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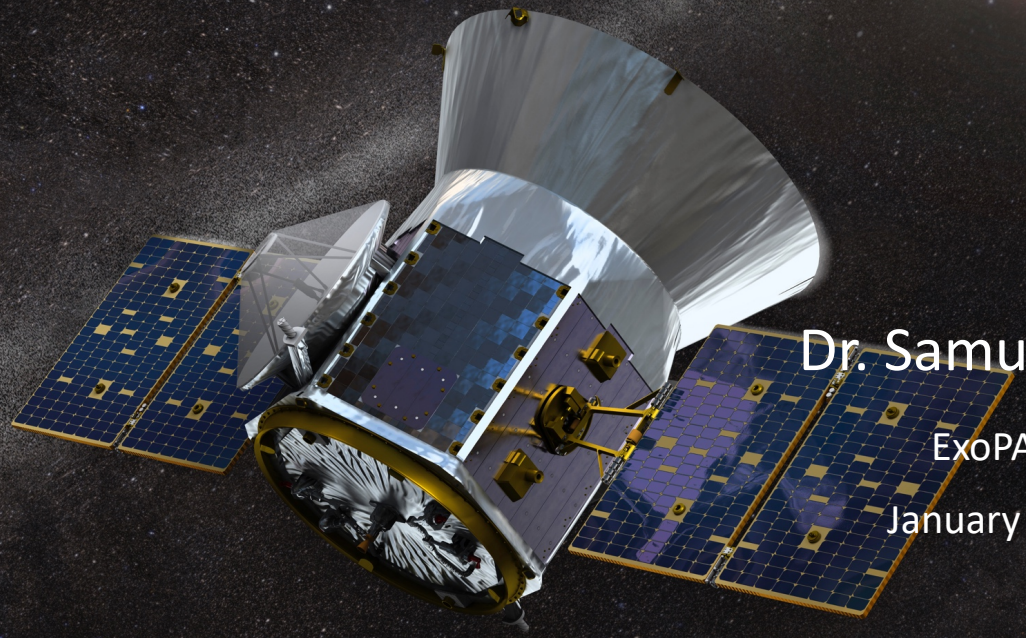
TESS and the NASA Exoplanet Exploration Program



