Constraining signatures around super metal-rich stars using HARPS

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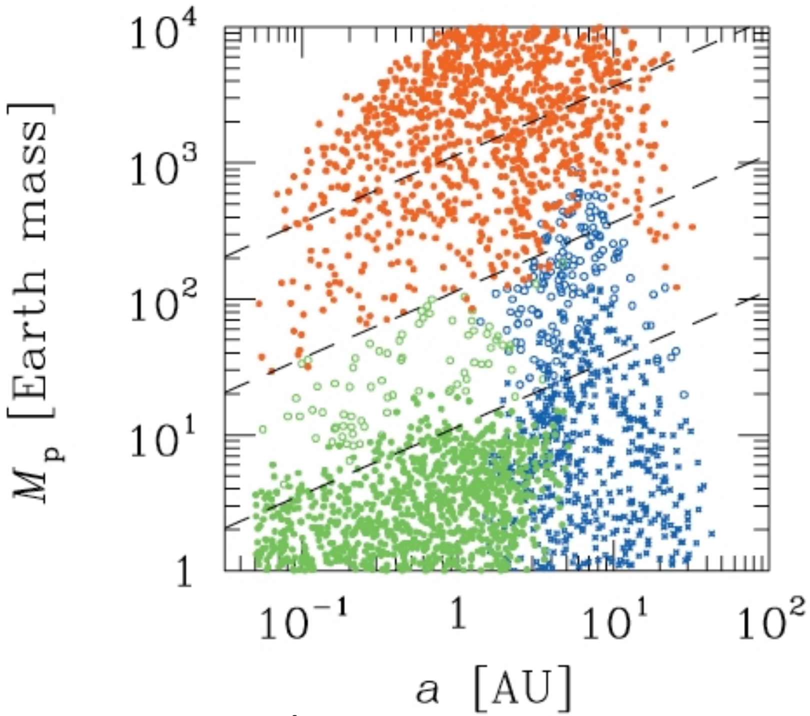
CONICYT
CHILE

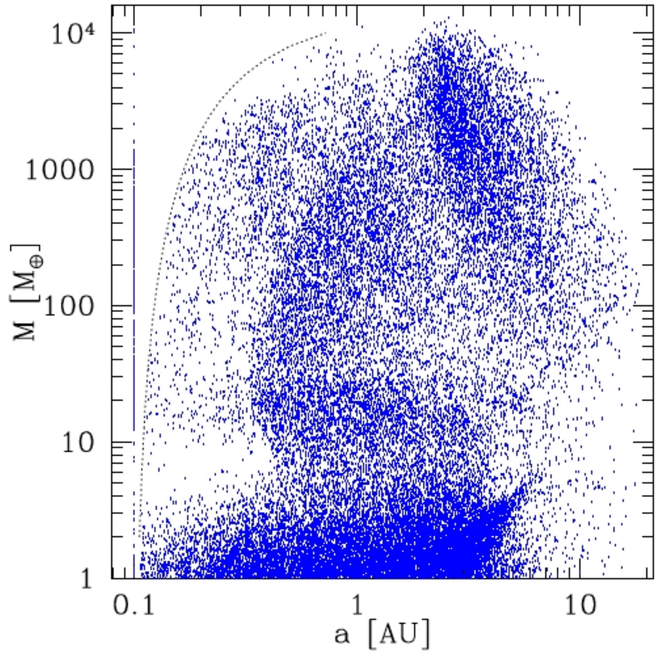
Aims

- INTRODUCTION
- CALAN-HERTFORDSHIRE EXTRASOLAR PLANET SEARCH – (CHEPS)
- NEW SUPER METAL-RICH SYSTEM
- LOW-MASS METALLICITY ANALYSIS AND THE METAL-RICH BOUNDARY
- SIGNALS FROM VERY LOW ACTIVITY AND SUPER METAL-RICH HARPS STARS
- CONCLUSIONS

INTRODUCTION



Ida & Lin 2004, 604, 388

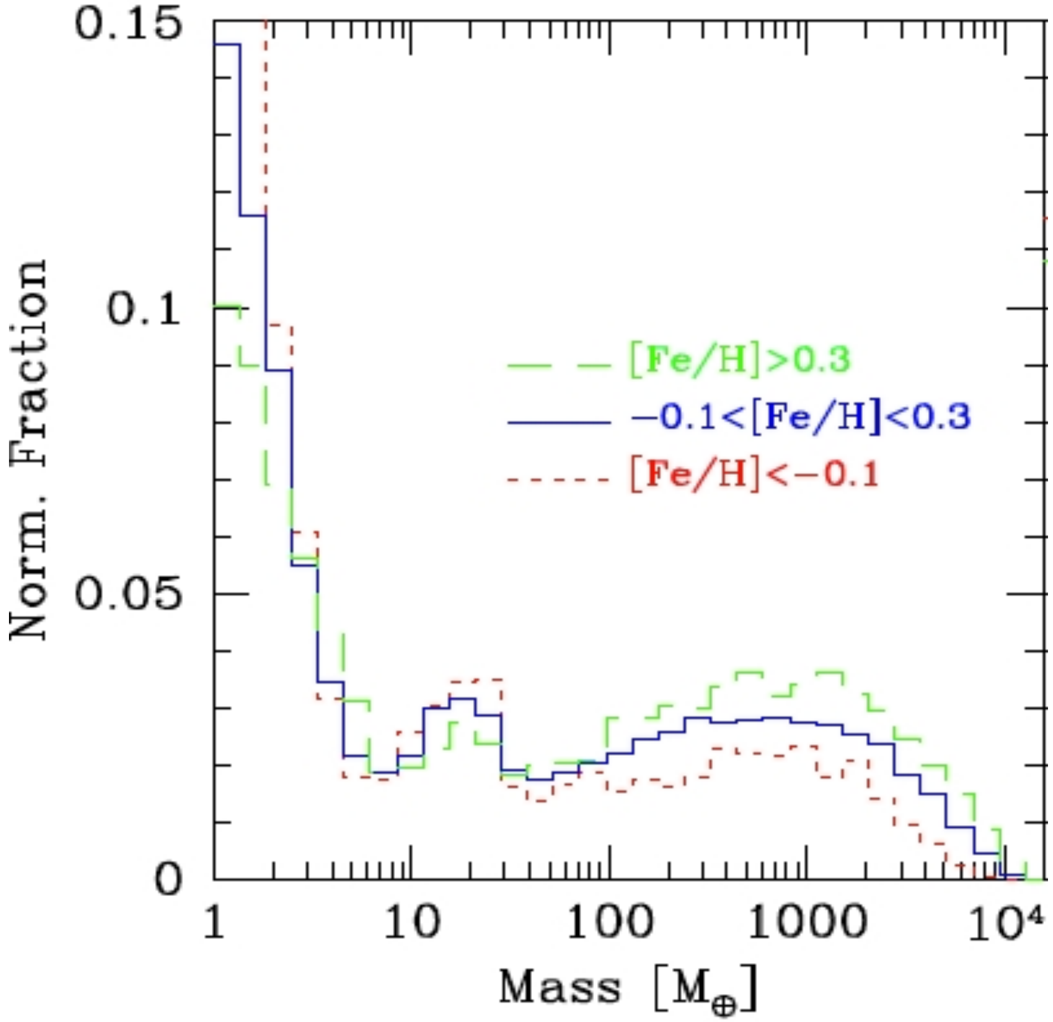


Mordasini et al. 2012, arxiv:1201.1036

1 DEARTH OF PLANETS FROM ~10-100M_{Earth}
2 DEARTH INDEPENDENT OF METALLICITY
3 THE MASS-SEMIMAJOR AXIS DISTRIBUTION IS ALSO METALLICITY INDEPENDENT – BUT FORMATION AND RETENTION DEPENDENT

1 DEARTH OF PLANETS FROM ~30-100M_{Earth}
2 METAL-RICH SYSTEMS FORM GIANT PLANETS EVERYWHERE
3 MASS-METALLICITY ALMOST UNCORRELATED
4 MIGRATION DECREASES WITH METALLICITY

