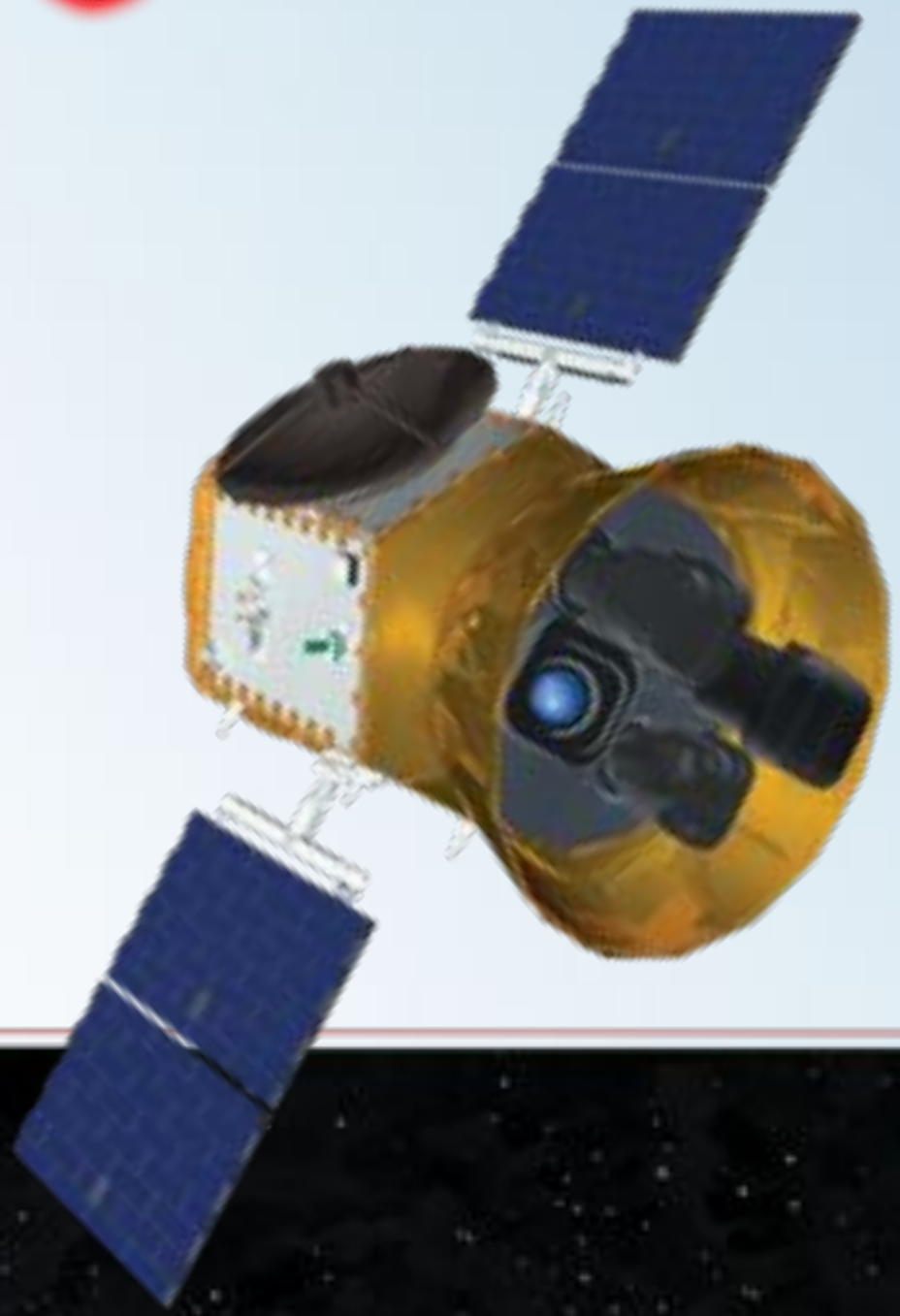
Transiting Exoplanet Survey Satellite



Transiting Exoplanet Targets for JWST Expected from the TESS Mission

George Ricker (MIT)

Workshop on Transit Observing with JWST
Pasadena CA
12 March 2014

TESS Simulations by Josh Winn & Peter Sullivan

Josh Winn
(MIT)

Peter Sullivan
(MIT)

TESS Partnerships

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

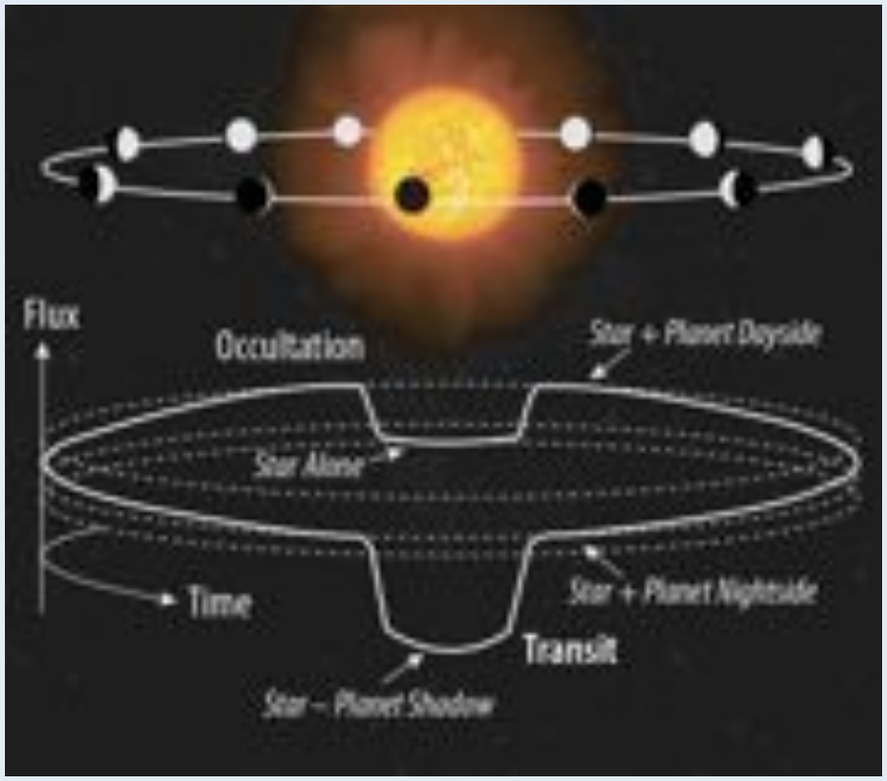
Follow-Up Program, Science Center

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.

