Synthetic STPAGB stars

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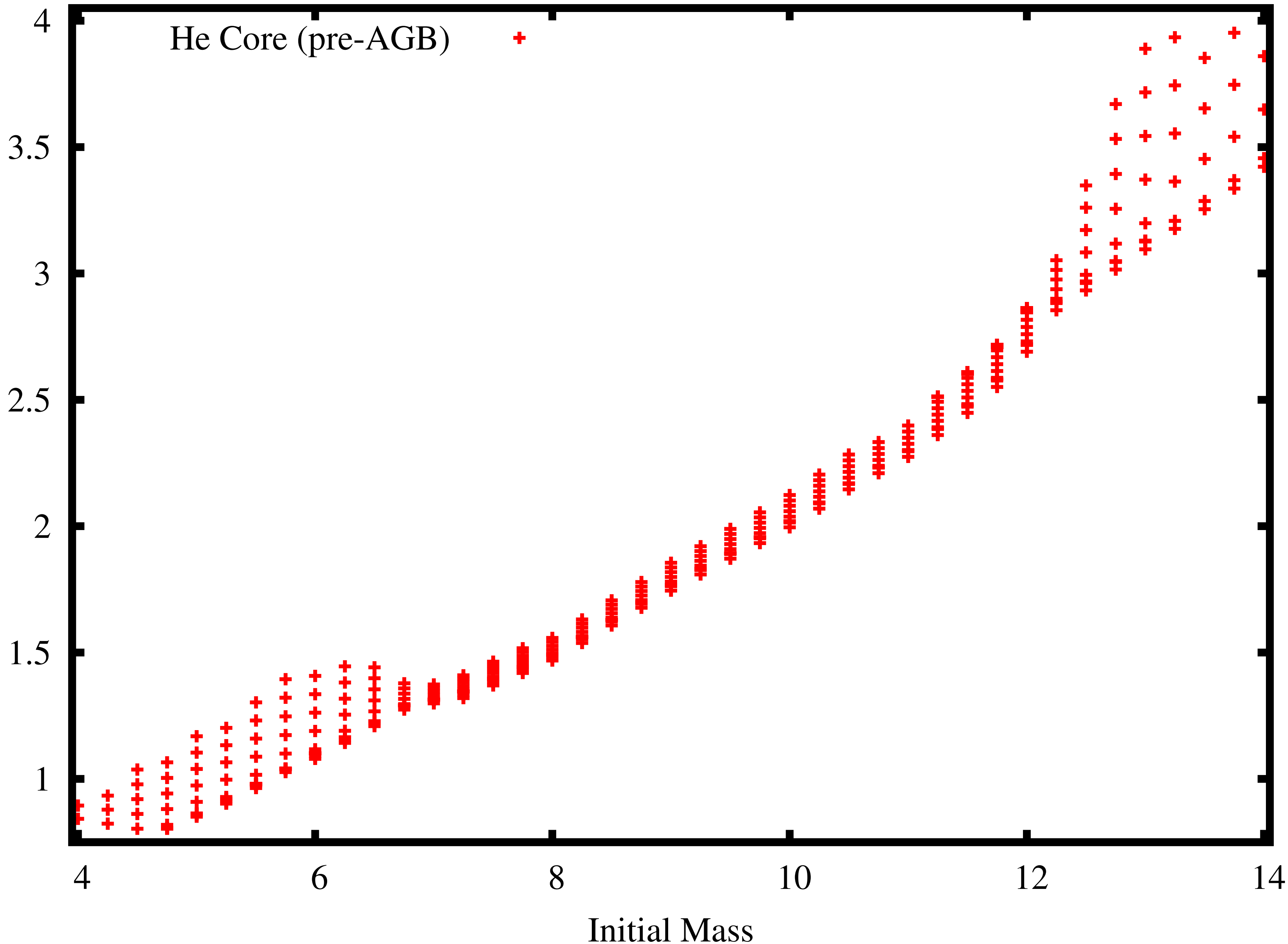
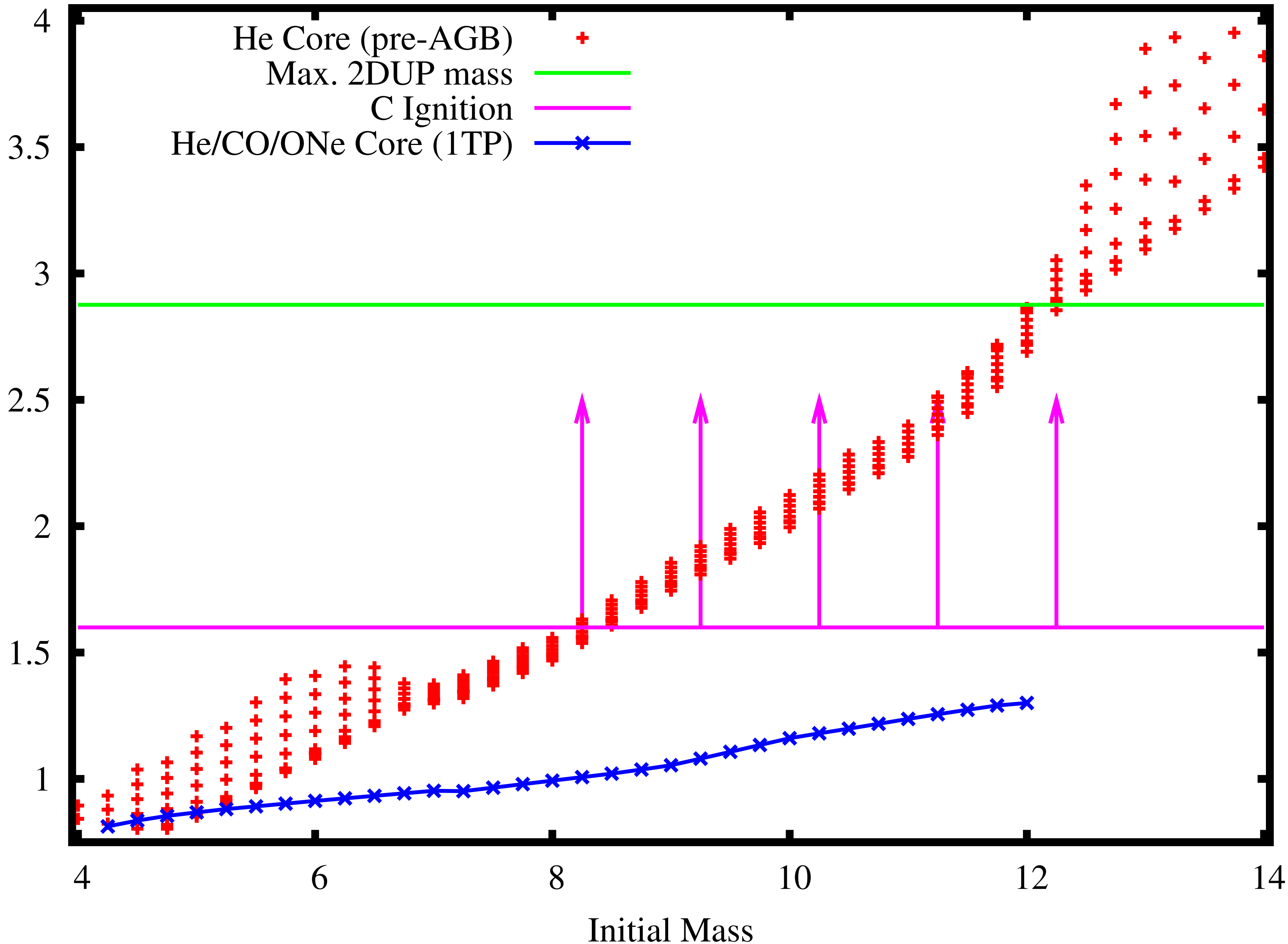
Introduction

