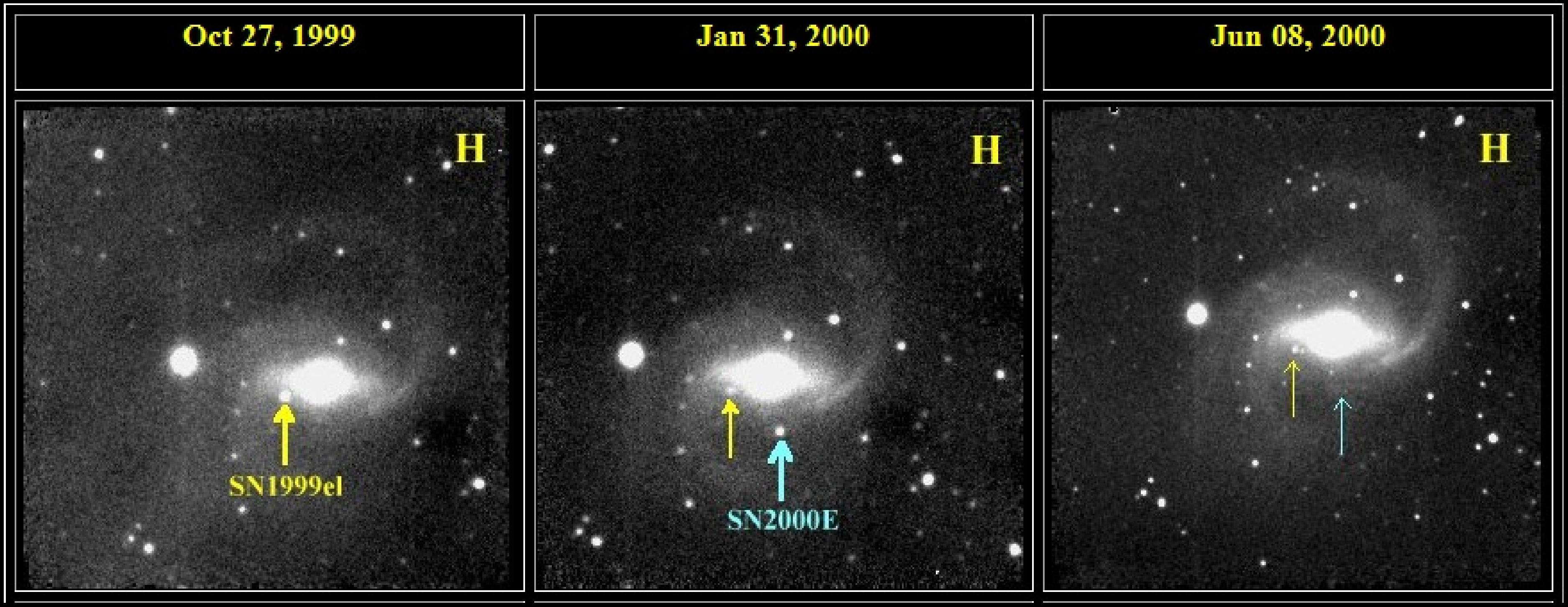
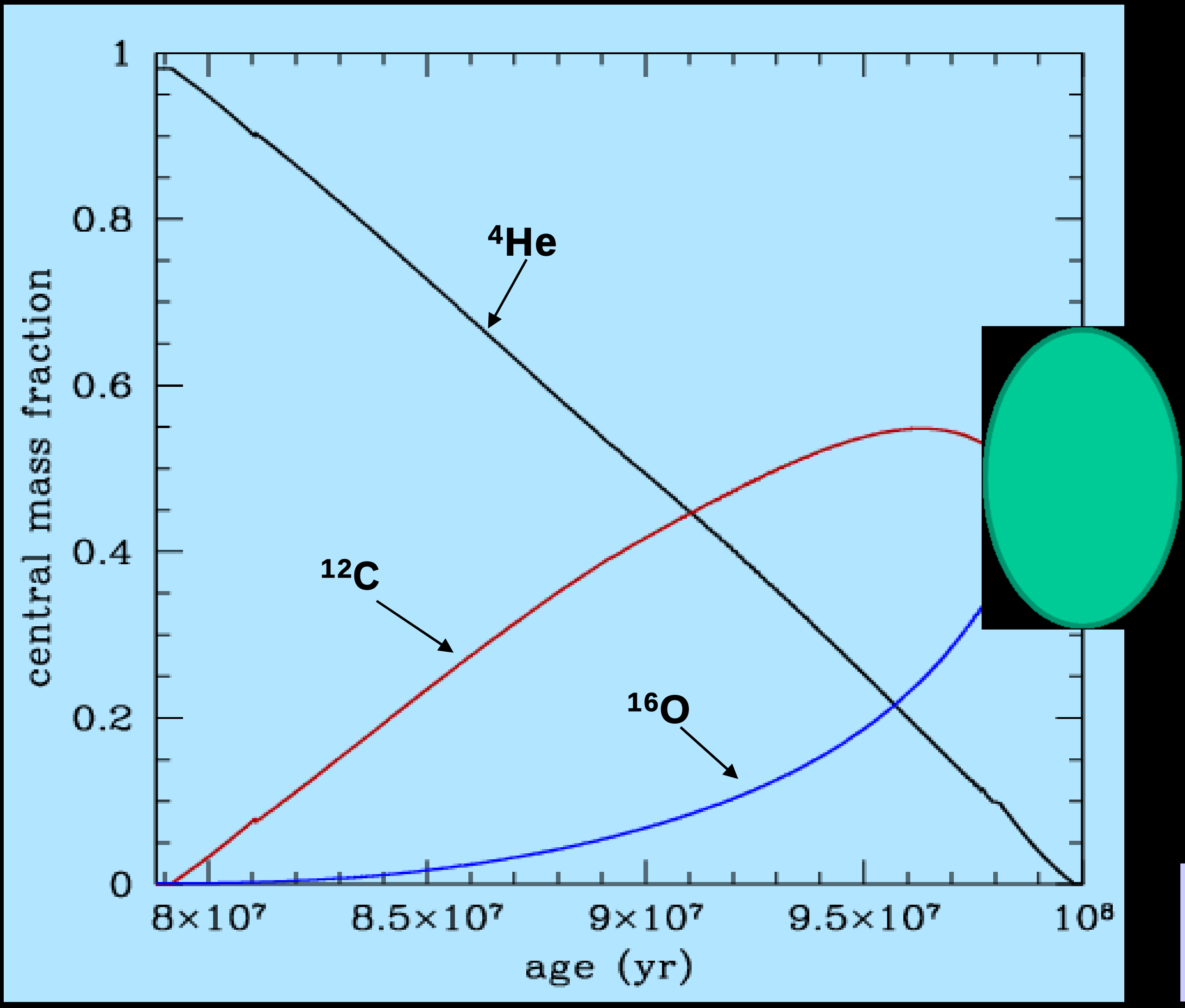
LUNA MV - LNGS Feb. 2011



SN1999el and SN2000E in NGC6951 as observed at the Campo Imperatore Observatory with the IR-camera@AZT24 telescope

He-burning: the competition between

$3\alpha \rightarrow {}^{12}C$ and ${}^{12}C+\alpha \rightarrow {}^{16}O+\gamma$



C/O

Core-He burning:
5 $M_{\odot}$ solar comp.

