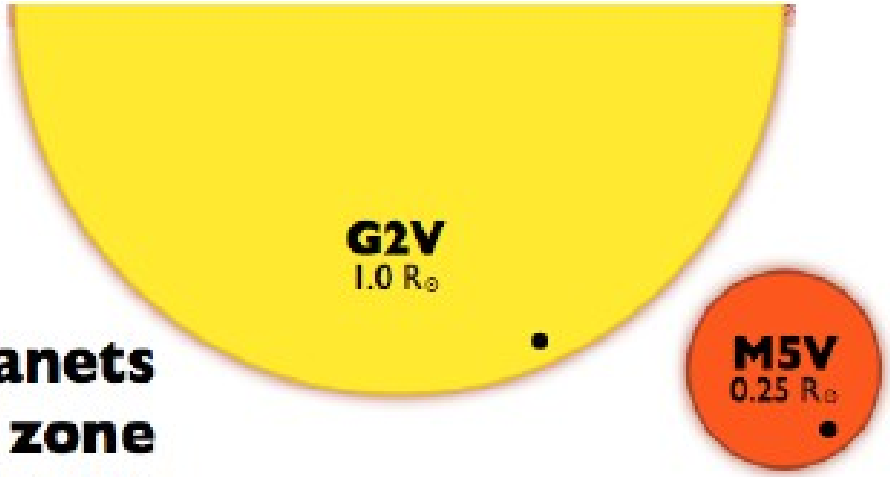
NIRPS Transit Follow-ups

Transiting planets around M-dwarfs :



super-Earth planets
in the **habitable zone**
2 $R_\oplus$, 7 $M_\oplus$, Earth-like insolation

transit depth =	**0.03%**	**0.5%**
Doppler wobble =	**60 cm/s**	**5 m/s**
transit probability =	**0.5%**	**1.5%**
orbital period =	**1 year**	**2 weeks**

Nutzman & Charbonneau (2008)

Cool and ultra-cool stars very frequent in the Galaxy
Small size, mass, temperature make transit of habitable planets much more frequent
Maximise the amplitude of atmospheric signatures detectable with JWST and E-ELT.

