

# Transiting Exoplanet Targets for JWST Expected from the TESS Mission

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**Workshop on Transit Observing with JWST  
Pasadena CA  
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## **MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MKI + LL)**

PI, Payload, Science Center

## **NASA'S GODDARD SPACE FLIGHT CENTER**

Mission Management, Engineering, Safety & Mission Assurance, E/PO

## **ORBITAL SCIENCES CORPORATION**

Spacecraft Bus, Observatory I&T, Mission Operations Center

### **NASA AMES**

Data Pipeline

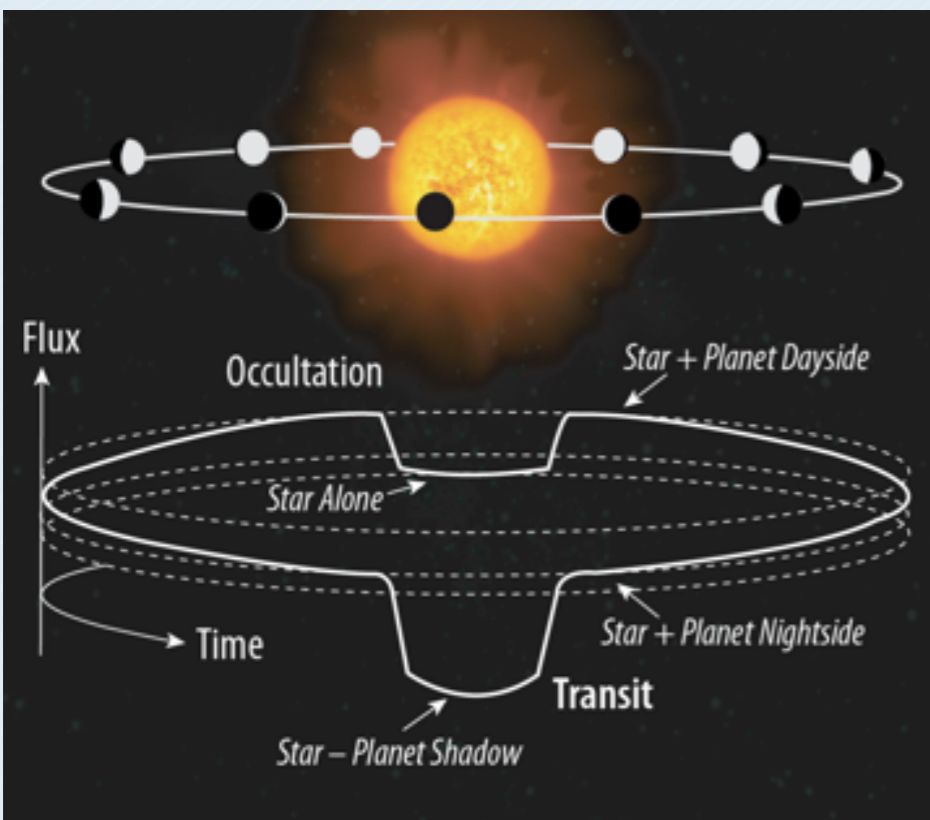
### **SAO**

Follow-Up Program,  
Science Center

### **STScI**

Archive, E/PO

Contributors include: SAO, MPIA-Germany, Las Cumbres Observatory, Geneva Observatory, OHP-France, University of Florida, Aarhus University-Denmark, Harvard College Observatory, STScI, and Vanderbilt University. There are no mission hardware contributions.

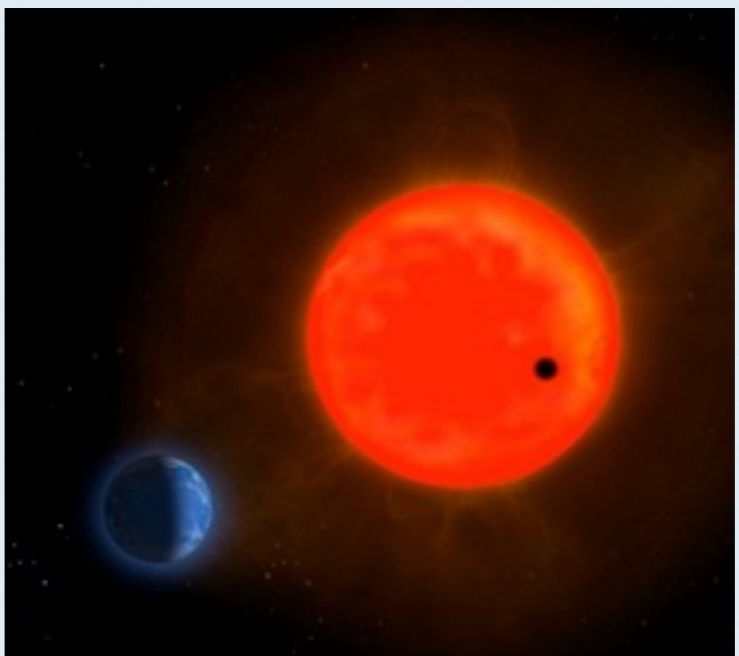


- ◆ **Primary Goal:** Discover Transiting Earths and Super-Earths Orbiting Bright, Nearby Stars
  - *Rocky Planets & Water Worlds*
  - *Habitable Planets*
- ◆ Discover the “Best” ~1000 **Small** Exoplanets
  - “Best” Means “Readily Characterizable”
    - *Bright Host Stars*
    - *Measurable Mass & Atmospheric Properties*
  - Present: Only 2 small transiting exoplanets orbiting bright hosts are known

