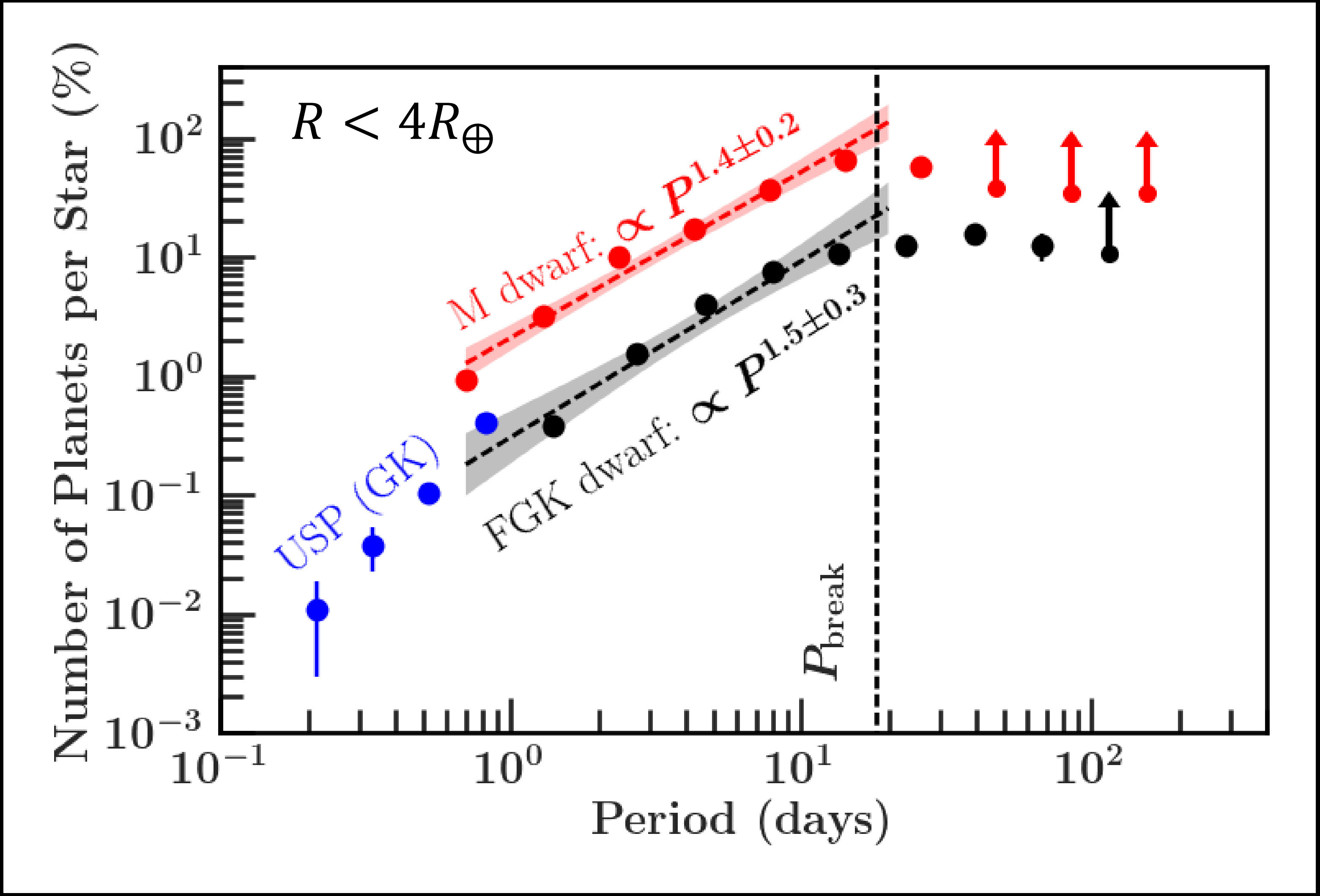
STELLAR SPIN, METALLICITY, AND PLANET FORMATION

Eve J. Lee (TAPIR, Caltech → McGill)

OBSERVED OCCURRENCE RATE PROFILE



Fressin+2013, Sanchis-Ojeda+2014, Dressing & Charbonneau 2015
see also Petigura+2013, Mulders+2015, Burke+2015

MAGNETOSPHERIC TRUNCATION

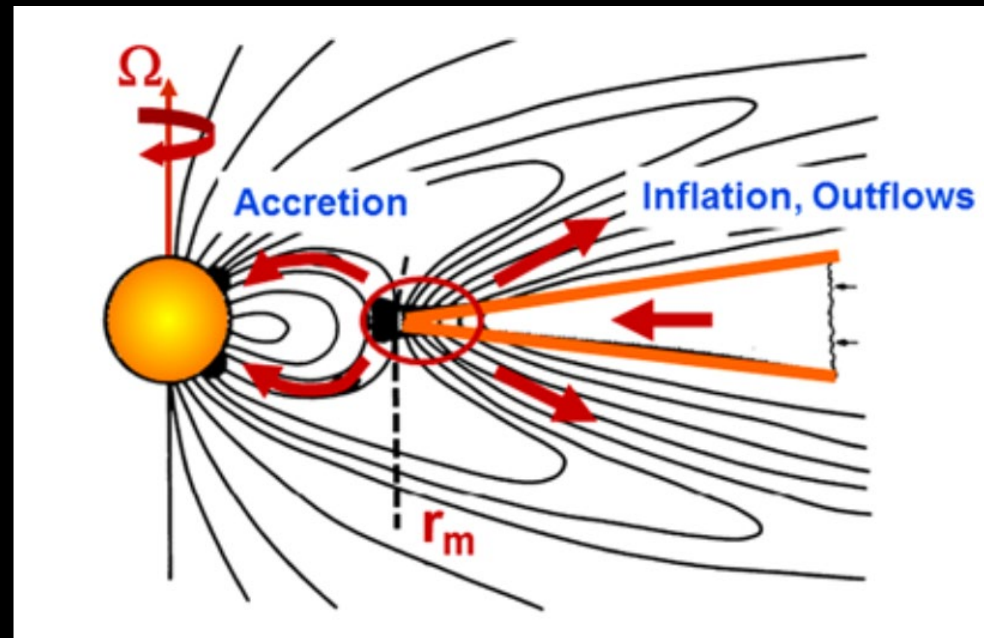
Truncation radius r_m:

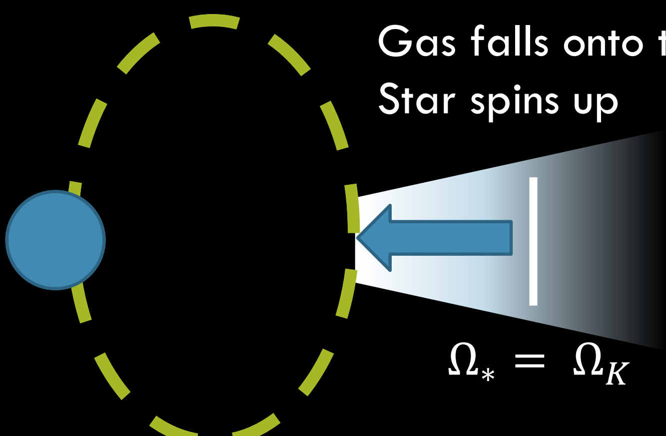
$$\frac{B^2}{8\pi} \sim \frac{\dot{M}\Omega}{r_m}$$

