Completing the Census of Exoplanets with WFIRST.

Wide-Field Infrared Survey Telescope
WFIRST
Astrophysics • Dark Energy • Exoplanets

AAS 229
WFIRST Status and Science Opportunities
January 5, 2017

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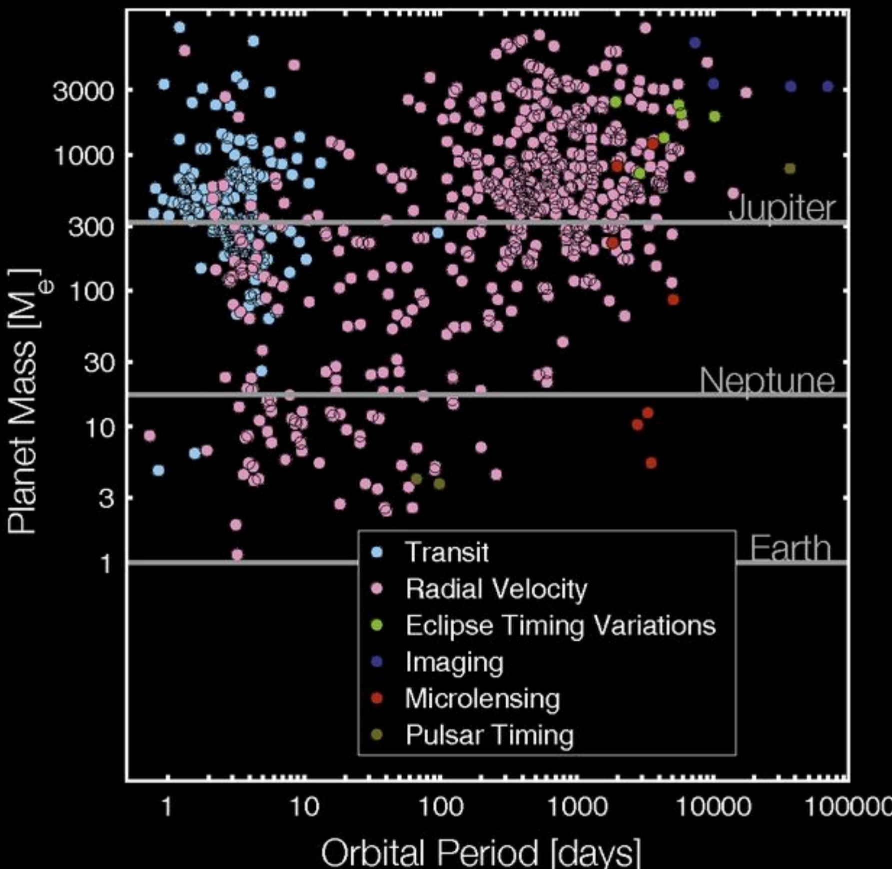
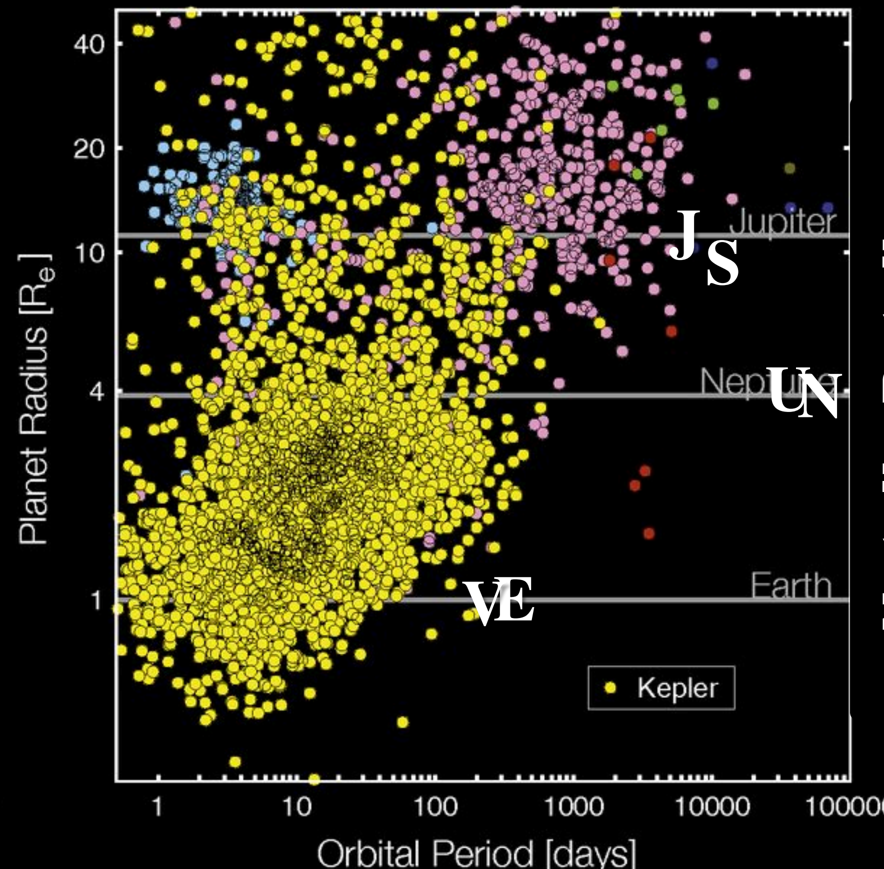
The Ohio State University

(with the WFIRST SDTs and on behalf of the WFIRST Microlensing SIT)

A Complete Exoplanet Census.

