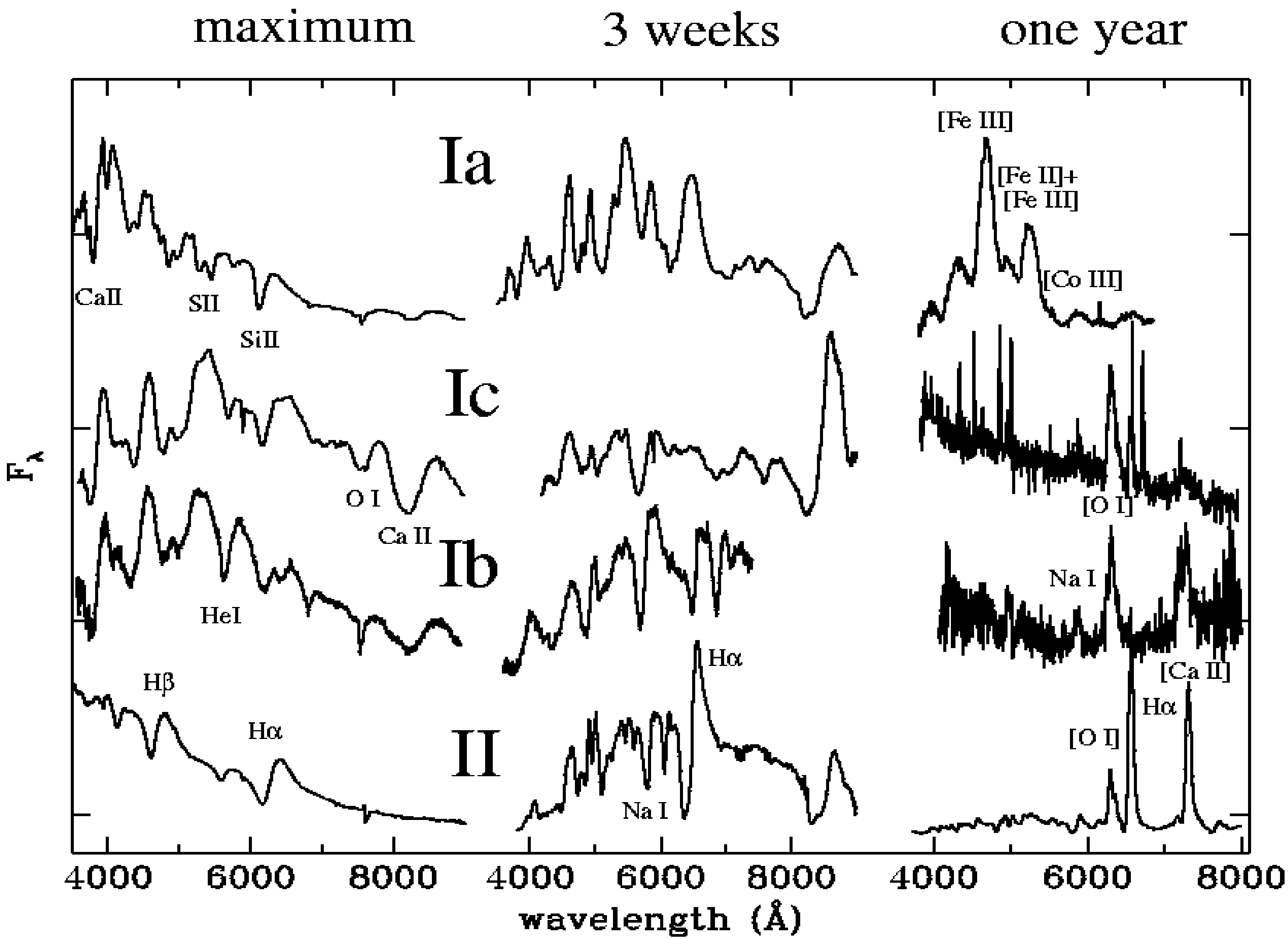
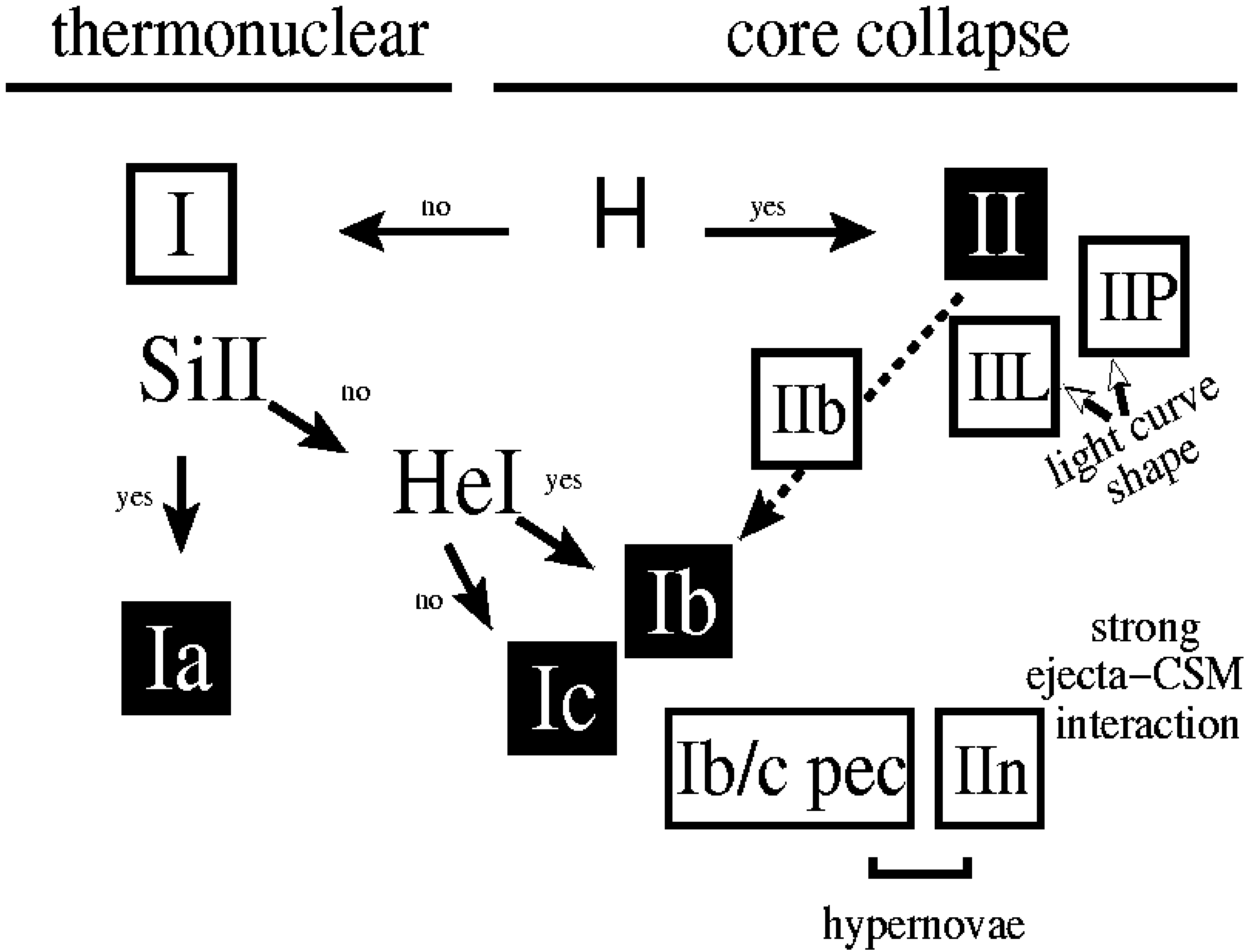
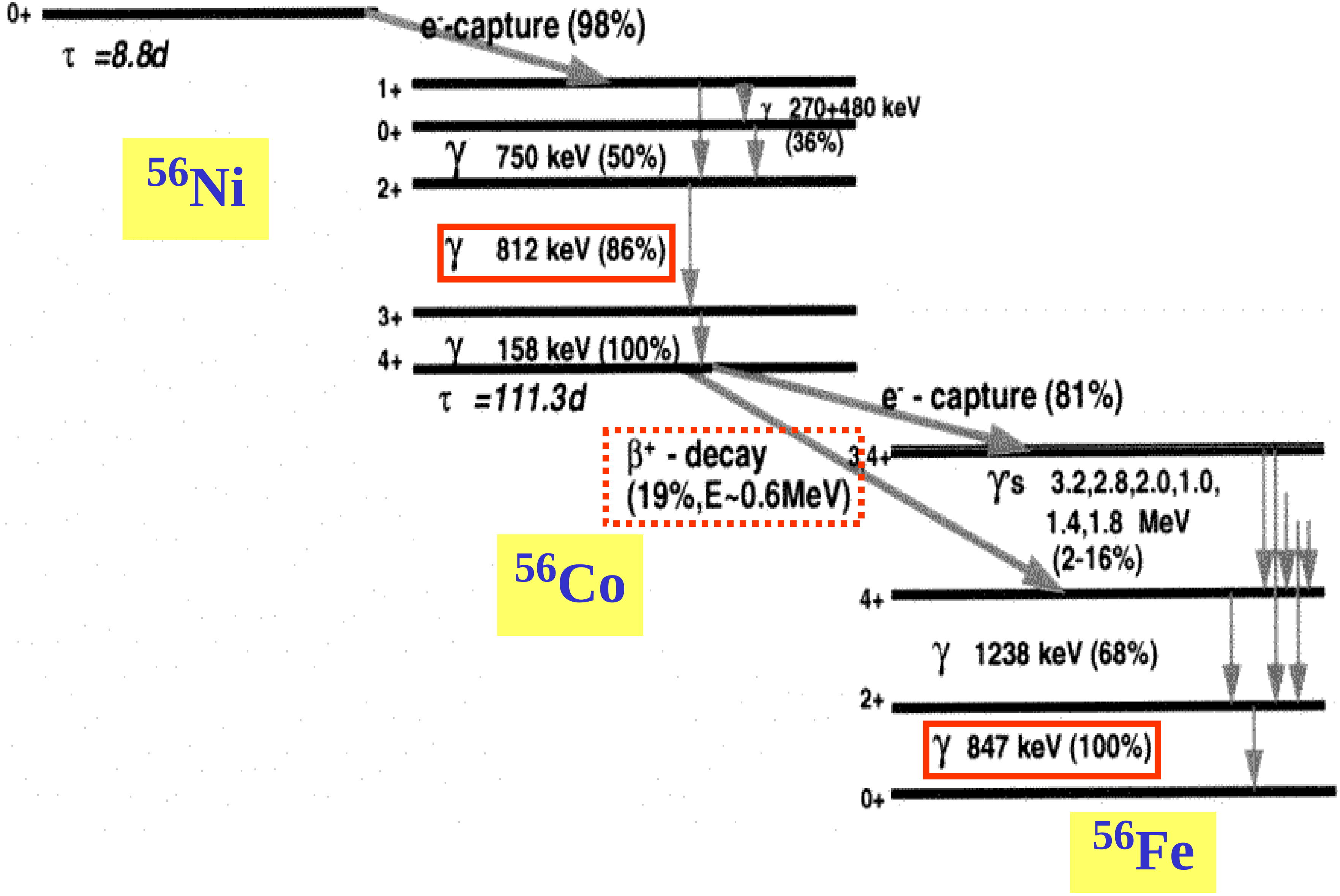
Supernova spectra

