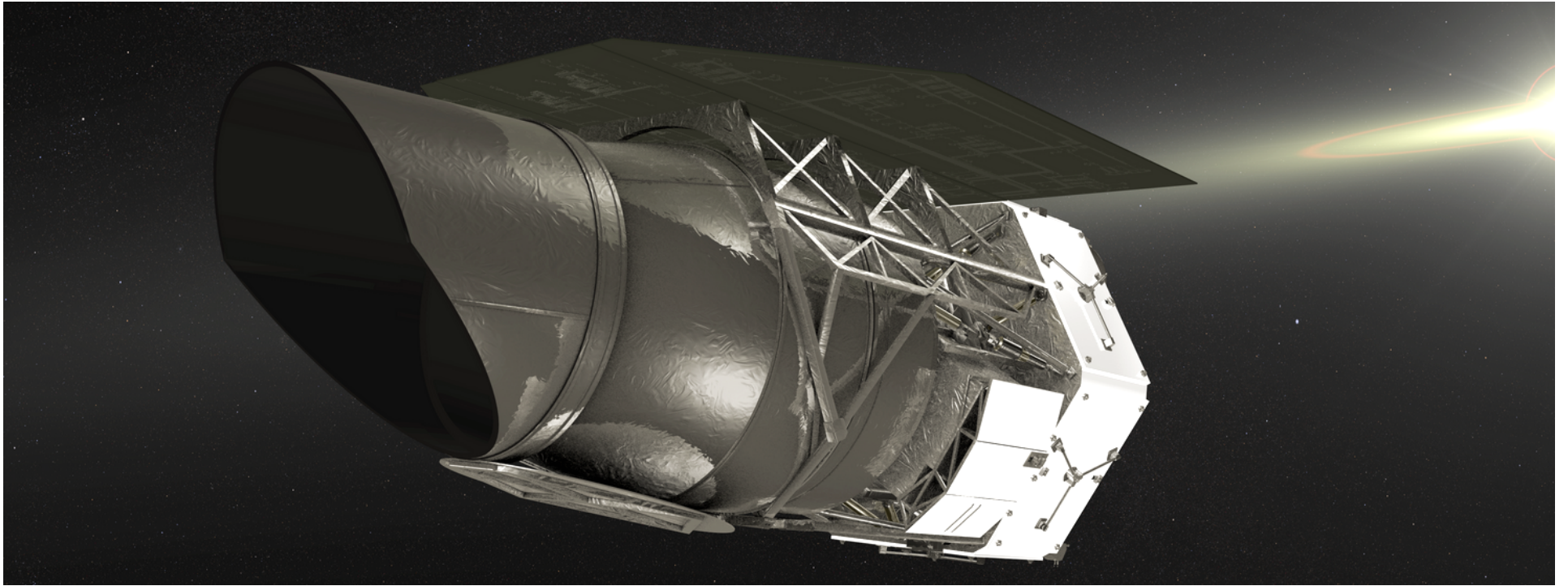


WFIRST is not just for Cold Planets: Transiting Planets with the WFIRST Microlensing Survey



Matthew Penny, Ben Montet, Jennifer Yee

WFIRST Microlensing Science Investigation Team

Ohio State University

penny@astronomy.ohio-state.edu

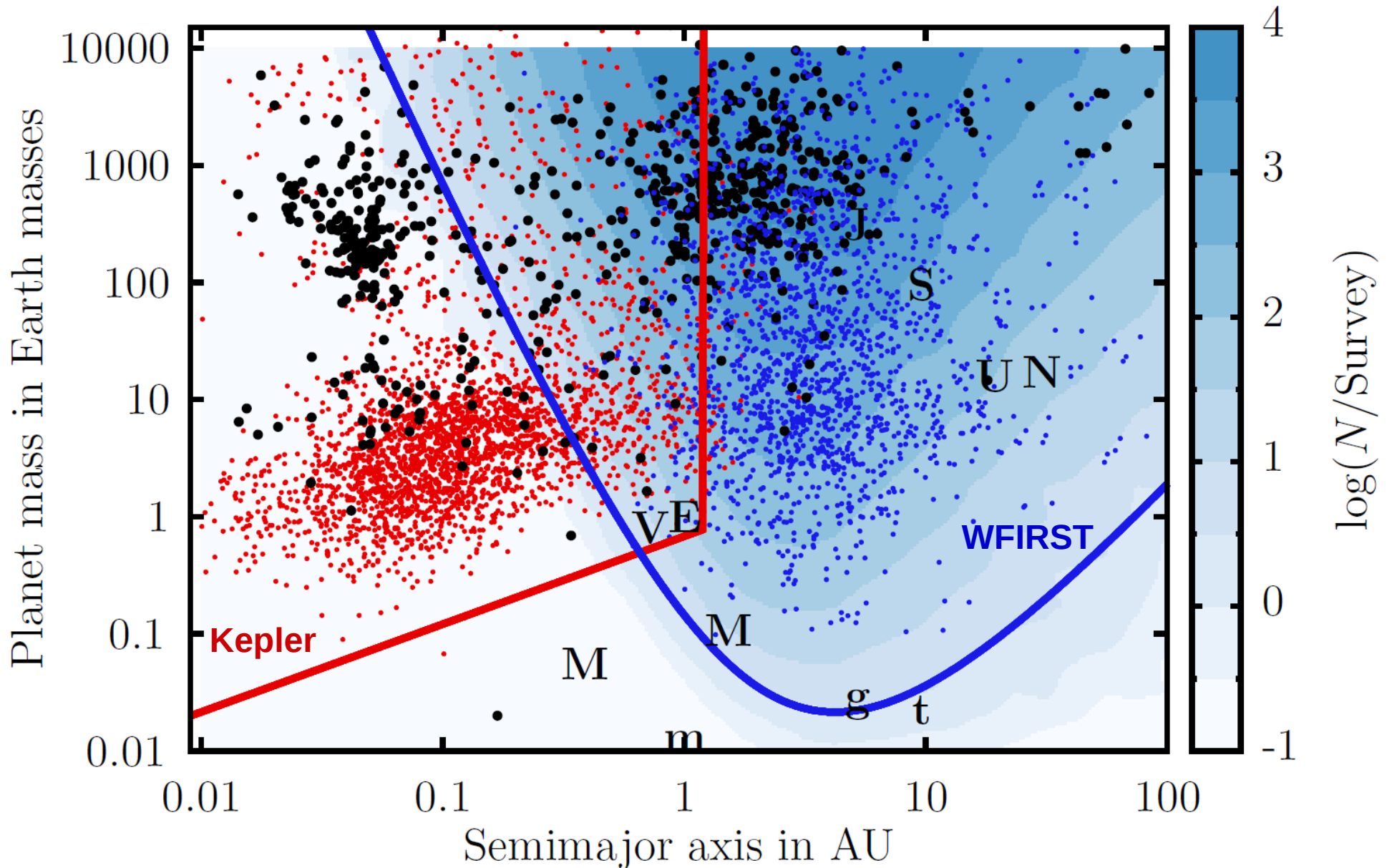
Acknowledgements

- Reporting the work of Ben Montet
 - “Measuring the Galactic Distribution of Transiting Planets with WFIRST”
[Montet, Yee & Penny 2017, PASP, 192, 044401](#)
- Also worth reading:
 - “ExELS: an exoplanet legacy science proposal for the ESA Euclid mission - II. Hot exoplanets and sub-stellar systems”
[McDonald et al. 2014, MNRAS, 445, 4137](#)

Conclusions

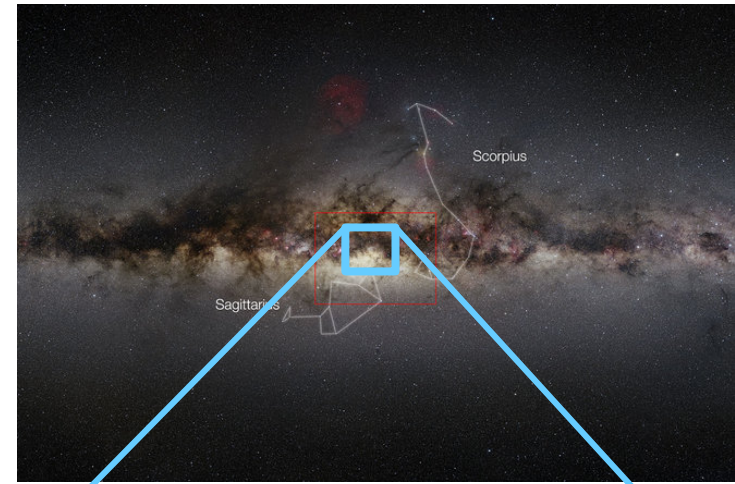
- The WFIRST microlensing is also a transit survey for free
- WFIRST will discover more transiting planet candidates than Kepler & TESS combined
- Many candidates will be confirmable with the survey data, and most false positives will be removed
- The transiting planets WFIRST will find will be an important link between WFIRST's microlensing discoveries and Kepler's planet sample

