

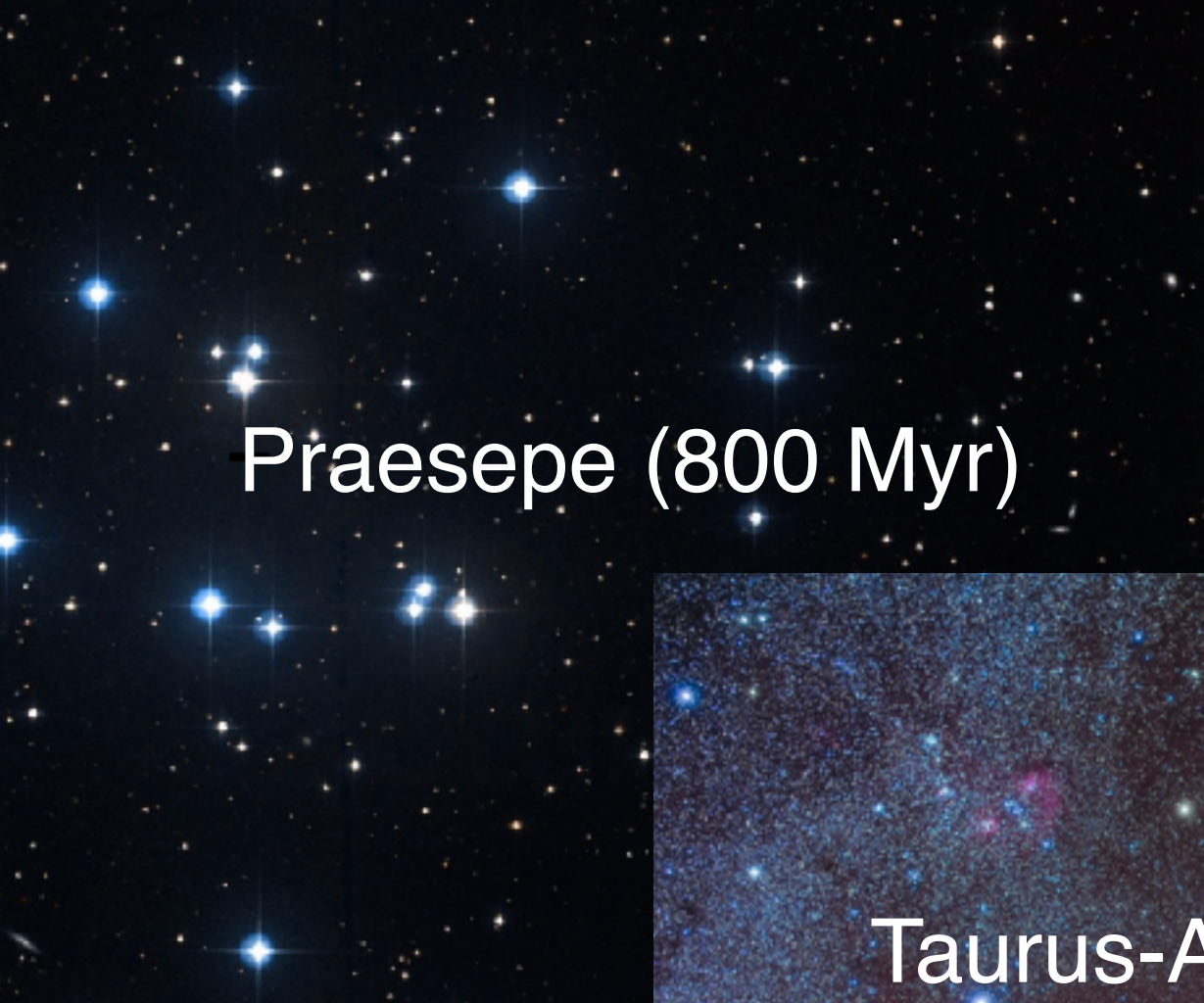


**Studying Exoplanet Evolution
Through Young Planets and their Host
Stars**


Andrew Mann

Hubble Fellow
Columbia University

Know Thy Star - Know Thy Planet
October, 2017

A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.


Praesepe (800 Myr)

A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.


Hyades (800 Myr)

A dense field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Taurus-Auriga (0-5 Myr)

A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Pleiades (125 Myr)

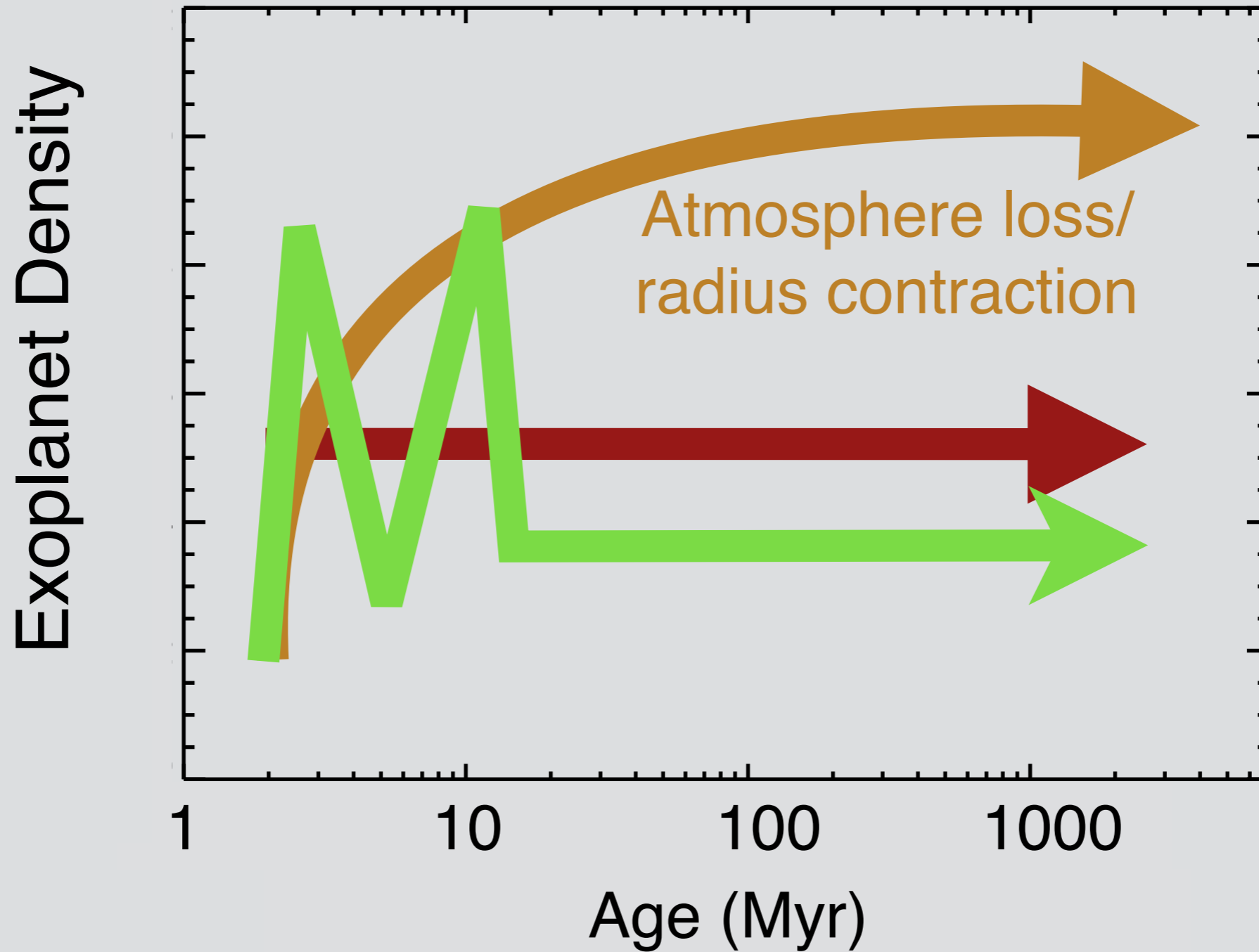
A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Upper Scorpius
(11 Myr)

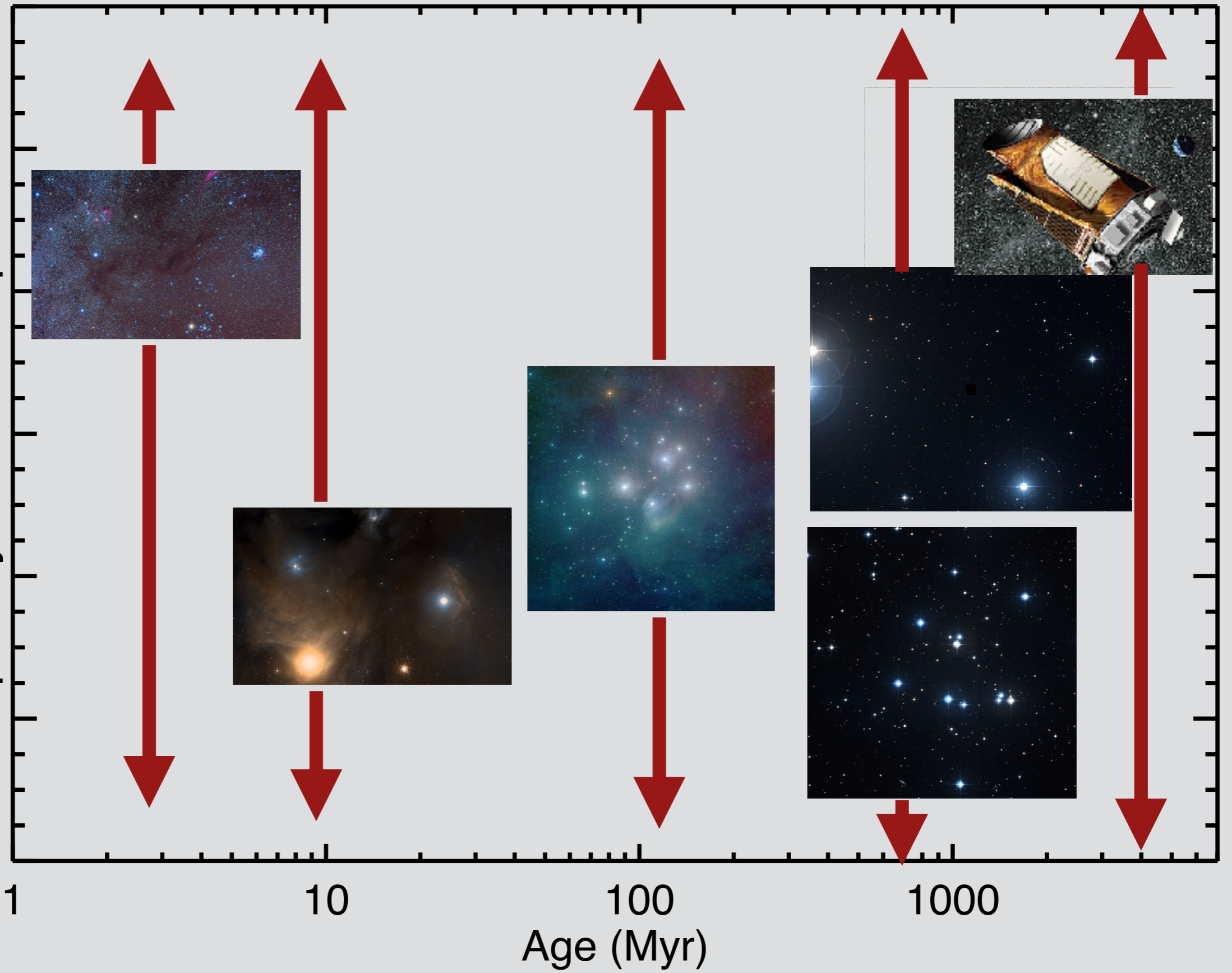
How do planets evolve over their lifetimes?



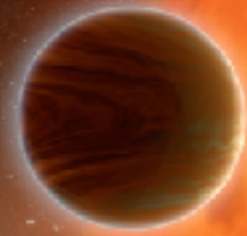
How do planet properties change with time?



