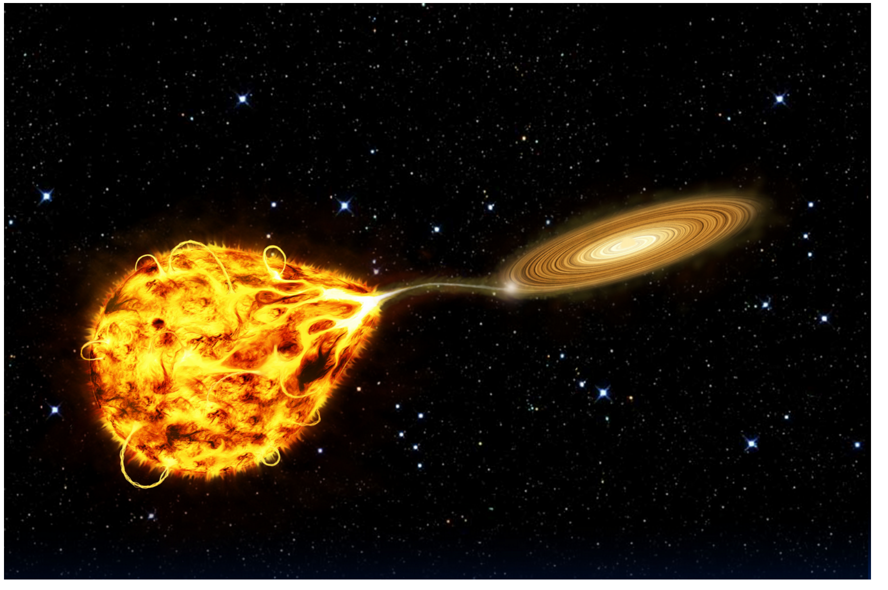
Using wide sdB+MS binaries to constrain RLOF models



Observing techniques, instrumentation and science for metre-class telescopes II
Tatranská Lomnica - 2018

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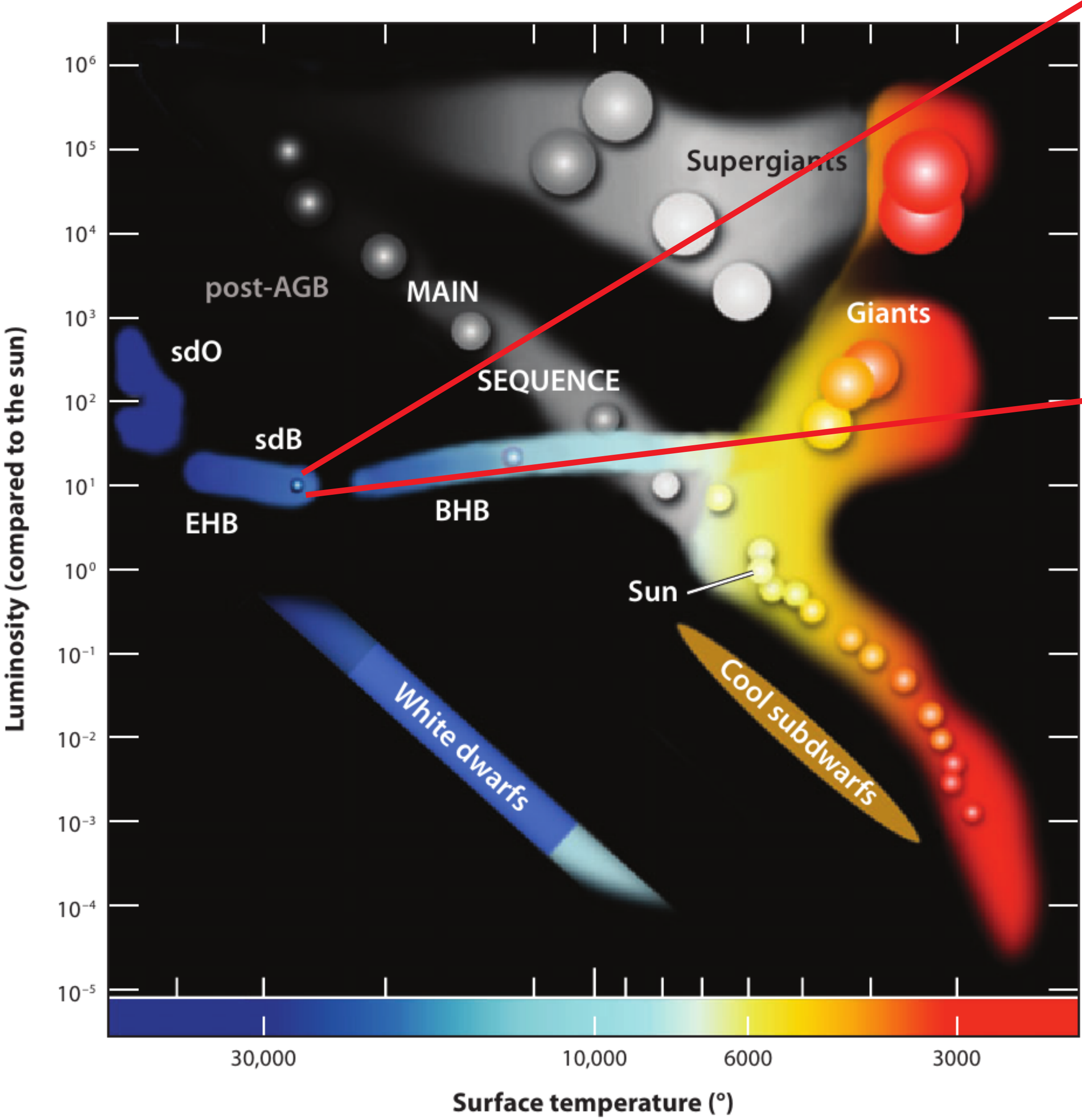
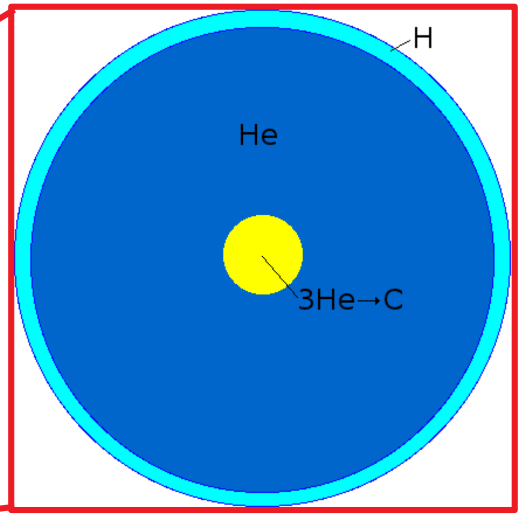
CONICYT Ministerio de Educación Gobierno de Chile
FONDECYT Fondo Nacional de Desarrollo Científico y Tecnológico
Universität Potsdam

Hot subdwarf-B stars

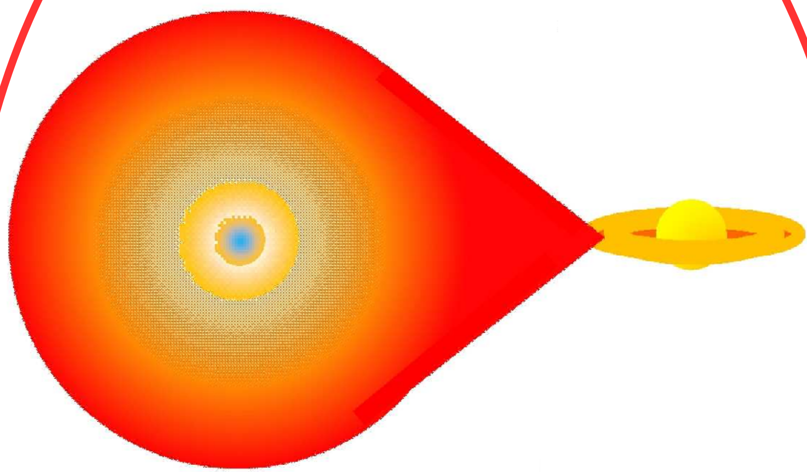




- Look like B-type stars with high surface gravity
- Evolved low mass stars, 1 – 3 Msol
- Located at extreme blue end of the horizontal branch
- Core He burning
- Lost the majority of their H envelope on the RGB

