# Exoplanet Demographics with WFIRST-AFTA

Scott Gaudi
Ohio State University

223rd AAS Meeting
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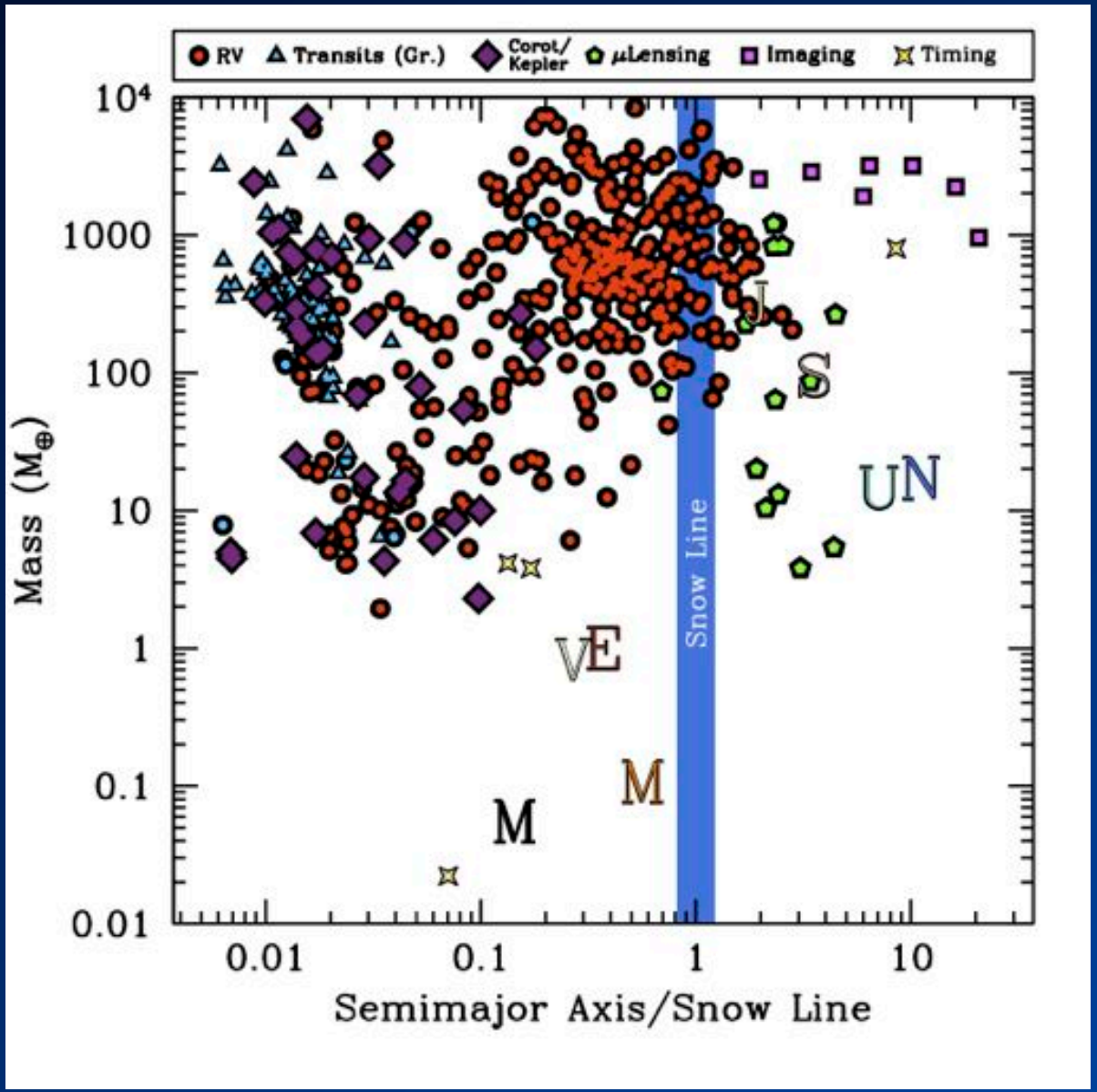
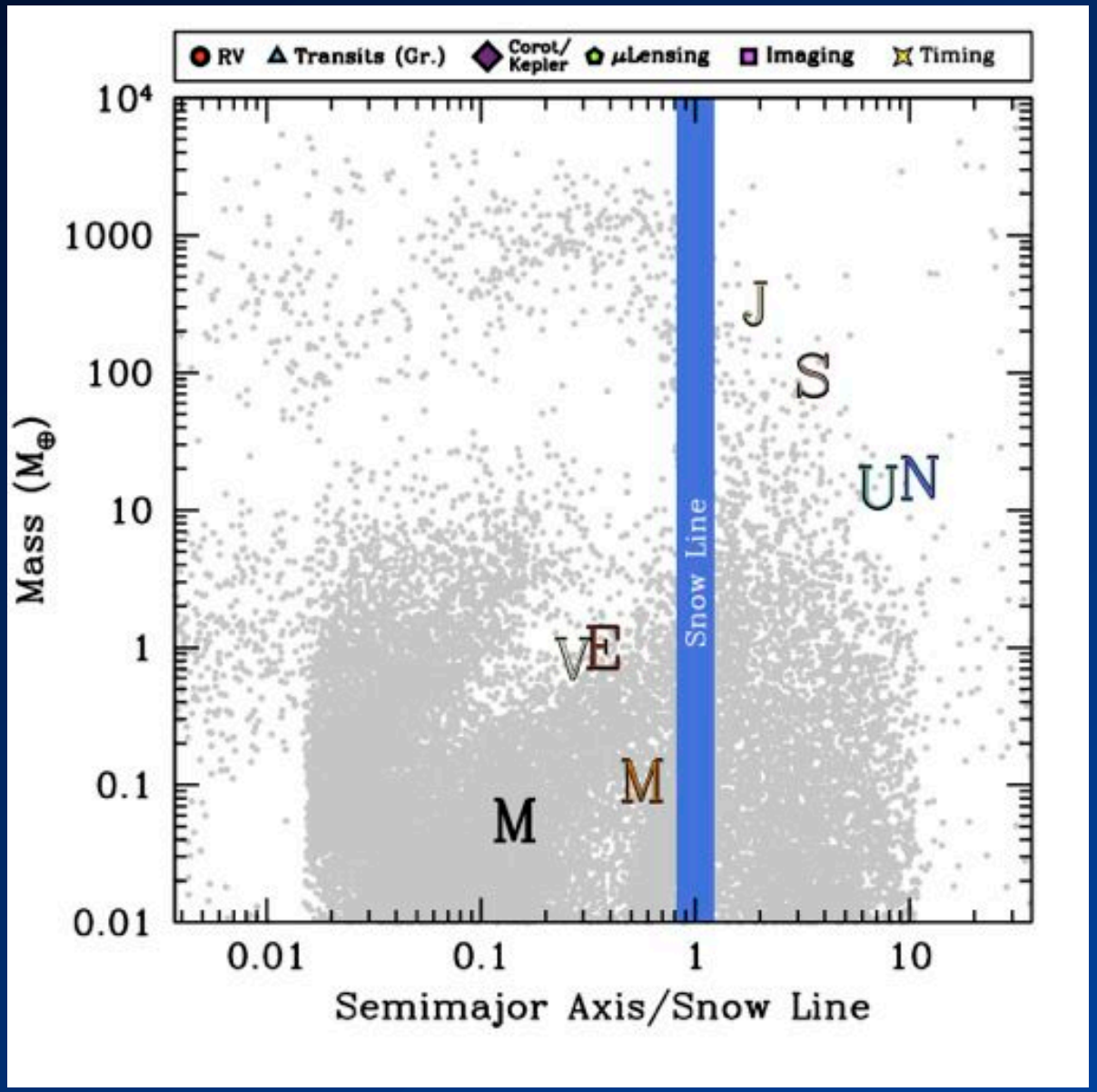
WFIRST-AFTA Special Session

