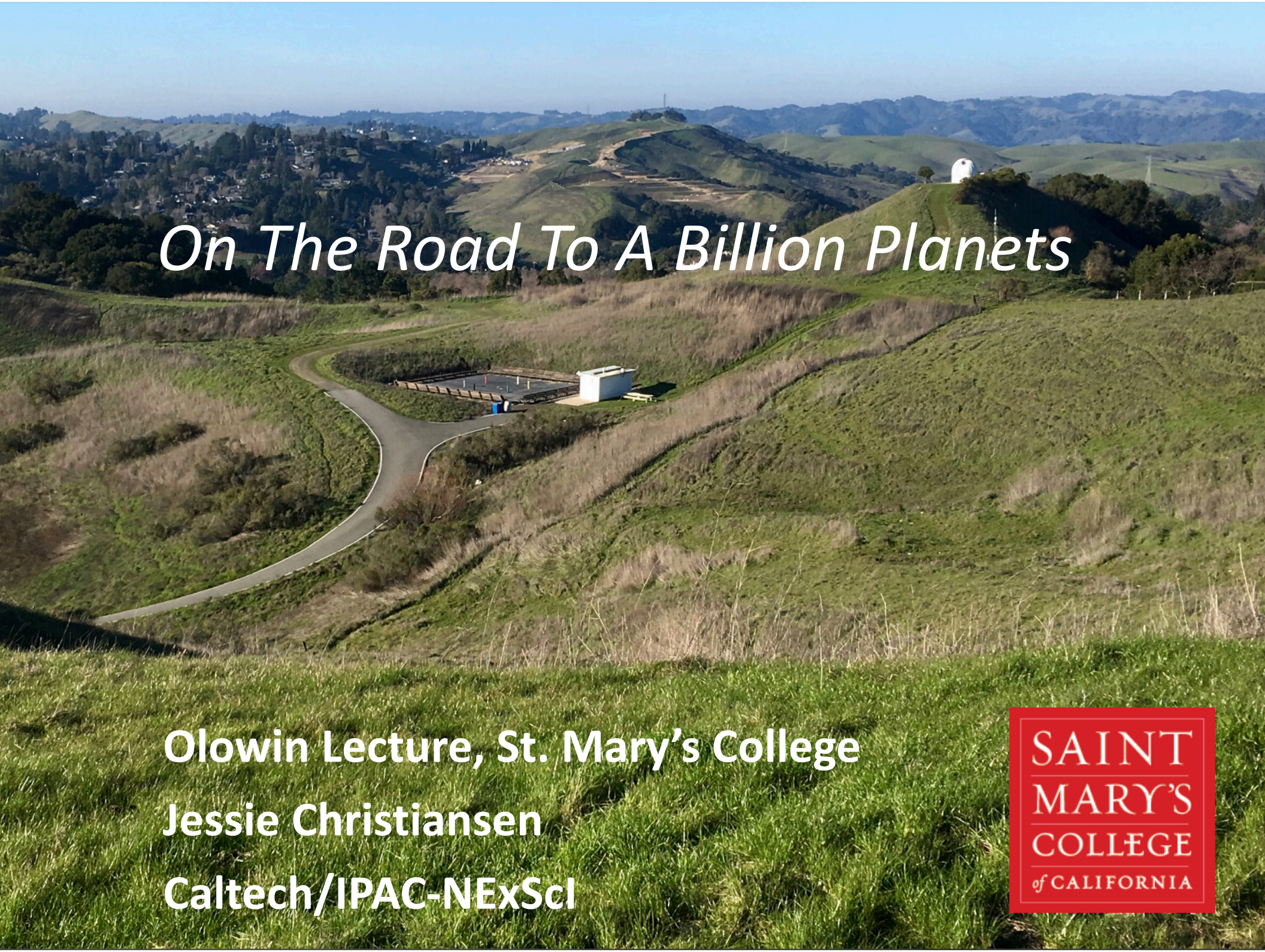

On The Road To A Billion Planets
Olowin Lecture, St. Mary's College
Jessie Christiansen
Caltech/IPAC-NExScI
SAINT MARY'S COLLEGE of CALIFORNIA


ST MARY'S
COLLEGE
1999
YEAR 12 DEBATING
ODU

A Brief (Pre-)History of Cosmic Pluralism

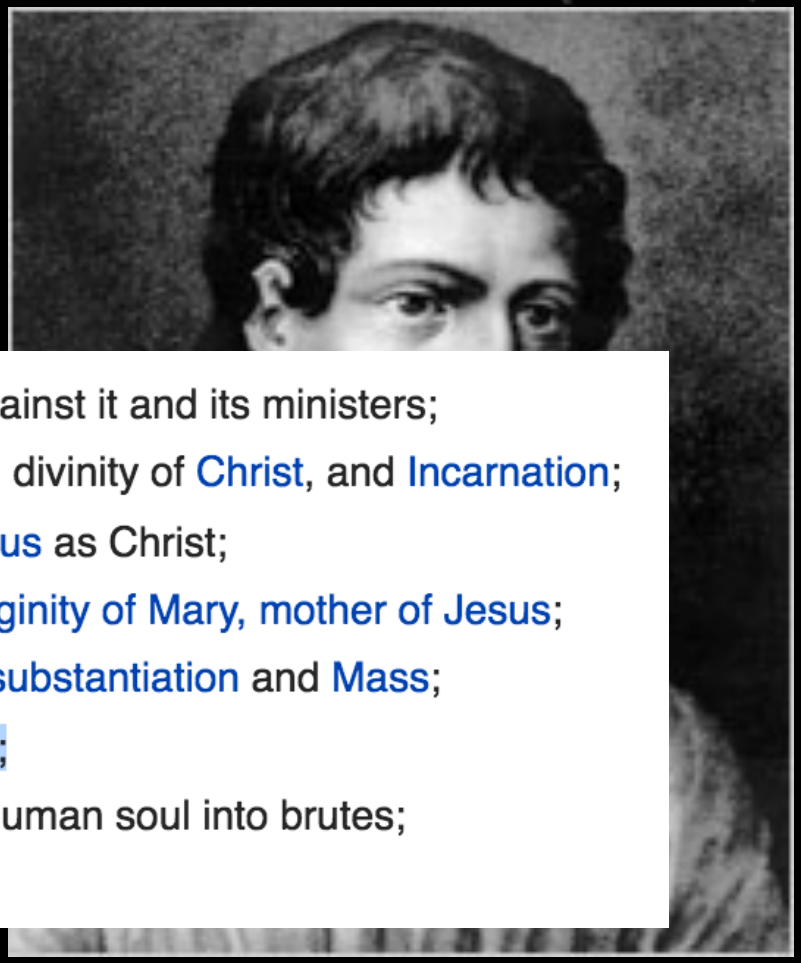
~600BC: Greek philosophers discuss the infinity or singularity of Earth as a purely abstract idea – Plato and Aristotle argue for the uniqueness of Earth

Raphael

~1200AD:Arabian, Muslim philosopher Fakhr al-Din al-Razi

"Therefore He the Most High has the power (qadir) to create a thousand thousand worlds (alfa alfi 'awalim) beyond this world such that each one of those worlds be bigger and more massive than this world as well as having the like of what this world has."

