Light and heavy elements nucleosynthesis in low mass AGB Stars

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OUTLINE

M=2M$_\odot$ AGB models (FRANEC Code)

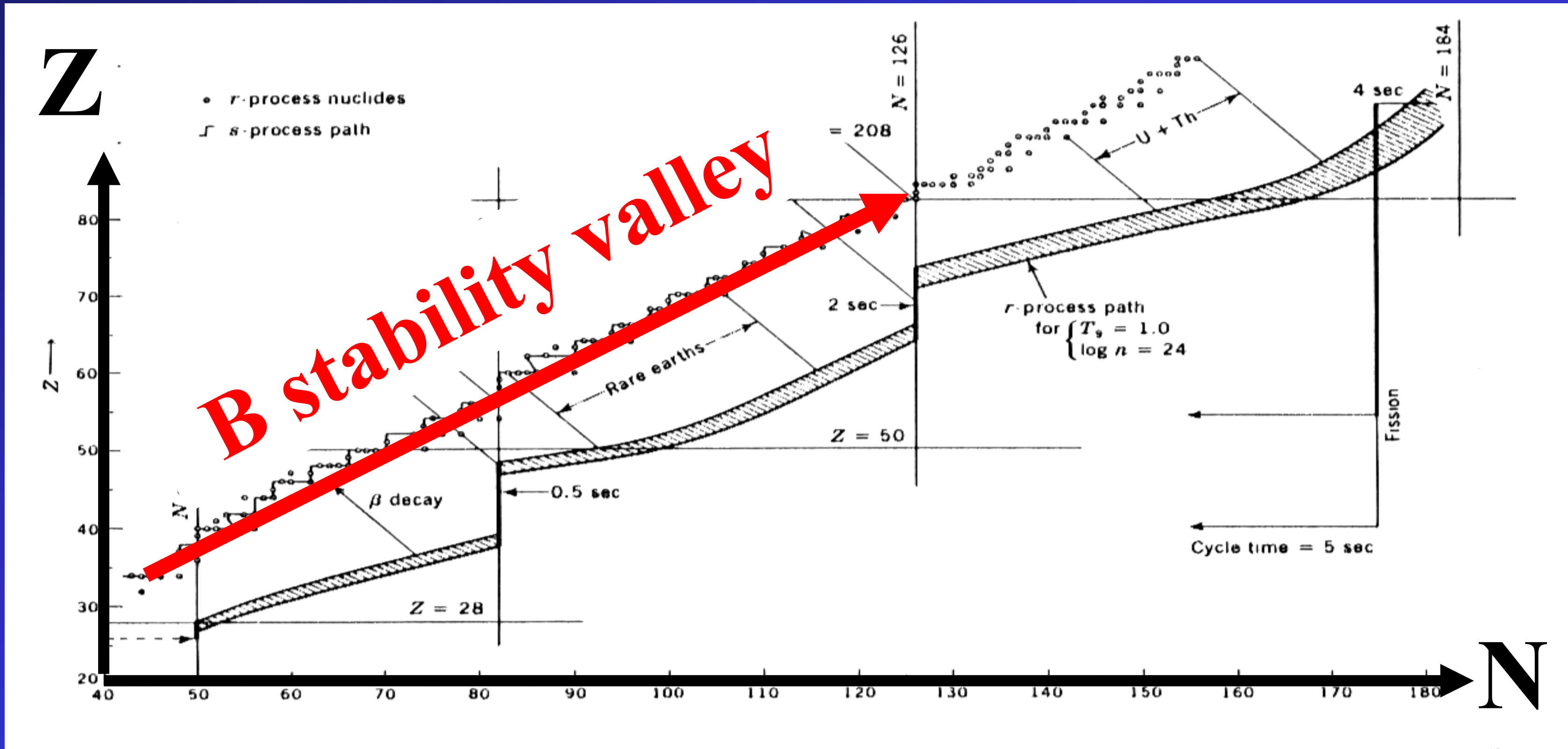
DISK STARS
($Z=1.5\mathrm{x}10^{-2} \equiv Z_\odot$)

HALO STARS
($Z=1\mathrm{x}10^{-4}$)

- **The formation of the ^{13}C pocket and the nuclear network**
- **Light and heavy elements nucleosynthesis**
- **Comparison with observations**

s-process

$^{13}C(\alpha,n)^{16}O$ reaction



AGB ↔

Weak component (A<90)

Main component (90<A<204)

Strong component (204<A<209)

How we treat the convection

- **Schwarzschild criterion:** to determine convective borders
- **Mixing length theory:** to calculate velocities inside the convective zones

At the inner border of the convective envelope, we assume that the velocity profile drops following an exponentially decaying law

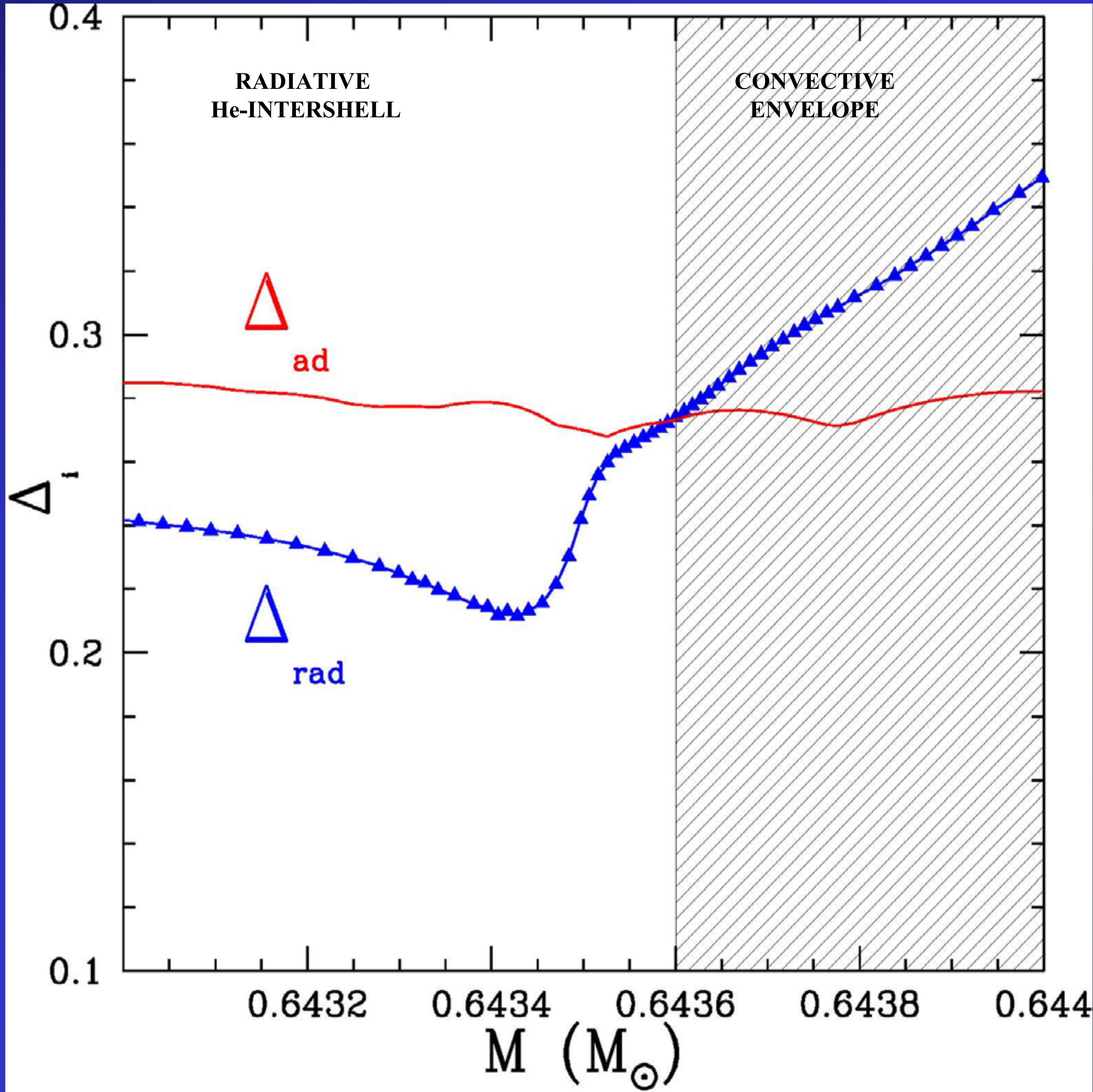
REF: Freytag (1996), Herwig (1997), Chieffi (2001), Straniero(2005), Cristallo (2001,2004,2006)

