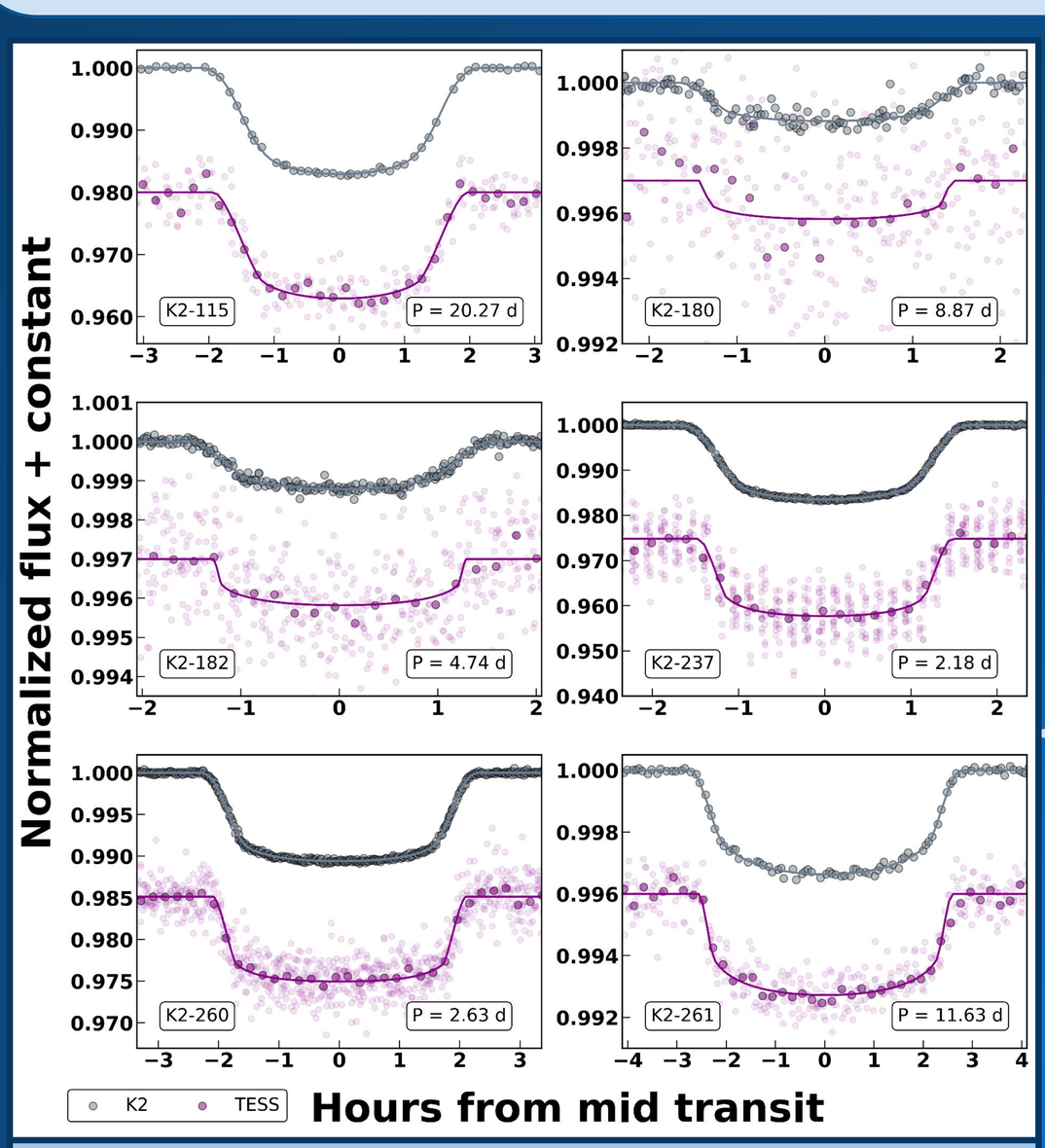
The K2 & TESS Synergy: Uniting NASA's Planet Hunters

Erica Thygesen and Joey Rodriguez
Michigan State University
Contact: thygesen@msu.edu **Website: ethygesen.github.io**

Problem: we don't know when to look!