The Renaissance

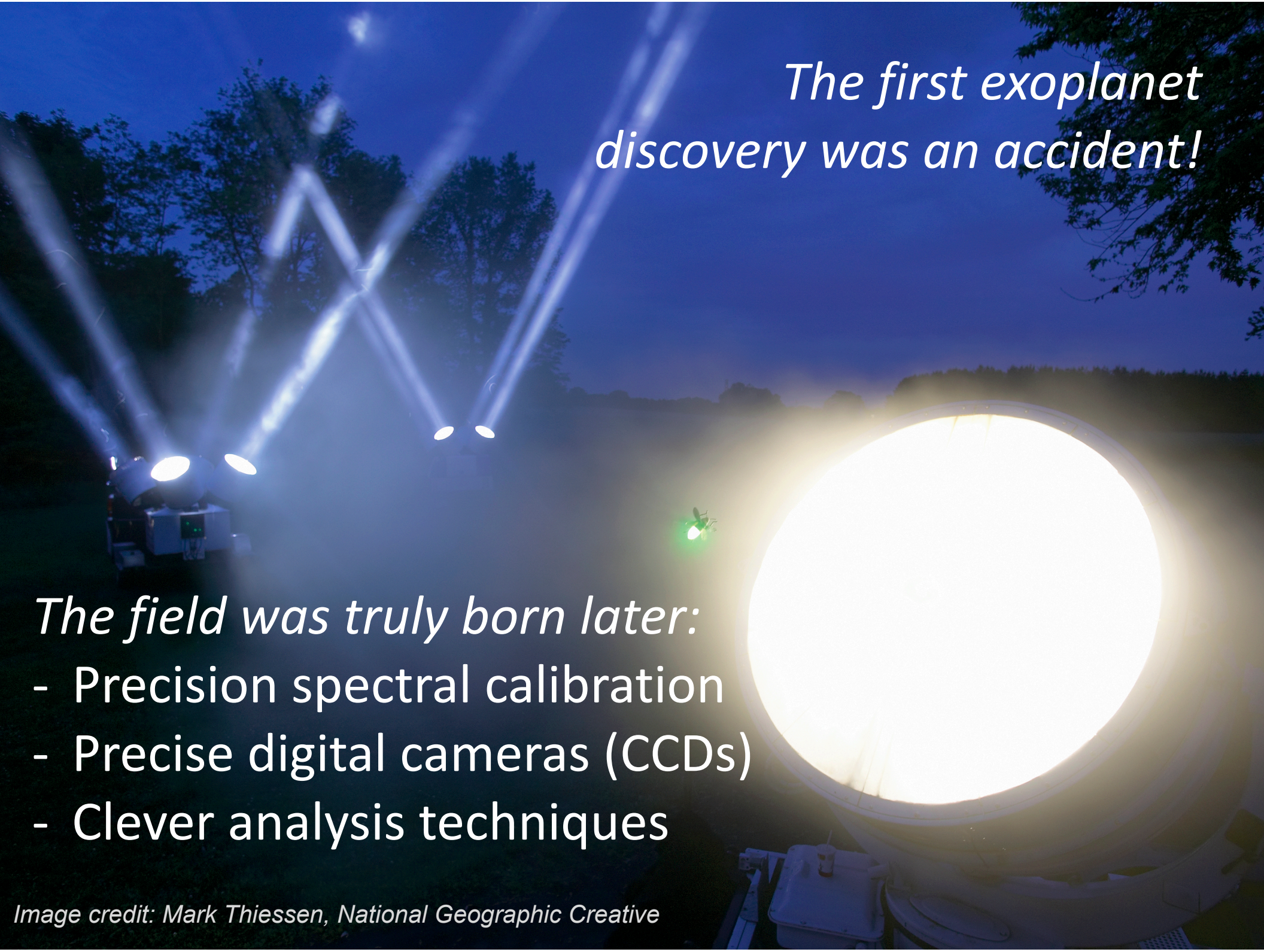


Giordano Bruno (1548-1600) – Italian philosopher, mathematician, ideas man, maverick

- holding opinions contrary to the Catholic faith and speaking against it and its ministers;
- holding opinions contrary to the Catholic faith about the Trinity, divinity of Christ, and Incarnation;
- holding opinions contrary to the Catholic faith pertaining to Jesus as Christ;
- holding opinions contrary to the Catholic faith regarding the virginity of Mary, mother of Jesus;
- holding opinions contrary to the Catholic faith about both Transubstantiation and Mass;
- claiming the existence of a plurality of worlds and their eternity;
- believing in metempsychosis and in the transmigration of the human soul into brutes;
- dealing in magics and divination.

He was arrested by the Roman Inquisition (after being turned over by his patron!)

“Perchance you who pronounce my sentence are in greater fear than I who receive it.”


The first exoplanet discovery was an accident!
The field was truly born later:
- Precision spectral calibration
- Precise digital cameras (CCDs)
- Clever analysis techniques
Image credit: Mark Thiessen, National Geographic Creative

The field today…

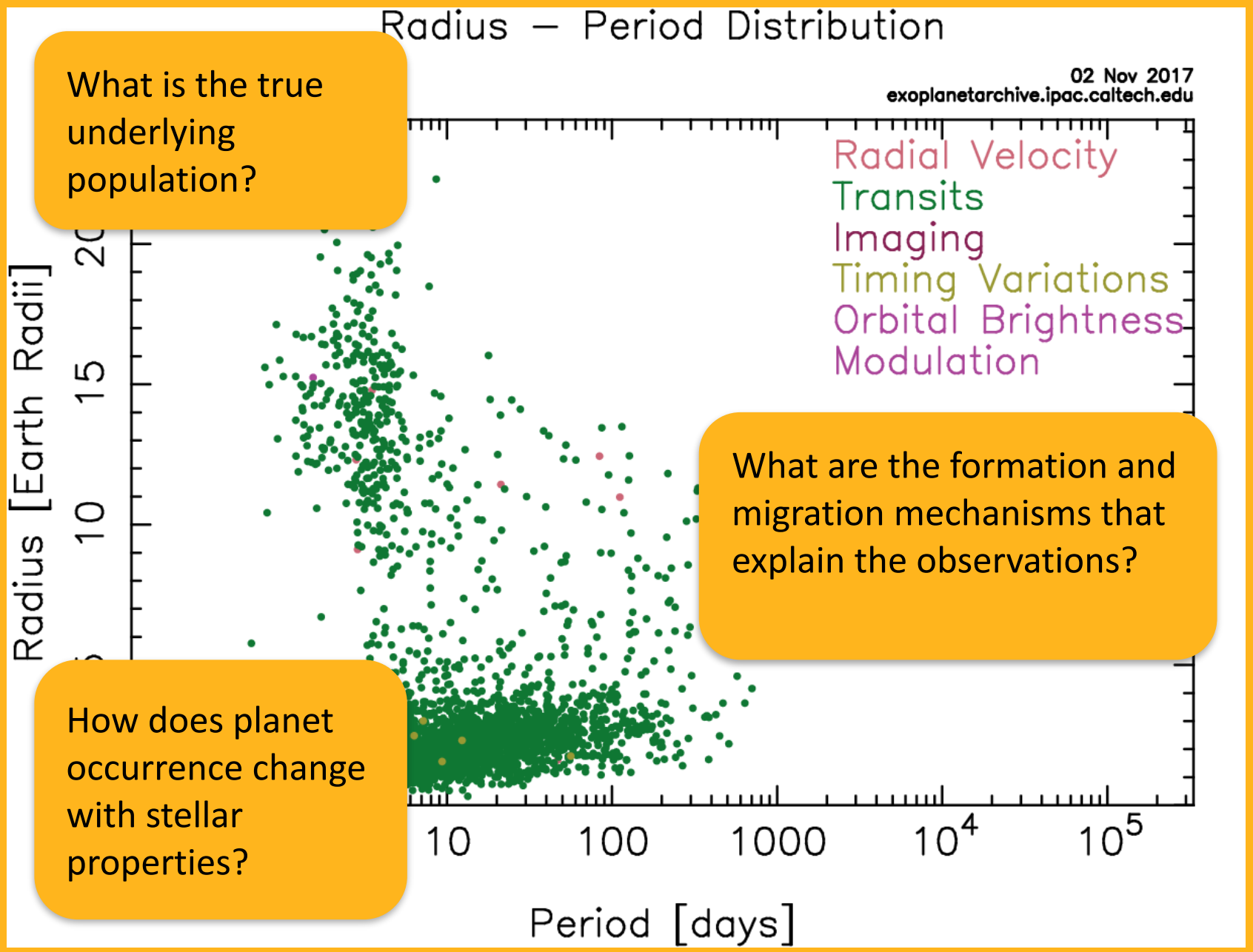
Mass vs. Period

29 years of Exoplanet Discoveries

1989-2017

Plots generated October 30, 2017

Today!

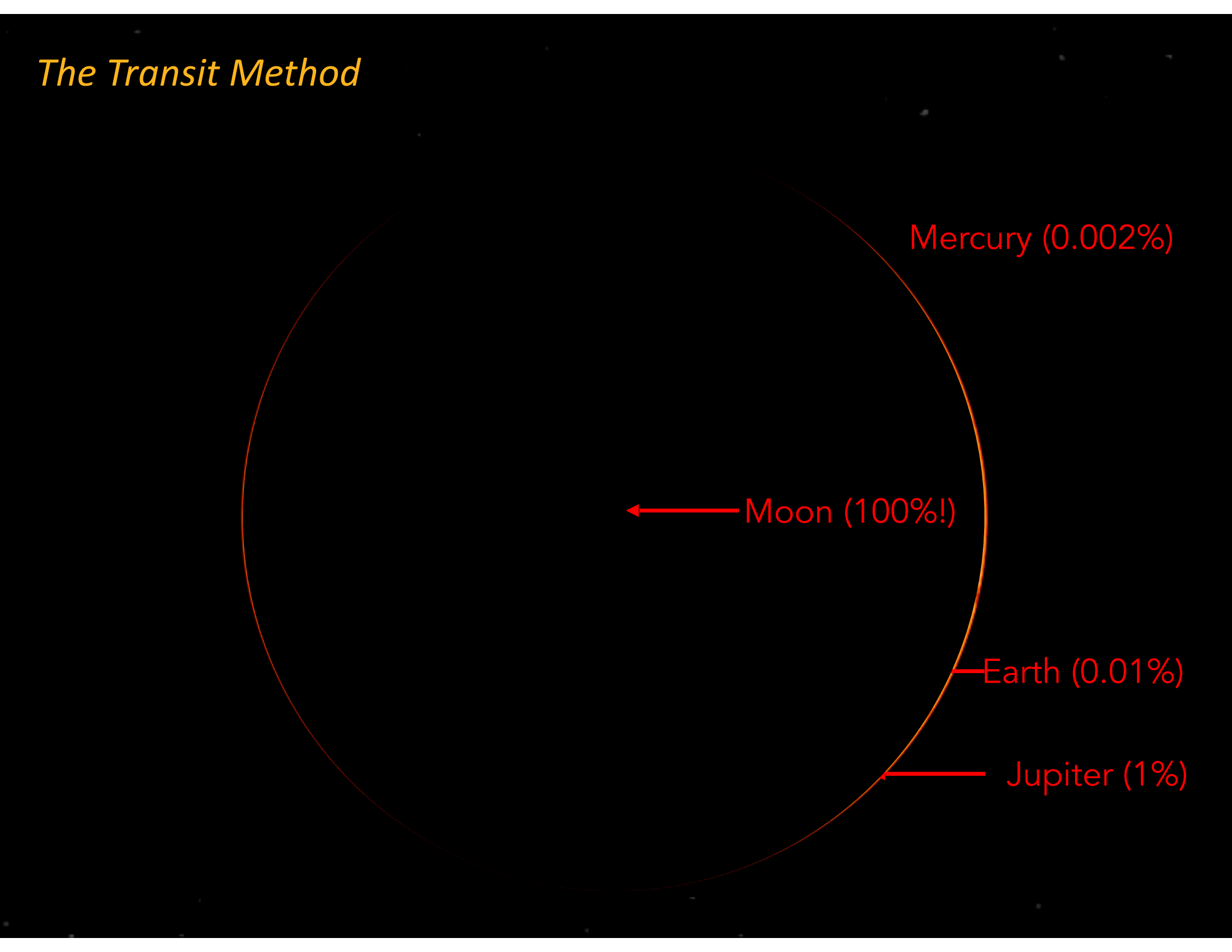


What is the true underlying population?