- STPAGB stars: carbon ignition, second dredge-up, *many* thermal pulses, HBB (talks by Lionel, Arend Jan)
- Models due to Arend Jan Poelarends (Langer's code)
  - no overshooting
  - $M = 8.5 - 12.5\,\mathrm{M}_{\odot}$
  - $Z = 0.02$
  - no mass loss
- Synthetic models: based on Izzard et al. 2004 models (based on Amanda Karakas' models), modified to include STPAGB stars
- Structure: M_{c}, L, R, $\dot{M}$, λ etc. as $f(M, Z)$
- Chemistry: Dredge-ups and HBB

Core mass evolution $\dot{M} = 0$



Core mass evolution $\dot{M} = 0$



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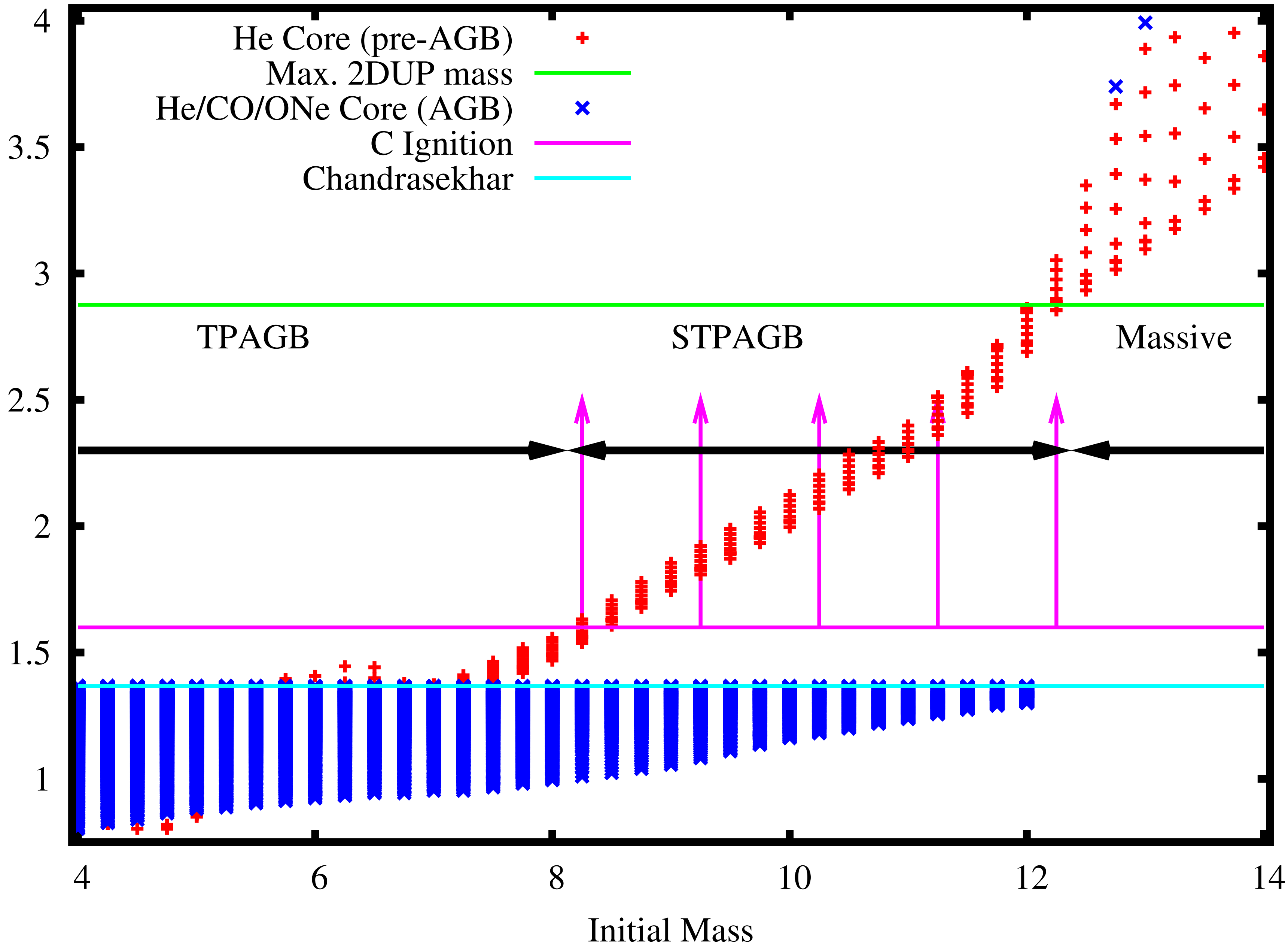
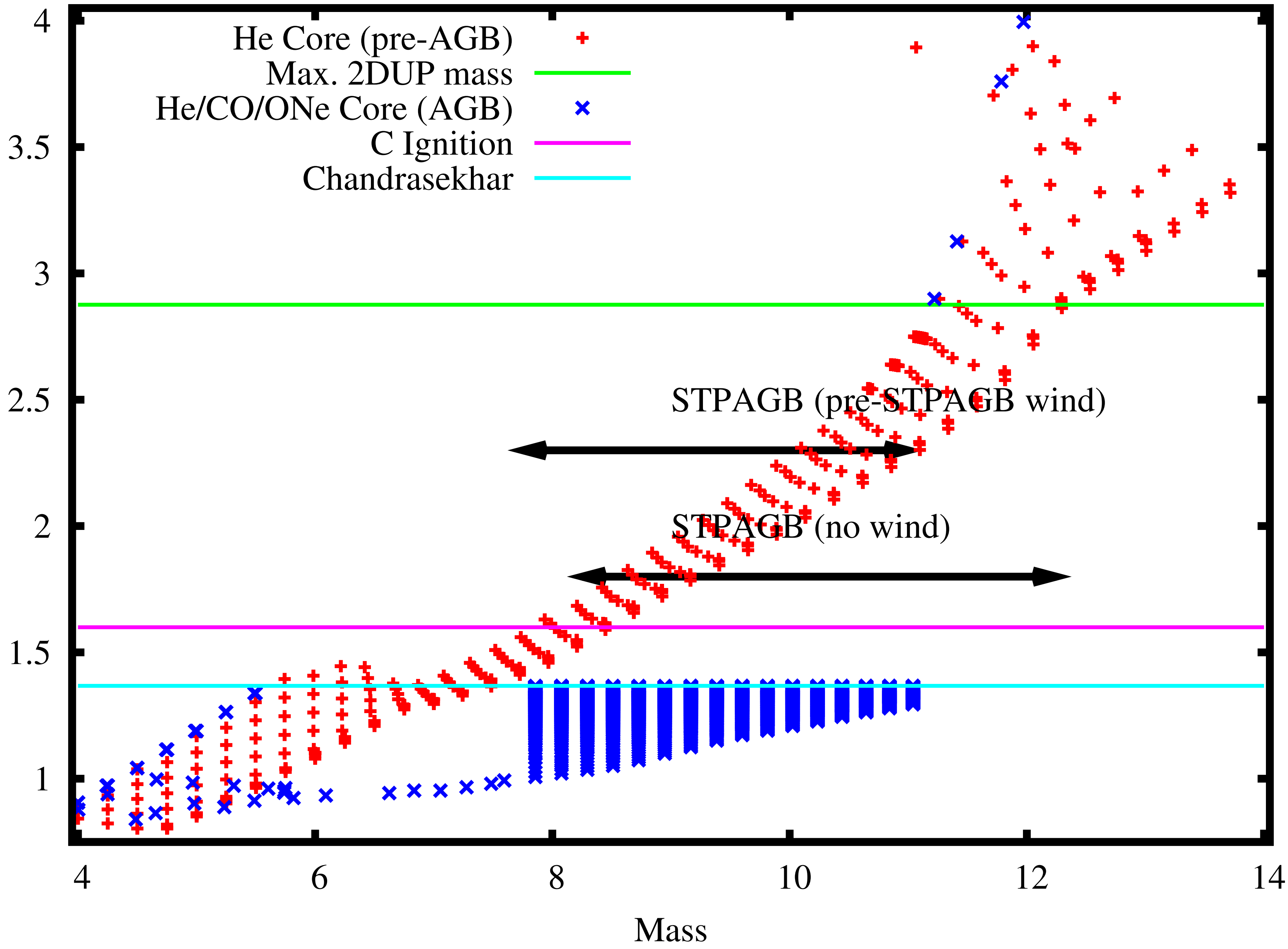
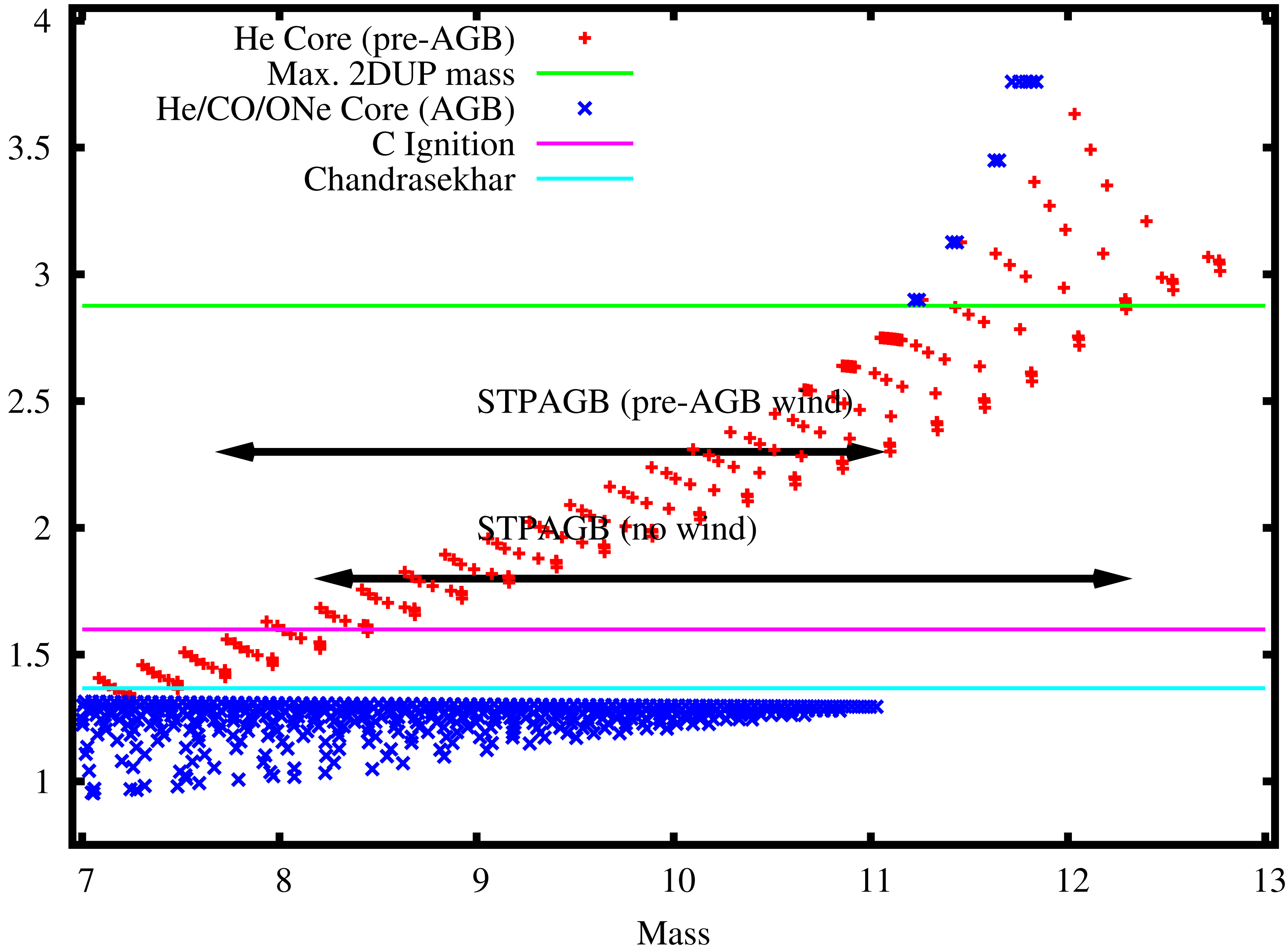