Main astro-context: late stellar evolution

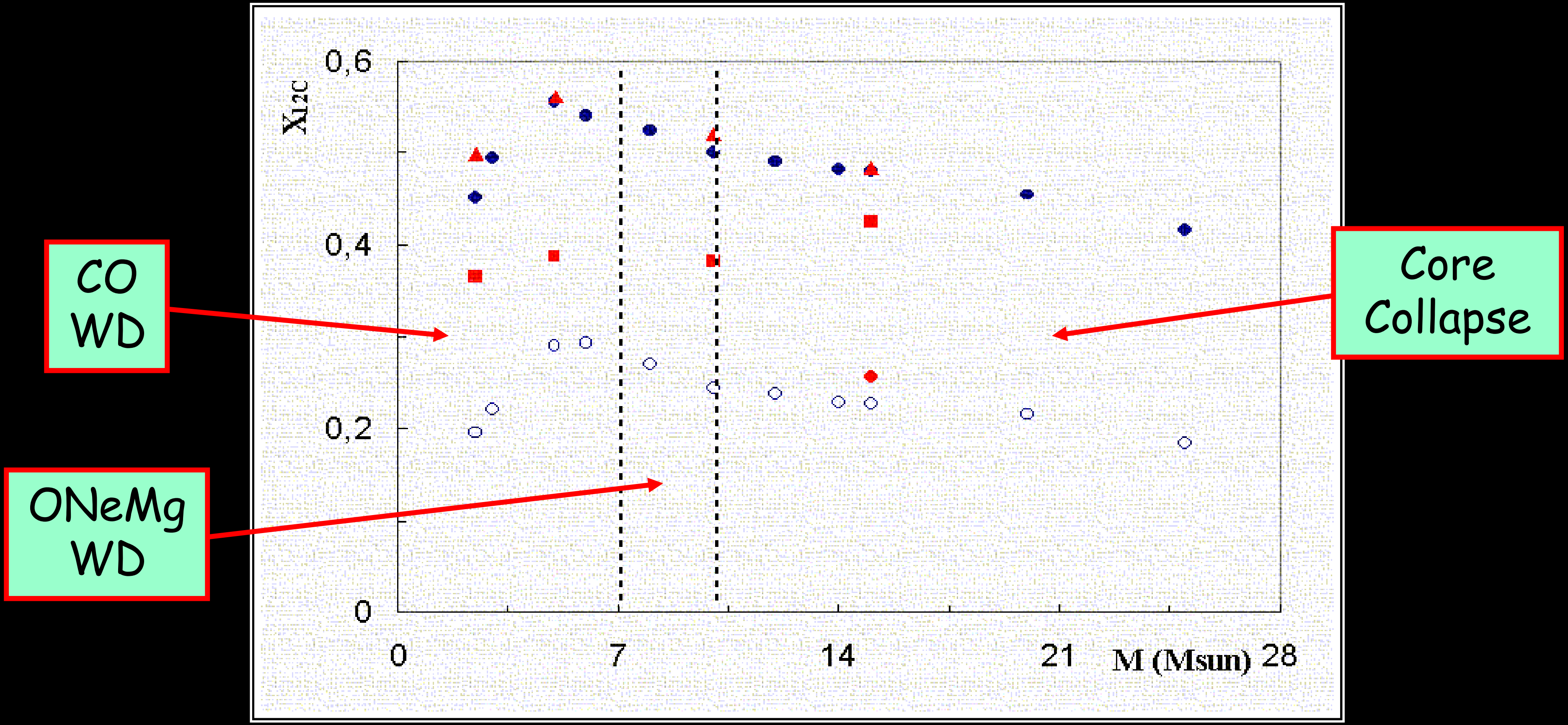
- Low and intermediate mass stars ($M<8\ M_{\odot}$)
  - → CO WDs & thermonuclear Sne
- Massive stars
  - → C to Si hydrostatic burning & core-collapse SNe

CF88(4.7) versus C85(11.3)

($N_a\langle\sigma,v\rangle$ (10^{-15} $cm^3 mol^{-1} s^{-1}$) @ T_9=0.2)

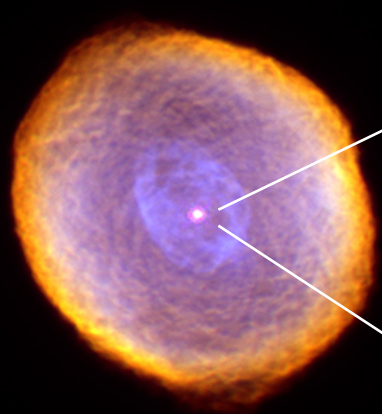
Carbon left in the core

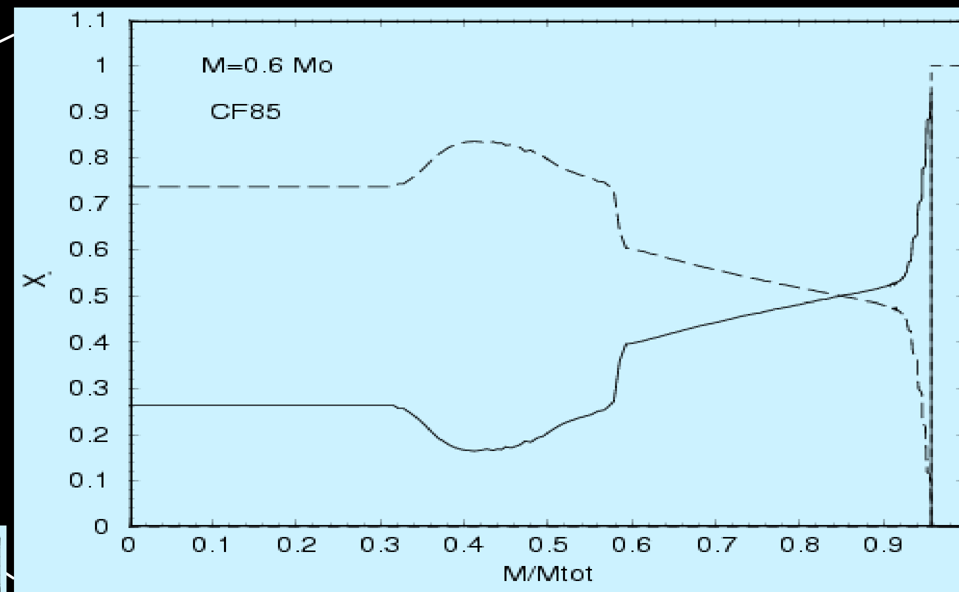
$0.8M_{\odot} < M < 25M_{\odot}$ (from Imbriani et al. 2001).