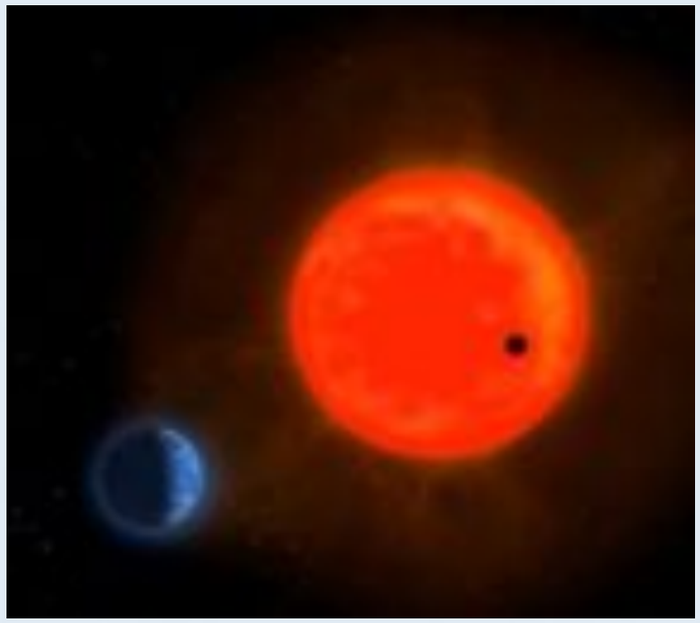
TESS Science Goals and Drivers



- **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: <u>Only 2</u> small transiting exoplanets orbiting bright hosts are known*

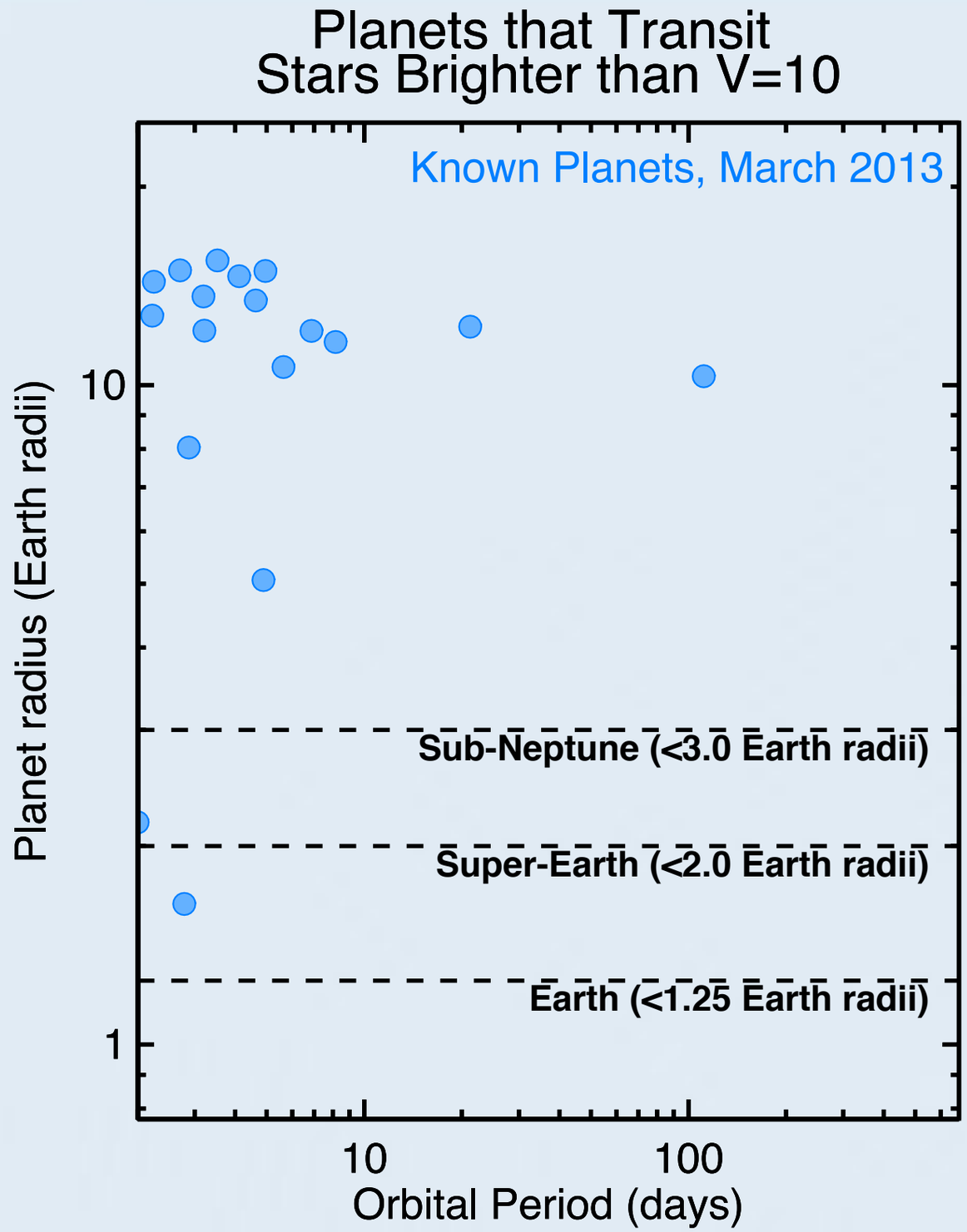
- **Large Area Surveys of Bright Stars**
  - *F, G, K dwarfs: +4 to +12 magnitude*
  - *M dwarfs known within ~60 parsecs*
  - *>200,000 target stars in two years*