The WFIRST Microlensing Survey

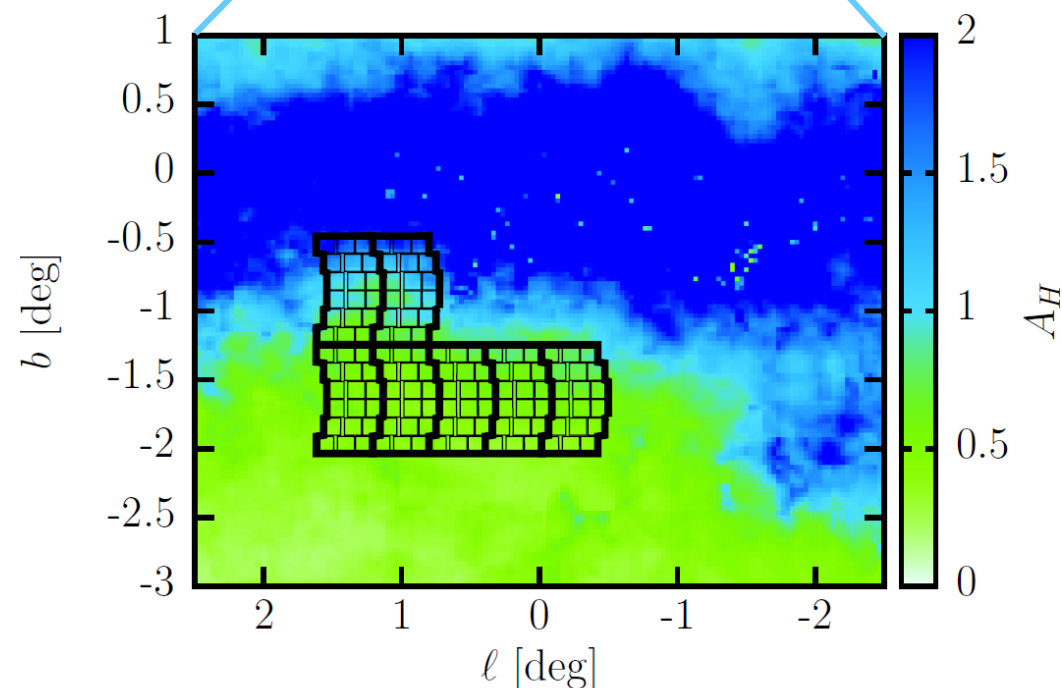


WFIRST Microlensing Survey

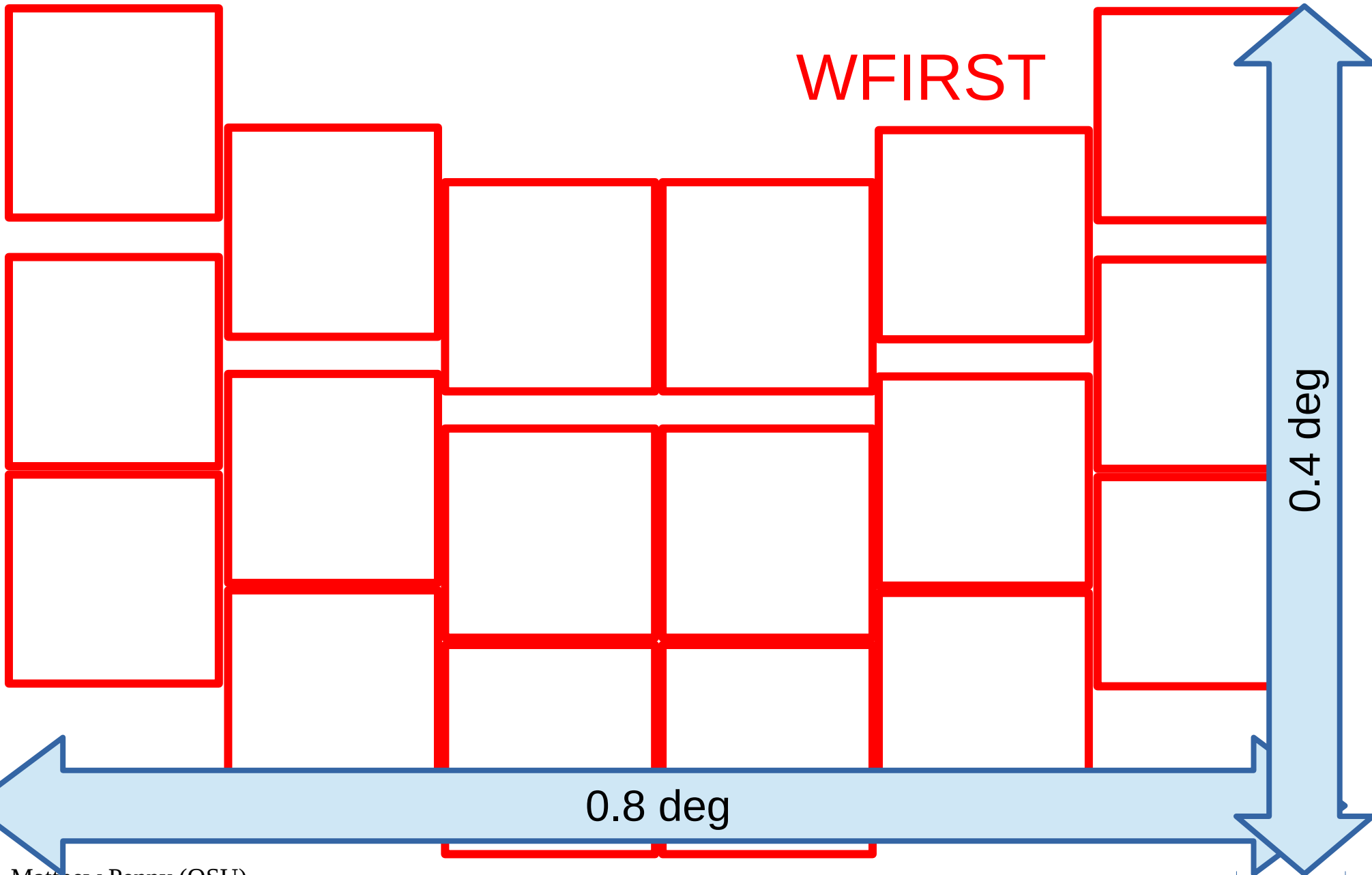
- 432 day survey
- 6x72 seasons over 5 years
- 2 deg²
- 15 min cadence
- Wide 1-2 μ m bandpass
- Discover ~1500 cold exoplanets, including ~200 Earth-mass planets and hundreds of free-floating planets



