Spitzer observations suggest a low Kepler false positive rate

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Determining the Kepler false positive rate

- Kepler False Positive Rate (FPR) <10% (Morton and Johnson 2011)

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Our project: determining the FPR **observationally**

- Selected a sample of candidates (34)
- Observed their transit with Spitzer (800h)
- Derive a False Positive Probability (FPP) for each object

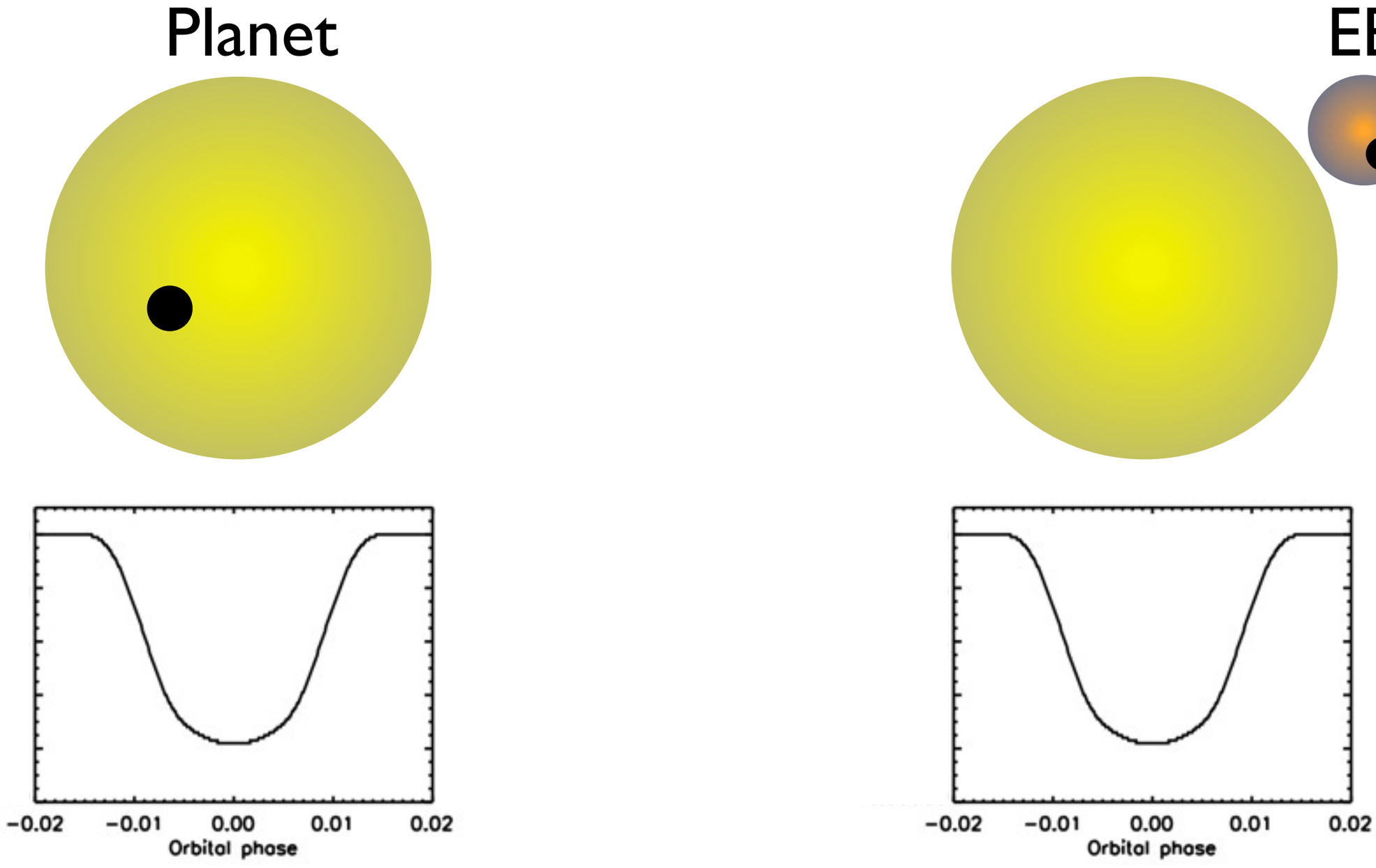
Validating planetary candidates

- No dynamical **confirmation** for most of the candidates (current radial velocity capabilities or TTVs)

- **Validation** of candidates by testing and ruling out false positive scenarios

Astrophysical False positives

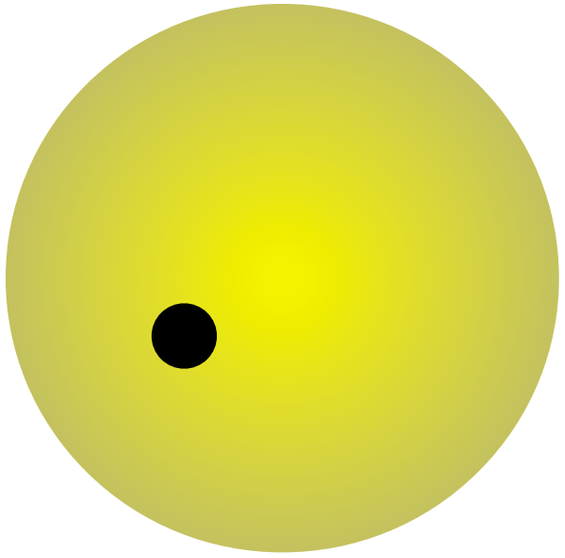
- Sources that could mimic a planetary transit light curve :

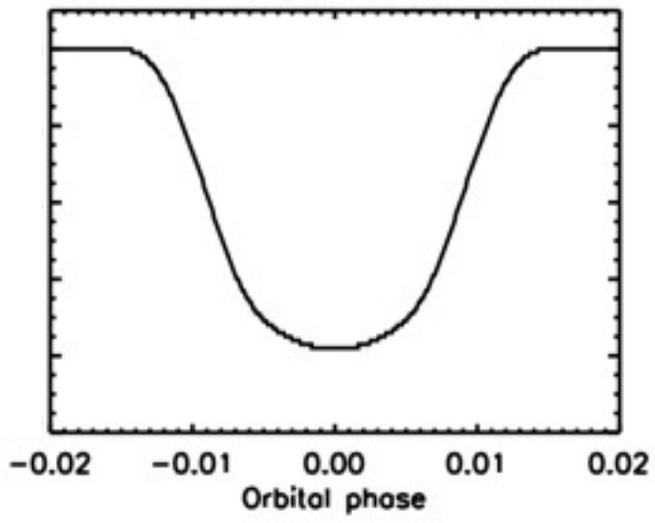


Astrophysical False positives

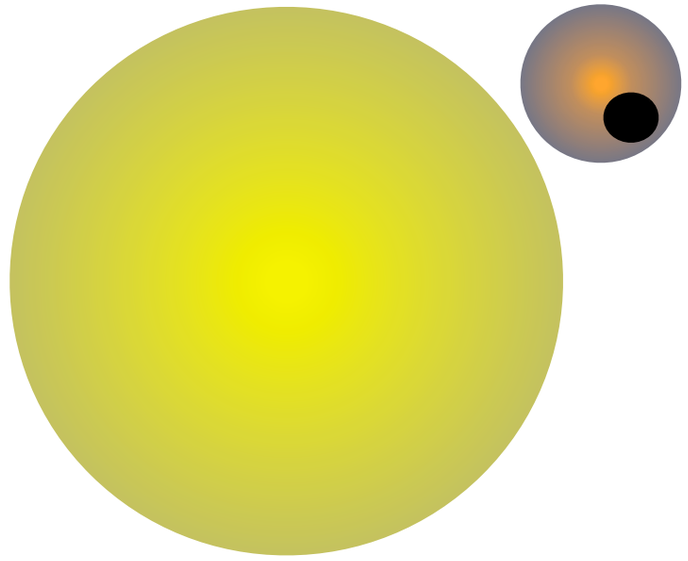
- Sources that could mimic a planetary transit light curve :
  - ✓ Blended background/foreground eclipsing binaries
  - ✓ Hierarchical triples

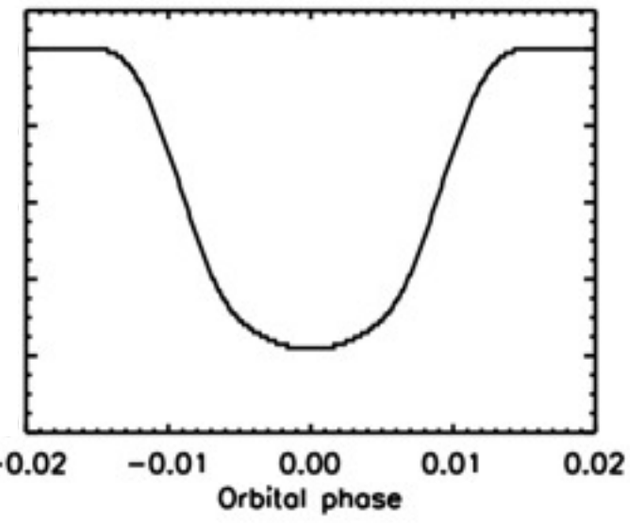
Planet





EB





Spitzer tests false positive scenarios

- A planetary transit depth is **achromatic**, a blend is not

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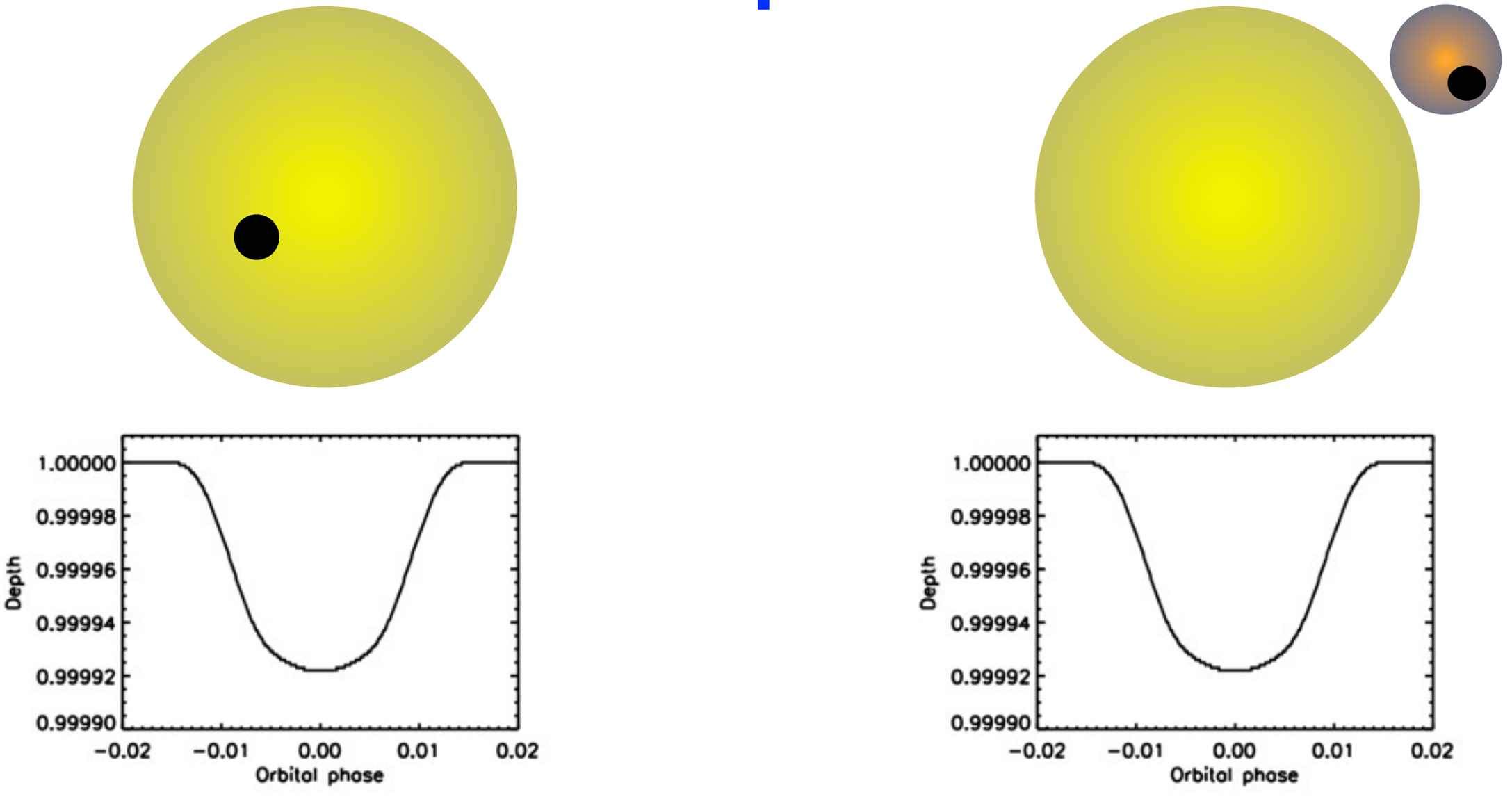
Kepler