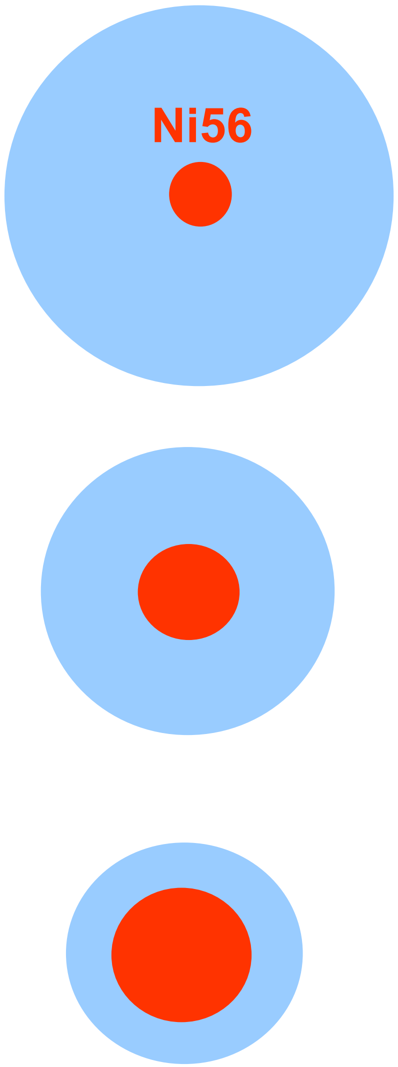


Supernova classification



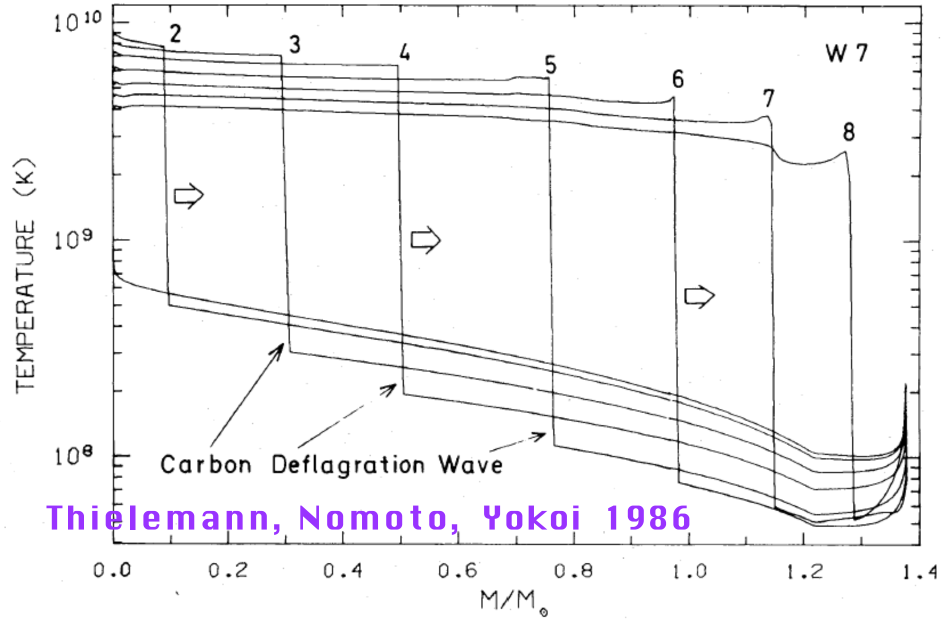
Ni56 decay scheme



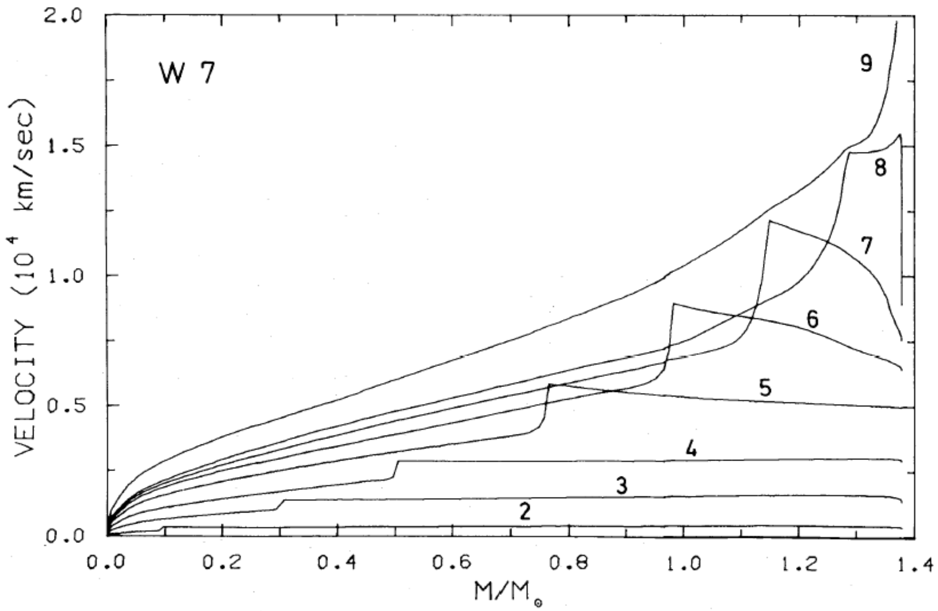


SN	M(Ni56) M_	M(Envelope) M_	$V_{Expansion}$ km/s	$F_{847\ keV}$ ph/cm^2/s at 10 Mpc
SNII	0.07	15	5000	$3\ 10^{-8}$
SNIb/c	0.15	5	10000	$5\ 10^{-6}$
SNIa	0.7	0.5	15000	$3\ 10^{-5}$