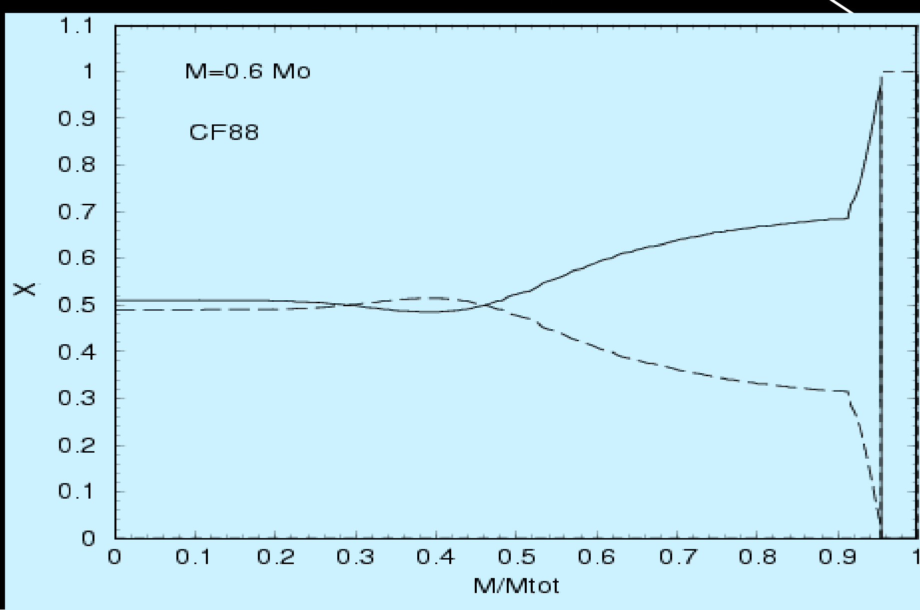


High rate – empty circle	**Low rate - Black circle**
1 Hp overshoot – triangle	**Breathing pulses - square**

