EXOPLANET CONFIRMATION AND CHARACTERIZATION

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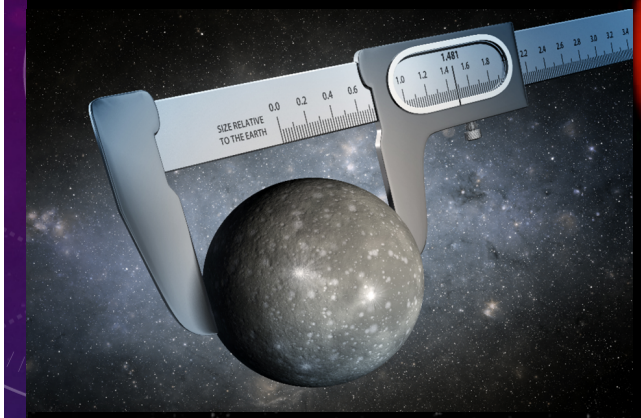
CALTECH/IPAC

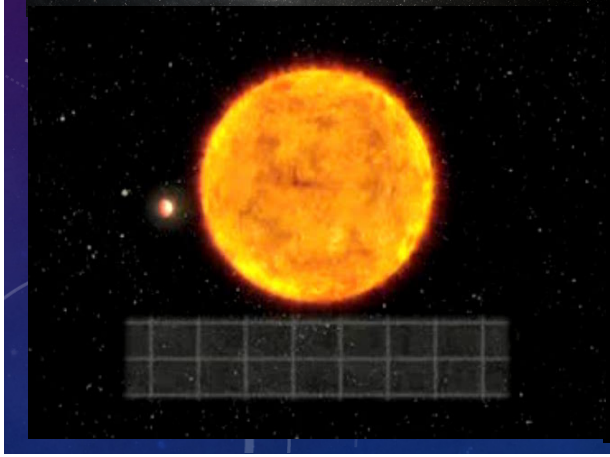
PALOMAR JAMBOREE MEETING

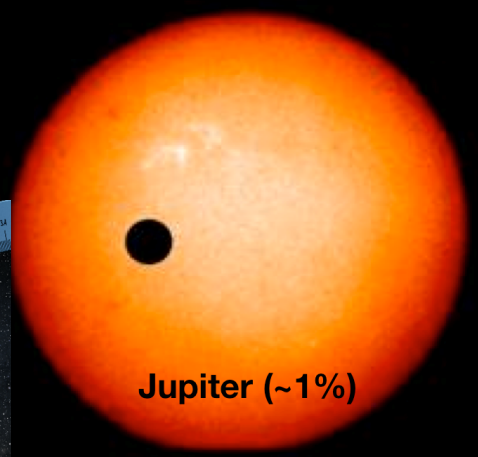
2019-03-28

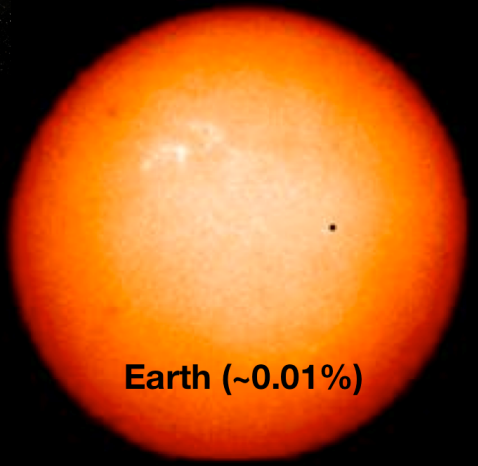
NExScI ipac Caltech

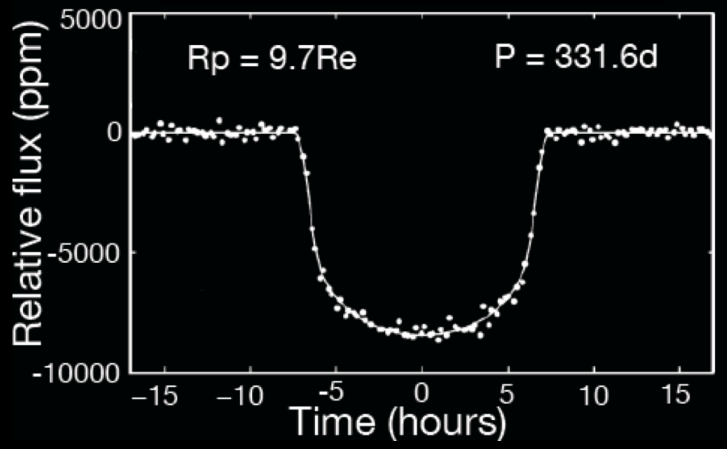
Transits Allow Us to Measure Sizes of Planets