Stellar magnetic pressure

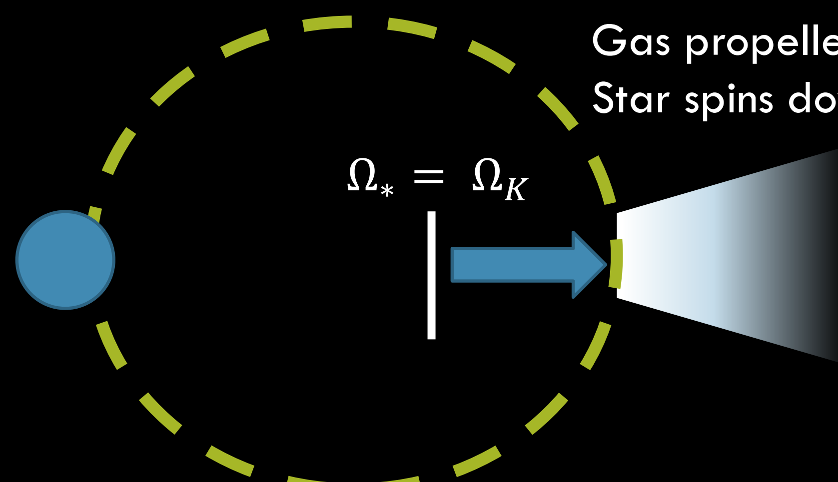
Disk accretion ram pressure

Romanova & Owocki 2016



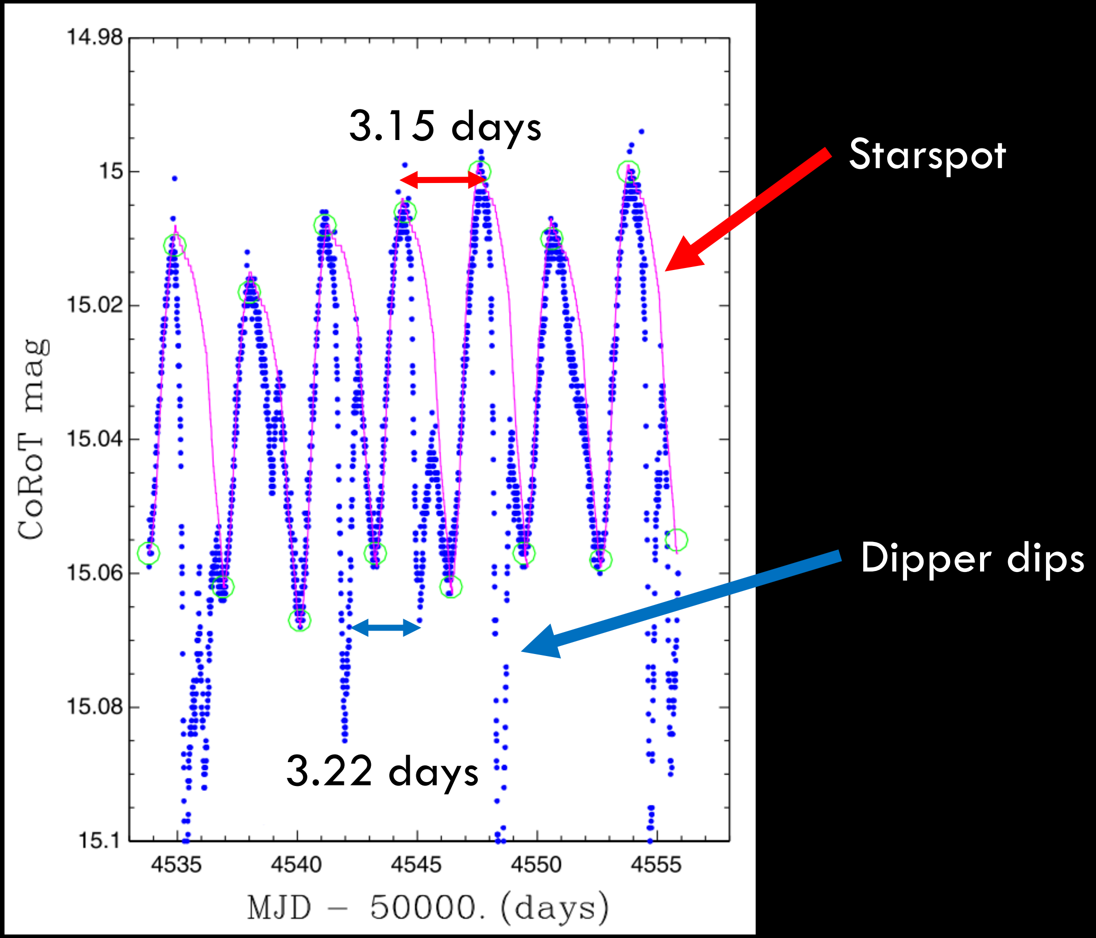


Gas falls onto the star,
Star spins up



Gas propelled away,
Star spins down

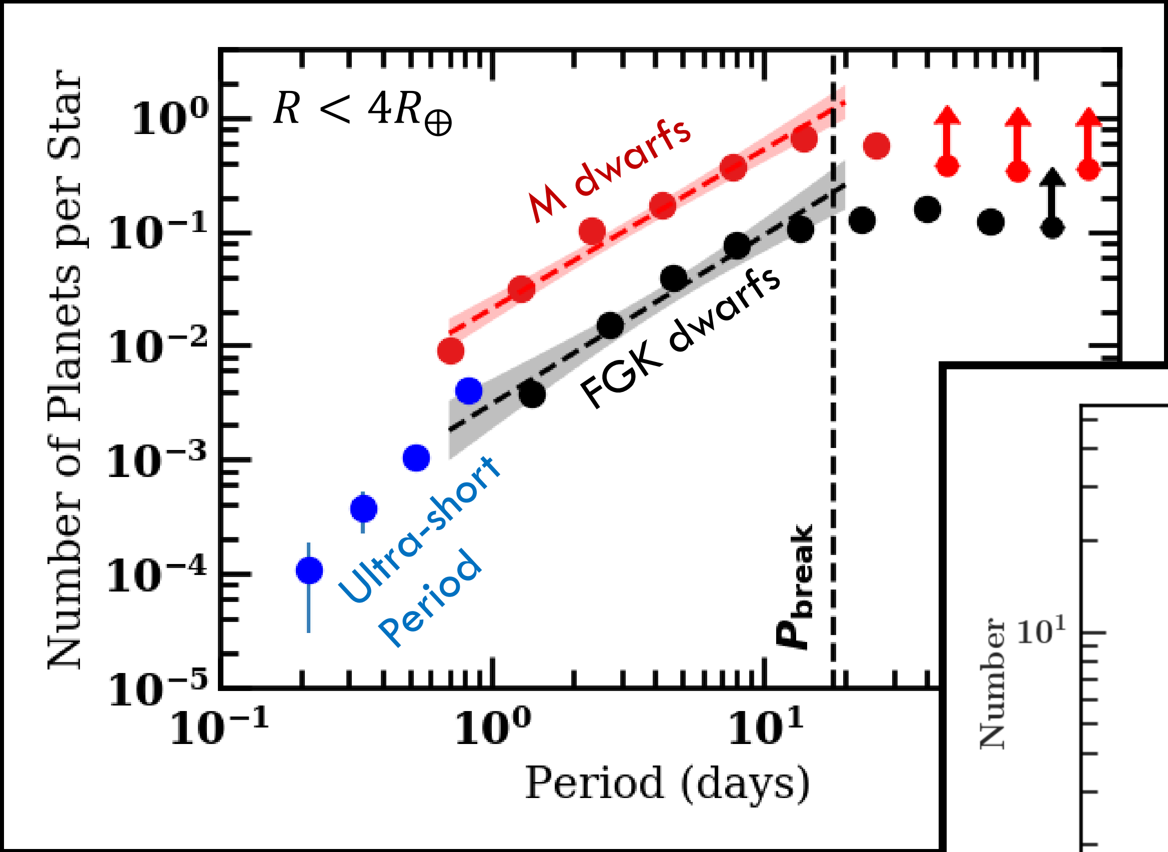
OBSERVATIONAL EVIDENCE OF TRUNCATION NEAR CO-ROTATION: DIPPERS



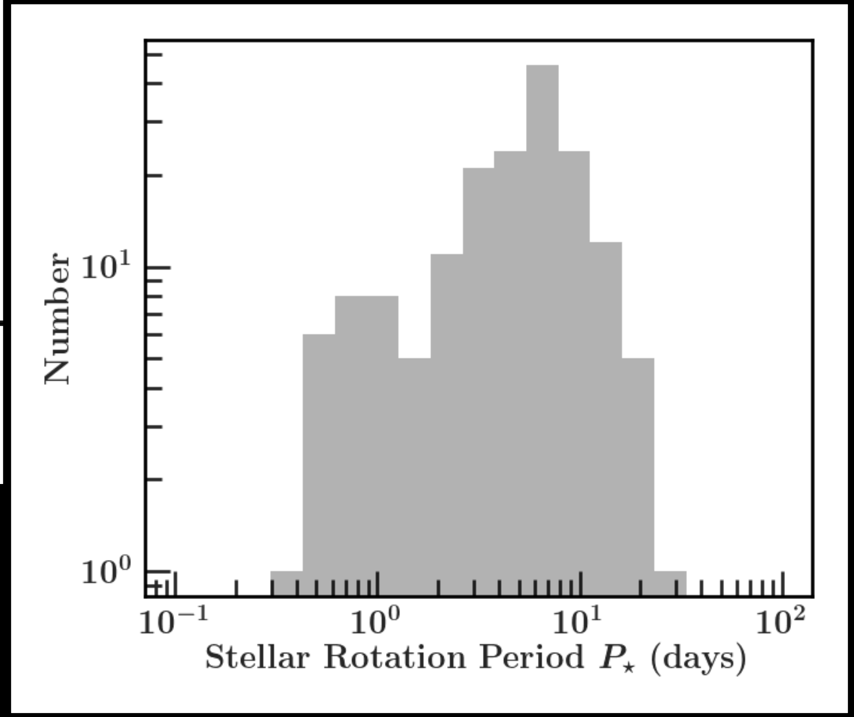
NGC 2264, Stauffer et al. (2015)
MON-21, CoRoT light curve