Launch in August 2017



Small Planets and Bright Stars

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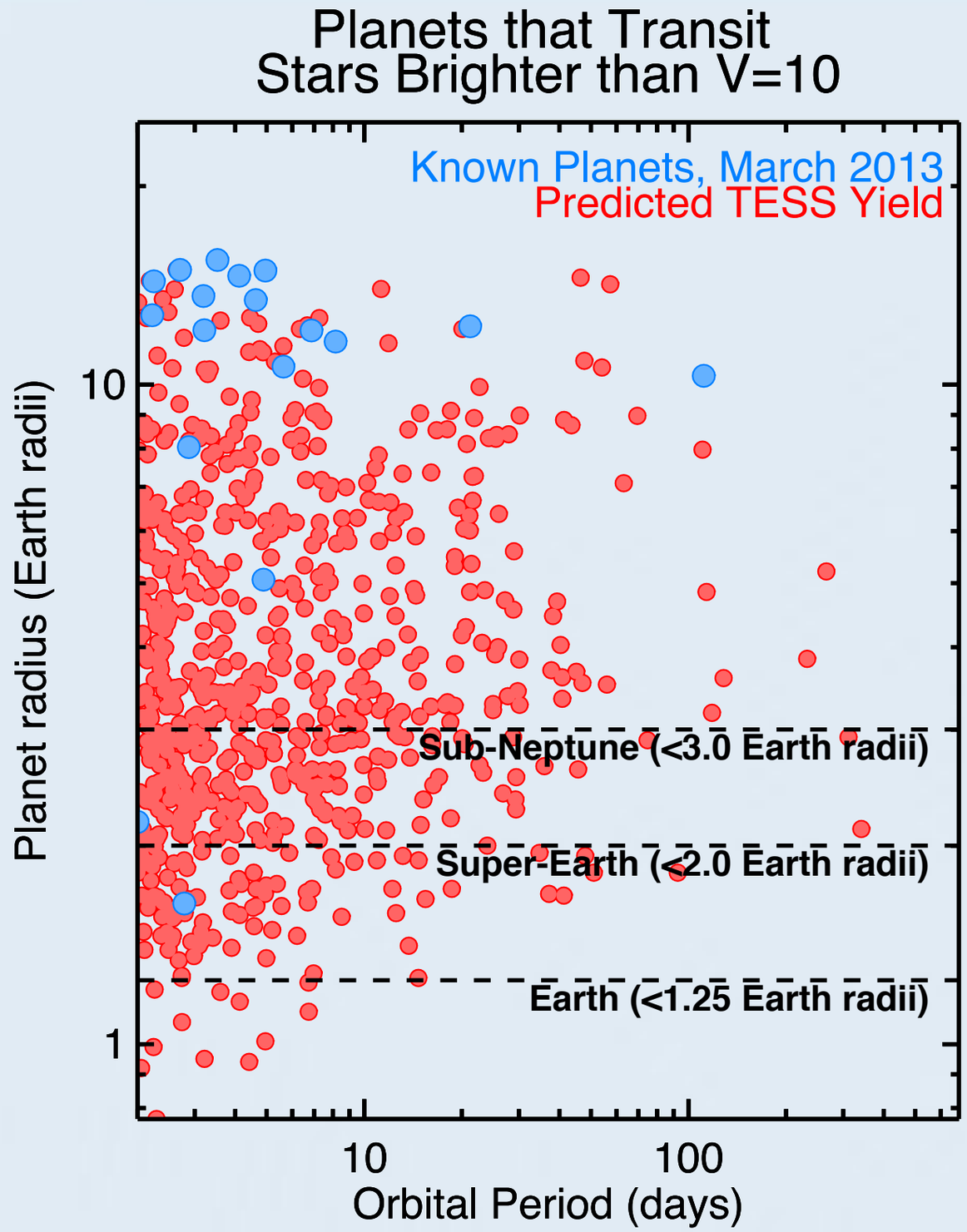
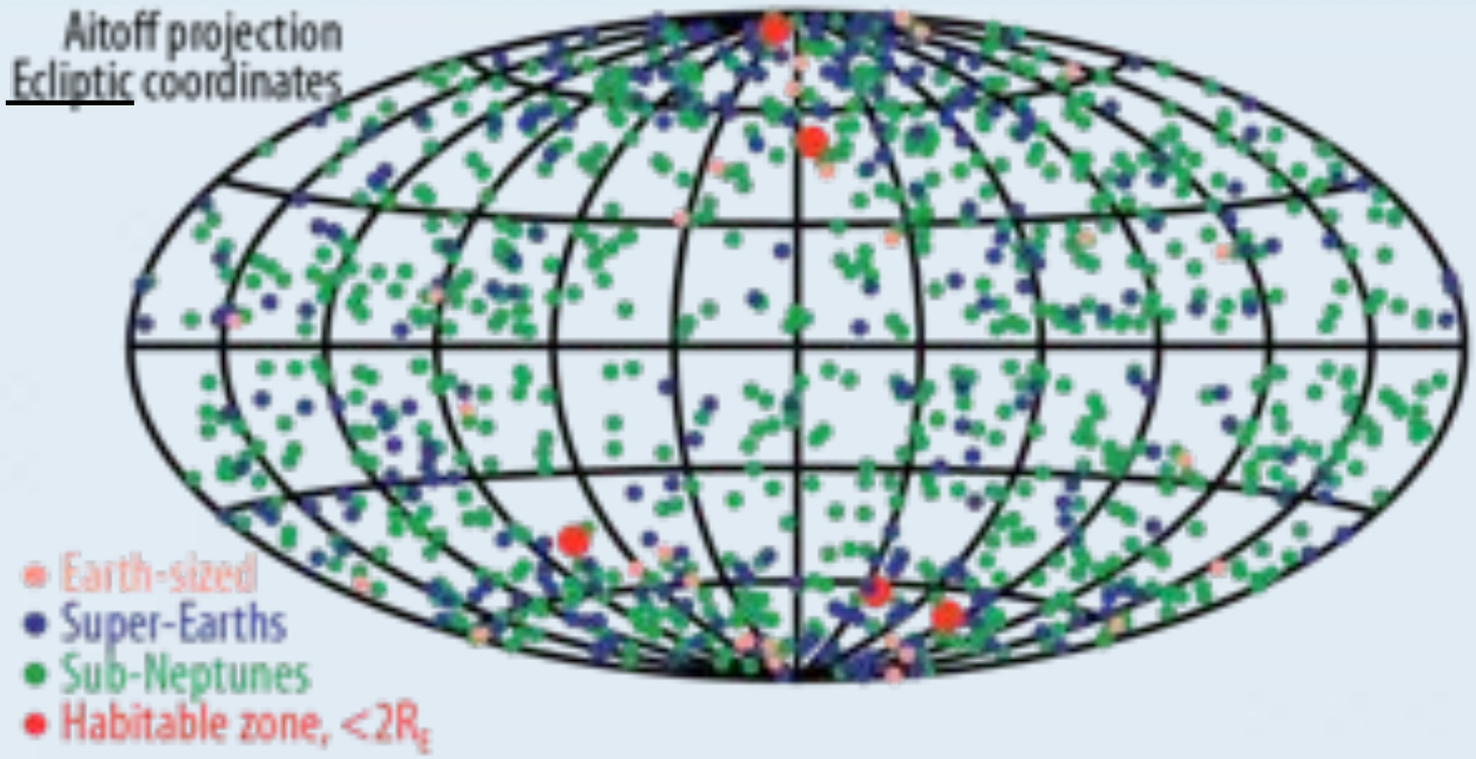
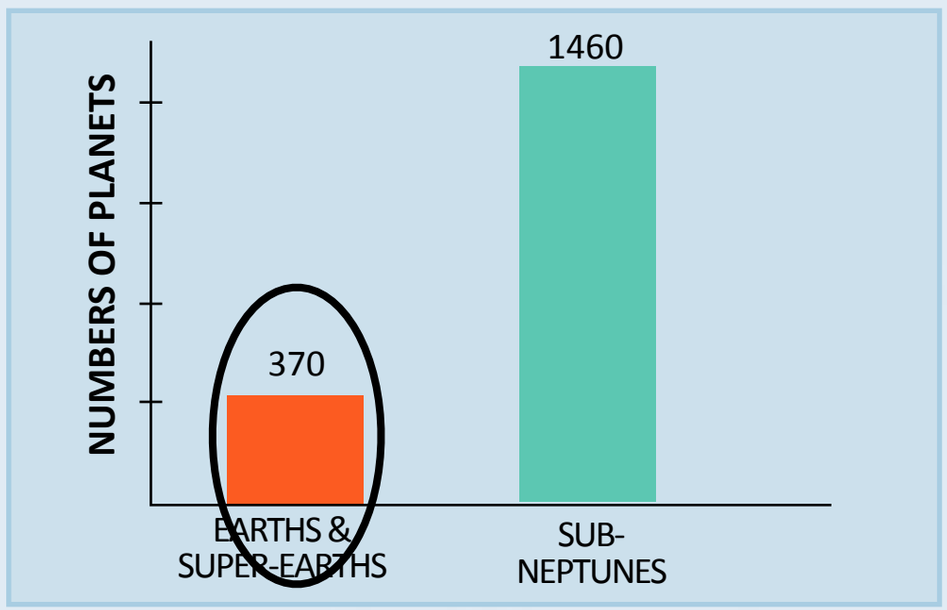
TESS Will Discover the Earths and Super-Earths Transiting the Brightest & Nearest Stars



