Characterizing Small Planets via Spectroscopy of their Host Stars

Johanna Teske

in collaboration with

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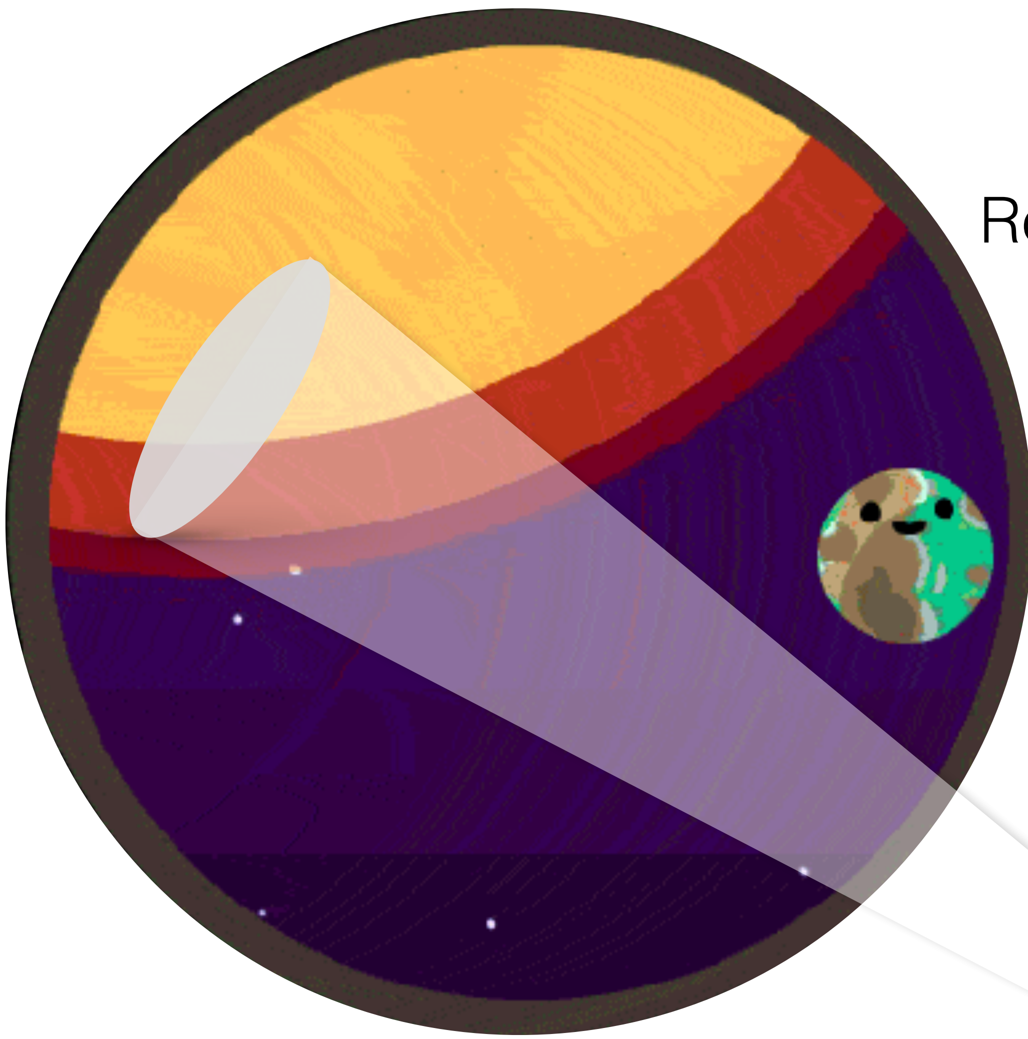
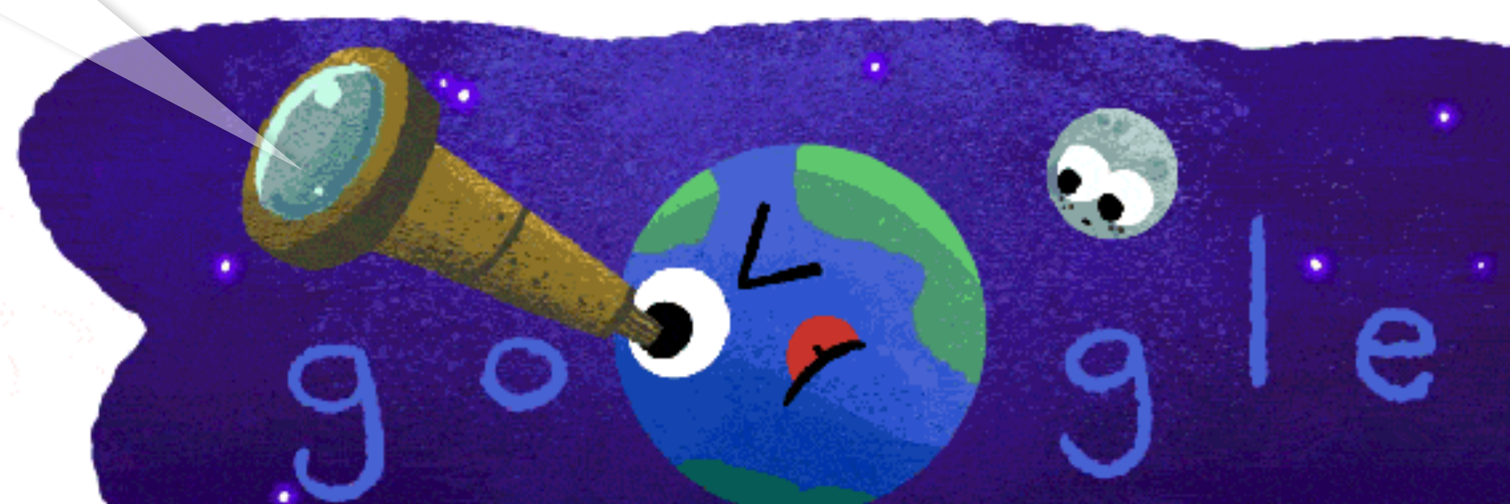
Nicholas Troup, Carlos Allende Prieto, Keivan Stassun

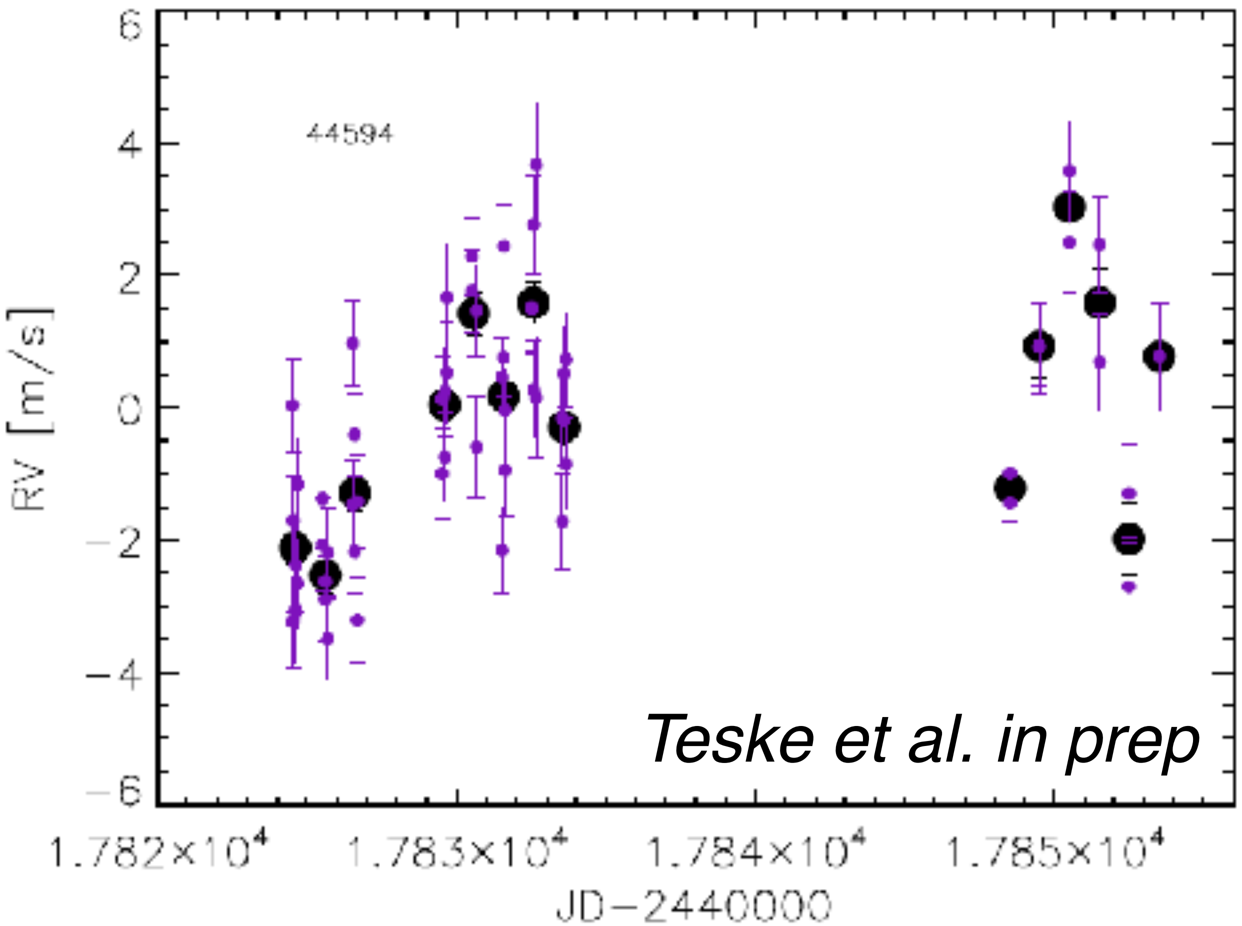
Cayman Unterborn, Wendy Panero,
Scott Hull, Jennifer Johnson

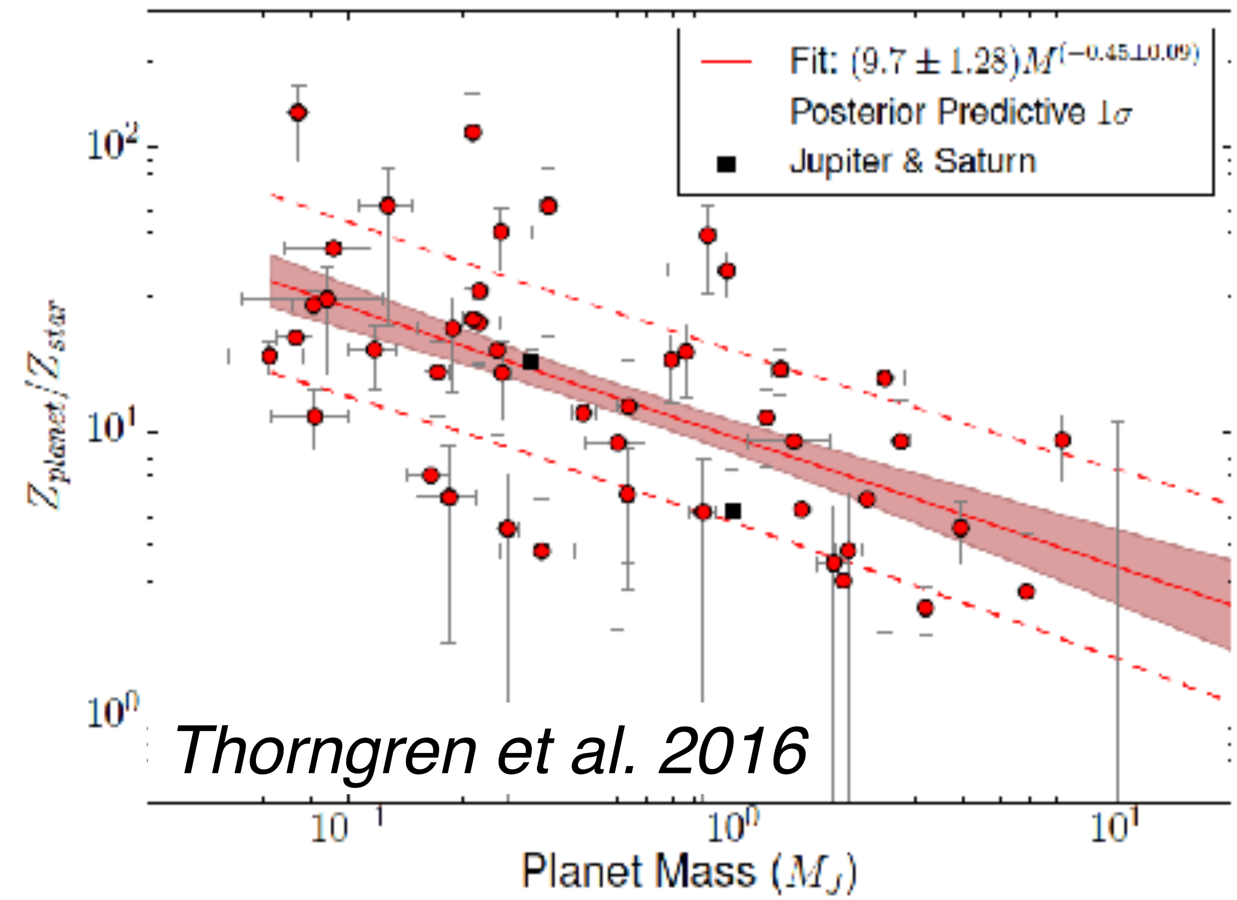
Stephen Shectman, Paul Butler, Jeff Crane,
Ian Thompson, Sharon Wang