Spitzer tests false positive scenarios

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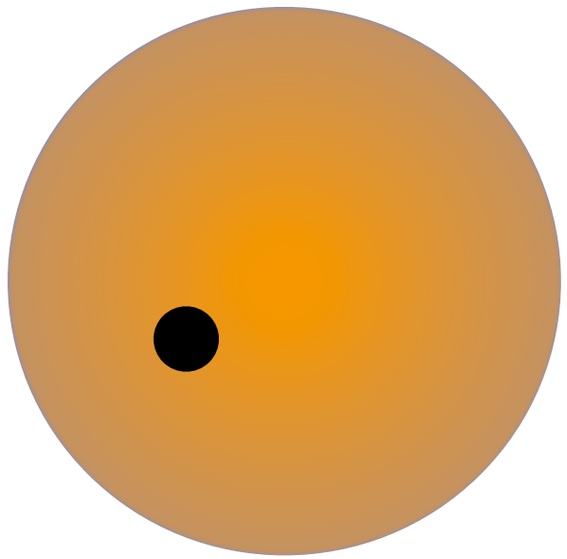
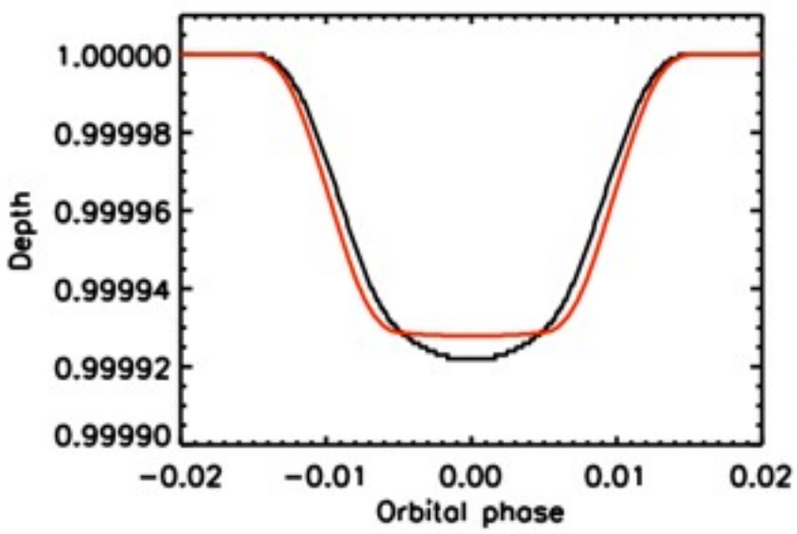
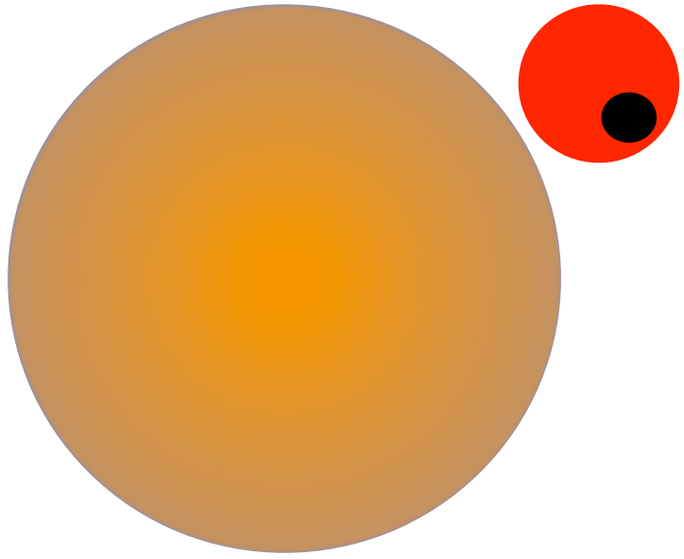
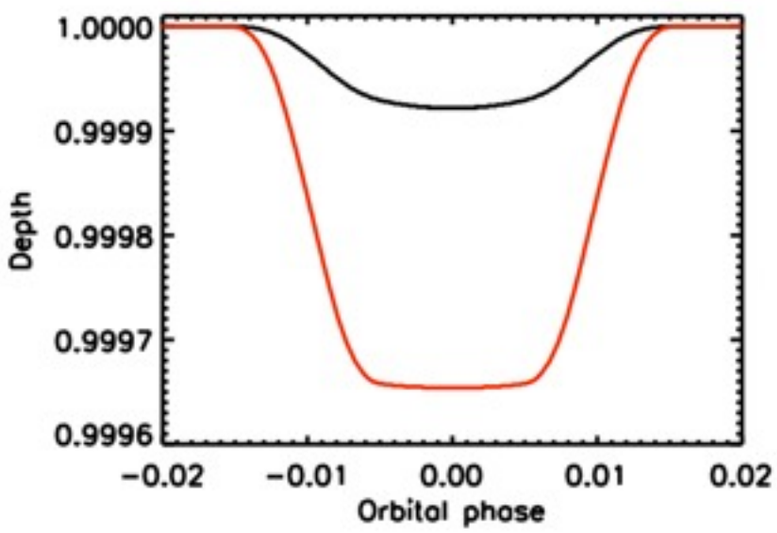
Spitzer



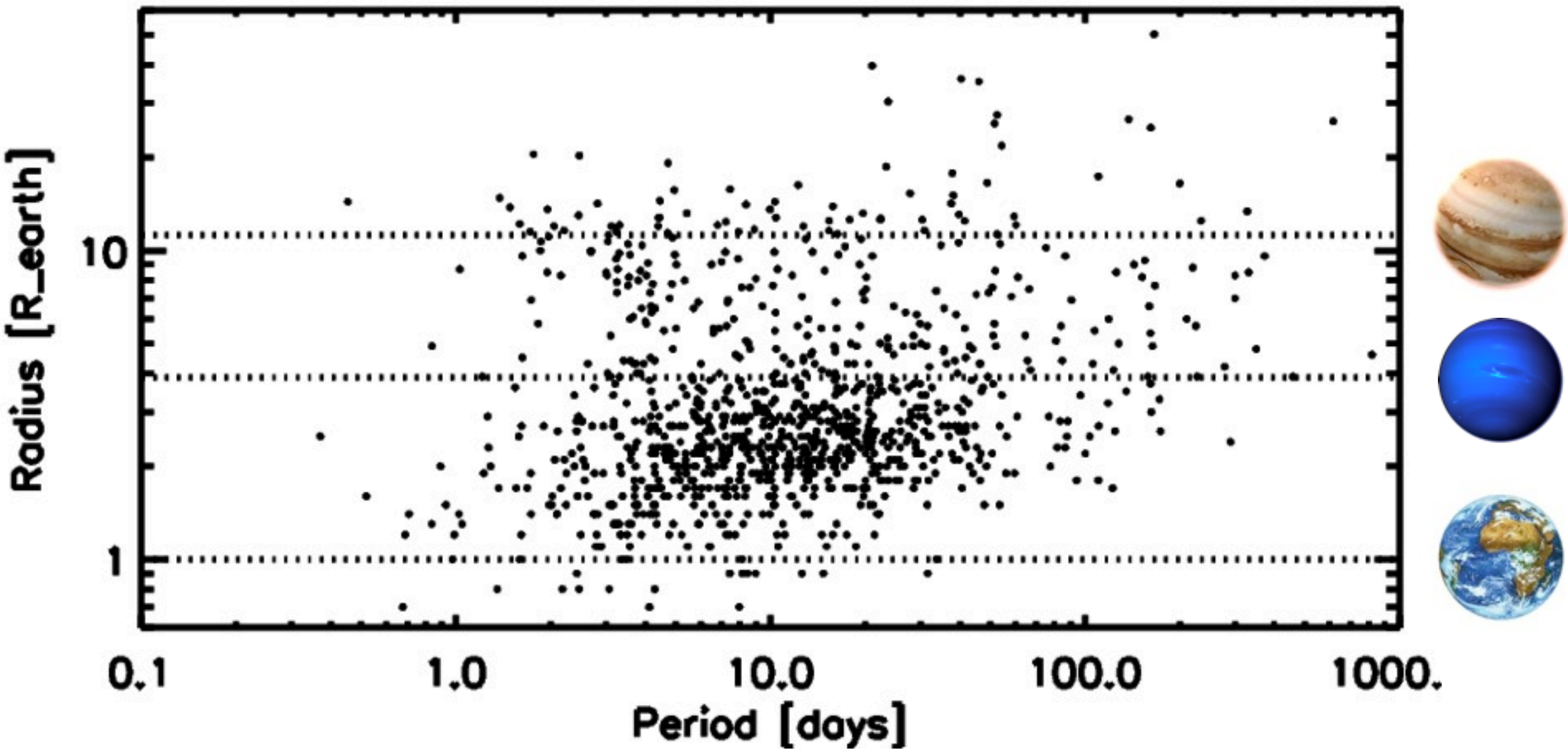






Spitzer sample

- : Kepler candidate (KOI)



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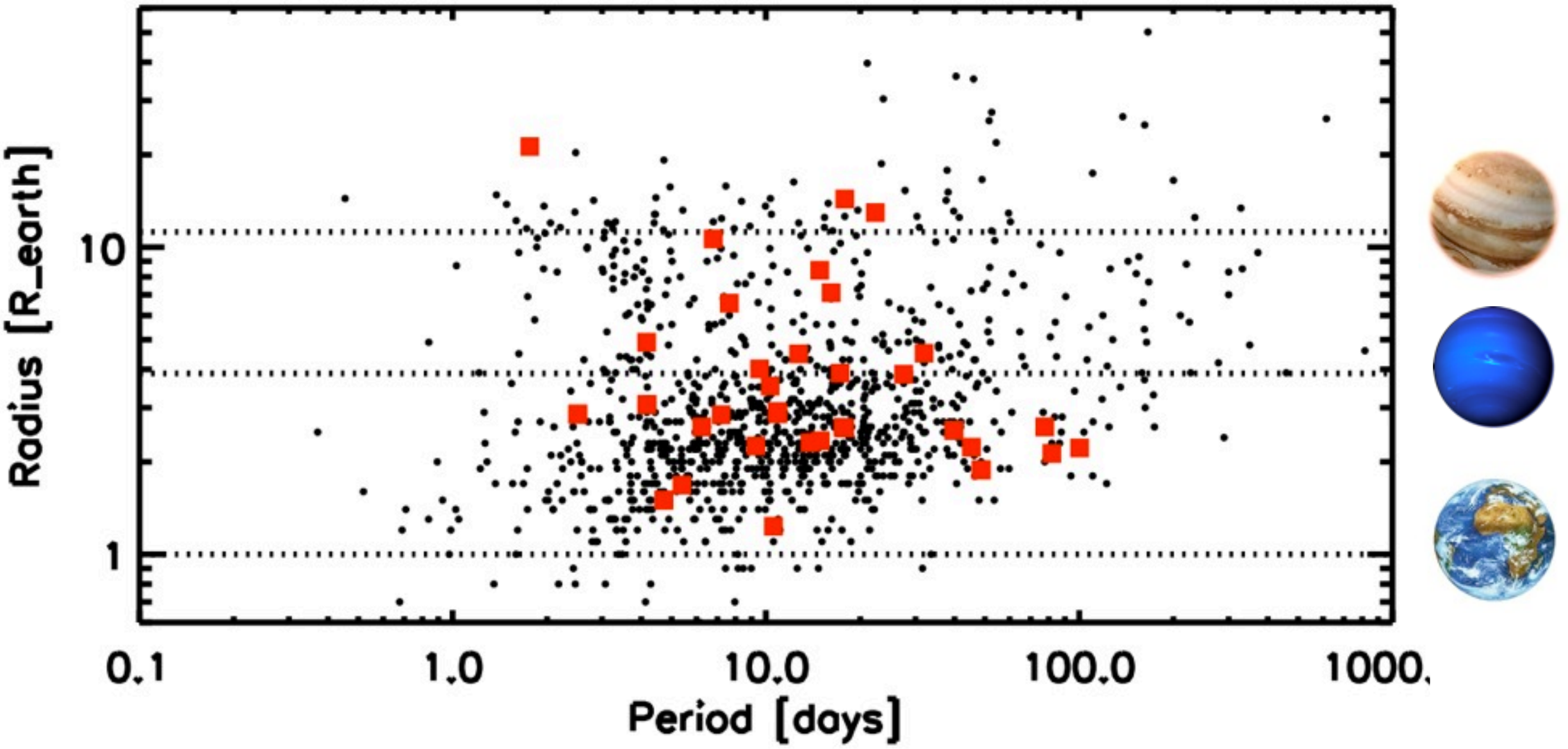