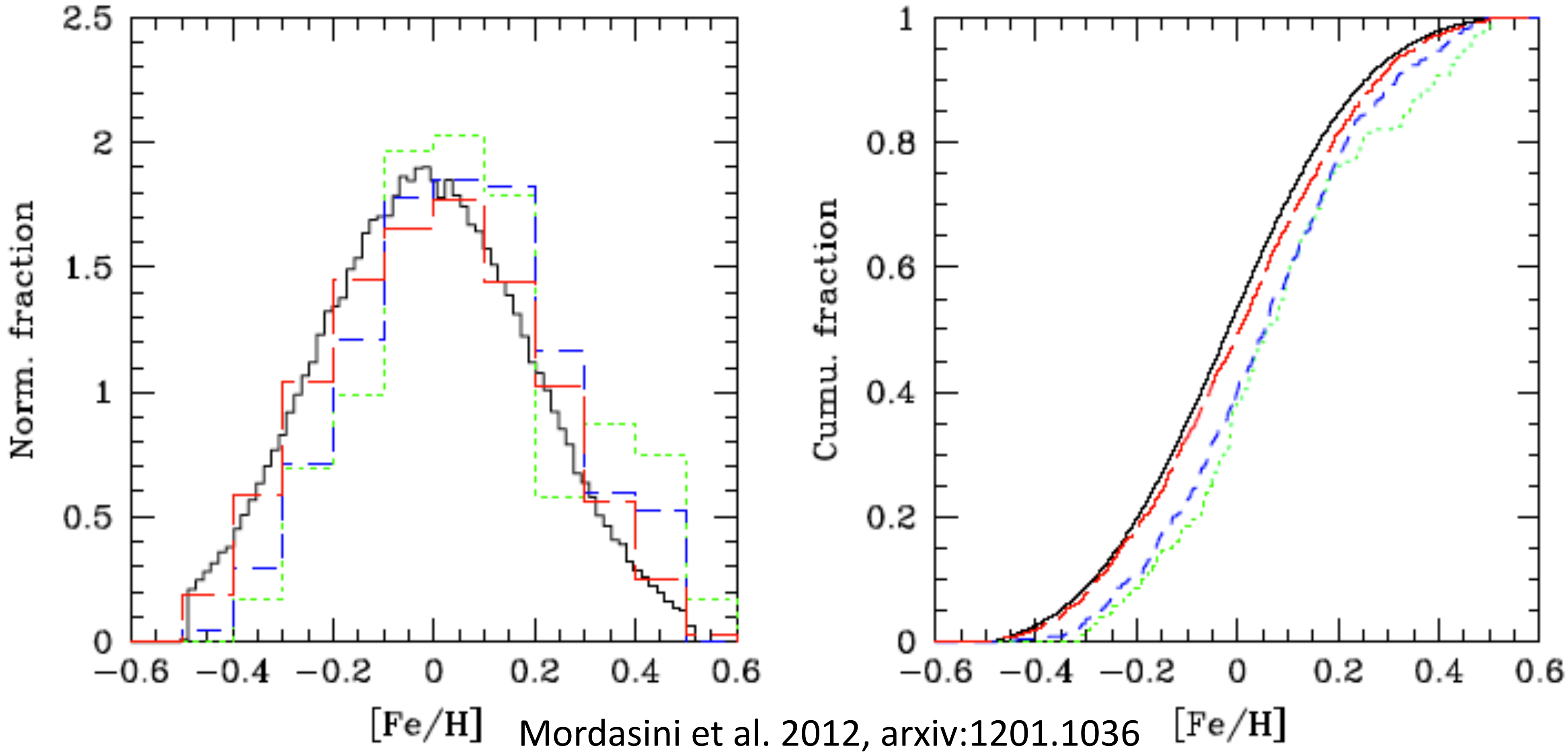
METALLICITY PREDICTIONS I



Mordasini et al. 2012, arxiv:1201.1036

- ❑ 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

METALLICITY PREDICTIONS II

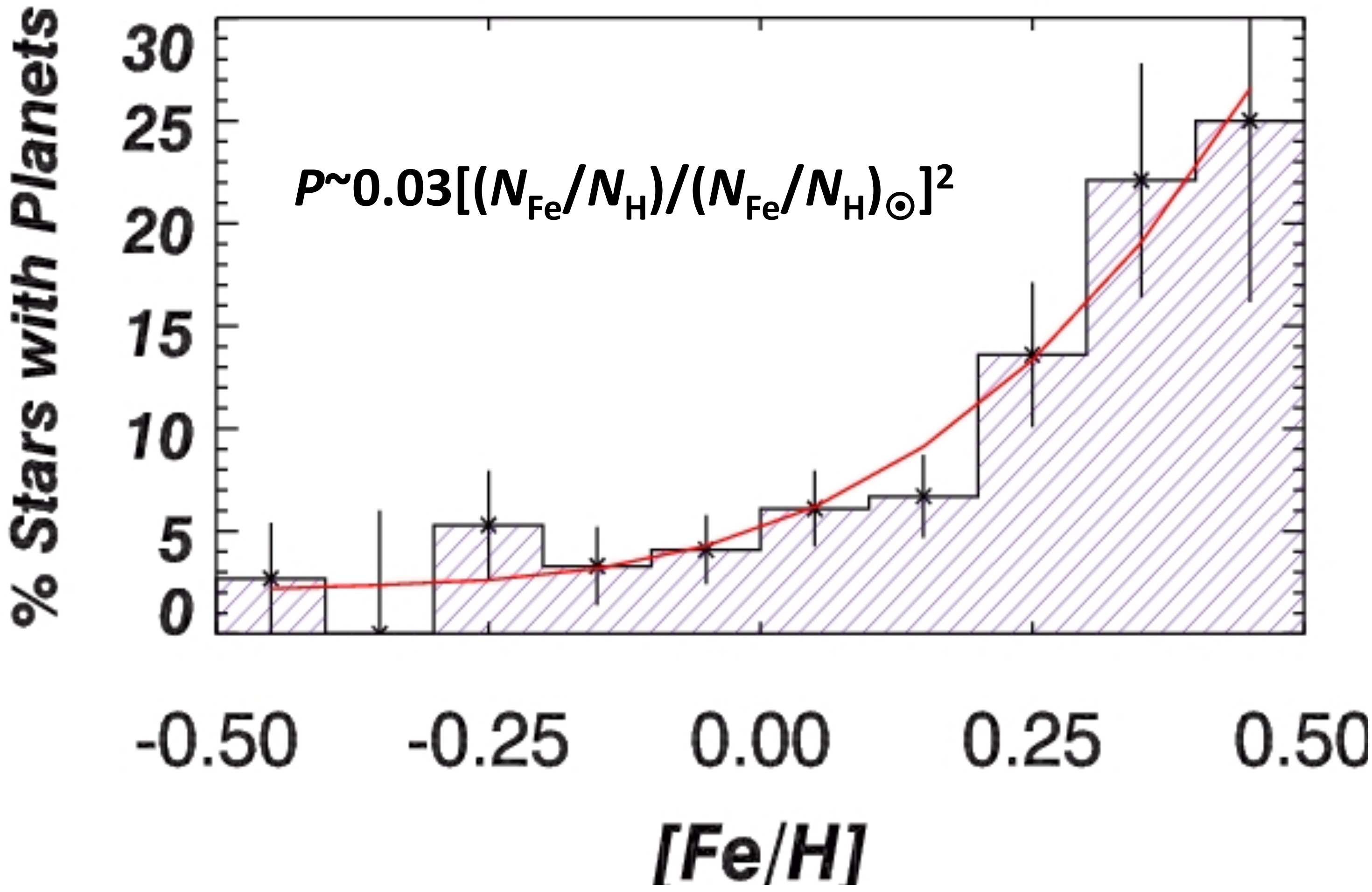


Mordasini et al. 2012, arxiv:1201.1036

- ❑ GREEN IS HIGH MASS PLANET BIN, BLUE INTERMEDIATE MASS BIN AND RED IS THE LOW MASS BIN

- ❑ SHIFT TOWARDS HIGHER METALLICITIES FOR THE HIGH MASS BIN

METALLICITY OBSERVATIONS



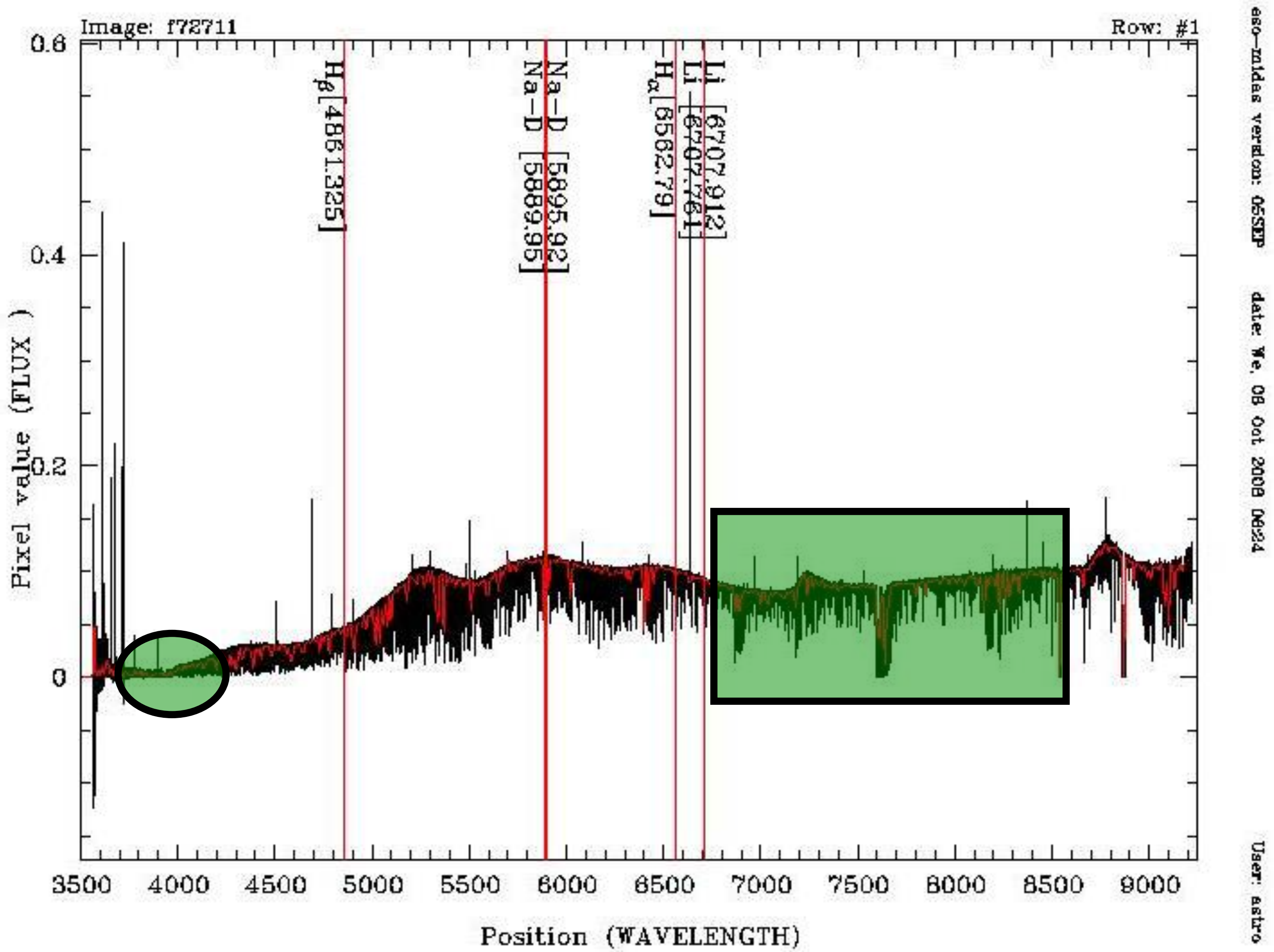
FISCHER & VALENTI 2005, ApJ, 622, 1102

THE CALAN-HERTFORDSHIRE EXTRASOLAR PLANET SEARCH

PRIMARY SAMPLE SELECTION

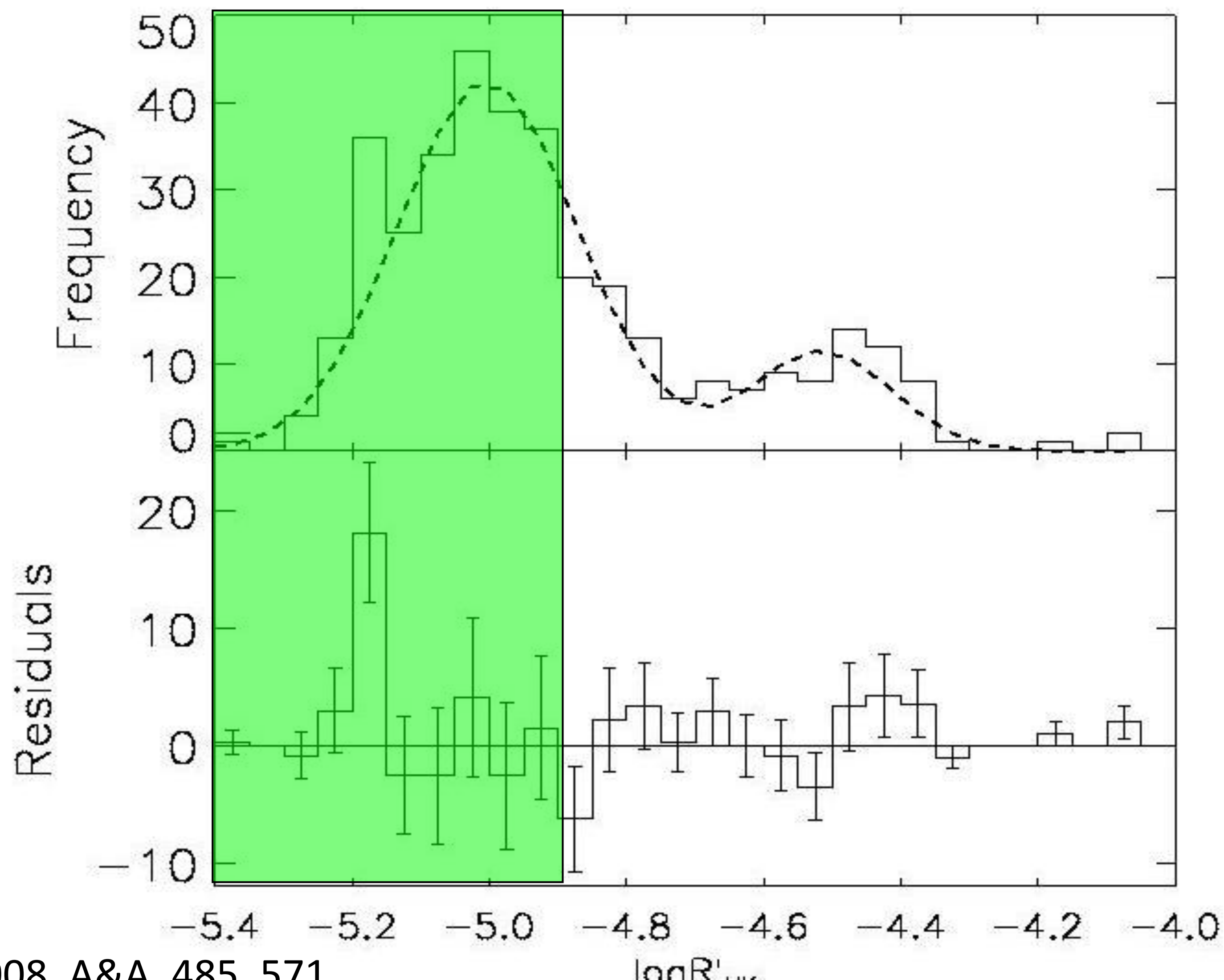
- **Hipparcos selected stars**
- **Visual magnitude range between 7.5 – 9.5**
- **Colour range (B – V) of between 0.5 – 0.9**
- **Hipparcos spectral types of V-IV i.e. no Hipparcos giants**
- **All southern objects i.e. dec ≤ 0^o**
- **Most have parallaxes ≥ 10”**
- **No double or multiple systems as of Hipparcos astrometry**
- **No significantly variable objects as of Hipparcos photometry**

CHEPS SELECTION I



