Ages & compositions of the CoRoT giant planets: a synthesis

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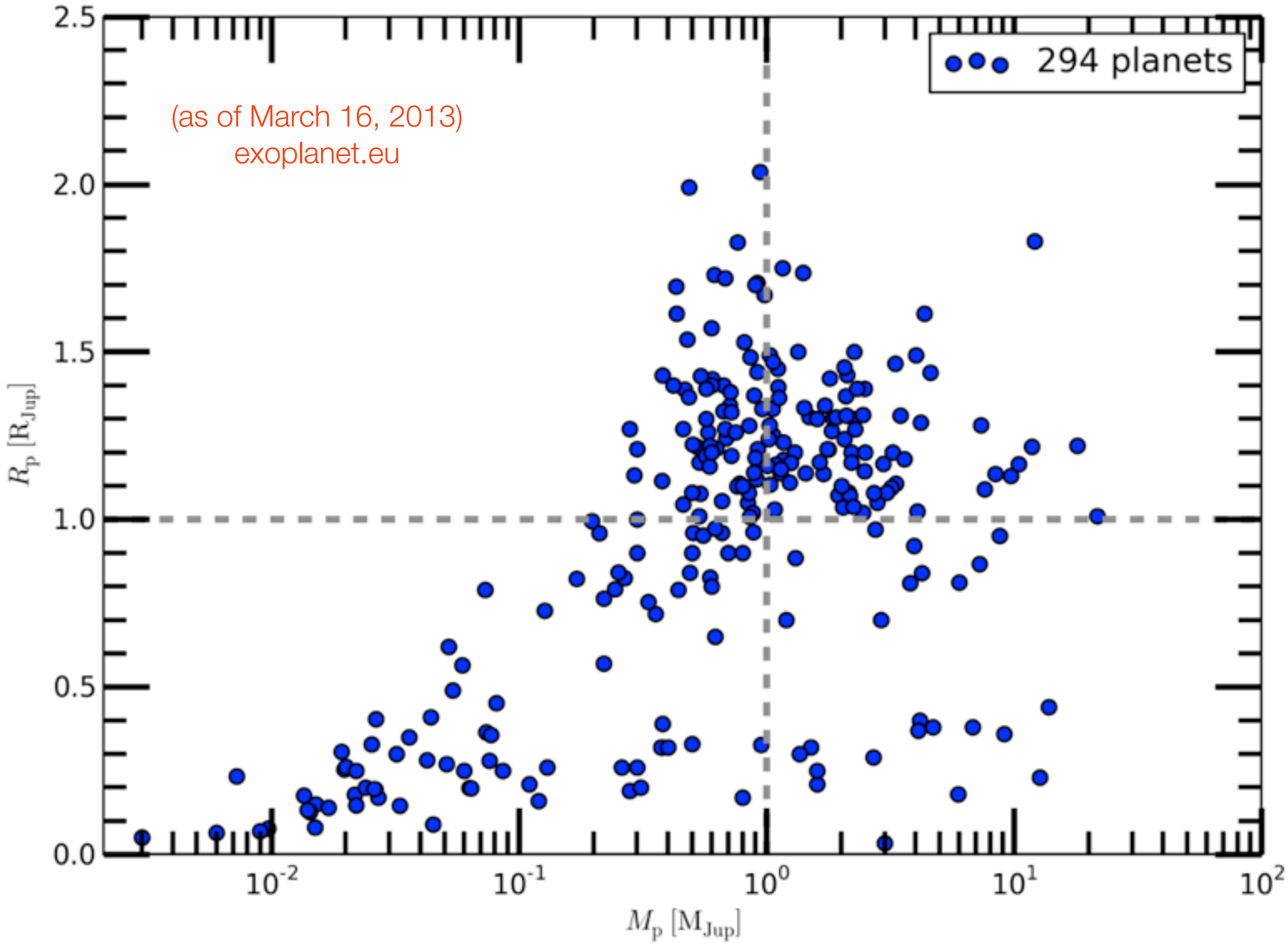
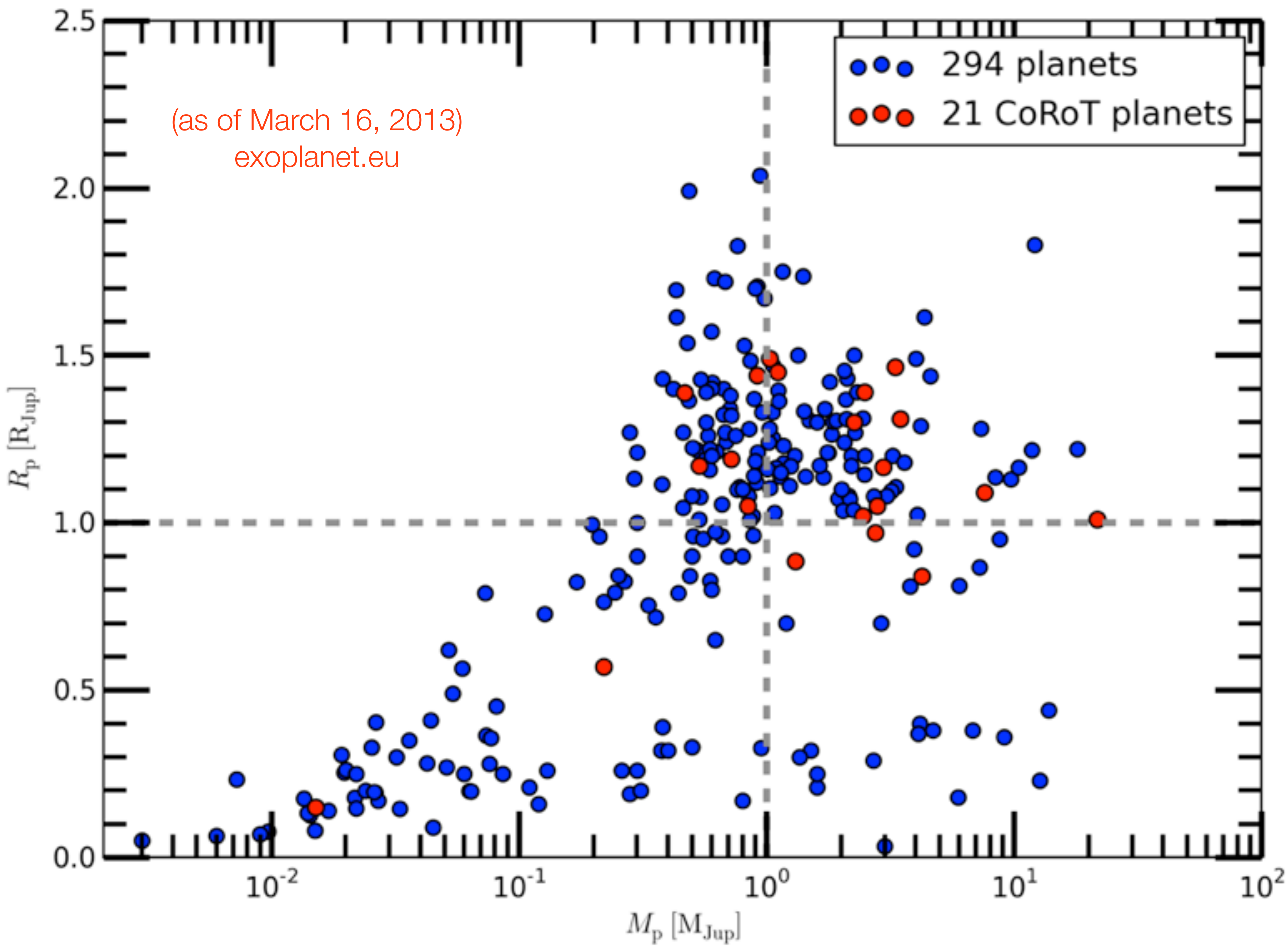
CoRoT and its very important contribution



CoRoT and its very important contribution



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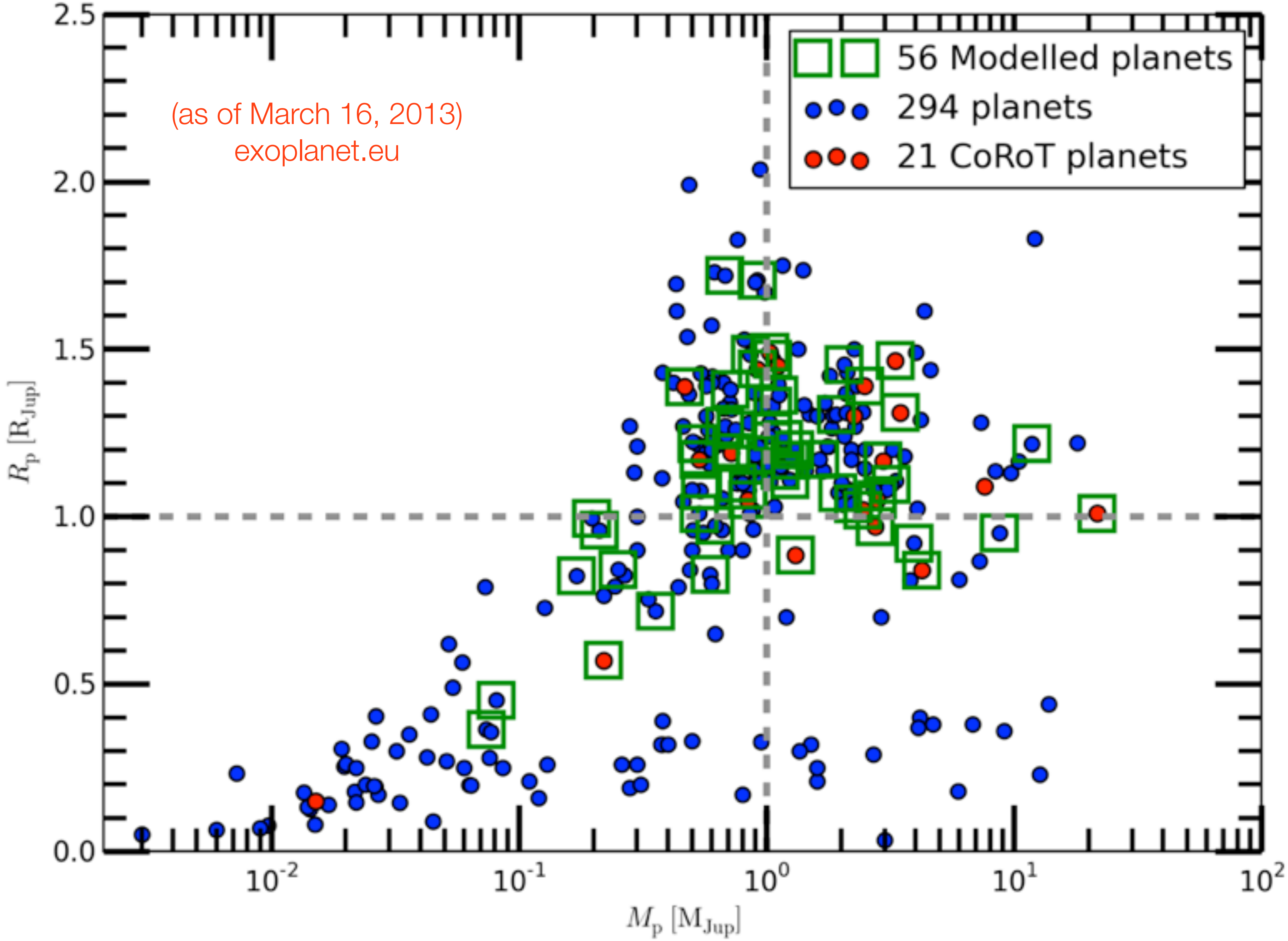
CoRoT and its very important contribution