After the He burning: CO core







High rate

$^{12}C(\alpha,\gamma)^{16}O$

Low rate

Low-mass stars,
WDs
&
Thermonuclear SNe

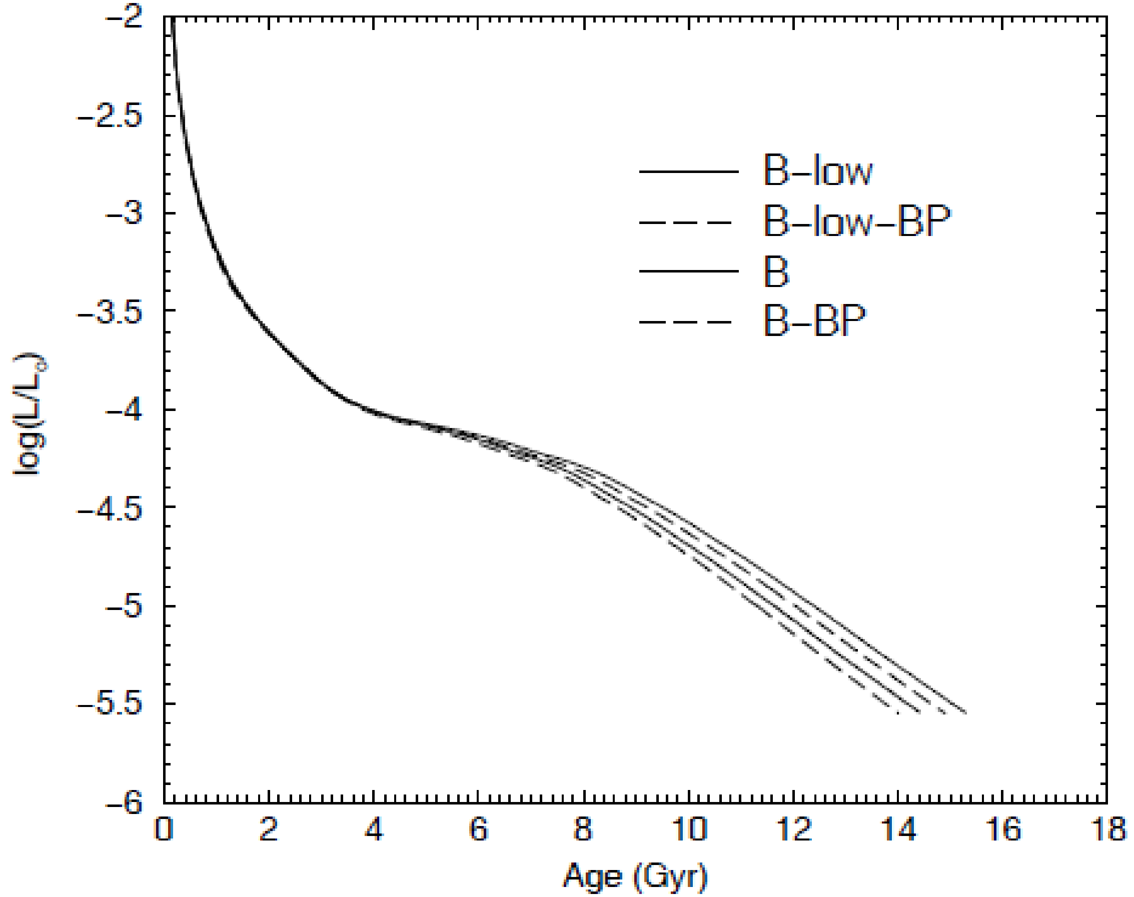


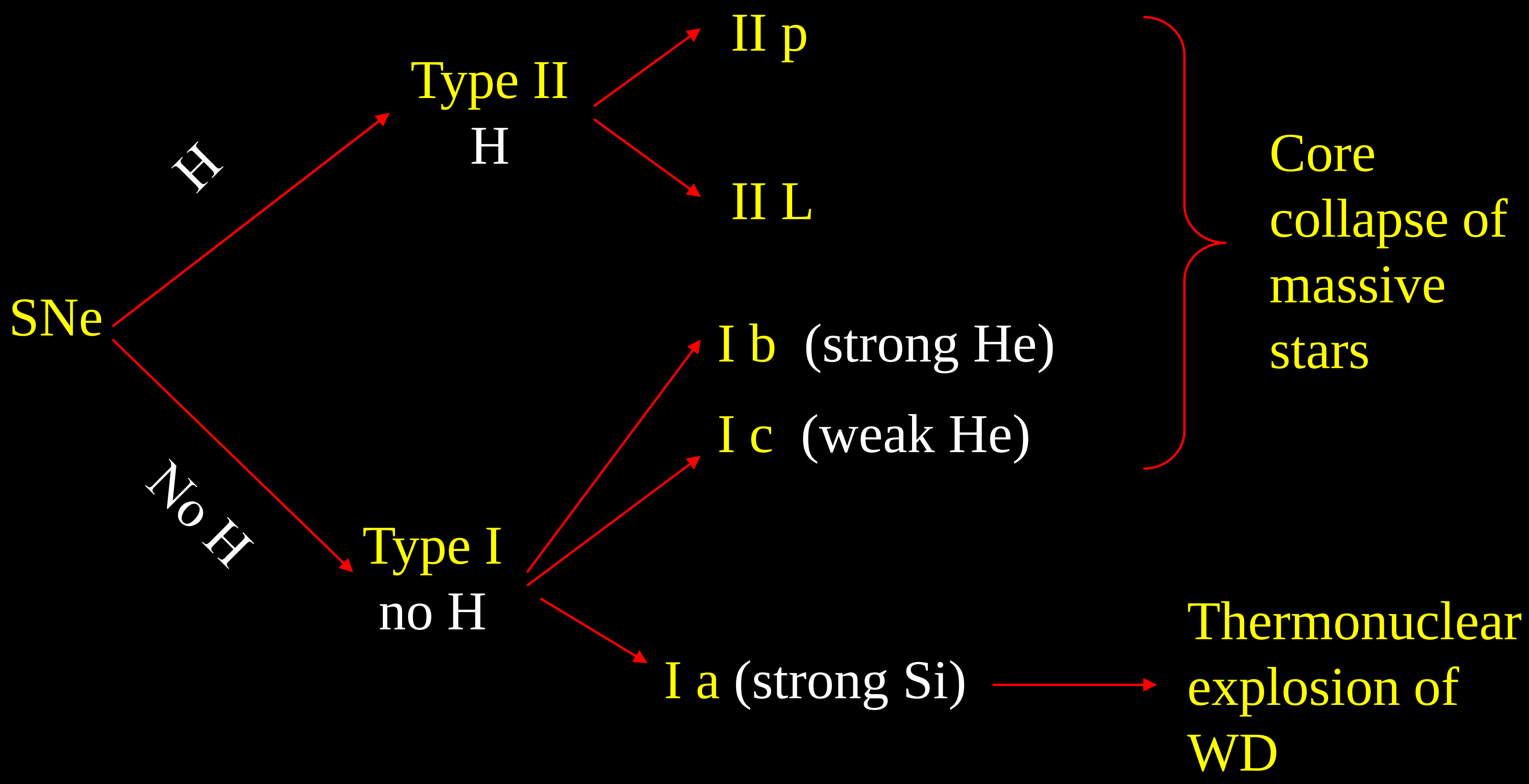
FIG. 7.—Cooling sequences obtained from progenitor evolutions with and without breathing pulses and different $^{12}C(\alpha,\gamma)^{16}O$ rate: no-BPs and CF88 (*thin solid line*), BPs and CF88 (*thin dashed line*), no-BPs and C85 (*thick solid line*), BPs and C85 (*thick dashed line*). Note that CF88 and C85 are representative of a low and a high rate for the $^{12}C(\alpha,\gamma)^{16}O$ (see text).

