Giant planets around low-mass stars

a challenge for core accretion theory

Martin Schlecker
(MPIA Heidelberg)

and **Remo Burn** (MPIA), **Silvia Sabotta** (LSW Heidelberg), **Antonia Seifert** (Uni Heidelberg), **Thomas Henning** (MPIA), **Alexandre Emsenhuber** (USM Munich), **Christoph Mordasini** (University of Bern), **Sabine Reffert** (LSW Heidelberg), **Yutong Shan** (Uni Göttingen), **Hubert Klahr** (MPIA)

Image Credit: NASA, ESA, G. Bacon (STScI)

www.mpia.de/homes/schlecker | github.com/matiscke | schlecker@mpia.de

Can planet formation theory* reproduce the giant planet detections as a function of $M_\star$?

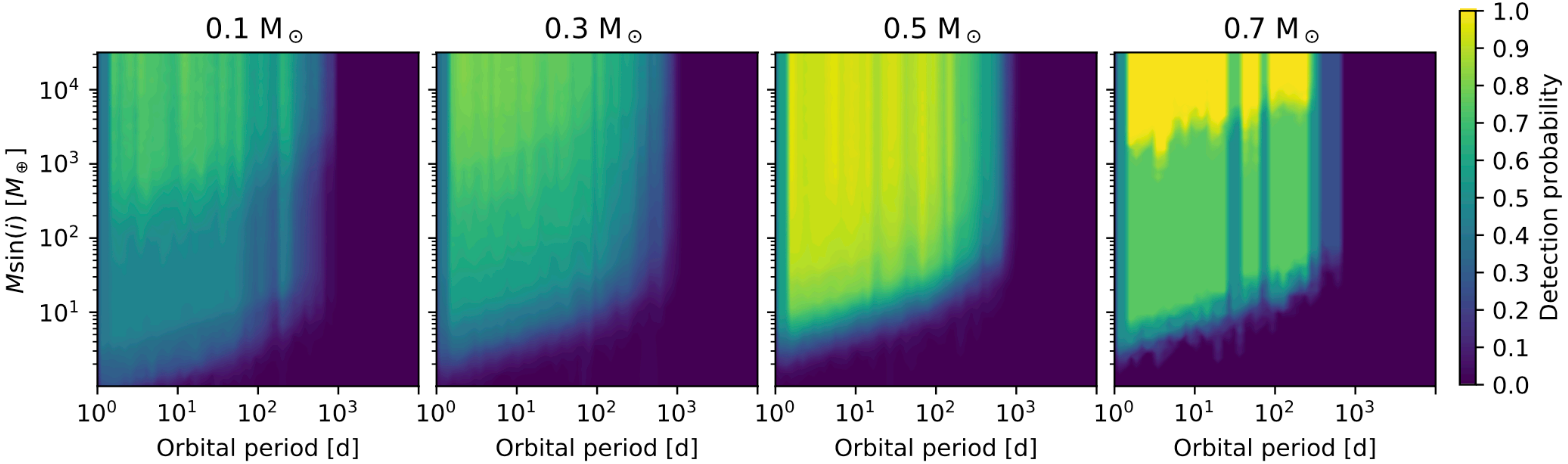
*** core accretion**

The planet sample: observed

combine HARPS *(Bonfils+2013)* and CARMENES *(Quirrenbach+2010, Reiners+2018)* M-dwarf surveys

↳ "HARPS&CARM70" survey: 148 stars, 35 planets

Detection bias: injection&retrieval of planets into original RV time series *(Sabotta+2021)*



