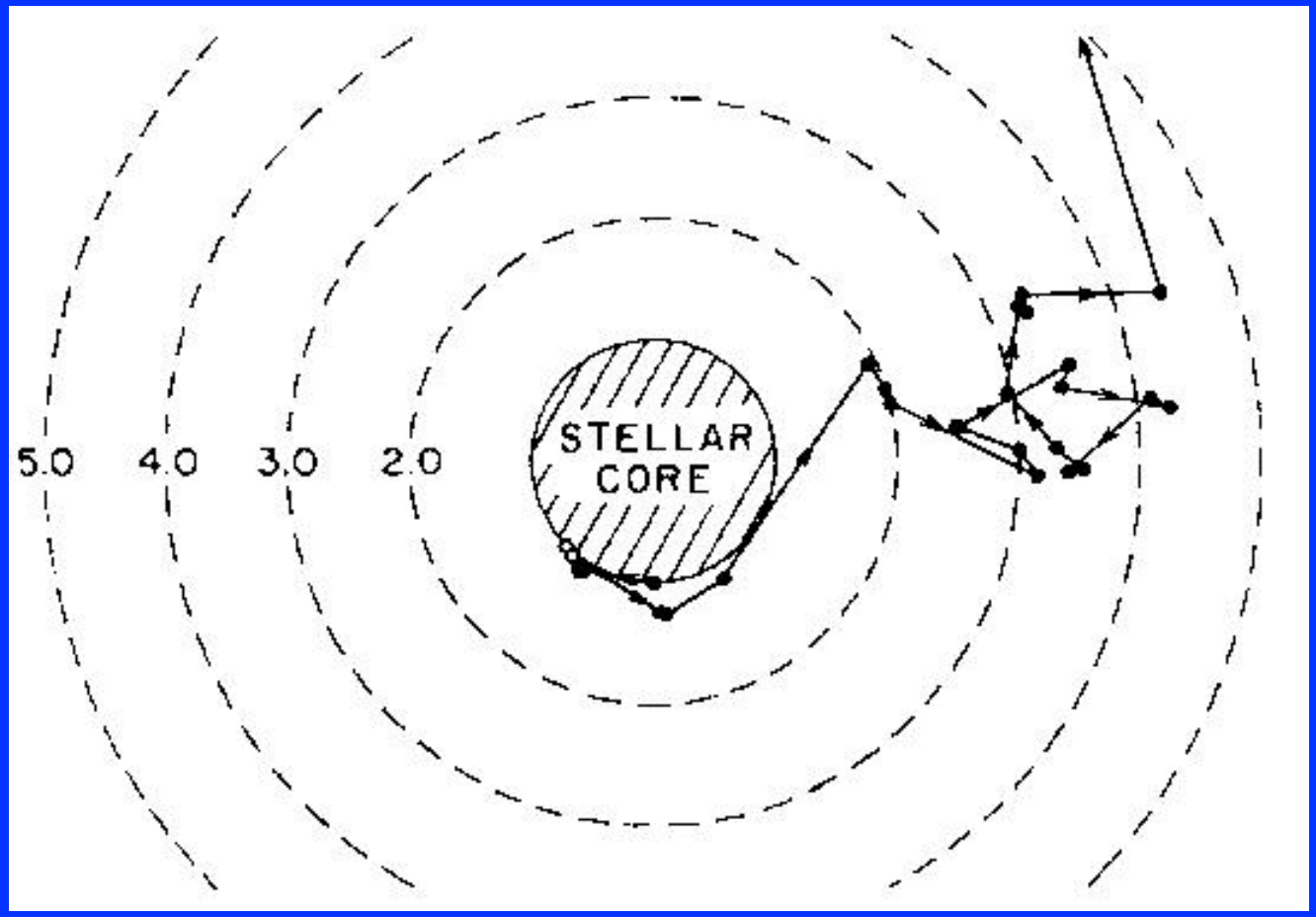
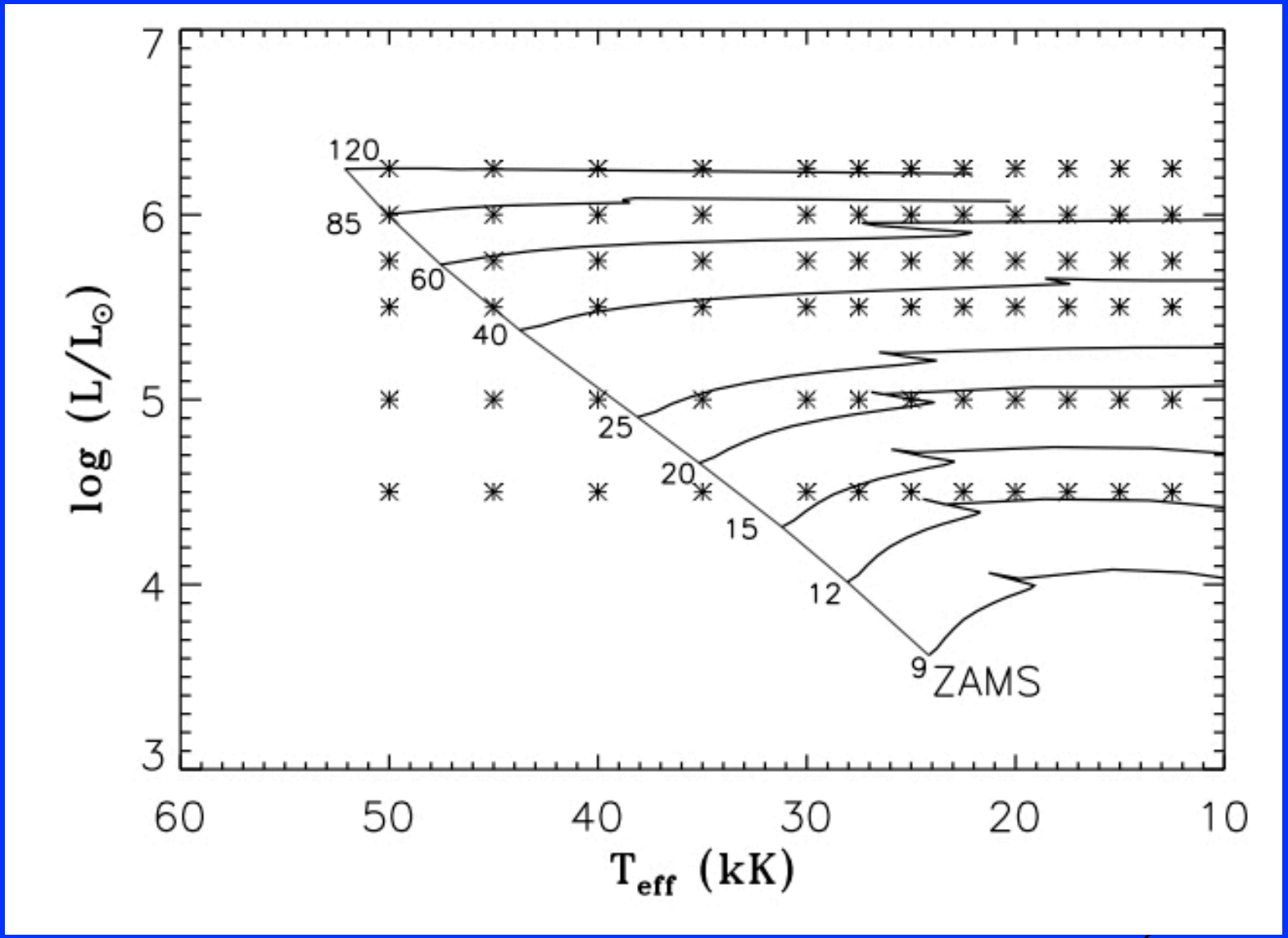
Hot star winds



(MC:Abbott & Lucy 1985, Vink et al. 2000
CMF: e.g. Bjorklund et al. 2021)

$$\dot{M}\ v_\infty > \frac{L_*}{c}$$

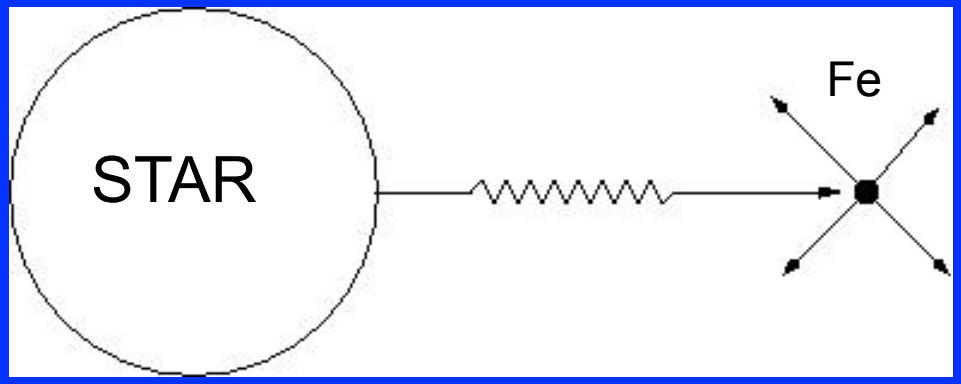
“Standard” Rates



Vink et al. (2000/2001)