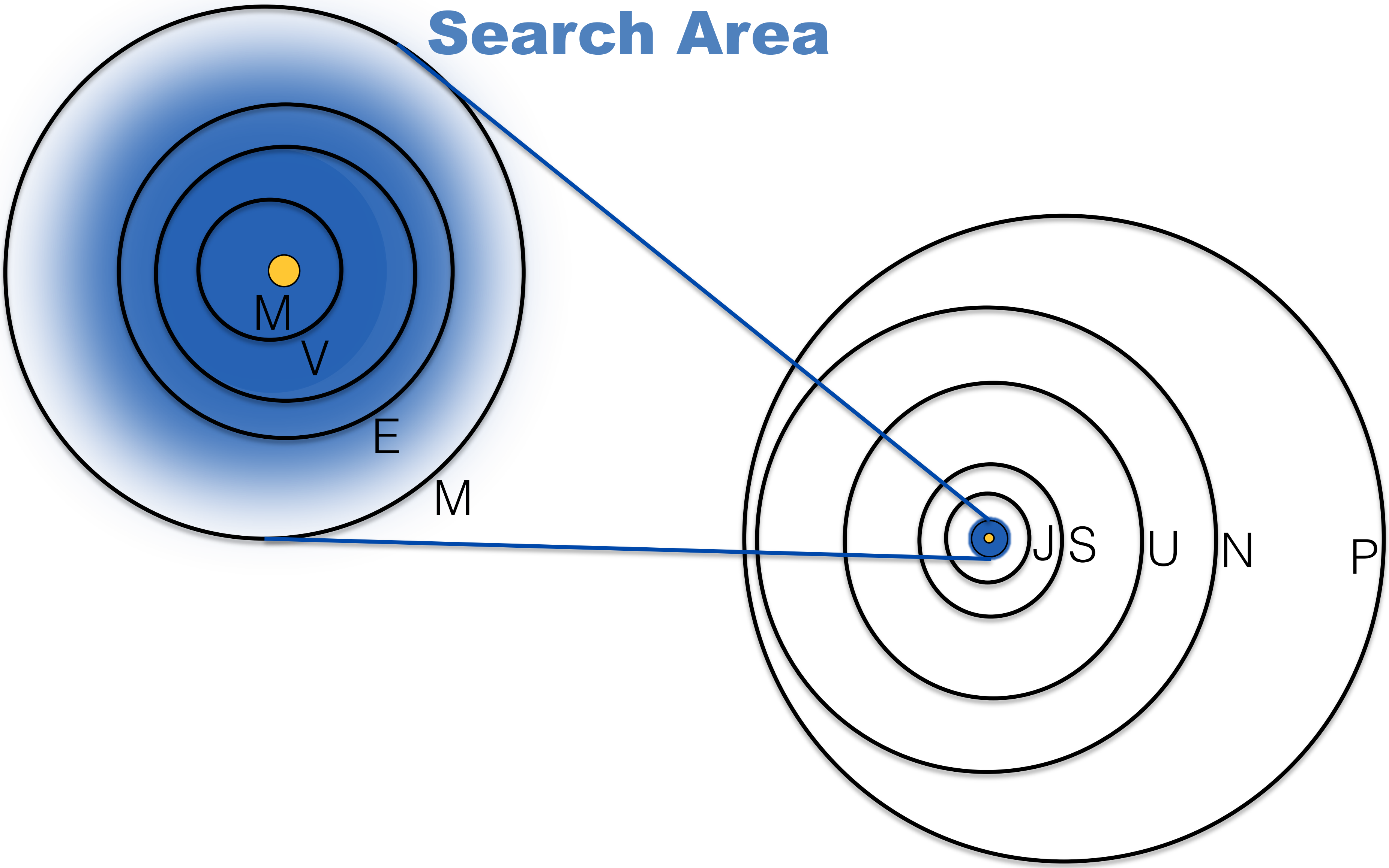




Natalie Batalha

~2950 Confirmed Planets
~2504 Planet Candidates

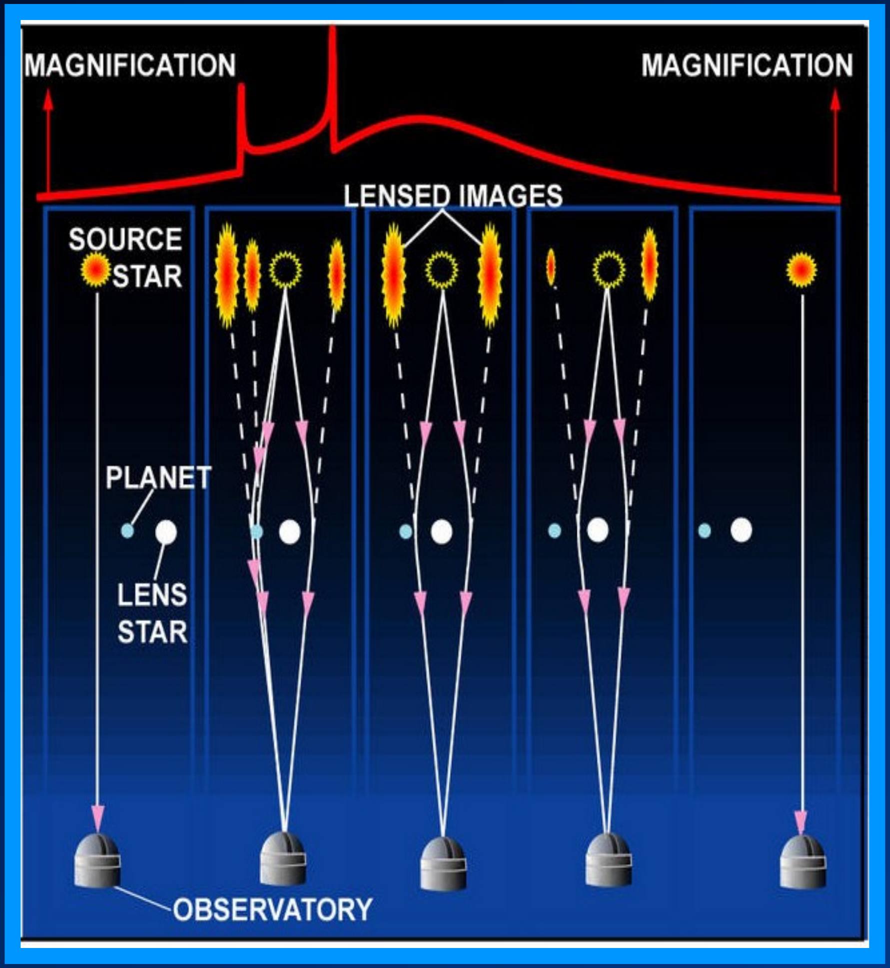
Kepler's Search Area

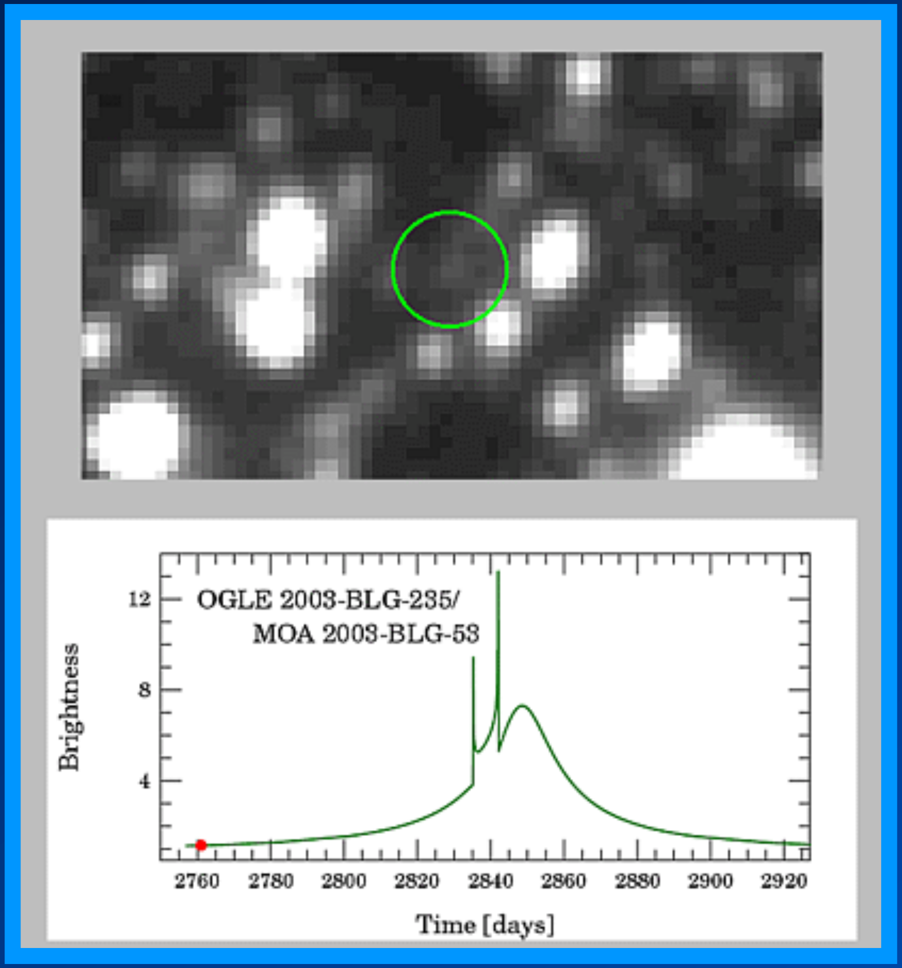


Why complete the census?

- A complete census is likely needed to understand planet formation and evolution.
  - Most giant planets likely formed beyond the snow line.
  - Place our solar system in context.
  - Water for habitable planets likely delivered from beyond the snow line.
- Mother nature is more imaginative that we are.

Microlensing.



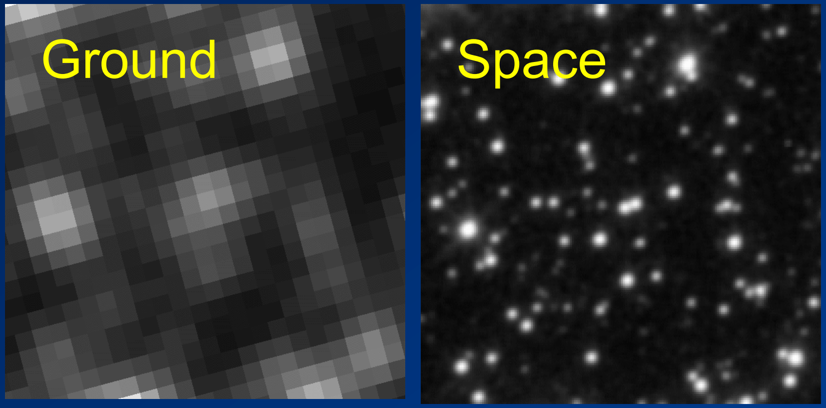


Earth Mass and Below?

- 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%.
- Resolve 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.