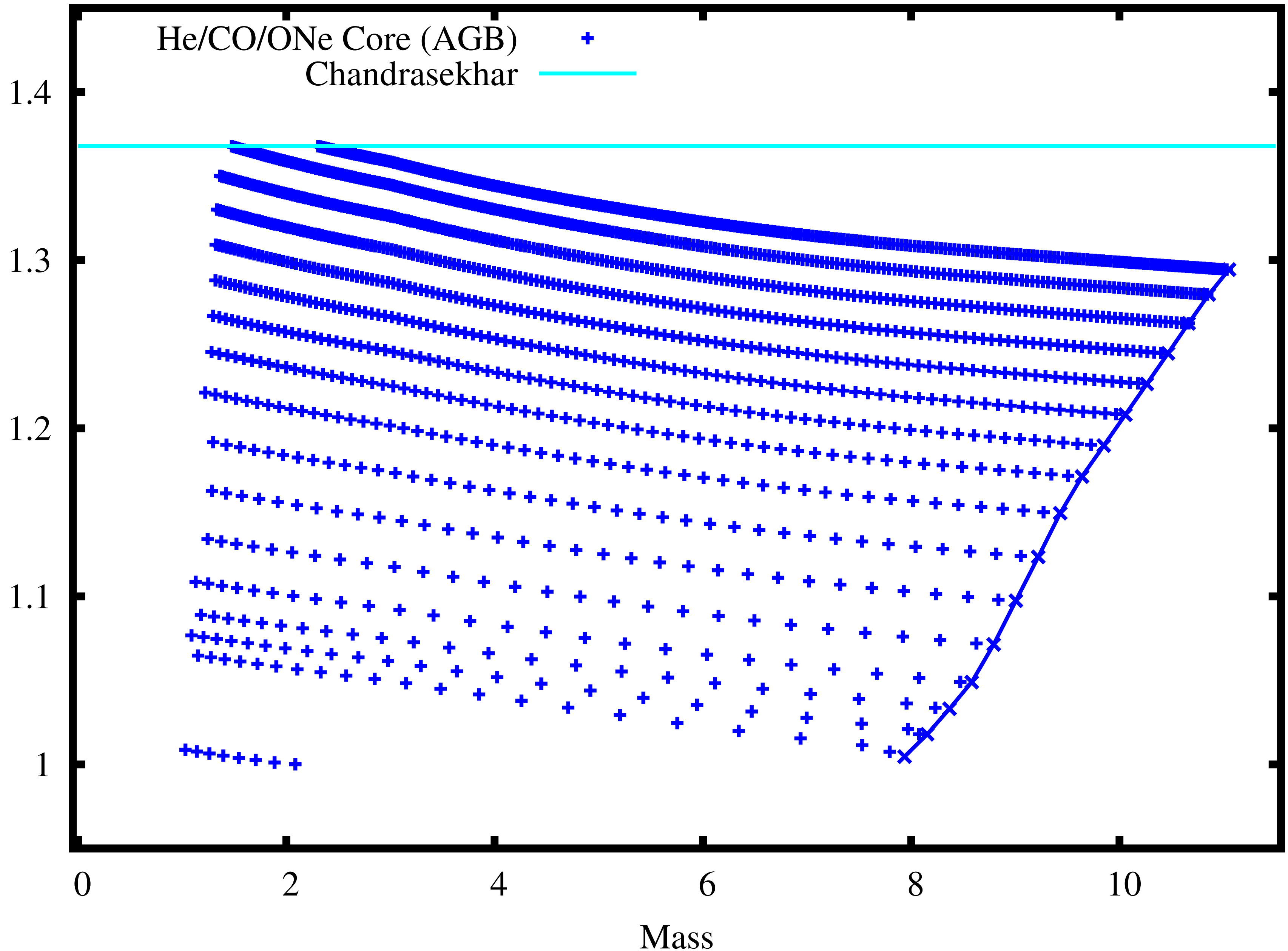
ore mass evolution $\dot{M}$ (H02, 0 for STPAGB



