# From Detection to Confirmation: Planet Vetting and Follow-Up at the Wendelstein Observatory

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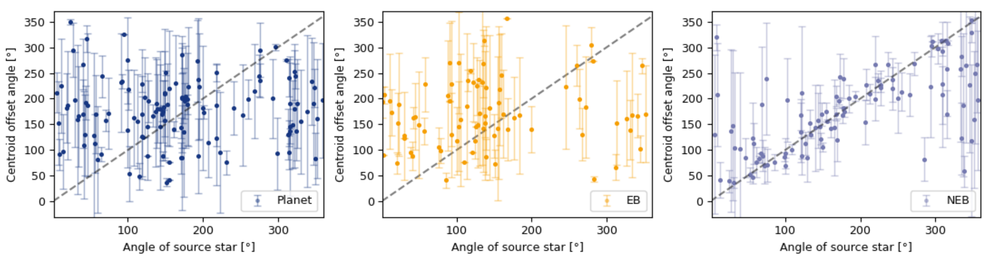
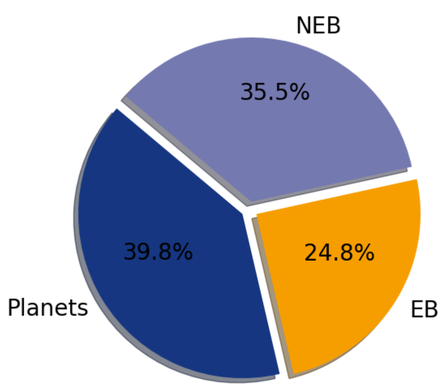
## *Pre-Follow-Up Planet Validation*

To use observation time on Mount Wendelstein more efficiently, known tests to rule out **False Positive Planet Scenarios** were implemented and tested on a categorized sample of TESS Planet Candidates. These tests shall later be combined to find ideal candidates for follow-up observation for individual nights and to rule out TOIs that are likely not planets.

Analysis of the **centroid motion** within the TESS aperture during transit events detects intensity shifts suggesting nearby eclipsing binaries. The following offset can be characterized by an angle, which should be opposite of the one of the source star. In a test the centroid offset, and the source angles are compared for the different scenarios.

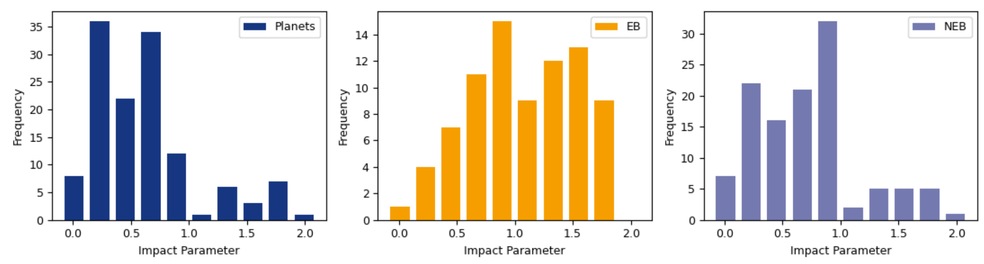


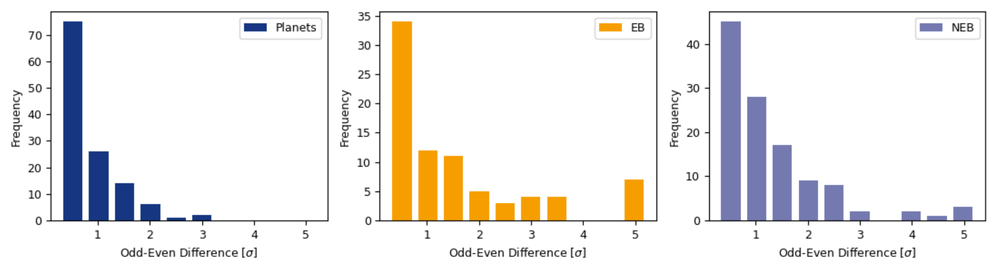

The **sample** includes a total of 331 TOIs divided in three categories:

- Planets
- Eclipsing Binaries (EB)
- Nearby Eclipsing Binaries (NEB)

After a fit of the lightcurves with *juliet [1]* the **impact parameter** was compared for the different scenarios.




Checking for possible eclipsing binaries, the transit depth of the numbered **odd and even events** for an object were compared. This difference is shown in units of standard deviations.




