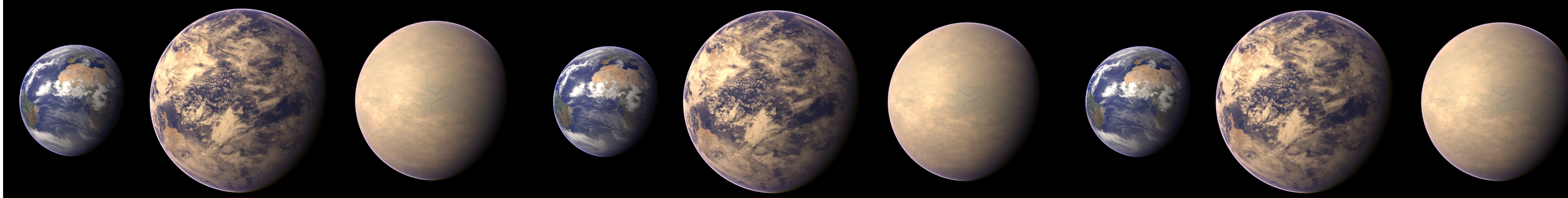
The Microlensing-Transit Population Comparison:



A Period-Dependent Mass-Radius Relation

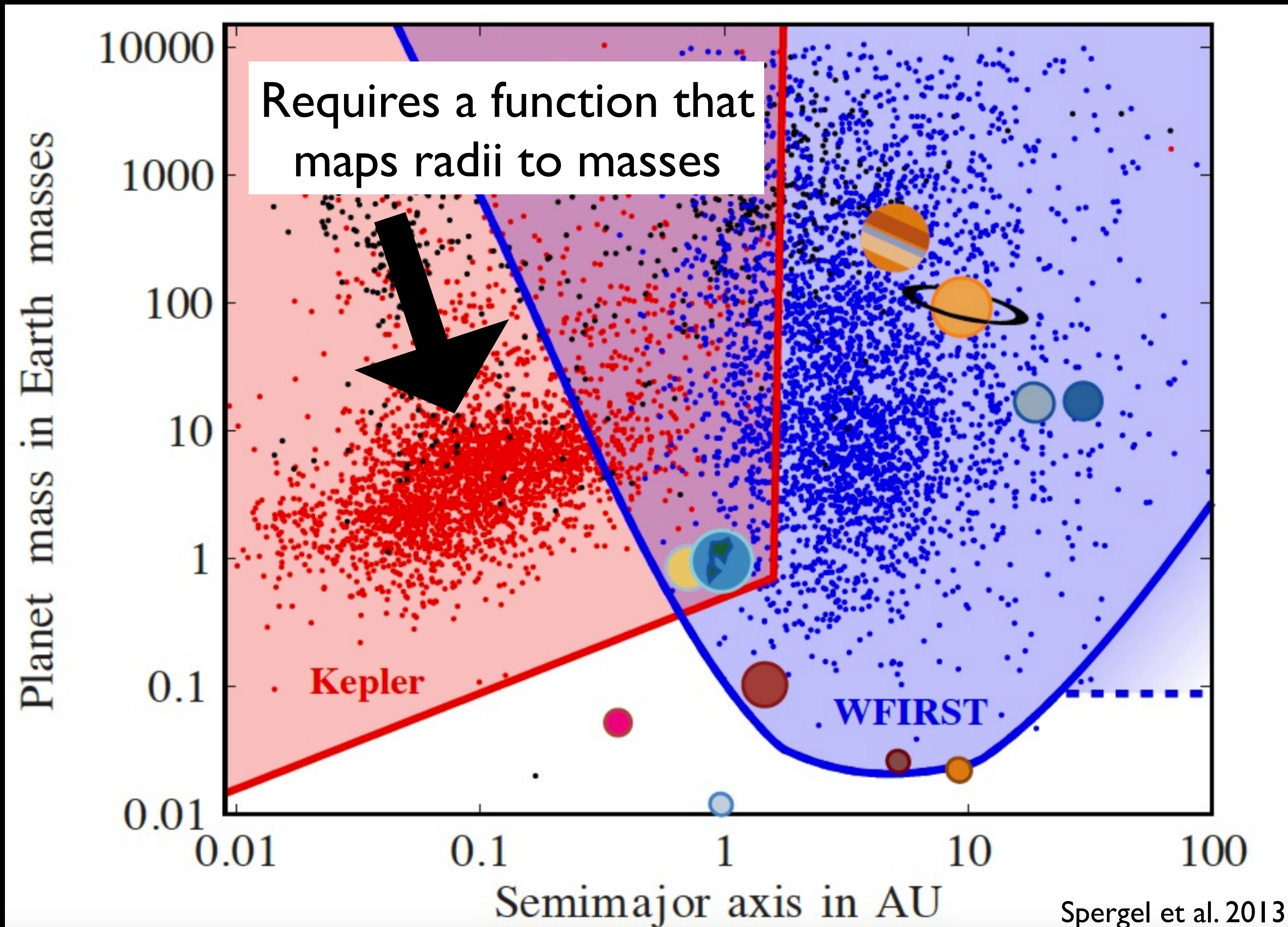
Angie Wolfgang

Penn State

NSF Postdoctoral Fellow

Eric Ford, Daniel Jontof-Hutter, Leslie Rogers, Eric Lopez

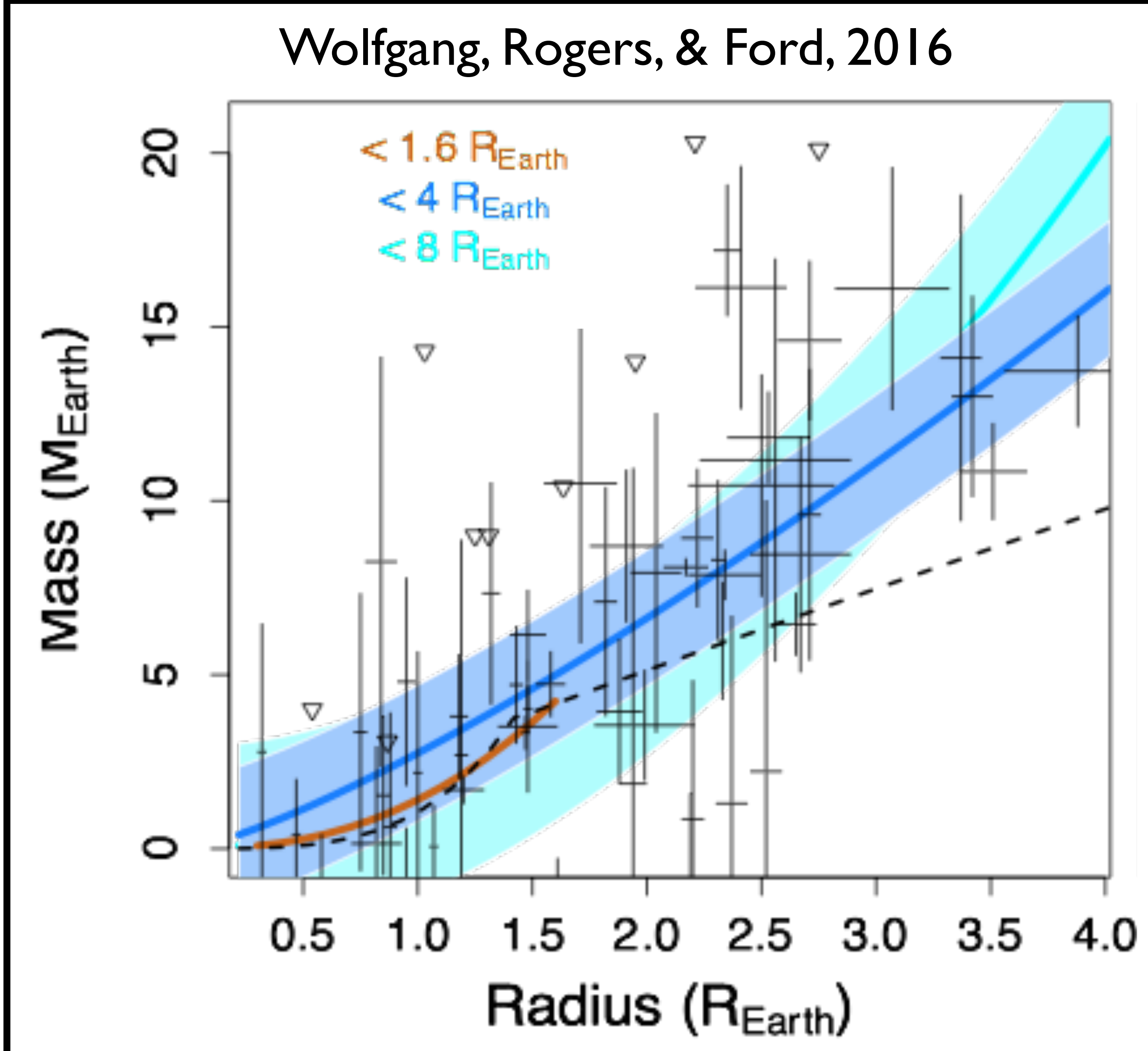
To Complete the Planet Census:



Spergel et al. 2013

