Proposal For SAG17:

Community Resources Needed For K2 And TESS Planetary Candidate Confirmation

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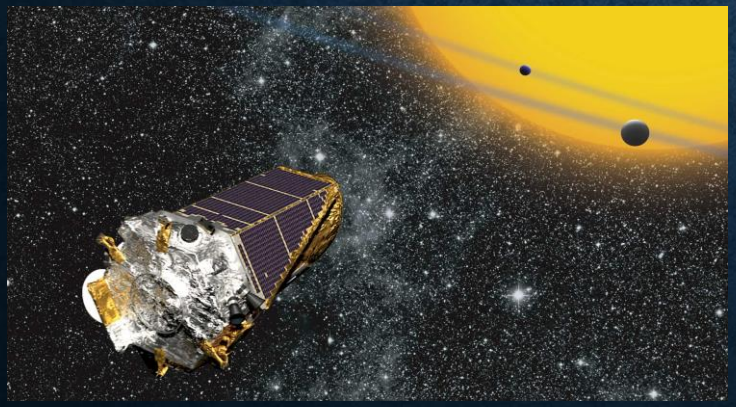
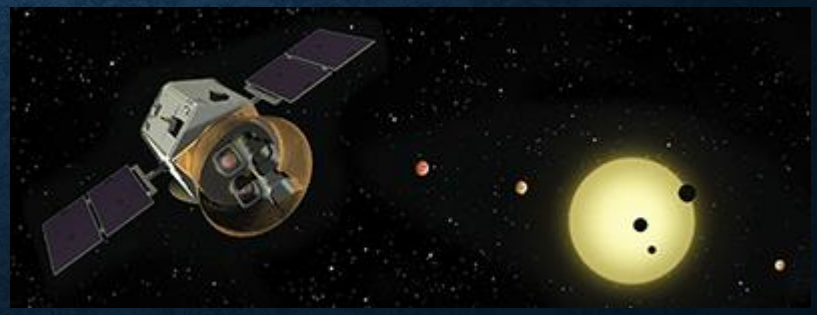
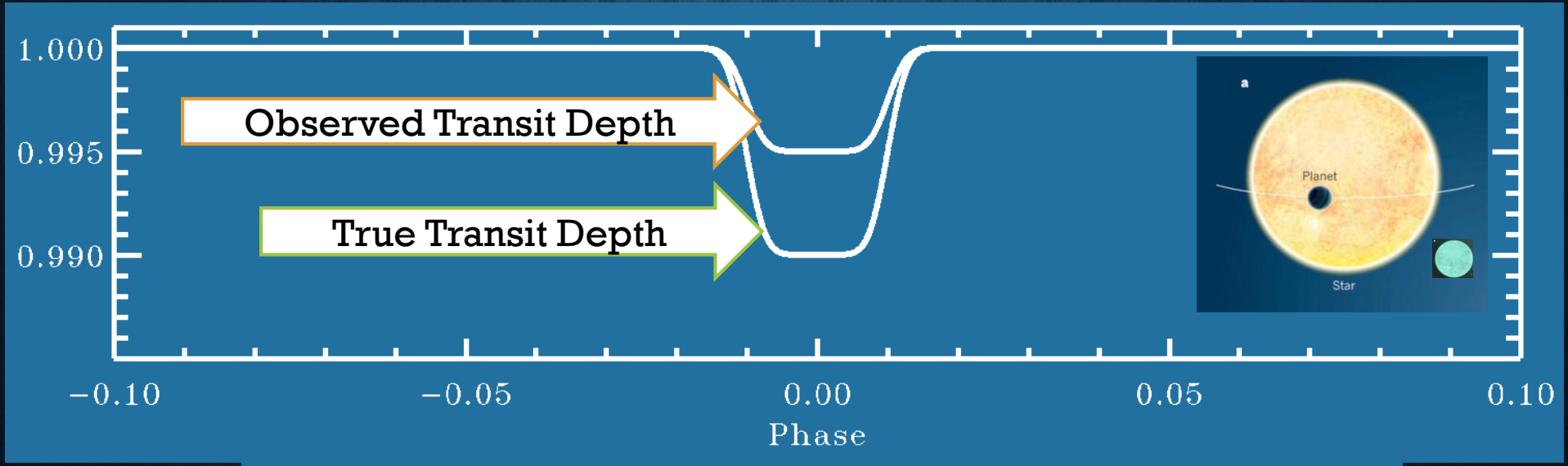
2016 June 11





