# SAG-14: Characterization of Stars Targeted for NASA Exoplanet Missions

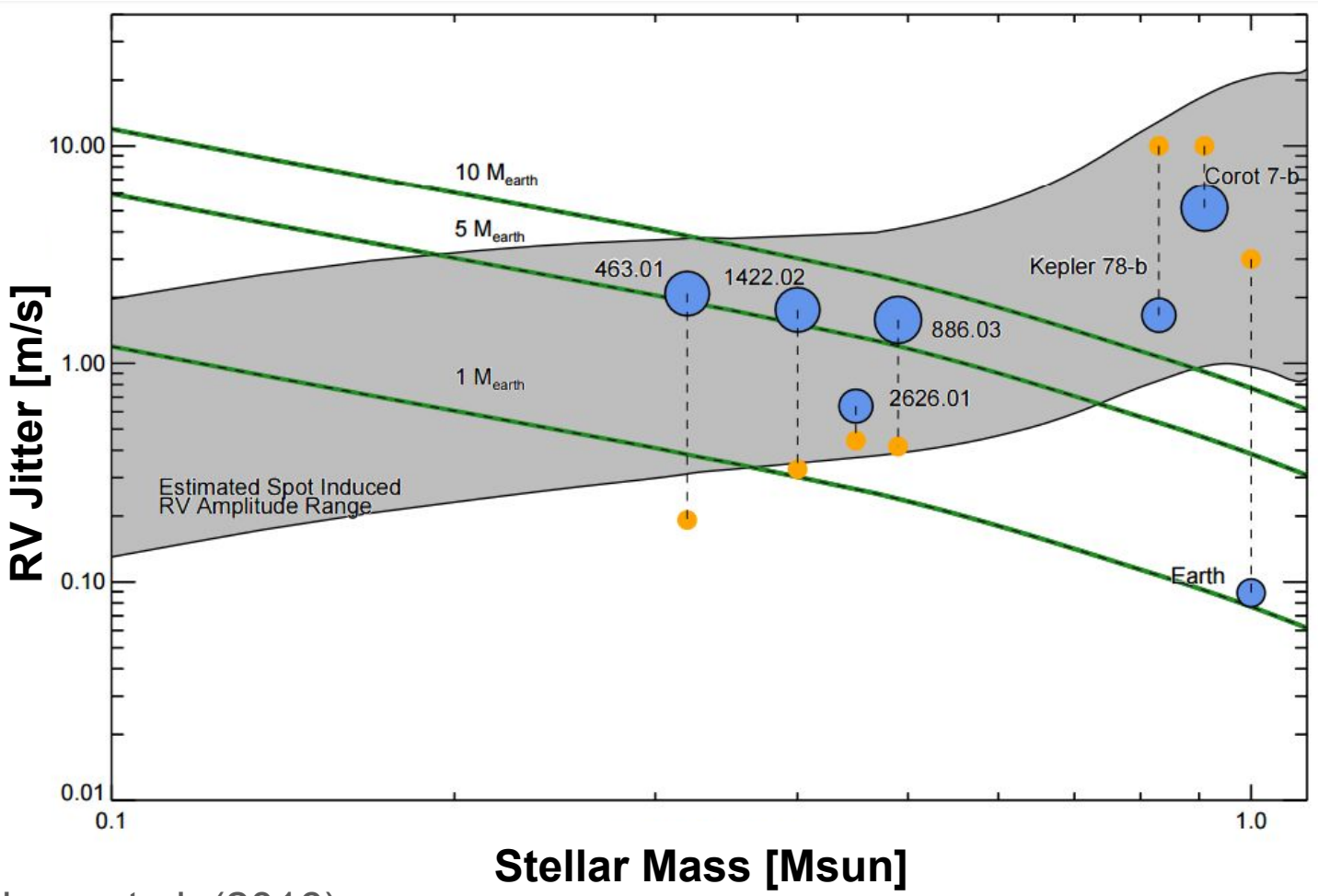
*Report Part 1:*
*RV Stability of TESS Candidate Target Stars*

# Mission deliverables and challenges for TESS

- Primary goal: discover ***50 Earth-sized transiting planets*** (R < 4 Rearth) ***whose masses can be measured*** by follow-up radial-velocity measurements.
- Desire a sufficient number of target stars that:
  - have good Doppler stability, i.e., ***low RV jitter***
  - preferably are bona fide dwarfs and ***not subgiants***
  - ideally have known ***metallicities/abundances***
  - especially in the TESS continuous viewing zones.
- TESS begins in ~18 months (south), ~30 months (north).

# Potential challenges

1. **TESS target sample includes rapidly rotating, magnetically active stars.**
    - Risk: Doppler noise (“RV jitter”) complicates measurement of planet masses.
    - Solution: Rotational velocity measurements via high-resolution ***spectroscopy*** to weed out high-activity stars.
2. **TESS target sample includes many subgiants.**
    - Risk: Larger stellar radii complicates detection of small planets.
    - Solution: (1) Gaia ***parallaxes*** or (2) surface gravity measurements via high-resolution ***spectroscopy*** to weed out subgiants.
3. **TESS target sample has very few stars with known abundances.**
    - Solution: Metallicity measurements via high-resolution ***spectroscopy***.




