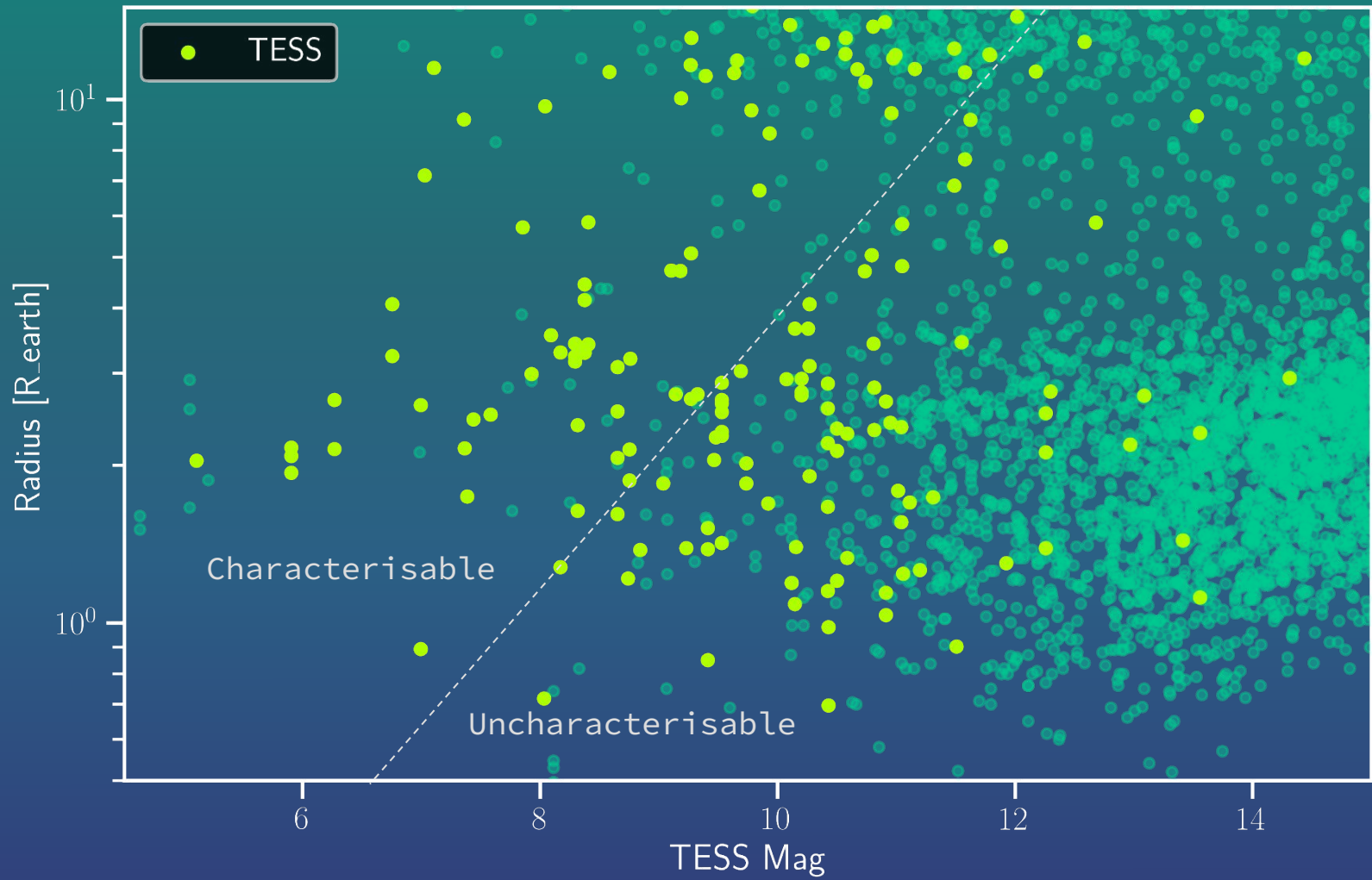
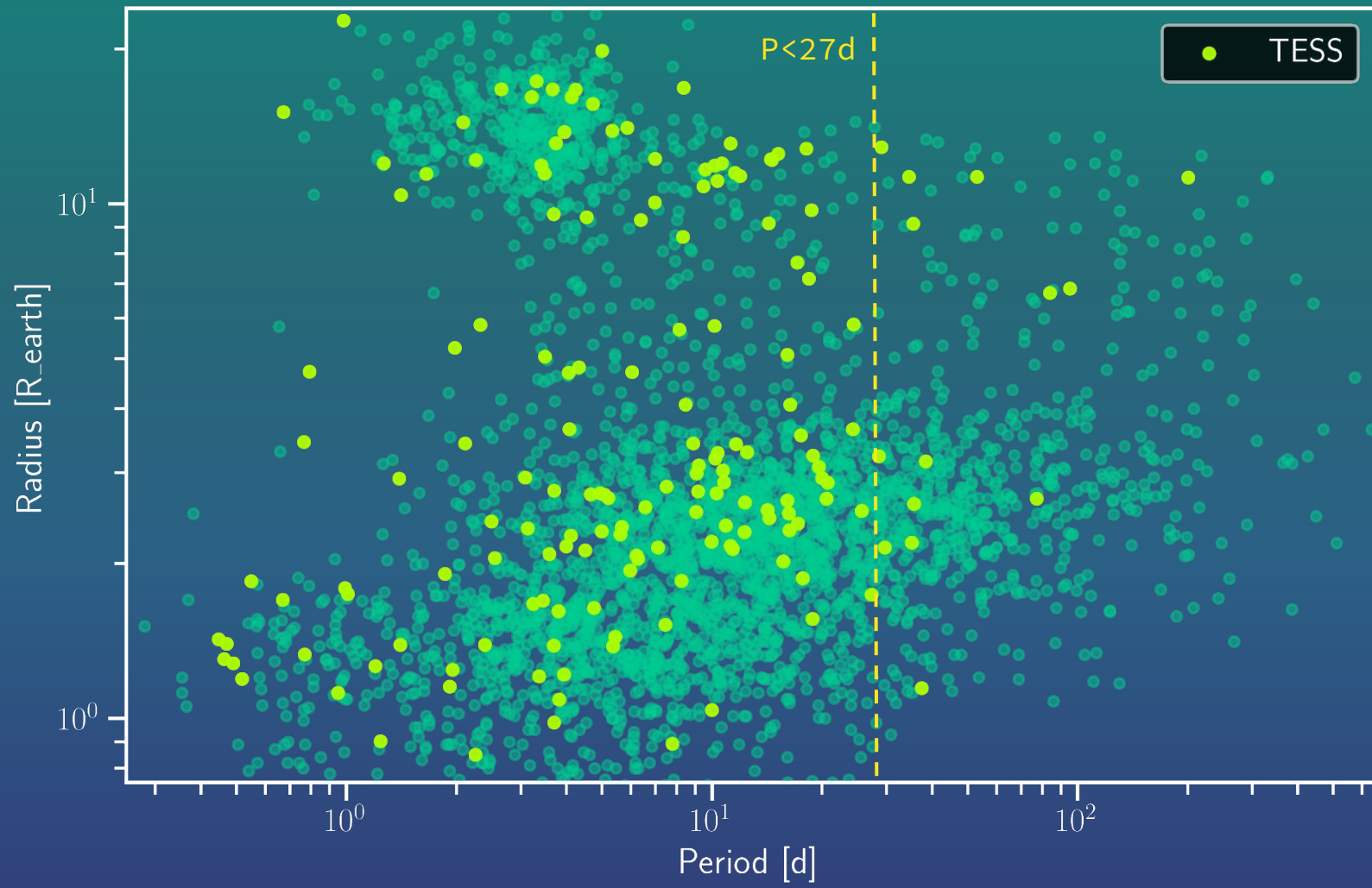


UNCOVERING THE TRUE PERIODS OF TWO SUB-NEPTUNES AROUND A BRIGHT, YOUNG STAR

Hugh P. Osborn, CHESS fellow, Uni. Bern & MIT

+CHEOPS GTO team +SAINT-Ex team +TFOP/SG1/LCO team +HARPS-N/GAPS team





WHY ARE LONG-PERIOD PLANETS IMPORTANT?

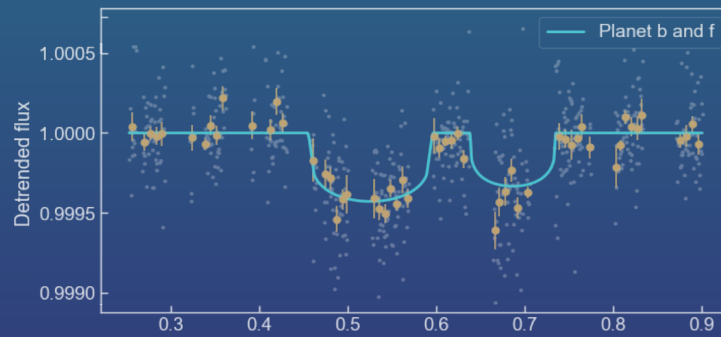
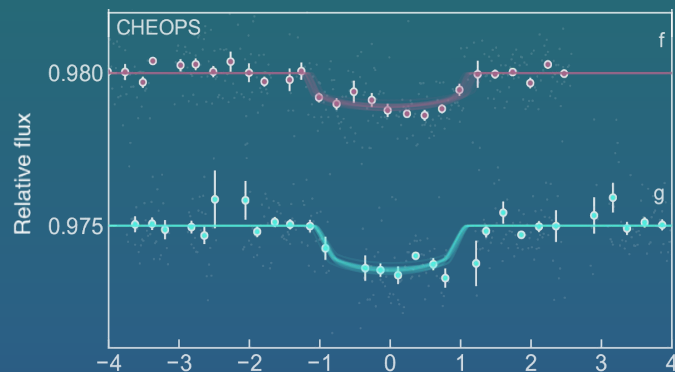
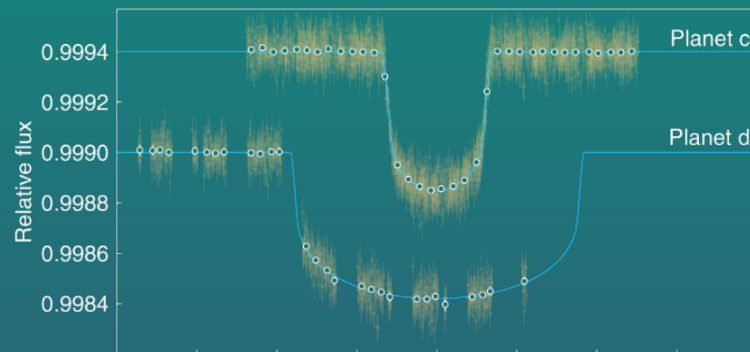
- Planets are not dominated by their host stars:
 - Insolation/evaporation
 - Tidal forces/recircularisation
- Cooler atmospheres with lower temperature molecules detectable from transmission spectra (H₂O, CH₄, etc)
- Closer to solar system analogues
- Stable exo-moon & ring systems
- “Habitable zones”

