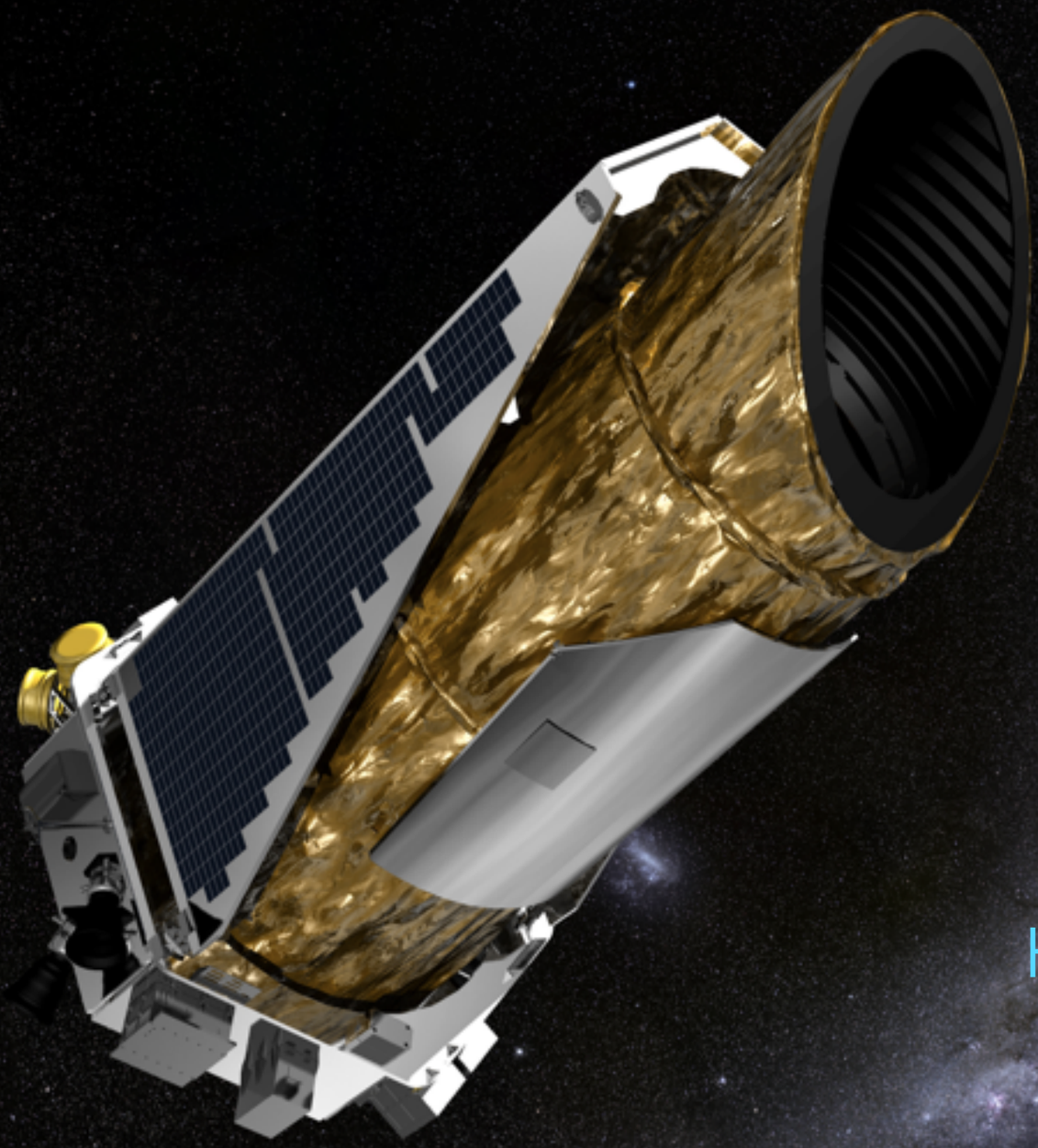
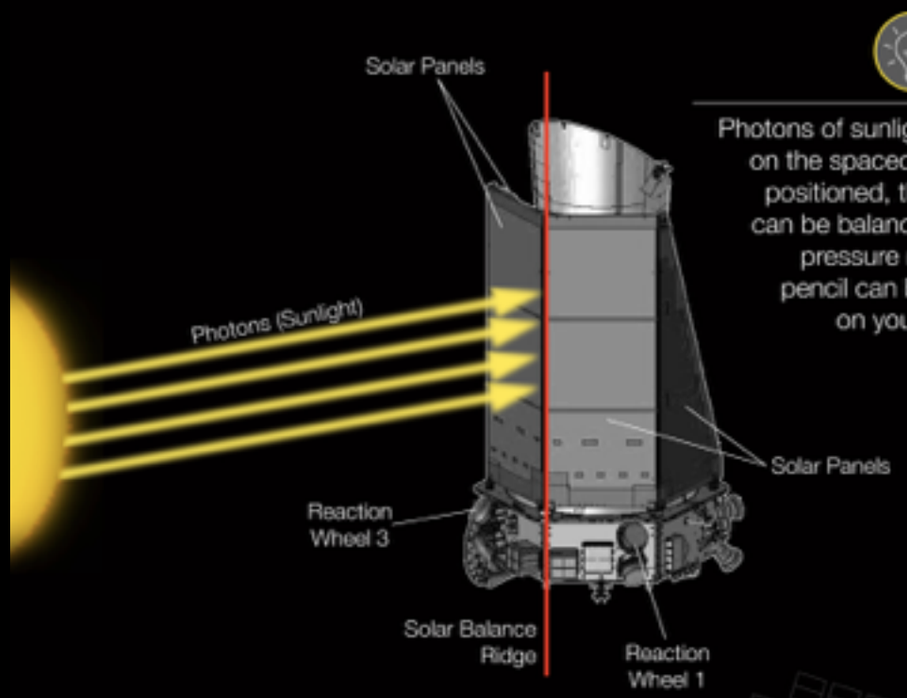
K2SC: UNLEASHING THE POTENTIAL OF K2 FOR ACTIVE STARS

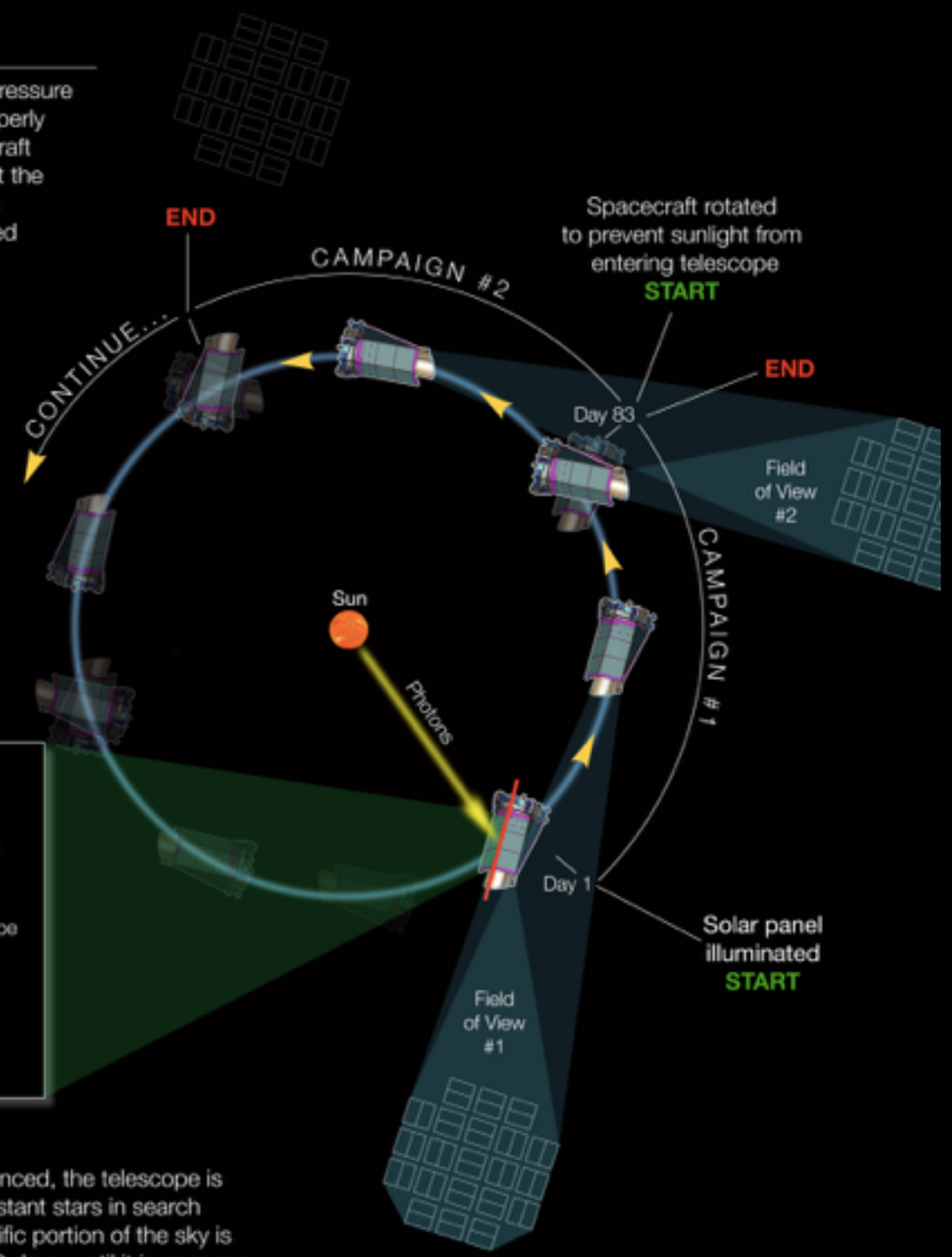


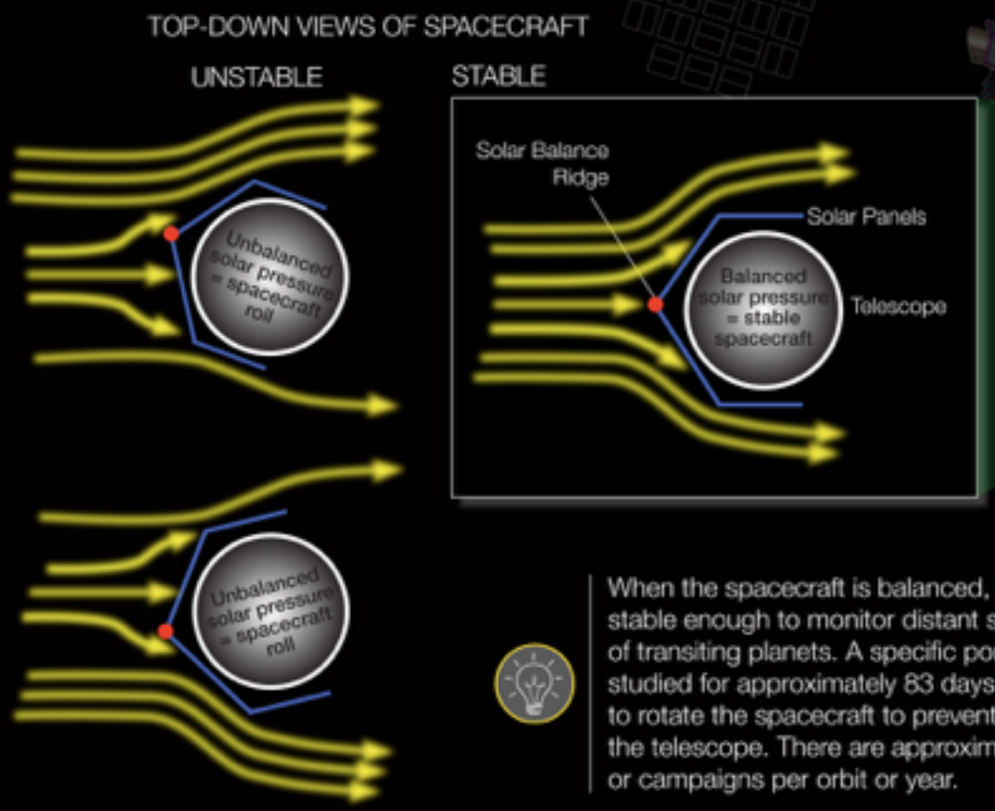
SUZANNE AIGRAIN
HANNU PARVIAINEN
BENJAMIN POPE
UNIVERSITY OF OXFORD

THE K2 MISSION



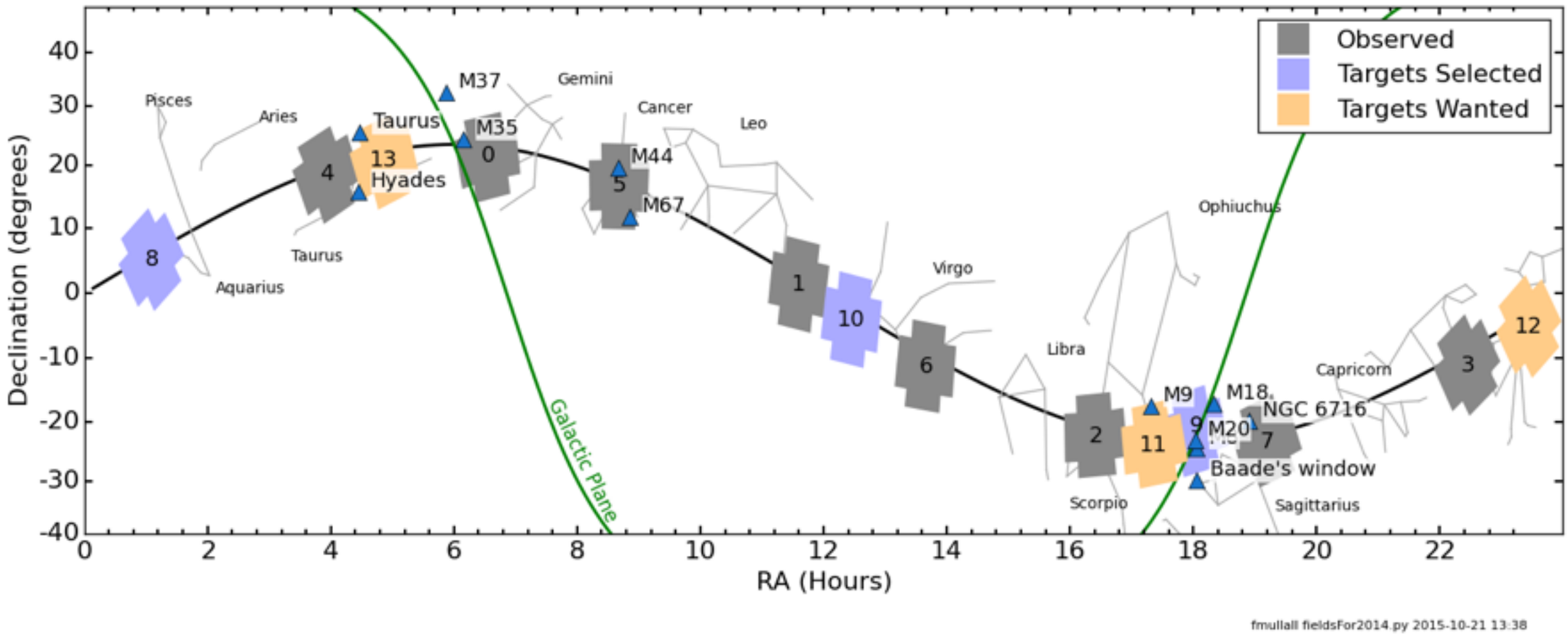
Photons of sunlight exert pressure on the spacecraft. If properly positioned, the spacecraft can be balanced against the pressure much as a pencil can be balanced on your finger.