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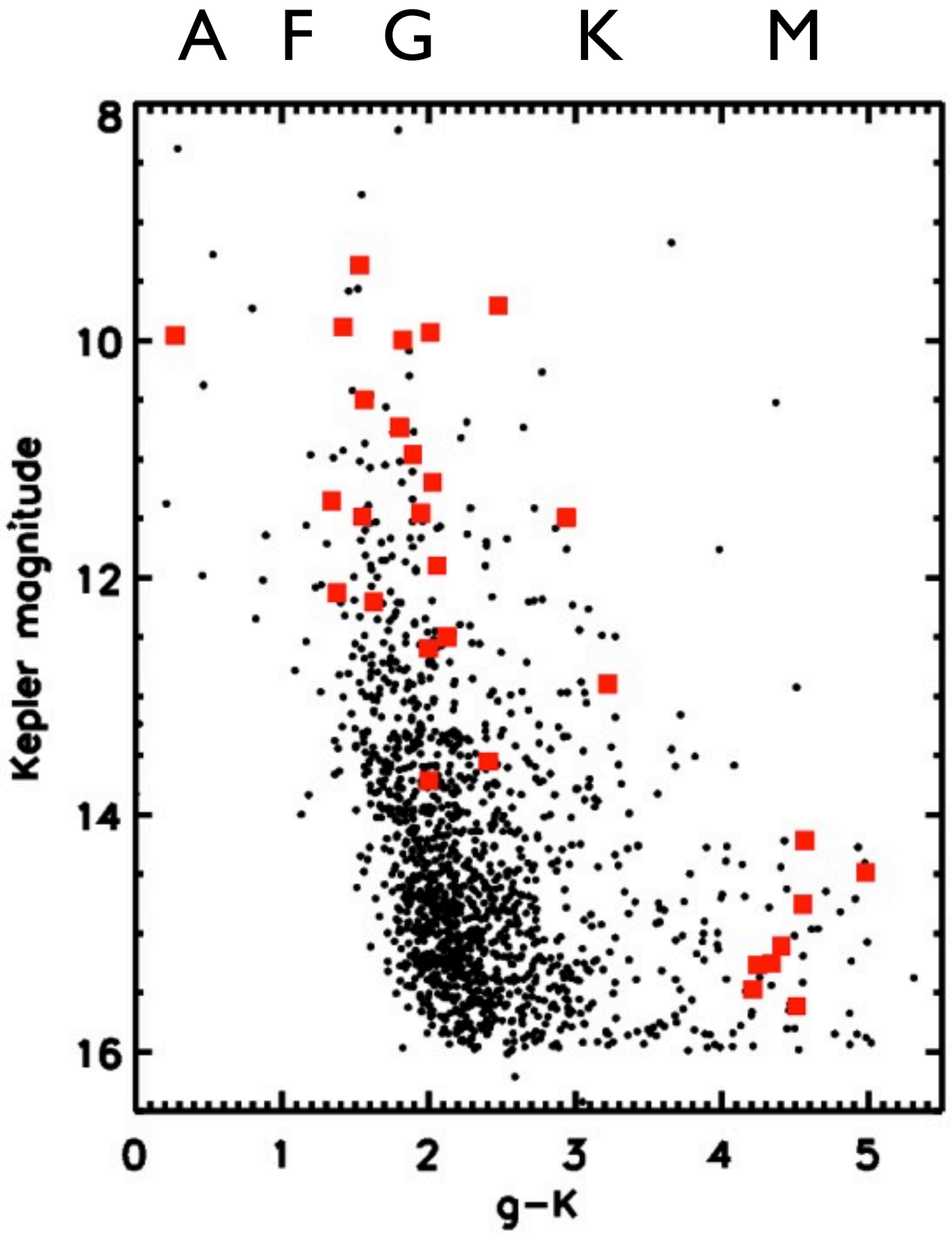

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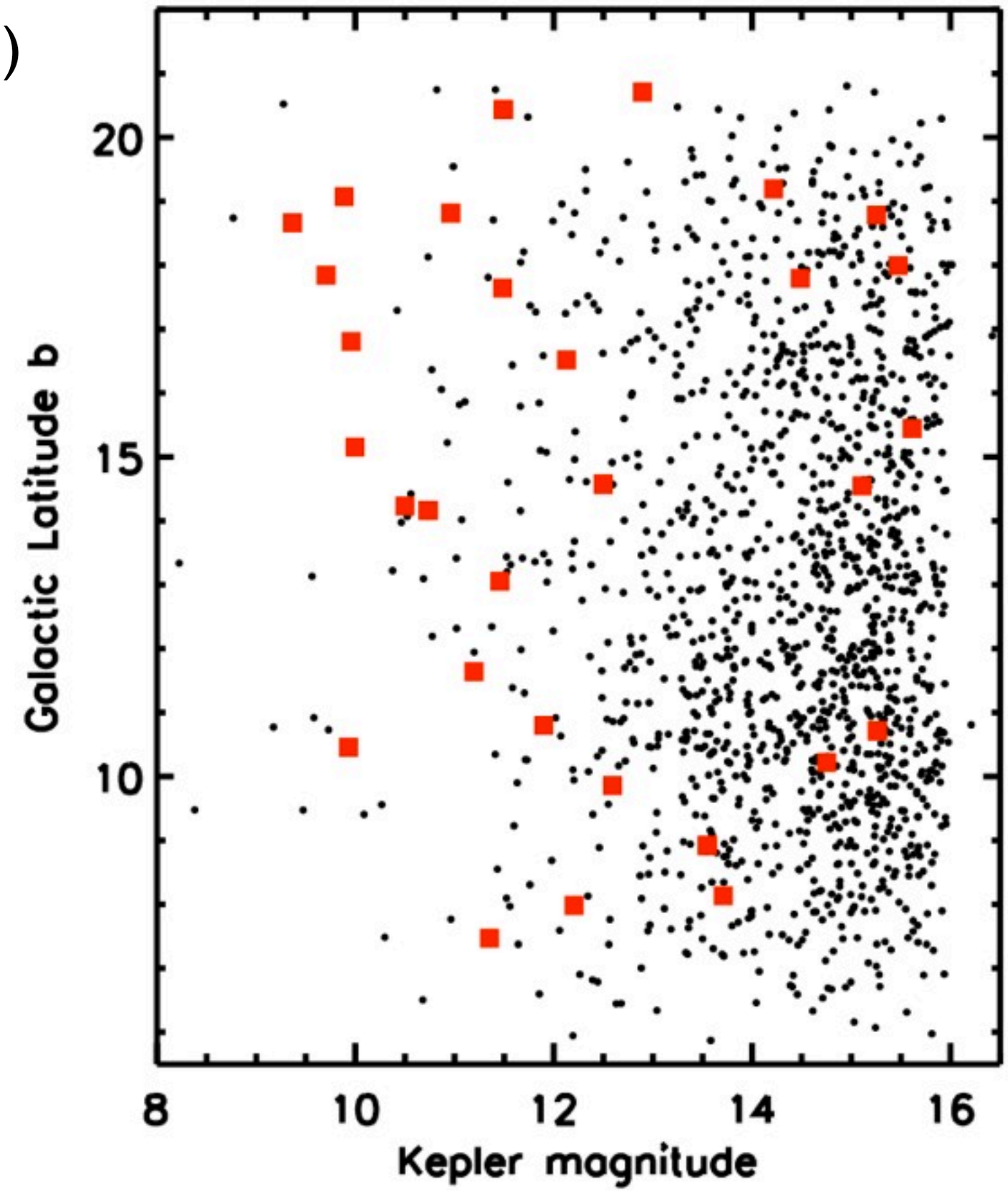
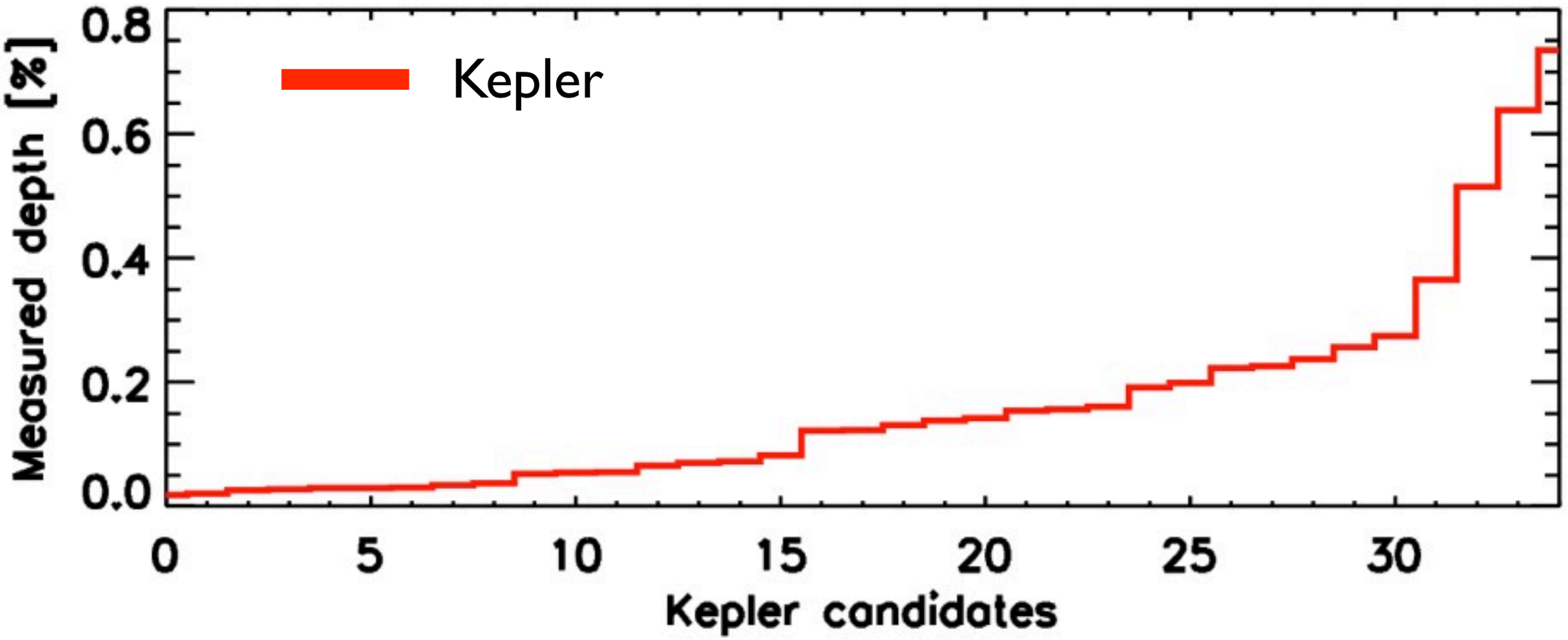
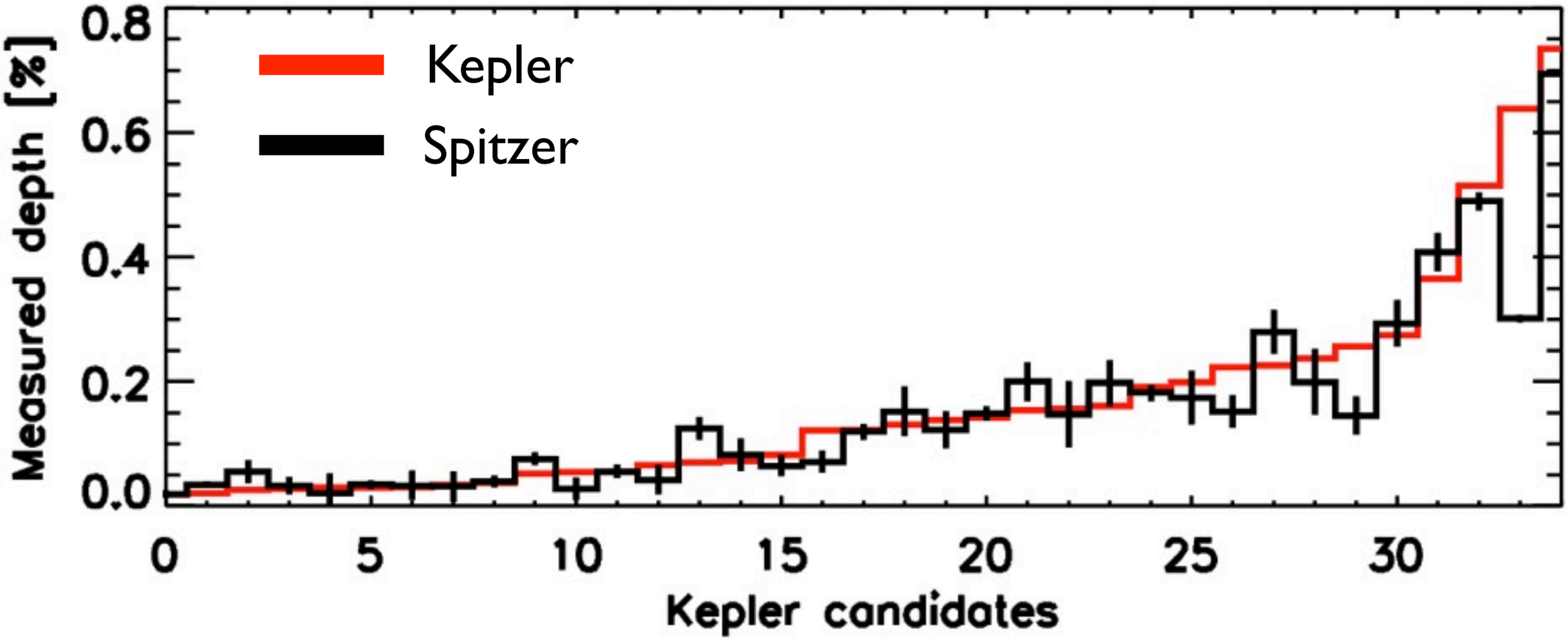