$$v = v_{bce} \cdot \exp(-d/\beta H_p)$$

- V_{bce} is the convective velocity at the inner border of the convective envelope (*CE*)
- d is the distance from the *CE*
- H_p is the scale pressure height
- $\beta = 0.1$

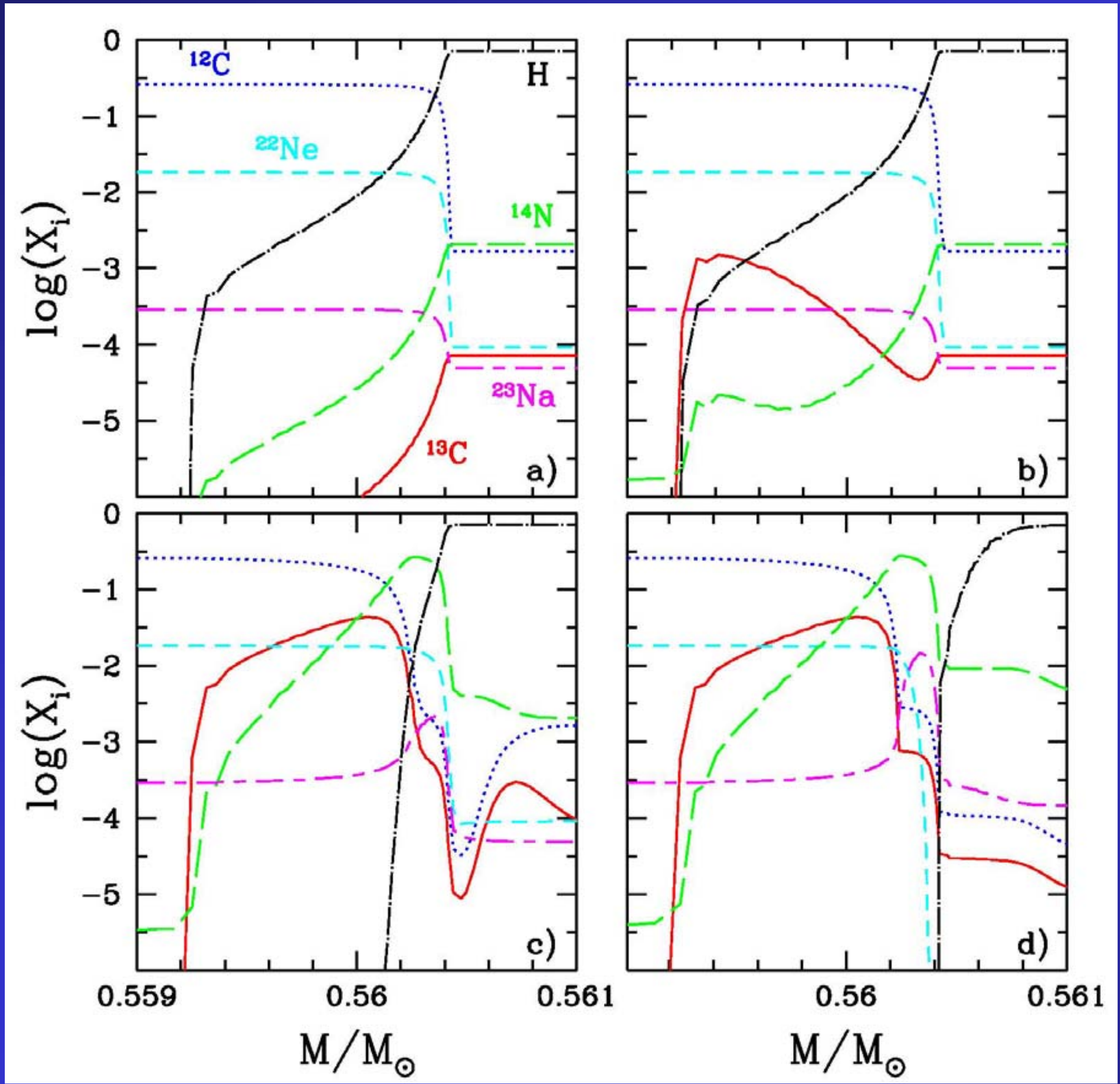
WARNING: v_{bce}=0 except during Dredge Up episodes

Gradients profiles WITH exponentially decaying velocity profile



During a TDU episode

Formation of the ^{13}C-pocket



$M=2M_{\odot}$
$Z=Z_{\odot}$

a) Maximum envelope penetration (during TDU);

b) $^{12}C(p,\gamma)^{13}N(\beta^{+})^{13}C$ and $^{13}C(p,\gamma)^{14}N$ reactions;

c) $^{22}Ne(p,\gamma)^{23}Na$;

