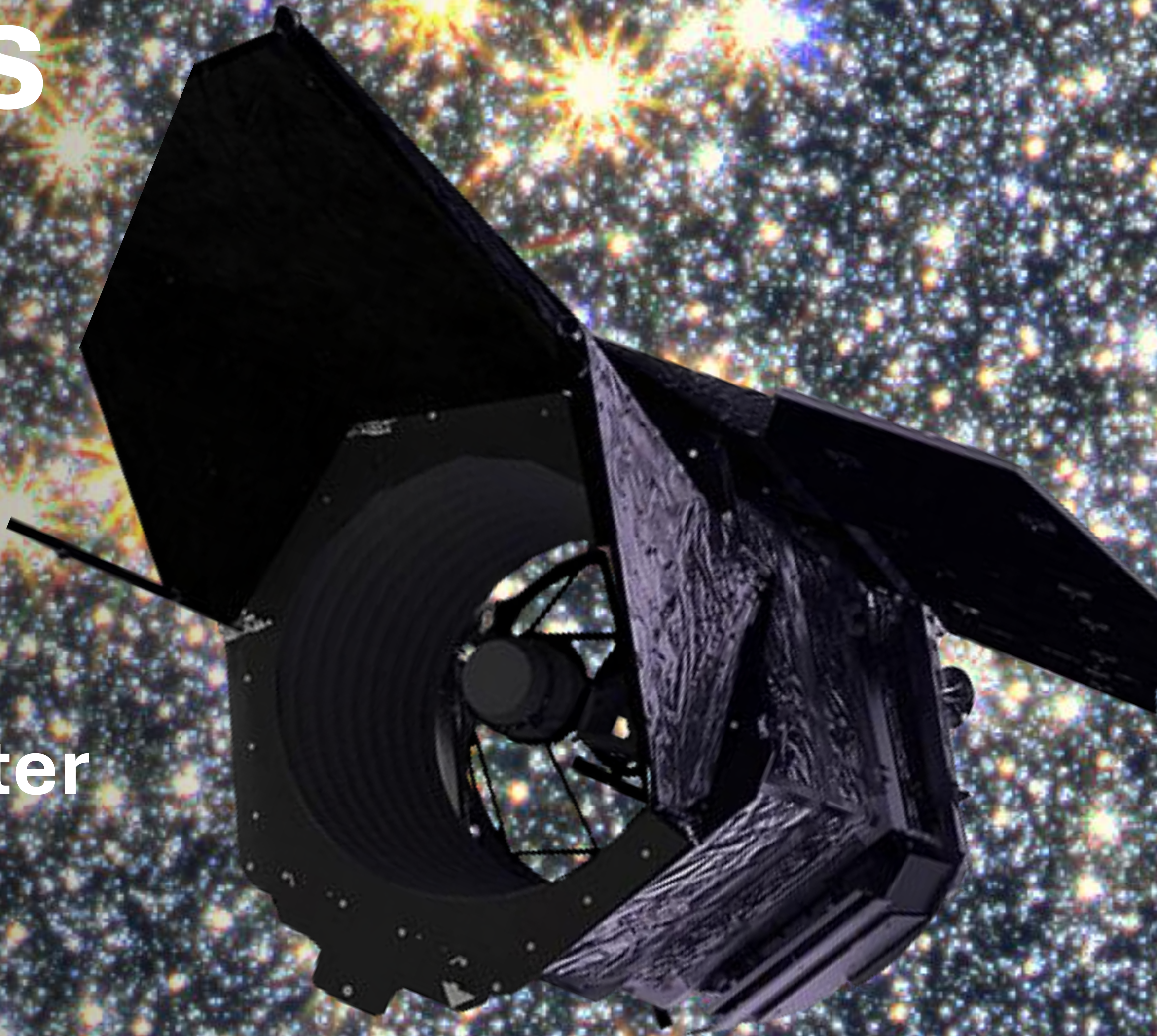
Transiting Planets in Roman

Robby Wilson

University of Maryland/
NASA Goddard Space Flight Center

ExoPAG 33
January 3, 2026



Searching the Galactic Bulge for Transiting Planets

Searching the Galactic Bulge for Transiting Planets

PLANETARY TRANSITS TOWARD THE GALACTIC BULGE

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Received 2000 April 24; accepted 2000 June 29; published 2000 August 3

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Transiting extrasolar planetary candidates in the Galactic bulge

Kailash C. Sahu, Stefano Casertano, Howard E. Bond, Jeff Valenti, T. Ed Smith, Dante Minniti, Manuela Zoccali, Mario Livio, Nino Panagia, Nikolai Piskunov, Thomas M. Brown, Timothy Brown, Alvio Renzini, R. Michael Rich, Will Clarkson & Stephen Lubow

Nature **443**, 534–540 (2006) | Cite this article

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I. McDonald,[1,2★] E. Kerins,[1,2] M. Penny,[1,2,3] J.-P. Beaulieu,[1,4] V. Batista,[1,3] S. Calchi Novati,[1,5,6,7†] A. Cassan,[1,4] P. Fouqué,[1,8] S. Mao,[1,2,9] J. B. Marquette,[1,4] N. Rattenbury,[2] A. C. Robin,[10] P. Tisserand[1,11] and M. R. Zapatero Osorio[1,12]

A LACK OF PLANETS IN 47 TUCANAE FROM A *HUBBLE SPACE TELESCOPE* SEARCH[1]

RONALD L. GILLILAND,[2] T. M. BROWN,[3] P. GUHATHAKURTA,[4] A. SARAJEDINI,[5] E. F. MILONE,[6] M. D. ALBROW,[2] N. R. BALIBER,[7] H. BRUNTT,[8] A. BURROWS,[9] D. CHARBONNEAU,[3,10] P. CHOI,[4] W. D. COCHRAN,[7] P. D. EDMONDS,[10] S. FRANDSEN,[8] J. H. HOWELL,[4] D. N. C. LIN,[4] G. W. MARCY,[11] M. MAYOR,[12] D. NAEF,[12] S. SIGURDSSON,[13] C. R. STAGG,[6] D. A. VANDENBERG,[14] S. S. VOGT,[4] AND M. D. WILLIAMS[6]
Received 2000 August 25; accepted 2000 October 10; published 2000 November 28

PHOTOMETRIC TRANSITS FROM THE MACHO PROJECT DATABASE

A. J. DRAKE[1,2] AND K. H. COOK[2]
Received 2003 September 22; accepted 2003 December 5

SEARCHING FOR TRANSITING PLANETS IN STELLAR SYSTEMS

JOSHUA PEPPER[1] AND B. SCOTT GAUDI[2]
Received 2005 April 6; accepted 2005 June 2

SURVEY FOR TRANSITING EXTRASOLAR PLANETS IN STELLAR SYSTEMS. III. A LIMIT ON THE FRACTION OF STARS WITH PLANETS IN THE OPEN CLUSTER NGC 1245

CHRISTOPHER J. BURKE,[1] B. SCOTT GAUDI,[2,3] D. L. DEPOY,[1] AND RICHARD W. POGGE[1]
Received 2005 December 7; accepted 2006 March 21

Searching the Galactic Bulge for Transiting Planets

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2014

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Christopher J. Burke,[1] B. Scott Gaudi,[2,3] D. L. DePoy,[1] and Richard W. Pogge[1]
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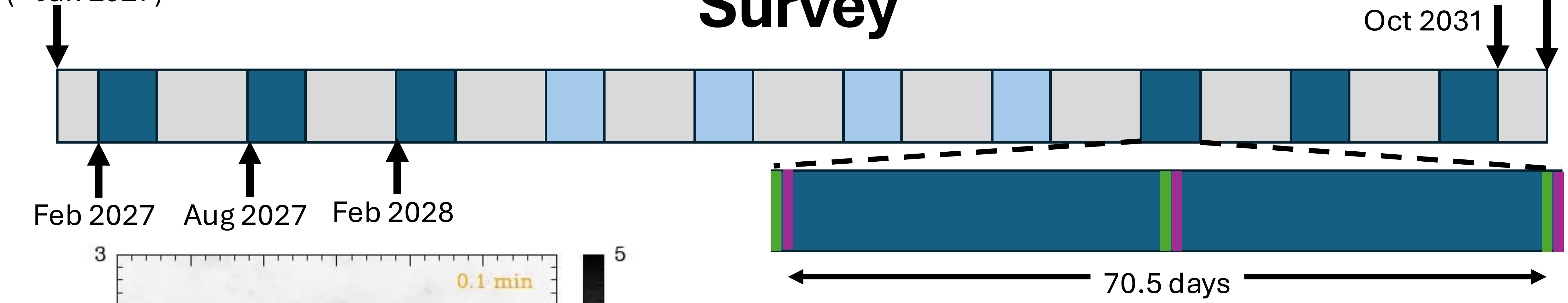
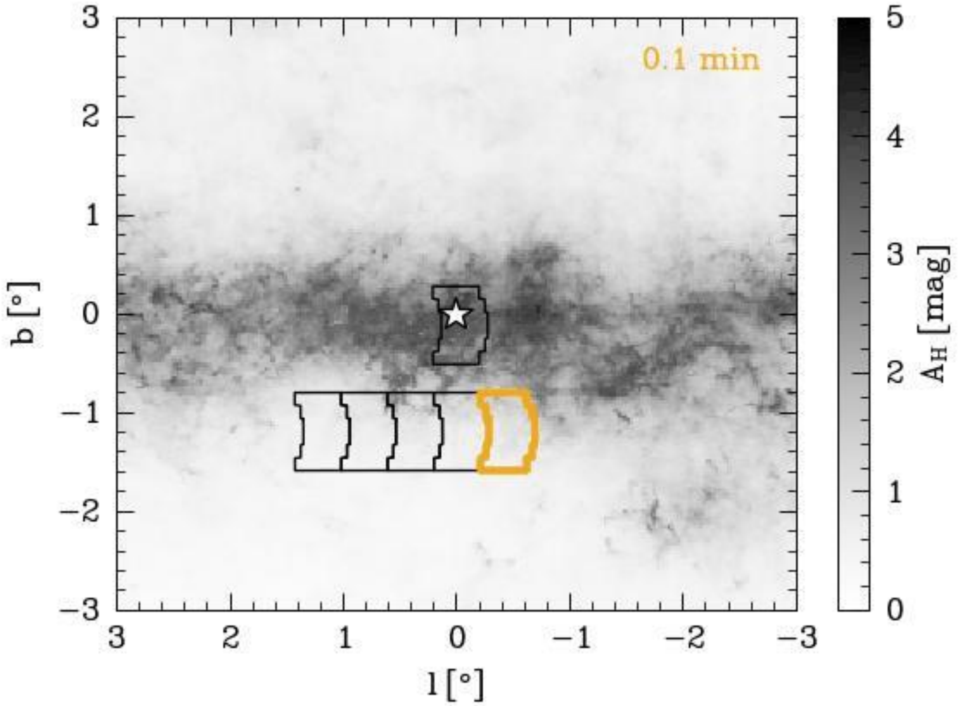
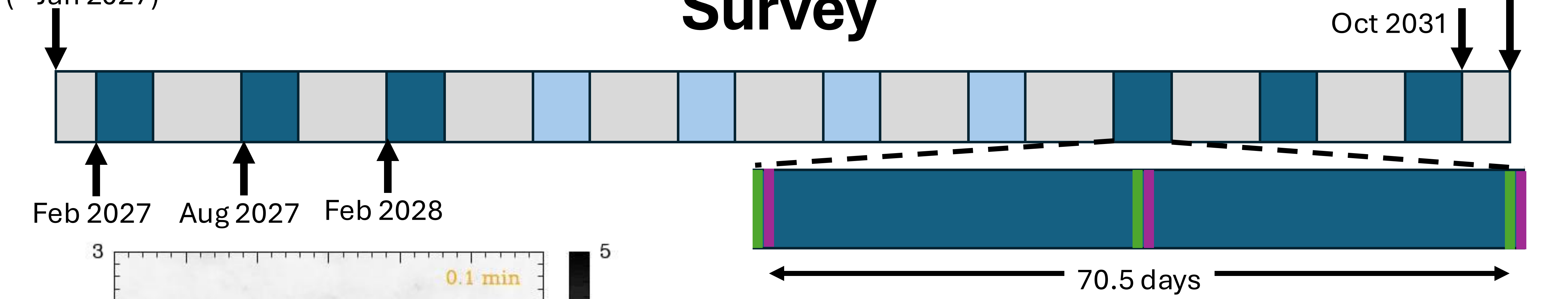
The Galactic Bulge Time Domain Survey

