The HARPS low-precision, volume limited sample

Planet detection statistics from the ongoing survey after 8 years of data taking

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ESO, Geneva Obs., LAM, CAUP

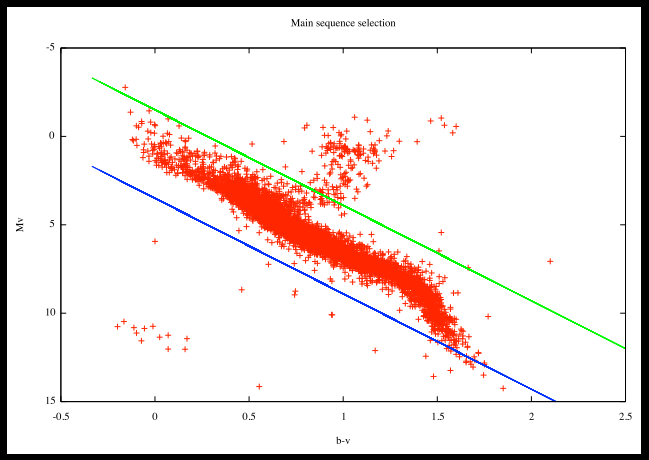
HARPS GTO programs

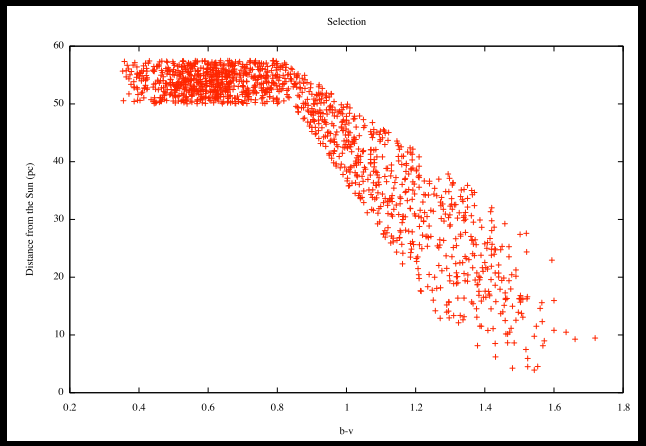
- Low mass planets search (~450 stars)
- **Volume limited sample** (~850 stars)
- Planets around low mass stars (~100 stars)
- Planets around metal poor stars (~100 stars)

Observations of the volume limited sample continued after the end of the HARPS GTO program via normal observing proposals to the ESO OPC.

The sample selection

- HIPPARCOS catalog
- F2-M0 spectral types
- Main sequence stars
- Declination < 0
- 50 pc < dist. < 57.5 pc
- Complement to the CORALIE sample