STELLAR ROTATION PERIOD DISTRIBUTION ALSO FALLS OFF AT SHORTER PERIODS

EJL & Chiang 2017
See also Mulders+ 2015



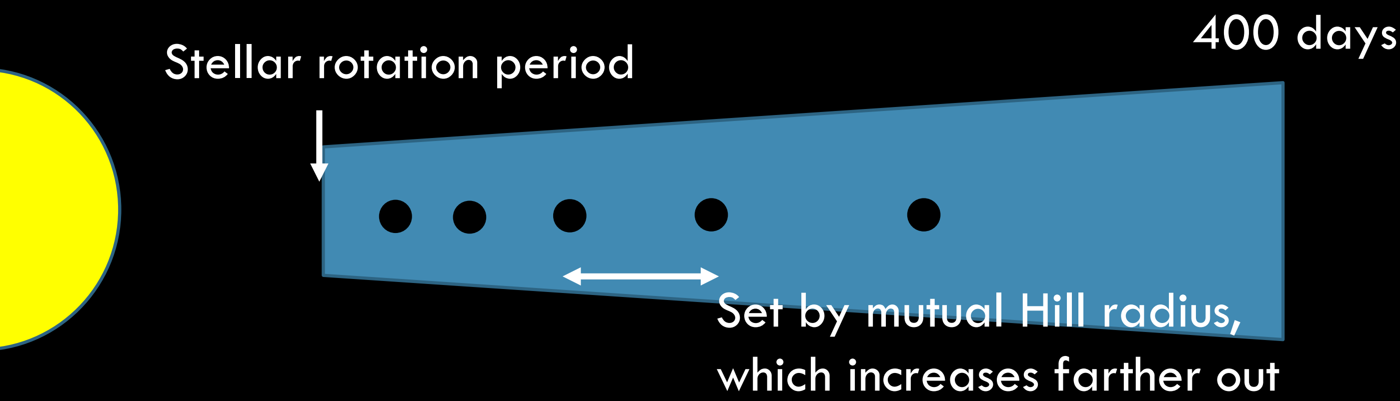
Data from Fressin+2013, Sanchis-Ojeda+2014, Dressing & Charbonneau 2015



NGC 2362 (Irwin+2008)

TWO CLASSES OF MODEL

1. In situ



Randomly distributed in log period

EJL & Chiang 2017

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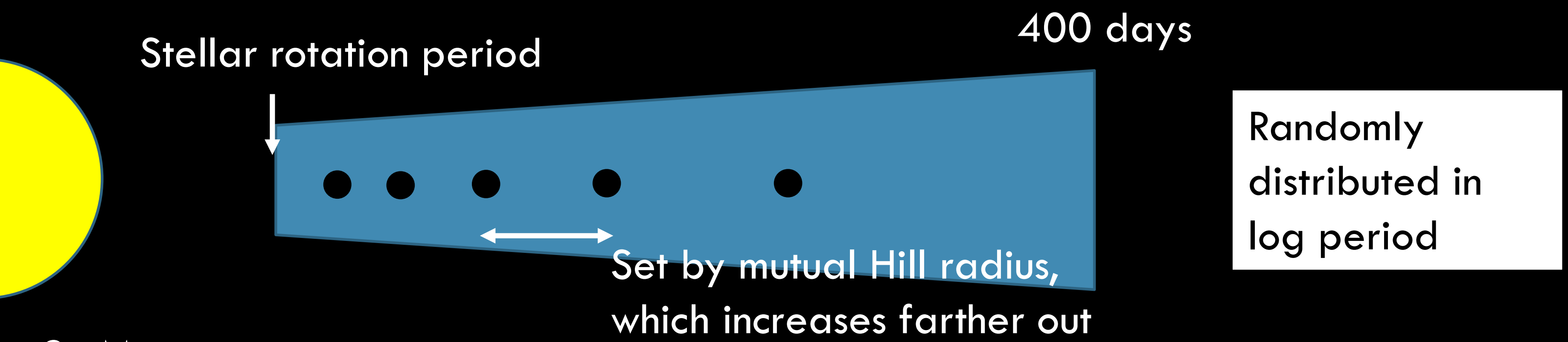
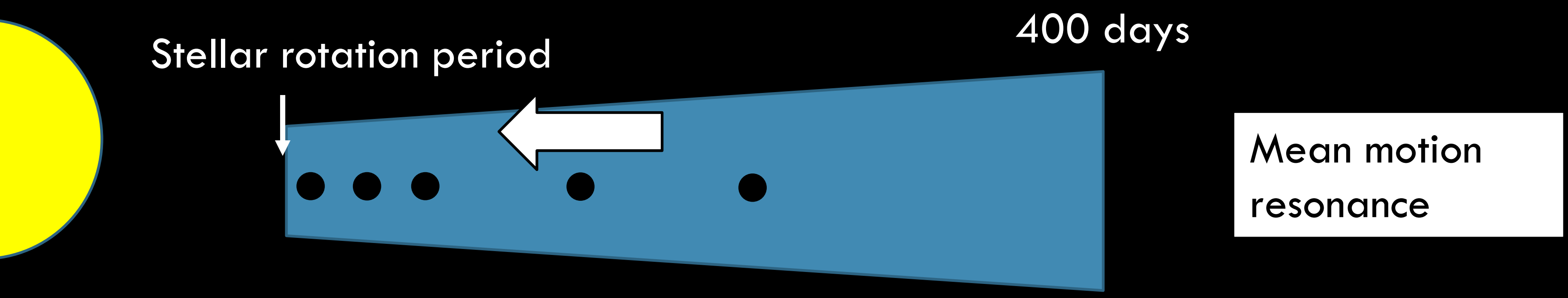


2. Migration



EJL & Chiang 2017

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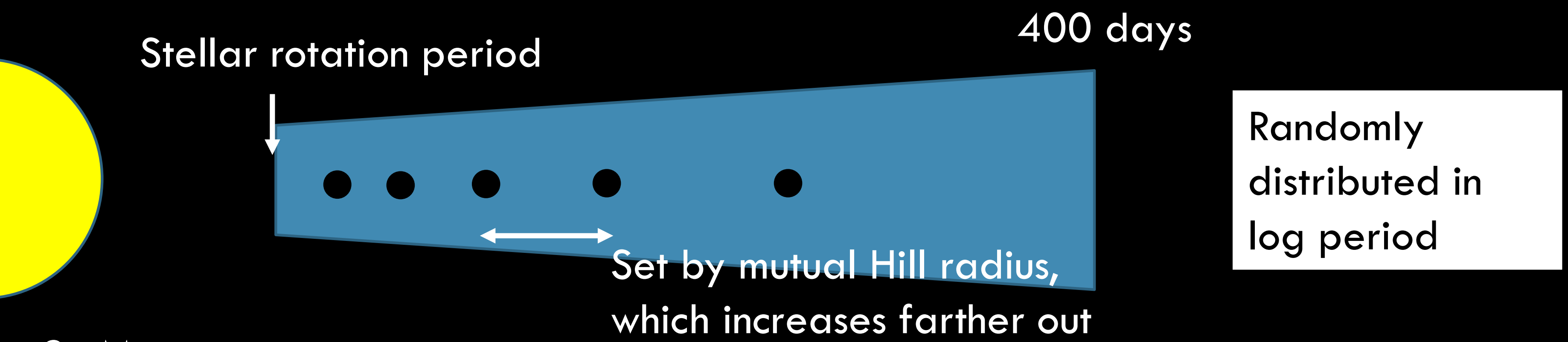

