Stellar Astrophysics, Exoplanets, and the Role of IRTF in the Gaia/TESS Era



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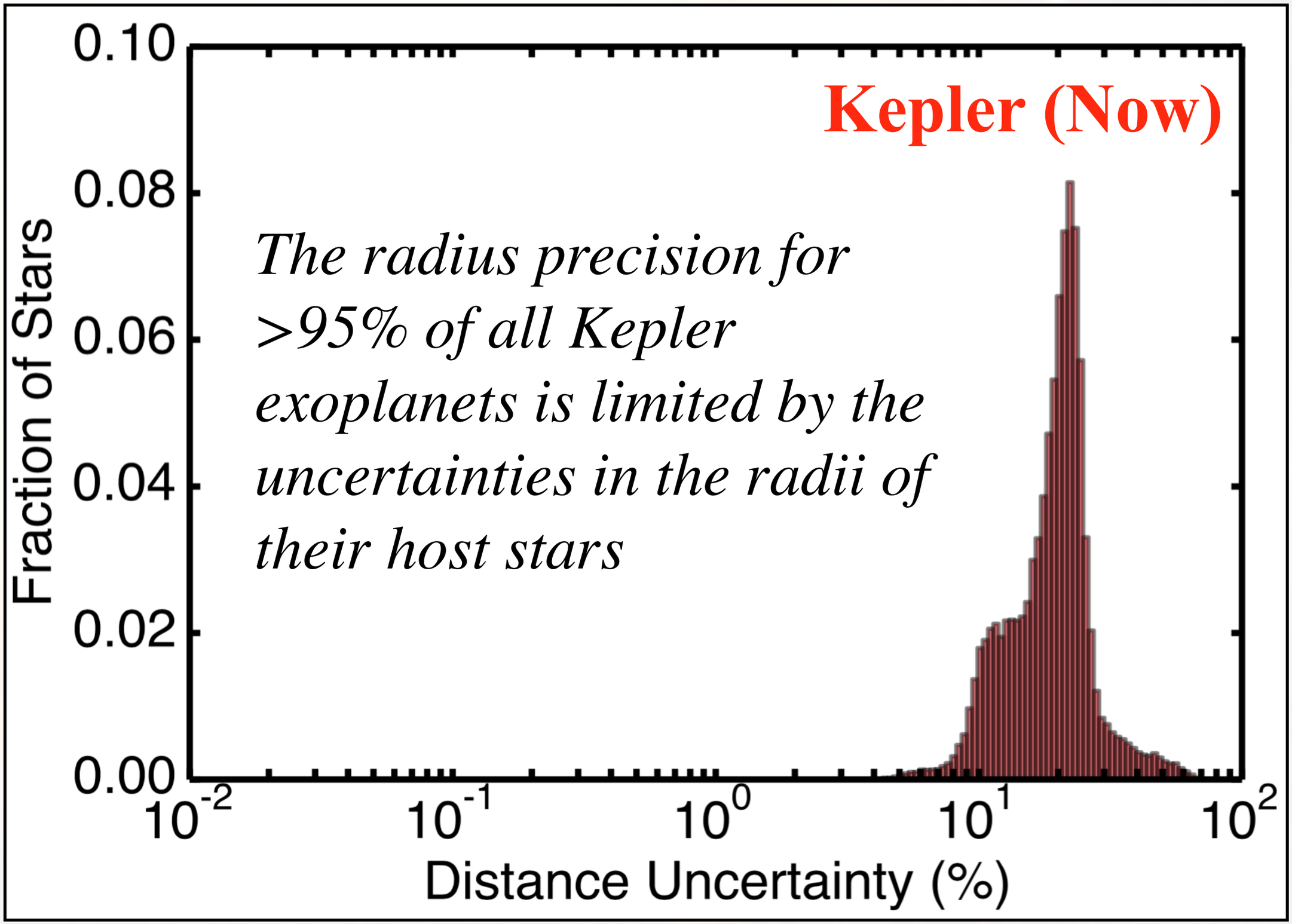


IRTF Future Directions Workshop

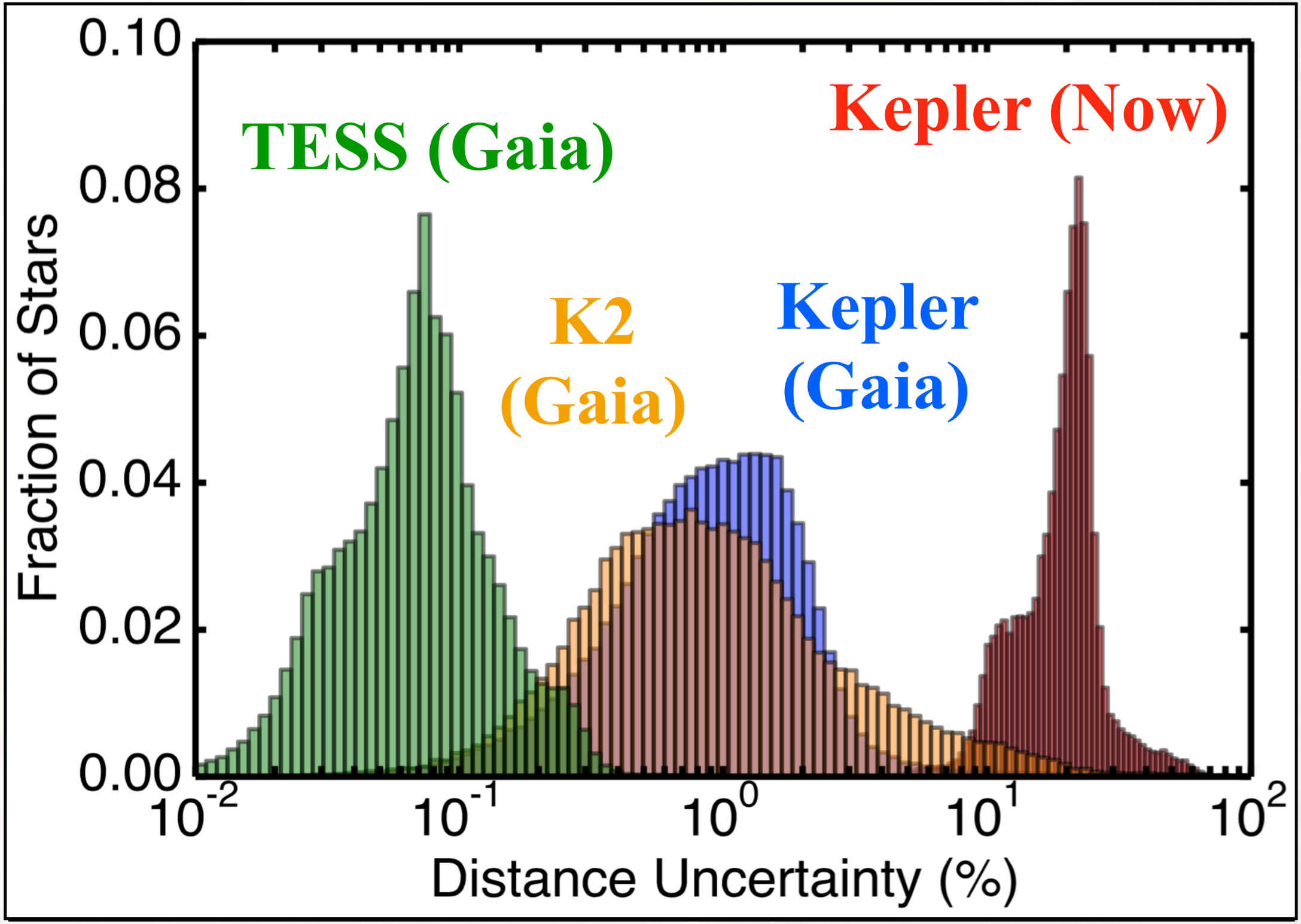
Feb 2018

IRTF & Exoplanet Host Stars in the Gaia Era

Current Distances to Kepler Stars



Gaia Distances in ~2 Months



Effective Temperatures: A solved problem?