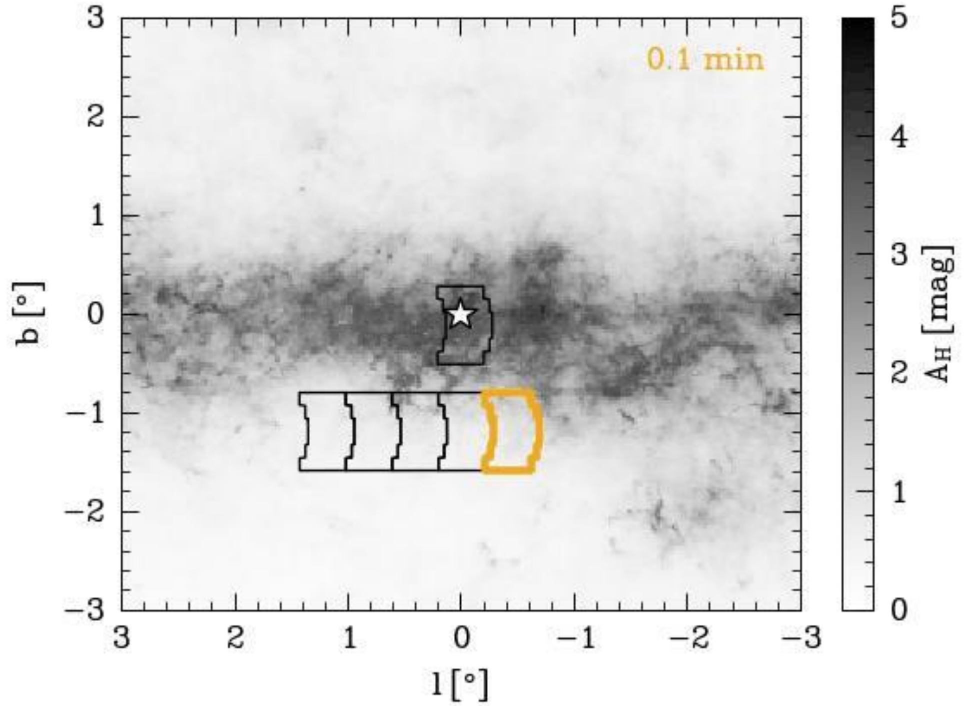




1. High-Cadence Seasons
2. Low-Cadence Seasons
3. Grism Snapshots
4. Multiband Snapshots

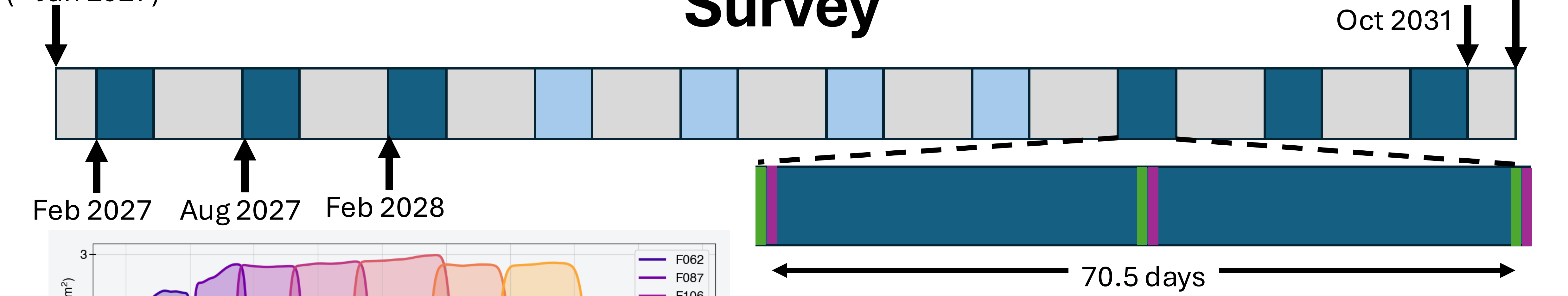
The Galactic Bulge Time Domain Survey

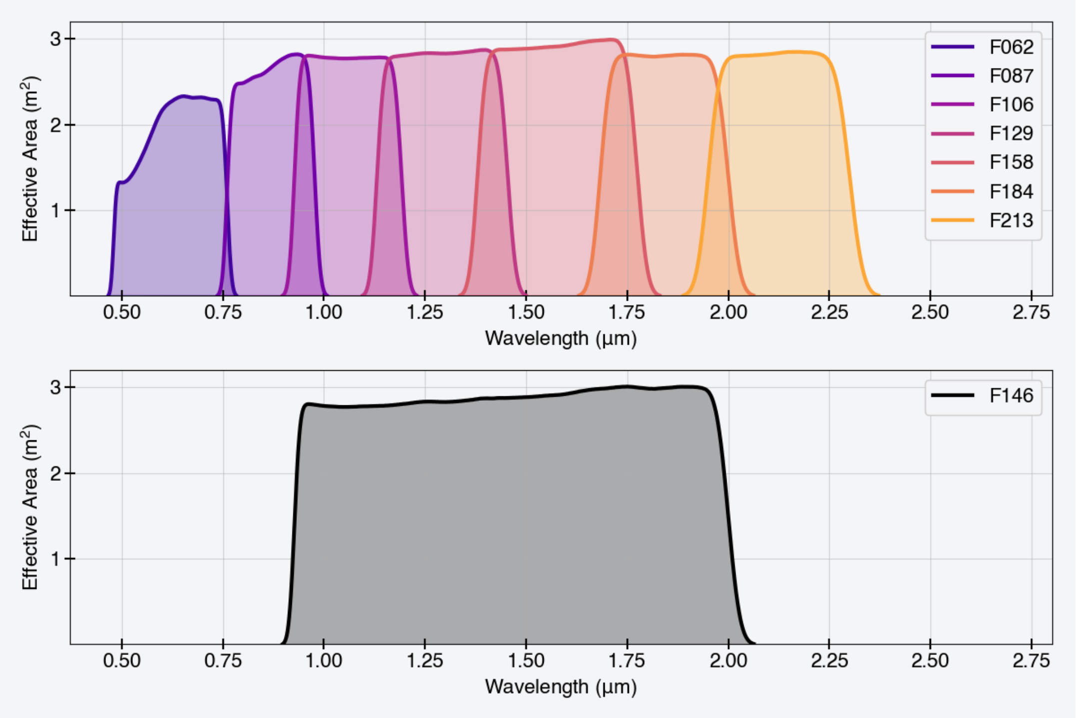




- **6 Seasons (S1-3, S8-10)**
  - **70.5 day duration**
  - **4.5-year Total Baseline**
  - **Primary Filter: F146 (0.9-2.0 um)**
  - **Secondary Filters:**
    - **F087 (0.8-1.0 um)**
    - **F213 (2.0-2.3 um)**
  - **Secondary Filters Taken at ~3 hr cadence (Every ~14th exposure)**

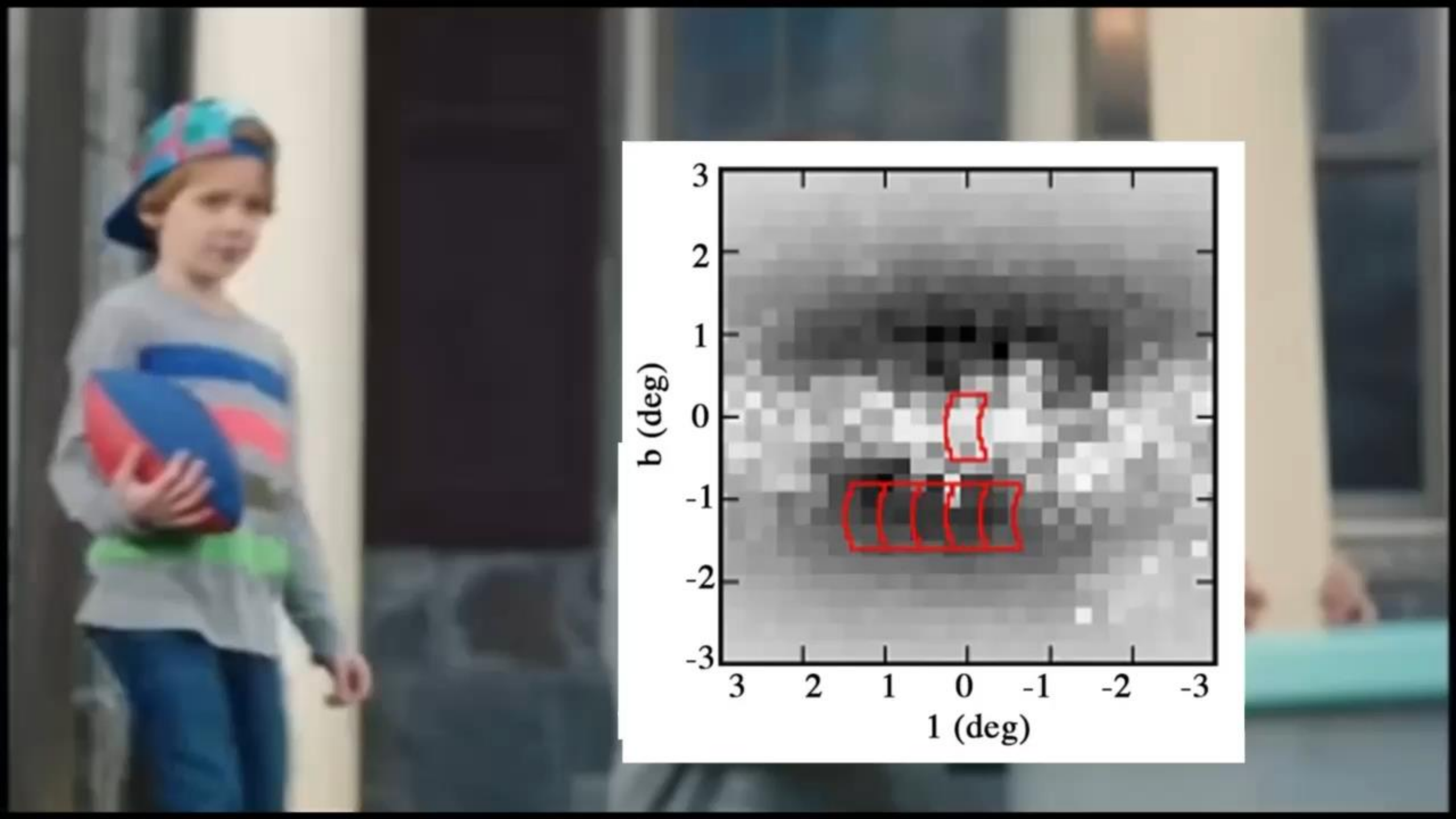
The Galactic Bulge Time Domain Survey





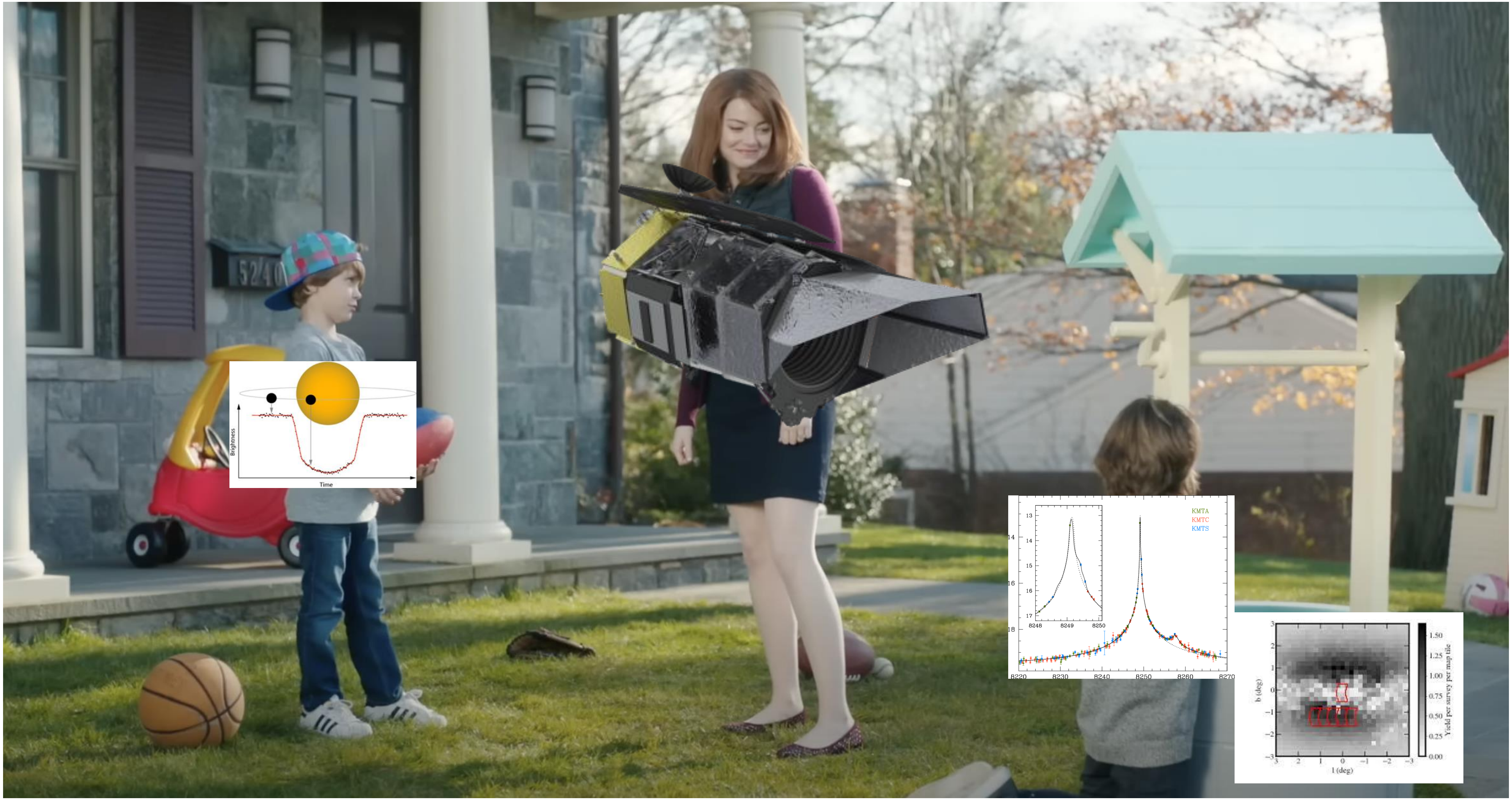
- S4-7: Low-Cadence (~3 days)
- Multi-bandpass Snapshots: 3x/season (30 total)
  - 5 Filters: F062, F106, F129, F158, F184
- Grism Snapshots: 3x/season (30 tot)
  - R~500-800, ~8-10 km/s resolution

The GBTDS for Transit Scientists



b (deg)
1 (deg)
3
2
1
0
-1
-2
-3


Brightness
Time
EVERYTHING IS FOR YOU!
AND THIS ONE THING IS FOR HIM!


5240
Brightness
Time
KMTA
KMTC
KMTS
b (deg)
l (deg)
Yield per survey per map tile

The GBTDS for Transit Scientists

Because for the first time ever, a space-based, high-cadence photometric survey is not ***just*** for us.