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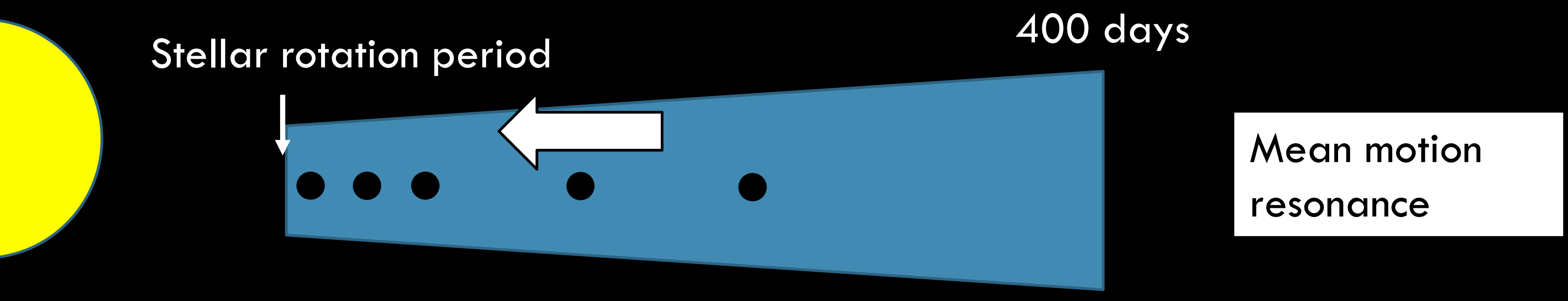
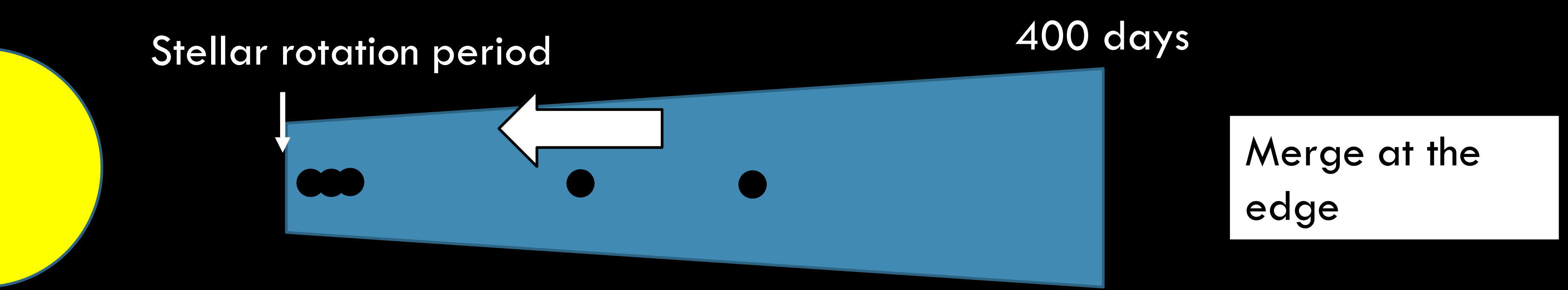
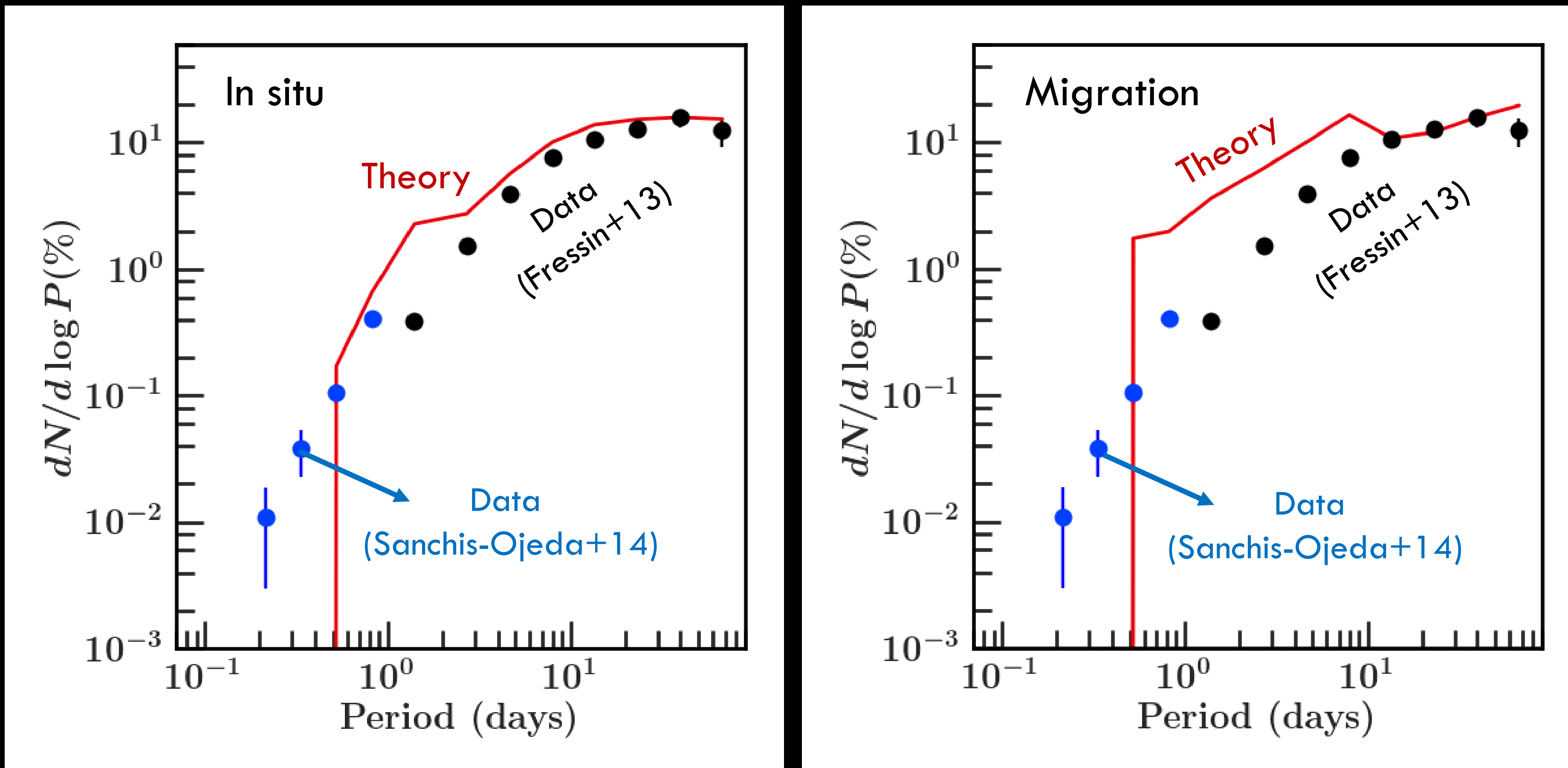