Line-driven winds

CAK: Castor, Abbott & Klein (1975)
Pauldrach, Puls & Kudritzki (1986)
Vink, ARA&A (2022)

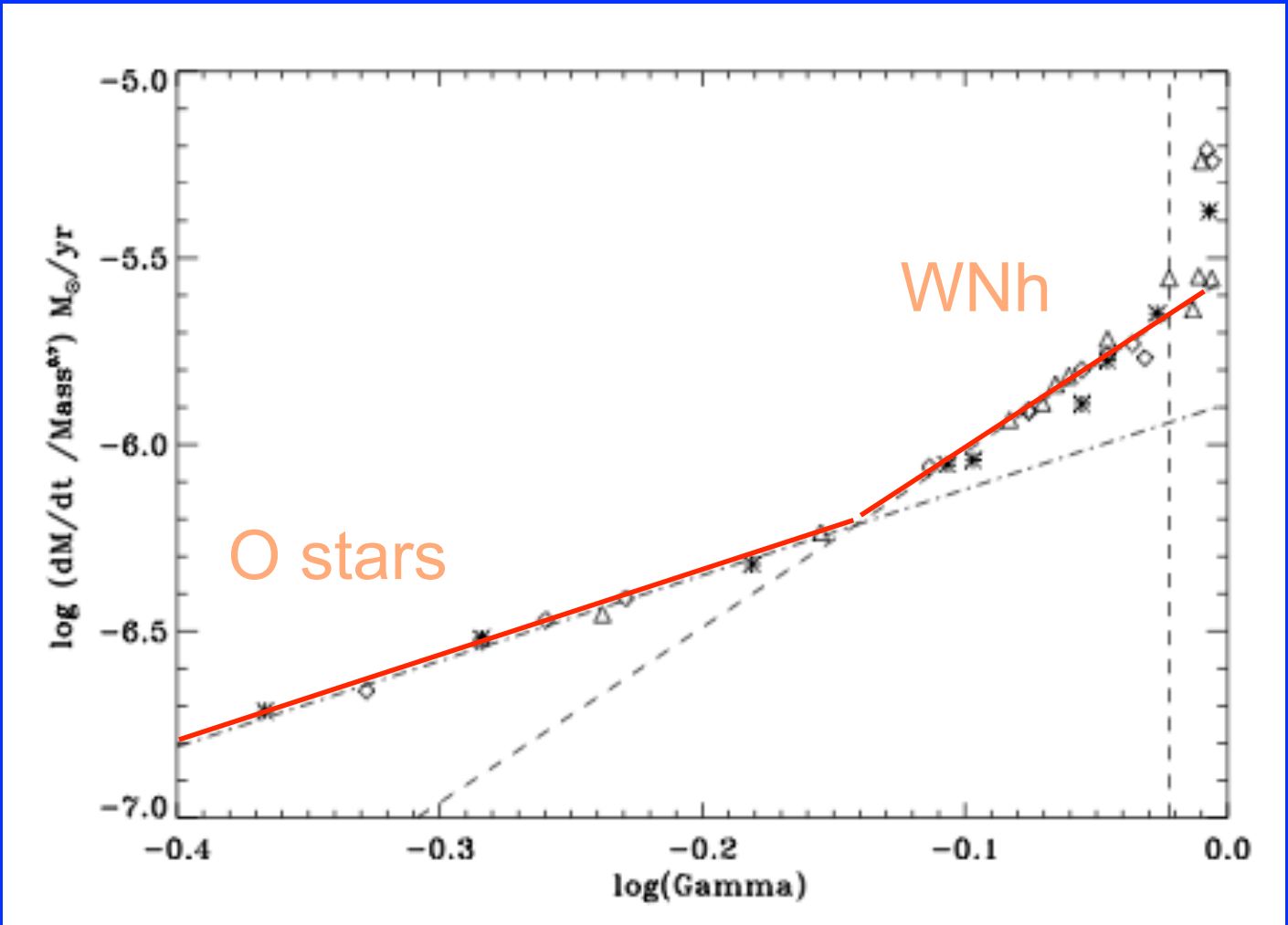


$$dM/dt = f(L, M, Z, T_{eff})$$

dM/dt = f (Gamma)

$$\Gamma = \frac{g_{\mathrm{rad}}}{g_{\mathrm{grav}}} = \frac{\kappa L}{4\pi c G M}$$

