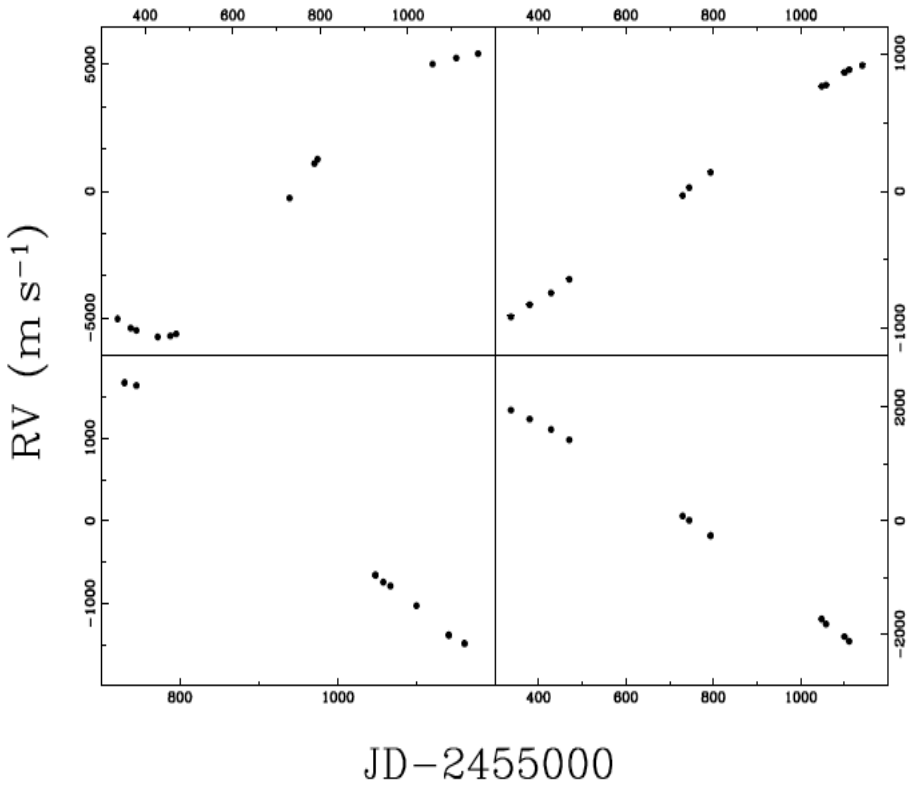
50Å regions used for RV computation
Again chunks > 2.5σ rejected