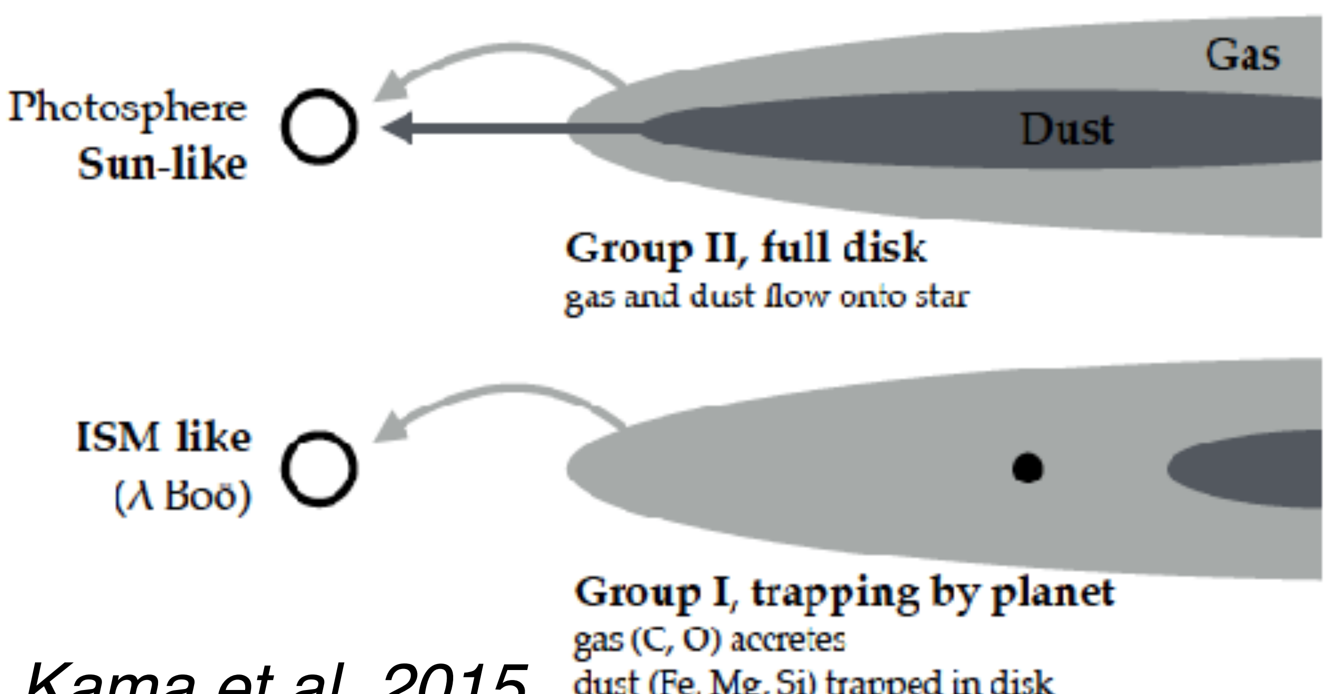




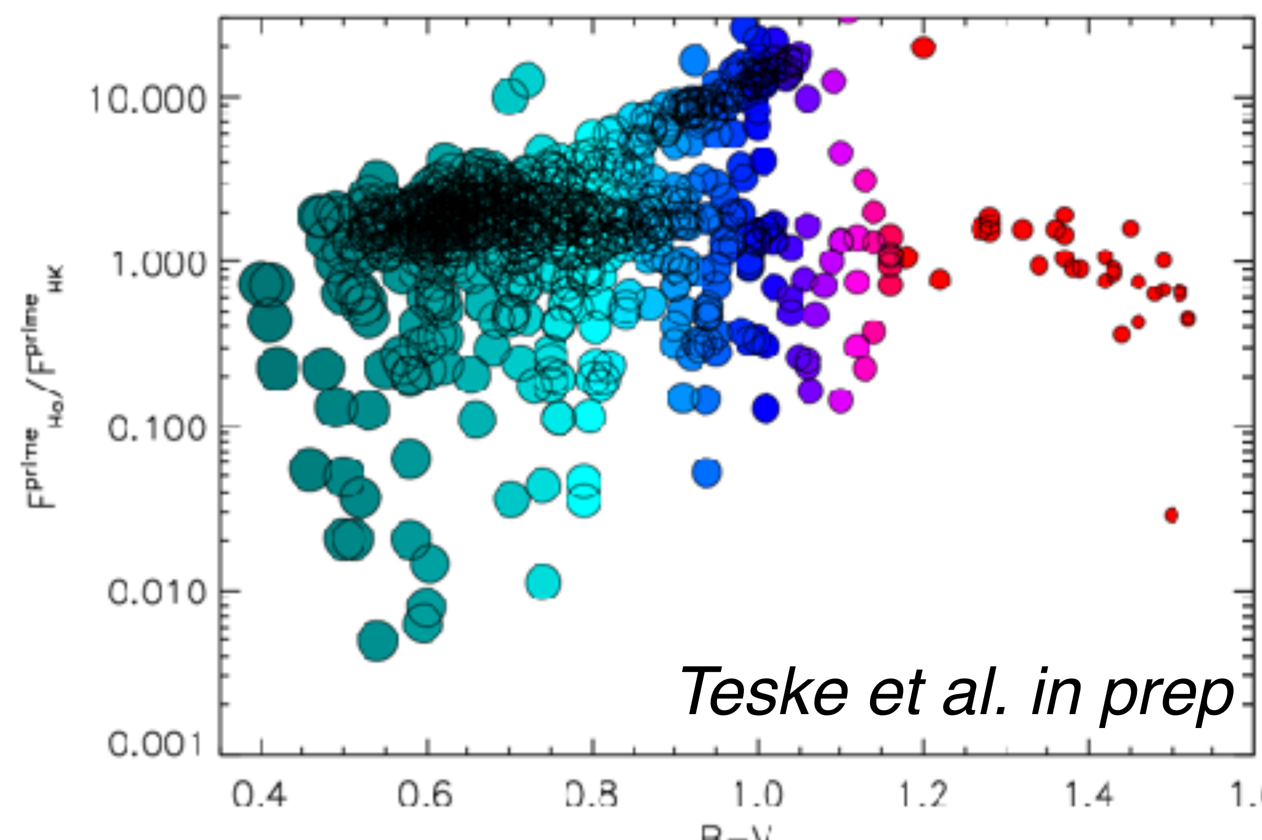
A few of my other projects…



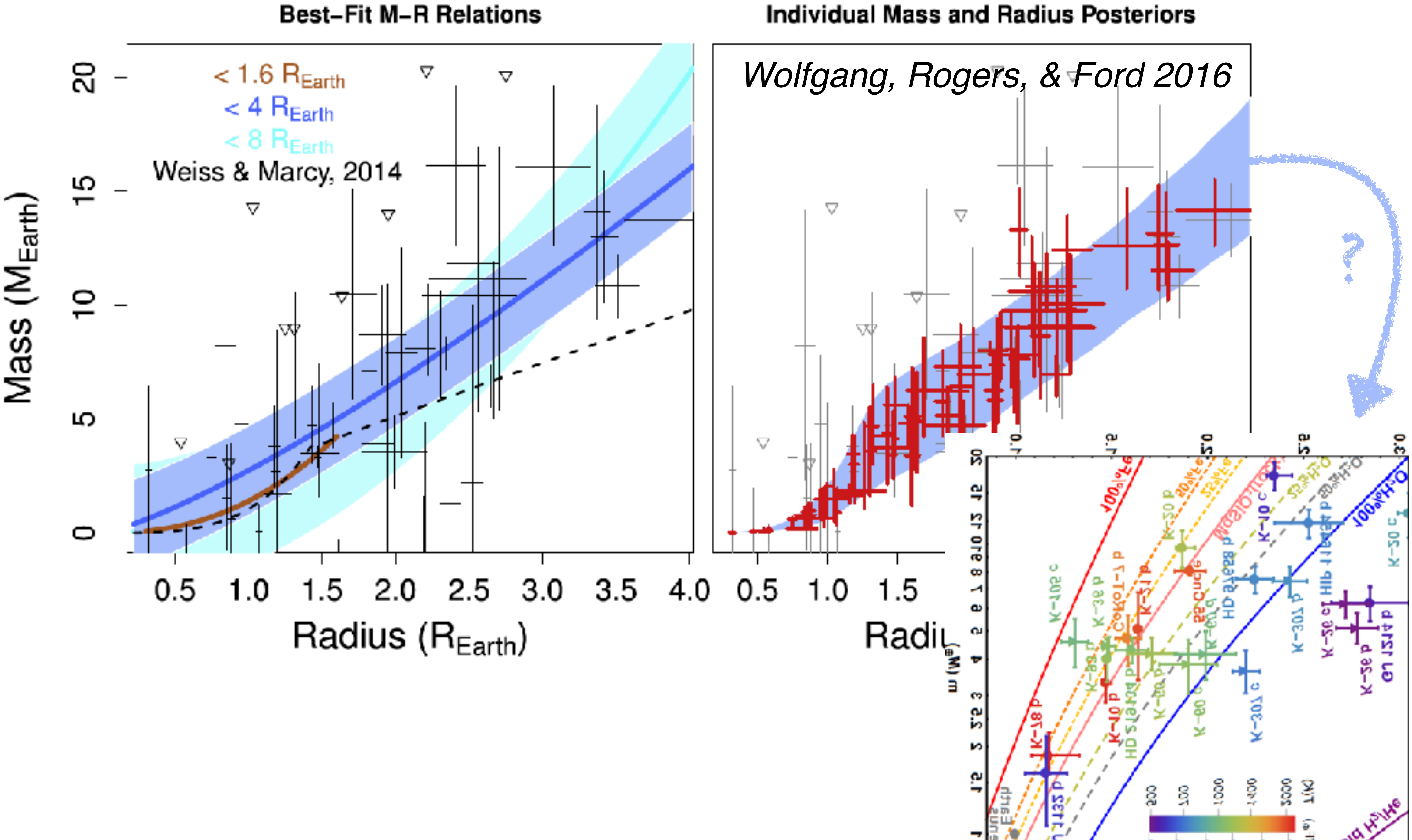




Kama et al. 2015



Small Planets Are Diverse*



Lopez-Morales et al. 2016,
Zeng, Sasselov, & Jacobsen 2016

***At least somewhat…**

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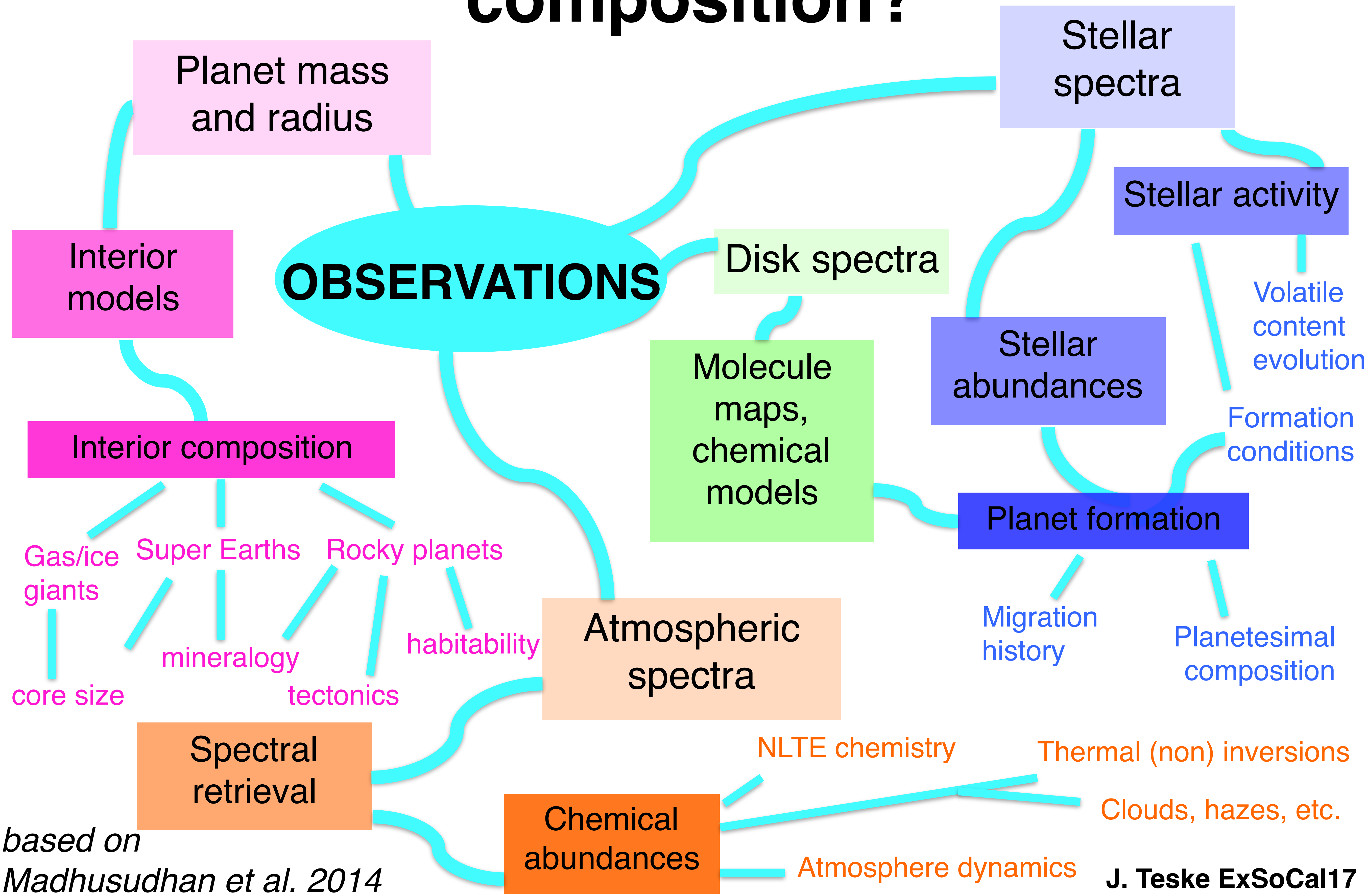
How do we learn about exoplanet composition?



based on Madhusudhan et al. 2014

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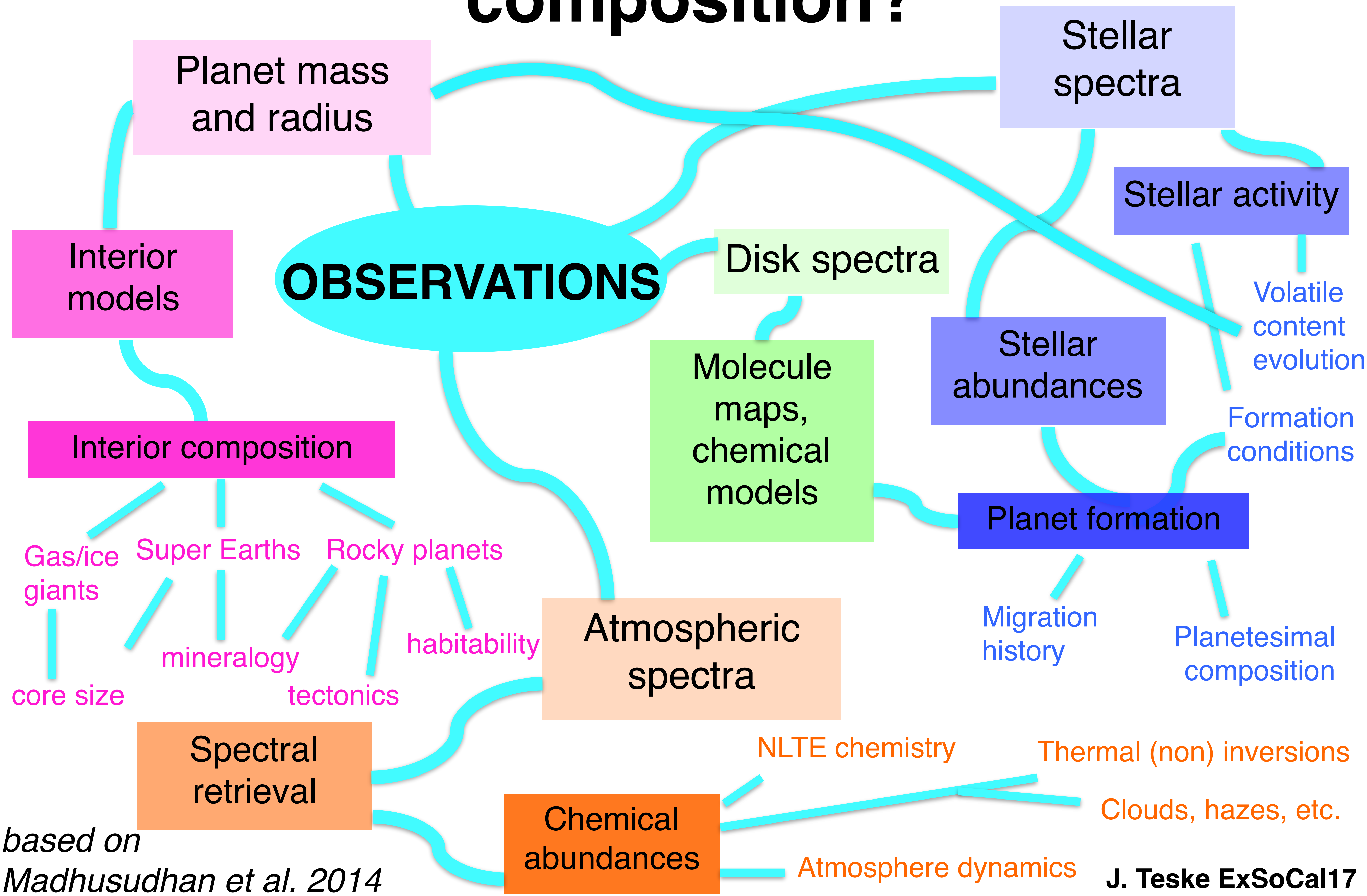