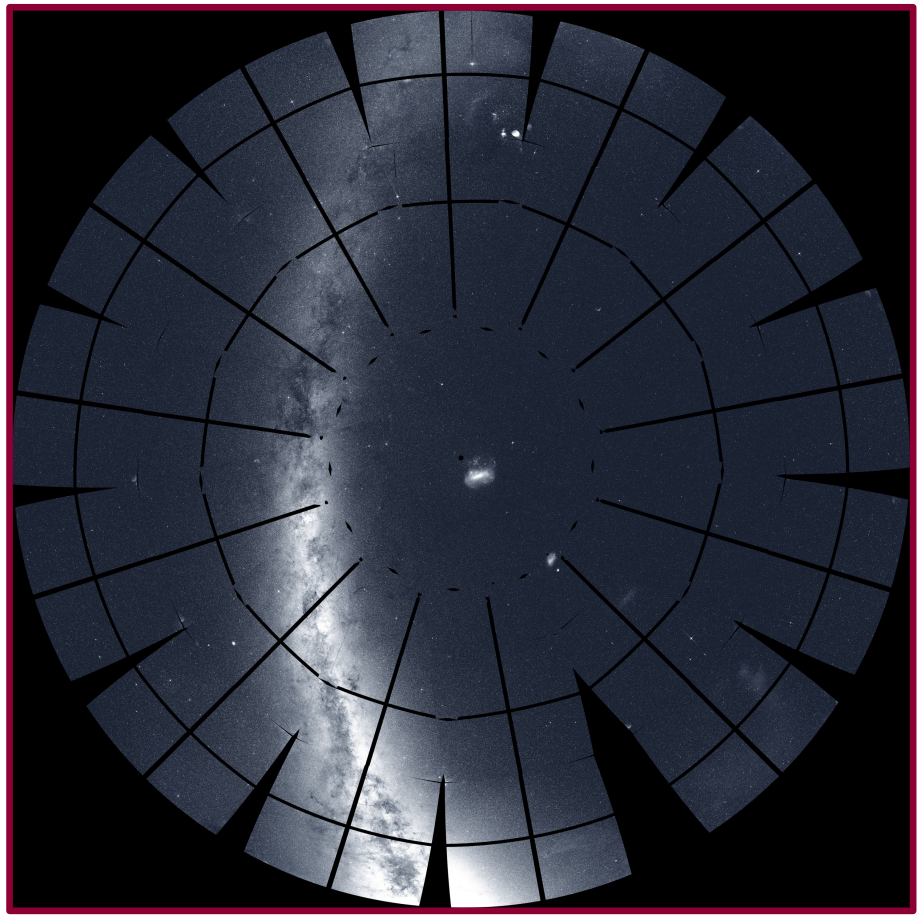
Dr. Samuel Quinn

ExoPAG 21

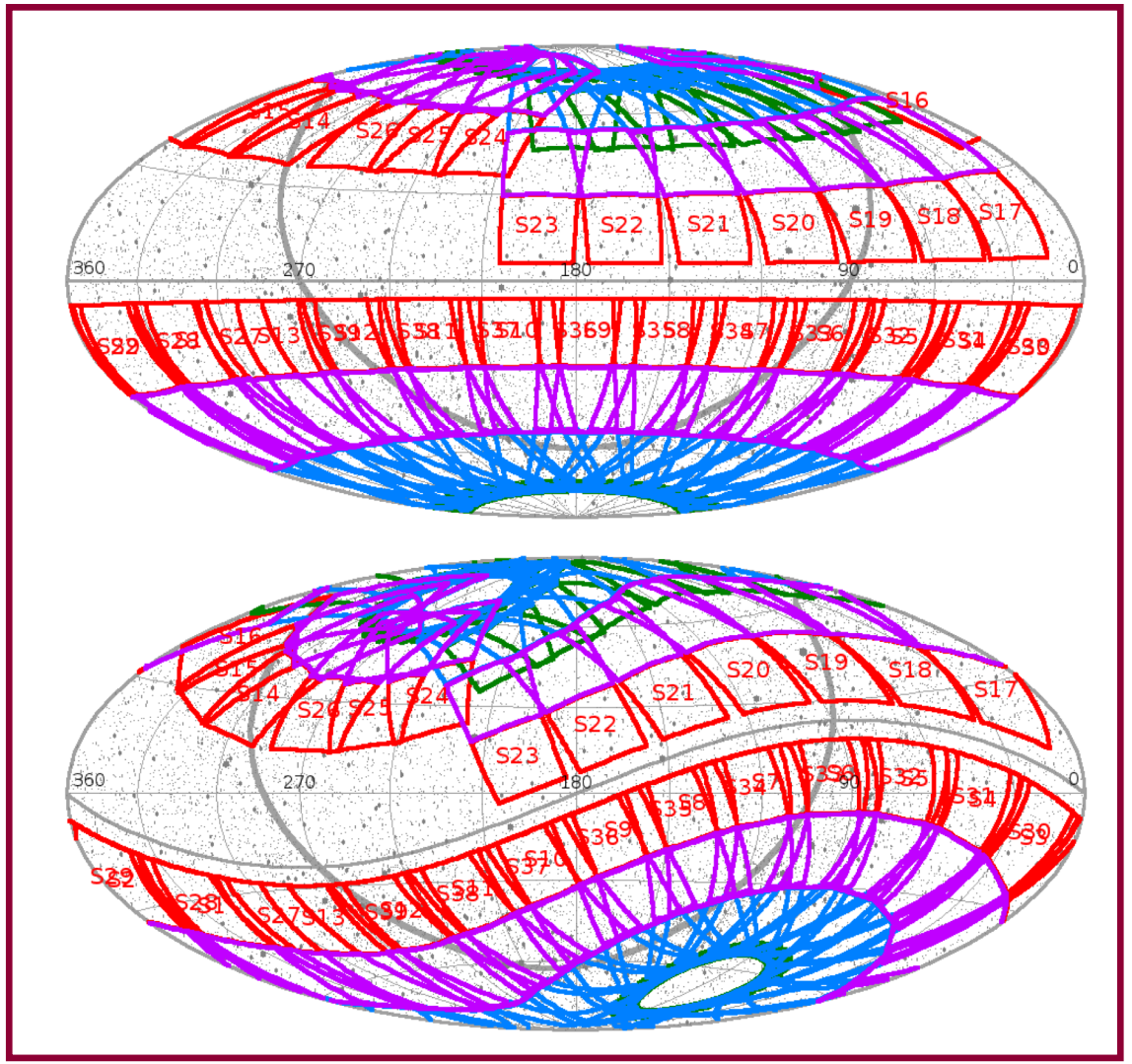
January 3, 2020

A brief update on the status of TESS

TESS launched April 18, 2018
- Southern hemisphere began July 26, 2018
- Northern hemisphere began July 18, 2019
- Approved for extended mission beginning July, 2020



NASA/MIT/TESS and Ethan Kruse (USRA)



