Gyrochronology

Rotation-based Ages for Stellar Populations

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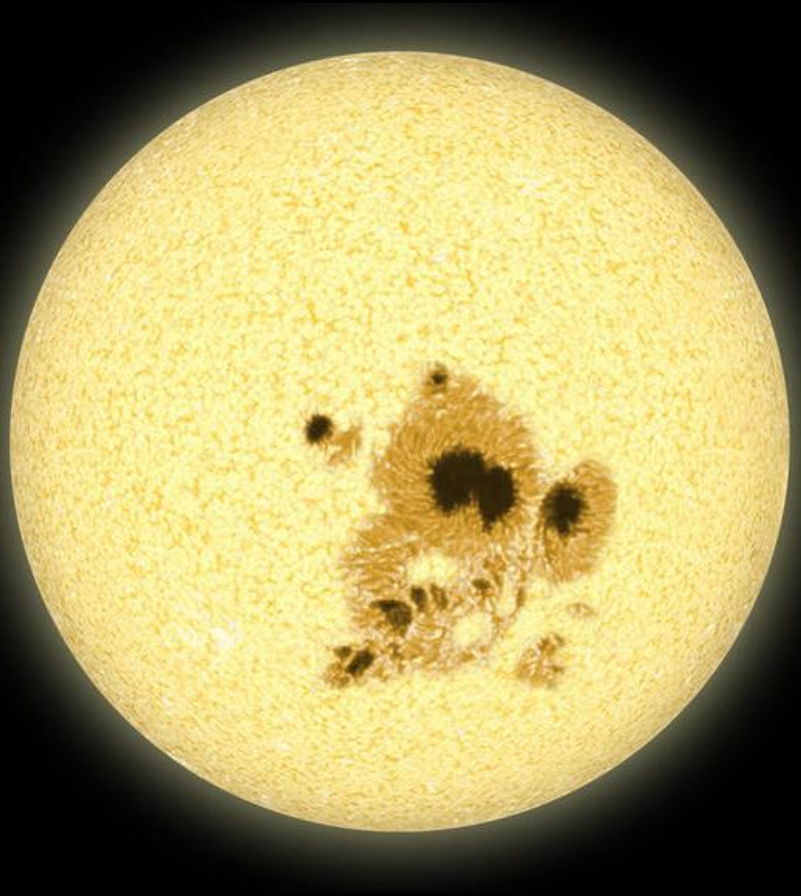
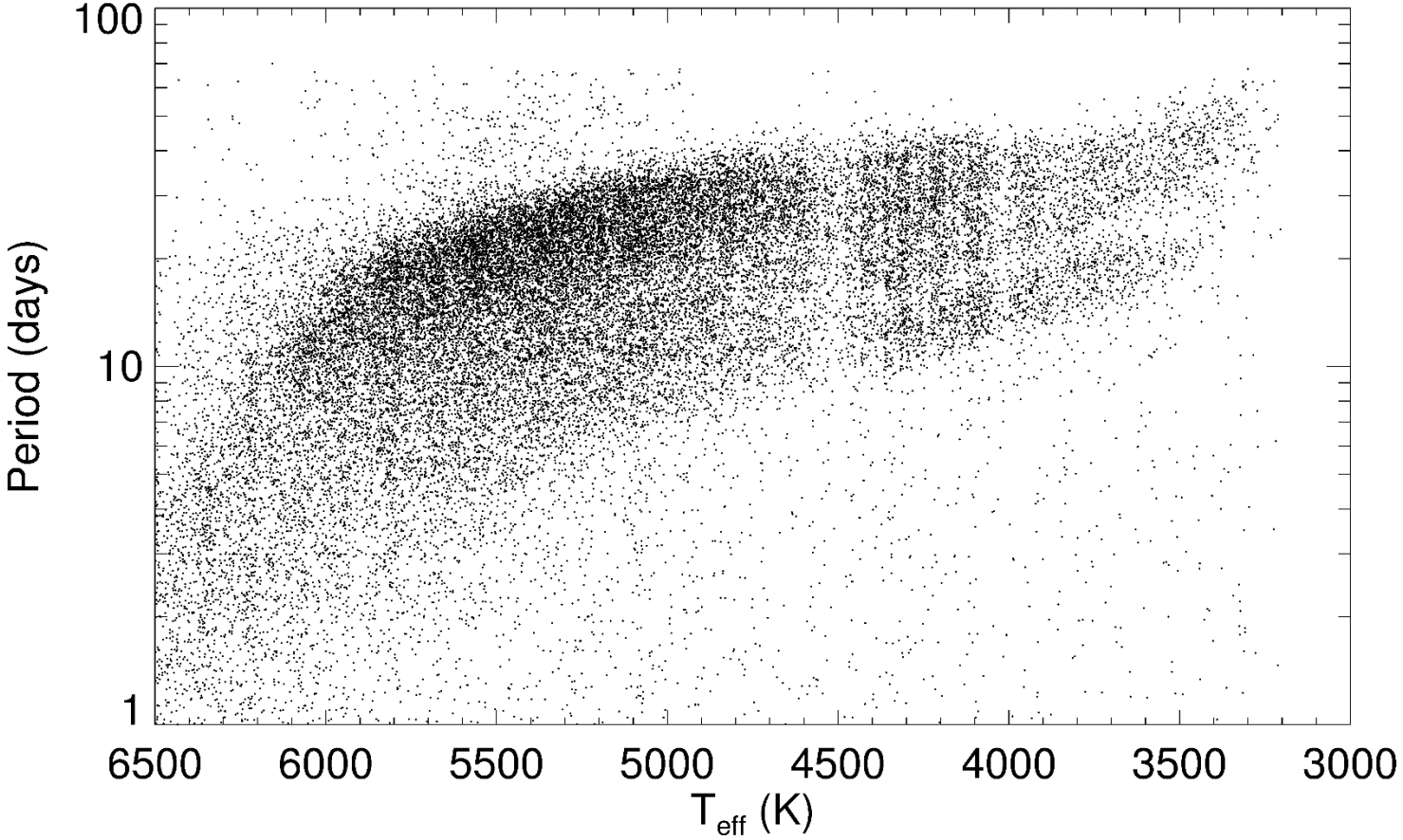
Carnegie Observatories