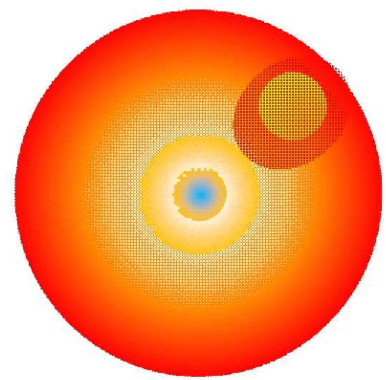
Hot subdwarf formation

stable-RLOF



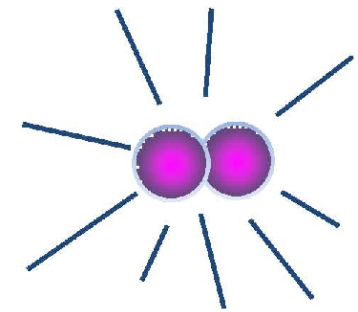
- long periods (> 2 year)
- sdB + MS

CE-ejection



- short periods (< 30 d)
- sdB + MS
- sdB + WD/BD

WD merger

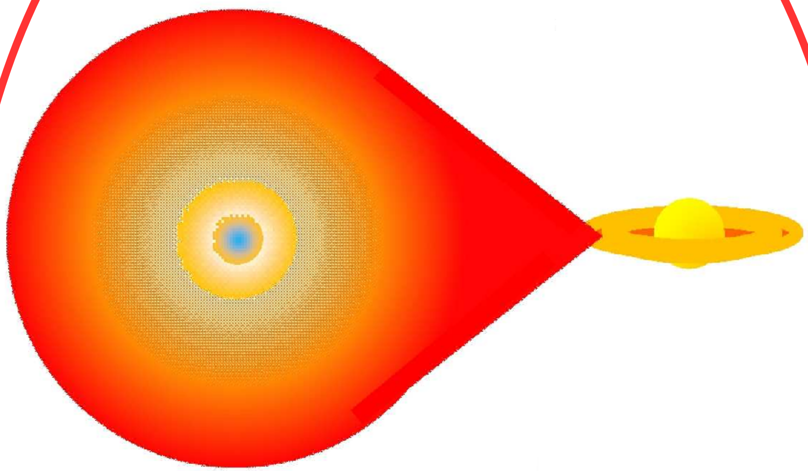


- single sdBs

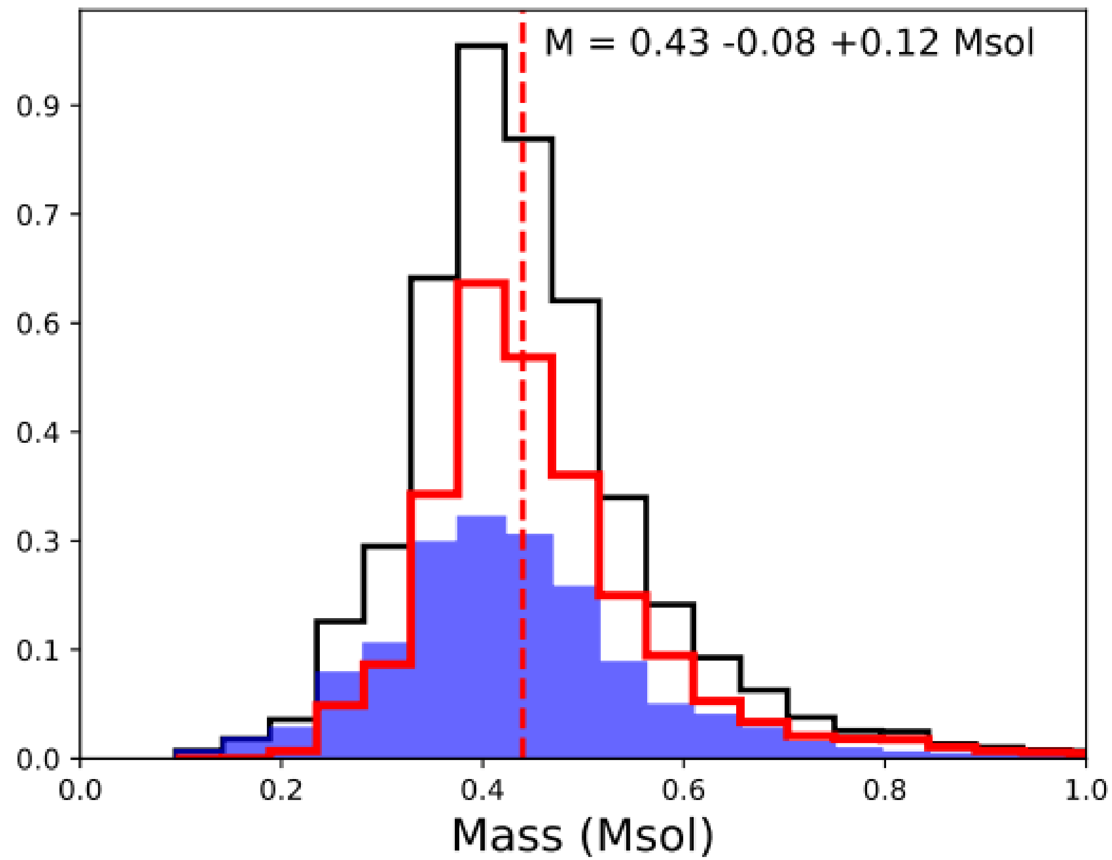
Benefits for theory: double lined, only formed in binaries