To compare microlensing yields to transits, need period-dependent mass-radius relation!

Observed M-R "Relation"



Population parameters (power law and σ) inferred via Hierarchical Bayesian Modeling …

Can distinguish between scatter due to measurement uncertainty and astrophysical scatter in the exoplanet population

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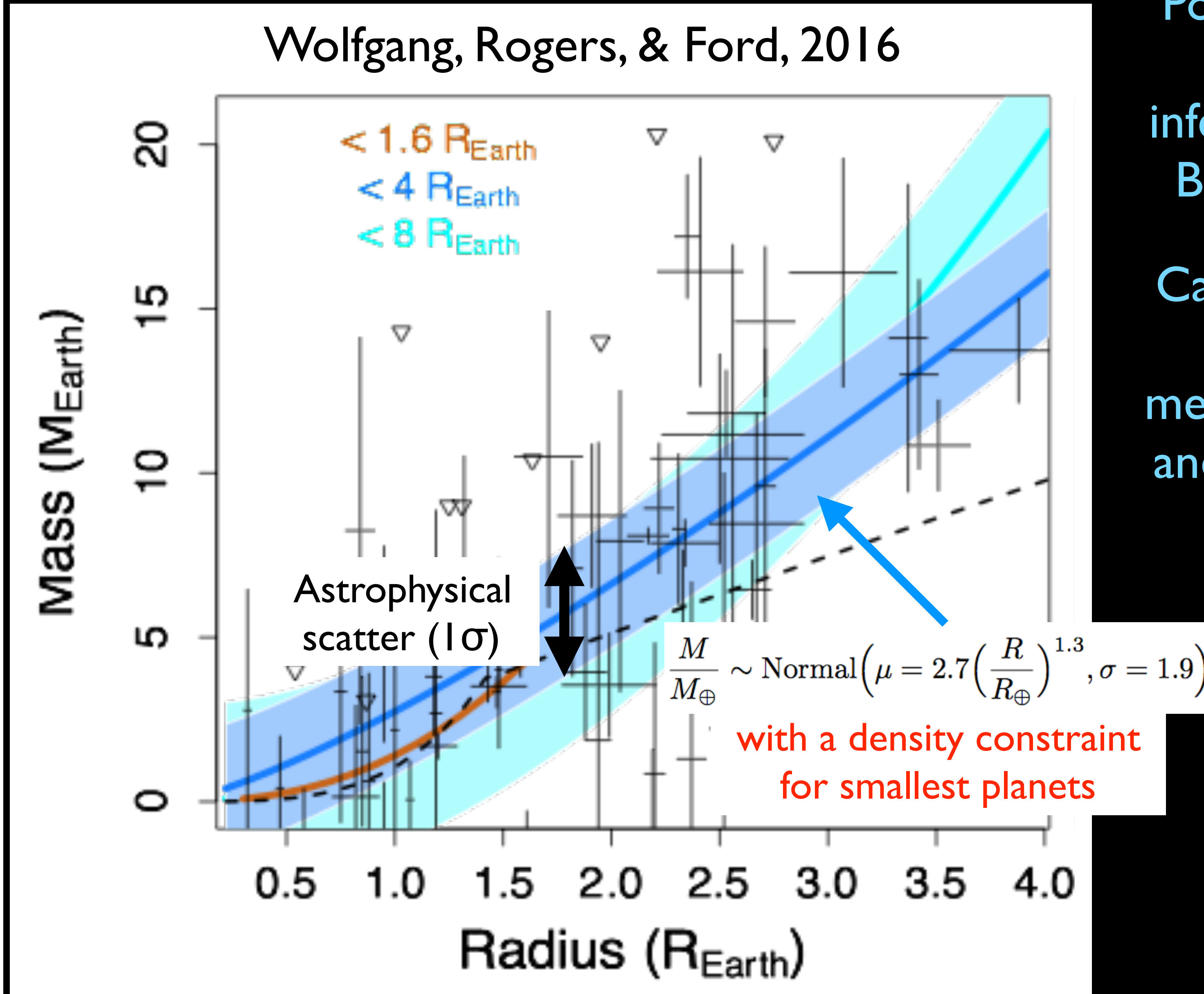