KITP February 2015

Rotation Today

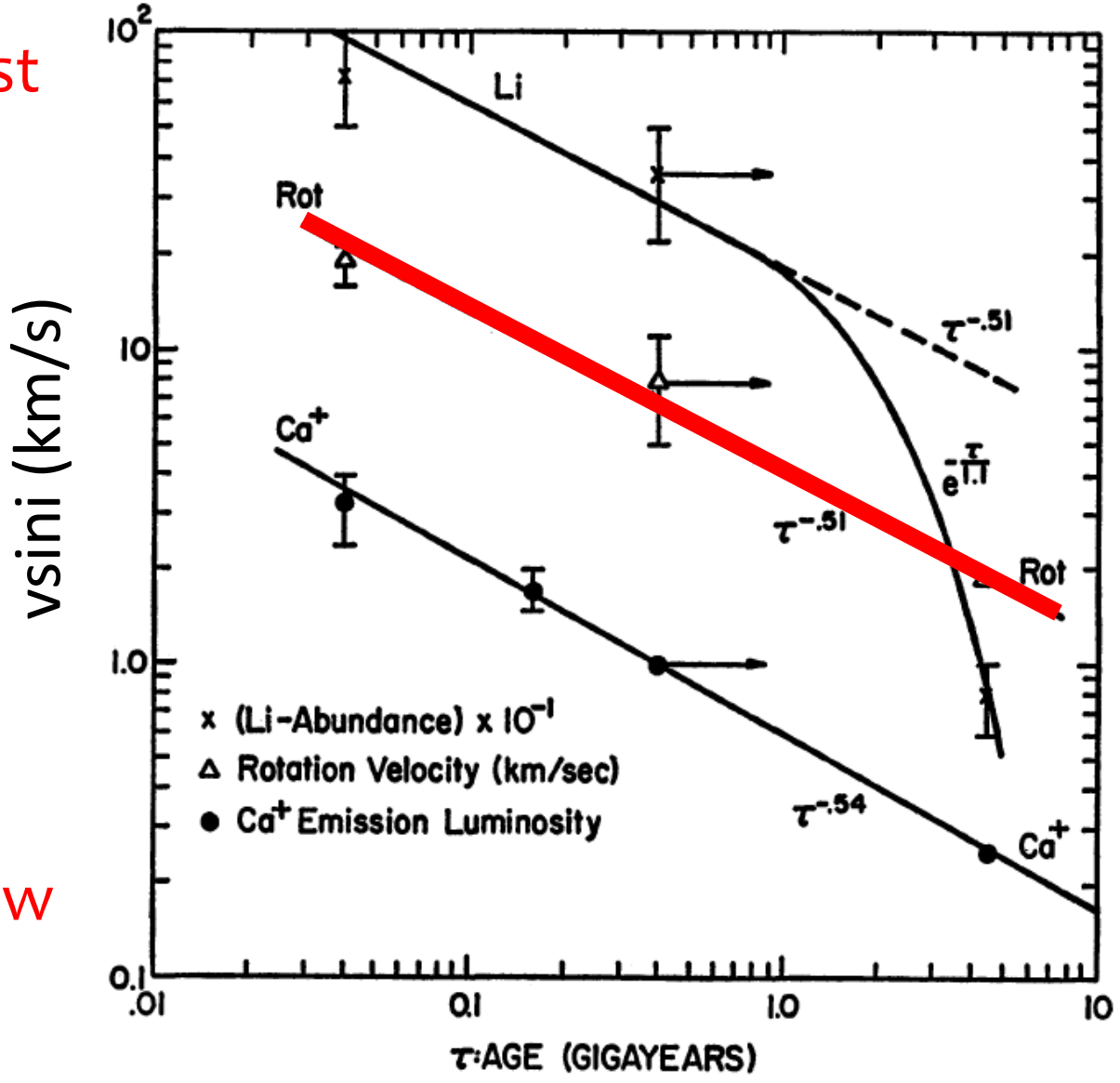


McQuillan et al. 2014

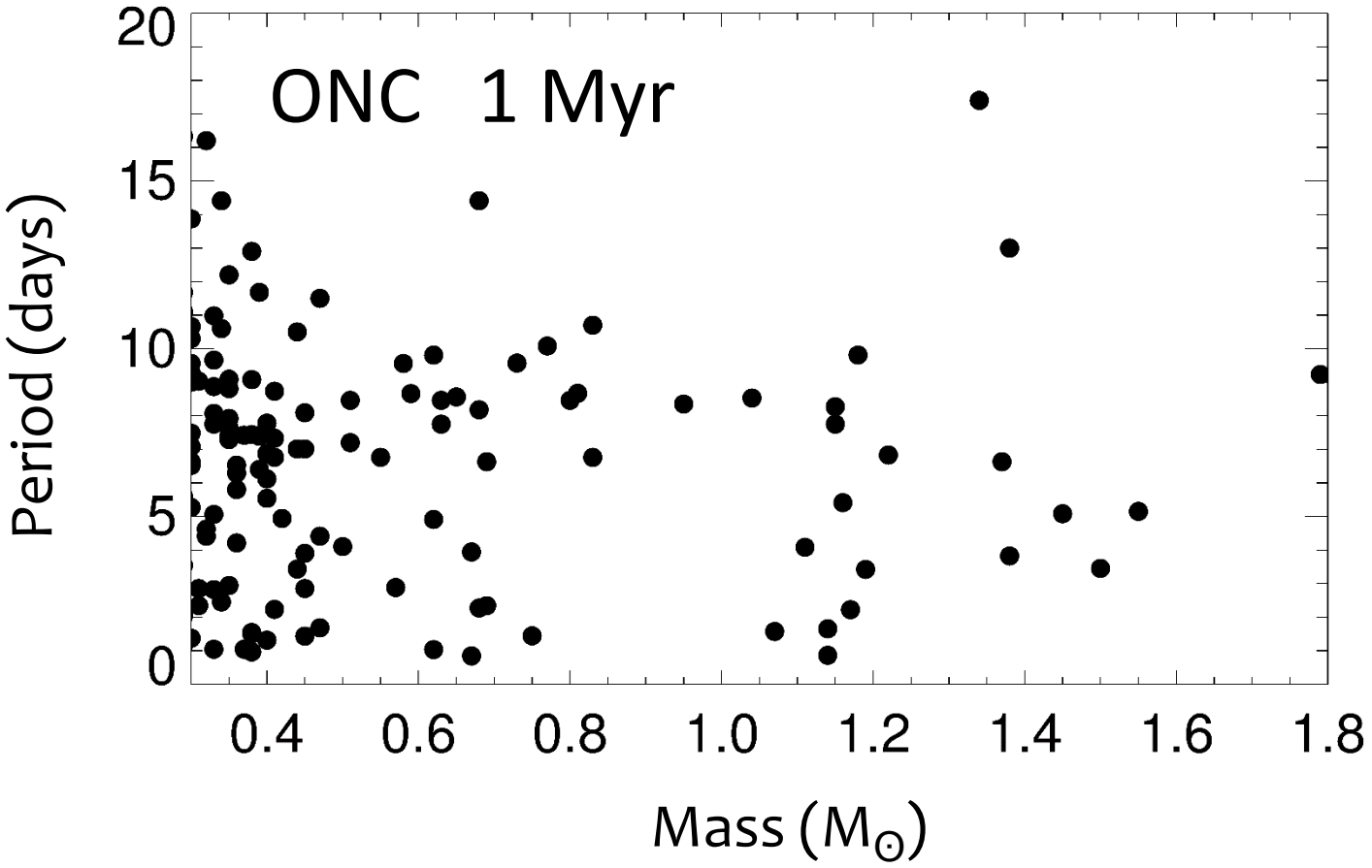
Skumanich 1972

fast

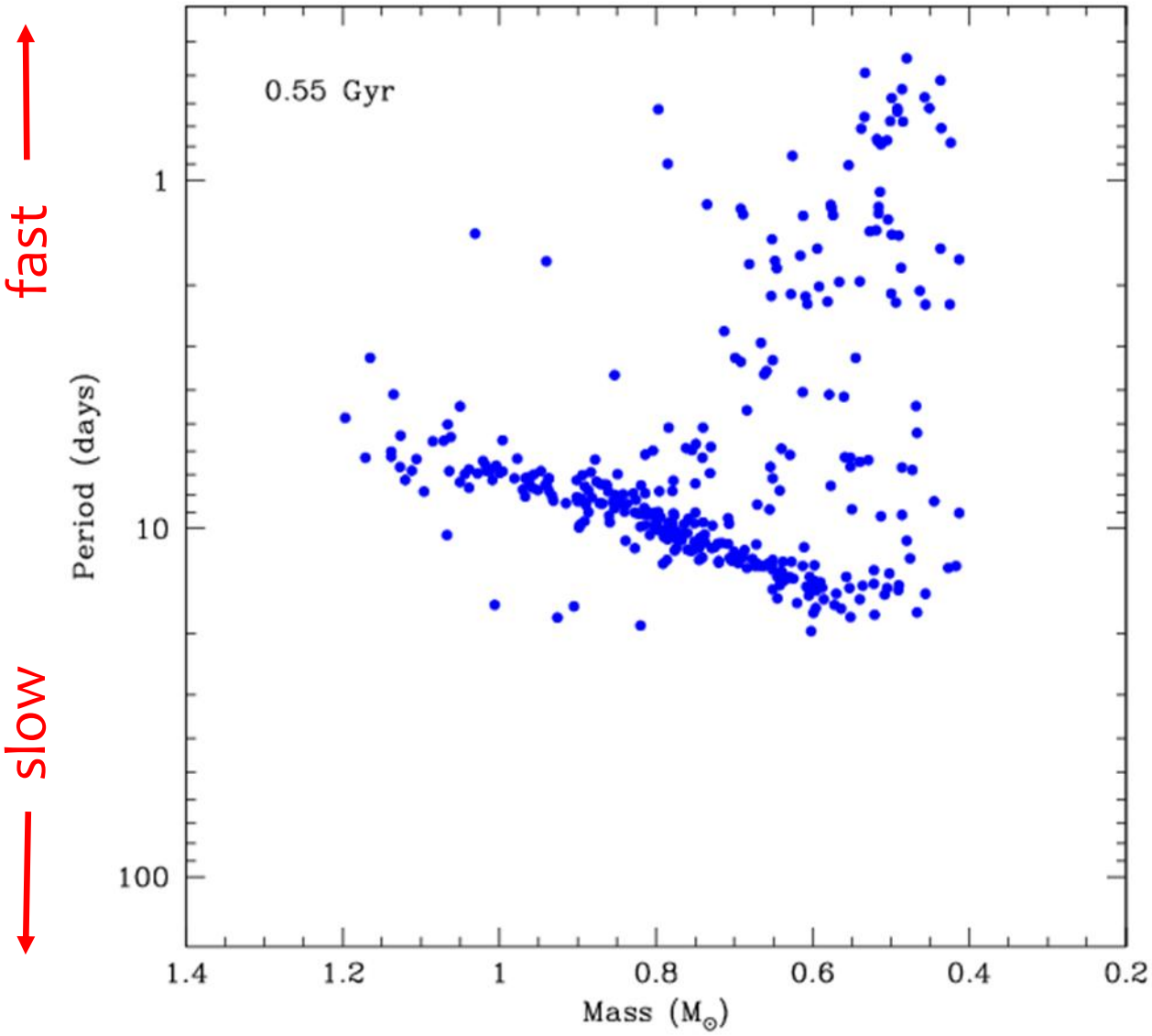
slow



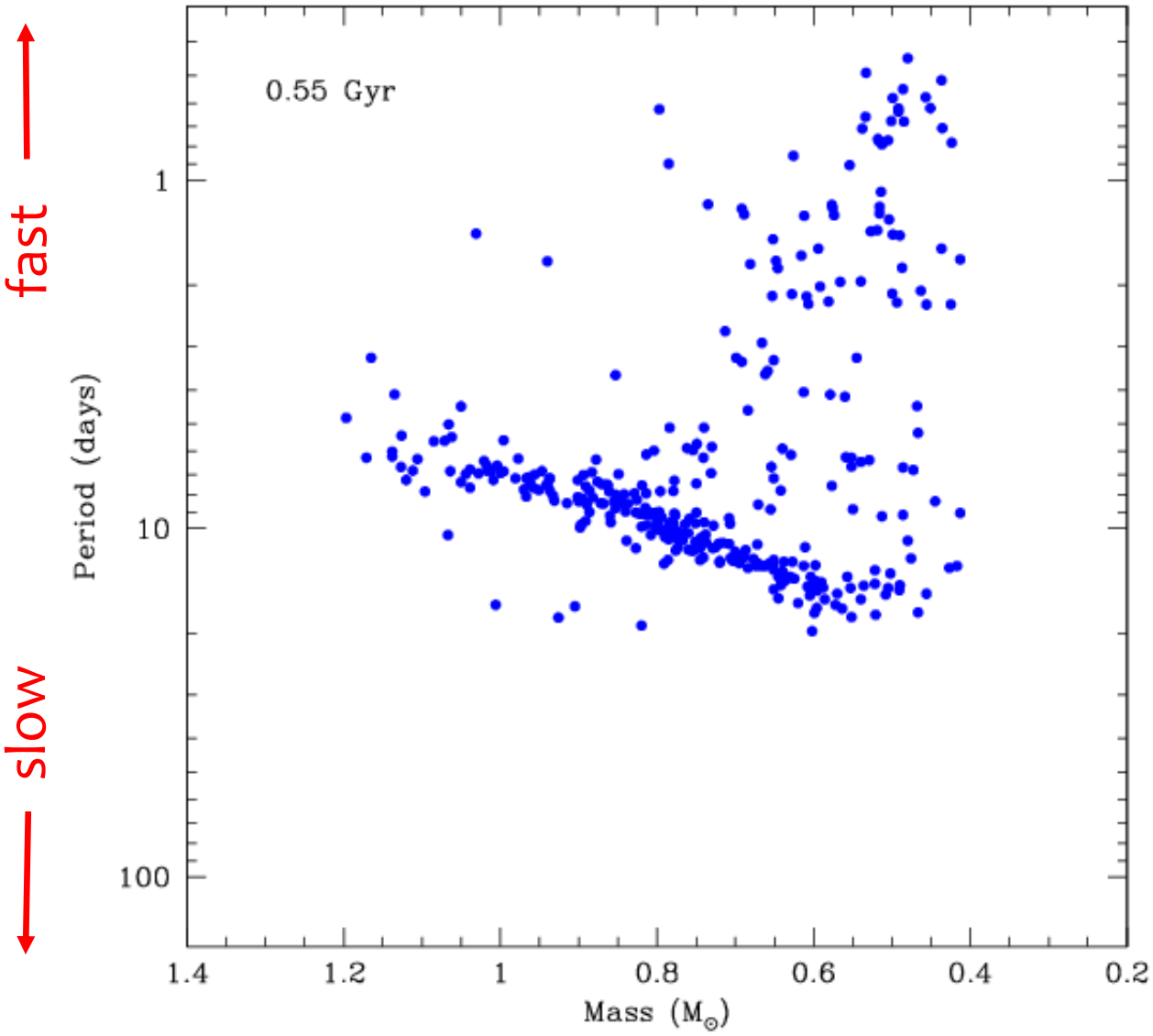
Initial Conditions



Herbst et al. 2002

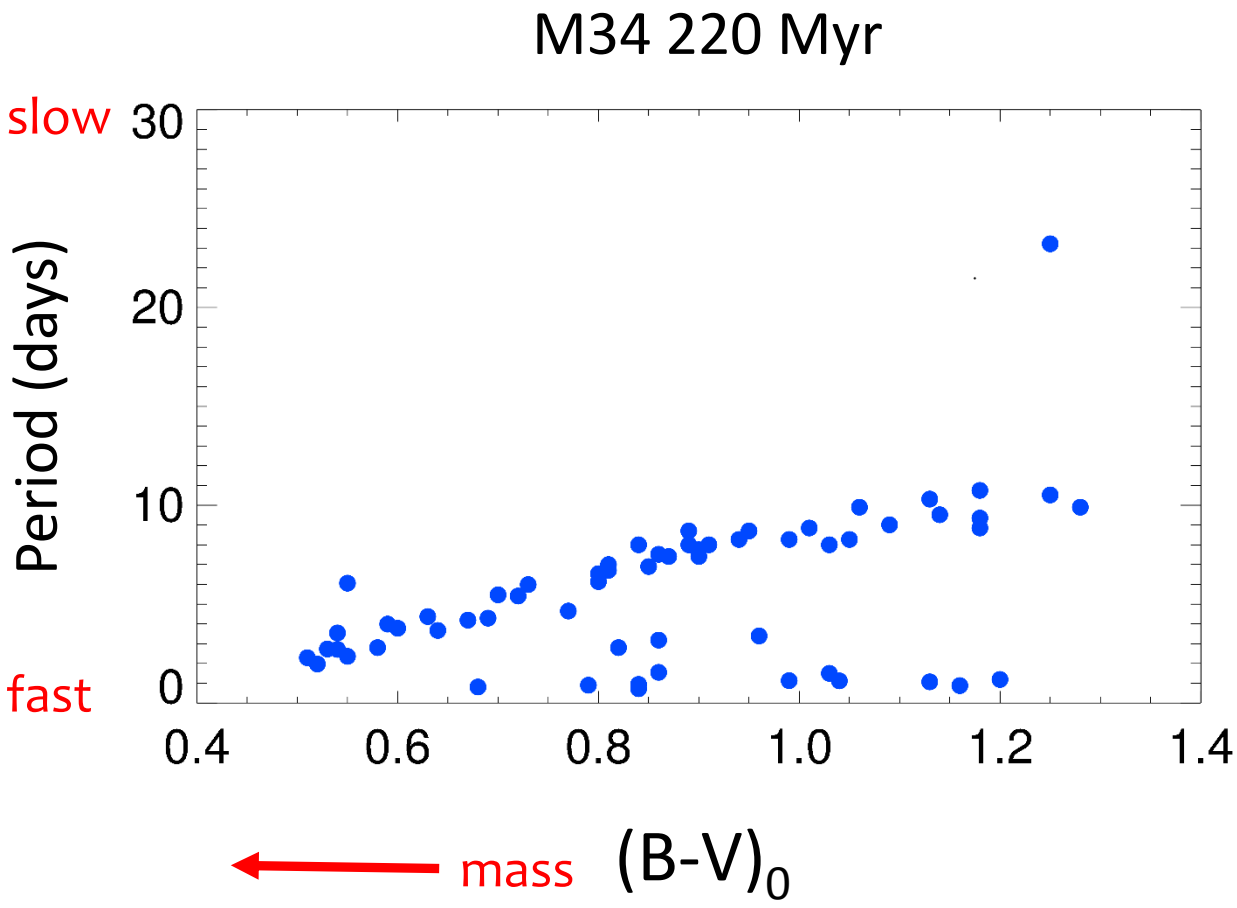


Animation courtesy of Courtney Epstein (Epstein et al. 2014)



