

ESTIMATING ETA EARTH:

The Fraction of Stars with Earth-sized
Planets in the Habitable Zone

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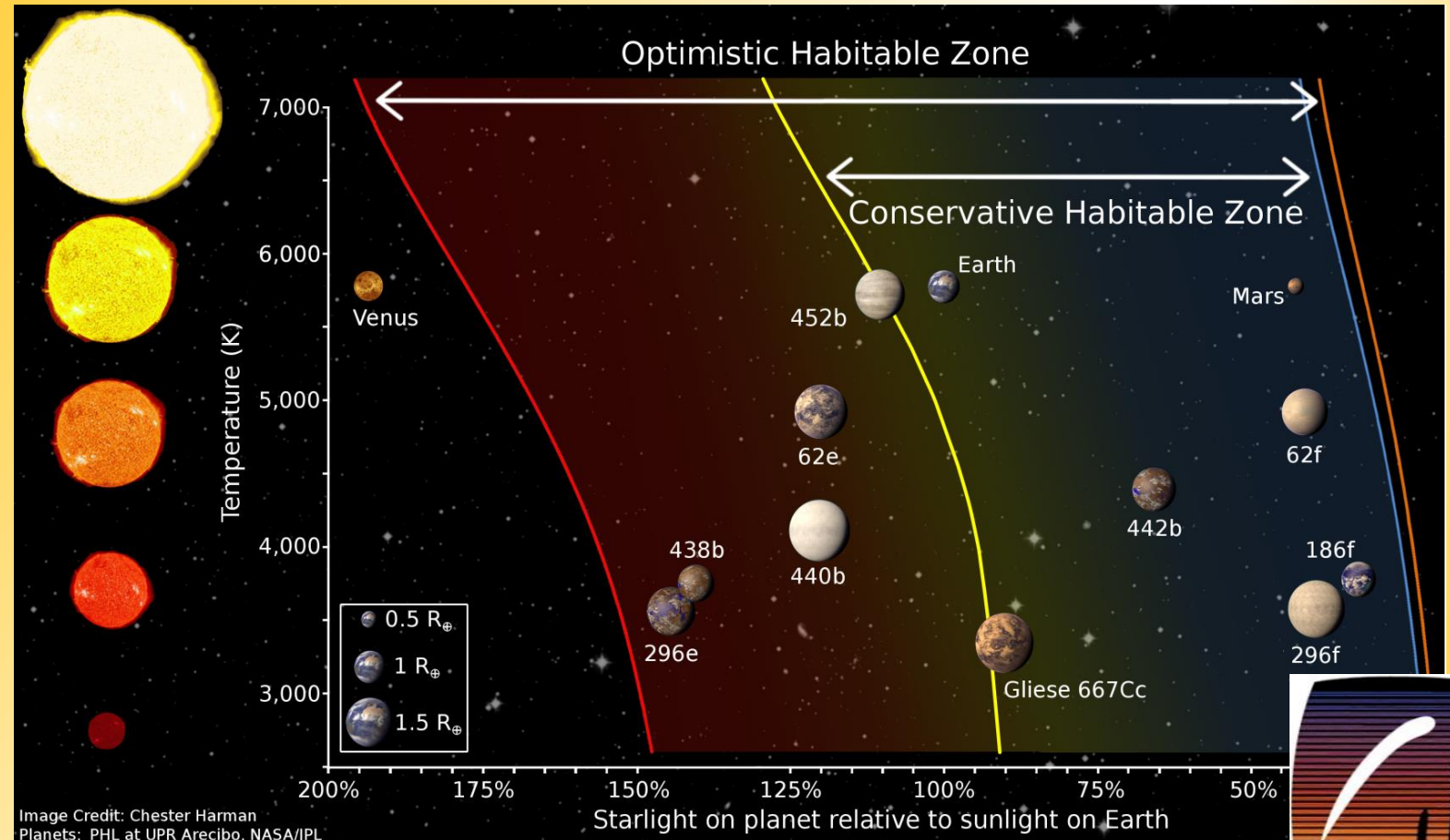