Planet Parameter
e.g., atmosphere thickness
or frequency of close-in planets



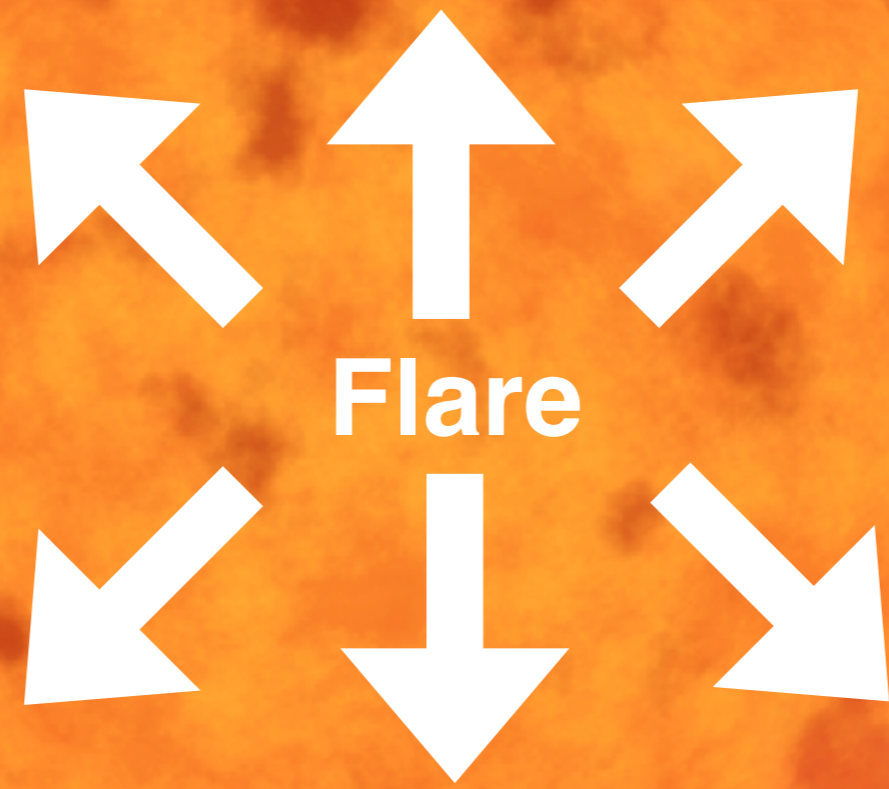
**Debris
disk**



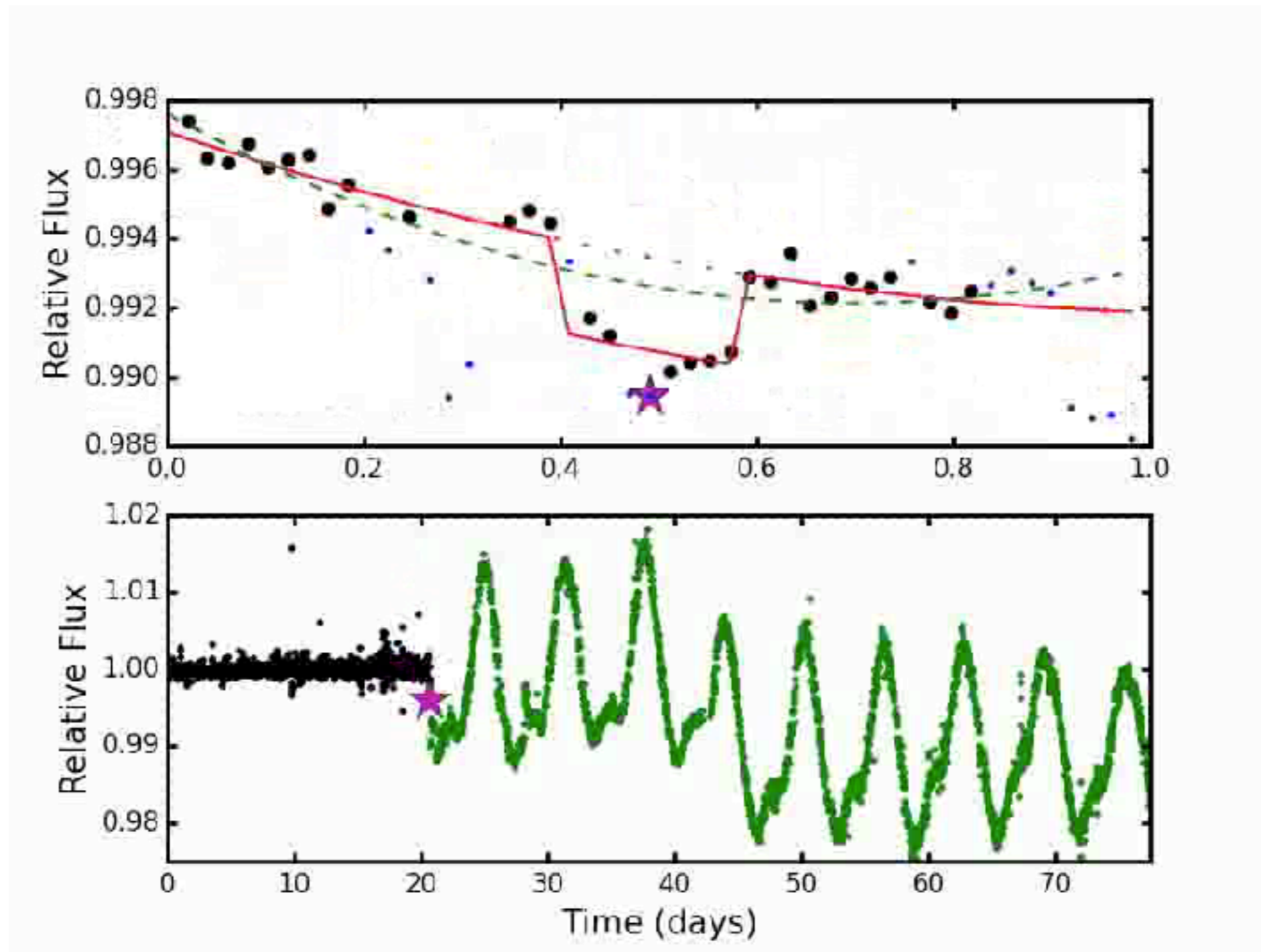
Spots



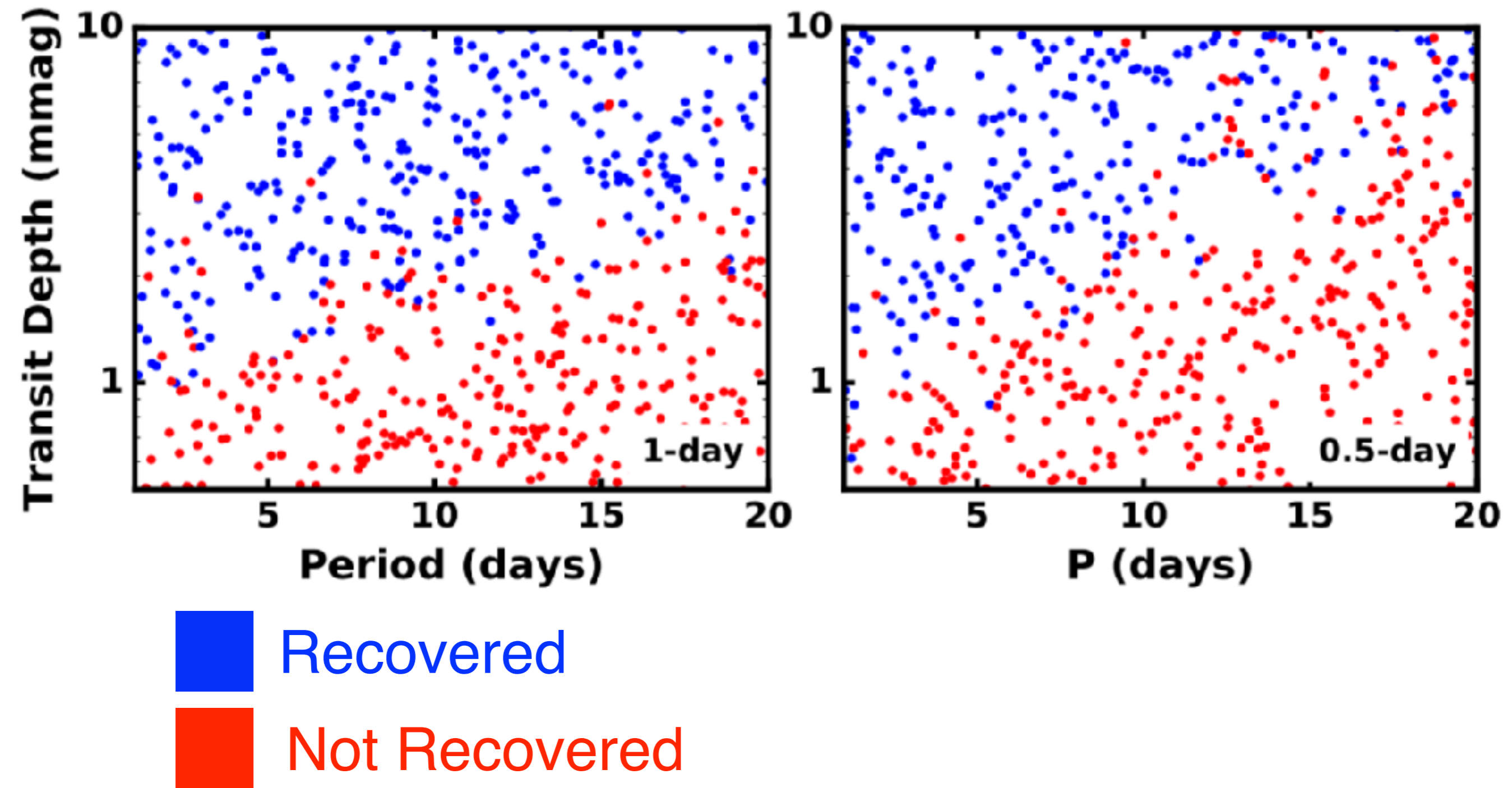
Flare



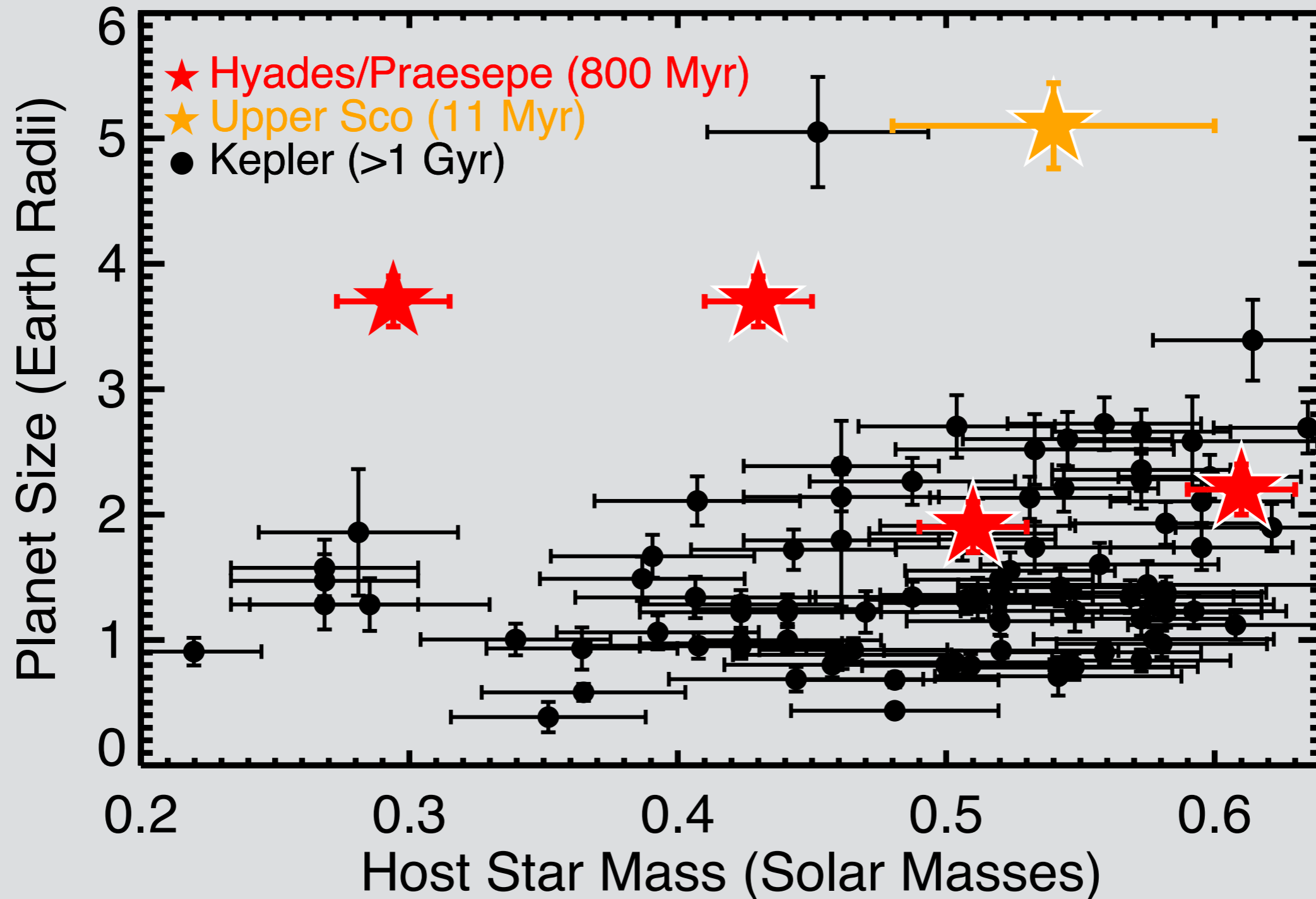
Notch Filter



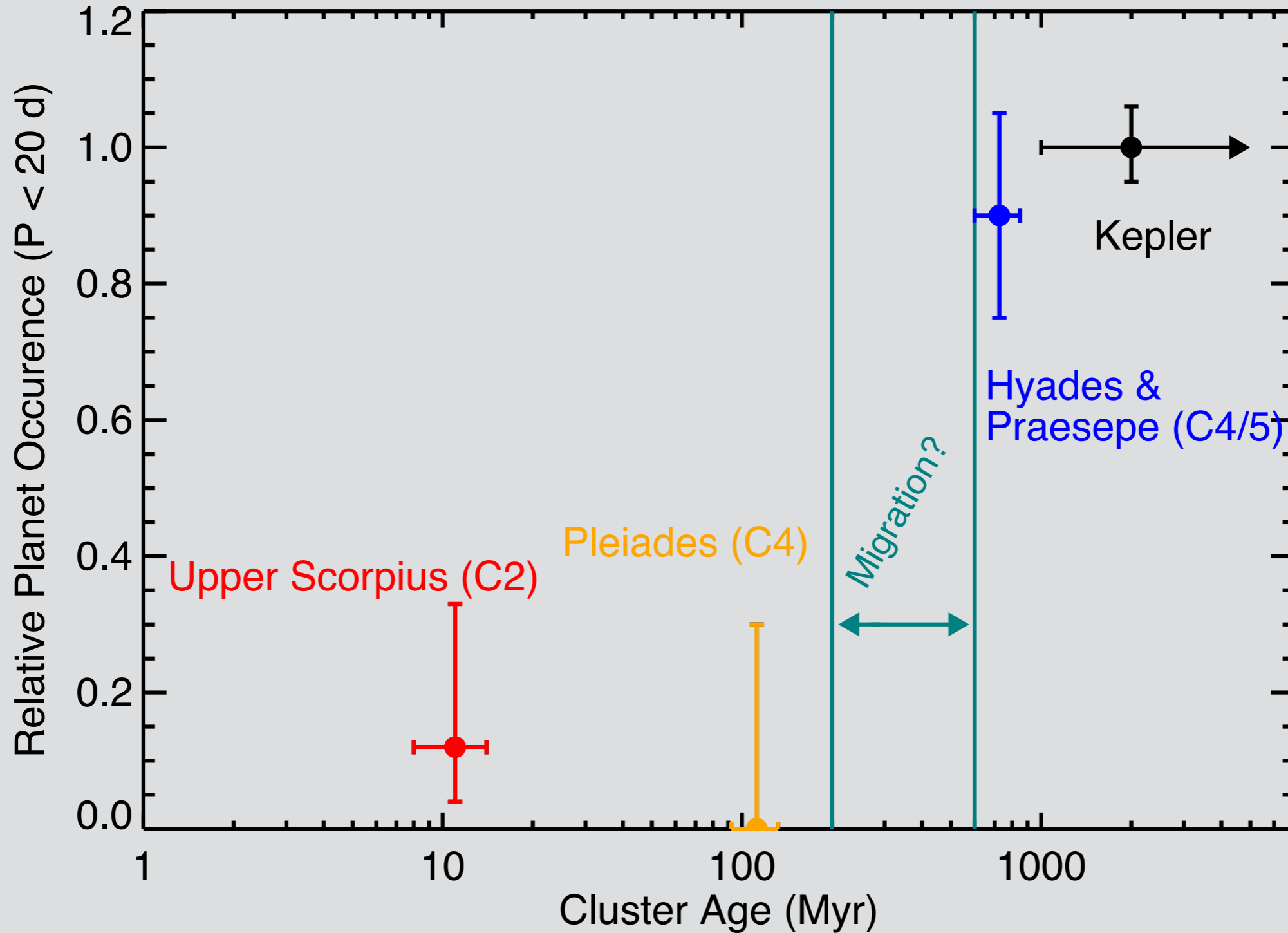
Full Injection/Recovery



Evidence for inflated radii at young ages



