

## Searching for Terrestrial Planets Orbiting Cool Stars and Brown Dwarfs with K2

This is the third proposal of a K2 program aiming to search for small planets orbiting the coolest stars and brown dwarfs (Demory et al., 2013b).

**Summary.** We propose to use K2 to conduct a detailed search for Earth-sized planets orbiting the brightest cool stars and brown dwarfs (spectral types from M0 to L8). This population of objects presents several advantages for exoplanet surveys. First, cool stars and brown dwarfs are small and thus result in favorable planet-to-star area ratios. Second, because of their low effective temperature, the inner edge of their habitable zone can be extremely close (down to a few days only). Third, our targets are bright at infrared wavelengths, which will enable detailed follow-up studies. Our program therefore represents a unique opportunity to find a transiting Earth-size exoplanet for which atmospheric features (including biosignatures) could be detected with near-to-come facilities such as JWST. Such an exoplanet has not been discovered yet. As of today, K2 is the only facility that provides the required stability and photometric precision to make this survey successful. Our Campaign 2 & 3 target sample includes 132 cool stars and brown dwarfs.

**Introduction.** In the search for terrestrial transiting planets, cool stars and brown dwarfs are extremely promising because of their small sizes of 0.5 to  $0.07 R_{\odot}$ . Terrestrial planets orbiting cool stars are therefore easier to characterize, as demonstrated by e.g., Bean et al. (2010) who obtained a ground-based transmission spectrum of GJ 1214 b, a  $2.7 R_{\oplus}$  super-Earth orbiting a  $0.16 M_{\oplus}$  M4.5 star (Charbonneau et al. 2009). Such observations for a similar planetary size would not have been possible for a solar host. The importance of cool stars for exoplanet surveys is now widely acknowledged by the exoplanet community as shown by the growth of projects focusing on this population of stars.

**Science Goals.** Our primary science goal is to find terrestrial planets orbiting bright nearby, ultra-cool stars and brown dwarfs. Our third list (tailored to field 2 & 3) encompasses 132 targets with stellar types from M0 to L8 extracted from Lepine & Gaidos (2011) and the Dwarf Archives. Nearly all targets benefit from spectroscopic observations that will facilitate the characterization of planets transiting them. None of the small planets found so far with *Kepler* will be amenable to detailed characterization, even with JWST. Our K2 proposed observations therefore represents a **unique opportunity to find a rocky planet for which a transmission/emission spec-**

**trum could be obtained with near-to-come facilities.**

High-precision monitoring of cool stars will also prove to be particularly useful for understanding the variability nature of these objects, even if no transit is detected throughout the sample. For M-stars, flares and rotational activity will be easily detected, thus allowing us to constrain the stellar magnetic field properties at the bottom of the main sequence. Coupling these observations to archival UV and X-ray monitoring will provide an estimate of the magnetic energy output from these objects and better assess the overall level of activity of ultra-cool stars (Welsh et al., 2007) as well as exploring possible relationships with age (Welsh et al., 2008) and rotational period. Our secondary science goal is exploratory in monitoring L0-L8 brown dwarfs located in field 2 & 3. Several of these objects are bright enough for exoplanet detection, opening tremendous prospects for small planet discoveries (see Demory et al. 2013b). For the fainter ones, studying their variability will be insightful to better understand brown-dwarf variability in the visible.

**Expected yield.** Dressing & Charbonneau (2013) find 3,897 dwarfs with temperatures below 4,000 K that perfectly match our proposed sample for field 2 & 3. They find 61 planet candidate host stars orbited by 90 transiting planet candidates with radii  $0.5 < R_P < 4R_{\oplus}$ . Based on these results, we therefore expect to find 2 to 4 small planet candidates in our proposed sample of 132 targets. These candidates will be significantly easier to confirm (high proper motion) and to characterize thanks to their brightness (nearly all M hosts have NIR  $K < 10$ ). Long-cadence photometry is suited to this program as we do not expect ultra-short ( $< 20$  min) transit durations to be the norm for these objects. We compute the transit detection significance based on the expected K2 performance (87ppm/6-hr for a  $K_p = 12$  star). We find that an  $R_P = 1.02R_{\oplus}$  planet orbiting an M0 having the mean magnitude of our sample ( $V = 11.7$ , one magnitude brighter than our previous Campaign 1's target list) on a 7.5-day orbital period (mean value from DC13) is detected at the  $8\text{-}\sigma$  level. We also find that a  $R_P = 2.21R_{\oplus}$  planet orbiting the faintest of our M-dwarf sample ( $V = 12.9$ ) is detected at the  $6\text{-}\sigma$  level with a single transit. Finally, we find that a Mars-size object ( $R_P = 0.49R_{\oplus}$ ) orbiting our brightest M6 target ( $V = 12.9$ ) on a 7.5-day period would be detected at the  $10\text{-}\sigma$  level over Campaign 2. **Our proposed program will therefore efficiently probe the parameter space of terrestrial planets orbiting bright M stars.**