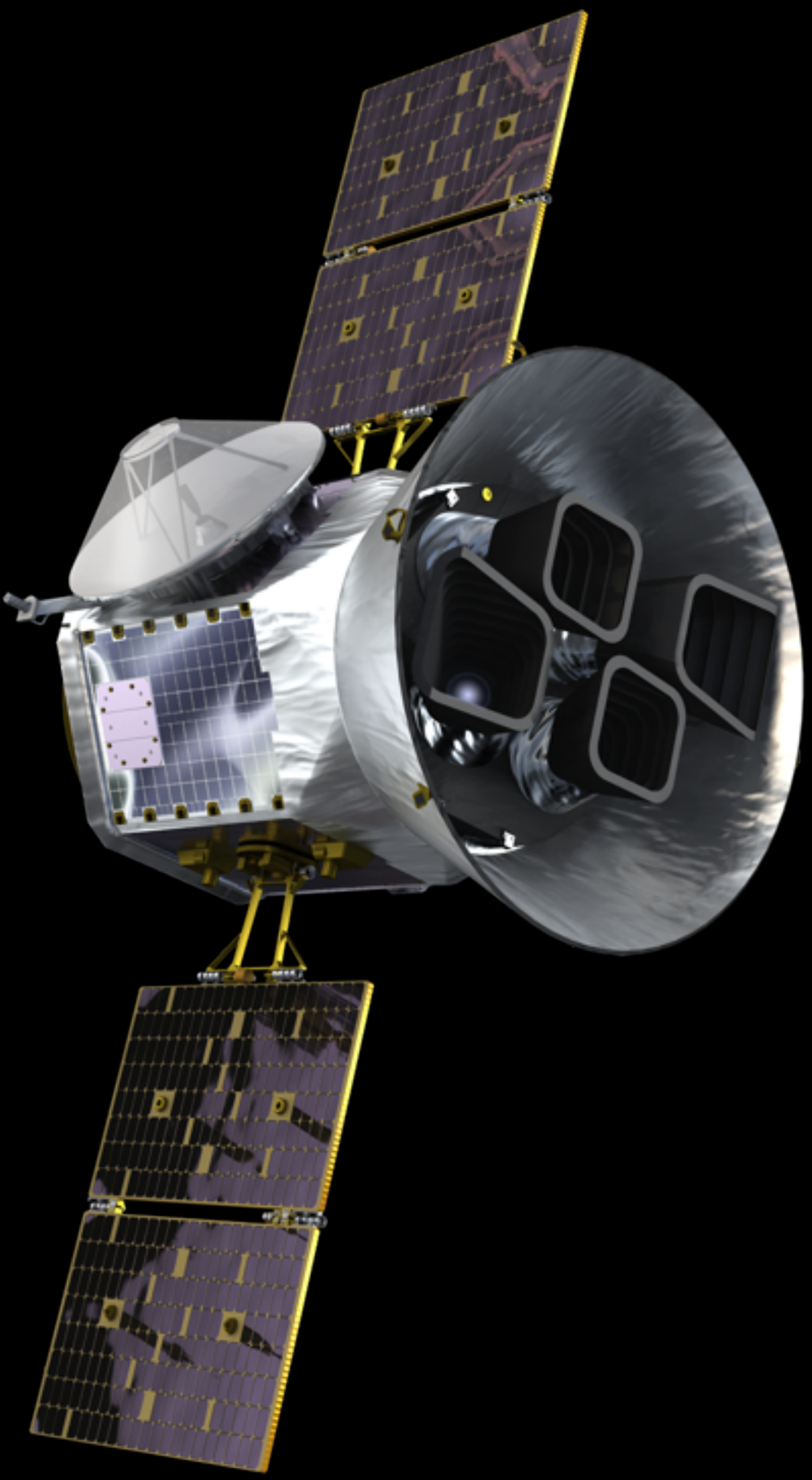


TESS

Discovering Nearby Exoplanets with the Transiting Exoplanet Survey Satellite

George Ricker
MIT

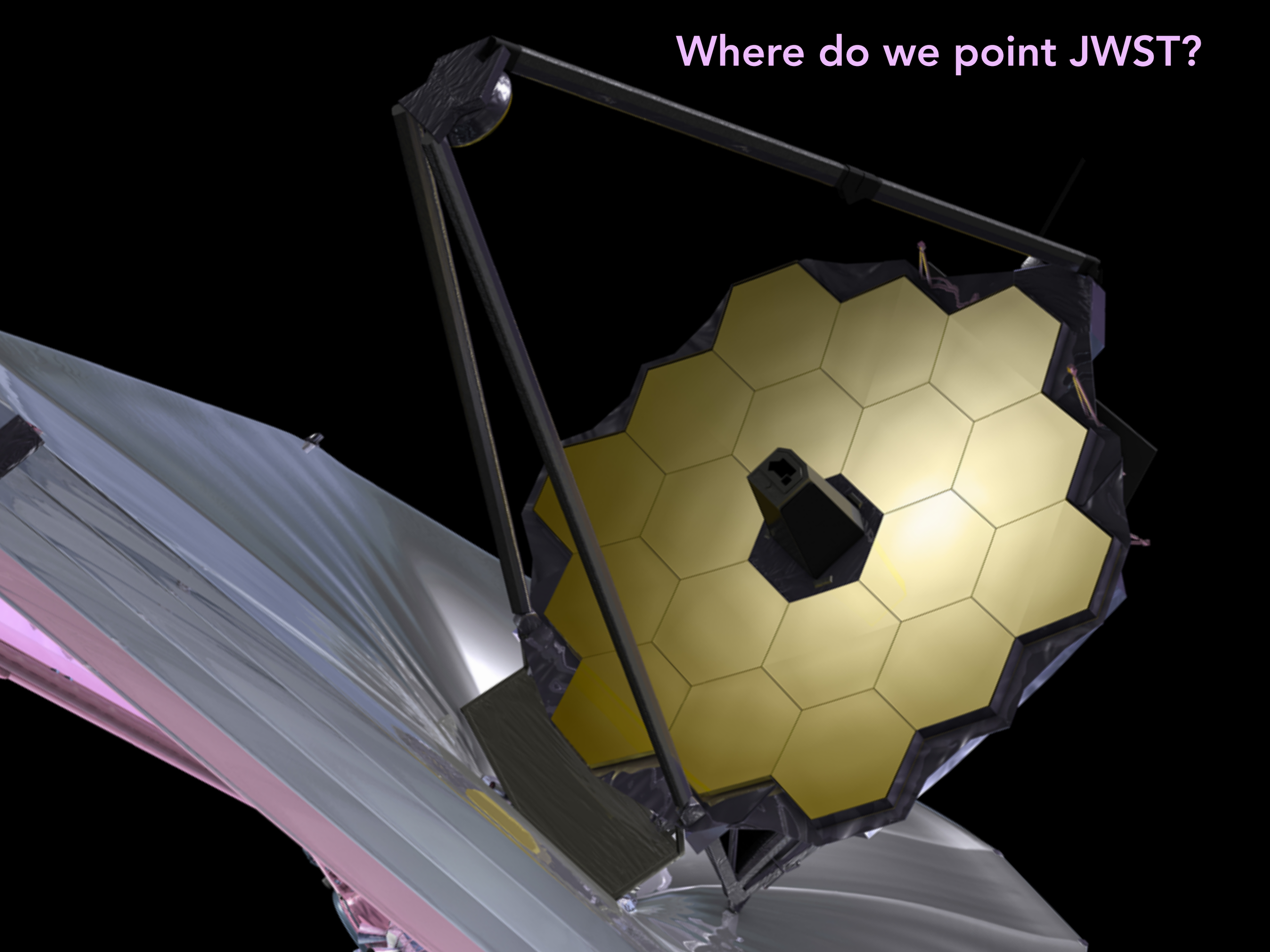
Know Thy Planet – Know Thy Star
Pasadena CA