Roland Vanderspek

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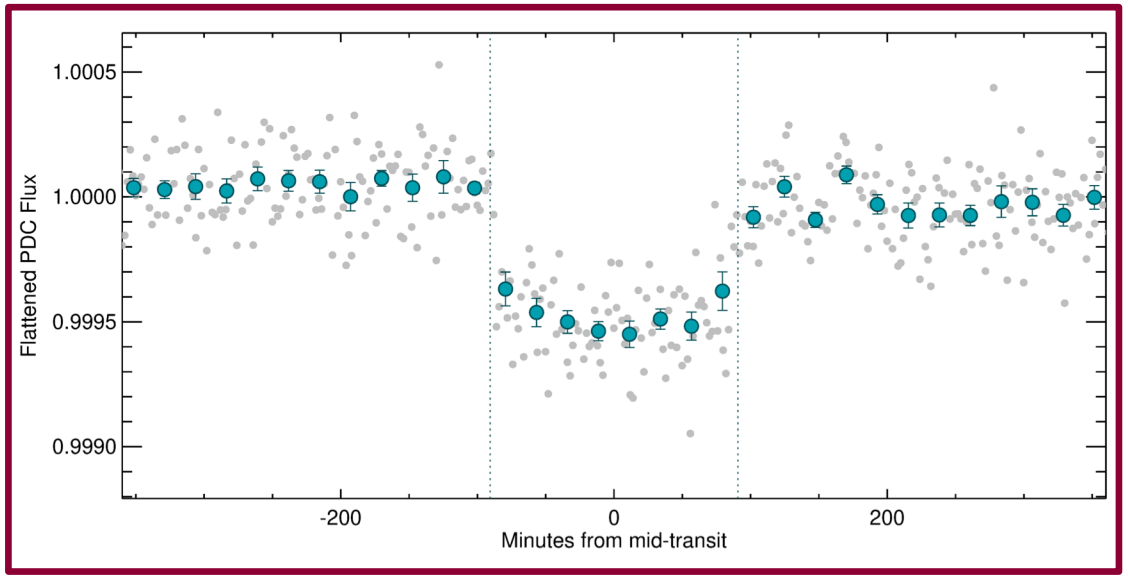
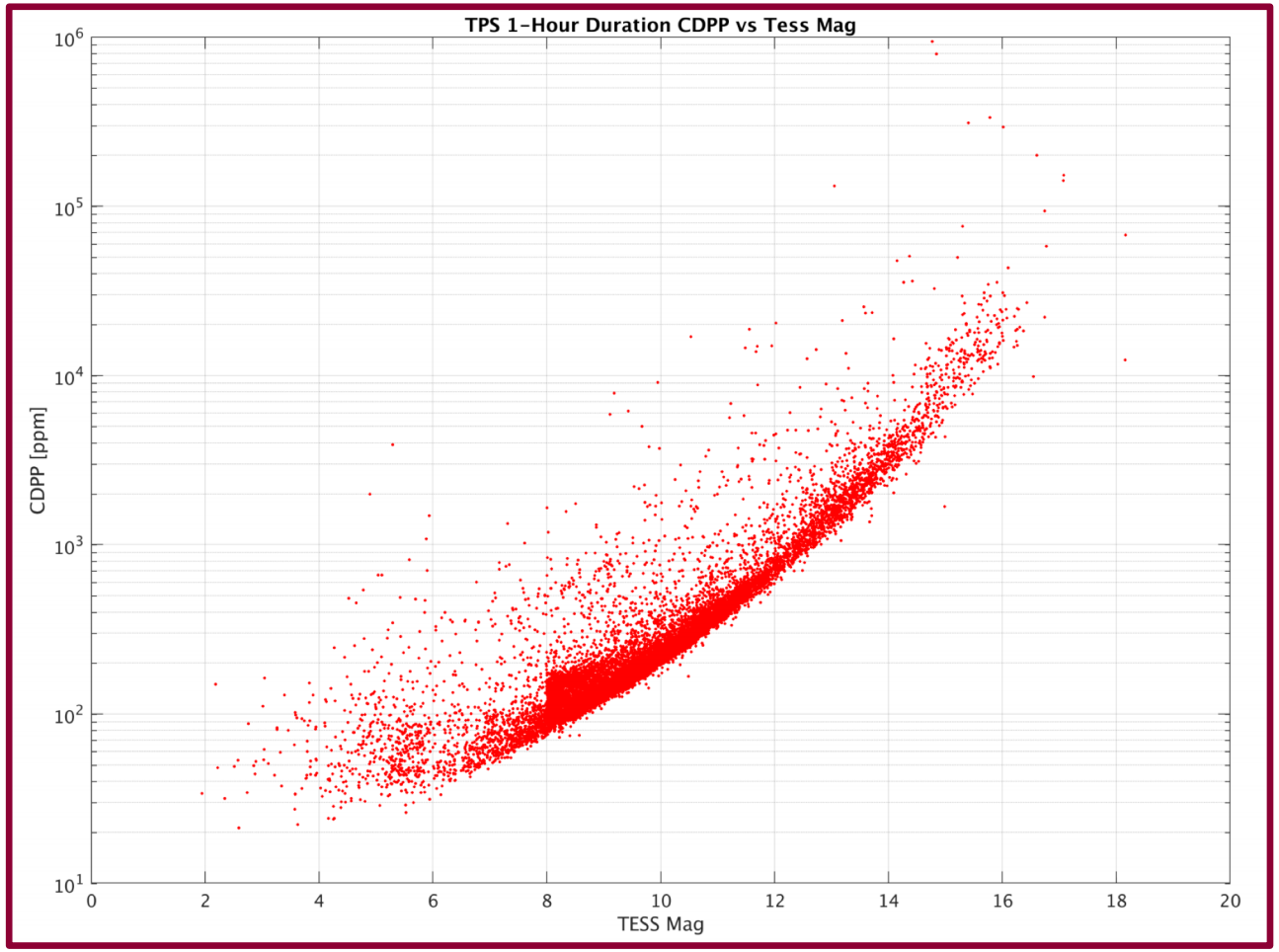
A brief update on the status of TESS

Photometric precision (1-hr CDPP) <30 ppm for bright stars.

Below is the detection of a single transit of a 2.2-R_E planet in a light curve with 1-hour CDPP of 29 ppm.





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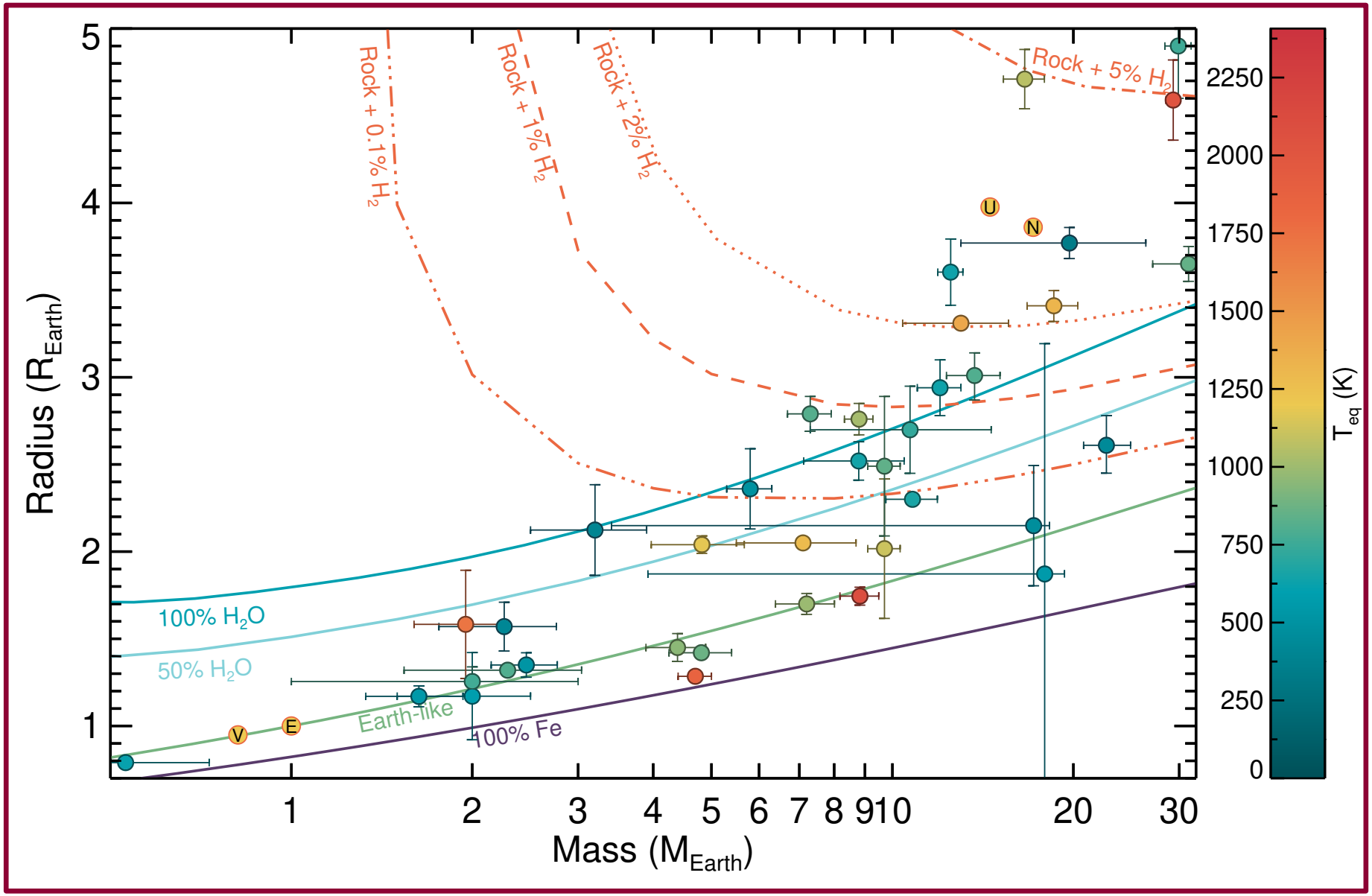
A brief update on the status of TESS