modeled = planetary bulk composition (core mass) has been derived



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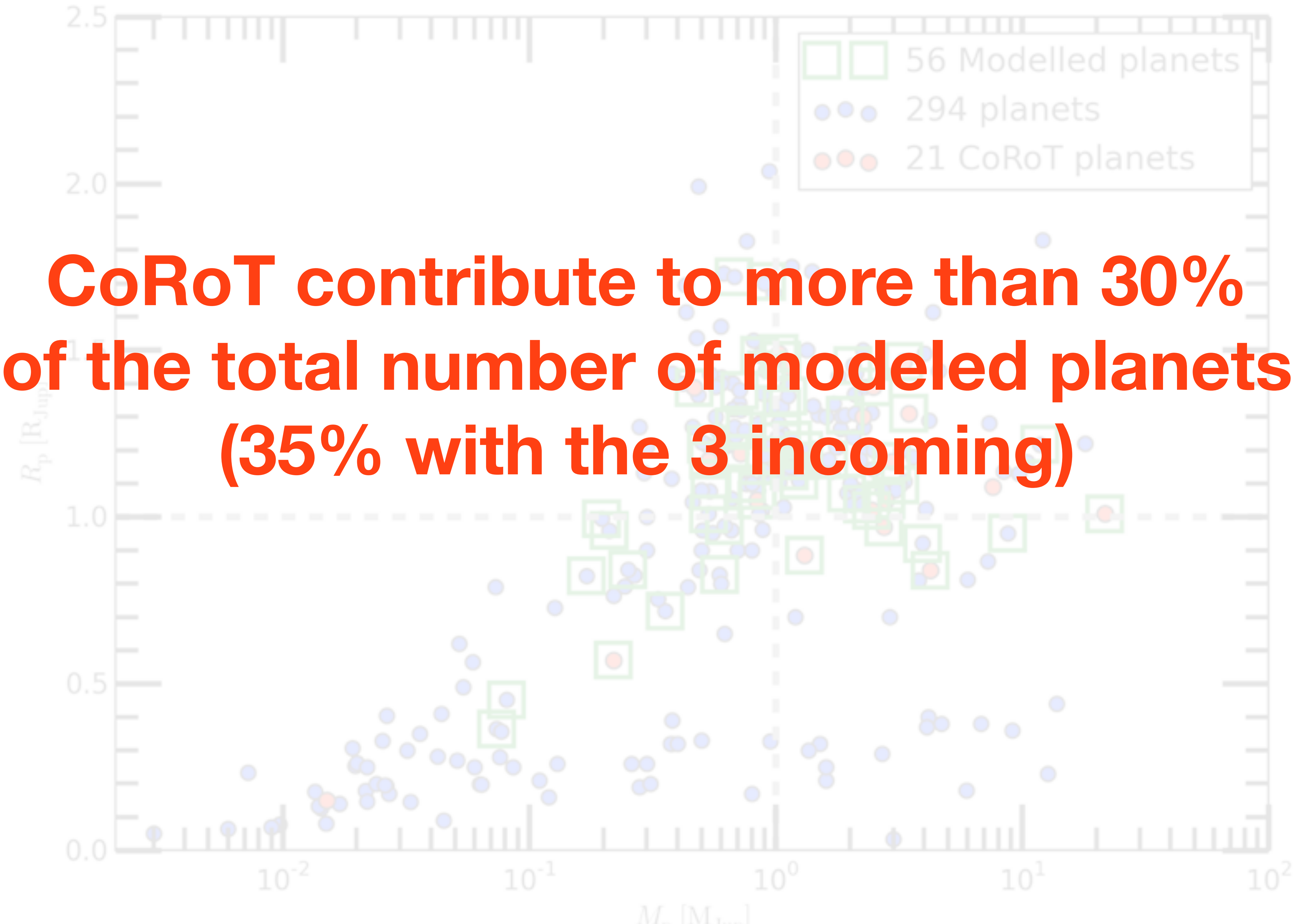
CoRoT and its very important contribution



CoRoT contribute to more than 30% of the total number of modeled planets (35% with the 3 incoming)

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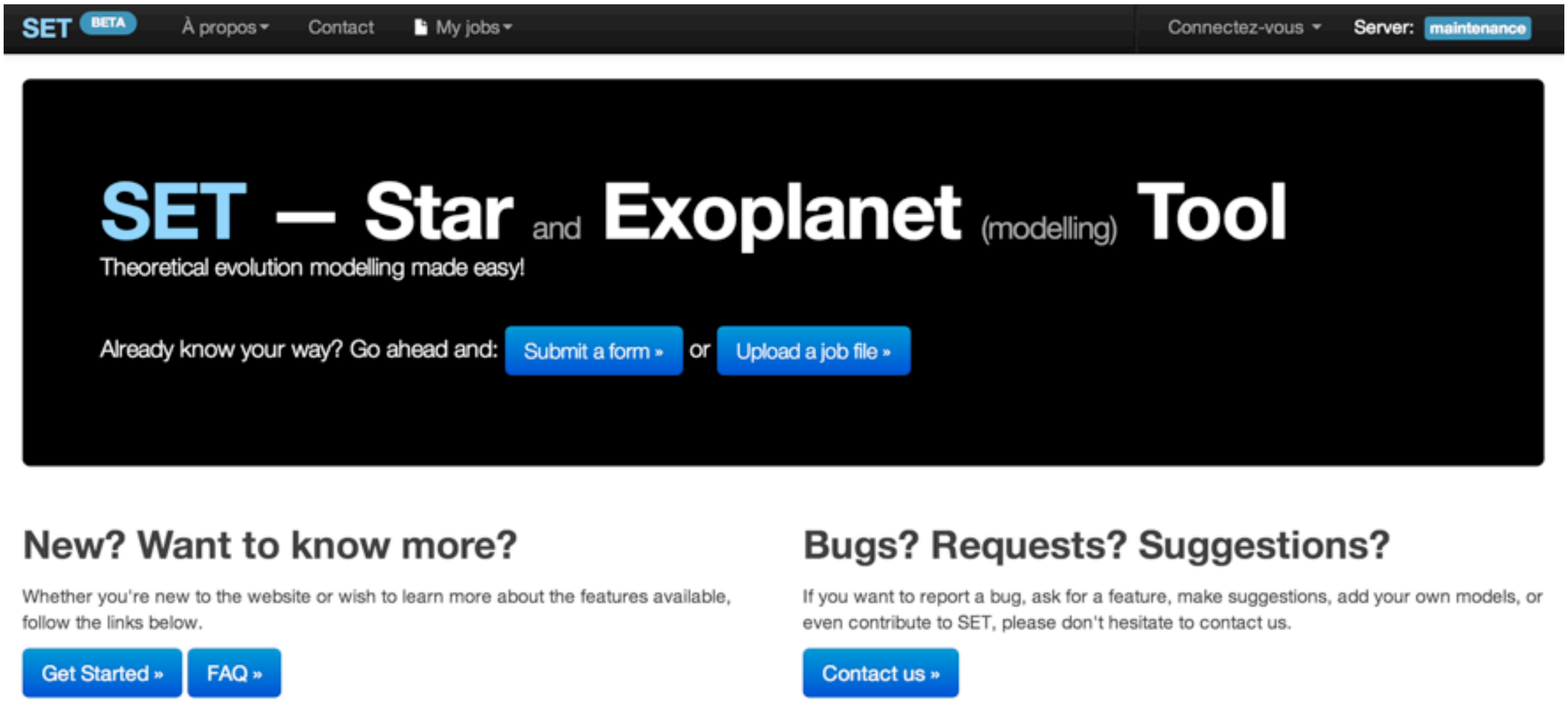
Modeling stars and planets: SET



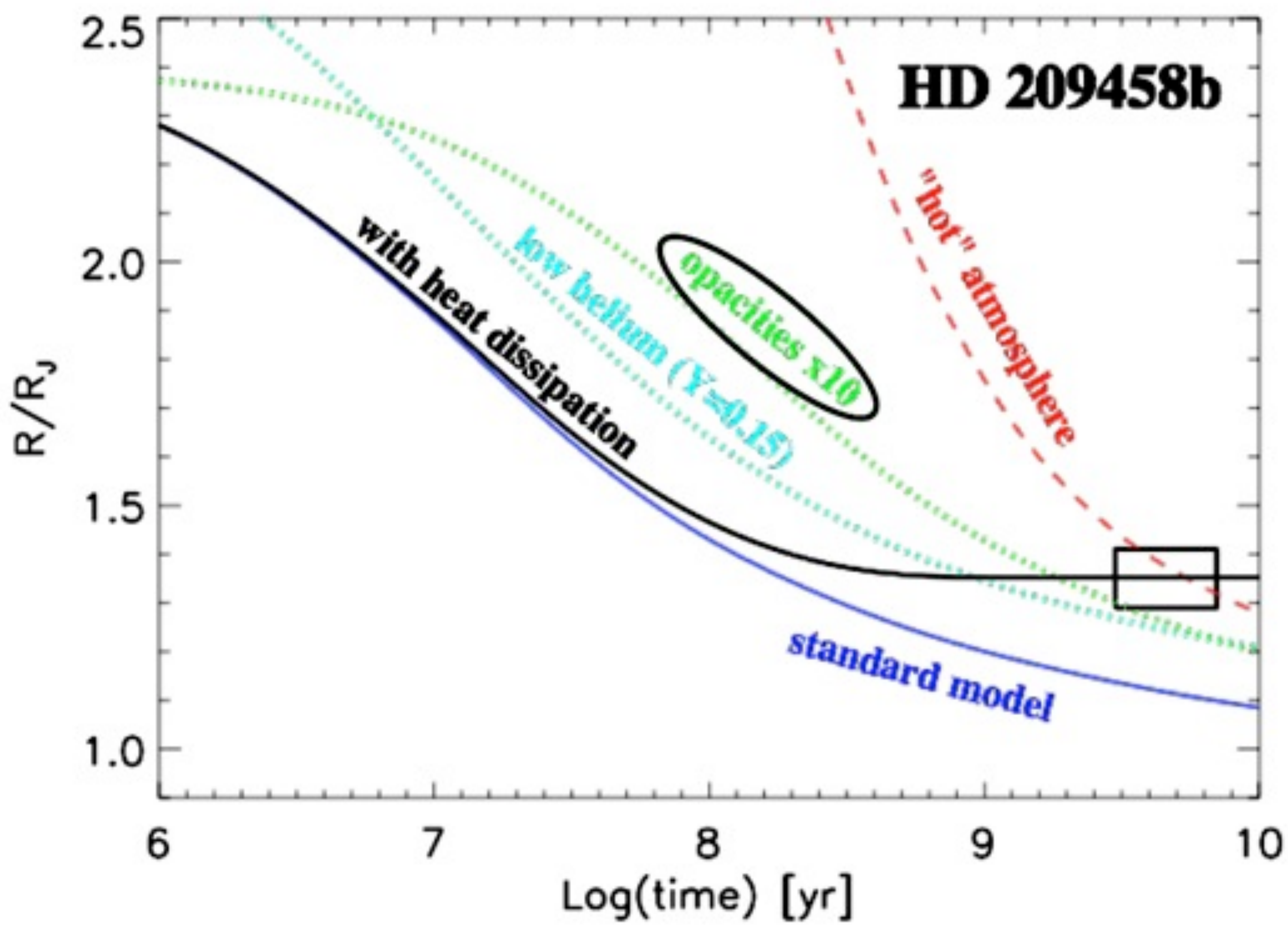
After 2.5 years of development, SET and its web interface will be ready in (late) May 2013:

set.oca.eu

SET in few words...