12 October 2017

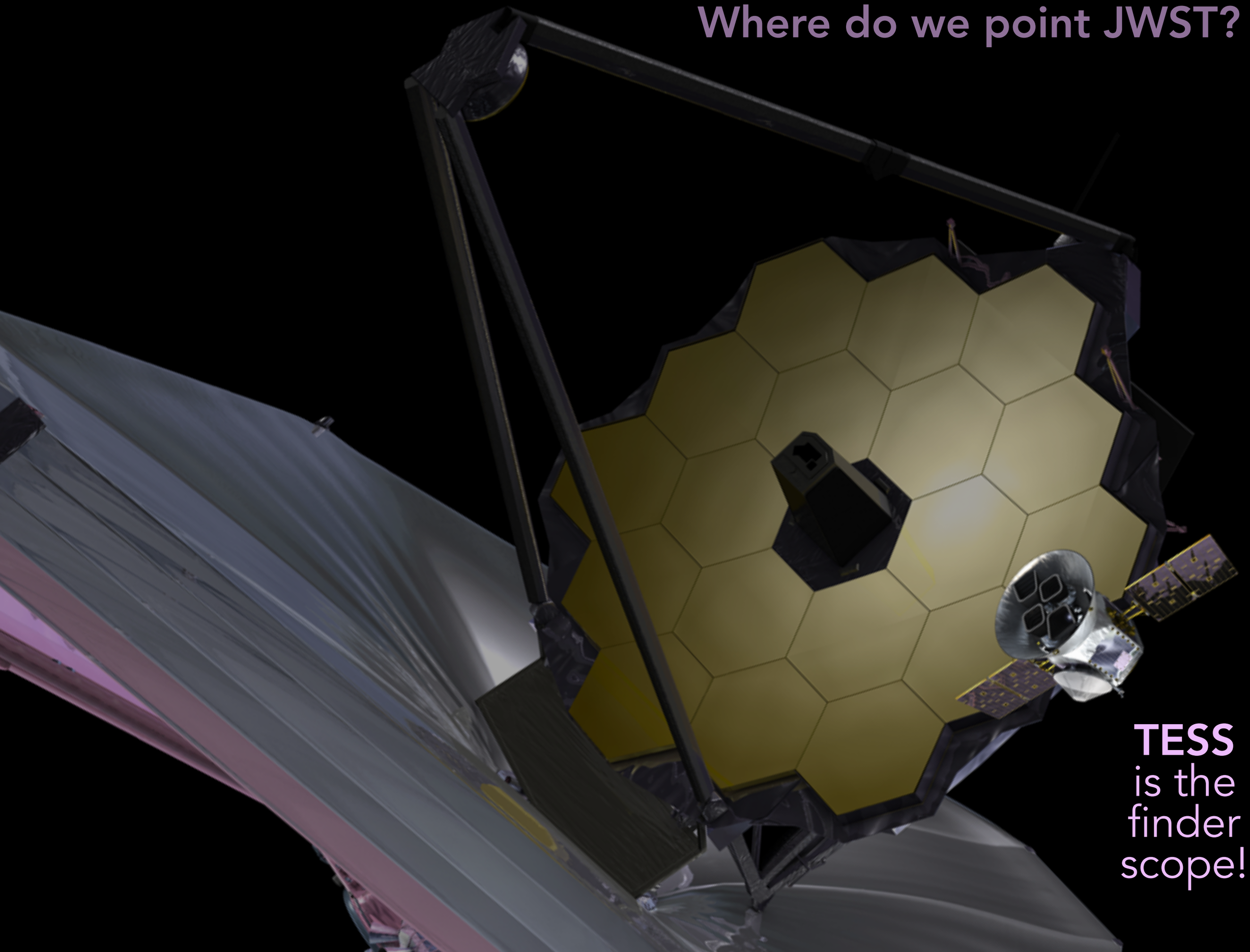
+ Scientific Collaboration including:
MIT/MKI, NASA Goddard, NASA Ames, STScI, SAO, Harvard University, Cornell University, Las Cumbres Observatory, Lowell Observatory, University of California, University of Maryland, Princeton University, Vanderbilt University, Yale University, Aarhus University, Geneva Observatory, OHP-France,

TESS: A Bridge to the Future...

Where do we point JWST?



Where do we point JWST?



TESS is the finder scope!

Etendue Comparison of TESS and Kepler

- Definition of Etendue [$m^2 * deg^2$]:

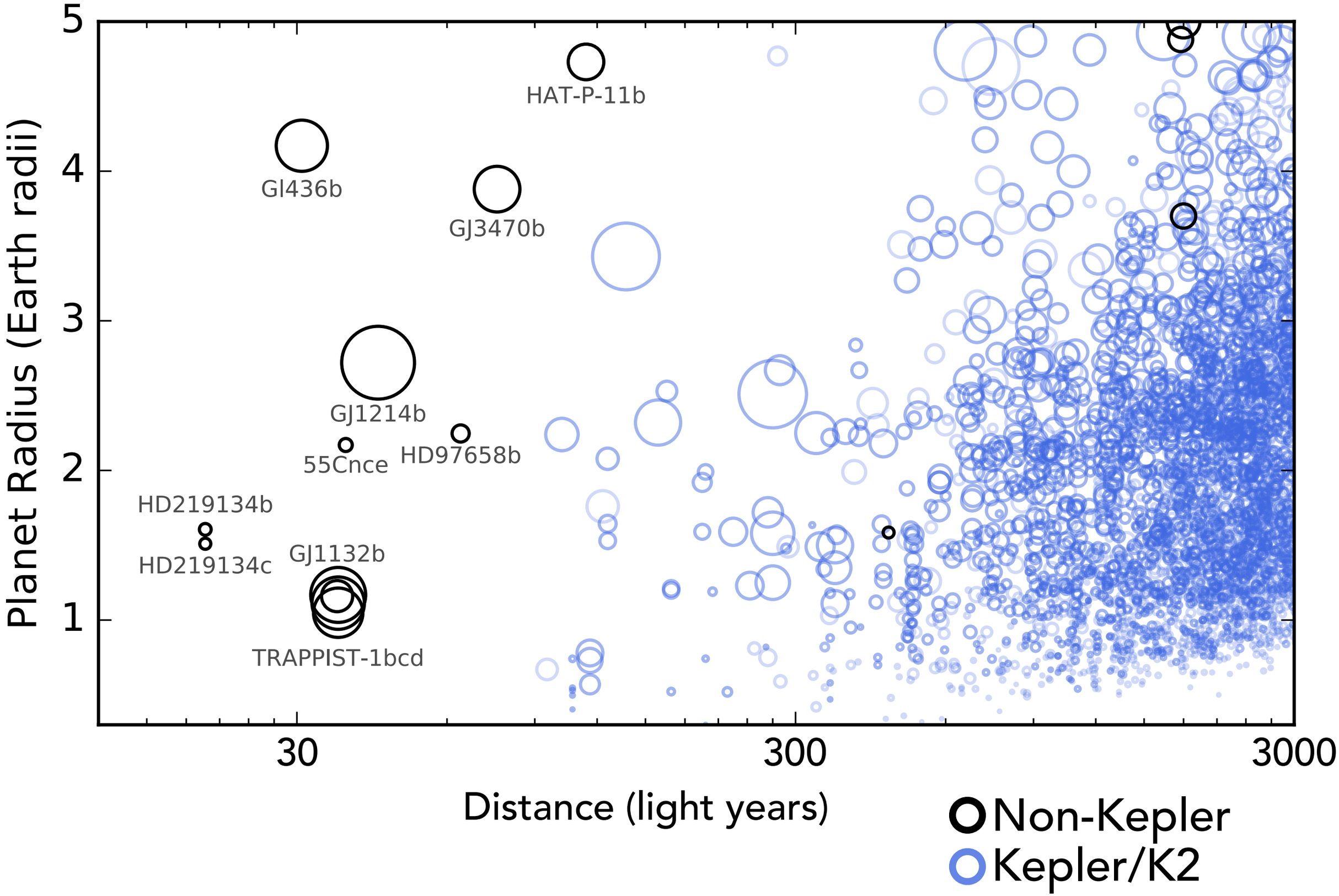
$$\mathbf{E} = A_{optics} * \Omega_{net}$$

$$\text{where } \Omega_{net} = \Omega_{gross} * \left(\frac{\textit{\# pixels telemetered}}{\textit{\# pixels in focal plane}} \right)$$

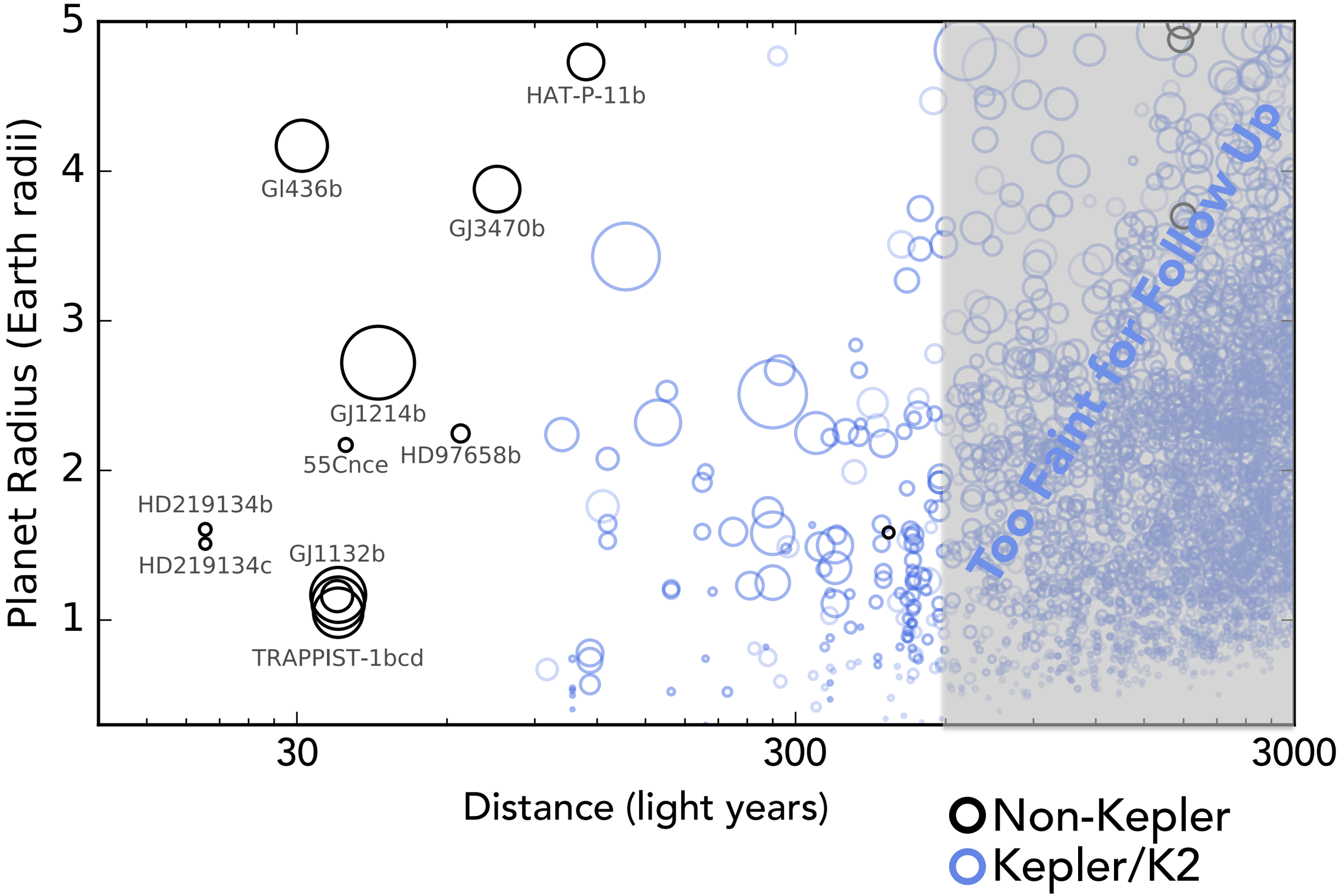
	A_{optics} $[m^2]$	Ω_{gross} $[deg^2]$	$\frac{\textit{\# pixels telemetered}}{\textit{\# pixels in focal plane}}$	**E** $[m^2\ deg^2]$
TESS	0.0095	2304	1	21.9
Kepler	0.71	105	0.06	4.2

