

Understanding Giant Planet Migration with TESS



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Future Faculty Leaders Postdoctoral Fellow
Center for Astrophysics | Harvard & Smithsonian
07/30/2019 TESS Science Conference



CENTER FOR **ASTROPHYSICS**
HARVARD & SMITHSONIAN



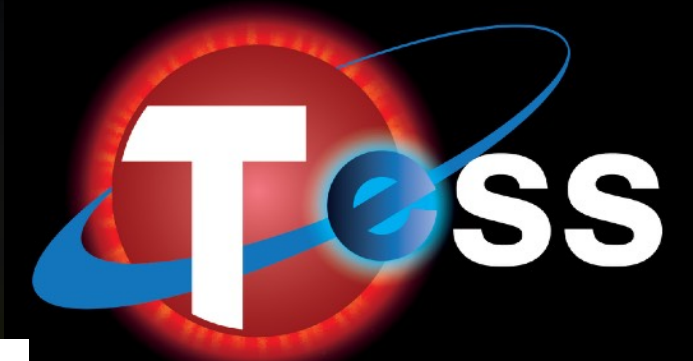
@Astro_JRod

Understanding Giant Planet Migration with TESS for FREE!



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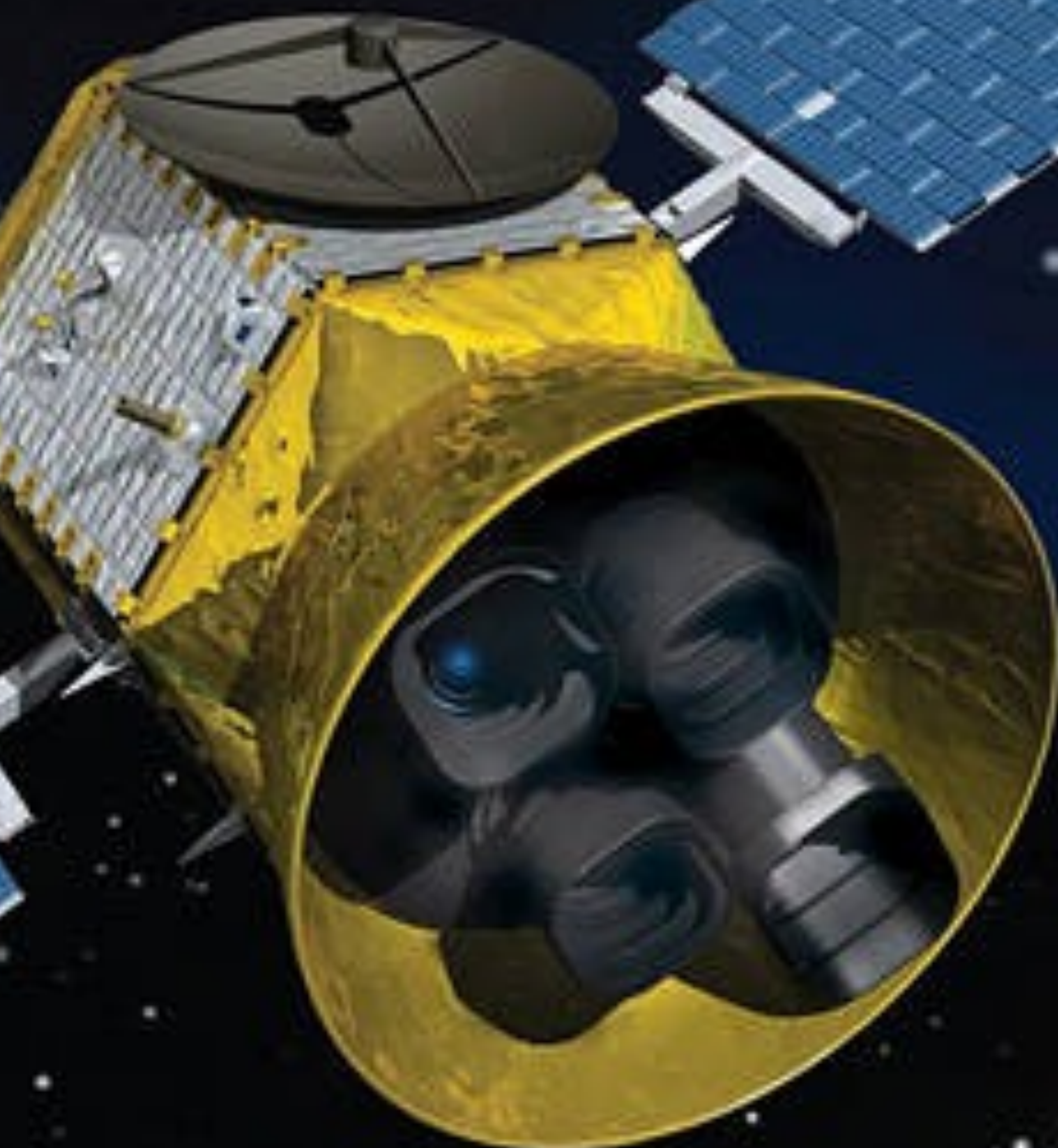


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@Astro_JRod

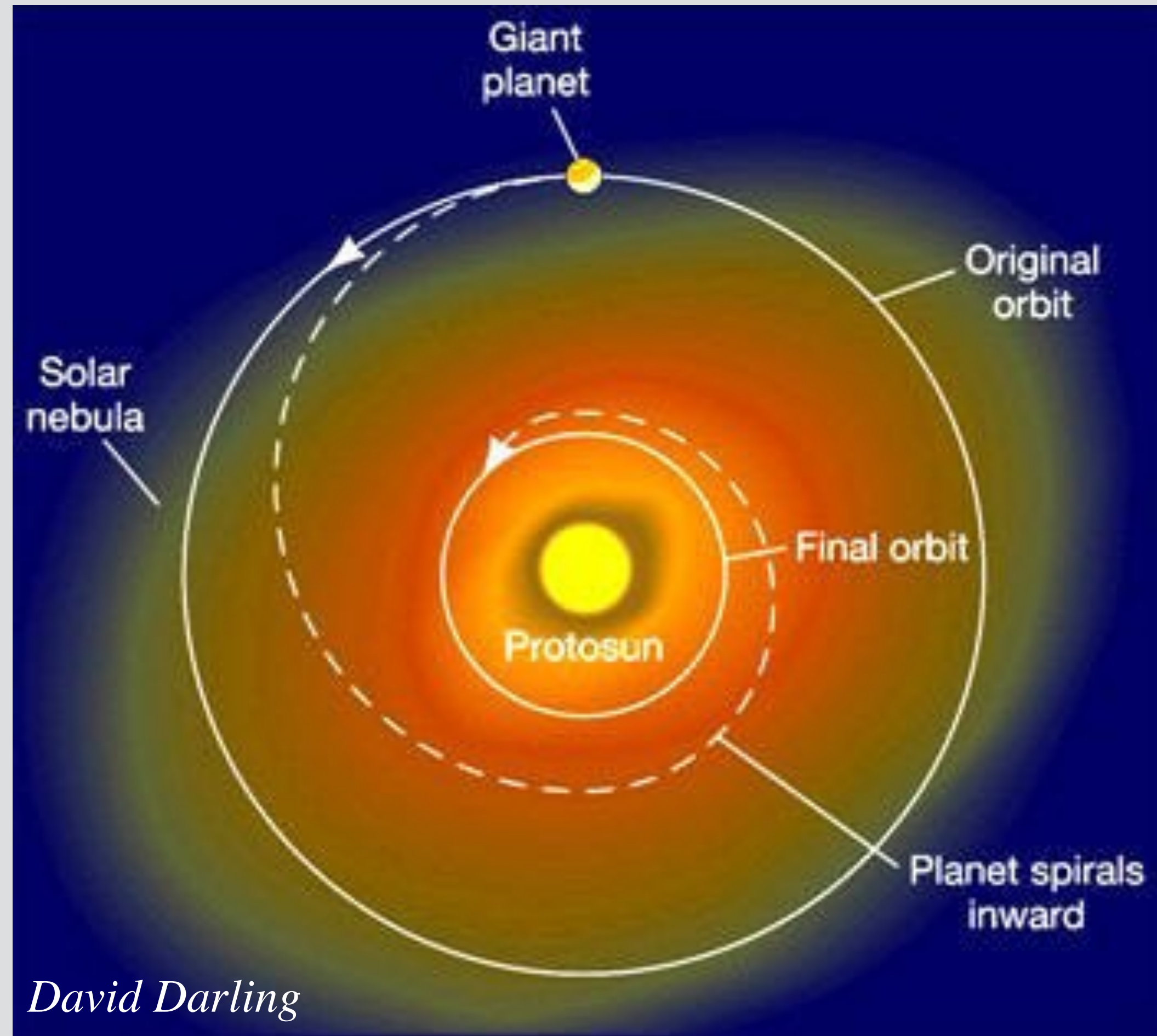
Other TESS Efforts



- K2 + TESS Synergy
(Poster #106 by: M. Ikwut-Ukwa)
- Understanding Brown Dwarfs
(Talk by: T. Carmichael)
- Single Transits with TESS + KELT
(Talk by: X. Yao)