White Dwarfs cooling sequence: dependence on the C/O.

from Prada-Moroni & Straniero 2002

SNe Classification

Based on Spectra and Light Curve morphologies



Supernovae Ia

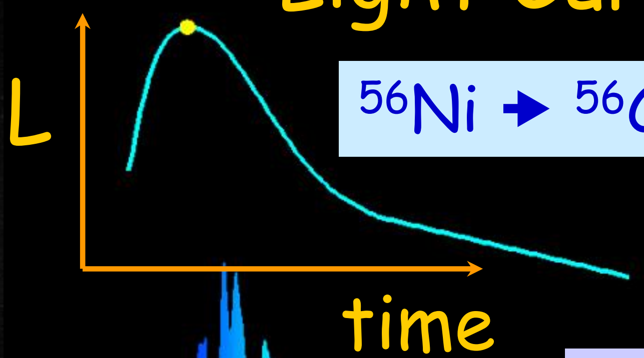
- Bright
- Homogeneous
- No evolutionary effects

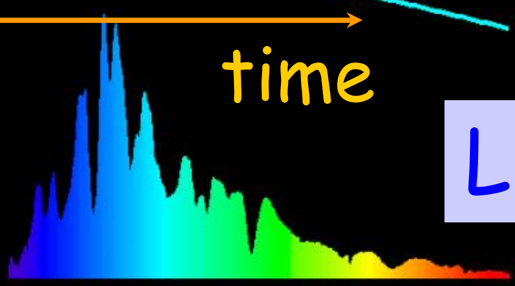
Thermonuclear Explosion of a CO WD

$M \sim M_{Chandrasekhar}$

$(1.4\ M_{\odot})$

Light Curve





$^{56}Ni \rightarrow {}^{56}Co \rightarrow {}^{56}Fe$

$L \propto M_{Ni}$

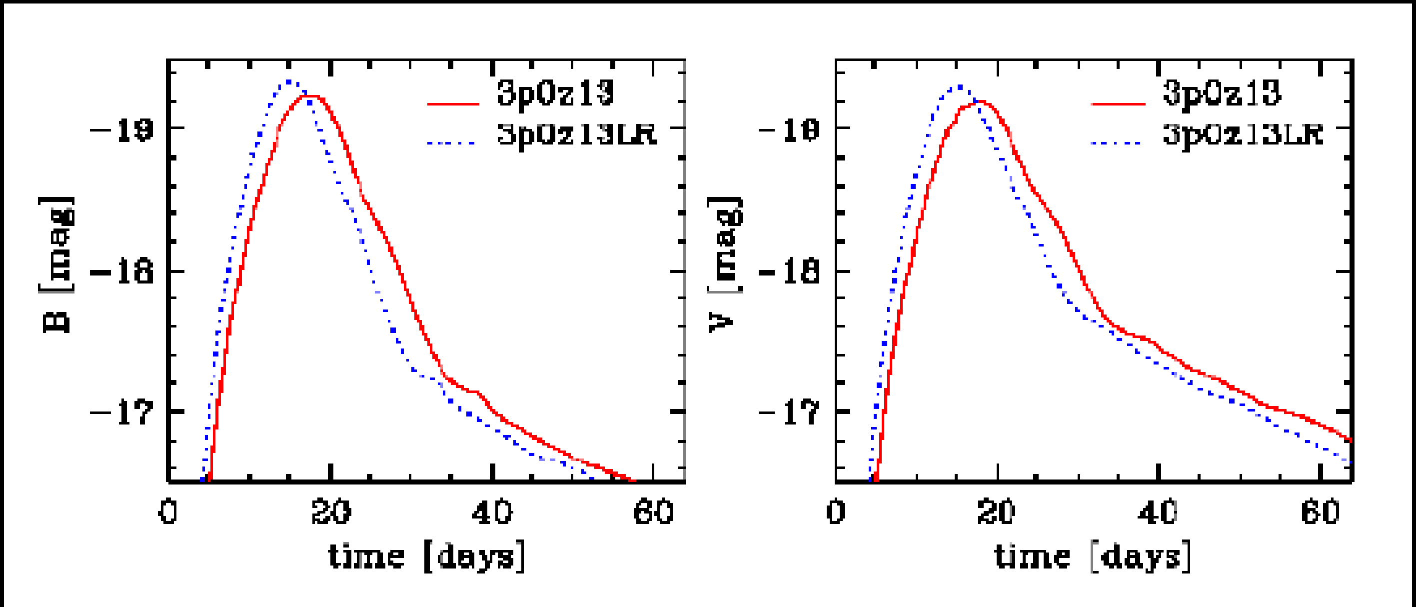
$^{12}C(\alpha,n)^{16}O$ and the final mass of ^{56}Ni