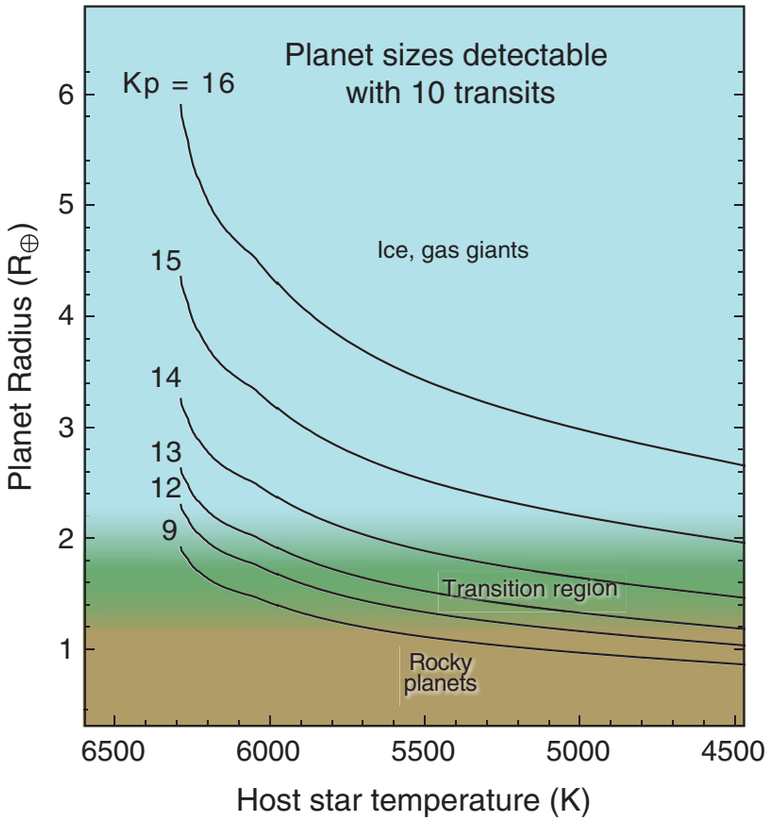


When the spacecraft is balanced, the telescope is stable enough to monitor distant stars in search of transiting planets. A specific portion of the sky is studied for approximately 83 days, until it is necessary to rotate the spacecraft to prevent sunlight from entering the telescope. There are approximately 4.5 viewing periods or campaigns per orbit or year.

THE K2 MISSION

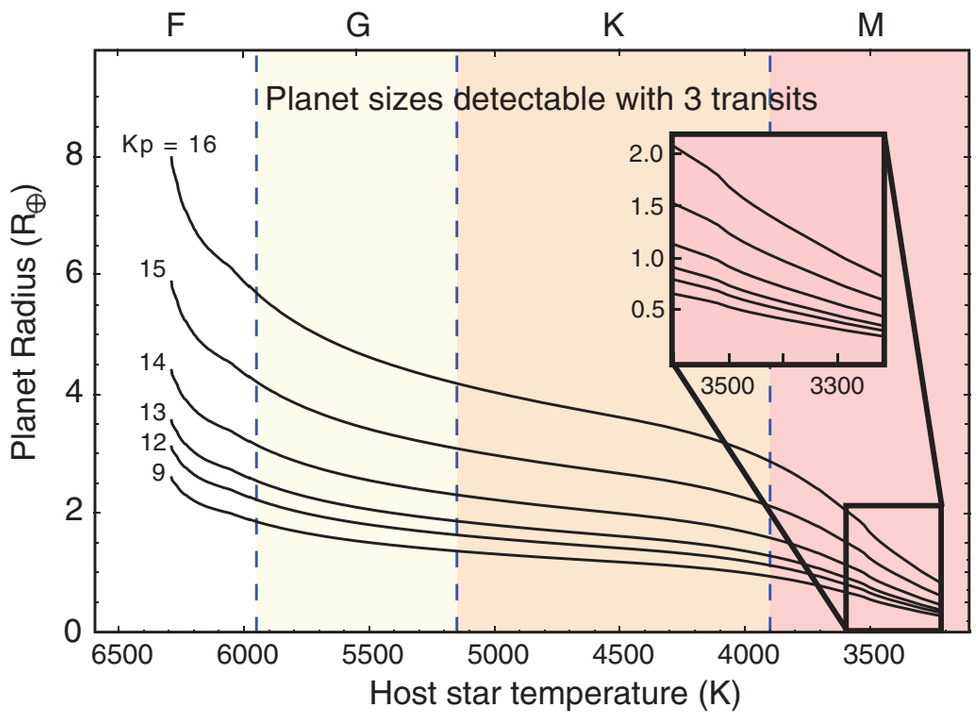


K2 KEY SCIENCE



bright (V<12) FGK dwarfs

Howell et al. (2014)



extragalatic sources
(AGN, supernovae)
microlensing

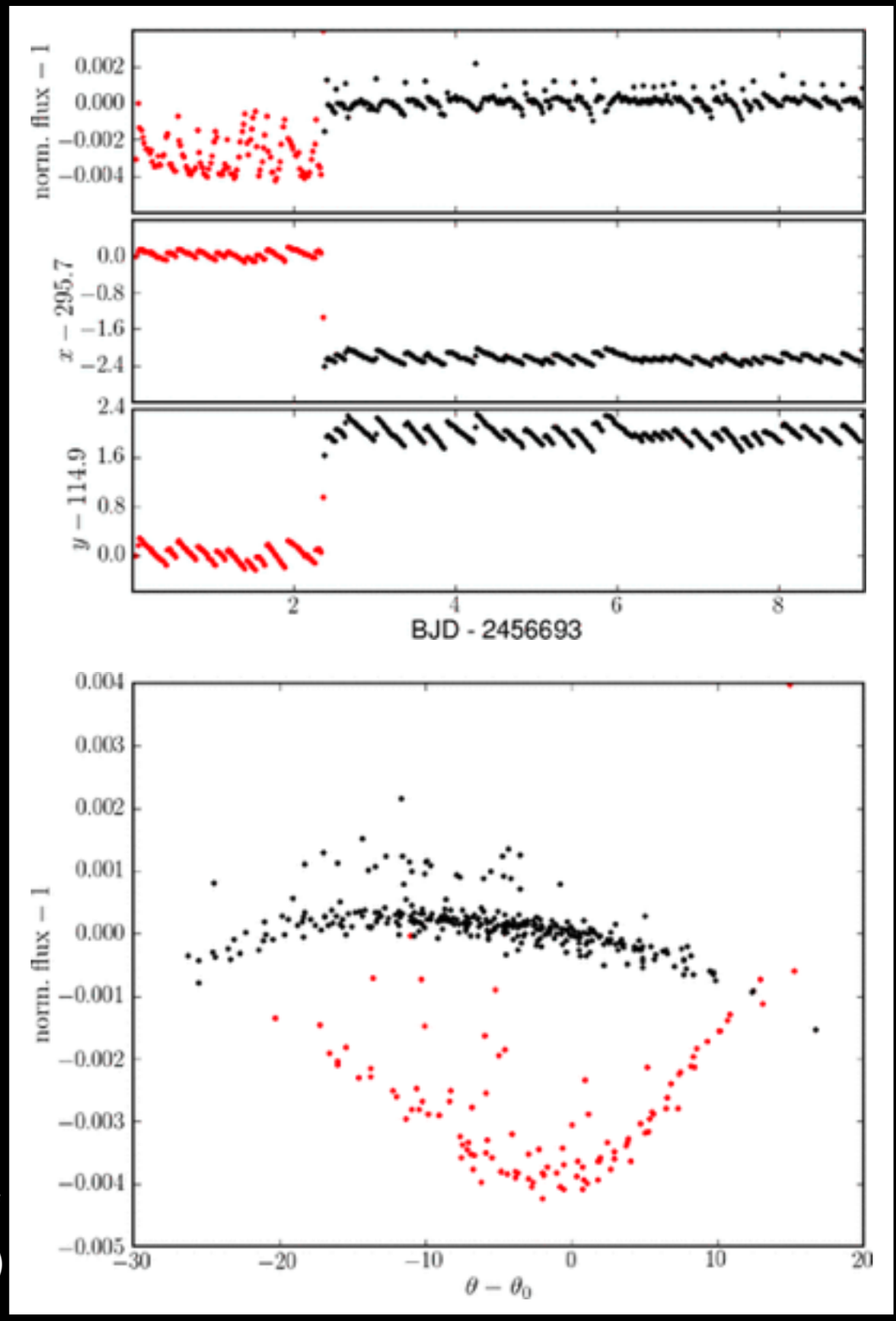
open clusters and star forming regions

TABLE 1
K2 OPEN CLUSTERS

Cluster	Age (Myr)	Distance (pc)	K2 Campaign (Proposed)	Ref.
Taurus	2	140	4	Rebull et al. (2012)
Upper Sco	10	130	2	Pecaut et al. (2012)
M21	12	1200	9	Piskunon et al. (2011)
M18	32	1300	9	Santos-Silva & Gregorio-Hetem (2012)
M25	92	620	9	Piskunon et al. (2011)
M35	100	800	0	McNamara et al. 2012
M45	125	135	4	Bell et al. (2012)
NGC 1647	150	547	10	Piskunon et al. (2011)
NGC 6716	150	547	7	Piskunon et al. (2011)
Hyades	630	46	4	Schilbach & Roser (2012)
M44	630	160	5	Boudreault et al. (2012)
M67	4300	908	5	Dias et al. (2012)

PRECISE PHOTOMETRY WITH K2?

- (initially) no light curves released (only images)
    - standard Kepler LC products released since campaign 3
- light curves affected by severe systematics
- many more active & variable stars than Kepler



example raw LC from “engineering test dataset” (Aigrain et al. 2015)

PRECISE PHOTOMETRY WITH K2?