Hot subdwarf formation

stable-RLOF

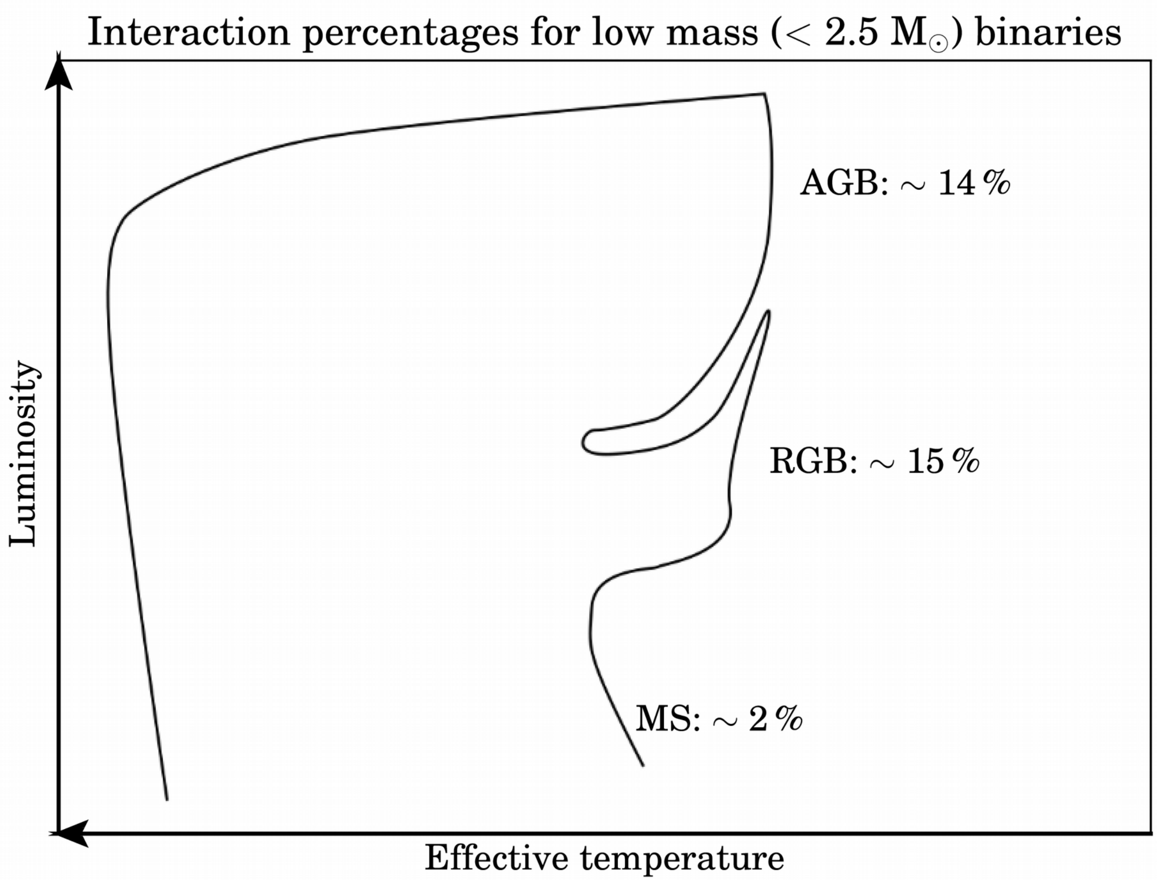


- long periods (> 2 year)
- sdB + MS



Benefits for theory: single population

Binary interaction



Roughly 1/3 of low mass binaries will at some point interact:
Supernova Ia, blue stragglers, sdBs, algols, CVs, ...

Issues:

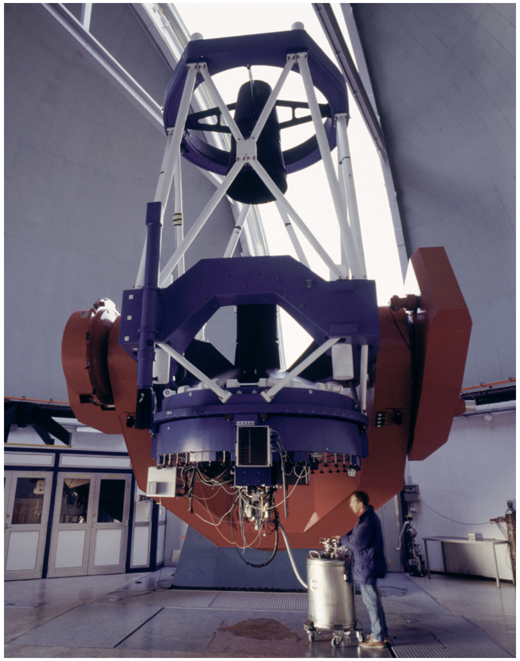
- Postulated increase in mass-loss before contact
- Precise description of common envelope
- Accretion efficiency onto the companion
- Mass-loss fractions during RLOF
- Formation/existence of circumbinary disk
- Interaction between disk and binary
- ...