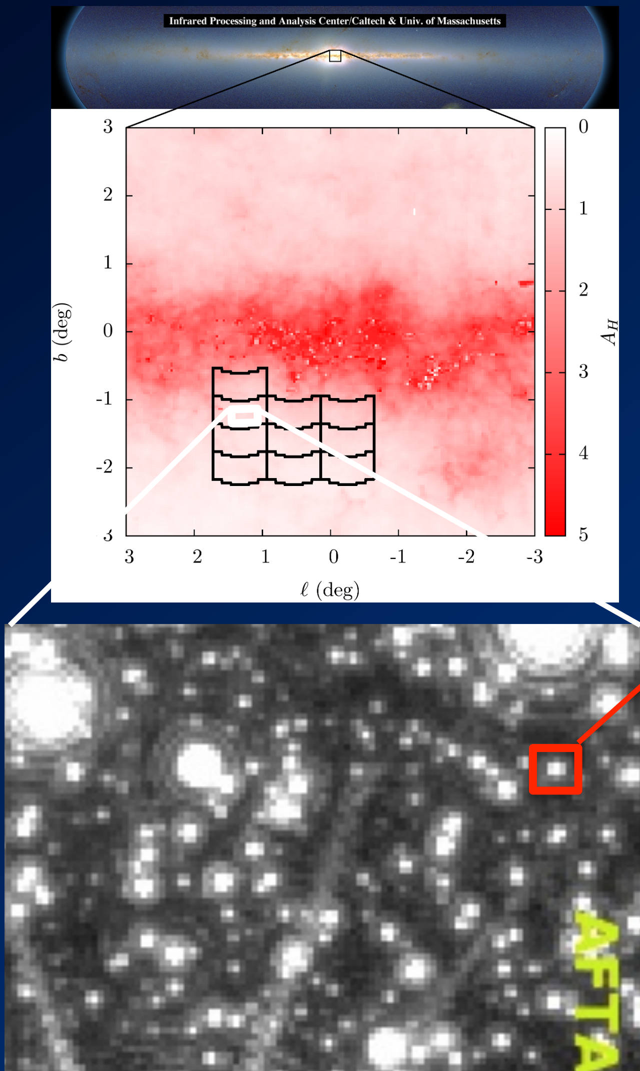


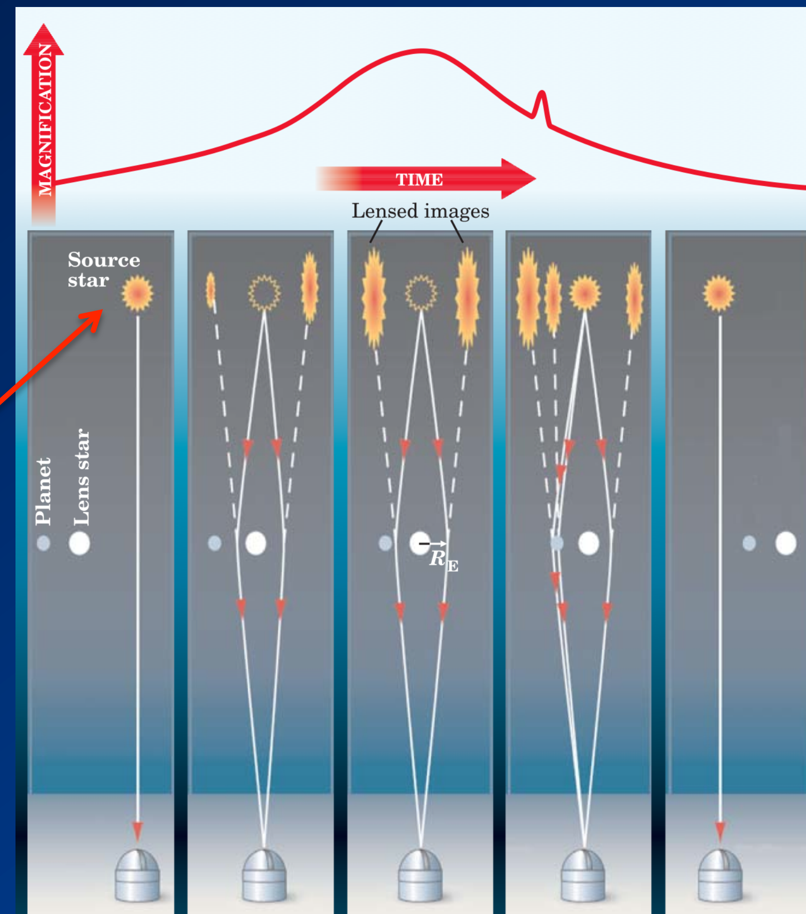
The field of microlensing event MACHO 96-BLG-5 (Bennett & Rhie 2002)

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

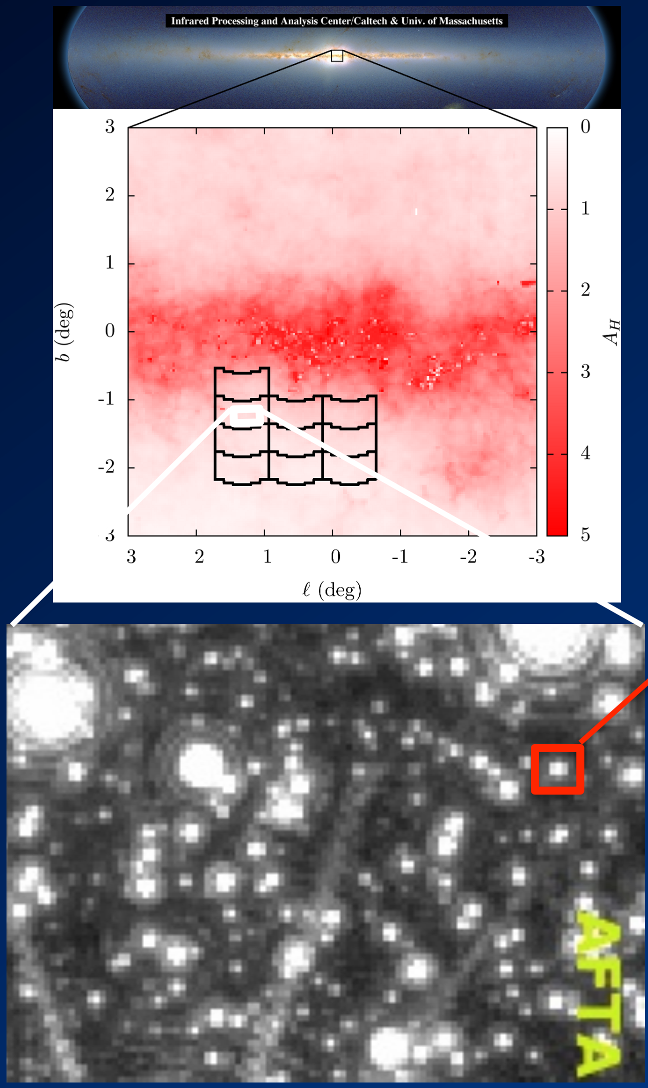
WFIRST.

