Very Massive Star in Local Universe

Norhasliza Yusof (UM)
in collaboration with
HA Kassim (UM), R Hirschi (Keele), C Georgy (Geneva), S Ekstrom (Geneva), G Meynet (Geneva), PA Crowther (Sheffield), O Schnurr (AIP), D Whalen (Heidelberg), A Heger (Monash)

Blowing in the Wind, Quy Nhon (11 August 2016)

BRIEF INTRODUCTION
UNIVERSITY OF MALAYA

Astrophysics@UM

- 37 academic staff in Department of Physics (4 in astrophysics research - 1 Professor, 1 Associate Professor, 2 Senior Lecturer)
- Research in astrophysics - stellar evolution, radio astronomy & optical astronomy
- Stellar evolution - massive & very massive stars
- Radio astronomy - focus on evolution of galaxy using HI & CO tracer, solar physics
- Optical astronomy - focusing Islamic astronomy using small telescope

How Massive Star can be?

- Do very massive star exist (VMS > 100 Mo)?

(Figer, 05, Crowther et al, 2010, Very Massive Star in Local Universe, 2014, Ed JS Vink)

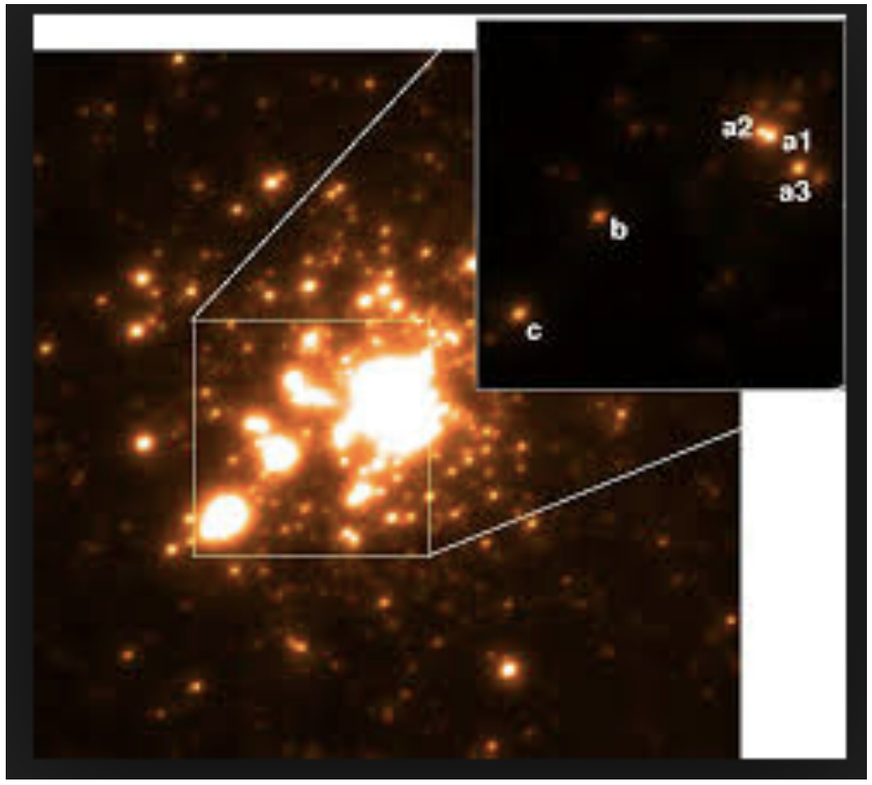
Star formation (difficulties for 30 Mo)

Stellar evolution : possible up to 1000 Mo (but mass loss/radiation)

- Can we see them?

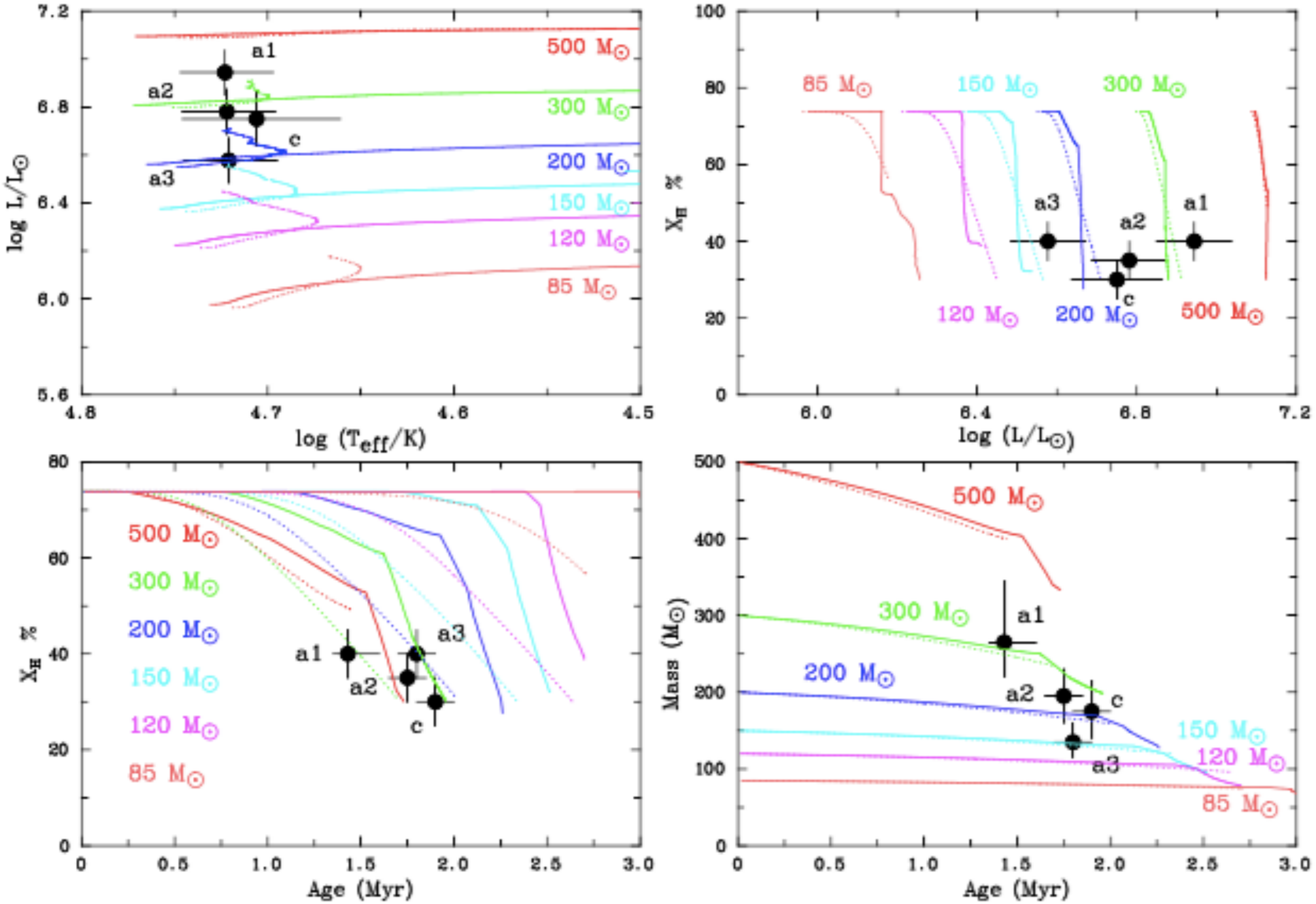
Rare, short-lived, need to see young massive cluster

Arches (Mass ~ 150 Mo) and NGC3603 and R136 (Mass ~ 320 Mo)