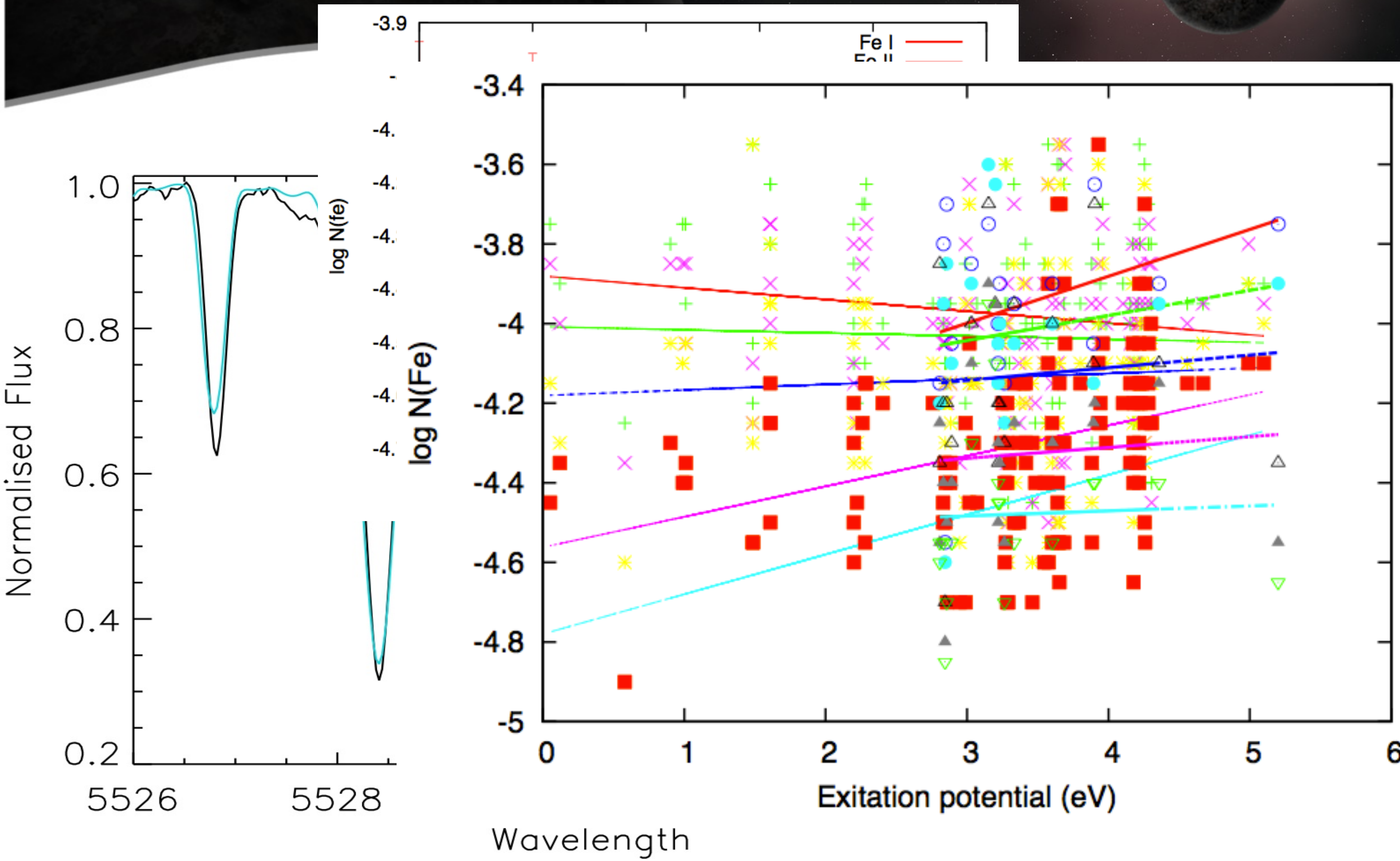
Jenkins et al. 2008, A&A, 485, 571

CHEPS SELECTION II



Jenkins et al. 2008, A&A, 485, 571

ABUNDANCE ANALYSIS I



Pavlenko et al. 2012, MNRAS, accepted (arxiv: 1201.5099)

ABUNDANCE ANALYSIS II

Table 5. Abundances in the atmosphere of HD1835

	5807/4.47/+0.2, V_t = 0.75 km/s			5857/4.47/+0.2, V_t = 0.75 km/s		
	Mean log [X/H]	log [X/H] averaged	$v \sin i$	Mean log [X/H]	log [X/H] averaged	$v \sin i$
Ca I	-5.262 ± 0.036	-5.322 ± 0.213	7.000 ± 2.111	-5.229 ± 0.040	-5.282 ± 0.121	7.042 ±2.123
Cr I	-6.016 ± 0.034	-6.017 ± 0.121	7.560 ± 1.181	-6.000 ± 0.032	-6.203 ± 0.083	7.500 ±1.217
Fe I	-4.135 ± 0.020	-4.110 ± 0.008	7.137 ± 0.626	-4.124 ± 0.018	-4.111 ± 0.006	7.094 ±0.632
Fe II	-4.117 ± 0.060	-4.146 ± 0.060	6.722 ± 1.630	-4.121 ± 0.057	-4.222 ± 0.116	6.737 ±1.588
Ni I	-5.482 ± 0.036	-5.469 ± 0.033	7.596 ± 1.064	-5.445 ± 0.034	-5.434 ± 0.036	7.539 ±1.066
Ti I	-6.815 ± 0.058	-6.719 ± 0.066	7.352 ± 1.442	-6.728 ± 0.059	-6.614 ± 0.084	7.429 ±1.430
Ti II	-6.663 ± 0.069	-7.037 ± 0.152	7.407 ± 1.453	-6.643 ± 0.070	-7.040 ± 0.141	7.444 ±1.460