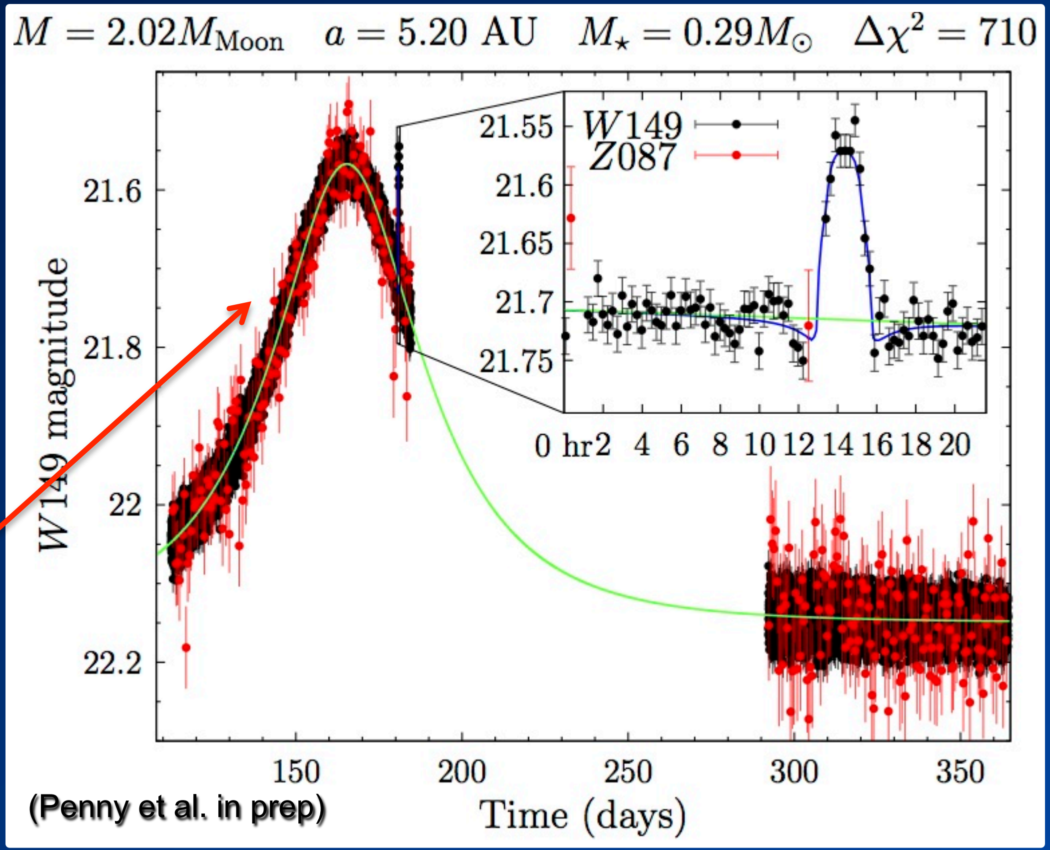
Microlensing Simulations.
(Matthew Penny)