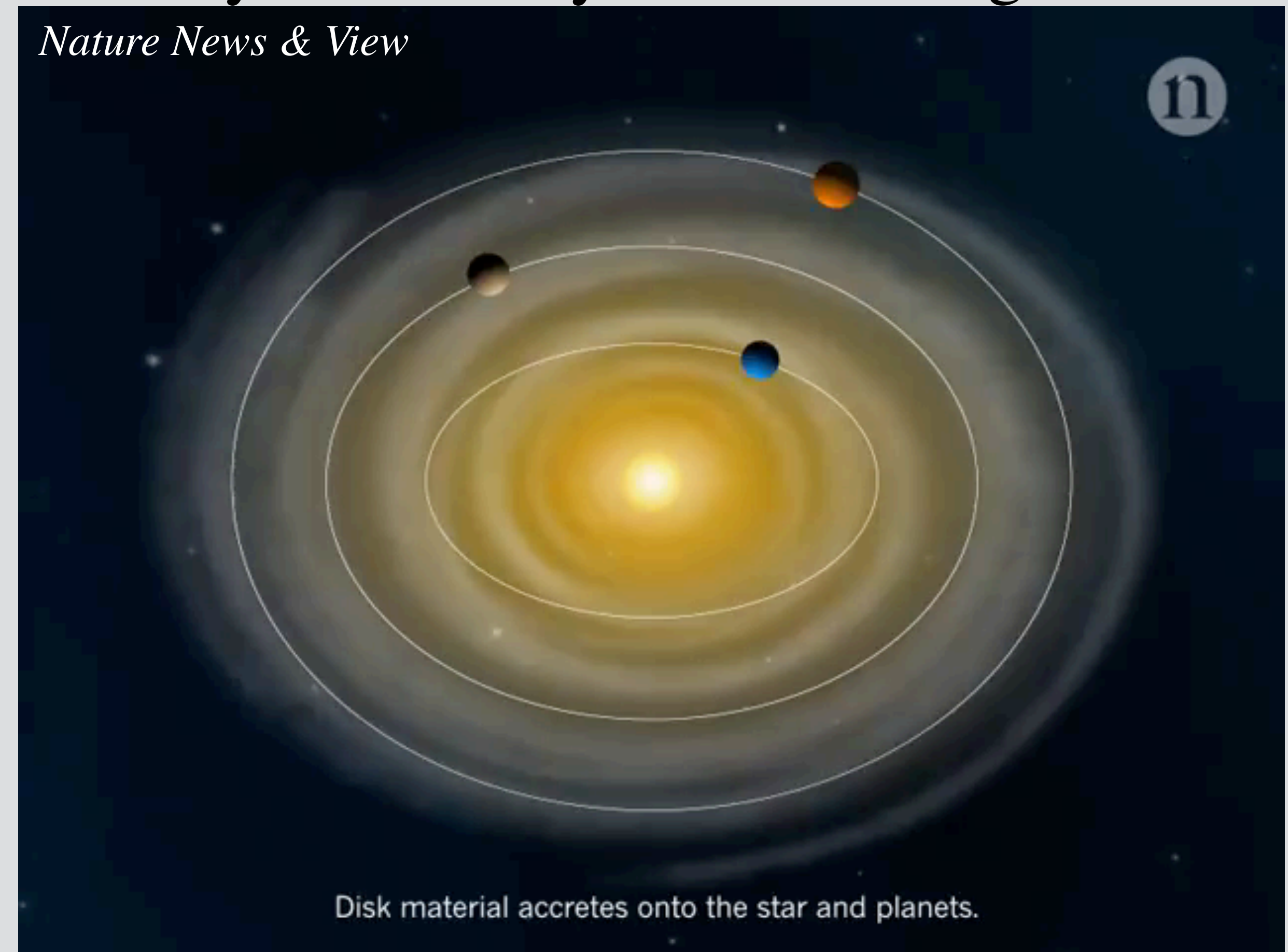
Giant Planet Migration: Smooth or Dynamic?

Smooth = ~~Circular~~ Circular/Aligned



Goldreich & Tremaine 1980; Lin et al. 1996; Dangelo et al. 2003

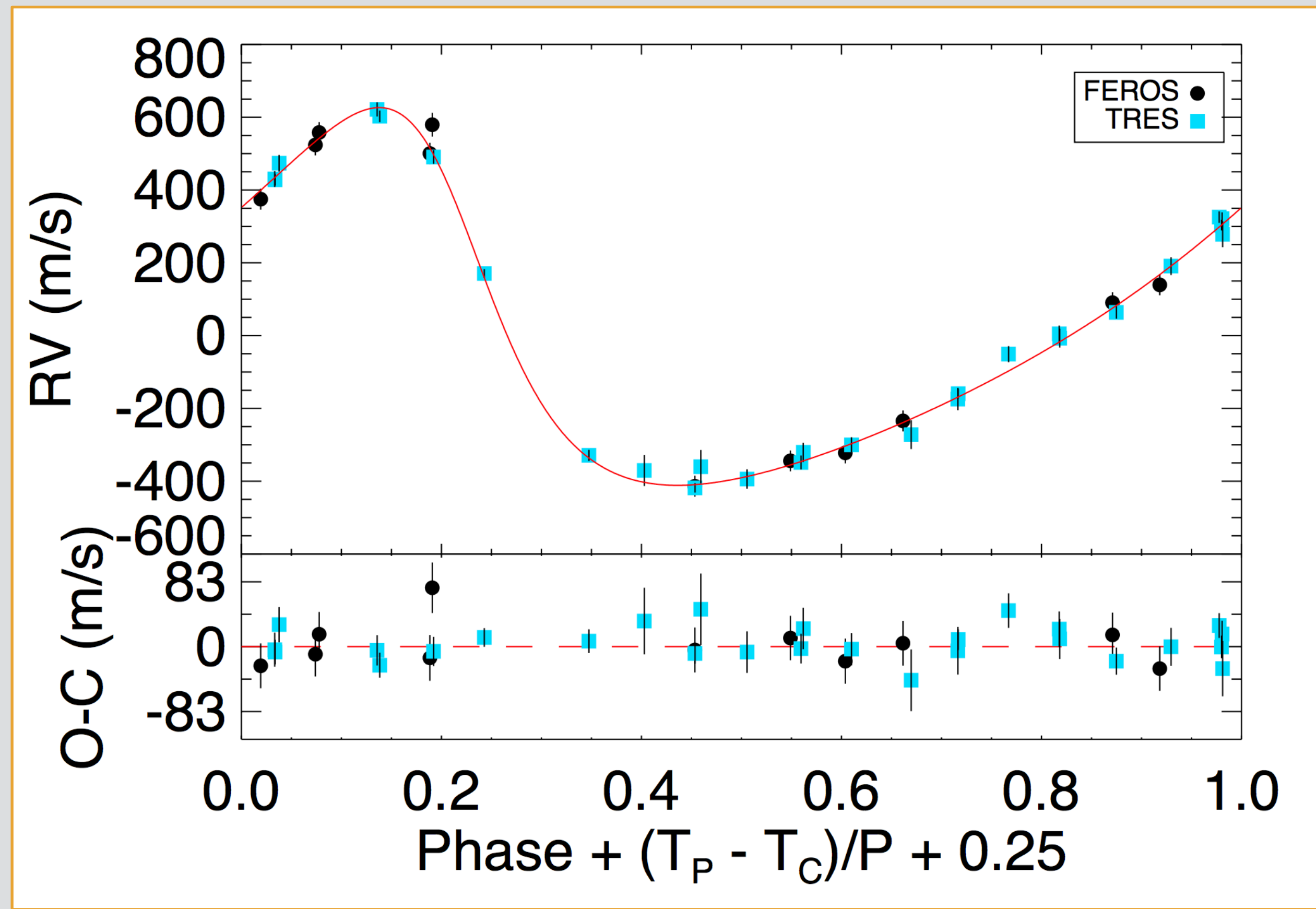
Dynamic = ~~Eccentric~~ Eccentric/Misaligned