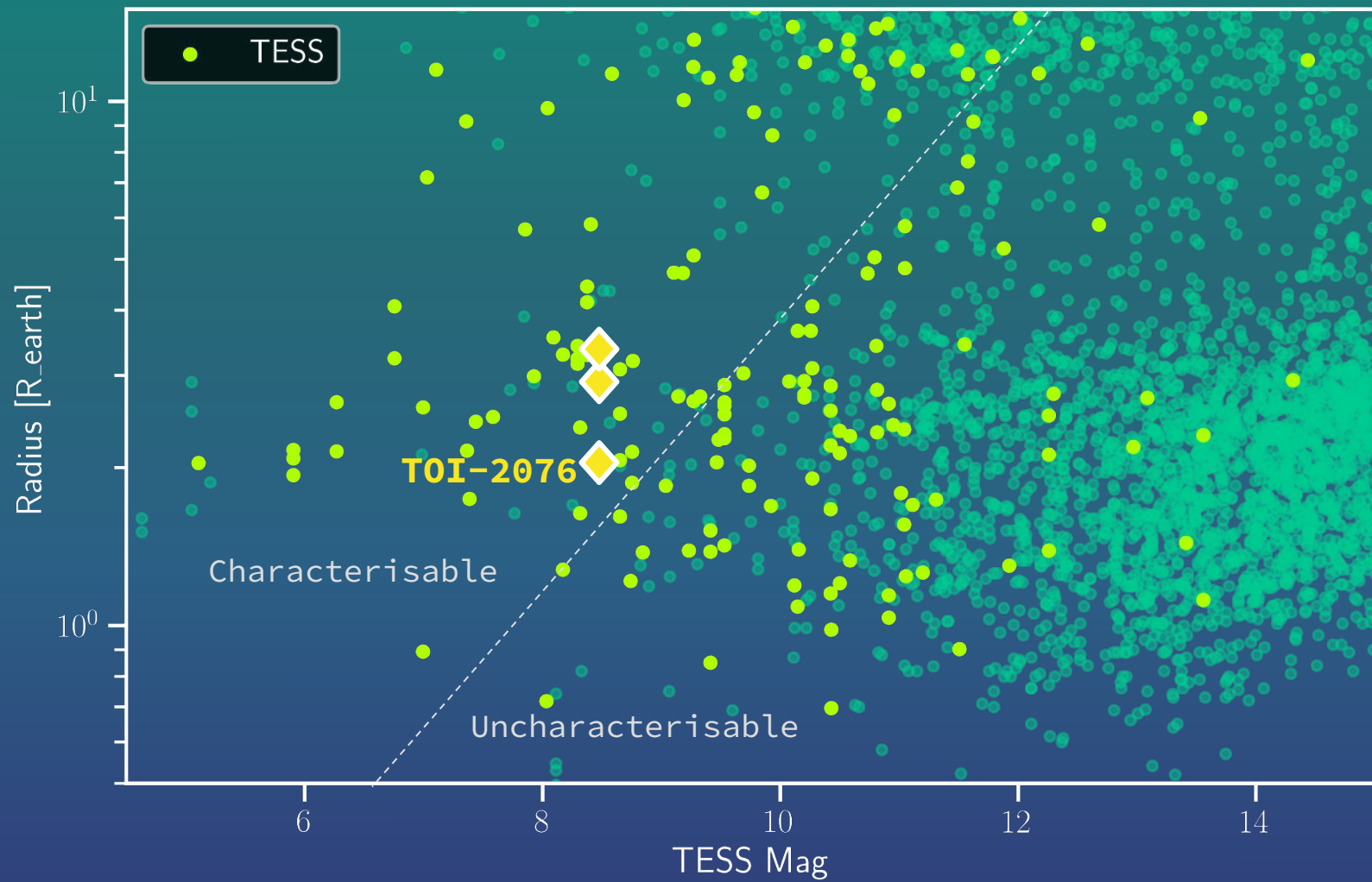
CHEOPS CAN HELP

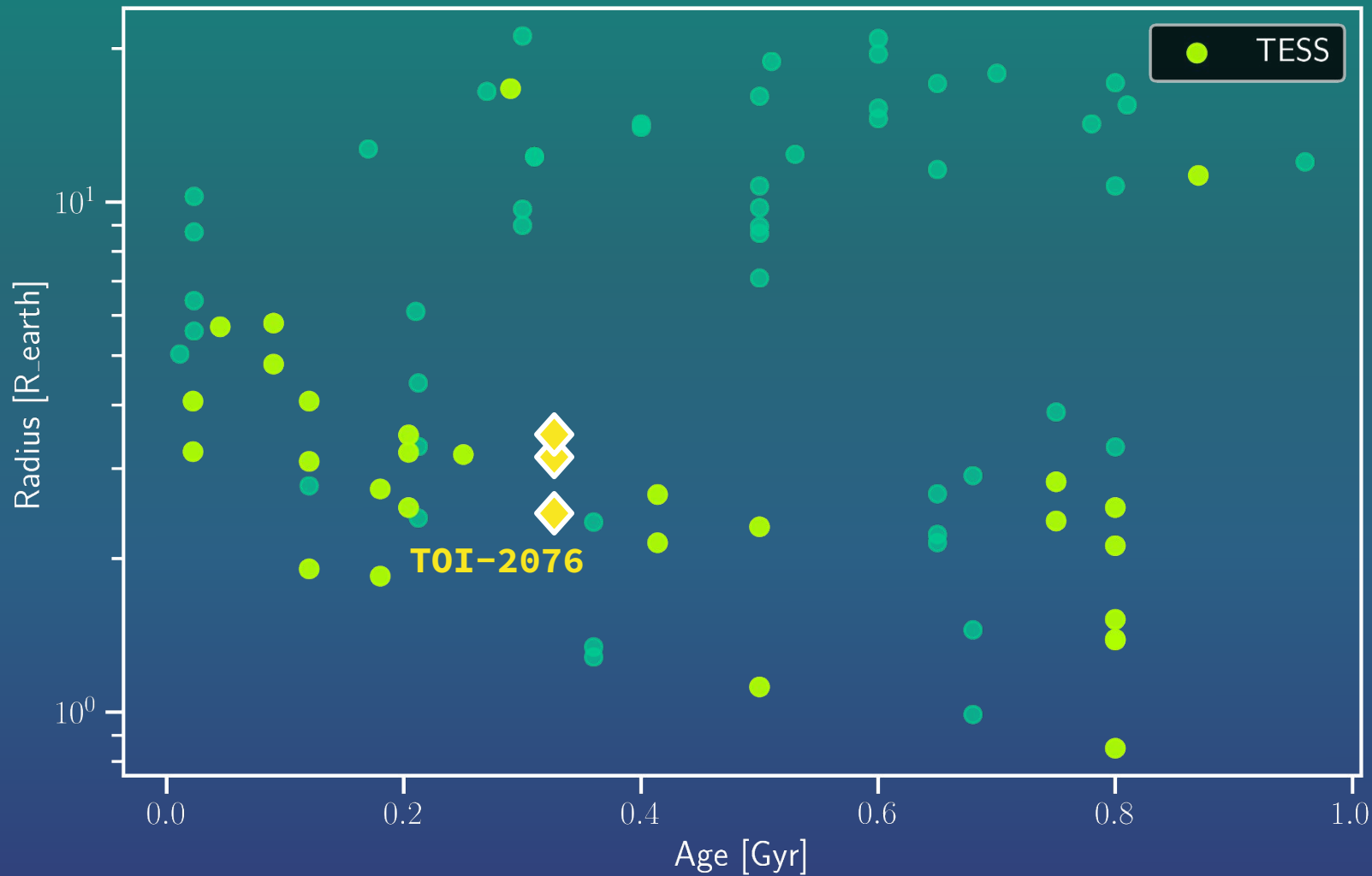
Nu² Lupi d (110d) –
Delrez et al 2021

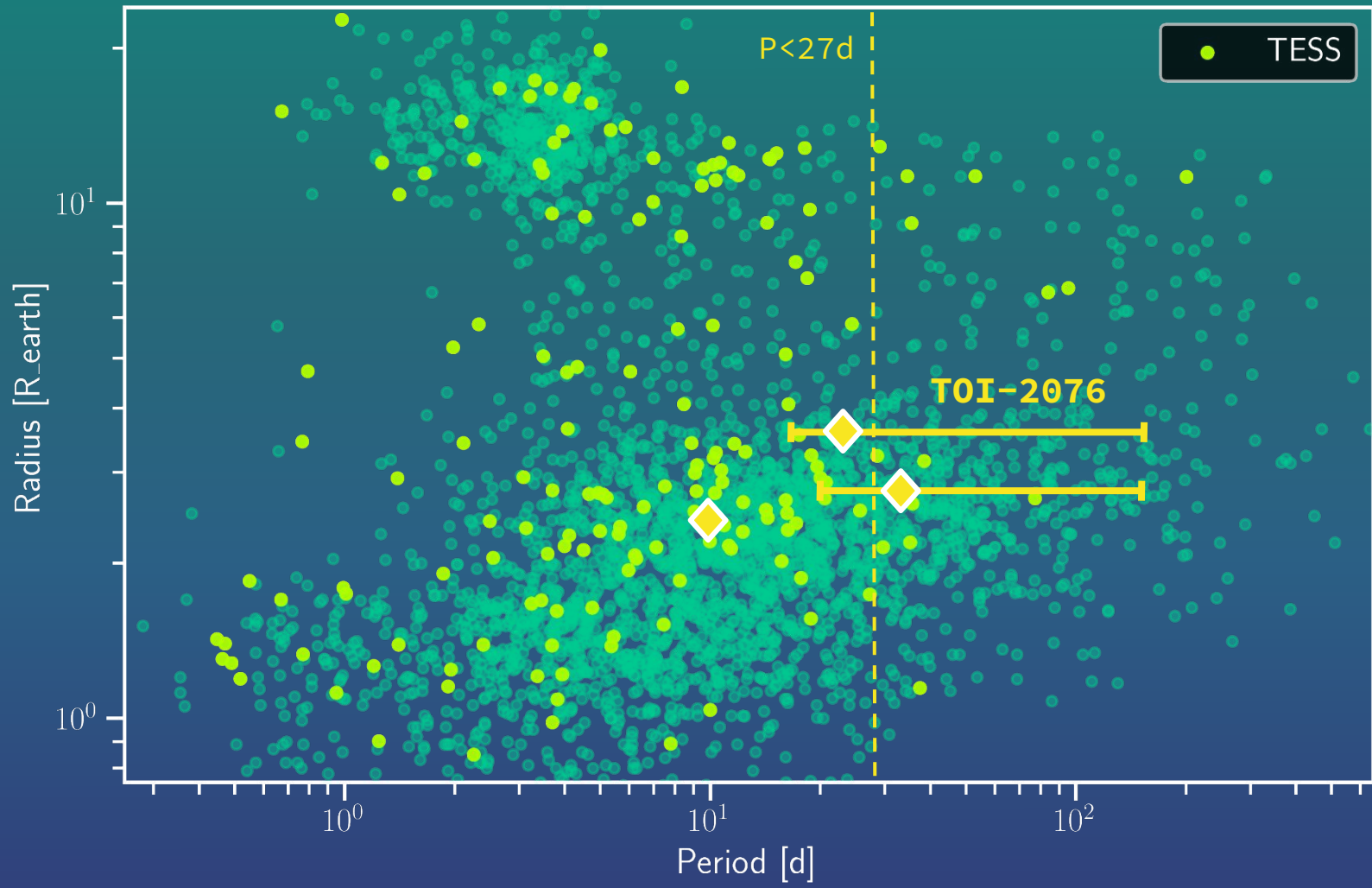
TOI-178 e & f (15.2, 20.7d) –
Leleu et al 2021

