

TESS: TRANSITING EXOPLANET SURVEY SATELLITE

CHETAN CHAWLA

TECH CONSULTANT @ZS, EX-ASTROPHYSICS RESEARCHER @ASIAA, TAIWAN



Source: NASA

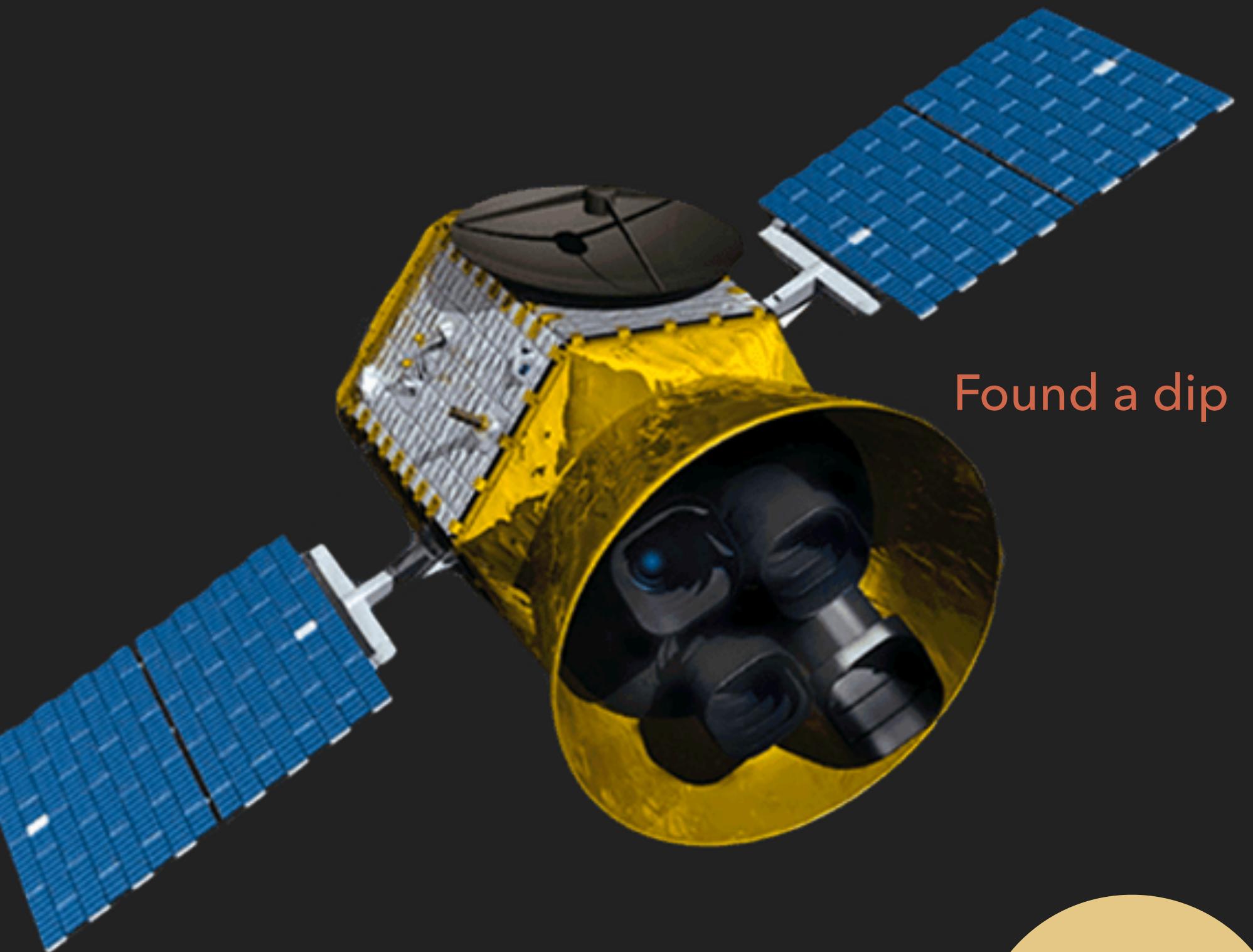
2

1. INTRODUCTION

TRANSITING EXOPLANET SURVEY SATELLITE

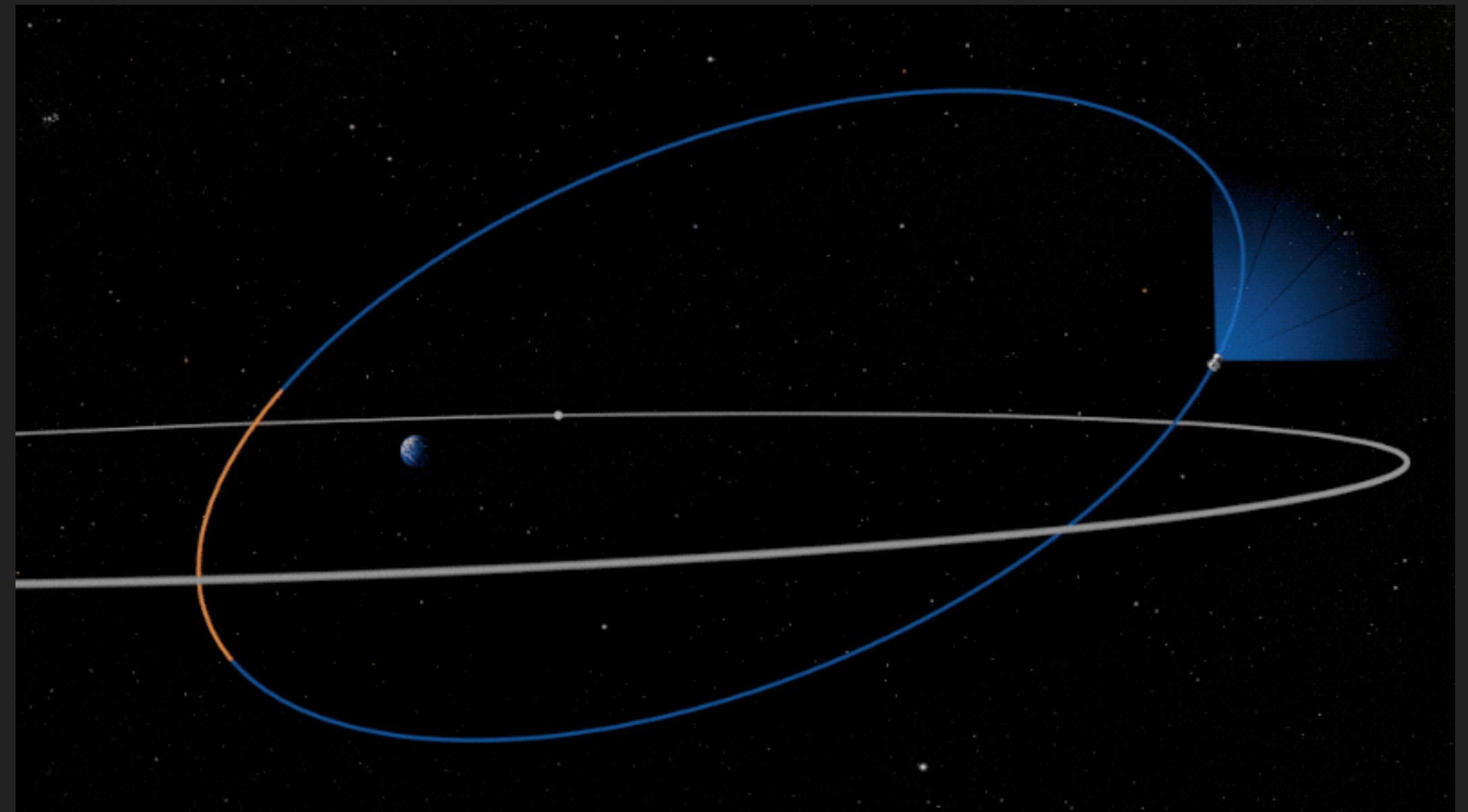
TESS

- ▶ Transiting Exoplanet Survey Satellite (TESS) is a planet hunter satellite by NASA
- ▶ All-sky survey monitoring **>200,000 bright stars** for planetary transits
- ▶ 4 2K x 2K resolution cameras covering 24×96 degree strips of sky at 600-1000nm wavelengths, called **sectors**
- ▶ **Takes images at 2 minutes for selected targets and 30 minute cadences for Full Frame Images** to look for transits