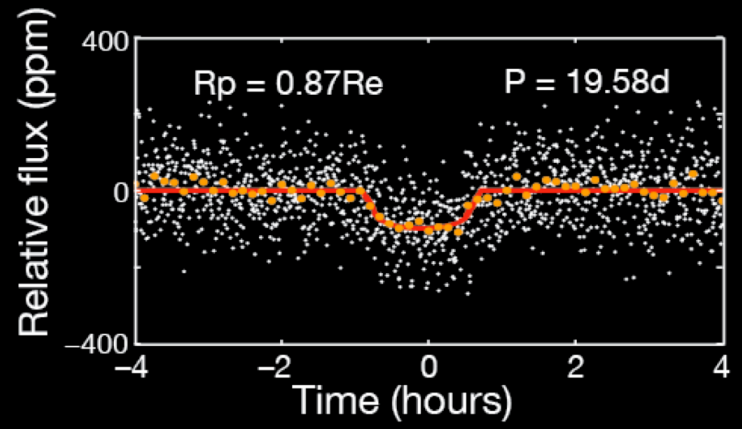




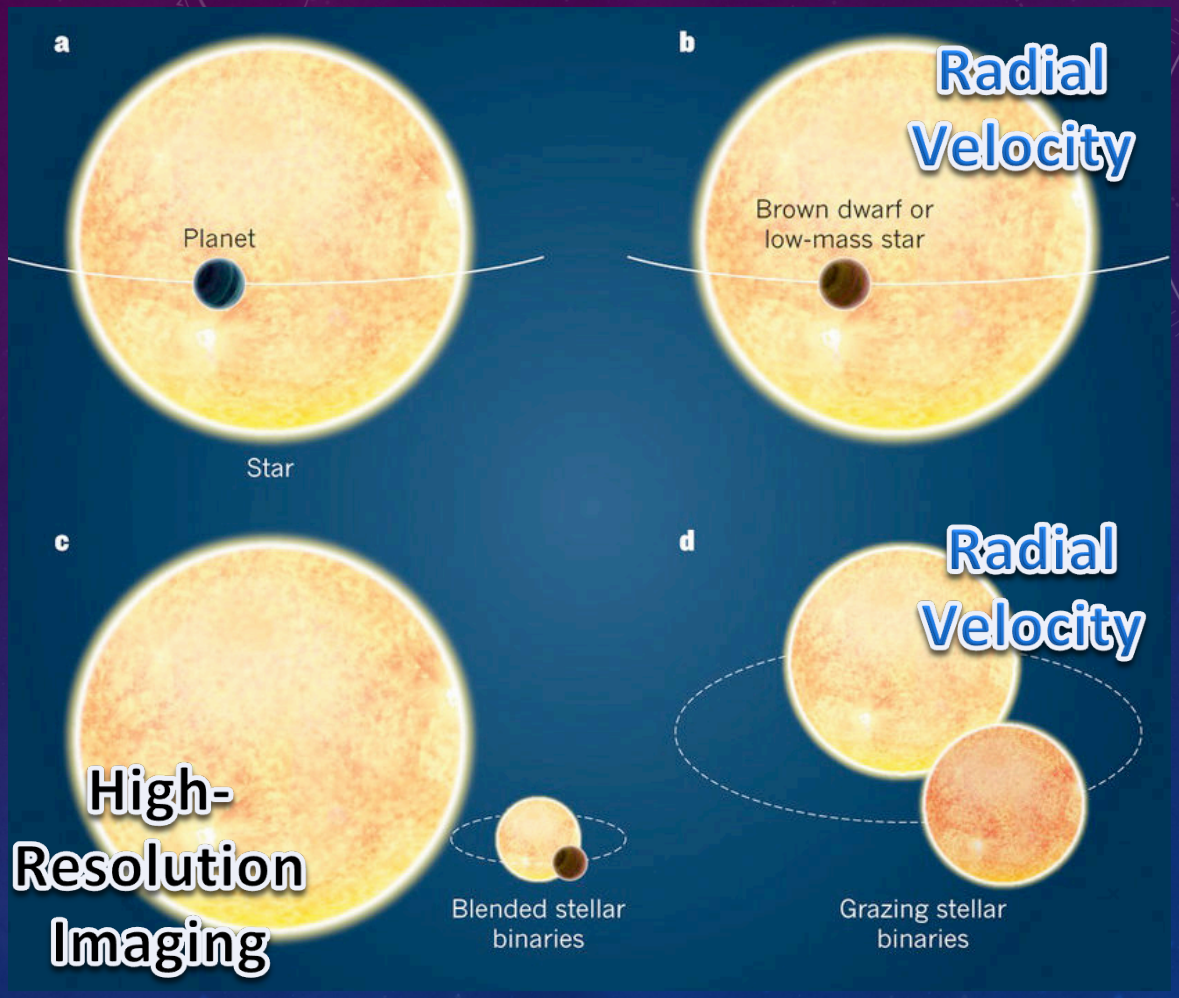








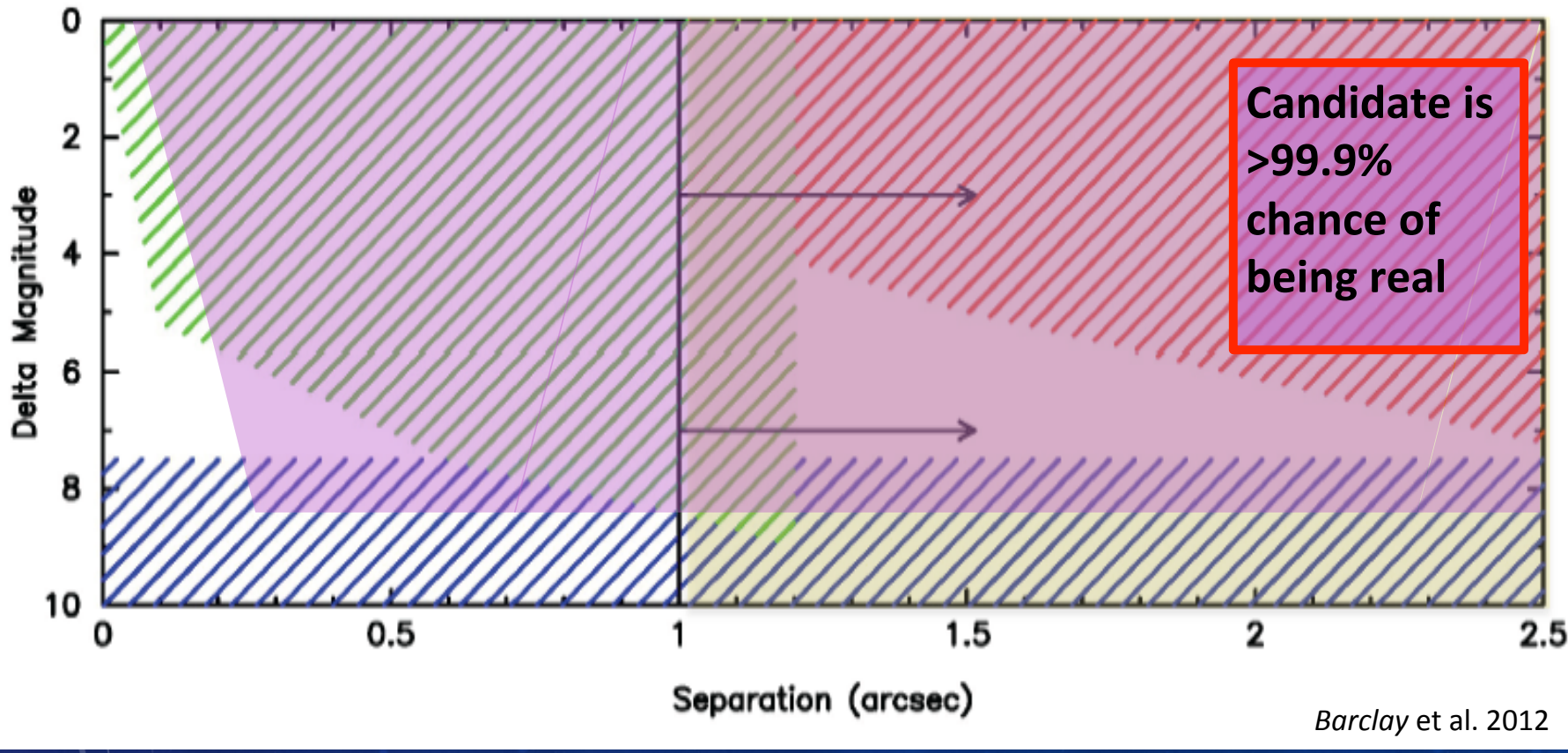
MIMICS


a
Planet
Star
b
Radial Velocity
Brown dwarf or low-mass star
c
High-Resolution Imaging
Blended stellar binaries
d
Radial Velocity
Grazing stellar binaries

VALIDATING THE EXOPLANETS

- Assess the probability that a blended eclipsing binary could be responsible for the observed transit event
- Palomar AO used to validate planets by searching for (and not finding) blended stars