Core mass evolution with $\dot{M}$ (H02+VW)



Core mass evolution with $\dot{M}$ (VW)



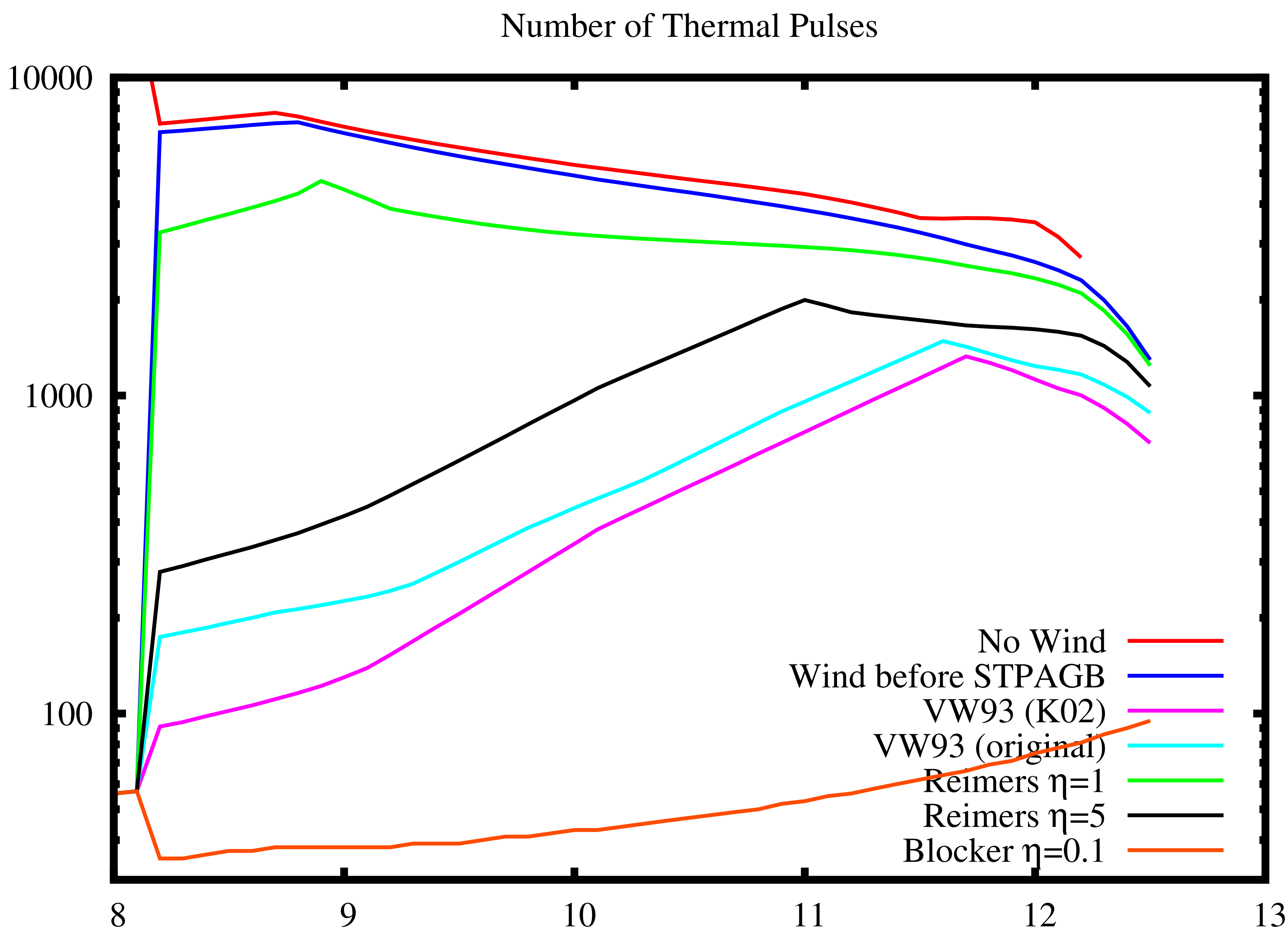
As promised: dodgy statistics

- Mass ranges and formation rates (KTG93 IMF)

