

# Exploring the Radius Valley among the lowest mass stars with TESS

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## Introduction

The close-in transiting exoplanets observed by Kepler provided evidence for the photoevaporation of atmospheres, revealing a radius valley in the distribution of exoplanets around sun-like stars<sup>1</sup>. Later, through this feature, a linear mass dependence between the planet and stellar mass was observed<sup>2</sup>. To further understand this scaling around low-mass stars and their exoplanets, we turn to the Transiting Exoplanet Survey Satellite (TESS) mission. With its sensitivity to redder wavelengths, it has observed ten times more low-mass stars, significantly enhancing planet detections around M dwarfs.

## Low mass stars

For our study, we cross-matched all TESS Objects of Interest (TOIs) planet candidates with the Bioverse catalog<sup>3</sup> using GAIA IDs. This process yielded approximately 720 planet candidates and 400 confirmed planets. We chose to focus on the planet candidates to gain a better understanding of the radius valley. Our dataset includes around 280 M dwarfs, 260 K dwarfs, and 150 G dwarfs within 120 parsecs, all with precise stellar masses and radii.

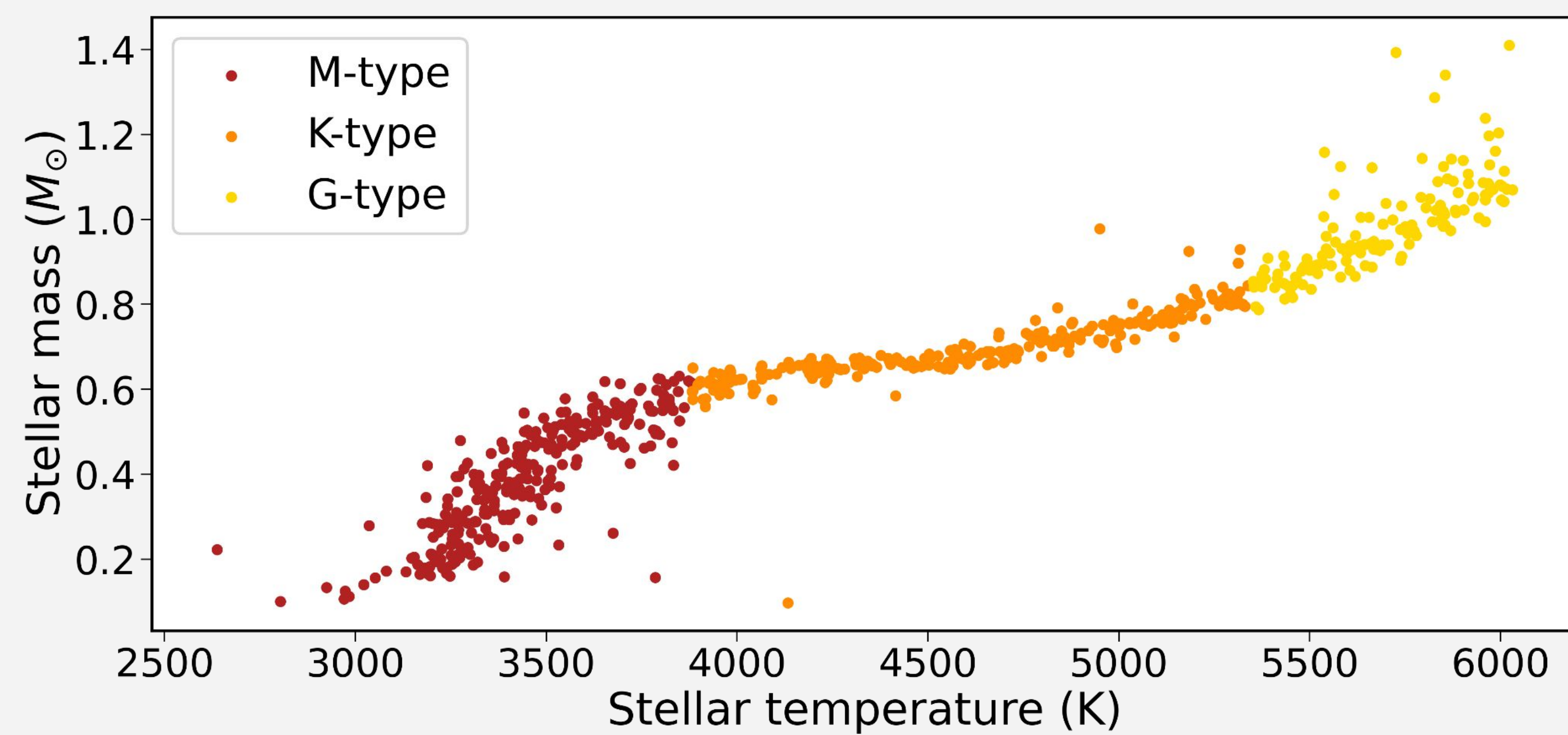


Figure 1: Stellar mass vs stellar temperature of the entire low mass star sample in the study.