TABLE 1

PROPERTIES OF THE MODELS

Initial Composition (1)	Model (2)	M_{MS} ($M_\odot$) (3)	M_{CO}^{TP} ($M_\odot$) (4)	C_{cen} (5)	M_{cen} ($M_\odot$) (6)	C/O_{Mch} (7)	^{56}Ni ($M_\odot$) (8)
$Z = 0.02$	1p5z22	1.5	0.55	0.21	0.27	0.75	0.589
$Y = 0.28$	3p0z22	3.0	0.57	0.21	0.28	0.76	0.584
	5p0z22	5.0	0.87	0.29	0.46	0.72	0.561
	7p0z22	7.0	0.99	0.28	0.70	0.60	0.516
$Z = 10^{-3}$	1p5z13	1.5	0.59	0.24	0.31	0.76	0.587
$Y = 0.23$	3p0z13	3.0	0.77	0.26	0.39	0.74	0.567
	5p0z13	5.0	0.90	0.29	0.58	0.66	0.541
	6p0z13	6.0	0.98	0.29	0.71	0.60	0.522
	Low Rate 3p0z13LR	3.0	0.76	0.51	0.38	1.22	0.620
$Z = 10^{-4}$	3p0z14	3.0	0.80	0.27	0.41	0.73	0.568
$Y = 0.23$	5p0z14	5.0	0.90	0.29	0.58	0.65	0.541
	6p0z14	6.0	0.99	0.28	0.72	0.59	0.511
$Z = 10^{-10}$	5p0z00	5.0	0.89	0.32	0.49	0.70	0.549
$Y = 0.23$	7p0z00	7.0	0.99	0.31	0.59	0.62	0.525