TESS is the highest etendue optical space mission ever flown:
~5 times greater than Kepler

Bryson et al. 2010
Ricker et al. 2016



Graphics: Zach Berta-Thompson



Graphics: Zach Berta-Thompson

Planet Radius (Earth radii)

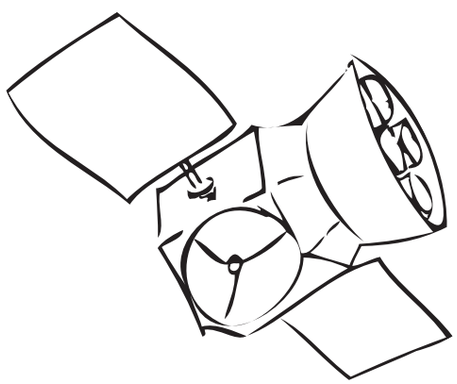
5
4
3
2
1

HAT-P-11b
Gl436b
GJ3470b
GJ1214b
55Cnce
HD97658b
HD219134b
HD219134c
GJ1132b
TRAPPIST-1bcd

Too Faint for Follow Up

30
300
3000

Distance (light years)



Non-Kepler
Kepler/K2
TESS (expected)

Graphics: Zach Berta-Thompson

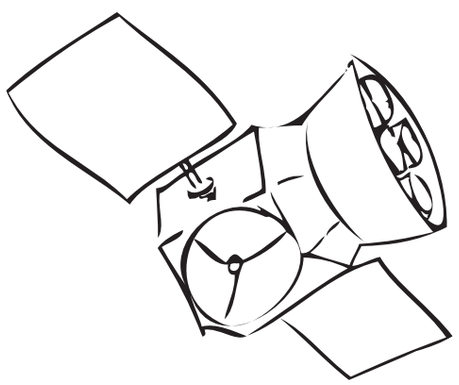
Planet Radius (Earth radii)

5
4
3
2
1

HAT-P-11b
Gl436b
GJ3470b
Level 1
Candidates
GJ1214b
55Cnce
HD97658b
HD219134b
HD219134c
GJ1132b
TRAPPIST-1bcd
Too Faint for Follow Up

30
300
3000

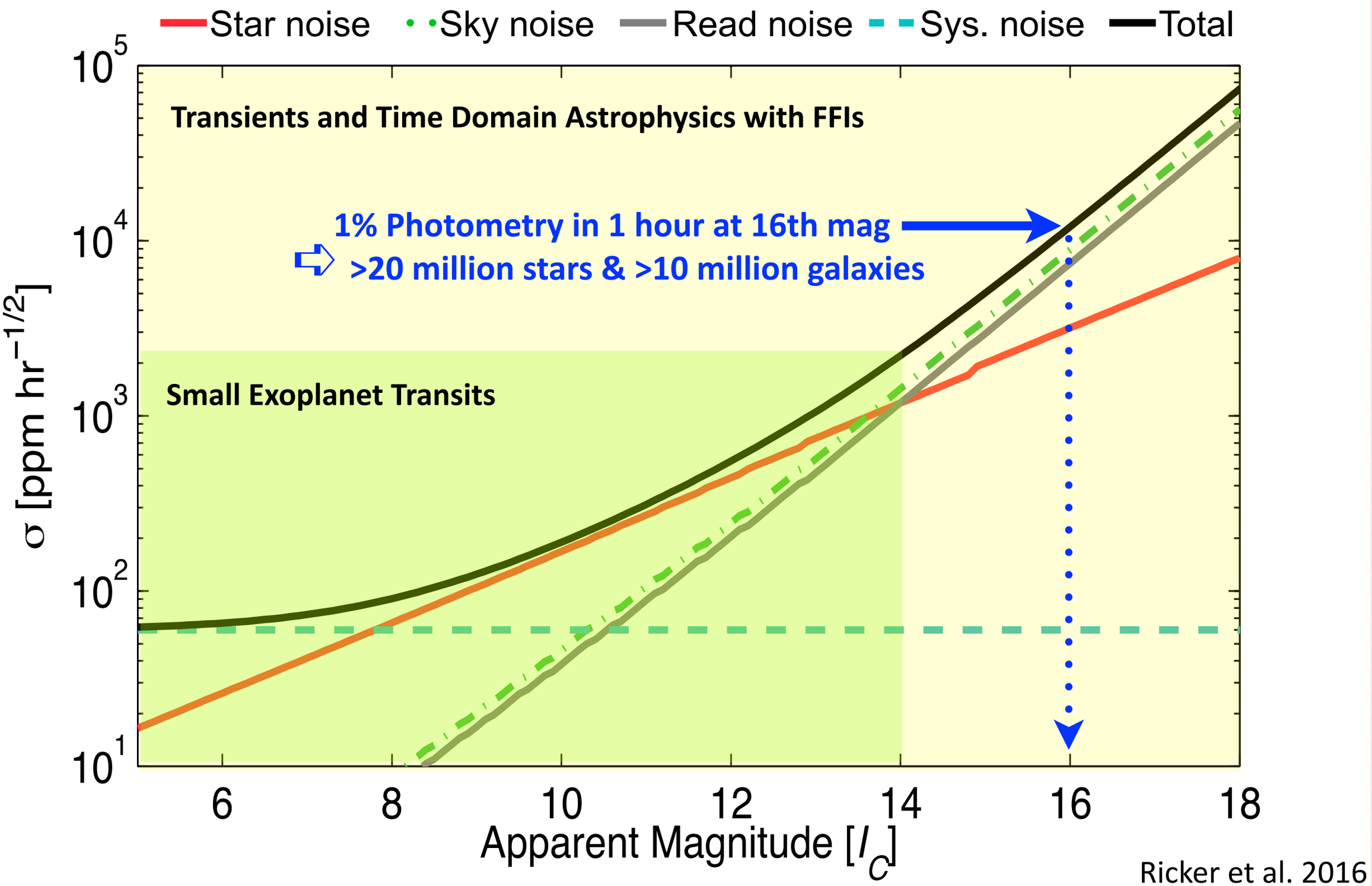
Distance (light years)



Non-Kepler
Kepler/K2
TESS (expected)