- Goal: easy, automatic modeling of any object (or system of objects) supported by SET (from giant planets to giant stars ; could be extended later, especially for rocky / smaller planets)
- 1D stellar and planetary evolution models:
    - for the stars: CESAM, PARSEC, Yale, Teramo, BCAH, Dartmouth, (MESA)
    - for the (giant) planets: CEPAM, (MESA)... released later in the summer
- MCMC analysis: derive the unknown (mass, radius, age, composition, ...)
- Future: theoretical spectra and structures

Planetary radii vs. age



factor 10 in radius (0.15 to 1.5 Rj)

> factor 100 in mean density and period (0.2 to 25 g/cm**3 and 0.9 to 95 days respectively)

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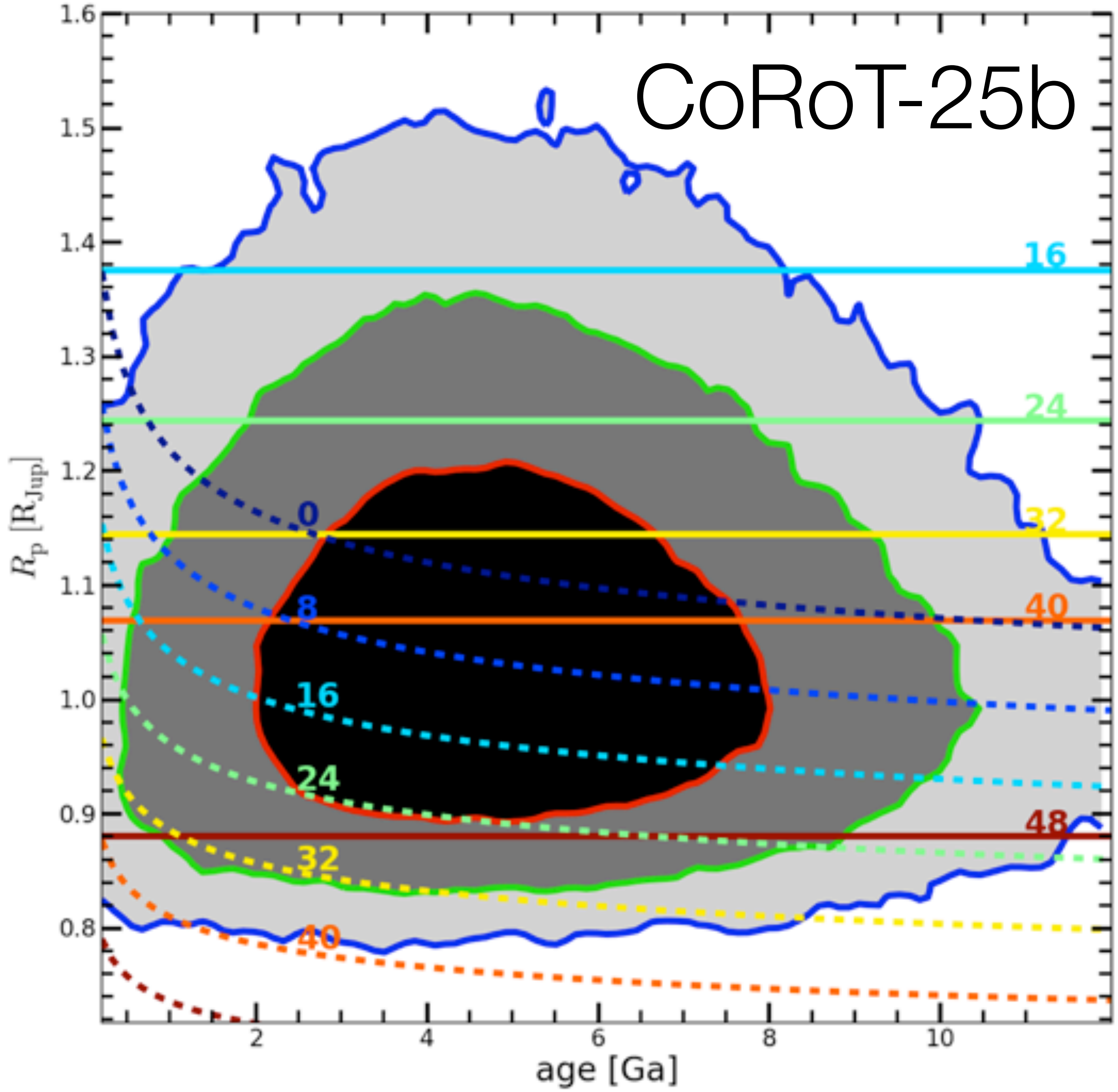
Planetary radii vs. age

(Almanera et al., in prep)



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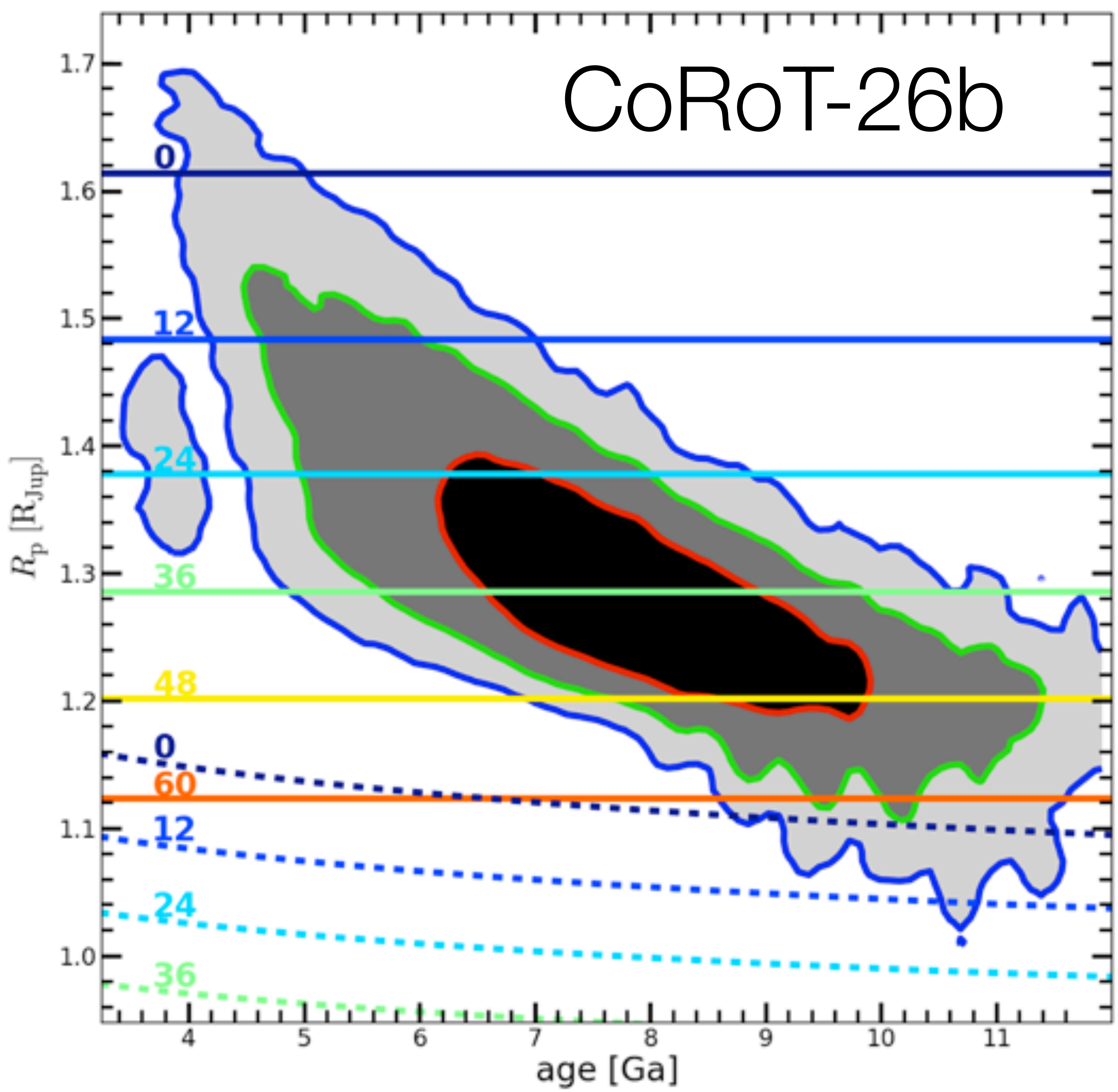
Planetary radii vs. age

- errors are often non gaussian

(Almanera et al., in prep)



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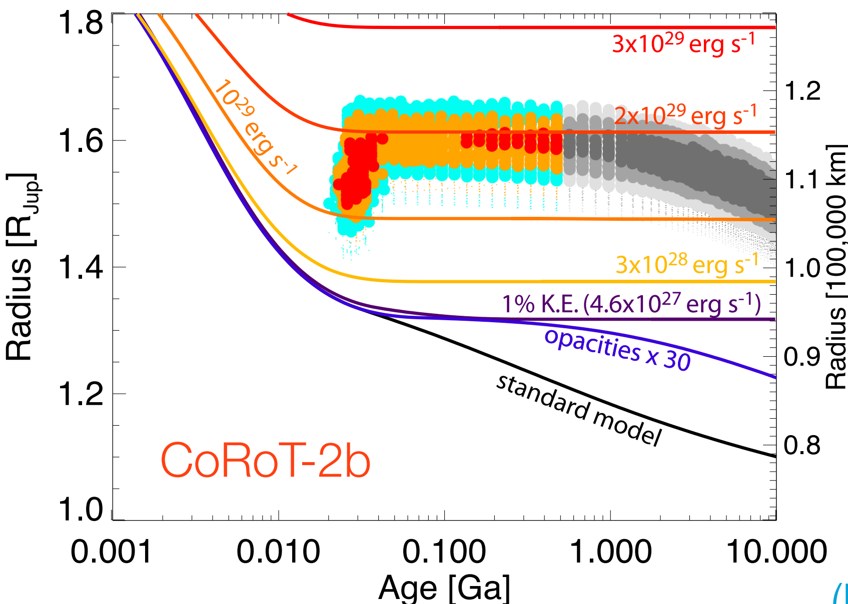
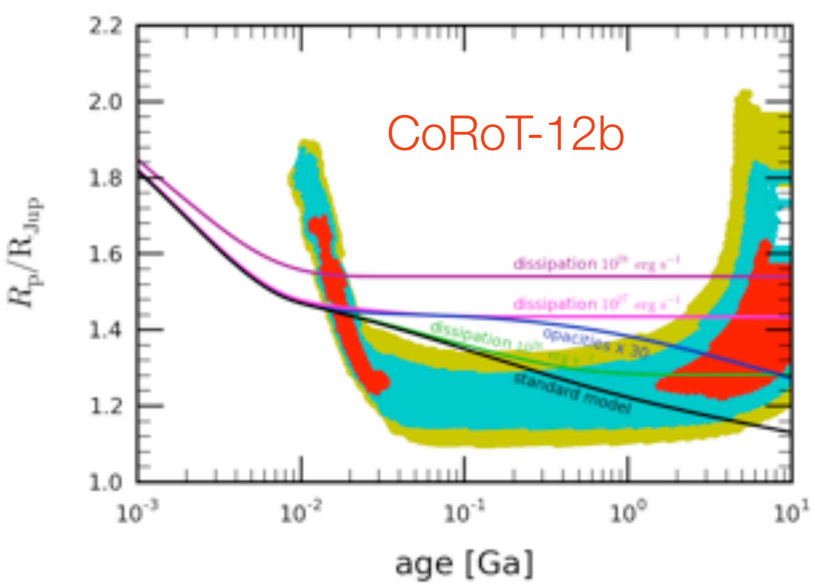
CoRoT giant planets: 3 interesting categories