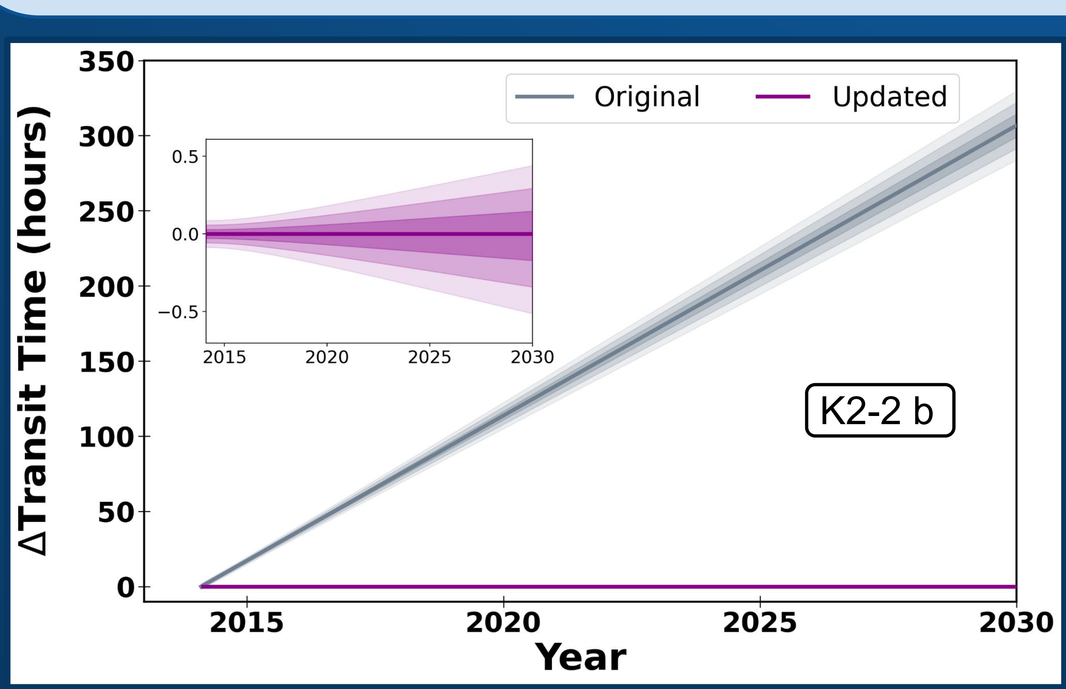
The early success of JWST provides an exceptional opportunity to study the atmospheres of exoplanets with unprecedented detail. However, most (>80%) confirmed transiting exoplanets will not be accessible during the mission's lifetime. This widespread problem is due mostly to ephemeris degradation: uncertainties on transit time and period compound over time, which can culminate in predicted future transits being off by hours to days. Ideally, uncertainties on future transit times should be under 30 minutes to schedule targeted observations for atmospheric characterisation.