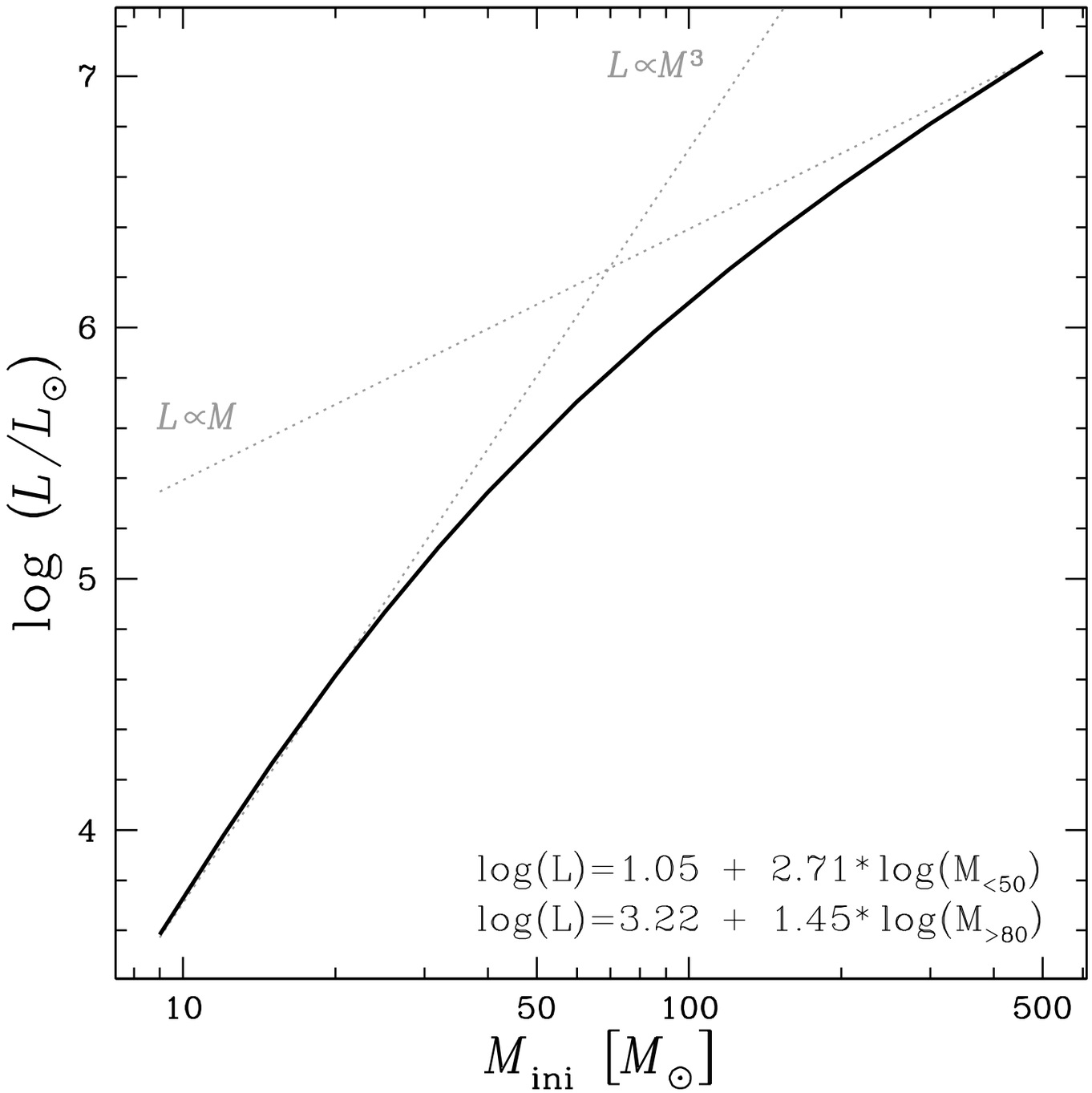
Crowther et al, 2010

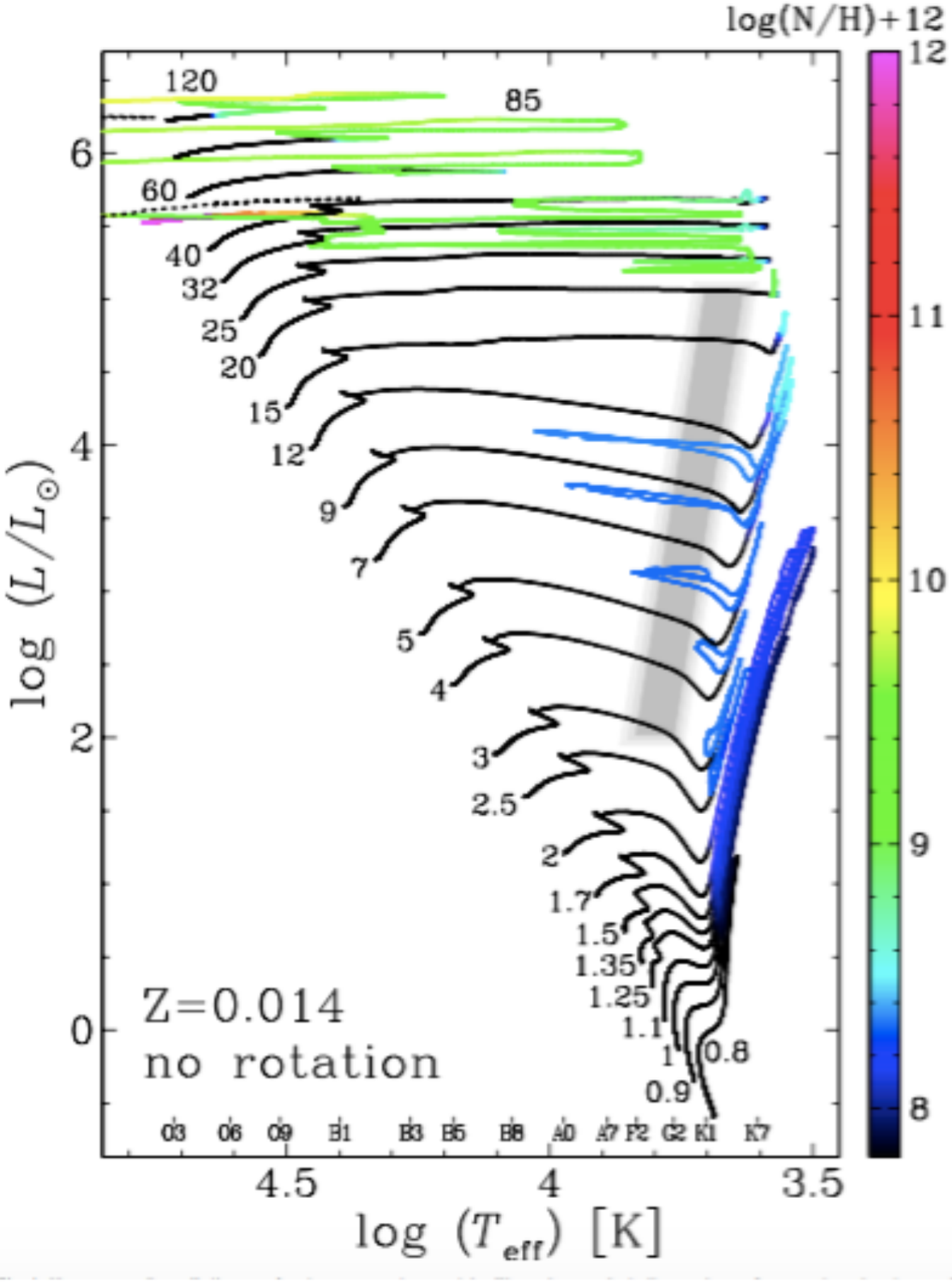
R136a1

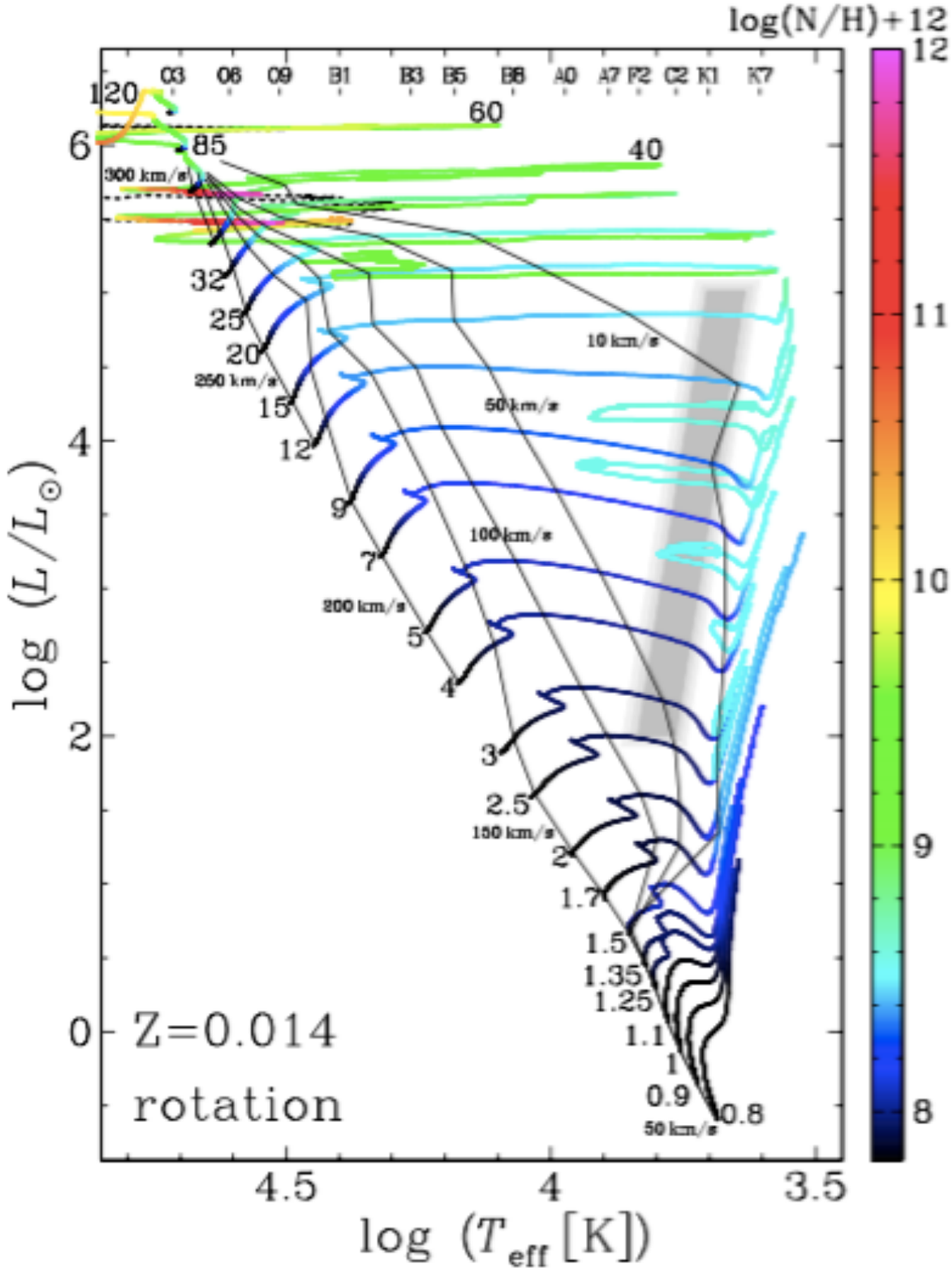


Crowther et al (2010)

