Evolution of Metal-poor AGB stars

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Motivation

- To understand how evolution is affected by low metallicity
- To understand the nucleosynthesis history of early universe
- To fit the observed abundances of peculiar CEMP stars
- To help deduce the initial mass function at early Universe

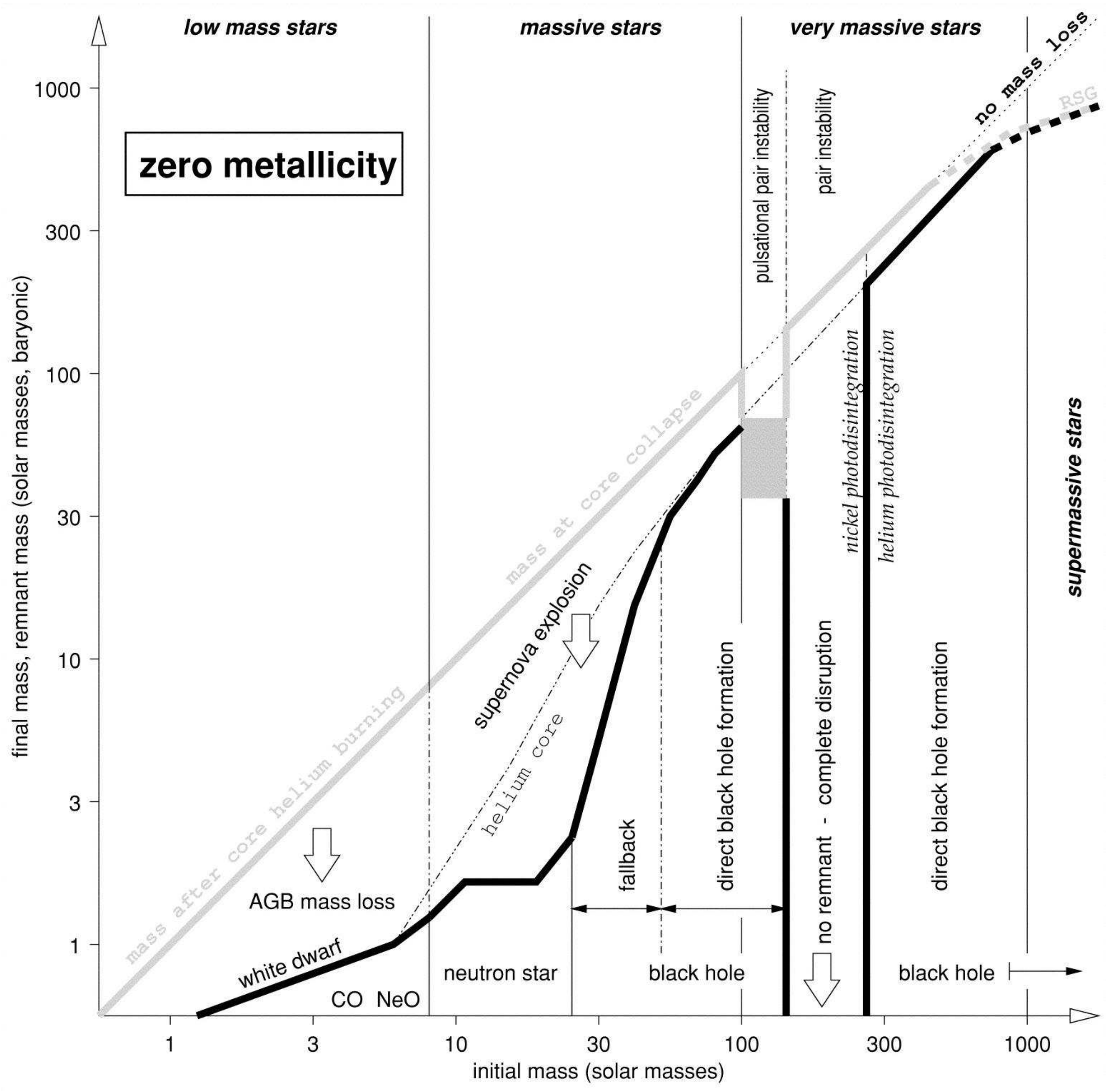
