

Accounting for Incompleteness due to Transit Multiplicity

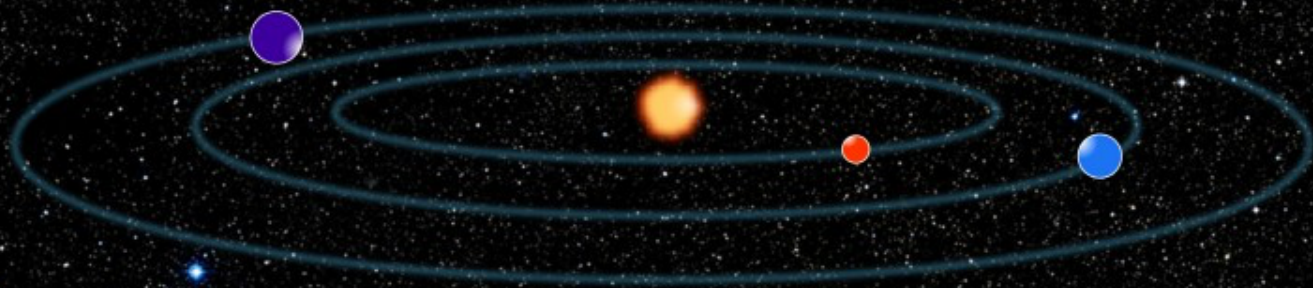
Advisor: Brad Hansen

Collaborator: Jessie Christiansen

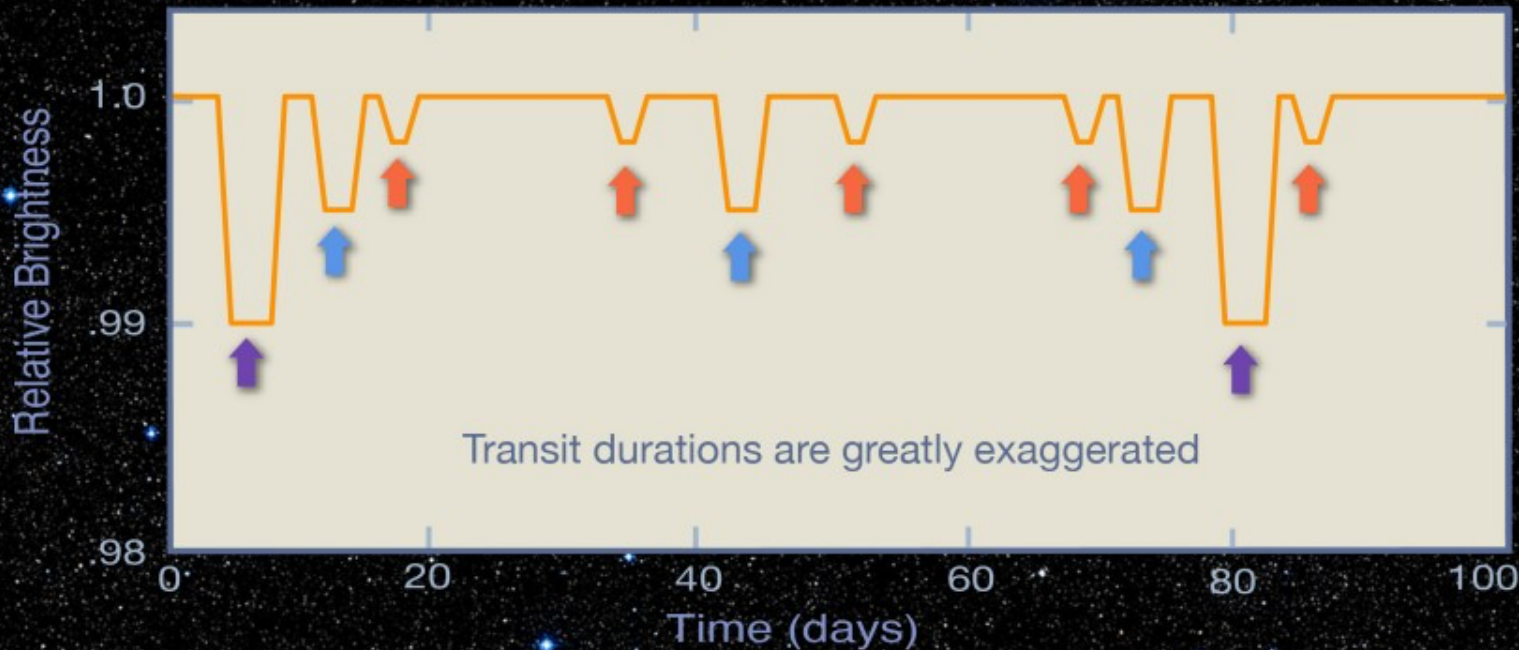