W7: a very successful parameterized SNIa model

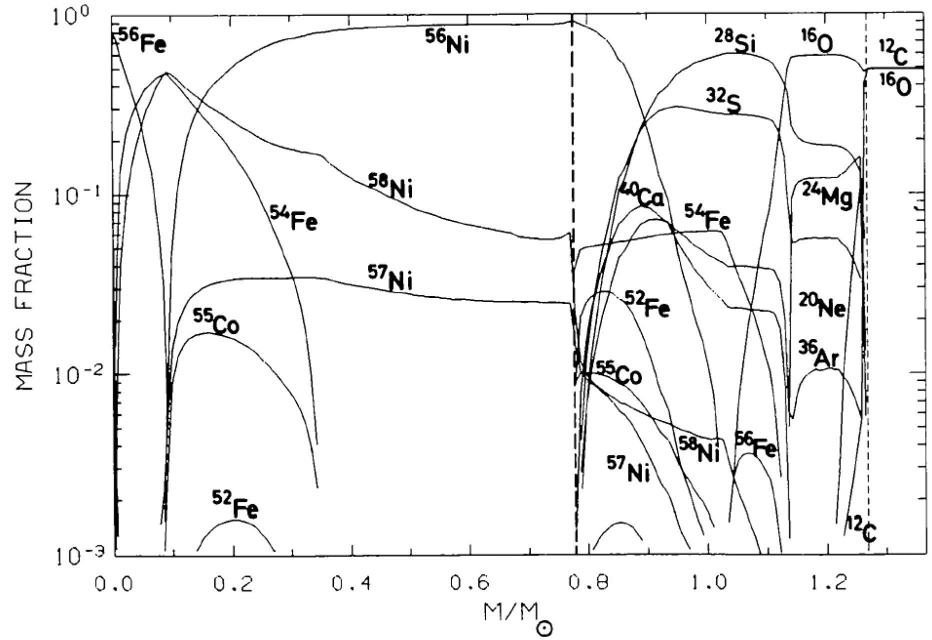


Thielemann, Nomoto, Yokoi 1986

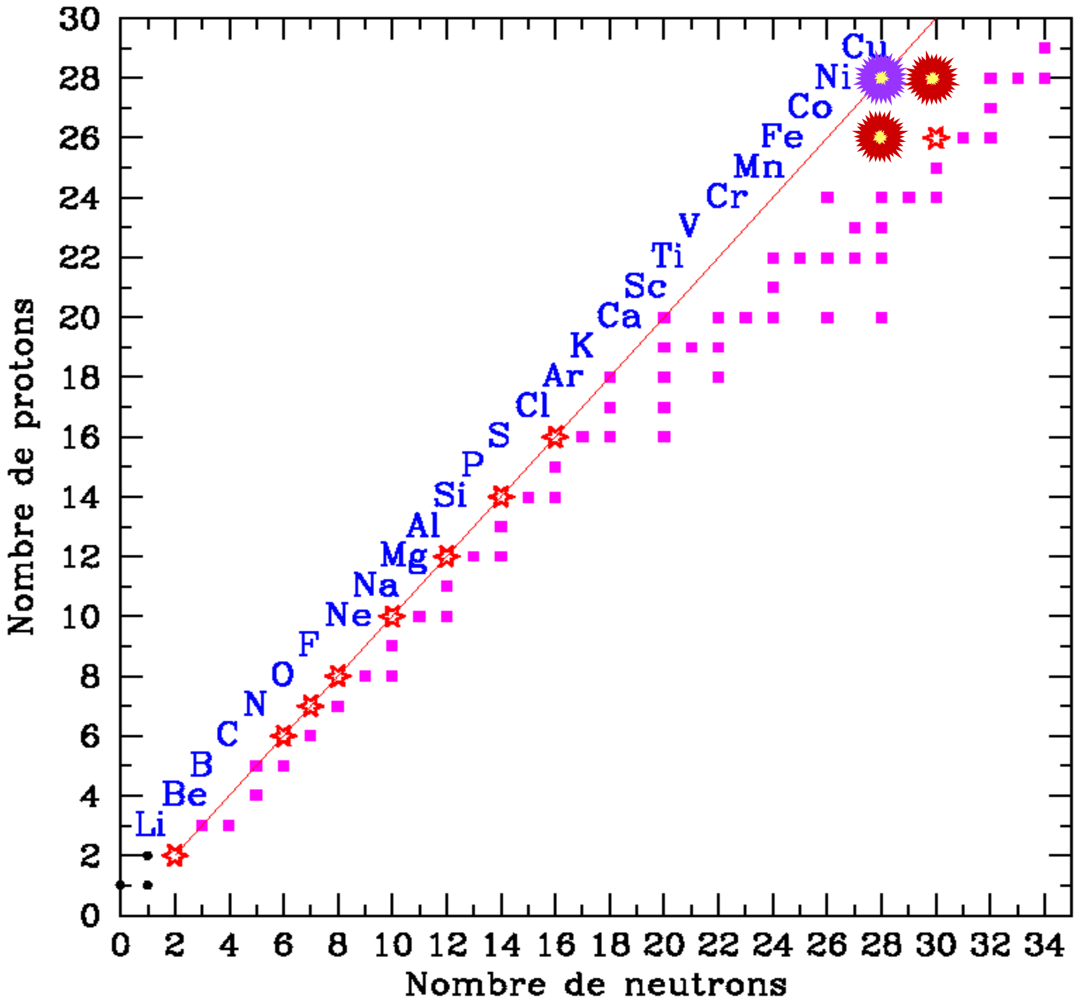


The flame should start **slowly** and pre-expand the star, to avoid too much e^- captures and production of Fe54, Ni58 (for nucleosynthesis)

Then move rapidly, at densities 10^7-10^8 g/cm^3 to produce ≈0.6 M_ of Ni56 in intermediate layers (for the optical lightcurve) and ≈0.2 M_ of Si, S, Ar, Ca (for the early spectra)



Nuclear Statistical Equilibrium in SNIa

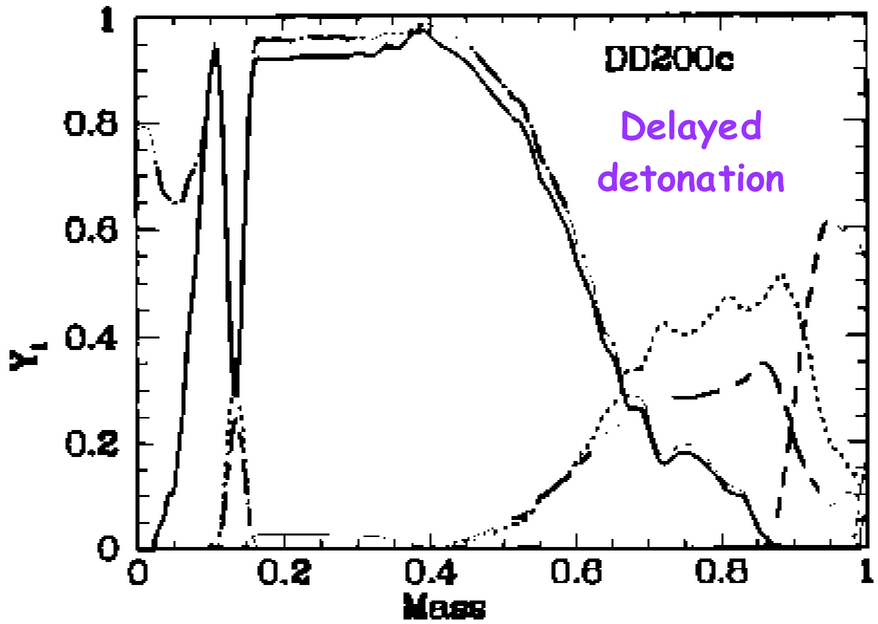


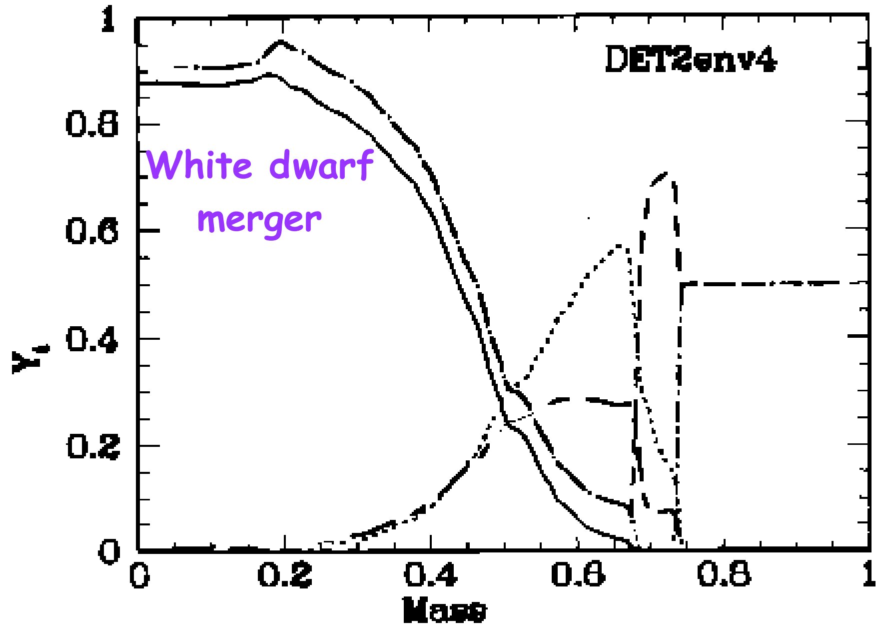
In "low" densities ($<10^8$ g/cm^3) electron captures are negligible during the explosion and material burns at Z=N up to unstable **Ni56** (which beta decays to Fe56 after the explosion)

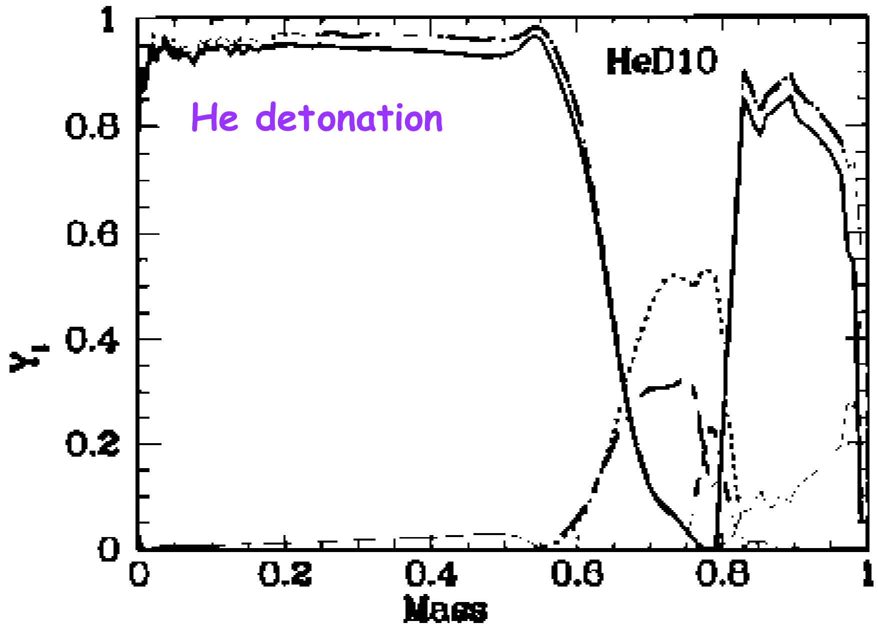
In higher densities ($>10^9$ g/cm^3) electron captures are important during the explosion and NSE produces stable **Fe54** and **Ni58**