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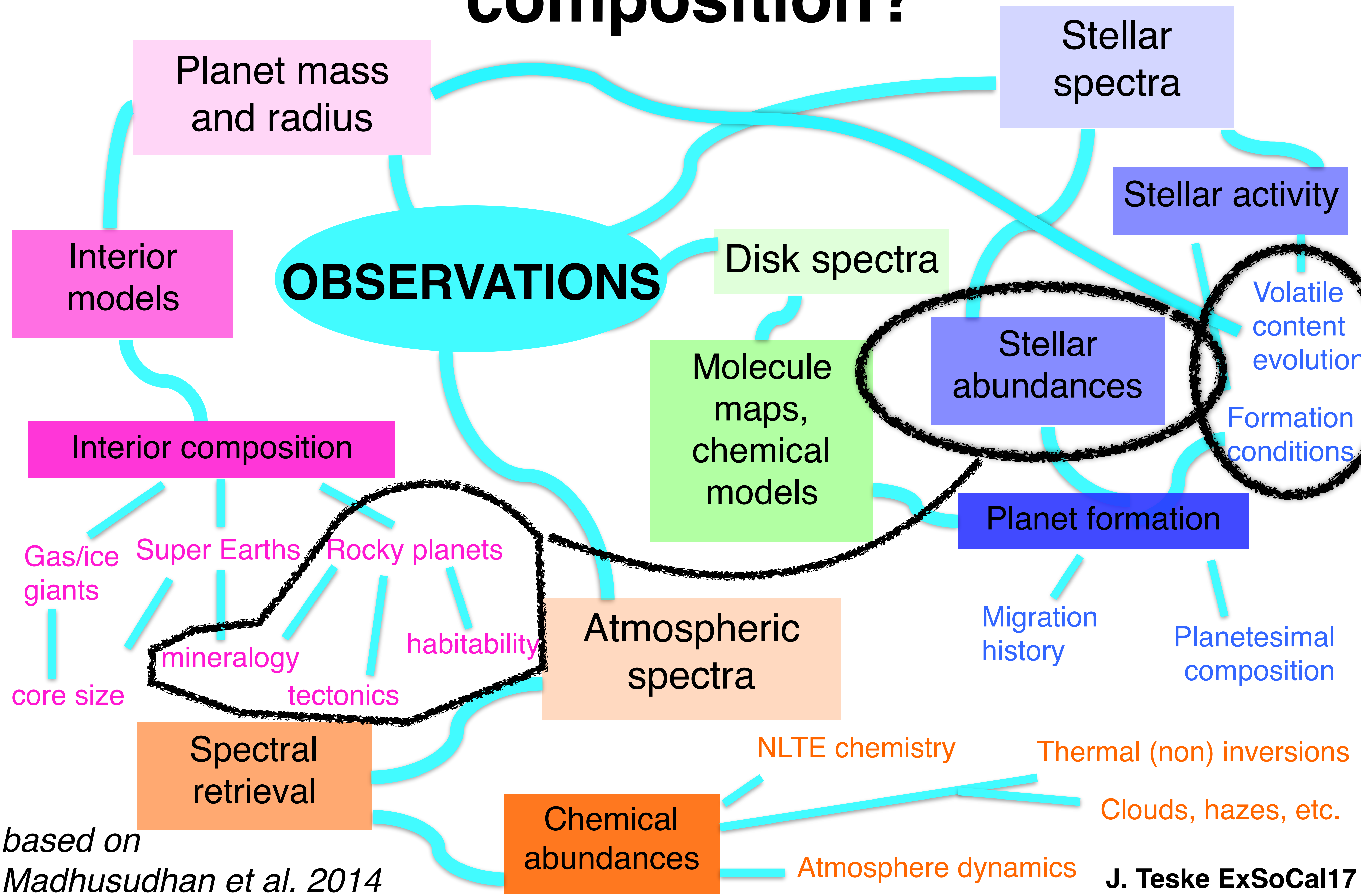
How do we learn about exoplanet composition?



based on Madhusudhan et al. 2014

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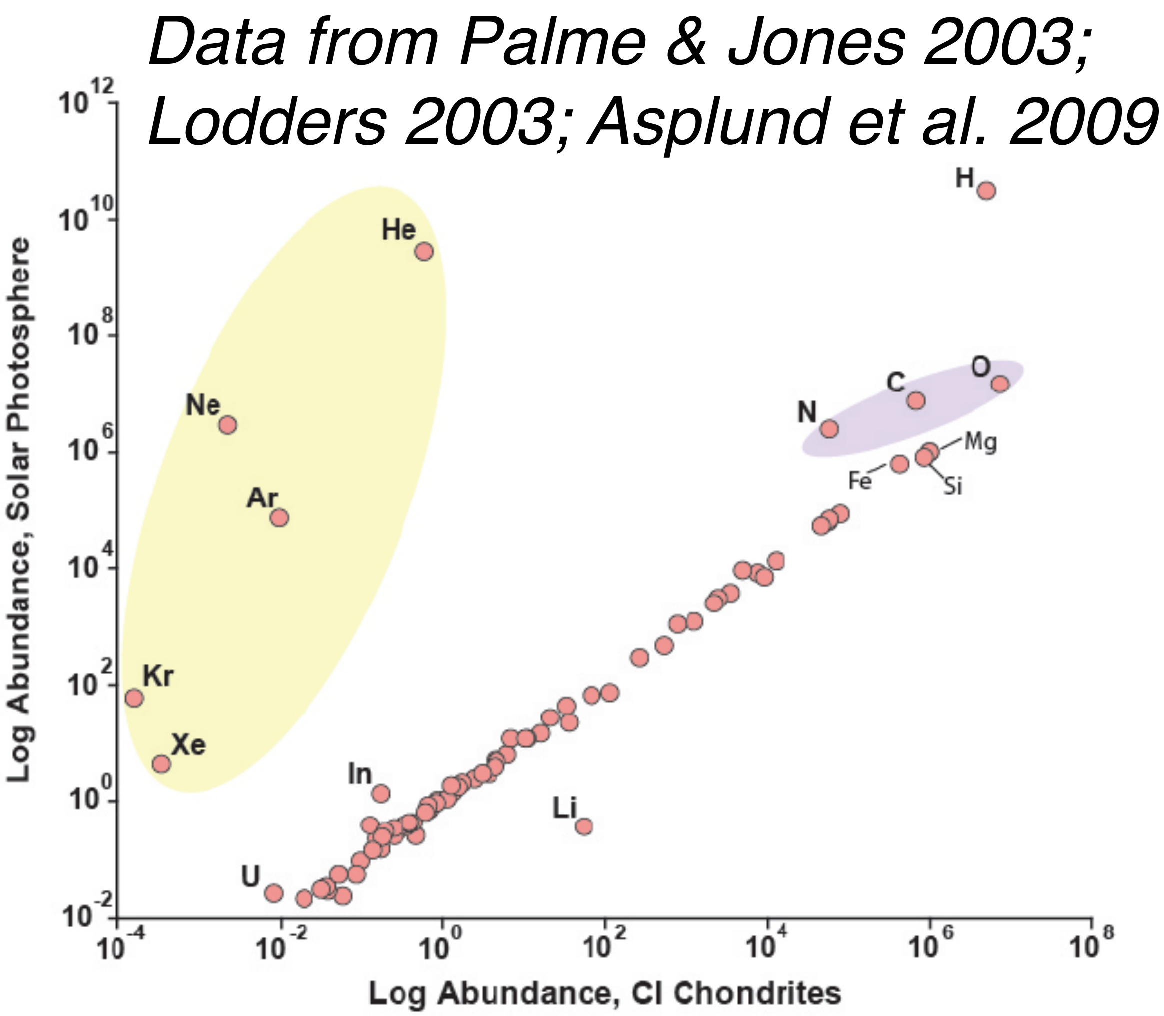
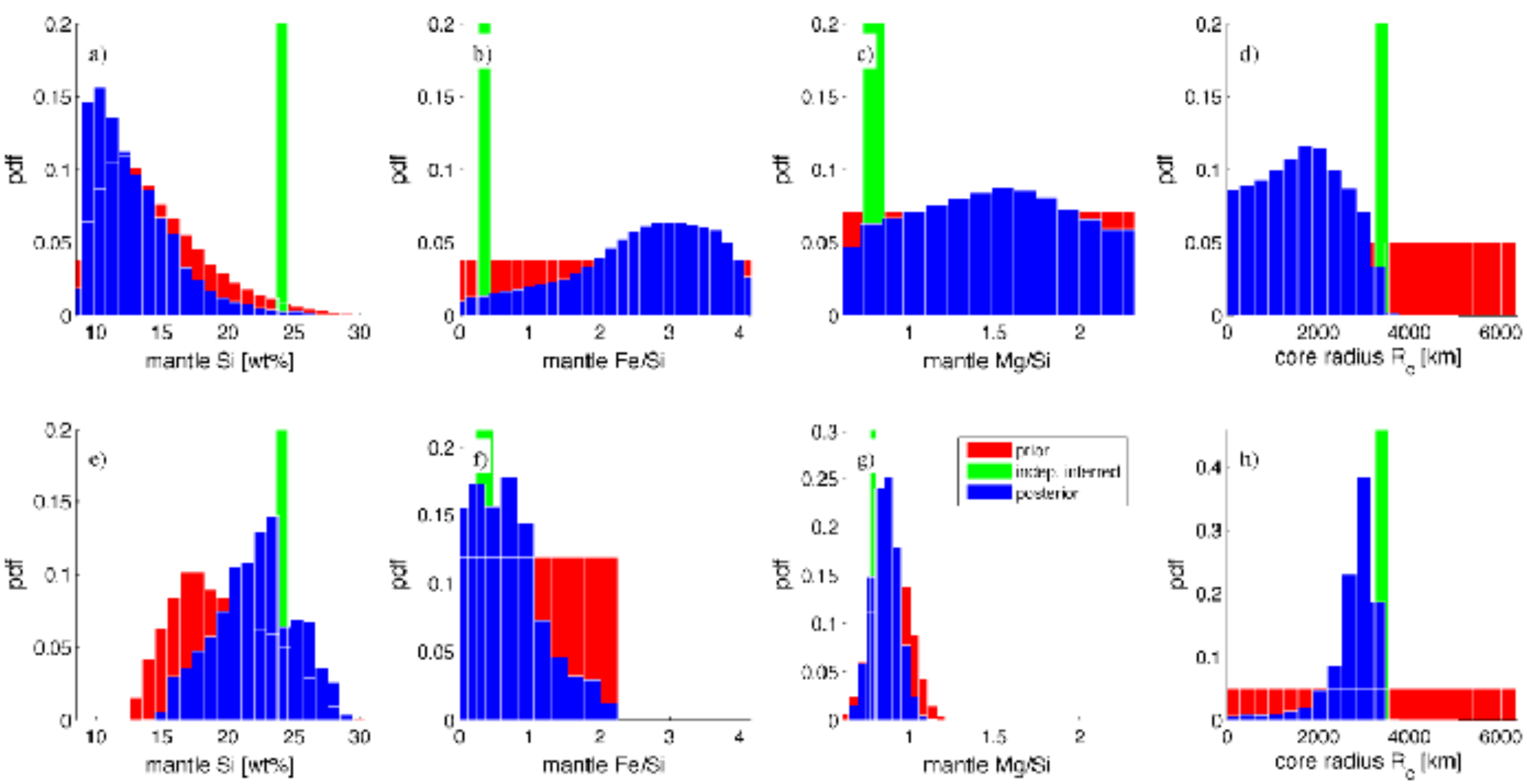
Why should we believe the star-planet composition connection?



The Sun's abundances match those of primitive solar system material

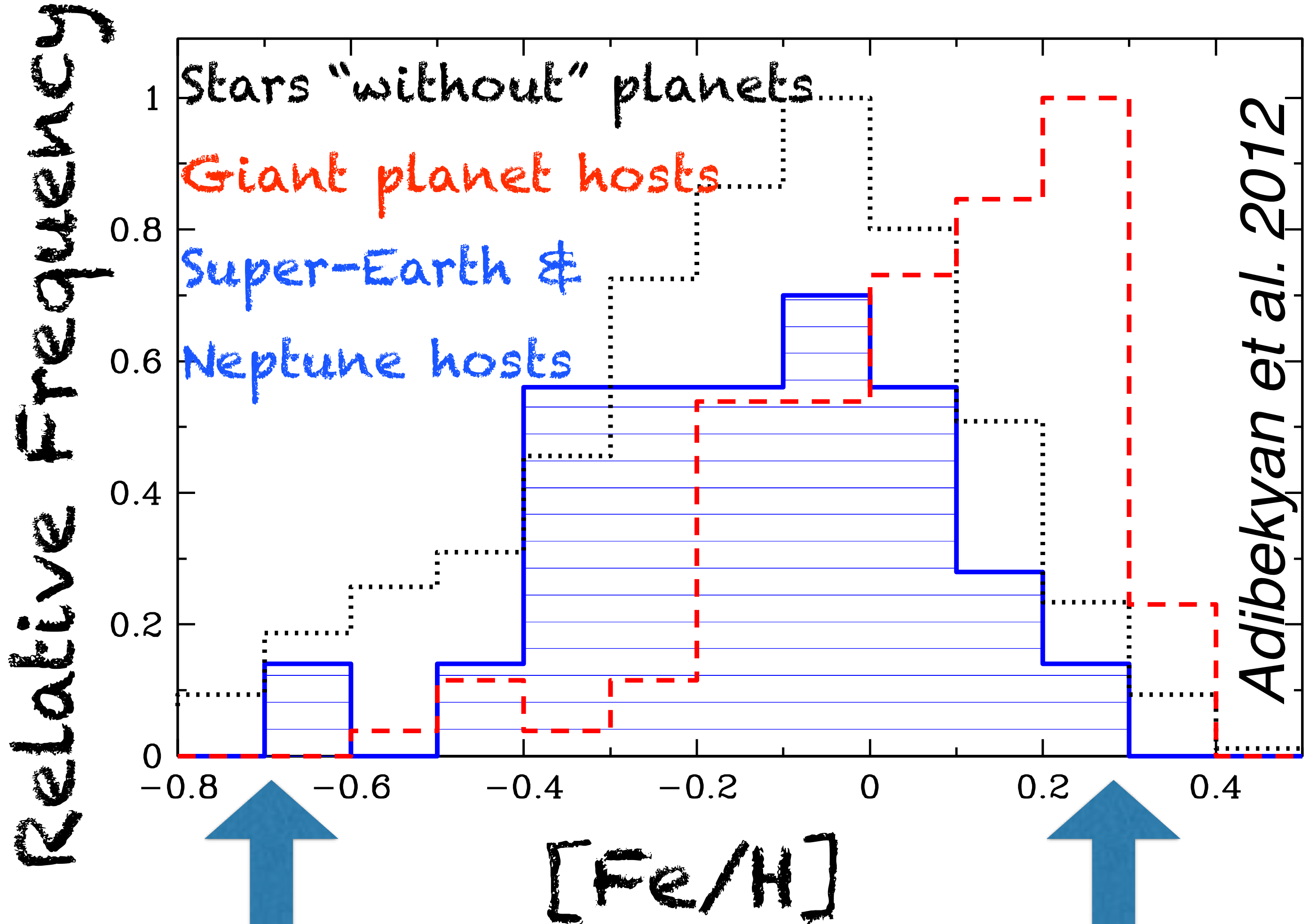


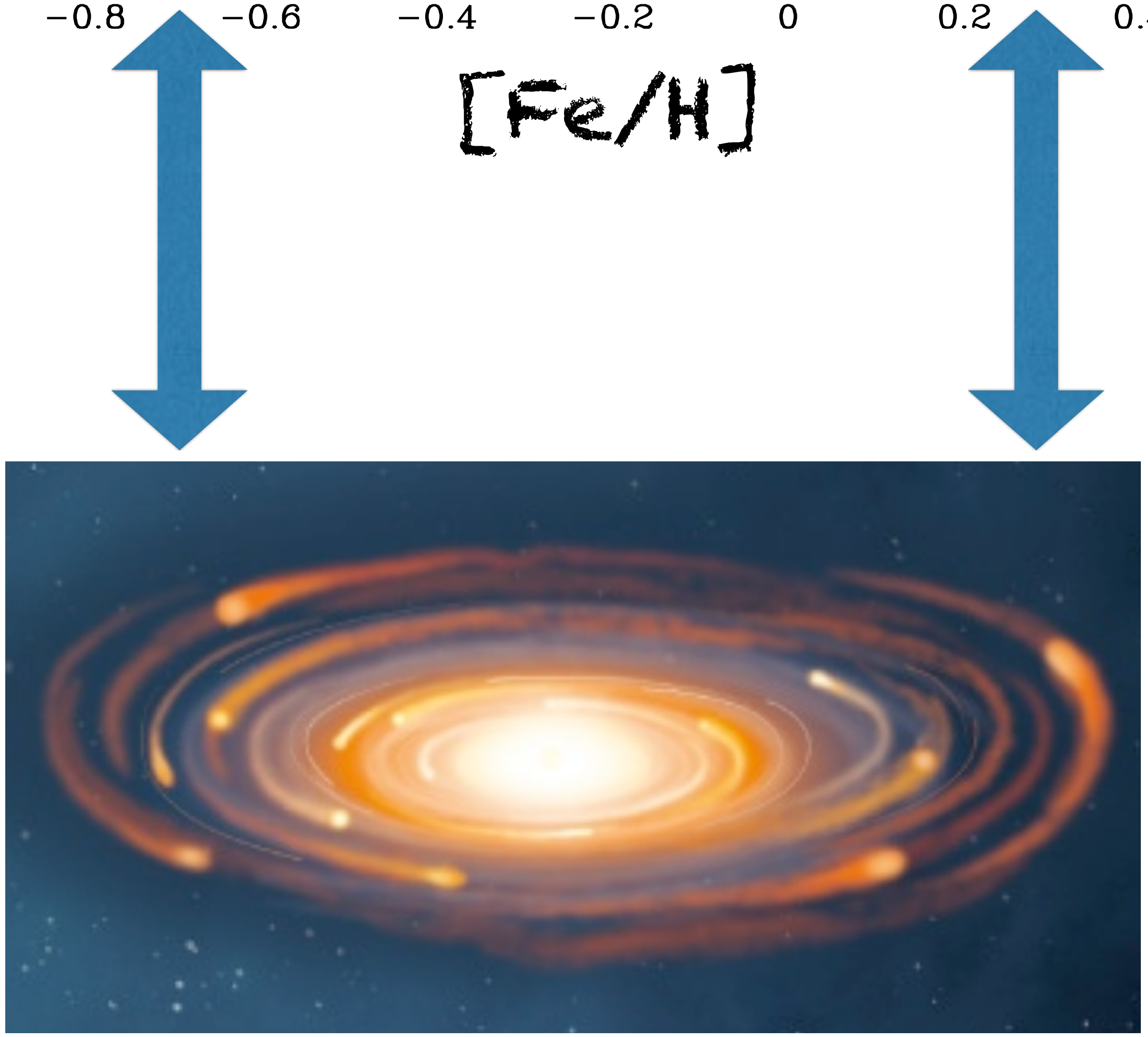
Earth's mantle composition & R_{core} retrieved more accurately with host star abundance constraints