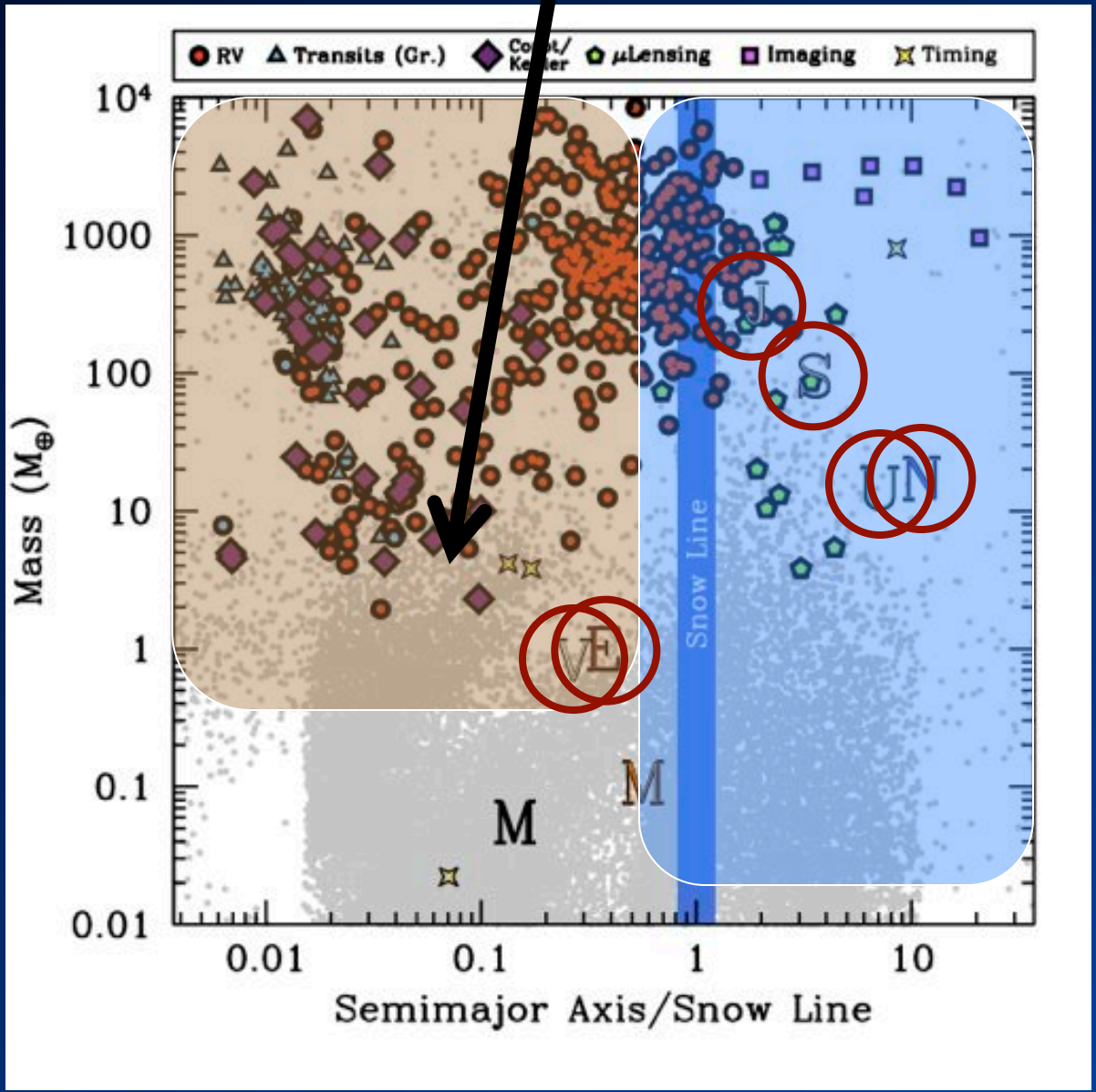
# Strange New Worlds.