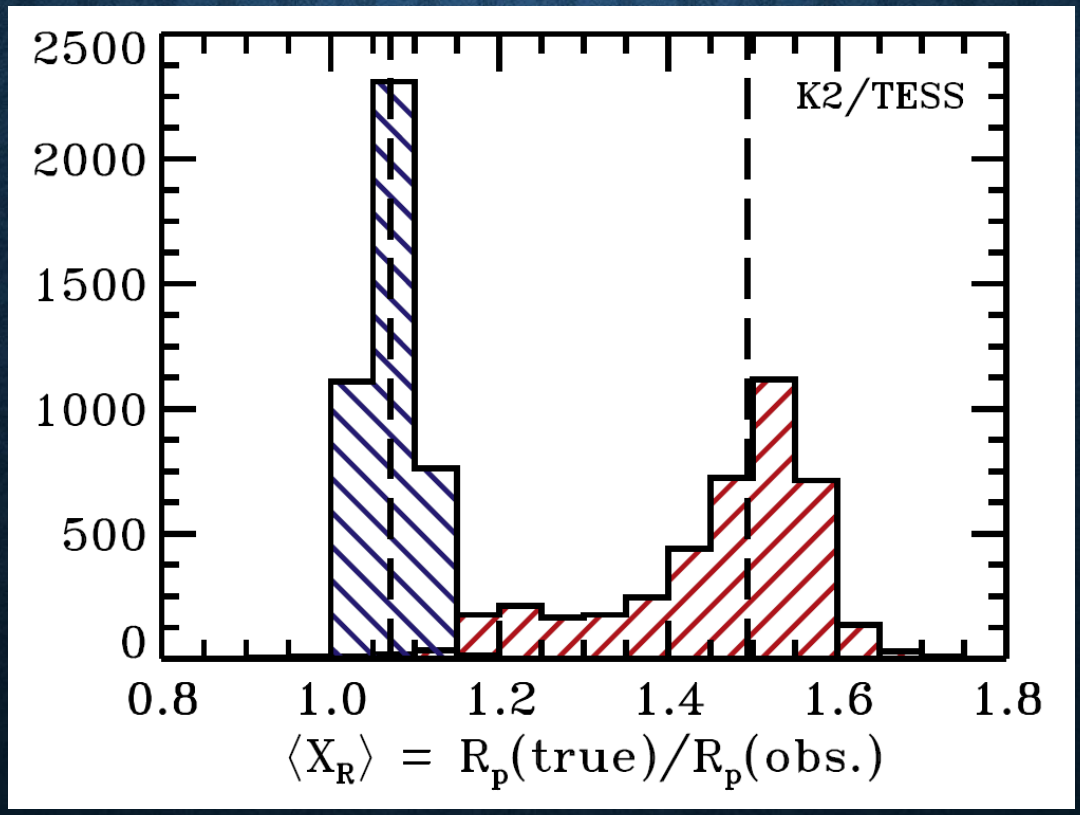
Good Planet Radii Require Good Stellar Radii and a Good Understanding of the Photometric Blending



$$\delta_o = \left(\frac{F_t}{F_{total}}\right)\left(\frac{R_p}{R_{t\star}}\right)^2$$