## Planet radius distribution

After calculating the planet radii using the updated stellar parameters from the Bioverse catalog<sup>3</sup>, we observed the radius valley through histograms and Kernel Density Estimation (KDE). To accurately measure the radius valley, we applied a Gaussian Mixture Model (GMM) to fit the bimodal distribution of TESS planets.

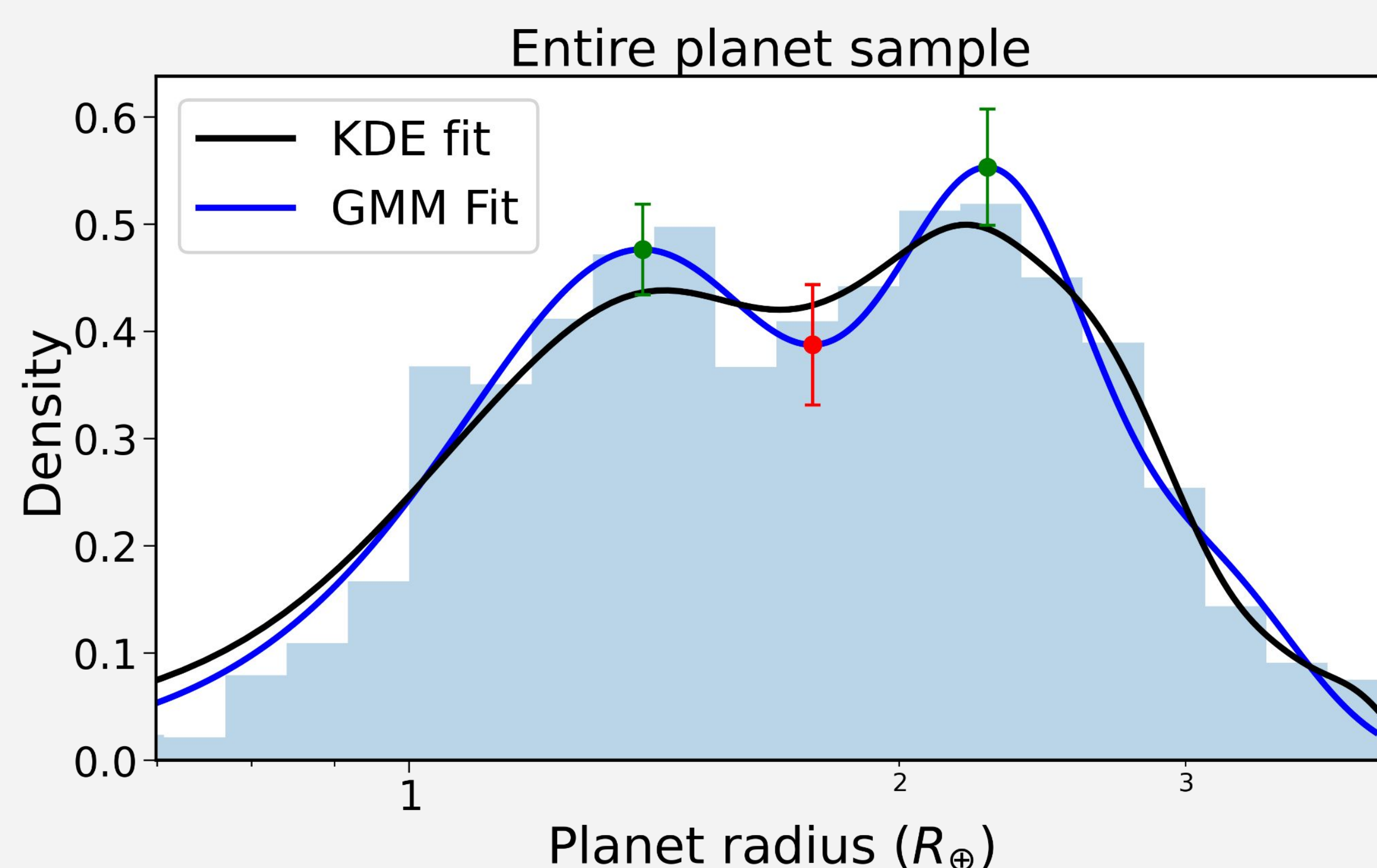


Figure 2: Planet radius distribution of all the low-mass stars in our sample shows a bimodal distribution, as seen in the histogram, KDE, and GMM fits. The Super-Earth and Mini-Neptune peaks are indicated by green points, while the radius valley is marked by a red point, all with their respective uncertainties.