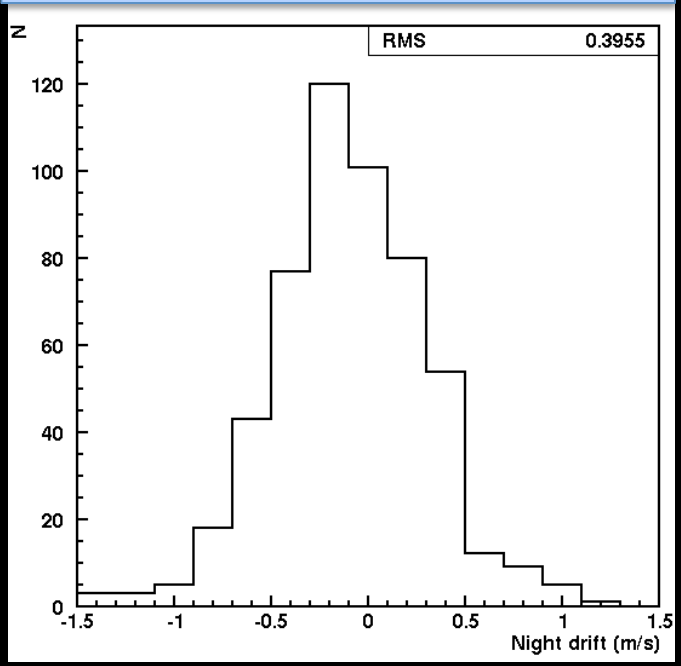




Observing strategy

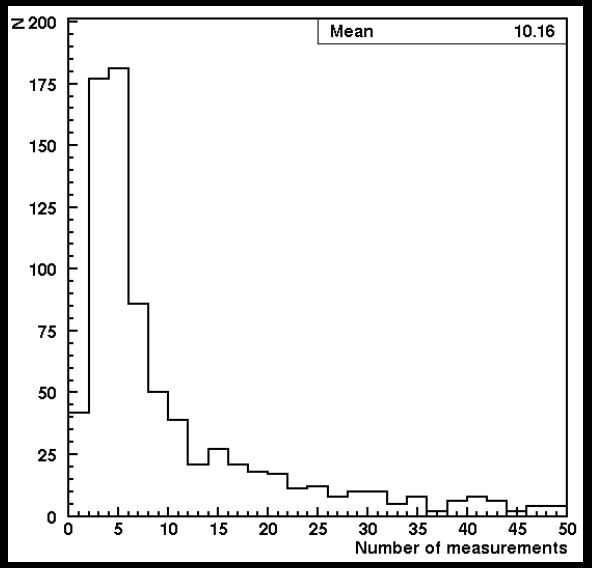
- Limit to 2-3m/s RV precision
- S/N ~ 40 (@ 550nm)
- No simult. Th-Ar reference
  - Night drift is low:
    - drift<0.5m/s : 83%
    - drift<1.0m/s : 98%
- Single exposures
- Telescope time ~8'/exp.
- Follow up if RV varying over 5m/s