Dorn et al. 2015

Host star [Fe/H]

Host star [Fe/H]





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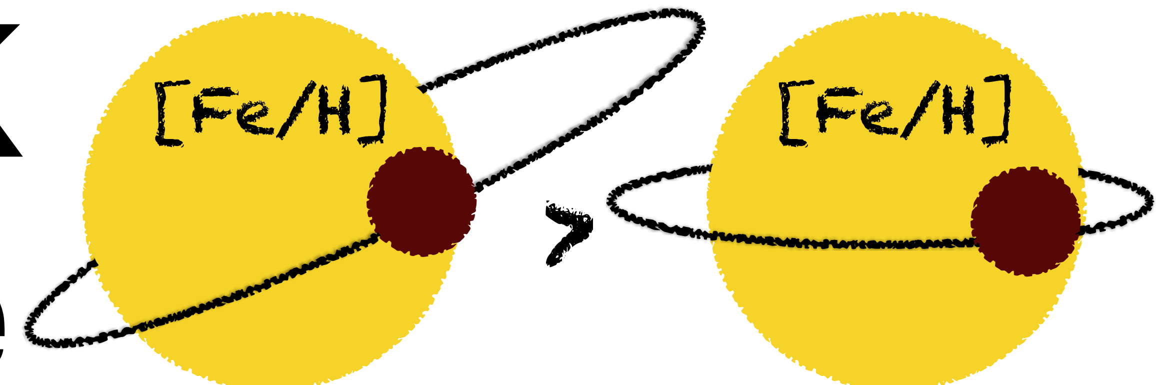
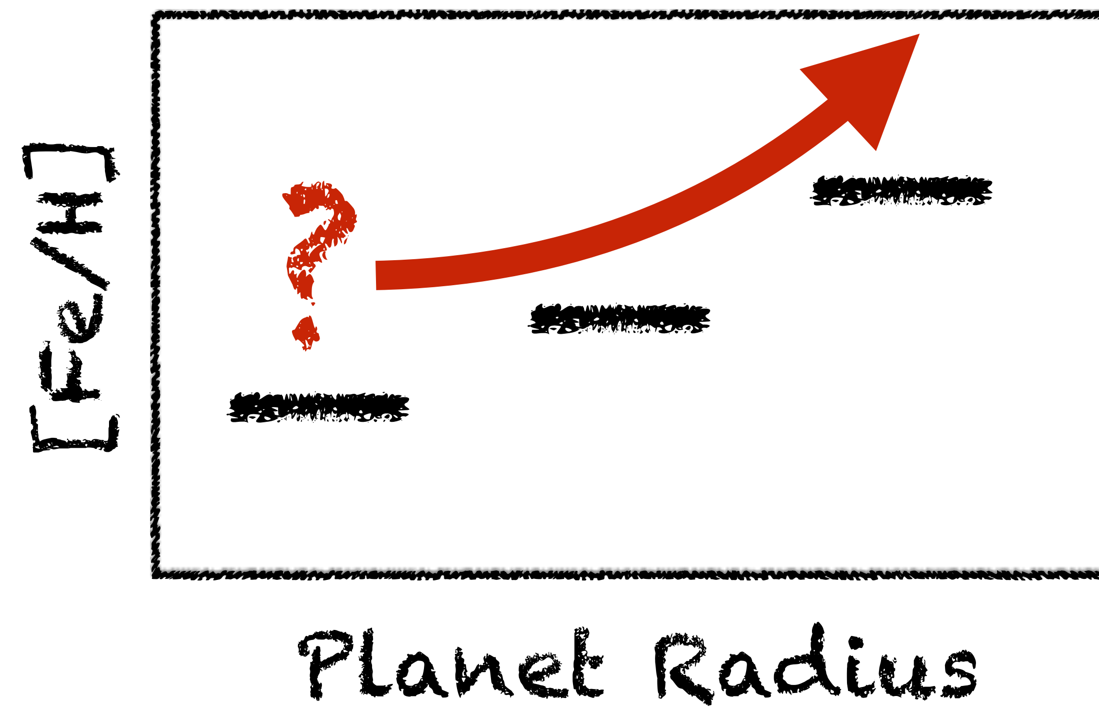