sdB observing campaign

HERMES
1.2m Mercator
La Palma

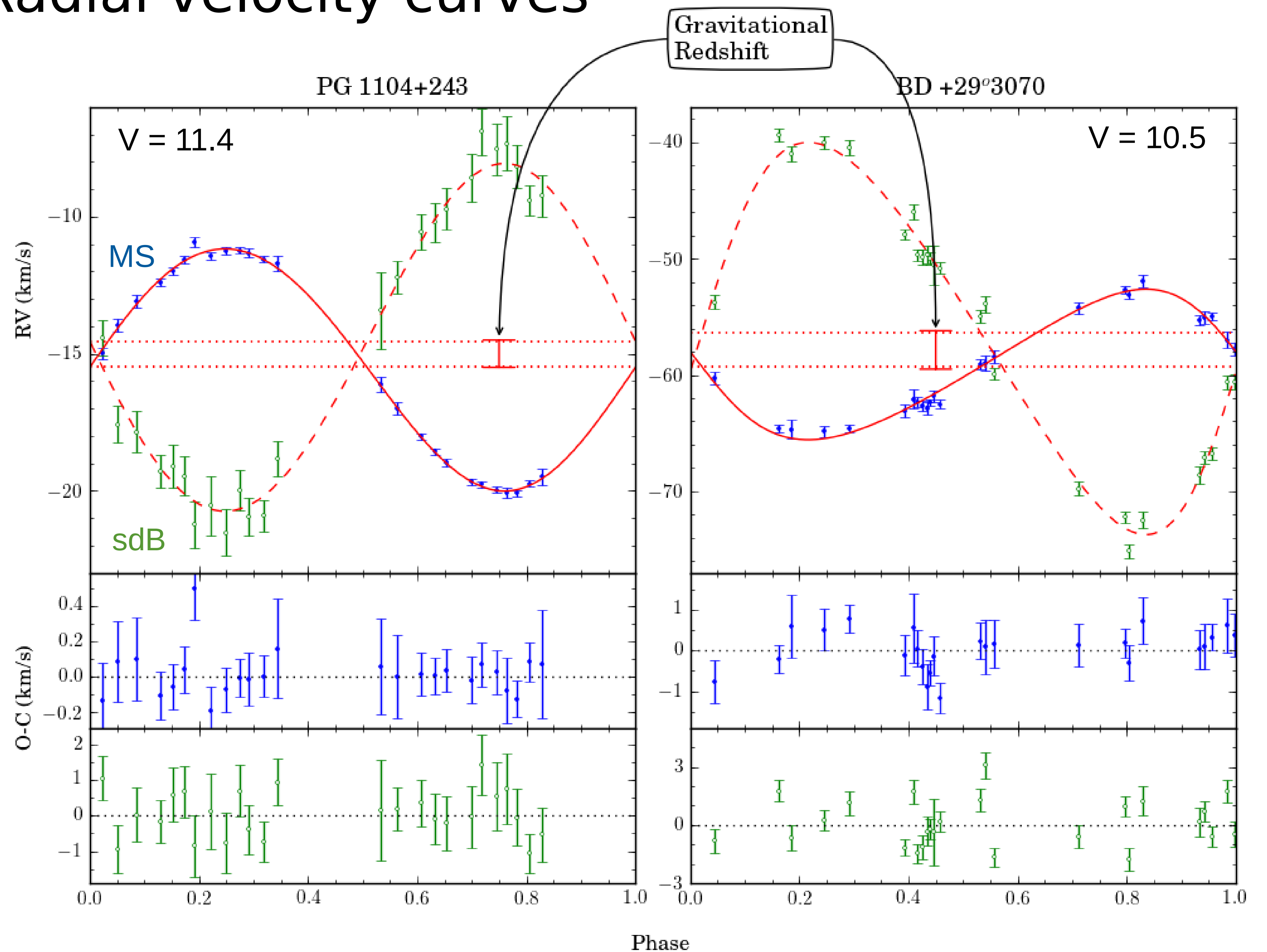
CHIRON
1.5m SMARTS
Chile

FEROS
2.2m MPG
Chile

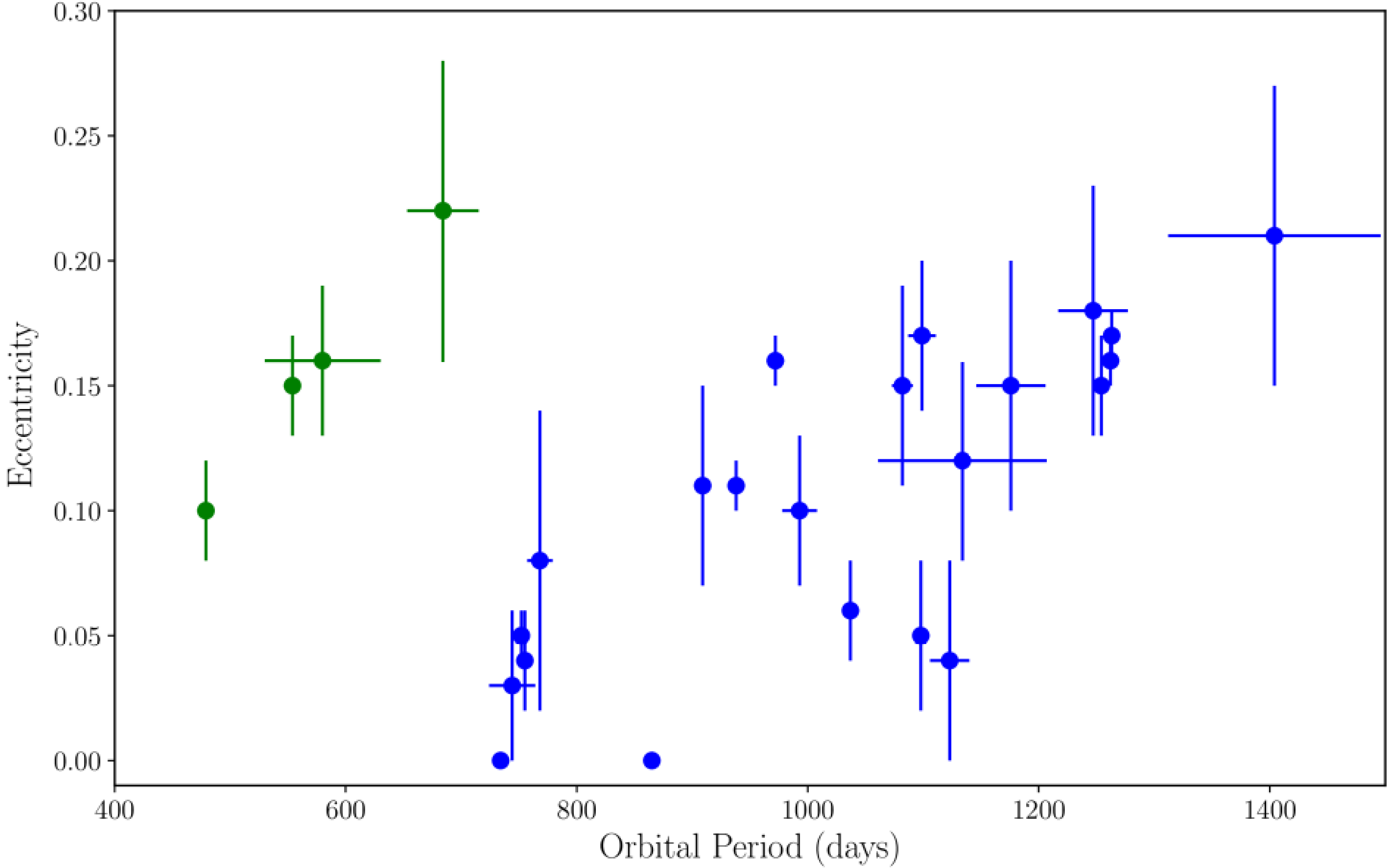


36 Targets • 8 years of observations • 24 solved systems

Radial velocity curves

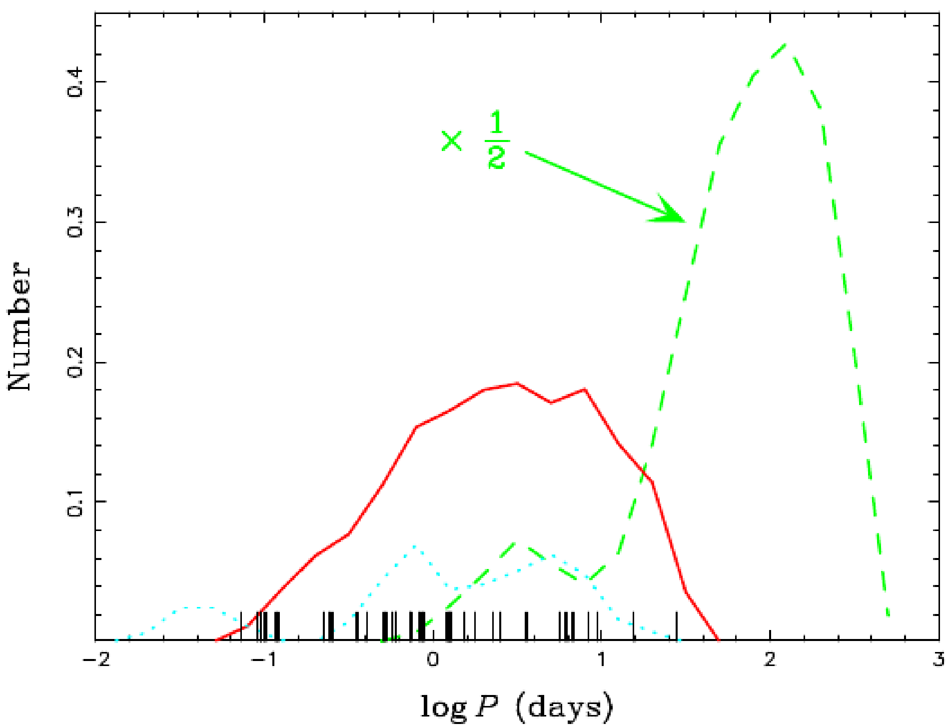


Period – Eccentricity

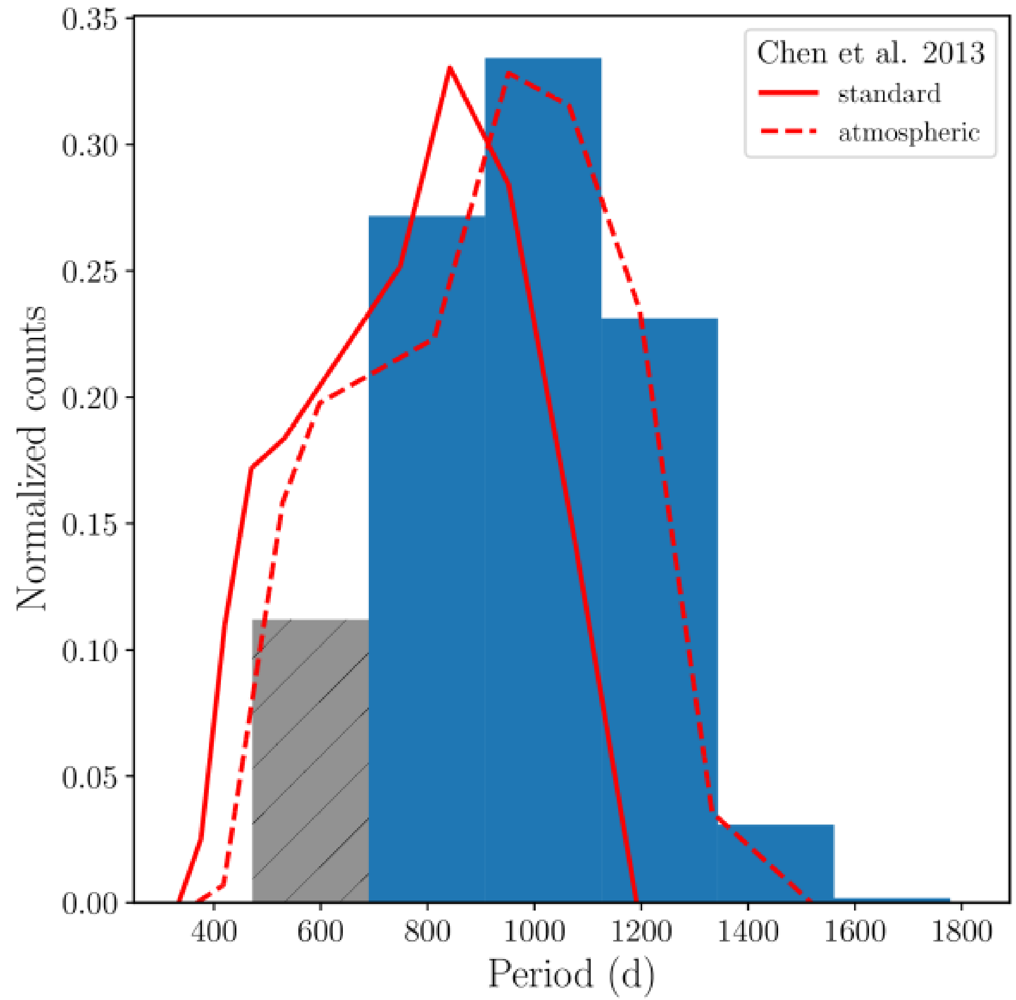


- Could be 2 distinct groups
- Main group with orbital periods around 2 – 4 years