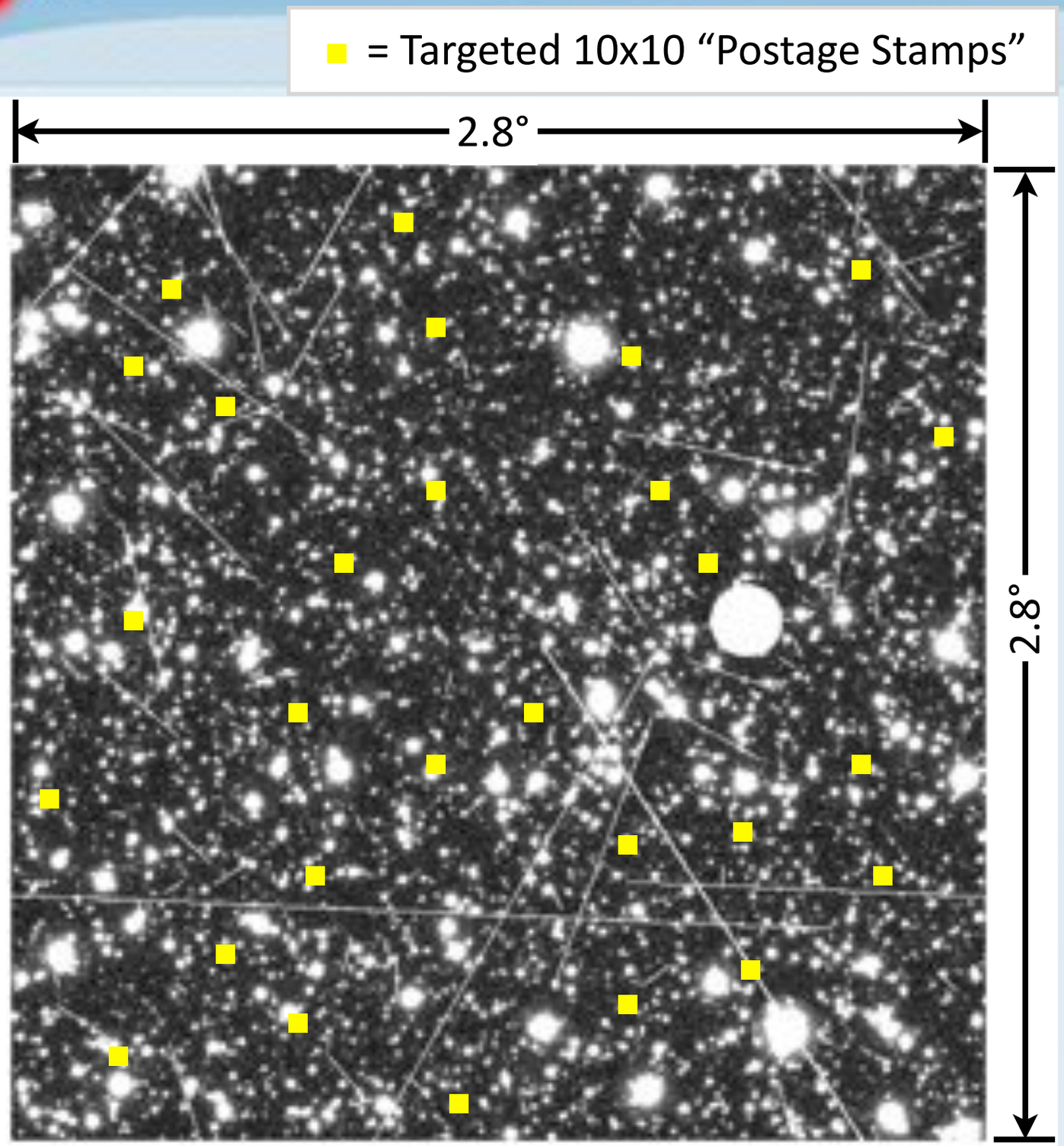
Predicted Science Yield from TESS Mission





TESS Will Discover ~300 Earths & Super-Earths

Simulated ½ Hour Stacked Full Frame TESS Image



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^2 out of 570 deg^2/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	≳