Arizona Space Grant Symposium April 14th, 2018



OBJECTIVE

- CALCULATE η_{Earth}
 - η_{Earth} : Fraction Earth-like planets in habitable zone
 - **Earth-like:** Terrestrial planets, radii $0.55-1.6 R_{\text{Earth}}$
 - **Habitable zone:** Region within which a planet may host liquid water



PROCEDURE

- Used Kepler DR-25
 - Collected by Kepler Space Telescope
 - Most recent release, over 9,000 objects
 - “Score” value included
 - “the recommended catalog for estimating planet occurrence rates” –NASA

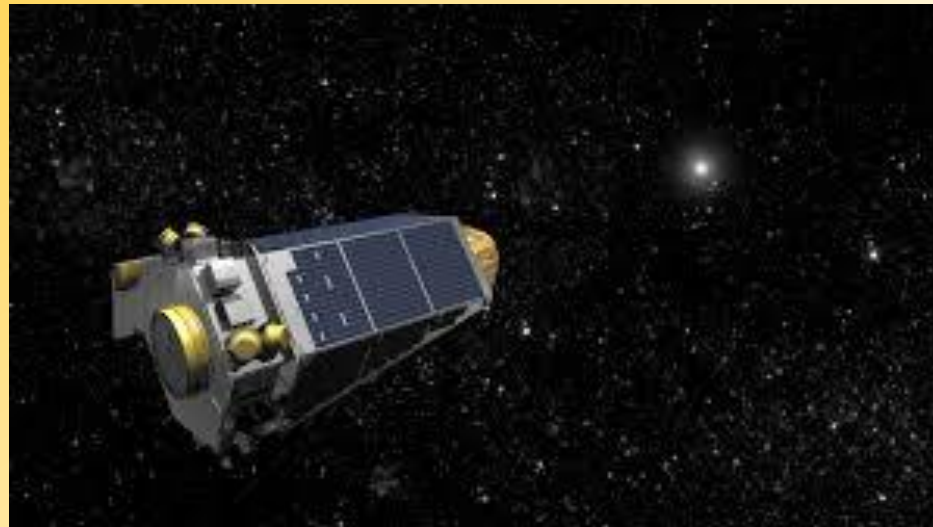
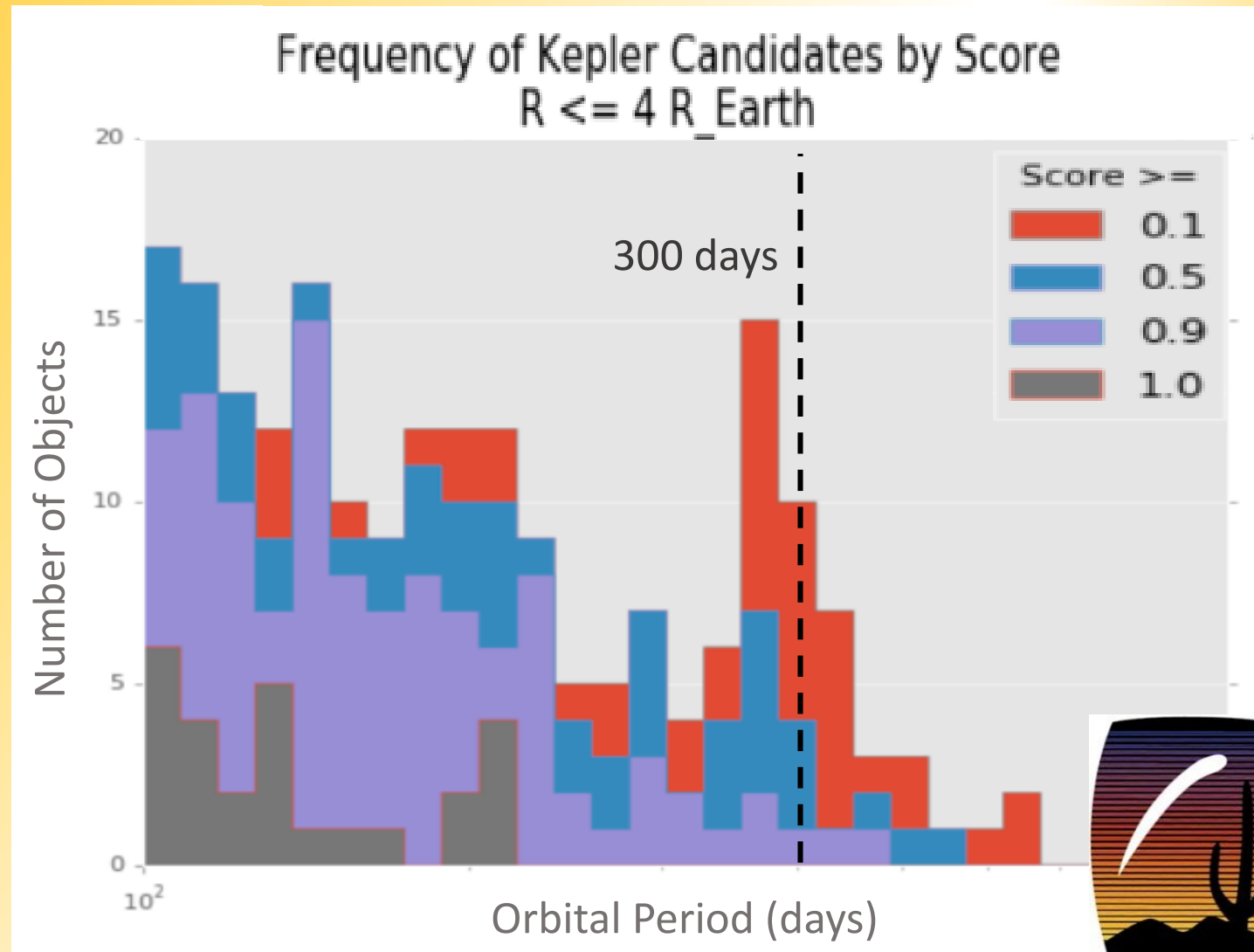