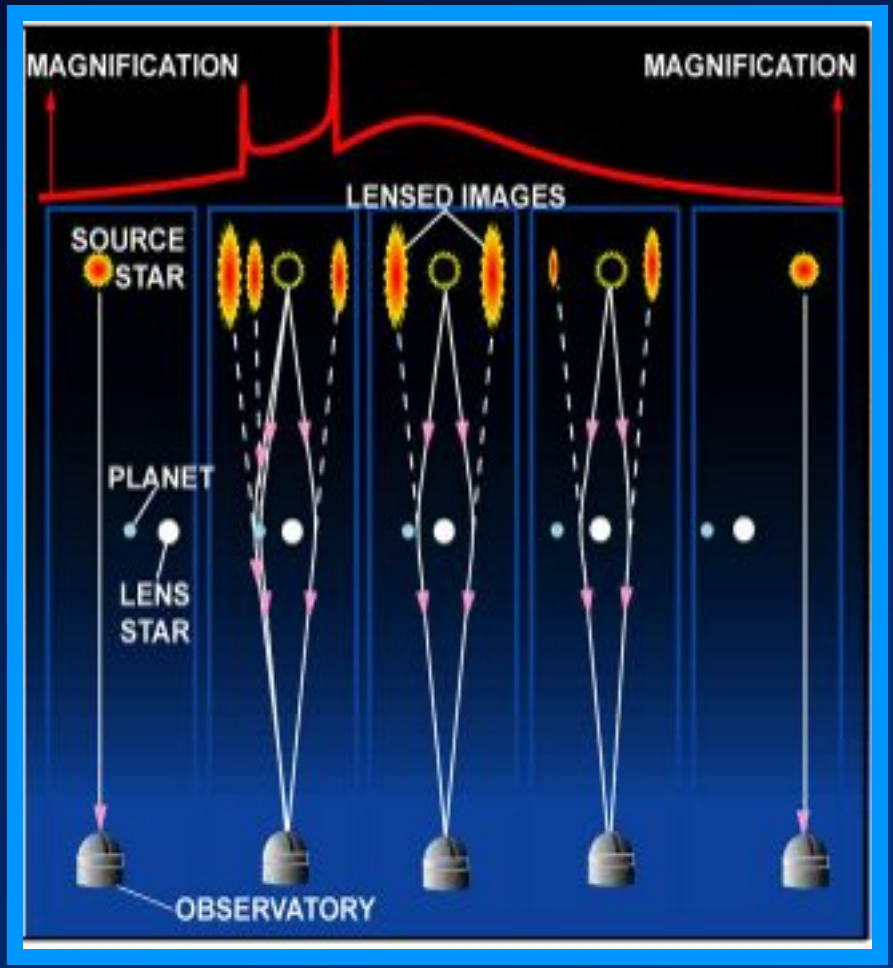

RV
Transits (Gr.)
Corot/ Kepler
μLensing
Imaging
Timing
Mass ($M_\oplus$)
$10^4$
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
Semimajor Axis/Snow Line
Snow Line
J
S
UN
VE
M
M

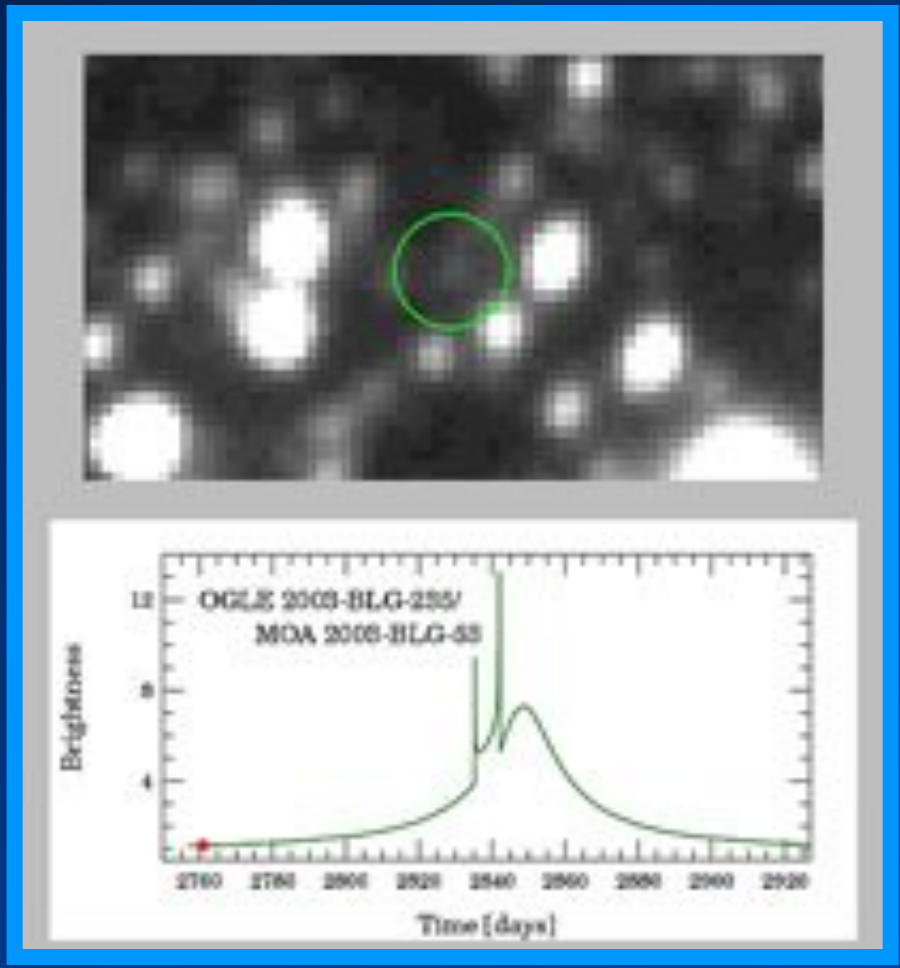
(Ida & Lin)