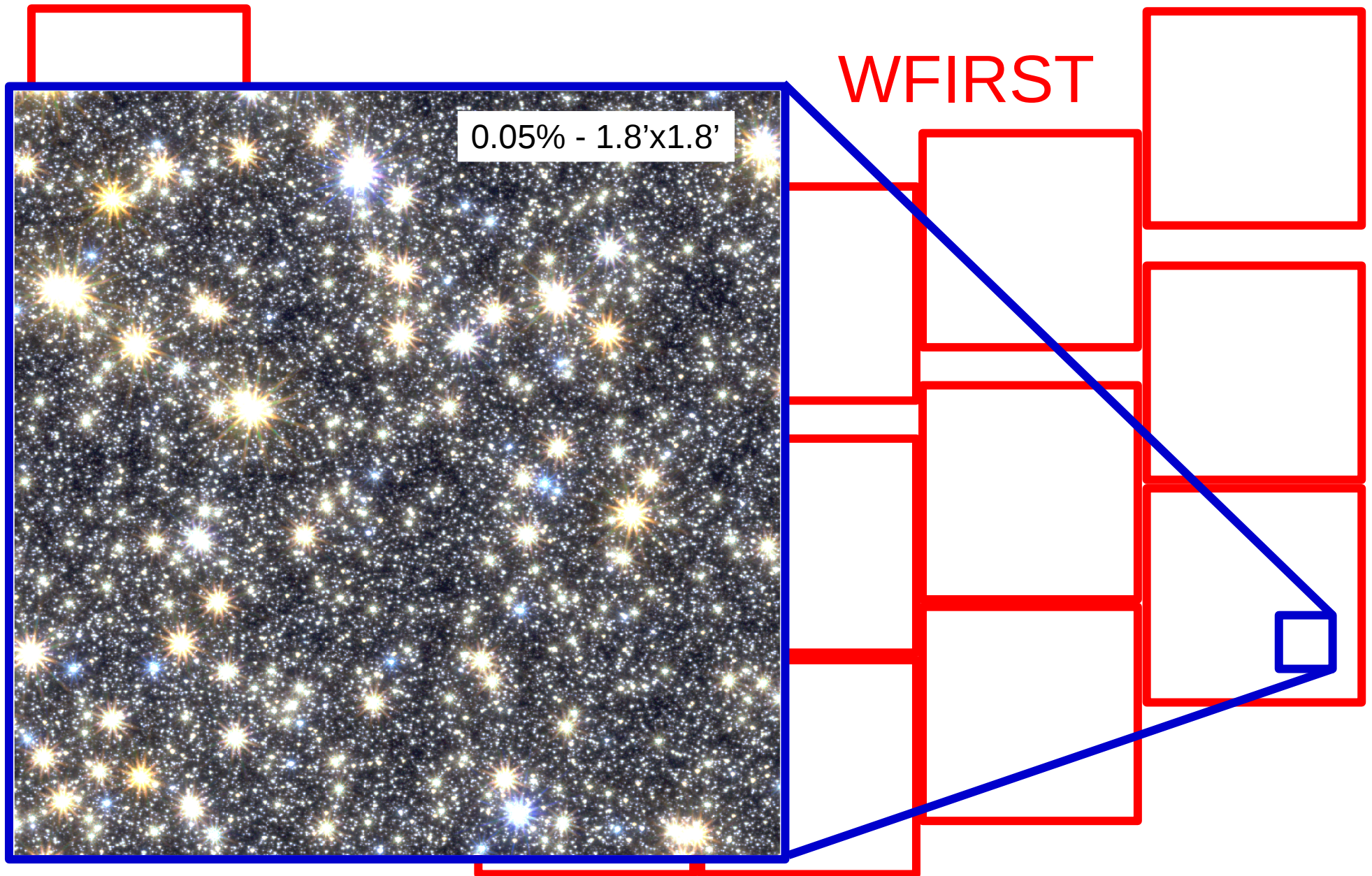
WFIRST fields with 6 Reaction Wheels



WFIRST Field of View



WFIRST Field of View

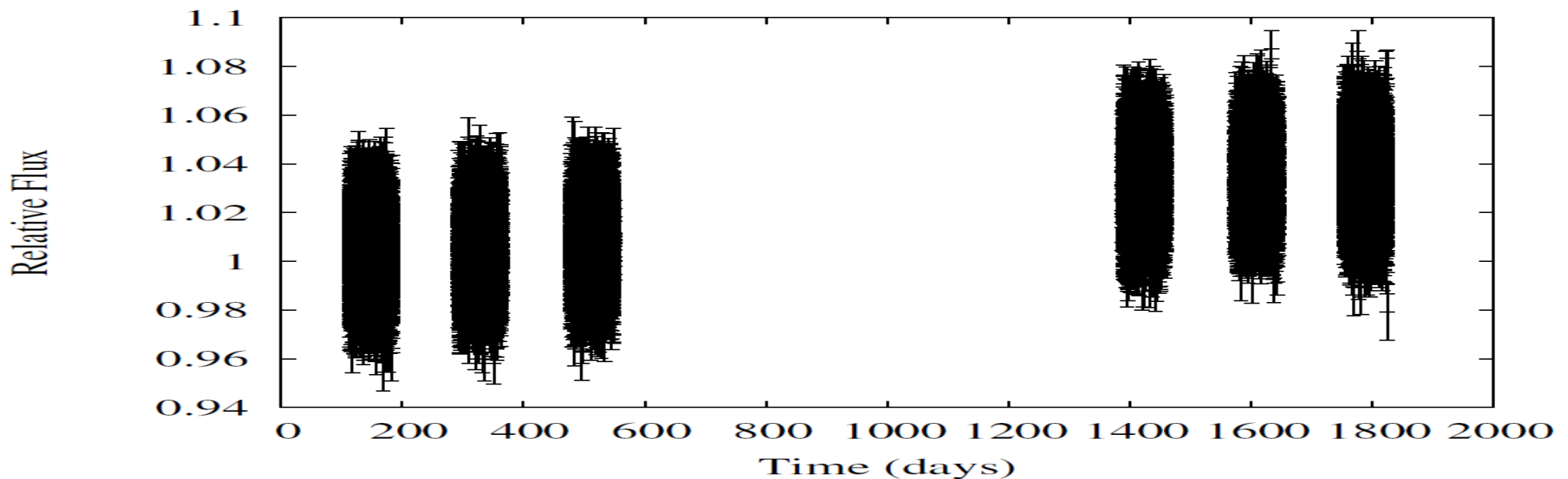


WFIRST Compared to Transit Surveys

	Kepler	TESS	WFIRST
Area	~100 deg ²	~37,000 deg ²	~2 deg ²
Cadence	30 min (+1 min)	30 min (+2 min)	15 min (+sub-exp.)
Baseline	4.25 years	27 days-1 year	72 days-4.5 years
Total Exposure	4.25 years	27 days-1 year	432 days
Filter	0.4-0.9 um	0.6-1.0 um	1.0-2.0 um + some of R,Z,Y,J,H,F184
Systematic floor	~0.02 mmag/30 min	<0.06 mmag/hr	1 mmag/15 min

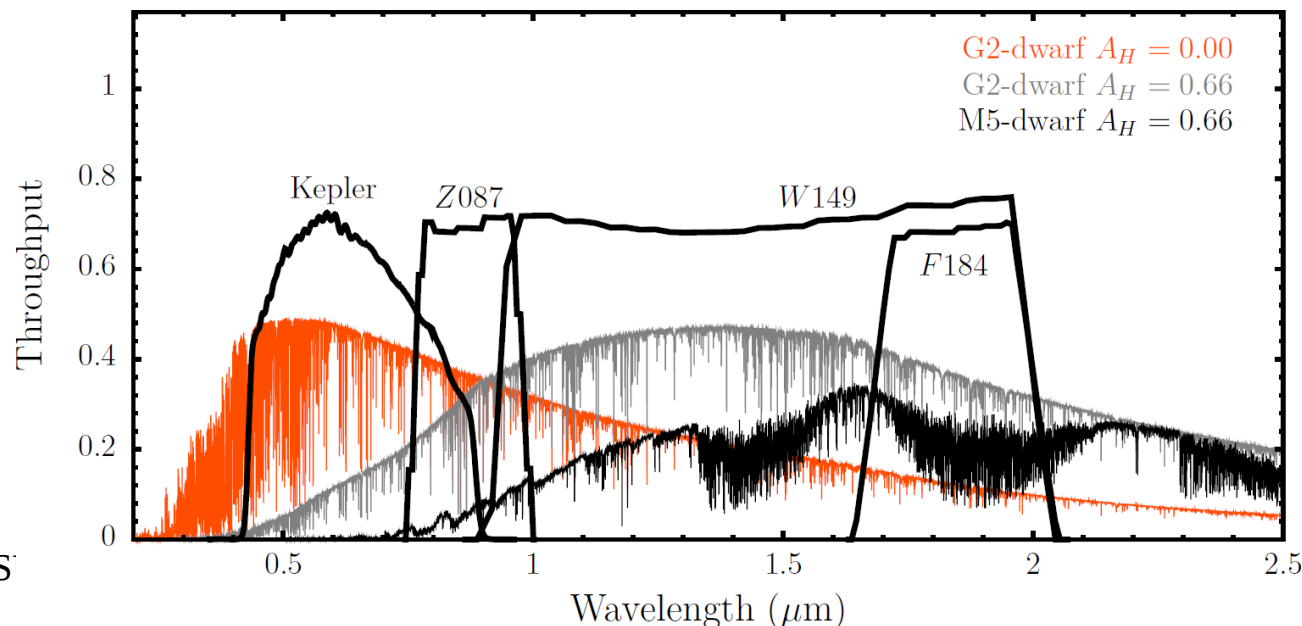
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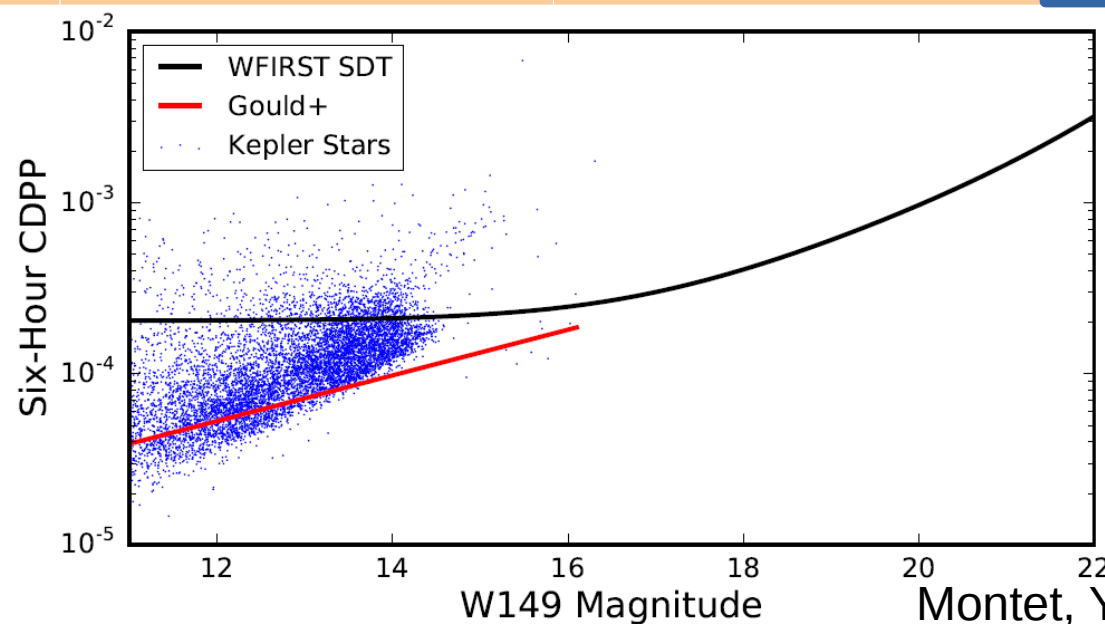
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Measuring the Galactic Distribution of Transiting Planets with *WFIRST*

Benjamin T. Montet^{1,4}, Jennifer C. Yee^{2,4}, and Matthew T. Penny^{3,4}

¹ Department of Astronomy and Astrophysics, University of Chicago, 5640 S. Ellis Avenue, Chicago, IL 60637, USA; bmontet@uchicago.edu

² Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138, USA

³ Department of Astronomy, Ohio State University, 140 West 18th Avenue, Columbus, OH 43210, USA

Received 2016 October 12; accepted 2017 January 7; published 2017 February 24

- Combine Galactic Model (Besancon) + Kepler Planet Occurrence Rates (Howard et al. 2012, Morton & Swift 2014 for M-dwarfs). Consider effect of [Fe/H] on occurrence.
- Apply WFIRST SNR relations for WFIRST Microlensing Survey
- Inject transits into simulated lightcurves