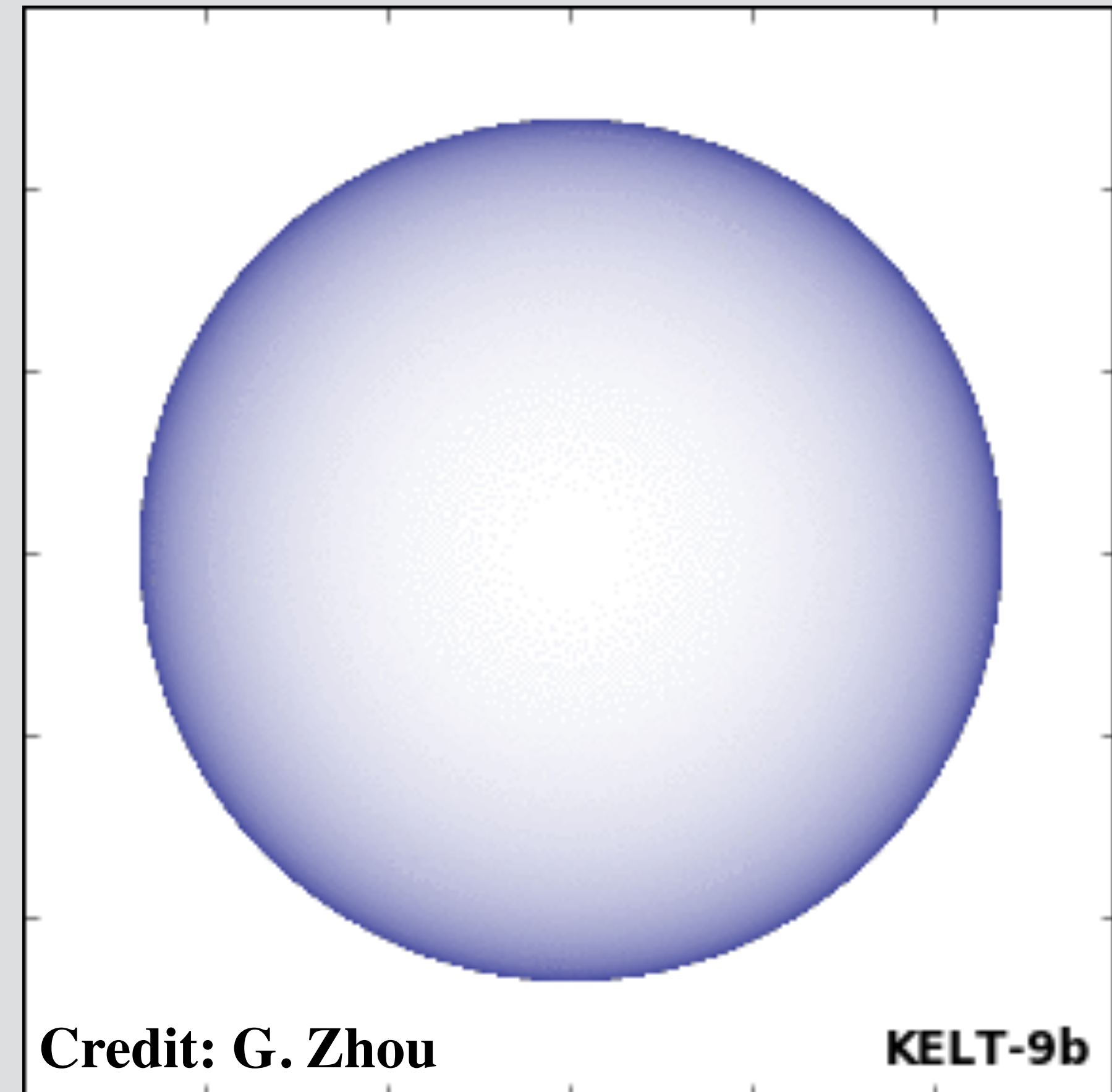
Rasio & Ford 1996; Wu et al. 2003, 2011; Fabrycky & Tremaine 2007

Giant Planet Migration: Smooth or Dynamic?

