

Reflections on Transiting Exoplanet Validation

The Exoplanet Validation Working Group

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Transiting Exoplanet Validation

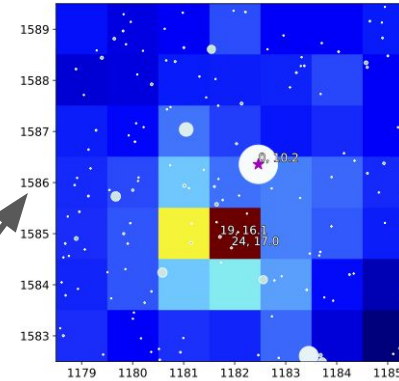
- Validation: reaching 99% confidence that an exoplanet detection is of a true exoplanet
 - Exoplanet likelihood $> 99 \times$ sum of all non-exoplanet likelihoods
- Validated exoplanets go on confirmed planet lists
- But there are different validation methods
 - Variation in validation completeness
 - Different validation thresholds
- Result: the confirmed exoplanet table has exoplanets validated to different standards

Problems We Have Seen

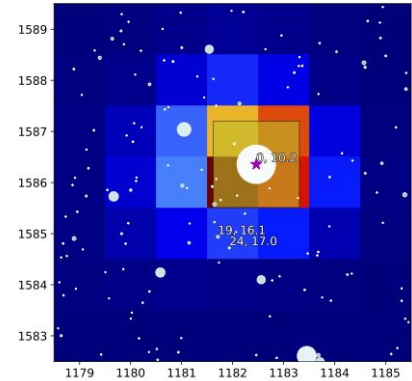
- Ignoring available relevant data
 - Spectra that refine stellar properties
 - Ground-based transit detection
- Assuming without checking that the signal is on the target star
- Ignoring instrumental or observational systematics at low SNR
- Unknown stellar multiplicity

TOI-4332 (PC)

