A Pilot Study to Search for Earth-Sized Planets Orbiting Nearby Cool Stars

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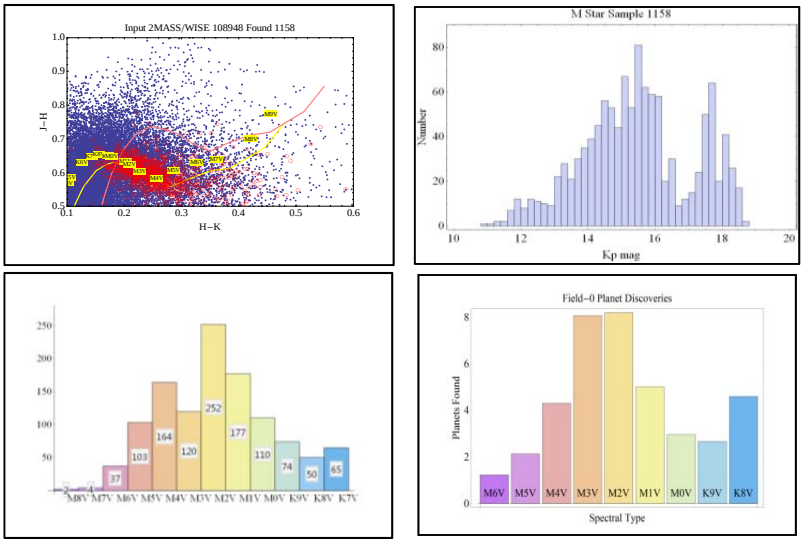
Introduction: In a 2-3 year mission K2 will be able to cover up to 10 times as much sky as Kepler did in its prime mission, enabling K2 to carry out searches for planets orbiting bright main sequence stars, young stars, and M stars (Beichman et al 2013). We propose here a pilot study to assess K2's capabilities with a sample of ~1,200 carefully chosen M stars. While M stars are known *not* to harbor many gas giants, there is growing evidence that lower mass stars have a high incidence of lower mass planets, Uranus mass and below (Howard et al 2012; Dressing and Charbonneau 2013). These star/planet systems have deep transit signals which are readily detectable even with K2's reduced photometric sensitivity (noise floor of 80 ppm vs. 30 ppm for Kepler's prime mission) and their relatively large radial velocity signatures, e.g. few m/s for GJ 581's planets, make them easier to validate and characterize than comparable planets orbiting higher mass stars. K2 is sufficiently sensitive that even this modest pilot program could result in the discovery of up to 40 planets, including Earths, Super Earths, and up to Uranus-sized planets (1-3 $R_\oplus$).

The Sample: Since the Campaign-0 field is located close to the galactic plane we have been very conservative to avoid both spatial and spectral type confusion. Our methodology starts with objects seen in both the 2MASS and WISE catalogs (including POSS associations when available) in a 12 deg square field. An initial cut in J-H, H-K colors yields over 100,000 objects with J<16 mag and |galactic latitude| >5^o , and each with no other 2MASS sources within 10". By comparing up to 6 observed colors (B-V, V-J, J-H, H-K_s, J-WISE1, and WISE1-WISE2) with standard colors (Pecaut and Mamajek 2013; Kirkpatrick et al 2010) and using reduced proper motions between the 2MASS and WISE positions, we can define a high reliability M dwarf sample with ~1,200 objects (Figure 1). By including reddening in our χ^2 calculation, we retain objects with A_V~0 mag appropriate for nearby M dwarfs and reject reddened objects near the galactic plane.



1) 2MASS color-color diagram showing entire 100,000 object input sample. Selected M dwarfs (red circles) follow the no-reddening main sequence; 2) Kp mag distribution of potential hosts of 1-3 $R_\oplus$ planets; 3) Distribution of host stars bright enough for 1-3 $R_\oplus$ planet detection; 4) Distribution of detected 1-3 $R_\oplus$ planets.

The Yield: We adopted the Jenkins et al (2010) noise characteristics (where their Fig 1b gives SNR at 6 hr as a function of Kp mag), but degraded for K2's demonstrated noise floor of 80 ppm using a root mean square combination of the two values. We estimated Kp from 2MASS data (Howell et al 2012) and used a transit integration time appropriate to the host star properties and planet orbit. For a mission-final SNR>7.1 and assuming every star has one planet drawn from observed distributions with R$\in$(1-3 $R_\oplus$) and Period $\in$ (1-25 days) to allow a minimum of 3 transits per 75 day campaign, we predict a yield of over 15 1-2 $R_\oplus$ planets and up to 40 1-3 $R_\oplus$ objects, including Uranus-sized objects extending into the Habitable Zones of the coolest stars. We will use Keck and Palomar AO, Keck/HIRES spectroscopy, as well as LCOGT and Spitzer photometry for validation and characterization. The brightest of these targets, either in Campaign-0 or in subsequent campaigns, will be extremely valuable for spectroscopic follow-up with JWST.

References: Beichman et al 2013, 2013arXiv1309.0918B; Dressing & Charbonneau 2013,ApJ,767,95; Howard et al 2012, ApJS,201,15; Howell et al, ApJ, 746,123; Jenkins et al 2010, ApJ,713,120; Kirkpatrick et al 2010, ApJS,190,100; Pecaut & Mamajek 2013,ApJ,208,9.