Eccentric Orbits: RV+Transit



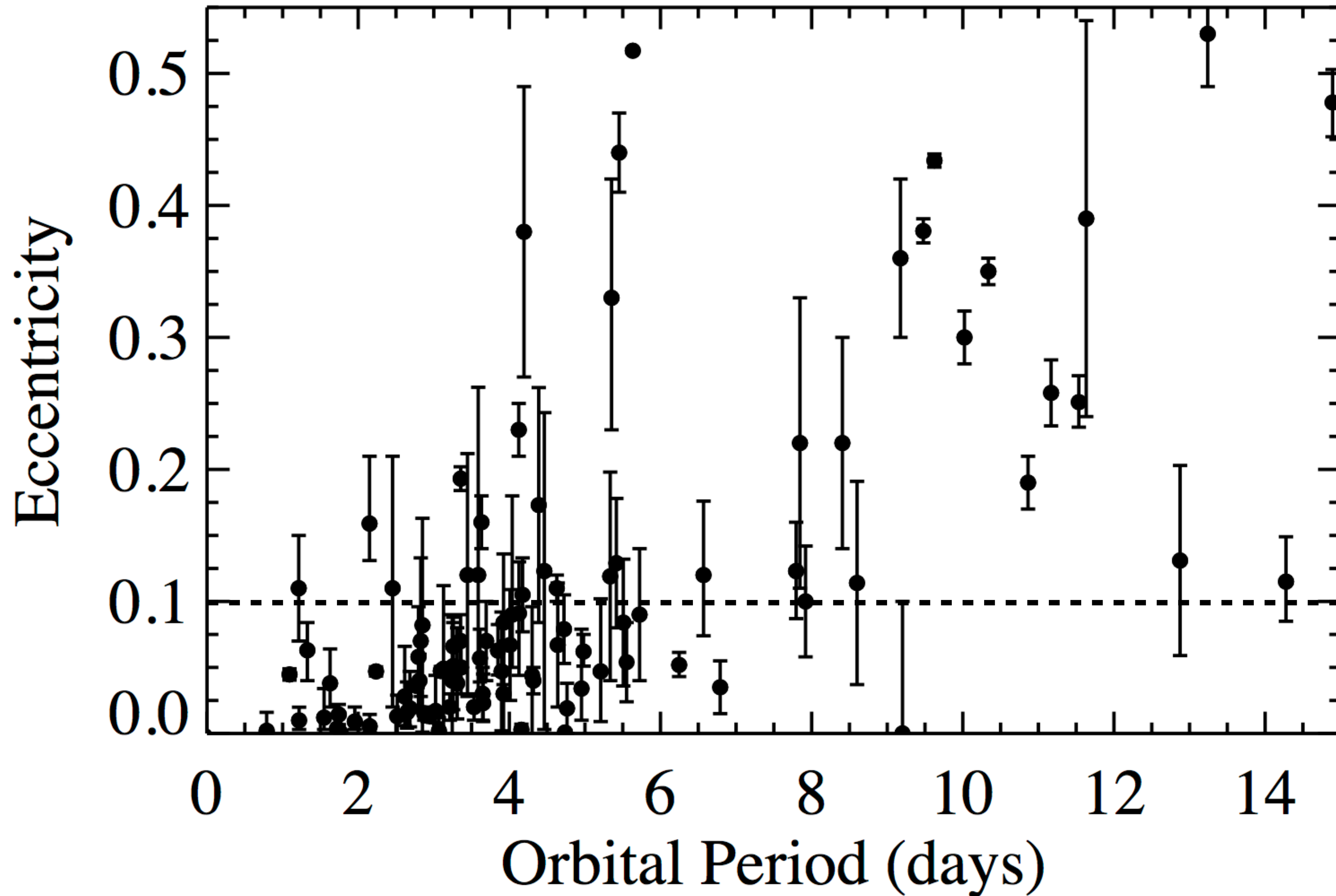
Misaligned-Orbits: RM & DT



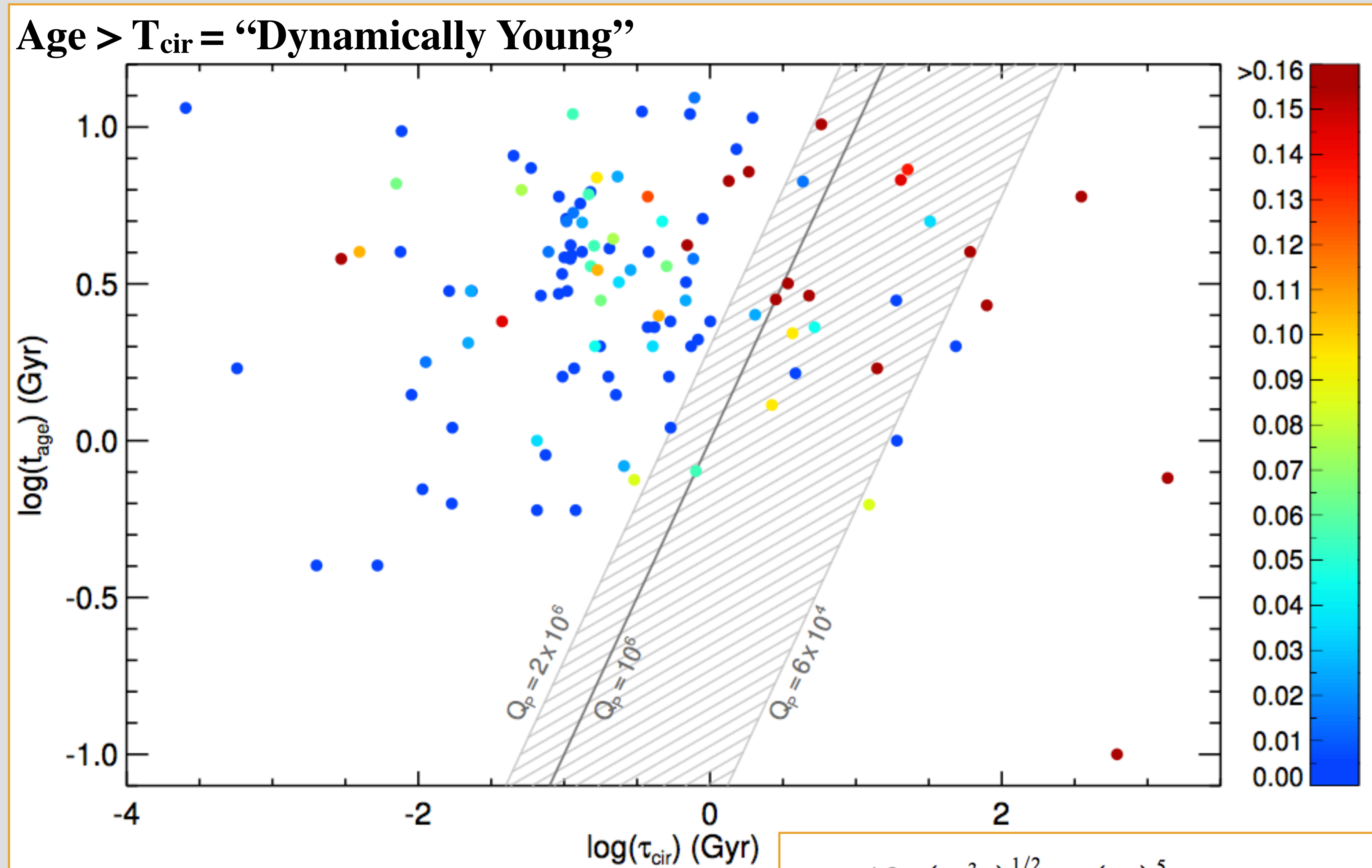
See Talk Wednesday by G. Zhou

Hot Jupiter Migration: Dynamical or Smooth

$R_p > 0.7 R_J$
 $\sigma_e > 0.0$



Hot Jupiter Migration: Dynamical or Smooth



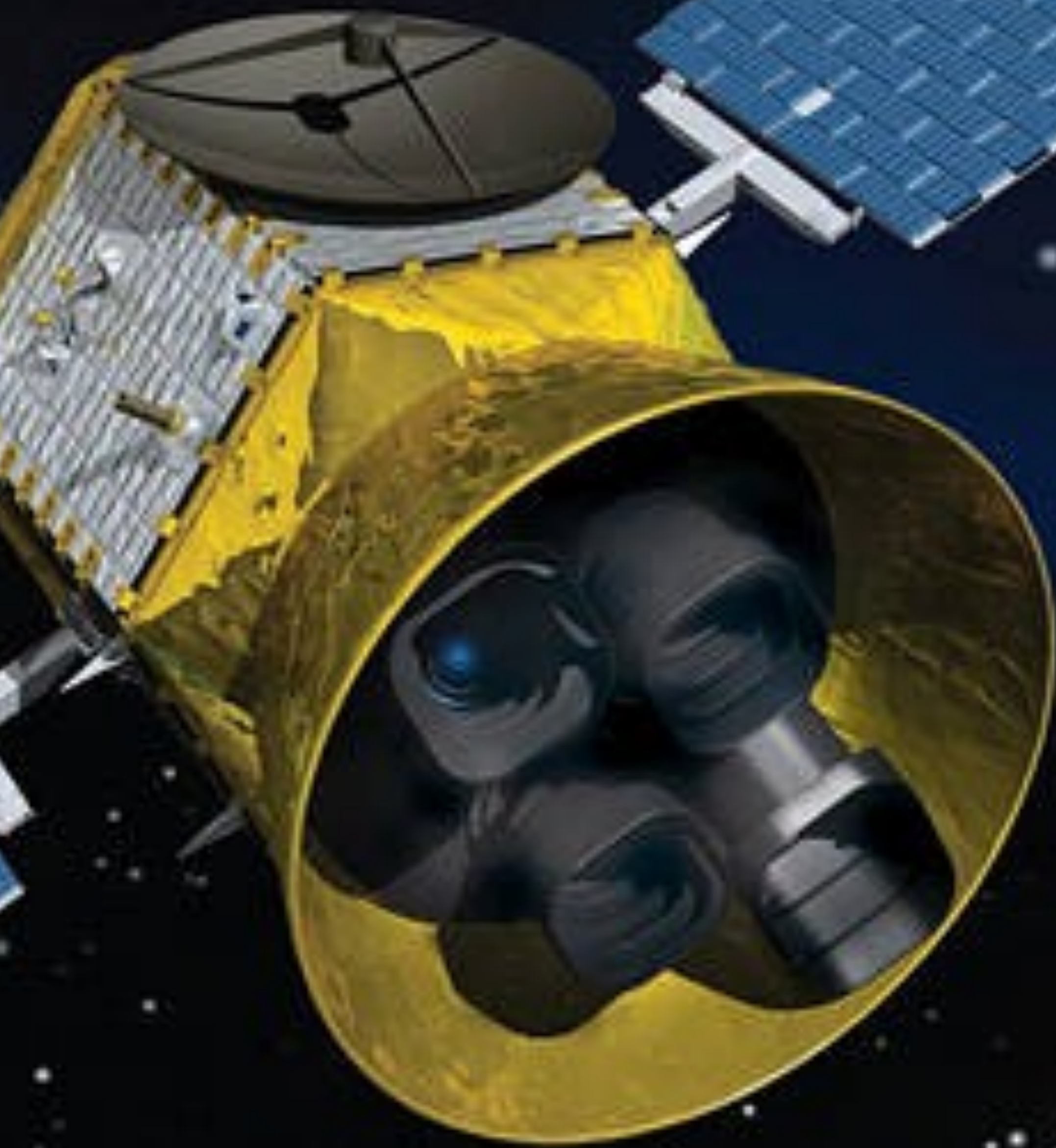
$$\tau_{\text{cir}} \approx \frac{4Q_P}{63} \left(\frac{a^3}{GM_*} \right)^{1/2} \frac{m_P}{M_*} \left(\frac{a}{R_P} \right)^5 (1 - e^2)^{13/2} [F(e^2)]^{-1}$$

Adams & Laughlin 2006

Quinn, White, Latham, et al. 2014, ApJ



TESS Contribution to Long Period Hot Jupiters



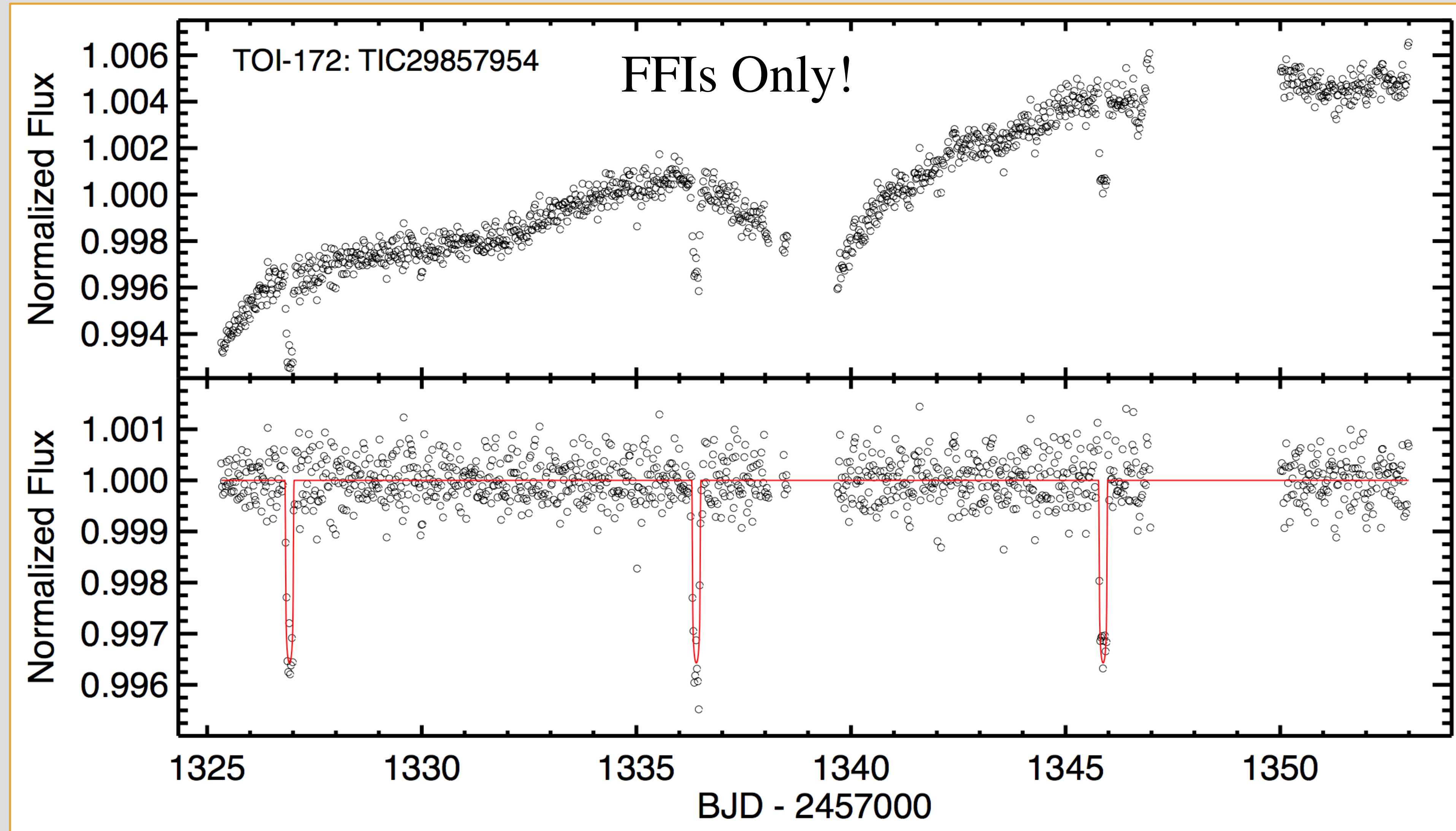
- Groundbased surveys struggle $P > 5$ days
- Brighter host allow for precise eccentricity measurements with RVs
- ~ 27 day baseline, $P < 9$ days complete (See Zhou et al. 2019)
- 30 min FFIs (I.E. for FREE!)
- Planets well-suited for C/O future atmospheric measurements (Madhusudhan et al. 2014)