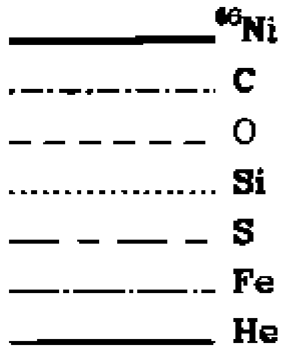
Problem: A large part of the inner white dwarf has densities of 10^9 g/cm^3

Nucleosynthesis in 1D models of SNIa



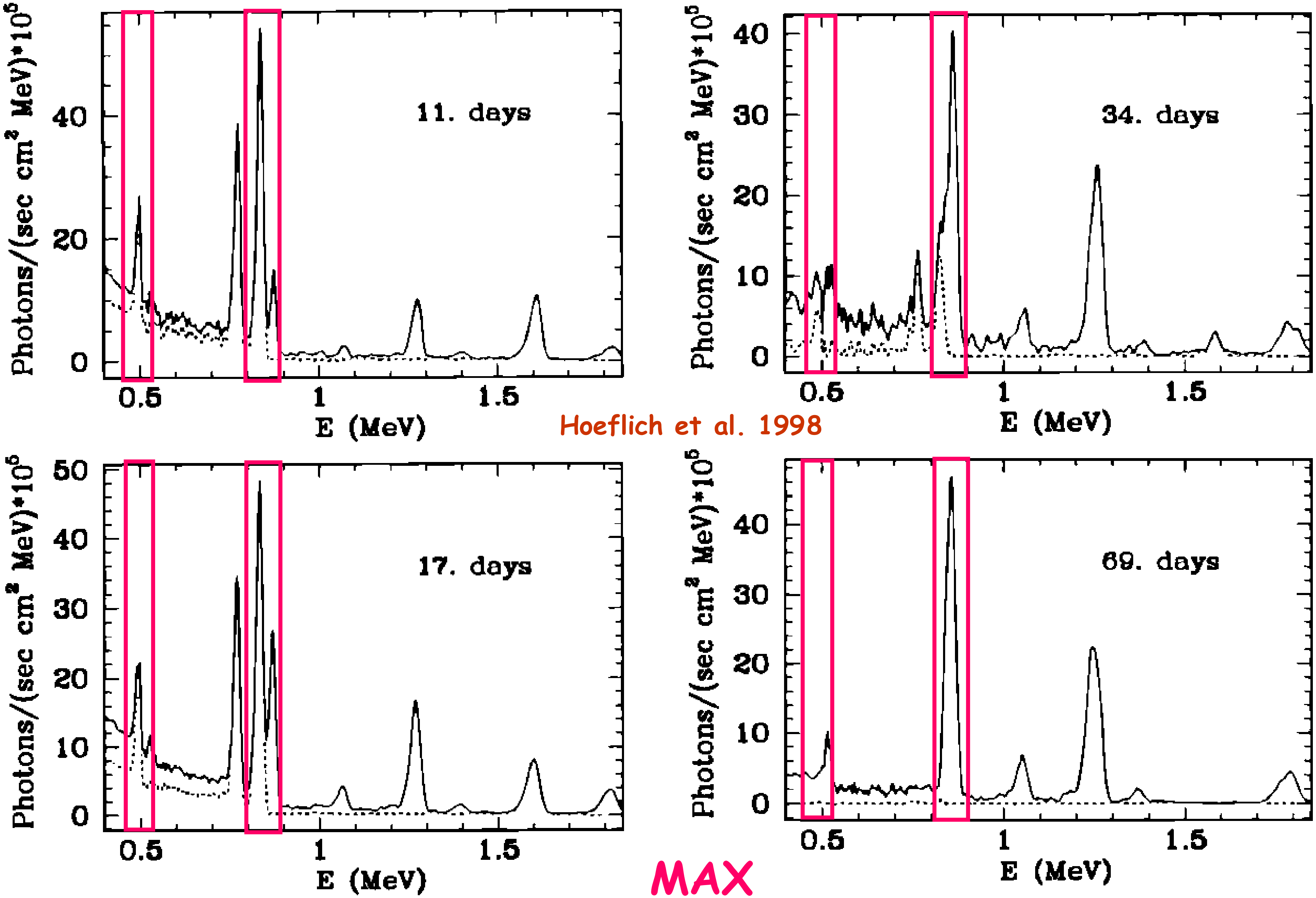






Hoeflich et al. 1998

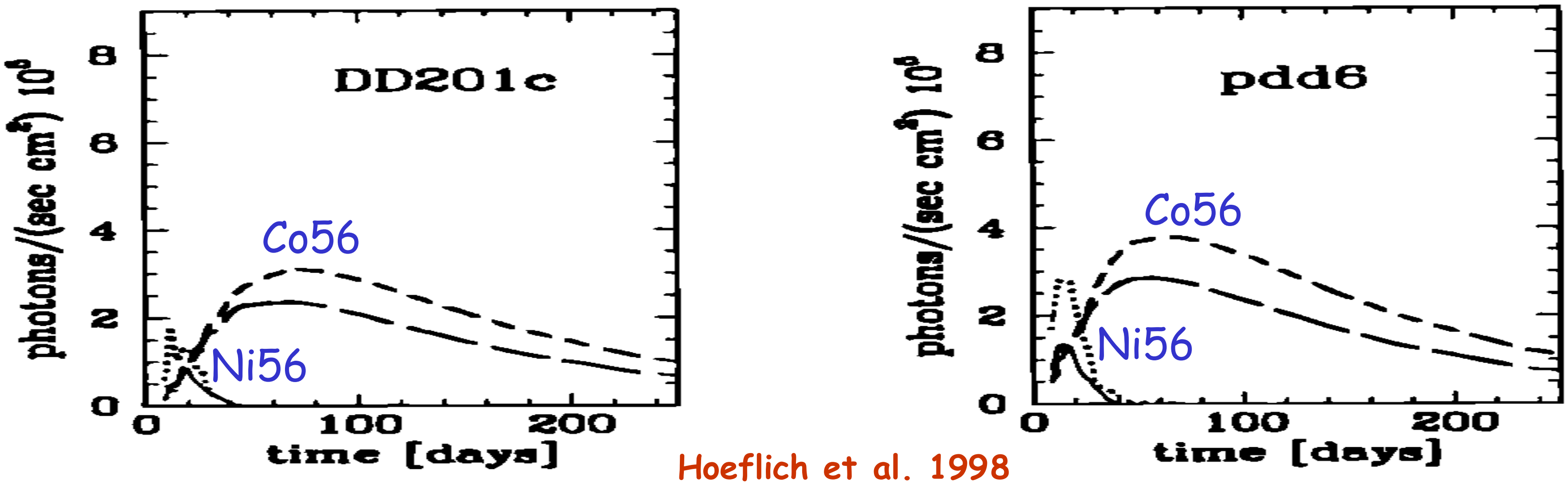
Gamma-ray spectra of Delayed detonation 1D models of SNIa