Slide courtesy of F.Bouchy

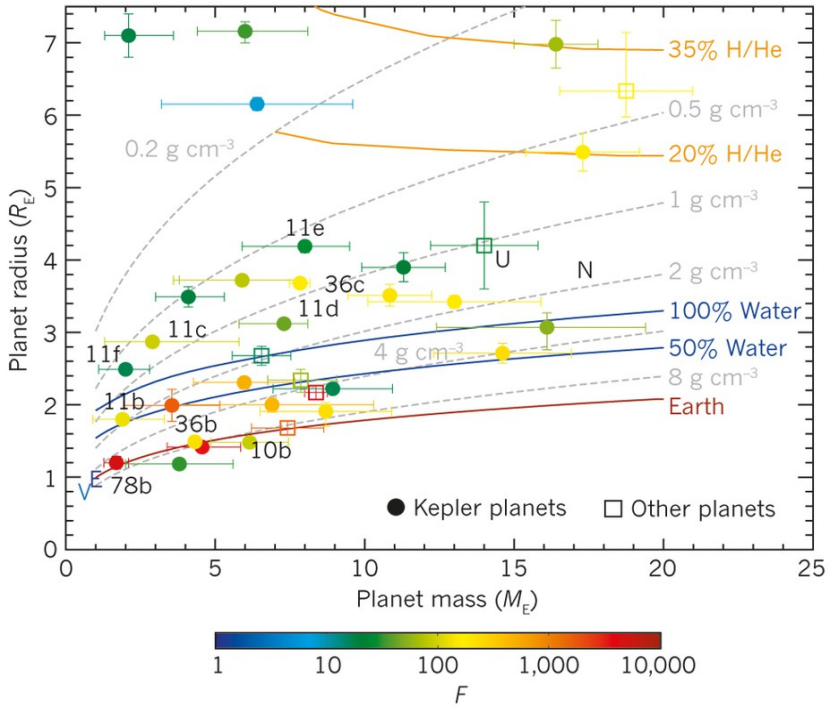
Transit Follow-ups

Sciences Objectives

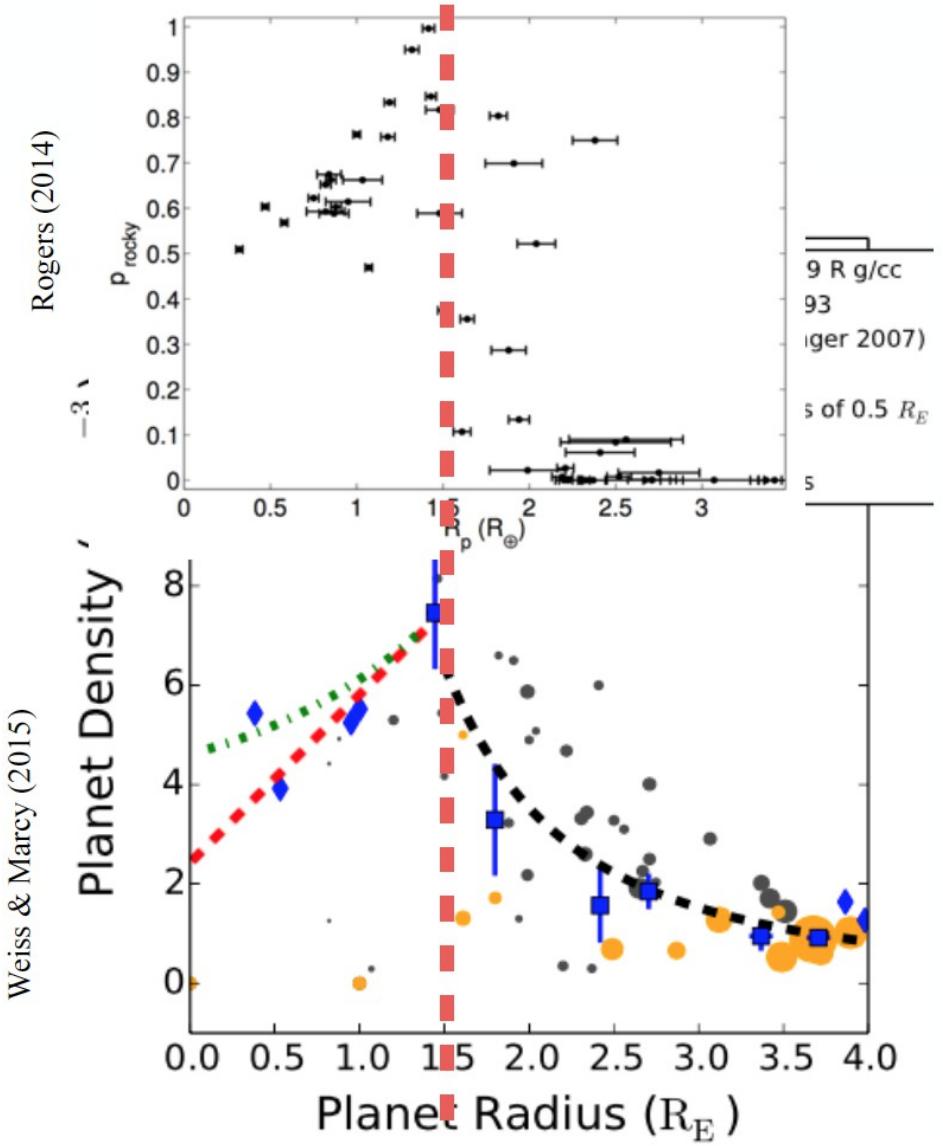
- Confirm planets candidates from transit survey
- Measure mass of Super-Earth planets with typical accuracy of ~10 % ?
- Search for supplementary planets in transiting system
- RV measurement of mono-transit candidates ?
- ...

- Characterize planetary internal structure in measuring the mass
- Characterize star-planet obliquities : Rossiter McLaughlin measurements ?
- Search/confirm the best transit candidates (telluric ?) for atmospheric characterization (JWST/ELT)
- Characterize system dynamic
- ...

Transit Follow-ups



Lissauer et al. 2014



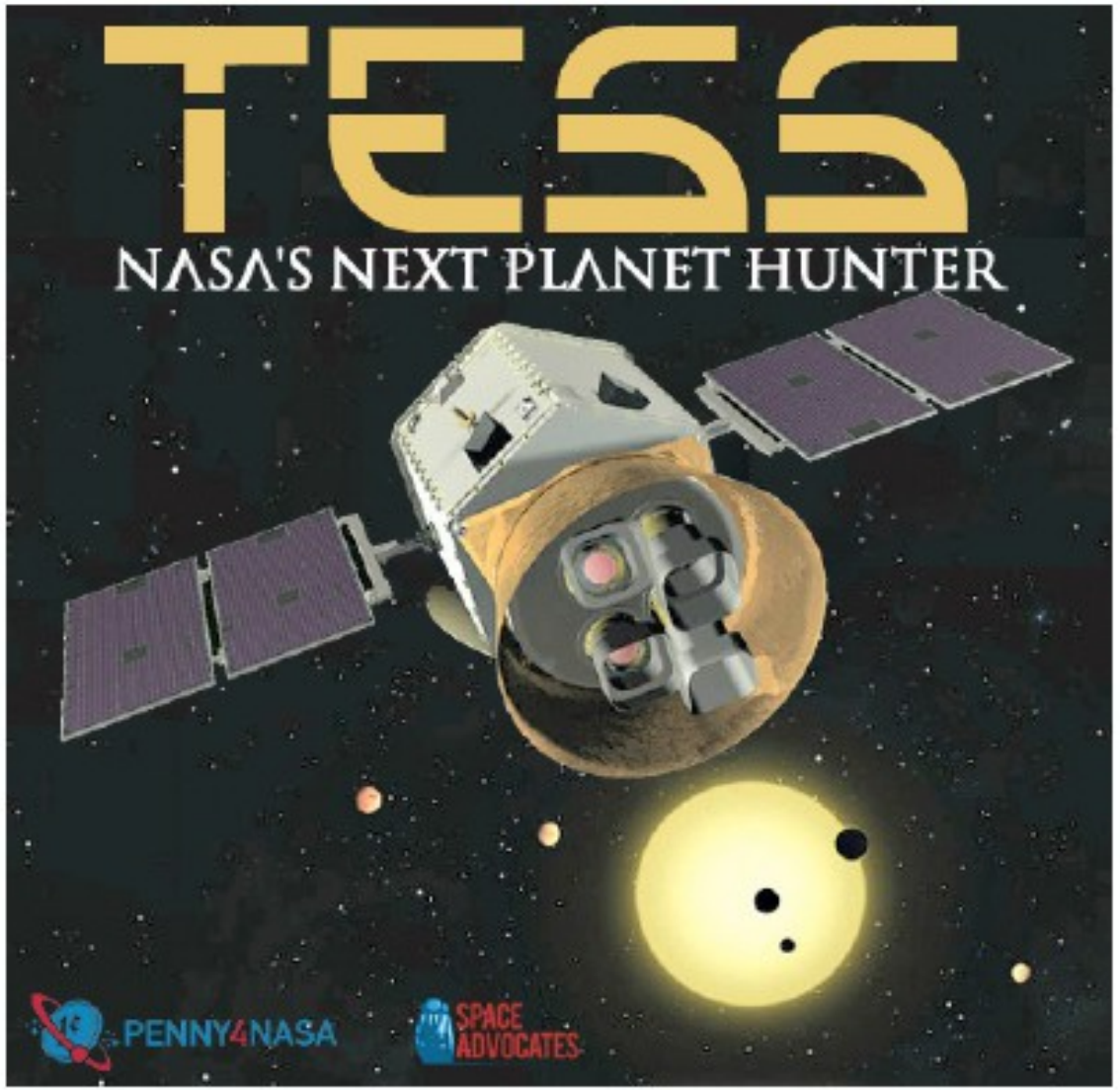
Obtain mass determination w. accuracy < 10 %