Mass vs Luminosity

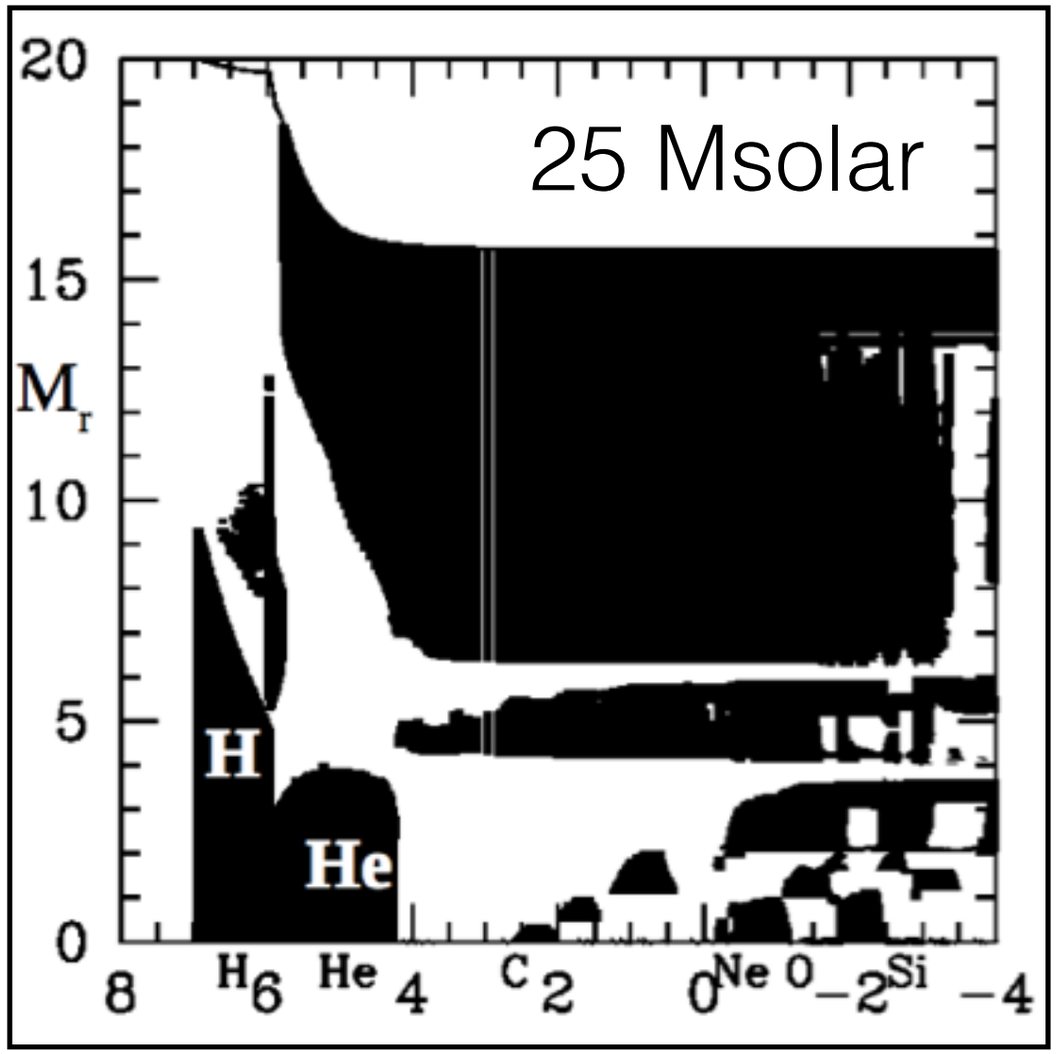




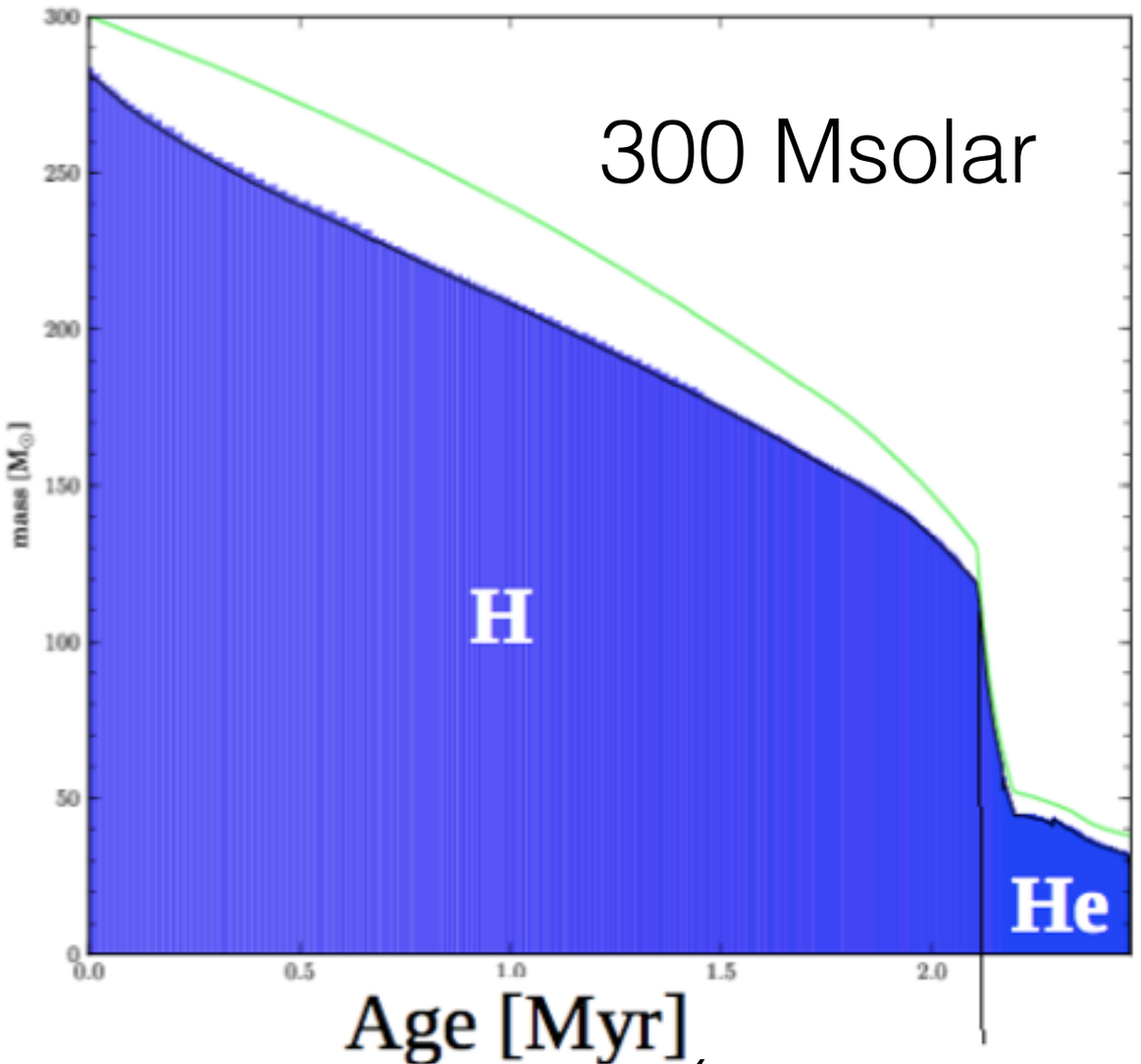


Ekstrom et al (2012)