Measuring the Galactic Distribution of Transiting Planets with *WFIRST*

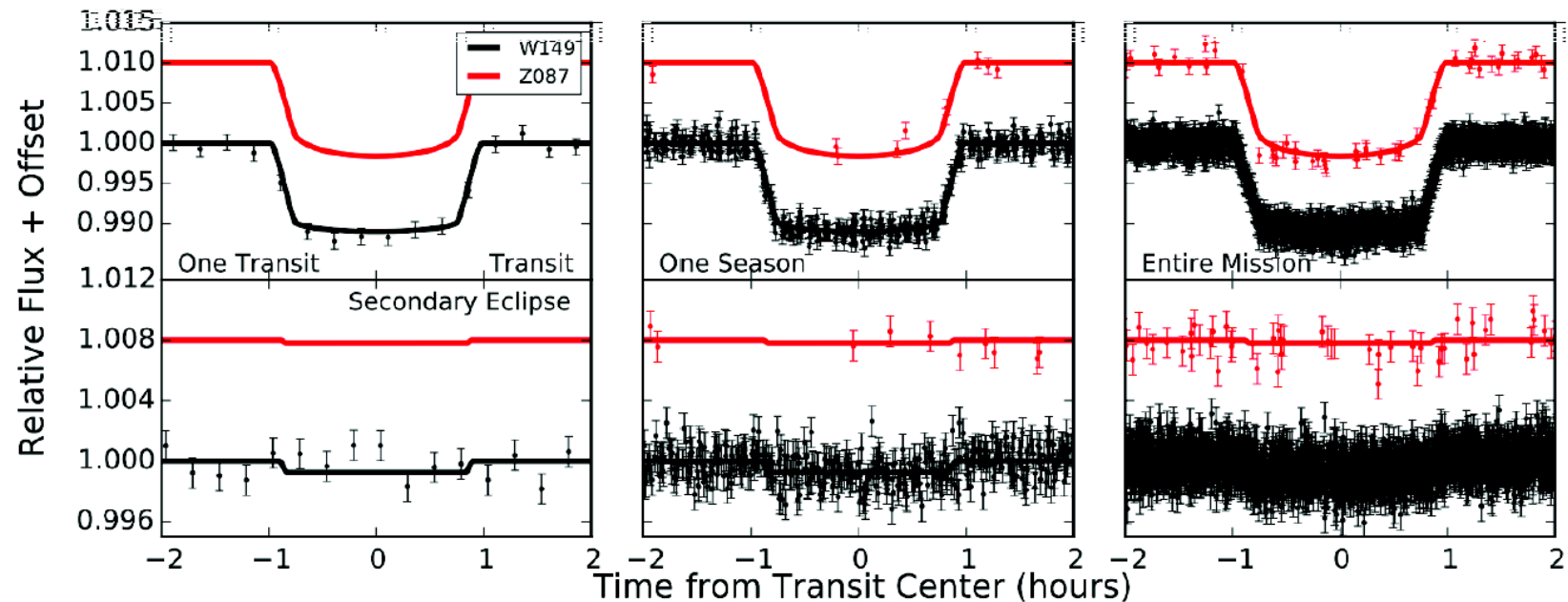
Benjamin T. Montet^{1,4}, Jennifer C. Yee^{2,4}, and Matthew T. Penny^{3,4}

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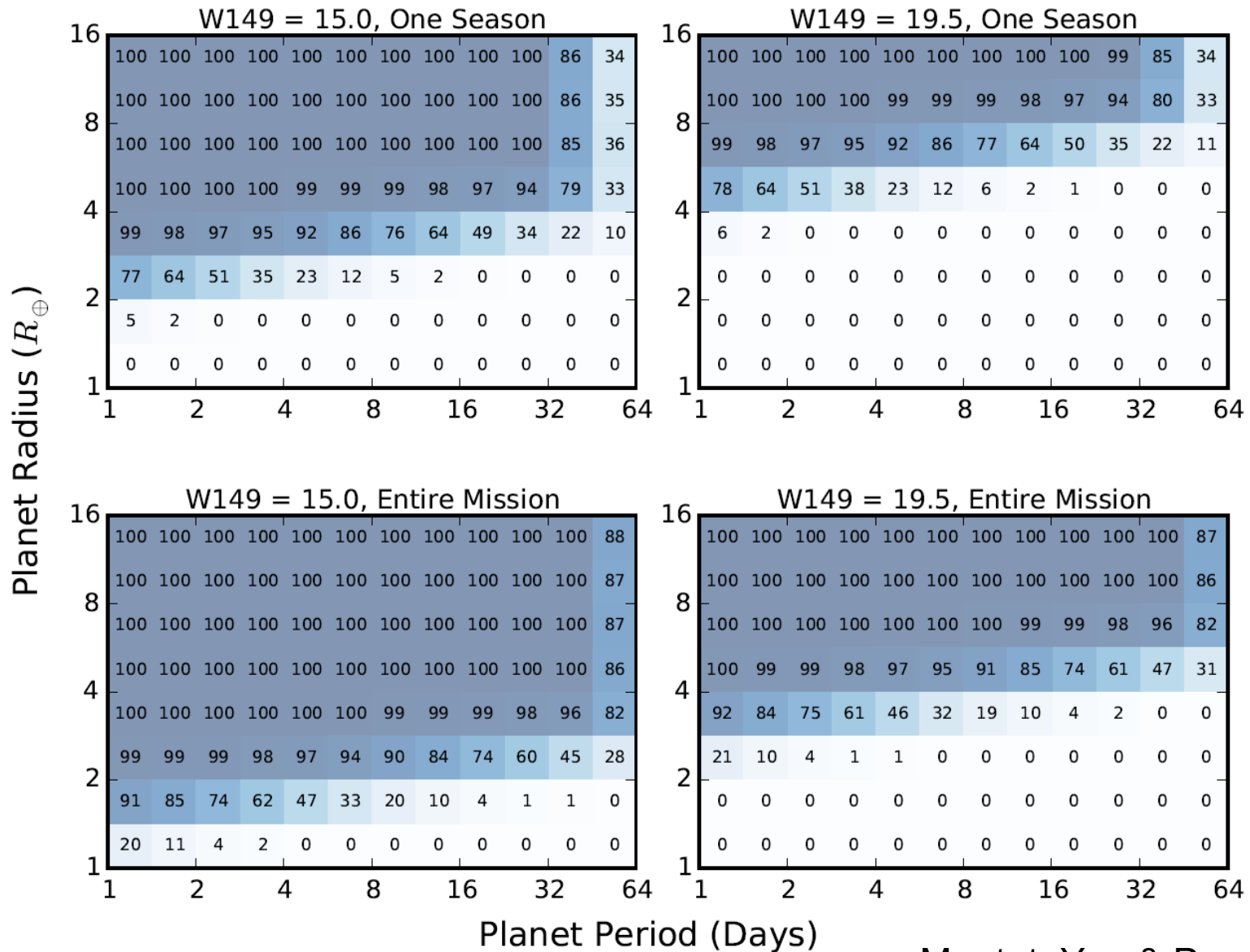
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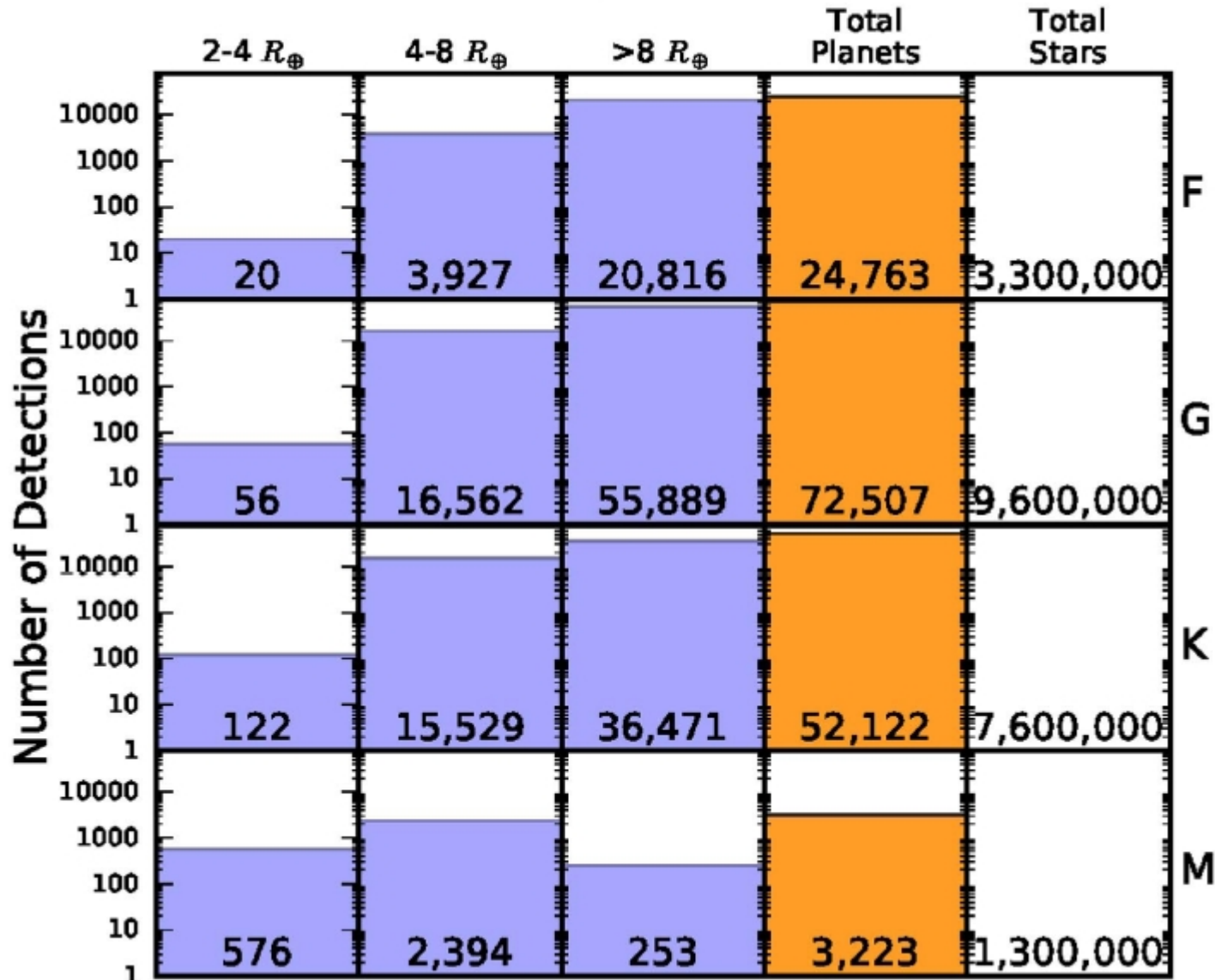
- Inject transits into simulated lightcurves