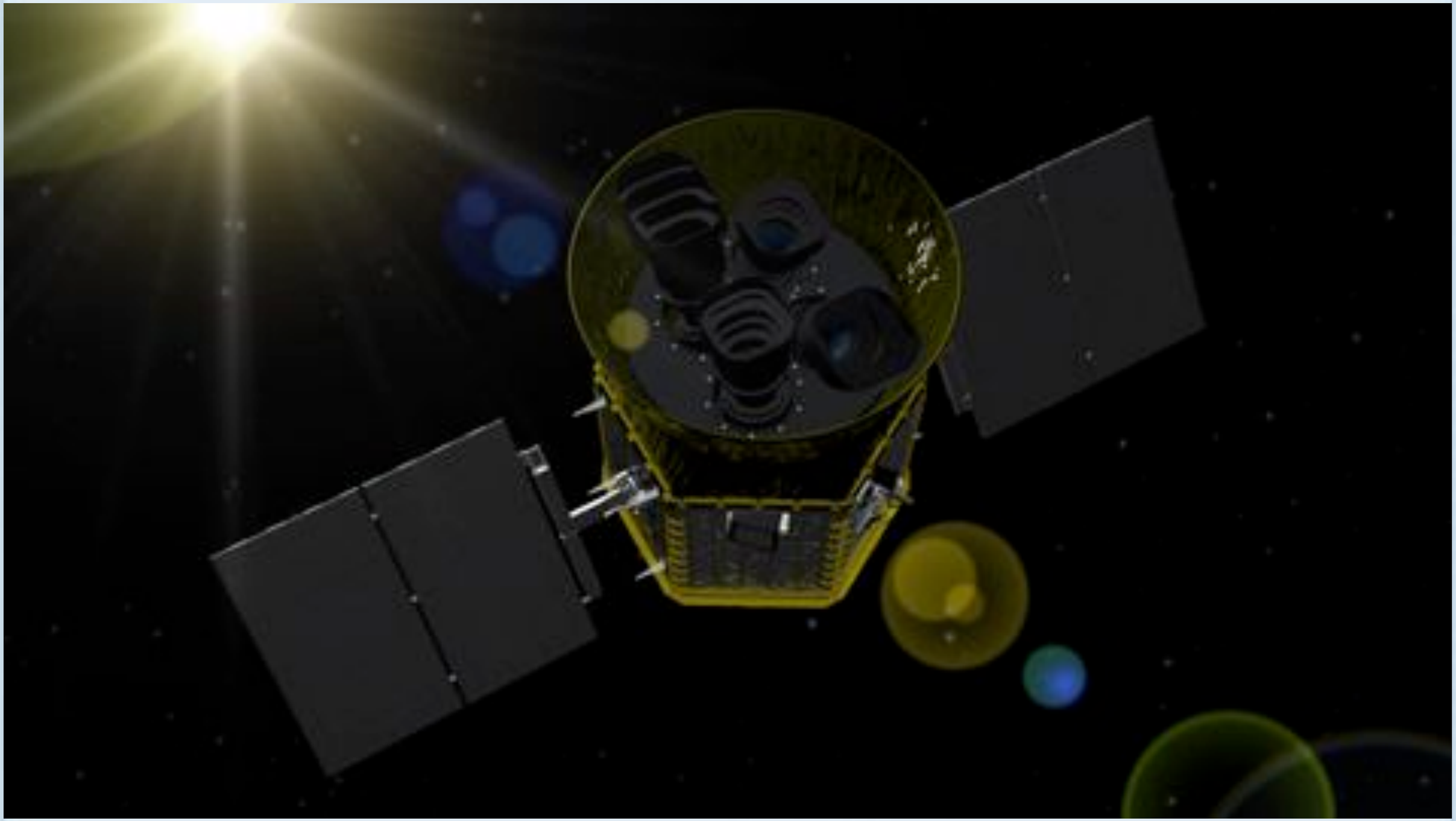
*R band mean star counts from Bahcall & Soneira (1980) re-scaled to I band assuming R-I = +1.0 mag, appropriate for early M stars.

