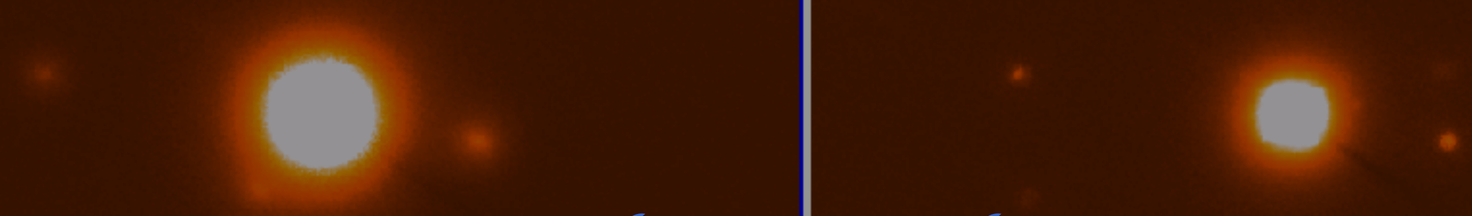
The discovery of a planet in a polar orbit of a star with 1.4 solar-masses



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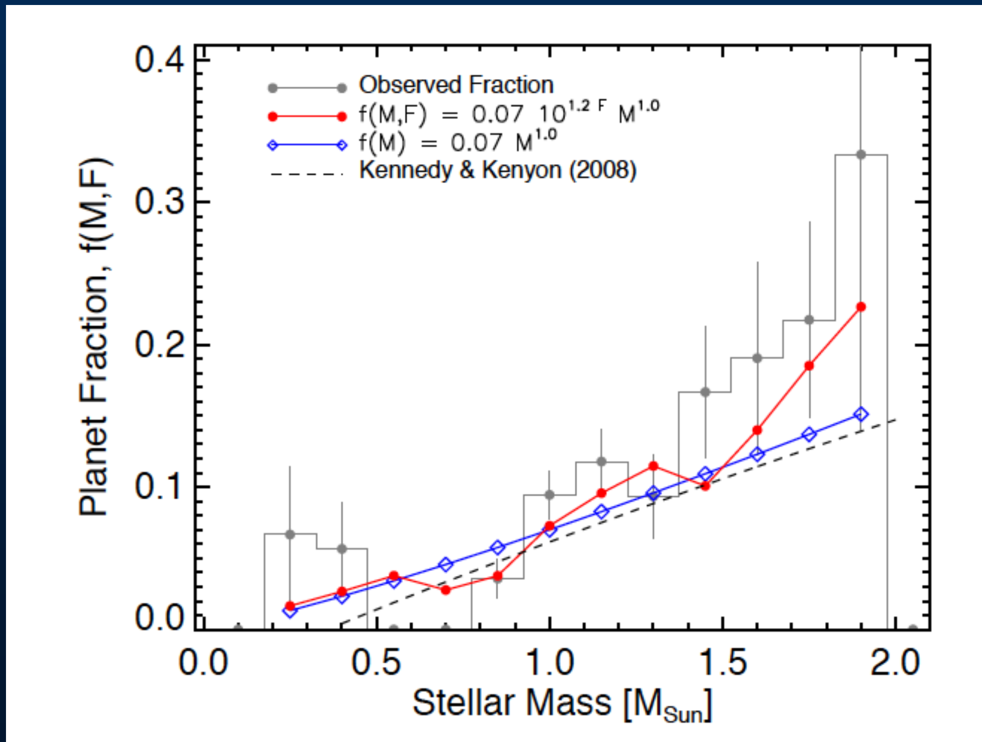
TLS

Surveys of giant stars show that massive stars also have a lot of massive planets.

However, we do not know, whether intermediate-mass stars also have close-in planets!
(The only known transiting plant of an A-star is WASP-33b)



Johnson et al. 2010

Why is it interesting to search for short-period planets of intermediate-mass stars?

- **Theory predicts that stars more massive than the sun should have a higher frequency of planets. However, the life-time of the disk is short (τ_{disk}=2.5 Myrs for M*~1.0 M_{sun}, τ_{disk}=1.2 Myrs for M*>1.3 M_{sun}).**

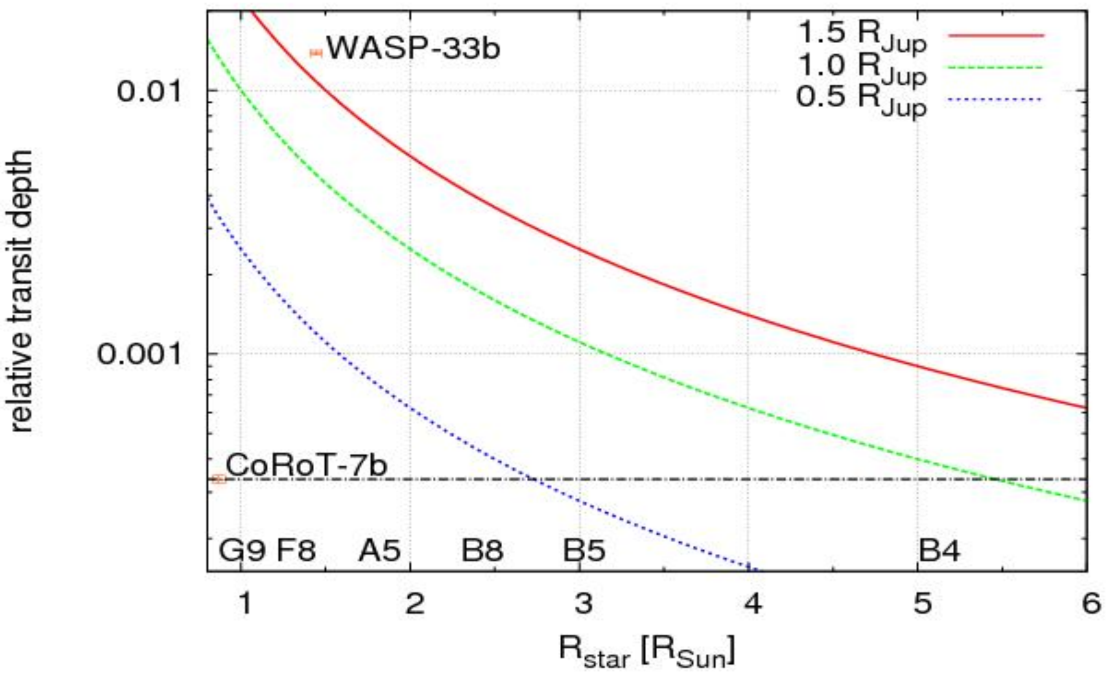
----> Is there enough time for the planets to form and migrate inwards?