Angular diameter

$$\Theta = (F_{\rm bol}/\sigma_{\rm SB} T_{\rm eff}^4)^{1/2}$$

Effective Temperature

Bolometric Flux

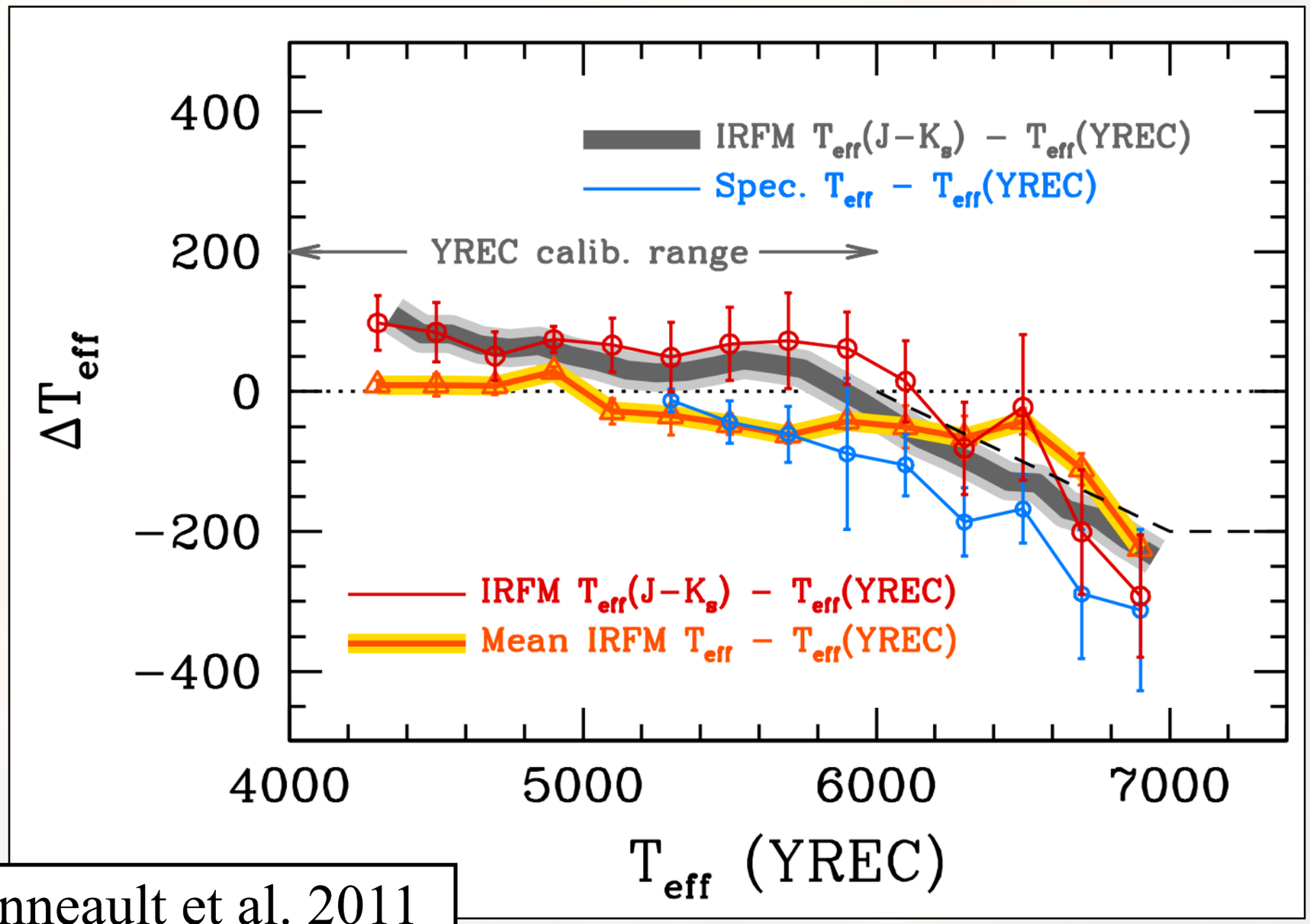
Effective Temperatures: A solved problem?