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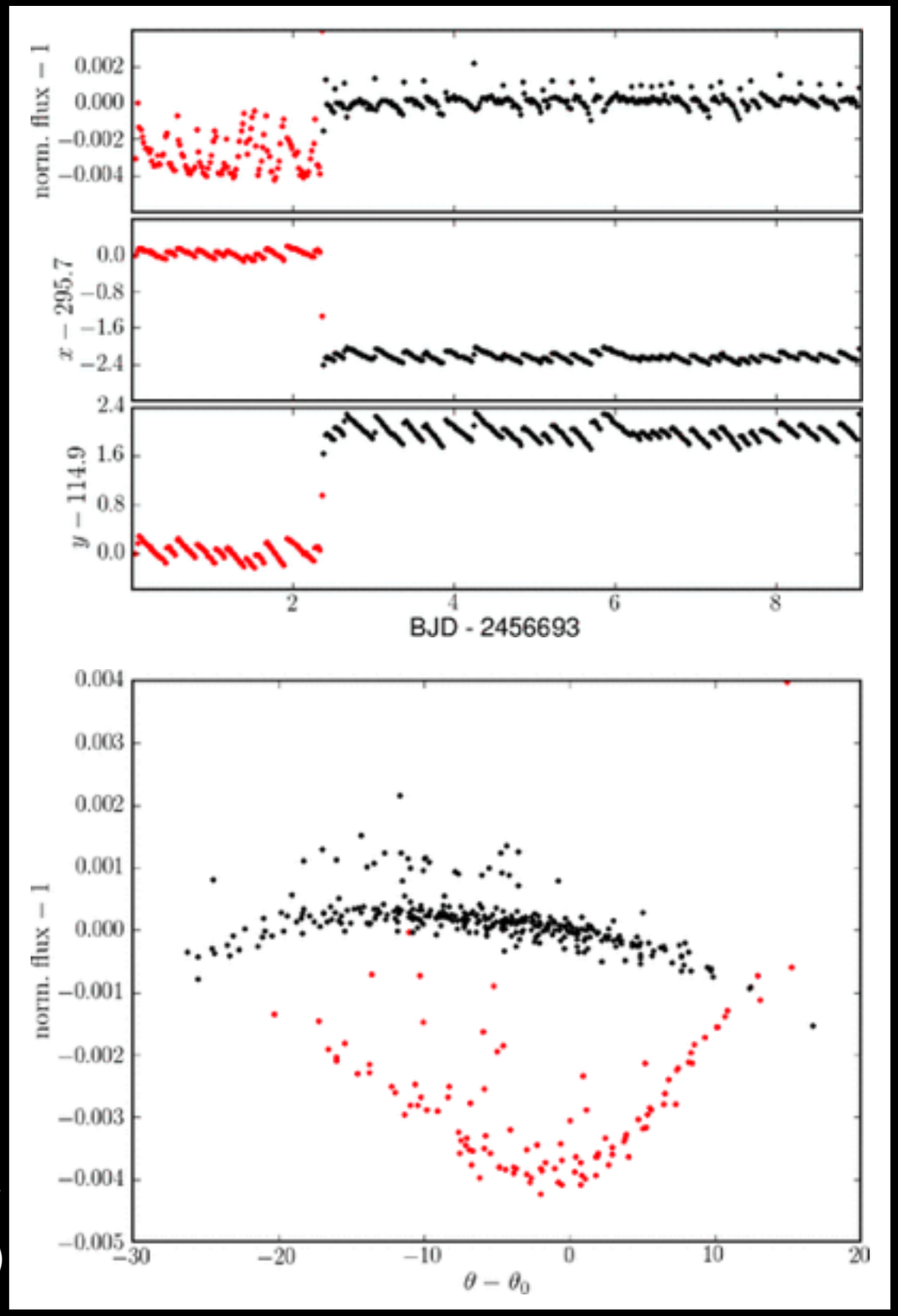
several K2 pipelines published

- K2SFF (Vanderburg & Johnson 2014);
- K2VARCAT (Armstrong et al. 2014, 2015);
- K2PP (Lund et al. 2015);
- PSF-based (Libralato et al. 2015);
- List-driven photometry (Huang et al. 2015, Aigrain et al. 2015)

+ many more in individual science papers



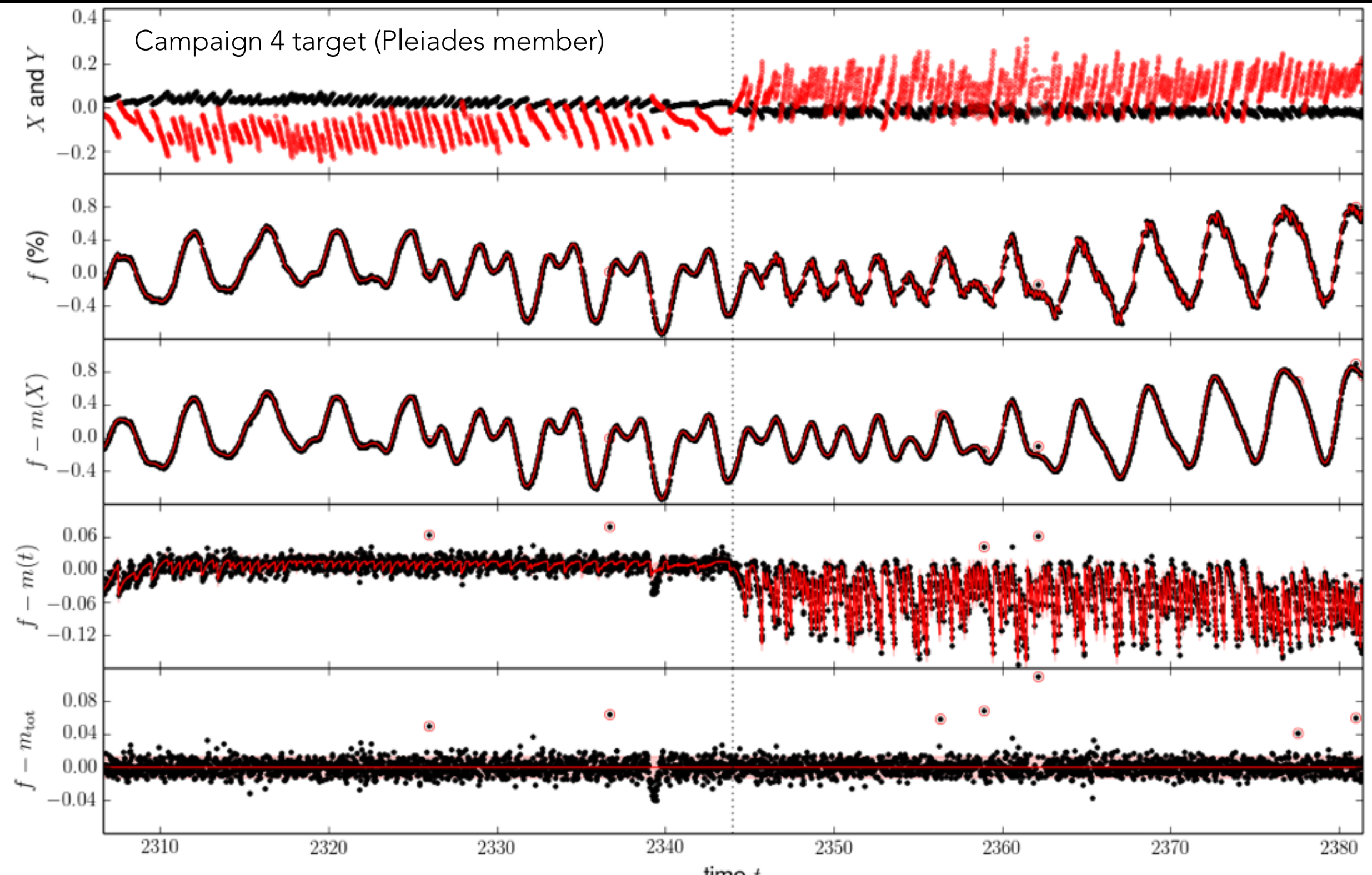
example raw LC from “engineering test dataset” (Aigrain et al. 2015)

K2 SYSTEMATICS CORRECTION

Aigrain, Parviainen & Pope (MNRAS in press)

- K2SC is a detrending-only pipeline
  - start from (any) light curve
- Key differences from other K2 detrending tools
  - model systematics and variability jointly - disentangle but preserve
  - use Gaussian process regression in modelling process - flexible, robust, principled

K2 SYSTEMATICS CORRECTION (K2SC)



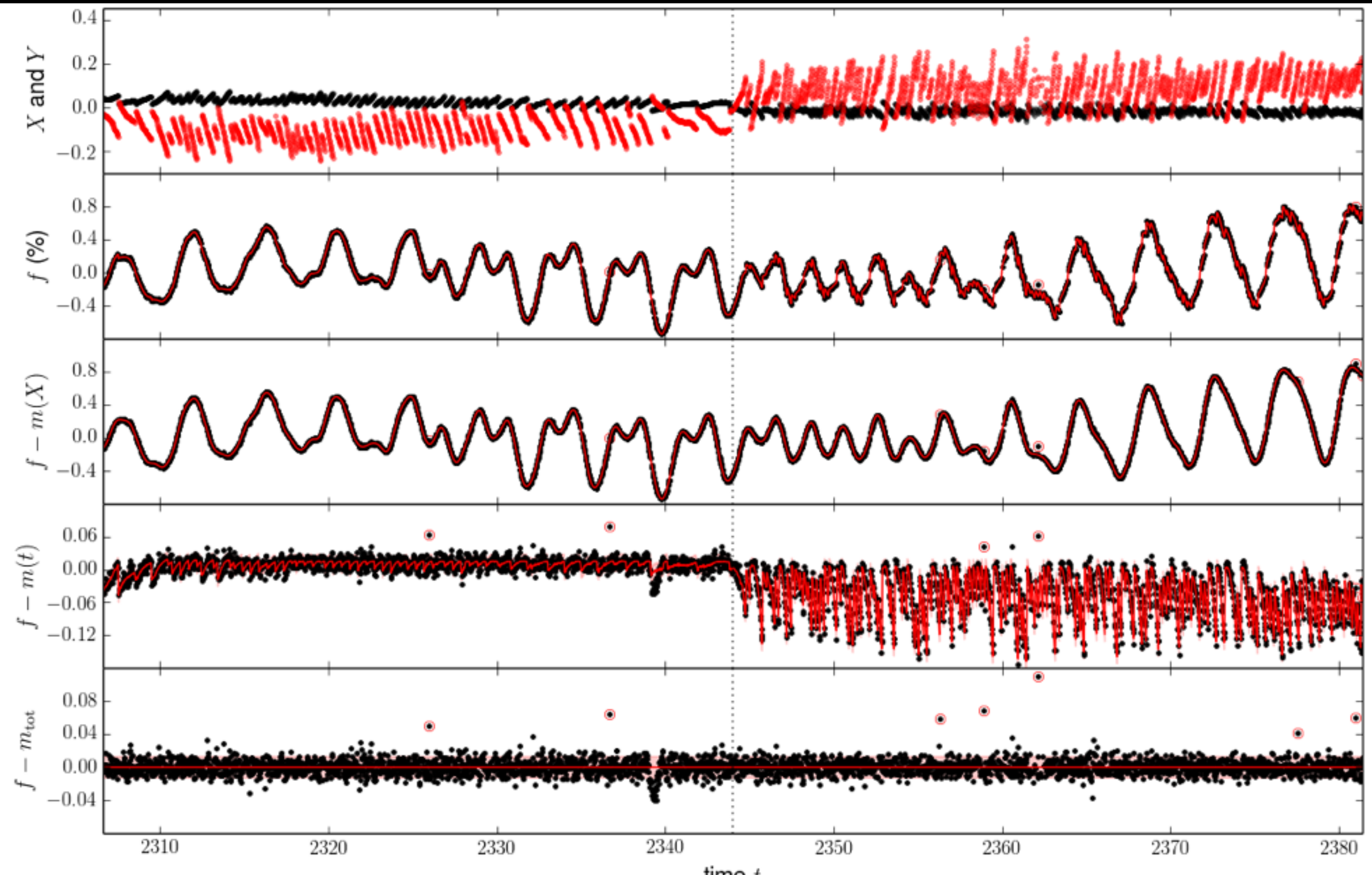
WHY VARIABILITY MATTERS IN SPACE-BASED TRANSIT SURVEYS

- affects systematics correction
- hinders transit detection
- hinders confirmation by radial velocity (cf. talk by V. Rajpaul)
- know thy star - know thy planet
  - asteroseismology: precise stellar parameters including densities, masses, radii, ages, inclination
  - rotation (gyrochronology?), activity, star-planet interaction?
  - open cluster membership → age, composition…

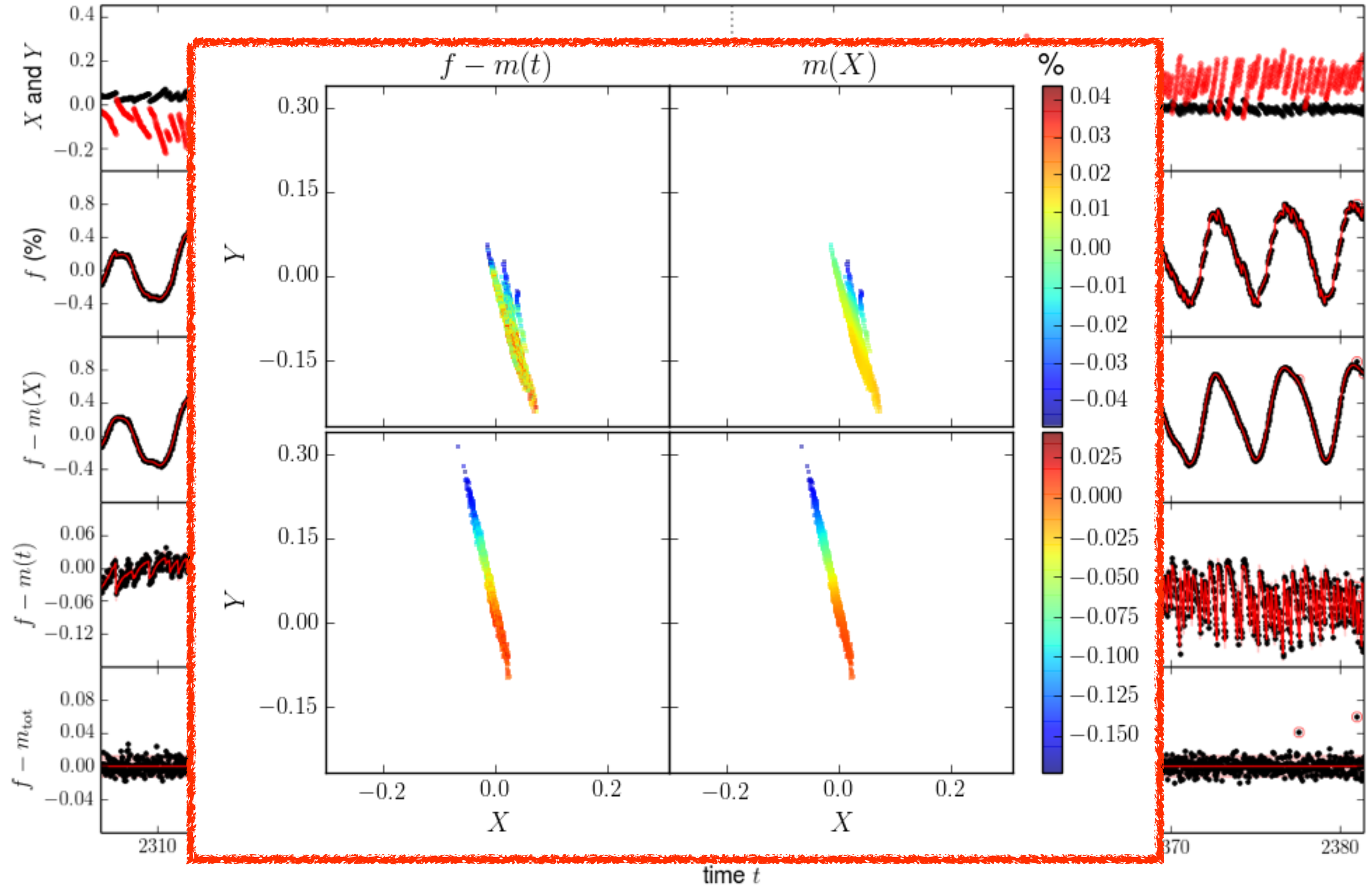
HOW K2SC WORKS

- start from any K2 light curve - need times, fluxes, x & y positions
- model flux as: f = f_1(time) + f_2(x,y) + white noise
- f_1 and f_2 are smooth functions of unknown shape
- Gaussian processes
- f_2 = systematics due to roll-angle variations
- f_1 = stellar variability (+ any other long term trends!)
- if appropriate, f_1 is treated as quasi-periodic