Dawson & Murray-Clay 2013

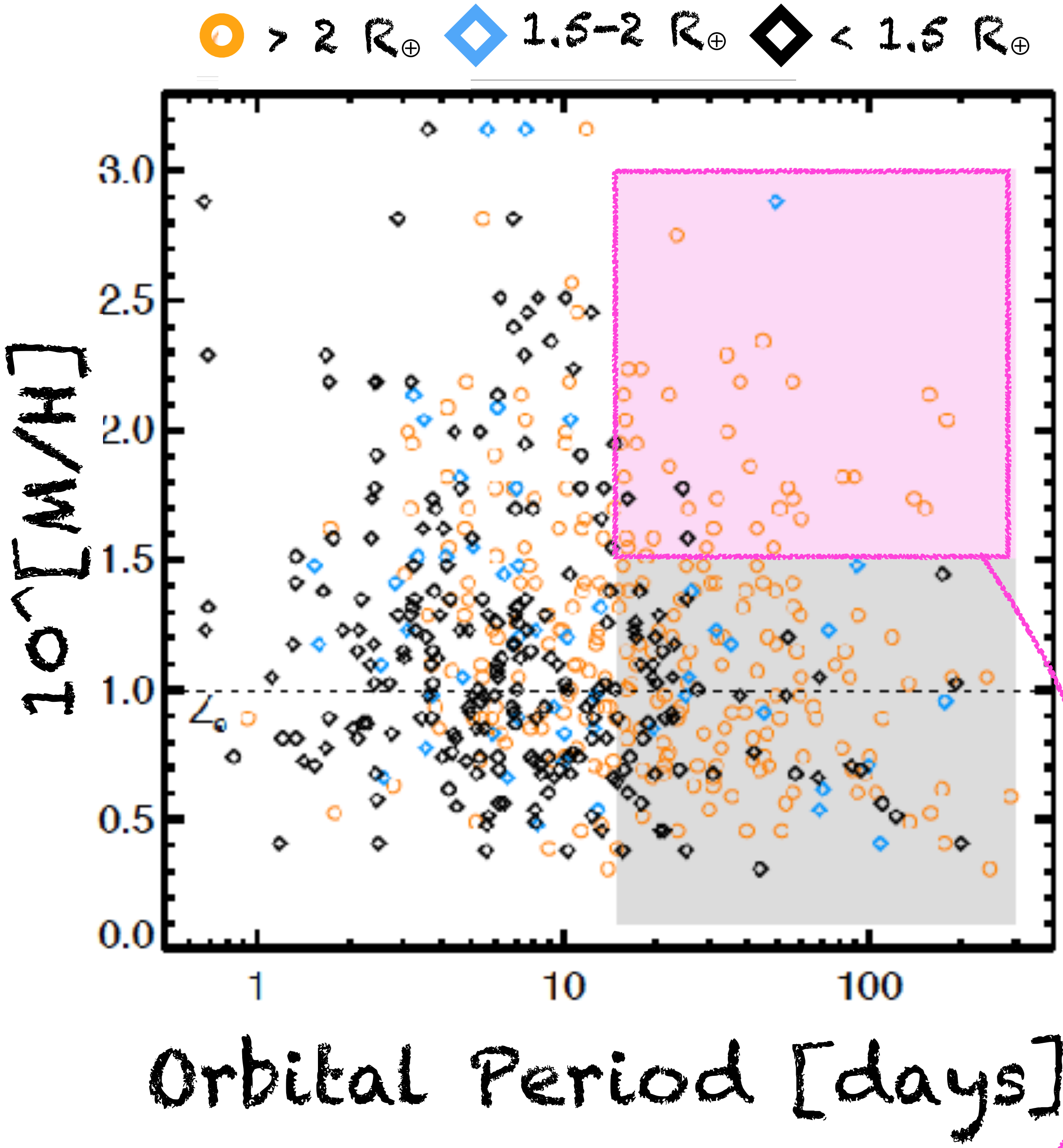


Buchhave et al. 2014, Schlaufman 2015

see also Winn et al. 2017

$[Fe/H]_{star}$ vs. $Period_{planet}$

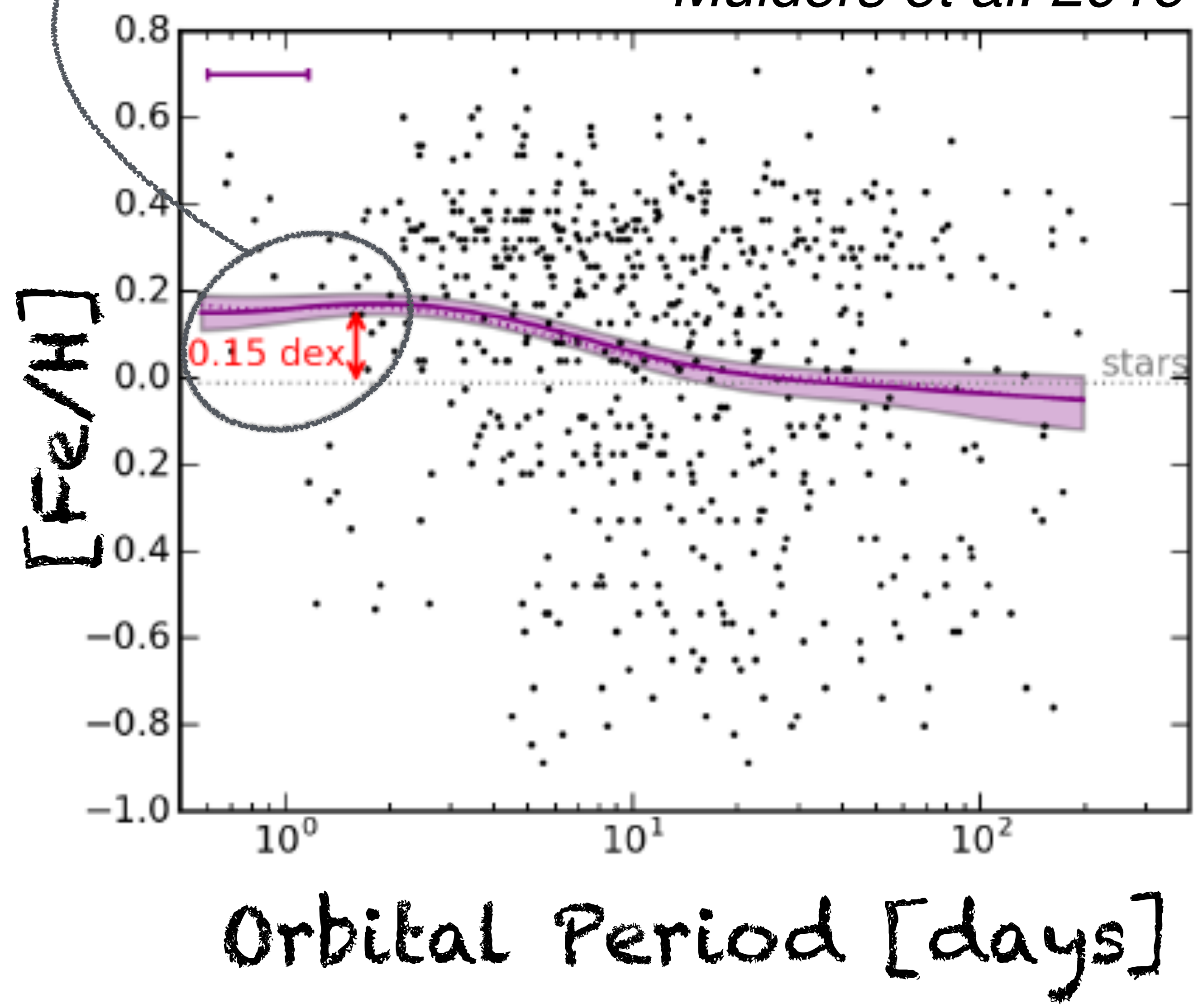
Dawson et al. 2015



No small, longer period planets around "metal-rich" stars → embryos grow faster

Short period planets prefer metal-rich stars

Mulders et al. 2016



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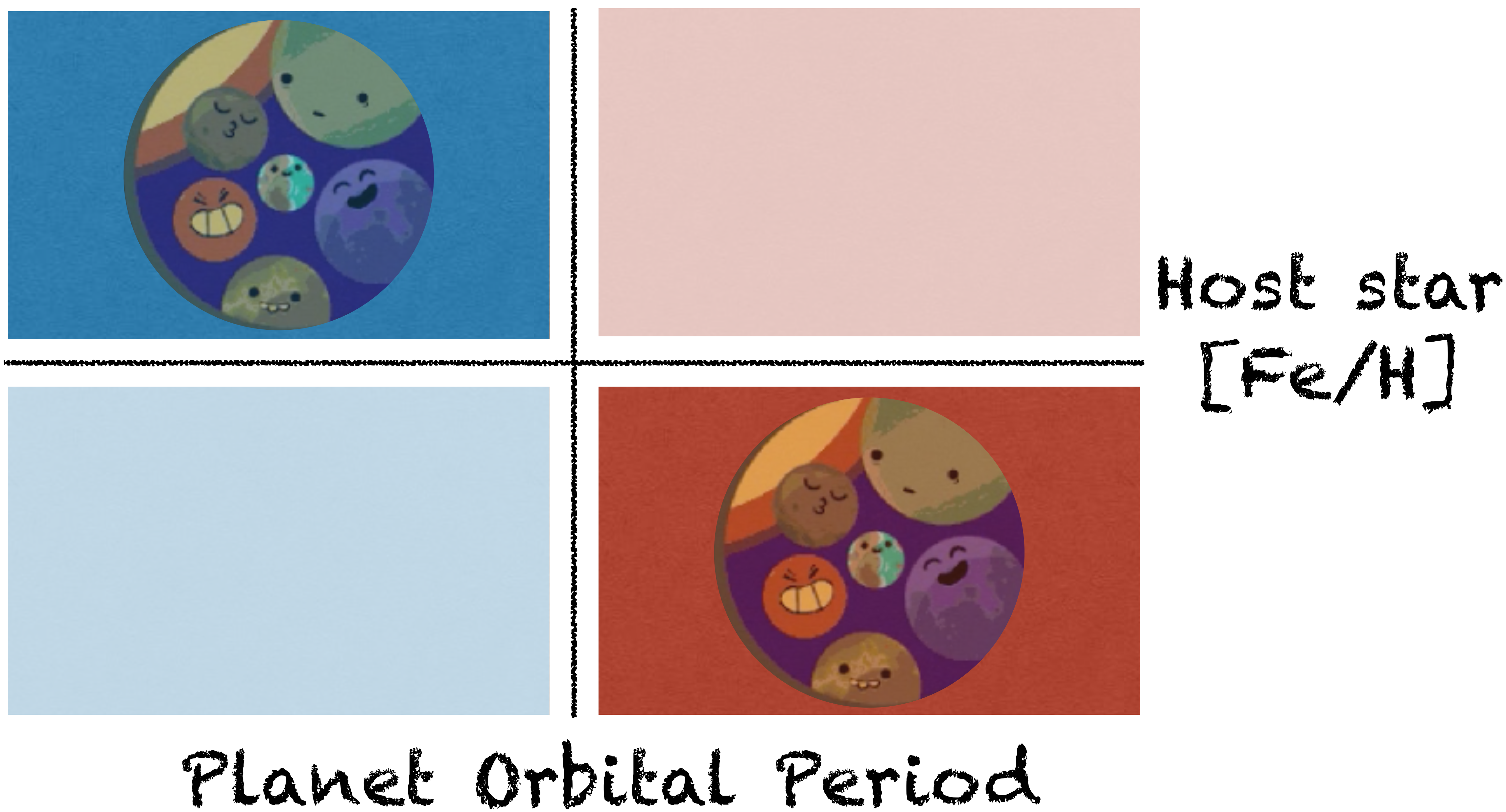
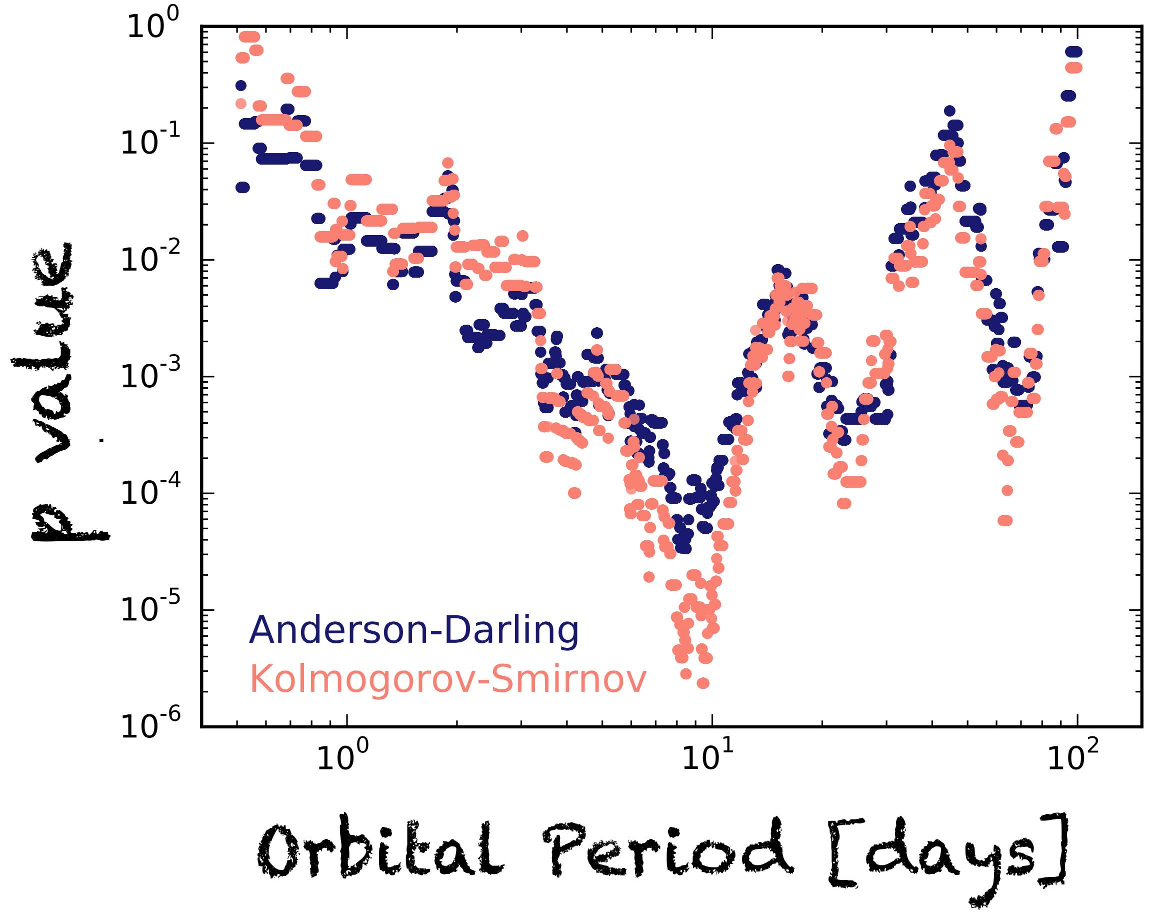
Two Distinct Orbital Period Regimes Inferred from Host Star [Fe/H]

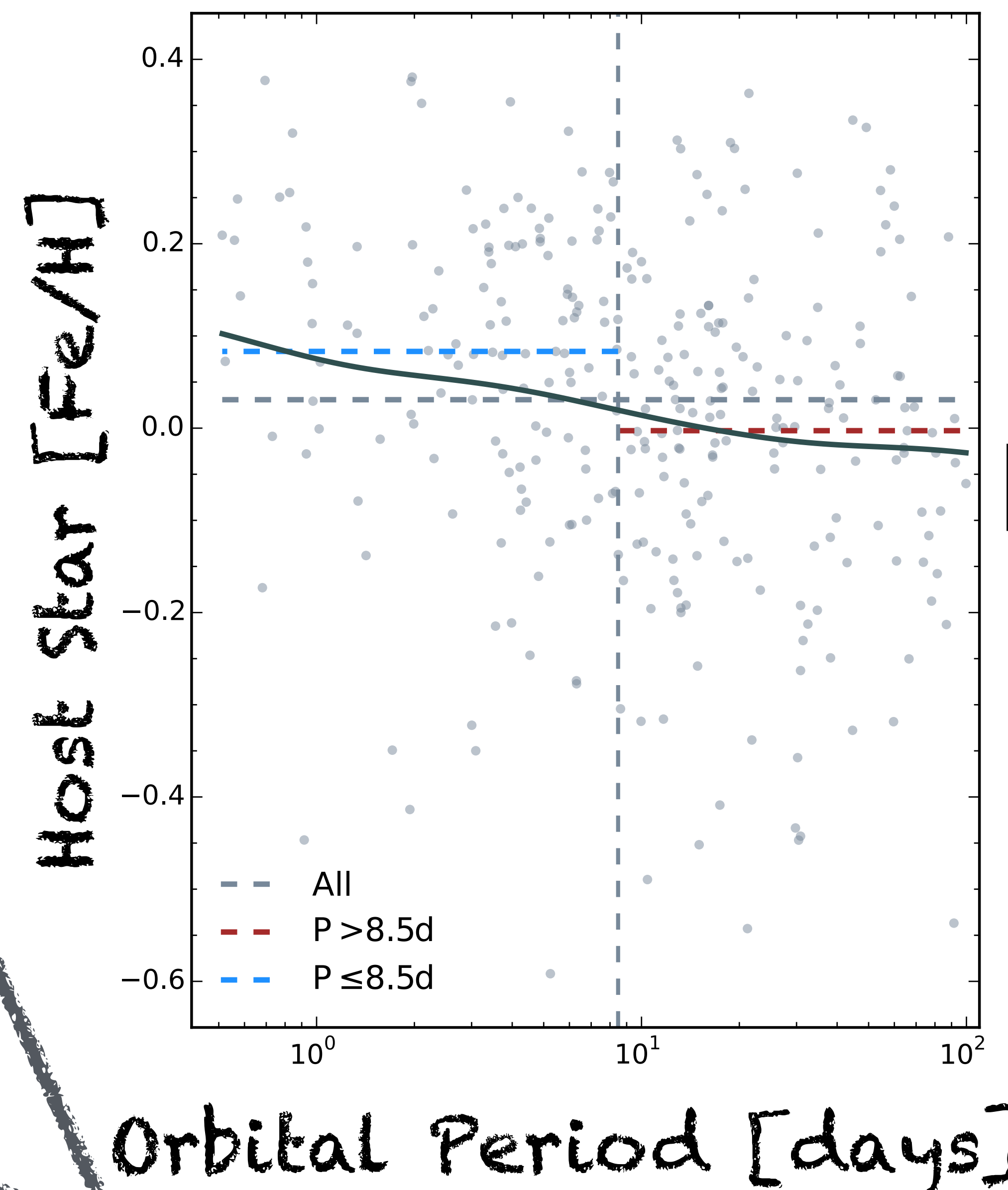
measured with APOGEE



$[Fe/H]_{star}$ vs. $Period_{planet}$

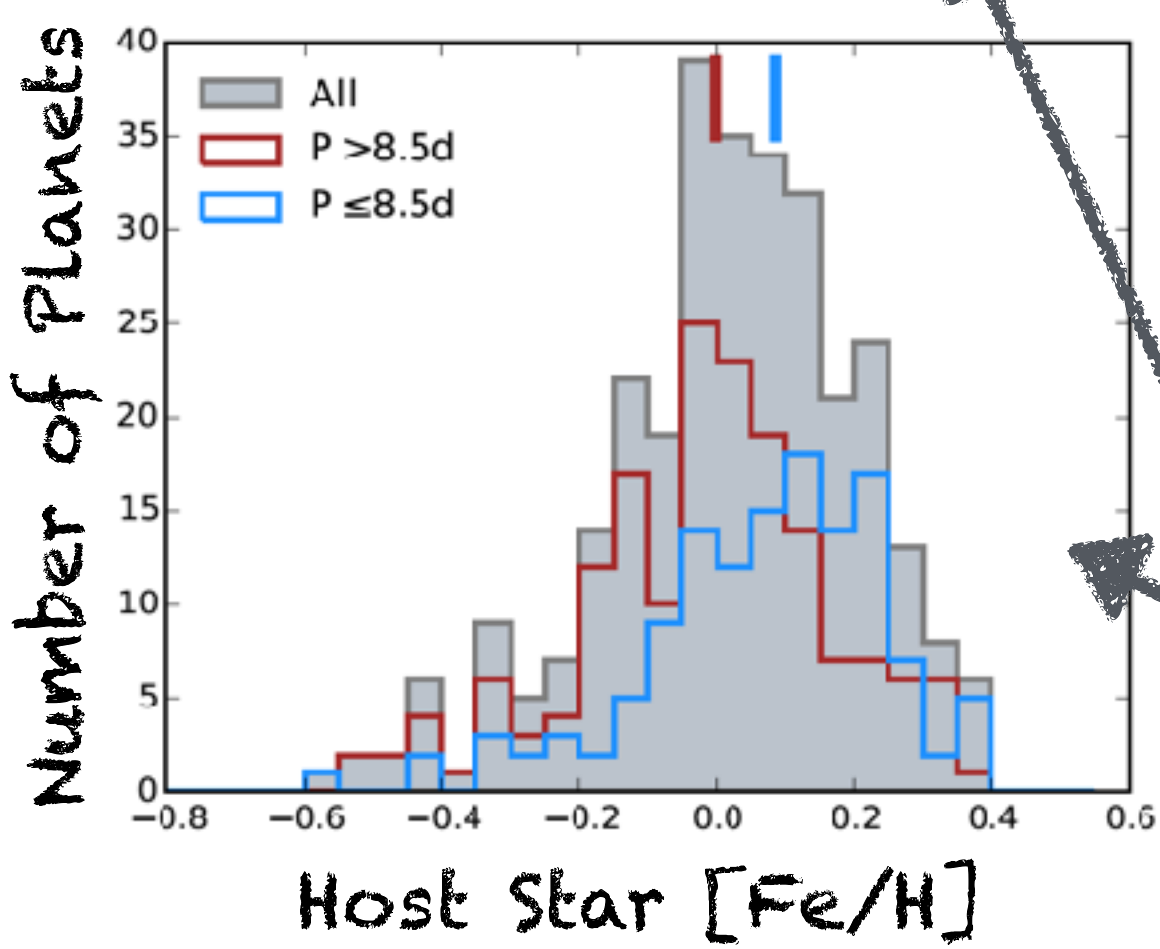
Wilson, Teske et al. almost submitted :)





300 KOI dwarfs

P_{crit} = 8.5 days (~0.08-0.1 AU)



Need ≤ 0.1 dex precision to detect

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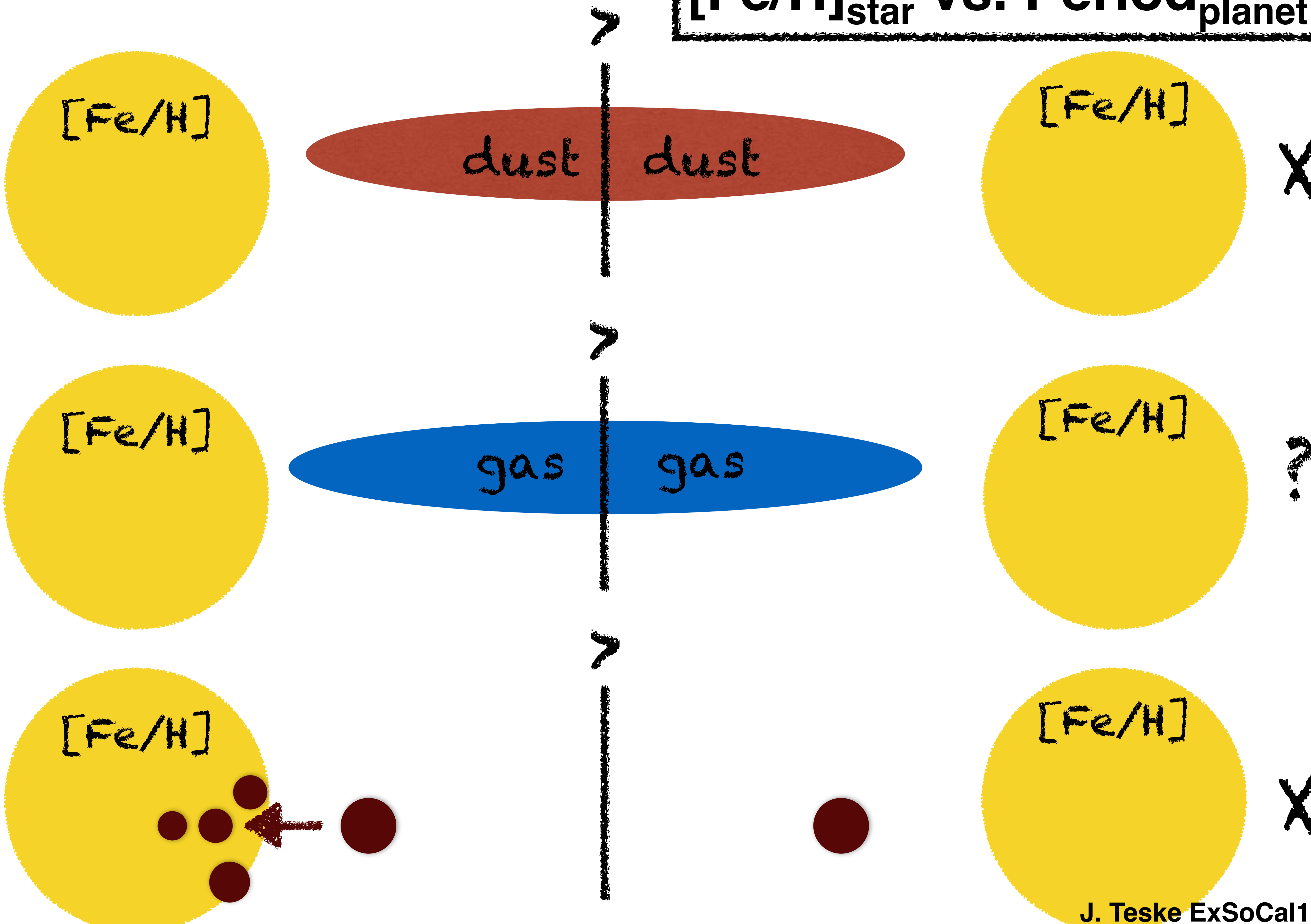
$[Fe/H]_{star}$ vs. $Period_{planet}$