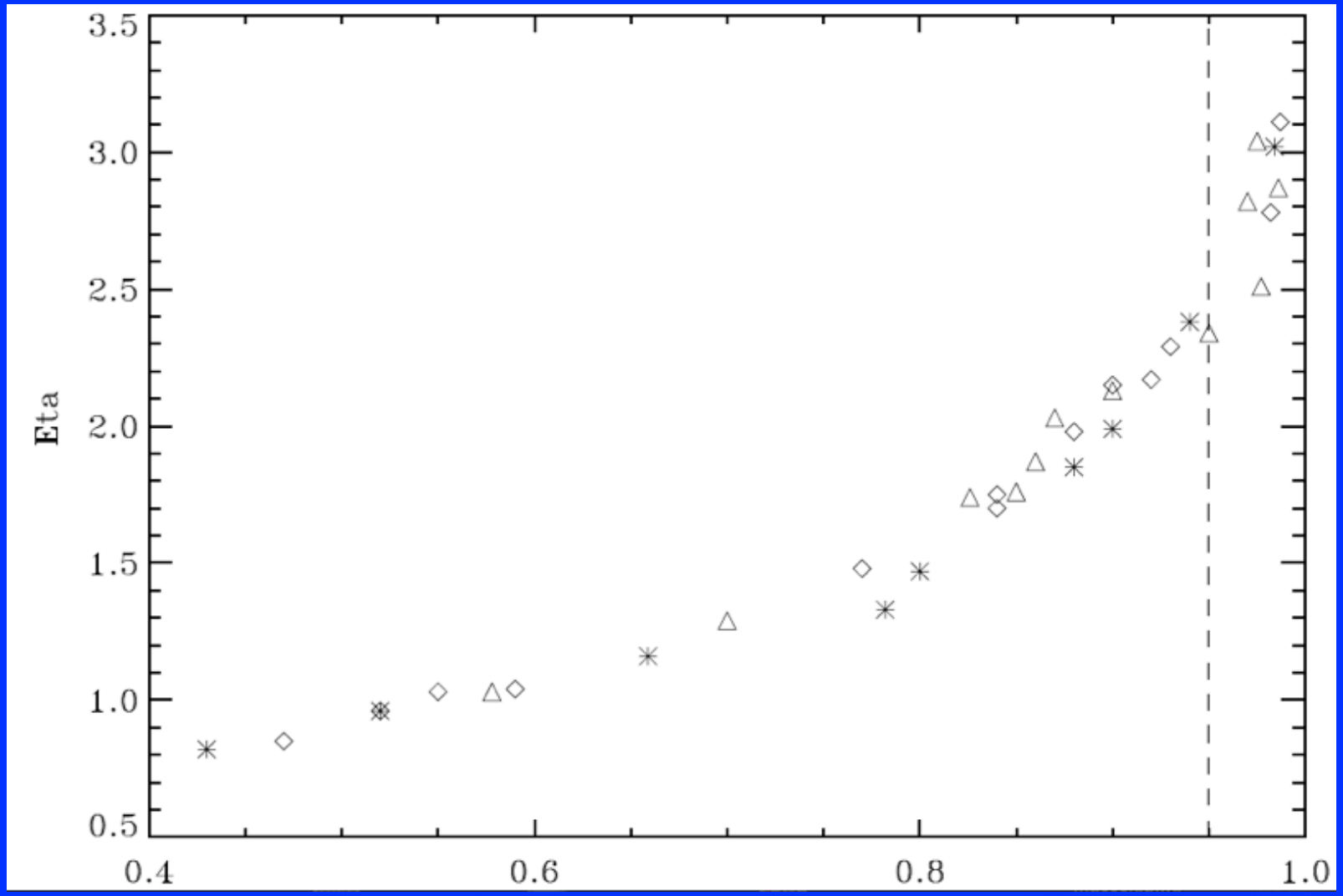
Transition in Mass Loss

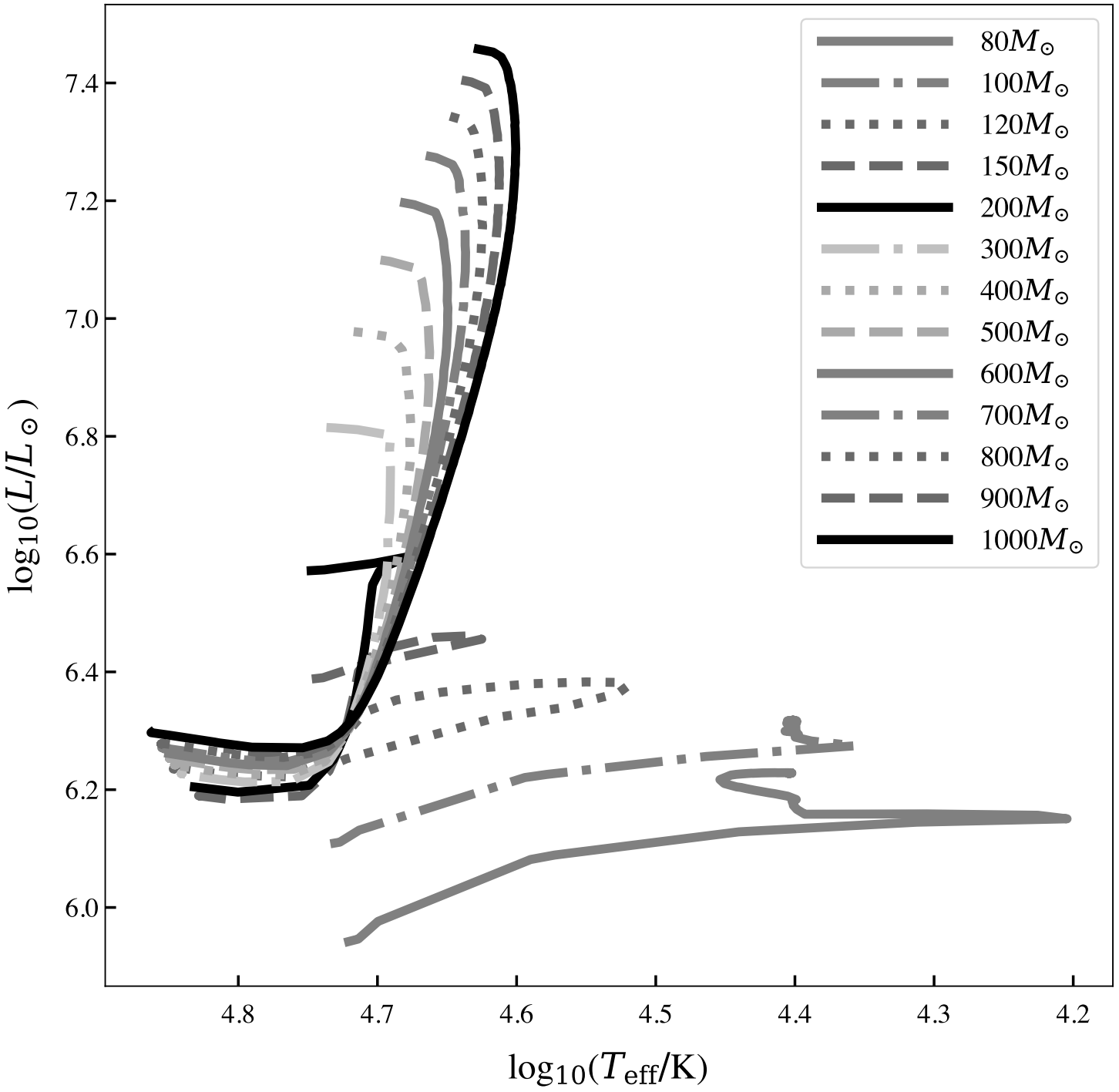


Vink et al. (2011)

Wind efficiency

$$\eta = \frac{\dot{M} v_\infty}{L/c}$$



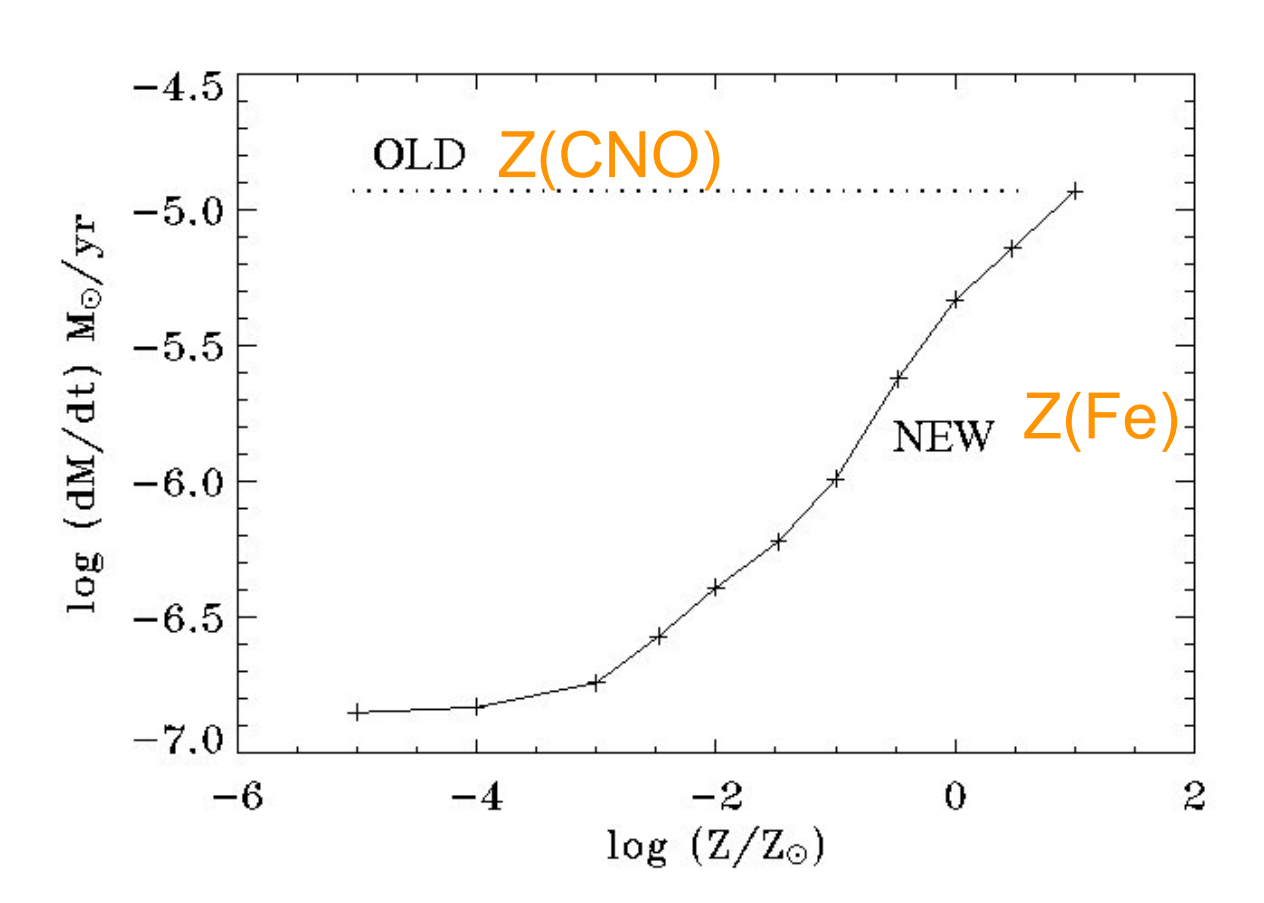


Sabhahit, Vink, Higgins & Sander (2022, MNRAS 514, 3736)

Higgins, Vink, Sabhahit & Sander (2022, MNRAS 516,4052)