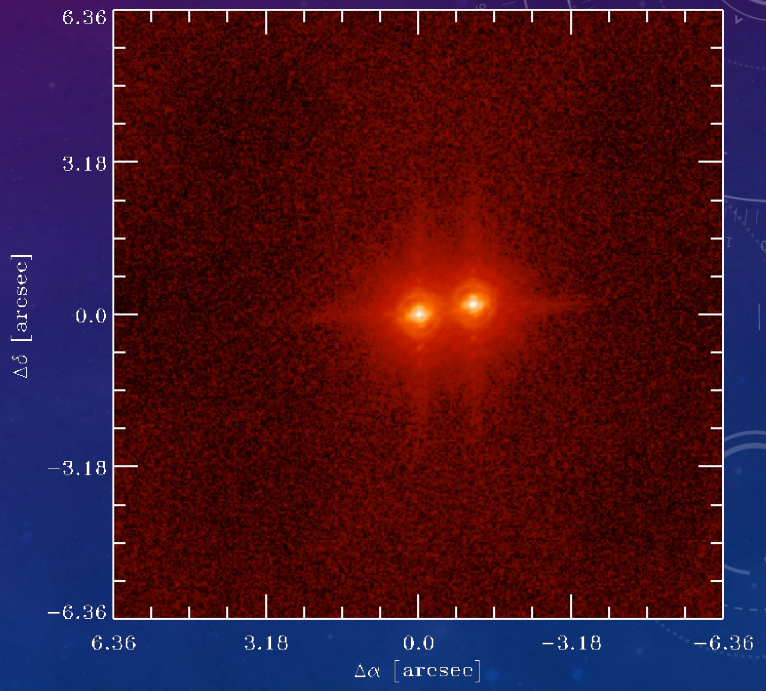
VALIDATING THE EXOPLANETS



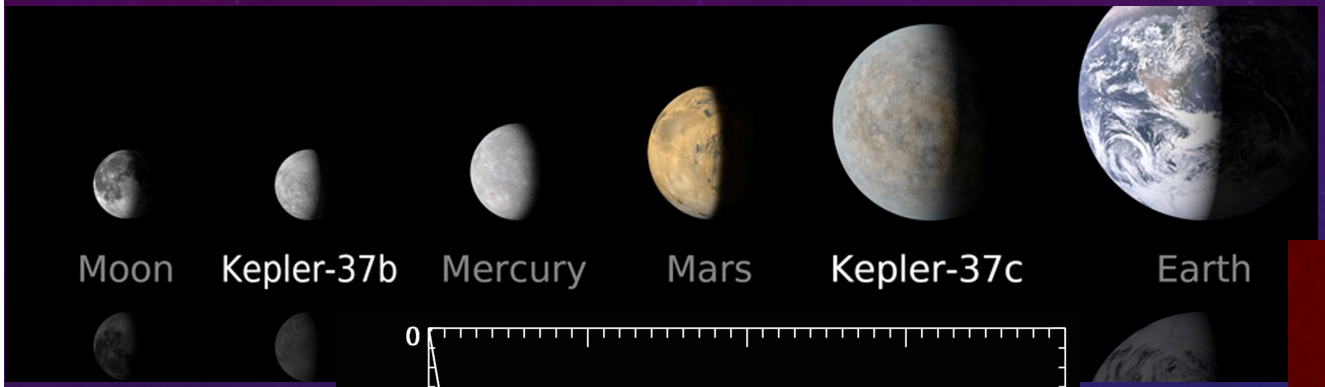
Barclay et al. 2012

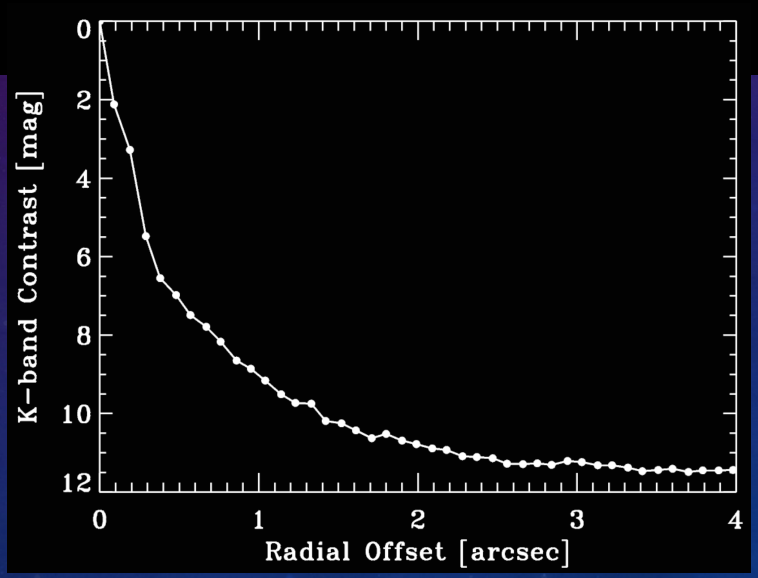
Palomar 200" Has Been A Workhorse

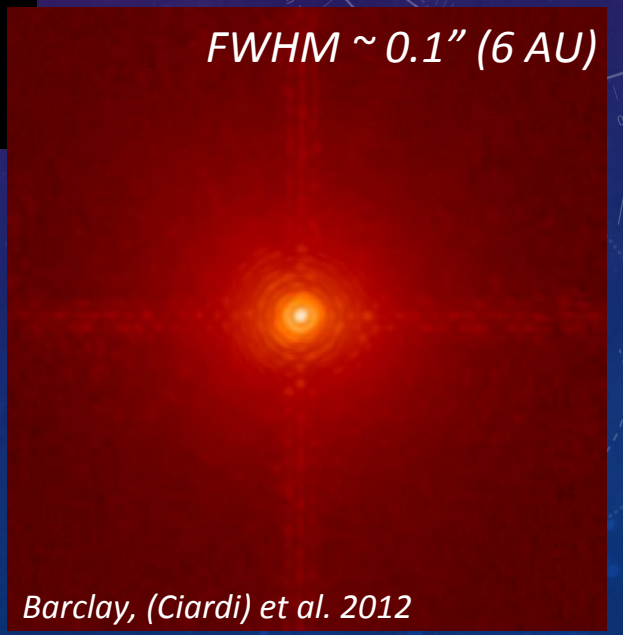
- Cassegrain-mounted near-infrared camera PHARO mounted behind the P3K AO system
  - 25" FOV
  - ~0.1" resolution at 2μm
  - Rmag ≤ 15 mag
- 100+ nights and >1000 stars observed since 2009