Period-Radius Sensitivity



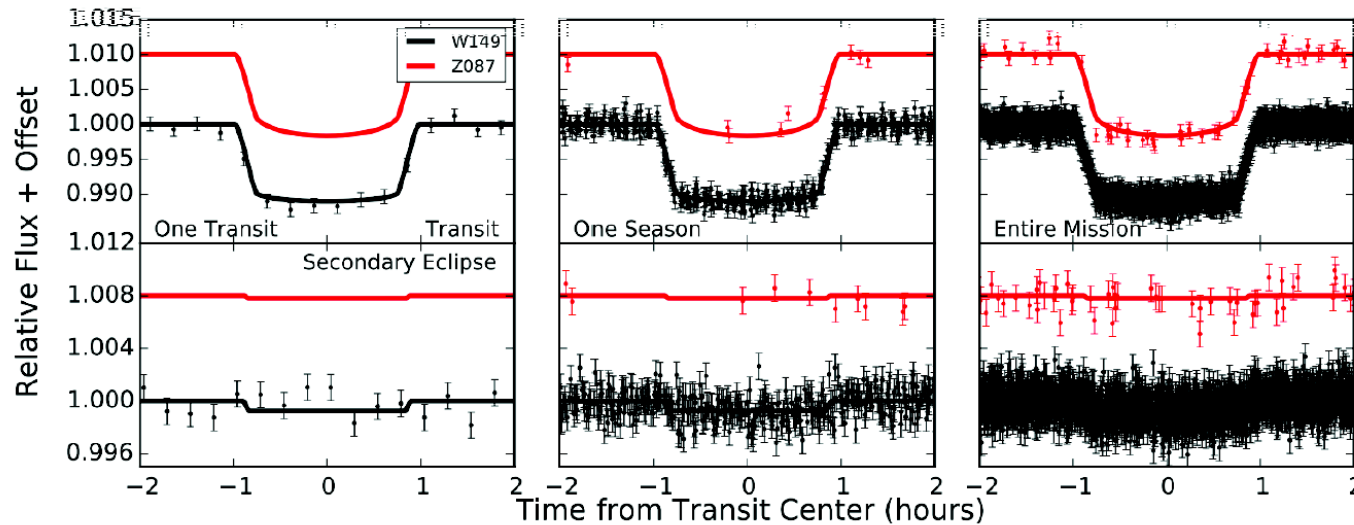
Host Type Distribution

W149 < 21.0, Scaled Occurrence



*Numbers are here too large by ~30% due to switch from 10 to 7 fields [slew rates]

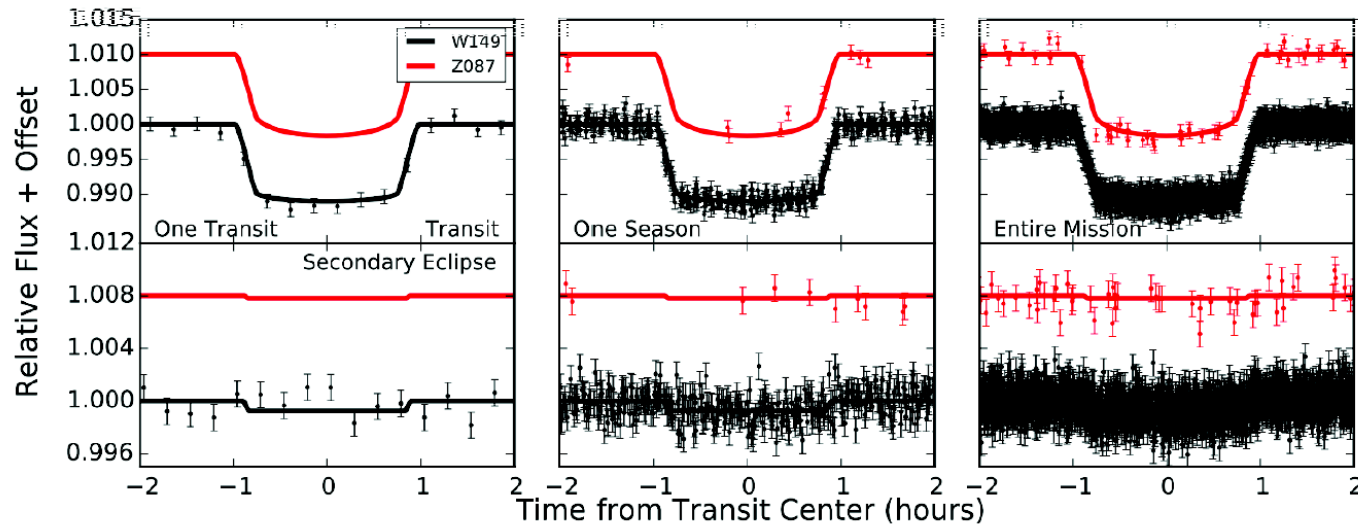
False Positive Rejection



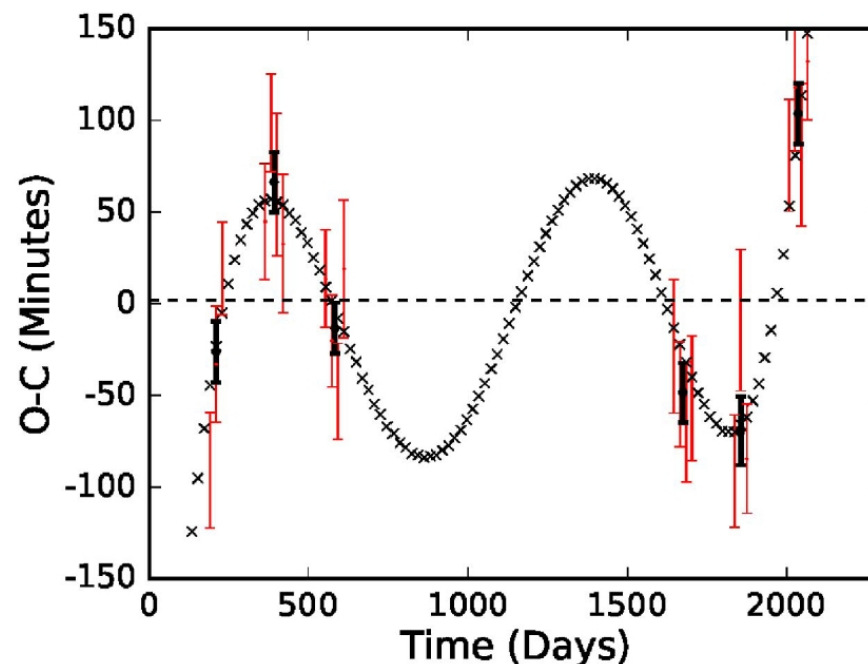
Montet, Yee & Penny (2017)

- Secondary Eclipses detectable for 1100 hot Jupiters in W149 bandpass – secondary eclipses of EB impostors much easier to detect.
- Also, ingress & egress durations can distinguish planets from EBs
- (A)chromatic primary eclipses? Not yet investigated