Population parameters (power law and σ) inferred via Hierarchical Bayesian Modeling …

Can distinguish between scatter due to measurement uncertainty and astrophysical scatter in the exoplanet population

Is an empirical description of exoplanet composition distribution.

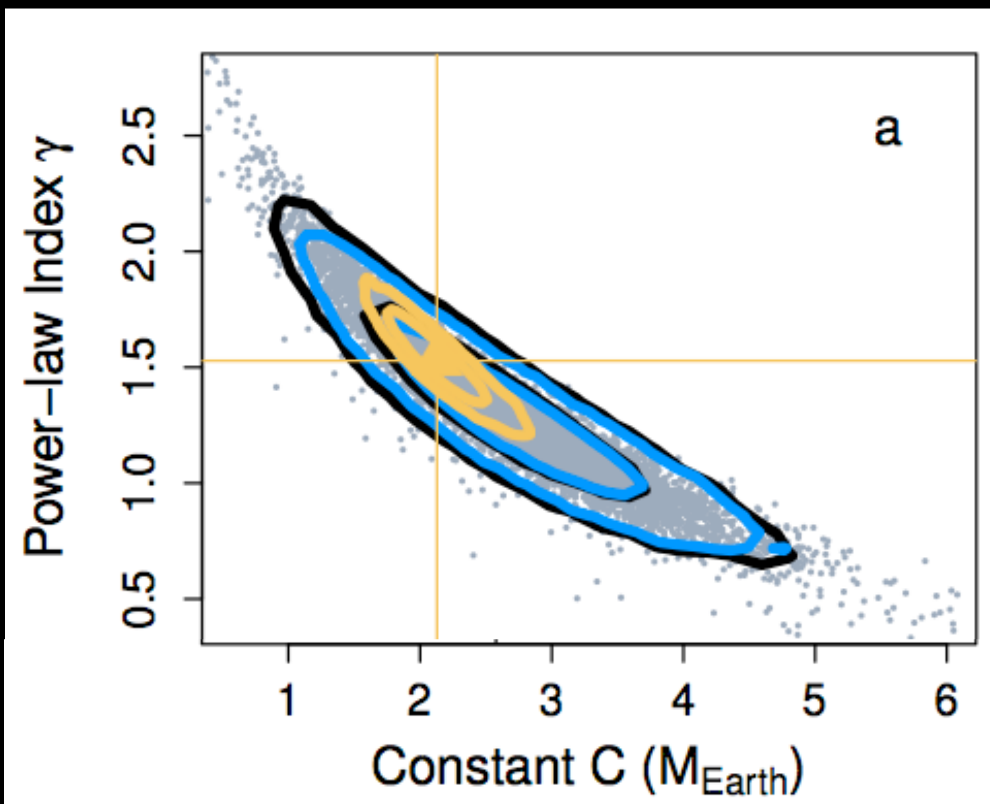
In Parameter Space . . .

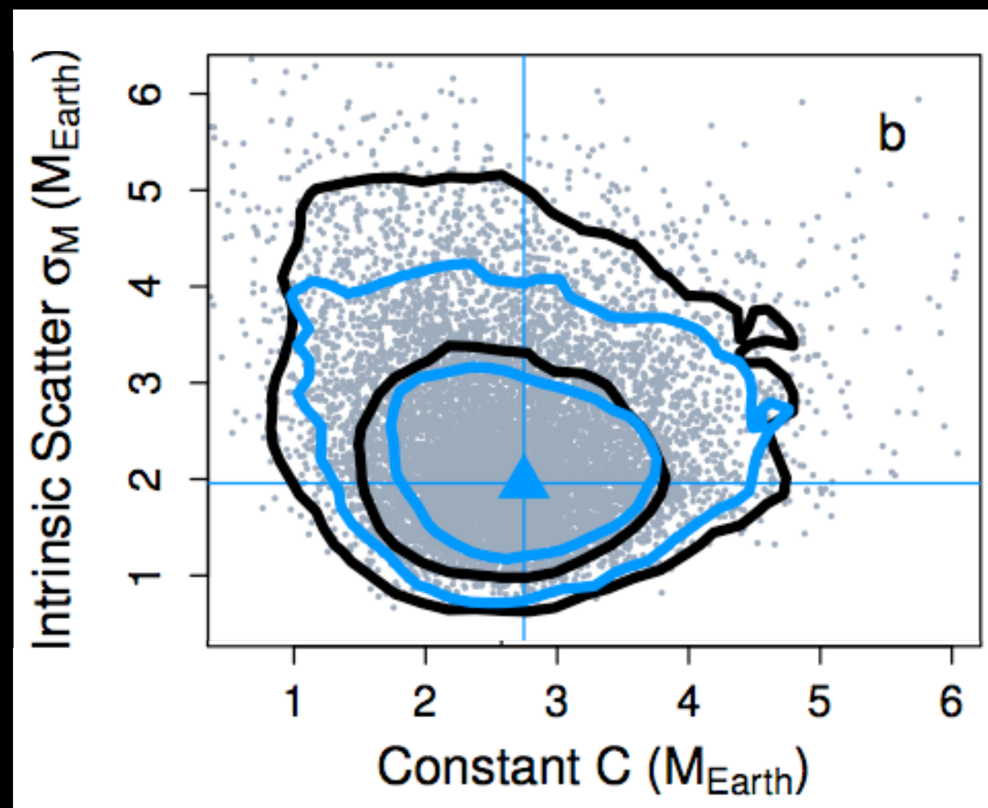
deterministic M-R relation:

$$\frac{M}{M_\oplus} = C\left(\frac{R}{R_\oplus}\right)^\gamma$$

probabilistic M-R relation:

$$\frac{M}{M_\oplus} \sim \text{Normal}\left(\mu = C\left(\frac{R}{R_\oplus}\right)^\gamma, \sigma = \sigma_M\right)$$