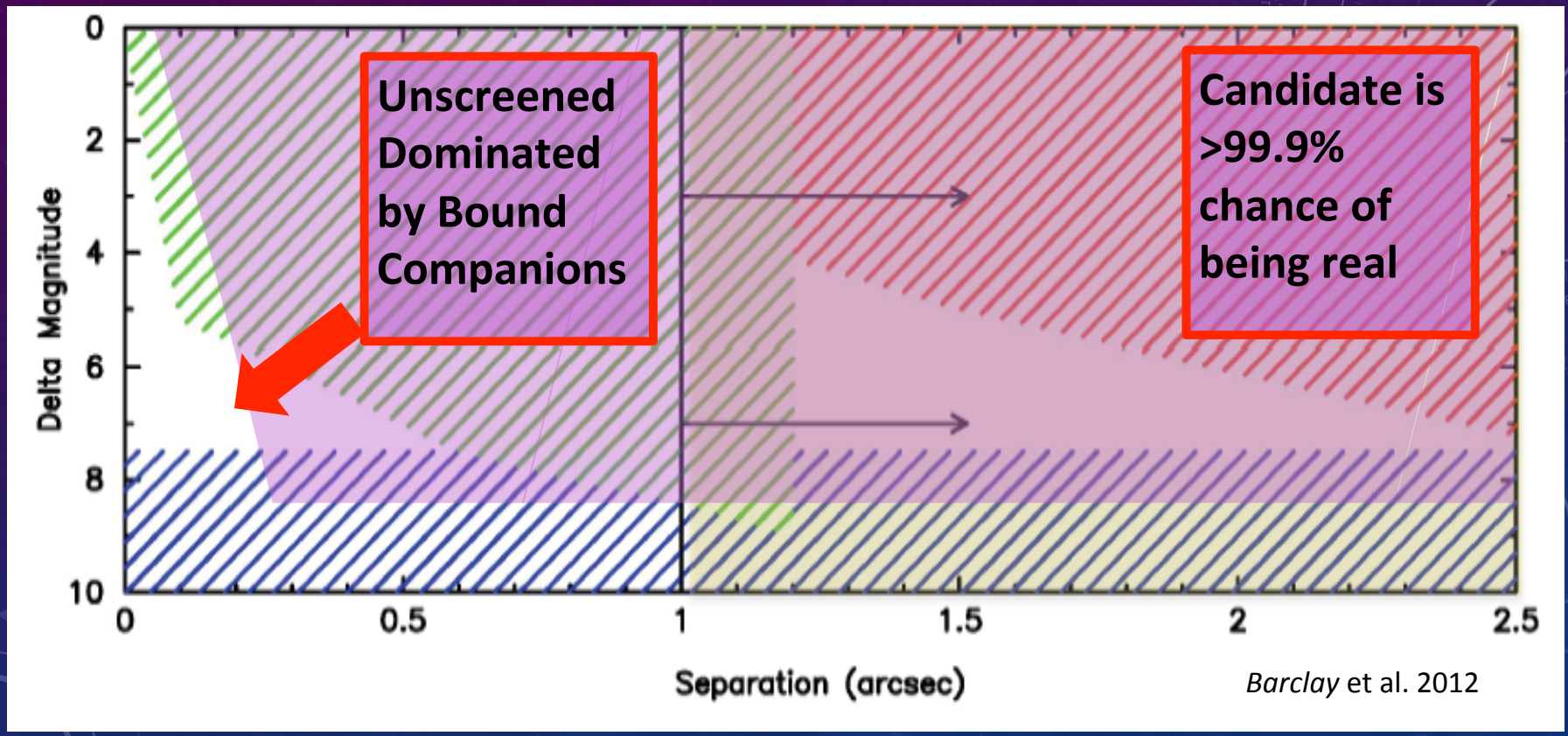
KEPLER-37B: THE SMALLEST EXOPLANET







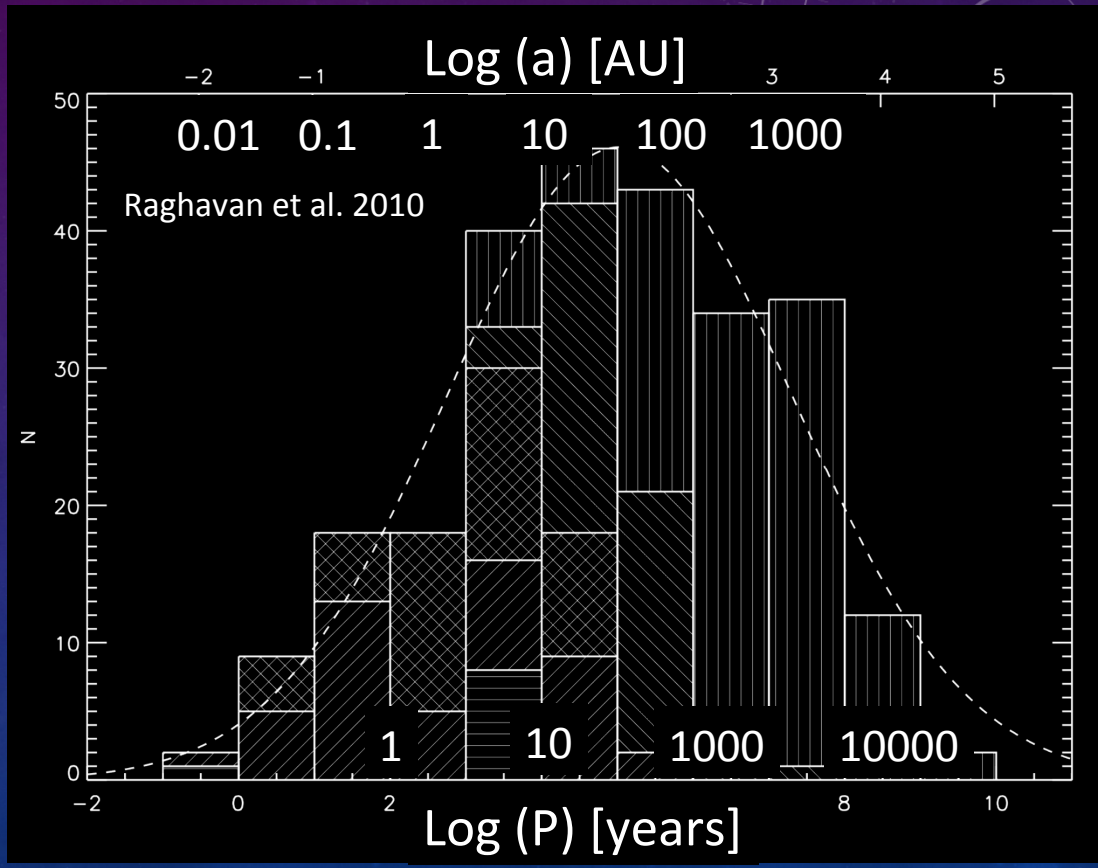
VALIDATING THE EXOPLANETS



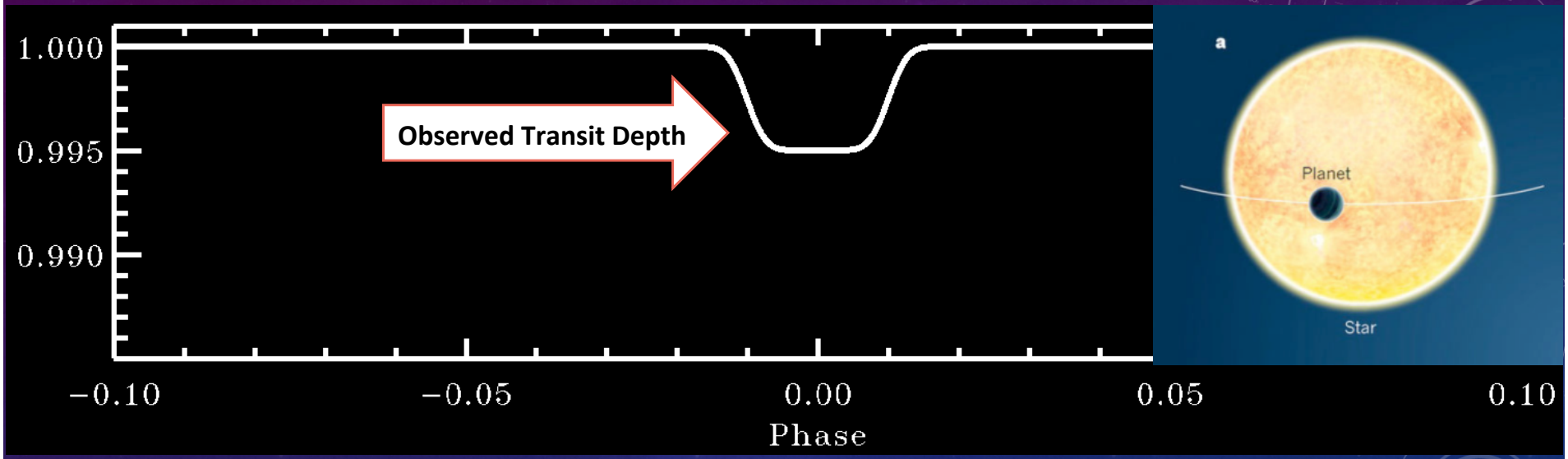
Barclay et al. 2012

Stars Can Have Stellar Companions

- Multiplicity fraction for field stars is 40 – 50%
- Multiplicity fraction may correlate with stellar mass
- Planet host stars may have different companion distributions than the general field stars

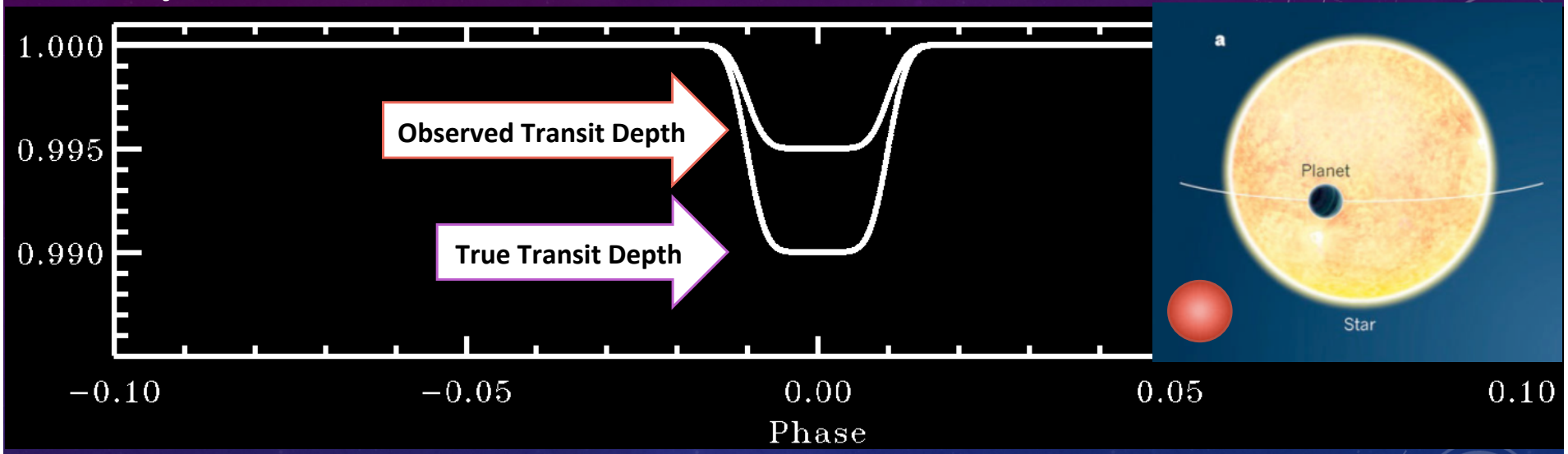


Planet Radii From Transit Depths



$$\delta_o = \left(\frac{R_p}{R_{t\star}}\right)^2$$

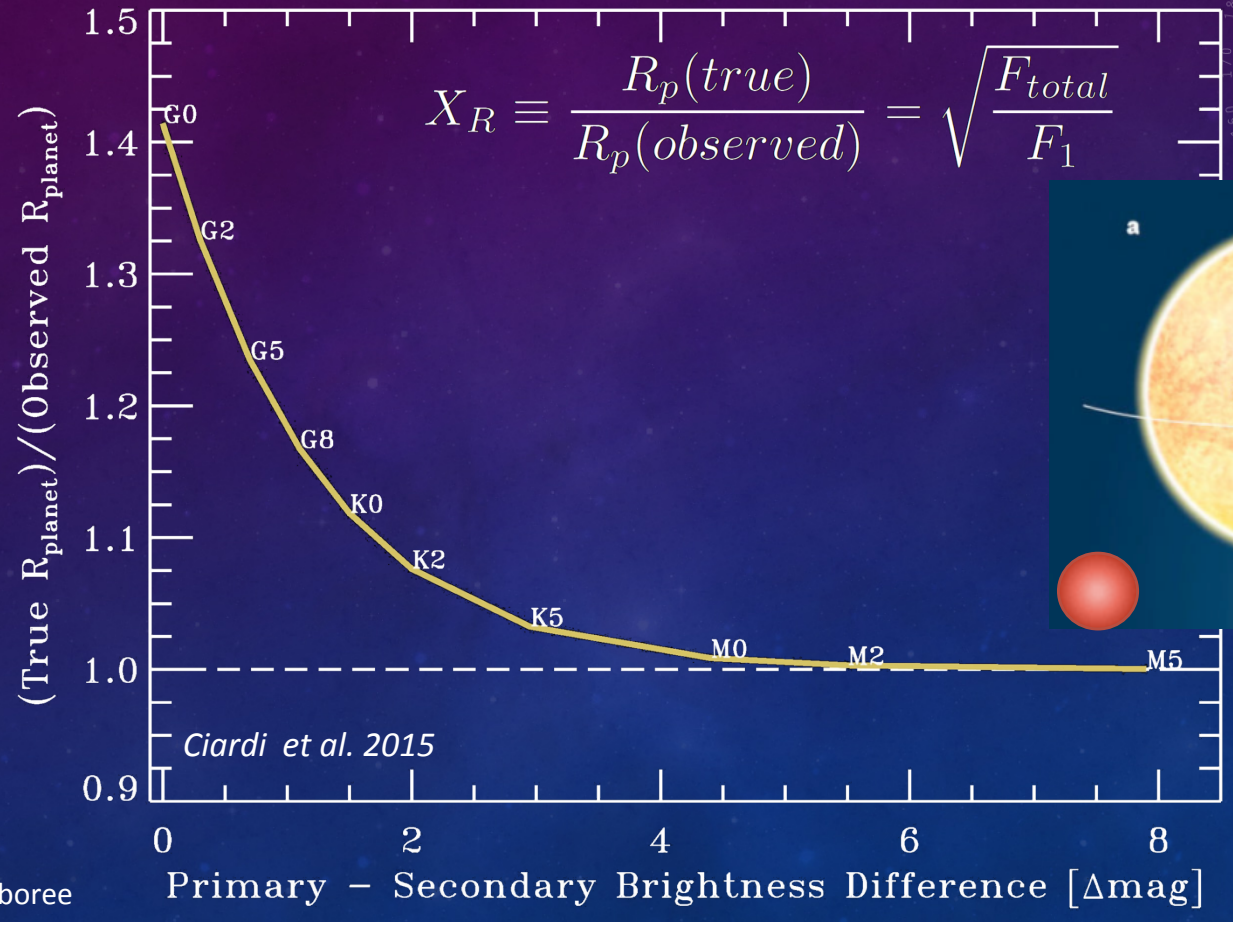
But, It's More Complicated …

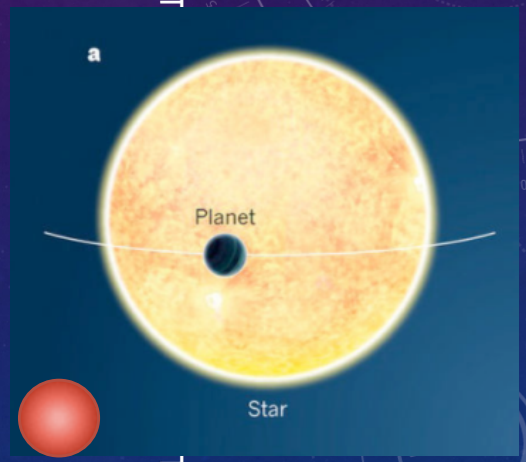


$$\delta_o = \left(\frac{F_t}{F_{total}}\right)\left(\frac{R_p}{R_{t\star}}\right)^2$$