- **Close-in planets of intermediate-mass stars would be engulfed when the star becomes a giant: How does this effect stellar evolution?**

- **An A5V star is in the optical regime 14 times brighter than the sun! How does this affect the atmosphere of the planet?**

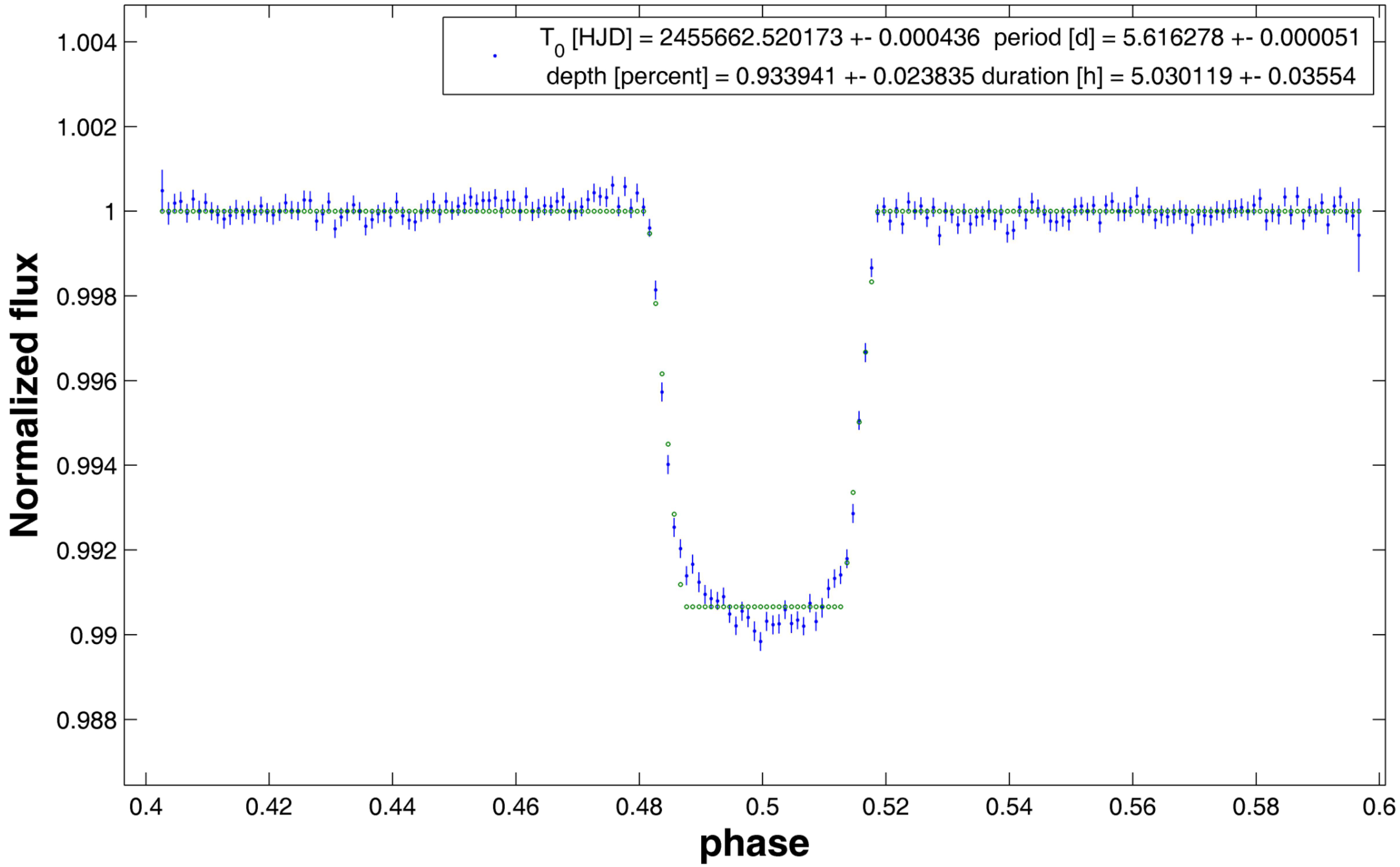
A survey for short period transiting planets of stars more massive than the sun using the CoRoT satellite

CoRoT has the capability to detect hot Jupiters of stars as early as B4V, and planets of 2 R_{Earth} around G-type stars