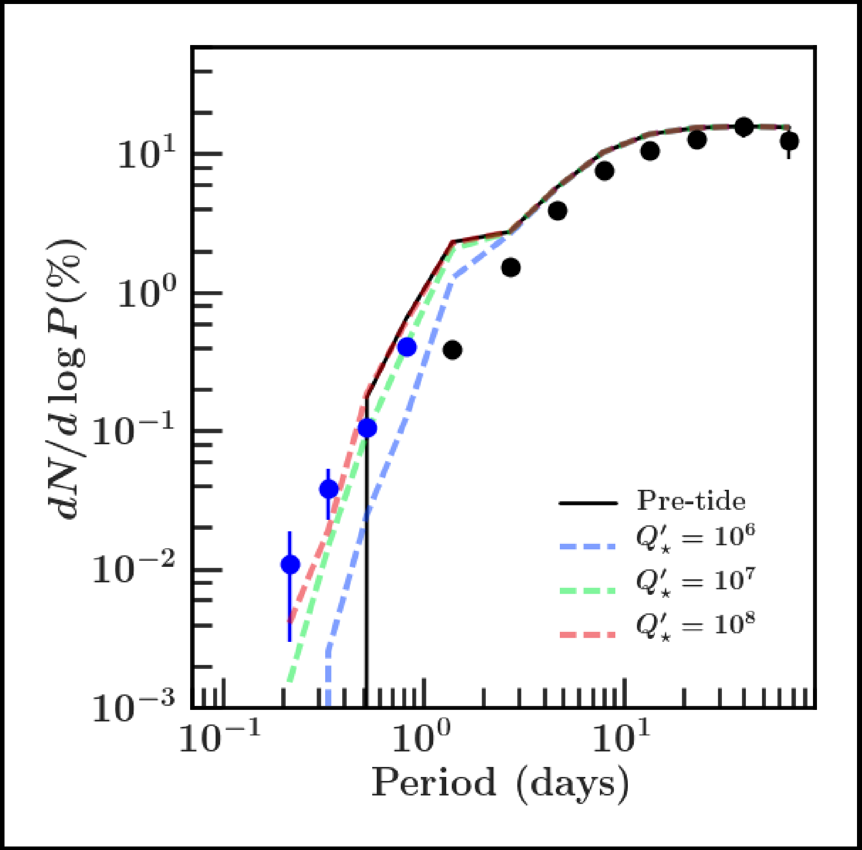


EJL & Chiang 2017

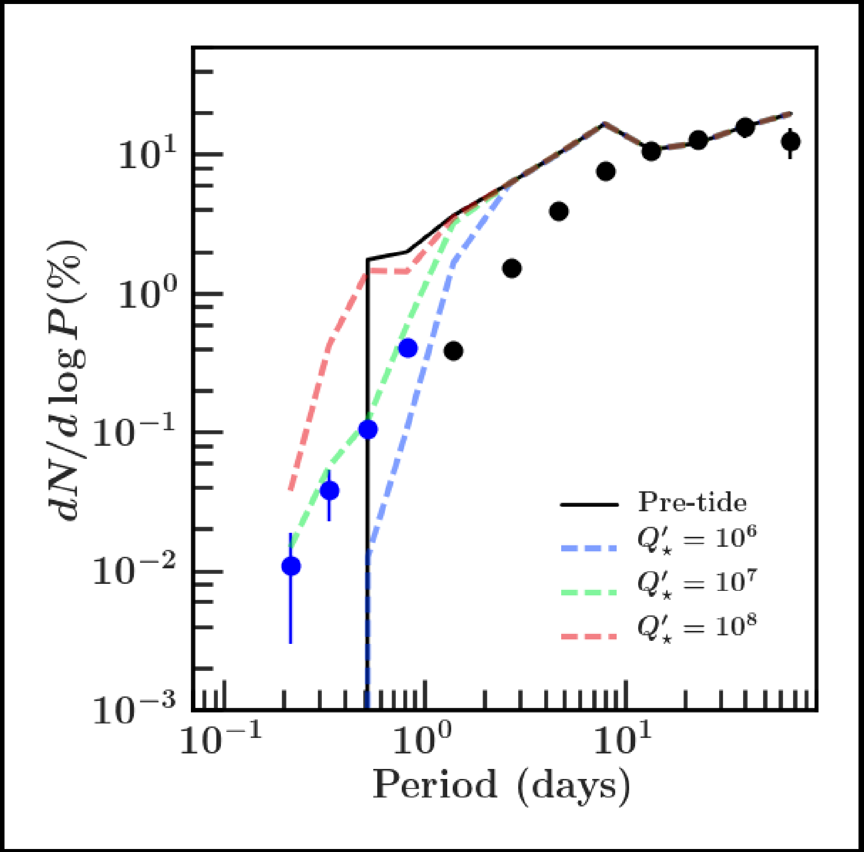


(merged at the edge;
resonance lock case looks similar)

In situ + tides



Migration + tides



See also Pu & Lai (2019) and Petrovich et al. (2018) for USPs formed by tides raised on the planet on eccentric orbits

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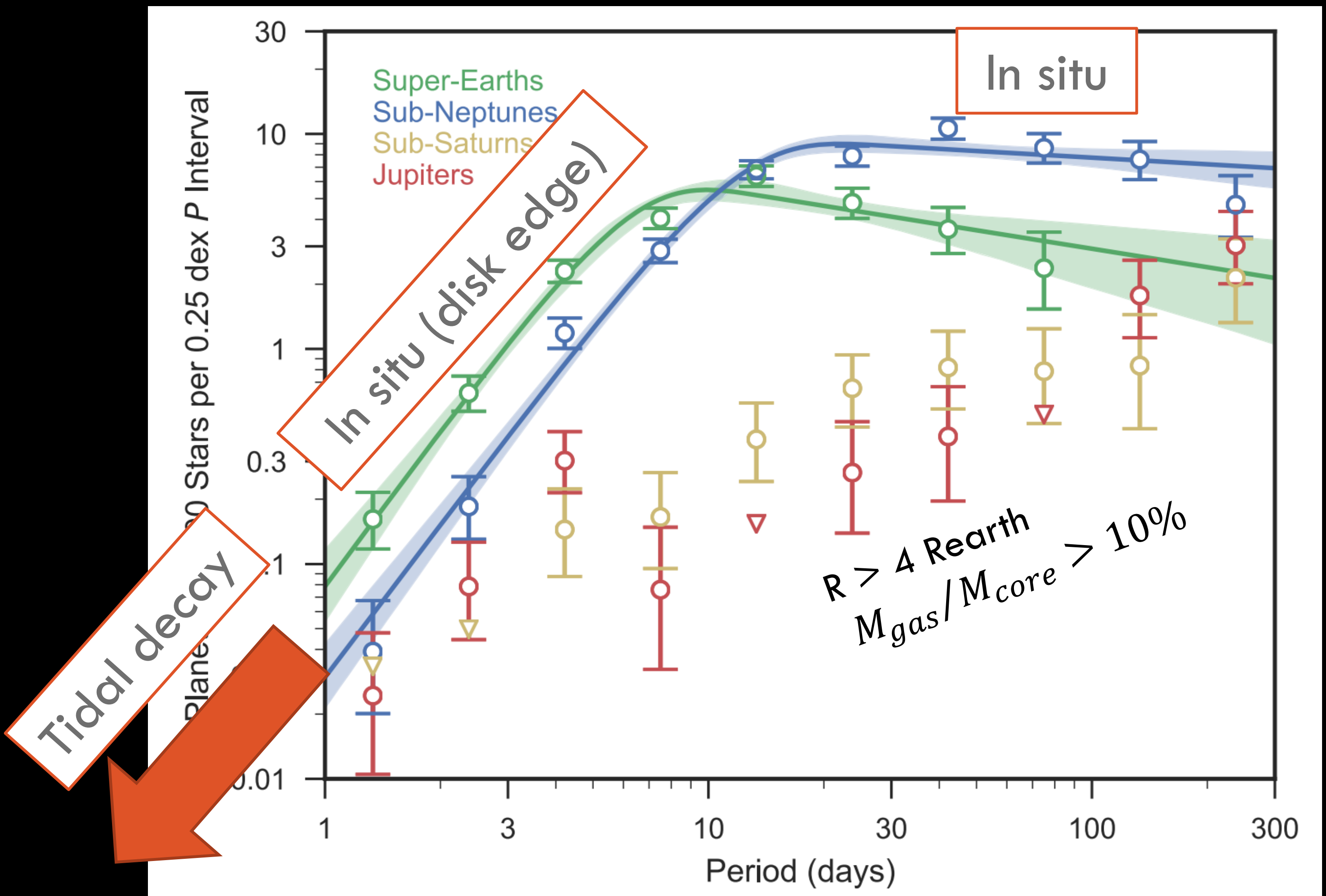
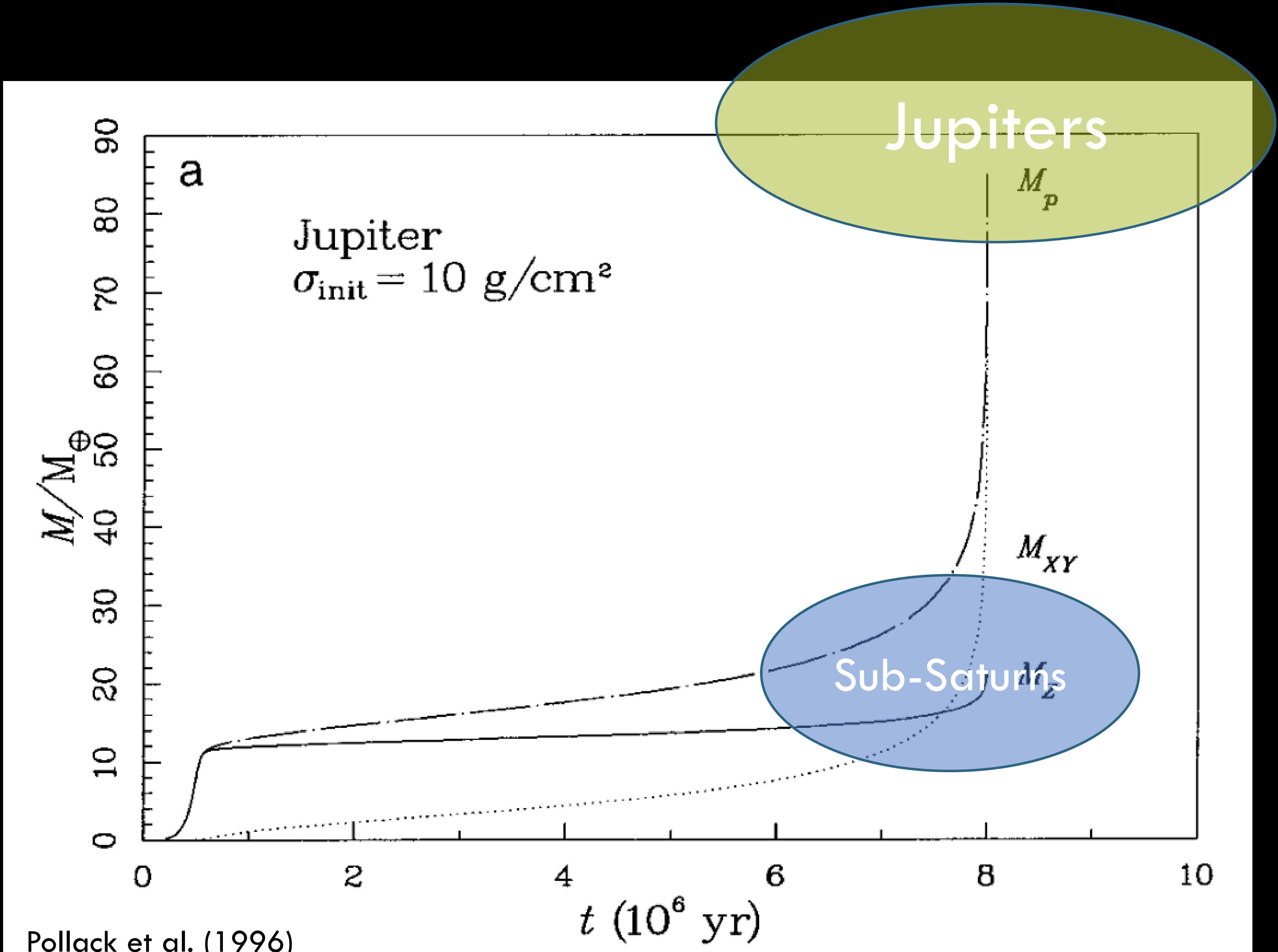
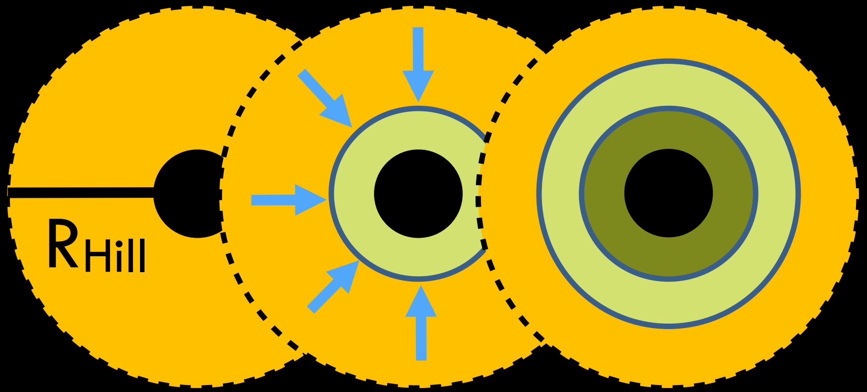