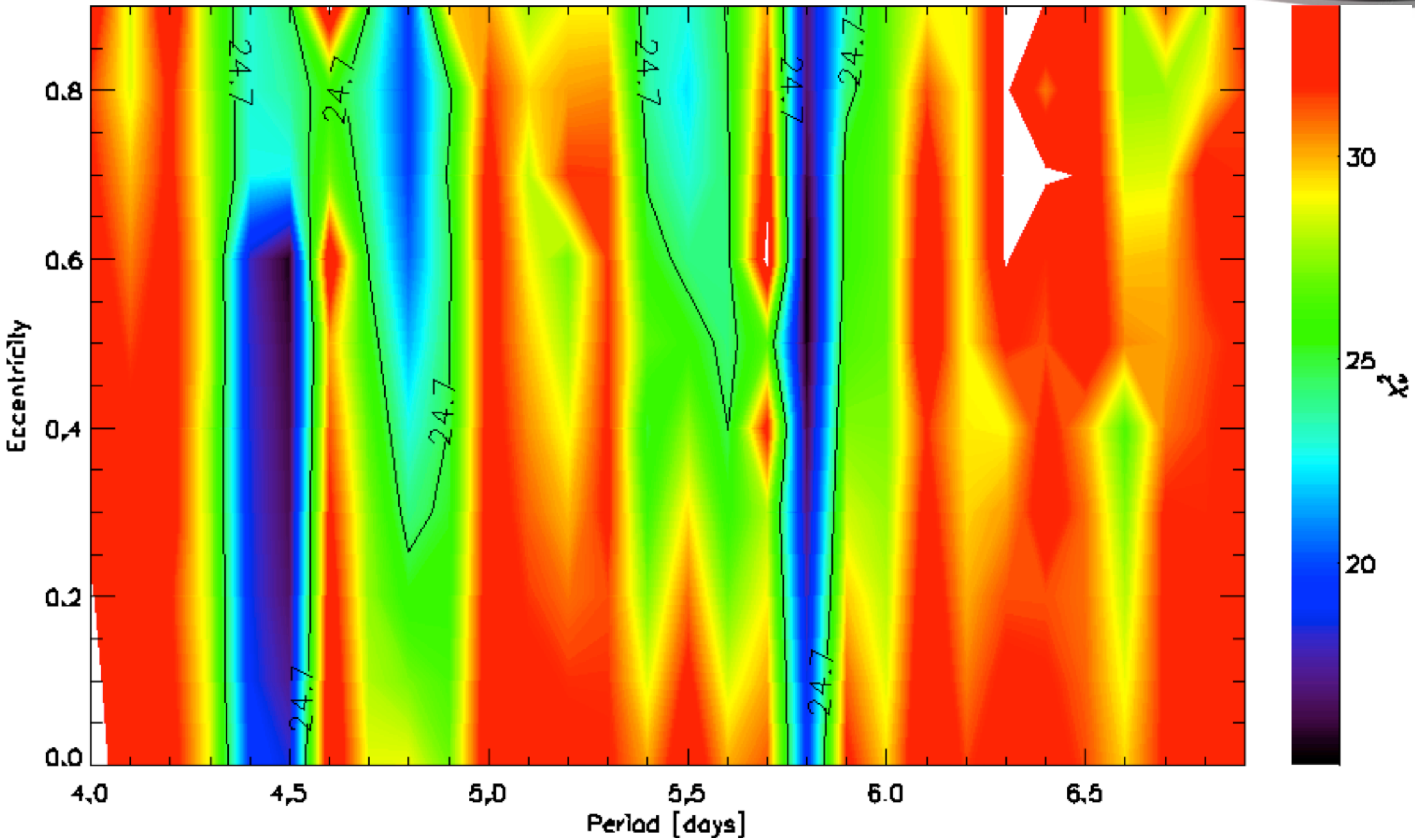
Table 6. Abundances in the atmosphere of HD10700

	5333/4.59/-0.6, V_t =0.5 km/s			5383/4.49/-0.6, V_t =0.5 km/s		
	Mean log [X/H]	log [X/H] averaged	$v \sin i$	Mean log [X/H]	log [X/H] averaged	$v \sin i$
Ca I	-5.942 ± 0.034	-5.958 ± 0.131	2.250 ± 0.678	-5.933 ± 0.032	-5.943 ± 0.108	2.167 ± 0.653
Cr I	-6.837 ± 0.024	-6.877 ± 0.041	2.733 ± 0.412	-6.814 ± 0.024	-6.846 ± 0.056	2.700 ± 0.407
Fe I	-4.939 ± 0.011	-4.911 ± 0.005	2.622 ± 0.230	-4.936 ± 0.011	-4.910 ± 0.005	2.580 ± 0.226
Fe II	-4.955 ± 0.032	-4.910 ± 0.080	2.632 ± 0.620	-4.955 ± 0.031	-4.905 ± 0.097	2.711 ± 0.639
Ni I	-6.254 ± 0.013	-6.257 ± 0.061	2.000 ± 0.283	-6.253 ± 0.013	-6.250 ± 0.051	2.000 ± 0.283
Ti I	-7.298 ± 0.035	-7.412 ± 0.107	2.643 ± 0.509	-7.271 ± 0.034	-7.492 ± 0.183	2.571 ± 0.495
Ti II	-7.290 ± 0.038	-7.239 ± 0.105	2.500 ± 0.521	-7.281 ± 0.038	-7.257 ± 0.104	2.521 ± 0.526

- SELF-CONSISTENT APPROACH
- AUTOMATIC MEASURES OF METALLICITY USING FeI AND FeII INDEPENDENTLY
- DERIVES Vt, T_{EFF}, LOG(G) AND VSIN(I)
- OTHER ATOMIC ABUNDANCES MEASURED IN PROCESS

THE CALAN-HERTFORDSHIRE EXTRASOLAR PLANET SEARCH NEW RESULTS

χ^2 CONTOUR



PROPERTIES

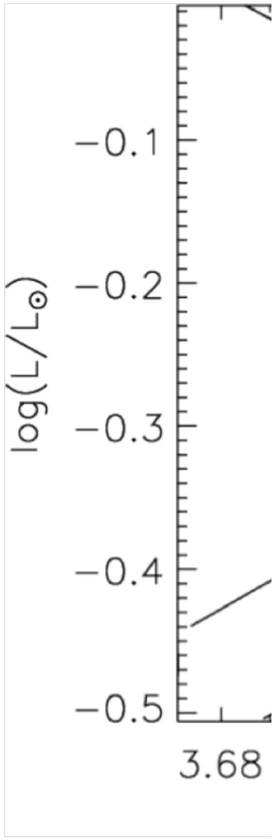


Table 3: Stellar parameters

Parameter	Value	Reference
Spectral Type	K0IV	Perryman et al. (1997)
$B-V$	0.833	Perryman et al. (1997)
V	[illegible]	Perryman et al. (1997)
$v\sin i$(km/s)	2.8±1.5	Jenkins et al. (2011)
$v\sin i$(km/s)	2.33±0.05	This Work
Age$_{R'HK}$ (Gyrs)	7.5	This Work
Age (Gyrs)	$3.97^{+4.23}_{-3.00}$	This Work
Jitter - S_{MW} (m/s)	2.10	Isaacson & Fischer (2010)
Jitter - fit (m/s)	1.59	This Work