A new object: CoRoT 35b

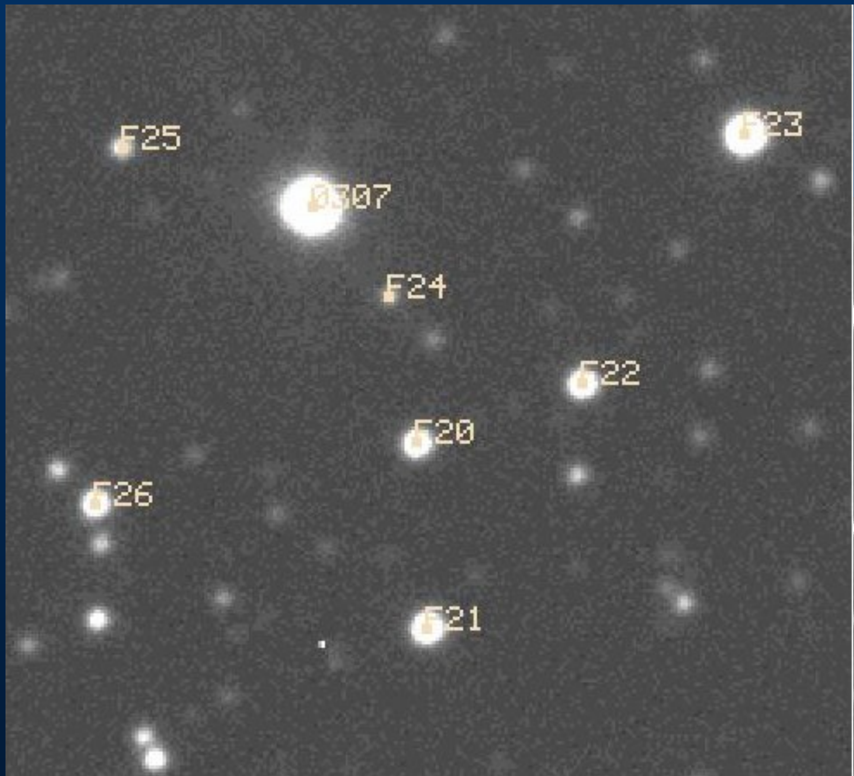
Transit light-curve obtained by CoRoT

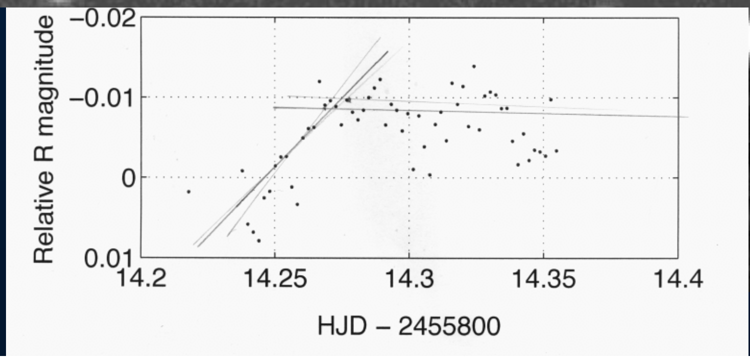


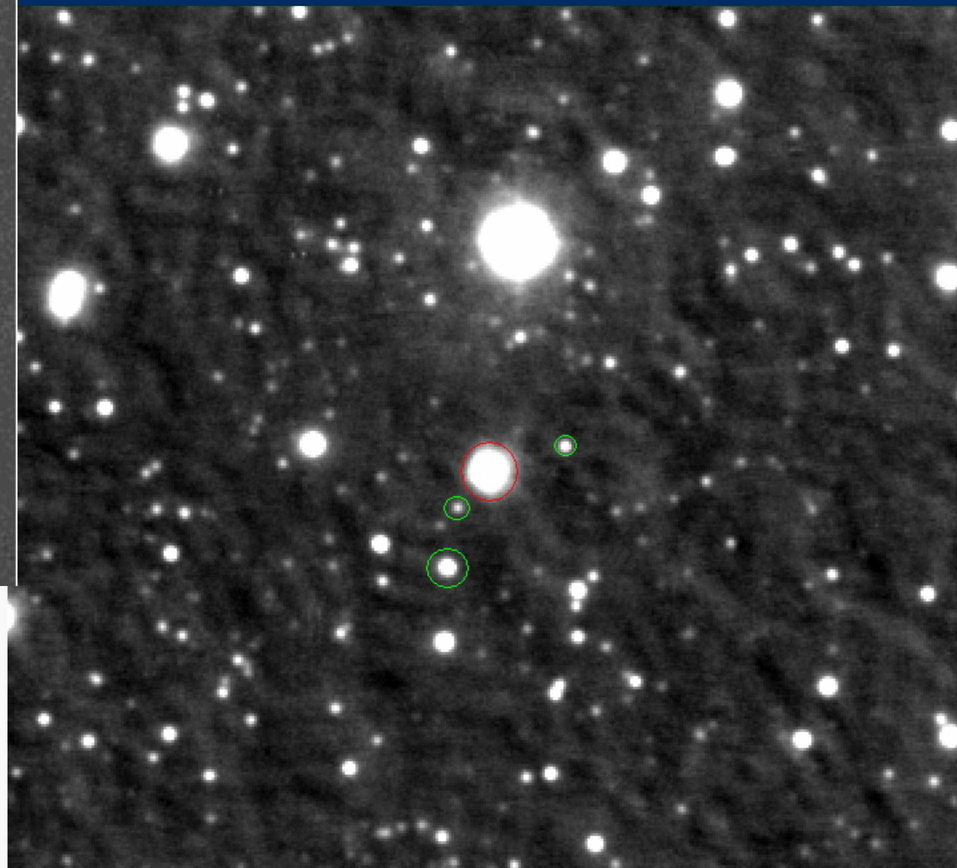
Excluding false-positives

- Detailed modelling of the light-curve
- High-resolution spectrum excludes giant star
- Radial-velocity measurements to exclude binary (M_{planet}<1.4 $M_{Jupiter}$)
- Seeing-limited observation in and out of transit
- AO-imaging

Seeing limited imaging with 1-m WISE& IAC 0.8 m telescopes: Transit is detected on source!