TESS - ORBIT, SECTORS, COVERAGE

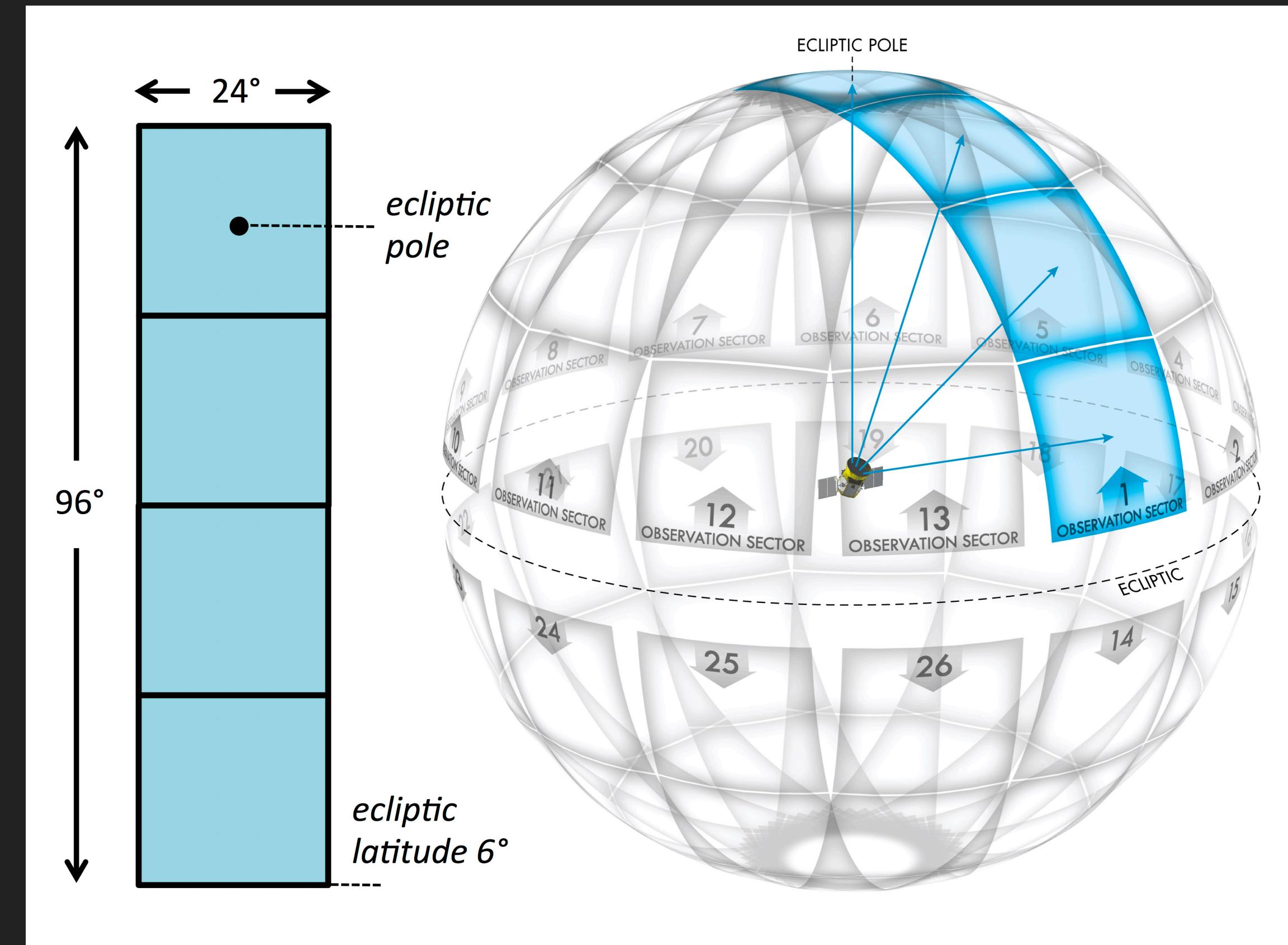
- ▶ 13.7 day, highly elliptical cislunar orbit (at a 2:1 resonance with the moon) around earth
- ▶ Observes one sector for 27.4 days, dividing sky into 26 sectors
- ▶ Completes Observing one hemisphere in an year
- ▶ Launched in April 2018, completed the primary mission in 2 years



Source: [NASA Goddard Media Studios](#)

TESS - CONTINUOUS VIEWING ZONE

- ▶ Overlap between sectors give rise to continuous viewing zone
- ▶ Present at the poles
- ▶ Covers a time baseline of **351 days**, providing opportunity to find bigger orbital period temperate planet candidates
- ▶ Subset of CVZ also to be covered by the upcoming JWST mission



Source: [TESS MIT](#)