Inflated

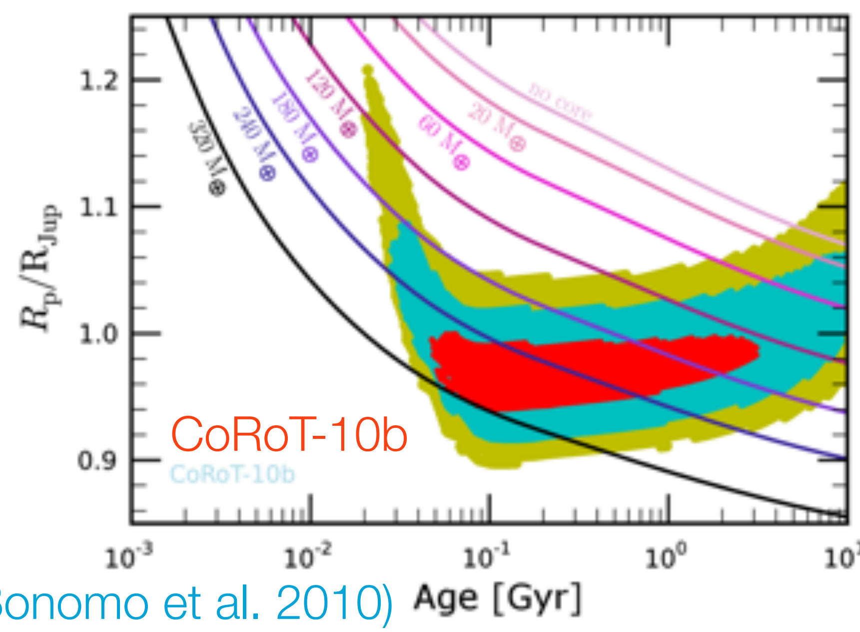


(Alonso et al. 2008, Guillot & Havel 2010)

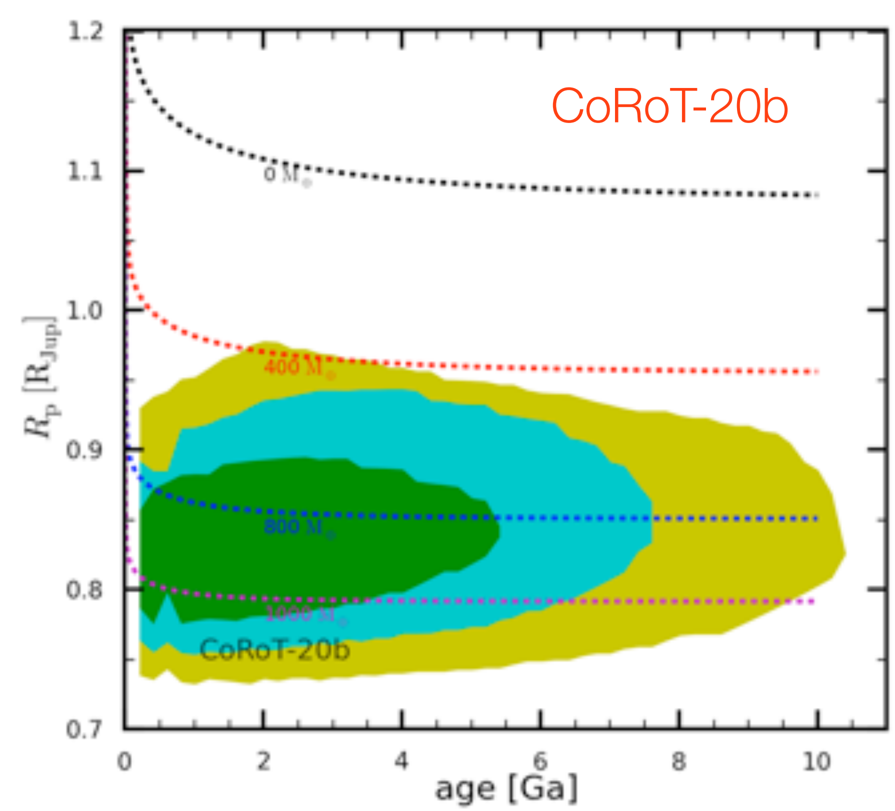


(Gillon et al. 2010)

Massive core

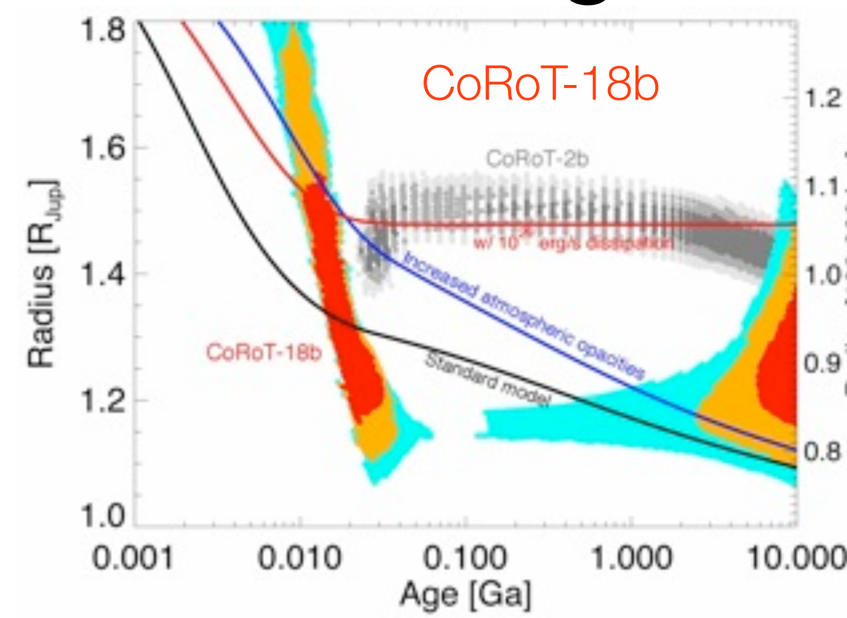


(Bonomo et al. 2010)



(Deleuil et al. 2012)

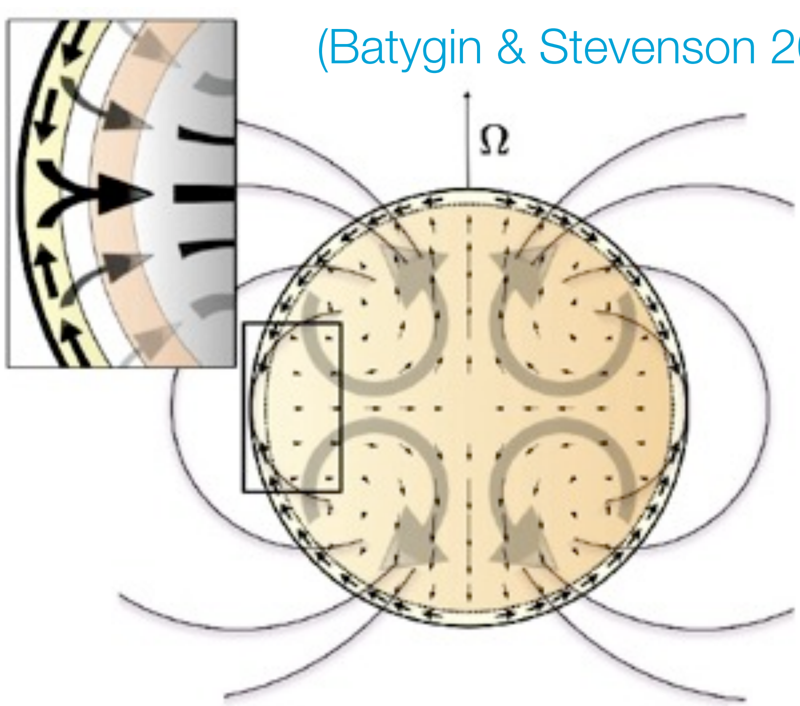
Young



(Hébrard et al. 2011)

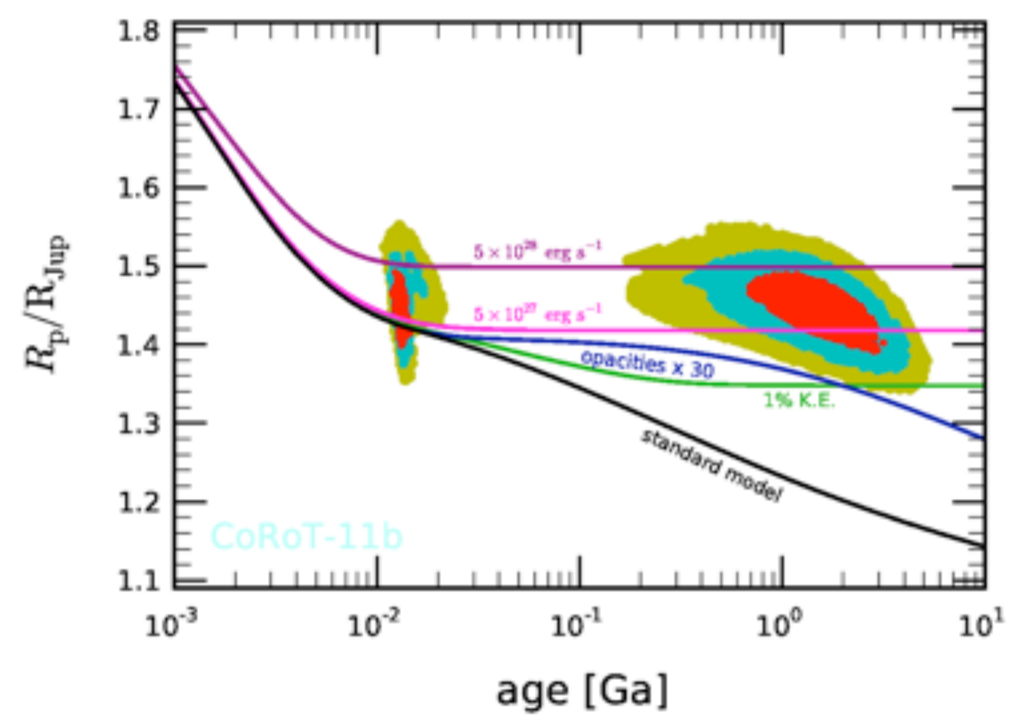
CoRoT inflated planets

- Additional source of energy is needed to explain the observed radius
- Physical process at play is unknown. One of the most promising: Ohmic dissipation (able to dissipate about 10^23 to 10^28 erg/s)
- 7 CoRoT planets with a positive radius anomaly (ie. too much inflated for standard models): CoRoT-1, 2, 5, 6, 11, 12, 19



(Batygin & Stevenson 2010)

(Gandolfi et al. 2010)