Image: NASA/JPL



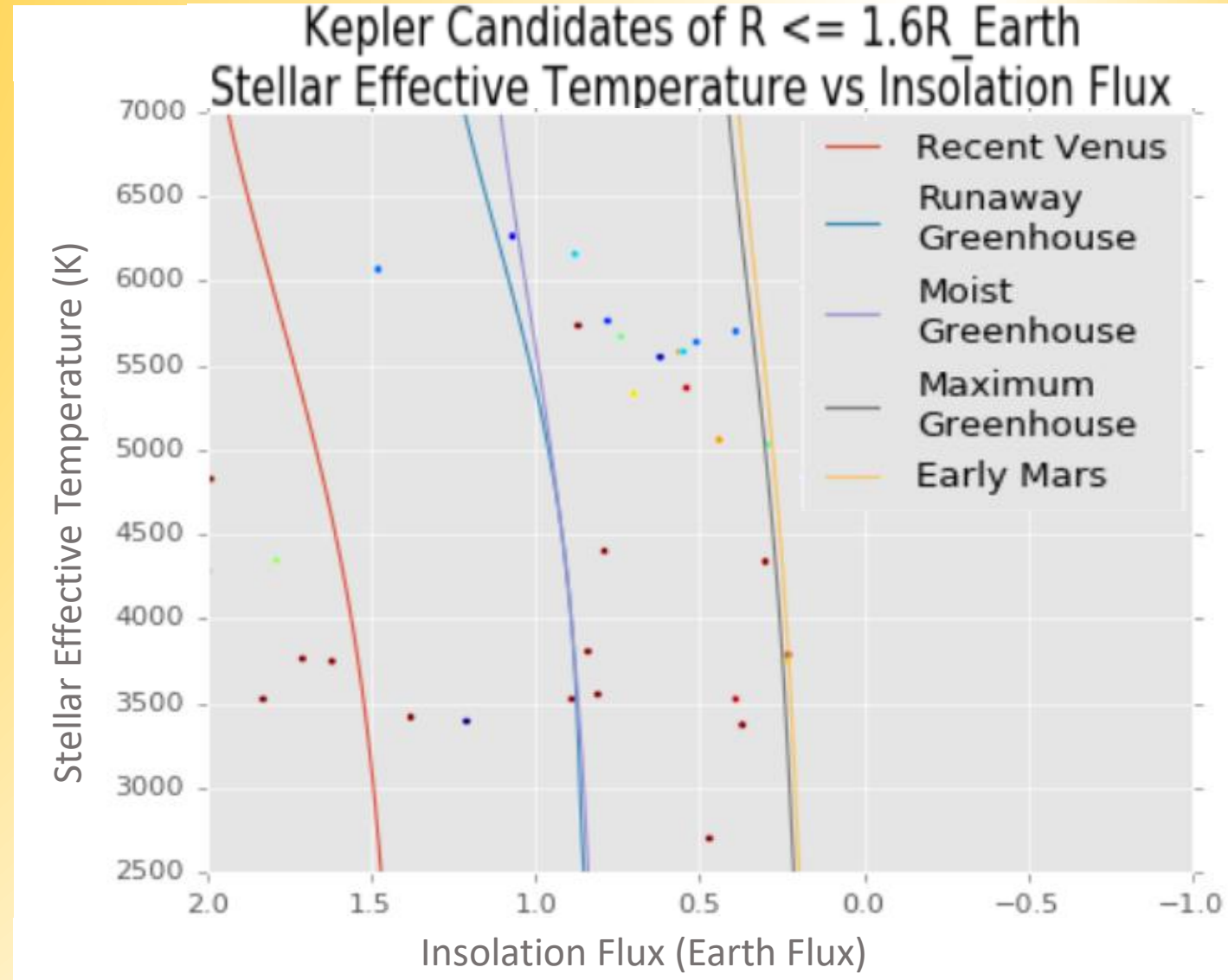
PROCEDURE

- Determined score cut-off
 - Remove false positives
 - Retain as much data as possible
 - Peak in low-score objects at ~300 days
 - Used peak as a flag
 - Found ideal cut-off of 0.9



PROCEDURE

- Calculated habitable zone
 - Equations from Kopparapu et. al. 2013
- Lines denote inner and outer habitable zone
- Chose Runaway Greenhouse and Early Mars lines
- Determined exoplanets within lines

