

Planet Hunters: Crowdsourcing the Extrasolar Planet Inventory

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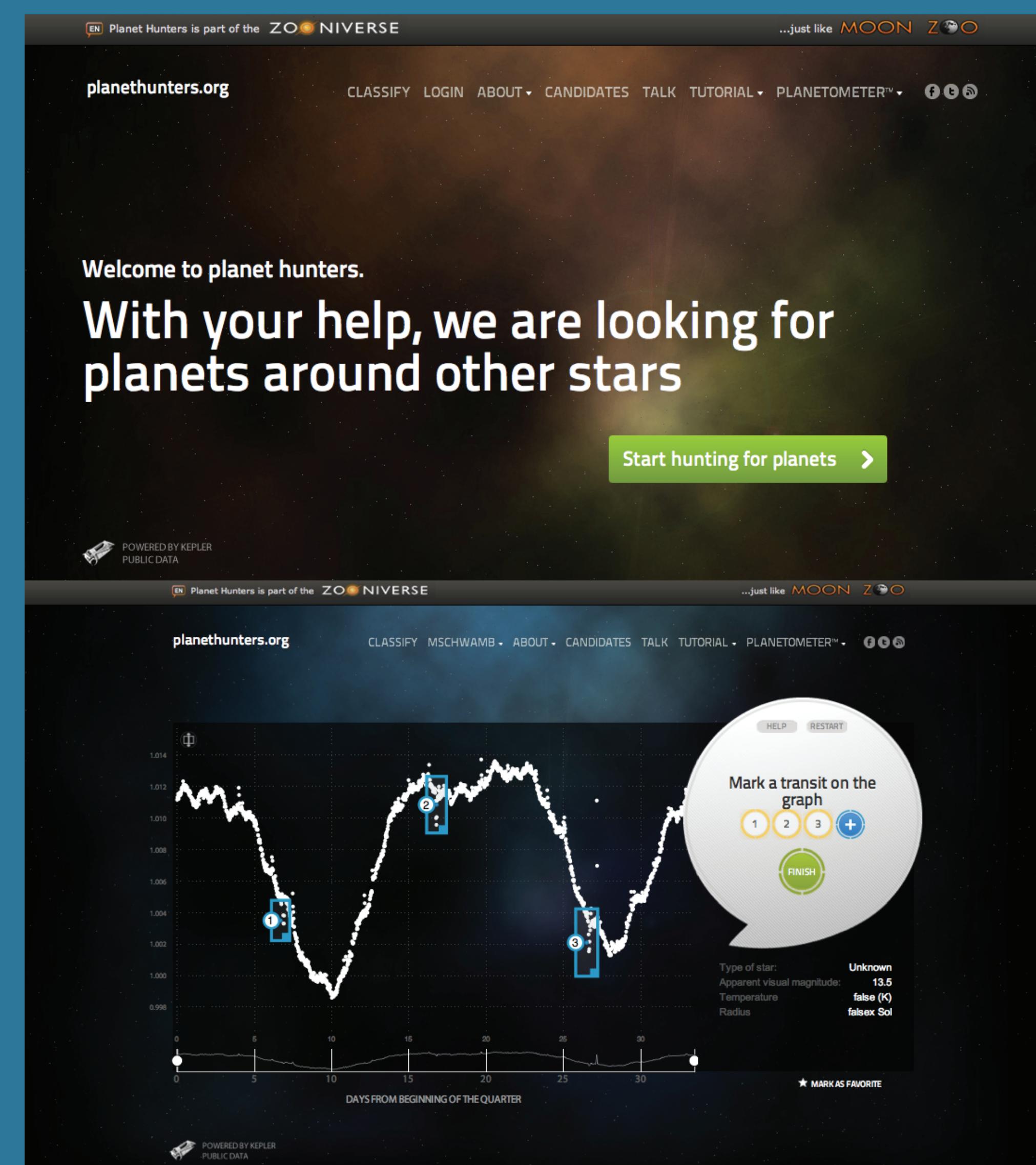
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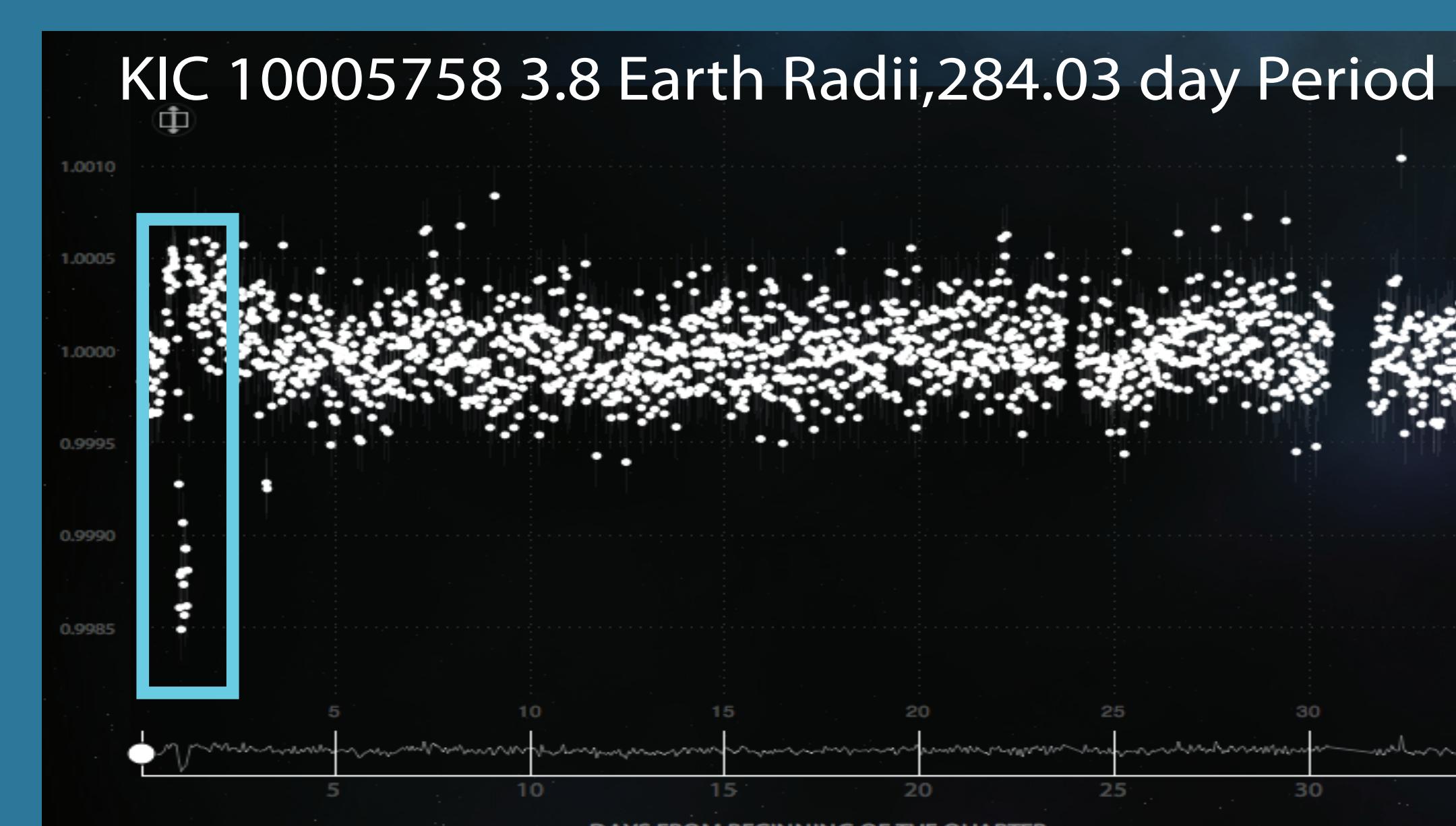