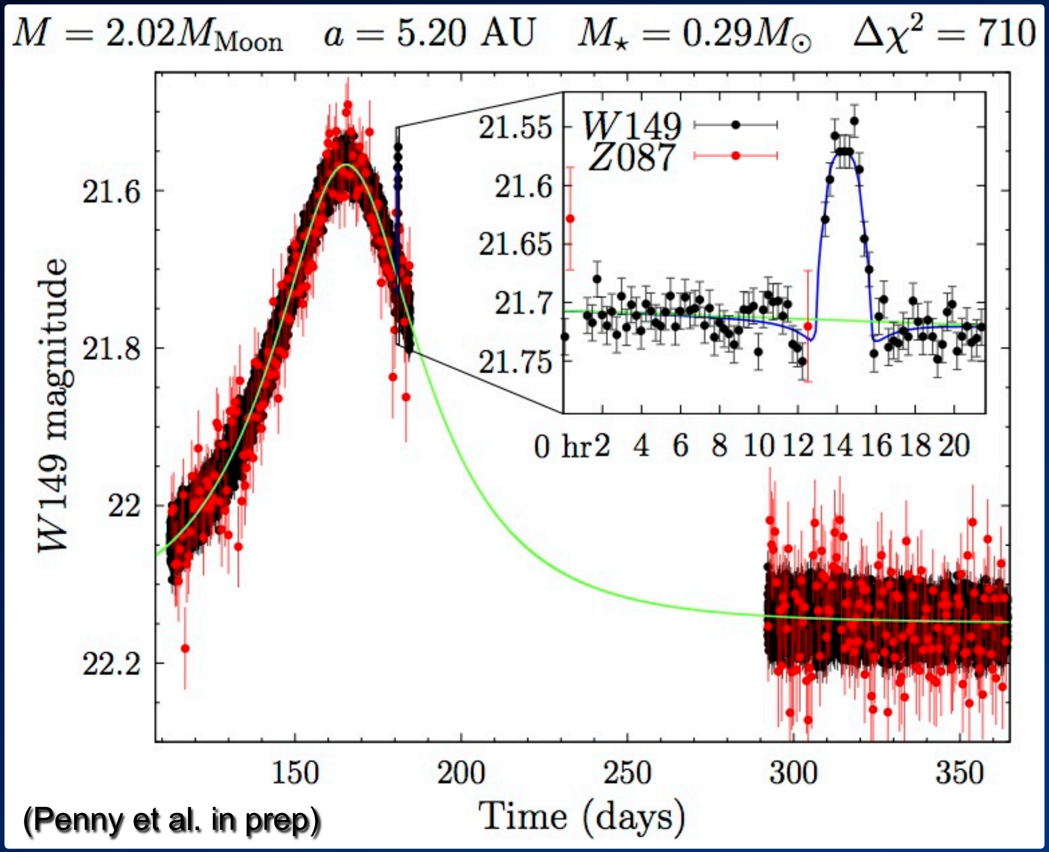


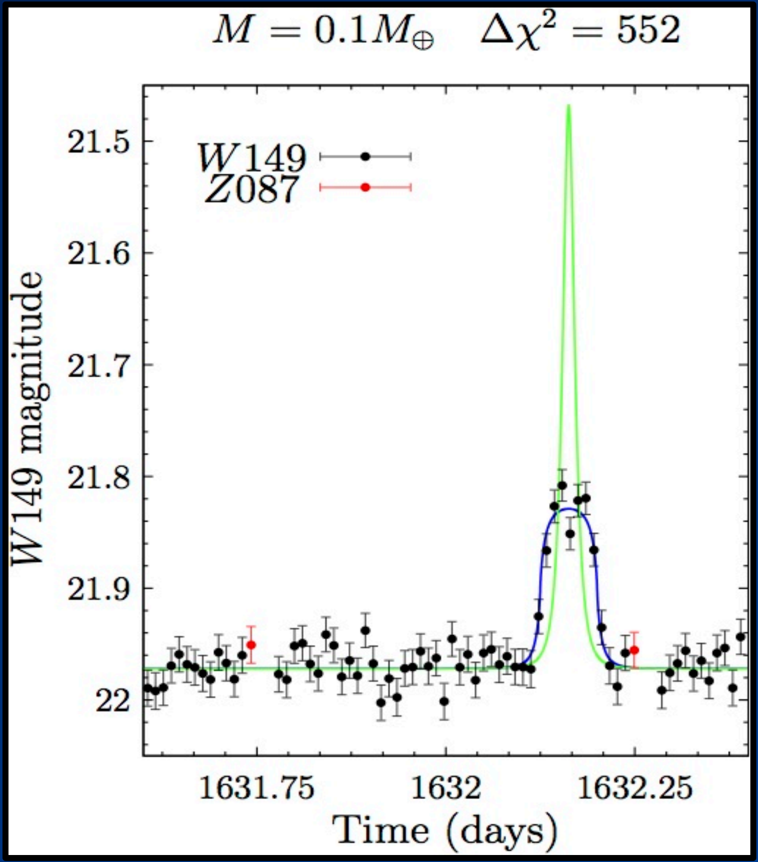


Microlensing Simulations.
(Matthew Penny)