Hoeflich et al. 1998

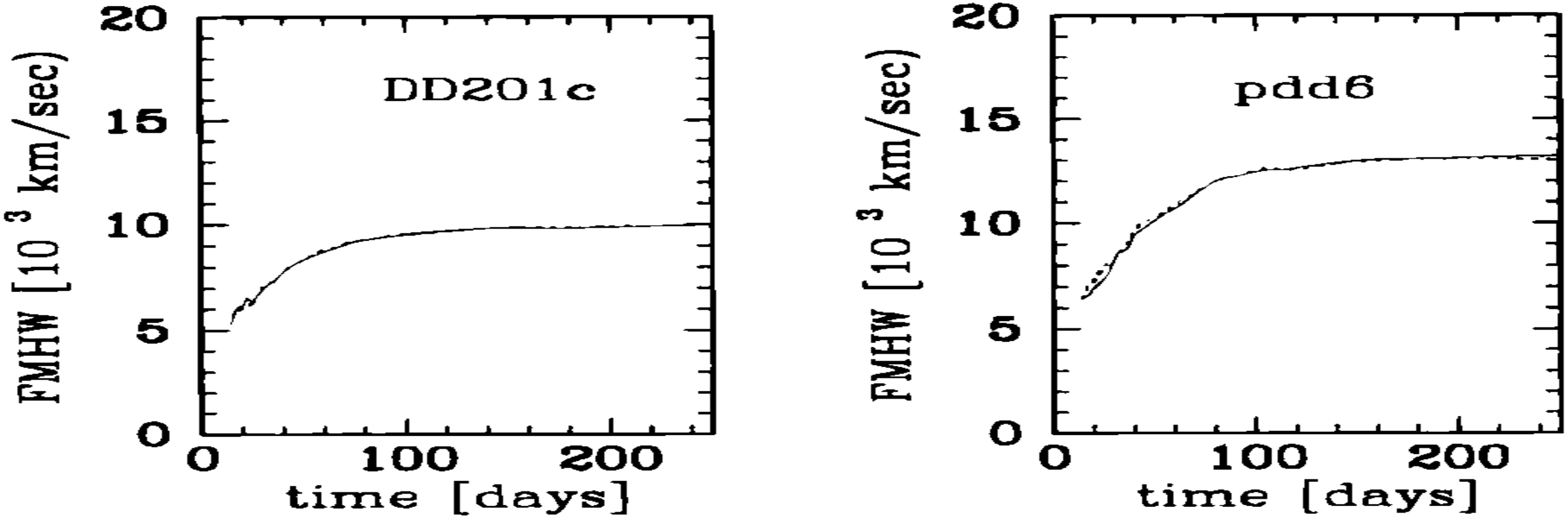
MAX

Evolution of Ni56 and Co56 line intensities in 1D models of SNIa

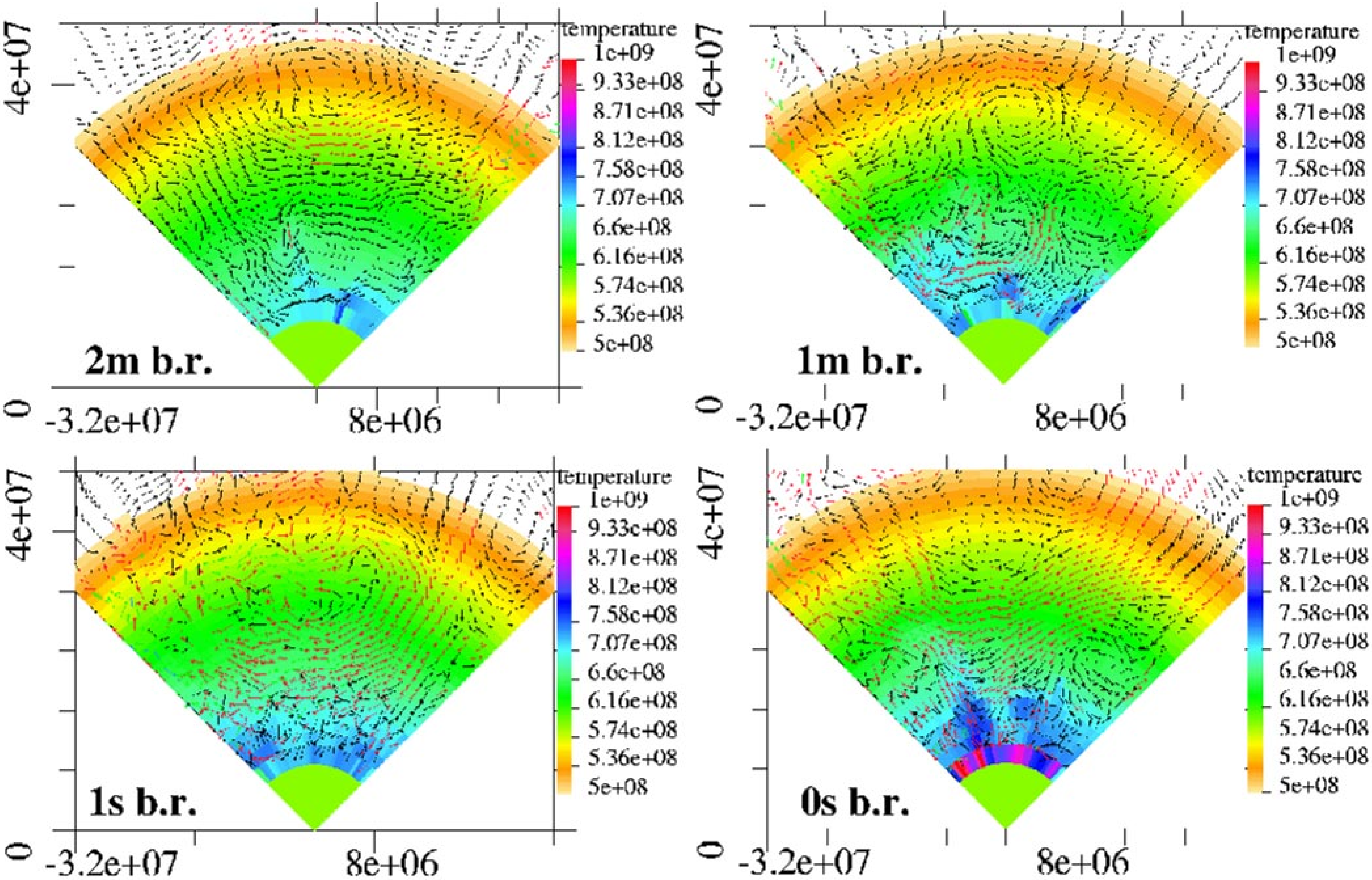


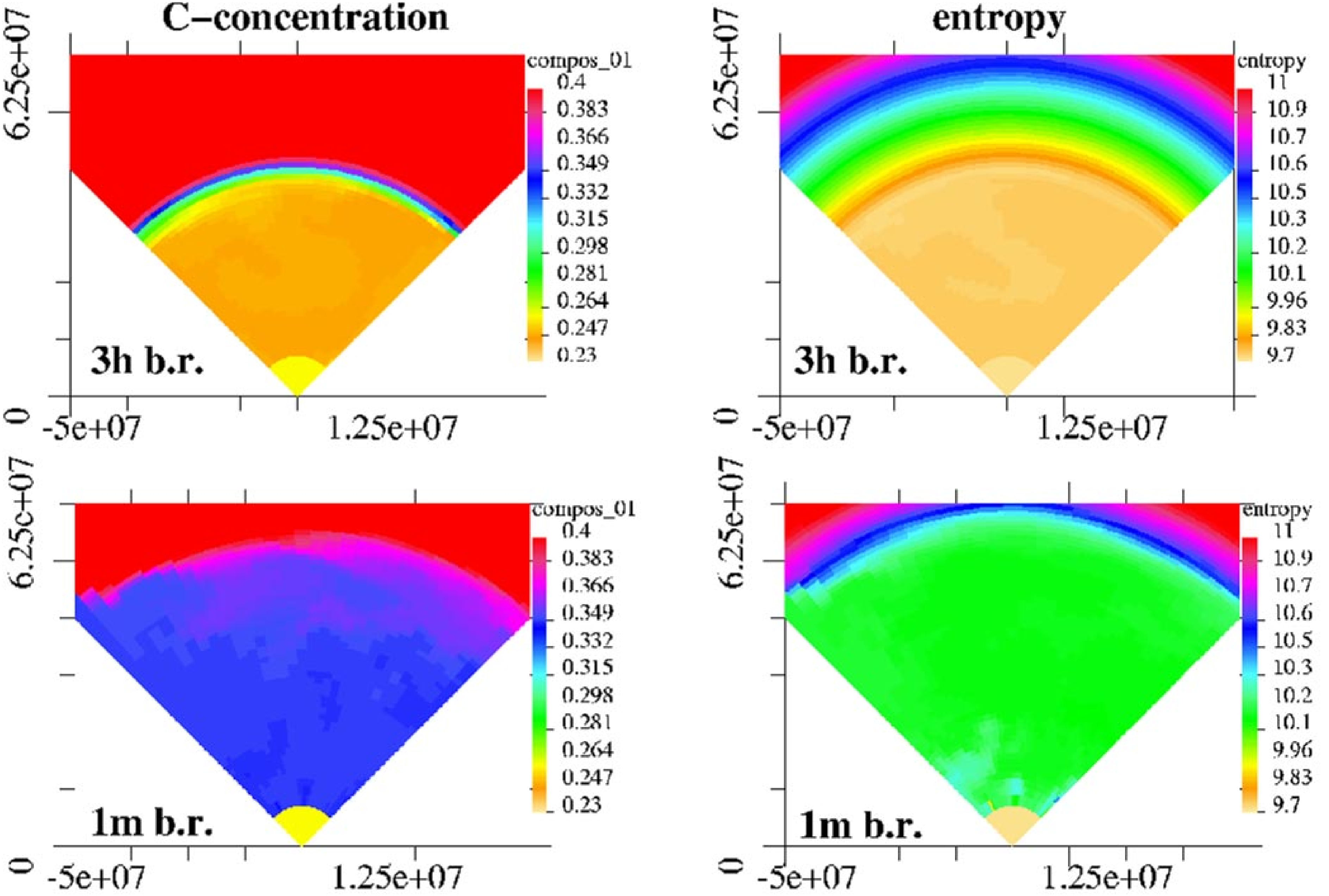
Hoeflich et al. 1998

Evolution of 0.847 MeV line FWHM in 1D models of SNIa



Role of pre-runaway evolution (Hoeflich and Stein 2002, 2D simulations)




C−concentration
entropy
compos_01
0.4
0.383
0.366
0.349
0.332
0.315
0.298
0.281
0.264
0.247
0.23
entropy
11
10.9
10.7
10.6
10.5
10.3
10.2
10.1
9.96
9.83
9.7
3h b.r.
1m b.r.
6.25e+07
0
-5e+07
1.25e+07

3D simulations of flame propagation (Reineke et al. 2001)