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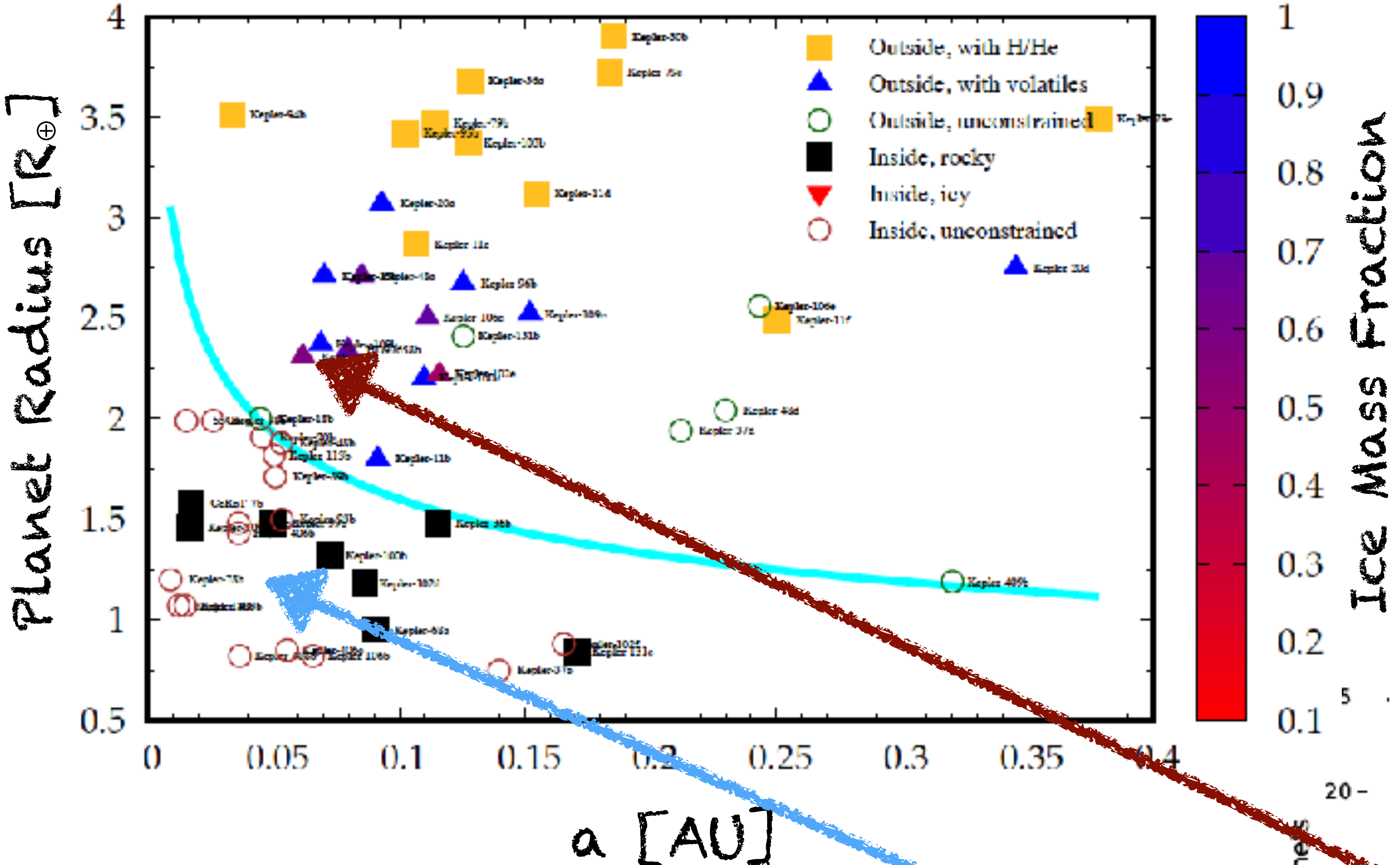
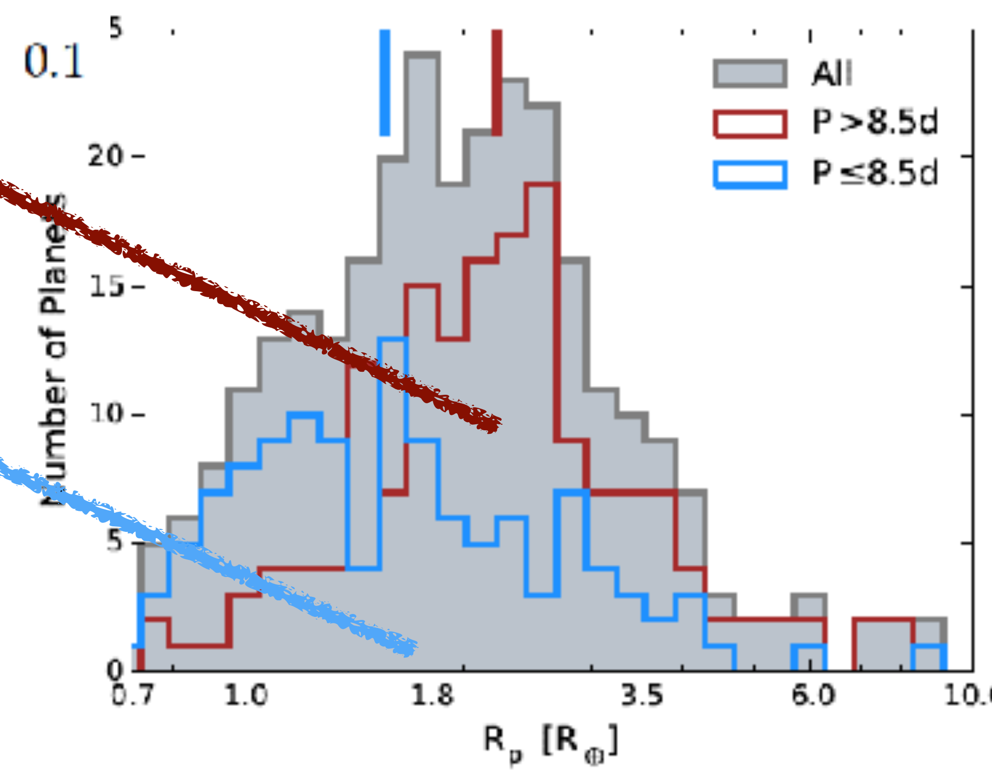
Jin & Mordasini 2017
based on Fulton et al. 2017
see also Owen & Wu 2017, 2013

$[Fe/H]_{star}$ vs. $Period_{planet}$

vs. R_{planet}





Small planets around more metal-rich stars orbit closer in and are predominantly rocky

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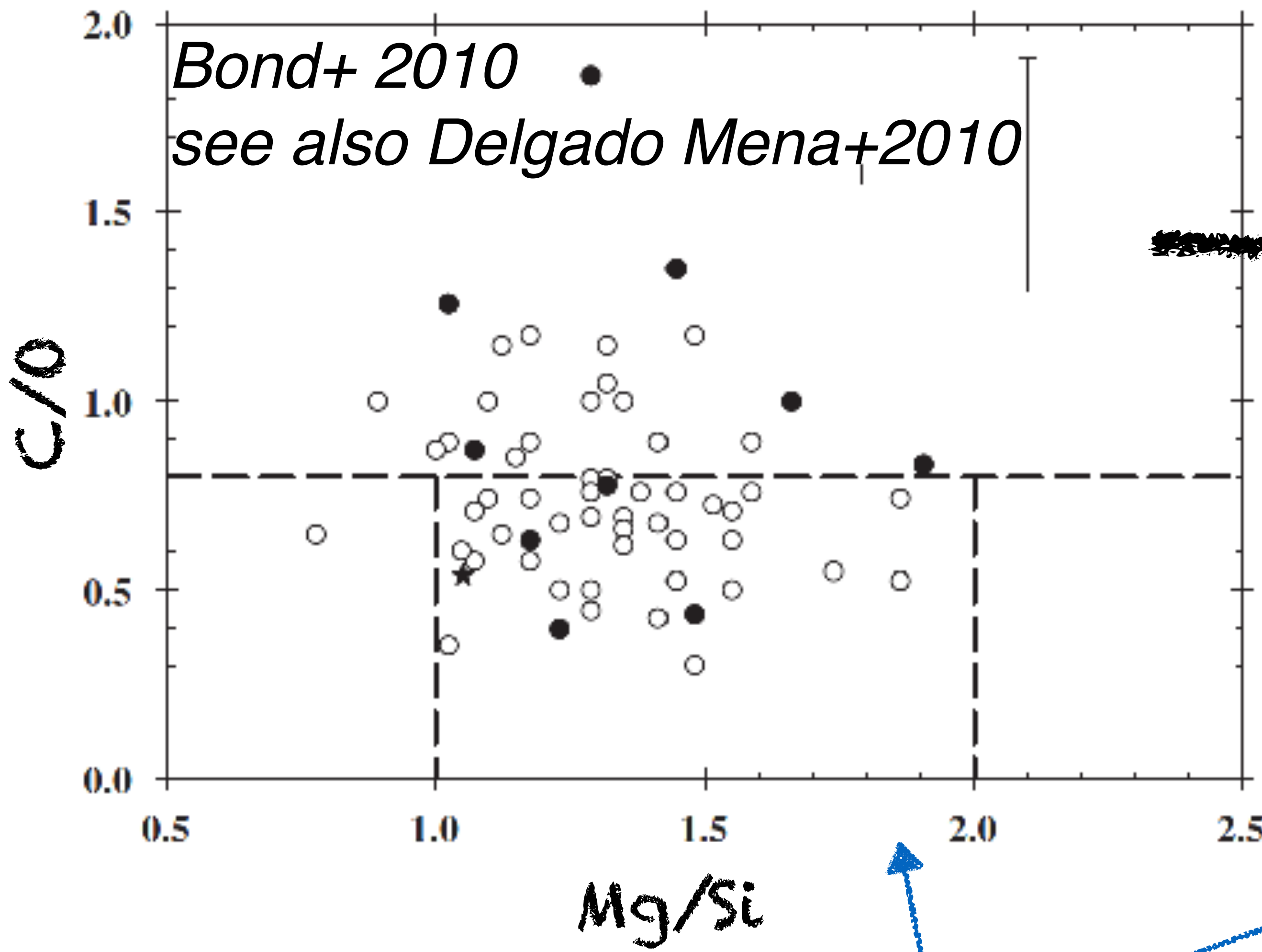
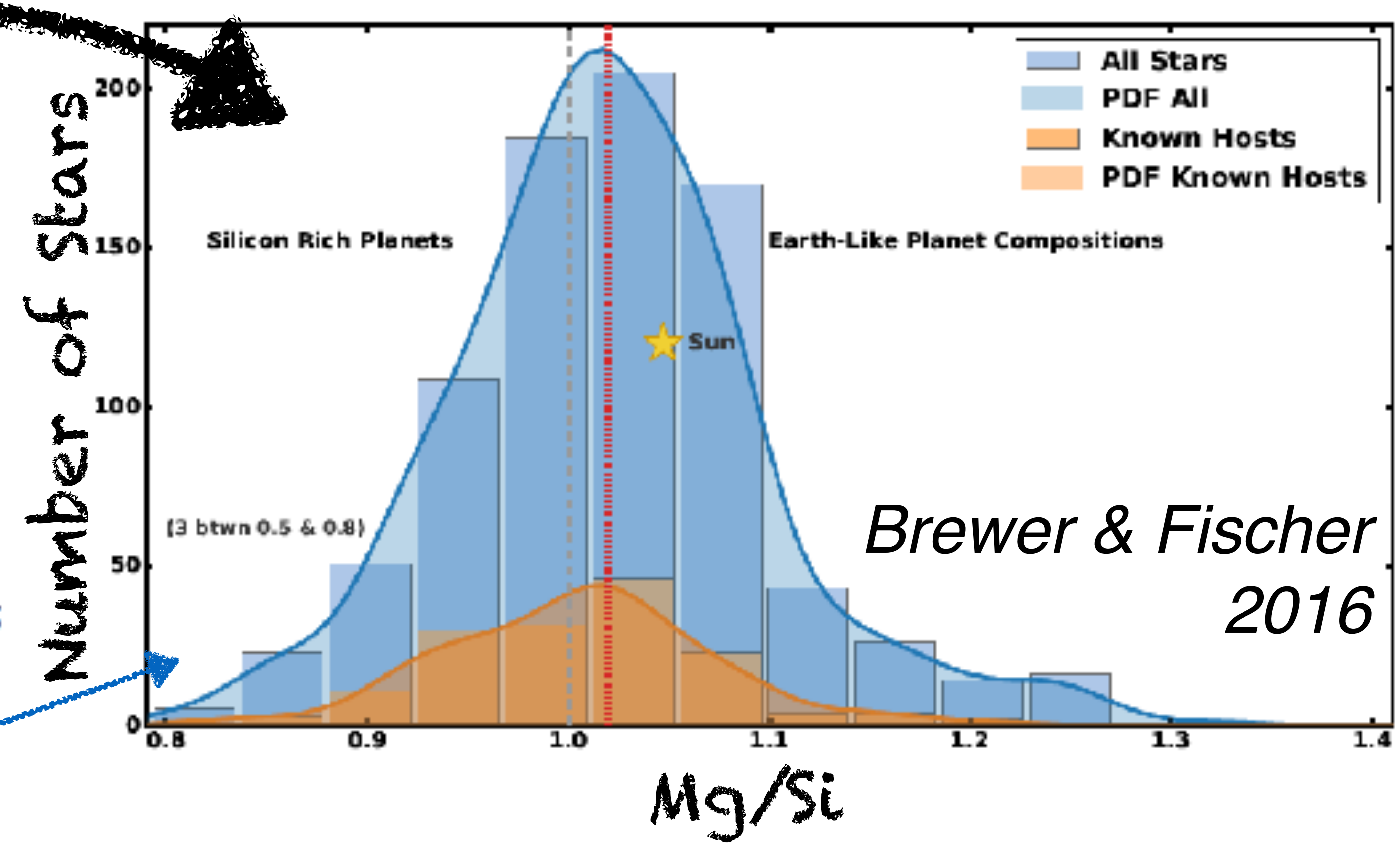
Host star Mg, Si

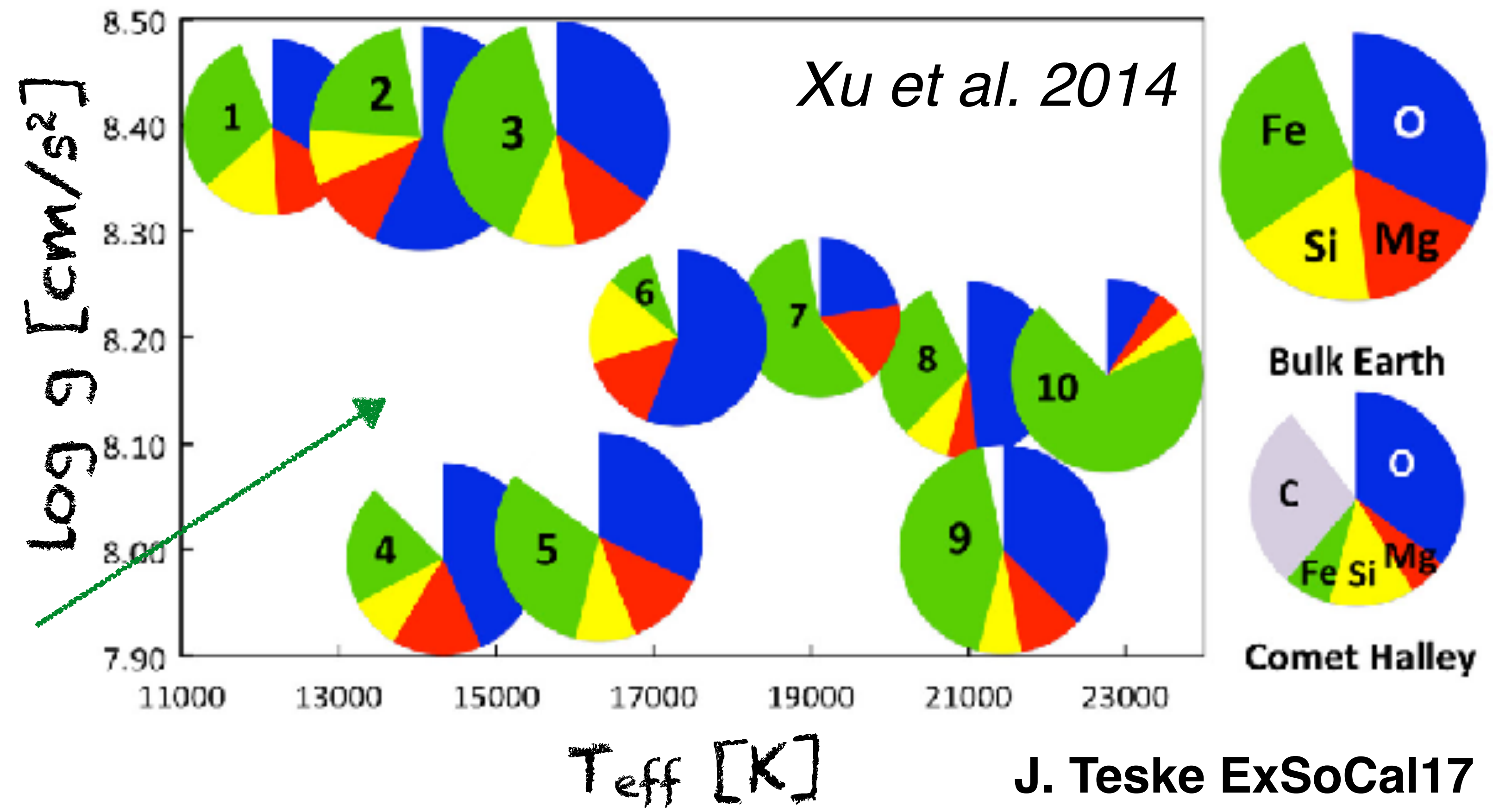
Host star Mg, Si





Wide variety in stellar Mg/Si, result in different interior compositions?