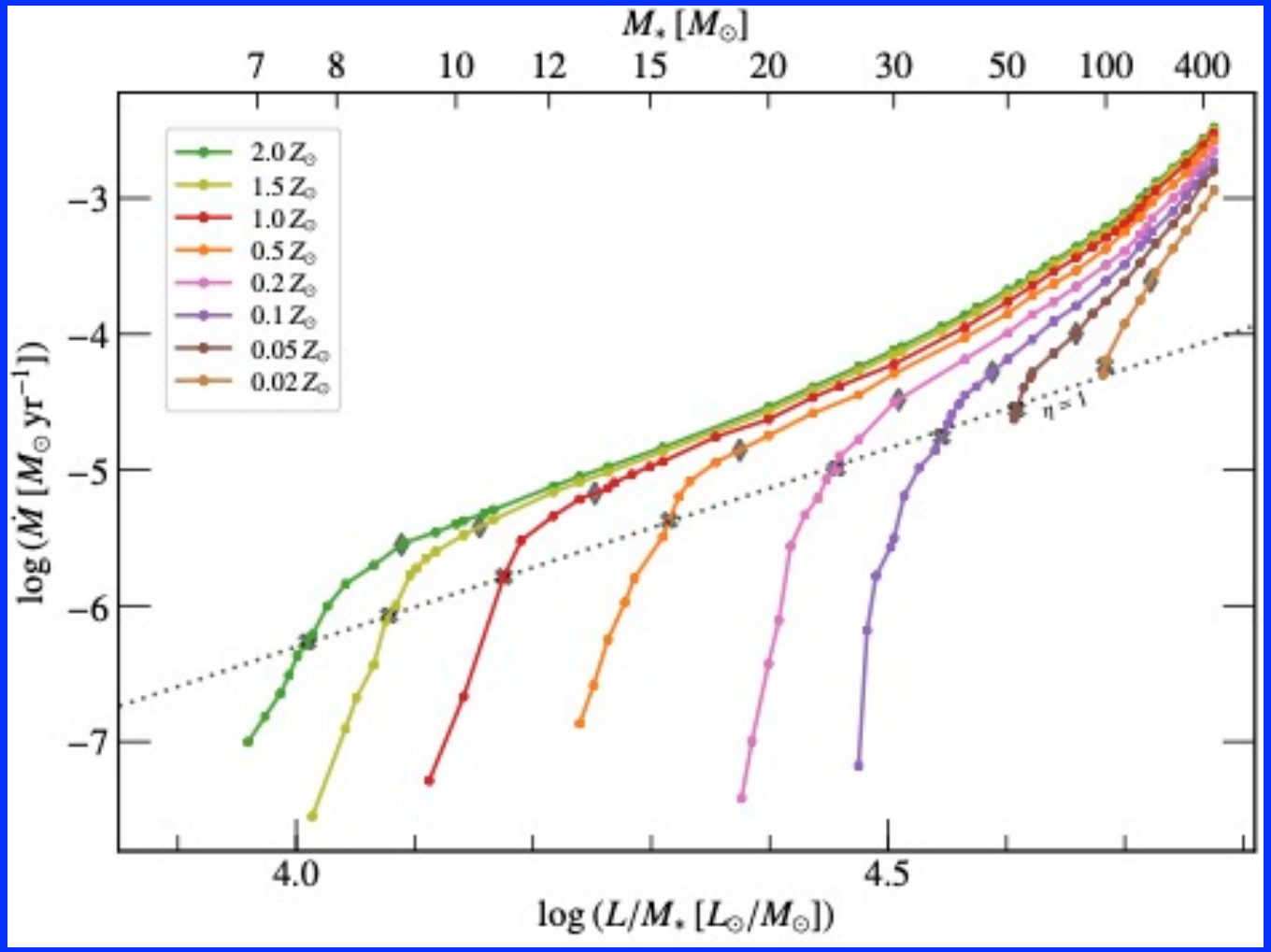
$$dM/dt = f(Z)$$

Z-dependence of WR winds



Vink & de Koter (2005)

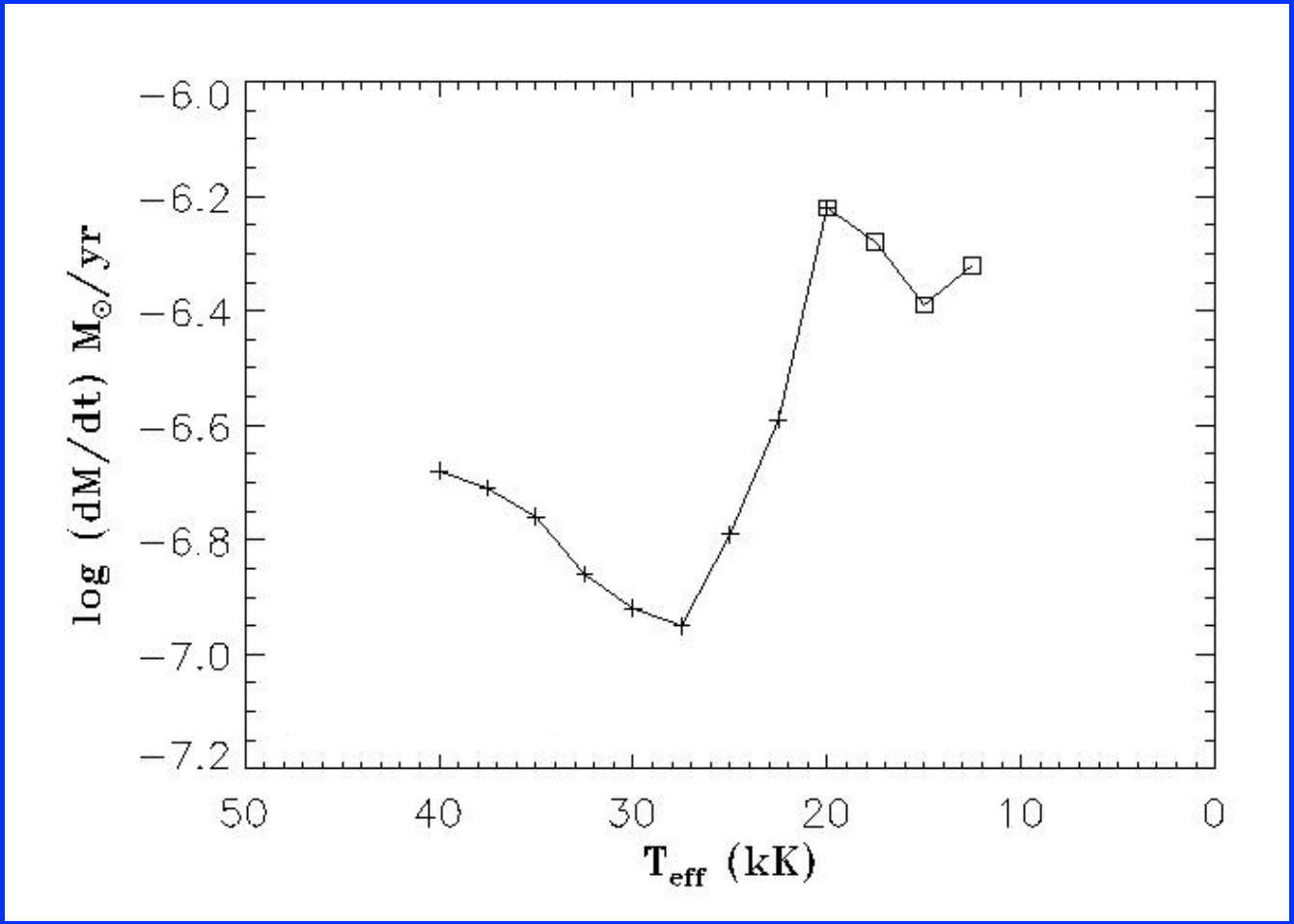
Z-dependence of He Stars



Sander & Vink (2020) Vink (2017)