◆ **Large Area Surveys of Bright Stars**

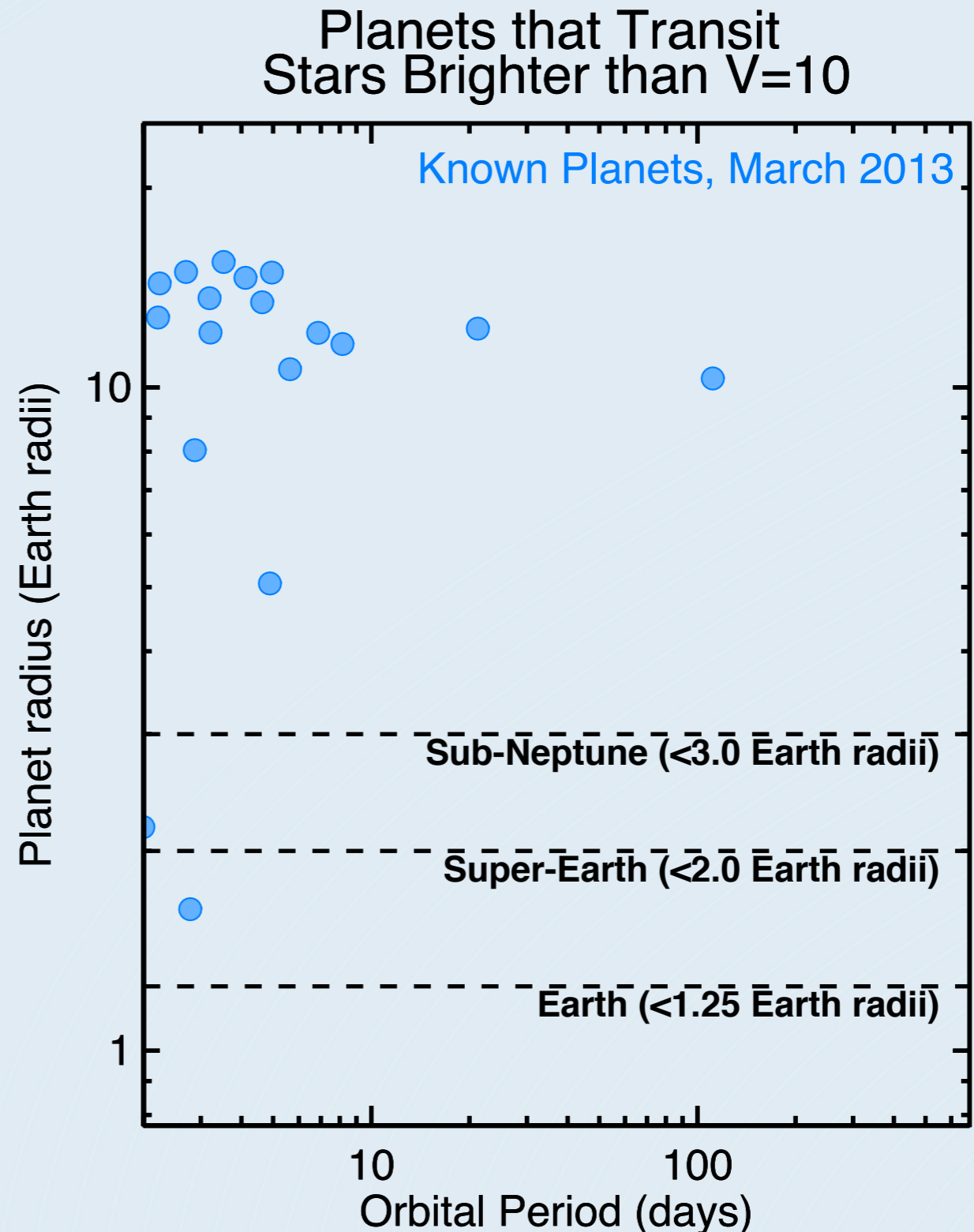
- *F, G, K dwarfs: +4 to +12 magnitude*
- *M dwarfs known within ~60 parsecs*
- *>200,000 target stars in two years*

**Launch in August 2017**



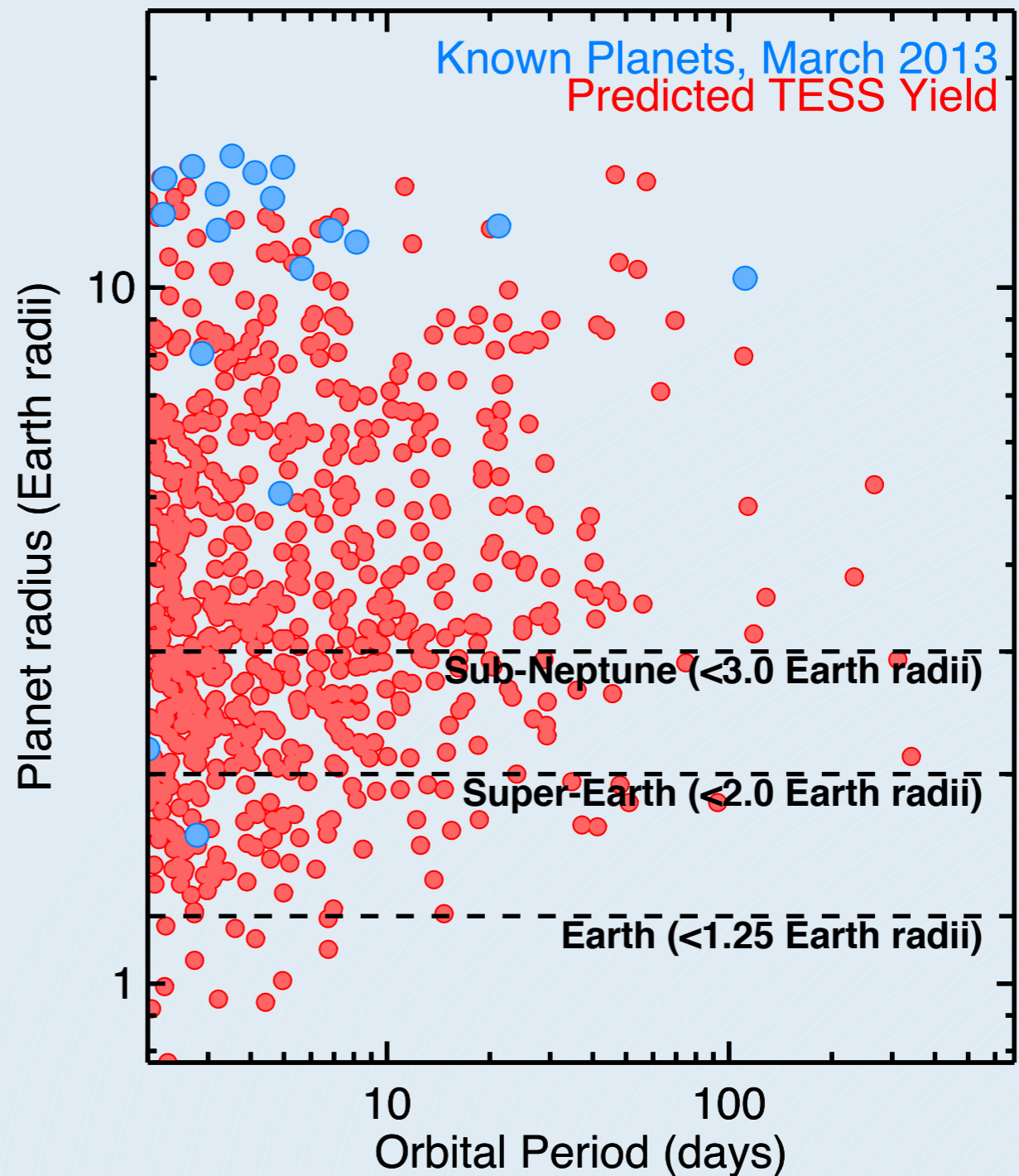


- ◆ **Kepler:** The most common members of the exoplanet family are Earths and Super-Earths
- ◆ Population of characterizable Earths and Super-Earths is extremely impoverished
- ◆ Two smallest transiting exoplanets with bright hosts were discovered from space:
  - *Kepler-21b: Kepler Team*
  - *55 Cnc e: MOST [Co-I Josh Winn]*