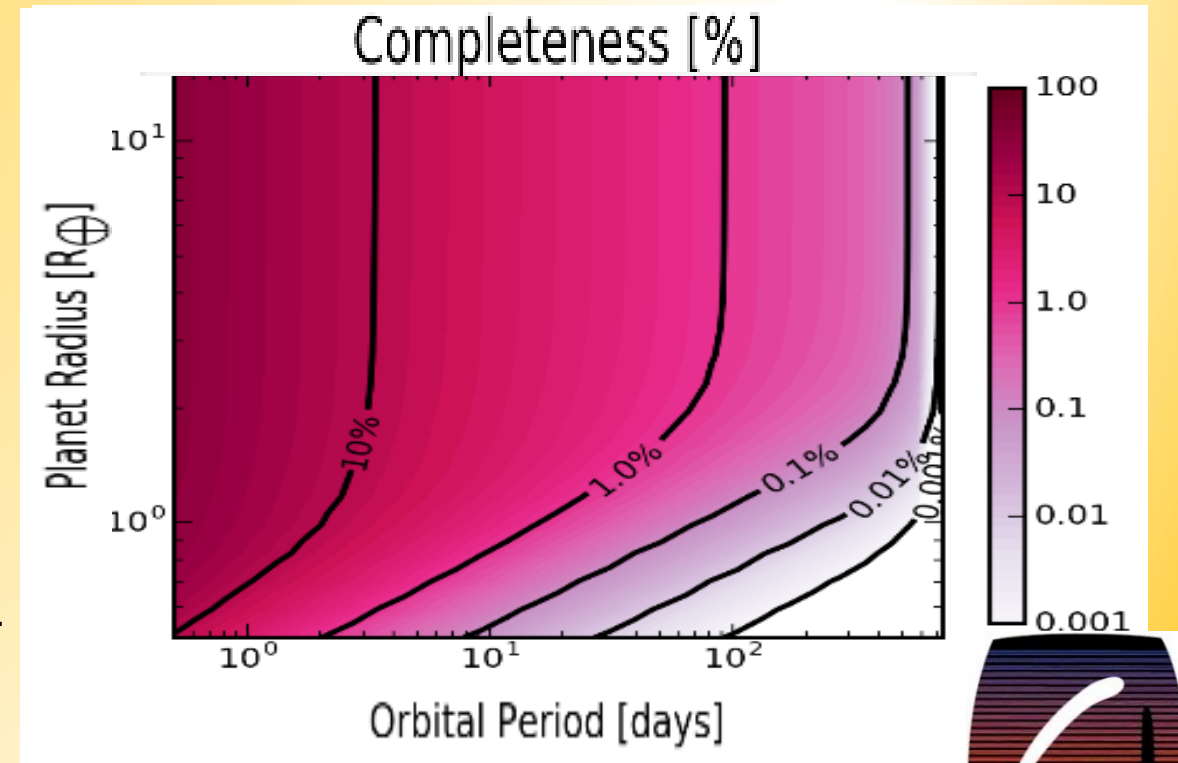
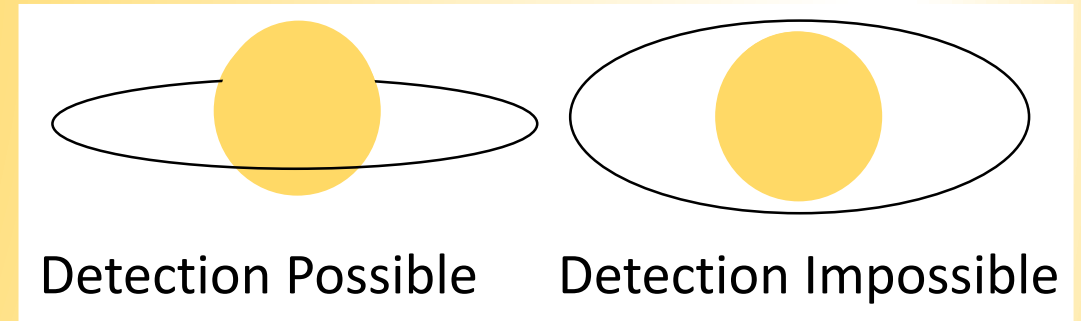


PROCEDURE

- Calculated completeness
 - Account for undetected planets
 - Detections via transit method
 - Probability of detection is function of planet and stellar radii
 - Calculated detection efficiency
 - Completeness value obtained