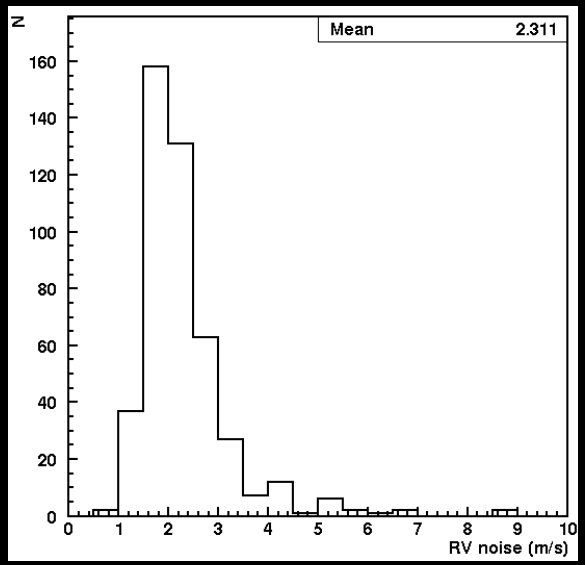
Instrumental stability over one night

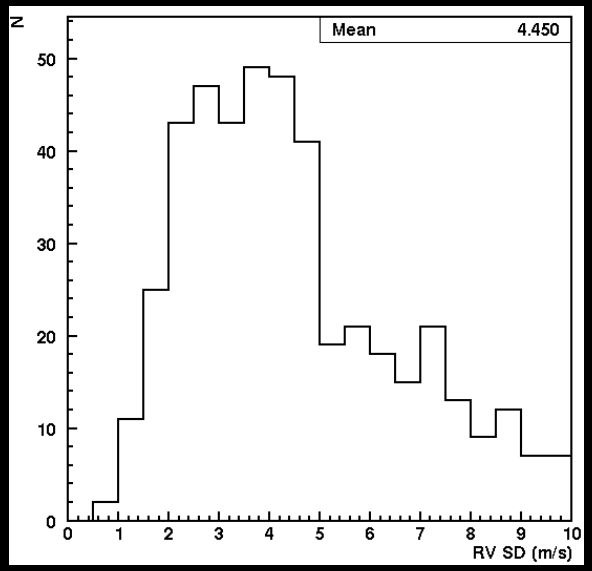


Measurements statistics

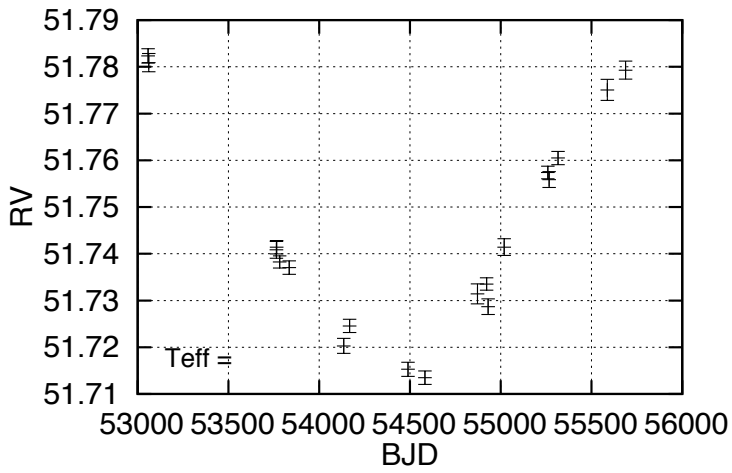
- 10 measurements per target on average
- <RV variations> > 2 * <RV noise>