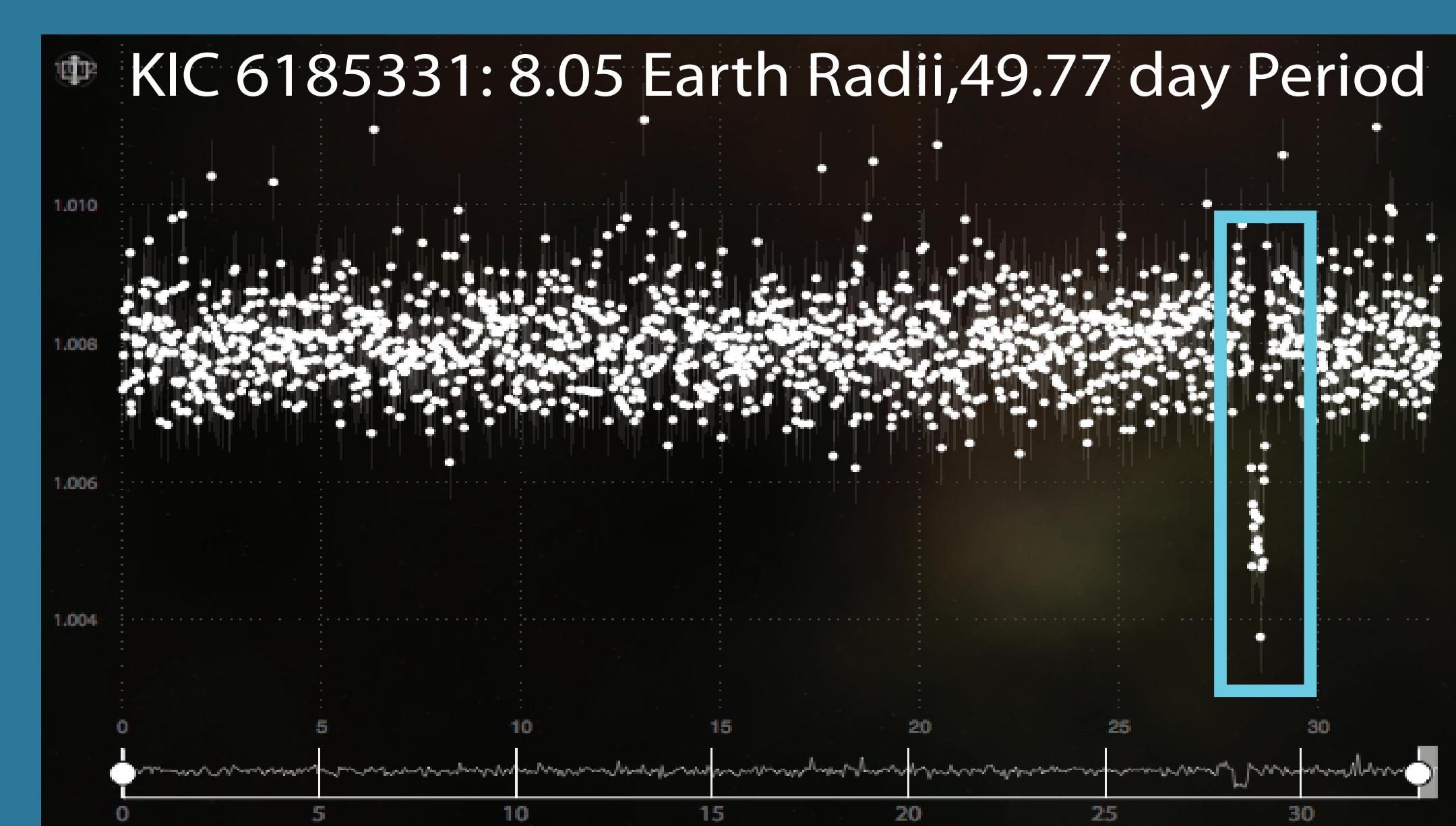
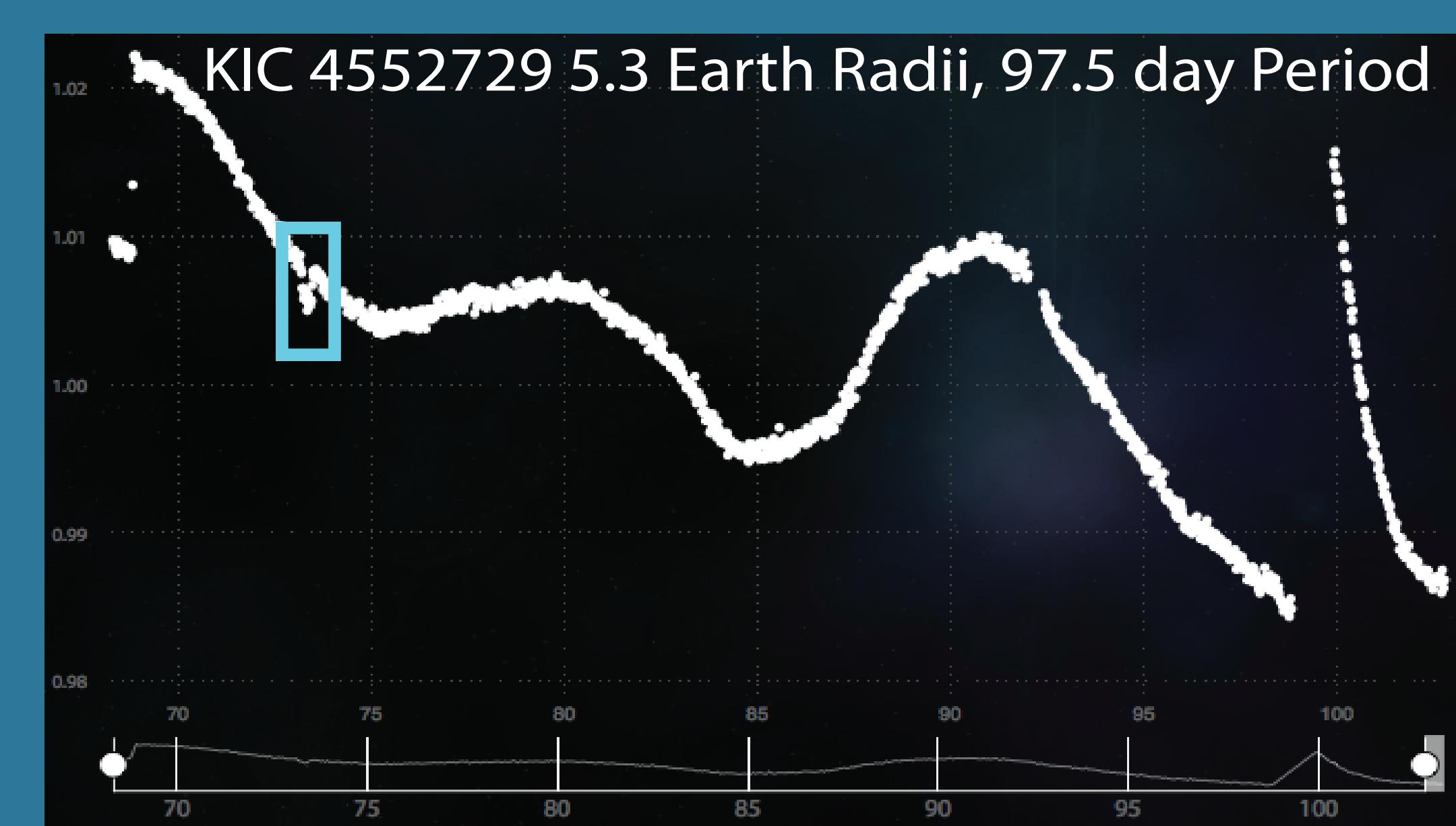
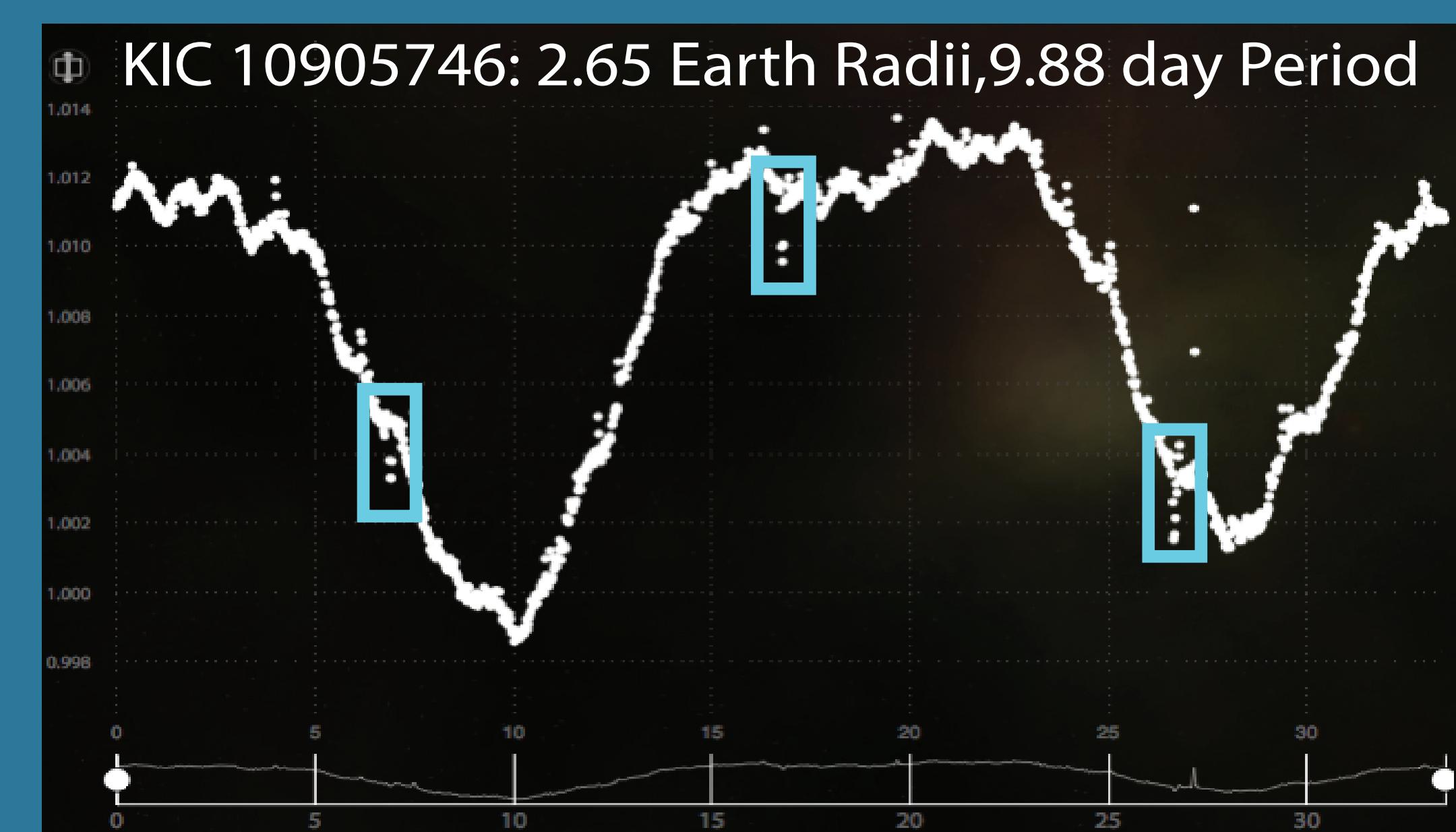
NASA's *Kepler* space mission is monitoring ~160,000 stars for the drop in starlight caused when an extrasolar planet (exoplanet) transits or passes in front of its parent star. **Planet Hunters** (<http://planethunters.org>), part of the Zooniverse (<http://zooniverse.org>) collection of citizen science projects, uses the power of human pattern recognition via the World Wide Web to identify planet transits in the *Kepler* public data. Visitors to the website are presented with ~30-day light curve segments (the time series of brightness measurements) from one of *Kepler*'s target stars. Volunteers are asked to draw boxes to mark the locations of visible transits. 5-10 independent classifiers review each 30-day light curve.