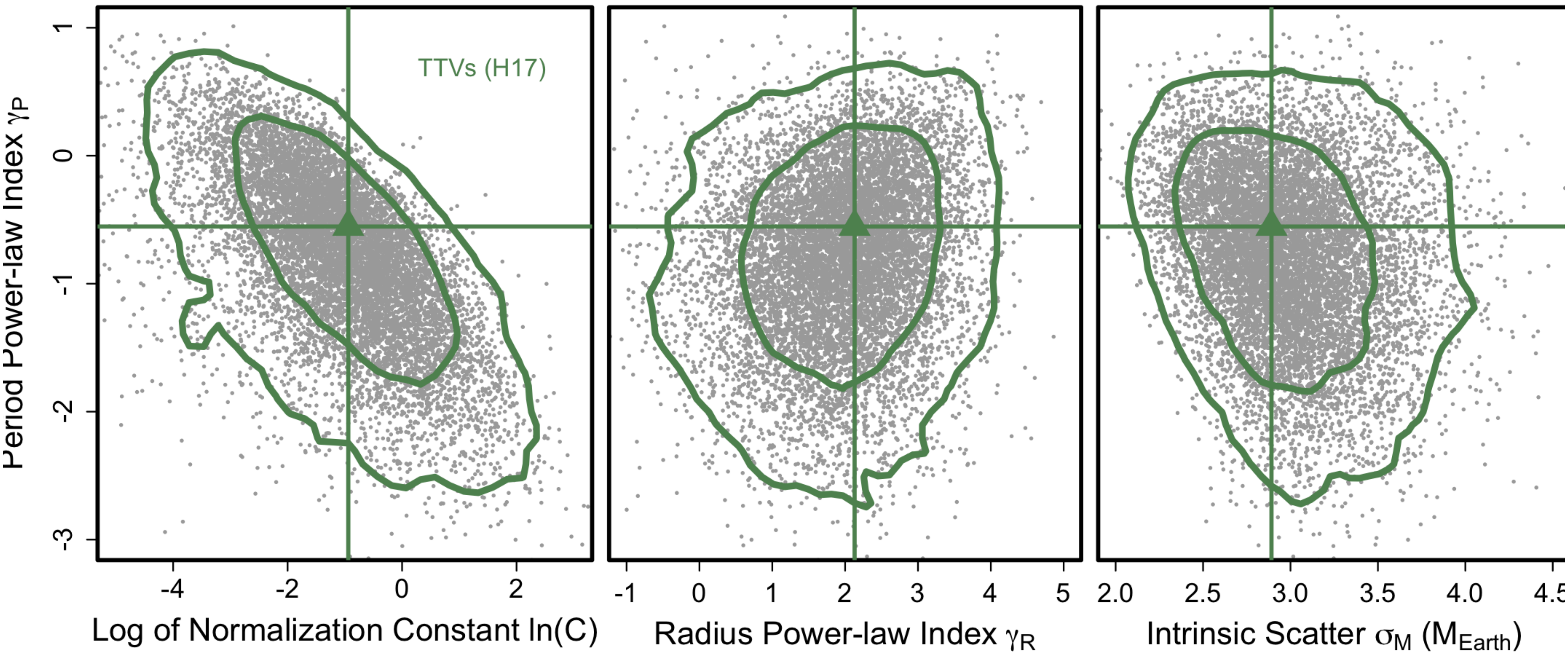




There is intrinsic scatter in the current set of R,M measurements . . .
Nature produces a range of compositions for planets with similar masses!

Allow a Period Dependence:

$$\frac{M}{M_\oplus} \sim \text{Normal}\left(\mu = C\left(\frac{R}{R_\oplus}\right)^{\gamma_R}\left(\frac{P}{P_\oplus}\right)^{\gamma_P}, \sigma = \sigma_M\right)$$



Marginally negative γ_P → decreasing average mass at longer periods; note that the astrophysical scatter is larger now . . .