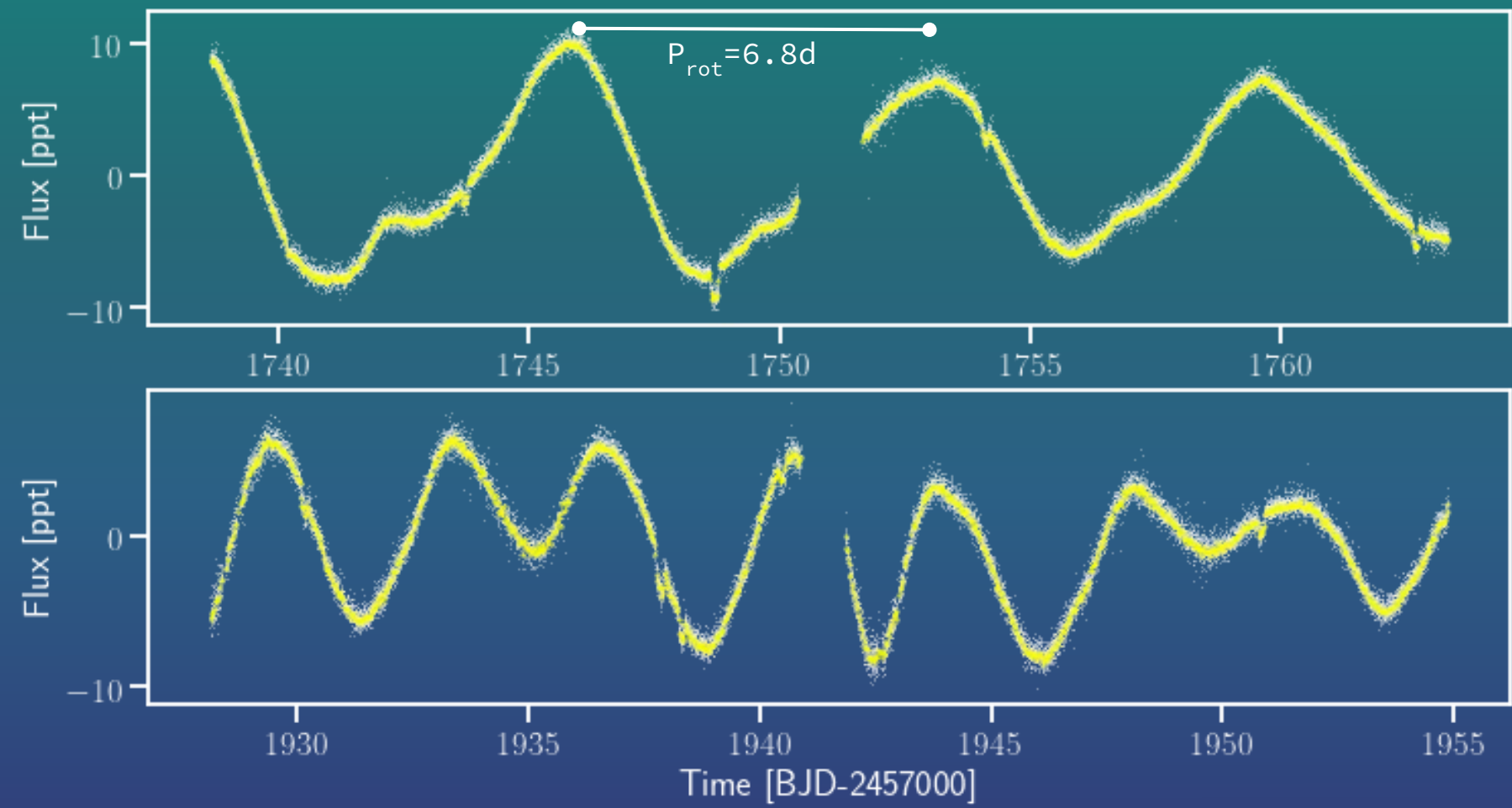
TOI-1233 f (29.5d) –
Bonfanti et al 2021