TESS Can Provide FFI’s at Kepler’s 30 Minute Cadence

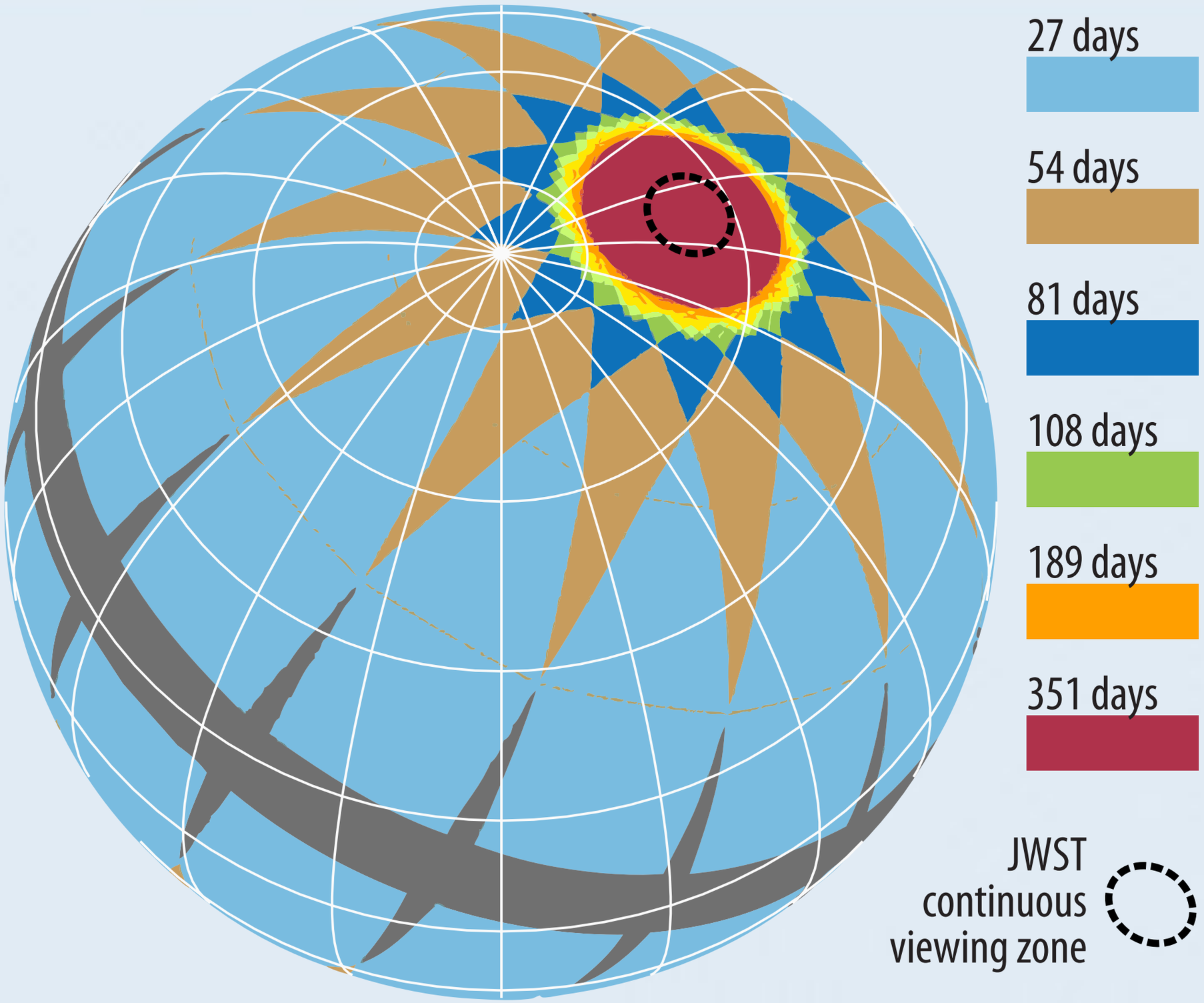
TESS Wide FOV CCD Camera Prototype

Full Size Replica of TESS

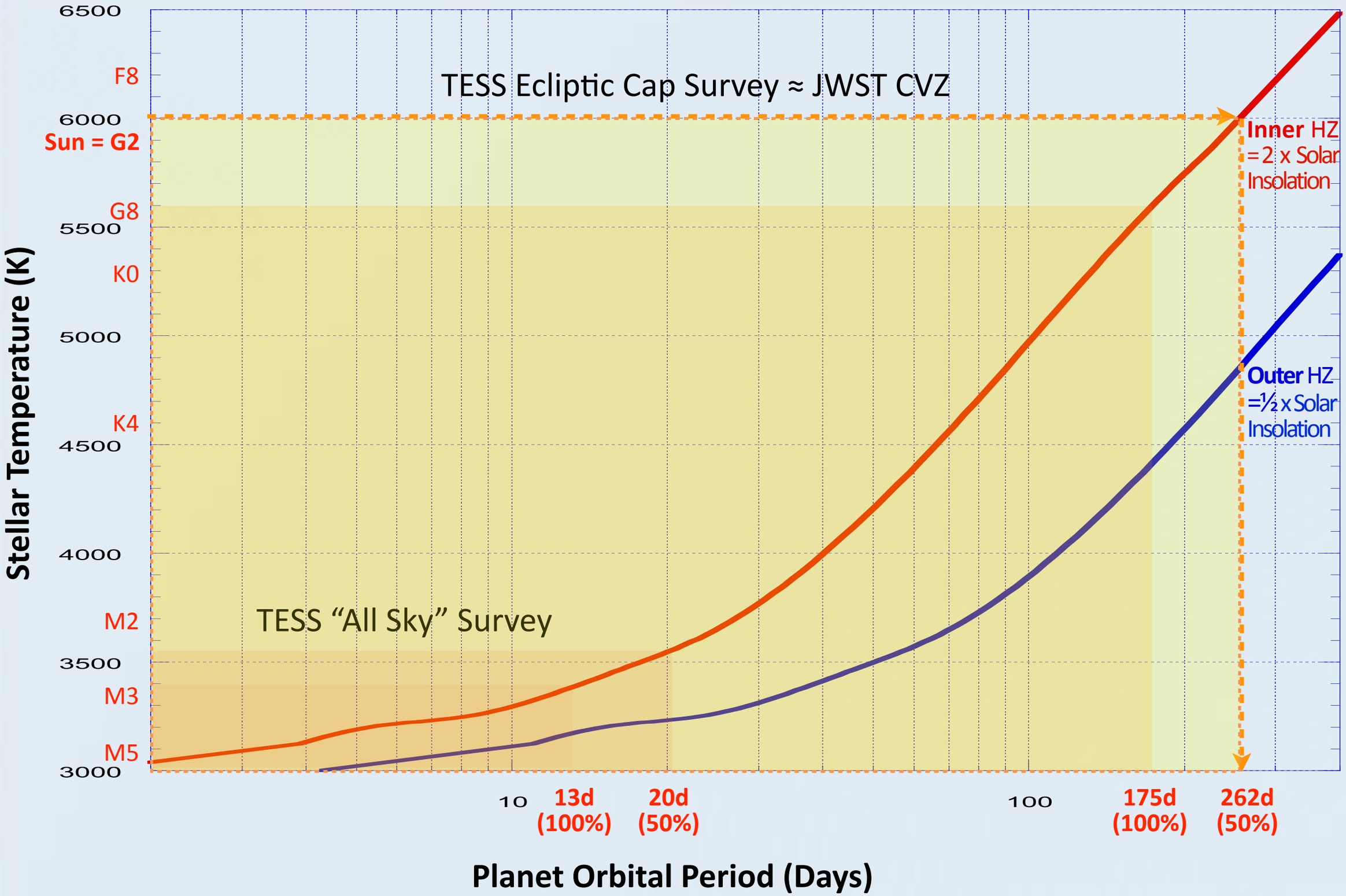
TESS Sky Mapping Strategy



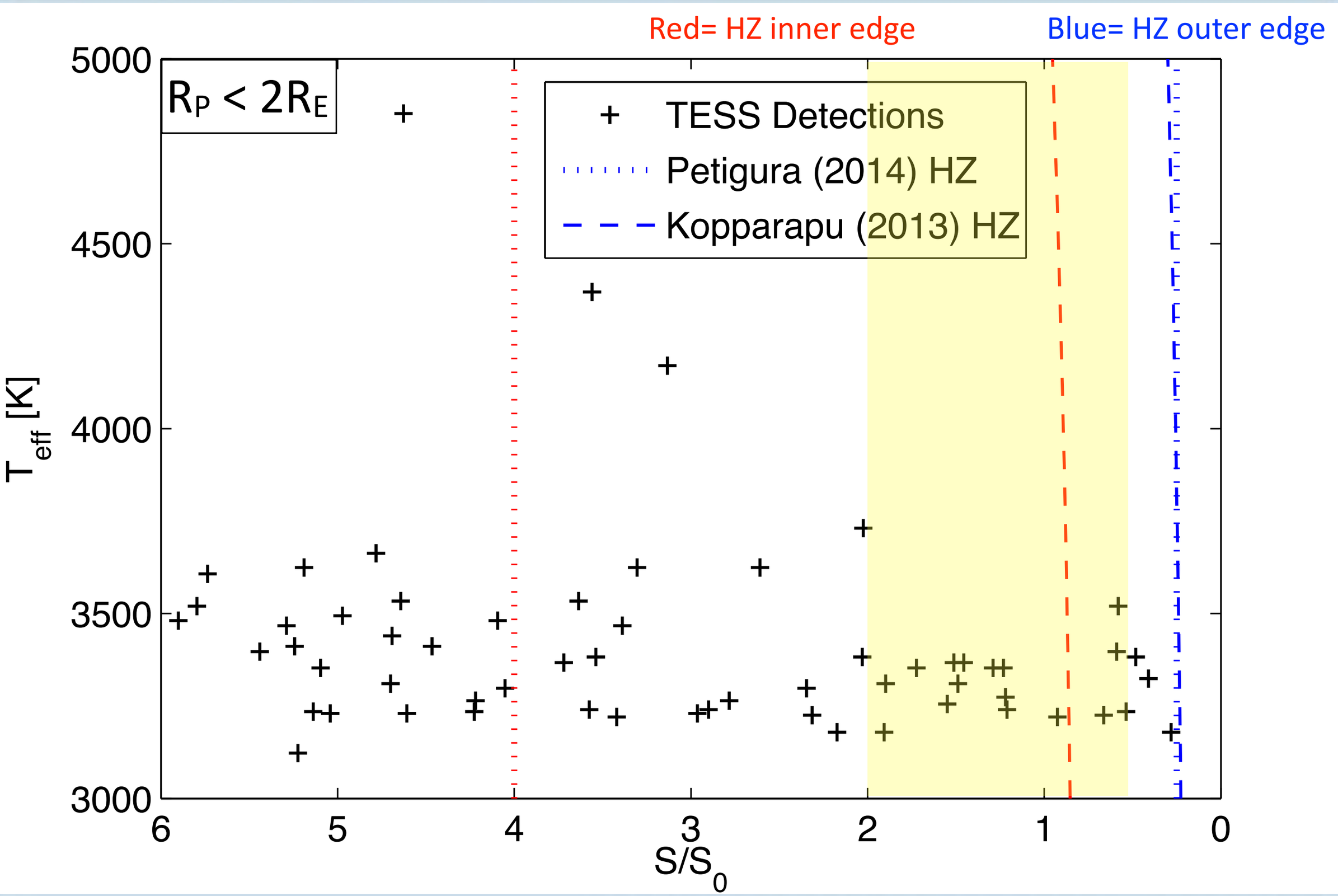
TESS 2-year Sky Coverage Map



Stellar Habitable Zones Accessible to TESS



Small TESS Planets and the Habitable Zone



Assumptions for TESS Yield Simulations