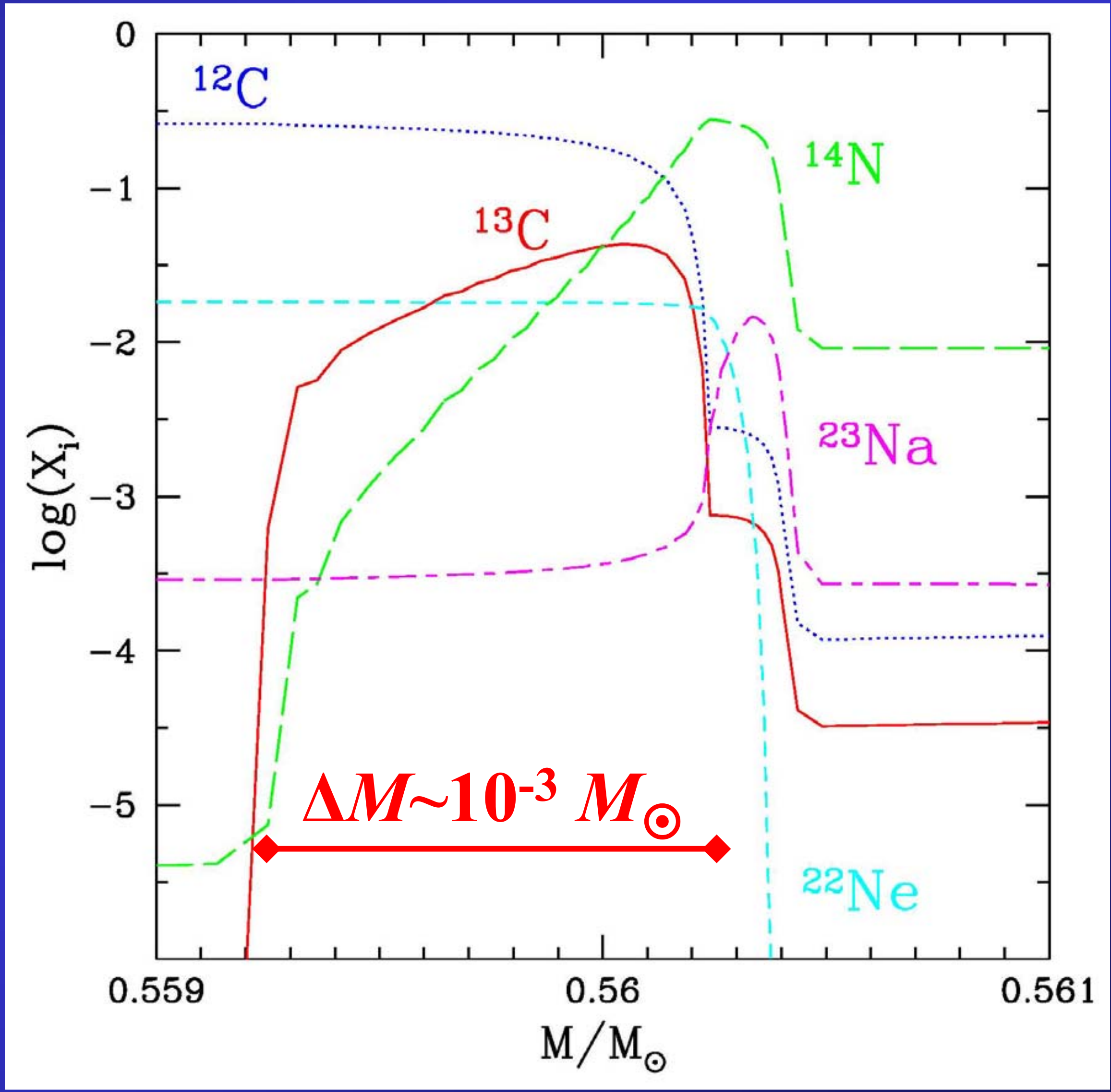
d) the envelope receeds.

The resulting pocket(s)