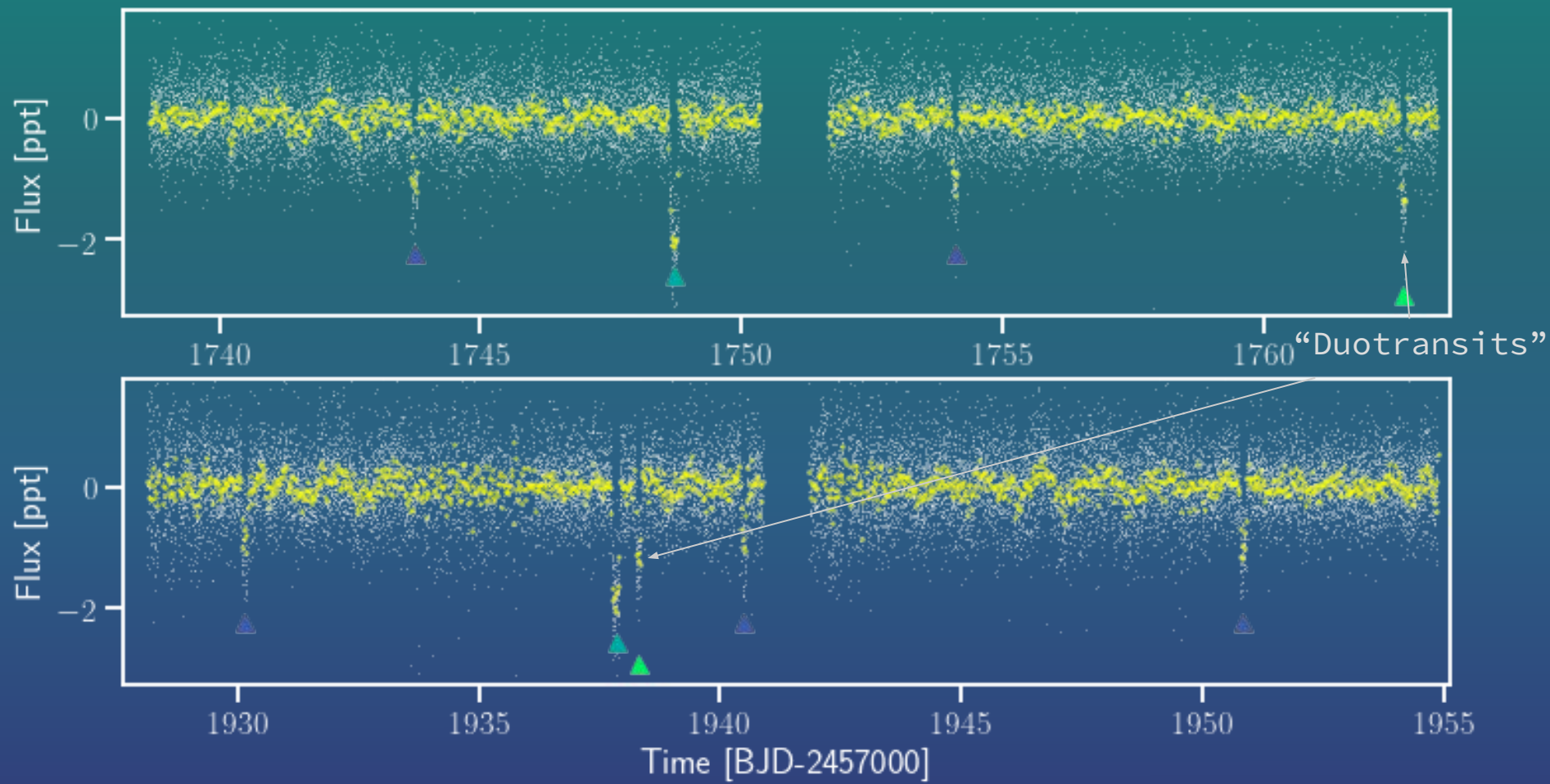


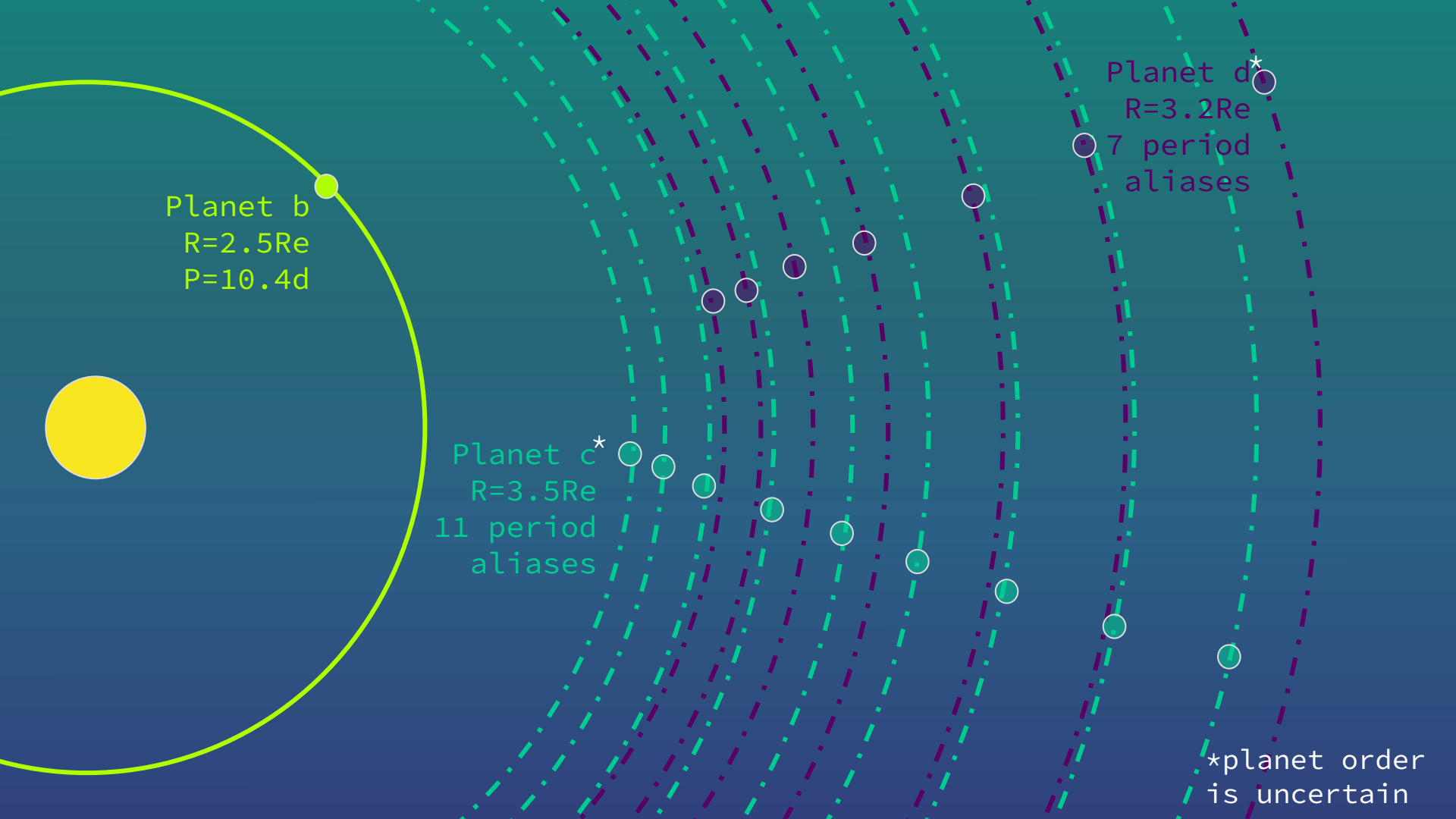








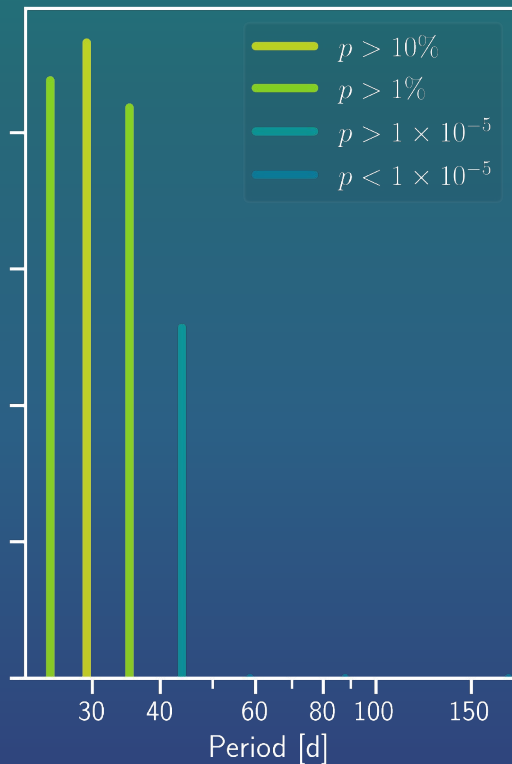
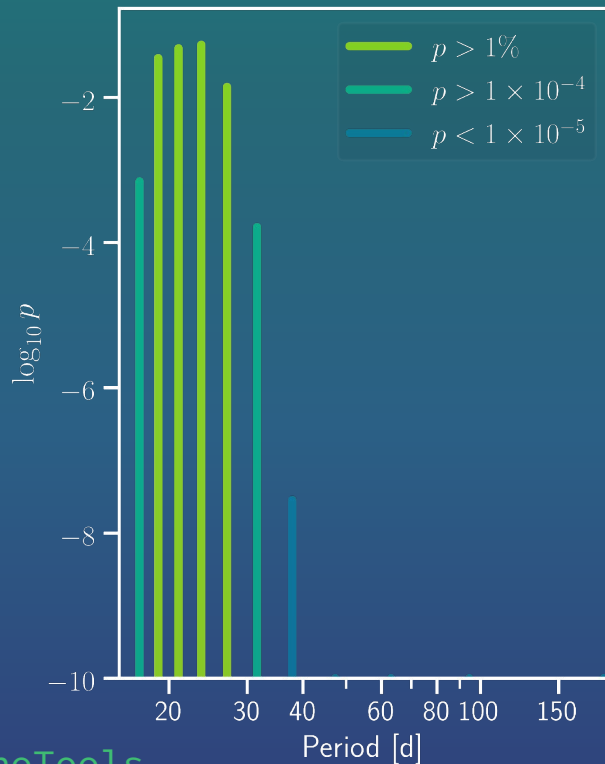


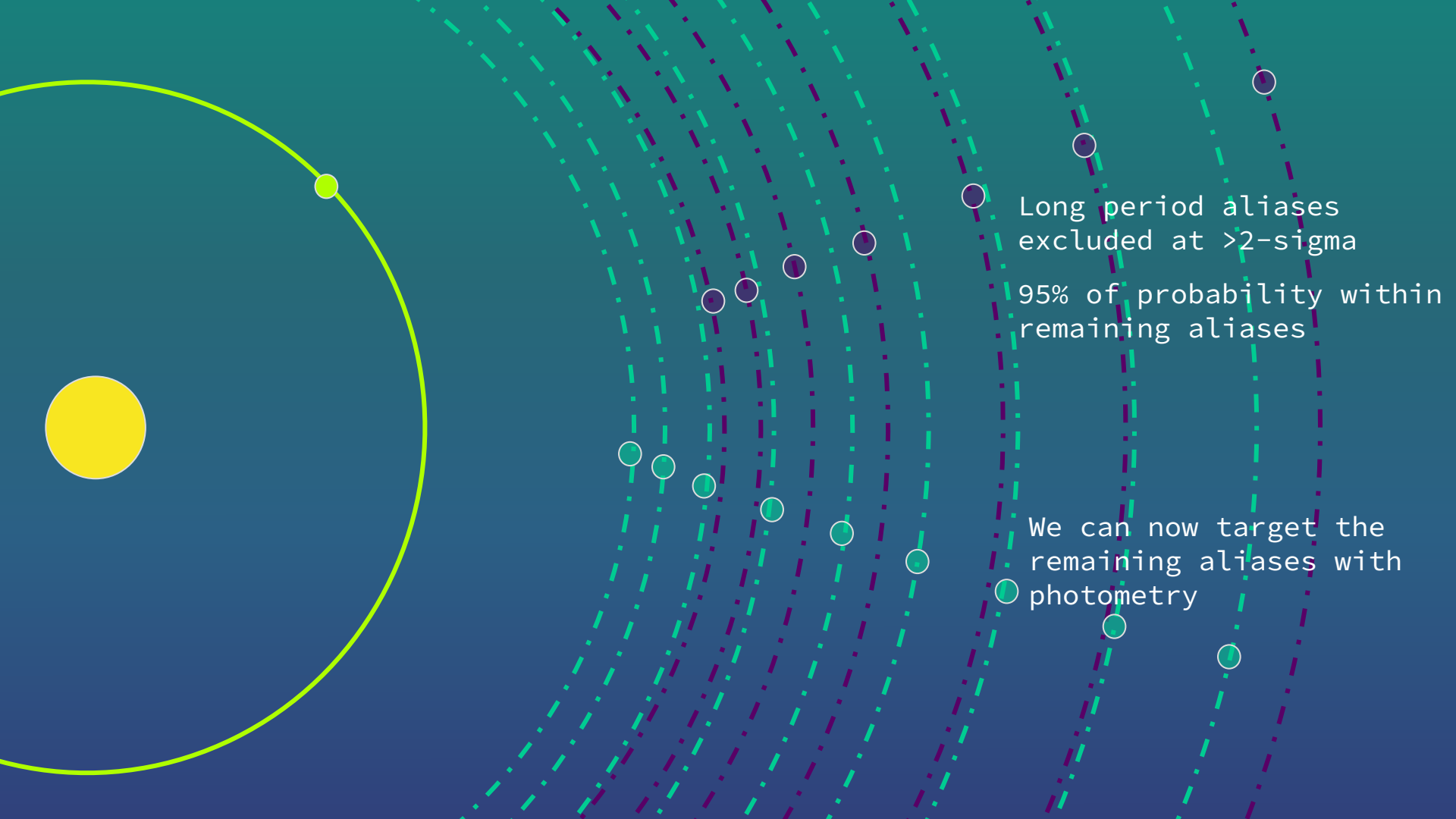


HOW CAN WE FIND THE TRUE PERIODS?

PERIOD PROBABILITIES FROM THE TESS DATA

Probability
=
model likelihood
x
period prior
x
eccentricity prior
x
(stability prior)





Long period aliases
excluded at >2-sigma

95% of probability within
remaining aliases

We can now target the
remaining aliases with
photometry

WHY CHEOPS?

KELT-11b

lightcurves:

9 ground-based
scopes combined.

Effective
aperture 1.8m.