## Stellar dependence

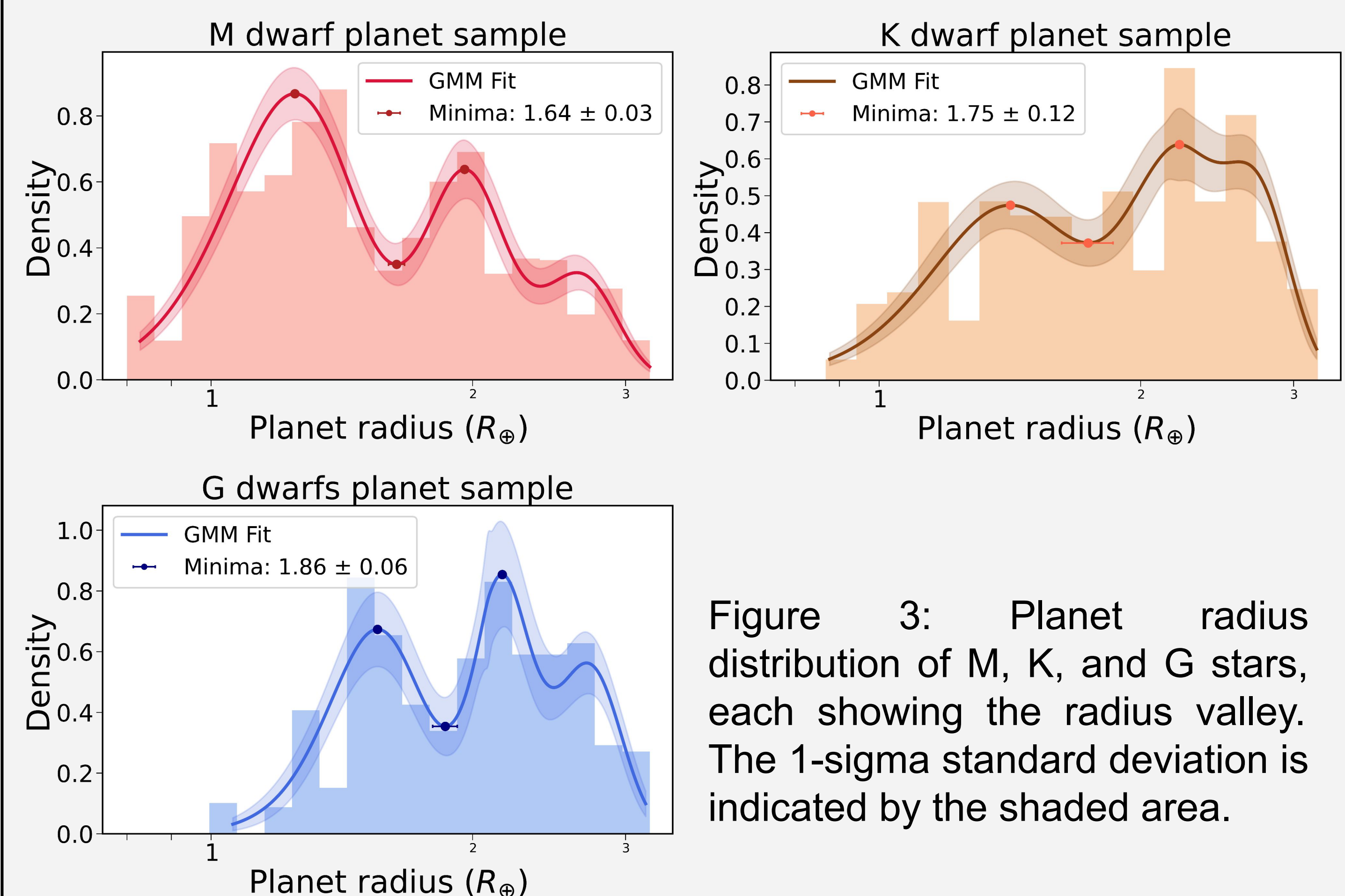
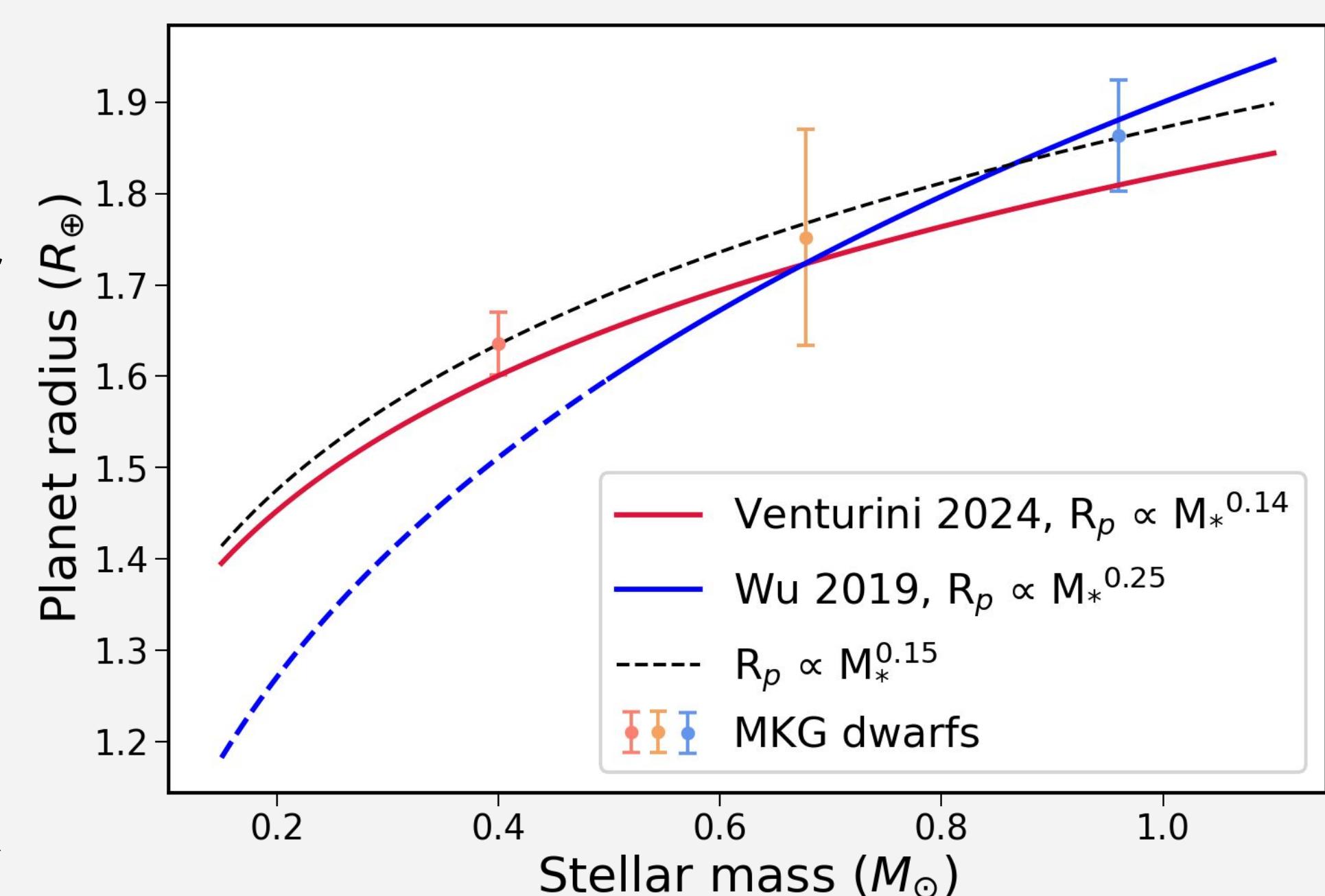