1588 TOIs

Dozens of confirmed planets

More on the way, including mass measurements of small planets.



A brief update on the status of TESS

The TESS Follow-up Observing Program (TFOP) WG is a mission-organized, community-driven effort.

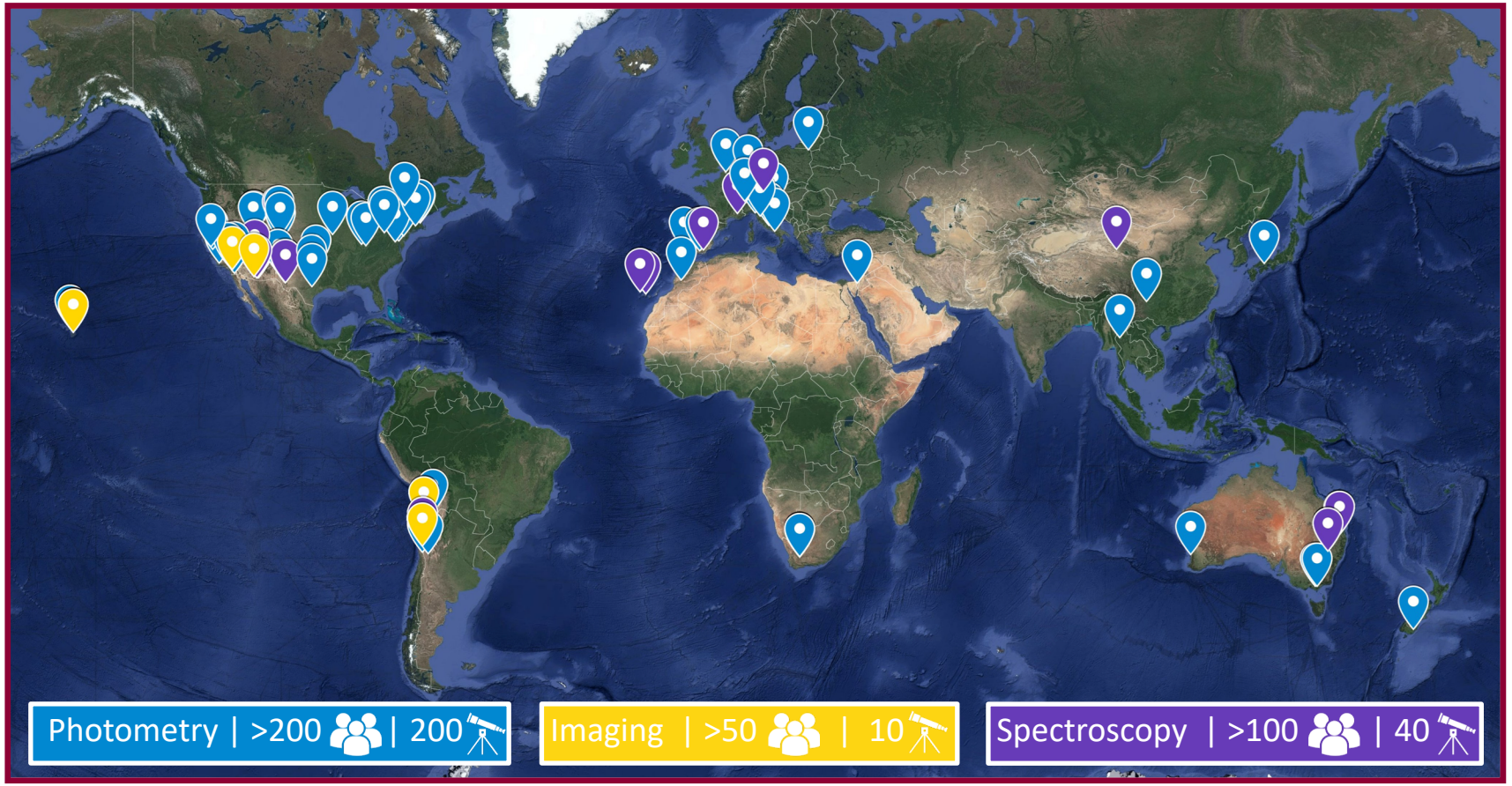
We aim to:

- Measure masses for 50 planets $<4R_E$ (Level 1 Science Requirement)
- Foster communication, coordination, and collaboration within the exoplanet community
  - Minimize unnecessary duplication, maximize science yield
  - Enhance the legacy of TESS by looking beyond the Level 1 Science Requirement to build a lasting collaborative community.