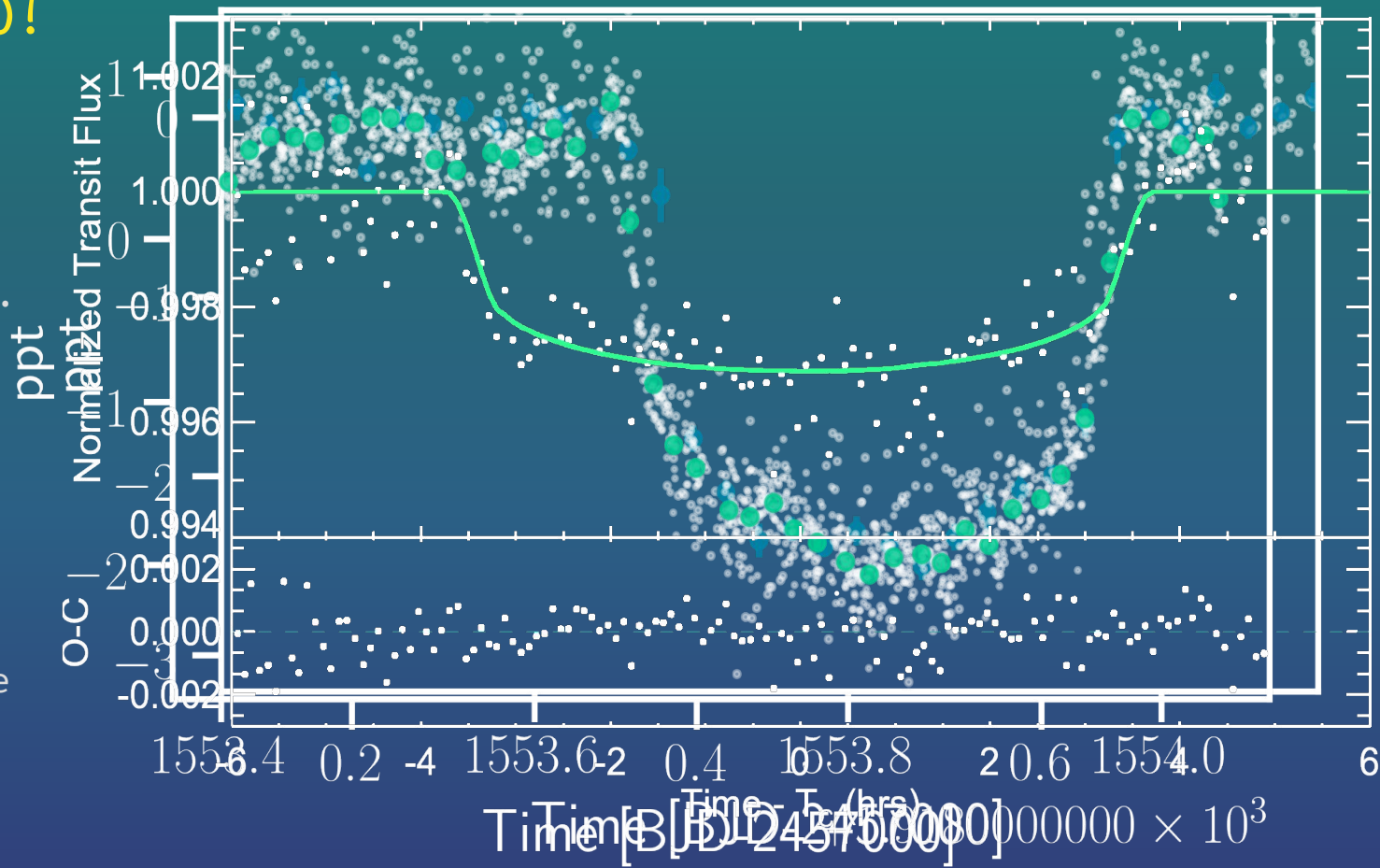
SNR ~ 20

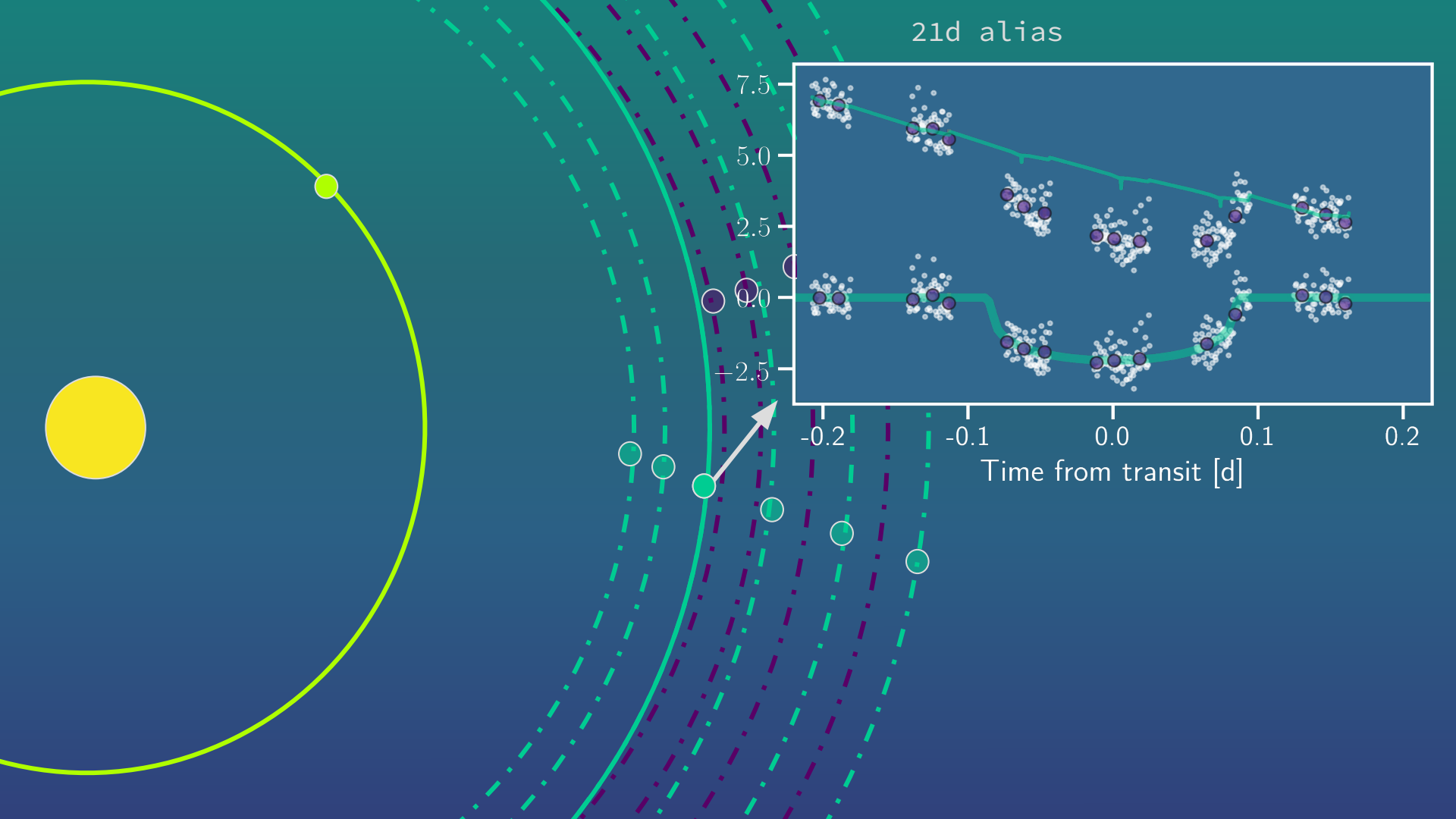
TESS. Aperture

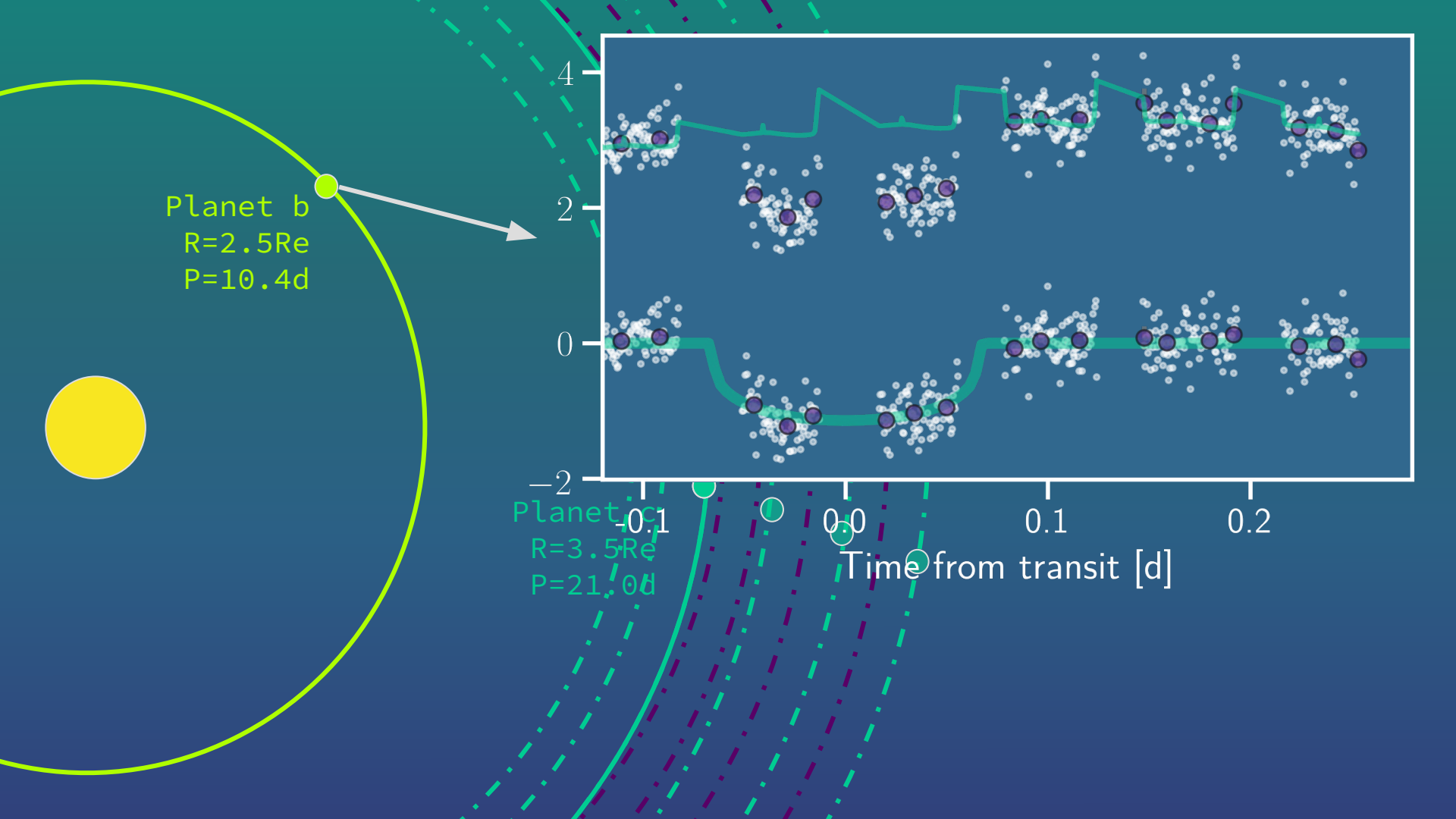
10cm. SNR ~ 127

Cheops. Aperture