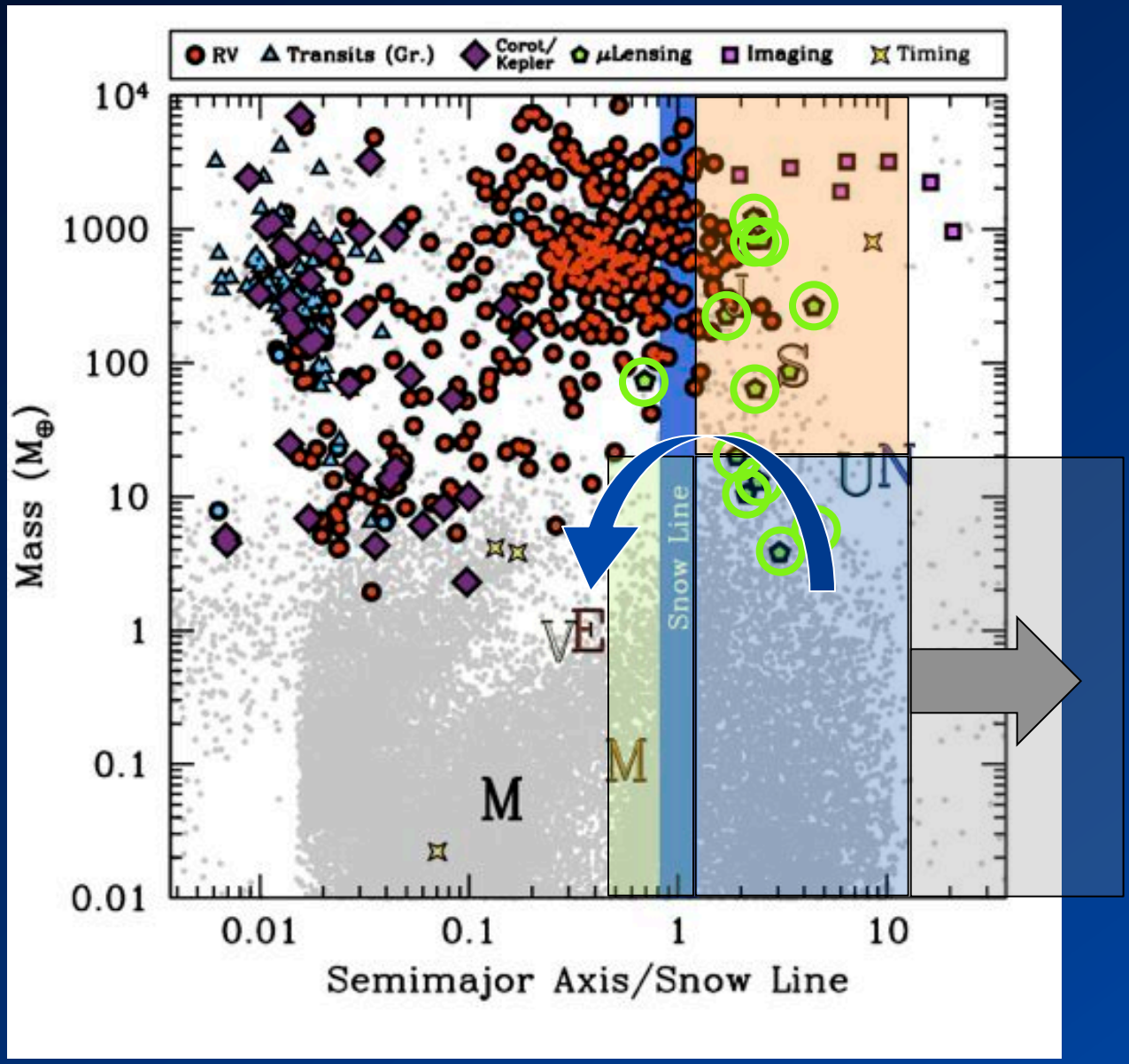
# *Kepler* is revolutionizing our understanding of exoplanets here!



# Detecting Planets with Microlensing

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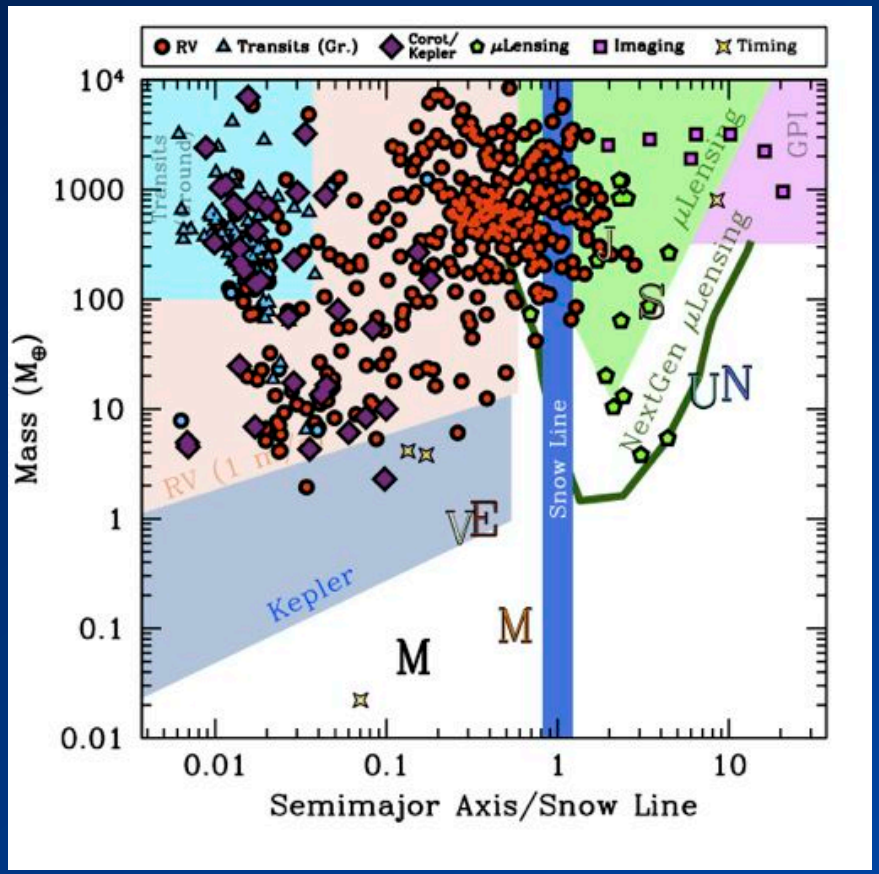
# Ground-based Surveys.