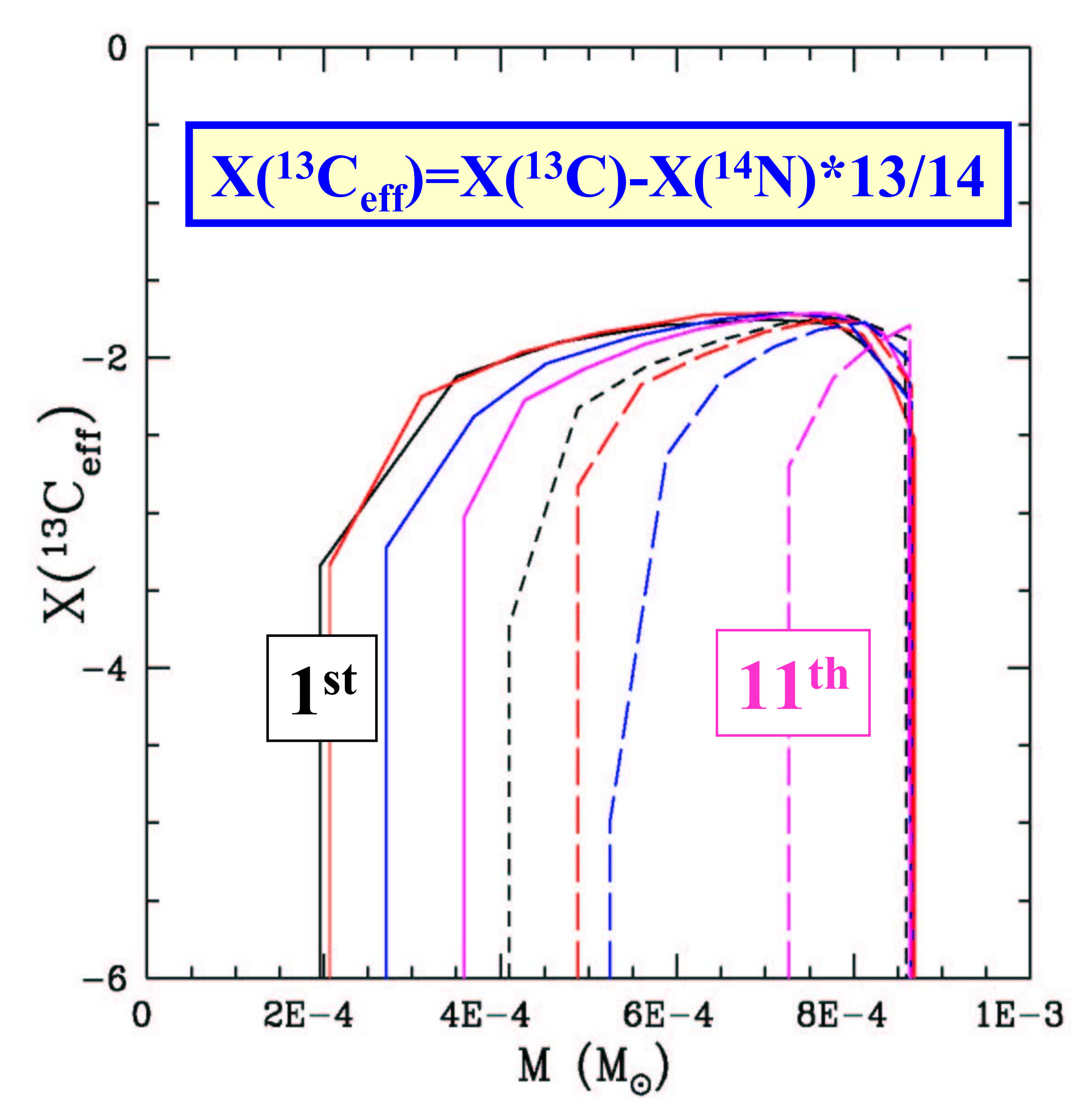
^{13}C-pocket

^{14}N-pocket

^{23}Na-pocket

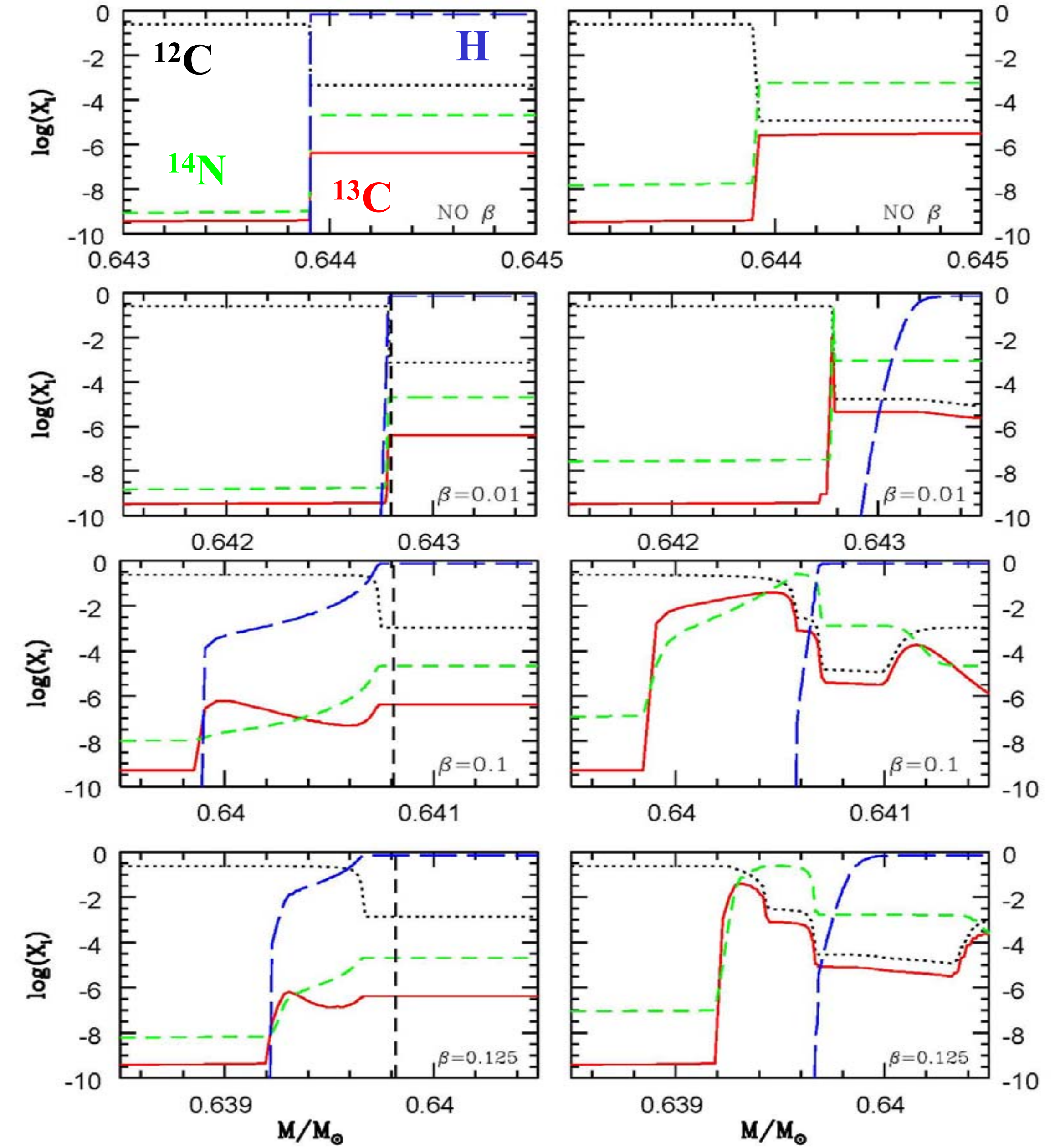


Variation of the ^{13}C-pocket pulse by pulse



^{14}N strong neutron poison via ^{14}N(n,p)^{14}C reaction

Calibration of the free parameter



Different choices of the β parameter in the velocity profile algorithm

β~0.1

1. Low mass AGB Stars
2. Treatment of convection

Cristallo S. (*PhD Thesis*)