Multi-planet formation & evolution model

Alibert+2005; Mordasini+2009, 2012, 2016; Emsenhuber+2020a,b; Schlecker+2020a

1D viscous accretion disk

+photoevaporation

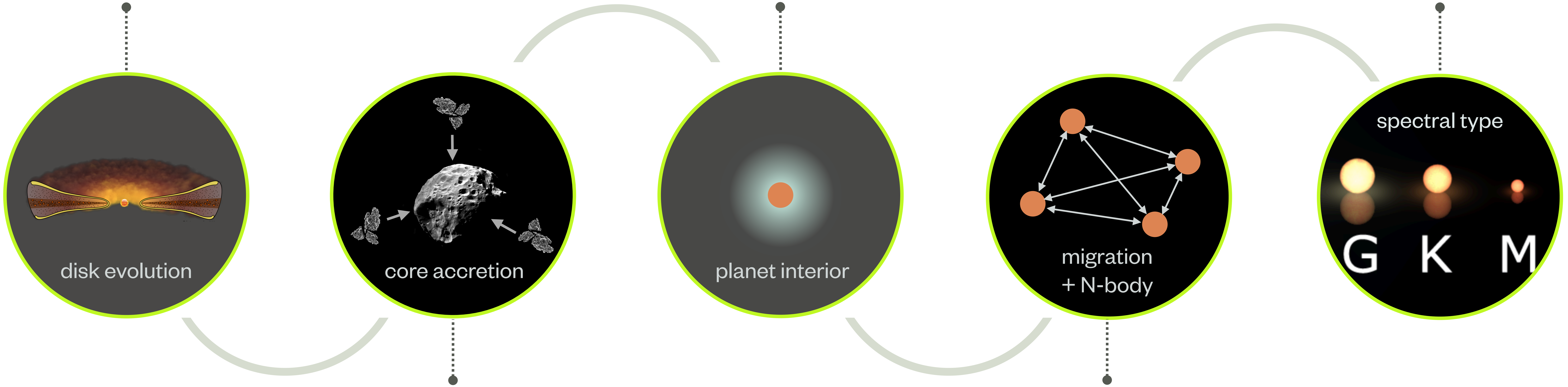
Hueso&Guillot 2005

1D structure equation; $t \rightarrow 5\,\mathrm{Gyr}$

Mordasini+2012,2015; Jin+2014

Stellar mass dependency

Burn+2021; Schlecker+ (in prep.)