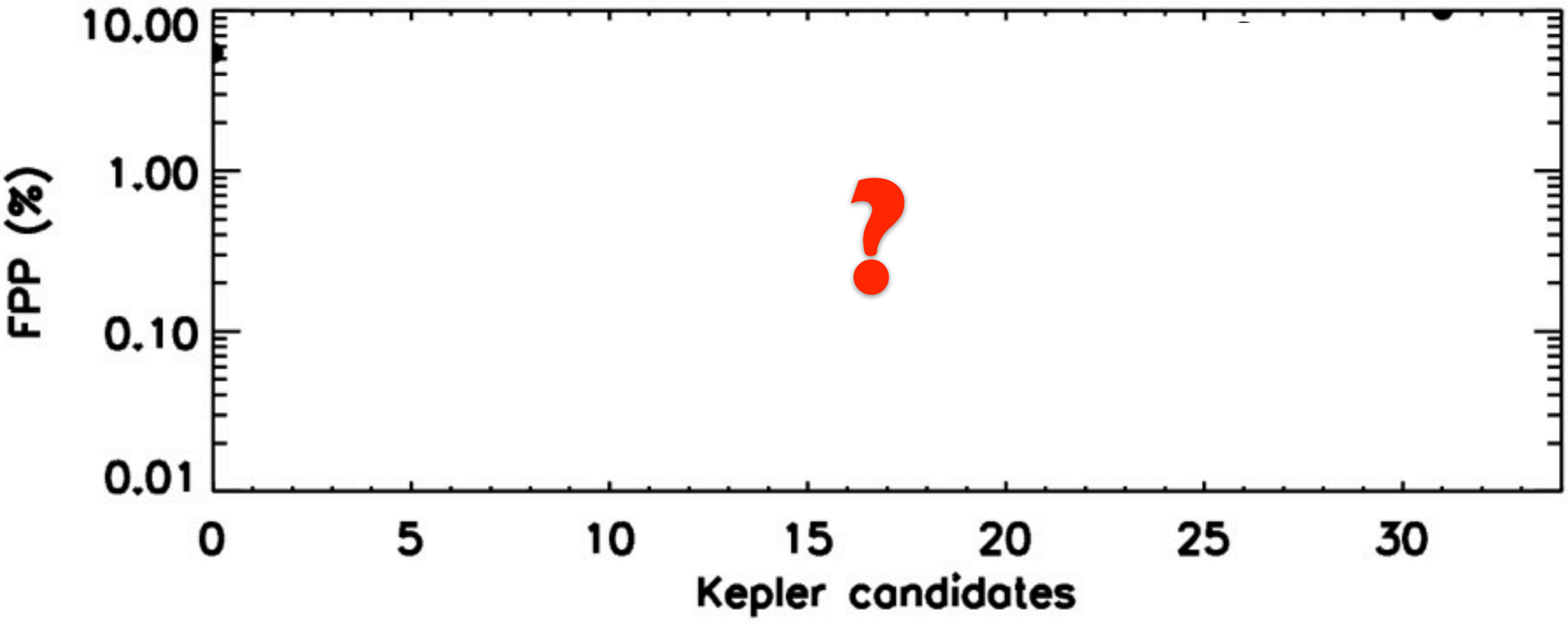
Kepler depths



Kepler vs Spitzer depths



False Positive Probability (FPP)



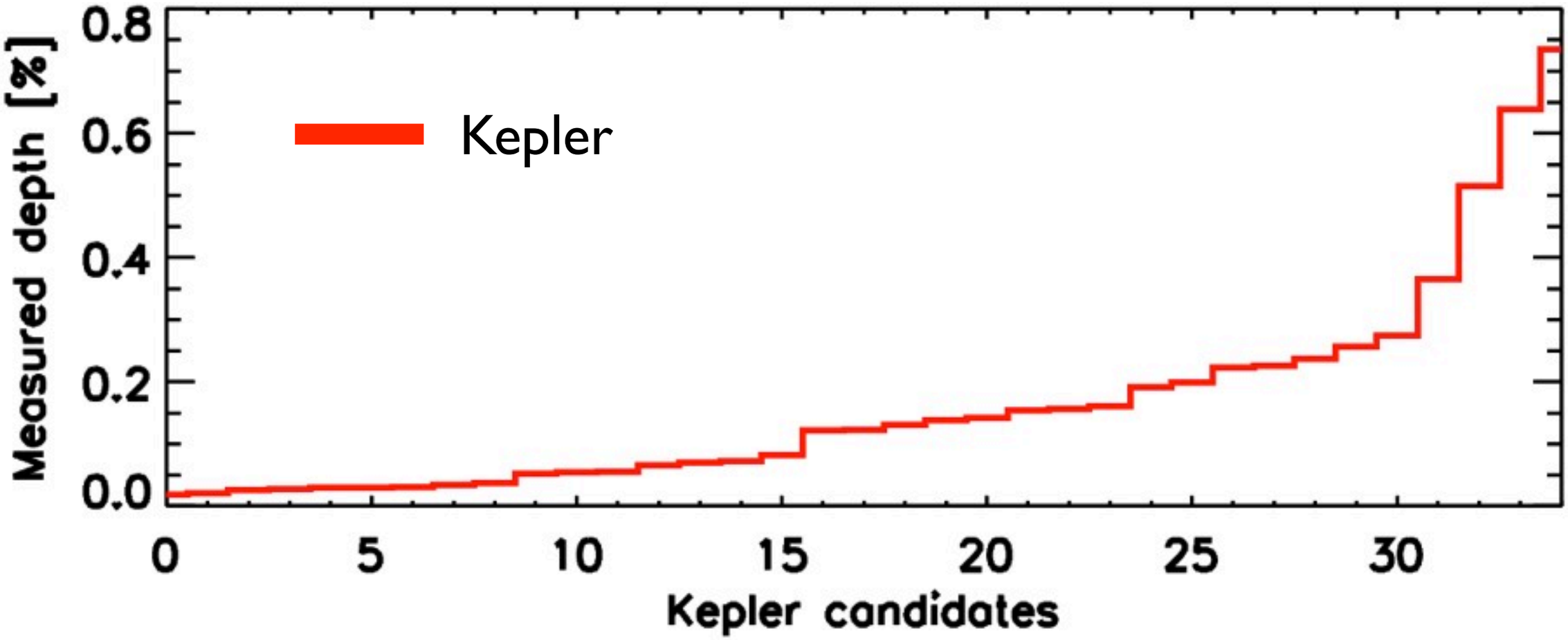
Framework

- Stellar characterization (spectroscopy)

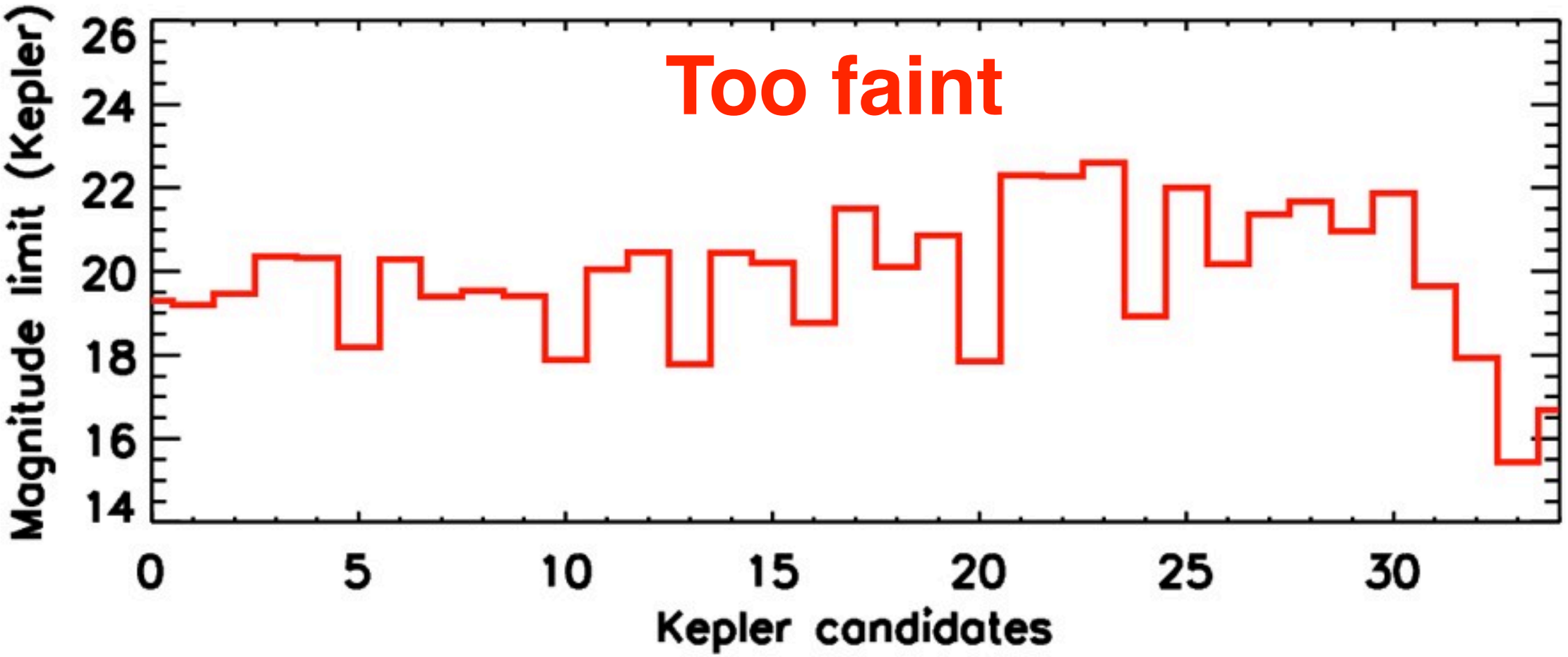
- Local sky density
    - Stellar population synthesis (Besançon)
    - Kepler (photometry)
    - Centroid analysis (Kepler), Imaging (Adaptive optics, Speckle, ...)
    - **Spitzer** observations