Angular diameter

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Effective Temperature

Bolometric Flux



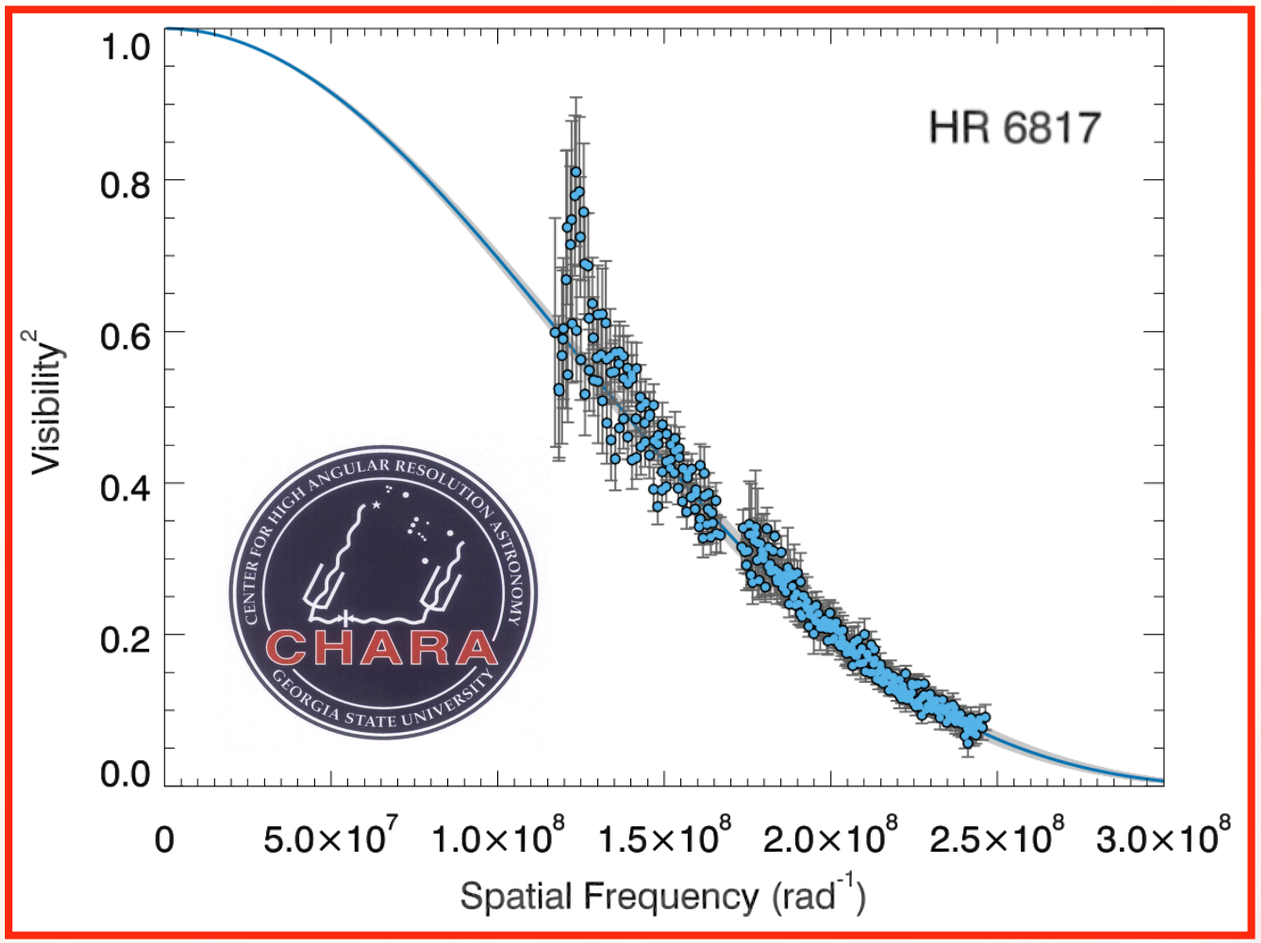
~7% in Radius

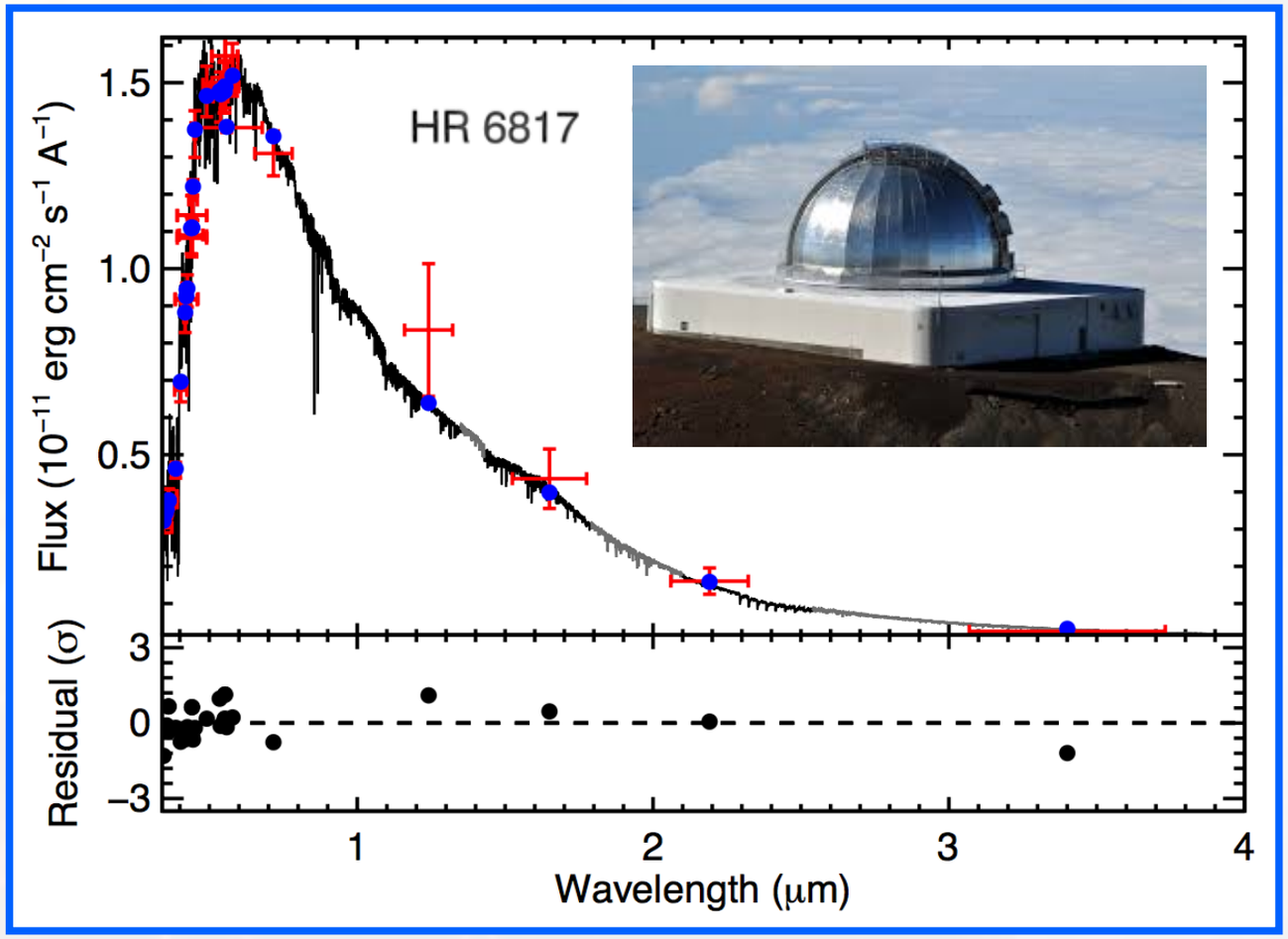
Pinsonneault et al. 2011

Interferometry

Spectrophotometry

$$\Theta = \left(F_{\rm bol}/\sigma_{\rm SB}T_{\rm eff}^4\right)^{1/2}$$