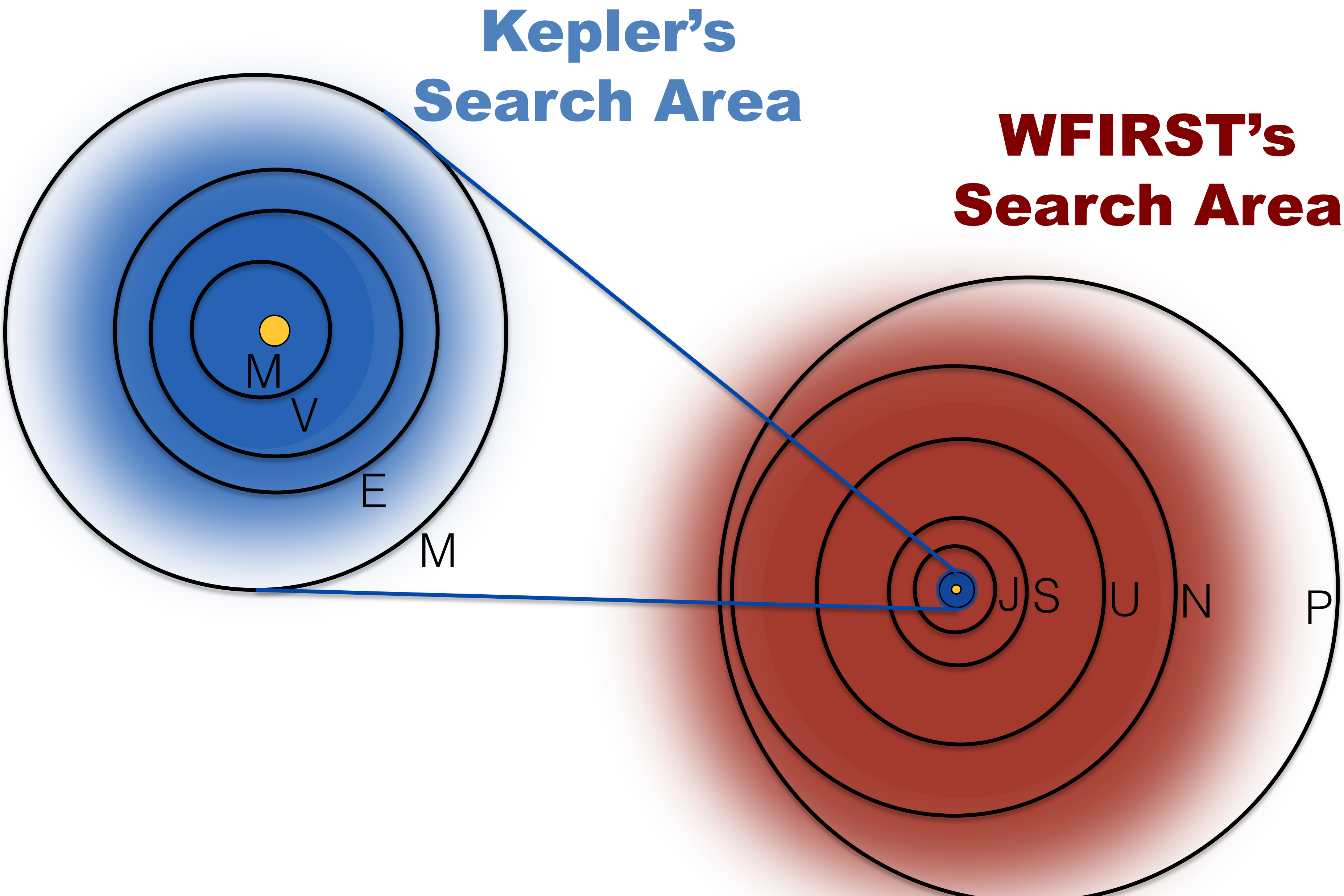


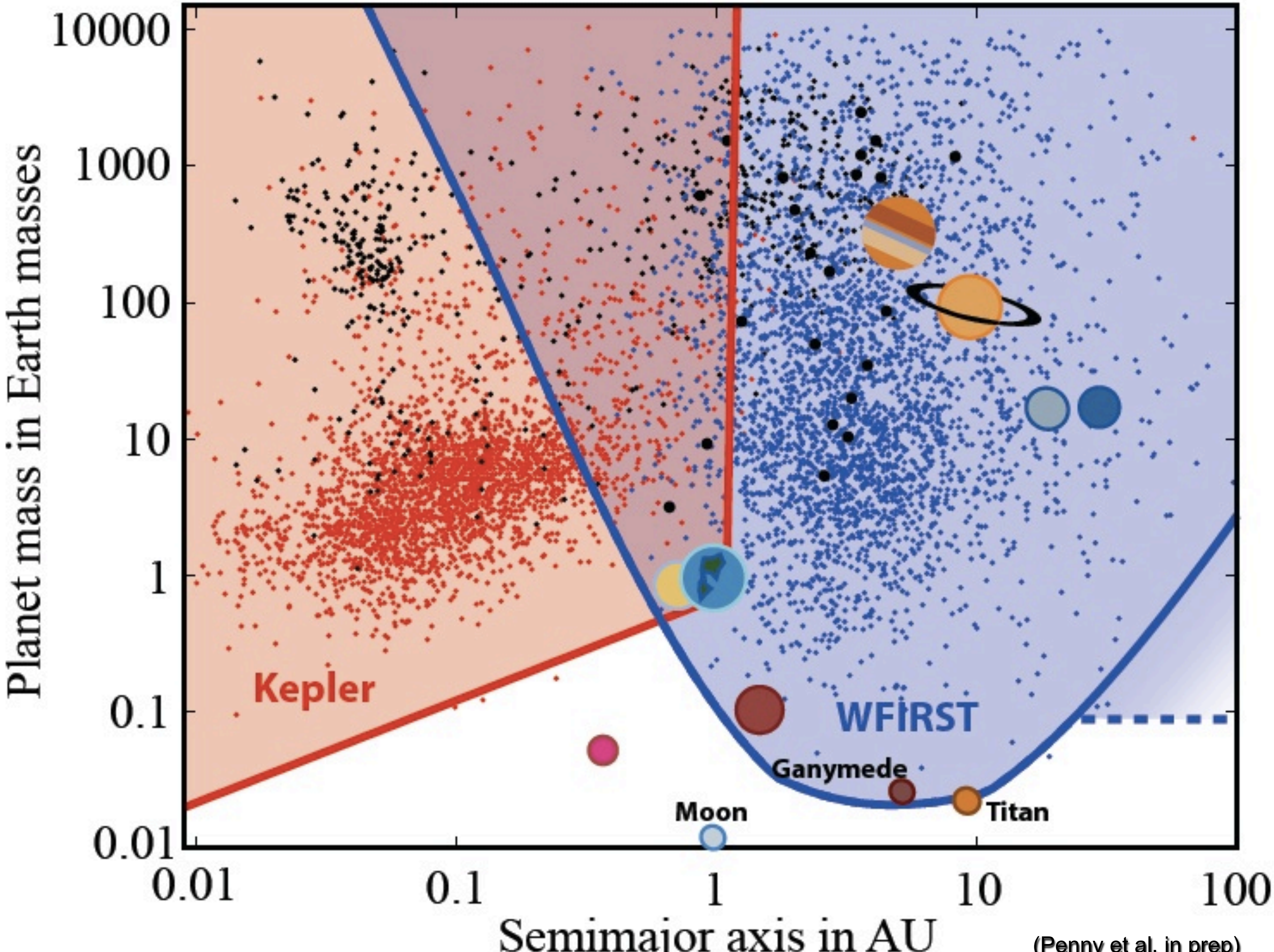




2 × Mass of the Moon @ 5.2 AU (~27 sigma)

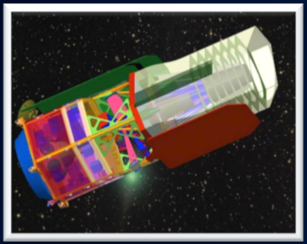
Free floating Mars (~23 sigma)