Evolution of VMS

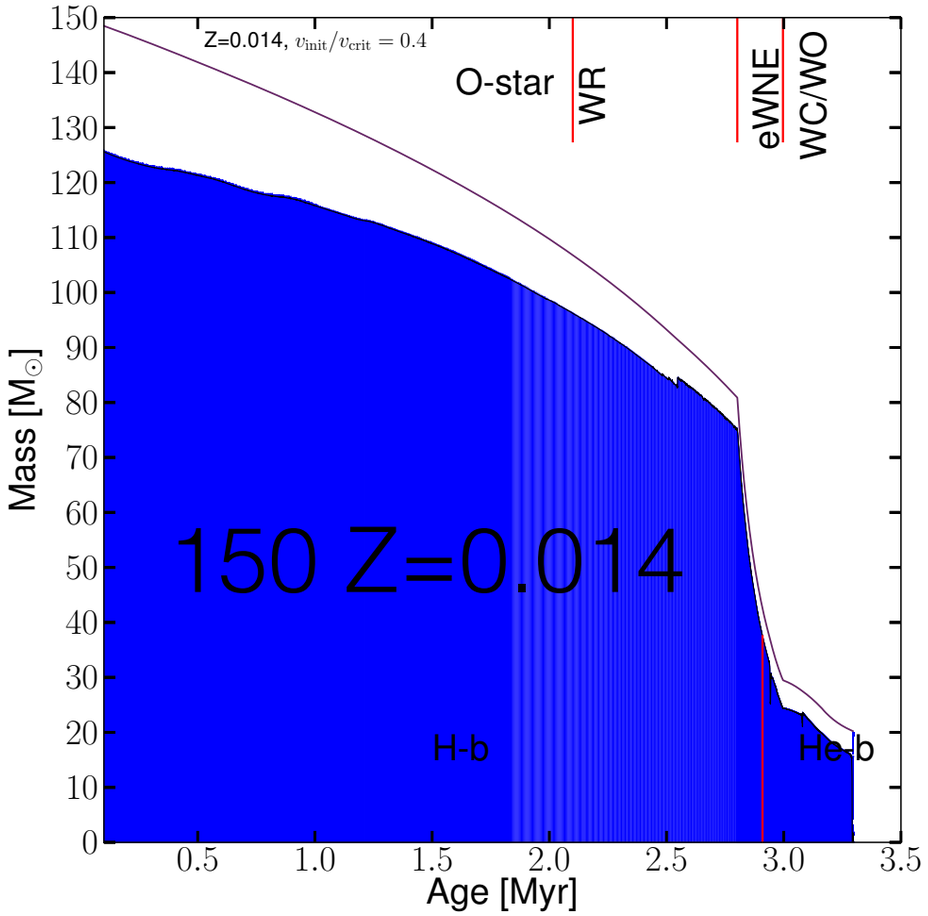


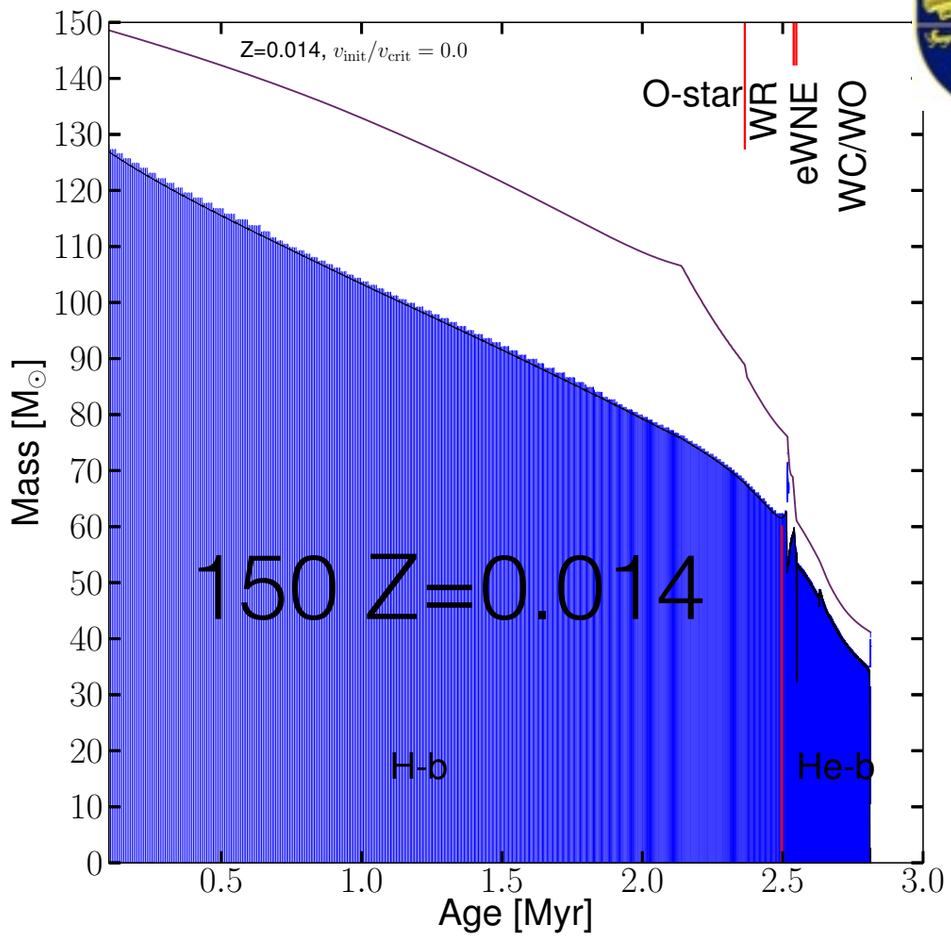
(Hirschi, 2004)

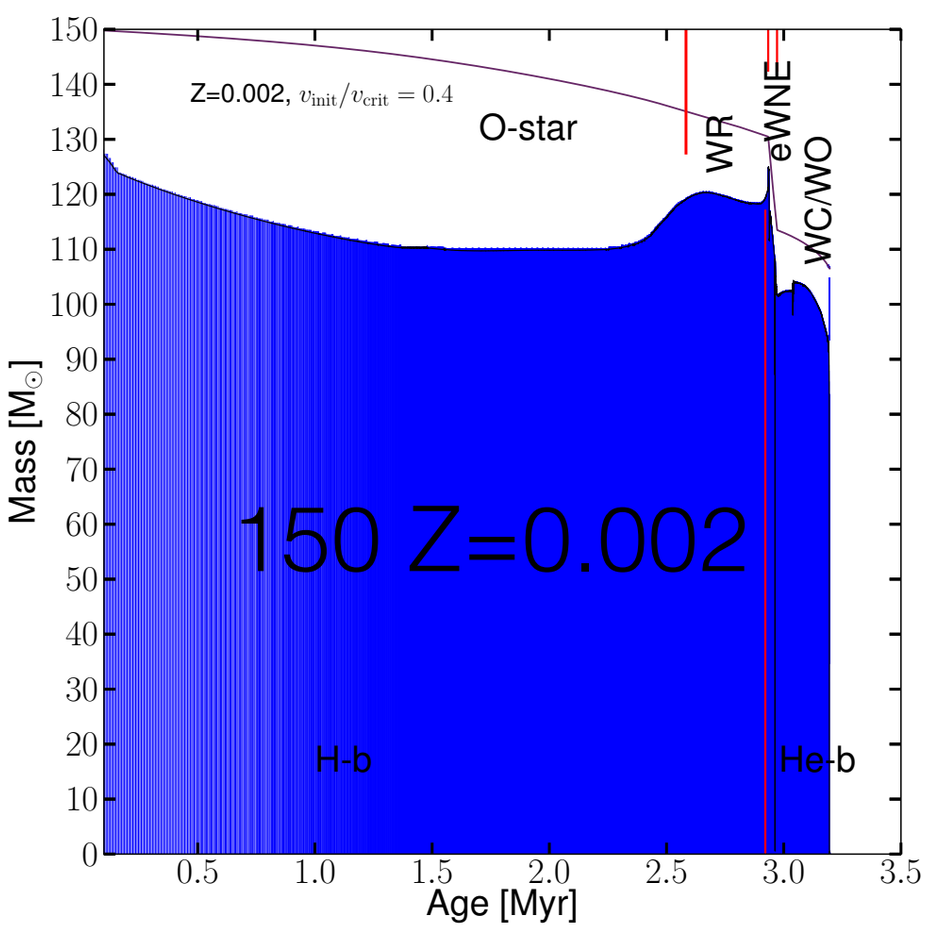


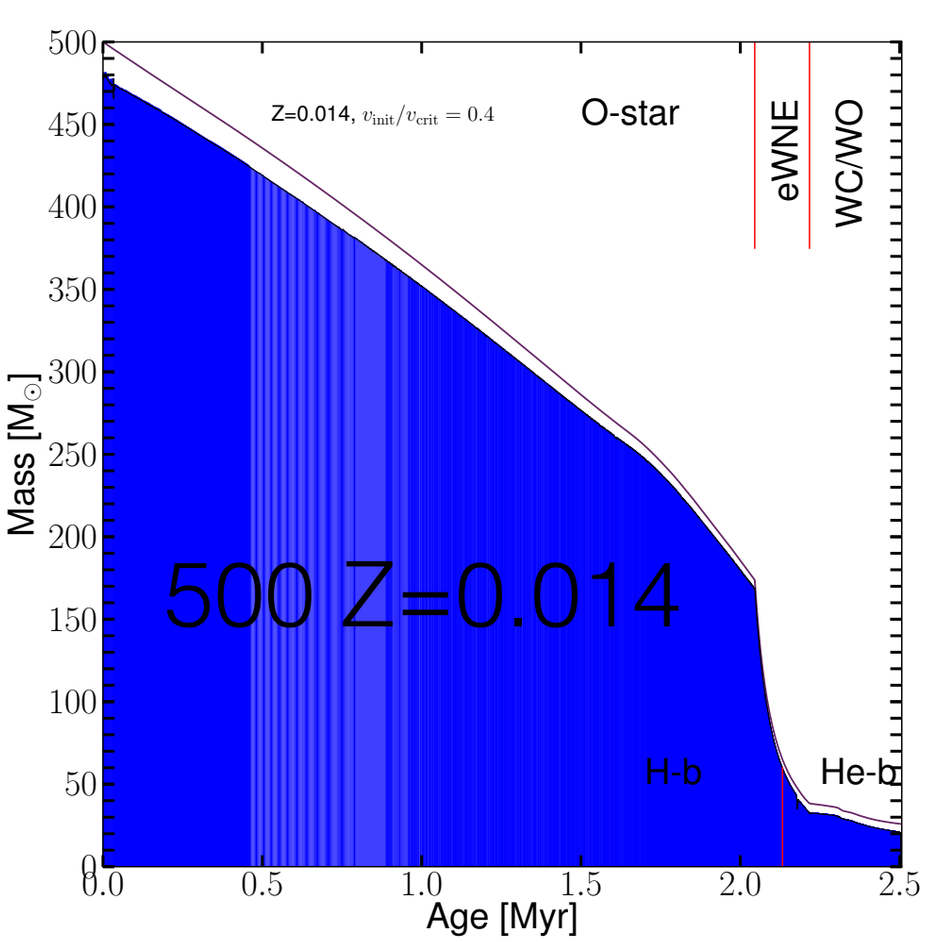
(Yusof, 2012)