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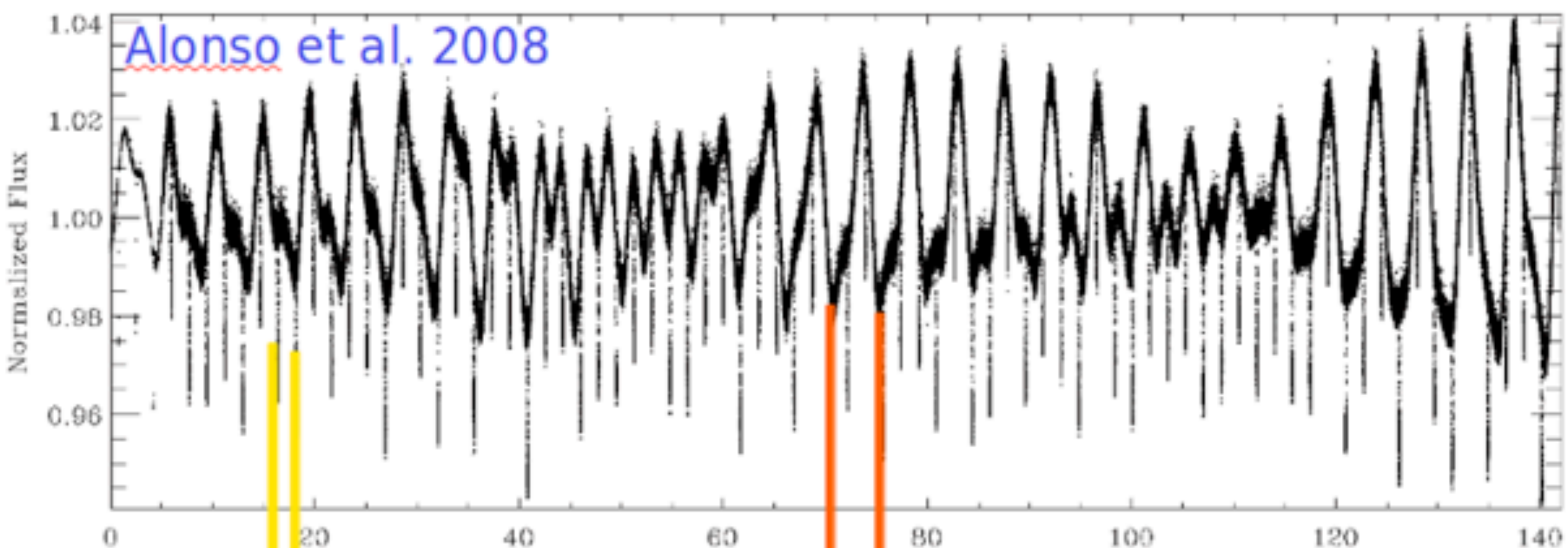
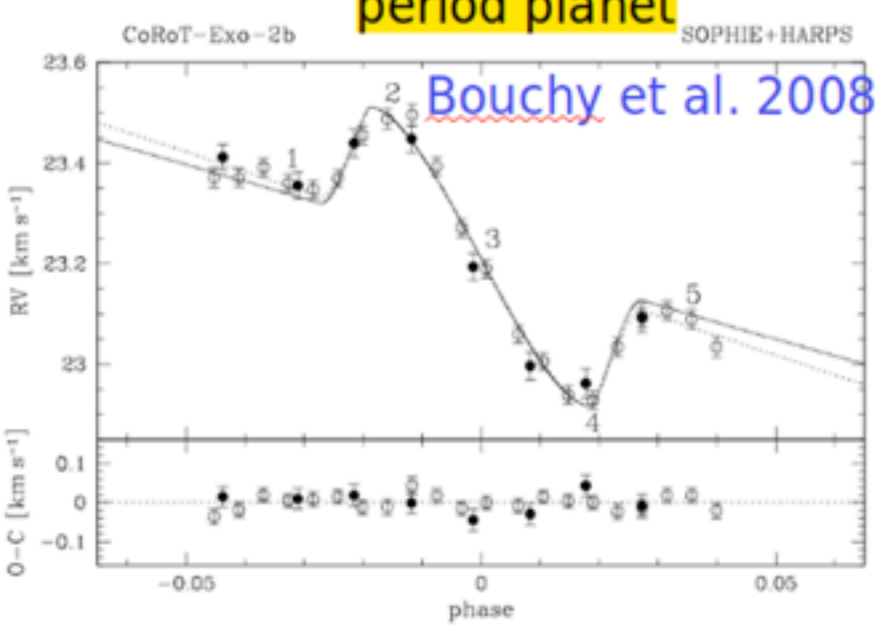
CoRoT inflated planets: CoRoT-2b

- CoRoT-2b is one of the most problematic planet: inflated and massive

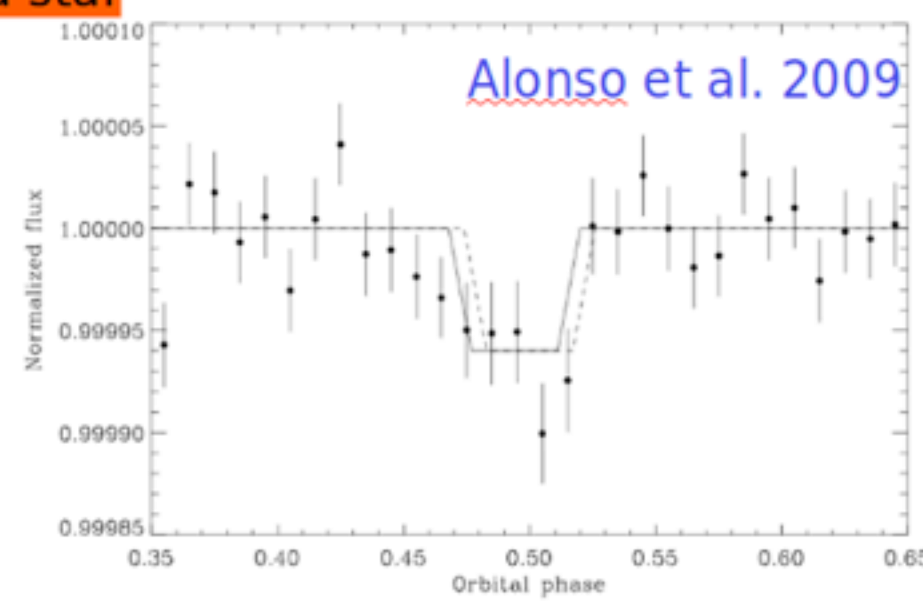


Active star with spots

Planet: ~3 Mjup, ~1.5 Rjup



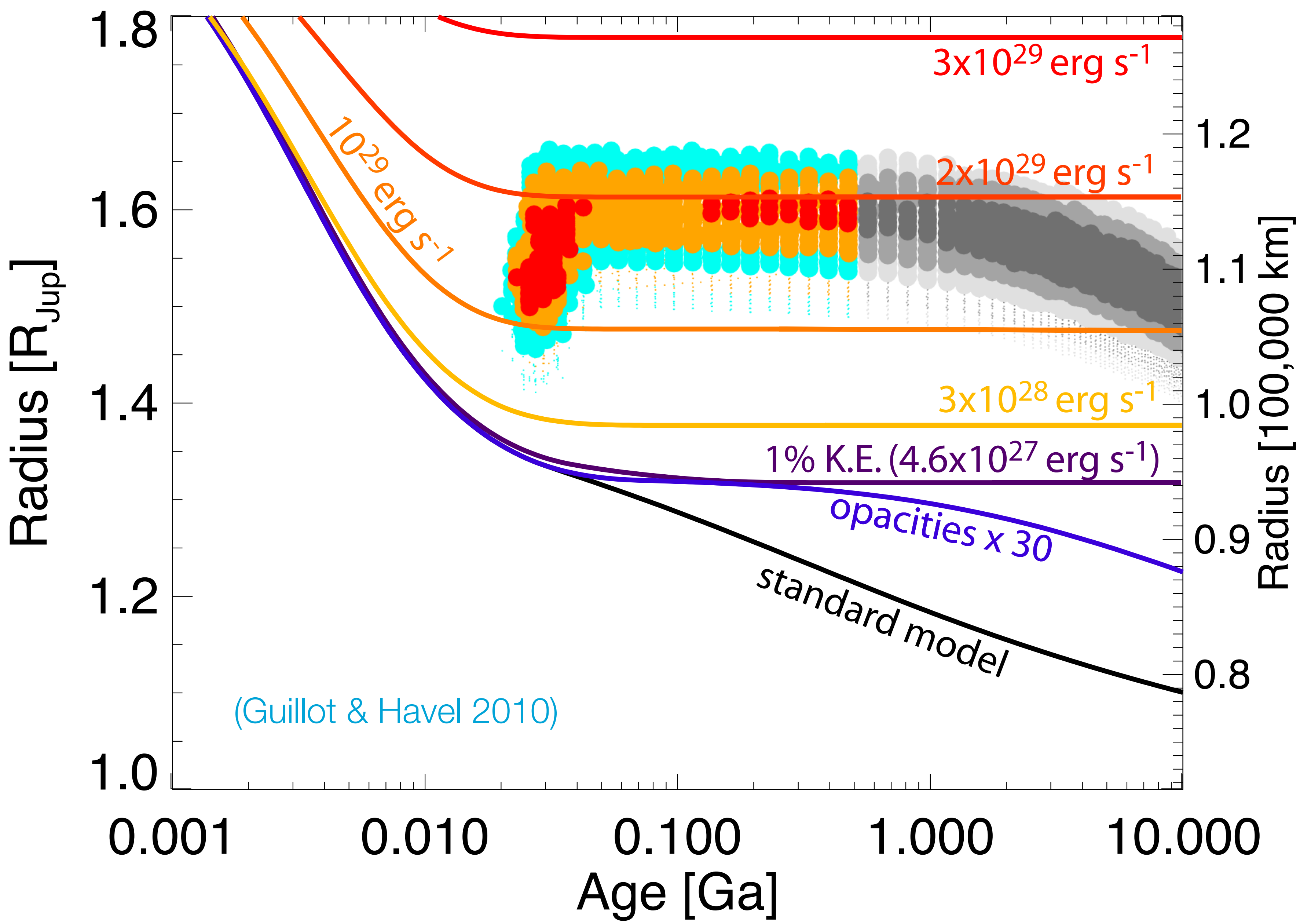
Rossiter: λ=7.2° +/- 4.5°



Secondary transit: e=0.03 +/- 0.03

CoRoT inflated planets: CoRoT-2b

- Usually, 0.25% of stellar irradiation σT_{eq}^4 is enough to explain the large radius



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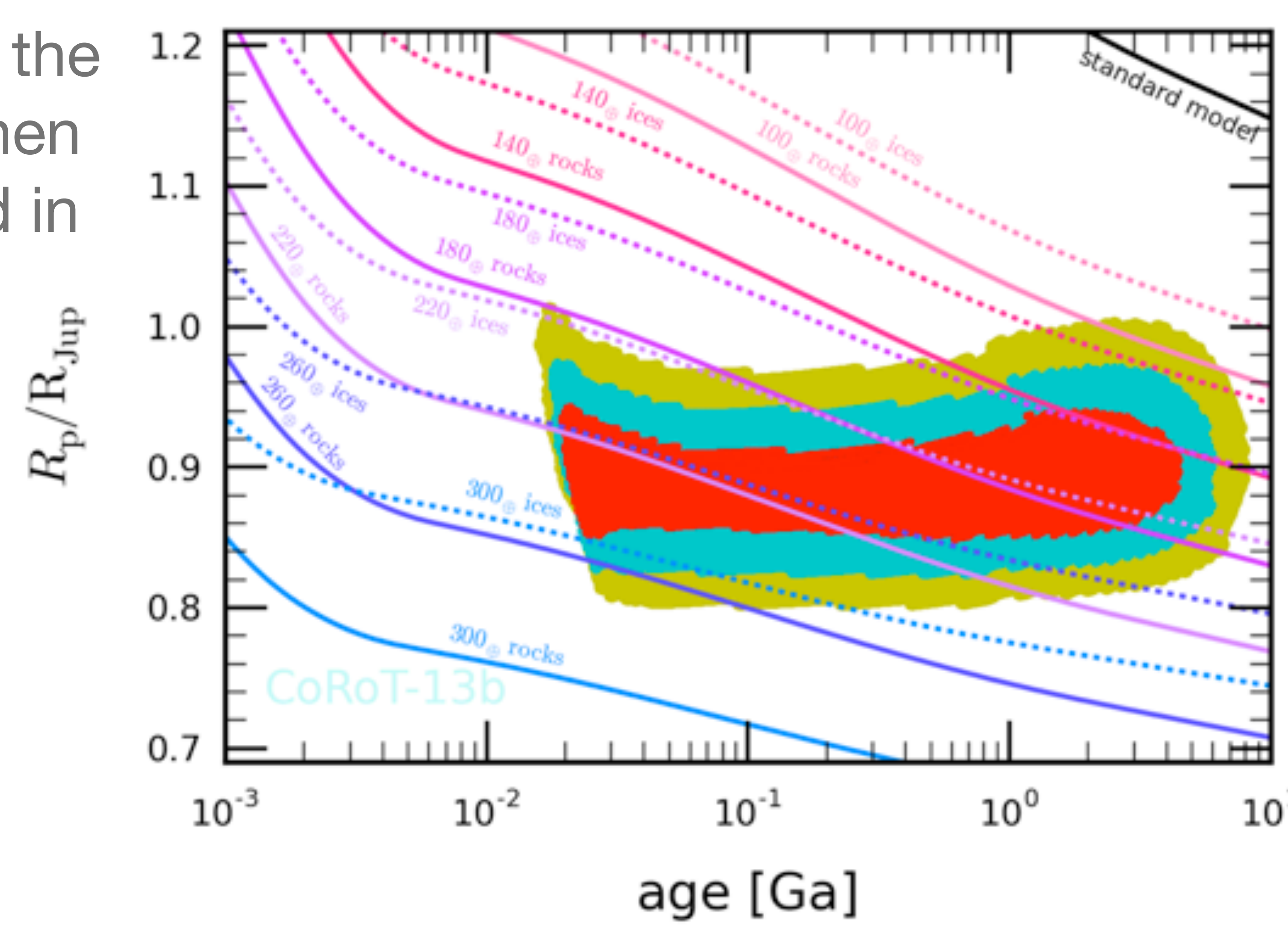
CoRoT superdense planets

- 6 planets with a core mass (Mc) > 70 Me: CoRoT-10b, 13b, 14b, 17b, 20b, 23b.