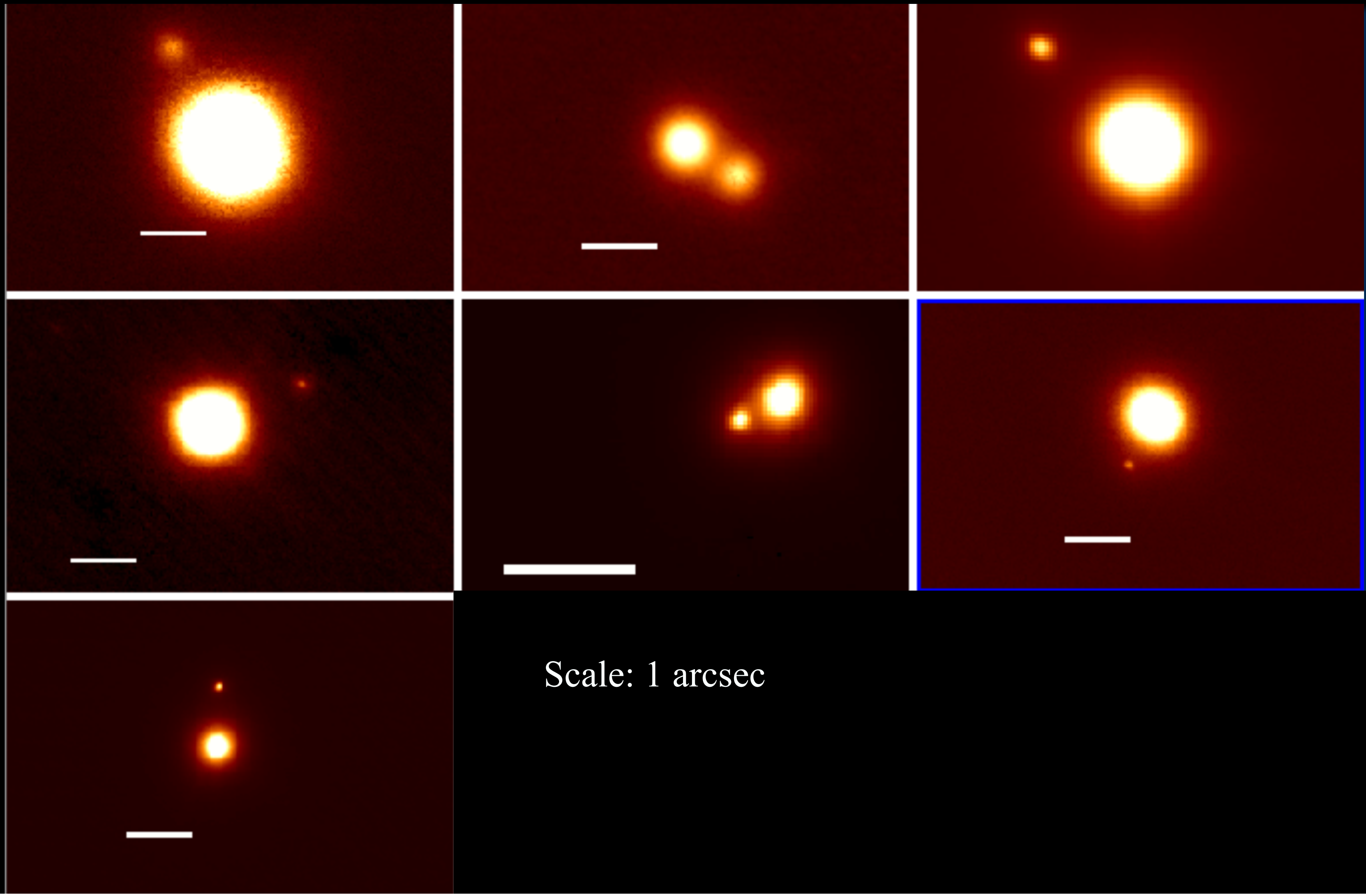




AO-imaging:

Expectation: <10% of the stars should have a companions.

Result: 30-40% have one!

