# Determining The Host Stars of Planets in Binary Star Systems

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**Background:** Recent research has found that **the radius gap may not be present in binary star systems** (Sullivan, et al. 2023) or may be dependent on binary separation (Sullivan et al. 2024). However, this analysis assumed that all planets were orbiting the brighter primary star. In many cases, the radius of the planet would be significantly larger if it were orbiting the companion star, in some cases placing its radius above the radius gap range. **Identifying the host star is important for obtaining accurate planet properties.**

**Observations:**

- Selected Kepler Objects of Interest (KOI) known to be binary stars
- Selected for 1 or 2 planet systems with $R_{p,pri}$ in the canonical radius gap

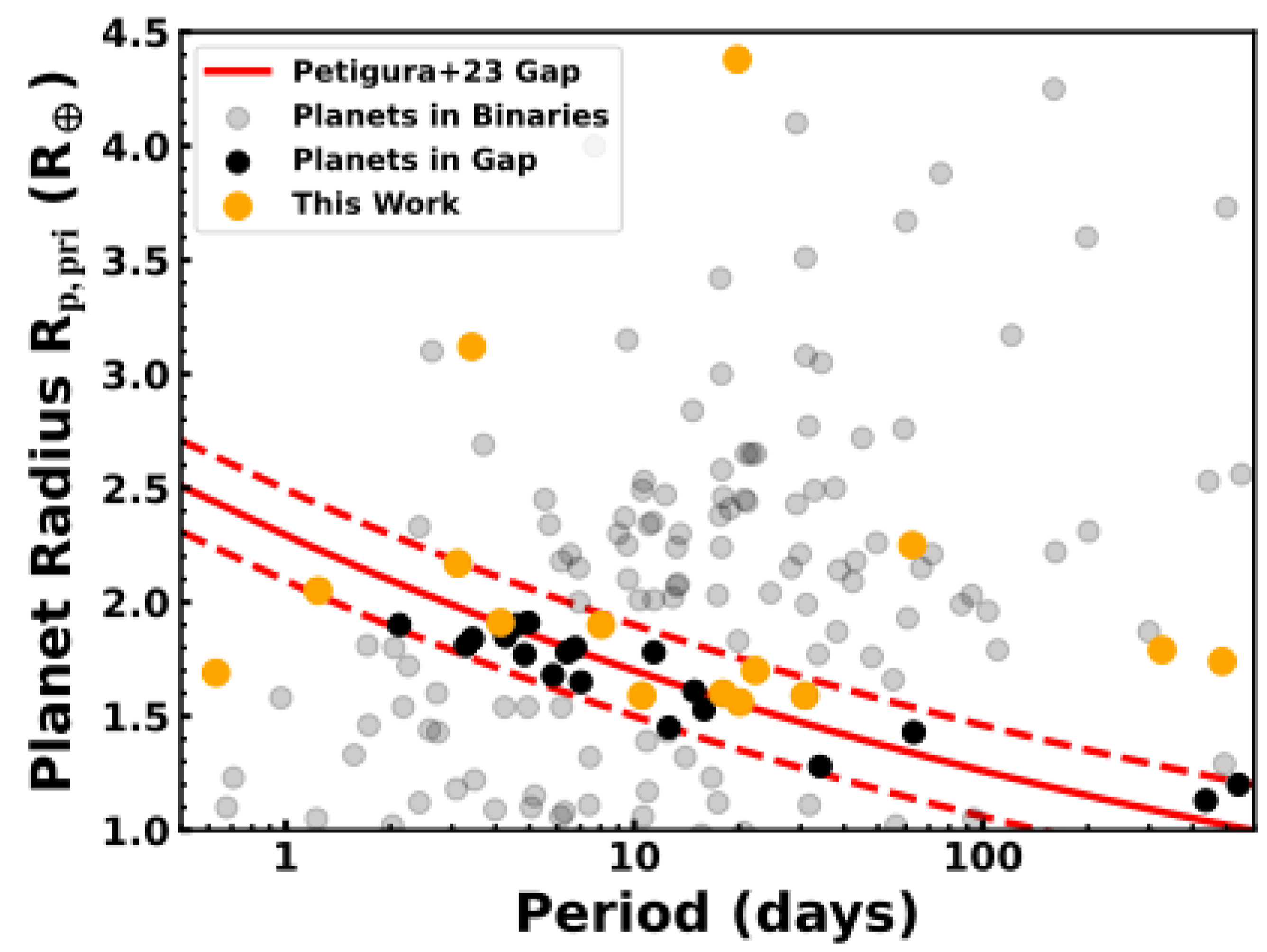
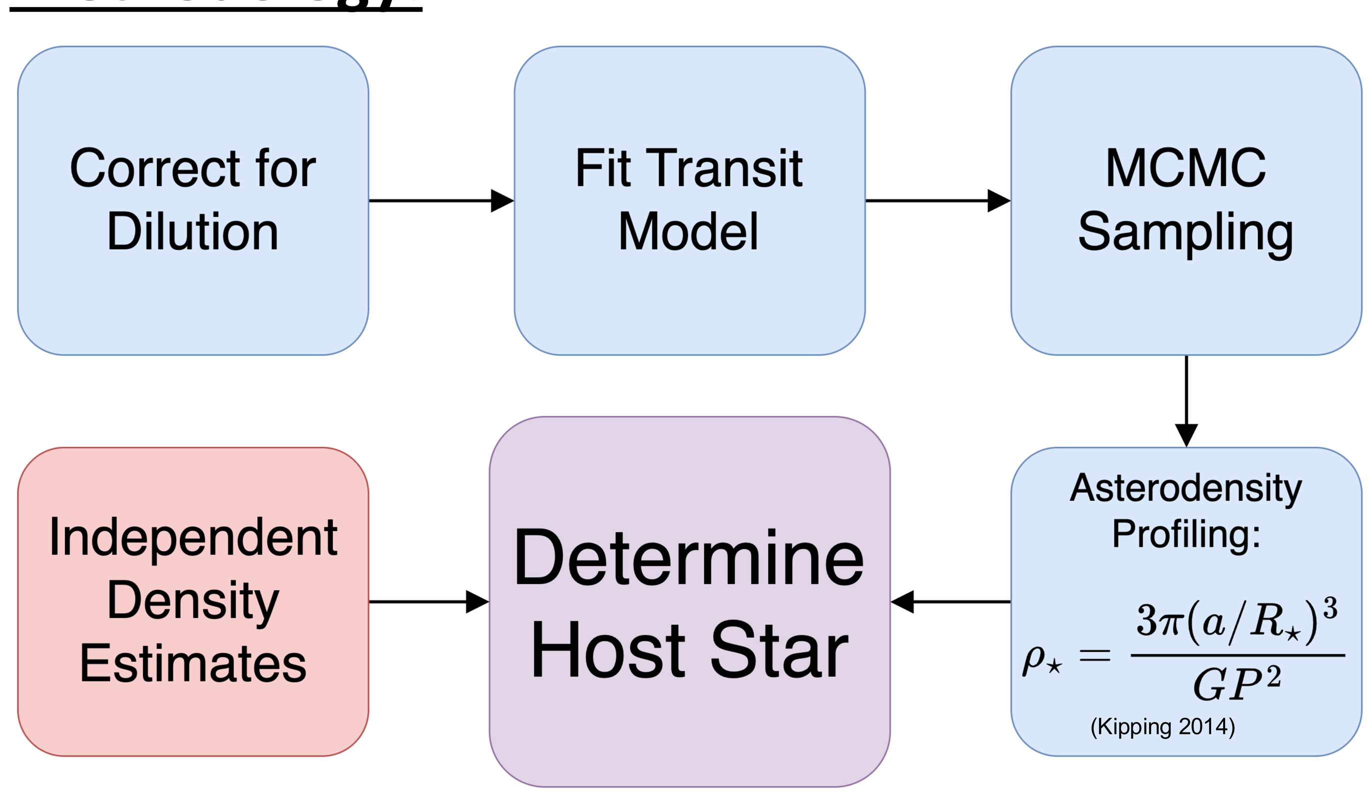



Figure 1: The circumprimary planetary radius ($R_{p,pri}$) vs orbital period for the planets in binaries. Gray points are planets in binaries from Sullivan et al. (2023). Red line is canonical radius gap from Petigura et al. (2023) +/- 0.2 $R_{Earth}$. Black points are radius gap planets not analyzed in this work. Orange points are planets analyzed in this work.