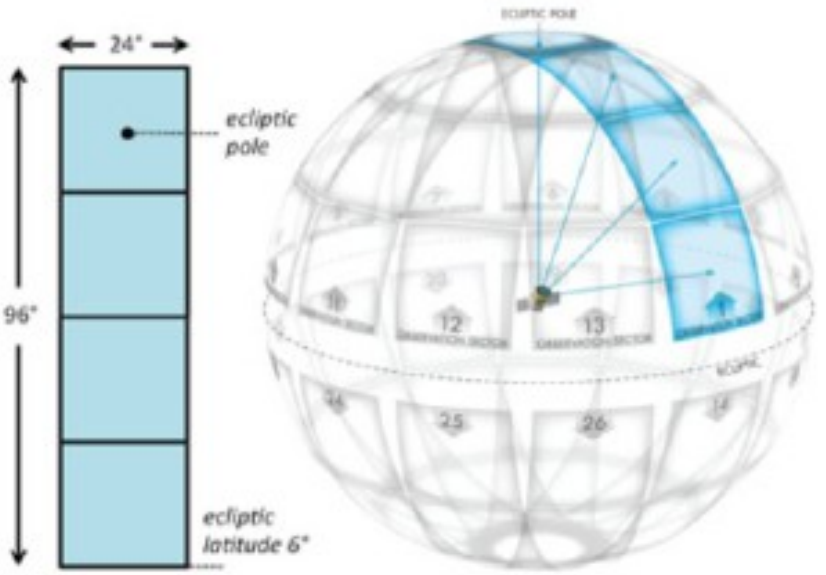
Transit Follow-ups

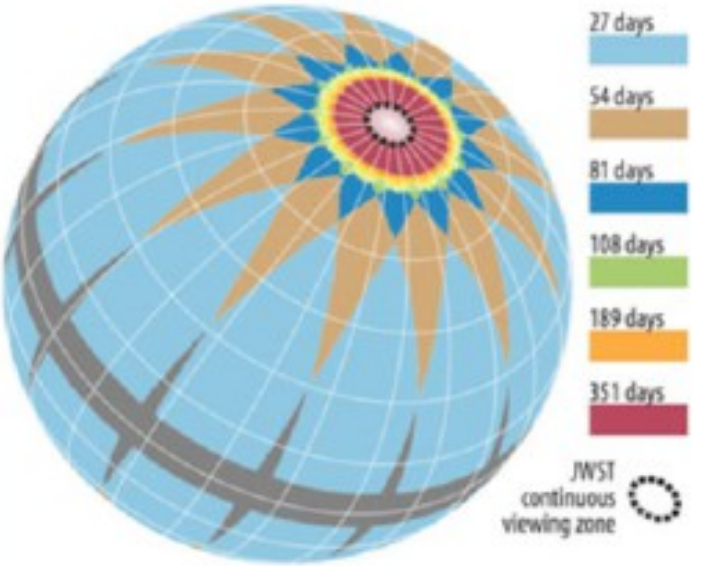
Transit Surveys :