Spec Type = K0IV

[Fe/H]=+0.35±0.06 dex

M_{star}/M_{sun}=0.93±0.05

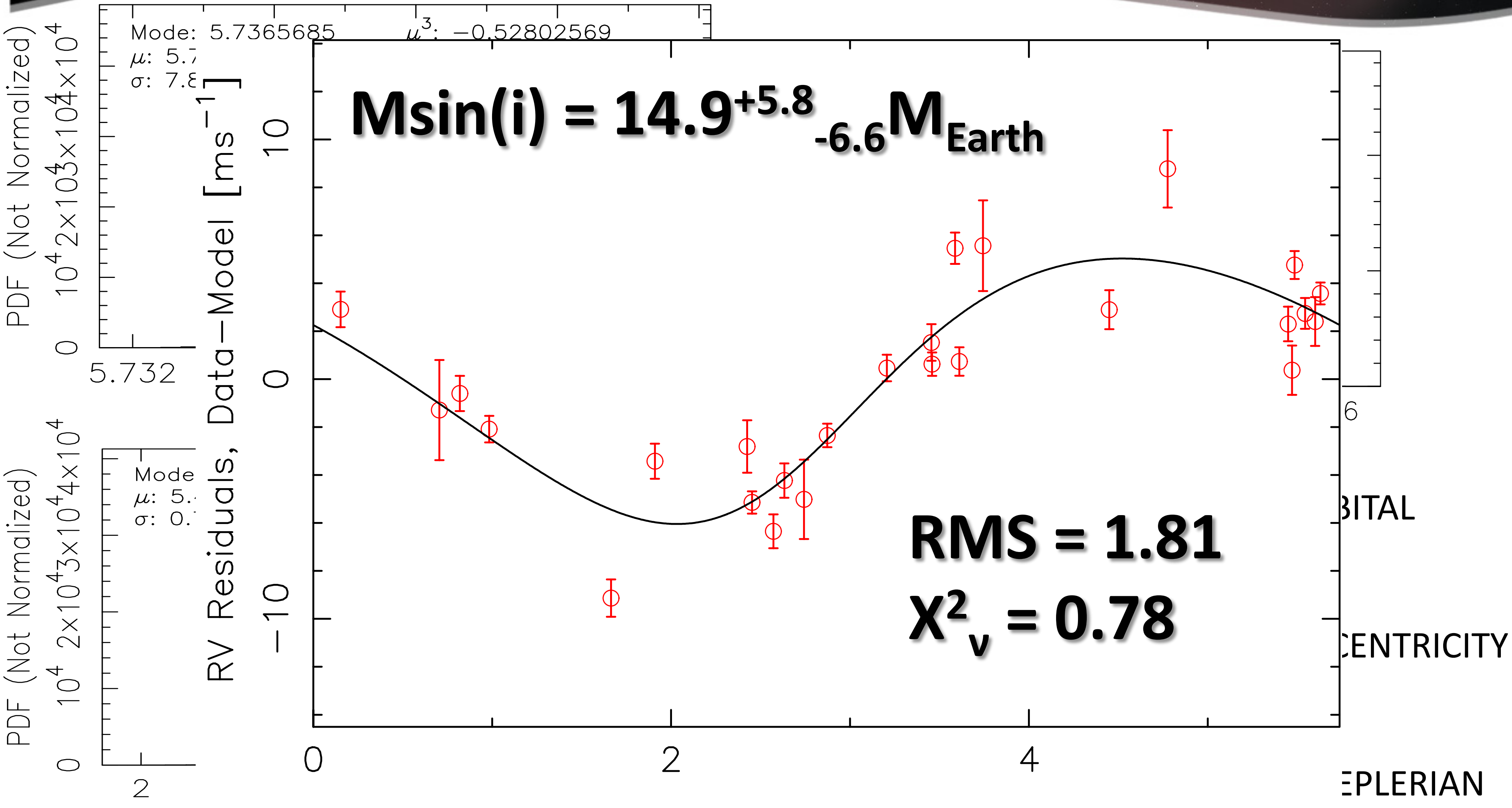
Vsin(i)=2.33±0.05 km/s

Age=$3.97^{+4.23}_{-3.00}$ Gyrs

logR'_{HK}=-5.05

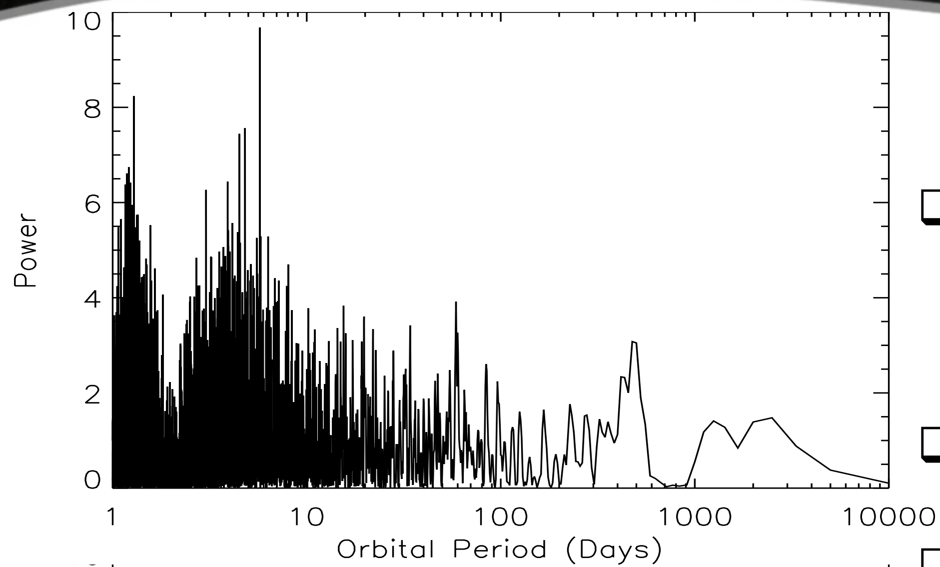
U,V,W=39.1,-27.7,-24.8 km/s

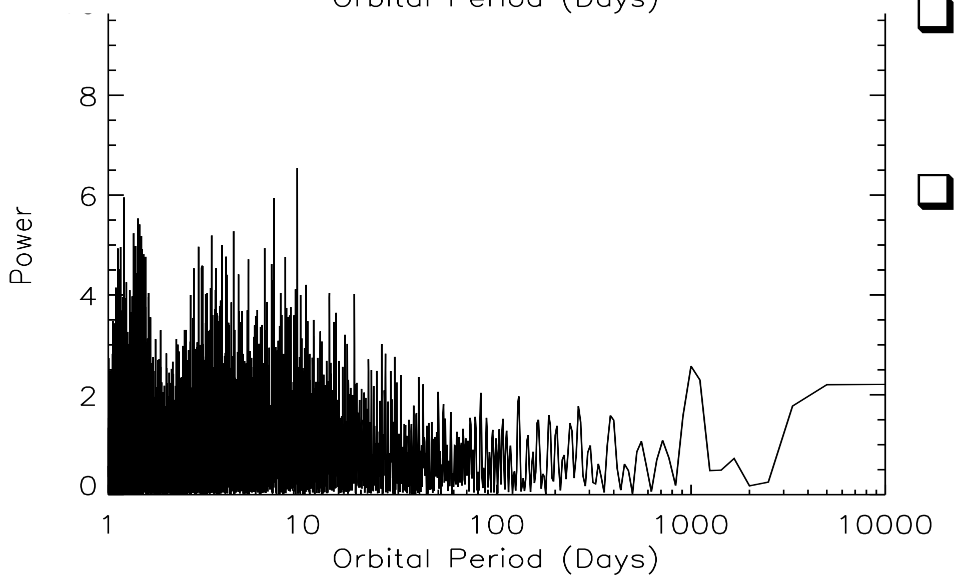
BAYESIAN ANALYSIS



Jenkins et al. 2012, ApJ, submitted

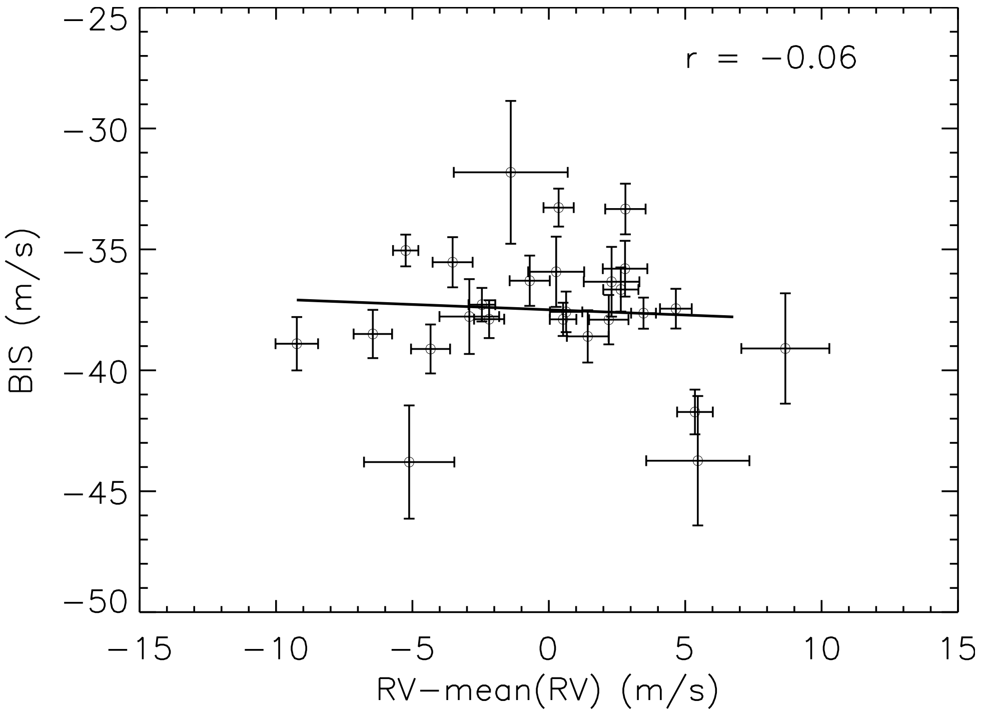
PERIODOGRAMS

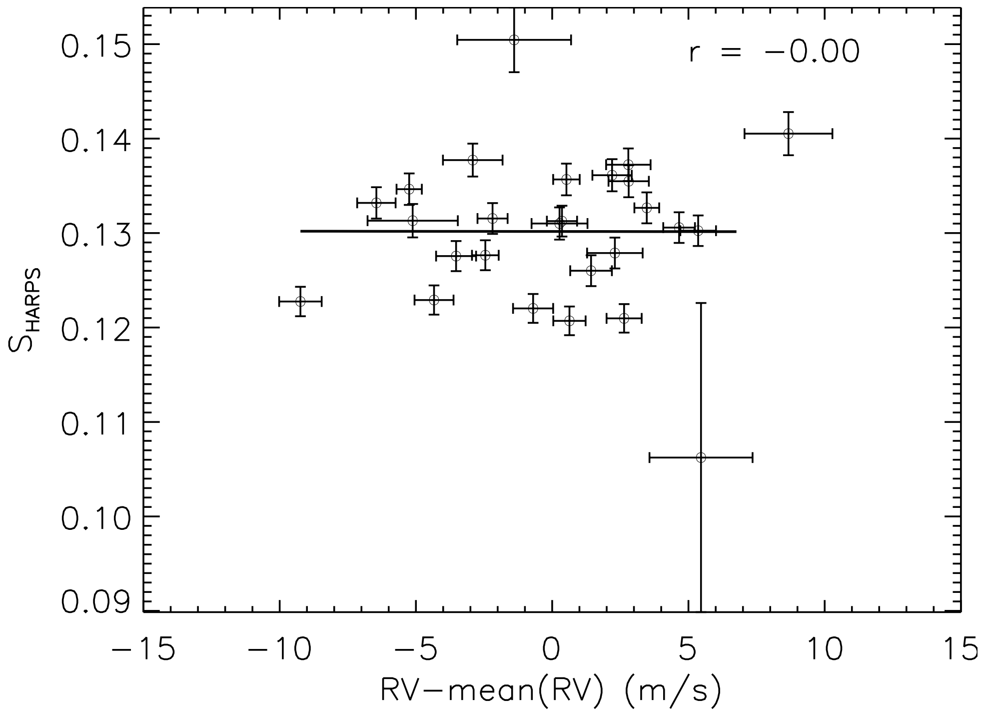




- ❑ RAW RADIAL VELOCITIES (TOP) AND RESIDUALS TO THE 1-PLANET FIT (BOTTOM)
- ❑ STRONGEST PEAK CLEAR AT ~5.7 DAYS
- ❑ FALSE ALARM PROBABILITY OF THIS PEAK IS ONLY 0.02%
- ❑ NO SIGNIFICANT SIGNAL IN THE RESIDUALS, WITH A ~9.5 DAY PEAK POSSIBLY EMERGING