A brief update on the status of TESS

Contributions toward mass measurements come from many teams, using facilities such as:

HARPS	CHIRON	SPIRou
HARPS-N	CORALIE	ANU2.3m
ESPRESSO	SOPHIE	APF
CARMENES	TRES	SONG
PFS	FIES	FIDEOS
HIRES	NRES	Tautenburg
FEROS	McDonald-Tull	SALT/HRS
MINERVA-Australis	IRD	IGRINS
Veloce	iSHELL	NEID
		...and more



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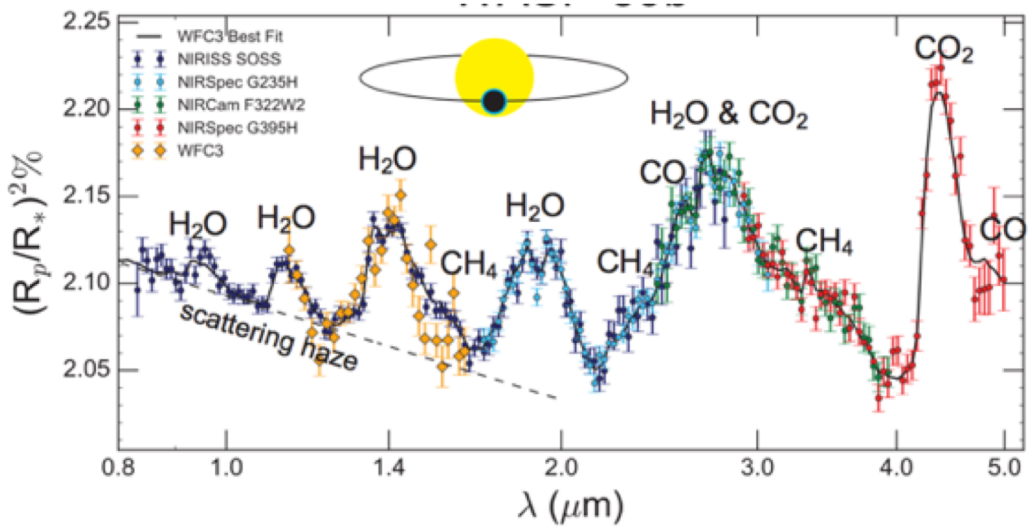
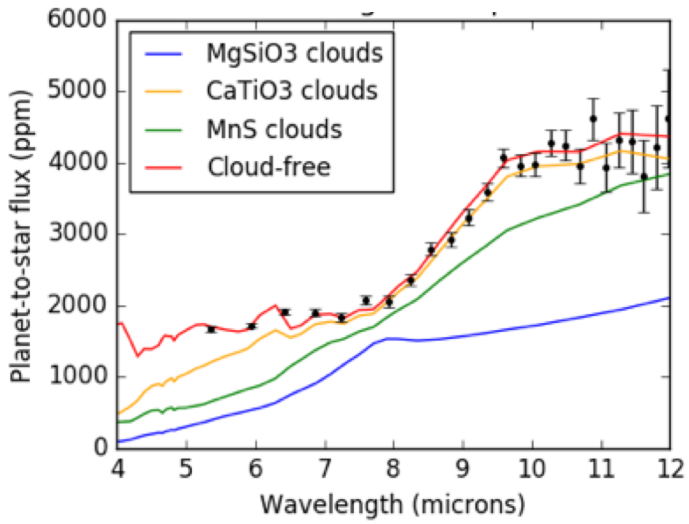
TESS and JWST: giant planets

JWST will reveal the atmospheres of gas giants in unprecedented detail

Simulated hot Jupiter transmission spectrum



Emission Spectrum



Bean et al. (2018)

JWST observations for the Transiting Exoplanet Community Early Release Science Program will:

- Determine atmospheric chemical composition with precision comparable to Solar System measurements
- Detect nightside spectra to determine cloud properties and composition

TESS will:

- Provide **updated ephemerides** for nearly all transiting giant planets.
- Discover **transits of RV planets** (e.g., Pepper et al., 2020)
- Observe **optical phase curves** of some hot Jupiters, yielding brightness temperatures, albedos, and constraints on atmospheric dynamics.