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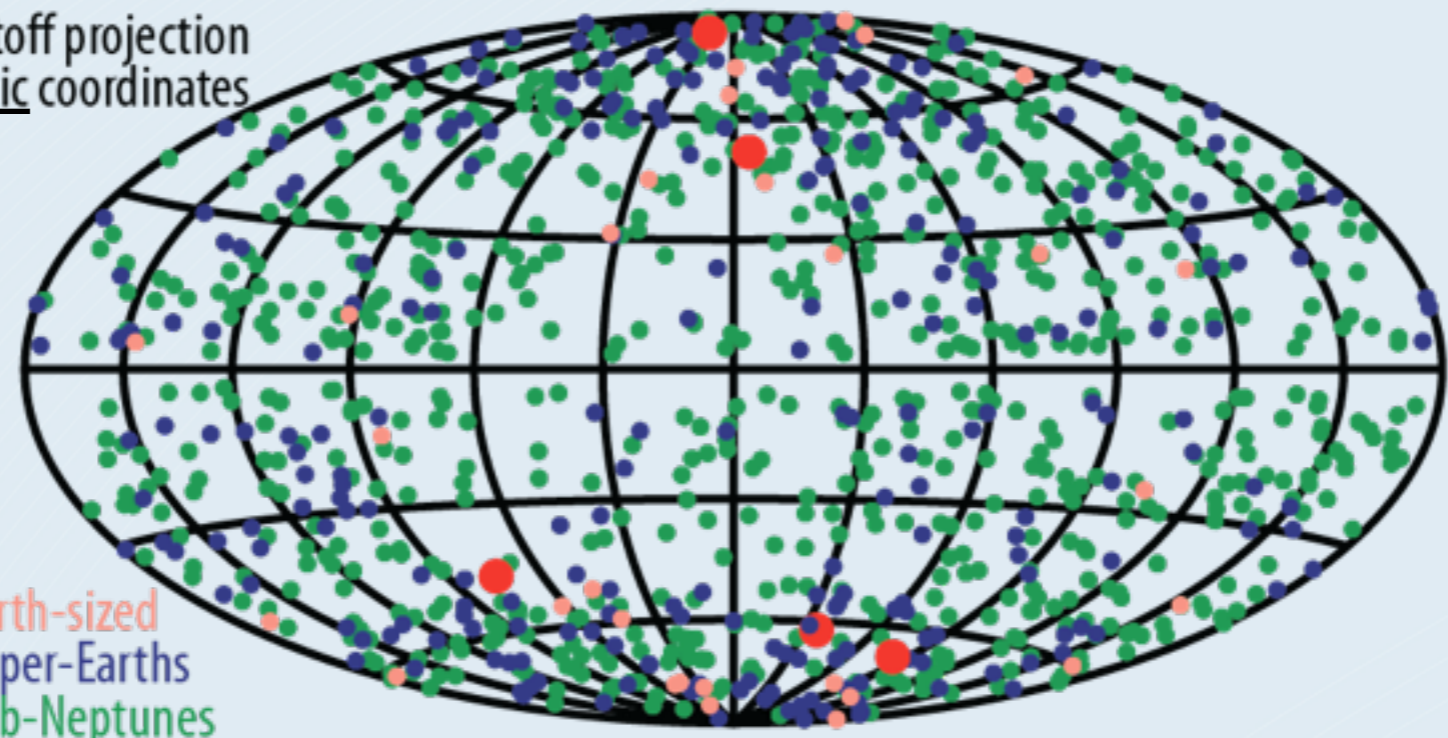
Planets that Transit Stars Brighter than  $V=10$



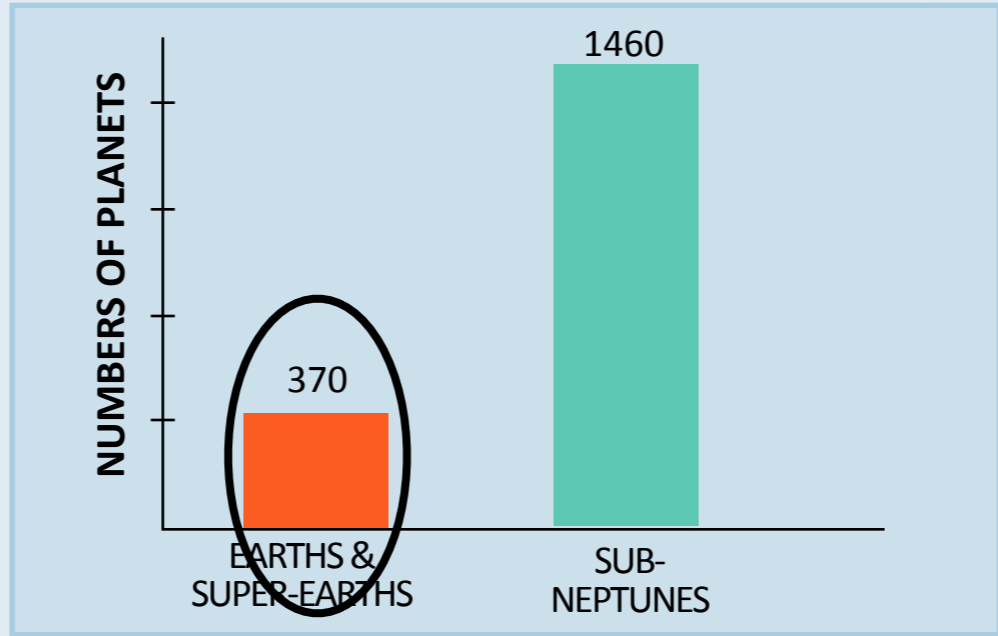
**TESS Will Discover the Earths and Super-Earths Transiting the Brightest & Nearest Stars**