What are the formation and migration mechanisms that explain the observations?

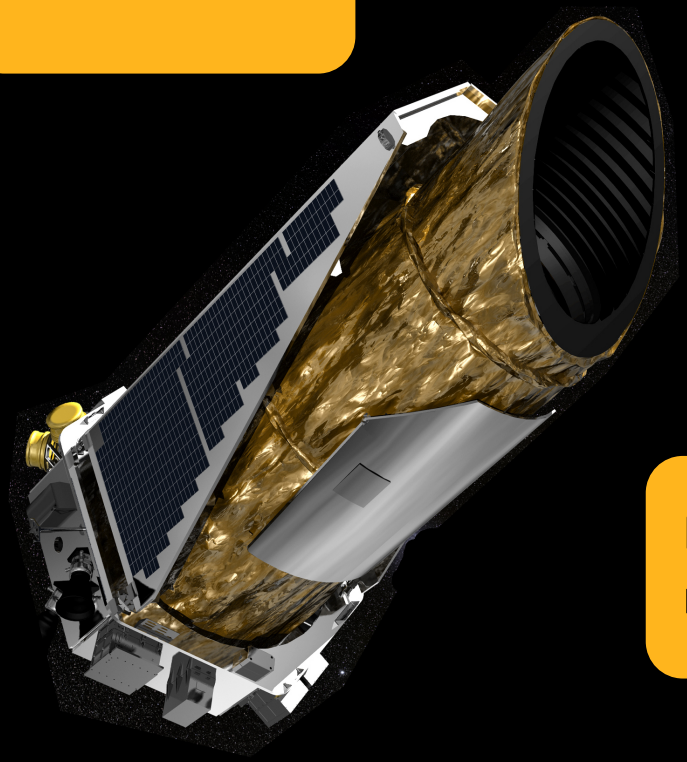
How does planet occurrence change with stellar properties?

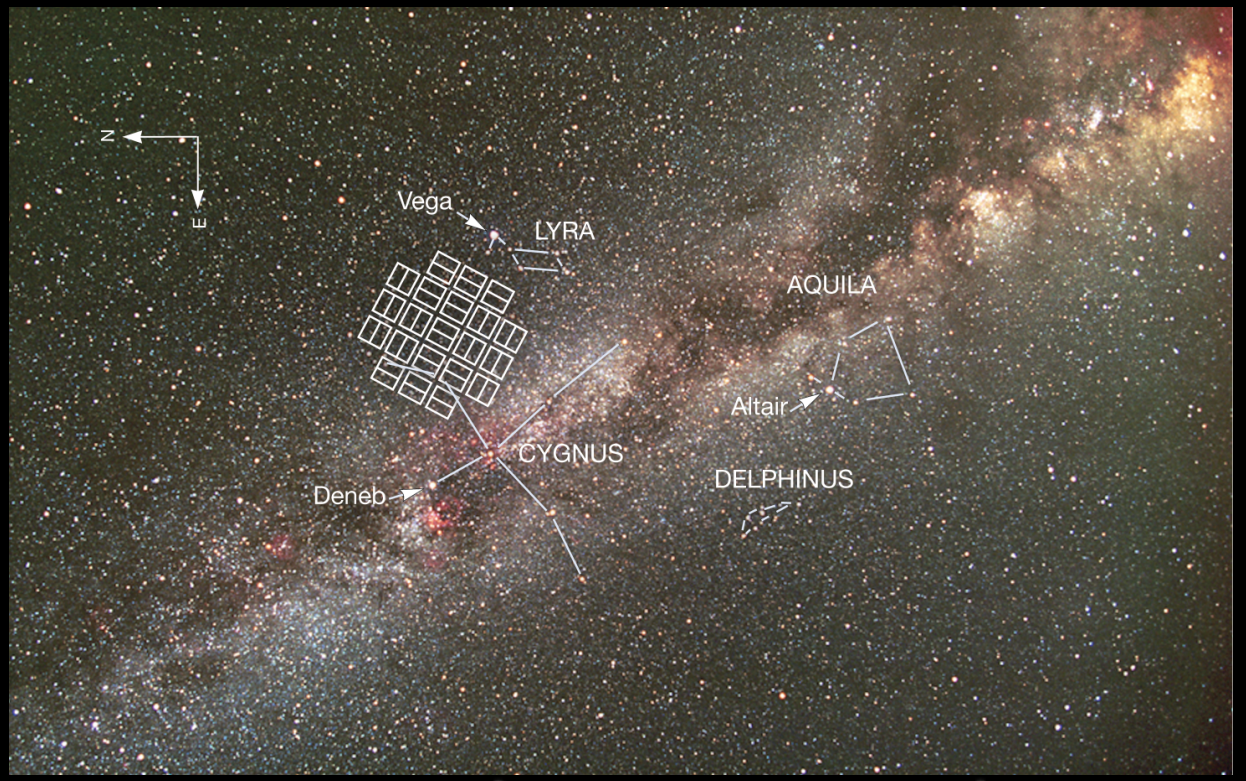
The Transit Method



The NASA Kepler Mission

Launched in 200



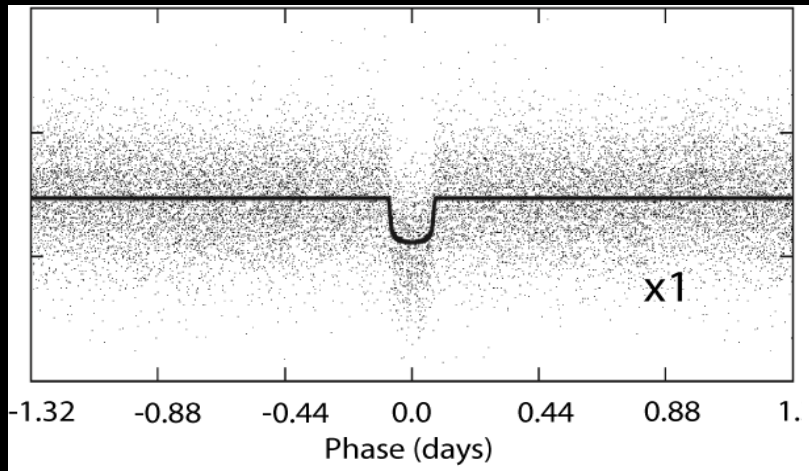


Designed to measure η_{Earth}

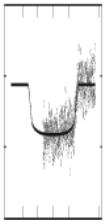
Using the transit method of planet discovery