## *2.1 m Fraunhofer Telescope Wendelstein (FTW) [2] – 3KK*

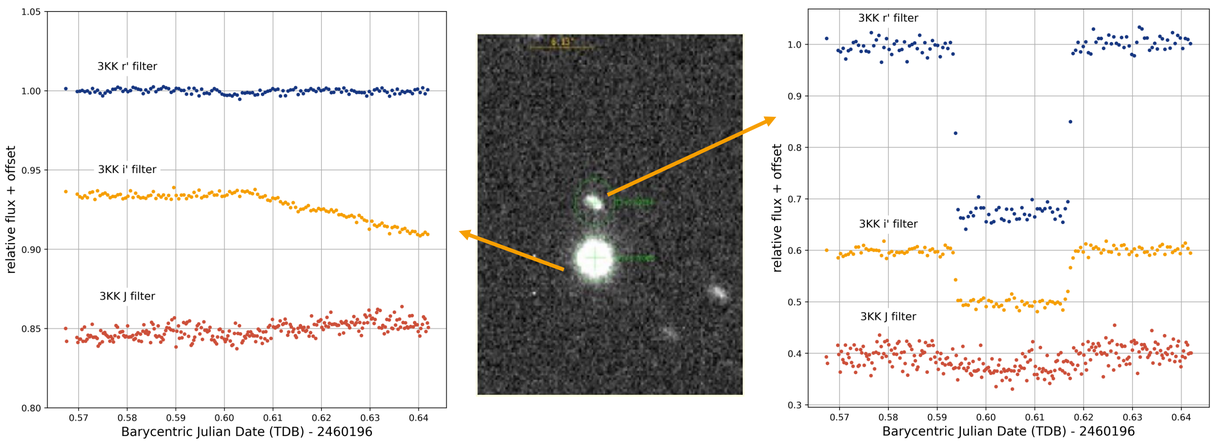
The largest optical telescope in Germany harbors a total of three instruments: the high-resolution spectrograph MaHPS (Manfred Hirt Planet finder Spectrograph)*[3,4]* and the two imagers WWFI (Wendelstein Wide Field Imager) and 3KK (3 Kanal Kamera) *[5]*, a three-channel imager.

Picture by Matthias Kluge

| | Blue channel | Red channel | NIR channel |
|---|---|---|---|
| Filter | u‘, g‘, r‘ | i‘, z‘ | Y, J, H, Ks |
| Pixel scale | 0.2 arcsec/pixel | 0.2 arcsec/pixel | 0.24 arcsec/pixel |
| Wavelength Range | 340-695 nm | 695-970 nm | 970-2310 nm |
| Field of View | 6.8 x 6.8 arcmin | 6.8 x 6.8 arcmin | 8.2 x 8.2 arcmin |
| Median Seeing | 0.8 – 0.9 | 0.8 – 0.9 | 0.8 – 0.9 |

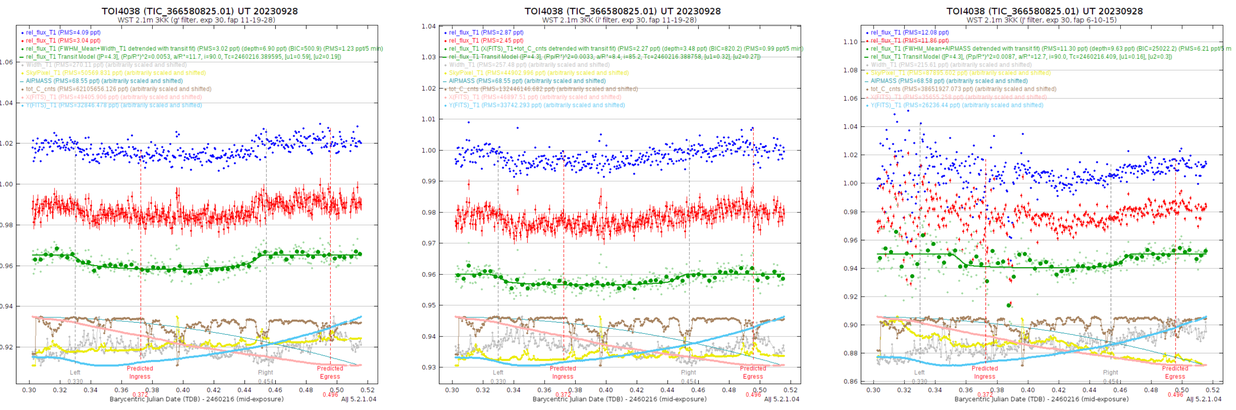
### Contributions

M-Dwarf – White Dwarf Binary




3KK is especially useful for TESS follow-up due to the ability to do chromaticity checks. Recent observations were done in the following parameter space:

- V-magnitude between 10.7 and 15.4
- Minimum observed Transit Depth of 2.5 ppt
- Minimum separation between nearby sources of 3 arcseconds
- Minimum elevation of 24°