Aitoff projection  
Ecliptic coordinates



- Earth-sized
- Super-Earths
- Sub-Neptunes
- Habitable zone,  $< 2R_E$

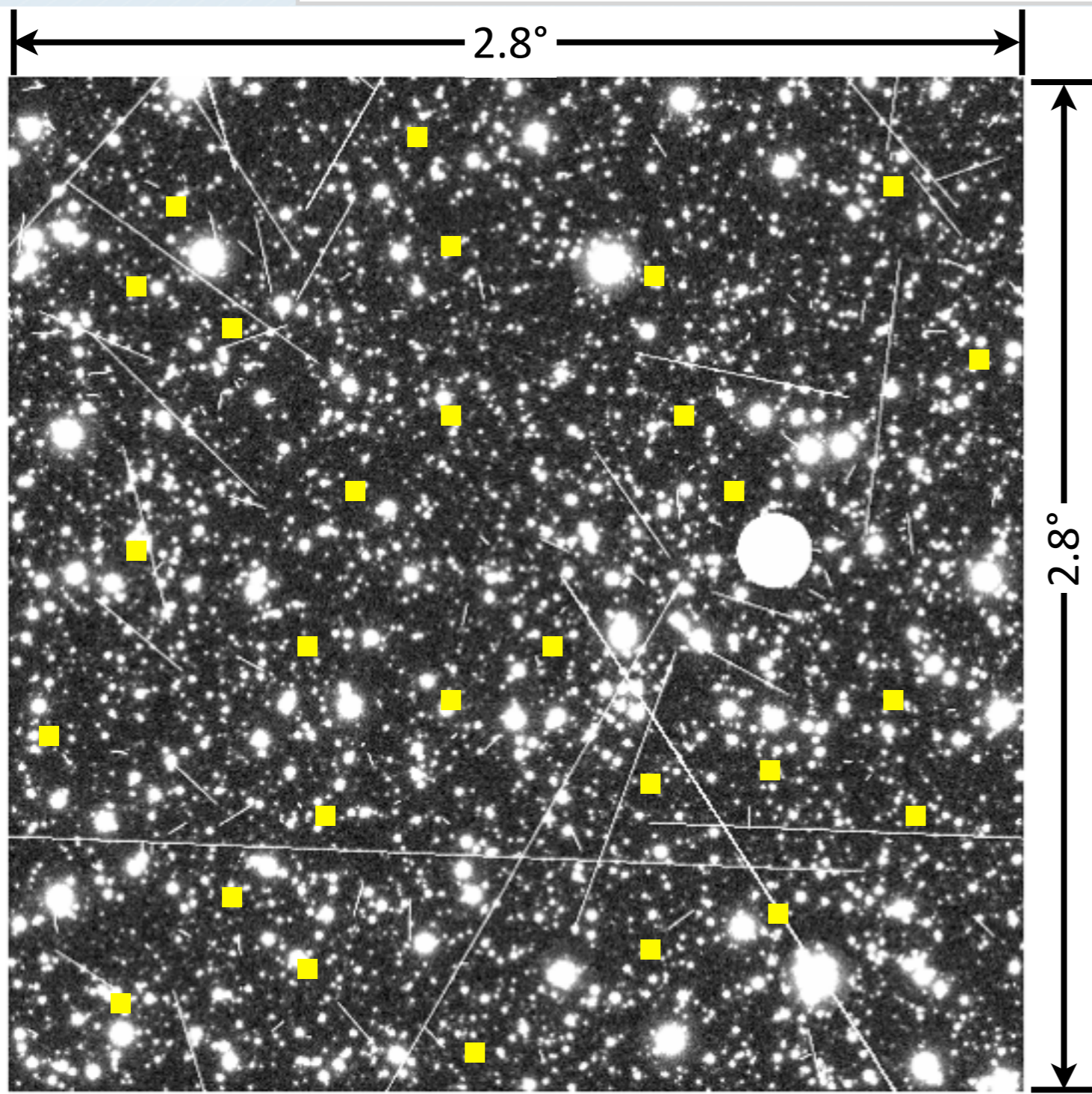


**TESS Will Discover ~300 Earths & Super-Earths**



# Simulated 1/2 Hour Stacked Full Frame TESS Image

■ = Targeted 10x10 "Postage Stamps"



Definition:

Full Frame Image = FFI = 100% of FOV  
 cf: 10x10 "postage stamps" = 2% of FOV

FFI Stack:

900 TESS images @ 2s/integration

Portion of Image Stack Shown:

= 7.8 deg<sup>2</sup> out of 570 deg<sup>2</sup>/camera  
 = 0.34% of instantaneous TESS FOV

Limiting Mag in I Band	S/N Ratio Achieved by TESS in 30 minutes	# Stars* in 40,000 deg
12	1350	≈
13	600	≈
14	250	≈

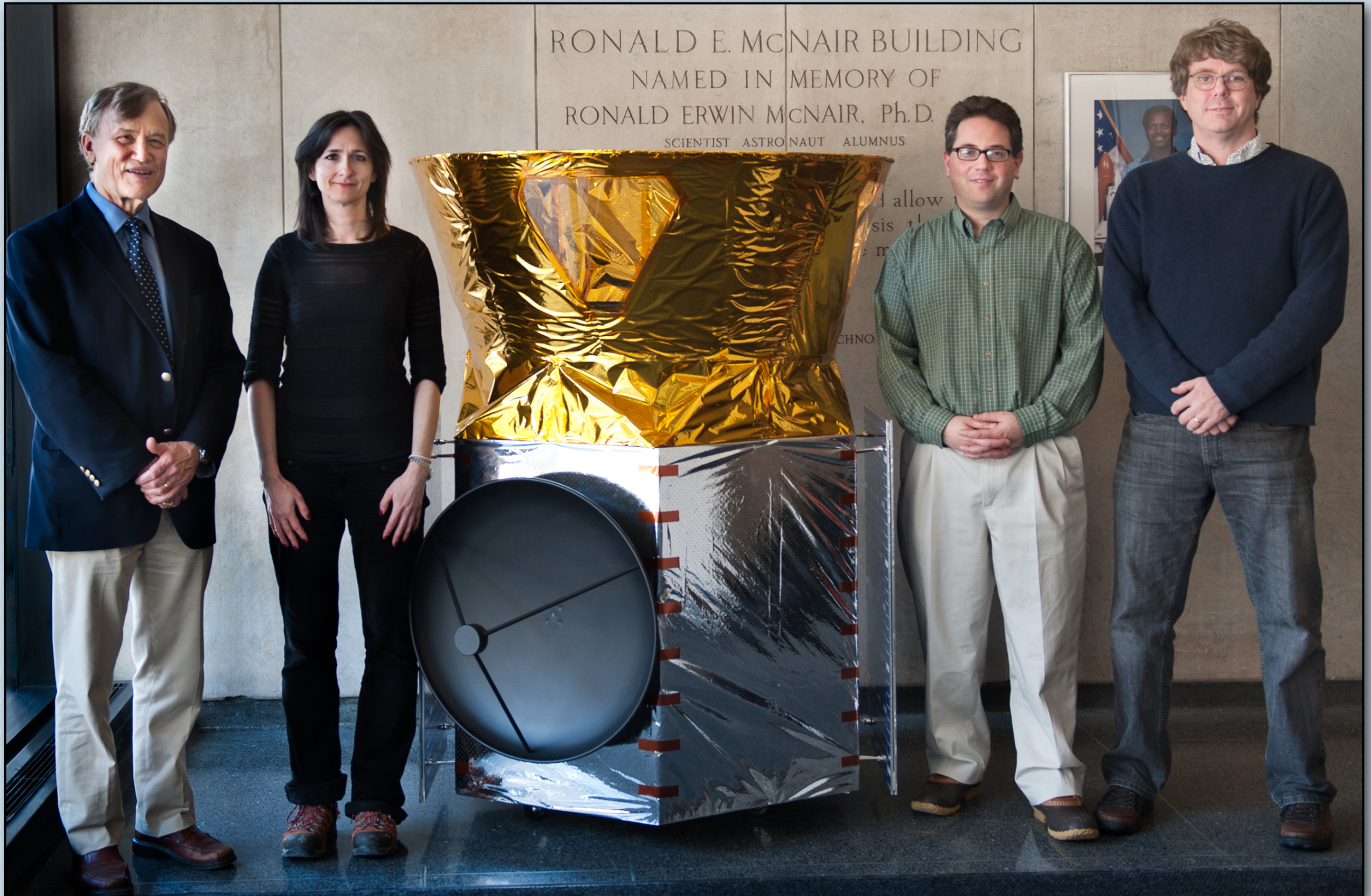
\*R band mean star counts from Bahcall & Soneira (1980) re-scaled to I band assuming R-I = +1.0 mag, appropriate for early M stars.