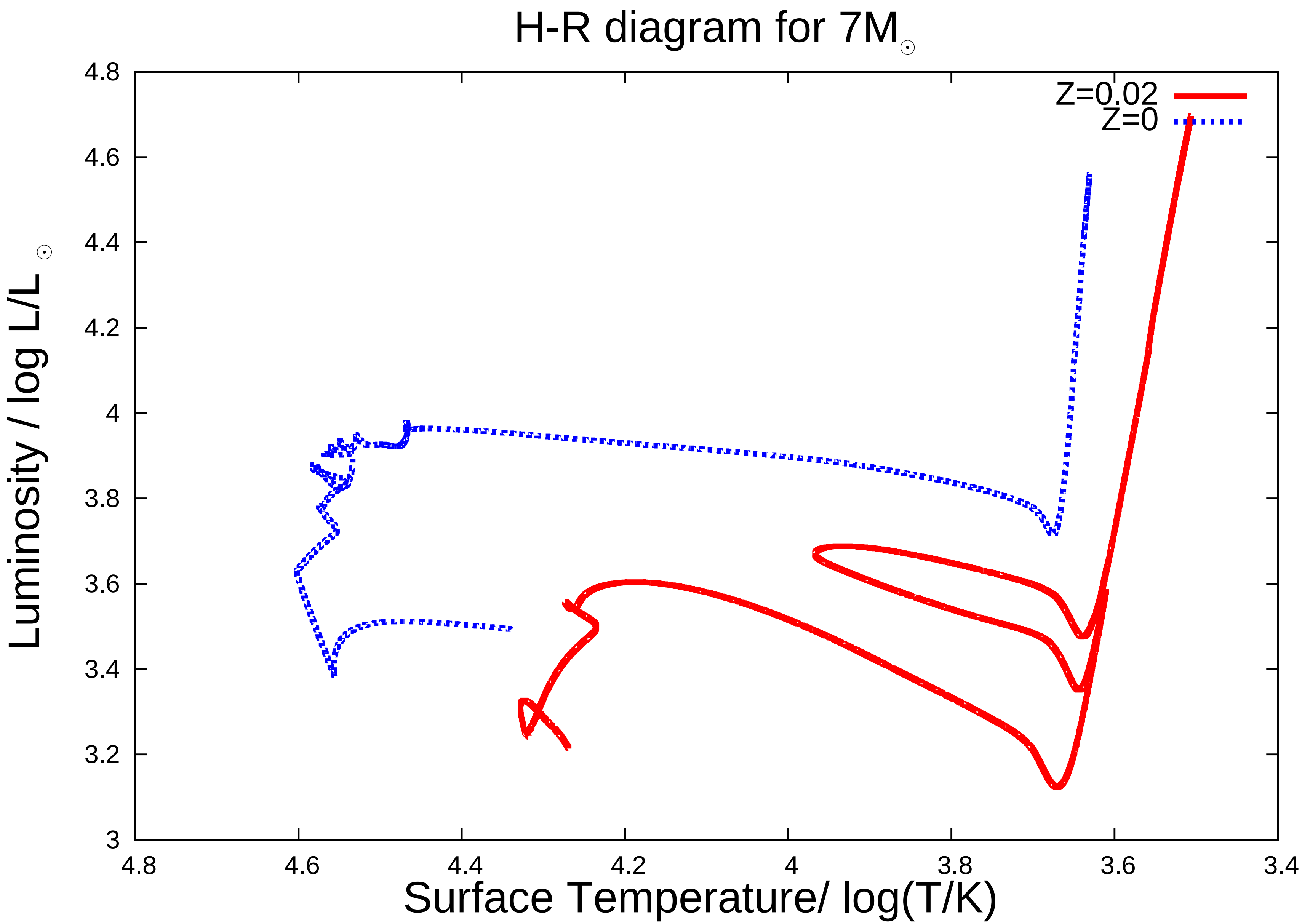
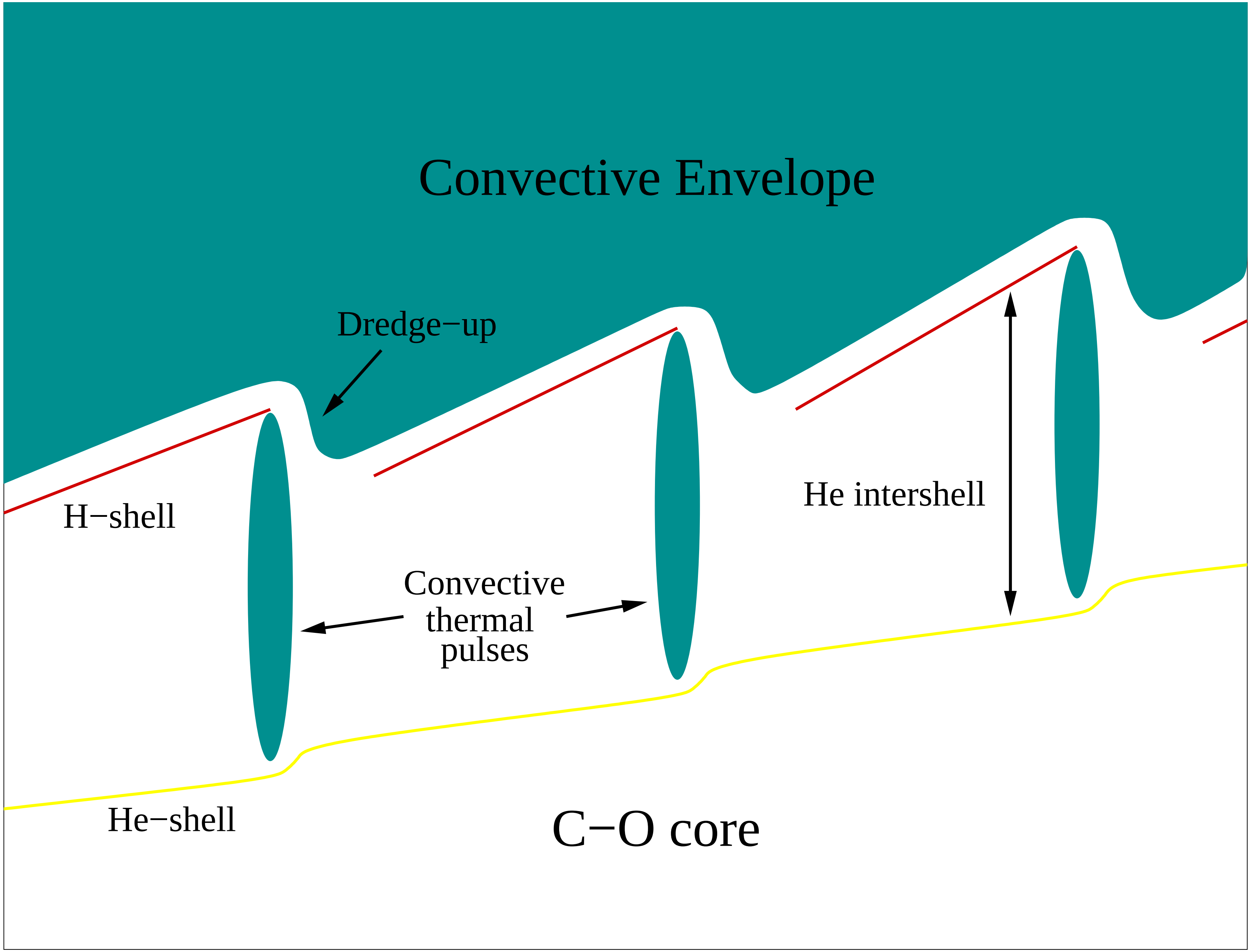
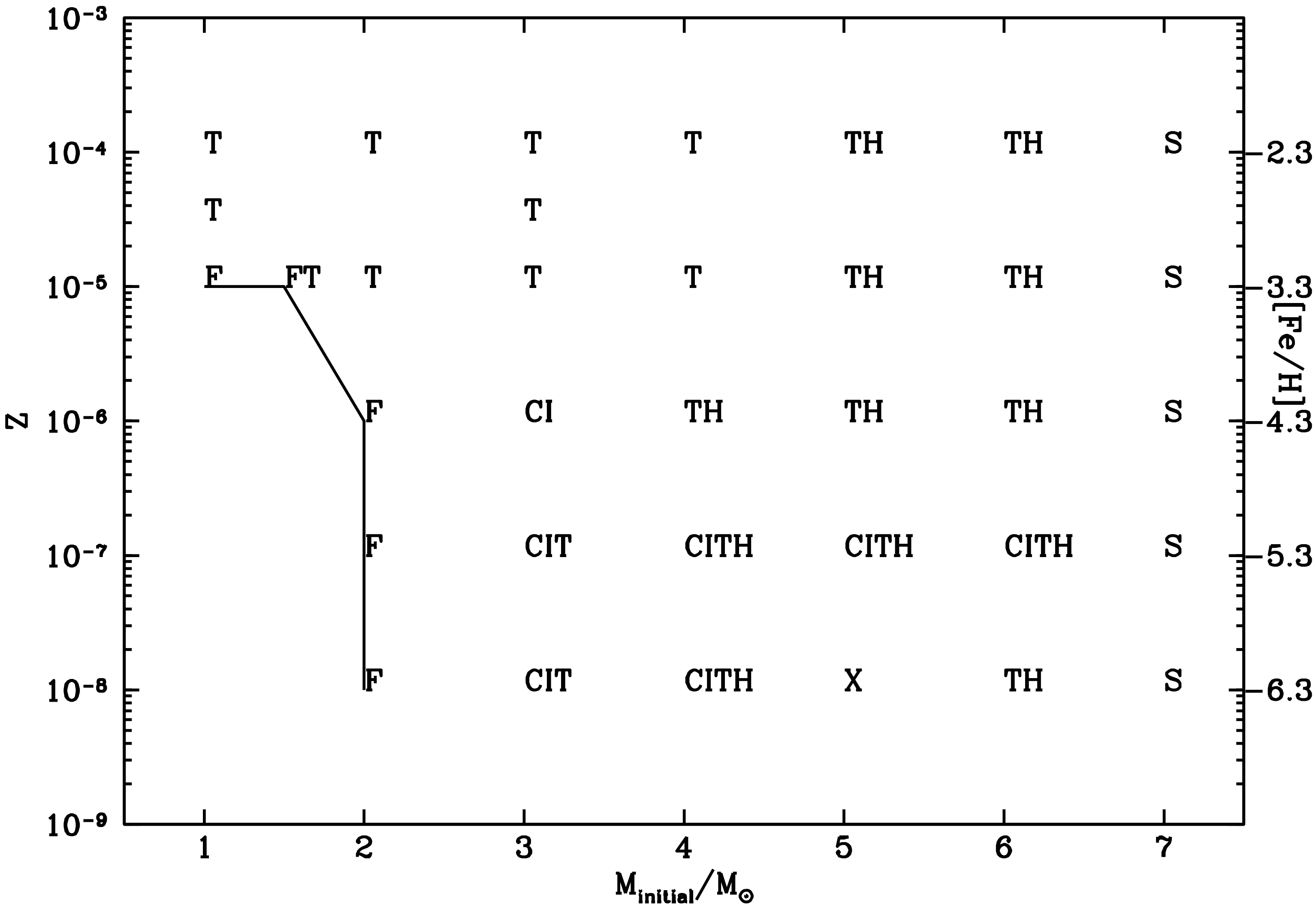