Period distribution



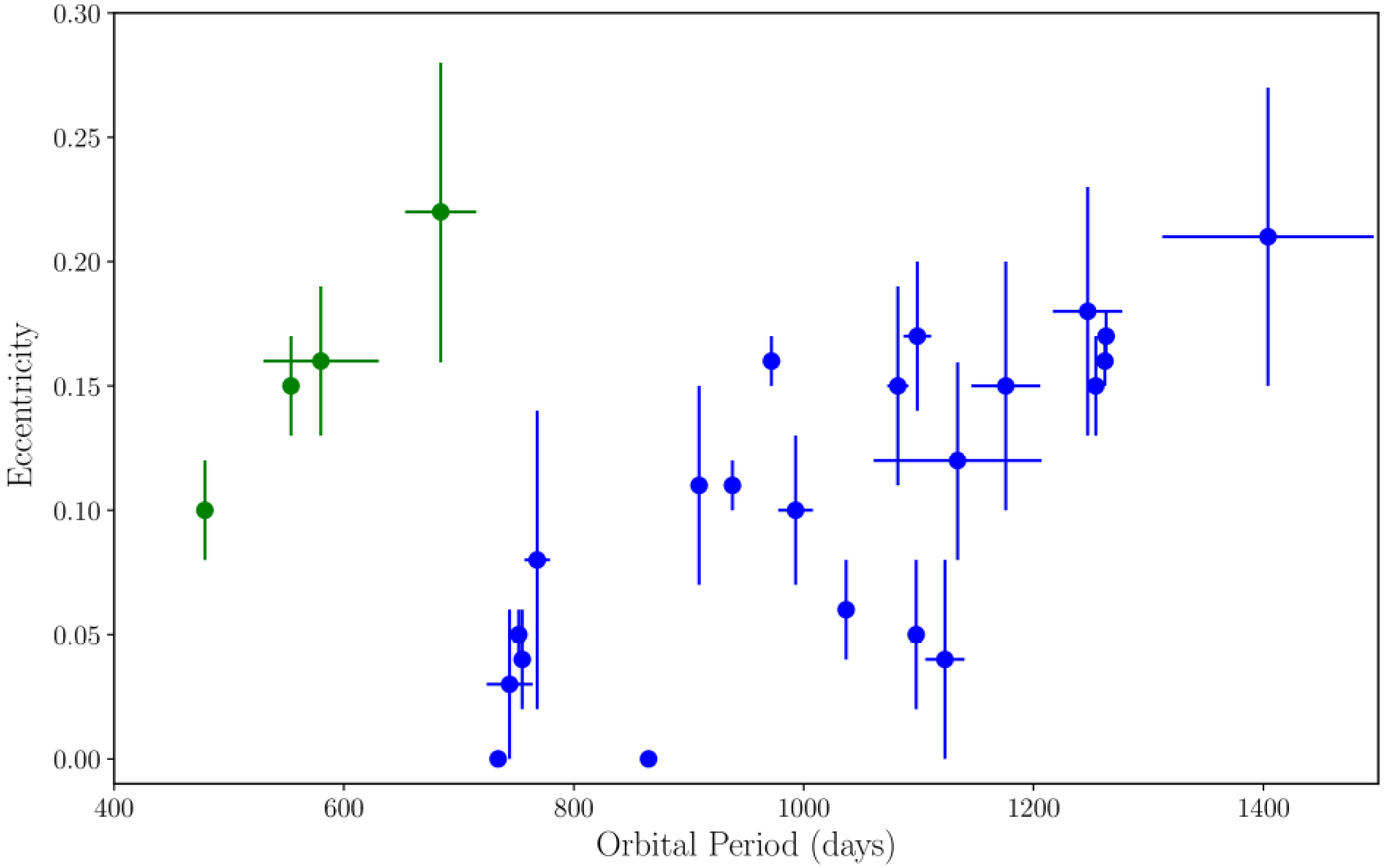
- Original predictions around 100 days



- Adjustments to angular momentum loss
- Inclusion of atmospheric RLOF

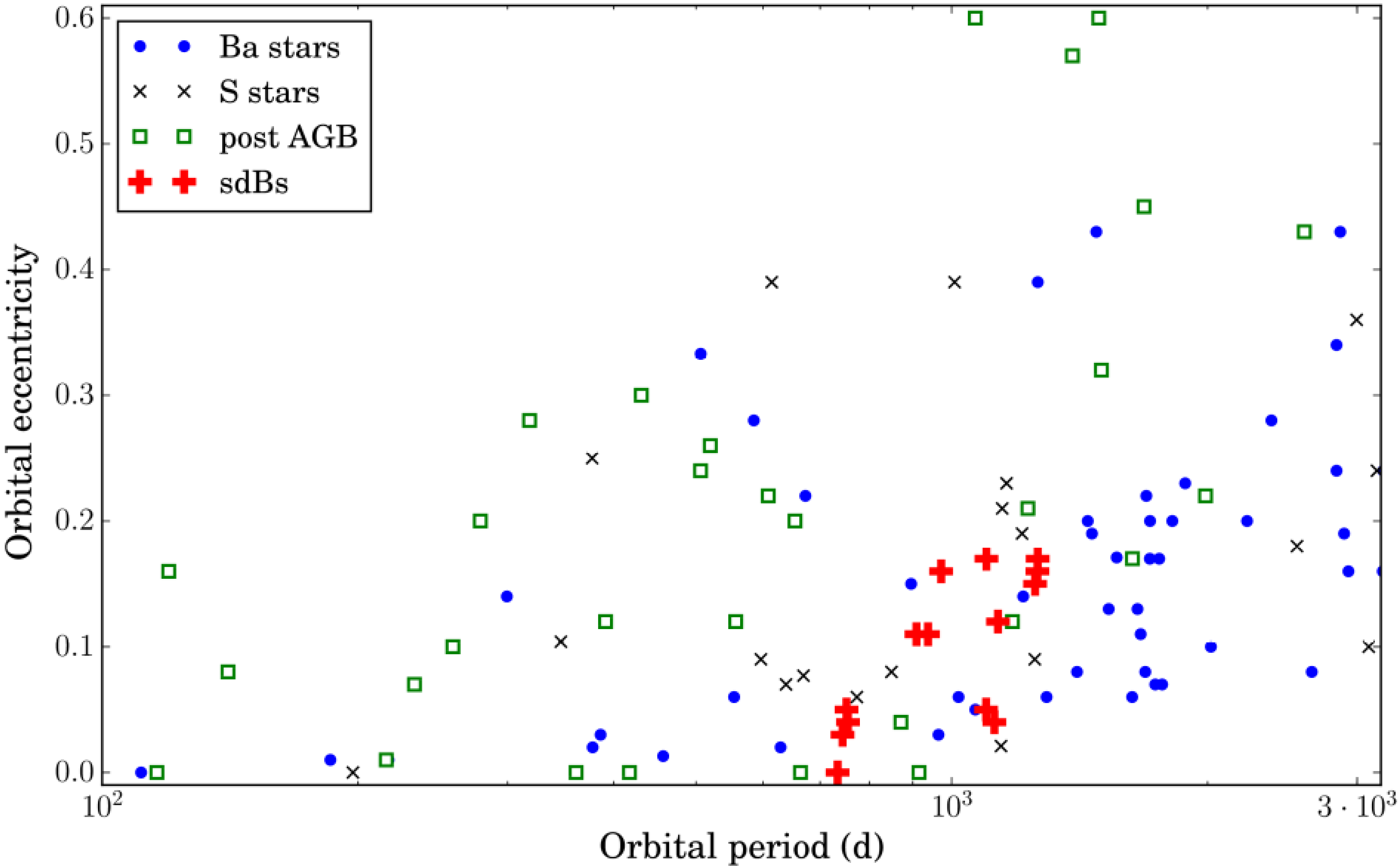
Vos et al. 2018 MNRAS in press.