Jon Zink

UCLA Graduate Student

Multiples Block Light More Often

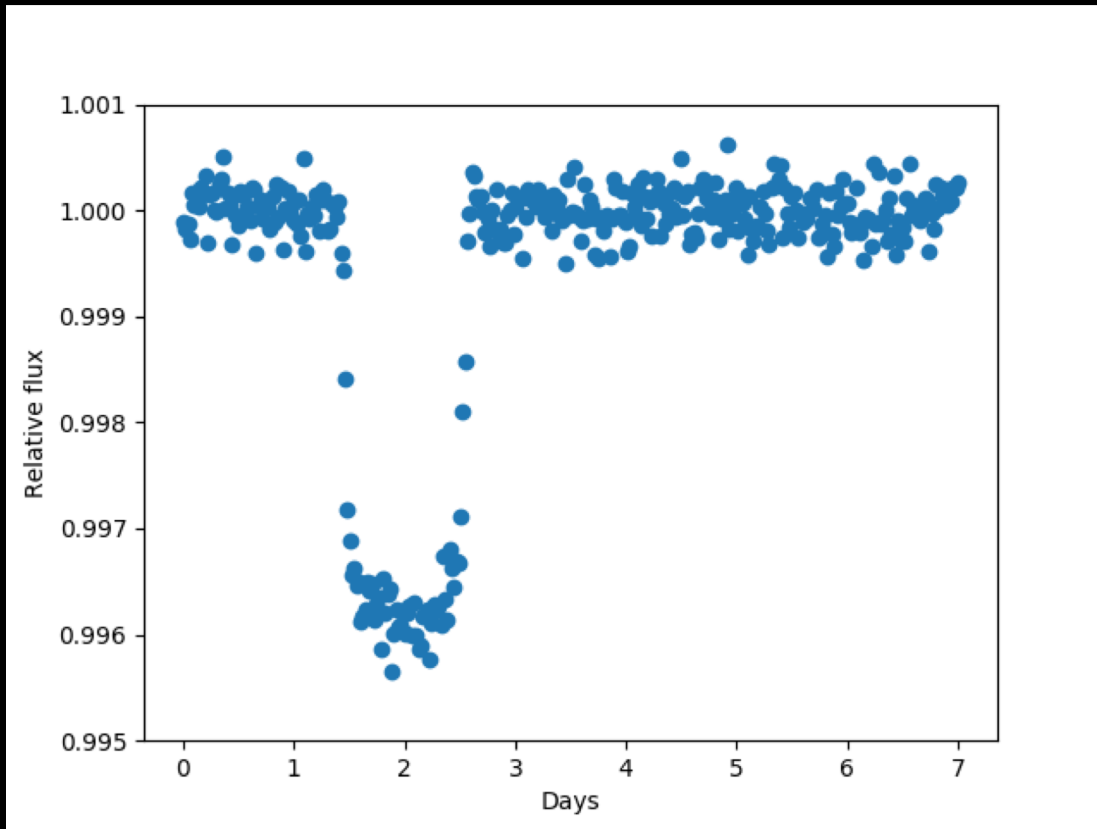


- Planets can be distinguished by:
- Different periods
 - Different depths
 - Different durations