Vanderburg et al. (2016)

# Quantifying the risk of high-activity target stars:

## Number of Planets with Measurable Masses: All Sky, not pre-screened

| | High Activity | Median Activity | Low Activity | Total |
|---|---|---|---|---|
| | Planets < 4 Rearth | | | |
| Total | 293 (16%) | 1247 (68%) | 293 (16%) | 1833 |
| Ratio > 1 | 119 | 931 | 283 | 1333 |
| Ratio > 3 | 18 | 678 | 223 | 879 |
| Ratio > 5 | 8 | 448 | 183 | 639 |

Ratio of planet orbital RV semi-amplitude to RV jitter amplitude

Worst case: Rapidly rotating, high-activity stars

Best case: Slowly rotating, low-activity stars

# Quantifying the risk of high-activity target stars:

## Number of Planets with Measurable Masses: North Ecliptic Pole Continuous Viewing Zone, not pre-screened

**Ratio of planet orbital RV semi-amplitude to RV jitter amplitude**

| | High Activity | Median Activity | Low Activity | Total |
|---|---|---|---|---|
| | Planets < 4 Rearth | | | |
| **Total** | 43 (16%) | 172 (68%) | 43 (16%) | 258 |
| **Ratio > 1** | 12 | 101 | 39 | 152 |
| **Ratio > 3** | 2 | 65 | 25 | 92 |
| **Ratio > 5** | 1 | 38 | 20 | 59 |

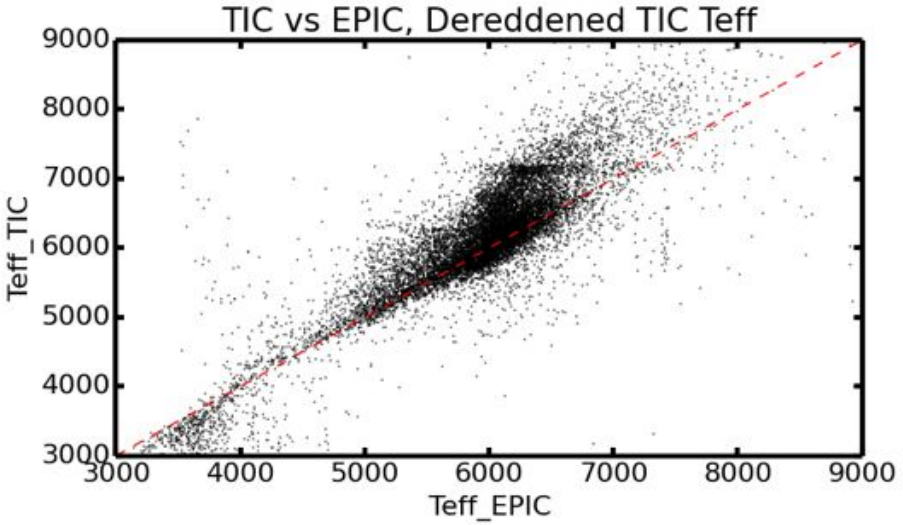
**Worst case: Rapidly rotating, high-activity stars**

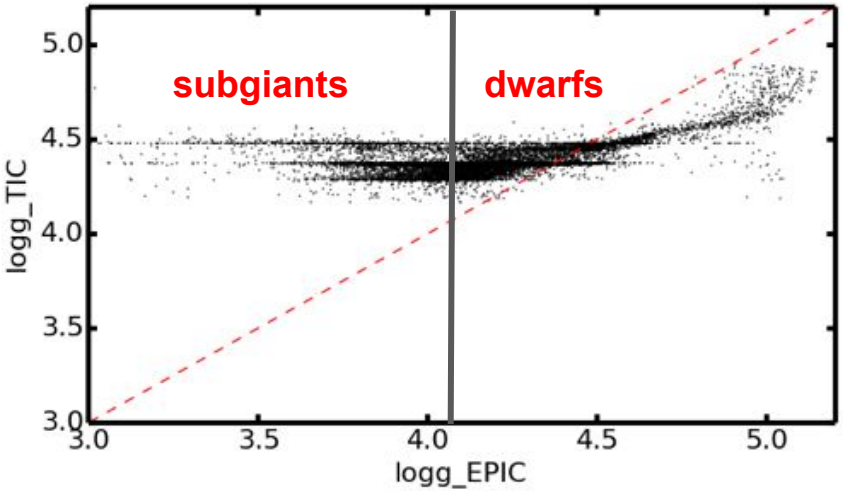
**Best case: Slowly rotating, low-activity stars**

# TESS Dwarfs vs Subgiants

Based on spectroscopic samples in TESS Input Catalog, nominal TESS dwarfs are in fact:

- 2-3% red giants
- 50-60% subgiants



# APOGEE Spectroscopic Survey: TESS NEP CVZ

- In CVZ (450 square degrees total area), TESS observes for 1 year, enabling ***discovery of Earth-like planets in the habitable zones*** of K-type stars and even solar-like G-type stars.
  - There are ~6500 nominal TESS targets in NEP CVZ with spectral types of G2 and later.
- APOGEE: 7 square degree FOV, 200 fibers. At the faint limit of TESS targets, need 3 visits for APOGEE to get S/N = 100.
  - Multiple epochs on all stars in order to identify RV variables.
  - Need 450 / 7 = 65 fields to cover NEP CVZ, times 3 visits each gives 65 x 3 = 200 visits.
  - 100 targets per field on average, which leaves about half of the fibers available.
  - 30 nights of observing, or about 30,000 fiber-hours for 100 fibers in average field/visit.
  - SDSS estimates cost of $2.5M to guarantee the full 30,000 fiber-hours, process the data, deliver shovel-ready stellar parameters and make them fully publicly accessible.
- Deliverables:
  - Rotational velocities, surface gravities, effective temperatures, detailed chemical abundances.