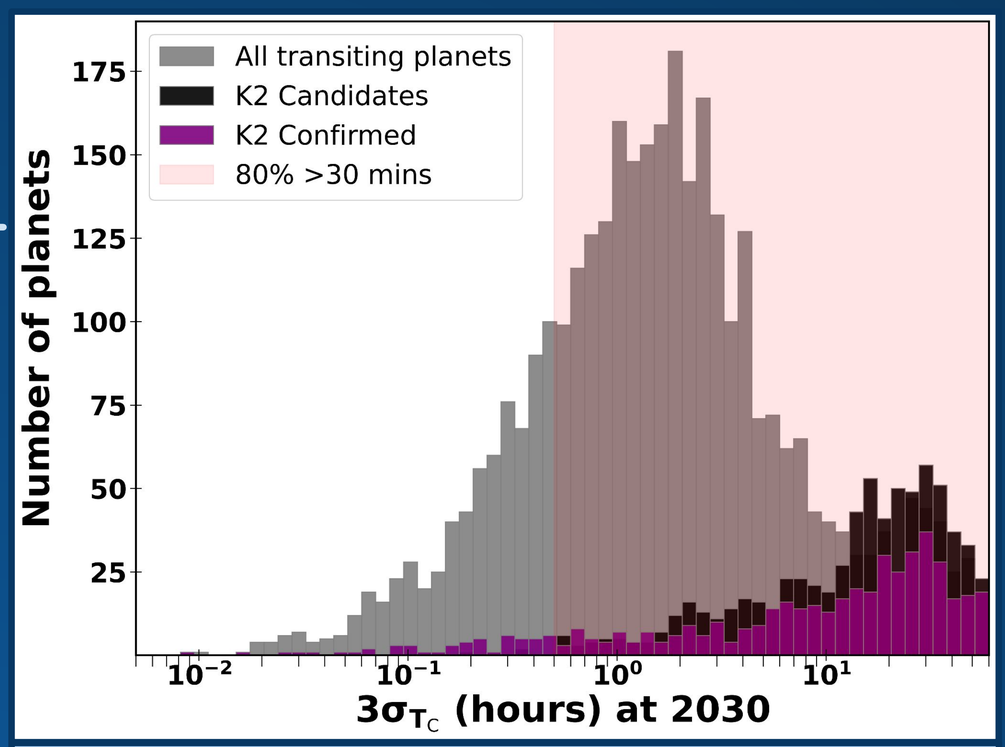
Phase folded K2 (grey) and TESS (purple) light curves showing the transits for a sample of systems we revisited in the Synergy series. The K2 ID is at the bottom left of each subplot, and the planet period in days at the bottom right.

Current and future work

We reanalysed 28 single-planet K2 systems observed during the TESS primary mission[4] in the second paper of the series, and improved the average 3σ uncertainties by 2030 from 26.7 to 0.35 hours. We will revisit all confirmed K2 exoplanets that have TESS light curves to update ephemerides and system parameters, resulting in a self-consistent catalogue of ~250 systems. We will prioritise planets that are likely to be well-suited targets for JWST. For transits that are too shallow to recover by TESS, we still provide updated parameters using only the K2 light curves. The next batch will include 50+ of the top atmospheric targets before the end of the year.