Petigura et al. (2018); see also Dong & Zhu (2013)



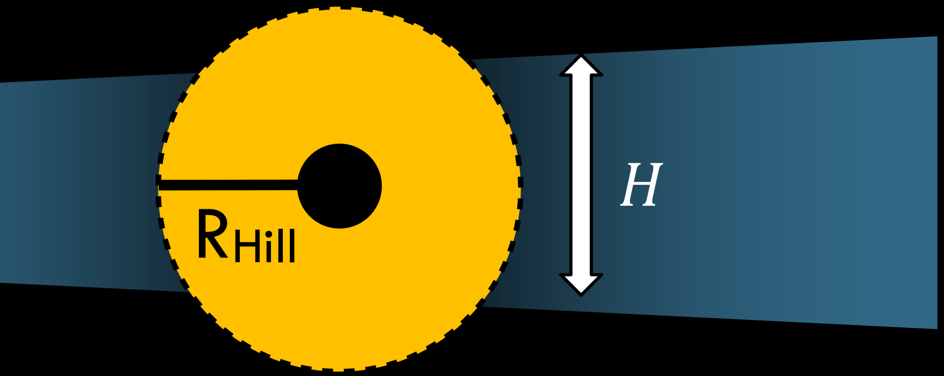
Pollack et al. (1996)



Thermodynamic

$$\frac{M_{gas}}{M_{core}} \sim 0.06 \left(\frac{t}{1\ Myr}\right)^{0.4} \left(\frac{M_{core}}{5M_\oplus}\right)^{1.7}$$

EJL & Chiang (2015)
See also Ginzburg et al. (2016)

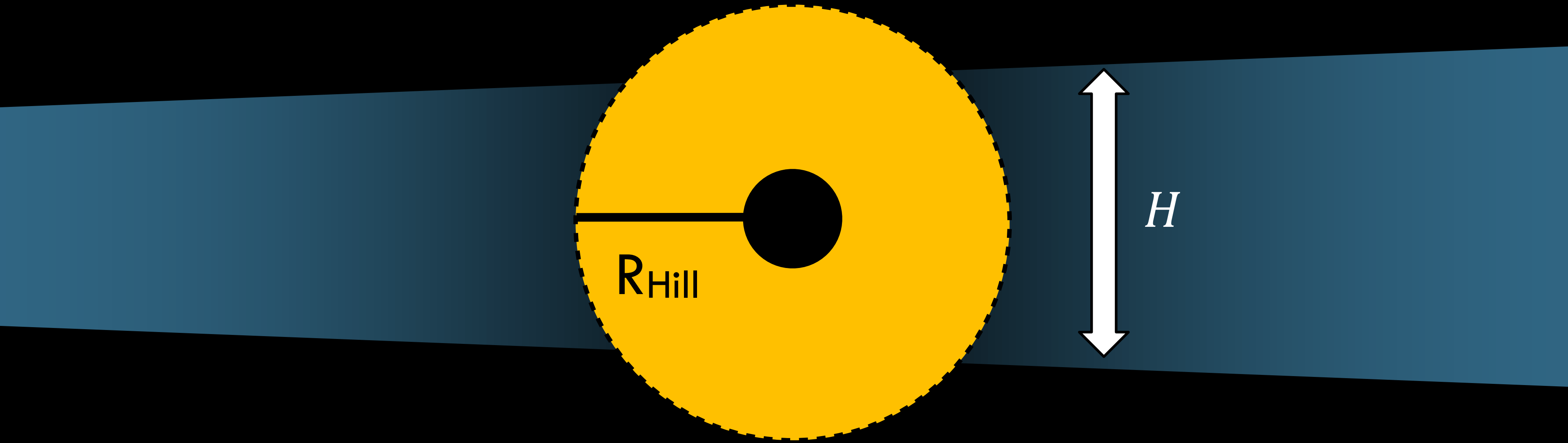


Hydrodynamic

$$\dot{M} \propto \left(\frac{M_p}{M_*}\right)^{4/3} \Sigma_{disk} \left(\frac{a}{H}\right)^2 a^2 \Omega$$

Tanigawa & Tanaka (2016)
EJL (ApJ in press; arXiv:1904.10470)

GAS ACCRETION BY LOCAL HYDRODYNAMIC FLOWS

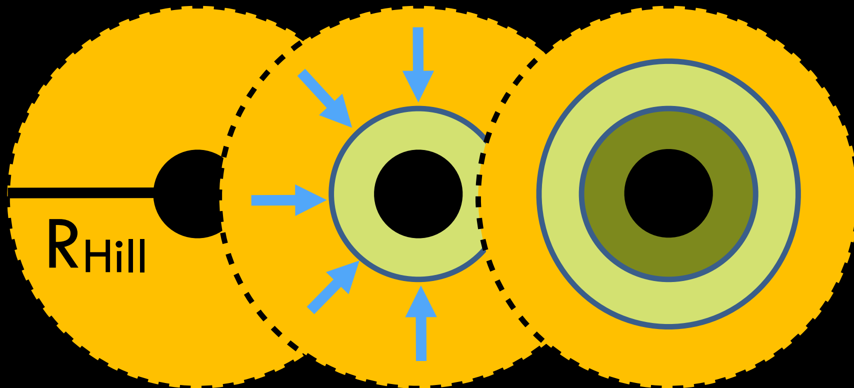


$$\dot{M} \propto 2\pi R_{Hill} H \rho_{in} v_{in}$$

$$v_{in} \sim R_{Hill}\Omega$$

$$\rho_{in} \sim \rho_{disk}\left(\frac{R_{Hill}\Omega}{c_s}\right)^2$$

$$\dot{M} \propto \left(\frac{M_p}{M_*}\right)^{4/3} \Sigma_{disk}\left(\frac{a}{H}\right)^2 a^2\Omega$$



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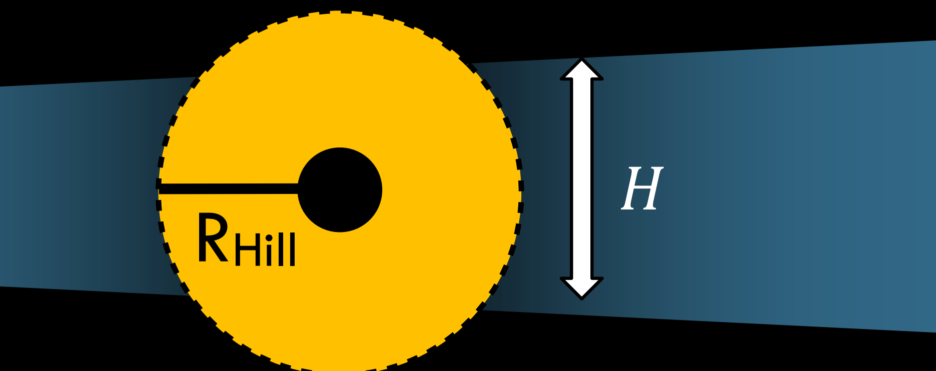

