Using K2 to understand the rocky-gaseous transition

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Summary: We propose to use the Kepler telescope to detect small transiting planets, particularly those orbiting stars amenable to radial velocity (RV) follow-up. To this end we provide a catalog of 14,500 stars in K2 Field 1, selected by virtue of planet detectability. Our catalog of late F, G and K dwarf stars with bright Kepler magnitudes provides the best targets for both transit searching and follow-up observations.

Target selection: We created a list of the brightest main-sequence stars in Field 1. Our starting point was the provisional TESS Dwarf Star Catalog, an all-sky catalog of 3m F5-M5 candidate stars selected from the 2MASS and Tycho-2 after rejecting giants via reduced proper-motion. The catalog provides VIJHK magnitudes and an estimated $T_{\rm eff}$ based on those magnitudes. For K2, we chose stars according to apparent-magnitude limit that varies with effective temperature (a proxy for stellar radius), optimized for planet detectability and follow-up observations (**see Figure 1**). We selected 7,000 stars (solid circle in the Figure) that lie within the CCDs, and 7,500 additional stars that are near the focal plane (open circles).

Target prioritization: The stars are separated into nine priority groups, according to their potential for RV follow-up. We estimate the amount of telescope time required to detect a 10 Earth mass planet with an orbital period of 2 days, based on the estimated stellar mass, and on the estimated RV noise (which increases with the apparent magnitude and the expected width of spectral lines, which in turn depends on effective temperature). The dashed green lines in Figure 1 separate different priority groups. Each successively lower line represents a factor-of-2 increase in telescope time with respect to the next higher line. Within each group, stars are prioritized according to the smallest detectable planet. For each star, we evaluated the potential for transiting-planet detection based on its estimated stellar radius and achievable photometric precision (assumed to be 4 times worse than a star of the same apparent magnitude observed by Kepler). We calculated the radius of the smallest transiting planet that could be detected in a 2-day orbit with SNR > 7. The colored lines in **Figure 1** show the minimum planet radius.

Expected yield: We estimated the yield of K2 if all 7,000 stars are selected, based on the transit-detection rates of the normal Kepler mission. We predict that approximately 45 planet candidates will be detected, of which 30 have radii from 1.75 to 3 Earth radii. We estimate that 5 nights of Keck time would be enough to measure the masses of the five 5 most favorable objects in this size range. This estimate does not take into account contamination by giants, stars that will be identified via the flicker technique.

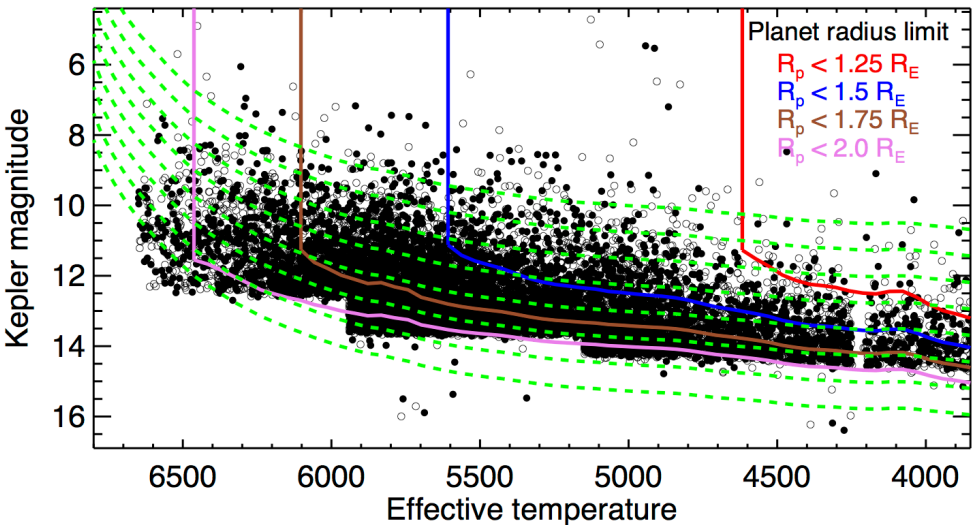

Figure 1. Estimated effective temperatures, and apparent Kepler magnitudes, of the 15,000 stars in our catalog. Colored lines are approximate thresholds for the detection of transiting planets of various sizes.