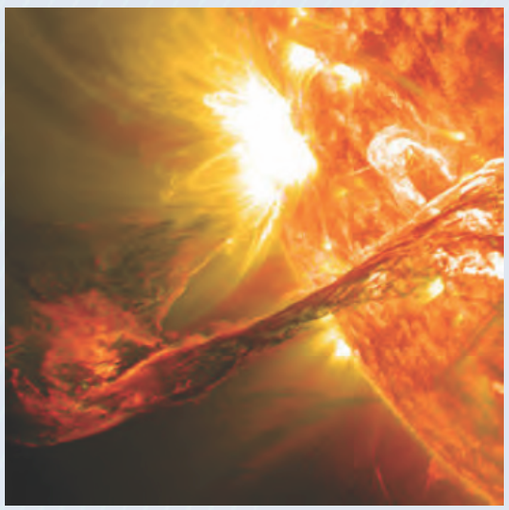
Graphics: Zach Berta-Thompson

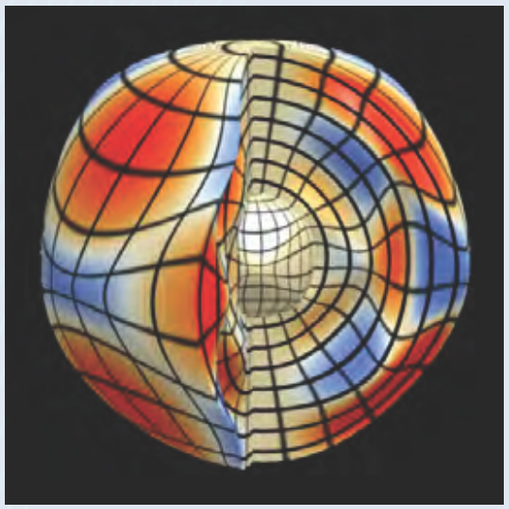
TESS Photometric Precision vs Magnitude



Ricker et al. 2016

Time Domain Astrophysics with TESS FFIs





Non-Transiting Exoplanets

- Microlensing events

Solar System

- Occultation Events
- Comets
- Asteroids

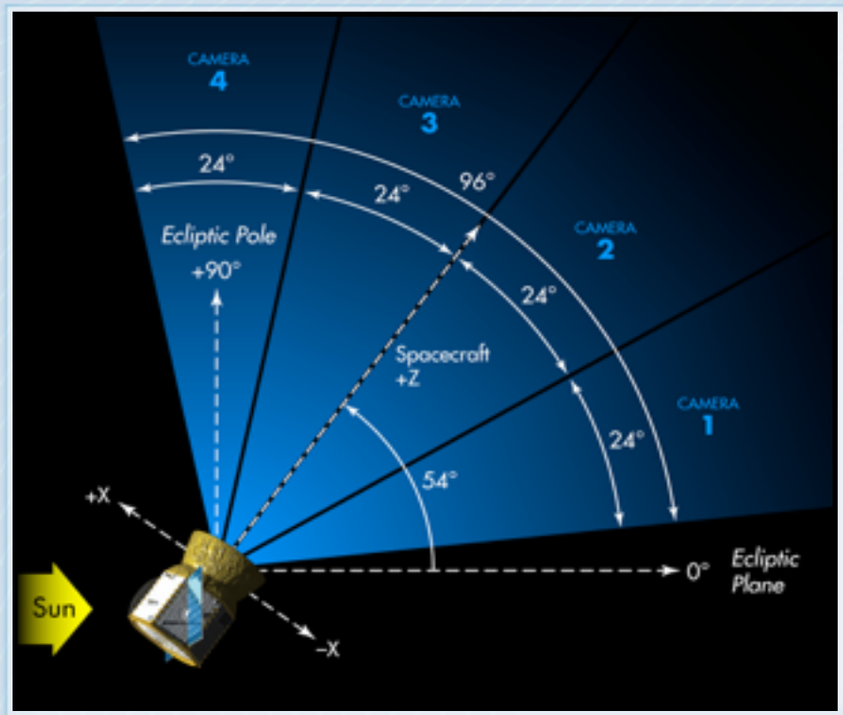
Extragalactic Sources

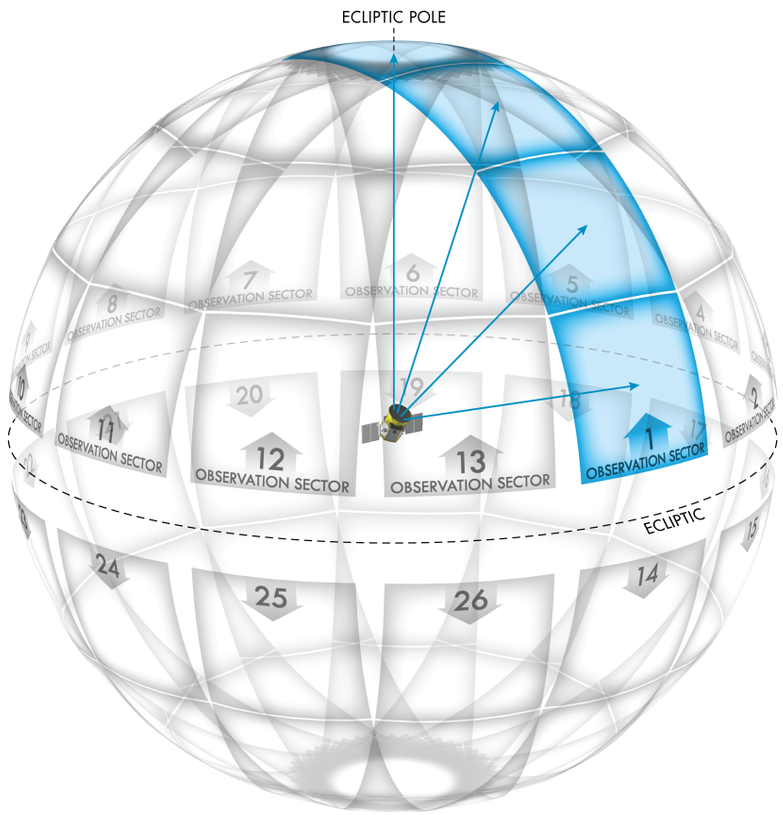
- Supernovae
- AGNs
- Blazars
- Quasars
- Tidal Disruption Events
- Gamma-ray Bursts
- Kilonovae
- Hypernovae

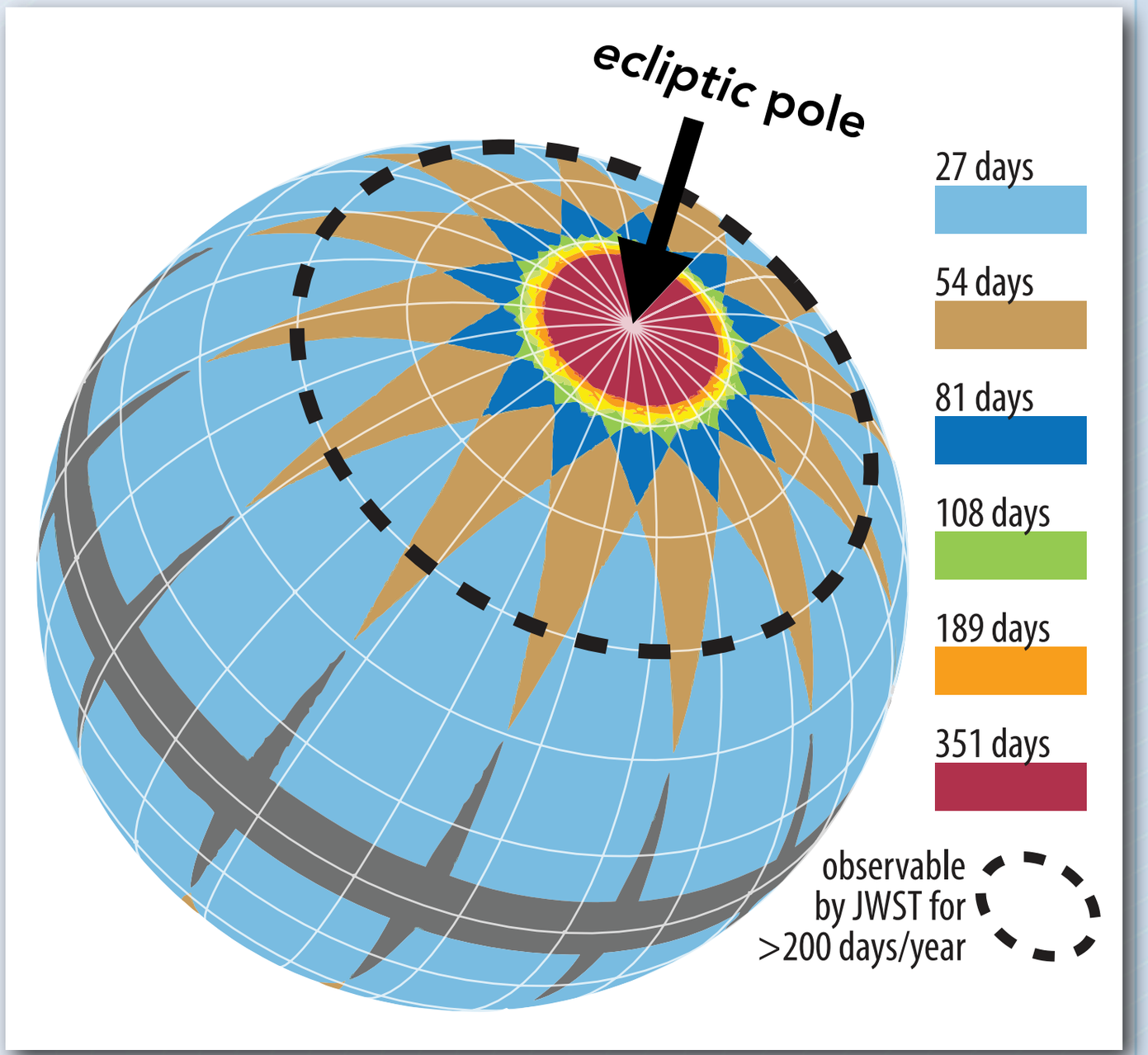
Stars

- Asteroseismology
- Brown Dwarfs
- Eclipsing Binaries
- Flare Stars
- Cepheids
- T Tauri Stars
- Cluster Gyrochronology
- White Dwarfs
- Neutron Stars
- Emission line stars (Be stars)
- RR Lyrae Stars
- WD Oscillations
- Novae
- Young Stellar Objects