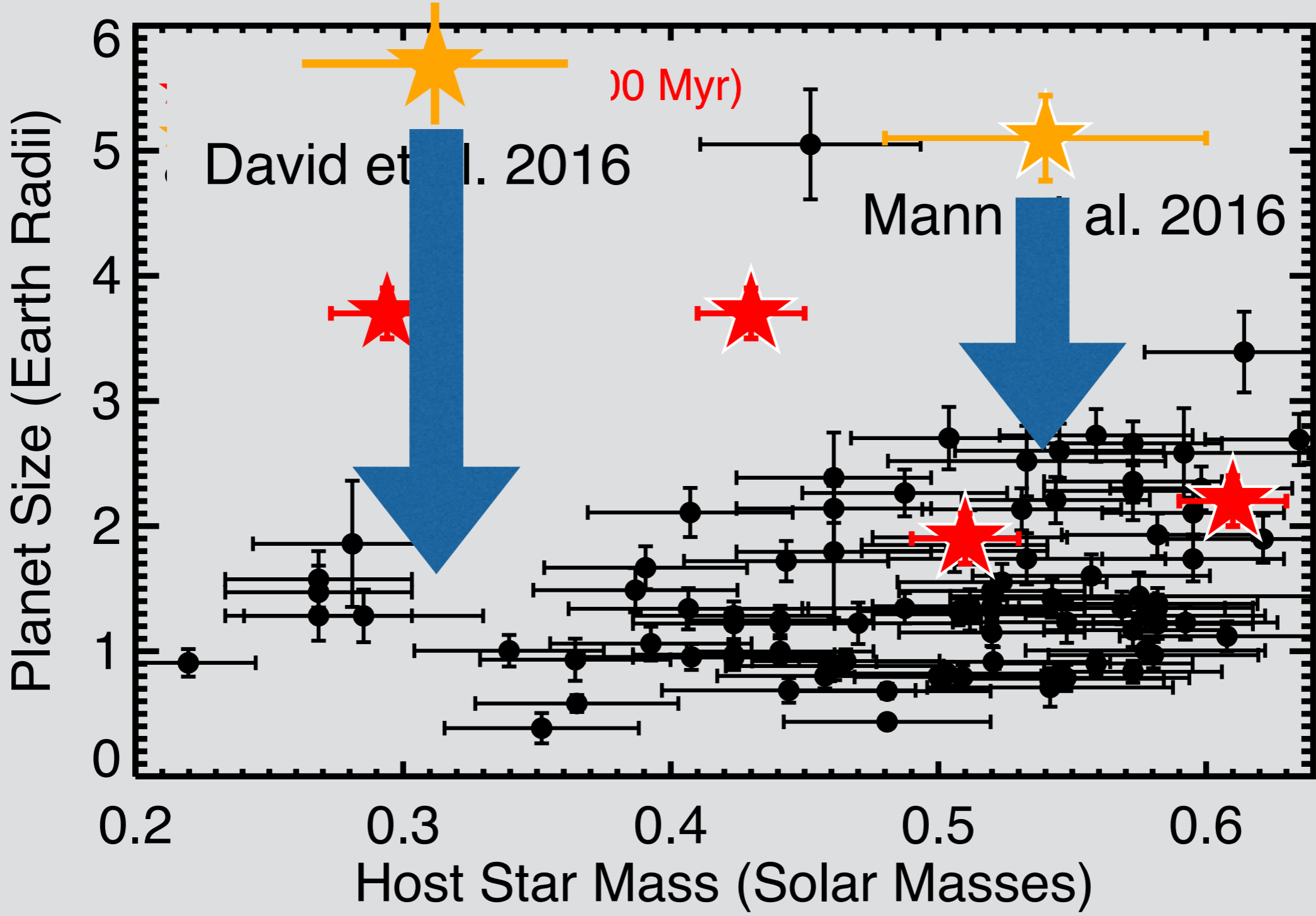
Exoplanet Migration Timescale of 100-800 Myr



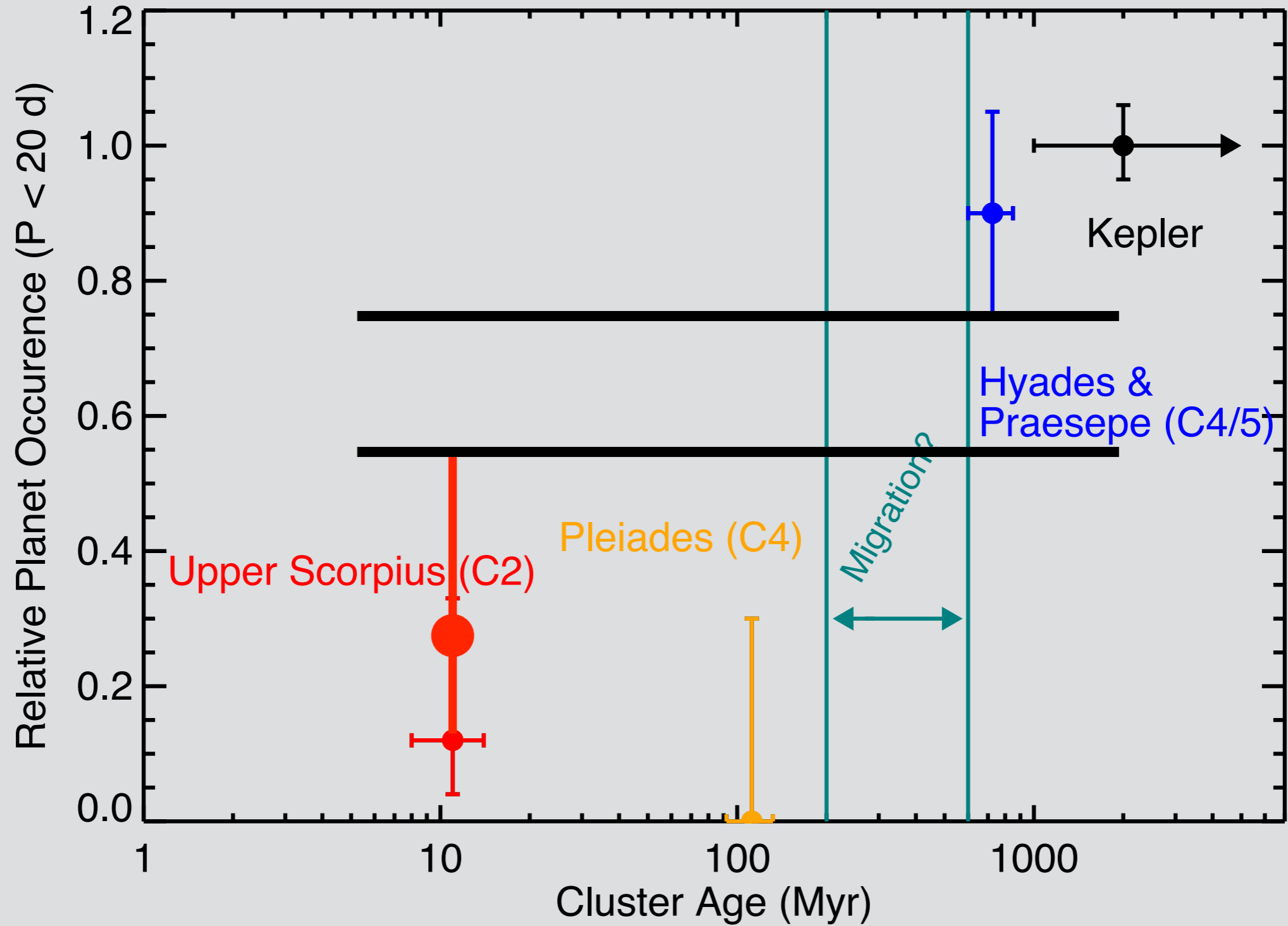
If

the stellar parameters are
statistically correct

Differences in Stellar Parameters

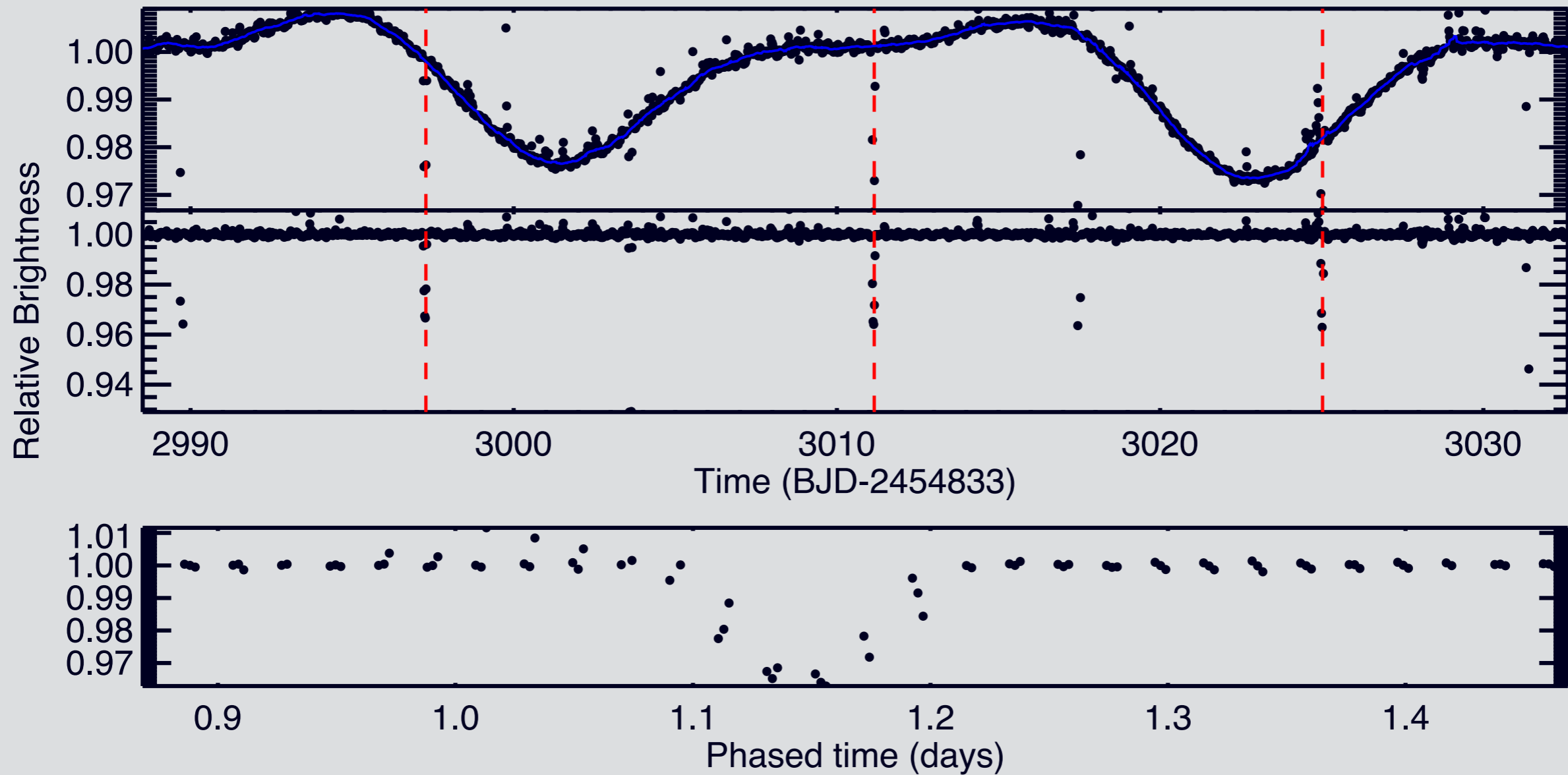


This can change occurrence calculations

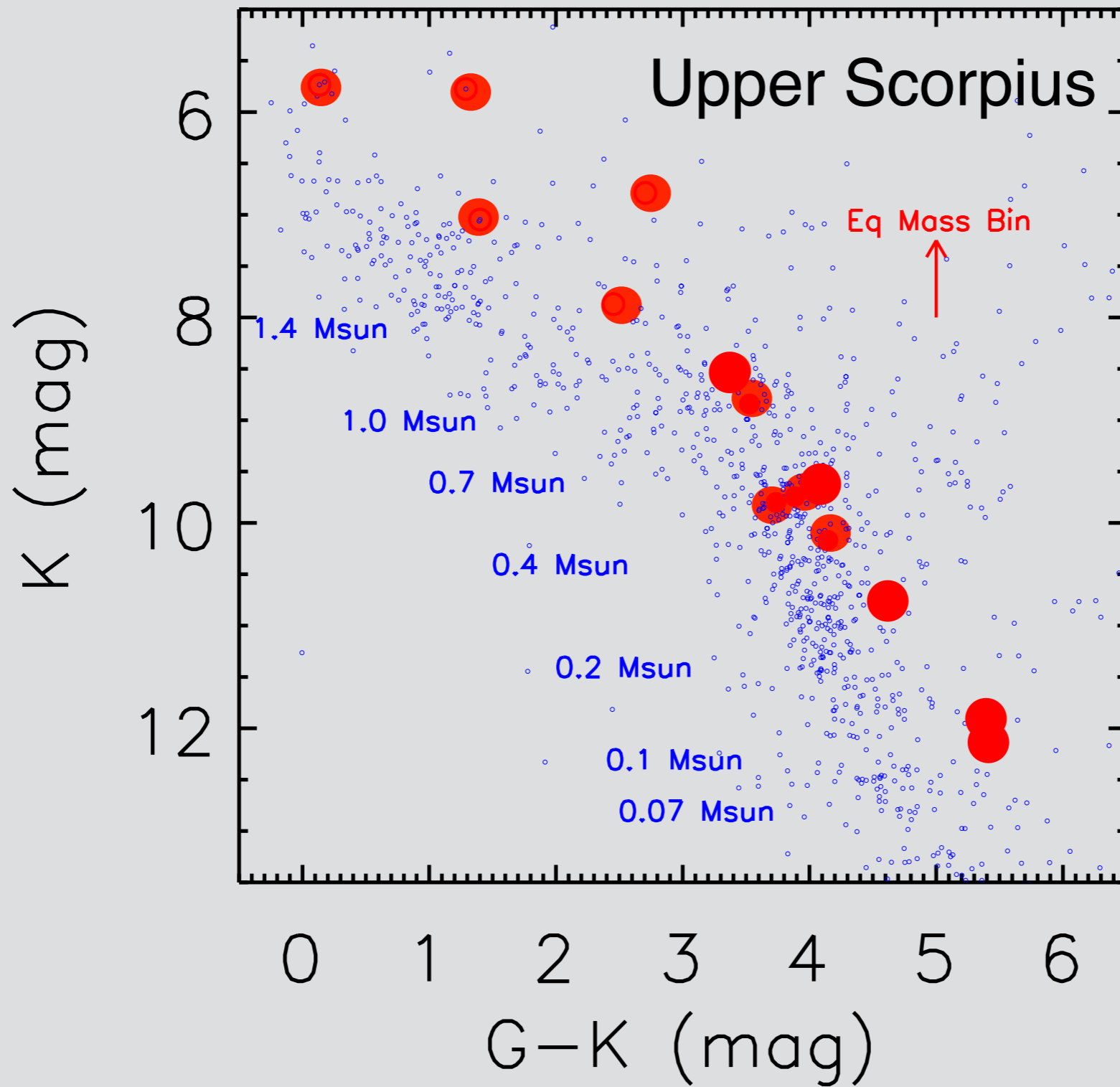


How good are our assigned stellar parameters for each cluster/age?