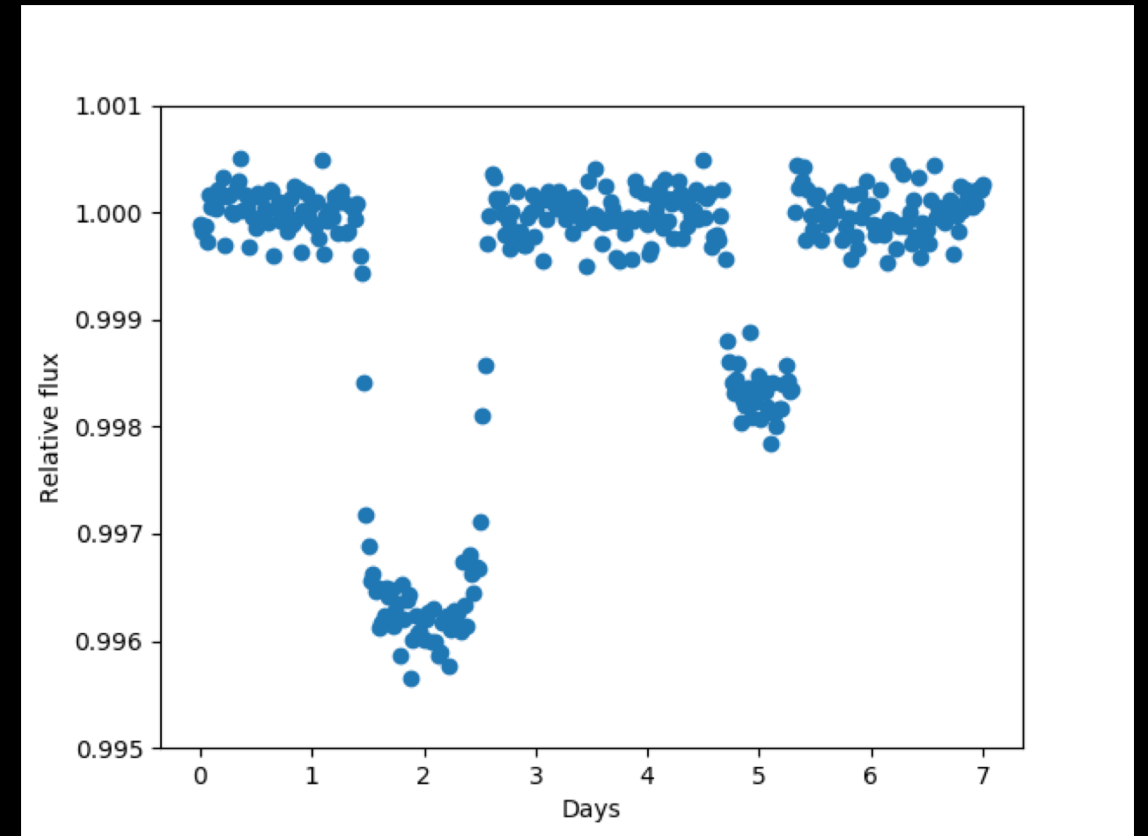


When in Doubt... Simulate!