- TESS
- K2
- ExTrA
- SPECULOOS
- Mearth
- APACHE
- NGTS

TESS



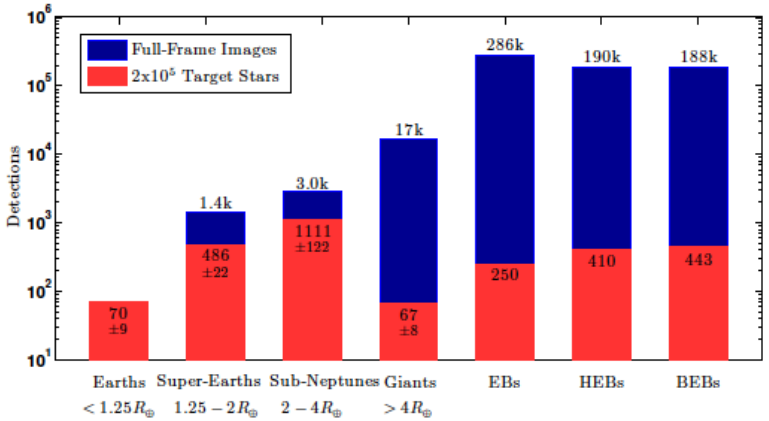


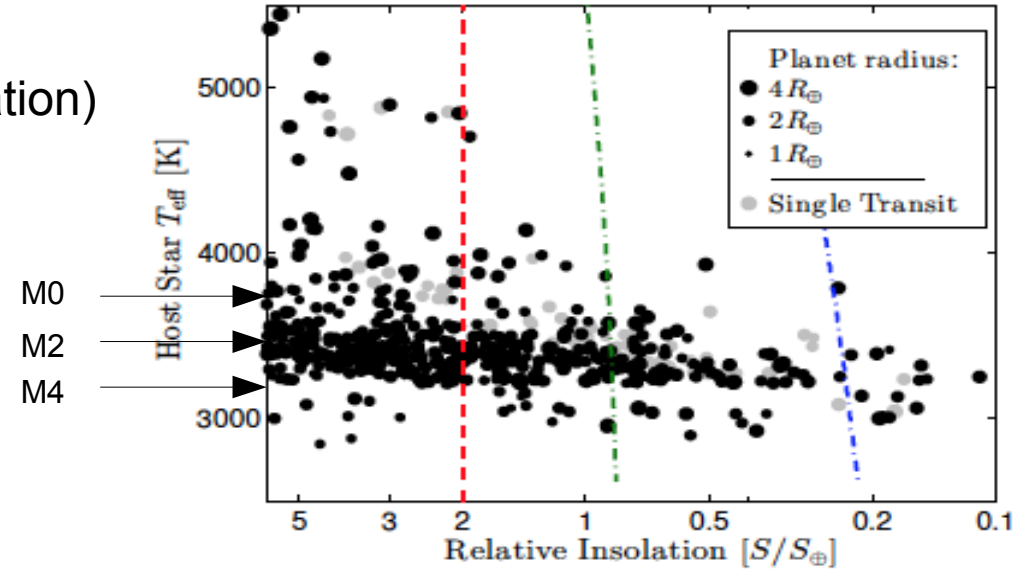


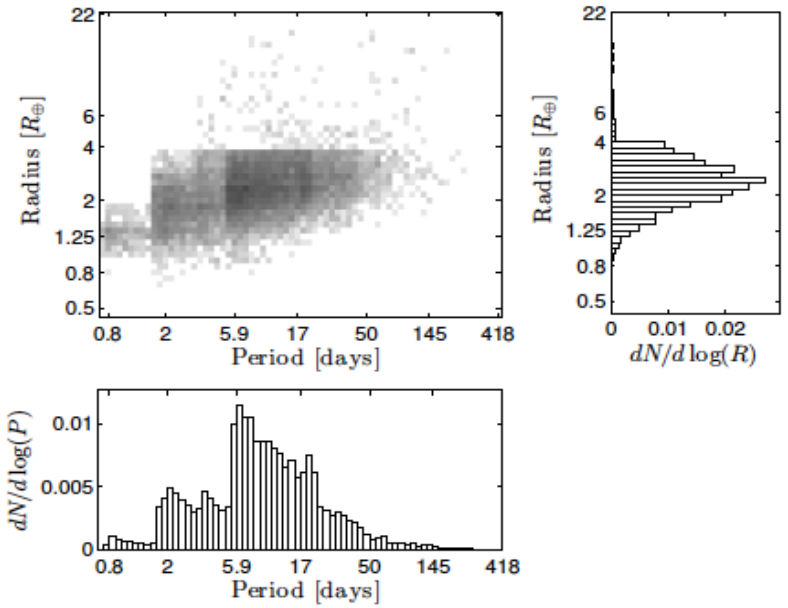
Slide courtesy of X.Bonfils

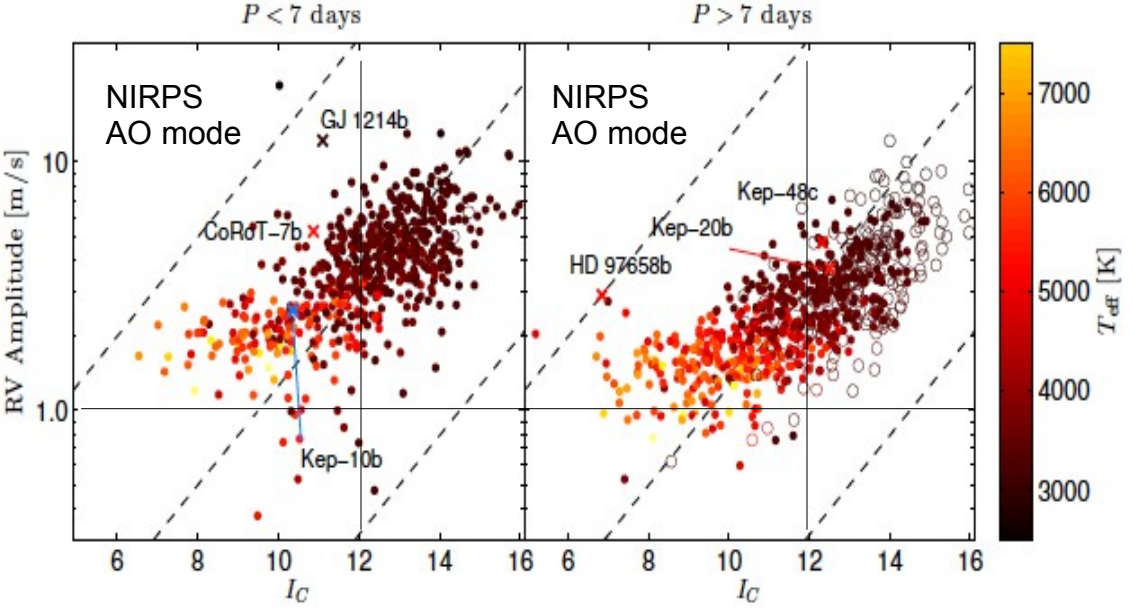
Transit Follow-ups

TESS (Sullivan et al. 2015 detections simulation)









Transit Follow-ups

TESS (Sullivan et al. 2015 detections simulation) :