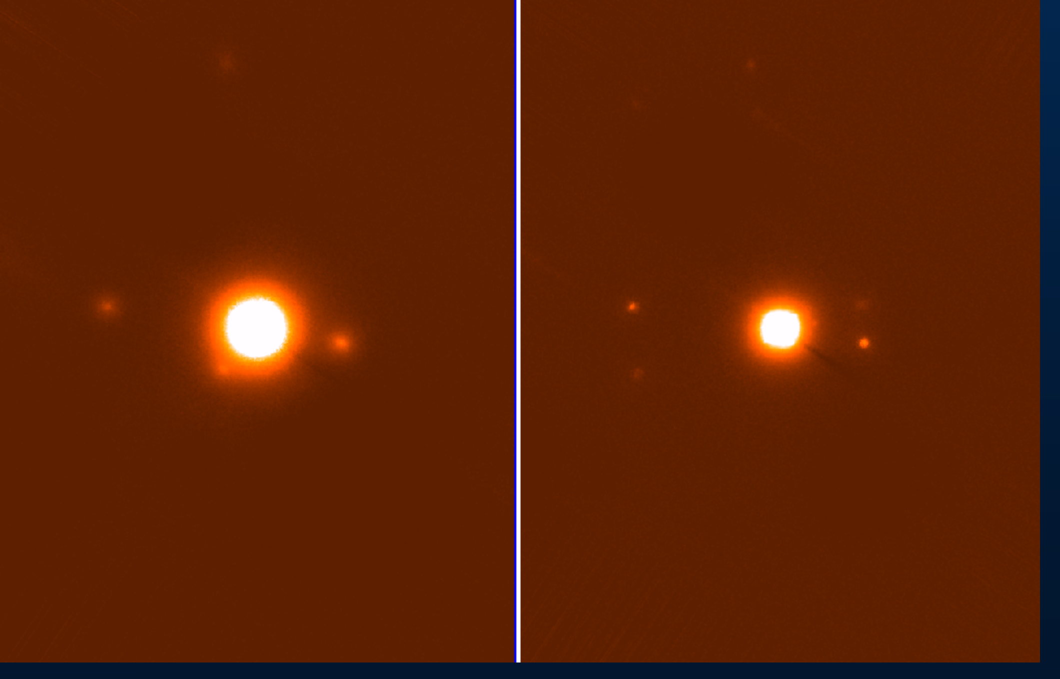


AO-imaging

- PISCES@LBT in J and K-band
- CoRoT LC shows transit with period 5.6d, DF/F=0.9%
- V=13.055+/-0.066 --> we have to exclude stars of V=18.2 mag
- PISCES observations show two additional stars:

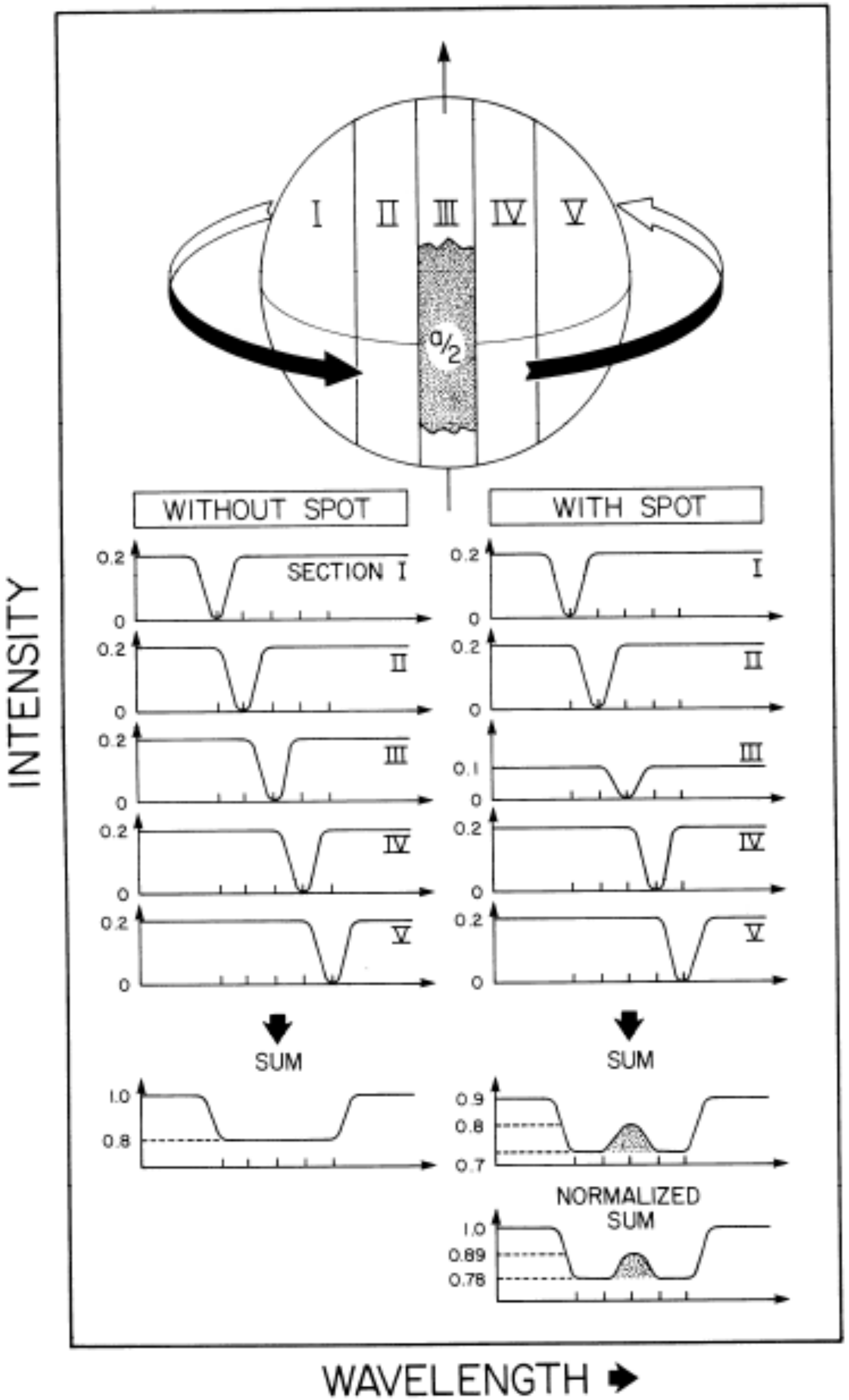
  star1: 1.96 arcsec distance, J=15.7+/-0.1, K=16.2+/-0.1 --> fainter than V=18.2