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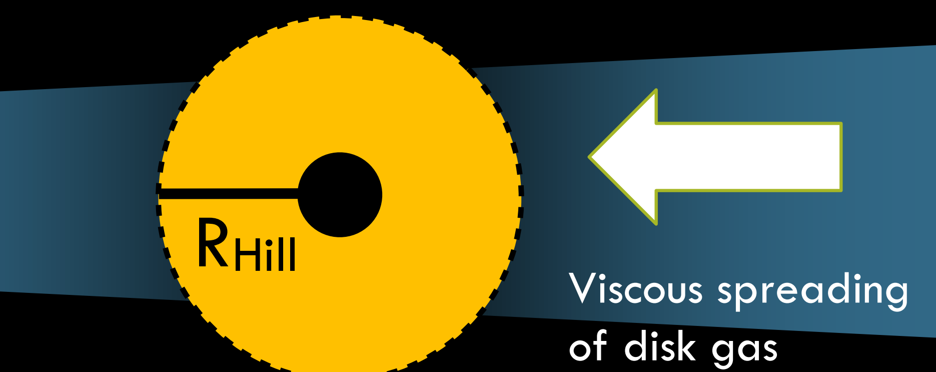


Global gas supply

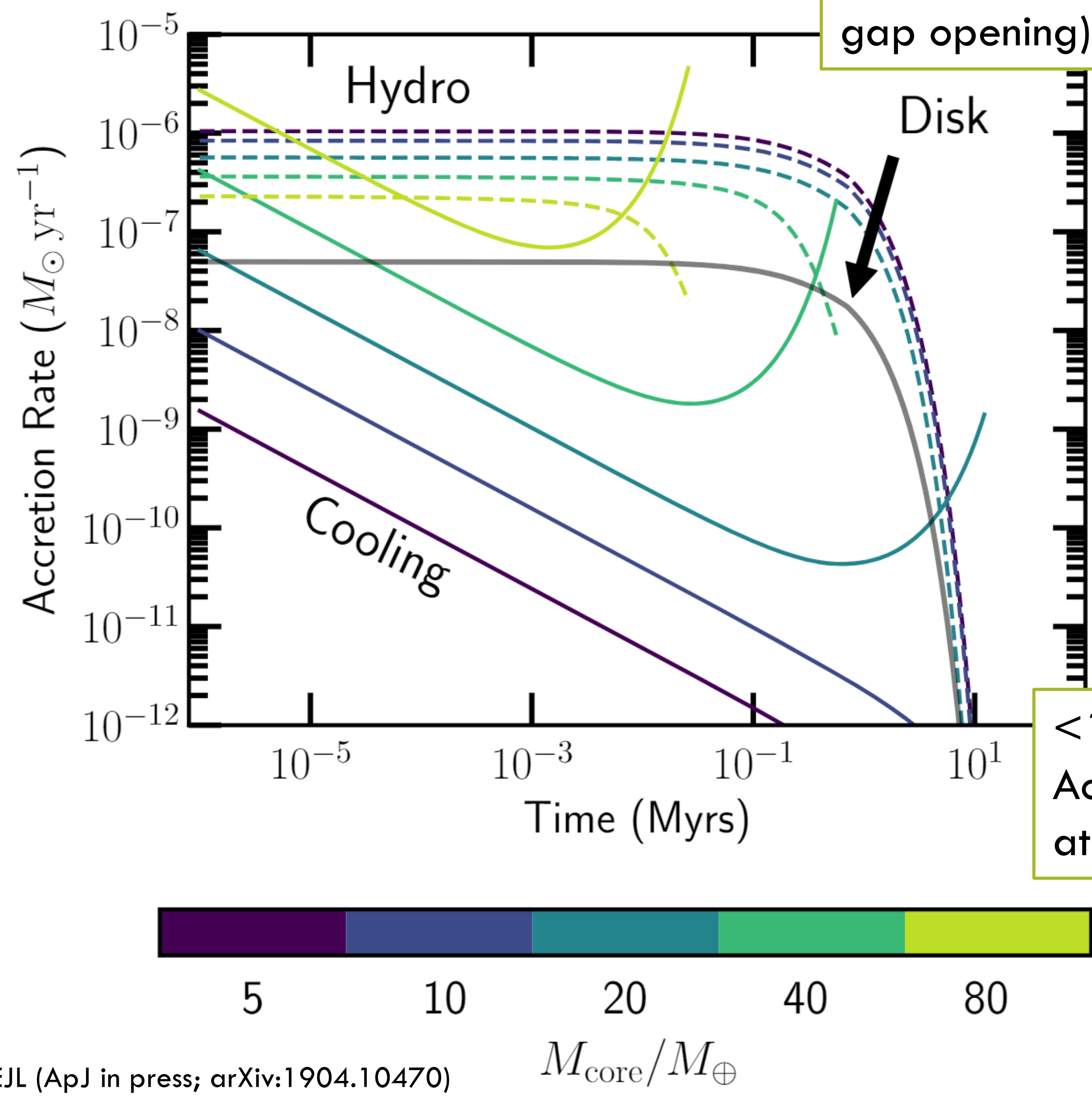
$$\dot{M} = 3\pi\alpha c_s H \Sigma_{disk,bg}$$

>80 Mearth:
Gas mass set by disk accretion

40-80 Mearth:
Runaway halted by hydrodynamic flows (with gap opening)

10-40 Mearth:
Runaway halted by disk accretion during rapid dispersal

<10 Mearth:
Accretion by cooling at all times



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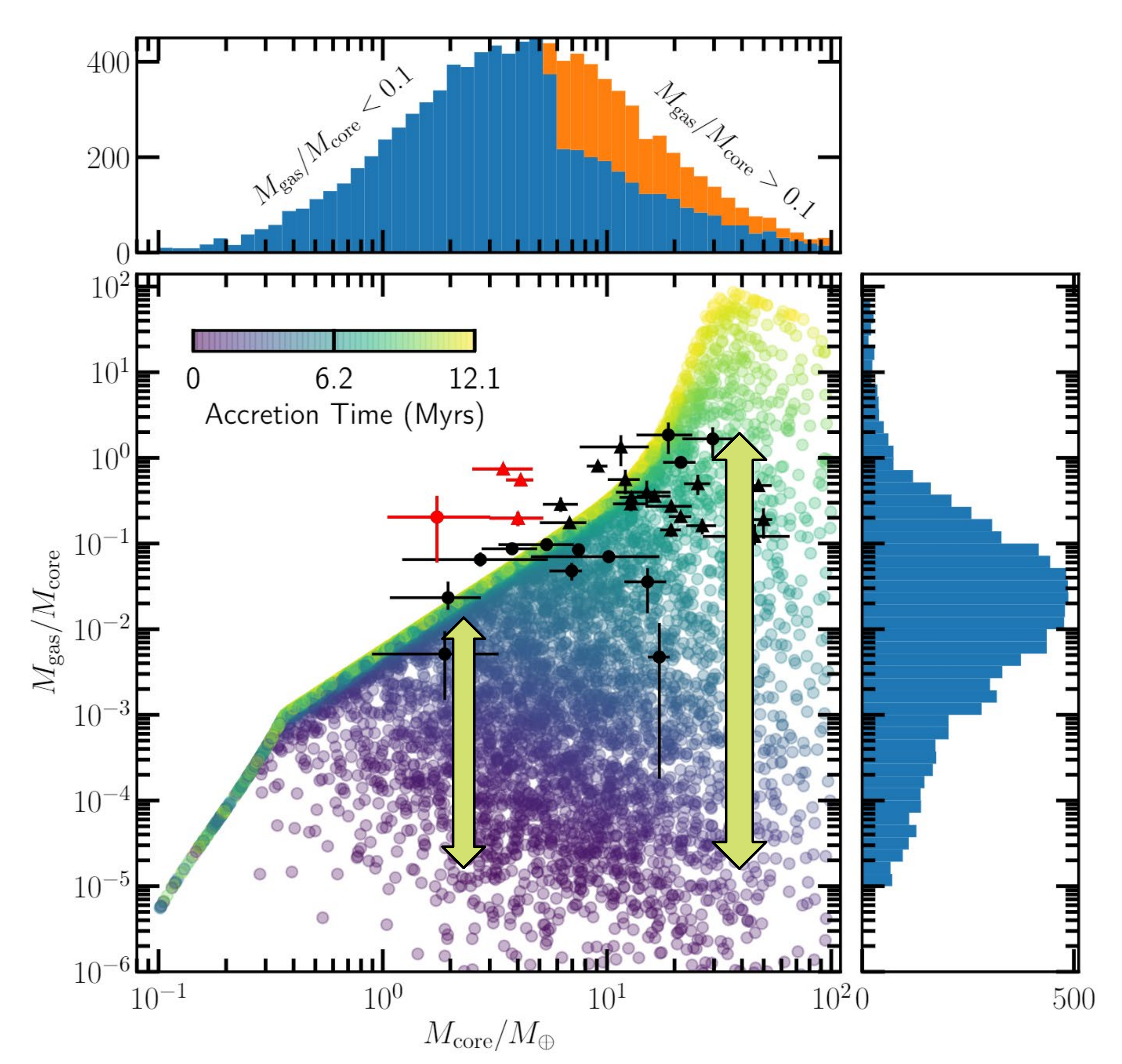