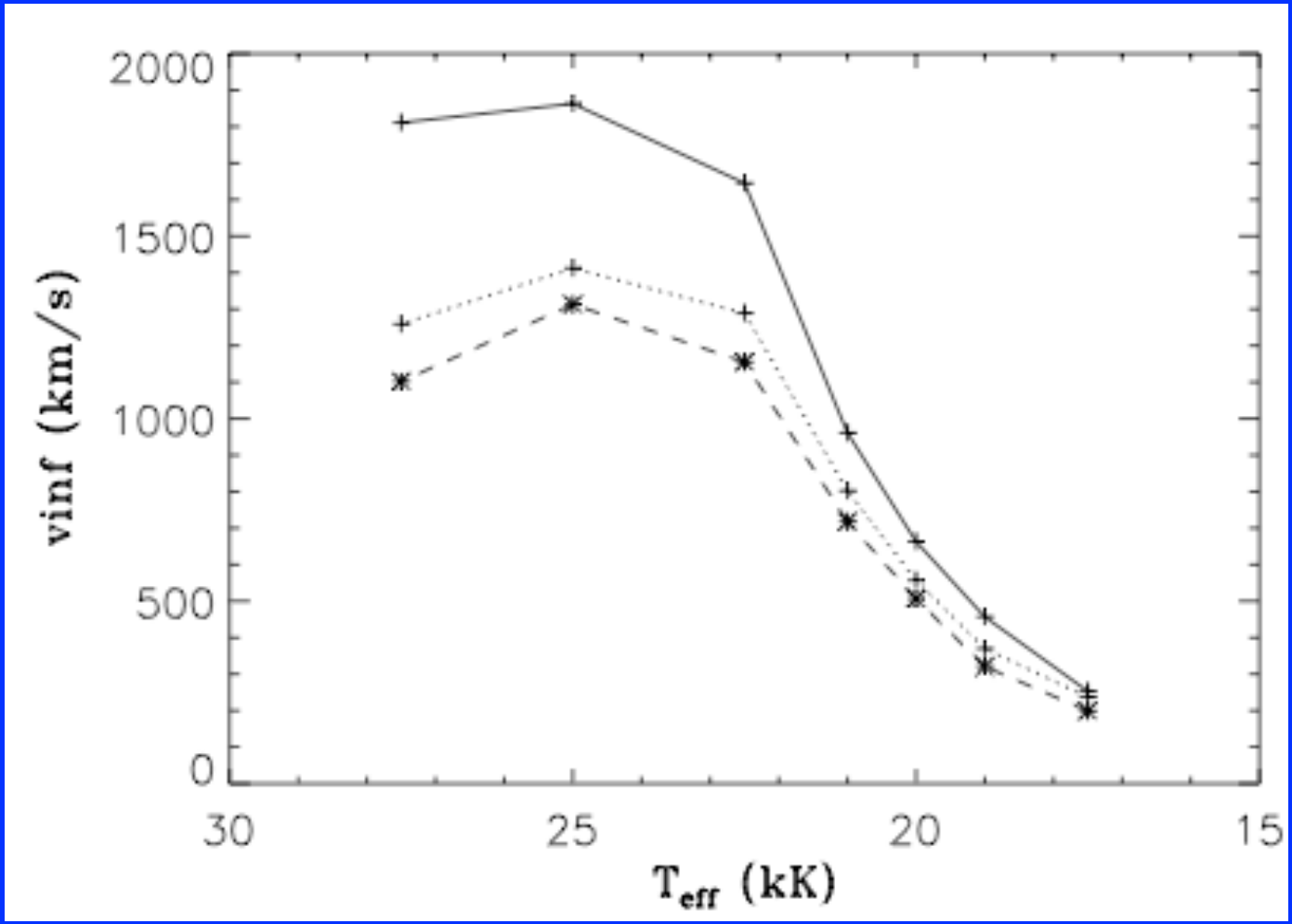
$$dM/dt = f\,(T_{eff})$$

Bi-stability Jump



(Vink et al. 1999
Pauldrach & Puls 1990)

Slow winds predicted



Vink et al. (2018b)