THE NETWORK

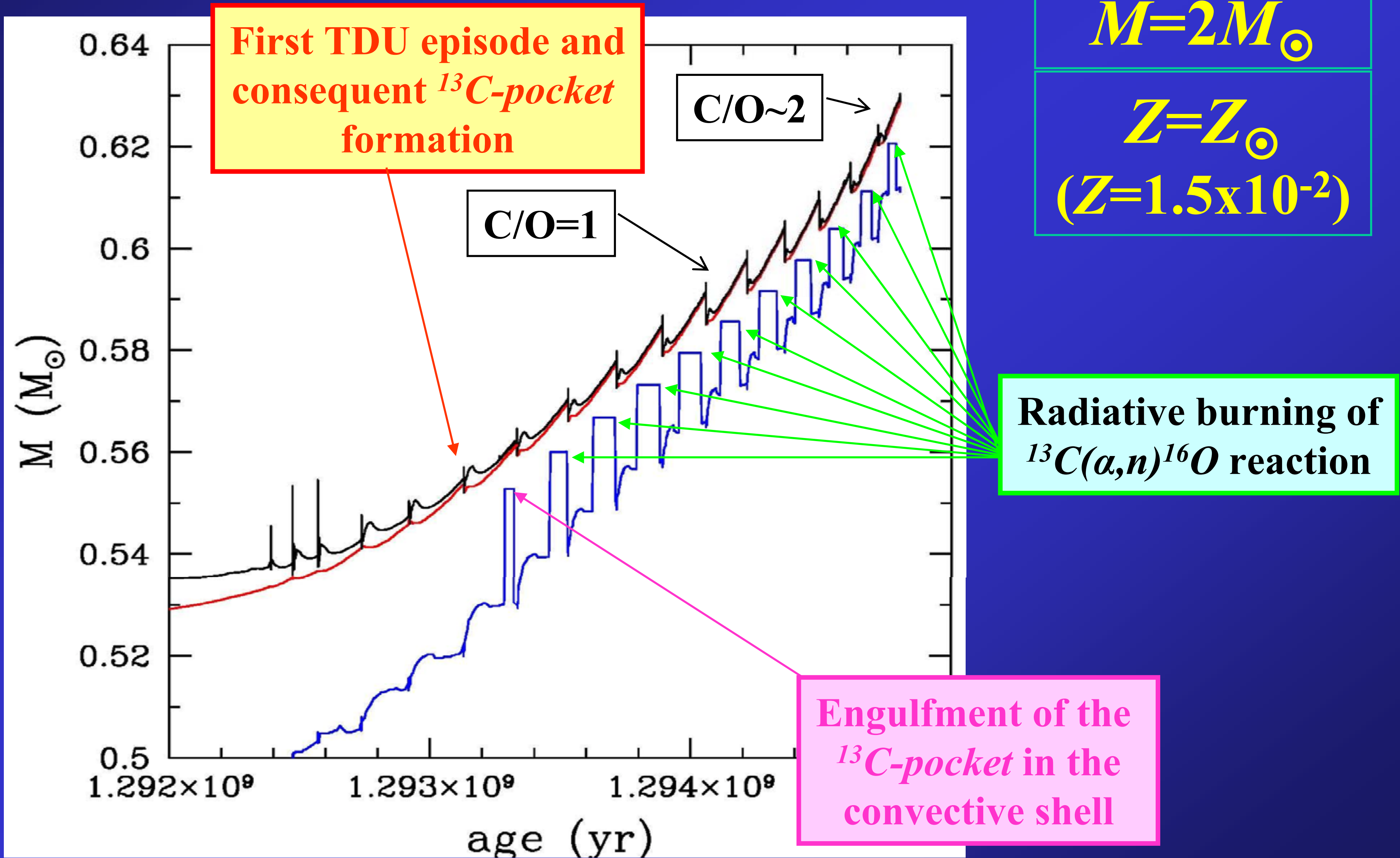
About 500 isotopes

linked by more than 700 reactions

Reactions	Reference
(n,γ) (n,p) and (n,α) p and α captures β decays	Bao & Kaeppeler Koehler,Wagemans NACRE Takahashi&Yokoi