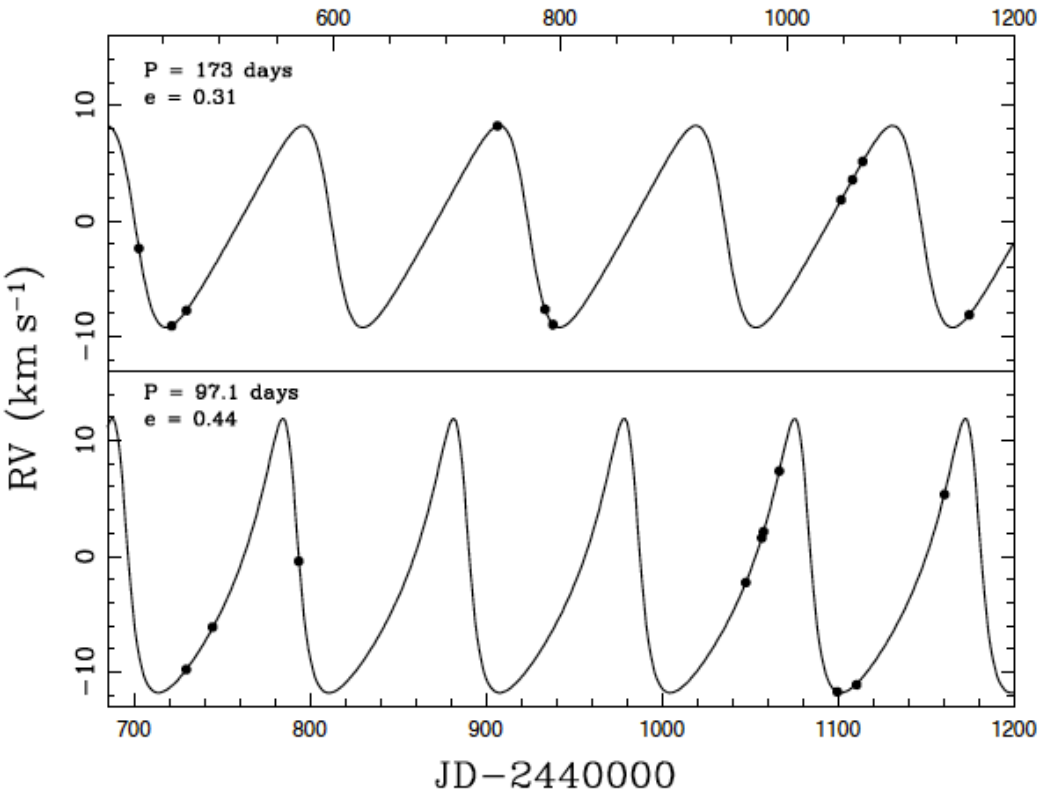


τ Ceti FEROS precision 5.2m/s
Binned RVs of 4.4m/s

Jones, Jenkins, Rojo, Melo 2012b, A&A, in prep

Stellar Binaries and BDs



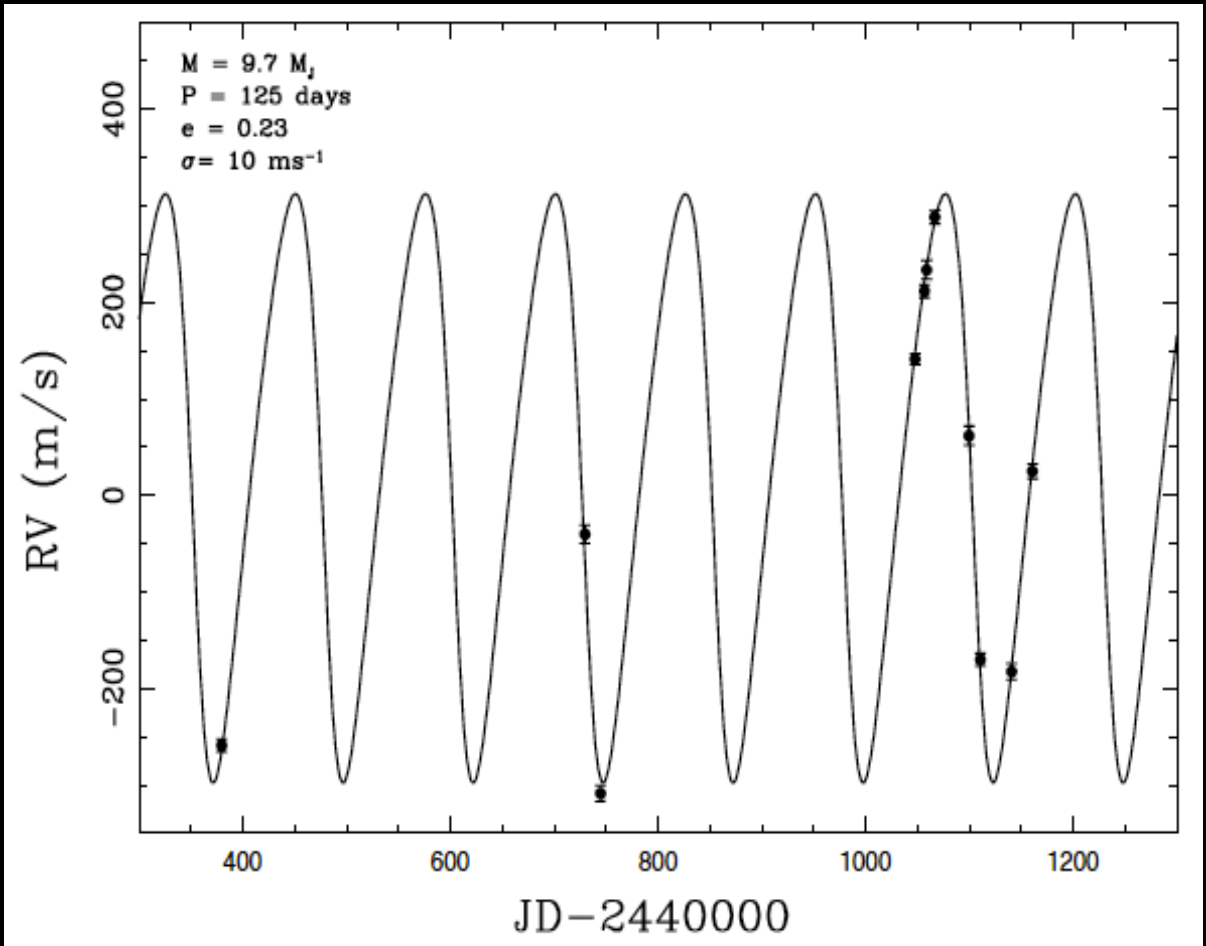


Range of candidate stellar and sub-stellar binaries

M-dwarf binary companions