Early to mid M

AO mode : I = 12 → K = 10

~10 planets Rp < 2Rearth in HZ

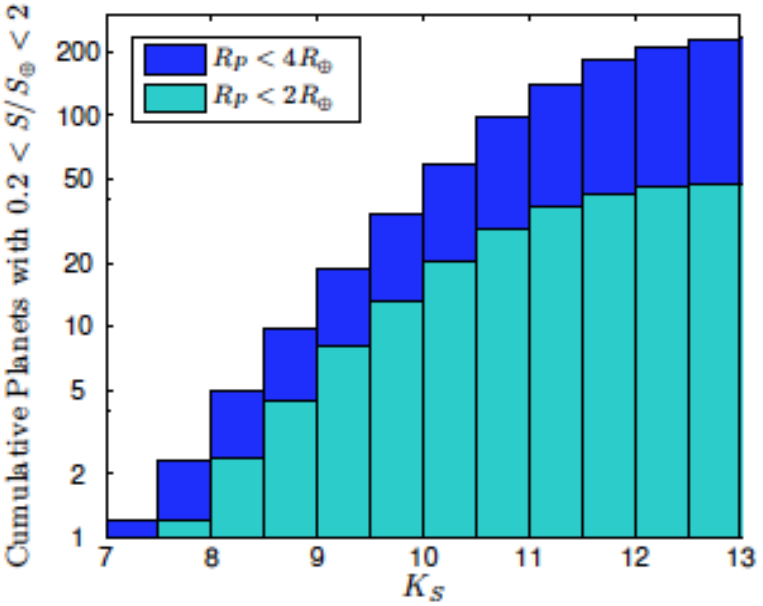
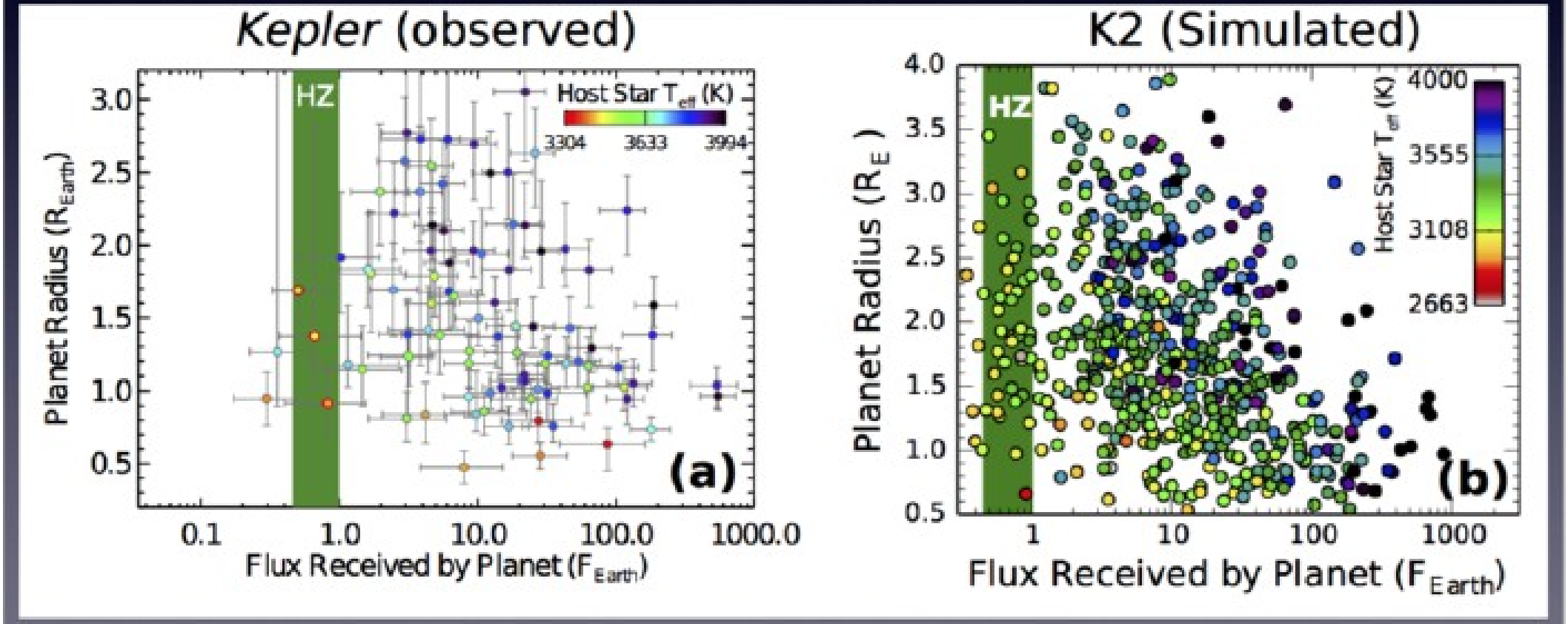


FIG. 33.— The cumulative distribution of apparent K_s magnitudes of the *TESS*-detected planets with $0.2 < S/S_\oplus < 2$.

K2 M Dwarf Planet Yield

- K2 will observe ~60000 M dwarfs, 400 planets predicted
  - Nearby Stars
  - HZ planets and Transit Spectroscopy Targets