False Positive Rejection



- TTVs can also be used to confirm planets in favorable cases

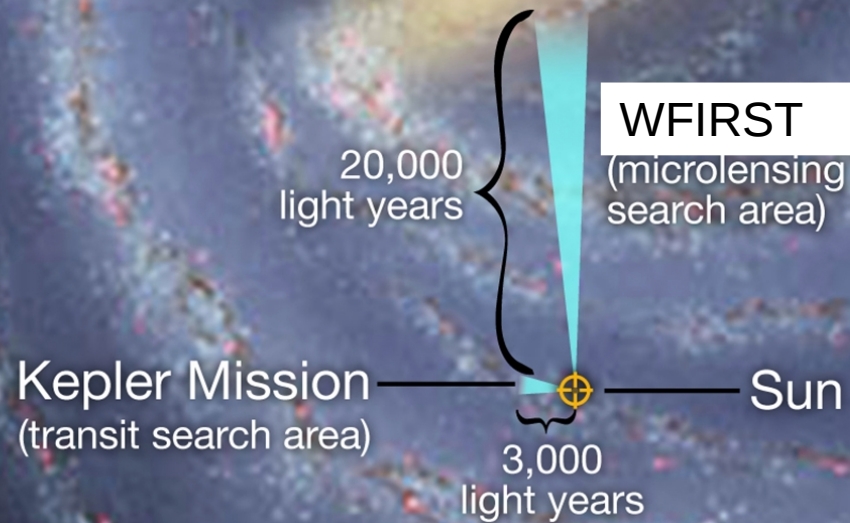


WFIRST Compared to Transit Surveys

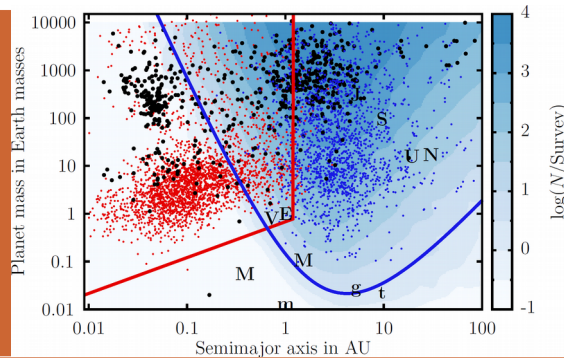
	Kepler	TESS	WFIRST
Number of Stars	~100,000	~million	~100 million
Horizon	~1 kpc (G2V)	~200 pc (G2V)	~8 kpc
Populations	Thin+thick disk	Local	Thin disk, bulge
Planets			
Jupiters $>8R_{\oplus}$	~200	} 17000	~30-80,000*
Neptunes 4-8	~300		~13-27,000*
S. Earths 2-4	~1500	3000	~500* *f([Fe/H])
Earths $<2R_{\oplus}$	~2300 Thompson et al. (2018)	~600 Sullivan et al. (2015)	~0 Montet, Yee & Penny (2017)

Why more transits?

Milky Way Galaxy



Combining WFIRST & Kepler



Disk

Bulge

**F, G, K, early
M-dwarfs**

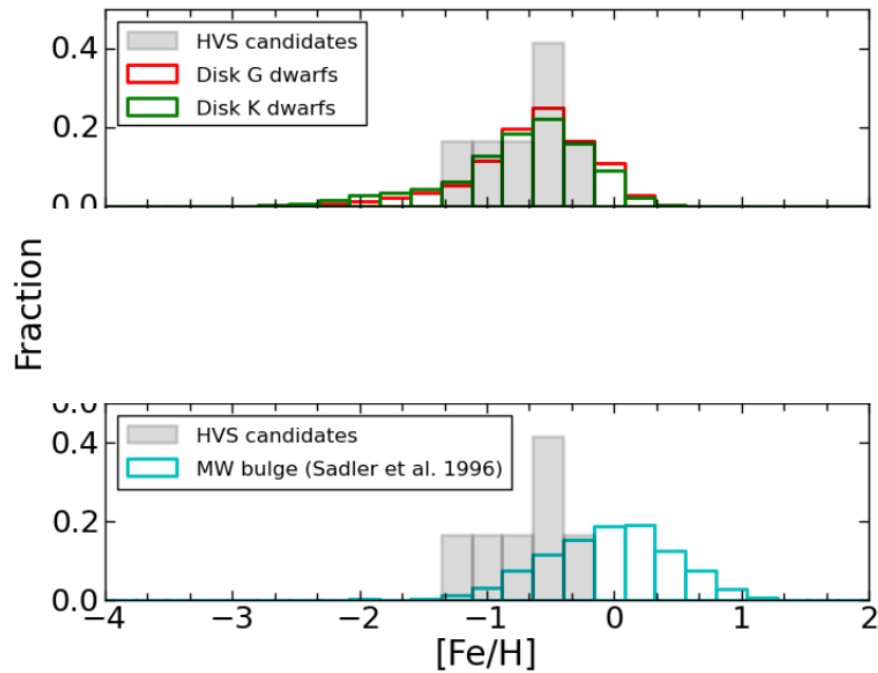
Kepler

WFIRST

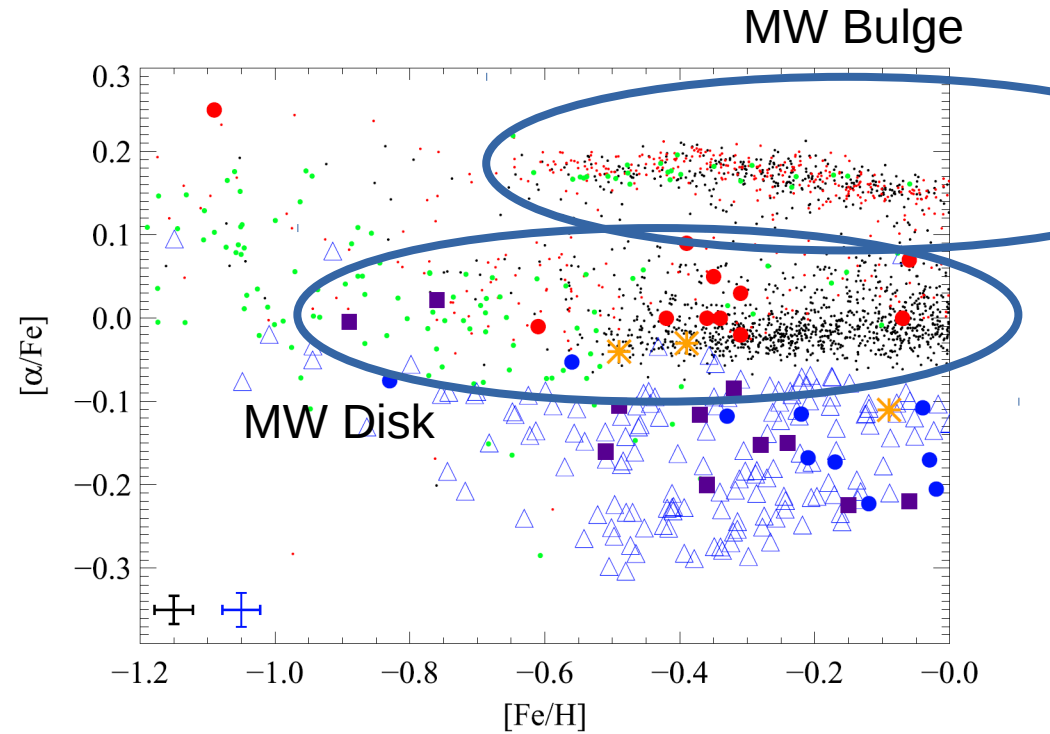
**Late M-
dwarfs**

WFIRST

Combining WFIRST & Kepler

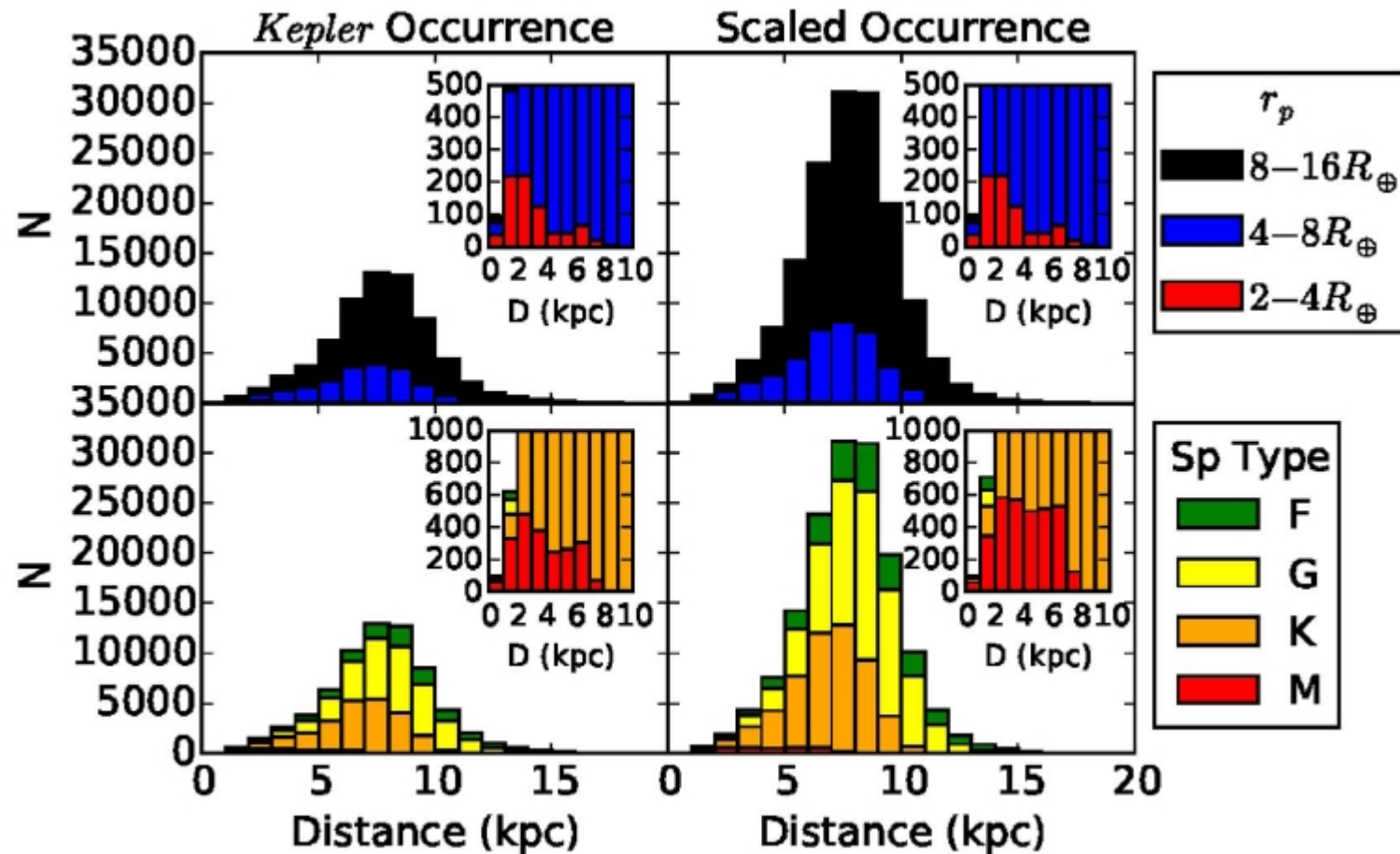


Palladino et al. (2014)