EXOFASTv2: A Public, Generalized, Publication-Quality Exoplanet Modeling Code

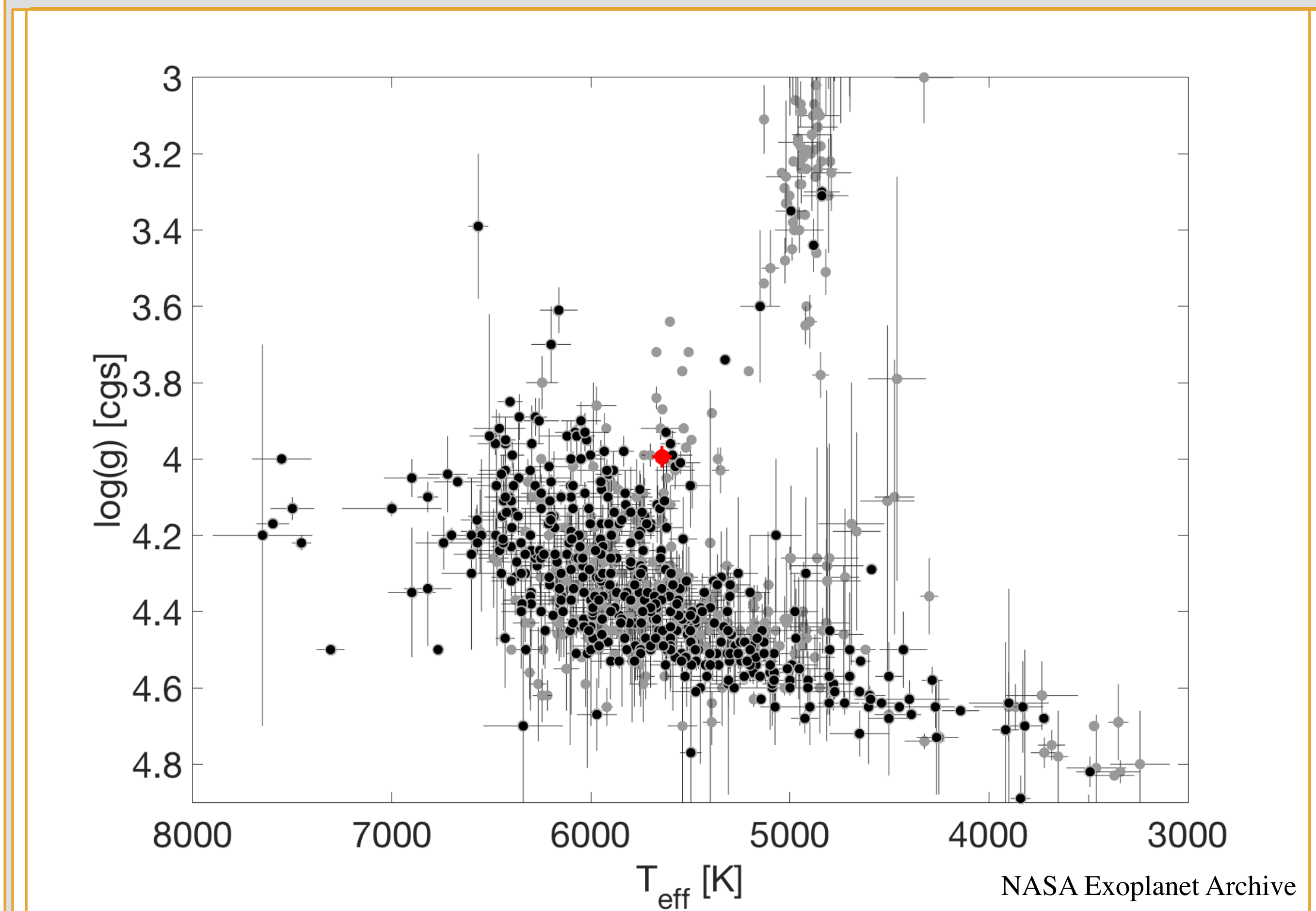
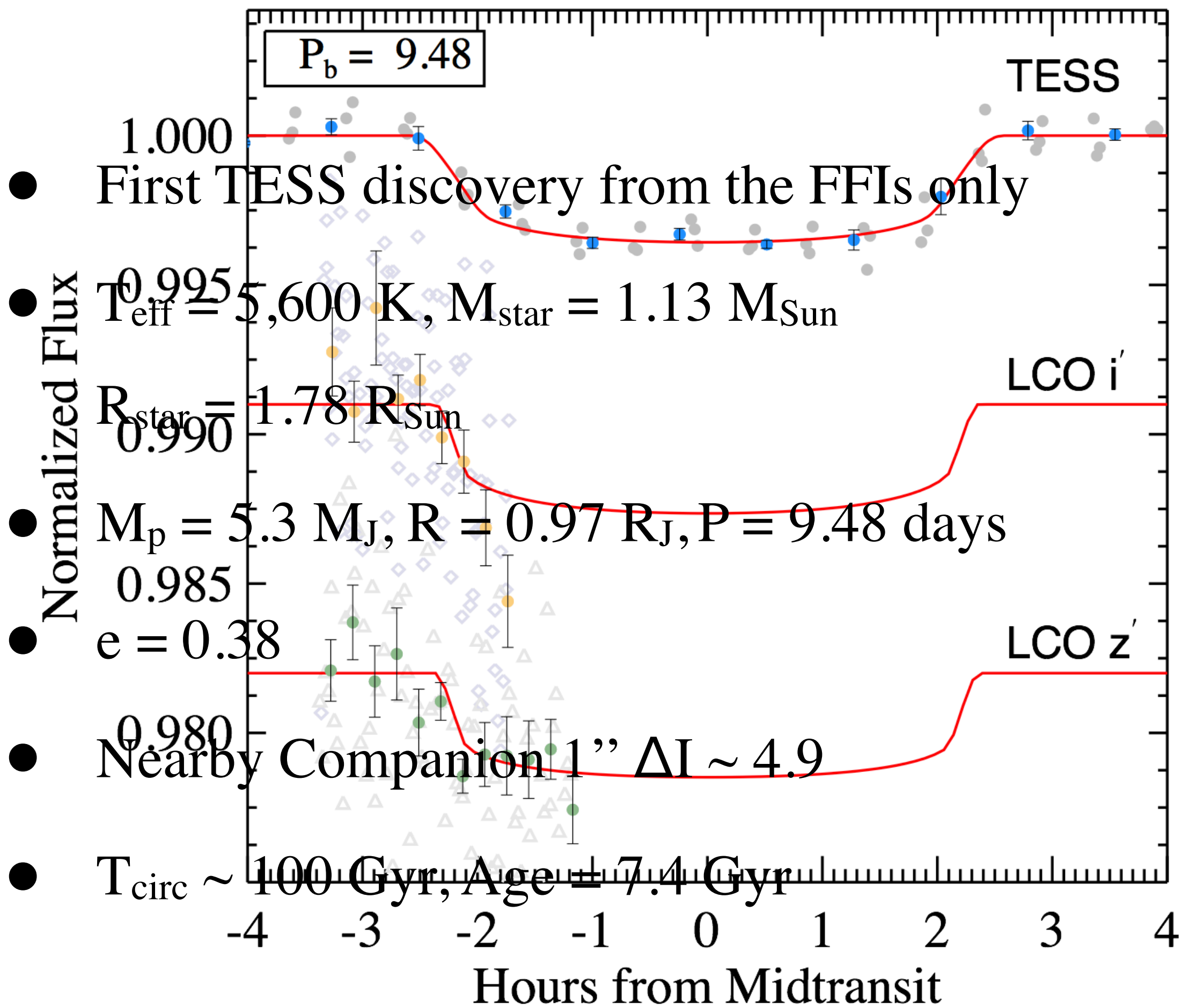
Eastman, Rodriguez, Agol et al. 2019, arXiv:1907.09480

- **Arbitrary number of planets**
 - Arbitrary mix of circular, eccentric, RM, DT, RV, and/or transit data
 - Dynamical constraints on eccentricity
 - Single transit planets
 - **Astrometric data sets**
 - Simultaneously model
 - Will be huge for Gaia
 - **Simultaneous Stellar Properties**
 - SED modeling
 - Gaia, Schlegel priors
 - **MIST stellar tracks**
 - YY stellar evolutionary model
 - Torres relations
 - Direct priors
 - **Transit constraint**
 - **Discrepancy => false positive**
 - Arbitrary number of wavelengths
 - Secondary eclipse depth
 - Quadratic Limb darkening parameters
 - **Priors on any fitted or derived quantities**
 - Arbitrary number of RV data sources
 - Jitter
 - Zero point
 - **Parallel Tempering**
- ~1/2 of the TESS Discoveries to Date** ng conditions
- Robustly samples multi-modal distributions
 - **Chen & Kipping exoplanet mass-radius relation**
 - Arbitrary number of transits
 - Arbitrary number of detrending parameters
 - Normalization
 - TTV, TDV, TV
 - Red noise
 - **No IDL License required!**