Kepler's
Search Area
WFIRST's
Search Area
M
V
E
M
J
S
U
N
P

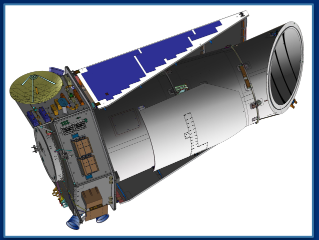


(Penny et al. in prep)

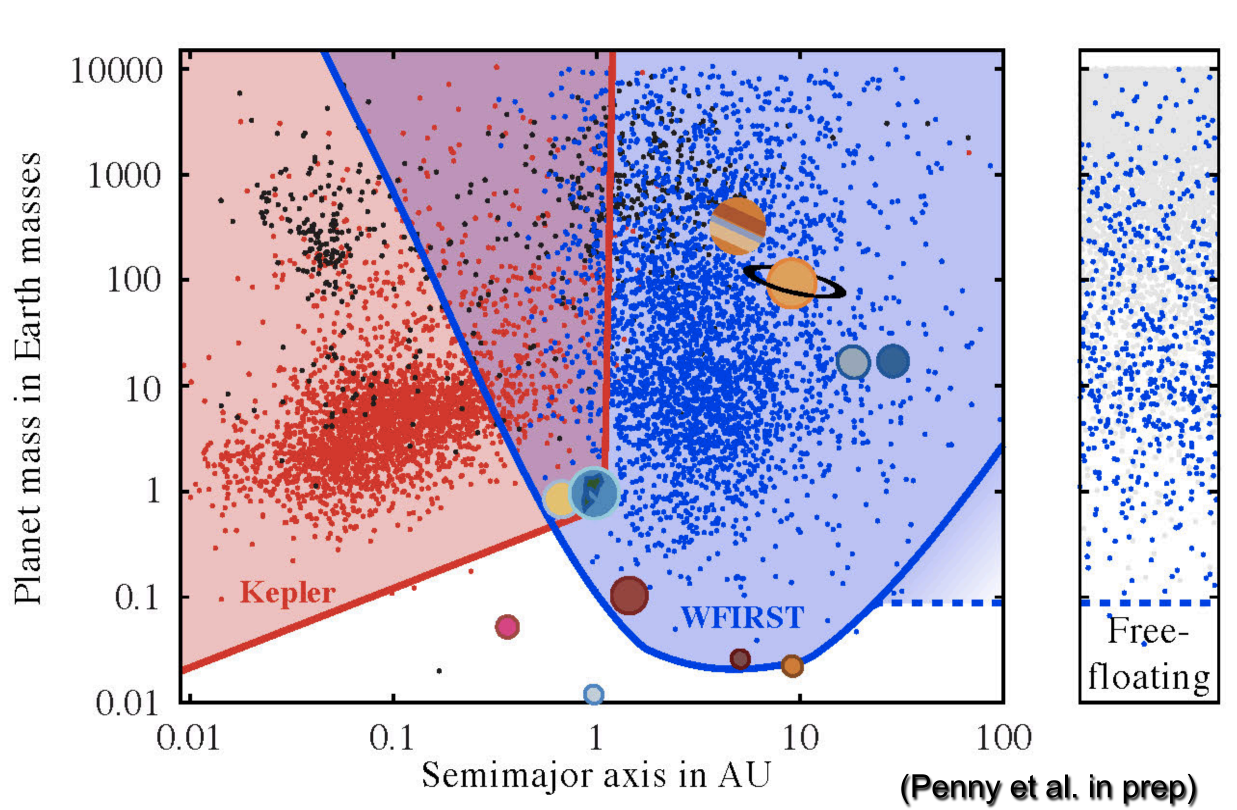
Completing the Exoplanet Census.