$\Delta M(^{56}Ni)=10\%$



Rate	HIGH	LOW
M_V	-19.21	-19.30
Rise time	18.0 d	15.3 d

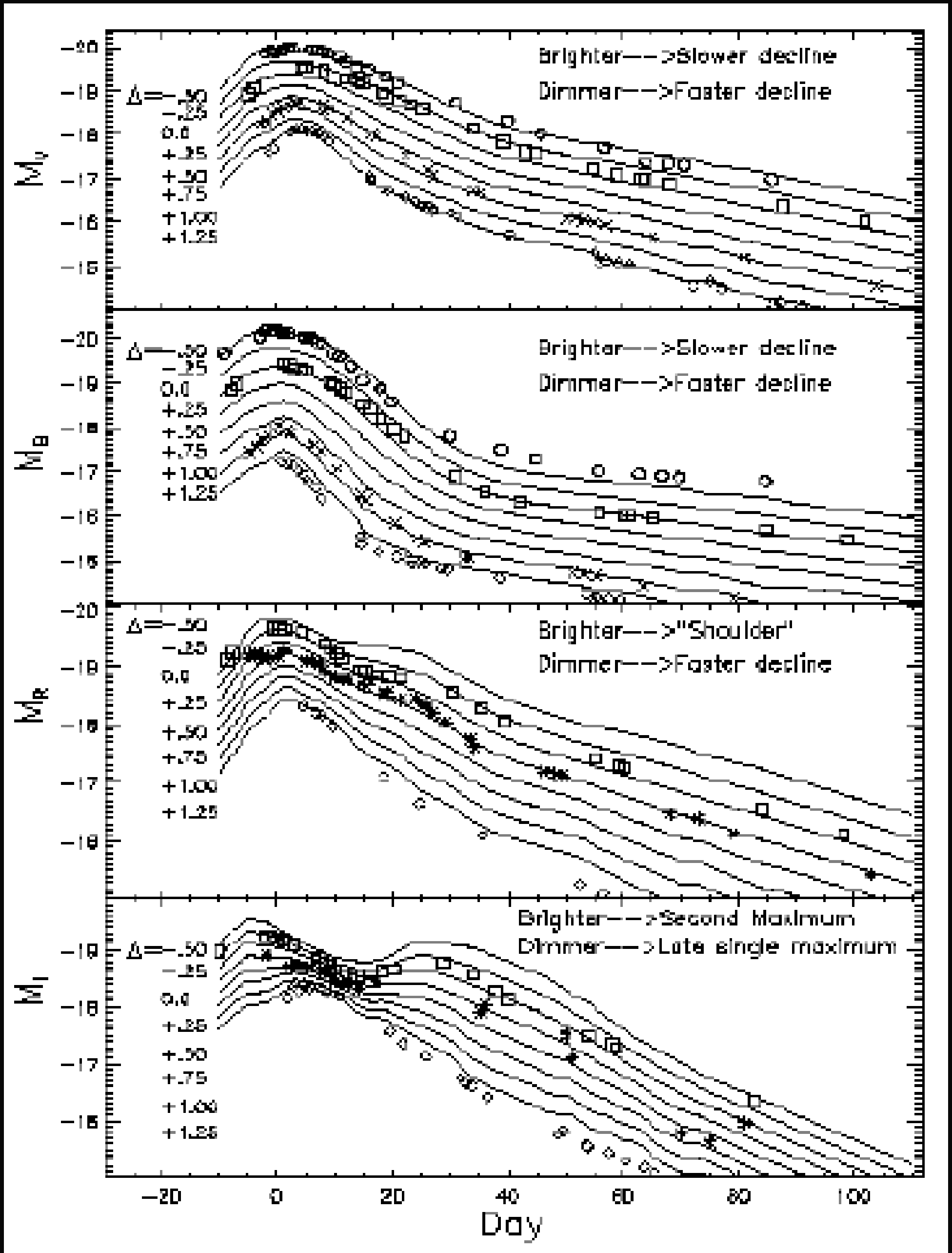
from
Dominguez, Hoflich, Straniero 2002

HIGH Rate C/O ↓

Observed: 18± 0.4 d

Type Ia light curve

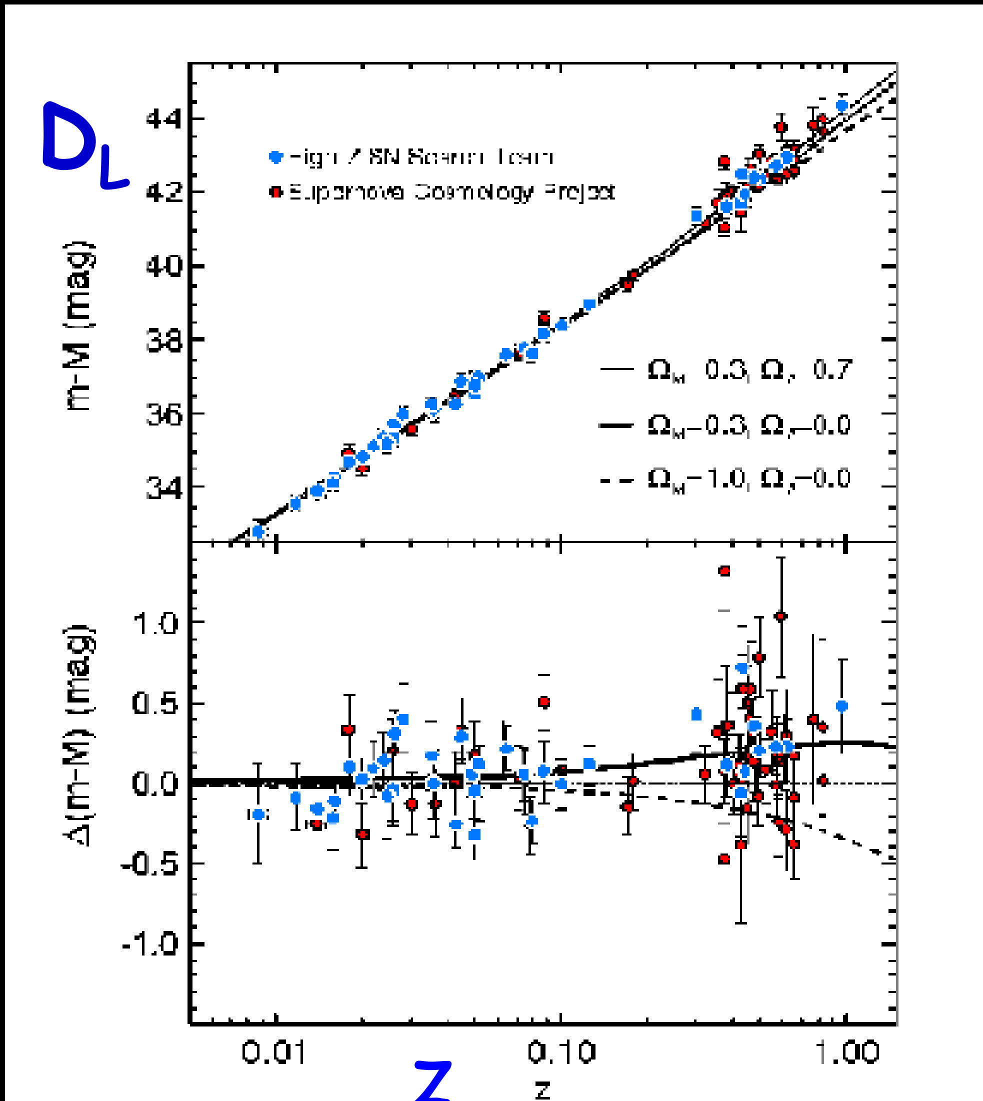
Riess et al. , 1997



Brighter
Slower Decline

Dimmer
Faster Decline

standard candles
visible up to z ~ 1



- High-z Team
  (Brian Schmidt & co)
- Supernova Cosmology Project
  (Saul Perlmutter & co.)

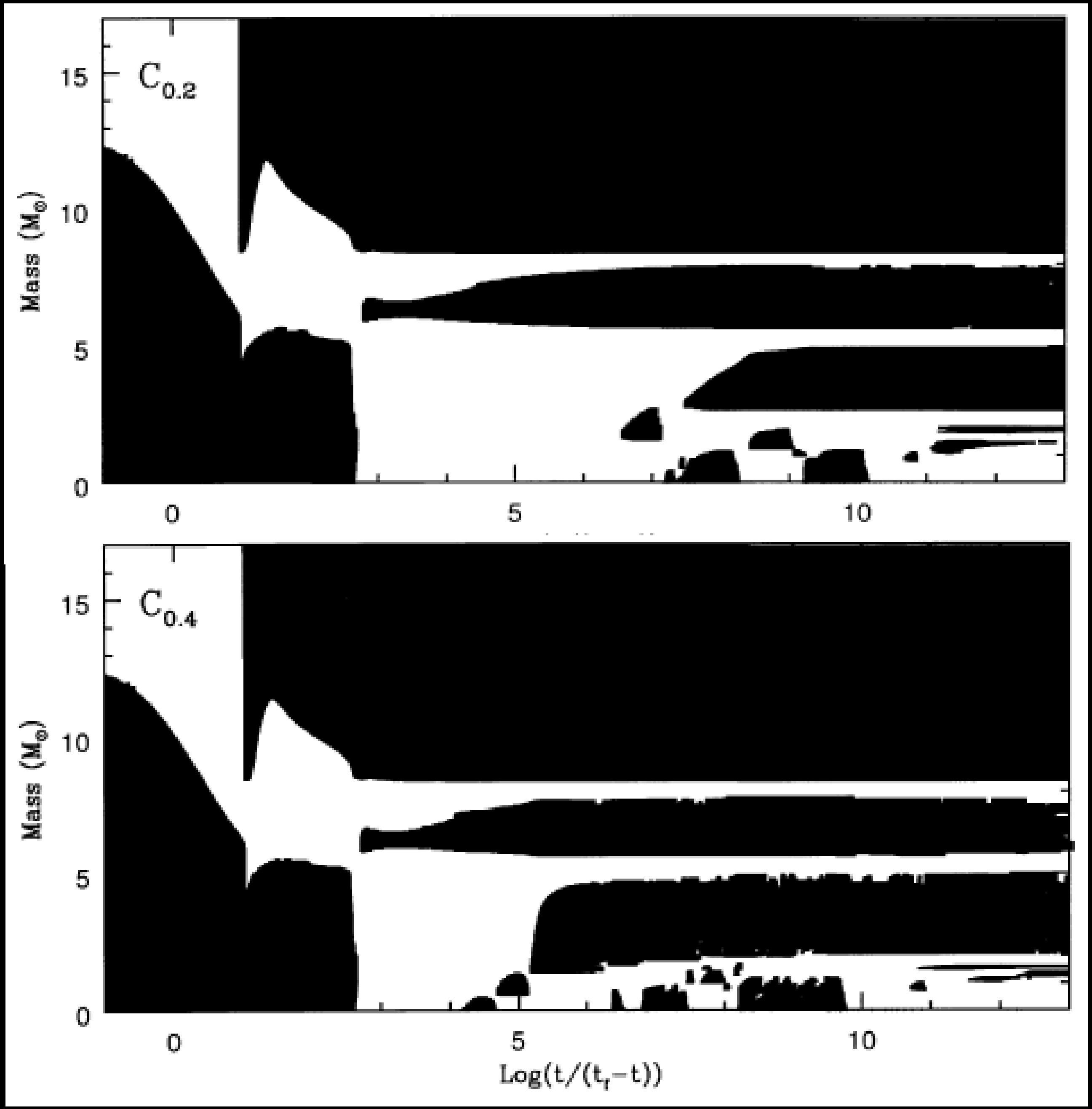
0.25 mag fainter than for an EMPTY Universe