The Dynamically Young TOI-172 System

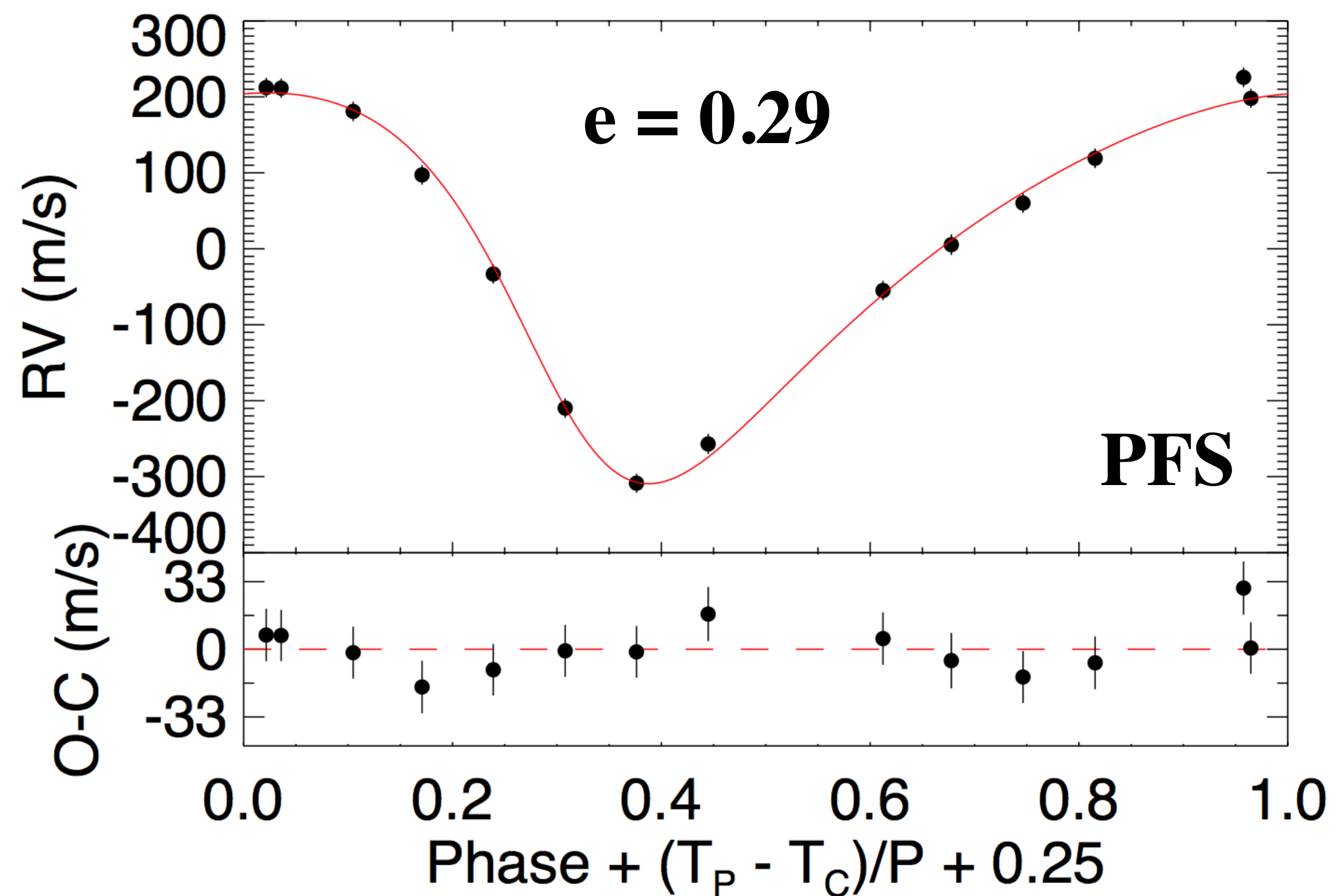
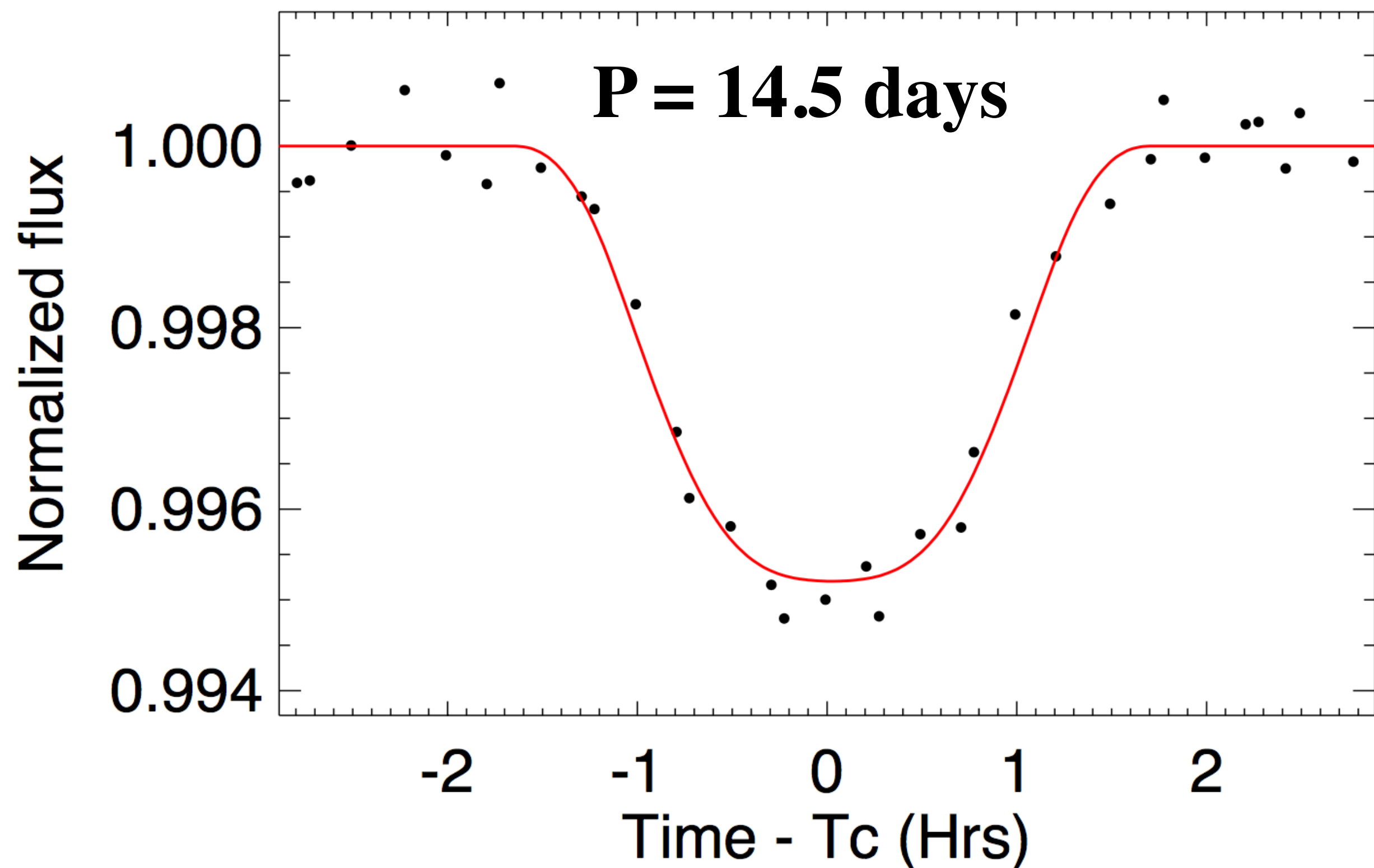