Before Injection



After Injection

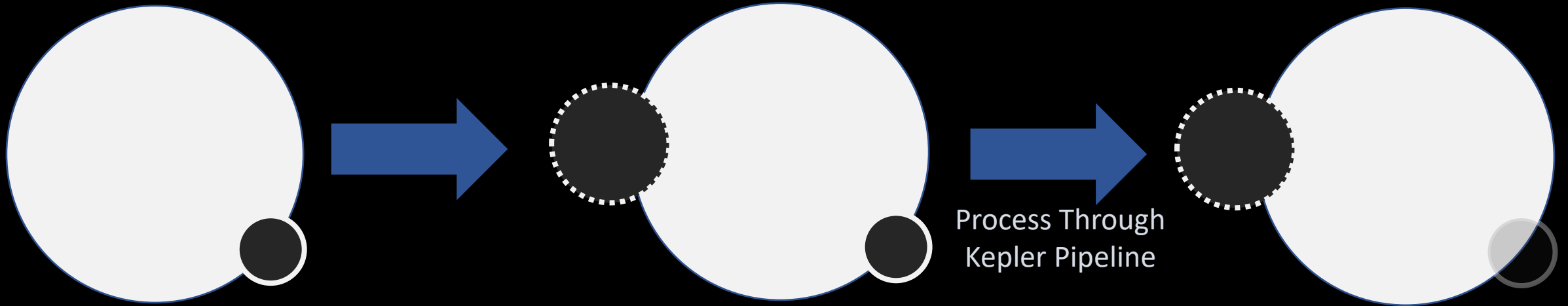


Some Planets are Lost Due to Injections

START with 4,034
Kepler Candidates