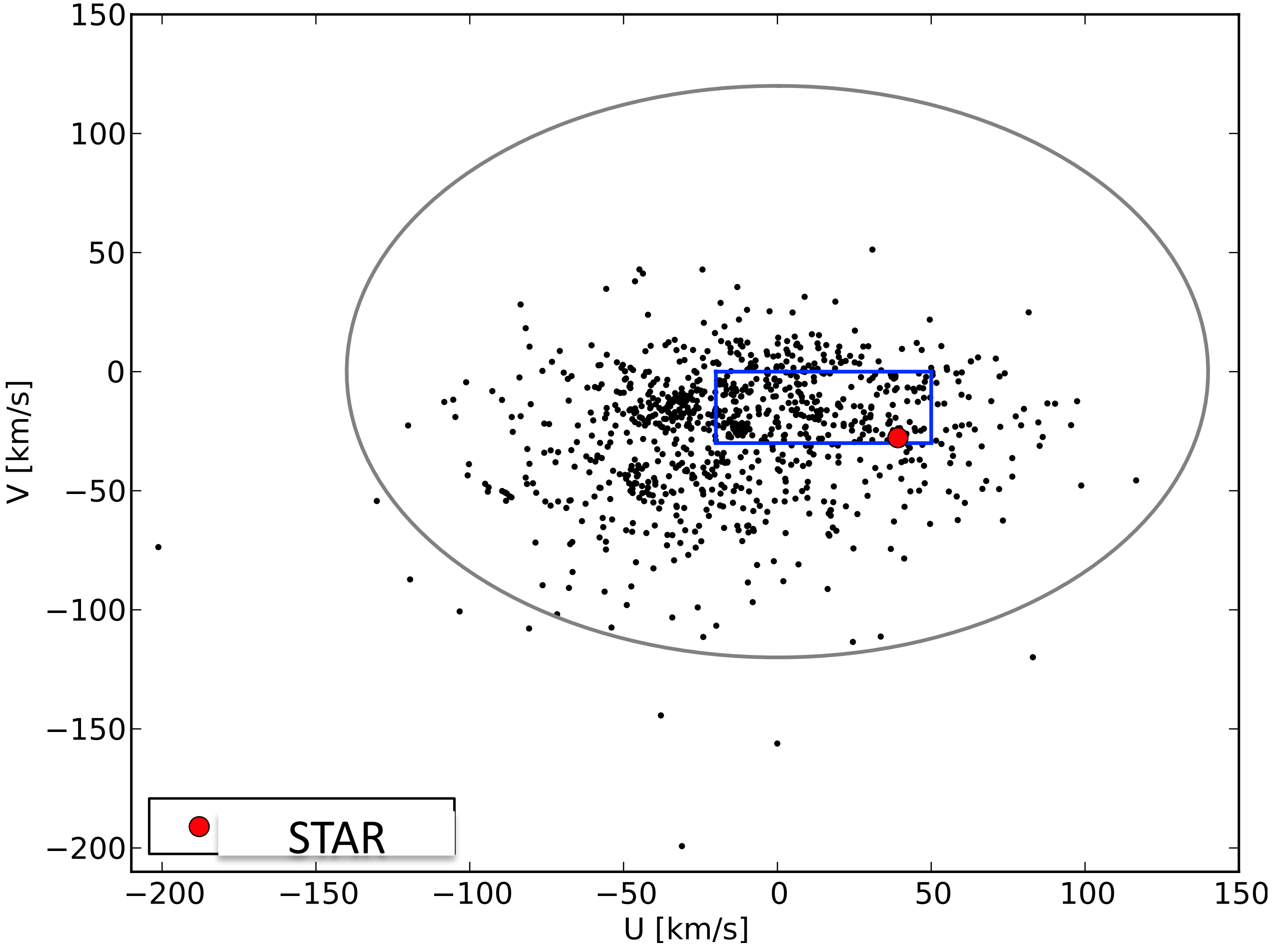
ACTIVITY CORRELATIONS?





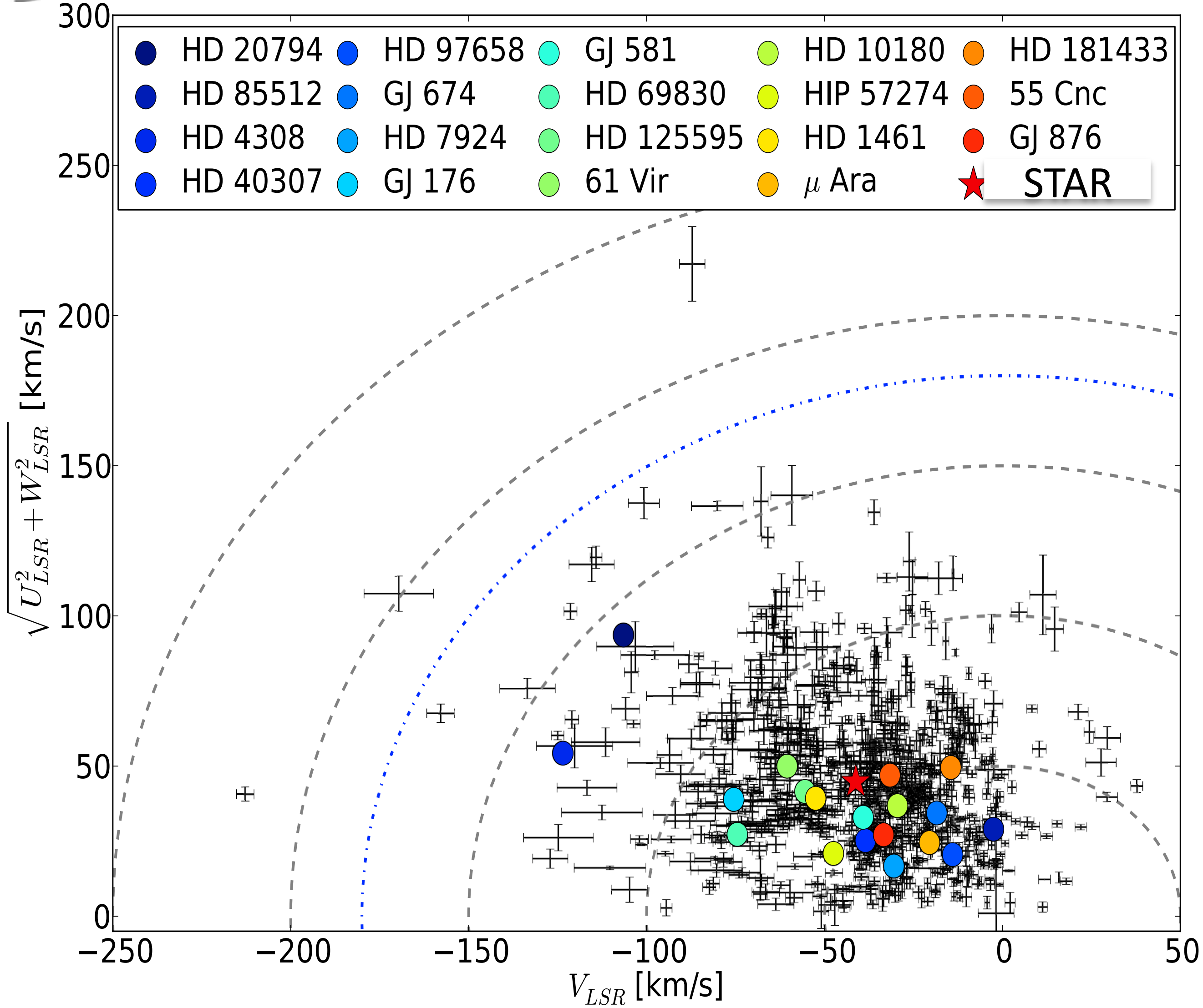
- NO CORRELATION BETWEEN THE BISECTOR SPAN AND THE RADIAL VELOCITIES
- LINEAR CORRELATION COEFFICIENT IS -0.06
- NO CORRELATION BETWEEN THE ACTIVITY INDICES AND THE RADIAL VELOCITIES
- LINEAR CORRELATION COEFFICIENT IS -0.00

KINEMATICS



- DATA FROM JENKINS et al. 2011, A&A, 531, 8
- BLACK ELLIPSE MARKS THE OLD DISK
- BLUE BOX BOUNDS THE YOUNG DISK, BOTH FROM EGGEN 1969, PASP, 81, 553
- RED FILLED CIRCLE IS OUR STAR
- ON THE EDGE OF THE YOUNG AND OLD DISK BOUNDARY