Fainter → Further

The Universe is Accelerating

$$q_o = \frac{1}{2}\Omega_M - \Omega_\lambda$$

Massive stars
&
Core Collapse SNe

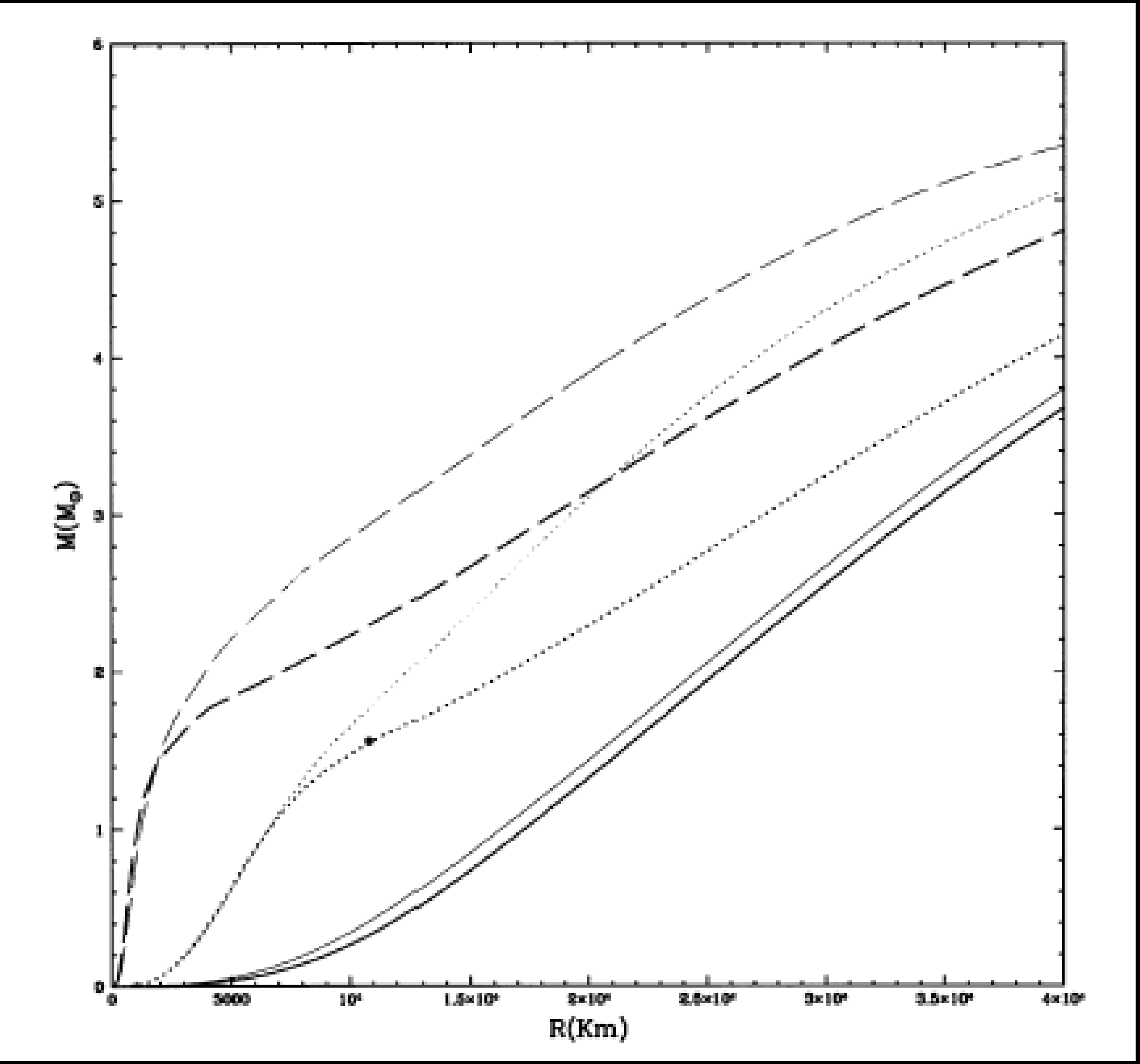


25 $M_\odot$

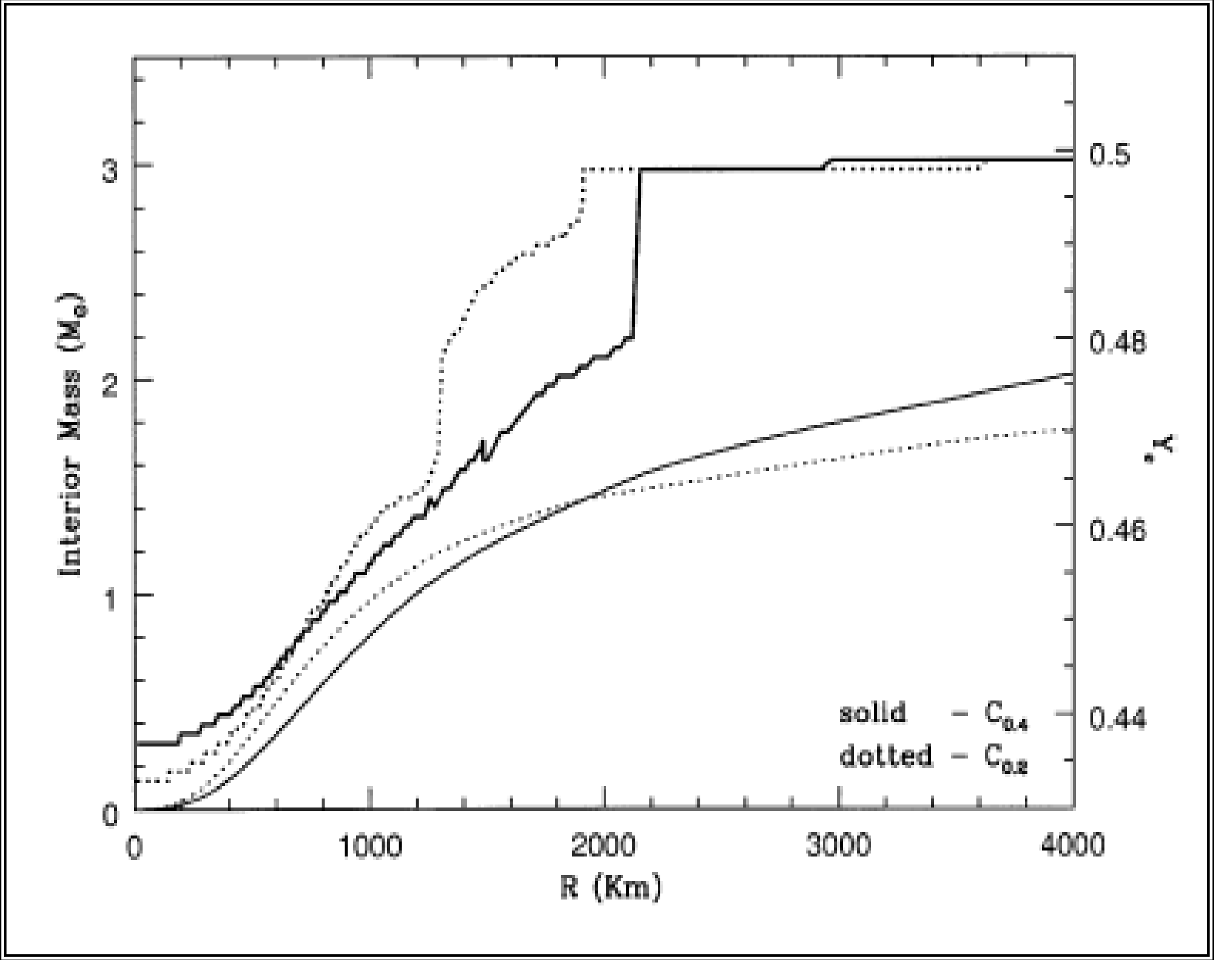
The convective regions mark the efficiency of nuclear burnings.

M-R relation:

high rate = shorter C burning = more compact progenitor



Y_e and $^{12}C(\alpha,\gamma)^{16}O$



low rate=high C
(solid)

high rate=low C
(dotted)

$$<Y_e> = 0.45 \Rightarrow M_{Ch} \approx 1.18$$

Yields of a core collapse Sne: low rate versus high rate

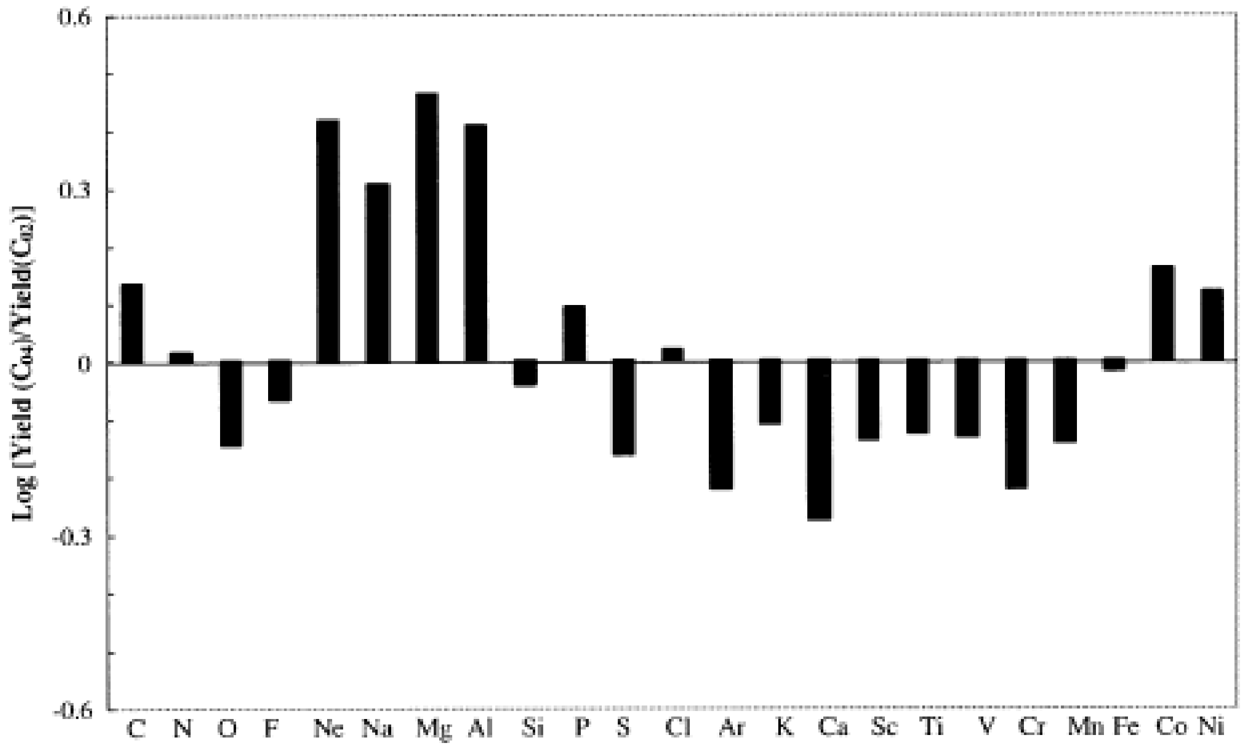


FIG. 13.—Logarithmic ratio between the yields produced by the $C_{0.4}$ run and those produced by the $C_{0.2}$ run

Observable consequences: CC-SN yields

1. Intermediate-light elements, Ne, Na, Mg, and Al (which are produced in the C convective shell), scale directly with the C abundance left by the He burning, because they depend on the amount of available fuel.

2. Elements produced by any of the four explosive burnings (complete explosive Si burning, incomplete explosive Si burning, explosive O burning, and explosive Ne burning) scale inversely with the C, because of the mass-radius relation .

3. Low C (about 0.2 by mass fraction) implies yields with a scaled solar distribution.

4. Low C implies smaller iron cores, thus favouring the explosion.