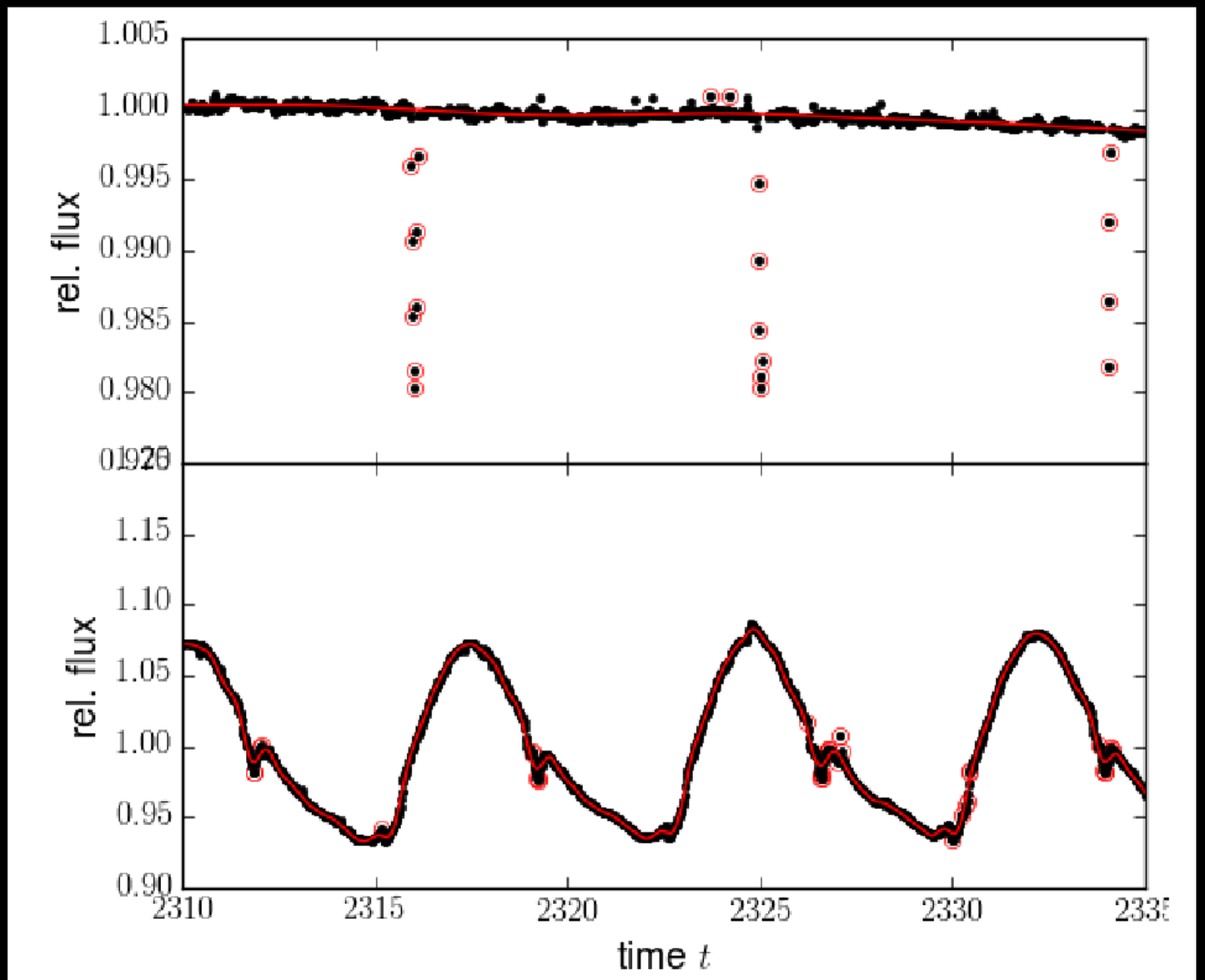
SOME SUBTLETIES - SPLITS



SOME SUBTLETIES - SPLITS



SOME SUBTLETIES - OUTLIERS

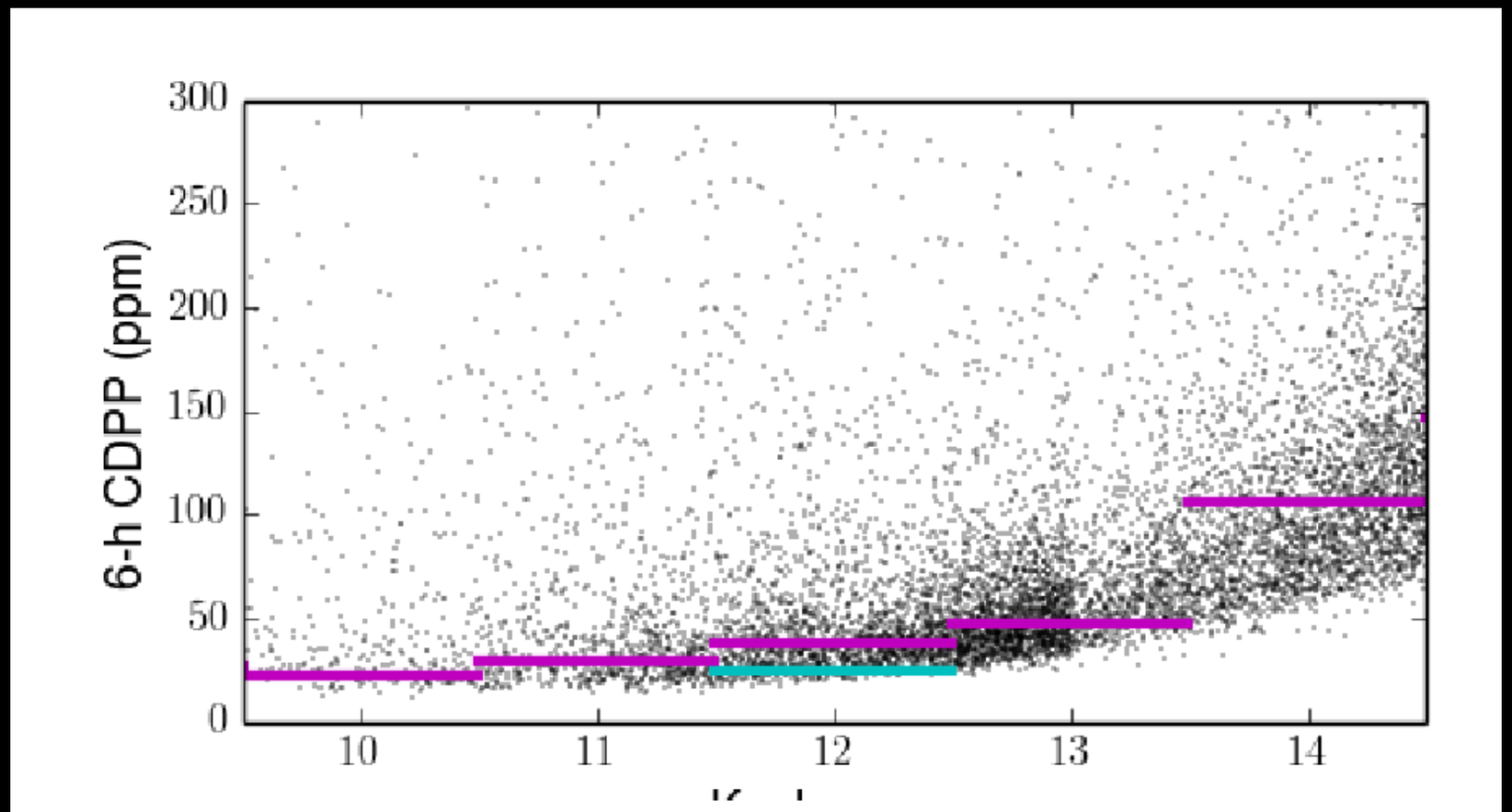


good

bad

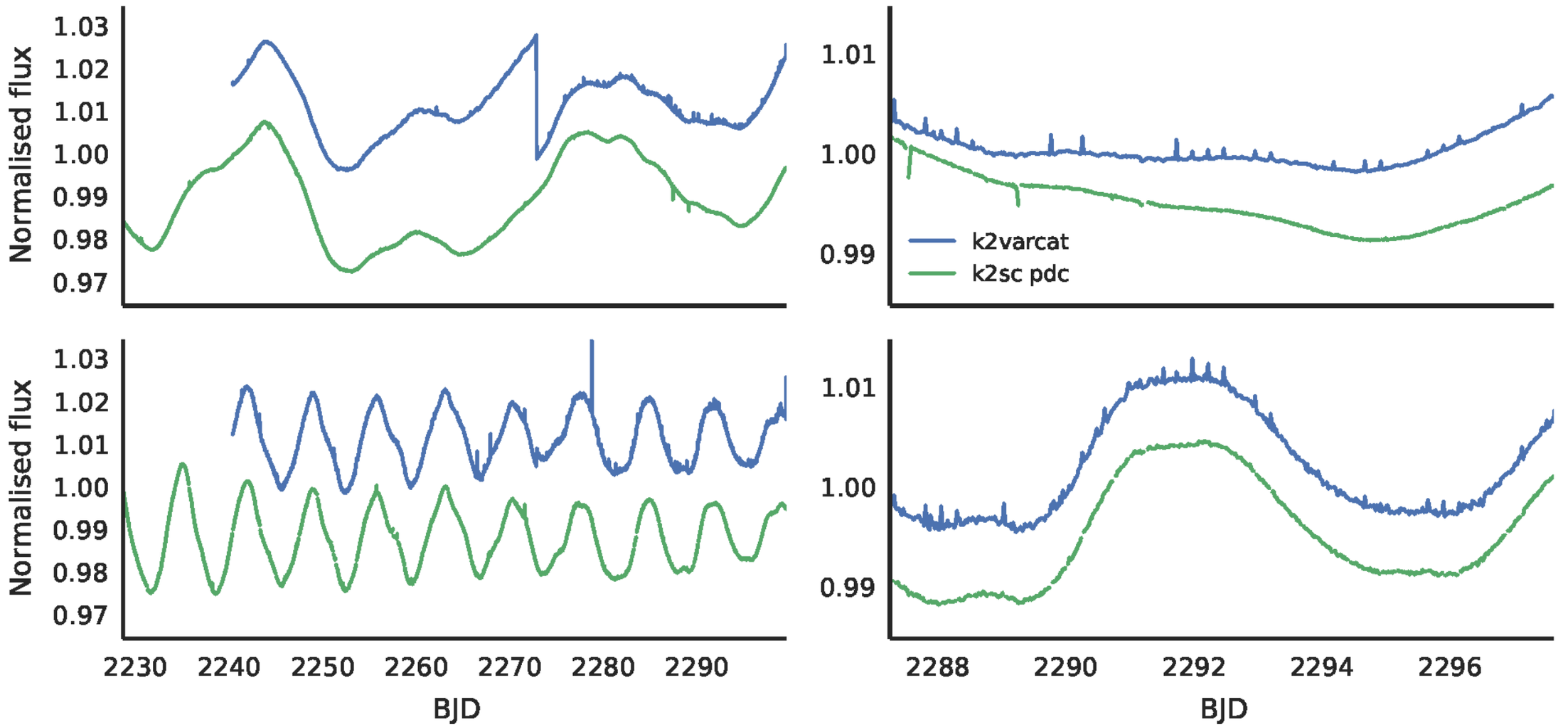
but… K2SC includes options to improve detrending on an object by object basis