Vetting Needed for Confirmation and Accurate Radii

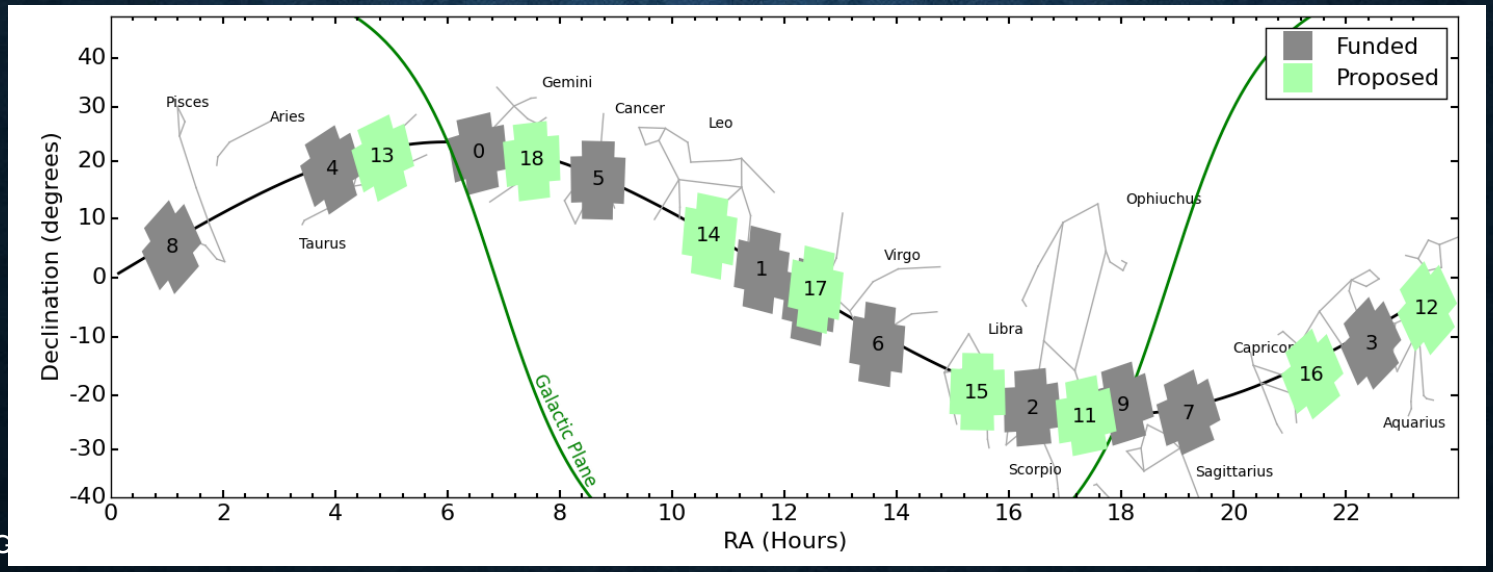
- Hierarchical triples and Background Eclipsing Binaries masquerade as planets and/or make planets look smaller than they are in reality
- Follow-up reduces radius bias from 50 – 60% to <10%