Figure by Heger and Woosley(2002)

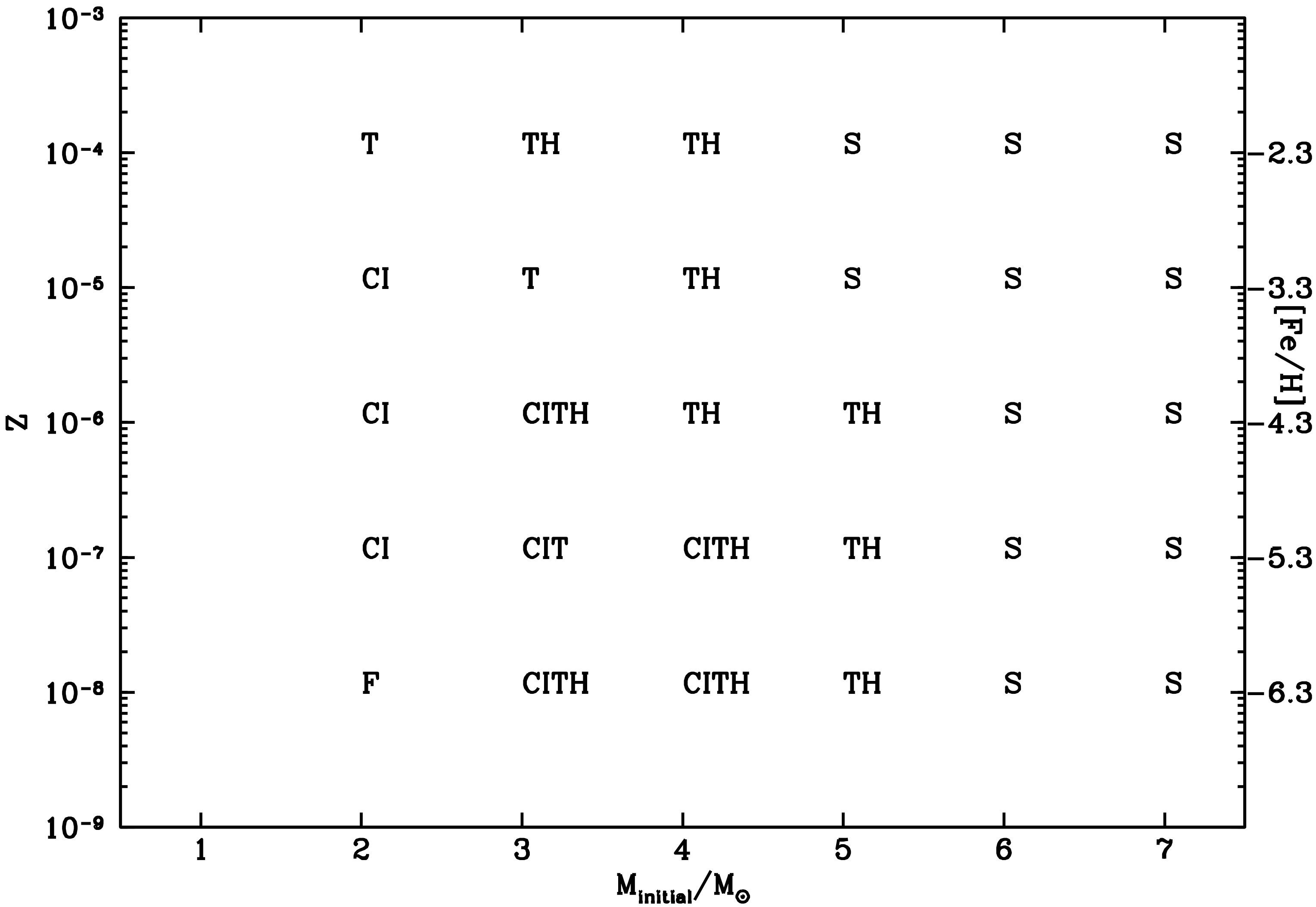


Different evolutionary behaviour in solar and zero metallicity.