Bi-stability Jump

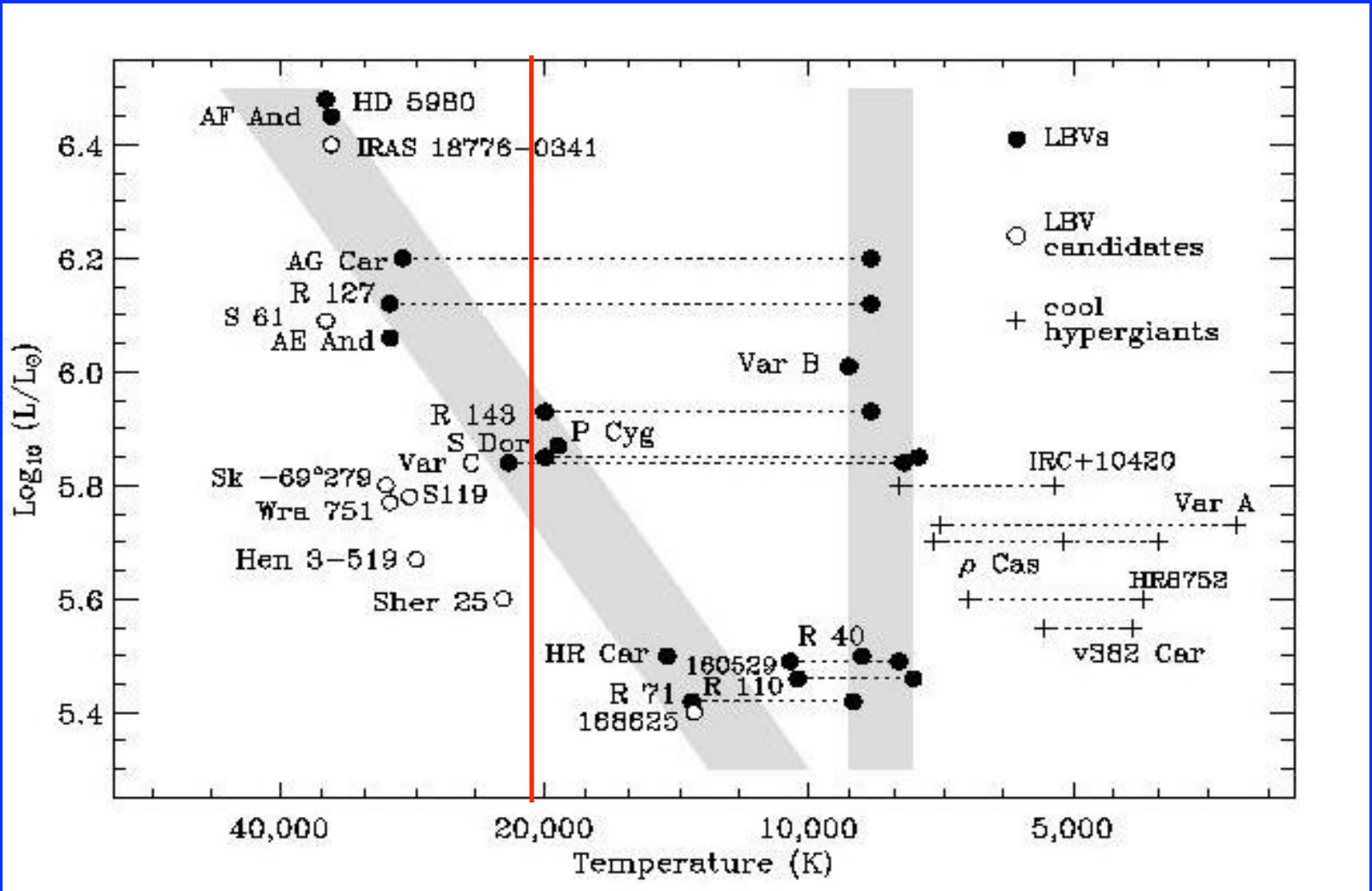
HOT = O stars
Fe IV

dM/dt
fast wind

COOL = B supergiants
Fe III

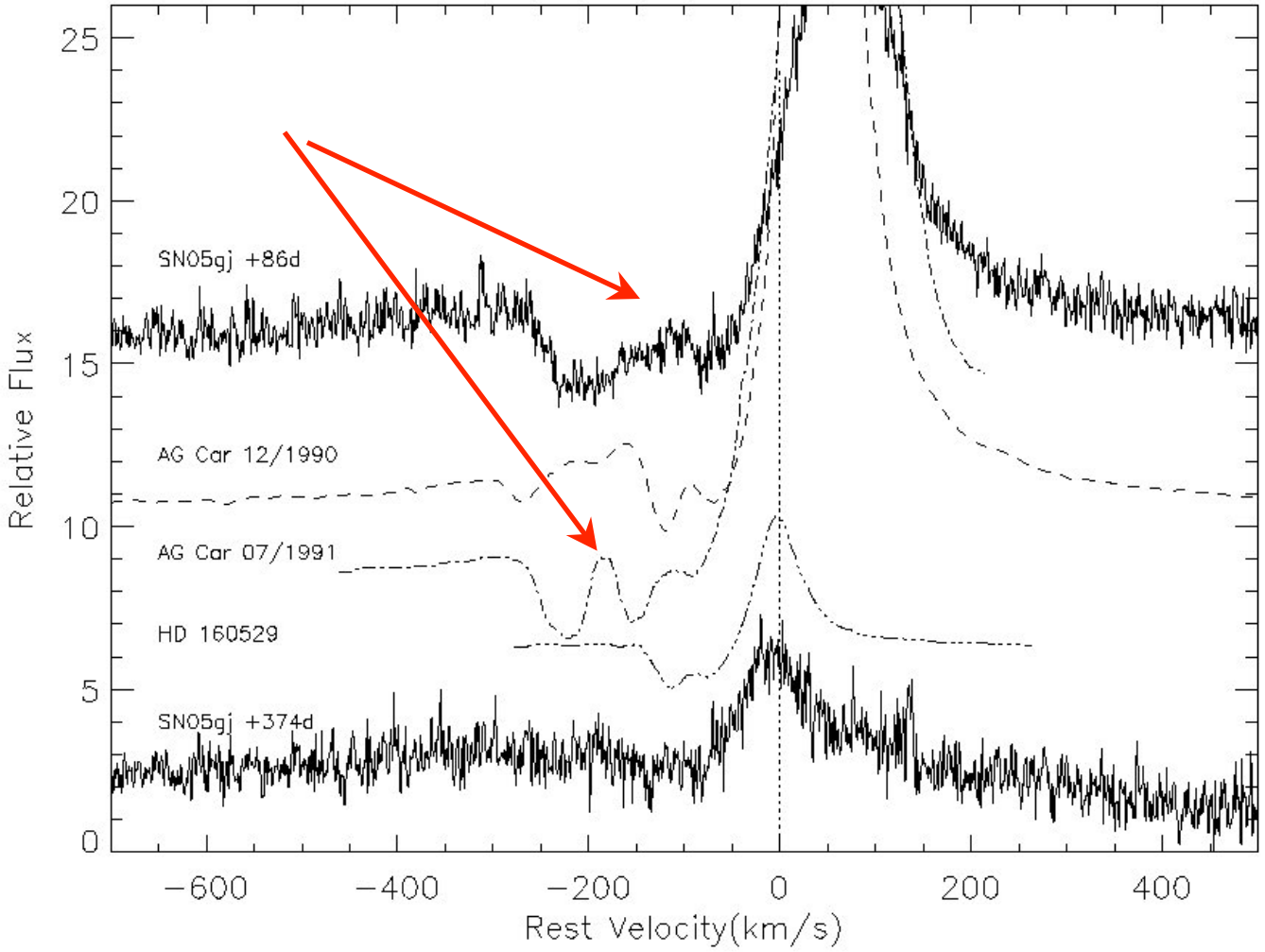
large dM/dt
slow wind

LBVs in the HRD



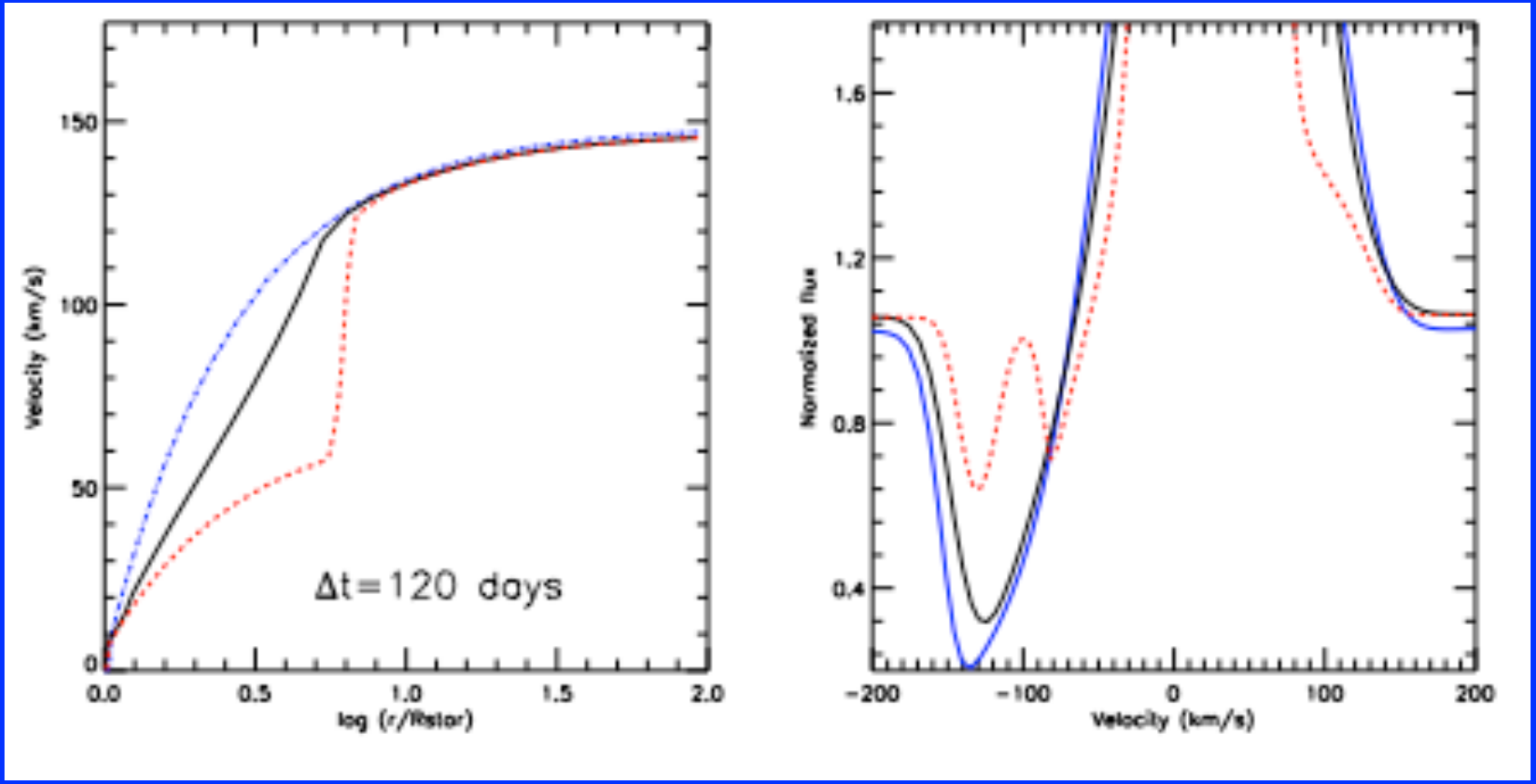
Smith, Vink & de Koter (2004)

Do LBVs make Supernovae?



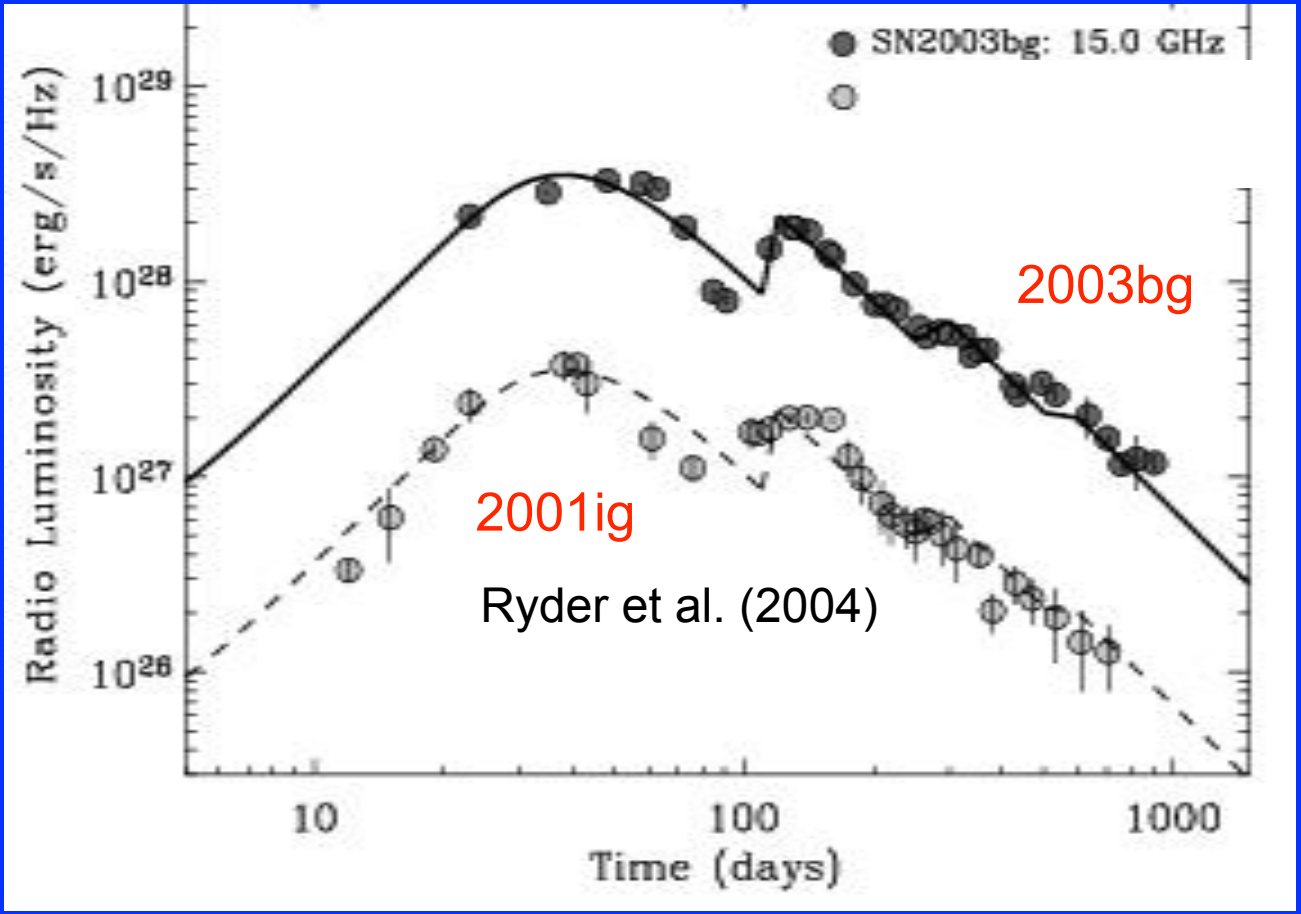
Trundle et al. (2008)