Ciardi et al. 2015

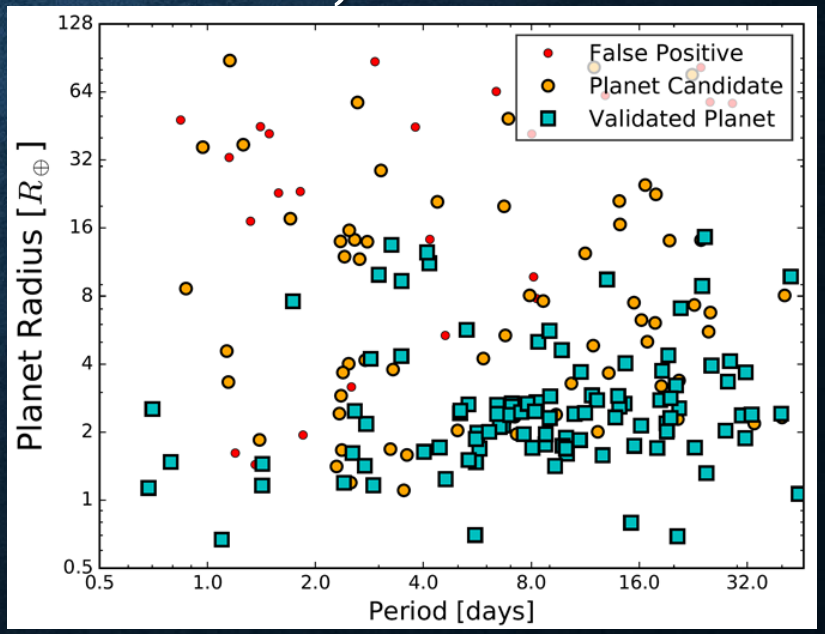
NASA's Transit Missions – K2

- Repurposed Kepler Spacecraft
- Surveying the ecliptic
- 2014 – 2016: Fields 0 – 10 (data through field 7 currently available)
- Approved for extension 2016 – 2018: Fields 11 – 17
- 18 Fields ~100 sq. degrees per field
- 15,000 – 25,000 targets per field



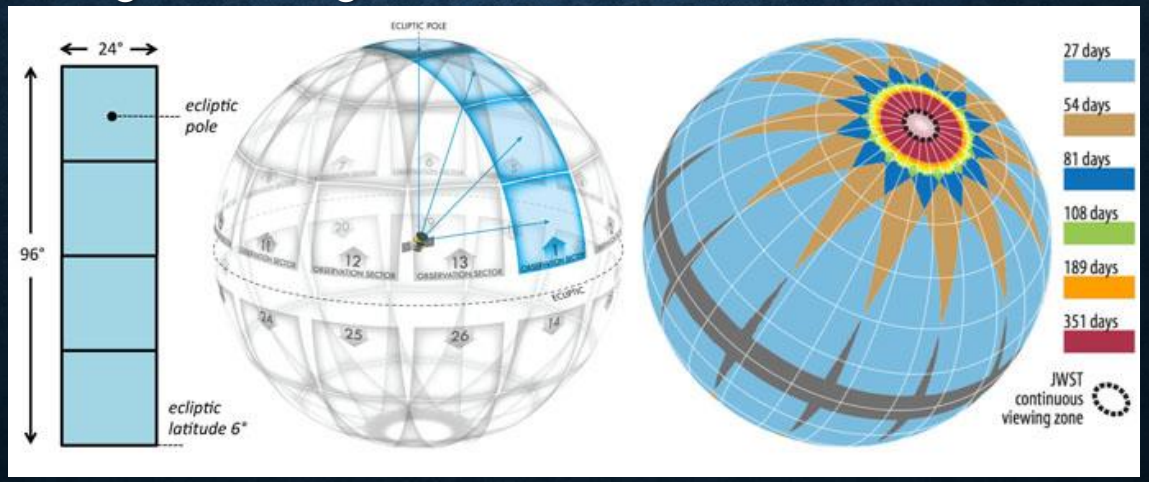
K2 – Ongoing Yield

- Community has self organized to search for planets in K2 data
- Approximately 450+ candidates for Field 0 – 6
  - Adams et al. 2016, Montet et al. 2015, Pope et al. 2016, Schmidt et al. 2016, Vanderburg et al. 2015
  - Averaging 50 – 100 candidates per field
  - >40 confirmed/validated planets
- Validation for Field 0 – 4 (Crossfield, Ciardi et al. 2016)
  - > 100 confirmed planets
  - ~ 10 – 20% FP rate
- For all 18 fields expect >1500 – 2000 candidates
  - Yield has improved as algorithms have improved