$\theta = 0.772 \pm 0.006$ mas

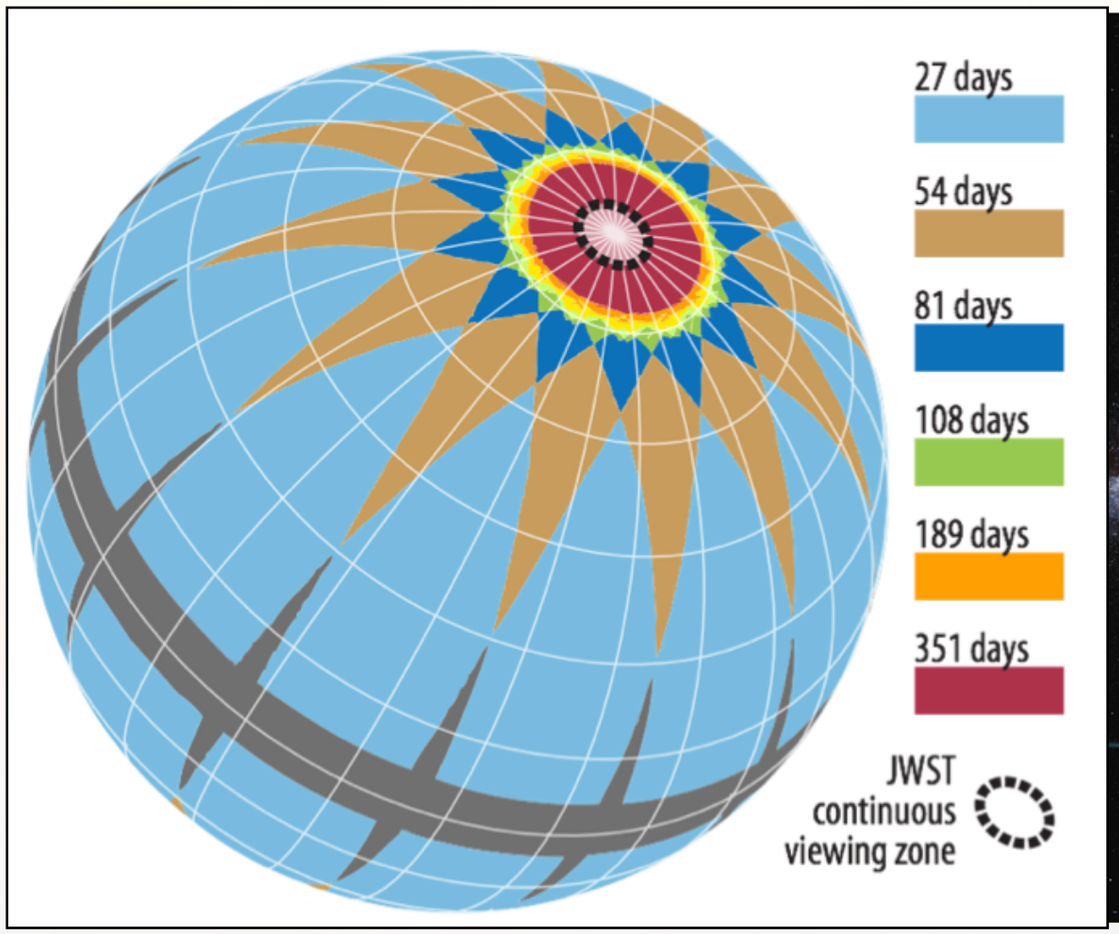
$F_{bol} = 142.6 \pm 5.5$ pW m^{-2}

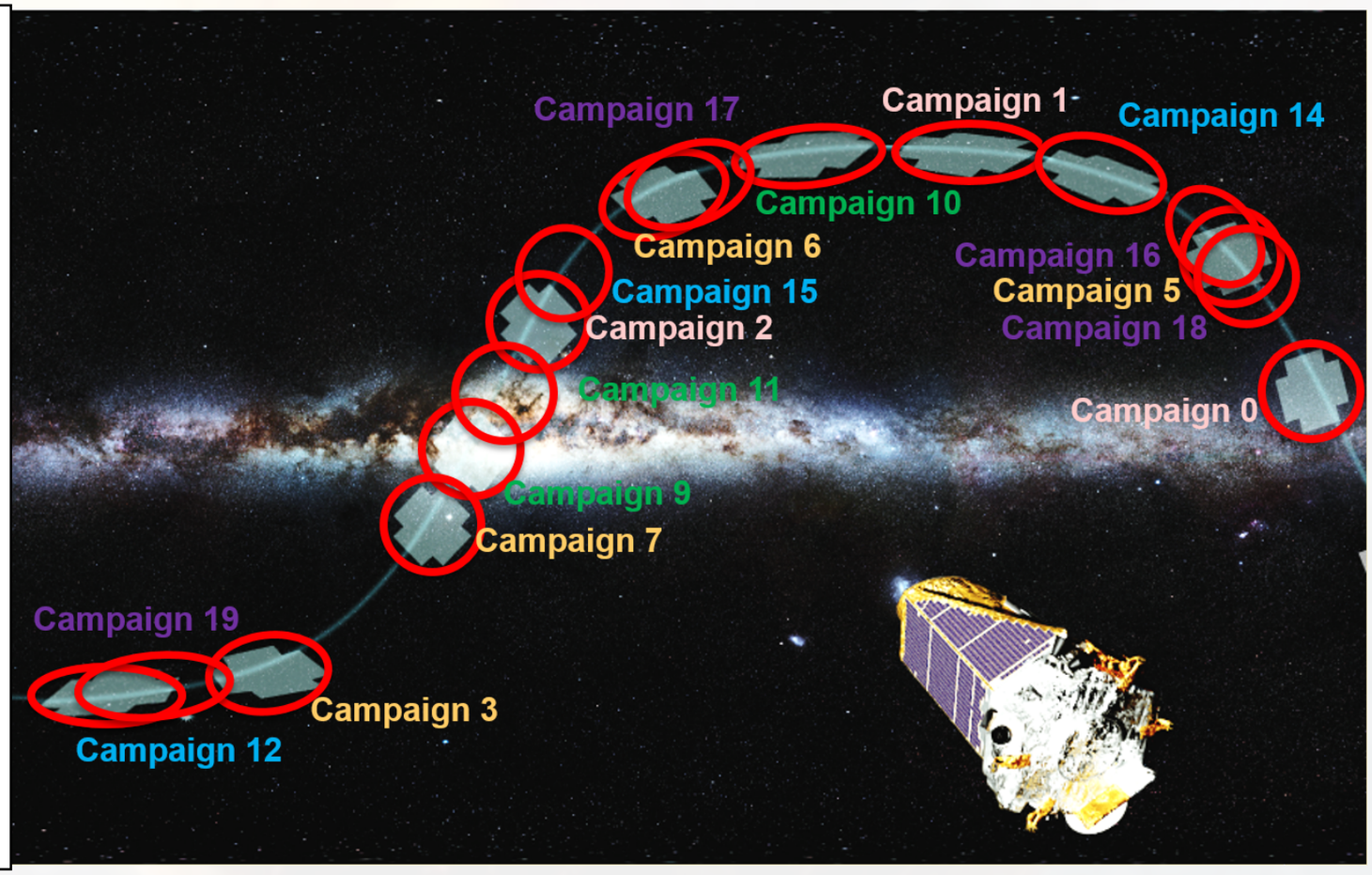
→ $T_{eff} = 5013$ +/- 59 K

Huber et al. (2012), Boyajian et al. (2013), Mann et al. (2015), White et al. 2018 (in prep)