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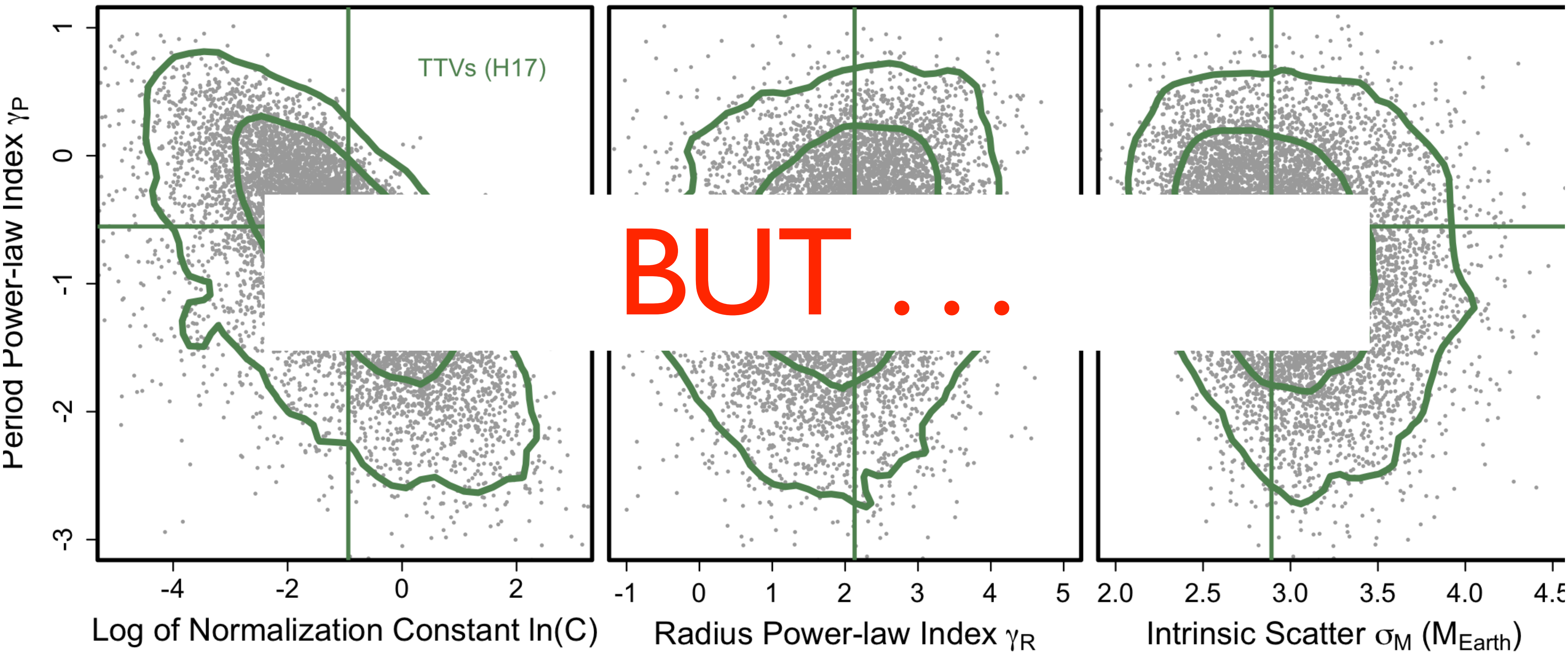

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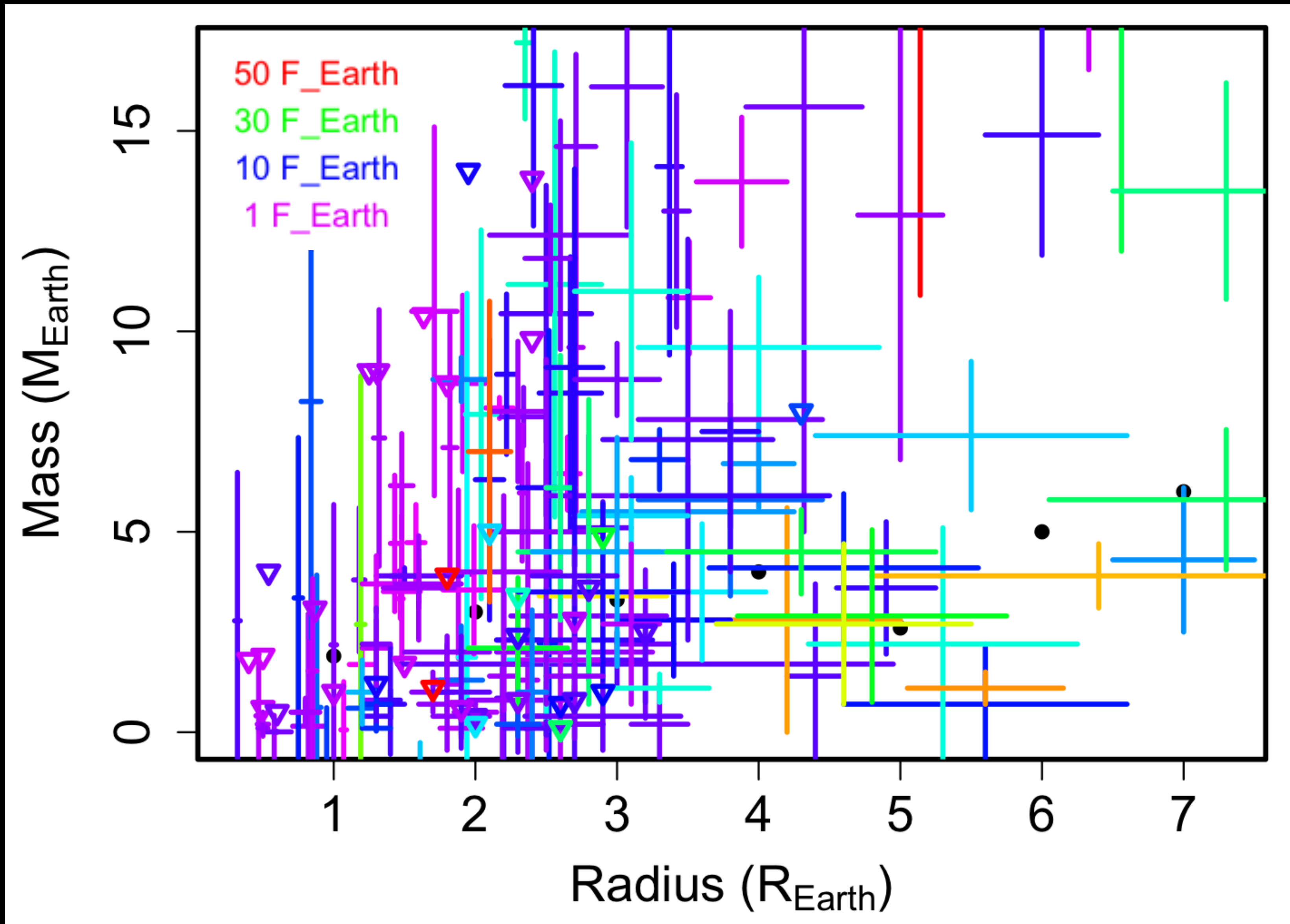
The Data?