35cm. SNR ~ 409





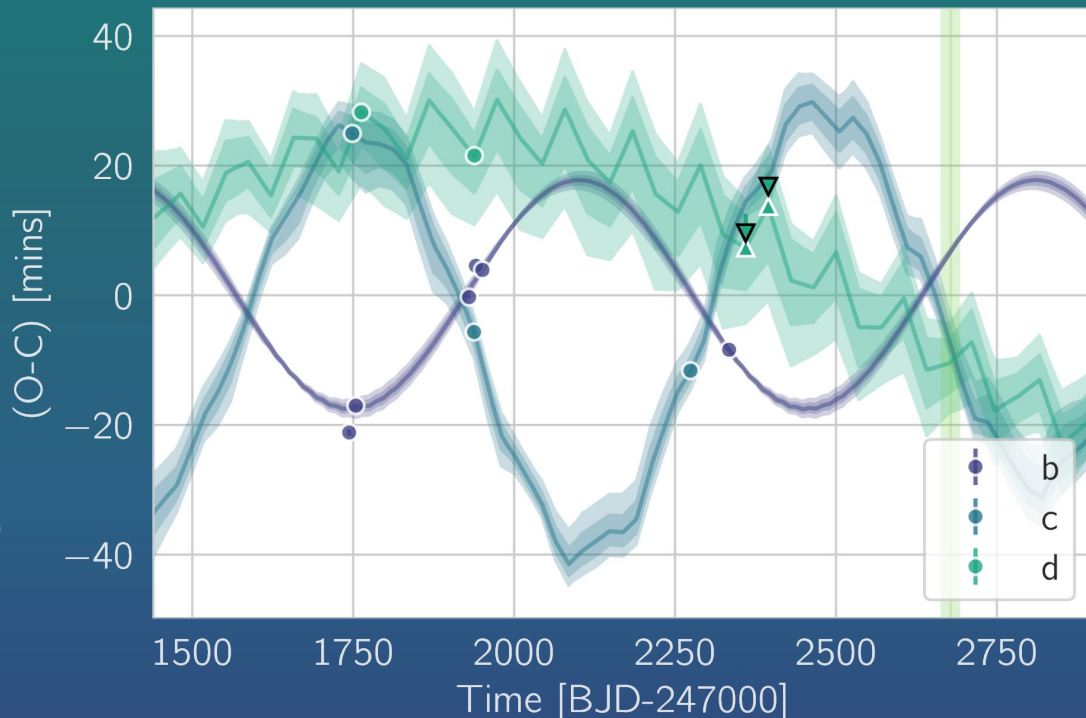


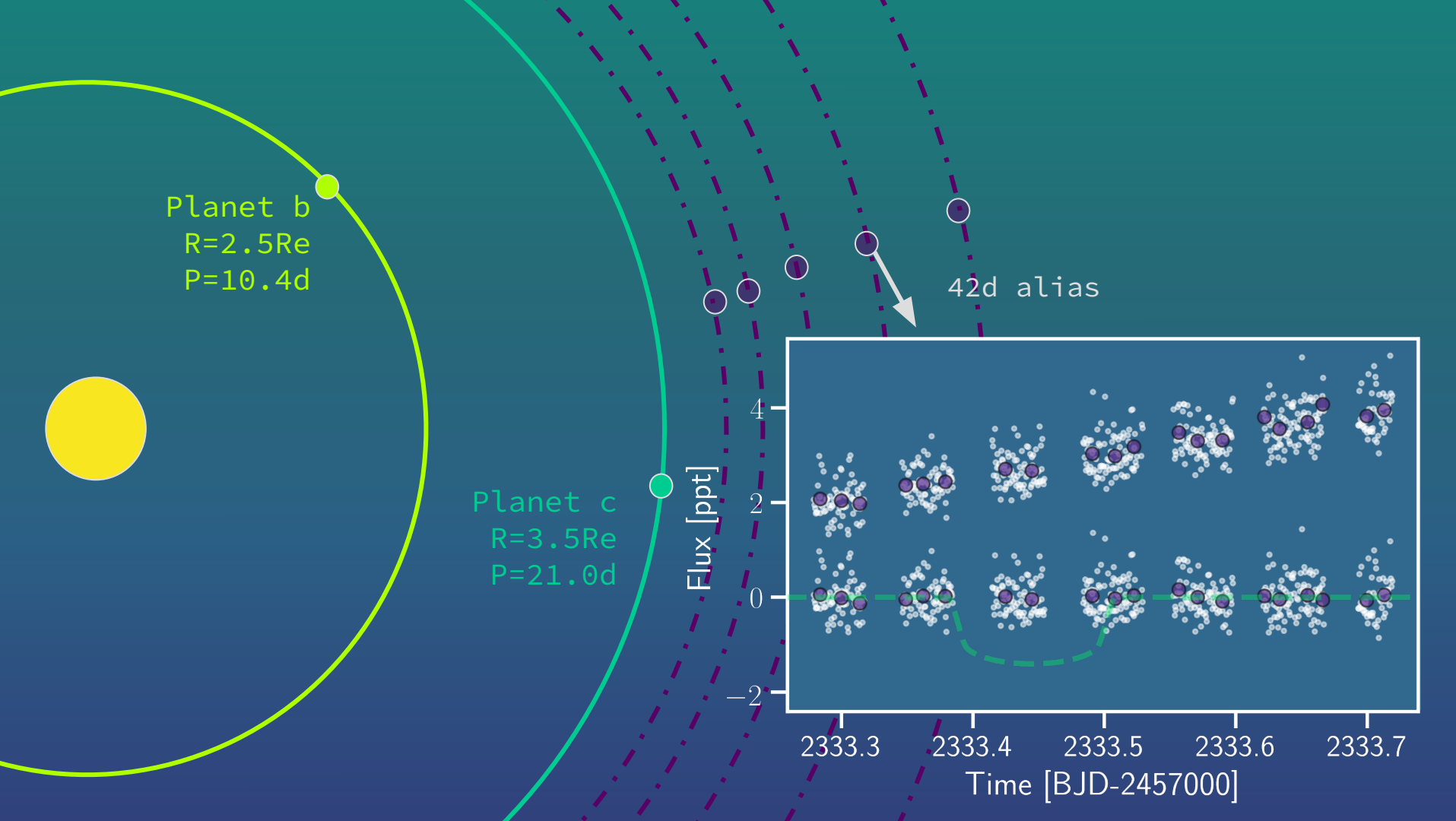
TTVs

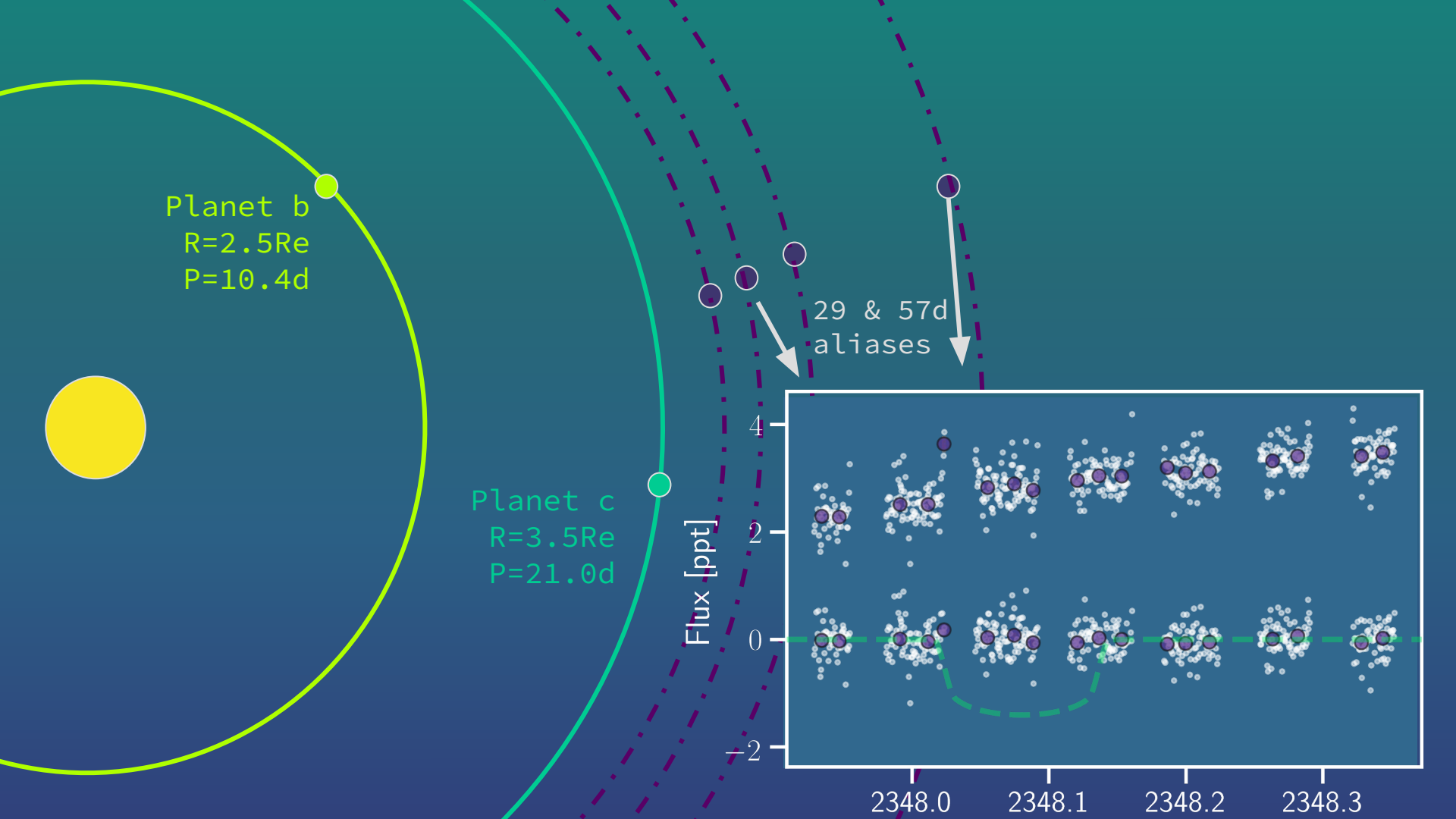
Planets b & c near 2:1
period commensurability