Planet Hunters employs a complementary technique to that of the *Kepler* detection pipeline and validation processes, providing an independent assessment of the *Kepler* inventory of exoplanets. Referred to as 'crowd-sourcing' or 'citizen science', the combined assessment of many non-expert human classifiers with minimal training can equal or best that of a trained expert or machine-learning algorithms. **To date more than 200,000 volunteers worldwide have participated in Planet Hunters, contributing over 15 million classifications.**



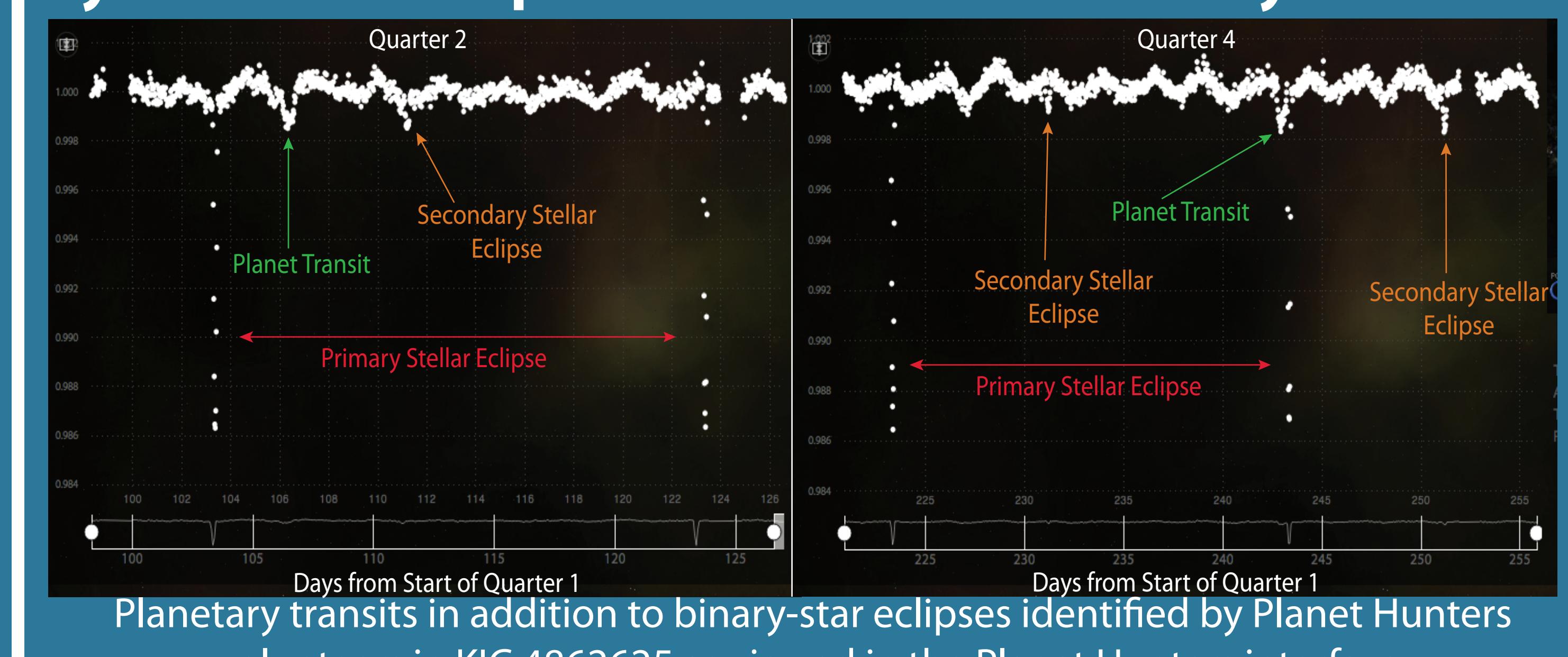
Front page (top) and main classification interface (below) of the Planet Hunters website

