

# Evolution of Metal-poor AGB stars



*H.B. Lau*

*Kavli Institute of Astronomy and Astrophysics, Peking University*

*Collaborators: R.J. Stancliffe, C.A. Tout*

## 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

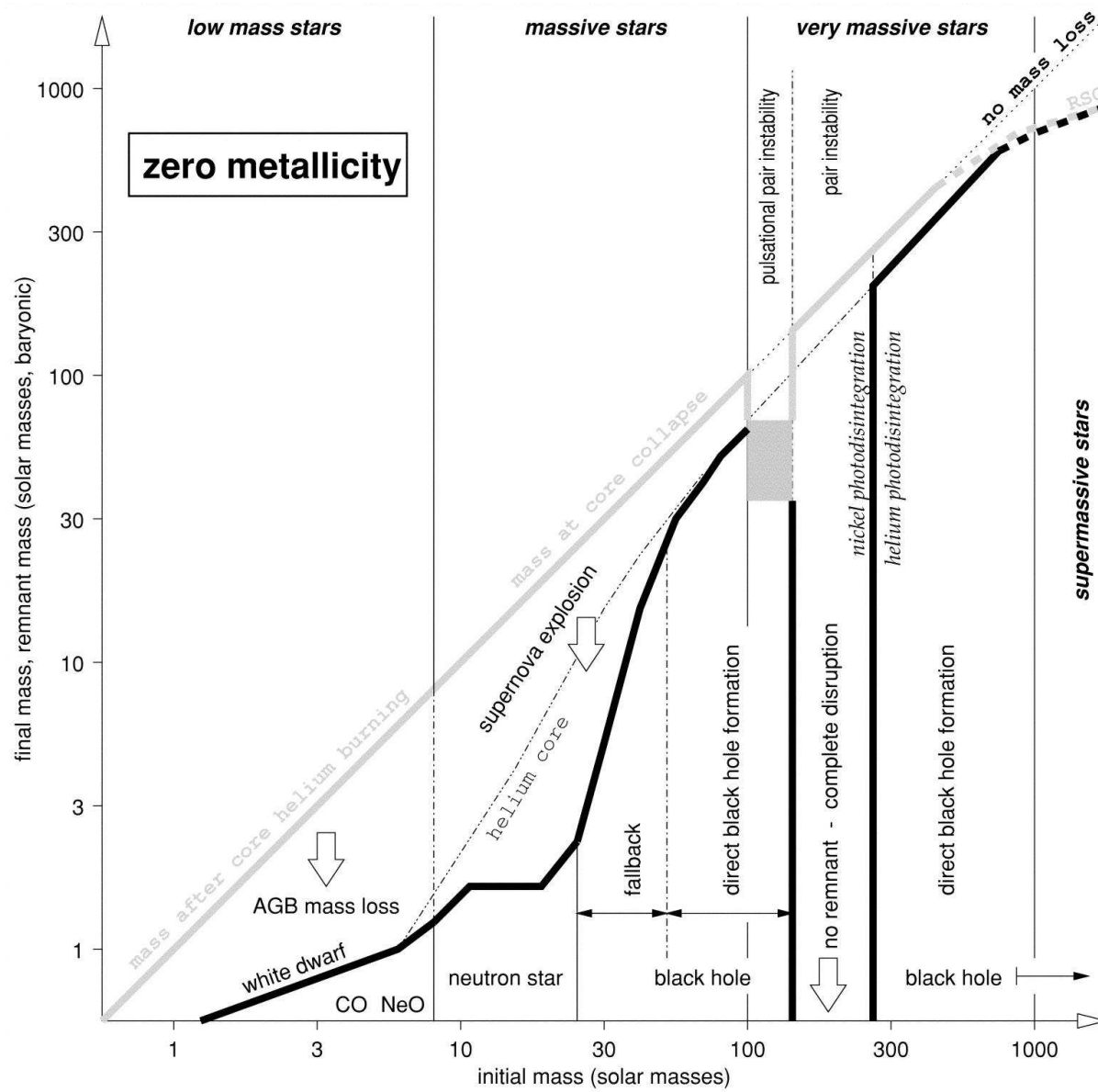
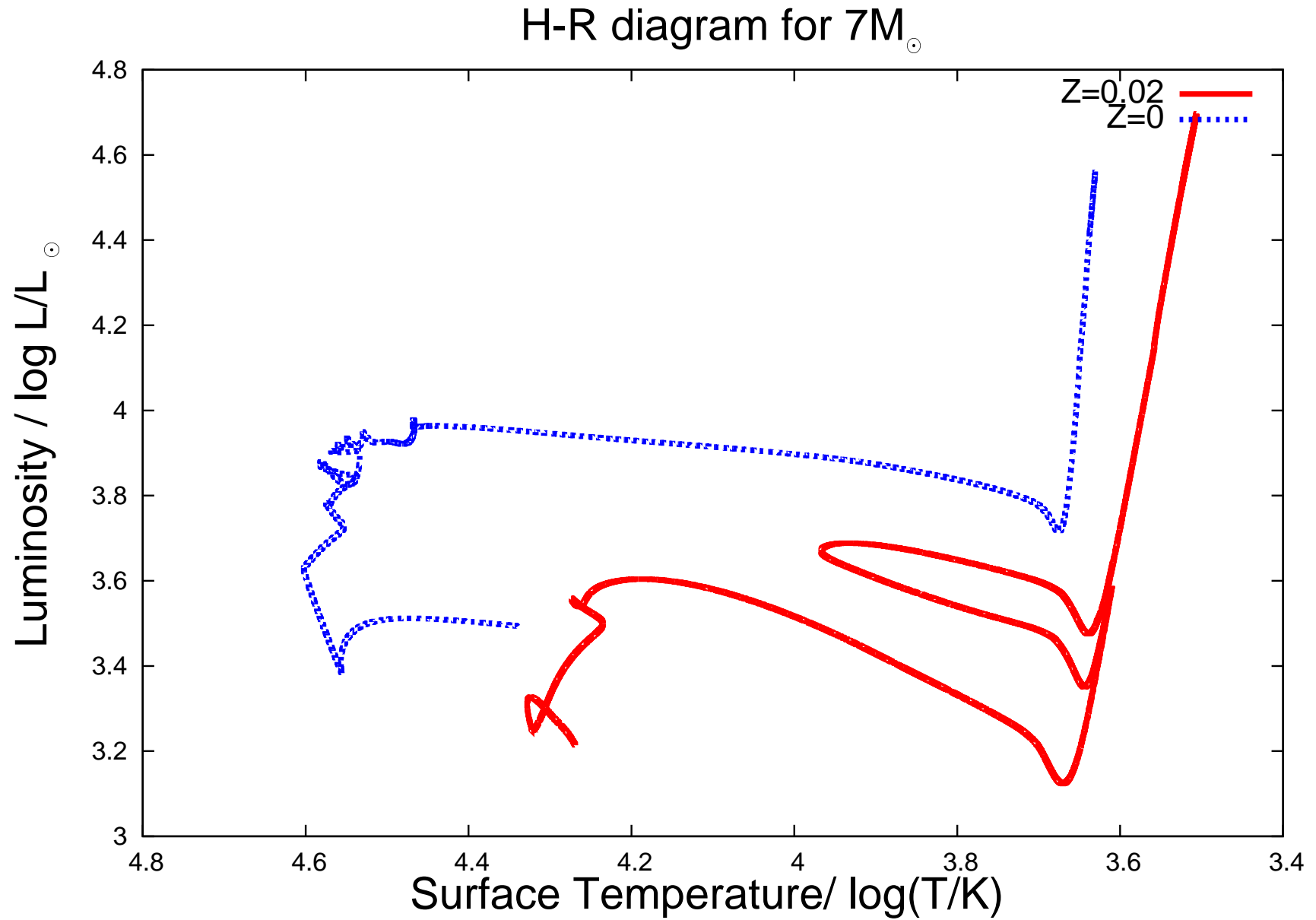