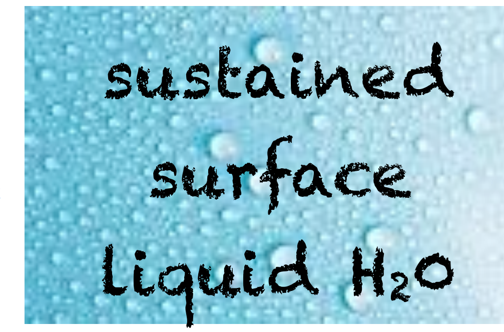
Planet "leftovers" as measured from polluted white dwarfs show range in Mg/Si (~0.7-2.3)



Stellar Chemical Clues as to the Rarity of Exoplanetary Tectonics

and thus Earth-likeness

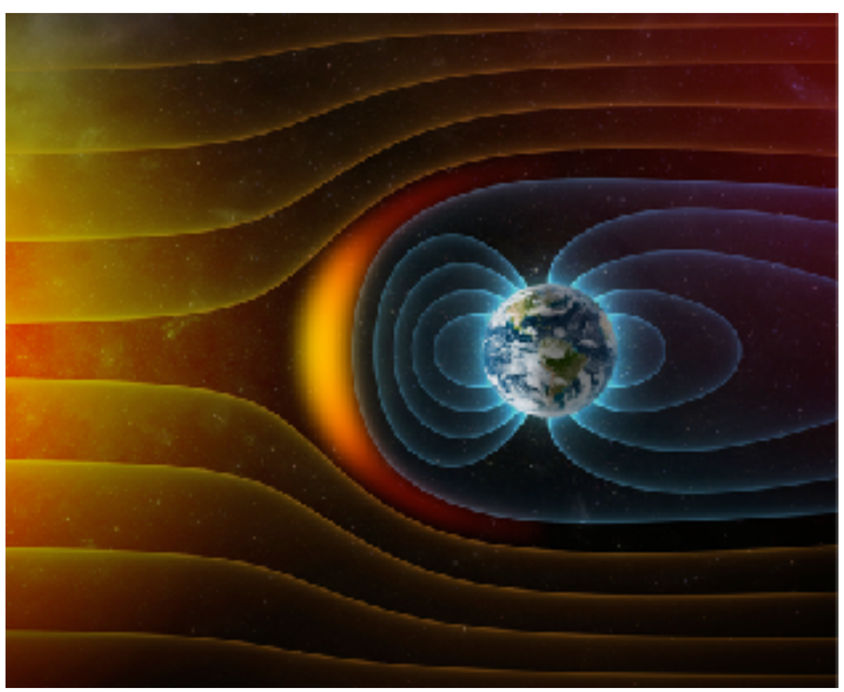
atmospheric escape

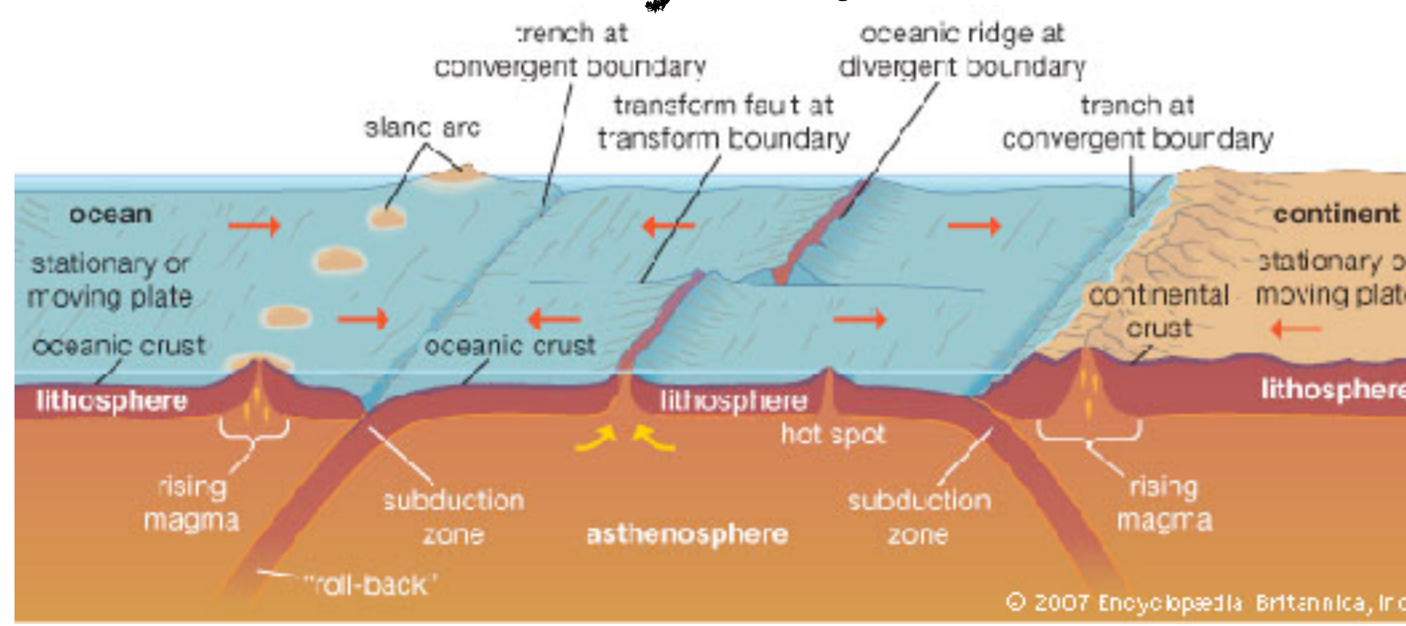


surface temp
rock weathering

volatile recycling

core cooling





Based on Foley & Driscoll 2016, Fig. 1
Images from ISS, Mysterious Universe, Britannica

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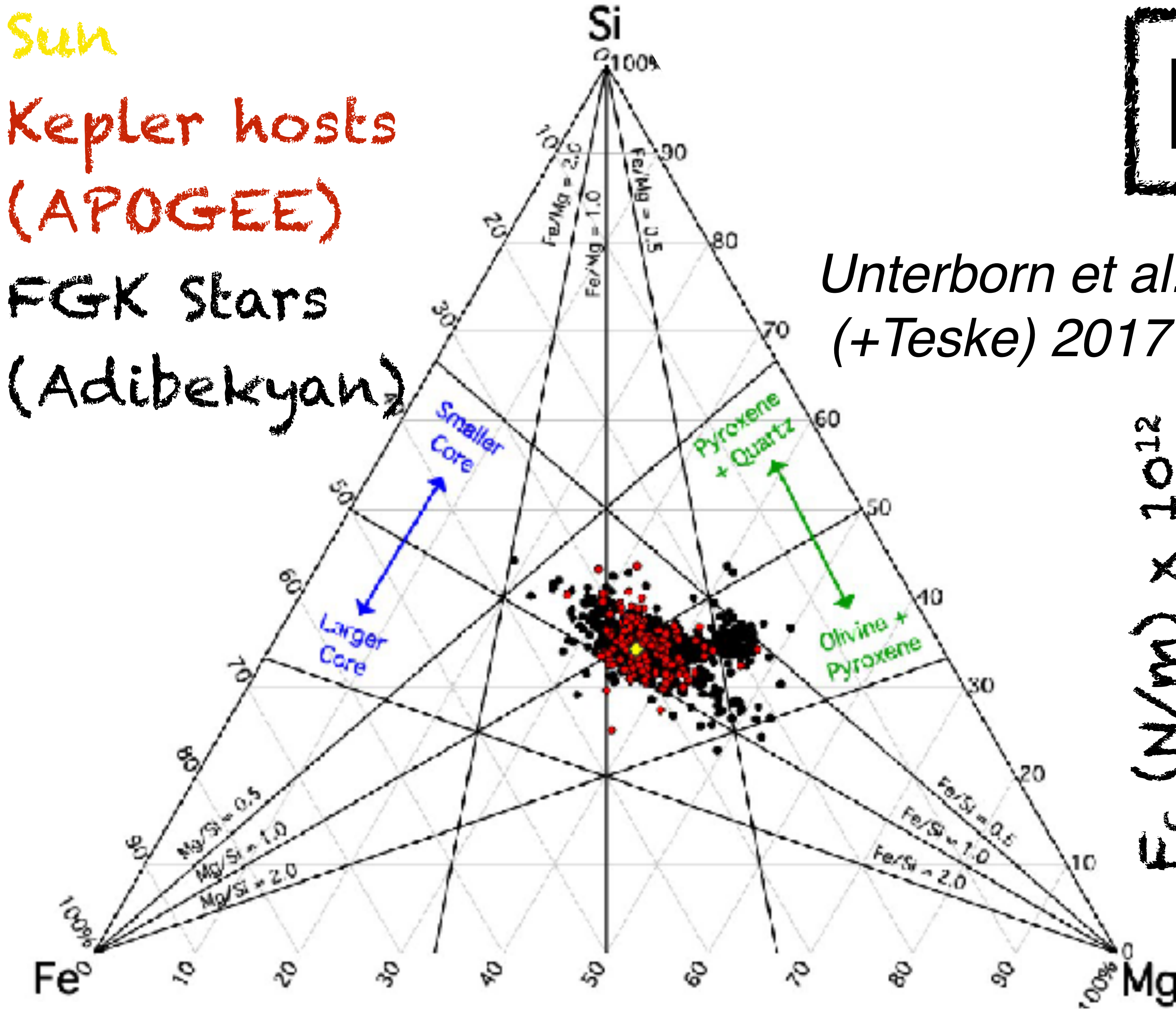
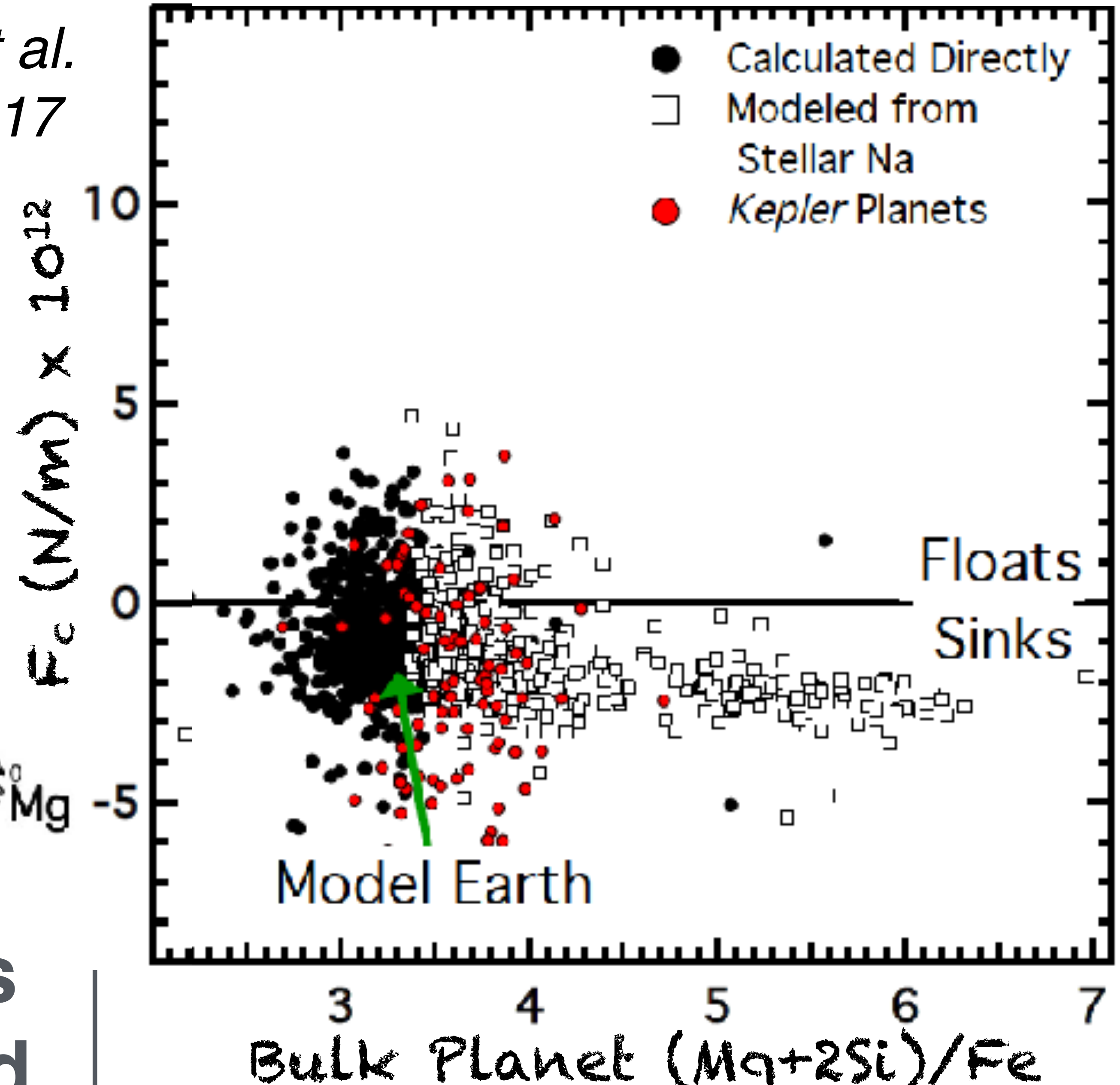
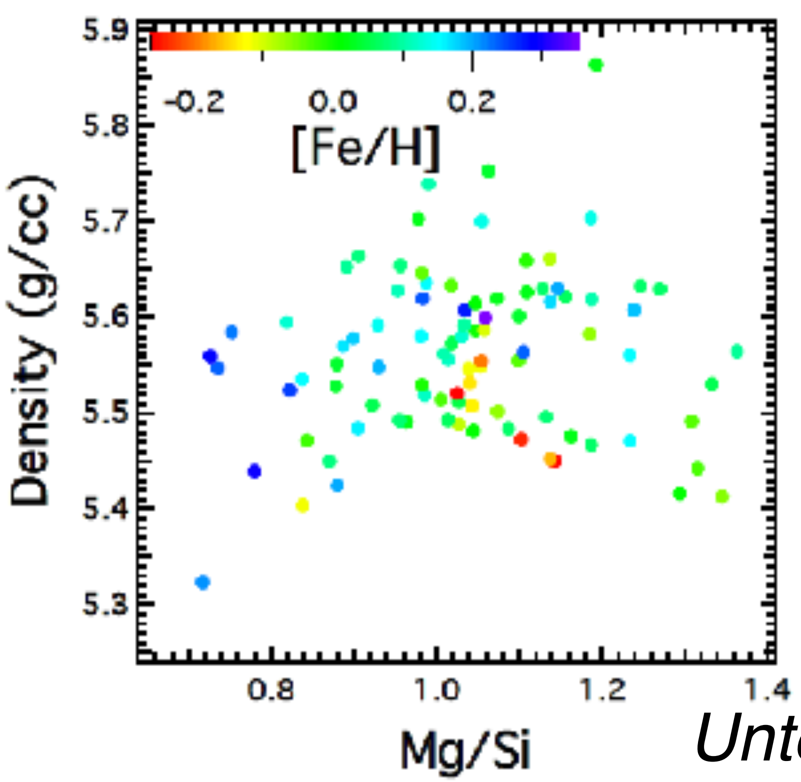
Host star Mg, Si