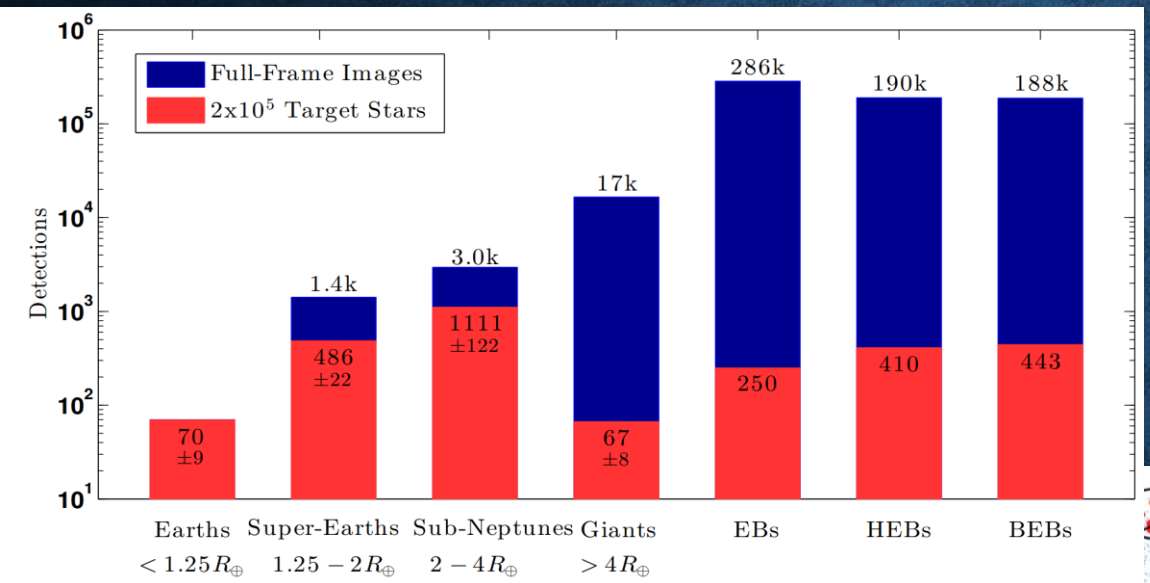
NASA's Transit Missions - TESS

- Transiting Exoplanet Survey Explorer (launch Dec 2017)
  - 'All-Sky' transit mission – 2 year mission – Southern Hemisphere first
  - ~200,000 postage stamps: 2 minute cadence
  - Full-frames (all-sky) 30 minute cadence
- Project will produce TESS Objects of Interest from postage stamps
  - Publicly available – no private or proprietary period
  - Focused project follow-up program on 50 planet masses (see below)
- FFIs: Tremondous resource for the community
  - Community-led light curve generation and candidate identification