- Assumption: all heavy elements in the core -> up to 5-10% difference when considering heavy elements mixed in the envelope. Mc overestimated? (Deleuil et al. 2012, Baraffe et al. 2008).

- Strongly link with the formation mechanism of these planets, and their interior structure: need more theoretical studies.

(Cabrera et al. 2010)



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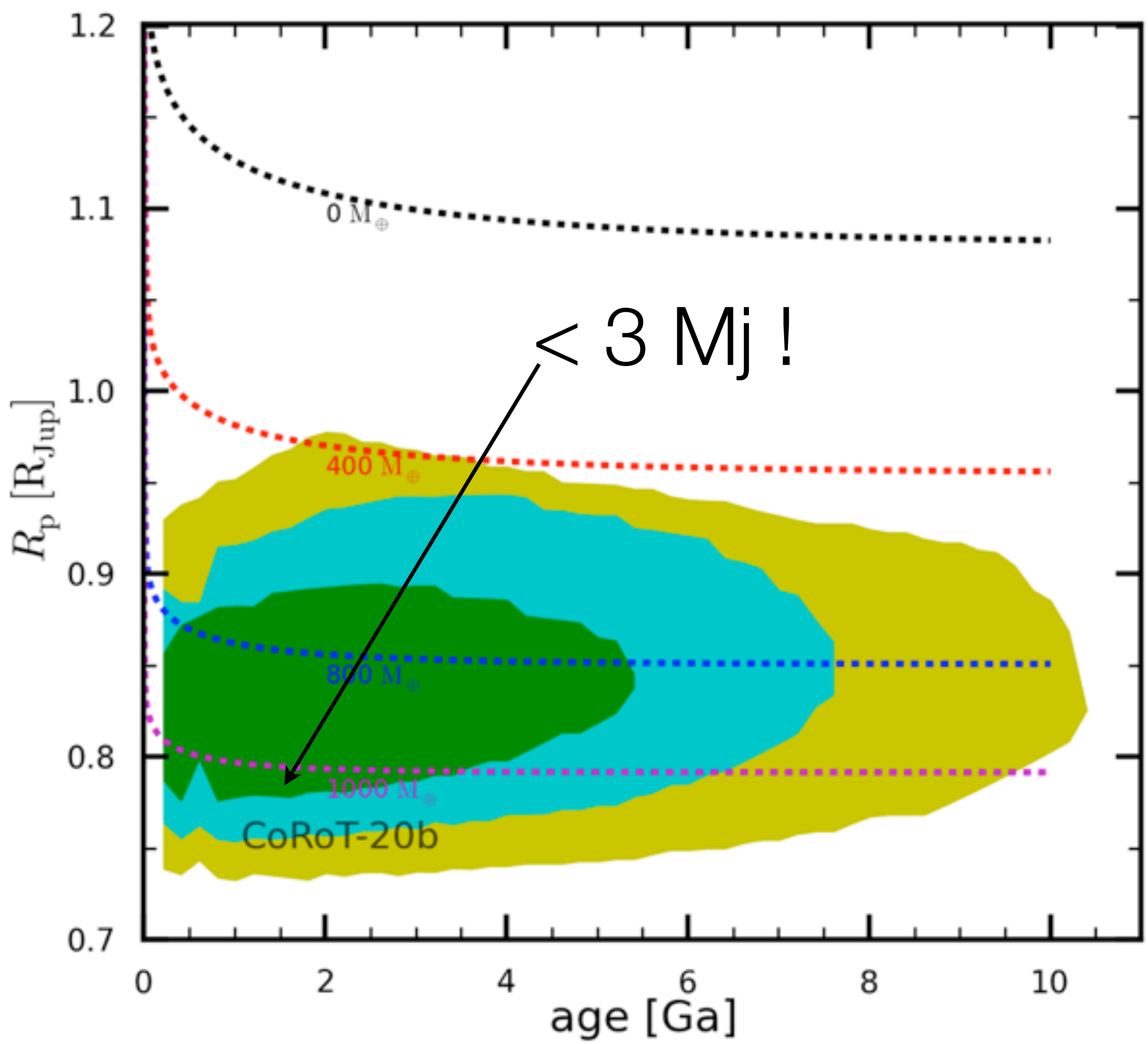
CoRoT superdense planets: CoRoT-20b



- planet: 4.24 M_{Jup} and 0.84 R_{Jup} (~ 7 × ϱ_{Jup}!)
- star: G2V, 1.14 $M_{\odot}$ and 1.02 $R_{\odot}$
- orbit: $P \sim 9.2$ days; $e = 0.56$

However, Southworth et al. (2012) derived a much larger radius of 1.16 +/- 0.26 Rj...

Believed to be young: < 1 Ga (Li)

(Deleuil et al. 2012)

CoRoT young systems

- 3 planets younger than 1 Ga: CoRoT-2b, 18b, 20b.
- Thanks to CoRoT in-depth studies, we have more information on the age of the stars: rise a lot of interesting questions / problems
- Good age indicators? (spots, rotation period, Li, ...).
- Problems: 2b too large, 18b's age, 20b too small. Understanding of young systems appears to be poor

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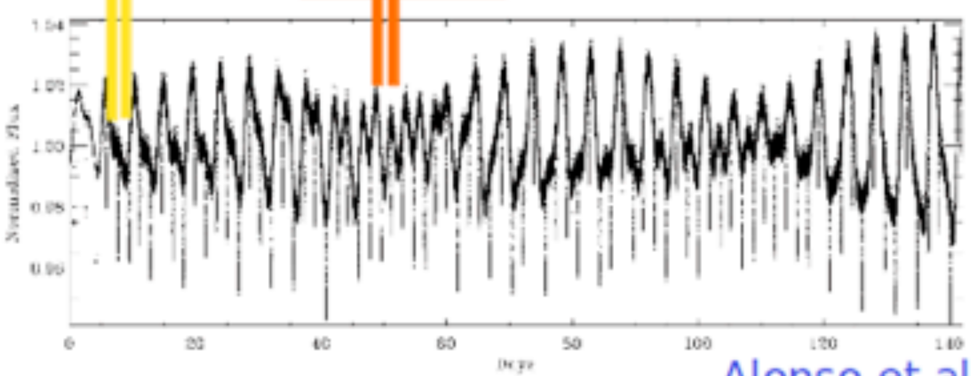
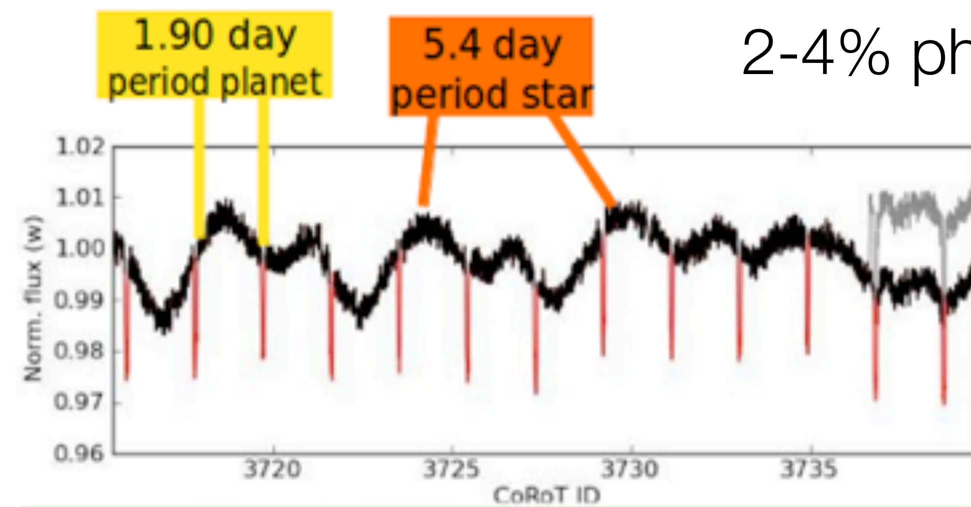
CoRoT young systems: CoRoT-2 and 18