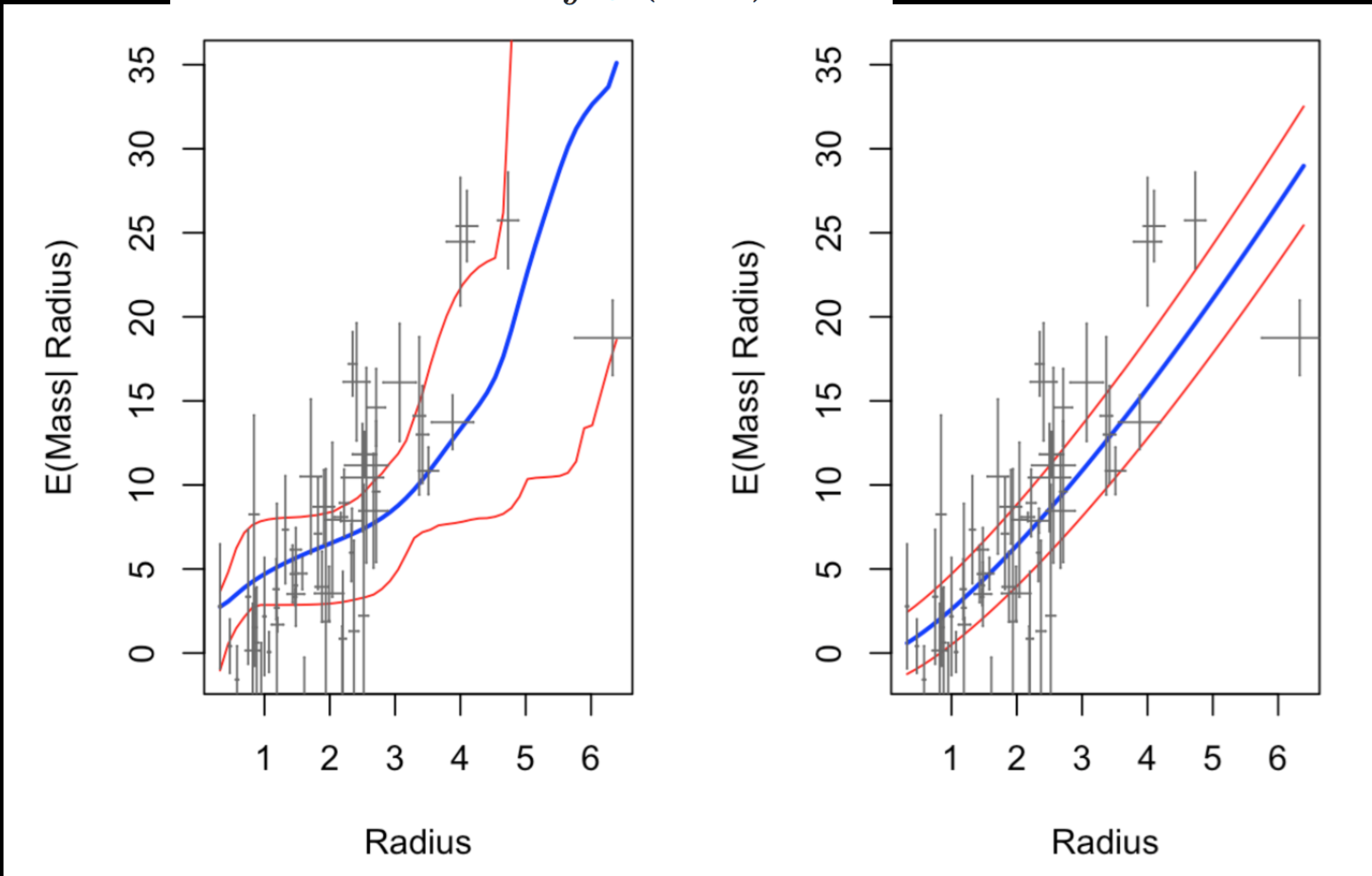


Not clear a power law is warranted any longer . . .

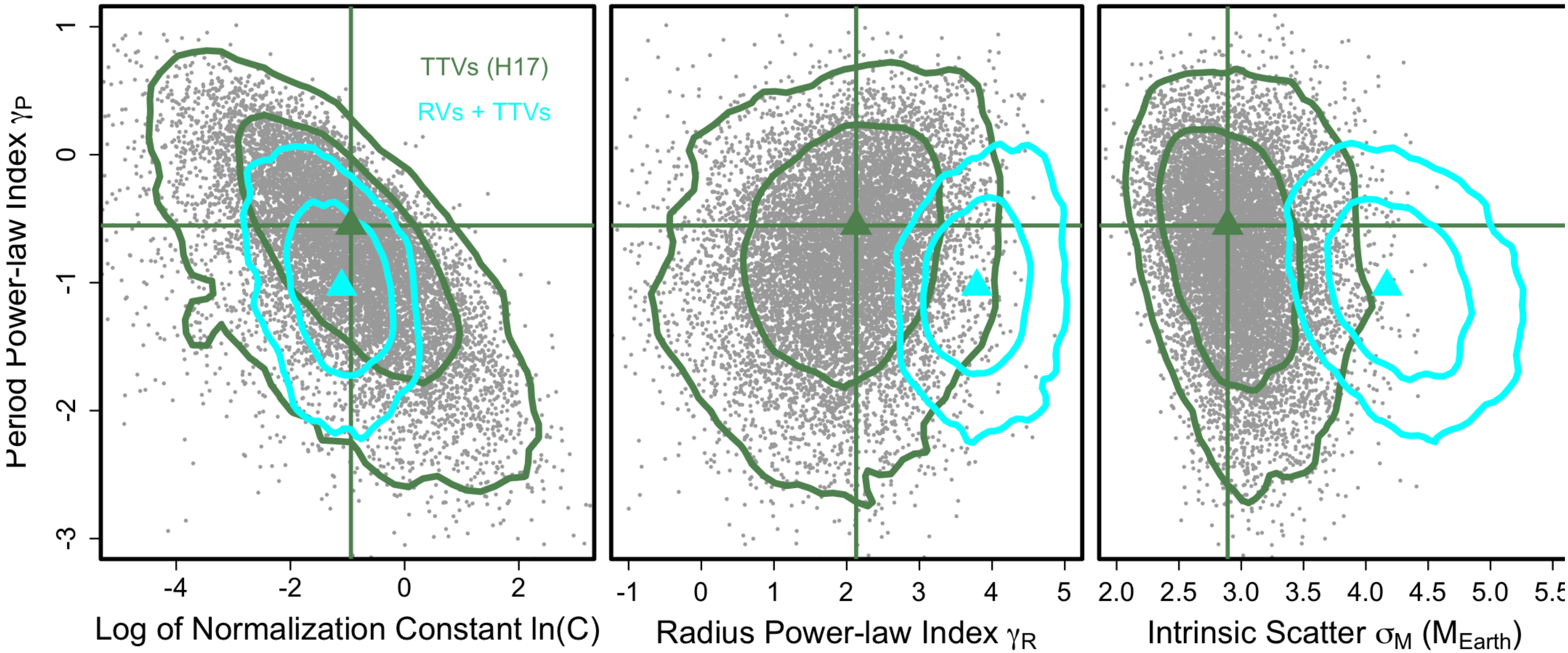
Beyond the Power Law:

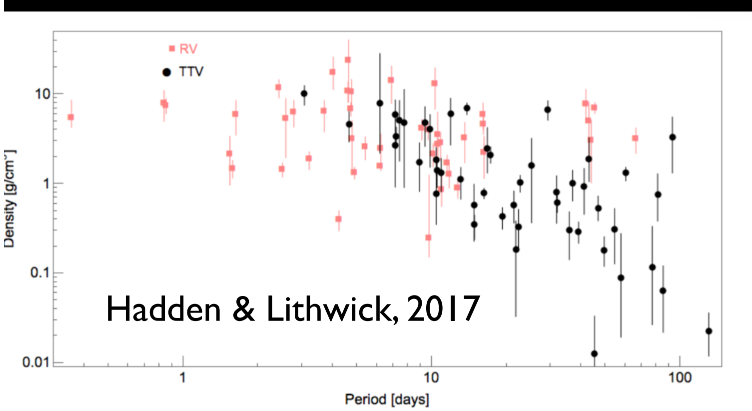
$$E[M|R=r] = \frac{\int m f(m,r) dm}{\int f(m,r) dm}$$

Ning, Wolfgang, & Ghosh, in prep.

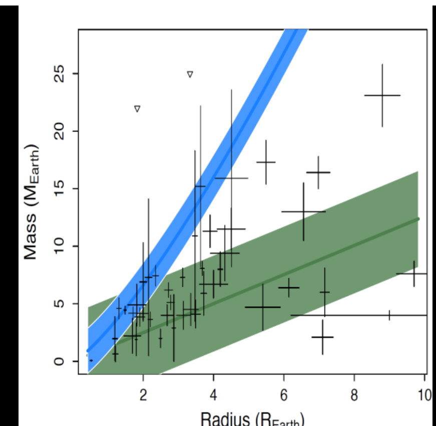


Depends on Mass Method





Most RVs at P < 20 days, so use TTVs to probe period dependence . . .
But the two samples produce different M-R relations!



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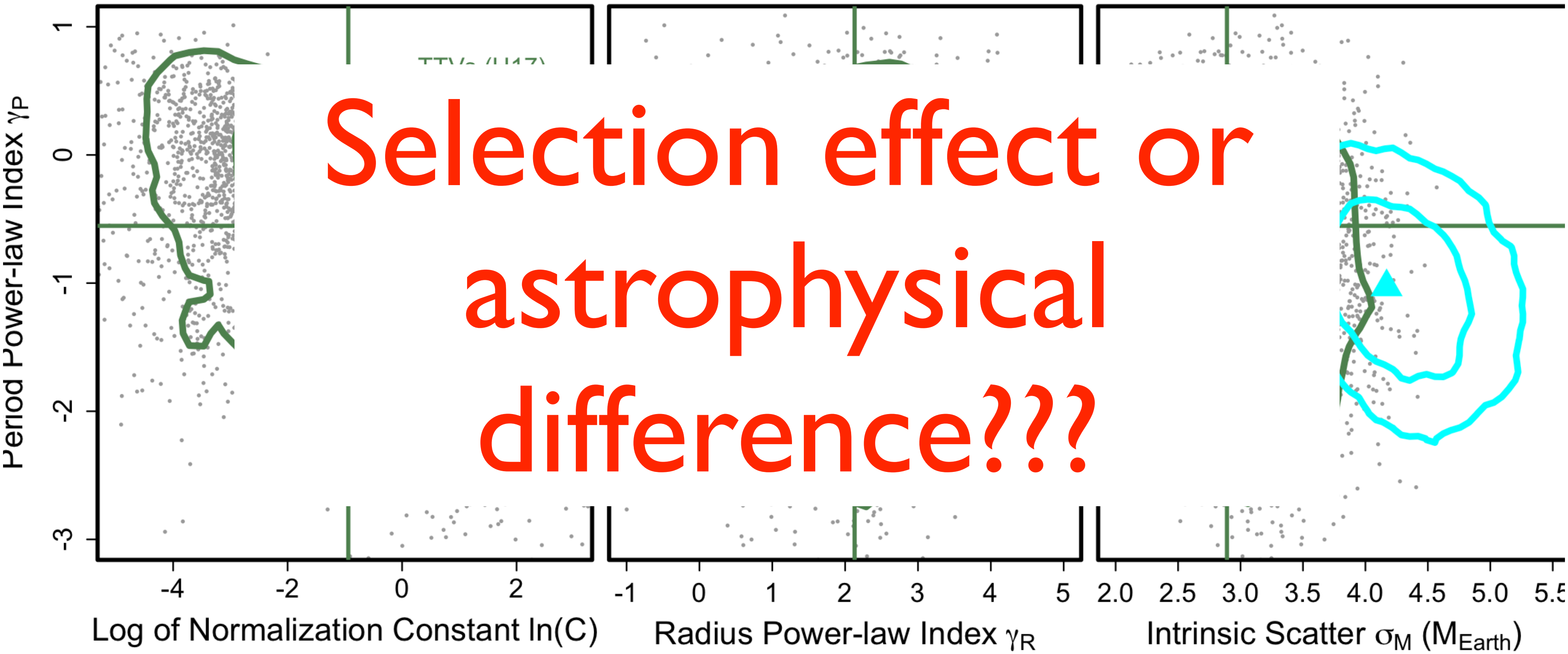
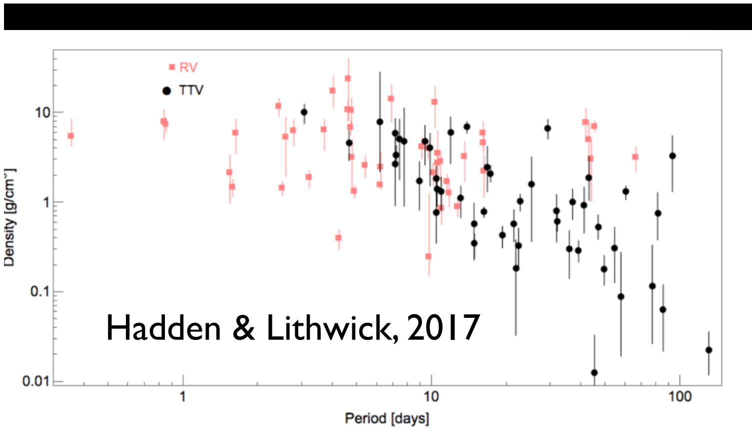