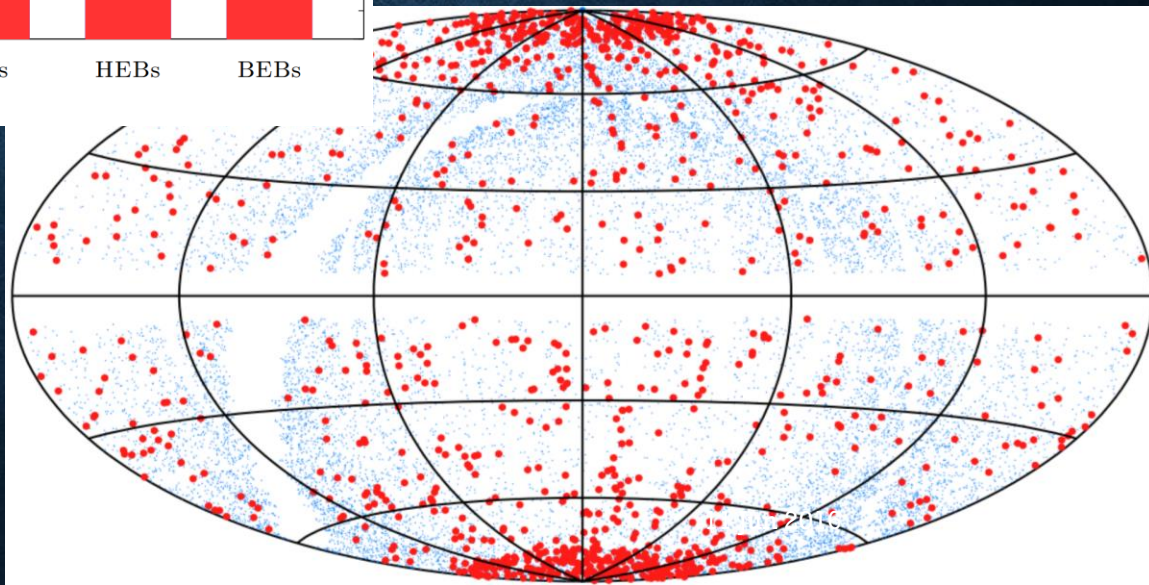


TESS: Expected Yield

- >1000's of candidates from postage stamps
- >10000's of candidates from FFIs

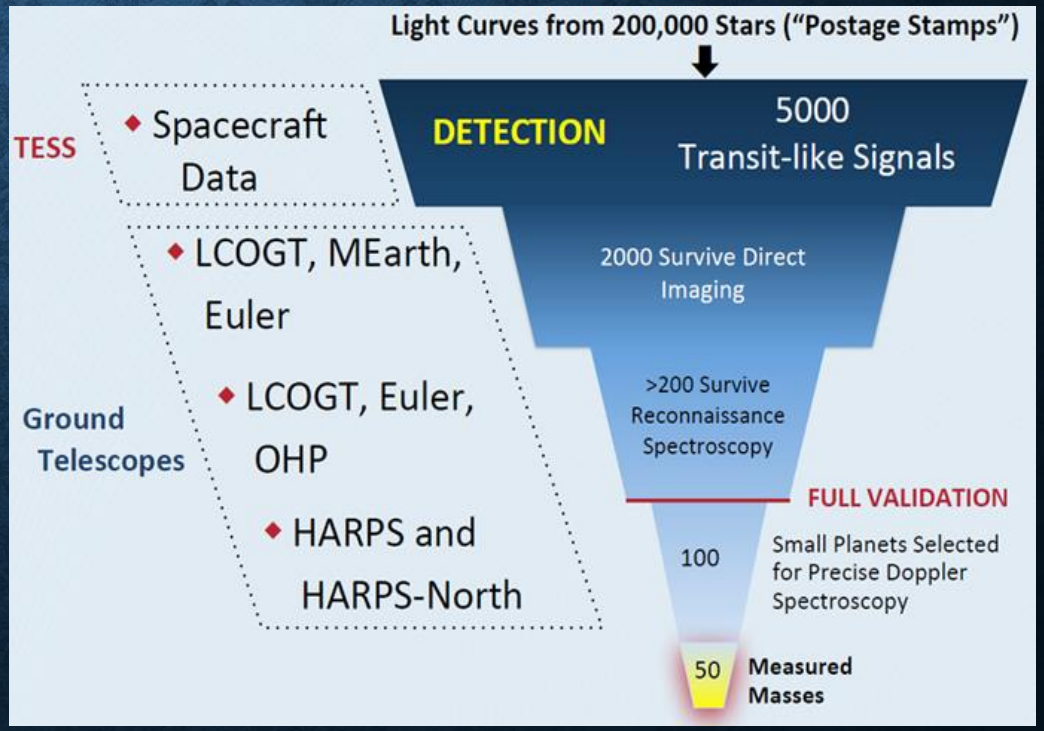


Sullivan et al. 2015



Project Follow-Up Resources

- K2
  - Unlike Kepler mission, there is no funded or coordinated follow-up program organized by NASA or the project
  - K2 community has self-organized into loose collaborations with some overlap
- TESS
  - Focused follow-up program funded by program
  - Aimed at Level 1 science requirement: measure 50 planet masses
  - No additional resources specifically for community follow-up efforts – in particular the FFIs