Lots of Eclipsing Binaries in the same Clusters

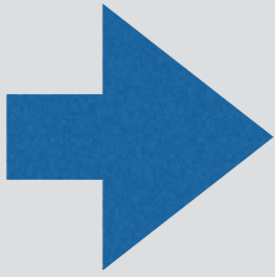


Sample Spans Parameter Space

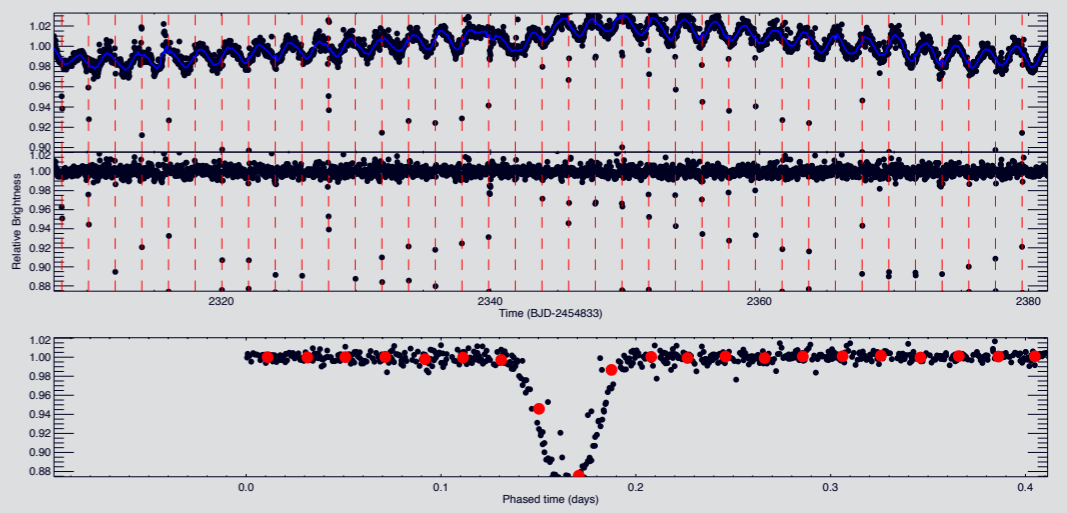




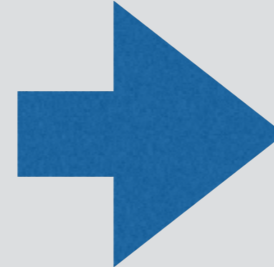
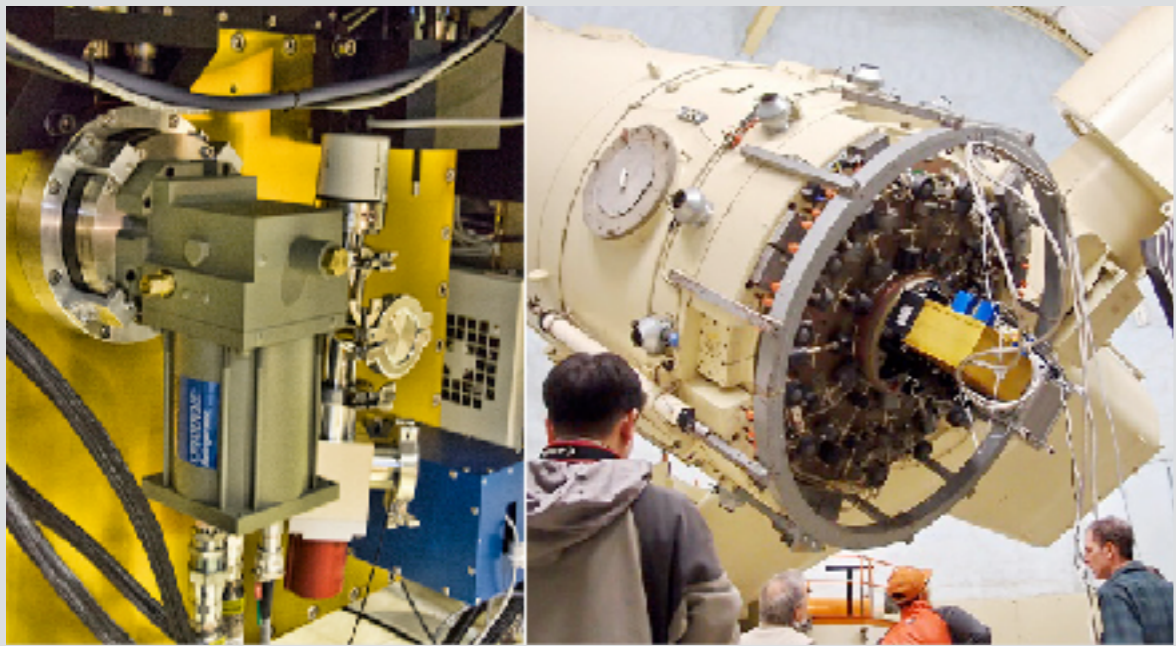
K2