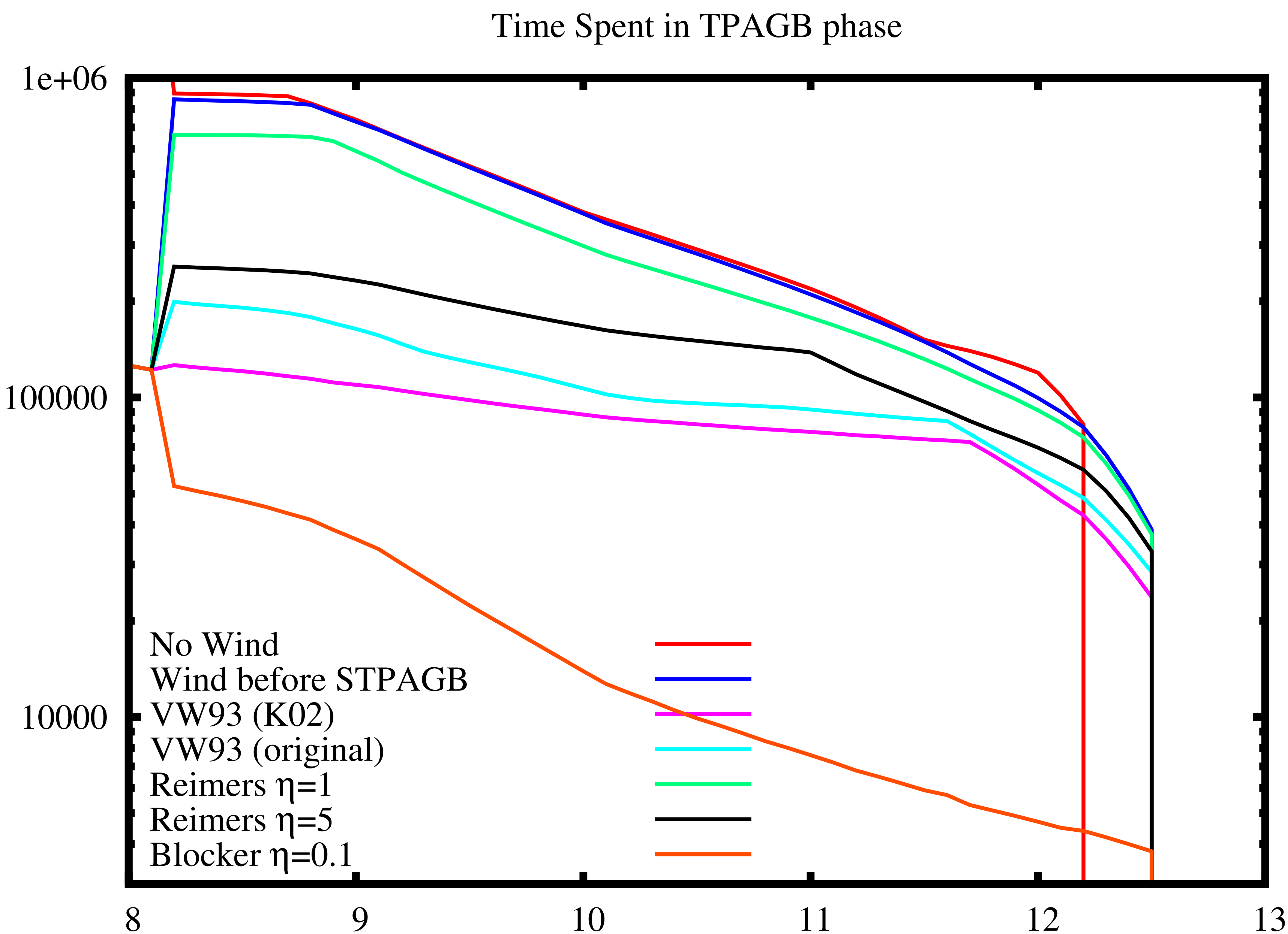
$\dot{M}$	STPAGB M_{ZAMS}	M_{1TP}
no	$8.11 \leq M \leq 11.99$	same
yes (H02+VW93)	$8.15 \leq M \leq 12.19$	$7.98 \leq M \leq 11.20$

- 0.13% of stars go on to an STPAGB phase
- c.f. 8.9% of stars which have normal TPAGB ($M > 1$)
- 0.35% of all stars have HBB $5 \lesssim M \lesssim 8$

Number of pulses



Time in (S)TPAGB phase



EC Supernovae

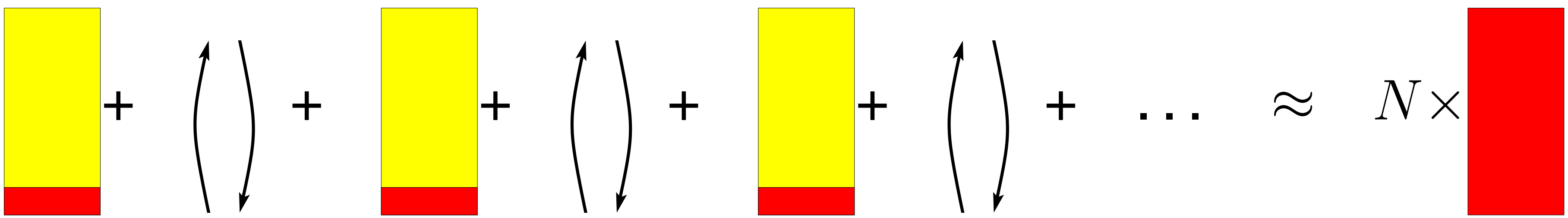
- The most massive STPAGB cores reach M_{Ch} before mass loss removes the envelope
- Core collapses: Electron-capture SN (?)

$\dot{M}$	p_{ECSN}	p_{CCSN}	Ratio EC/CC
no	1.3×10^{-3}	1.2×10^{-3}	~ 1
yes (VW93/K02)	8.6×10^{-5}	1.1×10^{-3}	7%

- Either way, we should see some EC supernovae
- Yield: assume envelope lost to space, no fallback ($\dot{M} = \infty$)
- core→neutron star ($M = 1.368\,\mathrm{M}_\odot$)

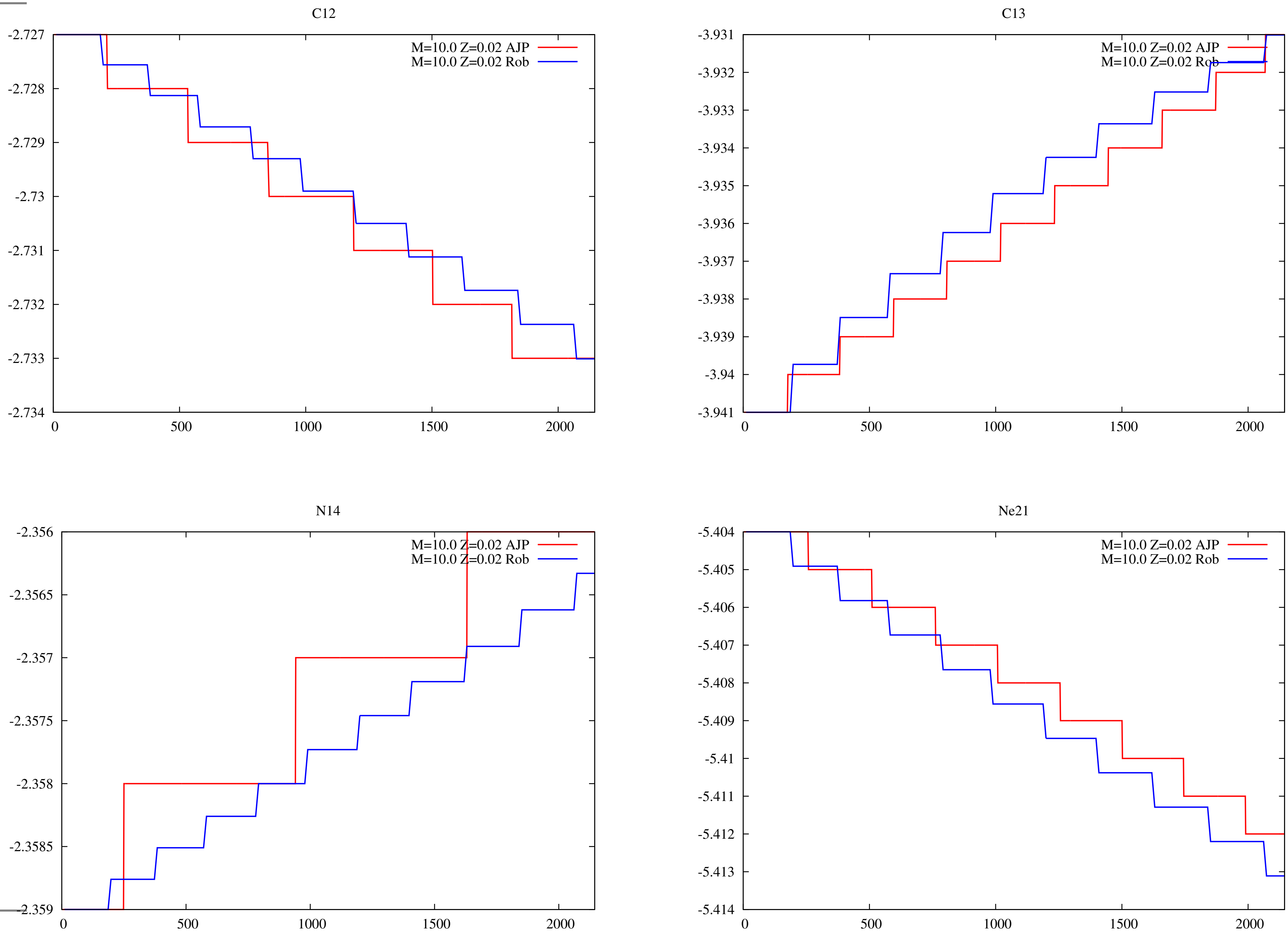
Hot Bottom Burning

- Base of convective envelope $\log_{10} T \to 8$
- CNO, NeNa and MgAl cycles activate