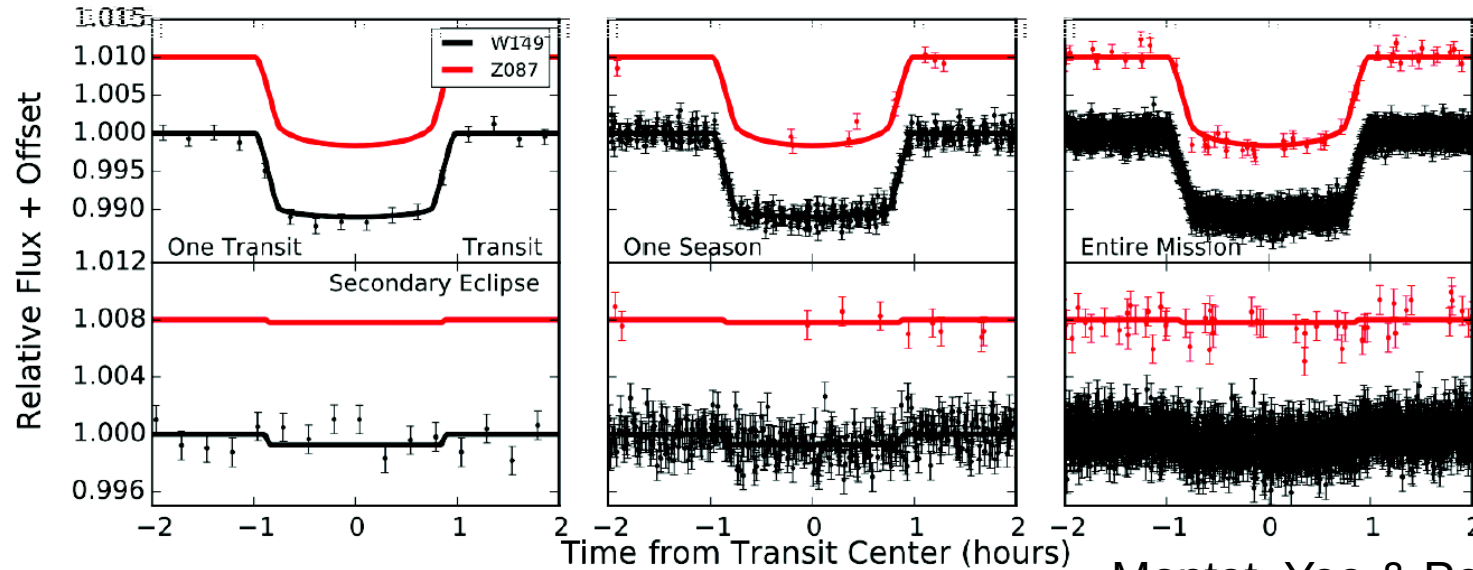
Hasselquist+2017 (APOGEE)

WFIRST's Transiting Planets



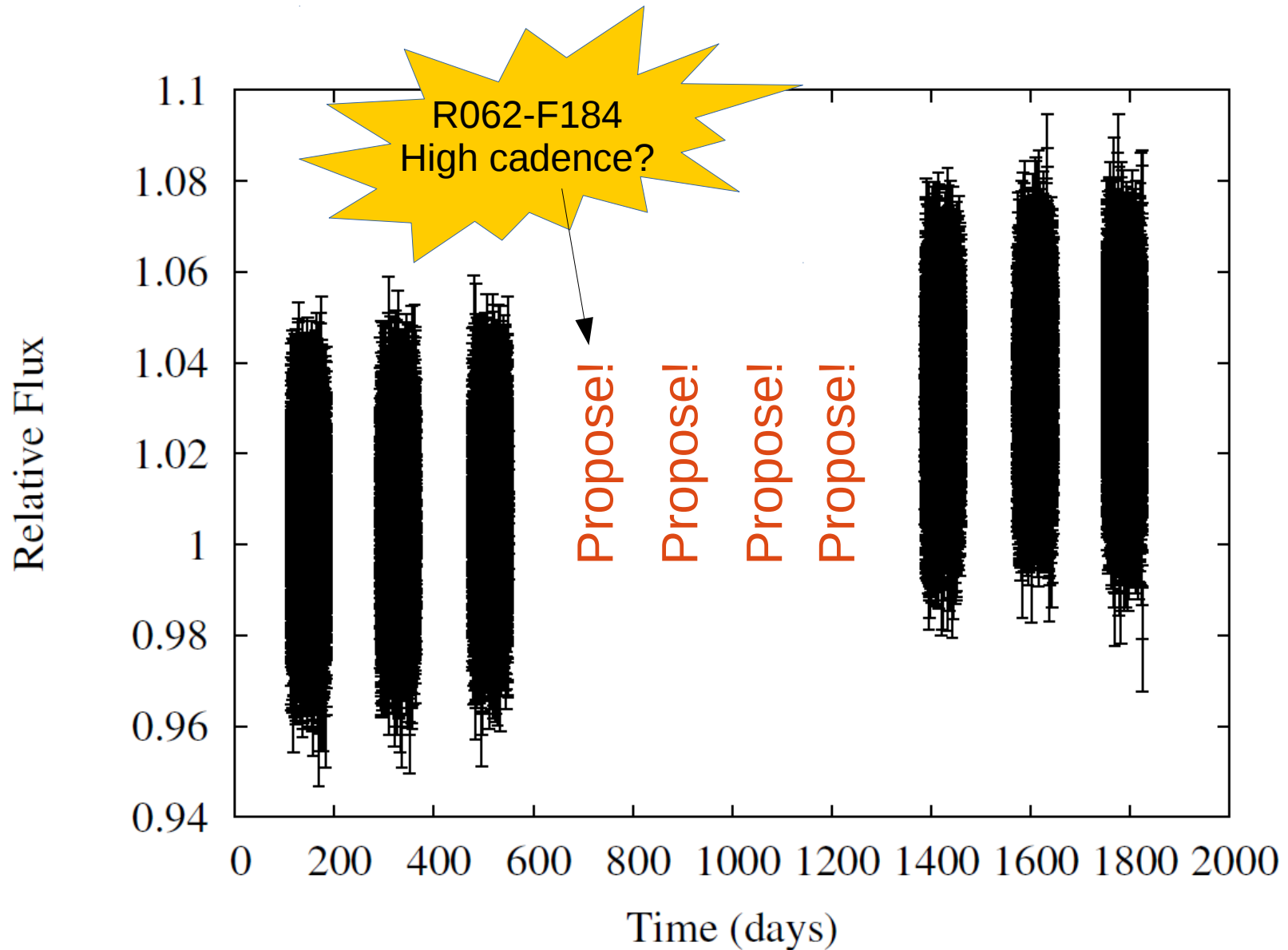
Montet, Yee & Penny (2017)