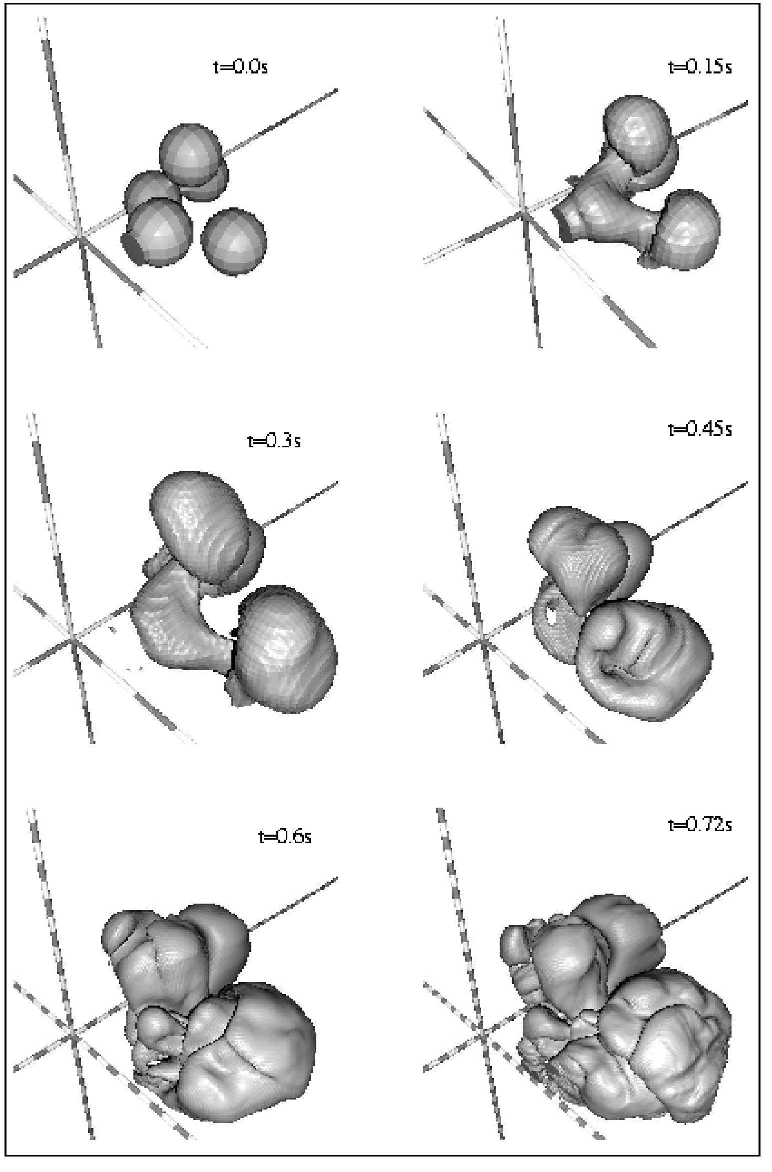


Fig. 1. Snapshots of the flame front for scenario b5_3d. The fast merging between the leading and trailing bubbles and the rising of the entire burning region is clearly visible.

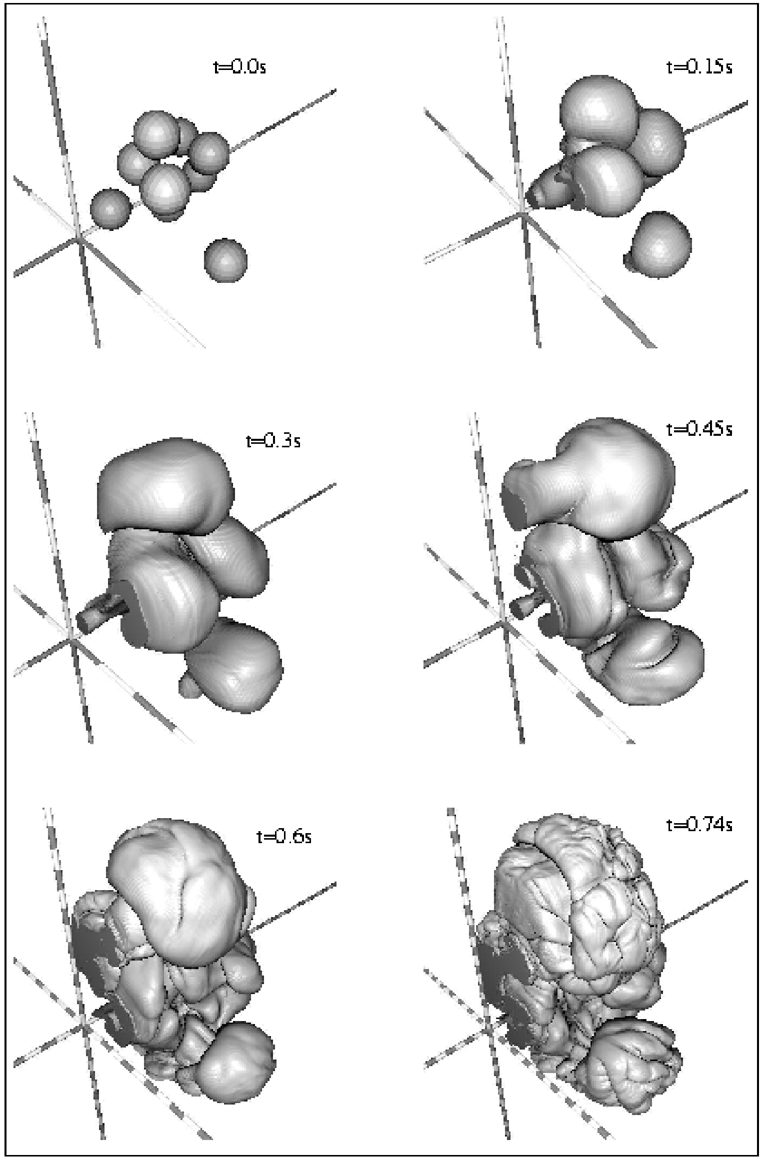
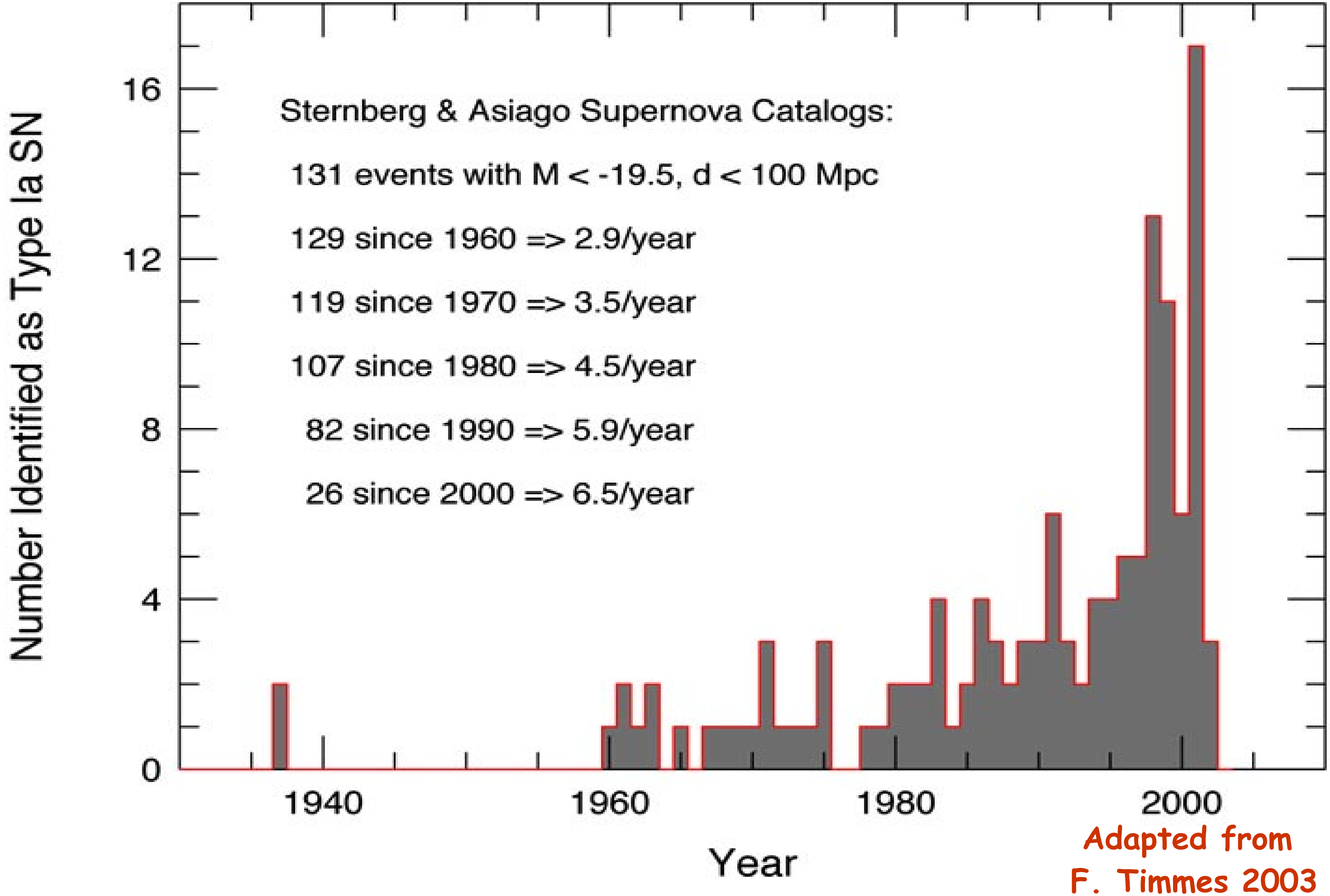
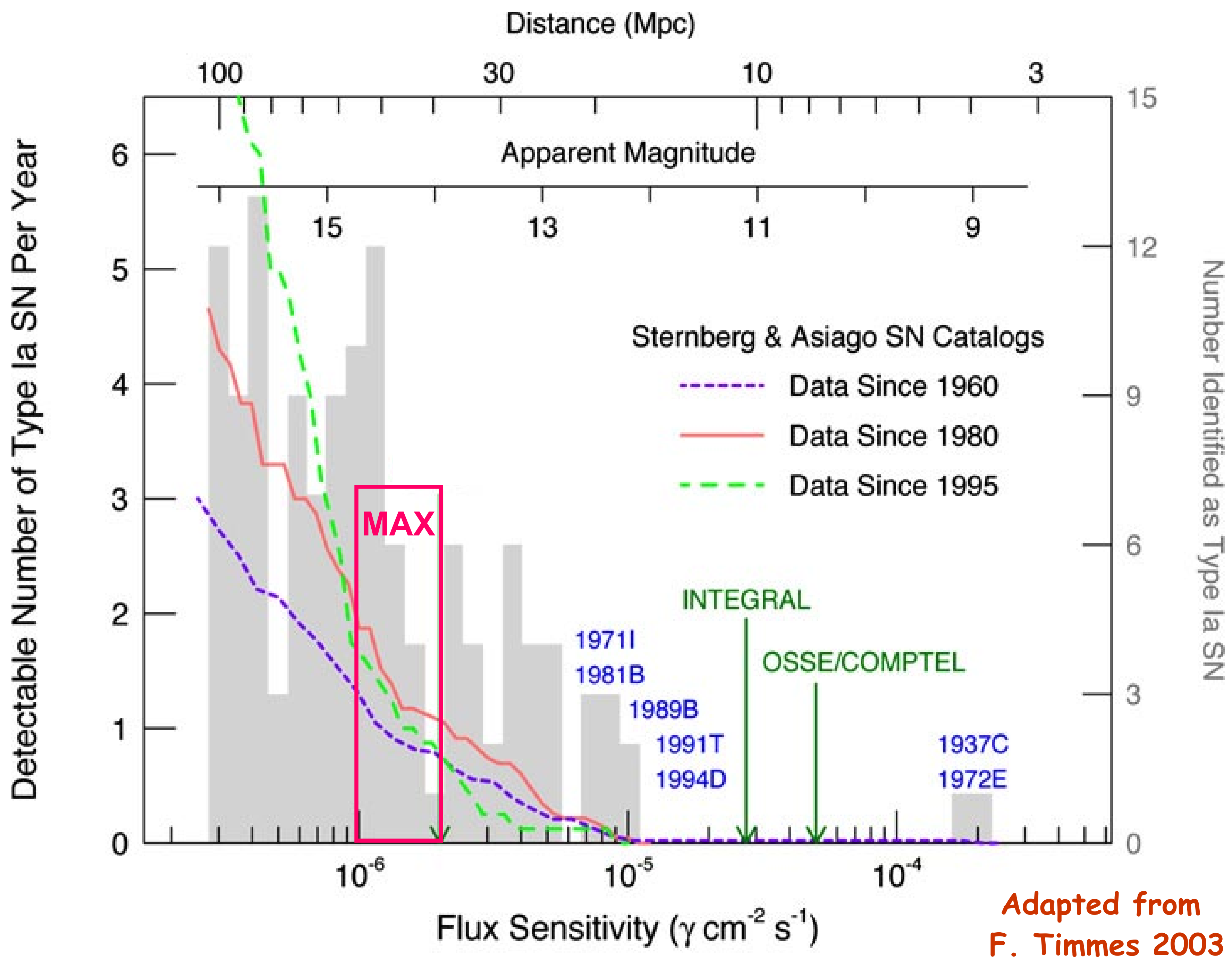