Solar metallicity

THE AGB PHASE

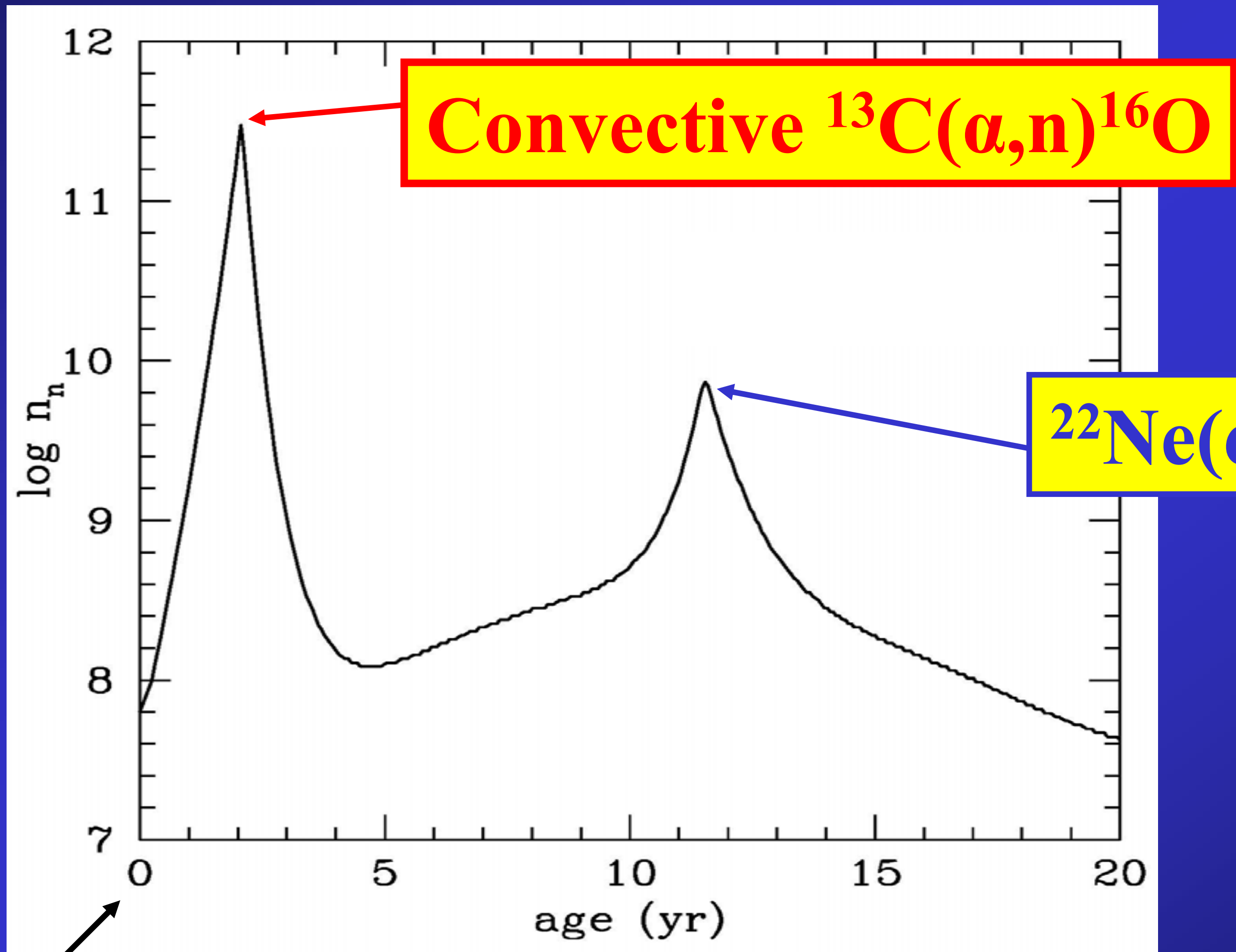


$M = 2M_\odot$

$Z = Z_\odot$

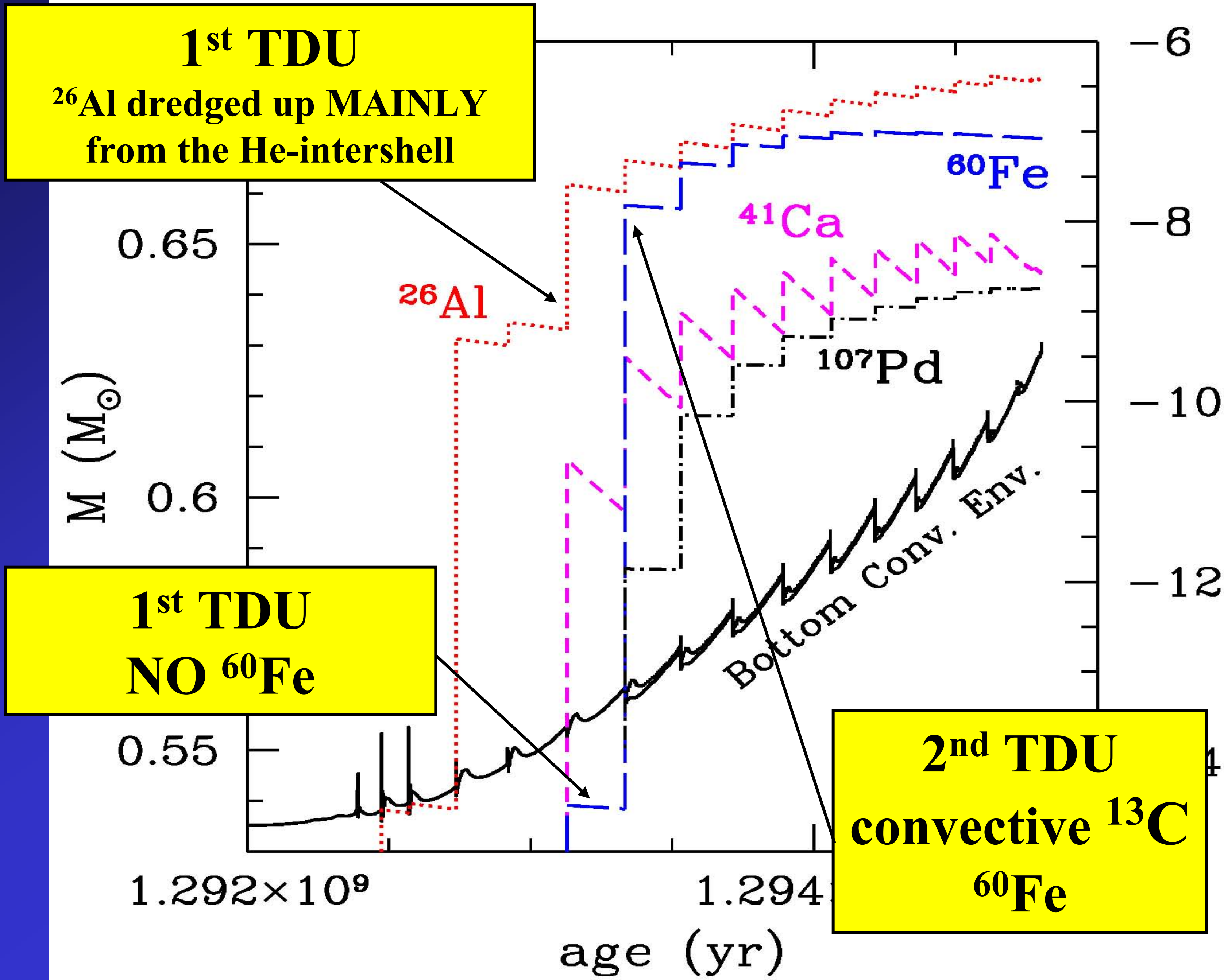
($Z = 1.5 \times 10^{-2}$)

CONVECTIVE ^{13}C burning → ^{60}Fe production

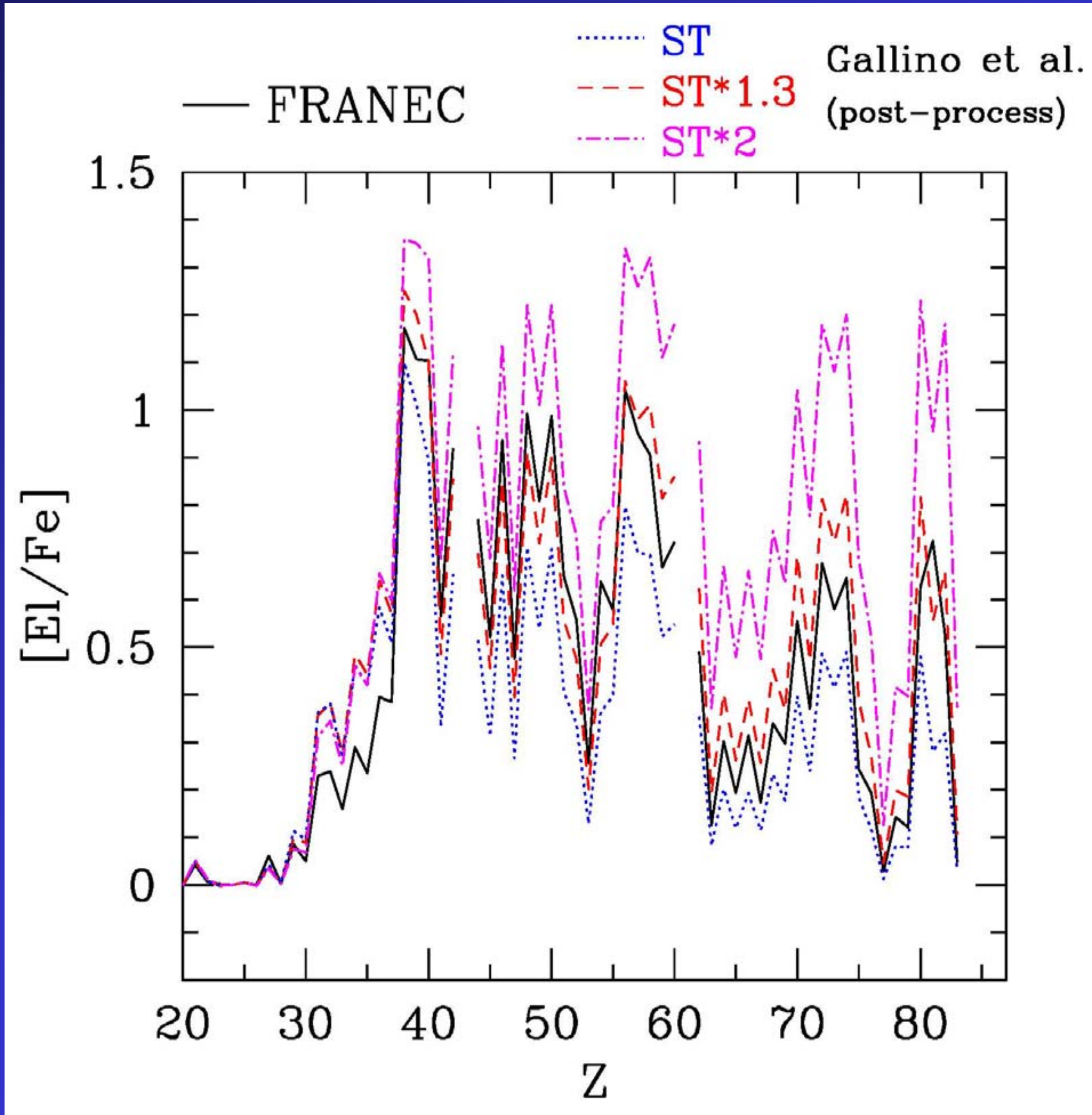


t=0 at the ^{13}C-pocket ingestion in the convective shell

Cristallo et al. 2006 (astro-ph/0606374)