initially 50 embryos

gas and planetesimals

Fortier+2013

type I & II migration

Paardekooper+2011

N-body: key for small planets

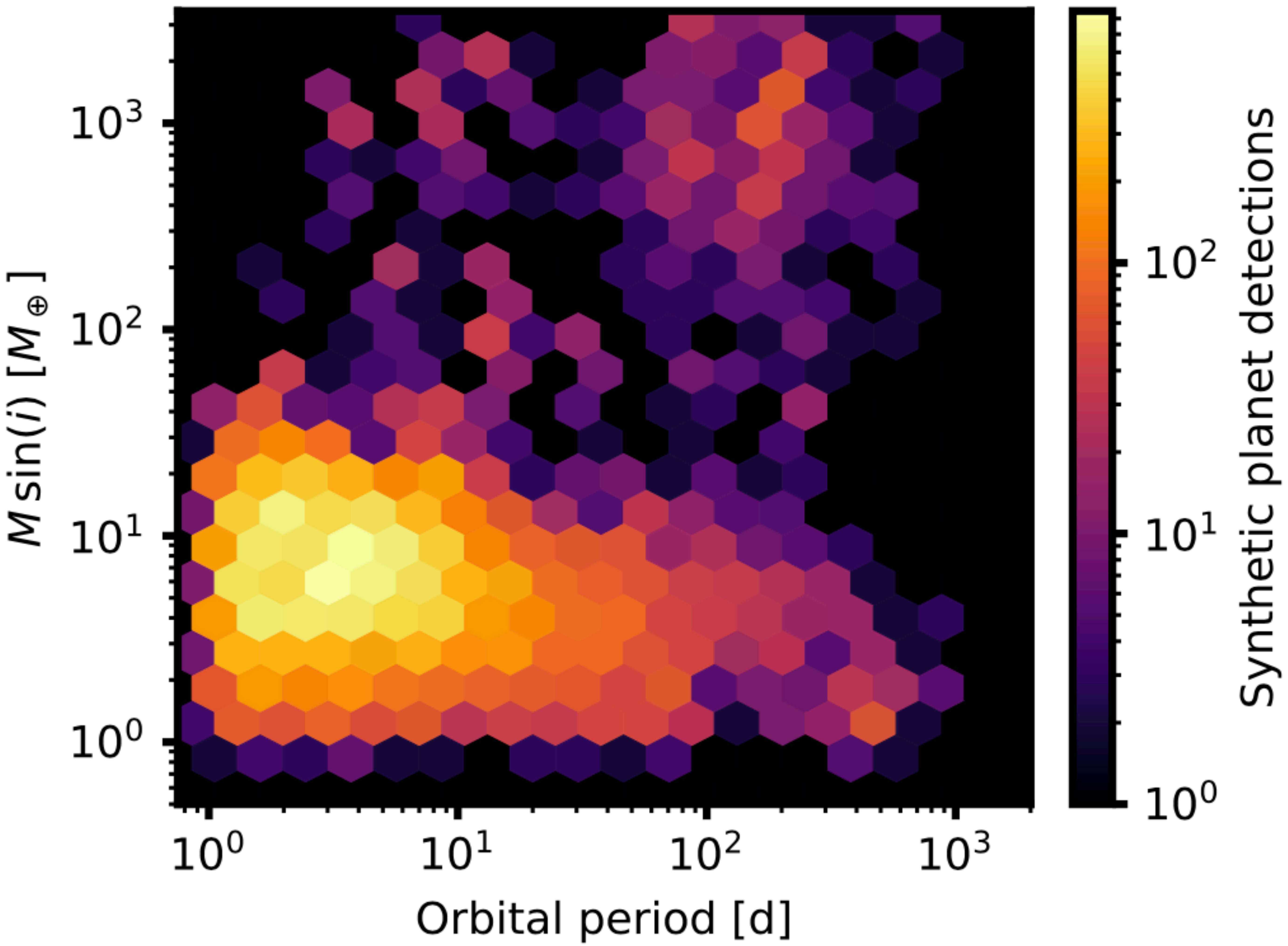
Alibert+2013

The planet sample: synthetic

100,000 simulated multi-planet systems

host star masses as in the observed sample

-> 20,082 *detectable* synthetic planets



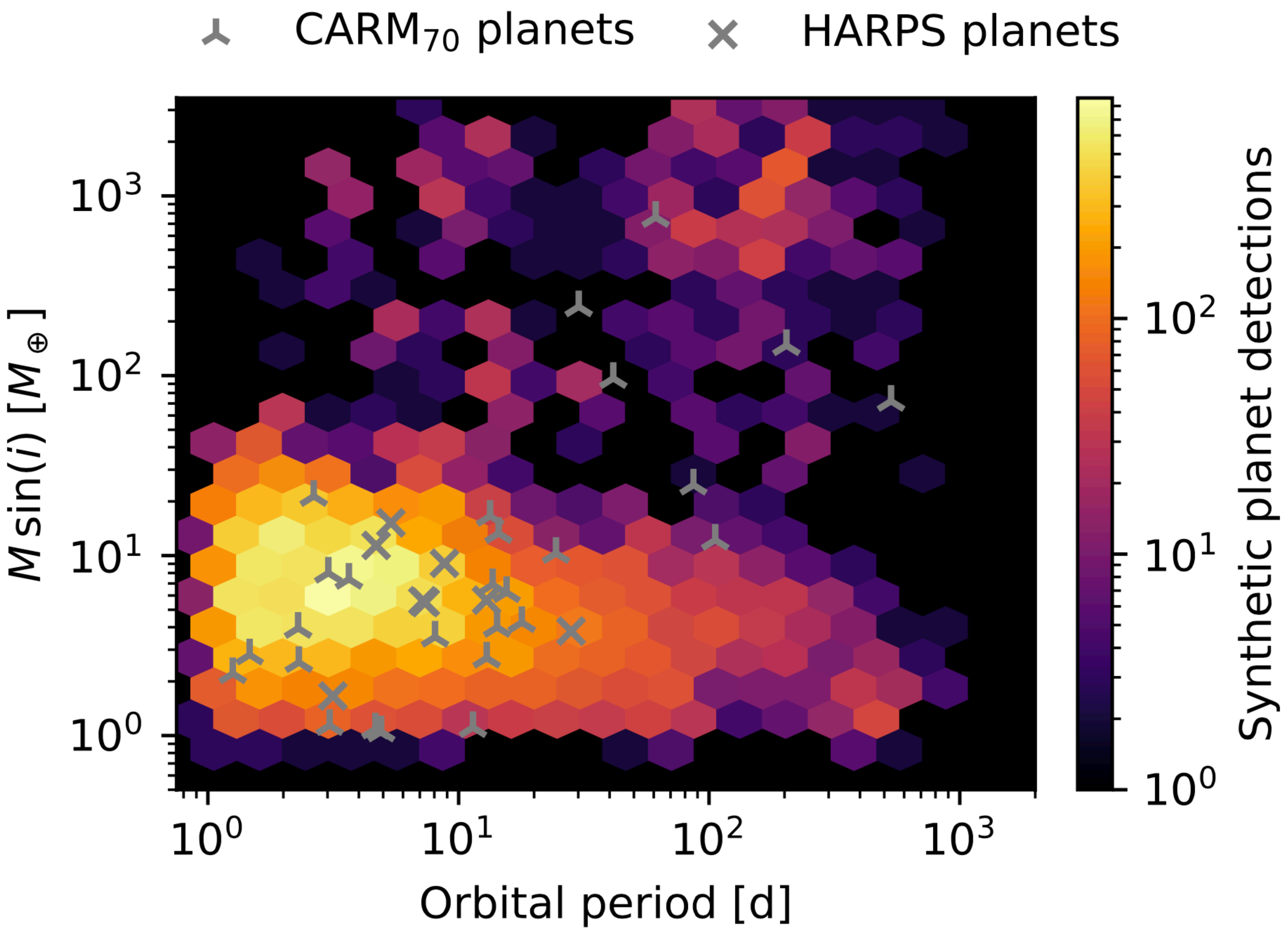
Schlecker et al. (in prep.)