Changing mass loss!



Groh & Vink (2011)

Radio supernova lightcurves

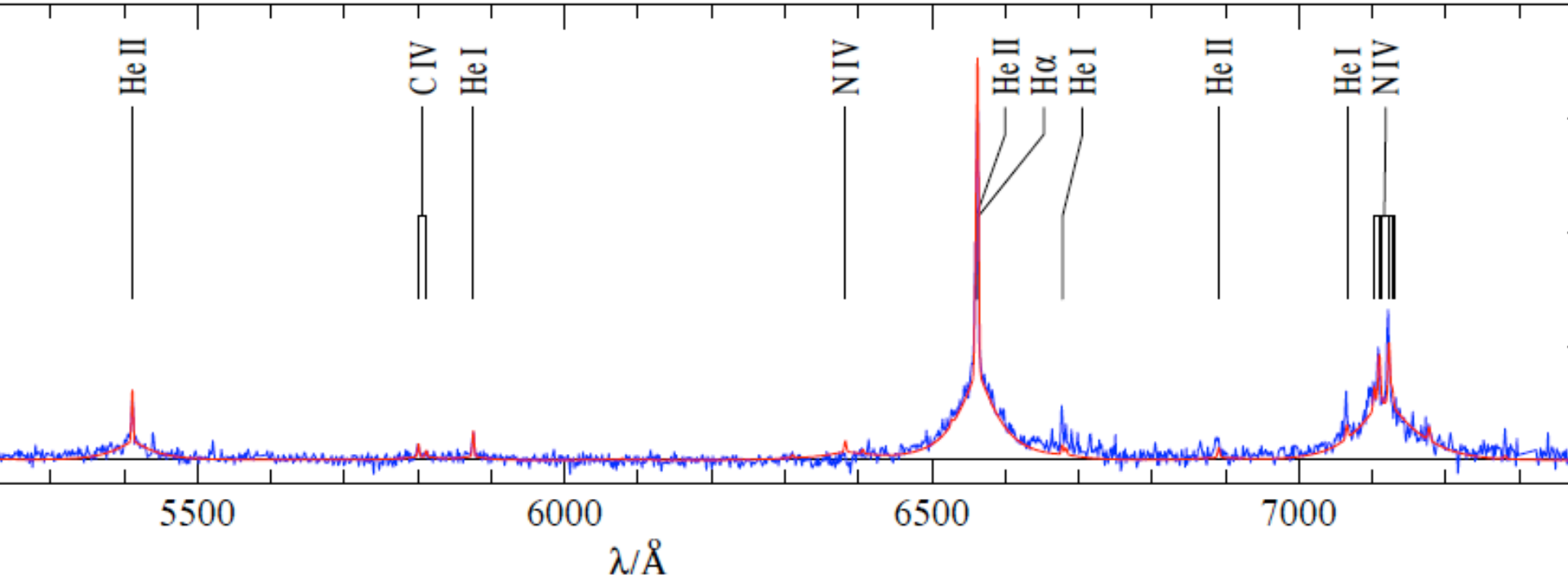


Soderberg et al. (2006) WR

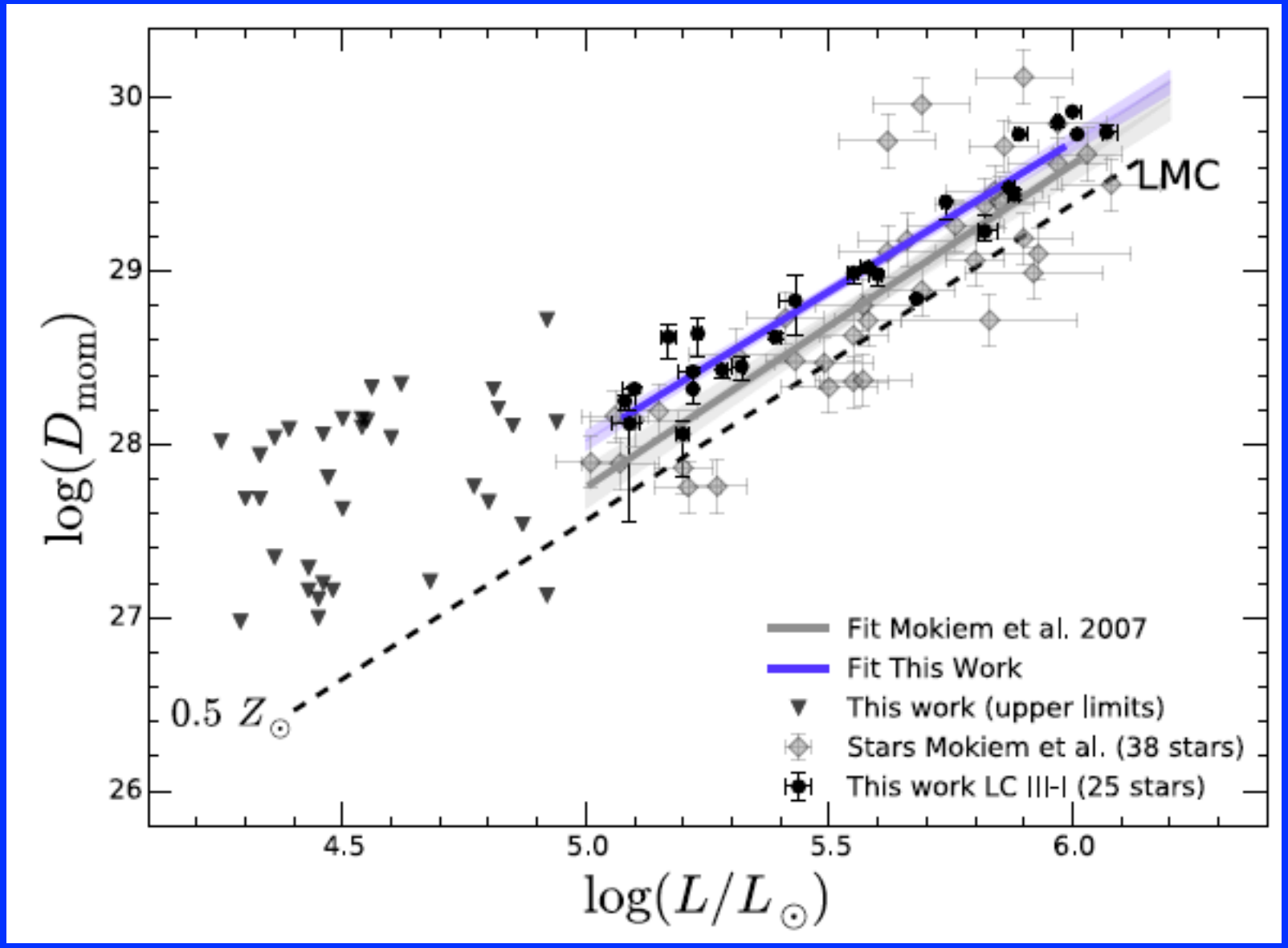
Kotak & Vink (2006) LBV

The IIb SN 2013cu

(Gal-Yam+14: wind Groh+14: LBV/YHG)



Graefener & Vink (2016) Superwind!