1st TDU
26Al dredged up MAINLY
from the He-intershell
1st TDU
NO 60Fe
2nd TDU
convective 13C
60Fe
26Al
60Fe
41Ca
107Pd
Bottom Conv. Env.
M (M⊙)
0.65
0.6
0.55
log(Xi)
−6
−8
−10
−12
1.292×10⁹
1.294
age (yr)

Comparison with post-process calculations



POST PROCESS
(Gallino et al. 1998)

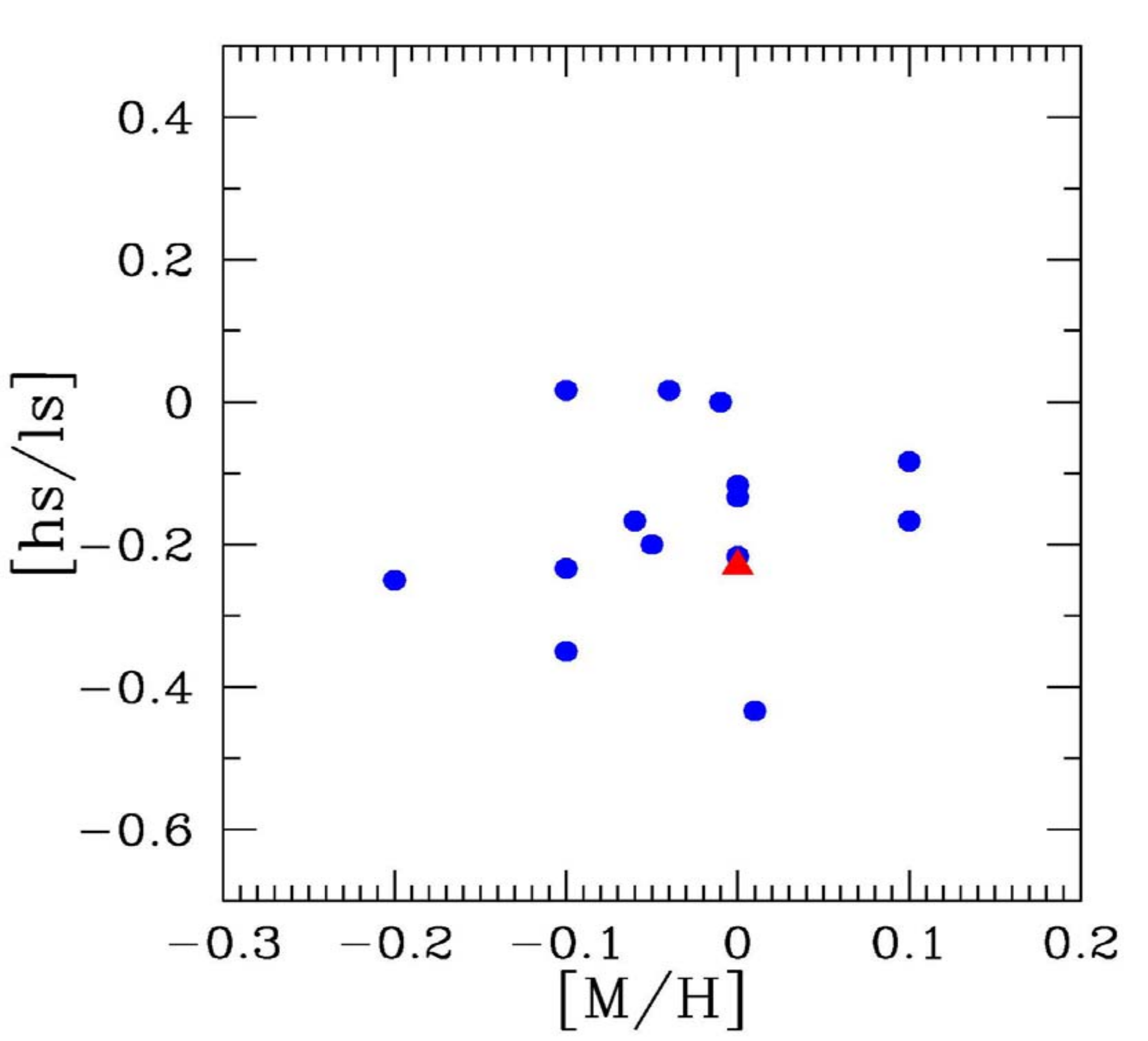
$M=2M_{\odot}, Z=2\text{x}10^{-2}$
(Straniero et al. 2003)

^{13}C pocket

1. Artificially introduced
2. Constant pulse after pulse

Final distributions

Comparison with Galactic Carbon Stars



$Z \sim Z_{\odot}$

Surface C/O=1

● **Abia et al. 2002**

▲ **FRANEC**

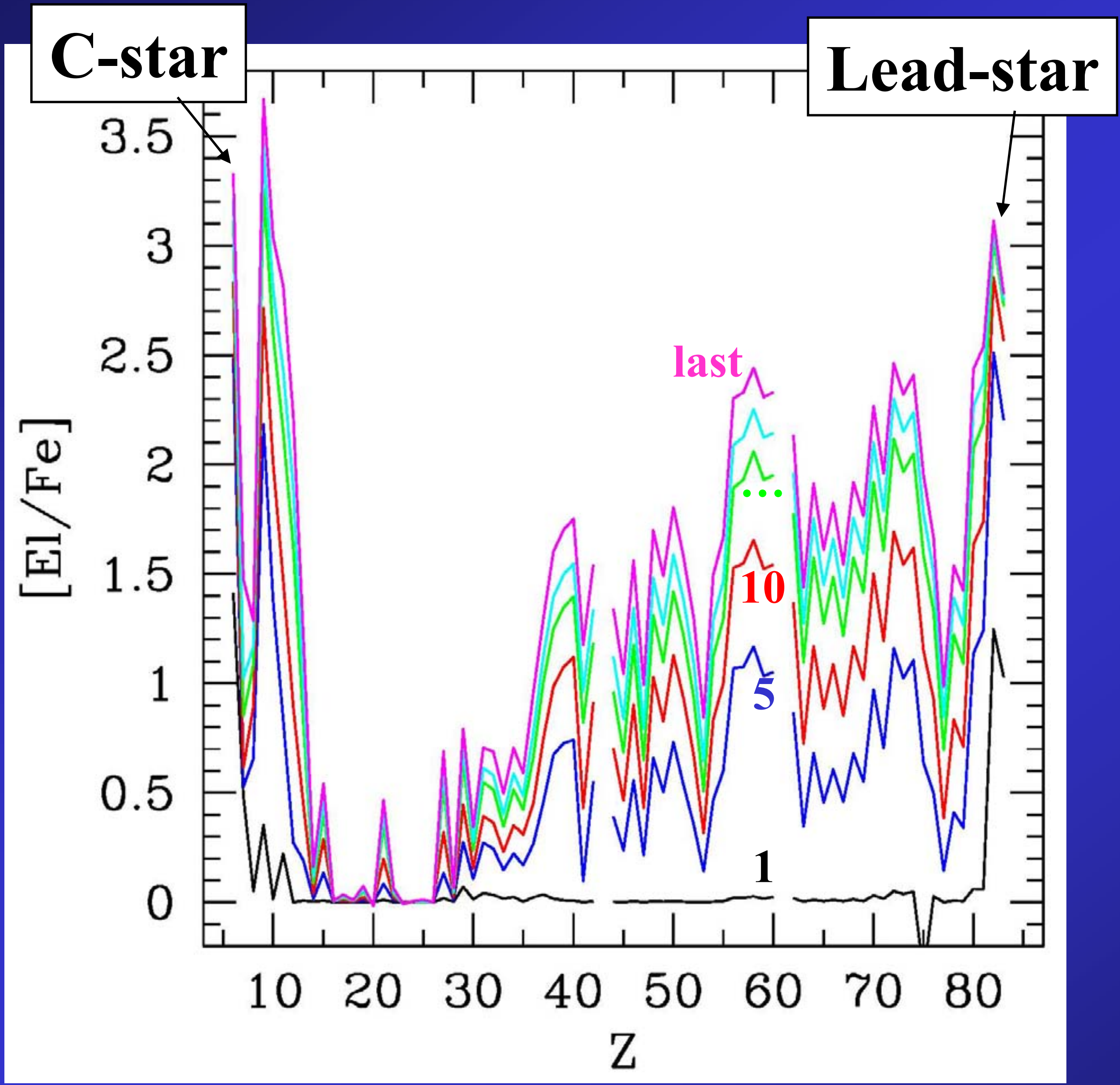
(6th pulse with TDU)