- T, ρ from full evolution models
- Fit burn time and amount
- Two numbers: fit $N \sim 10$ isotopes (CNO, NeNa, MgAl)
- Works with Amanda's TPAGB models...
- Apply to Arend Jan's STPAGB models

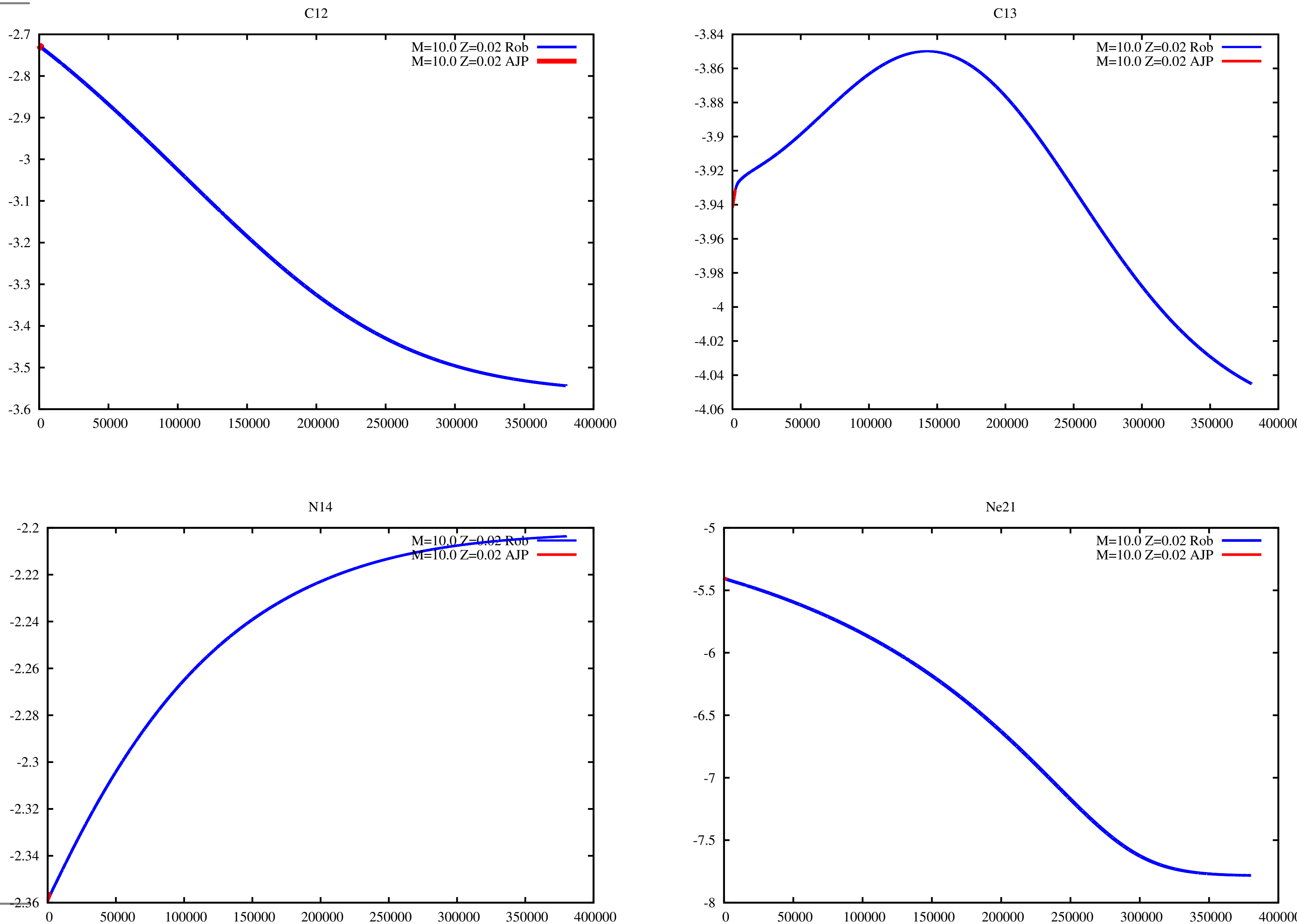
HBB Fitted ($10\,M_\odot$)



Problems

- Model timescale very short (20 pulses $\sim$ few thousand years!)
- Surface abundance change of most isotopes is small
- Some (C,N,^{21}Ne, sometimes $^{24/25}$Mg) change enough to fit or
- Model resolution (0.001 in log$X$) comparable to surface changes!
- Some isotopes hard to fit
- Asymptotic fit usually OK
- "Reasonable" results compared to lower mass TPAGB models
- Extrapolate to end of STPAGB…