Period – Eccentricity



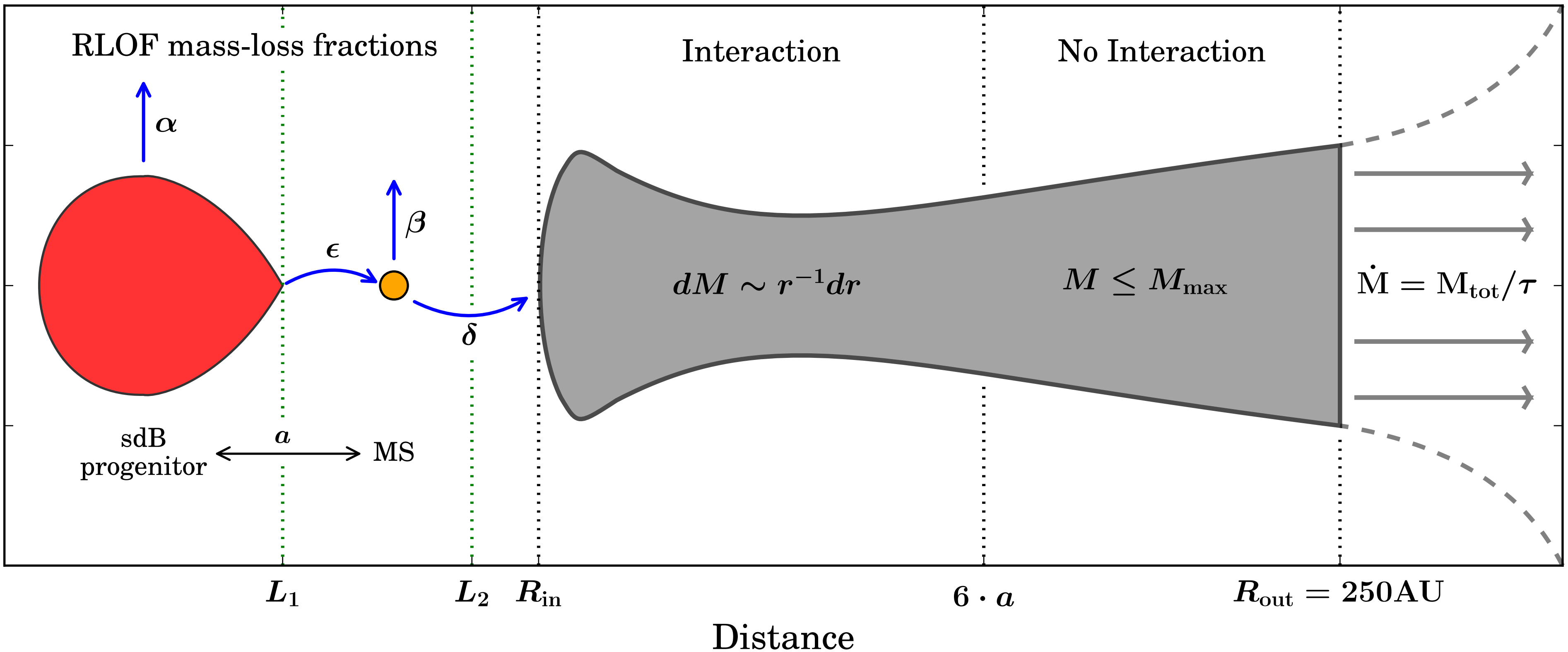
- Theory predicts circular systems
- Almost all systems have significantly eccentric orbits

Period – eccentricity comparison



Vos et al. 2017 A&A 605, A109

MESA : Eccentricity pumping



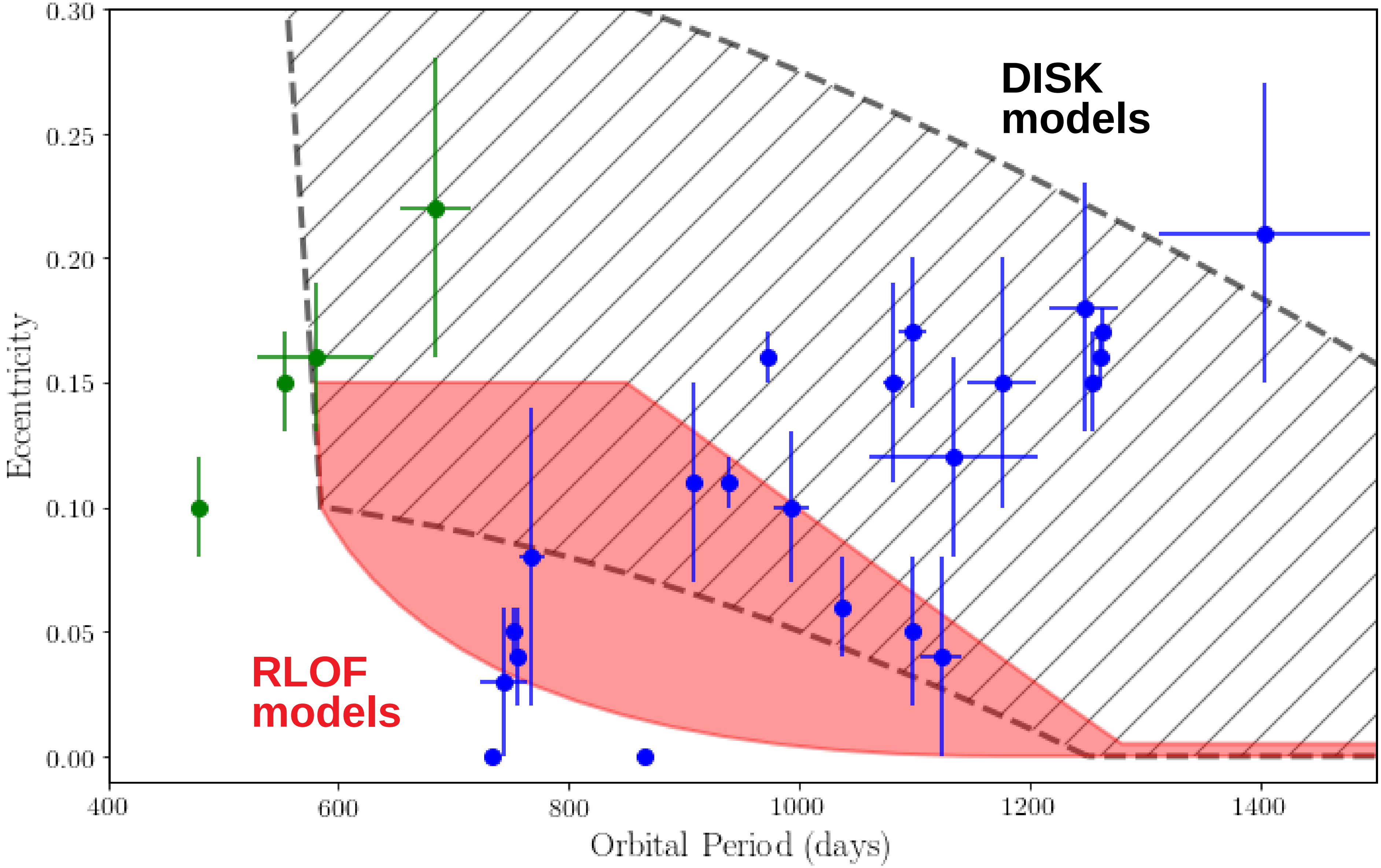
Phase dependent mass loss

Soker (2000)
Bonacic et al. (2008)