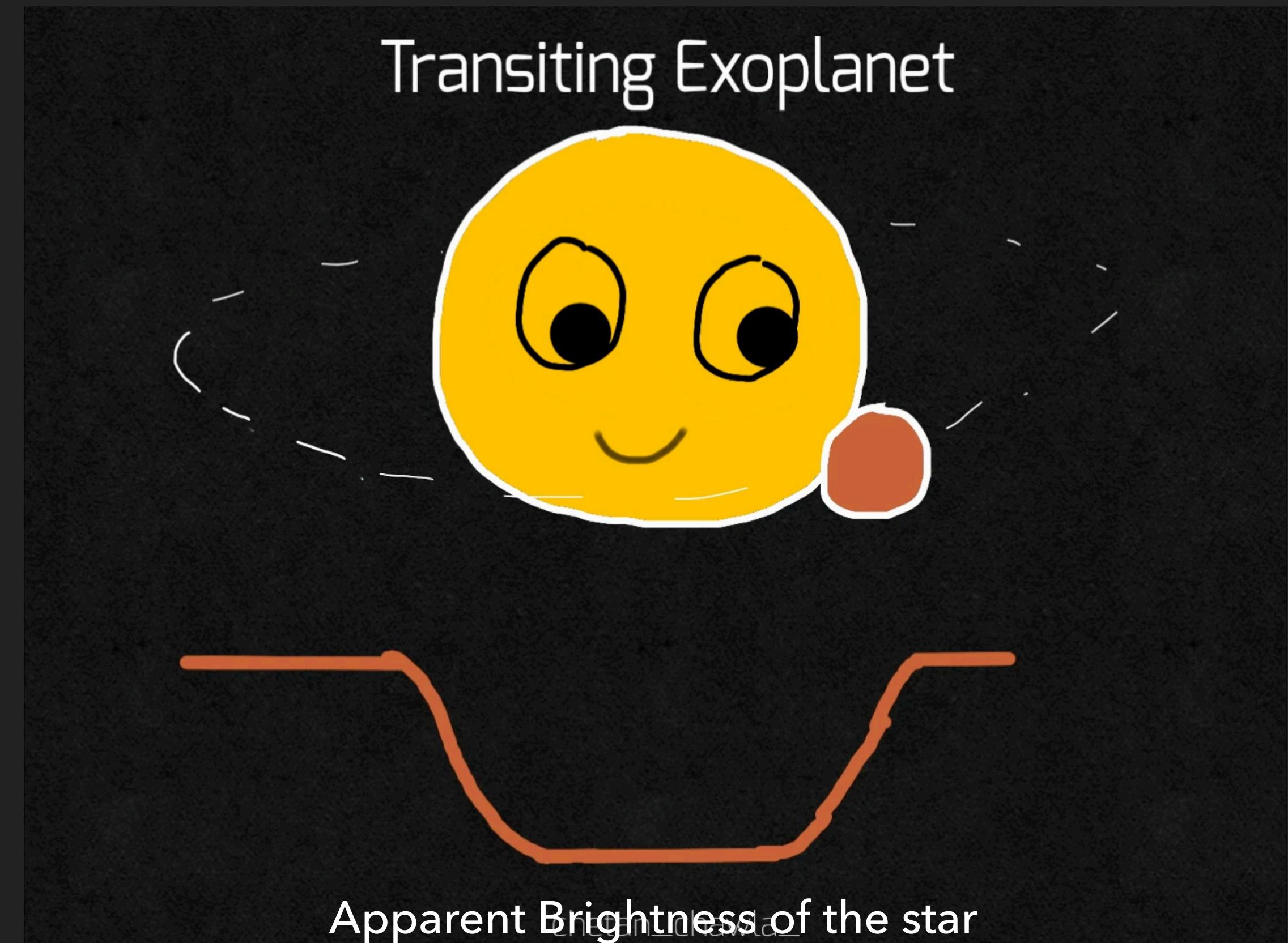
Source: [Exoplanet Memes for Habitable Planets](#)

2. A GENERAL VIEW

TRANSIT DETECTION FOR EXOPLANETS

TRANSIT DETECTION

- ▶ Looking for periodic momentary dips in the apparent brightness of a star (or the flux) as a planet passes in front of the star
- ▶ Can be due to exoplanets or some other astrophysical false positives like eclipsing binaries
- ▶ Measuring change in flux over time gives us a lightcurve. We can model the
 - ▶ Transit Depth \propto planet's radius
 - ▶ Transit Duration \propto planet's orbital period