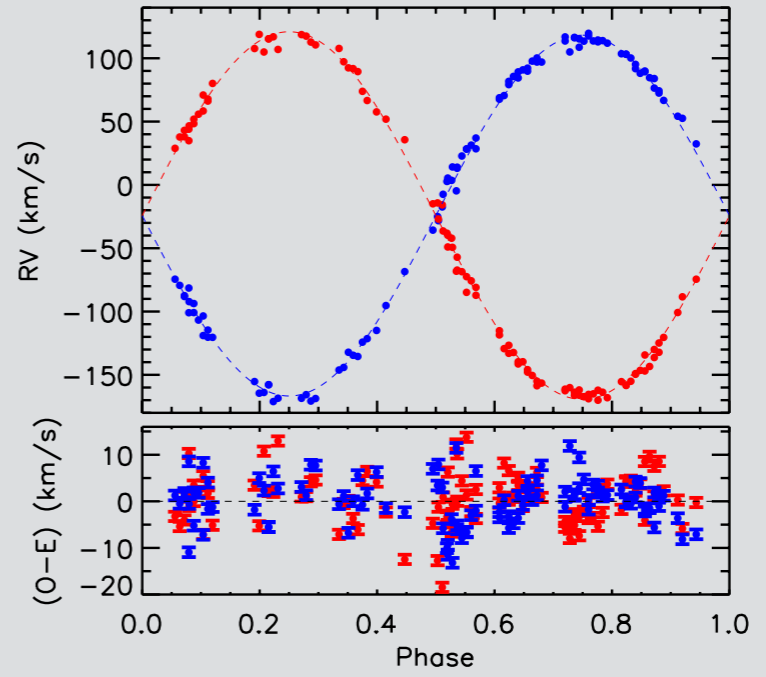
discovery +
light curve



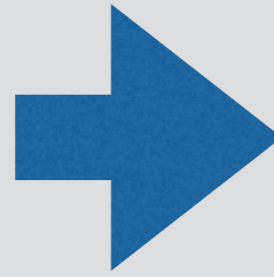
Harlan J. Smith/IGRINS



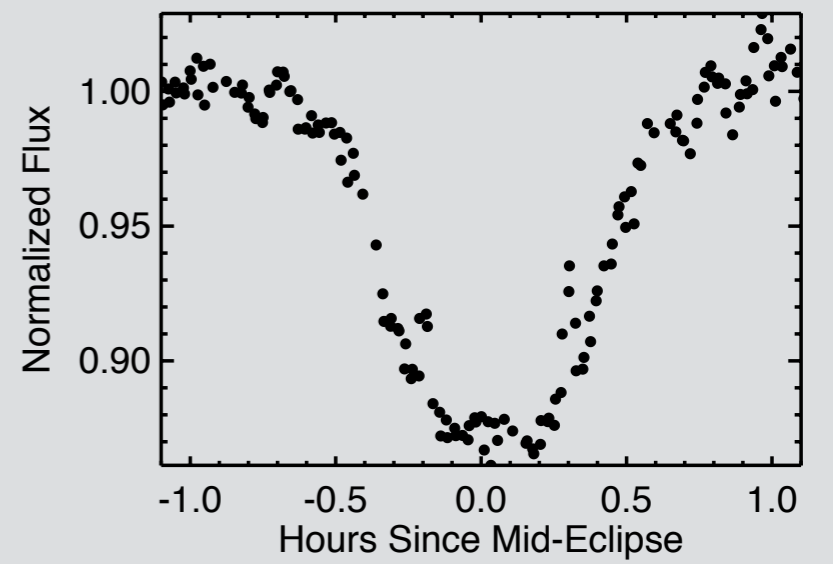
Radial Velocities



LCO

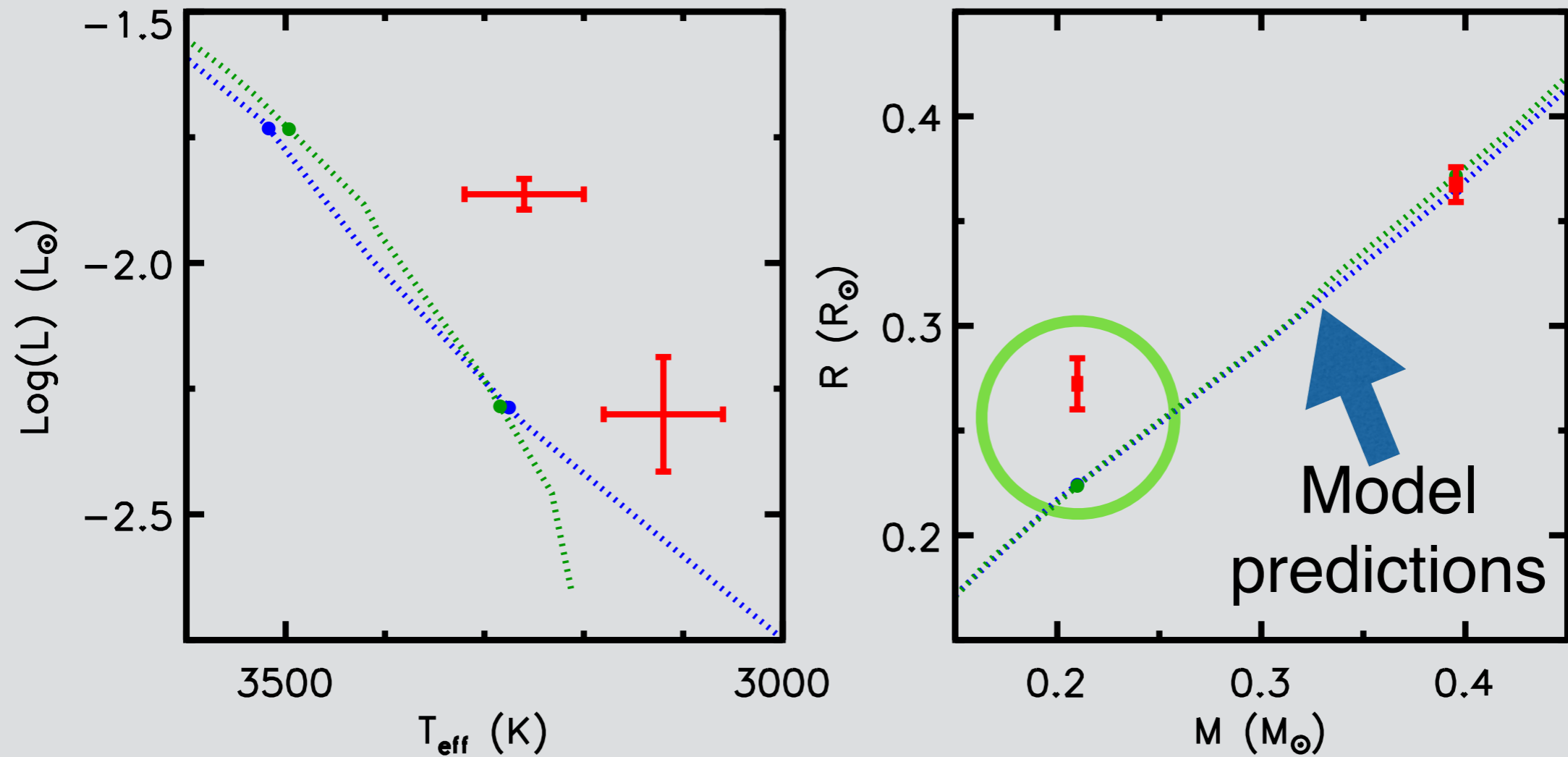


multi-wavelength
light curves

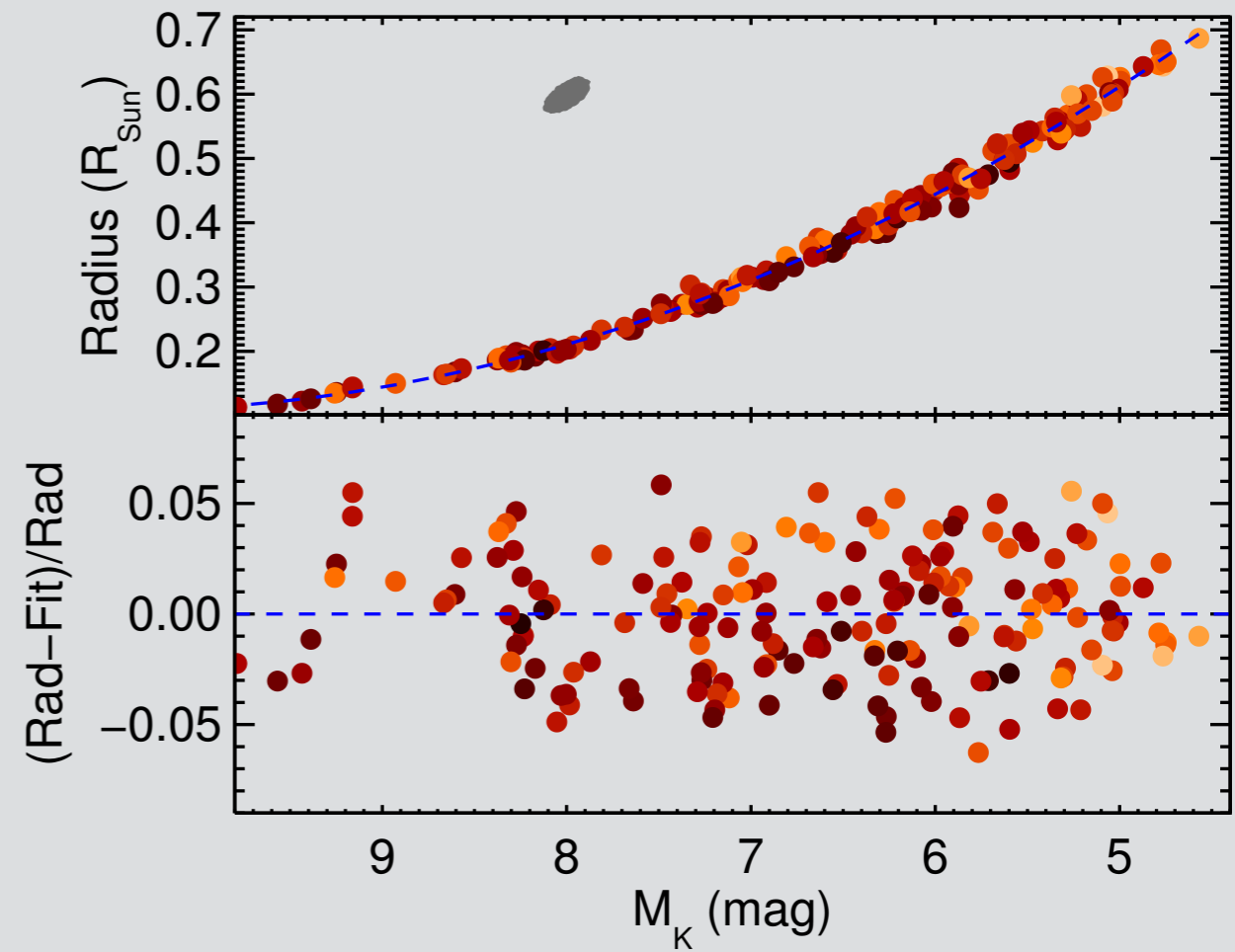
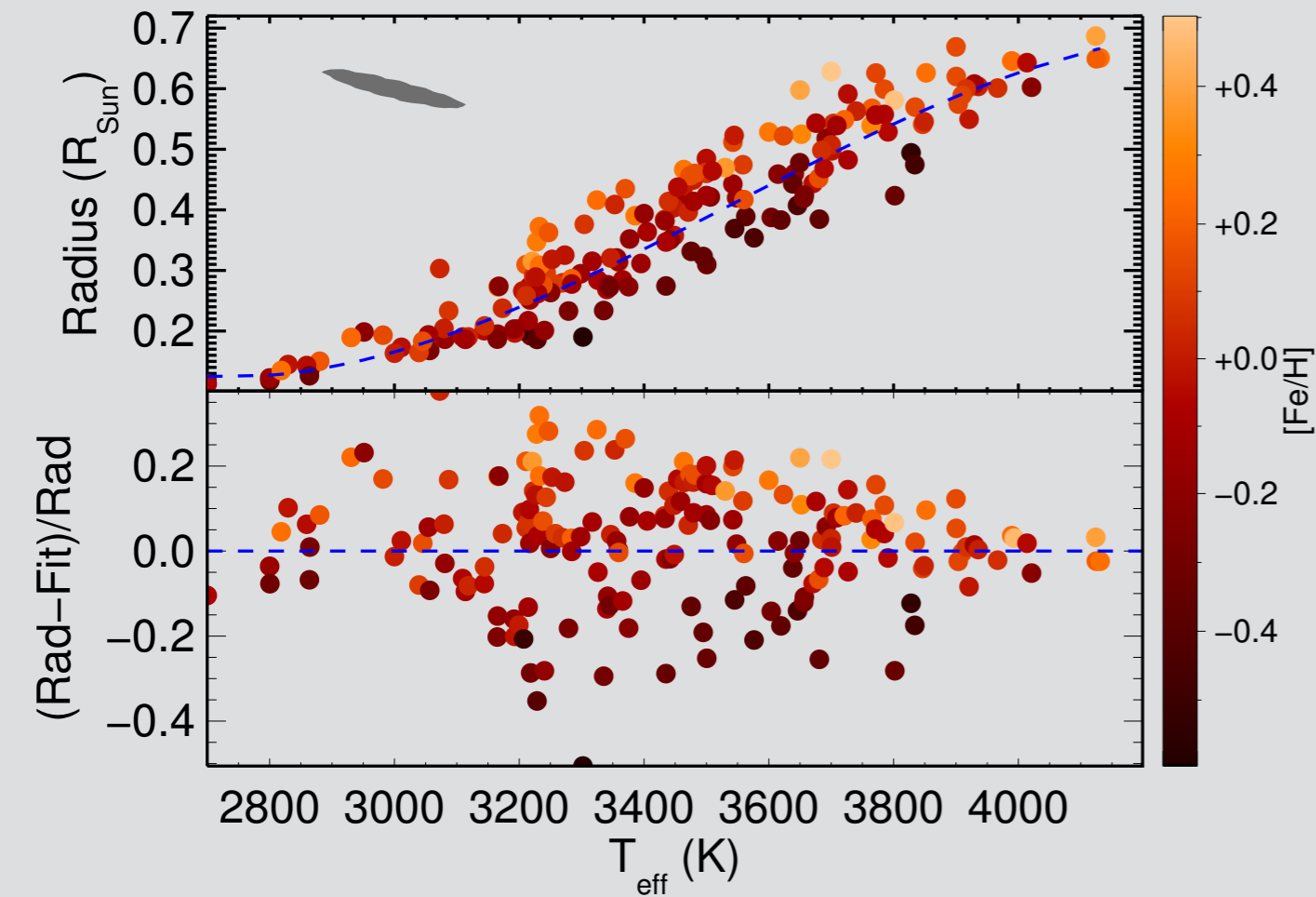


Early results show tension with models

Praesepe

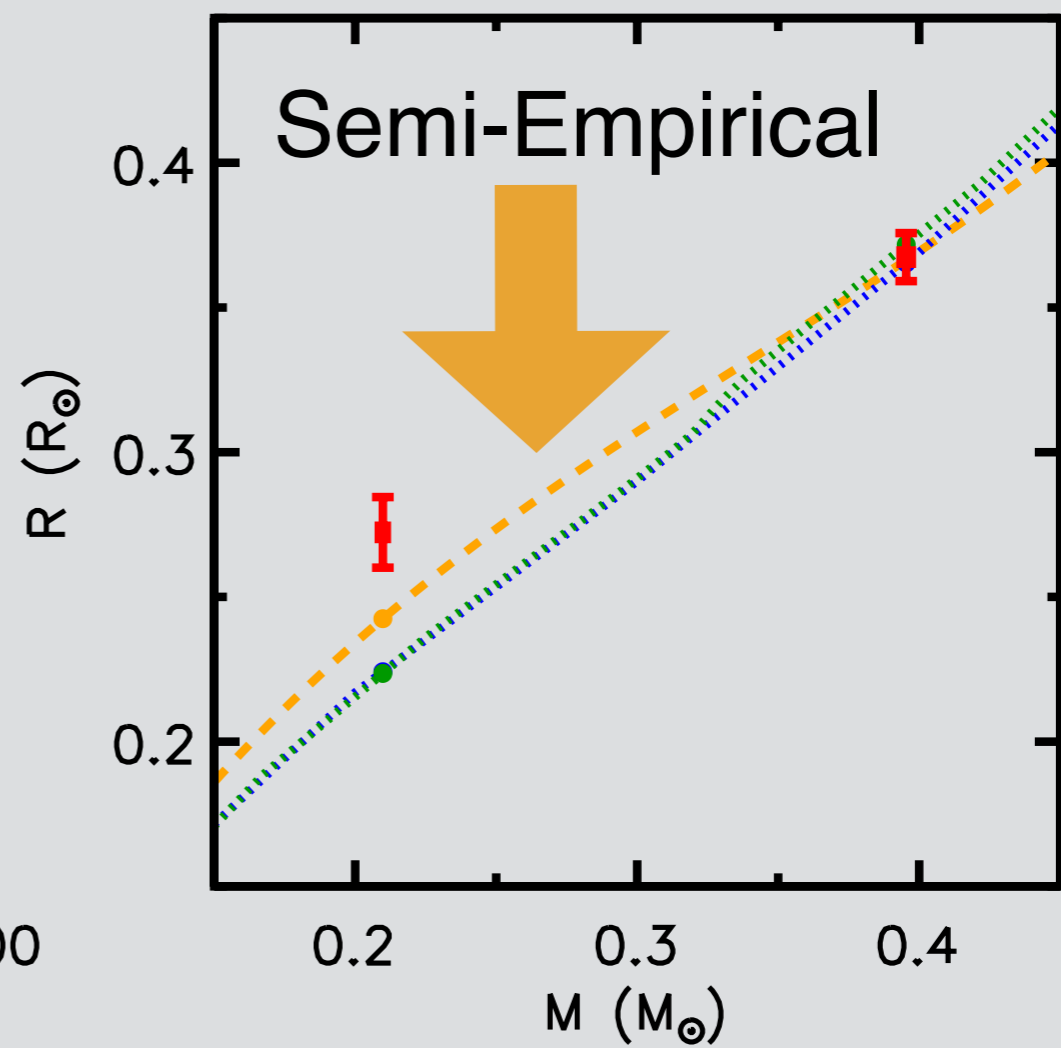
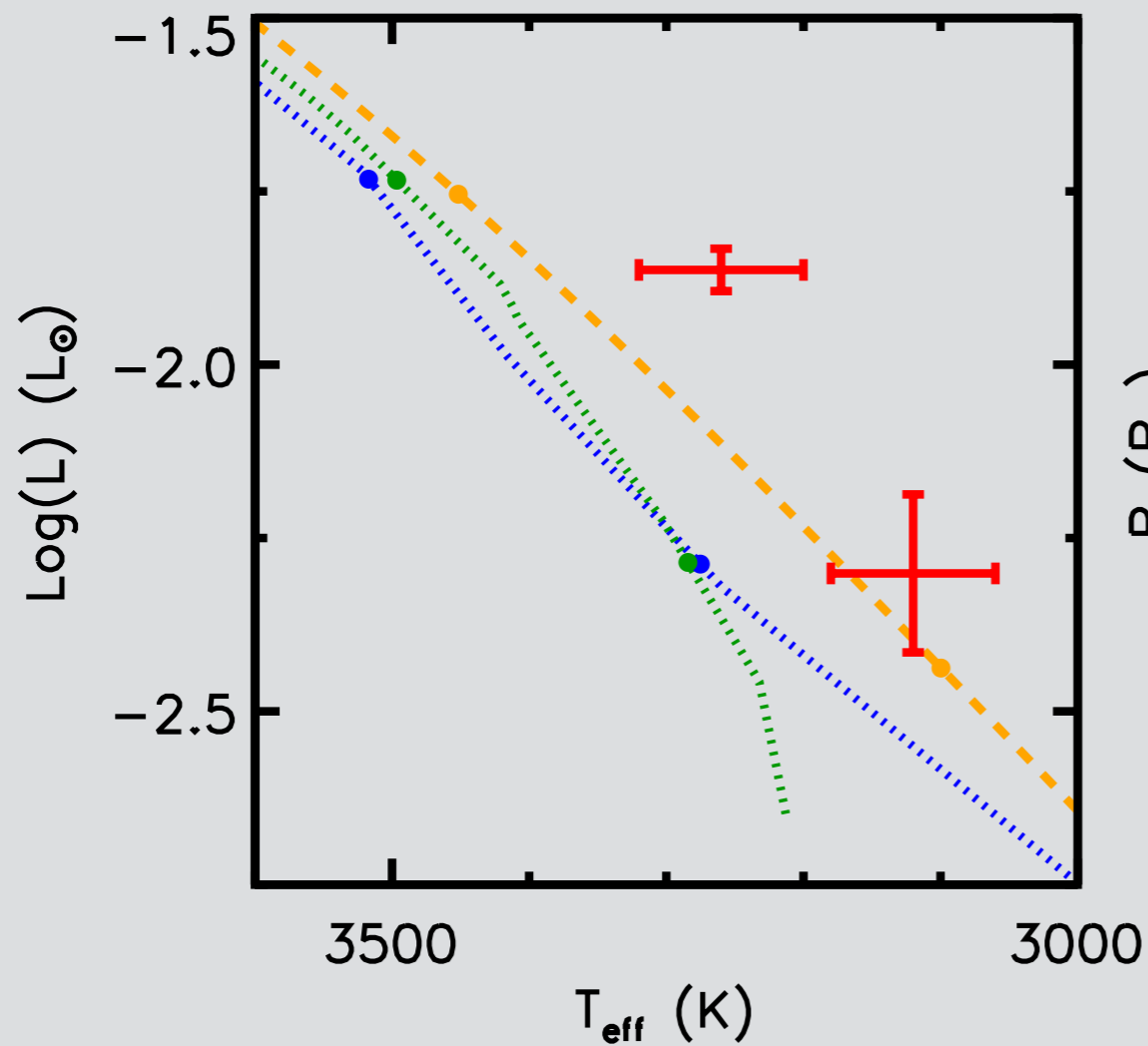