- Ground-based surveys only sensitive to masses greater than ~$M_{earth}$.
- Narrow range near near peak sensitivity, roughly 1-4 times the snow line.
- Only sensitive to giant free-floating planets.

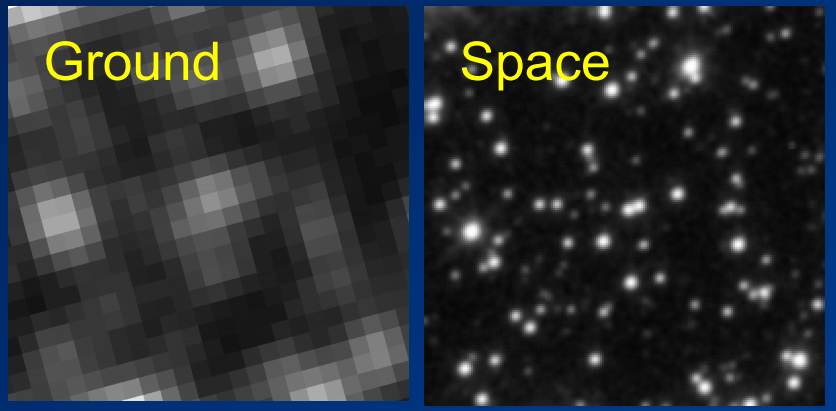


# Earth Mass and Below?

- Monitor hundreds of millions of bulge stars continuously on a time scale of ~10 minutes.
  - Event rate ~$10^{-5}$/year/star.
  - Detection probability ~0.1-1%.
  - Shortest features are ~30 minutes.
- Relative photometry of a few %.
  - Deviations are few – 10%.
- Main sequence source stars for smallest planets.
- Masses: resolve background stars for primary mass determinations.

# Ground vs. Space.

- Infrared.
  - More extincted fields.
  - Smaller sources.
- Resolution.
  - Low-magnification events.
  - Isolate light from the lens star.
- Visibility.
  - Complete coverage.
- Smaller systematics.
  - Better characterization.
  - Robust quantification of sensitivities.