Lower system is pre-common envelope

Jones, Jenkins, Rojo, Melo 2012a, A&A, submitted

Planet Candidates I

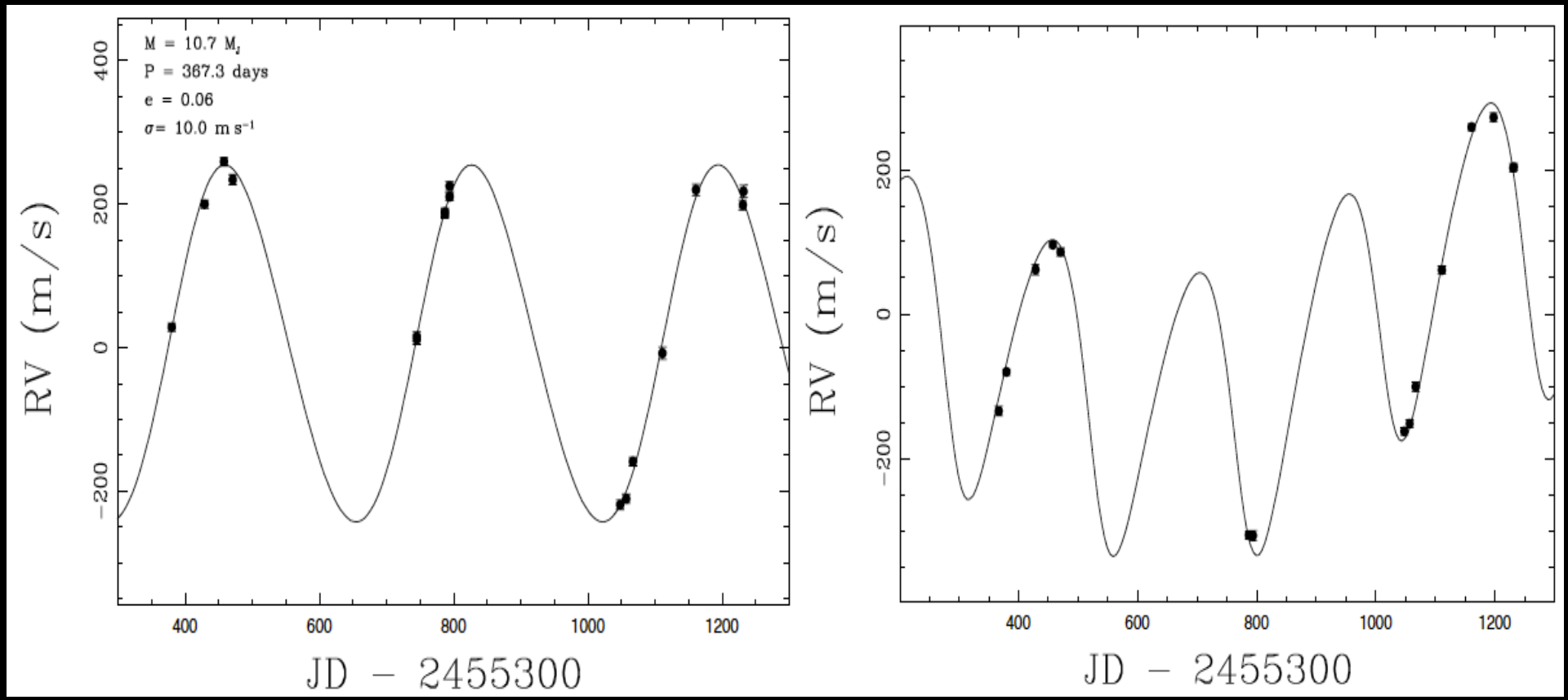


Parameter	Value
P (days)	125.2
K ($\mathrm{m\,s^{-1}}$)	304.2
a (AU)	0.57
e	0.23
ω (deg)	110.8
T_0 (JD)	2455355.8
$M_p \sin i$ (M_J)	9.7