- Calculated Occurrence

- $\eta_{Earth} = \sum \frac{1}{completeness * stars\ observed}$



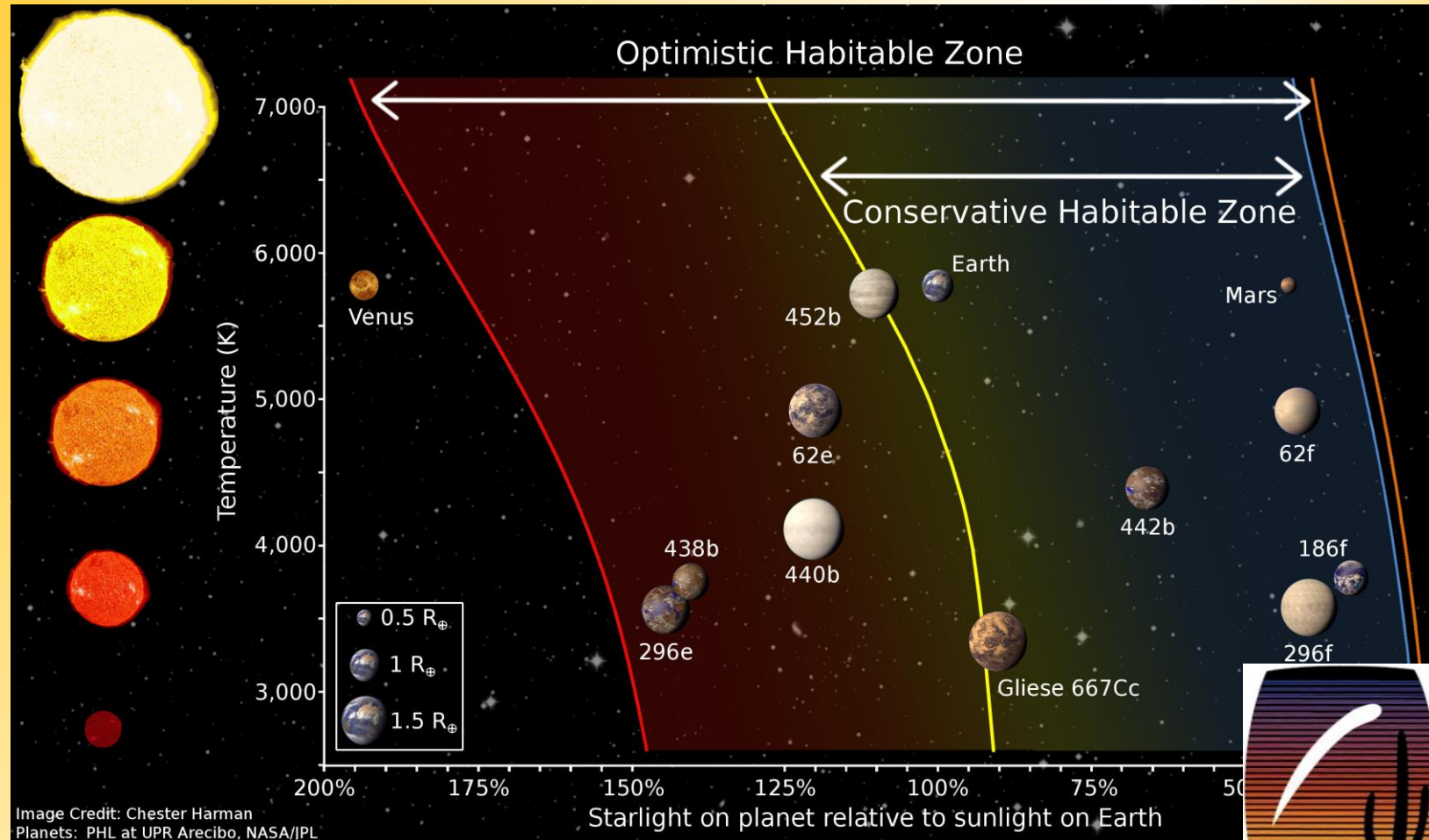
RESULTS & ANALYSIS

- Occurrence results

- M stars: 28.5%
- K stars: 3.8%
- G stars: 7.7%
- K, G may be underestimates

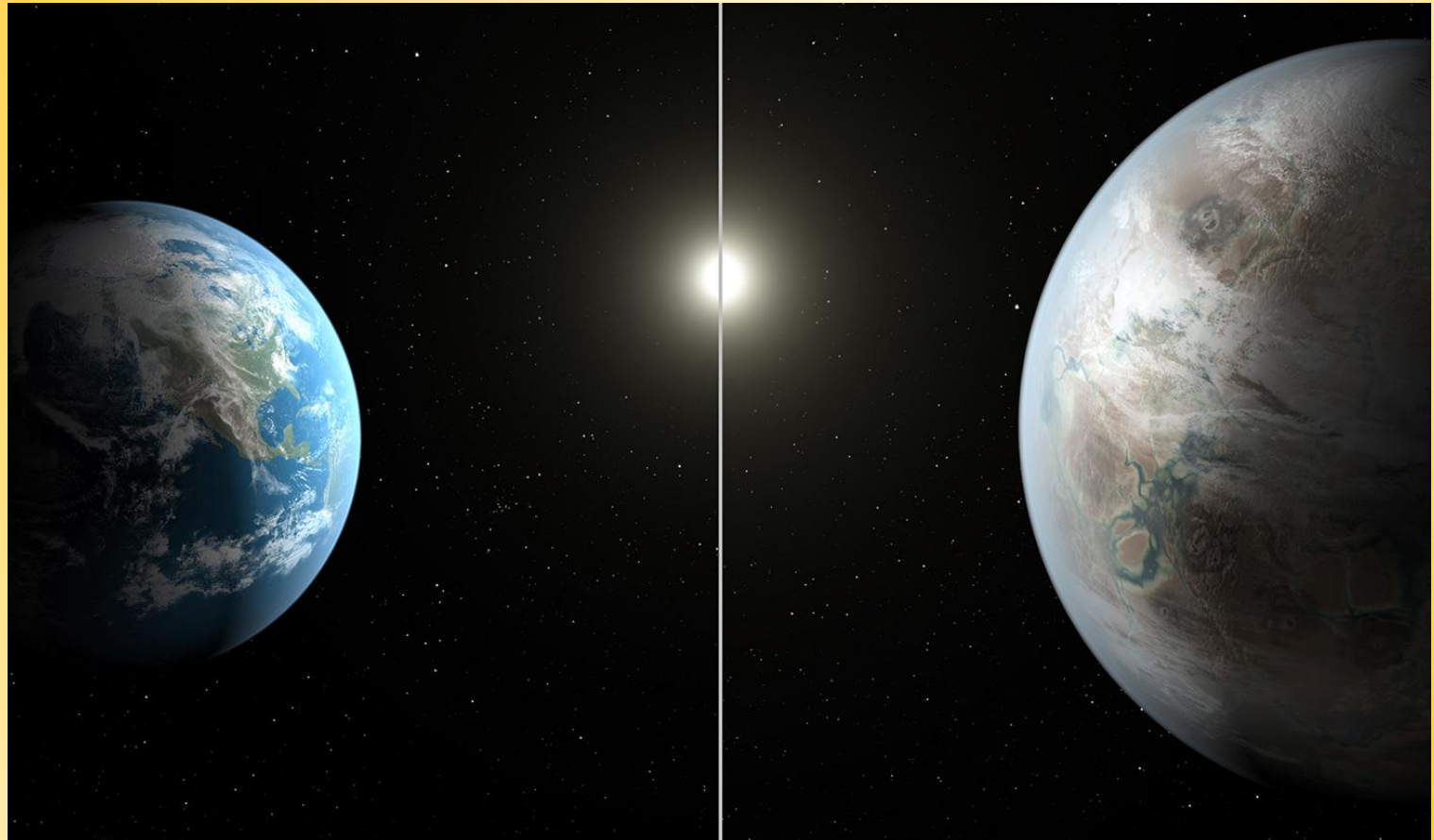
- Previous Calculations

- Dressing and Charbonneau 2015
- Petigura et al 2013



SIGNIFICANCE

- Future missions
 - Habitable Exoplanet Imaging Mission (HabEx)
 - Directly image exoplanets
 - Must be nearby
 - η_{Earth} determines distance
 - Closer planets mean smaller mirror, lower cost



THANK YOU