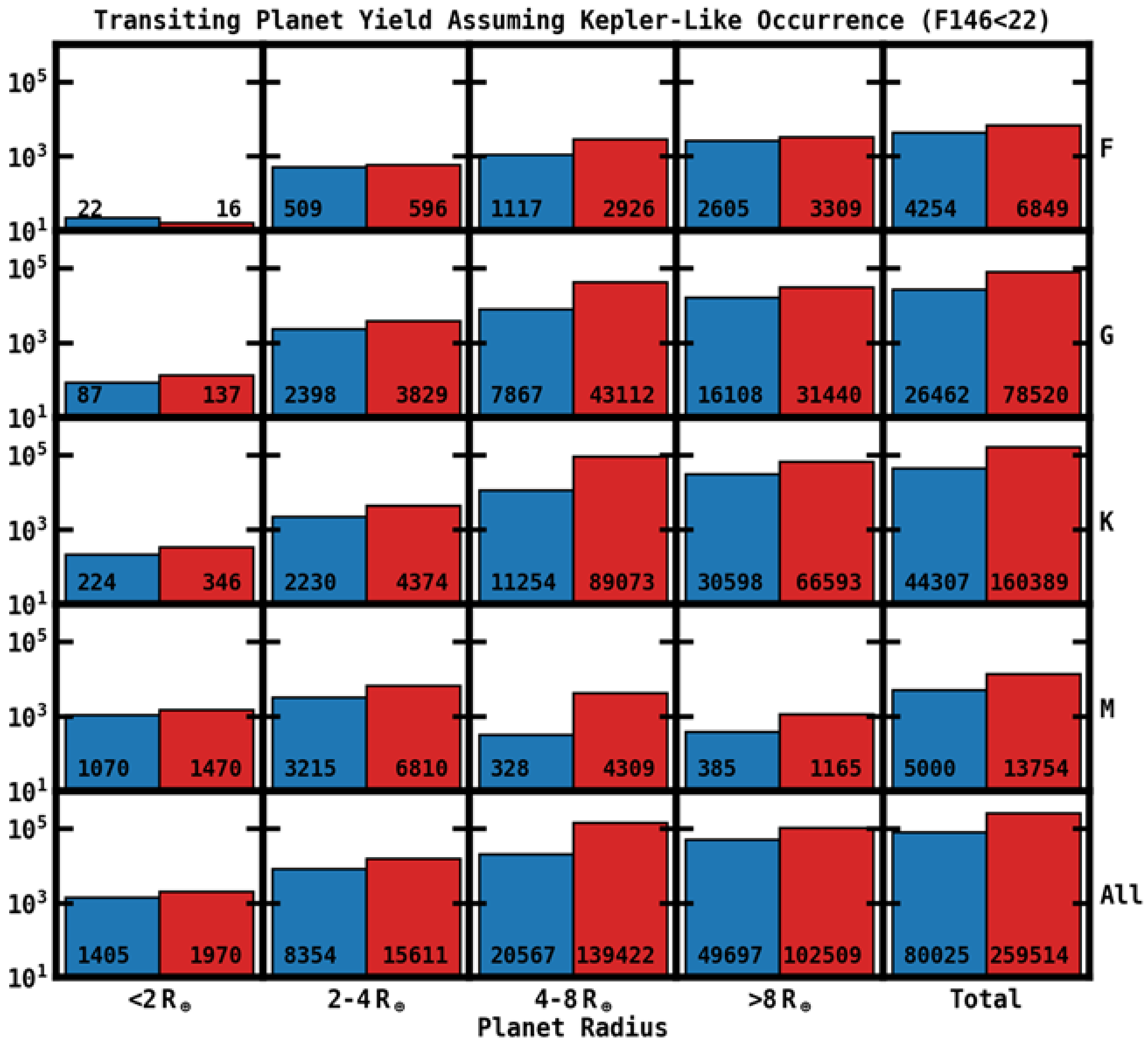
Transiting Planets in Roman

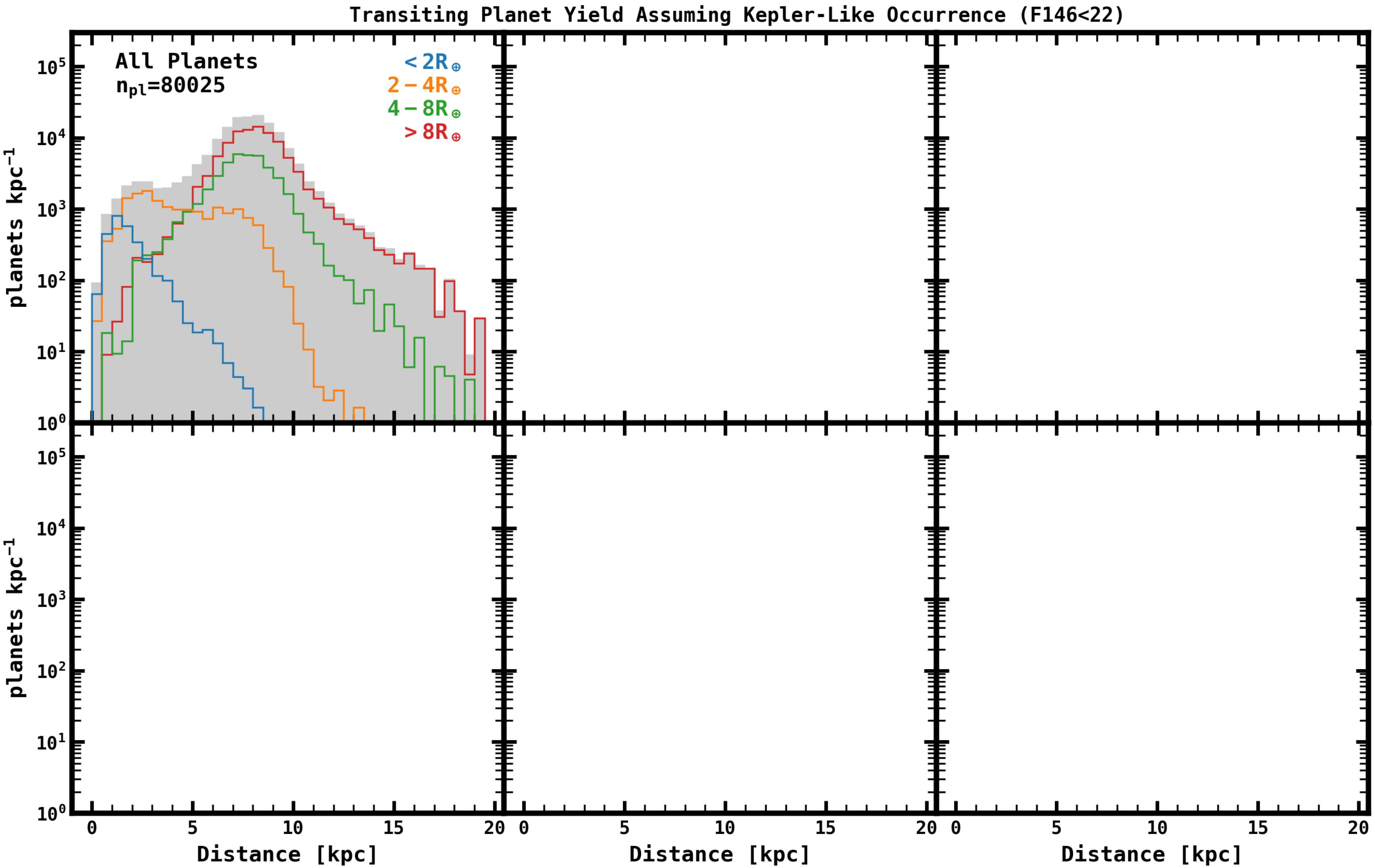
Transiting Planets in Roman

1. Demographics for ***Rare**** Planetary Systems
2. Demographics across all major Galactic populations
3. Demographics of (Ultra-) Hot Jupiter Atmospheres

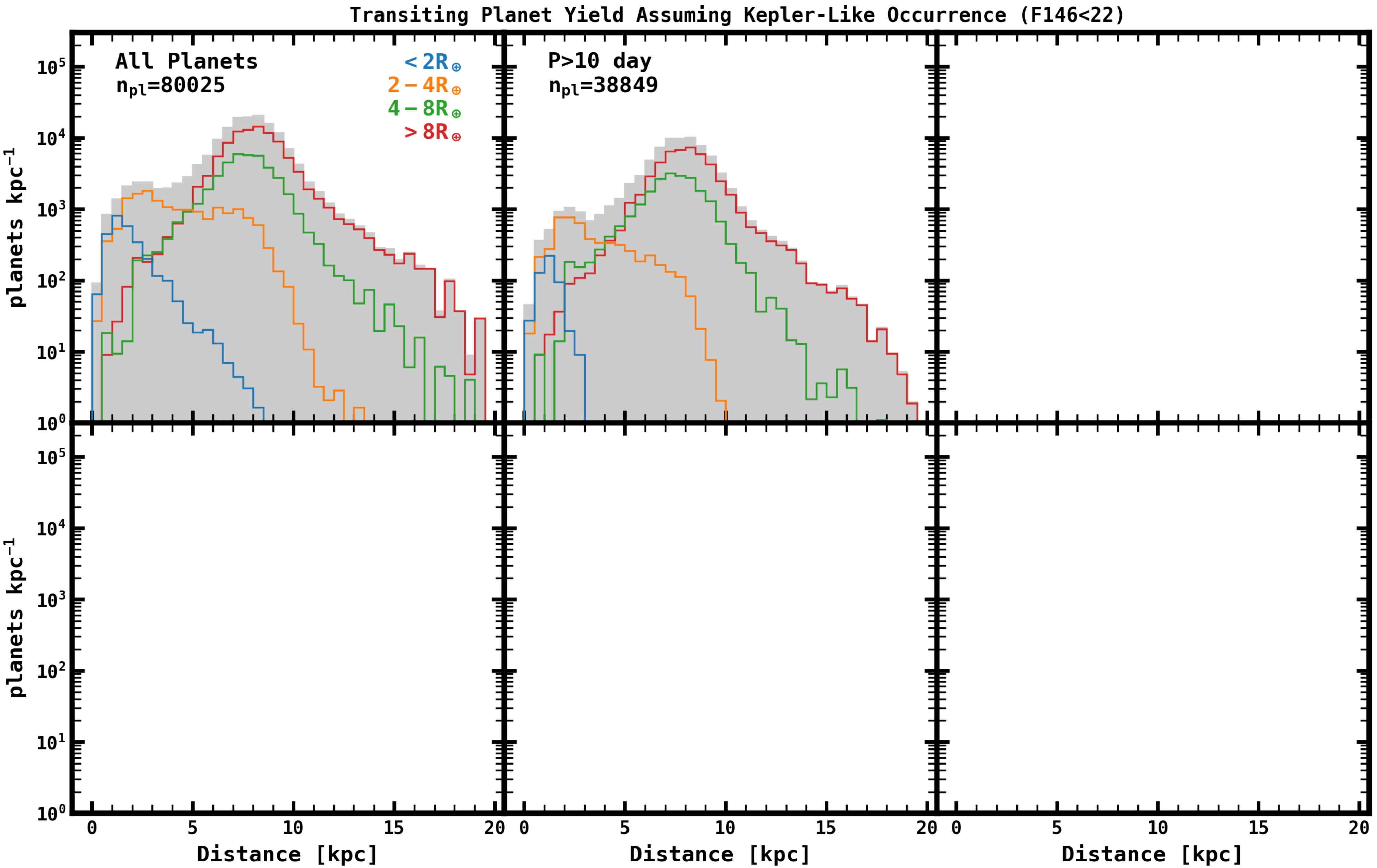
Rare*: occurrence has yet to be measured well due to sample size

Kepler-Like Occurrence   [M/H]-Scaled Occurrence

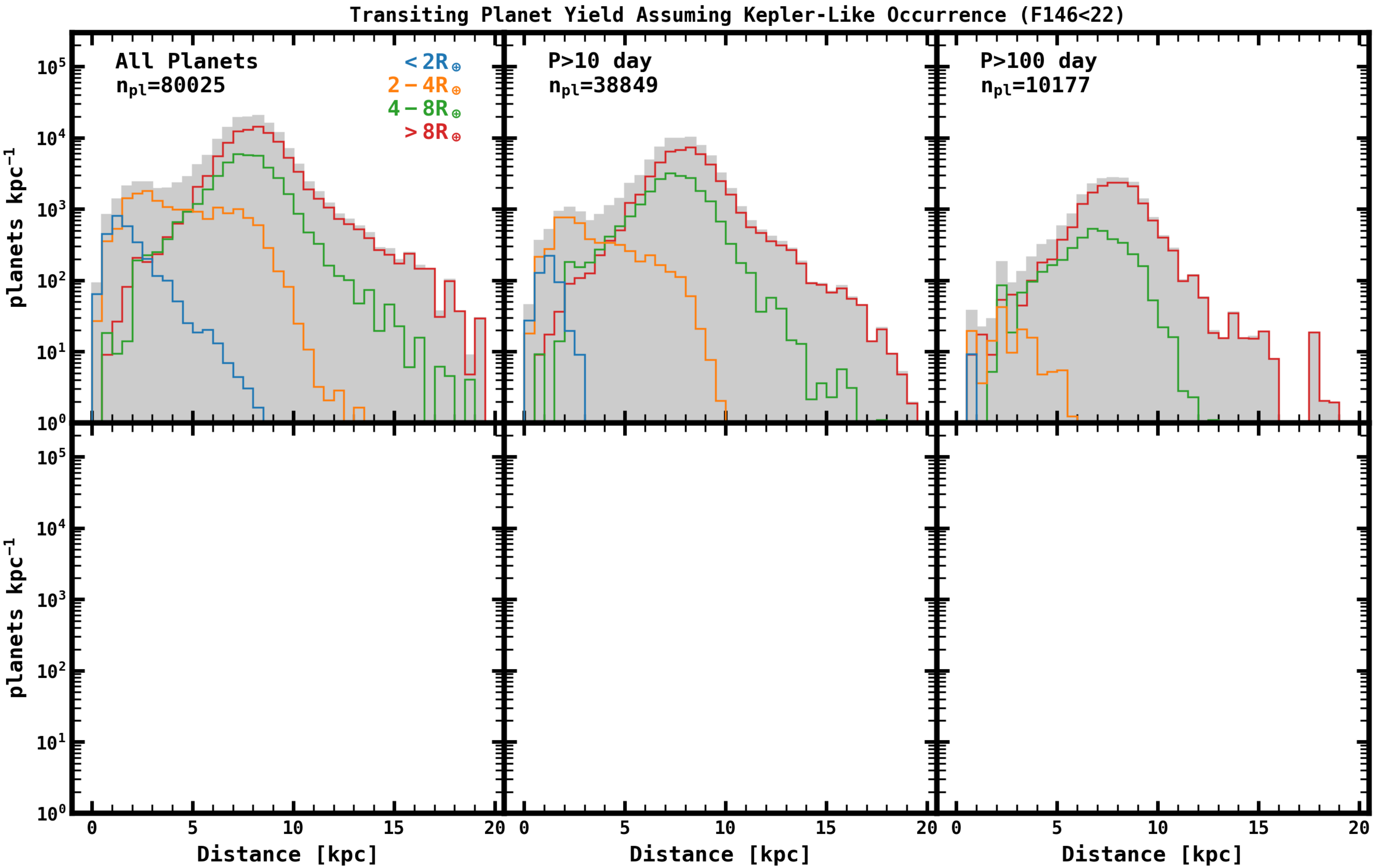


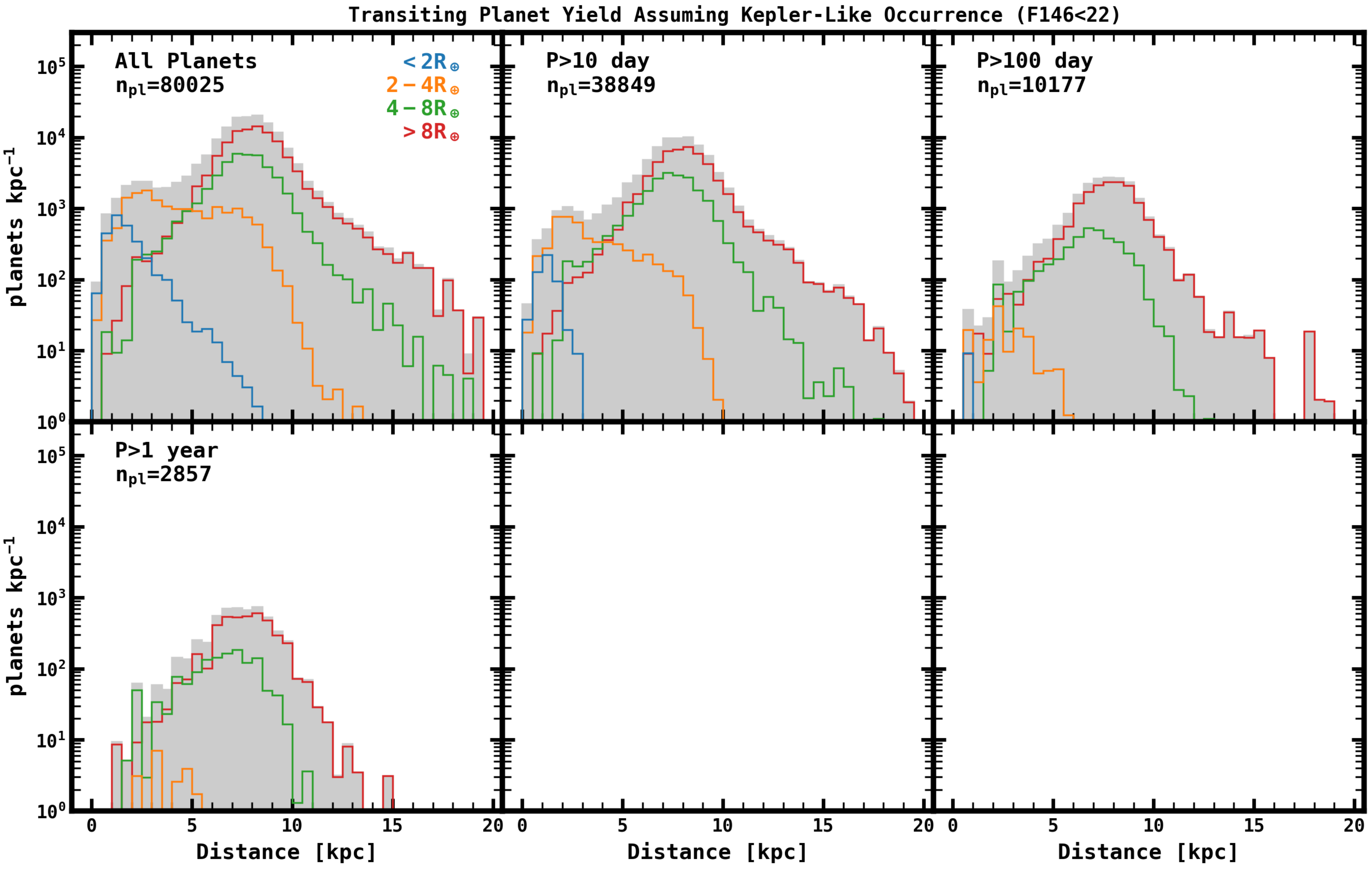


Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_pl=80025
<2R⊕
2−4R⊕
4−8R⊕
>8R⊕
planets kpc⁻¹
Distance [kpc]