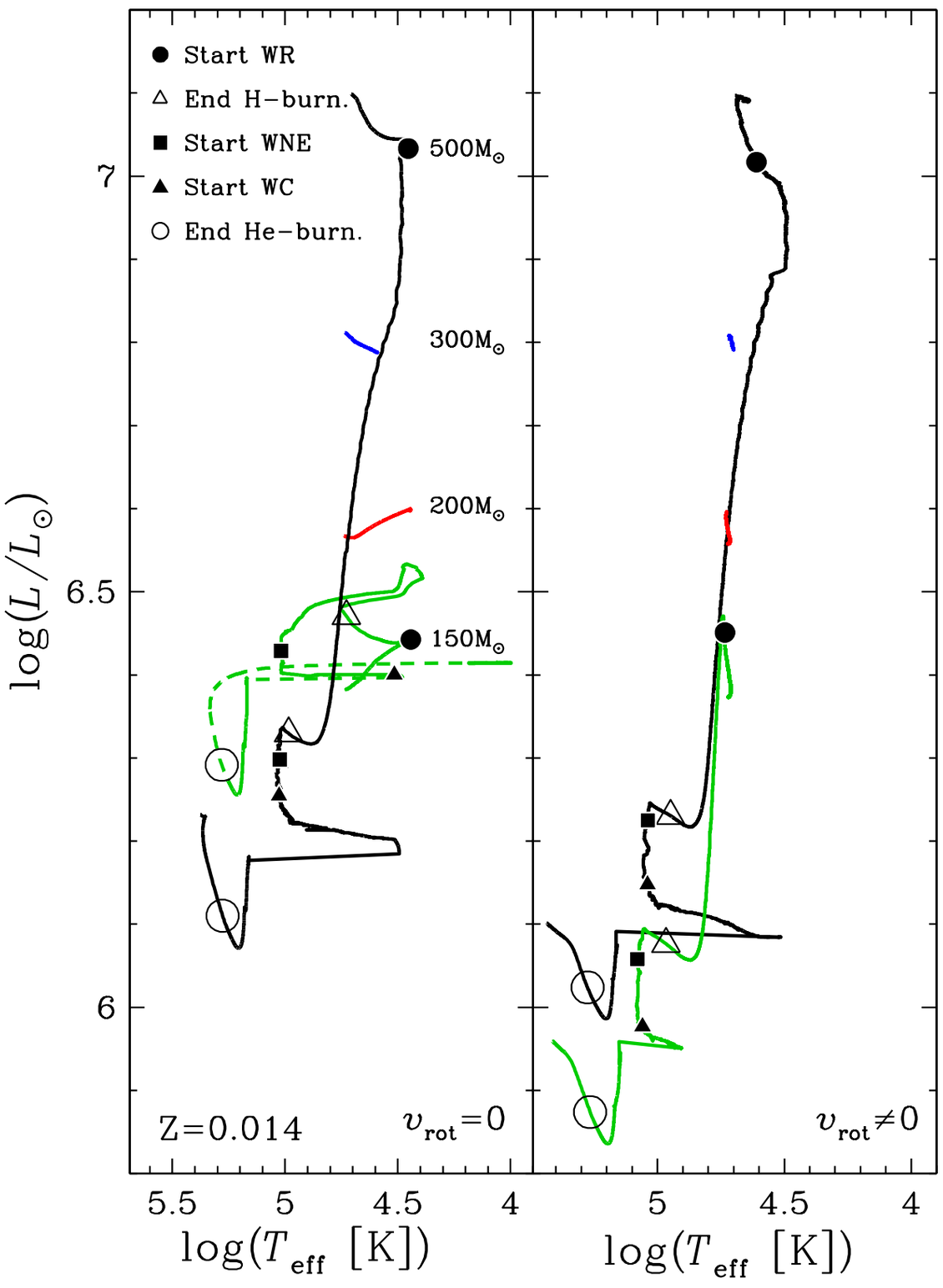
VMS : Larger convective core and mass loss

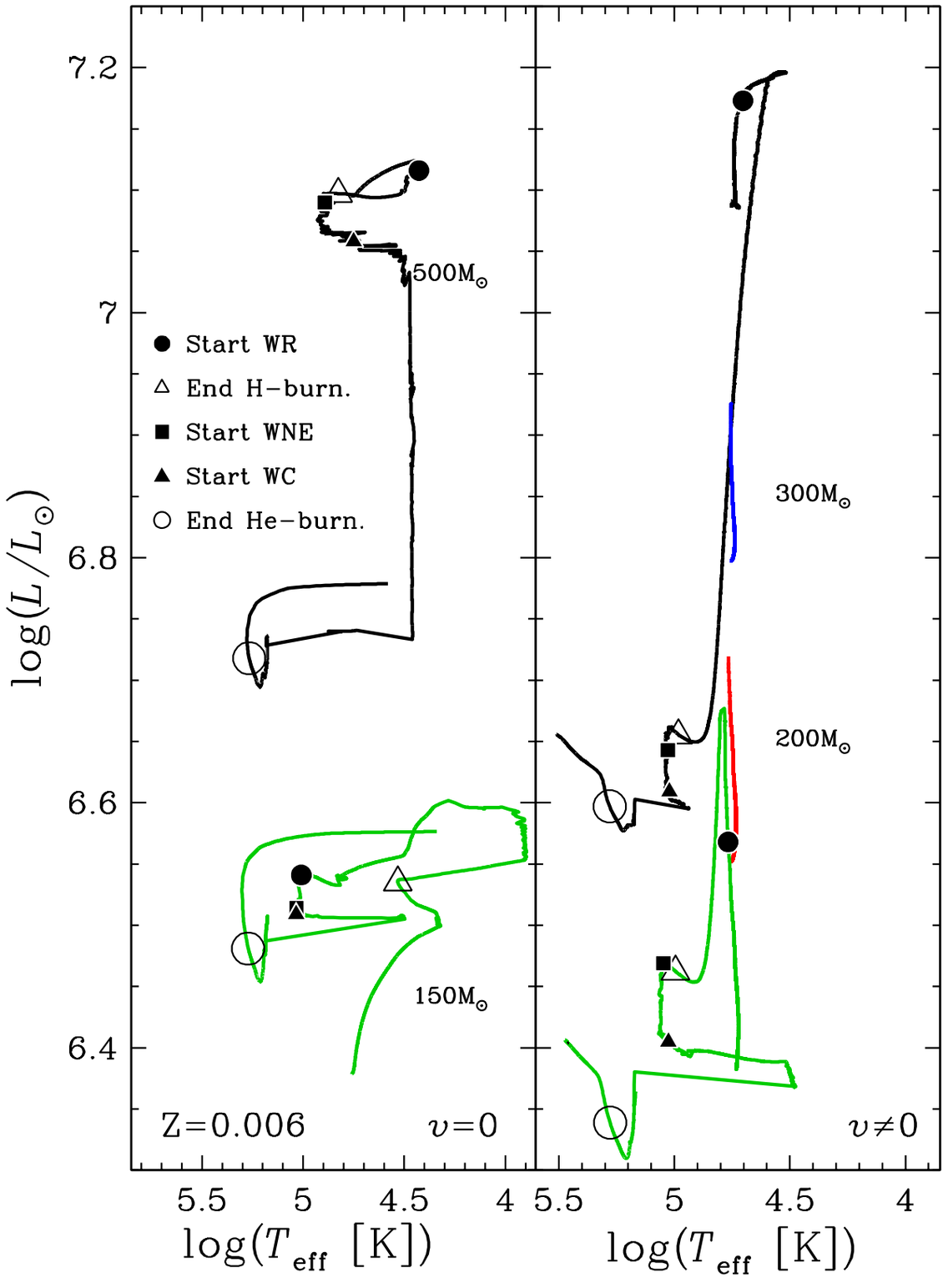

Z=0.014, $v_{\rm init}/v_{\rm crit}$ = 0.4
O-star
WR
eWNE
WC/WO
150 Z=0.014
H-b
He-b
Mass [M$_\odot$]
Age [Myr]


Z=0.014, $v_{\rm init}/v_{\rm crit}$ = 0.0
O-star
WR
eWNE
WC/WO
150 Z=0.014
H-b
He-b
Mass [M$_\odot$]
Age [Myr]


Z=0.002, $v_{\rm init}/v_{\rm crit}$ = 0.4
O-star
WR
eWNE
WC/WO
150 Z=0.002
H-b
He-b
Mass [M$_\odot$]
Age [Myr]