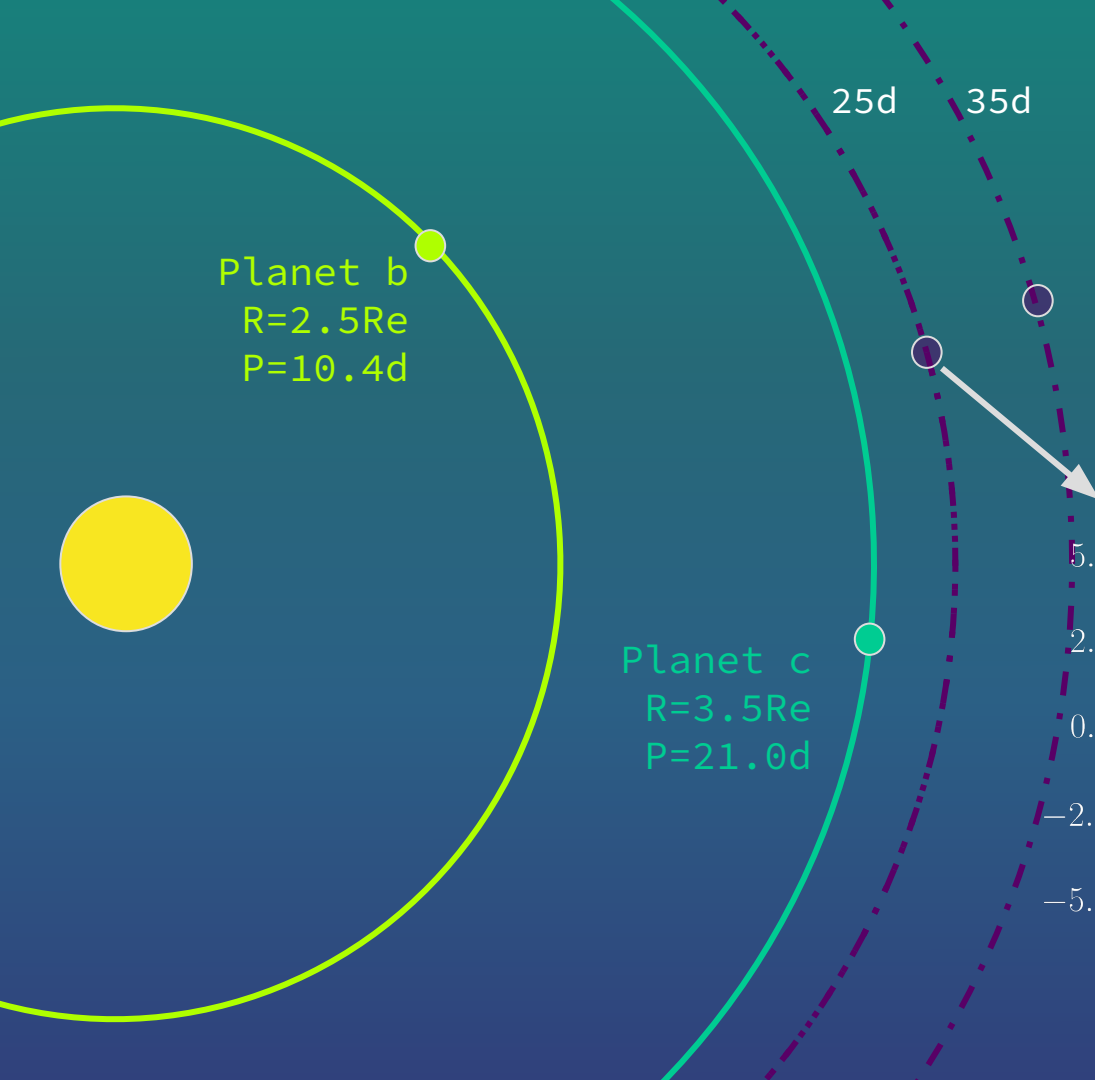
Potential TTV amplitudes
up to 1 hour

With so few transits,
masses are very sensitive
to input priors

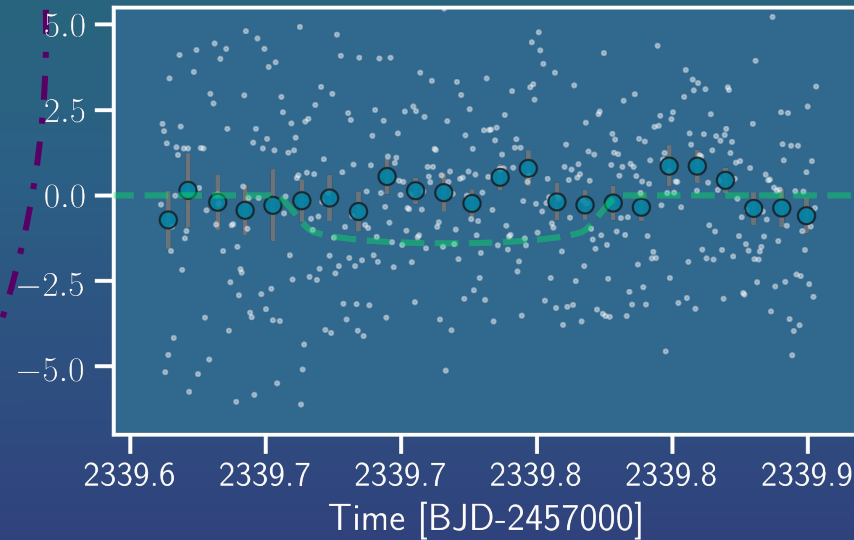


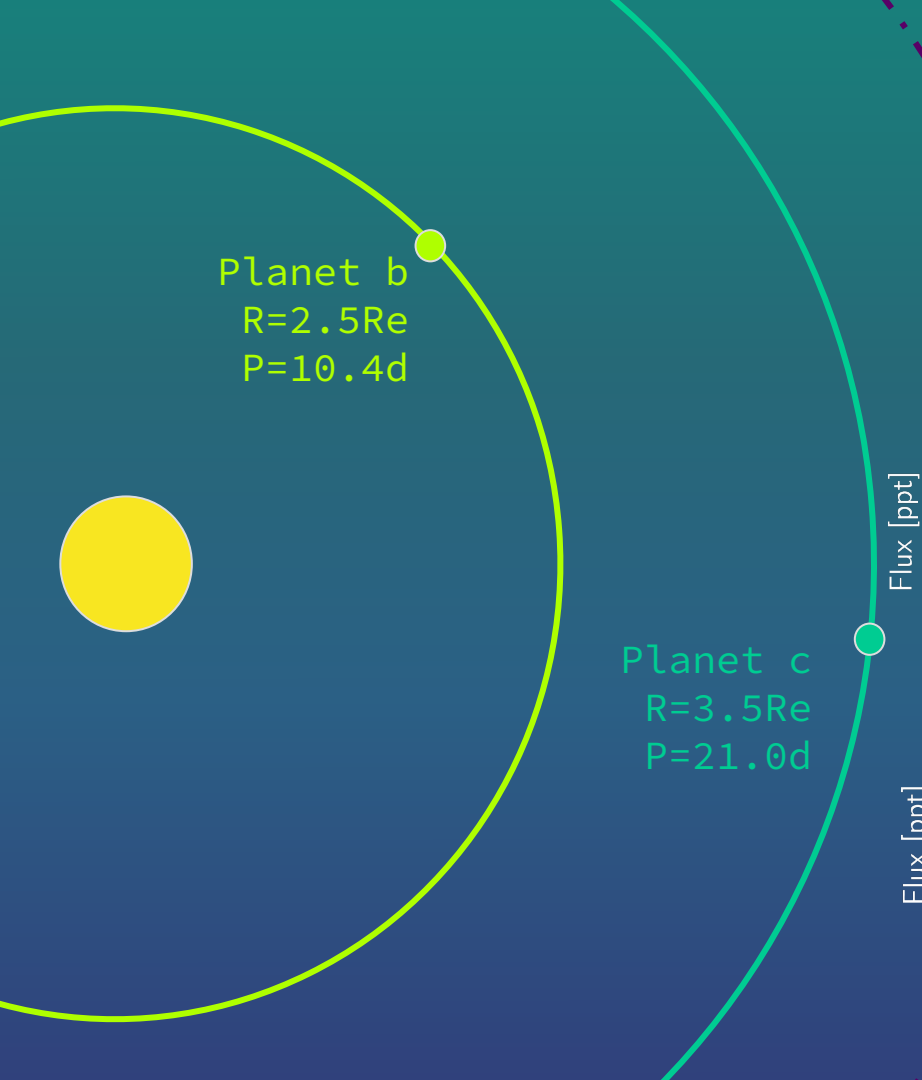






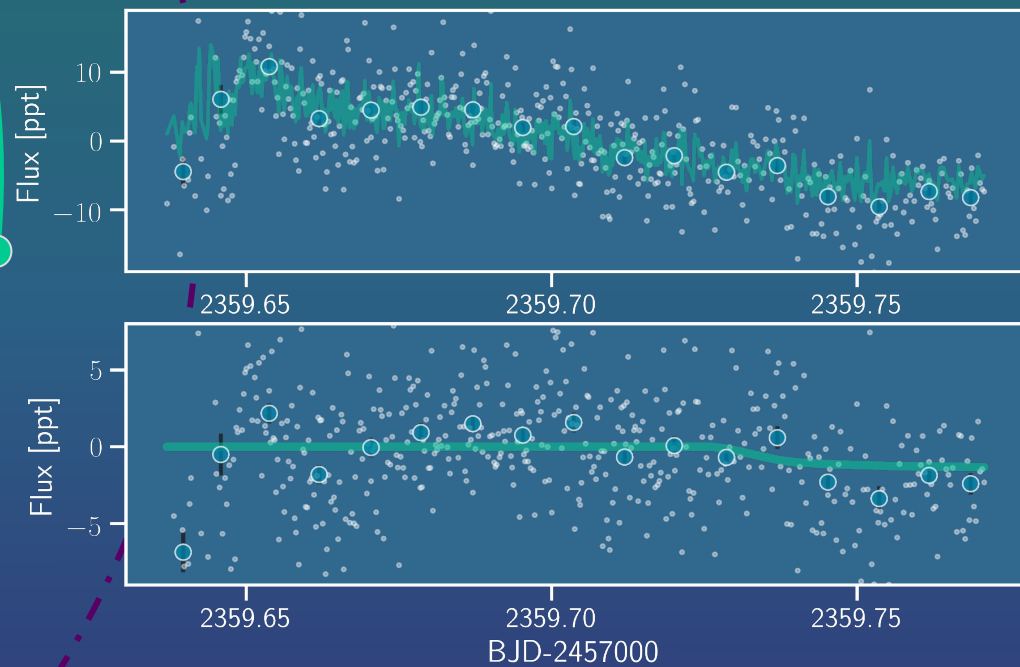
- $P=25d$ alias disfavoured by TESS-only model due to orbit-crossing solutions
- Rebound orbital stability analyses disfavours 25d alias (5% vs 89%)
- LCO lightcurve rules out 25d alias

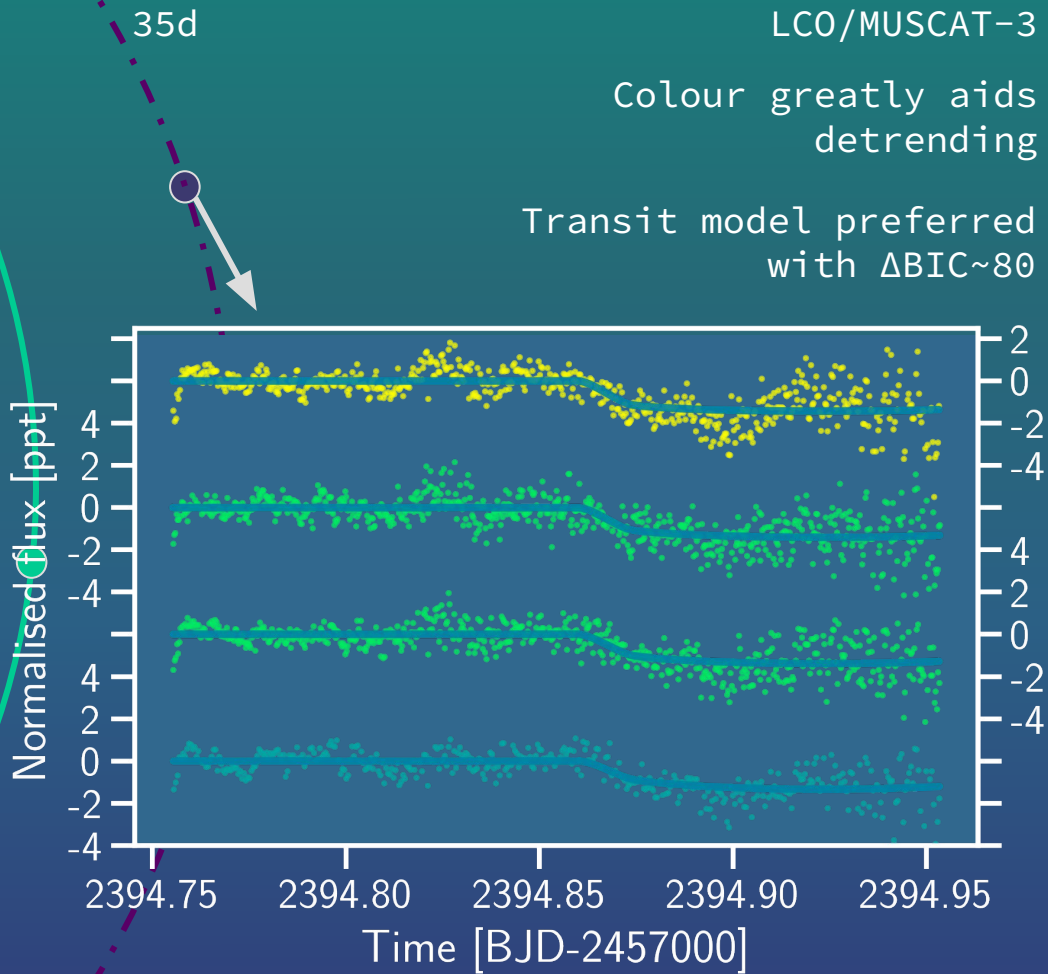
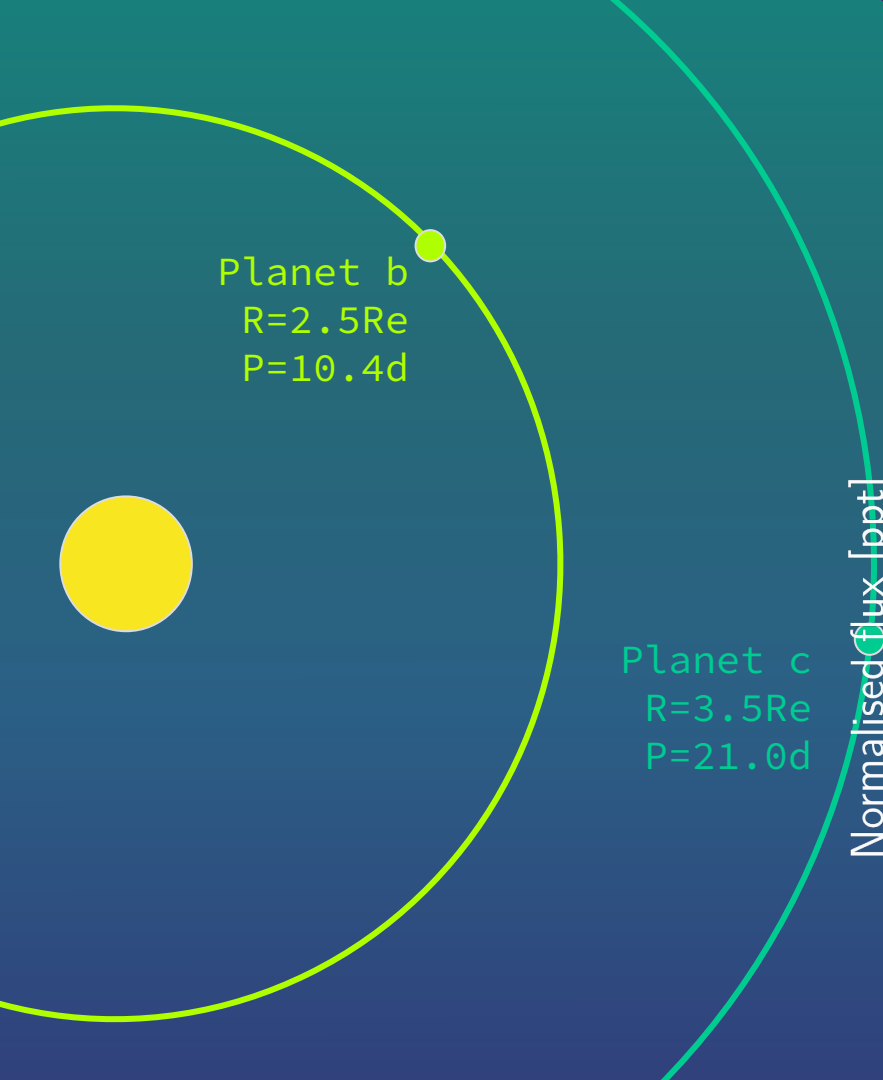