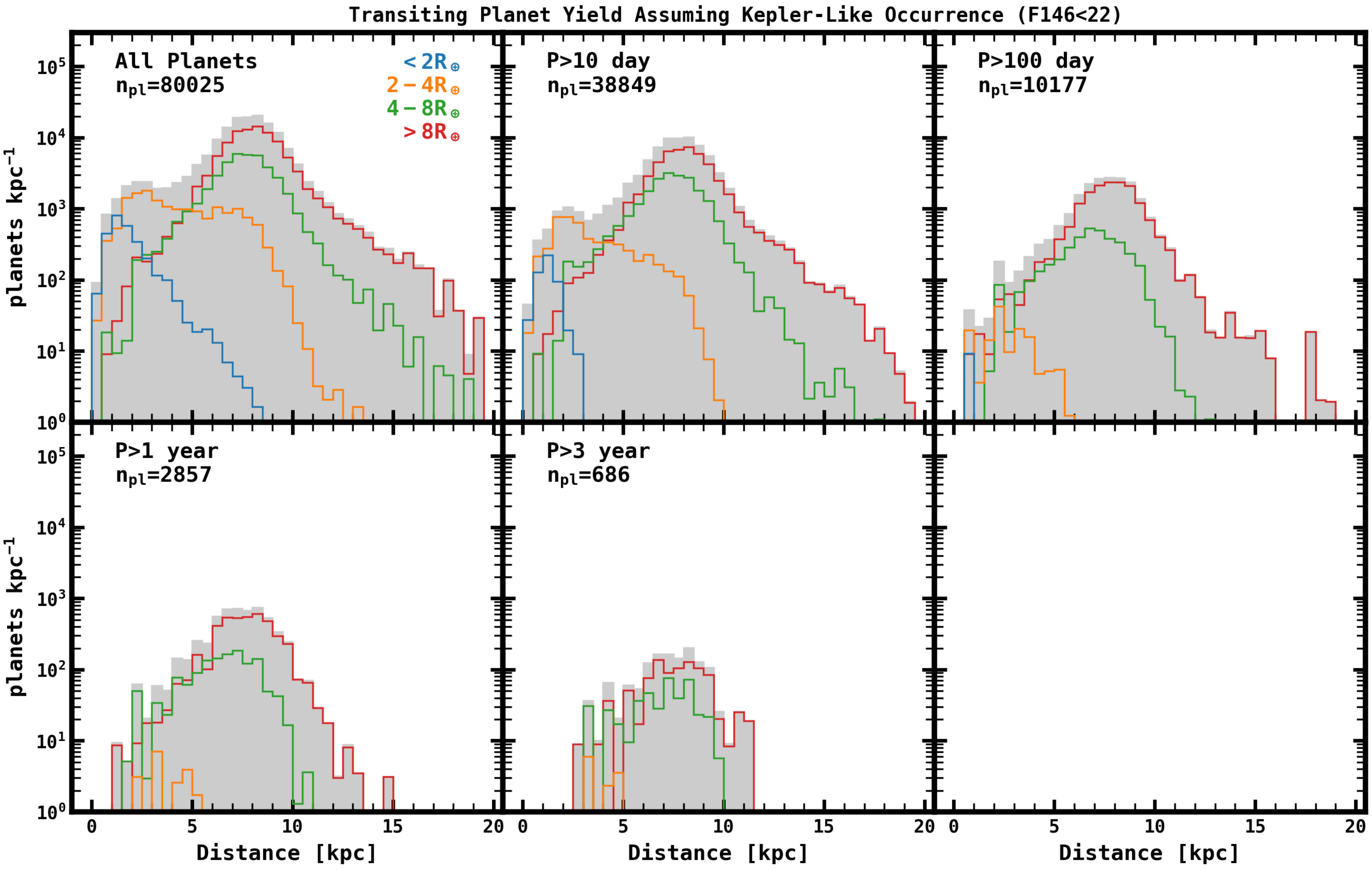


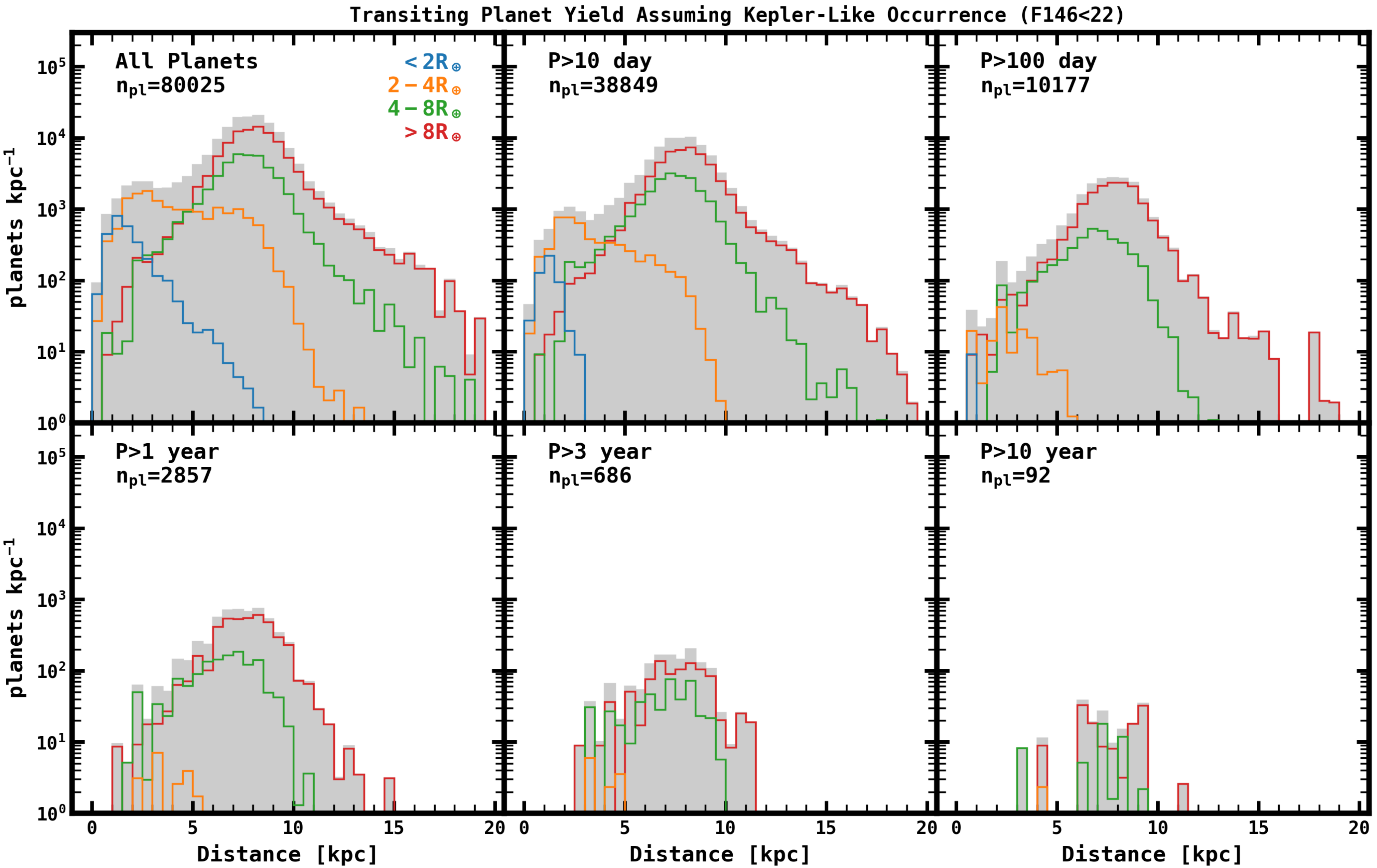
Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_{pl}=80025
$<2R_\oplus$
$2-4R_\oplus$
$4-8R_\oplus$
$>8R_\oplus$
P>10 day
n_{pl}=38849
planets kpc^{-1}
10^0
10^1
10^2
10^3
10^4
10^5
0
5
10
15
20
Distance [kpc]


Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_pl=80025
<2R⊕
2−4R⊕
4−8R⊕
>8R⊕
P>10 day
n_pl=38849
P>100 day
n_pl=10177
planets kpc⁻¹
Distance [kpc]



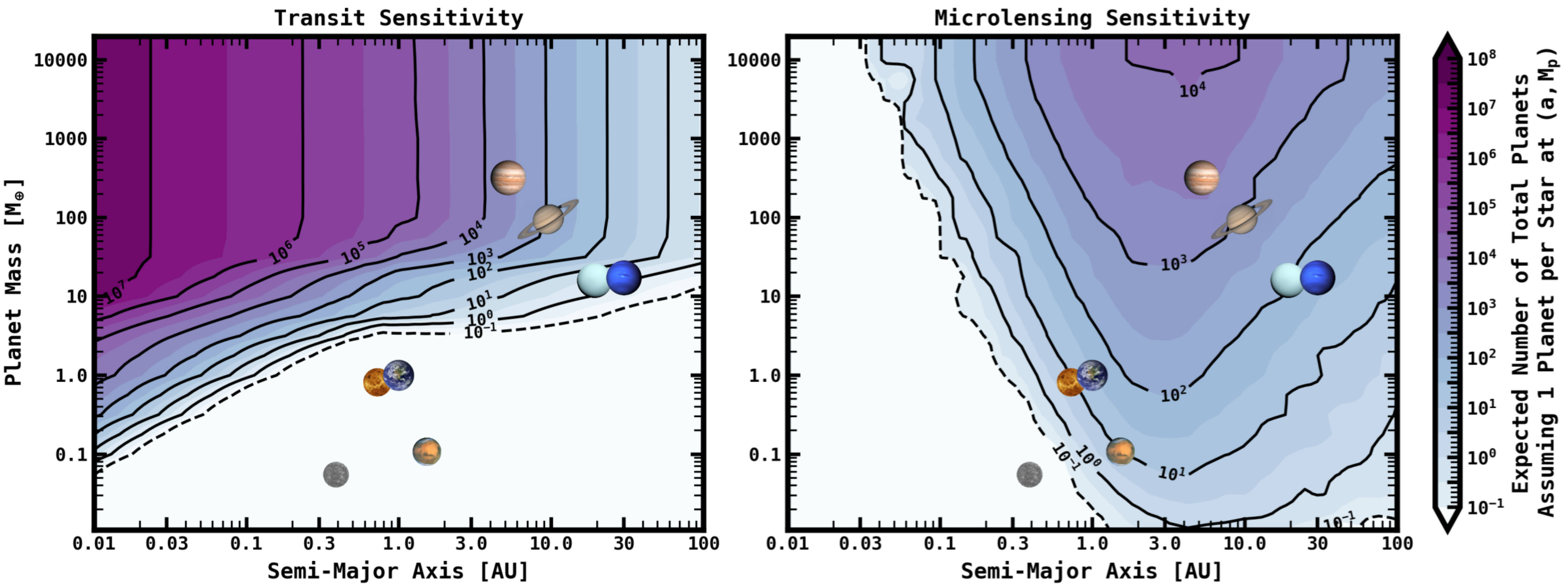
Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_{pl}=80025
$<2R_\oplus$
$2-4R_\oplus$
$4-8R_\oplus$
$>8R_\oplus$
P>10 day
n_{pl}=38849
P>100 day
n_{pl}=10177
P>1 year
n_{pl}=2857
planets kpc^{-1}
Distance [kpc]


Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_{pl}=80025
$<2R_\oplus$
$2-4R_\oplus$
$4-8R_\oplus$
$>8R_\oplus$
P>10 day
n_{pl}=38849
P>100 day
n_{pl}=10177
P>1 year
n_{pl}=2857
P>3 year
n_{pl}=686
planets kpc^{-1}
Distance [kpc]



Transiting Planet Yield Assuming Kepler-Like Occurrence (F146<22)
All Planets
n_pl=80025
< 2R⊕
2 − 4R⊕
4 − 8R⊕
> 8R⊕
P>10 day
n_pl=38849
P>100 day
n_pl=10177
P>1 year
n_pl=2857
P>3 year
n_pl=686
P>10 year
n_pl=92
planets kpc⁻¹
Distance [kpc]

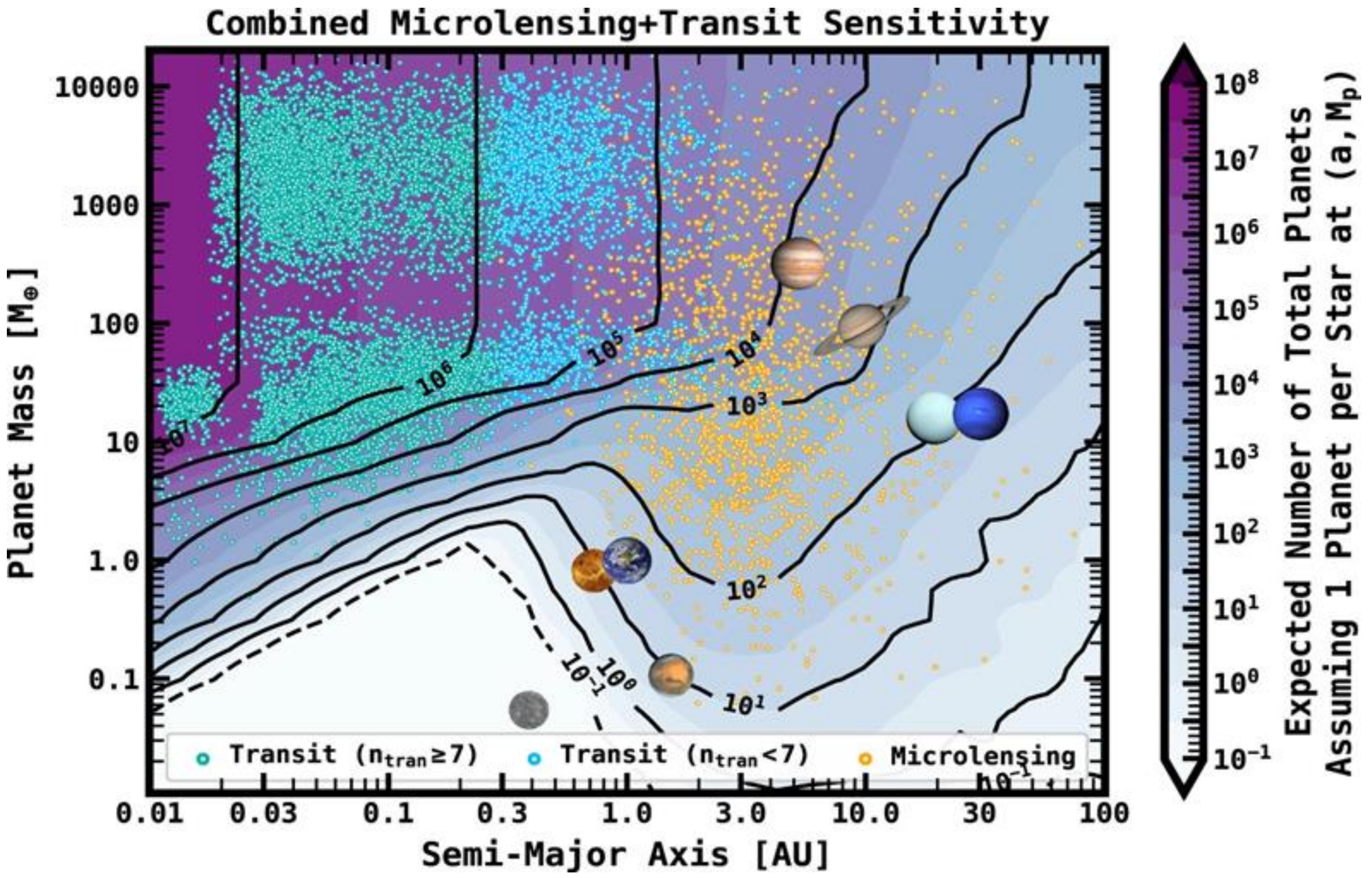
Roman Transits vs. Microlensing



Roman Transits <u>and</u> Microlensing

Joint Demographics!