Figure 3: Planet radius distribution of M, K, and G stars, each showing the radius valley. The 1-sigma standard deviation is indicated by the shaded area.

Figure 4: The radius valley among low-mass stars shift to the right with increasing stellar mass. The observed linear dependence fits better with the pebble accretion models<sup>4</sup> (Red line) rather than the photoevaporation model as seen before among the Kepler FGK planets<sup>2</sup> (Blue line).



## Conclusions and Future work

We measure the position of the radius valley among the TESS M dwarfs and observe a linear dependence between planet size and host star mass, suggesting that mechanisms shaping the radius distribution around FGK stars—such as photoevaporation or core-powered mass loss—also extend to M dwarfs. However, we observe a flatter scaling (Figure 4) than predicted by photoevaporation models, with results more consistent with pebble accretion theories that include the formation of water worlds<sup>4</sup>.

However, our study<sup>5</sup> includes TOIs that encompass both confirmed and candidate planets, which may contain false positives. Additionally, we did not correct for detection efficiency, indicating that super-Earths are likely underrepresented compared to mini-Neptunes. This underrepresentation appears to most strongly affect the detection of the radius gap in K dwarfs. To improve the precision of the radius valley measurement, we plan to combine K2 and TESS stars and include a detection bias correction in future work.

## References

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