**Methodology:**




## Example: KOI-1300.01

## Unambiguous Circumprimary Planet

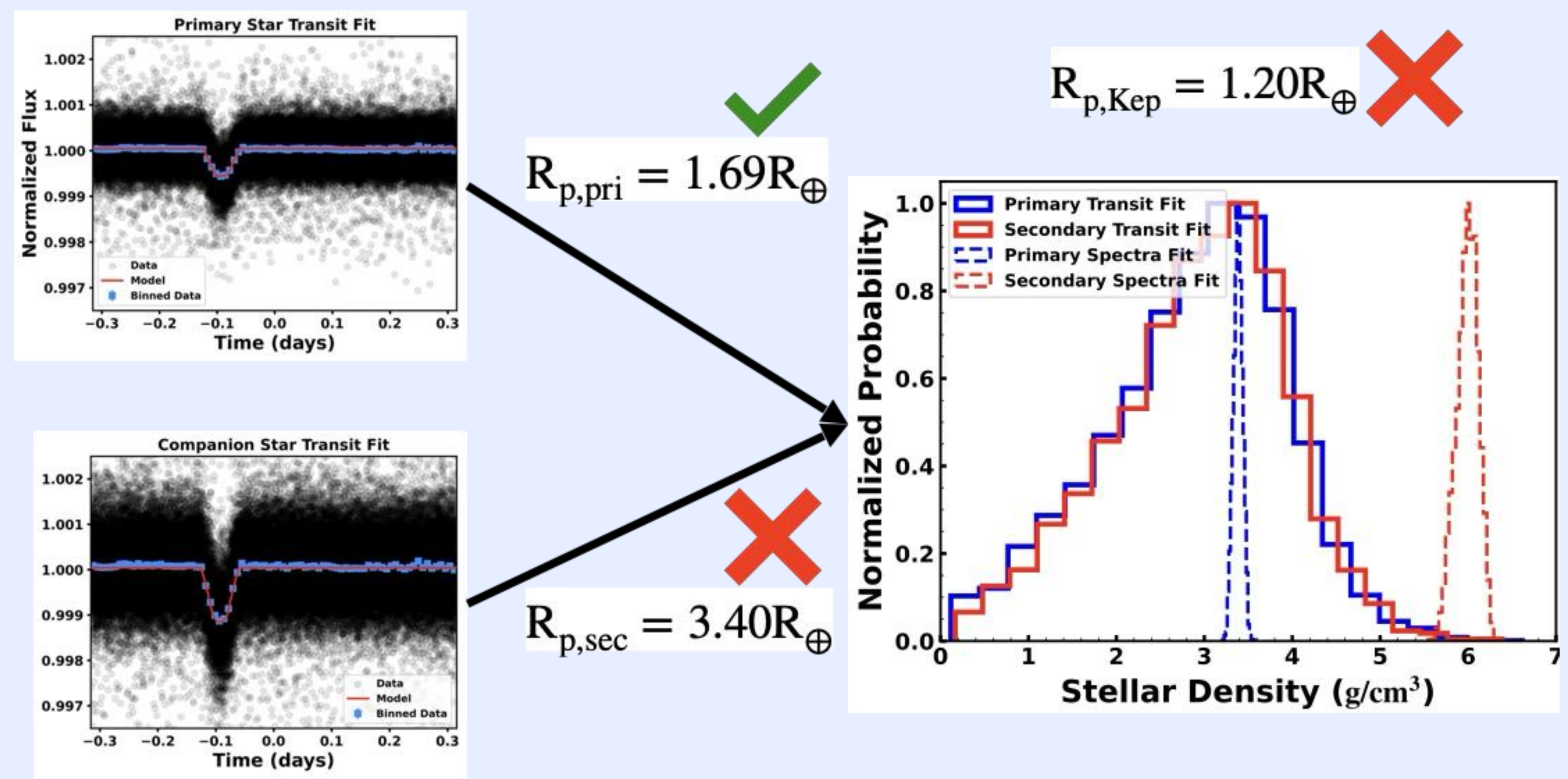



Figure 2: Upper left is the phase folded lightcurve for the circumprimary case. Lower left is the same for the circumsecondary case. Right is the density posterior distributions. The dashed histograms are the independent density estimates from Sullivan et al. (2023). The solid histograms are the asterodensity posteriors from the transit fitting in this work. Blue corresponds to the primary star and red to the secondary star.