- Sensitivity to different features
  - Mass vs. Radius
  - Mutual inclinations & multiplicity
  - Coverage from 0-infinity AU for gas-giants
- Same Stellar Population at long periods



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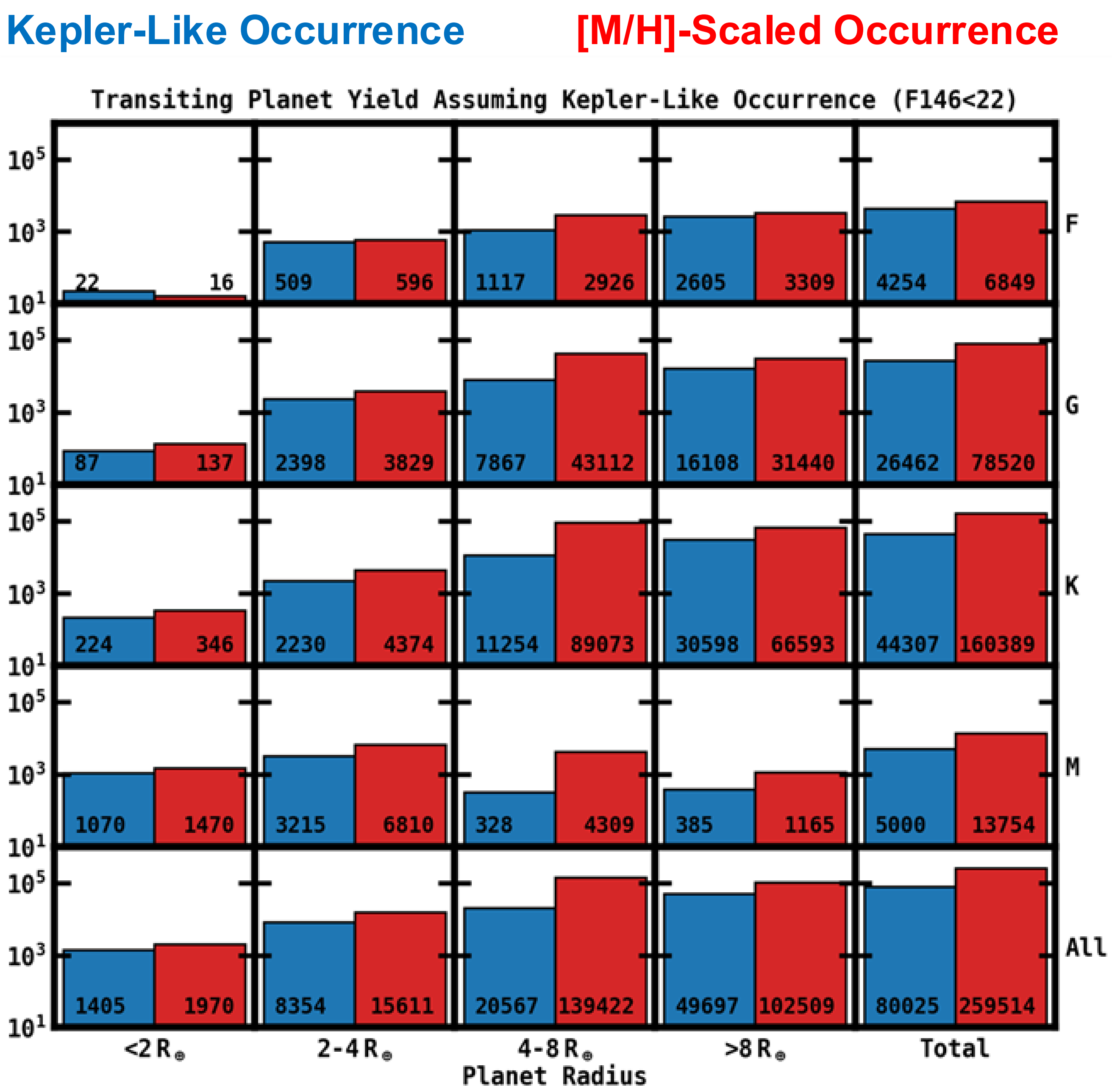
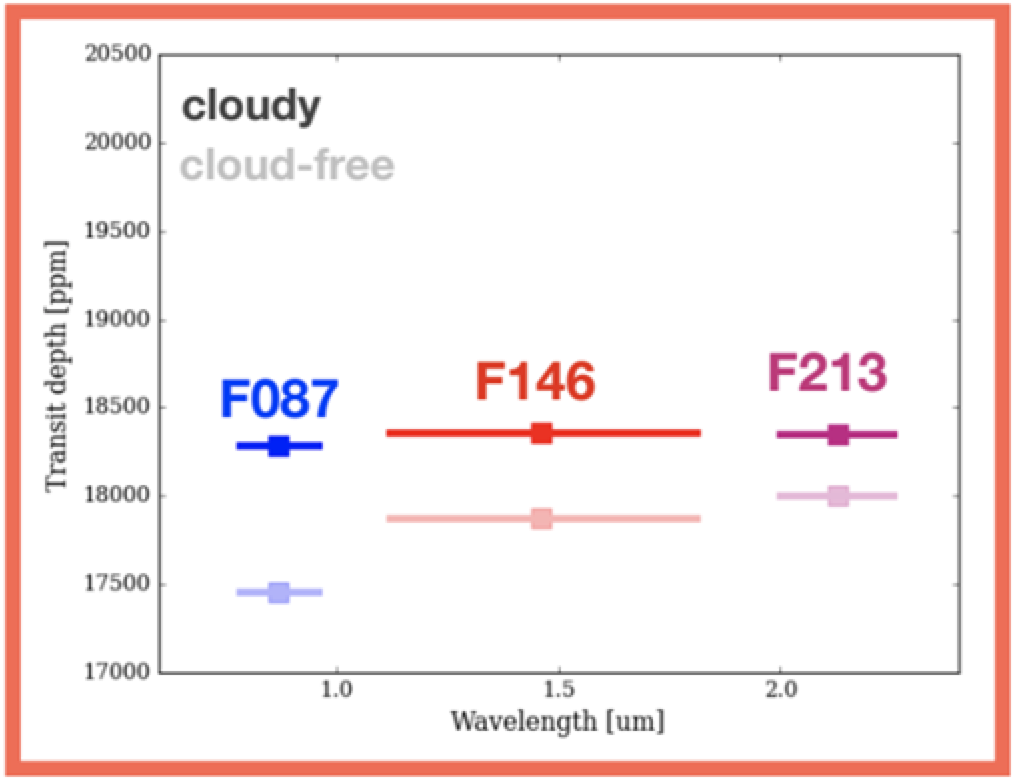


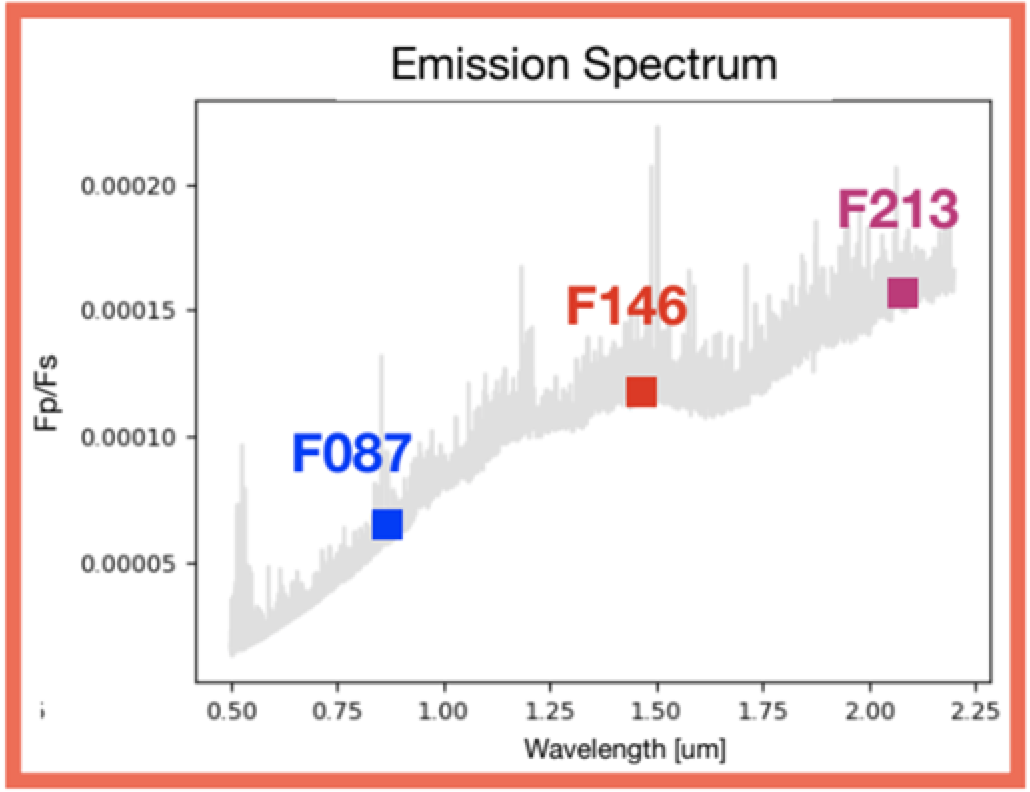
Exoplanet Atmospheres with Roman

Yiwei Chai
(JHU)

Case 1: **Broadband** Transit Spectrophotometry



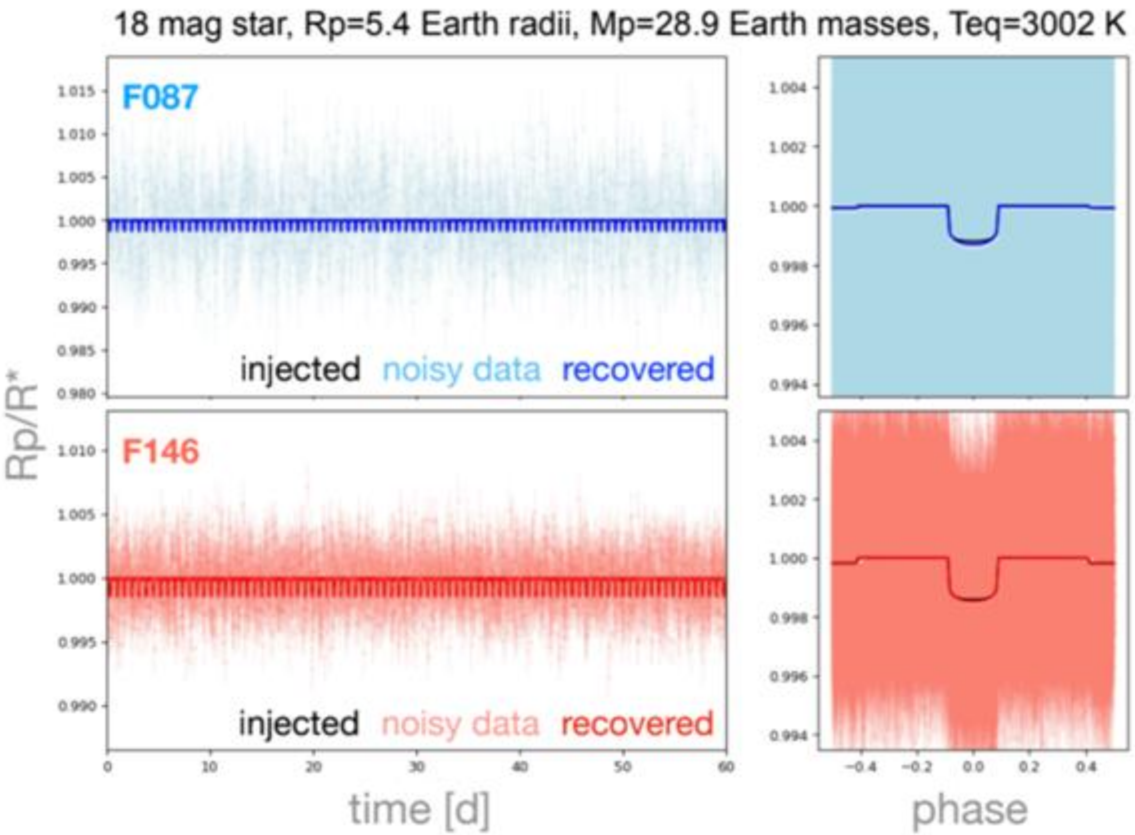
Case 2: **Broadband** Secondary Eclipses

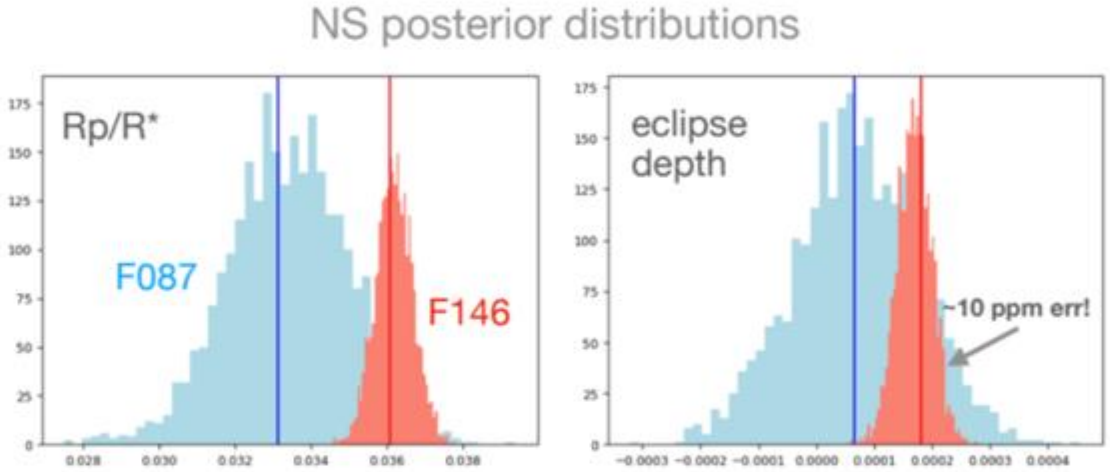


Credit: NASA, ESA, CSA, Joseph Olmsted (STScI), Aaron Bello-Arufe (NASA-JPL)

Exoplanet Atmospheres with Roman

Yiwei Chai
(JHU)





Able to distinguish Rp/Rs + Fp/Fs depths between filters!