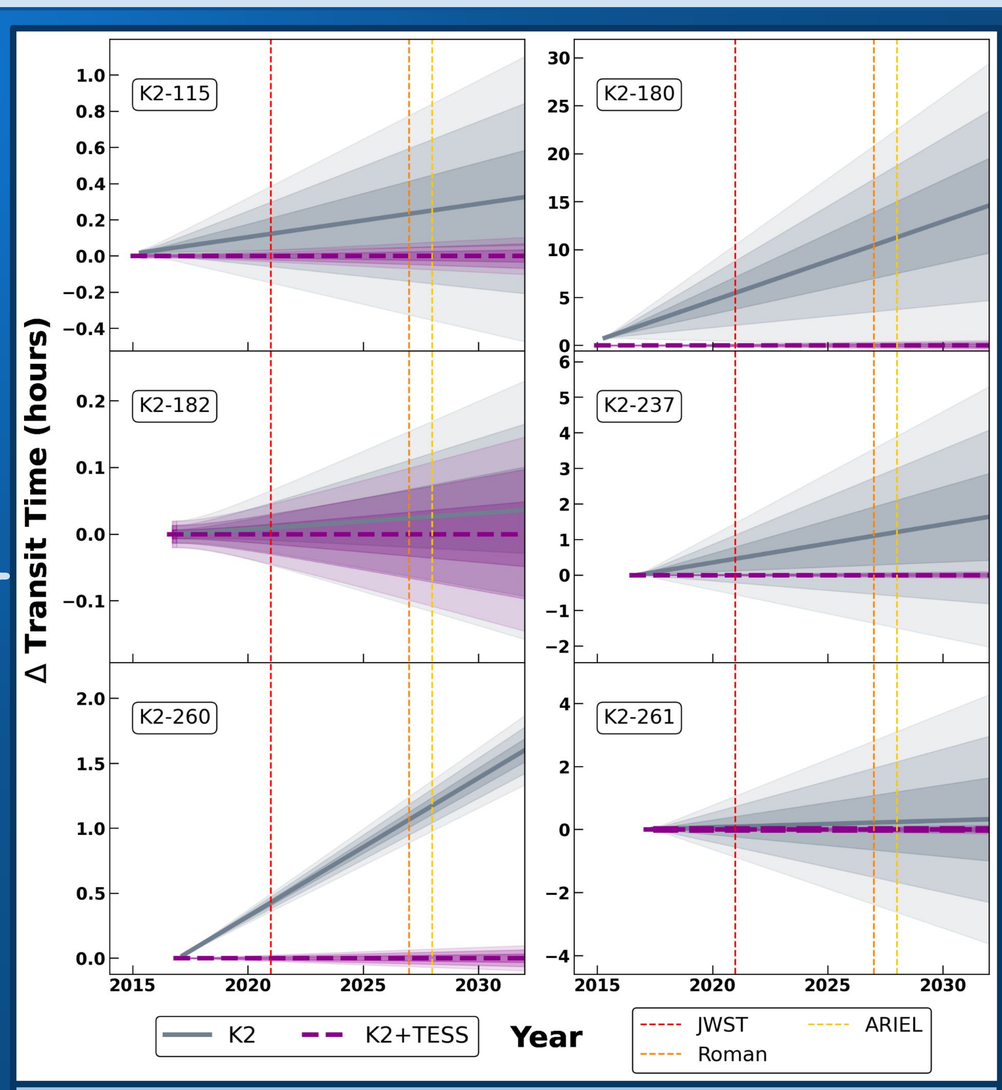
Projected difference in the time of transit for K2-2 b to the year 2030 using the original ephemeris (grey) and the new ephemeris from this work (purple). Shaded regions indicating up to the 3σ level uncertainty are shown. The inset shows the updated ephemeris, zoomed in for clarity.



Uncertainties on transit times for transiting exoplanets by 2030. The red region indicates uncertainties >30 minutes, making them difficult targets for JWST. The subset of K2 candidates and confirmed planets are shown, which is the focus of the K2 & TESS Synergy. Values from the NASA Exoplanet Archive[1].

K2 and TESS join forces!

The goal of the K2 & TESS Synergy is to update the ephemerides and system parameters for all exoplanets originally discovered by K2 that have been observed by TESS. By combining light curves from both missions, we can improve our ability to predict future transit times that are required for detailed characterisation. We use EXOFASTv2[2] to perform global fits that obtain updated parameters for the entire system. Where available, the fits make use of light curves from K2 and TESS, archival radial velocities, Gaia parallaxes, stellar SEDs and MESA Isochrones and Stellar Tracks[3] (MIST) stellar evolution models.



Projected transit time uncertainties for a selection of systems we have reanalysed. The shaded regions indicate the 1, 2 and 3σ uncertainties, where grey is using the discovery ephemeris obtained with K2 and purple is our updated version including both K2 and TESS. Launch dates of facilities with particular significance for atmospheric characterisation are indicated by the vertical dashed lines.

Added bonus: amend incorrect ephemerides

Systematically combing through the K2 catalogue means we are also updating transit times that were incorrect at discovery - including for K2's first planet[5], K2-2 b. The original period was ~30 minutes from the true period, meaning if we observed it today we would miss the transit by around 8 days.

References
[1]https://exoplanetarchive.ipac.caltech.edu/
[2]Eastman, J. D., Rodriguez, J. E., Agol, E., et al. 2019, arXiv e-print
[3]Paxton, B., Bildsten, L., Dotter, A., et al. 2011, ApJS, 192, 3
[4]Thygesen, E., Ranshaw, J. A., Rodriguez, J. E., et al., 2023
[5]Thygesen, E., Rodriguez, J. E., De Beurs, Z. L., et al., under review

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