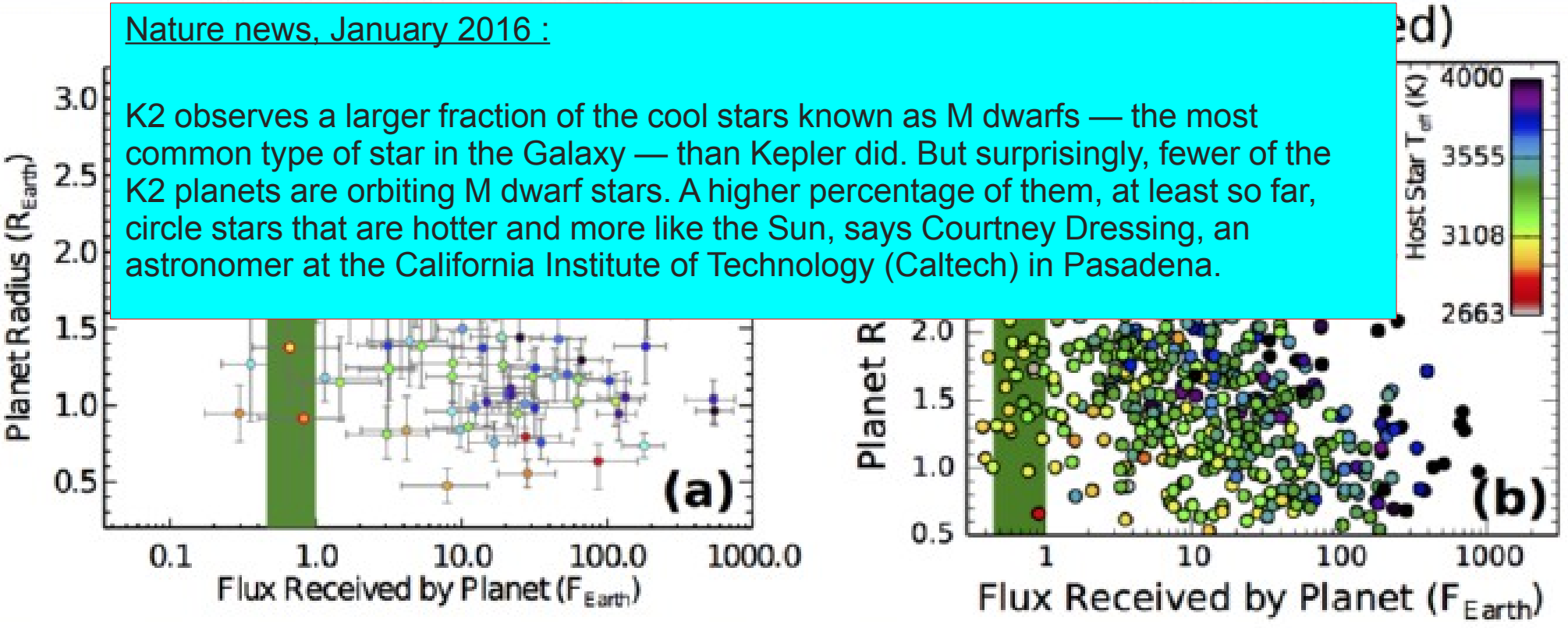
slide courtesy of Ian Crossfield

K2 M Dwarf Planet Yield

- K2 will observe ~60000 M dwarfs, 400 planets predicted
  - Nearby Stars
  - HZ planets and Transit Spectroscopy Targets

Nature news, January 2016 :

K2 observes a larger fraction of the cool stars known as M dwarfs — the most common type of star in the Galaxy — than Kepler did. But surprisingly, fewer of the K2 planets are orbiting M dwarf stars. A higher percentage of them, at least so far, circle stars that are hotter and more like the Sun, says Courtney Dressing, an astronomer at the California Institute of Technology (Caltech) in Pasadena.



slide courtesy of Ian Crossfield

K2-3 could become the 1st system with a HZ planet candidate w/ both mass and radius

Kepler photometry

Crossfield et al. (2015)

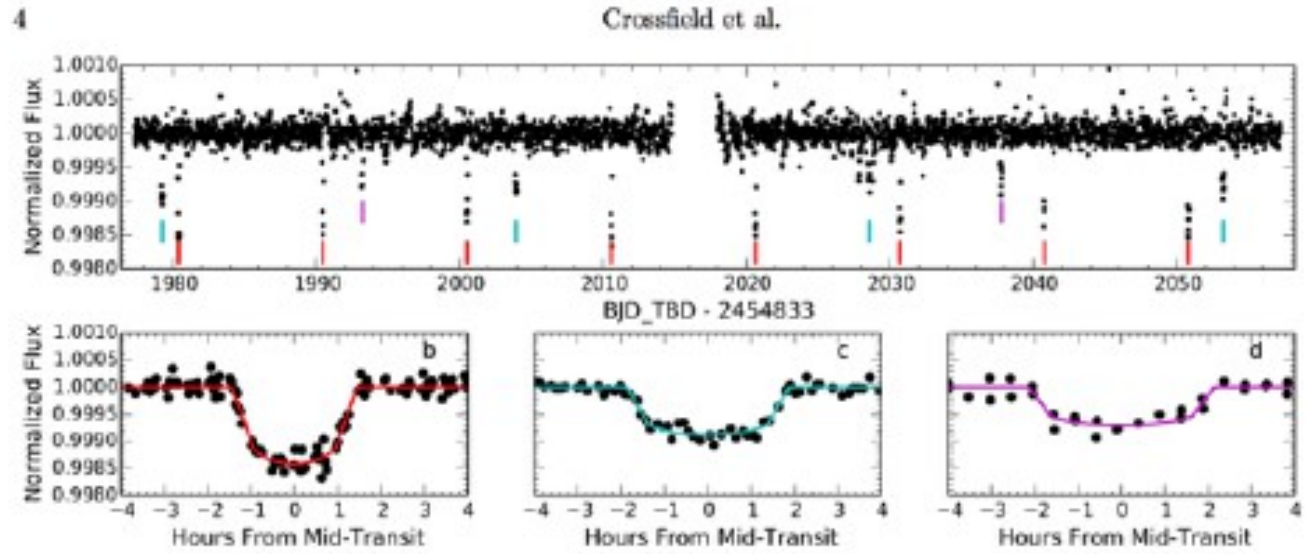
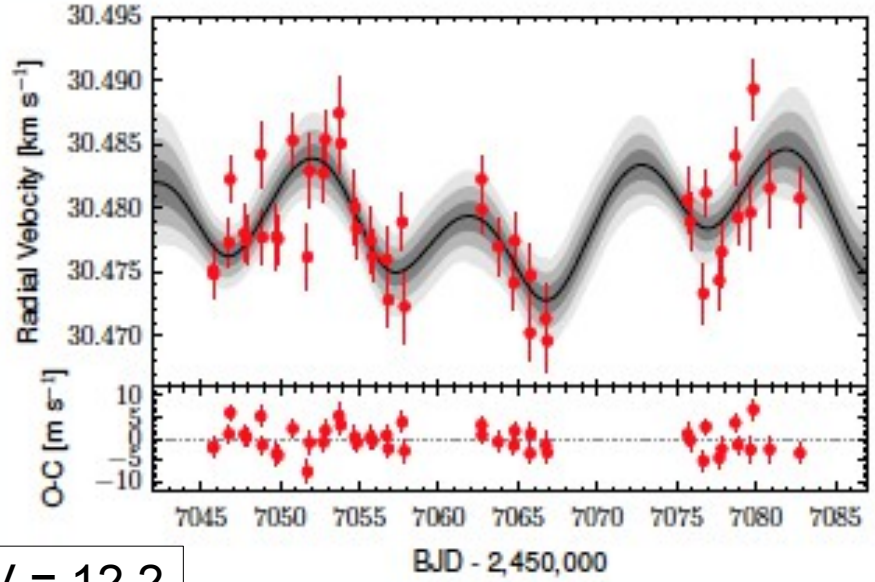
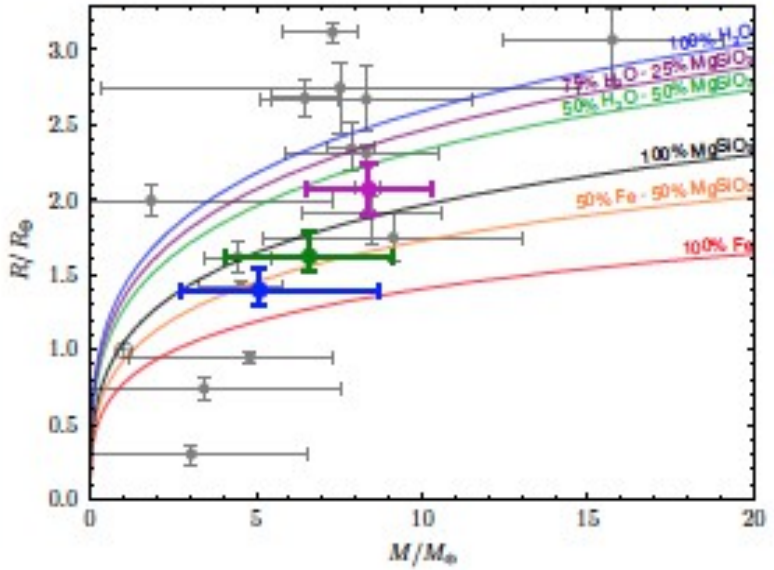