Circumbinary disk interaction

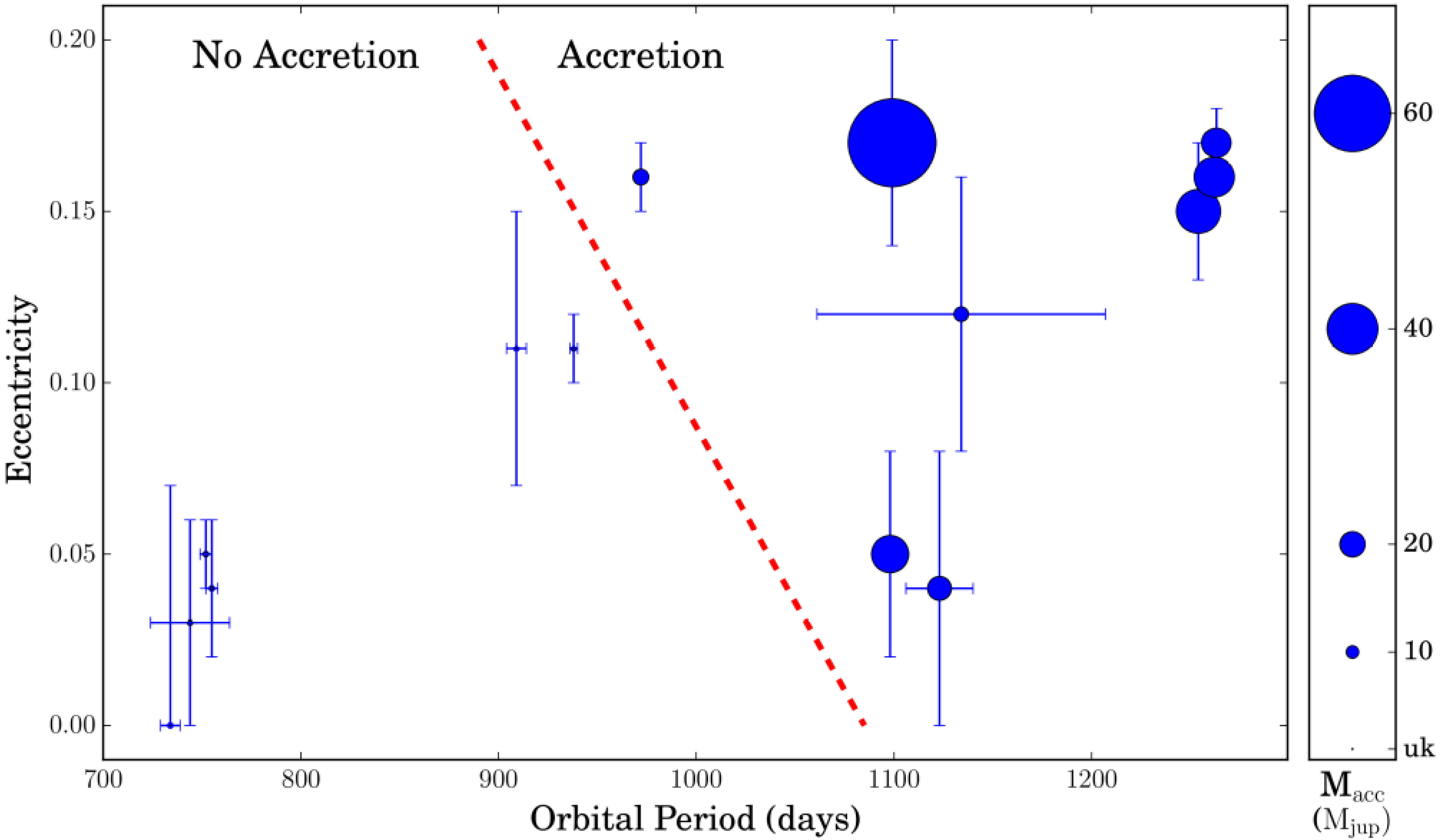
Artymowics & Lubow (1994)
Dermine et al. (2013)

Period – Eccentricity: Models



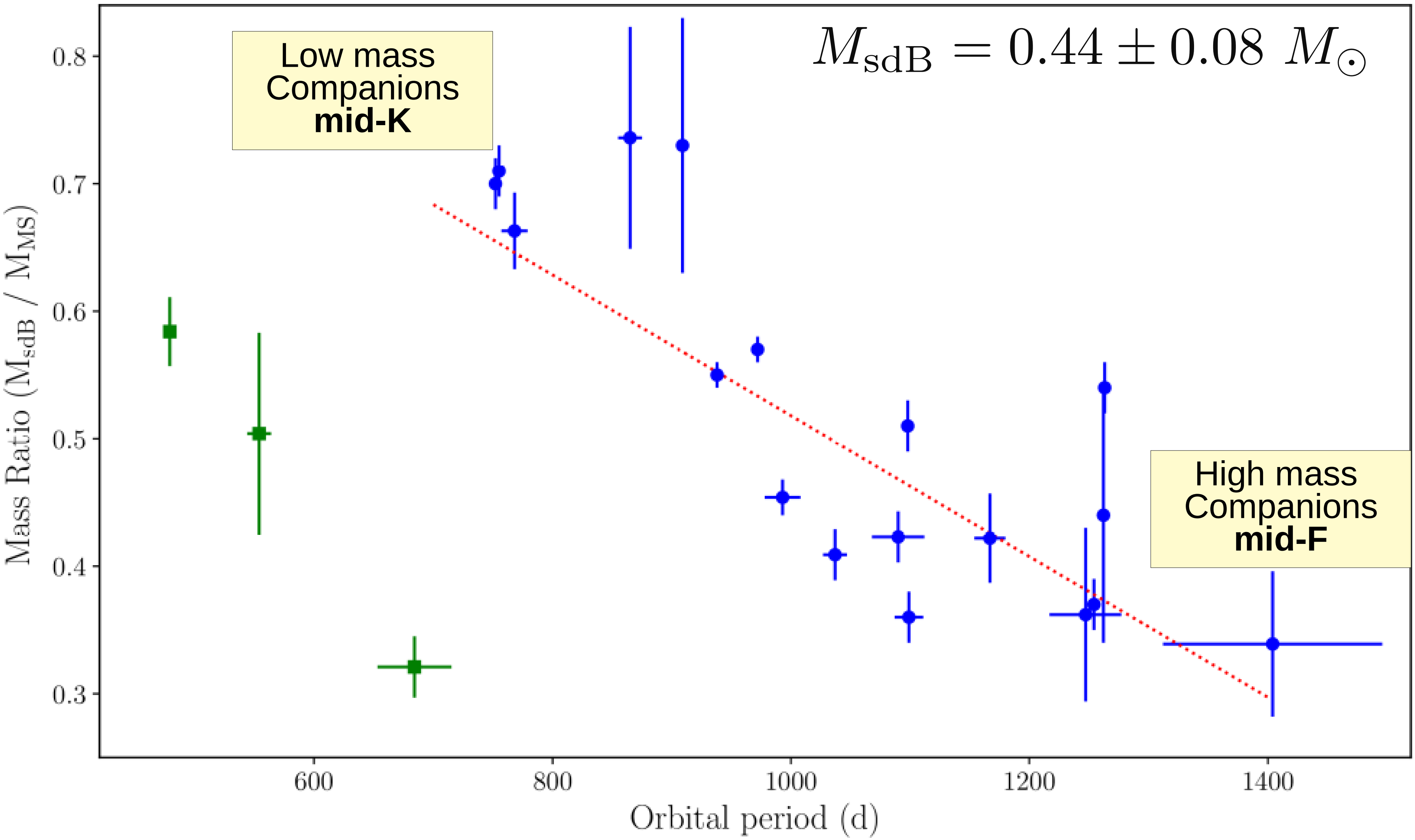
Vos et al. 2015 A&A 597A, 49V; Deca et al 2018 MNRAS 474, 433D