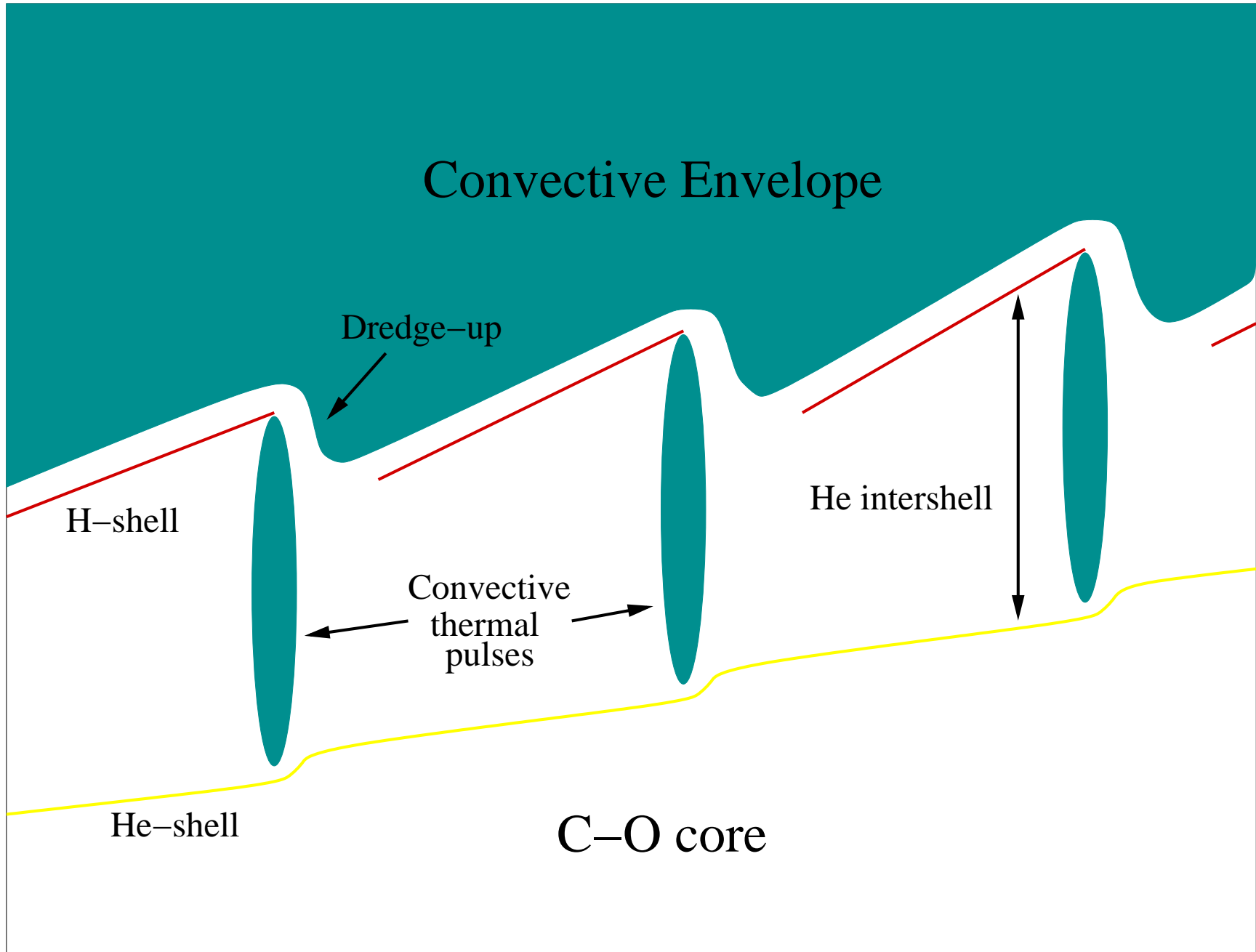
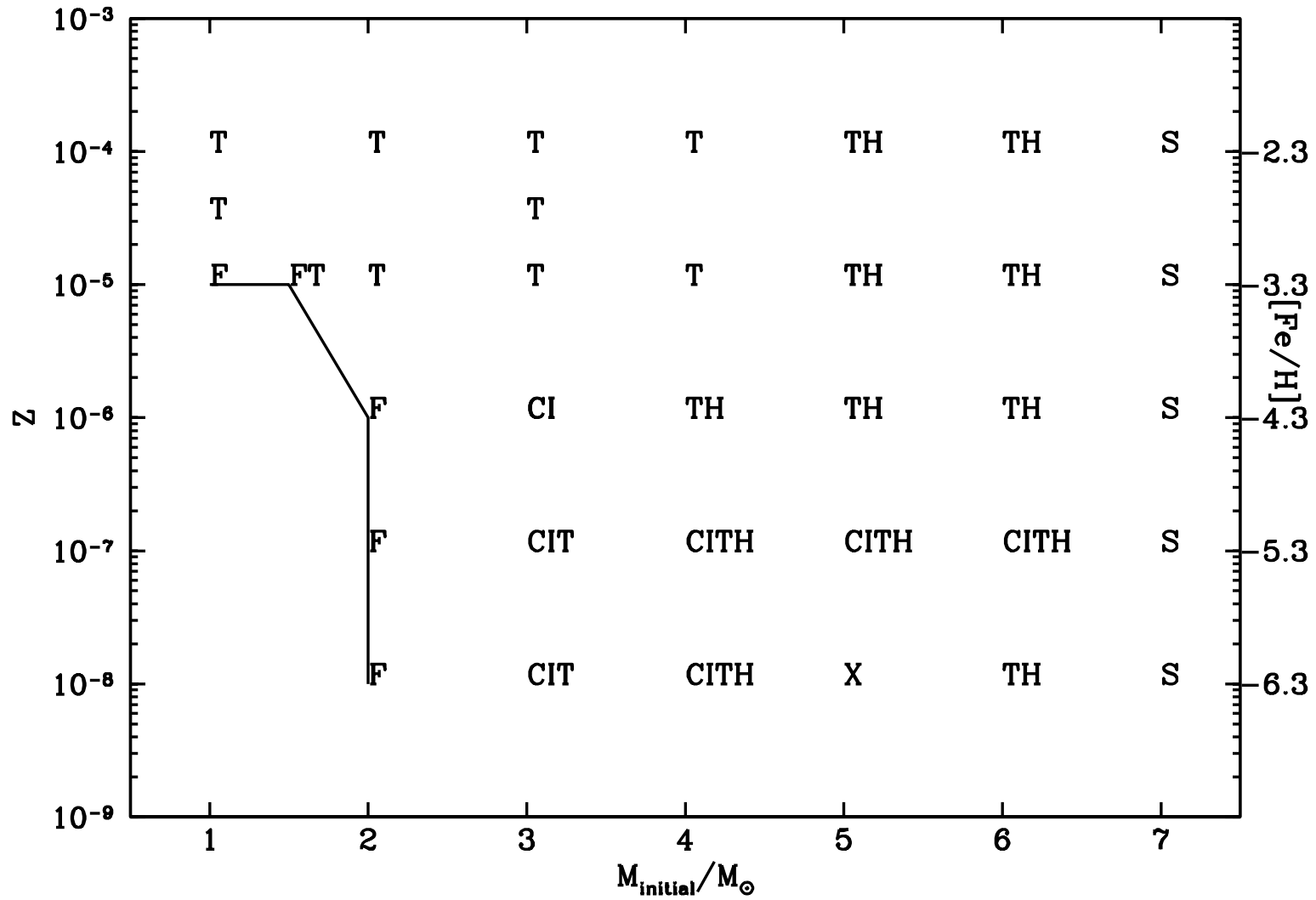


Figure by Heger and Woosley(2002)