Inject One Planet Into
Each System

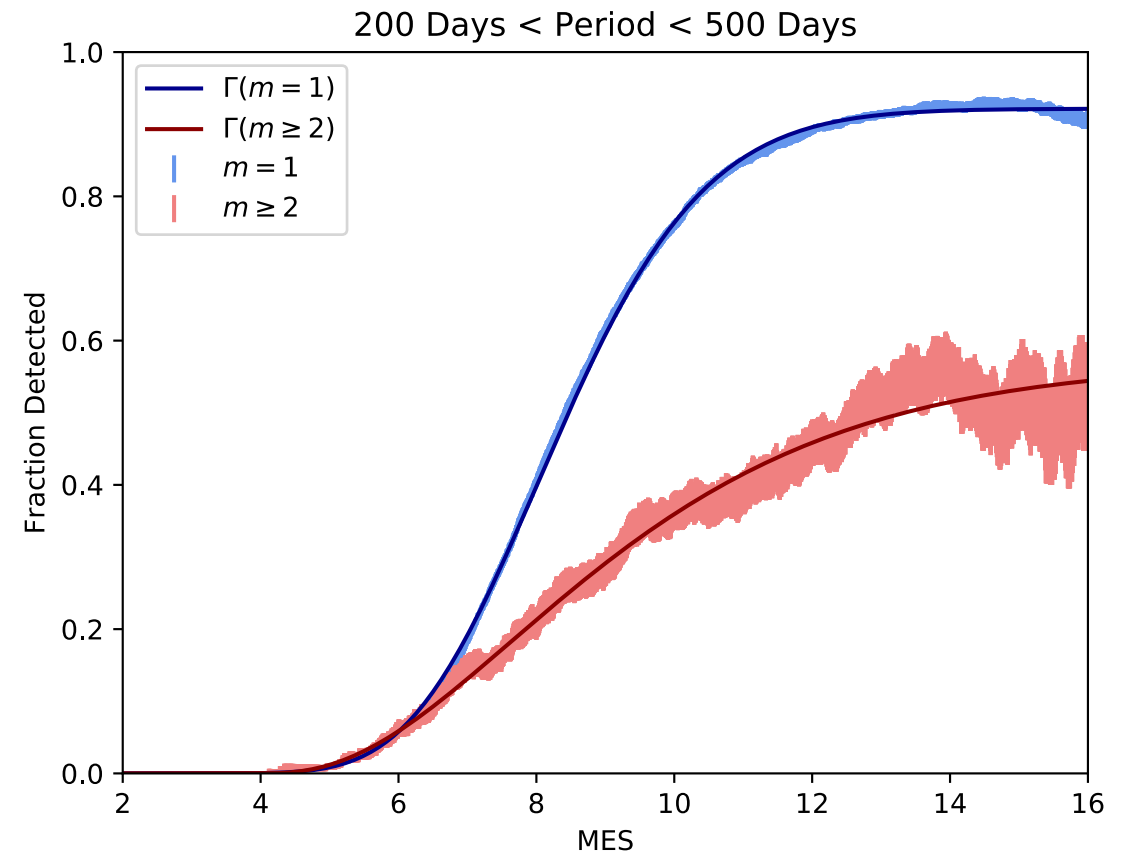
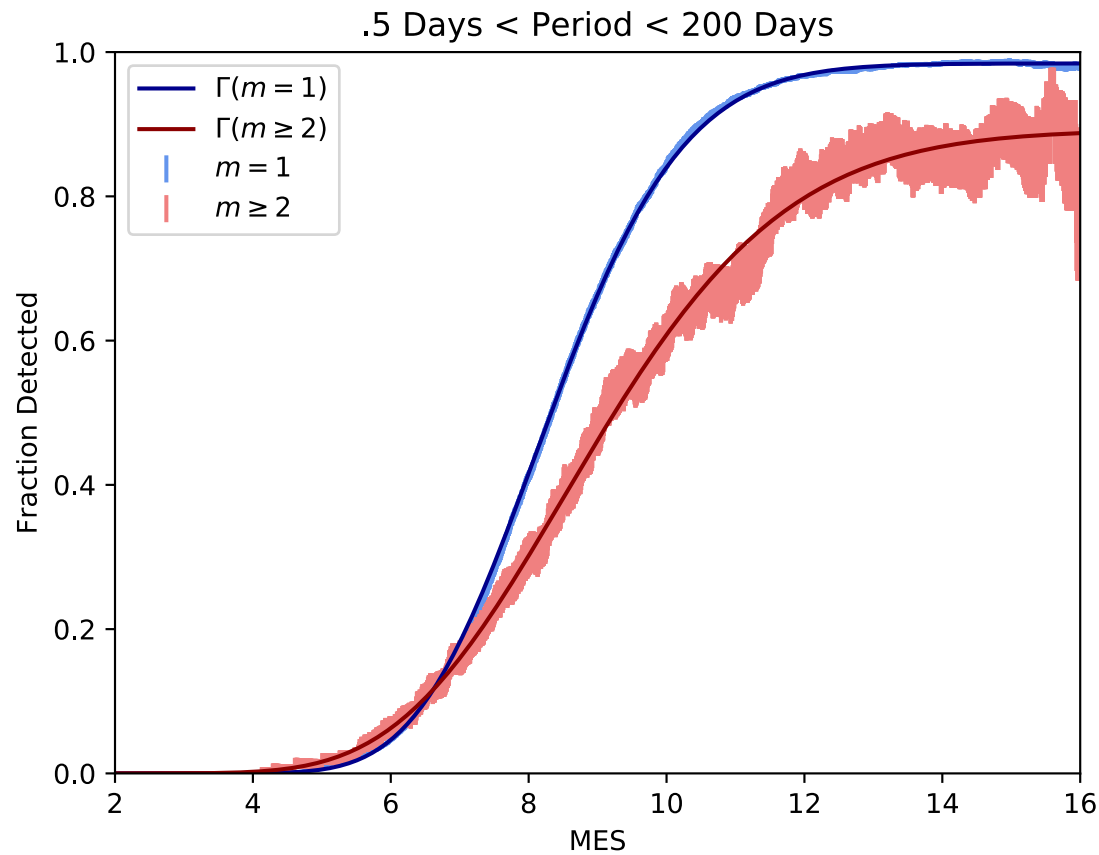
ONLY 3,965 Kepler
Candidates Returned