TRANSIT DETECTION PIPELINES

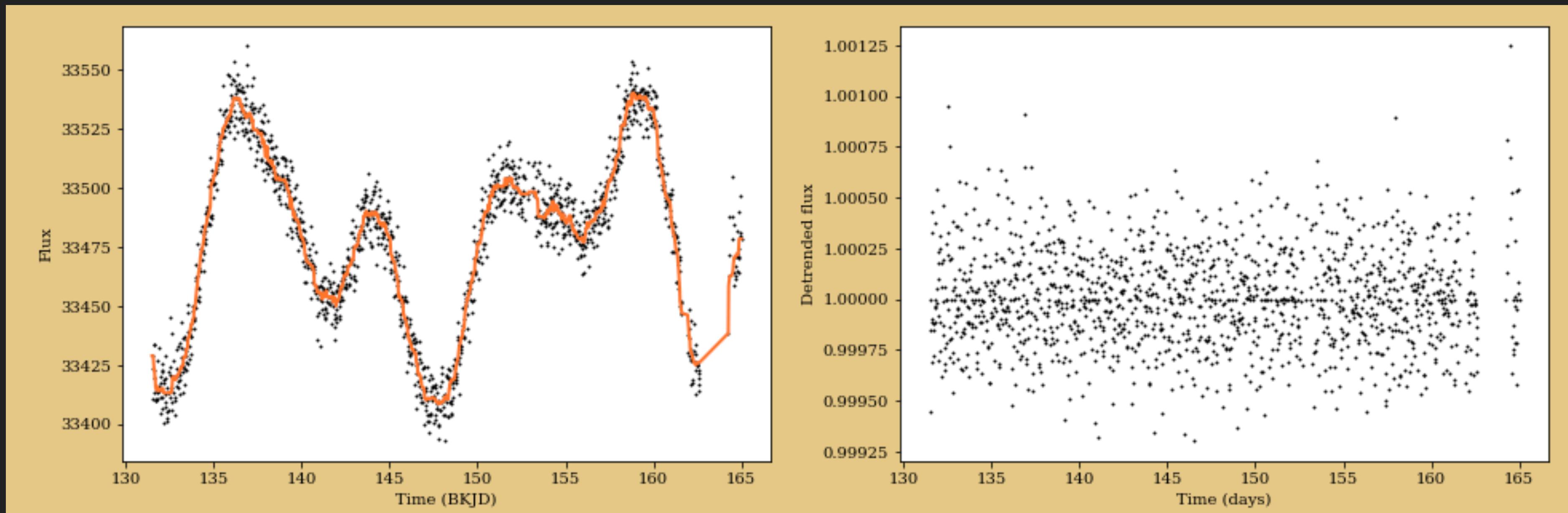
- Downloading and pre-processing lightcurves
- Detrending Lightcurves
- Outlier Detection and Deletion
- Transit Search
- Transit Signal Identification and Follow Up

TRANSIT DETECTION PIPELINES

- Downloading and pre-processing lightcurves
- Detrending Lightcurves
- Outlier Detection and Deletion
- Transit Search
- Transit Signal Identification and Follow Up

DETRENDING LIGHTCURVES

- ▶ Fitting a trend to the fluxes to remove the variability due to stellar activity and noise without removing the actual transits
- ▶ We get the **detrended fluxes or residuals** by dividing fluxes by the trend line



TRANSIT DETECTION PIPELINES

- Downloading and pre-processing lightcurves
- Detrending Lightcurves
 - Outlier Detection and Deletion
 - Can be done both pre-detrending and post-detrending; It removes outlier fluxes.
- Transit Search
- Transit Signal Identification and Follow Up