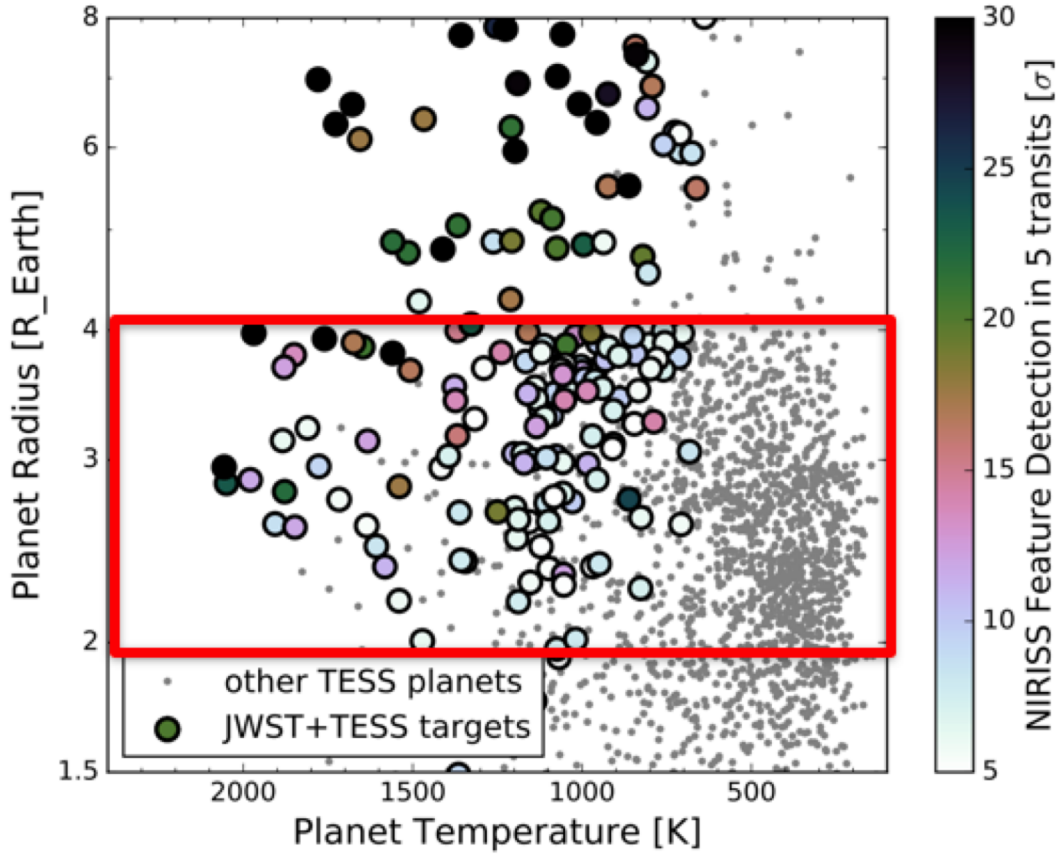
TESS and JWST: small planets

What are super-Earths and sub-Neptunes?

Planets in the 2-4 R_E regime have no solar system analogue.

Atmospheric spectra, in conjunction with mass measurements, will tell us what they are made of.

Studying them in different environments (stellar masses, equilibrium temperatures) and at different ages can provide additional evidence.



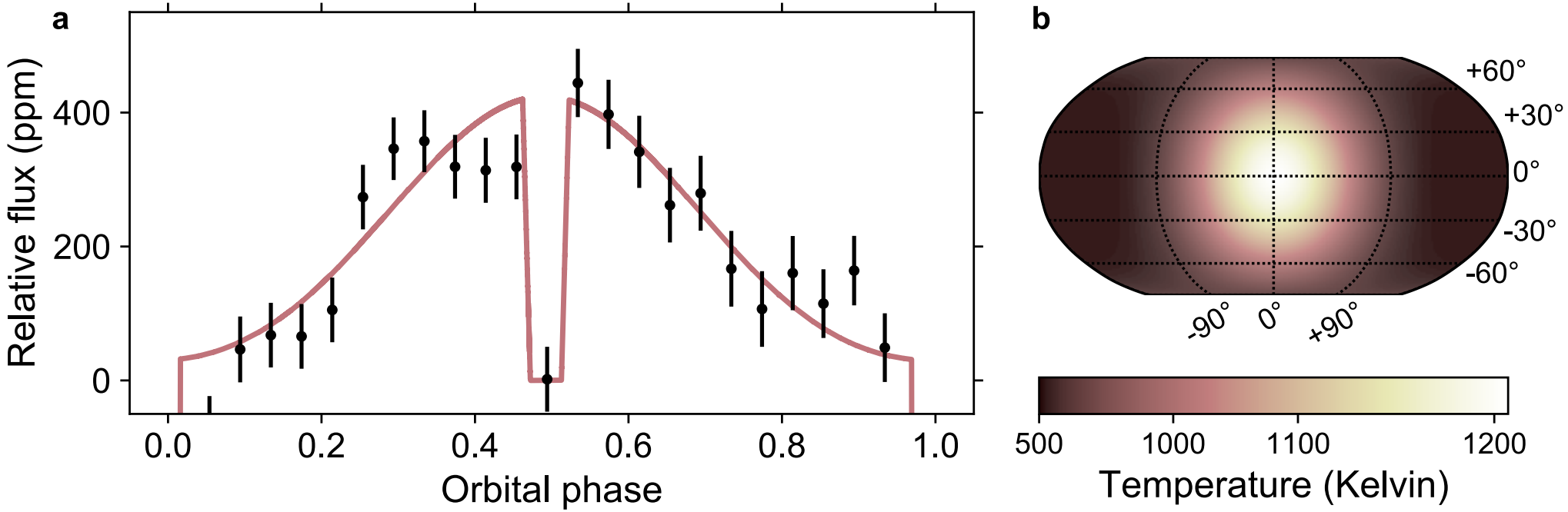
Crossfield & Kreidberg (2017)

TESS is:

- Discovering the **nearest super-Earths and sub-Neptunes** that are the most accessible targets for **JWST**.
- These are also accessible for mass measurement with PRV instruments like **NEID, HIRES**.
- Discovering planets in **young associations** (Newton et al. 2019), around **young field stars** (Zhou et al., in prep), and in groups shown to be young via TESS rotation periods (Curtis et al. 2019).

TESS and JWST: small planets

Do rocky planets typically have atmospheres?