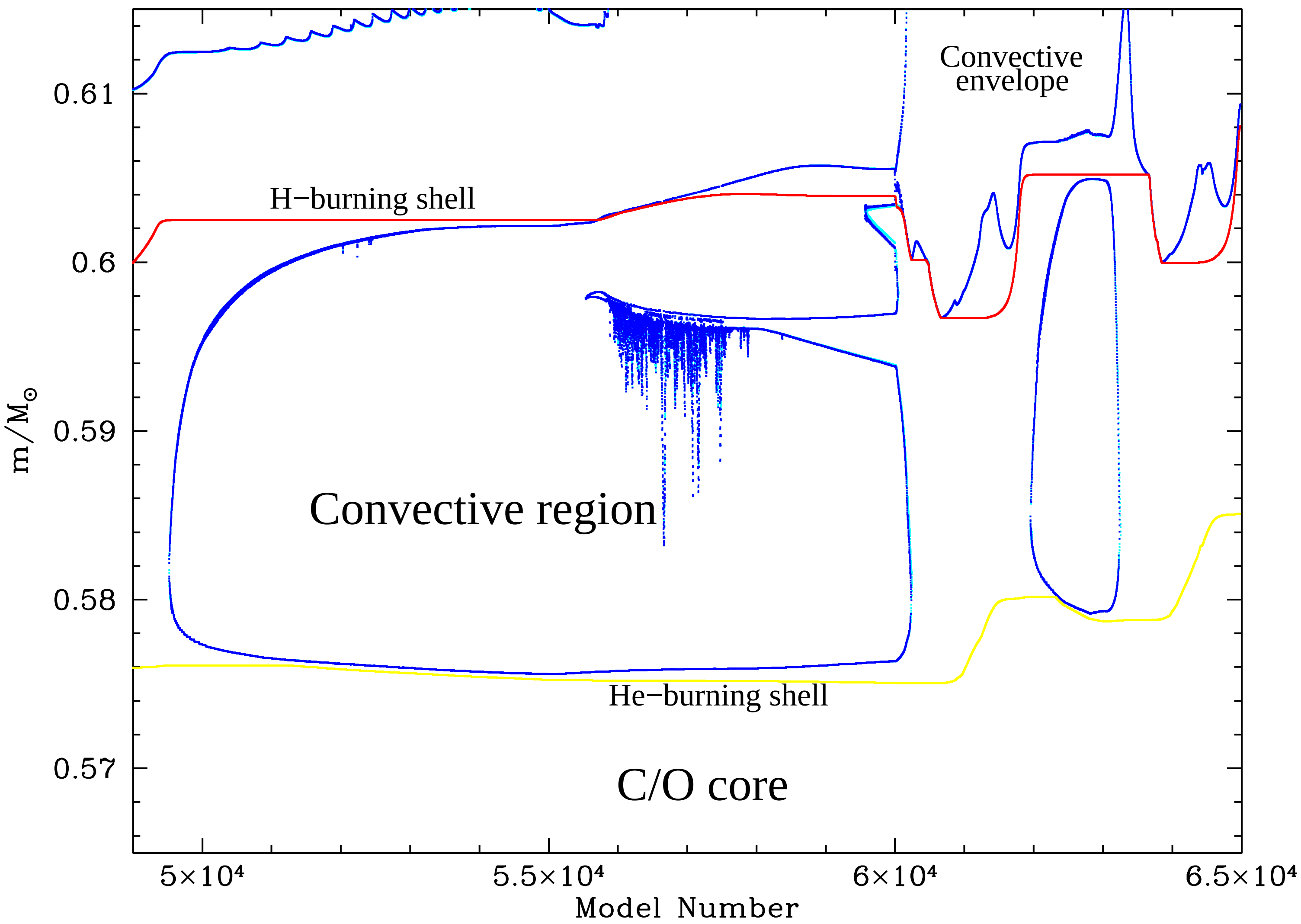

Convective Envelope
Dredge−up
H−shell
He intershell
Convective
thermal
pulses
He−shell
C−O core