**TESS Can Provide FFI's at Kepler's 30 Minute Cadence**

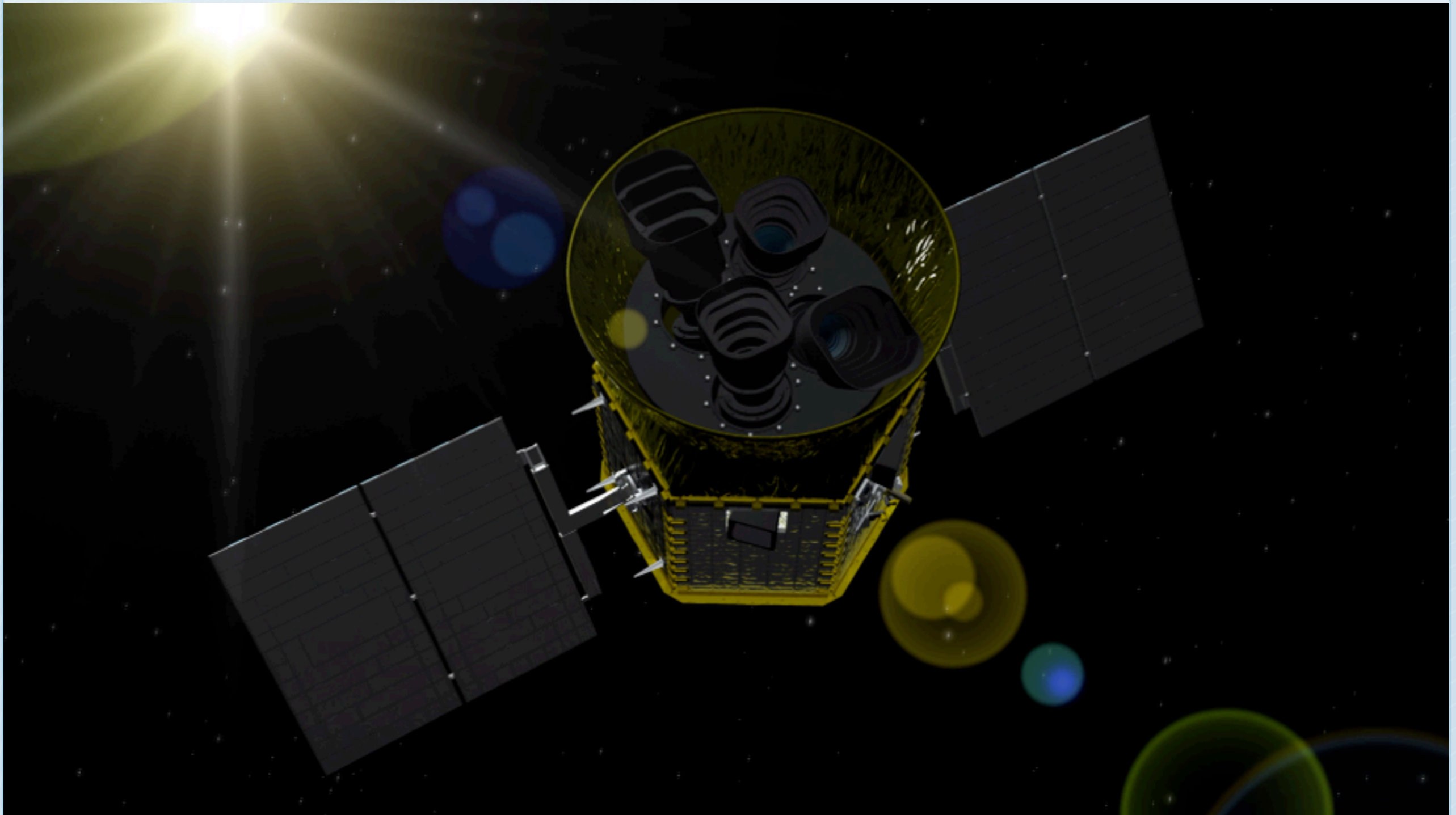


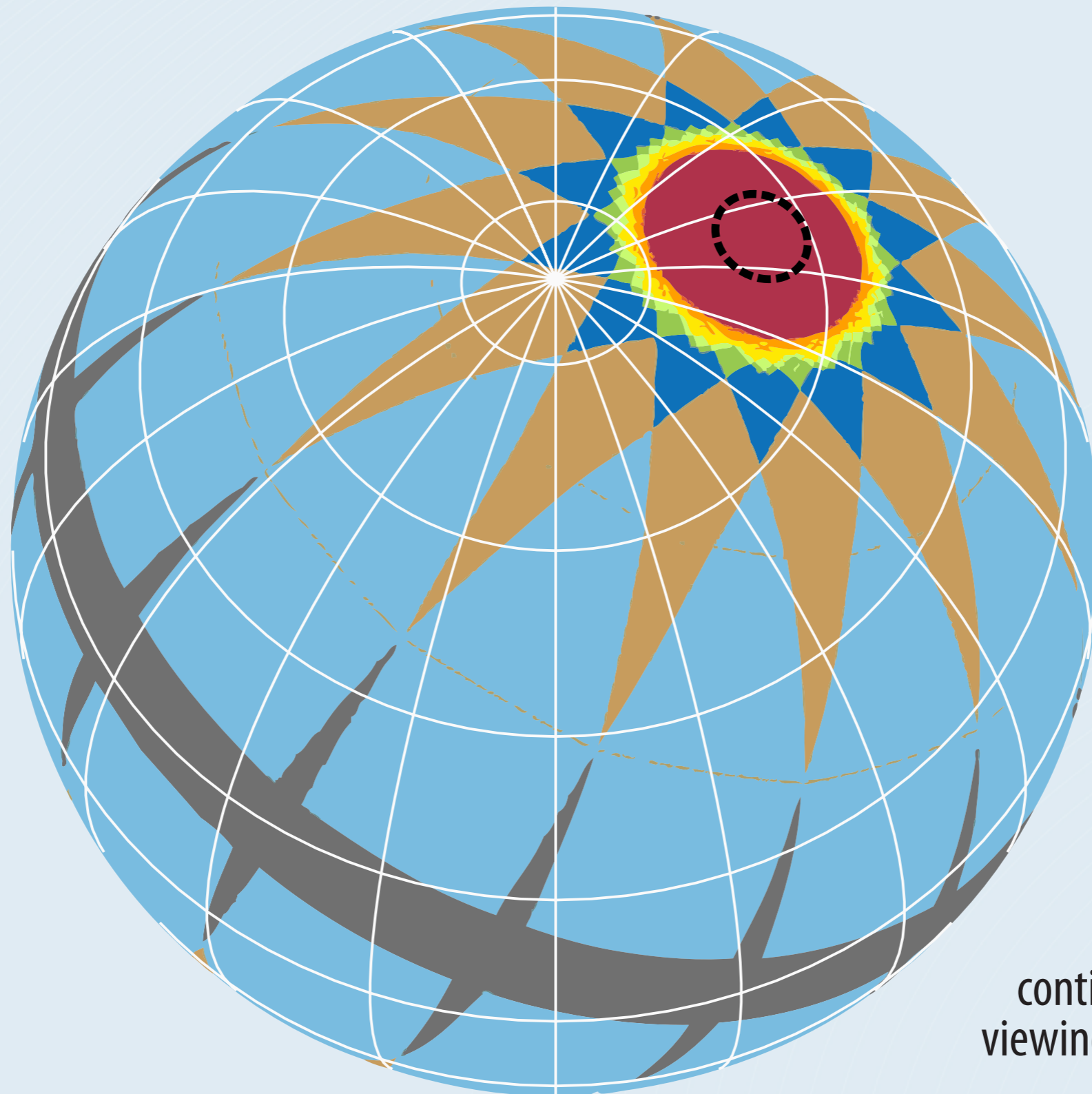












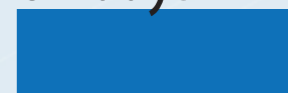
27 days



54 days



81 days



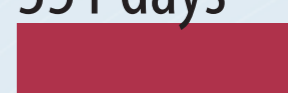
108 days



189 days



351 days



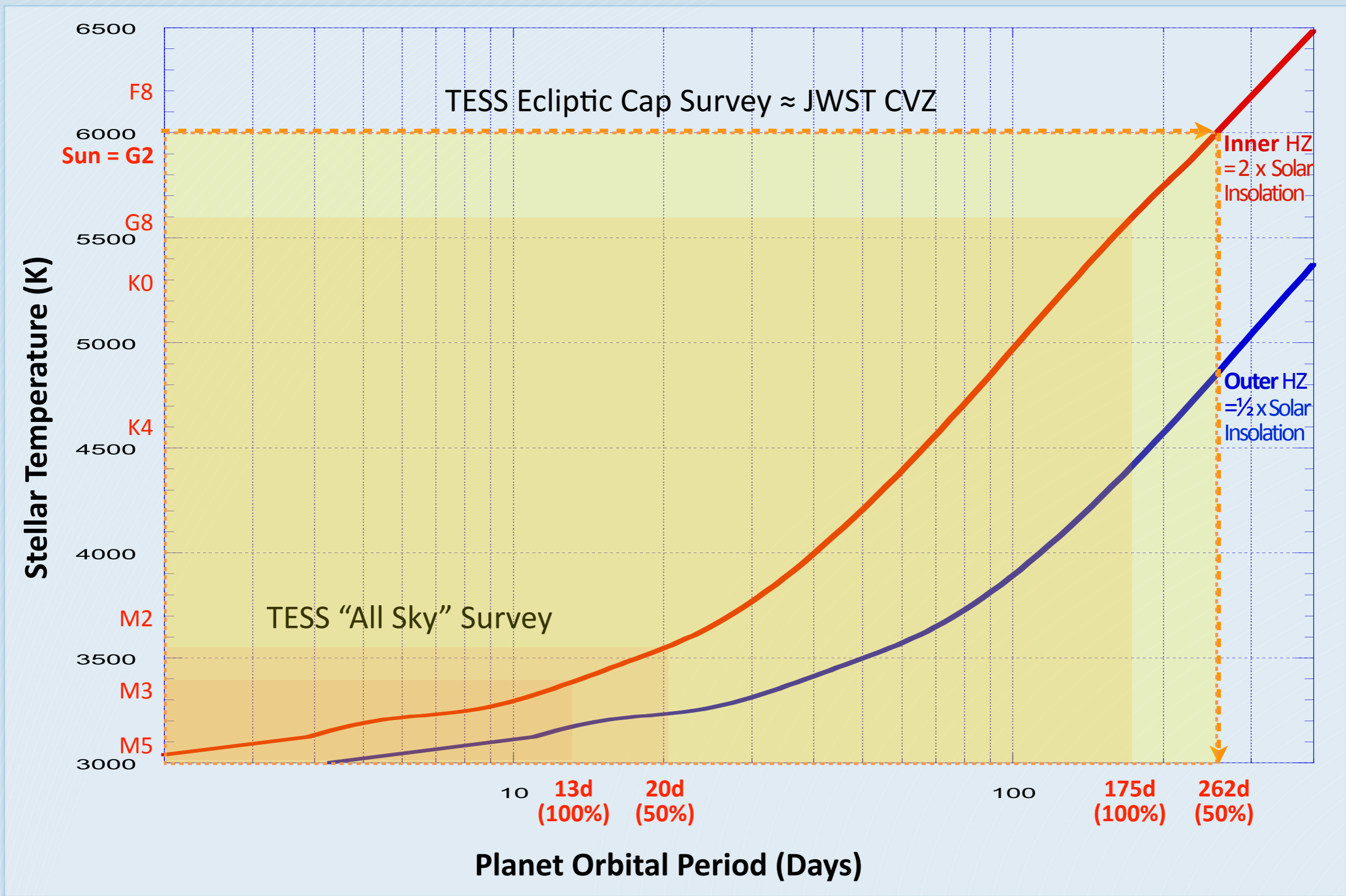