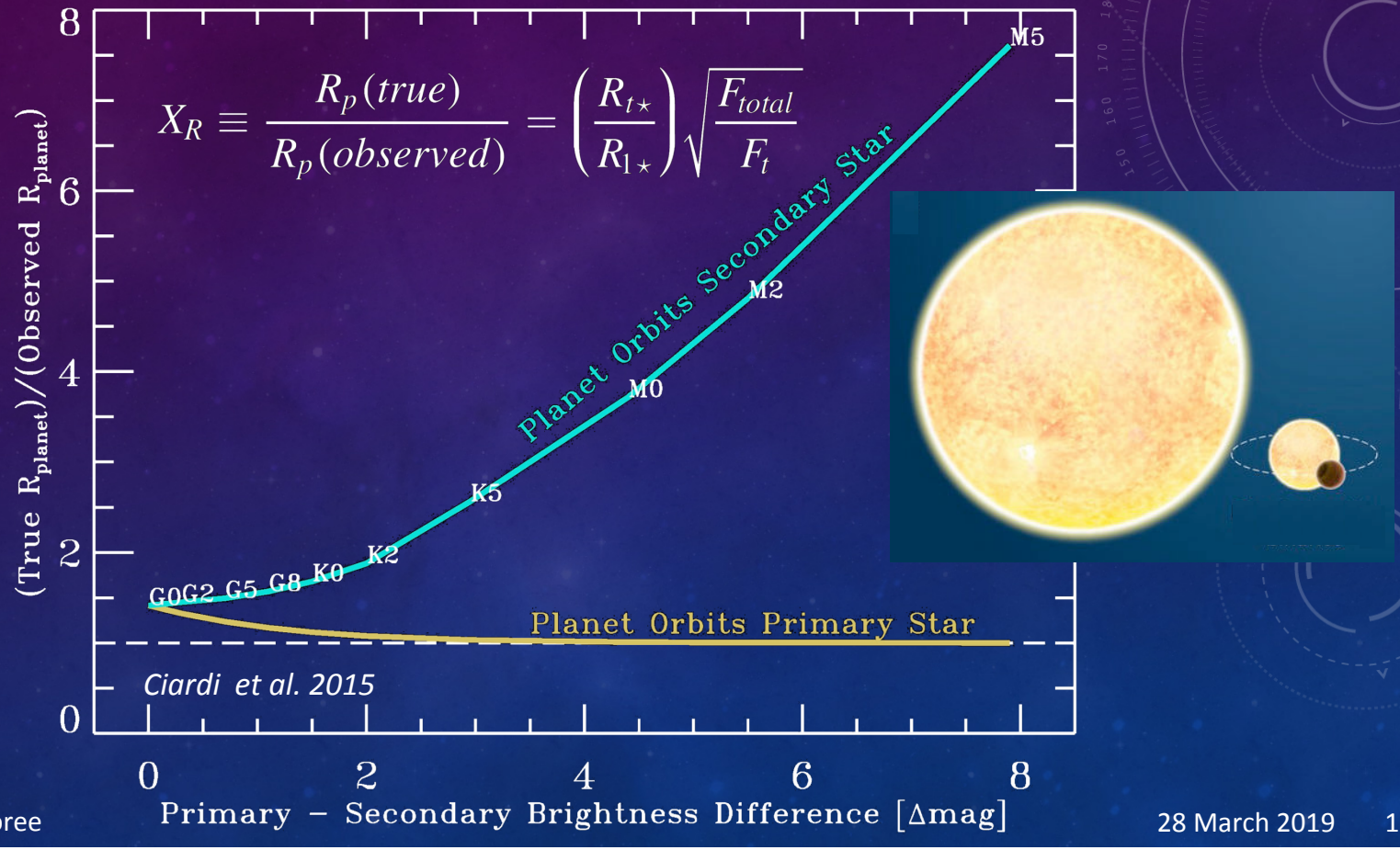
Underestimate Radius From Blends

$$X_R \equiv \frac{R_p(true)}{R_p(observed)} = \sqrt{\frac{F_{total}}{F_1}}$$





IF THE PLANET ORBITS THE COMPANION ?

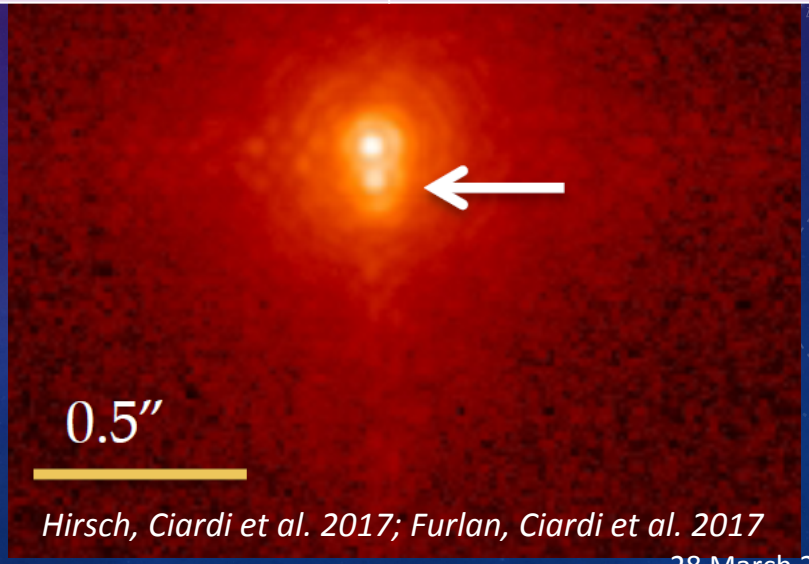


Kepler 907: Earth-sized Planet

	Assumed Single Star
Kepler 907	**1.31+/-0.06 Re**

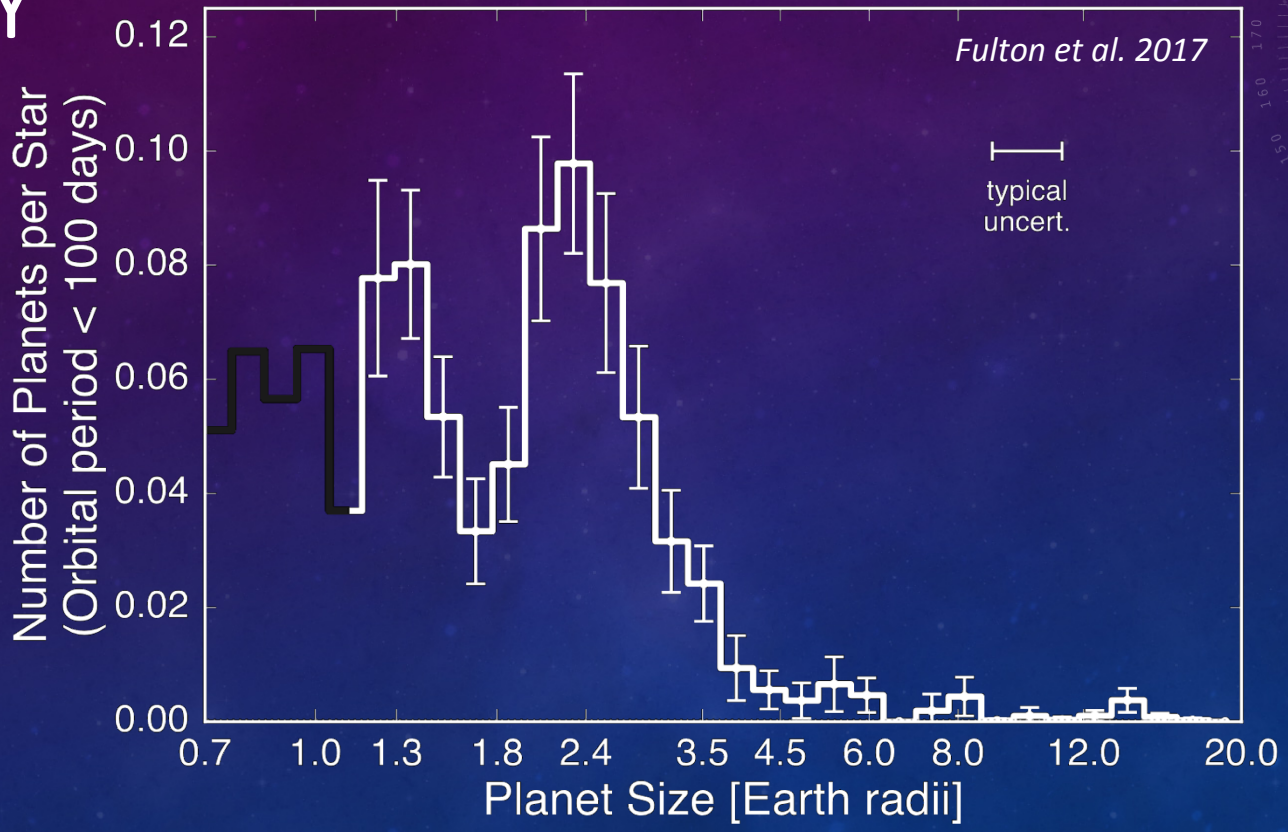
KEPLER 907: EARTH-SIZED PLANET TO MAYBE NOT

	Assumed Single Star	Orbits Primary Star	Orbits Secondary Star
Kepler 907	**1.31+/-0.06 Re**	**1.6+/-0.1 Re**	**1.9+/-0.1 Re**