Data Processing

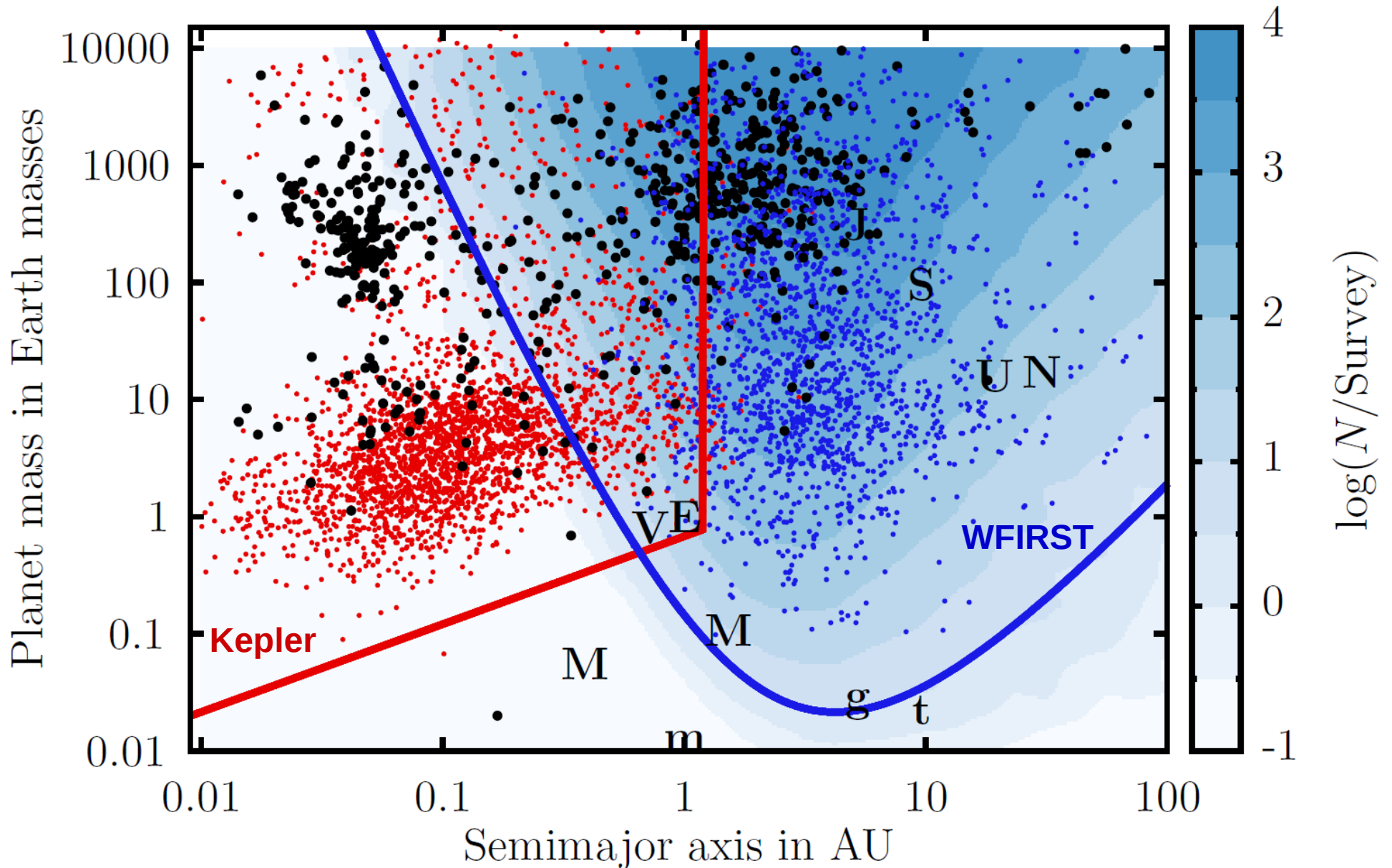


- Raw star lightcurves provided as data downloaded + delay ~day-week, calibrated
- No detrending, transit search, ... it's up to you!
- Funding will be available through the WFIRST Guest Investigator program!

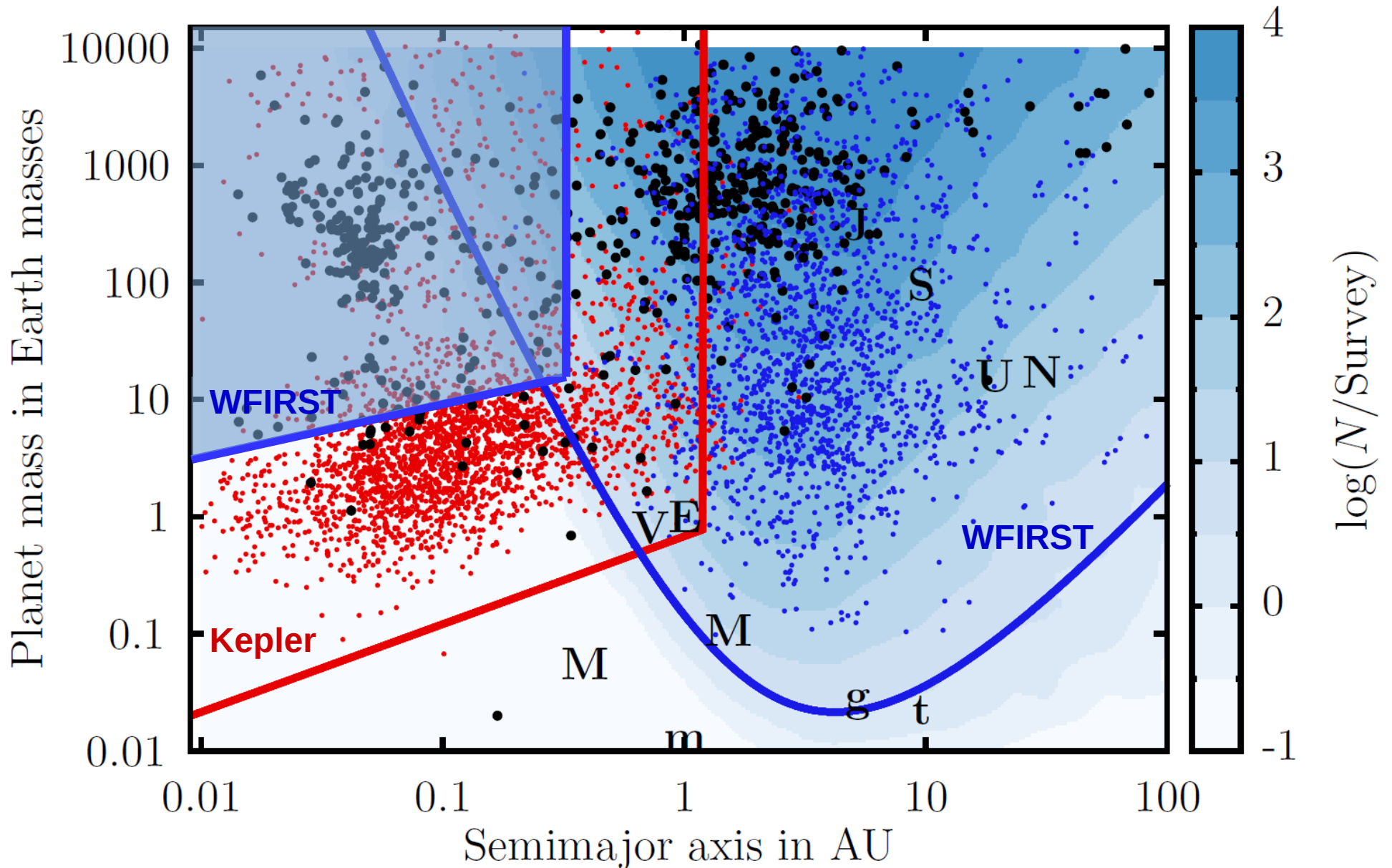
Possibilities for GO Proposals



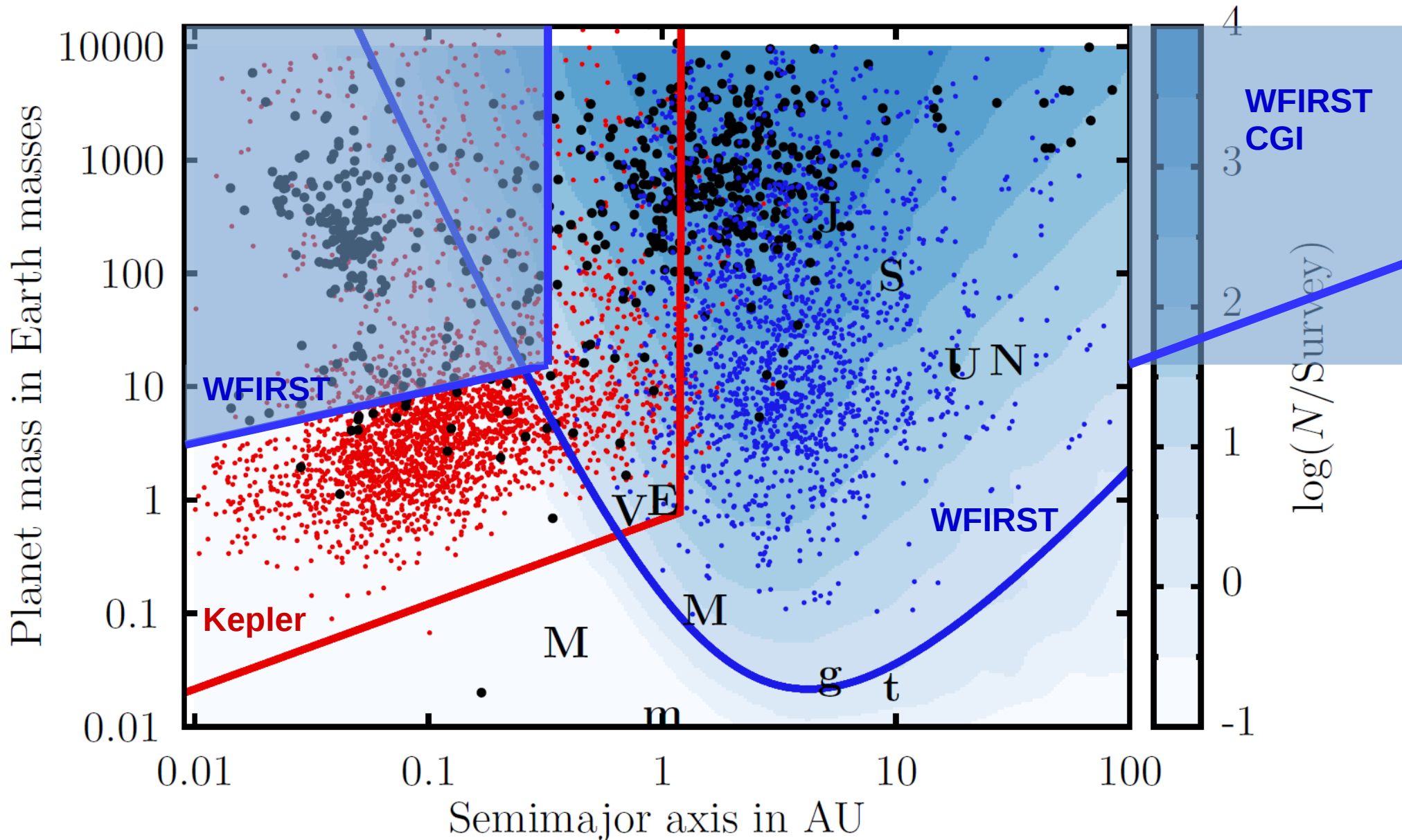
The WFIRST Microlensing Survey



The WFIRST Microlensing+Transit Survey



The WFIRST Microlensing+Transit Survey



Backup slides

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