TESS 2-Year Sky Mapping Plan

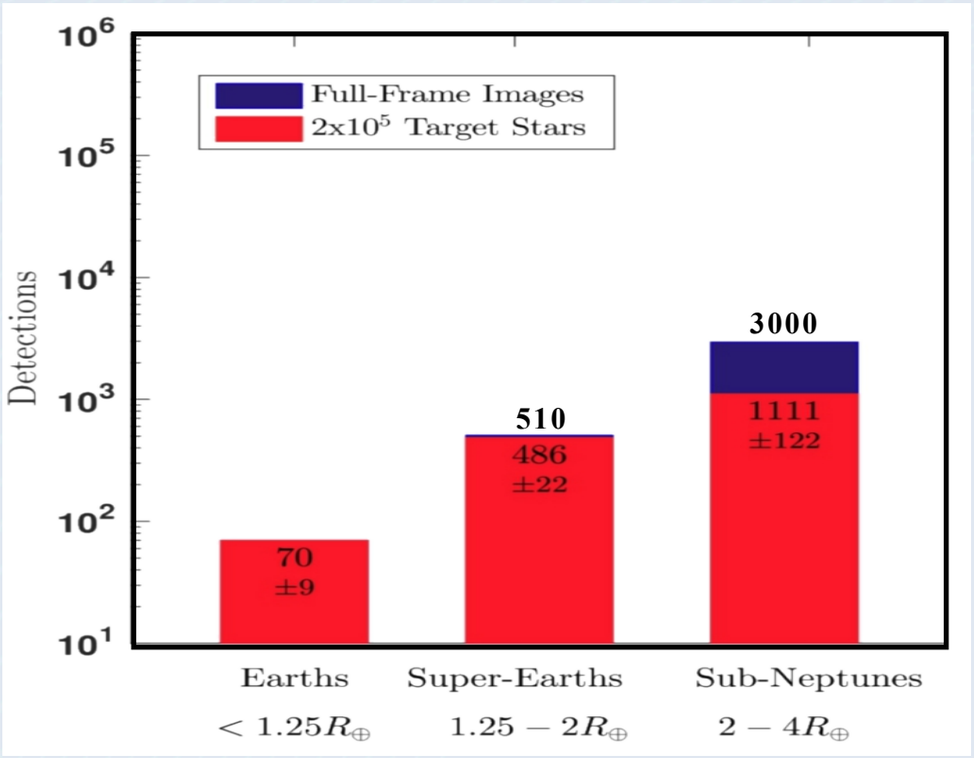






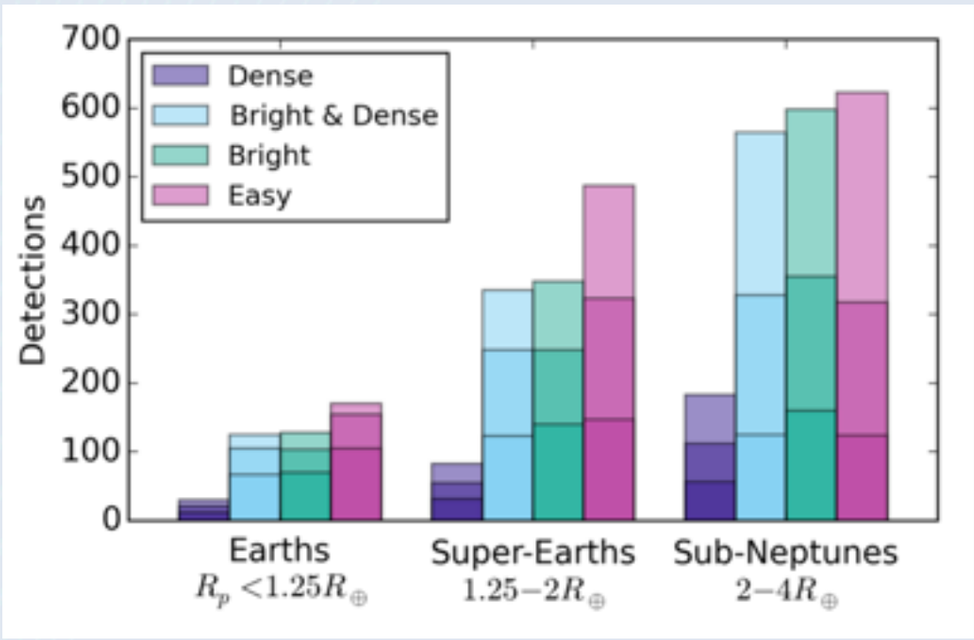
Ricker et al., JATIS, (2014)

Yield Estimates for TESS Small Planets ($R_P < 4\ R_{Earth}$)



Sullivan et al. 2015

Sullivan+15	For 2 x 10^5 2min Targets	Scaled: For 5 x 10^4 2min Targets
Earths	70	18
Super-Earths	486	122
Sub-Neptunes	1111	278
TOTAL	**1667**	**417**



Muirhead et al. 2017

Muirhead+17	For 5 x 10^4 "Bright" 2min Targets	For 5 x 10^4 "Easy" 2min Targets
Earths	127	171
Super-Earths	348	489
Sub-Neptunes	599	625
TOTAL	**1,074**	**1,284**

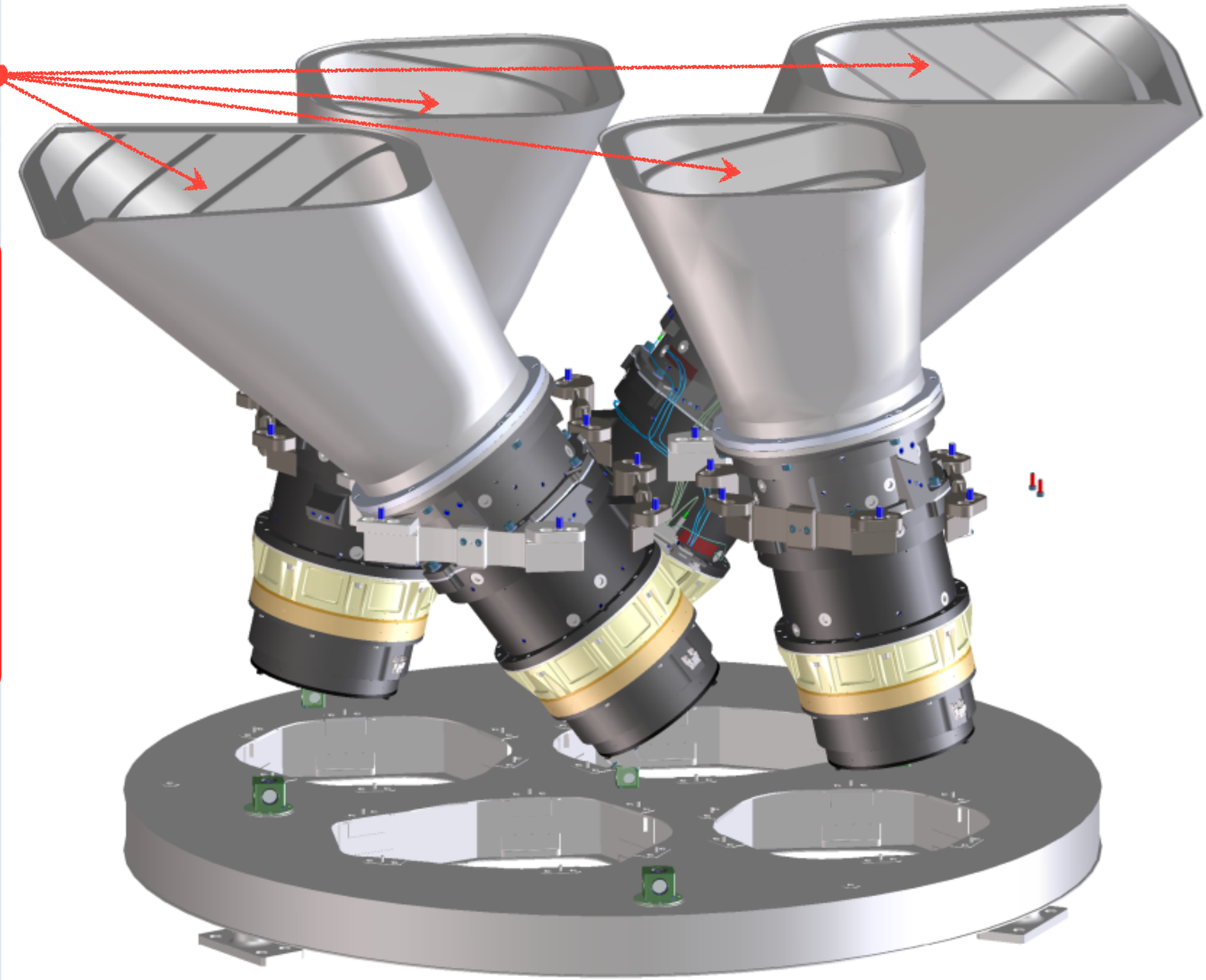
All TESS Flight Instruments are delivered and integrated.

Environmental Testing in Progress!

Layout of TESS Camera Array

4 Cameras

FOV of 4 camera ensemble 24° x 96° or 2300 deg²



In Case You Have Ever Wondered:

How Many Engineers Are Needed to Mount the Tess Cameras?

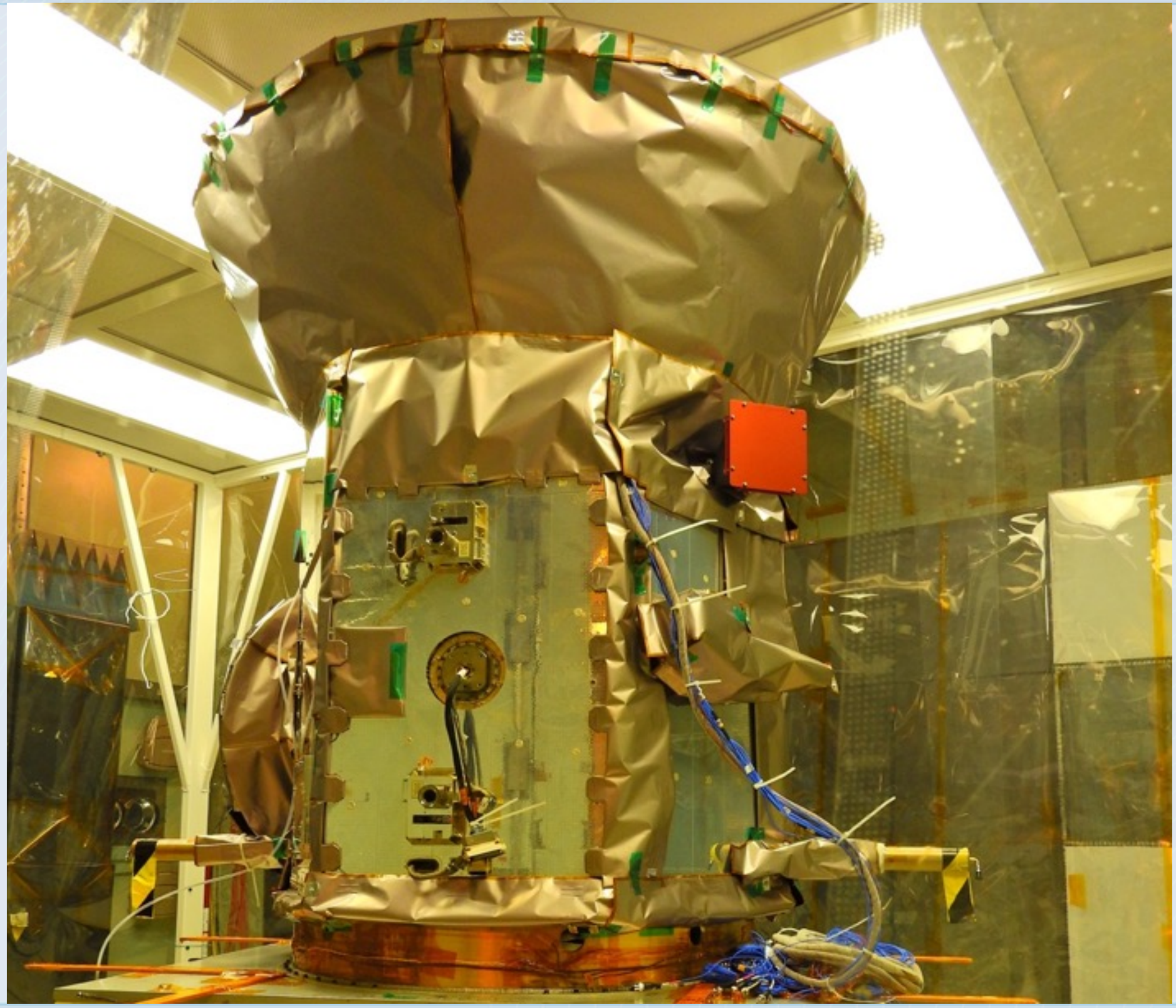
Answer:

7 (plus 1 photographer)

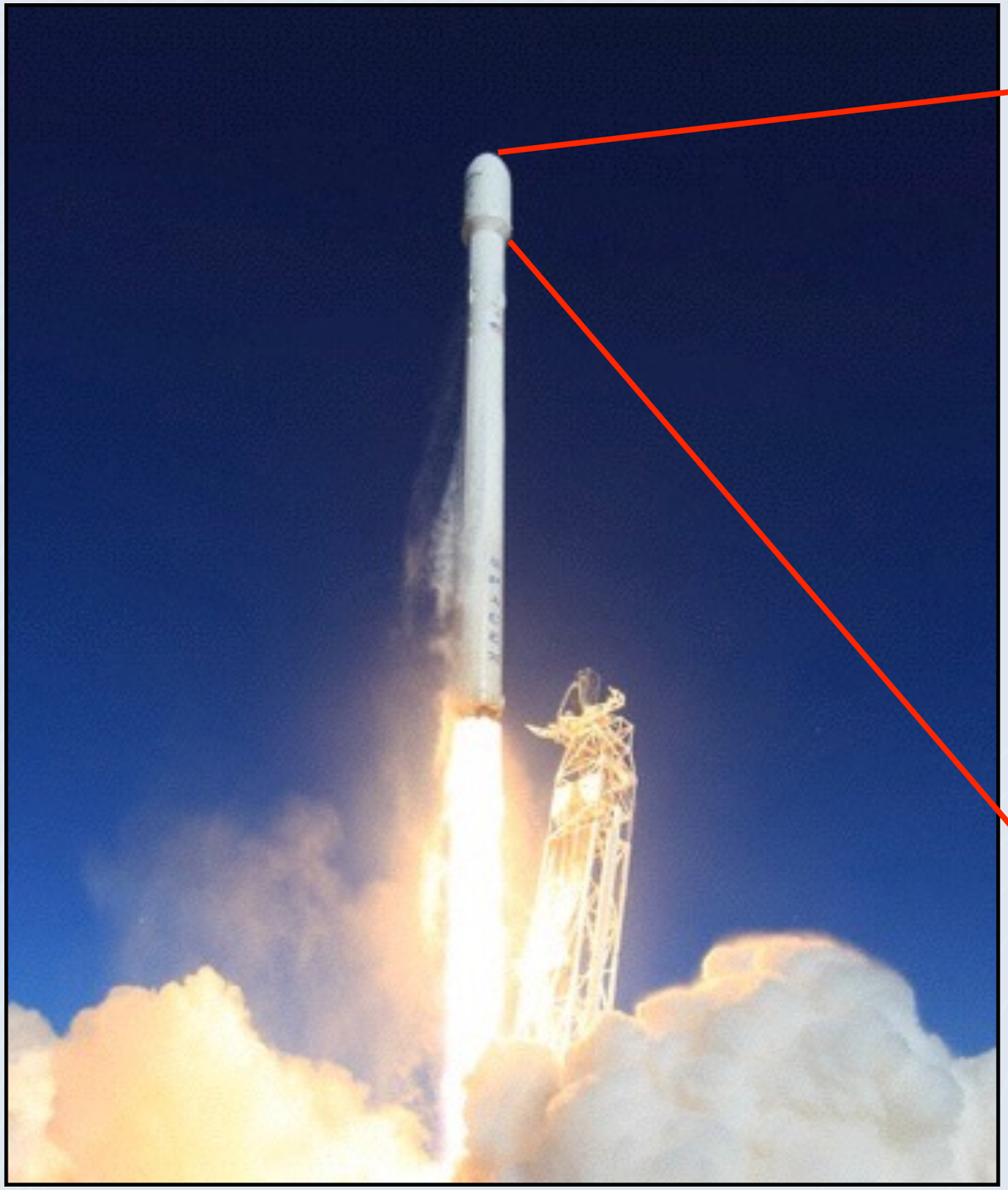

200 Volt
50 Amp 3ph

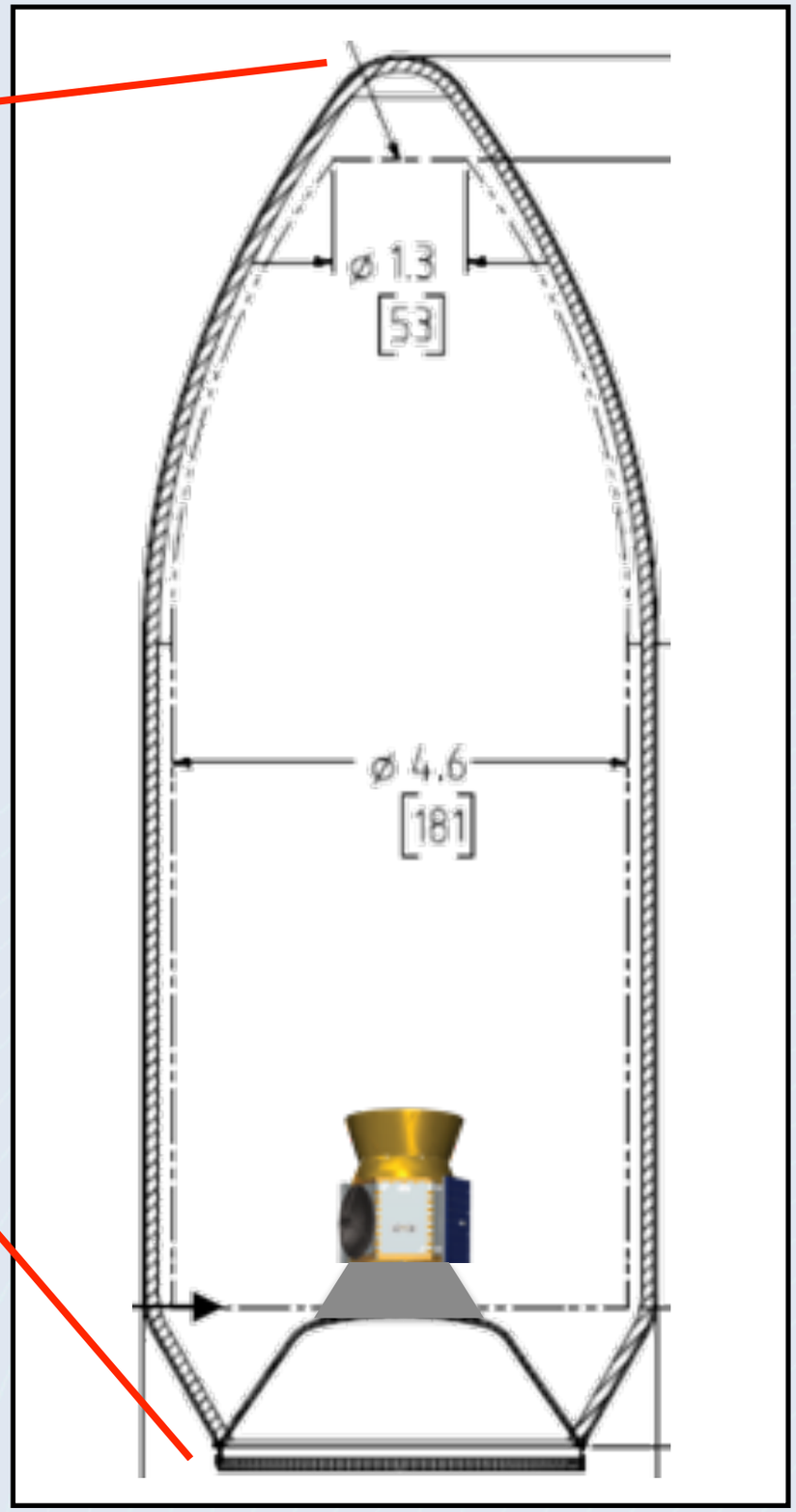
TESS: Ready for Integration and Pre-Launch Testing