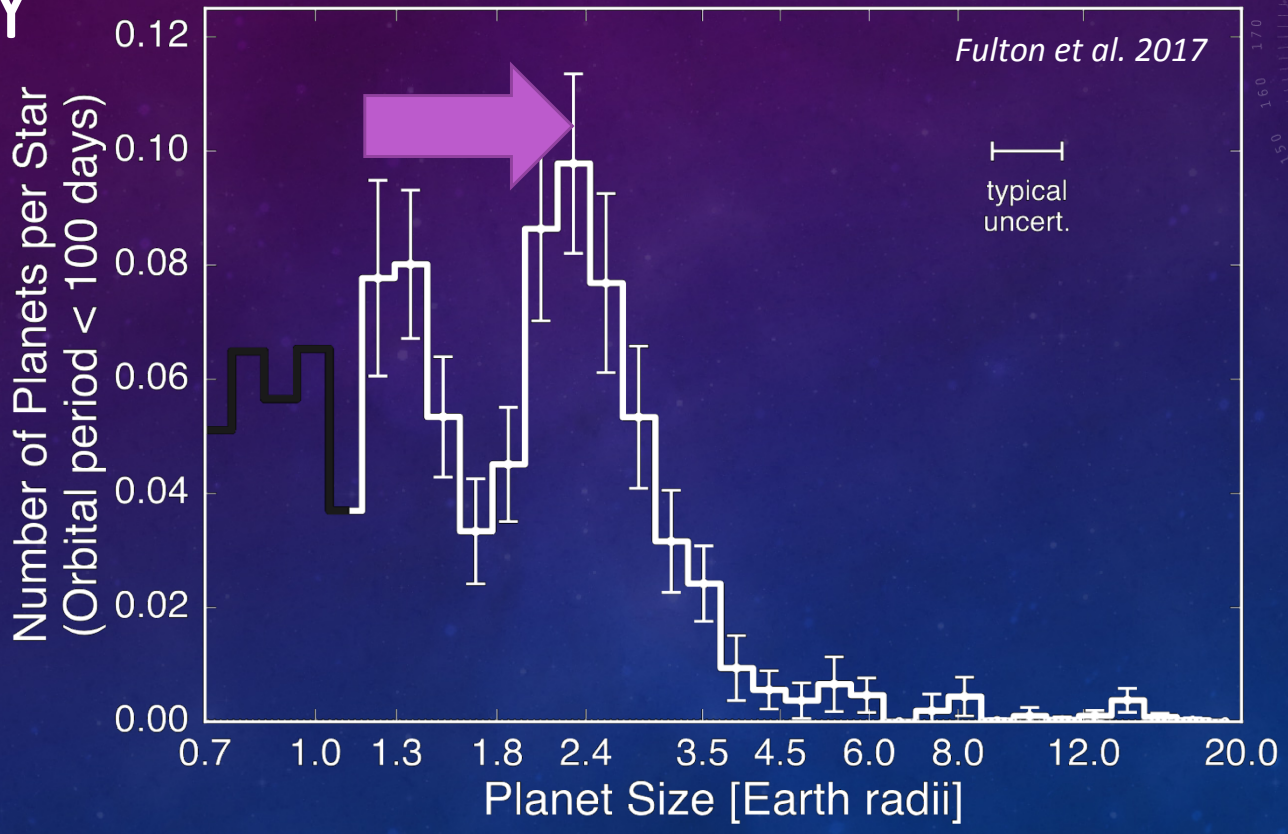


Hirsch, Ciardi et al. 2017; Furlan, Ciardi et al. 2017

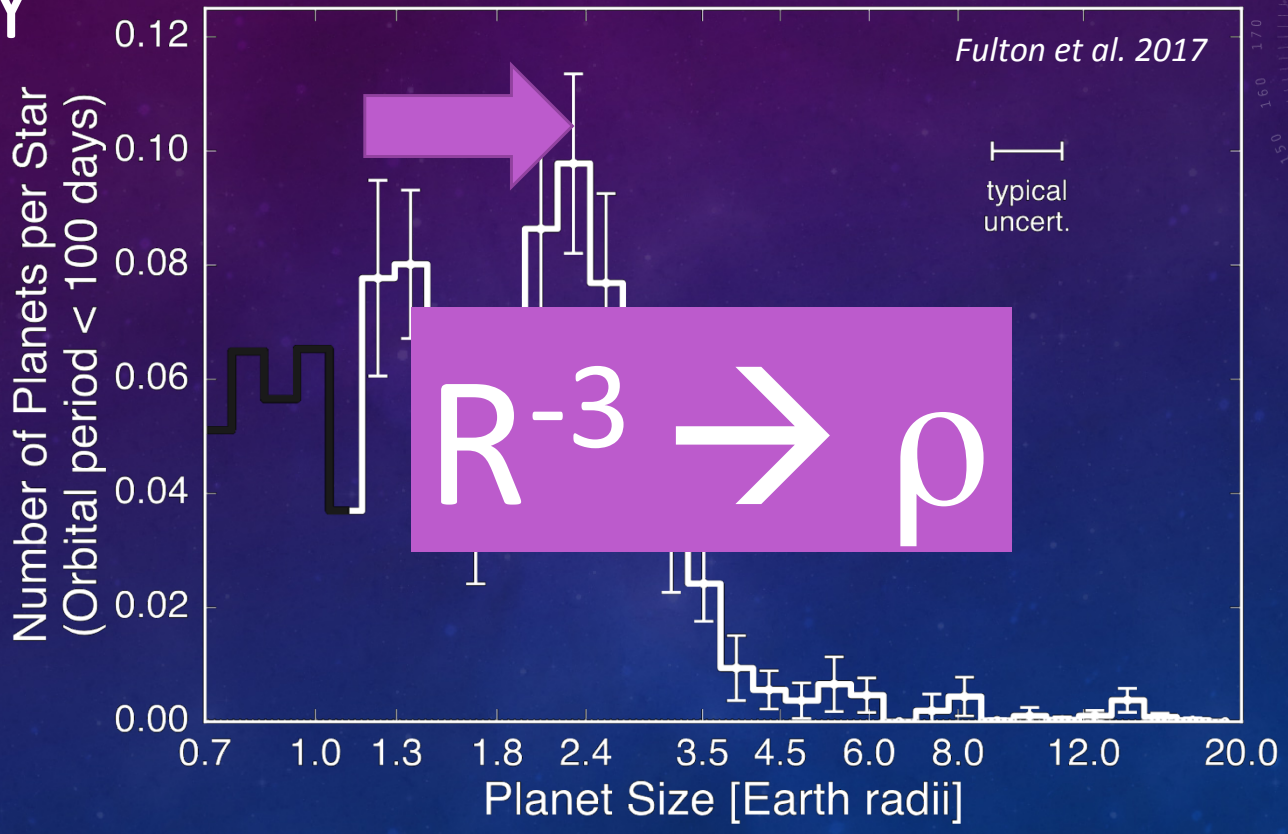
Kepler 907: Rocky



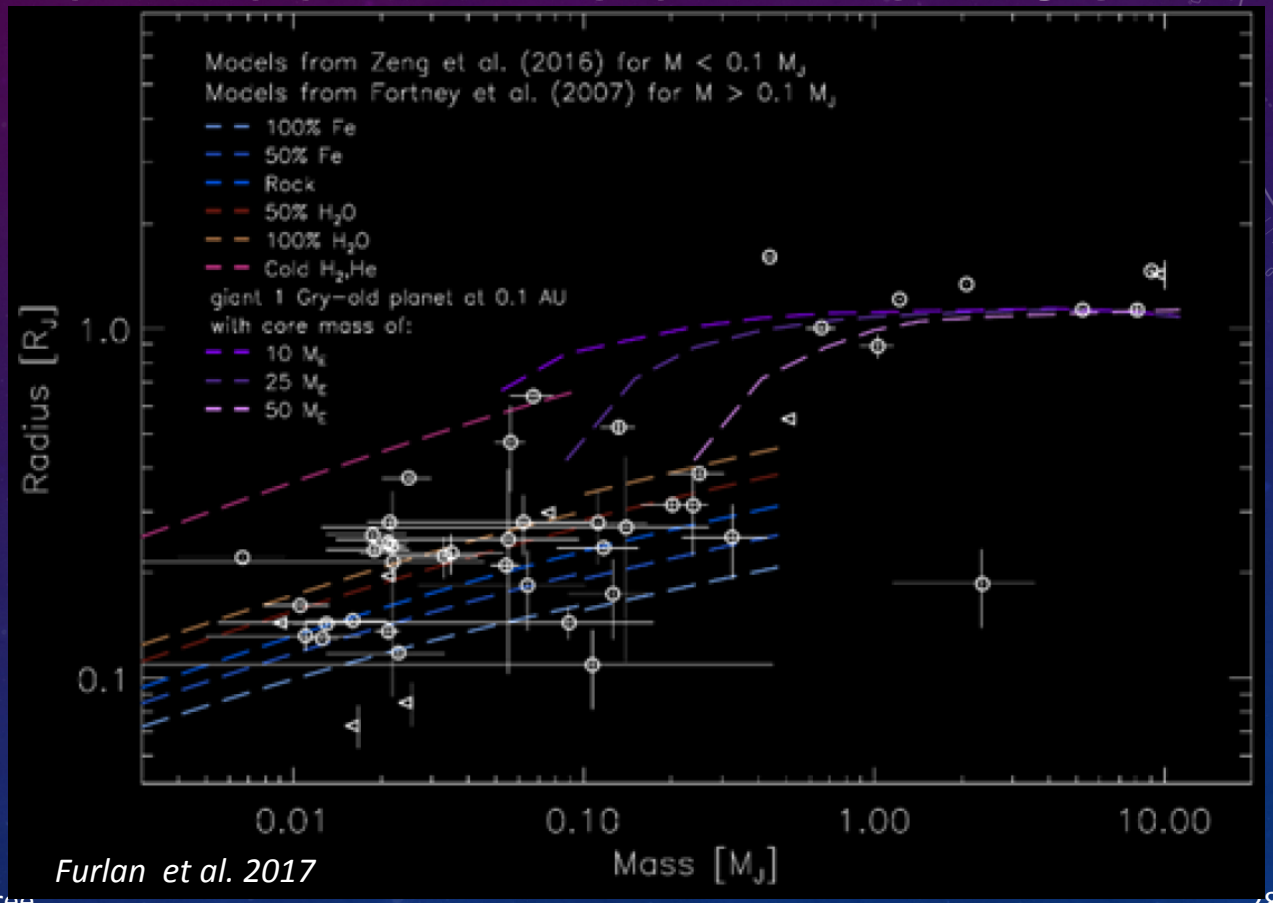
Kepler 907: Rocky To Maybe Not-Rocky Rocky