  star2: 3.46 arcsec distance, J=17.1+/-0.1, K=16.8+/-0.1 --> fainter than V=18.2



CoRoT-35b

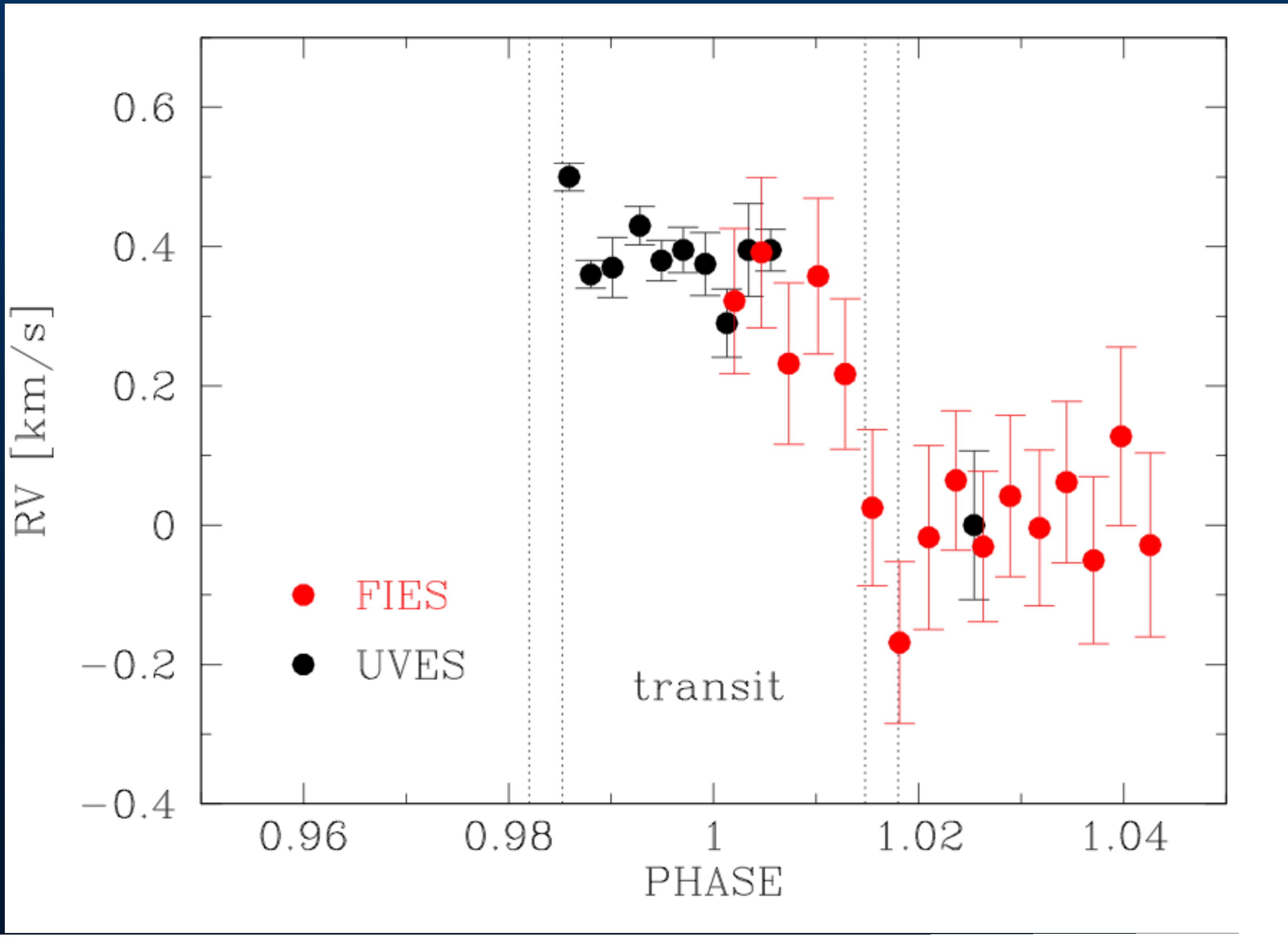
Mass / radius	1.43±0.04 M_{sun} 1.93±0.11 Rs_{un}
spectral type	F4V
T_{eff}	6430±100 K
log(g)	4.0±0.1
v sin i	21 kms^{-1}
[M/H]	0.0±0.0
Orbital period	5.616278±0.000051 days
Planet mass	<1.4 M_{jup}
Planet radius	1.9±0.1 R_{jup}
Orbital separation, a	0.064 AU = 7 R_{star}
Projected obliquity λ	90° VTLS-UVES, NOT-FIES



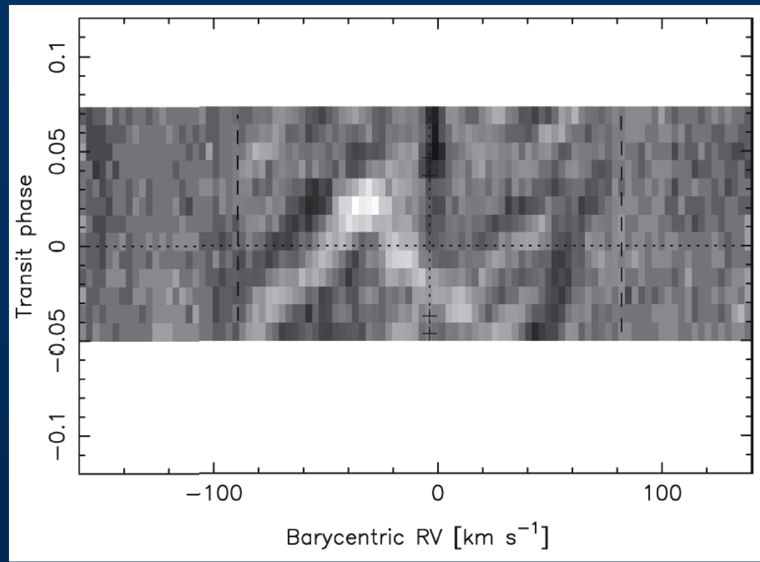
Detecting planets in rapidly rotating stars using time resolved spectroscopy