We actually use a semi-empirical approach



The relations we use for planet hosts looks better

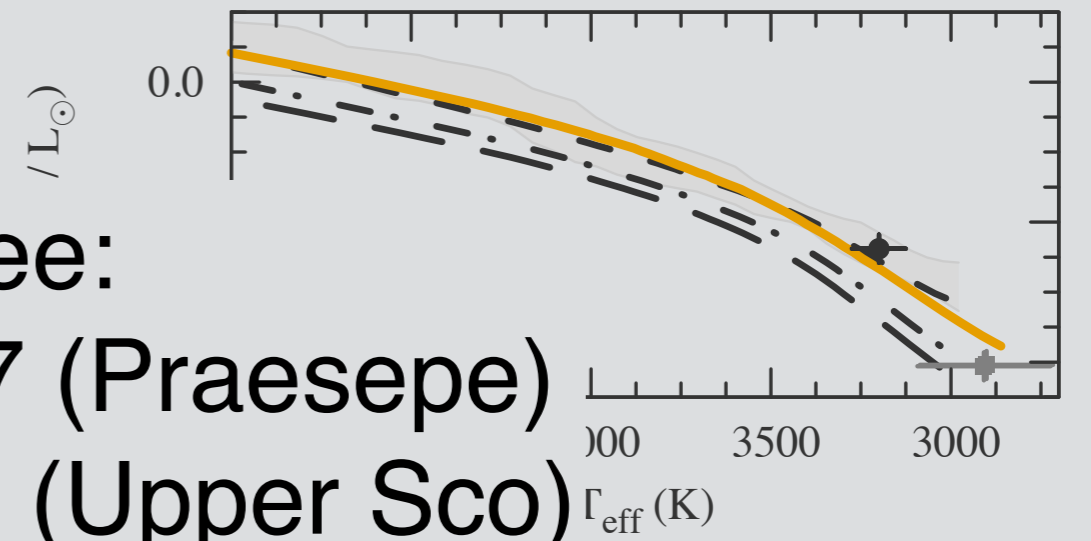
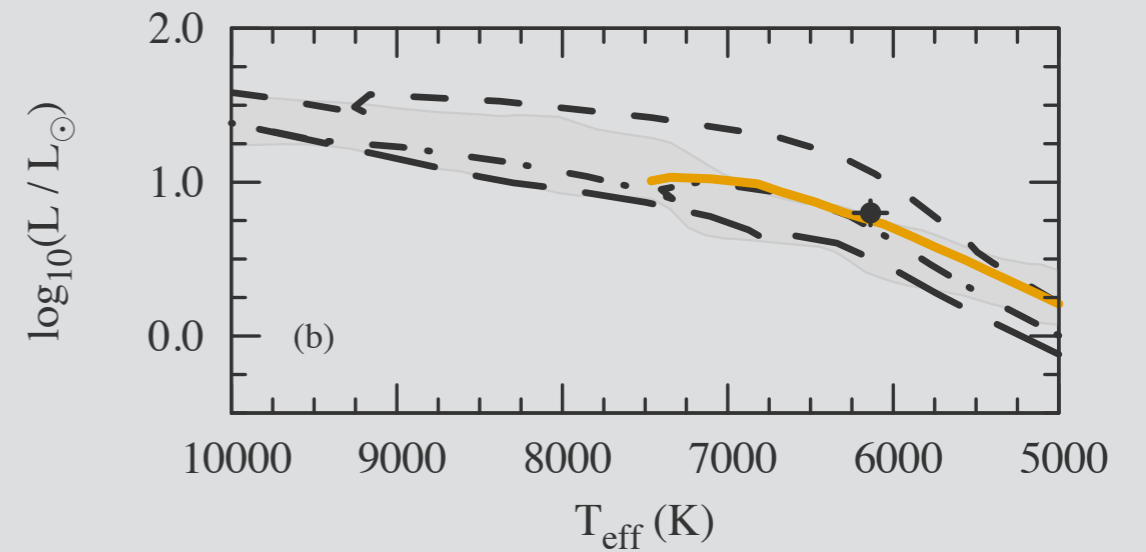
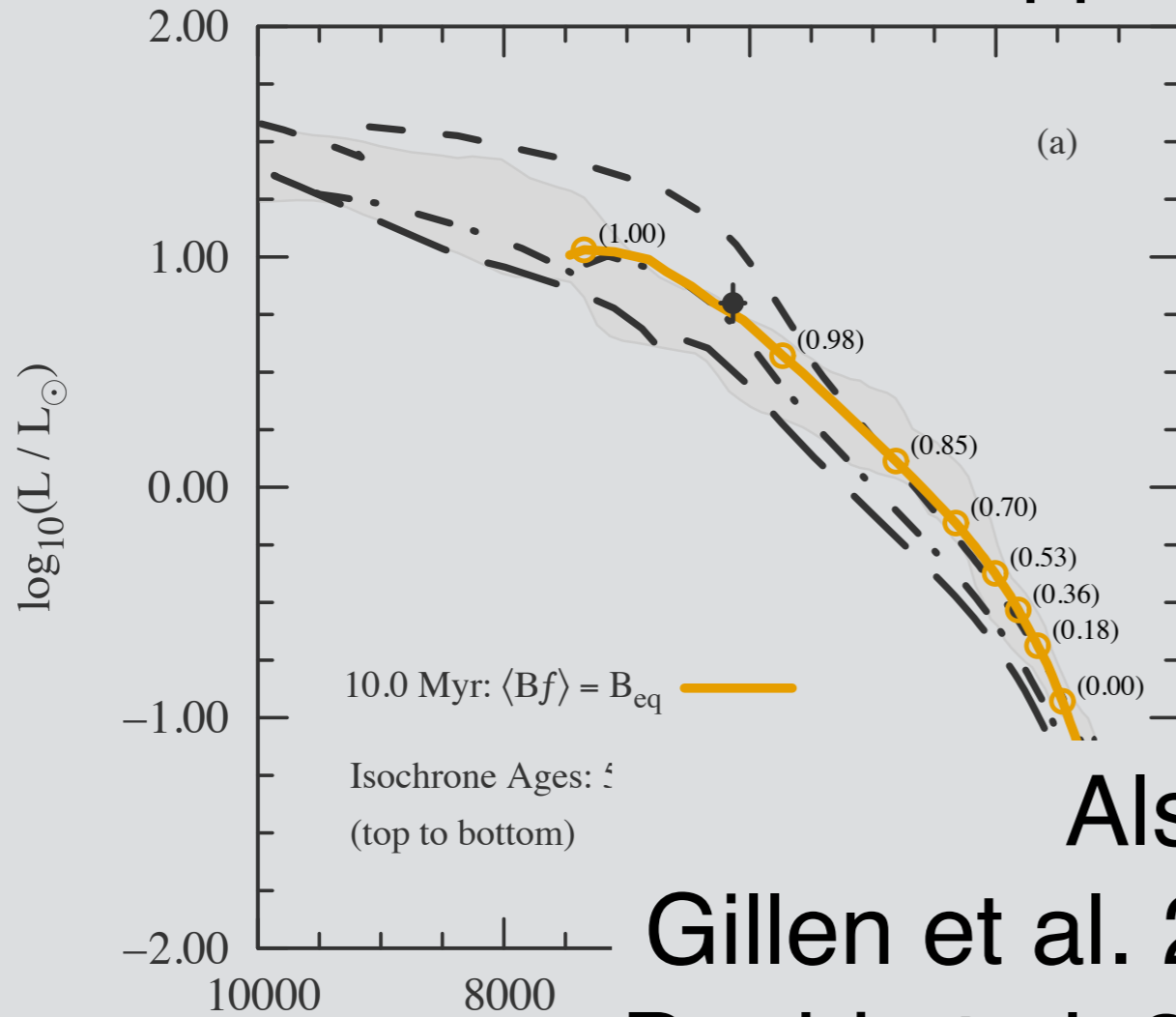
Praesepe



Mann et al. (2015b)
Kraus et al. (2017)

Including for the pre-main-sequence stars

Upper Scorpius



Also see:

Gillen et al. 2017 (Praesepe)

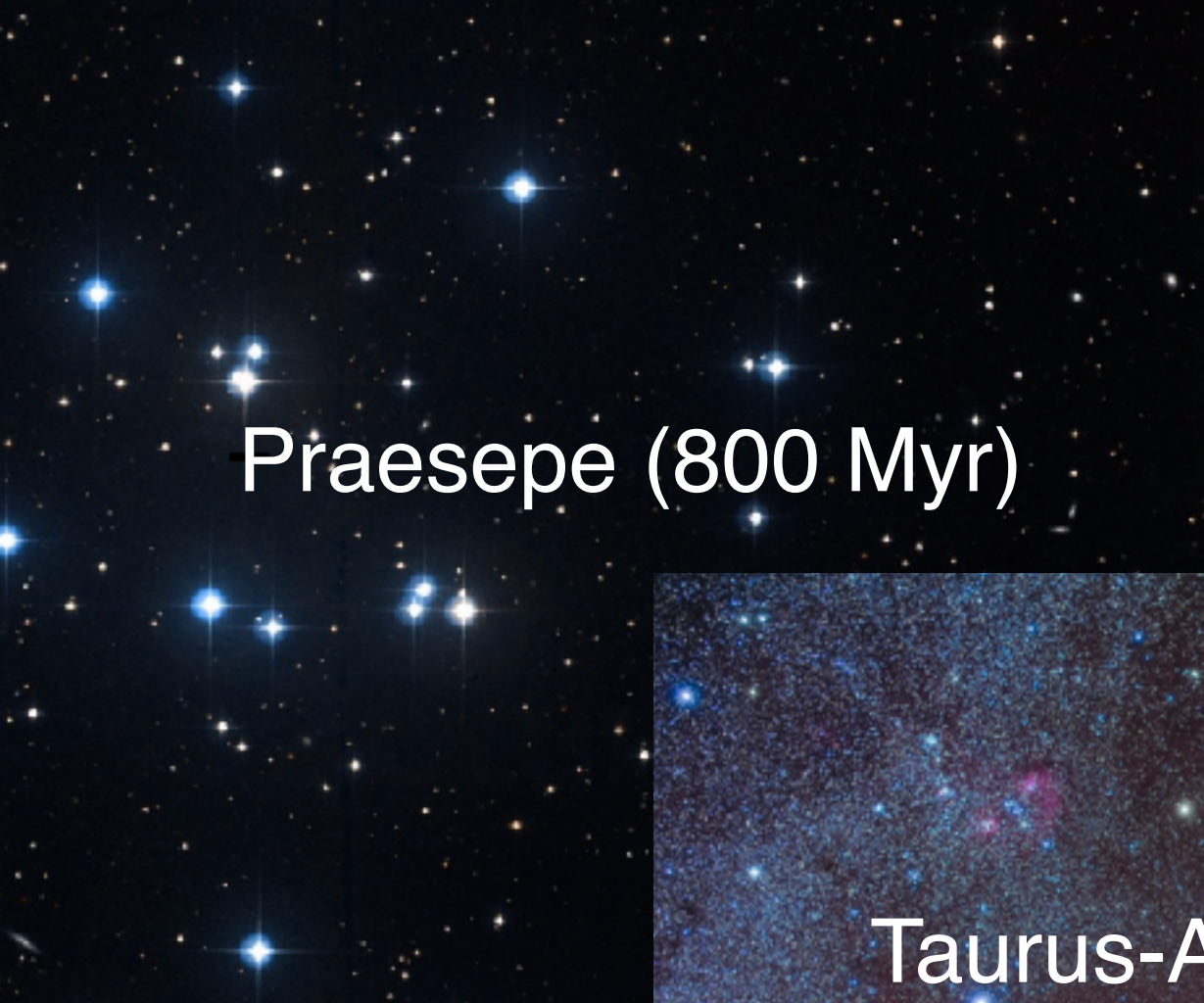
David et al. 2015 (Upper Sco)

Mann et al. (2016a)


Feiden et al. (2016)

Kraus et al. (2015)

Begin bonus
slides

A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.


Praesepe (800 Myr)

A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.


Hyades (800 Myr)

A dense field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Taurus-Auriga (0-5 Myr)

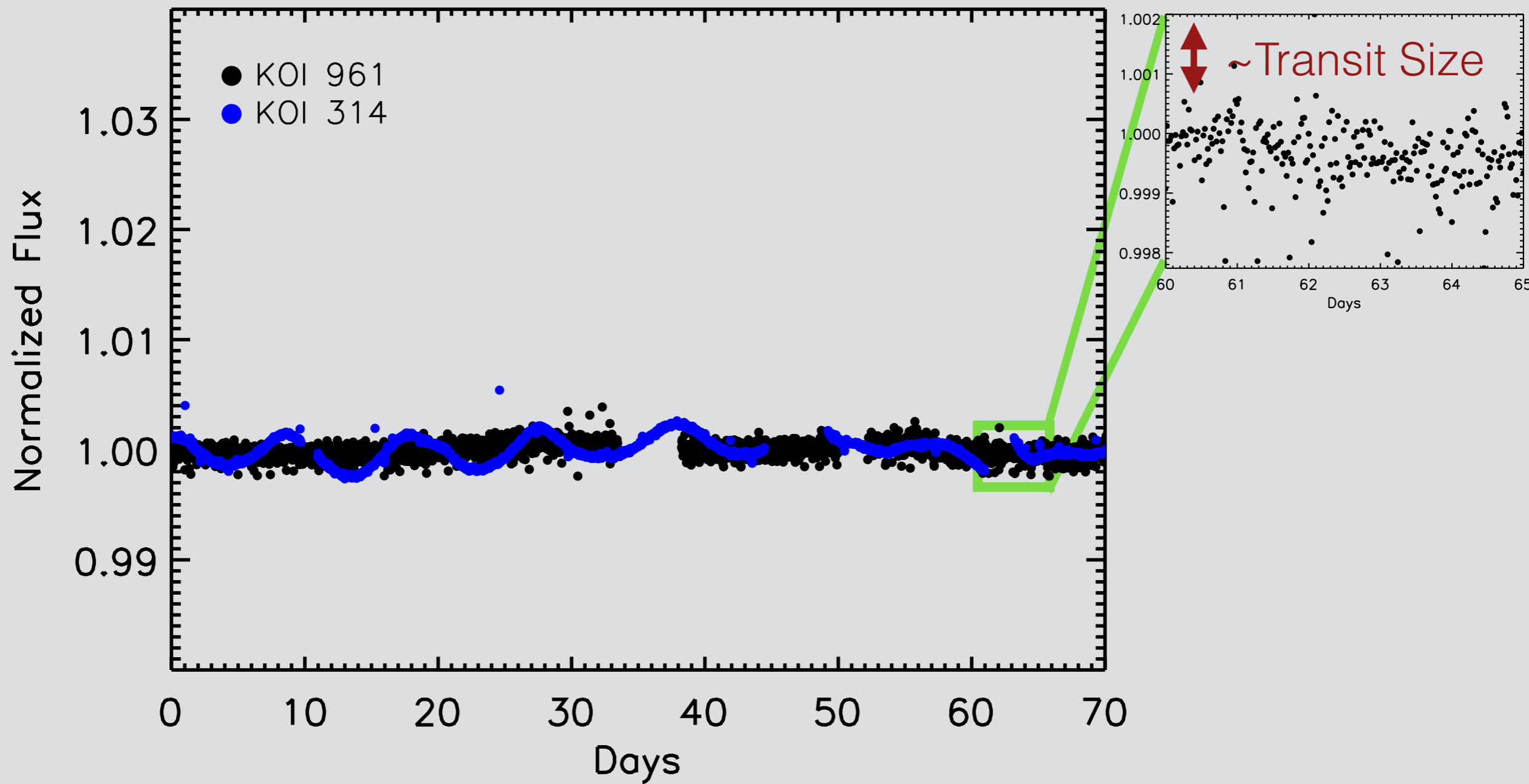
A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Pleiades (125 Myr)