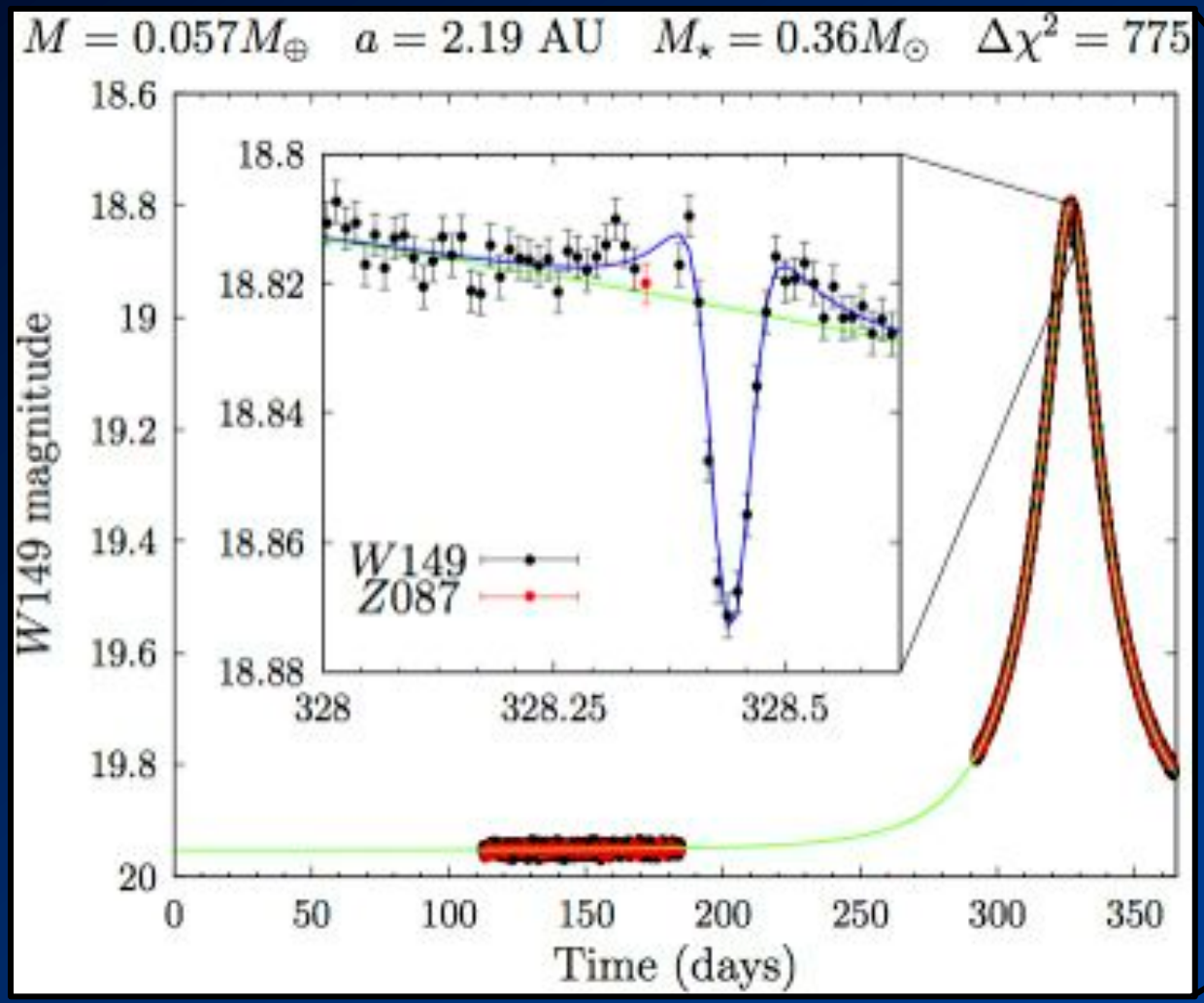


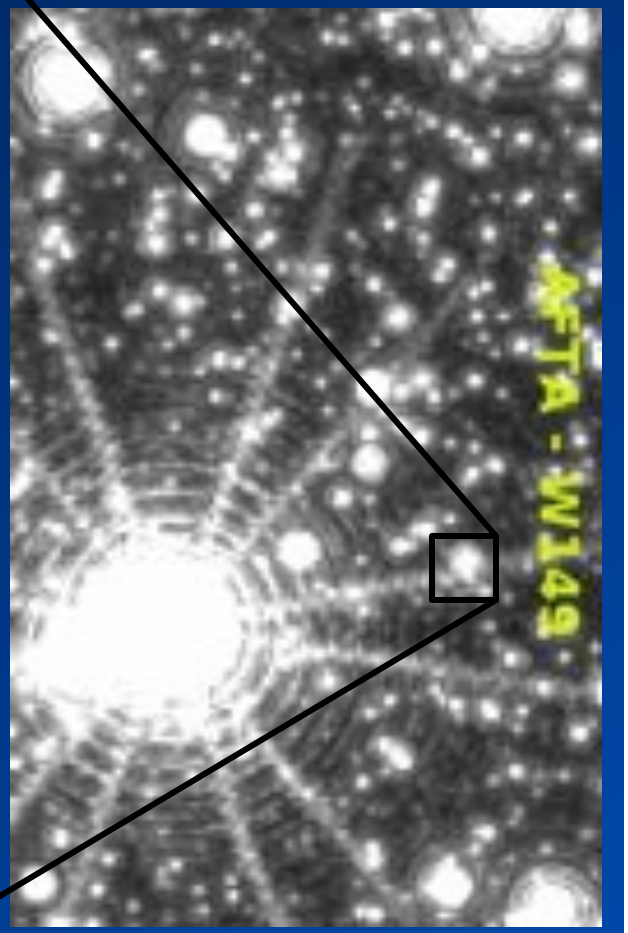

The field of microlensing event
MACHO 96-BLG-5
(Bennett & Rhie 2002)

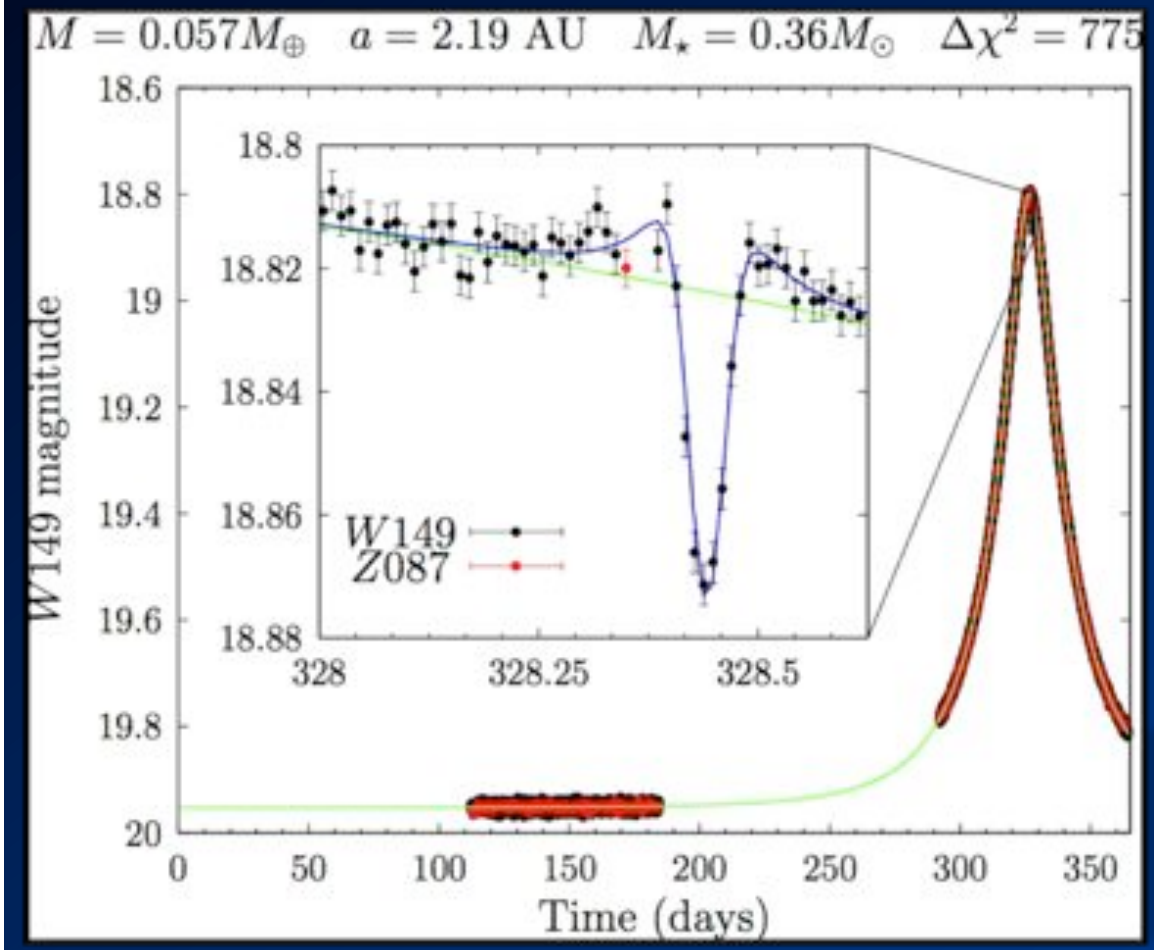
Science enabled from space: sub-Earth mass planets, habitable zone planets, free-floating Earth-mass planets, mass measurements.