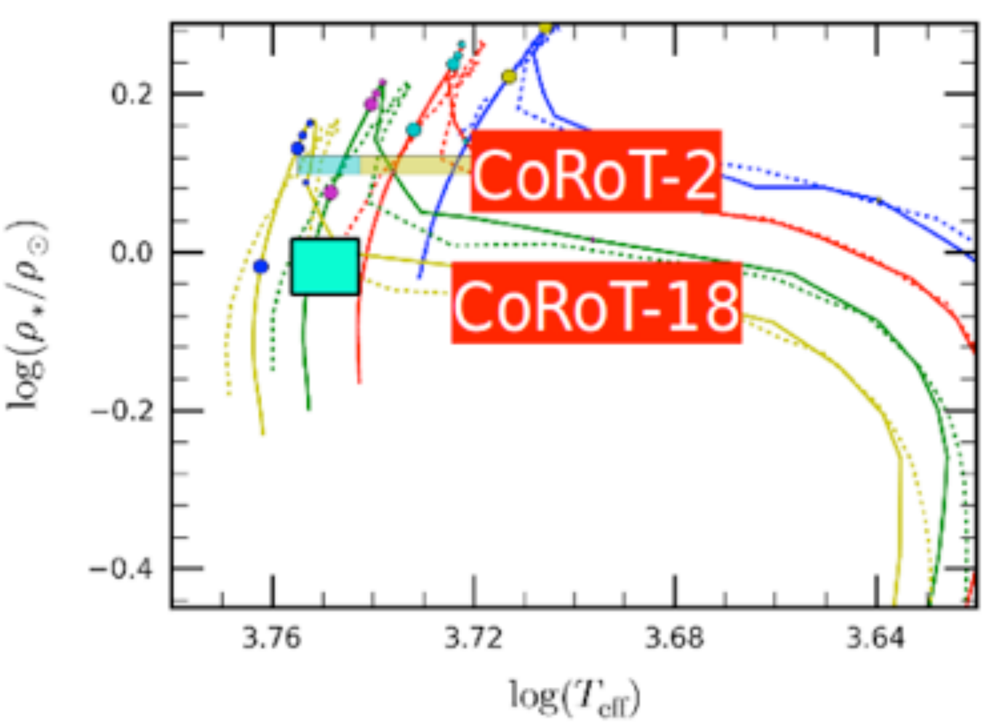
Alonso et al. 2008

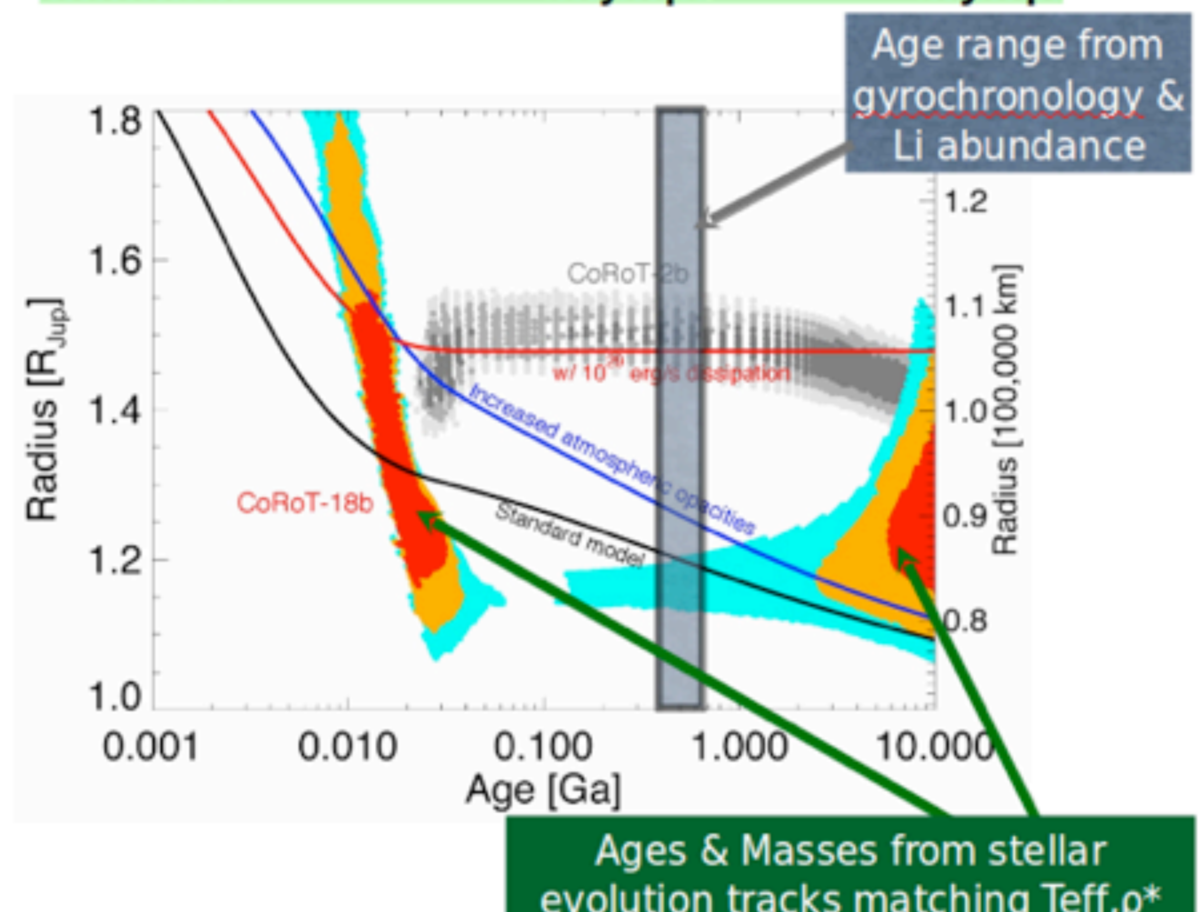
CoRoT-2b: ~3 Mjup, ~1.5 Rjup



2-4% phot. variabilities

CoRoT-18b: 3.5 Mjup, ~1.4 Rjup





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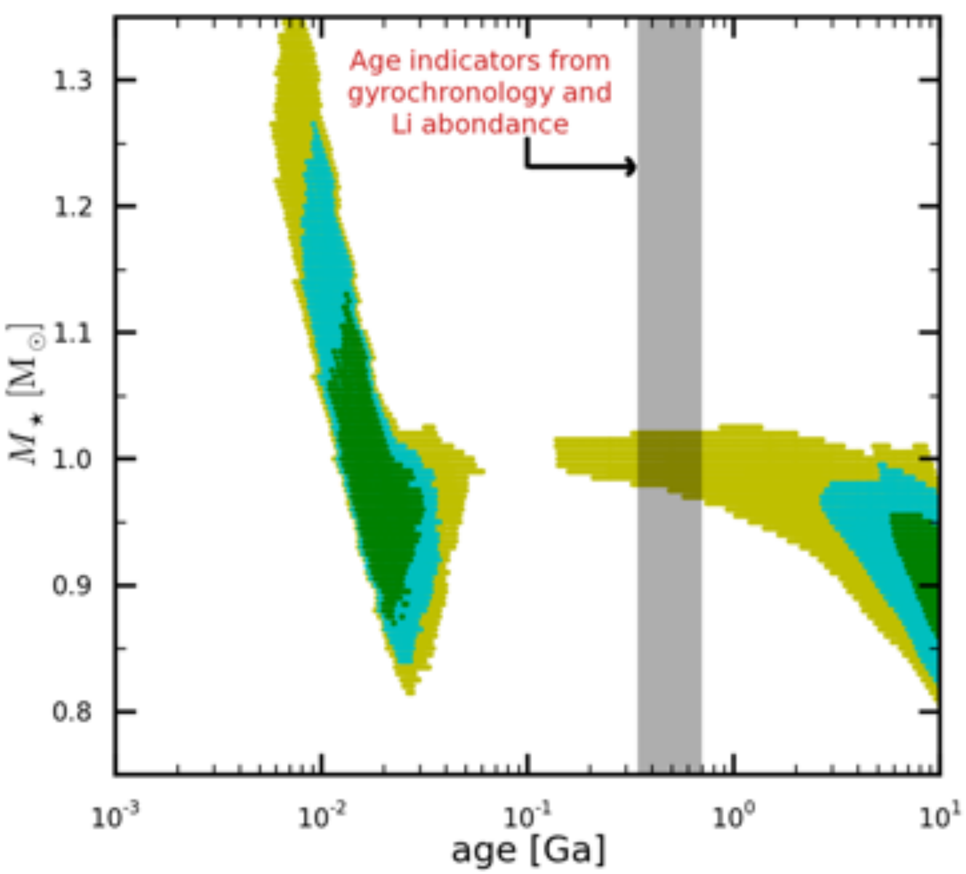
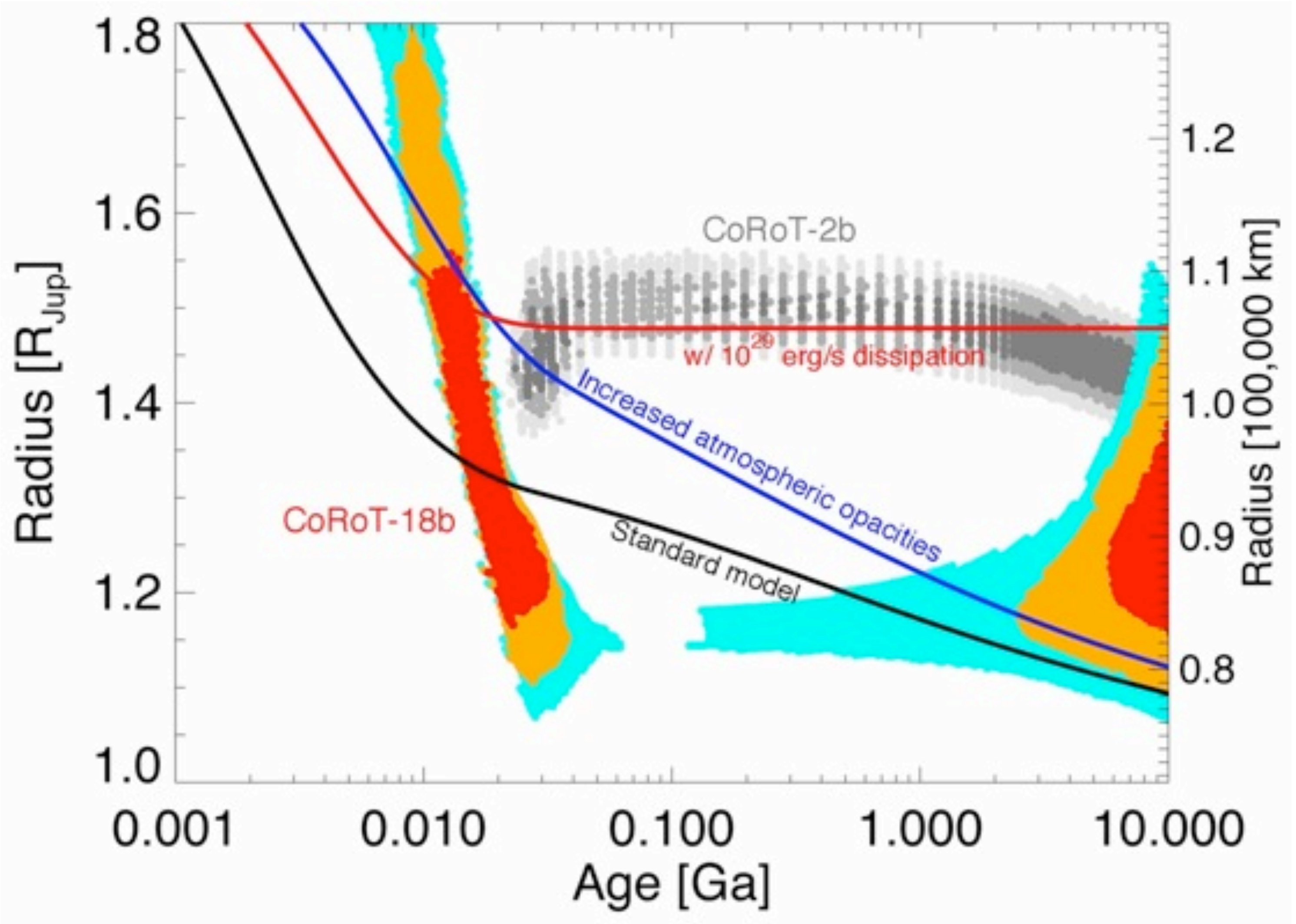
CoRoT young systems: CoRoT-2 and 18





(Hébrard et al. 2011)

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CoRoT young systems: summary

- All young system pose problem...
- All the young planets are relatively massive... Two on small orbital periods and one with high eccentricity: strong interactions with the star
- Extra observations and care are needed: large uncertainties on the planetary radii due to the activity of the host stars.
- Clearly linked to the formation of planetary systems

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Getting better constraints: log gp