TOI 4038

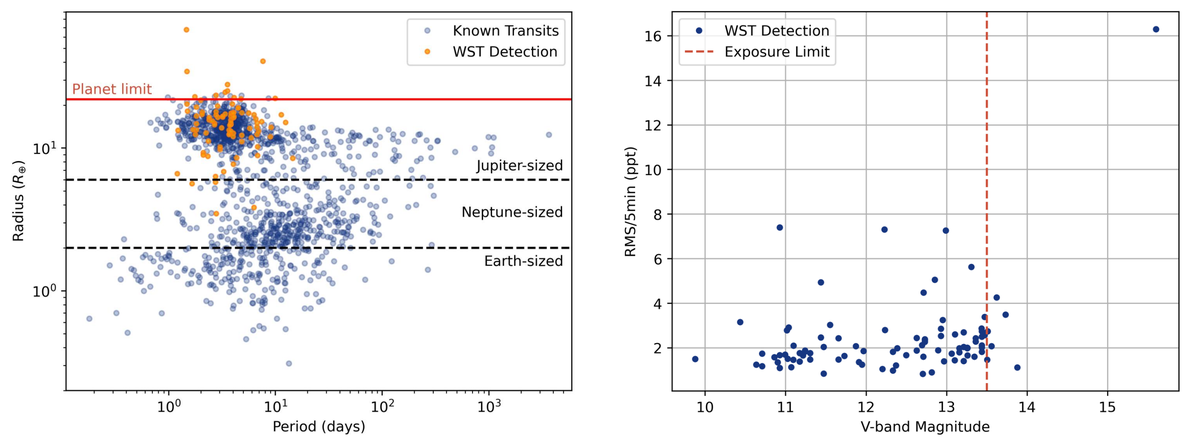
## *43cm Telescope [2]*

The 43 cm Telescope situated at Mount Wendelstein’s primary goal is to perform follow-up observations associated with the TESS mission. Consequently, it is equipped with an automated system to identify optimal targets each night and automatically conducts observations of the planet candidates.

Picture by Raphael Zöller

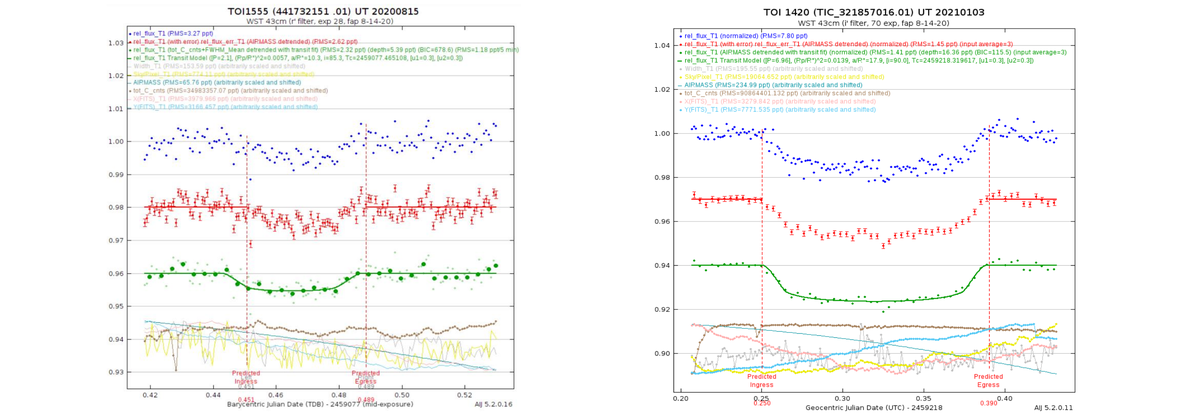
| | QHY 600 M Pro |
|---|---|
| Filter | g‘, r‘, i‘ |
| Pixel Scale | 0.265 arcsec/ pixel |
| Wavelength Range | 400 – 840 nm |
| Field of View | 42.4 x 28.4 arcmin |
| Median Seeing | 0.8-1.2 |

### Contributions




The 43 cm telescope can detect Neptune-sized planets orbiting sun-like stars within a broad range of magnitudes. Limiting factors include:

- V-magnitude between 7.9 (1 s exposure) and 13.5 (180 s exposure)
- Minimum Transit depth of 2 ppt
- Minimum separation between nearby sources of 6 arcseconds
- Minimum elevation of 20°




TOI 1555

TOI 1420

## References

[1] Espinoza, N. et al. (2019). juliet: a versatile modelling tool for transiting and non-transiting exoplanetary systems. , 490(2):2262–2283

[2] Hopp, U. et al. (2014). Commissioning and science verification of the 2m-Fraunhofer Wendelstein Telescope. In Stepp, L. M., Gilmozzi, R., and Hall, H. J., editors, Ground-based and Airborne Telescopes V, volume 9145 of Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, page 91452D

[3] Pfeiffer, M. J. et al. (1998). FOCES -a fibre optics Cassegrain Echelle spectrograph. , 130:381–393

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If you‘re curious or have questions, don‘t hesitate to chat with me or drop me an email!

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