# Microlensing Simulations.

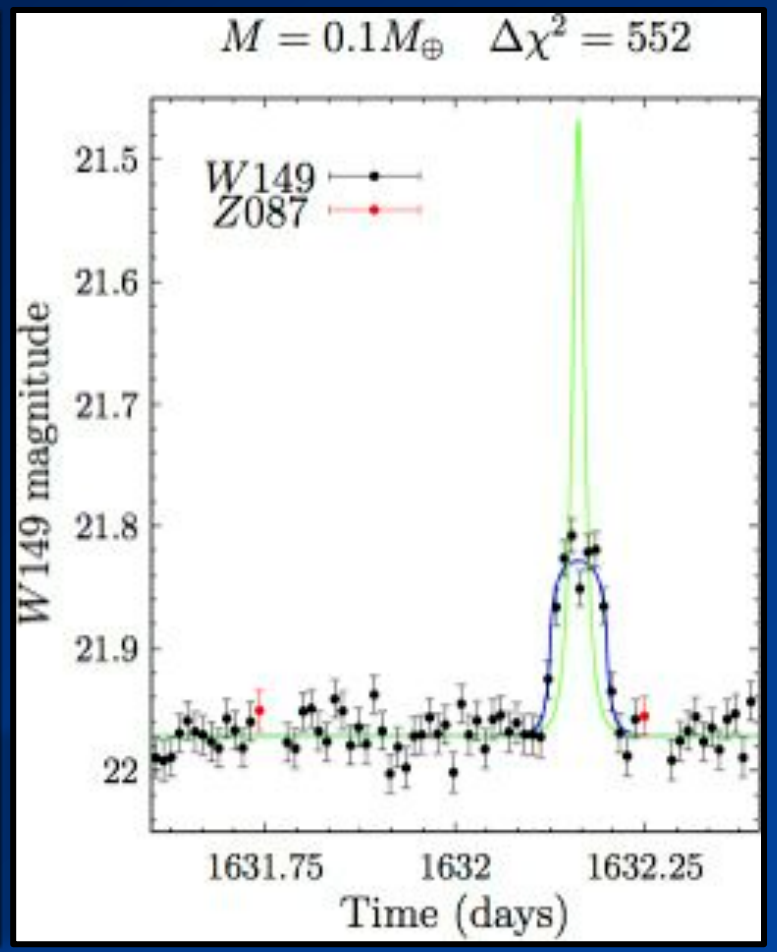
**(Matthew Penny)**






**Mercury @ 2.2 AU**
**(~28 sigma)**




**Free floating Mars**
**(~23 sigma)**

# Predicted Planet Yields.

Bound

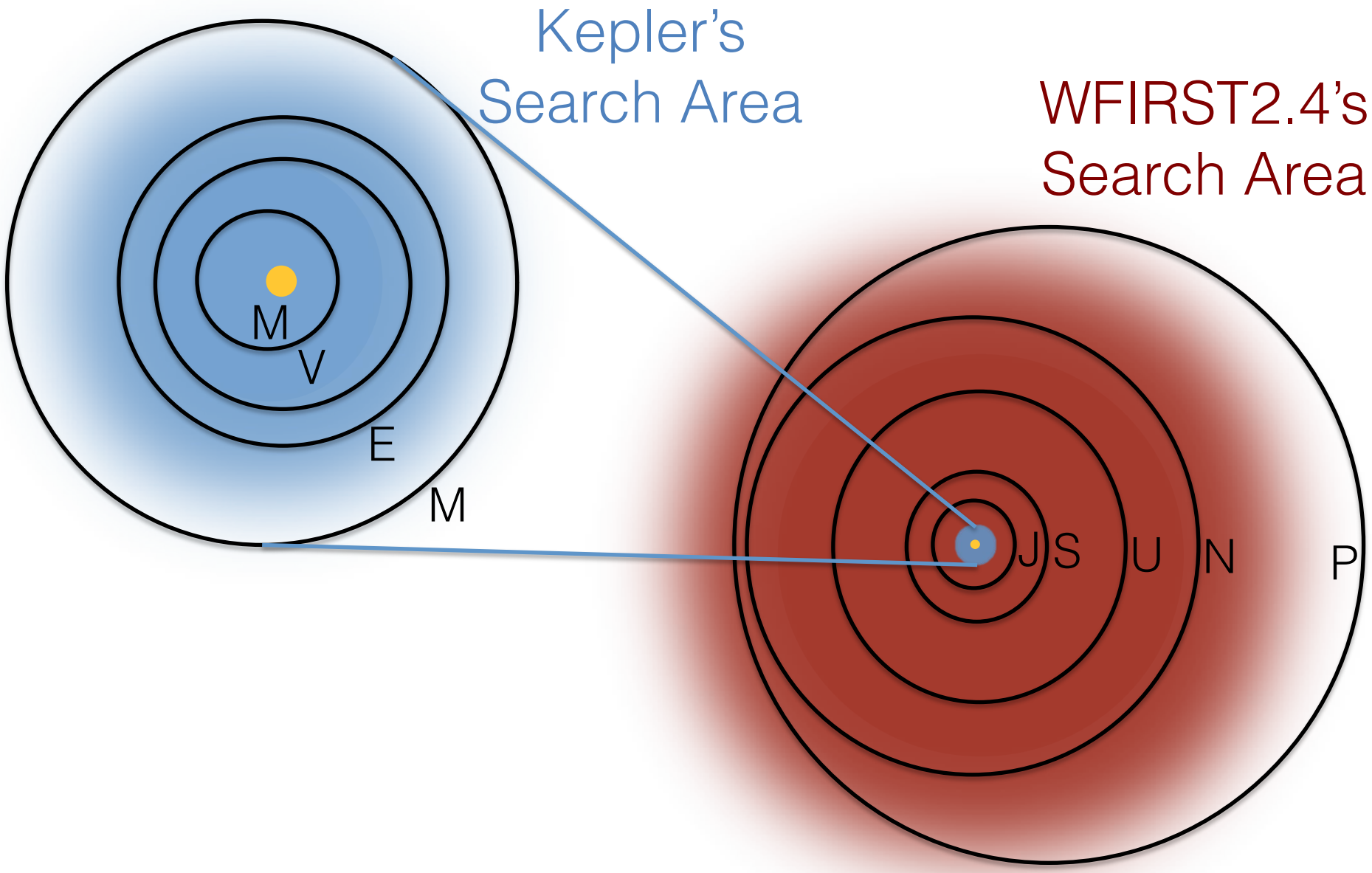
| $M/M_{Earth}$ | Euclid | DRM1 | AFTA-WFIRST |
|---|---|---|---|
| 0.1 | 10 | 30 | 39 |
| 1 | 66 | 239 | 301 |
| 10 | 197 | 794 | 995 |
| 100 | 144 | 630 | 791 |
| 1000 | 88 | 367 | 460 |
| 10,000 | 41 | 160 | 201 |
| Total | 546 | 2221 | 2787 |