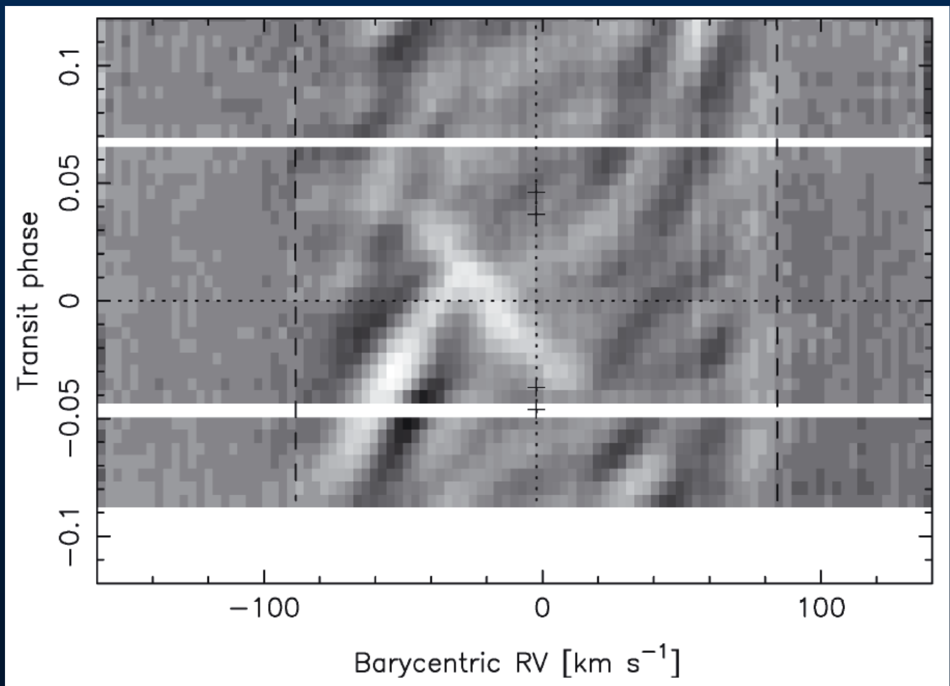
Volgt &Penrod 1983

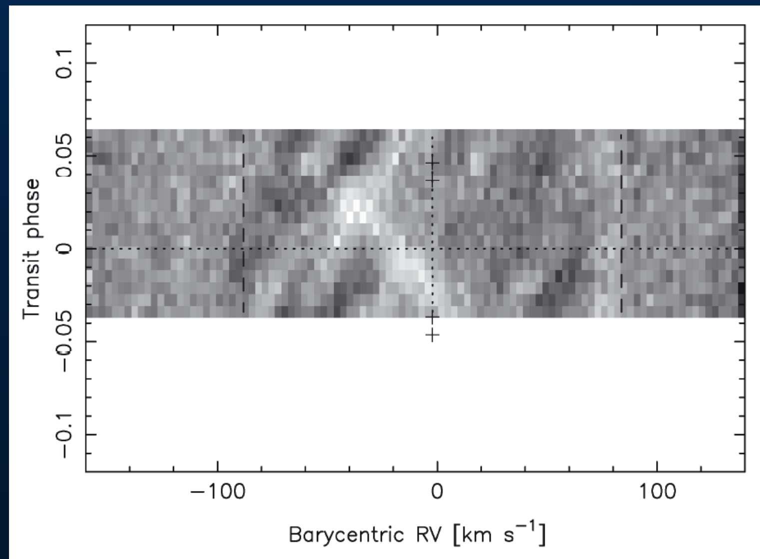
RV-measurements during the transit



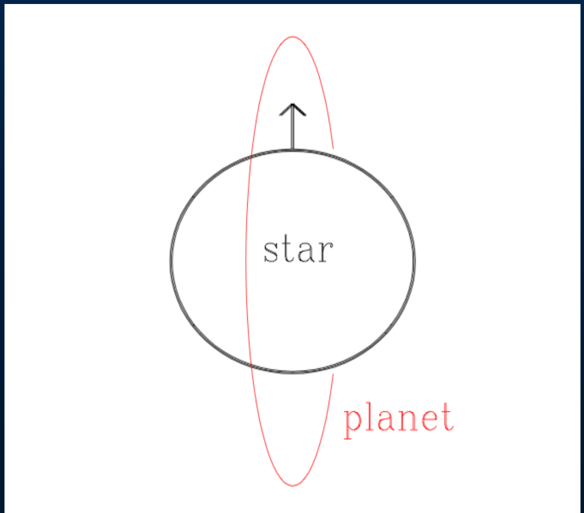
HD15082b (WASP-33b): Time series of the residual average spectral line: the “white” line from the middle right to the upper left is the signature of the planet (NOT, McDO, TLS-data)