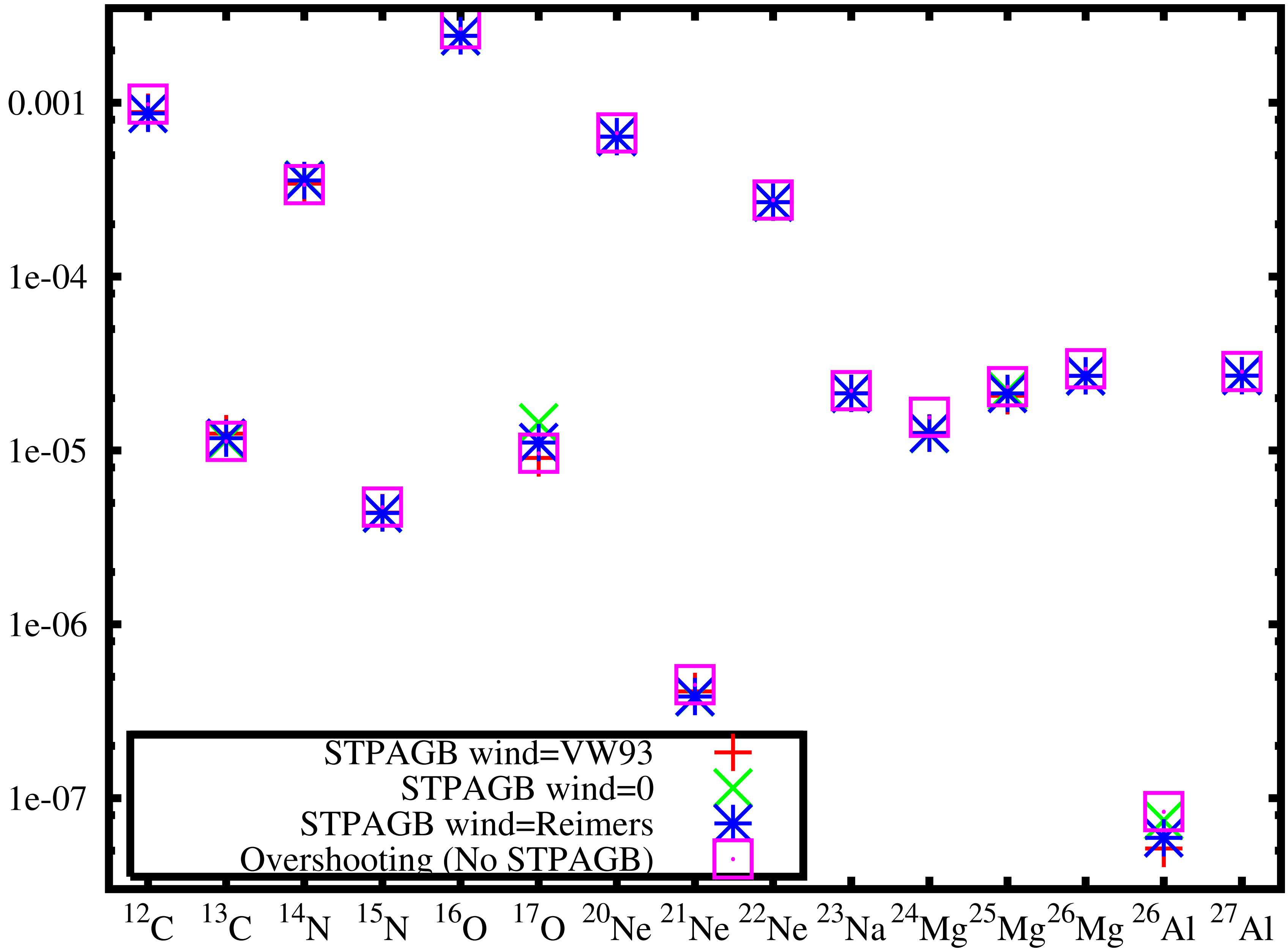
Extrapolation $(10\,M_\odot)$



Galactic Production Factors

- $1 < M < 80$, KTG93 IMF, AGB+SNe
- Could STPAGB stars produce anything to rival TPAGB production?
- It seems not...
- IMF works against them
- Small mass range
- Supernovae ($M \gtrsim 12.5\,\mathrm{M}_{\odot}$) always dominate C, O, Ne, Mg yields
- Normal AGB stars dominate N yield
- STPAGB squeezed out!