Kepler 907: Rocky To Maybe Not-Rocky Rocky

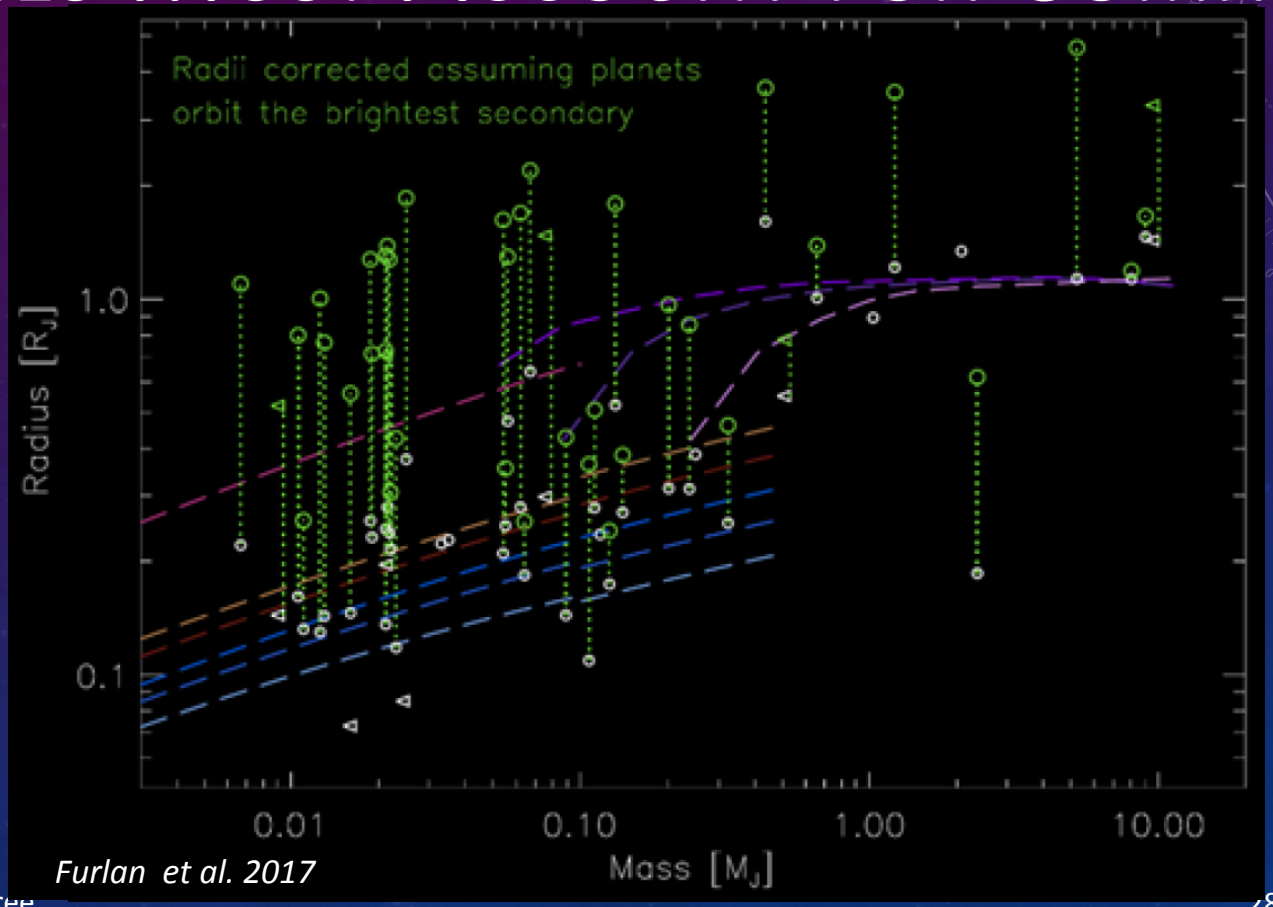


Densities Must Account for Companions



Furlan et al. 2017

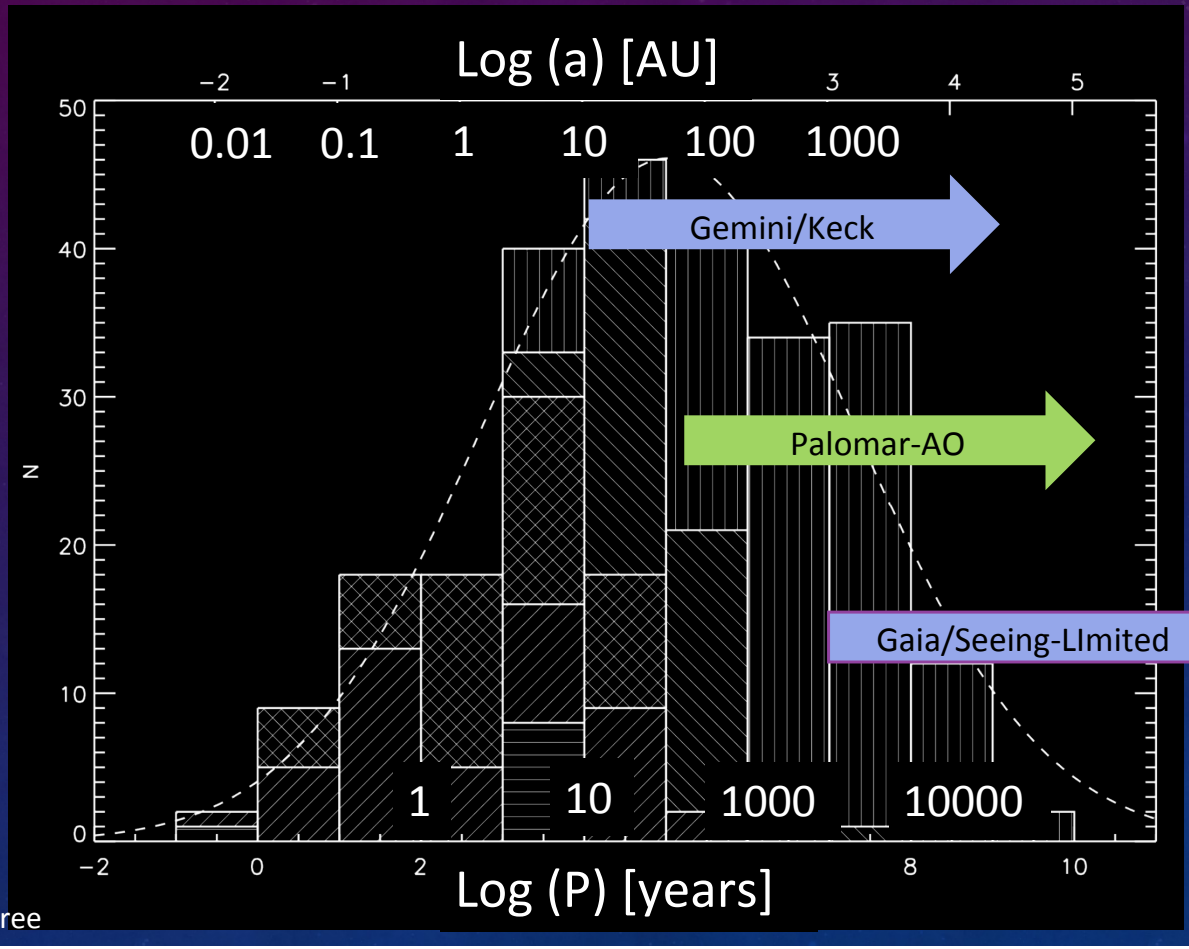
Densities Must Account for Companions



Furlan et al. 2017

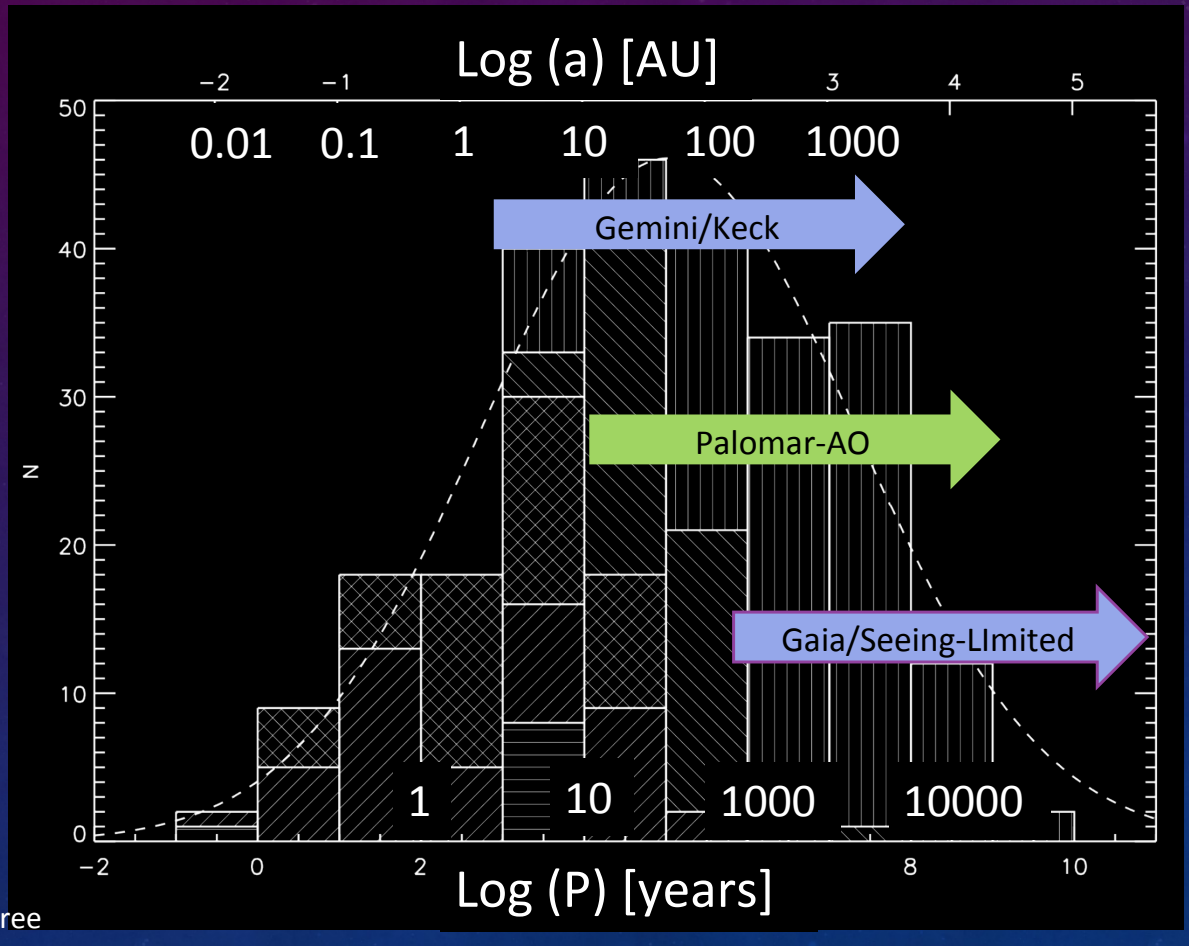
Sampling the Companion Period Distribution

Kepler
~800 pc



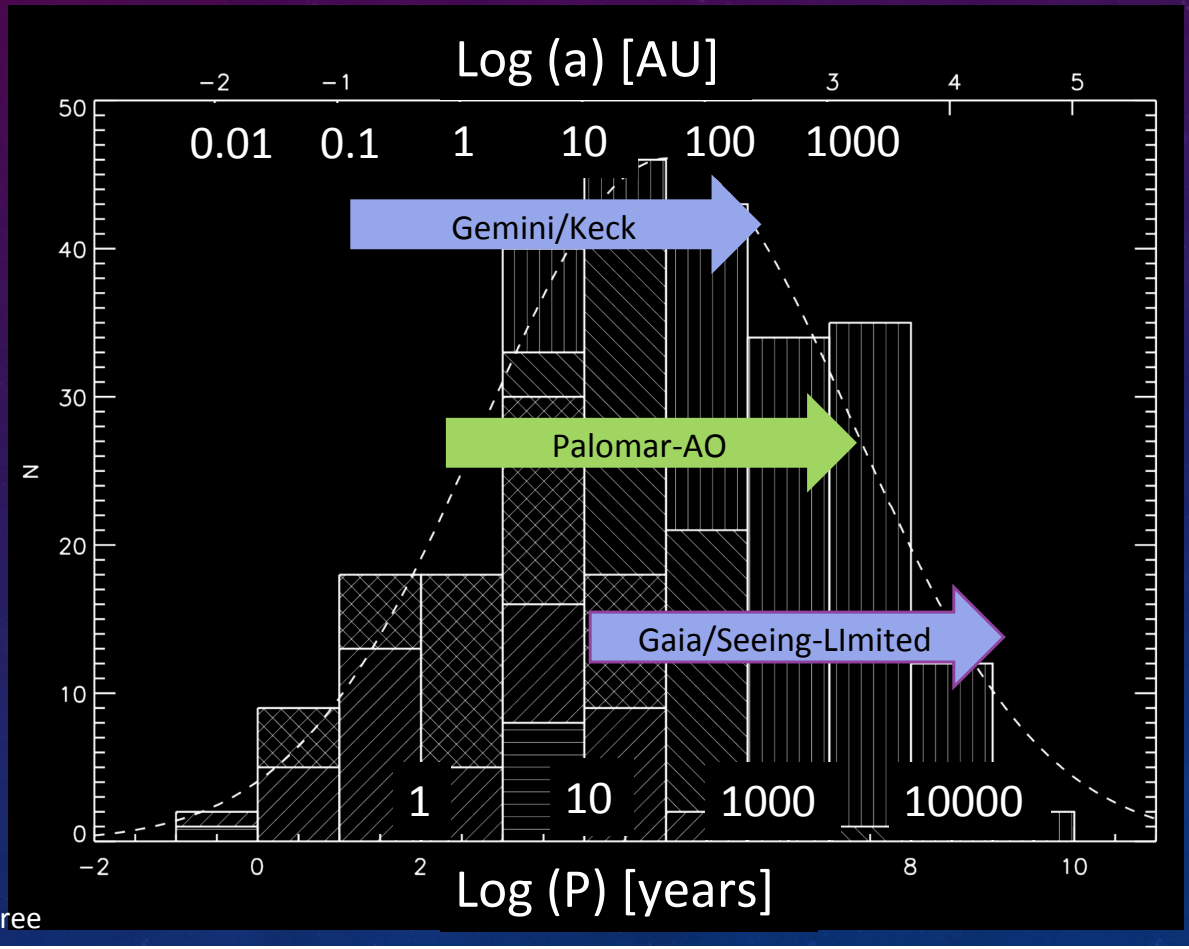
Sampling the Companion Period Distribution

K2
~300 pc



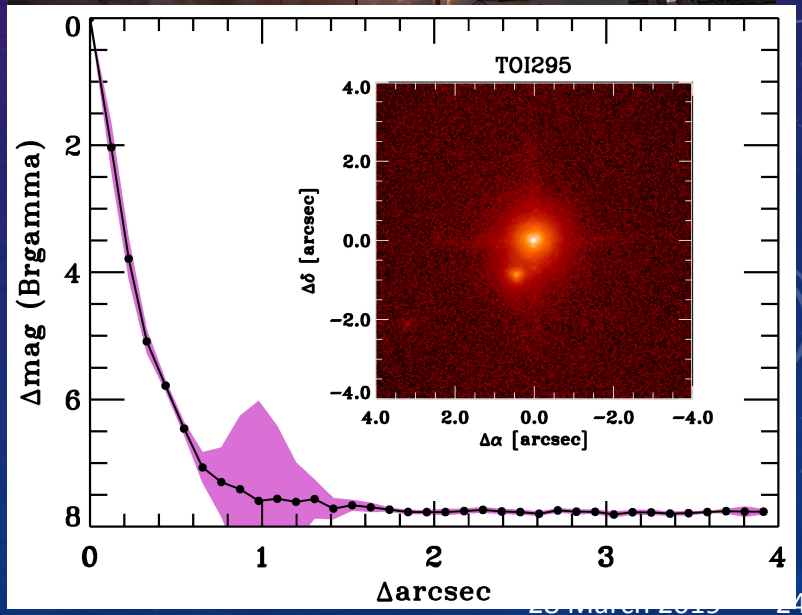
Sampling the Companion Period Distribution

Very Near Stars ~10 – 100 pc



TESS Launched in 2018

- Transiting Exoplanet Survey Satellite
- Designed to find transiting planets around nearby stars
- Surveying the entire sky
- Order of magnitude more planets than Kepler



SUMMARY

- **Palomar Critical to the Success of Kepler/K2 – and now TESS**
- **High resolution imaging necessary to validate the transiting planets and get accurate planet radii**
- **~100 refereed papers on Kepler planets**
- **~50 refereed papers on K2 planets**