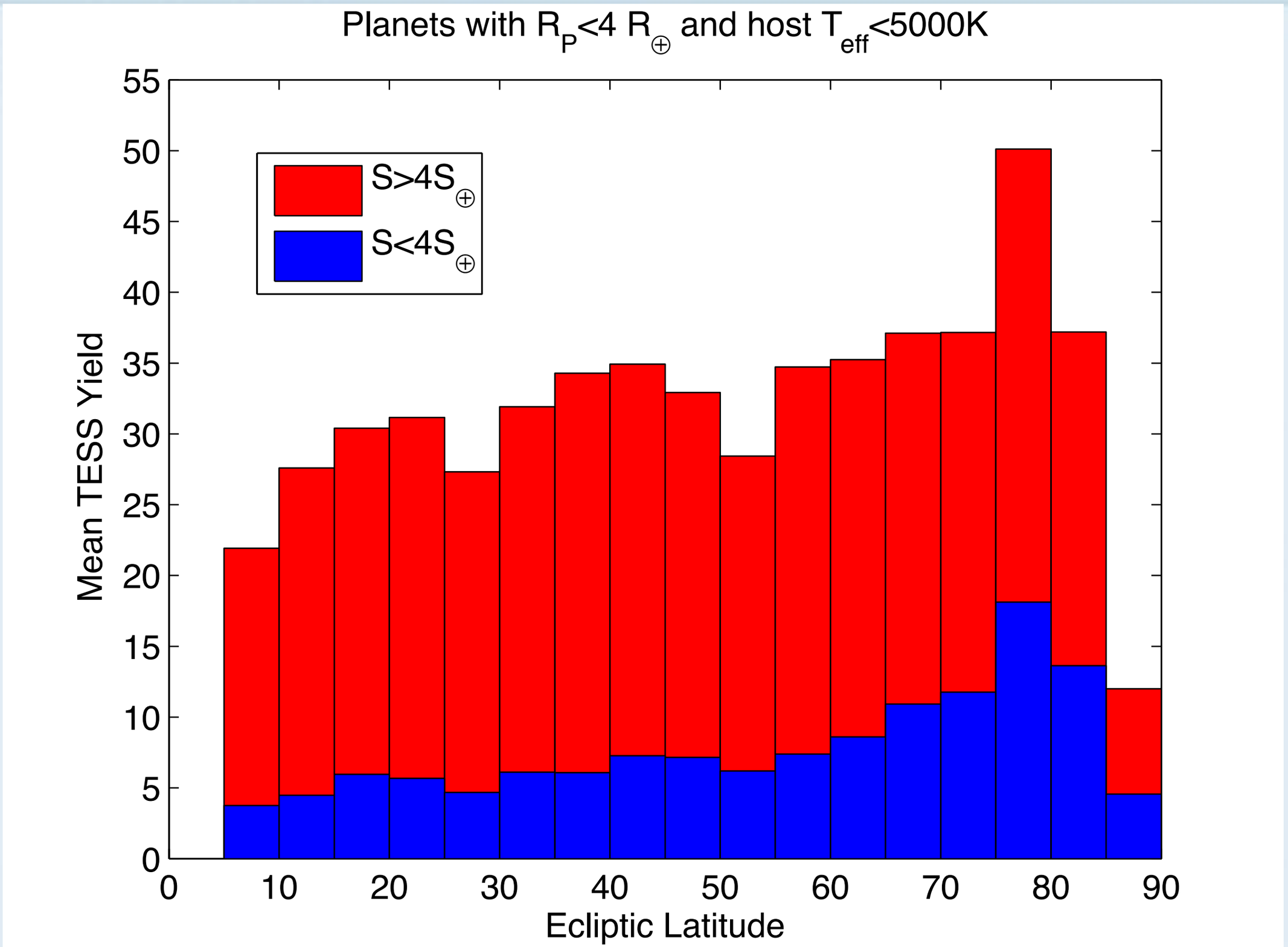
Field of view [deg]:	24.0
Offset from ecliptic [deg]:	6.0
Number of Segments:	$13 * 2$
EPD [mm]:	105
Effective Area [cm^2]:	67.5
PSF Scaling from Baseline:	1.0
Read Noise [e-]:	10.0
Systematics [ppm]:	60
Minimum SNR:	7.0
Minimum number of transits:	2
Binarity:	Yes
Total number of stars:	1432942
Number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