- Blend frequencies + planet priors => FPP

Kepler depths



Faint limit condition



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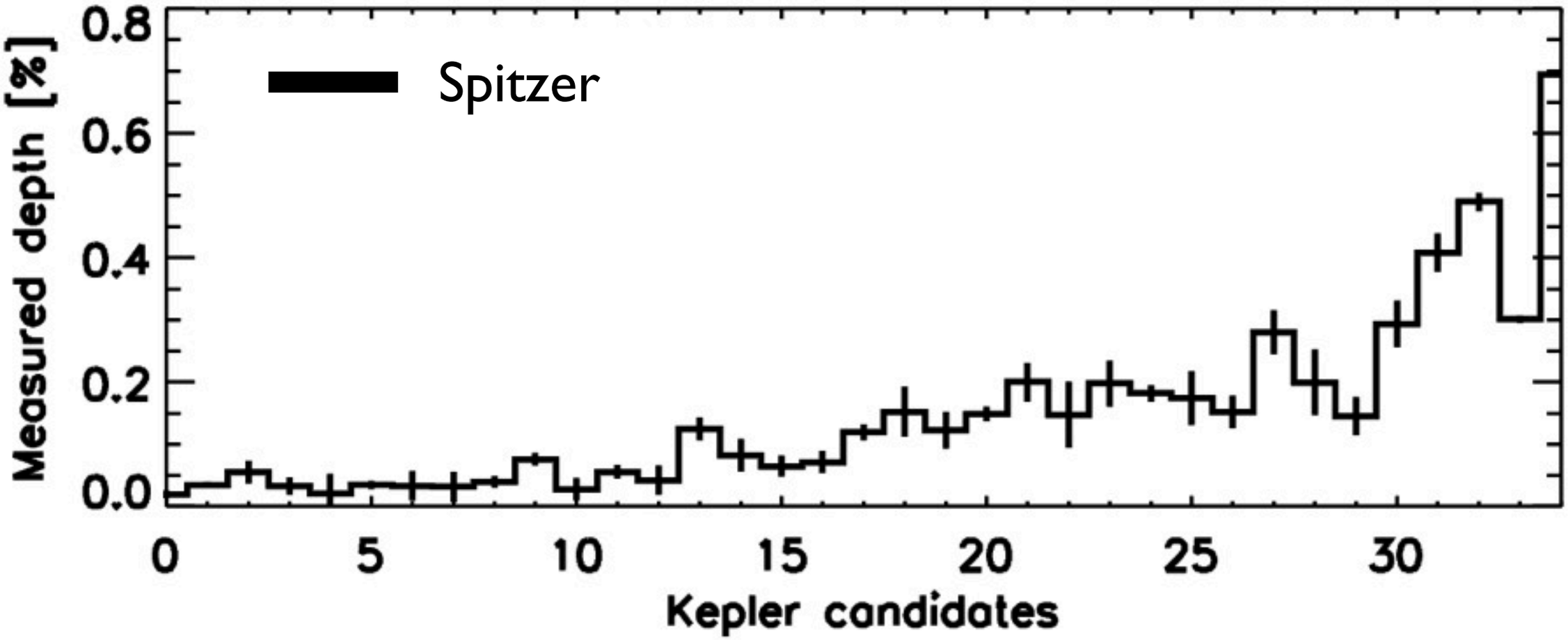
- Stellar characterization (spectroscopy)

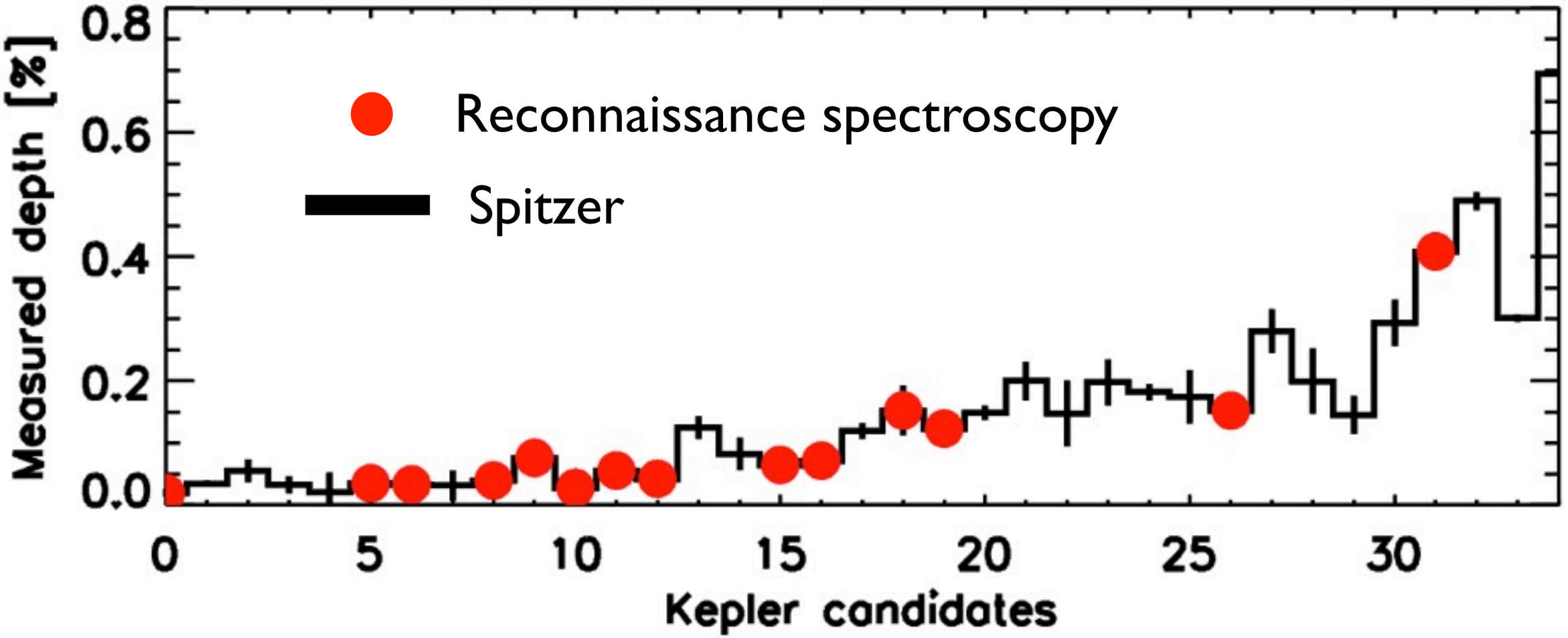
- Local sky density
    - Stellar population synthesis (Besançon)
    - Kepler (photometry)
    - Centroid analysis (Kepler), Imaging (Adaptive optics, Speckle, ...)
    - **Spitzer** observations (depths and magnitudes)