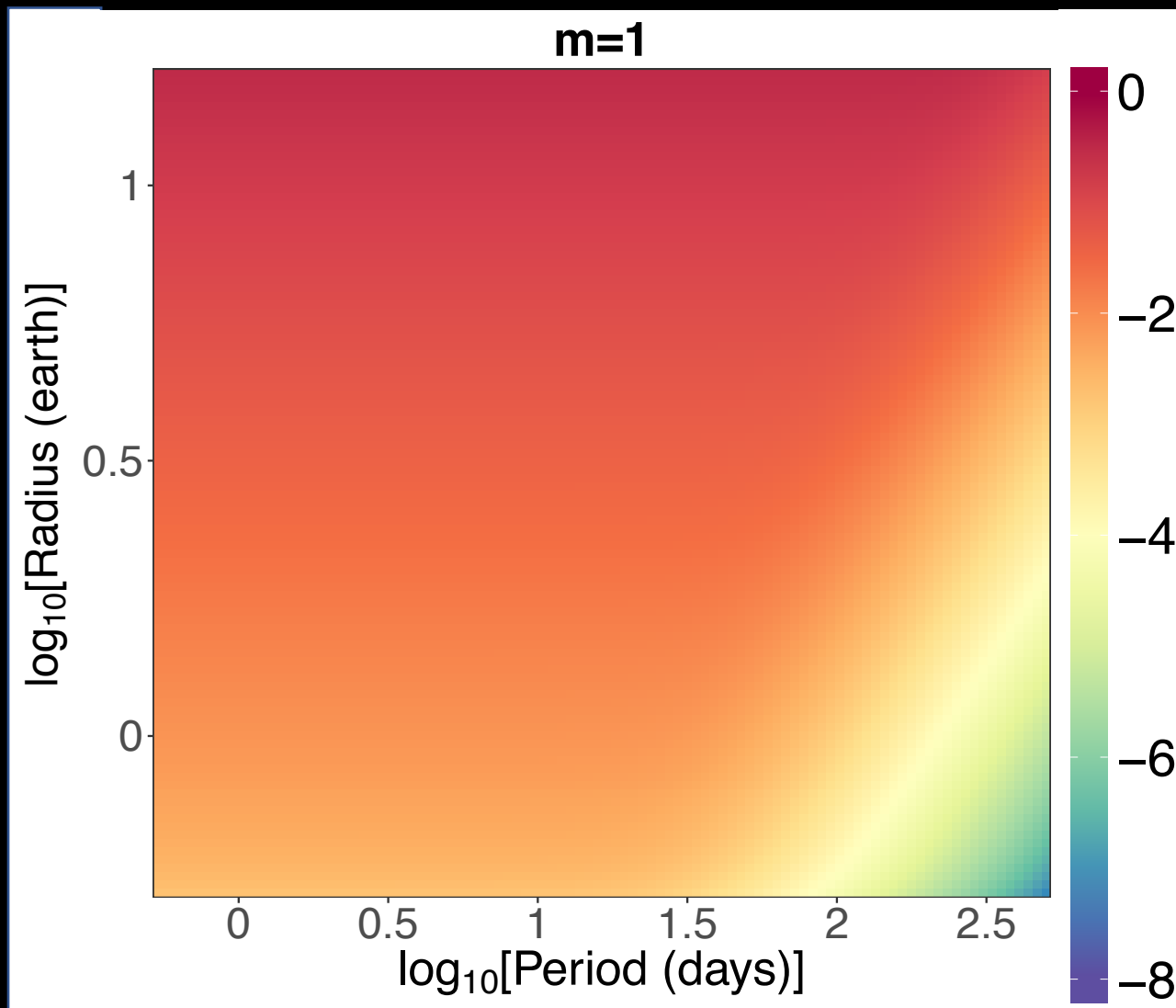
69 Candidates are Lost

Multiples are Harder to Detect

$$\text{SNR} \sim \text{MES} \sim R^2/p^{1/3}$$



We Can Map Out Kepler's Biases



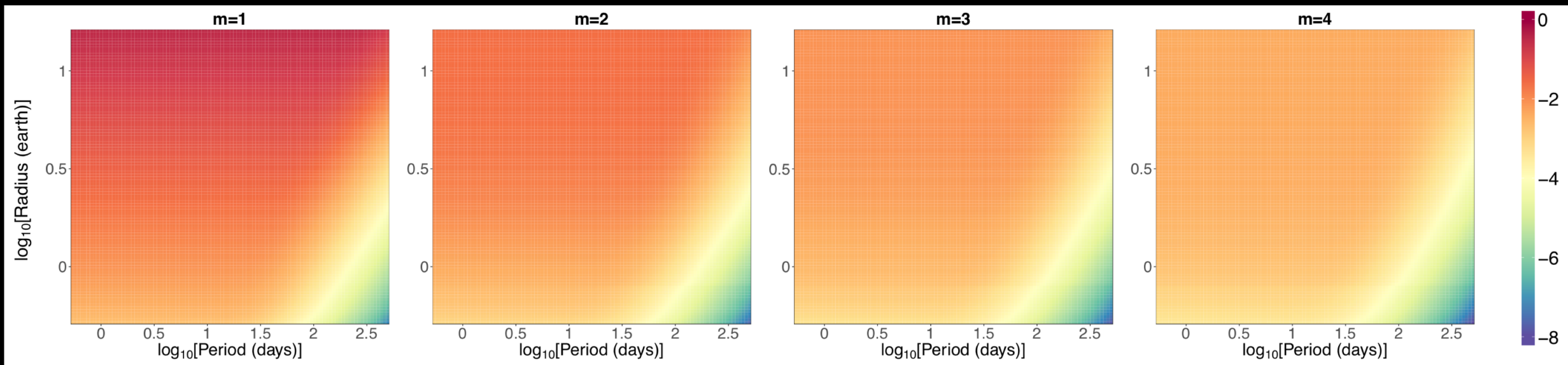
(Zink, Christiansen, & Hansen 2018)