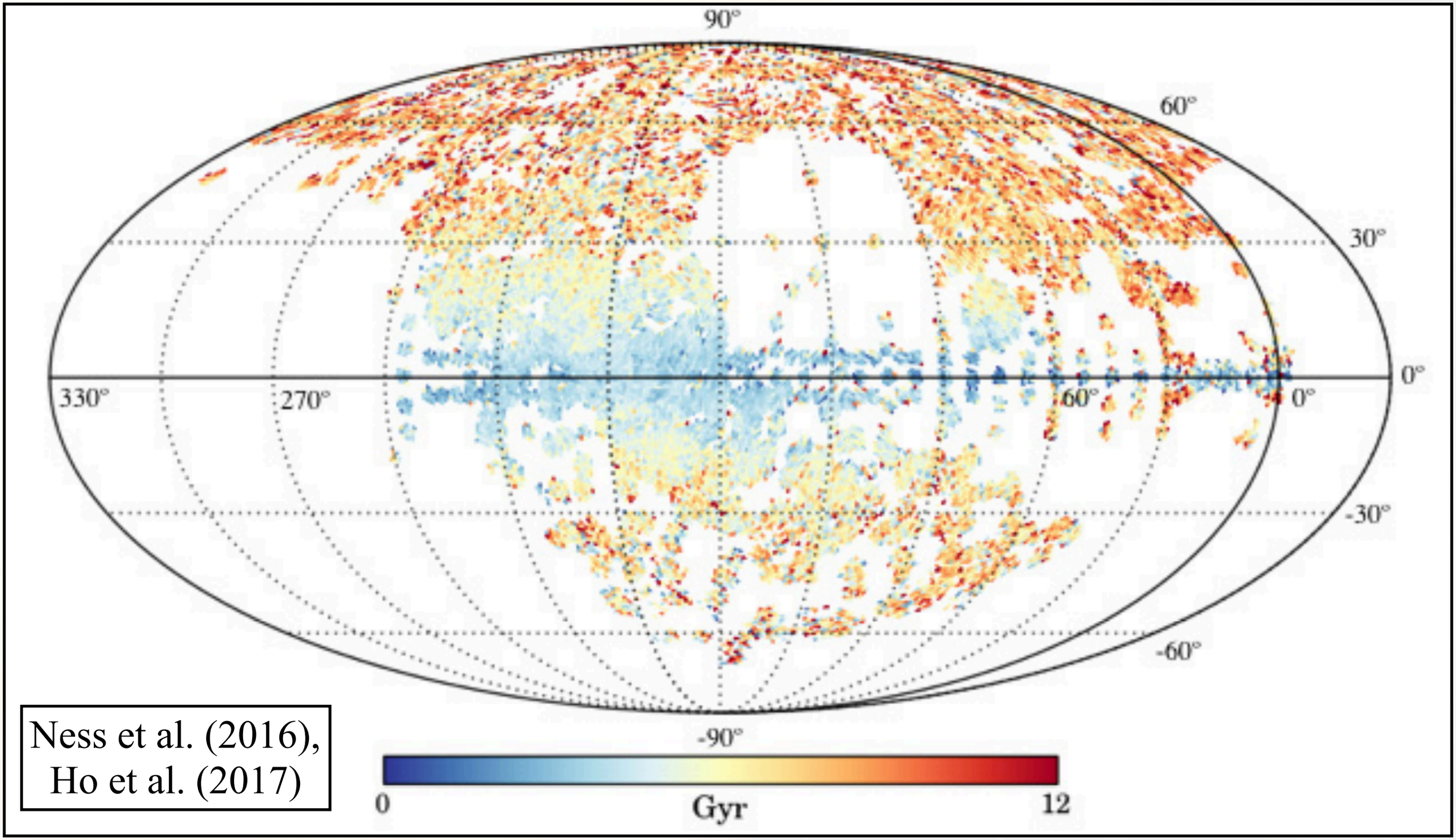
IRTF & Red Giants in the Era of TESS

K2 & TESS will deliver an all-sky treasure trove of high-cadence, high-precision photometry for millions of red giants across the galaxy





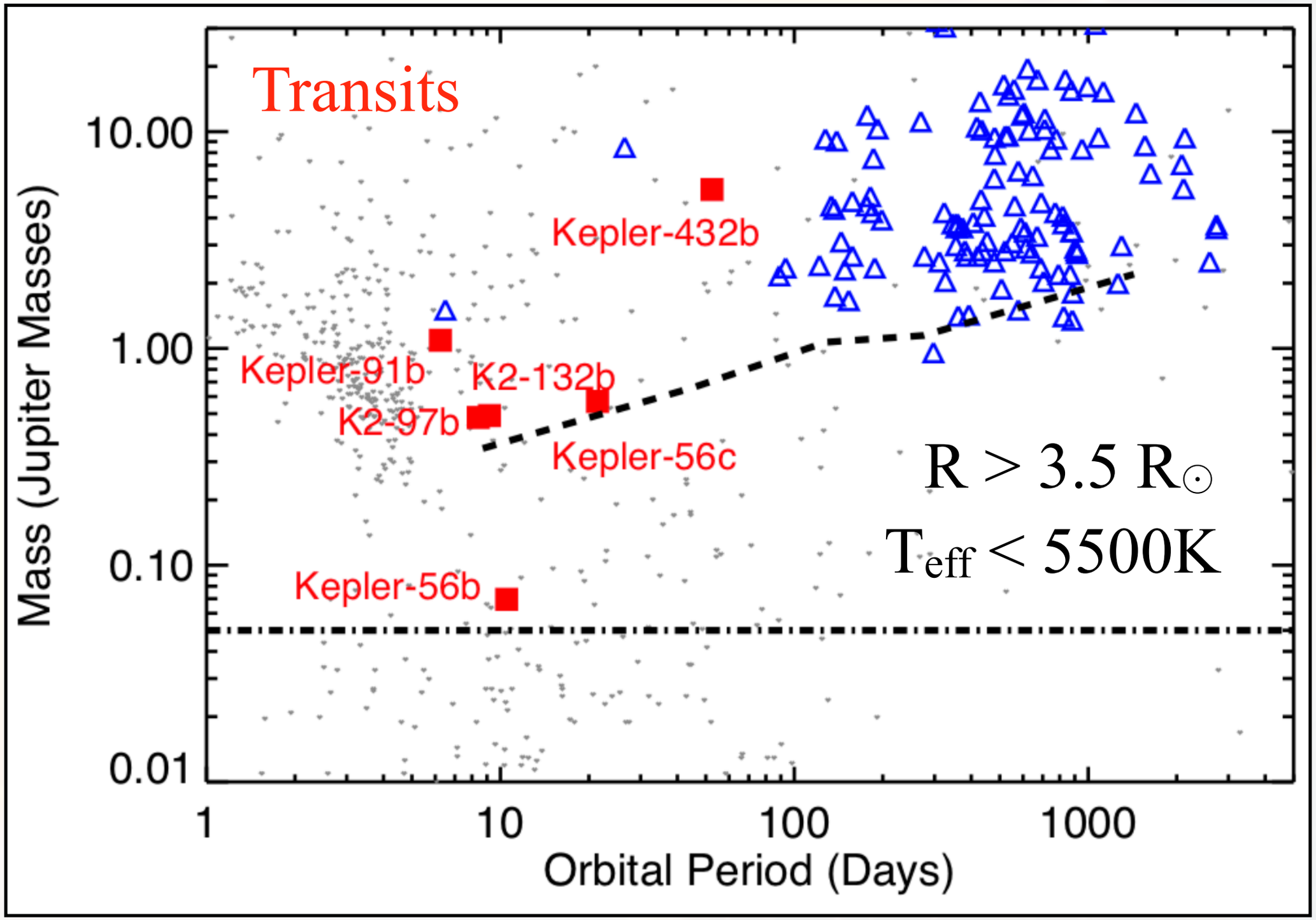
Ricker et al. (2014), Howell et al. (2014)



Ness et al. (2016),
Ho et al. (2017)