The planet sample: synthetic & observed

combined HARPS&CARM$_{70}$ sample:

35 planets around 148 stars

biased



Schlecker et al. (in prep.)

The planet sample: synthetic & observed

Increasing host star mass

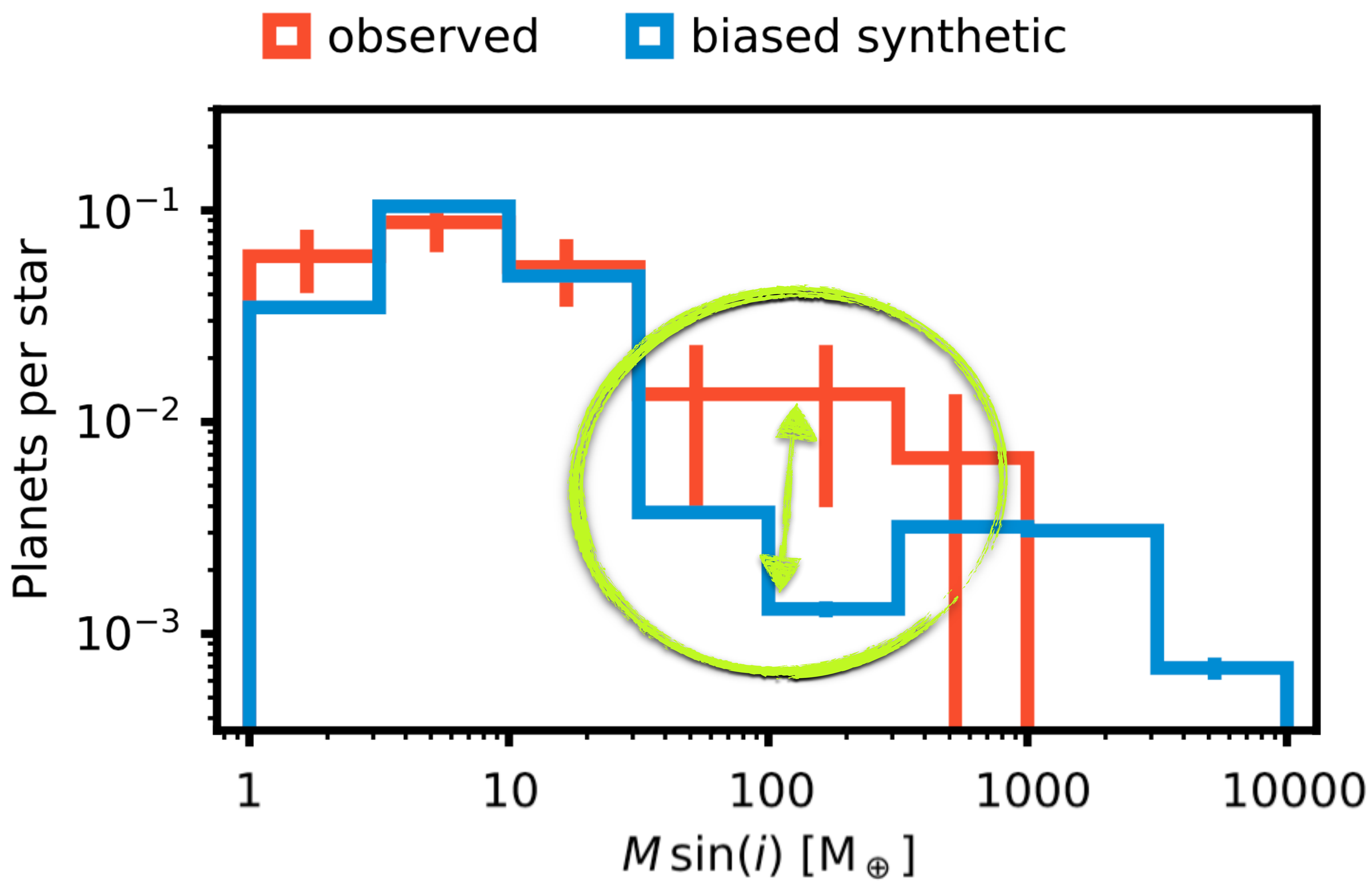
Schlecker et al. (in prep.)

Two issues with the planetary mass function

1. "sub-Saturn desert" only in the simulated population

Core accretion theory robustly predicts this valley.

=> Something wrong with our gas accretion formalism?