Monitored 200,000 stars for 4 years

First light curves from Kepler…



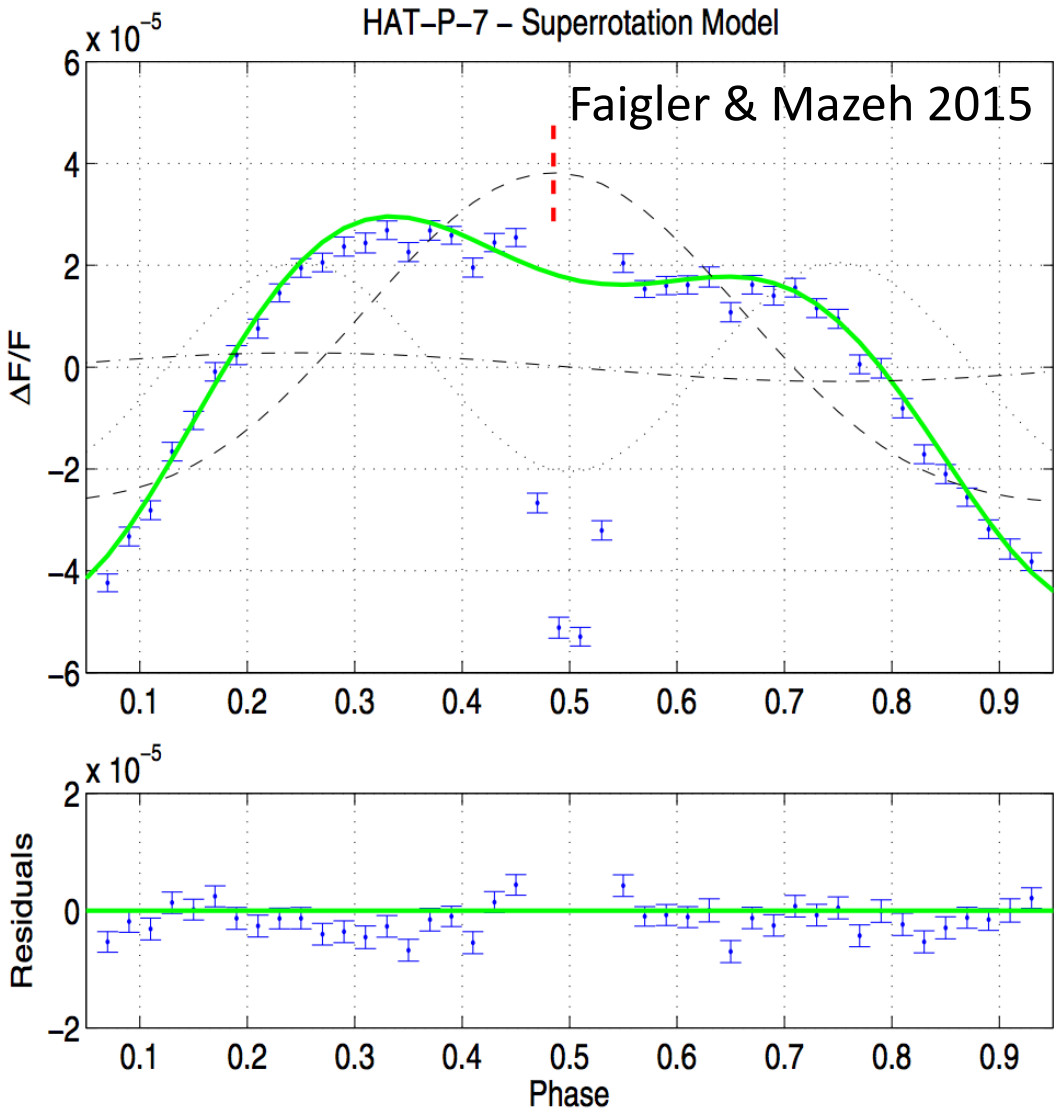
16,620 HATNet data points (57.7 days of data)