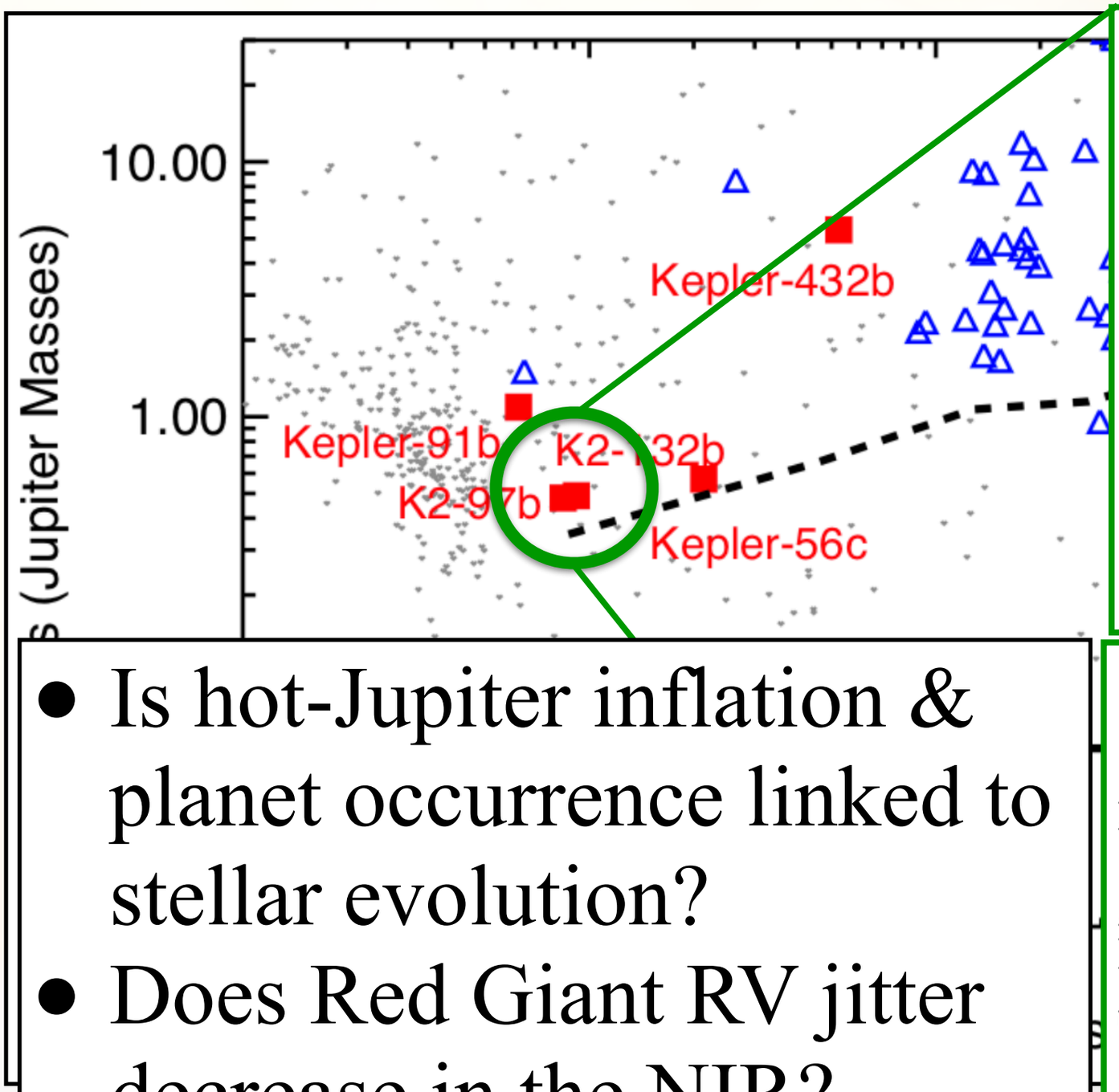
SDSS/APOGEE Spectroscopy (H-Band, R~20000) + Kepler/K2/TESS Asteroseismology ➔ Stellar Ages!

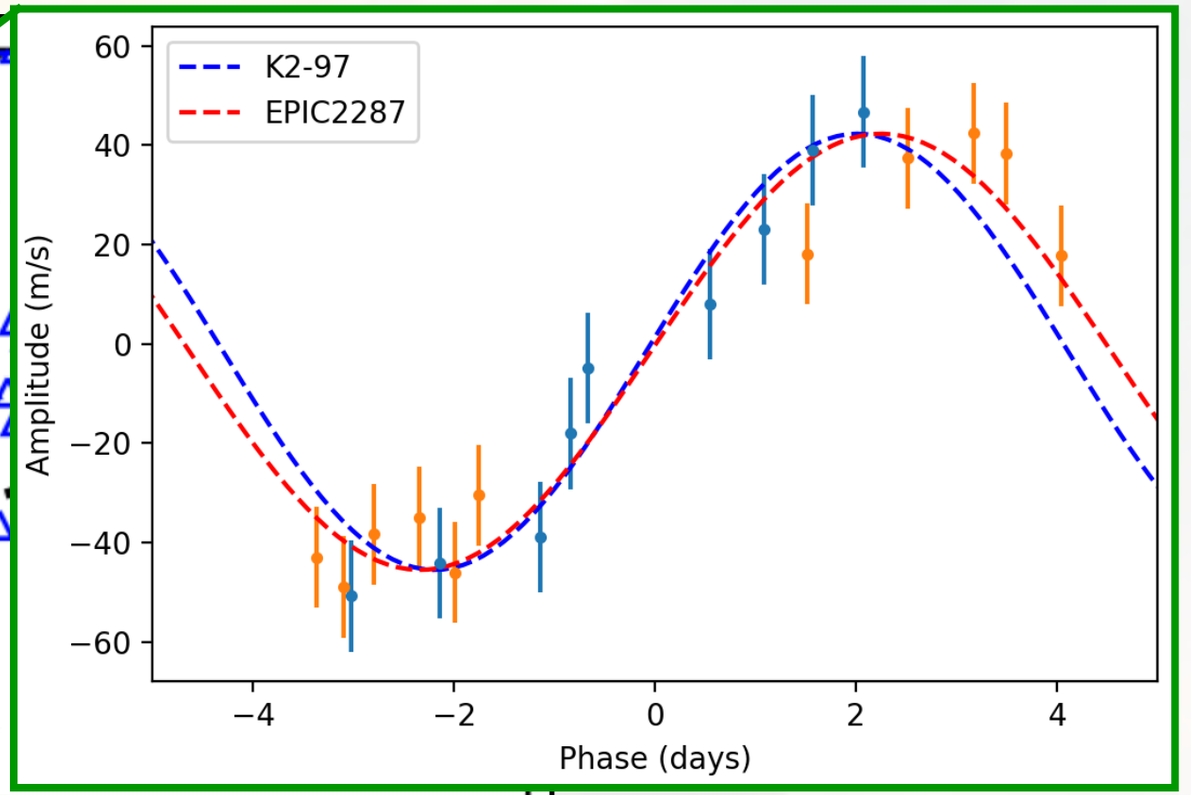
Giant Planets Orbiting Giant Stars



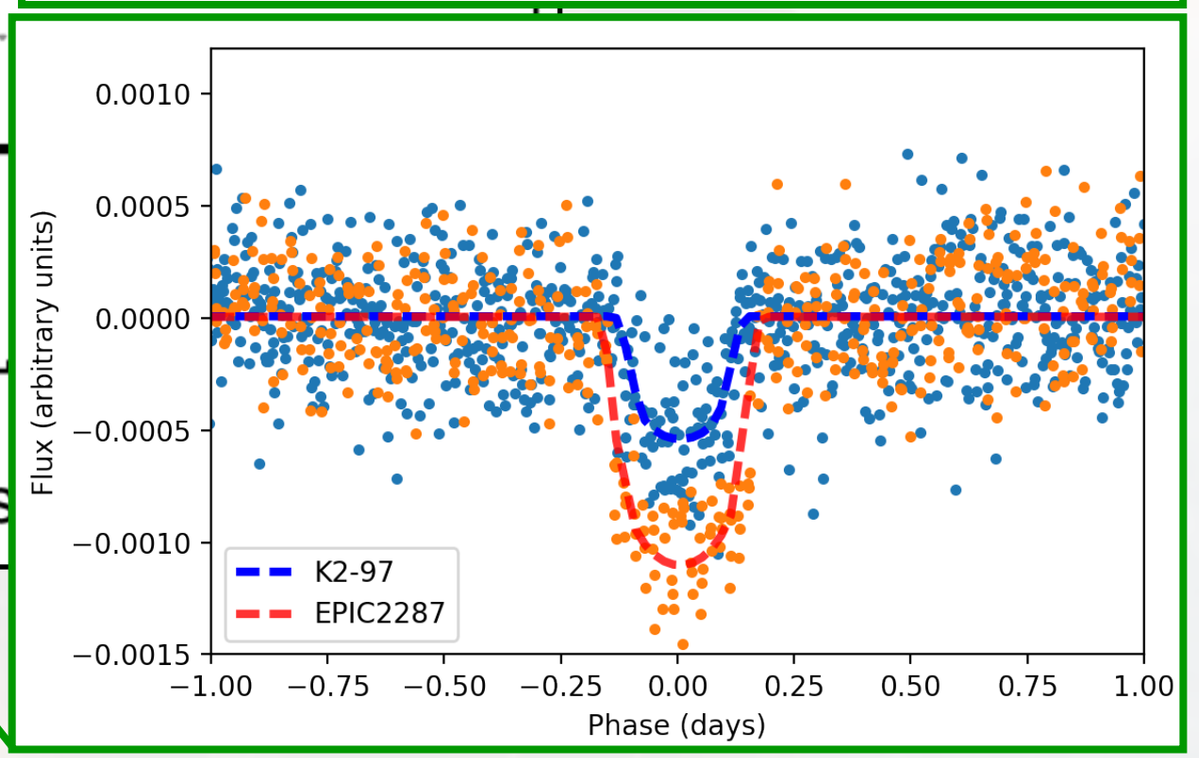
Huber 2015

Giant Planets Orbiting Giant Stars





- Is hot-Jupiter inflation & planet occurrence linked to stellar evolution?
- Does Red Giant RV jitter decrease in the NIR?