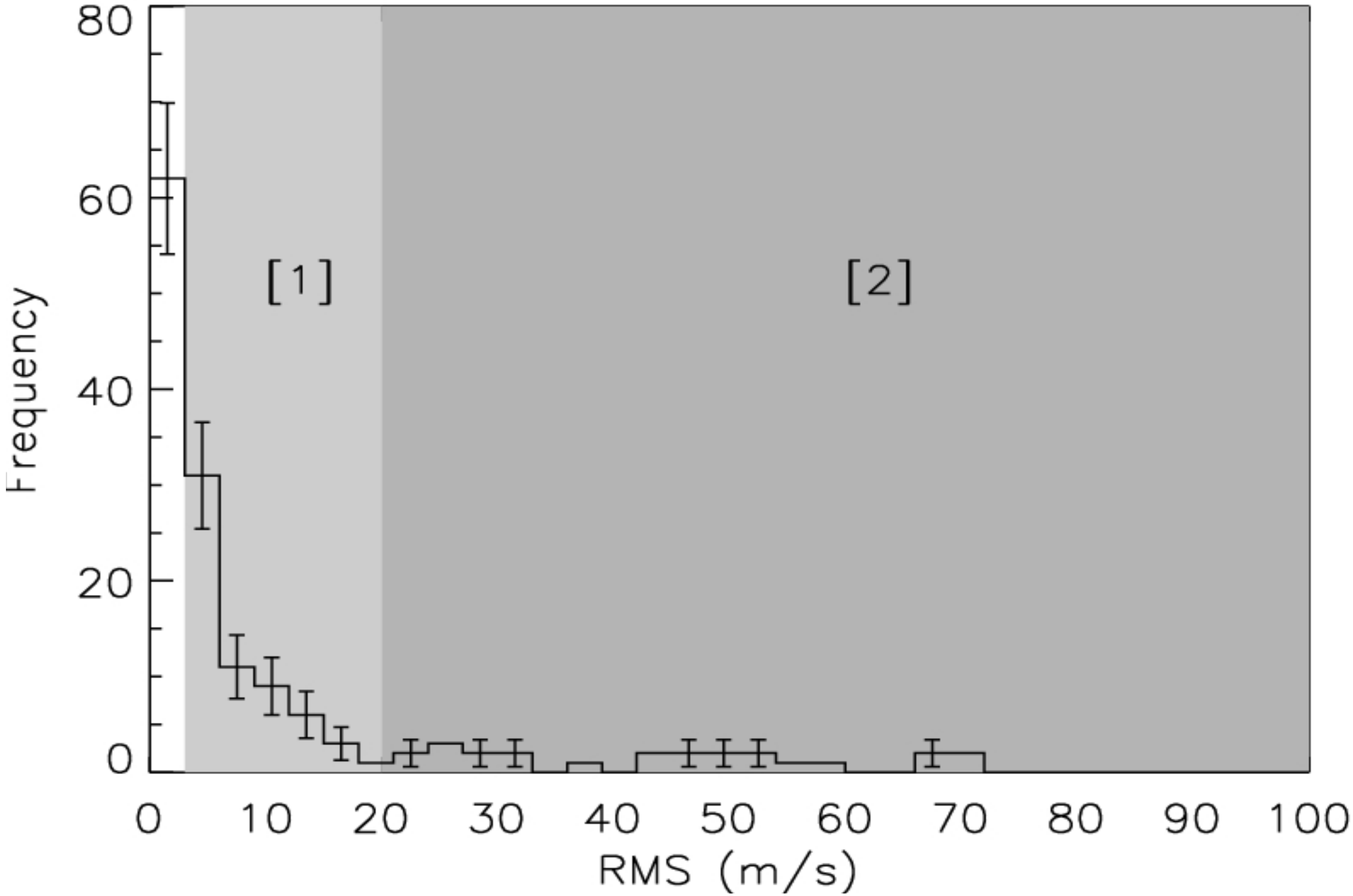
TOOMRE: PLANET HOSTS



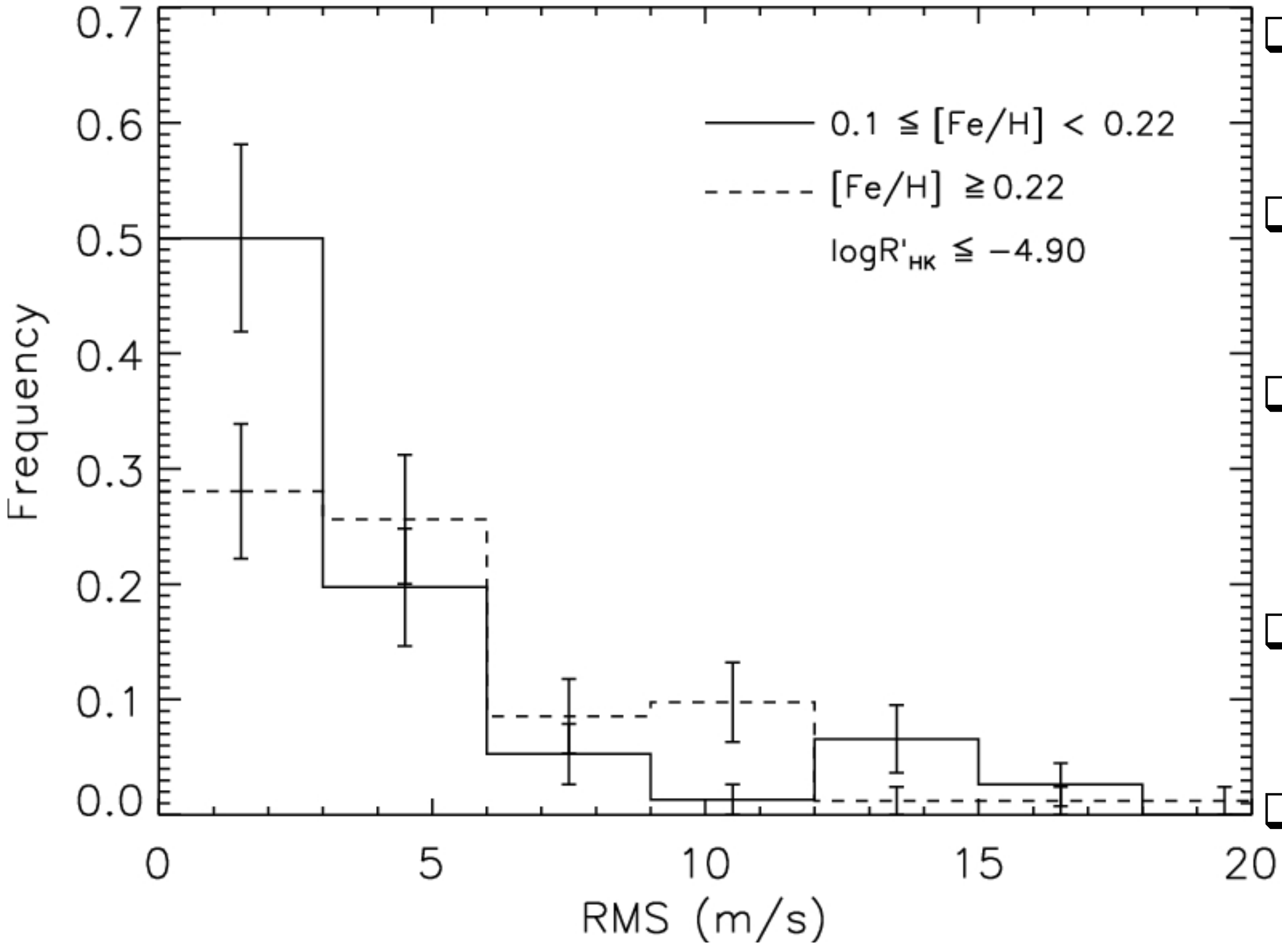
- COLOURS ARE ORDERED IN INCREASING METALLICITY
- ROCKY PLANET HOSTS CLUSTERED AROUND THE THIN AND INTERMEDIATE DISK REGION
- THIS STAR HAS A RELATIVELY HIGH KINEMATIC ENERGY COMPONENT
- TWO ROCKY HOSTS, HD4308 AND HD20794, HAVE HIGH KINEMATIC VELOCITIES

METAL-RICH SIGNALS FROM HARPS

METAL-RICH STAR SIGNALS I

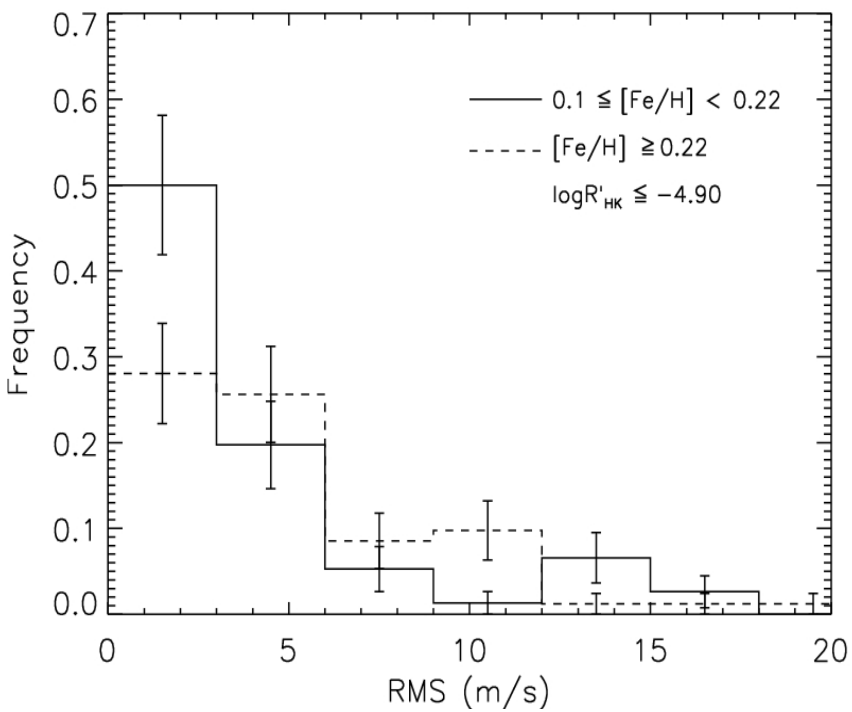


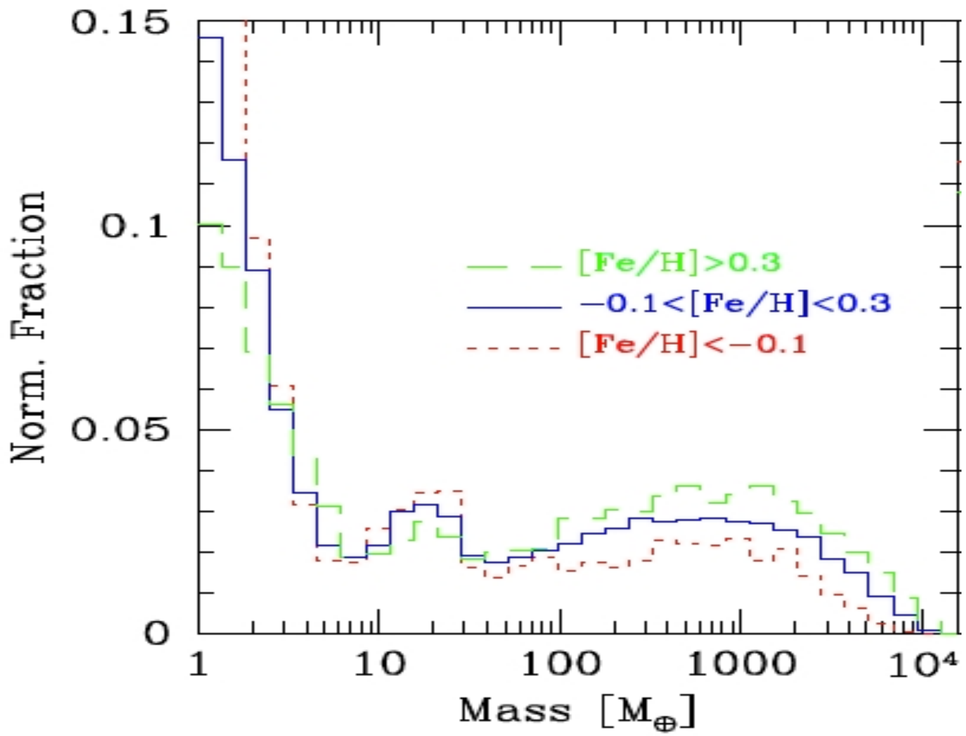
METAL-RICH STAR SIGNALS II



- ASSUMPTION IS RMS IS A GOOD PROXY FOR AMPLITUDE
- LOWER METALLICITY BIN IS MORE PEAKY
- SUPER-METAL-RICH BIN SHOWS MORE HIGHER AMPLITUDE SIGNALS
- ~48±29% HIT RATE FOR THE SUPER METAL-RICH PLANETS
- SLIGHTLY LOWER FOR THE LOWER METALLICITY BIN OF 36±22%