## We (Tentatively) Confirm that

## The Radius Gap is Filled in for Planets in Binaries

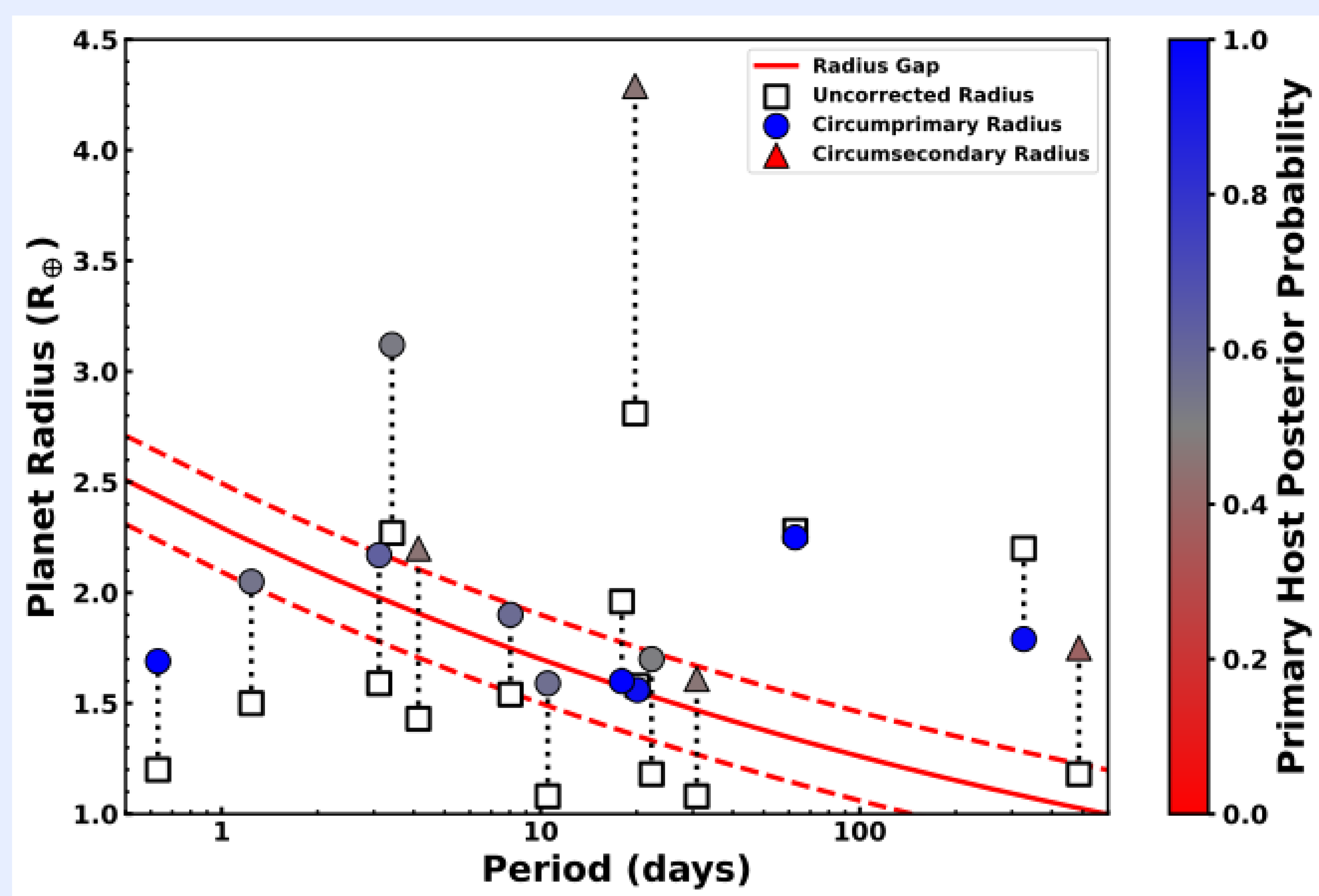



Figure 3: Radius versus period for the planets analyzed in this work. The empty squares are the uncorrected radii reported by the Kepler team (Thompson et al. 2018). The closed points are the corrected radii, color-coded by host star posterior probability. Planets with a higher circumprimary probability are marked with circles, and the circumprimary radius is used as the corrected radius. Similarly, a higher circumsecondary probability is marked with a triangle, and the circumsecondary radius is used.