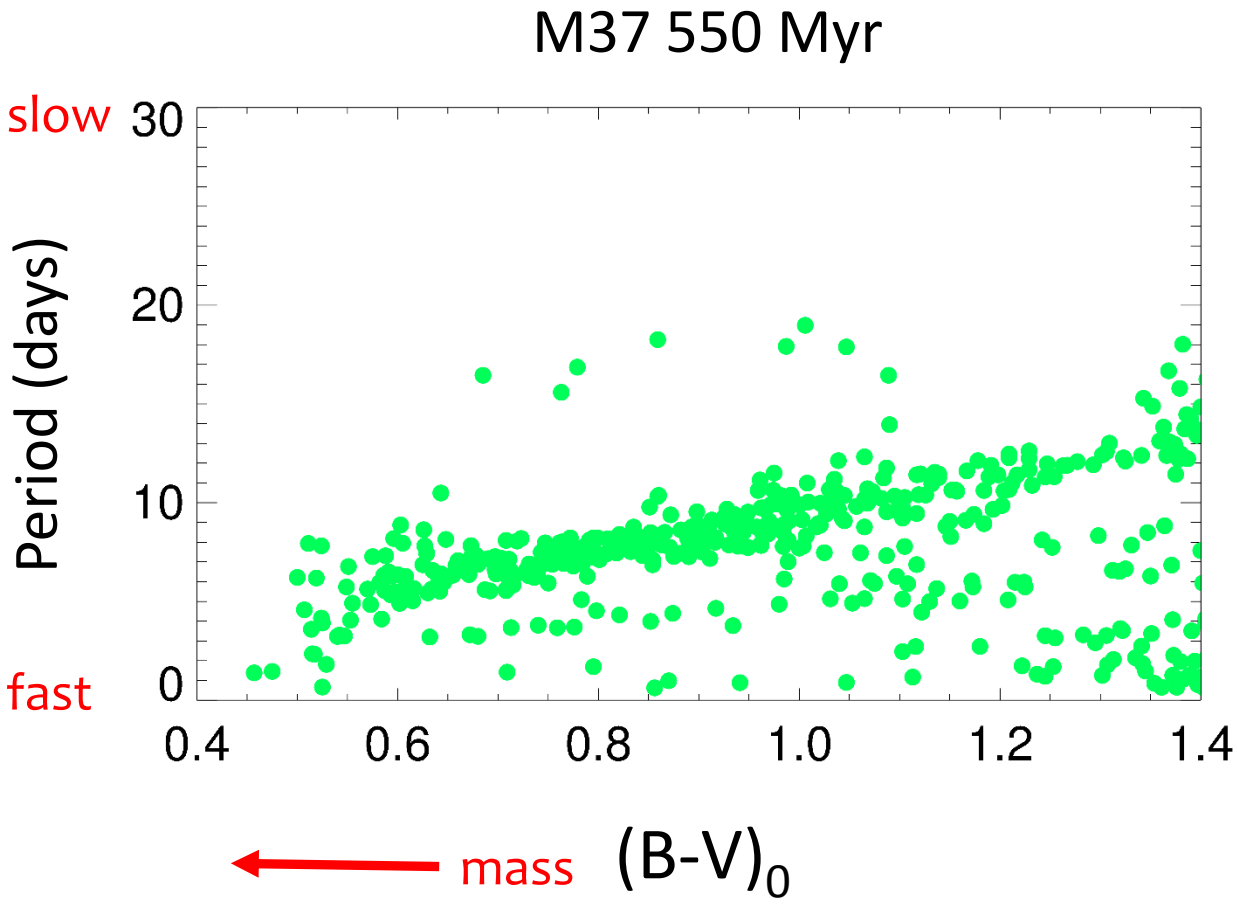
Animation courtesy of Courtney Epstein (Epstein et al. 2014)

Open Cluster Data



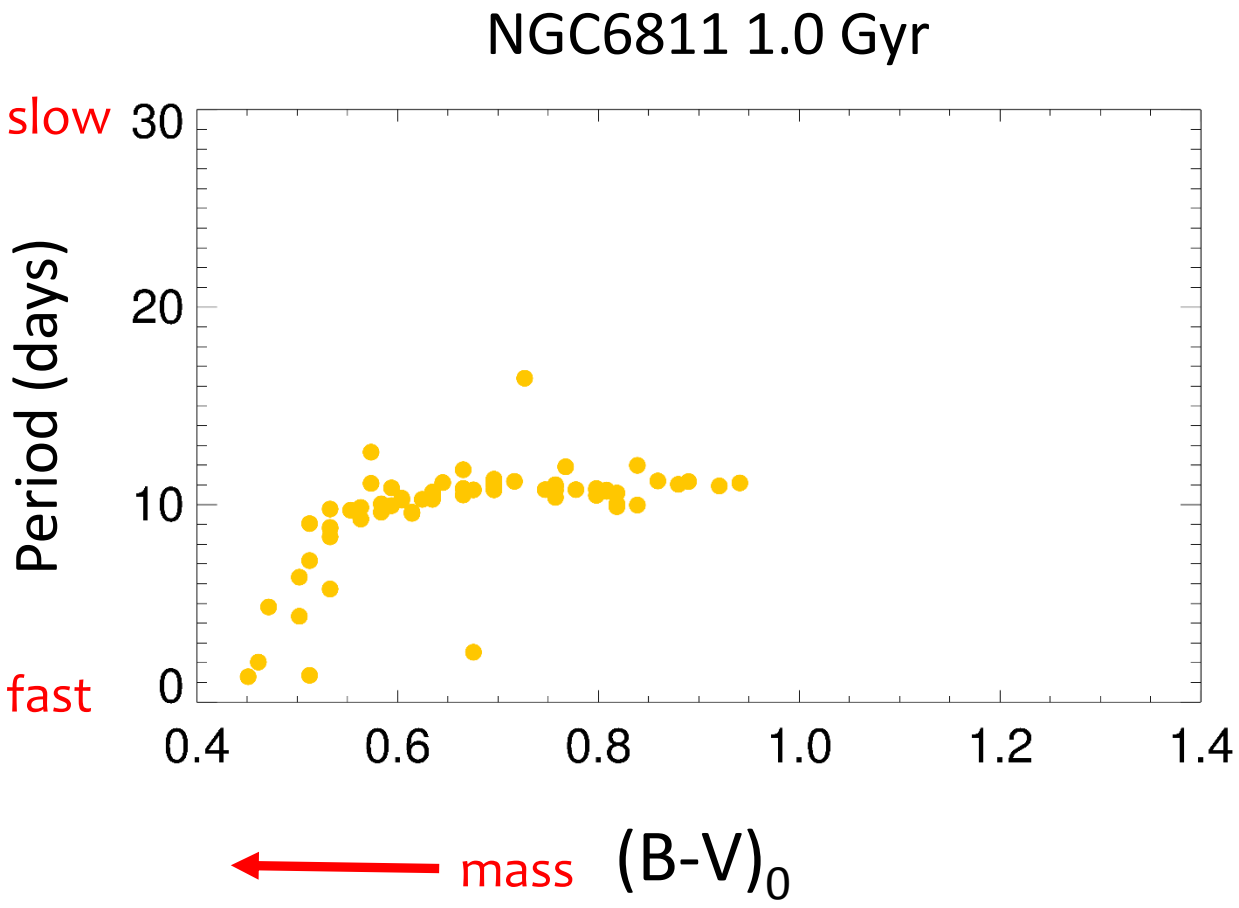
Meibom et al. 2011

Open Cluster Data



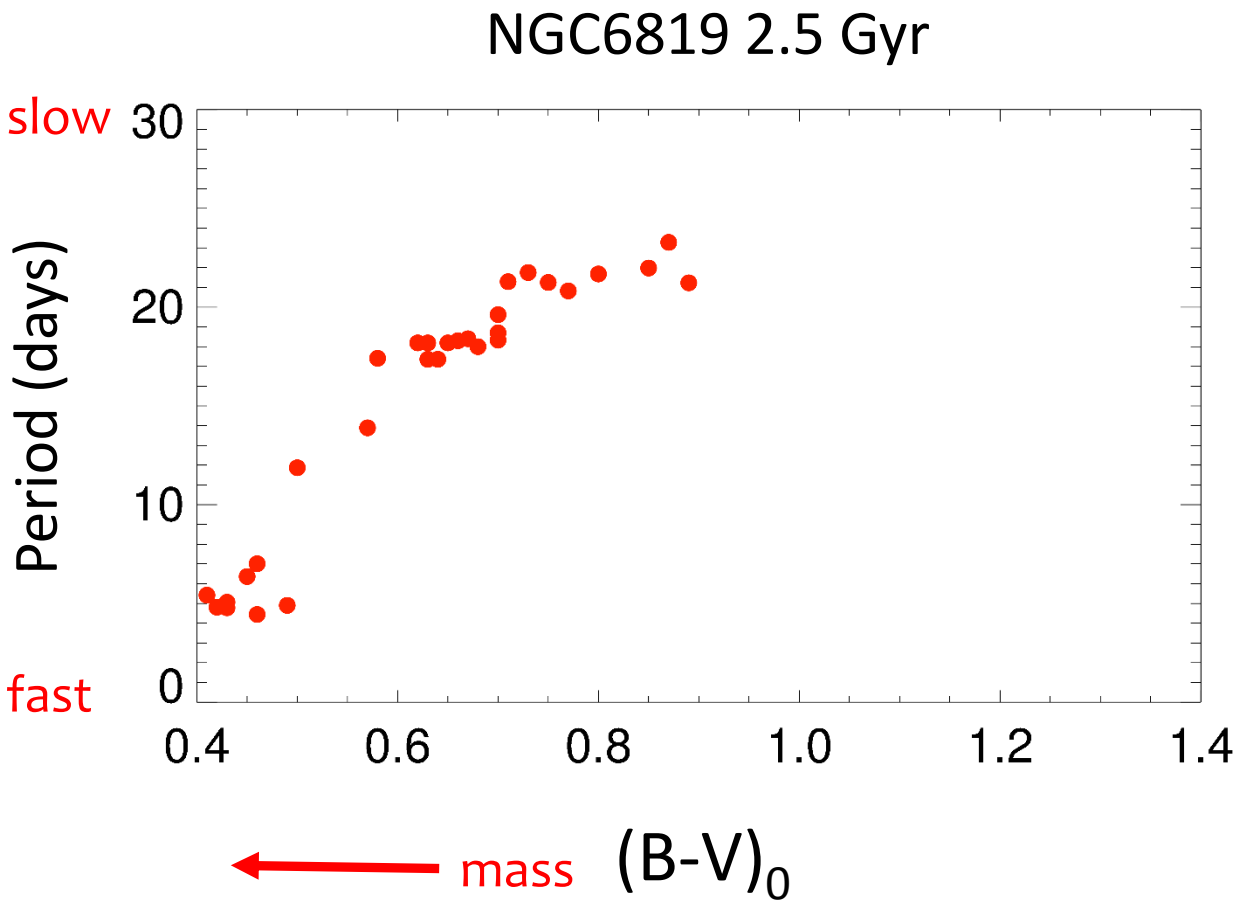
Hartman et al. 2009

Open Cluster Data



Meibom et al. 2011

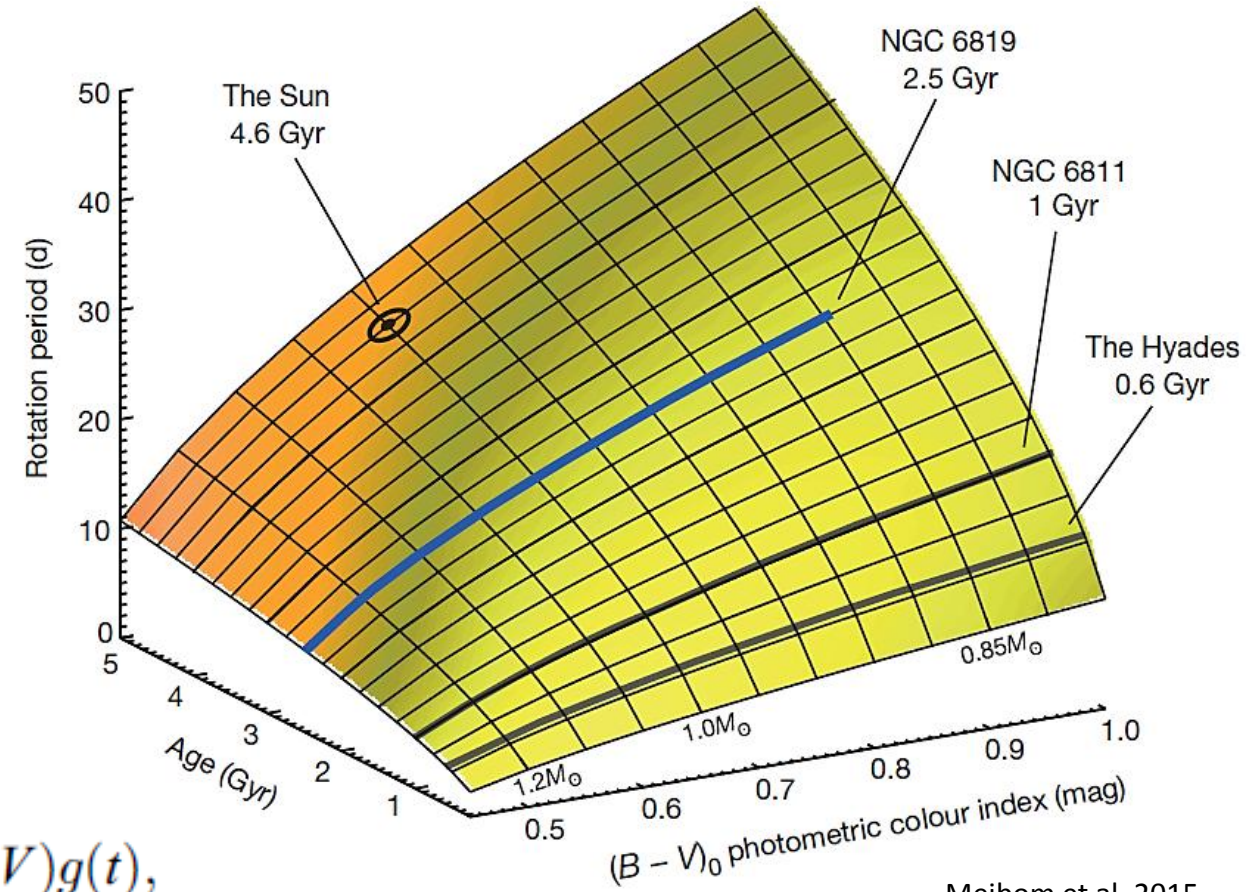
Open Cluster Data



Meibom et al. 2015

How do we build a gyrochronology relation?