(Ramirez+17 VFTS) Empirical dM/dt down factor 2-3 (CI 6-8)
If theory OK

The reason for the *jump*

- Temperature drops

→ Fe recombines from Fe IV to Fe III

→ Line force increases

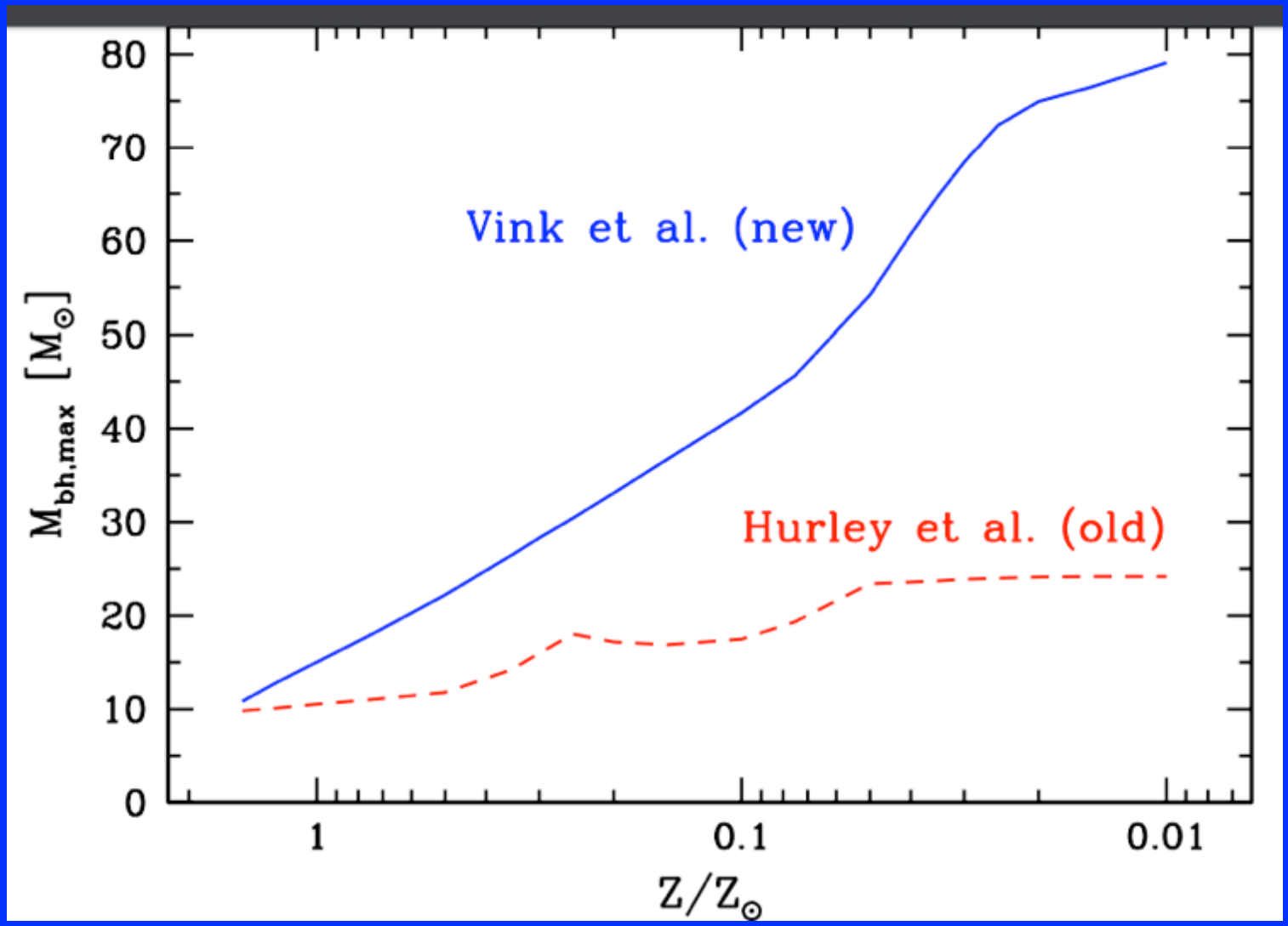
→ dM/dt up

→ density up

→ V(inf) drops

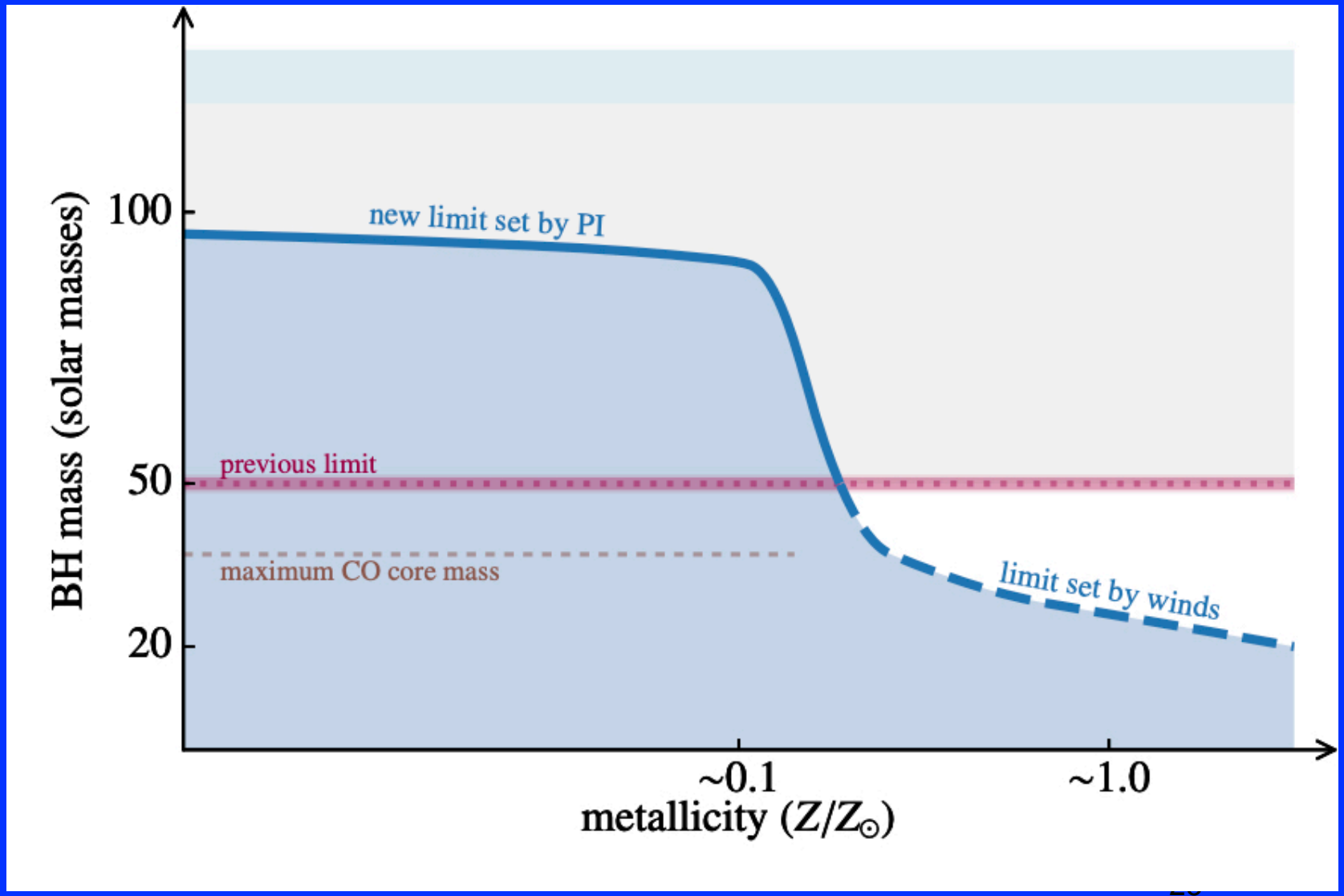
→ “Runaway”

“Heavy” black holes: how?



Belczynski..Vink..et al. (2010)

Maximum Black Hole Mass



Vink et al. (2021, MNRAS 504, 146)