FIG. 1.— *Top:* Calibrated K2 photometry for EPIC 201367065. Vertical ticks indicate the locations of each planets' transits. *Bottom:* Phase-folded photometry and best-fit light curves for each planet.

HARPS RV

Almenara, Astudillo-Defru, Bonfils et al. sub. A&A





V = 12.2
J = 9.4
H = 8.8

I ~ 10.8 : NIRPS AO mode

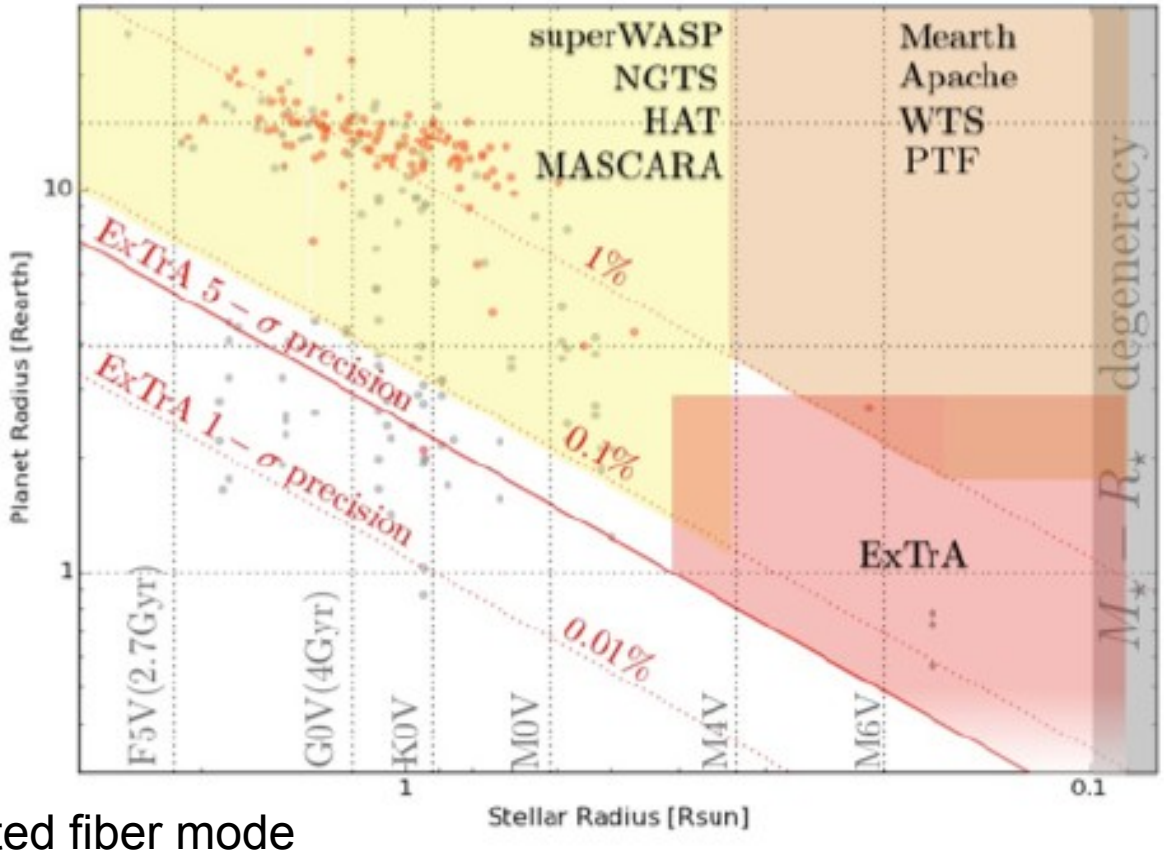
Slide courtesy of X.Bonfils

Transit Follow-ups

ExTrA (Bonfils et al.) SPECULOOS (Gillon et al.) :