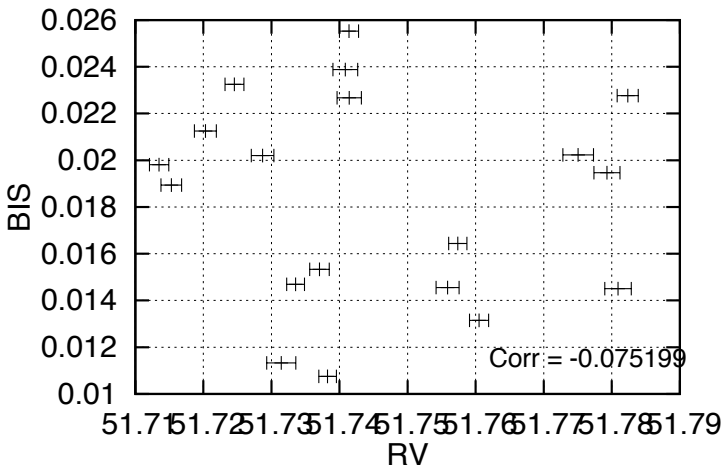


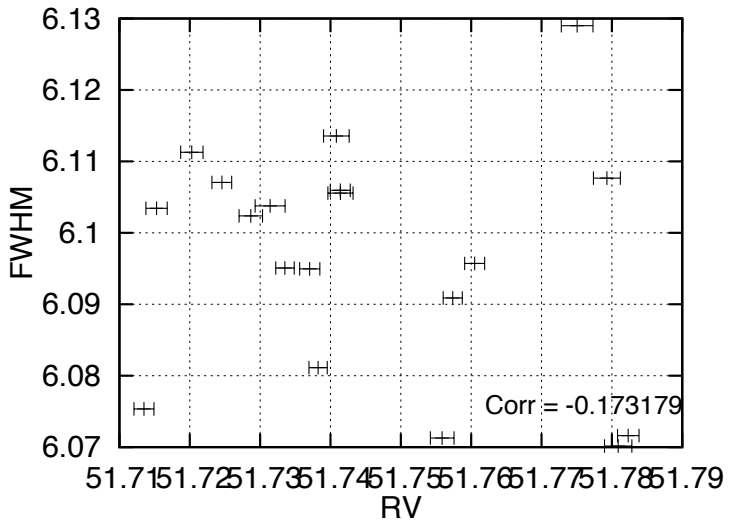


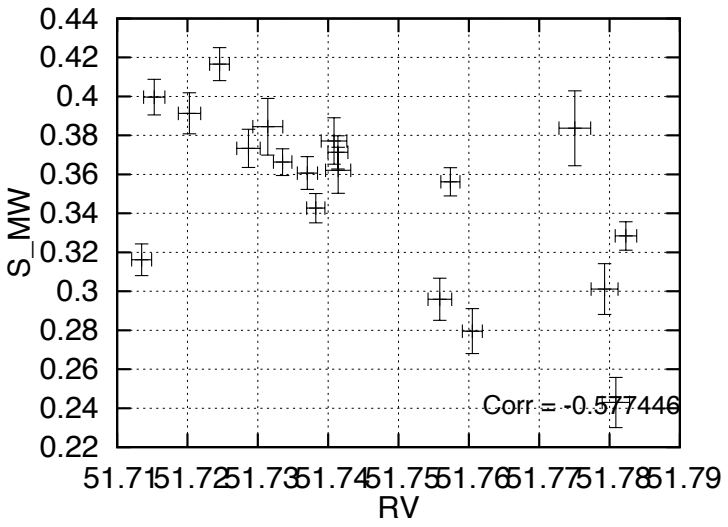


Origin of the signals









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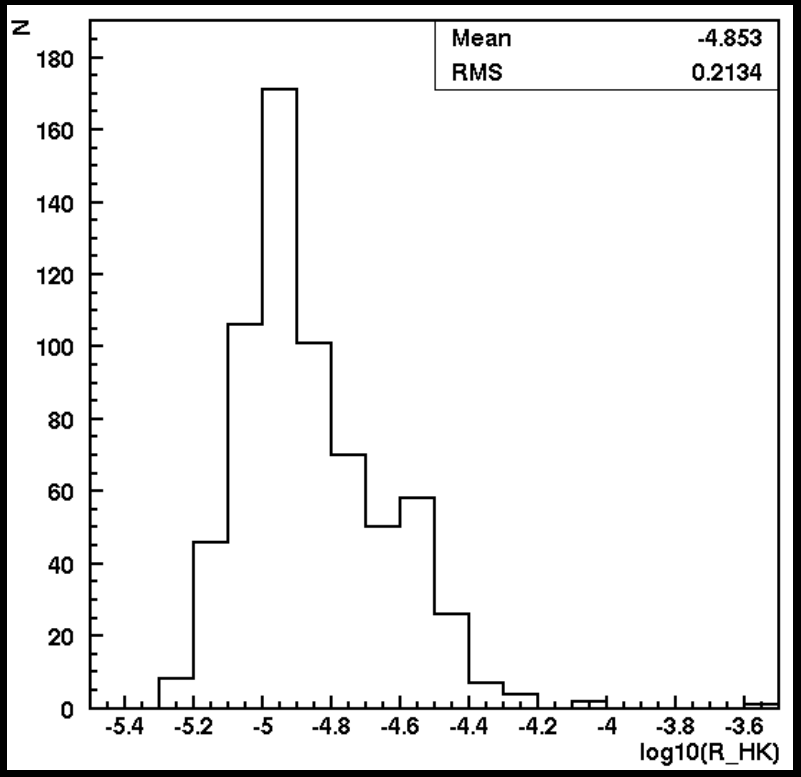
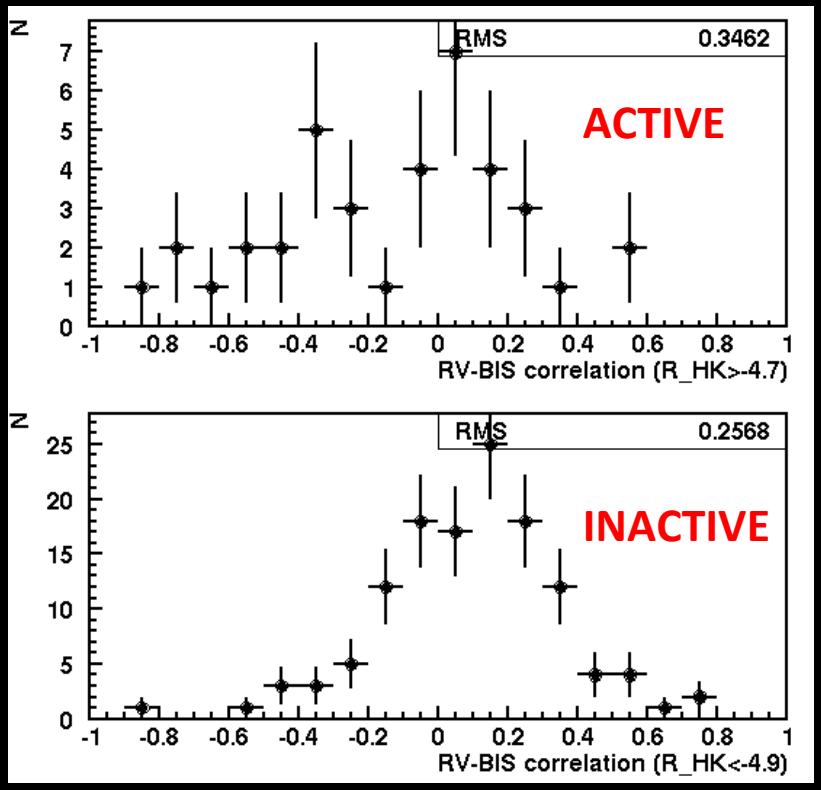
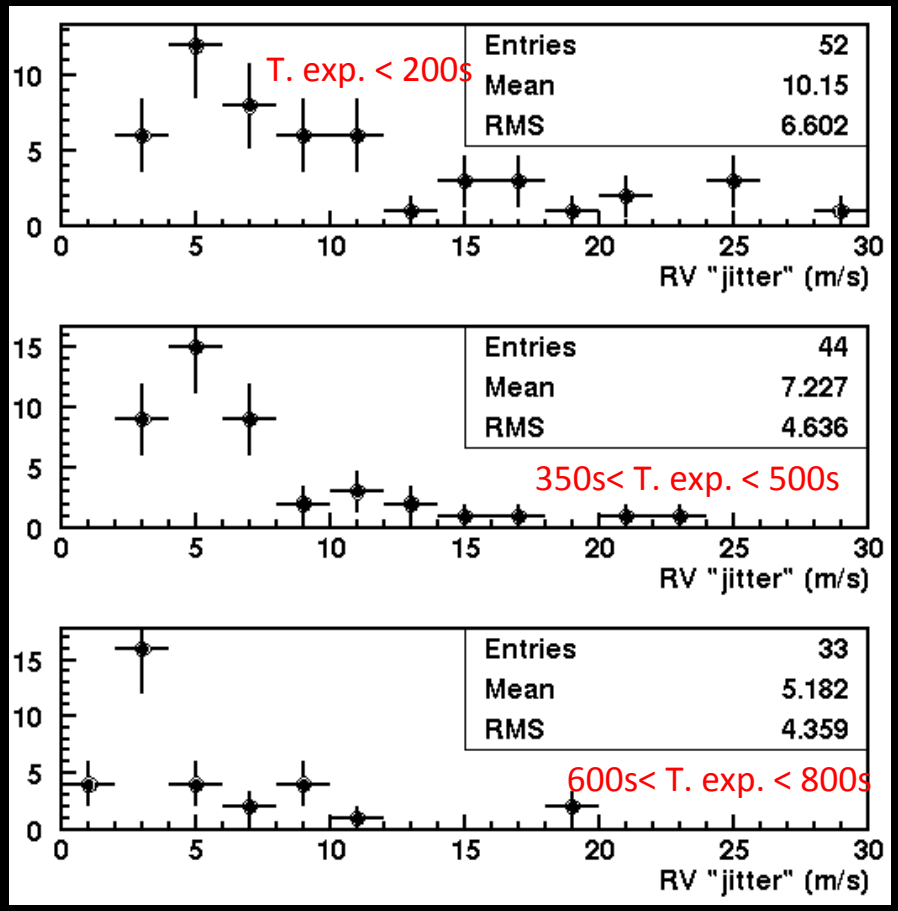




Origin of the signals

- Study the variation of the CCF parameter (BIS, FWHM) and the activity index with RV
- Define the origin of the signal as “stellar” when a clear correlation is detected
  - CAVEAT: absence of correlation does not mean that the signal is “keplerian” (Santos 2004).
- Stellar pulsations are an issue!

S/N constant !