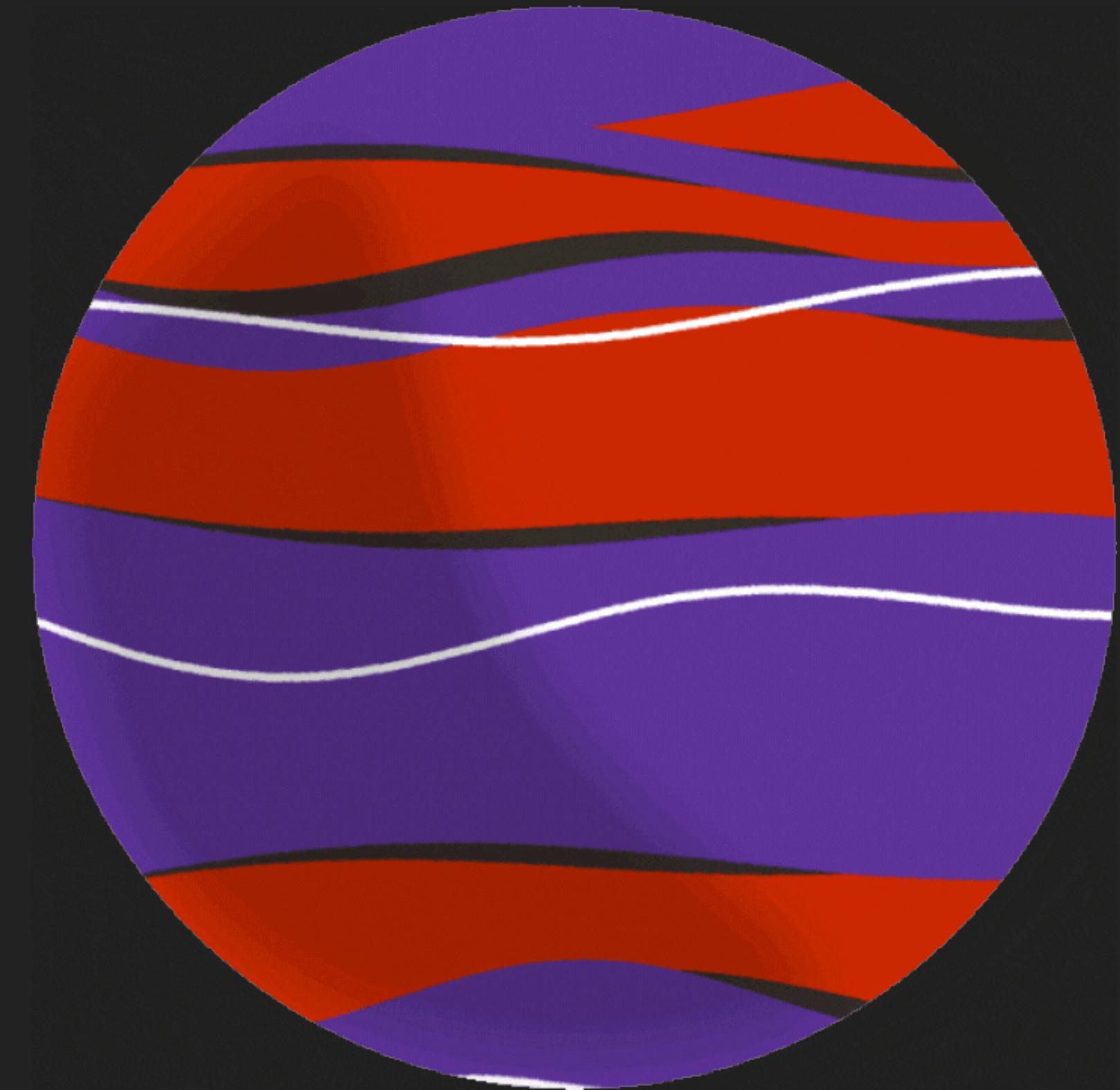
TRANSIT DETECTION PIPELINES

- Downloading and pre-processing lightcurves
- Detrending Lightcurves
- Outlier Detection and Deletion
- Transit Search

Finding periodic signals in the data by sliding over the fluxes and returning a periodogram. The peak represents the transit period
- Transit Signal Identification and Follow Up

TRANSIT DETECTION PIPELINES

- Downloading and pre-processing lightcurves
- Detrending Lightcurves
- Outlier Detection and Deletion
- Transit Search
- Transit Signal Identification and Follow Up
 - For Vetting
 - Checking for False Positives



3. CODING

USING LIGHTKURVE FOR TESS

ASSIGNMENT

- ▶ Head over to the [**NASA Exoplanet Archive**](#)
- ▶ Select your favorite TESS planet
- ▶ Use the TIC ID, Epoch and Period, plot its transit lightcurve like we did for a random target today

Bonus Assignment

- ▶ Try to find the period of this planet using the Box Least Square Method
- ▶ You can follow the official [**Lightkurve Tutorial**](#) to learn more about the same



THANK YOU FOR YOUR ATTENTION

Feel free to send questions to
chetanchawlacc4@gmail.com

Website: sites.google.com/view/chetanchawla