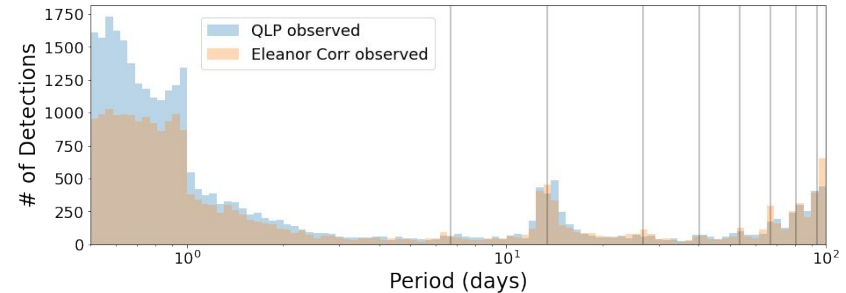
Transit Signal



Target Star



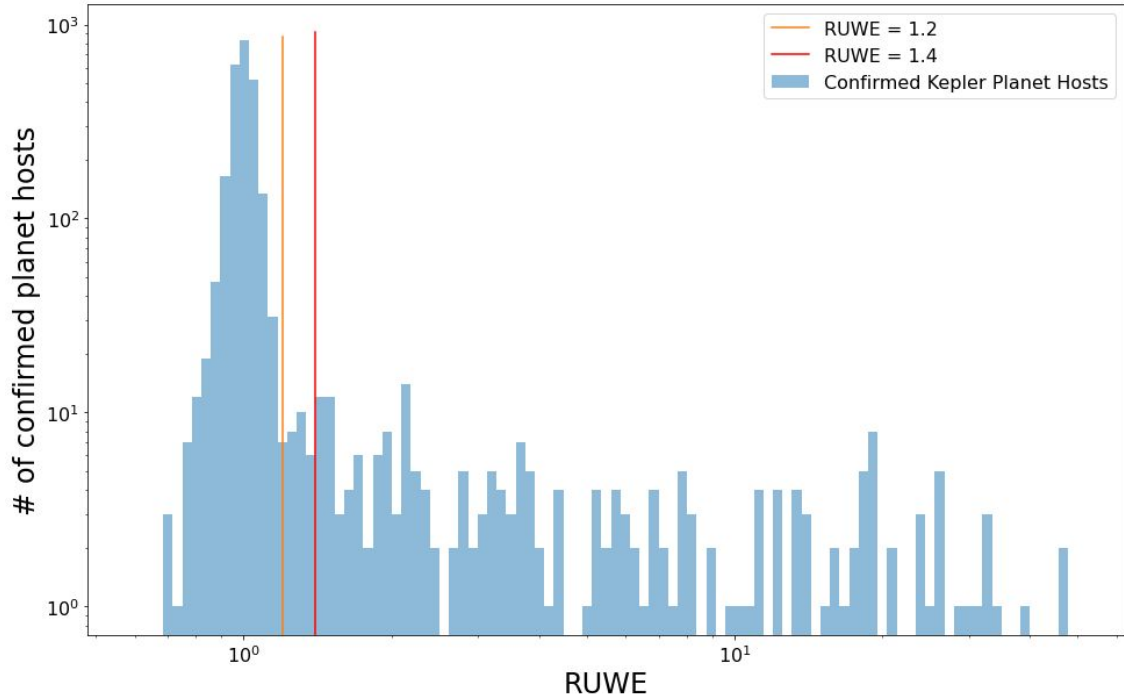
Excess TESS detections at some periods



From arXiv:2301.01900

Example: Undetected Stellar Multiplicity

- Gaia is incomplete within 1 arcsec of brighter (G<13) stars
- The Gaia RUWE metric flags possible multiplicity
 - RUWE>1.4 on a “single” star can indicate an undetected companion
- 216 confirmed Kepler planets (8%) have RUWE > 1.4



Example: The Problem of Priors

- All validation techniques make assumptions
- Not all validation techniques validate those assumptions
- Two extremes:
 - **Comprehensive validation**: both exoplanet and assumptions are validated
 - Often not possible
 - **Conditional validation**: validated IF the assumptions are true
 - Assumptions are not validated
 - **Useful**, but there is an unknown chance that a validation can become invalid with new data

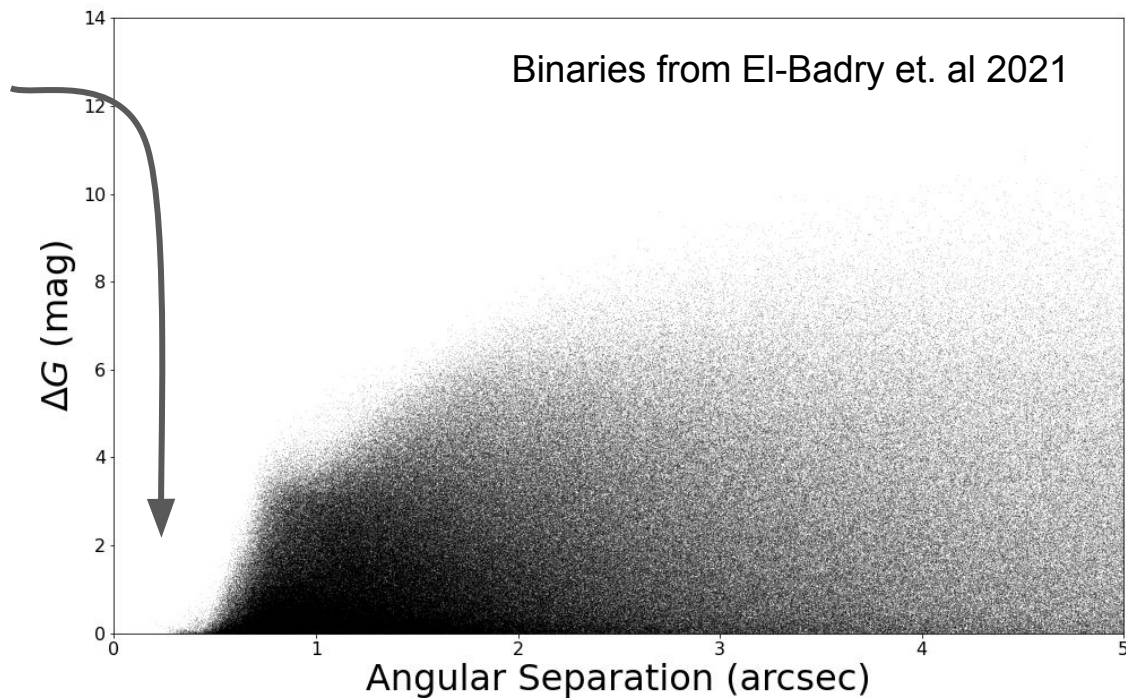
What Can Be Done? The Working Group Response

- Reviewers decide whether a validation is successful
 - We do not advise “formal standards”
- Improve the rigour of validation
 - Looking at you, practitioners and reviewers
 - We’re writing a position paper that
 - Lists the false positive scenarios that must be addressed
 - Compares and contrasts validation methods that have appeared in the literature
 - Provides guidelines for a successful validation
 - Example: when RUWE is high, validation must be robust against undetected stellar multiplicity
- Raise community awareness of issues with validation and the confirmed planet table

Backup Slides

Example: Undetected Stellar Multiplicity

- Gaia is incomplete close to brighter ($G < 13$) stars



Example: Undetected Stellar Multiplicity

- Gaia is incomplete close to brighter ($G < 13$) stars
- The Gaia RUWE metric flags possible multiplicity
 - Large for close binaries
 - So high RUWE on a “single” star can indicate an undetected companion