PHOTOMETRIC PERFORMANCE FOR BRIGHT DWARFS



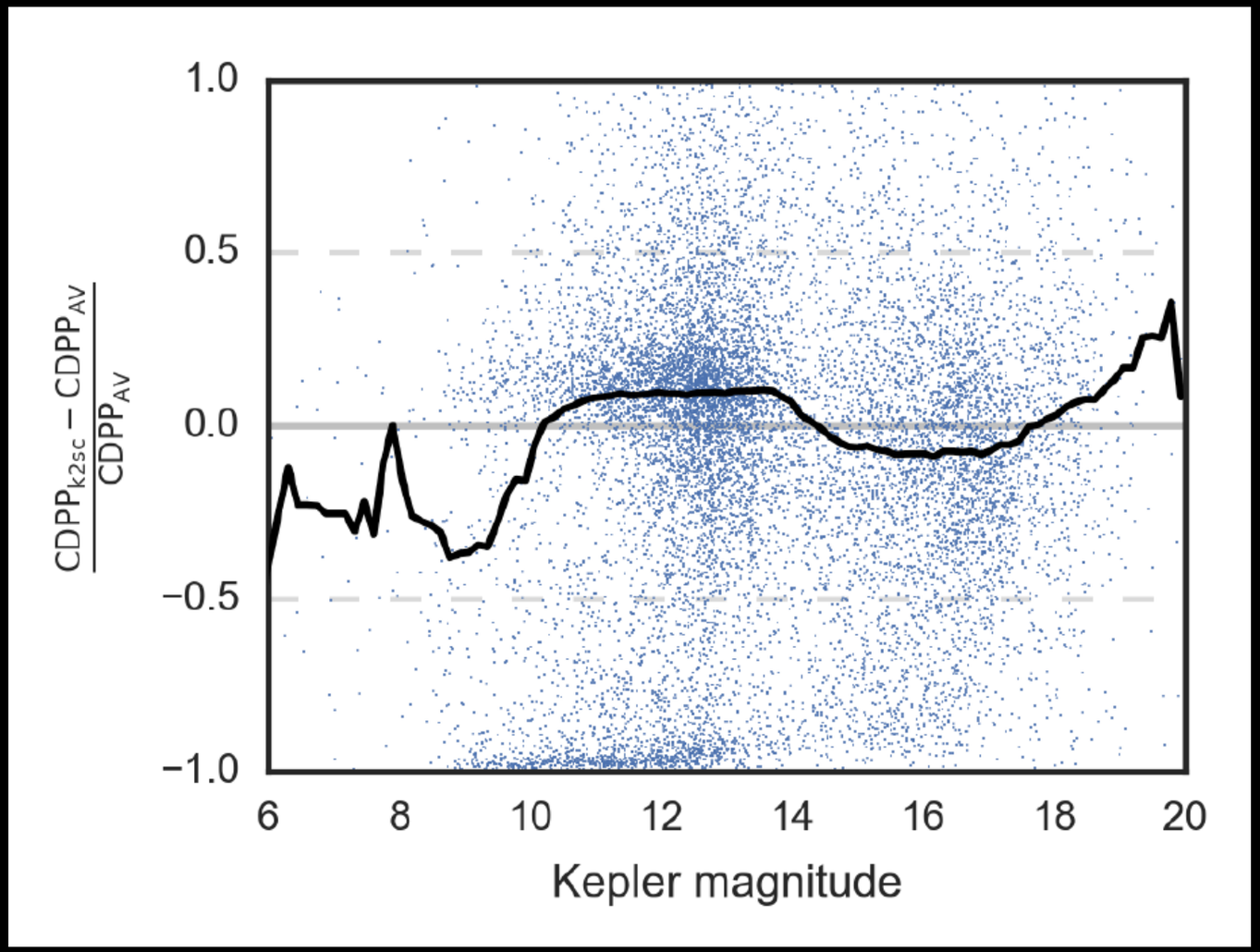
COMPARISON TO K2VARCAT

Armstrong et al. (2014, 2015)



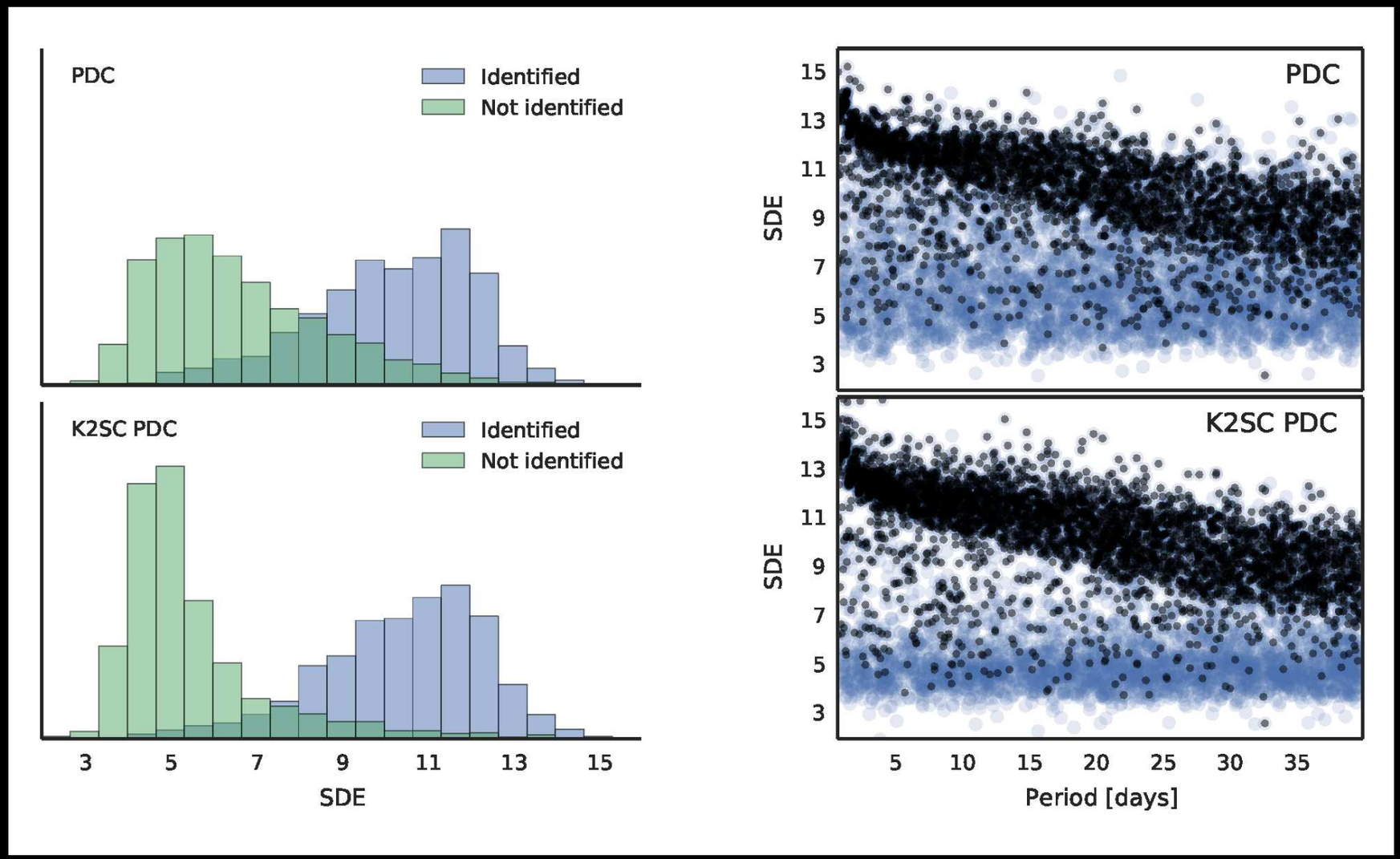
COMPARISON TO K2SFF

Vanderburg & Johnson (2014), Vanderburg (2014)



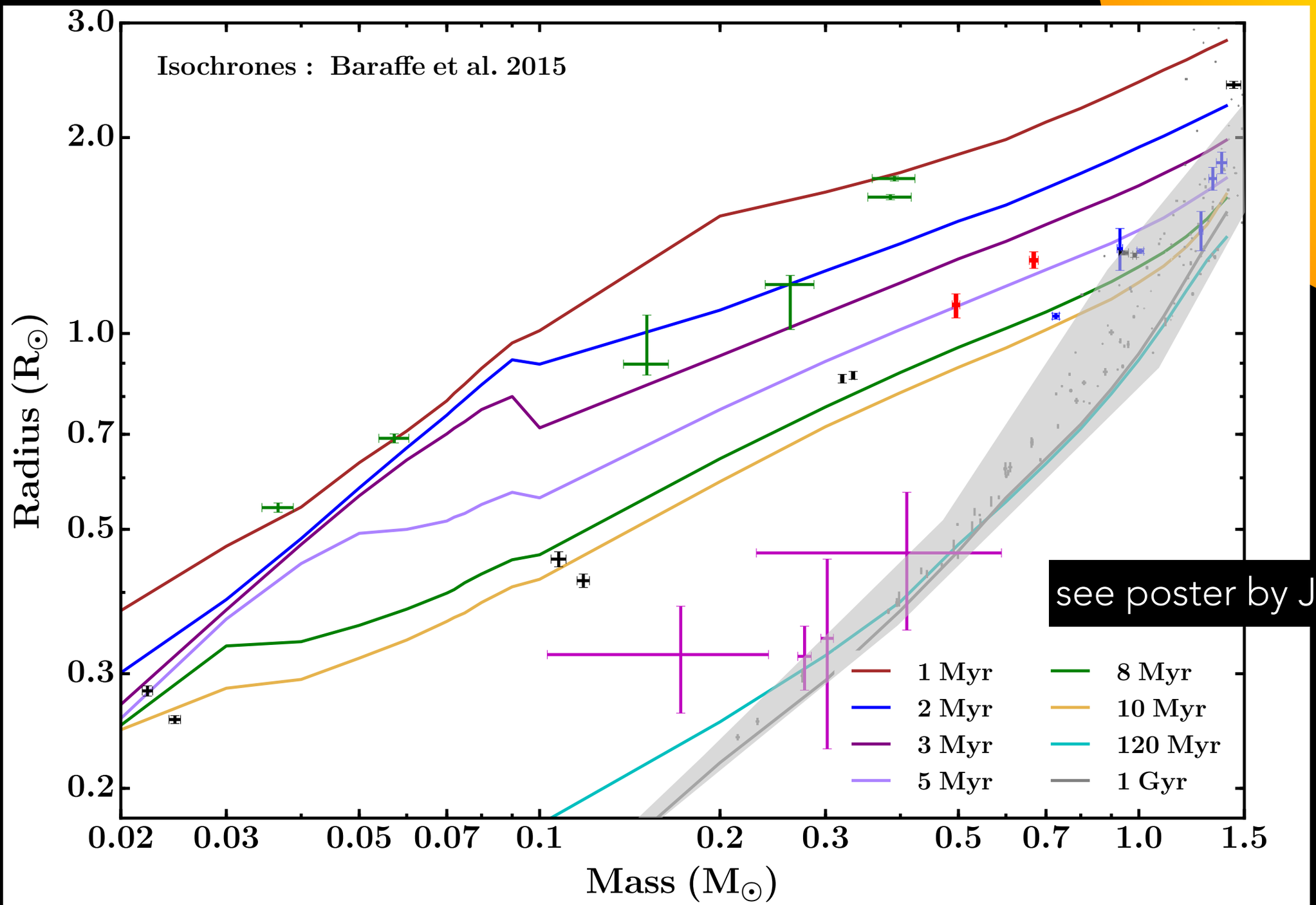
K2SFF apertures more optimised for bright stars

TRANSIT INJECTION TESTS



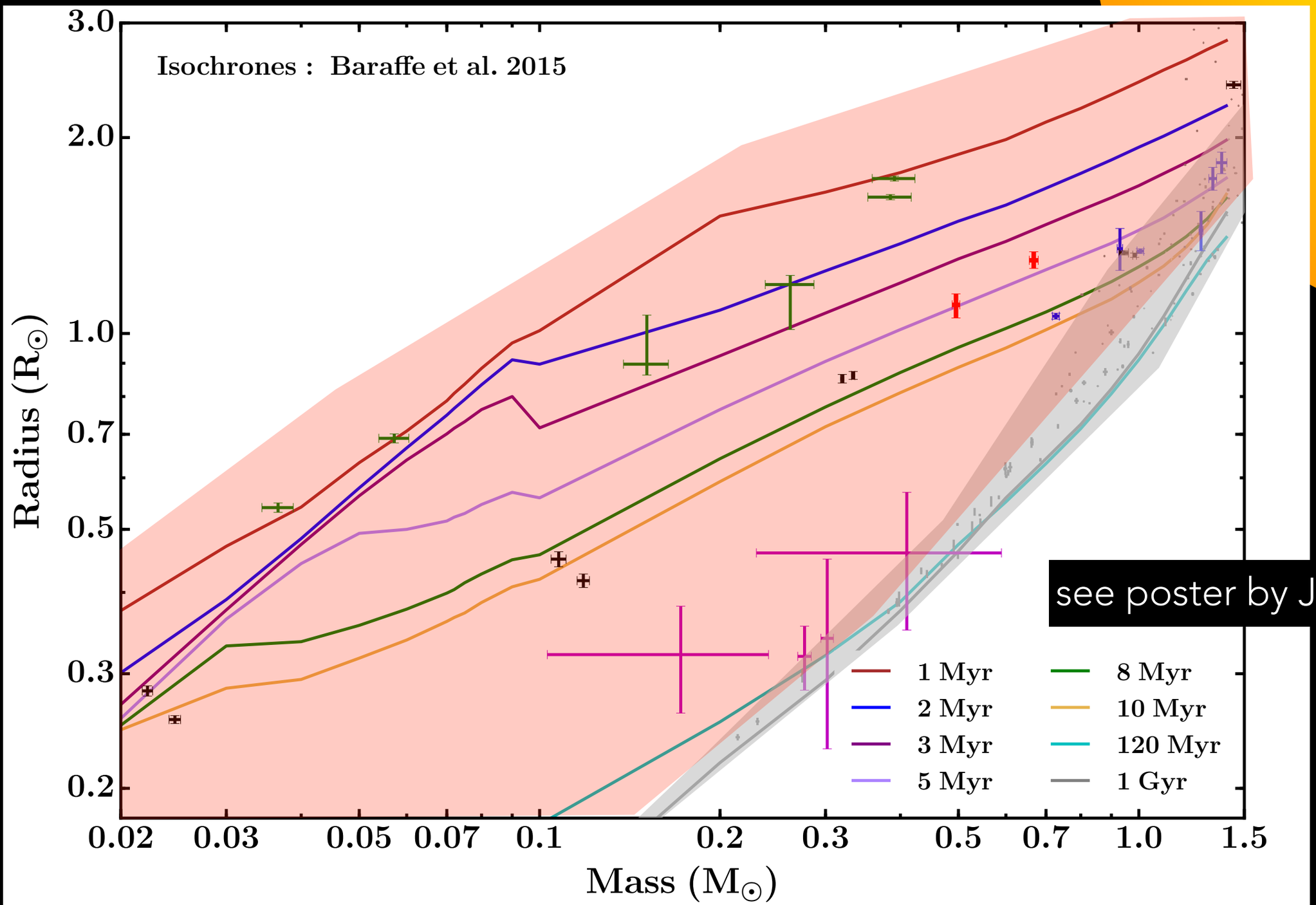
For actual transit search, see Ben Pope's poster