Community Efforts

- Kepler – Project produced light curves & planetary candidates
  - Significant project funded follow-up program – all observations shared on ExoFOP (at the time called CFOP)
  - Significant "outside" community efforts
  - In the end, nearly all KOIs have some form of spectroscopy or high resolution imaging (about 1/3 came from non-project funded community)
- K2 – the Wild West: no Project light curves (until later) or candidates
  - Community produced light curves and candidates
  - Initially large number of separate groups
  - Slowly groups coalesced into collaborations – starting to share information and observations on ExoFOP
  - Ongoing duplication of effort and use of resources
- TESS – Project produced light curves and TOIs from postage stamps
  - Community will likely focus on these candidates first
  - FFIs – Community produced light curves and candidates
  - ExoFOP being expanded to help community communication and organization

SAG 17: Proposed Charter

- Identify needed follow-up observations for K2 and TESS
  - Imaging: Seeing-limited and High Spatial resolution
  - Spectroscopy: Stellar parameters and radial velocity
  - Photometric Time – series
- Identify resources available to the US community
  - Telescopes and Instruments (space and ground)
  - Estimate available time
  - Financial
- Identify how archival resources can be utilized (e.g., Gaia)
- Identify how the community and resources can be organized
  - TESS FFIs analyzed, candidates identified, and candidates prioritized
  - Community communication – lessons learned from Kepler and K2
- Identify needs to ensure efficient and effective characterization with JWST (and WFIRST)
- Identify connections to other SAG efforts (e.g., SAGs 15 and 16)
- Identify synergies of resources with non-exoplanet science

SAG 17: Proposed Timeline

- 2016 Jun/Jul: (Next Few Weeks)
  - Finalize charter
  - Send out email to engage community involvement
- 2016 Jul: Kick-off Telecom
- 2016 Aug: Outline of SAG Plan
- 2016 Sep – Dec Monthly Telecoms
  - Organization, identification of relevant areas, data collection
- 2017 Jan: Interim Report of SAG Progress at ExoPAG/AAS
- 2016 Feb – May: Monthly telecoms
  - Draft sections of report
- 2017 Jun: Complete Draft of Report at ExoPAG/AAS
- 2017 Jul – Dec: Monthly telecoms
  - Finalize report based on feedback from ExoPAG
- 2018 Jan: Final Report and Close-Out of SAG at ExoPAG/AAS

Backup

Proposed SAG 17 Abstract

K2, operating since 2013 and expected to continue operations through 2017, is producing hundreds of candidate planets (approximately 50 per field). Additionally, TESS, when launched in 2017, will produce thousands of candidates from the selected TESS targets, and potentially hundreds of thousands of candidates from the full-frame images. In order to confirm these candidates, follow-up observations, from either the ground or space, are required. Spectroscopy is needed for stellar characterization; radial velocity observations are needed to determine companion masses, and imaging (both seeing-limited and high-resolution) is needed to ascertain the target blending and hence determine accurate planetary radii and possible false positives. Some amount of triage work can also be done by time-series photometric follow-up with higher angular resolution. Additionally, in the era of Gaia, an entirely new resource is at the disposal of the community to aid in the validation of these planetary candidates. How all of this fits together and can be organized into a coherent set of community-led observations is unclear. We are proposing a SAG to study and enumerate the resources needed by the community to validate effectively and efficiently as many K2 and TESS candidates as possible. The SAG will identify areas where the Gaia dataset will be most useful and what observational resources are necessary. This SAG is complementary to previous and ongoing SAGs (8: RV; 10: Atmospheres; 12: Astrometry; 14: TESS Stars); this SAG is geared more towards the validation efforts needed rather than the characterization of the systems, but, of course, the two efforts are related. Finally, the purpose of this SAG is not to define what is needed by the TESS project to satisfy their level 1 science requirements, but rather what is needed by the community to validate and study the bounty of the full range of planetary candidates being discovered by K2 and will be discovered by TESS.

For Reference: Kepler

- In > 3000 nights at the telescope over 6 observing seaons
  - Spectroscopy: 2/3 of KOIs observed
  - Imaging: 1/2 of KOIs observed
- This doesn't include other community efforts
  - Estimate ~1000 telescope-nights