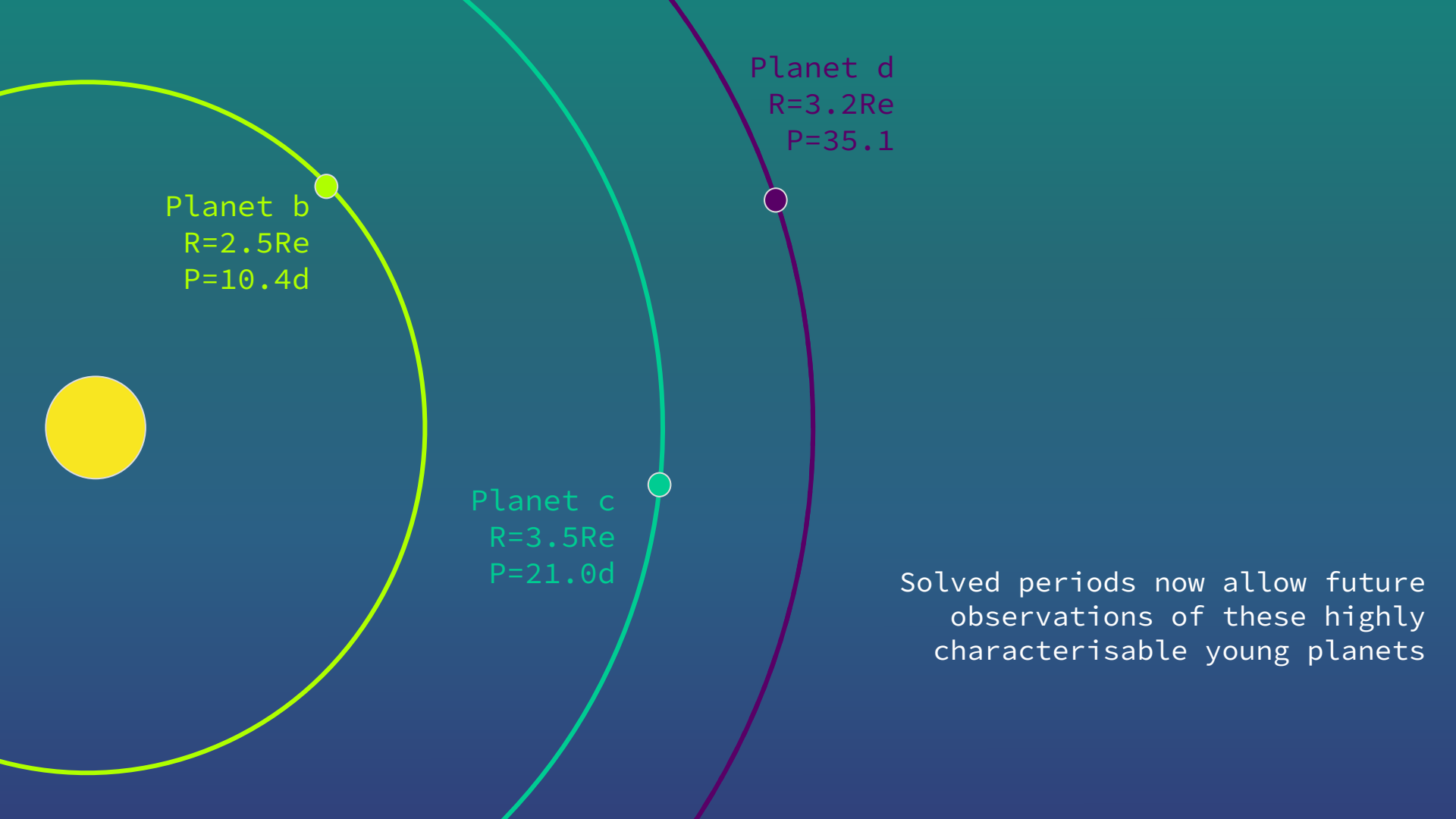


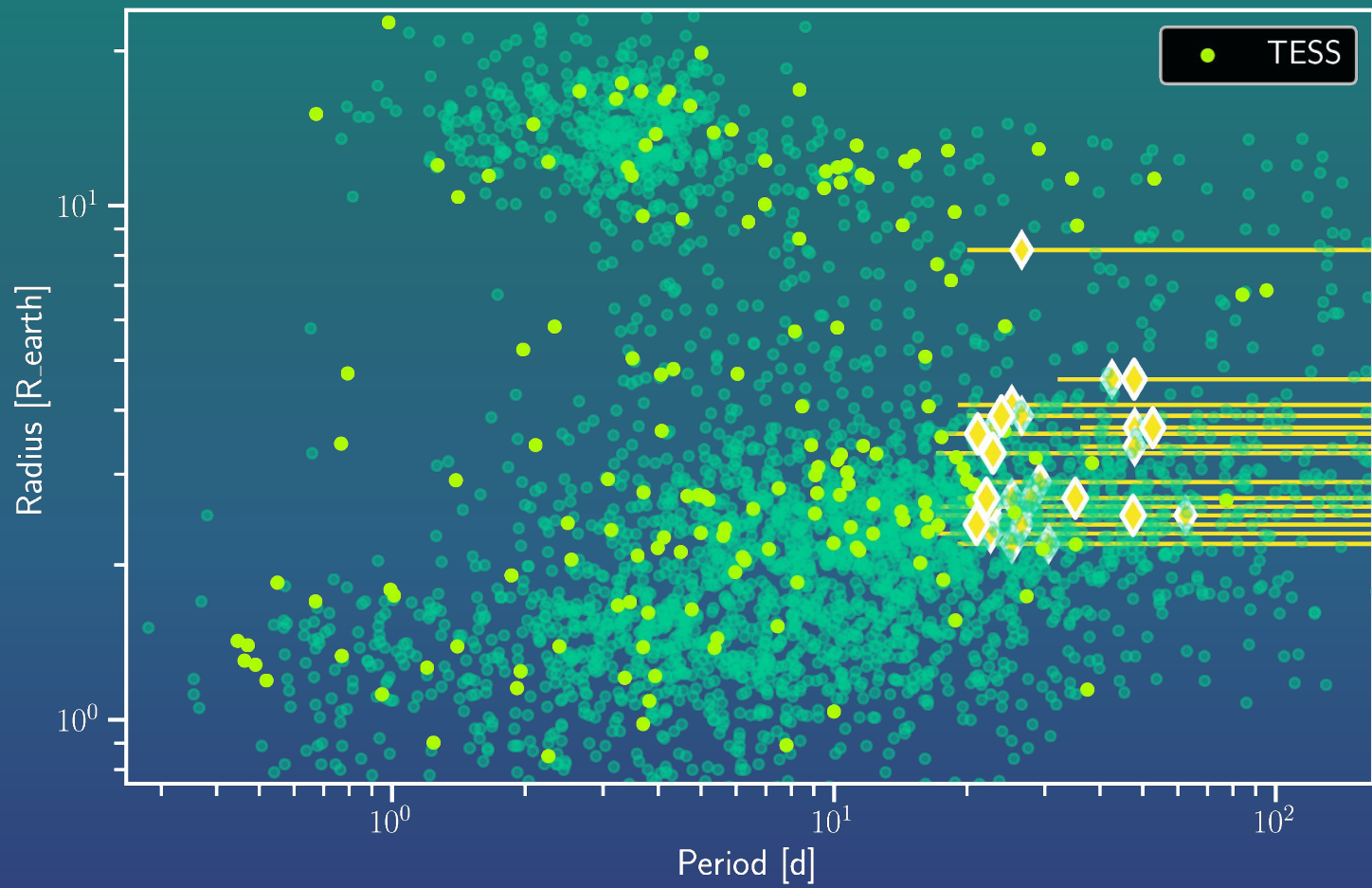
35d

Saint-ex observations









CONCLUSIONS

- Targeted follow-up of “duotransits” is needed to reveal the orbits of long-period planets
- CHEOPS is the perfect instrument to follow small duotransit candidates
- We find the true periods of TOI-2076 c & d, improved the radii, and revealed high-amplitude TTVs
- These planets are now viable for future follow-up
- Many other long-period planets to be published soon.