Grunblatt et al. 2016, 2017

Conclusions

Gaia & TESS will revolutionize stellar astrophysics & exoplanet science over the next decade. Critical follow-up and potential roles of IRTF include:

- *Accurate optical/IR spectrophotometry to calibrate effective temperatures (radii) for exoplanet hosts*
[SpeX, new low-res spectrograph?]

- *High-resolution spectroscopy (& AO?) of red giants for galactic archeology & exoplanet confirmation*
[iShell, Robo-AO, multi-object capabilities?]

Era of Multi-Object Spectroscopy

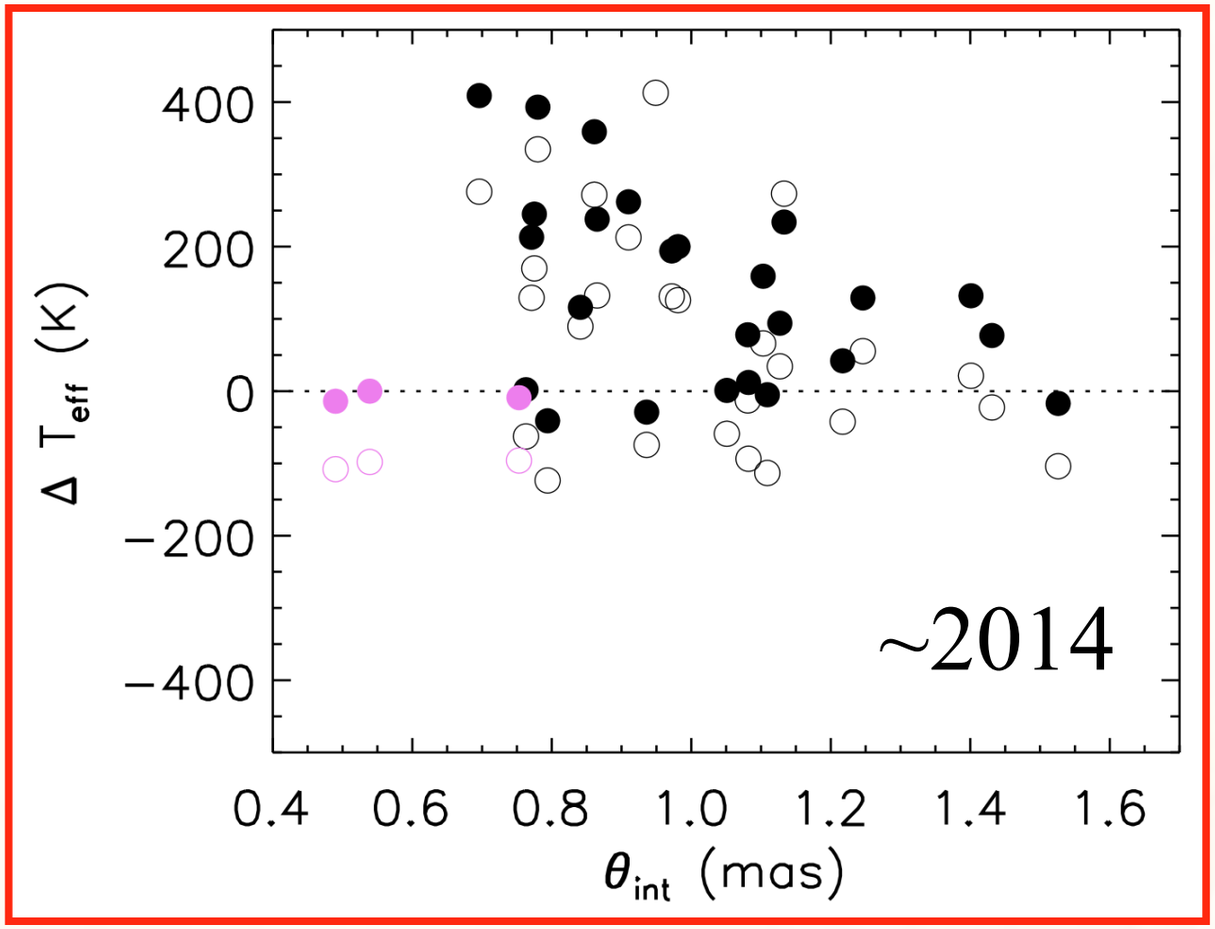
Spectroscopic Survey Facilities by 2020–2025								
Survey (facility)	$N_{\rm target}$	$R_{\rm spectra}$	$N_{\rm multi}$	$\lambda\,[\mu m]$	$\Omega_{\rm sky}$	$N_{\rm epoch}$	Timeframe	$m_{\rm primary}$
SDSS-V	7×10^6	**22,000** **2,000**	**500**	**1.51–1.7** **0.37–1.0**	4π	**1–174**	**2020–2024**	$m_H \lesssim 13.4$ $m_i \lesssim 20$
Gaia (RVS)	8×10^6	11,000	—	0.85–0.87	4π	∼60	2013–2020	$m_G \lesssim 12$
Gaia-ESO	0.1×10^6	17,000	140	0.55 & 0.85	0.02π	∼1	2013–2018	$m_G \lesssim 17$
GALAH	0.8×10^6	28,000	400	0.40–0.85	π, $\lvert b\rvert \geq 10$	∼1	2015–2020	$m_G \lesssim 13$
WEAVE	0.8×10^6	5,000 20,000	1000	0.37–0.9	$\sim\pi$	∼1–2	2018–2023	$m_G \lesssim 19$
DESI	4×10^7	3,000	5000	0.36–0.98	1.35π, $\lvert b\rvert \geq 25°$	1–4	2019–2024	$m_r \lesssim 23$
LAMOST	8×10^6	1,800	4000	0.4–0.9	0.5π	∼1	2010–2020	$m_G \lesssim 16$
4MOST	10×10^6	5,000 20,000	1600 800	0.4–0.9	1.5π	1–2	2023–2028	$m_r \lesssim 22$ $m_V \lesssim 16$
APOGEE-1& 2	5×10^5	22,000	300	1.51–1.7	0.5π	∼1–30	2011–2019	$m_H \lesssim 12.2$
PFS	1×10^6	3,000	2400	0.4–1.6	0.05π	1	2018–2021	$m_i \lesssim 23$
MOONS	2×10^6	5,000 20,000	1000	0.6–1.8	0.05π	1	2020–2025	$m_g \lesssim 22$ $m_H \lesssim 17$