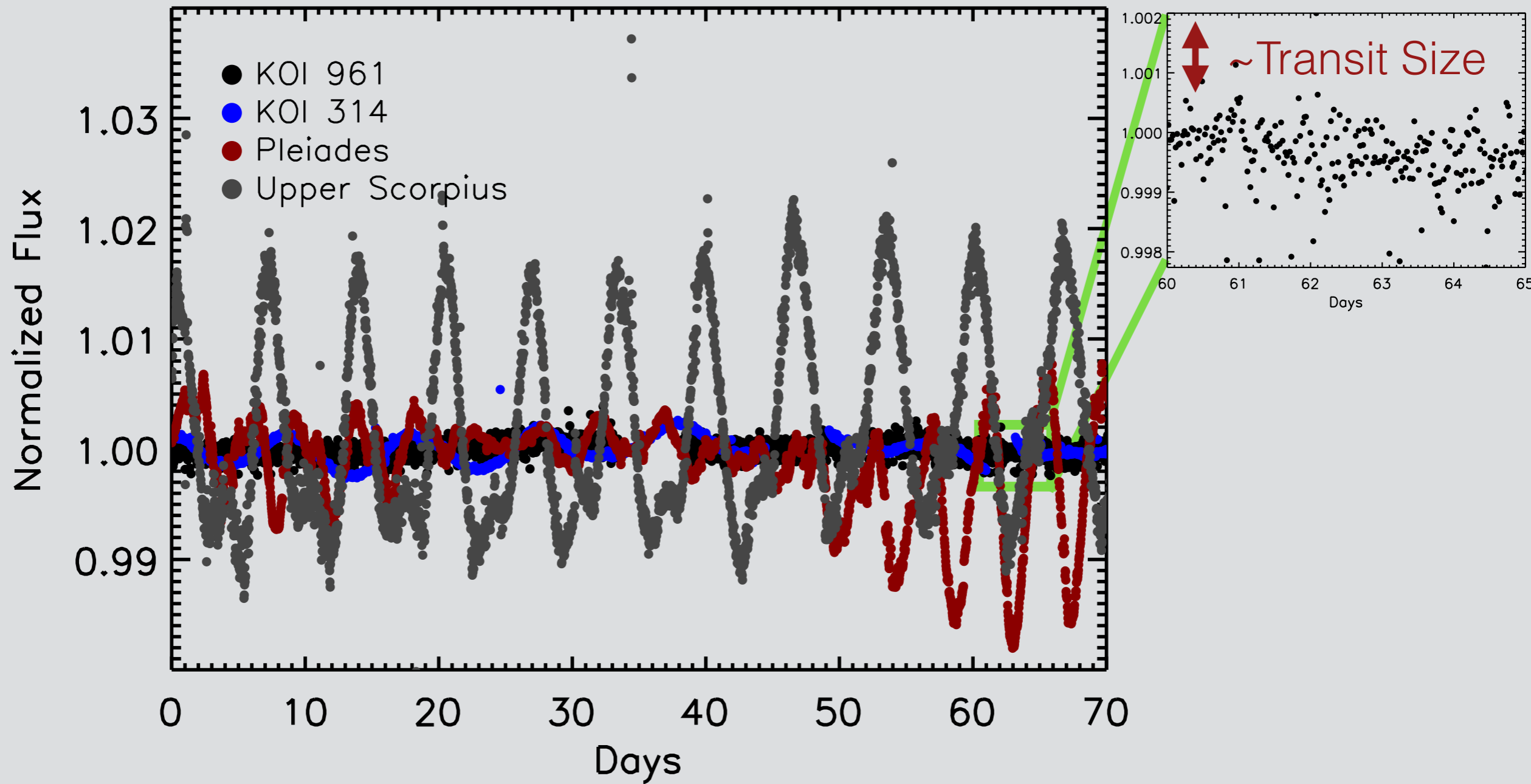
A field of stars, primarily blue and white, with some yellow and orange stars scattered throughout. The stars are of various sizes and brightness, set against a dark background.

Upper Scorpius
(11 Myr)

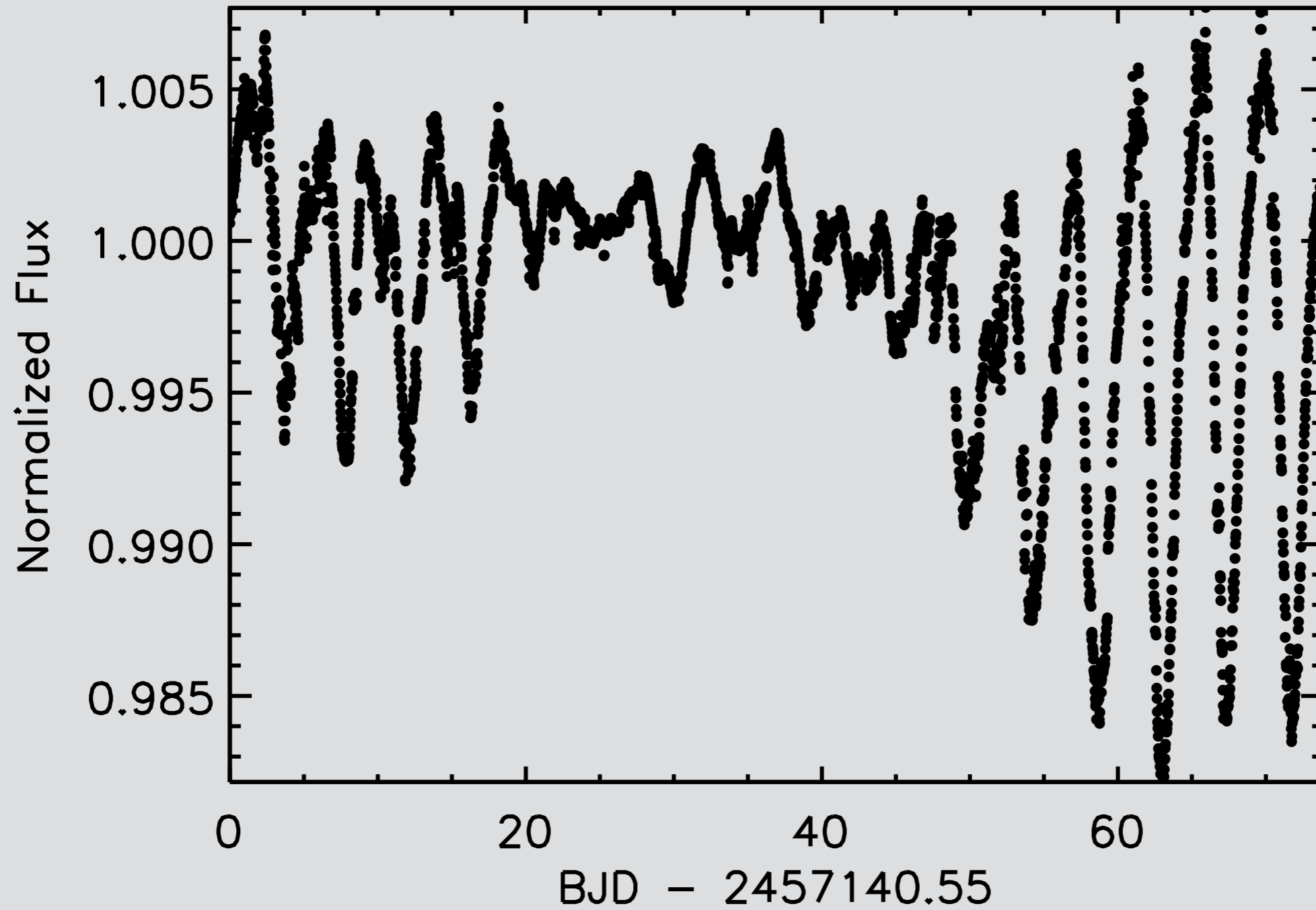
Stellar variability for old stars



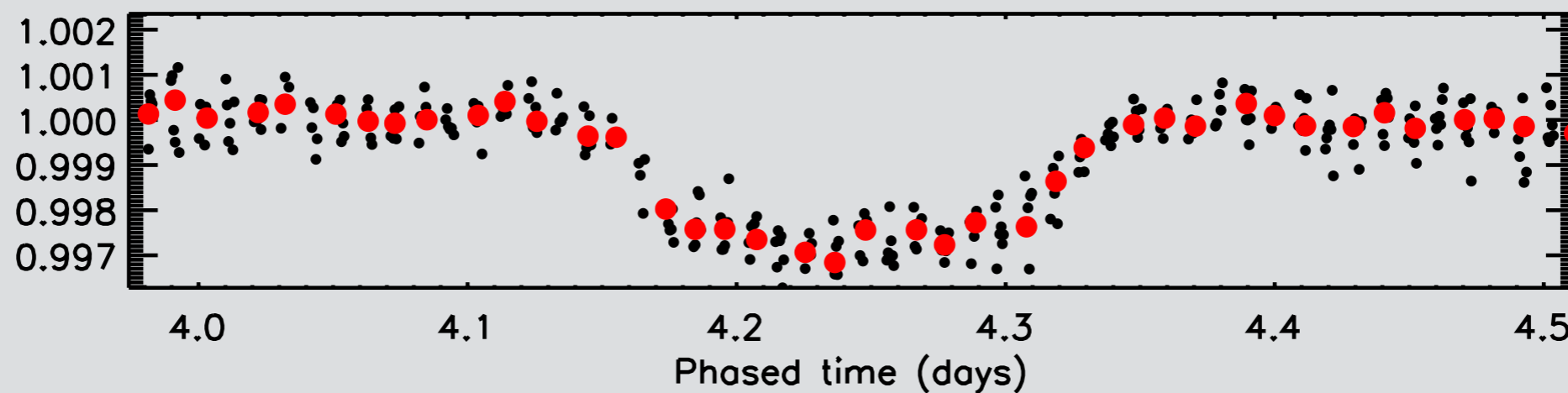
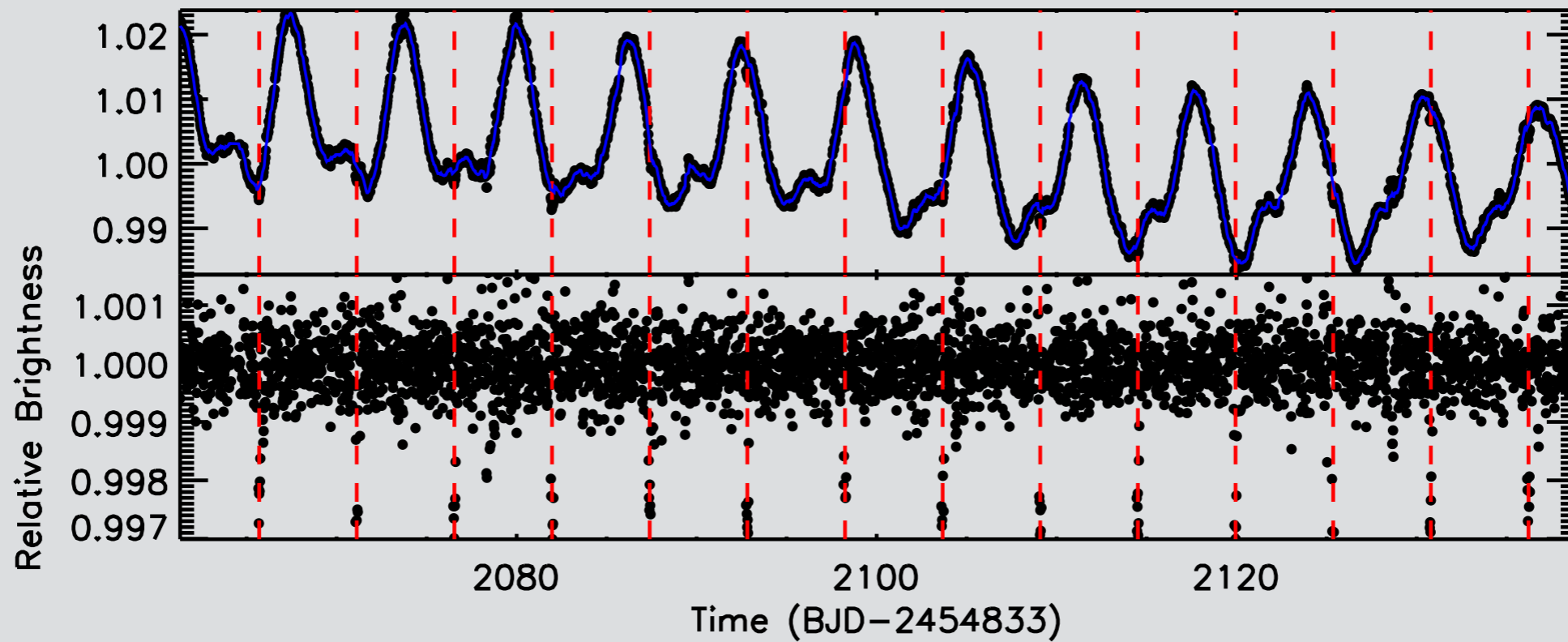
Compared to variability in young stars