We Can Map Out Kepler's Biases

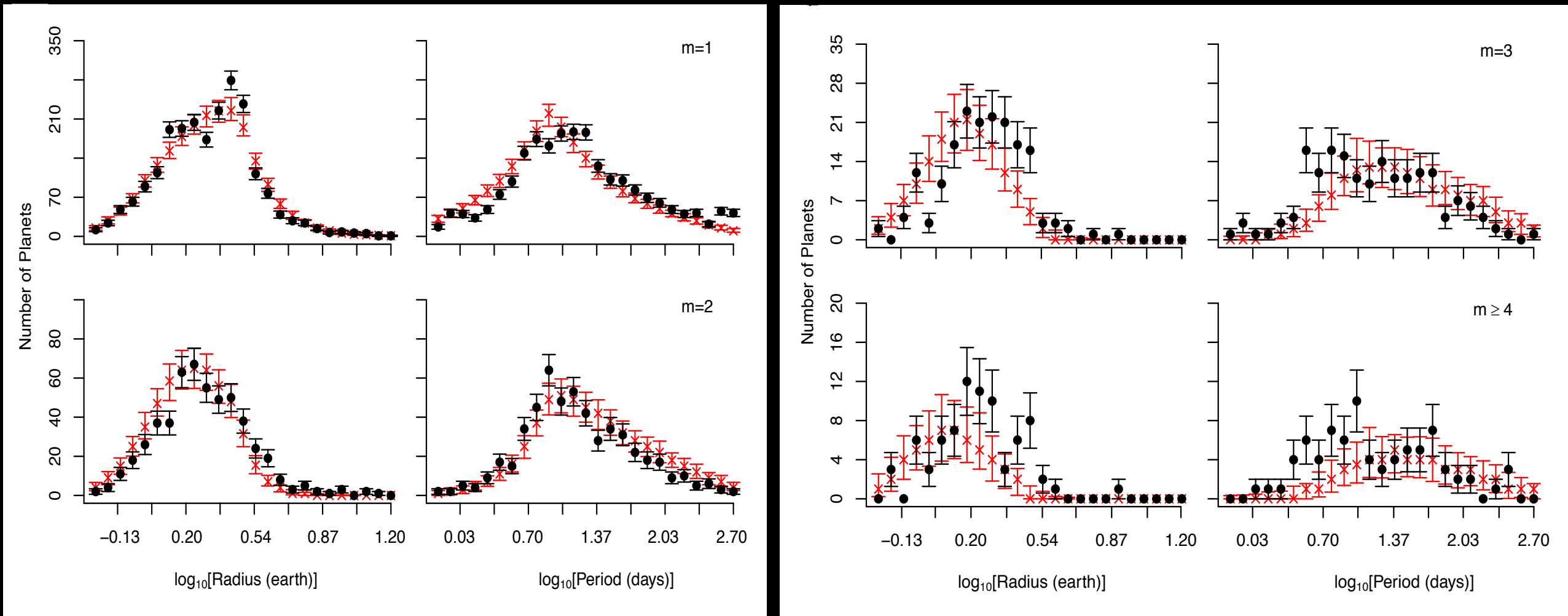
Higher MES



Lower MES



The Model Appears to Fit the Data



We Can Extrapolate Higher Order Multiplicities

Survival Function

1 - CDF(Poisson)