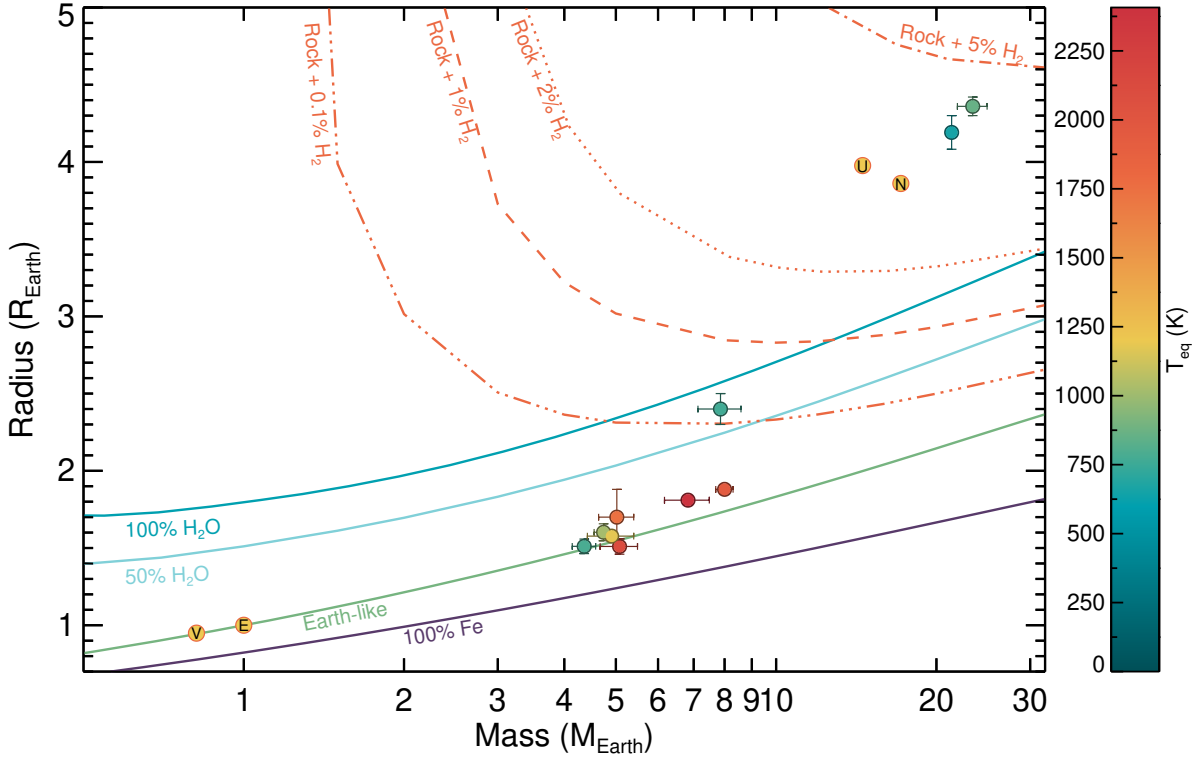
Kreidberg et al. (2019)

TESS is detecting many **Earth-size planets** that are accessible for **JWST thermal emission spectroscopy**. These measurements will determine their atmospheric composition (or surface composition if no atmosphere is present).

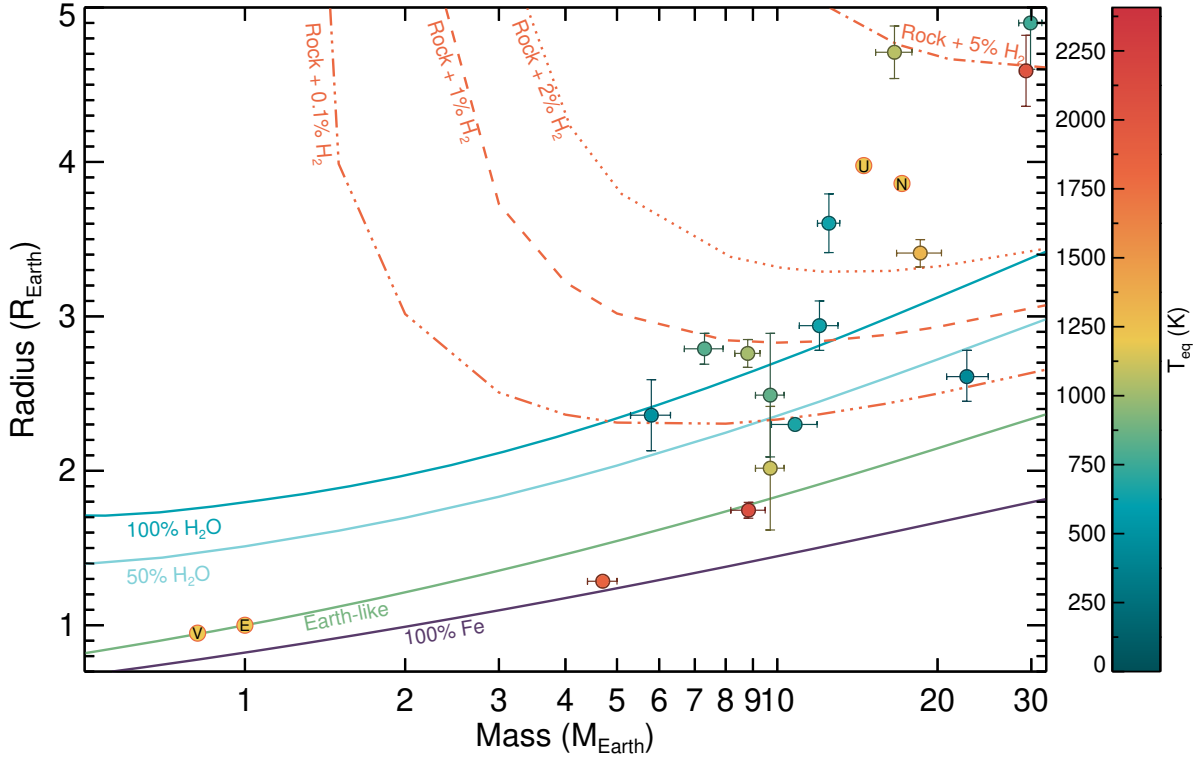
TESS and PRV

Finding the best targets for mass measurements

Intrepretation of transmission spectra relies upon knowing the mass of the planet. TESS detects planets orbiting the brightest stars, suitable for NEID can measure masses. In the southern hemisphere, the community has already measured more (preliminary!) 10-sigma RV masses of small TESS planets than exist from all previous transit surveys.