- Compute blend frequencies + planet priors => FPP

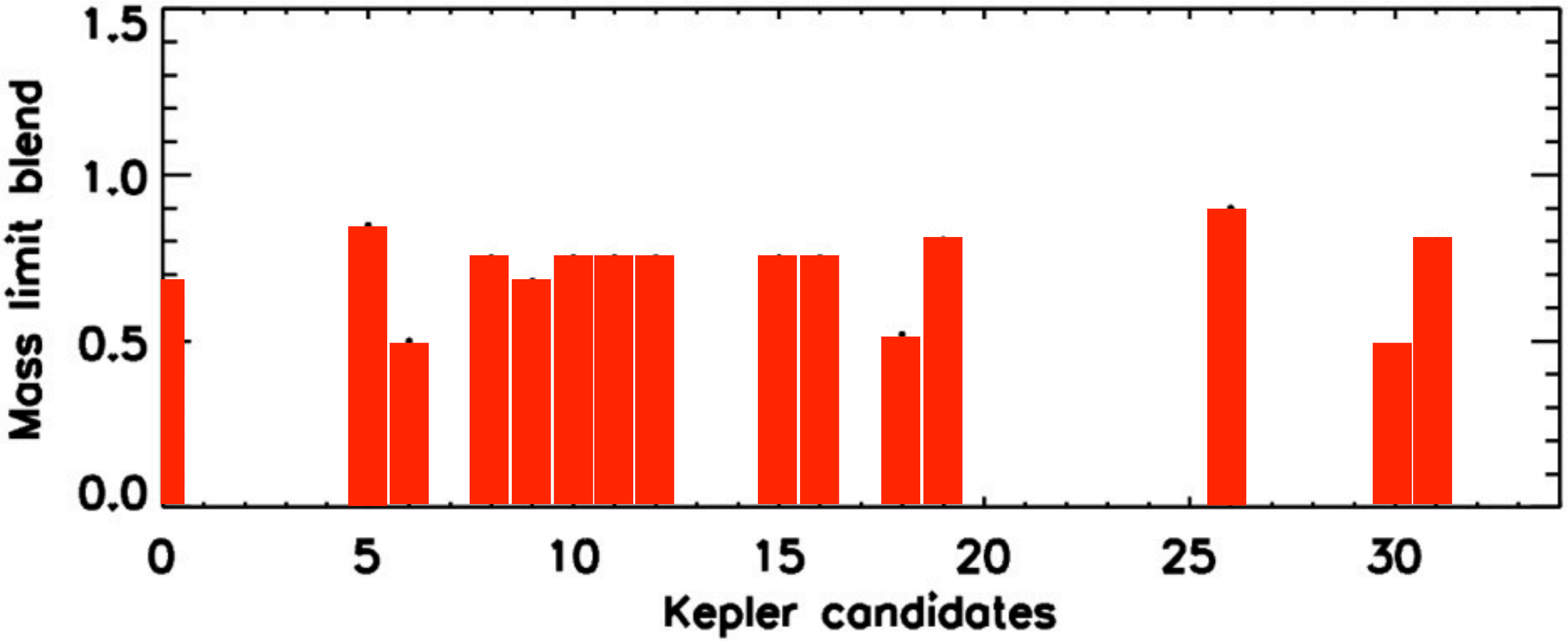
Spitzer depths



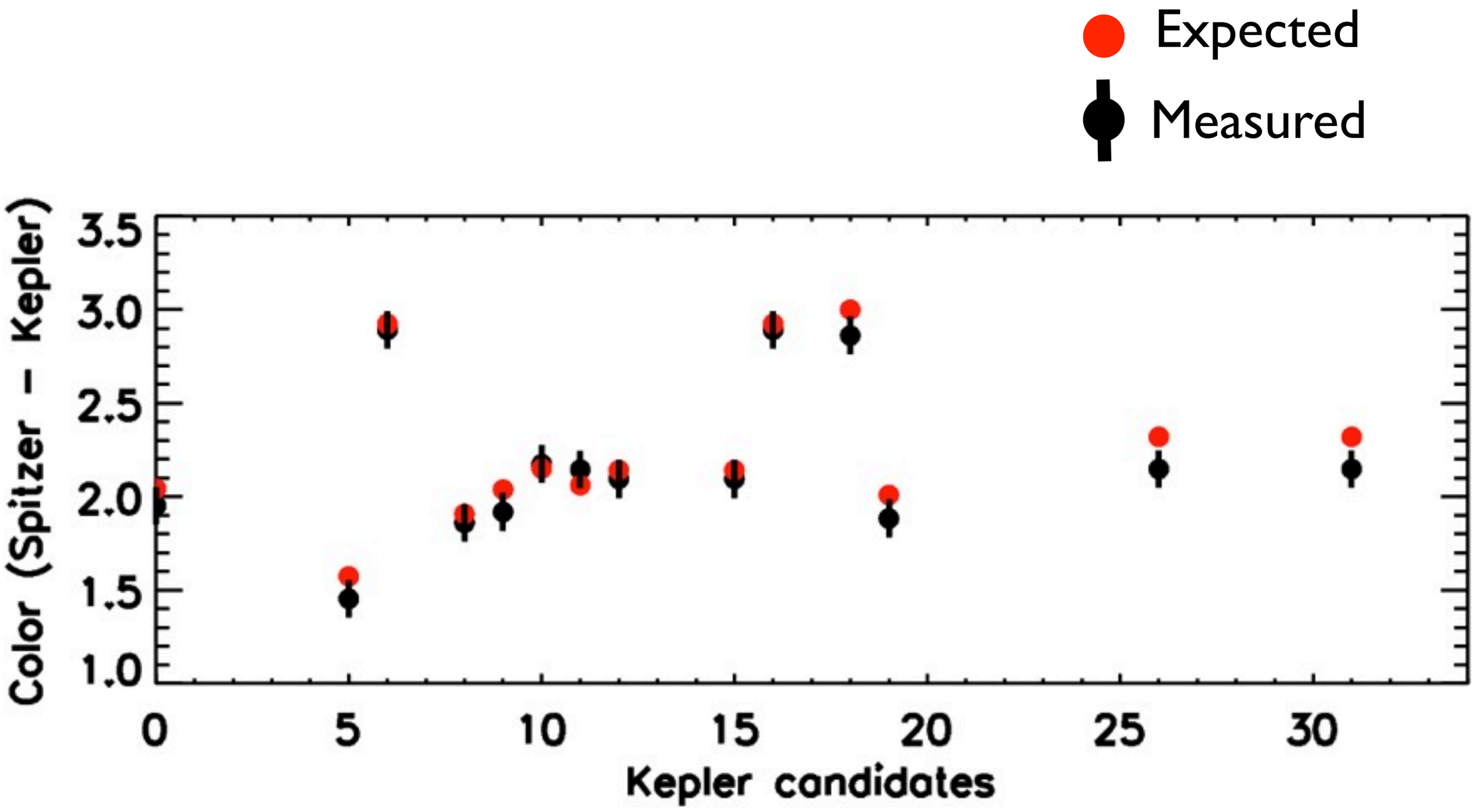
Good stellar characterization



Mass limit secondary (blend)

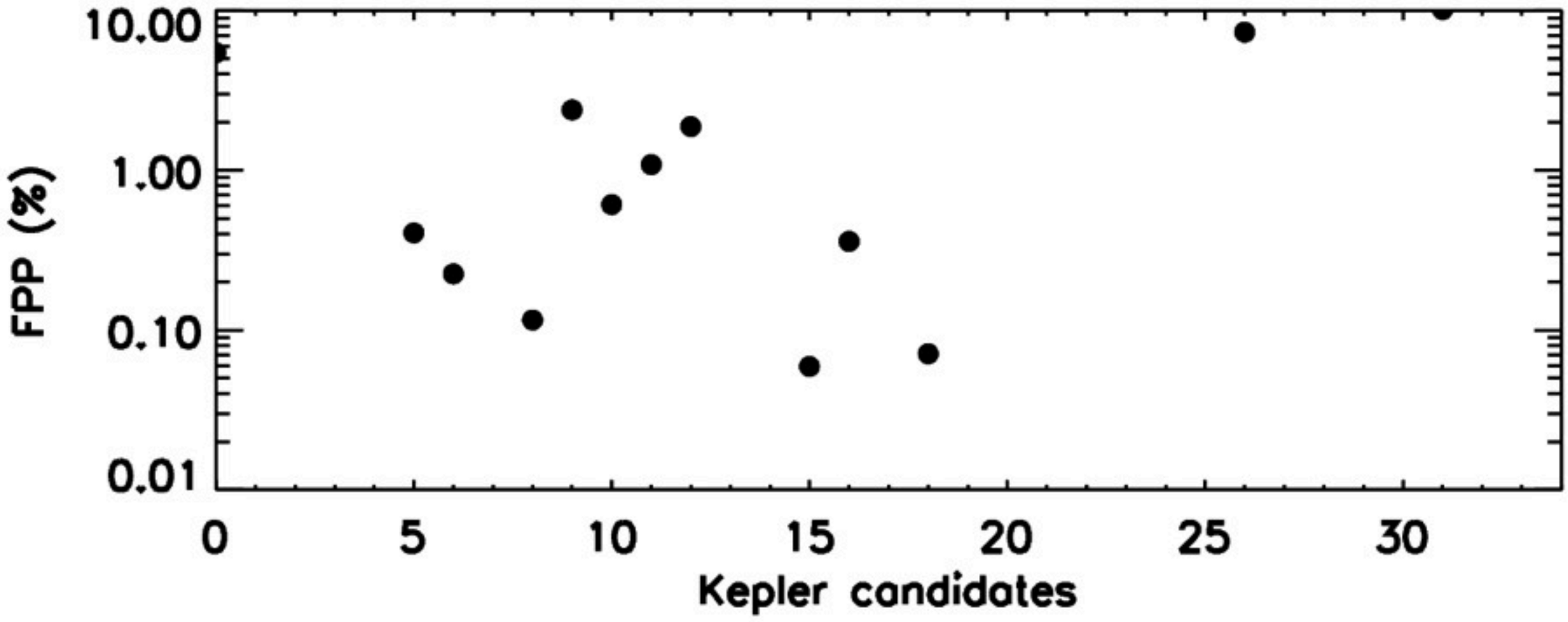


Color (Spitzer - Kepler)



False Positive Probability (FPP)

Spectroscopy, **Spitzer**, AO, Kepler centroid



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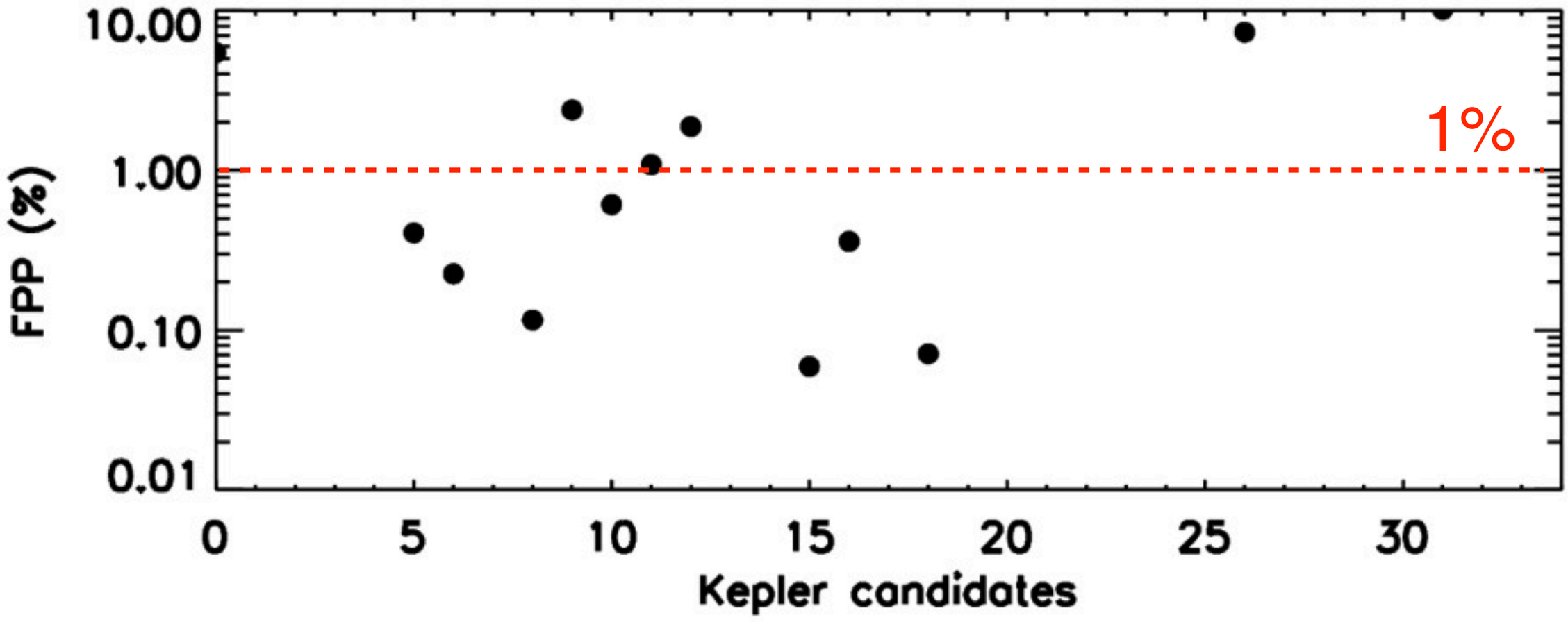

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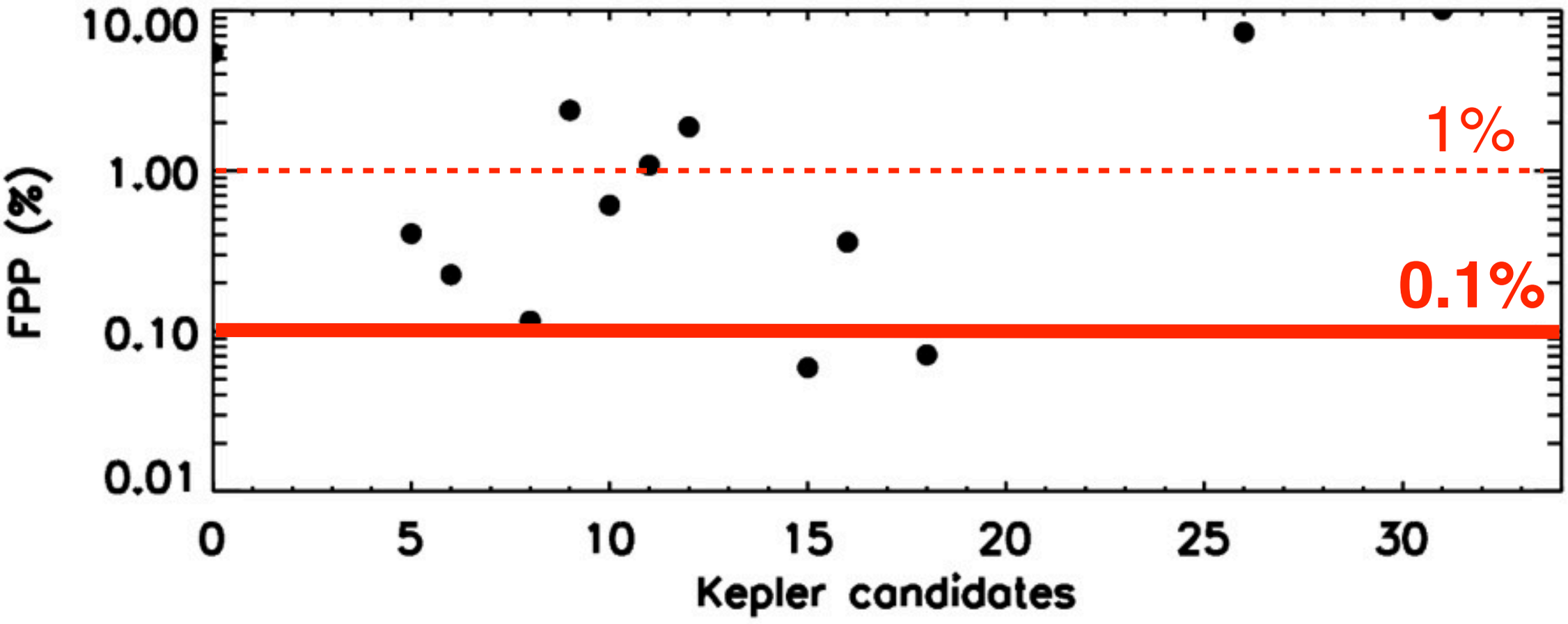