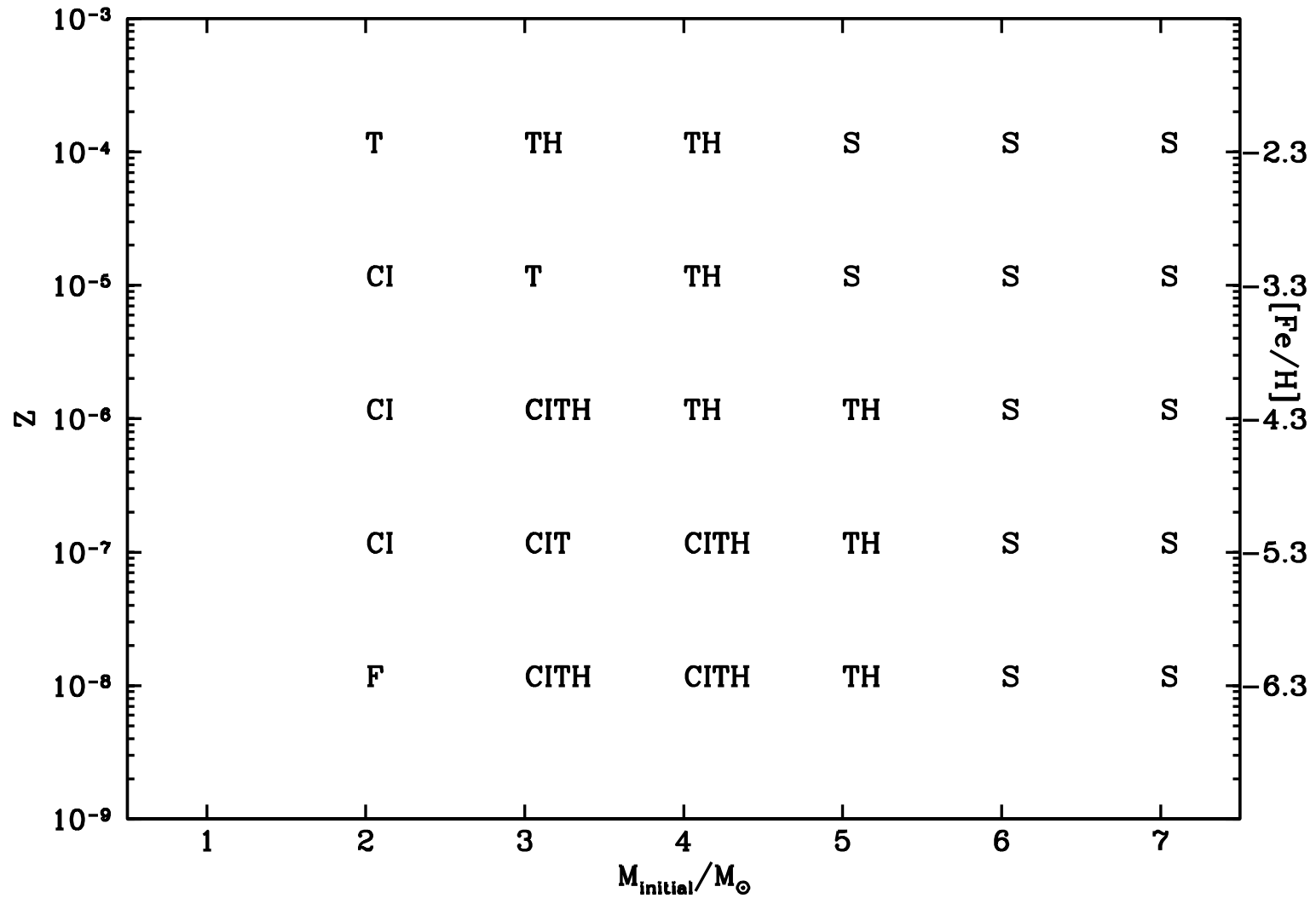


Different evolutionary behaviour in solar and zero metallicity.