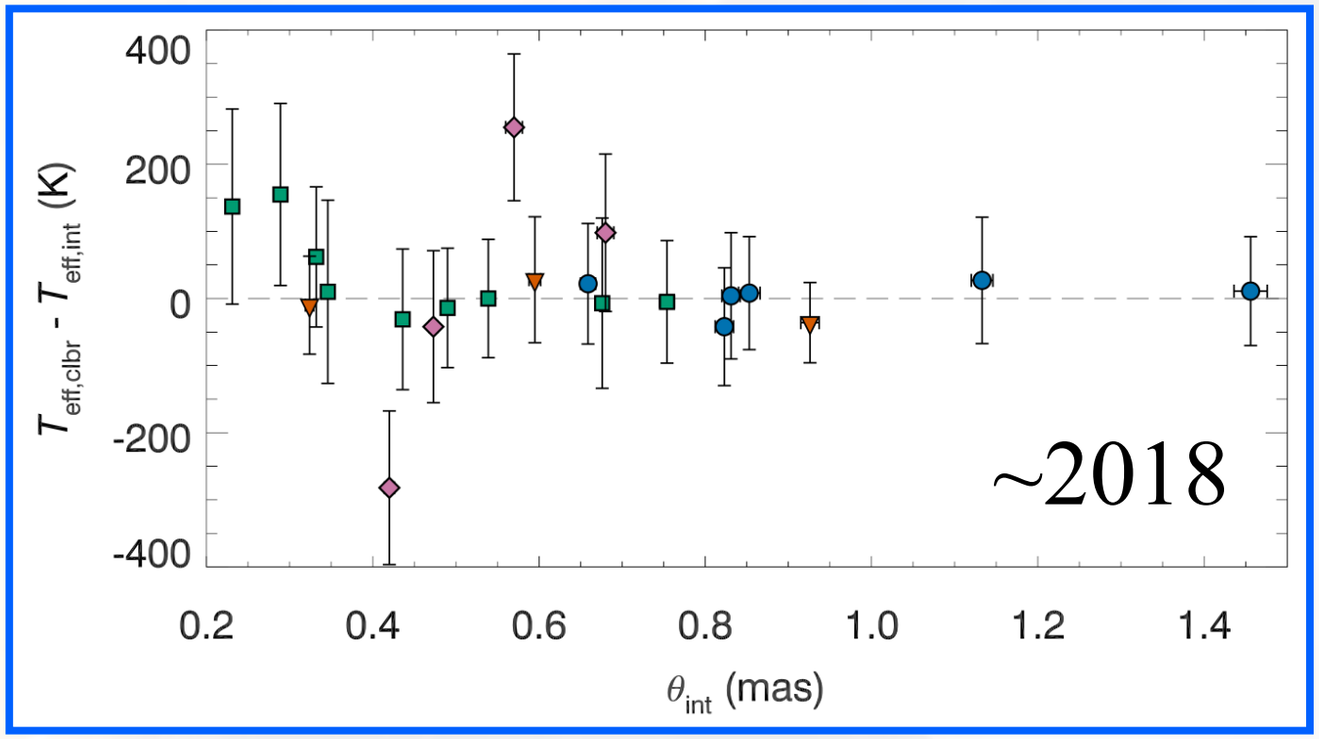
Potential IRTF roles:

- high-resolution follow-up (iShell)
- AO imaging (Robo-AO?)
- multi-object capabilities?

Kollmeier et al. 2017

Towards ~1% Effective Temperatures





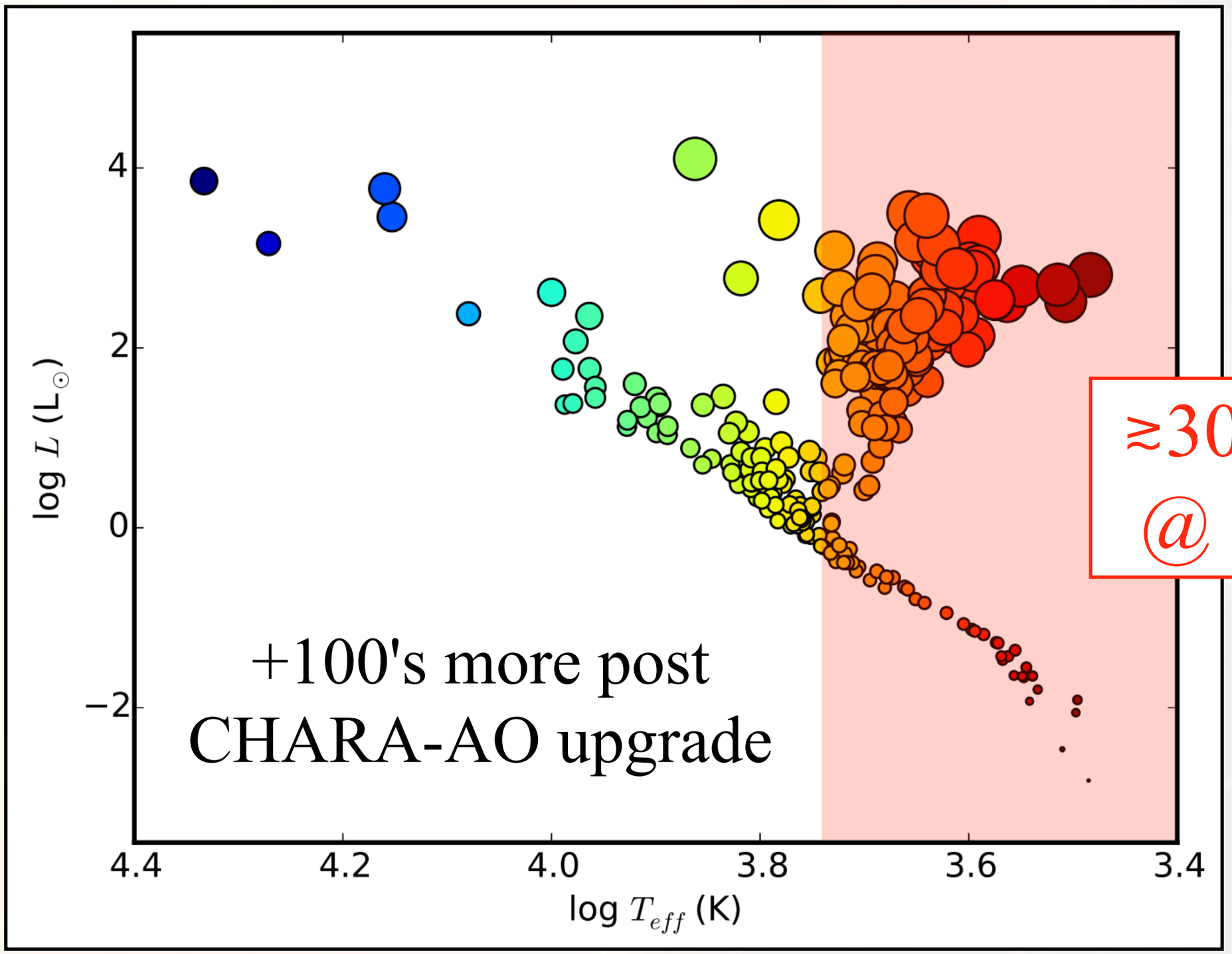
~200K offsets

Broadband Photometry +
Single Beam Combiner
Interferometry

~50K offsets

Spectrophotometry +
Multi Beam Combiner
Interferometry

White, Huber, Mann et al. 2018 (in prep)



von Braun & Boyajian (2018)