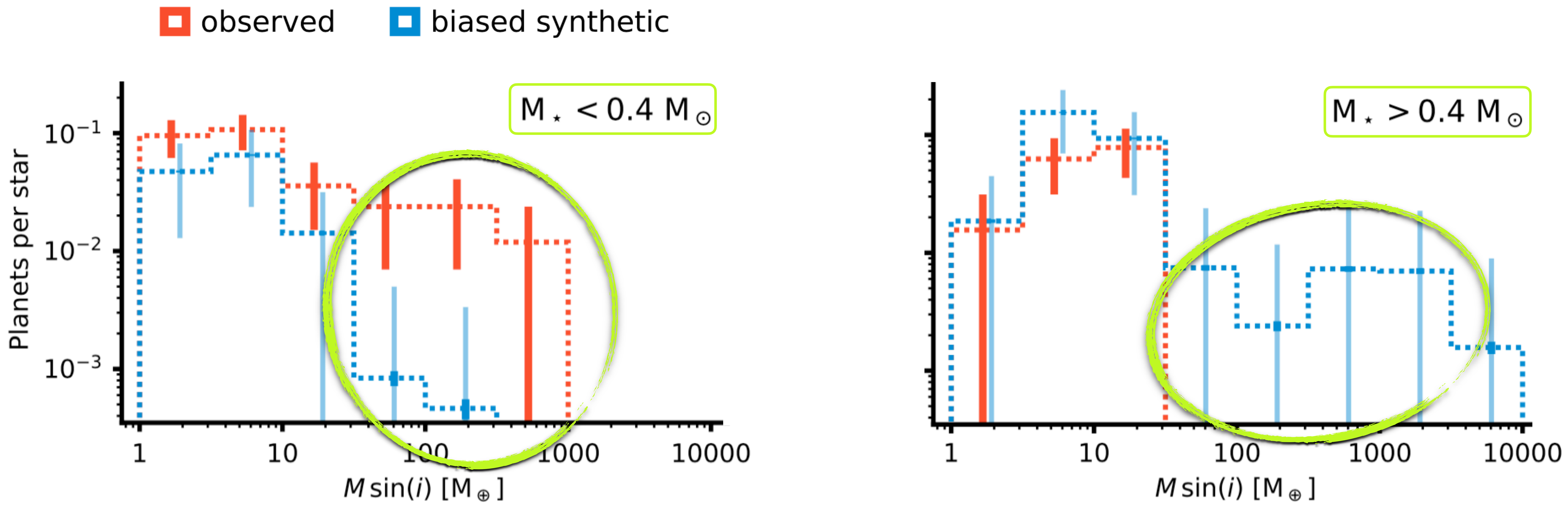


Schlecker et al. (in prep.)