Struggles with longer period + lower SNR planets

Also pretty computationally expensive…

Exoplanet Atmospheres with Roman – Yield Estimates

Yiwei Chai
(JHU)

Case 1 - Chromatic Transits (at least ~500 total)

Clear, C/O=0.55, logZ=0.0

	F087-F146	F146-F213
3 hour	121	4
6 hour	73	1
12 hour	38	1

Cloudy, C/O=0.55, logZ=0.0

	F087-F146	F146-F213
3 hour	90	0
6 hour	49	0
12 hour	23	0

Able to detect more chromatic transits for clear atmospheres

Case 2 - Secondary Eclipses (at least ~900 total)

clear/cloudy, C/O=0.55, logZ=0.0 thermal only

	F146	F087	F213
3 hour	166	0	5
6 hour	173	0	1
12 hour	175	0	1

clear/cloudy, C/O=0.2, logZ=0.0 thermal only

	F146	F087	F213
3 hour	169	0	3
6 hour	177	0	0
12 hour	180	0	0

Detecting Orbital Decay with Roman

Kylee Carden
(JHU)

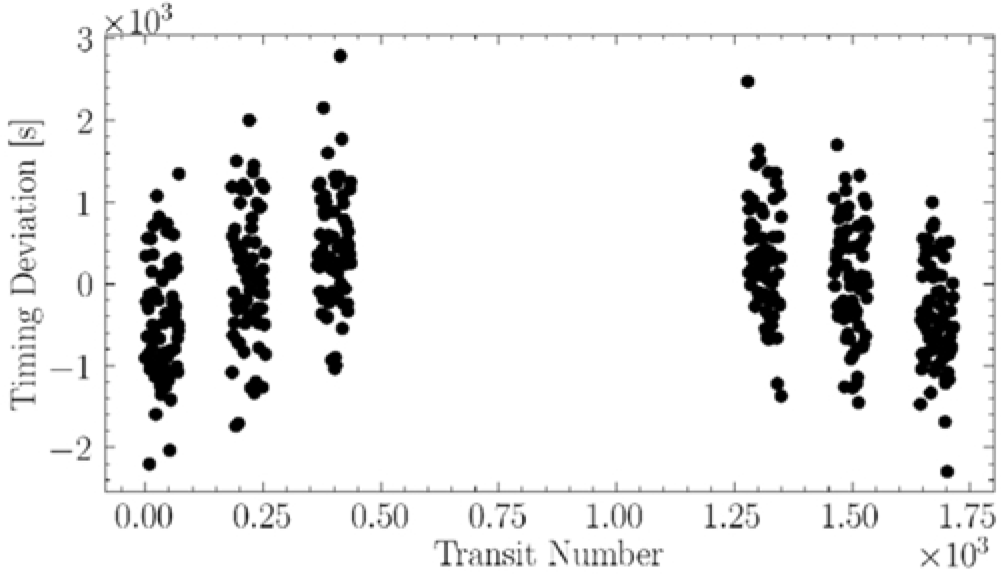
Carden et al. (2025)

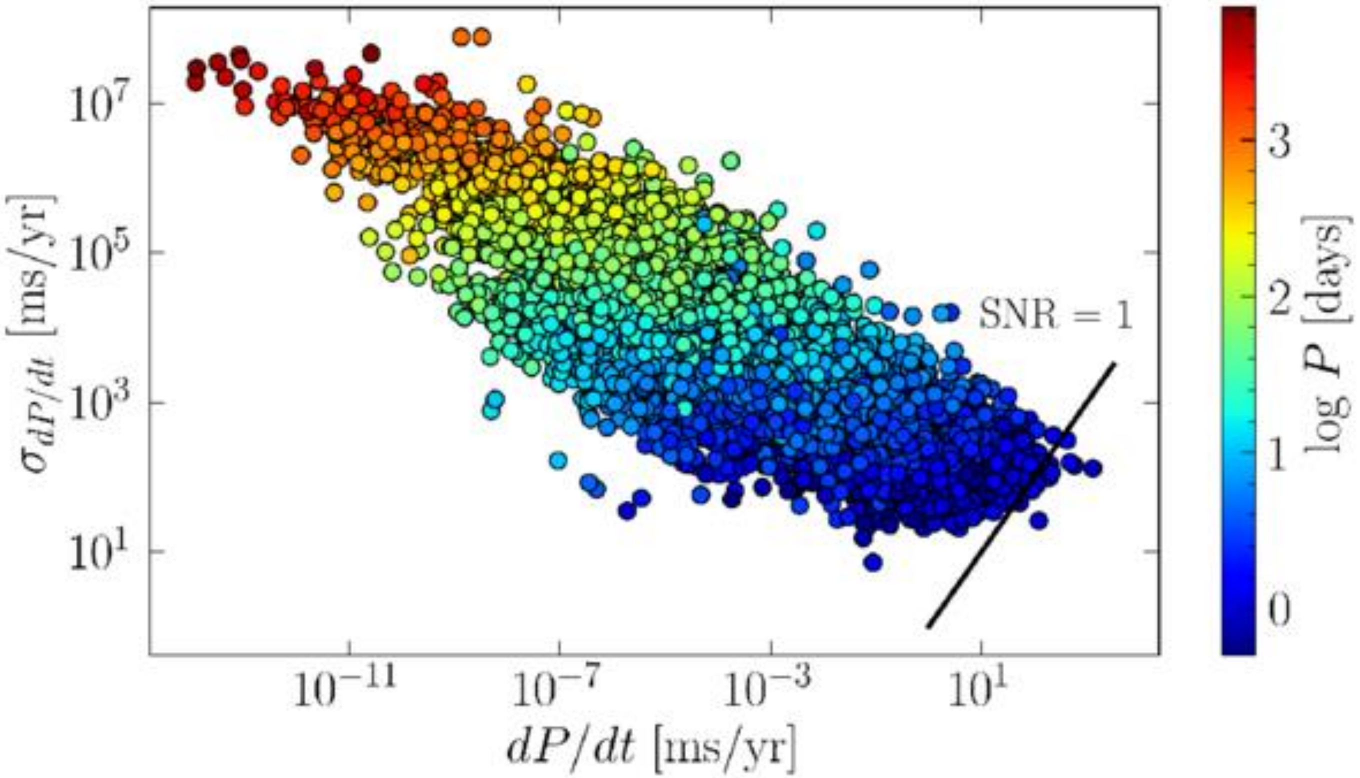
Predicting up to ~10 planets with detectable orbital decay in the GBTDS

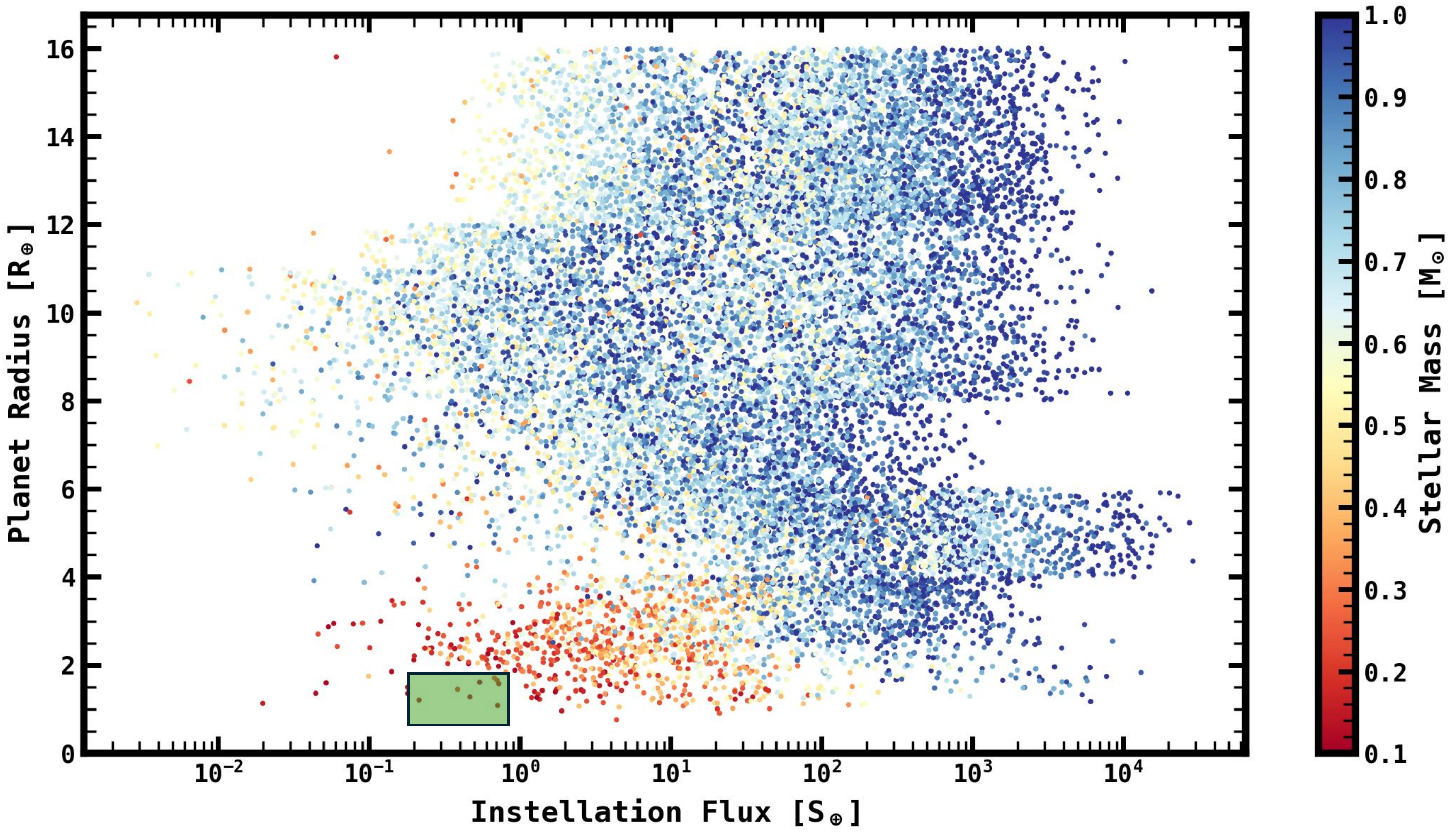
CrossMark

A Short History of (Orbital) Decay: Roman's Prospects for Detecting Dying Planets

Kylee Carden[1], B. Scott Gaudi[1], and Robert F. Wilson[2,3]
[1] Department of Astronomy, The Ohio State University, 140 West 18th Avenue, Columbus, OH 43210, USA; carden.33@osu.edu
[2] Department of Astronomy, University of Maryland, College Park, MD, USA
[3] NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD, USA
Received 2025 April 21; revised 2025 June 4; accepted 2025 June 9; published 2025 July 16







Planet Radius [R⊕]
Instellation Flux [S⊕]
Stellar Mass [M☉]
16
14
12
10
8
6
4
2
0
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Roman's Habitable Transiting Planet Yield

See also: Tamburo et al. (2023)

Earth-like:

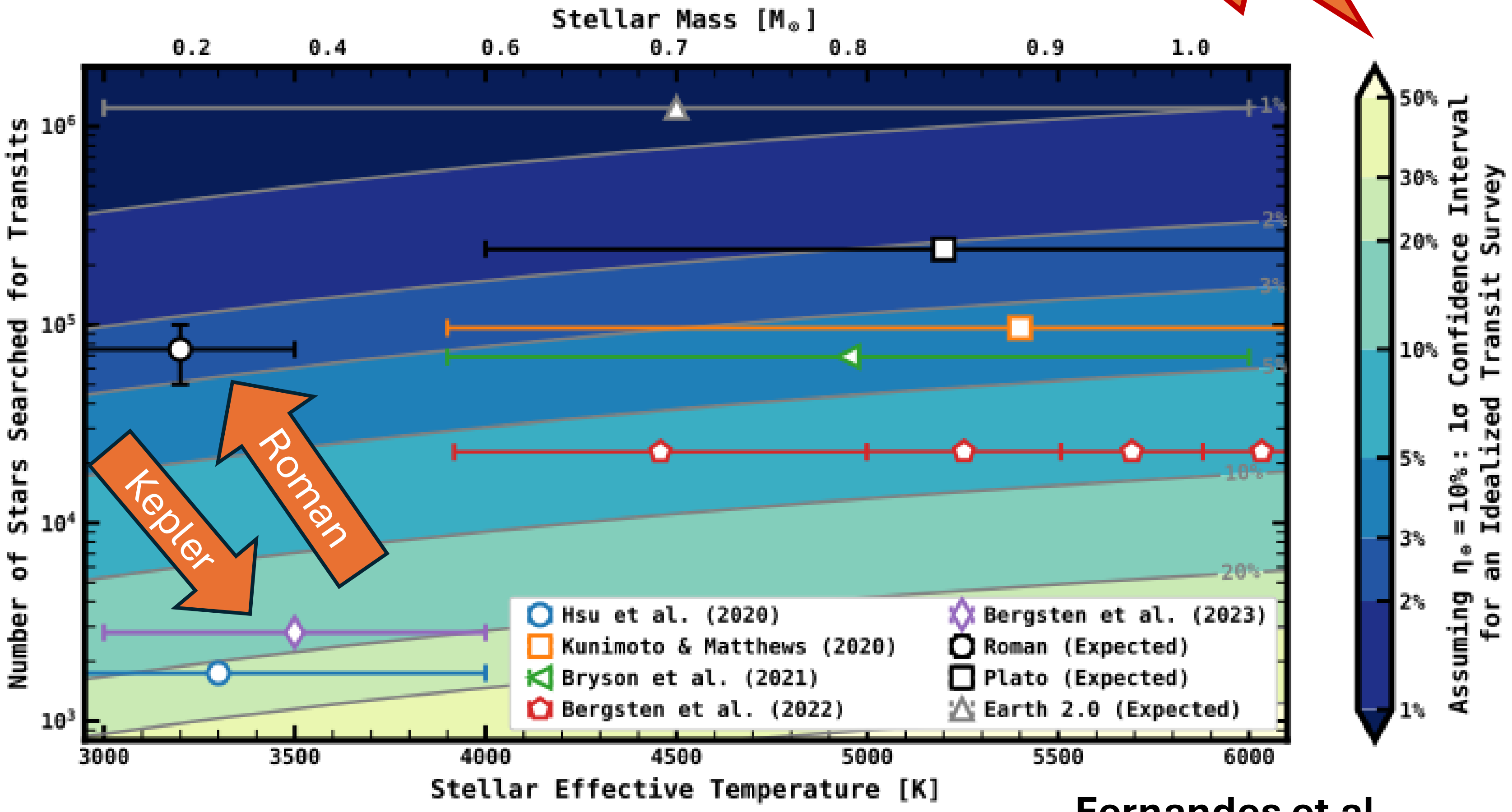
- R = 0.5-1.5 R_e

Conservative HZ Yield: 18 +/- 6

Optimistic HZ Yield: 33 +/- 6

Host stars all late M dwarfs

- 0.1-0.3 M_sun
- Periods from ~9-40 days
- F146 = 18-21 mag_AB
- Distance: ~1-1.5 kpc

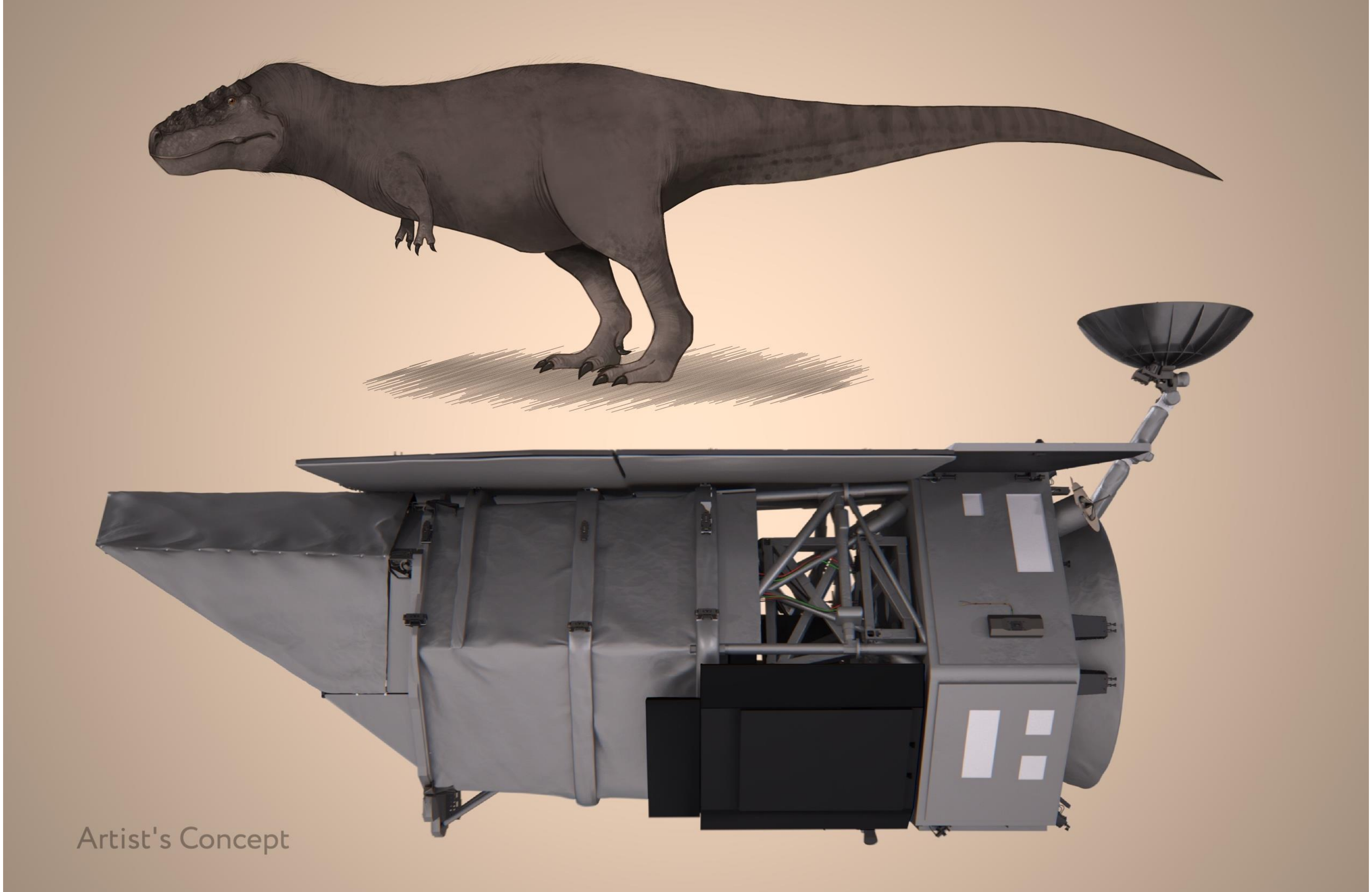


Fernandes et al. (Accepted)