JWST  
continuous  
viewing zone





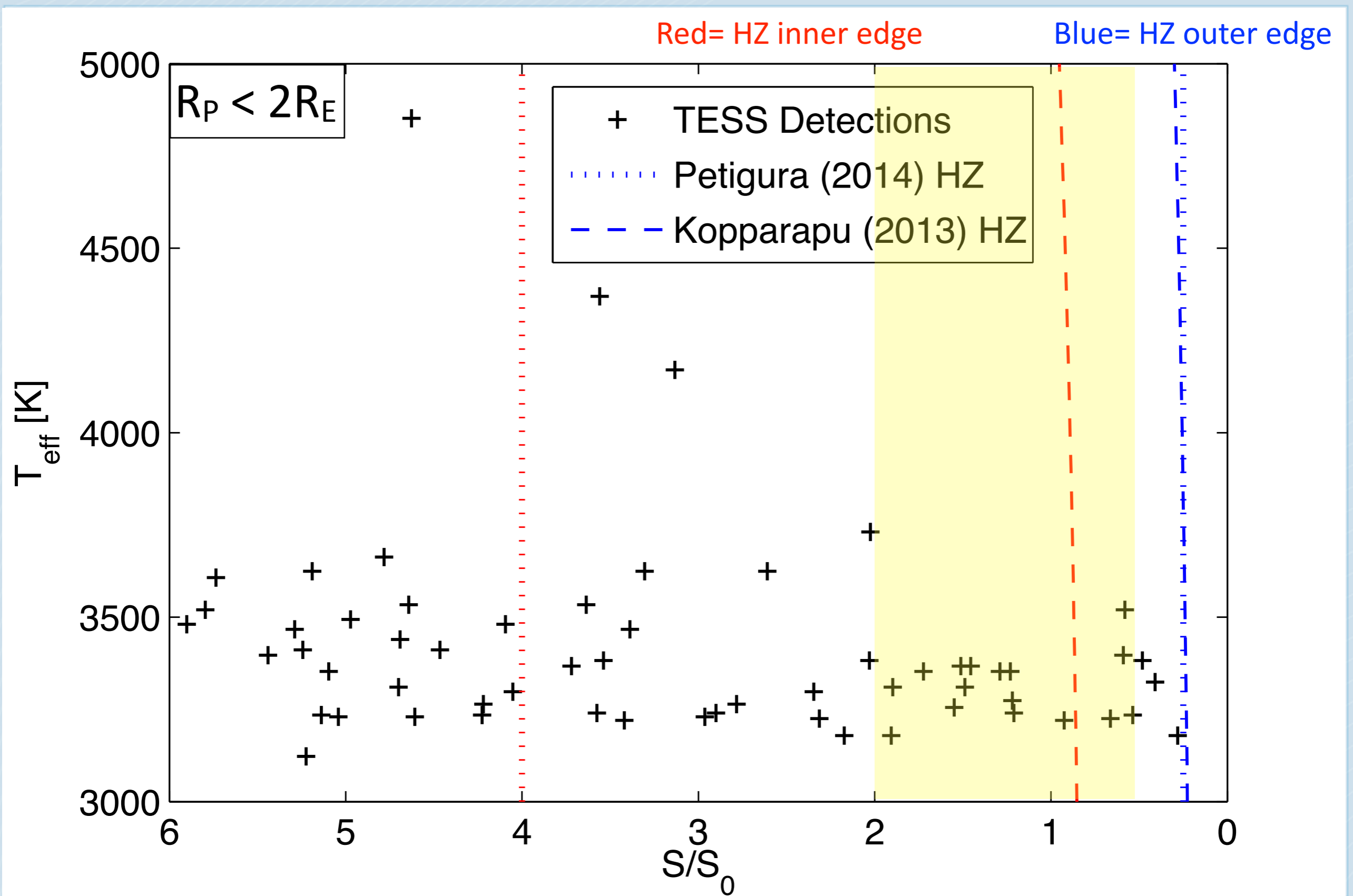


# Stellar Habitable Zones Accessible to TESS





# Small TESS Planets and the Habitable Zone





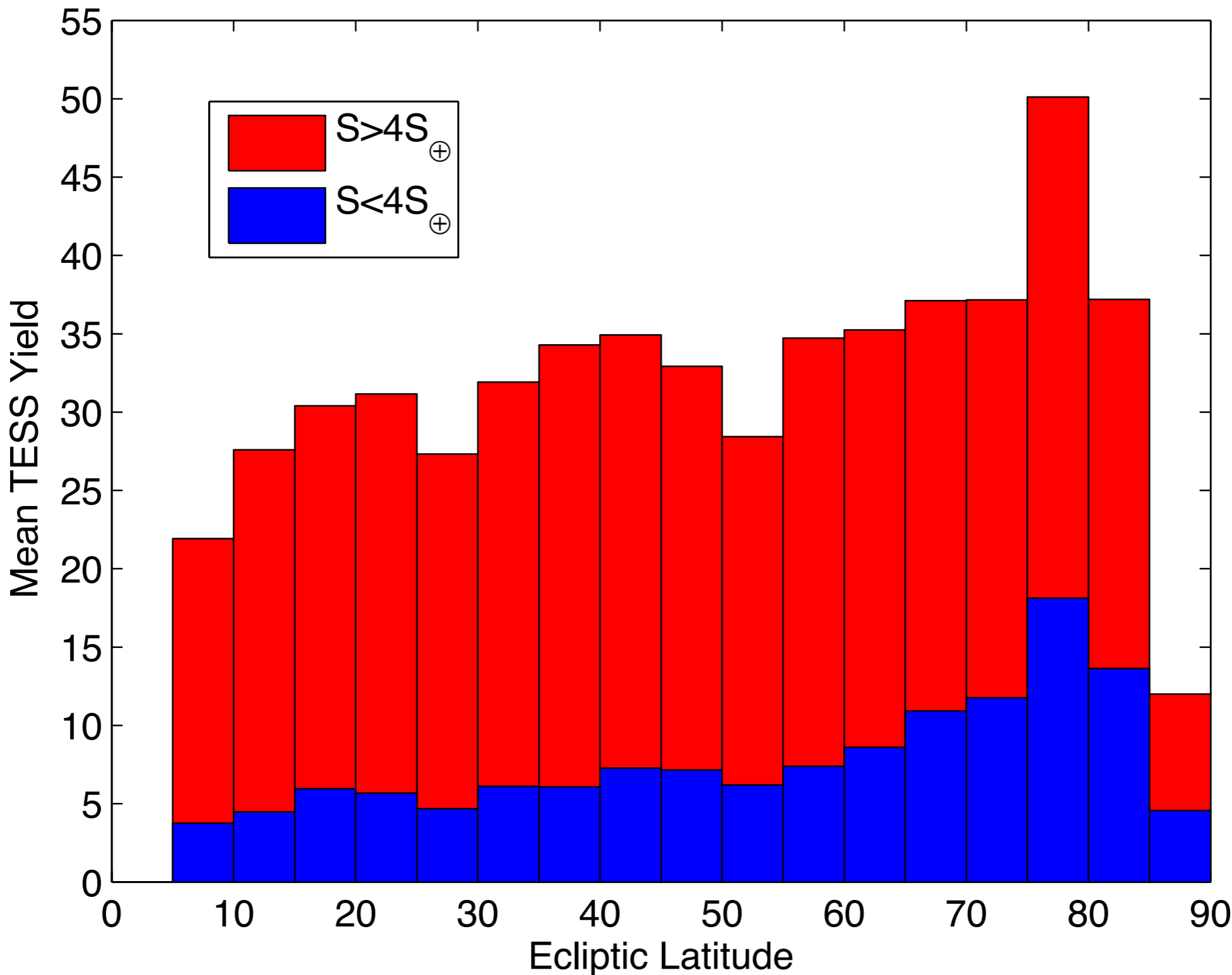
Field of view [deg]:	24.0
Offset from ecliptic [deg]:	6.0
Number of Segments:	13 * 2
EPD [mm]:	105
Effective Area [cm <sup>2</sup> ]:	67.5
PSF Scaling from Baseline:	1.0
Read Noise [e-]:	10.0
Systematics [ppm]:	60
Minimum SNR:	7.0
Minimum number of transits:	2
Binarity:	Yes
Total number of stars:	1432942
Number of stars with 1-minute postage stamps:	200K
Full-frame image cadence [min]:	30
Number of trials:	25