Two issues with the planetary mass function

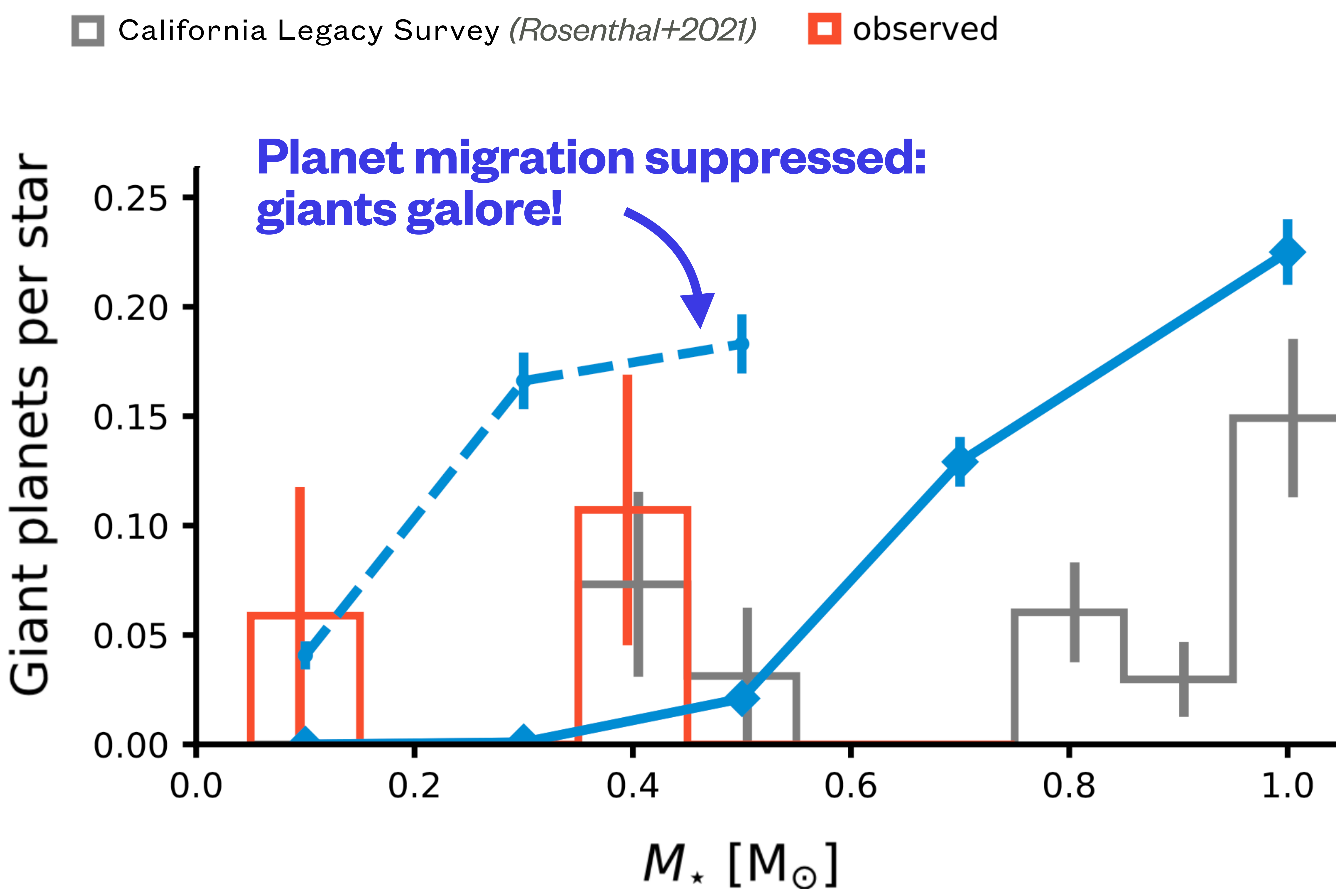
1. "sub-Saturn desert" only in the simulated population

2. core accretion predicts giant planets around early stars, RV sample has them around late stars