Pace & Pasquini 2004
Barnes 2007
Mamajek & Hillenbrand 2008
Barnes 2010
Meibom et al. 2010
Meibom et al. 2011
Meibom et al. 2015

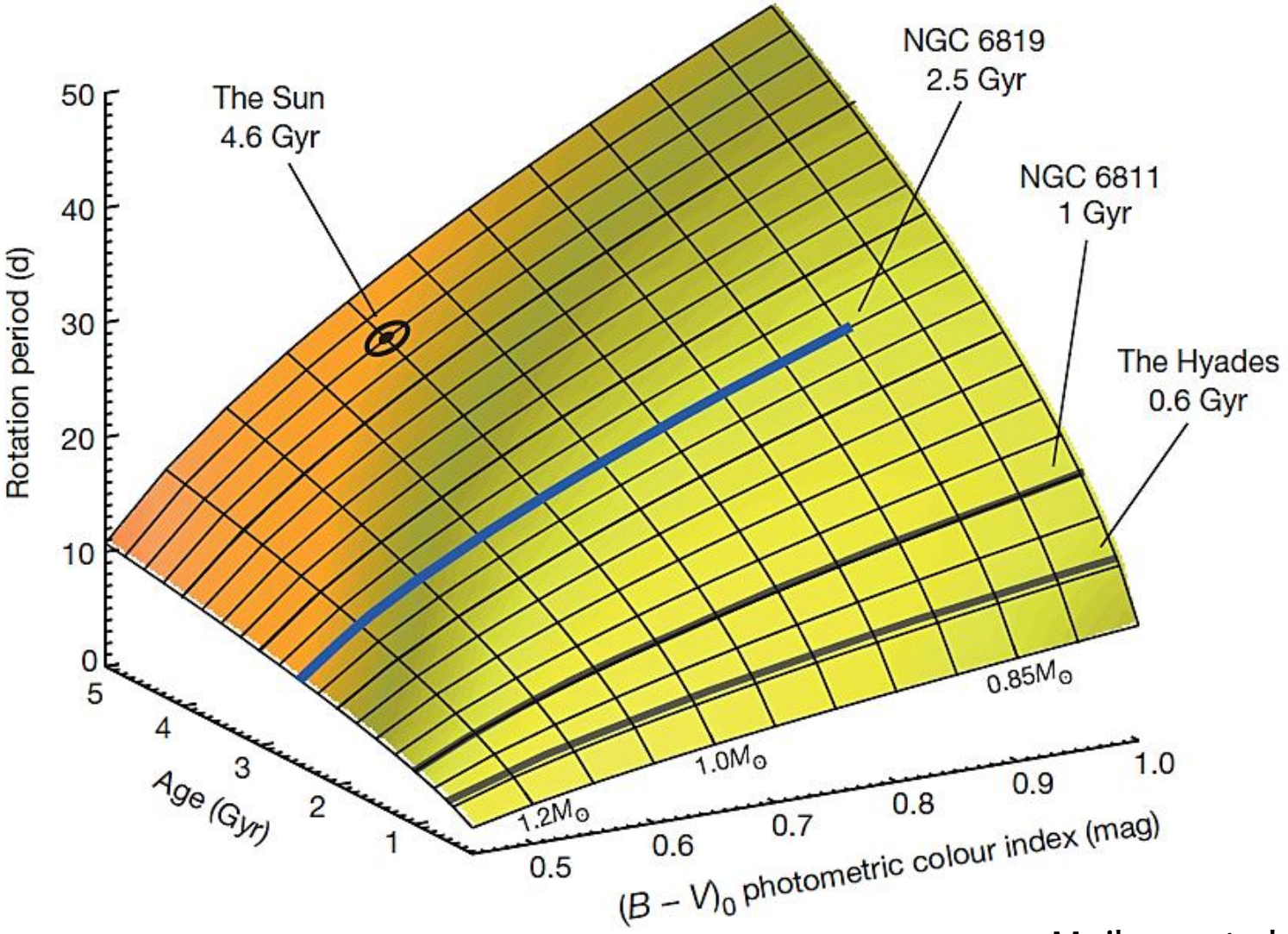


Meibom et al. 2015

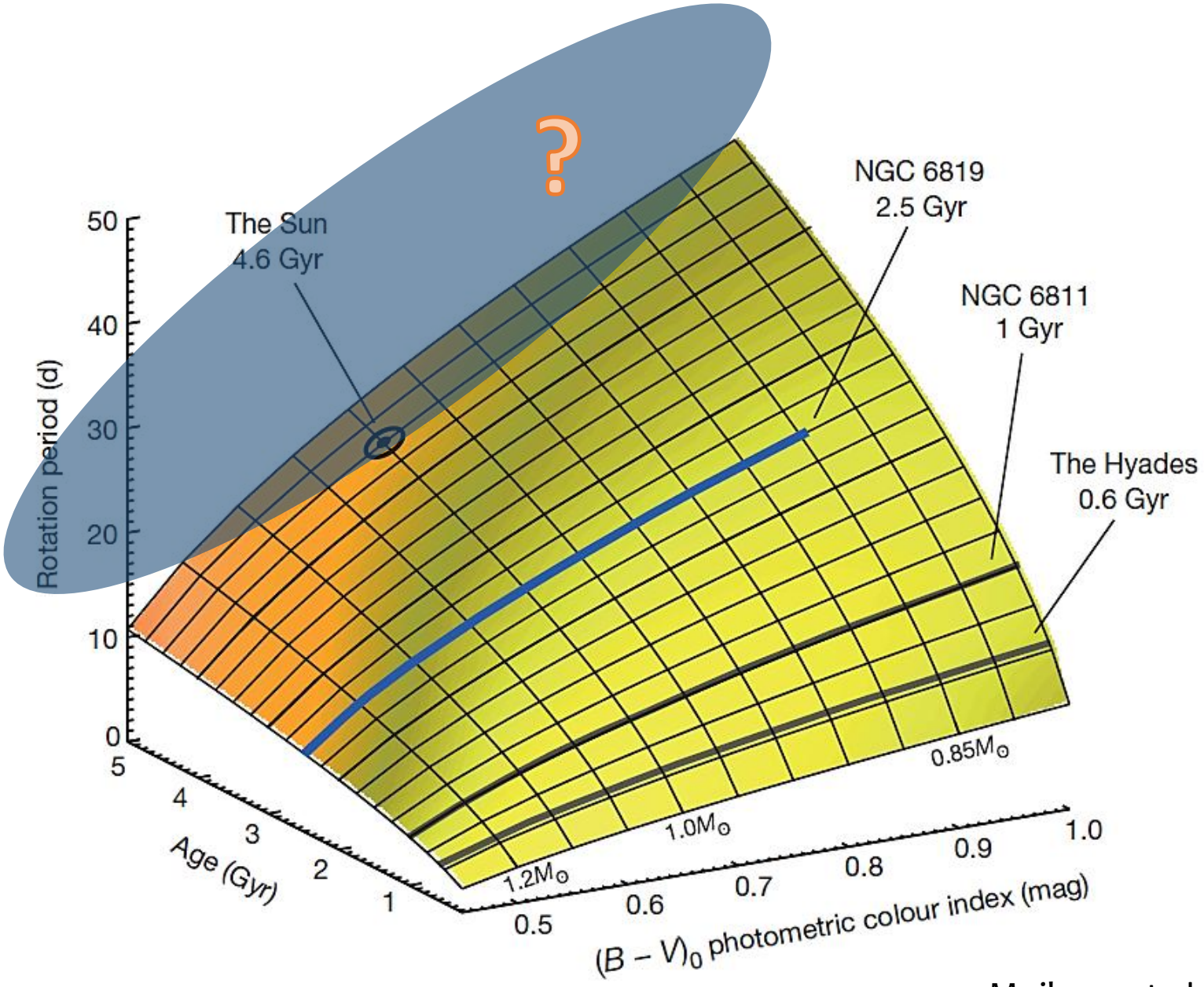
$$P(B-V,\,t) = f(B-V)g(t),$$

$$f(B-V) = a\left[(B-V)_0 - c\right]^b,$$

$$g(t) = t^n.$$

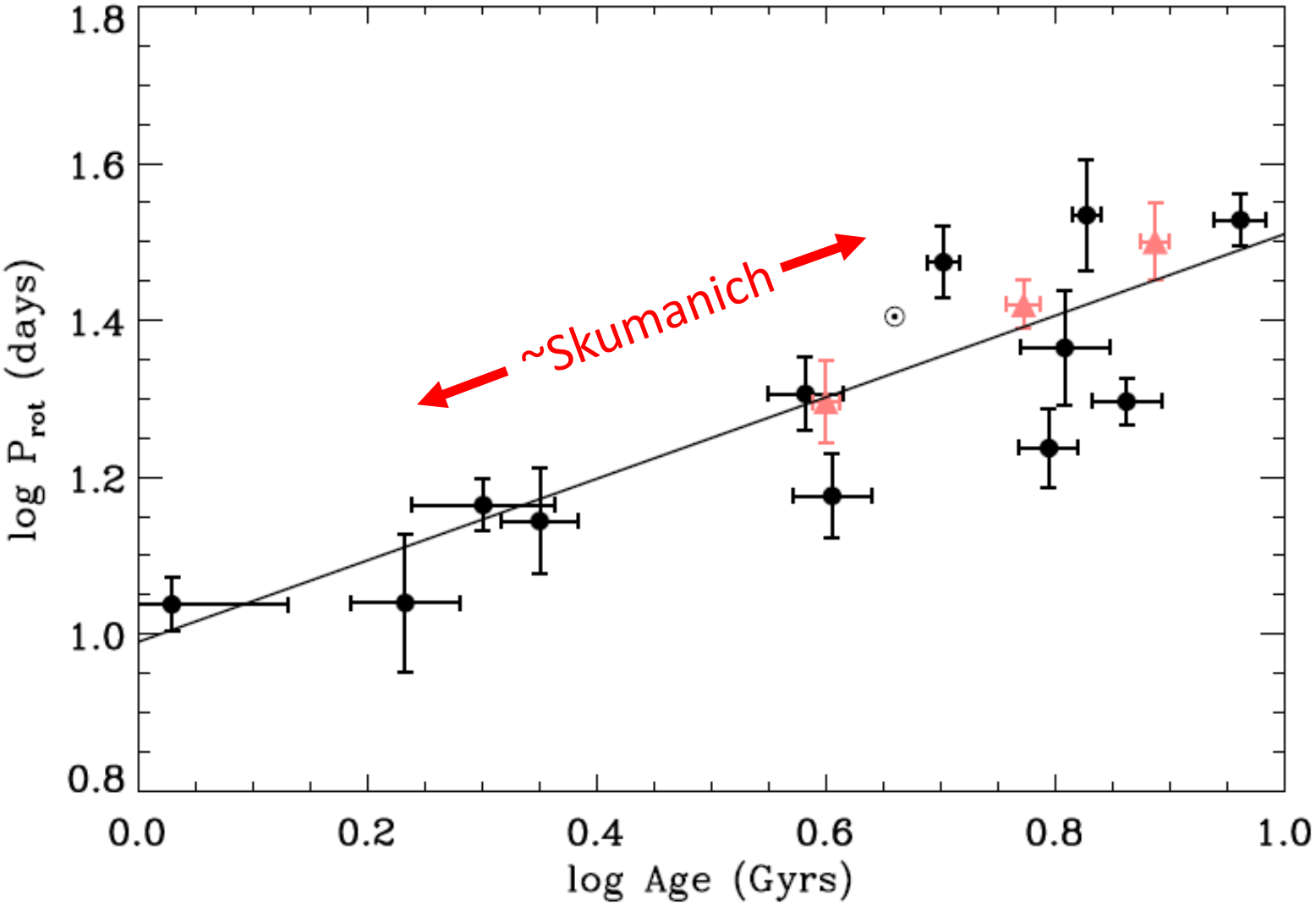


Meibom et al. 2015

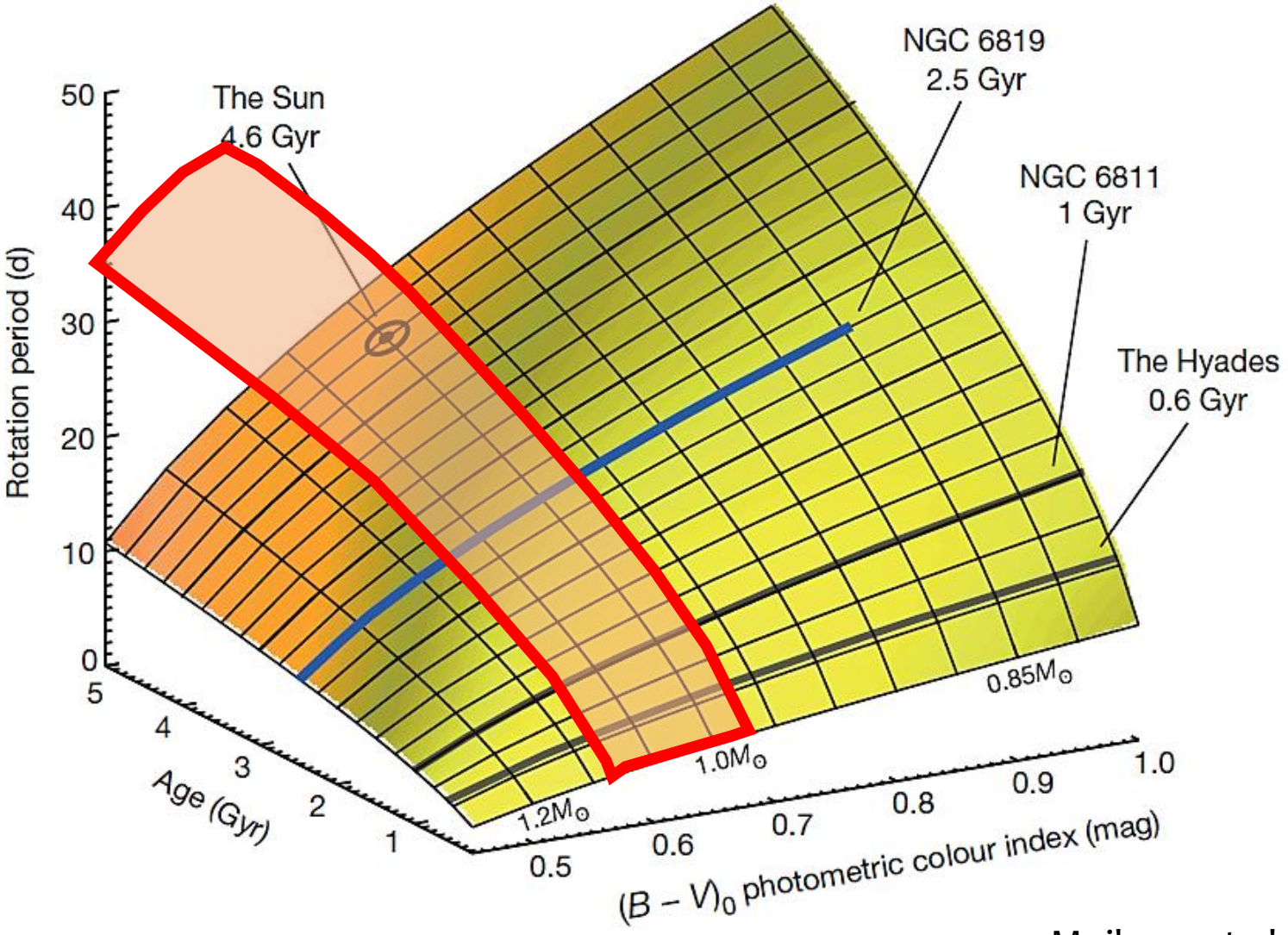