TOI-172b: A Dynamically Young Jupiter on a 9.5 day orbit around a sub-Giant



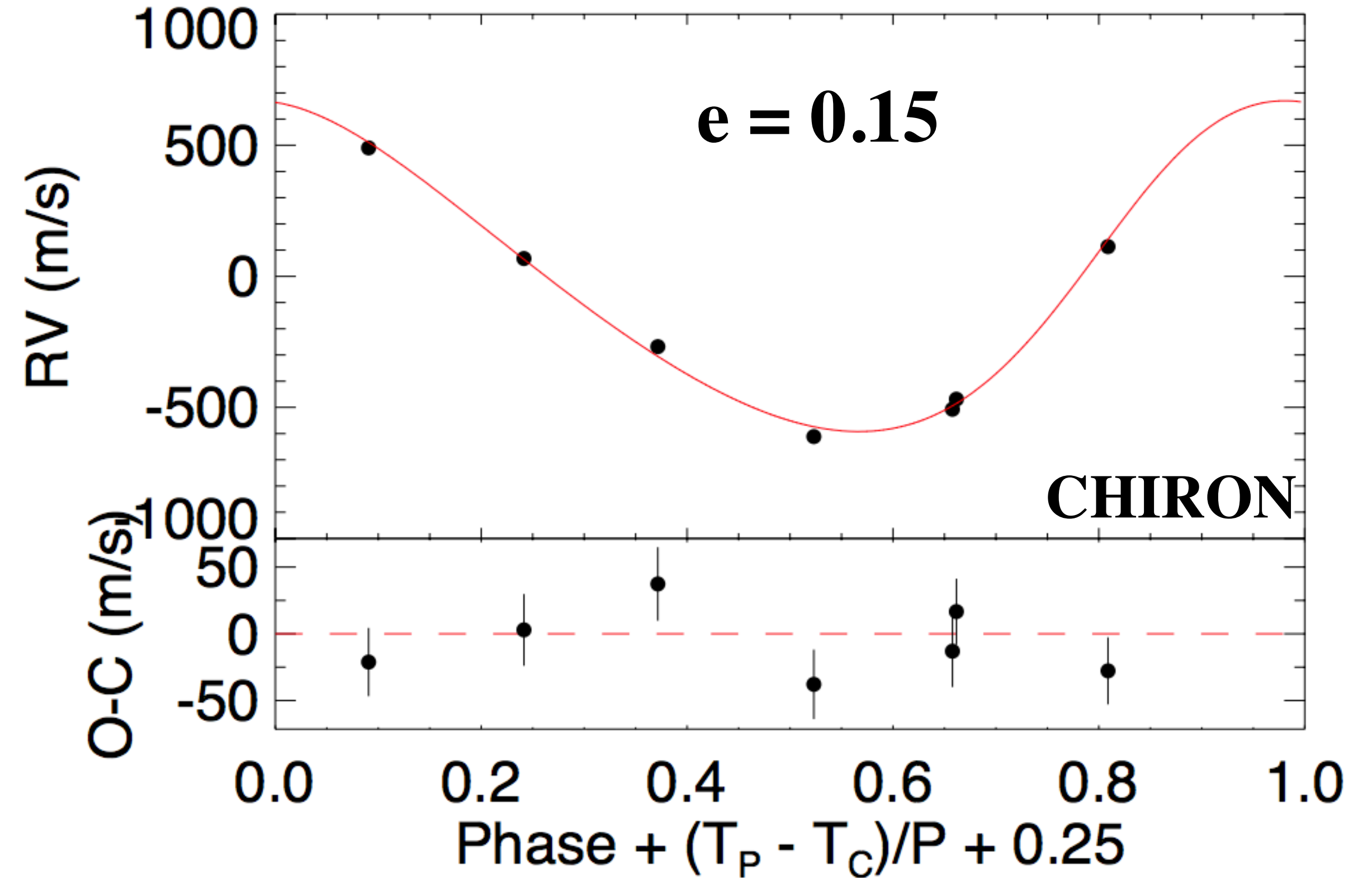
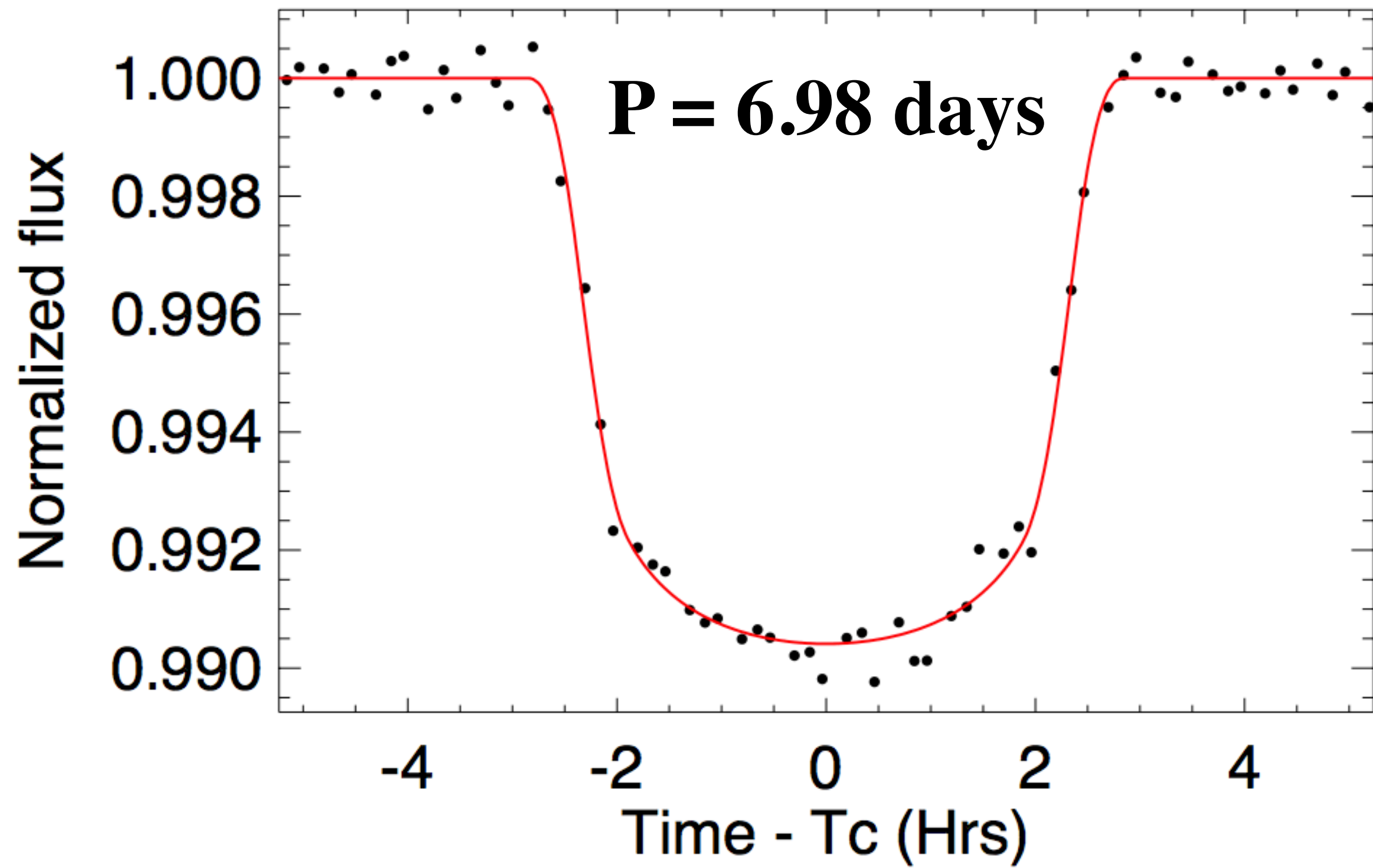
See Poster #6 by S. Quinn on TFOP!

Two More Dynamically Young Jupiters from TESS FFIs!



$$M_p = 3.4 M_J, \quad R_p = 1.21 R_J$$

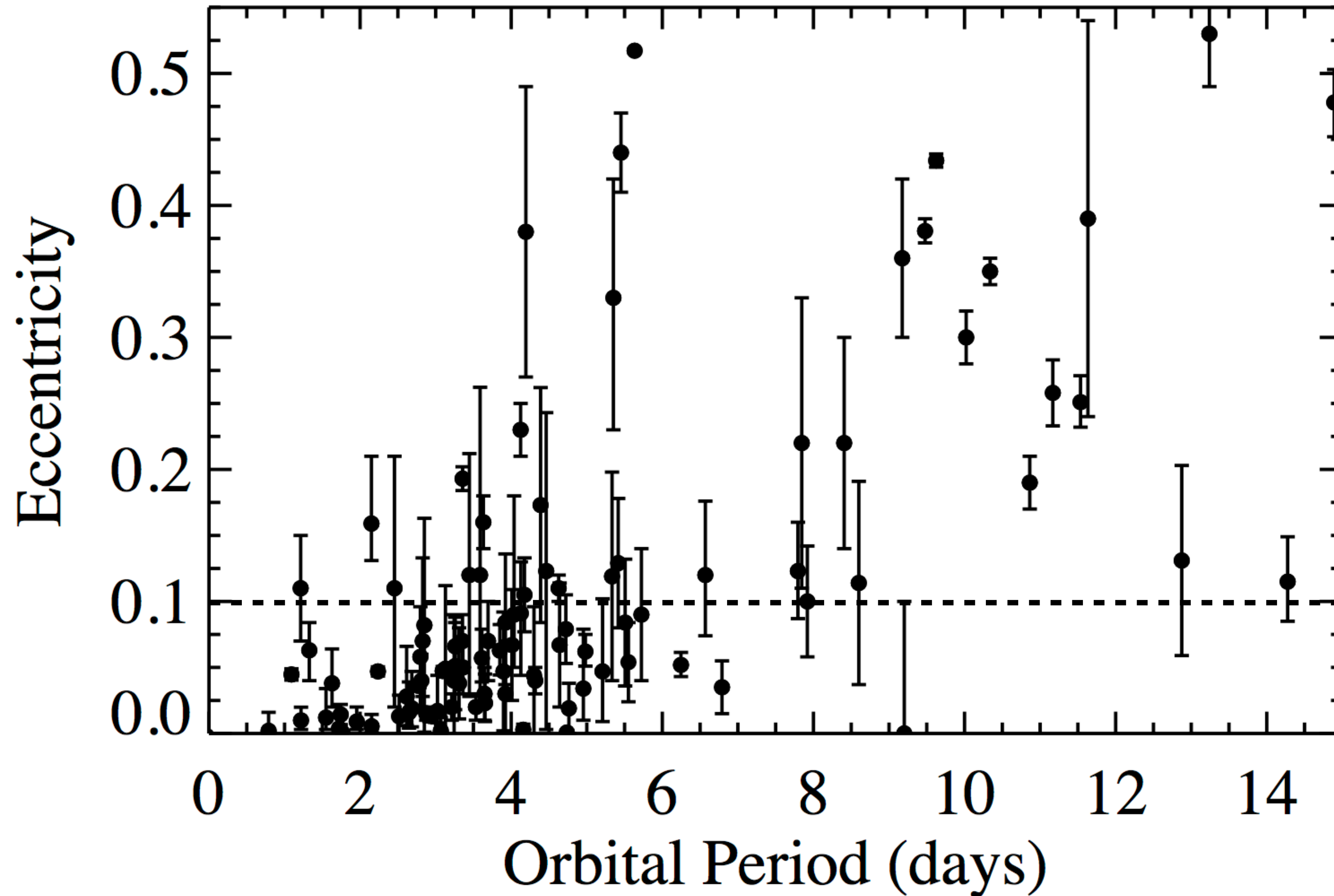
Two More Dynamically Young Jupiters from TESS FFIs!