F.F. Earth

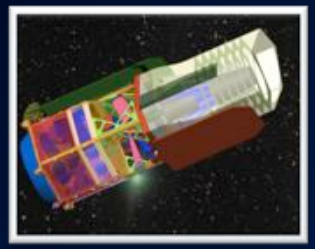
| Euclid | DRM1 | WFIRST-2.4 |
|---|---|---|
| 5 | 33 | 41 |

All yields by Matthew Penny.

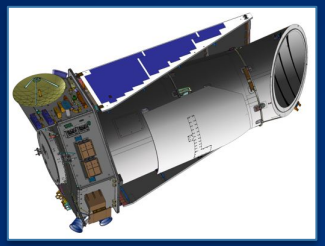
# Achieving a Census of Planets with WFIRST2.4



# Exoplanet Demographics with WIFRST.

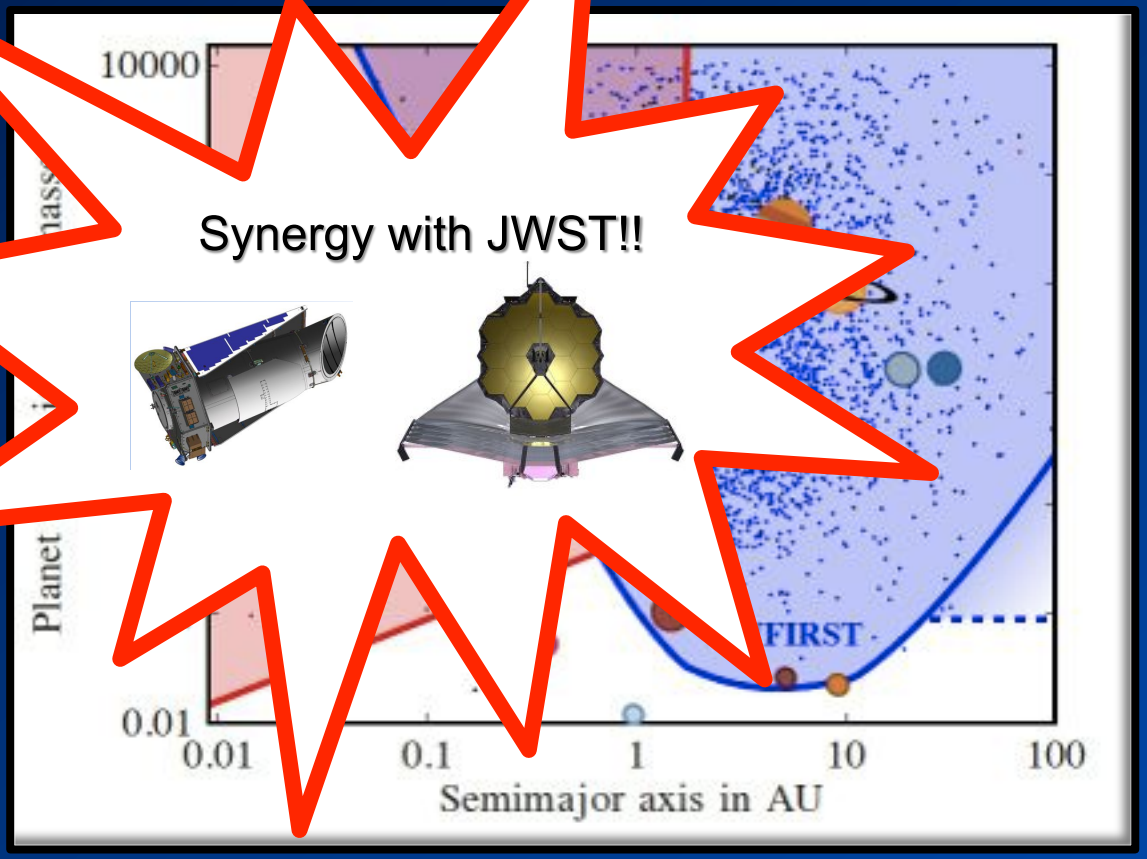


Together, Kepler and WFIRST complete the statistical census of planetary systems in the Galaxy.



WFIRST will:

- Detect 2800 planets, with orbits from the habitable zone outward, and masses down to a few times the mass of the Moon.
- Have some sensitivity to "outer" habitable zone planets (Mars-like orbits).
- Be sensitive to analogs of all the solar systems planets except Mercury.
- Measure the abundance of free-floating planets in the Galaxy with masses down to the mass of Mars
- Characterize the majority of host systems.



# To Do.

- HST imaging of target fields.
- Spitzer/Kepler monitoring of microlensing events.
- HST follow-up of planet detections.
- H-band ground-based microlensing survey.
- Manpower!

# Summary.

- The demographics of planets beyond the snow line provides crucial constraints on planet formation theories and habitability.
- AFTA-WFIRST enables qualitatively new, exciting science: sub-Earth-mass planets, free-floating planets, outer habitable zone planets, mass measurements.
- AFTA-WIFRST will complete the census begun by *Kepler*, and will revolutionize our understanding of cold planets.
- But, lots to do!

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| 0.1 | 10 | 30 | 21 | 39 |
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