Spots Appear and Dissapear

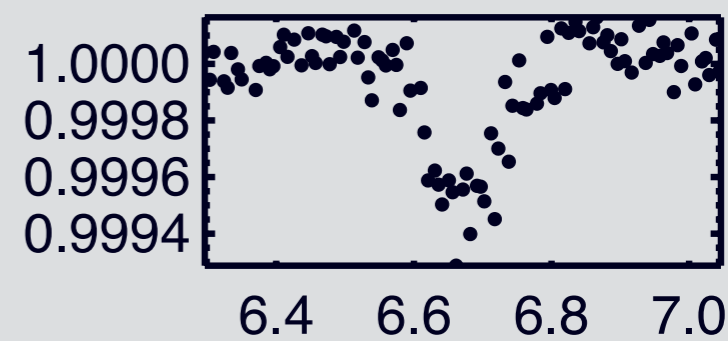
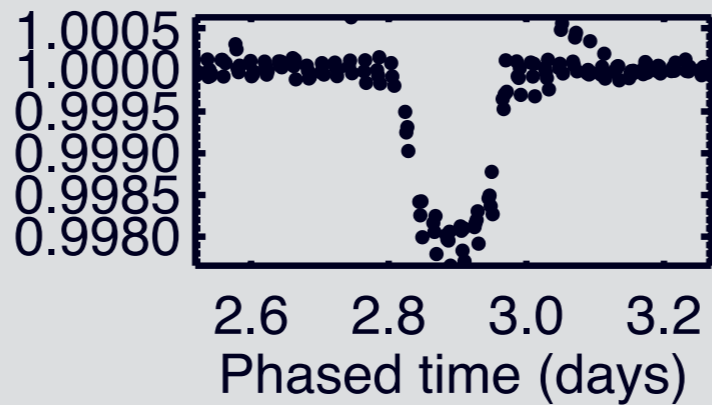
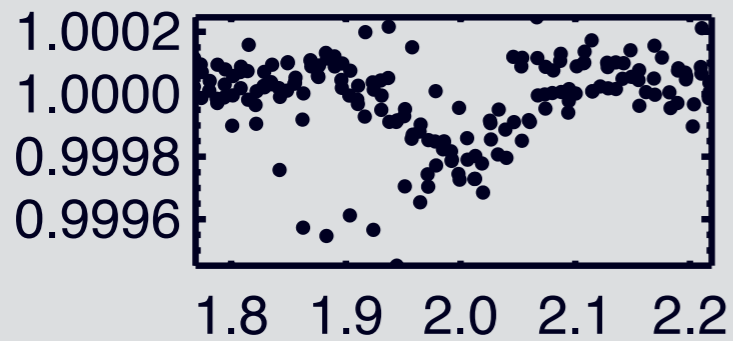
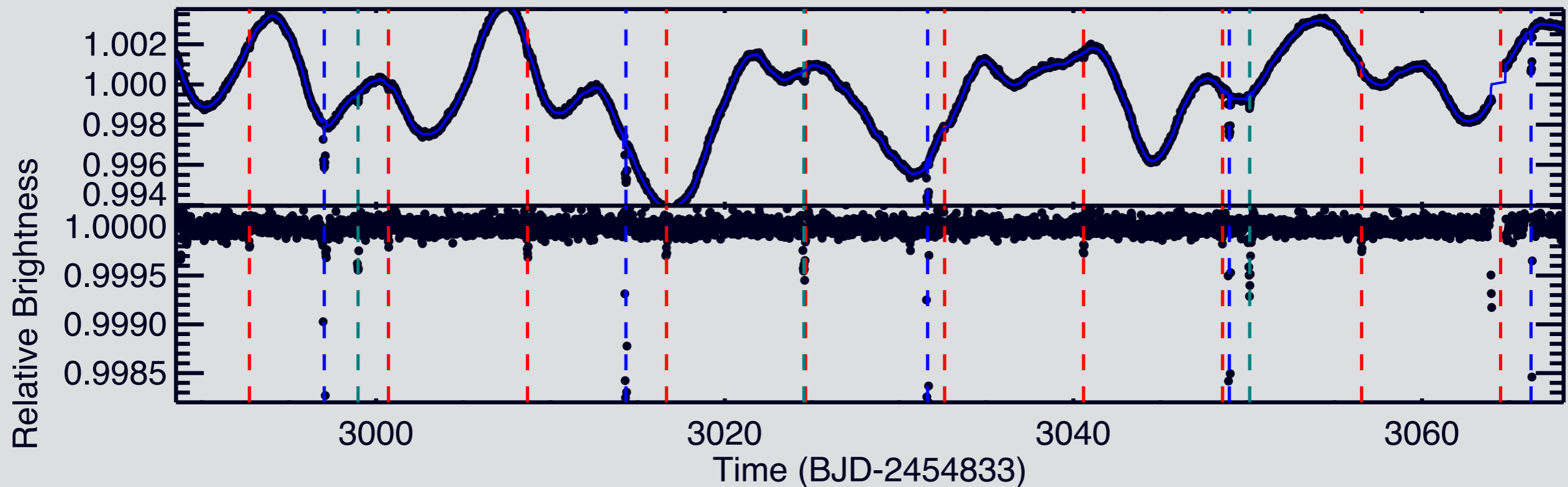


K2-33b: youngest transiting planet (~11 Myr)



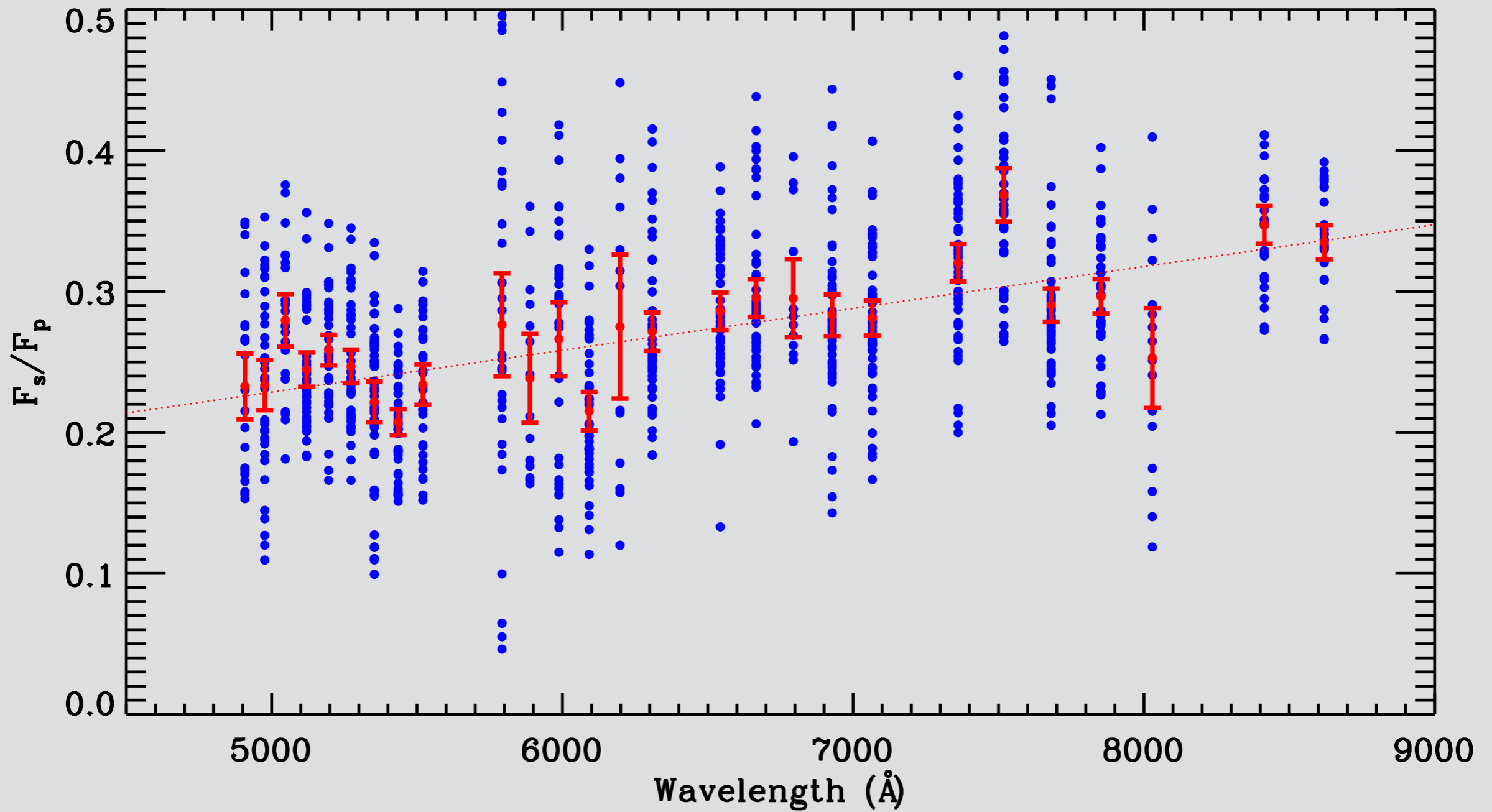
Mann et al. (2016b)
Also see David et al. (2016)

LP 358-348bcd: 3-planet system in the Hyades

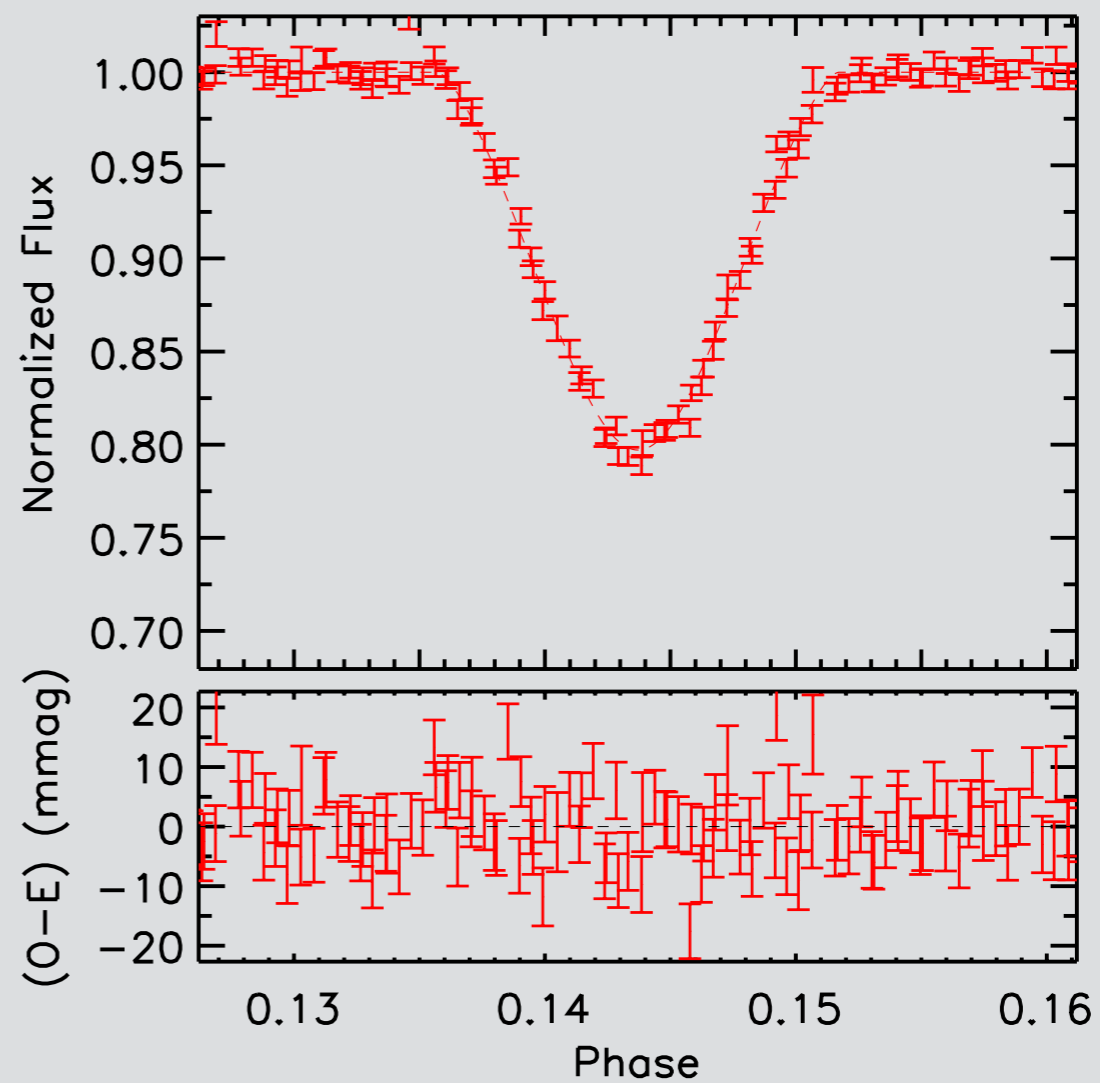
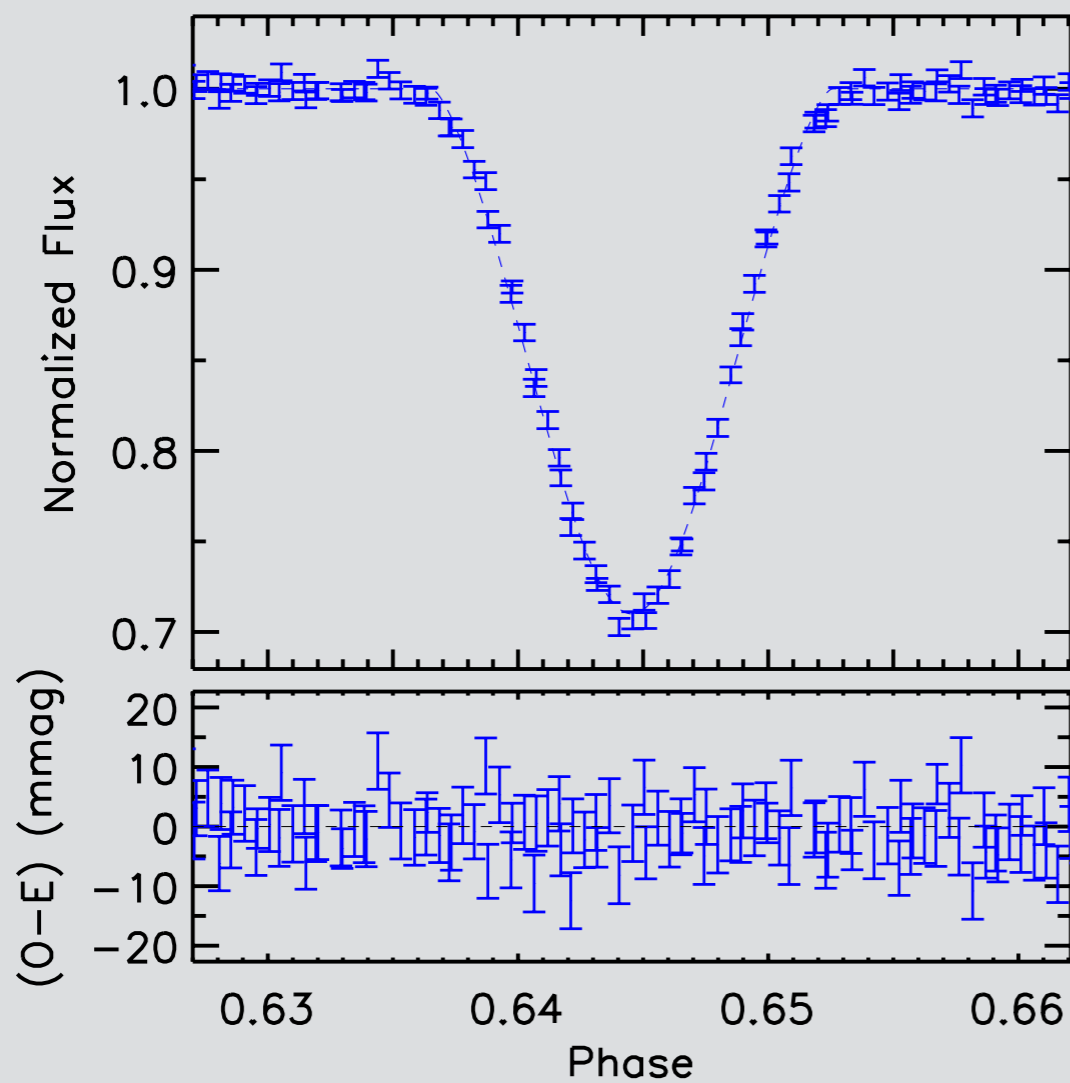


Mann et al. (2017c)
Also see Ciardi et al. (2017)

Flux Ratios from SB2 Spectra



Light Curve Analysis



Fit the unresolved spectra with two templates