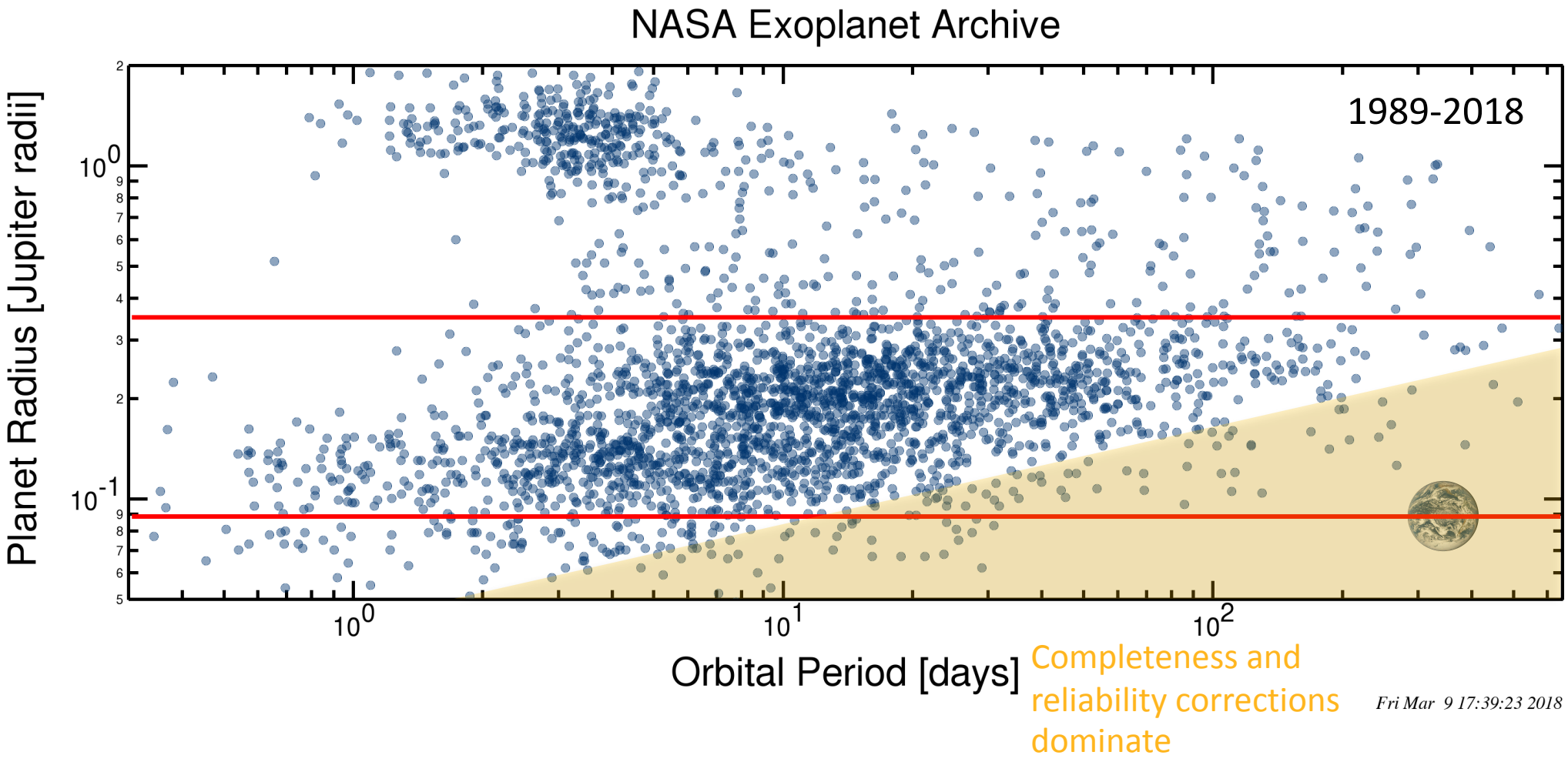
x1

Single night at 1.2 m FLWO with Kepler Cam

HAT-P-7b data from the ground
A. Pal et al., 2008



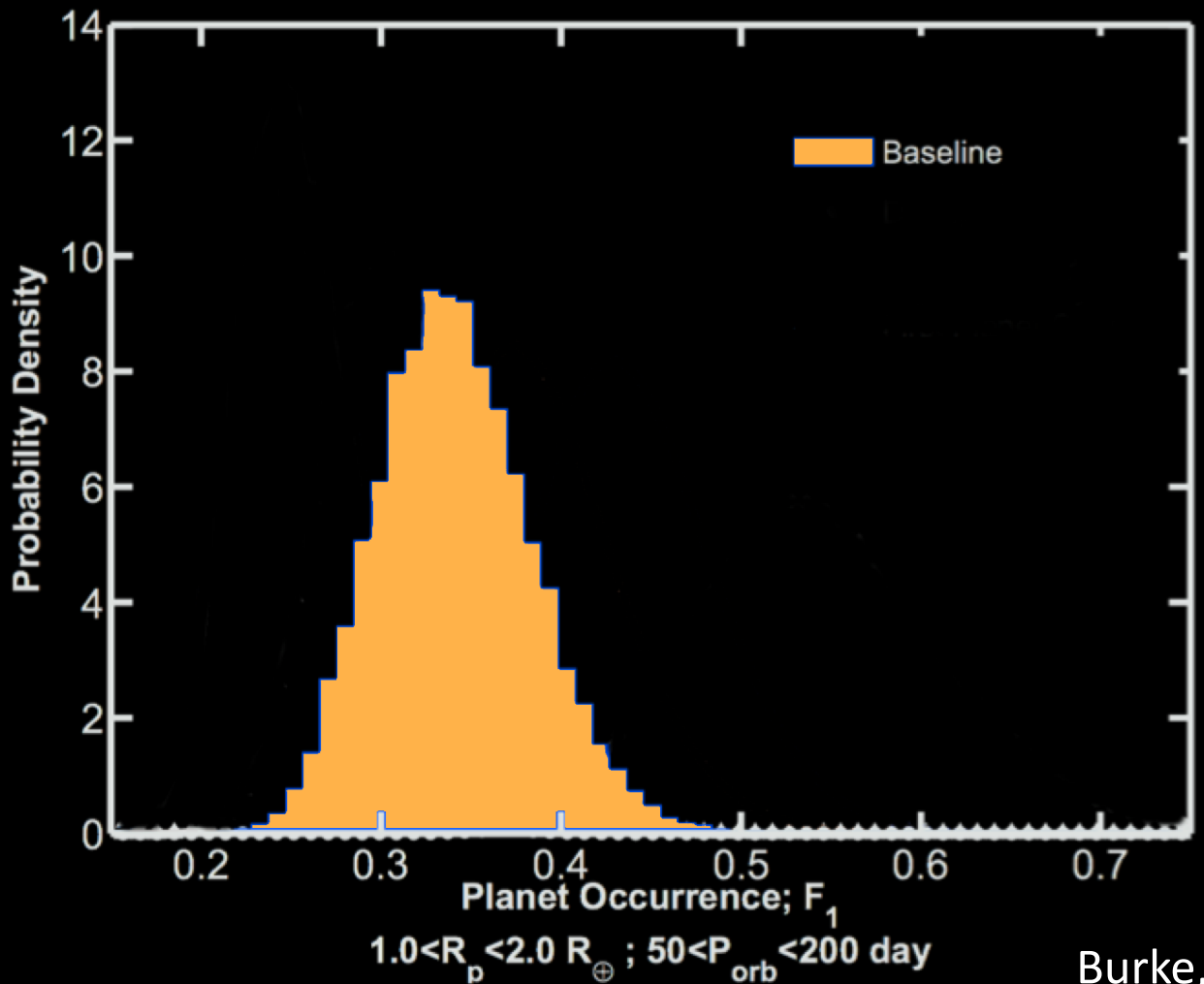
The impact of the Kepler Mission



Thompson et al., accepted

Preliminary planet occurrence rates

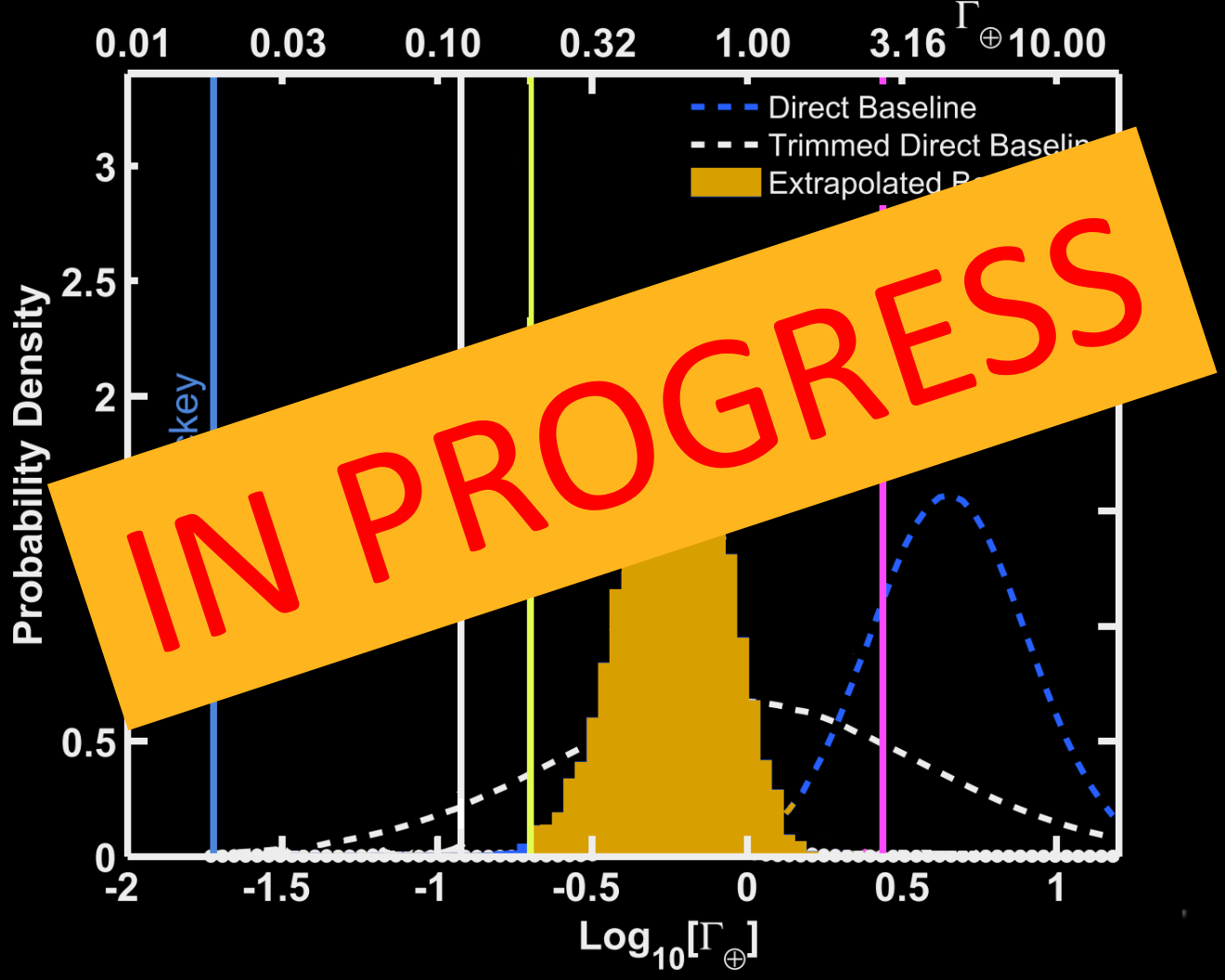
33% of sunlike stars have a planet 1-2Re
with periods from 50-200 days



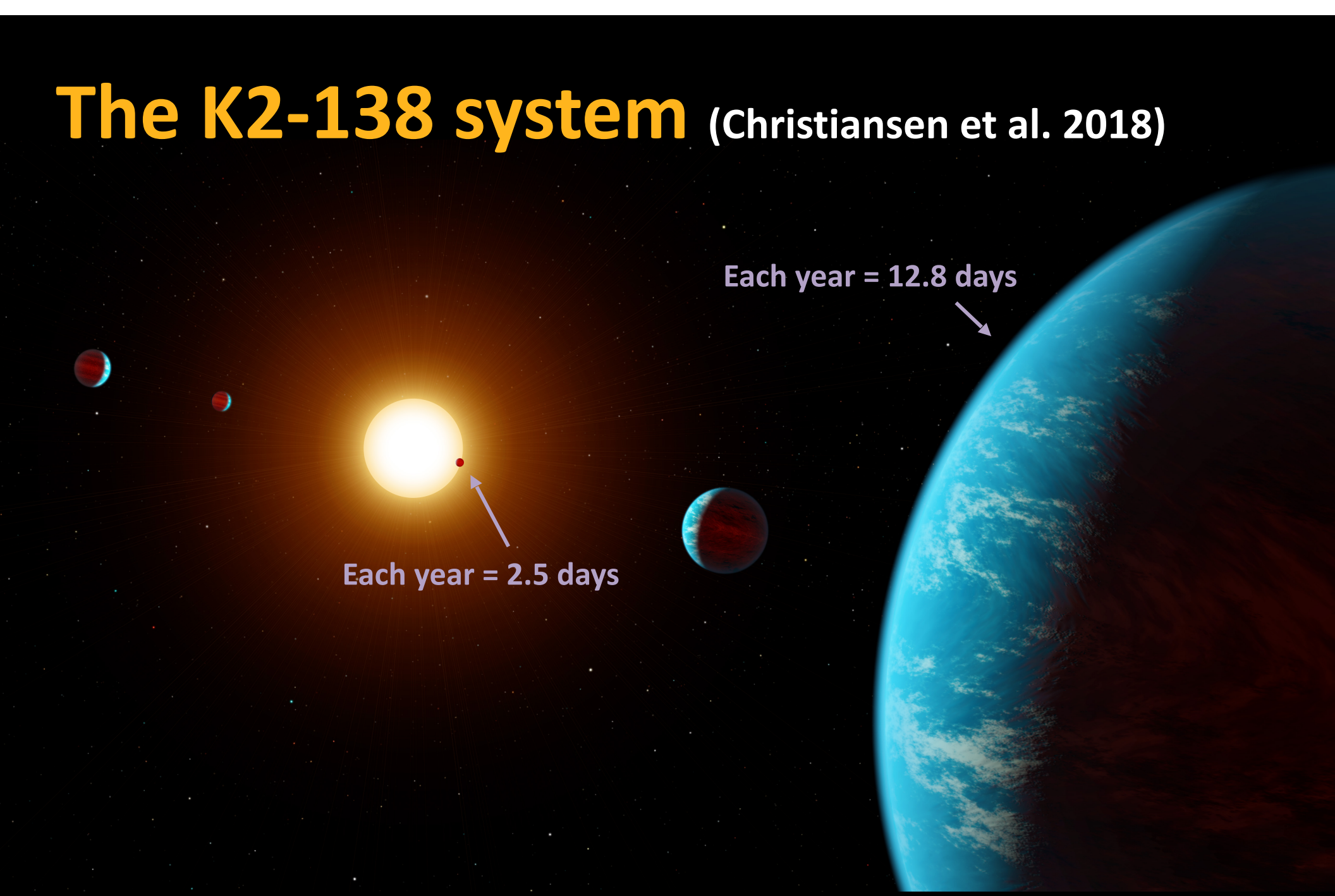
Burke,Christiansen+2015

Extrapolating to longer periods…

50% of sunlike stars have a planet like Earth – but this is still wildly uncertain