TESS Simulation Yields: All-Sky, Two Years

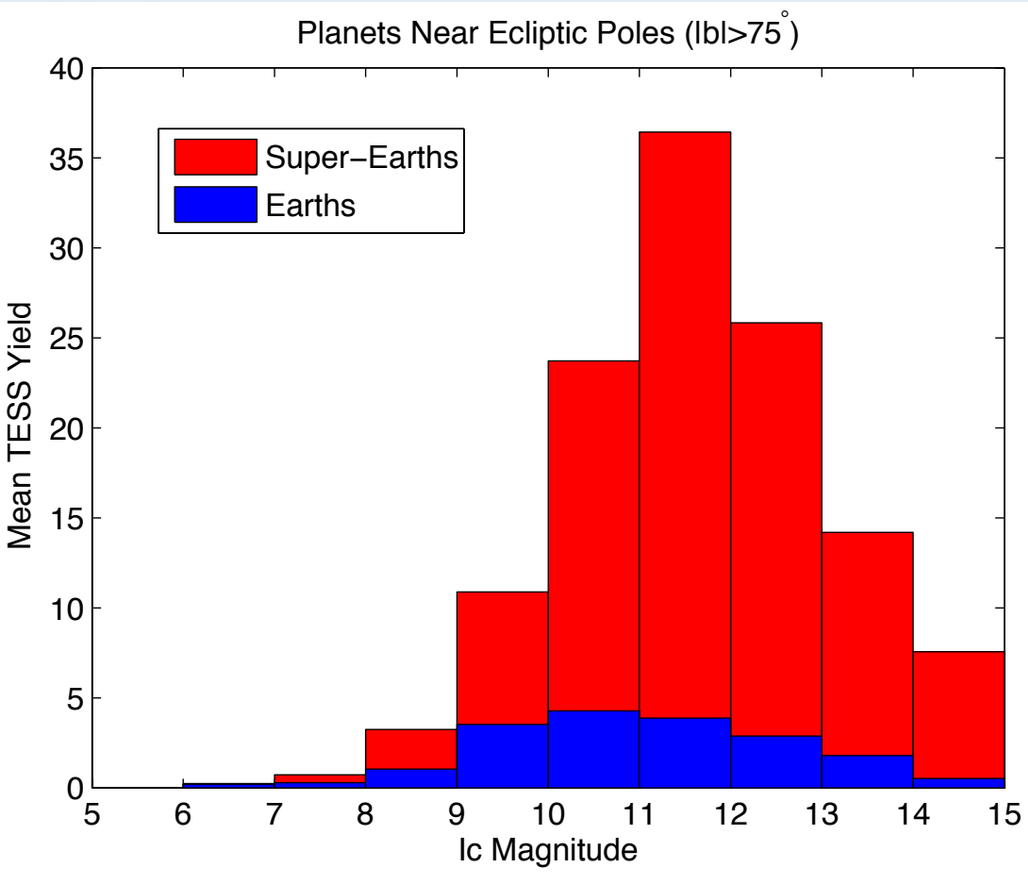
Earths	Super-Earths	Sub-Neptunes
0.8–1.25 $R_\oplus$	1.25–2.0 $R_\oplus$	2.0–4.0 $R_\oplus$
38.2 ± 8.9	335 ± 39	1460 ± 130

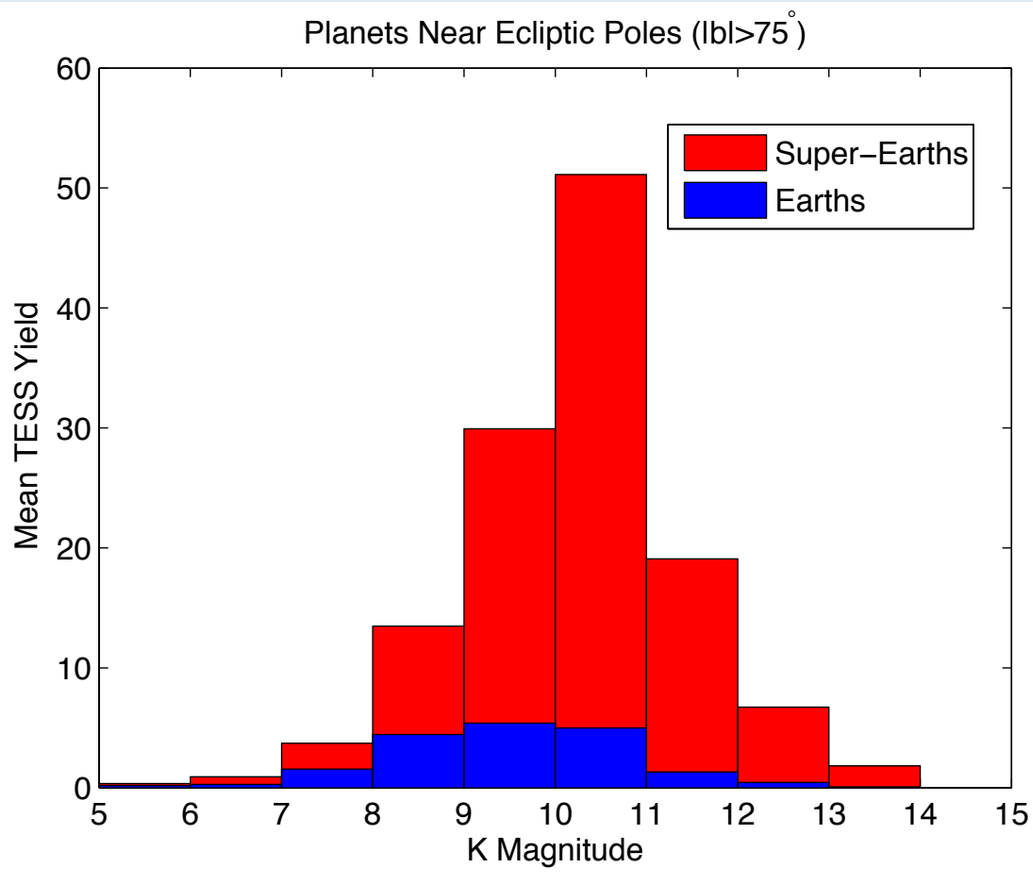
Small HZ Planets	JWST HZ
$0.5 < S < 2$	$b > 75°$
17.1 ± 5.8	7.3 ± 3.2

TESS Small Planet Yield vs. Ecliptic Latitude



TESS Small Planet Yield Near JWST CVZ





Totals

Super-Earths: **127**

Earths: **19**

Planet Numbers by $K_{Host\ Star}$

5<K<8: **5**

8<K<9: **13**

9<K<10: **30**

Conclusions

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