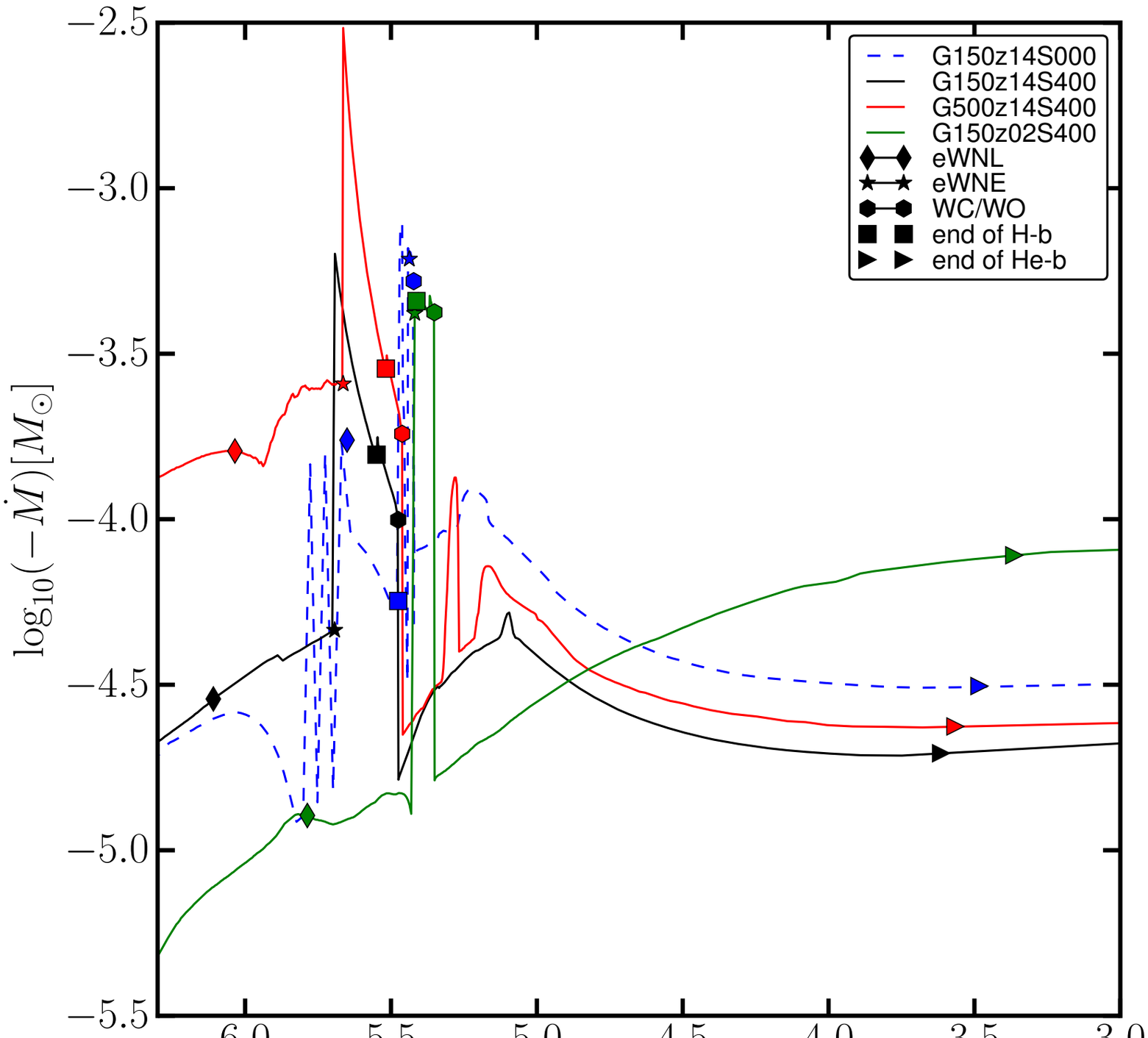

Z=0.014, $v_{\rm init}/v_{\rm crit}$ = 0.4
O-star
eWNE
WC/WO
500 Z=0.014
H-b
He-b
Mass [M$_\odot$]
Age [Myr]