Selection effect or astrophysical difference???



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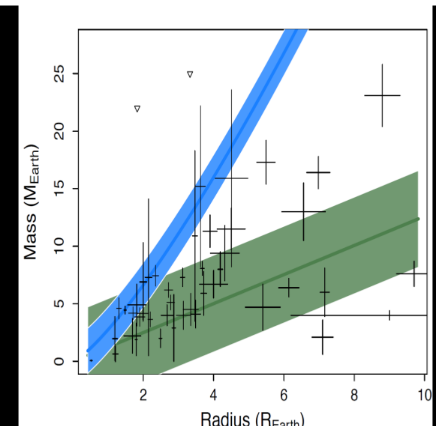
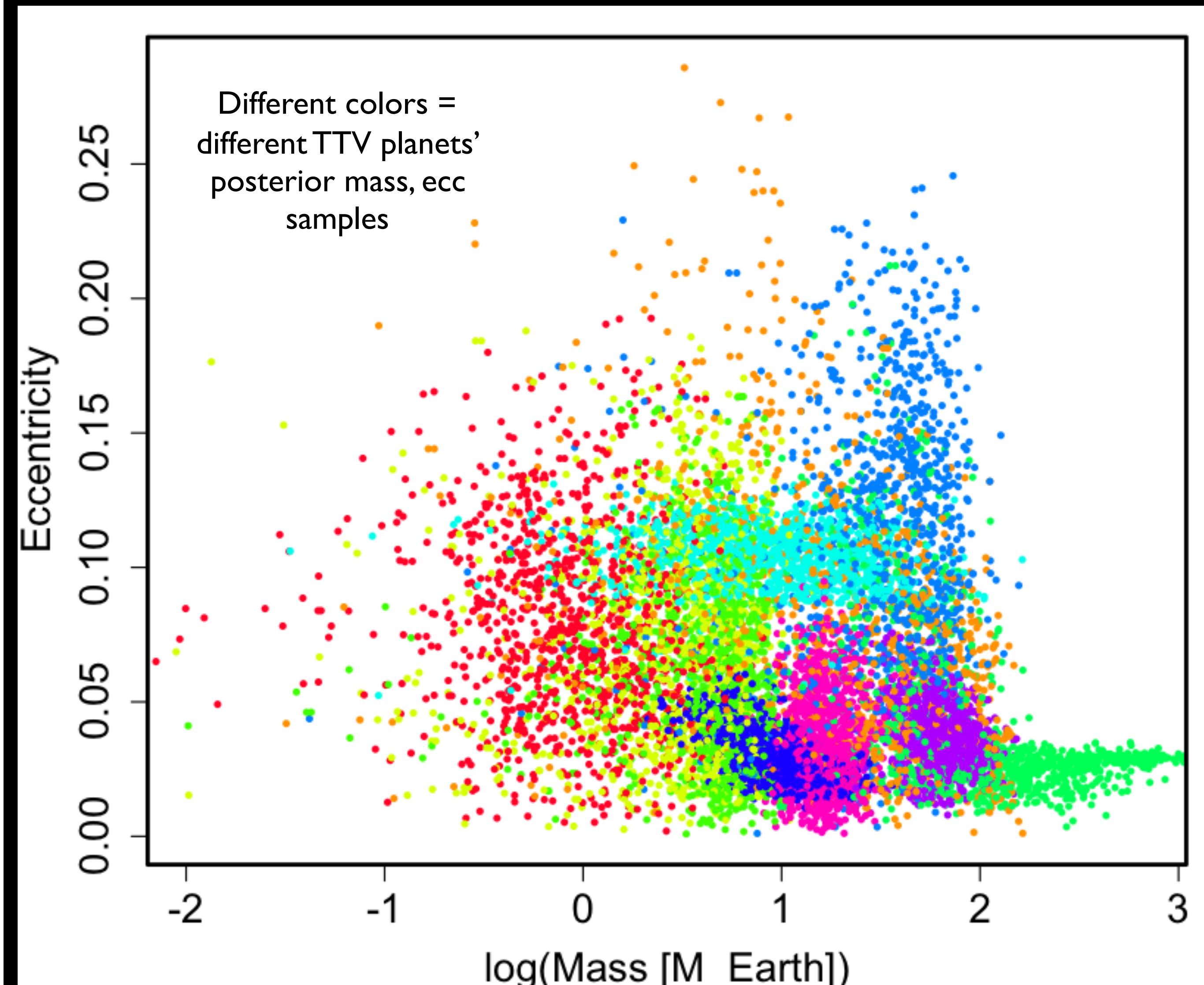


TTV Masses Degenerate w/ e



State-of-the-art: incorporate joint M,e posteriors into the hierarchical modeling

Ongoing effort with collaborators Daniel Jontof-Hutter and Eric Ford to characterize TTV sample selection effects and systematics

But need similar work on RV side . . .

Summary

The observed **mass-radius relation** is an **empirical** description of the exoplanet **composition distribution**.

A **period-dependent** relation is crucial for **comparing microlensing and transit** surveys.

Suggestive weak period dependence:
how much is **astrophysical vs. selection effect**?

Lots of work needed to understand biases in M-R relation and how we can **characterize its multi-dimensional nature**.