See work by X. Dumusque (A&A 2011)

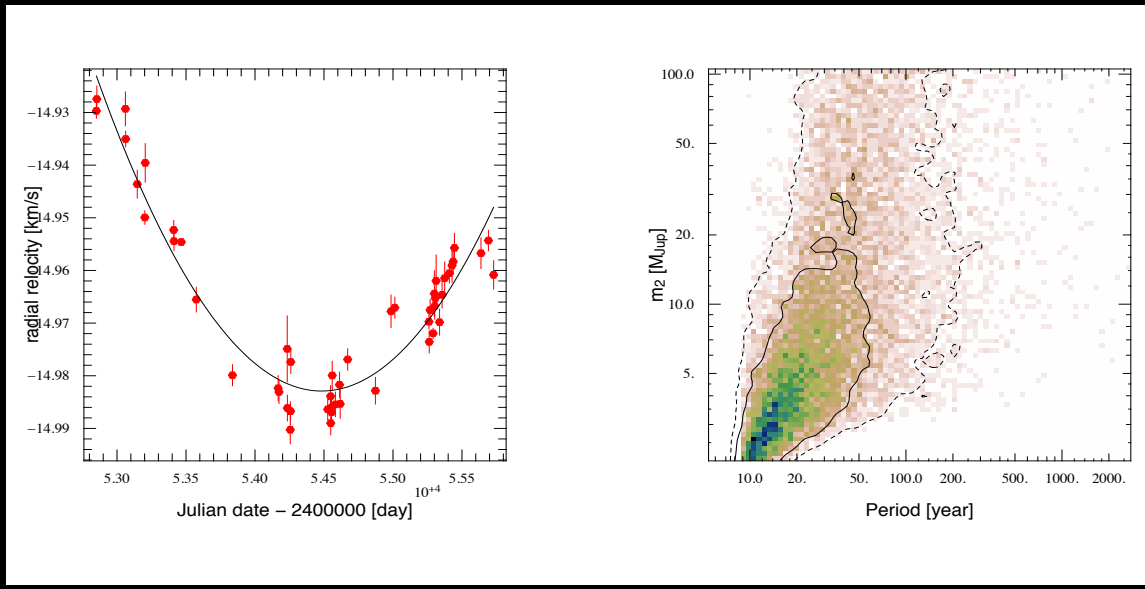
Origin of the signals

Stars with > 5 data points : 422

- Long period drifts => 57
- Confirmed orbits : 47
  - Brown dwarfs => 2
  - Planets => 45
    - in multiple systems 11
    - Neptun mass planets: 3
    - Super-Earth: 1
    - Jupiter mass planets: 41 => ~ 10% yield
- Stars (RV correlates with BIS, FWHM, R_{HK}) => 60

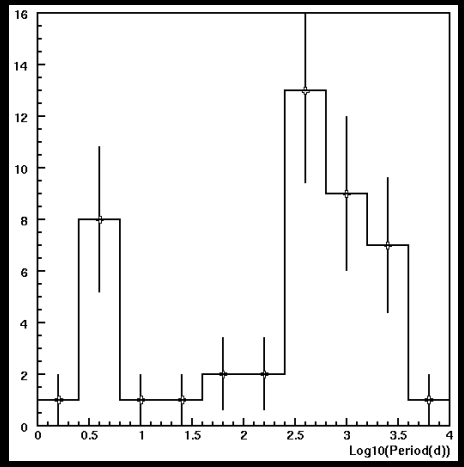
Drifts / incomplete orbits

- Only ~ 50% of the long term drifts analyzed so far
- 80% of the drifts (25 objects) are more likely to be attributed to brown dwarfs candidates
- All the possible brown dwarfs, including the 2 with fully reconstructed orbits lie in the “brown dwarf desert”.