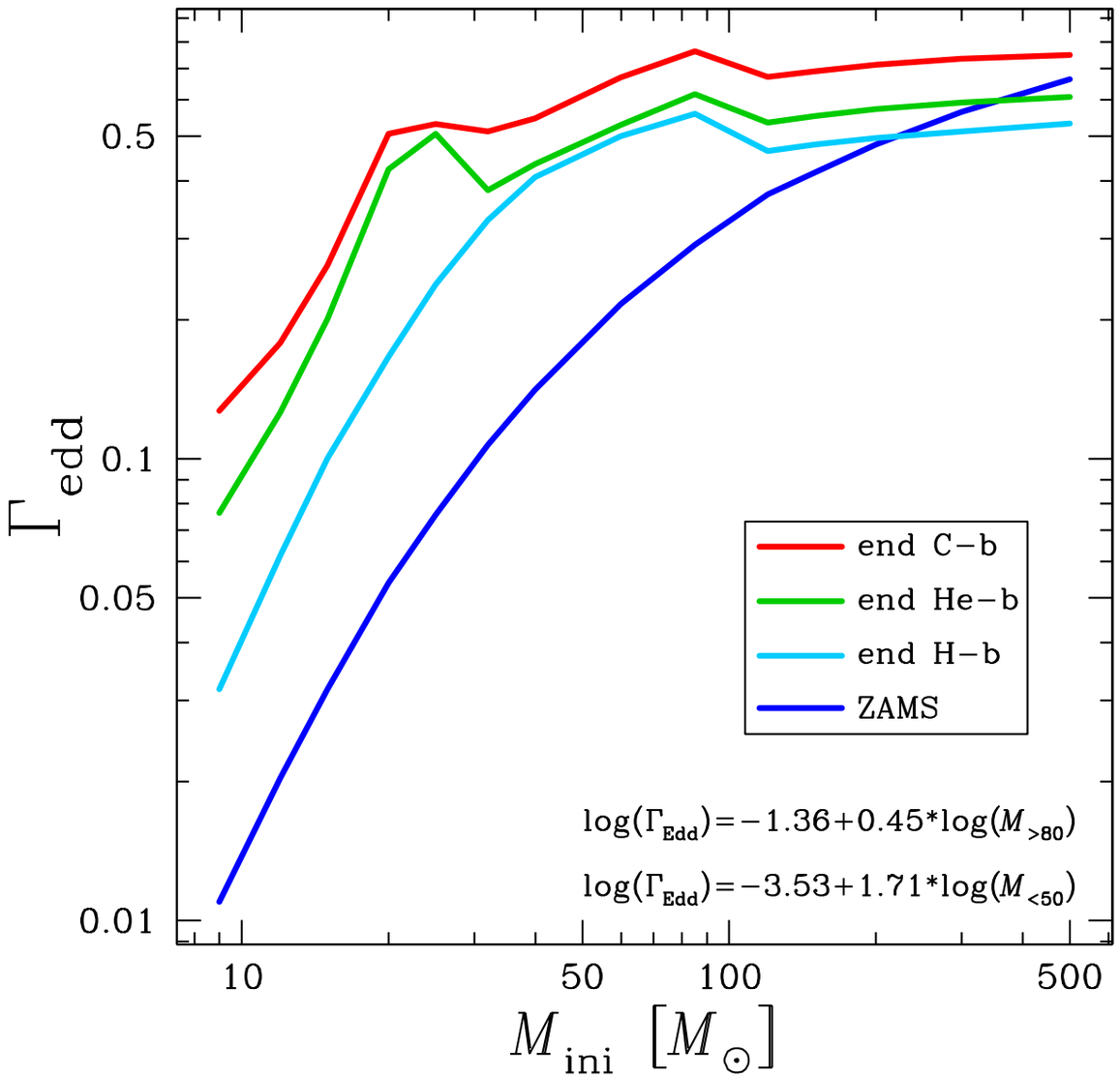


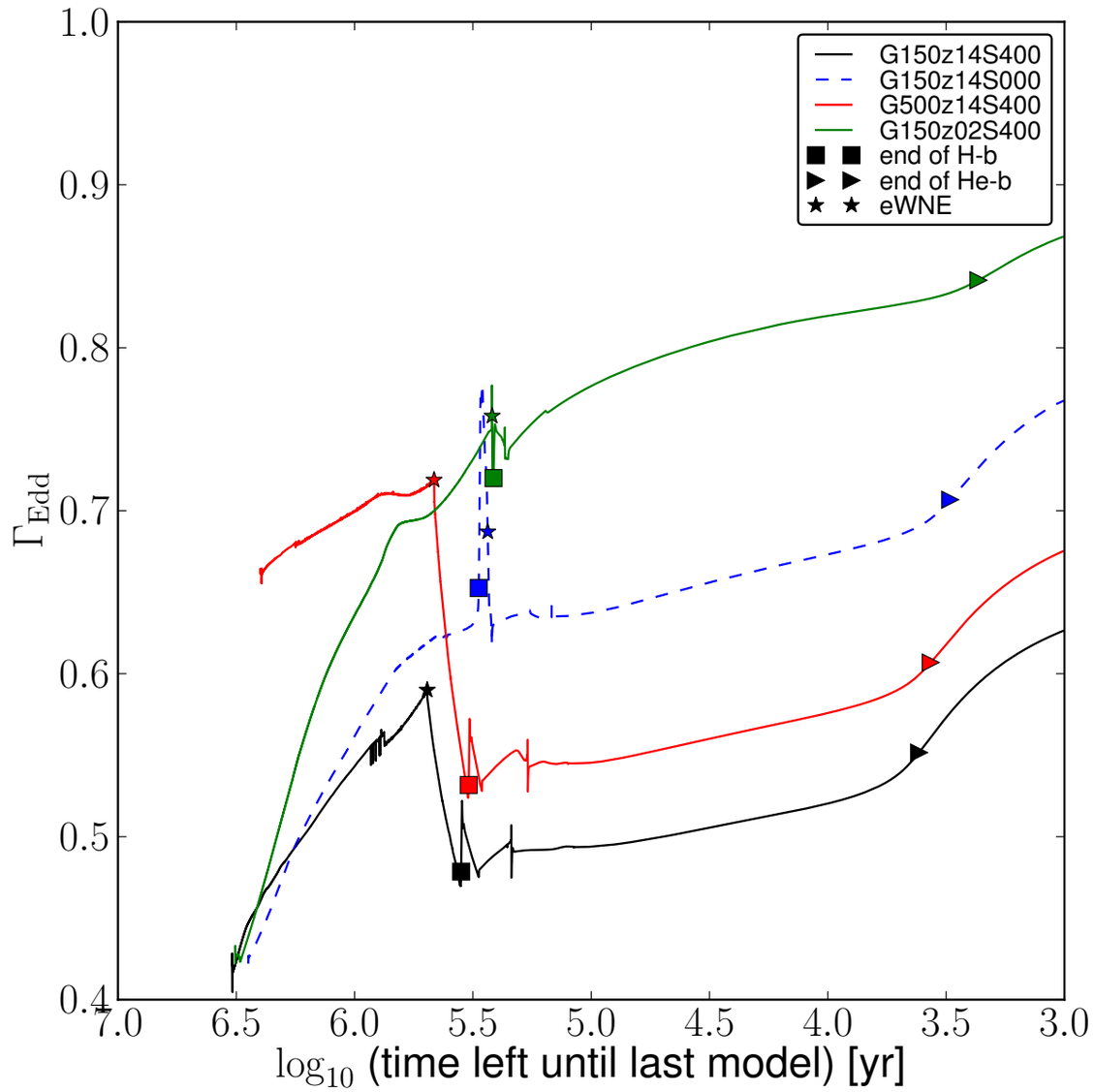
Yusof et al (2013)