The efficacy of a citizen science approach to detect exoplanets has been demonstrated with the discovery of 4 planet candidates identified by Planet Hunters that were not previously known

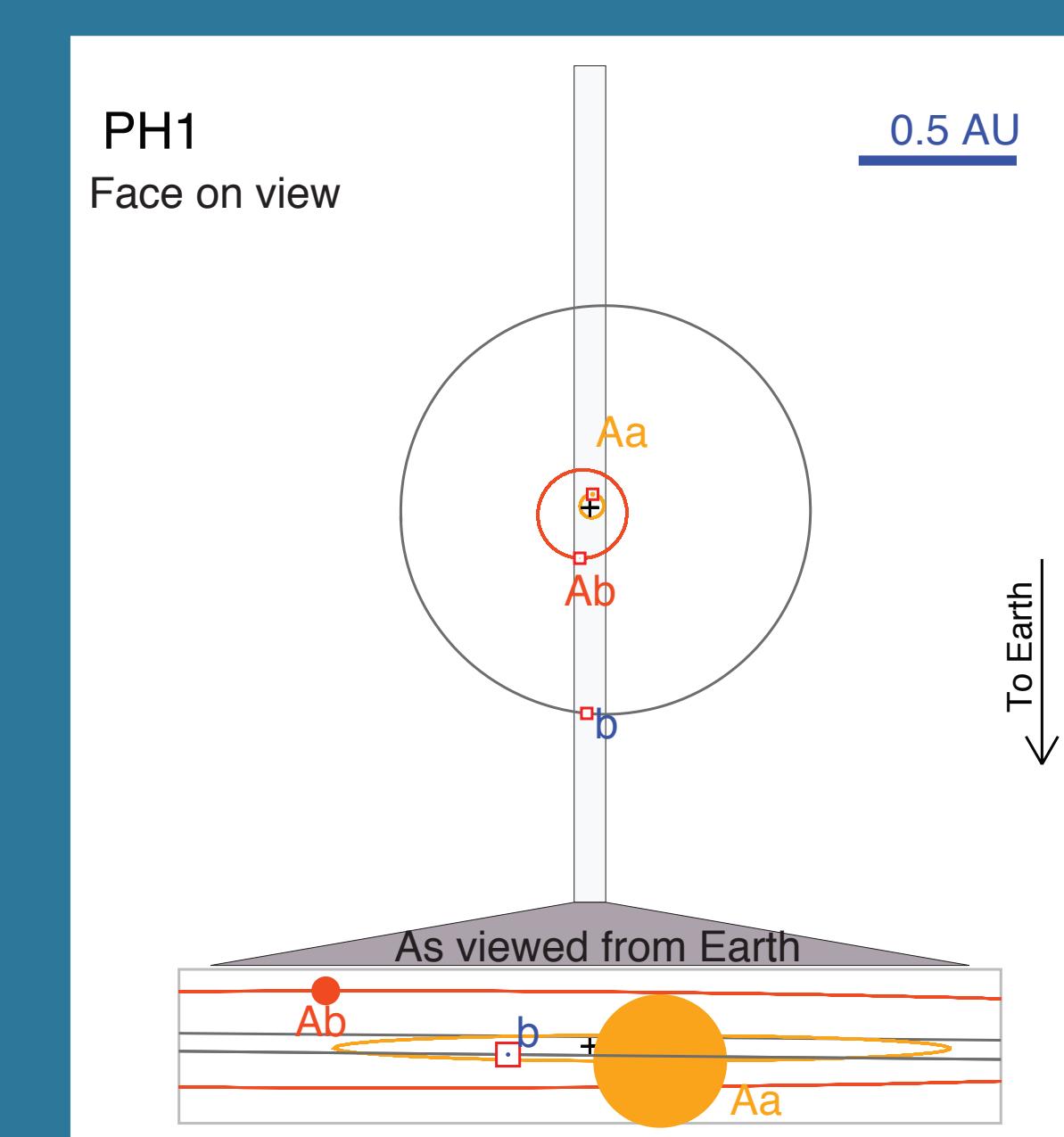


Discovery of a Circumbinary Planet in a Four Star System

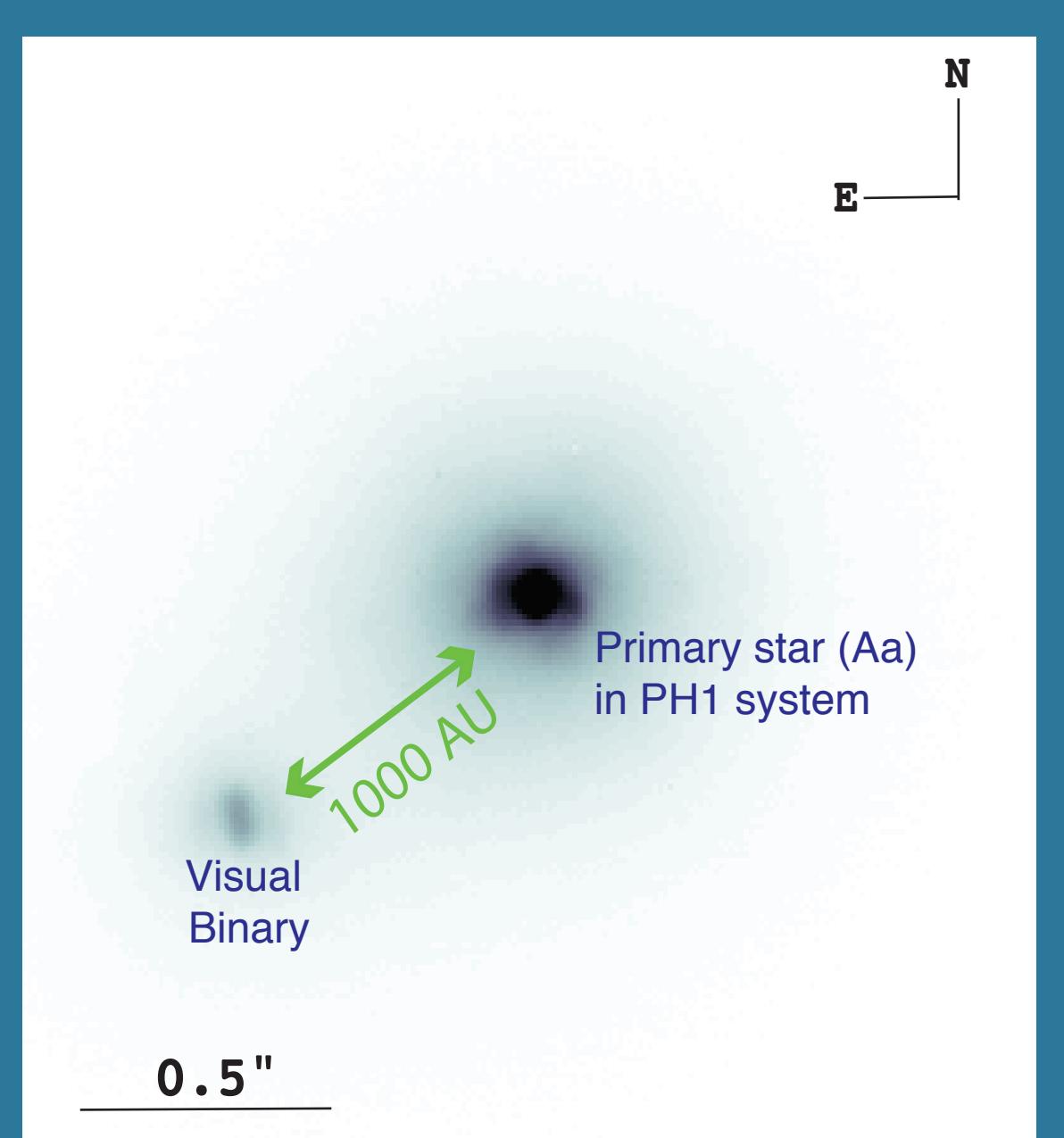
Circumbinary planets, planets orbiting both stars in a binary star system, present a new paradigm for solar system architecture as the extremes of planet formation compared to our own Solar System. **Planet Hunters has discovered PH1, the 6th circumbinary planetary system and first planet to be in a four star system.**



PH1 System: The 6.2 Earth radii circumbinary planet resides outside the 20-day orbit of an eclipsing pair of 1.5 and 0.4 Solar mass stars. Transits of the planet across the larger and brighter of the eclipsing stars are visible every ~138 days. Beyond the planet's orbit at ~1000 AU (1000 times the distance between the Earth and Sun) is a 2nd pair of stars orbiting the entire planetary system.



Orbital configuration of the PH1 system. The inner two stars (Aa & Ab) and the planet (labeled b) are shown. The outer binary star is not depicted.



Natural Guide Star Adaptive Optics observations reveal a visual binary (2nd pair of stars) orbiting the PH1 system.

Future work includes a dedicated systematic search for transits in binary star light curves in order to better assess the frequency and population statistics of circumbinary planets.

planethunters.org