STAR AND BROWN DWARF EVOLUTION



see poster by Jessica Kirkby-Kent

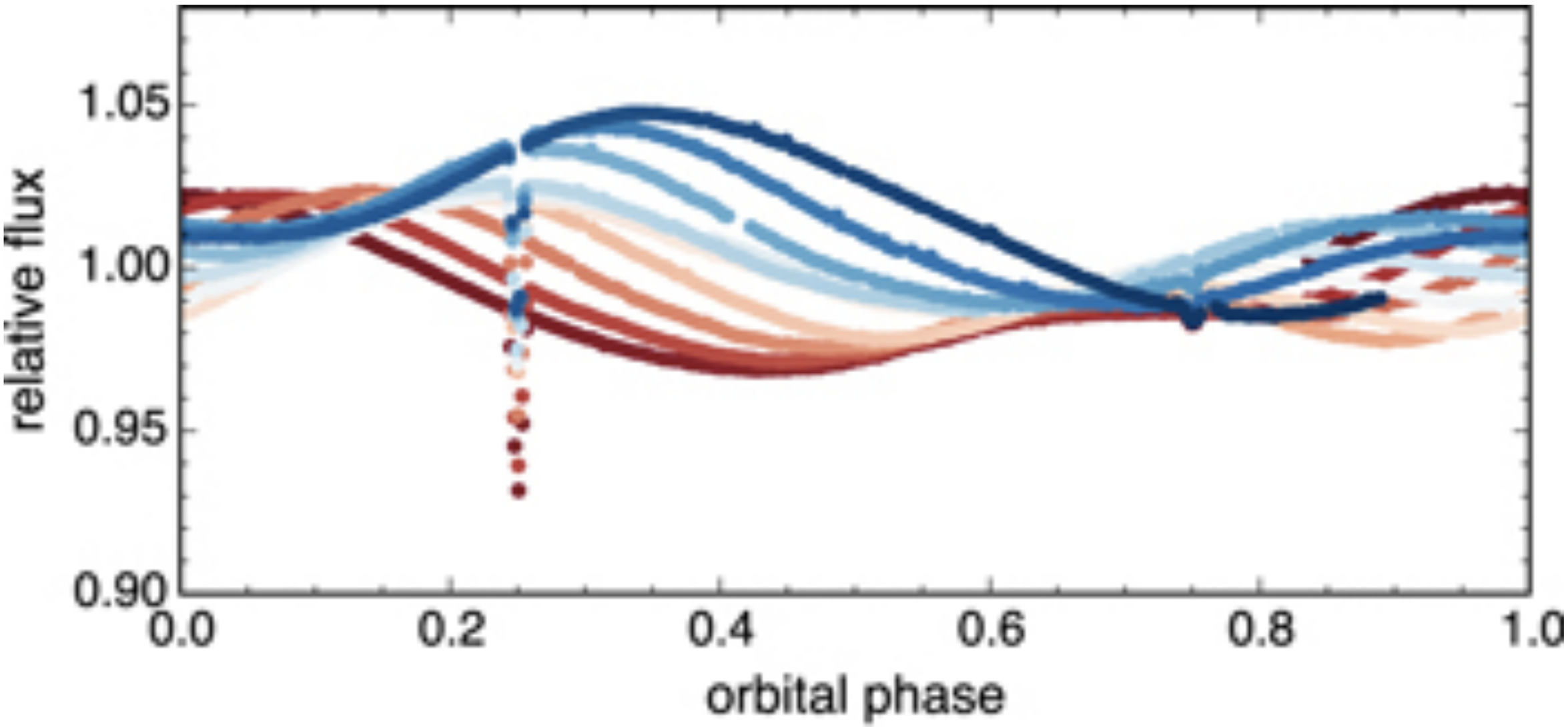
STAR AND BROWN DWARF EVOLUTION



see poster by Jessica Kirkby-Kent

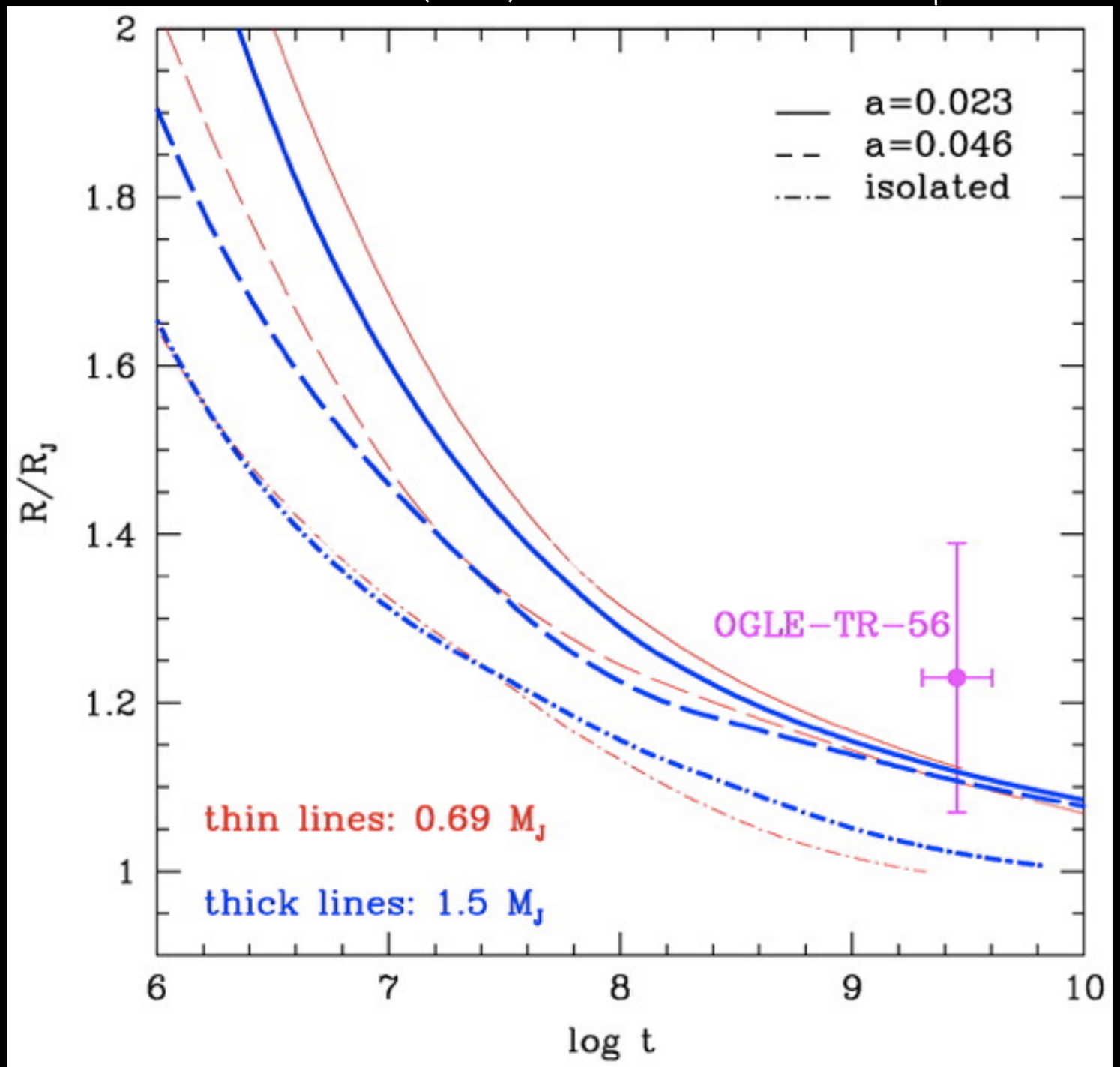
David et al. (2016)