Non-TESS, 10-sigma RV masses

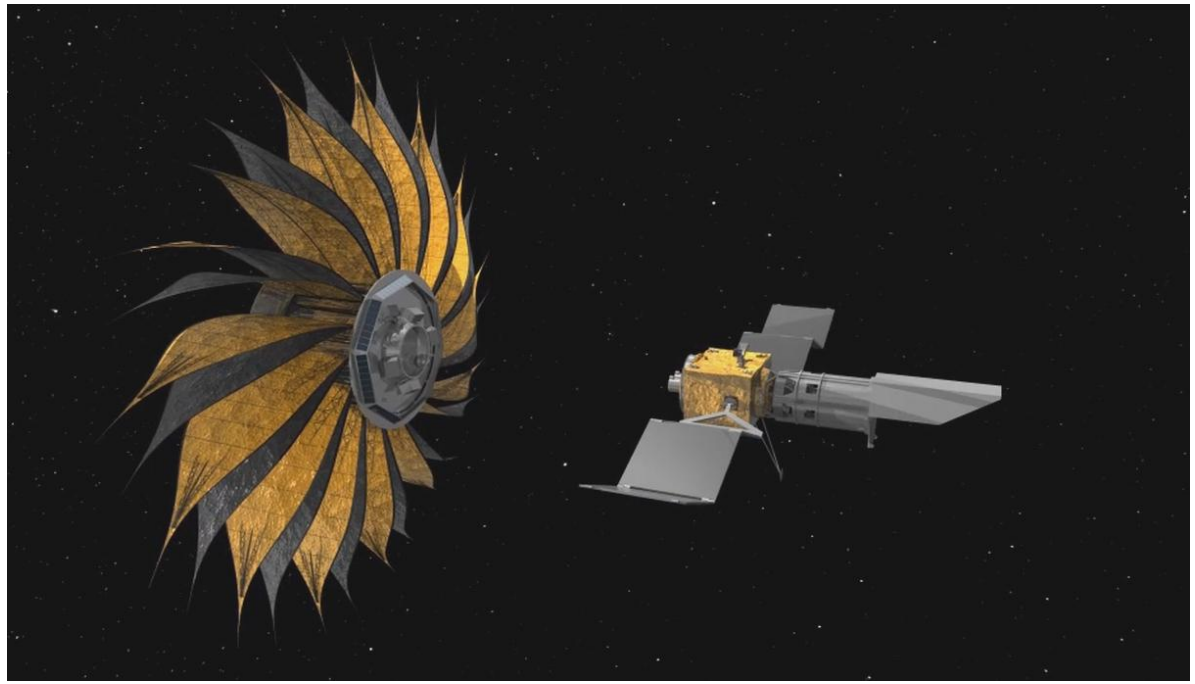


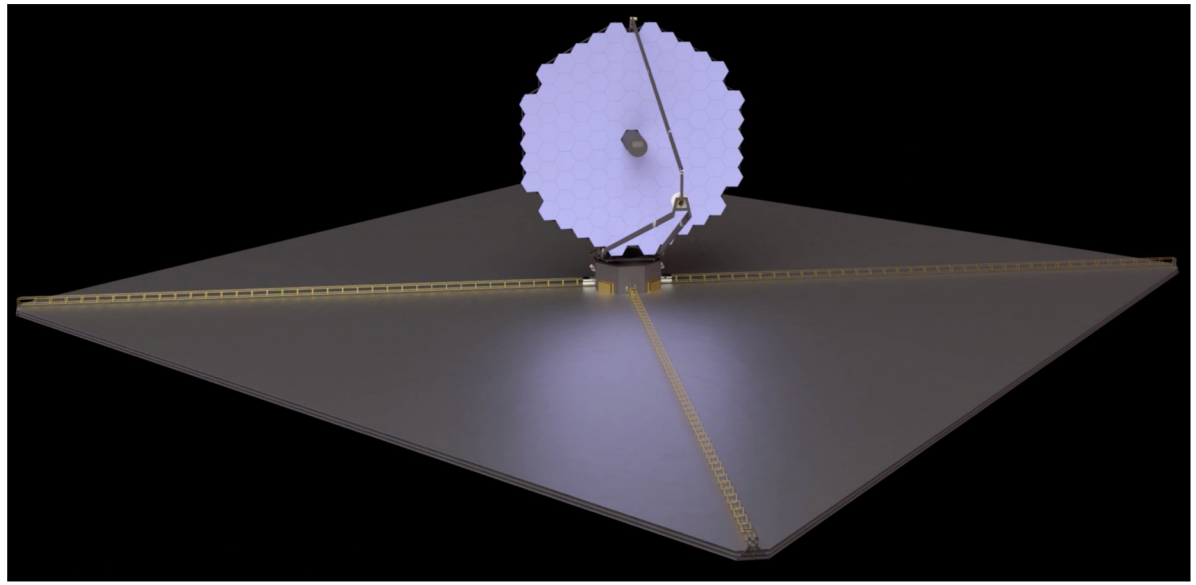
TESS, 10-sigma RV masses (**preliminary**!)

TESS and direct imaging

Though most TESS planets will be short period, the continuous viewing zones at the ecliptic poles, as well as the extended mission(s), provide an opportunity to detect long period planets around nearby, bright stars.

A small number may be detectable by future missions. The combination of transit and direct observations would make these valuable benchmark objects.





TESS will support ExEP in many ways

TESS will (continue to) discover transiting planets around nearby, bright stars, crucial for ensuring strong **exoplanet science returns from JWST**.

- As an all-sky mission, it will discover the **best targets for detailed characterization**.
- Will also provide much of the **ensemble of planets** for population studies to be carried out by missions like ARIEL

Many TESS planets will be suitable for **efficient PRV mass measurements**, e.g., with NN-EXPLORE initiatives like NEID (and future EPRV instruments?). Photometric characteristics from TESS light curves can inform additional target selection.

TESS may also deliver, particularly in the extended mission(s) a small number **transiting planets suitable for direct imaging and spectroscopy** with a future flagship mission.