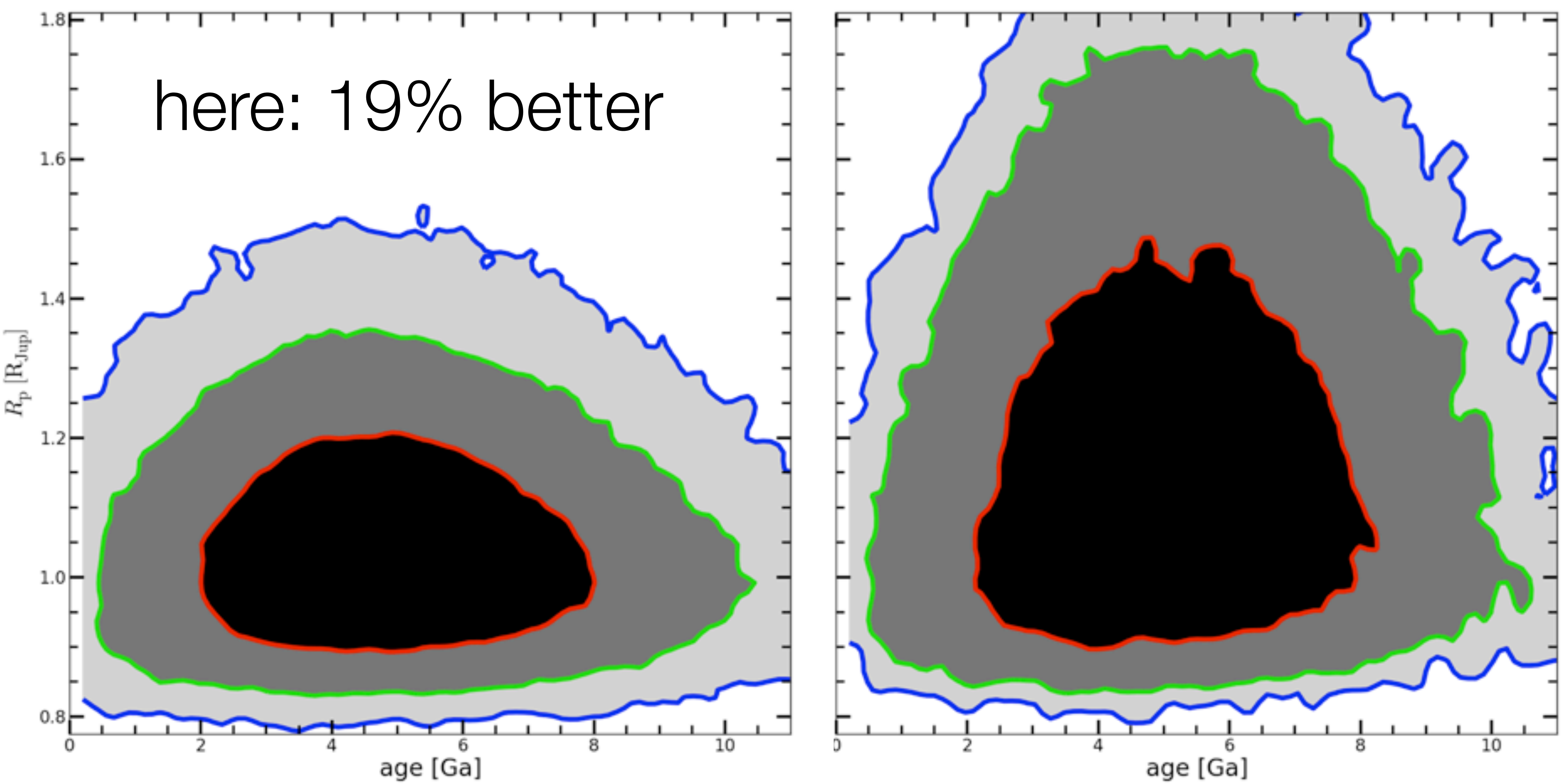
- log gp is an observational constraint from transit + RV (no model involved)

$$
\begin{aligned}
\log g_{\rm p} \;\; = \;\; & -2.1383 - \log P + \log K_\star \\
& -\frac{1}{2}\log\left[1-\left(\frac{b}{a/R_\star}\,\frac{1-e^2}{1+e\sin\omega}\right)^2\right] \\
& +2\log\left(\frac{a/R_\star}{k}\right) \\
& +\frac{1}{2}\log(1-e^2)
\end{aligned}
$$

(eg. Southworth 2004, 2007 ; Beatty 2007)

Getting better constraints: log gp

- with (left) and without (right) the constraint on log gp => 10 to 30% improvements!



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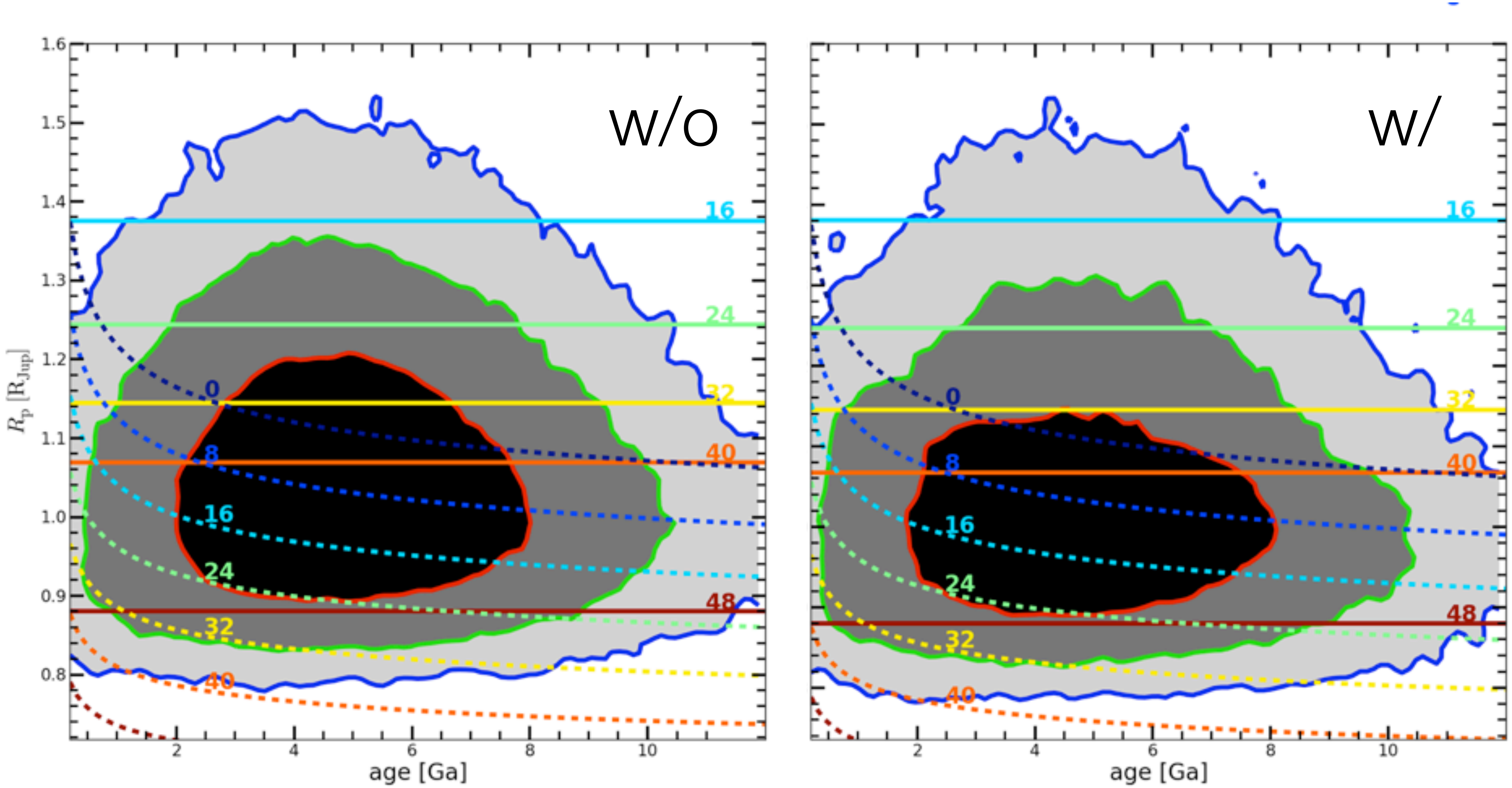
Getting better constraints: planetary models

- Planetary models (**IF** believed!) can be used to further constrain the parameters: planetary feedback awesomeness :)



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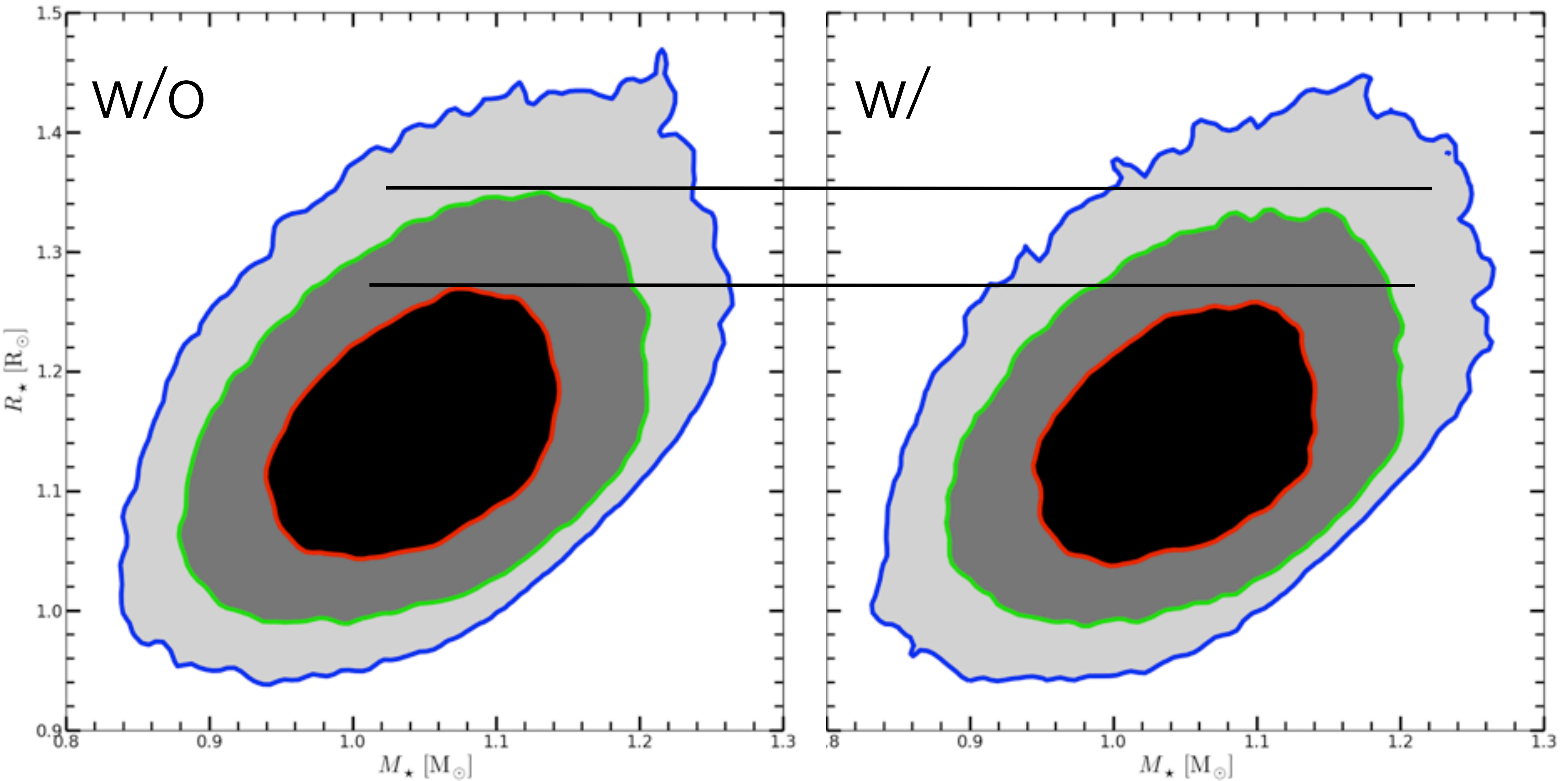
Getting better constraints: planetary models

- ...much less significant on the stellar parameters (at least in this case)



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Conclusions

- CoRoT is a big success and has provided us with priceless data on giant planets and stars. The planetary (and stellar) models has already benefited and will continue to benefit from this.
- CoRoT has some of the main interesting / challenging planets
- Please use the log g of the planet as the constraint
- Remodeling of all CoRoT (giant) planets with a better propagation of errors is ongoing...
- Something that already has been said many times: a huge part of the uncertainties come from the star. Age is a major issue, as well as the radius.

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Thank you!

Let’s go have diner!

I’m also looking for a postdoc (starting december)

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