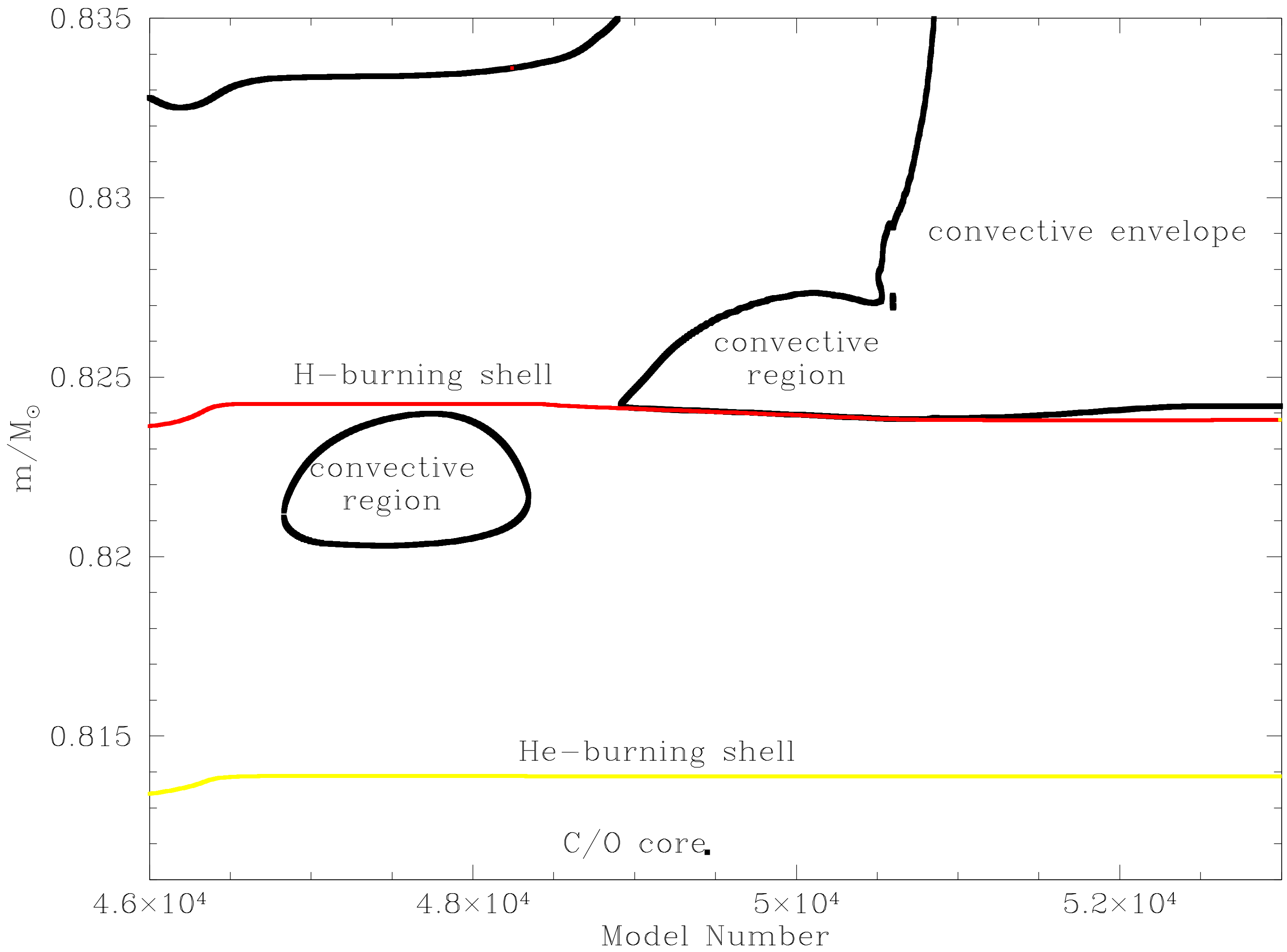
AGB behaviour as function of Metallicity and Mass