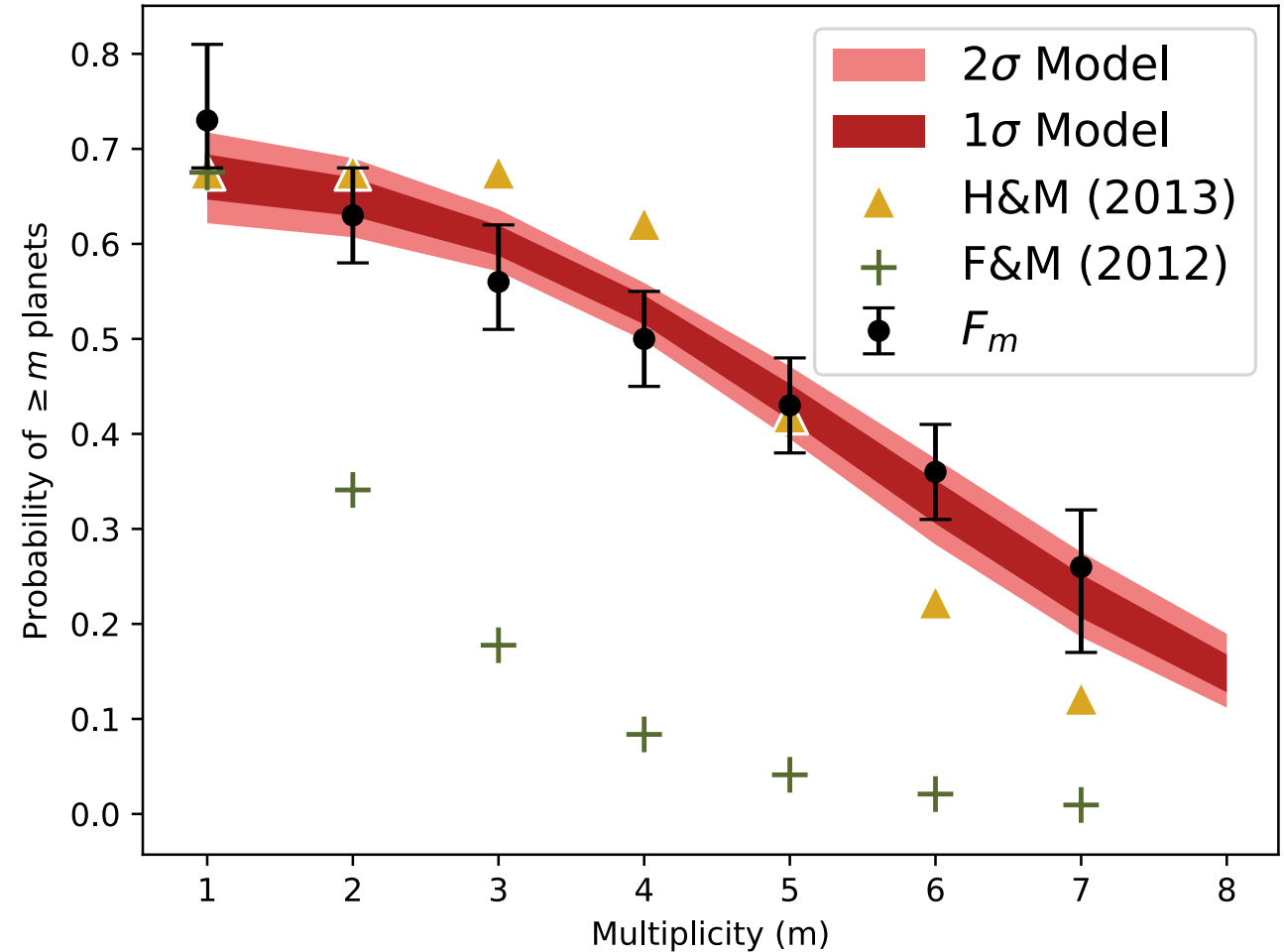
Probability($m \geq 8$) =

0.15 ± 0.02

Kepler 90i



(Zink et al. 2018)



(Zink, Christiansen, & Hansen 2018)

Detection Efficiency Closes the Gap

	Geometric	Multiple Detection Efficiency (Data)	Multiple Detection Efficiency (Model)	Real <i>Kepler</i> Data
<i>Singles</i>	1612	1616 ± 92	1622 ± 75	1648
<i>Doubles</i>	563	389 ± 34	399 ± 35	347
<i>Triples</i>	262	118 ± 15	118 ± 13	119
<i>Quadruples</i>	164	33 ± 7	29 ± 8	43
<i>Quintuples</i>	52	7 ± 3	6 ± 4	13
<i>Sextuples</i>	78	1 ± 1	1 ± 1	2
<i>Septuples</i>	104	0 ± 1	0 ± 1	1

Summary

- Multiples are Harder to Detect with Kepler
- Poisson Model Fits Exoplanet Multiplicity
- Closed Much of the Kepler Dichotomy