STAR MASS IS 1.54±0.05$M_\odot$ SO PLANET IS IN THE DESERT REGION

Jones, Jenkins, Rojo, Melo 2012b, MNRAS, in prep

Planet Candidates II

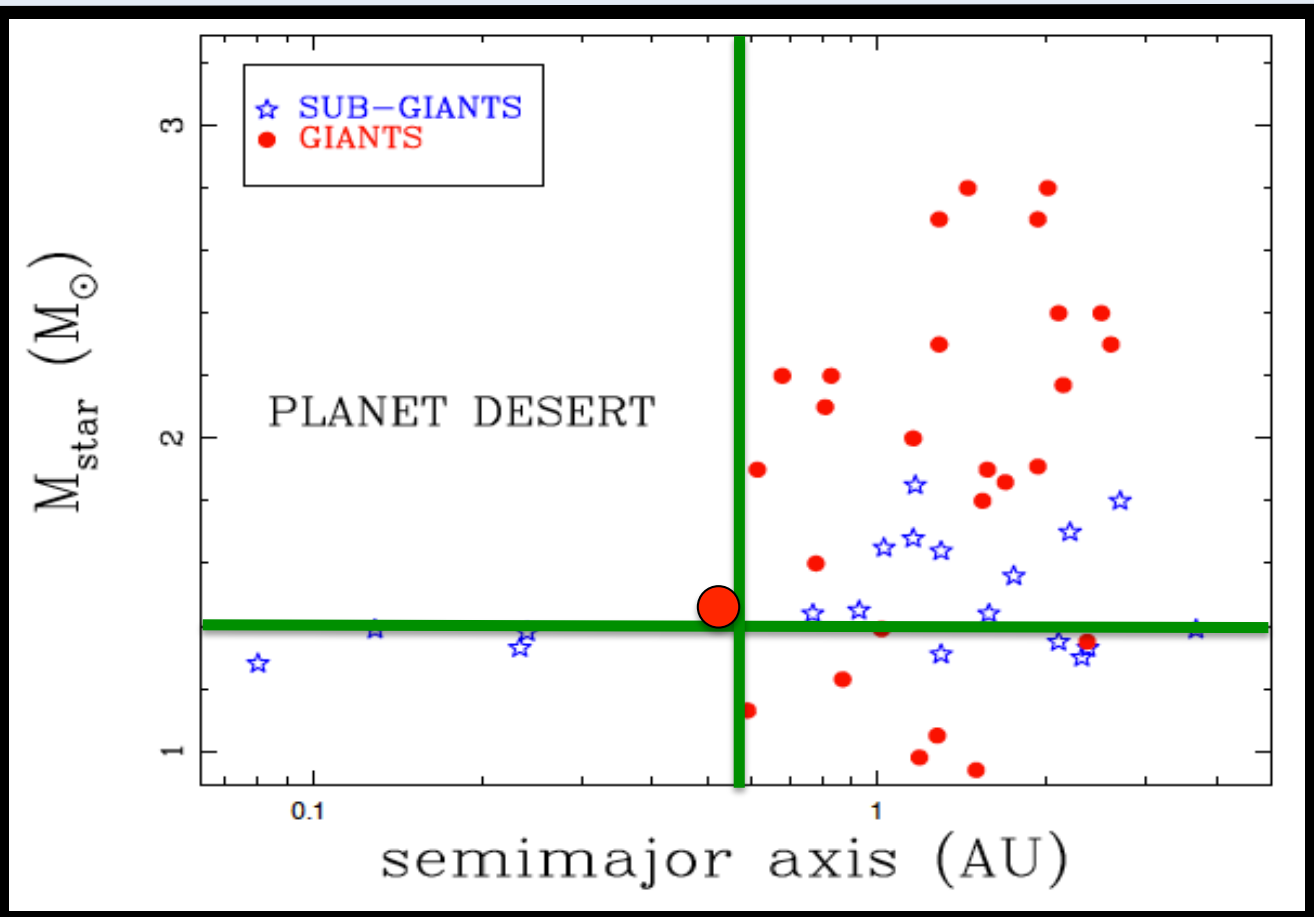


Single gas giant planet

Multi-planet giant planet system

Jones, Jenkins, Rojo, Melo 2013, in prep

Short Period Planet Desert?



- No short period planets around our clump giants
- Candidate short period planet in the desert on the RGB
- Preliminary direct evidence for tidal destruction
- Analysis of the parameter space and RV needs to be complete

Summary

CHEPS

- CHEPS RVs are now at the point where full orbits are being characterised
- Planets and BDs detected – including a new hot Uranus planet around the most metal-rich single star yet known
- Preliminary agreement between CHEPS signals and the distributions predicted by population synthesis models - >30% of targets with signals

Giant Stars

- First binaries, BDs, and planets around giant stars – including the first candidate planet around a giant star closer than 0.6AU
- No clump giant planets
- Preliminary evidence for tidal destruction of short period planetary systems around giant stars