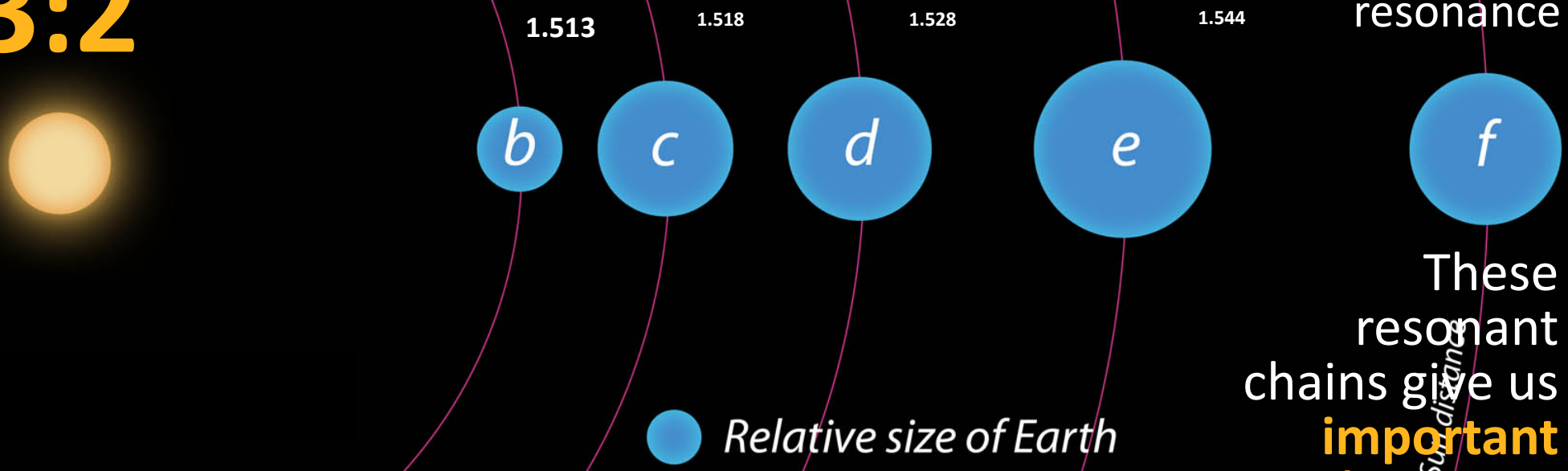
The K2-138 system (Christiansen et al. 2018)



A very compact system of **five sub-Neptune planets**

A Special Spacing…

3:2

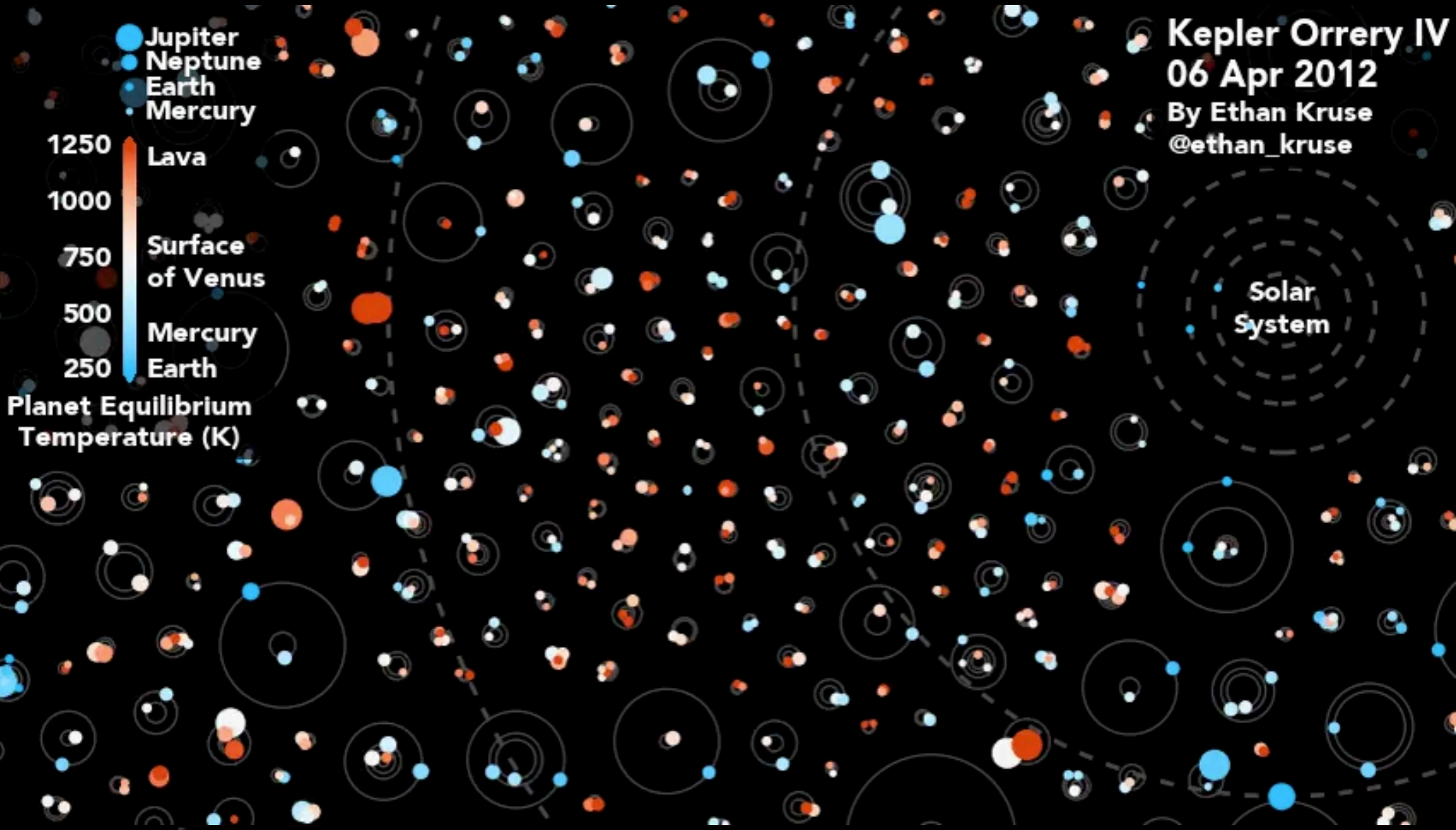


K2-138 has the **longest chain** found close to this type of fundamental resonance

These resonant chains give us **important clues** as to how planets form and migrate

Artwork: Sudiana

The legacy of the NASA Kepler Mission…



The NASA TESS Mission

Launching in ~~2017!~~ 2018!