Summary and Things to Look Forward to

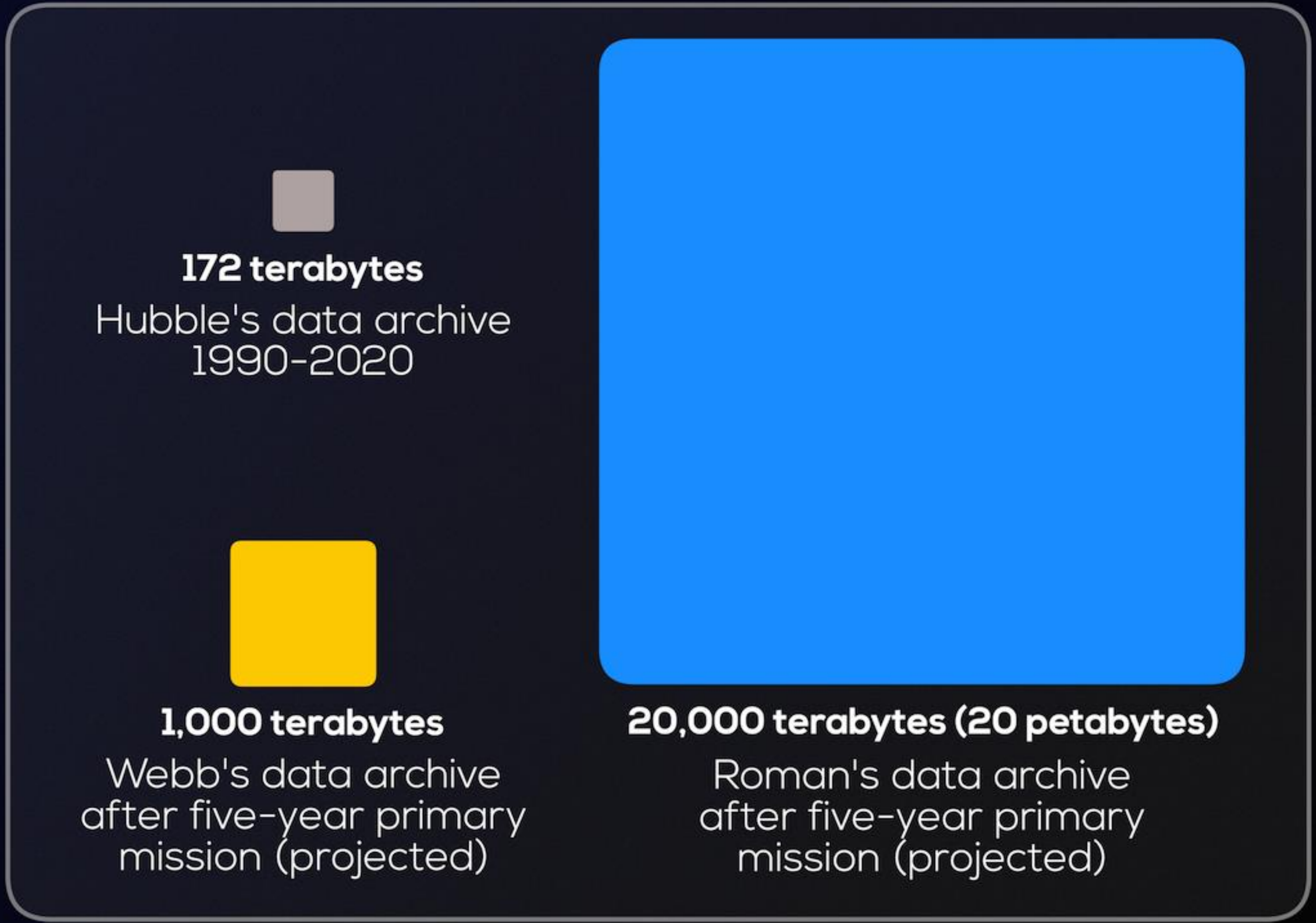
- **At this time next year, Roman will be collecting data.**
- Challenges for GBTDS Transiting Planets
  - Faint stars
  - High Noise Floor
  - Uncertain Stellar Parameters (Patience!)
- Roman Transiting Exoplanets have a lot of new science to offer
  - Demographics of Hot Jupiter Atmospheres: ~1000 secondary eclipses
  - Transit + Microlensing covers giant planets at all orbital separations
  - And yes, even habitable zone planets!

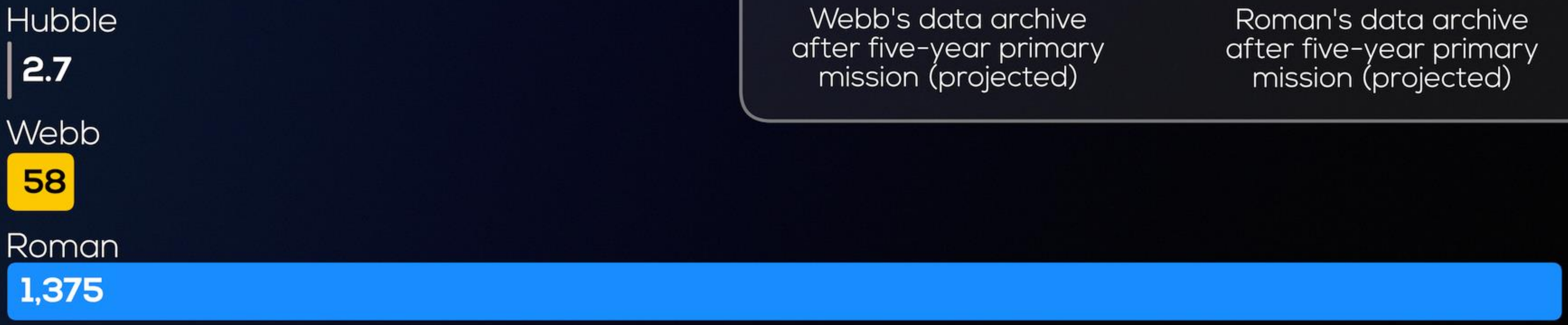
BACKUP SLIDES


Artist's Concept

BIG DATA

The Nancy Grace Roman Space Telescope will transmit an unprecedented amount of data from its orbit a million miles away from Earth. Scientists expect it to average almost 1.4 terabytes each day, and after just five years of observations, it should total 20,000 terabytes on MAST, the Mikulski Archive for Space Telescopes. The Hubble Space Telescope sends less than three gigabytes a day, while in the same time even the James Webb Space Telescope will send less than 60 gigabytes.

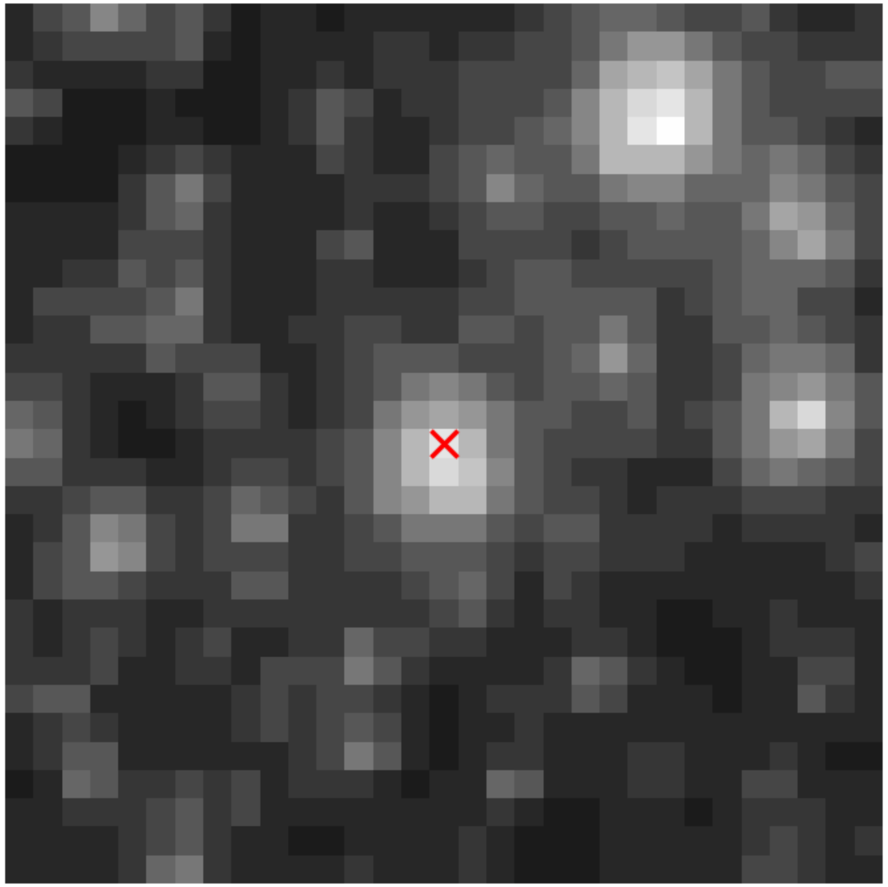




Gigabytes per day sent to Earth

Quirks of the GBTDS for Transit Scientists:
Roman will not be Staring.

- **Images will be Dithered**
    - Likely sensitive to systematics such as inter-/intra-pixel sensitivity variations



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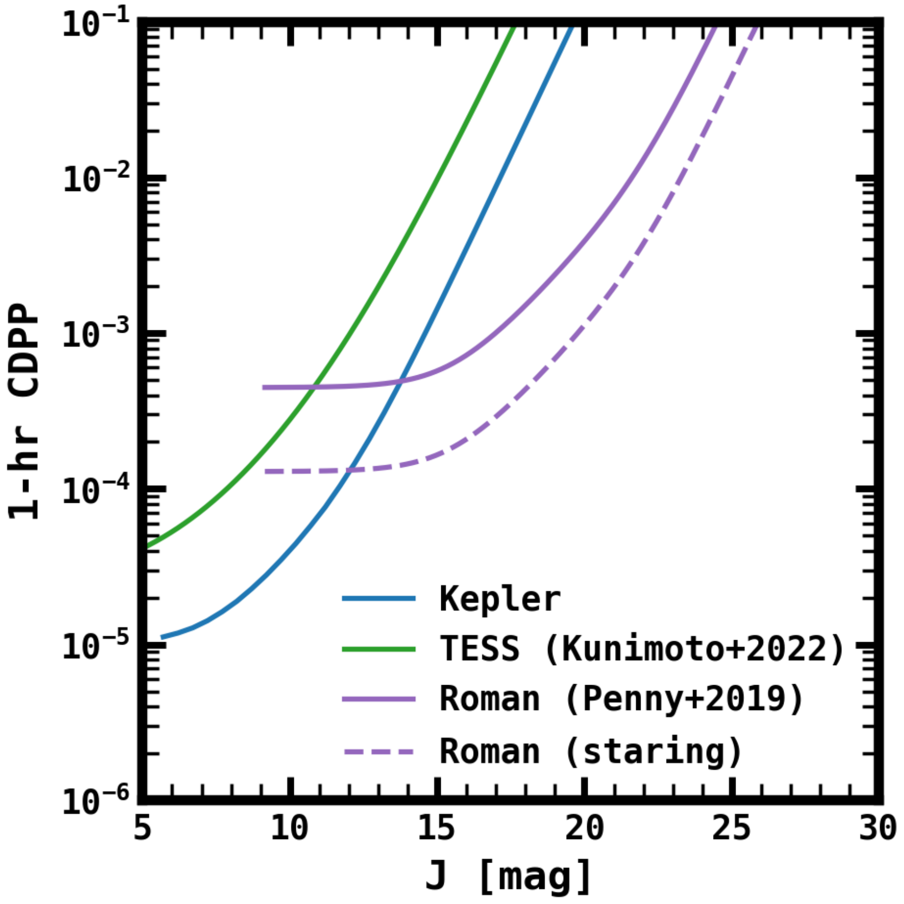
- **Increased Overhead:**
  - Each Star has ~91% Overhead
  - Noise Equivalent to a ~0.8-m Aperture with no Overhead



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- **Increased Overhead:**
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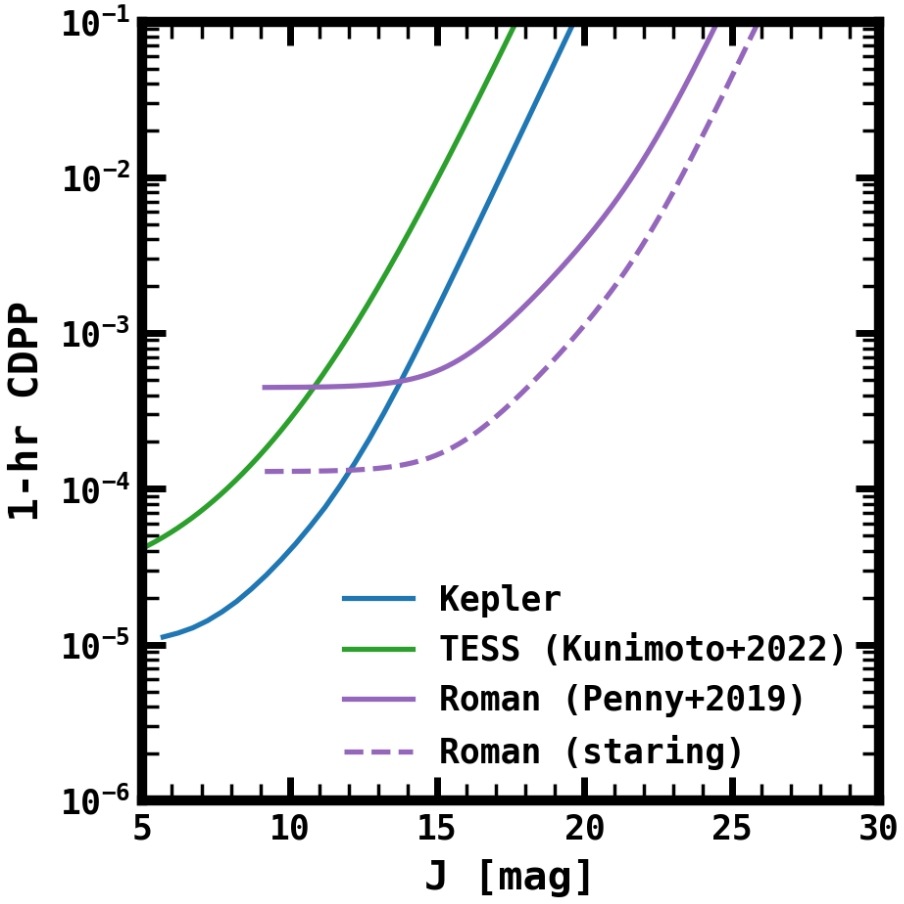
  - Noise Equivalent to a ~0.8-m Aperture with no Overhead
- **Transits are Undersampled**
  - Likely some implications for TTVs