## A lot of planets remain ambiguous:

## Are Circumsecondary Planets More Common than Expected?

**Methodology Cont'd:** Use single-star radius distribution as prior: **Smaller planets are more common than larger planets.**

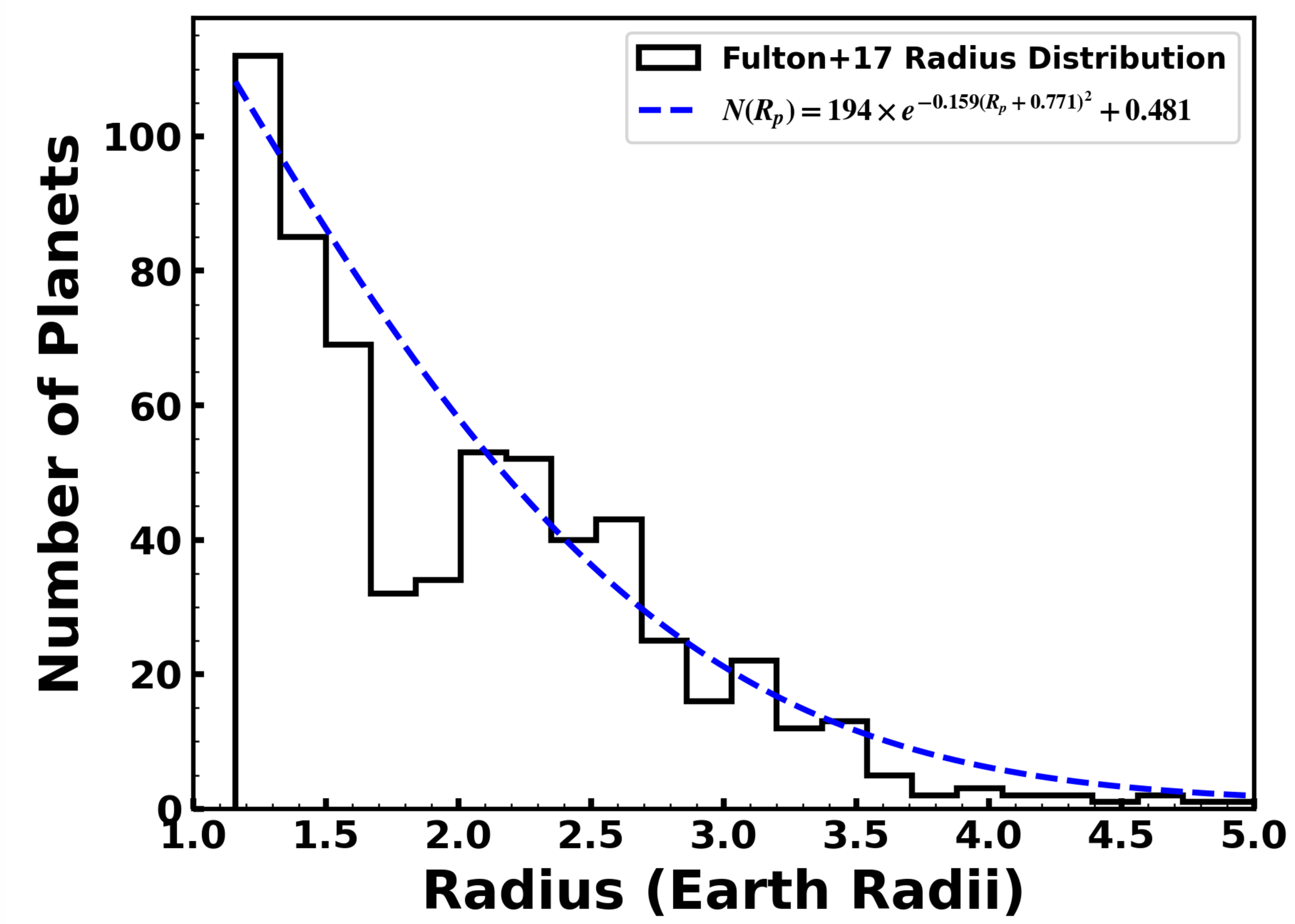



Figure 4: The black histogram is the radius distribution of planets hosted by single stars from Fulton et al. (2017). The dashed blue curve is the model radius distribution that was used as the prior for this work.

**Results:** 15 total planets, 5 unambiguously circumprimary, the rest are ambiguous

**Discussion Points:**

- **Radius gap appears to be filled in**
- Many ambiguous cases, even though the methodology favors circumprimary case
- **Does this mean that circumsecondary planets are common?**
- Precision is limited by SNR of data

**Future Work:**

- ~200 total Kepler planets in binary systems to analyze with asterodensity technique
- Larger sample to measure statistics and assess effect of binary separation
- Other methods for determining host star?

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