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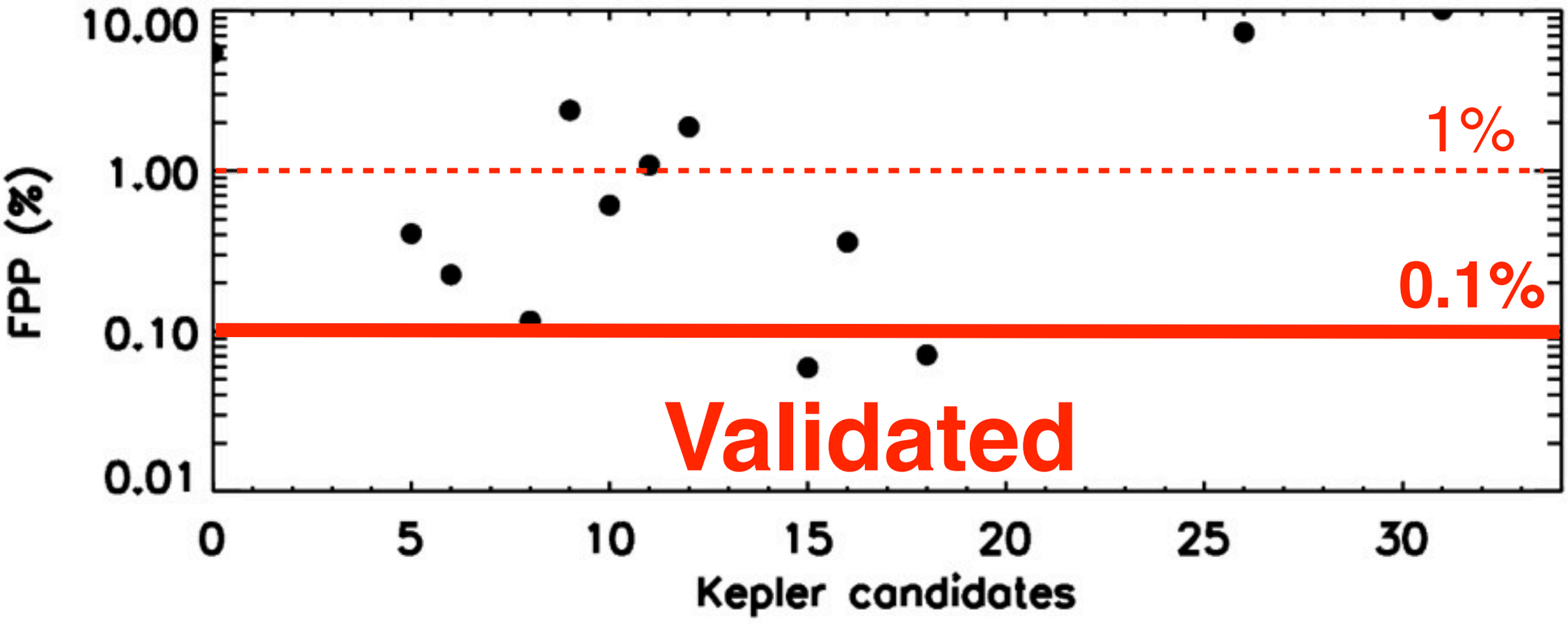


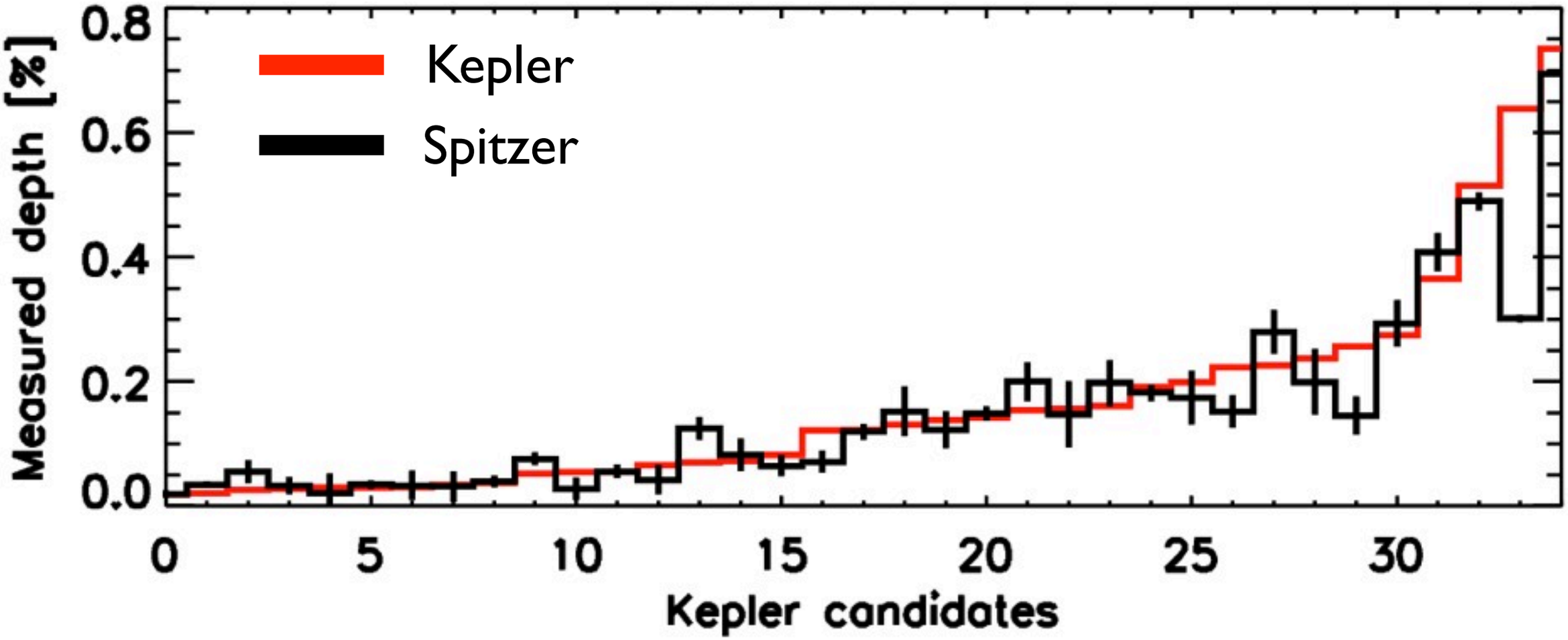
Talk take-home points

- We use Spitzer NIR transit observations of a sample of Kepler candidates to estimate the **false positive rate.**

- The 34 candidates observed have **all achromatic** transit depths as expected from planetary signals.

- These observations suggest that the false positive rate is low.

Kepler vs Spitzer depths



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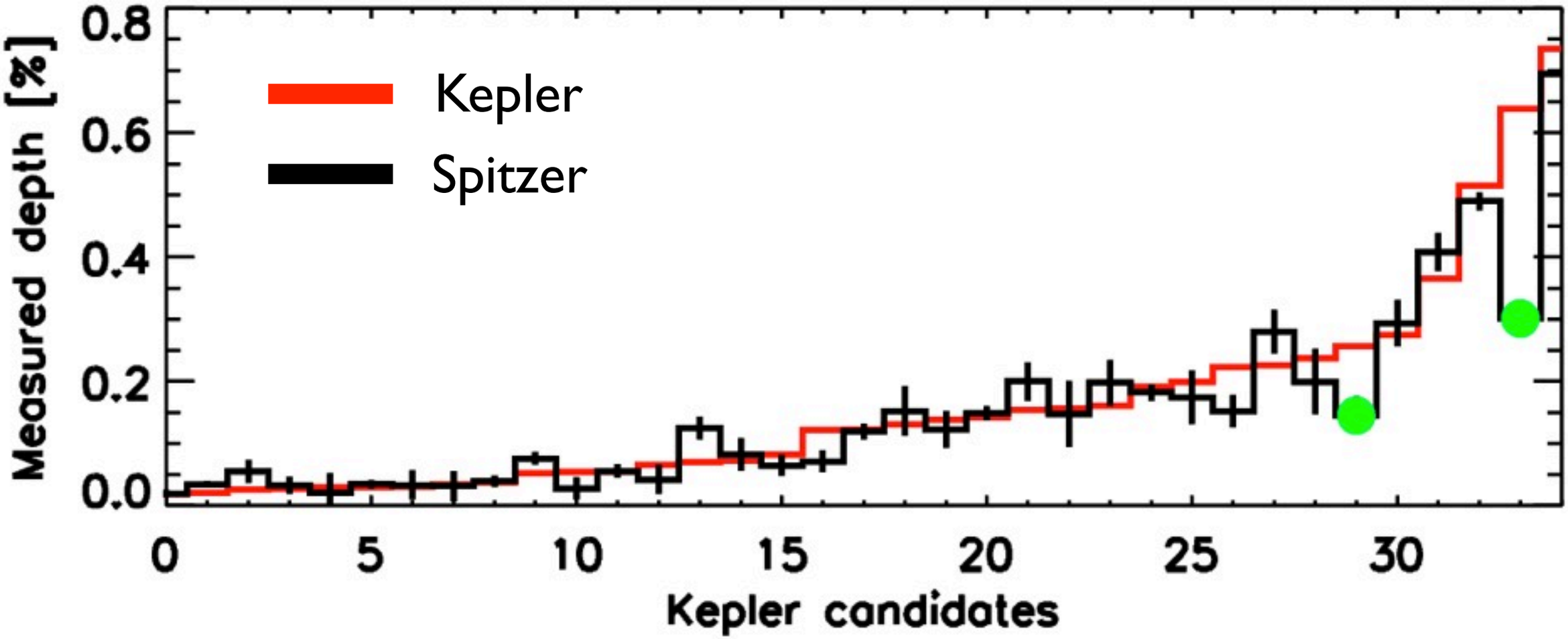
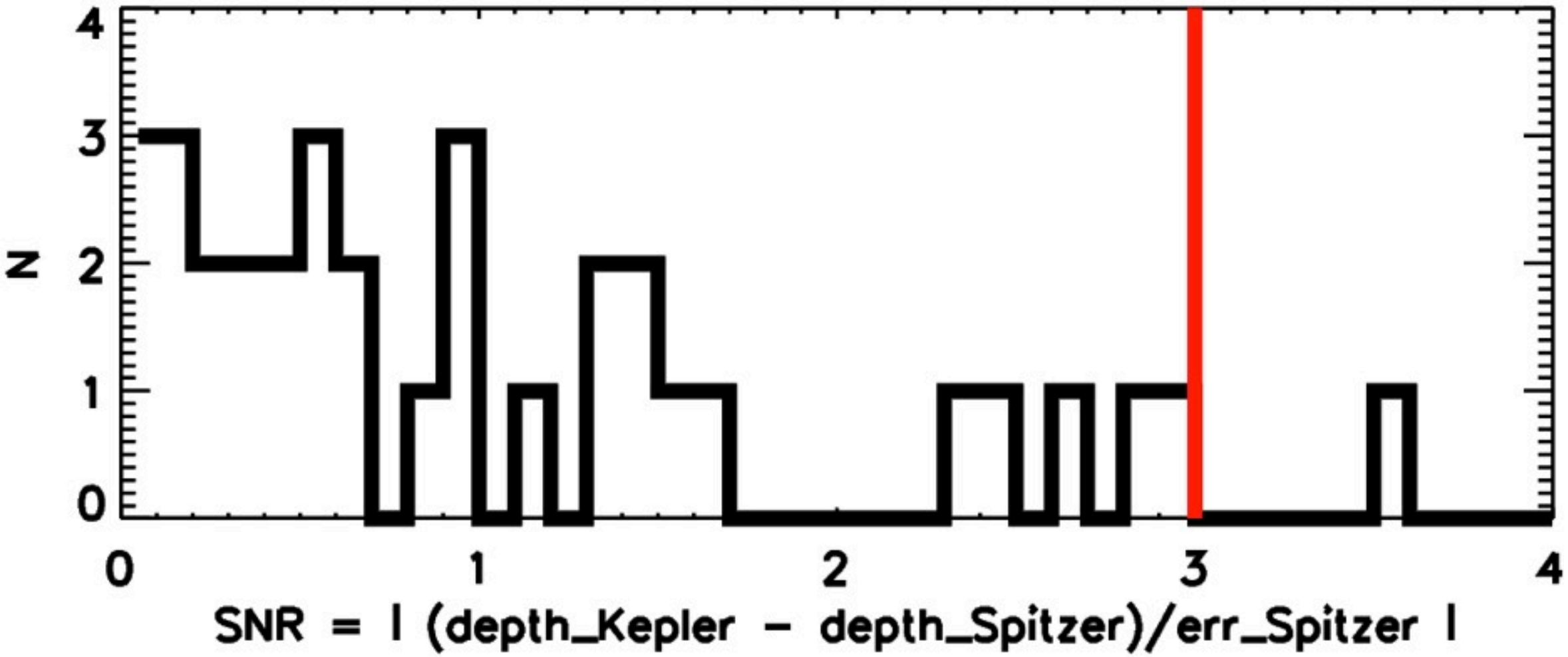
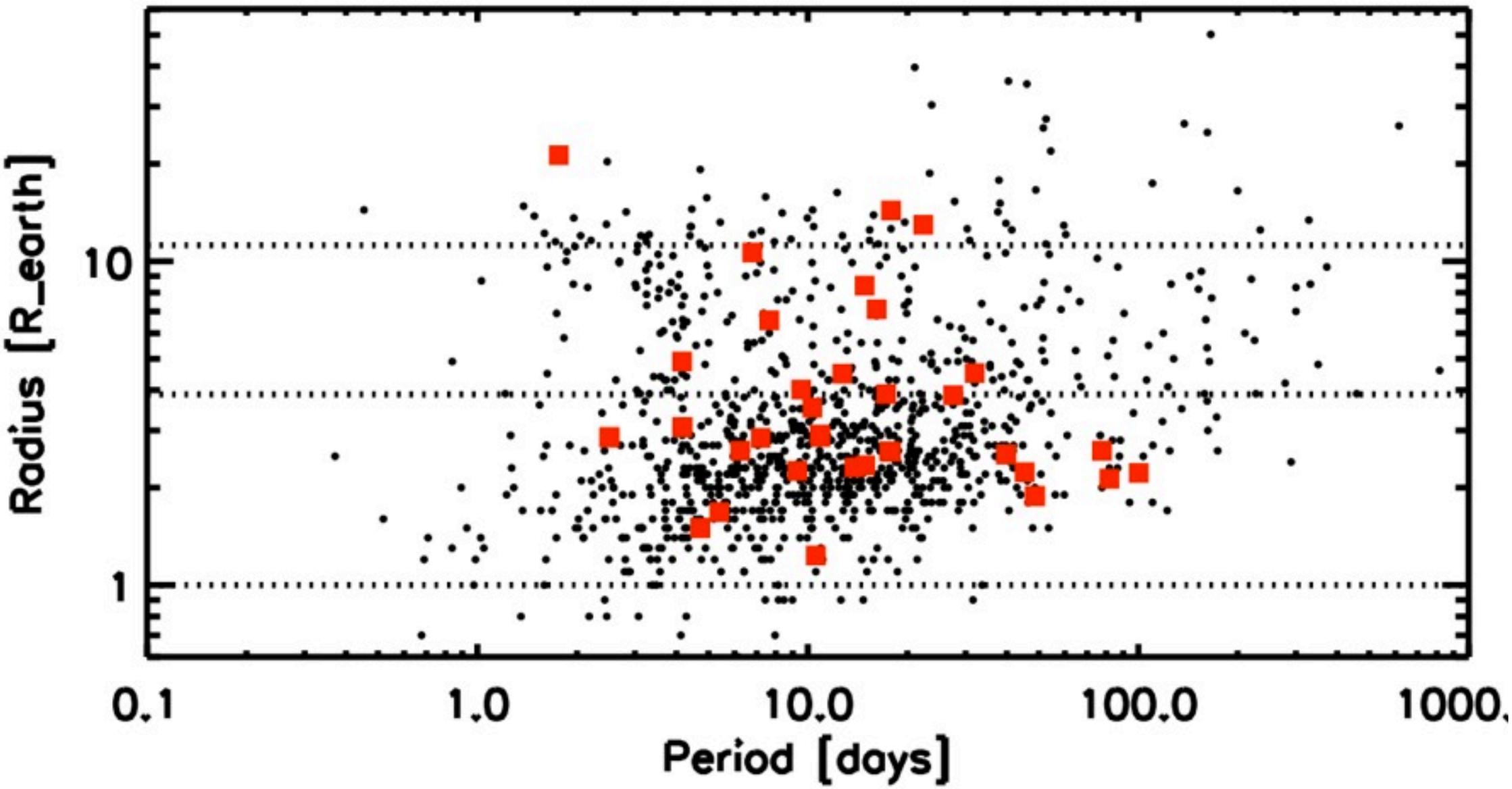