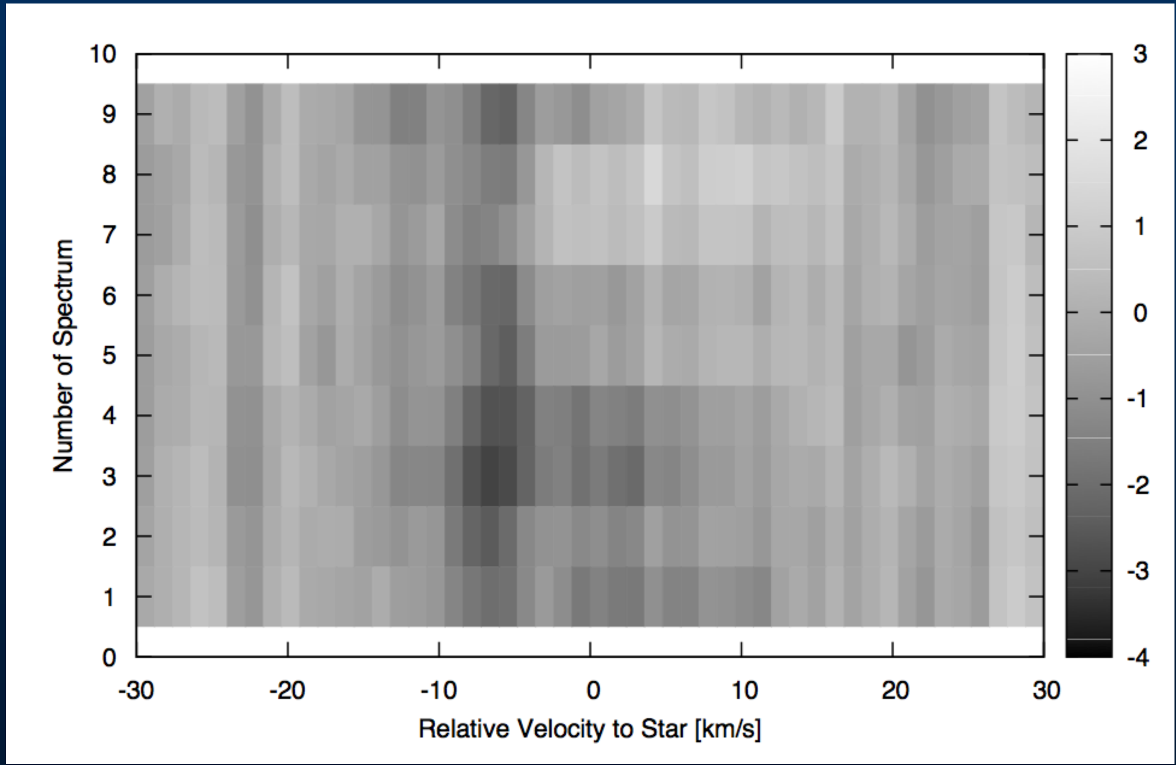






Time-resolved spectroscopy of CoRoT-35b: The planet has a polar orbit!





Sub-stellar companions orbiting stars with M>1.1 M_{sun} discovered by CoRoT

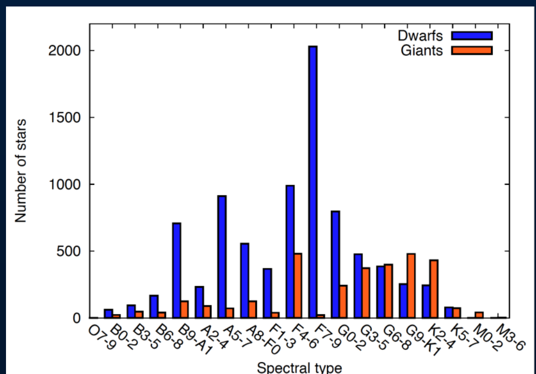
Name	M_{star}	Period[d]	Rplanet [R_{Jup}]	Mplanet [M_{Jup}]	Density [g cm^{-3}]
CoRoT-3b	1.37±0.09	4.3	1.01±0.07	21.7±1.0	26.4±5.6
CoRoT-15b	1.32±0.12	3.0	1.12±0.23	63.3±4.1	59±35
CoRoT-21b	1.29±-0.09	2.7	1.30±0.14	2.53±0.37	1.53±0.53
CoRoT-11b	1.27±-0.05	3.0	1.43±0.03	2.33±0.34	0.99±0.15
CoRoT-19b	1.20±-0.05	3.9	1.29±0.03	1.14±0.05	0.51±0.05
CoRoT-4b	1.16±-0.02	9.2	1.17±0.05	0.75±0.01	0.58±0.15
CoRoT-22b	1.15±-0.08	9.7	0.52±0.12	<0.15	<1.3
CoRoT-20b	1.14±-0.08	9.2	0.84±0.04	4.24±0.23	9.87±1.10
CoRoT-23b	1.14±-0.08	3.6	1.05±0.13	2.8±0.3	3.3±1.0
CoRoT-14b	1.13±-0.09	1.5	1.09±0.07	7.6±0.6	7.3±1.5
CoRoT-35b	1.4	5.6	1.9	<1.4	

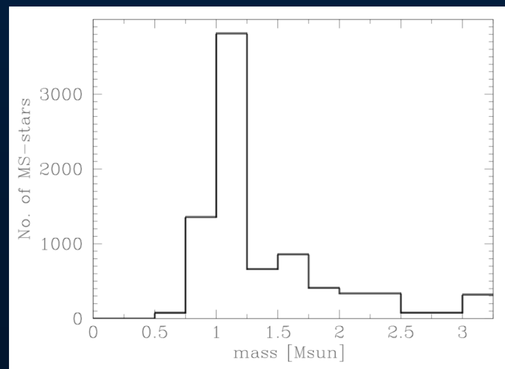
Statistics of the planet discoveries:

- 0-5% are orbiting stars of 1.3-3.2 M_{sun} ("A-stars")
- 30-32% are orbiting stars of 1.1 to 1.3 M_{sun} ("F-stars")
- 50-54% are orbiting stars of 0.9- 1.1 M_{sun} ("G-stars")
- 13-16% are orbiting stars of 0.4-0.8 M_{sun} ("K-stars")

The sample:

- 16% are stars of 1.3-3.2 M_{sun} ("A-stars")
- 35% are stars of 1.1 to 1.3 M_{sun} ("F-stars")
- 15% are stars of 0.9- 1.1 M_{sun} ("G-stars")
- 5% are stars of 0.4-0.8 M_{sun} ("K-stars")





Results:

---> We have survey 19 candidates with spectral-types B5V to F8V.

---> Although 25% of the CoRoT stars have masses in the range from 1.5 and 3.2 M_{sun}, we found only 1-2 that have sub-stellar companions.

--> We do not find the same rapid increase of the frequency of massive planets for close-in planets as it is found for planets at large orbital distance (RV-surveys of giant stars).

---> The number of planets found for stars in the mass-range between 1.1 and 1.5 M_{sun} is within the errors the same as for solar-like stars.