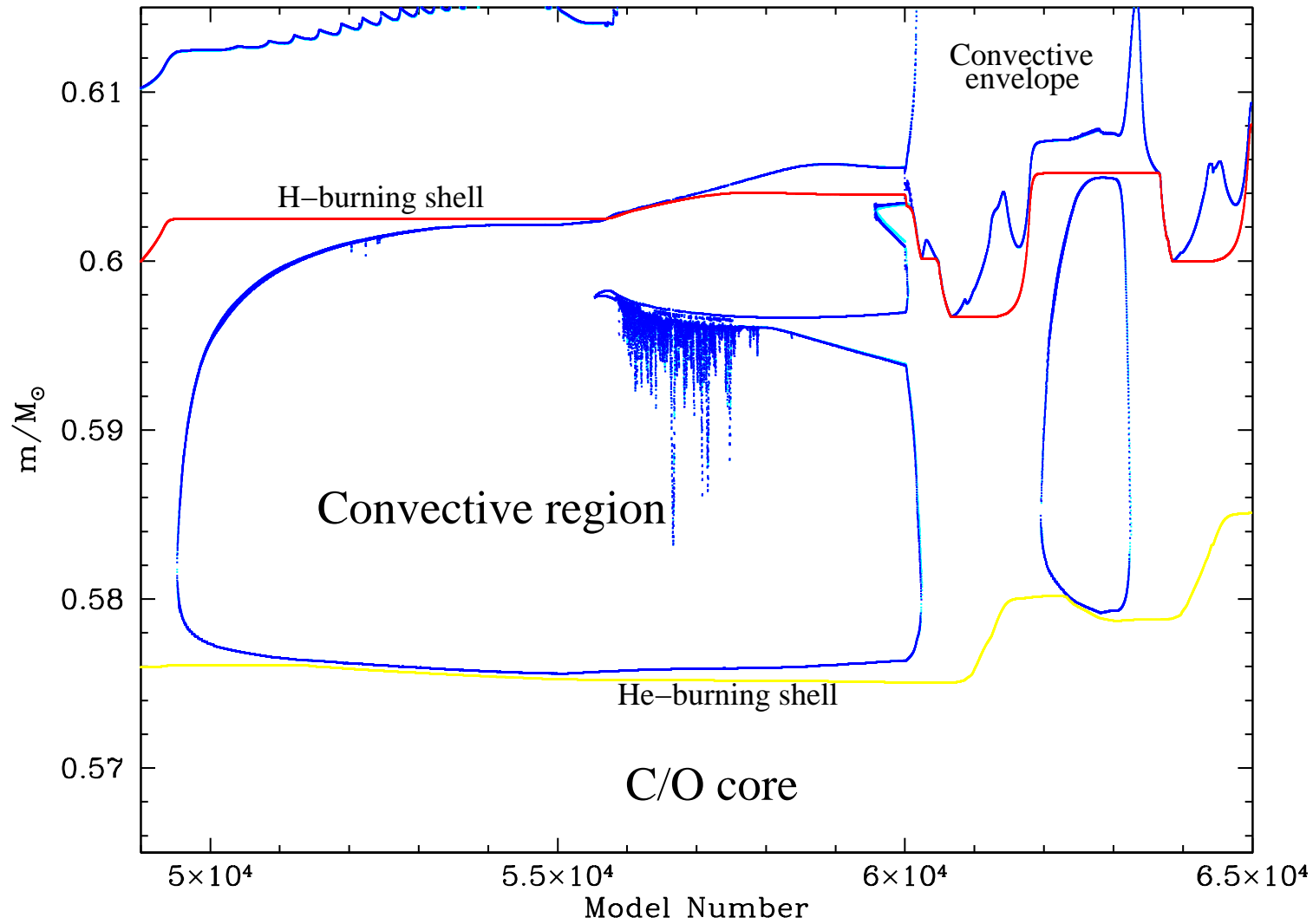




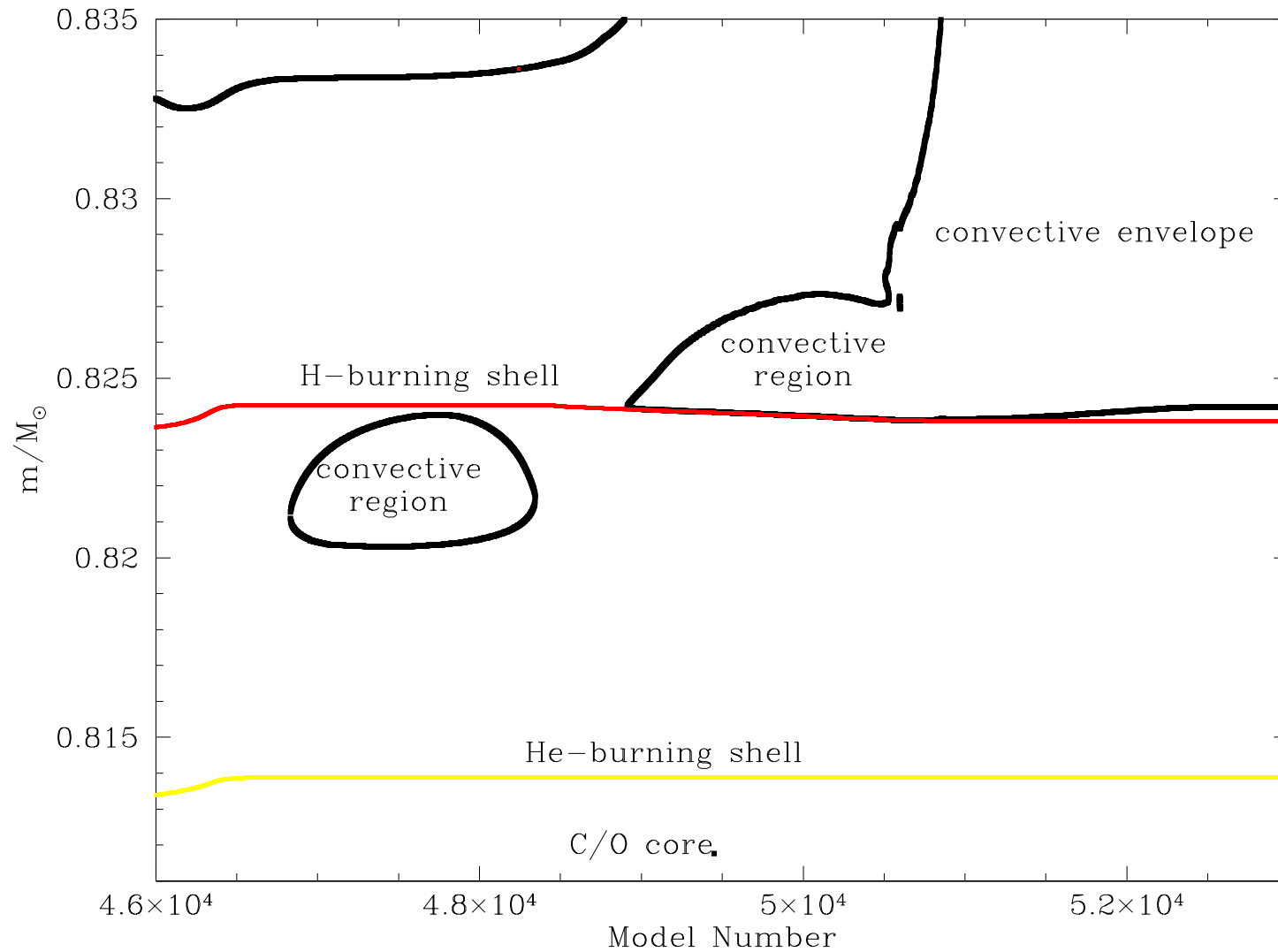
AGB behaviour as function of Metallicity and Mass



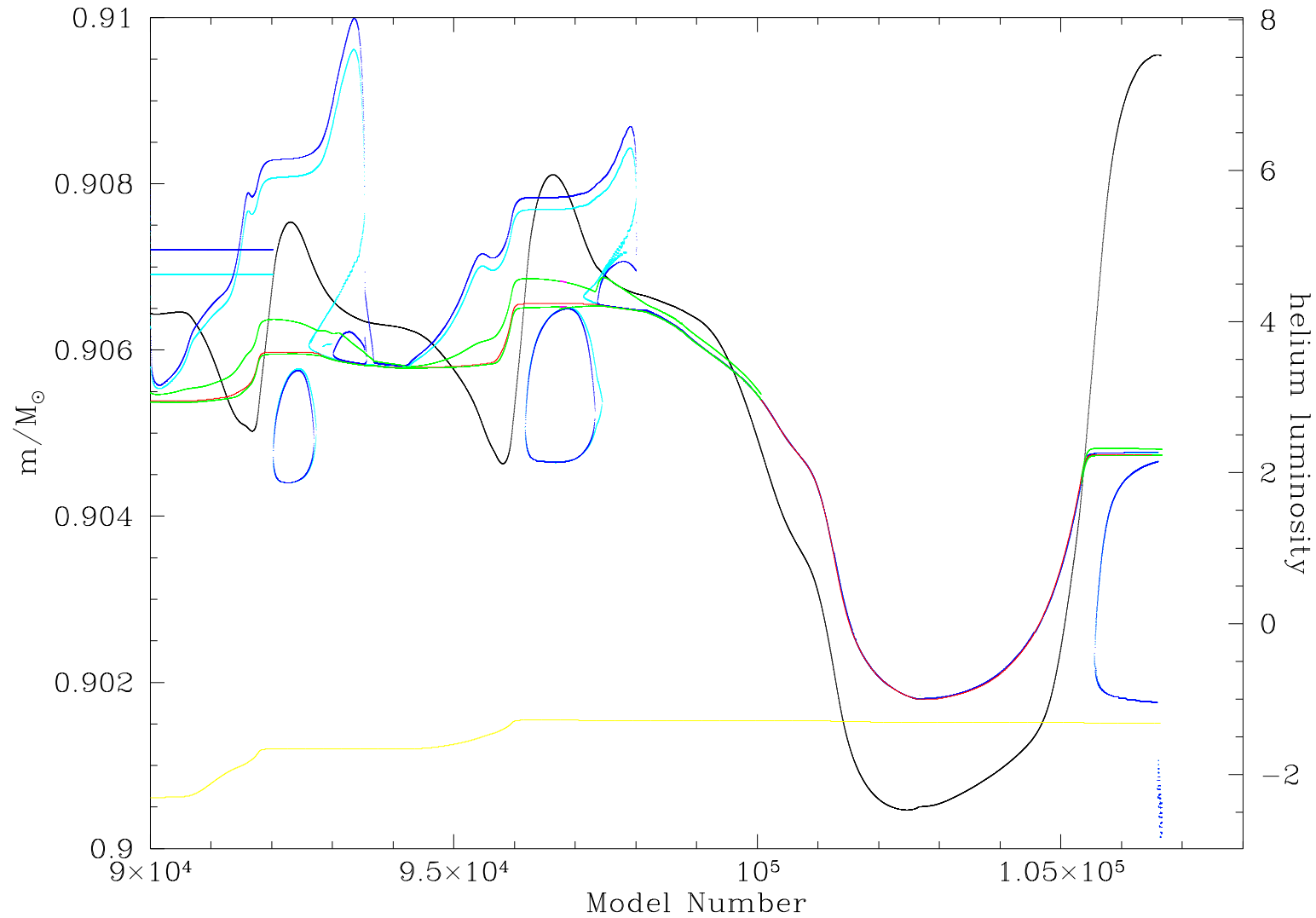
AGB behaviour as function of Metallicity and Mass With Overshooting



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 transfer 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.
- Struggle 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 simultaneously 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.