Giant planets around late M dwarfs challenge core accretion

Nominal model:
no giant planets at $\lesssim 0.5 M_\odot$

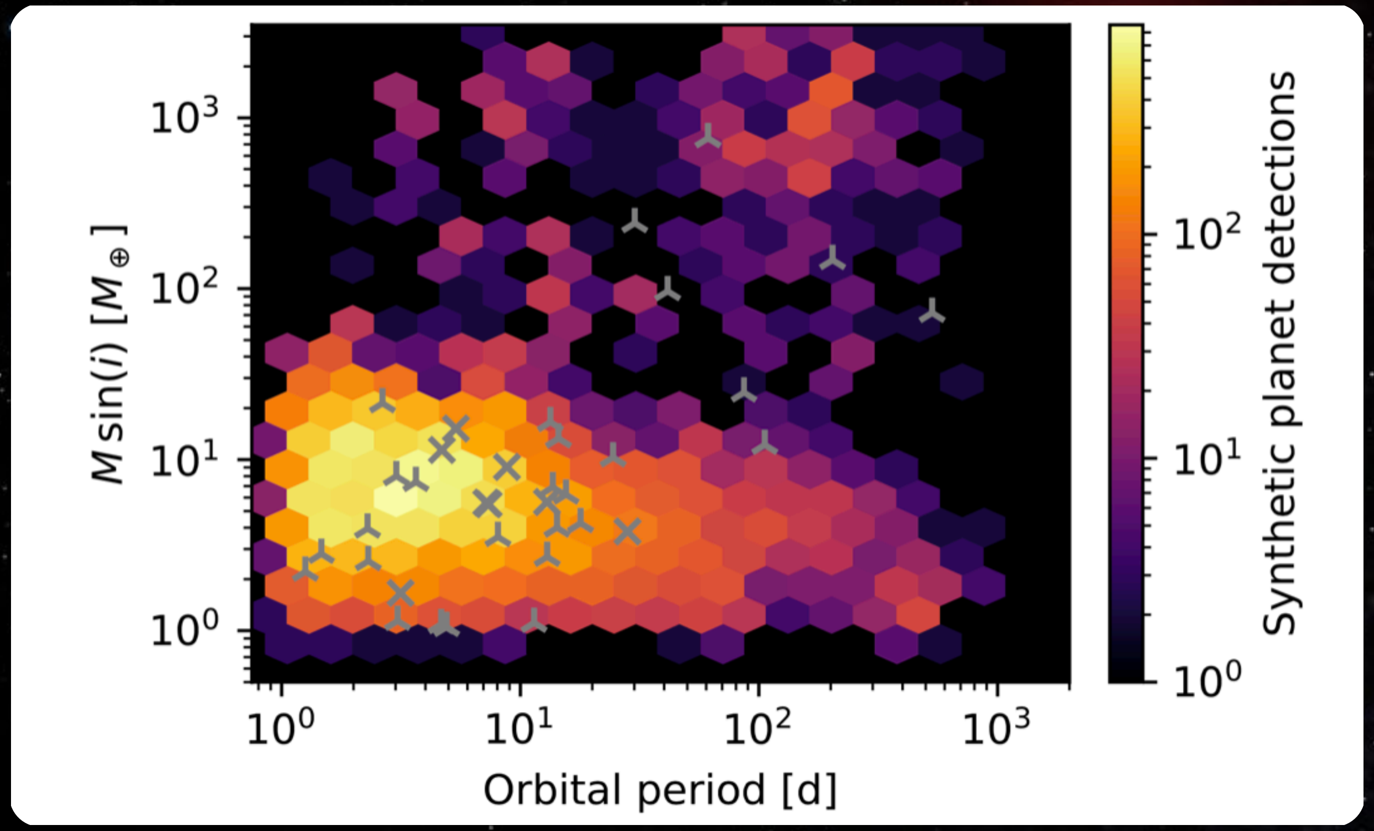


Core accretion with 10x longer migration timescale reconciles giants around the latest stars.

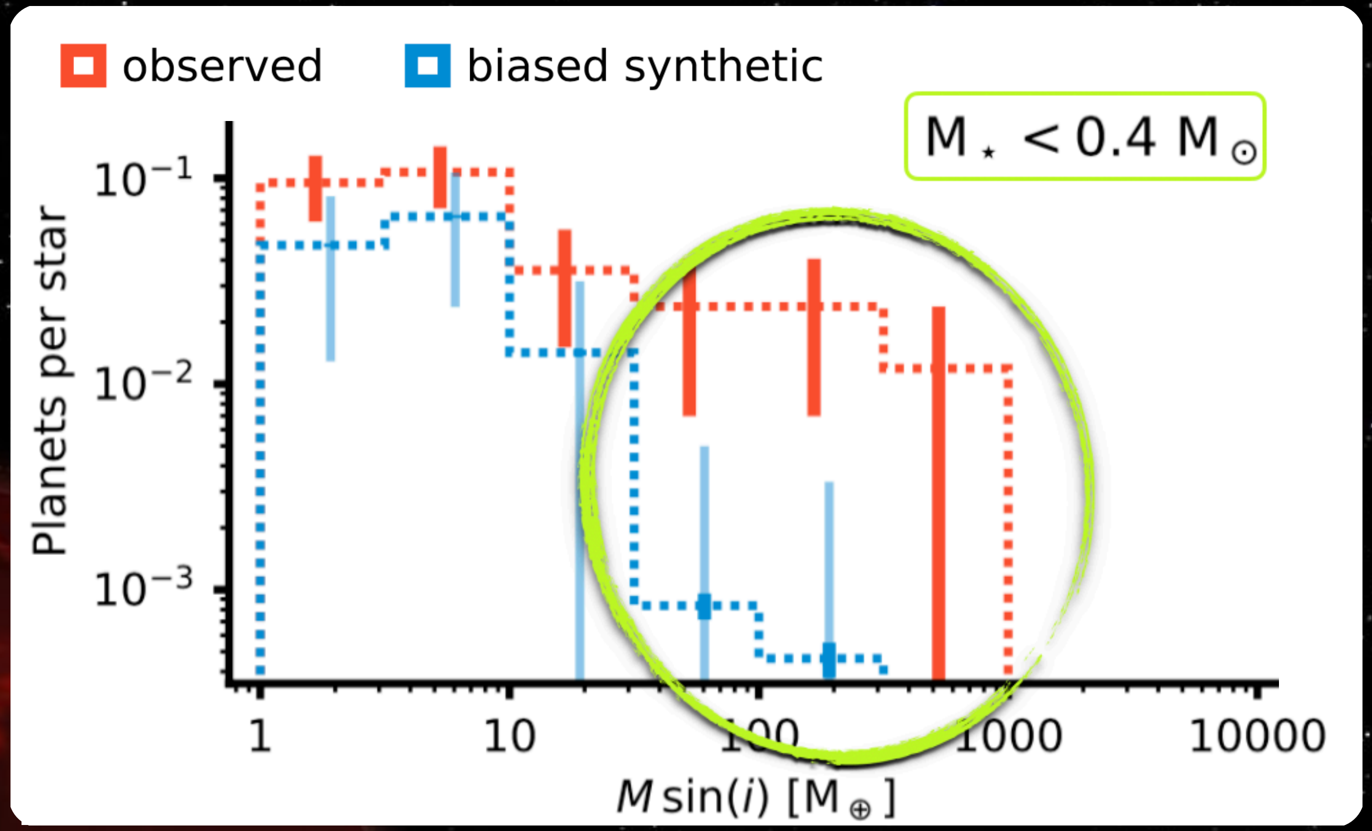
=> hint for migration traps from disk substructure at work

Schlecker et al. (in prep.)