Mass loss evolution



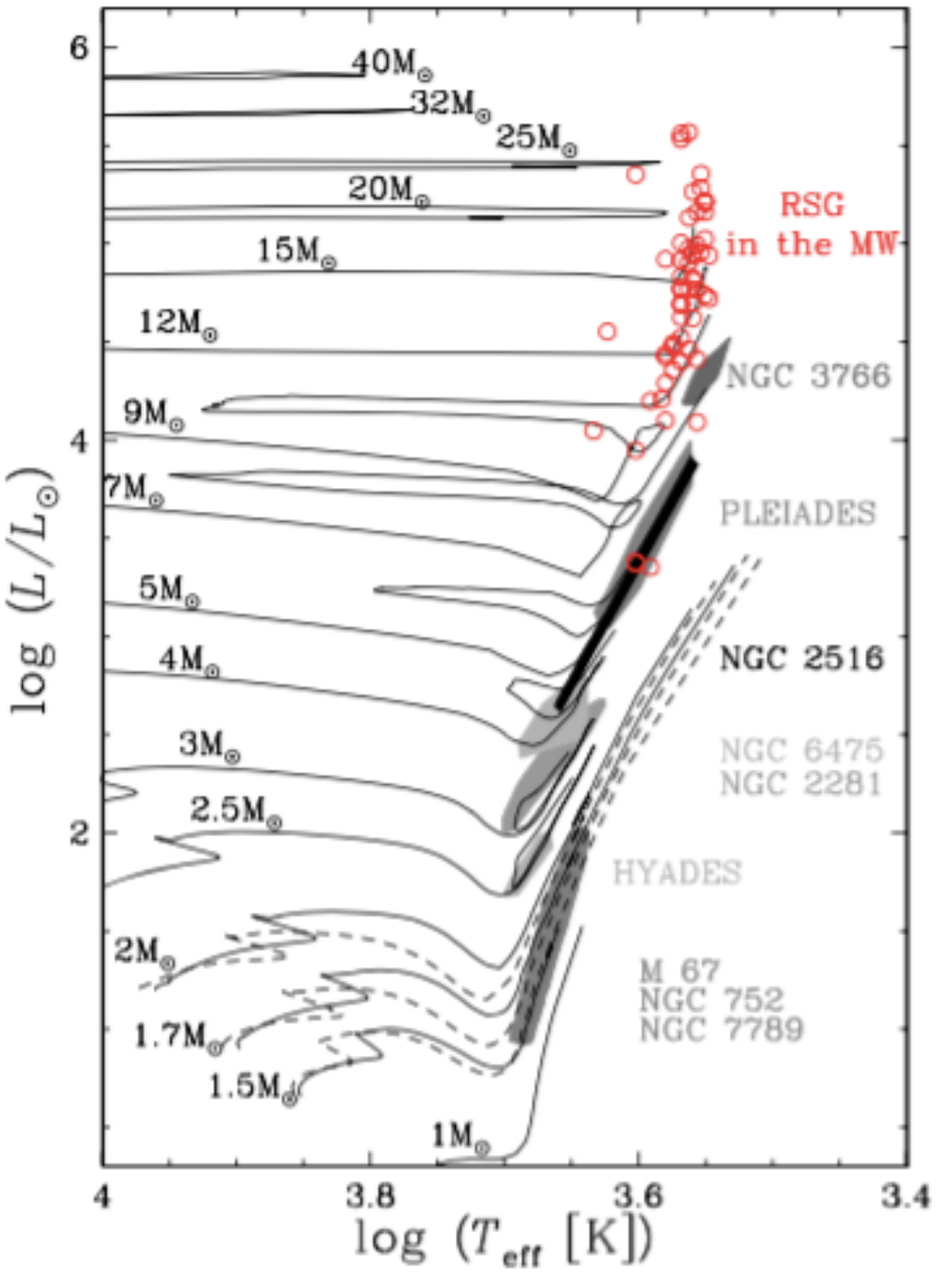
Evolution of mass loss



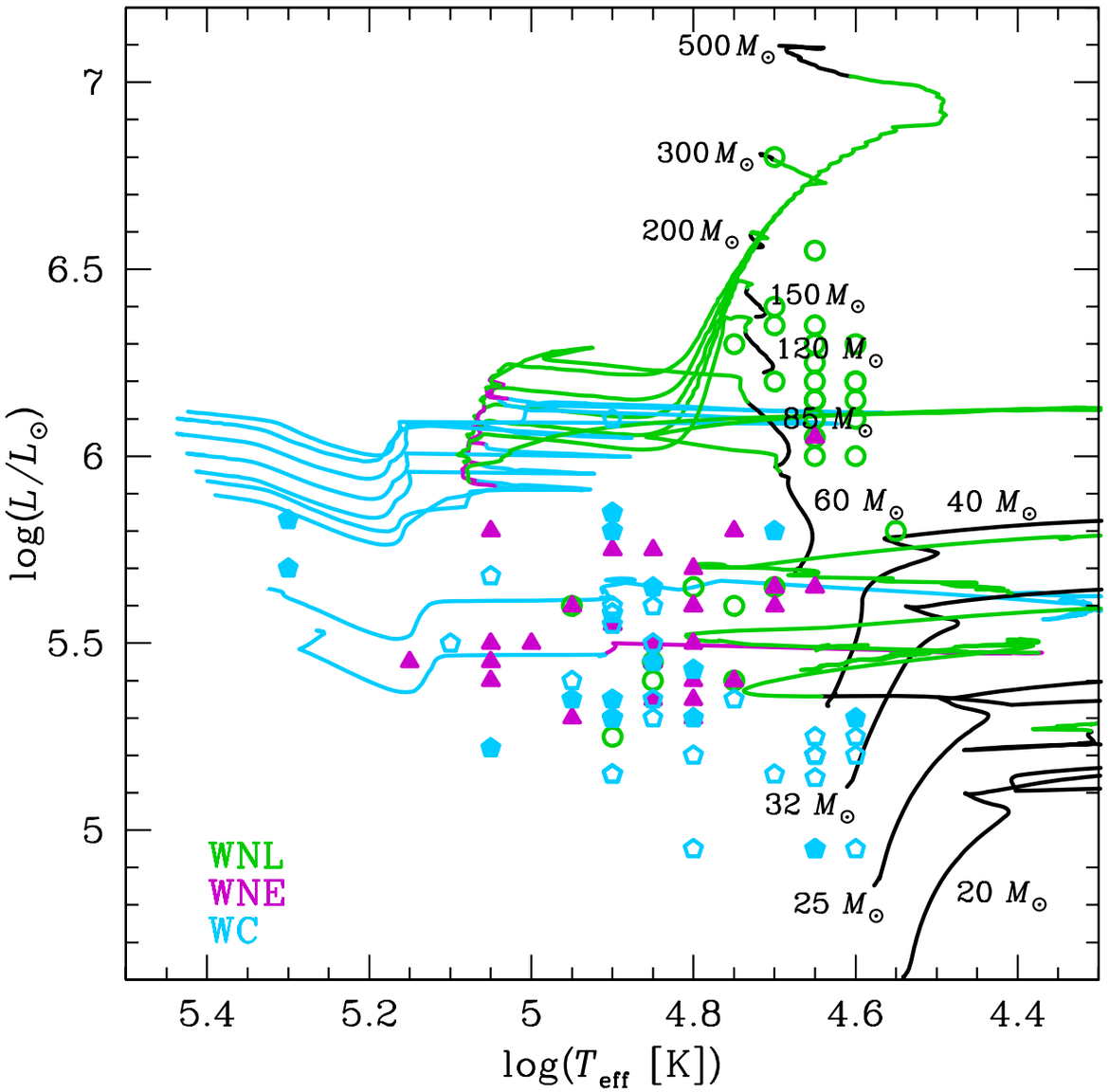


$$\Gamma_{\rm Edd} \propto \kappa L/M$$

WR stars from VMS



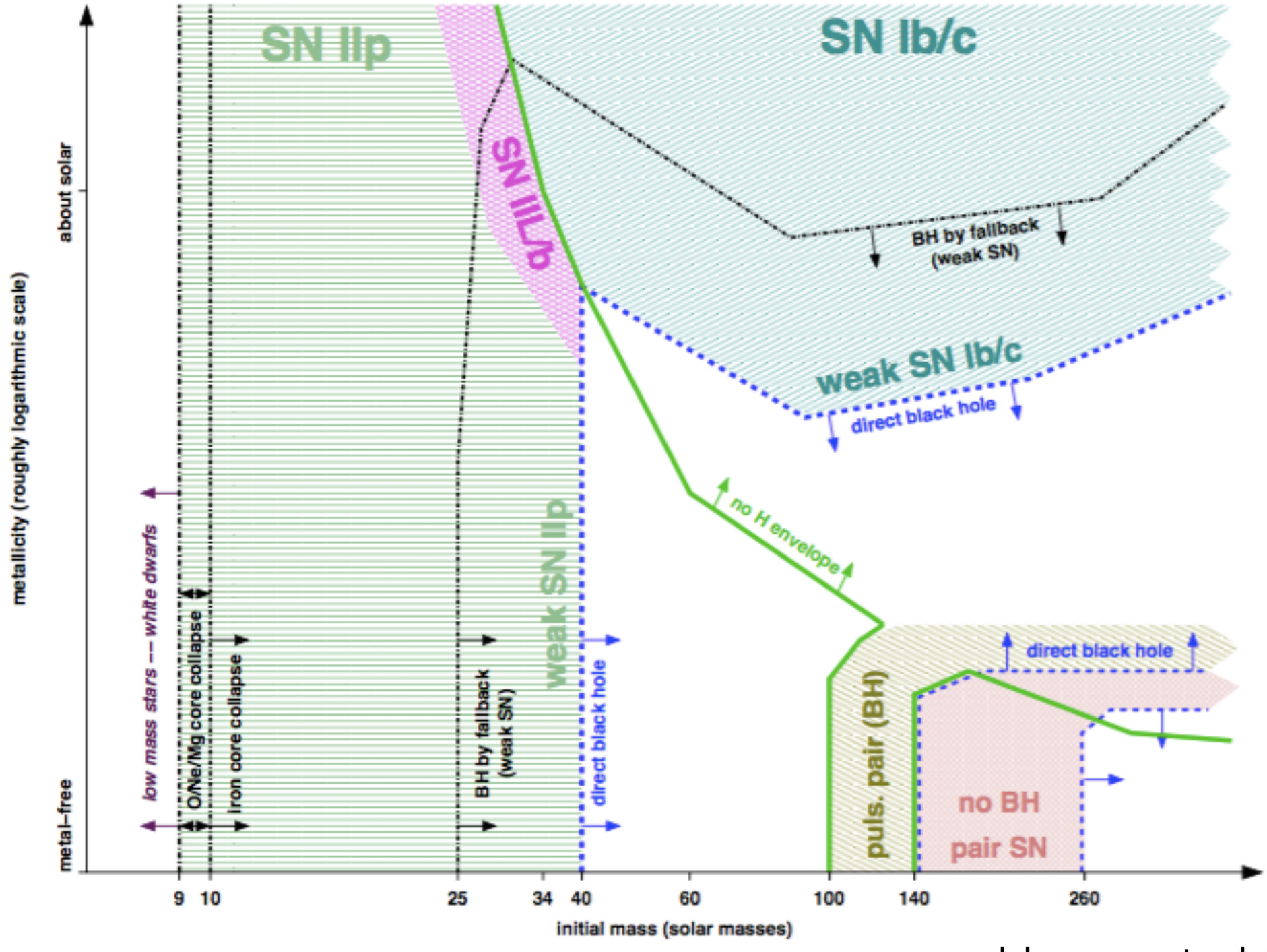
Ekstrom et al. (2012)



Position of WR observed by Hamman (2006) and Sanders (2016)

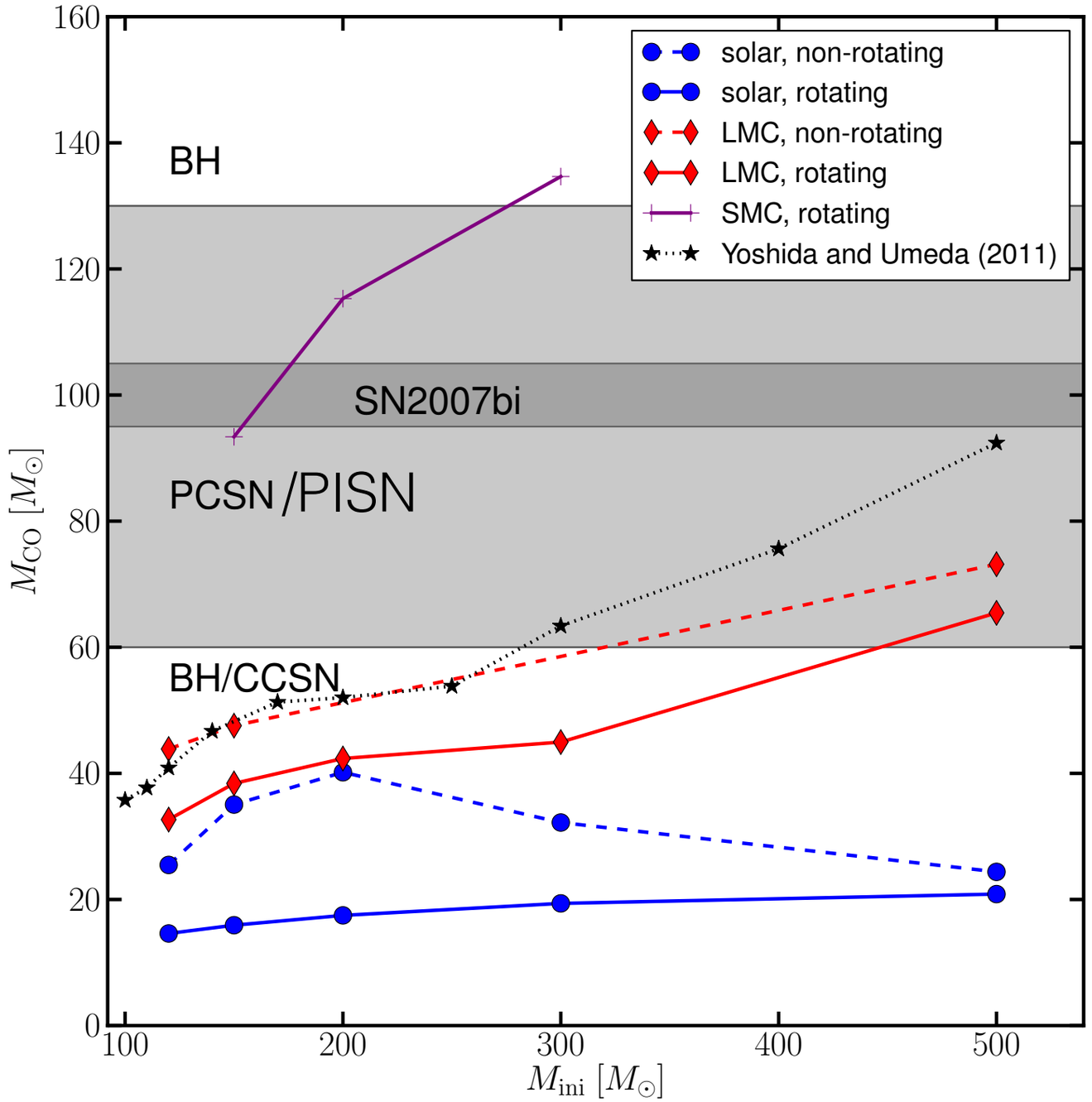
Yusof et al (2013)

FATE OF VMS



Heger et al 2003

FATE OF VMS


160
140
120
100
80
60
40
20
0
100
200
300
400
500
$M_{\rm CO}$ $[M_\odot]$
$M_{\rm ini}$ $[M_\odot]$
BH
SN2007bi
PCSN/PISN
BH/CCSN
solar, non-rotating
solar, rotating
LMC, non-rotating
LMC, rotating
SMC, rotating
Yoshida and Umeda (2011)

SUMMARY

- VMS posses large convective core during MS
- VMS evolve almost homogeneously
- Most VMS stays at blue regions in HRD and do not become LBV
- All enter the WR phase : Of → WNE → WNL → WC/WO
- Due to the mass loss, different initial mass end similar final mass due to the increasing mass loss with mass