$$M_p = 5.5 M_J, \quad R_p = 1.1 R_J$$

Eccentric Giant Planets

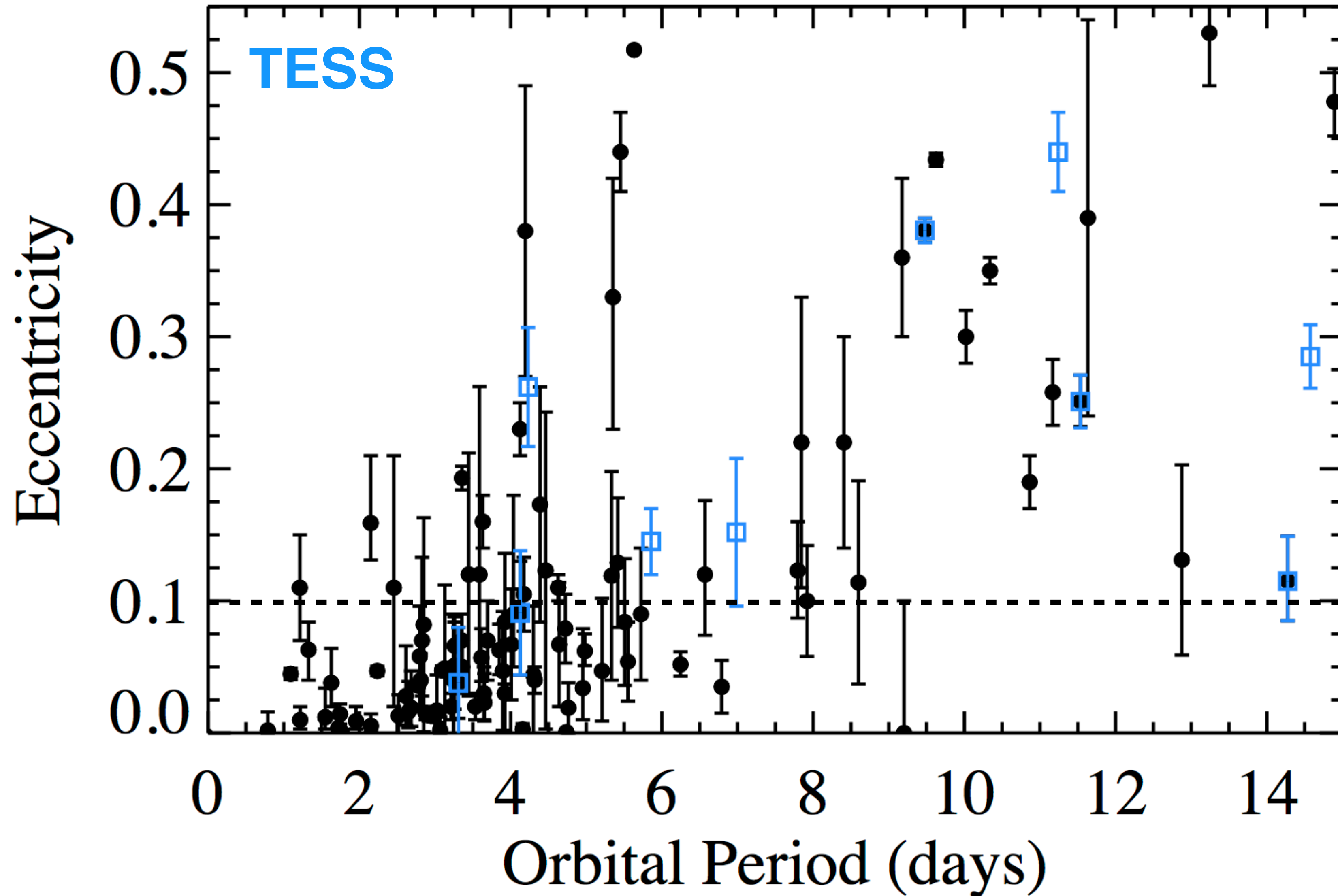
$R_p > 0.7 R_J$
 $\sigma_e > 0.0$



NASA Exoplanet Archive

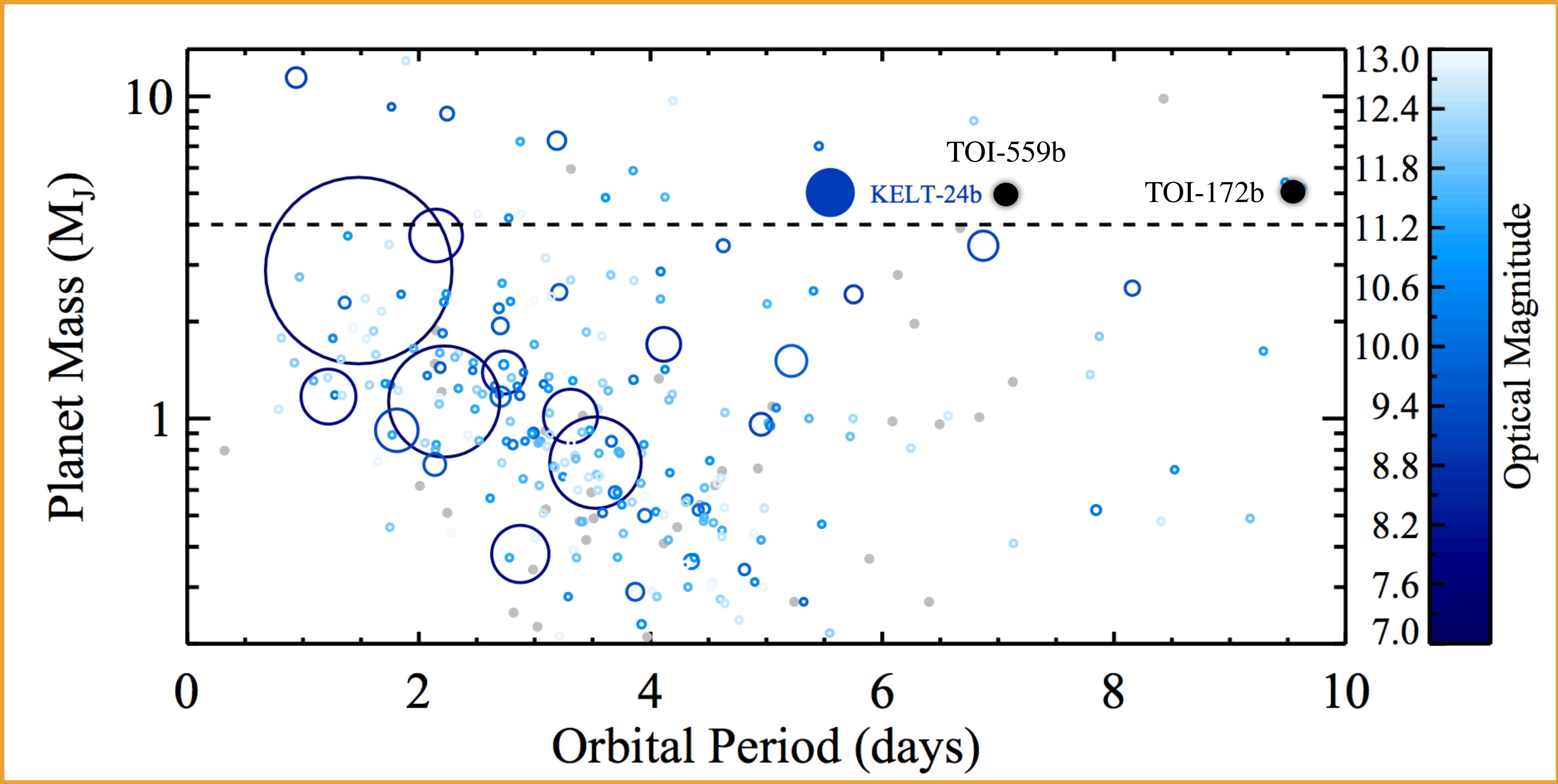
TESS Eccentric Giant Planets

$R_p > 0.7 R_J$
 $\sigma_e > 0.0$



NASA Exoplanet Archive

Massive Giant Planets



Rodriguez Eastman, Zhou et al. 2019, Submitted AAS

Rodriguez Shporer, Quinn et al. (in Prep)

The Future Continues to be Bright with TESS

- Eccentricity and Obliquities are key
- Dozens of long period (>5 day) giant planet candidates in the TOIs
- Ongoing PFS, CHIRON, and TRES programs
- EXOFASTv2 uniform analysis of all hot and warm Jupiters. Ages from MIST + *Gaia*.
(See Posters on STOKED, #41 & #42)
- “As we race to the bottom, let us not forget about the top”