Period – Accreted mass

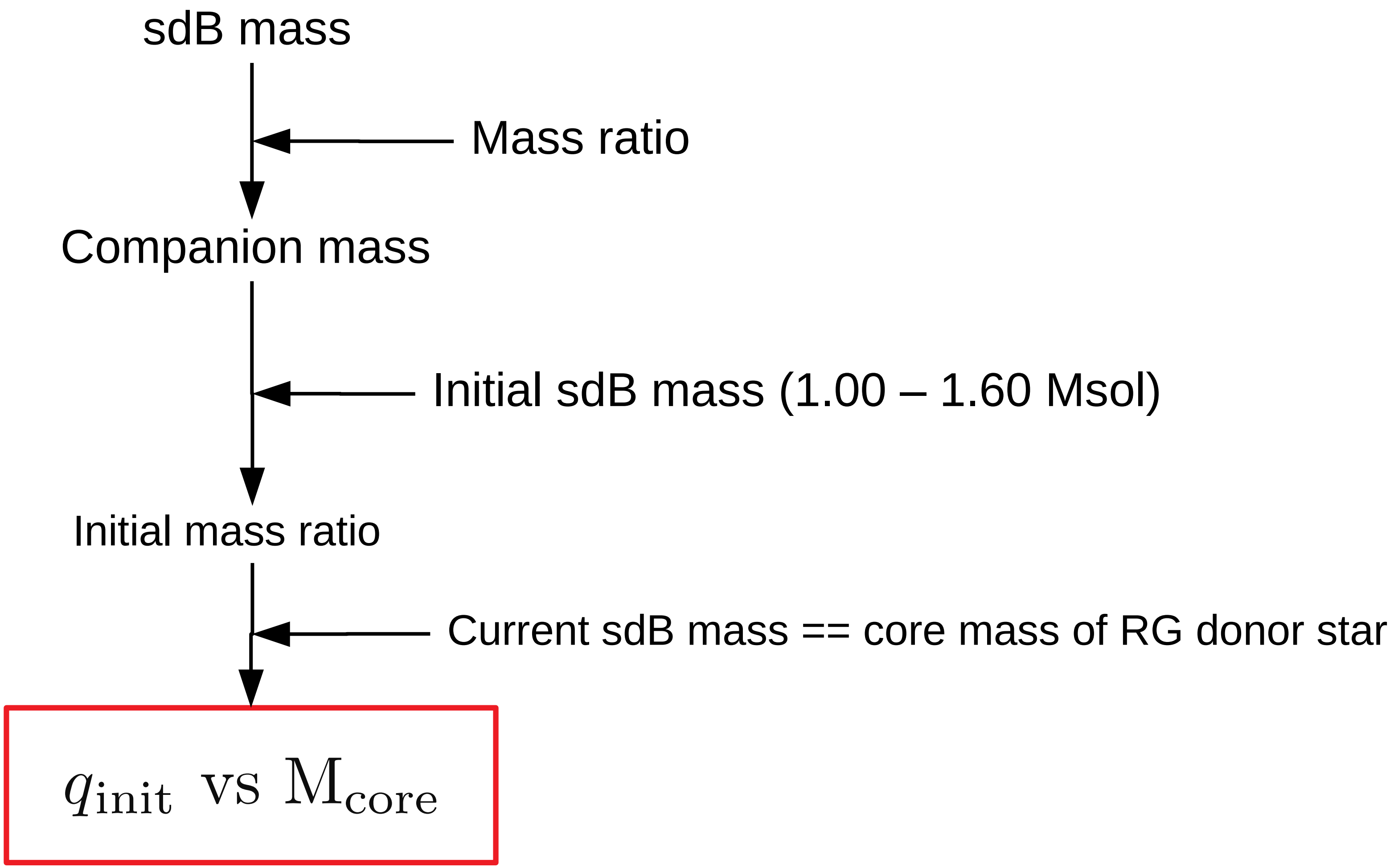


Accreted Mass: 0.001 → 0.05 $M_{\odot}$ ⟹ ~1 $M_{\odot}$ lost from the system

Period – Mass ratio

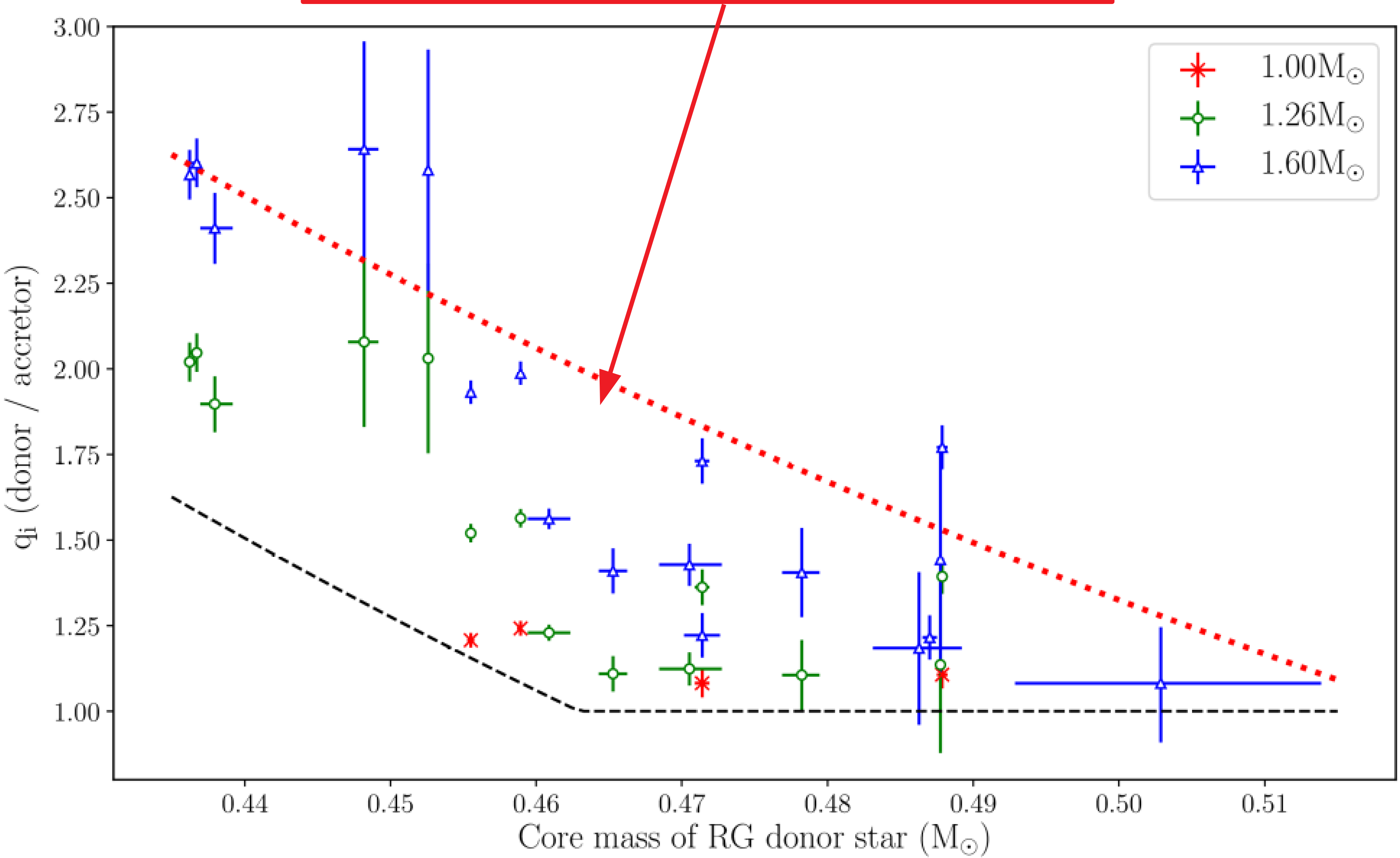


Mass loss stability criterion



Mass loss stability criterion

$$q_c = M_{\rm core}^{-2} - 0.25 M_{\rm core} - 2.55$$



Vos et al. 2018 MNRAS in press.

Summary

- sdB+MS binaries are ideal systems to study stable RLOF on the RGB
- 24 binaries have now been analyzed
- Orbital periods range from 1 – 4 years
- Orbital periods match theoretical predictions is atmospheric RLOF is included
- Almost all systems are eccentric, which can be explained by phase depended mass loss in combination with the formation of a circumbinary disk during the RLOF phase
- The main sequence companions accrete very little mass
- Strong correlation between mass-ratio and orbital period.
- The P-q correlation is used to derive a stability criterion for RLOF on the RGB defining the critical mass ratio in function of the core mass of the donor star.