SPECULOOS : near IR photometry –-> M5-M9
ExTrA : near IR spectro-photometry –-> M4-L0

M4 - M7 J = 8 - 11
M8 - L0 J = 11 - 13

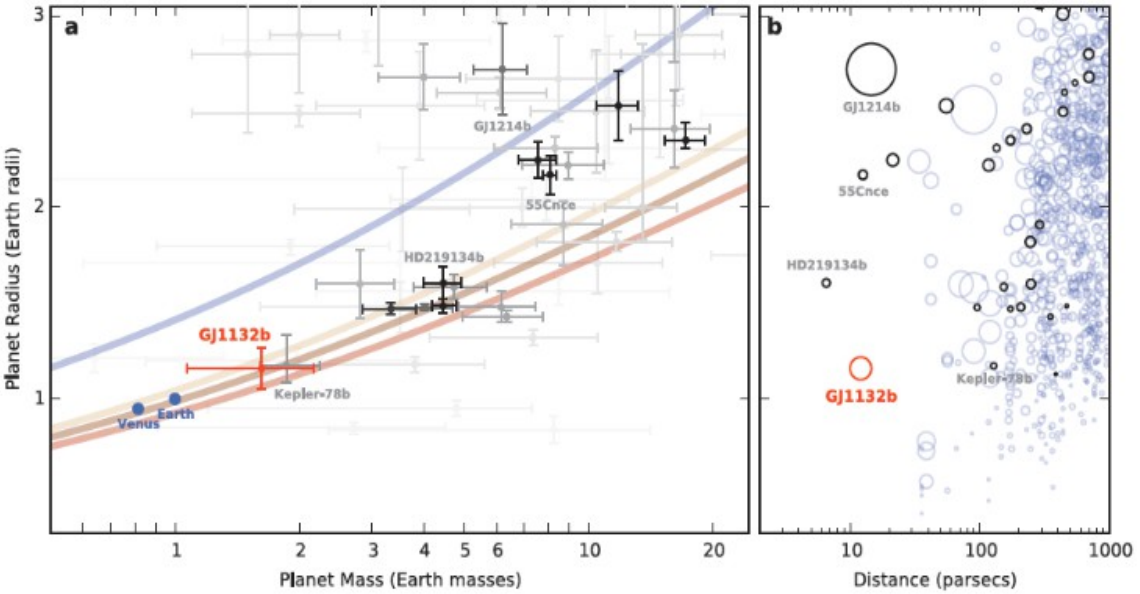


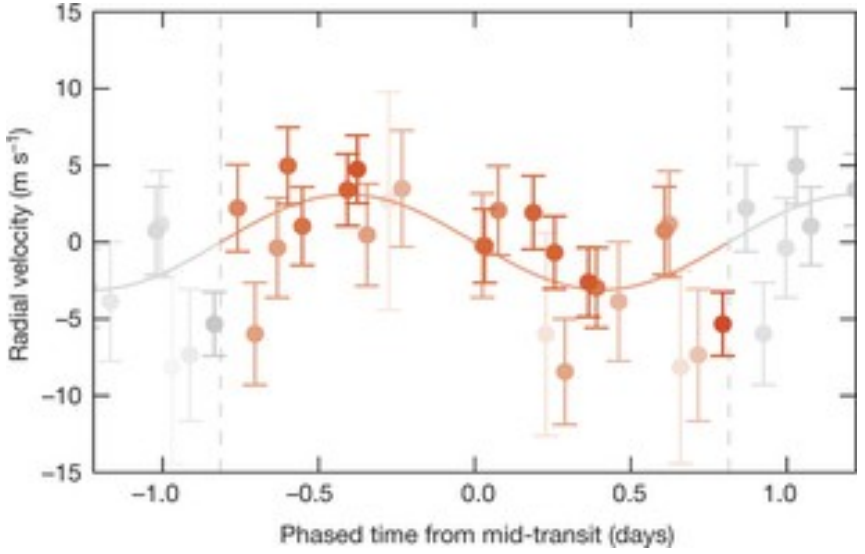
Detection of Earth Radius planets around Mid to Late M

I > 12... Not observable with NIRPS AO
Follow up with NIRPS seeing limited fiber mode

Transit Follow-ups

Mearth :





GJ1132b :
Mp ~ 1.5 - 2Mearth
GJ1132 (M4) :
J = 9.2 ; I~10.6

GJ1214b :
Mp ~ 6.55 Mearth
GJ1214
J=9.7 ; I=11.52

Transit Follow-ups

Surveys :

- TESS : Numerous planets around early M at short P. Very few in HZ
- K2 : Numerous planets around early-mid-M dwarfs, faintest that TESS candidates (close or above to the NIRPS AO mode)
- ExTrA : Late-M several candidates per year
- SPECULOOS : Late-M several candidates per year
- Mearth : Early – Mid – M ; few candidates
- APACHE : Early–M ; few candidates
- NGTS : Early–M ; few candidates

Transit Follow-ups in nIR

Coordination with :

- CARMENES/SPIRou ?