Meibom et al. 2015

Asteroseismic Kepler Dwarfs

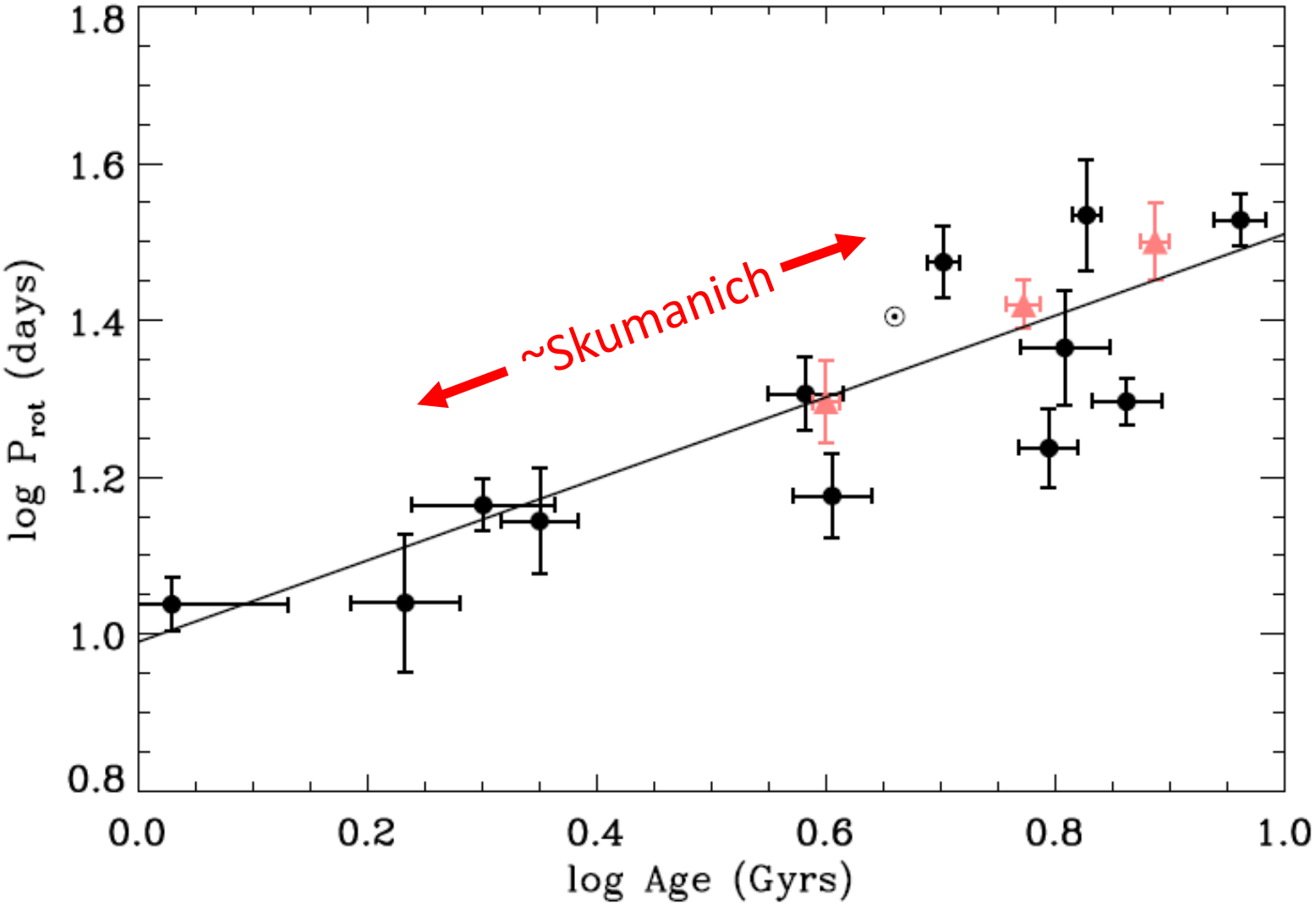


Garcia et al. 2014



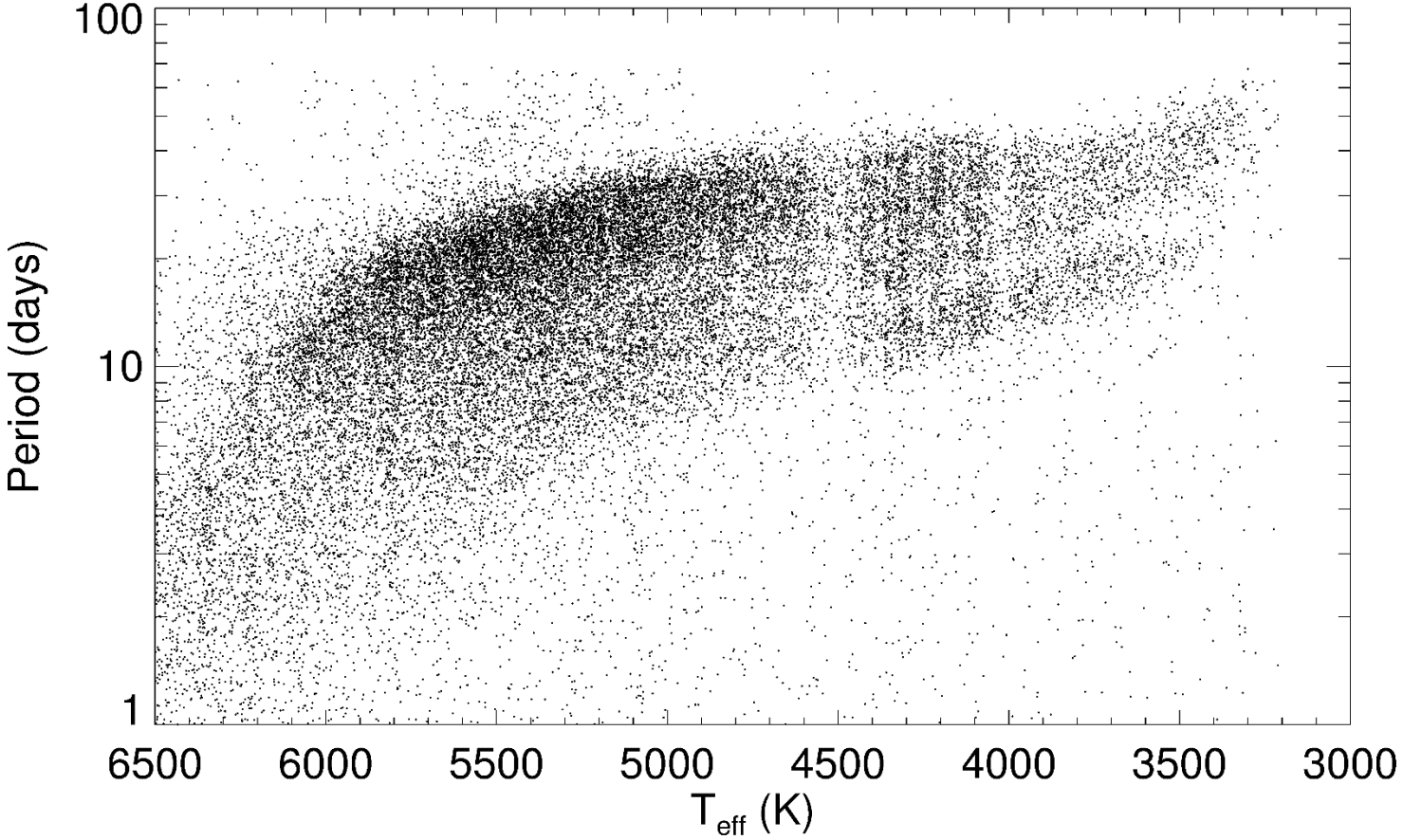
Meibom et al. 2015

Asteroseismic Kepler Dwarfs



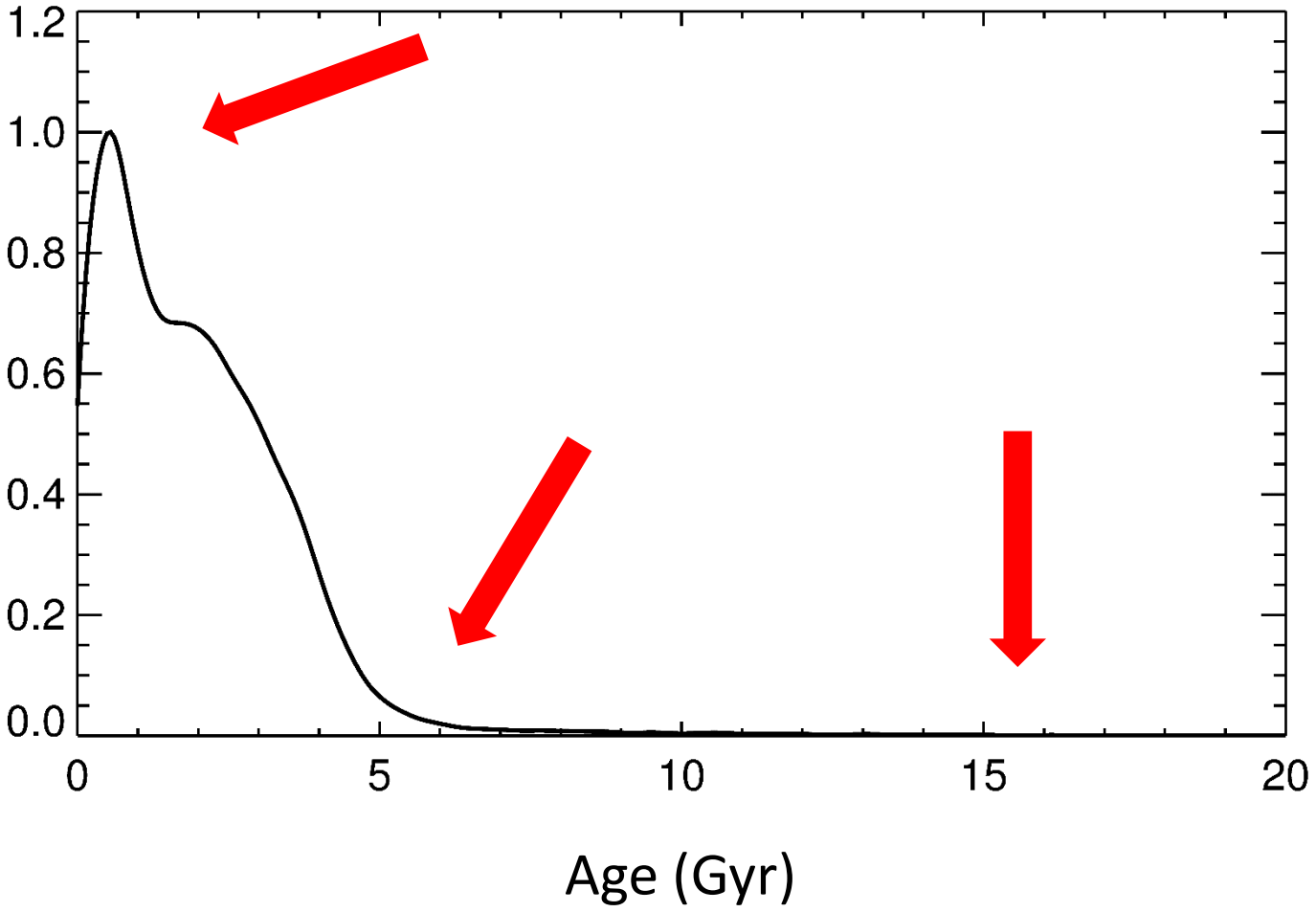
Garcia et al. 2014

Naïve Gyro



McQuillan et al. 2014

Naïve Gyro



1.

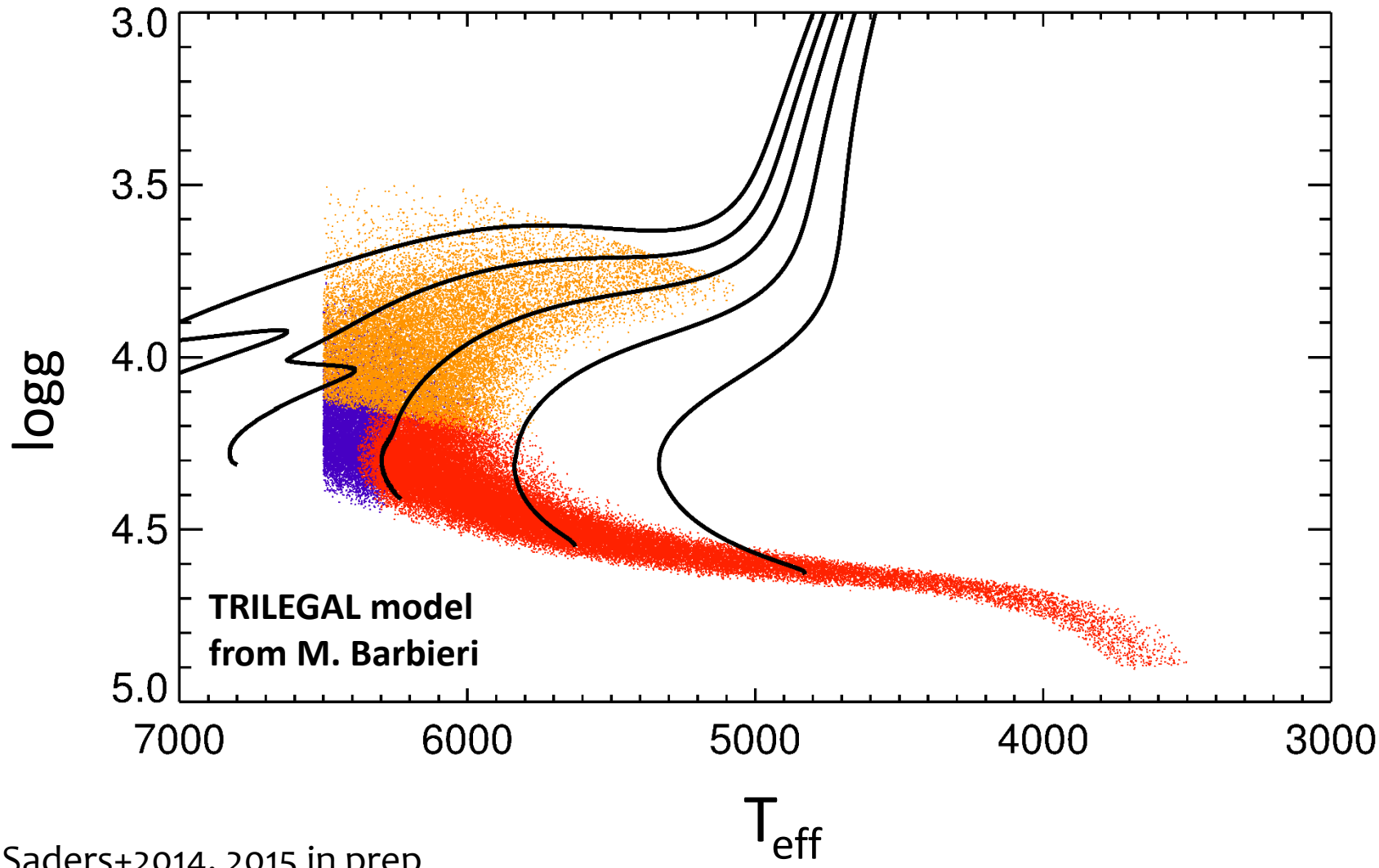