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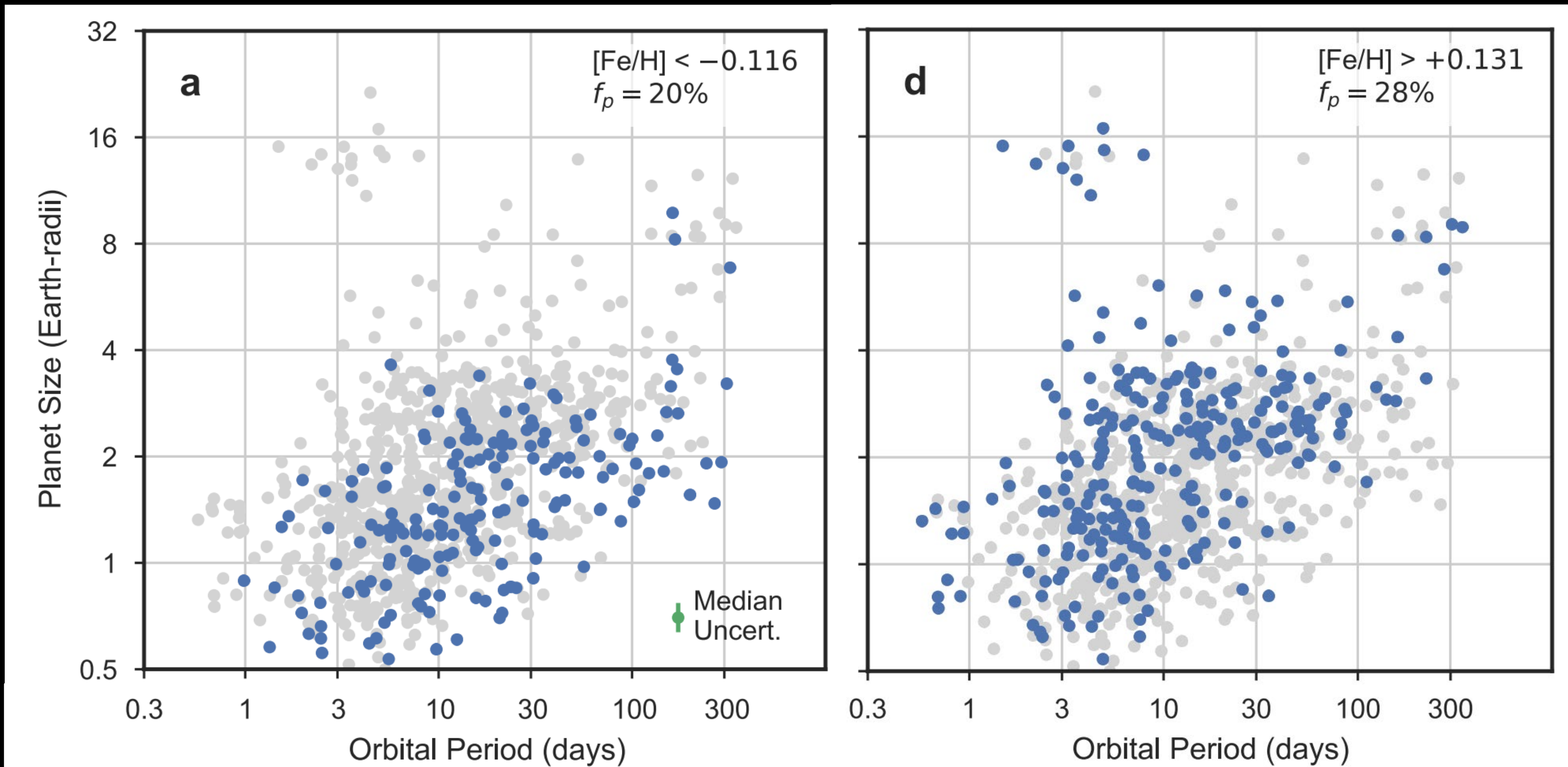
MORE DIVERSITY FOUND AROUND METAL-RICH STARS



Petigura et al. (2018); see also Wang & Fischer (2015), Mulders et al. (2016), Wilson et al. (2017), Dong et al. (2018)

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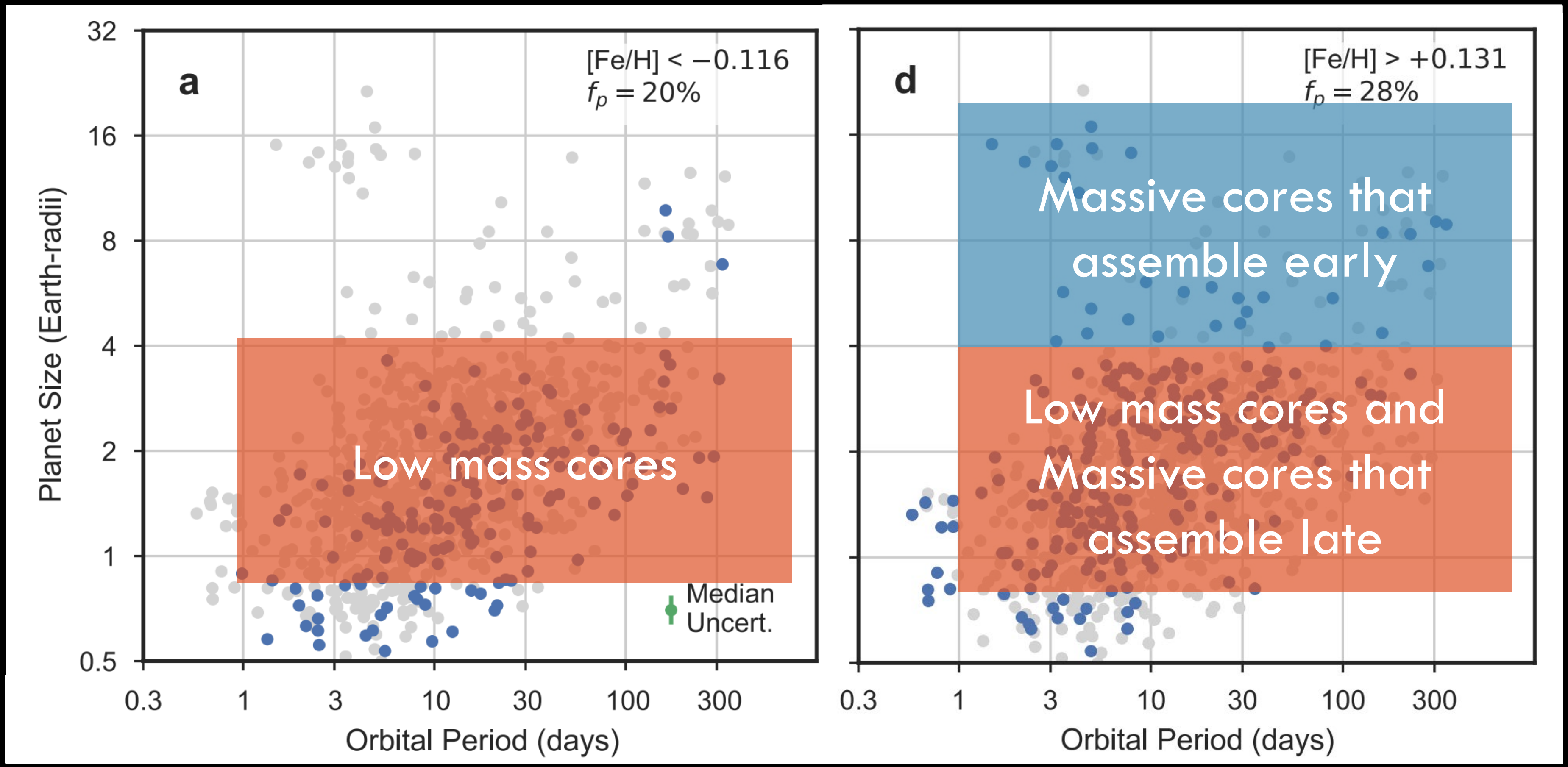

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Core mass expected to correlate with host star metallicity

Wider distribution of core mass expected for smaller planets