[ls/Fe]=([Sr/Fe]+[Y/Fe]+[Zr/Fe])/3

[hs/Fe]=([Ba/Fe]+[La/Fe]+[Ce/Fe] +[Nd/Fe] +[Sm/Fe])/5

Low metallicity

Pulse by pulse surface enrichments ($Z=10^{-4}$)



[C/Fe]=3.3 deX

[F/Fe]=3.7 deX

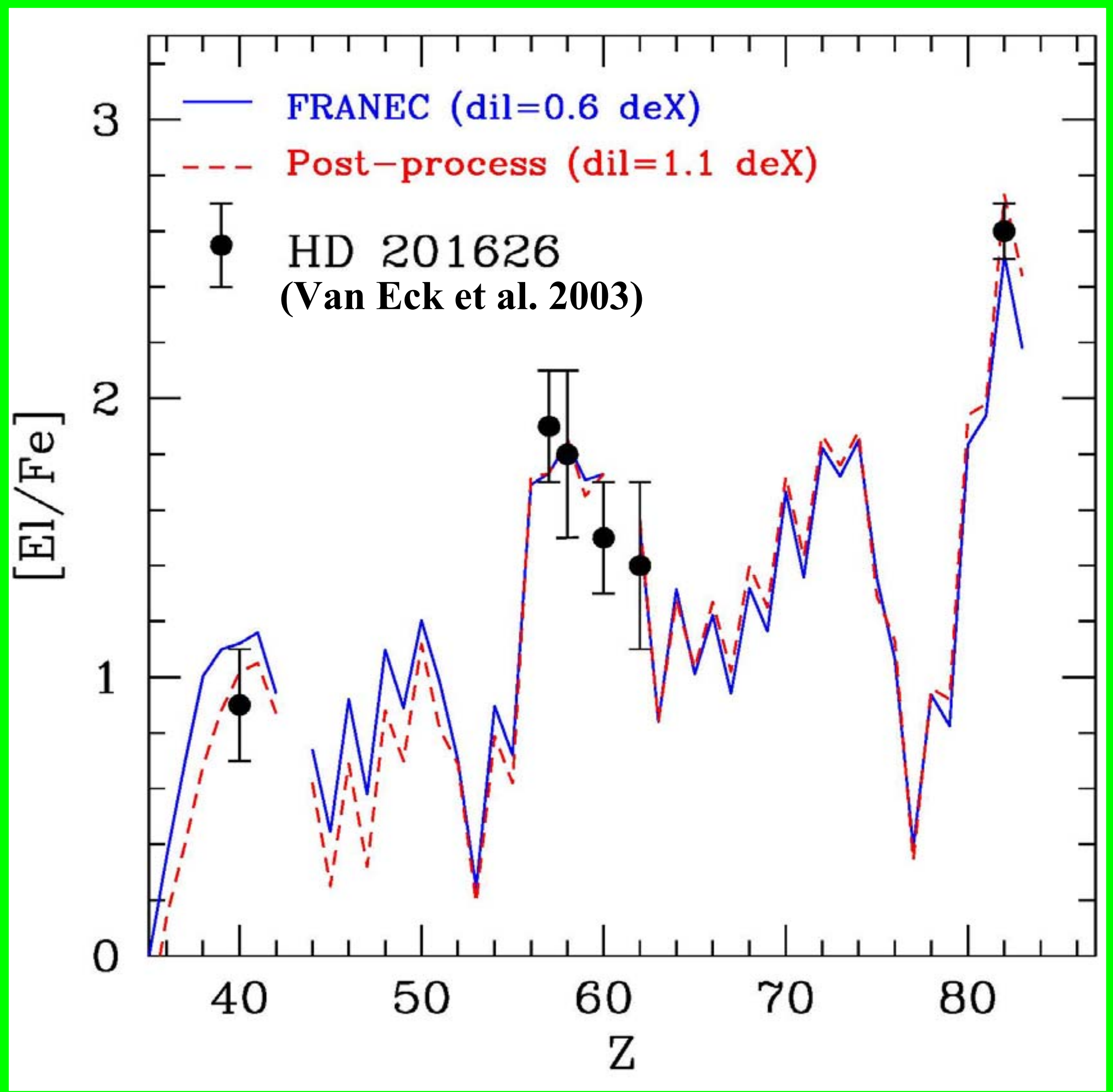
[Na/Fe]=2.8 deX

[ls/Fe] ~ 1.7

[hs/Fe] ~ 2.3

[Pb/hs] ~ 3.1

Comparison with LEAD (Halo) stars



REQUESTED DILUTION

EXTRINSIC AGB √

McClure & Woodsworth 1990

ORBITAL PARAMETERS

Future plans

- Exploring effects induced by C/O surface variations in models at low metallicities

- Performing new models with a reduced mass-loss

- Calculating more massive AGB stars (Al production)

1. $M=3M_{\odot}$ and $Z=Z_{\odot}$ (already done)
2. Currently running $M=6M_{\odot}$ and $Z=Z_{\odot}$

Yields and pulse by pulse [El/Fe] soon available on-line at:

http://www.oa-teramo.inaf.it/osservatorio/personale/cristallo/data_online.html