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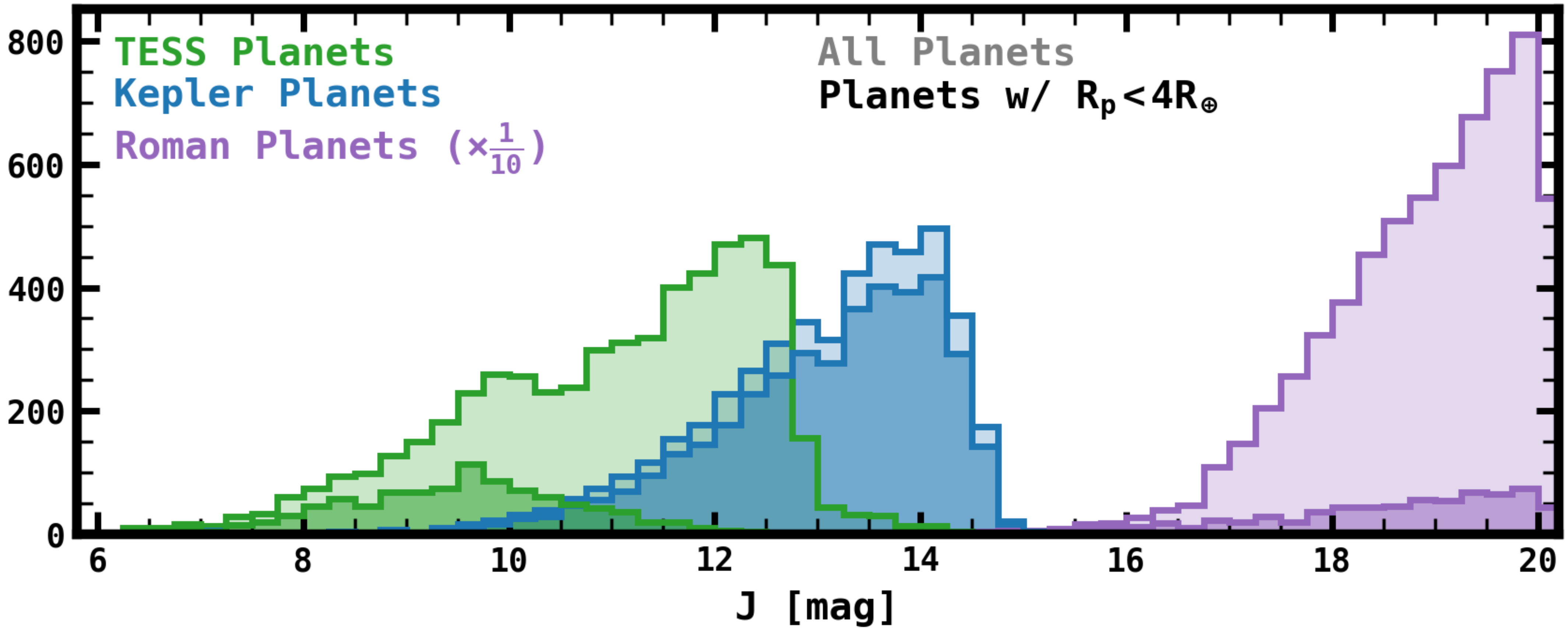

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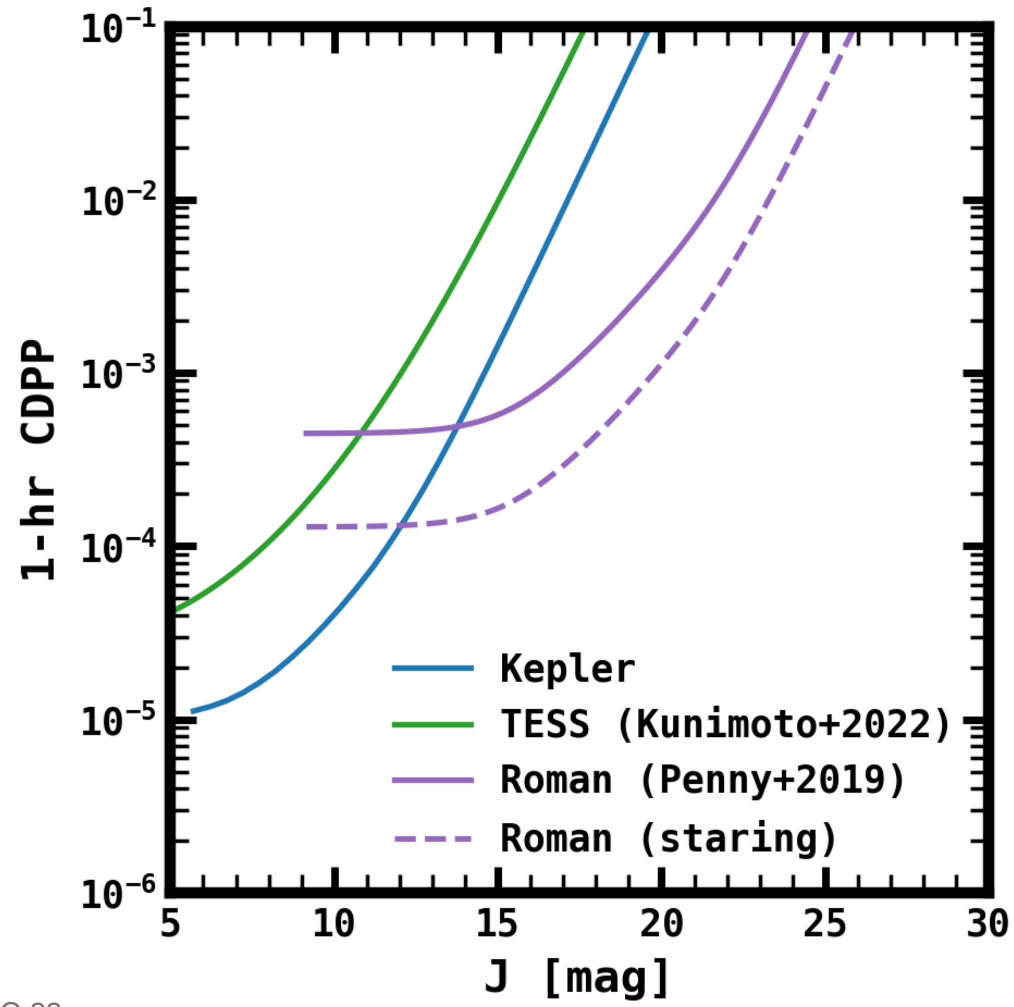

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***see Sean's talk next*

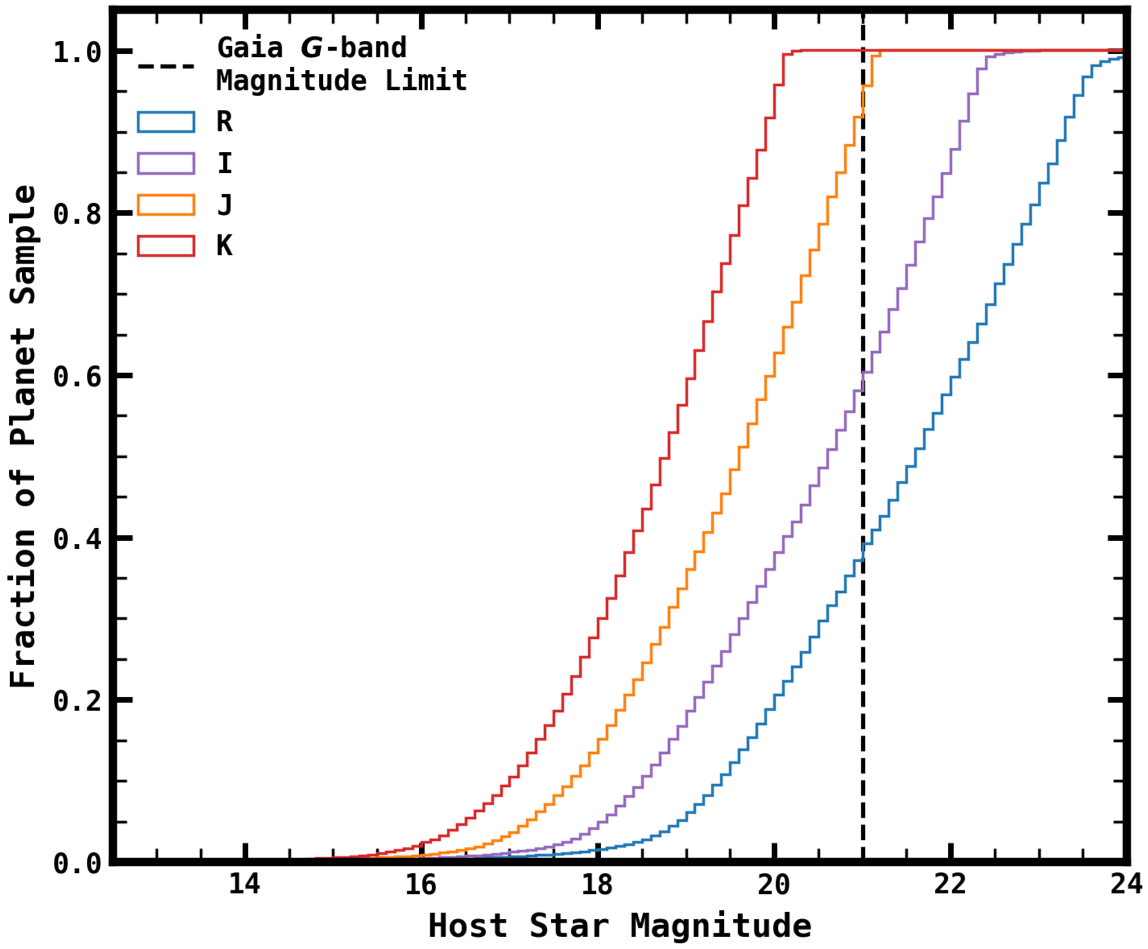

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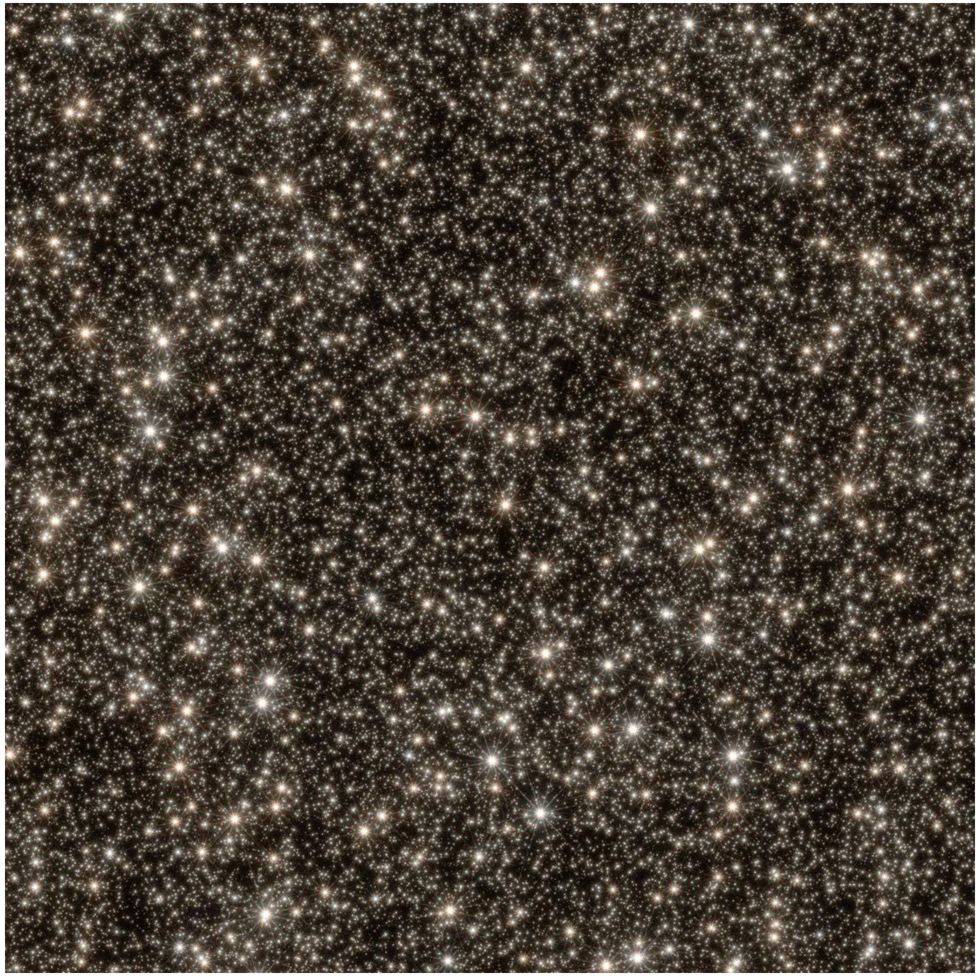
Image Credit: Troxel/Duke



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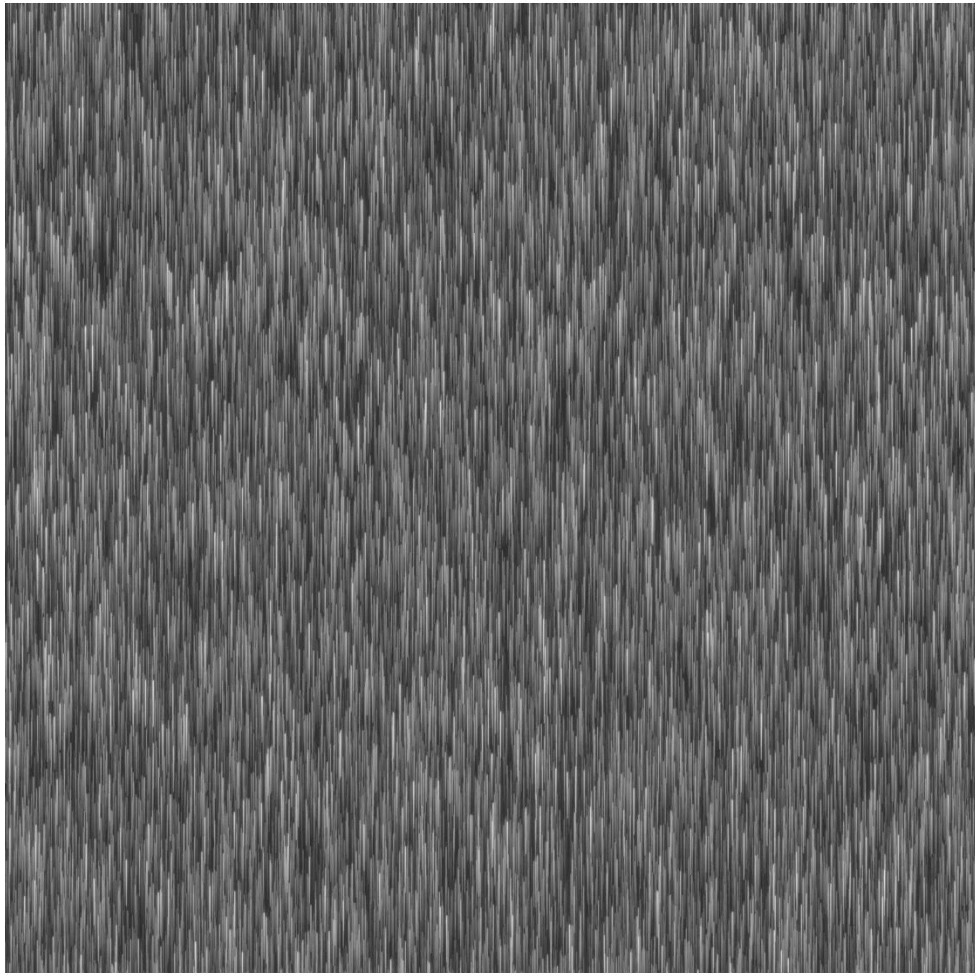

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Stellar Parameters in the GBTDS

- Will rely on