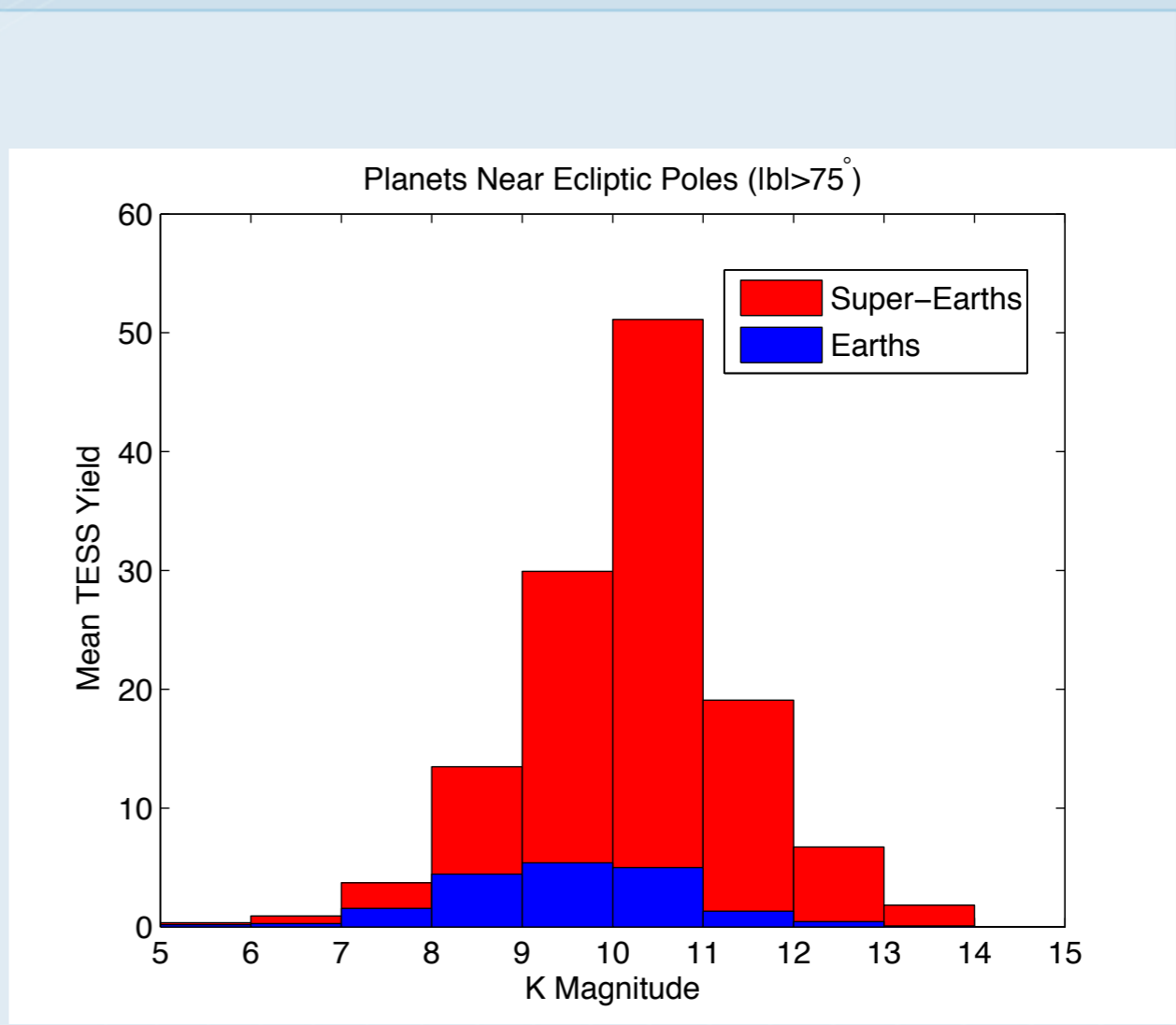
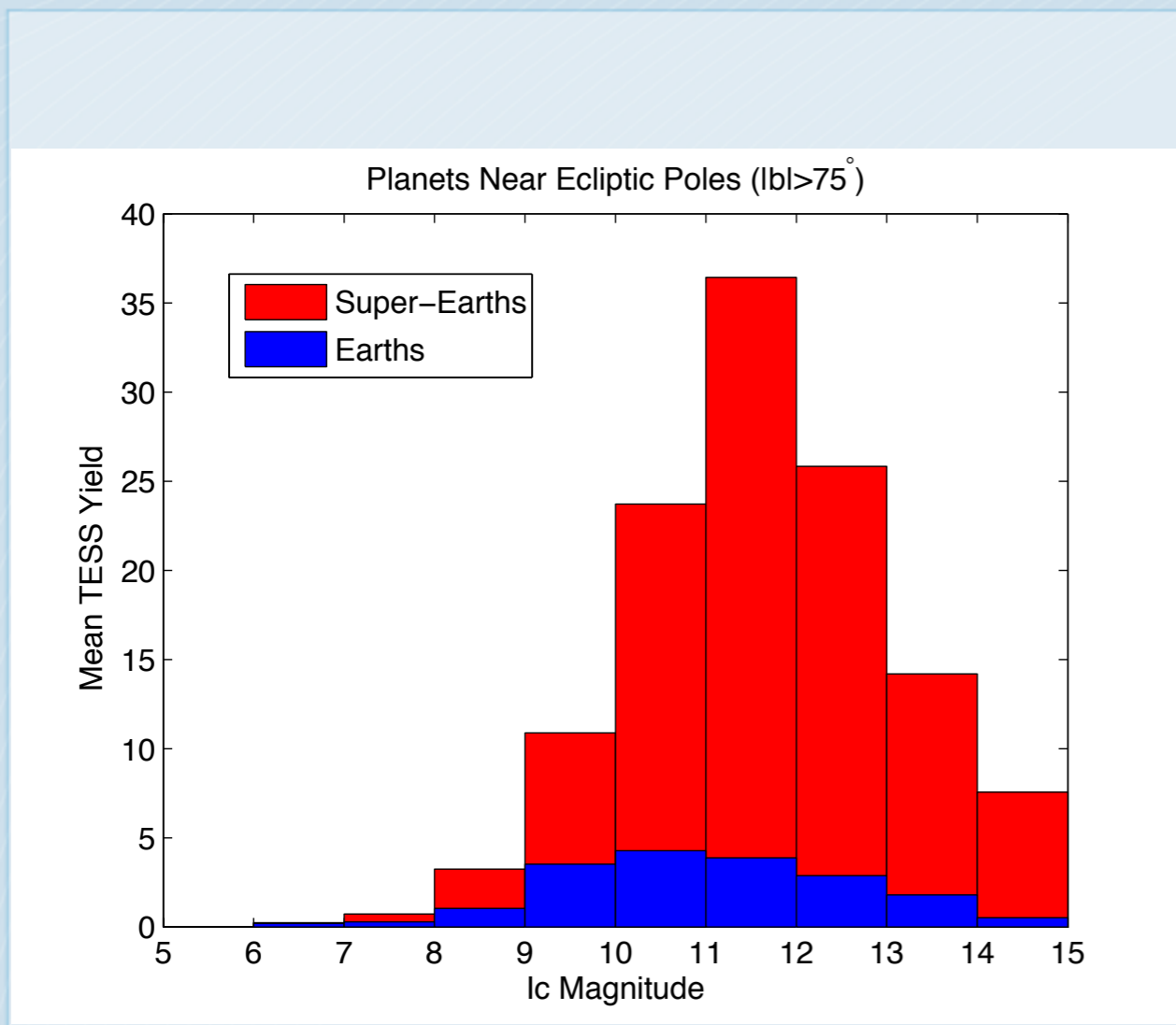
Earths $0.8-1.25 R_{\oplus}$	Super-Earths $1.25-2.0 R_{\oplus}$	Sub-Neptunes $2.0-4.0 R_{\oplus}$
$38.2 \pm 8.9$	$335 \pm 39$	$1460 \pm 130$

Small HZ Planets $0.5 < S < 2$	JWST HZ $b > 75^{\circ}$
$17.1 \pm 5.8$	$7.3 \pm 3.2$

Planets with  $R_p < 4 R_{\oplus}$  and host  $T_{\text{eff}} < 5000\text{K}$







## Totals

Super-Earths: **127**  
 Earths: **19**

## Planet Numbers by $K_{\text{Host Star}}$

$5 < K < 8$ : **5**  
 $8 < K < 9$ : **13**  
 $9 < K < 10$ : **30**

## TESS should provide JWST with:

- ◆ ~100 small exoplanets ( $R_P < 2R_E$ ) in or near JWST's CVZ
  - ~20 with  $5 < K < 9$  stellar hosts
  
- ◆ ~Handful of Earth-sized planets in HZ