Populations of stars include more than just cool dwarfs and have a greater variety of rotational histories

2.

Detection biases in periods = detection biases in age

Forward modelling

TRILEGAL model, Kp < 16, same Teff-logg cuts as McQuillan+ 2014



van Saders+2014, 2015 in prep

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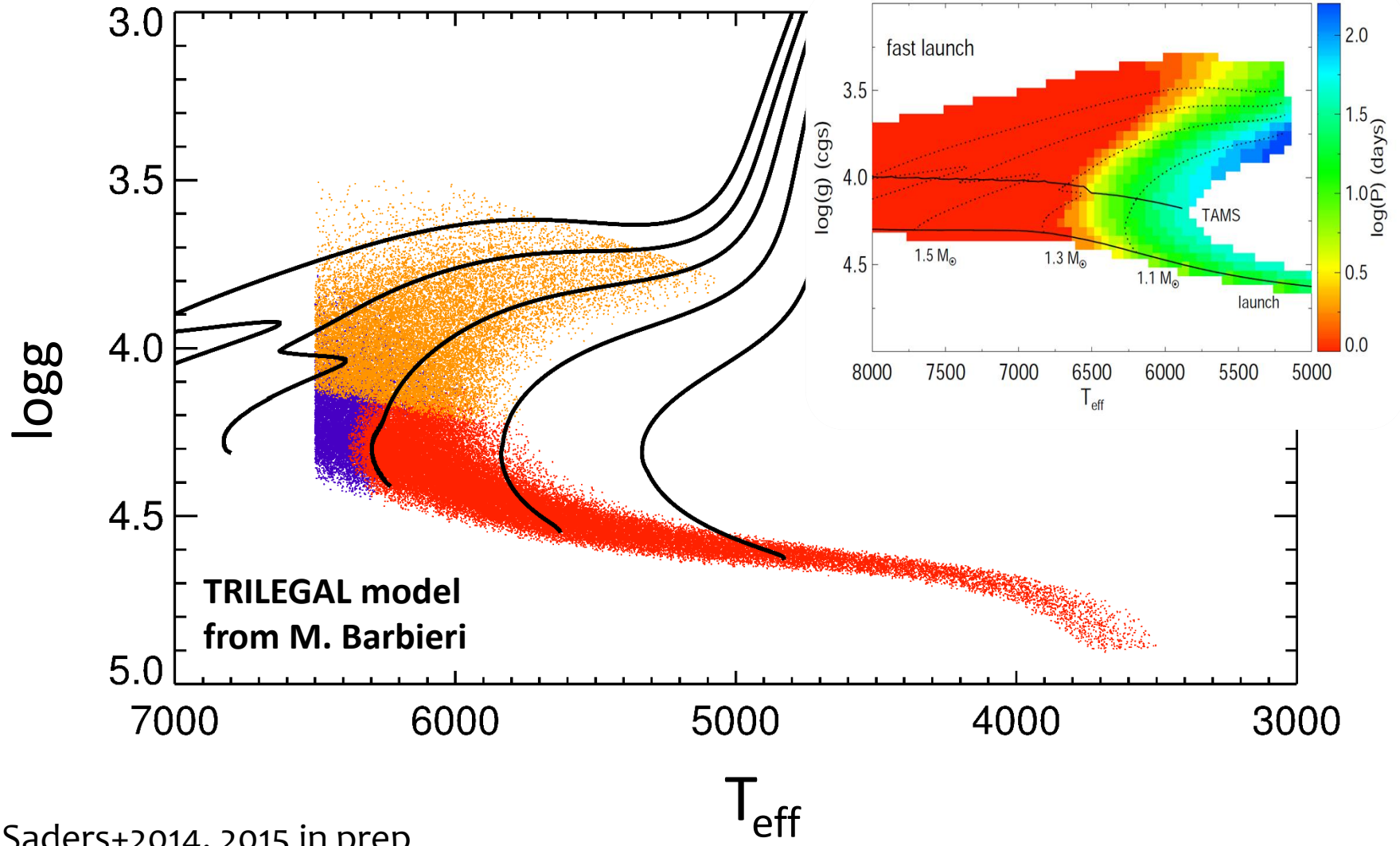
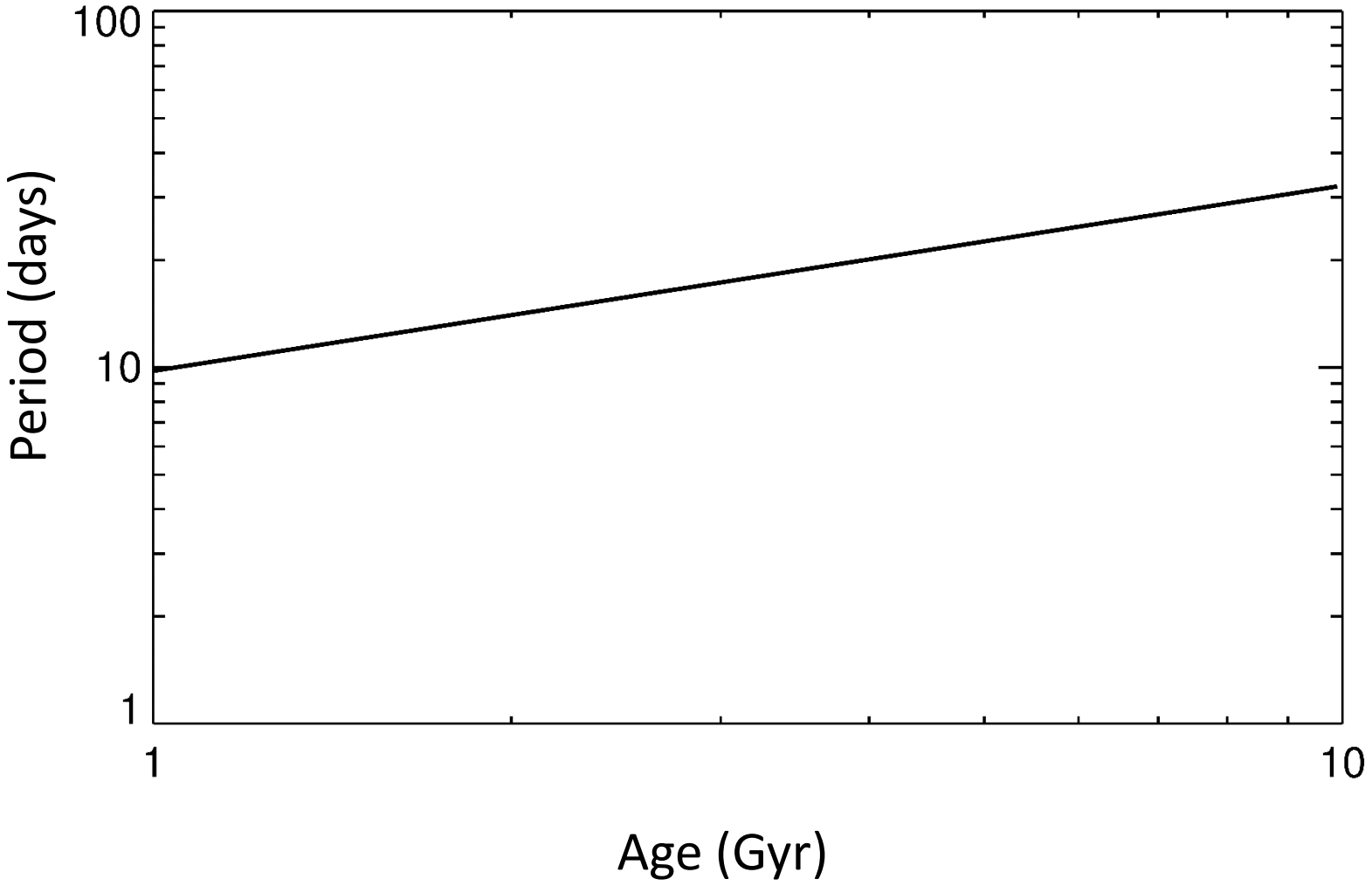
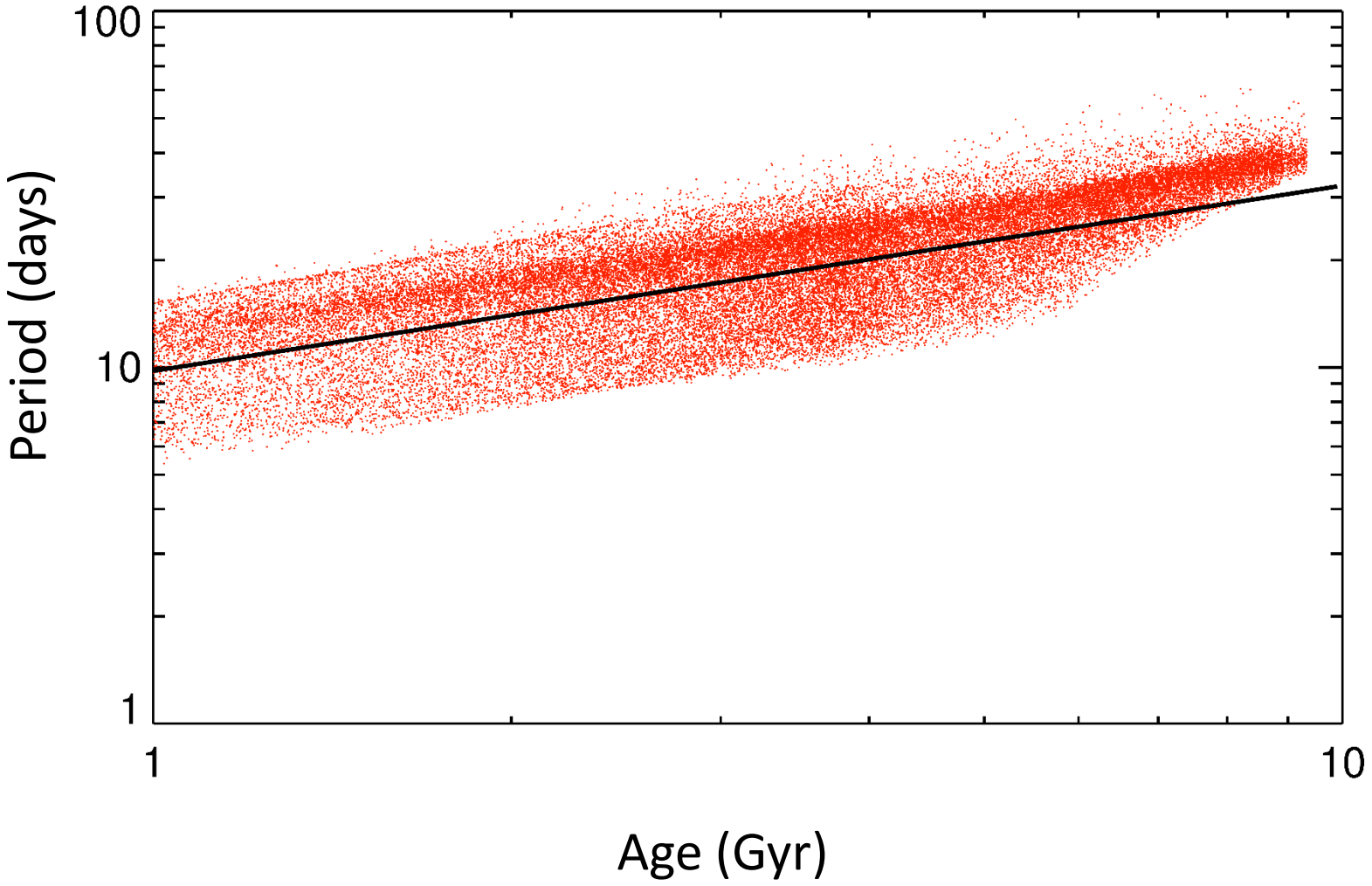