METAL-RICH STAR SIGNALS III

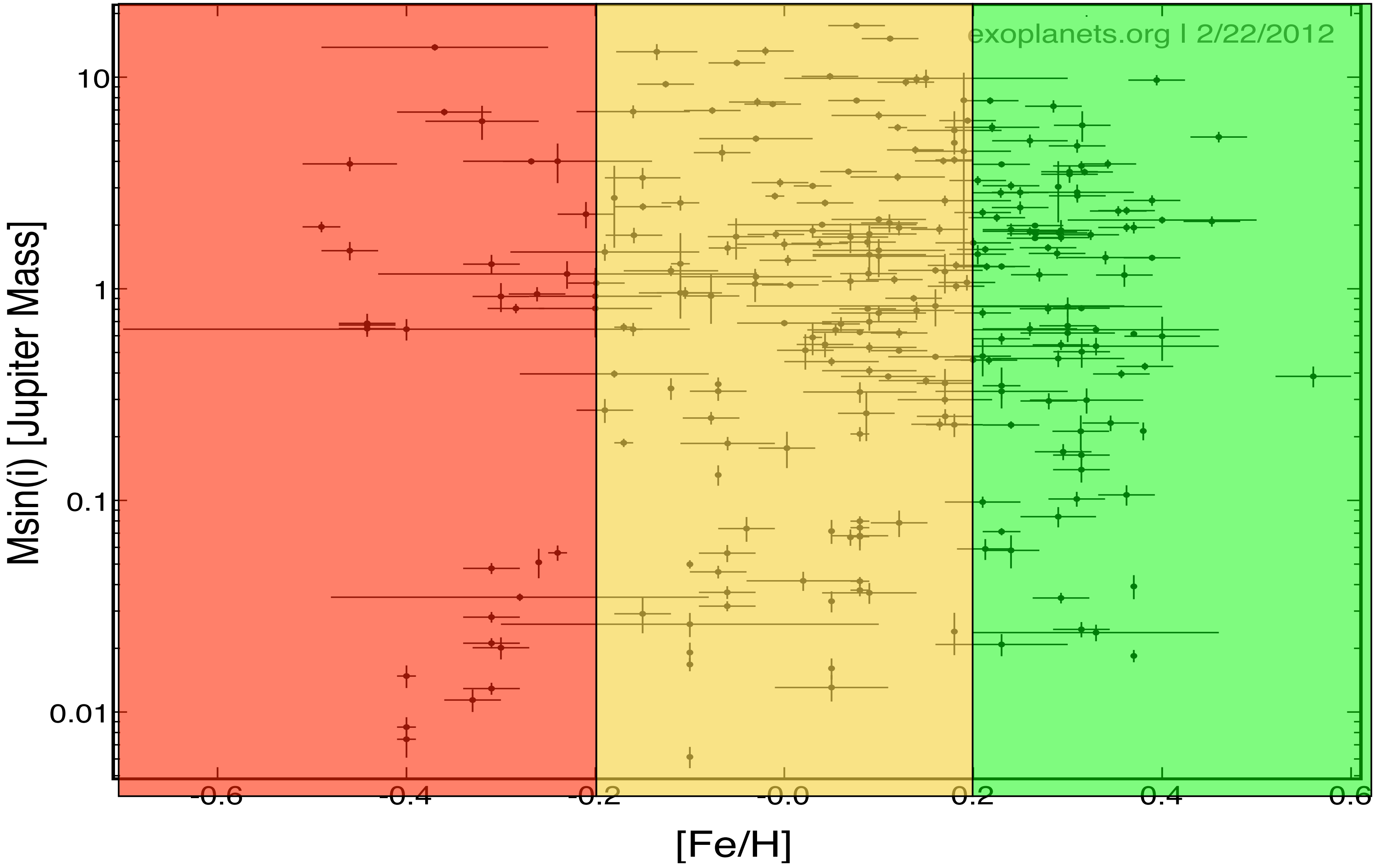




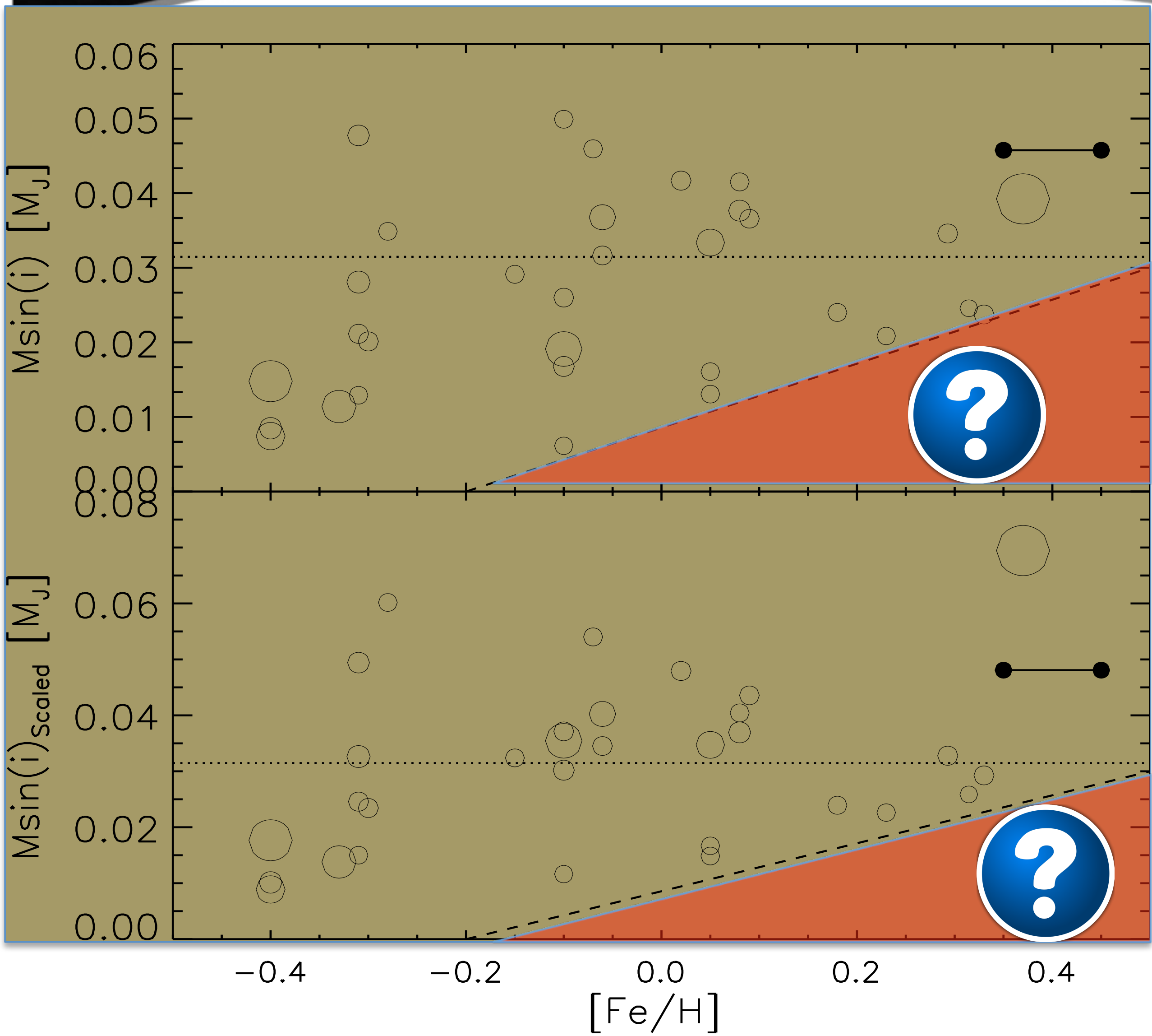
THE HIGHEST METALLICITY BIN IN THE MODELS AGREES WITH THE FRACTION WE FIND DIRECTLY FROM THE SUPER METAL-RICH STELLAR DATA!!

METAL-RICH PLANET HOST STARS

METAL-RICH PLANETS



LOW-MASS AND METAL-RICH



- ❑ LACK OF REALLY LOW-MASS PLANETS AROUND SUPER METAL-RICH STARS
- ❑ SOLID BOUNDARY REAL?
- ❑ MASS-METALLICITY CORRELATED FOR ROCKY PLANETS?
- ❑ IS THERE A METALLICITY VALLEY?
- ❑ WORK TO BETTER UNDERSTAND THE BIASES

SUMMARY

① EXCITING PLANETS COMING FROM THE CHEPS THAT ARE WELL POSITIONED FOR TRANSIT FOLLOW-UP

② MOST METAL-RICH LOW-MASS PLANET DETECTED

③ METAL-RICH AND INACTIVE STARS INDICATE A DETECTION RATE OF >30% OF SIGNALS

④ METAL-RICHNESS SEEMS TO COVER ALL MASS REGIMES DOWN TO THE TELLURIC PLANETS

⑤ THERE ARE A LACK OF REALLY LOW MASS PLANETS ORBITING THE MOST METAL-RICH STARS

⑥ IS THE BOUNDARY REAL GIVING RISE TO A MASS-[Fe/H] CORRELATION FOR ROCKY PLANETS

**** CHECK OUT THE POSTER BY LOPEZ & JENKINS IN THE HALL ****