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

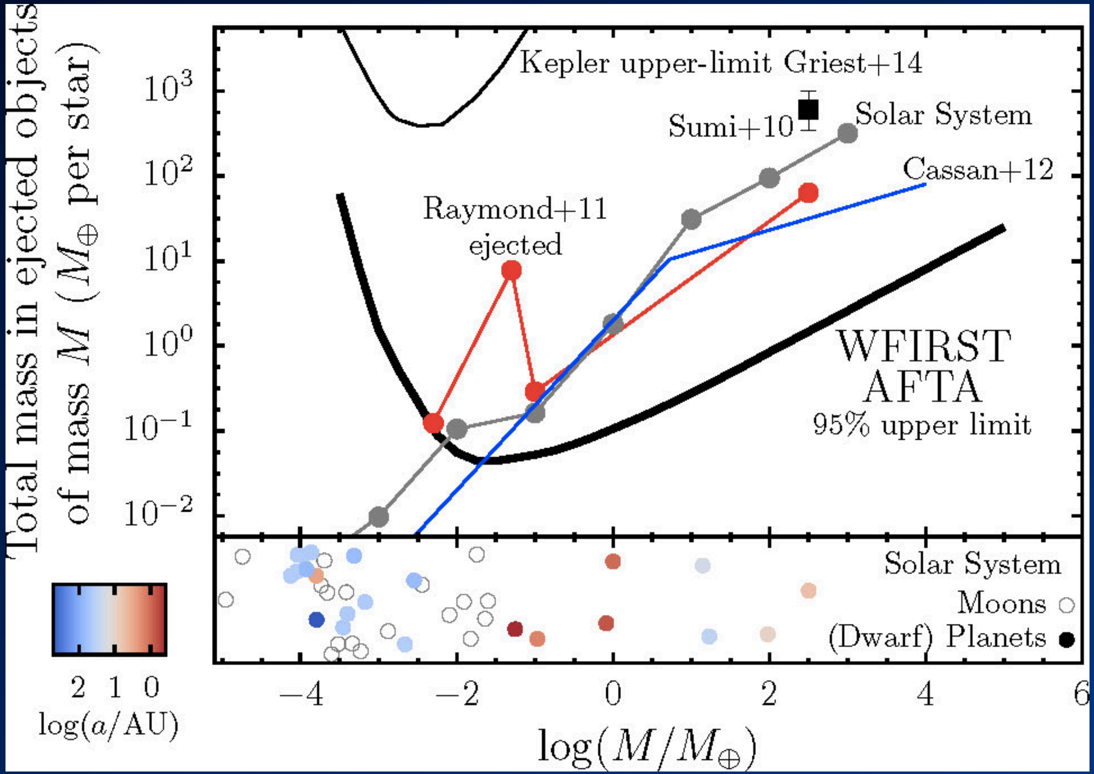


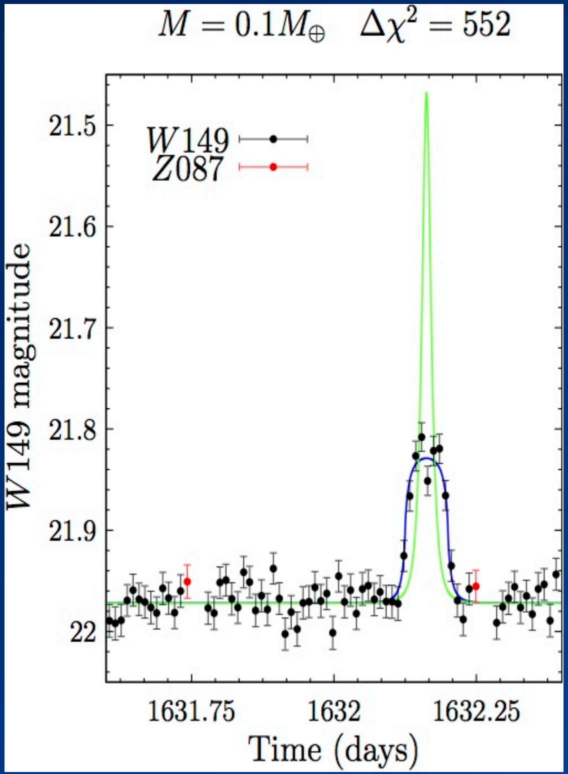
- ~1500 detections.
- Some sensitivity to “outer” habitable zone planets.
- Sensitive to analogs of all the solar systems planets except Mercury.
- Hundreds of free-floating planets.
- Characterize the majority of host systems.
- Galactic distribution of planets.
- Sensitive to lunar-mass satellites.
- 10^5 Transiting Planets.



(Penny et al. in prep)

Free Floating* Planets.





(Penny et al., in prep)

WFIRST-AFTA will measure the compact object mass function over at least 8 orders of magnitude in mass (from Mars to ~30 solar masses).

*Also known as “Rogue Planets”, “Solivagant Planets”, or “Nomads”.

To Do.

- Lots!
  - Improve our understanding of microlensing event rates:
    - Refine Galactic models.
    - Near-IR microlensing survey.
    - Near-IR luminosity function.
    - Measure the Galactic distribution of planets (Spitzer, K2).
  - Optimize the survey strategy:
    - Field location, number, and cadence.
    - Optimize number and choice of filters.
    - Contemporaneous ground and space-based observations.
  - Determine the precision of the measured event parameters.
  - Determine hardware, software, and calibration requirements.
  - Identify and carry out needed precursor observations.
  - Develop data reduction and analysis tools.
- WFIRST Microlensing Science Investigation Team (PI S. Gaudi, Deputy PI D. Bennett)
- Help!