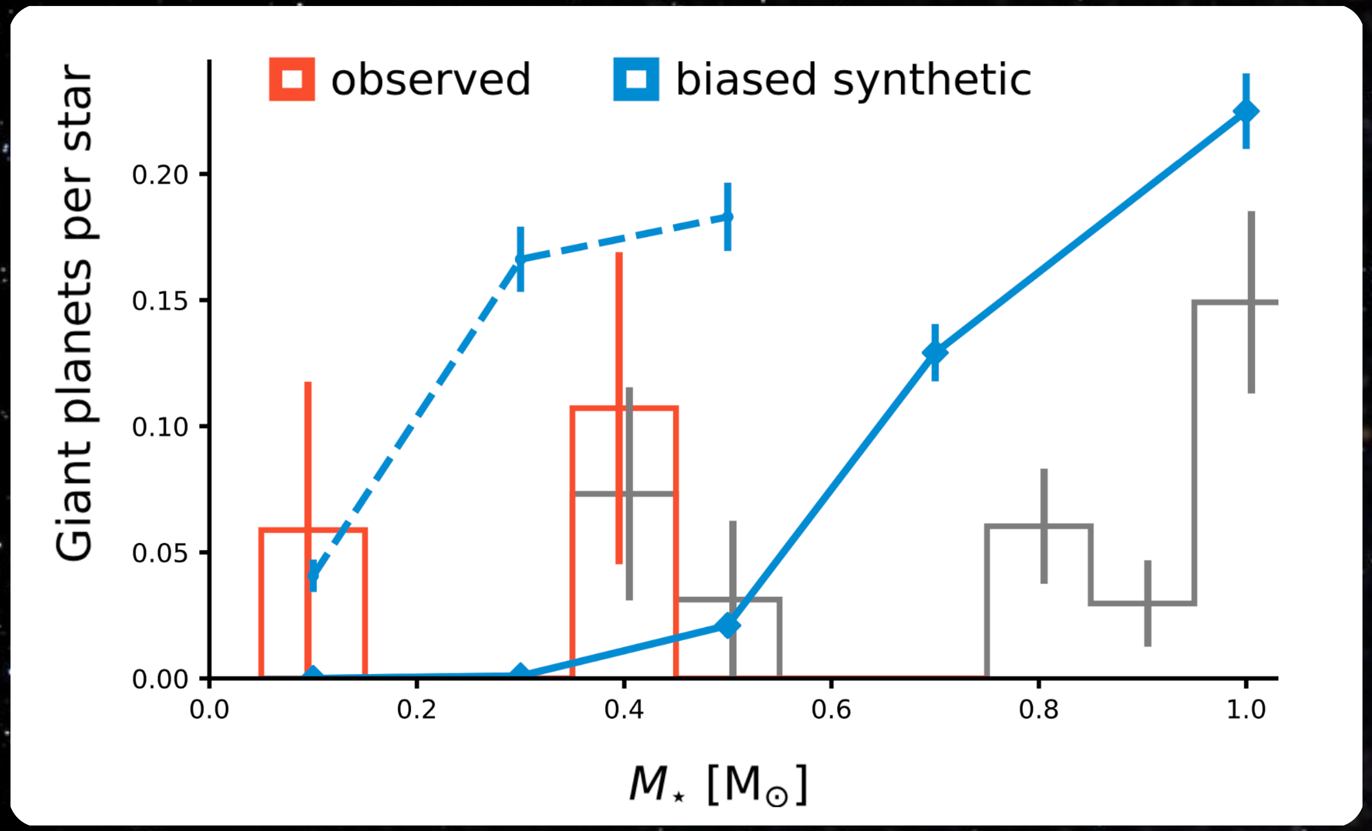
Giant planets around low-mass stars: key takeaways



RV-detected rocky planets match with core accretion.
No clear sub-Saturn valley in the sample.



Giant planets around lowest-mass stars are at odds with core accretion.



Suppressing planet migration eliminates the discrepancy.
→ Migration traps might be at work in M dwarf disks.