Unterborn et al. (+Teske) 2017



Mg/Si affects whether crust sinks or not and thus plate tectonics



Mg/Si affects core size and thus planet density

based on Unterborn & Panero 2017

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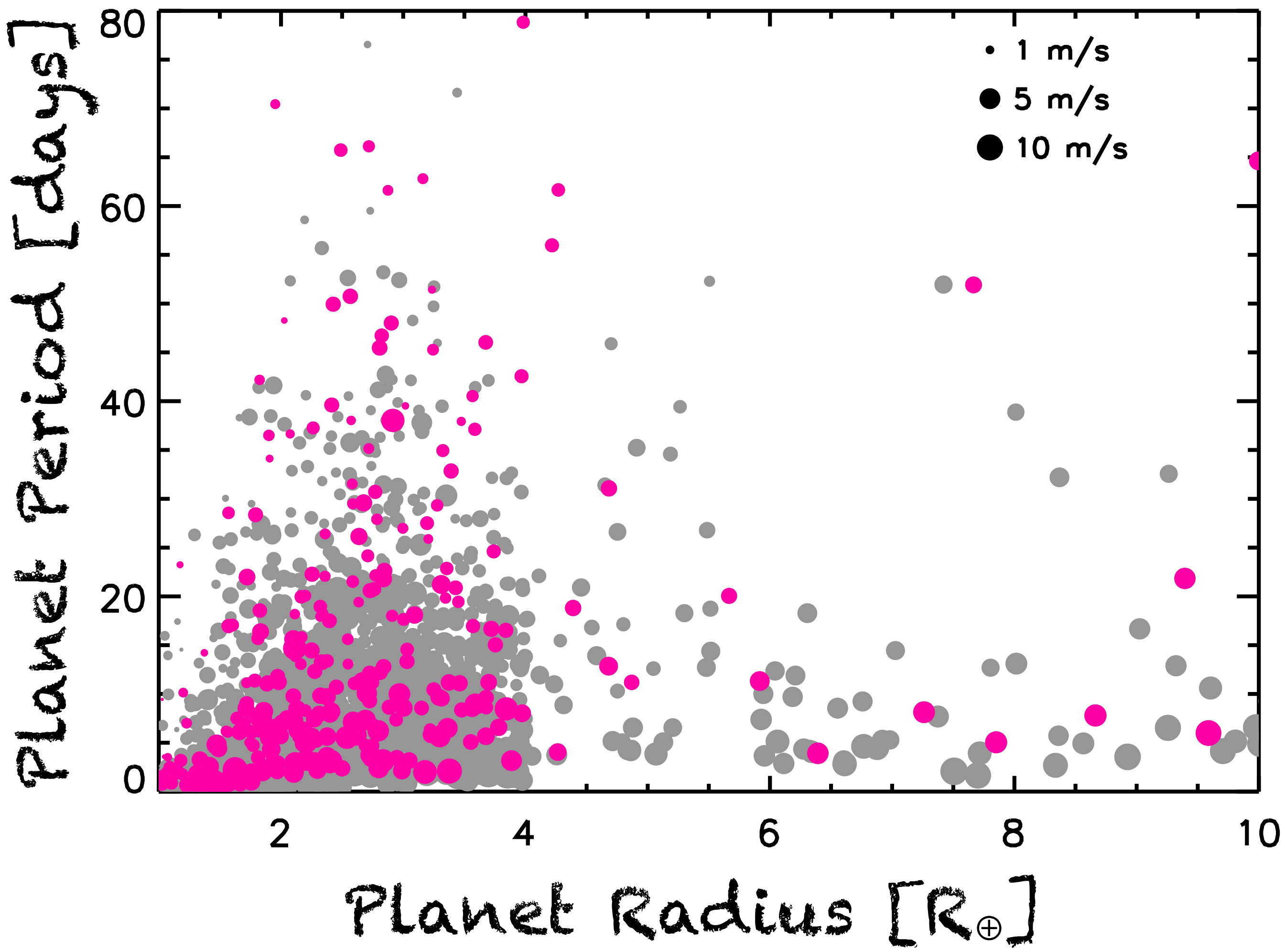
Looking Ahead to TESS

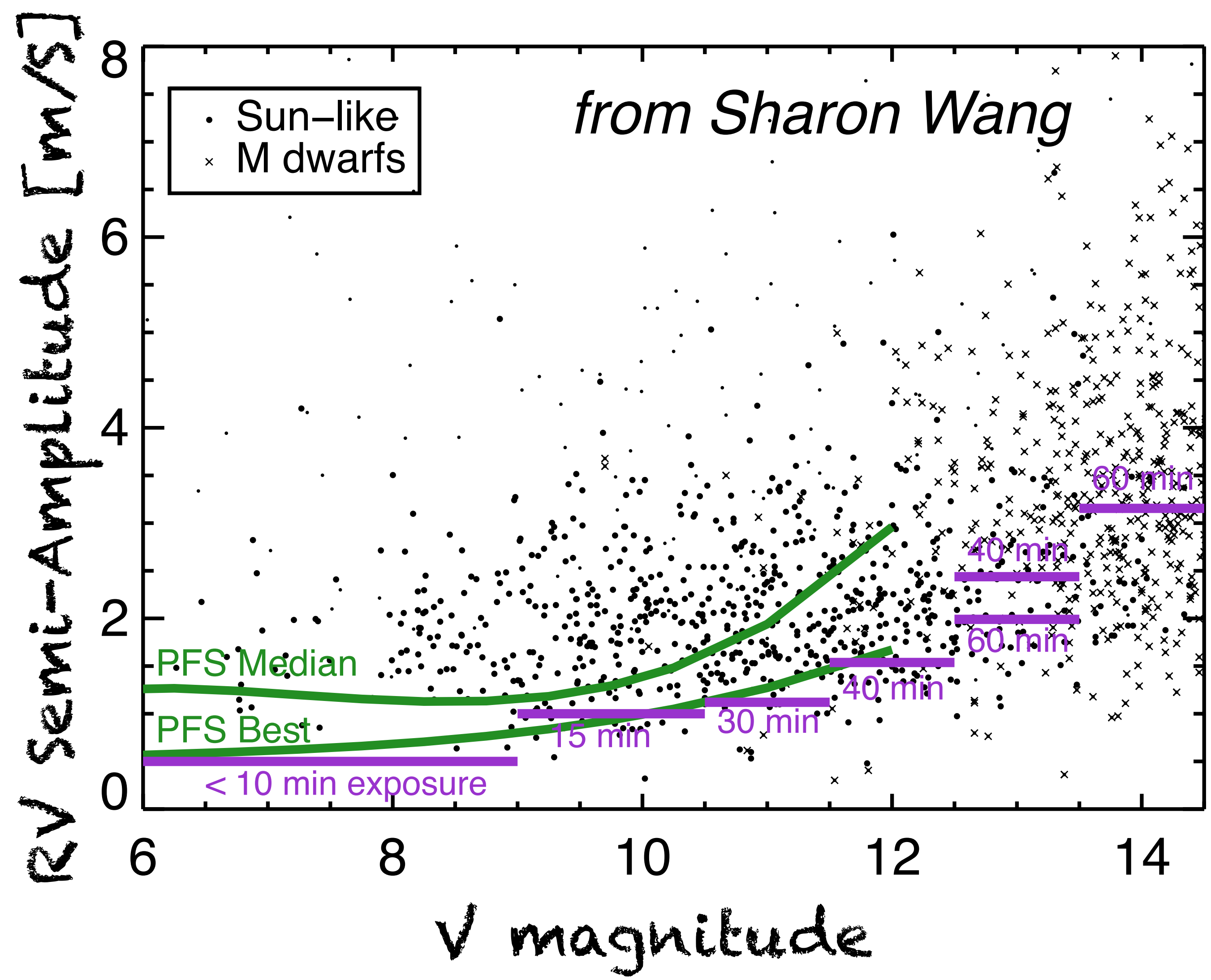
Looking Ahead to TESS

TESS+Magellan II/PFS2



Looking to collaborate!

simulated TESS detections from Sullivan et al. 2015



Observe TESS Southern CVZ targets, focusing on fainter stars where we can make best use of 6.5m

Given realistic plan, could acquire ~25 RVs on ~50 targets *or* ~80 RVs on ~20 targets, over 2 yrs…?

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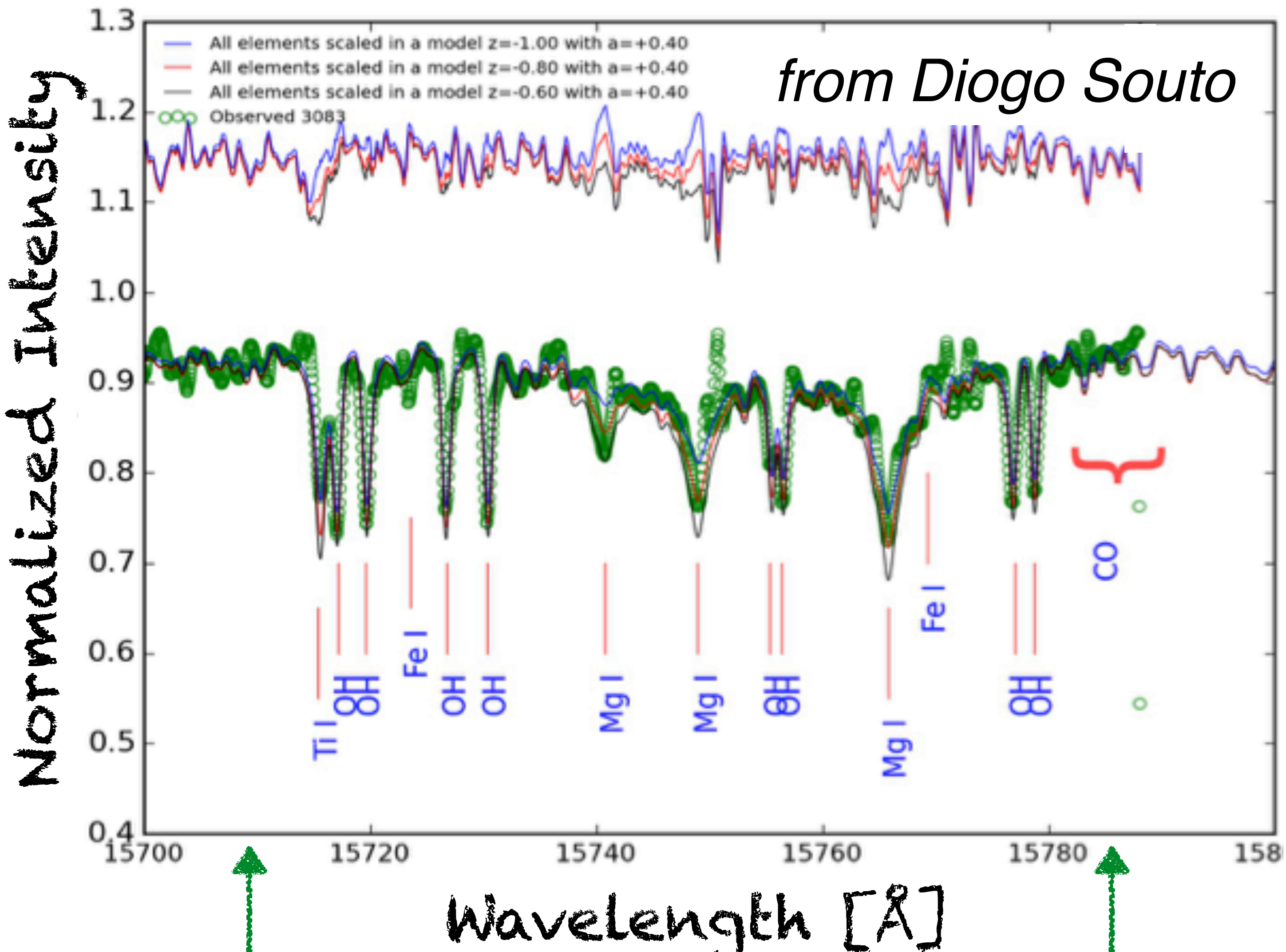
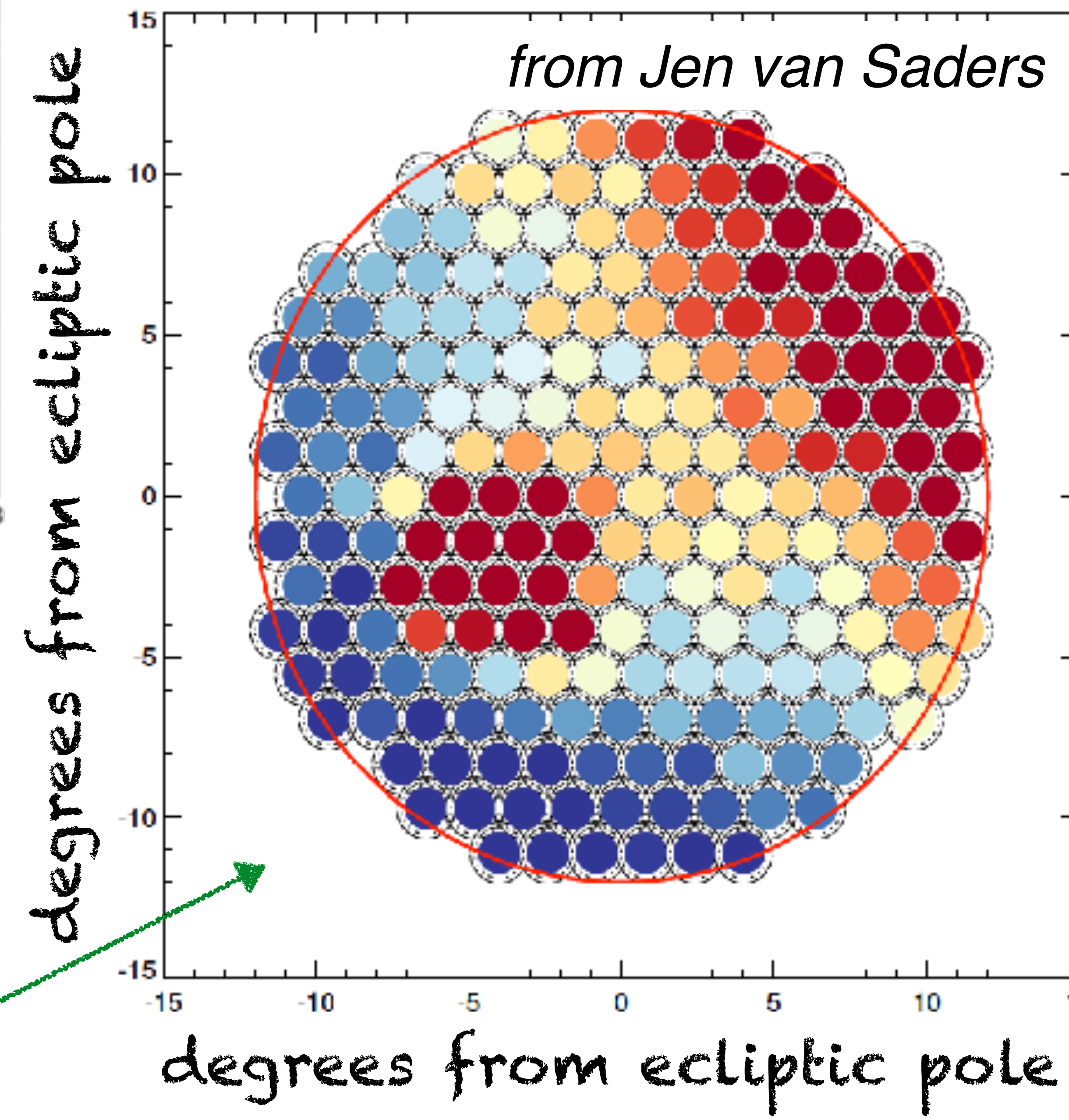
TESS+du Pont/APOGEE-2S



Join SDSS-V!



APOGEE has started to break open the M dwarf abundance field!

2018A: Begin pilot CIW program to observe TESS SCVZ, various science cases (one is exoplanets). AS4: Milky Way Mapper.

Knowledge Nuggets

Host star abundances can help constrain when/where/from what material the planets formed, and thus their current compositions.

Interior compositions and dynamics of small exoplanets are important in determining their Earth-likeness (“habitability”).

TESS has the potential to significantly expand our knowledge of (small) planet formation and composition.