Fig. 2. Snapshots of the flame front for the highly resolved scenario b9_3d. One ring on the coordinate axes corresponds to 10^7cm.

SNIa discovery rate (<2003)

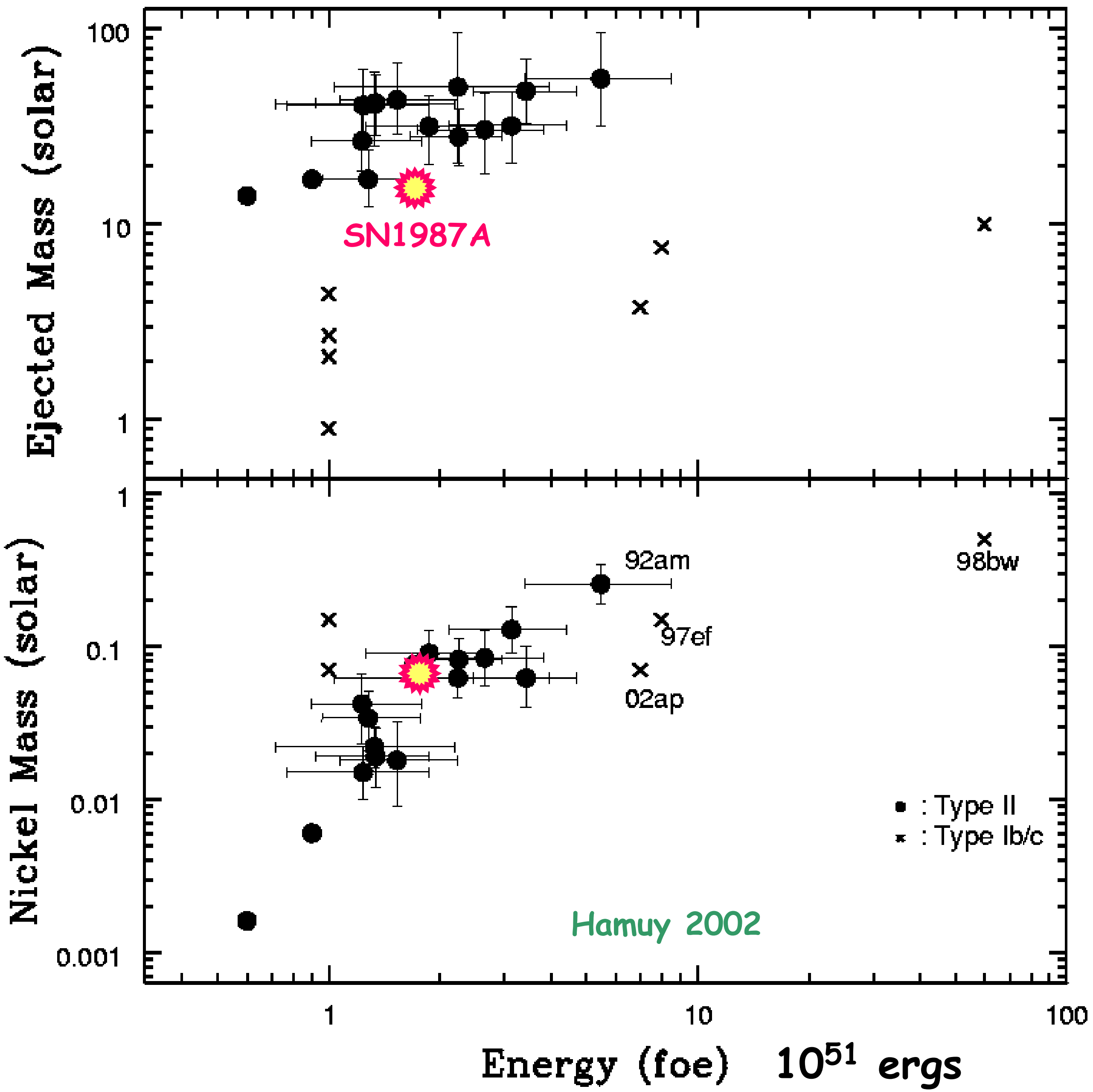


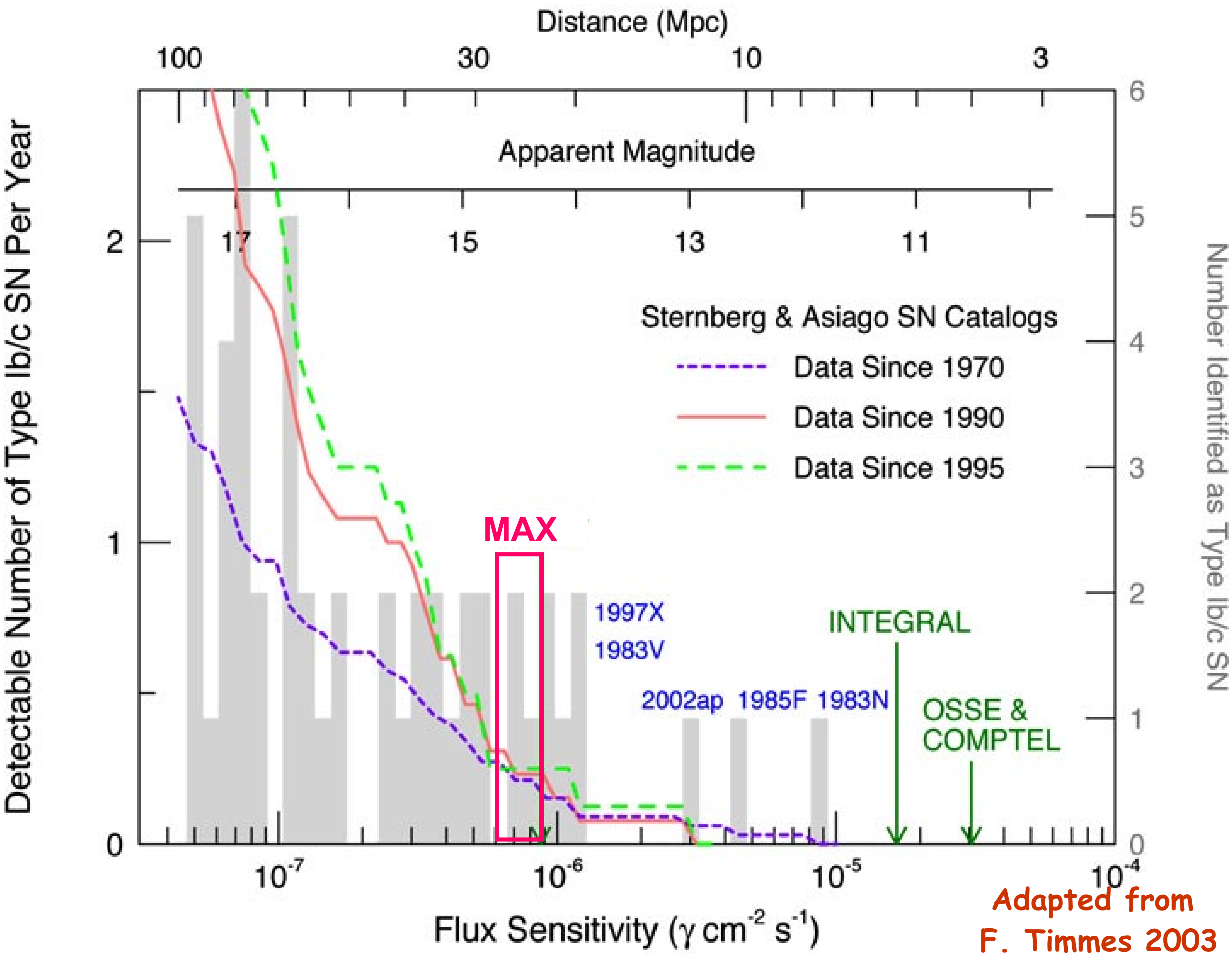
Adapted from
F. Timmes 2003



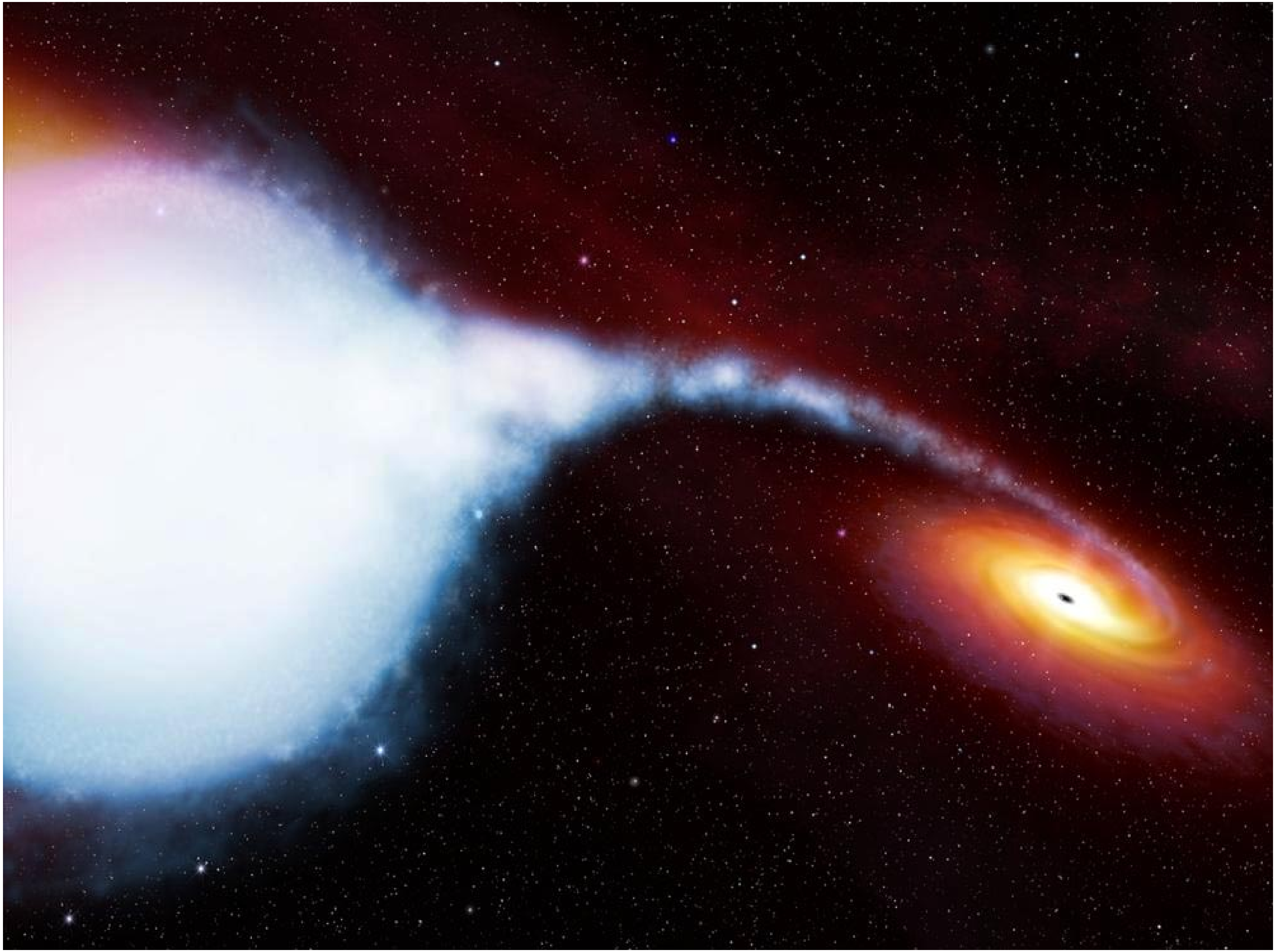
Adapted from
F. Timmes 2003

SNIb/c (core collapse)



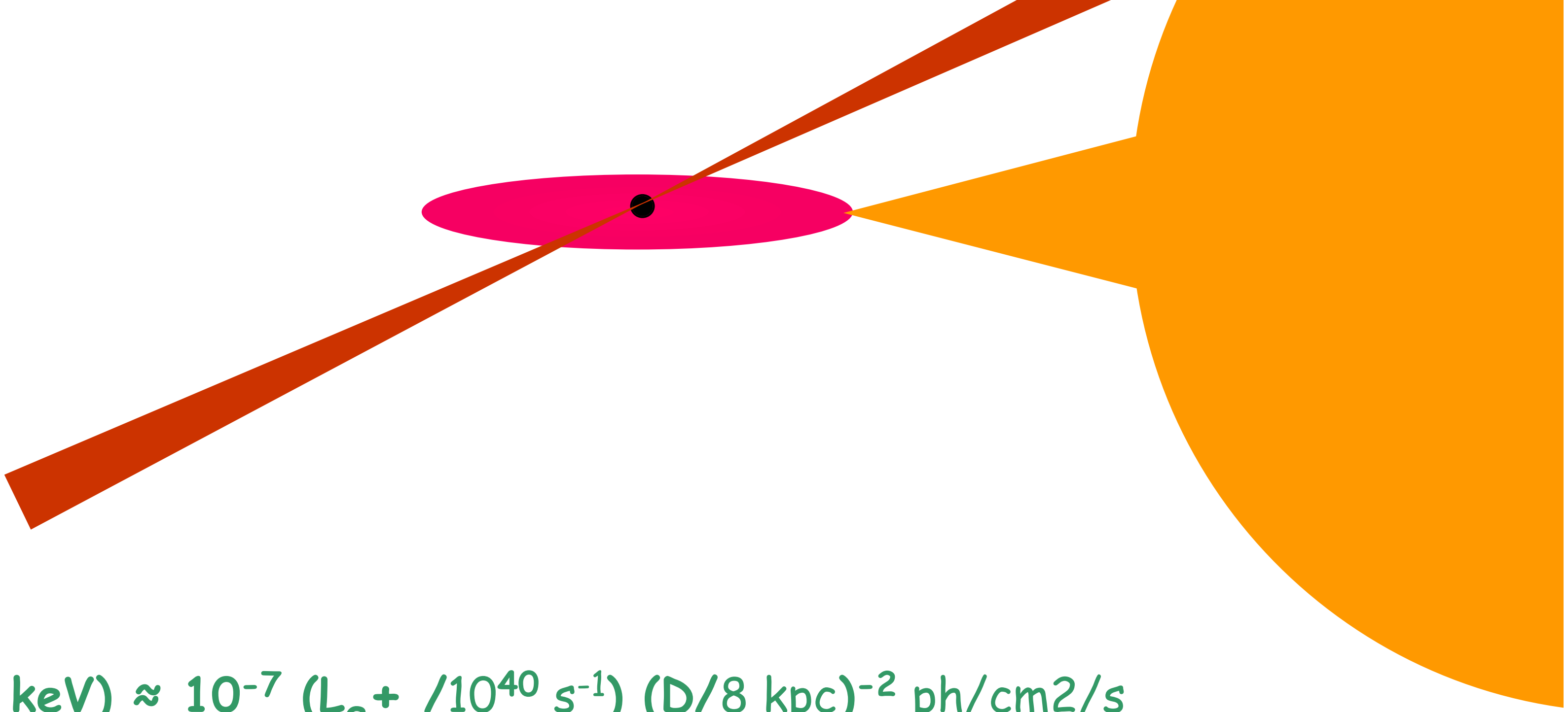


Adapted from
F. Timmes 2003



In some X-ray binaries, the inclination axis may be such that
the jets from the compact object periodically hit the companion
(e.g. V4641 Sgr, $i \sim 14\text{-}36^{o}$ **Orosz et al. 2001**)

Depending on the jet composition (baryons or positrons)
the jets will produce de-excitation lines
(0.478 keV of Li7* from _+_, or 511 keV from positrons)
(**Butt, Maccarone and Prantzos 2003**)



$$F(511\ \text{keV}) \approx 10^{-7}\ (L_{e+}\ /10^{40}\ s^{-1})\ (D/8\ \text{kpc})^{-2}\ \text{ph/cm2/s}$$