4
3
2
1
0
N
0
1
2
3
4
SNR = | (depth_Kepler − depth_Spitzer)/err_Spitzer |

● : Kepler candidate (KOI)

■ : Spitzer sample



First 400 KOIs

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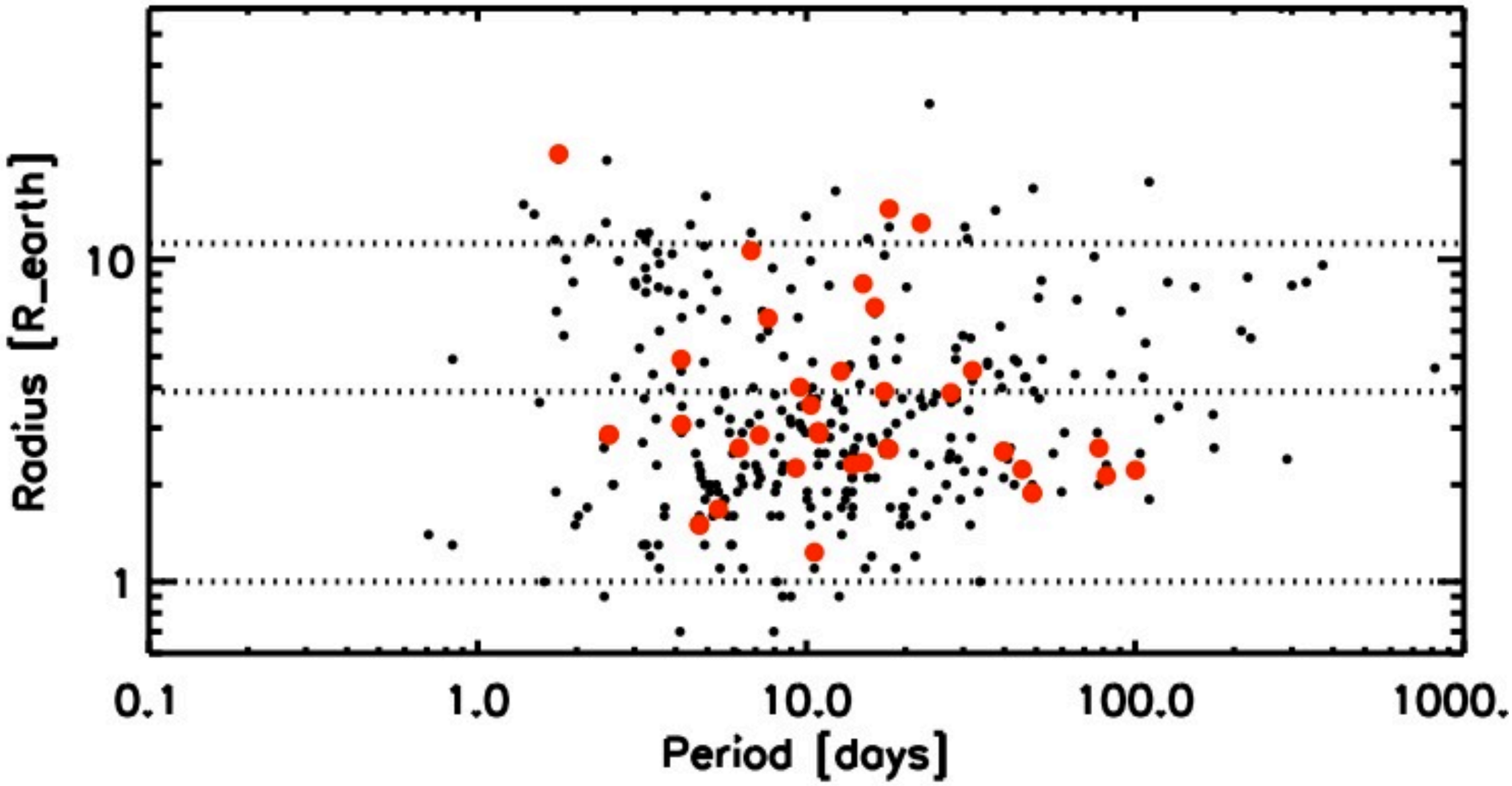
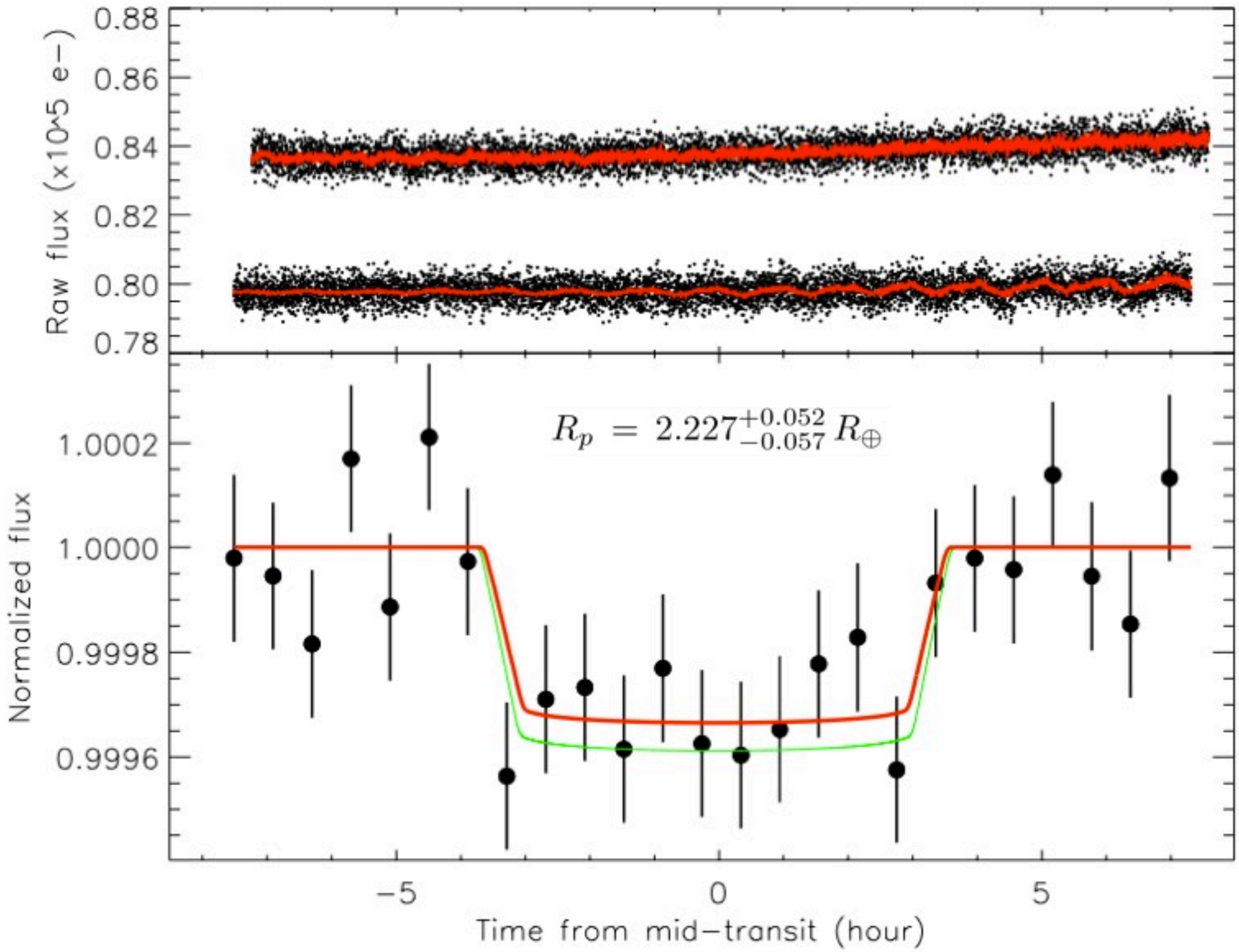
Spitzer/4.5μm