TESS "Dressed Up" with Multilayer Insulation on Sunshade



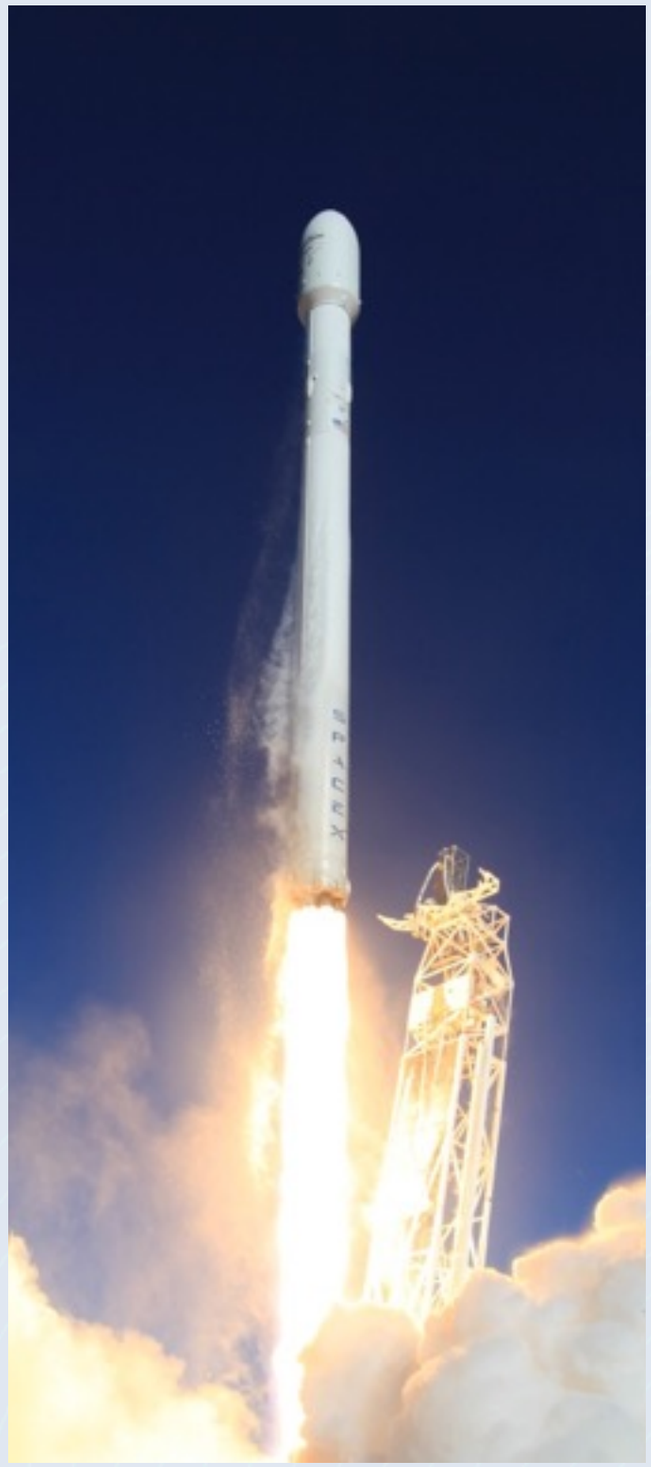
TESS's Falcon 9: An Interesting Launcher Choice...



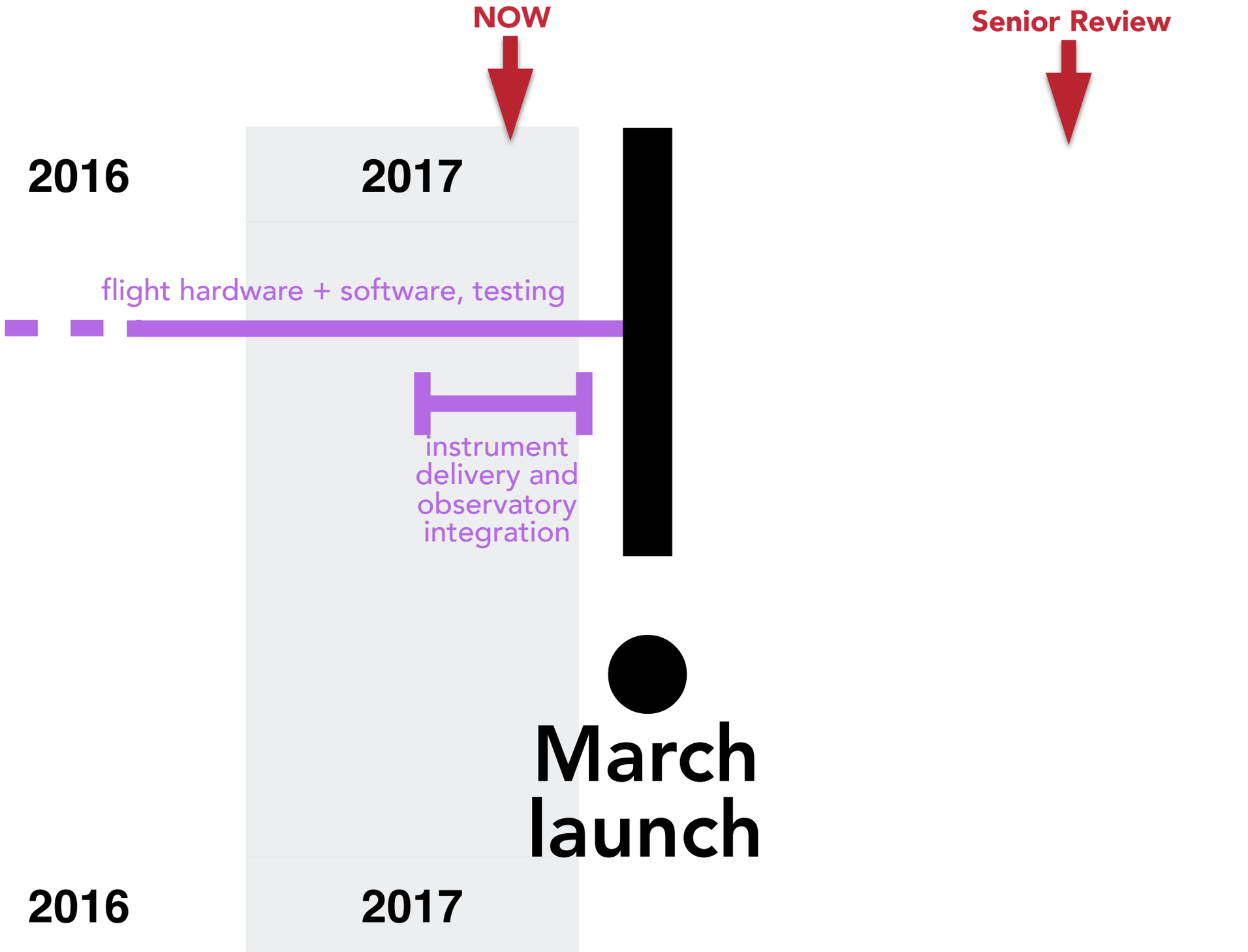


TESS Launch Vehicle: Falcon 9 Status

- SpaceX Falcon 9 successfully returned to flight in January 2017:
  - ~~***Seven***~~ ~~***13***~~ ***15*** *successful launches already in 2017*
- ~~20~~ ~~15~~ ***11*** additional Falcon 9 flights anticipated before TESS launches
- TESS's Falcon 9 will possibly be a Block 5 vehicle
  - *Recoverable fairing?*
  - *NASA re-certification needed (launch loads)*
  - *TESS launch scheduled in March 2018*

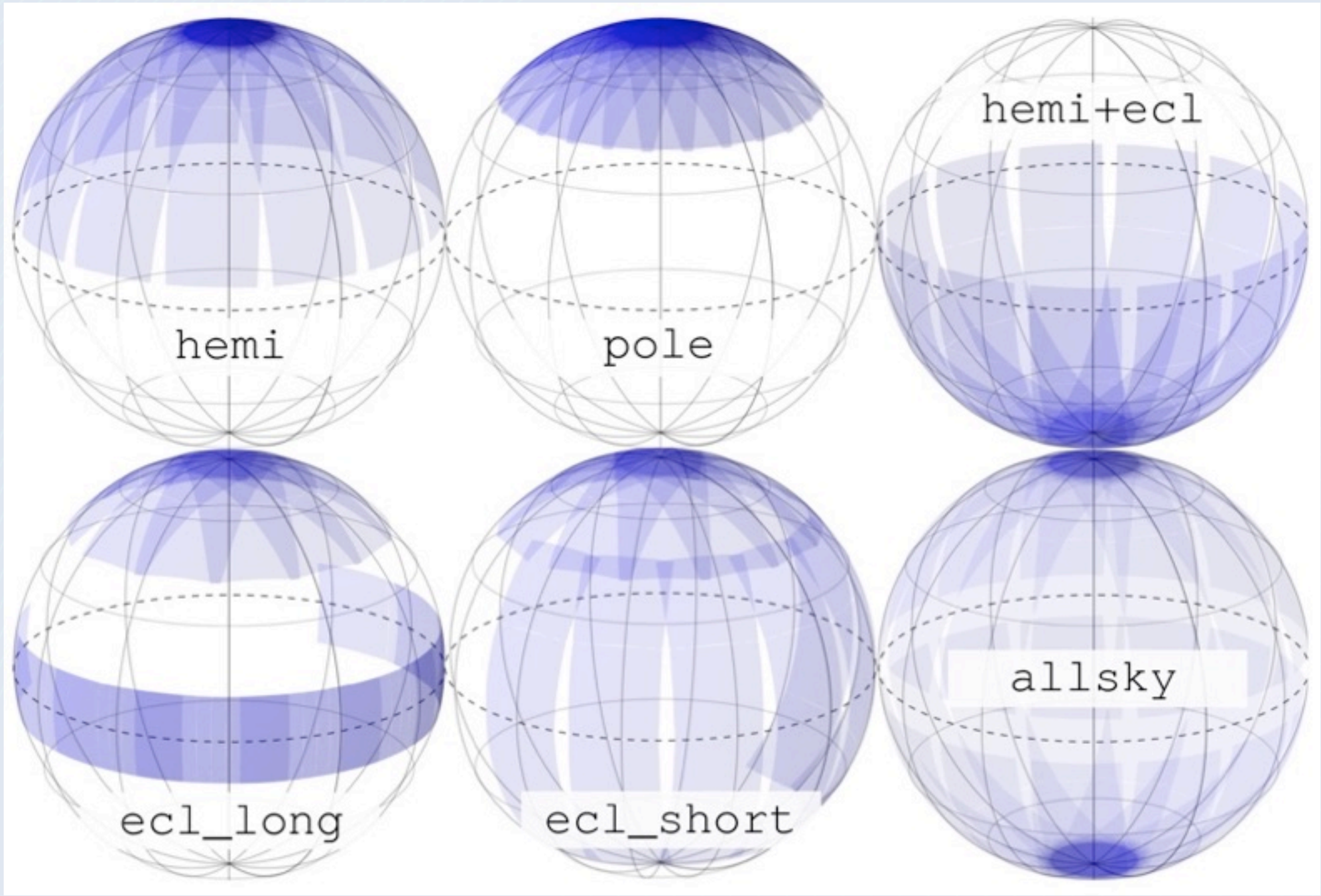


TESS timeline:



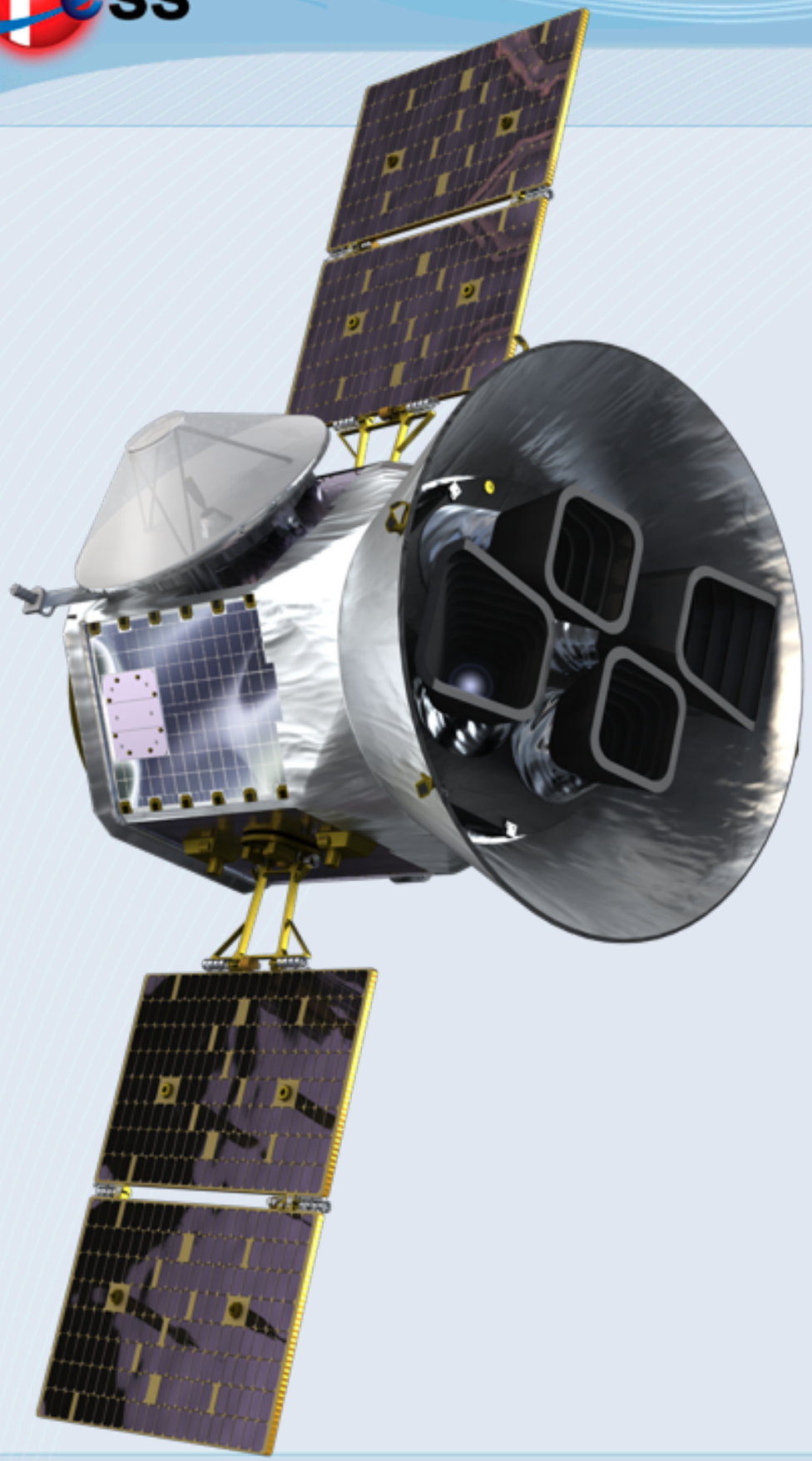
Extended Mission Scenarios for TESS

- TESS Orbit is Stable for >20 Years....



Bouma et al. 2017 (in prep)

Takeaways



- TESS will find nearby bright small transiting planets for followup by JWST and upcoming giant 20-, 30-, and 40-meter ground-based telescopes.
- TESS could operate for more than two decades.
- TESS planets will endure as the best small planet targets for radial velocity mass measurements and atmospheric characterization.
- TESS will fly a highly adaptable data handling unit, enabling support of a broad range of time domain astrophysics, well beyond exoplanet studies.


Tess

Backup Slides

TESS Candidate Target List (Stassun et al 2017)

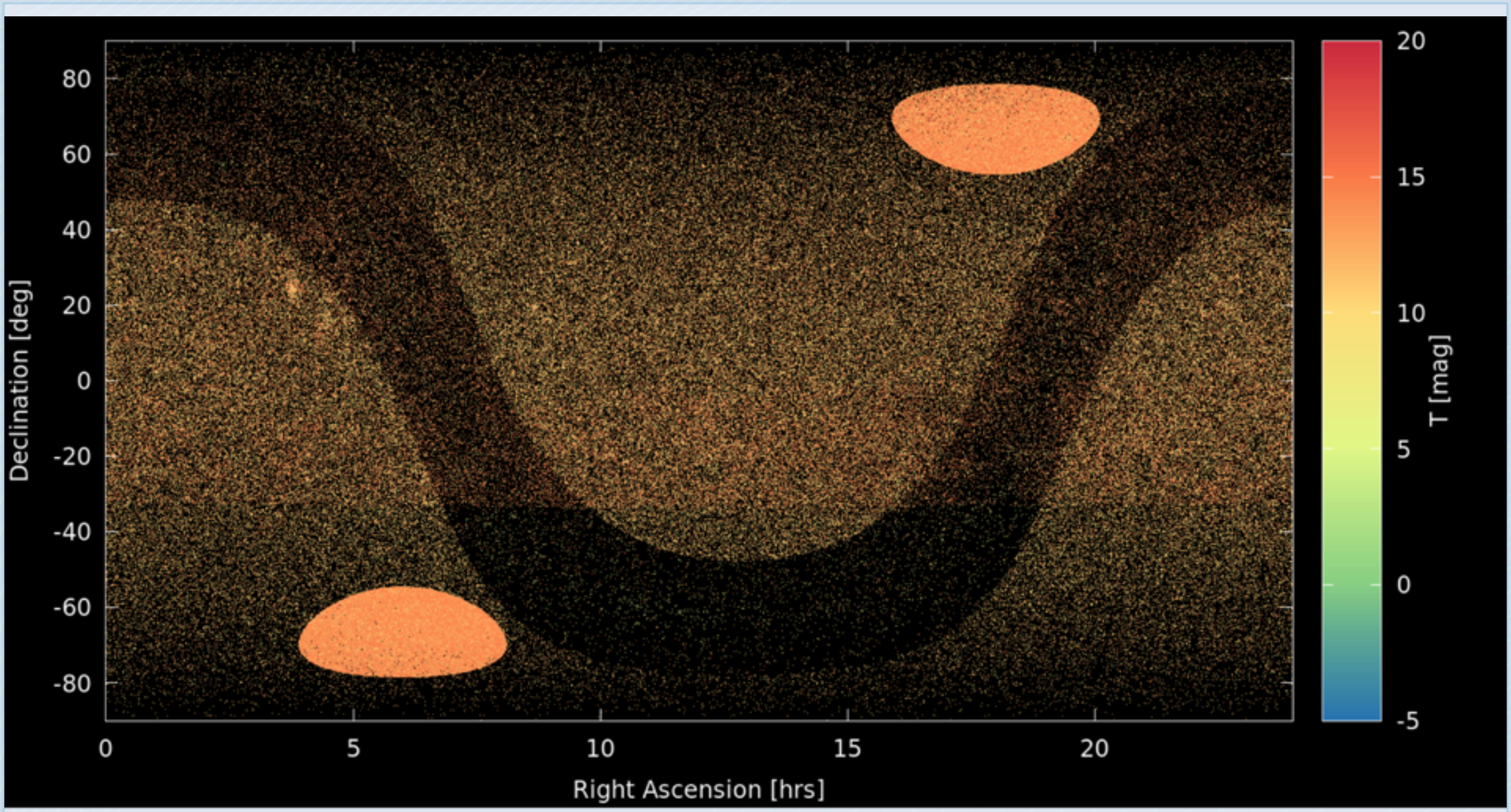


Fig. 19.— The distribution of top CTL targets in right ascension and declination, colored by T magnitude. Clear patterns arise due to de-boosting in the Galactic Plane (|b| < 15°), the special boosting within the ecliptic poles (|β| > 78°), and the coverage of the proper motion catalogs (the lines near 35)

Spectral Passbands of Kepler and TESS