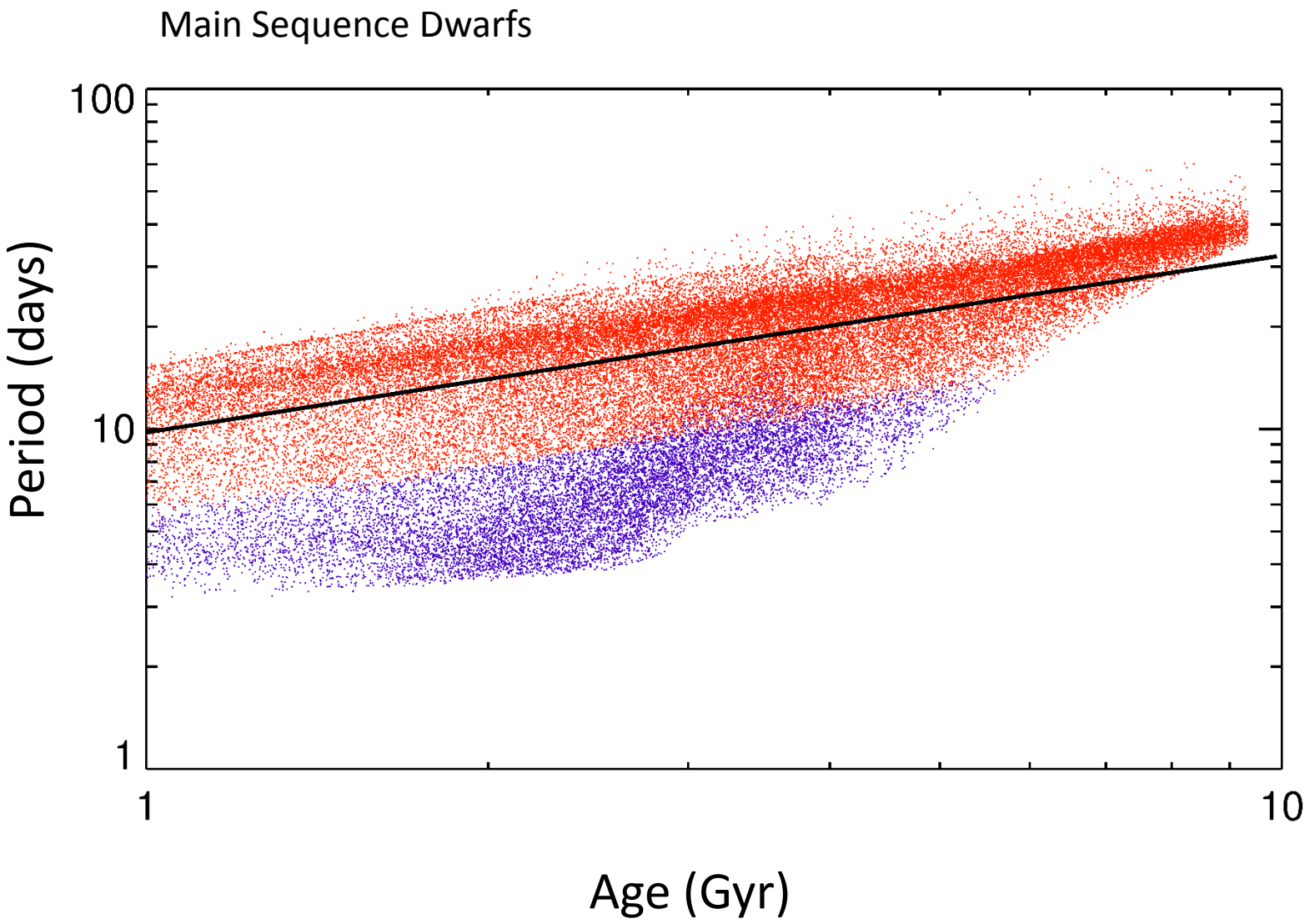
van Saders+2014, 2015 in prep



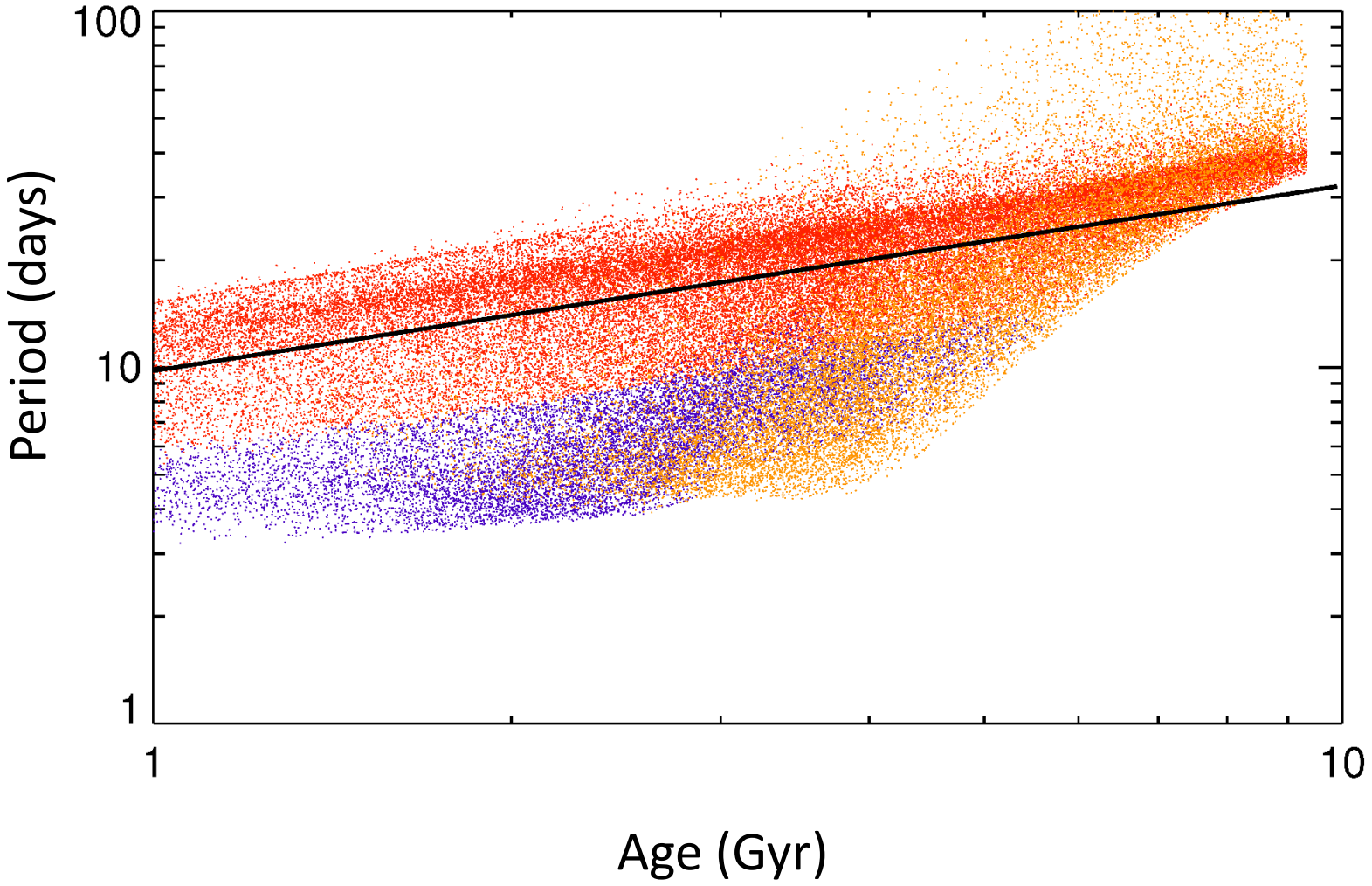
van Saders+2014, 2015 in prep



van Saders+2014, 2015 in prep



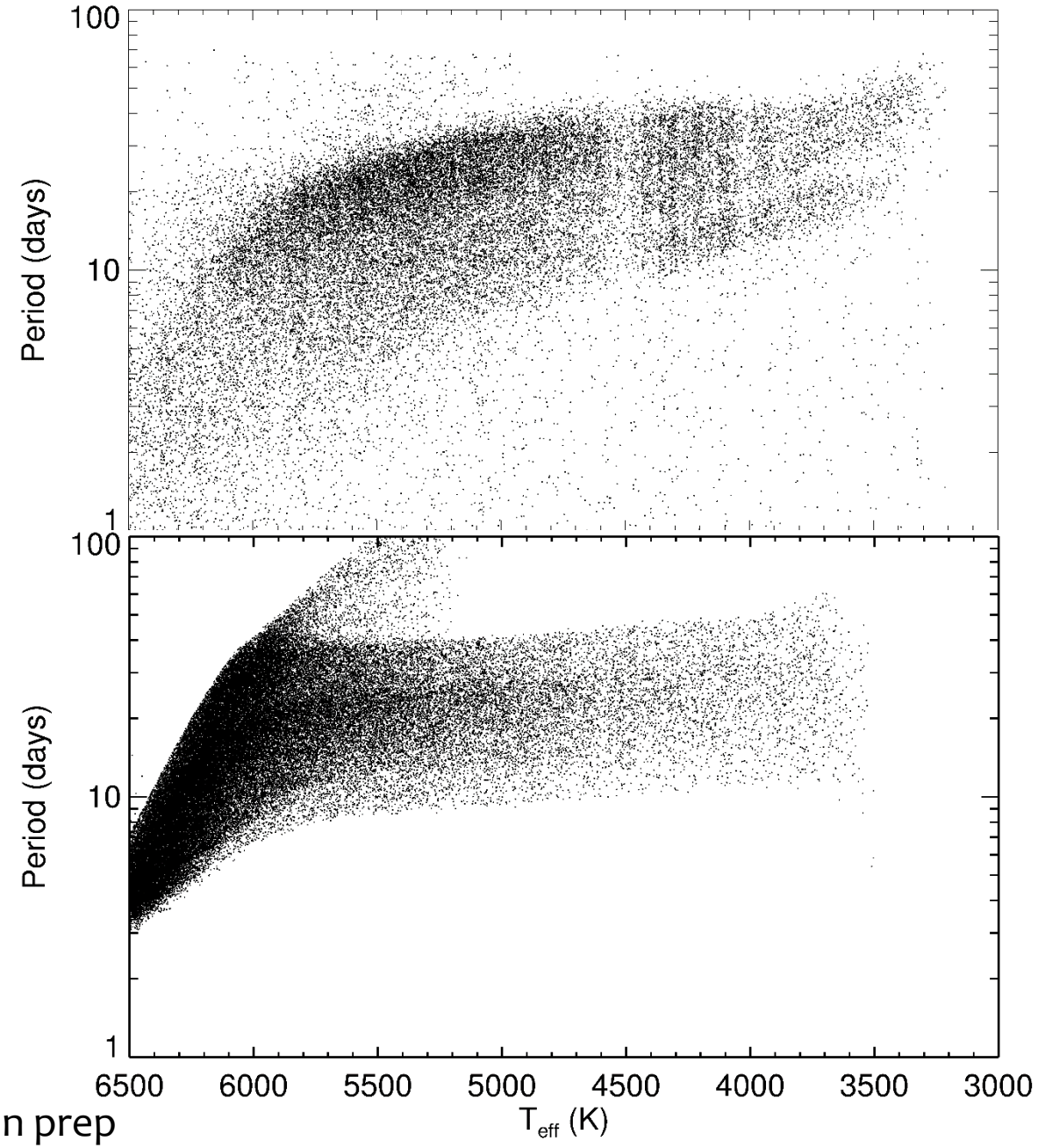
van Saders+2014, 2015 in prep



van Saders+2014, 2015 in prep

Data

Forward Model



van Saders+2014, 2015 in prep

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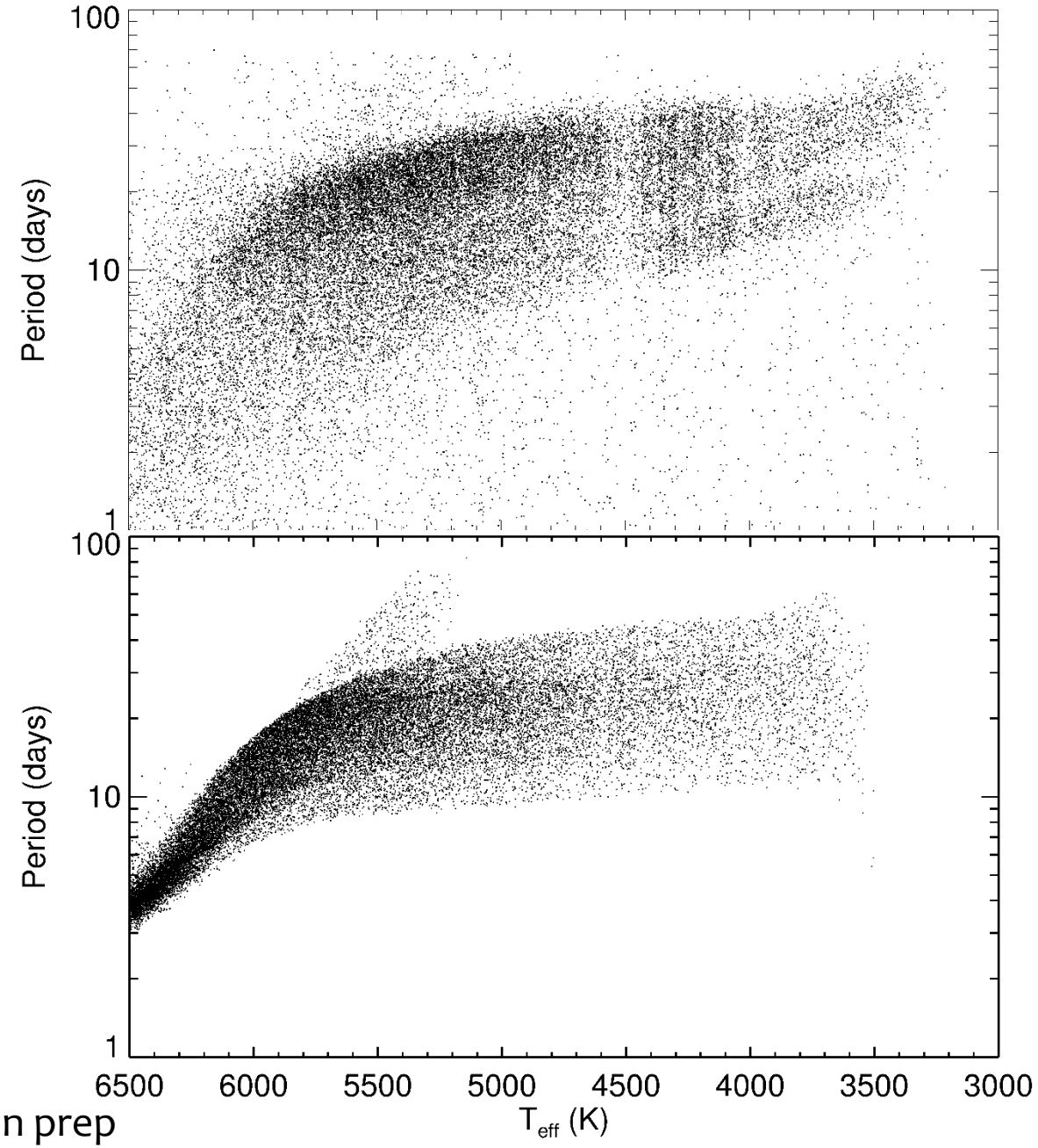
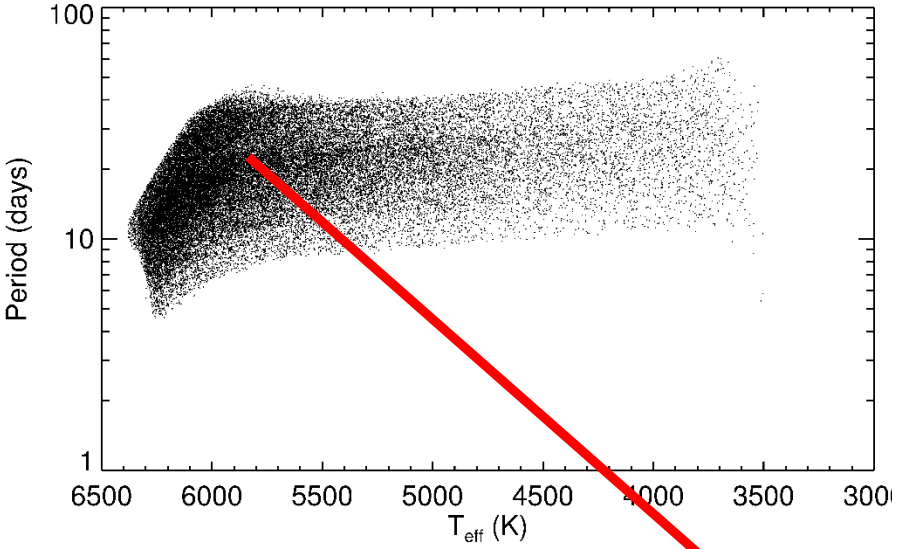
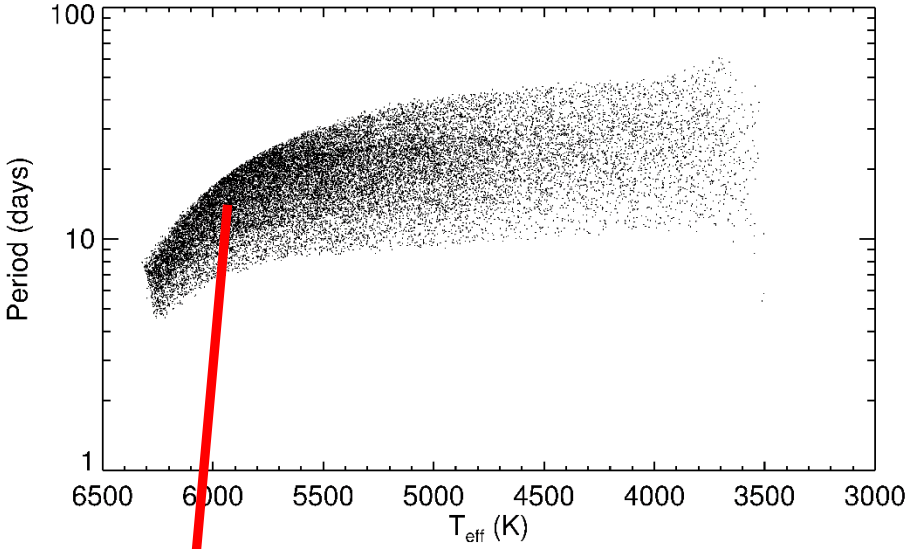


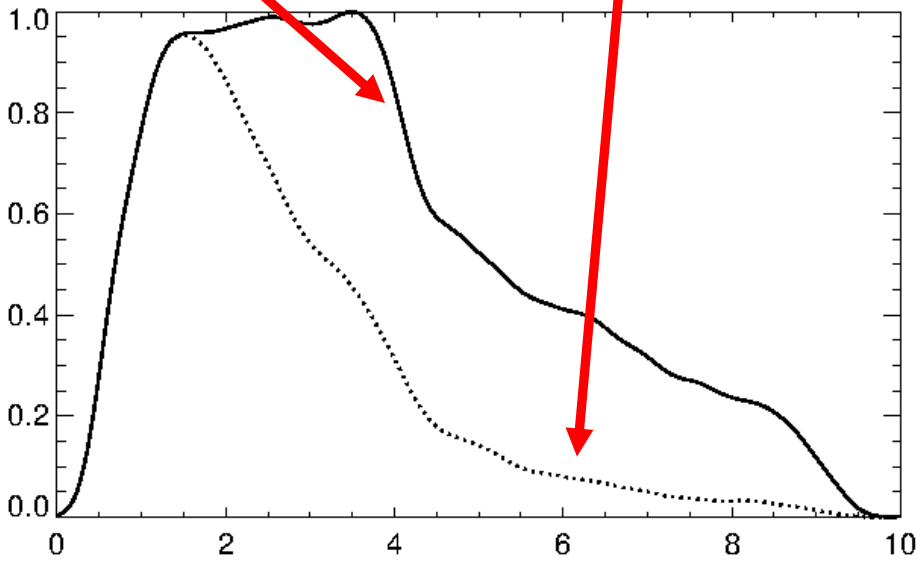
van Saders+2014, 2015 in prep

Dwarfs only, no Ro cut



Dwarfs only, Ro < 2





van Saders+2014, 2015 in prep

Conclusions

Ongoing work with Kepler data is providing anchors and calibration for the gyrochronology relations

Calibrations for stars older than 1 Gyr and younger than the Sun are looking particularly promising

Stellar populations matter! Naïve gyrochronology yields misleading ages. We must select a pure cool-dwarf sample if we want to do this correctly.

Detection of periods corresponding to ages older than that of the Sun has proven challenging. This may fundamentally limit the ages range over which gyrochronology is a useful tool.

Discussion Points

Are the simple calibrations in color and period enough? Do we need more complex models?

We are still fundamentally tied to the cluster age scale. In fact, you might argue that most (if not all) stellar diagnostics end up tied to the clusters in some way!

Suppose this is as good as it gets: what can you do with precise ages at a few Gyrs, and lower limits for objects 4 Gyr and older?

I've only briefly mentioned the problem of binaries (synchronized and not) and blending! This is yet another way that you can be fooled in large surveys.