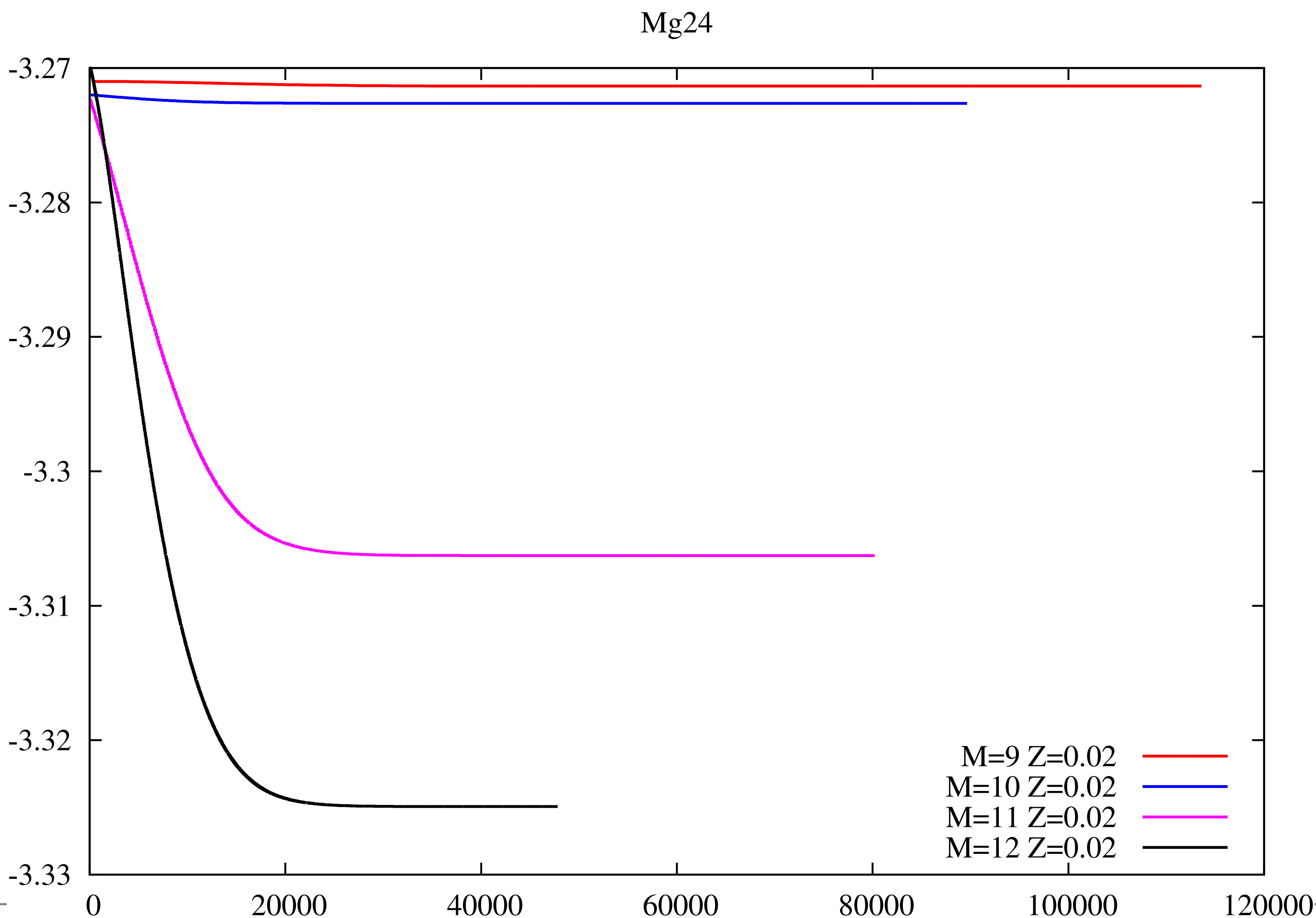
Galactic Chemistry



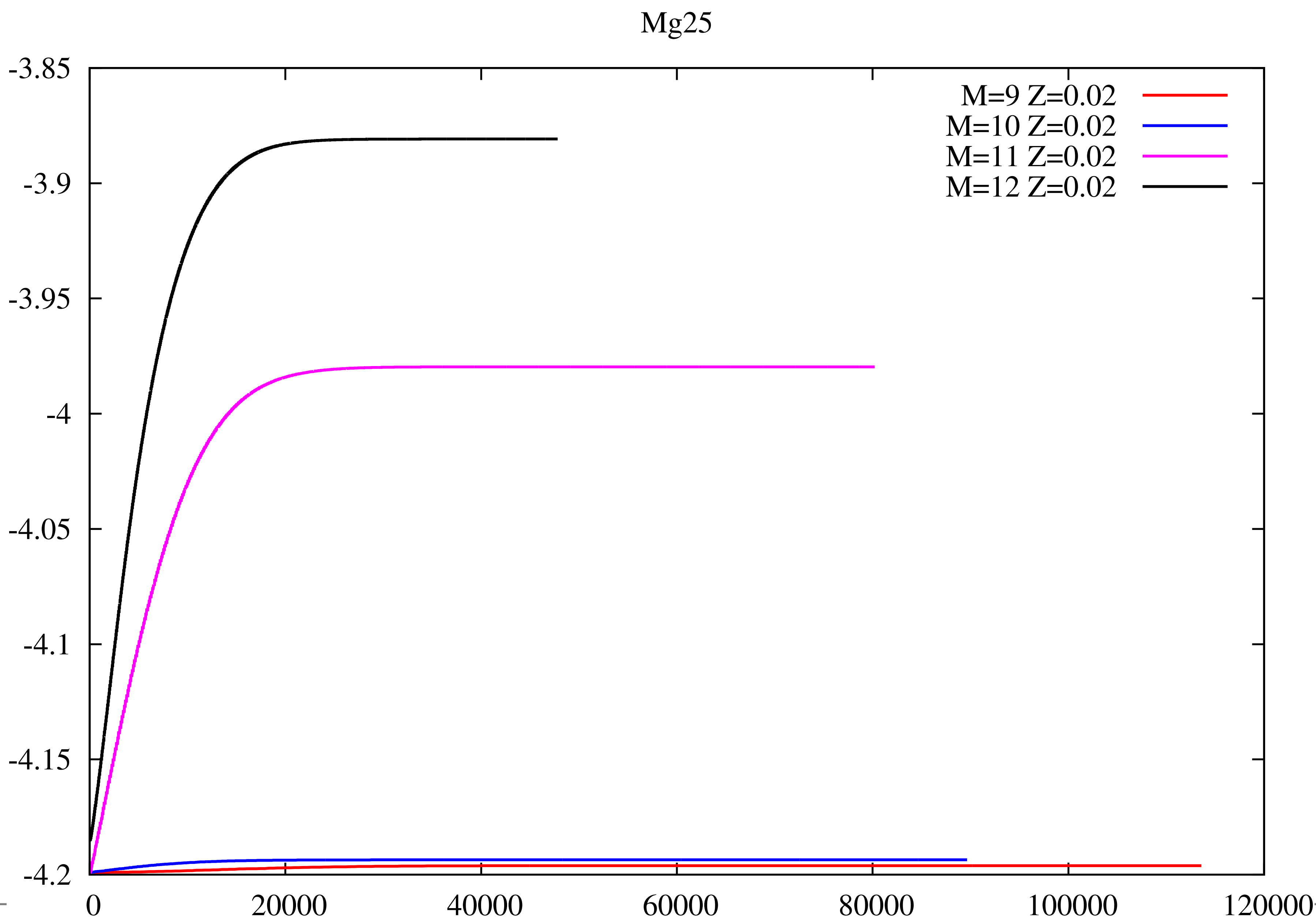
Globular Clusters

- Supernova ejecta is fast $\rightarrow$ escapes GC
- AGB wind is slow $\rightarrow$ accretes on other stars?
- e.g. Magnesium anomalies
- TPAGB models: not enough ^{25,26}Mg compared to observations
- What do STPAGB models do?
- Burn: $^{24}\mathrm{Mg} \rightarrow ^{25}\mathrm{Mg} \rightarrow ^{26}\mathrm{Mg}$
- Create: $^{20}\mathrm{Ne} \rightarrow {}^{21}\mathrm{Ne} \rightarrow {}^{22}\mathrm{Ne} \rightarrow {}^{23}\mathrm{Na} \rightarrow ^{24}\mathrm{Mg} \rightarrow \ldots$
- Destroy: $^{26}\mathrm{Mg} \rightarrow ^{27}\mathrm{Al} (\rightarrow ^{28}\mathrm{Si}?)$
- complicated!
- Don't want DUP: $\mathrm{C} + \mathrm{N} + \mathrm{O} = \mathrm{constant} \rightarrow \mathrm{STPAGB}?$

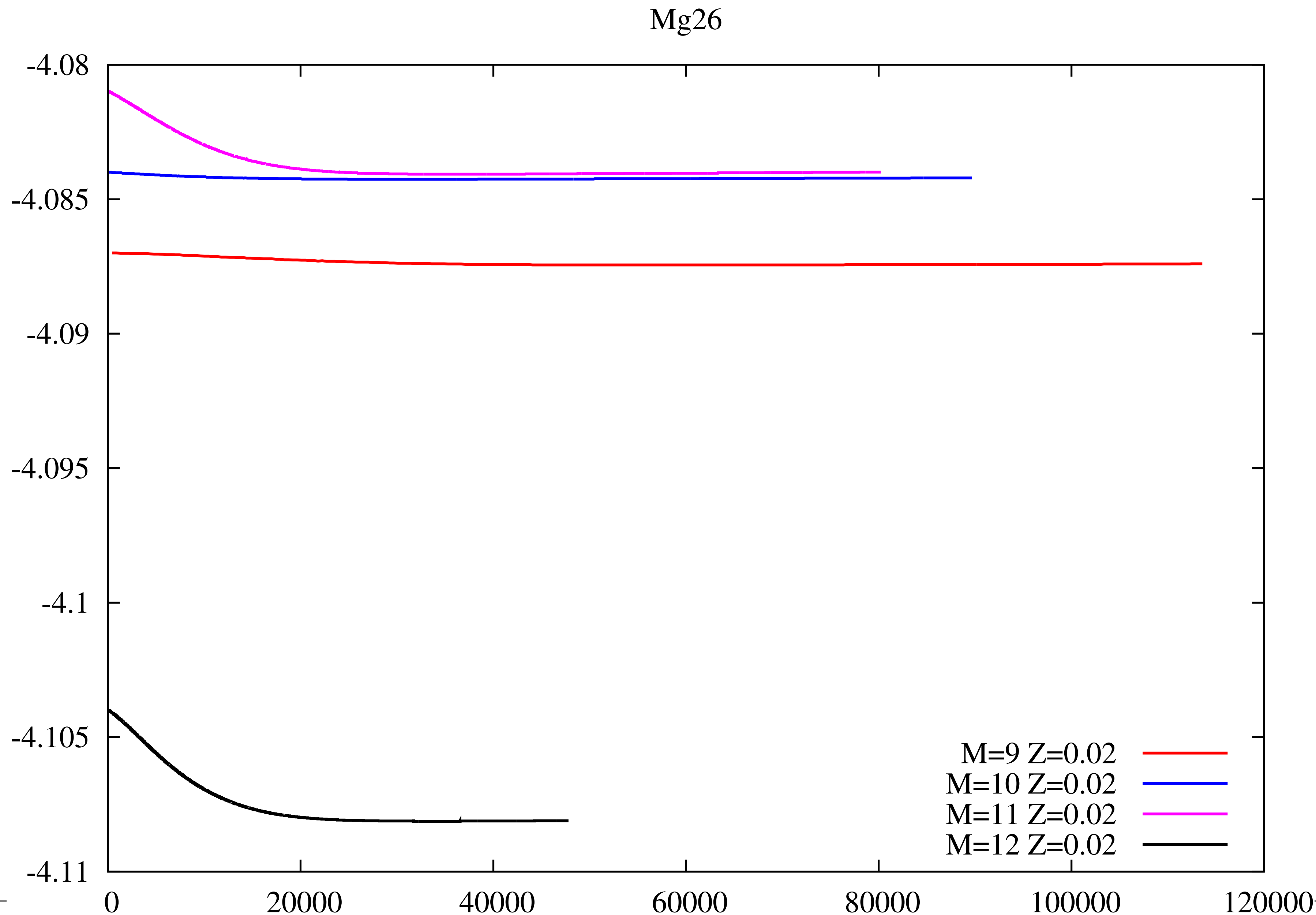
Magnesium-24 destruction



Magnesium-25 production



Magnesium-26 destruction!



Conclusions, Future Work

- STPAGB phase seems not to be important for GCE
- STPAGB promising for GC Mg problem
- Extrapolation is dodgy!
- Dredge-up??? Binaries?!
- We're working on it! (Not this week. . .)
- Proper results soon. . . (by next Torino workshop?!)