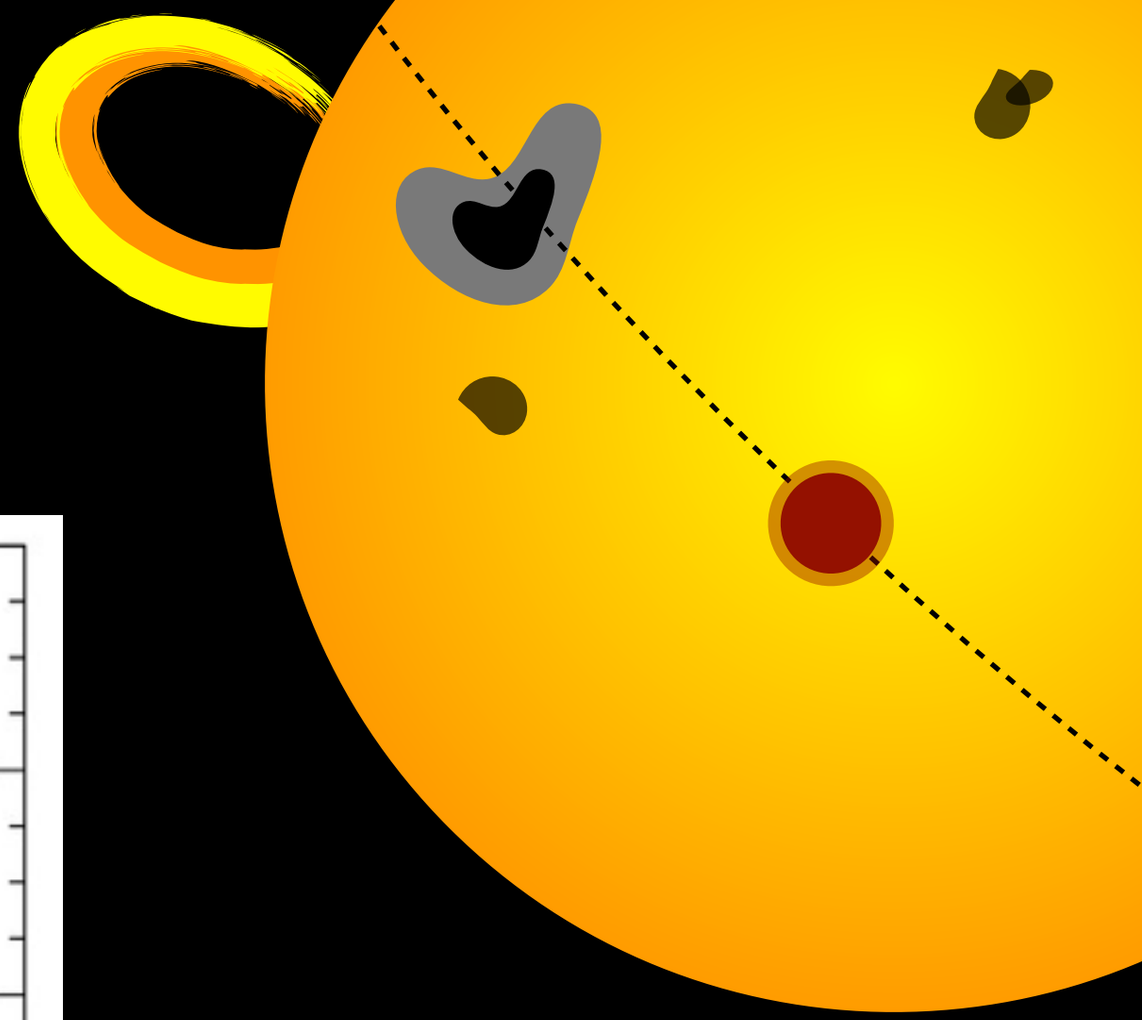
PLEIADES EBS



HOT JUPITER EVOLUTION

Chabrier et al. (2004) - Evolution of irradiated planets





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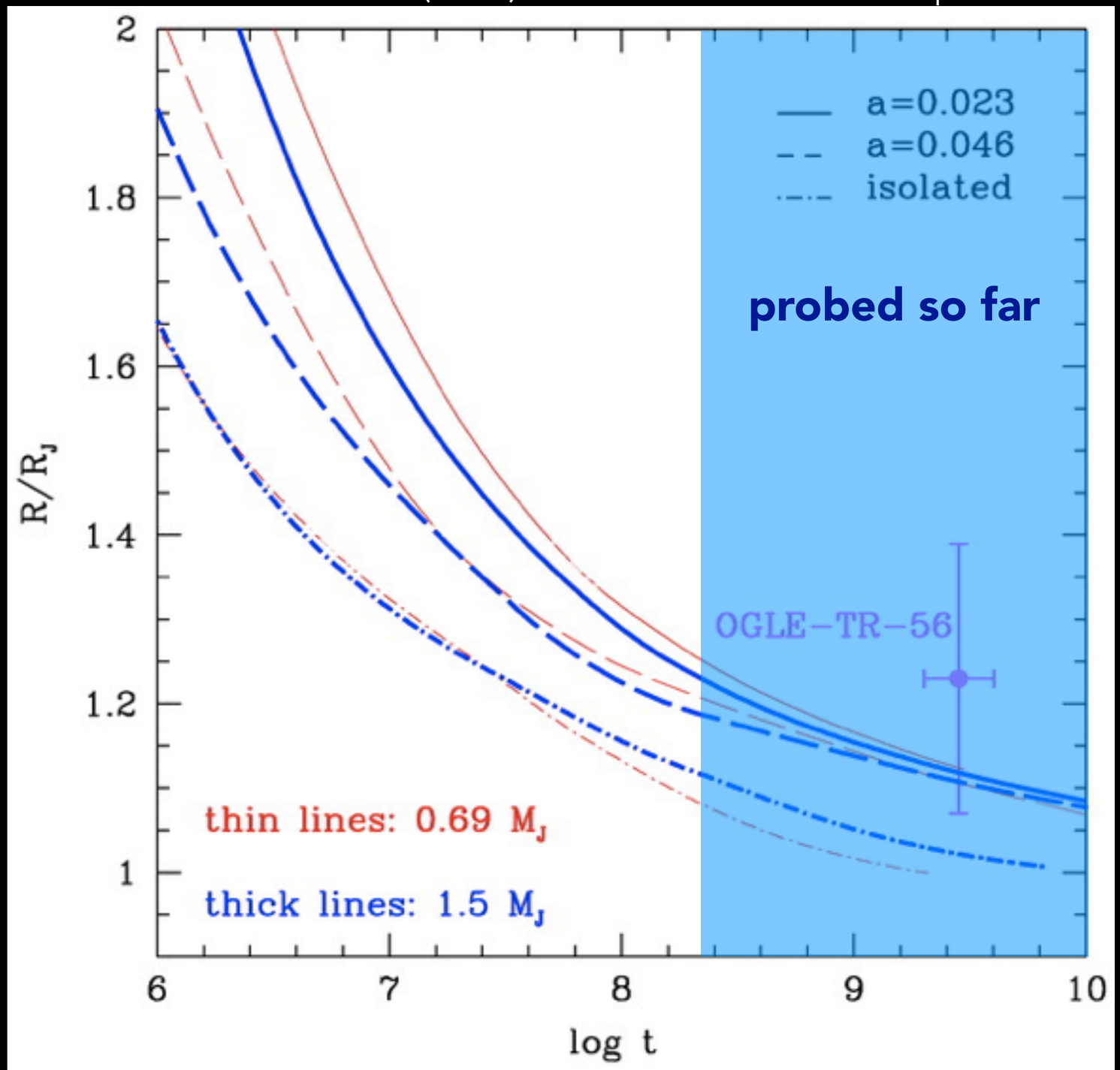

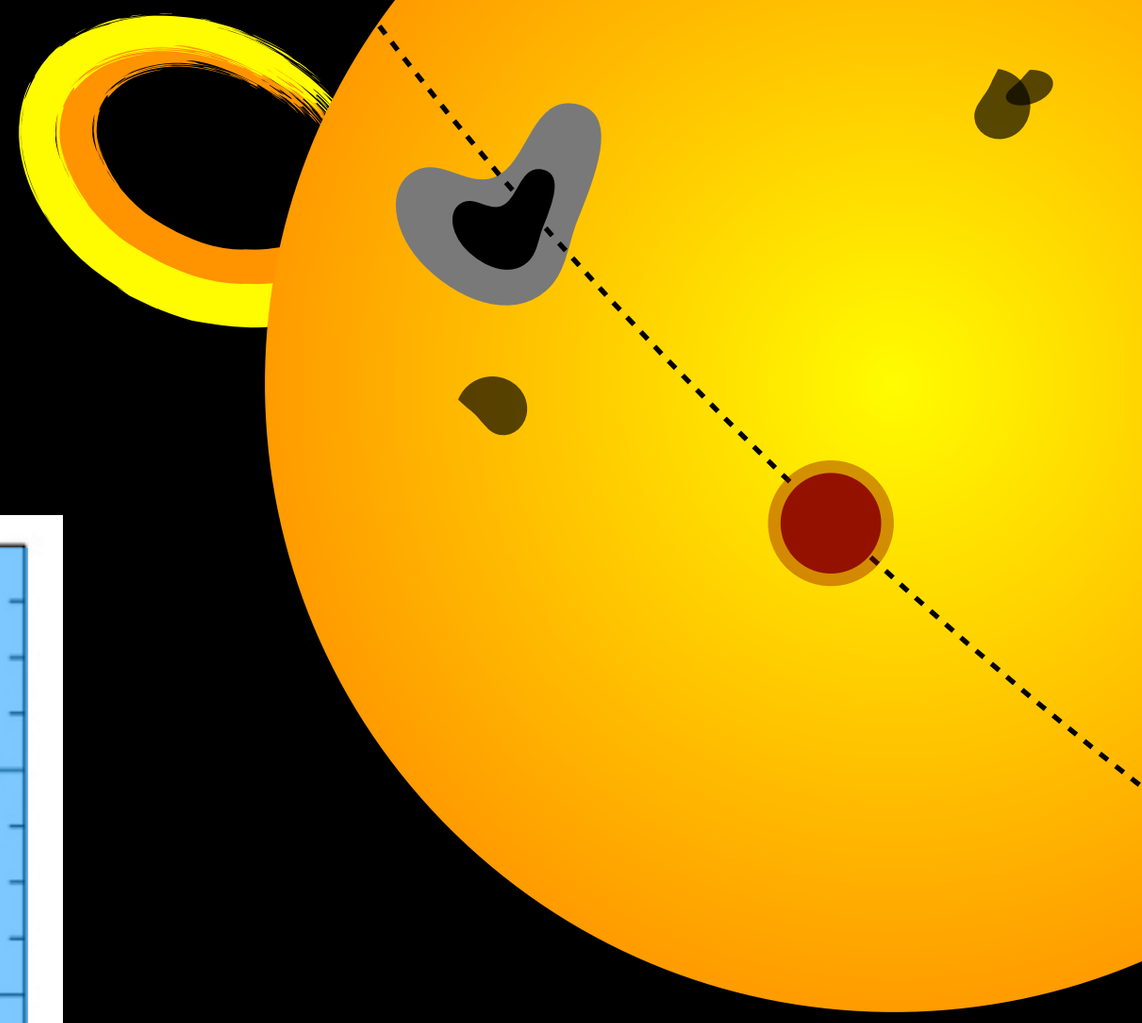

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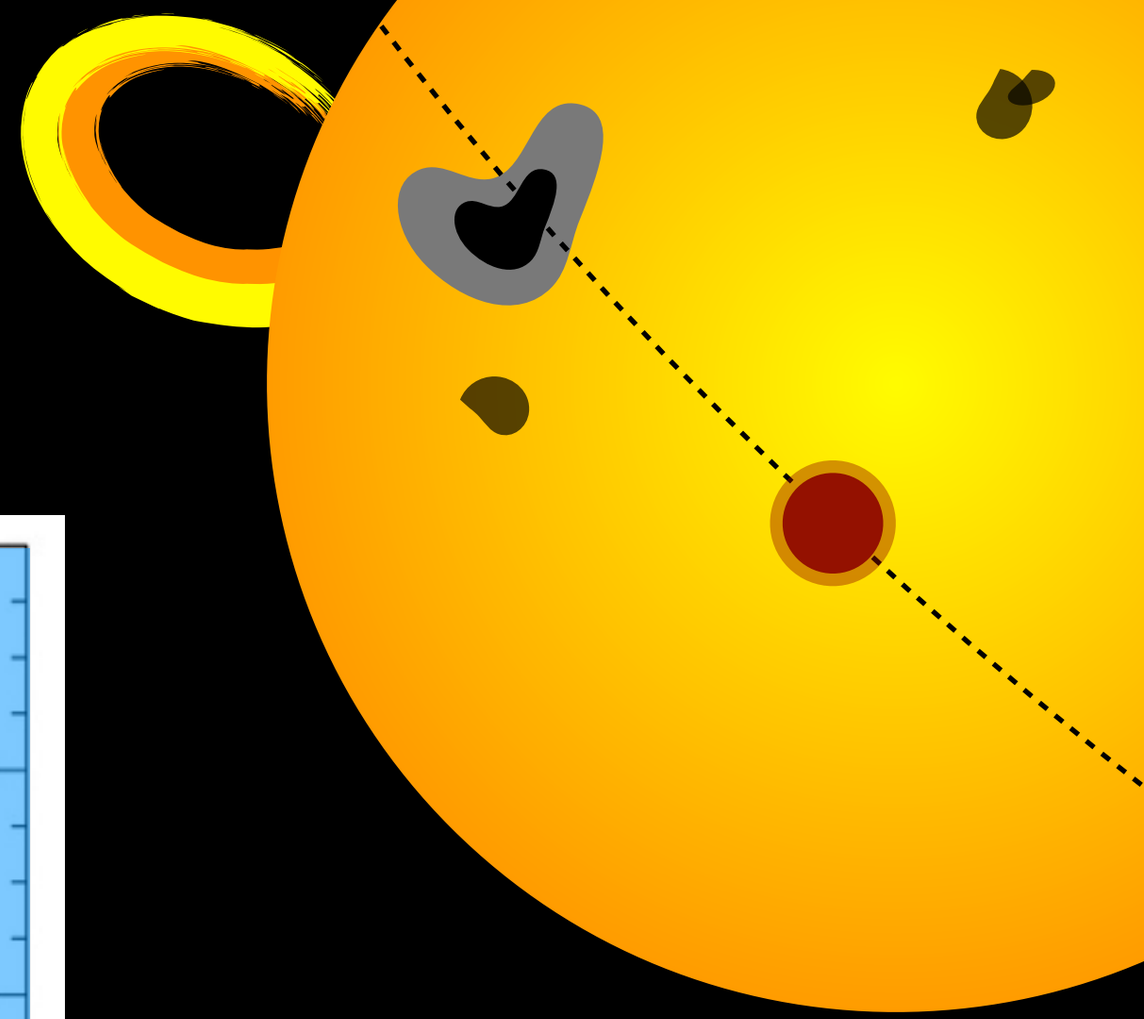

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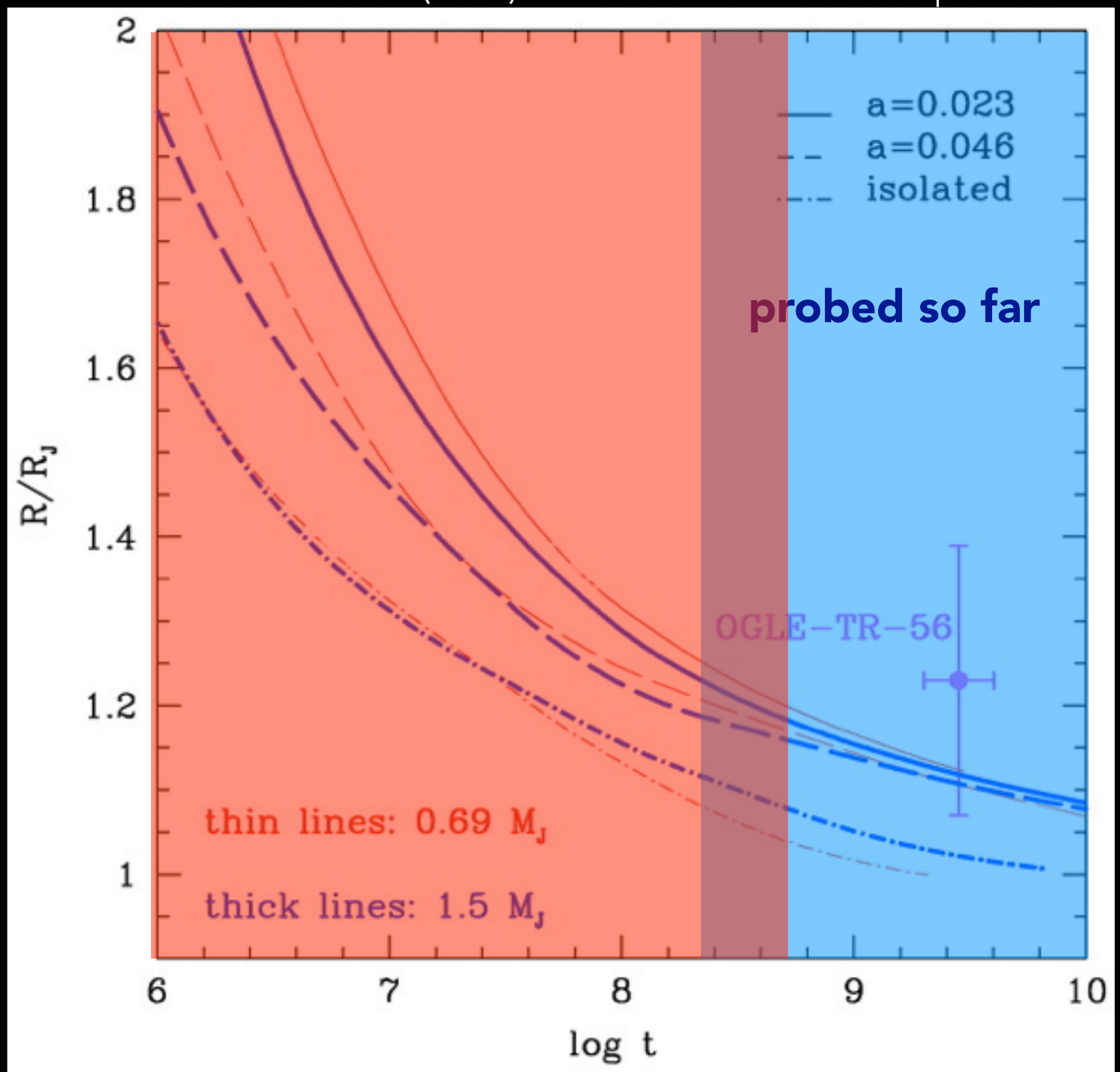
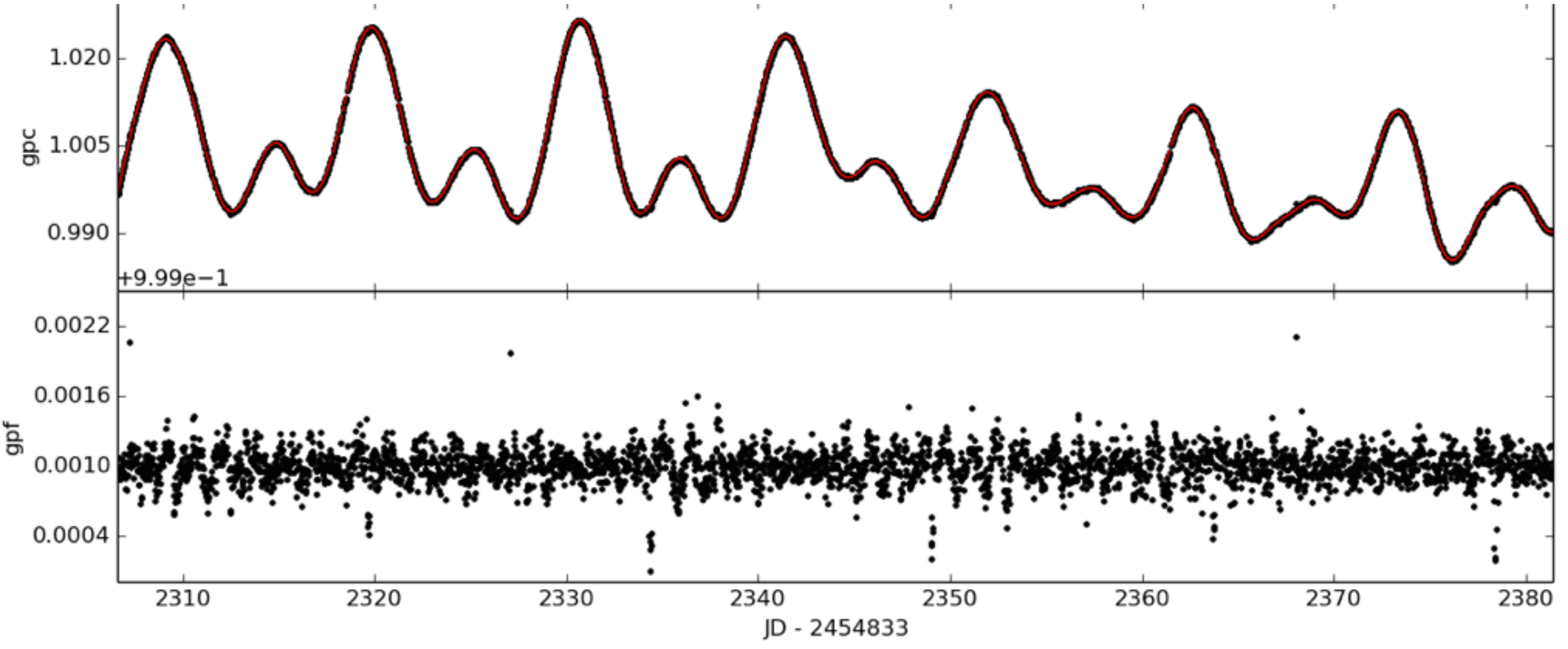