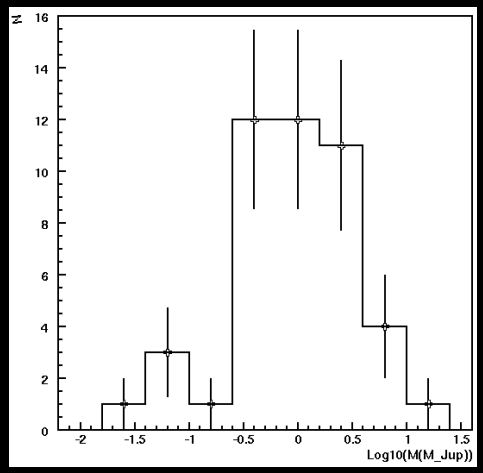


Distribution of the orbital elements

- Bimodal period distribution
  peaks at P ~ 4d – 400d



- Bimodal mass distribution
  peaks at ~ $1M_{Nept}$ and $1\ M_{Jup}$
  Evidence of the peak at low mass
  is only marginal
  Sensitivity very low in this mass range



Multiple planetary systems

11 planets are found in 5 multiple systems:

~ 23% of the planets of this program.

Very similar to the global statistics.

Planets seem to exhibit lower mass when they are in multiple systems:

	All programs	This program
All systems	3.1 M_{Jup}	2.3 M_{Jup}
Multiple systems	2.8 M_{Jup}	1.2 M_{Jup}

Eccentricity

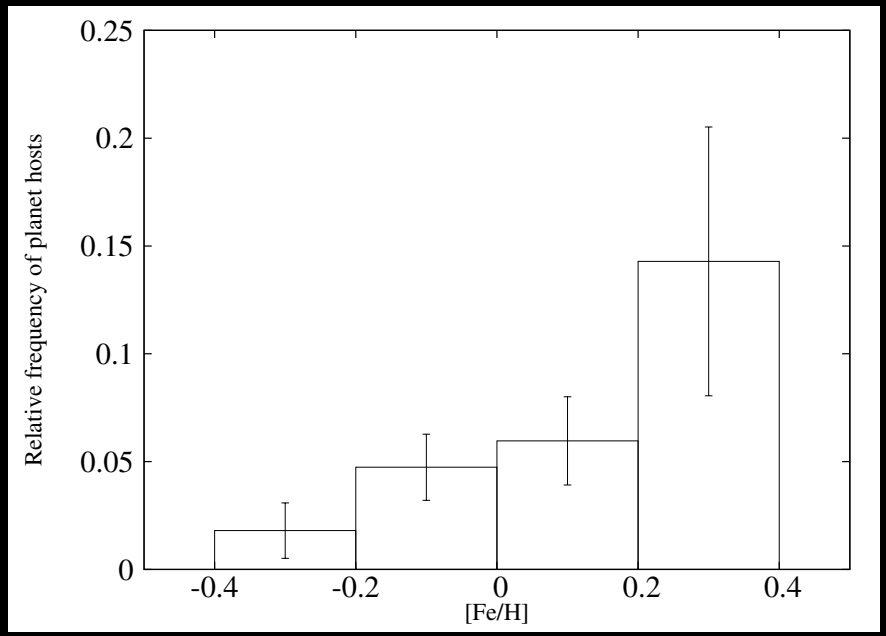
Unconstrained a	All programs	This program
All systems	0.20	0.28
Multiple systems	0.20	0.34

a<0.1	All programs	This program
All systems	0.06	0.07
Multiple systems	0.10	0.16

Work in progress...

Metallicity distribution

- Planet host stars are preferentially metal-rich
- ~ 1/3 hosts have [Fe/H]<=0
- ~ 2/3 hosts have [Fe/H]>0



See also the work of S. Sousa, A&A 2011

Conclusions

- Period distribution is bimodal (peaks at 4d and 400d)
- Mass distribution is bimodal (peaks at ~ 1 Neptune and 1 Jupiter mass)
- (Giant) Planet host stars are metal rich (2/3 have [Fe/H] > 0)
- Multiple planets frequency is of ~ 23%
- Planets in multiple systems have a lower mass (close to a factor 2 less)
- Close in planets in multiple systems seem to have higher eccentricity than single planet systems
- The frequency of Jupiters in our sample is of ~ 10%
- A population of brown dwarfs in the brown dwarfs desert is appearing