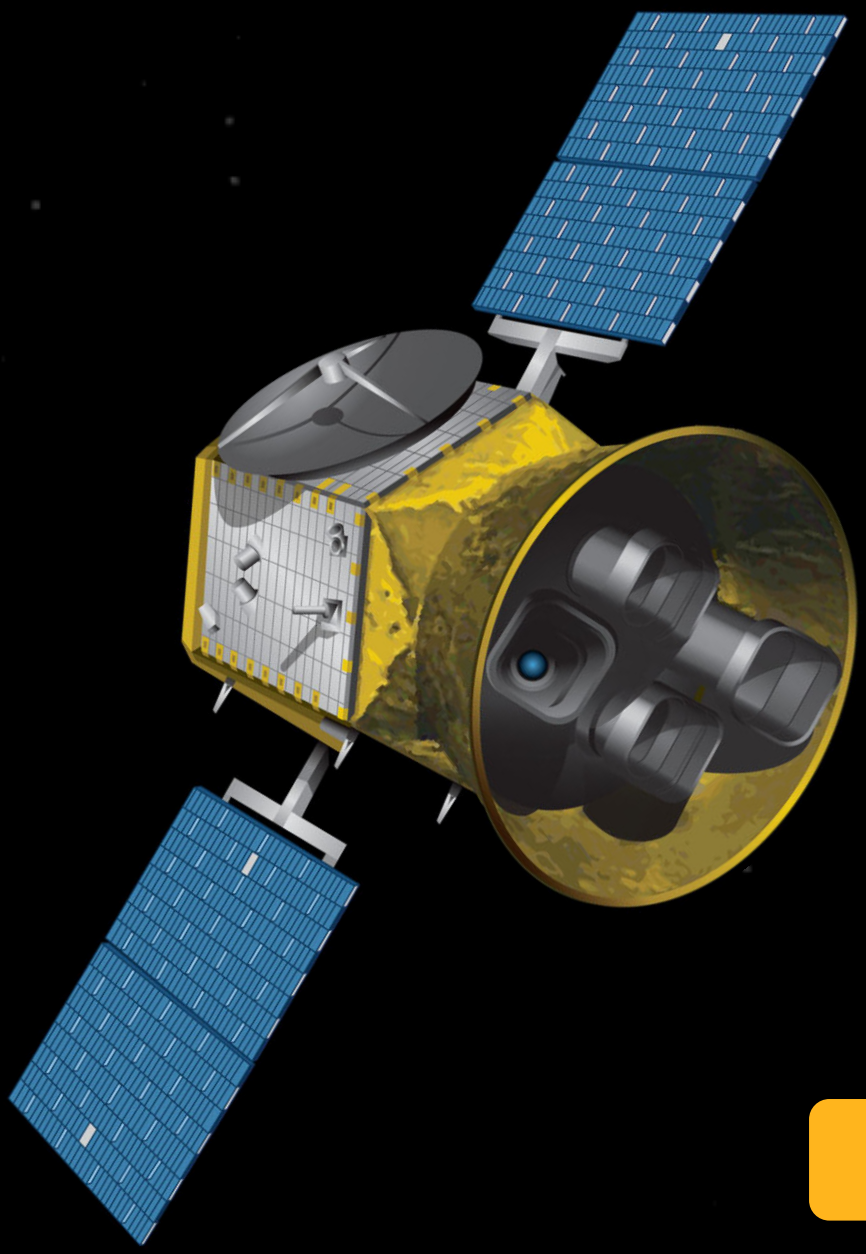
4x10cm optical telescope

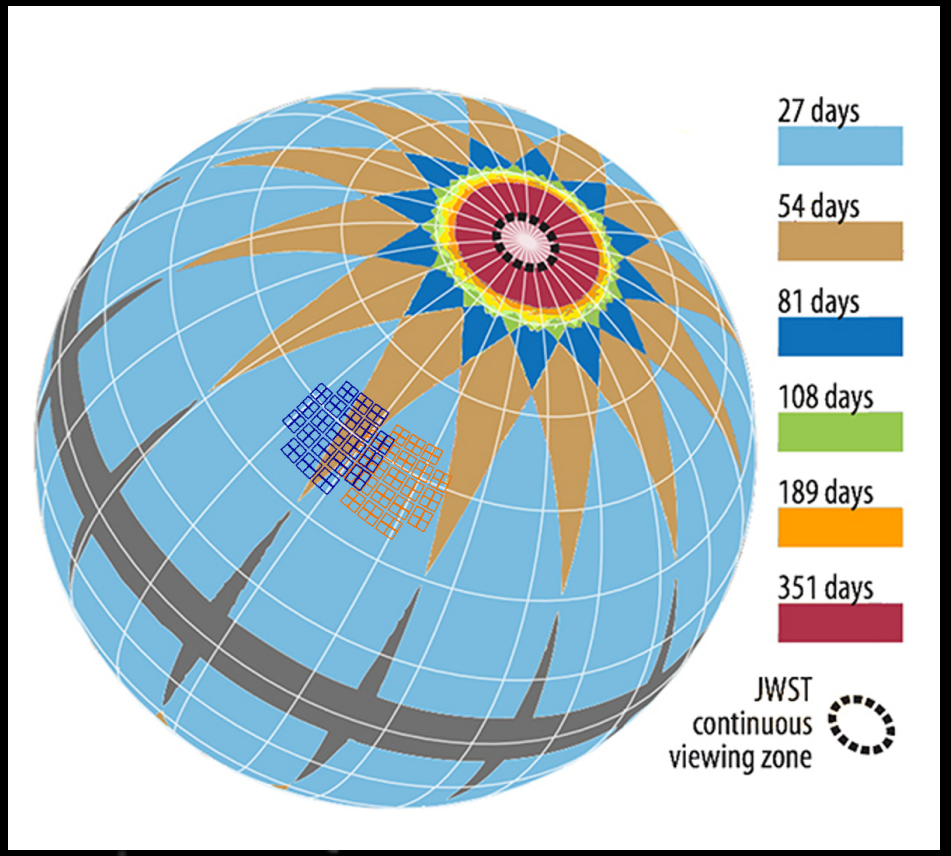
Designed to find nearest planets

Using the transit method of planet discovery

Monitoring 200,000 stars for up to 1 year

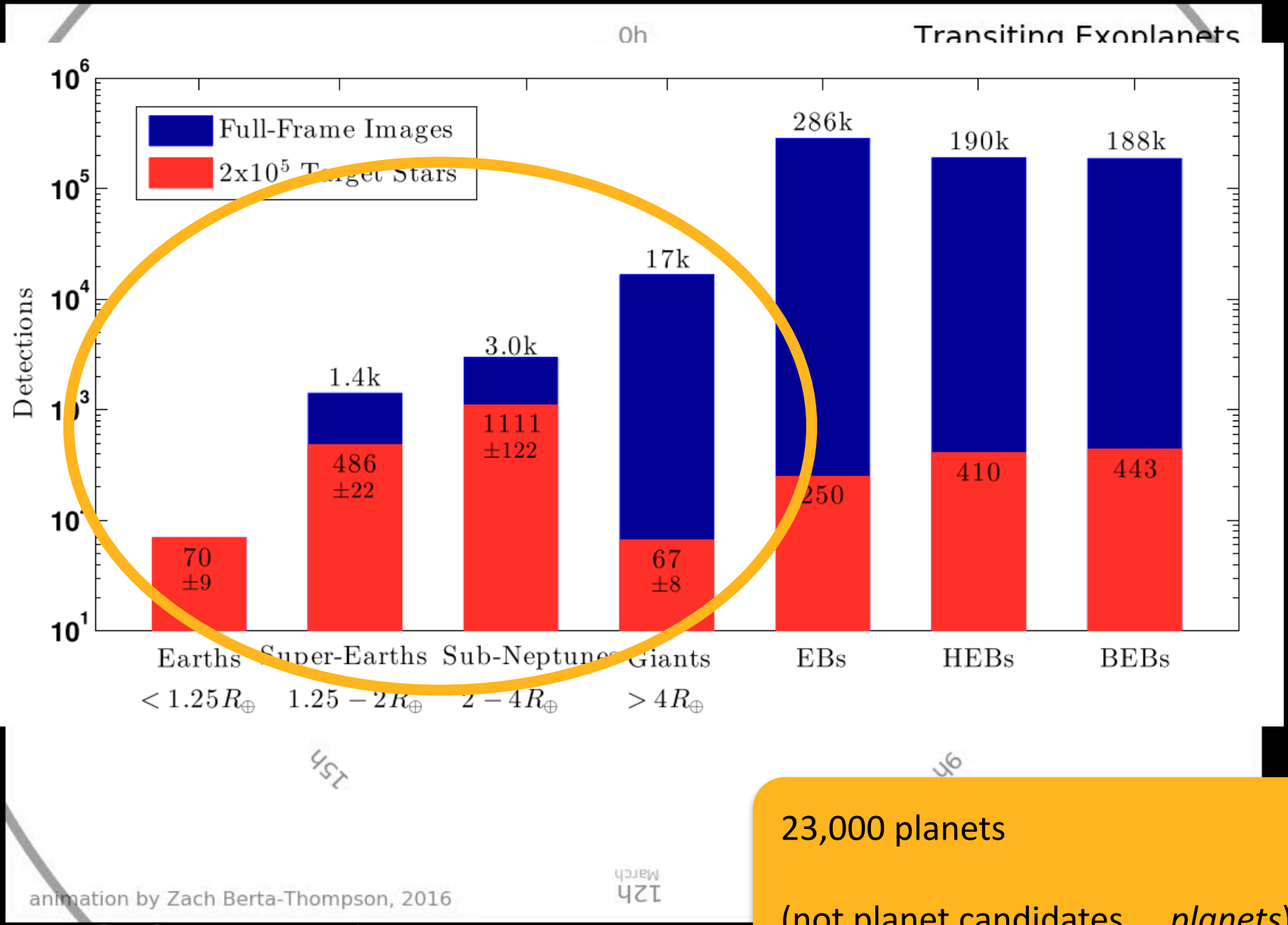
The NASA TESS Mission





TESS observing strategy video

The NASA TESS Mission



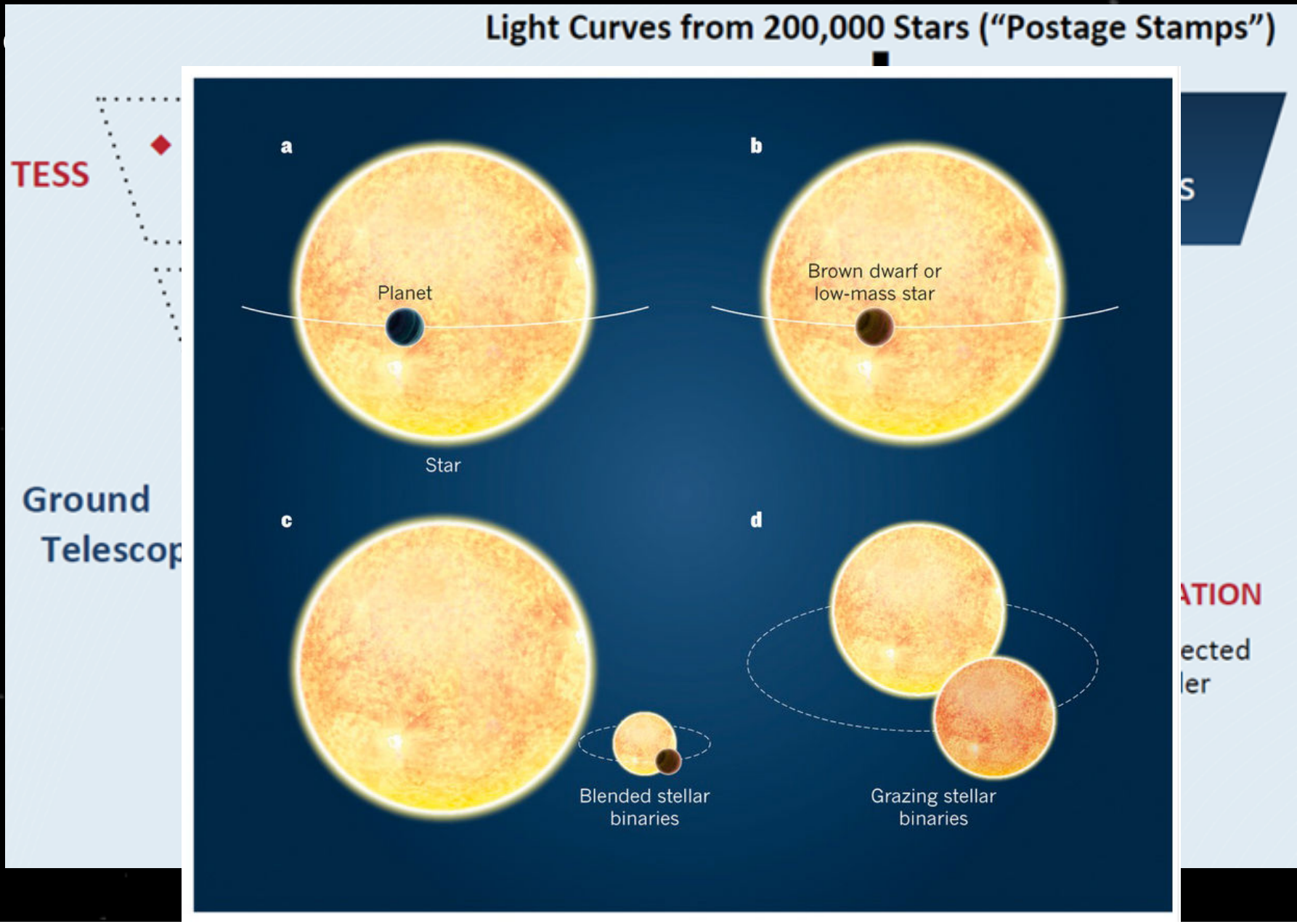
23,000 planets

(not planet candidates.... *planets*)

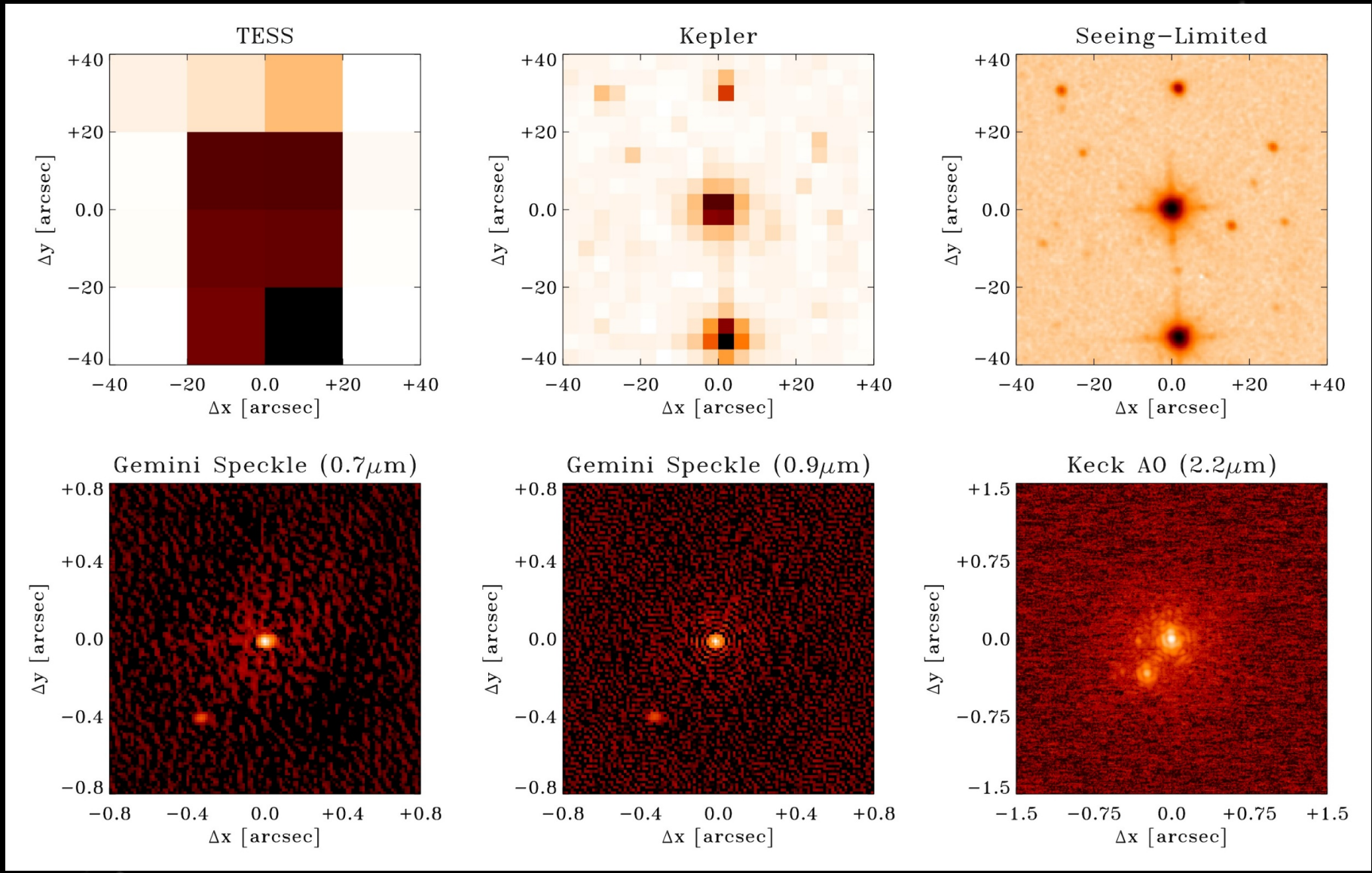
Following up TESS Planet Candidates

TESS is going to have a LOT of planet candidates…

… An



TESS has big pixels…



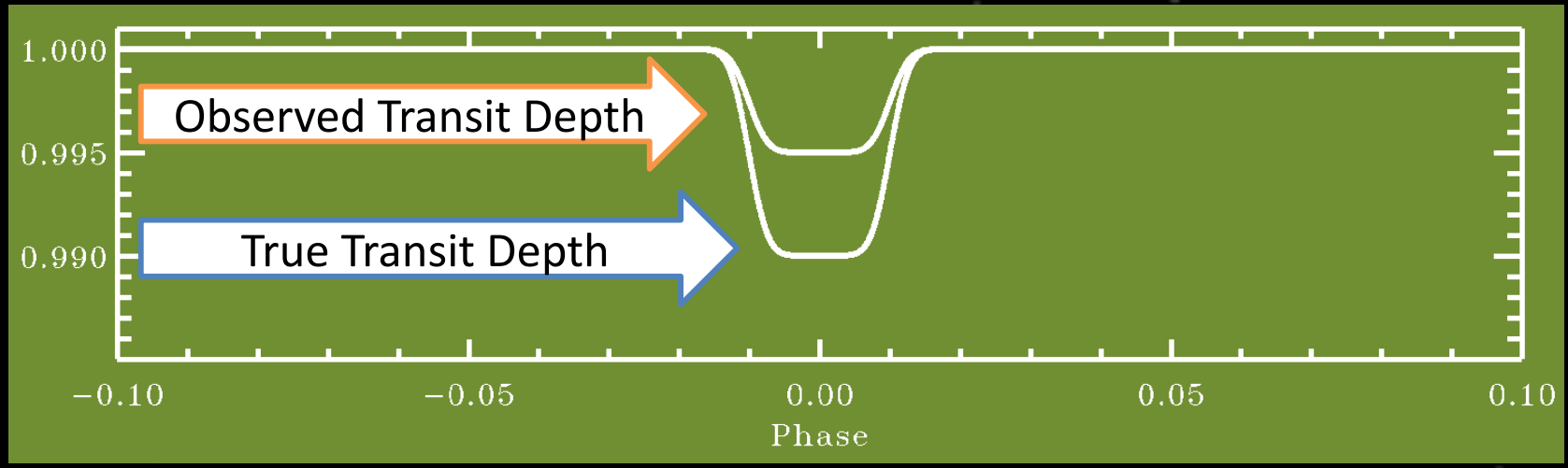
Ciardi+2017

Ground-based, seeing-limited photometry

Most pixels will have >1 stars!

We will need a much larger ground-based effort to identify the source of the transit signal and to identify which are the most promising candidates after correcting the resulting planet parameters

*Contamination is one of the metrics for selecting the 200,000 target stars



How can St. Mary's get involved?

The TESS Follow-up Observing Program (TFOP) has organised a series of sub-groups

Karen Collins (karenacollins@outlook.com) is marshalling the army of ground-based resources – small telescopes in use by colleges or amateurs across the world

The instruments on hand at the Geissberger Observatory position St Mary's to continue Ron Olowin's legacy

Candidates will be released on a ~monthly basis for at least 2 years – there will always be more things to **observe!**


Thank you…
…Ron and Mary Olowin
…Jane and Louis Geissberger
…St Mary's College of California
…my excellent colleagues
…my wonderful family
SAINT MARY'S COLLEGE of CALIFORNIA