There are NO confirmed transiting planets orbiting stars <800 Myr old

Any detection = “cornerstone” system key target for next gen. observatories

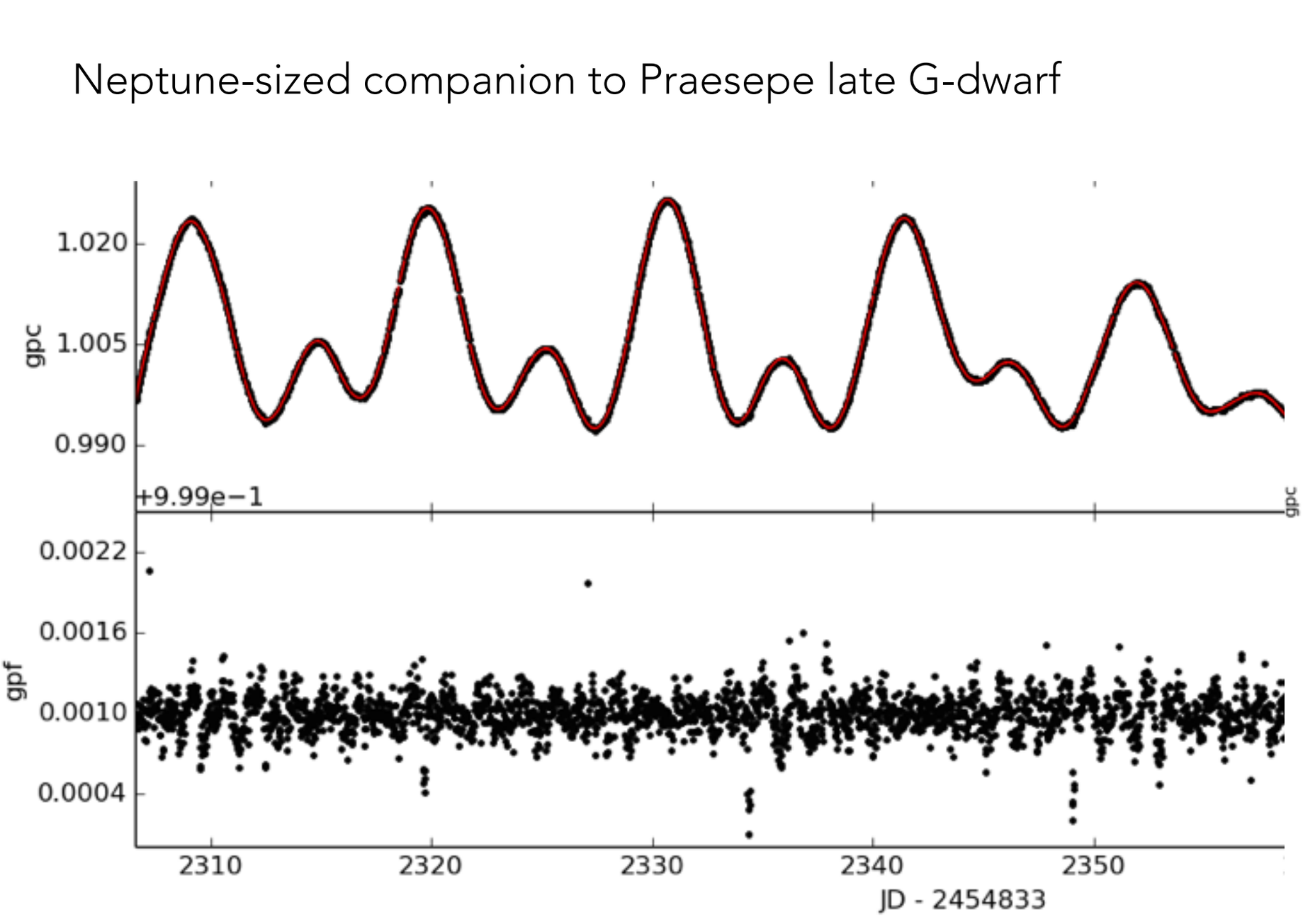
YOUNG TRANSITING PLANET CANDIDATES (PRAESEPE)

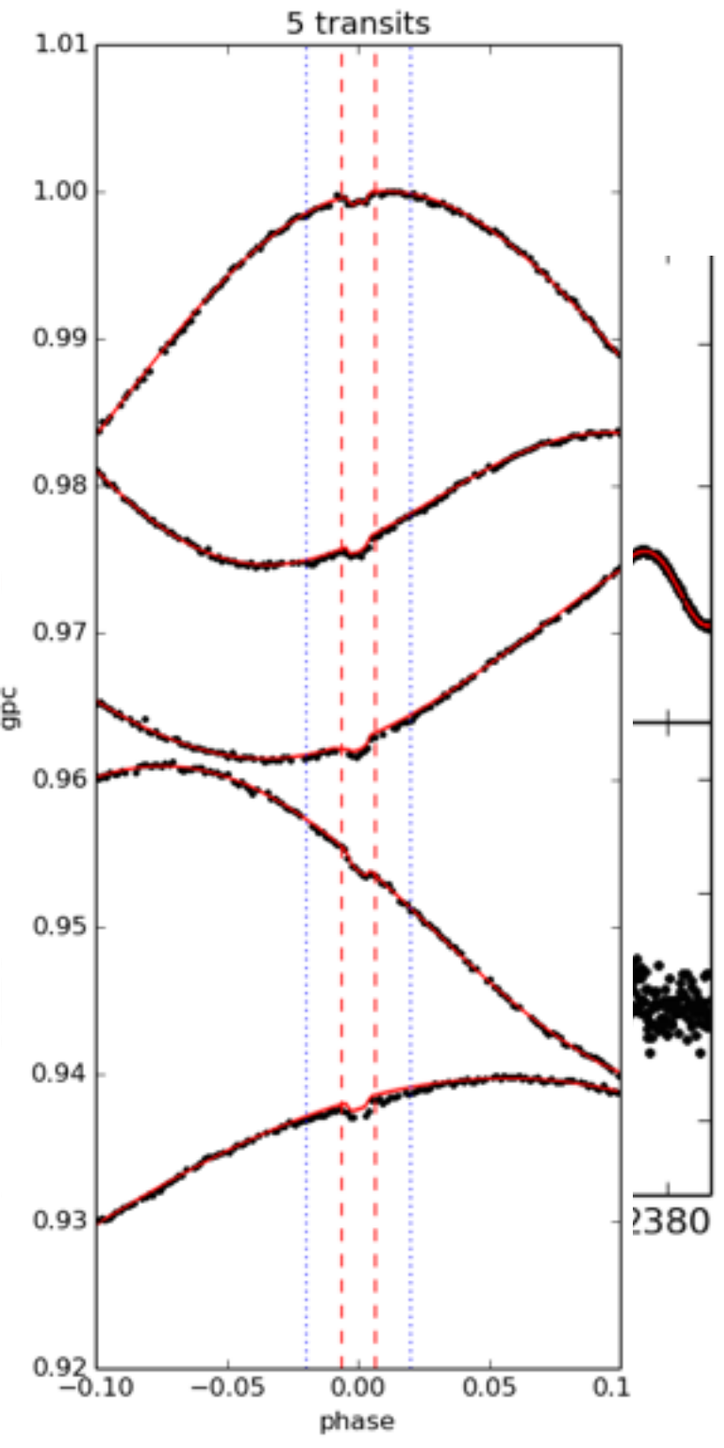
Neptune-sized companion to Praesepe late G-dwarf



YOUNG TRANSITING PLANET CANDIDATES (PRAESEPE)

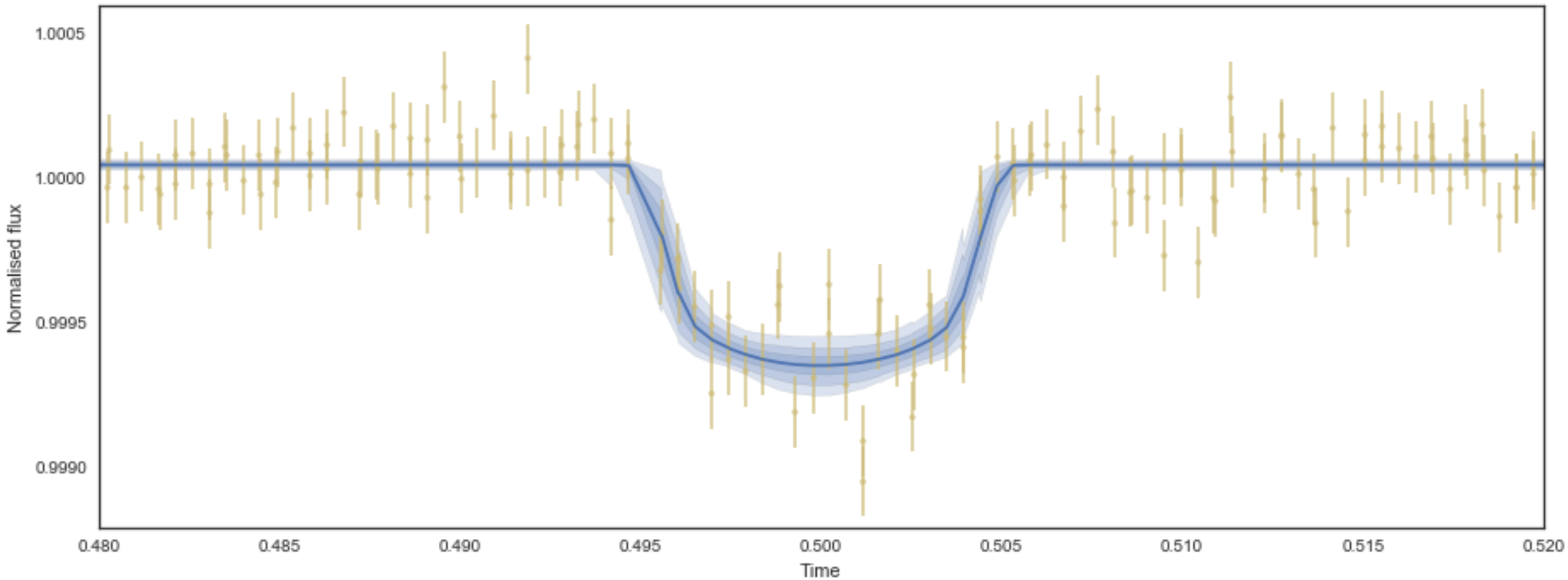
Neptune-sized companion to Praesepe late G-dwarf





YOUNG TRANSITING PLANET CANDIDATES (PRAESEPE)

Neptune-sized companion to Praesepe late G-dwarf (12th mag)



Existing RV data confirms planetary nature of companion

Mass measurement will require tens of RV observations to model activity-induced variations

ARXIV: 1603.09167

HTTPS://GITHUB.COM/OXES/K2SC

HTTPS://ARCHIVE.STSCI.EDU/PREPDS/K2SC

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