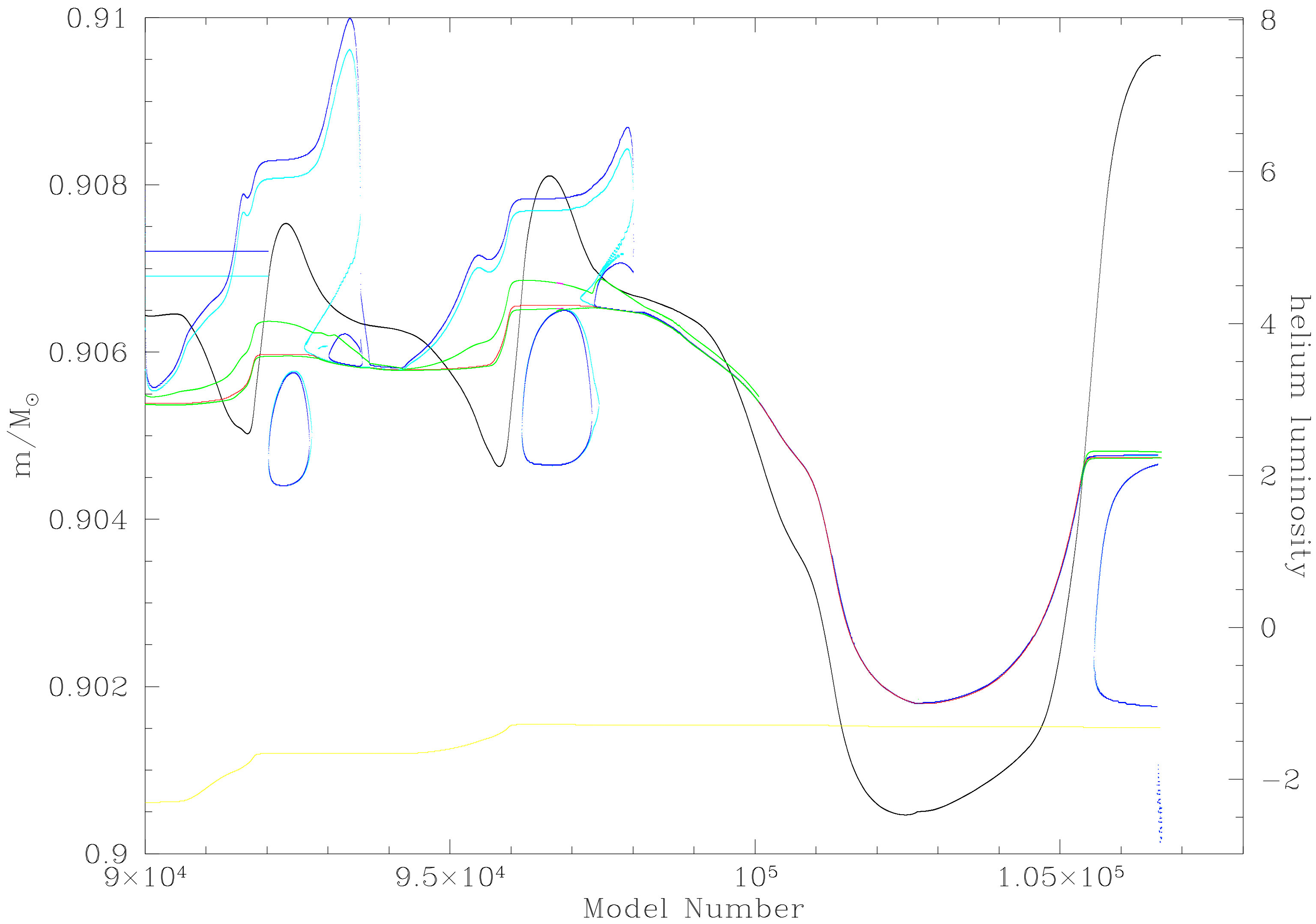
AGB behaviour as function of Metallicity and Mass With Overshooting



Evolution of $1.5\,M_\odot$ $Z = 10^{-5}$ model during HE-FDDM.



Evolution of $3\,M_\odot$ $Z = 10^{-7}$ model during carbon ingestion.



Evolution of $4\,M_{\odot}$ $Z = 10^{-7}$ model (with overshooting) during hot dredge up.

What is Carbon Enhanced Metal-Poor stars

- stars with $[C/H] > 1.0$(carbon-enhanced), $[Fe/H] < -2.0$ (metal-poor)
- up to 20% of metal-poor stars are carbon enhanced (Beers & Christlieb 2005)
- fraction increases with decreasing metallicity (Lucatello et al 2006)
- compositions not uniform, some have s-process or/and r-process enhanced
- C/N varies from 1 to 100
- Most (70%) are observed in binary suggesting they could be formed by binary mass tranfer from a AGB primary.

Compares with models with observation

- Easy to enhance carbon. Flash-driven mixing, Carbon Ingestion and Third Dredge Up all enhance carbon to various degree.
- Models can fit abundances of carbon strongly enhanced with nitrogen weakly enhanced stars very well.
- Carbon is converted into nitrogen in high mass AGB star during hot dredge up.
- Stuggle to make enough stars that are both enhanced in carbon and nitrogen to fit observation because hot dredge up is too inefficient
- Nitrogen-enhanced metal-poor stars are predicted, but so far very few of them are observed.

Hint of Initial Mass Function

- C/N ratio is very good indicator. High C/N ratio implies low mass AGB stars.
- If models cannot fit observed abundances below certain metallicity, e.g. if most CEMP stars are simaltenously enhanced in C and N
- That would suggest some critical metallicity that AGB stars no longer formed.
- Currently, too few stars below $z = 10^{-6}$ are observed to be conclusive. (about 50/50 at the moment)

Summary

- Working on stars that may never ever exist could be fun...
- Current theory only partially agree with observations...Some way out:
- 1) Some unknown observation biased that cause NEMP stars harder to find?? Not likely..
- 2) We do not know enough about AGB evolution, and model is wrong? Certainly Possible
- 3) Some interesting IMF function that favour stars to form around $1-2\,M_\odot$??Possible, but contraversial in terms of star formation theory.